SUBMITTAL COVER SHEET				DATE: 10/12/2016	X	NEW SUBMITTAL	Division 26-219
						RESUBMITTAL	

TO:	(Owner) Arlington County: 3201 S. Eads Street Arlington, VA 22202 (Architect) STV, Inc. - 2722 Merrilee Dr. Suite 350 Fairfax, VA 22031 (Engineer) Atkins N. America, Inc. - 2318 Mill Rd., Suite 1040 Alexandria, VA 22314	FROM:	W. M. SCHLOSSER CO., INC. 2400 51ST PLACE HYATTSVILLE, MD 20781
ATTN:	Rami Natour, Jeremy Jenkins, Patrick Standiford, George Clark		

ART Bus Facility and Streetscape Improvements
Contract Agreement 722-15

ITEM NO.	DESCRIPTION OF ITEM SUBMITTED	Subcontractor, Manufacturer, Supplier	PROJECT SPEC SECTION	REVIEW CLASSIFICATION: A/E=ARCHITECT/ENGINEER/MIN APPROVAL I=INFORMATION ONLY	NO. OF COPIES P=PAPER E=ELECTRONIC
	Electrical O&M Manuals	Subcontractor, Manufacturer, Supplier	Spec. #	A/E	1E
	Division 26 O&M Manuals - Engine Generator	(Sub) Monacacy	263213	A/E	1E

Clarifications, Deviations and Comments:

This is a preliminary submittal only. Final O&M manuals will be submitted as a package per spec section 017823 - Operational and Maintenance Data. - CC, WMS

I HEREBY CERTIFY THAT THE EQUIPMENT, MATERIAL AND/OR ARTICLE SHOWN/MARKED IN THIS SUBMITTAL IS IN COMPLIANCE WITH THE CONTRACT DRAWINGS AND SPECIFICATIONS, CAN BE INSTALLED IN THE ALLOCATED SPACES AND IS APPROVED FOR USE.

NAME AND SIGNATURE OF CONTRACTOR

Chris Chapman, WMS

************* THIS SECTION FOR OWNER / ARCHITECT / ENGINEER USE ONLY *************

NAME, TITLE AND SIGNATURE OF APPROVING AUTHORITY

NAME: Jeremy Jenkins - ACG

TITLE: Construction Manager

SIGNATURE:

DATE IN:

DATE OUT: 10/24/16

ACTION TAKEN BY CONSTRUCTION MANAGER (CHECK APPLICABLE BOX):

- APPROVED (A)
- ✓ APPROVED AS NOTED (AAN)
- DISAPPROVED, REVISE AND RESUBMIT (RR)
- INFORMATION ONLY/NOT REVIEWED (FIO)

Comply with MBP submittal comments, see next page

This review is for the equipment manuals only and all other requirements under 017823 and 263213 need to be met in order to meet the O&M requirements under your final submission. - ACG

Construction Review **Draft**

MBP | ART Bus Facility | J13195

DRAFT

Division 26-219 - Engine Generator - Specific Manual Review Only

Author RJ Thompson
Date Reviewed 10/14/2016
Remark Reviewed
Submittal Division 26-219
Type O&M Manual

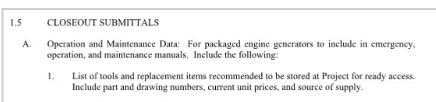
Issues 4

CR-DRAFT-1 OPEN MODERATE

Recommend indicating on the parts list and drawings which parts are recommended to be stored on site in case of an emergency or failure, any special tools required for repairs, and the supplier source with prices for the recommended parts per 263213/1.5/A/1.

Required action for final submittal - Jeremy Jenkins - ACG

Assigned To General Contractor
Asset Engine Generator
Discipline Electrical
Drawing Division 26-219
Created By RJ Thompson
Identified On 10/14/2016 1:38 PM


1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. Include the following:

1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

CR-DRAFT-2 OPEN LOW

Recommend reviewing the "Service Weekly Inspection Checklist" during the factory authorized demonstration in the future.

Required action for final submittal - Jeremy Jenkins - ACG

Assigned To Chris Chapman
Asset Engine Generator
Discipline Electrical
Drawing Division 26-219
Created By RJ Thompson
Identified On 10/14/2016 1:43 PM

CR-DRAFT-3 OPEN MODERATE

Recommend the factory start up request form is completed prior to start up of the engine generator.

Required action for final submittal - Jeremy Jenkins - ACG

Assigned To Chris Chapman
Asset Engine Generator
Discipline Electrical
Drawing Division 26-219
Created By RJ Thompson
Identified On 10/14/2016 1:46 PM

CR-DRAFT-4 OPEN MODERATE

Recommend the contractor ensures the factory authorized personnel on site to start-up the unit fully completes the start-up validation and pre-inspection form to not void the manufacturer's warranty.

Assigned To	Chris Chapman
Asset	Engine Generator
Discipline	Electrical
Drawing	Division 26-219
Created By	RJ Thompson
Identified On	10/14/2016 1:53 PM

Required action for final submittal as required by this manufacturer - Jeremy Jenkins - ACG

SERVICE
WEEKLY INSPECTION CHECKLIST

Please use the attached checklist to perform weekly service inspections on generator set equipment.

Before beginning any service, please conduct the following steps:

1. Perform lockout/tagout procedures before performing pre-start checks.
2. Refer to owner and operator manual for correct specifications.

DESCRIPTIONS:

Date	Record the date of the inspection.
Ambient Temp	Record air temperature around generator.
Oil Level	Record the level from the oil dipstick and the amount of oil added to the engine if it was needed.
Coolant Level	Record level of coolant in the radiator and add approved coolant, if needed.
Heaters	Check inlet and outlet hose temperature to verify operation.
Belts	Visually inspect belts for damage or fraying. Verify the **engine control** is in the **OFF** position.
Battery Charger	Visually inspect battery charger to verify operation. If equipped with a display, verify charge rate. If equipped with LEDs, verify correct LEDs are lit.
Battery Levels and Cables	Verify battery(s) are full of acid, cables are tight, and battery posts clean.
Leaks: Oil, Water, Fuel	Check all hoses and connections for dripping fluids. If needed, tighten hose clamps to contain leaks.
Amps	Record the amp reading when unit is running with load.
AC Volts	Record the AC volt reading when unit is running with load.
Frequency	Record the hertz reading when unit is running with load.
Oil Pressure	Record the oil pressure when unit is running with load.
Coolant Temp	When unit is running with load, record the coolant temperature reading once stabilized.
DC Volts	Record control panel DC voltage reading.
RTM	Record the Running Time Meter total before each test. Variances will show run time between inspection exercises.
ATS	Automatic Transfer Switch mark as **OK,** if test performed properly.
Maintenance Contact	Maintenance technician performing inspections should initial in this box.

TIM-ID: 0000077122 - 001

SERVICE: WEEKLY INSPECTION CHECKLIST

Date	Ambient Temp	Oil Level	Coolant Level	Heaters	Belts	Battery Charger	Battery Levels and Cables	Leaks: Oil, Water, Fuel	Amp	AC Volts	Frequency	Oil Pressure	Coolant Temp	DC Volts	RTM	ATS	Maintenance Contact	Comments

TIM-ID: 0000077122 - 001

1.6 Start-Up Request Form

START-UP REQUEST FORM

To provide an authorized factory start-up at the lowest possible prices, we must request that the following checklist and tasks be completed prior to a MTU Onsite Energy representative's arrival at the installation site to perform the start-up.

(Please Print)
Unit Serial Number: ___________________ **Contact Name:** ___________________

Company Name: ______________________ **Title:** ___________________________

Please attach a map or directions to the site. **Phone Number:** ___________________

- ☐ Unit set in place on vibration pads with floor anchor/studs to prevent movement.
- ☐ Radiator ducted to properly sized air discharge louvers.
- ☐ Doors on unit in alignment.
- ☐ Unit full of oil and water/anti-freeze mix.
- ☐ Battery filled with acid and fully charged.
- ☐ Battery charger mounted with AC and DC wired, if not supplied mounted by the factory.
- ☐ All AC and DC electrical connections made.
- ☐ Engine heater wired to normal AC power supply.
- ☐ Fuel inlet and return lines run between the unit and fuel storage system, system filled and primed to the engine with proper fuel.
- ☐ Exhaust system in place and supported so that the exhaust manifold does not carry weight of exhaust system.
- ☐ Air inlet louver motor wired to an emergency generator source point to open upon the start of an engine generator set.
- ☐ Generator room cleaned of construction debris including excess nails, bolts, nuts, panel knockouts, etc. It is very important that the radiator fan area is checked for debris, as damage to the equipment and personal injury can occur if loose items come in contact with the fan when the unit is initially started.

Consult your Installation Guide on any questions.

If, upon arrival at the installation site, our representative cannot perform the start-up as a result of defective equipment, the problems will be resolved and we will reschedule another start-up date at the earliest possible date at no additional charge.

If the start-up cannot be performed due to an incomplete installation or for reasons beyond MTU Onsite Energy's control, you may incur an additional start-up charge at a later date.

Signature: _______________________________ **Date:** ____________________________

TIM-ID: 0000079639 - 001

1.2 Start-Up Validation and Pre-Inspection Form

100 Power Drive, Mankato, MN 56001
800-325-5450
A Rolls-Royce Power Systems Company

Warranty, Start-up Validation and Pre-Inspection Form
(Inspections to be performed by factory authorized personnel only)

Start-up Date

_____/_____/_____

Follow the Startup Checklist on pages 2 – 4 of this form, then complete page 1.
This form is required for coverage under the MTU Onsite Energy Limited Warranty and must be completed in its entirety at time of initial start-up. The distributor and owner representative must sign the form. Site location address must be filled out. Signing this form represents acceptance of unit and that all information on the start-up is correct. The owner representative signature acknowledges review and understanding of this *Warranty, Start-up Validation and Pre-Inspection Form*. Please return a copy of the completed Warranty, Start-up Validation, and Pre-Inspection Form to MTU Onsite Energy within 60 days of the start-up date.

Authorized Representative Performing Startup			**Owner/Site Location**		
Company Name			Owner Name		
Address			Address		
City	State	ZIP/Postal Code	City	State	ZIP/Postal Code
Telephone			Telephone		
Technician Name (print)			Owner or Owner's Representative Name (print)		
Signature and Date mo.______day______year______			**Signature and Date** mo.______day______year______		

Generator Set Nameplate Data		**Engine Data**	
Model #		Engine Serial (found on engine block)	
Serial #		Fuel Type ☐ Diesel ☐ NG ☐ LP Vapor ☐ Liquid LP	
Rating		**ATS Data**	
Engine Model		Model #	
RPM	HZ	Serial # (found in ATS cabinet)	
kW	kVA	**Utility Service**	
Volts	Phase	Volts	Phase
Amps Per Terminal		Phase Rotation	AMPS
Generator			
Phase Rotation			

The MTU Onsite Energy Limited Warranty will be null and void if any aspect of the installation does not meet the general guidelines, standards, and recommendations as laid out in the Installation Guide (provided with the product) and all local standards and codes applicable in the location of installation.

Distributors: White Copy: Mail to MTU Onsite Energy Yellow Copy: Distributor Pink Copy: Owner WV-472 Rev. 2014-01

TIM-ID: 0000077121 - 002

INSTALLATION CHECKS

CHECK ONLY THE ITEMS THAT APPLY TO THE SPECIFIC APPLICATION.

Yes	No	N/A		
☐	☐	☐	1.	Is the equipment installed in a fire-resistant room (made of non-combustible material) or in an outdoor weather protected housing?
☐	☐	☐	2.	Is there emergency lighting available at the equipment room or weather protected housing?
☐	☐	☐	3.	When operating in an area that reaches sub-freezing temperatures is there adequate protection to prevent potential damage in the equipment room?
☐	☐	☐	4.	Is the equipment room protected with a fire protection system?
☐	☐	☐	5.	Is the mounting surface(s) visually properly constructed and leveled?
☐	☐	☐	6.	Is the mounting surface made from non-combustible material?
☐	☐	☐	7.	Has the wood skid been removed?
☐	☐	☐	8.	Is there adequate inlet and outlet air flow (electric louvers adjusted and ventilation fan motor(s) connected to the corresponding voltage)?
☐	☐	☐	9.	Is the radiator duct properly sized and connected to the air vent or louver?
☐	☐	☐	10.	Are flexible sections installed in the cooling water lines (remote radiator application)?
☐	☐	☐	11.	Is there an adequate/dedicated fuel supply?
☐	☐	☐	12.	Are the fuel filters installed?
☐	☐	☐	13.	Is there adequate fuel transfer tank pump lift capacity and is the pump motor connected to the corresponding voltage?
☐	☐	☐	14.	Is the fuel transfer tank pump connected to the emergency power source?
☐	☐	☐	15.	Are flexible fuel lines installed between the engine fuel inlet and fuel piping?
☐	☐	☐	16.	Is the specified gas pressure available at the fuel inlet? Note pressure (not running) ____________
☐	☐	☐	17.	Does the gas solenoid valve function?
☐	☐	☐	18.	Are the manually operated fuel and cooling water valves installed allowing manual operation or bypass of the solenoid valves?
☐	☐	☐	19.	Does the exhaust line have flexible connector(s)? Is the flexible connector(s) straight?
☐	☐	☐	20.	Is there an exhaust line condensate trap with a drain installed?
☐	☐	☐	21.	Is the specified silencer installed and are the hanger and mounting hardware tightened?

Yes	No	N/A		
☐	☐	☐	22.	Is a heat-isolating thimble(s) installed at points where exhaust lines pass through combustible wall(s) or partition(s)?
☐	☐	☐	23.	Is the exhaust line free of excessive bends and restrictions?
☐	☐	☐	24.	Is the exhaust line installed with a downward pitch toward the outside of the building?
☐	☐	☐	25.	Is the exhaust line protected from entry by rain, snow, and animals?
☐	☐	☐	26.	Does the exhaust system outlet location prevent entry of exhaust gases into buildings or structures?
☐	☐	☐	27.	Are individuals protected from exposure to high temperature exhaust parts and are hot parts safety decals present?
☐	☐	☐	28.	Does the nameplate voltage/frequency of the generator set and transfer switch match normal/utility source ratings?
☐	☐	☐	29.	Do the generator set load conductors have adequate ampacity and are they correctly connected to the circuit breakers and/or the emergency side of the transfer switch?
☐	☐	☐	30.	Are the load conductors, remote start loads, battery charger cables, and remote annunciator leads installed in separate conduits?
☐	☐	☐	31.	Is the battery charger AC circuit connected to the corresponding voltage and energized?
☐	☐	☐	32.	Is the tank heater AC circuit connected to the corresponding voltage and energized?
☐	☐	☐	33.	Is the battery(ies) filled with electrolyte and connected to the battery charger?
☐	☐	☐	34.	Are the engine starting cables connected to the battery(ies)?
☐	☐	☐	35.	Do the engine starting cables have adequate length and gauge?
☐	☐	☐	36.	Is the battery(ies) installed with adequate air ventilation?
☐	☐	☐	37.	Does earthquake protection (if required) support the system properly?
☐	☐	☐	38.	Does the equipment have lightning protection?

TIM-ID: 0000077121 - 002

PRE-START/RUNNING CHECKS
CHECK ONLY THE ITEMS THAT APPLY TO THE SPECIFIC APPLICATION.
** RECORD ALL RUNNING CHECKS ON PAGE 4

Yes	No	N/A	
☐	☐	☐	1. Inspect unit for freight damage (ensure components are tight).
☐	☐	☐	2. Verify that the engine is filled with oil, the cooling system is filled with coolant/antifreeze and battery(ies) are filled with acid.
☐	☐	☐	3. Inspect for proper belt alignment and tension.
☐	☐	☐	4. Inspect all electrical connections in control panel verify connections are tight and secure.
☐	☐	☐	5. Open all water and fuel valves. Temporarily remove the radiator cap to eliminate air in the cooling system. Replace radiator cap in step 21.
☐	☐	☐	6. Prime the fuel system.
☐	☐	☐	7. Press the LED test, if equipped on controller. Do all the LEDs on the panel illuminate?
☐	☐	☐	8. Place the generator set engine control switch in the OFF/RESET position. Observe Not-in-Auto LED and alarm, if equipped, on the controller.
☐	☐	☐	9. Open the generator main line circuit breakers.
☐	☐	☐	10. Verify the presence of lube oil in the turbocharger, if equipped.
☐	☐	☐	11. Verify power on to the water/oil heaters and fuel lift pumps.
☐	☐	☐	12. Verify that the day tank, if equipped, is energized.
☐	☐	☐	13. Place the generator set engine control switch in the RUN position. Allow the engine to start and run.
☐	☐	☐	14. Check the battery charger voltmeter and ammeter for battery charging indication.
☐	☐	☐	15. Verify whether there is sufficient oil pressure.
☐	☐	☐	16. If the speed is unstable, adjust.*
☐	☐	☐	17. Adjust the AC output voltage to match the utility voltage using the voltage adjusting control.
☐	☐	☐	18. Allow the engine to reach normal operating coolant temperature. Check for oil, coolant, and exhaust leaks. Check and tighten all hose connectors and clamps.
☐	☐	☐	19. Check the operating temperature on city water-cooled models and adjust the thermostatic valve as necessary.
☐	☐	☐	20. Manually overspeed (if applicable) the engine to cause an engine shutdown (71 Hz on 60 Hz models and 61 Hz on 50 Hz models). Place the generator set engine control switch in the OFF/RESET position.*
☐	☐	☐	21. Check the coolant level, add coolant as necessary, and replace the radiator cap. Verify that all hose clamps are tight and secure.

Yes	No	N/A	
☐	☐	☐	22. Place the generator set engine control switch in the RUN position.
☐	☐	☐	23. Verify the engine low oil pressure and high coolant temperature shutdowns.*
☐	☐	☐	24. Check the overcrank shutdown.*
☐	☐	☐	25. Check and verify any additional protective devices. List them: ___________, ___________, __________
☐	☐	☐	26. Place the generator set engine control switch in the OFF/RESET position.
☐	☐	☐	27. Check the utility source voltage, frequency, and phase sequence on three-phase models. The generator set must match utility source and load.
☐	☐	☐	28. Verify that all the wire connections from the generator set to the transfer switch and optional accessories are tight and secure.
☐	☐	☐	29. Close the generator set main line circuit breakers connected to the transfer switch.
☐	☐	☐	30. Place the generator set engine control switch in the RUN position.
☐	☐	☐	31. Check the generator set voltage, frequency, and phase sequence on three-phase models. The generator set must match utility source and load.
☐	☐	☐	32. Place the generator set engine control switch in the OFF/RESET position.
☐	☐	☐	33. Is the specified gas pressure available at the fuel inlet? Note pressure while running ____________
☐	☐	☐	34. Perform a proper fuel system setup with a wide range O2 sensor. Record air fuel ratio (AFR) NO LOAD_____ BUILDING LOAD or FULL LOAD_____ With Load Bank _____. If Building Load used List AMPS_____ (only required on 8.1LGMs and larger)
☐	☐	☐	35. Place the transfer switch in the TEST position. NOTE: Obtain permission from the building authority before proceeding. This procedure tests transfer switch operation and connects building load to generator set power.
☐	☐	☐	36. Readjust frequency to 50 or 60 Hz with total building loads.* Verify no load frequency to be no more than 62.0. Adjust if necessary. (Mechanical governor only)
☐	☐	☐	37. Verify that the current phase is balanced for three phase systems. List them ____________
☐	☐	☐	38. Release the transfer switch test switch. The transfer switch should retransfer to the utility source after appropriate time delay(s).
☐	☐	☐	39. Allow the generator set to run and shut down automatically after the appropriate cool down time delay(s).
☐	☐	☐	40. Set the plant exerciser with load to the customer's required exercise period, if equipped.

TIM-ID: 0000077121 - 002

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Yes	No	N/A		
☐	☐	☐	41.	Verify that all options on the transfer switch are adjusted and functional for the customer's requirements. Transfer Switch delay setting: TDES____TNE____TDN____TDEC____
☐	☐	☐	42.	In phase monitor ON_____ OFF_____
☐	☐	☐	43.	Verify that all options on the transfer switch are adjusted and functional for the customer's requirements.
☐	☐	☐	44.	If possible, run the building loads on the generator set or perform the load bank test if required.
☐	☐	☐	45.	Verify that the customer has the appropriate engine/generator set and transfer switch literature. Instruct the customer in the operation and maintenance of the power system.

* Some models with electronic engine controls may limit or prohibit adjusting the engine speed or testing shutdowns.

Time of Day	Gen. Amps	Gen. Volts	Gen. Freq.	Amb. Temp.	Oil Press.	DC Charg. Volts.	Water Temp.	Run Time Meter	Notes:

☐ Instruct customer on functions and operation of total EPSS (Emergency Power Supply System)

I ____ received training on ___________________________.
Please print name of person receiving training and have him/her sign his/her name Date

Notes

____

____

____

____

____

____

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Operation and Maintenance Manual

Gas engine-generator set

MTU 10V0068 GS75 (75 kW Standby)

Built in North America

131486244E

Order No.	131486244
Serial No.	94070600226

Table of Contents

DCL-ID: 0000041631 - 001

1 Manufacturer's Documentation

1.1 Parts List - Shop Order 94070600226

ORDER SUMMARY

BASIC INFORMATION			
SALES ORDER #: (1 per Sales Order)	131486244		
MATERIAL/SLU #: (1 per Sales Order)	GG10VF068A1N	**MODEL #:** (1 per Sales Order)	MTU 10V0068 GS75
APPLICATION:	☒ Standby ☐ Prime	**kW:** (1 per Sales Order)	75
DOC TYPE / QTY	With Unit: 1 HARDCOPY 1 CD ______ USB Separate: ______ HARDCOPY ______ CD ______ USB		

UNIT SPECIFIC INFORMATION		
PROD ORDER #: (1 or more per Sales Order)	**SERIAL #:** (1 per Production Order)	**FINISH DATE:** (1 per Production Order / Serial Number)
1. 403006242	1. 94070600226	1. 02/10/2016

Configuration Summary

Ford
MTU 10V0068 GS75
GG10VF068A1N

```
Customer:           Curtis Engine & Equipment Company

Project:            326200536
MTU Order:          1314862
                    27.01.2016

II.                 Selection Criteria for the Scope of Supply

Criteria
                    Selection           for Product No.
Fuel Type           Natural gas         1,
Frequency           60 Hz               1,
```

```
Voltage for starters                    480 V               1,
Phase               3 Phase             1,
Unit Specification  Standard Unit       1,
Temp Rise           130°                1,
Power Output        70 kW               1,
Exhaust Emissions (EPA)                 EPA 40 CFR Part 60/90                  1,
Radiator Design Temperature             50°C                1,
Circuit Breaker Options                 Single Circuit Breaker                 1,
Breaker Wire Color Scheme               Standard Breaker Wire Color Scheme     1,
Control Panel       With Control Panel  1,
OPU/HSD             Level 1 - Standard  1,
Country of Operation                    USA / Canada        1,
Acceptance testing  Factory acceptance  1,
Publications        Standard Publications (English)         1,


III.                Scope of Supply

                                        valid for product no.
1                   SYSTEM CONFIGURATION                    1,
1.1                 System Description  1,
                    Model: GG10VF068A1N

ELECTRICAL DRAWING: 808-Q-1314862  JAG  8-18-15

Dimensional:    XZG3100100054

                    1,
1.2                 Cooling Package     1,
                    50 Deg C Cooling System
-                   Closed loop, liquid cooled, with radiator factory mounted on engine-
generator set mounting frame and integral engine-driven coolant pump
                    1,
1.3                 Circuit Breaker     1,
                    Single Circuit Breaker
                    1,
                    Specify Circuit Breaker #1
                    1,
                    125 Amp 3 Pole 100% CB SQ-D  HDL36125C
                    1,
                    Circuit Breaker Factory Mounted
                    1,
                    Circuit Breaker Mounted Right Side
                    1,
                    Circuit Breaker #1 Accessories:
                    1,
                    Aux Contact
                    1,
                    Shunt Trip
```

TIM-ID: 0000104674 - 001

1,
Standard breaker wire scheme:
- Phase 1 (A) is Black label "L1"
- Phase 2 (B) is Red label "L2"
- Phase 3 (C) is Blue label "L3"
- Neutral is White label "NEU"
1,
1.4 Starting Aids 1,
Battery, Rack and Acid
1,
Battery Charger: Guest 12-6a
1,
Battery Charger Mounted & AC/DC Wired
1,
With Coolant Preheating
1,
Block Heater: 20 Deg F Block Heater (120V 1PH - 1500W) Model: TPS151GT10-005
1,
Block Heater Mounted & AC Wired
1,
1.5 Genset Enclosure 1,
Level 1
- Weather proof enclosure constructed of heavy gauge steel or aluminum with fixed storm proof panels. Enclosure consists of a bolted and welded construction with unit-mounted internal muffler included. Hinged, lockable double-door access on both sides of the enclosure
1,
190mph Wind Rated
1,
1.6 Vibration Isolation 1,
Pad Isolators (Std)

- ¼ inch thick elastomeric pad in square shape placed under the base frame at each of the pre-drilled isolator mounting holes
1,
2 ENGINE CONFIGURATION 1,
2.1 Engine System 1,
EPA Certification Tier Level: Tier 2
1,
10V 6.8L Gaseous Engine Naturally Aspirated
1,
2.2 Exhaust System 1,
Hospital Grade Exhaust

- Provides 35 – 40dB of sound attenuation 1,
2.3 FUEL SYSTEM 1,
Fuel System: Natural Gas
1,

TIM-ID: 0000104674 - 001

Fuel System Plumbed to Base
1,
Dry Fuel Strainer
1,
Fuel System Single NG or LP Vapor (Plumbed to Unit Base)
(SUAPH104897 – FORD 6.8L)
1,
2.4 Air Intake System 1,
Air Filter 2-Stage (Heavy Duty)
1,
3 GENERATOR CONFIGURATION 1,
3.1 Generator system 1,
Generator Model Number: 362/1604
1,
3.2 Generator accessories 1,
MVC63-4 Regulator
1,
Generator Strip Heater
- Strip heater mounted permanently in the generator winding to prevent condensation in the generator. 1,
4 CONTROL PANEL CONFIGURATION 1,
4.1 Control panel 1,
MGC- 2000 Series

• MTU Onsite Energy's Digital Genset Controller MGC-2000 series is a highly advanced integrated generator set control system. The MGC-2000 series is perfectly focused, combining rugged construction and microprocessor technology to offer a product that will hold up to almost any environment and flexible enough to meet your application's needs. This device provides generator set control, transfer switch control, metering, protection, and programmable logic in a simple, easy-to-use, reliable, rugged, and cost effective package.

1,
MGC-2010 Control Panel
1,
Control Panel Mounted Left Side
1,
Remote E-Stop
1,
5 SERVICES AND AFTER SALES SUPPLY 1,
5.1 Warranty 1,
2Yr/3000 Hr Basic Stdby Limited Warranty (Std)
1,
6 MISCELLANEOUS 1,
6.1 Painting 1,
Paint Color: ANSI 61 Gray
1,
6.2 Documentation 1,

TIM-ID: 0000104674 - 001

	English	
	1,	
	1 CD Format	
	1,	
	English	
	1,	
	1 Hard Copy	
	1,	
6.3	Additional Options	1,
8	FUNCTIONAL TESTING	1,
8.1	Acceptance Testing	1,
	Standard Commercial Test	
	1,	
9	SHIPPING CONDITIONS	1,
9.1	Shipment	1,
	Ship Unit Wet - Fluids Installed	
	1,	

Raw Material Components

Material	Material Description	Requirement quantity	Base Unit of Measure
XS526500.00143	CONTROL PANEL	1	PC
SUA103815	MGC-2010 (MICROPROCESSOR DGC-2020 REV3 L	1	PC
XSG30300.00015	ASSEMBLY KIT	1	PC
SUA63015	MOUNT VIBE PAD 3 X 8 X 1/4 SP NEOPRENE	6	PC
XSG30340.00084	HEATER	1	PC
SUA86487	HEATER STRIP 360F 250 WATT (361F-363F) M	1	PC
XSG31080.00002	FUEL SYSTEM	1	PC
SUA100022	LOCK NUT 5/16-18 18-8 STAINLESS STEEL NY	4	PC
SUA101348	NUT FLANGE LOCK HEX NYLON-INSERT M6-1.0	2	PC
SUA102094	BRACKET BAR FUEL SYSTEM FORD 6.8L	1	PC
SUA102354	BRACKET SUPPORT SINGLE FUEL SYSTEM FORD	1	PC
SUA44316	CLAMP MUFFLER 2" SP	1	PC
SUA47428	FITTING PIPE ELBOW 90 DEG 1-1/2" SCHEDUL	2	PC
SUA47536	COUPLING PIPE 1-1/2" NPT SCHED 40 THREAD	1	PC
SUA48515	FITTING PIPE NIPPLE 1-1/2" NPT X CLOSE	4	PC
SUA48549	FITTING PIPE BUSHING 1 1/2" MALE NPT X 1	1	PC
SUA48606	FITTING PIPE NIPPLE 1-1/2" NPT X 3" LONG	1	PC
SUA74356	ADAPTER PIPE TO 37DEG FLARE 1 1/2" NPT M	1	PC
SUA83648	PLUG PIPE 1-1/2" NPT PLASTIC BLACK PLAST	1	PC
SUA85836	FLANGE BOLT M6X20 DIN6921 CLASS 8.8 ZINC	3	PC
SUA88624	BRACKET FUEL BASE CONNECTION 1-1/2 INCH	1	PC
SUA88740	CAP SCREW 5/16"-18 X 1" 18-8 STAINLESS S	4	PC
SUA88992	LOCK NUT M8-1.25 DIN 985 ZINC PLATED NYL	1	PC
SUA89192	WASHER 5/16" X 3/4" 18-8 STAINLESS STEEL	8	PC
SUA92586	HOSE FLEX BRAIDED 24" LENGTH WITH FITTIN	1	PC
SUA93627	NIPPLE PIPE 1 1/2" NPT X 12" LG SCHED 40	1	PC
SUA97425	WASHER FLAT M8 X 8.4MM ID X 17MM OD ZINC	1	PC
SUA98631	PLUG DOME 2-1/4 INCH DIAMETER HOLE CONVE	1	PC
XG3241200001	SOLENOID VALVE	2	PC
SUA80614	PLUG PIPE BRASS 1/8" NPT	1	PC
SUA94443	BUSHING PIPE 1/2" X 1/8" NPT SCHED 40 BL	1	PC
SUA80623	FITTING PIPE TEE PIPE REDUCING 1-1/2" NP	1	PC
XSG31140.00003	EXHAUST SILENCER	1	PC

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ORDER SUMMARY

Material	Material Description	Requirement quantity	Base Unit of Measure
SUA101370	UL2200 "CAUTION HOT SURFACES DO NOT TOUC	1	PC
SUA101686	SPACER BRACKET 11X25X15 FORD 6.8L	2	PC
SUA101703	EXHAUST TUBE FLANGE TO MUFFLER FORD 6.8L	1	PC
SUA101705	BRACKET EXHAUST MUFFLER PLATFORM FORD 6.	1	PC
SUA101706	BRACKET LEG MUFFLER PLATFORM FORD 6.8L	4	PC
SUA101740	MUFFLER SPACE SAVER INSULATED V-CLAMP FO	1	PC
SUA101955	CLAMP V-BAND 3 INCH DIAMETER	1	PC
SUA44320	CLAMP MUFFLER	1	PC
SUA47851	GROMMET RUBBER 13/4"O.D. X 1"I.D. X 3/8"	2	PC
SUA77141	SHIELD RAIN 4"	1	PC
SUA79868	BRACKET HOT SIGN MOUNTING - 3"/3 1/2"/4"	1	PC
SUA80541	CAP RAIN VERTICAL/HORIZONTAL 4" NEW FITS	1	PC
SUA88778	CAP SCREW M10-1.5 X 25MM 8.8 DIN 933 FUL	8	PC
SUA88932	HEX CAP SCREW M8-1.25 X 25MM 8.8 DIN 933	4	PC
SUA88933	HEX CAP SCREW M8-1.25 X 30MM 8.8 DIN 933	8	PC
SUA88941	HEX FULL NUT M8-1.25 DIN 934 Z CL8 COARS	4	PC
SUA89102	LOCK NUT M10-1.5 DIN 985 NYLON INSERT ZI	12	PC
SUA90484	V-CLAMP 4" DIAMETER FOR FLANGED MUFFLERS	1	PC
SUA94725	WASHER FLAT HARDENED M8 X 16MM	34	PC
SUA94928	NUT M8 X 1.25 HEX LOCKNUT (NYLON INSERT)	4	PC
SUA97425	WASHER FLAT M8 X 8.4MM ID X 17MM OD ZINC	8	PC
SUA97475	TUBE EXHAUST ELBOW OUTLET 80-125KW REVEL	1	PC
SUA98566	CAP SCREW M10-1.5 X 90MM DIN 931 CLASS 1	2	PC
SUA98916	BRACKET SUPPORT MUFFLER 14 INCH SPECIAL	2	PC
XSG31200.00002	RADIATOR	1	PC
SUA101938	RADIATOR FORD 6.8L NA 50°C	1	PC
SUA101947	FAN RADIATOR FORD 6.8L NA 50°C	1	PC
SUA102143	SPACER FAN DRIVE 80-100KW FORD 6.8L	1	PC
SUA102150	ELBOW SILICONE JW 90 DEGREE 1.75" ID FOR	1	PC
SUA102152	HOSE 1.75"ID X 4"L SILICONE FORD 6.8L	3	PC
SUA102222	CAP SCREW HEX M8-1.25 X 180MM GR 10.9 YE	4	PC
SUA102235	BRACKET LEFT RADIATOR FORD 6.8L	1	PC
SUA102236	BRACKET RIGHT RADIATOR FORD 6.8L	1	PC
SUA102569	WASHER 1/2", .531 ID X 1.75 OD X .100 TH	2	PC
SUA103046	SENSOR LOW WATER LEVEL "ROCHESTER	1	PC

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Material	Material Description	Requirement quantity	Base Unit of Measure
	GAUGE"		
SUA43329	CLAMP HOSE 1 9/16" - 2 1/2" OD HEX HEAD	8	PC
SUA49473	CAP SCREW M12-1.75 X 30MM 8.8 DIN 933 FU	4	PC
SUA71117	MOUNT VIBE PVC DONUT TYPE SP 2.3" X 1" J	2	PC
SUA88661	CAP SCREW 1/2-13 X 2" GRADE 5 ZINC PLATE	2	PC
SUA88878	WASHER FLAT 1/2" SAE ZINC	2	PC
SUA88933	HEX CAP SCREW M8-1.25 X 30MM 8.8 DIN 933	4	PC
SUA92666	WASHER INSULATOR GASKET 2.5 OD X 1.063 I	2	PC
SUA94725	WASHER FLAT HARDENED M8 X 16MM	4	PC
SUA95544	WASHER, FLAT HARDENED, M12 X 13MM ID X 2	4	PC
XG3120200001	PIPE	1	PC
XG3120200002	PIPE	1	PC
XSG31210.00006	GENERATOR	1	PC
SUA87260	GENERATOR 362/1604 SP SAE 3 FLYWHEEL 11.	1	PC
XSG31230.00013	BASE	1	PC
SUA102017	BASE WELDED 100L X 48W X 6H 6.8L FORD	1	PC
XSG31230.00014	MOUNT	1	PC
SUA47701	LOCK NUT ZINC PLATED SERRATED FL	16	PC
SUA47719	WASHER FLAT1/2" ZINC PLATED USS	4	PC
SUA47728	LOCK WASHER ZINC PLATED MEDIUM SPLI	4	PC
SUA85783	MOUNT VIBE UNIT TO BASE EBCO 4690-80-J -	4	PC
SUA88660	SCREW CAP HEX 1/2"-13 X 1-1/4" GRADE 5	4	PC
SUA88870	BOLT FLANGE 5/16"-18 X 3/4" HARDENED Z	16	PC
SUA96132	BRACKET GENERATOR RISER 4 INCHES 80-125K	2	PC
XSG31240.00001	GAS ENGINE	1	PC
XG3134200003	GAS ENGINE FOR GENSET	1	PC
MS65038/00E	DOCUMENTATION EMISSION CONFORMITY	1	PC
XSG31300.00042	ADHESIVE LABEL FOR GENSET	1	PC
SUA79477	LABEL HEATER 120VAC CHARGER 120VAC WHITE	1	PC
XSG31300.00076	NAMEPLATE FOR GENSET	1	PC
SUA87005	NAMEPLATE - BLANK GEN-SET (ANODIZED)	1	PC
XSG31300.00174	CIRCUIT BREAKER	1	PC
SUA85650	BREAKER 125A 600V 3P 100% H-FRAME SQUARE	1	PC
XSG31300.00222	CONNECTION BLOCK	1	PC
SUA85948	BLOCK NEUTRAL KIT 125A-400A SN400LA SQUA	1	PC

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ORDER SUMMARY

Material	Material Description	Requirement quantity	Base Unit of Measure
XSG31300.00228	MOUNTING PLATE	1	PC
SUA47700	LOCK NUT ZINC PLATED SERRATED FLA	8	PC
SUA88859	FLANGE BOLT CASE HARDENED Z	8	PC
SUA96118	BRACKET BREAKER MOUNT PLATE SINGLE JD250	1	PC
XSG31300.00254	RECEPTACLE	1	PC
SUA100595	BLOCK TERMINAL 4-QUATTRO PE 3031461	1	PC
SUA39156	COVER DUPLEX RECEPTACLE STANDARD	1	PC
SUA88443	PLATE SEPARATING FOR QUATTRO TERMINAL BL	1	PC
SUA89015	MACHINE SCREW 8-32 X 1/2" PHILLIPS PAN	2	PC
SUA90460	TERMINAL BLOCK MARKER BLANK	5	PC
SUA95852	HARNESS WIRING DUPLEX RECEPTACLE SPECIAL	1	PC
SUA96594	TERMINAL BLOCK DOUBLE DOUBLE 30A MAX ST	4	PC
SUAMF96981	RECEPTACLE DUPLEX 120V 20A NEMA 5-20R 2P	1	PC
XSG31300.00261	CONNECTING ELEMENT	1	PC
SUA89079	NUT HEX M8-1.25 DIN 934 CLASS 8 ZINC	1	PC
SUA49430	STUD GROUND LUG CSA TD COMPRESSION --SP-	2	PC
SUA88865	BOLT FLANGE 3/8-16 X 3/4" CASE HARDENED	1	PC
SUA89006	WASHER LOCK SPLIT M8 DIN 127 ZINC	1	PC
SUA89078	NUT M8 FLNG. LK	1	PC
SUA93138	WIRE GROUNDING UL LISTED 12" 2/0 AWG GRE	1	PC
SUA93801	STUD M8 X 1.25 X 2" LOW CARBON	1	PC
SUA95313	WASHER, FLAT HARDENED, M8 X 8.4MM ID X 1	2	PC
XSG31300.00263	TERMINAL	1	PC
SUA88443	PLATE SEPARATING FOR QUATTRO TERMINAL BL	1	PC
SUA90460	TERMINAL BLOCK MARKER BLANK	2	PC
SUA96594	TERMINAL BLOCK DOUBLE DOUBLE 30A MAX ST	2	PC
XSG31300.00266	SWITCH HOUSING	1	PC
SUA100530	ADHESIVE LABEL	1	PC
SUA34137	TRIM VINYL PROTECTIVE	1.88	FT
SUA49430	STUD GROUND LUG CSA TD COMPRESSION --SP-	1	PC
SUA87437	ENCLOSURE BREAKER SINGLE H/J-FRAME (480V	1	PC
SUA88709	CAP SCREW 3/8-16 X 1" GRADE 5 ZINC PLATE	4	PC
SUA88709	CAP SCREW 3/8-16 X 1" GRADE 5 ZINC PLATE	1	PC
SUA89062	NUT ZINC PLATED NYLON INSERT LOCK	4	PC
SUA89195	WASHER M10 DIN 127 ZINC PLATED SPLIT LOC	1	PC

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ORDER SUMMARY

Material	Material Description	Requirement quantity	Base Unit of Measure
SUA95543	WASHER, FLAT HARDENED, M10 X 10.5MM ID X	2	PC
SUA95543	WASHER, FLAT HARDENED, M10 X 10.5MM ID X	8	PC
SUA89057	NUT GRADE 5 ZINC PLATED HEX FULL	1	PC
XSG31300.00275	BATTERY CHARGER	1	PC
SUA79100	12V 6A 120VAC 2-STAGE (GUEST) ONSITE ENE	1	PC
XSG31300.00278	LABEL	1	PC
SUA97884	DECAL LIFT POINT 2L X 2W ISO STANDARD	4	PC
XSG31300.00280	FUSE	1	PC
SUA42820	BLOCK FUSE	1	PC
SUA42828	FUSE	3	PC
SUA47761	MACHINE SCREW 10-24 X 1/2" SLOTTED PAN H	2	PC
SUA88964	K-LOCK NUT (KEPS NUT) 10-24NC ZINC PLAT	2	PC
XSG31300.00281	PLUG	1	PC
SUA95977	PLUG DOME 3" DIAMETER HOLE CONVEX MATTE	4	PC
XSG31300.00282	LABEL	1	PC
SUA75981	PLATE RAINPROOF ENCLOSURE 1" X 2" BLACK	1	PC
XSG31300.00291	ALARM SWITCH	1	PC
SUA90090	1A 1B + ALARM SWITCH (BELL ALARM) SQ-D	1	PC
XSG31300.00294	TRIPPING UNIT	1	PC
SUA90088	SHUNT TRIP 12V DC D-H-J-LD-FRAME SQUARE-	1	PC
XSG31300.00298	DUCT	1	PC
SUA102697	FLANGE DUCT 80-100KW FORD 6.8L	1	PC
SUA85832	FLANGE BOLT 1/4-20 X 5/8 STAINLESS STEEL	6	PC
XSG31300.00299	AIR FILTER	1	PC
SUA102372	BRACKET SUPPORT AIR FILTER FORD 6.8L	1	PC
SUA43303	ELBOW HOSE RUBBER 4" 90 DEG USED ON AIR	1	PC
SUA43339	CLAMP HOSE 3" TO 5 1/2" OD HEX HEAD WORM	3	PC
SUA77168	FILTER AIR (UL) BALDWIN	1	PC
SUA94105	ADAPTER TUBE AIR FILTER TO MIXER MOUNTIN	1	PC
SUA95201	TUBE AIR CLEANER 4.0 DIA X 31.50"	1	PC
SUA95538	FLANGE BOLT, M6-1.0 X 16MM, DIN 6921 CLA	4	PC
SUA44323	CLAMP MUFFLER 4"	1	PC
XSG31300.00305	HOUSING	1	PC
SUA101171	ENCLOSURE DOOR ROD SUPPORT STEEL 6R1600	4	PC
SUA101989	ENCLOSURE KIT ANSI 61 GRAY 150MPH STEEL	1	PC

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ORDER SUMMARY

Material	Material Description	Requirement quantity	Base Unit of Measure
SUA102736	BOLT FLANGE NON-SERRATED 3/8-16 X 1 GRA	25	PC
SUA102738	NUT FLANGE NON-SERRATED NYLON-INSERT 1/4	54	PC
SUA102739	NUT FLANGE NON-SERRATED NYLON-INSERT 3/8	25	PC
SUA45221	FLANGE ANGLE RING 6" I.D. --SP	1	PC
SUA77163	STRAP DOOR GROUNDING 12.5L 5/16 RING LUG	4	PC
SUA77784	LATCH FLUSH MOUNTED FOLDING T-HAND ADJUS	2	PC
SUA82538	FOAM INSULATION 5/8" X 3/8" DOMED W.STRI	25	FT
SUA82554	FOAM INSULATION 3/4" WIDE X 1/16" THICK	22	FT
SUA85832	FLANGE BOLT 1/4-20 X 5/8 STAINLESS STEEL	46	PC
SUA88978	LOCK NUT 10-24 18-8 STAINLESS STEEL NYLO	12	PC
SUA88992	LOCK NUT M8-1.25 DIN 985 ZINC PLATED NYL	48	PC
SUA89001	WASHER LOCK 5/16" ZINC PLATED EXTERNAL T	8	PC
SUA89082	FLANGE BOLT 1/4-20 X 5/8 STAINLESS STEEL	80	PC
SUA96031	BOLT ON (BLIND) POWDER BLACK STAINLESS P	12	PC
SUA96086	WASHER FLAT NYLON 1/4 X 1/16 THICK	110	PC
SUA96194	ROD FOR DOOR LATCH - REVELATION HSG	4	PC
XSG31300.00310	HEATER	1	PC
SUA43320	CLAMP HOSE HEX HEAD WOR	4	PC
SUA47407	NIPPLE PIPE 3/8"NPT X 4" LG SCHED 40 BLK	2	PC
SUA47414	NIPPLE PIPE SCHED 40 BLK	2	PC
SUA47425	ELBOW PIPE SCHED 40 BLK	1	PC
SUA47441	BUSHING PIPE 1/2" X 3/8" BLACK STEEL HEX	2	PC
SUA48519	ELBOW PIPE 1/2" NPT 45 DEG SCHED 40 BLK	2	PC
SUA52057	BALL 1/2" NPT BRASS USE AS STANDARD	2	PC
SUA52748	HEATER TANK 1500W 120V 1PH KIM HOTSTART	1	PC
SUA57057	FITTING HOSE 5/8 HOSE BARB TO 1/2" NPT	2	PC
SUA80452	HOSE 5/8" ID 2 PLY GREEN STRIPE (300' SP	2.2	FT
SUA80452	HOSE 5/8" ID 2 PLY GREEN STRIPE (300' SP	0.75	FT
XSG31300.00312	BATTERY	1	PC
SUA101052	CABLE	1	PC
SUA120299	BATTERY 12V HP-31 ENGINE STARTING BATTER	1	PC
SUA71142	BOLT BATTERY HOLD DOWN TO RACK MATERIAL	2	PC
SUA80412	BRACKET BATTERY HOLD DOWN BAR USED WITH	1	PC
SUA88705	CAP SCREW 3/8-16 X 1 18-8 SS	4	PC
SUA97234	CABLE BATTERY 2/0 AWG X 24"L W/ AUX. WIR	1	PC

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ORDER SUMMARY

Material	Material Description	Requirement quantity	Base Unit of Measure
SUA98777	3/8" 18-8 STAINLESS STEEL LARGE OD FLAT	4	PC
SUA98778	3/8"-16 18-8 STAINLESS STEEL SERRATED FL	4	PC
SUA89057	NUT GRADE 5 ZINC PLATED HEX FULL	4	PC
SUA47717	FLAT WASHER 3/8 ZINC PLATED SAE	2	PC
SUA105488	BATTERY RACK - 30-60KW DIESEL	1	PC
XSG31300.00315	CONNECTING HARDWARE	1	PC
SUA87301	WASHER FLAT (GOLD)	20	PC
SUA87304	SCREW CAP SOCKET 3/8"-16 X 7/8" ASTM A5	8	PC
SUA88713	CAP SCREW GRADE 5 ZINC PLATED	12	PC
XSG31300.00316	OIL DRAIN VALVE	1	PC
SUA43314	HOSE 3/8" ID 50 PSI (FUEL) (UL) GATES 42	4	FT
SUA48307	VALVE OIL DRAIN 14MM - 1 1/2" USED ON FO	1	PC
XSG31300.00317	CONNECTING HARDWARE	1	PC
SUA49473	CAP SCREW M12-1.75 X 30MM 8.8 DIN 933 FU	1	PC
SUA49516	HEX CAP SCREW M12-1.75 X 20MM 8.8 DIN 93	1	PC
SUA78974	CLAMP SUPPORT PLASTIC COATED (SP	1	PC
SUA80505	CLAMP SUPPORT PLASTIC COATED W/	2	PC
SUA88882	FLAT WASHER 12MM ID X 24MM OD DIN 125 ZI	2	PC
SUA89004	LOCK WASHER ZINC PLATED SPLI	2	PC
XSG31300.00318	V-BELT GUARD	1	PC
SUA102409	GUARD BELT RIGHT FORD 6.8L	1	PC
SUA102410	GUARD BELT LEFT FORD 6.8L	1	PC
SUA85836	FLANGE BOLT M6X20 DIN6921 CLASS 8.8 ZINC	6	PC
SUA88992	LOCK NUT M8-1.25 DIN 985 ZINC PLATED NYL	1	PC
SUA89102	LOCK NUT M10-1.5 DIN 985 NYLON INSERT ZI	1	PC
SUA96084	FLANGE BOLT M8-1.25 X16MM 8.8 DIN6921 ZI	1	PC
SUA97425	WASHER FLAT M8 X 8.4MM ID X 17MM OD ZINC	1	PC
SUA97437	WASHER FLAT M10 X 1.5MM ID X 21MM OD ZIN	1	PC
XSG31300.00322	FOAM	1	PC
SUA102748	FOAM WITH ALUMINUM FACING FOR HSG - 80-1	2	PC
XSG31300.00323	HEAT SHIELD	1	PC
SUA103067	SHIELD RIGHT MANIFOLD - FORD 6.8L	1	PC
SUA104336	SHIELD HEAT Y-PIPE 80-125KW FORD 6.8L	1	PC
SUA44317	CLAMP MUFFLER 2 1/4"	2	PC
XSG31300.00324	TAG	1	PC

ORDER SUMMARY

Material	Material Description	Requirement quantity	Base Unit of Measure
SUA95546	TAG NATURAL GAS GREEN	1	PC
XSG31300.00330	BOX	1	PC
SUA100527	PLATE COVER FOR DVR-PLUS REGULATOR	1	PC
SUA100661	OUTLET BOX PANEL DUAL BREAKERS J-FRAME W	1	PC
SUA102182	PANEL OUTLET BOX REAR - 360 FRAME	1	PC
SUA102183	PANEL OUTLET BOX CONTROLS - 360 FRAME	1	PC
SUA102184	PANEL OUTLET BOX FRONT - 360 FRAME	1	PC
SUA64014	CHANNEL RUBBER 1/16 "U" SHAPED USED ON A	1	FT
SUA82554	FOAM INSULATION 3/4" WIDE X 1/16" THICK	1	FT
SUA88858	FLANGE BOLT CASE HARDENED Z	12	PC
SUA96043	MACHINE SCREW 10-24 X 1/2" PHILLIPS PAN	2	PC
SUA96372	PANEL TOP COVER OUTLET BOX 360 FRAME 80-	1	PC
SUA88858	FLANGE BOLT CASE HARDENED Z	4	PC
XSG31300.00357	BUSBAR	1	PC
SUA75825	BUSBAR COPPER 1-1/2L X 7/8W X 3/16 INCH	1	PC
XSG31300.00364	PAINT	1	PC
SUA82193	PAINT 2-PART (ANSI DARK GRAY) PINNACLE 4	2	GAL
XSG31300.00366	COOLANT	1	PC
SUA90763	COOLANT 50/50 FLEET CHARGE - EG	7	PC
XSG31300.00367	CONNECTING HARDWARE	1	PC
SUA49224	GROMMET RUBBER 4" OD X 2-5/8" ID X 13/32	1	PC
SUA88858	FLANGE BOLT CASE HARDENED Z	4	PC
XSG31300.00371	TAG	1	PC
SUA88487	DECAL "MTU/ONSITE" (X-LARGE) .	4	PC
XSG31300.00372	TAG	1	PC
SUA70782	LABEL VOLTAGE REGULATOR ADJUST BLACK ON	1	PC
XSG31300.00373	TAG	1	PC
SUA100426	TAG TAG NFPA 37 EXHAUST	1	PC
SUA102673	DECAL CAUTION HOT SIGN 2 INCH X 3.5 INCH	2	PC
SUA103675	LABEL 66.50/66.49 ENGINE EPA CERTIFIED F	1	PC
SUA39003	PLATE "PAC" W/ ADHESIVE BACKING BLK PRIN	1	PC
SUA39015	PLATE "WARNING" (UL) (UNIT MAY	1	PC
SUA39016	PLATE "DANGER" (UL)	1	PC
SUA47938	PLATE "ISOLATED NEUTRAL N0T BONDED.."	1	PC
SUA70682	LABEL CAUTION HIGH LEG POSITION 2-1/2L X	1	PC

ORDER SUMMARY

Material	Material Description	Requirement quantity	Base Unit of Measure
SUA71558	PLATE - GROUND (UL)	1	PC
SUA72039	TAG N0TICE: COOLING SYSTEM HAS BEEN FILL	1	PC
SUA72044	TAG CAUTION CHECK OIL LEVEL BEFORE START	1	PC
SUA72045	TAG CAUTION EXHAUST SYSTEM HAS BEEN SEAL	1	PC
SUA72047	TAG DO NOT REMOVE TAG UNTIL WARRANTY REG	1	PC
SUA72709	LABEL "CAUTION" FOR LOW WATER LEVEL SHUT	1	PC
SUA73369	PLATE "NOTICE" DISCONNECT BATTERY CABLES	1	PC
SUA73791	PLATE "CAUTION" RISK OF ELECTRICAL SHOCK	1	PC
SUA73799	PLATE "NOTICE" SERVICE ACCESS DO N0T BLO	1	PC
SUA73800	PLATE "NOTICE" AC+DC CIRCUITS MUST BE RU	1	PC
SUA75985	TAG WARNING!!! BATTERY MUST BE FULLY CHA	1	PC
SUA76197	PLATE "WARNING" 2" X 3" (UL) "UNIT STAR	2	PC
SUA77823	DECAL "MADE IN THE USA"	1	PC
SUA83389	TAG "IMPORTANT" REFER TO INSTALLTION GUI	1	PC
SUA92623	LABEL CAUTION RISK OF ELECTRIC SHOCK REC	1	PC
SUA95856	LABEL NOTICE CIRCUIT BREAKER IS RATED LE	1	PC
SUA96612	TAG-CONNECT BATTERIES BEFORE ENERGIZIING	1	PC
XSG31300.00377	Y-PIPE	1	PC
SUA47466	STRAINER PIPE 1 1/2"NPT WATT Y WATTS 77	1	PC
SUA48653	PLUG PIPE SCHED 40 BLK IRON PIP	1	PC
XSG31300.00384	REMOTE CONTROL	1	PC
SUASA150340	ASY REMOTE E-STOP 24VDC	1	PC
XSG31300.00391	JUNCTION BOX	1	PC
SUA100351	BOX HANDY SCREW COVER WITH KNOCKOUTS 8W	1	PC
SUA100392	BLOCK TERMINAL MARKER LABELS PHOENIX 503	1	PC
SUA44106	CONNECTOR WIRE RING LUG 10 INSULATED 14	1	PC
SUA47190	WIRE 14 AWG 90 DEG C GREEN TYPE THNN	0.75	FT
SUA93505	TERMINAL BLOCK, END BLOCK	2	PC
SUA95528	K-LOCK NUT, M5-0.8 KEP ZINC PLATED	2	PC
SUA95635	MACHINE SCREW, M5-0.8 X 10MM, DIN 7985 P	2	PC
SUAMF95279	RAIL MOUNTING DIN 35MM X 7.5MM X 7-1/8"	1	PC
XSG31300.00392	JUNCTION BOX	1	PC
SUA100394	CONDUIT NON METALIC LIQ MN 1/2	1	FT
SUA100396	CONNECTOR 1/2 NON-METALLIC STR LIQ (NMLT	1	PC
SUA100544	BRACKET AC ACCESSORY CONNECTION BOX	2	PC

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ORDER SUMMARY

Material	Material Description	Requirement quantity	Base Unit of Measure
SUA100564	CONNECTOR 1/2 INCH 45 DEGREE NON-METALLI	1	PC
SUA100673	LABEL DANGER RISK OF ELECTRIC SHOCK UL 4	1	PC
SUA105201	LABEL STRANDED WIRE ONLY	1	PC
SUA47700	LOCK NUT ZINC PLATED SERRATED FLA	4	PC
SUA76718	PLATE "DANGER HIGH VOLPLATEE"	1	PC
SUA88858	FLANGE BOLT CASE HARDENED Z	8	PC
XSG31300.00399	RELAY	1	PC
SUA100225	RELAY SOCKET 12V DC 14MM PLC BASIC TERMI	1	PC
SUA90460	TERMINAL BLOCK MARKER BLANK	2	PC
SUA98838	RELAY 1PDT 12VDC/21HC AU 2961532	1	PC
XSG31300.00405	CONTROL PANEL	1	PC
SUA102321	HARNESS WIRING ENGINE FORD	1	PC
SUA102520	CONTROL BOX ENCLOSURE - FORD	1	PC
SUA102521	CONTROL BOX DOOR DGC-2020 - FORD	1	PC
SUA102705	ALARM BUZZER 12-24VDC STD PANEL ALARM SO	1	PC
SUA103934	FUSE 25A 32VDC AUTOMOTIVE BLADE-TYPE UL	1	PC
SUA106299	HARNESS WIRING 2020 PANEL REV 3 FORD	1	PC
SUA106826	SWITCHES SWITCH	1	PC
SUA41804	DIODE 1N5408 1000V 3A ARIAL LEAD GENERAL	1	PC
SUA47700	LOCK NUT ZINC PLATED SERRATED FLA	12	PC
SUA55021	RAIL MOUNTING DIN 35MM	11	"
SUA73395	KNOB PULL BLACK PHENOLIC THREADED INSERT	1	PC
SUA76718	PLATE "DANGER HIGH VOLPLATEE"	1	PC
SUA77832	LATCH SLOTTED RECESS STYLE USED ON CONTR	1	PC
SUA77906	LABEL NOTICE NOT RESPONSIBLE FOR LOOSE C	1	PC
SUA79008	RESISTOR 120 OHM 1/4W 1% METAL	1	PC
SUA80504	CLAMP SUPPORT 1" ID PLASTIC COATED W/ .5	1	PC
SUA88949	NUT HEX 1/4-20 GRADE A ZINC	4	PC
SUA88964	K-LOCK NUT (KEPS NUT) 10-24NC ZINC PLAT	4	PC
SUA90460	TERMINAL BLOCK MARKER BLANK	2	PC
SUA90532	HINGE CONTINUOUS STAINLESS REVELATION CO	1	PC
SUA92608	LABEL CONTROL PANEL MODEL 1.75L X 4.25W	1	PC
SUA93502	TERMINAL BLOCK, JUMPER	9	PC
SUA93505	TERMINAL BLOCK, END BLOCK	2	PC
SUA93571	TERMINAL BLOCK, MARKERS BLANK	28	PC

ORDER SUMMARY

Material	Material Description	Requirement quantity	Base Unit of Measure
SUA93573	DOUBLE DOUBLE 20A MAX ST 2.5-QUATTRO	24	PC
SUA95692	TERMINAL BLOCK FUSE HOLDER MODULAR ST 4-	2	PC
SUA95694	FUSE 5A 32VDC AUTOMOTIVE BLADE-TYPE (U	1	PC
SUA95756	M25 X 1.5 BLACK	1	PC
SUA96018	PANEL COMPONENTS CONTROL BOX REVELATION	1	PC
SUA97367	BLOCK TERMINAL PLUG-IN BRIDGE FBS 2-8 2	1	PC
SUA95327	TERMINAL BLOCK, END CAP, USED WITH PN935	1	PC
XSG31300.00406	MOUNTING RAIL	1	PC
SUA88964	K-LOCK NUT (KEPS NUT) 10-24NC ZINC PLAT	2	PC
SUAMF95279	RAIL MOUNTING DIN 35MM X 7.5MM X 7-1/8"	1	PC
XSG33090.00001	VOLTAGE REGULATOR	1	PC
SUA77199	REGULATOR VOLTAGE MAVC63-4D UL (SE350)	1	PC
XSG33230.00013	RUBBER GROMMET	1	PC
SUA49224	GROMMET RUBBER 4" OD X 2-5/8" ID X 13/32	1	PC
XSG33300.00021	ADAPTER CABLE	1	PC
SUAMF140006	HARNESS FUSE BLOCK 3/8" 3P	1	PC
XSG33300.00025	ADAPTER CABLE	1	PC
SUAMF140010	HARNESS FUSE BLOCK 3/8" 1P	1	PC
XS00D000.05948	TECHN. INSTR. MANUAL FOR GENSET	1	PC
SUA107378	DOCUMENTATION MANUAL (PRINTED) - ENGLISH	1	PC
XS00D000.05950	TECHN. INSTR. MANUAL FOR GENSET	1	PC
SUA107380	DOCUMENTATION MANUAL (CD) - ENGLISH	1	PC
XSG31000.00008	DIMENSIONAL DRAWING FOR GENSET	1	PC
XZG3100100054	DIMENSIONAL DRAWING FOR GENSET	1	PC
XSG32300.00282	WORK SCHEDULE	1	EA
TXT00016703	DUMMY FOR IPAS PM GASSYSTEM DEVELOPMENT	1	PC
XSG21990.00001	ADHESIVE LABEL FOR GENSET	1	PC
XG3000400004	LABEL	1	PC
XSG21500.00077	CURRENT TRANSFORMER	1	PC
SUA41705	TRANSFORMER CURRENT 150:5 600V 5.0VA SEC	3	PC

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1.2 Start-Up Validation and Pre-Inspection Form

100 Power Drive, Mankato, MN 56001
800-325-5450
A Rolls-Royce Power Systems Company

Warranty, Start-up Validation and Pre-Inspection Form
(Inspections to be performed by factory authorized personnel only)

Start-up Date

_____/_____/_____

Follow the Startup Checklist on pages 2 – 4 of this form, then complete page 1.
This form is required for coverage under the MTU Onsite Energy Limited Warranty and must be completed in its entirety at time of initial start-up. The distributor and owner representative must sign the form. Site location address must be filled out. Signing this form represents acceptance of unit and that all information on the start-up is correct. The owner representative signature acknowledges review and understanding of this *Warranty, Start-up Validation and Pre-Inspection Form*. Please return a copy of the completed Warranty, Start-up Validation, and Pre-Inspection Form to MTU Onsite Energy within 60 days of the start-up date.

Authorized Representative Performing Startup			**Owner/Site Location**		
Company Name			Owner Name		
Address			Address		
City	State	ZIP/Postal Code	City	State	ZIP/Postal Code
Telephone			Telephone		
Technician Name (print)			Owner or Owner's Representative Name (print)		
Signature and Date mo.______day______year______			**Signature and Date** mo.______day______year______		

Generator Set Nameplate Data		**Engine Data**	
Model #		Engine Serial (found on engine block)	
Serial #		Fuel Type ☐ Diesel ☐ NG ☐ LP Vapor ☐ Liquid LP	
Rating		**ATS Data**	
Engine Model		Model #	
RPM	HZ	Serial # (found in ATS cabinet)	
kW	kVA	**Utility Service**	
Volts	Phase	Volts	Phase
Amps Per Terminal		Phase Rotation	AMPS
Generator			
Phase Rotation			

The MTU Onsite Energy Limited Warranty will be null and void if any aspect of the installation does not meet the general guidelines, standards, and recommendations as laid out in the Installation Guide (provided with the product) and all local standards and codes applicable in the location of installation.

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INSTALLATION CHECKS
CHECK ONLY THE ITEMS THAT APPLY TO THE SPECIFIC APPLICATION.

Yes	No	N/A		
☐	☐	☐	1.	Is the equipment installed in a fire-resistant room (made of non-combustible material) or in an outdoor weather protected housing?
☐	☐	☐	2.	Is there emergency lighting available at the equipment room or weather protected housing?
☐	☐	☐	3.	When operating in an area that reaches sub-freezing temperatures is there adequate protection to prevent potential damage in the equipment room?
☐	☐	☐	4.	Is the equipment room protected with a fire protection system?
☐	☐	☐	5.	Is the mounting surface(s) visually properly constructed and leveled?
☐	☐	☐	6.	Is the mounting surface made from non-combustible material?
☐	☐	☐	7.	Has the wood skid been removed?
☐	☐	☐	8.	Is there adequate inlet and outlet air flow (electric louvers adjusted and ventilation fan motor(s) connected to the corresponding voltage)?
☐	☐	☐	9.	Is the radiator duct properly sized and connected to the air vent or louver?
☐	☐	☐	10.	Are flexible sections installed in the cooling water lines (remote radiator application)?
☐	☐	☐	11.	Is there an adequate/dedicated fuel supply?
☐	☐	☐	12.	Are the fuel filters installed?
☐	☐	☐	13.	Is there adequate fuel transfer tank pump lift capacity and is the pump motor connected to the corresponding voltage?
☐	☐	☐	14.	Is the fuel transfer tank pump connected to the emergency power source?
☐	☐	☐	15.	Are flexible fuel lines installed between the engine fuel inlet and fuel piping?
☐	☐	☐	16.	Is the specified gas pressure available at the fuel inlet? Note pressure (not running) ____________
☐	☐	☐	17.	Does the gas solenoid valve function?
☐	☐	☐	18.	Are the manually operated fuel and cooling water valves installed allowing manual operation or bypass of the solenoid valves?
☐	☐	☐	19.	Does the exhaust line have flexible connector(s)? Is the flexible connector(s) straight?
☐	☐	☐	20.	Is there an exhaust line condensate trap with a drain installed?
☐	☐	☐	21.	Is the specified silencer installed and are the hanger and mounting hardware tightened?

Yes	No	N/A		
☐	☐	☐	22.	Is a heat-isolating thimble(s) installed at points where exhaust lines pass through combustible wall(s) or partition(s)?
☐	☐	☐	23.	Is the exhaust line free of excessive bends and restrictions?
☐	☐	☐	24.	Is the exhaust line installed with a downward pitch toward the outside of the building?
☐	☐	☐	25.	Is the exhaust line protected from entry by rain, snow, and animals?
☐	☐	☐	26.	Does the exhaust system outlet location prevent entry of exhaust gases into buildings or structures?
☐	☐	☐	27.	Are individuals protected from exposure to high temperature exhaust parts and are hot parts safety decals present?
☐	☐	☐	28.	Does the nameplate voltage/frequency of the generator set and transfer switch match normal/utility source ratings?
☐	☐	☐	29.	Do the generator set load conductors have adequate ampacity and are they correctly connected to the circuit breakers and/or the emergency side of the transfer switch?
☐	☐	☐	30.	Are the load conductors, remote start loads, battery charger cables, and remote annunciator leads installed in separate conduits?
☐	☐	☐	31.	Is the battery charger AC circuit connected to the corresponding voltage and energized?
☐	☐	☐	32.	Is the tank heater AC circuit connected to the corresponding voltage and energized?
☐	☐	☐	33.	Is the battery(ies) filled with electrolyte and connected to the battery charger?
☐	☐	☐	34.	Are the engine starting cables connected to the battery(ies)?
☐	☐	☐	35.	Do the engine starting cables have adequate length and gauge?
☐	☐	☐	36.	Is the battery(ies) installed with adequate air ventilation?
☐	☐	☐	37.	Does earthquake protection (if required) support the system properly?
☐	☐	☐	38.	Does the equipment have lightning protection?

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PRE-START/RUNNING CHECKS
CHECK ONLY THE ITEMS THAT APPLY TO THE SPECIFIC APPLICATION.
** RECORD ALL RUNNING CHECKS ON PAGE 4

Yes	No	N/A	
☐	☐	☐	1. Inspect unit for freight damage (ensure components are tight).
☐	☐	☐	2. Verify that the engine is filled with oil, the cooling system is filled with coolant/antifreeze and battery(ies) are filled with acid.
☐	☐	☐	3. Inspect for proper belt alignment and tension.
☐	☐	☐	4. Inspect all electrical connections in control panel verify connections are tight and secure.
☐	☐	☐	5. Open all water and fuel valves. Temporarily remove the radiator cap to eliminate air in the cooling system. Replace radiator cap in step 21.
☐	☐	☐	6. Prime the fuel system.
☐	☐	☐	7. Press the LED test, if equipped on controller. Do all the LEDs on the panel illuminate?
☐	☐	☐	8. Place the generator set engine control switch in the OFF/RESET position. Observe Not-in-Auto LED and alarm, if equipped, on the controller.
☐	☐	☐	9. Open the generator main line circuit breakers.
☐	☐	☐	10. Verify the presence of lube oil in the turbocharger, if equipped.
☐	☐	☐	11. Verify power on to the water/oil heaters and fuel lift pumps.
☐	☐	☐	12. Verify that the day tank, if equipped, is energized.
☐	☐	☐	13. Place the generator set engine control switch in the RUN position. Allow the engine to start and run.
☐	☐	☐	14. Check the battery charger voltmeter and ammeter for battery charging indication.
☐	☐	☐	15. Verify whether there is sufficient oil pressure.
☐	☐	☐	16. If the speed is unstable, adjust.*
☐	☐	☐	17. Adjust the AC output voltage to match the utility voltage using the voltage adjusting control.
☐	☐	☐	18. Allow the engine to reach normal operating coolant temperature. Check for oil, coolant, and exhaust leaks. Check and tighten all hose connectors and clamps.
☐	☐	☐	19. Check the operating temperature on city water-cooled models and adjust the thermostatic valve as necessary.
☐	☐	☐	20. Manually overspeed (if applicable) the engine to cause an engine shutdown (71 Hz on 60 Hz models and 61 Hz on 50 Hz models). Place the generator set engine control switch in the OFF/RESET position.*
☐	☐	☐	21. Check the coolant level, add coolant as necessary, and replace the radiator cap. Verify that all hose clamps are tight and secure.

Yes	No	N/A	
☐	☐	☐	22. Place the generator set engine control switch in the RUN position.
☐	☐	☐	23. Verify the engine low oil pressure and high coolant temperature shutdowns.*
☐	☐	☐	24. Check the overcrank shutdown.*
☐	☐	☐	25. Check and verify any additional protective devices. List them: ___________, ___________, __________
☐	☐	☐	26. Place the generator set engine control switch in the OFF/RESET position.
☐	☐	☐	27. Check the utility source voltage, frequency, and phase sequence on three-phase models. The generator set must match utility source and load.
☐	☐	☐	28. Verify that all the wire connections from the generator set to the transfer switch and optional accessories are tight and secure.
☐	☐	☐	29. Close the generator set main line circuit breakers connected to the transfer switch.
☐	☐	☐	30. Place the generator set engine control switch in the RUN position.
☐	☐	☐	31. Check the generator set voltage, frequency, and phase sequence on three-phase models. The generator set must match utility source and load.
☐	☐	☐	32. Place the generator set engine control switch in the OFF/RESET position.
☐	☐	☐	33. Is the specified gas pressure available at the fuel inlet? Note pressure while running ____________
☐	☐	☐	34. Perform a proper fuel system setup with a wide range O2 sensor. Record air fuel ratio (AFR) NO LOAD_____ BUILDING LOAD or FULL LOAD_____ With Load Bank _____. If Building Load used List AMPS_____ (only required on 8.1LGMs and larger)
☐	☐	☐	35. Place the transfer switch in the TEST position. NOTE: Obtain permission from the building authority before proceeding. This procedure tests transfer switch operation and connects building load to generator set power.
☐	☐	☐	36. Readjust frequency to 50 or 60 Hz with total building loads.* Verify no load frequency to be no more than 62.0. Adjust if necessary. (Mechanical governor only)
☐	☐	☐	37. Verify that the current phase is balanced for three phase systems. List them ____________
☐	☐	☐	38. Release the transfer switch test switch. The transfer switch should retransfer to the utility source after appropriate time delay(s).
☐	☐	☐	39. Allow the generator set to run and shut down automatically after the appropriate cool down time delay(s).
☐	☐	☐	40. Set the plant exerciser with load to the customer's required exercise period, if equipped.

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Yes No N/A

☐ ☐ ☐ 41. Verify that all options on the transfer switch are adjusted and functional for the customer's requirements.
Transfer Switch delay setting:
TDES____TNE____TDN____TDEC____

☐ ☐ ☐ 42. In phase monitor ON_____ OFF_____

☐ ☐ ☐ 43. Verify that all options on the transfer switch are adjusted and functional for the customer's requirements.

Yes No N/A

☐ ☐ ☐ 44. If possible, run the building loads on the generator set or perform the load bank test if required.

☐ ☐ ☐ 45. Verify that the customer has the appropriate engine/generator set and transfer switch literature. Instruct the customer in the operation and maintenance of the power system.

* Some models with electronic engine controls may limit or prohibit adjusting the engine speed or testing shutdowns.

Time of Day	Gen. Amps	Gen. Volts	Gen. Freq.	Amb. Temp.	Oil Press.	DC Charg. Volts.	Water Temp.	Run Time Meter	Notes:

☐ Instruct customer on functions and operation of total EPSS (Emergency Power Supply System)

I ____ received training on ____________________________.
Please print name of person receiving training and have him/her sign his/her name Date

Notes

____

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1.3 Two (2) Year 3000 Hour Basic Standby Limited Warranty_OE-M-GEN-S-006

STANDBY LIMITED WARRANTY
Two (2) Year / 3,000 Hour Basic

LIMITED WARRANTY

Your MTU Onsite Energy product has been manufactured and inspected with care by experienced craftspeople. If you are the original consumer, MTU Onsite Energy warrants, for the limited warranty period indicated below, each product will be free from defects in materials and workmanship, and will perform under normal use and service from valid start-up performed by MTU Onsite Energy. This Limited Warranty shall apply only when the product has been properly installed, serviced, and operated in accordance with the applicable MTU Onsite Energy instruction manuals. If this Limited Warranty applies, the liability of MTU Onsite Energy shall be limited to the replacement, repair, or appropriate adjustment of the product, at MTU Onsite Energy's option. This Limited Warranty does not apply to malfunctions caused by normal wear and tear, or by damage, unreasonable use, misuse, repair, or service by unauthorized persons.

LIMITED WARRANTY PERIOD

Engine Generator Set: Parts and labor for twenty-four (24) months will begin with the first commissioning of the product(s). In all cases, the warranty period will expire not later than thirty-six (36) months from the date of shipment ex-works MTU Onsite Energy or after 3,000 operation hours, whichever occurs first. Accessories: Parts and labor for one (1) year from date of shipment. For a description of accessories and items excluded from this Limited Warranty, review the listings below.

LIMITED WARRANTY CONDITIONS

Before there is any protection under this Limited Warranty, the distributor must: (1) complete the MTU Onsite Energy Warranty and the Start-Up Validation and Pre-Inspection form, and return them to MTU Onsite Energy within 60 days of the start-up date, and (2) complete the engine registration form and return it to the manufacturer as stated in the instructions with engine registration form (when applicable). In addition, this Limited Warranty is not valid or enforceable unless: (1) all supporting maintenance records are kept on file with the end user and made available upon request from factory, (2) the generator set is routinely exercised in accordance with operating instructions, and (3) the installation meets the general guidelines, standards, recommendations (as laid out in the Installation Guide provided with the product), and all local standards and codes applicable in the location of installation.

Engine generator sets that are stored by Owner / Buyer longer than 180 days from date of shipment are subject to special requirements. Contact MTU Onsite Energy's Service Center for instructions.

TO OBTAIN WARRANTY SERVICE

Warranty service may only be performed by MTU Onsite Energy authorized service providers. **Service provided by unauthorized persons will void this Limited Warranty. Non-MTU Onsite Energy replacement part(s) will void this Limited Warranty.** Contact your nearest MTU Onsite Energy Service Representative to obtain warranty service. For assistance in locating your nearest authorized service representative, see contact information at the bottom of this page.

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THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES EXPRESS OR IMPLIED. NO WARRANTIES SHALL BE IMPLIED OR OTHERWISE CREATED UNDER THE UNIFORM COMMERCIAL CODE, INCLUDING BUT NOT LIMITED TO A WARRANTY OF MERCHANTABILITY OR A WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE.
MTU ONSITE ENERGY SHALL NOT BE LIABLE FOR ANY CLAIM GREATER IN AMOUNT THAN THE PURCHASE PRICE OF THE PRODUCT AT ISSUE, AND IN NO EVENT SHALL MTU ONSITE ENERGY BE LIABLE

FOR ANY SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES. STATE LAWS REGARDING THE RIGHTS OF CONSUMERS MAY VARY FROM STATE TO STATE.

1. The following items are not considered nor will they be covered under this Limited Warranty. If there are questions as to coverage under this Limited Warranty, it is advisable to contact the factory in advance of filing a claim.
   a. Battery or batteries of any type or kind. The battery manufacturer's warranty, if any, is the only warranty that applies to batteries. Any warranty claim should be handled with the manufacturer according to its policies.
   b. Adjustments to fuel systems or governor system at time of start-up or any time after. A warranty claim for such adjustments is acceptable only when a defective part has been replaced, returned to the factory, and approved as defective.
   c. Normal maintenance costs, including but not limited to adjustments, loose and/or leaking fittings or clamps, and tune-ups performed during start-up or anytime thereafter.
   d. Due to shipping, manufacturer is not responsible for loose connections. All connections must be checked at time of start-up.
   e. Non-MTU Onsite Energy replacement part(s) will void this Limited Warranty.
   f. Products that are modified in any form without the written consent of MTU Onsite Energy will void this Limited Warranty.
   g. Shipping damage of any type.
   h. Any installation errors or damage of the equipment when shipped as ordered.
   i. Any overtime travel or labor to make repairs under warranty.
   j. Any special access fees required to gain access to MTU Onsite Energy equipment, including but not limited to any training or safety policy requirements to gain access.
   k. Additional costs associated with inaccessible installations, including but not limited to removal and reinstallation of the generator set.
   l. Rental equipment used during warranty work including but not limited to generators, rigging equipment such as a crane or boom truck, load banks, and special test equipment above factory requirements.
   m. Excess mileage charges. Any authorized service provider may perform warranty service anywhere, but will only be paid for mileage expenses from the nearest service center and limited to 400 miles / 644 Kilometers round-trip.
   n. Any equipment not factory approved and engineered for use on MTU Onsite Energy products. This includes but is not limited to aftermarket items such as special fuel systems, enclosures, exhaust systems, or switch gear that had been sought out and quoted by a third party to be included in billing of the MTU Onsite Energy equipment.
   o. Misuse or abuse during installation and thereafter.
   p. Normal wear and tear, maintenance, and consumable items that are not required as part of a warranty repair. Consumable items include but are not limited to belts, hoses, coolant, oil, filters, and fuses.
   q. Acts of nature or acts of God such as lightning, wind, flood, tornado, hurricane, or earthquake.
   r. Any damage due to situations beyond the control of the manufacturing of the product or workmanship of the product.
   s. Installation or operation outside the guidelines as stated in the Installation Guide and Owner's Manual.
   t. Diesel engine "Wet Stacking" due to lightly loaded diesel engines.
   u. Misapplication of the equipment such as usage outside the original design parameters as stated on the nameplate of the equipment.
   v. Travel expense on portable equipment.
   w. Trailer lights, wiring, and brakes.

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   x. More than one trip to the job site because a service vehicle was not stocked with normal service parts.
   y. Lodging expense of person(s) performing service, unless approved in advance by factory.
   z. Engine fluids.
   aa. Units purchased at the standby power rating that are being used in a prime power application.
   ab. Any repair labor time that is determined to be excessive, e.g., two or more people performing a one-person job.
   ac. Any expenses associated with investigating performance complaints in which no defect is found.
   ad. Any associated costs for replacing components that are found not to be defective.
   ae. Any adjustments covered in the start-up and inspection forms that are to be completed during start-up.
2. The accessories that are limited to one (1) year parts and labor from date of shipment include but are not limited to:
   a. Cords, receptacles, and cord reels
   b. Gas flex pipes
   c. Housing lights, space heaters, and associated equipment

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100 Power Drive / Mankato, MN 56001 / 800-325-5450

MTU Onsite Energy
A Rolls-Royce Power Systems Brand

www.mtuonsiteenergy.com

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TERMS AND CONDITIONS

Effective date: September 1, 2015

General

Any purchase order submitted by a customer of MTU Onsite Energy resulting from this proposal shall become a binding contract only after MTU Onsite Energy formally accepts said purchase order, in all respects, in writing. Any modification of an accepted purchase order must be mutually agreed upon in writing. MTU Onsite Energy reserves the right to adjust prices for modifications, alterations, or changes authorized or ordered by the customer. MTU Onsite Energy shall not be responsible for any services claimed to be rendered on its behalf, unless said services were authorized in advance in writing by MTU Onsite Energy.

Liability

MTU Onsite Energy shall not be liable for any losses or delays occasioned by strikes, accidents, acts of nature, acts of God, or any other event or happening beyond MTU Onsite Energy's control.

Delivery - Risk of Loss

All sales are F.O.B. Seller's factory or other point designated by Seller for all Buyers located in the U.S. when a common carrier is used, and Ex Works Seller's factory or other point designated by Seller for all Buyers located outside the U.S. When the Product is delivered to Buyer using Seller's truck, Buyer shall also bear all risk of loss as well as the full cost of delivering the Product. Freight and handling charges by Seller may not reflect actual freight charges prepaid to the carrier by Seller due to incentive discounts earned by Seller based upon Seller's aggregate volume of freight tendered to a carrier or when a carrier must be used which charges a rate which is different than the rate upon which Seller's freight and handling charges were based. Buyer agrees that Buyer is not entitled to any such incentive discounts that may be earned by Seller. When shipments are delivered in Seller's private trucks, Buyer will be charged an amount approximating the prevailing common carrier rate.

Claims for shortages or other errors in delivery must be made in writing to Seller within ten (10) days after Buyer's receipt of shipment. Failure to give such notice shall constitute unqualified acceptance and a waiver of all such claims by Buyer. Claims for loss or damage to equipment in transit by common carrier must be made to the carrier and not to the Seller. Shipping dates are estimates only which are not guaranteed and are based upon prompt receipt from Buyer of all necessary shipping instructions and other information.

Security Agreement and Financing Statements

To secure payment of the purchase price and of all monies which may be due hereunder, and to secure performance of all of Buyer's additional obligations hereunder, Buyer hereby grants to Seller a purchase money security interest in all equipment sold to Buyer by Seller, and agrees to immediately execute such other Security Agreements and Financing Statements as Seller may reasonably request.

Buyer hereby appoints Seller as Buyer's attorney-in-fact to execute on behalf of Buyer any necessary Security Agreements and Financing Statements as necessary to carry out the terms of the parties' agreement.

Taxes

State and local sales and use taxes where applicable will be quoted and billed in addition to the prices set out in the purchase order. It is the Buyer's responsibility to provide MTU Onsite Energy with adequate evidence of tax exemption or other reason for non-liability for such taxes.

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Limited Warranty

Your MTU Onsite Energy Product has been manufactured and inspected with care by experienced craftspeople. If you are the original consumer, MTU Onsite Energy warrants, for the limited warranty period indicated, each product to be free from defects in materials and workmanship, and will perform under normal use and service from valid start-up performed by MTU Onsite Energy. This Limited Warranty shall apply only when the product has been property installed, serviced, and operated in accordance with the applicable MTU Onsite Energy instruction manuals. If this Limited Warranty applies, the liability of MTU Onsite Energy shall be limited to the replacement,

Limited Warranty, continued:

repair, or appropriate adjustment of the product, at MTU Onsite Energy's option. This Limited Warranty does not apply to malfunctions caused by normal wear and tear, or by damage, unreasonable use, misuse, repair, or service by unauthorized persons.

Limited Warranty Conditions

Before you have any protection under this Limited Warranty, you must: (1) complete the MTU Onsite Energy Warranty, Start-Up Validation, and Pre-Inspection form and return it to MTU Onsite Energy within 60 days of the start-up date, and (2) complete the engine registration form and return it to the manufacturer as stated in the instructions with engine registration form. In addition, this Limited Warranty is not valid or enforceable unless: (1) all supporting maintenance records is be kept on file with the end user and made available upon request from factory, (2) the generator set is routinely exercised in accordance with operating instructions, and (3) the installation meets the general guidelines, standards, and recommendations as laid out in the Installation Guide provided with the product and all local standards and codes applicable in the location of installation. Owner / Buyer shall bear the full cost and risk of loss to transport the Product to and from the Seller's factory or other designation service outlet for service provided under this warranty. Engine generator sets that are stored by Buyer longer than 180 days from date of shipment are subject to special requirements. Contact MTU Onsite Energy's Factory Service Center for instructions. Seller shall return the Product to Buyer, F.O.B. Seller's factory or other point designated by Seller for all Buyers located in the U.S. when a common carrier is used, and Ex Works Seller's factory or other point designated by Seller for all Buyers located outside the U.S. When the Product is returned to Buyer using Seller's truck, Buyer shall also bear all risk of loss as well as the full cost of delivering the Product.

THE LIMITED WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES EXPRESS OR IMPLIED. NO WARRANTIES SHALL BE IMPLIED OR OTHERWISE CREATED UNDER THE UNIFORM COMMERCIAL CODE, INCLUDING BUT NOT LIMITED TO A WARRANTY OF MERCHANTABILITY OR A WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE.

MTU ONSITE ENERGY SHALL NOT BE LIABLE FOR ANY CLAIM GREATER IN AMOUNT THAN THE PURCHASE PRICE OF THE PRODUCT AT ISSUE, AND IN NO EVENT SHALL MTU ONSITE ENERGY BE LIABLE FOR ANY SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES.

Returned Material

No material may be returned for credit without first obtaining the written approval of MTU Onsite Energy. All shipping costs on returned material must be pre-paid by the customer. Material returned in connection with claims shall be governed by the provisions of the applicable Limited Warranty.

Payments

In addition to the terms of payment stated herein, the following conditions shall apply. If a customer orders material to be held by MTU Onsite Energy beyond the normal shipment date, such material shall be held at the risk and expense of the customer. If there is a delay in the manufacture of a product authorized, ordered, or caused to be ordered by the customer, payment shall be made based upon the contract price and the percentage of completion at the time of commencement of the delay. If there is a delay in shipment of product ordered, authorized, or caused to be ordered by the customer, payment of the contract price shall be due on the date MTU Onsite Energy is prepared to make shipment. If at any time during manufacture or prior to shipment, MTU Onsite Energy determines that the financial condition of the customer is such that MTU Onsite Energy does not reasonably feel secure in the continued manufacture or the shipment of the merchandise on the credit terms previously agreed upon, then MTU Onsite Energy may require full or partial payment before completing manufacture or in advance of shipment of the merchandise.

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TERMS AND CONDITIONS

Cancellation

Cancellation charges will apply to any order that is cancelled. The amount of the cancellation charge will be determined by MTU Onsite Energy based on the type of equipment and potential market opportunities for resale and the vendor component cancellation charges and any other charges accrued for a particular cancelled order. MTU Onsite Energy will treat an invoice for cancellation charges like any other invoice in that the standard credit and collection policies will apply. A past due invoice for cancellation charges will adversely affect MTU Onsite Energy's ability to ship product and enter new orders as stated in our standard credit and collection policies.

Storage Charges

Due to the limited amount of space available at MTU Onsite Energy and the cost MTU Onsite Energy incurs if completed units are stored (including potential liability exposure to MTU Onsite Energy and insurance costs to provide coverage on stored units), it is necessary to clearly define our "Unit Storage Policy."

MTU Onsite Energy will notify the distributor when product is ready to ship. Distributor and/or representative will then have 48 hours to arrange shipment. If arrangements are not made within the 48 hour period, McDonough Truck Lines will pick up the equipment and store it at their facility. MTU Onsite Energy will invoice the distributor for the equipment and normal payment terms will apply.

McDonough Truck Line will invoice the distributor for storage, handling, and freight to their warehouse. Distributor and/or representative will be responsible for invoice payment to McDonough Truck Line before equipment will ship from their warehouse. Inside and outside storage are both available. Please contact your factory representative for the current storage rates.

Arrangements to ship the equipment from the warehouse will be the responsibility of the distributor and/or representative. To arrange payment and shipping, contact McDonough Truck Lines at 800-642-1374.

MTU Onsite Energy has adopted this policy in order to maintain efficiency in manufacturing our product. It is not our intent to restrict or diminish the importance we place on serving the needs of our distributors and/or representatives.

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100 Power Drive / Mankato, MN 56001 / 800-325-5450

Responsible: MTU Onsite Energy Finance Department
Publisher: MTU Onsite Energy Document Management Department

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1.5 Service Weekly Inspection Checklist

SERVICE
WEEKLY INSPECTION CHECKLIST

Please use the attached checklist to perform weekly service inspections on generator set equipment.

Before beginning any service, please conduct the following steps:

1. Perform lockout/tagout procedures before performing pre-start checks.
2. Refer to owner and operator manual for correct specifications.

DESCRIPTIONS:

Date	Record the date of the inspection.
Ambient Temp	Record air temperature around generator.
Oil Level	Record the level from the oil dipstick and the amount of oil added to the engine if it was needed.
Coolant Level	Record level of coolant in the radiator and add approved coolant, if needed.
Heaters	Check inlet and outlet hose temperature to verify operation.
Belts	Visually inspect belts for damage or fraying. Verify the **engine control** is in the **OFF** position.
Battery Charger	Visually inspect battery charger to verify operation. If equipped with a display, verify charge rate. If equipped with LEDs, verify correct LEDs are lit.
Battery Levels and Cables	Verify battery(s) are full of acid, cables are tight, and battery posts clean.
Leaks: Oil, Water, Fuel	Check all hoses and connections for dripping fluids. If needed, tighten hose clamps to contain leaks.
Amps	Record the amp reading when unit is running with load.
AC Volts	Record the AC volt reading when unit is running with load.
Frequency	Record the hertz reading when unit is running with load.
Oil Pressure	Record the oil pressure when unit is running with load.
Coolant Temp	When unit is running with load, record the coolant temperature reading once stabilized.
DC Volts	Record control panel DC voltage reading.
RTM	Record the Running Time Meter total before each test. Variances will show run time between inspection exercises.
ATS	Automatic Transfer Switch mark as **OK,** if test performed properly.
Maintenance Contact	Maintenance technician performing inspections should initial in this box.

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SERVICE: WEEKLY INSPECTION CHECKLIST

Date	Ambient Temp	Oil Level	Coolant Level	Heaters	Belts	Battery Charger	Battery Levels and Cables	Leaks: Oil, Water, Fuel	Amp	AC Volts	Frequency	Oil Pressure	Coolant Temp	DC Volts	RTM	ATS	Maintenance Contact	Comments

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1.6 Start-Up Request Form

START-UP REQUEST FORM

To provide an authorized factory start-up at the lowest possible prices, we must request that the following checklist and tasks be completed prior to a MTU Onsite Energy representative's arrival at the installation site to perform the start-up.

(Please Print)
Unit Serial Number: ___________________ **Contact Name:** ___________________

Company Name: ______________________ **Title:** ___________________________

Please attach a map or directions to the site. **Phone Number:** ___________________

- ☐ Unit set in place on vibration pads with floor anchor/studs to prevent movement.
- ☐ Radiator ducted to properly sized air discharge louvers.
- ☐ Doors on unit in alignment.
- ☐ Unit full of oil and water/anti-freeze mix.
- ☐ Battery filled with acid and fully charged.
- ☐ Battery charger mounted with AC and DC wired, if not supplied mounted by the factory.
- ☐ All AC and DC electrical connections made.
- ☐ Engine heater wired to normal AC power supply.
- ☐ Fuel inlet and return lines run between the unit and fuel storage system, system filled and primed to the engine with proper fuel.
- ☐ Exhaust system in place and supported so that the exhaust manifold does not carry weight of exhaust system.
- ☐ Air inlet louver motor wired to an emergency generator source point to open upon the start of an engine generator set.
- ☐ Generator room cleaned of construction debris including excess nails, bolts, nuts, panel knockouts, etc. It is very important that the radiator fan area is checked for debris, as damage to the equipment and personal injury can occur if loose items come in contact with the fan when the unit is initially started.

Consult your Installation Guide on any questions.

If, upon arrival at the installation site, our representative cannot perform the start-up as a result of defective equipment, the problems will be resolved and we will reschedule another start-up date at the earliest possible date at no additional charge.

If the start-up cannot be performed due to an incomplete installation or for reasons beyond MTU Onsite Energy's control, you may incur an additional start-up charge at a later date.

Signature: ______________________________ **Date:** ___________________________

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Installation and Basic Operation Manual

TIM-ID: 0000002924 - 021

MTU Onsite Energy Corporation
100 Power Drive, Mankato, MN 56001
Phone 800-325-5450 www.mtuonsiteenergy.com
2015-03

CALIFORNIA PROPOSITION 65

WARNING

ENGINE EXHAUST FROM THIS PRODUCT CONTAINS CHEMICALS KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER, BIRTH DEFECTS, AND OTHER REPRODUCTIVE HARM.

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Contents

Product Identification Information

Locate and record numbers in the spaces below immediately after unpacking your generator set. This ensures that the numbers are readily available for future reference.

Model Designation: ______________________________

Serial Number: ______________________________

How to Read Model Numbers

MTU Onsite Energy's model numbering format is composed of 7 sections:

MTU 18 V 2000 D S 1250

- MTU — Equipment brand identifier (MTU – MTU Onsite Energy)
- 18 — Number of engine cylinders
- V — Cylinder arrangement (R – Inline, V – V-block)
- 2000 — MTU Series or nominal displacement per cylinder (4-digit identifier)
- D — Engine type (D – Diesel, G – Gas)
- S — Equipment type (S – System)
- 1250 — Nominal power node (based on standby application) kW for 60 Hz (kVA for 50 Hz)

MTU Series or nominal displacement per cylinder
(4-digit identifier)

Example shown is for MTU Series units (Series 1600, Series 2000, Series 4000).
For Non-MTU Engine units, use nominal displacement per cylinder calculation:

(Engine Displacement ÷ Number of Cylinders) × 100 = Nominal Displacement per Cylinder

NOTE: Apply standard rounding rules after calculation. Add leading zero when calculations result in 3 digits. For example, the calculation for an engine with a 4.5L displacement and 4 cylinders is: (4.5 / 4) × 100 = 0113

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Forward

This Installation Guide provides general instructions for installing your MTU Onsite Energy generator set properly. It is essential that every person who works on or with the generator set be completely familiar with the contents of this manual, and that he/she carefully follows the instructions contained herein.

Each installation may require some modification of the suggested guidelines in this manual. Installations must be consistent with locally applicable standards and take into consideration safety guidelines and measures.

Following this guide will result in an efficient and reliable installation. Carefully follow all procedures and safety precautions to ensure proper equipment operation and to avoid bodily injury. Read and follow the Safety Precautions section at the beginning of this manual.

IMPORTANT

Information in this publication represents data available at the time of print. MTU Onsite Energy reserves the right to change this publication and the products represented without notice and without any obligation or liability whatsoever.

All instructions and diagrams have been checked for accuracy and simplicity of application. However, the skills of the installer are most important. MTU Onsite Energy does not guarantee the result of any installation contained in this manual. Nor can MTU Onsite Energy assume responsibility for any injury or damage to property. Persons engaging in installation do so entirely at their own risk.

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Figures and Tables

The following is a list of all figures and tables contained in this manual.

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Safety Precautions

IMPORTANT SAFETY INSTRUCTIONS

Electromechanical equipment, including generator sets, transfer switches, switchgear, and accessories, can cause bodily harm and pose life-threatening danger when improperly installed, operated, or maintained.

Dangers, Warnings and Cautions are used in this manual to alert the operator to special instructions concerning a particular procedure that may be hazardous if performed incorrectly. These safety alerts alone cannot eliminate the hazards that they signal. Strict compliance to these special instructions and common sense operation are major accident prevention measures. Observe all warnings found on the equipment. Ensure that warning labels are legible and not obstructed by dirt, grease or other equipment. MTU Onsite Energy cannot anticipate every possible circumstance that might involve a hazard. The warnings in this manual and on tags and decals affixed to equipment are, therefore, not all inclusive.

DANGER

Danger indicates the presence of a hazard that will cause severe personal injury, death, or substantial property damage.

WARNING

Warning indicates the presence of a hazard that can cause severe personal injury, death, or substantial property damage.

CAUTION

Caution indicates the presence of a hazard that will or can cause minor personal injury or property damage.

This symbol signifies high voltage.

The following safety rules should be strictly complied with:

ACCIDENTAL STARTING

Be aware that the generator set could start at any time in the "AUTO" mode. Keep clear of all moving parts and be sure to turn switch to the "OFF" position before servicing and disconnect the negative battery cable after disconnecting the battery charger circuit.

Battery

For proper unit operation, battery minus (-) terminal must always be connected to ground. Reverse connection of the battery will severely damage or destroy the battery charging alternator, regulator and other polarity sensitive devices.

Wear protective safety eyeglasses and gloves when handling starting batteries and electrolyte. Battery acid can cause serious burns if it contacts eyes or skin.

Servicing of batteries is to be performed or supervised by personnel knowledgeable of batteries and the required precautions. Keep unauthorized personnel away from batteries.

Do not smoke or use an open flame when servicing batteries. Batteries generate an explosive gas during charging.

The replacement starting battery or batteries must be of equal size and cold cranking amps.

The generator controls must be in the off position when replacing the batteries.

Do not dispose of battery or batteries in a fire. The battery is capable of exploding.

Do not open or mutilate the battery. Released electrolyte has been known to be harmful to the skin and eyes and to be toxic.

A battery presents a risk of electrical shock and high short circuit current. The following precautions are to be observed when working on batteries:

1. Remove watches, rings, or other metal objects
2. Use tools with insulated handles

Vented Batteries

The installation of the engine generator shall provide enough ventilation to ensure that gases generated by vented batteries during charging or caused by equipment malfunction are removed.

The electrolyte is a dilute sulfuric acid that is harmful to the skin and eyes. It is electrically conductive and corrosive. The following procedures are to be observed:

1. Wear full eye protection and protective clothing
2. Where electrolyte contacts the skin, wash it off immediately with water
3. Where electrolyte contacts the eyes, flush thoroughly and immediately with water
4. Spilled electrolyte is to be washed down with an acid-neutralizing agent. A common practice is to use a solution of 500 g (1 lb) bicarbonate of soda solution to be added until the evidence of reaction (foaming) has ceased. The resulting liquid is to be flushed with water and the area dried.

Lead acid batteries present a risk of fire because they generate hydrogen gas. The following procedures are to be followed:

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1. DO NOT SMOKE when near batteries
2. DO NOT cause flame or spark in battery area
3. Discharge static electricity from body before touching batteries by first touching a grounded metal surface

Fire Hazard

Keep fire extinguishers in accessible locations. Use appropriate fire extinguishers as recommended by NFPA.

Remove all unnecessary grease and oil from the unit. Accumulated grease and oil can cause overheating and engine damage, which present a potential fire hazard.

When an open bottom base is used, the stationary engine generator assembly is to be installed over noncombustible materials. It should be located such that it prevents combustible materials or loose debris from accumulating under or inside the generator set.

Do not service the engine when any ignition source such as an open flame is present. "DANGER" signs must be placed to warn of the fire hazard. No work may be performed on the engine involving an ignition source such as open flames, cutting, welding, or grinding.

A fire extinguisher (dry chemical or carbon dioxide, CO2) must be immediately available to the mechanics while working. When liquefied or natural gas leaks or escapes, it can result in dangerous accumulations of gas, which might cause a serious flash or explosion. Careful ventilation of the area is mandatory in the event of a fuel leak.

Exhaust System

Engine exhaust gases contain DEADLY carbon monoxide gas, which is colorless and odorless. If breathed in sufficient concentrations, this gas can cause severe nausea, fainting, or death. Provide adequate ventilation to prevent buildup of exhaust gases. When the generator is installed inside a room or enclosure, exhaust gases must be piped outdoors. Install the exhaust system so exhaust gas does not leak at joints or piping connections. Make certain that the extended exhaust piping is plumbed properly and that the exhaust is not near an intake ventilator.

Increase the exhaust pipe diameter as necessary to reduce back pressure. Use a minimum number of fittings and elbows to prevent back pressure in the engine exhaust system. Be sure the enclosure has proper ventilation to accommodate the engine cooling system.

Fuel System

Gaseous, Natural Gas and Liquid Propane Gas are extremely flammable, and vapors are EXPLOSIVE. Comply with all laws regulating the storage and handling of these fuels. Check for leaks frequently and correct such leakage immediately.

Do not fill fuel tanks while the engine is running.

Do not smoke or use open flame at any time when fuel is being handled. Fuel vapors are both toxic and flammable.

Liquid petroleum gas (LPG) systems operate at tank pressures around 690 kPa (100 psi) or above. The tank pressures are regulated down. Vaporized LPG systems operate at pressures near 2.7 kPa (11 in H_2O), as do most natural gas systems.

Safety precautions when handling liquefied petroleum gas cannot be over-emphasized. There are state, county and city codes, and fire regulations covering the handling and storage of liquefied petroleum gas or natural gas. In addition to the safety suggestions in this manual, all local codes and fire regulations on this subject must be followed explicitly. Where local codes are more stringent than the suggestions in this manual, the local codes must be given priority.

Before proceeding with any service, be certain that all switches are in the OFF position, disconnect battery ground cable, remove fuses in DC systems and turn off the battery charger. These safety suggestions apply to service of any engine using liquefied petroleum gas or natural gas fuel regardless of the work to be performed. When servicing the engine, ensure that there is adequate ventilation. This is to avoid the accumulation of gas/air mixtures in and about the engine caused by undetected leaks.

Any service performed on the fuel system requires that:

- All threaded connections are sealed with proper pipe thread compound. Replace defective fittings and reseal all connections.
- Fuel system is checked for leaks. Leaks are not permissible. Odorants, which are strong smelling components (an odor similar to spoiled cabbage), are added to liquefied petroleum gas as a warning agent to indicate the leakage of even small quantities of gas.
- A soap solution applied with a soft brush will bubble to indicate leaks. Never use an open flame to check for leaks. All leaks must be sealed.
- All flexible fuel connections are checked, metallic and neoprene, with the soap solution.

It is important to remember that all gas fuel systems are pressurized. Be certain that the fuel valves are tightly closed and all fuel has been vented before starting any repair work on the fuel system.

HAZARDOUS NOISE

Prolonged unprotected exposure to hazardous noise levels may cause loss of hearing. Never operate the generator set without a muffler or with a faulty exhaust system. Ear protection may be required.

HAZARDOUS VOLTAGE/ELECTRICAL ENERGY

Safe practices MUST be followed while performing work on electrical equipment to prevent death or injury from electric shock, electrocution, arc flash, and arc blast hazards. The Standard for Electrical Safety in the Workplace, NFPA 70E, requires that the owner of this electrical equipment provide a field-applied label which includes incident energy level, minimum Personal Protective Equipment (PPE) required, safe working distance, and arc flash boundary. This information is determined through an arc flash hazard analysis performed by a licensed professional electrical engineer who is familiar with the electrical system design.

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Dangerous voltages are present at power terminals of this equipment. Contact with such terminals will result in extremely dangerous and possibly lethal electric shock. Never allow any unqualified person to install, operate or service the equipment. The standby electric system must be installed, tested, and inspected per the manufacturer's recommendations. All codes, standards, regulations, and laws pertaining to the installation must be strictly complied with.

Accidental contact with electrical equipment can cause severe injury and death if the equipment is not properly grounded. The frame and external electrically conductive parts of this equipment must be properly connected to an approved earth ground, in accordance with applicable electrical codes. A grounding lug is provided on the generator and in other equipment for this purpose.

CAUTION: RISK OF ELECTRIC SHOCK!

The grounded conductor must be bonded to ground in accordance with the National Electrical Code, NFPA 70. The unit shall not be used in floating output applications.

Remove all electrical power before removing protective shields for service or maintenance. Exercise extreme caution when working on or around electrical components. Open or poorly insulated conductors are extremely dangerous during operation. Severe, possibly fatal, shock may result. Make certain that all conductors are properly insulated or guarded, all grounds are made and that the area is dry. Do not tamper with interlocks.

In the event of an accident from electrical shock, shut down the generator set immediately. If the set cannot be shut down, free the victim from contact with a dry nonconductor, avoiding direct contact with victim until free of the conductor. If the victim is unconscious, apply artificial respiration if qualified and get medical help immediately.

Verify that all power leads and control connections are properly insulated before starting the generator set. Neglecting this may result in extensive damage to equipment and personal injury. This problem arises if the unit is started before electrical installation is completed.

Make certain the area is well ventilated to dissipate any flammable vapors, which may collect from fuels. When servicing any part of the electrical system or making any connections, be sure the main switch is OFF and disconnect battery ground cable or remove fuse in DC system. Turn off the battery charger. Clean or service the generator set only when the engine is shut down. If the unit stops because of an engine safety device, do not attempt to restart until the cause for shutdown has been corrected.

HOT PARTS

The exhaust manifold, turbocharger(s), and extended exhaust piping are HOT when the engine is running. These can remain hot for long periods of time after the engine shuts off. Avoid contact with these parts. Consider insulating the exhaust system if installation is such that unintentional contact with the exhaust system components is likely.

Coolants under pressure have a higher boiling point than water. DO NOT open a radiator or heat exchanger pressure cap while the engine is running. Allow the generator set to cool and bleed the system pressure first.

Moving Parts

Moving parts can cause severe personal injury or death. Do not wear loose clothing or jewelry in the vicinity of moving parts, or while working on electrical equipment. Loose clothing and jewelry can become caught in moving parts. Jewelry can short out electrical contacts and cause shock or burning.

Handling

Do not use lifting devices with marginal capacities when lifting or moving the unit. Observe the center of gravity of the equipment to be lifted and do not allow the generator set to swing if suspended. Make certain the supporting structure is adequate to support the unit. Failure to observe this warning may result in equipment damage and serious or fatal injury.

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1 General

When installed properly and according to applicable codes, your MTU Onsite Energy generator set will perform safely and reliably. Incorrect installation can cause continuing problems. Figure 1-1 illustrates a typical installation. Your authorized generator set distributor/dealer can provide advice about or assistance with your installation.

This manual references organizations and their codes that govern generator set selection and installation for US installations. Installers must comply with national and local codes when applicable.

NFPA 37…………………..Stationary Engines and Gas Turbines
NFPA 54…………………..National Fuel Gas Code
NFPA 70…………………..National Electric Code®
NFPA 99…………………..Standard for Health Care Facilities
NFPA 101…………………Life Safety Code
NFPA 110…………………Emergency Standby Power Systems
UL-2200…………………...Stationary Engine Generator Assemblies

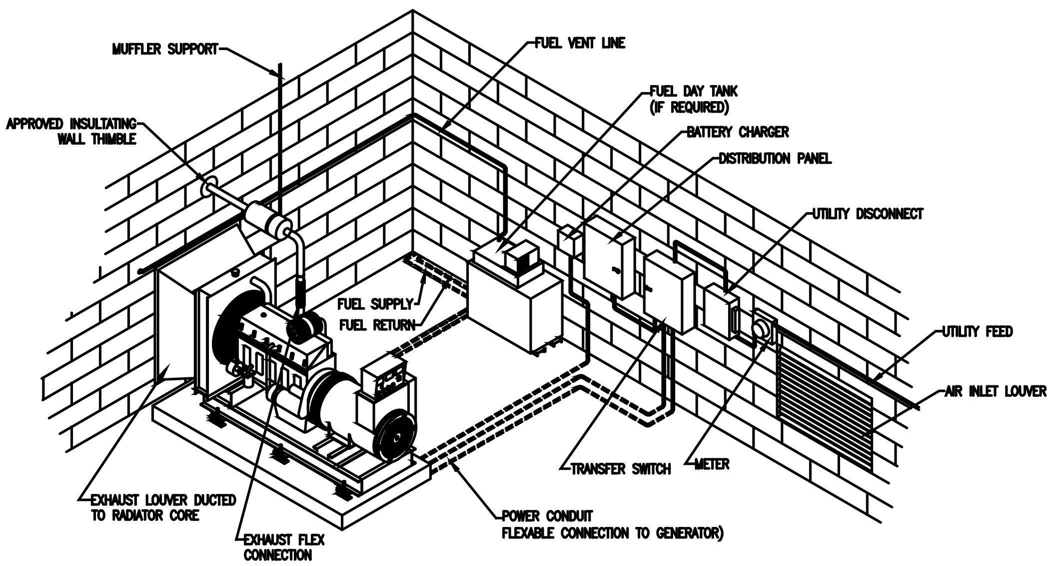

Figure 1-1: Typical generator set installation

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2

Lifting Provisions

To ensure personal safety and prevent damage to the product, we strongly recommend the guidelines in Figure 2-1 be observed when lifting MTU Onsite Energy generator sets. Due to the different designs, dimensions and weights of the generator sets, specific instructions for each model are not provided. It is the responsibility of the dealer/distributor to see that generator set lifting is performed within the framework of these guidelines.

CAUTION

Lifting brackets are for lifting purposes only. Do not use for any other purpose.

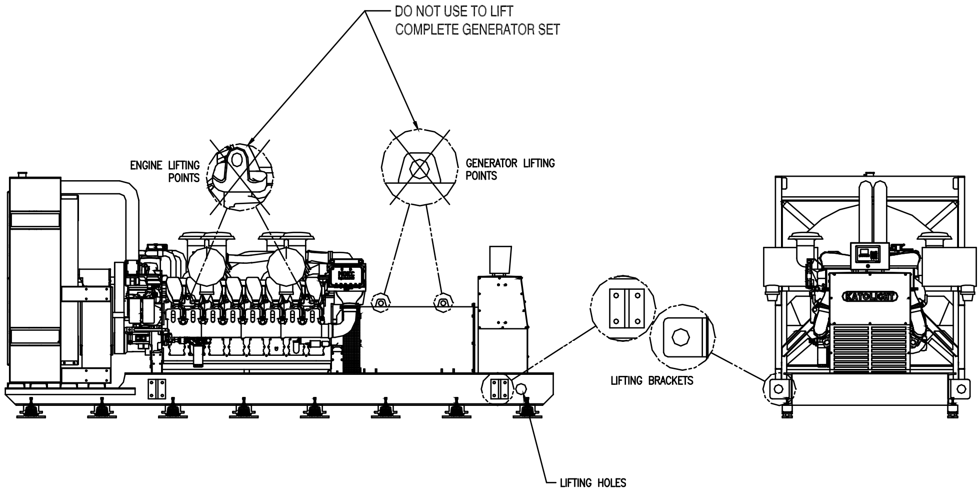

Figure 2-1: Lifting provisions

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Location

The location of the generator set is influenced by factors such as ventilation, exhaust piping, electrical service, fuel supply and accessibility for maintenance and service.

Before selecting the location for your generator set, consider the following:

- Supporting structure must be adequate for the generator set and accessories. For information on mounting on an inertia pad, see Section 4. For any other set-up, consult a structural engineer for an appropriate design.
- Area should be clean, dry and not subject to flooding.
- Ventilation should be available in the area with a minimum amount of duct work
- Exhaust gas must be piped away from the structure and any ventilation intakes. Piping must incorporate large radius, low restriction elbows.
- An adequate supply of fuel should be available at all times to sustain operation.
- The main diesel fuel supply should be as close as possible to the unit. If the main fuel tank is installed underground, an auxiliary pump and day tank are necessary to transfer fuel from the main tank to the day tank.
- Vibration should be effectively isolated and dampened to reduce transmission of vibration and prevent fatigue fractures of connected systems.
- Area should provide easy access for maintenance and repair. A minimum clearance of 0.91 m (3 ft) between an installed generator set and adjacent walls or other electrical equipment should be maintained on three sides of the generator set. Clearance of 1.52 m (5 ft) should be maintained at the rear of the generator set to facilitate removal, should it become necessary.
- Applicable fire rating codes and standards must be met.
- When an open bottom base is used, the stationary engine generator assembly is to be installed over noncombustible materials. It should be located such that it prevents combustible materials or loose debris from accumulating under or inside the generator set.

Local weather conditions will have a direct influence on location of the unit and the type of accessory equipment required to assure reliable operation. Extreme ambient temperature variations should be avoided. For ambient temperatures below 16 °C (60 °F), starting aids such as jacket water heaters and lubricating oil heaters will ensure dependable starting. Anti-condensation or strip heaters are available for control panels and generators to maintain a temperature above the dew point to prevent condensation of moisture.

Standard transfer switches located indoors in heated facilities are enclosed in NEMA 1 enclosures. Various other NEMA enclosures may be needed. If the generator set is located outside, heaters are needed below 0 °C (32 °F).

Consider preventive maintenance issues when selecting a generator set location. See Section 9 for a list of service points that should be accessible.

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4

Mounting

Your generator set should be installed in a location that is able to support the weight of the unit and accessories, resist dynamic loading, and does not transmit generator noise and vibration. See Section 3 for detailed information on selecting a location for your generator set.

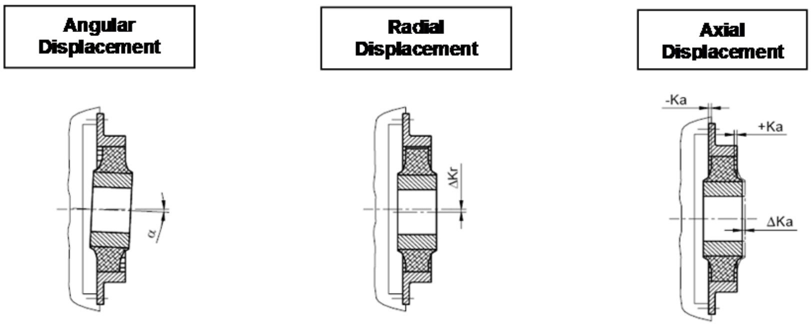
NOTE: Skid brackets are not to be used as mounting brackets. Make sure to follow proper installation instructions.

Field Alignment

Field alignment after the generator set is installed corrects any changes in the coupling alignment during transport and installation. This realignment ensures that the coupling will perform as needed and reduces the possibility of excess vibrations that decrease the useful life of the generator set.

After final installation, the following measurements must be checked to confirm proper alignment as noted in the table and illustration below:

Measurement	Specification
Angular Displacement	Less than or equal to 0.3°
Radial Displacement	Less than or equal to 1.49 mm (0.059 in)
Axial Displacement	Less than or equal to 3.99 mm (0.157 in)



Alignment can be validated by using dial indicators or a laser alignment tool.

NOTE: This applies only to models equipped with a two-bearing generator.

Engine Locks

All generator sets must be locked using the crankshaft locks provided with the engine by the engine manufacturer. If the generator sets are using vibration isolators, these must be blocked as well. Before installing the generator set, these engine locks and vibration isolator blocks must be removed.

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NOTE: This affects Series 4000 engine serial numbers beginning with 526, 527, and 528.

Weight

The weight of the generator set and accessories will determine the type and design of the support structure. Generator set weight can be found in the specification sheet for your particular model. Be sure that the weight of accessory items and fuel (if a sub-base tank is used) are added to the total requirements.

Inertia Pad/Base

Your generator set must be mounted on a substantial inertia pad or base. The composition of the inertia pad should follow standard practice for the required loading. Common specifications call for 17 MPa (2,500 psi) concrete reinforced with 8-gauge wire mesh (4.06 mm or 0.16 in) or number 6 reinforcing bars on 30 cm (12 in) centers.

To determine the depth of the inertia pad, the following formula can be used:

$$\text{BASE DEPTH} = \frac{Wu}{d * w * l}$$

Where Wu = engine-generator set weight in kg (lb)
d = concrete density (usually 2,322.68 kg/m^3 or 145 lb/ft^3)
w = foundation width in m (ft)
l = foundation length in m (ft)

The inertia pad should be a minimum of 30.48 cm (12 in) wider and 30.48 cm (12 in) longer than the unit base. The inertia pad may be constructed higher than the floor level by 8 to 20 cm (3 to 8 in) for ease of maintenance.

To reduce the amount of unit vibration transmitted, you must isolate your inertia pad from the foundation. One method for isolating the inertia pad from the foundation is to use 20 to 25 cm (8 to 10 in) of wet gravel or sand as a bed in the inertia pad pit. For other methods, consult a qualified structural engineer.

To allow settlement of the inertia pad from the foundation, expansion joints should be incorporated between the inertia pad and the foundation.

Vibration Isolation

Vibration is a normal by-product of the operation of any generator set. Vibration transmitted to surrounding areas will increase the noise level and if severe, can cause structural damage. To minimize this risk, all generator sets should have vibration isolation between the generator base and inertia pad.

All fuel, coolant, exhaust and electrical connections must have flexible sections to isolate vibration. Leaks or fractures can develop rapidly without vibration isolation and there is a danger of eventual total failure.

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For generator sets enclosed within a building, where maximum vibration isolation is required, spring mounts provide vibration isolation between the generator base and the structure. Check state and local codes for such requirements.

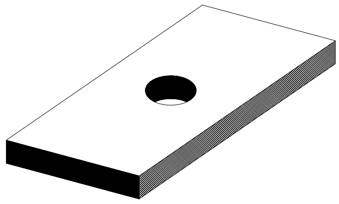

Figure 4-1: Typical pad type vibration

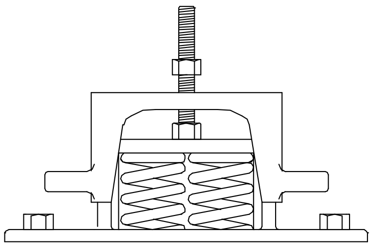

Figure 4-2: Spring mount vibration isolator

Anchor bolts should be loosened and double nutted after installation to avoid base distortion caused by unlevel inertia pads.

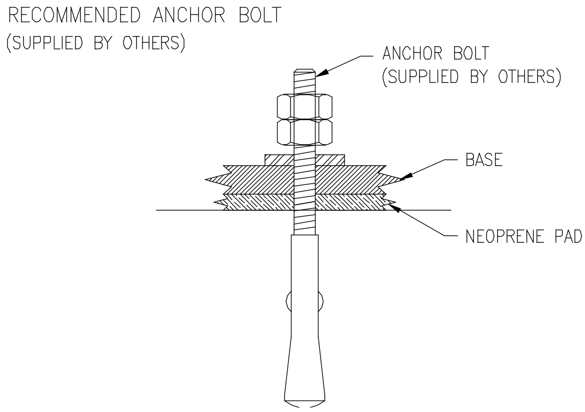

Figure 4-3: Recommended anchor bolt

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5

Air Requirements

GENERAL

When installing engine generator sets, great care must be taken to ensure adequate ventilation. Proper installations require enough ventilation to cool the engine generator set as well as supply adequate air for combustion.

When installing the ventilation system, the following factors should be considered:

- Location of intake and exhaust louvers
- Method of actuation of intake and exhaust louvers
- Ambient temperature
- Routing of exhaust air duct

The air intake and exhaust should be in line to provide engine room ventilation air flow which will parallel the generator set air flow over the engine, through the radiator and/or exhaust louver. The inlet and outlet openings must be large enough to provide the volume of air required by the engine generator.

NOTE

Exhaust louver effective opening should be at least 25% to 50% larger than engine radiator core. Intake louver should be 50% to 100% larger in effective opening than engine radiator core.

In most applications, intake and exhaust louvers should be used. Figure 5-1 indicates a typical louver.

Care should be taken to provide adequate open space outside the exhaust louver so as not to obstruct airflow.

Units with mounted radiators should be installed with ducting between the radiator and the exhaust louver to prevent recirculation of air.

CAUTION

Ensure that the exhaust ducting is installed so that no recirculation of radiator exhaust air occurs. Failure to prevent recirculation could cause the unit to overheat and shut down.

The exhaust louver should not be exposed to high prevailing winds, since wind pressure may reduce fan discharge and reduce cooling. The duct should be constructed with as few bends as possible. All units can be supplied with radiator duct flanges of the required size to meet the customer’s application.

If bends are required, they should be in the form of gradual sweeps to allow airflow with minimum restriction. Increase duct size one-fourth to one-half to compensate for bends.

Motorized and gravity louvers may be used to prevent entry of cold air which may cause difficulty in engine starting. (Refer to Chapter 8 for recommendations for wiring motorized louvers). Louvers also reduce the entry of rain, snow and insects into the building.

A gravity-operated louver can be used for the exhaust air. When the set operates, outlet airflow will open the louver and it will close automatically by gravity when the unit is shut down.

Generating sets with automatic start require the use of motor operated intake or fixed louvers or dampers. Motor operated louvers are held closed by spring tension and are driven to the open position by a motor operating through a mechanical linkage.

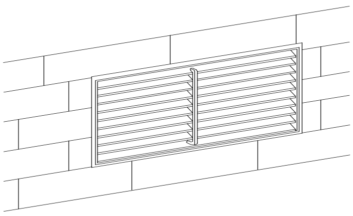

Figure 5-1: Typical center top pivoted louver

CAUTION

Care should be taken in wiring the system to ensure that the intake louver motor is supplied with power during all possible modes of unit operation, i.e. true power failure, simulated power failure due to incorporation of a system test switch, or automatic plant exercising. Incorrectly wired louver motors could result in the louvers closing prematurely during engine cool-down, which can cause overheating, engine shutdown, and possible damage to the unit.

In some extreme cold weather applications, the opening of intake louvers immediately upon starting may cause carburetor icing and vaporizing problems with engines utilizing gaseous fuels. Diesel engines may also be affected if lightly loaded. Thermostatically controlled louvers may be used to reduce the difficulties encountered with cold weather applications.

Figure 5-2 illustrates a typical generator set installation for units with unit-mounted radiators, indicating ducting and preferred locations of the louvers.

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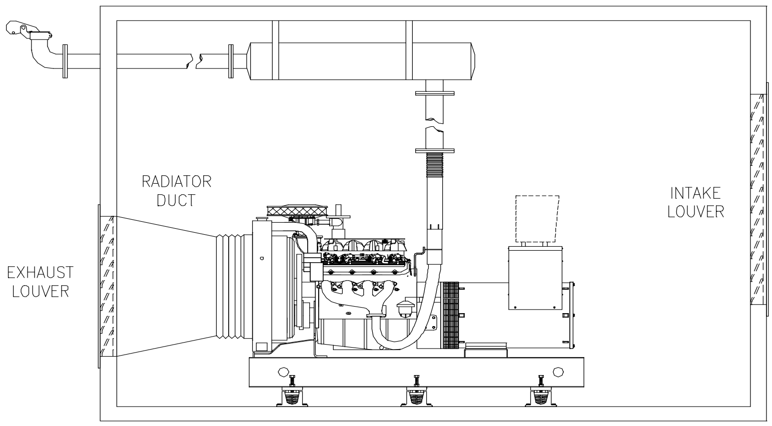

Figure 5-2: Typical installation with louvers

Engine-generator sets with remote cooling will not have an engine driven fan to move air through the generator room. As a result, a fan or some other means of moving air through the room must be considered. The fan must move the required amount of air against the allowable static friction.

The following formula may be used to estimate the amount of airflow required to remove engine and generator radiated heat and supply sufficient combustion air. The formula is based on air temperature of 38 °C (100 °F). Allowable room air temperature rise is 11 to 16 °C (20 to 30 °F).

$$V = \frac{Q}{F * \Delta T}$$

Where V = Air flow through the engine-generator room in m^3/min (ft^3/min)
Q = Engine-generator set radiated heat in kW (BTU/min)
F = 0.02 for metric units (0.018 for imperial units)
ΔT= Allowable room air temperature rise in °C (°F)

Higher elevation installations will require increased airflow. Add 10% for each increase of 762 m (2,500 ft). Also increase airflow for non-insulated exhaust silencer and other equipment that may add to the radiated heat in the room. Also keep in mind the required combustion airflow for the engine.

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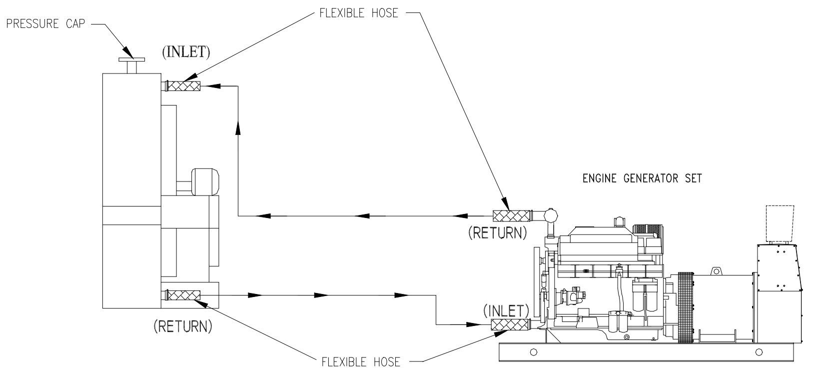

Figure 5-3: Typical remote radiator installation

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6 Exhaust System

Proper exhaust system installation is essential for maximum generator set engine efficiency. Because exhaust fumes are deadly, great care must be taken when installing the exhaust system. Consideration must be given to back pressure, piping, and placement. Figures 6-1 and 6-2 show the general arrangement of recommended exhaust systems.

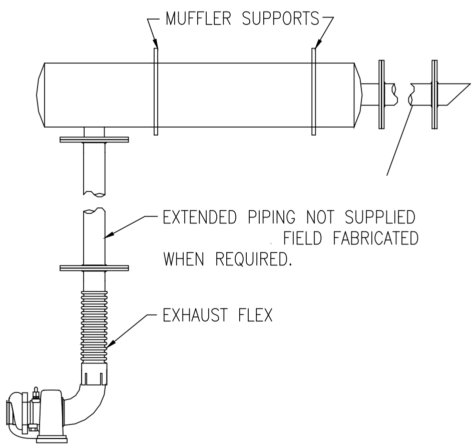

Figure 6-1: Typical side inlet exhaust

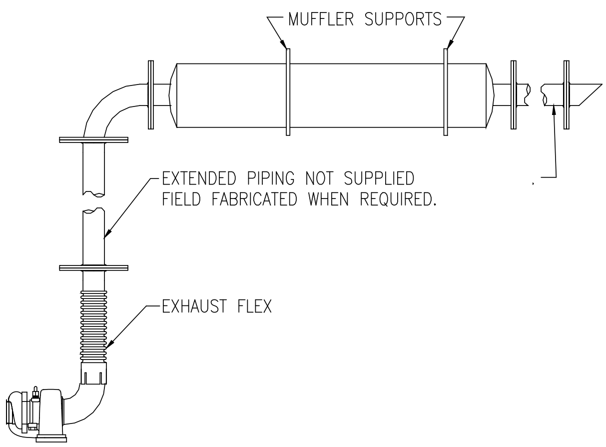

Figure 6-2: Typical end inlet exhaust

PLACEMENT

The exhaust pipe should terminate outdoors, away from doors, windows, or other building openings in an area where exhaust can dissipate. Placement of piping and exhaust silencer should take into account the location of combustible materials. If location cannot avoid these concerns, remove combustible materials on a regular basis. Keep dry grass, foliage, and combustible landscaping material a safe distance from the exhaust system.

WARNING

Inhalation of exhaust gases can cause death. Exhaust pipes must not terminate near fresh inlet vents of any type or near combustible materials. Avoid exhaust gas recirculation which could cause the engine-generator set to overheat. Generator sets installed outdoors inside enclosures should have their exhaust directed so that it will disperse away from buildings and building air intakes.

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Back Pressure
The installed exhaust system must not exceed the engine manufacturer's maximum exhaust back pressure limit. Damage may result from excessive back pressure. Causes may include:

- Insufficient exhaust pipe diameter
- Exhaust run too long
- Exhaust silencer too small or designed improperly
- Too many bends and/or constrictions in piping
- Obstruction in exhaust piping

Your generator set has been sized so that exhaust system back pressure is kept within the acceptable limits. However, in situations when extended piping or a flex connector other than the one supplied must be used, contact MTU Onsite Energy to ensure that back pressure will not exceed the engine manufacturer's specification.

Piping
Exhaust piping must conform to all applicable codes. Routing of exhaust piping should be as short and direct as possible. Exhaust piping should be of Schedule 40 black iron, steel or other suitable material having adequate strength and durability. The recommended material for exhaust piping is Schedule 40 black iron pipe. Where possible, sweep elbows with a radius of at least 3 times the pipe diameter should be used.

Exhaust pipes must be independently supported with no weight applied to the engine, turbocharger, exhaust manifold or flex connector. Where exhaust pipes attach to the engine, they must be connected with flexible connectors to minimize vibrations that can cause damage to the exhaust system.

CAUTION

Weight applied and vibration extended to the exhaust manifold or turbocharger could result in damage to these components. No exhaust piping weight may be carried by the engine, exhaust manifold or turbocharger.

The following applies to UL 2200 Listed engine-generator sets. When the complete exhaust system is not factory installed, exhaust piping and chimneys shall be designed, constructed, and installed in accordance with NFPA 37, Standard for the Installation and Use of Stationary combustion Engines and Gas Turbines.

Flexible Section
The supplied exhaust flex should be installed directly off the engine turbo elbow/manifold. This limits the stress on the engine exhaust manifold or turbocharger resulting from engine motion on its vibration mounts and temperature-induced changes in pipe dimensions. The flexible section should not be bent or used to make up for misalignment between the engine exhaust and the exhaust piping. Since typical exhaust temperatures range from 427 °C (800 °F) to over 649 °C (1,200 °F) for some engines, seamless stainless steel should be used for the flexible section.

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CAUTION

When installing a silencer, make certain flow direction is correct. Check inlet and outlet marking on the silencer nameplate.

Extended Piping

Engine exhaust piping can accumulate a considerable amount of condensed moisture after unit shutdown, particularly if the exhaust system is run through lengthy piping. To prevent condensed moisture from running back into the engine, exhaust piping should be sloped away from the engine and a condensate trap and drain should be incorporated at a low point ahead of engine manifolds. The trap should be drained periodically.

Horizontal extended exhaust pipe should terminate with a 45° tail pipe to prohibit rain from entering the system. A screen should be placed across the end of the tail pipe to keep birds and rodents from entering the system.

Where vertical exhaust stack is necessary, a rain cap should be fitted to exclude rain and snow from the exhaust pipe.

Where there is a danger of extending piping coming in contact with combustible material or personnel, the piping should be insulated or shielded.

Piping Insulation

The heat rejected by exhaust piping and the amount of ventilating air required can be substantially reduced by insulating exhaust piping with suitable high-temperature insulation. Exhaust temperatures are given on each generator model's specification sheet. DO NOT insulate piping for the turbocharger or manifold.

WALL OR ROOF THIMBLES

Exhaust piping passing through combustible walls or partitions must be guarded at the point of passage by an approved metal ventilated thimble to prevent exhaust pipe heat from being transmitted to the combustible material (Figure 6-3). Thimbles must be suitable for the application. Consider the type of exhaust system, construction materials used and local fire codes.

Roof Thimbles

Approved roof thimbles should be constructed so that they extend at least 23 cm (9 in) both ways from the surface of the roof. Ventilation holes are located on both ends for roof thimbles, therefore, a rain shield must be included above the thimble. Rain caps on the end of the exhaust pipe are recommended only in areas not subject to freezing temperatures. In an area where freezing is common, extend the exhaust piping well beyond the roof and use a gradual "U" bend at the end to direct the exhaust outlet downward which will keep rain, snow, etc., out of the pipe. The outlet of the pipe should be far enough away from the roof to prevent ignition of the roof material from hot exhaust.

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WALL THIMBLES

Approved wall thimbles should be constructed so that they extend at least 15 cm (6 in) both ways from the surface of the wall. Wall thimbles have ventilation holes on one end which should be oriented to the inside of the building.

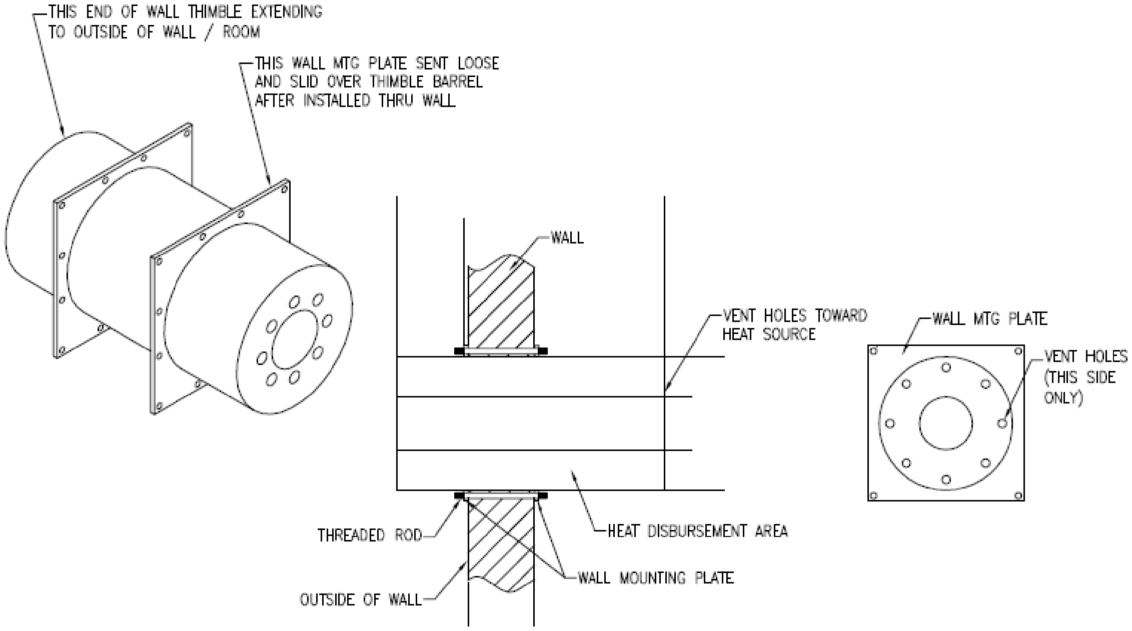

Figure 6-3: Wall thimble installation

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7

Fuel System

General

The fuel system must be installed properly to assure availability of fuel for starting and continuous running throughout the emergency. Before connecting the fuel lines to the engine, ensure that fuel connections are free from dirt, grease, water and other contaminants that could damage the engine.

The components comprising a fuel system will differ according to the generator set location, type of fuel and anticipated time of operation desired.

Diesel Applications

The following basic components comprise a representative diesel fuel system:

1. Main Fuel Tank Incorporating:
   a. Fill Line
   b. Vent Line
   c. Supply Line with Foot Valve
   d. Return Line

2. Day Tank (if required)
   a. Pump Control Switch

3. Electric Fuel Transfer Pump (if necessary)

Main Fuel Tank

The best location for the main fuel tank is as close to the engine as possible. If building codes and insurance regulations permit, the tank could be located in the same room as the generator set, or in an adjoining room. If this is not possible, the tank should be located in a convenient location compliant with local, regional and national codes.

The fuel level in the main tank should be level with the engine's fuel transfer pump inlet. If located in the room, the tank should be on the same general level as the engine's fuel injection pump but lower than the injectors. When the tank must be placed higher or lower than this, it often requires the usage of priming or float tanks. When the main tank can be located close to the set and where the vertical lift is 1.52 m (5 ft) or less, the fuel injection pump may be capable of supplying sufficient fuel. If the horizontal run is too great, or the vertical height exceeds 1.52 m (5 ft), a transfer pump is required. As a general rule, when static head and dynamic suction (horizontal head) exceed 20 kPA (6 inHg), an auxiliary pump and tank are required. A float tank or transfer tank is required with the auxiliary pump. The auxiliary pump should be of the positive displacement type, operated electrically from the load side of the transfer switch.

All tanks must be vented to a safe area in the event of an overflow and to allow air and other gases to escape to atmosphere. The vent must, however, prevent dust, dirt and moisture from entering the tank. Return lines are required. Keep the return space at least 30.48 cm (12 in) away from the pick-up or fuel supply in the day tank. If this is not done, air bubbles could be entrapped in the fuel and cause erratic operation. At least 5% of capacity should be allowed in a diesel main tank for expansion of the fuel. If the main tank is to be located overhead, an auxiliary fuel shut-off solenoid should be used.

The capacity of the fuel tank will be determined by the fuel consumption of the unit and the continuous operating time necessary. Minimum fuel supply must be sufficient to allow the set to operate for the prescribed number of hours. Before installing a fuel tank, review all local code requirements governing fuel tanks.

The number of lines connected to an underground fuel tank, whose depth of burial exceeds the below grade depth of the electric generating unit, will vary as a function of day tank positioning with regard to the engine and the number of ancillary devices utilized. However, all underground tanks must have the following:

- A vent line terminating above ground level in a screened or hooded type vent cap with unrestricted opening to atmosphere and a safe area, in the event of an overflow, that meets all necessary codes.
- A fuel fill line terminating above grade level, and fitted with an appropriate cap, and terminating in a fuel filler box with an appropriate cap plainly marked for the fuel utilized.
- A fuel supply line connected from the tank to an electric fuel transfer pump is needed when the fuel tank is located below the fuel lifting capacity of the set. The end of the fuel supply line within the tank must be fitted with a foot valve (permits flow in one direction only) to prevent loss of transfer pump prime when the transfer pump is not in operation.
- The day tank should be positioned so that the bottom of the day tank is above the level of the engine fuel filters in order to provide a positive head of pressure for the fuel injection pump. The mounting of the day tank in this manner will prevent loss of prime to the unit fuel injection pump and is recommended particularly in applications where the unit is utilized as a standby power source. In all applications, the return lines should returned to the main tank.

Local and national regulations governing fuel tank location must be checked before planning the installation. Fuel tanks must be adequately vented to prevent pressurization due to fuel expansion when heated.

CAUTION

The fuel system needs to be sized to handle the fuel flow required by the engine. Engine fuel flow is greater than engine fuel consumption and varies for different engine models. Engine fuel flow and consumption can be found on the model specification sheets located in the Operation and Maintenance manual.

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The fill, supply and return lines as well as all diesel fuel system piping must be constructed of black iron pipe. Do not use galvanized pipe for diesel fuel applications.

CAUTION

Galvanized tanks and piping must not be used since the diesel fuel and the galvanized coating react chemically to produce flaking which quickly clogs filters or causes failure of the fuel pump or injectors. Do not use Teflon tape on fuel fittings as it can clog the fuel injectors.

Cast iron and aluminum fittings and pipe should be avoided since they are porous and can leak fuel. Flexible fuel lines must be used to connect the unit to the fuel supply and return lines. Flexible lines must be of the type approved for diesel fuels.

WARNING!

Leaky fuel lines and fuel connections can introduce the possibility of explosion and fire, which can result in injury or death. Ensure fuel lines are properly connected and flexible lines are used between the engine and supply and return lines.

Fuel filters and drains must be located in easily accessible areas to promote regular and frequent service. Cleanliness of the fuel is critical for diesel engines that have easily damaged or clogged precision fuel injectors and pumps.

Day Tank

The day tank provides a ready supply of fuel at the injector pump. Day tanks are used when the engine pump does not have the necessary lift to draw fuel from the main tank. If the main tank is above the level of the injectors, the day tank is used to remove the fuel head pressure that would otherwise be placed on the engine fuel system components.

A slight head of fuel can cause leakage through the injectors and result in hydraulic lock problems such as filling of the engine cylinder with liquid fuel. The injector return line must always be at or below the level of the fitting on the engine. The line must drain toward the day tank.

Fuel Oil Transfer Pump

The fuel oil transfer pump (auxiliary pump) is used to supply fuel from the main tank to the day tank.

Single phase 120 VAC or 240 VAC, the AC power supply for the transfer pump should be taken from the load side of the transfer switch. The pump will operate when its circuit is closed by the action of the level switch.

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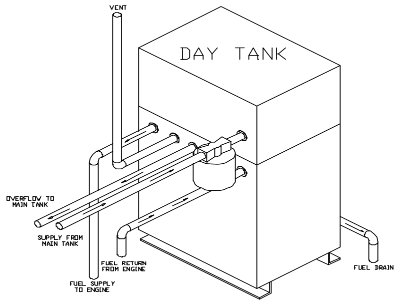

Figure 7-1: Fuel day tank

Fuel is then drawn from the main tank through a foot valve and is pumped into the day tank. Operation continues until the fuel level in the day tank rises causing the float to rise, opening the float switch and disconnecting the pump motor.

DIESEL FUEL RECOMMENDATIONS

MTU Onsite Energy recommends the use of #2-D diesel fuel.

#2-D Diesel Fuel:
A good quality 40 cetane (min) #2-D diesel fuel is best for most MTU Onsite Energy diesel generator set installations. This must be a distillate fuel which meets the requirements for #2-D in the ASTM diesel fuel classification D-975-60T. Most major brands of fuel oils conform to ASTM specifications.

#1-D Diesel Fuel:
A #1-D grade 40 cetane (min) diesel fuel may be best if operating at altitudes above 1,524 m (5,000 ft) or in cold weather (below 4 °C or 40 °F) conditions. Kerosene is included in the #1-D class of fuel. This fuel has a lower flash point (more volatile) and is of lower viscosity (flows more freely) than #2-D.

#2 Domestic Type (Furnace) Oil:
#2 domestic or furnace oil may be used. The #2 domestic fuel should have properties as close as possible to that of #2 diesel fuel. Check ASTM D-396-60T. Particular attention must be given to the sulfur content – this must be less than 1% by weight. High sulfur content can lead to increased engine wear and shorter injector life, especially if intermittent operation or low operating temperatures exist.

#4-D Grade Fuel: (NOT RECOMMENDED)
The high sulfur content plus low cetane rating of this class of fuel makes it unsuitable for diesel generator set use.

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GASEOUS FUEL SYSTEMS

System Variations: The gaseous fuel systems used can be grouped in 4 general classifications. The systems are covered in the following sequence:

1. Natural Gas (including manufactured gas)
2. LP Vapor
3. Liquefied Withdrawal
4. Dual Fuel Systems (natural gas and LP gas)
5. Zero Pressure Regulation

1. & 2. NATURAL GAS AND VAPOR PROPANE (FIGURE 7-2A):

Natural, manufactured, sewage and most LP Vapor gas systems are vapor fuels as supplied by the utilities. These fuel system components are used in a similar manner. When the heating content of the fuel falls below 35,315 BTU/m^3 (1000 BTU/ft^3), as it does with manufactured sewage and some natural gas fuels, the set will have to be derated. Check with the factory for application details. The gas distribution companies will provide piping from the main transmission line to the building. The primary regulator should be furnished by the utility company. It is the responsibility of the utility company to ensure that sufficient pressure is present at all times to operate the primary regulator. Installation, repair and alteration to gas piping should be undertaken only by the utility company or personnel authorized by them. Piping should be rigidly mounted but protected against damage from vibration. Only UL or AGA approved flexible connection should be used.

3. LIQUID WITHDRAWAL

Most LPG systems are operated from vapor. The main tank is sized to vaporize the fuel volume needed for ambient temperature of the installation. Sizing the LPG tank must be the responsibility of the fuel supplier. Give the fuel supplier the fuel volume required.

Vaporizers: Vaporizers are devices used exclusively with LPG systems. LPG in liquid form is introduced under tank pressure into the vaporizer which uses engine coolant heat to convert the liquid into a vapor state. Vaporizers may be referred to as converters; both names describe its function. There are several types of vaporizers. One type is strictly a vaporizer and must be used in conjunction with other pressure regulators. This type of vaporizer may be required if tank size is limited; low ambient temperatures or high fuel volume are conditions affecting the installation. The type classified as vaporizer-regulators provide vaporization plus primary and secondary regulation of gas pressure.

Fire regulations in most localities prohibit liquid LP high-pressure fuel lines inside a building or enclosure. This automatically precludes high-pressure equipment on or near an engine installed inside a building. Under such regulations, the coolant lines can be extended and the vaporizer mounted outside the structure.

Gas at permissible pressure (usually about 140 kPa or 20 psi maximum) is allowed inside the building. The vaporizer must be mounted below the level of the engine water pump and within 7.62 m (25 ft) of the engine. If freezing temperatures are common, don't overlook the fact that water inside the vaporizer could freeze unless antifreeze is added to the system.

4. Dual Fuel Systems (Natural or LP Vapor)

In many applications, natural gas is the main fuel and LPG is used as the emergency fuel when natural gas is not available. The dual fuel system (in common use) offers automatic changeover from one fuel to the other.

During operation on natural gas, pressure existing in the common line to the carburetor closes off the LP Vapor regulator. Cutting off the natural gas operates a pressure switch in the line which automatically opens the LP Vapor solenoid and closes the natural gas solenoid.

5. Zero Pressure Regulation

The Zero Pressure Regulator System works on Zero Pressure air and Zero Pressure gas, the engine vacuum is what mixes the fuel and air through the mixer on the carb.

The system still requires 1.74 to 2.74 kPa (7 to 11 in H_2O) on either Natural Gas or LP Vapor.

The flow control valve is left with the tower in the upright position on either fuel and with the spring left in. The Zero Pressure System only requires the installer to give the correct pressure and volume to the system. NOTE: A dog tag on the system shows the fuel consumption and pressures required for each system.

Gas Piping: Piping must never be used to ground electrical apparatus. Piping must be rigidly mounted but protected against vibration. Where flexible connections are required, use only approved connections. A flexible section should be used between the point where the gas leaves the rigid fuel line and enters the engine. Only connections capped off by a temporary plastic plug are intended to be connected to by the end user.

All gas lines and piping should be of black iron. Joints and connections must be sealed. The pipe should be of sufficient size to maintain the proper pressure level when operating at full load. In addition to the actual fuel consumption, the following factors must be considered:

- Pressure loss due to number of fittings
- Specific gravity of gas
- Pressure loss due to length of piping

At the end of the chapter is a list of steps to follow when calculating pipe capacities for gas flow rates.

This procedure is based on a pressure drop of 0.125 kPa (0.5 in H_2O) which allows for a normal amount of restriction from fittings.

Tables 7-1 and 7-2, Gaseous Fuel Pipe Capacity, list the capacity of various sizes and lengths of pipe. The capacity in m^3/hr (ft^3/hr) is calculated using the specific gravity of 0.6 as base. A pressure drop of 0.125 kPa (0.5 in H_2O) is used to account for a nominal number of fittings and metering equipment in this table.

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Main Components: Solenoid valves used in a gaseous fuel system are designed to close and stop fuel the instant the engine stops. They should not be relied upon to completely seal the fuel system. A ruptured diaphragm or a piece of grit could prevent the valves from sealing resulting in gas continuing to flow through the carburetor into the engine and out into the surrounding air. Some gaseous fuels are heavier than air and tend to settle in low areas. This could present a serious hazard, especially in enclosed applications. Safeguards against this should be incorporated in each system.

The common components of a gas system are as follows:

Primary regulator: This regulator is used to provide pressure regulation of the gas from the high-pressure supply line or with LPG with the supply tank.

The primary regulator reduces line pressures to allowable inlet pressures for the secondary regulator. This regulator is supplied by the utility or fuel company.

Secondary regulator: The low-pressure type regulator admits fuel to the engine in response to engine demand similar to the float valve in a gasoline carburetor. The secondary regulator is not supplied and must be supplied by the purchaser. Natural gas and LPG vapor withdrawal inlet pressures must be from 1.74 to 2.74 kPa (7 to 11 in H_2O).

PRESSURE REDUCING VALVE

The pressure-reducing valve regulates the volume of fuel to the carburetor. The volume is proportional to the load on the engine.

This device is factory mounted for LP gas vapor withdrawal fuel systems, the valve is inverted and the internal spring removed. Consult factory for drawings showing modifications for propane fuel systems.

Fuel shut-off solenoid: This device automatically shuts off the fuel supply when the engine stops. All MTU Onsite Energy automatic fuel shut-off valves are electrically activated solenoids that seal off the fuel the instant the ignition switch is turned off.

Carburetor: Gas carburetors operate on gaseous fuels only.

*NFPA 37 requires the electric solenoid to be placed ahead of any flexible connector. This solenoid is not supplied by MTU Onsite Energy.

Determining Pipe Size for Gaseous Fuel Systems

1. Obtain the fuel consumption in m^3/hr (ft^3/hr) at 100% load from the engine generator model specification sheet for the type of fuel used.
2. Refer to the correction chart below, and select the correction factor for the type of fuel used.

Fuel Specific Gravity	Fuel	Correction Factor
0.65	Natural Gas	0.962
1.00	Air	0.775
1.50	Propane	0.633
2.10	Butane	0.535

3. Divide the fuel consumption from step one by the correction factor to obtain adjusted flow rate.
4. Determine length of pipe between the fuel source and generator set.
5. From table 7-1 or 7-2, choose the column of the nearest pipe length.
6. Move down the column until the figure equal to or greater than the adjusted flow rate obtained in step three is encountered.
7. Move horizontally to the left column to determine the correct pipe size (NPS = Nominal Pipe Size).

NPS	Length of Pipe (ft)													
	10	20	30	40	50	60	70	80	90	100	125	150	175	200
1/4	43	29	24	20	18	16	15	14	13	12	11	10	9	8
3/8	95	65	52	45	40	36	33	31	29	27	24	22	20	19
1/2	175	120	97	82	73	66	61	57	53	50	44	40	37	35
3/4	360	250	200	170	151	138	125	118	110	103	93	84	77	72
1	680	465	375	320	285	260	240	220	205	195	175	160	145	135
1-1/4	1400	950	770	660	580	490	460	460	430	400	360	325	300	280
1-1/2	2100	1460	1180	990	900	810	750	690	650	620	550	500	460	430
2	3950	2750	2200	1900	1680	1520	1400	1300	1220	1150	1020	950	850	800
2-1/2	6300	4350	3520	3000	2650	2400	2250	2050	1950	1850	1650	1500	1370	1280
3	11000	7700	6250	5300	4750	4300	3900	3700	3450	3250	2950	2650	2450	2280
4	23000	15800	12800	10900	9700	8800	8100	7500	7200	6700	6000	5500	5000	4600

Table 7-1: Gaseous Fuel Pipe Capacity (Imperial: ft^3/hr)

DN	Length of Pipe (m)													
	3	6	9	12	15	18	21	24	27	30	38	46	53	61
8	1.2	0.82	0.68	0.57	0.51	0.45	0.42	0.4	0.37	0.34	0.31	0.28	0.25	0.23
10	2.7	1.8	1.5	1.3	1.1	1	0.93	0.88	0.82	0.76	0.68	0.62	0.57	0.54
15	5	3.4	2.8	2.3	2.1	1.9	1.7	1.6	1.5	1.4	1.3	1.1	1	1
20	10	7.1	5.7	4.8	4.3	3.9	3.5	3.3	3.1	2.9	2.6	2.4	2.2	2
25	19	13	11	9.1	8.1	7.4	6.8	6.2	5.8	5.5	5	4.5	4.1	3.8
32	40	27	22	19	16	14	13	13	12	11	10	9.2	8.5	7.9
40	59	41	33	28	25	23	21	20	18	18	16	14	13	12
50	112	78	62	54	48	43	40	37	35	33	29	27	24	23
65	178	123	100	85	75	68	64	58	55	52	47	42	39	36
80	311	218	177	150	135	122	110	105	98	92	84	75	69	65
100	651	447	362	309	275	249	229	212	204	190	170	156	142	130

Table 7-2: Gaseous Fuel Pipe Capacity (Metric: m^3/hr)

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Example

- Engine – generator set operating with a fuel consumption of 700 cubic feet per hour and at a distance of 50 feet from the fuel supply

- Fuel used is propane and has a specific gravity of 1.5
- Dividing the flow rate of 700 CFH by the correction factor of 0.633 for propane gives the adjusted capacity of 1105 CFH
- Reading down the 50-foot pipe length column in table 7-1 until a figure equal to or greater than 1106 is encountered, we get a figure of 1680
- Reading directly across to the left column gives the required pipe size of 2 inches

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8

Electrical Requirements

General
The electrical system consists of the AC power supplied to the generator and the DC starting and control circuitry. These circuits must be enclosed in separate conduits.

Batteries
The batteries need to be provided with enough capacity to provide the cranking motor current specified on the unit specification sheet. The recommended batteries are lead-acid or nickel cadmium. They can be shipped wet or dry. If shipped dry, they can be stored indefinitely and when ready to use filled with electrolyte (acid) with a specific gravity of 1.250 to 1.265. It is recommended that batteries be placed on trickle charge for 12 hours after electrolyte is added.

Batteries should be located as close as possible to the generator set to eliminate line losses.

Nickel cadmium batteries are shipped wet. It is advisable that batteries be placed on trickle charge for 12 hours when received.

Coat battery terminal connections with grease to prevent corrosion. Check the electrolyte level periodically. Make certain all vent caps are in place and unobstructed.

Battery Racks and Cables
Where the battery installation requires remote battery location, the correct cross sectional area of battery cables is of importance in minimizing line drop. Battery racks or boxes are supplied by MTU Onsite Energy for lead-acid batteries.

AC Power Output Wiring
All wiring must be in accordance with applicable electrical codes. Wires must be of adequate size, properly insulated and supported in an approved manner. Wires should not be placed where they may interfere with plant operation. Figure 8-1 illustrates the various generator connections for MTU Onsite Energy generators.

The following applies to UL 2200 Listed engine-generator sets where installed in accordance with NFPA 70, National Electric Code. For the generator output wiring, use listed stranded copper wire with 90 °C rated insulation. If wire terminals are not factory provided, use UL Listed wire terminals which are suitable for the application and ratings. When an output circuit breaker is not factory provided, install an approved overcurrent protection device rated equal to or greater than the generator voltage with a current rating no more than 125% of the output current of the unit, located within 7.6 m (25 ft) of the generator output terminals.

WARNING

Accidental contact with electrical equipment can cause severe injury and death if the equipment is not properly grounded. Ensure that all equipment is properly grounded.

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Automatic Transfer Switch

Installing an automatic transfer switch is primarily an electrical operation and, therefore, should be handled by a licensed electrician. Instructions and detailed wiring diagrams will accompany the switch.

The transfer switch is designed to be mounted on a wall or other vertical surface free from vibration. The switch should be at the electrical service entrance and yet within 30.48 m (100 ft) with No. 12 AWG (3.31 mm^2) wire from the generator set control cabinet.

Remote/Audible Alarm

An external fault indicator or audible alarm can be wired to the generator set. Make certain external fault indicator or audible alarm is rated for 2 amperes maximum and 12 or 24 VDC depending on the DC voltage of the system. The indicator will become illuminated or the alarm will sound when an overcrank, low lube pressure, high coolant temperature or overspeed condition occurs.

Accessory Wiring

When motor operated louvers are required for a generator set installation, the louver motors must be wired to operate whenever the engine generator set runs, during emergency conditions, normal periodic exercising, or for maintenance.

MTU Onsite Energy suggests the louver motors be wired to a distribution panel on the load side of the automatic transfer switch. The louver motor control circuit is wired to “energized to run” contacts in the generator set control panel.

Voltage Selector Tap Switch (Optional)

WARNING

Never attempt to change the voltage selector tap switch while the engine is running! This will cause severe arcing and damage to the switch and generator windings. Refer to the electrical drawings for your generator set for more detailed information.

The optional voltage selector tap switch mechanically changes the connection between the generator output leads and the connection lugs or optional cam lock connectors. Voltage range is selected by moving the tap switch to the corresponding position.

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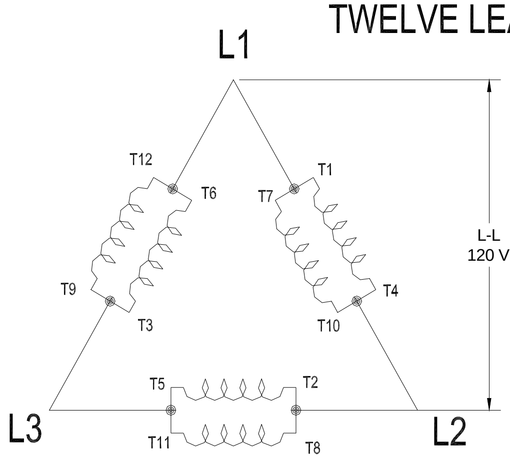
TWELVE LEAD PARALLEL DELTA

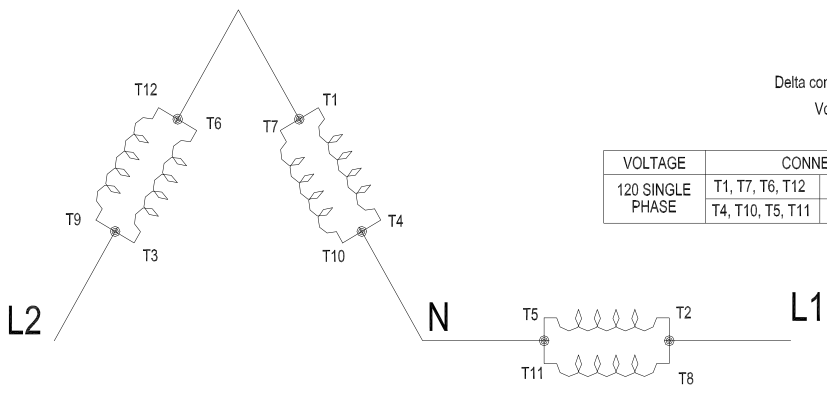


Delta connection with 12 lead generators only.

Voltages: 60 Hz 120v TO 139v
50 Hz 100v TO 120v

VOLTAGE	CONNECT		L1	L2	L3
120 DELTA	T1, T7, T6, T12	T2, T8, T4, T10	T1	T2	T3
	T3, T5, T9, T11				

TWELVE LEAD ZIG-ZAG OR OPEN DELTA



Delta connection with 12 lead generators only.

Voltages: 60 Hz 120/240v single phase
50 Hz 110/220v single phase

VOLTAGE	CONNECT		L1	L2
120 SINGLE PHASE	T1, T7, T6, T12	T3, T9	T2, T8	T3, T9
	T4, T10, T5, T11	T2, T8		

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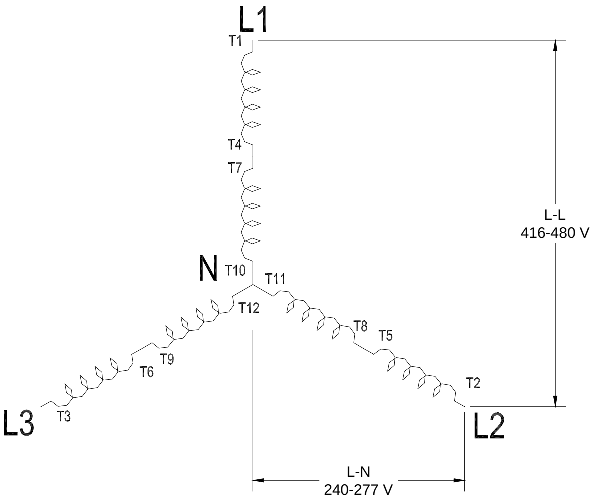
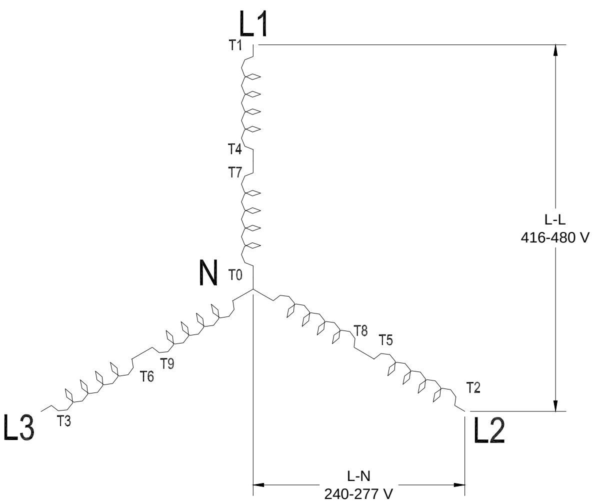
TWELVE LEAD SERIES WYE



Voltages: 60 Hz 240/416v TO 277/480v
50 Hz 220/380v TO 240/416v

VOLTAGE	CONNECT			L1	L2	L3	NEUTRAL
480-416 WYE	T10, T11, T12			T1	T2	T3	T10, T11, T12
	T4, T7	T5, T8	T6, T9				

TEN LEAD SERIES WYE



Voltages: 60 Hz 240/416v TO 277/480v
50 Hz 220/380v TO 240/416v

VOLTAGE	CONNECT			L1	L2	L3	NEUTRAL
480-416 WYE				T1	T2	T3	T0
	T4, T7	T5, T8	T6, T9				

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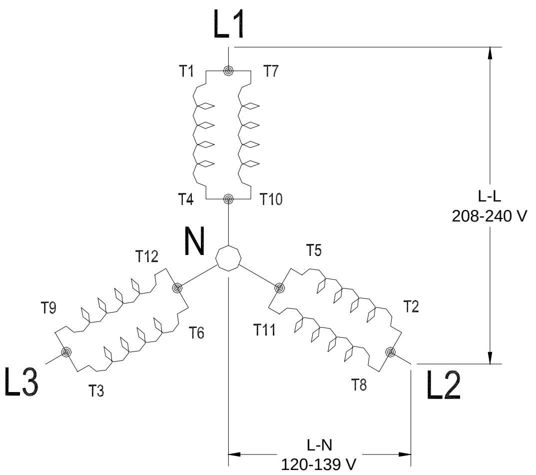
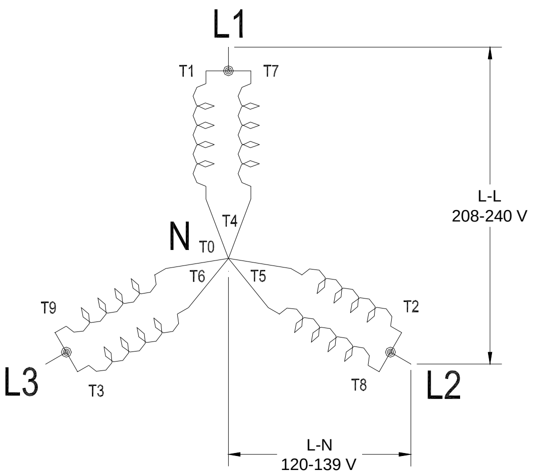
TWELVE LEAD PARALLEL WYE



Voltages: 60 Hz 120/208v TO 139/240v
50 Hz 110/190v TO 120/208v

VOLTAGE	CONNECT			L1	L2	L3	NEUTRAL
240-208 WYE	T10, T11, T12	T4, T5, T6		T1	T2	T3	T10, T11, T12
	T1, T7	T2, T8	T3, T9				T4, T5, T6

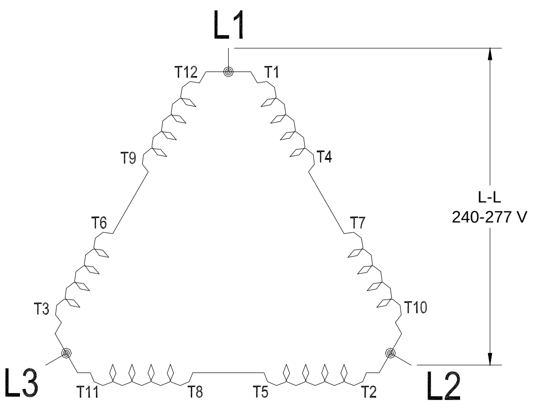
TEN LEAD PARALLEL WYE



Voltages: 60 Hz 120/208v TO 139/240v
50 Hz 110/190v TO 120/208v

VOLTAGE	CONNECT			L1	L2	L3	NEUTRAL
240-208 WYE	T4, T5, T6, T0			T1	T2	T3	T4, T5, T6
	T1, T7	T2, T8	T3, T9				

TWELVE LEAD SERIES DELTA



Voltages: 60 Hz 120/240v TO 138/277v
50 Hz 110/220v TO 120/240v

VOLTAGE	CONNECT			L1	L2	L3
240-277 DELTA	T4, T7	T5, T8	T6, T9	T1	T2	T3
	T1, T12	T2, T10	T3, T11			

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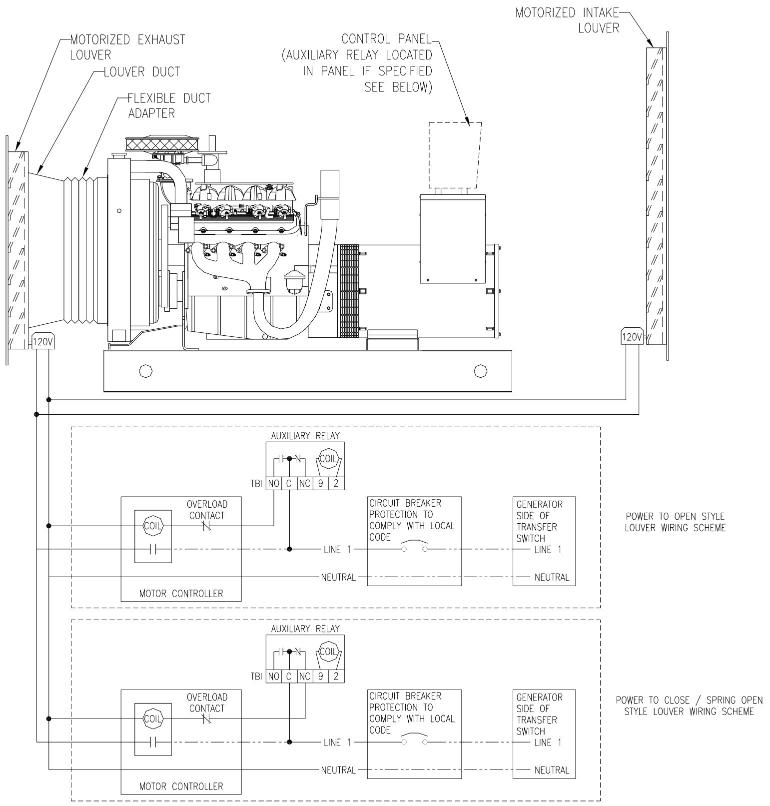

Figure 8-1: Suggested motorized louver wiring

As an alternate-wiring scheme, the louver motor may be wired directly to the generator output leads, prior to the mainline circuit breaker. The installation contractor must add any necessary wiring devices and circuit protection to comply with the local electrical code requirements.

There are many other wiring schemes which may be used to safely wire the louver motors and control circuits to ensure the louvers will open when the engine generator set runs. If there are any questions, consult your generator set supplier.

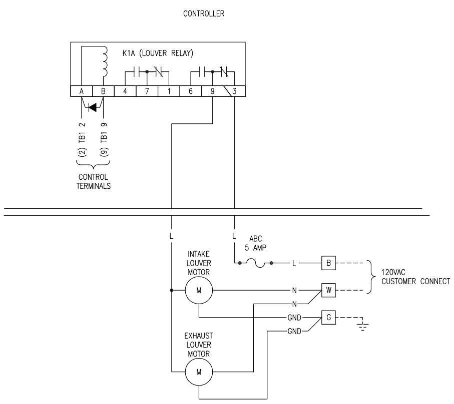

Figure 8-2: Optional motorized louver wiring

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9

Service

Install the generator set in an area that can be quickly reached for repair in case of malfunction. Service entrances should be large enough to permit service of components such as engine, radiator or generator in the event major overhaul or replacement is needed.

The location for items requiring service varies from model to model. All service items should be known and considered when planning the installation. An item requiring routine attention must, of course, be made more accessible.

In general, the following service points should be accessible:

- Air Cleaner
- Primary Fuel Filter
- Secondary Fuel Filter
- Lube Oil Dip Stick
- Oil Filter
- Starting Battery
- Starter
- Battery Charger & Voltage Regulator
- Generator & Control Systems

If your generator set requires service or repairs, simply contact an authorized MTU Onsite Energy dealer for assistance. Service technicians are factory-trained and are capable of handling all of your service needs.

When contacting a MTU Onsite Energy Authorized Dealer, always supply the complete model number and serial number of your unit, which are located on your generator set nameplate.

To locate the MTU Onsite Energy Authorized Dealer nearest you, call 800-325-5450.

NOTE

For standby units, it is important that servicing is performed on a calendar basis. Failure to do this may result in the generator set not starting or operating properly when the unit is most needed. Consult your Operation and Instruction Manual provided with the generator set for servicing information.

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10 Installation Checklist

Prior to initial start-up, refer to the following installation checklist to ensure that the generator set is installed properly.

CHECK	OK	CHECK	OK
1. Adequate clearance on all sides.		19. Exhaust nipple installed on manifold below flexible exhaust connection (condensate trap).	
2. Doors on unit must be in alignment.		20. Exhaust piping sloped away from engine.	
3. Remove engine locks and vibration isolator blocks.		21. Condensate trap or drain installed.	
4. Confirm proper alignment of angular displacement, radial displacement and axial displacement (applicable only to two-bearing generators only).		22. Muffler exhaust flow in right direction.	
5. Adequate incoming air flow.		23. Exhaust line free of excessive elbows and restrictions.	
6. Adequate outgoing air flow.		24. Exhaust line shielded/protected.	
7. Radiator duct flange connected.		25. Battery in cool location.	
8. Antifreeze required/installed.		26. Battery properly charged.	
9. Water heater properly connected and of proper voltage.		27. Battery of proper size and voltage.	
10. Proper size fuel line and connectors.		28. Battery cables correct size.	
11. Fuel lines protected.		29. Battery charger operating.	
12. Fuel pump lift adequate.		30. Generator properly connected.	
13. Flexible fuel connectors.		31. All controller contacts clean.	
14. Fuel return line.		32. Transfer switch operating correctly.	
15. Gas pressure acceptable.		33. Binding posts tight (all connections).	
16. Solenoid shut-off valve installed (gas).		34. Operator has instruction manual.	
17. Proper size exhaust line.		35. Maintenance schedule posted.	
18. Flexible exhaust connection installed.		36. No loose parts, belts, bolts, nuts, etc.	

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11 Start-Up Request Form

To provide an authorized factory start-up at the lowest possible prices, we must request that the following checklist and tasks be completed prior to an MTU Onsite Energy representative's arrival at the installation site to perform the start-up.

Unit Serial Number: ___________________________ Contact Name: ____________________________

Company Name: ______________________________ Title: ____________________________________

Please attach a map or directions to the site. Phone Number: (_______)_____________________

- ☐ Unit set in place on vibration pads with floor anchor/studs to prevent movement.
- ☐ Doors on unit in alignment.
- ☐ Radiator ducted to properly sized air discharge louvers.
- ☐ Unit full of oil and water/anti-freeze mix.
- ☐ Battery filled with acid and fully charged.
- ☐ Battery charger mounted with AC and DC wired, if not supplied mounted by the factory.
- ☐ All AC and DC electrical connections made.
- ☐ Engine heater wired to normal AC power supply.
- ☐ Fuel inlet and return lines run between the unit and fuel storage system, system filled and primed to the engine with proper fuel.
- ☐ Exhaust system in place and supported so that the exhaust manifold does not carry weight of exhaust system.
- ☐ Air inlet louver motor wired to an emergency generator source point to open upon the start of an engine generator set.
- ☐ Generator room cleaned of construction debris including excess nails, bolts, nuts, panel knockouts, etc. It is very important that the radiator fan area is checked for debris, as damage to the equipment and personal injury can occur if loose items come in contact with the fan when the unit is initially started.

Consult your Installation Guide on any questions.

If, upon arrival at the installation site, our representative cannot perform the start-up as a result of defective MTU Onsite Energy equipment, the problems will be resolved and we will reschedule another start-up date at the earliest possible date at no additional charge.

If the start-up cannot be performed due to an incomplete installation or for reasons beyond MTU Onsite Energy's control, you may incur an additional start-up charge at a later date.

Signature: ____ Date: _____________________

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12

Operating Procedures

CAUTION

Be aware that the generator set could start at any time in the "AUTO" mode. Keep clear of all moving parts and be sure to turn the switch to "OFF" position before servicing and disconnect the negative battery cable after disconnecting the battery charger circuit.

The high engine temperature shutdown system will not operate if the coolant level is too low. The high engine temperature sensor monitors coolant temperature. Loss of coolant will prevent sensor operation and allow the engine to overheat causing severe damage to the engine. Therefore, maintain adequate coolant level for proper operation of the high engine temperature shutdown system.

Low Coolant Level Shutdown: A submerged sensor in the top portion of the radiator shuts down the engine and lights the Hi Engine Temp fault lamp when the coolant level falls below the level of the sensor. Top off coolant frequently.

Prior to starting or testing the generator set, refer to the engine manual for maintenance checkpoints. Items such as oil level, coolant level, belt tension, battery electrolyte level, wire connections, and air filter are some of those that should be checked frequently.

CAUTION

Stop engine before filling fuel tank. Never fill tank when engine is hot.

STARTING PROCEDURE

The following sections cover the three systems used to start the generator set.

Starting at Control Panel (Manual Start)

1. Press the "RUN" button to activate the engine control system and the starting system.
2. The engine will begin cranking, and after a few seconds, will start.

If the engine does not start:

3. MTU Onsite Energy generator sets will automatically attempt two more crank cycles then will produce an overcrank alarm.
4. To clear an overcrank alarm, press the "OFF" button.
5. Wait two minutes for the starter motor to cool and then repeat the starting procedure.
6. If the engine does not run after a second attempt at starting, refer to the **Troubleshooting** section.

Automatic Operations

For automatic operation, the generator set will be controlled by the automatic transfer switch and the automatic engine control.

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For detailed operations of the transfer switch, refer to the Operations Manual supplied with the transfer switch.

For detailed operations of the automatic engine control, refer to the Operations Manual supplied with the generator set.

1. Leave the engine in the “AUTO” position.
2. Leave the generator set circuit breaker in the “ON/CLOSED” position.
3. Automatic starting and stopping is controlled by the transfer switch.
4. If issues for starting or stopping occur, refer to the **Troubleshooting** section.

EMERGENCY STOP PUSH BUTTON

In case of emergency the operator may shut down the generator set by pushing the red E-Stop button. This will stop and disable the generator set. The E-Stop button must be reset to resume generator set operation. Press the “OFF” button on the controller to reset the engine control before restarting the unit.

STOPPING PROCEDURE

Before Stopping

Run the generator set at no load for 3 to 5 minutes before stopping. This allows the lubricating oil and engine coolant to carry heat away from the combustion chamber and bearings.

To Stop

If the set was started at the set control panel or at a remote control panel, move the RUN/OFF/AUTO switch or remote starting switch to the OFF position. If an automatic transfer switch started the set, the set will automatically stop after the normal power source returns and time delays have been satisfied.

BREAK-IN

Drain and replace the crankcase oil and oil filter(s) after the first 30 to 50 hours of operation on new generator sets. Refer to the **MAINTENANCE** section of the Engine manual for the recommended procedures. It is recommended to achieve the break in during the first 2 months after installation is completed. This will familiarize the operator with the system.

NO-LOAD OPERATION

Periods of no load operation should be held to minimum. If it is necessary to keep the engine running for long periods of time when no electric output is required, best engine performance will be obtained by connecting a “dummy” electrical load. Such a load could consist of Load Banks.

EXERCISE PERIOD

Generator sets on continuous standby must be able to go from a cold start to being fully operational in a matter of seconds. This can impose a severe burden on engine parts. Regular exercising keeps engine parts lubricated, prevents oxidation of electrical contacts and in general helps provide reliable engine starting.

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According to the NFPA 99-2005, NFPA 110-2010, and applicable national and local laws, ordinances, and regulations, exercise the generator set with load so the engine reaches normal operating exhaust gas temperatures. Generator sets must be tested 12 times a year, with testing intervals set at a minimum of 20 days and maximum of 40 days. For recommended minimum operating exhaust gas temperatures, refer to the engine manufacturer's documentation.

Testing the emergency power supply systems (EPSS) includes:

- using building load, as long as the load is in excess of 30% of the nameplate rating of the EPSS, or
- operating the engine maintaining a minimum exhaust gas temperature as recommended by the engine manufacturer to prevent "wet stacking" of the exhaust.

The Automatic Transfer switch has an optional exerciser that can be preset to provide regular exercise periods. Typically the exerciser can be set for time of start, length of run, and day of week. Consult the factory for additional guidance as needed.

Low Operating Temperatures

Use a coolant heater if a separate source of power is available. The optional heater will help provide reliable starting under adverse weather conditions.

Be sure the voltage of the separate power source is correct for the heater element rating. The heater should be in use year round. A heater is required on all automatic systems to prevent engine damage due to short warm up cycles.

AUTOMATIC TRANSFER SWITCH

DANGER

HAZARDOUS VOLTAGE will cause severe injury or death. Turn OFF all power before installation, adjustment or removal of transfer switch or any of its components.

Equipment Inspection

Immediately inspect the transfer switch when received to detect any damage, which may have occurred during transit. If damage is found or suspected, file claims as soon as possible with the carrier and notify the nearest MTU Onsite Energy representative. The switch cabinet should be opened at inspection to check for internal freight damage, even if the box and cabinet enclosure appear undamaged.

Final Equipment Inspection

Prior to energizing the transfer switch:

- Remove any debris incurred due to shipment or installation. DO NOT use a blower since debris may become lodged in the electrical and mechanical components and cause damage. Use of a vacuum is recommended.
- Verify that all cabled connections are correct. Verify phase rotation and position of the high leg at both sources on the delta system.
- Check engine start connections and verify the correct connection of all control wires.

- Check settings of all timers and adjust as necessary. Also adjust any optional accessories as required.
- Check the integrity of power connections by verifying actual lug torque values as specified in the ATS manual.
- Make sure that all covers and barriers are installed and properly fastened.

FUNCTIONAL TEST

Since there are various transfer switch designs available, please refer to the operator manual provided with the transfer switch for specific details.

The functional testing of the transfer switch consists of electrical tests described in this section. Before proceeding, refer to the information package supplied with the transfer switch. Read and understand all instructions and review the operation of all accessories provided.

Before starting the operation test, check the equipment-rating nameplate on the transfer switch to **verify the correct system voltage**.

To begin the test, close the Normal source circuit breaker. The micro-controller will illuminate the Normal Available LED if proper voltage is sensed. Verify the phase-to-phase voltages at the Normal line terminals.

Next, close the Emergency source breaker and start the engine generator. The Emergency Available LED indicator will illuminate when preset voltage and frequency levels are achieved. Check the phase-to-phase voltages at the Emergency line terminals. Also, verify that the phase rotation of the Emergency source is the same as the phase rotation of the Normal source.

After the sources have been verified, shut down the engine generator, and put the starting control in the automatic position. Complete the visual inspection of the transfer switch, and close and lock the cabinet door.

Initiate the electrical transfer test by activating the test switch. **Hold the test switch until transfer to Emergency is accomplished**. After the engine start time delay, the micro-controller will send an engine start signal and sensing will determine when the auxiliary source reaches preset levels. The switch will transfer to the Emergency source after the time delay of the transfer to the Emergency timer.

Deactivating the test switch will start retransfer to the Normal source. The switch will retransfer to the Normal source after the time delay of the retransfer to Normal timer. The engine over-run timer allows the engine generator to run unloaded for a preset cool-down period.

For complete details of timer and voltage sensing operations, please refer to the Automatic Transfer Switch Operation Manual.

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Maintenance and Testing

A preventive maintenance program will ensure high reliability and long life for the transfer switch. The preventive maintenance program for the transfer switch should include the following items.

Inspection and Cleaning

DANGER

HAZARDOUS VOLTAGE. De-energize all sources of power before doing any work on the transfer switch. Note: If approved disconnects are not in place contact your Local Electric Utility or a qualified Electrician before proceeding.

The switch should be inspected for any accumulation of dust, dirt, or moisture, and should be cleaned by vacuuming or wiping with a dry cloth or soft brush. DO NOT use a blower since debris may become lodged in the electrical and mechanical components and cause damage.

Remove the transfer switch barriers and check the condition of the contacts. Any surface deposits must be removed with a clean cloth (DO NOT USE EMERY CLOTH OR A FILE). If the contacts are pitted or worn excessively, they should be replaced. A general inspection of mechanical integrity should be made to include loose, broken or badly worn parts.

Servicing

All worn or inoperative parts must be replaced using recommended replacement parts. Please contact your nearest Distributor for specific replacement part information and ordering procedures.

The operating mechanism of the transfer switch is lubricated. The lubricant applied at the factory provides adequate lubrication for the lifetime of the switch. Should debris contaminate the mechanism, clean and apply additional lubricant. (See Automatic Transfer Switch Manual for proper lubricant type).

Testing

A manual operator handle is provided with the transfer switch for maintenance purposes only. Manual operation of the switch must be checked before it is operated electrically. Both power sources MUST be disconnected before manual operation of the switch. Insert the handle and operate the transfer switch between the Normal and Emergency positions. The transfer switch should operate smoothly without binding. Return the switch to the Normal position, remove the handle, and return it to the holder provided.

After completing the inspection, cleaning and servicing of the transfer switch, reinstall the switch cover, and close and lock the cabinet door. Reclose the circuit breakers feeding the utility and generator sources to the switch.

Initiate the electrical transfer test by activating the test switch. Engine start timer will time out and the micro-controller will send an engine start signal. When the transfer to Emergency time has elapsed, the switch will complete its transfer by closing into the Emergency source.

Deactivating the test switch will start retransfer to the Normal source. The switch will complete its retransfer to Normal after the time delay of the retransfer to Normal timer. The engine over-run timer allows the engine generator to run unloaded for a preset cool down period.

GOVERNORS

MECHANICAL GOVERNOR ADJUSTMENTS

All MTU Onsite Energy generator sets are tested at full load prior to shipment and the speed settings are adjusted. The typical settings will vary from 60 – 63 Hz at no load and are set to operate at 60 Hz when loaded to the nameplate rating. If the system load does not reach the nameplate rating the speed can be adjusted down to 60 Hz. Care must be taken to ensure that the MTU Onsite Energy generator set operates at no less than 60 Hz when the entire load to be on the unit is applied. See Figures 12-1 and 12-3 to find the typical speed adjust locations.

ELECTRONIC GOVERNOR DIESEL ADJUSTMENTS

Governor Speed Setting (Diesel)

The governed speed set point is increased by clockwise rotation of the Speed adjustment control. Remote speed adjustment can be obtained with an optional Speed Trim Control. See Figure 12-1.

Governor Performance (Diesel)

Once the engine is at operating speed and at no load, the following governor performance adjustments can be made: Rotate the Gain adjustment clockwise until instability develops. Gradually move the adjustment counterclockwise until stability returns. Move the adjustment 1/8 of a turn further counterclockwise to ensure stable performance.

Rotate the Stability adjustment clockwise until instability develops. Gradually move the adjustment counterclockwise until stability returns. Move the adjustment 1/8 of a turn further counterclockwise to ensure stable performance.

Gain and stability adjustment may require minor changes after engine load is applied. Normally, adjustments made at no load achieve satisfactory performance. A strip chart recorder can be used to optimize the adjustments further. If instability cannot be corrected or further performance improvements are required, contact the nearest distributor or Service Center.

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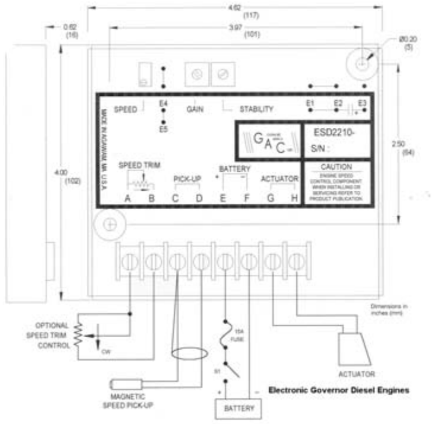

Figure 12-1: Standard GAC Governor Control

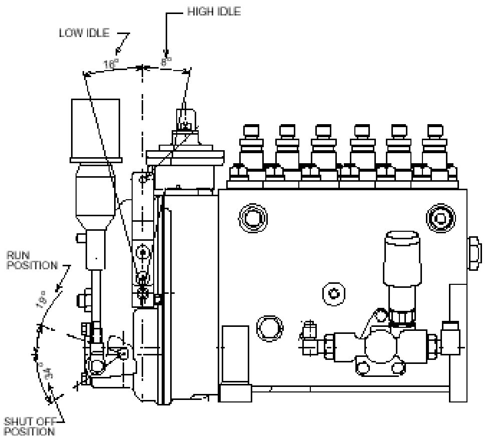

Figure 12-2: Standard Mechanical Governor for Diesel Engines

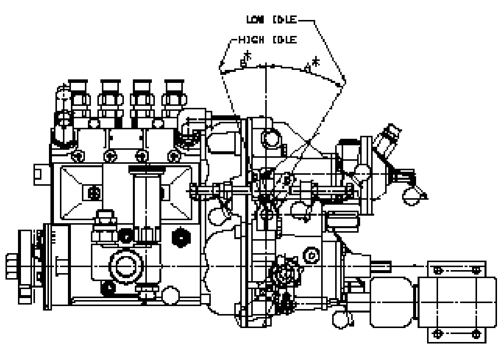

Figure 12-3: Standard Mechanical Governor for Diesel Engines

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GAS ENGINE GOVERNOR SYSTEM

The gaseous engines utilize an electronic governor as standard. The governors are microprocessor controlled and have no operator accessible adjustments. The speed is factory set to operate at 60.1 hertz.

13

Troubleshooting

The generator set has a number of sensor units that continuously monitor the engine for abnormal conditions such as low oil pressure or high coolant temperature. If an abnormal condition does occur, the engine monitor will activate a fault lamp and may also stop the engine depending on the condition. If the generator set does shut down, the operator may be able to restart the set after making certain adjustments or corrections. This section describes the operation of the fault condition system and suggested troubleshooting procedures for the operator.

Depending on the model of the generator set, set points, pre-alarms and alarms may vary for oil pressure and coolant temperature. **Note:** These are generator control set points and **not** engine control set points.

Please consult your distributor for exact set point, pre-alarm and alarm values for your specific generator set.

SAFETY CONSIDERATIONS

High voltages are present within the control panel and generator outlet box when the generator is running.

WARNING

Contacting high voltage components can cause serious personal injury or death. Keep control and outlet box covers in place during troubleshooting.

Generator set installations are normally designed for automatic starting or remote starting. When troubleshooting a set that is shut down make certain the generator set cannot be accidentally restarted. Press the OFF button on the controller and remove the negative battery cable from the starting battery. Also, be sure to turn battery charger disconnect off before servicing battery circuits.

WARNING

Accidental starting of the generator set during troubleshooting can cause severe personal injury or death. Disable the generator set before troubleshooting.

When a fault comes on during operation the type of fault will be displayed on the LCD panel. The control panel will also illuminate an indicator light to correspond with the display. The red LED light will indicate fault (shutdown alarm) or the yellow LED pre-alarm (approaching shut down point).

DISPLAY MODE SWITCH

This switch allows the operator to lock the display by moving the switch upward when in the scroll lock mode, the display will not update. By moving the toggle downward the display will show total run time. When the mode switch is in the mid position (normal mode), the display

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will scroll through all parameters. Follow the trouble shooting procedures to locate and correct the problem. For any symptom not listed, contact your Distributor for service. Voltage and amperage may display 3 phases, when operated single phase. The unused positions will display “0”.

RESETTING THE CONTROL

Placing the RUN/OFF/AUTO switch in the OFF position and pressing the alarm silence switch can deactivate the external alarm and fault lamp. Locate the problem and make the necessary corrections before restarting the generator set.

MAIN LINE CIRCUIT BREAKER

The generator output mainline circuit breaker is mounted inside the generator outlet box. If the load exceeds the breaker current rating, the breaker will open to prevent the generator from being overloaded. If the circuit breaker trips, locate the source of the overload and correct as required. Manually reset the breaker to reconnect the load to the generator, by pushing the handle down to the open OFF position, then up to the closed ON position.

WARNING

Many troubleshooting procedures present hazards, which can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review safety precautions on inside cover page.

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SYMPTOM As Indicated on Display Screen	CORRECTIVE ACTION
1. PRE HI ENGINE TEMP. Engine continues to operate.	Indicates engine temperature has risen above the normal operating range, and unit may shut down if corrective action is not taken. If generator is powering non-critical and critical loads and cannot be shut down, use the following: • Reduce load, if possible, by turning off non-critical loads. • Check air inlets and outlets and remove any obstructions to airflow. • Open doors or windows in generator area to increase ventilation. If engine can be stopped, follow procedure in Step 2.
2. HI ENGINE TEMP LED. Engine shuts down.	Indicates engine temperature has exceeded allowable limit or coolant level is low (on sets with coolant level sensor). Allow engine to cool down completely before proceeding with the following checks: • Check coolant level and replenish if low. Look for possible coolant leakage points and repair if necessary. • Check for obstructions to cooling airflow and correct as necessary. • Check for a slipping fan belt and tighten if loose. • Reset control and restart after locating and correcting problem.
3. PRE LOW OIL PRESSURE. Engine continues to operate.	Indicates engine oil pressure has dropped below the normal operating range and unit may shut down if corrective action is not taken. If generator is powering critical loads and cannot be shut down, wait until next shutdown period and then follow Step 4 procedure. If engine can be stopped, follow procedures in Step 4.
4. LOW OIL PRESSURE. Engine shuts down. NOTE: Also see Step 5.	Indicates engine oil pressure has dropped below an acceptable level, and the unit has stopped. Check oil level, lines and filters. If oil system is stable, but oil level is low, replenish. Reset control and restart.

SYMPTOM As Indicated on Display Screen	CORRECTIVE ACTION
5. OVERCRANK. Engine stops cranking. Or Engine runs, shuts down, and LOW OIL PRESSURE.	Indicates possible fuel system problem. • Check for empty fuel tank, fuel leaks, or plugged fuel lines and correct as required. • Check for dirty fuel filter and replace if necessary (See Maintenance section of Engine Manual). • Check for dirty or plugged air filter and replace if necessary (See Maintenance section of Engine Manual). • Refer to Step 4. • Reset the control and restart after correcting the problem. Contact your Dealer or Distributor for service if none of the above.
6. OVERSPEED. Engine runs and then shuts down.	Indicates engine has exceeded normal operating speed. Refer to governor adjust procedure. Contact your Dealer or Distributor for service.
7. UNIT NOT IN AUTO.	Indicates AUTO/OFF/RUN switch is in the OFF position which will prevent automatic starting if an automatic transfer switch is used. Move the AUTO/OFF/RUN switch to the AUTO position for automatic starting.
8. LOW FUEL. Engine continues to run.	Indicates diesel fuel supply is running low. Check fuel supply and replenish as required.
9. LOW FUEL and LOW OIL.	Indicates engine has run out of fuel. Check fuel level and replenish as required. See Engine Manual for fuel system priming procedure.
10. LOW ENGINE TEMPERATURE. Set is in standby mode but not operating.	Indicates engine coolant heater is not operating or is not circulating coolant. Check for the following conditions: • Coolant heater not connected to power supply. Check for blown fuse, open circuit breaker or disconnected heater cord and correct as required. • Check for low coolant level and replenish if required. Look for possible coolant leakage points and repair as required.
11. Engine starts from generator control panel, but will not start automatically or from a remote panel. Note: The AUTO/OFF/RUN switch must be in the AUTO position. Automatic or remote starting.	Indicates possible fault with remote start circuit. Check the following: • Check wire to ATS. • See ATS section for further troubleshooting. • Contact your Dealer or Distributor for assistance.

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SYMPTOM As Indicated on Display Screen	CORRECTIVE ACTION
12. Engine will not crank.	Indicates possible fault with control or starting system. Check for the following conditions: • Fault lamp on. Correct fault and reset control. • Poor battery cable connections. Clean the battery cable terminals and tighten all connections. • Discharged or defective battery. Recharge or replace the battery. • Contact your Dealer or Distributor for assistance if none of the above.
13. No AC output voltage.	Indicates possible fault with voltage regulator. • Verify output with another meter. If OK, check meter. If OK, check meter fuses. • Regulator fuse is blown. Replace fuse. Contact your Dealer or Distributor if voltage build-up causes fuse to blow. • Check rotating rectifier for damaged diodes. Replace all diodes if any are failed.
14. No Engine Start.	Indicates Engine Start wires not terminated properly or Generator in OFF position. • Check Engine Start connections. • Investigate why Engine Control Switch was put in off. • Contact your Dealer or Distributor for assistance.
15. No Engine Stop.	Indicates Timing Cycle not complete, Engine Start wires not terminated correctly or Generator in RUN. • Check Engine Start Timer setting. • Check Engine Start Connections. • Investigate why the Engine Control Switch was put in Manual. • Contact your Dealer or Distributor for assistance.

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SYMPTOM As Indicated on Display Screen	CORRECTIVE ACTION
16. ATS will not transfer to Emergency.	Indicates Emergency voltage or frequency not within acceptable parameters, power supply harness unplugged, limit switch harness unplugged or timing cycle not complete. • Check Engine Start connections, generator output, and engine control switch. • Plug in power supply harness. • Plug in limit switch harness. • Check transfer to emergency timer setting. • Contact your Dealer or Distributor for assistance.
17. ATS will not transfer to Normal.	Indicates Normal voltage or frequency not within acceptable parameters, power supply harness unplugged, limit switch harness unplugged or retransfer to Normal timing cycle not complete. • Check utility and utility breakers. • Plug in power supply harness. • Plug in limit switch harness. • Check retransfer to Normal Timer setting. • Contact your Dealer or Distributor for assistance.

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13 Version History

Indicated below is a summary of the changes that have occurred in the Installation and Basic Operation Manual.

Version	Description of Change
2015-03	Updated **Product Identification Information** section with new nomenclature.
2014-10	Added direction to install overcurrent protection device when needed in **AC Power Output Wiring** section under **Electrical Requirements**.
2014-06	Added metric units to all measurements. Removed Table 6-1 and added Table 7-2 in **Determining Pipe Size for Gaseous Fuel Systems** section.
2014-04	Updated **Starting at Control Panel** section and added **Automatic Operations** section.
2014-02	Corrected table references in **Determining Pipe Size for Gaseous Fuel Systems** section. Previously, Table 6-1 was incorrectly referenced. References were corrected to refer to Table 7-1.
2013-12	Added arc flash safety information to **Hazardous Voltage/External Energy** section.
2013-09	Added tap switch information to **Voltage Selector Tap Switch (Optional)** section.
2013-07	Added statements for proper lifting and mounting to **Lifting Provisions** and **Mounting** sections.
2013-06	Added statements to **Piping** and **AC Power Output Wiring** sections based on UL feedback
2013-01v2	Updated **Exercise Period** section and references to website.
2013-01	Updated to include min./max. testing periods in **Exercise Period** section.
2012-08	Updated graphic by removing reference to Katolight

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GAS GENERATOR SET
MTU 10V0068 GS75

75 kWe / 60 Hz / Standby
208 - 600V

SYSTEM RATINGS

Standby

Voltage (L-L)	240V**	240V**	208V**	240V**	480V**	600V**
Phase	1	1	3	3	3	3
PF	1	1	0.8	0.8	0.8	0.8
Hz	60	60	60	60	60	60
Natural Gas Ratings: Amps	292	292	243	210	105	84
Natural Gas Ratings: kW/kVA	70/70	70/70	70/87.5	70/87.5	70/87.5	70/87.5
LP Gas Ratings: Amps	313	313	260	226	113	90
LP Gas Ratings: kW/kVA	75/75	75/75	75/93.75	75/93.75	75/93.75	75/93.75
skVA@30% Voltage Dip	311	107	216	216	288	235
Generator Model	363CSL1617	431CSL6202	362CSL1604	362CSL1604	362CSL1604	362PSL1635
Temp Rise	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C
Connection	4 LEAD	12 LEAD ZIG-ZAG	12 LEAD LOW WYE	12 LEAD HI DELTA	12 LEAD HI WYE	4 LEAD WYE

** UL 2200 Offered
Note: This unit is available with a dual fuel configuration.

CERTIFICATIONS AND STANDARDS

// **Generator set is designed and manufactured in facilities certified to standards ISO 9001:2008 and ISO 14001:2004**

// **Seismic Certification – Optional**
– IBC Certification
– OSHPD Pre-Approval

// **UL 2200 / CSA – Optional**
– UL 2200 Listed
– CSA Certified

// **Performance Assurance Certification (PAC)**
- Generator Set Tested to ISO 8528-5 for Transient Response
- Verified product design, quality and performance integrity
- All engine systems are prototype and factory tested

// **Power Rating**
- Accepts Rated Load in One Step Per NFPA 110

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STANDARD FEATURES*

- // MTU Onsite Energy is a single source supplier
- // Global Product Support
- // 2 Year Standard Warranty
- // 6.8L Engine
  - 6.8 Liter Displacement
  - 4-Cycle
- // Optional Fuels: LP Liquid and Dual Fuel
- // Engine-generator resilient mounted
- // Complete Range of Accessories
- // Generator
  - Brushless, Rotating Field Generator
  - 2/3 Pitch Windings
  - 300% Short Circuit Capability
- // Digital Control Panel
  - UL Recognized, CSA Certified, NFPA 110
  - Complete System Metering
  - LCD Display
- // Cooling System
  - Integral Set-Mounted
  - Engine-Driven Fan

STANDARD EQUIPMENT*

// Engine

Heavy Duty Air Cleaner
Oil Pump
Oil Drain Extension and S/O Valve
Full Flow Oil Filter
Jacket Water Pump
Thermostat
Blower Fan and Fan Drive
Radiator - Unit Mounted
Electric Starting Motor - 12V
Governor – Electronic Isochronous
Base - Formed Steel
SAE Flywheel and Bell Housing
Charging Alternator - 12V
Battery Rack and Cables
Flexible Exhaust Connection
EPA Certified Engine

// Generator

NEMA MG1, IEEE and ANSI standards compliance for temperature rise and motor starting
Sustained short circuit current of up to 300% of the rated current for up to 10 seconds
Self-Ventilated
Superior Voltage Waveform
Solid State, Volts-per-Hertz Regulator
±1% Voltage Regulation No Load to Full Load Regulation
Brushless Alternator with Brushless Pilot Exciter
4 Pole, Rotating Field
130 °C Max. Standby Temperature Rise
1 Bearing, Sealed
Flexible Coupling
Full Amortisseur Windings
125% Rotor Balancing
3-Phase Voltage Sensing
100% of Rated Load - One Step
5% Max. Total Harmonic Distortion

// Digital Control Panel(s)

Digital Metering
Engine Parameters
Generator Protection Functions
Engine Protection
SAE J1939 Engine ECU Communications
Windows®-Based Software
Multilingual Capability
Remote Communications to RDP-110 Remote Annunciator
Programmable Input and Output Contacts
UL Recognized, CSA Certified, CE Approved
Event Recording
IP 54 Front Panel Rating with Integrated Gasket
NFPA110 Compatible

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* Represents standard product only. Consult Factory/MTU Onsite Energy Distributor for additional configurations.

APPLICATION DATA

// Engine

Manufacturer	Ford
Model	6.8L V10
Type	4-Cycle
Aspiration	Naturally Aspirated
Arrangement	10-V
Displacement: L (in^3)	6.8 (415)
Bore: cm (in)	9 (3.55)
Stroke: cm (in)	10.6 (4.17)
Compression Ratio	9:1
Rated RPM	1,800
Engine Governor	Bosch
Max. Power (NG): kWm (bhp)	85.6 (114.8)
Max. Power (LP): kWm (bhp)	89.4 (119.9)
Speed Regulation	C/F
Air Cleaner	Dry

// Liquid Capacity (Lubrication)

Total Oil System: L (gal)	5.7 (1.5)
Engine Jacket Water Capacity: L (gal)	5.9 (1.55)
System Coolant Capacity: L (gal)	25.58 (6.75)

// Electrical

Electric Volts DC	12
Cold Cranking Amps Under -17.8 °C (0 °F)	925

// Fuel Inlet - Vaporous Supply

Fuel Supply Connection Size	1 1/2" NPT
Fuel Supply Pressure: mm H_2O (in. H_2O)	178–279 (7–11)

// Fuel Inlet - Liquid Supply

Fuel Supply Connection Size	#6 (3/8") Female SAE 45° Flare
Max. Fuel Supply Pressure: kPa (PSI)	2,150 (312)

// Fuel Consumption (NG-1000 BTU/ft^3 / LP-2500 BTU/ft^3)

	NG	LPG
At 100% of Power Rating: m^3/hr (ft^3/hr)	27.2 (960)	11.4 (403)
At 75% of Power Rating: m^3/hr (ft^3/hr)	21.5 (759)	9.3 (328)
At 50% of Power Rating: m^3/hr (ft^3/hr)	15.6 (551)	6.8 (239)

// Cooling - Radiator System

	NG and LPG
Ambient Capacity of Radiator: °C (°F)	50 (122)
Max. Restriction of Cooling Air: Intake and Discharge Side of Rad.: kPa (in. H_2O)	0.12 (0.5)
Water Pump Capacity: L/min (gpm)	123 (32.5)
Heat Rejection to Coolant: kW (BTUM)	78.2 (4,448)
Heat Radiated to Ambient: kW (BTUM)	19.1 (1,086)
Fan Power: kW (hp)	2.8 (3.8)

// Air Requirements

	NG and LPG
Aspirating: *m^3/min (SCFM)	4.54 (160.5)
Air Flow Required for Rad. Cooled Unit: *m^3/min (SCFM)	303.4 (10,715)
Remote Cooled Applications; Air Flow Required for Dissipation of Radiated Generator Set Heat For a Max. of 25 °F Rise: *m^3/min (SCFM)	103 (3,369)

* Air density = 1.184 kg/m^3 (0.0739 lbm/ft^3)

// Exhaust System

	NG and LPG
Gas Temp. (Stack): °C (°F)	660 (1,220)
Gas Volume at Stack Temp: m^3/min (CFM)	15.3 (539)
Max. Allowable Back Pressure: kPa (in. H_2O)	4.98 (20)

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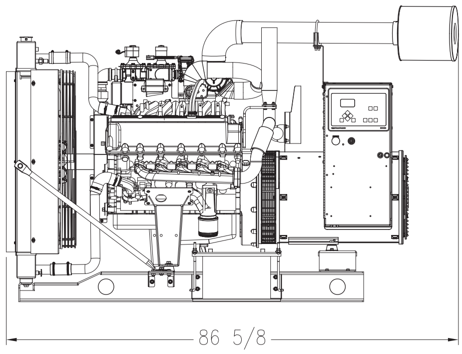
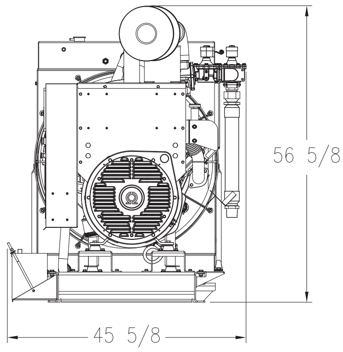
WEIGHTS AND DIMENSIONS





Drawing above for illustration purposes only, based on standard open power 480 volt generator set. Lengths may vary with other voltages. Do not use for installation design. See website for unit specific template drawings.

System	Dimensions (L x W x H)	Weight (dry)
Open Power Unit (OPU)	2,199 x 1,158 x 1,438 mm (86.6 x 45.6 x 56.6 in)	1,125 kg (2,481 lb)

Weights and dimensions are based on open power units and are estimates only. Consult the factory for accurate weights and dimensions for your specific generator set.

SOUND DATA

Unit Type	Standby Full Load (NG)	Standby Full Load (LP)
Level 0: Open Power Unit dB(A)	75.5	76.1

Sound data is provided at 7 m (23 ft). Generator set tested in accordance with ISO 8528-10 and with infinite exhaust.

EMISSIONS DATA

Fuel Type	THC + NO_x	CO
Natural Gas	7.53	30.49
Liquid Propane	7.65	47.95

All units are in g/hp-hr and are EPA weighted cycle values. Emission levels of the engine may vary with ambient temperature, barometric pressure, humidity, fuel type and quality, installation parameters, measuring instrumentation, etc. The data was obtained in compliance with US EPA regulations.

RATING DEFINITIONS AND CONDITIONS

- // Standby ratings apply to installations served by a reliable utility source. The standby rating is applicable to varying loads for the duration of a power outage. No overload capability for this rating. Ratings are in accordance with ISO 3046-1, BS 5514, and AS 2789. Average load factor: ≤ 85%.
- // Deration Factor:
  Altitude: Consult your local MTU Onsite Energy Power Generation Distributor for altitude derations.
  Temperature: Consult your local MTU Onsite Energy Power Generation Distributor for temperature derations.

C/F = Consult Factory/MTU Onsite Energy Distributor
N/A = Not Available

Ford 6.8L Engine

Operation and Maintenance Manual

WSG-1068/T/TA

Table of Contents

Preface

This Operation and Maintenance Manual provides general instructions for operating the Ford 6.8L engine properly. It is essential that every person who works on or with the engine be completely familiar with the contents of this manual and that he/she carefully follows the instructions contained herein. Each operation and maintenance may require some modification of the suggested guidelines in this manual. They must be consistent with locally applicable standards and take into consideration safety guidelines and measures.

Carefully follow all procedures and safety precautions to ensure proper equipment operation and to avoid bodily injury. All instructions and diagrams have been checked for accuracy and simplicity of application, however, the skills of the operator are most important. MTU Onsite Energy does not guarantee the result of any operation contained in this manual nor can MTU Onsite Energy assume responsibility for any injury or damage to property. Persons engaging in operating do so entirely at their own risk.

Specifications

General Specifications	
Engine Type	V-10 4 stroke spark ignition 90 degree overhead valve (OHV) chain driven camshaft operating the valves via roller cam followers and hydraulic lash adjusters
Liter / CID	6.8 / 415
Bore: mm (in)	90.215 (3.55)
Stroke: mm (in)	105.8 (4.17)
Number of Cylinders	10
Compression Ratio	9:1

Fuel System	
LPG **Type** **Fuel Specifications**	Liquified Petroleum Gas Fumigation EN 589 (European) HD-5 (USA)
NG **Type** **Fuel Specifications**	Natural Gas Fumigation 38.7 MJ / m3 (UK) 39.0 MJ / m3 (USA)

Lubrication System	
Max. Oil Pressure	Hot @ 1800 RPM: 275.79 – 413.69 kPa (40-60 PSI)
Oil Type	Motorcraft SAE 5W30 Full Synthetic WSS M2C930-A
Service Oil Fill Capacity (Including Filter)	5.68 L (6 qt) = 5.5 qt pan + 0.5 qt filter

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Oil Filter	MTU Onsite Energy Part Number: 120105

Cooling System	
Thermostat	Type: Wax Element Commences Opening: 85 °C (185 °F) Fully open: 99 °C (210 °F)
Coolant	50% Motorcraft Premium Engine Coolant Plus 50% Distilled Water Ford Specification WSS M97B44-D or ESE-M97B44-A

Drive Belt	
Alternator Belt Length Tension: mm (in)	6 Groove: 1,618 (63.7)

Electrical System	
Polarity	Negative to Earth (ground)
Alternator Drive Belt Tension	Tension is within specification if the tensioner is within the indicator markings
Alternator Output	95 Amp @ 3,400 RPM

Ignition	
Spark Plug	Naturally Aspirated: Dedicated LPG & NG – Motorcraft AGSF-22F-M1 Gap: 1.12 mm (0.044 in.) Turbocharged: Dedicated LPG & NG – Motorcraft AGSF-22F-M1 Gap: 0.89 mm (0.035 in.)
Firing Order	1-6-5-10-2-7-3-8-4-9

Tightening Torques			
Item	**Nm**	**ft lb**	**lb in**
Oil Pan Drain Plug	20 – 34	15 – 25	98 – 143
Spark Plugs	8 – 12	7 – 15	71 – 106
Oil Filter	14 – 17	11 – 12	-
Coil Hold Down Bolts	5 – 7	-	44 – 62

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Electrical System

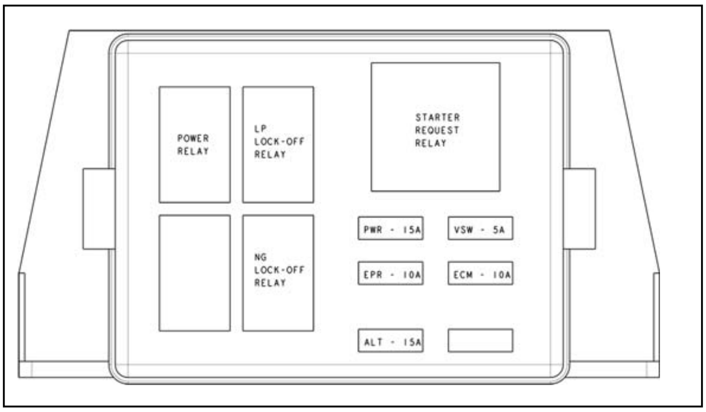

Figure 1: Fuse Box

Fuse	Amps	Circuits Protected
PWR	15A	Main Power
VSW	5A	Switched, Ignition Voltage
EPR	10A	Electronic Pressure Regulator
ECM	10A	Engine Control Module
ALT	15A	Alternator
Blank	-	Not Used

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Ignition System

The Ford 6.8L engine is equipped with a coil-on-plug ignition system. Rather than a remotely-mounted coil with secondary ignition wires, this system has separate coils mounted on each spark plug. Operation of the coils is controlled by the engine control module (ECM), which computes ignition timing based on input from engine sensors.

Alternator

The alternator is mounted on a bracket at the front of the engine and is driven from the crankshaft by a serpentine belt.

The charging rate is adjusted automatically by the built-in regulator to provide sufficient electric current to keep the battery charged under normal operating conditions.

The alternator requires no lubrication or maintenance.

WARNING: It is essential that the wiring connections to the alternator are not removed while the engine is running, as this will result in damage to the regulator or personal injury.

Fluids and Lubricants Specifications

The importance of correct lubrication, periodic inspection and adjustment cannot be over emphasized. It will determine, to a very large extent, the service the engine will give. Detailed instructions regarding this maintenance are provided in the *Maintenance* section of this document.

Fuel Recommendation

This engine is designed to operate on dry fuel such as LPG Grade HD5 or NG (1,050 BTU/ft^3).

CAUTION: Use of fuels lower than the grade specified above may cause persistent, heavy spark knock, which can lead to engine damage. If your engine knocks heavily or you hear continuous spark knock while maintaining constant operating speeds, consult your distributor or another qualified engine technician.

Recommended Lubricants

SAE 5W30 oil is recommended for all applications and temperatures.

CAUTION: Use Ford / Motorcraft formula “E” SAE 5W30 synthetic engine oil or equivalent that meets Ford specification WSS-M2C930-A (API Classification – SJ). If SJ oils are not available, SH oils are acceptable. Use only engine oil displaying the American Petroleum Institute Certification Mark on the front of the container or API specification SH or SJ.

CAUTION: Do not use supplemental oil additives or other engine treatments. They are unnecessary and could, under certain conditions, lead to engine damage which is not covered by warranty.

Lubricating oil cleanliness is vital for successful operation of your engine. The oil should be stored under the cleanest possible conditions. When changing or topping up engine oil, use only clean receptacles. Do not allow the oil to come in contact with rubber hoses on the engine.

NOTE: Ford engines are designed to perform with synthetic oils that are licensed by the American Petroleum Institute (API) and oils carrying the most current API classification should be used. API classifications are broken into two categories, gasoline and diesel engines. API’s classification is designed by a two letter system. The first letter, the prefix, designates gasoline or diesel. An “S” designates gasoline and a “C” designates diesel. The second letter in the system designates the level of the classification. It should be noted that alternative fuel engines fall into the “gasoline” API category.

The Ford 6.8L engine must use oils labeled SH and / or SJ. Do not use oils that are specifically formulated for diesel engines only. CC or CD classification oils, even when labeled Heavy Duty or for Natural Gas Engines, are not acceptable.

Maintenance

The following Maintenance Schedule provides the maximum recommended service periods. Since operating conditions can vary, it may be advisable to carry out some operations, for example changing the engine oil, at an interim period. Your operating experience is the best guide for determining this time.

When carrying out any of the following maintenance operations, any fault or malfunction should be reported immediately to the supervisor or person responsible for engine overhaul or repair.

Please contact your authorized MTU Onsite Energy Distributor for regular maintenance assistance.

Maintenance Schedule Preface

Emission regulations prohibit alteration, removal or addition of any mechanical or electronic component or calibration that could affect the emissions characteristics of the engine. Maintenance, replacement, or repair of emission control devices and systems can only be performed using approved components or equivalents. Failure to adhere to these guidelines may be a violation of the Clean Air Act.

Maintenance Schedules ensure the reliability and performance of the engine and must be adhered to during the full life of the engine.

The maintenance system is based on a preventive maintenance concept. Preventive maintenance facilitates advance planning and ensures a high level of equipment availability.

Special operating conditions and technical requirements may require additional maintenance work and/or modification of the maintenance intervals. In order to be authorized to carry out the individual maintenance jobs, maintenance personnel must be appropriately trained to perform the task at hand.

The maintenance schedule matrix normally finishes with extended component maintenance. Following this, maintenance work is to be continued at the intervals indicated.

Notes on maintenance

Specifications for fluids and lubricants, guideline values for their maintenance and change intervals and lists of recommended fluids and lubricants are contained in the *Fluids and Lubricants Specifications*.

Amongst other items, the operator/customer must carry out the following additional maintenance work:

- Protect components made of rubber or synthetic material from oil. Never treat them with organic detergents. Wipe with a dry cloth only.
- Battery maintenance depends on the level of use and the ambient conditions. The battery manufacturer's instructions must be obeyed.

Out-of-service periods

If the engine-generator set is to remain out of service for more than one month, carry out engine preservation procedures in accordance with the *Preservation Guidelines* in this document.

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Maintenance Tasks

Below is a table that outlines maintenance tasks that need to be performed in the first 3,000 operating hours.

Interval [h]	Limit	Item	Maintenance tasks
Engine operation			
Daily	1 m	Engine operation	Check engine oil level. Carry out visual inspection of engine for general condition and leaks.
-	2 a	Engine oil filter	Fit new engine oil filters each time the engine oil is changed or, at the latest, on expiry of the time limit (given in years).
First 50, then every 100	1 a	Engine oil	Change engine oil.
500	2 a	Fuel strainer	Clean or replace fuel strainer.
200	3 a	Belt drive	Check belt condition and tension. Fit new belts(s) if necessary.
400	5 a	Air filters	Fit new air filters.
400	5 a	Spark plugs	Clean, adjust and replace spark plugs.
800	5 a	PCV Valve	Replace PCV valve.
800	5 a	PCV hoses, tubes and fittings	Clean PCV hoses, tubes and fittings.
Cooling system			
500	6 m	Radiator	Check cooler elements externally for contamination and leaks.
Daily 100	3 m	Engine coolant	Check engine coolant level and top up if necessary with correct mixture.
-	1 a	Radiator cap	Clean radiator cap. Pressure test and replace if needed.
w = weeks m = months a = years			

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Task Description

Cooling System

Inspect the exterior of the radiator. Remove all obstructions and foreign material.

Check all hoses and connections for leaks. If any of the hoses are cracked, frayed or feel spongy, they should be replaced.

CAUTION: Never use a cold coolant mixture to top up the radiator of a hot engine if the coolant level is very low, this could cause serious damage.

The radiator is equipped with a pressure cap. It is dangerous to remove this when the system is very hot.

WARNING: Never remove the pressure relief cap while the engine is operating or when the cooling system is hot. This may cause personal injury or damage to the cooling system or engine. To reduce the risk of having scalding hot coolant or steam blow out of the top radiator tank when removing the pressure relief cap, wait until the engine has cooled down to at least 40 °C (110 °F).

1. Wrap a thick cloth around the pressure relief cap and turn it slowly one half turn counter clockwise, stepping back while the pressure is released from the cooling system.
2. When you are sure all the pressure has been released, (still with the cloth) turn counter clockwise and remove the pressure relief cap.

The coolant should consist of a 50 / 50 mixture of plain water and approved antifreeze. This antifreeze contains additional corrosion inhibitors designed to provide lasting protection for the engine.

Only this antifreeze or proprietary antifreeze meeting Ford specifications WSS-M97B44-D or Ford specification ESE-M97B44-A should be used when topping up or refilling the cooling system.

NOTE: If a major component of the cooling system is replaced such as the radiator, water pump, etc., the system should be flushed and refilled with a 50 / 50 mixture of distilled water and approved antifreeze.

WARNING: Antifreeze contains monoethylene glycol and other constituents which are toxic if taken internally and can be absorbed in toxic amounts on repeated or prolonged skin contact persons using antifreeze are recommended to adhere to the following precautions:

- Antifreeze must never be taken internally. If antifreeze is swallowed accidentally, medical advice should be sought immediately.
- Precautions should be taken to avoid skin contact with antifreeze. In the event of accidental spillage onto the skin, antifreeze should be washed off as soon as possible. If clothing is splashed with antifreeze, it should be removed and washed before being worn again to avoid prolonged contact with the skin.
- For regular and frequent handling of antifreeze, protective clothing (plastic or rubber gloves, boots and impervious overalls or aprons) must be used to minimize skin contact.

Draining, Flushing and Filling the Cooling System

WARNING: Never remove the pressure relief cap while the engine is operating or the cooling system is hot. This may cause personal injury or damage to the cooling system or engine. To reduce the risk of having scalding hot coolant or steam blow out of the de-gas bottle, when removing the pressure relief cap, wait until the engine has cooled down to at least 40 °C (110 °F).

-

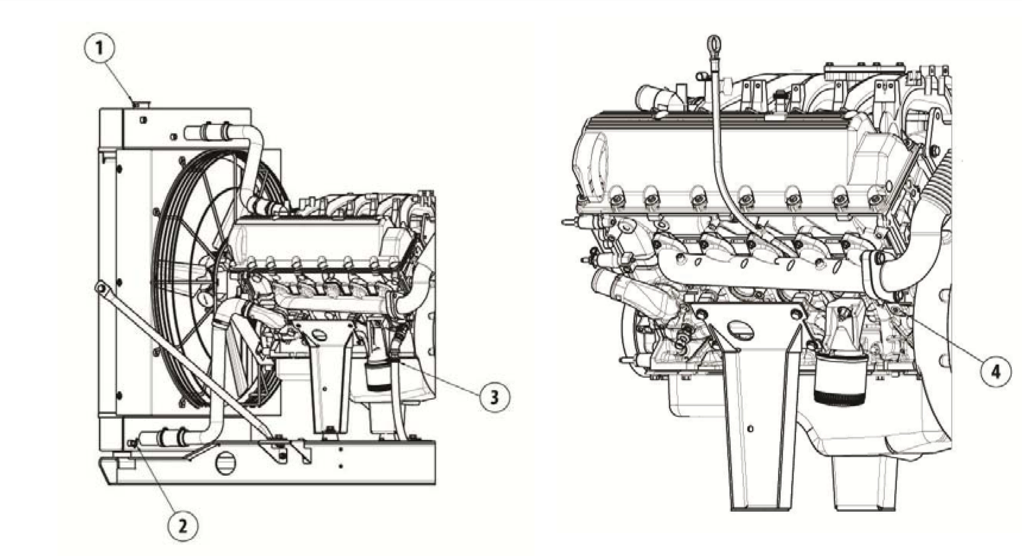

Figure 2: Cooling System

1. Wrap a thick cloth around the pressure relief cap (1) and turn it slowly one half turn counter clockwise. Stepping back while the pressure is released from the cooling system.
2. When the pressure has been completely released, (still with the cloth) turn counter clockwise and remove the pressure relief cap.
3. Remove the radiator filler cap and open the radiator drain cock (2) or detach the lower radiator hose. Remove water heater hose (3) or drain plug (4).
4. Flush the cooling system with water using a hose, until clean water emerges and allow all water to drain out. Close the drain cock (or replace the bottom of the radiator hose). Recover all old antifreeze and dispose of properly. Contact your local municipal government for proper disposal.
5. Fill the system with the correct coolant mixture via the radiator filler neck. Fill the system slowly to avoid air locks.
6. Run engine and check hose connections for leaks. Check and if necessary, top off the coolant in the radiator.

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Check Engine Coolant Level

WARNING: To reduce the risk of injury when checking a hot engine, cover the radiator cap with a thick cloth and turn it slowly to the first stop. After the pressure has been completely released, press downward and finish removing the cap. Failure to follow these instructions could cause damage to the cooling system or engine and / or personal injury.

CAUTION: Do not add coolant to an engine that has become overheated until the engine cools. Adding coolant to an extremely hot engine could result in a cracked block or cylinder head.

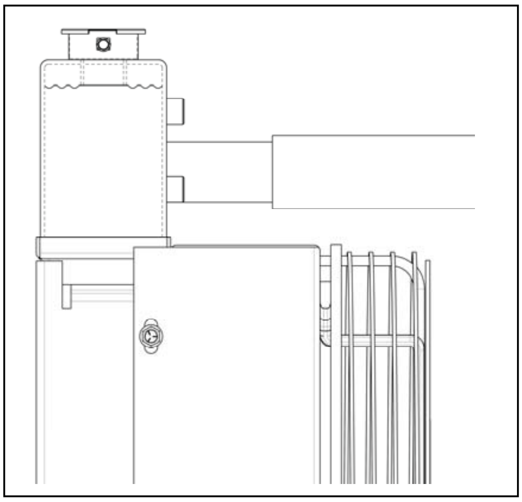

Figure 3: Coolant Level

NOTE: This cooling system does not require an external reservoir. An expansion chamber is designed into the top tank of the radiator.

1. Allow engine to cool down to 40 °C (110 °F).
2. Turn the radiator filler cap 90 degrees in a counter clockwise direction. Pause to allow any pressure to drop, then turn cap fully counter clockwise and remove it.
3. Top up as necessary with a 50 / 50 mixture of distilled water and antifreeze meeting spec WSS-M97B44-D or ESE-M97B44-A.

   NOTE: It is imperative that only the correct type of antifreeze is used.
4. Replace the filler cap and turn down tightly.

Replace Engine Oil Filter

The Ford 6.8L engine is equipped with a Motorcraft oil filter. A filter of this quality should be used throughout the life of the engine. It is designed to protect your engine by filtering harmful, abrasive and sludgy particles without clogging up or blocking the flow of oil to vital engine parts. This filter is especially designed for use in engines built by Ford to give successful operation with the recommended oil filter change intervals. Contact your MTU Onsite Energy Distributor to obtain the correct filter. Before commencing, place a drain pan below the filter to catch any spilled oil.

1. Using a suitable strap wrench, unscrew the oil filter canister.
2. Thoroughly clean the oil filter housing face.
3. Partly fill the new filter with clean engine oil of the correct type and grade. Apply a thin film of clean engine oil to the oil filter sealing ring.
4. Screw on new filter canister until sealing ring contacts the filter head and tighten a further half turn. Do NOT use a strap wrench or similar tool to tighten the oil filter.
5. Run engine and check for any leaks from oil filter.
6. Stop engine and allow oil to settle and top off as necessary.

Replace Spark Plugs

WARNING: The ignition system commonly carries voltages in excess of 30,000 volts. Please use caution.

CAUTION: Do not pull directly on the lead as this could cause the wire connection inside the boot to become separated.

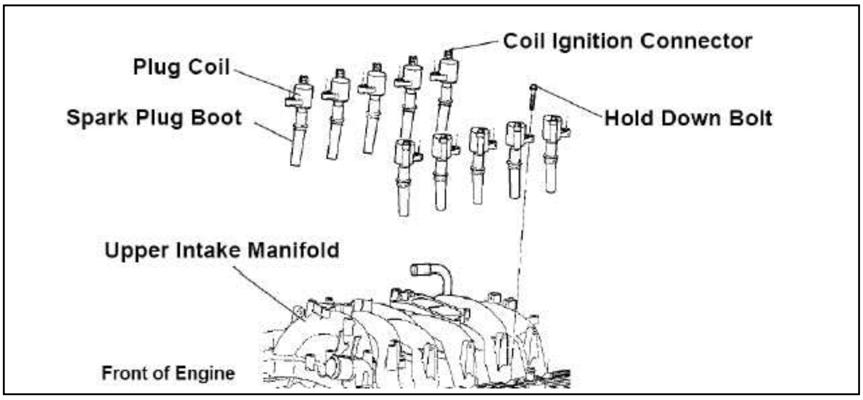

Figure 4: Ignition System

NOTE: To remove spark plugs, you must first remove coils.

1. Disconnect the ignition coil wire connectors.
2. Remove hold down screw, then the coil.
3. After loosening each spark plug one or two turns with a proper spark plug spanner, clean the area around each spark plug port with compressed air then remove the spark plugs.

   WARNING: Protective goggles must be worn to protect the eyes when using compressed air.
4. Check the gaps of the new spark plugs with a feeler gauge and, where necessary, bend the outer ground extension to achieve the specified gap.
5. Use a proper spark plug spanner to avoid damaging the insulators. Screw the new spark plugs into the cylinder head and tighten them to the specified torque value listed under specification of this manual.

   NOTE: Do not over tighten spark plugs as the gap may change considerably due to distortion of the plug's outer shell.
6. Coat the inside of each spark plug boot with silicone dielectric compound, using a small screwdriver blade.
7. Install the plug coils and tighten the hold down bolt to 5-7Nm (44-62 in-lb).

   NOTE: Coils are interchangeable.
8. Reconnect ignition coil wire connectors.

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Check Condition of Ancillary Drive Belt

WARNING: Engine should be stopped and any remote starter disabled before checking belts.

The serpentine ancillary belt used to drive the generator and water pump is tensioned automatically and does not require adjustment.

Ancillary Drive Belt Inspection

1. Remove belt guard, if necessary.
2. Visually inspect the condition of the ancillary drive belt for signs of wear or damage, such as:
    a. Singular cracks
    b. Cracks on entire surface
    c. Chunking

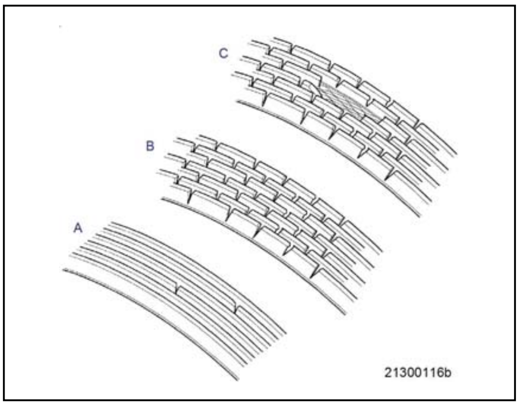

Figure 5: Ancillary Drive Belt Conditions

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Ancillary Drive Belt Replacement

1. Remove belt guard (1), if necessary.
2. Relieve spring tension (2) on the belt tensioner using a ½ inch ratchet.
3. Remove ancillary drive belt (3).
4. Install new ancillary drive belt.
5. Reinstall belt guard, if necessary.

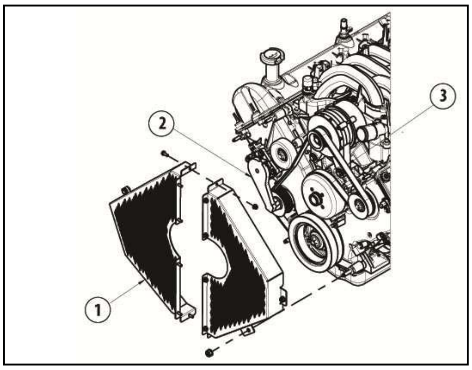

Figure 6: Ignition System

NOTE: May be purchased from your authorized MTU Onsite Energy Distributor.

PCV Replacement

NOTE: This maintenance is not necessary to keep the emissions warranty valid.

1. Detach hose (1) and oil separator (2) (if present) from the PCV valve (3) located at the top rear of the right valve cover and from the fuel mixer.
2. Detach hose (4) from the top of the left valve cover and from the fuel mixer.
3. Withdraw the PCV valve from the valve cover grommet (5) by rotating the PCV valve counter clockwise 90 degrees.
4. Discard the PCV valve and the O-ring (6).
5. Thoroughly clean the inside and outside of the hose and oil separator (if present).
6. Insert the new PCV valve, complete with a new O-ring.
7. Reconnect the hoses and oil separator (if present) to the PCV valve and to the fuel mixer.

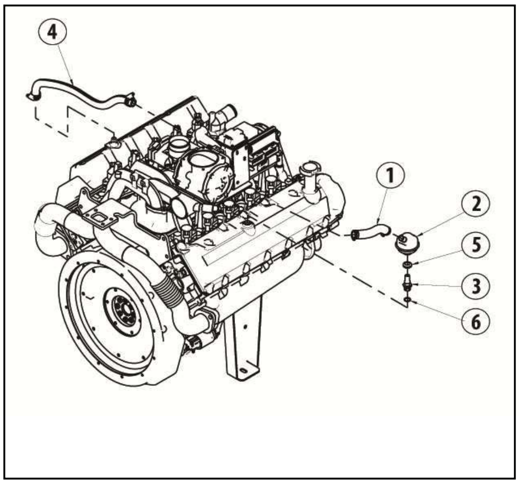

Figure 7: PCV System

NOTE: Graphic represents turbocharged engines only.

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Preservation Guidelines

Storage – One Month

1. While the engine is running, treat upper cylinders by spraying engine fogging agent into the air intake for two minutes. Shut off engine and allow it to come to a stop while continuing to spray into the air intake.
2. Leave spark plugs in holes or seal spark plug holes with suitable threaded metal plugs and cover all openings into engine with dust proof caps or shields (suitable non-hygroscopic material).
3. Check coolant protection. Store indoors in a dry area.

Storage – Indefinite Period

1. Run engine and treat upper cylinders by spraying engine fogging agent into the air intake for two minutes. Shut off engine and allow it to come to a stop while continuing to spray into the air intake.
2. Drain crankcase completely and refill with recommended engine oil.
3. Check coolant protection.
4. Disconnect and remove battery.
5. Clean exterior surface of engine.
6. Leave spark plugs in holes or seal spark plug holes with suitable threaded metal plugs.
7. Seal all openings in engine and accessories with non-hygroscopic material. Mask off all areas to be used for electrical contact.
8. Coat or spray non-painted parts with corrosion inhibitor for external preservation.

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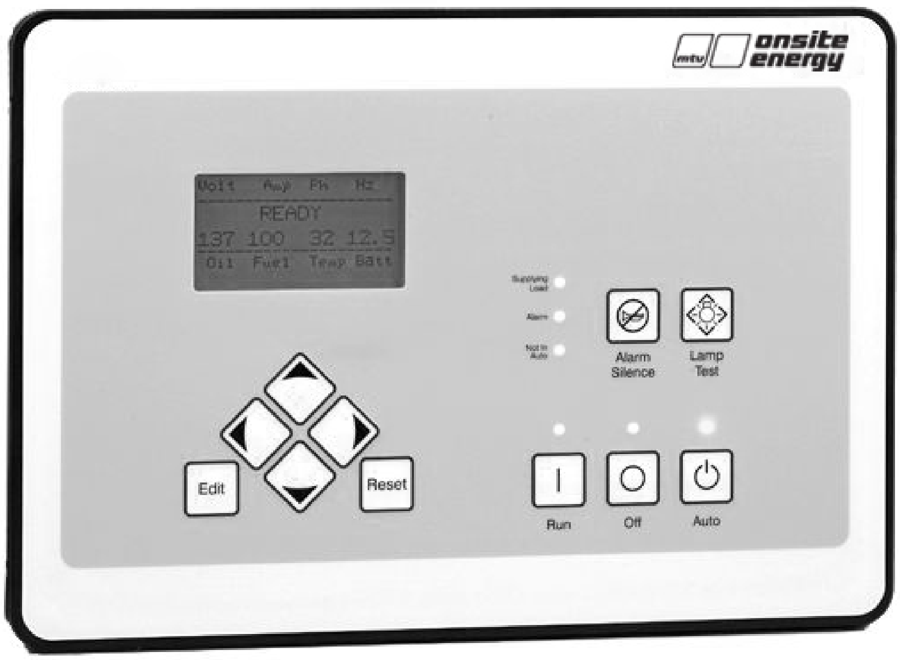
INSTRUCTION MANUAL

FOR

DIGITAL GENSET CONTROLLER
MGC-2000 SERIES



TIM-ID: 0000099917 - 001

Publication: 9400200990
Revision: X Oct-14

TIM-ID: 0000099917 - 001

INTRODUCTION

This instruction manual provides information about the operation and installation of the MGC-2000 Series Digital Genset Controller. To accomplish this, the following information is provided:

- General Information and Specifications
- Controls and Indicators
- Functional Description
- Graphical User Interface Operation
- Installation
- Setup
- Maintenance and Troubleshooting
- LSM-2020 (Load Share Module)
- CEM-2020 (Contact Expansion Module)
- AEM-2020 (Analog Expansion Module)
- Time Overcurrent Characteristic Curves
- Modbus™ Communication
- PID Tuning Settings
- MTU Fault Codes

WARNING!

To avoid personal injury or equipment damage, only qualified personnel should perform the procedures in this manual.

NOTES

MGC-2000 Series controllers are mounted using the four permanently-attached 10-24 studs and the provided self-locking nuts. Failure to use the proper 10-24 locking nuts may damage the stud threads and/or improperly secure the MGC-2000 Series.

Be sure that the controller is hard-wired to earth ground with no smaller than 12 AWG copper wire attached to the chassis ground terminal on the rear of the unit. When the controller is configured in a system with other devices, it is recommended to use a separate lead to the ground bus from each unit.

The MGC-2000 Series utilizes password protection that guards against unauthorized changing of MGC-2000 Series settings. Instructions for changing passwords are provided in Section 4, *BESTCOMSPlus® Software, General Settings, Device Security Setup.* The default passwords are listed below.

- OEM access level: **OEM**
- Settings access level: **SET**
- Operator access level: **OP**

BOX DEFINITIONS

WARNING!

A warning box indicates a potentially hazardous situation which could result in death or injury.

CAUTION

A caution box indicates a potentially hazardous situation which could result in equipment or property damage.

NOTE

A note box provides helpful information.

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It is not the intention of this manual to cover all details and variations in equipment, nor does this manual provide data for every possible contingency regarding installation or operation. The availability and design of all features and options are subject to modification without notice. Should further information be required, contact Basler Electric.

For terms of service relating to this product and software, contact MTU Onsite Energy.

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TIM-ID: 0000099917 - 001

REVISION HISTORY

The following information provides a historical summary of the changes made to this instruction manual (9400200990), BESTCOMS*Plus*® software, firmware package, and hardware of the MGC-2000 Series.

Manual Revision and Date	Change
X, 10/14	• Revised to support firmware package version 1.19.00 (see firmware package version history) and BESTCOMS*Plus* version 3.07.00 (see BESTCOMS*Plus* revision history). • Added *Diagnostics* under *Metering Explorer* in Section 4. • Added *Offline Logic Simulator* in Section 5. • Improvements to Appendix C, *Tuning PID Settings*. • Replaced several BESTCOMS*Plus* screenshots where the layout changed throughout manual. • Minor text edits throughout manual.
W, 04/14	• Added German and Portuguese language support. • Added DGC-2000 legacy Modbus option and register table. • Added Breaker configuration one-line diagram (front panel only) and mains fail transfer status screen. • Increased unique recorded events to 50 from 30.
V, 03/14	• Added features of DGC-2020 hardware version 3. • Added Windows 8 compatibility and updated system recommendations for BESTCOMS*Plus* and .NET framework. • Expansion modules (AEM-2020, CEM-2020, and LSM-2020) now have gold-plated communication terminals for increased signal integrity. • Removed product registration information. • Added EMC wiring requirements for the LSM-2020 BATT and GOV terminals. • Minor text edits. • This revision was released in English language only.
U, 03/13	• Revised to support firmware package version 1.17.02 (see firmware package version history). • Added new breaker hardware and mains fail transfer settings • Minor text edits
T, 01/13	• Revised to support firmware package version 1.17.00 (see firmware package version history).
S, 05/12	• Revised to support firmware package version 1.15.00 (see firmware package version history). • Enhanced description of DTCs (diagnostic trouble codes). • Added Tables 3-5 *DTCs Displayed by the DGC-2020 (FMI Strings)* and 3-6 *DTCs Displayed by the DGC-2020*. • Removed *Setup* from *Section 6 • Installation*, and created separate *Section 7 • Setup*. • Added *Appendix E • EXHAUST TREATMENT.*
R, 10/11	• Added Disclaimer of Liability and Warranty in *Introduction*.
Q	• This revision letter not used.

Manual Revision and Date	Change
P, 08/11	• Revised to support firmware package version 1.13.04 (see firmware package version history) and BESTCOMS*Plus* version 2.10.02 (see BESTCOMS*Plus* version history). • Added LCD Heater specifications in Section 1. • Added Analog Input Burden data in Section 10. • Updated *Activation of DGC-2020 Plugin for BESTCOMSPlus* and *Communication* in Section 4. • Improved Figure 8-9, *Typical LSM-2020 Interconnection Diagram*.
O	• This revision letter not used.
N, 04/10	• Revised to support firmware package version 1.10.00 (see firmware package version history) and BESTCOMS*Plus* version 2.07.01 (see BESTCOMS*Plus* version history). • Changed Battery Backup for Real-Time Clock to a standard feature. • Added Table 3-3, *J1939 Data Transmitted from the DGC-2020.* • Added Table 4-2, *Generator Parameter Transmit*.
M, 11/09	• Section 1: Under *Specifications, Metering, Power Factor,* changed calculation method from "PF = P (3-phase average) / S (3-phase average)" to "PF = Cosine of the Angle between Phase AB voltage (Vab) and Phase A current (Ia)". • Added "Diagnostics" to Figure 2-2, *Metering Screen Branches*. • Section 3: Updated MTU Fault Code list. • Added description for Logic Control Relays in Table 5-1. • Updated cutout dimensions in Figure 6-1, *Panel Cutting and Drilling Dimensions.* • Section 6: Added *Setting Up DGC-2020 Programmable Inputs and Outputs, Synchronizer,* and *Setting up a DGC-2020 and LSM-2020 for a Load Sharing and kW Control Application.* • Section 10: Added Maximum Consumption under *Specifications, Operating Power.* • Appendix B: Improved description for registers 40020, 43750, and 45754.

TIM-ID: 0000099917 - 001

Manual Revision and Date	Change
L, 05/09	• Added information for CEM-2020H in Section 9. • Added CSA Certification in Sections 1 (DGC-2020), 8 (LSM-2020), 9 (CEM-2020), and 10 (AEM-2020). • Added DGC-2020 Setup in Section 6, *Installation.* • Added description of special strings displayed (NC, SF, NS, NA, UF) under *DGC-2020 Function Blocks, Communication Ports, CANbus* in Section 3. • Improved procedure for upgrading firmware in Section 4. • Expanded explanation of configurable elements in Section 4. • Added "P" (programmable) curves for overcurrent protection in Section 4. • Added Figure 4-51, *Synchronizer Screen,* and re-numbered remaining figures. • Clarified low-line scale factor on Bus Condition Detection and Pre-Alarms in Section 4. • Added "1/2 watt" for resistor in #1 in NOTE box for CANbus in Sections 1, 6, 8, 9, and 10. • In Figure 8-7, corrected LSM-2020 terminal numbering for AVR & GOV inputs. • Added Figure 8-9, additional method for interfacing an external control device with a DGC-2020 - LSM-2020 system. • Added "P" curve to Tables A-1 and A-2 in Appendix A, *Time Overcurrent Curves.* • Corrected bit numbering for registers 44812 through 45572 and added missing bits in Appendix B, *Modbus Communication.* • Added registers 44936 through 44946, 44982, and 44984 in Appendix B, *Modbus Communication.*
K, 01/09	• Updated manual to support firmware package 1.08.01 changes and BESTCOMS*Plus* version 2.03.00 changes. (See firmware package and BESTCOMS*Plus* revision history below for details.) • Removed duplicate Speed Controller Tuning Procedure from Appendix C. • In Appendix B, added additional information for registers 40436 - 40476.
J, 08/08	• Added Section 10, *AEM-2020 (Analog Expansion Module).* • Added information for Automatic Generator Detection in Section 4. • Improved CAN bus diagrams and notes throughout manual. • Added information for Integrating Reset function in Section 4. • Added information for Configurable Protection in Section 4. • Improved definition of Emergency Stop Input in Section 6. • Added installation diagrams for MTU MDEC ECU in Section 6. • Added Typical LSM-2020 Interconnection Diagram in Section 8. • Enhanced Section 7, *Maintenance and Troubleshooting.* • Added *Synchronizer Operation* under *Breaker Management* in Section 3. • Improved *Communication* in Section 4. • Added Bits 6 through 10 to register 44822 in Appendix B. • Added Appendix C, *Tuning PID Settings.*
I, 07/08	• Changed Output Contacts 13 through 24 rating from 2 Adc to 1 Adc. • Changed Output Contacts 25 through 36 rating from 10 Adc to 4 Adc.
H, 02/08	• Added Section 9, *CEM-2020 (Contact Expansion Module).*
G, 11/07	• Added Section 8, *LSM-2020 (Load Share Module).* • Updated HMI screens layout in Section 2. • Added BESTCOMS*Plus* Multigen Management screens.

Manual Revision and Date	Change
F, 08/07	• Updated manual to support firmware package 1.02.00 changes and BESTCOMS*Plus* version 1.03.00 changes. (See firmware package and BESTCOMS*Plus* revision history below for details.)
E, 05/07	• Added description of *Clock Setup* screen in BESTCOMS*Plus*. • Updated several BESTCOMS*Plus* screen shots. • Increased Low Coolant Temp Pre-Alarm range to 30 - 150°F.
D, 03/07	• Removed International Modem option from *Style Chart* in Section 1. • Added coverage of part numbers 9400200105 and 9400200106.
C, 02/07	• Added *Event Recording* in Section 3, *Functional Description.* • Minor text edits throughout manual.
B, 11/06	• Initial release

BESTCOMS*Plus*® Version and Date	Change
3.07.00, 10/14	• Updated to support firmware package 1.19.00 (see firmware package version history). • Added Load Share and Control Diagnostics screens. • Changed to allow the Metering Status screen to open before a connection is made. • Removed duplicate results in the device discovery list. • Improvements to device directory on Connection screen. • Changed how the LSM-2020 model number is reported on the Device Info screen. • Changed to allow a comma in the Device ID. • Changed to annunciate a connection failure message when a device is not present on a selected port. • Improved prompts to save settings when choosing to close all open views. • Changed to hide security settings for the LSM-2020 when opening a settings file. • Changed to allow the middle mouse button to close the security view. • Improved display of raw analog input currents. • Changed to make BESTlogic*Plus* status LEDs report all logic errors.
3.06.00, 04/14	• Maintenance release (BE1-11 changes)
3.05.03, 03/14	• Maintenance release (DECS-250N changes)
3.05.02, 01/14	• Updated to support firmware package 1.18.00 (see firmware package version history).
3.04.01. 10/13	• Maintenance release (BE1-11 changes)
3.04.00, 08/13	• Maintenance release (BE1-11 changes)
3.03.03, 06/13	• Maintenance release (BE1-11 changes)
3.03.00, 03/13	• Updated to support firmware package 1.17.02 (see firmware package version history). • Added breaker hardware settings. • Added new mains fail transfer screen.
3.02.00, 01/13	• Updated to support firmware package 1.17.00 (see firmware package version history). • Added Windows® 8 compatibility. • Increased number of logic gates per level from 10 to 20.
3.01.01, 11/12	• Maintenance release (DECS-250 changes)

BESTCOMS*Plus*® Version and Date	Change
3.00.02, 09/12	• Maintenance release (BE1-11 changes)
2.14.00, 07/12	• Maintenance release (BE1-11 changes)
2.13.01, 05/12	• Updated to support firmware package 1.15.00 (see firmware package version history).
2.13.00, 04/12	• Changes invisible to the user.
2.11.02, 12/11	• Added a *Cancel* button on the *Rated Data* dialog. • Added the ability to disable settings download after reconnect or initial connect on the *Advanced Properties* dialog in the *DGC-2020 Connection* screen. • Improved workspace files.
2.11.01, 11/11	• Changed Manual Regeneration setting to use a button instead of a drop-down menu on the *ECU Setup* screen. • Enhanced settings file printout.
2.10.02, 06/11	• Updated to support firmware package version 1.13.04 (see firmware package version history). • Settings for generator protection, battery voltage protection, and configurable protection can now be entered in secondary or per unit values. • Added the ability to set IP Address of LSM-2020 through device discovery. • Added the ability to select what data to view/export from the Preview Metering and Export Metering buttons. • Added the ability to save workspace. • Added the ability to auto reconnect when connection is lost. • Added the ability to close multiple views. • Enhanced BESTlogic™*Plus*.
2.08.01, 10/10	• Improved off-page logic.
2.08.00, 08/10	• Updated to support firmware package version 1.11.00 (see firmware package version history).
2.07.03, 06/10	• Changes invisible to the user.
2.07.01, 03/10	• Updated to support firmware package version 1.10.00 (see firmware package version history). • Added *Export Metering*. • Added Windows® 7 64-bit compatibility and removed Windows 2000 compatibility.
2.06.02, 01/10	• Changes invisible to the user.
2.06.01, 12/09	• Added *Total Engine Run Time Minutes* on *Engine* and *Summary* screens in the Metering Explorer. • BESTCOMS*Plus* shell enhancements. • Added Windows 7 32-bit compatibility.
2.05.00, 07/09	• Made a correction to announce a message that logic will not be saved if the maximum number of logic gates on any one level has been exceeded. • On the *Breaker Management, Breaker Hardware* screen, changed the Gen and Mains Breaker Closing Time from 0.1-600 in increments of 0.1 to 0-800 in increments of 5. • Corrected Settings Compare error when there are remote outputs or logic control relay outputs in the logic diagram.
2.04.01, 05/09	• Changes invisible to the user.

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BESTCOMS*Plus*® Version and Date	Change
2.03.01, 02/09	• Added "P" (programmable) curve selection for the 51 function. • Improvement to allow spaces in Initializing Message 1 & 2 on *General Settings, Front Panel HMI* screen in the Settings Explorer. • Improved backwards compatibility. • Improved Commission Date setting on *Run Statistics* screen in the Metering Explorer.
2.03.00, 12/08	• Added support for CEM-2020H. • Added Export to File feature. • Added settings for Phase Toggle and Initializing Messages on *General Settings, Front Panel HMI* screen. • Re-arranged *CANbus Setup* screen and added *ECU Setup* screen under *Communications*. • Added settings for 51-3 element under *Generator Protection, Current.* • Added setting for Off Mode Cooldown on *System Parameters, System Settings* screen. • Added *Remote Module Setup* screen under *System Parameters.* • Added *Remote LSM Inputs* settings and metering screens under *Programmable Inputs.* • Added settings to *Bias Control* screens for Var/PF control. • Added kvar A, B, C, and Total to *Power* and *Summary* metering screens. • Re-arranged MTU metering screens. • Added *MTU Status* screen and *MTU Engine Status* screen. • Added BESTlogic*Plus* Input Objects for Configurable Elements, Configurable Protection, Front Panel Buttons, PF Mode Active, Pre Start Input, and Run Input. • Added BESTlogic*Plus* Pre-Alarms for Checksum Fail and CEM Hardware Mismatch. • Added BESTlogic*Plus* Elements for 51-3, COOLSTOPREQ, COOLDOWNREQ, EXTSTARTDEL, PRESTARTOUT, RUNOUTPUT, STARTDELBYP, and STARTOUTPUT. • Added Relay Control settings on *System Parameters, System Settings* screen.
2.02.01, 10/08	• Maintenance release (BE1-11 changes)
2.01.00, 05/08	• Added settings for AEM-2020. • Added settings for Automatic Generator Protection. • Added settings for Integrating Reset on 51 function. • Added settings for Configurable Protection.
2.00.01, 03/08	• Added settings for CEM-2020.
1.04.01, 11/07	• Added settings for LSM-2020.
1.03.00, 08/07	• Added/Updated screens to support firmware package version 1.03.00. (See firmware package version history for details.) • Added password protection for portions of the programmable logic. • Made all status LEDs available as inputs for PLC logic.
1.02.00, 05/07	• Added Spanish language support. • Added *Clock Setup* screen. • Changed layout of several screens.
1.01.02, 04/07	• Removed International Modem option from Style Chart.
1.01.01, 02/07	• Added Chinese language support.
1.00.07, 11/06	• Initial release

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Firmware Package Version and Date	Change
1.19.00, 10/14	• Modified Voltage Trim function to support paralleling of reconfigurable machines. • Added MTU Speed Demand Switch setting from logic capability. • Added a rest timer for cyclic cranking. • Added Mains Fail Return Fail pre-alarm and Mains Fail Max Return Time setting. • Added a deadband setting for speed trim and voltage trim. • Added Parallel to Mains Gain Factor for mains parallel operation. • Added System kW Generation in percent to Gen Status screen and configurable protection. • Added System Total Capacity on Generator Network Status screen. • Added DPF Outlet Gas Temperature to J1939 metering and configurable protection. • Added John Deere to list of ECU configurations. • Added AEM thermal protection settings to Modbus. • Changed DEF EMPTY pre-alarm to DEF LOW SEVERE. • Changed DEF ENGINE DERATE pre-alarm to DEF INDUCEMENT. • Added descriptive text for Diagnostic Trouble Codes (DTC's) broadcast by Mercedes, PSI, and MTU-ECU9 engine ECU's. • Added ECU9 Fault Code list for MTU.
1.18.02, 04/14	• Added German and Portuguese language support. • Added DGC-2000 legacy Modbus option. • Added Breaker configuration one-line diagram and mains fail transfer status screen to front panel. • Increased unique recorded events to 50 from 30.
1.17.07, 05/13	• Minor firmware improvements
1.17.02, 03/13	• Added new breaker hardware and mains fail transfer settings. • Improved breaker hardware, synch check, and mains fail logic. • Added a logic element which allows the EPS Supplying Load front panel LED to be driven via logic. • Improved event log processing rate. • Improved CAN transmit processing rate. • Added single-phase AC bus sensing configuration option. • Corrected battle override function preventing engine shut-off in rare cases. • Corrected DTCs not clearing when receiving a “no active” DTC frame. • Corrected frequency settings reverting to 60 Hz on startup for 400 Hz units.

Firmware Package Version and Date	Change
1.17.00, 01/13	• Added French language support. • Increased the number of gates per logic level to 20. • Allow Grounded Delta Override to be effective regardless of configured generator connection. • Increased the number of logic latches to 10. • Added phase rotation checks and pre-alarms. • Remote speed trim bias adjustable from analog input. • Added speed bias range in units of percent. • Added sequencing status display. • Added Ethernet kW and kvar sharing. • Phase Imbalance (47) disables in single-phase mode. • Improved response during Modbus writes. • Increased available configurable protection parameters. • Added system status display. • Modified breaker reset function so that breakers are only reset if *locked out*, *sync failed*, or *failed to open*. • Added a setting to breaker fail pre-alarm to be active on *transitions only* or *always*. • Modified sequencing to operate correctly when units are operating due to external ATS. • Corrected handling of Combined Code Red Alarm on ECU7/ECU8 engines. • Modified speed raise/lower so no change occurs if both conditions are true. • Corrected potential settings loss in weak battery and emergency stop scenarios.
1.15.00, 06/12	• Added Russian language support. • Added Auto Breaker Operation Inhibit, Mains Fail Transfer Inhibit, and Closed Transition Override logic elements. • Added Restart Delay setting. • Added SPN Conversion Method • Increased Max on Weak Battery and Low Battery Pre-alarms. 14 V for 12 V systems and 28 V for 24 V systems. • Added DPF Soot Level Pre-Alarms • Added DEF Fluid Level and Inducement Pre-Alarms • Added Unexpected Shutdown Alarm • Added function which disables the front panel buttons *Run*, *Off*, and *Auto* when logic elements *Run Mode*, *Off Mode*, and *Auto Mode* are set true. • Added 4 logic elements which override control of 4 LEDs on the RDP-110.
1.13.08, 11/11	• Made Diesel Particulate Filter Regeneration Request momentary. • Minor firmware improvements.

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Firmware Package Version and Date	Change
1.13.04, 07/11	• Enhanced configurable protection. • Enhanced synchronizer. • Enhanced J1939. • Added Q parameter to 51 programmable curve equation. • Added Sequenced System Startup logic element. • Added Low Fuel logic element. • Added Last Unit Shutdown enable/disable setting for generator sequencing. • Added the ability to set IP Address of LSM-2020 through the front panel. • Added governor load sharing over J1939. • Improved detection of Intergenset Communications failures.
1.11.02, 11/10	• Improved time dials for fixed time curves of the 51 function.
1.11.00, 08/10	• Changed synchronizer slip frequency to have minimum slip rate of 0.01 in increments of 0.01. • Added pre-alarms logic for Mains Fail Transfer Fail, Gen Breaker Sync Fail, Gen Breaker Fail to Close, Gen Breaker Fail to Open, Mains Breaker Sync Fail, Mains Breaker Fail to Close, and Mains Breaker Fail to Open. • Added status logic for Mains Fail Transfer Complete and Unloading State.
1.10.00, 03/10	• Added Loss of Mains Protection (78 Vector Shift and 81 ROCOF). • Added Dead Bus Breaker Close Arbitration. • Added GM and Cummins as settings for ECU type. • Added CAN settings for MTU 50/60 Hz Switch, NMT Alive Transmit Rate, Generator Parameter Transmit, and Diesel Particulate Filter. • Added Modem Setup through the Front Panel HMI. • Added settings for Clock Not Set Warning, Gen CT Low Line Scale Factor, Horn Enable, Not in Auto Horn Enable, Low Line Scale Factor for 47 function, Alternate Frequency Scale Factors, Alternate Frequency, Metric Pressure Units, and Dead Gen Close Enable. • Added logic for Idle Request, Alternate Frequency Override, Mains Fail Test, Load Take Over, Alarm Silence, Lamp Test, Generator Protection, DPF Regeneration Disabled, DPF Regeneration Required, and High Exhaust Temperature. • Added ranges for hours and minutes of Logic Timers. • Moved Engine Cooldown, Horn, Single-Phase Override, Auto Config Detection, and Relay Control for organizational purposes.
1.09.00, 07/09	• Corrected transmittal of parameters to engine for MDEC module types 201, 302, and 303. • Implemented most recent MTU fault codes. • Engine Total Run Time in metering now displays hours and minutes. Engine Total Run Time previously displayed hours only. • Added front panel diagnostics to show Modbus Read Count, Modbus Write Count, and Serial Flash Write Count. • Modbus™ legacy registers 40019 and 40020 are now read/write. Previously these registers were write only. • Improved MCS5 parameter handling. • Fixed spurious High Charge Air Temp Pre-Alarm every time engine starts on MTU-ECU7 machines. • Accelerator pedal position is now sent to Volvo ECU for load sharing. • Modified generator breaker logic to allow closure of generator breaker from a dead gen to a dead bus (if Dead Bus Close Enable is selected). In previous versions of firmware, closure of the generator breaker from a dead generator was not possible.

Firmware Package Version and Date	Change
1.08.01, 01/09	• Added support for CEM-2020H. • Changed time dial range of 51 element fixed time curve from 0-30 s to 0-7,200 s. • Added Phase Toggle Delay setting for front panel HMI. • Added Off Mode Cooldown feature. • Added 51-3 element. • Added Var/PF control. • Added LSM Input settings. • Added Checksum Fail and CEM Hardware Mismatch pre-alarms. • Added kvar A, B, C, and Total metering. • Added several MTU items to metering. • Re-arranged *CANbus Setup* screens and added *ECU Setup* screens on front panel HMI. • Added "P" (programmable) curve selection for the 51 function.
1.07.02, 09/08	• Finalized settings for AEM-2020.
1.06.00, 07/08	• Added settings for AEM-2020. • Added settings for Automatic Generator Detection. • Added settings for Integrating Reset on 51 function. • Added settings for Configurable Protection.
1.05.00, 04/08	• Added settings for CEM-2020.
1.04.00, 12/07	• Added settings for LSM-2020.
1.03.00, 08/07	• Added 32 and 40Q protection functions. • Added Automatic Restart function and Exercise Timer. • Added dual settings for 51, 27, and 59 functions. • Added Oil Pressure Crank Disconnect Enable. • Modified Prestart operation during rest cycle. • Added 2 additional Engine kW Overload Pre-Alarms. • Added Low Line Scale Factor for EPS Supplying Load and Engine kW Overload Pre-Alarms. • Changed the metering range of coolant temperature to 32-410 F. • Changed the Low-Coolant Temp Pre-Alarm range to 32-150 F.
1.02.00, 05/07	• Added Spanish language support.
1.00.08, 03/07	• Minor firmware improvements.
1.00.07, 01/07	• Added Chinese language support.
1.00.06, 11/06	• Initial release

DGC-2020 Hardware Revision and Date	Change
AK, 10/14	• Released firmware package 1.19.00 and BESTCOMS*Plus* 3.07.00.
AJ, 07/14	• Updated internal documentation.
AH, 04/14	• Released firmware package 1.18.02.
AG, 04/14	• Updated internal documentation.
AF, 11/13	• Improved membrane venting to prevent moisture accumulation in LCD window.
AE, 11/13	• Released DGC-2020 rev 3 hardware: Three-phase bus sensing capability, RS-232 port, enhanced microprocessor for expanded programmable logic, greatly increased mini-B USB transfer rate • Expanded panel cutout dimensions for easier fit.

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DGC-2020 Hardware Revision and Date	Change
AD, 07/13	• Improved LCD heater cable routing.
AC, 06/13	• Upgraded injection mold tool.
AB, 05/13	• Released firmware package 1.17.07
AA, 03/13	• Released firmware package 1.17.02 and BESTCOMS*Plus* 3.03.00
Z, 01/13	• Released firmware package 1.17.00 and BESTCOMS*Plus* 3.02.00.
Y, 06/12	• Released firmware package 1.15.00 and BESTCOMS*Plus* 2.13.01.
X, 06/12	• Changed PCB to enhance product.
W, 09/11	• Released firmware package 1.13.04 and BESTCOMS*Plus* 2.10.02.
V, 02/11	• Released firmware package 1.11.02.
U, 04/10	• Released firmware package 1.10.00 and BESTCOMS*Plus* 2.07.01.
T, 01/10	• Improved panel gasket.
S, 10/09	• Improved transient protection.
R, 07/09	• Added ribbon cable slot for front overlay to prevent cable damage.
P, 01/09	• Released firmware package 1.08.01 and BESTCOMS*Plus* 2.03.00.
N, 09/08	• Released firmware package 1.07.02.
M, 07/08	• Released firmware package 1.06.00 and BESTCOMS*Plus* 2.01.00.
L, 04/08	• Released firmware package 1.05.00 and BESTCOMS*Plus* 2.00.01.
K, 01/08	• Added definition of emergency stop input terminals.
J, 12/07	• Released firmware package 1.04.00 and BESTCOMS*Plus* 1.04.01.
H, 12/07	• Switched LCD heater types for manufacturability.
G, 08/07	• Released firmware package 1.03.00 and BESTCOMS*Plus* 1.03.00.
F, 04/07	• Released BESTCOMS*Plus* 1.02.00.
E, 03/07	• Released firmware 1.00.08 and changed LCD heater.
D, 02/07	• LCD heater and battery holder made as a standard feature.
C, 01/07	• Deleted, added, or changed components to enhance product.
B, 11/06	• Initial release

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DETAILED FIRMWARE RELEASE HISTORY

Pkg. File Ver.	Digital Genset Controller (DGC-2020) Application Code Version & P/N	Digital Genset Controller (DGC-2020) Flash Language Module Version & P/N	Flash Language Module Lang.*	Load Share Module (LSM-2020) CANBus App. Version & P/N	Load Share Module (LSM-2020) Ethernet App. Version & P/N	Contact Expansion Module (CEM-2020/H) Version & P/N	Analog Expansion Module (AEM-2020) Version & P/N
1.19.00	3.18.00 10/16/14 9400209013/-14 2.18.00 10/16/14 9400206035/-36 1.18.00 10/16/14 9400201087/-88	5.06.00 9/18/14 9400201089	C,E,F, G,P,R, S	1.04.00 08/20/14 9417501031	1.04.00 08/20/14 9417501032	1.01.04 02/14/13 9421001014	1.00.05 02/14/13 9421103002
1.18.02	3.17.02 04/25/14 9400209011/-12 2.17.02 04/25/14 9400206033/-34 1.17.02 04/25/14 9400201085/-86	5.05.01 02/04/14 9400201081	C,E,F, G,P,R, S	1.03.02 10/28/13 9417501029	1.03.02 10/28/13 9417501030	1.01.04 02/14/13 9421001014	1.00.05 02/14/13 9421103002
1.17.07	3.16.07 05/09/13 9400209009/-010 2.16.07 05/09/13 9400206029/-030 1.16.07 05/09/13 9400201082/-083	5.04.03 05/08/13 9400201084	C,E,F R,S	1.03.01 03/15/13 9417501024	1.03.01 03/15/13 9417501025	1.01.04 02/14/13 9421001014	1.00.05 02/14/13 9421103002
1.17.02	3.16.02 03/13/13 9400209005/-006 2.16.02 03/13/13 9400206022/-023 1.16.02 03/13/13 9400201076/-077	5.04.01 02/20/13 9400201078	C,E,F R,S	1.03.01 03/13/13 9417501024	1.03.01 03/13/13 9417501025	1.01.04 02/14/13 9421001014	1.00.05 02/14/13 9421103002
1.17.00	3.16.00 11/16/12 9400209002/-03 2.16.00 11/16/12 9400206015/-016 1.16.00 11/16/12 9400201070/-071	5.04.00 11/16/12 9400201072	C,E,F R,S	1.03.00 11/07/12 9417501022	1.03.00 11/07/12 9417501023	1.01.03 03/29/12 9421001013	1.00.04 03/29/12 9421103001

Pkg. File Ver.	Digital Genset Controller (DGC-2020)			Load Share Module (LSM-2020)		Contact Expansion Module (CEM-2020/H)	Analog Expansion Module (AEM-2020)
	Application Code	Flash Language Module		CANBus App.	Ethernet App.		
	Version & P/N	Version & P/N	Lang.*	Version & P/N	Version & P/N	Version & P/N	Version & P/N
1.15.00	2.14.00 08/13/12 9400206009/-010 1.14.00 08/13/12 9400201065/-066	5.02.00 06/18/12 9400201064	C,E, R,S	1.02.05 06/12/12 9417501020	1.02.05 06/12/12 9417501021	1.01.03 03/29/12 9421001013	1.00.04 03/29/12 9421103001
1.13.08	2.12.08 11/10/11 9400206003/-004 1.12.08 11/10/11 9400201058/-059	4.06.05 11/04/11 9400201060	C,E,S	1.02.03 07/21/11 9417501016	1.02.03 07/21/11 9417501017	1.01.02 06/06/11 9421001012	1.00.03 06/06/11 9421101012
1.13.04	2.12.04 07/01/11 9400206001/-002 1.12.04 07/01/11 9400201051/-054	4.06.03 07/01/11 9400201055	C,E,S	1.02.03 07/21/11 9417501016	1.02.03 07/21/10 9417501017	1.01.02 06/06/11 9421001012	1.00.03 06/06/11 9421101012
1.11.02	1.10.00 07/09/10 9400201046/-052	4.04.01 11/24/10 9400201053	C,E,S	1.01.00 02/04/10 9417501014	1.01.00 02/04/10 9417501015	1.01.00 12/09/08 9421001009	1.00.01 12/09/08 9421101009
1.11.00	1.10.00 07/09/10 9400201046/-047	4.04.00 08/02/10 9400201048	C,E,S	1.01.00 02/04/10 9417501014	1.01.00 02/04/10 9417501015	1.01.00 12/09/08 9421001009	1.00.01 12/09/08 9421101009
1.10.00	1.09.00 03/05/10 9400201043/-044	4.03.00 03/05/10 9400201045	C,E,S	1.01.00 02/04/10 9417501014	1.01.00 02/04/10 9417501015	1.01.00 12/09/08 9421001009	1.00.01 12/09/08 9421101009
1.09.00	1.08.00 06/24/09 9400201039/-040	4.02.00 06/24/09 9400201041	C,E,S	1.00.05 12/09/08 9417501012	1.00.05 12/09/08 9417501013	1.01.00 12/09/08 9421001009	1.00.01 12/09/08 9421101009
1.08.01	1.07.01 01/14/09 9400201036/-035	4.00.01 01/14/09 9400201037	C,E,S	1.00.05 12/09/08 9417501012	1.00.05 12/09/08 9417501013	1.01.00 12/09/08 9421001009	1.00.01 12/09/08 9421101009
1.07.02	1.06.01 07/5/08 9400201030	3.00.03 07/16/08 9400201031	C,E,S	1.00.04 07/22/08 9417501010	1.00.04 07/22/08 9417501011	1.00.03 07/22/08 9421001007	1.00.00 07/22/08 9421101007
1.06.00	1.05.00 05/19/08 9400201028	3.00.00 05/19/08 9400201029	C,E,S	1.00.03 05/19/08 9417501008	1.00.03 05/19/08 9417501009	1.00.01 05/19/08 9421001005	N/A
1.05.00	1.04.00 01/15/08 9400201025	2.03.00 01/15/08 9400201026	C,E,S	1.00.02 01/02/08 9417501006	1.00.02 01/02/08 9417501007	1.00.00 01/02/08 9421001004	N/A
1.04.00	1.03.00 11/21/07 9400201022	2.01.00 11/15/07 9400201023	C,E,S	1.00.00 11/21/07 9417501005	1.00.00 11/21/07 9417501004	N/A	N/A
1.03.00	1.02.00 08/14/07 9400201020	2.01.00 08/09/07 9400201021	C,E,S	N/A	N/A	N/A	N/A

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Pkg. File Ver.	Digital Genset Controller (DGC-2020)			Load Share Module (LSM-2020)		Contact Expansion Module	Analog Expansion Module
	Application Code	Flash Language Module		CANBus App.	Ethernet App.	(CEM-2020/H)	(AEM-2020)
	Version & P/N	Version & P/N	Lang.*	Version & P/N	Version & P/N	Version & P/N	Version & P/N
1.02.00	1.01.00 05/02/07 9400201016	2.00.00 05/01/07 9400201017	C,E,S	N/A	N/A	N/A	N/A
N/A	1.00.08 9400201015	1.00.00/1.00.00 9400201011/-012	C,E	N/A	N/A	N/A	N/A
N/A	1.00.07 9400201013	1.00.00/1.00.00 9400201011/-012	C,E	N/A	N/A	N/A	N/A
N/A	1.00.06 9400201008	N/A	N/A	N/A	N/A	N/A	N/A

* C = Chinese, E = English, F = French, G = German, P = Portuguese, R = Russian, S = Spanish
Note: For firmware upgrade procedure, refer to Section 4, *BESTCOMSPlus® Software.*

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SECTION 1 • GENERAL INFORMATION

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SECTION 1 • GENERAL INFORMATION

Description

The MGC-2000 Series Digital Genset Controller provides integrated engine-genset control, protection, and metering in a single package. Microprocessor based technology allows for exact measurement, setpoint adjustment, and timing functions. Front panel controls and indicators enable quick and simple MGC-2000 Series operation. Basler Electric communication software (BESTCOMS*Plus*®) allows units to be easily customized for each application. Because of the low sensing burden in the MGC-2000 Series, dedicated potential transformers (PTs) are not required. A wide temperature-range liquid crystal display (LCD) with backlighting can be viewed under a wide range of ambient light and temperature conditions.

Hardware Versions

This instruction manual covers all hardware versions of the MGC-2000 Series. Differences between hardware versions are listed in *Table 1-1* below, and noted throughout this publication where applicable.

Table 1-1. MGC-2000 Series Hardware Version Differences

Feature	Versions 1 and 2∗	Version 3
Three-phase bus sensing	Single-phase bus sensing only	Available
Optional RS-232 port for communication with external modem	Optional RJ-11 jack for internal modem communication only	Available

∗Versions 1 and 2 are no longer available for ordering.

Identifying MGC-2000 Series Version

MGC-2000 Series version information can be found through the front-panel interface and via connection to a PC running BESTCOMS*Plus* software.

Version information is displayed on the front panel LCD immediately after applying operating power and on the *Version Info* screen. To view the *Version Info* screen, navigate to Settings > General Settings > Version Info > DGC-2020 > Firmware version. The firmware version number consists of five digits. The first digit is the hardware version number. Refer to *Section 2, Controls and Indicators* for information on using the front panel.

In BESTCOMS*Plus,* the MGC-2000 Series hardware version is found on the *Device Info* screen. Connect to the MGC-2000 Series and download settings and logic. Using the *Settings Explorer*, open *General Settings*, *Device Info*. The hardware version of the MGC-2000 Series is shown in the *Application Version* field. The application version number consists of five digits. The first digit is the hardware version number. Refer to *Section 4, BESTCOMSPlus Software* for details on installing and using BESTCOMS*Plus*.

Features

MGC-2000 Series Digital Genset Controllers have the following features:

- Local and Remote Generator Control
- Engine, Generator, and Loss of Mains Protection
- Automatic Transfer Switch Control (Mains Failure)
- Automatic Generator Configuration Detection
- Generator Sequencing
- Generator Soft Loading/Unloading
- Auto Synchronizing
- Programmable Analog Engine Senders
- 16 Programmable Contact Inputs
- Programmable Logic
- Exercise Timer
- ECU Communications via SAE J1939
- Marathon DVR2000E+ Voltage Regulator Control via SAE J1939
- Integrated RS485 communication (optional)
- Dial-Out Modem communication (optional)
- Additional modules available to expand the capabilities of the MGC-2000 Series

Functions

MGC-2000 Series Digital Genset Controllers perform the following functions:

Generator Protection and Metering

Multifunction generator protection guards against generator overvoltage, undervoltage, reverse power, loss of excitation, underfrequency, and overfrequency. Overcurrent, phase imbalance, and loss of mains protection are available as an option. Each generator protection function has an adjustable pickup and time delay setting. Sixteen inverse time curves enable the MGC-2000 Series to offer overcurrent protection in a variety of applications.

Metered generator parameters include voltage, current, real power (watts), apparent power (VA), and power factor (PF).

Engine Protection and Metering

Engine protection features include oil pressure and coolant temperature monitoring, overcrank protection, ECU specific protection elements, and diagnostic reporting.

Metered engine parameters include oil pressure, coolant temperature, battery voltage, speed, fuel level, engine load, coolant level (from ECU), ECU specific parameters, and run-time statistics.

Event Recording

An event log retains a history of system events in nonvolatile memory. Up to 30 event types are retained and each record contains a time stamp of the first and last occurrence, and the number of occurrences for each event. For more information, see Section 3, *Functional Description, Event Recording.*

Auto-Synchronizer

An optional automatic synchronizer monitors the bus and generator voltages and supplies discrete raise/lower correction signals to synchronize the generator voltage, frequency, and slip angle with that of the bus.

Contact Inputs and Output Contacts

MGC-2000 Series controllers have one, dedicated emergency stop contact input and 16 programmable contact inputs. All contact inputs recognize dry contacts. The programmable inputs can be configured to initiate a pre-alarm or alarm. A programmable input can be programmed to receive an input from an automatic transfer switch or override MGC-2000 Series alarms and protection functions. Each programmable input can be assigned a user-defined name for easy identification at the front panel display and in fault records.

Output contacts include three dedicated relays for energizing an engine's glow plugs, fuel solenoid, and starter solenoid. An additional four user-programmable output contacts are provided if the style number is xxAxxxxxx. If the style number is xxBxxxxxx, an additional twelve output contacts are provided.

Additional contact inputs and output contacts can be accommodated with an optional CEM-2020 (Contact Expansion Module). Contact Basler Electric for ordering information.

Automatic Transfer Switch Control (Mains Failure)

The MGC-2000 Series has the ability to detect a mains failure via a single- or three-phase Bus input. A mains failure is established when any one of the following conditions are met:

- Any phase of bus voltage falls below dead bus threshold
- Any phase of bus voltage unstable due to overvoltage or undervoltage
- Any phase of bus voltage unstable due to overfrequency or underfrequency

At this time, the MGC-2000 Series will start the genset and when ready, apply power to the load via the genset. The MGC-2000 Series implements open or closed transitions to and from the mains. When the mains returns and is considered stable, the MGC-2000 Series will transfer the load back to the mains. When closed transitions are required, the Auto Synchronizer option of the MGC-2000 Series is required in order to synchronize the generator to the mains when transferring a load from generator power to utility power.

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Communication

Standard MGC-2000 Series communication features include a standard USB port and SAE J1939 interface. Optional communication features include an RS-232 port for connection with an external dial-out modem and RS-485 communication port. BESTCOMS*Plus*® can communicate with the MGC-2000 Series through Ethernet via an optional LSM-2020 (Load Share Module). Contact MTU Onsite Energy for ordering information.

USB Port

A USB communication port can be used with BESTCOMS*Plus*® software to quickly configure an MGC-2000 Series with the desired settings or retrieve metering values and event log records.

CAN Bus Interface

A CAN bus interface provides high-speed communication between the MGC-2000 Series and the engine control unit (ECU) on an electronically controlled engine. This interface provides access to oil pressure, coolant temperature, and engine speed data by reading these parameters directly from the ECU. When available, engine diagnostic data can also be accessed.

The CAN bus interface also provides communication between the MGC-2000 Series and the Marathon DVR2000E+ voltage regulator. Voltage setpoint and underfrequency knee-point settings can be sent directly to the DVR2000E+ from the MGC-2000 Series.

The CAN bus interface supports the following protocols:

- SAE J1939 Protocol - Oil pressure, coolant temperature, and engine speed data are received from the ECU. In addition, DTCs (Diagnostic Trouble Codes) help diagnose any engine or related failures. The engine DTCs are displayed on the front panel of the MGC-2000 Series and may be obtained using BESTCOMS*Plus*® software.
- MTU Protocol - An MGC-2000 Series connected to a genset equipped with an MTU engine ECU receives Oil pressure, coolant temperature, and engine speed data from the engine controller, along with various alarms and pre-alarms that are MTU specific. In addition, the MGC-2000 Series tracks and displays the active fault codes issued by the MTU engine ECU.

External Dial-Out Modem Port

An optional RS-232 communication port uses the ASCII protocol to communicate with a user-supplied external modem. The optional external dial-out modem enables remote control, monitoring, and setting of the MGC-2000 Series. When an alarm or pre-alarm condition occurs, the MGC-2000 Series can dial up to four telephone numbers, in sequence, until an answer is received and the condition is annunciated.

RS-485 Port

An optional RS-485 communication port uses the Modbus™ communication protocol and enables remote control and monitoring of the MGC-2000 Series over a polled network.

AEM-2020 (Analog Expansion Module)

The optional AEM-2020 provides eight remote analog inputs, eight remote RTD inputs, two remote thermocouple inputs, and four remote analog outputs to the MGC-2000 Series. The AEM-2020 communicates with the MGC-2000 Series through a CAN bus interface. Refer to Section 11, *AEM-2020 (Analog Expansion Module),* for more information.

CEM-2020 (Contact Expansion Module)

The optional CEM-2020 provides 10 additional contact inputs and 18 or 24 additional output contacts (depending on module type) to the MGC-2000 Series. The CEM-2020 communicates with the MGC-2000 Series through a CAN bus interface. Refer to Section 10, *CEM-2020 (Contact Expansion Module),* for more information.

LSM-2020 (Load Share Module)

The optional LSM-2020 in conjunction with the MGC-2000 Series provides load sharing between governors through an analog load share line. The LSM-2020 communicates through an Ethernet port and provides access to the MGC-2000 Series via Ethernet. Refer to Section 9, *LSM-2020 (Load Share Module),* for more information.

Style Number

Standard-order MGC-2000 Series controllers are identified by a style number which consists of a combination of letters and numbers that define the controller's electrical characteristics and operational features. The model number, together with the style number, describes the options included in a specific controller. Figure 1-1 illustrates the MGC-2000 Series style number identification chart for hardware version 3. Figure 1-2 illustrates the MGC-2000 Series style number identification chart for hardware versions 1 and 2.

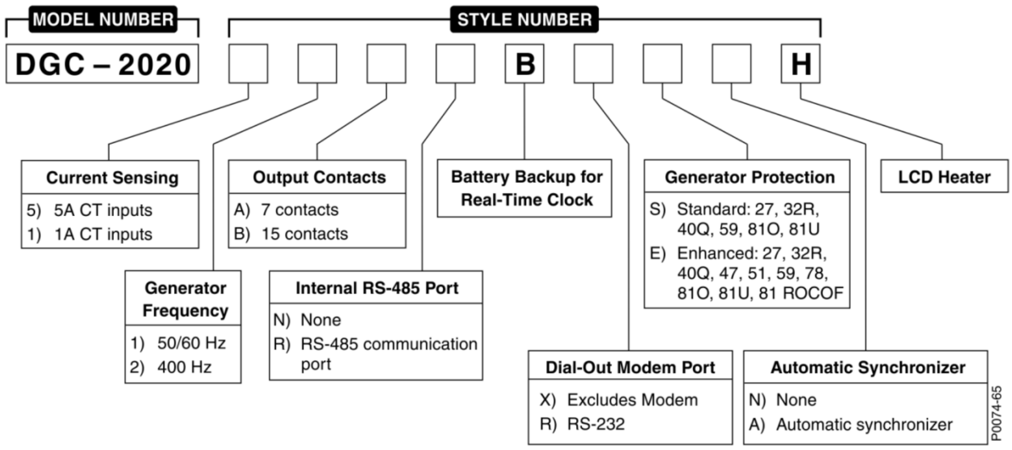

Figure 1-1. MGC-2000 Series Style Chart for Hardware Version 3

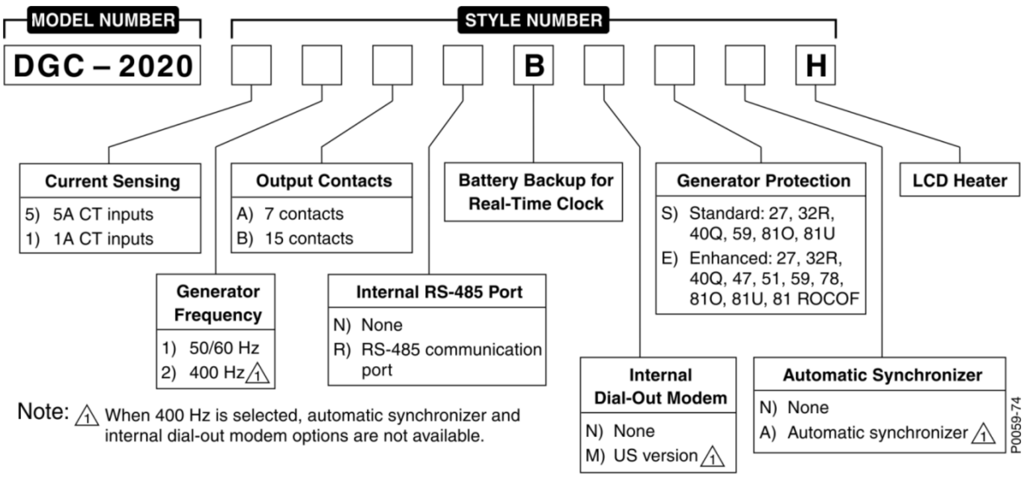

Figure 1-2. MGC-2000 Series Style Chart for Hardware Versions 1 and 2

For example, if an MGC-2000 Series (hardware version 3) style number were **51BNBREAH**, the controller would have the following characteristics and operating features.

5 5 Aac current sensing inputs
1 50/60 hertz nominal generator frequency
B Three fixed-function output contacts and 12 programmable output contacts
N No RS-485 communication port
B Battery backup for real-time clock during losses of control power
R External dial-out modem port
E Enhanced generator protection (27 undervoltage, 32R reverse power, 40Q loss of excitation, 47 phase imbalance, 51 overcurrent, 59 overvoltage, 78 vector shift, 81O overfrequency, 81U underfrequency, and 81 ROCOF)
A Auto-synchronizer
H LCD heater

Specifications

Operating Power

Nominal..12 or 24 Vdc
Range ....6 to 32 Vdc
Terminals ....3 (+), 2 (–), 1 (chassis ground)

Power Consumption

Sleep Mode.......................................5W with all relays non-energized
Normal Operational Mode ....7.9W - Run mode, LCD heater off, 3 relays energized
Maximum Operational Mode ....14.2W - Run mode, LCD heater on, 6 relays energized

Battery Ride Through

Withstands cranking ride-through down to 0 V for 50 ms, starting at 10 Vdc.

Current Sensing

Burden ....1 VA
Terminals ....68, 69 (A-phase)
71, 72 (B-phase)
74, 75 (C-phase)

1 Aac Current Sensing

Continuous Rating ....0.02 to 1.0 Aac
1 Second Rating ....2 Aac

5 Aac Current Sensing

Continuous Rating ....0.1 to 5.0 Aac
1 Second Rating ....10 Aac

Voltage Sensing

Generator Configuration ....Line-to-line or line-to-neutral
Bus Configuration ....Line-to-line
Range ....12 to 576 V rms, line-to-line
Frequency...Style selectable, 50/60 Hz or 400 Hz
Frequency Range ....10 to 72 Hz for 50/60 style and 10 to 480 Hz for 400 Hz style
Burden ....1 VA
1 Second Rating ....720 V rms
Generator Sensing Terminals...........41 (A-phase)
39 (B-phase)
37 (C-phase)
35 (Neutral)

Bus Sensing Terminals

Hardware Version 3..........................76, 45 (A-phase)∗
78, 43 (B-phase)∗
80 (C-phase)

Hardware Versions 1 and 2 ....45 (A-phase)
43 (B-phase)

∗ In version 3 hardware, terminal 45 is internally tied to 76 and terminal 43 is internally tied to 78. This accommodates the use of connectors wired for legacy MGC-2000 Series versions.

Contact Sensing

Contact sensing inputs include 1 emergency stop input and 16 programmable inputs. All inputs accept dry contacts.

Time from an MGC-2000 Series input application to:

Shutdown the generator via an alarm = 490 ms max
Close a relay on board the MGC-2000 Series = 215 ms max
Close a relay on board the CEM-2020 = 400 ms max

NOTES

A contact input is true (on) if the input is connected to battery ground with a resistance of less than 240 ohms.

The maximum length of wire that can be accommodated depends on the resistance of the wire, and the resistance of the contacts of the device driving the input at the far end of the wire.

The maximum wire length can be calculated as follows:

L_{max} = (240 – R_{device})/(Resistance per Foot of Desired Wire)

Terminals

Emergency Stop 46, 47

Programmable

Input 1 ....30, 2
Input 2 ....29, 2
Input 3 ....28, 2
Input 4 ....27, 2
Input 5 ....26, 2
Input 6 ....25, 2
Input 7 ....24, 2
Input 8 ....23, 2
Input 9 ....22, 2
Input 10 ....21, 2
Input 11 ....20, 2
Input 12 ....19, 2
Input 13 ....18, 2
Input 14 ....17, 2
Input 15 ....16, 2
Input 16 ....15, 2

Engine System Inputs

Stated accuracies are subject to the accuracy of the senders used. Values within these ranges are deemed “good” and the MGC-2000 Series will use them for the appropriate calculation and protection. Values outside these ranges are deemed “bad” and the MGC-2000 Series will begin timing towards a sender failure condition.

Fuel Level Sensing

Resistance Range ....0 to 250 Ω nominal
Terminals ....9, 11 (sender common)

Coolant Temperature Sensing

Resistance Range ....10 to 2,750 Ω nominal
Terminals ....10, 11 (sender common)

Oil Pressure Sensing

Resistance Range ....0 to 250 Ω nominal
Terminals ....8, 11 (sender common)

Engine Speed Sensing

Magnetic Pickup

Voltage Range ....3 to 35 V peak (6 to 70 V peak-peak)
Frequency Range ....32 to 10,000 Hz
Terminals ....31 (+), 32 (–)

Generator Voltage

Range ....12 to 576 V rms
Terminals ....41 (A-phase)
39 (B-phase)
37 (C-phase)

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Output Contacts

PRESTART, START, and RUN Relays

Rating ....30 Adc at 28 Vdc - General purpose, 3 A pilot duty∗

Programmable Relays (12)

Rating ....2 Adc at 28 Vdc - General purpose, 1.2 A pilot duty∗

∗ The load must be in parallel with a diode rated at least 3 times the coil current and 3 times the coil voltage.

Terminals†

Output 1 ....52, 51 (common)
Output 2 ....53, 51 (common)
Output 3 ....54, 51 (common)
Output 4 ....56, 55 (common)
Output 5 ....57, 55 (common)
Output 6 ....58, 55 (common)
Output 7 ....60, 59 (common)
Output 8 ....61, 59 (common)
Output 9 ....62, 59 (common)
Output 10 ....64, 63 (common)
Output 11 ....65, 63 (common)
Output 12 ....66, 63 (common)

† The number of programmable output contacts provided is determined by the output contacts character of the MGC-2000 Series style number. Controllers with output contacts option A have 4 programmable outputs (Outputs 1, 2, 3, and 4). Controllers with output contacts option B have 12 programmable outputs.

The programmable relays share common terminals: terminal 51 is used for outputs 1, 2, and 3, terminal 55 is used for outputs 4, 5, and 6, terminal 59 is used for outputs 7, 8, and 9, 63 is used for outputs 10, 11, and 12.

Metering

Generator and Bus Voltage (rms)

Metering Range ....0 to 576 Vac (direct measurement)
577 to 9,999 Vac (through VT using VT ratio setting)
VT Ratio Range ....1:1 to 125:1 in primary increments of 1
Accuracy* ....±1.0% of programmed rated voltage or ±2 Vac
Display Resolution ....1 Vac

* Voltage metering indicates 0 V when generator voltage is below 2% of the full-scale rating.

Generator Current (rms)

Generator current is measured at the secondary windings of user-supplied 1 A or 5 A CTs.

Metering Range ....0 to 5,000 Aac
CT Primary Range ....1 to 5,000 Aac in primary increments of 1 Aac
Accuracy* ....±1.0% of programmed rated current or ±2 Aac
Display Resolution ....1 Aac

* Current metering indicates 0 A when generator current is below 2% of the full-scale rating.

Generator and Bus Frequency

Generator frequency is sensed through the generator voltage input.

Metering Range ....10 to 72 Hz (50/60 Hz)
10 to 480 (400 Hz)
Accuracy ....±0.25% or 0.05 Hz
Display Resolution ....0.1 Hz

Apparent Power

Indicates total kVA and individual line kVA (4-wire, line-to-neutral or 3-wire, line-to-line).

Measurement/Calculation Methods

Total .... kVA = $(V_{L-L} \times I_L \times \sqrt{3}) \div 1000$
4-Wire, Line-to-Neutral .... kVA calculated with respect to neutral
3-Wire, Line-to-Line .... A-phase kVA = $V_{AB} \times I_A \div 1000 \div \sqrt{3}$
B-phase kVA = $V_{BC} \times I_B \div 1000 \div \sqrt{3}$
C-phase kVA = $V_{CA} \times I_C \div 1000 \div \sqrt{3}$
Accuracy .... ±3% or the full-scale indication or ±2 kVA ∗†

∗ kVA metering indicates 0 kVA when the generator kVA is below 2% of the full-scale rating.

† Applies when temperature is between –40°C to +70°C.

Power Factor

Metering Range .... 0.2 leading to 0.2 lagging
Calculation Method .... PF = cosine of the angle between phase AB voltage (Vab) and phase A current (Ia) *
Accuracy .... ±0.02 †

* In single-phase AC-connected machines, it is the cosine of the angle between phase CA voltage (Vca) and phase C current (Ic).

† Applies when temperature is between –40°C to +70°C (–40°F to +158°F).

NOTE

For the MGC-2000 Series to correctly meter power factor, the generator must be rotating clockwise (A-B-C).

Real Power

Indicates total kW and individual line kW (4-wire, line-to-neutral or 3-wire line-to-line)

Measurement/Calculation Methods

Total .... PF × Total kVA
4-Wire, Line-to-Neutral .... kW calculated with respect to neutral
3-Wire, Line-to-Line .... A-phase kW = $V_{AB} \times I_A \times PF \div 1000 \div \sqrt{3}$
B-phase kW = $V_{BC} \times I_B \times PF \div 1000 \div \sqrt{3}$
C-phase kW = $V_{CA} \times I_C \times PF \div 1000 \div \sqrt{3}$
Accuracy .... ±3% of the full-scale indication or ±2 kW ∗†

∗ kW metering indicates 0 kW when the generator kW is below 2% of the full-scale rating.

† Applies when temperature is between –40°C to +70°C.

Oil Pressure

Metering Range .... 0 to 150 psi, 0 to 10.3 bar, or 0 to 1,034 kPa
Accuracy .... ±3% of actual indication or ±2 psi, ±0.12 bar, or ±12 kPa (subject to accuracy of sender)
Display Resolution .... 1 psi, 0.1 bar, or 1 kPa

Coolant Temperature

Metering Range .... 32 to 410°F or 0 to 204°C
Accuracy .... ±3% of actual indication or ±2° (subject to accuracy of sender)

Battery Voltage

Metering Range .... 6 to 32 Vdc
Accuracy .... ±3% of actual indication or ±0.2 Vdc
Display Resolution .... 0.1 Vdc

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Engine RPM

Metering Range ....0 to 4,500 rpm
Accuracy* ....±2% of actual indication or ±2 rpm
Display Resolution ....2 rpm

* When engine speed is below 2% of full-scale, reported rpm is 0.

Engine Run Time

Engine run time is retained in nonvolatile memory.

Metering Range ....0 to 99,999 hours
Update Interval ....6 min
Accuracy ....±1% of actual indication or ±12 min
Display Resolution ....1 minute

Maintenance Timer

Maintenance timer indicates the time remaining until genset service is due. Value is retained in nonvolatile memory.

Metering Range ....0 to 5,000 hours
Update Interval ....6 min
Accuracy ....±1% or actual indication or ±12 min
Display Resolution ....1 minute

Fuel Level

Metering Range ....0 to 100%
Accuracy ....±2% (subject to accuracy of sender)
Display Resolution 1.0%

Generator Protection Functions

Overvoltage (59) and Undervoltage (27)

Pickup Range ....70 to 1,000 Vac
Pickup Increment ....1 Vac
Inhibit Frequency Range ....20 to 400 Hz (27 function only)
Activation Delay Range ....0 to 30 s
Activation Delay Increment ....0.1 s

NOTE

The maximum voltage that can be safely applied to the MGC-2000 Series is 576 volts. The pickup range is higher so that when the low-line override is used, and the scale factor is 0.5 or less, effective protection levels of 500 volts can be reached with a scale factor of 0.5.

Underfrequency (81U) and Overfrequency (81O)

Pickup Range ....45 to 66 Hz (50/60 Hz nominal)
360 to 440 Hz (400 Hz nominal)
Pickup Increment ....0.1 Hz (50/60 Hz nominal)
0.1 Hz (400 Hz nominal)
Activation Delay Range ....0 to 30 s
Activation Delay Increment ....0.1 s
Inhibit Voltage Range ....70 to 576 Vac (81U function only)

Reverse Power (32)

Pickup Range ....–50 to 5% of Genset kW Rating
Pickup Increment 0.1%
Hysteresis Range ....1 to 10% of Genset kW Rating
Hysteresis Increment 0.1%
Activation Delay Range ....0 to 30 s
Activation Delay Increment ....0.1 s

Loss of Excitation (40Q)

Pickup Range ....–150 to 0% of Rated kvar*
Pickup Increment.............................0.1%
Hysteresis Range ....1 to 10% of Rated kvar*
Hysteresis Increment........................0.1%
Activation Delay Range ....0 to 30 s
Activation Delay Increment...............0.1 s

* Rated kvar is calculated on the *System Settings, Rated Data* screen in BESTCOMS*Plus*®.

Overcurrent (51) (Optional)

Pickup Range ....0.18 to 1.18 Aac (1 A current sensing)
0.9 to 7.75 Aac (5 A current sensing)
Time Dial Range ....0 to 7,200 s (fixed time curve)
0 to 9.9 (inverse curve time multiplier)
Time Dial Increment..........................0.1
Inverse Time Curves.........................See Appendix A, *Time Overcurrent Characteristic Curves*

Phase Imbalance (47) (Optional)

Pickup Range ....5 to 100 Vac
Pickup Increment.............................1 Vac
Activation Delay Range ....0 to 30 s
Activation Delay Increment...............0.1 s

ROCOF (Rate of Change of Frequency) (81) (Optional)

Pickup Range ....0.2 to 10 Hz/s
Pickup Increment.............................0.1 Hz/s
Activation Delay Range ....0 to 100 s
Activation Delay Increment...............0.01 s

Vector Shift (78) (Optional)

Pickup Range ....2 to 90°
Pickup Increment.............................1°

Logic Timers

Hours Setting Range ....0 to 250
Hours Setting Increment...................1
Minutes Setting Range ....0 to 250
Minutes Setting Increment................1
Seconds Setting Range....................0 to 1,800
Seconds Setting Increment 0.1
Accuracy ....±15 ms

Communication Interface

USB

Specification Compatibility................USB 2.0
Data Transfer Speed ....115200 baud
Connector Type ....Mini-B jack

External Dial-Out Modem (Optional)

Protocol..ASCII
Data Transmission............................Full Duplex
Baud 9600
Data Bits 8
Parity..None
Stop Bits 1
Connector Type ....DB-9 Connector (Male)

RS-485 (Optional)

Baud 9600
Data Bits 8

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Parity...None
Stop Bits 1
Terminals ....14 (A), 13 (B), and 12 (shield)

RDP-110

Minimum Wire Size..........................20 AWG
Maximum Wire Length.....................4,000 feet (1,219 meters)
Terminals ....6 (RDP TXD–), 7 (RDP TXD+)

CAN

NOTES

1. If the MGC-2000 Series is providing one end of the J1939 bus, a 120 Ω, ½ watt terminating resistor should be installed across terminals 48 (CANL) and 49 (CANH).
2. If the MGC-2000 Series is not part of the J1939 bus, the stub connecting the MGC-2000 Series to the bus should not exceed 914 mm (3 ft) in length.
3. The maximum bus length, not including stubs, is 40 m (131 ft).
4. The J1939 drain (shield) should be grounded at one point only. If grounded elsewhere, do not connect the drain to the MGC-2000 Series.

Differential Bus Voltage ....1.5 to 3 Vdc
Maximum Voltage ....–32 to +32 Vdc with respect to negative battery terminal
Communication Rate ....250 kb/s
Terminals ....48 (low), 49 (high), and 50 (shield)

Real-Time Clock

Clock has leap year and selectable daylight saving time correction. Backup capacitor and backup battery sustain timekeeping during losses of MGC-2000 Series operating power.

Resolution..1 s
Accuracy ....±1.73 s/d at 25°C

Clock Holdup

Battery Holdup Time.........................Approximately 10 yrs
Battery Type ....Rayovac BR2032, lithium, coin-type, 3 Vdc, 195 mAh
Basler Electric P/N 38526

CAUTION

Replacement of the backup battery for the real-time clock should be performed only by qualified personnel.

Do not short-circuit the battery, reverse battery polarity, or attempt to recharge the battery. Observe polarity markings on the battery socket while inserting a new battery. The battery polarity must be correct in order to provide backup for the real-time clock.

It is recommended that the battery be removed if the MGC-2000 Series is to be operated in a salt-fog environment. Salt-fog is known to be conductive and may short-circuit the battery.

NOTE

Failure to replace the battery appropriately may void the warranty. Contact MTU Onsite Energy for information on battery part #121826.

LCD Heater

The ambient temperature is monitored by a temperature sensor located near the LCD inside the MGC-2000 Series. The LCD heater turns on when the ambient temperature falls below 0°C (32°F). The heater turns off when the ambient temperature rises above 5°C (41°F). This range of operation implements 5°C (9°F) of hysteresis between heater turn on and turn off.

Type Tests

Vibration...EN60068-2-6
Dielectric Strength EN60664-1
Impulse EN60664-1
Transients EN61000-4-4
Static Discharge................................EN61000-4-2

Shock

Withstands 15 G in 3 perpendicular planes.

Vibration

Swept over the following ranges for 12 sweeps in each of three mutually perpendicular planes with each 15-minute sweep consisting of the following:

5 to 29 to 5 Hz ....1.5 G peak for 5 minutes
29 to 52 to 29 Hz ....0.036 inches (0.914 mm) double amplitude for 2.5 minutes
52 to 500 to 52 Hz ....5 G peak for 7.5 minutes

Radio Interference

Type tested using a 5 W, hand-held transceiver operating at random frequencies centered around 144 and 440 MHz with the antenna located within 150 mm (6") of the device in both vertical and horizontal planes.

HALT (Highly Accelerated Life Testing)

HALT is used by Basler Electric to prove that our products will provide the user with many years of reliable service. HALT subjects the device to extremes in temperature, shock, and vibration to simulate years of operation, but in a much shorter period span. HALT allows Basler Electric to evaluate all possible design elements that will add to the life of this device. As an example of some of the extreme testing conditions, the MGC-2000 Series was subjected to temperature tests (tested over a temperature range of –100°C to +115°C), vibration tests (of 5 to 50 G at +20°C), and temperature/vibration tests (tested at 40 G over a temperature range of –80°C to +90°C). Combined temperature and vibration testing at these extremes proves that the MGC-2000 Series is expected to provide long-term operation in a rugged environment. Note that the vibration and temperature extremes listed in this paragraph are specific to HALT and do not reflect recommended operation levels. These operational ratings are included in Section 1 of this manual.

Ignition System

Tested in close proximity to an unshielded, unsuppressed Altronic DISN 800 Ignition System.

Environment

Operating Temperature ....–40 to +70°C (–40 to +158°F)
Storage Temperature........................–40 to +85°C (–40 to +185°F)
Humidity..IEC 60068-2-38
Salt Fog ....ASTM B 17-73, EN 68-2-11
Ingress Protection.............................IEC IP54 for front panel

UL Recognition

The MGC-2000 Series is recognized to applicable Canadian and US safety standards and requirements by UL.
Standards used for evaluation:

- UL6200
- CSA C22.2 No. 14

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CAUTION
To follow UL guidelines, replacement of the backup battery for the real-time clock should be performed only by qualified personnel.

MGC-2000 Series with Hazardous Location Certification

"cURus" recognized per Standard 1604, *Electrical Equipment for Use in Class* `I` *and* `II`*, Division 2, and Class* `III` *Hazardous (Classified) Locations,* Class `I`, Division 2, Zone 2, Groups A, B, C, D, Temperature Code - T3C.

This equipment is suitable for use in Class `I`, Division 2, Groups A, B, C, D, or non-hazardous locations only.

Currently, only style MGC-2000 Series -51BRBXEAH is available with Hazardous Location certification. If an additional style option is needed with this certification, contact MTU Onsite Energy.

WARNING! - EXPLOSION HAZARD
Substitution of components may impair suitability for Class `I`, Division 2. Do not disconnect equipment unless power has been switched off or the area is known to be non-hazardous. Exposure to some chemicals may degrade the sealing properties of materials used in the sealed relay device.

CSA Certification

The MGC-2000 Series was tested and has met the certification requirements for electrical, plumbing and/or mechanical products.
Standards used for evaluation:

- CSA C22.2 No. 0
- CSA C22.2 No. 14

NFPA Compliance

Complies with NFPA Standard 110, *Standard for Emergency and Standby Power*.

CE Compliance

This product has been evaluated and complies with the relevant essential requirements set forth by the EU legislation.

EC Directives:

- LVD – 2006/95/EC
- Electromagnetic Compatibility (EMC) – 2004/108/EC

Harmonized Standards used for evaluation:

- EN 50178: Electronic Equipment for use in Power Installations
- EN 61000-6-4: Electromagnetic Compatibility (EMC), Generic Standards, Emission Standard for Industrial Environments
- EN 61000-6-2: Electromagnetic Compatibility (EMC), Generic Standards, Immunity for Industrial Environments

GOST-R Certification

The MGC-2000 Series has been evaluated and complies with the relevant essential requirements set forth to meet the Russian certification system.

Physical

Weight..4.40 lb (1.99 kg)
Dimensions......................................See Section 6, *Installation*.

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SECTION 2 • HUMAN-MACHINE INTERFACE

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SECTION 2 • HUMAN-MACHINE INTERFACE

Introduction

This section describes the components of the MGC-2000 Series human-machine interface (HMI). MGC-2000 Series HMI components are located on the front panel (controls and indicators) and the rear panel (terminals and connectors).

Front Panel

Figure 2-1 illustrates the front panel HMI of the MGC-2000 Series. Table 2-1 lists the call-outs of Figure 2-1 along with a description of each HMI component.

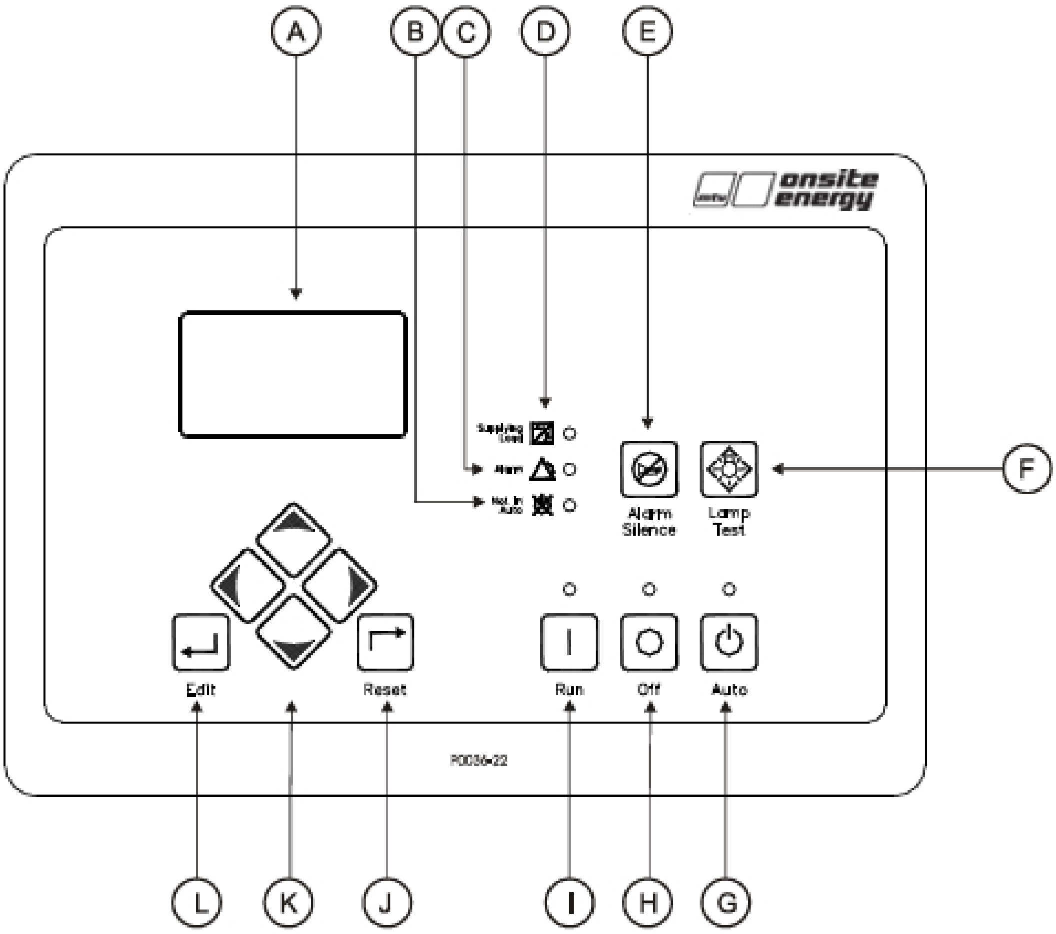

Figure 2-1. Front Panel HMI

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Table 2-1. Front Panel HMI Descriptions

Locator	Description
A	*Liquid Crystal Display.* The backlit, 64 by 128 pixel LCD serves as the local information source for metering, alarms, pre-alarms, and protective functions. Display operation is maintained at –40°C.
B	*Not in Auto Indicator.* This red LED lights when the MGC-2000 Series is not operating in Auto mode.
C	*Alarm Indicator.* This red LED lights continuously during alarm conditions and flashes during pre-alarm conditions.
D	*Supplying Load Indicator.* This green LED lights when the generator current is greater than EPS threshold current.
E	*Alarm Silence Pushbutton.* Pressing this button opens the relay output programmed as the horn output.
F	*Lamp Test Pushbutton.* Pressing this button tests the MGC-2000 Series indicators by exercising all LCD pixels and lighting all LEDs.
G	*Auto Pushbutton and Mode Indicator.* Pressing the Auto button places the MGC-2000 Series in Auto mode. The green Auto mode LED lights when Auto mode is active.
H	*Off Pushbutton and Mode Indicator.* Pressing this button places the MGC-2000 Series in Off mode. The red Off mode LED lights when the MGC-2000 Series is in Off mode. This button also resets the Breaker Management Pre-Alarms and all MTU ECU Alarms.
I	*Run Pushbutton and Mode Indicator.* Pressing this button places the MGC-2000 Series in Run mode. The green Run mode LED lights when Run mode is active.
J	*Reset Pushbutton.* This button is pressed to cancel a settings editing session and discard any settings changes. When pressed momentarily, this button also resets the Breaker Management Pre-Alarms and all MTU ECU Alarms. This button is also used to reset the Maintenance Interval when pressed for 10 seconds while viewing Hours Until Maintenance or Maintenance Due Pre-Alarm.
K	*Arrow Pushbuttons.* These four buttons are used to navigate through the front panel display menus and modify settings. The left- and right-arrow buttons are used to navigate through the menu levels. The right-arrow button is pressed to move downward through the menu levels and the left-arrow button is pressed to move upward. Within a level, the up-arrow and down-arrow buttons are used to move among items within the menu level. Pressing the down-arrow button moves to items lower in the list. Pressing the up-arrow button moves to items higher in the list. During a settings editing session, the up- and down-arrow buttons are used to raise and lower the value of the selected setting.
L	*Edit Pushbutton.* Pressing this button starts an editing session and enables changes to MGC-2000 Series settings. At the conclusion of an editing session, the Edit pushbutton is pressed again to save the setting changes.

Display Operation

The front panel display is used to make settings changes and display metering values. Refer to call-outs J, K, and L in Table 2-1 for information on changing settings through the front panel and navigating through the Metering screens.

Login and Permissions

Login

To login, navigate to the SETTINGS, ENTER PASSWORD screen and press the *Edit* key. Use the *Up/Down* arrow keys to scroll through the characters. Use the *Left/Right* arrow keys to enter more characters. Once the password has been entered, press the *Edit* key to login. A LOGOUT selection now

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appears in the list of SETTINGS. To logout, navigate to SETTINGS > LOGOUT and press the *Edit* key. The LOGOUT selection is removed from the SETTINGS list.

If a front-panel key is not pressed for more than 15 minutes, the user is automatically logged out.

Permissions

If communications access is active through the modem or USB, the front panel will display REMOTE COMMS, FRONT PANEL IS READ ONLY and the summary screen. This informs the user that the front panel can only be used for viewing metering data and settings information. Remote access must be ended before modifying settings through the front panel.

Summary Screen and Configurable Metering

The summary screen can be set to standard or scrolling. When set to standard, only the following are displayed:

- VOLT∗
- AMP∗
- PH∗
- Hz
- OIL
- FUEL/DEF†
- TEMP
- BATT

∗ When set to standard, individual phase information can be automatically toggled at a rate set by the Phase Toggle Delay setting. Navigate to the SETTINGS > GENERAL SETTINGS > FRONT PANEL HMI screen and edit PH TOG DELAY. When the Phase Toggle Delay is set to zero, information for each phase is obtained by pressing the *Up* or *Down* arrow keys on the front panel HMI. When it is set to a number other than zero, the display will toggle through the phases automatically at the rate specified by the Phase Toggle Delay Setting.

† When a Selective Catalytic Reduction (SCR) with Diesel Exhaust Fluid (DEF) exhaust after-treatment system is implemented, the Summary screen automatically alternates the display of FUEL level and DEF level.

When the summary screen is set to scrolling, you can select/configure the metering values that are displayed. Up to 20 values can be displayed and these values will scroll at a delay time specified by the user. To select a standard or scrolling summary, navigate to the SETTINGS > GENERAL SETTINGS > FRONT PANEL HMI screen and edit the SUMMARY VIEW. The SCROLL DELAY setting is also found on this screen.

To select the scrolling values, navigate to the SETTINGS > GENERAL SETTINGS > FRONT PANEL HMI screen and edit the CONFIGURABLE METERING. The following items may be selected by the user to be placed in the scrolling summary:

- NONE (Removes a line from the scrolling list)
- BLANK (Shows nothing on this line)
- OIL P
- TEMP
- BATT V
- RPM
- RPM SRC
- FUEL
- RUN HRS
- GEN VAB
- GEN VBC
- GEN VCA
- GEN VAN
- GEN VBN
- GEN VCN
- BUS Hz
- BUS V
- GEN Hz
- GEN PF
- kWH
- GEN IA
- GEN IB
- RTD IN X (X = 1 to 8) (with AEM-2020)
- THRM CPL X (X = 1 to 2) (with AEM-2020)
- FUEL DELV P
- kvar A
- kvar B
- kvar C
- kvar TOTAL
- INJ RAIL PRS
- TOTAL FUEL USED
- FUEL TEMP
- ENG OIL TEMP
- ENG INTCLR TEMP
- COOLANT PRESS
- FUEL RATE
- BOOST PRESS
- INTAK MNFLD TMP
- CHRG AIR TMP
- ENGINE % LOAD
- BUS VAB
- BUS VBC
- BUS VCA
- DEF 1 %

- GEN IC
- kW A
- kW B
- kW C
- kW TOT
- kVA A
- kVA B
- kVA C
- kVA TOT
- ALG IN X (X = 1 to 8) (with AEM-2020)
- DEF 2 %
- KW LD%
- ON LINE
- # UNITS
- SYS CAP
- SYS KW
- SY KVAR
- SYS TOTAL KW
- SYS GEN KW %

Sleep Mode

Sleep mode serves as a power saving feature. If the MGC-2000 Series is in Off mode or Auto mode not running and a key is not pressed for more than 15 minutes, the front panel LCD backlight and LCD heater are turned off. The MGC-2000 Series resumes normal display operation when any front panel button is pressed or the genset is started remotely via the ATS input. The MGC-2000 Series will not go to sleep while in an Alarm state. If needed, Sleep mode can be permanently disabled via BESTCOMS*Plus*® or the front panel.

Changing a Setting

To change a setting, navigate to the setting you want to change and press the *Edit* key. If you are not already logged in, you will be asked to enter your password at this time. Use the *Up/Down* arrows to raise or lower the value. Press the *Edit* key again when finished.

Front Panel Display Structure

The front panel display begins with the SUMMARY SCREEN. Pressing the *Right* arrow key will open the MAIN MENU screen. The MAIN MENU screen consists of METERING, SETTINGS, and, when enabled, the ONE-LINE DIAGRAM, indicated by this symbol: The METERING screen branches are shown in Figure 2-2. Details of the METERING screen branches follow Figure 2-2. The SETTINGS screen branches are shown in Figure 2-3. Details of the SETTINGS screen branches follow Figure 2-3. The ONE-LINE DIAGRAM screen options are shown in Figure 2-4.

METERING
ENGINE
GENERATOR
POWER
BIAS CONTROL (Available when LSM-2020 is enabled.)
RUN STATISTICS
ALARMS-STATUS
DIAGNOSTICS

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Figure 2-2. Metering Screen Branches

ENGINE

- **OIL PRESSURE**
- **COOLANT TMP**
- **BATTERY VOLT**
- **RPM**
- **SPEED SRC**
- **FUEL LEVEL**
- **ENGINE LOAD**
- **COOLANT LEVL** (Visible when CAN BUS is enabled.)
- **TOTAL RUN TM**
- **HRS TO MAINT**
- **DEF TANK 1 LVL %**
- **DEF TANK 2 LVL %**

GENERATOR

- **GEN CONNECT**
- **GEN VAB**
- **GEN VBC**
- **GEN VCA**
- **GEN VAN**
- **GEN VBN**
- **GEN VCN**
- **GEN FREQ**
- **GEN AMPS A**
- **GEN AMPS B**
- **GEN AMPS C**
- **BUS CONNECT**
- **BUS VAB**
- **BUS VBC** (Visible when three-phase bus connection is selected.)
- **BUS VCA** (Visible when three-phase bus connection is selected.)
- **BUS FREQ**
- **SYNCHRONIZER**
    - SLIP ANGLE
    - DELTA HERTZ
    - DELTA VOLTS
    - STATUS
- **MAX VECT SHIFT (Optional)**
- **MAX ROCOF (Optional)**
- **ROCOF (Optional)**

POWER

- **kW A**
- **kW B**
- **kW C**
- **kW TOTAL**
- **kVA A**
- **kVA B**
- **kVA C**
- **kVA TOTAL**
- **kvar A**
- **kvar B**
- **kvar C**
- **kvar TOTAL**
- **PF**

BIAS CONTROL (Visible when LSM-2020 is enabled.)

- **var MODE**
- **PF MODE**
- **BL LV SRC**
- **BASELOAD LVL**
- **kvar SRC**
- **kvar SETPT**
- **PF SRC**
- **PF SETPT**

RUN STATISTICS

- **CUMULATIVE**
    - CUMULATIVE
        - START
        - # STARTS
        - HRS TO MAINT
        - kW-HRS
    - TOTAL RUN TIME
        - HOURS
        - MINUTES

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- LOADED RUN TIME
    - HOURS
    - MINUTES
- UNLOADED RUN TIME
    - HOURS
    - MINUTES

- **SESSION**
  - SESSION
    - START
    - kW-HRS
  - TOTAL RUN TIME
    - HOURS
    - MINUTES
  - LOADED RUN TIME
    - HOURS
    - MINUTES
  - UNLOADED RUN TIME
    - HOURS
    - MINUTES

ALARMS-STATUS

- **ACTIVE ALARMS**
- **ACTIVE PRE-ALARMS**
- **MTU FAULT CODES** (Visible when ECU is configured for MTU MDEC, MTU ADEC, or MTU ECU7/ECU8.)
- **MTU STATUS** (Visible when ECU is configured for MTU MDEC, MTU ADEC, MTU ECU7/ECU8, or MTU Smart Connect.)
  - NMT-ALIVE STATUS (Visible when ECU is configured for MTU MDEC or MTU ECU7/ECU8.)
    - SPS NODE
    - SW TYP
    - SW VAR
    - SW ED1
    - SW ED2
    - REV
    - SW MOD
  - TRIP FUEL (Visible when ECU is configured for MTU ECU7/ECU8.)
    - TRIP HRS
    - TRIP IDLE HRS
    - FUEL RATE
    - TRIP FL RATE
    - TOTAL RUN TM
    - DAILY FUEL
    - TOTAL FUEL
  - FUEL (Visible when ECU is configured for MTU ADEC.)
    - DAY TANK LVL
    - STORE TANK LVL
  - ENGINE STATUS (Visible when ECU is configured for MTU ADEC, MTU ECU7/ECU8, or MTU Smart Connect.)
    - MTU FAULT CODES
    - ENG RUNNING
    - CYL CUTOUT
    - ENG OPTIMIZED (Visible when ECU is configured for MTU ADEC or MTU ECU7/ECU8.)
    - PREHT NT RCHD (Visible when ECU is configured for MTU ADEC or MTU ECU7/ECU8.)
    - SPEC TORQUE (Visible when ECU is configured for MTU ADEC or MTU ECU7/ECU8.)
    - SPD DMD FL MD (Visible when ECU is configured for MTU ADEC.)
    - CURR P DEGREE (Visible when ECU is configured for MTU ADEC.)
    - LOAD GEN ON (Visible when ECU is configured for MTU ADEC, MTU ECU7/ECU8, or MTU Smart Connect.)
    - PRIME PUMP ON (Visible when ECU is configured for MTU ADEC.)
    - RUNUP SPD LO (Visible when ECU is configured for MTU ADEC.)
    - IDLE SPD LO (Visible when ECU is configured for MTU ADEC.)
    - CYL CUTOUT CD (Visible when ECU is configured for MTU ECU7/ECU8.)
    - RPM (Visible when ECU is configured for MTU ECU7/ECU8.)
    - DROOP % (Visible when ECU is configured for MTU ECU7/ECU8 or MTU Smart Connect.)
    - ENG COOL TEMP (Visible when ECU is configured for MTU ECU7/ECU8.)
    - CHRG AIR TMP (Visible when ECU is configured for MTU ECU7/ECU8.)
    - INTRCOOLR TEMP (Visible when ECU is configured for MTU ECU7/ECU8.)
    - ENG OIL TEMP (Visible when ECU is configured for MTU ECU7/ECU8.)

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- FUEL TEMP (Visible when ECU is configured for MTU ECU7/ECU8.)
- ECU TEMP (Visible when ECU is configured for MTU ECU7/ECU8.)
- OIL PRESSURE (Visible when ECU is configured for MTU ECU7/ECU8.)
- CHG AIR P (Visible when ECU is configured for MTU ECU7/ECU8.)
- FUEL DELV P (Visible when ECU is configured for MTU ECU7/ECU8.)
- FL RAIL P (Visible when ECU is configured for MTU ECU7/ECU8.)
- CAMSHAFT RPM (Visible when ECU is configured for MTU ECU7/ECU8.)
- IDLE RPM (Visible when ECU is configured for MTU ECU7/ECU8.)
- ECU SHUTDOWN (Visible when ECU is configured for MTU ECU7/ECU8.)
- TOTAL RUN TM (Visible when ECU is configured for MTU ECU7/ECU8.)
- ECU SUPP VOLTS (Visible when ECU is configured for MTU ECU7/ECU8.)
- INJCT DBR % (Visible when ECU is configured for MTU ECU7/ECU8.)
- RATED RPM (Visible when ECU is configured for MTU ECU7/ECU8.)
- INJCT QTY (Visible when ECU is configured for MTU ECU7/ECU8.)
- RATED KW (Visible when ECU is configured for MTU ECU7/ECU8.)
- RESRV PWR % (Visible when ECU is configured for MTU ECU7/ECU8.)
- START SEQ (Visible when ECU is configured for MTU ECU7/ECU8 or MTU Smart Connect.)
- ECU OVRD FDBK (Visible when ECU is configured for MTU Smart Connect.)
- COOLNT PRHT DONE (Visible when ECU is configured for MTU Smart Connect.)
- REQ TORQUE (Visible when ECU is configured for MTU Smart Connect.)
- EXT STOP (Visible when ECU is configured for MTU Smart Connect.)
- OPERATING MODE (Visible when ECU is configured for MTU Smart Connect.)

- SPEED (Visible when ECU is configured for MTU ADEC, MTU ECU7/ECU8, or MTU Smart Connect.)
  - SEL SPD DMD
  - EFF SET SPEED
  - CAN SPD DMD
  - ANLG SPD DMD
  - SPD DMD FL MD
  - RATED RPM (Visible when ECU is configured for MTU ECU7/ECU8.)
  - RPM (Visible when ECU is configured for MTU ECU7/ECU8.)
  - CAMSHAFT RPM (Visible when ECU is configured for MTU ECU7/ECU8.)
  - IDLE RPM (Visible when ECU is configured for MTU ECU7/ECU8.)
  - SPD DMD SRC (Visible when ECU is configured for MTU ECU7/ECU8.)
  - FREQ RPM DMD (Visible when ECU is configured for MTU ECU7/ECU8.)
- SIGNL FEEDBK (Visible when ECU is configured for MTU ADEC, MTU ECU7/ECU8, or MTU Smart Connect.)
  - ECU_OVRD_FDBK
  - EXT STOP
  - SPD UP IN
  - SPD DN IN
  - CAN MODE FDBK
  - CYL CUTOUT (Visible when ECU is configured for MTU ECU7/ECU8.)
- DIAGNOSTICS (Visible when ECU is configured for MTU ECU7/ECU8.)
  - AL PWR AMP 1
  - AL PWR AMP 2
  - XSTR OUT AL
  - XSTR OUT STS
  - ECU SHUTDOWN
- CAN Bus (Visible when ECU is configured for MTU ECU7/ECU8.)
  - CAN MODE FDBK
  - CAN NODES
  - LOST NODES
- LIMITS (Visible when ECU is configured for MTU ECU7/ECU8.)
  - OIL PRESSURE
  - LO LIM OILP
  - LOLOLIM OILP
  - ENG COOL TEMP
  - CLNT LMT HI
  - CLNT LMT HIHI
  - CHRG AIR TMP
  - CHG AIR LMT HI
  - ECU SUPP VOLTS
  - L1L ECU VOLTS
  - L2L ECU VOLTS
  - U1L ECU VOLTS
  - U2l ECU VOLTS
  - INTRCOOLR TMP
  - INTCLR LMT HI

- **STATUS**
  - AUTO XFER SWITCH (Visible when the Auto Transfer Switch programmable function is configured to be driven by an input.)
  - EPS SUPP. LOAD
  - GEN BREAKER
  - MAINS BREAKER
  - BATTLE OVERRIDE (Visible when the Battle Override programmable function is configured to be driven by an input.)
  - LOW LINE OVERRIDE (Visible when the Low Line Override programmable function is configured to be driven by an input.)
  - LOW COOL LEVEL (Visible when the Low Coolant Level programmable function is configured to be driven by an input.)
  - BATT CHRG FAIL (Visible when the Battery Charger Fail programmable function is configured to be driven by an input.)
  - FUEL LEAK DETECT (Visible when the Fuel Leak Detect programmable function is configured to be driven by an input.)
  - GRND DELTA O-RIDE (Visible when Generator Connection is configured for Delta and the Grounded Delta Override programmable function is configured to be driven by an input.)
  - 1 PHASE O-RIDE (Visible when the 1-Phase Override programmable function is configured to be driven by an input.)
  - 1 PHASE AC O-RIDE (Visible when the 1-Phase AC Override programmable function is configured to be driven by an input.)
  - BUS DEAD
  - BUS STABLE
  - BUS FAILED
  - BUS FWD ROT
  - BUS REV ROT
  - GEN DEAD
  - GEN STABLE
  - GEN FAILED
  - GEN FWD ROT
  - GEN REV ROT
  - ENG RUNNING
  - CLDN TMR ACTVE
  - OFF MODE COOLDN
  - COOLDN REQ
  - COOL & STOP REQ
  - var MODE
  - PF MODE
  - EXT START DEL
  - START DEL BYPASS
  - ALT FRQ O-RIDE
  - RESET
  - ALARM SILENCE
  - LAMP TEST
  - IDLE REQUEST
  - LOAD TAKEOVER
  - MAINS FAIL TEST
  - SYNCHRONIZING
  - SYNC VOLT OK
  - SYNC SLIP FRQ OK
  - SYNC ANGLE OK
  - SYNC BRK CL OK
  - PARALLEL TO MAINS
  - LSM CONNECTED
  - CEM CONNECTED
  - AEM CONNECTED
- **INPUTS**
  - INPUT X (X = 1 to 16 (17 to 26 optional))
- **OUTPUTS**
  - START
  - RUN
  - PRESTART
  - OUTPUT X (X = 1 to 12 (13 to 36 optional))

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- **LOGIC CTL RELAYS**
    - LCR X (X = 1 to 16)
- **LSM INPUTS** (Visible when LSM-2020 is enabled.)
    - SCALED
    - RAW
        - LSM IN
- **ANALOG INPUTS** (Visible when AEM-2020 is enabled.)
    - SCALED
        - ALG IN X (X = 1 to 8)
    - RAW
        - ALG IN X (X = 1 to 8)
- **THERMAL INPUTS** (Visible when AEM-2020 is enabled.)
    - SCALED
        - RTD IN X (X = 1 to 8)
        - THRM CPL X (X = 1 to 2)
    - RAW
        - RTD IN X (X = 1 to 8)
        - THRM CPL X (X = 1 to 2)
- **ANALOG OUTPUTS** (Visible when AEM-2020 is enabled.)
    - SCALED
        - ALG OUT X (X = 1 to 4)
    - RAW
        - ALG OUT X (X = 1 to 4)
- **ANALOG STATUS** (Visible when AEM-2020 is enabled.)
- **CONF ELEMENTS**
    - CONFIG ELEMENT X (X = 1 to 8)
- **CONF PROT STATUS**
- **EVENT LOG**
    - [EVENT NAME]
        - ACTIVE
        - OCCURRENCE COUNT
        - FIRST DATE
        - FIRST TIME
        - LAST DATE
        - LAST TIME
        - FIRST ENG HRS
        - LAST ENG HRS
        - DETAILS
            - OCCURRENCE (Use the *Edit/Up/Down* keys to change the occurrence.)
            - DATE
            - TIME
            - ENG HRS
        - CLEAR EVENT (Visible when logged in through the front panel.)
- **J1939 DATA** (Visible when CAN bus is enabled and ECU is configured for Standard, Volvo Penta, MTU ADEC, GM/Doosan, Cummins, Scania, or John Deere.)
    - THROTTLE POSITN
    - LOAD @ CRNT RPM
    - ACTUAL ENG TORQ
    - ENGINE SPEED
    - INJ CNTRL PRESS
    - INJ RAIL PRS
    - ENGINE HOURS
    - TRIP FUEL
    - TOTAL FUEL USED
    - ENG COOLANT TEMP
    - FUEL TEMP
    - ENG OIL TEMP
    - ENG INTCLR TEMP
    - FUEL DELV P
    - ENG OIL LEVEL
    - ENG OIL PRESS
    - COOLANT PRESS
    - COOLANT LEVEL
    - FUEL RATE
    - BAROMETRIC PRESS
    - AMB AIR TEMP
    - AIR INLET TEMP
    - BOOST PRESS

- INTAK MNFLD TEMP
- AIR FLTR DIF PRS
- EXHAUST GAS TEMP
- BATTERY VOLTAGE
- ECU INPUT VOLTS
- TRANS OIL PRESS
- TRANS OIL TEMP
- WINDG 1 TEMP
- WINDG 2 TEMP
- WINDG 3 TEMP
- ECU TEMP
- AUX PRESSURE1
- AUX PRESSURE2
- RATED KW
- RATED RPM
- EXHAUST TMP A
- EXHAUST TMP B
- CHRG AIR TMP
- FUEL 1 LEAK
- FUEL 2 LEAK
- ALARM RST FDBK
- ECU SHUTDOWN
- DEF TANK 1 LVL %
- DEF TANK 2 LVL %

- **J1939 ENGINE CONFIG** (Visible when ECU is configured for Standard, Volvo Penta, MTU ADEC, GM/Doosan, or Cummins.)
  - SPD @ IDLE PNT 1
  - TRQ @ IDLE PNT 1
  - SPD @ PNT 2
  - TRQ @ PNT 2
  - SPD @ PNT 3
  - TRQ @ PNT 3
  - SPD @ PNT 4
  - TRQ @ PNT 4
  - SPD @ PNT 5
  - TRQ @ PNT 5
  - SPD @ PNT 6
  - ENDSPEED GOV KP
  - REF ENG TORQUE
  - O-RIDE SPD PNT 7
  - O-RIDE TIME LMT
  - SPEED LOWER LMT
  - SPEED UPPER LMT
  - TORQUE LOWER LMT
  - TORQUE UPPER LMT
- **J1939 ACTIVE DTC** (Visible when DTC support is enabled and any ECU type is selected.)
  - CLEAR DTCs
- **J1939 PREV DTC** (Visible when DTC support is enabled and any ECU type is selected.)
  - CLEAR DTCs
- **NETWORK STATUS** (Visible when Multiple Generator is selected as System Type.)
  - SYSTEM MANAGER (Displays “0” when LSM-2020 is not connected.)
  - NUMBER OF UNITS (Displays “0” when LSM-2020 is not connected.)
  - ID (Visible when LSM-2020 is connected.)
  - NUM ON LINE (Displays “0” when LSM-2020 is not connected.)
  - ID X (X = 1 to 16) (The ID of each online unit is displayed)
  - SYS KW CAP
  - SYS GEN KW
  - SYS GEN KVAR
- **SEQUENCING STATUS** (Visible when Demand Start/Stop is enabled.)
  - NEXT TO START (Displays “0” when LSM-2020 is not connected.)
  - NEXT TO STOP (Displays “0” when LSM-2020 is not connected.)
  - START TMR 1
  - START TMR 2
  - STOP TIMER
  - WATT DEMAND
  - MODE
  - SEQUENCE ID (Displays “0” when LSM-2020 is not connected.)
  - SYSTEM MANAGER (Displays “0” when LSM-2020 is not connected.)

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  - START LVL 1
  - START LVL 2
  - STOP LVL
  - START TD 1
  - START TD 2
  - STOP TD
- **MAINS FAIL TRANSFER** (Visible when Mains Fail Transfer is enabled.)
  - MAINSFAIL XFER STATE
    - DISABLED (The possible mains fail transfer states are as follows: Power From Mains, Transfer Timer Active, Transferring to Gens, Power From Gens, Return Timer Active, Transferring to Mains, Disabled (when MGC is in OFF or RUN modes, or in the alarm state))
  - TRANSFER DELAY (Visible when actively counting and relevant to mains fail transfer.)
  - RETURN DELAY (Visible when actively counting and relevant to mains fail transfer.)
  - MAX TRANSFER TIME (Visible when actively counting and relevant to mains fail transfer.)
  - MAX PARALLEL TIME (Visible when actively counting and relevant to mains fail transfer.)
  - OPEN TRANS DELAY (Visible when actively counting and relevant to mains fail transfer.)

DIAGNOSTICS

- **MODBUS RD**
- **MODBUS WR**
- **FLASH WR**

SETTINGS

GENERAL SETTINGS
COMMUNICATIONS
SYSTEM PARAMS
PROGRAMMABLE INPUTS
PROGRAMMABLE OUTPUTS
CONFIG PROTECTION
ALARM CONFIGURATION
GENERATOR PROTECTION
BREAKER MANAGEMENT
BIAS CONTROL
MULTIGEN MANAGEMENT (Available when LSM-2020 is enabled.)
LOGIC TIMERS
ENTER PASSWORD

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Figure 2-3. Settings Screen Branches

GENERAL SETTINGS

- **FRONT PANEL HMI**
  - SUMMARY VIEW
  - SCROLL DELAY
  - PH TOG DELAY
  - LCD CONTRAST
  - SLEEP MODE
  - LANGUAGE
  - CONFIGURABLE METERING
    - ITEM X (X = 1 to 20)
  - ONE-LINE DIAGRAM
- **CONFIGURE DATE/TIME**
  - YEAR
  - MONTH
  - DAY
  - HOURS
  - MINUTES
  - SECONDS
  - UTC OFFSET

- DST ENABLED
- CLK NOT SET WRN

- **VIEW DATE/TIME**
- **VERSION INFO**
    - DGC-2020
        - FIRMWARE VERSION
        - BOOT CODE VERSION
        - SERIAL NUMBER
        - PART NUMBER
        - MODEL NUMBER
        - LANGUAGE VERSION
        - LANGUAGE PART NUM
        - STYLE CODE
    - LSM-2020 (Visible when LSM-2020 is enabled.)
        - VERSION INFO
            - FIRMWARE VERSION
            - BOOT CODE VERSION
        - TCP/IP SETTINGS
            - IP ADDRESS
            - SUBNET MASK
            - GATEWAY ADDRESS
            - DHCP ENABLE
    - CEM-2020 (Visible when CEM-2020 is enabled.)
        - FIRMWARE VERSION
        - BOOT CODE VERSION
        - SERIAL NUMBER
        - PART NUMBER
        - MODEL NUMBER
        - BUILD DATE
    - AEM-2020 (Visible when AEM-2020 is enabled.)
        - FIRMWARE VERSION
        - BOOT CODE VERSION
        - SERIAL NUMBER
        - PART NUMBER
        - MODEL NUMBER
        - BUILD DATE

COMMUNICATIONS

- **CAN Bus SETUP**
    - CAN Bus SETUP
        - CAN Bus ENABLE
        - DTC ENABLE (Visible when CAN bus is enabled.)
        - SPN CONV METHOD (Visible when CAN bus is enabled.)
        - CAN Bus ADDR (Visible when CAN bus is enabled.)
        - ECU OPT SLCT (Visible when CAN bus is enabled.)
        - ECU PULSING (Visible when CAN bus is enabled.)
        - ENG SHTDN TM (Visible when CAN bus is enabled.)
        - PLS CYCL TM (Visible when CAN bus is enabled.)
        - ECU SET TM (Visible when CAN bus is enabled.)
        - RESP TIMEOUT (Visible when CAN bus is enabled.)
    - ECU SETUP (Visible when CAN bus is enabled.)
        - ECU CONF
        - GEN DATA TRANSMIT (Visible when ECU is configured for Standard, Volvo Penta, MTU ADEC, GM/Doosan, Cummins, or MTU Smart Connect.)
        - ENGINE PARAM XMT
        - TRIP RESET (Visible when ECU is configured for Standard, Volvo Penta, MTU ADEC, GM/Doosan, Cummins, or MTU Smart Connect.)
        - DPF REGENRATE SETUP (Visible when ECU is configured for Standard, Volvo Penta, MTU ADEC, GM/Doosan, Cummins, or MTU Smart Connect.)
            - DPF MANUAL REGEN
            - DPF REGEN DISABLE
        - SPEED SELECT (Visible when ECU is configured for Volvo Penta.)
        - ACCEL POSITION (Visible when ECU is configured for Volvo Penta.)
        - MODULE TYPE (Visible when ECU is configured for MTU MDEC or MTU ECU7/ECU8.)
        - ALIVE MSG (Visible when ECU is configured for MTU MDEC or MTU ECU7/ECU8.)
        - SPEED SETUP (Visible when ECU is configured for (MTU ADEC, MTU MDEC 304, MTU ECU7/ECU8, or MTU Smart Connect.)

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- J1939 RPM ENABLE (Visible when ECU is configured for Standard, Volvo Penta, MTU ADEC, GM/Doosan, Cummins, or MTU Smart Connect.)
- ENGINE RPM
- RPM BAND WIDTH
- IDLE RPM
- SPEED UP (Visible when ECU is configured for MTU ADEC, MTU MDEC 304, MTU ECU7/ECU8, or MTU Smart Connect.)
- SPEED DN (Visible when ECU is configured for MTU ADEC, MTU MDEC 304, MTU ECU7/ECU8, or MTU Smart Connect.)
- TEST OVRSPEED (Visible when ECU is configured for MTU ADEC, MTU MDEC 304, MTU ECU7/ECU8, or MTU Smart Connect.)
- SPD DMAND SRC (Visible when ECU is configured for MTU MDEC 304, MTU ECU7/ECU8, or MTU Smart Connect.)
- IDLE REQUEST (Visible when ECU is configured for MTU MDEC 304, MTU ECU7/ECU8, or MTU Smart Connect.)
- INCREASE IDLE (Visible when ECU is configured for MTU MDEC 304, or MTU ECU7/ECU8.)

- ECU SETUP (Visible when ECU is configured for MTU ADEC, MTU ECU7/ECU8, or MTU Smart Connect.)
  - TRIP RESET (Visible when ECU is configured for MTU ECU7/ECU8.)
  - INT OIL PRIME
  - GOV PRM SW (Visible when ECU is configured for MTU ADEC or MTU Smart Connect.)
  - ENG STRT PRIME (Visible when ECU is configured for MTU ECU7/ECU8.)
  - FAN OVERRIDE (Visible when ECU is configured for MTU ECU7/ECU8.)
  - MODE SWITCH (Visible when ECU is configured for MTU ECU7/ECU8.)
  - GOV PARAM SET (Visible when ECU is configured for MTU ECU7/ECU8.)
  - CAN RATING SW 1 (Visible when ECU is configured for MTU ECU7/ECU8.)
  - CAN RATING SW 2 (Visible when ECU is configured for MTU ECU7/ECU8.)
  - DIS CYL CUT 1 (Visible when ECU is configured for MTU ECU7/ECU8.)
  - DIS CYL CUT 2 (Visible when ECU is configured for MTU ECU7/ECU8 or MTU Smart Connect.)
  - OPERATING MODE (Visible when ECU is configured for MTU Smart Connect.)

- **MODEM SETUP**
  - DIALOUT X (X = 1 TO 4)
  - PAGER ID X (X = 1 TO 4)
  - RINGS FOR ANSWER
  - OFFLN DELAY
  - DIALOUT DLY
  - PGR BUFF LMT
  - PGR COM
- **RS485 SETUP**
  - COMM BAUD
  - COMM PARITY
  - MODBUS ADDR
  - LEGACY MODBUS

SYSTEM PARAMS

- **SYSTEM SETTINGS**
  - GEN CONNECT
  - BUS CONNECT
  - RATED kW
  - RATED VOLTS
  - RATED FREQ
  - ALTRNATE FRQ
  - RATED RPM
  - RATED PF
  - ROTATION
  - SYSTEM TYPE

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- EPS
  - EPS THRESHLD
  - LOW LINE SF (Visible when an input is selected for the Low Line Override programmable function.)
- FUEL LEVEL SETUP
  - FUEL LVL TYP
  - FUEL LVL SRC (Visible when AEM-2020 is enabled)
  - FL MAX ALG % (Visible when AEM-2020 is enabled)
  - FL MIN ALG % (Visible when AEM-2020 is enabled)
- SYSTEM UNITS
- PRESSURE UNITS (Visible when Metric is selected for System Units.)
- BATTERY VOLT
- FLYWHL TEETH
- SPEED SOURCE
- MAINT RESET
- NFPA LEVEL
- POWER UP DELAY

- **REMOTE MODULE SETUP**
  - LSM SETUP
    - ENABLE
    - CAN Bus ADDRESS (Visible when LSM-2020 is enabled.)
    - AUX IN SRC
    - VERSION INFO (Visible when LSM-2020 is enabled.)
      - FIRMWARE VERSION
      - BOOT CODE VERSION
    - TCP/IP SETTINGS (Visible when LSM-2020 is enabled.)
      - IP ADDRESS
      - SUBNET MASK
      - GATEWAY ADDRESS
      - DHCP ENABLE
    - LOAD SHARE DEBUG (Visible when LSM-2020 is enabled.)
      - FDBK VOLT
      - AUX VOLT
      - AUX CURR
      - SPEED BIAS
      - VOLT BIAS
      - WATT DEMAND
      - kW TOTAL
      - RATED kW
      - var DEMAND
      - kvar TOTAL
      - RATED kvar
      - LSM RT BIN
      - DGC RT BIN
  - CEM SETUP
    - ENABLE
    - OUTPUTS (Visible when CEM-2020 is enabled.)
    - CAN Bus ADDR (Visible when CEM-2020 is enabled.)
    - VERSION INFO (Visible when CEM-2020 is enabled.)
      - FIRMWARE VERSION
      - BOOT CODE VERSION
      - SERIAL NUMBER
      - PART NUMBER
      - MODEL NUMBER
      - BUILD DATE
    - CEM DEBUG MENU (Visible when CEM-2020 is enabled.)
      - DGC TO CEM BP
      - CEM TO DGC BP
  - AEM SETUP
    - ENABLE
    - CAN Bus ADDR (Visible when AEM-2020 is enabled.)
    - VERSION INFO (Visible when AEM-2020 is enabled.)
      - FIRMWARE VERSION
      - BOOT CODE VERSION
      - SERIAL NUMBER
      - PART NUMBER

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            - MODEL NUMBER
            - BUILD DATE
        - AEM DEBUG MENU (Visible when AEM-2020 is enabled.)
            - DGC TO AEM BP
            - AEM TO DGC BP
            - ANALOG INPUTS
                - SCALED
                    - ALG IN X (X = 1 TO 8)
                - RAW
                    - ALG IN X (X = 1 TO 8)
            - THERMAL INPUTS
                - SCALED
                    - RTD IN X (X = 1 TO 8
                    - THRM CPL X (X = 1 TO 2)
                    - AMBIENT
                - RAW
                    - RTD IN X (X = 1 TO 8
                    - THRM CPL X (X = 1 TO 2)
            - ANALOG OUTPUTS
                - SCALED
                    - ALG OUT X (X = 1 TO 4)
                - RAW
                    - ALG OUT X (X = 1 TO 4)
- **CRANK SETTINGS**
    - DISCNCT LMIT
    - PRECRNK DELY
    - PRESTRT CNTCT
    - STYLE
    - # CYCLES (Visible when Cycle is selected for Cranking Style.)
    - CONT TIME (Visible when Continuous is selected for Cranking Style.)
    - CYCLE TIME
    - COOLDWN TIME
    - OFF MODE COOLDN
    - PRESTART REST CONFIG
        - CONF
    - OIL PRS CRANK DISC
        - ENABLE
        - CRANK DISC PRS
- **AUTOMATIC RESTART**
    - ENABLE
    - ATTEMPTS
    - INTERVAL
- **EXERCISE TIMER**
    - MODE
    - RUN WITH LOAD
    - START HOUR
    - START MINUTE
    - RUN HOURS
    - RUN MINUTES
- **SENSING TRANS**
    - GEN PT PRI V
    - GEN PT SEC V
    - GEN CT PRI A
    - CT LOW LINE SF (Visible when an input is selected for the Low Line Override programmable function.)
    - BUS PT PRI V
    - BUS PT SEC V
- **RELAY CONTROL**
    - START
    - RUN
    - PRESTART
- **AUTO CONFIG DETECT**
    - ENABLE
    - LOW LINE THRESH
    - 1-PH THRESH
    - 1-PH GEN CONN
- **ENGINE STATISTICS**
    - START YEAR
    - START MONTH

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- START DAY
- # STARTS
- HRS TO MAINT
- kW-HRS
- TOTAL HRS
- LOADED HRS
- UNLOADED HRS

PROGRAMMABLE INPUTS

- **CONFIGURABLE INPUTS**
  - INPUT X (X = 1 to 26)
    - ALARM CONFIG
    - ACTIVATN DLY
    - RECOGNITION
    - NAME
- **PROG FUNCTIONS**
  - AUTO XFER SWITCH
    - INPUT
  - GRND DELTA O-RIDE
    - INPUT
    - RECOGNITION (Visible when an INPUT is selected.)
  - BATTLE OVERRIDE
    - INPUT
    - RECOGNITION (Visible when an INPUT is selected.)
  - LOW LINE OVERRIDE
    - INPUT
    - RECOGNITION (Visible when an INPUT is selected.)
  - 1 PHASE O-RIDE
    - INPUT
    - RECOGNITION (Visible when an INPUT is selected.)
    - 1 PH O-RIDE CFG (Visible when an INPUT is selected.)
  - 1 PHASE AC O-RIDE
    - INPUT
    - RECOGNITION (Visible when an INPUT is selected.)
  - BATT CHRG FAIL
    - INPUT
    - ALARM CONFIG (Visible when an INPUT is selected.)
    - ACTIVATN DLY (Visible when an INPUT is selected.)
  - LOW COOL LEVEL
    - INPUT
    - ALARM CONFIG (Visible when an INPUT is selected.)
    - ACTIVATN DLY (Visible when an INPUT is selected.)
  - FUEL LEAK DETECT
    - INPUT
    - ALARM CONFIG (Visible when an INPUT is selected.)
    - ACTIVATN DLY (Visible when an INPUT is selected.)
- **LSM INPUTS** (Visible when LSM-2020 is enabled.)
  - ALG IN 1
    - INPUT TYPE
    - MIN VOLTAGE
    - MAX VOLTAGE
    - MIN CURRENT
    - MAX CURRENT
- **ANALOG INPUTS** (Visible when AEM-2020 is enabled.)
  - ALG IN X (X = 1 to 8)
    - INPUT TYPE
    - MIN VOLTAGE
    - MAX VOLTAGE
    - MIN CURRENT
    - MAX CURRENT
    - PARAM MIN
    - PARAM MAX
    - OVER 1
      - THRESHOLD
      - ALARM CONFIG
    - OVER 2
      - THRESHOLD

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            - ALARM CONFIG
        - UNDER 1
            - THRESHOLD
            - ALARM CONFIG
        - UNDER 2
            - THRESHOLD
            - ALARM CONFIG
        - ARMING DELAY
        - THR1 ACT DLY
        - THR2 ACT DLY
        - HYSTERESIS
        - OOR ALM CFG
        - NAME
- **THERMAL INPUTS** (Visible when AEM-2020 is enabled.)
    - RTD IN X (X = 1 to 8)
        - TYPE
        - OVER 1
            - THRESHOLD
            - ALARM CONFIG
        - OVER 2
            - THRESHOLD
            - ALARM CONFIG
        - UNDER 1
            - THRESHOLD
            - ALARM CONFIG
        - UNDER 2
            - THRESHOLD
            - ALARM CONFIG
        - ARMING DELAY
        - THR1 ACT DLY
        - THR2 ACT DLY
        - HYSTERESIS
        - OOR ALM CFG
        - NAME
    - THRM CPL X (X = 1 to 2)
        - OVER 1
            - THRESHOLD
            - ALARM CONFIG
        - OVER 2
            - THRESHOLD
            - ALARM CONFIG
        - UNDER 1
            - THRESHOLD
            - ALARM CONFIG
        - UNDER 2
            - THRESHOLD
            - ALARM CONFIG
        - ARMING DELAY
        - THR1 ACT DLY
        - THR2 ACT DLY
        - HYSTERESIS
        - OOR ALM CFG
        - NAME

PROGRAMMABLE OUTPUTS

- **OUTPUTS**
    - OUTPUT X (X = 1 to 12) (X = 1 to 36 when CEM-2020 is enabled.)
        - NAME
- **CONFIG ELEMENTS**
    - CONFIG ELEMENT X (X = 1 to 8)
        - ALARM CONFIG
        - ACTIVATN DLY
        - RECOGNITION
        - NAME
- **ANALOG OUTPUTS** (Visible when AEM-2020 is enabled.)
    - ANALOG OUTPUT X (X = 1 to 4)
        - OUTPUT TYPE

            - MIN VOLTAGE
            - MAX VOLTAGE
            - MIN CURRENT
            - MAX CURRENT
            - PARAM MIN
            - PARAM MAX
            - OOR ALM CFG
            - OOR ACT DLY
            - PARAM

CONFIG PROTECTION

- **SCALE FACTORS**
    - ALT FREQ SF
    - VOLT LO LINE SF
    - AMPS LO LINE SF
- **CONFIG PROT X (X = 1 to 9)**
    - PARAM
    - OVER 1
        - THRESHOLD
        - ALARM CONFIG
    - OVER 2
        - THRESHOLD
        - ALARM CONFIG
    - UNDER 1
        - THRESHOLD
        - ALARM CONFIG
    - UNDER 2
        - THRESHOLD
        - ALARM CONFIG
    - ARMING DELAY
    - THR1 ACT DLY
    - THR2 ACT DLY
    - HYSTERESIS
    - NAME

ALARM CONFIGURATION

- **HORN CONFIGURATION**
    - HORN
    - NOT IN AUTO HORN
- **PRE-ALARMS**
    - HIGH COOLANT TEMP
        - ENABLE
        - THRESHOLD
    - LOW COOLANT TEMP
        - ENABLE
        - THRESHOLD
    - LOW OIL PRESSURE
        - ENABLE
        - THRESHOLD
    - LOW FUEL LEVEL
        - ENABLE
        - THRESHOLD
    - ENGINE OVERLOAD
        - ENG kW OVRLD-X (X = 1 to 3)
            - ENABLE
            - LOW LINE SF (Visible when an input is selected for the Low Line Override programmable function.)
            - 3 PHASE SETTINGS
                - THRESHOLD
                - HYSTERESIS

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- 1 PHASE SETTINGS
  - THRESHOLD
  - HYSTERESIS
- MAINTENANCE INTERVAL
  - ENABLE
  - THRESHOLD
- BATTERY OVERVOLTAGE
  - ENABLE
  - THRESHOLD
- LOW BATTERY VOLTAGE
  - ENABLE
  - THRESHOLD
  - ACTIVATN DLY
- WEAK BATTERY VOLTAGE
  - ENABLE
  - THRESHOLD
  - ACTIVATN DLY
- HIGH FUEL LEVEL
  - ENABLE
  - THRESHOLD
  - ACTIVATN DLY
- ACTIVE DTC (Visible when DTC is enabled.)
  - ENABLE
- ECU COMMS FAIL (Visible when CAN bus is enabled.)
  - ENABLE
- COOLANT LEVEL (Visible when CAN bus is enabled.)
  - ENABLE
  - THRESHOLD
- AVR OUTPUT LIMIT (Visible when LSM-2020 is enabled.)
  - ENABLE
  - ACTIVATN DLY
- GOV OUTPUT LIMIT (Visible when LSM-2020 is enabled.)
  - ENABLE
  - ACTIVATN DLY
- INTERGENSET COMM FAIL (Visible when LSM-2020 is enabled.)
  - ENABLE
- LSM COMM FAIL (Visible when LSM-2020 is enabled.)
  - ENABLE
- CEM COMM FAIL (Visible when CEM-2020 is enabled.)
  - ENABLE
- AEM COMM FAIL (Visible when AEM-2020 is enabled.)
  - ENABLE
- ID MISSING (Visible when LSM-2020 is enabled.)
  - ENABLE
- ID REPEAT (Visible when LSM-2020 is enabled.)
  - ENABLE
- CHECKSUM FAIL
  - ENABLE
- SYNC FAIL PALM
  - ENABLE
- BRK CLOSE FAIL PALM
  - ENABLE
  - MONITOR
- BRK OPEN FAIL PALM
  - ENABLE
  - MONITOR
- REVERSE ROTATION
  - ENABLE

- **ALARMS**
  - HIGH COOLANT TEMP
    - ENABLE
    - THRESHOLD
    - ARMING DELAY
  - LOW OIL PRESSURE
    - ENABLE
    - THRESHOLD
    - ARMING DELAY
  - LOW FUEL LEVEL

            - ENABLE
            - THRESHOLD
            - ACTIVATN DLY
    - OVERSPEED
        - ENABLE
        - THRESHOLD
        - ACTIVATN DLY
    - COOLANT LEVEL (Visible when CAN bus is enabled.)
        - ENABLE
        - THRESHOLD

> **NOTE**
>
> The HIGH COOLANT TEMP and LOW OIL PRESSURE alarms have an ARMING DELAY setting that disables the alarm for the specified time after engine startup.

- **SENDER FAIL**
    - COOL TEMP SENDR FAIL
        - CONFIG TYPE
        - ACTIVATN DLY
    - OIL PRESS SENDR FAIL
        - CONFIG TYPE
        - ACTIVATN DLY
    - FUEL LEVL SENDR FAIL
        - CONFIG TYPE
        - ACTIVATN DLY
    - VOLTAGE SENSE FAIL
        - CONFIG TYPE
        - ACTIVATN DLY
    - SPEED SENDR FAIL
        - TIME DELAY

GENERATOR PROTECTION

- **27 UNDERVOLTAGE**
    - 27-1 / 27-2
        - LOW LINE SF (Visible when an input is selected for the Low Line Override programmable function.)
        - 3 / 1 PHASE SETTINGS
            - PICKUP
            - HYSTERESIS
            - TIME DELAY
            - FREQ INHIBIT
            - ALARM CONFIG
- **59 OVERVOLTAGE**
    - 59-1 / 59-2
        - LOW LINE SF (Visible when an input is selected for the Low Line Override programmable function.)
        - 3 / 1 PHASE SETTINGS
            - PICKUP
            - HYSTERESIS
            - TIME DELAY
            - ALARM CONFIG
- **47 PHASE IMBALANCE (Optional)**
    - PICKUP
    - HYSTERESIS
    - TIME DELAY
    - ALARM CONFIG
    - LOW LINE SF (Visible when an input is selected for the Low Line Override programmable function.)
- **81 O/U FREQUENCY**
    - UNDERFREQUENCY
        - INHIBIT VOLTS
        - PICKUP
        - HYSTERESIS
        - TIME DELAY

- ALARM CONFIG
- OVERFREQUENCY
  - PICKUP
  - HYSTERESIS
  - TIME DELAY
  - ALARM CONFIG
- ALTRNT FRQ SCALE FCTR
  - ALT FREQ SF
- **51 OVERCURRENT (Optional)**
  - 51-1 / 51-2 / 51-3
    - LOW LINE SF (Visible when an input is selected for the Low Line Override programmable function.)
    - 3 / 1 PHASE SETTINGS
      - PICKUP
      - TIME DIAL
      - CURVE
      - ALARM CONFIG
      - RESET TYPE
    - PROG CURVE CONSTANTS
      - A
      - B
      - C
      - N
      - R
- **32 REVERSE POWER**
  - 3 / 1 PHASE SETTINGS
    - PICKUP
    - HYSTERESIS
    - TIME DELAY
    - ALARM CONFIG
- **40 LOSS OF EXCITATION**
  - 3 / 1 PHASE SETTINGS
    - PICKUP
    - HYSTERESIS
    - TIME DELAY
    - ALARM CONFIG
- **LOSS OF MAINS PROTECT (Optional)**
  - 78 VECTOR SHIFT
    - PICKUP
    - ALARM CONFIG
    - OPEN MAINS ON TRP
    - OPEN GEN ON TRP
  - 81 ROCOF
    - PICKUP
    - TIME DELAY
    - ALARM CONFIG
    - OPEN MAINS ON TRP
    - OPEN GEN ON TRP

BREAKER MANAGEMENT

- **BREAKER HARDWARE**
  - MAINS FAIL TRANSFER
    - ENABLE
    - RETURN DELAY
    - TRANSFER DELAY
    - MAX TRANSFER TIME
    - TRANSFER TYPE
    - IN PHASE MON EN
    - MAX PARALLEL TIME
  - CLOSE WAIT TIME
    - TIME
  - GEN BREAKER
    - CONTINUOUS
    - CLOSING TIME
    - DEAD BUS CL ENBL
    - DEAD GEN CL ENBL
    - OPEN CMD

    - CLOSE CMD
  - MAINS BREAKER
    - CONFIGURED
    - CONTINUOUS (Visible when configured.)
    - CLOSING TIME (Visible when configured.)
    - OPEN CMD (Visible when configured.)
    - CLOSE CMD (Visible when configured.)
  - BRK CLOSE FAIL PALM
  - BRK OPEN FAIL PALM
- **BUS CONDITION DETECT**
  - GEN DEAD
    - THRESHOLD
    - TIME DELAY
  - GEN STABLE
    - OV PICKUP
    - OV DROPOUT
    - UV PICKUP
    - UV DROPOUT
    - OF PICKUP
    - OF DROPOUT
    - UF PICKUP
    - UF DROPOUT
    - TIME DELAY
    - LOW LINE SF (Visible when an input is selected for the Low Line Override programmable function.)
    - ALT FREQ SF
  - GEN FAILED
    - TIME DELAY
  - BUS DEAD
    - THRESHOLD
    - TIME DELAY
  - BUS STABLE
    - OV PICKUP
    - OV DROPOUT
    - UV PICKUP
    - UV DROPOUT
    - OF PICKUP
    - OF DROPOUT
    - UF PICKUP
    - UF DROPOUT
    - TIME DELAY
    - LOW LINE SF (Visible when an input is selected for the Low Line Override programmable function.)
    - ALT FREQ SF
  - BUS FAILED
    - TIME DELAY
- **SYNCHRONIZER (Optional)**
  - TYPE
  - SLIP FREQ
  - MIN SLIP CTL LMT
  - MAX SLIP CTL LMT
  - VOLT WINDOW
  - CLOSING ANGLE
  - VG>VB
  - TIME DELAY
  - FAIL DELAY
  - VOLT GAIN
  - SPEED GAIN
  - SYNC FAIL PALM

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BIAS CONTROL

- **AVR BIAS CONTROL**
  - OUTPUT (Visible when LSM-2020 is enabled.)
    - TYPE
  - CONTACT (Visible when LSM-2020 is disabled or when LSM-2020 is enabled and OUTPUT TYPE = CONTACT.)
    - TYPE
    - CORRECTION PULSE (Visible when OUTPUT TYPE = CONTACT and CONTACT TYPE = PROPORTIONAL.)
      - WIDTH
      - INTERVAL
  - VOLT CONTROL (Visible when LSM-2020 is enabled.)
    - VOLT CTRL GAINS
      - KP
      - KI (Visible when OUTPUT TYPE = ANALOG.)
      - KD (Visible when OUTPUT TYPE = ANALOG.)
      - TD (Visible when OUTPUT TYPE = ANALOG.)
      - LOOP GAIN (Visible when OUTPUT TYPE = ANALOG.)
    - VOLTAGE TRIM
      - ENABLE
      - DEADBAND
      - VOLT TRIM SETPT RATED VOLTS (Rev 3 hardware only.)
      - RMT VLT BIAS (Rev 3 hardware only.)
      - VOLT TRM BIAS (Rev 3 hardware only.)
  - VAR CTRL
    - DROOP
    - DROOP GAIN
    - var CTRL ENABLE (Visible when LSM-2020 is enabled.)
    - var CTRL MODE (Visible when LSM-2020 is enabled.)
    - KP (Visible when LSM-2020 is enabled.)
    - RAMP RATE (Visible when LSM-2020 is enabled.)
    - kvar SETPT (Visible when LSM-2020 is enabled.)
    - kvar SRC (Visible when LSM-2020 is enabled.)
    - kvar ALG MAX (Visible when LSM-2020 is enabled.)
    - kvar ALG MIN (Visible when LSM-2020 is enabled.)
    - PF SETPT (Visible when LSM-2020 is enabled.)
    - PF SRC (Visible when LSM-2020 is enabled.)
    - PF ALG MAX (Visible when LSM-2020 is enabled.)
    - PF ALG MIN (Visible when LSM-2020 is enabled.)
    - KI (Visible when LSM-2020 is enabled and OUTPUT TYPE = ANALOG.)
    - KD (Visible when LSM-2020 is enabled and OUTPUT TYPE = ANALOG.)
    - TD (Visible when LSM-2020 is enabled and OUTPUT TYPE = ANALOG.)
    - LOOP GAIN (Visible when LSM-2020 is enabled and OUTPUT TYPE = ANALOG.)
- **GOV BIAS CONTROL**
  - OUTPUT (Visible when LSM-2020 is enabled.)
    - TYPE
  - CONTACT (Visible when LSM-2020 is disabled or when LSM-2020 is enabled and OUTPUT TYPE = CONTACT.)
    - TYPE
  - SPEED CONTROL
    - SPEED CTRL GAINS
      - KP
      - KI (Visible when LSM-2020 is enabled and OUTPUT TYPE = ANALOG.)
      - KD (Visible when LSM-2020 is enabled and OUTPUT TYPE = ANALOG.)
      - TD (Visible when LSM-2020 is enabled and OUTPUT TYPE = ANALOG.)
      - LOOP GAIN (Visible when LSM-2020 is enabled and OUTPUT TYPE = ANALOG.)
    - SPEED TRIM
      - ENABLE
      - SETPOINT
      - DEADBAND
      - RMT SPD BIAS
      - SPEED BIAS
  - kW CTRL
    - LOAD CTRL ENABLE (Visible when LSM-2020 is enabled.)
    - LOAD SHARE (Visible when LSM-2020 is enabled.)
    - KP (Visible when LSM-2020 is enabled.)

        - KI (Visible when LSM-2020 is enabled and OUTPUT TYPE = ANALOG.)
        - KD (Visible when LSM-2020 is enabled and OUTPUT TYPE = ANALOG.)
        - TD (Visible when LSM-2020 is enabled and OUTPUT TYPE = ANALOG.)
        - LOOP GAIN (Visible when LSM-2020 is enabled and OUTPUT TYPE = ANALOG.)
        - DROOP
        - DROOP GAIN
        - RAMP RATE (Visible when LSM-2020 is enabled.)
        - BASELOAD LVL (Visible when LSM-2020 is enabled.)
        - BL LV SRC (Visible when LSM-2020 is enabled.)
        - PF SRC (Visible when LSM-2020 is enabled.)
        - BL ALG MAX (Visible when LSM-2020 is enabled.)
        - BL ALG MIN (Visible when LSM-2020 is enabled.)
        - BRKR OPEN PT (Visible when LSM-2020 is enabled.)
- **CONTROL DEBUG** (Visible when LSM-2020 is enabled.)
    - kW RAMP
    - kW RAMP DMD
    - WATT DEMAND
    - SPEED PID
    - kW PID
    - SPEED ERR
    - kW ERR
    - SPEED BIAS
    - PF SETPT
    - kvar RAMP
    - var RAMP DMD
    - var DEMAND
    - VOLT PID
    - kvar PID
    - VOLT ERR
    - kvar ERR
    - VOLT BIAS

MULTIGEN MANAGEMENT (Visible when LSM-2020 is enabled.)

- **AVR ANALOG OUTPUT**
    - OUTPUT TYPE
    - MIN OUTPUT
    - MAX OUTPUT
    - VOLT RESPONSE
- **GOV ANALOG OUTPUT**
    - OUTPUT TYPE
    - MIN OUTPUT
    - MAX OUTPUT
    - SPD RESPONSE
- **LOAD SHARE LINE**
    - MIN VOLTAGE
    - MAX VOLTAGE
- **DEMAND START STOP**
    - ENABLE
    - START TD 1
    - START TD 2
    - STOP TD
    - START LVL 1
    - START LVL 2
    - STOP LVL
- **SEQUENCING**
    - SEQUENCE ID
    - MODE
    - MAX GEN START
    - MAX GEN STOP
    - LAST UNIT SHUTDN
- **NETWORK CONFIG**
    - EXP SEQ ID X (X = 1 TO 16)

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LOGIC TIMERS

- **TIMER X (X = 1 to 10)**
    - HOURS
    - MINUTES
    - SECONDS

ENTER PASSWORD

LOGOUT (Visible when logged in through the front panel.)

Breaker Hardware One-Line Diagram

A one-line diagram of the breaker hardware configuration can be displayed on the front panel. This diagram changes in real time to reflect the current state of the configured breakers. The breaker hardware one-line diagram is disabled by default. To display the breaker hardware one-line diagram using front panel controls, navigate to Settings > General Settings > Front Panel HMI > One-Line Diagram and enable the setting. If using BESTCOMS*Plus,* navigate to Settings Explorer, General Settings, Front Panel HMI and select Enable on the One-Line Diagram setting.

Once enabled, the one-line diagram appears on both the front panel Summary and Main Menu screens. The One-Line Diagram Menu screen provides metering for mains fail transfer, generator and bus parameters as well as breaker controls. To reach the One-Line Diagram Menu screen, go to the Main Menu and select the one-line diagram as you would a normal menu option and press the right arrow pushbutton. The one-line diagram, mains fail transfer state (if enabled), generator and bus parameters, and breaker controls are displayed respectively from the top of the menu.

Further mains fail transfer state metering is available by selecting the “MAINSFAIL XFER STATE” and pressing the right arrow pushbutton. Mains fail transfer state, transfer delay, return delay, max transfer time, max parallel time, and open transition delay are displayed.

To issue a breaker open or breaker close command, select the appropriate menu option, press Edit and select ON.

The ONE-LINE DIAGRAM screen options are shown in Figure 2-4. Figure 2-5, below, illustrates and describes the different configurations of the one-line diagram.

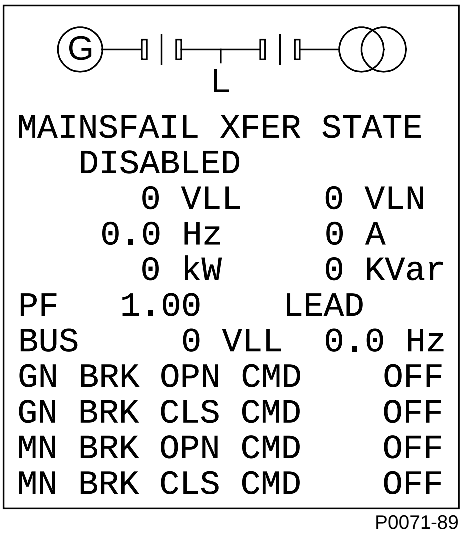
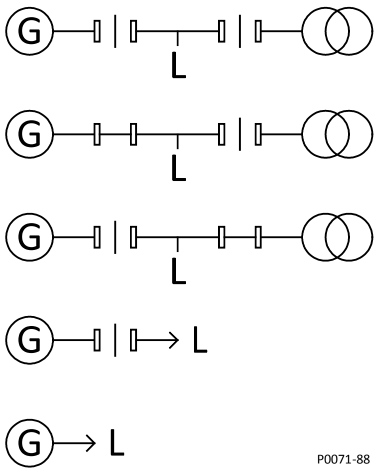


Figure 2-4. One-Line Diagram Menu Options (Available when One-Line Diagram is Enabled)



Generator and mains breakers are configured and both breakers are open.

Generator and mains breakers are configured. The generator breaker is closed and the mains breaker is open.

Generator and mains breakers are configured. The generator breaker is open and the mains breaker is closed.

Generator breaker is configured and open.

No breakers are configured.

Figure 2-5. Breaker Hardware One-Line Diagram

Generator Network Status Display

The status of the generator network is available on the front panel of each MGC-2000 Series when the generator is part of a multi-machine network. The *System Type* setting (found under Settings > System Parameters > System Settings) configures the machine to be part of a multi-machine network. When *System Type* is set to Multiple Generator, the machine is configured for participation in a multiple machine system.

Generator network status is found on the front panel under Metering > Alarms-Status > Network Status.

- System Manager - the sequencing ID of the machine that controls all dead bus arbitration and generator sequencing. This ID is always assigned to the machine on the network that has the lowest nonzero value of sequencing ID.
- Number of Units - the number of units on the generator network. The sequencing IDs of all machines on the network are listed as ID1:, ID2:, etc.

All machines on the network display the same value for System Manager and Number of Units. Each unit to be used as part of generator sequencing or dead bus breaker arbitration must have a unique nonzero sequencing ID. The ID Missing and ID Repeat pre-alarms annunciate when a machine is not configured for proper system operation.

The System Manager and Number of Units parameters display zero when the MGC-2000 Series is not communicating with an LSM-2020. The System Manager parameter displays –1 when a system manager is not present on the network (all unit IDs are zero).

Mains Fail Transfer Status Display

Mains Fail Transfer Status can be viewed in three locations, however, Mains Fail Transfer must first be enabled.

To enable Mains Fail Transfer, navigate to Settings > Breaker Management > Breaker Hardware > Mains Fail Transfer using the front panel controls or Settings Explorer, Breaker Management, Mains Fail using BESTCOMS*Plus*.

Mains Fail Transfer Status is displayed on the front panel in Metering > Alarms-Status > Mains Fail Transfer and also on the Breaker Hardware One-Line Diagram screen. It is displayed in BESTCOMS*Plus* on the Metering Explorer, Mains Fail Transfer Status screen.

These screens display the Mains Fail Transfer State and any timers relevant to the mains fail transfer process. These parameters are listed below.

Mains Fail Transfer State: The different mains fail transfer states are described below.

Power From Mains: Power is being supplied to the load from the mains bus.

Transfer Timer Active: Transfer Delay timer is actively counting.

Transferring to Gens: Load is being transferred to the generator bus.

Power From Gens: Power is being supplied to the load from the generator bus.

Return Timer Active: Return Delay timer is actively counting.

Transferring to Mains: Load is being transferred to the mains bus.

Disabled: MGC-2000 Series is in the OFF or RUN operating mode or in the alarm state.

Transfer Delay: Displays the current timer value in seconds.

Return Delay: Displays the current timer value in seconds.

Max Transfer Time: Displays the current timer value in seconds.

Max Parallel Time: Displays the current timer value in seconds.

Open Transition Delay: Displays the current timer value in seconds.

Note
The Mains Fail Transfer screen found at Metering > Alarms-Status > Mains Fail Transfer only shows timers that are actively counting and are relevant to mains fail transfer. They are not otherwise visible.

Rear Panel

All MGC-2000 Series terminals and connectors are located on the rear panel. Rear panel terminals and connectors, for hardware version 3, are illustrated in Figure 2-6. Table 2-2 lists the call-outs of Figure 2-6 along with a description of each connector type. Rear panel terminals and connectors, for hardware versions 1 and 2, are illustrated in Figure 2-7. Table 2-3 lists the call-outs of Figure 2-7 along with a description of each connector type. The MGC-2000 Series rear panel is shown in Figure 2-6 and Figure 2-7 with the rear cover removed.

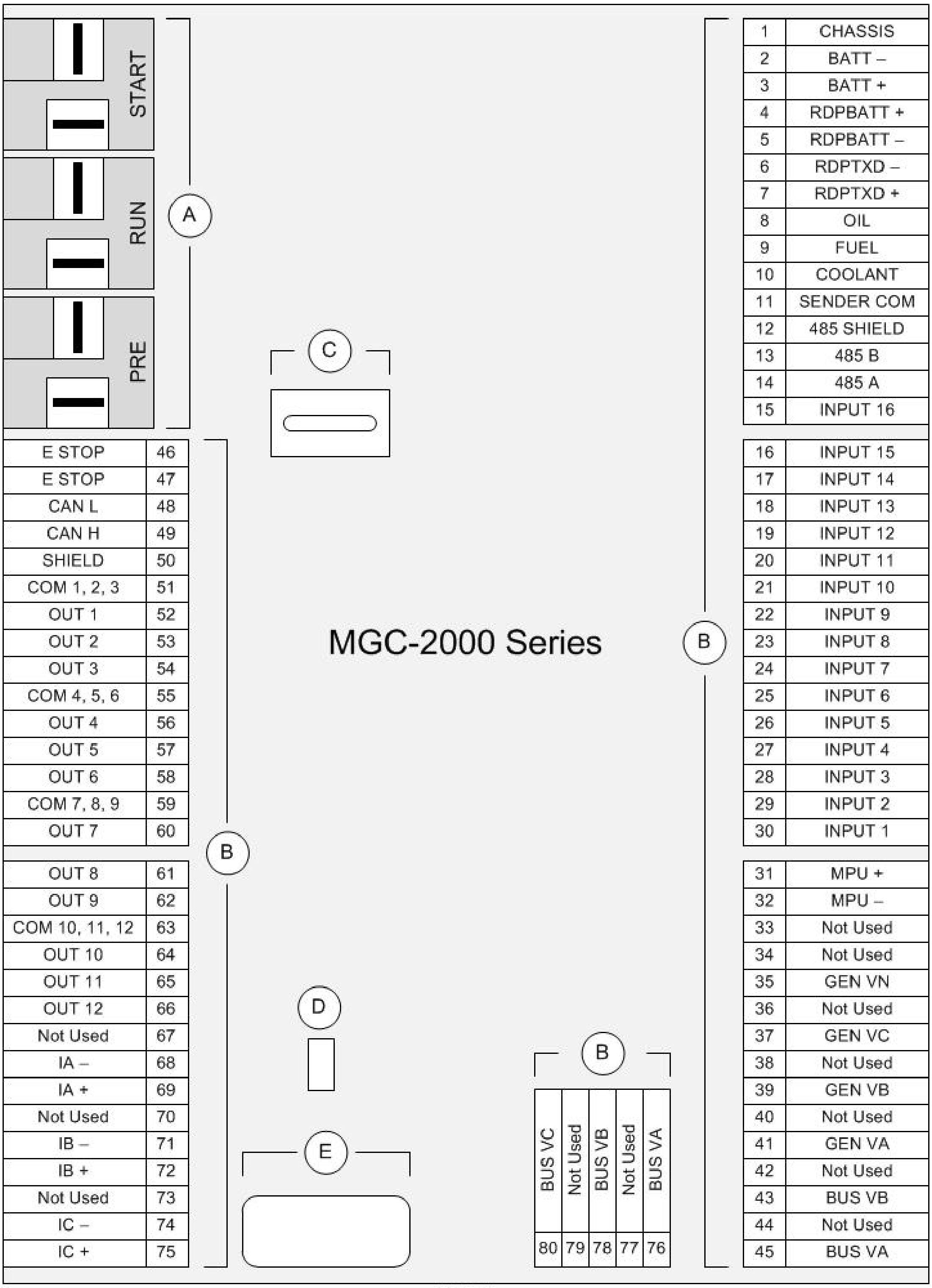


Figure 2-6. Rear Panel for MGC-2000 Series Hardware Version 3

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Table 2-2. Descriptions for Figure 2-6. Rear Panel for MGC-2000 Series Hardware Version 3

Locator	Description
A	Connections to the MGC-2000 Series Start (starter), Run (fuel solenoid), and Pre (glow plug) output contacts are made directly to each relay through quarter-inch, male, quick-connect terminals.
B	The majority of external, MGC-2000 Series wiring is terminated at 15-position connectors with compression terminals. These connectors plug into headers on the MGC-2000 Series. The connectors and headers have a dovetailed edge that ensures proper connector orientation. Each connector and header is uniquely keyed to ensure that a connector mates only with the correct header. Connector screw terminals accept a maximum wire size of 12 AWG. Bus sensing terminal 76 (BUS VA) is internally tied to terminal 45 (BUS VA) and terminal 78 (BUS VB) is internally tied to terminal 43 (BUS VB). This maintains backward compatibility with hardware versions 1 and 2 of the MGC-2000 Series.
C	The MGC-2000 Series provides a battery backup for the real-time clock. See Section 8, *Maintenance and Troubleshooting,* for instructions on replacing the battery. Failure to replace the battery with MTU Onsite Energy P/N 121826 may void the warranty.
D	The mini-B USB socket mates with a standard USB cable and is used with a PC running BESTCOMS*Plus*® software for local communication with the MGC-2000 Series.
E	MGC-2000 Series controllers equipped with the optional external modem port, connect to the user-supplied modem using a standard RS-232 cable.

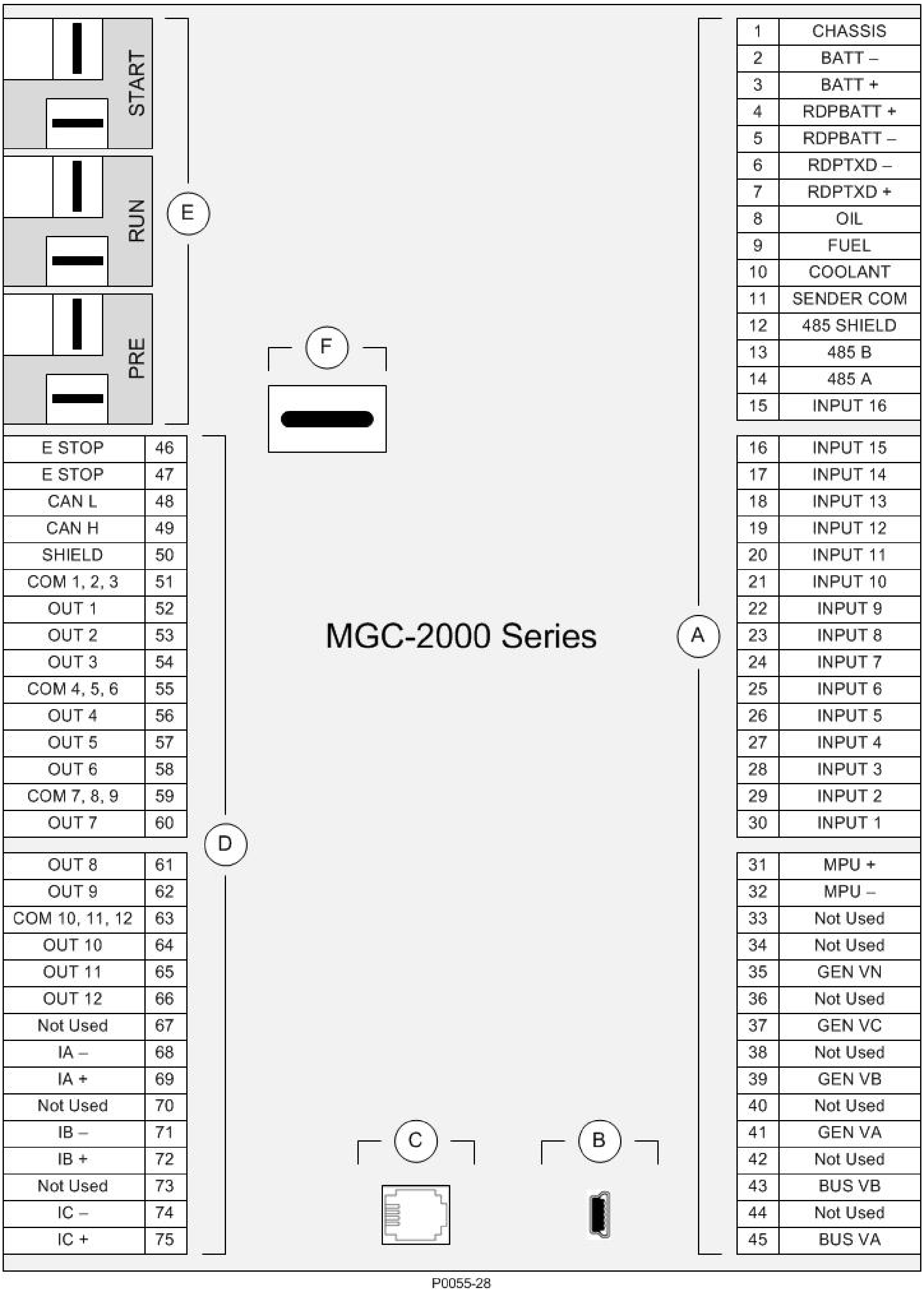

Figure 2-7. Rear Panel for MGC-2000 Series Hardware Versions 1 and 2

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Table 2-3. Descriptions for Figure 2-7. Rear Panel for MGC-2000 Series Hardware Versions 1 and 2

Locator	Description
A, D	The majority of external, MGC-2000 Series wiring is terminated at 15-position connectors with compression terminals. These connectors plug into headers on the MGC-2000 Series. The connectors and headers have a dovetailed edge that ensures proper connector orientation. Each connector and header is uniquely keyed to ensure that a connector mates only with the correct header. Connector screw terminals accept a maximum wire size of 12 AWG (3.31 mm^2).
B	The mini-B USB socket mates with a standard USB cable and is used with a PC running BESTCOMS*Plus*® software for local communication with the MGC-2000 Series.
C	MGC-2000 Series controllers equipped with an optional, internal, dial-out modem port, connect to a telephone line through a USOC RJ-11 jack.
E	Connections to the MGC-2000 Series Start (starter), Run (fuel solenoid), and Pre (glow plug) output contacts are made directly to each relay through quarter-inch, male, quick-connect terminals.
F	The MGC-2000 Series provides a battery backup for the real-time clock. See Section 8, *Maintenance and Troubleshooting,* for instructions on replacing the battery. Failure to replace the battery with Basler Electric P/N 38526 may void the warranty.

SECTION 3 • FUNCTIONAL DESCRIPTION

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Tables

SECTION 3 • FUNCTIONAL DESCRIPTION

Introduction

This section describes how the MGC-2000 Series functions. A detailed description of each function block is provided in the paragraphs under the heading of MGC-2000 Series Function Blocks.

MGC-2000 Series operating and metering features are described in Section 4, BESTCOMS*Plus*® *Software.*

MGC-2000 Series Function Blocks

To ease understanding, MGC-2000 Series functions are illustrated in the block diagram of Figure 3-1. The following paragraphs describe each function in detail.

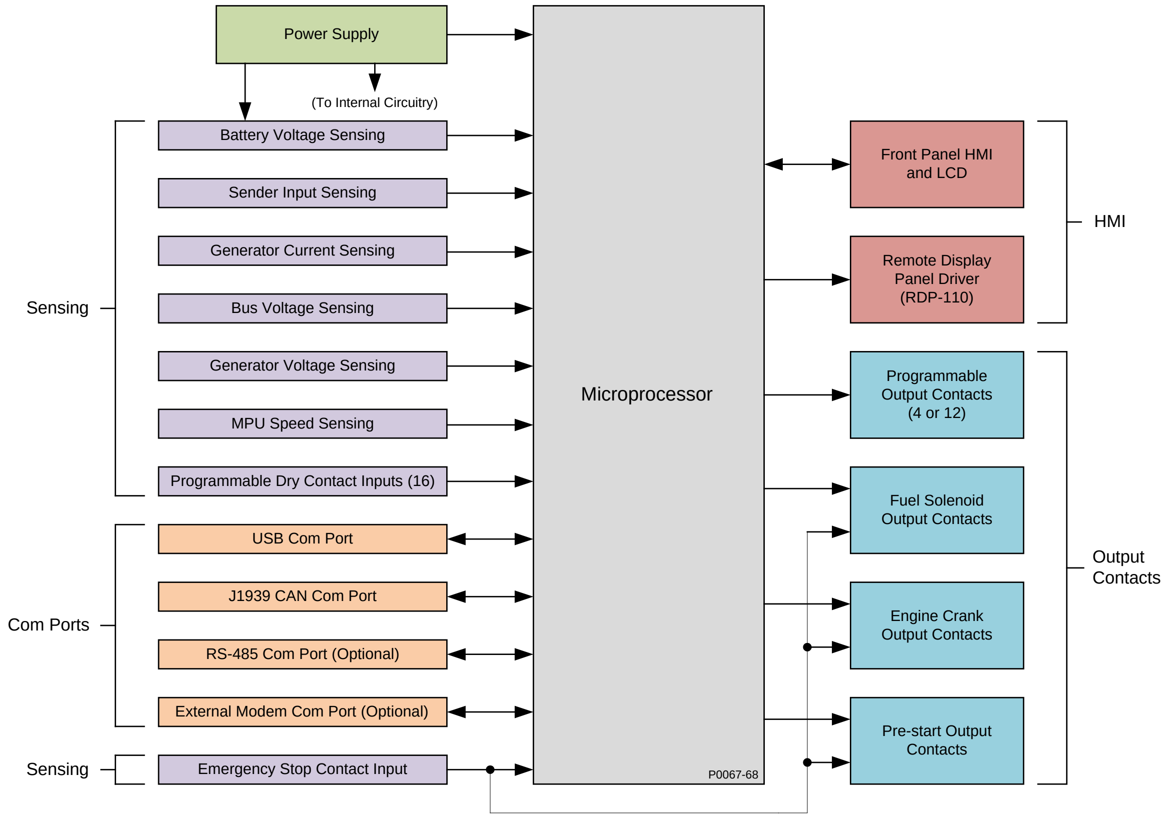

Figure 3-1. Function Block Diagram

Power Supply

The internal, switch-mode power supply uses the applied battery voltage to generate operating power for the internal circuitry of the MGC-2000 Series. The power supply accepts a nominal battery voltage of 12 or 24 Vdc and has an operating range of 6 to 32 Vdc. Battery voltage is applied to terminals 2 (–) and 3 (+). Operating power must be of the correct polarity. Although reverse polarity will not cause damage, the MGC-2000 Series will not operate.

Battery Voltage Sensing

Voltage applied to the power supply is filtered and reduced to a suitable level for sensing by the microprocessor.

Microprocessor

The microprocessor controls the overall functionality of the MGC-2000 Series and makes decisions based on programming and system inputs.

Circuits relating to the microprocessor inputs are described in the following paragraphs.

Zero Crossing Detection

The zero crossing of A-phase to B-phase or A-phase to C-phase (user-selectable) line voltage is detected and used to calculate the generator frequency. The zero crossing of A-phase to B-phase bus voltage is used to calculate the bus frequency.

Analog-to-Digital Converter

Scaled and conditioned signals representing the sensing voltage, sensing current, coolant temperature, fuel level, oil pressure, and battery voltage are digitized by the microprocessor's analog-to-digital converter. The digitized information is stored in random access memory (RAM) and used by the microprocessor for all metering and protection functions.

Watchdog Timer

The watchdog timer monitors the firmware executed by the microprocessor. If the firmware ceases normal operation, the watchdog timer will reset the microprocessor. After reset, the microprocessor will resume normal operation if the condition that caused the watchdog reset is no longer present. If the condition is still present, the unit will reset repeatedly until it can resume normal operation.

Generator Voltage Sensing Inputs

Voltages applied to the generator voltage sensing inputs are scaled to levels suitable for use by the internal circuitry. Generator voltage sensing configuration is menu-selectable.

The generator voltage sensing inputs accept a maximum voltage of 576 Vrms, line-to-line. Sensing voltage is applied to terminals 41 (A-phase), 39 (B-phase), 37 (C-phase), and 35 (neutral).

Bus Voltage Sensing Inputs

Voltage applied to the bus voltage sensing input is scaled to a level suitable for use by the internal circuitry.

The bus voltage sensing input accepts a maximum voltage of 576 Vrms. For hardware version 3, sensing voltage is applied to terminals 76 (A-phase), 78 (B-phase), and 80 (C-phase). For hardware versions 1 and 2, sensing voltage is applied to terminals 45 (A-phase) and 43 (B-phase).

In version 3 hardware, terminal 45 is internally tied to 76 and terminal 43 is internally tied to 78. This accommodates the use of connectors wired for legacy MGC-2000 Series versions.

Current Sensing Inputs

Generator currents are sensed and scaled to values suitable for use by the internal circuitry.

MGC-2000 Series controllers with 1 ampere current sensing (style number 1xxxxxxxx) accept a maximum current value of 1 Aac. MGC-2000 Series controllers with 5 ampere current sensing (style number 5xxxxxxxx) accept a maximum current value of 5 Aac. Sensing current is applied to terminals 68 (IA–) and 69 (IA+), 71 (IB–) and 72 (IB+), and 74 (IC–) and 75 (IC+).

Analog Engine Sender Inputs

Programmable analog engine sender inputs give the MGC-2000 Series user the flexibility to select the engine sender to be used in an application. Information about programming the sender inputs is provided in Section 4, BESTCOMS*Plus*® *Software*.

Oil Pressure

A current is provided to the oil pressure sender. The developed voltage is measured and scaled for use by the internal circuitry. An open circuit or short circuit across the oil pressure sender terminals will cause the MGC-2000 Series to indicate a failed sender. Oil pressure senders that are compatible with the MGC-2000 Series include Datcon model 02505-00, Isspro model R8919, and Stewart-Warner models 411K and 411M. Other senders may also be used. BESTCOMS*Plus*® software allows for the programming of sender characteristics. See Section 4, BESTCOMS*Plus*® *Software*, for more information.

Oil pressure sender connections are made at terminals 8 and 11 (sender common).

Coolant Temperature

A current is provided to the coolant temperature sender. The developed voltage is measured and scaled for use by the internal circuitry. An open circuit or short circuit across the coolant temperature sender terminals will cause the MGC-2000 Series to indicate a failed sender. Coolant temperature senders that are compatible with the MGC-2000 Series include Datcon model 02019-00, Faria model TS4042, Isspro model R8959, and Stewart-Warner model 334P. Other senders may be used. BESTCOMS*Plus*® software allows for the programming of sender characteristics. See Section 4, BESTCOMS*Plus*® *Software*, for more information.

Coolant temperature sender connections are made at terminals 10 and 11 (sender common).

Fuel Level

A current is provided to the fuel level sender. The developed voltage is measured and scaled for use by the internal circuitry. An open circuit or short circuit across the fuel level sender terminals will cause the MGC-2000 Series to indicate a failed sender. Fuel level senders that are compatible with the MGC-2000 Series include Isspro model R8925. Other senders may be used. BESTCOMS*Plus*® software allows for the programming of sender characteristics. See Section 4, BESTCOMS*Plus*® *Software*, for more information.

Fuel level sender connections are made at terminals 9 and 11 (sender common).

Speed Signal Inputs

The MGC-2000 Series uses signals from the generator voltage sensing inputs and magnetic pickup input to detect machine speed.

Generator Voltage Sensing Input

The generator voltage sensed by the MGC-2000 Series is used to measure frequency and can be used to measure machine speed.

Sensing voltage is applied to terminals 41 (A-phase), 39 (B-phase), 37 (C-phase), and 35 (Neutral).

Magnetic Pickup Input (MPU)

Voltage supplied by a magnetic pickup is scaled and conditioned for use by the internal circuitry as a speed signal source. The MPU input accepts a signal over the range of 3 to 35 volts peak and 32 to 10,000 hertz.

Magnetic pickup connections are provided at terminals 31 (+) and 32 (–).

Contact Inputs

The MGC-2000 Series has seventeen contact sensing inputs: an emergency stop input and 16 programmable inputs. Additional contact inputs can be accommodated with a CEM-2020 (Contact Expansion Module). Contact Basler Electric for availability and ordering information.

Emergency Stop Input

This input accepts Form B, dry contacts. An open circuit at this continuously monitored input initiates an emergency stop. An emergency stop removes operating power from the MGC-2000 Series Pre-Start, Run, and Fuel output relays.

Emergency stop contact connections are made at terminals 46 and 47.

Programmable Inputs

Each programmable input (Input 1 through Input 16) can be independently configured to perform the following functions. By default, each programmable input is disabled.

- Auto Transfer Switch
- Battery Charger Fail
- Battle Override
- Fuel Leak Detect
- Grounded Delta Override
- Low Coolant Level
- Low Line Override
- Single-Phase A-C Override
- Single-Phase Override

The programmable inputs accept dry contacts. A contact is connected between a programmable input and the negative side of the battery. Through BESTCOMS*Plus*®, each programmable contact input can be assigned a name (16 alphanumeric characters, maximum) and configured as an alarm input, a pre-alarm input, or neither. The default names for the inputs are INPUT_x (where x = 1 to 16). When a programmable contact input is closed, the front panel display shows the name of the closed input if it was programmed as an alarm or pre-alarm input. Alarm inputs are annunciated through the Normal display mode screens of the front panel. Pre-alarm inputs are annunciated through the pre-alarm metering screen of the front panel. If neither is programmed, no indication is given. Programming an input as neither is useful when a programmable input is used as an input to programmable logic.

Connections for the programmable inputs are provided at terminals 15 (Input 16) through 30 (Input 1). The negative side of the battery voltage (terminal 2) serves as the return connection for the programmable inputs.

Front Panel HMI

The front panel HMI provides a convenient interface for viewing system parameters and for controlling the MGC-2000 Series/generator set. Front panel HMI components include an LCD (liquid crystal display), LED (light emitting diodes) indicators, and pushbuttons.

LCD

The backlit LCD provides metering, pre-alarm, and alarm information. Detailed information about the LCD is provided in the *Software Operation* sub-section.

LED Indicators

The LEDs indicate pre-alarm and alarm conditions along with MGC-2000 Series status and generator status.

Pushbuttons

The pushbuttons are used to scroll through and select parameters displayed on the LCD, change setpoints, start and stop the generator, and reset alarms.

Remote Display Panel (Optional)

Applications that require remote annunciation can use Basler Electric's Remote Display Panel, RDP-110. Using the RDP-110 with the MGC-2000 Series meets the requirements of NFPA Standard 110. The RDP-110 uses a dedicated, four-terminal interface with the MGC-2000 Series. It communicates with the MGC-2000 Series via terminals 6 (RDP TXD–) and 7 (RDP TXD+) and receives power from terminals 4 (RDP BATT+) and 5 (RDP BATT-). Remote indication of many pre-alarm and alarm conditions is provided by the RDP-110.

The following pre-alarm conditions are indicated by LEDs on the RDP-110 front panel:

- Battery charger failure ∗†
- Battery overvoltage †
- High coolant temperature
- Low coolant temperature
- Low fuel level
- Low oil pressure
- Weak battery or low battery voltage

The following alarm conditions are indicated by LEDs and an audible alarm on the RDP-110 front panel:

- Low coolant level ∗
- High coolant temperature
- Low oil pressure
- Overcrank
- Overspeed
- Emergency stop
- Fuel leak/fuel sender failure ∗†
- Engine sender unit failure †

∗ Can be configured in the MGC-2000 Series as *None, Alarm,* or *Pre-Alarm.* See Section 4, BESTCOMS*Plus*® *Software, Programmable Inputs, Programmable Functions,* for more information. The light on the RDP-110 turns on when the input that is assigned to the programmable function is closed, whether the function is configured as *None, Alarm,* or *Pre-Alarm*.

† For MGC-2000 Series units loaded with firmware version X.14.00 and higher this LED is fully programmable via BESTlogic™*Plus*.

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Additionally, the RDP-110 indicates when the MGC-2000 Series is not operating in Auto mode and when the generator is supplying load. When the MGC-2000 Series is in an alarm state not listed above, the *Switch Not In Auto* LED lights and the horn sounds. For more information about the RDP-110, request product bulletin SNE.

RDP-110 communication connections are made at MGC-2000 Series terminals 6 (RDP TXD–) and 7 (RDP TXD+). RDP-110 operating power is supplied at MGC-2000 Series terminals 4 (RDP BATT+) and 5 (RDP BATT–).

Communication Ports

MGC-2000 Series communication ports include a USB jack, CAN terminals, optional RS-485 terminals, and an optional modem jack.

USB

The rear-panel, mini-B USB socket enables local communication with a PC running BESTCOMS*Plus*® software. The MGC-2000 Series is connected to a PC using a standard USB cable. BESTCOMS*Plus*® is a Windows® based communication software package that is supplied with the MGC-2000 Series. A detailed description of BESTCOMS*Plus*® is provided in Section 4, *BESTCOMSPlus® Software*.

CAN

A Controller Area Network (CAN) is a standard interface that enables communication between multiple controllers on a common network using a standard message protocol. MGC-2000 Series controllers have a CAN bus interface that supports the SAE J1939 protocol and the MTU protocol.

Applications using an engine-driven generator set controlled by an MGC-2000 Series may also have an Engine Control Unit (ECU). The CAN bus interface allows the ECU and MGC-2000 Series to communicate. The ECU reports operating information to the MGC-2000 Series through the CAN bus interface. Operating parameters and diagnostic information, if supported by the ECU, are decoded and displayed for monitoring.

The primary use of the CAN bus interface is to obtain engine operating parameters for monitoring speed, coolant temperature, oil pressure, coolant level, and engine hours without the need for direct connection to individual senders. Table 3-1 lists the ECU parameters and Table 3-2 lists the engine configuration parameters supported by the MGC-2000 Series CAN bus interface. These parameters are transmitted via the CAN bus interface at preset intervals. See the column labeled Update Rate in Table 3-1 for transmission rates. This information can also be transmitted upon user request.

CAN bus interface connections are made at 48 (CAN L), 49 (CAN H), and 50 (SHIELD).

Table 3-1. ECU Parameters Obtained from CAN bus Interface

ECU Parameter	Metric Units	English Units	Update Rate	* SPN
Actual Engine Percent Torque	%	%	Engine Speed Dependent	513
Aftertreatment 1 Diesel Particulate Filter Outlet Temperature	°C	°F	500 ms	3246
Air Filter Differential Pressure	kPa	psi	500 ms	107
Air Inlet Temperature	kPa	°F	1 s	172
Alarm Reset Feedback	Binary (0 or 1)		1 s	2815
Ambient Air Temperature	°C	°F	1 s	171
Auxiliary Pressure 1	kPa	psi	On Request	1387
Auxiliary Pressure 2	kPa	psi	On Request	1388
Barometric Pressure	kPa	psi	1 s	108
Battery Voltage	Vdc	Vdc	1 s	168
Boost Pressure	kPa	psi	500 ms	102
Charge Air Temperature	°C	°F	1 s	2629
Coolant Level	%	%	500 ms	111
Coolant Pressure	kPa	psi	500 ms	109
DEF Inducement Level - Level of Inducement Not to Run the Engine	%	%	1 s	5246

ECU Parameter	Metric Units	English Units	Update Rate	* SPN
DEF Severity Level - Severity of Tank Low Level	%	%	1 s	5245
DEF Tank 1 Level	%	%	1 s	1761
DEF Tank 2 Level	%	%	1 s	4367
ECU Temperature	°C	°F	1 s	1136
Engine Coolant Preheated State	Binary (0 or 1)		500 ms	3552
Engine Coolant Temperature	°C	°F	1 s	110
Engine Desired Operating Speed	rpm	rpm	250 ms	515
Engine Intake Manifold #1 Absolute Pressure	kPa	psi	500 ms	3563
Engine Intercooler Coolant Level	%	%	500 ms	3668
Engine Intercooler Temperature	°C	°F	1 s	52
Engine Oil Level	%	%	500 ms	98
Engine Oil Pressure	kPa	psi	500 ms	100
Engine Oil Temperature	°C	°F	1 s	175
Engine Speed	rpm	rpm	Engine Speed Dependent	190
Exhaust Gas Temperature	°C	°F	500 ms	173
Exhaust Temperature A	°C	°F	500 ms	2433
Exhaust Temperature B	°C	°F	500 ms	2434
Fuel Delivery Pressure	kPa	psi	500 ms	94
Fuel Leak Filter 1	Binary (0 or 1)		1 s	1239
Fuel Leak Filter 2	Binary (0 or 1)		1 s	1240
Fuel Rate	liter/hr	gal/hr	100 ms	183
Fuel Temperature	°C	°F	1 s	174
High Exhaust System Temp (HEST) Lamp/Indicator	—	—	500 ms	3698
Injection Control Pressure	MPa	psi	500 ms	164
Injector Metering Rail Pressure	MPa	psi	500 ms	157
Intake Manifold Temperature	°C	°F	500 ms	105
Particulate Filter (DPF) Lamp/Indicator	—	—	500 ms	3697
Percent Load at Current rpm	%	%	50 ms	92
Rated Power	watts	watts	On Request	166
Rated rpm	rpm	rpm	On Request	189
Regeneration Disabled (Inhibit) Lamp/Indicator	—	—	500 ms	3703
Shutdown from ECU	Binary (0 or 1)		1 s	1110
Switched Battery Voltage (at ECU)	Vdc	Vdc	1 s	158
Throttle (Accelerator Pedal) Position	%	%	50 ms	91
Total Engine Hours	hours	hours	Requested 1.5 s	247
Total Fuel Used	liters	gallons	Requested 1.5 s	250
Transmission Oil Pressure	kPa	psi	1 s	127
Transmission Oil Temperature	°C	°F	1 s	177
Trip Average Fuel Rate	liters	gallons	500 ms	1029
Trip Fuel	liters	gallons	Requested 1.5 s	182
Winding 1 Temperature	°C	°F	1 s	1124
Winding 2 Temperature	°C	°F	1 s	1125
Winding 3 Temperature	°C	°F	1 s	1126

* SPN is suspect parameter number.

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Table 3-2. Engine Configuration Parameters Obtained from CAN bus Interface

ECU Parameter	Metric Units	English Units	Update Rate	* SPN
Engine Speed at High Idle Point 6	rpm	rpm	5 s	532
Engine Speed at Idle Point 1	rpm	rpm	5 s	188
Engine Speed at Point 2	rpm	rpm	5 s	528
Engine Speed at Point 3	rpm	rpm	5 s	529
Engine Speed at Point 4	rpm	rpm	5 s	530
Engine Speed at Point 5	rpm	rpm	5 s	531
Gain (Kp) of End Speed Governor	%/rpm	%/rpm	5 s	545
Maximum Momentary Engine Override Speed Point 7	rpm	rpm	5 s	533
Maximum Momentary Engine Override Time Limit	seconds	seconds	5 s	534
Percent Torque at Idle Point 1	%	%	5 s	539
Percent Torque at Point 2	%	%	5 s	540
Percent Torque at Point 3	%	%	5 s	541
Percent Torque at Point 4	%	%	5 s	542
Percent Torque at Point 5	%	%	5 s	543
Reference Engine Torque	N•m	ft-lb	5 s	544
Requested Speed Control Range Lower Limit	rpm	rpm	5 s	535
Requested Speed Control Range Upper Limit	rpm	rpm	5 s	536
Requested Torque Control Range Lower Limit	%	%	5 s	537
Requested Torque Control Range Upper Limit	%	%	5 s	538

* SPN is suspect parameter number.

CAUTION

When the CAN bus is enabled, the MGC-2000 Series will ignore the following sender inputs: oil pressure, coolant temperature, and magnetic pickup.

Under certain circumstances, the following strings may be displayed on the front panel HMI and in the Metering Explorer of BESTCOMS*Plus*®:

- *NC (Not Connected)* - String displayed for a J1939 parameter when the engine ECU is not connected to the MGC-2000 Series.
- *SF (Sender Fail)* - String displayed for a J1939 parameter when the engine ECU sends a special code indicating a measurement failure for the parameter. For example, if oil sender is determined to be bad by the ECU, it sends a special code in place of the J1939 oil pressure data indicating a sender fail condition.
- *NS (Not Sent)* - String displayed for a J1939 parameter when the J1939 parameter has not been sent to the MGC-2000 Series by the engine ECU.
- *NA (Not Applicable)* - String displayed for a J1939 parameter when the engine ECU sends a special code for the parameter indicating that the parameter is not implemented or not applicable in the ECU.
- *UF (Unknown Failure)* - String displayed when the J1939 parameter data received by the ECU is not within the valid J1939 data range for the parameter but is not one of the special codes above.

Table 3-3 lists the J1939 data transmitted from the MGC-2000 Series.

Table 3-3. J1939 Data Transmitted from the MGC-2000 Series

ECU Parameter	Update Rate	* SPN
Battle Override Switch	100 ms	1237
Speed Request	10 ms	518

ECU Parameter	Update Rate	* SPN
Note: Requests from the MGC-2000 Series to the Engine ECU for various parameters are made by issuing the request.		
Address Claim Request	Once on power up, and any time a Global Request for Address Claim (GRAC) PGN is received.	NA
Currently Active Diagnostic Trouble Codes Request	Whenever a refresh of Currently Active Diagnostic Trouble Code Request is received.	NA
Previously Active Diagnostic Trouble Codes Request	2 s	NA
Clear Currently Active Diagnostic Trouble Codes Request	Whenever a request to reset Currently Active Diagnostic Trouble Code Request is made.	NA
Clear Previously Active Diagnostic Trouble Codes Request	Whenever a request to reset Previously Active Diagnostic Trouble Code Request is made.	NA
Engine Hours/Revolutions Request	2 s	NA
Fuel Consumption Request	2 s	NA
Electronic Engine Controller #4 (Rated Speed and Power) Request	2 s	NA
Auxiliary Analog Information	2 s	N/A
Data Transmitted to Marathon DVR2000E+ Voltage Regulator		
Primary Voltage Setpoint	1 s	N/A
Alternate Voltage Setpoint	1 s	N/A
Voltage Adjustment Bandwidth	1 s	N/A
Field Current	1 s	N/A
Primary Underfrequency Knee-point	1 s	N/A
Alternate Underfrequency Knee-point	1 s	N/A
Underfrequency Slope	1 s	N/A

* SPN is suspect parameter number.

Diagnostic Trouble Codes (DTCs)

The MGC-2000 Series obtains diagnostic engine information from a compatible engine control unit (ECU). The MGC-2000 Series will receive an unsolicited message of a currently active diagnostic trouble code (DTC). Previously active DTCs are available upon request. Active and previously active DTCs can be cleared on request. Table 3-4 lists the diagnostic information that the MGC-2000 Series obtains over the CAN bus interface.

Table 3-4. Diagnostic Information Obtained Over the CAN bus Interface

Parameter	Transmission Repetition Rate
Active diagnostic trouble code	1 s
Lamp status	1 s
Previously active diagnostic trouble code	On request
Request to clear active DTCs	On request
Request to clear previously active DTCs	On request

DTCs are reported in coded diagnostic information that includes the Suspect Parameter Number (SPN), Failure Mode Identifier (FMI), and Occurrence Count (OC). All parameters have an SPN and are used to display or identify the items for which diagnostics are being reported. The FMI defines the type of failure detected in the subsystem identified by an SPN. The reported problem may not be an electrical failure but a subsystem condition needing to be reported to an operator or technician. The OC contains the number of times that a fault has gone from active to previously active.

For certain DTCs, if the MGC-2000 Series recognizes a pair of SPN and FMI numbers, it displays a single string as listed in Table 3-6. If the MGC-2000 Series recognizes an SPN in Table 3-6, but the FMI does not match the FMI in Table 3-6, then it displays the string from Table 3-6 corresponding to the table entry

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where the FMI is # and a second string corresponding to the FMI number listed in Table 3-5. For example, if the MGC-2000 Series receives SPN 29 and FMI 13, it displays ACCEL PEDAL 2 POSITN and OUT OF CALIBRATION. If the MGC-2000 Series does not have descriptive information about an SPN and FMI that was received, the description will display as “NO TEXT AVAILABLE”.

Table 3-5. DTCs Displayed by the MGC-2000 Series (FMI Strings)

FMI	String Displayed	Description
0	DATA HI MOST SEVERE	Data is higher than expected at the most severe level
1	DATA LO MOST SEVERE	Data is lower than expected at the most severe level
2	DATA ERRATIC OR BAD	Data is erratic, intermittent, or incorrect
3	VOLTS HI OR SHORTED	Measured voltage is higher than expected or shorted to a high source
4	VOLTS LO OR SHORTED	Measured voltage is lower than expected or shorted to a low source
5	CURRENT LO OR OPEN	Measured current is lower than expected or the circuit is open
6	CURRENT HI OR SHORTED	Measured current is higher than expected or shorted
7	MECHANICAL SYSTM ERR	Mechanical system error
8	FREQ OR PWM ERROR	Error in frequency, pulse width or period of any frequency or PWM signal is outside its predetermined limits.
9	ABNORMAL UPDATE RATE	Update rate of parameter is abnormal.
10	DATA RT OF CHG ERR	Rate of change of data is abnormal.
11	FAILURE CAUSE UNKNOWN	String indicating failure cause is unknown.
12	BAD INTELLIGNT DEVICE	Engine ECU is reporting that an intelligent device or component failure has been detected.
13	OUT OF CALIBRATION	Device or parameter is out of calibration.
14	CONSULT ENG MFG DATA	User should consult engine manufacturer's data.
15	DATA HI LST SEVERE	Data is higher than expected at the least severe level.
16	DATA HI MODERATE SVR	Data is higher than expected at a moderately severe level.
17	DATA LO LST SEVERE	Data is lower than expected at the least severe level.
18	DATA LO MODERATE SVR	Data is lower than expected at a moderately severe level.
19	NETWORK DATA ERR	String Indicating Network Data contained an error indication.
20	DATA DRIFTED HI	Data has drifted to a value higher than the maximum valid value.
21	DATA DRIFTED LO	Data has drifted to a value lower than the minimum valid value.
22	FMI RESERVED BY SAE	This FMI is reserved by the Society of Automotive Engineers.
23	FMI RESERVED BY SAE	This FMI is reserved by the Society of Automotive Engineers.
24	FMI RESERVED BY SAE	This FMI is reserved by the Society of Automotive Engineers.
25	FMI RESERVED BY SAE	This FMI is reserved by the Society of Automotive Engineers.
26	FMI RESERVED BY SAE	This FMI is reserved by the Society of Automotive Engineers.
27	FMI RESERVED BY SAE	This FMI is reserved by the Society of Automotive Engineers.
28	FMI RESERVED BY SAE	This FMI is reserved by the Society of Automotive Engineers.
29	FMI RESERVED BY SAE	This FMI is reserved by the Society of Automotive Engineers.
30	FMI RESERVED BY SAE	This FMI is reserved by the Society of Automotive Engineers.
31	CONDTN EXST OR FMI NA	If the SPN refers to a parameter with status of ON or OFF, an FMI of 31 indicates ON. If the SPN refers to a parameter with a numeric value, an FMI of 31 indicates that there is no FMI to describe the parameter’s condition.

Table 3-6. DTCs Displayed by the MGC-2000 Series

SPN	FMI	String Displayed	Description
27	#	EGR1 VALVE POSITN	Caption Indicating EGR1 Valve Position
28	3	Throttle Volt HI	Throttle Voltage High
28	4	Throttle Volt LO	Throttle Voltage Low
28	14	Throttle Volt OOR	Throttle Input Voltage Out of Range
29	#	ACCEL PEDAL 2 POSITN	Caption string for accelerator pedal 2 position
29	3	Throttle Volt HI	Throttle Voltage High
29	4	Throttle Volt LO	Throttle Voltage Low
29	14	Throttle Volt OOR	Throttle Input Voltage Out of Range
51	#	ENG THROTTLE POSITN	Caption Indicating Engine Throttle Position

SPN	FMI	String Displayed	Description
52	15	INTERCOOLER TEMP HI	Engine Intercooler Temperature is above the HIGH threshold
69	#	2 SPEED AXLE SWITCH	Caption Indicating Two Speed Axle Switch
70	#	PARKING BRAKE SWITCH	Caption Indicating Parking Brake Switch
84	#	VEHICLE SPEED	Caption string for vehicle speed signal
91	#	ACCEL POSITION	Caption string for Accelerator Position
91	3	Thr Pos Sns Volt HI	Throttle Position Sensor Input Voltage (High)
91	4	Thr Pos Sns Volt LO	Throttle Position Sensor Input Voltage (Low)
91	14	Thr Pos Sns Volt OOR	Throttle Voltage (Out of Range)
94	1	FUEL DELIV PRS LO LO	Engine Fuel Delivery Pressure is below the LOW LOW threshold
94	3	Fuel Pmp Prs Volt HI	Fuel Pump Pressure Input Voltage (High)
94	4	Fuel Pmp Prs Volt LO	Fuel Pump Pressure Input Voltage (Low)
94	17	Fuel Pressure LO	Fuel Supply Pressure (Low Least Severe)
96	#	FUEL LEVEL	Caption string for Fuel Level
97	3	Water In Fl Volt HI	Water In Fuel Signal Voltage High
97	4	Water In Fl Volt LO	Water In Fuel Signal Voltage Low
97	16	Water in Fuel	Water In Fuel Detected
98	#	ENG OIL LEVEL	Caption used on front panel for Display of J1939 Parameter
99	#	OIL FILTER DIFF PRESS	Caption string for oil filter differential pressure parameter
100	1	ENG OIL PRESS LO LO	Engine Oil Pressure is below the LOW LOW threshold
100	3	Oil Prs Snsr Volt HI	Oil Pressure Sensor Input Voltage (High)
100	4	Oil Prs Snsr Volt LO	Oil Pressure Sensor Input Voltage (Low)
100	17	ENG OIL PRESS LO	Engine Oil Pressure is below the LOW threshold
100	18	Oil Prs Snsr Volt MLO	Oil Pressure Sensor Input Voltage (Moderately Low)
100	31	Oil Pressure INVLD	Oil Pressure (Invalid)
101	#	CRANKCASE PRESSURE	Caption string for crankcase pressure
102	#	INTK MNFLD1 PRESSURE	Caption string for intake manifold 1 pressure
102	2	Manifld Air Prs INVD	Manifold Air Pressure Invalid
102	3	Mnfld AirP SnsVlt HI	Manifold Air Pressure Sensor Input Voltage High
102	4	Mnfld AirP SnsVlt LO	Manifold Air Pressure Sensor Input Voltage Low
103	0	Trbo Overspd Severe	Turbo Overspeed (Most Severe)
103	2	Trbo Speed MisMatch	Turbo Speed (Mismatch)
103	5	Trbo Spd Sns Curr LO	Turbo Speed Sensor Current (Low)
103	6	Trbo Spd Sns Curr HI	Turbo Speed Sensor Current (High)
103	8	Trbo Speed INVLD	Turbo Speed (Invalid)
103	31	Trbo Speed MISSING	Turbo Speed (Missing)
105	0	EGR Mixed Air Tmp HI	Exhaust Gas Recirculation Mixed Air High (Least Severe)
105	3	EGR Air Temp Vlt HI	Exhaust Gas Recirculation Mixed Air Temp Voltage (High)
105	4	EGR Air Temp Vlt LO	Exhaust Gas Recirculation Mixed Air Temp Voltage (Low)
105	15	EGR Mixed Air Tmp HI	Exhaust Gas Recirculation Mixed Air High (Least Severe)
105	16	EGR MxdAir Tmp MHI	Exhaust Gas Recirculation Mixed Air Temp (Moderately High)
106	#	INTAKE AIR PRESSR	Caption Indicating Intake Air Pressure
107	0	Air Filt Restricted	Air Filter Restriction (High)
108	2	Barometrc Prs INVLD	Barometric Pressure (Invalid)
108	31	Barometrc Prs ERR	Barometric Pressure (Error)
109	1	ENG COOLNT PRS LO LO	Engine Coolant Pressure is below the LOW LOW threshold
109	17	ENG COOLANT PRS LO	Engine Coolant Pressure is below the LOW threshold
110	0	ENG COOLNT TMP HI HI	Engine Coolant Temperature is above the HIGH HIGH threshold
110	3	Cool Tmp Sns Volt HI	Coolant Temp Sensor Input Voltage (High)
110	4	Cool Tmp Sns Volt LO	Coolant Temp Sensor Input Voltage (Low)
110	15	ENG COOLANT TEMP HI	Engine Coolant Temperature is above the HIGH threshold
110	16	Cool Temp MHI	Coolant Temp Sensor Input (Moderately High)
110	17	Cool Temp LO	Coolant Temp Sensor Input (Low Least Severe)

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SPN	FMI	String Displayed	Description
111	#	LOW COOL LEVEL	Low Coolant Level string used in event log and/or Alarm and Prealarm annunciation
111	1	Coolnt Lvl LO	Coolant Level (Low)
111	17	ENG COOLANT LVL LO	Engine Coolant Level is below the LOW threshold
157	3	Fuel Rail Prs Vlt HI	Fuel Rail Pressure Input Voltage (High)
157	4	Fuel Rail Prs Vlt LO	Fuel Rail Pressure Input Voltage (Low)
157	10	Fuel Rail Prs LOSS	Fuel Rail Pressure Loss Detected
157	17	Fuel Rl Prs NOT DEV	Fuel Rail Pressure Not Developed
158	#	BATTERY VOLTAGE	Caption Indicating Battery Voltage
158	#	KEY SW BATT VOLTAGE	Caption string for key switch battery potential
158	0	KSW BATT VOLTS HI HI	Key Switch Battery Potential is above the HIGH HIGH threshold
158	1	KSW BATT VOLTS LO LO	Key Switch Battery Potential is below the LOW LOW threshold
158	15	KSW BATT VOLTS HI	Key Switch Battery Potential is above the HIGH threshold
158	17	KSW BATT VOLTS LO	Key Switch Battery Potential is below the LOW threshold
161	#	TR INPUT SHAFT SPD	Caption Indicating Transmission Input Shaft Speed
168	#	LOW BATT VOLT	Low Battery Voltage string used in event log and/or Alarm and Pre-alarm annunciation
174	0	Fuel Temp EXT HI	Fuel Temp (Extremely High)
174	3	Fuel Tmp Sns Volt HI	Fuel Temp Sensor Input Voltage (High)
174	4	Fuel Tmp Sns Volt LO	Fuel Temp Sensor Input Voltage (Low)
174	16	Fuel Temp MHI	Fuel Temp (Moderately High)
175	#	ENG OIL TEMP	Caption used on front panel for Display of J1939 Parameter
188	17	SPEED AT IDLE LO	Metering string for ECU trouble code metering indicates Engine Idle speed is below the LOW threshold
189	0	Engine Spd DERATE	Engine Speed Derate
190	#	ENGINE SPEED	Caption used on front panel for Display of J1939 Parameter
190	0	Engine OvrSpd EXTRM	Engine Overspeed (Extreme)
190	1	ENGINE SPEED LOW	Engine speed is below the LOW threshold
190	16	Engine OvrSpd MODRT	Engine Overspeed (Moderate)
190	17	SPEED AT IDLE LO	Engine Idle speed is below the LOW threshold
191	#	TR OUTPUT SHAFT SPD	Caption Indicating Transmission Output Shaft Speed
237	2	VIN Data MisMatch	VIN Data Mismatch with other controllers
354	#	RELATIVE HUMIDITY	Caption Indicating Relative Humidity
412	0	EGR Temp EXT HI	Exhaust Gas Recirculation Temp (Extremely High)
412	3	EGR Temp In Vlt HI	Exhaust Gas Recirculation Temp Input Voltage (High)
412	4	EGR Temp In Vlt LO	Exhaust Gas Recirculation Temp Input Voltage (Low)
412	16	EGR Temp MHI	Exhaust Gas Recirculation Temp (Moderately High)
442	#	AUX TEMP 2	Caption Indicating Aux Temperature 2
443	#	BATTERY VOLT 2	Caption Indicating Battery Voltage 2
444	#	AUX PRESSURE2	Caption Indicating Auxiliary Pressure 2
515	#	DESIRED SPEED	Caption string for parameter that indicates speed demand desired from the engine.
520	#	RETARDER % TORQUE	Caption string for retarder % torque
523	#	TRANS CURRNT GEAR	Caption Indicating Transmission Current Gear
524	#	TRANS SELECTD GEAR	Caption Indicating Transmission Selected Gear
558	#	ACCEL PEDAL IDLE SW	Caption Indicating Accelerator Pedal Idle Switch
559	#	ACCEL PEDAL KICKDN SW	Caption Indicating Accelerator Pedal Kickdown Switch
563	#	ABS ACTIVE	Caption String for Antilock Brake System (ABS) active
573	#	TRQCNV LOCKUP ENGAGD	Caption Indicating Transmission Torque Converter Lockup Engaged
574	#	TR SHIFT IN PROGRESS	Caption Indicating Transmission Shift in Process
596	#	CRUISE CNTL ENABLE SW	Caption Indicating Cruise Control Enable Switch
597	#	BRAKE SWITCH	Caption Indicating Brake Switch
598	#	CLUTCH SWITCH	Caption Indicating Clutch Switch
599	#	CRUISE CNTL SET SW	Caption Indicating Cruise Control Set Switch

SPN	FMI	String Displayed	Description
600	#	CRUISE CNTL COAST SW	Caption Indicating Cruise Control Coast (Decelerate) Switch
601	#	CRUISE CNTL RESUME SW	Caption Indicating Cruise Control Resume Switch
602	#	CRUISE CNTL ACCEL SW	Caption Indicating Cruise Control Accelerate Switch
609	#	CONTROLLER #2	Caption Indicating Controller Number 2
611	#	SYS DIAGNST CODE 1	Caption Indicating System Diagnostic Code 1
611	3	Inj Short to PWR	Injector Wiring Shorted to Power
611	4	Inj Short to GND	Injector Wiring Shorted to Ground
620	#	5 VOLT SUPPLY	Caption Indicating 5 Volt Supply
623	#	RED STOP LAMP	Caption Indicating Red Stop Lamp
624	#	DIAGNOSTIC LAMP	Caption String for Diagnostic Lamp
624	#	COMBINED YELLOW	Caption Indicating a Yellow Alarm from the Engine ECU
625	#	PROP COMM NETWK 1	Caption Indicating Proprietary Communications Network 1
627	1	Inj Spply Vlt Problm	Injector Supply Voltage Problem
627	13	ECU ERROR	ECU Error
627	16	ECU Power Volt HI	ECU Power High Voltage
627	18	ECU Power Volt LO	ECU Power Low Voltage
628	#	PROGRAM MEMORY	Caption Indicating Program Memory
629	#	CONTROLLER #1	Caption Indicating Controller 1
630	#	ECU INTERNAL ERROR	Caption string for ECU Internal Error
630	#	ECU INTERNAL ERROR	Caption string for ECU Internal Error
636	#	ENG POSITION SENSOR	Caption Indicating Engine Position Sensor
636	2	Pump Pos Sns Noisy	Pump Position Sensor Input Noise
636	5	Pump Pos Sns Curr LO	Pump Position Sensor Current (Low)
636	6	Pump Pos Sns Curr HI	Pump Position Sensor Current (High)
636	8	Pump Pos Sns In MSNG	Pump Position Sensor Input Missing
636	10	Pump Pos Sns In ERR	Pump Position Sensor Input Pattern Error
637	2	Crank Pos Sns Noisy	Crank Position Input Noise
637	5	Crank Pos Sns Curr LO	Crank Position Sensor Current (Low)
637	6	Crank Pos Sns Curr HI	Crank Position Sensor Current (High)
637	7	Crnk/Pmp Pos Tmg OOS	Crank/Pump Position Timing Moderately Out of Sync
637	8	Crank Pos Sns MSNG	Crank Position Missing
637	10	Crank Pos Sns In ERR	Crank Position Input Pattern Error
639	#	J1939 NETWORK 1	Caption String for J1939 Network number 1
641	4	Trbo Actuator ERR	Turbo Actuator Error
641	12	ECU/Trbo Comm ERR	ECU/Turbo Communication Error
641	13	TrboAct Lrnd Val ERR	Turbo Actuator Learned Value Error
641	16	Trbo Act Temp MHI	Turbo Actuator Temp (Moderately High)
645	#	J1939 NETWORK 1	Caption String for J1939 Network number 1
651	#	CYLINDER 1 INJECTOR	Caption String for Cylinder 1 Injector
651	2	Cyl 1 EUI PN INVLD	Cylinder #1 EUI Part Number (Invalid)
651	5	Cyl 1 EUI Ckt OPEN	Cylinder #1 EUI Circuit (Open)
651	6	Cyl 1 EUI Ckt SHORT	Cylinder #1 EUI Circuit (Shorted)
651	7	Cyl 1 EUI Ckt MECH FL	Cylinder #1 EUI Circuit (Mechanical Failure)
651	13	Cyl 1 EUI QR INVLD	Cylinder #1 EUI Circuit QR Code (Invalid)
652	#	CYLINDER 2 INJECTOR	Caption String for Cylinder 2 Injector
652	2	Cyl 2 EUI PN INVLD	Cylinder #2 EUI Part Number (Invalid)
652	5	Cyl 2 EUI Ckt OPEN	Cylinder #2 EUI Circuit (Open)
652	6	Cyl 2 EUI Ckt SHORT	Cylinder #2 EUI Circuit (Shorted)
652	7	Cyl 2 EUI Ckt MECH FL	Cylinder #2 EUI Circuit (Mechanical Failure)
652	13	Cyl 2 EUI QR INVLD	Cylinder #2 EUI Circuit QR Code (Invalid)
653	#	CYLINDER 3 INJECTOR	Caption String for Cylinder 3 Injector
653	2	Cyl 3 EUI PN INVLD	Cylinder #3 EUI Part Number (Invalid)
653	5	Cyl 3 EUI Ckt OPEN	Cylinder #3 EUI Circuit (Open)

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SPN	FMI	String Displayed	Description
653	6	Cyl 3 EUI Ckt SHORT	Cylinder #3 EUI Circuit (Shorted)
653	7	Cyl 3 EUI Ckt MECH FL	Cylinder #3 EUI Circuit (Mechanical Failure)
653	13	Cyl 3 EUI QR INVLD	Cylinder #3 EUI Circuit QR Code (Invalid)
654	#	CYLINDER 4 INJECTOR	Caption String for Cylinder 4 Injector
654	2	Cyl 4 EUI PN INVLD	Cylinder #4 EUI Part Number (Invalid)
654	5	Cyl 4 EUI Ckt OPEN	Cylinder #4 EUI Circuit (Open)
654	6	Cyl 4 EUI Ckt SHORT	Cylinder #4 EUI Circuit (Shorted)
654	7	Cyl 4 EUI Ckt MECH FL	Cylinder #4 EUI Circuit (Mechanical Failure)
654	13	Cyl 4 EUI QR INVLD	Cylinder #4 EUI Circuit QR Code (Invalid)
655	#	CYLINDER 5 INJECTOR	Caption String for Cylinder 5 Injector
655	2	Cyl 5 EUI PN INVLD	Cylinder #5 EUI Part Number (Invalid)
655	5	Cyl 5 EUI Ckt OPEN	Cylinder #5 EUI Circuit (Open)
655	6	Cyl 5 EUI Ckt SHORT	Cylinder #5 EUI Circuit (Shorted)
655	7	Cyl 5 EUI Ckt MECH FL	Cylinder #5 EUI Circuit (Mechanical Failure)
655	13	Cyl 5 EUI QR INVLD	Cylinder #5 EUI Circuit QR Code (Invalid)
656	#	CYLINDER 6 INJECTOR	Caption String for Cylinder 6 Injector
656	2	Cyl 6 EUI PN INVLD	Cylinder #6 EUI Part Number (Invalid)
656	5	Cyl 6 EUI Ckt OPEN	Cylinder #6 EUI Circuit (Open)
656	6	Cyl 6 EUI Ckt SHORT	Cylinder #6 EUI Circuit (Shorted)
656	7	Cyl 6 EUI Ckt MECH FL	Cylinder #6 EUI Circuit (Mechanical Failure)
656	13	Cyl 6 EUI QR INVLD	Cylinder #6 EUI Circuit QR Code (Invalid)
657	#	CYLINDER 7 INJECTOR	Caption String for Cylinder 7 Injector
658	#	CYLINDER 8 INJECTOR	Caption String for Cylinder 8 Injector
659	#	CYLINDER 9 INJECTOR	Caption String for Cylinder 9 Injector
660	#	CYLINDER 10 INJECTOR	Caption String for Cylinder 10 Injector
661	#	CYLINDER 11 INJECTOR	Caption String for Cylinder 11 Injector
662	#	CYLINDER 12 INJECTOR	Caption String for Cylinder 12 Injector
663	#	CYLINDER 13 INJECTOR	Caption String for Cylinder 13 Injector
664	#	CYLINDER 14 INJECTOR	Caption String for Cylinder 14 Injector
665	#	CYLINDER 15 INJECTOR	Caption String for Cylinder 15 Injector
666	#	CYLINDER 16 INJECTOR	Caption String for Cylinder 16 Injector
667	#	CYLINDER 17 INJECTOR	Caption String for Cylinder 17Injector
668	#	CYLINDER 18 INJECTOR	Caption String for Cylinder 18 Injector
669	#	CYLINDER 19 INJECTOR	Caption String for Cylinder 19 Injector
670	#	CYLINDER 20 INJECTOR	Caption String for Cylinder 20 Injector
671	#	CYLINDER 21 INJECTOR	Caption String for Cylinder 21 Injector
672	#	CYLINDER 22 INJECTOR	Caption String for Cylinder 22 Injector
673	#	CYLINDER 23 INJECTOR	Caption String for Cylinder 23 Injector
674	#	CYLINDER 24 INJECTOR	Caption String for Cylinder 24 Injector
675	#	ENG GLOW PLUG LAMP	Caption Indicating Glow Plug Lamp
676	#	ENG GLOW PLUG RELAY	Caption String for Engine Glow Plug Relay
677	#	ENGINE START RELAY	Caption String for Engine Start Relay
697	#	AUX PWM DRIVER 1	Caption Indicating Auxiliary PWM Driver 1
698	#	AUX PWM DRIVER 2	Caption Indicating Auxiliary PWM Driver 2
699	#	AUX PWM DRIVER 3	Caption Indicating Auxiliary PWM Driver 3
700	#	AUX PWM DRIVER 4	Caption Indicating Auxiliary PWM Driver 4
701	#	AUX I/O 1	Caption String for Auxiliary I/O 1
702	#	AUX I/O 2	Caption String for Auxiliary I/O 2
703	#	AUX I/O 3	Caption String for Auxiliary I/O 3
704	#	AUX I/O 4	Caption String for Auxiliary I/O 4
705	#	AUX I/O 5	Caption String for Auxiliary I/O 5
706	#	AUX I/O 6	Caption String for Auxiliary I/O 6
707	#	AUX I/O 7	Caption String for Auxiliary I/O 7

SPN	FMI	String Displayed	Description
708	#	AUX I/O 8	Caption String for Auxiliary I/O 8
709	#	AUX I/O 9	Caption String for Auxiliary I/O 9
710	#	AUX I/O 10	Caption String for Auxiliary I/O 10
711	#	AUX I/O 11	Caption String for Auxiliary I/O 11
712	#	AUX I/O 12	Caption String for Auxiliary I/O 12
713	#	AUX I/O 13	Caption String for Auxiliary I/O 13
714	#	AUX I/O 14	Caption String for Auxiliary I/O 14
715	#	AUX I/O 15	Caption String for Auxiliary I/O 15
716	#	AUX I/O 16	Caption String for Auxiliary I/O 16
723	#	SPEED SENSOR #2	Caption Indicating Engine Speed Sensor #2
724	#	O2 SENSOR	Caption Indicating O2 Sensor
729	#	INTAKE HEATER #1	Caption Indicating Intake Air Heater #1
730	#	INTAKE HEATER #2	Caption Indicating Intake Air Heater #2
731	#	KNOCK SENSOR #1	Caption Indicating Knock Sensor 1
870	#	HEATER REGEN SYSTM	Caption Indicating Heater Regeneration System
898	#	ENGINE REQSTED SPEED	Caption String for Engine Requested Speed
898	2	REQ SPD DATA ERRATIC	Speed Demand Data is erratic
898	9	Spd/Trq Msg INVLD	Vehicle Speed/Torque Message Invalid
904	#	FRONT AXLE SPEED	Caption Indicating Front Axle Speed
920	#	AUDIBLE ALARM	Caption Indicating Audible Alarm
923	#	PWM OUTPUT	Caption String for Engine PWM Output
924	#	AUX OUT #1	Caption Indicating Auxiliary Output 1
925	#	AUX OUT #2	Caption Indicating Auxiliary Output 2
926	#	AUX OUT #3	Caption Indicating Auxiliary Output 3
970	2	Aux Eng SD SW INVLD	Auxiliary Engine Shutdown Switch (Invalid)
970	31	Aux Eng SD SW ACTV	Auxiliary Engine Shutdown Switch Active
971	31	Eng Derate SW ACTV	External Engine Derate Switch Active
973	#	ENG RETARDR SELECTN	Caption Indicating Engine Retarder Selection
974	#	REMOTE ACCEL PEDAL	Caption Indicating Remote Accelerator Pedal
975	#	FAN SPEED	Caption String for Engine Fan Speed
986	#	REQSTD FAN SPEED	Caption Indicating Requested Fan Speed
1004	#	TRIP VEH IDLE FL USED	Caption Indicating Trip Vehicle Idle Fuel Used
1005	#	TRIP CRUISE FL USED	Caption Indicating Trip Cruise Fuel Used
1015	#	TRIP AVG LOAD FACTOR	Caption Indicating Trip Average Load Factor
1072	#	ENG BRAKE OUTPUT 1	Caption String for Engine Brake Output 1
1072	#	ENG COMPR BRK OUTPUT1	Caption Indicating Engine (Compression) Brake Output 1
1073	#	ENG COMPR BRK OUTPUT2	Caption Indicating Engine (Compression) Brake Output 2
1074	#	ENG EXHAUST BRAKE OUT	Caption String for Engine Exhaust Brake Output
1075	5	Fuel TR Pump Curr LO	Fuel Transfer Pump Current (Low)
1075	6	Fuel TR Pump Curr HI	Fuel Transfer Pump Current (High)
1075	12	Fuel TR Pump ERR	Fuel Transfer Pump (Error)
1079	#	SENSOR SUPPLY VOLTS 1	Caption String for Sensor Supply Voltage 1
1080	#	SENSOR SUPPLY VOLTS 2	Caption String for Sensor Supply Voltage 2
1080	3	Snsr Supp 1 Volt LO	Sensor Supply 1 Voltage (Low)
1080	4	Snsr Supp 1 Volt HI	Sensor Supply 1 Voltage (High)
1081	#	ENG WAIT TO START LMP	Caption String for Engine Wait to Start Lamp
1109	#	EPS SHUTDN APPROACHG	Caption String for indication that Engine Protective System Shutdown Is Approaching
1109	31	Eng Shutdown WARNING	Engine Shutdown Warning
1110	31	Eng Prot Shutdown	Engine Protection Shutdown
1127	#	TURBOCHG1 BOOST PRS	Caption Indicating Turbo Charger 1 Boost Pressure
1128	#	TURBOCHG2 BOOST PRS	Caption Indicating Turbo Charger 2 Boost Pressure
1129	#	TURBOCHG3 BOOST PRS	Caption Indicating Turbo Charger 3 Boost Pressure
1130	#	TURBOCHG4 BOOST PRS	Caption Indicating Turbo Charger 4 Boost Pressure

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SPN	FMI	String Displayed	Description
1132	#	INTK MNFLD3 TEMP	Caption Indicating Intake Manifold 3 Temperature
1133	#	INTK MNFLD4 TEMP	Caption Indicating Intake Manifold 4 Temperature
1136	0	ECU Temp EXT HI	ECU Temperature (Extremely High)
1136	15	ENG ECU TEMP HI	ECU Temperature has exceeded the HIGH level
1136	16	ECU Temp MHI	ECU Temperature (Moderately High)
1172	3	Trbo Cmp Tmp Volt HI	Turbo Compressor Inlet Temp Input Voltage (High)
1172	4	Trbo Cmp Tmp Volt LO	Turbo Compressor Inlet Temp Input Voltage (Low)
1172	16	Trbo Cmp In Tmp MHI	Turbo Compressor Inlet Temp (Moderately High)
1180	0	Trbo Trbn Tmp EXT HI	Turbo Turbine Inlet Temp (Extremely High)
1180	16	Trbo Trbn In Tmp MHI	Turbo Turbine Inlet Temp (Moderately High)
1184	#	TURBOCHG1 OUTLET TEMP	Caption Indicating Turbo Charger 1 Outlet Temperature
1185	#	TURBOCHG2 OUTLET TEMP	Caption Indicating Turbo Charger 2 Outlet Temperature
1186	#	TURBOCHG3 OUTLET TEMP	Caption Indicating Turbo Charger 3 Outlet Temperature
1187	#	TURBOCHG4 OUTLET TEMP	Caption Indicating Turbo Charger 4 Outlet Temperature
1188	#	TRBO WST GT ACT1 POS	Caption Indicating Turbo Waste Gate Actuator 1 Position
1189	#	TRBO WST GT ACT2 POS	Caption Indicating Turbo Waste Gate Actuator 2 Position
1192	#	TRBO WSTGT ACT AIR PR	Caption Indicating Engine Turbocharger Waste gate Actuator Control Air Pressure
1213	#	MALFUNC LAMP	Caption string for the malfunction indicator lamp status that is broadcast by ECU as part of diagnostic trouble code information
1227	#	TEST LIMIT MAX	Caption Indicating Test Limit Maximum
1231	#	J1939 NETWORK 2	Caption String for J1939 Network number 2
1235	#	J1939 NETWORK 3	Caption String for J1939 Network number 3
1237	#	ENG SHUTDN ORIDE SW	Caption String for Engine Shutdown Override Switch
1240	#	FUEL LEAKAGE2	Caption Indicating Fuel Leakage 2 Parameter
1268	#	IGNITION COIL 1	Caption Indicating Engine Ignition Coil 1
1269	#	IGNITION COIL 2	Caption Indicating Engine Ignition Coil 2
1270	#	IGNITION COIL 3	Caption Indicating Engine Ignition Coil 3
1271	#	IGNITION COIL 4	Caption Indicating Engine Ignition Coil 4
1272	#	IGNITION COIL 5	Caption Indicating Engine Ignition Coil 5
1273	#	IGNITION COIL 6	Caption Indicating Engine Ignition Coil 6
1274	#	IGNITION COIL 7	Caption Indicating Engine Ignition Coil 7
1275	#	IGNITION COIL 8	Caption Indicating Engine Ignition Coil 8
1276	#	IGNITION COIL 9	Caption Indicating Engine Ignition Coil 9
1277	#	IGNITION COIL 10	Caption Indicating Engine Ignition Coil 10
1278	#	IGNITION COIL 11	Caption Indicating Engine Ignition Coil 11
1279	#	IGNITION COIL 12	Caption Indicating Engine Ignition Coil 12
1280	#	IGNITION COIL 13	Caption Indicating Engine Ignition Coil 13
1281	#	IGNITION COIL 14	Caption Indicating Engine Ignition Coil 14
1282	#	IGNITION COIL 15	Caption Indicating Engine Ignition Coil 15
1283	#	IGNITION COIL 16	Caption Indicating Engine Ignition Coil 16
1284	#	IGNITION COIL 17	Caption Indicating Engine Ignition Coil 17
1285	#	IGNITION COIL 18	Caption Indicating Engine Ignition Coil 18
1286	#	IGNITION COIL 19	Caption Indicating Engine Ignition Coil 19
1287	#	IGNITION COIL 20	Caption Indicating Engine Ignition Coil 20
1288	#	IGNITION COIL 21	Caption Indicating Engine Ignition Coil 21
1289	#	IGNITION COIL 22	Caption Indicating Engine Ignition Coil 22
1290	#	IGNITION COIL 23	Caption Indicating Engine Ignition Coil 23
1291	#	IGNITION COIL 24	Caption Indicating Engine Ignition Coil 24
1321	#	STARTER LKOUT RLY DRV	Caption Indicating Engine Starter Solenoid Lockout Relay Driver Circuit
1322	#	MULTI CYL MISFIRE	Caption String for Misfire detected on multiple engine cylinders
1323	#	MISFIRE CYLINDER 1	Caption String for Misfire detected on a single engine cylinder
1324	#	MISFIRE CYLINDER 2	Caption String for Misfire detected on a single engine cylinder

SPN	FMI	String Displayed	Description
1325	#	MISFIRE CYLINDER 3	Caption String for Misfire detected on a single engine cylinder
1326	#	MISFIRE CYLINDER 4	Caption String for Misfire detected on a single engine cylinder
1327	#	MISFIRE CYLINDER 5	Caption String for Misfire detected on a single engine cylinder
1328	#	MISFIRE CYLINDER 6	Caption String for Misfire detected on a single engine cylinder
1329	#	MISFIRE CYLINDER 7	Caption String for Misfire detected on a single engine cylinder
1330	#	MISFIRE CYLINDER 8	Caption String for Misfire detected on a single engine cylinder
1331	#	MISFIRE CYLINDER 9	Caption String for Misfire detected on a single engine cylinder
1332	#	MISFIRE CYLINDER 10	Caption String for Misfire detected on a single engine cylinder
1333	#	MISFIRE CYLINDER 11	Caption String for Misfire detected on a single engine cylinder
1334	#	MISFIRE CYLINDER 12	Caption String for Misfire detected on a single engine cylinder
1335	#	MISFIRE CYLINDER 13	Caption String for Misfire detected on a single engine cylinder
1336	#	MISFIRE CYLINDER 14	Caption String for Misfire detected on a single engine cylinder
1337	#	MISFIRE CYLINDER 15	Caption String for Misfire detected on a single engine cylinder
1338	#	MISFIRE CYLINDER 16	Caption String for Misfire detected on a single engine cylinder
1339	#	MISFIRE CYLINDER 17	Caption String for Misfire detected on a single engine cylinder
1340	#	MISFIRE CYLINDER 18	Caption String for Misfire detected on a single engine cylinder
1341	#	MISFIRE CYLINDER 19	Caption String for Misfire detected on a single engine cylinder
1342	#	MISFIRE CYLINDER 20	Caption String for Misfire detected on a single engine cylinder
1343	#	MISFIRE CYLINDER 21	Caption String for Misfire detected on a single engine cylinder
1344	#	MISFIRE CYLINDER 22	Caption String for Misfire detected on a single engine cylinder
1345	#	MISFIRE CYLINDER 23	Caption String for Misfire detected on a single engine cylinder
1346	#	MISFIRE CYLINDER 24	Caption String for Misfire detected on a single engine cylinder
1347	#	FUEL PUMP ASSY #1	Caption Indicating Fuel Pump Pressurizing Assembly #1
1347	3	Pump Ctrl Vlv Curr HI	Pump Control Valve Current (High)
1347	5	Pmp Ctrl Vlv C MSMCH	Pump Control Valve Current (Mismatch)
1347	7	Fuel Rl Prs Ctrl ERR	Fuel Rail Pressure Control (Error)
1348	#	FUEL PUMP ASSY #2	Caption Indicating Fuel Pump Pressurizing Assembly #2
1350	#	TIME SINCE LST SERVC	Caption Indicating Time Since Last Service
1384	#	J1939 COMANDED SHUTDN	Caption Indicating J1939 Commanded Shutdown
1385	#	AUX TEMP 1	Caption Indicating Aux Temperature 1
1386	#	AUX TEMP 2	Caption Indicating Aux Temperature 2
1387	#	AUX PRESSURE1	Caption Indicating Auxiliary Pressure 1
1388	#	AUX PRESSURE2	Caption Indicating Auxiliary Pressure 2
1390	#	FUEL VALVE1 INLET PRS	Caption Indicating Fuel Valve 1 Inlet Pressure
1485	#	ECU MAIN RELAY	Caption Indicating ECM Main Relay
1569	#	Engine Torque Derate	Engine Torque Derate
1569	31	Fuel Derate	Fuel Derate
1623	#	TACOGRPH OUT SHFT SPD	Caption Indicating Tachograph Output Shaft Speed
1624	#	TACOGRPH VEHICLE SPD	Caption Indicating Tachograph Vehicle Speed
1633	#	CRUISE CNTL PAUSE SW	Caption Indicating Cruise Control Pause Switch
1634	#	CALIB VERIFICATN NMBR	Caption Indicating Calibration Verification Number
1636	#	INTK MNFD1 TMP HI RES	Caption Indicating Intake Manifold 1 Air Temperature (High Resolution)
1638	#	HYDRAULIC TEMP	Caption String for Hydraulic Temperature
1639	1	Fan Speed Zero	Fan Speed Detected (Zero)
1639	16	Fan Speed HI	Fan Speed Detected (High)
1639	18	Fan Speed LO	Fan Speed Detected (Low)
1692	#	INTKMNFLD1 DESIRD PR	Caption Indicating Engine Intake Manifold Desired Absolute Pressure
1695	#	EGO SNSR FUEL CORRCTN	Caption Indicating Exhaust Gas Oxygen Sensor Fueling Correction
1716	#	RETRDR SEL NON ENGINE	Caption Indicating Retarder Selection non-engine
1761	#	DEF 1 TANK LEVEL	Diesel Exhaust Fluid 1 Tank Level
1908	#	AUX VLV0 STATE CMD	Caption Indicating Aux Valve 0 State Command

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SPN	FMI	String Displayed	Description
2000	13	Security Violation	Security Violation
2005	9	TSC CAN Msg NT RCV	TSC CAN Message Not Received
2030	9	AC Clutch Msg NT RCV	A/C Clutch Status CAN Message Not Received
2071	9	Tr Oil Can Msg NT RCV	Trans. Oil, Tier Size, Vehicle Speed CAN Message Not Received
2436	#	GEN AVG FREQUENCY	Caption Indicating Generator Average AC Frequency
2629	0	TRBO 1 OUT TMP HI HI	Turbocharger 1 outlet pressure is above the HIGH HIGH threshold
2629	15	TURBO 1 OUT TMP HI	Turbocharger 1 outlet pressure is above the HIGH threshold
2630	0	EGR FrAir Tmp EXT HI	Exhaust Gas Recirculation Fresh Air Temp (Extremely High)
2630	3	EGR FrAir Tmp Vlt HI	Exhaust Gas Recirculation Fresh Air Temp Input Voltage (High)
2630	4	EGR FrAir Tmp Vlt LO	Exhaust Gas Recirculation Fresh Air Temp Input Voltage (Low)
2630	15	EGR FrAir Tmp HI	Exhaust Gas Recirculation Fresh Air Temp (High Least Severe)
2630	16	EGR FrAir Tmp MHI	Exhaust Gas Recirculation Fresh Air Temp (Moderately High)
2634	#	POWER RELAY	Caption String for main Power Relay
2646	#	AUX OUT #4	Caption Indicating Auxiliary Output 4
2647	#	AUX OUT #5	Caption Indicating Auxiliary Output 5
2659	2	EGR Flo/Tmp MISMATCH	Exhaust Gas Recirculation Flow/Temp Mismatch
2659	15	EGR Flo Rt High	Exhaust Gas Recirculation Flow Rate (High Least Severe)
2659	17	EGR Flo Rt LO	Exhaust Gas Recirculation Flow Rate (Low Least Severe)
2790	16	Trbo Cmp Out Tmp HI	Turbo Compressor Outlet Temp (Moderately High)
2791	#	EGR VALVE CONTROL	Caption String for EGR Valve Control
2791	2	EGR Vlv Pos Invld	Exhaust Gas Recirculation Valve Position Invalid
2791	3	EGRVlv Pos In Vlt HI	Exhaust Gas Recirculation Valve Position Input Voltage (High)
2791	4	EGRVlv Pos In Vlt LO	Exhaust Gas Recirculation Valve Position Input Voltage (Low)
2791	13	EGR Vlv Control ERR	Exhaust Gas Recirculation Valve Control Error
2791	31	EGR Valve Cal ERR	Exhaust Gas Recirculation Valve Calibration Error
2795	7	Trbo Act Pos MSMATCH	Turbo Actuator Position Mismatch
2797	#	INJECTOR GROUP 1	Caption Indicating Engine Injector Group 1
2798	#	INJECTOR GROUP 2	Caption Indicating Engine Injector Group 2
2899	#	START ENABL DEV 1 CFG	Caption Indicating Engine Start Enable Device 1 Configuration
3050	#	CATALYST SYSTM MONITR	Caption Indicating Catalyst 1 System Monitor
3056	#	EGO SENSOR MONITOR 1	Caption Indicating Exhaust Gas Oxygen Sensor 1 Monitor
3057	#	EGO SENSOR MONITOR 2	Caption Indicating Exhaust Gas Oxygen Sensor 2 Monitor
3217	#	AFTR TRT 1 INTK O2	Caption Indicating Aftertreatment 1 Intake O2
3218	#	AFT1 INTK SNSPWR IN RG	Caption Indicating Aftertreatment 1 Intake Gas Sensor Power In Range
3219	#	AFT1 INTK SNSR AT TMP	Caption Indicating Aftertreatment 1 Intake Gas Sensor at Temperature
3220	#	AFT1 INTK NOX STBL	Caption Indicating Aftertreatment 1 Intake NOx Reading Stable
3221	#	AFT1 INTK WR O2 STBL	Caption Indicating Aftertreatment 1 Intake Wide-Range Percent O2 Reading Stable
3222	#	AFT1 INTK SNS HTR FMI	Caption Indicating Aftertreatment 1 Intake Gas Sensor Heater Preliminary FMI
3224	#	AFT1 INTK NOXSNSR FMI	Caption Indicating Aftertreatment 1 Intake NOx Sensor Preliminary FMI
3225	#	AFT1 INTK O2 SNSR FMI	Caption Indicating Aftertreatment 1 Intake O2 Sensor Preliminary FMI
3232	#	AFT1 OUT SNS HTR FMI	Caption Indicating Aftertreatment 1 Outlet Gas Sensor Heater Preliminary FMI
3234	#	AFT1 OUT NOX SNSR FMI	Caption Indicating Aftertreatment 1 Outlet NOx Sensor Preliminary FMI
3250	#	DPF INTRMED GAS TEMP	Caption Indicating Aftertreatment 1 Diesel Particulate Filter Intermediate Gas Temperature
3256	#	AFTR TRT 2 INTK O2	Caption Indicating Aftertreatment 2 Intake Percent O2
3257	#	AFT2 INTK SNSPWR IN RG	Caption Indicating Aftertreatment 2 Intake Gas Sensor Power In Range

SPN	FMI	String Displayed	Description
3260	#	AFT2 INTK WR O2 STBL	Caption Indicating Aftertreatment 2 Intake Wide-Range Percent O2 Reading Stable
3261	#	AFT2 INTK SNS HTR FMI	Caption Indicating Aftertreatment 2 Intake Gas Sensor Heater Preliminary FMI
3264	#	AFT2 INTK O2 SNSR FMI	Caption Indicating Aftertreatment 2 Intake O2 Sensor Preliminary FMI
3271	#	AFT2 OUT SNS HTR FMI	Caption Indicating Aftertreatment 2 Outlet Gas Sensor Heater Preliminary FMI
3361	#	AFT1 CTLYST DOSE UNIT	Caption Indicating Aftertreatment 1 SCR Catalyst Dosing Unit
3363	#	AFT1 SCR TANK HTR	Caption Indicating Aftertreatment 1 SCR Tank Heater
3464	#	THROTTLE ACT 1 CNTL	Caption Indicating Throttle Actuator 1 Control
3465	#	THROTTLE ACT 2 CNTL	Caption Indicating Throttle Actuator 2 Control
3485	#	AFT1 SUPPLY AIR PRESS	Caption Indicating Aftertreatment 1 Supply Air Pressure
3509	#	SENSOR SUPPLY VOLTS 1	Caption String for Sensor Supply Voltage 1
3510	#	SENSOR SUPPLY VOLTS 2	Caption String for Sensor Supply Voltage 2
3511	#	SNSR SUPPLY VOLT 3	Caption Indicating Sensor Supply Voltage 3
3512	#	SNSR SUPPLY VOLT 4	Caption Indicating Sensor Supply Voltage 4
3513	#	SNSR SUPPLY VOLT 5	Caption Indicating Sensor Supply Voltage 5
3514	#	SNSR SUPPLY VOLT 6	Caption Indicating Sensor Supply Voltage 6
3515	#	DEF TEMP	String for Diagnostic Trouble Code Indicating DEF Temperature
3516	#	DEF CONCENTRATION	Caption Indicating Aftertreatment 1 SCR Catalyst Reagent Concentration
3520	#	DEF QUALITY	Caption Indicating Aftertreatment 1 SCR Catalyst Reagent Properties Preliminary FMI
3597	#	ECU SUPPLY VOLTAGE 1	Caption Indicating ECU Power Supply Voltage 1
3598	#	ECU SUPPLY VOLTAGE 2	Caption Indicating ECU Power Supply Voltage 2
3599	#	ECU SUPPLY VOLTAGE 3	Caption Indicating ECU Power Supply Voltage 3
3601	#	FUEL VLV LK TEST CTL	Caption Indicating Engine Fuel Shutoff Valve Leak Test Control
3605	#	COOLANT PUMP CTL	Caption Indicating Coolant Pump Control
3609	#	DPF INTAKE PRESSR 1	Caption Indicating DPF Intake Pressure 1
3610	#	DPF OUTLET PRESSR 1	Caption Indicating DPF Outlet Pressure 1
3611	#	DPF INTAKE PRESSR 2	Caption Indicating DPF Intake Pressure 2
3612	#	DPF OUTLET PRESSR 2	Caption Indicating DPF Outlet Pressure 2
3673	#	THROTTLE POSITION 2	Caption Indicating Engine Trhottle 2 Position
3719	0	DPF SOOT LVL EXT HI	String for Diagnostic Trouble Code Indicating Diesel Particulate Filter Soot Level High - Most Severe Level
3719	15	DPF SOOT LVL HI	String for Diagnostic Trouble Code Indicating Diesel Particulate Filter Soot Level High - Least Severe Level
3719	16	DPF SOOT LVL MOD HI	String for Diagnostic Trouble Code Indicating Diesel Particulate Filter Soot Level High - Moderately Severe Level
3822	#	EGR1 VLV 2 POSITION	Caption Indicating Engine Exhaust Gas Recirculation 1 Valve 2 Position
3826	#	DEF AVG CONSUMPTION	Caption Indicating DEF Average Consumption
3828	#	DEF CURRNT CONSUMPTN	Caption Indicating DEF Current Consumption
4096	#	NOx HI DEF EMPTY	NOx Limits Exceeded Due to Diesel Exhaust Fluid Empty
4213	#	ENG CRNK WITHOUT_FUEL	Caption Indicating Engine Crank Without Fuel
4332	#	DEF SYSTEM STATE	Caption Indicating DEF System State
4334	#	DEF ABSOLUTE PRESSR	Caption Indicating DEF Absolute Pressure
4335	#	DEF DOSING AIR ABS PR	Caption Indicating DEF Dosing Air Assist Absolute Pressure
4336	#	AFT1 DOSE AIR ASSTVLV	Caption Indicating Aftertreatment 1 SCR Dosing Air Assist Valve
4354	#	AFT1 DEF LINE HTR	Caption Indicating Aftertreatment 1 SCR Catalyst Reagent Line Heater 1
4364	#	SCR CNVRSN EFFICIENCY	Caption Indicating SCR Conversion Efficiency
4755	#	AFT1 CTLYST DIFF PRS	Caption Indicating Aftertreatment 1 Gas Oxidation Catalyst Differential Pressure
4794	#	AFT1 CTLYST SYS MSSNG	Caption Indicating Aftertreatment 1 SCR Catalyst System Missing

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SPN	FMI	String Displayed	Description
4809	#	AFT1 DEF WARM IN TMP	Caption Indicating Aftertreatment 1 Warm Up Diesel Oxidation Catalyst Inlet Temperature
4810	#	AFT1 DEF WARM OUT TMP	Caption Indicating Aftertreatment 1 Warm Up Diesel Oxidation Catalyst Outlet Temperature
5246	#	SCR INDUCMT SEVERITY	Selective Catalytic Reduction Inducement Severity Level
5264	#	EGR2 VALVE 1 CONTROL	Caption Indicating Engine Exhaust Gas Recirculation 2 Valve 1 Control
520837	1	STARTER SPEED LO LO	Starter Speed is below the LOW LOW threshold
520838	1	RUN UP SPEED LO LO	Run Up Speed is below the LOW LOW threshold
522192	12	MTU ENGINE BAD	Component failure of the MTU engine control ECU
523212	#	ENGPRT CAN MSG	Caption String for CAN bus Message
523216	#	PREHTENCMD CAN MSG	Caption String for CAN bus Message
523218	#	RxCCVS CAN MSG	Caption String for CAN bus Message
523222	#	TC01 CAN MSG	Caption String for CAN bus Message
523238	#	SWTOUT CAN MSG	Caption String for CAN bus Message
523239	#	DECV1 CAN MSG	Caption String for CAN bus Message
523240	#	FUNMODCTL CAN MSG	Caption String for CAN bus Message
523350	#	CYL BANK 1 INJECTORS	Caption String for Cylinder Bank 1 Injectors
523351	#	CYL BANK 1 INJECTORS	Caption String for Cylinder Bank 1 Injectors
523352	#	CYL BANK 2 INJECTORS	Caption String for Cylinder Bank 2 Injectors
523353	#	CYL BANK 2 INJECTORS	Caption String for Cylinder Bank 2 Injectors
523354	#	ECU ERROR	String for Diagnostic Trouble Code Indicating ECU Error
523355	#	ECU ERROR	String for Diagnostic Trouble Code Indicating ECU Error
523370	#	RAIL PRESSURE	Caption String for Rail Pressure
523420	#	ECU ERROR	String for Diagnostic Trouble Code Indicating ECU Error
523450	#	MULTI STATE SWITCH 1	Caption String for Multi State Switch 1
523451	#	MULTI STATE SWITCH 2	Caption String for Multi State Switch 2
523452	#	MULTI STATE SWITCH 3	Caption String for Multi State Switch 3
523470	#	RAIL PRESSURE LMT VLV	Caption String for Rail Pressure Limit Valve
523490	#	ECU ERROR	String for Diagnostic Trouble Code Indicating ECU Error
523500	#	CAN MSG TIMEOUT	Caption String indicating Can Message Timeout has occurred
523550	#	ECU ERROR	String for Diagnostic Trouble Code Indicating ECU Error
523561	#	INJECTN PERIOD CYL 1	Caption String for Single Cylinder Injection Period
523562	#	INJECTN PERIOD CYL 2	Caption String for Single Cylinder Injection Period
523563	#	INJECTN PERIOD CYL 3	Caption String for Single Cylinder Injection Period
523564	#	INJECTN PERIOD CYL 4	Caption String for Single Cylinder Injection Period
523565	#	INJECTN PERIOD CYL 5	Caption String for Single Cylinder Injection Period
523566	#	INJECTN PERIOD CYL 6	Caption String for Single Cylinder Injection Period
523567	#	INJECTN PERIOD CYL 7	Caption String for Single Cylinder Injection Period
523568	#	INJECTN PERIOD CYL 8	Caption String for Single Cylinder Injection Period
523600	#	ECU ERROR	String for Diagnostic Trouble Code Indicating ECU Error
523601	#	ECU ERROR	String for Diagnostic Trouble Code Indicating ECU Error
523602	#	FAN SPEED	Caption String for Engine Fan Speed
523604	#	RXENGTMP CAN MSG	Caption String for CAN bus Message
523605	#	TSC1-AE MSG MISSING	Caption String for CAN bus Message
523606	#	TSC1-AR MSG MISSING	Caption String for CAN bus Message
523607	#	TSC1-DE MSG MISSING	Caption String for CAN bus Message
523608	#	TSC1-DR MSG MISSING	Caption String for CAN bus Message
523609	#	TSC1-PE MSG MISSING	Caption String for CAN bus Message
523610	#	TSC1-VE MSG MISSING	Caption String for CAN bus Message
523611	#	TSC1-VR MSG MISSING	Caption String for CAN bus Message
523612	#	ECU ERROR	String for Diagnostic Trouble Code Indicating ECU Error
523613	#	RAIL PRESSURE	Caption String for Rail Pressure

SPN	FMI	String Displayed	Description
523615	#	METERING UNIT VALVE	Caption String for Metering Unit Valve
523617	#	ECU ERROR	String for Diagnostic Trouble Code Indicating ECU Error

MTU Fault Codes

An MGC-2000 Series connected to a genset equipped with an MTU engine ECU tracks and displays the active fault codes issued by the MTU engine ECU. Active MTU fault codes can be viewed through BESTCOMS*Plus*® by using the Metering Explorer to expand the MTU tree or through the front panel display by navigating to METERING, ALARMS-STATUS, MTU FAULT CODES.

Each fault code is displayed with a fault description and the fault number. If the MGC-2000 Series does not have descriptive information about a fault number that was received, the fault description will display as "NO TEXT AVAILABLE". Fault codes displayed by the MGC-2000 Series are described in Appendix D, *MTU Fault Codes*.

RS-485 (Optional)

MGC-2000 Series controllers with the optional RS-485 communication port (style number xxxRxxxxx) can be monitored and controlled via a polled network using the Modbus™ protocol. The RS-485 port supports a user-selectable baud rate of 1200, 2400, 4800, or 9600. Odd, even, or no parity is supported. Fixed communication settings include the number of data bits (8) and stop bits (1). Modbus register values for the MGC-2000 Series are listed and defined in Appendix B, *Modbus™ Communication.* RS-485 port connections are made at MGC-2000 Series terminals 14 (485A), 13 (485B), and 12 (485 SHIELD).

Modem (Optional)

When MGC-2000 Series hardware version 3 is equipped with the optional external modem port (style number xxxxxExxx), it can be connected to an external, user-supplied dial-out modem. When MGC-2000 Series hardware versions 1 and 2 are equipped with the optional internal dial-out modem (style number xxxxxMxxx), it can be connected to a standard telephone line through its RJ-11 jack. The modem enables the MGC-2000 Series to dial up to four pager telephone numbers and annunciate conditions selected by the user. These conditions include any MGC-2000 Series alarm or pre-alarm, closure of any programmable contact input, and an active cooldown timer. The modem accommodates pagers that use seven data bits with even parity or modems using eight data bits with no parity.

Output Contacts

Output contact operation is controlled by the operating mode of the MGC-2000 Series. The state of the Emergency Stop contact input also affects output contact operation. When the Emergency Stop contact input is open (emergency stop condition), the PRESTART, START, and RUN outputs open. When the Emergency Stop input is closed, all output contacts operate normally.

MGC-2000 Series output contacts include PRESTART, START, RUN, and up to 12 standard programmable outputs. Additional output contacts can be accommodated with a CEM-2020 (Contact Expansion Module).

PRESTART

This output closes to energize the engine glow plugs. The PRESTART output can be programmed to close up to 30 seconds prior to engine cranking. The PRESTART output can also be programmed to open upon engine startup or remain closed as long as the engine is operating.

During the resting state, the PRESTART can be set to Off, On, or Preheat Before Crank. If Preheat Before Crank is selected, the PRESTART output will be closed for a time equal to the Pre-crank delay time prior to re-entering the cranking state. If the Pre-crank delay setting is longer than the rest interval, the PRESTART output will be closed for the entire rest time.

PRESTART output connections are made through terminals located on the PRESTART relay.

START

This output closes when engine cranking is initiated by the MGC-2000 Series and opens when the magnetic pickup (MPU) or generator frequency indicates that the engine has started. Prior to engine starting, the duration of cranking is determined by the cranking style (cycle or continuous) selected. Cycle cranking permits up to 7 crank cycles with crank cycle duration of 5 to 15 seconds. The continuous crank time is adjustable from 5 to 60 seconds.

START output connections are made through terminals located on the START relay.

RUN

This output closes when engine cranking is initiated by the MGC-2000 Series. The RUN output remains closed until an off command or emergency stop command is received.

RUN output connections are made through terminals located on the RUN relay.

Programmable

MGC-2000 Series controllers with a style number of xxAxxxxxx have four programmable output contacts (OUT 1 through 4). Twelve programmable outputs (OUT 1 through 12) are provided on controllers with a style number of xxBxxxxxx.

Modes of Operation

OFF

When in the OFF mode, the MGC-2000 Series will not start under any circumstance. It cannot be started automatically. Programmable logic functions normally in this mode.

RUN

When in the RUN (manual) mode, the MGC-2000 Series runs and cannot be shut off automatically. The breaker can be open or closed through programmable logic inputs. Programmable logic functions normally in this mode.

AUTO

When in the AUTO mode, the MGC-2000 Series may be started automatically or "self-start" from an automatic starting feature listed in the following paragraphs. If the MGC-2000 Series is not in AUTO mode, the self-starting modes will have no effect. The self-starting modes are independent, with one exception, meaning that if any self-starting mode indicates that the unit should run, it will run. It will not shut down unless all self-starting modes indicate that the unit should not be running.

ATS Contact Input

The ATS programmable function has an input mapped to it from BESTCOMS*Plus*®. The unit will start and run when this contact is closed, and will stop when the contact is open. This mode is independent of the other self-starting modes.

Generator Exerciser

The unit will start at the designated time and will run for the specified duration. The breaker will be closed if "Run with Load" is checked in the generator exerciser settings. This mode is independent of the other self-starting modes.

Mains Fail Transfer Functionality

If mains fail transfer is enabled, the unit will run when the utility is determined to be bad, and will not stop until the utility has been determined to be good and the load has been transitioned to the utility. This mode is independent of the other self-starting modes.

Run with Load Logic Element

When the run with load logic element start input is energized, the unit will start, close its breaker, and take on load at the programmed load rate. If the unit is the only one on the load, it will provide the full load. When the run with load logic element stop input is energized, the unit will unload at the programmed load rate, open its breaker, and stop. This mode works in conjunction with demand start/stop, otherwise it is completely independent of the other self-starting modes.

Engine Run Logic Element

When the engine run logic element start input is energized, the unit will start. When the engine run logic element stop input is energized, the unit will unload if loaded, open its breaker if needed, cool down, and then stop.

Demand Start/Stop Function

If the system demand is above the configured level setting for the specified time, and sequencing is enabled, the unit will start, close its breaker, and take on load at the programmed load rate. Note the unit will not start if sequencing is not enabled. If the unit is the only one on the load, it will provide the full load.

If the load drops below the stop level for the specified time, the unit will unload at the programmed load rate, open its breaker, and stop. This mode works in conjunction with the run with load logic element, otherwise it is completely independent of the other self-starting modes.

Interoperability of the Run with Load Logic Element and the Demand Start/Stop Function

These two functions can be used together; they are not independent of each other. Either one can start or stop the system, but they can share functionality in that one can stop the system even if the other one started it. Thus, if a machine was started by pulsing the run with load start, it could be stopped by demand start/stop. This can be useful in a scenario where it may be desired to start a number of generators all at the same time but sequence some off if the load does not require them. Run with load start could be pulsed on all the units causing them to start and close their breakers, then demand start/stop and sequencing could cycle them on and off as the load requirements change.

In order for Run With Load and Sequencing to operate reliably, it is recommended that the inputs to the Run with Load logic element be pulsed rather than held constant. For example, if a unit was started by sequencing, a pulse on the Run with Load Stop will shut down the unit. However, if the Run with Load Stop is held constant, sequencing could never start a unit because the sequencing starts would be immediately negated by Run with Load Stops. Similarly, if a Run with Load Start is applied and held constant, sequencing cannot shut down the unit. Any stops generated by sequencing would immediately be negated by the Run with Load Start.

Breaker Management

Introduction

The MGC-2000 Series is capable of controlling the generator breaker and the mains breaker. Once it is determined that a valid breaker request is available, the MGC-2000 Series will attempt to operate the breaker if possible. The user can choose to control only the generator breaker, the generator and mains breakers, or none. BESTCOMS*Plus*® is used to configure breaker management. Refer to Section 4, *BESTCOMSPlus® Software, Breaker Management,* for setting information.

Determining Breaker Status

The status of the breakers is determined by using BESTlogic*Plus* Programmable Logic to setup the GENBRK and MAINSBRK logic blocks. These logic blocks have outputs that can be configured to energize an output contact and control a breaker as well as inputs for breaker control and status.

Processing Breaker Requests

Types of breaker operate requests include:

- Local Request - generated by internal functions and based on operating modes.
- Com Request - generated through a communication port using BESTCOMS*Plus*® or the front panel HMI.
- Logic Request - generated from BESTlogic*Plus*.

The type of response given for a local request depends on the operating mode of the MGC-2000 Series.

RUN Mode

When in RUN mode, the generator and mains breakers can be closed manually using contact inputs or the breaker buttons on the BESTCOMS*Plus*® *Control* screen.

OFF or AUTO Mode (Not Running)

If operating in the OFF mode or AUTO and not running, the generator breaker cannot be closed because the generator will not be stable.

AUTO Mode (Running)

When in AUTO mode and running, the mains fail transfer feature will automatically control the mains breaker and the generator breaker or the external ATS (automatic transfer switch) will start the generator and control the breakers itself. In addition, the generator breaker can be automatically controlled by the demand start/stop function, the exercise timer function, or a RUNWLOAD (run with load) start from BESTlogic*Plus*. The generator breaker can be manually controlled using contact inputs and outputs or the breaker buttons on the BESTCOMS*Plus*® *Control* screen.

TIM-ID: 0000099917 - 001

Breaker Operation

The MGC-2000 Series will attempt to close a breaker only after verifying that it can be closed. If the breaker cannot be closed, the close request will be ignored. Only one breaker can be closed at a time. Synchronization is required before closing the breaker to a live bus. Closure to a dead bus can be performed after meeting dead bus threshold and timing requirements set by the user.

Determining if it is Acceptable to Close a Breaker

Before the generator breaker can be closed, it must be configured in BESTCOMS*Plus*®. If only the generator breaker is configured (mains breaker not configured) the MGC-2000 Series looks at user settings to determine if the generator side of the breaker is stable and the bus side is stable or dead. If both the generator and the mains breakers are configured and open, the MGC-2000 Series will close the generator breaker if the generator side of the breaker is stable. If both breakers are configured and the mains breaker is closed, the MGC-2000 Series will close the generator breaker after verifying that both sides of the generator breaker are stable and the MGC-2000 Series is synchronizing.

Before the mains breaker can be closed, it must be configured in BESTCOMS*Plus*®. If both the mains and the generator breakers are configured and open, the MGC-2000 Series will close the mains breaker if the mains side of the breaker is stable. If both breakers are configured and the generator breaker is closed, the MGC-2000 Series will close the mains breaker after verifying that both sides of the mains breaker are stable.

Changing the Breaker State

Synchronization is required when closing a breaker to a live bus. Bus conditions act as a supervisory control over the synchronizing function. If synchronization is in process and either bus goes unstable, synchronization is suspended. To close the breaker on a dead bus, the MGC-2000 Series generates a breaker close request. The closing function is then run without synchronization.

The GENBRK and MAINSBRK logic blocks contain both Open and Close logic outputs that can be configured to energize an output contact, which would in turn operate the breaker. The Synchronizer screen in BESTCOMS*Plus*® is used to set the output contact type to pulses or continuous.

If the breaker does not seem to operate properly, refer to Section 8, *Maintenance and Troubleshooting.*

Synchronizer Operation

The synchronizer acts to align the generator voltage and frequency with that of the bus inputs when the MGC-2000 Series desires to close the generator to a live, stable bus. Several situations must exist before the synchronizer function will begin to execute:

- The MGC-2000 Series must include the synchronizer option
- The generator voltage must be stable
- The bus voltage must be stable
- The MGC-2000 Series must be in the process of initiating a breaker close

Breaker close sources are:

- The MGC-2000 Series itself when the automatic transfer (ATS) feature is enabled.
- The MGC-2000 Series itself when the Run with Load logic element receives a Start pulse in the programmable logic.
- The MGC-2000 Series itself when started from a Demand Start as part of demand start/stop and sequencing.
- The MGC-2000 Series itself when started from the Exercise Timer and the *Run with Load* box is checked in the Generator Exerciser Settings.
- Manual Breaker Close Input Contacts applied to the Open and Close inputs on the left side of the Generator Breaker logic element in the programmable logic.

Any of the above close sources will work when the MGC-2000 Series is in AUTO mode. Only the Manual Breaker Close Input Contacts can initiate a breaker closure when the MGC-2000 Series is in RUN mode.

In wye, delta, grounded delta, or single-phase AB configurations, the synchronizer aligns the voltage on the GEN VA terminal with that on the BUS VA terminal, and the voltage on the GEN VB terminal with that on the BUS VB terminal. In other words, the MGC-2000 Series aligns the generator phase AB L-L voltage with the bus phase AB L-L voltage. In order for the synchronizer to provide correct phase alignment across a breaker, the phase AB L-L voltages on the generator side of the breaker must be wired to the GEN VA and GEN VB terminals on the MGC-2000 Series. The phase AB L-L voltages on the bus side of the breaker (the bus to which the generator will be connected when the breaker is closed) must be wired to the BUS VA and BUS VB terminals on the MGC-2000 Series. See Section 6, *Installation*, for a three-phase wye connection for typical applications diagram.

In single-phase AC configuration, the synchronizer aligns the voltage on the GEN VA terminal with that on the BUS VA terminal, and the voltage on the GEN VC terminal with that on the BUS VB terminal. In other words, the MGC-2000 Series aligns the generator phase CA L-L voltage with the bus phase CA L-L voltage. In order for the synchronizer to provide correct phase alignment across a breaker, the phase CA L-L voltages on the generator side of the breaker must be wired to the GEN VA and GEN VC terminals on the MGC-2000 Series. The phase CA L-L voltage on the bus side of the breaker (the bus to which the generator will be connected when the breaker is closed) must be wired to the BUS VA and BUS VB terminals on the MGC-2000 Series. See Section 6, *Installation*, for a single-phase AC connection for typical applications diagram.

Generator speed can be influenced by either the speed trim function, which is active at all times if enabled, and the synchronizer. Since the speed trim function can cause some activity on the speed bias outputs, when performing synchronizer troubleshooting it is recommended that the speed trim function be disabled.

One way to tell if the synchronizer is active is to observe the MGC-2000 Series front panel. When the synchronizer is active the MGC-2000 Series displays a synchronizer scope and angle and voltage error values on the front panel.

Another method is to check for governor and AVR *raise* and *lower* output signals. First, disable the speed trim function. If the governor or AVR bias control output type is contact, check for raise and/or lower pulses coming from the MGC-2000 Series during synchronization. If the governor or AVR bias control output type is analog, check the governor and/or AVR bias analog outputs on the load share module with a voltmeter during synchronization. The voltages or raise/lower pulses should be changing when the synchronizer is active. If there are no raise/lower pulses, or if the analog bias voltages do not change, the synchronizer is not active.

A readily available method of verifying synchronizer operation during initial set up and commissioning is to connect a light bulb from phase B of the machine being synchronized to phase B of the bus. Three bulbs, one on each phase can be employed if so desired. The bulb(s) should be off or very dim when it is OK for the breaker to close.

If it is not practical to use light bulbs, a voltmeter can be connected across the GEN VA and BUS VA terminals. When the MGC-2000 Series reports that the slip angle is near zero, the voltage read by the meter should be near zero. For single-phase ac systems, connect the voltmeter across the GEN VA and BUS VA or GEN VC and BUS VB terminals.

If the MGC-2000 Series is indicating that the slip angle is at or near zero, but the slip angle measured across the breaker is not near zero, it is likely that the signals measured by the MGC-2000 Series are not the signals that are present at the breaker. In this case, all wiring should be checked to verify that the voltage at the GEN VA terminal of the MGC-2000 Series matches the voltage present at the Phase A connection on the generator side of the breaker, that the voltage at the GEN VB terminal of the MGC-2000 Series matches the voltage present at the Phase B connection on the generator side of the breaker, and that the voltage at the GEN VC terminal of the MGC-2000 Series matches the Phase C connection on the generator side of the breaker. Similar verification should be performed from the BUS VA and BUS VB terminals on the MGC-2000 Series to the Phase A and Phase B connections on the bus side of the breaker.

It is also required that phase rotation is the same on both sides of the breaker for synchronization to be possible.

NOTES

When using the MGC-2000 Series synchronizer, it is recommended that local MGC-2000 Series relay outputs be used for breaker closing commands to minimize the possibility of closures outside of desired breaker closing angles.

If remote (CEM-2020) outputs are to be used for breaker close commands, it is recommended that the anticipatory synchronizer type be used, and the breaker close wait time be adjusted to account for possible CEM-2020 output delays (typically 50 ms) to achieve desired breaker closing angles.

If the synchronizer does not seem to operate properly, refer to Section 8, *Maintenance and Troubleshooting.*

Dead Bus Breaker Close Arbitration

Dead bus breaker close arbitration ensures that only one machine (assigned by the system manager) closes its breaker to a dead bus. The system manager controls generator sequencing. The system manager is the unit with the lowest numbered nonzero sequencing ID. After a machine issues a dead bus close request and the system manager grants it, the machine that received the grant closes its breaker to the dead bus. Now that the bus is no longer dead, all remaining units must synchronize to the live bus.

Individual units issue dead bus close requests to the system manager when they want to close their generator breaker and a dead bus is detected. An individual unit issues a dead bus close request when all of the following are true:

1. The generator is stable
2. A dead bus is detected
3. A generator breaker close request is received

An individual unit with its System Type parameter set to Multiple Generator will not close its breaker onto the dead bus unless it receives a dead bus close grant from the system manager via Ethernet. The LSM-2020 provides Ethernet communication between the MGC-2000 Series and the network. The System Type parameter is found on the *System Settings* screen in BESTCOMS*Plus*®. After an individual unit issues a dead bus close request and receives a dead bus close grant from the system manager, the unit maintains its dead bus close request unless one of the following occurs:

- The dead bus close grant is removed by the system manager
- The generator breaker encounters a breaker close fail
- A generator breaker open request is received
- The generator becomes unstable

An individual unit can close to a dead bus at any time when the System Type parameter is set to Single Generator or an LSM-2020 is not providing Ethernet communication between the MGC-2000 Series and the network.

The Unit ID of the system manager can be found on the front panel of each unit and in BESTCOMS*Plus*®. Refer to Section 2, *Human-Machine Interface, Display Operation, Generator Network Status Display.*

All units in the system reporting a dead bus must be visible to the system manager via Ethernet before any dead bus close grant is issued. The system manager removes any dead bus close grant if any machine reports the bus is not dead. A dead bus close grant is not removed by the system manager unless the unit that received the grant removes its request or another machine reports that the bus is not dead.

For consistent operation, all units should be set up with the same demand start/stop and sequencing criteria. This ensures that system manger functionality is transferred accordingly as the lowest numbered nonzero sequence ID changes in the system.

Event Recording

An event log retains history of system events in nonvolatile memory. Fifty event records are retained and each record contains a time stamp of the first and last event occurrence, and the number of occurrences for each event. In addition, each record contains details of the time, date, and engine hours for the most recent 30 occurrences of the event. The number of occurrences stops incrementing at 99. If an event occurs which is of a type that differs from those in the 50 records in memory, the record that has the oldest “last” event occurrence is removed from the log, and the new category takes its place. Since 50 event records with up to 99 occurrences each are retained in memory, a history of nearly 5,000 specific events are retained in the MGC-2000 Series. Detailed occurrence information is retained for the most recent 30 occurrences of each event record, and there are 50 event records; thus the time, date, and engine hours details for up to 1,500 specific event occurrences are retained in the event log.

BESTCOMS*Plus*® can be used to view and download the event log. The event log may also be viewed through the front panel HMI by navigating to *Metering, Alarms-Status, Event Log.* Use the Up/Down keys to highlight an event and press the *Right* key to view the summary of that event record. The summary contains the description of the event, date, time, and engine hours of the first occurrence of the event, along with date, time, and engine hours of the most recent occurrence of the event. To view details of specific event occurrences, press the *Down* key until DETAILS is highlighted, and then, press the *Right* key. The occurrence number can be changed by pressing the *Edit* key, *Up/Down* keys to select #, and pressing the *Edit* key again to exit. Table 3-7 lists all possible event strings (as shown in the event log).

Table 3-7. Event List

Event String	Event Description	Event Type
27-1 UNDVOLT TRP A	27-1 Undervoltage Trip	Alarm
27-1 UNDVOLT TRP P	27-1 Undervoltage Trip	Pre-Alarm
27-2 UNDVOLT TRP A	27-2 Undervoltage Trip	Alarm
27-2 UNDVOLT TRP P	27-2 Undervoltage Trip	Pre-Alarm
32 RVS PWR TRP A	32 Reverse Power Trip	Alarm
32 RVS PWR TRP P	32 Reverse Power Trip	Pre-Alarm
40 EXC LOSS TRP A	40 Loss of Excitation Trip	Alarm
40 EXC LOSS TRP P	40 Loss of Excitation Trip	Pre-Alarm
47 PHS IMBAL TRP A	47 Phase Imbalance Trip	Alarm
47 PHS IMBAL TRP P	47 Phase Imbalance Trip	Pre-Alarm
51-1 OVRCURR TRP A	51-1 Overcurrent Trip	Alarm
51-1 OVRCURR TRP P	51-1 Overcurrent Trip	Pre-Alarm
51-2 OVRCURR TRP A	51-2 Overcurrent Trip	Alarm
51-2 OVRCURR TRP P	51-2 Overcurrent Trip	Pre-Alarm
51-3 OVRCURR TRP A	51-3 Overcurrent Trip	Alarm
51-3 OVRCURR TRP P	51-3 Overcurrent Trip	Pre-Alarm
59-1 OVRVOLT TRP A	59-1 Overvoltage Trip	Alarm
59-1 OVRVOLT TRP P	59-1 Overvoltage Trip	Pre-Alarm
59-2 OVRVOLT TRP A	59-2 Overvoltage Trip	Alarm
59-2 OVRVOLT TRP P	59-2 Overvoltage Trip	Pre-Alarm
78 VECTOR SHIFT TRIP A	78 Vector Shift Trip	Alarm
78 VECTOR SHIFT TRIP P	78 Vector Shift Trip	Pre-Alarm
81 ROC DF/DT TRIP A	81 Rate of Change of Frequency DF/DT Trip	Alarm
81 ROC DF/DT TRIP P	81 Rate of Change of Frequency DF/DT Trip	Pre-Alarm
81O OVRFREQ TRP A	81 Overfrequency Trip	Alarm
81O OVRFREQ TRP P	81 Overfrequency Trip	Pre-Alarm
81U UNDFREQ TRP A	81 Underfrequency Trip	Alarm
81U UNDFREQ TRP P	81 Underfrequency Trip	Pre-Alarm
AEM COMM FAIL P	AEM-2020 Communications Failure	Pre-Alarm
AEM OUTX OUT RNG (X = 1 to 4)	User Configurable Analog Output X Out of Range (X = 1 to 4)	Status
AEM OUTX OUT RNG A (X = 1 to 4)	User Configurable Analog Output X Out of Range (X = 1 to 4)	Alarm
AEM OUTX OUT RNG P (X = 1 to 4)	User Configurable Analog Output X Out of Range (X = 1 to 4)	Pre-Alarm
AL ECU FAULTY P	ECU Faulty	Pre-Alarm
ALG IN X O1 (X = 1 to 8)	User Configurable Analog Input X Over 1 (X = 1 to 8)	Status
ALG IN X O1 A (X = 1 to 8)	User Configurable Analog Input X Over 1 (X = 1 to 8)	Alarm
ALG IN X O1 P (X = 1 to 8)	User Configurable Analog Input X Over 1 (X = 1 to 8)	Pre-Alarm
ALG IN X O2 (X = 1 to 8)	User Configurable Analog Input X Over 1 (X = 1 to 8)	Status
ALG IN X O2 A (X = 1 to 8)	User Configurable Analog Input X Over 1 (X = 1 to 8)	Alarm
ALG IN X O2 P (X = 1 to 8)	User Configurable Analog Input X Over 1 (X = 1 to 8)	Pre-Alarm
ALG IN X OOR (X = 1 to 8)	User Configurable Analog Input X Out of Range (X = 1 to 8)	Status
ALG IN X OOR A (X = 1 to 8)	User Configurable Analog Input X Out of Range (X = 1 to 8)	Alarm
ALG IN X OOR P (X = 1 to 8)	User Configurable Analog Input X Out of Range (X = 1 to 8)	Pre-Alarm
ALG IN X U1 (X = 1 to 8)	User Configurable Analog Input X Under 1 (X = 1 to 8)	Status
ALG IN X U1 A (X = 1 to 8)	User Configurable Analog Input X Under 1 (X = 1 to 8)	Alarm
ALG IN X U1 P (X = 1 to 8)	User Configurable Analog Input X Under 1 (X = 1 to 8)	Pre-Alarm
ALG IN X U2 (X = 1 to 8)	User Configurable Analog Input X Under 1 (X = 1 to 8)	Status
ALG IN X U2 A (X = 1 to 8)	User Configurable Analog Input X Under 1 (X = 1 to 8)	Alarm
ALG IN X U2 P (X = 1 to 8)	User Configurable Analog Input X Under 1 (X = 1 to 8)	Pre-Alarm
ATS INPUT CLOSED	ATS Input	Status
AUTO MODE	MGC-2000 Series has entered Auto mode.	Status
AUTO RESTART	Automatic Restart in Progress	Status
AUTO RESTART FAIL A	Automatic Restart Fail	Alarm
BATT CHRG FAIL A	Battery Charger Fail	Alarm

Event String	Event Description	Event Type
BATT CHRG FAIL P	Battery Charger Fail	Pre-Alarm
BATT OVERVOLT P	Battery Overvoltage	Pre-Alarm
BATTLE OVERRIDE	Battle Override	Status
BUS REV ROT	Bus Reverse Rotation	Pre-Alarm
CAN BUS OFF	CAN bus entered Bus Off state	Status
CAN ERROR PASSIVE	CAN bus entered Error Passive state	Status
CEM COMM FAIL P	CEM-2020 Communications Failure	Pre-Alarm
CEM HW MISMATCH P	Connected CEM-2020 is wrong type	Pre-Alarm
CHECKSUM FAIL P	Corrupt user settings or firmware code	Pre-Alarm
COMBINED RED A	Combined Red	Alarm
COMBINED YELLOW P	Combined Yellow	Pre-Alarm
CONF PROT X O1 (X = 1 to 8)	Configurable Protection X (X = 1 to 8) Over Threshold 1	Status
CONF PROT X O1 A (X = 1 to 8)	Configurable Protection X (X = 1 to 8) Over Threshold 1	Alarm
CONF PROT X O1 P (X = 1 to 8)	Configurable Protection X (X = 1 to 8) Over Threshold 1	Pre-Alarm
CONF PROT X O2 (X = 1 to 8)	Configurable Protection X (X = 1 to 8) Over Threshold 2	Status
CONF PROT X O2 A (X = 1 to 8)	Configurable Protection X (X = 1 to 8) Over Threshold 2	Alarm
CONF PROT X O2 P (X = 1 to 8)	Configurable Protection X (X = 1 to 8) Over Threshold 2	Pre-Alarm
CONF PROT X U1 (X = 1 to 8)	Configurable Protection X (X = 1 to 8) Under Threshold 1	Status
CONF PROT X U1 A (X = 1 to 8)	Configurable Protection X (X = 1 to 8) Under Threshold 1	Alarm
CONF PROT X U1 P (X = 1 to 8)	Configurable Protection X (X = 1 to 8) Under Threshold 1	Pre-Alarm
CONF PROT X U2 (X = 1 to 8)	Configurable Protection X (X = 1 to 8) Under Threshold 2	Status
CONF PROT X U2 A (X = 1 to 8)	Configurable Protection X (X = 1 to 8) Under Threshold 2	Alarm
CONF PROT X U2 P (X = 1 to 8)	Configurable Protection X (X = 1 to 8) Under Threshold 2	Pre-Alarm
CONFIG ELEMENT X A (X = 1 to 8)	Configurable Element X (X = 1 to 8)	Alarm
CONFIG ELEMENT X P (X = 1 to 8)	Configurable Element X (X = 1 to 8)	Pre-Alarm
COOL LVL SNDR FL A	Coolant Level Sender Fail	Alarm
COOL SNDR FAIL	Coolant Temperature Sender Fail	Status
COOL SNDR FAIL A	Coolant Temperature Sender Fail	Alarm
COOL SNDR FAIL P	Coolant Temperature Sender Fail	Pre-Alarm
DEFAULTS LOADED	Default settings were uploaded into the MGC, indicating either a successful firmware upload or a manual reset (UP and DOWN pushbuttons being held).	Status
DEF ENGINE DERATE P	Diesel Exhaust Fluid Engine Derate	Pre-Alarm
DEF FLUID EMPTY P	Diesel Exhaust Fluid Empty	Pre-Alarm
DEF FLUID LOW P	Diesel Exhaust Fluid Low	Pre-Alarm
DEF INDUCMT O-RIDE P	Diesel Exhaust Fluid Inducement Override	Pre-Alarm
DEF PRESVR INDUCMT P	Diesel Exhaust Fluid Pre-Severe Inducement	Pre-Alarm
DEF SEVERE INDUCMT P	Diesel Exhaust Fluid Severe inducement	Pre-Alarm
DEF WARNING	Diesel Exhaust Fluid Pre-Inducement Warning Level 1	Pre-Alarm
DEF WARNING LEVEL 2	Diesel Exhaust Fluid Pre-Inducement Warning Level 2	Pre-Alarm
DEMAND START	Demand Start Request	Status
DEMAND STOP	Demand Stop Request	Status
DGC HEARTBEAT FAIL P	MGC-2000 Series Heartbeat Fail	Pre-Alarm
DIAG TRBL CODE P	Diagnostic Trouble Code	Pre-Alarm
DIAL OUT FAILED	Modem Dialout Failed	Status
DIAL OUT SUCCESS	Modem Dialout Success	Status
DPF REGNRATE DISABLD P	Regeneration Disabled	Pre-Alarm
DPF REGEN REQD P	Regeneration Required	Pre-Alarm
DPF SOOT LVL EXT HI P	Diesel Particulate Filter Soot Level Extremely High	Pre-Alarm
DPF SOOT LVL MOD HI P	Diesel Particulate Filter Soot Level Moderately High	Pre-Alarm
ECU SHUTDOWN A	ECU Shutdown	Alarm
EMERGENCY STOP A	Emergency Stop	Alarm
ENGINE RUN START	Engine Run logic element received a *start* request.	Status
ENG kW OVRLD-1 P	Engine kW Overload 1	Pre-Alarm
ENG kW OVRLD-2 P	Engine kW Overload 2	Pre-Alarm
ENG kW OVRLD-3 P	Engine kW Overload 3	Pre-Alarm
ENGINE RUNNING	Engine Running	Status
ENTERED PROG MODE	MGC-2000 Series has entered programming mode to update firmware.	Status

Event String	Event Description	Event Type
FUEL FLT PRS HI P	Fuel Filter Differential Pressure High	Pre-Alarm
FUEL LEAK 1 P	Fuel Filter 1 Leak	Pre-Alarm
FUEL LEAK 2 P	Fuel Filter 2 Leak	Pre-Alarm
FUEL LEAK DETECT A	Fuel Leak Detect	Alarm
FUEL LEAK DETECT P	Fuel Leak Detect	Pre-Alarm
FUEL LEVL SENDR A	Fuel Level Sender Fail	Alarm
FUEL LEVL SENDR FAIL	Fuel Level Sender Fail	Status
FUEL LEVL SENDR P	Fuel Level Sender Fail	Pre-Alarm
GEN REV ROT	Generator Reverse Rotation	Pre-Alarm
GEN TEST LOADED	Generator Exerciser Test with Load	Status
GEN TEST UNLOADED	Generator Exerciser Test without Load	Status
GLBL SNDR FAIL A	Global Sender Fail	Alarm
GN BKR CL FL P	Generator Breaker Fail to Close	Pre-Alarm
GN BKR OP FL P	Generator Breaker Fail to Open	Pre-Alarm
GN BKR SYN FL P	Generator Breaker Synchronization Fail	Pre-Alarm
HI COOLANT TMP A	High Coolant Temp	Alarm
HI COOLANT TMP P	High Coolant Temp	Pre-Alarm
HI DAY TANK LEVEL P	High Day Tank Level	Pre-Alarm
HI ECU VOLTS A	High ECU Supply Voltage	Alarm
HI EXHAUSE B T P	High Exhaust Temp B	Pre-Alarm
HI EXHAUST A T P	High Exhaust Temp A	Pre-Alarm
HI PRESSURE IN 1 P	High Pressure Input 1	Pre-Alarm
HI PRESSURE IN 2 P	High Pressure Input 2	Pre-Alarm
HI SUPPLY VOLTS P	High Voltage Supply	Pre-Alarm
HI T FUEL P	High Fuel Temp	Pre-Alarm
HIGH AMB TEMP P	High Ambient Temp	Pre-Alarm
HIGH CHARGE AIR TEMP A	High Charge Air Temp	Alarm
HIGH CHARGE AIR TEMP P	High Charge Air Temp	Pre-Alarm
HIGH COIL TEMP 1 P	High Temp Coil 1	Pre-Alarm
HIGH COIL TEMP 2 P	High Temp Coil 2	Pre-Alarm
HIGH COIL TEMP 3 P	High Temp Coil 3	Pre-Alarm
HIGH COOLANT TEMP A	High Coolant Temp	Alarm
HIGH COOLANT TEMP P	High Coolant Temp	Pre-Alarm
HIGH ECU TEMPERATURE P	High ECU Temp	Pre-Alarm
HIGH EXHAUST TEMP P	High Exhaust Temp	Pre-Alarm
HIGH FUEL LEVEL P	High Fuel Level	Pre-Alarm
HIGH FUEL RAIL PRESS P	High Fuel Rail Pressure	Pre-Alarm
HIGH INTRCOOLER TEMP P	High Intercooler Temp	Pre-Alarm
HIGH OIL TEMPERATURE P	High Oil Temp	Pre-Alarm
HIGH OIL TERMPERATURE A	High Oil Temp	Alarm
HIGH STRG TANK LEVEL P	High Storage Tank Level	Pre-Alarm
ID MISSING P	LSM-2020 ID Missing	Pre-Alarm
ID REPEAT P	LSM-2020 ID Repeated	Pre-Alarm
IDLE SPD LO P	Idle Speed Low	Pre-Alarm
INPUT X A (X = 1 to 40)	User Configurable Input X (X = 1 to 40)	Alarm
INPUT X P (X = 1 to 40)	User Configurable Input X (X = 1 to 40)	Pre-Alarm
LO AFTERCLR COOL LVL A	Low After Cooler Cool Level	Alarm
LO CHG AIR CLNT LVL P	Low Charge Air Coolant Level	Pre-Alarm
LO DAY TANK LEVEL P	Low Day Tank Level	Pre-Alarm
LO ECU VOLTS P	Low ECU Supply Voltage	Pre-Alarm
LO FUEL DLV PRESSURE A	Low Fuel Delivery Pressure	Alarm
LO SUPPLY VOLTS P	Low Voltage Supply	Pre-Alarm
LOAD TAKEOVER	Load Takeover	Status
LOGIC OUPUT A	Logic Output	Alarm
LOGIC OUPUT P	Logic Output	Pre-Alarm
LOSS OF VOLT	Voltage Sensing Fail	Status
LOSS OF VOLT A	Voltage Sensing Fail	Alarm
LOSS OF VOLT P	Voltage Sensing Fail	Pre-Alarm

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Event String	Event Description	Event Type
LOSS REM COMS P	Loss of Remote Module Communication	Pre-Alarm
LOST ECU COMM A	Loss of ECU Communication	Alarm
LOST ECU COMM P	Loss of ECU Communication	Pre-Alarm
LOW BATT VOLT P	Low Battery Voltage	Pre-Alarm
LOW CHARGE AIR PRESS P	Low Charge Air Pressure	Pre-Alarm
LOW COOL LEVEL A	Low Coolant Level	Alarm
LOW COOL LEVEL P	Low Coolant Level	Pre-Alarm
LOW COOL TMP A	Low Coolant Temperature	Alarm
LOW COOL TMP P	Low Coolant Temperature	Pre-Alarm
LOW COOLANT LEVEL P	Low Coolant Level	Pre-Alarm
LOW FUEL DELIV PRESS P	Low Fuel Delivery Pressure	Pre-Alarm
LOW FUEL LEVEL A	Low Fuel Level	Alarm
LOW FUEL LEVEL P	Low Fuel Level	Pre-Alarm
LOW FUEL RAIL PRESS P	Low Fuel Rail Pressure	Pre-Alarm
LOW OIL PRES A	Low Oil Pressure	Alarm
LOW OIL PRES P	Low Oil Pressure	Pre-Alarm
LOW OIL PRESSURE A	Low Oil Pressure	Alarm
LOW OIL PRESSURE P	Low Oil Pressure	Pre-Alarm
LOW STRG TANK LEVEL P	Low Storage Tank Level	Pre-Alarm
LSM AVR OUT LMT P	LSM-2020 AVR Output Limit	Pre-Alarm
LSM COMMS FAIL P	LSM-2020 Communications Failure	Pre-Alarm
LSM GOV OUT LMT P	LSM-2020 GOV Output Limit	Pre-Alarm
LSM HEARTBEAT FAIL P	LSM-2020 Heartbeat Failed	Pre-Alarm
LSM INTERGEN COM FAIL P	LSM-2020 Intergen Communications Failure	Pre-Alarm
MAINS FAIL TEST	Mains Fail Test	Status
MAINT INTERVAL P	Maintenance Interval	Pre-Alarm
MF TRANSFER	Mains Fail Transfer Complete	Status
MF TRANSFER FAIL	Mains Fail Transfer Fail	Status
MN BKR CL FL P	Mains Breaker Fail to Close	Pre-Alarm
MN BKR OP FL P	Mains Breaker Fail to Open	Pre-Alarm
MN BKR SYN FL P	Mains Breaker Synchronization Fail	Pre-Alarm
MPU FAIL P	Magnetic Pickup Fail	Pre-Alarm
MULTIPLE AEM P	Multiple AEM-2020's	Pre-Alarm
MULTIPLE CEM P	Multiple CEM-2020's	Pre-Alarm
MULTIPLE LSM P	Multiple LSM-2020's	Pre-Alarm
NORM SHUTDOWN	Normal Shutdown	Status
OFF MODE	MGC-2000 Series has entered Off mode.	Status
OIL SNDR FAIL	Oil Pressure Sender Fail	Status
OIL SNDR FAIL A	Oil Pressure Sender Fail	Alarm
OIL SNDR FAIL P	Oil Pressure Sender Fail	Pre-Alarm
OVERCRANK A	Overcrank	Alarm
OVERSPD TEST ON P	Overspeed Test On	Pre-Alarm
OVERSPEED A	Overspeed	Alarm
PRIMING FAULT P	Priming Fault	Pre-Alarm
PROT SHUTDOWN	Protective Shutdown	Status
REMOTE START	*Remote Start* was requested via BESTCOMS*Plus* or Modbus.	Status
RESET	MGC-2000 Series has been reset.	Status
RTD IN X OOR A (X = 1 to 8)	User Configurable Analog Input X Out of Range (X = 1 to 8)	Alarm
RTD IN X O1 (X = 1 to 8)	User Configurable Analog Input X Over 1 (X = 1 to 8)	Status
RTD IN X O1 A (X = 1 to 8)	User Configurable Analog Input X Over 1 (X = 1 to 8)	Alarm
RTD IN X O1 P (X = 1 to 8)	User Configurable Analog Input X Over 1 (X = 1 to 8)	Pre-Alarm
RTD IN X O2 (X = 1 to 8)	User Configurable Analog Input X Over 1 (X = 1 to 8)	Status
RTD IN X O2 A (X = 1 to 8)	User Configurable Analog Input X Over 1 (X = 1 to 8)	Alarm
RTD IN X O2 P (X = 1 to 8)	User Configurable Analog Input X Over 1 (X = 1 to 8)	Pre-Alarm
RTD IN X OOR (X = 1 to 8)	User Configurable RTD Input X Out of Range (X = 1 to 8)	Status
RTD IN X OOR P (X = 1 to 8)	User Configurable Analog Input X Out of Range (X = 1 to 8)	Pre-Alarm
RTD IN X U1 (X = 1 to 8)	User Configurable Analog Input X Under 1 (X = 1 to 8)	Status
RTD IN X U1 A (X = 1 to 8)	User Configurable Analog Input X Under 1 (X = 1 to 8)	Alarm

Event String	Event Description	Event Type
RTD IN X U1 P (X = 1 to 8)	User Configurable Analog Input X Under 1 (X = 1 to 8)	Pre-Alarm
RTD IN X U2 (X = 1 to 8)	User Configurable Analog Input X Under 1 (X = 1 to 8)	Status
RTD IN X U2 A (X = 1 to 8)	User Configurable Analog Input X Under 1 (X = 1 to 8)	Alarm
RTD IN X U2 P (X = 1 to 8)	User Configurable Analog Input X Under 1 (X = 1 to 8)	Pre-Alarm
RUN MODE	MGC-2000 Series has entered Run mode.	Status
RUNUP SPD LO P	Run Up Speed Low	Pre-Alarm
RUN WITH LOAD START	*Run with Load* logic element received a *start* request.	Status
RUN WITH LOAD STOP	*Run with Load* logic element received a *stop* request.	Status
SCREEN ERROR	Screen Error	Status
SERFLASH RD FAIL	Serial Flash Read Fail	Pre-Alarm
SETTINGS CHANGED	A setting was changed via BESTCOMS*Plus*, Modbus, or front panel interface.	Status
SPD SNDR FAIL	Speed Sender Fail	Status
SPD SNDR FAIL A	Speed Sender Fail	Alarm
SPEED DMD FL P	Speed Demand Fail	Pre-Alarm
SPEED TOO LOW P	Engine Speed Too Low	Pre-Alarm
SS OVERRIDE ON P	Shutdown Override	Pre-Alarm
START SPEED LOW P	Start Speed Low	Pre-Alarm
THRM CPL X O1 (X = 1 to 2)	User Configurable Thermocouple Input X Over 1 (X = 1 to 2)	Status
THRM CPL X O1 A (X = 1 to 2)	User Configurable Thermocouple Input X Over 1 (X = 1 to 2)	Alarm
THRM CPL X O1 P (X = 1 to 2)	User Configurable Thermocouple Input X Over 1 (X = 1 to 2)	Pre-Alarm
THRM CPL X O2 (X = 1 to 2)	User Configurable Thermocouple Input X Over 1 (X = 1 to 2)	Status
THRM CPL X O2 A (X = 1 to 2)	User Configurable Thermocouple Input X Over 1 (X = 1 to 2)	Alarm
THRM CPL X O2 P (X = 1 to 2)	User Configurable Thermocouple Input X Over 1 (X = 1 to 2)	Pre-Alarm
THRM CPL X OOR (X = 1 to 2)	User Configurable Thermocouple Input X Out of Range (X = 1 to 2)	Status
THRM CPL X OOR A (X = 1 to 2)	User Configurable Thermocouple Input X Out of Range (X = 1 to 2)	Alarm
THRM CPL X OOR P (X = 1 to 2)	User Configurable Thermocouple Input X Out of Range (X = 1 to 2)	Pre-Alarm
THRM CPL X U1 (X = 1 to 2)	User Configurable Thermocouple Input X Under 1 (X = 1 to 2)	Status
THRM CPL X U1 A (X = 1 to 2)	User Configurable Thermocouple Input X Under 1 (X = 1 to 2)	Alarm
THRM CPL X U1 P (X = 1 to 2)	User Configurable Thermocouple Input X Under 1 (X = 1 to 2)	Pre-Alarm
THRM CPL X U2 (X = 1 to 2)	User Configurable Thermocouple Input X Under 1 (X = 1 to 2)	Status
THRM CPL X U2 A (X = 1 to 2)	User Configurable Thermocouple Input X Under 1 (X = 1 to 2)	Alarm
THRM CPL X U2 P (X = 1 to 2)	User Configurable Thermocouple Input X Under 1 (X = 1 to 2)	Pre-Alarm
VOLTAGE SENSE FAIL	Voltage Sensing Fail	Status
VOLTAGE SENSE FAIL A	Voltage Sensing Fail	Alarm
VOLTAGE SENSE FAIL P	Voltage Sensing Fail	Pre-Alarm
WEAK BATTERY P	Weak Battery	Pre-Alarm

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SECTION 4 • BESTCOMS*Plus*® SOFTWARE

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SECTION 4 • BESTCOMS*Plus*® SOFTWARE

Introduction

BESTCOMS*Plus*® is a Windows®-based, PC application that provides a user-friendly, graphical user interface (GUI) for use with Basler Electric communicating products. The name BESTCOMS*Plus* is an acronym that stands for Basler Electric Software Tool for Communications, Operations, Maintenance, and Settings.

BESTCOMS*Plus* provides the user with a point-and-click means to set and monitor the MGC-2000 Series. The capabilities of BESTCOMS*Plus* make the configuration of one or several MGC-2000 Series controllers fast and efficient. A primary advantage of BESTCOMS*Plus* is that a settings scheme can be created, saved as a file, and then uploaded to the MGC-2000 Series at the user's convenience.

BESTCOMS*Plus* uses plugins allowing the user to manage several different Basler Electric products. The MGC-2000 Series plugin must be activated before use.

The MGC-2000 Series plugin opens inside the BESTCOMS*Plus* main shell with the same default logic scheme that is shipped with the MGC-2000 Series. This gives the user the option of developing a custom setting file by modifying the default logic scheme or by building a unique scheme from scratch.

BESTlogic™*Plus* Programmable Logic is used to program MGC-2000 Series inputs and outputs, alarms, and generator protection functions. This is accomplished by the drag-and-drop method. The user can drag elements, components, inputs, and outputs onto the program grid and make connections between them to create the desired logic scheme.

Figure 4-1 illustrates the typical user interface components of the MGC-2000 Series plugin with BESTCOMS*Plus*.

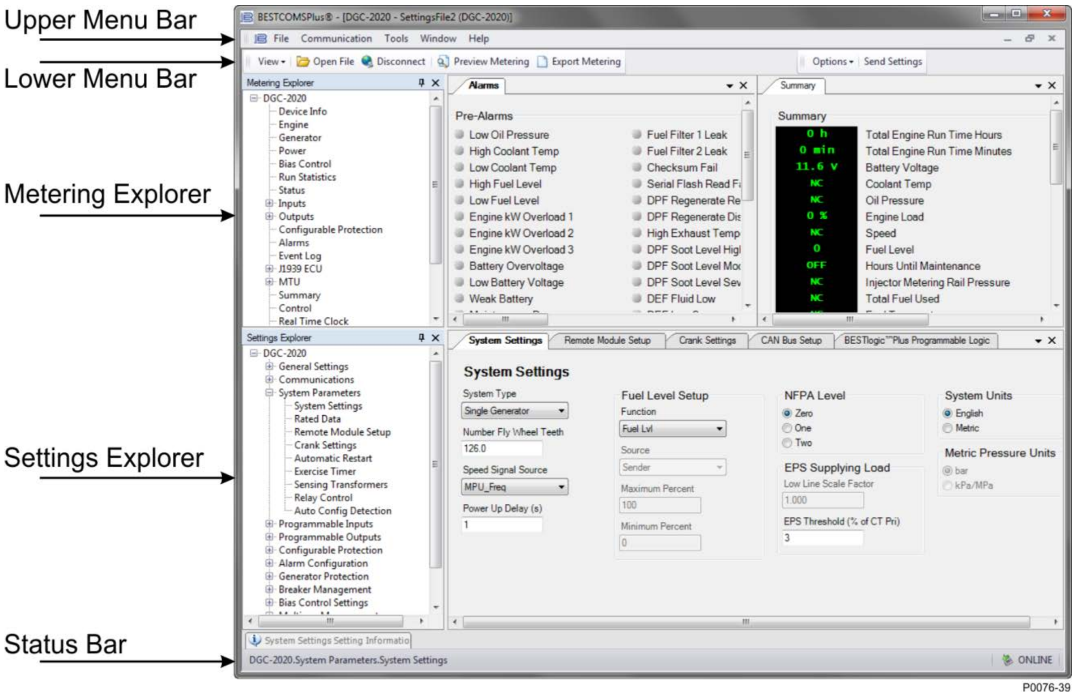

Figure 4-1. Typical User Interface Components

Installation

BESTCOMS*Plus* software is built on the Microsoft® .NET Framework. The setup utility that installs BESTCOMS*Plus* on your PC also installs the MGC-2000 Series plugin and the required version of .NET Framework (if not already installed). BESTCOMS*Plus* operates with systems using Windows® XP 32-bit SP2/SP3, Windows Vista 32-bit (all editions), Windows 7 32-bit (all editions), Windows 7 64-bit (all editions), and Windows 8. Microsoft Internet Explorer 5.01 or later must be installed on your PC before installing BESTCOMS*Plus*. System recommendations for the .NET Framework and BESTCOMS*Plus* are listed in Table 4-1.

Table 4-1. System Recommendations for BESTCOMSPlus and the .NET Framework

System Type	Component	Recommendation
32/64 bit	Processor	2.0 GHz
32/64 bit	RAM	1 GB (minimum), 2 GB (recommended)
32 bit	Hard Drive	100 MB (if .NET Framework is already installed on PC.)
		950 MB (if .NET Framework is not already installed on PC.)
64 bit	Hard Drive	100 MB (if .NET Framework is already installed on PC.)
		2.1 GB (if .NET Framework is not already installed on PC.)

To install and run BESTCOMS*Plus*, a Windows user must have Administrator rights. A Windows user with limited rights might not be permitted to save files in certain folders.

Installing BESTCOMS*Plus*®

NOTE

Do <u>not</u> connect a USB cable until setup completes successfully. Connecting a USB cable before setup is complete might result in unwanted or unexpected errors.

1. Insert the BESTCOMS*Plus* CD-ROM into the PC CD-ROM drive.
2. When the BESTCOMS*Plus* Setup and Documentation CD menu appears, click the *Install* button for the BESTCOMS*Plus* application. The setup utility installs BESTCOMS*Plus*, the .NET Framework (if not already installed), the USB driver, and the DGC-2020 plugin for BESTCOMS*Plus* on your PC.

When BESTCOMS*Plus* installation is complete, a Basler Electric folder is added to the Windows programs menu. This folder is accessed by clicking the Windows *Start* button and then accessing the Basler Electric folder in the *Programs* menu. The Basler Electric folder contains an icon that starts BESTCOMS*Plus* when clicked.

Activate the MGC-2000 Series Plugin for BESTCOMSPlus®

The MGC-2000 Series plugin is a module that runs inside the BESTCOMS*Plus* shell. The MGC-2000 Series plugin contains specific operational and logic settings for only the MGC-2000 Series. Uploading settings to the MGC-2000 Series is possible only after activating the MGC-2000 Series plugin.

The MGC-2000 Series plugin can be activated automatically or manually. Automatic activation is achieved by using a USB cable to establish communication between the MGC-2000 Series and BESTCOMS*Plus*. Manual activation is initiated by contacting Basler Electric for an activation key and entering the key into BESTCOMS*Plus*. Manual activation is useful if you want to create a settings file prior to receiving your MGC-2000 Series. Refer to *Manual Activation of MGC-2000 Series Plugin.*

Connect a USB Cable

The USB driver was copied to your PC during BESTCOMS*Plus* installation and is installed automatically after powering the MGC-2000 Series. USB driver installation progress is shown in the Windows taskbar area. Windows will notify you when installation is complete.

Connect a USB cable between the PC and your MGC-2000 Series. Apply operating power to the MGC-2000 Series. Wait until the boot sequence is complete.

Start BESTCOMS*Plus*® and Activate MGC-2000 Series Plugin Automatically

To start BESTCOMS*Plus*, click the Windows *Start* button, point to *Programs*, *Basler Electric*, and then click the *BESTCOMSPlus* icon. During initial startup, the *BESTCOMSPlus Select Language* screen is displayed (Figure 4-2). You can choose to have this screen displayed each time BESTCOMS*Plus* is started, or you can select a preferred language and this screen will be bypassed in the future. Click *OK* to continue. This screen can be accessed later by selecting *<u>T</u>ools* and *<u>S</u>elect Language* from the menu bar.

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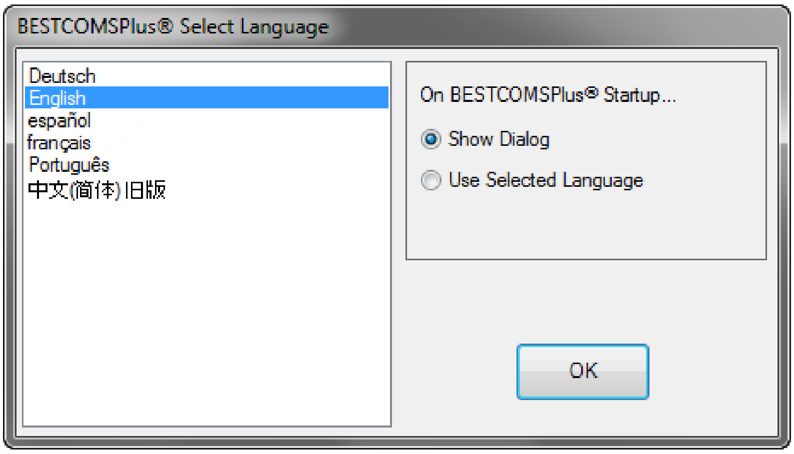

Figure 4-2. BESTCOMSPlus Select Language

The BESTCOMS*Plus* splash screen is shown for a brief time. See Figure 4-3.

Figure 4-3. Splash Screen

The BESTCOMS*Plus* platform window opens. Select *New Connection* from the *Communication* pull-down menu and select *DGC-2020* which is the equivalent of the MGC-2000 Series. See Figure 4-4. The MGC-2000 Series plugin is activated automatically after connecting to an MGC-2000 Series.

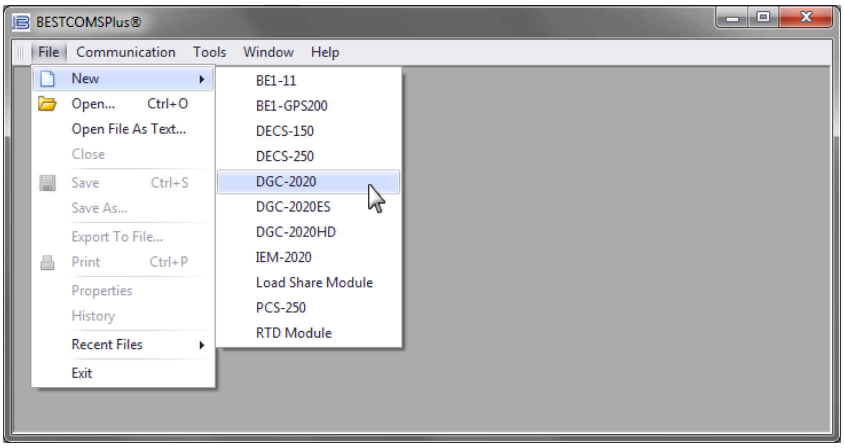

Figure 4-4. Communication Pull-Down Menu

The *DGC-2020 Connection* screen shown in Figure 4-5 will appear.

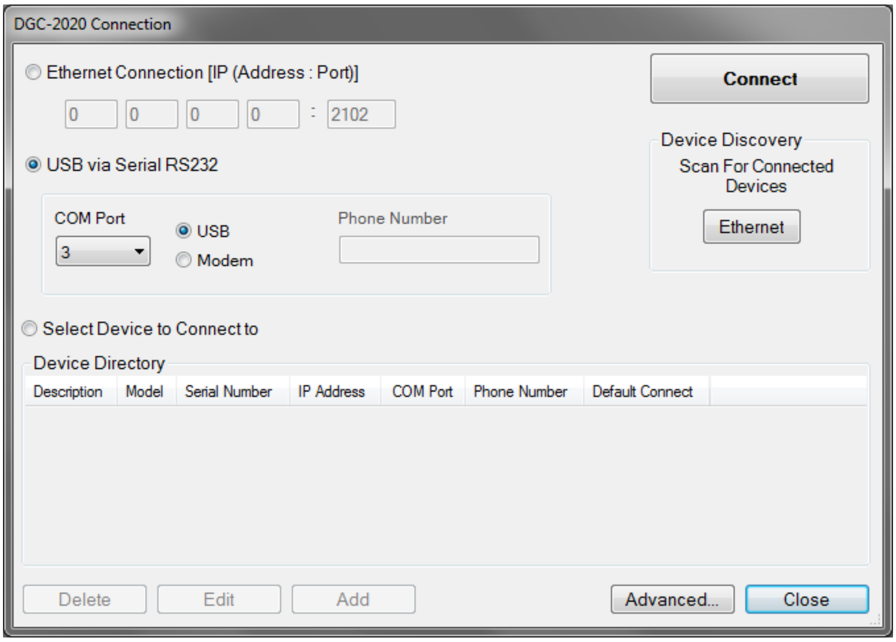

Figure 4-5. MGC-2000 Series Connection

Select *USB via Serial RS232, USB,* and enter *COM Port.* The USB drivers are installed automatically during the BESTCOMS*Plus* installation process. To select the correct *COM Port,* open the Windows Device Manager and expand the *Ports (COM & LPT)* branch. Locate the device named *CP2101 USB to UART Bridge Controller (COMx).* The *COM Port* number will be displayed in parenthesis *(COMx).* Be sure operating power is applied to the MGC-2000 Series and the USB cable is connected before opening the Device Manager. See Figure 4-6.

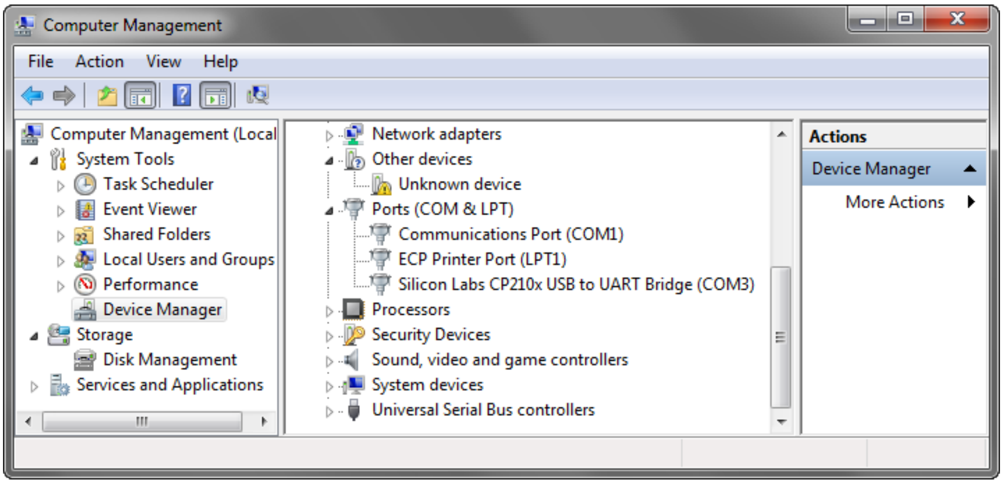

Figure 4-6. Device Manager

The MGC-2000 Series plugin opens indicating that activation was successful. You can now configure the MGC-2000 Series communication ports and other MGC-2000 Series settings.

Installing the USB Driver if Automatic Installation Fails

To install the USB driver for the MGC-2000 Series:

1. Apply operating power to the MGC-2000 Series and wait for the boot sequence to complete.
2. Connect a USB cable between the PC and MGC-2000 Series.
3. The *Found New Hardware Wizard* dialog box appears.

4. Select “**No, not this time**” and select *Next* to continue.
5. Choose to “**Install from a list or specific location (Advanced)**” and select *Next* to continue.
6. Insert the CD-ROM labeled BESTCOMS*Plus* into the PC CD-ROM drive.
7. Navigate to C:\Program Files\Basler Electric\BESTCOMSPlus\USBDeviceDrivers\ and select *Next* to continue.

When installation of the driver is complete, you might be asked to restart your computer.

Manual Activation of the MGC-2000 Series Plugin

Manual activation of theMGC-2000 Series plugin is required only if your initial use of BESTCOMS*Plus* will be on a PC that is not connected to an MGC-2000 Series. Manual activation is described in the following paragraphs.

Requesting an Activation Key

When initially running the MGC-2000 Series plugin, the *Activate Device Plugin* pop-up appears. You must contact Basler Electric for an activation key before you can activate the MGC-2000 Series plugin. You can request an activation key through email or the Basler Electric website. Click either the *Website* or *Email* button. Click the *Activate* button when you are ready to enter the activation key you received from Basler Electric. The *Activate Device Plugin* pop-up appears. Refer to Figure 4-7.

Entering an Activation Key

Select DGC-2020 from the *Device* pull-down menu. Enter your *Email Address* and *Activation Key* provided by Basler Electric. If you received an email containing the *Activation Key*, you can select all of the text in the email and copy it to the Windows clipboard using normal Windows techniques. The *Get Data* button will extract the *Device, Email Address,* and *Activation Key* from the Windows clipboard and paste it into the appropriate fields. Click the *Activate* button to continue. The *Activate Device Plugin* screen is also found by selecting *Activate Device* from the *Tools* pull-down menu of the BESTCOMS*Plus* main screen.

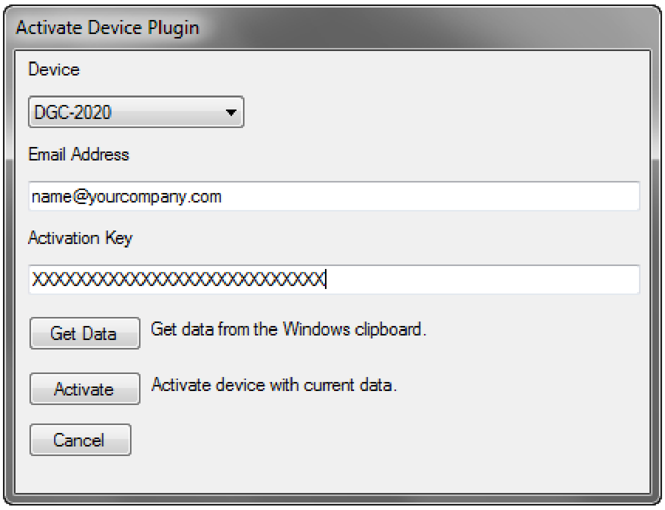

Figure 4-7. Activate Device Plugin

Communication

Modem (Optional)

If connecting to the MGC-2000 Series through a telephone line, select *USB via Serial RS232, Modem,* and enter *Phone Number.* To select the correct *COM Port,* open Windows Device Manager and expand the *Modems* branch. Right-click on the modem name and choose *Properties*. Open the *Advanced* tab to view the COM port. Refer to *Communications, Modem Setup,* for more information.

Ethernet Communication

Communication with the MGC-2000 Series can be made through an optional LSM-2020 (Load Share Module). In order to use the Ethernet capabilities of the LSM-2020, the network settings in the LSM-2020 must first be configured. LSM-2020 network settings can be configured through Device Discovery in

BESTCOMS*Plus,* through the front panel of the MGC-2000 Series, or through the MGC-2000 Series and sent to the LSM-2020 over the CANBus interface. The following procedures can be used to configure LSM-2020 network settings and connect to the MGC-2000 Series through Ethernet via an LSM-2020.

Configure LSM-2020 Network Settings through Device Discovery in BESTCOMSPlus

1. Navigate to the *Settings, System Params, Remote Module Setup, LSM Setup* screen on the front panel HMI and verify that the LSM-2020 is enabled with the correct CANBus address so that the MGC-2000 Series and LSM-2020 are properly linked together. If a USB connection to the MGC-2000 Series is active, the LSM-2020 enable setting and CANBus address can be found by using the Settings Explorer in BESTCOMS*Plus* to open the *System Parameters, Remote Module Setup* tree branch. The MGC-2000 Series will annunciate a pre-alarm if the LSM-2020 is not connected properly when it is enabled. If the connection is valid, the network settings of the LSM-2020 can be configured through the front panel of the MGC-2000 Series.
2. In BESTCOMS*Plus*, click the *Communication* drop-down menu and select *New Connection, Load Share Module.* The *Load Share Module Connection* screen appears. See Figure 4-8.

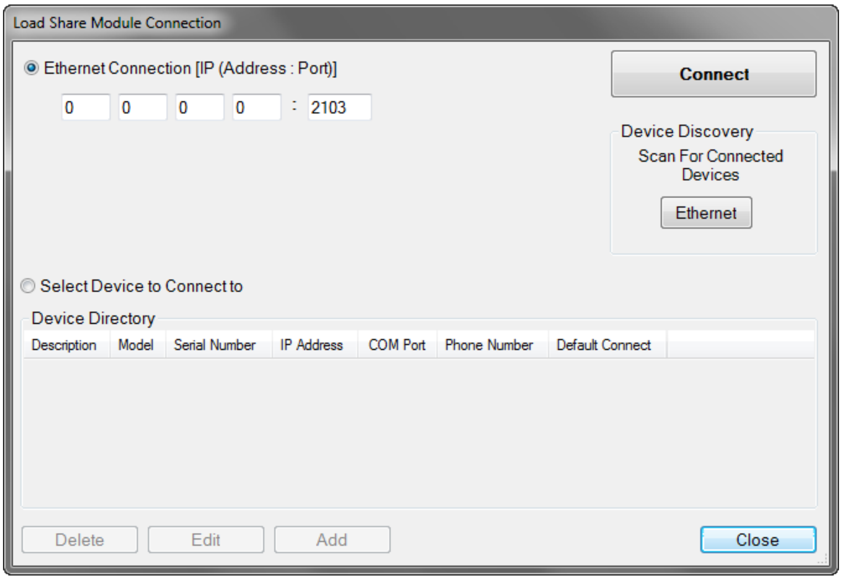

Figure 4-8. Load Share Module Connection

3. Click the *Ethernet* button under *Device Discovery (Scan For Connected Devices).*
4. After scanning for connected devices, the *Device Discovery* screen appears. See Figure 4-9.

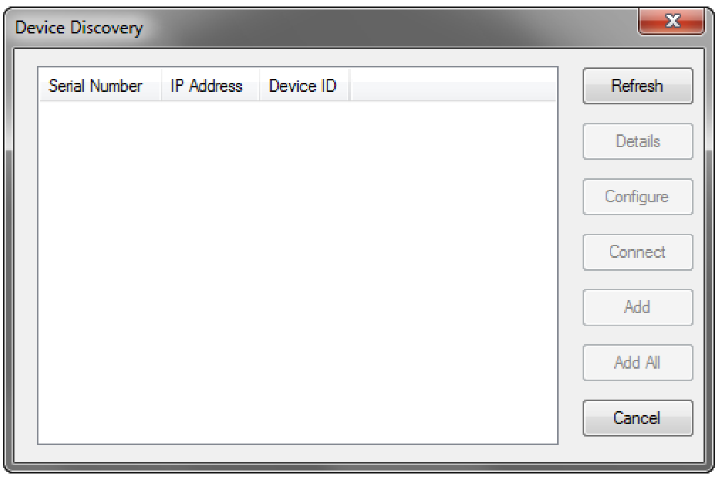

Figure 4-9. Device Discovery

5. Use the mouse to highlight the desired Load Share Module and click the *Configure* button.
6. The *Configure Ethernet Port* screen appears. See Figure 4-10.

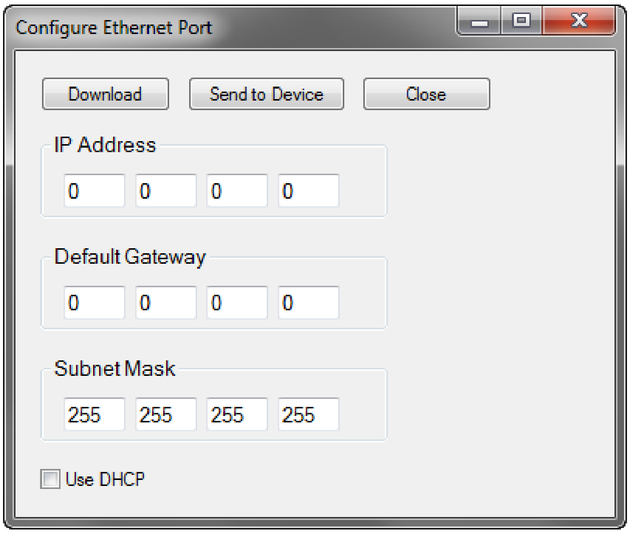

Figure 4-10. Configure Ethernet Port

7. Assign an IP Address, Default Gateway, and Subnet Mask to the Load Share Module by entering values in the same range as your network or PC. If DHCP will be used, check the *Use DHCP* box.
8. Click *Send to Device*. A password is required. The default password is "**OEM**". The LSM-2020 will reboot and use the new settings.

Configure LSM-2020 Network Settings through the Front Panel of the MGC-2000 Series

1. Navigate to the *Settings, System Params, Remote Module Setup, LSM Setup* screen on the front panel HMI and verify that the LSM-2020 is enabled with the correct CANBus address so that the MGC-2000 Series and LSM-2020 are properly linked together. If a USB connection to the MGC-2000 Series is active, the LSM-2020 enable setting and CANBus address can be found by using the Settings Explorer in BESTCOMS*Plus* to open the *System Parameters, Remote Module Setup* tree branch. The MGC-2000 Series will annunciate a pre-alarm if the LSM-2020 is not connected properly when it is enabled. If the connection is valid, the network settings of the LSM-2020 can be configured through the front panel of the MGC-2000 Series.
2. Navigate to the *Settings, System Params, Remote Module Setup, LSM Setup, TCP/IP* Settings screen on the front panel HMI.

   Configurable options include:

IP Address:	Internet Protocol Address to be used by the LSM-2020.
Subnet Mask:	Mask used to determine the range of the current network subnet.
Gateway Address:	Default host to send data destined for a host not on the network subnet.
Use DHCP:	Automatically configures IP Address, Default Gateway, and Subnet Mask via DHCP. This can be used only if the Ethernet network has a properly configured DHCP server running. The LSM-2020 does not act as a DHCP server.

The values for these options should be obtained from the site administrator if the LSM-2020 is intended to share the network with other devices. If the LSM-2020 is operating on an isolated network, the IP address might be chosen from one of the following ranges as listed in IETF publication RFC 1918, *Address Allocation for Private Networks.*

10.0.0.0 - 10.255.255.255
172.16.0.0 - 172.31.255.255
192.168.0.0 - 192.168.255.255

If the LSM-2020 is operating on an isolated network, the *Subnet Mask* can be left at 0.0.0.0 and the *Default Gateway* can be chosen as any valid IP address from the same range as the LSM-2020 IP address.

3. Click the *Edit* button to change settings. After settings are configured, click the *Edit* button again to exit.
4. Use the *Left* arrow key to navigate back to the *LSM Setup* screen on the front panel HMI. After leaving the leaving the *TCP/IP Settings* screen, the LSM-2020 will reboot and use the new settings.

Alternate Method to Configure LSM-2020 Network Settings through the MGC-2000 Series

1. Navigate to the *Settings, System Params, Remote Module Setup, LSM Setup* screen on the front panel HMI and verify that the LSM-2020 is enabled with the correct CANBus address so that the MGC-2000 Series and LSM-2020 are properly linked together. If a USB connection to the MGC-2000 Series is active, the LSM-2020 enable setting and CANBus address can be found by using the Settings Explorer in BESTCOMS*Plus* to open the *System Parameters, Remote Module Setup* tree branch. The MGC-2000 Series will annunciate a pre-alarm if the LSM-2020 is not connected properly when it is enabled. If the connection is valid, the network settings of the LSM-2020 can be configured through the USB interface of the MGC-2000 Series.
2. Connect to the MGC-2000 Series through the USB port as described under *USB Communication.* Select *Configure, Ethernet* from the *File* pull-down menu. If the LSM-2020 is connected properly, the *Configure Ethernet Port* screen shown in Figure 4-11 will appear.

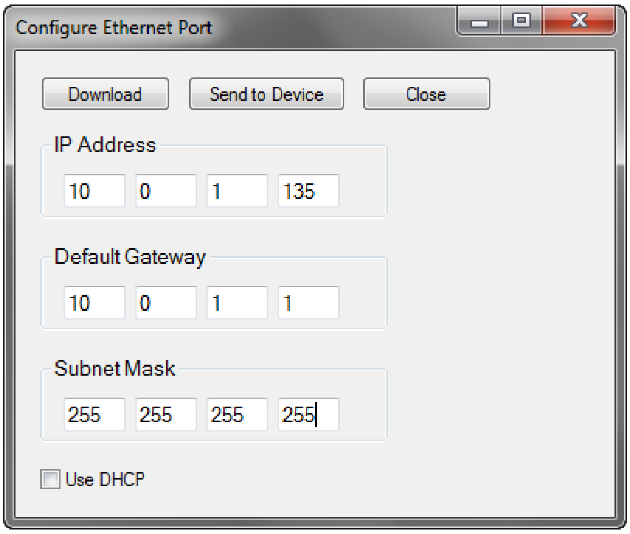

Figure 4-11. Configure Ethernet Port

Configurable options include:

IP Address:	Internet Protocol Address to be used by the LSM-2020.
Default Gateway:	Default host to send data destined for a host not on the network subnet.
Subnet Mask:	Mask used to determine the range of the current network subnet.
Use DHCP:	Automatically configures IP Address, Default Gateway, and Subnet Mask via DHCP. This can be used only if the Ethernet network has a properly configured DHCP server running. The LSM-2020 does not act as a DHCP server.

The values for these options should be obtained from the site administrator if the LSM-2020 is intended to share the network with other devices. If the LSM-2020 is operating on an isolated network, the IP address might be chosen from one of the following ranges as listed in IETF publication RFC 1918, *Address Allocation for Private Networks.*

10.0.0.0 - 10.255.255.255
172.16.0.0 - 172.31.255.255
192.168.0.0 - 192.168.255.255

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If the LSM-2020 is operating on an isolated network, the *Subnet Mask* can be left at 0.0.0.0 and the *Default Gateway* can be chosen as any valid IP address from the same range as the LSM-2020 IP address.

3. Click the *Send to Device* button located on the *Configure Ethernet Port* screen. A confirmation popup will be displayed notifying the user that the LSM-2020 will reboot after settings are sent. Click the *Yes* button to allow settings to be sent. After the unit has rebooted and the power-up sequence is complete, the LSM-2020 is ready to be used on a network.
4. If desired, LSM-2020 settings can be verified by selecting *Download Settings and Logic* from the *Communication* pull-down menu. Active settings will be downloaded from the LSM-2020 and MGC-2000 Series. Verify that the downloaded settings match the previously sent settings.
5. Connection to the MGC-2000 Series can be made through Ethernet via an LSM-2020 with properly configured network settings. When making a new connection to the MGC-2000 Series, the *Ethernet Connection* option shown in Figure 4-5 will allow the user to enter the IP address of the LSM-2020 with which to connect. The *Ethernet* button under *Device Discovery, Scan for Connected Devices,* allows automatic detection of any LSM-2020 devices connected to the local network.

NOTES

The PC running BESTCOMS*Plus* software must be configured correctly to communicate with the LSM-2020. The PC must have an IP address in the same subnet range as the LSM-2020 if the LSM-2020 is operating on a private local network. Otherwise, the PC must have a valid IP address with access to the internet and the LSM-2020 must be connected to a properly configured router. The network settings of the PC depend on the operating system installed. Refer to the operating system manual for instructions. On most Microsoft Windows based PCs, the network settings can be accessed through the *Network Connections* icon located inside the Control Panel.

Microsoft Windows 2000 and XP SP1 contain a potential bug that might prevent device discovery from functioning properly. This issue might present itself if the PC running BESTCOMS*Plus* has more than one network interface card. See Microsoft KB article 827536 for more information.

Firmware updates to the LSM-2020 are made through the Ethernet port. Firmware updates to the MGC-2000 Series are only available through the USB port of the MGC-2000 Series.

Establishing Communication

Communication between BESTCOMS*Plus* and the MGC-2000 Series is established by clicking on the *Connect* button on the *DGC-2020 Connection* screen (see Figure 4-5) or by clicking on the *Connect* button on the lower menu bar of the main BESTCOMS*Plus* screen (Figure 4-1). If you receive an “Unable to Connect to Device” error message, verify that communications are configured properly. If communication is established, BESTCOMS*Plus* will read all settings and logic from the MGC-2000 Series and load them into BESTCOMS*Plus* memory. See Figure 4-12.

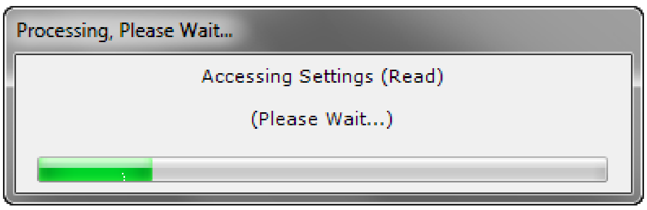

Figure 4-12. Accessing Settings, Please Wait…

Advanced Properties

Click the *Advanced* button on the *Connection* screen to display the *Advanced Properties* dialog. Default settings are shown in Figure 4-13.

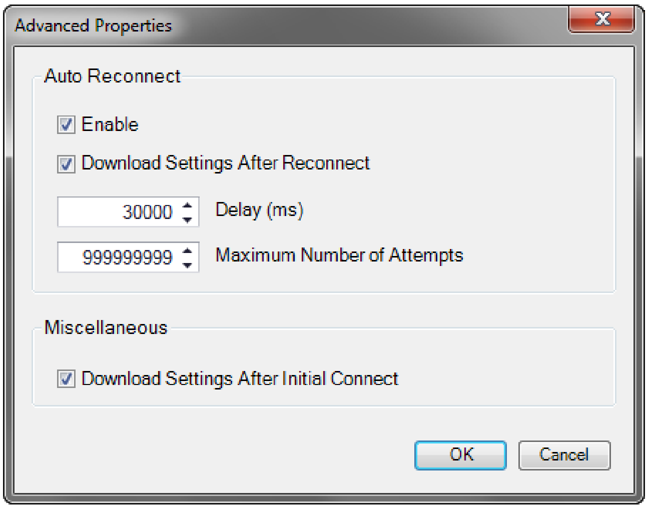

Figure 4-13. Advanced Properties

Menu Bars

The menu bars are located near the top of the BESTCOMS*Plus* screen (see Figure 4-1). The upper menu bar has five pull-down menus. With the upper menu bar, it is possible to manage settings files, configure communication settings, upload and download settings/security files, and compare settings files. The lower menu bar consists of clickable icons. The lower menu bar is used to change BESTCOMS*Plus* views, open a settings file, connect/disconnect, preview metering printout, export metering, switch to live mode, and send a settings file to the MGC-2000 Series.

Upper Menu Bar (BESTCOMS*Plus*® Shell)

Upper menu bar functions are listed and described in Table 4-2.

Table 4-2. Upper Menu Bar (BESTCOMSPlus Shell)

Menu Item	Description
File	
New	Create a new settings file
Open	Open an existing settings file
Open File As Text	Generic file viewer for *.csv, *,txt, etc. files
Close	Close settings file
Save	Save settings file
Save As	Save settings file with a different name
Export To File	Save settings as a *.csv file
Print	Print, export, or send a settings file
Properties	View properties of a settings file
History	View history of a settings file
Recent Files	Open a previously opened file
Exit	Close BESTCOMS*Plus* program
Communication	

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Menu Item	Description
New Connection	Choose new device or MGC-2000 Series
Close Connection	Close communication between BESTCOMS*Plus* and MGC-2000 Series
Download Settings and Logic from Device	Download operational and logic settings from the device
Upload Settings and Logic to Device	Upload operational and logic settings to the device
Upload Settings to Device	Upload operational settings to the device
Upload Logic to Device	Upload logic settings to the device
Download Security from Device	Download security settings from the device
Upload Security to Device	Upload security settings to the device
Configure	Ethernet settings
Upload Device Files	Upload firmware to the device
Tools	
Select Language	Select BESTCOMS*Plus* language
Activate Device	Activate the MGC-2000 Series plugin
Set File Password	Password protect a settings file
Compare Settings Files	Compare two settings files
Auto Export Metering	Exports metering data on a user-defined interval
Event Log - View	View the BESTCOMS*Plus* event log
Event Log - Clear	Clear the BESTCOMS*Plus* event log
Event Log - Set New File Name	Set a new file name for event log
Window	
Cascade All	Cascade all windows
Tile	Tile horizontally or vertically
Maximize All	Maximize all windows
Help	
Check for Updates	Check for BESTCOMS*Plus* updates via the internet
Check for Update Settings	Enable or changed automatic checking for updates
About	View general, detailed build, and system information

Lower Menu Bar (MGC-2000 Series Plugin)

The lower menu bar functions are listed and described in Table 4-3.

Table 4-3. *Lower Menu Bar (MGC-2000 Series Plugin)*

Menu Button	Description
View	Show or hide the Metering Panel, Settings Panel, or Settings Info Panel. Opens and saves workspaces. Customized workspaces make switching between tasks easier and more efficient.
Open File	Opens a saved settings file.
Connect	Connect: Opens the *DGC-2020 Connection* screen which enables you to connect to the MGC-2000 Series via USB or a modem. This button only appears when an MGC-2000 Series is not connected.
Disconnect	Disconnect: Used to disconnect a connected MGC-2000 Series. This button only appears when an MGC-2000 Series is connected.
Preview Metering	Displays the *Print Preview* screen where a preview of the Metering printout is shown. Click on the printer button to send to a printer.

Menu Button	Description
	Enables all metering values to be exported into a *.csv file.
	Displays an option entitled *Live Mode Settings* which enables *Live* mode where settings are automatically sent to the device in real time as they are changed.
	Sends settings to the MGC-2000 Series when BESTCOMS*Plus*® is not operating in Live Mode. Click this button after making a setting change to send the modified setting to the MGC-2000 Series.

Settings Explorer

The Settings Explorer is a convenient tool within BESTCOMS*Plus* used to navigate through the various settings screens of the MGC-2000 Series plugin.

Logic setup will be necessary after making certain setting changes. For more information, refer to Section 5, *BESTlogic™Plus Programmable Logic*.

MGC-2000 Series and System Parameters

Prior to use, the MGC-2000 Series must be configured for operation in the intended application. Descriptions of these configuration settings are organized as follows:

- General Settings
- Communications
- System Parameters
- Programmable Inputs
- Programmable Outputs
- Configurable Protection
- Alarm Configuration
- Generator Protection
- Breaker Management
- Bias Control Settings
- Multigen Management
- Programmable Senders
- BESTlogic™*Plus* Programmable Logic

NOTE

In the following descriptions, superscript letters (e.g., setting[X]) mark words and phrases relating to MGC-2000 Series settings. Each letter references settings illustrated in BESTCOMS*Plus*. Lettered notes at the end of each group of descriptions provide the range and increment for each setting.

General Settings

General MGC-2000 Series settings consist of settings controlling the HMI display and indicators. Additional general settings include style number configuration, MGC-2000 Series identification, MGC-2000 Series version information, and device security setup.

Front Panel HMI

The contrast[A] of the front panel LCD (liquid crystal display) can be adjusted to suit the viewing angle used or compensate for environmental conditions.

A power saving feature, referred to as Sleep mode[B], will turn the front panel LCD backlight and LCD heater off when the MGC-2000 Series is in Off mode or Auto mode (not in Run mode) and a key is not pressed for more than 15 minutes. Normal display operation is resumed when any front panel button is pressed or the genset is started remotely via the ATS. Sleep mode is enabled and disabled in BESTCOMS*Plus*.

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A one-line diagram[C] of the breaker hardware configuration can be displayed on the front panel. This diagram changes in real time to reflect the current state of the configured breakers. The one-line diagram is disabled by default. See Section 2 for more information.

Specific language modules can be uploaded into the MGC-2000 Series. When the language module upload is complete, use the Language[D] selector to select the correct language.

When Scrolling Screen is enabled[E], the front panel summary screen will scroll through the list of Scrolling Screen Items[F]. The Scrolling Screen Delay[G] determines the scrolling speed. When this feature is disabled only VOLT, AMP, PH, Hz, OIL, FUEL, TEMP, and BATT are shown on the front panel summary screen. The phase values are toggled at a rate defined by the Phase Toggle Delay[H] setting. When the phase toggle delay is set to zero, information for each phase is obtained by pressing the *Up* or *Down* arrow keys on the front panel HMI.

Two custom initializing messages[IJ] are displayed on the initial boot screen of the MGC-2000 Series.

The BESTCOMS*Plus* Front Panel HMI screen is illustrated in Figure 4-14.

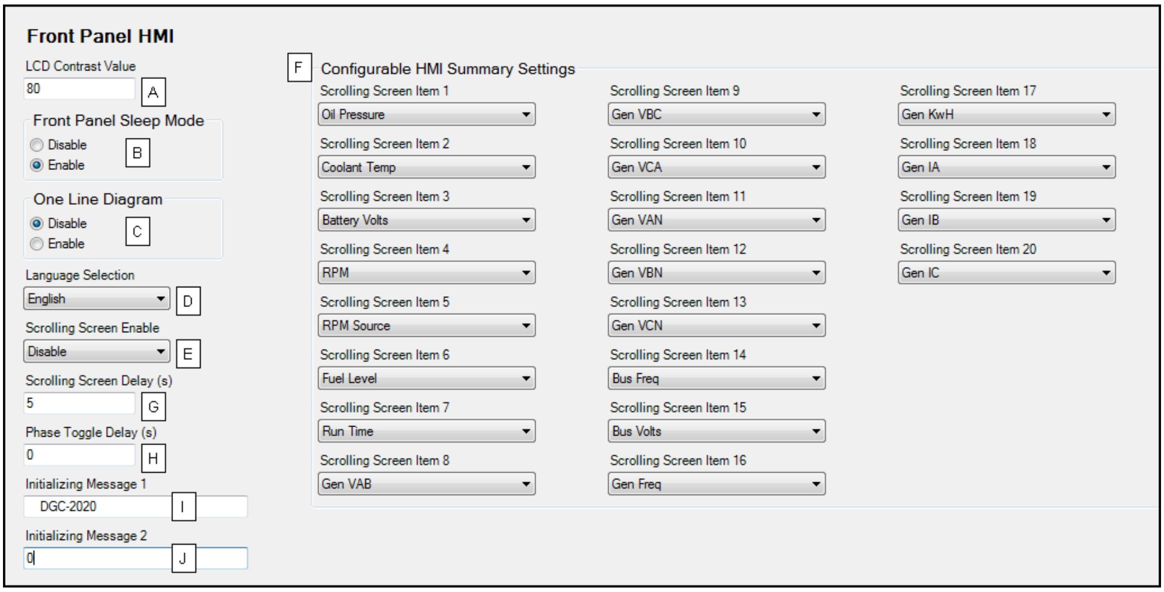

Figure 4-14. Front Panel HMI

[A] *LCD Contrast Value:* Adjustable from 0 to 100 (maximum contrast) in increments of 1.
[B] *Front Panel Sleep Mode:* Enable or Disable.
[C] *One-Line Diagram:* Disable or Enable.
[D] *Language Selection:* Select English, Chinese, Spanish, Russian, French, Portuguese, or German.
[E] *Scrolling Screen Enable:* Enable or Disable.
[F] *Configurable HMI Summary Settings:* Select Scrolling Screen Item 1 through 20.
[G] *Scrolling Screen Delay:* Adjustable from 1 to 120 s in 1 s increments.
[H] *Phase Toggle Delay:* Adjustable from 0 to 120 s in 1 s increments.
[I] *Initializing Message 1:* Accepts an alphanumeric string of up to 16 characters. Displayed on the second line of the initial boot screen.
[J] *Initializing Message 2:* Accepts an alphanumeric string of up to 16 characters. Displayed on the third line of the initial boot screen.

Style Number

When a PC operating BESTCOMS*Plus* is communicating with an MGC-2000 Series, the style number of the MGC-2000 Series is automatically displayed on the BESTCOMS*Plus* Style Number screen.

When configuring MGC-2000 Series settings off-line, the style number for the unit to be configured can be entered into BESTCOMS*Plus* to enable configuration of the required settings.

The BESTCOMS*Plus* Style Number screen, for hardware version 3, is illustrated in Figure 4-15.

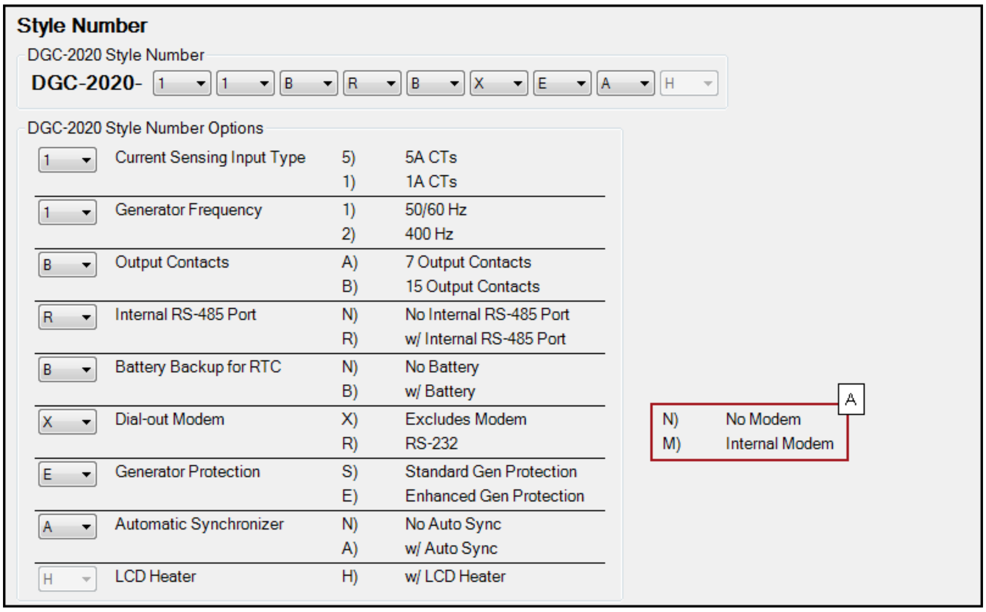

Figure 4-15. Style Number (Hardware version 3)

[A] *MGC-2000 Series dial-out modem options for hardware versions 1 and 2.*

Device Info

Information about an MGC-2000 Series, LSM-2020 (Load Share Module), and CEM-2020 (Contact Expansion Module) can be obtained when communicating with BESTCOMS*Plus*.

MGC-2000 Series

Information about an MGC-2000 Series communicating with BESTCOMS*Plus* can be obtained on the Device Info tab of BESTCOMS*Plus*.

Select application version[A] and hardware version[B] when configuring MGC-2000 Series settings off-line. When on-line, read-only information includes the application version[C], boot code version[D], application build date[E], serial number[F], application part number[G], model number[H], Language Module Version[I], and Language Module Part Number[J]. A site-specific unit name[K] can be assigned to the MGC-2000 Series.

Load Share Module

Information about an LSM-2020 communicating with BESTCOMS*Plus* can also be obtained on the Device Info tab of BESTCOMS*Plus*.

When on-line, read-only information includes the application version[L], boot code version[M], application build date[N], serial number[O], application part number[P], and model number[Q].

Contact Expansion Module

Information about a CEM-2020 communicating with BESTCOMS*Plus* can also be obtained on the Device Info tab of BESTCOMS*Plus*.

When on-line, read-only information includes the application version[R], boot code version[S], application build date[T], serial number[U], application part number[V], and model number[W].

BESTCOMS*Plus* device information values and settings are illustrated in Figure 4-16.

Analog Expansion Module

Information about an AEM-2020 communicating with BESTCOMS*Plus* can also be obtained on the Device Info tab of BESTCOMS*Plus*.

When on-line, read-only information includes the application version[X], boot code version[Y], application build date[Z], serial number[AA], application part number[BB], and model number[CC].

The BESTCOMS*Plus* Device Info screen is illustrated in Figure 4-16.

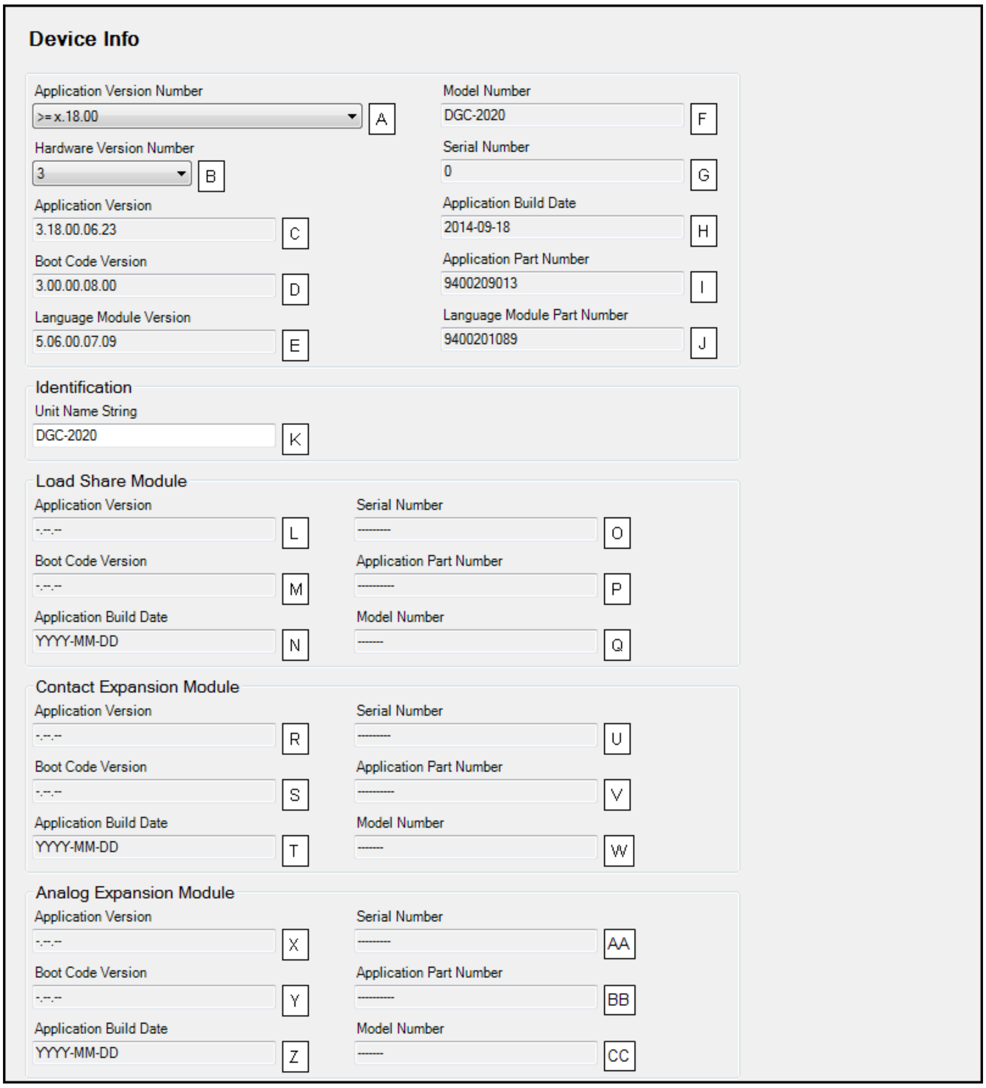

Figure 4-16. Device Info

[A] *Application Version:* When configuring MGC-2000 Series settings off-line, the application version for the unit to be configured must be selected.
[B] *Hardware Version*: When configuring MGC-2000 Series settings off-line, the hardware version for the unit to be configured must be selected.
[C] *Application Version:* Read-only value obtained when BESTCOMS*Plus* is communicating with the MGC-2000 Series.
[D] *Boot Code Version:* Read-only value obtained when BESTCOMS*Plus* is communicating with the MGC-2000 Series.
[E] *Application Build Date:* Read-only value obtained when BESTCOMS*Plus* is communicating with the MGC-2000 Series.
[F] *Serial Number:* Read-only value obtained when BESTCOMS*Plus* is communicating with the MGC-2000 Series.
[G] *Application Part Number:* Read-only value obtained when BESTCOMS*Plus* is communicating with the MGC-2000 Series.
[H] *Model Number:* Read-only value obtained when BESTCOMS*Plus* is communicating with the MGC-2000 Series.
[I] *Language Module Version:* Read-only value obtained when BESTCOMS*Plus* is communicating with the MGC-2000 Series.
[J] *Language Module Part Number:* Read-only value obtained when BESTCOMS*Plus* is communicating with the MGC-2000 Series.

[K] *Unit Name String:* Accepts an alphanumeric character string of up to 16 characters.
[L] *Application Version:* Read-only value obtained when BESTCOMS*Plus* is communicating with an optional LSM-2020.
[M] *Boot Code Version:* Read-only value obtained when BESTCOMS*Plus* is communicating with an optional LSM-2020.
[N] *Application Build Date:* Read-only value obtained when BESTCOMS*Plus* is communicating with an optional LSM-2020.
[O] *Serial Number:* Read-only value obtained when BESTCOMS*Plus* is communicating with an optional LSM-2020.
[P] *Application Part Number:* Read-only value obtained when BESTCOMS*Plus* is communicating with an optional LSM-2020.
[Q] *Model Number:* Read-only value obtained when BESTCOMS*Plus* is communicating with an optional LSM-2020.
[R] *Application Version:* Read-only value obtained when BESTCOMS*Plus* is communicating with an optional CEM-2020.
[S] *Boot Code Version:* Read-only value obtained when BESTCOMS*Plus* is communicating with an optional CEM-2020.
[T] *Application Build Date:* Read-only value obtained when BESTCOMS*Plus* is communicating with an optional CEM-2020.
[U] *Serial Number:* Read-only value obtained when BESTCOMS*Plus* is communicating with an optional CEM-2020.
[V] *Application Part Number:* Read-only value obtained when BESTCOMS*Plus* is communicating with an optional CEM-2020.
[W] *Model Number:* Read-only value obtained when BESTCOMS*Plus* is communicating with an optional CEM-2020.
[X] *Application Version:* Read-only value obtained when BESTCOMS*Plus* is communicating with an optional AEM-2020.
[Y] *Boot Code Version:* Read-only value obtained when BESTCOMS*Plus* is communicating with an optional AEM-2020.
[Z] *Application Build Date:* Read-only value obtained when BESTCOMS*Plus* is communicating with an optional AEM-2020.
[AA] *Serial Number:* Read-only value obtained when BESTCOMS*Plus* is communicating with an optional AEM-2020.
[BB] *Application Part Number:* Read-only value obtained when BESTCOMS*Plus* is communicating with an optional AEM-2020.
[CC] *Model Number:* Read-only value obtained when BESTCOMS*Plus* is communicating with an optional AEM-2020.

Device Security Setup

Password protection guards against unauthorized changing of MGC-2000 Series settings. MGC-2000 Series passwords are case sensitive. Three levels of password protection are available. Each level is described in the following paragraphs.

- *OEM Access.* This password level allows access to all settings. The default, OEM-access password is **OEM**.
- *Settings Access.* This password level allows all except uploading of firmware and clearing of device event log. The default, settings-access password is **SET**.
- *Operator Access.* The default, operator-access password is **OP**. This password level allows all settings to be read and allows changes to be made to the following:
    - LCD Contrast
    - Sleep Mode
    - Date/Time
    - All Sender Fail Time Delays
    - Metric Conversion
    - Low Fuel Pre-Alarm Level
    - Low Fuel Alarm Level
    - Pre-Start Contact after Cranking
    - Cooldown Time

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- o Pre-Crank Time Delay
- o Reset of Maintenance Interval
- o All controls on the Control screen available via the Metering Explorer in BESTCOMS*Plus*

Changing Passwords

Passwords can be changed only after communication between the PC and MGC-2000 Series is established. Changes to passwords are made through the *Device Security Setup* screen. Use the Settings Explorer in BESTCOMS*Plus* to open the *General Settings, Device Security Setup* screen.

The content of the *Device Security Setup* screen depends on the password level used when accessing the screen. For example, someone logged in with a settings-access password will be able to change only the settings-access and operator-access passwords - not the OEM-access password.

The BESTCOMS*Plus* Device Security Setup screen is illustrated in Figure 4-17. All three access levels are shown.

A password is changed by clicking on the access level[A], entering the new password[B], and then clicking on the *Save Password* button[C].

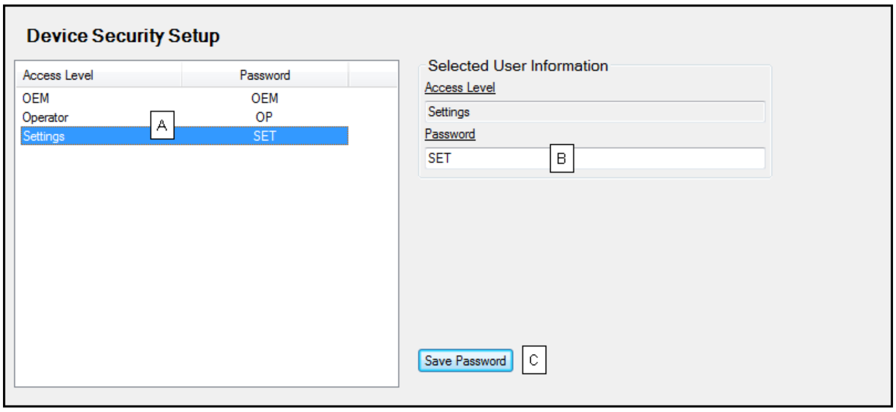

Figure 4-17. Device Security Setup

[A] *Access Level/Password:* Read-only value obtained when BESTCOMS*Plus* is communicating with the MGC-2000 Series.
[B] *Password:* Accepts an alphanumeric character string of up to 16 characters.
[C] *Save Password:* Clicking this button will save the password changes in BESTCOMS*Plus* memory.

Saving Passwords in an MGC-2000 Series Settings File

The passwords can be modified while BESTCOMS*Plus* is connected to an MGC-2000 Series, then the settings from the BESTCOMS*Plus* session can be saved into a settings file. The settings file will contain the new passwords. Also, the passwords in a settings file can be modified off line, saved with the file, and then later loaded into an MGC-2000 Series.

Saving passwords to a settings file when BESTCOMS*Plus* is connected to an MGC-2000 Series (on line):

1. When connected to an MGC-2000 Series with BESTCOMS*Plus*, click on SETTINGS EXPLORER > GENERAL SETTINGS > DEVICE SECURITY.
2. You will be prompted to enter a password.
3. Enter a password that is of a level as high as or higher than the password you wish to modify. BESTCOMS*Plus* will display all passwords of a level equal to and below the level of the password that was entered.
4. Click on the password you wish to modify. Type in the new password under the "Password" setting that became active when the password to modify was clicked.
5. Click the "Save" button to save the new password into BESTCOMS*Plus* memory (it's not in the MGC-2000 Series yet).
6. Repeat steps 4 and 5 for all password levels you with to modify.
7. Once all password modifications are complete, in the main menu of BESTCOMS*Plus*, select *Upload Security* from the *Communications* pull-down menu. This is the step where passwords are

sent to the MGC-2000 Series. Failure to perform this step might cause all password modifications to be lost.

8. Close the *Device Security* tab in BESTCOMS*Plus*.
9. Re-open the *Device Security* tab in BESTCOMS*Plus*. This will read the passwords back out of the MGC-2000 Series.
10. Verify the passwords obtained from the MGC-2000 Series are correct.
11. Once all desired settings have been loaded into the MGC-2000 Series, save the settings file. The resulting settings file has the passwords saved as part of the saved settings.
12. At this point, the password information has been successfully saved in the settings file. The process of saving the passwords into the settings file is complete.

Saving passwords to a settings file when working off line

1. When the settings file is open in BESTCOMS*Plus*, click on SETTINGS EXPLORER > GENERAL SETTINGS > DEVICE SECURITY.
2. You will be prompted to enter a password.
3. Enter a password that is of a level as high as or higher than the password you wish to modify. BESTCOMS*Plus* will display all passwords of a level equal to and below the level of the password that was entered.
4. Click on the password you wish to modify. Type in the new password under the “Password” setting that became active when the password to modify was clicked.
5. Click the “Save” button to save the new password into BESTCOMS*Plus* memory.
6. Repeat steps 4 and 5 for all password levels you wish to modify.
7. Close the *Device Security* tab in BESTCOMS*Plus*.
8. Save the settings file.
9. Close the settings file by clicking on the X in the upper right-hand corner of the settings file, or close BESTCOMS*Plus*.
10. Restart BESTCOMS*Plus* if you have shut it down.
11. Re-open the settings file that you have saved with the password information.
12. When the settings file is open in BESTCOMS*Plus*, click on SETTINGS EXPLORER > GENERAL SETTINGS > DEVICE SECURITY.
13. You will be prompted to enter a password.
14. Enter the password for the highest level of password modified; it should be the new modified password.
15. When passwords are shown, verify they are correct.
16. At this point the password information has been successfully saved in the settings file. The process of saving the passwords into the settings file is complete.

Loading Passwords from a Settings File into the MGC-2000 Series

1. Connect to the MGC-2000 Series with BESTCOMSPlus.
2. Once connected, click the “Open File” button that is used to load a settings file into the MGC-2000 Series.
3. You will be prompted asking if you wish to load settings and logic into the MGC-2000 Series. Select *Yes* if you need to upload settings and logic. Select *No* if all you need to do is update security. If you select *No*, the settings file opens into BESTCOMS*Plus* memory.
4. Whether you have loaded settings and logic to the MGC-2000 Series or not, the next step is to select *Upload Security* from the *Communications* pull-down menu.
5. DO NOT try to view the passwords before performing step 4. This would download the existing passwords from the MGC-2000 Series and they will overwrite the new passwords that were loaded into BESTCOMS*Plus* memory from opening the settings file.
6. If you are prompted for a password, enter a password of a level equal to that of the highest level password you wish to modify.
7. The passwords are uploaded to the MGC-2000 Series.

8. After you have uploaded the new passwords, select GENERAL SETTINGS→DEVICE SECURITY SETUP in the settings explorer of BESTCOMS*Plus.* Verify the passwords are correct.
9. This concludes loading passwords from a settings file into the MGC-2000 Series.

Clock Setup

Configuration of daylight saving time and coordination of the local time with universal time (if desired) is performed on this screen. If required, enter the *UTC (Universal Time Coordinates) Offset*[A]. Choose the type of *DST Configuration*[B] and then set the *Start Day*[C], *End Day*[D], and *Bias*[E].

The BESTCOMS*Plus* Clock Setup screen is illustrated in Figure 4-18.

Clock Not Set Warning

When the clock not set warning[F] is enabled, the MGC-2000 Series will notify the user when the clock is not set.

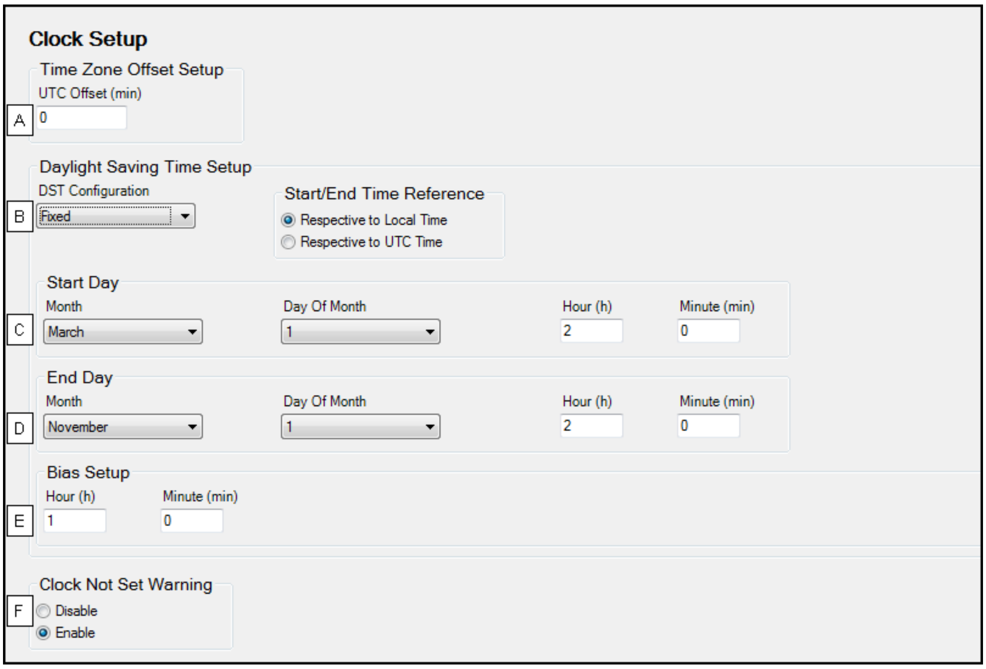

Figure 4-18. Clock Setup

[A] *UTC Offset (min):* Adjustable from -1,440 to 1,440 minutes in increments of 1.
[B] *DST Configuration:* Disabled, Fixed, or Floating.
[C] *Start Day:*

Fixed DST Configuration
Month (January to December), Day of Month (1 to 31 in increments of 1), Hour (0 to 23 in increments of 1), Minute (0 to 59 in increments of 1).
Floating DST Configuration
Month (January to December), Occurrence of Day (First to Fourth, or Last), Weekday (Sunday to Saturday), Hour (0 to 23 in increments of 1), Minute (0 to 59 in increments of 1).

[D] *End Day:*

Fixed DST Configuration
Month (January to December), Day of Month (1 to 31 in increments of 1), Hour (0 to 23 in increments of 1), Minute (0 to 59 in increments of 1).
Floating DST Configuration
Month (January to December), Occurrence of Day (First to Fourth, or Last), Weekday (Sunday to Saturday), Hour (0 to 23 in increments of 1), Minute (0 to 59 in increments of 1).

[E] *Bias:* Hour (0 to 23 in increments of 1), Minute (0 to 59 in increments of 1).
[F] *Clock Not Set Warning:* Enable or Disable.

Communications

MGC-2000 Series communication settings include setup parameters for CANBus, ECU, modem, and RS-485 communication.

CANBus Setup

The MGC-2000 Series CANBus interface provides high-speed communication between the MGC-2000 Series and the engine control unit (ECU) on an electronically controlled engine. When ECU support is enabled[A], the MGC-2000 Series will ignore the analog coolant temperature, oil pressure, and engine speed inputs and rely upon the ECU for these parameters. The MGC-2000 Series will also stop calculating engine run time and begin using the run time recorded by the ECU.

When enabled[B], the MGC-2000 Series will receive and retain unsolicited diagnostic trouble codes (DTCs) from an ECU with DTC capabilities.

Early versions of the J1939 specifications were unclear about how the 19 bits of the SPN were arranged within their allocated places in the data. While it was clear which bytes and bits contained the 19 bits of SPN data, it was not clear whether the data within the bytes was arranged with the most significant bit first or least significant bit first. It was also unclear which byte was most significant and which was least significant. The ambiguity led to various engine manufacturers adopting three different methods of converting the data into SPN numbers.

This was remedied in the J1939 specs, and the SPN Conversion Method[C] bit was added. When this bit is a zero, the conversion method is indicated as version 4. The MGC-2000 Series will automatically set the conversion method to 4 when the CM bit is zero; this occurs for most engine types. However, if the CM bit is 1, indicating the SPN conversion method is NOT 4, the user will have to consult the engine manufacturer to learn the correct method of SPN conversion, and set the SPN Conversion Method setting in the MGC-2000 Series accordingly.

An MGC-2000 Series operating on a CANBus network is identified by a unique address number[D]. The CANBus Address is set internally by the MGC-2000 Series when certain types of ECUs are selected on the ECU Setup screen, and in this case, the user-entered value does not apply. See Table 4-4.

Table 4-4. CANBus Address per ECU Type

ECU Type	CANBus Address
Standard	User-selectable
Volvo Penta	17
MTU MDEC	6
MTU ADEC	1
MTU ECU7/ECU8	6
GM/Doosan	User-selectable
Cummins	220
MTU Smart Connect	234

In applications where the ECU is not continuously powered, the MGC-2000 Series has provisions for applying power to the ECU and pulsing the ECU to update its engine monitoring data. Either the MGC-2000 Series RUN or PRESTART relay output can be used to apply power to the ECU[E]. If the PRESTART contact is selected, the RUN output will still close during cranking and genset operation to provide a separate indication that the genset is running. For applications where pulsing of the ECU is not desired, this pulsing feature[F] can be disabled.

The BESTCOMS*Plus* CAN Bus Setup screen is illustrated in Figure 4-19.

ECU Limitations

For some ECUs, an external source cannot stop the engine without removing power from the ECU. Turning off power to the ECU is the only way to remove fuel from the engine and shut it down. Different ECU manufacturers have their own rpm setpoints for reapplying fuel to an engine. If the ECU is powered up and the engine is still spinning above 60 rpm, then the ECU will automatically turn the fuel on. Detroit Diesel J1939 ECUs, for example, have a setpoint of 60 rpm.

Not being able to stop the engine without removing ECU power causes two problems. The first problem is that the only way to stop the engine is to turn the ECU off and wait for the engine speed to decrease below 60 rpm before powering the ECU back on. Otherwise, the engine will take off running. The second problem is that while the ECU is off, you can no longer meter and update coolant level, coolant temperature alarm/pre-alarm, and crank control.

The MGC-2000 Series Solution

The MGC-2000 Series resolves ECU limitations by using four timers:

- *Engine Shutdown.*[G] The time in seconds to stay disconnected from the ECU when going from running to shutdown before starting the first pulse. This timer should allow enough time for the engine to slow down so that when the MGC-2000 Series pulses, the ECU will not start the engine.
- *Pulse Cycle Time.*[H] The time in minutes that the controller waits before pulsing.
- *Settling Time.*[I] The time in tenths of seconds to gather data after connecting to the ECU during the pulsing state. This allows all the metered values to be sent and ramp as designated by the J1939 protocol. ECU values initially sent are low and the ECU takes time to average out its own data values.
- *Response Timeout.*[J] The time in seconds to attempt communication with the ECU when the MGC-2000 Series is in the pulsing state or connecting state.

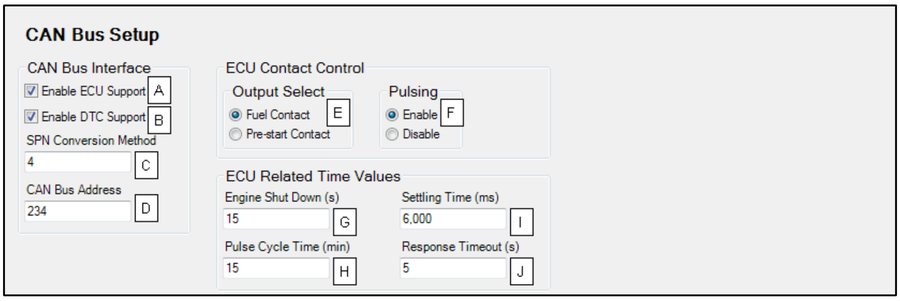

Figure 4-19. CAN Bus Setup

[A] *Enable ECU Support:* Check box to enable ECU support.
[B] *Enable DTC Support:* Check box to enable DTC support.
[C] *SPN Conversion Method:* 1, 2, 3, or 4.
[D] *CAN bus Address:* Accepts an address number from 1 to 253 in increments of 1.
[E] *Output Select:* Fuel Contact (RUN) or Pre-start Contact.
[F] *Pulsing:* Enable or Disable.
[G] *Engine Shutdown:* Adjustable from 1 to 60 s in 1 s increments.
[H] *Pulse Cycle Time:* Adjustable from 1 to 60 min in 1 min increments.
[I] *Settling Time:* Adjustable from 5,500 to 30,000 ms in 1 ms increments.
[J] *Response Timeout:* Adjustable from 1 to 60 s in 1 s increments.

ECU Setup

The MGC-2000 Series can be configured for Standard, Volvo Penta, MTU MDEC, MTU ADEC, MTU ECU7/ECU8, GM/Doosan, Cummins, MTU Smart Connect, Scania, or John Deere[A]. When the Generator Parameter Transmit[B] setting is enabled, the MGC-2000 Series broadcasts generator metered parameters over CANBus as listed in Table 4-5. The Generator Parameter Transmit setting is not used when ECU Type is set for MTU MDEC, MTU ECU7/ECU8, or MTU Smart Connect.

Table 4-5. Generator Parameter Transmit

PGN Name	PGN (Hex)	SPN	Parameter	Units	Scaling / Offset	Bytes Within PGN Data
Generator	65018	2468	Generator Total kW Hours Export	kWh	n/a	1 to 4

PGN Name	PGN (Hex)	SPN	Parameter	Units	Scaling / Offset	Bytes Within PGN Data
Total AC Energy	(FDFA)	2469	Generator Total kW Hours Import	kWh	n/a	5 to 8
Generator Total AC Reactive Power	65028 (FE04)	2456	Generator Total Reactive Power	vars	n/a	1 to 4
		2464	Generator Overall Power Factor	PF x 16,384	-1 offset	5 to 6
		2518	Generator Overall Power Factor Lagging	n/a	00=leading 01=lagging 10=error 11=not available	7, bits 1 & 2
Generator Total AC Power	65029 (FE05)	2452	Generator Total Real Power	Watts	n/a	1 to 4
		2460	Generator Total Apparent Power	VA	n/a	5 to 8
Generator Average Basic AC Quantities	65030 (FE06)	2440	Generator Average L-L AC RMS Voltage	Volts	n/a	1 to 2
		2444	Generator Average L-N AC RMS Voltage	Volts	n/a	3 to 4
		2436	Generator Average AC Frequency	Hz x 128	n/a	5 to 6
		2448	Generator Average AC RMS Current	Amps	n/a	7 to 8
Engine Temperature	65262 (FEEE)	110	Engine Coolant Temperature (Not sent when CAN is enabled)	°C	-40°C offset	1
Engine Fluid Level / Pressure	65263 (FEEF)	100	Engine Oil Pressure (Not sent when CAN is enabled)	kPa x 4	n/a	4
Dash Display	65276 (FEFC)	96	Fuel Level	% x 2.5	n/a	2

When the Engine Parameter Transmit[C] setting is enabled, the MGC-2000 Series broadcasts commands to the ECU over CANBus. When the Engine Parameter Transmit setting is disabled, transmission of J1939 commands from the MGC-2000 Series to the engine are disabled, but commands from the engine to the MGC-2000 Series are allowed.

Volvo Penta

Configuring the MGC-2000 Series for Volvo Penta* necessitates the configuration of two additional settings: Speed Select and Accelerator Position. The Speed Select setting[D] configures the Volvo Penta ECU to operate the engine at the primary or secondary base speed. If the engine is configured by Volvo for 60 Hz applications, the primary base speed is 1,800 rpm and the secondary base speed is 1,500 rpm. If the engine is configured by Volvo for 50 Hz applications, the primary base speed is 1,500 rpm and the secondary base speed is 1,800 rpm. The Accelerator Position setting[E] is expressed as a percentage and tells the Volvo Penta ECU where to set the engine speed (trim) relative to the base speed. The range of

TIM-ID: 0000099917 - 001

the setting is the base speed ±120 rpm. A setting of 0% will cause the engine to run at 120 rpm below the base speed, a setting of 50% will cause the engine to run at the base speed, and a setting of 100% will cause the engine to run at 120 rpm above the base speed. The Accelerator Position setting is linear with a gain of 2.4 rpm/percentage. This setting is not saved in nonvolatile memory and defaults back to 50% after MGC-2000 Series operating power is cycled.

The MGC-2000 Series sends the following parameters to a Volvo Penta ECU through Volvo Proprietary J1939 communications:

- Start Request - sent when starting the engine.
- Stop Request - sent when shutting down the engine.
- Idle Request - sent when the Idle Request logic element is true in BESTlogic*Plus.*
- Preheat Request - sent anytime the MGC-2000 Series would normally have its PRE relay closed for engines requiring a preheat contact.
- Accelerator Pedal Position - sent based on the Accelerator Position setting. If the Accelerator Pedal Position setting is left at the default 50%, this is calculated and sent based on the programmed Engine RPM setting to achieve the desired engine RPM. If an LSM-2020 is present and the MGC-2000 Series senses the generator breaker is closed, the MGC-2000 Series is in kW control mode and the Accelerator Pedal Position is sent based on the kW controller output to adjust engine throttle for kW control.
- Primary/Secondary Engine Speed - sent based on the Speed Select setting and the state of the Alternate Frequency Override element in BESTlogic*Plus*. Primary speed is sent when the Speed Select setting is set for Primary and Secondary speed is sent when the Speed Select setting is set for Secondary. However, these are reversed if the Alternate Frequency Override is true. A setting of Primary results in Secondary being sent and a setting of Secondary results in Primary being sent when the Alternate Frequency Override is true.

∗ The Volvo Penta ECU configuration is applicable only to the EDC3 and EMS2 models of Volvo Penta engine controllers.

Cummins

When Cummins is selected as the ECU type, the following parameters are sent to the engine via Cummins Proprietary J1939 communications:

- Start Request - sent when starting or running the engine.
- Stop Request - sent when stopping the engine.
- Idle Request - sent when the Idle Request logic element is true in BESTlogic*Plus.*
- Rated Speed (50 or 60 Hz) - sent based on the Rated Speed setting of the MGC-2000 Series. However, these are reversed if the Alternate Frequency Override is true. A setting of 60 Hz Rated Speed results in 50 Hz being sent and a setting of 50 Hz Rated Speed results in 60 Hz being sent when the Alternate Frequency Override is true.

Diesel Particulate Filter (DPF)

The diesel particulate filter settings are used when the ECU is configured for Standard, Volvo Penta, MTU ADEC, GM/Doosan, Cummins, or MTU Smart Connect. The MGC-2000 Series supports the CAN bus parameters that are related to the diesel particulate filter implemented on certain engines to meet Tier 4 emission requirements. Three pre-alarms provide DPF status:

- DPF Regenerate Required pre-alarm – announced when the DPF lamp status broadcast over CANBus indicates that regeneration is required.
- DPF Regenerate Disabled pre-alarm – announced when the engine ECU reports via CAN bus that DPF regeneration is disabled.
- High Exhaust Temperature pre-alarm – announced when the ECU reports via CAN bus that a high exhaust temperature condition exists.

Two parameters are provided to initiate or disable DPF regeneration. The first, Manual Regeneration[F], is transmitted to the engine over CAN bus to initiate DPF regeneration. The second, Disable Regeneration[G], is transmitted to the engine over CAN bus to disable DPF regeneration. Extended operation with regeneration disabled is not recommended.

MTU

If the engine is configured as MTU MDEC, the configuration of the following settings is necessary:

- MDEC Module Type[H] - Specifies the type of MDEC module.
- Speed Demand Switch[I] - Specifies speed demand source for the MTU engine ECU.
- NMT Alive Transmit Rate[J] - Specifies the rate at which messages are transmitted to the MTU engine.

If the engine is configured as MTU ADEC, the configuration of the following settings is necessary:

- Speed Demand Switch[M] - Specifies speed demand source for the MTU engine ECU.
- Overspeed Test[K] - Temporarily drives an MTU ECU into overspeed for testing overspeed.
- Governor Param Switch Over[L] - Specifies which governor parameters an MTU ECU should use.
- Trip Reset[M] - Resets trip information such as trip fuel used, trip hours, trip idle time, etc.
- Int Oil Prime[N] - Causes an MTU ECU engine to perform an internal lubrication cycle.

If the engine is configured as MTU ECU7/ECU8, the configuration of the following settings is necessary:

- Speed Demand Switch[M] - Specifies speed demand source for the MTU engine ECU.
- Overspeed Test[O] - Temporarily drives an MTU ECU into overspeed for testing overspeed.
- Speed Up[O] - Increases speed of the MTU ECU.
- Speed Down[P] - Decreases speed of the MTU ECU.
- Idle Request[Q] - Turns the idle request on or off.
- Increased Idle[R] - Sets the MTU ECU idle.
- Trip Reset[Q] - Resets trip information such as trip fuel used, trip hours, trip idle time, etc.
- Int Oil Prime[R] - Causes an MTU ECU engine to perform an internal lubrication cycle.
- MTU 50 Hz 60 Hz Switch Setting[S] - Set automatically based on rated frequency of the MGC-2000 Series and the state of the alternate frequency override.
- Engine Start Prime[T] - Turns the engine start prime on or off.
- Fan Override[U] - Turns the fan override on or off.
- Mode Switch[V] - Turns the mode switch on or off.
- Governor Param Switch Over[P] - Specifies which governor parameters an MTU ECU should use.
- Governor Param Set Select[W] - Sets the governor parameter set select.
- CAN Rating Switch 1 & 2[X] - Turns the CAN rating switch 1 & 2 on or off.
- Cylinder Cutout Disable 1 & 2[Y] - Turns the cylinder cutout disable 1 & 2 on or off.
- MTU ECU7/ECU8 Module Type[Z] - Specifies ECU7/ECU8 Module type.
- NMT Alive Transmit Rate[N] - Specifies the rate at which messages are transmitted to the MTU engine.

If the engine is configured as MTU Smart Connect, the configuration of the following settings is necessary:

- Speed Demand Switch[M] - Specifies speed demand source for the MTU engine ECU.
- Overspeed Test[O] - Temporarily drives an MTU ECU into overspeed for testing overspeed.
- Speed Up[S] - Increases speed of the MTU ECU.
- Speed Down[T] - Decreases speed of the MTU ECU.
- Idle Request[U] - Turns the idle request on or off.
- Trip Reset[Q] - Resets trip information such as trip fuel used, trip hours, trip idle time, etc.
- Int Oil Prime[R] - Causes an MTU ECU engine to perform an internal lubrication cycle.
- Governor Param Switch Over[P] - Specifies which governor parameters an MTU ECU should use.
- Cylinder Cutout Disable 2[CC] - Turns the cylinder cutout disable 2 on or off.
- Engine Operating Mode[AA] - Selects engine operating mode 1 or 2.

Scania Engine ECU Communications

The majority of CANBus parameters are sent from Scania Engine ECUs via standard J1939 communications. However, some additional proprietary parameters are sent via Scania proprietary J1939 communications. Proprietary Start, Stop, and Emergency Stop commands are sent from the MGC-2000 Series to the Scania ECU. The ECU communicates Diesel Exhaust Fluid (DEF) Levels, as well as DEF Fluid Low, DEF Low Severe, DEF Inducement, and DEF Severe Inducement Pre-Alarms to the MGC-2000 Series through Proprietary Scania parameters. Additional information on DEF related parameters can be found in Appendix E, *Exhaust Treatment*.

John Deere

The Regeneration Interlock setting[BB] enables John Deere proprietary parameters to be broadcast over the J1939 CAN bus. This setting is applicable to hardware version 3 units.

The Regeneration Interlock parameter is sent via the Stationary Regeneration/Cleaning CAN Lockout Message PGN, which is PGN 61194. When the DGC Regeneration Interlock value is set to Enabled, the MGC-2000 Series sends a value of 01 (binary) for the two bit “Allowed” configuration which allows regeneration to occur. When the MGC-2000 Series Regeneration Interlock value is set to Disabled, the MGC-2000 Series sends a value of 00 (binary) for the two bit “Not Allowed” configuration which inhibits regeneration.

The MGC-2000 Series sends starter engagement requests to the ECU via the SAE J1939 Engine Start Control PGN. When the MGC-2000 Series requests the starter to be engaged it sends a value of 01 (binary) for the two bit starter engagement parameter. Otherwise the MGC-2000 Series sends a value of 00 (binary) for the two bit starter engagement parameter.

The BESTCOMS*Plus* ECU Setup screen is illustrated in Figure 4-20.

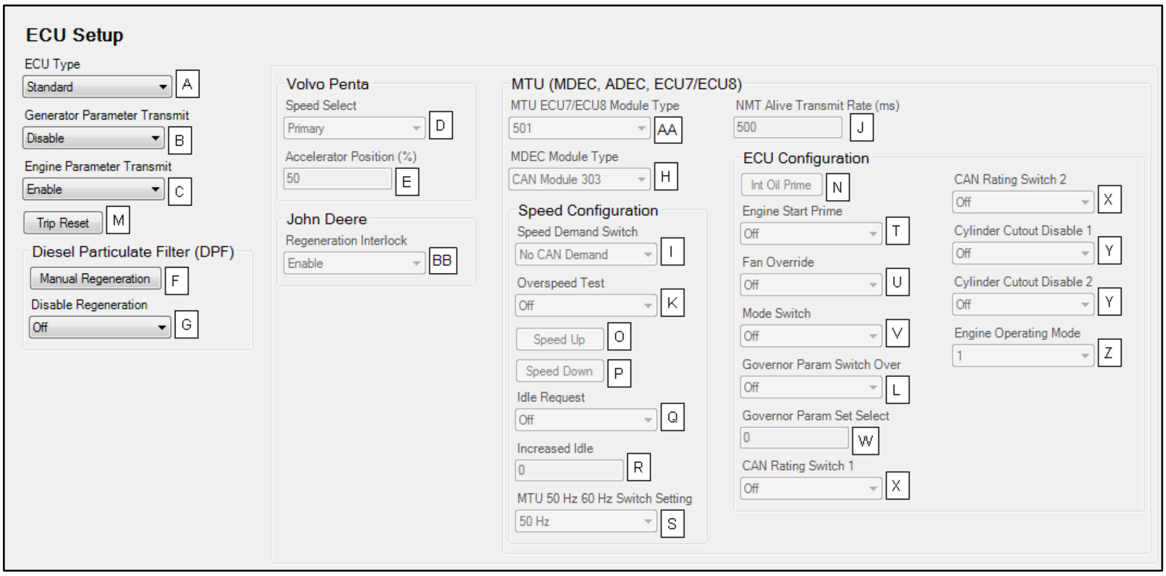

Figure 4-20. ECU Setup

[A] *ECU Type:* Standard, Volvo Penta, MTU MDEC, MTU ADEC, MTU ECU7/ECU8, GM/Doosan, Cummins, MTU Smart Connect, Scania, or John Deere.
[B] *Generator Parameter Transmit:* Enable or Disable.
[C] *Engine Parameter Transmit:* Enable or Disable.
[D] *Speed Select:* Primary or Secondary.
[E] *Accelerator Position:* Adjustable from 0 to 100% in 1% increments.
[F] *Manual Regeneration:* Press to set.
[G] *Disable Regeneration:* Off or On.
[H] *MDEC Module Type:* CAN Module 201, 302, 303, or 304.
[I] *Speed Demand Switch:* Analog CAN, Up Down ECU, Up Down CAN, Analog ECU, Frequency, No CAN Demand.
[J] *NMT Alive Transmit Rate:* Adjustable from 100 to 500 ms in 100 ms increments.
[K] *Overspeed Test:* Off or On.
[L] *Governor Param Switch Over:* Off or On.
[M] *Trip Reset:* Press to set.
[N] *Int Oil Prime:* Press to set.
[O] *Speed Up:* Press to set.
[P] *Speed Down:* Press to set.
[Q] *Idle Request:* Off or On.
[R] *Increased Idle:* Adjustable from 0 to 1,000 in increments of 1.
[S] *MTU 50 Hz 60 Hz Switch Setting:* Set automatically by the MGC-2000 Series.
[T] *Engine Start Prime:* Off or On.

[U] *Fan Override:* Off or On.
[V] *Mode Switch:* Off or On.
[W] *Governor Param Set Select:* Adjustable from 0 to 1,000 in increments of 1.
[X] *CAN Rating Switch 1 & 2:* Off or On.
[Y] *Cylinder Cutout Disable 1 & 2:* Off or On.
[Z] *MTU ECU7/ECU8 Module Type:* 501 or 502.
[AA] *Engine Operating Mode:* 1 or 2.
[BB] *Regeneration Interlock:* Enable or Disable.

Speed Setup

Speed control and kW load sharing over J1939 and ECU7/ECU8 is implemented over CAN bus when the CAN Bus rpm Request[A] setting is enabled. This is implemented for all ECUs. The Engine rpm[B] setting defines the nominal requested engine rpm. The Idle rpm[C] setting is the requested rpm when the IDLE REQUEST logic element is true. The rpm Bandwidth[D] setting defines the range of rpm in which the MGC-2000 Series will use to accomplish load sharing. For example, if the Engine rpm setting is 1800 and the RPM Bandwidth is set to 100, the rpm request can go from 1750 to 1850 rpm when load sharing is in effect.

Figure 4-21. Speed Setup

[A] *CAN bus rpm Request:* Enable or Disable.
[B] *Engine rpm:* Adjustable from 1,400 to 2,000 in increments of 1.
[C] *Idle rpm:* Adjustable from 100 to 2,000 in increments of 1.
[D] *RPM Bandwidth:* Adjustable from 0 to 1,000 in increments of 1.

Voltage Regulator Setup

The MGC-2000 Series transmits voltage setpoint and underfrequency compensation parameters to Marathon DVR2000E+ voltage regulators. The Voltage Regulator Setup screen (Figure 4-22) is found in the BESTCOMS*Plus*® Settings Explorer under the *Communications, CANBus* category. The CAN Bus Type setting[A] allows the user to select which CAN Bus type is used to transmit parameters to the voltage regulator. The Primary Voltage Setpoint[B] value represents the normal desired system voltage setpoint. Alternate Voltage Setpoint[C] is the desired system voltage setpoint when low line override is true. The range in which the MGC-2000 Series is allowed to bias voltage regulator var sharing and voltage trim is adjustable using the Voltage Adjust Bandwidth[D] setting. When the DVR2000E+ is in Field Current Regulation (FCR) mode, the normal desired field current setpoint is adjusted using the Field Current Setting[E]. The Primary Underfrequency Knee[F] setting allows adjustment of the normal desired underfrequency knee-point. When low line override is true, the Alternate Underfrequency Knee[G] becomes the active underfrequency knee-point. The desired Underfrequency Slope[H] can also be specified.

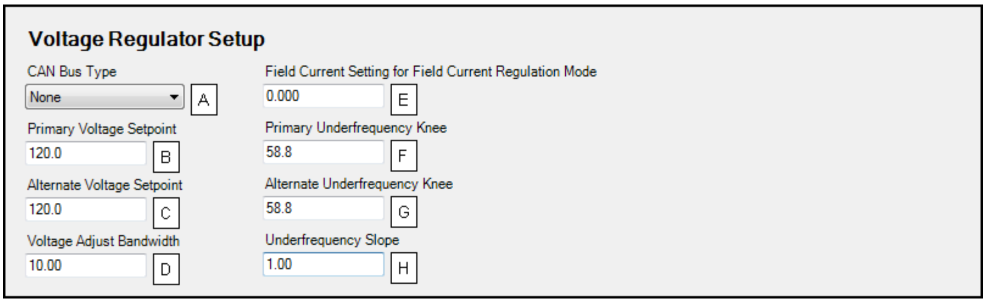

Figure 4-22. Voltage Regulator Setup

[A] *CAN bus Type*: Select None, Marathon, Basler, or J1939
[B] *Primary Voltage Setpoint*: Adjustable from 100 to 600 in increments of 0.1
[C] *Alternate Voltage Setpoint*: Adjustable from 100 to 600 in increments of 0.1
[D] *Voltage Adjust Bandwidth*: Adjustable from 0 to 3000 in increments of 1
[E] *Field Current Setting*: Adjustable from 0 to 3000 in increments of 1
[F] *Primary Underfrequency Knee*: Adjustable from 40 to 70 in increments of 0.1
[G] *Alternate Underfrequency Knee*: Adjustable from 40 to 70 in increments of 0.1
[H] *Underfrequency Slope*: Adjustable from 100 to 500 in increments of 1

Modem Setup (Optional)

MGC-2000 Series hardware version 3 controllers with style number xxxxxExxx are equipped with an RS-232 port. This port allows communication with an external, user-supplied modem with dial-in and dial-out capability. MGC-2000 Series hardware versions 1 and 2 with style number xxxxxMxxx are equipped with an internal modem with dial-in and dial-out capability.

A modem gives the MGC-2000 Series the ability to dial up to four telephone numbers[A] and annunciate user-selected conditions to specified pagers[B]. These user-selected conditions include[C]:

- 27-1 Trip Alarm
- 27-2 Trip Alarm
- 32 Trip Alarm
- 40 Trip Alarm
- 47 Trip Alarm
- 51-1 Trip Alarm
- 51-2 Trip Alarm
- 51-3 Trip Alarm
- 59-1 Trip Alarm
- 59-2 Trip Alarm
- 81O Trip Alarm
- 81U Trip Alarm
- 27-1 Trip Pre-Alarm
- 27-2 Trip Pre-Alarm
- 32 Trip Pre-Alarm
- 40 Trip Pre-Alarm
- 47 Trip Pre-Alarm
- 51-1 Trip Pre-Alarm
- 51-2 Trip Pre-Alarm
- 51-3 Trip Pre-Alarm
- 59-1 Trip Pre-Alarm
- 59-2 Trip Pre-Alarm
- 78 Vector Shift Trip
- 81O Trip Pre-Alarm
- 81U Trip Pre-Alarm
- 81 ROCOF Trip
- AEM Comm Failure
- Auto Restart Failure Alarm
- Auxiliary Input X Closed (X = 1 to 16)
- DPF Regeneration Required
- DPF Soot Level High Pre-Alarm
- DPF Soot Lvl Moderately High Pre-Alarm
- DPF Soot Level Severely High Pre-Alarm
- Duplicate AEM Pre-Alarm
- Duplicate CEM Pre-Alarm
- Duplicate LSM Pre-Alarm
- ECU Shutdown Alarm
- Emergency Stop Alarm
- Engine Running
- Fuel Leak Detect Status
- Fuel Level Sender Fail Alarm
- Fuel Level Sender Fail Pre-Alarm
- GOV Output Limit
- High Coolant Temperature Alarm
- High Coolant Temp Pre-Alarm
- High Exhaust Temperature
- High Fuel Pre-Alarm
- ID Missing Pre-Alarm
- ID Repeat Pre-Alarm
- Intergenset Comms Failure
- kW Overload 1 Pre-Alarm
- kW Overload 2 Pre-Alarm
- kW Overload 3 Pre-Alarm
- Loss of ECU Coms Alarm
- Loss of ECU Coms Pre-Alarm
- Loss of Generator Voltage Sensing Alarm
- Low Battery Voltage Pre-Alarm
- Low Coolant Level Status

- AVR Output Limit
- Battery Charger Fail Status
- Battery Overvoltage Pre-Alarm
- CEM Comm Failure
- Common Alarm
- Common Pre-Alarm
- Config Element X Status (X = 1 to 8)
- Coolant Temp Sender Fail Alarm
- Coolant Temp Sender Fail Pre-Alarm
- Cooldown Timer Active
- DEF Fluid Low Pre-Alarm
- DEF Fluid Empty Pre-Alarm
- DEF Engine Derate Pre-Alarm
- DEF Pre-Severe Inducement Pre-Alarm
- DEF Severe Inducement Pre-Alarm
- DEF Inducement Override Pre-Alarm
- DPF Regeneration Inhibited
- Low Coolant Temp Pre-Alarm
- Low Fuel Alarm
- Low Fuel Pre-Alarm
- Low Oil Pressure Alarm
- Low Oil Pressure Pre-Alarm
- LSM Comm Failure
- MPU Speed Sender Fail Alarm
- Oil Pressure Sender Fail Alarm
- Oil Pressure Sender Fail Pre-Alarm
- Overcrank Alarm
- Overspeed Alarm
- Scheduled Maintenance Pre-Alarm
- Switch Not in Auto
- Transfer Fail Alarm
- Virtual Output X Status (X = 1 to 8)
- Unexpected Shutdown Alarm
- Weak Battery Voltage Pre-Alarm

Dial-Out

The MGC-2000 Series uses telelocator alphanumeric protocol (TAP) version 1.7 when communicating with paging companies. This data format[D] specifies seven data bits with even parity. If required, eight data bits with no parity can be specified.

The message string sent by the MGC-2000 Series can be limited to a length supported by the receiving pagers[E]. If a message to be transmitted by the MGC-2000 Series exceeds the pager message limit, the MGC-2000 Series will make multiple calls to transmit the complete message.

Dial-out messages are sent by the MGC-2000 Series at a user-defined interval[F]. This interval gives an operator the opportunity to dial into the MGC-2000 Series. A second user-defined interval[G] determines how frequently dial-out attempts are made following a dial-out failure.

You may need to include a "1" or the area code, or both. If you are not sure you need the extra numbers, dial the phone number on your telephone. If the modem handshake is heard, the number dialed is correct.

Dial-In

When the MGC-2000 Series modem shares a line used for voice communication, the number of rings[H] required for the modem to answer can be increased to allow time for an operator to answer an incoming telephone call. Additional settings can be adjusted by use of modem initialization string[I] commands.

The BESTCOMS*Plus*® Modem Setup screen is illustrated in Figure 4-23.

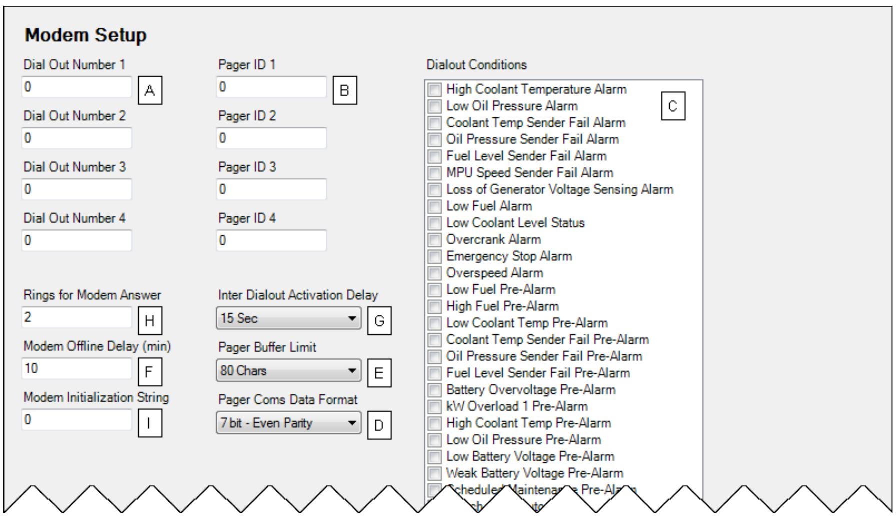

Figure 4-23. Modem Setup

[A] *Dial Out Number:* Accepts a telephone number of up to 16 characters.

[B] *Pager ID:* Accepts a pager identification number of up to 16 characters.
[C] *Modem Dialout Conditions:* Check boxes to select conditions that will initiate a dial-out message.
[D] *Pager Coms Data Format:* 7 bit – Even Parity or 8 bit – No Parity.
[E] *Pager Buffer Limit:* Adjustable from 80 to 200 characters in increments of 40.
[F] *Modem Offline Delay:* Adjustable from 1 to 240 min in 1 min increments.
[G] *Inter Dialout Activation Delay:* A delay of 15, 30, 60, or 120 s can be selected.
[H] *Rings for Modem Answer:* Adjustable from 1 to 9 in increments of 1.
[I] *Modem Initialization String:* Accepts a modem initialization (AT command) string of up to 50 characters. Refer to the documentation included with your modem for the compatible initialization strings.

Modem Setup through the Front Panel HMI

If a USB or Ethernet connection is not available, the modem can be completely set up through the front-panel interface. Navigate to MAIN MENU → SETTINGS → COMMUNICATION → MODEM SETUP and enter parameters for Dialout Numbers, Pager IDs, Rings for Answer, Offline Delay, Dialout Delay, Pager Buffer Limit, and Pager Communication Data Format.

After the modem is set up properly, a modem connection between a computer running BESTCOMS*Plus* and the MGC-2000 Series can be established.

RS485 Setup (Optional)

MGC-2000 Series controllers with the optional RS-485 communication port (style number xxxRxxxxx) can be monitored and controlled via a polled network using the Modbus protocol. Adjustable RS-485 port settings include the baud rate[A], parity[B], port address[C] and legacy Modbus map[D]. Fixed RS-485 port settings include the number of data bits (8) and stop bits (1).

Modbus register values for the MGC-2000 Series are listed and defined in Appendix B, *Modbus Communication*.

The BESTCOMS*Plus* RS485 Setup screen is illustrated in Figure 4-24.

Figure 4-24. RS485 Setup

[A] *Baud Rate:* A value of 1200, 2400, 4800, or 9600 can be selected.
[B] *Parity:* No Parity, Odd Parity, or Even Parity.
[C] *Modbus Address:* A value of 1 to 247 can be entered in increments of 1.
[D] *Legacy Modbus Map:* DGC-2000 or DGC-1000

System Parameters

System parameters configure the MGC-2000 Series for operation with a specific application and are divided into eight categories: system settings and rated data, remote module setup, crank settings, automatic restart, exercise timer, sensing transformers, relay control, and auto config detection.

System Settings and Rated Data

The following settings are used to configure the MGC-2000 Series for operation with a specific genset application. Refer to Figure 4-25, *System Settings*, and Figure 4-26, *Rated Data*. Click the *Edit* button on the *Rated Data* screen to make changes to rated data and click the *Save* button when finished. Sensing Transformers settings are described later in this section under *Sensing Transformers*.

Genset Electrical Parameters

Genset electrical parameters used by the MGC-2000 Series include the genset connection type, power rating, and voltage rating.

Genset connection types[A] accommodated by the MGC-2000 Series include three, three-phase configurations (delta, wye, and four-wire delta) and two single-phase configurations (sensing across phases A and B or A and C).

Bus sensing connection[B] types include Single-Phase and Three-Phase (hardware version 3 only).

The Phase Rotation[C] setting allows selection of ABC or CBA rotation according to the phase rotation connection of the machine. The MGC-2000 Series calculates the power angle as the angle between the Phase AB voltage and phase B current, then applies an angle compensation factor determined by the phase rotation setting. If the actual phase rotation connection of the machine does not match the phase rotation setting, calculation of the power angle will be incorrect, which could result in a miscalculation of kW, kvar, and Power Factor.

The MGC-2000 Series is compatible with gensets having power ratings[D] up to 9,999 kW and voltage ratings[E] up to 99,999 Vac.

The System Type setting[F] is used with dead bus breaker close arbitration. For more information, refer to Section 3, *Functional Description, Dead Bus Breaker Close Arbitration*.

The Alternate Frequency setting[G] defines the rated machine speed for the speed trim function when the alternate frequency override logic element is true. The MGC-2000 Series recalculates the speed trim setpoint as:

$$Alternate\ Speed\ Trim\ Setpoint = Speed\ Trim\ Setpoint\ \times \left(\frac{Alternate\ Frequency\ Setting}{Rated\ Frequency\ Setting}\right)$$

For example, a machine has a rated frequency of 60 Hz, the speed trim setpoint is set for 59.5 Hz, and the alternate frequency is set for 50 Hz. When the alternate frequency override logic element is true, the MGC-2000 Series calculates the alternate speed trim setpoint to be 59.5 X (50/60) = 49.58 Hz.

The 32 protection function uses the Genset KW Rating when determining pickup. The 40Q protection function uses the Rated kvar (which is calculated from the Genset KW Rating) and the Rated Power Factor setting[H] when determining pickup.

Engine Speed Measurement

The MGC-2000 Series can be configured to detect engine speed[I] from a magnetic pickup (MPU), the genset frequency, or both the MPU and genset frequency. On engines with CANBus ECUs, if MPU or MPU Freq is selected as the Speed Signal Source, the MGC-2000 Series uses CANBus as the speed source when CANBus is enabled. If Gen Freq is set as the Speed Signal Source, the MGC-2000 Series uses the generator frequency.

When engine speed is obtained from the genset frequency, the MGC-2000 Series uses the rated (nominal) genset frequency[J] and nominal rpm rating[K] when calculating engine rpm.

When engine speed is obtained from an MPU, the MGC-2000 Series uses the nominal rpm rating[I] and the number of flywheel teeth[L] when calculating engine rpm.

The speed signal from the MPU takes priority when both the genset frequency and MPU are selected as the engine speed source. If both MPU and genset frequency are selected and the MPU fails, the MGC-2000 Series will automatically switch to the genset frequency as the engine speed source.

When the CANBus interface is used, the speed signal source settings must be set at MPU or MPU_Gen. This allows the MGC-2000 Series to receive the engine speed data sent by the ECU via the SAE J1939 protocol.

EPS Threshold

Indication that the emergency power system is supplying load is determined by a user-adjustable threshold setting[M] expressed as a percentage of the genset CT (nominal) primary rating.

The Low Line Scale Factor setting[N] is used to automatically adjust the EPS threshold setting in applications that might utilize more than one type of genset connection. The scale factor setting is implemented when the MGC-2000 Series senses a contact closure at a contact input programmed to activate scaling of the settings. The value of the scale factor setting serves as a multiplier for the threshold setting. For example, if a scale factor contact input is received by the MGC-2000 Series and the scale factor setting is 2.000, the threshold setting will be doubled (2.000 x Threshold setting).

Measurement/Metering Units

The user can configure the MGC-2000 Series to display and report engine oil pressure and coolant temperature in English or metric units of measure[O]. Engine oil pressure has an additional parameter[P] for Metric Pressure Units.

Battery Voltage

The nominal voltage[Q] of the starter battery is used by the MGC-2000 Series to detect and annunciate battery overvoltage and low or weak battery voltage.

NFPA Compliance Level

The MGC-2000 Series can be used in an application requiring compliance with NFPA Standard 110. Levels 1 and 2 of Standard 110 are supported[R]. Selecting level 1 or 2 affects MGC-2000 Series operation in the following ways:

- The number of crank cycles is fixed at 3
- Crank cycle time is fixed at 15 seconds
- Continuous crank time is fixed at 45 seconds
- The low coolant temperature pre-alarm setting is fixed at 70°F

Fuel Level

The Function setting[S] allows the selection of four fuel types: Fuel Lvl, Natural Gas, Liquid Propane, or Disabled. Selecting a fuel type other than Fuel Lvl will disable any fuel level indication, alarm, and pre-alarm and disable the Fuel Level value on the Engine screen of the Metering Explorer in BESTCOMS*Plus*.

The use of a 0 - 10 V or 4 - 20 mA transducer is possible when an Analog Expansion Module (AEM-2020) is connected. Use the Source setting[T] to select the AEM-2020 analog input tied to the transducer.

Set the maximum and minimum percentage range for the AEM-2020 analog inputs using the Maximum[U] and Minimum percent[V] settings. The maximum and minimum range of the AEM-2020 analog inputs are set separately. See *Programmable Inputs, Remote Analog Inputs*, below, for more information.

Power Up Delay

In some cases, the ECU takes longer than the MGC-2000 Series to power up. The power up delay setting[W] is used to delay the initial pulsing of the ECU for data on MGC-2000 Series power up.

Generator Frequency

The generator frequency[X] is defined by the MGC-2000 Series Style Number (Figure 4-15).

Calculated Rated Data

The calculated rated data parameters[Y] are listed below.

$$Rated\ kVA = \frac{Rated\ kW}{Rated\ PF}$$

$$Rated\ kvar = Rated\ kVA\sqrt{1 - Rated\ PF^2}$$

$$Rated\ Phase\ Amps\ (3\text{-}phase\ machine) = \frac{Rated\ kVA}{Rated\ L\text{-}L\ Volts\sqrt{3}}$$

$$Rated\ Phase\ Amps\ (1\text{-}phase\ machine) = \frac{Rated\ kVA}{Rated\ L\text{-}L\ Volts}$$

$$Rated\ Secondary\ Volts = Rated\ Volts\left(\frac{Gen\ PT\ Secondary\ Volts}{Gen\ PT\ Primary\ Volts}\right)$$

$$Rated\ Secondary\ Phase\ Amps = Rated\ Phase\ Amps\left(\frac{CT\ Secondary\ Amps}{CT\ Primary\ Amps}\right)$$

Rated Voltage Low Line Scale Factor

The rated voltage low line scale factor setting[Z] preserves the system gains when a machine is changed from high line (where the windings are typically in series) to low line (where the windings are typically in parallel) configuration. When the windings are in series, typically a given change in voltage regulator bias will result in twice the change in output voltage as the same change in bias on a low line configuration.

Correct use of the rated voltage setting and the rated voltage low line scale factor setting on a reconfigurable machine, is to set the rated voltage to the high line voltage of the machine and set the scale factor to 0.5 to adjust the rated voltage in the voltage trim calculation when the low line override is active.

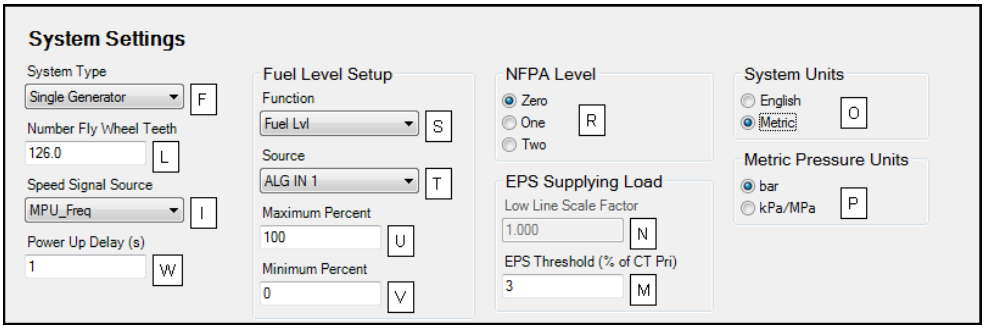

Figure 4-25. System Settings

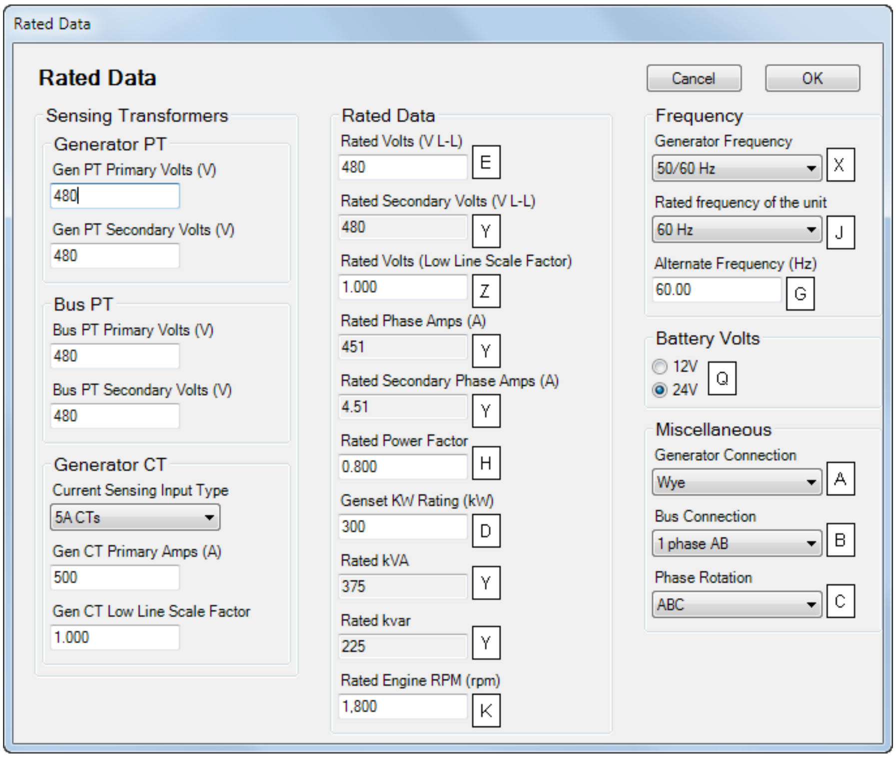

Figure 4-26. Rated Data

TIM-ID: 0000099917 - 001

[A] *Generator Connection:* Delta, Wye, 1-Phase A-B, 1-Phase A-C, or Grounded Delta.
[B] *Bus Connection:* Single-Phase or Three-Phase
[C] *Phase Rotation:* ABC or ACB.
[D] *Genset kW Rating:* Adjustable from 5 to 9,999 kW in 1 kW increments.
[E] *Rated Volts:* Adjustable from 1 to 99,999 Vac in 1 Vac increments.
[F] *System Type:* Single Generator or Multiple Generator.

[G] *Alternate Frequency:* Adjustable from 10 to 450 Hz in 0.01 Hz increments.
[H] *Rated Power Factor:* Adjustable from –1 to +1 in increments of 0.0001.
[I] *Speed Signal Source:* MPU, Gen Freq, or MPU Freq.
[J] *Rated Frequency:* 50/60 or 400 Hz.
[K] *Rated Engine RPM:* Adjustable from 750 to 3,600 in increments of 1.
[L] *Number Fly Wheel Teeth:* Adjustable from 1 to 500 in increments of 0.1.
[M] *EPS Current Threshold:* Adjustable from 3 to 10% of the CT primary rating in 1% increments.
[N] *Low Line Scale Factor:* Adjustable from 0.001 to 3 in increments of 0.001.
[O] *System Units:* English or Metric.
[P] *Metric Pressure Units:* Bar or kPa/MPa.
[Q] *Battery Volts:* 12 or 24 Vdc.
[R] *NFPA Level:* 0 disables NFPA compliance, 1 enables Level 1 NFPA compliance, 2 enables Level 2.
[S] *Fuel Level Function:* Disable, Fuel Lvl, Natural Gas, or Liquid Propane.
[T] *Source:* Sender or ALG IN 1 through ALG IN 8.
[U] *Maximum Percent:* Adjustable from 0 to 200% in 1% increments.
[V] *Minimum Percent:* Adjustable from 0 to 200% in 1% increments.
[W] *Power Up Delay:* Adjustable from 0 to 60 s in 1 s increments.
[X] *Generator Frequency:* 50/60 Hz or 400 Hz.
[Y] Calculated Values.
[Z] *Rated Volts (Low Line Scale Factor):* Adjustable from 0.001 to 3.000 in increments of 0.001.

Remote Module Setup

The following settings are used to configure the LSM-2020, CEM-2020, and AEM-2020.

Load Sharing Module

A J1939 Address[A] must be entered when an optional LSM-2020 is enabled[B]. Use the LSM Auxiliary Input Source setting[C] to select the source of the input values used for controlling the MGC-2000 Series. If *Local* is selected, the LSM-2020 uses its locally measured input values. If *System Manager* is selected, the LSM-2020 uses the input values received through inter-genset communications from the unit designated as the system manager. Note that the unit in the system with the lowest nonzero sequencing ID is the system manager.

Contact Expansion Module

A J1939 Address[D] must be entered when the optional CEM-2020 is enabled[E]. Select number of CEM-2020 outputs[F].

Analog Expansion Module

A J1939 Address[G] must be entered when the optional AEM-2020 is enabled[H].

The BESTCOMS*Plus* Remote Module Setup screen is illustrated in Figure 4-27.

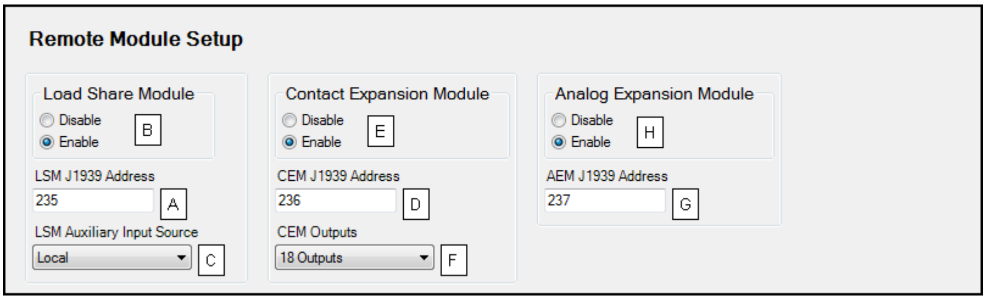

Figure 4-27. Remote Module Setup

[A] *LSM J1939 Address:* Adjustable from 1 to 253 in increments of 1.
[B] *Load Share Module:* Enable or Disable.
[C] *LSM Auxiliary Input Source:* Local or System Manager
[D] *CEM J1939 Address:* Adjustable from 1 to 253 in increments of 1.
[E] *Contact Expansion Module:* Enable or Disable.
[F] *CEM Outputs:* 18 Outputs or 24 Outputs.
[G] *AEM J1939 Address:* Adjustable from 1 to 253 in increments of 1.

[H] *Analog Expansion Module:* Enable or Disable.

Crank Settings

The MGC-2000 Series can be programmed for either cycle or continuous engine cranking[A]. Cycle cranking provides multiple engine starting attempts[B]. Each starting attempt consists of a fixed interval of engine cranking[C] followed by a rest interval[D]. Continuous cranking[E] provides a single, extended engine-starting attempt.

The MGC-2000 Series uses the engine speed signal (supplied by a magnetic pickup (MPU) or the generator frequency) and the Crank Disconnect Limit setting[F] to detect engine startup (and determine when engine cranking can be stopped). The Crank Disconnect Limit setting is expressed as a percentage of the nominal engine speed.

If desired, cycle or continuous cranking can be delayed after initiating engine startup. During this delay[G], the Pre-Start output closes to energize the engine glow plugs or pre-start lubrication pump. The Pre-Start output can be configured to open upon the conclusion of engine cranking or remain closed as long as the engine is running[H].

The Pre-Start can be configured[I] during the resting state. If Preheat Before Crank is selected, the Pre-Start output will be closed for a time equal to the Pre-crank delay time prior to re-entering the cranking state. If the Pre-crank delay setting is longer than the rest interval, the Pre-Start output will be closed for the entire rest time.

Under normal operation, engine rpm is used to determine crank disconnect. The Oil Pressure Crank Disconnect[J] provides a secondary indication that the engine is running so that the starter will be disconnected even if no engine rpm sources are functioning. When enabled, oil pressure is used as a check of whether the engine is running. If the engine oil pressure is above the threshold[K], the starter will be disconnected from the engine.

Engine Cooldown

After a genset's load is removed, the MGC-2000 Series implements a smart cooldown function which ensures proper engine and turbocharger cooldown by maintaining engine operation for a user-specified duration[L]. The cooldown time delay is initiated for any one of the following conditions:

- Genset load is removed and engine shutdown is permitted while in AUTO mode
- Auto transfer switch (ATS) opens while operating in AUTO mode
- Remote shutdown is initiated while in AUTO mode
- Off Mode Cooldown is initiated
- The Cooldown Request logic element is initiated
- The Cool and Stop Request logic element is initiated

Note that the MGC-2000 Series only goes through a cooldown sequence if the generator has supplied load (i.e. there was enough current for the Supplying Load LED to illuminate on the front panel while the generator was running) and one of the above conditions occurs to initiate the cooldown sequence. In addition, cooldown can occur during normal running before any of the above conditions occur. If the engine was loaded, then the load is removed during normal running and the cooldown timer begins timing since cooldown is occurring due to the absence of load. If one of the above conditions occurs after the load has been removed, there may be a shortened "normal" cooldown period since some cooling has already occurred, or the cooldown may be skipped if the cooldown timer elapsed during normal engine running. This reduces unnecessary fuel expenditure going through a cooldown cycle that is not required since partial or complete cooldown has already occurred.

Off Mode Cooldown

When Off Mode Cooldown[M] is enabled, pressing the MGC-2000 Series front panel OFF button one time will cause the unit to unload, open its breaker, and go through a cooldown cycle for the duration of the No Load Cooldown Time[K]. At the end of the cool down cycle, the unit will go to OFF mode. If it is desired to stop the machine immediately, pressing the OFF button twice will cause the unit to go to OFF mode immediately. Furthermore, if an Off Mode Cooldown is in progress and the OFF button is pressed, the unit will immediately shut down. If the unit was in RUN mode when the OFF button was pressed, it remains in RUN for the remainder of the cooldown cycle. If the machine was in the AUTO mode when the OFF button was pressed, it remains in AUTO mode until the cooldown and shutdown cycle are completed, or until the OFF button is pressed a second time forcing the unit to OFF mode. The OFF LED will flash to indicate an off mode cooldown is in progress. In addition, the unit will display "OFF MODE COOLDN" while the cooldown timer is displayed.

If the RUN button is pressed while an Off Mode Cooldown is in progress, the cooldown will be aborted and the unit will go to RUN mode.

If the AUTO button is pressed while an Off Mode Cooldown is in progress, the Off Mode Cooldown is cleared and the unit returns to normal AUTO operation. Thus, if conditions exist where the unit would normally run in AUTO, it will resume running in AUTO. If conditions exist where the unit would normally shut down in AUTO, the unit will finish the remaining cooldown cycle then stop and remain in AUTO.

If Off Mode Cooldown is not enabled, pressing the OFF button once at any time will immediately force the unit to OFF mode.

The Off Mode Cooldown feature works from the front panel HMI buttons only. Any OFF command received through BESTlogic*Plus* or BESTCOMS*Plus* control result in an immediate transition of the machine to OFF.

If the NFPA level setting is set for 1 or 2, the Off Mode Cooldown enable setting is cleared and OFF mode cooldown is not allowed.

Restart

Attempting to start an engine after a normal shutdown before the engine RPM has settled to zero can stress an engine in certain situations. The Restart Delay[N] inhibits attempts to start the engine immediately after a normal shutdown for the duration of the Restart Delay timer. This delay should allow an engine to properly spin down before attempting to restart.

The BESTCOMS*Plus* Crank Settings screen is illustrated in Figure 4-28.

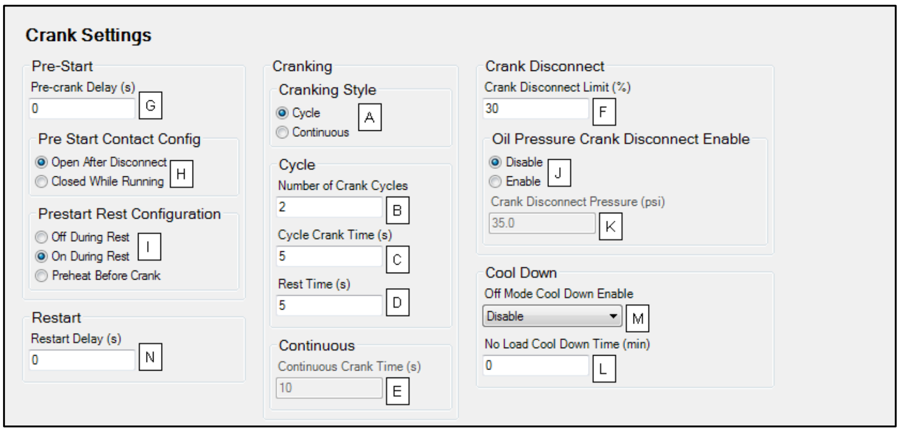

Figure 4-28. Crank Settings

[A] *Cranking Style*: Cycle or Continuous.
[B] *Number of Crank Cycles*: Adjustable from 1 to 7 cycles in 1 cycle increments. Controllers configured for NFPA compliance have a 1 to 3-cycle range.
[C] *Cycle Crank Time*: Adjustable over the range of 5 to 15 s in 1 s increments.
[D] *Rest Time:* Adjustable from 5 to 15 s in 1 s increments.
[E] *Continuous Crank Time*: Adjustable from 5 to 60 s in 1 s increments. Controllers configured for NFPA compliance have a 1 to 45 second range.
[F] *Crank Disconnect Limit*: Adjustable from 10 to 100% of nominal engine speed.
[G] *Pre-Crank Delay*: Adjustable from 0 to 30 s in 1 s increments.
[H] *Pre-Start Contact Configuration*: Open After Disconnect or Closed While Running.
[I] *Prestart Rest Configuration:* Off During Rest, On During Rest, or Preheat Before Crank.
[J] *Oil Pressure Crank Disconnect Enable:* Disable or Enable.
[K] *Crank Disconnect Pressure (psi):* Adjustable from 2.9 to 150 psi in 0.1 psi increments, 0.2 to 10.3 Bar in 0.1 Bar increments, or 20 to 1,034.5 kPa in 0.1 kPa increments.
[L] *No Load Cool Down Time:* Adjustable from 0 to 60 min in 1 min increments.
[M] *Off Mode Cool Down Enable:* Enable or Disable.
[N] *Restart Delay:* Adjustable from 0 to 120 s in 1 s increments.

Automatic Restart

If the MGC-2000 Series has shut down due to an alarm condition, the automatic restart, when enabled[A], will automatically clear alarms. An attempt to restart the engine is made after a predetermined time delay[B] if the ATS contact input is closed. If an ATS contact is not present, the unit will remain in READY state with its alarms cleared. A restart will not be attempted if a low fuel alarm or emergency stop is present. The number of restart attempts[C] is programmable. Automatic restart attempts are recorded in the event log.

The BESTCOMS*Plus* Automatic Restart screen is illustrated in Figure 4-29.

Figure 4-29. Automatic Restart

[A] *Auto Restart Enable:* Enable or Disable.
[B] *Auto Restart Interval:* Adjustable from 0.5 to 30 min in 0.5 min increments.
[C] *Auto Restart Attempts:* Adjustable from 1 to 10 in increments of 1.

Exercise Timer

The exercise timer is used to start the genset at a predetermined time and run for the user-defined period. The mode[A] defines how often the genset will run. If monthly is selected, you must select the day of the month[B] to start. If weekly is selected, you must select the day of the week[C] to start. Settings for Start Hour[D] and Start Minutes[E] can also be defined. The Run Period Hours[F] and Minutes[G] define how long the genset will run each time. If Run with Load[H] is enabled, the MGC-2000 Series will close its GEN breaker during the RUN time.

Contact inputs and outputs can be assigned to the function. Refer to Section 5, *BESTlogicPlus Programmable Logic,* for more information.

The BESTCOMS*Plus* Exercise Timer screen is illustrated in Figure 4-30.

Figure 4-30. Exercise Timer

[A] *Mode:* Monthly, Weekly, or Daily.
[B] *Start Day Of Month:* Adjustable from 1 to 31 in increments of 1.
[C] *Start Day Of Week:* Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, or Saturday.
[D] *Start Hour:* Adjustable from 0 to 23 in increments of 1.
[E] *Start Minute:* Adjustable from 0 to 59 in increments of 1.
[F] *Run Period Hours:* Adjustable from 0 to 23 in increments of 1.
[G] *Run Period Minutes:* Adjustable from 0 to 59 in increments of 1.
[H] *Run with Load:* Enable or Disable.

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Sensing Transformers

Three sets of transformer settings configure the MGC-2000 Series for operation with a specific system. These settings, along with the generator voltage, generator current, and bus voltage detected by the MGC-2000 Series, enable the MGC-2000 Series to accurately meter system values, offer generator protection, and synchronize the generator with the bus (style number xxxxxxxAx only).

Click the *Rated Data* button on the *Sensing Transformers* screen to make changes to rated data and click the *Save* button when finished. Click the *Cancel* button to discard changes.

Generator PT Settings

The generator PT settings establish the nominal primary[A] (generator side) and secondary[B] (MGC-2000 Series side) voltage levels at the generator voltage-sensing transformer.

Bus Transformer Settings

Primary and secondary bus transformer ratings are used by the automatic transfer switch function, which monitors a single- or three-phase∗ bus input to detect mains failure. Controllers equipped with an automatic synchronizer (style number xxxxxxxAx) also use the primary and secondary bus transformer ratings. The primary setting[C] establishes the nominal voltage present at phases A and C of the bus. The secondary setting[D] establishes the nominal voltage seen at the bus voltage input of the MGC-2000 Series.

∗ Three-phase bus input is available to MGC-2000 Series hardware version 3 only.

Generator CT Settings

The generator CT setting[E] establishes the nominal, primary (generator side) current level at the generator current sensing transformer. The secondary value of the generator CT is dictated by the style number[F] of the controller. An MGC-2000 Series with a style number of 1xxxxxxxx uses a nominal CT secondary rating of 1 Aac. An MGC-2000 Series with a style number of 5xxxxxxxx uses a nominal CT secondary rating of 5 Aac.

The Gen CT Low Line Scale Factor setting[G] is used to automatically adjust the Gen CT Primary Amps setting in applications that might utilize more than one type of genset connection. The scale factor setting is implemented when the MGC-2000 Series senses a contact closure at a contact input programmed to activate scaling of the settings. The value of the scale factor setting serves as a multiplier for the Gen CT Primary Amps setting. For example, if a scale factor contact input is received by the MGC-2000 Series and the scale factor setting is 2.000, the Gen CT Primary Amps setting will be doubled (2.000 x Gen CT Primary Amps setting).

The BESTCOMS*Plus* Sensing Transformers screen is illustrated in Figure 4-31.

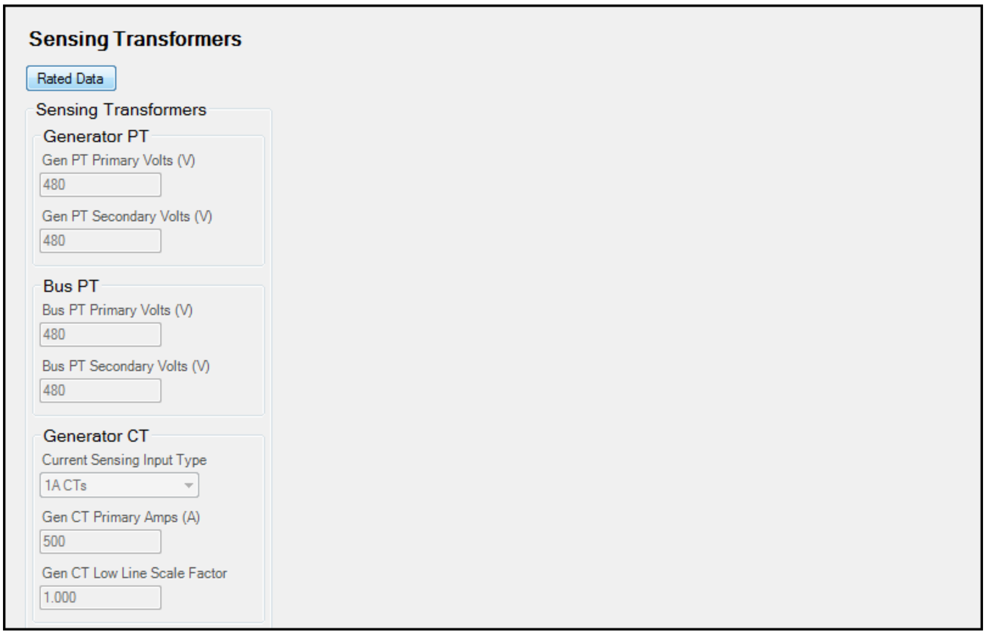

Figure 4-31. Sensing Transformers

[A] *Gen PT Primary Volts:* Adjustable from 1 to 99,999 Vac in 1 Vac increments.
[B] *Gen PT Secondary Volts:* Adjustable from 1 to 480 Vac in 1 Vac increments.
[C] *Bus PT Primary Volts:* Adjustable from 1 to 99,999 Vac in 1 Vac increments.
[D] *Bus PT Secondary Volts:* Adjustable from 1 to 480 Vac in 1 Vac increments.
[E] *Gen CT Primary Amps:* Adjustable from 1 to 9,999 Aac in 1 Aac increments.
[F] *Current Sensing Input Type:* 5A CTs or 1A CTs.
[G] *Gen CT Low Line Scale Factor:* Adjustable from 0.001 to 3 in increments of 0.001.

Relay Control

The default operational setting for the Start[A], Run[B], and Prestart[C] relays is “Predefined” or standard. Any of these relays can be logic driven by selecting the “Programmable” setting. Logic driven (programmable) relays must be set up using BESTlogic*Plus*.

The BESTCOMS*Plus* Relay Control screen is illustrated in Figure 4-32.

Figure 4-32. Relay Control

[A] *Start:* Predefined or Programmable.
[B] *Run:* Predefined or Programmable.
[C] *Prestart:* Predefined or Programmable.

Auto Config Detection

When enabled[A], this feature allows the MGC-2000 Series to automatically detect its sensing configuration in relation to the generator. The possible sensing configurations are three-phase, single-phase AB, and single-phase AC which are based upon line to line (L-L) voltage measurements.

Upon starting the genset, the configuration of the generator is automatically detected. Metering and generator protection are adjusted accordingly. Single Phase Override, Single Phase AC Sense Override, and Low Line Override programmable functions are set automatically as indicated by the detected Line to Line voltages.

When single-phase operation is detected, the MGC-2000 Series switches to single-phase A-B or single-phase A-C configuration, as specified by the Single Phase Detect Generator Connection setting.

There is a one-second delay in the detection to prevent the MGC-2000 Series from alternating between detected configurations. When the MGC-2000 Series is in the OFF mode or the engine is not running, the Automatic Configuration Detection is disabled. The MGC-2000 Series is assumed to be in the last valid automatically detected configuration.

It is recommended that the following programmable functions and logic element are not mapped to contact inputs when Automatic Configuration Detection is enabled.

- Single Phase Override programmable function
- Single Phase AC Sense Override programmable function
- Low Line Override programmable function
- Single Phase Override logic element

Single Phase Detect Threshold.[B] If the difference between the maximum and minimum L-L voltage exceeds this threshold, the unit will be auto detected to be in single-phase configuration. Single-phase detection sets the Single Phase Override programmable function and/or the Single Phase AC Override programmable function to force the MGC-2000 Series into the appropriate single-phase mode as specified by the *Single Phase Detection Generator Connection* setting. If contact inputs are also mapped to the Single Phase Override and Single Phase AC Sense Override programmable functions, the results of the Automatic Configuration Detection will be ORed with what is indicated by the contact inputs.

Low Line Detect Threshold.[C] If the average of the valid L-L voltages for the detected configuration is above this threshold, the unit will be auto detected as being in a high line configuration. If the average is below this threshold, it will be auto detected as being in a low-line configuration. When detected to be in a low-line configuration, the detection will set the Low Line Override programmable function to force the MGC-2000 Series into the low-line configuration. If contact inputs are also mapped to the Single Phase Override and Low Line Override programmable function, the results of the Automatic Configuration Detection will be ORed with what is indicated by the contact inputs.

Single Phase Detect Generator Connection.[D] This setting specifies whether the machine should go into a single-phase AC or single-phase AB configuration when the machine is detected to be in a single-phase configuration.

The BESTCOMS*Plus* Auto Config Detection screen is illustrated in Figure 4-33.

Figure 4-33. Auto Config Detection

[A] *Auto Config Detection:* Enable or Disable.
[B] *Single Phase Detect Threshold:* Adjustable from 0 to 480 V in 1 V increments.
[C] *Low Line Detect Threshold:* Adjustable from 0 to 480 V in 1 V increments.
[D] *Single Phase Detect Generator Connection:* A-B or A-C.

Programmable Inputs

MGC-2000 Series programmable inputs can be assigned to trigger various functions and, when triggered, annunciate an alarm or pre-alarm. A user-assigned label can be assigned to each input to make identification easier. The description of these settings is organized as follows:

- Contact Inputs
- Programmable Functions
- Remote LSM Inputs (Available with an optional LSM-2020 (Load Share Module).
- Remote Contact Inputs (Available with an optional CEM-2020 (Contact Expansion Module).
- Remote Analog Inputs (Available with an optional AEM-2020 (Analog Expansion Module).
- Remote RTD Inputs (Available with an optional AEM-2020 (Analog Expansion Module).
- Remote Thermocouple Inputs (Available with an optional AEM-2020 (Analog Expansion Module).

Contact Inputs

Each of the 16 contact inputs can be independently configured to annunciate an alarm or pre-alarm[A] when the input senses a contact closure. A user-adjustable time delay[B] can be set to delay generation of an alarm or pre-alarm when the input is configured as an alarm or pre-alarm. The status of the input is available immediately for BESTlogic*Plus* and on the Contact Inputs status screen on the front panel or in BESTCOMS*Plus*. By default, all inputs are configured so that they do not trigger an alarm or pre-alarm.

To make identifying the contact inputs easier, a user-assigned name[C] can be given to each input.

Contacts can be recognized[D] always or while the engine is running only.

The contact inputs are incorporated into a BESTlogic*Plus* programmable logic scheme by selecting them from the *I/O* group in BESTlogic*Plus*. For more details, refer to Section 5, *BESTlogicPlus Programmable Logic*.

Contact input status is available in BESTlogic*Plus* Programmable Logic when “None” is selected for Alarm Configuration.

The BESTCOMS*Plus* Contact Inputs screen is illustrated in Figure 4-34.

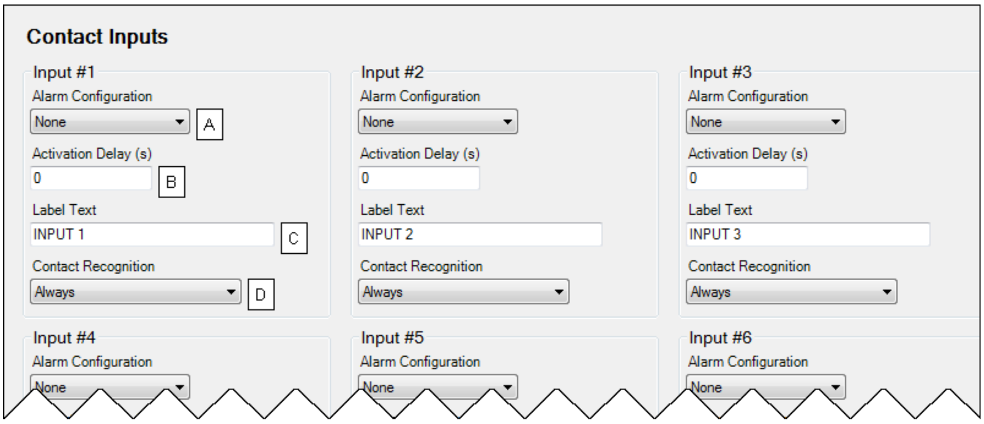

Figure 4-34. Contact Inputs

[A] *Alarm Configuration:* None, Alarm, or Pre-Alarm.
[B] *Activation Delay:* Adjustable from 0 to 300 s in 1 s increments.
[C] *Label Text:* An alphanumeric character string with a maximum of 16 characters.
[D] *Contact Recognition:* Always or While Engine Running Only.

Programmable Functions

Any of the 16 contact inputs can be programmed to recognize any one of nine function types:

- Automatic Transfer Switch (ATS)[A] - Disconnect from the mains and start the generator.
- Grounded Delta Override[B] - Uses Grounded Delta sensing if the generator connection is set for Delta.
- Battle Override[C] - The alarms programmed to shut down the unit will be overridden and ignored.
- Low-Line Override[D] - The 51, 27, and 59 settings are scaled by the low-line scale factor setting.
- Single-Phase Override[E] - The unit switches to single phase sensing configuration and uses the 1 Phase Override Sensing setting[F] (A-B or A-C). (Note: Applies only when the Single-Phase Override (A-C) input is <u>not</u> invoked.)
- Single-Phase Override (A-C)[G] - The unit switches to single phase A-C sensing configuration even if the 1 Phase Override Sensing setting is set for A-B. (Note: Applies only when the Single-Phase Override input is invoked.)
- Battery Charger Fail[H] - When the selected input is invoked, a user selectable pre-alarm or alarm is annunciated after the activation delay.
- Low Coolant Level[I] - When the selected input is invoked, a user selectable pre-alarm or alarm is annunciated after the activation delay.
- Fuel Leak Detect[J] - When the selected input is invoked, a user selectable pre-alarm or alarm is annunciated after the activation delay.

An Alarm Configuration setting of “None” prevents a function from being triggered by a contact input. Programmable function status is available in BESTlogic*Plus* Programmable Logic when “None” is selected.

The BESTCOMS*Plus* Programmable Functions screen is illustrated in Figure 4-35.

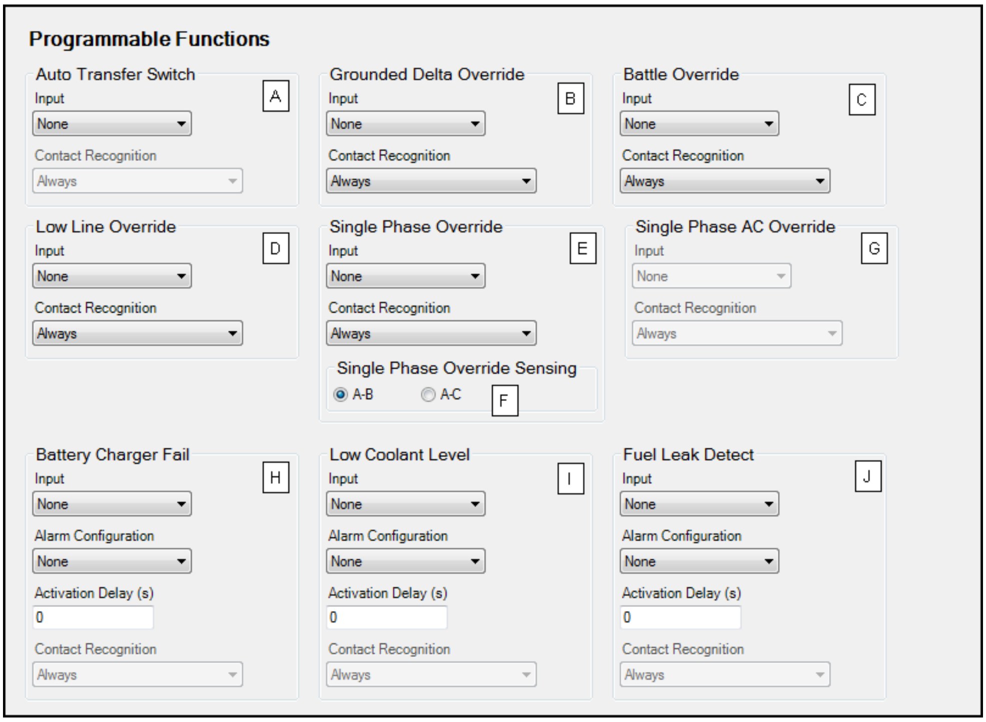

Figure 4-35. Programmable Functions

[A] *Auto Transfer Switch Input:* Select Input (None, 1-16)
[B] *Grounded Delta Override:* Select Input (None, 1-16) and Contact Recognition (Always or While Engine Running Only).
[C] *Battle Override:* Select Input (None, 1-16) and Contact Recognition (Always or While Engine Running Only).
[D] *Low Line Override:* Select Input (None, 1-16) and Contact Recognition (Always or While Engine Running Only).
[E] *Single Phase Override:* Select Input (None, 1-16) and Contact Recognition (Always or While Engine Running Only).
[F] *Single Phase Override Sensing:* A-B or A-C.
[G] *Single Phase AC Override:* Select Input (None, 1-16) and Contact Recognition (Always or While Engine Running Only).
[H] *Battery Charger Fail:* Select Input (None, 1-16), Alarm Configuration (None, Alarm, Pre-Alarm), Activation Delay (s) (0 to 300 s in increments of 1).
[I] *Low Coolant Level:* Select Input (None, 1-16), Alarm Configuration (None, Alarm, Pre-Alarm), Activation Delay (s) (0 to 300 s in increments of 1).
[J] *Fuel Leak Detect:* Select Input (None, 1-16), Alarm Configuration (None, Alarm, Pre-Alarm), Activation Delay (s) (0 to 300 s in increments of 1).

Remote LSM Inputs

An optional LSM-2020 (Load Share Module) provides one configurable[A] analog input that can be used as a setpoint source for var, PF, or kW control. Settings are provided for min and max input voltage[B], and min and max input current[C]. Refer to Bias Control Settings in this section for information selecting the LSM-2020 input as a setpoint source.

The remote LSM inputs are incorporated into a BESTlogic*Plus* programmable logic scheme by selecting them from the *I/O* group in BESTlogic*Plus*. For more details, refer to Section 5, *BESTlogicPlus Programmable Logic*.

The BESTCOMS*Plus* Remote LSM Inputs screen is illustrated in Figure 4-37.

Figure 4-36. Remote LSM Inputs

[A] *Input Type:* Voltage or Current.
[B] *Min/Max Input Voltage:* Adjustable from 0 to 10 V in 0.1 V increments.
[C] *Min/Max Input Current:* Adjustable from 4 to 20 mA in 0.1 mA increments.

Remote Contact Inputs

An optional CEM-2020 (Contact Expansion Module) provides 10 contact inputs. Each of the 10 contact inputs can be independently configured to annunciate an alarm or pre-alarm[A] when the input senses a contact closure. A user-adjustable time delay[B] can be set to delay recognition of a contact input. By default, all inputs are configured so that they do not trigger an alarm or pre-alarm.

To make identifying the contact inputs easier, a user-assigned name[C] can be given to each input.

Contacts can be recognized[D] always or only while the engine is running.

The remote contact inputs are incorporated into a BESTlogic*Plus* programmable logic scheme by selecting them from the *I/O* group in BESTlogic*Plus*. For more details, refer to Section 5, *BESTlogicPlus Programmable Logic*.

Remote contact input status is available in BESTlogic*Plus* Programmable Logic when “None” is selected for Alarm Configuration.

The BESTCOMS*Plus* Remote Contact Inputs screen is illustrated in Figure 4-37.

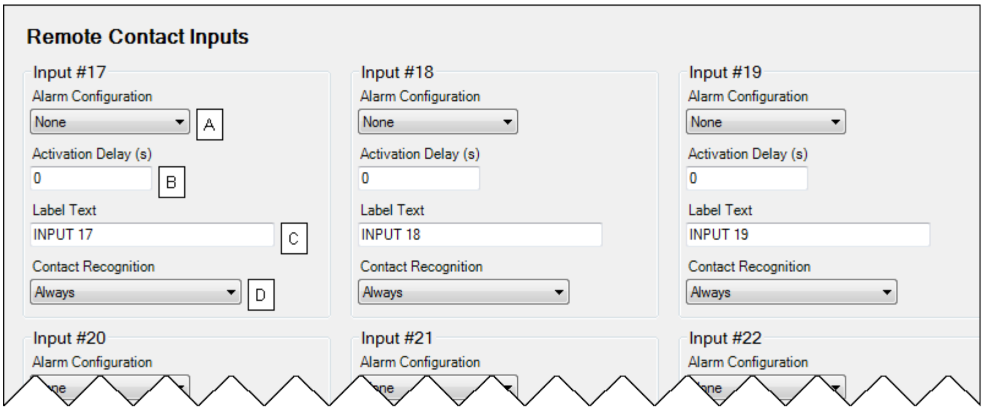

Figure 4-37. Remote Contact Inputs

[A] *Alarm Configuration:* None, Alarm, or Pre-Alarm.
[B] *Activation Delay:* Adjustable from 0 to 300 s in 1 s increments.
[C] *Label Text:* An alphanumeric character string with a maximum of 16 characters.
[D] *Contact Recognition:* Always or While Engine Running Only.

Remote Analog Inputs

An optional AEM-2020 (Analog Expansion Module) provides eight analog inputs. To make identifying the analog inputs easier, a user-assigned name[A] can be given to each input.

Select the input type[B] and amount of hysteresis[C]. The analog inputs are always monitored and their status is displayed on the appropriate metering screens. A user-adjustable arming delay[D] allows configuration of the analog input threshold monitoring in one of two ways. (1) When the arming delay is set to zero, threshold monitoring is performed all the time, whether the engine is running or not. (2) When the arming delay is set to a non-zero value, threshold monitoring begins when the arming delay time has expired after engine startup is complete. When enabled, an out of range alarm[E] alerts the user of an open or damaged analog input wire.

Ranges must be set for the selected input type. Param Min[F] correlates to Min Input Current[G] or Min Input Voltage[H] and Param Max[I] correlates to Max Input Current[J] or Max Input Voltage[K].

Each analog input can be independently configured to annunciate an alarm, pre-alarm, or status only[L] when the analog input signal falls beyond the threshold[M]. A user-adjustable activation delay[N] setting delays alarm annunciation after the threshold has been exceeded.

The remote analog inputs are incorporated into a BESTlogic*Plus* programmable logic scheme by selecting them from the *I/O* group in BESTlogic*Plus*. For more details, refer to Section 5, *BESTlogicPlus Programmable Logic*.

A remote analog input is disabled when Alarm Configuration is set to “None”. Remote analog input status is available in BESTlogic*Plus* Programmable Logic when “Status Only” is selected.

The BESTCOMS*Plus* Remote Analog Input #1 screen is illustrated in Figure 4-38.

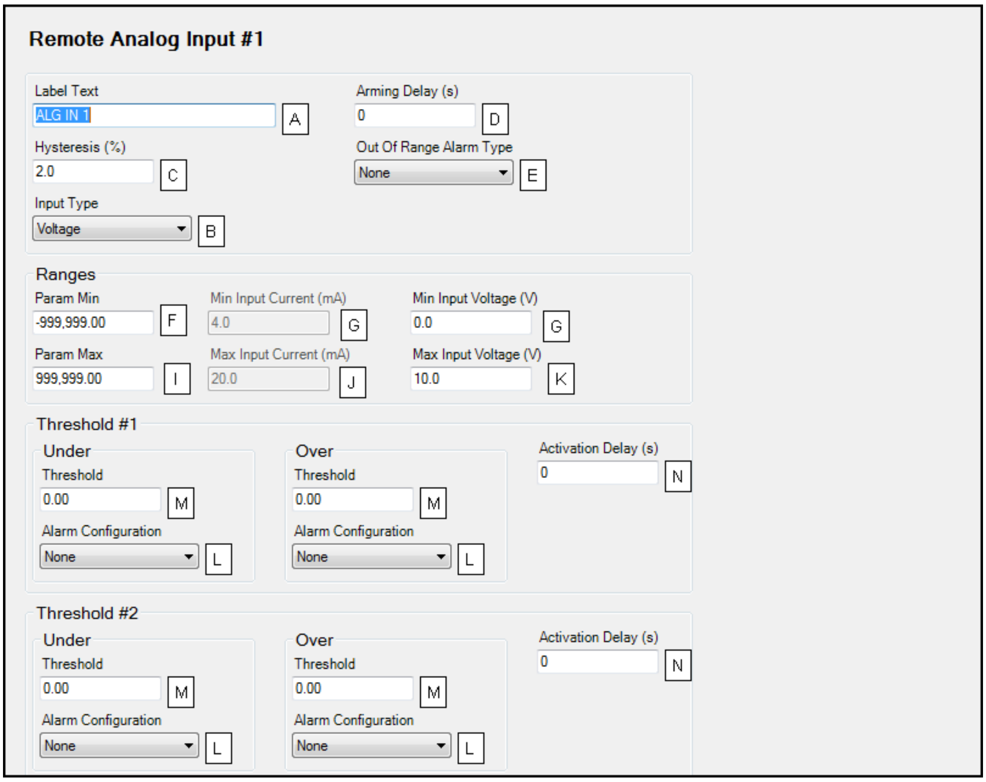

Figure 4-38. Remote Analog Input #1

[A] *Label Text:* An alphanumeric character string with a maximum of 16 characters.
[B] *Input Type:* Voltage or Current.
[C] *Hysteresis:* Adjustable from 0 to 100% in 0.1% increments.
[D] *Arming Delay:* Adjustable from 0 to 300 s in 1 s increments.
[E] *Out of Range Alarm Type:* None, Alarm, Pre-Alarm, or Status Only.
[F] *Param Min:* Adjustable from –9999.0 to +9999.0 in increments of 0.1.

[G] *Min Input Current:* Adjustable from 4 to 20 mA in 0.1 mA increments.
[H] *Min Input Voltage:* Adjustable from 0 to 10 V in 0.1 V increments.
[I] *Param Max:* Adjustable from –9999.0 to +9999.0 in increments of 0.1.
[J] *Max Input Current:* Adjustable from 4 to 20 mA in 0.1 mA increments.
[K] *Max Input Voltage:* Adjustable from 0 to 10 V in 0.1 V increments.
[L] *Alarm Configuration:* None, Alarm, Pre-Alarm, or Status Only.
[M] *Threshold:* Adjustable from –9999.0 to +9999.0 in increments of 0.1.
[N] *Activation Delay:* Adjustable from 0 to 300 s in 1 s increments.

Remote RTD Inputs

An optional AEM-2020 (Analog Expansion Module) provides eight RTD inputs. To make identifying the RTD inputs easier, a user-assigned name[A] can be given to each input.

Select the amount of hysteresis[B] and RTD type[C]. The RTD inputs are always monitored and their status is displayed on the appropriate metering screens. A user-adjustable arming delay[D] allows configuration of the RTD input threshold monitoring in one of two ways. (1) When the arming delay is set to zero, threshold monitoring is performed all the time, whether the engine is running or not. (2) When the arming delay is set to a non-zero value, threshold monitoring begins when the arming delay time has expired after engine startup is complete. When enabled, an out of range alarm[E] alerts the user of an open or damaged RTD input wire.

Each RTD input can be independently configured to annunciate an alarm, pre-alarm, or status only[F] when the RTD input signal falls beyond the threshold[G]. A user-adjustable activation delay[H] setting delays alarm annunciation after the threshold has been exceeded.

The remote RTD inputs are incorporated into a BESTlogic*Plus* programmable logic scheme by selecting them from the *I/O* group in BESTlogic*Plus*. For more details, refer to Section 5, *BESTlogicPlus Programmable Logic*.

A remote RTD input is disabled when Alarm Configuration is set to "None". Remote RTD input status is available in BESTlogic*Plus* Programmable Logic when "Status Only" is selected.

The BESTCOMS*Plus* Remote RTD Input #1 screen is illustrated in Figure 4-39.

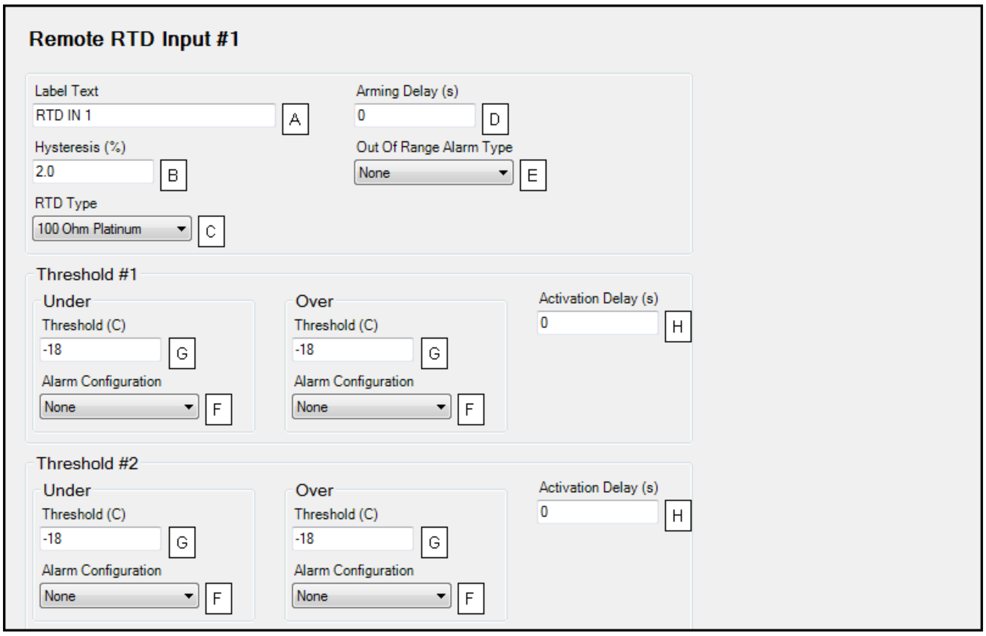

Figure 4-39. Remote RTD Input #1

TIM-ID: 0000099917 - 001

[A] *Label Text:* An alphanumeric character string with a maximum of 16 characters.
[B] *Hysteresis:* Adjustable from 0 to 100% in 0.1% increments.
[C] *RTD Type:* 100 Ohm Platinum or 10 Ohm Copper.
[D] *Arming Delay:* Adjustable from 0 to 300 s in 1 s increments.

[E] *Out of Range Alarm Type:* None, Alarm, Pre-Alarm, or Status Only.
[F] *Alarm Configuration:* None, Alarm, Pre-Alarm, or Status Only.
[G] *Threshold:* Adjustable from –58 to +482°F in 1°F increments or –50 to +250°C in 1°C increments.
[H] *Activation Delay:* Adjustable from 0 to 300 s in 1 s increments.

Remote Thermocouple Inputs

An optional AEM-2020 (Analog Expansion Module) provides two thermocouple inputs. To make identifying the thermocouple inputs easier, a user-assigned name[A] can be given to each input.

Select the amount of hysteresis[B]. The thermocouple inputs are always monitored and their status is displayed on the appropriate metering screens. A user-adjustable arming delay[C] allows configuration of the thermocouple input threshold monitoring in one of two ways. (1) When the arming delay is set to zero, threshold monitoring is performed all the time, whether the engine is running or not. (2) When the arming delay is set to a non-zero value, threshold monitoring begins when the arming delay time has expired after engine startup is complete.

Each thermocouple input can be independently configured to annunciate an alarm, pre-alarm, or status only[D] when the thermocouple input signal falls beyond the threshold[E]. A user-adjustable activation delay[F] setting delays alarm annunciation after the threshold has been exceeded.

A remote thermocouple input is disabled when Alarm Configuration is set to “None”.

The remote thermocouple inputs are incorporated into a BESTlogic*Plus* programmable logic scheme by selecting them from the *I/O* group in BESTlogic*Plus*. For more details, refer to Section 5, *BESTlogicPlus Programmable Logic*.

Remote thermocouple input status is available in BESTlogic*Plus* Programmable Logic when “Status Only” is selected.

The BESTCOMS*Plus* Remote Thermocouple Input #1 screen is illustrated in Figure 4-40.

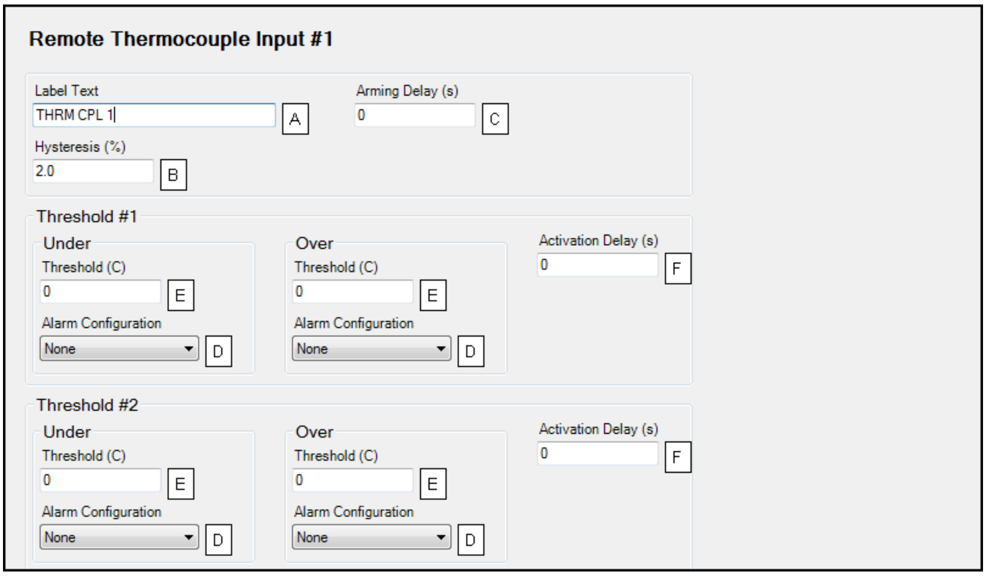

Figure 4-40. Remote Thermocouple Input #1

[A] *Label Text:* An alphanumeric character string with a maximum of 16 characters.
[B] *Hysteresis:* Adjustable from 0 to 100% in 0.1% increments.
[C] *Arming Delay:* Adjustable from 0 to 300 s in 1 s increments.
[D] *Alarm Configuration:* None, Alarm, Pre-Alarm, or Status Only.
[E] *Threshold:* Adjustable from 32 to 2,507°F in 1°F increments or 0 to 1,375°C in 1°C increments.
[F] *Activation Delay:* Adjustable from 0 to 300 s in 1 s increments.

Programmable Outputs

MGC-2000 Series programmable outputs include four user-programmable contact outputs if the style number is xxAxxxxxx. If the style number is xxBxxxxxx, twelve contact outputs are provided. An additional 24 contact outputs are provided with an optional CEM-2020 (Contact Expansion Module).

Contact Outputs

To make identifying the contact outputs easier, each of the contact outputs can be given a user-assigned name with a maximum of 16 alphanumeric characters.

The contact outputs are incorporated into a BESTlogic*Plus* programmable logic scheme by selecting them from the *I/O* group in BESTlogic*Plus*. For more details, refer to Section 5, *BESTlogicPlus Programmable Logic*.

The BESTCOMS*Plus* Contact Outputs screen is illustrated in Figure 4-41.

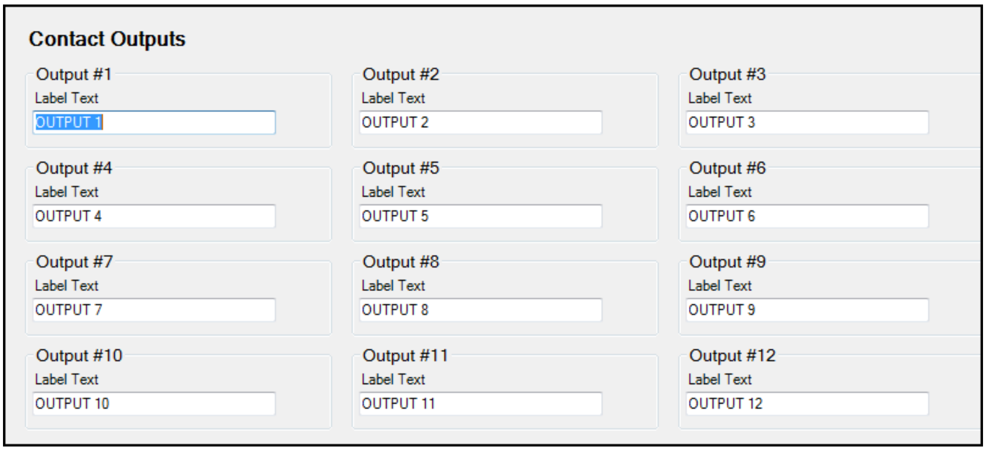

Figure 4-41. Contact Outputs

Configurable Elements

Configurable elements are connected to the logic scheme as outputs. The configurable elements are incorporated into a BESTlogic*Plus* programmable logic scheme by selecting them from the *Elements* group in BESTlogic*Plus*. For more details, refer to Section 5, *BESTlogicPlus Programmable Logic*. Each of the eight elements can be independently configured to annunciate an alarm or pre-alarm[A]. A user-adjustable time delay[B] can be set to delay recognition of an element. By default, all elements are configured so that they do not trigger an alarm or pre-alarm. To make identifying the element easier, each of the elements can be given a user-assigned name[C]. If used for an alarm or pre-alarm, the user-assigned name is what will appear in the alarm or pre-alarm annunciation and in the MGC-2000 Series event log. Elements can be recognized[D] always or only while the engine is running. Configurable element status is available in BESTlogic*Plus* Programmable Logic when "None" is selected for Alarm Configuration. Configurable element status can be used as logic inputs to drive other logic in the program, similar to logic control relays. In addition, the configurable element status can be used to generate modem dial outs which display the user-assigned name on modem equipped MGC-2000 Series.

The BESTCOMS*Plus* Configurable Elements screen is illustrated in Figure 4-42.

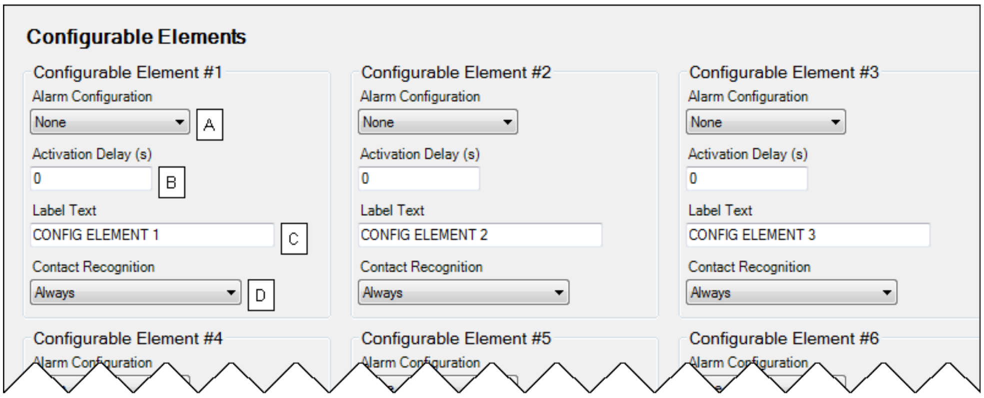

Figure 4-42. Configurable Elements

[A] *Alarm Configuration:* None, Alarm, or Pre-Alarm.
[B] *Activation Delay:* Adjustable from 0 to 300 s in 1 s increments.
[C] *Label Text:* An alphanumeric character string with a maximum of 16 characters.
[D] *Contact Recognition:* Always or While Engine Running Only.

Remote Contact Outputs

To make identifying the contact outputs easier, each of the contact outputs can be given a user-assigned name[A].

The remote contact outputs are incorporated into a BESTlogic*Plus* programmable logic scheme by selecting them from the *I/O* group in BESTlogic*Plus*. For more details, refer to Section 5, *BESTlogicPlus Programmable Logic*.

The BESTCOMS*Plus* Remote Contact Outputs screen is illustrated in Figure 4-43.

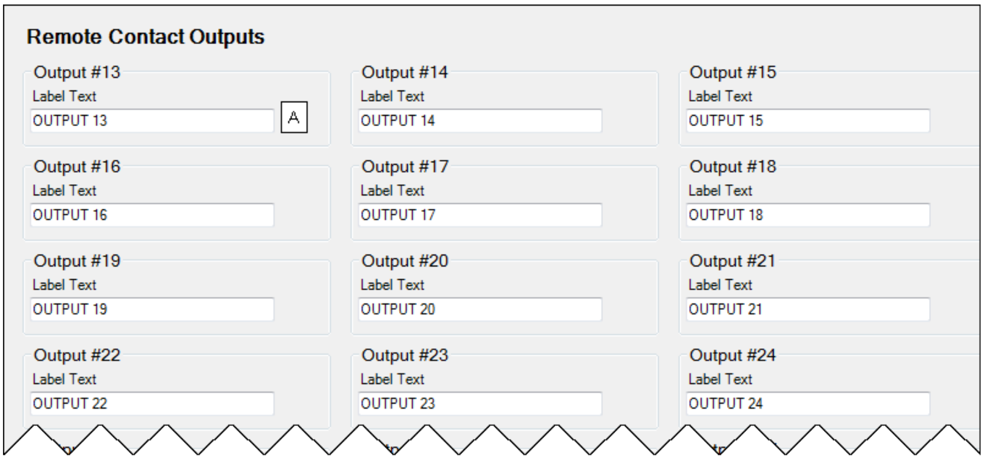

Figure 4-43. Remote Contact Outputs

[A] *Label Text:* An alphanumeric character string with a maximum of 16 characters.

Remote Analog Outputs

An optional AEM-2020 (Analog Expansion Module) provides four analog outputs.

Make a parameter selection[A] and select the output type[B]. When enabled, an out of range alarm[C] alerts the user of an open or damaged analog output wire. An out of range activation delay[D] setting delays alarm annunciation.

Ranges must be set for the selected output type. Param Min[E] correlates to Min Output Current[F] or Min Output Voltage[G] and Param Max[H] correlates to Max Output Current[I] or Max Output Voltage[J].

A remote analog output is disabled when Alarm Configuration is set to “None”. Remote analog output status is available in BESTlogic*Plus* Programmable Logic when “Status Only” is selected.

The remote analog outputs are incorporated into a BESTlogic*Plus* programmable logic scheme by selecting them from the *I/O* group in BESTlogic*Plus*. For more details, refer to Section 5, *BESTlogicPlus Programmable Logic*.

The BESTCOMS*Plus* Remote Analog Output #1 screen is illustrated in Figure 4-44.

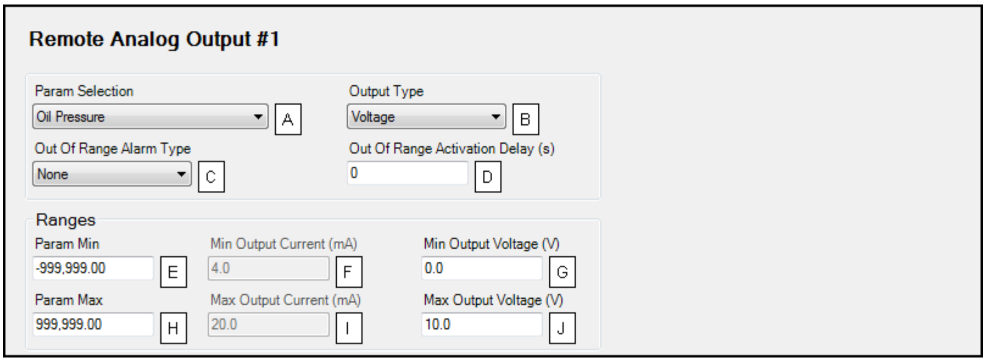

Figure 4-44. Remote Analog Output #1

[A] *Param Selection:* Oil Pressure, Coolant Temp, Battery Volts, RPM, Fuel Level, Gen VAB, Gen VBC, Gen VCA, Gen VAN, Gen VBN, Gen VCN, Bus Freq, Bus Volts, Gen Freq, Gen PF, Gen IA, Gen IB, Gen IC, kW A, kW B, kW C, kW Total, kVA A, kVA B, kVA C, kVA Total, Analog Input 1-8, RTD Input 1-8, Thermocouple Input 1-2, Fuel Delivery Pressure, kvar A, kvar B, kvar C, kvar Total, Injector Metering Rail Pressure, Total Fuel Used, Fuel Temperature, Engine Oil Temperature, Engine Intercooler Temperature, Coolant Pressure, Fuel Rate, Boost Pressure, Intake Manifold Temperature, Charge Air Temperature, Engine Percent Load.
[B] *Output Type:* Voltage or Current.
[C] *Out of Range Alarm Configuration:* None, Alarm, Pre-Alarm, or Status Only.
[D] *Out of Range Activation Delay:* Adjustable from 0 to 300 s in 1 s increments.
[E] *Param Min:* –99,999.0 to +99,999.0 in increments of 0.1.
[F] *Min Output Current:* Adjustable from 4 to 20 mA in 0.1 mA increments.
[G] *Min Output Voltage:* Adjustable from 0 to 10 V in 0.1 V increments.
[H] *Param Max:* –99,999.0 to +99,999.0 in increments of 0.1.
[I] *Max Output Current:* Adjustable from 4 to 20 mA in 0.1 mA increments.
[J] *Max Output Voltage:* Adjustable from 0 to 10 V in 0.1 V increments.

Configurable Protection

Configurable protection can be used when the standard protection available with the MGC-2000 Series does not meet the application needs. Eight configurable protection items are provided. To make identifying the items easier, each of the items can be given a user-assigned name[A].

Select a parameter[B] to monitor. A user-adjustable arming delay[C] disables configurable protection during engine startup. If the arming delay is set to zero, the configurable protection is active at all times, including when the engine is not running. If the arming delay is set to a non-zero value, the configurable protection is inactive when the engine is not running, and does not become active until after the engine is started and the arming delay has elapsed. A setting is provided to adjust the hysteresis[D].

Each configurable protection item can be independently configured to annunciate an alarm, pre-alarm, or status only[E] when the parameter selection falls beyond the threshold[F]. A user-adjustable activation delay[G] setting delays alarm annunciation after the threshold has been exceeded.

Configurable protection is disabled when Alarm Configuration is set to “None”.

NOTE

The Arming Delay should not be set to zero if *Oil Pressure* or *Battery Volts* is selected for configurable protection and the threshold alarm configuration is set to *Alarm*. Setting the arming delay to zero will cause an immediate alarm and the engine will not start.

The configurable protection items are incorporated into a BESTlogic*Plus* programmable logic scheme by selecting them from the *I/O* group in BESTlogic*Plus*. For more details, refer to Section 5, *BESTlogicPlus Programmable Logic*.

Configurable Protection status is available in BESTlogic*Plus* Programmable Logic when "Status Only" is selected.

The BESTCOMS*Plus* Configurable Protection #1 screen is illustrated in Figure 4-45.

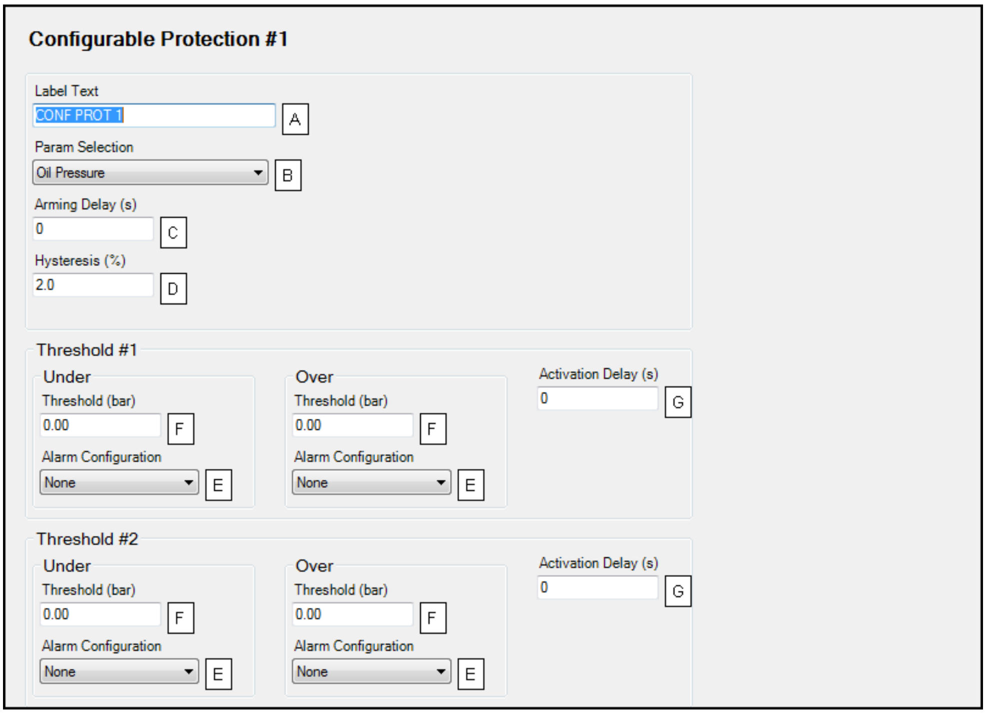

Figure 4-45. Configurable Protection #1

[A] *Label Text:* An alphanumeric character string with a maximum of 16 characters.
[B] *Param Selection:* Oil Pressure, Coolant Temp, Battery Volts, RPM, Fuel Level, Gen VAB, Gen VBC, Gen VCA, Gen VAN, Gen VBN, Gen VCN, Bus Freq, Bus Volts, Gen Freq, Gen PF, Gen IA, Gen IB, Gen IC, kW A, kW B, kW C, kW Total, kVA A, kVA B, kVA C, kVA Total, Analog Input 1-8, RTD Input 1-8, Thermocouple Input 1-2, Fuel Delivery Pressure, kvar A, kvar B, kvar C, kvar Total, Injector Metering Rail Pressure, Total Fuel Used, Fuel Temperature, Engine Oil Temperature, Engine Intercooler Temperature, Coolant Pressure, Fuel Rate, Boost Pressure, Intake Manifold Temperature, Charge Air Temperature, Engine Percent Load, Bus VAB, Bus VBC, Bus VCA, kW Load Percent, Number of Units On Line, System Online kW Capacity, System Generated kW, System Generated kvar, Number of Units, DEF Tank Level 1 %, DEF Tank Level 2 %, System Total kW Capacity, System Generated kW Percent, or DPF Outlet Gas Temperature.
[C] *Arming Delay:* Adjustable from 0 to 300 s in 1 s increments.
[D] *Hysteresis:* Adjustable from 0 to 100% in increments of 0.1%.
[E] *Alarm Configuration:* None, Alarm, Pre-Alarm, or Status Only.
[F] *Threshold:* Adjustable from −999,999 to 999,999 in increments of 0.01.
[G] *Activation Delay:* Adjustable from 0 to 300 s in 1 s increments.

Configurable Protection Scale Factors

The alternate frequency scale factor[A] is used when Gen Freq or Bus Freq is selected as the parameter for configurable protection. The voltage low line scale factor[B] is used when the parameter selection for configurable protection is set for Gen VAB, Gen VBC, Gen VCA, Gen VAN, Gen VBN, Gen VCN, or Bus

Volts. The current low line scale factor[C] is used when the parameter selection for configurable protection is set for Gen IA, Gen IB, or Gen IC.

The BESTCOMS*Plus* Scale Factors screen is illustrated in Figure 4-46.

Figure 4-46. Scale Factors

[A] *Alternate Frequency Scale Factor:* Adjustable from 0.001 to 100 in increments of 0.001.
[B] *Voltage Low Line Scale Factor:* Adjustable from 0.001 to 100 in increments of 0.001.
[C] *Current Low Line Scale Factor:* Adjustable from 0.001 to 100 in increments of 0.001.

Alarm Configuration

MGC-2000 Series alarms and pre-alarms can be used to annunciate system, genset, and engine sender conditions. The description of the alarm configuration settings is organized as follows:

- Horn Configuration
- Pre-Alarms
- Alarms
- Sender Fail

Horn Configuration

Horn

An output contact configured (through programmable logic) to energize a horn[A] can be enabled and disabled through BESTCOMS*Plus* or at the MGC-2000 Series front panel.

Not In Auto Horn Enable

This setting[B] allows the horn to annunciate when the MGC-2000 Series is not in auto mode.

The BESTCOMS*Plus* Horn Configuration screen is illustrated in Figure 4-47.

Figure 4-47. Horn Configuration

[A] *Horn:* Enable or Disable.
[B] *Not In Auto Horn Enable:* Enable or Disable.

Pre-Alarms

A pre-alarm is annunciated when a condition programmed to trigger a pre-alarm is met. When a pre-alarm condition exists, it is annunciated (flashed) on the LCD, the front panel Alarm indicator flashes on and off and the Horn output (if programmed and enabled) alternates between an energized and de-energized state. The audible alarm is reset by pressing the front panel Alarm Silence pushbutton. When a pre-alarm condition ceases to exist for most pre-alarms, all displayed annunciations are reset automatically. Certain pre-alarms do not clear automatically and must be cleared by either pressing the reset button on the front panel or providing an input to the Reset logic element in BESTlogic*Plus*. The following pre-alarms do not clear automatically:

- Weak Battery Pre-Alarm
- Breaker Close Fail Pre-Alarms
- Breaker Open Fail Pre-Alarms
- Synchronizer Fail Pre-Alarm
- 81 ROC DF/DT Rate of Change of Frequency Pre-Alarm
- 78 Vector Shift Pre-Alarm

Active pre-alarms are displayed on the main display of the LCD. The LCD annunciates an active pre-alarm by alternating the pre-alarm message with the normally displayed data. All pre-alarms are individually displayed, in sequence, by scrolling through the LCD pre-alarms list.

Each MGC-2000 Series pre-alarm is described in the following paragraphs. Pre-alarms can be enabled and adjusted in BESTCOMS*Plus* or through the front panel HMI.

The BESTCOMS*Plus* Pre-Alarms screen is illustrated in Figure 4-48.

High Fuel Level

High fuel level pre-alarm settings[A] consist of an enable/disable setting, a threshold setting, and an activation delay. If enabled, a high fuel level pre-alarm occurs when the metered fuel level increases above the threshold setting.

Low Battery Voltage

Low battery voltage pre-alarm settings[B] consist of an enable/disable setting, a threshold setting, and an activation delay. If enabled, a low battery voltage pre-alarm occurs when the battery voltage decreases below the threshold setting for the duration of the activation time delay. The threshold setting range is based on the nominal battery voltage setting on the BESTCOMS*Plus* System Settings tab (MGC-2000 Series, System Parameters, System Settings).

Weak Battery Voltage

Weak battery voltage pre-alarm settings[C] consist of an enable/disable setting, a threshold setting, and an activation time delay. If enabled, a weak battery voltage pre-alarm latches during engine cranking when the battery voltage decreases below the threshold setting for the duration of the activation delay. The threshold setting range is based on the nominal battery voltage setting on the BESTCOMS*Plus* System Settings tab (MGC-2000 Series, System Parameters, System Settings).

A weak battery pre-alarm condition is reset through the front panel by navigating to the *Alarms-Status, Pre-Alarms* screen, scrolling through the list of pre-alarms until “Weak Battery” is displayed, and pressing the *Reset* key.

Battery Overvoltage

Battery overvoltage pre-alarm settings[D] consist of an enable/disable setting and a threshold setting. If enabled, a battery overvoltage pre-alarm occurs when the battery voltage increases above the threshold setting for a duration of two seconds.

Maintenance Interval

Maintenance interval pre-alarm settings[E] consist of an enable/disable setting and a threshold setting. If enabled, a maintenance interval pre-alarm is annunciated when the MGC-2000 Series maintenance timer counts down to zero from the threshold time setting. The maintenance interval pre-alarm can be reset through the MGC-2000 Series front panel or by using BESTCOMS*Plus*.

To reset the maintenance interval pre-alarm through the MGC-2000 Series front panel, navigate to the SETTINGS > SYSTEM PARAMS > SYSTEM SETTINGS > MAINT RESET screen. Operator, Settings, or OEM access level is required to reset the maintenance interval pre-alarm. If the maintenance interval pre-alarm is not enabled, the MAINT RESET parameter is not visible on the front panel.

To reset the maintenance interval pre-alarm by using BESTCOMS*Plus*, use the Metering Explorer to open the Run Statistics screen and click on the *Reset Maintenance Interval* button.

Engine kW Overload

By comparing the genset power output with the rated genset output, the level of engine loading can be determined. Three engine overload pre-alarms are available that monitor three-phase real power when three-phase sensing is active or single-phase real power if single phase sensing is active. Settings[F] for each pre-alarm consist of an enable/disable setting, three-phase threshold setting, three-phase hysteresis setting, single-phase threshold setting, single phase hysteresis setting, and low-line scale factor setting. If enabled, an engine overload pre-alarm occurs when the metered power level exceeds the threshold setting. The threshold setting is expressed as a percentage of the genset kW rating on the BESTCOMS*Plus* System Settings tab (MGC-2000 Series, System Parameters, System Settings). The hysteresis setting functions as a pre-alarm dropout by preventing rapid switching of the alarm annunciation. When the low-line override is active, the thresholds for three phase and single phase detection are multiplied by the low-line scale factor. The effect is that low-line threshold = three phase or single phase threshold setting x low-line scale factor.

Low Fuel Level

Low fuel level pre-alarm settings[G] consist of an enable/disable setting and a threshold setting. If enabled, a low fuel level pre-alarm occurs when the metered fuel level decreases below the threshold setting for a duration of two seconds.

High Coolant Temp

High coolant temperature pre-alarm settings[H] consist of an enable/disable setting and a threshold setting. If enabled, a high coolant temperature pre-alarm is annunciated when the engine coolant temperature exceeds the threshold setting for a fixed duration of four seconds. The arming delay disables the High Coolant Temp pre-alarm function for a user-adjustable time during engine startup. Delay duration is determined by the High Coolant Temp Alarm Arming Delay setting. System units are configured on the System Settings screen.

Low Coolant Temp

Low coolant temperature pre-alarm settings[I] consist of an enable/disable setting and a threshold setting. If enabled, a low coolant temperature pre-alarm occurs when the engine coolant temperature decreases below the threshold setting for four seconds. System units are configured on the System Settings screen.

Low Coolant Level

Low coolant level pre-alarm settings[J] consist of an enable/disable setting and a threshold setting. If enabled, a low coolant level pre-alarm occurs when the metered coolant level decreases below the threshold setting for two seconds.

Low Oil Pressure

Low oil pressure pre-alarm settings[K] consist of an enable/disable setting and a threshold setting. If enabled, a low oil pressure pre-alarm is triggered after a two second delay when the engine oil pressure decreases below the threshold setting. The arming delay disables the low oil pressure pre-alarm function for a user-adjustable time during engine startup. Delay duration is determined by the Low Oil Pressure Alarm Arming Delay setting. System units and metric pressure units are configured on the *System Settings* screen.

ECU Coms Fail

ECU communication failure pre-alarm settings[L] consist of a single enable/disable setting. If enabled, an ECU communication failure pre-alarm is annunciated when the MGC-2000 Series detects a communication problem in the J1939 interface linking the MGC-2000 Series with the ECU (engine control unit).

Active DTC

Active DTC (diagnostic trouble code) pre-alarm settings[M] consist of a single enable/disable setting. If CAN and DTC support are both enabled, an “active DTC” pre-alarm can be enabled to announce the presence of a condition that is causing a DTC to be sent from the ECU to the MGC-2000 Series.

AVR Bias Output Limit

AVR bias output limit settings[N] consist of an enable/disable setting and an activation delay setting. If enabled, an AVR bias output limit pre-alarm is annunciated when the AVR bias output limit has been met and the activation delay has expired. This setting only applies when using the optional LSM-2020.

GOV Bias Output Limit

GOV bias output limit settings[O] consist of an enable/disable setting and an activation delay setting. If enabled, a GOV bias output limit pre-alarm is annunciated when the GOV bias output limit has been met and the activation delay has expired. This setting only applies when using the optional LSM-2020.

Intergenset Comm Failure

Intergenset communication failure pre-alarm settings[P] consist of a single enable/disable setting. If enabled, an Intergenset communication failure pre-alarm is annunciated when an individual generator detects that it had been connected to a generator network, but has lost the connection. This setting only applies when using an optional LSM-2020.

LSM Comm Failure

LSM-2020 communication failure pre-alarm settings[Q] consist of a single enable/disable setting. If enabled, an LSM-2020 communication failure pre-alarm is annunciated when communication between an optional LSM-2020 and MGC-2000 Series is lost.

ID Missing

ID missing pre-alarm settings consist of a single enable/disable setting[R]. If enabled, an ID missing pre-alarm is annunciated when an expected sequence ID of an optional LSM-2020 is not detected on the network.

ID Repeat

ID repeat pre-alarm settings consist of a single enable/disable setting[S]. If enabled, an ID repeat pre-alarm is annunciated when two or more optional LSM-2020's report the same expected sequence ID.

CEM Comm Failure

CEM-2020 communication failure pre-alarm settings[T] consist of a single enable/disable setting. If enabled, a CEM-2020 communication failure pre-alarm is annunciated when communication between an optional CEM-2020 and MGC-2000 Series is lost.

AEM Comm Failure

AEM-2020 communication failure pre-alarm settings[U] consist of a single enable/disable setting. If enabled, an AEM-2020 communication failure pre-alarm is annunciated when communication between an optional AEM-2020 and MGC-2000 Series is lost.

Checksum Failure

The checksum failure pre-alarm will occur whenever one of the internal checksum calculations used for data integrity purposes has failed. This indicates that some of the user settings or firmware code has been corrupted.

The checksum failure pre-alarm can be cleared by pressing the reset button on the front panel. However, the pre-alarm will reoccur the next time the checksum is verified if the data is still corrupted. Some checksum calculations are done only on power up, so this might not occur until the next time the unit's operating power is cycled.

If there are consistent checksum failure pre-alarms, attempt the following actions to correct the problem:

1. Load default settings by holding UP+DOWN on the front panel while cycling power. After loading defaults, upload settings file through BESTCOMS*Plus* if needed.

CAUTION
Loading default settings will erase all custom settings. All reports and events will be cleared. BESTCOMS*Plus* can be used to download settings and save to a file so that settings can be restored later.

2. If the problem still exists, reload the firmware file with BESTCOMS*Plus*.
3. If the problem still exists, contact Basler Electric Technical Support.

The checksum failure pre-alarm can be disabled with the Checksum Failure pre-alarm enable[V] setting. Disabling this setting disables only the annunciation of the pre-alarm and does not correct any error conditions.

The checksum failure pre-alarm might occur after changing firmware versions through BESTCOMS*Plus*. The checksum failure pre-alarm is not indicative of an error in this case. The pre-alarm can be cleared with the reset button or by cycling power to the unit. If the pre-alarm reoccurs, then the pre-alarm is indicative of an error and corrective action should be attempted as described above.

Synchronizer Failure

Synchronizer failure pre-alarm settings consist of a single enable/disable setting[W]. If enabled, a Synchronizer Failure pre-alarm is annunciated if the MGC-2000 Series is running the autosynchronizer to align the generator voltage and bus voltage to close a breaker, and the MGC-2000 Series does not receive feedback from the breaker status indicating it is closed before the sync fail activation delay time has elapsed.

Breaker Close Failure

Breaker Close failure pre-alarm settings consist of a single enable/disable setting[X] and a monitor setting[Y]. If enabled, a Breaker Close Failure pre-alarm is annunciated if the MGC-2000 Series has issued a breaker close output, and has not received feedback from the breaker status indicating it is closed before the breaker close wait time has elapsed. The Monitor setting determines whether this condition is monitored only during transitions or always.

Breaker Open Failure

Breaker Open failure pre-alarm settings consist of a single enable/disable setting[Z] and a monitor setting[AA]. If enabled, a Breaker Open Failure pre-alarm is annunciated if the MGC-2000 Series has issued a breaker open output, and has not received feedback from the breaker status indicating it is open before the breaker close wait time has elapsed. The Monitor setting determines whether this condition is monitored only during transitions or always.

Reverse Rotation

Reverse Rotation pre-alarm settings consist of an enable/disable setting[BB]. If enabled, a Reverse Rotation pre-alarm is annunciated if the sensed generator or bus phase rotation differs from the phase rotation specified in the System Parameters > System Settings screen.

Rated Data and Per Unit Values

Settings which are related to machine ratings can be set in either native units or in per unit values. When a native unit is edited, BESTCOMS*Plus* automatically recalculates the per unit value based on the native unit setting and the rated data parameter (on the *System Parameters, Rated Data* screen) associated with it. When a per unit value is edited, BESTCOMS*Plus* automatically recalculates the native value based on the per unit setting and the rated data parameter associated with it.

Once all per unit values are assigned, if the rated data parameters are changed, BESTCOMS*Plus* automatically recalculates all native unit settings based on the modified rated data parameters.

The following settings have native units of *Volts*, and the rated data associated with them is Battery Volts (on the *System Parameters, Rated Data* screen).

- Low Battery Voltage
- Weak Battery Voltage
- Battery Overvoltage

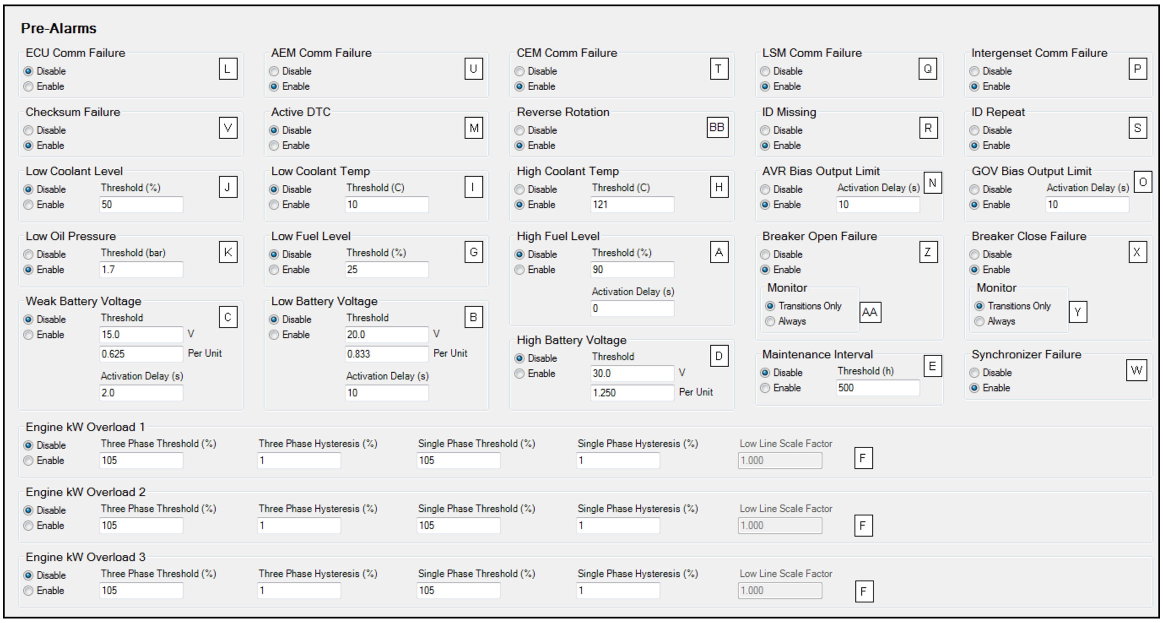

Figure 4-48. Pre-Alarms

[A] *High Fuel Level:* Enable or Disable, threshold is adjustable from 0 to 150% in 1% increments. Activation delay is adjustable from 0 to 30 s in 1 s increments.

[B] *Low Battery Voltage:* Enable or Disable, threshold is adjustable from 6 to 14 Vdc (12 Vdc battery) or 12 to 28 Vdc (24 Vdc battery) in 0.1 Vdc increments. Activation delay is adjustable from 1 to 60 s in 1 s increments.

[C] *Weak Battery Voltage:* Enable or Disable, threshold is adjustable from 4 to 14 Vdc (12 Vdc battery) or 8 to 28 Vdc (24 Vdc battery) in 0.1 Vdc increments. Activation time delay is adjustable from 0 to 10 s in 0.1 s increments.

[D] *Battery Overvoltage:* Enable or Disable, threshold is adjustable from 12 to 32 Vdc in 0.1 Vdc increments.

[E] *Maintenance Interval:* Enable or Disable, threshold is adjustable from 0 to 5,000 hrs in 1 hr increments.

[F] *Engine kW Overload:* Enable or Disable, threshold is adjustable from 0 to 200% of Genset kW Rating in 1% increments.

[G] *Low Fuel Level:* Enable or Disable, threshold is adjustable from 10 to 100% in 1% increments.

[H] *High Coolant Temp:* Enable or Disable, threshold is adjustable from 100 to 280°F or 38 to 138°C in 1° increments. Activation time delay is fixed at 60 s.

[I] *Low Coolant Temp:* Enable or Disable, threshold is adjustable from 0 to 151°F or -18 to 66°C in 1° increments.

[J] *Low Coolant Level:* Enable or Disable, threshold is adjustable from 1 to 99% in 1% increments.

[K] *Low Oil Pressure:* Enable or Disable, threshold is adjustable from 2.9 to 150 psi in 0.1 psi increments, 0.2 to 10.3 bar in 0.1 bar increments, or 20 to 1,034.5 kPa in 0.1 kPa increments. Activation time delay is fixed at 10 s.

[L] *ECU Comm Failure:* Enable or Disable.

[M] *Active DTC:* Enable or Disable.

[N] *AVR Bias Output Limit:* Enable or Disable, activation delay is adjustable from 1 to 15 s in 1 s increments.

[O] *GOV Bias Output Limit:* Enable or Disable, activation delay is adjustable from 1 to 15 s in 1 s increments.

[P] *Intergenset Comm Failure:* Enable or Disable.

[Q] *LSM Comm Failure:* Enable or Disable.

[R] *ID Missing:* Enable or Disable.

[S] *ID Repeat:* Enable or Disable.

[T] *CEM Comm Failure:* Enable or Disable.

[U] *AEM Comm Failure:* Enable or Disable.

[V] *Checksum Failure:* Enable or Disable.

[W] *Synchronizer Failure:* Enable or Disable.

[X] *Breaker Close Failure:* Enable or Disable.

[Y] *Monitor*: Transitions Only or Always.
[Z] *Breaker Open Failure:* Enable or Disable.
[AA] *Monitor*: Transitions Only or Always.
[BB] *Reverse Rotation:* Enable or Disable.

Alarms

An alarm is annunciated when a condition programmed to trigger an alarm is detected. When an alarm condition exists, the front panel Alarm indicator lights, the Horn output (if programmed and enabled) energizes, and the cause of the alarm is displayed on the front panel LCD. An alarm condition stops the engine by opening the Fuel output contact. Alarms are reset when the MGC-2000 Series is set to Off mode.

Each MGC-2000 Series alarm is described in the following paragraphs. Alarms can be enabled and adjusted in BESTCOMS*Plus* or through the front panel HMI.

The BESTCOMS*Plus* Alarms screen is illustrated in Figure 4-49.

High Coolant Temperature

High coolant temperature alarm settings[A] consist of an enable/disable setting and a threshold setting. If enabled, a high coolant temperature alarm is triggered after a four second delay when the engine coolant temperature exceeds the threshold setting. The arming delay disables the high coolant temperature alarm function for a user-adjustable time during engine startup. System units are configured on the System Settings screen.

Low Oil Pressure

Low oil pressure alarm settings[B] include an enable/disable setting, an arming time delay, and a threshold setting. If enabled, a low oil pressure alarm is triggered after a two second delay when the engine oil pressure decreases below the threshold setting. The arming delay disables the low oil pressure alarm function for a user-adjustable time during engine startup. System units and metric pressure units are configured on the System Settings screen.

Overspeed

Overspeed alarm settings[C] include an enable/disable setting, an activation delay, and a threshold setting. If enabled, an overspeed alarm occurs when the engine speed (in rpm) exceeds the threshold setting for the duration of the activation time delay.

Low Fuel Level

Low fuel level alarm settings[D] consist of an enable/disable setting, an activation delay setting, and a threshold setting. If enabled, a low fuel level alarm is triggered when the metered fuel level drops below the threshold setting for the duration of the activation time delay.

Low Coolant Level

Low coolant level alarm settings[E] consist of an enable/disable setting and a threshold setting. If enabled, a low coolant level alarm is triggered when the metered coolant drops below the threshold setting for two seconds.

Note that ECU Support must be enabled on the *Communications, CANBus Setup* screen before this alarm can be configured.

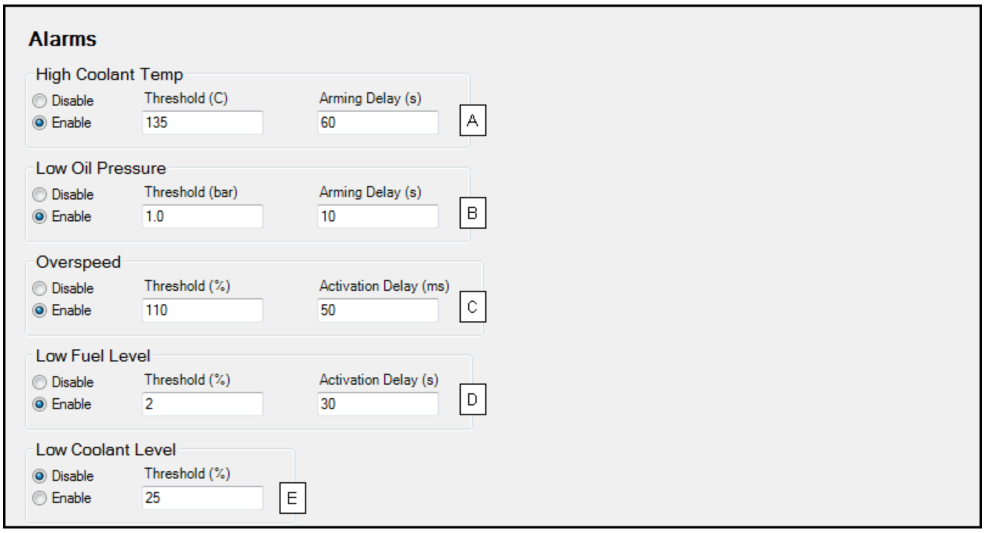

Figure 4-49. Alarms

[A] *High Coolant Temp:* Enable or Disable, threshold is adjustable from 100 to 280°F or 38 to 138°C in 1° increments. Arming time delay is adjustable from 0 to 150 in 1 s increments.
[B] *Low Oil Pressure:* Enable or Disable, threshold is adjustable from 2.9 to 150 psi in 0.1 psi increments, 0.2 to 10.3 Bar in 0.1 Bar increments, or 20 to 1,034.5 kPa in 0.1 kPa increments. Arming time delay is adjustable from 5 to 60 s in 1 s increments.
[C] *Overspeed:* Enable or Disable, threshold is adjustable from 105 to 140% of the rated engine rpm. Activation time delay is adjustable from 0 to 500 s in 1 s increments.
[D] *Low Fuel Level:* Enable or Disable, threshold is adjustable from 0 to 100% in 1% increments. Activation time delay is adjustable from 0 to 30 in 1 s increments.
[E] *Low Coolant Level:* Enable or Disable, threshold is adjustable from 1 to 99% in 1% increments.

Sender Fail

The MGC-2000 Series can be configured to annunciate a pre-alarm or alarm when a loss of signal is detected at the coolant temperature[A], oil pressure[B], or fuel level sender[C] input. A loss of generator sensing voltage[D] (when the MGC-2000 Series is operating in Run or Auto mode with the ATS closed) can also be configured to trigger a pre-alarm or alarm. The speed sender fail[E] alarm is always enabled. A user-adjustable time delay is provided for each sender/sensing alarm/pre-alarm.

Alarm and pre-alarm annunciations for loss of engine speed signals is not user-programmable and operates as follows. If the MPU (magnetic pickup) or generator frequency is programmed as the sole engine speed source and that signal source fails, an alarm (and shutdown) is triggered. If the engine speed source is configured as MPU and generator frequency and a loss of one of the signal sources occurs, a pre-alarm is annunciated. An alarm (and shutdown) is triggered if both speed signals are lost.

The BESTCOMS*Plus* Sender Fail screen is illustrated in Figure 4-50.

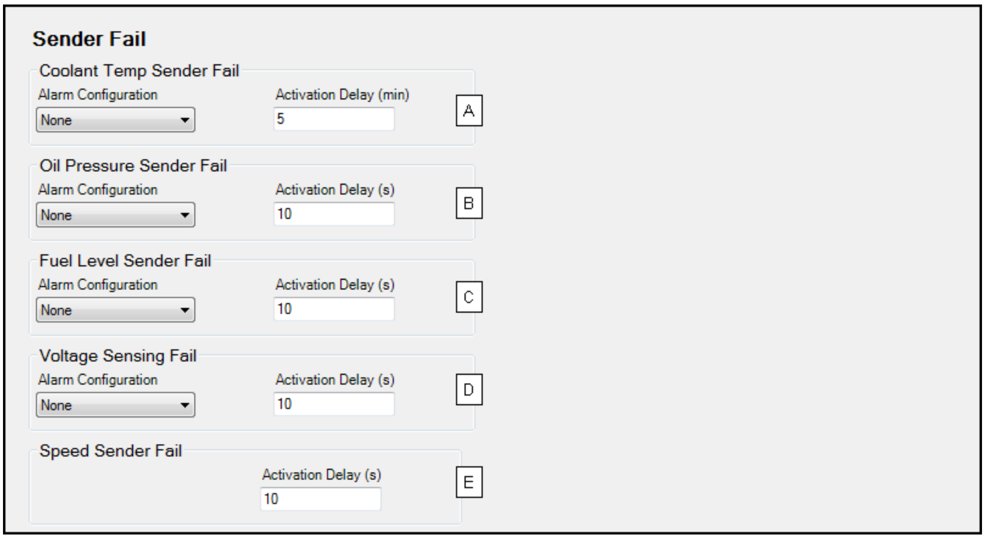

Figure 4-50. Sender Fail

[A] *Coolant Temp Sender Fail:* None, Alarm, or Pre-Alarm, time delay adjustable from 5 to 30 min in 1 min increments.
[B] *Oil Pressure Sender Fail:* None, Alarm or Pre-Alarm, time delay adjustable from 0 to 300 s in 1 s increments.
[C] *Fuel Level Sender Fail:* None, Alarm, or Pre-Alarm, time delay adjustable from 0 to 300 s in 1 s increments.
[D] *Voltage Sensing Fail:* None, Alarm, or Pre-Alarm, time delay adjustable from 0 to 300 s in 1 s increments.
[E] *Speed Sender Fail:* Time delay adjustable from 0 to 300 s in 1 s increments.

Generator Protection

Two tiers of generator protection are offered. MGC-2000 Series controllers with style number xxxxxxSxx offer standard protection consisting of undervoltage (27), overvoltage (59), overfrequency (81O), underfrequency (81U), reverse power (32R), and loss of excitation (40) elements. Controllers with style number xxxxxxExx offer enhanced protection, which consists of the standard protection elements *Plus* phase-sequence voltage (47), time overcurrent (51), vector shift (78), and ROCOF (81) elements.

The description of generator protection is organized as follows:

- Voltage (27, 59, 47)
- Frequency (81)
- Reverse Power (32R)
- Loss of Excitation (40Q)
- Overcurrent (51)
- Loss of MAINS Protection (78 Vector Shift and 81 ROCOF)

Voltage Protection (27, 59, 47)

Voltage protection consists of two undervoltage elements, two overvoltage elements, and one phase-sequence voltage element (style number xxxxxxExx only).

Undervoltage (27-1, 27-2)

Two sets of undervoltage settings are provided for each element: one for three-phase generator connections and one for single-phase generator connections. The pickup setting entered is based on the VT secondary side (MGC-2000 Series). When a single-phase override contact input is received, the MGC-2000 Series 0 automatically switches from the three-phase undervoltage settings to the single-phase undervoltage settings.

An undervoltage condition is annunciated when the average of the three-phase (three-phase mode) or the line-to-line voltage (single-phase mode) decreases below the corresponding 27 pickup setting[A] for the duration of the corresponding 27 activation delay[B]. An undervoltage annunciation can be user-selected to trigger a pre-alarm[C] (warning) or alarm[C] (shutdown). An undervoltage annunciation can also be user-configured to close a programmable output.

The hysteresis setting[D] functions as an undervoltage dropout by preventing rapid switching of the pickup output.

A frequency-based inhibit setting[E] prevents a 27 trip from occurring during an undervoltage condition associated with system startup.

A low-line scale factor setting[F] is used to automatically adjust the undervoltage pickup settings in applications that might utilize more than one type of genset connection. The scale factor setting is implemented when the MGC-2000 Series senses a contact closure at a contact input programmed to activate scaling of the protection settings. The value of the scale factor setting serves as a multiplier for the pickup settings. For example, if a scale factor contact input is received by the MGC-2000 Series and the scale factor setting is 2.000, the pickup setting will be doubled (2.000 × PU).

The element is disabled when Alarm Configuration is set to "None". Element status is available in BESTlogic*Plus* Programmable Logic when "Status Only" is selected.

Settings which are related to machine ratings can be set in either actual units of voltage or in per unit[G] values. When a native unit is edited, BESTCOMS*Plus* automatically recalculates the per unit value based on the native unit setting and the rated data parameter (on the *System Parameters, Rated Data* screen) associated with it. When a per unit value is edited, BESTCOMS*Plus* automatically recalculates the native value based on the per unit setting and the rated data parameter associated with it.

Once all per unit values are assigned, if the rated data parameters are changed, BESTCOMS*Plus* automatically recalculates all native unit settings based on the modified rated data parameters.

The following settings have native units of *Secondary Volts*, and the rated data associated with them is *Rated Secondary Volts* (on the *System Parameters, Rated Data* screen).

- Undervoltage 27-1 Three-Phase Pickup
- Undervoltage 27-1 Single-Phase Pickup
- Undervoltage 27-2 Three-Phase Pickup
- Undervoltage 27-2 Single-Phase Pickup

The BESTCOMS*Plus* Undervoltage screen is illustrated in Figure 4-51. The 27-1 element is shown.

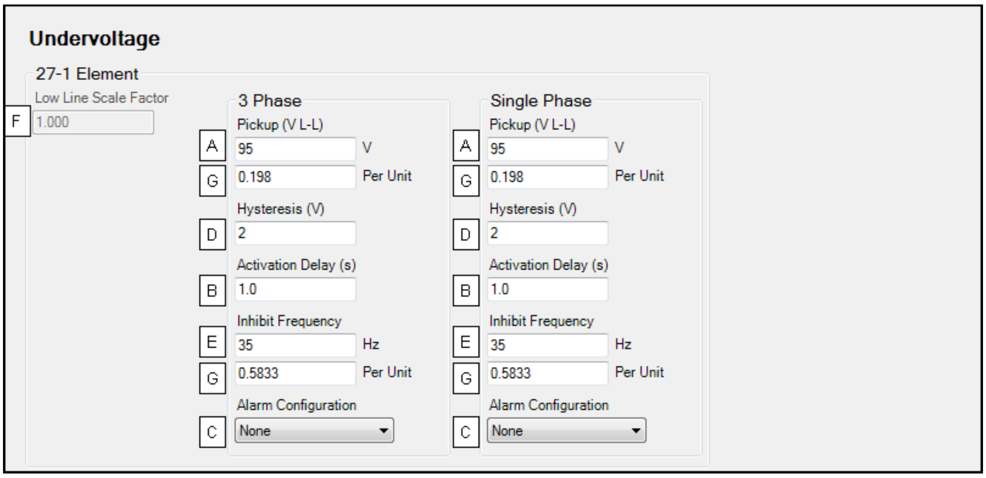

Figure 4-51. Undervoltage

[A] *Pickup:* Adjustable from 70 to 1,000 Vac in 1 Vac increments. (Note: The maximum voltage that can be safely applied to the MGC-2000 Series is 576 V. The pickup range is higher so that when the low-line override is used, and the scale factor is 0.5 or less, effective protection levels of 500 V can be reached with a scale factor of 0.5.)
[B] *Activation Delay:* Adjustable from 0 to 30 s in 0.1 s increments.
[C] *Alarm Configuration:* None, Alarm, Pre-Alarm, or Status Only.
[D] *Hysteresis:* Adjustable from 1 to 60 Vac in 1 Vac increments.
[E] *Inhibit Frequency:* Adjustable from 20 to 400 Hz in 1 Hz increments.
[F] *Low Line Scale Factor:* Adjustable from 0.001 to 3 in increments of 0.001.

[G] *Pickup (Per Unit):* Range varies based on the values of the native unit setting and the associated rated data parameter.

Overvoltage (59-1, 59-2)

Two sets of overvoltage settings are provided for each element: one for three-phase generator connections and one for single-phase generator connections. The pickup setting entered is based on the VT secondary side (MGC-2000 Series). When a single-phase override contact input is received, the MGC-2000 Series automatically switches from the three-phase overvoltage settings to the single-phase overvoltage settings.

An overvoltage condition is annunciated when the average of the three-phase (three-phase mode) or the line-to-line voltage (single-phase mode) increases above the corresponding 59 pickup setting[A] for the duration of the corresponding 59 activation delay[B]. An overvoltage annunciation can be user-selected to trigger a pre-alarm[C] (warning) or alarm[C] (shutdown). An overvoltage annunciation can also be user-configured to close a programmable output.

The hysteresis setting[D] functions as an undervoltage dropout by preventing rapid switching of the pickup output.

A low-line scale factor setting[E] is used to automatically adjust the overvoltage pickup settings in applications that might utilize more than one type of genset connection. The scale factor setting is implemented when the MGC-2000 Series senses a contact closure at a contact input programmed to activate scaling of the protection settings. The value of the scale factor setting serves as a multiplier for the pickup settings. For example, if a scale factor contact input is received by the MGC-2000 Series and the scale factor setting is 2.000, the pickup setting will be doubled (2.000 × PU).

The element is disabled when Alarm Configuration is set to “None”. Element status is available in BESTlogic*Plus* Programmable Logic when “Status Only” is selected.

Settings which are related to machine ratings can be set in either actual units of voltage or in per unit[F] values. When a native unit is edited, BESTCOMS*Plus* automatically recalculates the per unit value based on the native unit setting and the rated data parameter (on the *System Parameters, Rated Data* screen) associated with it. When a per unit value is edited, BESTCOMS*Plus* automatically recalculates the native value based on the per unit setting and the rated data parameter associated with it.

Once all per unit values are assigned, if the rated data parameters are changed, BESTCOMS*Plus* automatically recalculates all native unit settings based on the modified rated data parameters.

The following settings have native units of *Secondary Volts*, and the rated data associated with them is *Rated Secondary Volts* (on the *System Parameters, Rated Data* screen).

- Overvoltage 59-1 Three-Phase Pickup
- Overvoltage 59-1 Single-Phase Pickup
- Overvoltage 59-2 Three-Phase Pickup
- Overvoltage 59-2 Single-Phase Pickup

The BESTCOMS*Plus* Overvoltage screen is illustrated in Figure 4-52. The 59-1 element is shown.

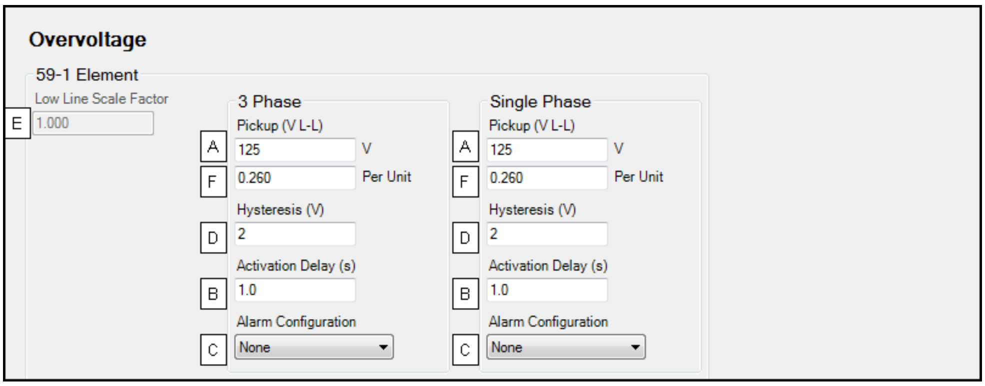

Figure 4-52. Overvoltage

[A] *Pickup:* Adjustable from 70 to 1,000 Vac in 1 Vac increments. (Note: The maximum voltage that can be safely applied to the MGC-2000 Series is 576 Volts. The pickup range is higher so that when the low-line

override is used, and the scale factor is 0.5 or less, effective protection levels of 500 Volts can be reached with 0.5 scale factor.)
[B] *Activation Delay:* Adjustable from 0 to 30 s in 0.1 s increments.
[C] *Alarm Configuration:* None, Alarm, Pre-Alarm, or Status Only.
[D] *Hysteresis:* Adjustable from 1 to 60 Vac in 1 Vac increments.
[E] *Low Line Scale Factor:* Adjustable from 0.001 to 3 in increments of 0.001.
[F] *Pickup (Per Unit):* Range varies based on the values of the native unit setting and the associated rated data parameter.

Phase Imbalance (47)

MGC-2000 Series controllers with enhanced generator protection (style number xxxxxxExx) are capable of protecting against voltage imbalances between any of the three phases. The pickup setting entered is based on the VT secondary side (MGC-2000 Series). A phase imbalance condition is annunciated when the difference between any of the three phases of generator voltage increases above the 47 pickup setting[A] for the duration of the 47 activation delay setting[B]. A phase imbalance annunciation can be user-selected to trigger a pre-alarm[C] (warning) or alarm[C] (shutdown). A phase imbalance annunciation can also be user-configured to close a programmable output.

The hysteresis setting[D] functions as a phase imbalance dropout by preventing rapid switching of the pickup output.

A low-line scale factor setting[E] is used to automatically adjust the phase imbalance pickup setting in applications that might utilize more than one type of genset connection. The scale factor setting is implemented when the MGC-2000 Series senses a contact closure at a contact input programmed to activate scaling of the protection settings. The value of the scale factor setting serves as a multiplier for the pickup setting. For example, if a scale factor contact input is received by the MGC-2000 Series and the scale factor setting is 2.000, the pickup setting will be doubled (2.000 × PU).

The element is disabled when Alarm Configuration is set to “None”. Element status is available in BESTlogic*Plus* Programmable Logic when “Status Only” is selected.

Settings which are related to machine ratings can be set in either actual units of voltage or in per unit[F] values. When a native unit is edited, BESTCOMS*Plus* automatically recalculates the per unit value based on the native unit setting and the rated data parameter (on the *System Parameters, Rated Data* screen) associated with it. When a per unit value is edited, BESTCOMS*Plus* automatically recalculates the native value based on the per unit setting and the rated data parameter associated with it.

Once all per unit values are assigned, if the rated data parameters are changed, BESTCOMS*Plus* automatically recalculates all native unit settings based on the modified rated data parameters.

The following setting has native units of *Secondary Volts*, and the rated data associated with it is *Rated Secondary Volts* (on the *System Parameters, Rated Data* screen).

- Phase Imbalance 47 Pickup

The BESTCOMS*Plus* Phase Imbalance screen is illustrated in Figure 4-53.

Figure 4-53. Phase Imbalance

[A] *Pickup:* Adjustable from 5 to 100 Vac in 1 Vac increments.
[B] *Activation Delay:* Adjustable from 0 to 30 s in 0.1 s increments.

[C] *Alarm Configuration:* None, Alarm, Pre-Alarm, or Status Only.
[D] *Hysteresis:* Adjustable from 1 to 5 Vac in 1 Vac increments.
[E] *Low Line Scale Factor:* Adjustable from 0.001 to 3 in increments of 0.001.
[F] *Pickup (Per Unit):* Range varies based on the values of the native unit setting and the associated rated data parameter.

Frequency Protection (81O/U)

Two sets of frequency protection settings are provided: one for underfrequency (81U) and one for overfrequency (81O).

Underfrequency (81U)

An underfrequency condition is annunciated when the generator frequency decreases below the 81U pickup setting[A] for the duration of the 81U activation delay setting[B]. An underfrequency annunciation can be user-selected to trigger a pre-alarm[C] (warning) or alarm[C] (shutdown). An underfrequency annunciation can also be user-configured to close a programmable output.

A voltage-based inhibit setting[D] prevents an 81U trip from occurring during an underfrequency condition associated with system startup.

The hysteresis setting[E] functions as an underfrequency dropout by preventing rapid switching of the pickup output.

Overfrequency (81O)

When the generator frequency increases above the 81O pickup setting[F] for the duration of the 81O activation delay setting[G], an overfrequency condition is annunciated. An overfrequency annunciation can be user-selected to trigger a pre-alarm[H] (warning) or alarm[H] (shutdown). An overfrequency condition can also be user configured to close a programmable output.

The hysteresis setting[I] functions as an overfrequency dropout by preventing rapid switching of the pickup output.

The element is disabled when Alarm Configuration is set to “None”. Element status is available in BESTlogic*Plus* Programmable Logic when “Status Only” is selected.

Alternate Frequency Scale Factor

An alternate frequency scale factor setting[J] is used for automatic adjustment of the frequency pickup settings in applications that might utilize more than one operating frequency. For example, a machine that is configurable between 50 or 60 Hz operation. The scale factor setting is implemented when the MGC-2000 Series senses a contact closure at a contact input that is connected to the Alternate Frequency Override logic element in BESTlogic*Plus* Programmable Logic. When the Alternate Frequency Override is true, the scale factor setting serves as a multiplier for the pickup settings. For example, if a scale factor contact input is received by the MGC-2000 Series and the scale factor setting is 2.000, the pickup setting will be doubled (2.000 x PU).

Per Unit

Settings which are related to machine ratings can be set in either actual units of hertz or in per unit values. Per unit settings are available for Pickup[K] (81O/81U) and Inhibit Volts[L] (81U). When a native unit is edited, BESTCOMS*Plus* automatically recalculates the per unit value based on the native unit setting and the rated data parameter (on the *System Parameters, Rated Data* screen) associated with it. When a per unit value is edited, BESTCOMS*Plus* automatically recalculates the native value based on the per unit setting and the rated data parameter associated with it.

Once all per unit values are assigned, if the rated data parameters are changed, BESTCOMS*Plus* automatically recalculates all native unit settings based on the modified rated data parameters.

The following settings have native units of *Frequency in Hz*, and the rated data associated with them is *Rated Frequency* (on the *System Parameters, Rated Data* screen).

- 81 U Pickup
- 81 O Pickup

The following setting has native units of *Secondary Volts*, and the rated data associated with it is *Rated Secondary Volts* (on the *System Parameters, Rated Data* screen).

- 81 U Inhibit Voltage

The BESTCOMS*Plus* Frequency screen is illustrated in Figure 4-54.

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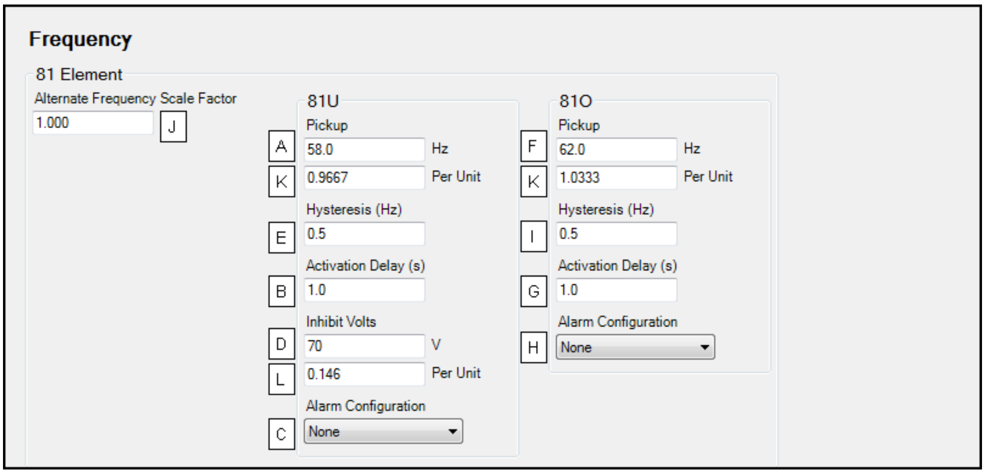

Figure 4-54. Frequency

[A] *Underfrequency Pickup:* Adjustable from 45 to 66 Hz in 0.1 Hz increments for 50/60 Hz controllers (style number x1xxxxxxx). Adjustable from 360 to 440 Hz in 0.1 Hz increments for 400 Hz controllers (style number x2xxxxxxx).
[B] *Underfrequency Activation Delay:* Adjustable from 0 to 30 s in 0.1 s increments.
[C] *Underfrequency Alarm Configuration:* None, Alarm, Pre-Alarm, or Status Only.
[D] *Underfrequency Inhibit Volts:* Adjustable from 70 to 576 Vac in 1 Vac increments.
[E] *Hysteresis:* Adjustable from 0.1 to 40 Hz in 0.1 Hz increments.
[F] *Overfrequency Pickup:* Adjustable from 45 to 66 Hz in 0.1 Hz increments for 50/60 Hz controllers (style number x1xxxxxxx). Adjustable from 360 to 440 Hz in 0.1 Hz increments for 400 Hz controllers (style number x2xxxxxxx).
[G] *Overfrequency Activation Delay:* Adjustable from 0 to 30 s in 0.1 s increments.
[H] *Overfrequency Alarm Configuration:* None, Alarm, Pre-Alarm, or Status Only.
[I] *Hysteresis:* Adjustable from 0.1 to 40 Hz in 0.1 Hz increments.
[J] *Alternate Frequency Scale Factor:* 0.001 to 100 in increments of 0.001.
[K] *Pickup (Per Unit):* Range varies based on the values of the native unit setting and the associated rated data parameter.
[L] *Inhibit Volts (Per Unit):* Range varies based on the values of the native unit setting and the associated rated data parameter.

Reverse Power Protection (32R)

Two sets of reverse power settings are provided: one for three-phase generator connections and one for single-phase generator connections. The pickup setting entered is based on the percentage of the Genset KW Rating on the Rated Data screen. When a single-phase override contact input is received by the MGC-2000 Series, the reverse power protection settings automatically switch from the three-phase settings to the single-phase reverse power protection settings. The 32R element monitors three-phase real power when three-phase sensing is active or single-phase real power if single-phase sensing is active.

When the total wattage in the tripping direction (generator absorbing power) is greater than the pickup setting[A] for the duration of the 32R activation delay setting[B], a reverse power condition is annunciated. A reverse power annunciation can be user-selected to trigger a pre-alarm[C] (warning) or alarm[C] (shutdown). A reverse power annunciation can also be user-configured to close a programmable output.

The hysteresis setting[D] functions as a reverse power dropout by preventing rapid switching of the pickup output.

The element is disabled when Alarm Configuration is set to “None”. Element status is available in BESTlogic*Plus* Programmable Logic when “Status Only” is selected.

The BESTCOMS*Plus* Reverse Power screen is illustrated in Figure 4-55.

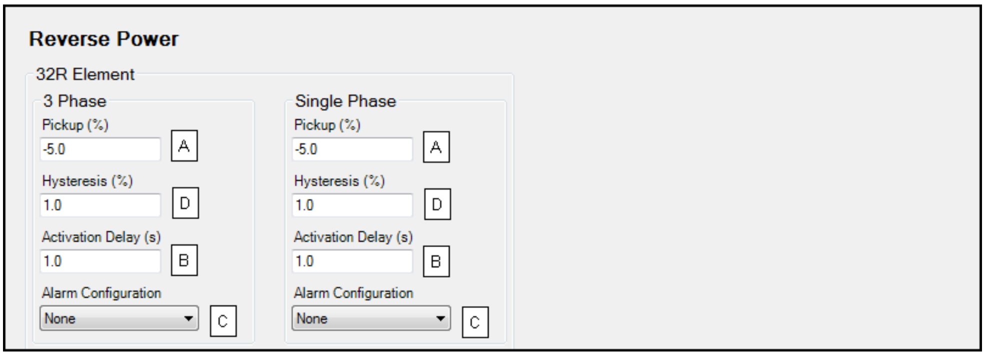

Figure 4-55. Reverse Power

[A] *Pickup:* –50% to +5% of rated watts in 0.1% increments.
[B] *Activation Delay:* Adjustable from 0 to 30 s in 0.1 s increments.
[C] *Alarm Configuration:* None, Alarm, Pre-Alarm, or Status Only.
[D] *Hysteresis:* Adjustable from 1 to 10% in 0.1% increments.

Loss of Excitation Protection (40Q)

Two sets of loss of excitation settings are provided: one for three-phase generator connections and one for single-phase generator connections. The pickup setting[A] entered is based on the percentage of the machine Rated kvar on the Rated Data screen. When a single-phase override contact input is received by the MGC-2000 Series, the loss of excitation protection settings automatically switch from the three-phase settings to the single-phase loss of excitation protection settings.

When a generator's excitation power is lost, the generator acts as a large inductor. The generator begins to absorb large quantities of vars. The 40Q acts on the principal that if a generator begins to absorb vars outside of its steady state capability curve, it has likely lost its normal excitation supply. The 40Q monitors three-phase reactive power when three-phase sensing is active or single-phase reactive power if single-phase sensing is active. It compares the reactive power to the 40Q response curve defined by the 40Q pickup setting. Refer to Figure 4-56.

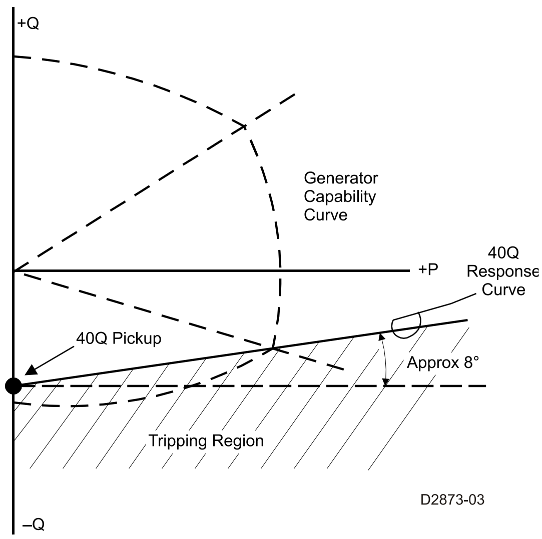

Figure 4-56. Generator Capability Curve vs. 40Q Response

If reactive power is within the 40Q tripping region for the duration of the 40Q activation delay setting[B], a loss of excitation condition is annunciated. A loss of excitation annunciation can be user-selected to trigger a pre-alarm[C] (warning) or alarm[C] (shutdown). A loss of excitation annunciation can also be user-configured to close a programmable output. The calculation used in the MGC-2000 Series for the approximate tripping region is given by:

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$$Tripping\ Region = 40Q\ Pickup + \left(\frac{1}{8}\right) * \left(\frac{Actual\ Watts * 100}{Rated\ var}\right)$$

where the units of the Tripping Region and the 40Q Pickup setting are percent of rated var.

The hysteresis setting[D] functions as a loss of excitation dropout by preventing rapid switching of the pickup output.

Activation delays[B] are recommended for tripping. Adding a small delay will help assure that false alarms do not occur for transient fault conditions or swings in the power system.

The element is disabled when Alarm Configuration is set to “None”. Element status is available in BESTlogic*Plus* Programmable Logic when “Status Only” is selected.

The BESTCOMS*Plus* Loss of Excitation (40Q) screen is illustrated in Figure 4-57.

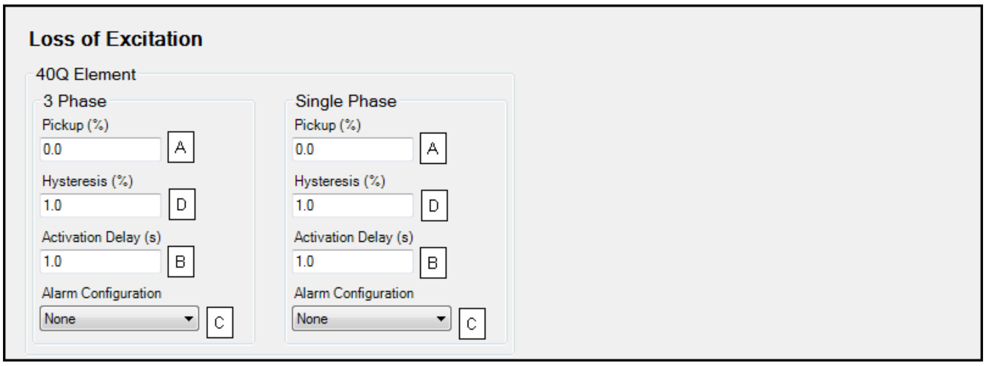

Figure 4-57. Loss of Excitation (40Q)

[A] Pickup: Adjustable from –150% to 0% of rated vars in 0.1% increments.
[B] *Activation Delay:* Adjustable from 0 to 30 s in 0.1 s increments.
[C] *Alarm Configuration:* None, Alarm, Pre-Alarm, or Status Only.
[D] *Hysteresis:* Adjustable from 1% to 10% in 0.1% increments.

Overcurrent Protection (51-1, 51-2, 51-3)

Two sets of overcurrent settings are provided for each element: one for three-phase generator connections and one for single-phase generator connections. The pickup setting entered is based on the CT secondary side (MGC-2000 Series). When a single-phase override contact input is received by the MGC-2000 Series, the overcurrent protection settings automatically switch from the three-phase settings to the single-phase overcurrent protection settings.

When any of the phase currents increase above the pickup setting[A] for the duration of the overcurrent time delay, an overcurrent condition is annunciated. An overcurrent annunciation can be user-selected to trigger a pre-alarm[B] (warning) or alarm[B] (shutdown). An overcurrent annunciation can also be user-configured to close a programmable output.

The overcurrent time delay is controlled by a time dial setting[C] and a curve setting[D]. The curve setting can be set at F (fixed), P (programmable), or one of 16 inverse time characteristic curves can be selected. When the fixed curve setting is selected, the time dial setting determines the overcurrent time delay with no regard to the generator current level. When one of the inverse time characteristic curves is selected, the time dial setting, along with the level of measured generator current, determines the overcurrent time delay. As overcurrent protection settings are entered in BESTCOMS*Plus*, a plot[E] of the settings is automatically created to illustrate the overcurrent pickup curve. The available time characteristic curves are listed below and illustrated in Appendix A, *Time Overcurrent Characteristic Curves*.

- A, standard inverse
- B, very inverse
- C, extremely inverse
- D, definite
- E1, extremely inverse
- E2, extremely inverse
- G, long inverse
- I1, inverse
- I2, inverse
- L1, long inverse
- L2, long inverse
- M, moderately inverse
- P, programmable
- S1, short inverse
- S2, short inverse
- V1, very inverse
- V2, very inverse

A low-line scale factor setting[F] is used for automatic adjustment of the overcurrent pickup settings in applications that might utilize more than one type of genset connection. The scale factor setting is implemented when the MGC-2000 Series senses a contact closure at a contact input programmed to activate scaling of the protection settings. The value of the scale factor setting serves as a multiplier for the pickup settings. For example, if a scale factor contact input is received by the MGC-2000 Series and the scale factor setting is 2.000, the pickup setting will be doubled (2.000 × PU).

The graph can be set[G] to display the 1 Phase or 3 Phase curve as determined by the settings on the left side of the chart.

Selection of integrated reset or instantaneous reset characteristics[H] is also provided. Refer to Appendix A, *Time Overcurrent Characteristic Curves,* when calculating time to reset.

The element is disabled when Alarm Configuration is set to "None". Element status is available in BESTlogic*Plus* Programmable Logic when "Status Only" is selected.

Settings which are related to machine ratings can be set in either actual units of current or in per unit[I] values. When a native unit is edited, BESTCOMS*Plus* automatically recalculates the per unit value based on the native unit setting and the rated data parameter (on the *System Parameters, Rated Data* screen) associated with it. When a per unit value is edited, BESTCOMS*Plus* automatically recalculates the native value based on the per unit setting and the rated data parameter associated with it.

Once all per unit values are assigned, if the rated data parameters are changed, BESTCOMS*Plus* automatically recalculates all native unit settings based on the modified rated data parameters.

The following settings have native units of *Secondary Amps*, and the rated data associated with them is *Rated Secondary Phase Amps* (on the *System Parameters, Rated Data* screen).

- Overcurrent 51-1 Three-Phase Pickup
- Overcurrent 51-1 Single-Phase Pickup
- Overcurrent 51-2 Three-Phase Pickup
- Overcurrent 51-2 Single-Phase Pickup
- Overcurrent 51-3 Three-Phase Pickup
- Overcurrent 51-3 Single-Phase Pickup

The BESTCOMS*Plus* Overcurrent screen is illustrated in Figure 4-58. The 51-1 element is shown.

Programmable Curves for Overcurrent Protection

Inverse overcurrent characteristics for trip and reset programmable curves are defined by Equation 4-1 and 4-2 respectively. These equations comply with IEEE Std C37.112-1996 - *IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays*. The curve-specific coefficients are defined for the standard curves as listed in Appendix A, *Time Overcurrent Characteristic Curves*. When inverse time overcurrent characteristic curve P is selected, the coefficients used in the equation are those defined by the user. Definitions for these equations are provided in Table 4-6.

Equation 4-1. Time OC Characteristics for Trip

$$T_T = \frac{AD}{\left(M^N - C\right)^Q} + BD + K$$

Equation 4-2. Time OC Characteristics for Reset

$$T_R = \frac{RD}{|M^2 - 1|}$$

Table 4-6. Definitions for Equations 4-1 and 4-2

Parameter	Description	Explanation
T_T	Time to trip	Time that the 51-x function will take to time out and trip.
D	Time dial setting	Time dial setting for the 51-x function.
M	Multiple of pickup	Measured current in multiples of pickup. The timing algorithm has a dynamic range of 0 to 40 times pickup.
A	Coefficient specific to selected curve	Affects the effective range of the time dial.
B	Coefficient specific to selected curve	Affects a constant term in the timing equation. Has greatest effect on curve shape at high multiples of pickup.

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Parameter	Description	Explanation
C	Coefficient specific to selected curve	Affects the multiple of pickup where the curve would approach infinity if allowed to continue below pickup. Has greatest effect on curve shape near pickup.
N	Multiple of Pickup exponent specific to selected curve	Affects how inverse the characteristics are. Has greatest effect on curve shape at low to medium multiples of pickup.
K	Constant	Characteristic minimum delay term. Fixed at 0.028.
T_R	Time to reset	Relevant if 51-x function is set for integrating reset.
R	Coefficient specific to selected curve	Affects the speed of reset when integrating reset is selected.
Q	Denominator exponent specific to selected curve.	Affects how inverse the characteristics are. Has greater affect as Q is increased.

Setting Programmable (P) Curves

Curve coefficients[J] are entered using BESTCOMS*Plus*. Table 4-7 lists the programmable curve settings.

Table 4-7. Programmable Time Current Characteristic Curve Coefficients

Setting	Range	Increment	Default
A Coefficient	0 to 600	0.0001	0.2663
B Coefficient	0 to 25	0.0001	0.0339
C Coefficient	0 to 1	0.0001	1.0000
N Coefficient	0.5 to 2.5	0.0001	1.2969
Q Coefficient	0.1 to 10	0.0001	1.0000
R Coefficient	0 to 30	0.0001	0.5000

BESTCOMS*Plus* is used to set the 51-x Programmable Curve Constants. To program the Curve Constants, open the *Generator Protection/Current* tree branch and select the overcurrent element to be modified. Select *P* from the *Curve* pull-down menu and then enter the calculated values for each constant.

Programmable curve coefficients can only be entered when the *P* curve is chosen for the protection element from the *Curve* drop-down menu.

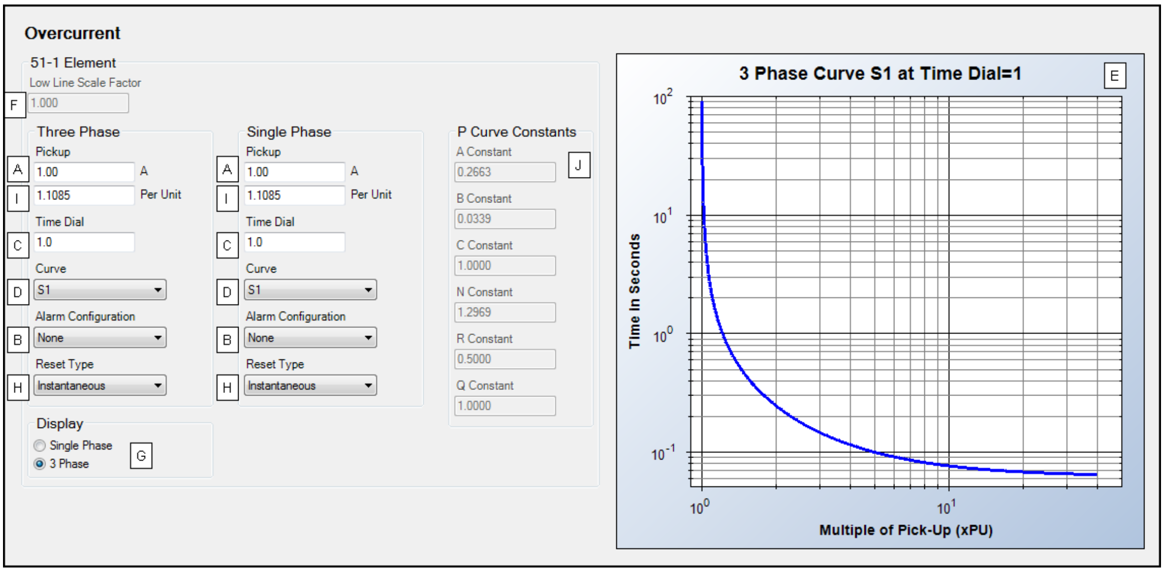

Figure 4-58. Overcurrent

[A] *Pickup:* Adjustable from 1 to 20 Aac for 5 Aac current sensing (style number 5xxxxxxxx) or 0 to 4 Aac for 1 Aac current sensing (style number 1xxxxxxxx).
[B] *Alarm Configuration:* None, Alarm, Pre-Alarm, or Status Only.
[C] *Time Dial:* Adjustable from 0 to 7,200 s for F (fixed) curve, 0 to 9.9 for all other curve selections.
[D] *Curve:* A, B, C, D, E1, E2, F, G, I1, I2, L1, L2, M, P, S1, S2, V1, or V2.
[E] *Overcurrent Pickup Curve*.
[F] *Low Line Scale Factor:* Adjustable from 0.001 to 3 in 0.001 increments.
[G] *Display:* Single Phase or 3 Phase.
[H] *Reset Type:* Instantaneous or Integrating.
[I] *Pickup (Per Unit):* Range varies based on the values of the native unit setting and the associated rated data parameter.
[J] *Programmable Curve (P) Coefficients:* Refer to Table 4-7.

Loss of Mains Protection

Loss of mains protection consists of one vector shift element and one rate of change of frequency element (style number xxxxxxExx only). The functionality of these elements is similar in that they are both intended to disconnect the generator from the grid when a loss of mains or mains failure occurs, preventing the generator from remaining tied to the mains if the mains returns due to an external reclose device. When the mains is lost, it is likely that the generator load will shift abruptly since the generator is driving everything between the generator output and the utility breaker that removed mains power. Such a load shift is likely to cause a speed shift, which might result in the generator being out of phase with the mains when a reclose occurs. If the generator is out of phase and connection with the mains is established, damage could occur.

Loss of mains protection is only active when the generator is paralleled to the mains as indicated when the Parallel To Mains logic element is true in BESTlogic*Plus*. The protection is inhibited for five seconds after Parallel To Mains first becomes true so that transients from closing onto the mains will not cause false trips.

To minimize false trips, loss of mains protection is disabled if any breakers are not closed.

Vector Shift (78)

The vector shift element trips the breaker when it detects a phase shift in the generator voltage. A sudden change in generator phase angle often occurs when the grid is lost. This change of phase angle results in an earlier zero crossing of the generator voltage if the generator load decreases or a later zero crossing if the generator load increases. This shift of the zero crossing (vector shift) is expressed in degrees. A trip will occur if the vector shift exceeds the Pickup setting[A]. A setting is provided to open the mains[B] breaker or generator[C] breaker on trip. An additional setting[D] is provided to configure the protection for Alarm, Pre-Alarm, or Status annunciation when tripped. The trip status of the Vector Shift (78) element is available to BESTlogic*Plus* when configured for Alarm, Pre-Alarm, or Status.

Vector Shift (78) trips are latched. They are cleared by pressing the *Reset* button on the front panel or by putting the MGC-2000 Series into Off mode.

The BESTCOMS*Plus* Vector Shift (78) screen is illustrated in Figure 4-59.

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Figure 4-59. Vector Shift (78)

[A] *Pickup:* Adjustable from 2 to 90° in 1° increments.
[B] *Open Mains Breaker on Trip:* Enable or Disable.
[C] *Open Generator Breaker on Trip:* Enable or Disable.

[D] *Alarm Configuration:* Alarm, Pre-Alarm, or Status Only.

ROCOF (81)

The ROCOF (rate of change of frequency) element trips the breaker when a change in frequency results from a sudden change in load. A trip will occur if the rate of change of frequency exceeds the Pickup setting[A] and the Activation Delay[B] has expired. A setting is provided to open the mains[C] breaker or generator[D] breaker on trip. An additional setting[E] configures the protection for Alarm, Pre-Alarm, or Status annunciation when tripped. The trip status of the ROCOF (81) element is available to BESTlogic*Plus* when configured for Alarm, Pre-Alarm, or Status.

ROCOF (81) trips are latched. They are cleared by pressing the *Reset* button on the front panel or by putting the MGC-2000 Series into Off mode.

The BESTCOMS*Plus* ROCOF (81) screen is illustrated in Figure 4-60.

Figure 4-60. ROCOF (81)

[A] *Pickup:* Adjustable from 0.2 to 10 Hz/s in 0.1 Hz/s increments.
[B] *Activation Delay:* Adjustable from 0 to 10 s in 0.001 s increments.
[C] *Open Mains Breaker on Trip:* Enable or Disable.
[D] *Open Generator Breaker on Trip:* Enable or Disable.
[E] *Alarm Configuration:* Alarm, Pre-Alarm, or Status Only.

Breaker Management

MGC-2000 Series breaker management features include the control of two, continuous- or pulse-controlled breakers, load transfer upon detection of a mains failure, two modes of automatic genset synchronization, and settings for stable or dead bus detection. Open transitions are implemented in load transfers to and from the mains.

The description of breaker management is organized as follows:

- Breaker Hardware
- Mains Failure
- Bus Condition Detection
- Synchronizer

Breaker Hardware

By default, one (generator) breaker is enabled[A] for control and monitoring by the MGC-2000 Series. In applications requiring control of a generator breaker and mains breaker, a second (mains) breaker can be enabled[B] and configured.

Breakers controlled by pulse or continuous inputs are supported[C]. Separate settings for each breaker's open[D] and close[E] pulse widths are provided as well as a transition delay. During the Transition Delay[F], open or close outputs are removed to allow any breaker interlocks to reset before a new open or close output is initialized. This setting accepts values from 0 to 1,000, in increments of 1 second.

During synchronization of the generator with the bus (Anticipatory mode only), the MGC-2000 Series uses the breaker closing time[G] to calculate the optimum time to close the breaker.

When a close command is issued, the MGC-2000 Series monitors the breaker status and annunciates a breaker failure if the breaker does not close within the time defined by the breaker-close wait-time delay[H]. Typically, this parameter is set to be longer than twice the breaker closing time.

The Breaker Fail Output Configuration[I] setting dictates whether the breaker output is removed or maintained during the breaker open fail or breaker close fail pre-alarm condition.

After a breaker open or close failure occurs, the MGC-2000 Series can attempt to reopen or reclose the breaker a pre-defined number of times. The number of attempts to open[J] or close[K] the breaker and the duration of time[L] between each attempt are user-programmable.

When an external device changes the state of the breaker, the External Status Change Action[M] setting dictates how the MGC-2000 Series responds to the state change. The MGC-2000 Series can ignore external breaker state changes, always follow breaker state changes, or only follow breaker state changes when in Auto mode. When the MGC-2000 Series is following external breaker state changes, it issues outputs that correspond to the change in breaker state. If an external source opens the breaker, the MGC-2000 Series issues a breaker open output. Likewise, if an external source closes the breaker, the MGC-2000 Series issues a breaker close output.

The dead bus close enable setting[N] enables a machine to close its breaker onto a dead bus. This can be used to make sure only one machine can close onto a dead bus at a time, if desired, preventing multiple machines closing to the dead bus at the same time, potentially out of phase with each other. When this setting is disabled, a machine can only close onto a stable bus.

Startup Synchronization

Startup synchronizing is a means of bringing up a system of generators, when the generator breakers are closed to a dead bus when the generator is stopped. After all breakers are closed, the gensets are started and pulled into sync when the AVRs are turned on. When enabled, the dead gen close enable parameter[O] allows closure of the breaker to a dead bus when the generator is dead.

Normally, it is not possible to close the generator breaker when the generator is dead. However, in cases where it is required to connect a generator that is "dead" to a bus that is "dead" for purposes of startup synchronization, both the generator and the bus must be recognized as "dead". To permit a close of the generator breaker from a "dead" generator to a "dead" bus, both the Dead Bus Close Enable setting and the Dead Gen Close Enable setting, in *Breaker Hardware* settings, must be set to enabled. After all breakers are closed, the gensets are started and pulled into sync when the AVRs are turned on. The user must develop logic to start the generators and turn on excitation in the voltage regulators at the correct time for orderly system startup.

CAUTION
Use caution when connecting "dead" generators to a "dead" bus. Undesired operation or system damage could occur if the bus becomes "live" while "dead" generators are connected to it.

The BESTCOMS*Plus* Breaker Hardware screen is illustrated in Figure 4-61.

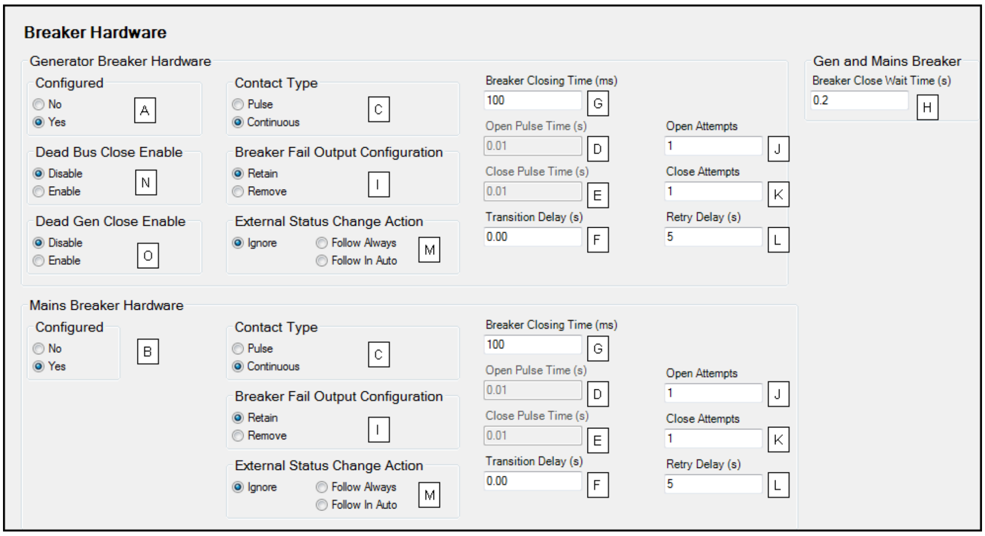

Figure 4-61. Breaker Hardware

[A] *Generator Breaker:* No or Yes.
[B] *Mains Breaker:* No or Yes.
[C] *Contact Type:* Continuous or Pulse. If Continuous is selected, the outputs will be on during the time that the desired Close or Open condition is in effect. If Pulse is selected, the duration of the pulses are set by the Open Pulse Time and Close Pulse Time settings.
[D] *Open Pulse Time:* Adjustable from 0.01 to 0.80 s in 0.01 s increments. This setting applies only when Contact Type is Pulse. This time should be ≥ the Breaker Closing Time setting.
[E] *Close Pulse Time:* Adjustable from 0.01 to 0.80 s in 0.01 s increments. This setting applies only when Contact Type is Pulse. This time should be ≥ the Breaker Closing Time setting.
[F] *Transition Delay:* Adjustable from 0 to 1,000, in increments of 1 second.
[G] *Breaker Closing Time:* Adjustable from 0 to 800 ms in 5 ms increments. This specifies the amount of time the breaker takes to close once a close contact is applied to it. This time is used for anticipatory synchronization to issue a close pulse a certain time before the 0 degree slip angle is reached so that when the breaker actually closes, the slip angle is near 0 degrees.
[H] *Breaker Close Wait Time:* Adjustable from 0.1 to 600 s in 0.1 s increments. This specifies the amount of time the MGC-2000 Series will wait between issuing a close pulse to a breaker and expecting the breaker status to be indicated as closed. If this time expires before the breaker status is indicated as closed, a Breaker Close Fail pre-alarm will be annunciated. The pre-alarm can be cleared by switching to OFF mode or pressing the *Reset* button on the front panel of the MGC-2000 Series.
[I] *Breaker Fail Output Configuration:* Retain or Remove.
[J] *Open Attempts:* Adjustable from 1 to 20, in increments of 1.
[K] *Close Attempts:* Adjustable from 1 to 20, in increments of 1.
[L] *Retry Delay:* Adjustable from 0 to 1,200, in 1 s increments.
[M] *External Status Change Action:* Ignore, Follow Always, Follow in Auto
[N] *Dead Bus Close Enable:* Disable or Enable.
[O] *Dead Gen Close Enable:* Disable or Enable.

Breaker Hardware One-Line Diagram

A one-line diagram of the breaker hardware setup can be displayed on the front panel. This diagram changes in real time to reflect the current state of the configured breakers. See Section 2, *Human-Machine Interface* for details.

Mains Failure

When two breakers are configured (enabled), the MGC-2000 Series can be enabled to automatically transfer load power from the mains to the genset during a mains failure[A]. This feature also enables the MGC-2000 Series to transfer the load back to the mains once mains power is restored. Settings include a transfer delay[B], return delay[C], max transfer time[D], and max return time[E].

Automatic breaker operation can be disabled through BESTlogic*Plus* Programmable Logic. When the Auto Breaker Operation Inhibit element is set true, it prevents all automatic breaker operation.

When Mains Fail Transfer is set to enabled, the machine is configured as a mains fail machine or standby power machine that takes over when utility power fails. There are two types of transitions[F] between the generator and the utility that are set with the Mains Fail Transfer Type setting: (1) Open transitions in which the generator and mains breaker are never closed at the same time, and (2) Closed transitions in which the generator parallels to the utility for a short time to transfer load to the generator from the utility (a load takeover) or transfer the load from the generator to the utility.

The Mains Fail Transfer function can be disabled through BESTlogic*Plus* Programmable Logic. When the Mains Fail Transfer Inhibit element is set true, it prevents automatic load transfer due to a mains failure.

In open transitions, when a mains failure occurs, the MGC-2000 Series starts the generator after the transfer time expires. The MGC-2000 Series opens the mains breaker either before the engine starts or after the generator is stable based on the Mains Breaker Open Configuration[G] setting. After the mains breaker is open, the MGC-2000 Series closes its generator breaker to drive the load. When the mains power returns, after the Mains Fail Return Delay time expires, the generator opens its generator breaker and then closes the mains breaker. If the in-phase monitor[H] is enabled and the Mains Fail Return Delay time has expired, the generator waits until it detects that the phases are aligned between the generator and the mains before performing the open transition from the generator back to the utility.

An Open Transition Delay[I] is provided to allow a user-specified amount of time where both breakers are open. For example, this may be used to prevent damage to large motors in the load by allowing them to spin down completely during open transitions. The Open Transition Delay is active when both the generator and mains breakers are open, or when the mains breaker is closed and the mains bus is dead.

In closed transitions, when a mains failure occurs, the MGC-2000 Series starts the generator after the transfer time expires. The MGC-2000 Series opens the mains breaker either before the engine starts or after the generator becomes stable based on the Mains Breaker Open Configuration setting. After the mains breaker is open the MGC-2000 Series closes its generator breaker to drive the load. When the mains power returns, after the Mains Fail Return Delay time expires, the generator synchronizes to the utility and closes the mains breaker, paralleling the generator to the utility. While paralleled to the utility, the generator will ramp down load until the load is at or below the level of the Breaker Open Setpoint or until the generator has been paralleled to the utility for the maximum allowed time as specified by the Max Parallel Time[J] setting. Finally, the generator opens its generator breaker, leaving the load on utility power, cools down, and stops. Since the kW output of the generator is ramped during closed transitions, a load sharing module (LSM-2020) is generally required to provide governor bias signals to the engine governor.

Closed transition override can be enabled through BESTlogic*Plus* Programmable Logic. When the Closed Transition Override element is set true, it forces a closed transition due to mains failure, overriding an *open* Mains Fail Transfer Type setting.

If the Alarm State Transfer to Mains[K] setting is enabled, the MGC-2000 Series can transfer the load to a stable utility when in the alarm state. If this setting is disabled, the MGC-2000 Series will not perform any transitions of the load to or from the utility when in the alarm state.

When enabled, Reverse Rotation Inhibit[L] prevents automatic load transfer due to a mains failure when the machine is determined to have reverse phase rotation.

The BESTCOMS*Plus* Mains Fail screen is illustrated in Figure 4-62.

Mains Failure Logic Elements

Four logic elements are present in BESTlogic*Plus* Programmable Logic that can be used on a machine configured for mains fail operation to transition the load from the mains to the generator. These four logic elements are Mains Fail Test, Load Take Over, Stop kvar Ramp, and Stop kW Ramp.

The Mains Fail Test logic element, when true, causes the generator to react exactly as if the mains has failed: the mains breaker opens, the Mains Fail Transfer Delay time expires, the generator starts, the generator becomes stable, and the generator closes its generator breaker to drive the load. When the Mains Fail Test logic element is false, the generator reacts as if the mains has returned: the Mains Fail Return Delay time expires and the generator transitions the load from the generator back to the utility in an Open or Closed transition, according to the Mains Fail Transfer Type setting.

The Load Take Over logic element is similar, except that the machine does not act as if the mains has failed, and the transfer and return delay timers are ignored. If the Mains Fail Transition Type is set to Open and the Load Take Over logic element is true, the mains breaker opens, the generator starts, the generator becomes stable, and the generator breaker closes to drive the load. When the Load Take Over logic element is false, the generator opens its generator breaker and closes the mains breaker to transition the load back to the utility. If the In Phase Monitor function is enabled, the transition does not occur until generator and utility phases are aligned.

If the Mains Fail Transition Type is set to Closed and the Load Take Over logic element is true, the generator starts, synchronizes to the utility, and closes the generator breaker. The generator will take on load until it is driving load at a level equal to the Base Load Level setting in the Governor Bias Control settings, or until the generator is paralleled to the utility for the maximum allowed time as specified by the Max Parallel Time setting. Once the load has reached the Base Load Level or the Max Parallel Time duration has expired, the mains breaker will open leaving the load on the generator. When the Load Take Over logic element is false, the generator parallels to the utility. While paralleled to the utility, the generator ramps down load until the load is at or below the Breaker Open Setpoint or until the generator has been paralleled to the utility for the maximum allowed time as specified by the Max Parallel Time setting. Finally, the generator opens its generator breaker, leaving the load on utility power, cools down, and stops.

NOTE

The Parallel to Mains logic element must be true any time the generator is in parallel with the utility. Parallel transitions to and from the mains will not operate properly if the Parallel to Mains logic element is not set correctly.

The Stop kW Ramp logic element, when true, causes the generator to freeze the ramping of kW and maintain a constant output. For example, this can be used in closed transitions where an external device senses power flow across the mains breaker. When the external device senses zero power flow across the mains breaker, it sends an input to the MGC-2000 Series. Through BESTlogic*Plus*, the Stop kW Ramp logic element receives the true input and causes kW ramping to freeze. In this setup, the generator takes on load until one of the following conditions is true:

- The Stop kW Ramp logic element becomes true
- The Max Parallel time delay expires
- A breaker open request is received by the MGC-2000 Series from an external device

The Stop kvar Ramp logic element, when true, causes the generator to freeze the ramping of kvar and maintain a constant output. This element has the same basic uses as the Stop kW Ramp element.

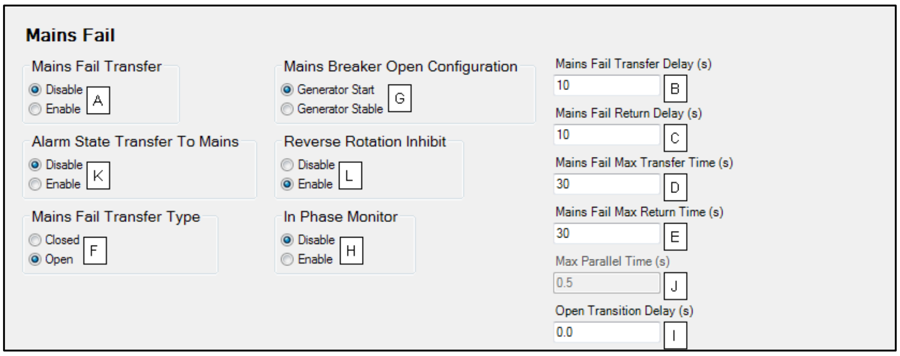

Figure 4-62 Mains Fail

[A] *Mains Fail Transfer:* Enable or Disable. This setting does not apply when generator frequency is 400Hz.
[B] *Mains Fail Transfer Delay:* Adjustable from 0 to 300 s in 1 s increments. This specifies the delay between detection of failed mains to initiation of the transfer to the generator.
[C] *Mains Fail Return Delay:* Adjustable from 0 to 1,800 s in 1 s increments. This specifies the delay between detection of restored (stable) mains and initiation of the return from the generator back to the mains.
[D] *Mains Fail Max Transfer Time:* Adjustable from 10 to 3,700 s in 1 s increments. This specifies the maximum time that is allowed for a transfer from failed mains to generator power. If the transfer has not been achieved in this time, a Mains Fail Transfer Fail pre-alarm is annunciated and the transfer is aborted. The pre-alarm can be cleared by switching to OFF mode or pressing the *Reset* button on the front panel of the MGC-2000 Series. Note that the Mains Fail Max Transfer Time setting must be longer than the time for the Mains Fail Transfer Delay plus the Sync Activation Delay plus the Breaker Close Wait Time.
[E] *Mains Fail Max Return Time:* Adjustable from 10 to 3,700 s in 1 s increments. This specifies the maximum time that is allowed for a transfer from generator power to mains power when returning to mains after a mains fail transfer to generators has occurred. This must be set to a time interval longer

than the Max Parallel Time when closed transitions are employed. In addition, it must be set longer than the time for the generator to ramp down from full load to no load when transferring to utility. If this timer times out when the MGC-2000 Series is attempting to transfer from generator power to mains power after mains returns, a Mains Fail Return Fail pre-alarm will be annunciated. The MGC-2000 Series will continue to attempt to return to mains even though the pre-alarm has been annunciated.
[F] *Mains Fail Transfer Type:* Closed or Open.
[G] *Mains Breaker Open Configuration:* Generator Start or Generator Stable.
[H] *In-Phase Monitor:* Disable or Enable.
[I] *Open Transition Delay:* Adjustable from 0 to 3,600 in 0.1 s increments.
[J] *Max Parallel Time:* Adjustable from 0.1 to 10,000 s in 0.1 s increments.
[K] *Alarm State Transfer to Mains:* Disable or Enable.
[L] *Reverse Rotation Inhibit:* Disable or Enable.

Bus Condition Detection

Bus condition detection settings are provided for generator sensing and bus sensing.

Generator Sensing

MGC-2000 Series detection of dead generator voltages is controlled by a Dead Gen Threshold setting[A] and a Dead Gen Activation Delay setting[B]. A dead generator is recognized when the voltage of all phases decreases below the threshold setting for the duration of the time delay setting. Normally, it is not possible to close the generator breaker when the generator is dead. However, in cases where it is required to connect a generator that is “dead” to a bus that is “dead” for purposes of startup synchronization, both the generator and the bus must be recognized as “dead”. To permit a close of the generator breaker from a “dead” generator to a “dead” bus, both the Dead Bus Close Enable setting and the Dead Gen Close Enable setting, in *Breaker Hardware* settings, must be set to enabled.

CAUTION
Use caution when connecting “dead” generators to a “dead” bus. Undesired operation or system damage could occur if the bus becomes “live” while “dead” generators are connected to it.

Before the MGC-2000 Series initiates a normal breaker closure (a stable generator is closed to a dead bus or stable bus), the generator voltage must be stable. The MGC-2000 Series uses several settings to determine voltage stability. These settings include pickup and dropout levels for overvoltage[C], undervoltage[D], overfrequency[E], and underfrequency[F]. Recognition of generator stability is further controlled by two timers. Voltage conditions must meet the stability pickup and dropout settings for the duration of the Gen Stable Activation Delay[G]. Breaker closure is not considered if the voltage conditions do not meet the stability pickup and dropout settings for the duration of the Gen Stable Activation Delay setting. When the generator does not meet the voltage or frequency criteria for the Gen Stable condition, the generator status is reported as Gen Failed (not stable and not dead) after the duration of the Gen Failed Activation Delay[H].

The Gen Stable overvoltage and undervoltage detection elements have the low-line scale factor[I] applied to them to enhance versatility for reconfigurable machines. When the low-line override is active, the thresholds for the overvoltage and undervoltage detection are multiplied by the low-line scale factor. The effect is that low-line threshold = element threshold setting x low-line scale factor.

An alternate frequency scale factor setting[J] is used for automatic adjustment of the frequency pickup settings in applications that might utilize more than one operating frequency. For example, a machine that is configurable between 50 or 60 Hz operation. The scale factor setting is implemented when the MGC-2000 Series senses a contact closure at a contact input that is connected to the Alternate Frequency Override logic element in BESTlogic*Plus* Programmable Logic. When the Alternate Frequency Override is true, the scale factor setting serves as a multiplier for the pickup settings. For example, if a scale factor contact input is received by the MGC-2000 Series and the scale factor setting is 2.000, the pickup setting will be doubled (2.000 x PU).

Settings which are related to machine ratings can be set in either actual units voltage or in per unit[K] values. When a native unit is edited, BESTCOMS*Plus* automatically recalculates the per unit value based on the native unit setting and the rated data parameter (on the *System Parameters, Rated Data* screen)

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associated with it. When a per unit value is edited, BESTCOMS*Plus* automatically recalculates the native value based on the per unit setting and the rated data parameter associated with it.

Once all per unit values are assigned, if the rated data parameters are changed, BESTCOMS*Plus* automatically recalculates all native unit settings based on the modified rated data parameters.

The following settings have native units of *Primary Volts*, and the rated data associated with them is *Rated Volts* (on the *System Parameters, Rated Data* screen).

- Dead Gen Threshold
- Gen Stable Overvoltage Pickup
- Gen Stable Overvoltage Dropout
- Gen Stable Undervoltage Pickup
- Gen Stable Undervoltage Dropout

The following settings have native units of *Frequency in Hz*, and the rated data associated with them is *Rated Frequency* (on the *System Parameters, Rated Data* screen).

- Gen Stable Overfrequency Pickup
- Gen Stable Overfrequency Dropout
- Gen Stable Underfrequency Pickup
- Gen Stable Underfrequency Dropout

Bus Sensing

Dead bus detection is controlled by a Dead Bus Threshold setting[L] and a Dead Bus Activation Delay setting[M]. A dead bus is recognized when the voltage of all phases decreases below the threshold setting for the duration of the time delay setting.

Before the MGC-2000 Series initiates a breaker closure to a bus that is not dead, the voltage must be stable. The MGC-2000 Series uses several settings to determine voltage stability. These settings include pickup and dropout levels for overvoltage[N], undervoltage[O], overfrequency[P], and underfrequency[Q]. Recognition of bus stability is further controlled by two timers. Voltage conditions must meet the stability pickup and dropout settings for the duration of the Bus Stable Activation Delay[R]. Breaker closure is not considered if the voltage conditions do not meet the stability pickup and dropout settings for the duration of the Bus Stable Activation Delay setting. When the bus does not meet the voltage or frequency criteria for the Bus Stable condition, the bus status is reported as Bus Failed (not stable and not dead) after the duration of the Bus Failed Activation Delay[S].

The Bus Stable overvoltage and undervoltage detection elements have the low-line scale factor[T] applied to them to enhance versatility for reconfigurable machines. When the low-line override is active, the thresholds for the overvoltage and undervoltage detection are multiplied by the low-line scale factor. The effect is that low-line threshold = element threshold setting x low-line scale factor.

An alternate frequency scale factor setting[U] is used for automatic adjustment of the frequency pickup settings in applications that might utilize more than one operating frequency. For example, a machine that is configurable between 50 or 60 Hz operation. The scale factor setting is implemented when the MGC-2000 Series senses a contact closure at a contact input that is connected to the Alternate Frequency Override logic element in BESTlogic*Plus* Programmable Logic. When the Alternate Frequency Override is true, the scale factor setting serves as a multiplier for the pickup settings. For example, if a scale factor contact input is received by the MGC-2000 Series and the scale factor setting is 2.000, the pickup setting will be doubled (2.000 x PU).

Settings which are related to machine ratings can be set in either actual units of voltage or in per unit[V] values. When a native unit is edited, BESTCOMS*Plus* automatically recalculates the per unit value based on the native unit setting and the rated data parameter (on the *System Parameters, Rated Data* screen) associated with it. When a per-unit value is edited, BESTCOMS*Plus* automatically recalculates the native value based on the per unit setting and the rated data parameter associated with it.

Once all per unit values are assigned, if the rated data parameters are changed, BESTCOMS*Plus* automatically recalculates all native unit settings based on the modified rated data parameters.

The following settings have native units of *Primary Volts*, and the rated data associated with them is *Rated Volts* (on the *System Parameters, Rated Data* screen).

- Dead Bus Threshold
- Bus Stable Overvoltage Pickup
- Bus Stable Overvoltage Dropout

- Bus Stable Undervoltage Pickup
- Bus Stable Undervoltage Dropout

The following settings have native units of *Frequency in Hz*, and the rated data associated with them is *Rated Frequency* (on the *System Parameters, Rated Data* screen).

- Bus Stable Overfrequency Pickup
- Bus Stable Overfrequency Dropout
- Bus Stable Underfrequency Pickup
- Bus Stable Underfrequency Dropout

The BESTCOMS*Plus* Bus Condition Detection screen is illustrated in Figure 4-63.

> **NOTE**
>
> Voltage threshold and pickup settings on the Bus Condition Detection screen are entered in primary values (generator side of VT).

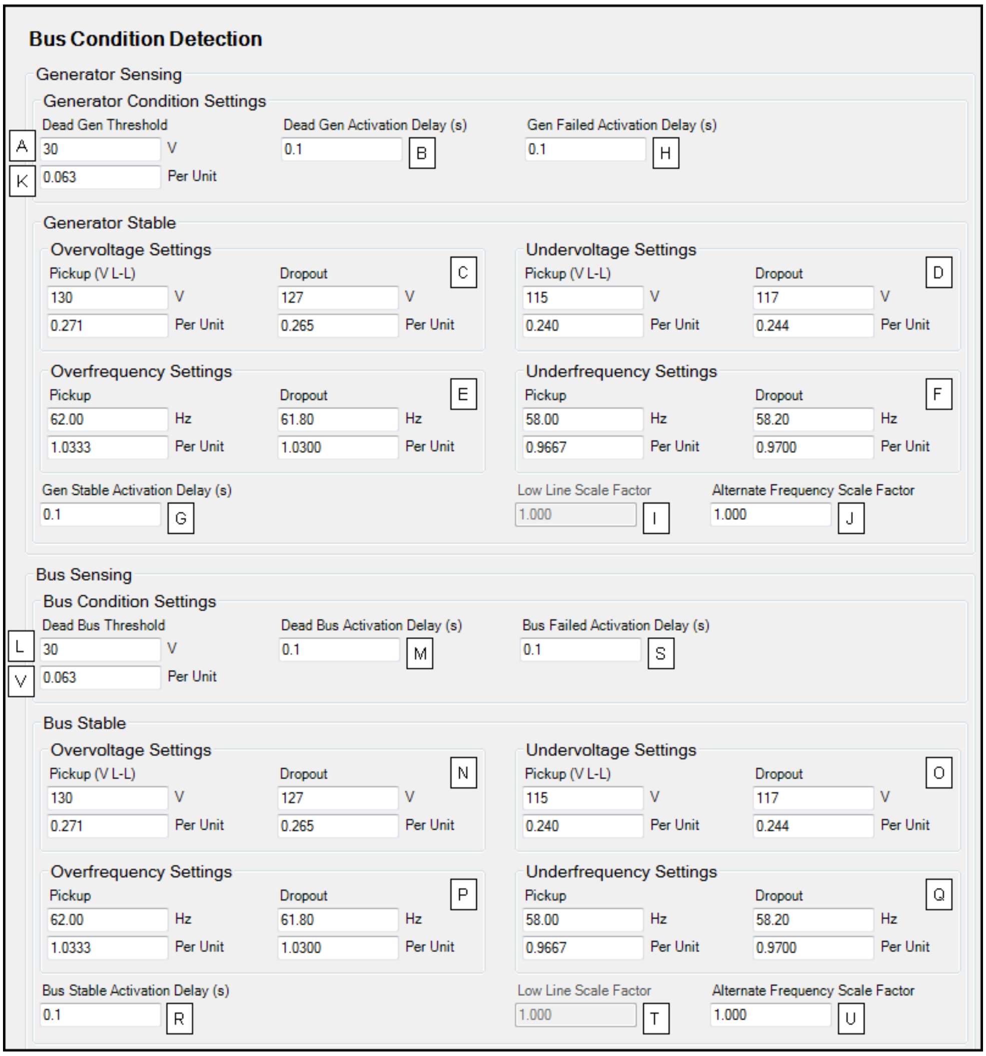

Figure 4-63. Bus Condition Detection

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[A] *Dead Gen Threshold:* Adjustable from 0 to 4,800 Vac in 1 Vac increments.
[B] *Dead Gen Activation Delay:* Adjustable from 0.1 to 600 s in 0.1 second increments.
[C] *Gen Stable Overvoltage Pickup and Dropout:* Adjustable from 10 to 99,999 Vac in 1 Vac increments.

[D] *Gen Stable Undervoltage Pickup and Dropout:* Adjustable from 10 to 99,999 Vac in 1 Vac increments.
[E] *Gen Stable Overfrequency Pickup and Dropout:* Adjustable from 46 to 64 Hz in 0.05 Hz increments for 50/60 Hz generator frequency (style number x1xxxxxxx).
[F] *Gen Stable Underfrequency Pickup and Dropout:* Adjustable from 46 to 64 Hz in 0.05 Hz increments for 50/60 Hz generator frequency (style number x1xxxxxxx).
[G] Gen *Stable Activation Delay:* Adjustable from 0.1 to 600 s in 0.1 s increments.
[H] Gen *Failed Activation Delay:* Adjustable from 0.1 to 600 s in 0.1 s increments.
[I] *Low Line Scale Factor:* Adjustable from 0.001 to 3 in increments of 0.001.
[J] *Alternate Frequency Scale Factor:* 0.001 to 100 in increments of 0.001.
[K] *Dead Gen Threshold (Per Unit):* Range varies based on the values of the native unit setting and the associated rated data parameter.
[L] *Dead Bus Threshold:* Adjustable from 0 to 4,800 Vac in 1 Vac increments.
[M] *Dead Bus Activation Delay:* Adjustable from 0.1 to 600 s in 0.1 s increments.
[N] *Bus Stable Overvoltage Pickup and Dropout:* Adjustable from 10 to 99,999 Vac in 1 Vac increments.
[O] *Bus Stable Undervoltage Pickup and Dropout:* Adjustable from 10 to 99,999 Vac in 1 Vac increments.
[P] *Bus Stable Overfrequency Pickup and Dropout:* Adjustable from 46 to 64 Hz in 0.05 Hz increments for 50/60 Hz generator frequency (style number x1xxxxxxx).
[Q] *Bus Stable Underfrequency Pickup and Dropout:* Adjustable from 46 to 64 Hz in 0.05 Hz increments for 50/60 Hz generator frequency (style number x1xxxxxxx).
[R] *Bus Stable Activation Delay:* Adjustable from 0.1 to 600 s in 0.1 s increments.
[S] *Bus Failed Activation Delay:* Adjustable from 0.1 to 600 s in 0.1 s increments.
[T] *Low Line Scale Factor:* Adjustable from 0.001 to 3 in increments of 0.001.
[U] *Alternate Frequency Scale Factor:* 0.001 to 100 in increments of 0.001.
[V] *Dead Bus Threshold (Per Unit):* Range varies based on the values of the native unit setting and the associated rated data parameter.

Automatic Synchronizer (Optional)

Two methods of generator synchronization are offered: phase lock loop and anticipatory[A]. In both methods, the MGC-2000 Series adjusts the frequency and voltage of the generator to match that of the bus (mains) and then connects the generator to the bus by closing the breaker. Anticipatory mode has the added capability of compensating for the breaker closing time (the delay between when a breaker close command is issued and the breaker blades close). The MGC-2000 Series calculates the advance phase angle that is required to compensate for the breaker closure time by monitoring the frequency difference between the generator and the bus.

A synchronizer metering screen is available on the front panel HMI under *Metering, Generator, Synchronizer.* See Figure 4-64.

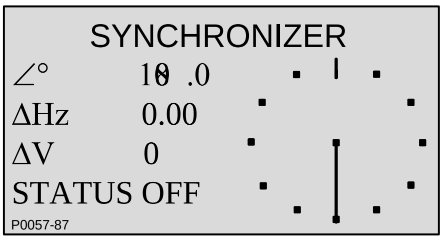

Figure 4-64. Synchronizer Screen

The BESTCOMS*Plus* Synchronizer screen is illustrated in Figure 4-66.

Frequency Correction

Generator frequency correction is defined by the slip frequency setting and further refined by the breaker closing angle setting. The slip frequency setting[B] establishes the maximum allowable deviation of the generator speed (frequency) from the bus frequency. The Min Slip Control Limit setting[C] and Max Slip Control Limit setting[D] are used to calculate the slip frequency error and to provide continuous slip frequency control while in phase lock synchronization. If the slip frequency magnitude is above the Max Slip Control Limit, the error is set equal to the Max Error in the opposite polarity. If the slip frequency magnitude is below the Min Slip Control Limit, the slip frequency error is 0. When it is between the two limits, the error is calculated internally by the MGC-2000 Series. Slip frequency error is shown in Figure 4-65. To minimize the impact on the bus during synchronization, the Fgen>Fbus setting[E] can be enabled to force the generator frequency to exceed the bus frequency at the moment of breaker closure. If this is the case, the MGC-2000 Series will drive the generator frequency higher than the bus frequency before closing the breaker. The breaker closing angle setting[F] defines the maximum allowable phase angle difference between the generator and the bus. For breaker closure to be considered, the slip angle must remain below this setting for the duration of the sync activation delay setting[G].

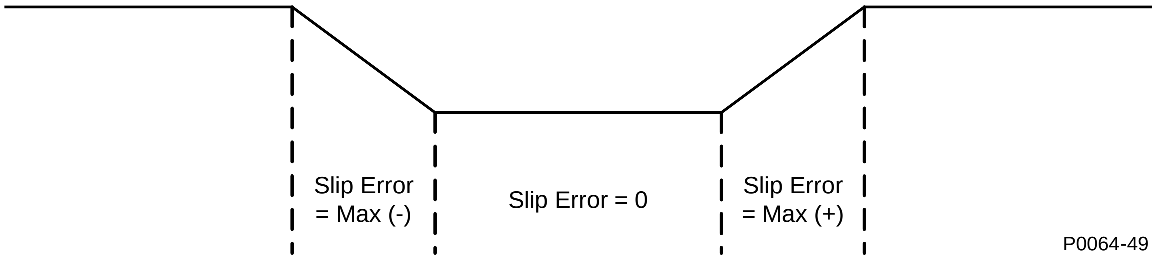

Figure 4-65. Slip Frequency Error

Voltage Correction

Generator voltage correction is defined by the voltage window setting[H]. This setting, expressed as a percentage of the bus voltage, determines the band of generator voltage surrounding the bus voltage when breaker closure will be considered. If the Vgen>Vbus setting[I] is enabled, the MGC-2000 Series will drive the generator voltage to be greater than the bus voltage by an amount equal to the regulation offset setting divided by two.

Synchronization Failure

The maximum desired duration for synchronizing to take place is established by the sync fail activation delay setting[J]. If synchronization (breaker closure) fails to occur within this time setting, generator synchronization will be aborted and a failure will be annunciated. Note that if either bus goes unstable, the synchronizer timers are reset.

Gain Settings

Sync speed[K] gain and sync voltage[L] gain settings are provided to increase the loop gain of the automatic synchronizer. This allows the synchronizer function to be aggressive during synchronization and stable during speed trim operation.

NOTES

If the generator frequency is 400 Hz, the settings on the Synchronizer screen do NOT apply. In this case, BESTCOMS*Plus* will not allow these settings to be changed.

When using the MGC-2000 Series synchronizer, it is recommended that local MGC-2000 Series relay outputs be used for breaker closing commands to minimize the possibility of closures outside of desired breaker closing angles.

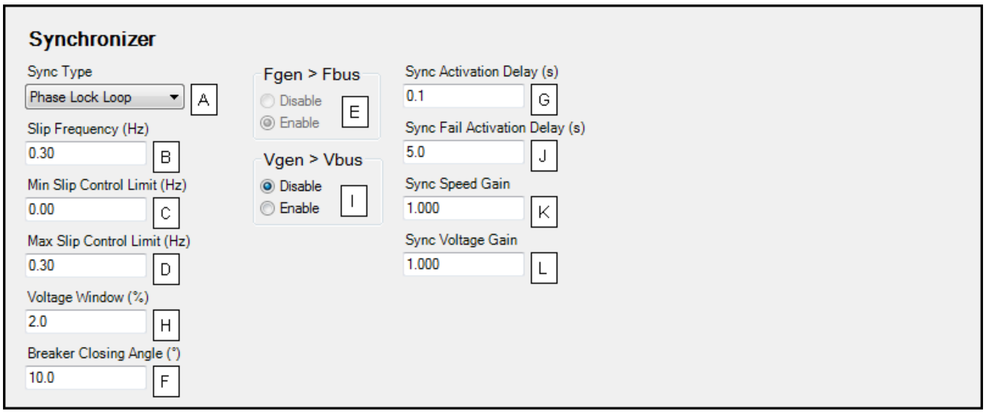

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Figure 4-66. Synchronizer

[A] *Sync Type:* Phase Lock Loop or Anticipatory.
[B] *Slip Frequency:* Adjustable from 0.01 to 0.5 Hz in 0.01 Hz increments. If Anticipatory synchronization is selected, this specifies the maximum acceptable slip under which a close command can occur. If Phase Lock Loop synchronization is selected and the slip angle is within the Breaker Closing Angle criterion for a period long enough to indicate the slip frequency criterion has been met, a breaker close command can be issued.
[C] *Min Slip Control Limit:* Adjustable from 0 to 2 Hz in 0.01 Hz increments.
[D] *Max Slip Control Limit:* Adjustable from 0 to 2 Hz in 0.01 Hz increments.
[E] *Fgen>Fbus:* Enable or Disable.
[F] *Breaker Closing Angle:* Adjustable from 3 to 20° in 0.5° increments. If Phase Lock Loop synchronization is selected, this specifies the maximum acceptable slip angle under which a breaker close command can be issued.
[G] *Sync Activation Delay:* Adjustable from 0.1 to 0.8 s in 0.1 s increments.
[H] *Voltage Window:* Adjustable from 2 to 15% of nominal generator voltage in 0.5% increments. This specifies the voltage acceptance window for the synchronization function.
[I] *Vgen>Vbus:* Enable or Disable.
[J] *Sync Fail Activation Delay:* Adjustable from 0.1 to 600 s in 0.1 s increments. This is the amount of time the MGC-2000 Series will allow the synchronizer to attempt to synchronize the generator to the bus before annunciating a Sync Fail pre-alarm. The pre-alarm can be cleared by switching to OFF mode or pressing the *Reset* button on the front panel of the MGC-2000 Series.
[K] *Sync Speed Gain:* Adjustable from 0.001 to 1000 in increments of 0.001.
[L] *Sync Voltage Gain:* Adjustable from 0.001 to 1000 in increments of 0.001.

Bias Control Settings

Settings are provided for AVR Bias Control and Governor Bias Control. Refer to Appendix C for instructions on Tuning Speed PID Settings and Load Control PID Settings.

AVR Bias Control Settings

The bias control output type[A] should be set to contact when operating without an optional LSM-2020.

The MGC-2000 Series adjusts the generator voltage and frequency by issuing voltage correction signals to the generator AVR (automatic voltage regulator). Correction signals are issued in the form of MGC-2000 Series output contact closures. These correction signals can be either continuous or proportional[B]. Proportional correction uses control pulses of varying widths[C] and intervals[D]. Initially, long pulses are issued when the voltage and frequency differences are large. As the correction pulses take effect and the voltage and frequency differences become smaller, the correction pulse widths are proportionally decreased. Proportional correction pulses are beneficial in applications where fixed correction pulses can result in overshooting the slip frequency and regulation offset targets.

When an optional LSM-2020 is connected, the bias control output type[A] should be set to analog. This enables a voltage trim setting and a PID controller.

To achieve Ethernet var sharing among machines in an islanded system, the following conditions must be met:

- Var/PF control must be enabled on the AVR Bias Control Settings screen
- A connection between the MGC-2000 Series and LSM-2020 must be established
- LSM-2020s must be connected to each other via Ethernet on the inter-genset communications network

Section 9, *LSM-2020 (Load Share Module)* provides setup information and connection diagrams for load sharing.

Voltage Trim

The voltage trim settings for Rev 1 & 2 hardware differ from those of Rev 3 hardware. Hardware version 3 units support paralleling of reconfigurable machines.

Revision 1 and 2 Hardware

The voltage trim enable setting[E] maintains system voltage at the setpoint while the system is in islanded var sharing mode.

The Voltage Trim error is calculated as the difference between the measured voltage and the voltage trim set point divided by the machine Rated Voltage. When this difference is less than the dead band setting[F], the voltage trim controller will treat this as zero error. If system operation appears "nervous" when voltage trim is enabled, setting a nonzero dead band may result in smoother system operation. In addition, if machines do not appear to share kvar equally when voltage trim is enabled, setting a nonzero dead band will likely result in improved kvar sharing. The Voltage Trim Dead Band is in units of Percent.

Revision 3 Hardware

The voltage trim enable setting[E] maintains system voltage at the setpoint while the system is in islanded var sharing mode. When Enable When Gen Breaker Closed is selected, voltage trim is enabled when the generator breaker is closed, but disabled when the generator breaker is open. This is the default value. When Enable Always is selected, voltage trim is always enabled.

The Voltage Trim error is calculated as the difference between the measured voltage and the voltage trim set point divided by the machine Rated Voltage. When this difference is less than the trim dead band setting[F], the voltage trim controller will treat this as zero error. If system operation appears "nervous" when voltage trim is enabled, setting a nonzero dead band may result in smoother system operation. In addition, if machines do not appear to share kvar equally when voltage trim is enabled, setting a nonzero dead band will likely result in improved kvar sharing. The Voltage Trim Dead Band is in units of Percent.

The voltage trim setpoint[G] defines the source for voltage trim. Selections are Rated Voltage and Trim Voltage Setting.

The remote trim bias setting[H] selects an analog input to use as a bias to the voltage trim set point. The remote trim bias (%) setting[I] specifies the range, in percent, of the active voltage trim set point over which the voltage trim can be biased.

The trim voltage setting[J] defines the voltage trim value in volts. The Alternate Voltage 1 through Alternate Voltage 4 settings[K] define the voltage trim value when the corresponding Alternate Voltage Override logic element is true in BESTlogic*Plus* programmable logic.

PID Controller

The PID controller controls the voltage bias from the LSM-2020 to the voltage regulator. The controller adjusts the bias output to drive the error between desired generator voltage and measured generator voltage to zero. Settings are provided for proportional gain[L], integral gain[M], derivative gain[N], derivative filter constant[O], and loop gain[P] of the PID controller.

var/PF Control

The var/PF controller is used to implement var and Power Factor control of the generator when it is paralleled to the utility as indicated by the Parallel to Mains logic element in BESTlogic*Plus*. If var/PF control is enabled, the generator breaker is closed, the generator is stable, and the bias control output type is set to *analog* (requires LSM-2020) the var/PF controller will become active. If the Parallel to Mains logic element is true, the var/PF controller will regulate the generator’s kvar output to achieve desired kvar or power factor levels. When not paralleled to mains, the var/PF controller will control the kvar output to achieve reactive power sharing between all generators in the system through Intergenset communications. If the generator breaker is open or controller is disabled, the machine will operate iin voltage droop.

When control[Q] is enabled and the control mode[R] is set to var, the var setpoint can be derived from either a user setting or an analog input. The MGC-2000 Series calculates an operating kvar setpoint based on the kvar setpoint source setting[S]. When this is set to User Setting, the operating kvar setpoint is equal to the configured kvar setpoint[T]. When the kvar setpoint source setting[S] is set to LSM-2020 input or an AEM-2020 input, the operating kvar setpoint is equal to the value calculated from the analog input. Parameters are available for kvar analog max[U] and kvar analog min[V].

When control mode[R] is set to PF, the PF setpoint can be derived either from a user setting or from an analog input. The MGC-2000 Series calculates an operating PF setpoint based on the PF setpoint source setting[W]. When this is set to User Setting, the operating PF setpoint is equal to the configured PF setpoint[X]. When the PF setpoint source setting[W] is set to LSM-2020 input or an AEM-2020 input, the operating PF setpoint is equal to the value calculated from the analog input. Parameters are available for PF analog max[Y] and PF analog min[Z].

When an optional LSM-2020 is connected, the bias control output type[A] should be set to analog. This enables a PID controller that controls the var/PF bias from the LSM-2020 to the voltage regulator. The controller adjusts the bias output to drive the error between desired generator var/PF and measured generator var/PF to zero. Settings are provided for proportional gain[AA], integral gain[BB], derivative gain[CC], derivative filter constant[DD], loop gain[EE], and parallel to mains gain[FF] of the PID controller.

The percent voltage droop to be used when the unit is in droop mode is determined by the droop percentage setting[GG]. Voltage droop mode is entered any time the generator breaker is open. Voltage droop is also the mode when the generator breaker is closed and var/PF control is disabled. If it is desired to disable voltage droop, set the droop percentage to 0. The voltage droop gain setting[HH] determines the gain factor applied to the voltage droop percentage to compensate for governor differences and achieve desired droop performance. In order to test the operation of droop, the unit must be loaded to full load and the resulting generator voltage should be compared to the desired droop. If it is not possible to load the unit to full load, the droop test can be performed at partial load. The expected voltage is determined by the following equation.

Expected voltage reduction in droop - (actual load/machine capacity) ∗ (droop percentage/100) ∗ rated voltage.

If the actual voltage drop does not match the expected value, calculate the error by dividing the expected drop by the actual drop, and putting the result in as the droop gain.

Ramp rate[II] is defined as the rate, in percentage of machine capacity, at which the machine will ramp up its var/PF when loading or coming online. The machine also uses this rate to unload prior to cooling down. If a machine is the only machine online, ramping will not be in effect.

After ramping a generator's kvar output, to bring it online or offline, overshoot may occur. The likeliness of kvar overshoot increases as the ramp rate increases. Typically, overshoot is reduced by lowering the ramp rate to the slowest possible setting. If overshoot is still a problem, the Ramp Overshoot Reduction[JJ] setting can be used. A setting of 0% overshoot reduction results in no change to the amount of overshoot. A setting of 100% provides maximum overshoot reduction. Ramp Overshoot Reduction must be tuned to the optimal level. Too little reduction may result in overshoot while too much reduction may result in undershoot.

The BESTCOMS*Plus* AVR Bias Control Settings screen is illustrated in Figure 4-67.

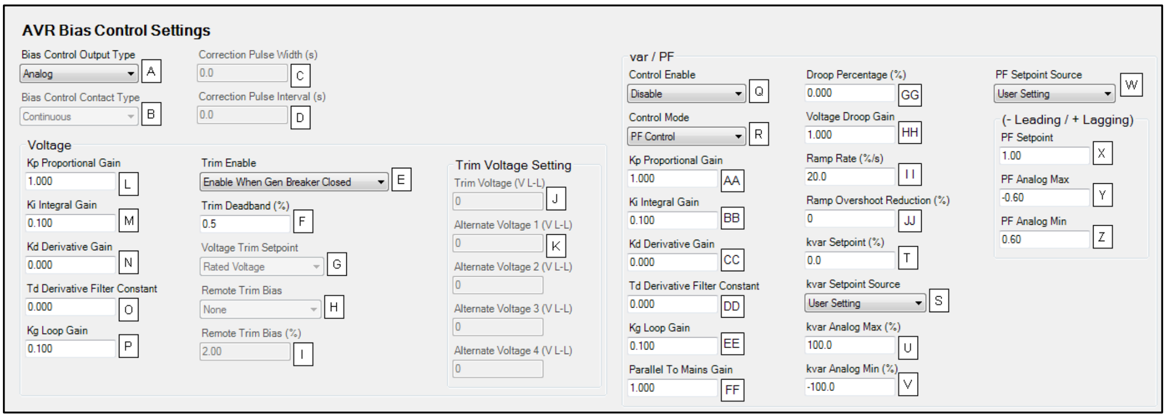

Figure 4-67. AVR Bias Control Settings

[A] *Bias Control Output Type:* Contact or Analog.
[B] *Bias Control Contact Type:* Continuous or Proportional.
[C] *Correction Pulse Width:* Adjustable from 0 to 99.9 s in 0.1 s increments.
[D] *Correction Pulse Interval:* Adjustable from 0 to 99.9 s in 0.1 s increments.
[E] *Trim Enable:* Disable, Enable, or Enable When Gen Breaker Closed (Rev 3 hardware only).
[F] *Trim Deadband:* Adjustable from 0 to 2 percent in increments of 0.1.
[G] *Voltage Trim Setpoint:* Rated Voltage or Trim Voltage Setting.
[H] *Remote Trim Bias:* None, LSM Analog Input 1, or ALG IN 1 through 8.
[I] *Remote Trim Bias:* Adjustable from 0 to 10 percent in increments of 0.01.
[J] *Trim Voltage:* Adjustable from 0 to 99,999 V_{L-L} in increments of 1.
[K] *Alternate Voltage 1-4:* Adjustable from 0 to 99,999 V_{L-L} in increments of 0.01.
[L] *Proportional Gain (Kp):* Adjustable from 0 to 1,000 in increments of 0.001.
[M] *Integral Gain (Ki):* Adjustable from 0 to 1,000 in increments of 0.001.
[N] *Derivative Gain (Kd):* Adjustable from 0 to 1,000 in increments of 0.001.
[O] *Derivative Filter Constant (Td):* Adjustable from 0 to 1 in increments of 0.001.

[P] *Loop Gain (Kg):* Adjustable from 0 to 1,000 in increments of 0.001.
[Q] *Control:* Disable or Enable.
[R] *Control Mode:* var Control or PF Control.
[S] *kvar Setpoint Source:* User Setting, LSM Analog Input 1, or Analog Inputs 1-8.
[T] *kvar Setpoint:* Adjustable from –100 to 100 percent in 0.1% increments.
[U] *kvar Analog Max:* Adjustable from 0 to 100 percent in 0.1% increments.
[V] *kvar Analog Min:* Adjustable from 0 to 100 percent in 0.1% increments.
[W] *PF Setpoint Source:* User Setting, LSM Analog Input 1, or Analog Inputs 1-8.
[X] *PF Setpoint:* Adjustable from –0.60 to 0.60 in increments of 0.01.
[Y] *PF Analog Max:* Adjustable from –0.60 to 0.60 in increments of 0.01.
[Z] *PF Analog Min:* Adjustable from –0.60 to 0.60 in increments of 0.01.
[AA] *Proportional Gain (Kp):* Adjustable from 0 to 1,000 in increments of 0.001.
[BB] *Integral Gain (Ki):* Adjustable from 0 to 1,000 in increments of 0.001.
[CC] *Derivative Gain (Kd):* Adjustable from 0 to 1,000 in increments of 0.001.
[DD] *Derivative Filter Constant (Td):* Adjustable from 0 to 1 in increments of 0.0001.
[EE] *Loop Gain (Kg):* Adjustable from 0 to 1,000 in increments of 0.001.
[FF] *Parallel To Mains Gain:* Adjustable from 0 to 1,000 in increments of 0.001.
[GG] *Droop Percentage:* Adjustable from 0 to 10% in 0.001% increments.
[HH] *Voltage Droop Gain:* Adjustable from 0 to 1,000 in increments of 0.001.
[II] *Ramp Rate:* Adjustable from 0 to 100 %/s in 0.1 %/s increments.
[JJ] *Ramp Overshoot Reduction:* Adjustable from 0 to 100% in increments of 1.

Governor Bias Control Settings

The bias control output type[A] should be set to contact when operating without an optional LSM-2020.

The MGC-2000 Series adjusts the generator voltage and frequency by issuing speed correction signals to the generator governor. Correction signals are issued in the form of MGC-2000 Series output contact closures. These correction signals can be either continuous or proportional[B]. Proportional correction uses control pulses of varying widths[C] and intervals[D]. Initially, long pulses are issued when the voltage and frequency differences are large. As the correction pulses take effect and the voltage and frequency differences become smaller, the correction pulse widths are proportionally decreased. Proportional correction pulses are beneficial in applications where fixed correction pulses can result in overshooting the slip frequency and regulation offset targets.

When an optional LSM-2020 is connected, the bias control output type[A] should be set to analog. This enables a PID controller that controls the bias signal from the LSM-2020 to the speed governor. The controller adjusts the bias output to drive the error between desired generator speed and measured generator speed to zero. Settings are provided for proportional gain[E], integral gain[F], derivative gain[G], derivative filter constant[H], and loop gain[I] of the PID controller.

The speed trim enable setting[J] sets speed trimming to the speed trim setpoint[K] when the generator breaker is closed and the machine is not paralleled to the utility.

When the difference between the measured speed and the speed trim set point is less than the trim dead band[L], the speed trim controller will treat this as zero error. If system operation appears "nervous" when speed trim is enabled, setting a nonzero dead band may result in smoother system operation. In addition, if machines do not appear to share kW equally when speed trim is enabled, setting a nonzero dead band will likely result in improved kW sharing. The Speed Trim Dead Band is in units of Hz.

The Remote Speed Bias setting provides for biasing the speed of a group of generators on a bus, by as much as ±5%, for synchronizing to the utility. When the Remote Speed Bias setting[M] is configured for the LSM-2020 input or an AEM-2020 input, the speed trim setpoint is calculated based on the specific analog input. The Remote Speed Bias (%) setting[N] corresponds to the maximum and minimum analog input range.

If speed trimming is enabled in all generators in an islanded system, it is ensured that the system will run at the speed trim setpoint. If it is not enabled in any units, the islanded system might deviate from the speed trim setpoint, depending on the initial speed settings of the isochronous governors. Speed trim should be enabled in all units or disabled in all units of an islanded system. If it is enabled in only a subset of the units, speed trimming and load sharing might conflict, resulting in unpredictable load sharing and system frequency.

The BESTCOMS*Plus* Governor Bias Control Settings screen is illustrated in Figure 4-68.

kW Control - Real Power Control Settings

When enabled[O], the MGC-2000 Series, used in conjunction with an optional LSM-2020, can accomplish kW sharing between similarly equipped generators. kW sharing can be performed via Ethernet or Analog lines. The communication method is selected using the Load Share Interface setting[P]. When an optional LSM-2020 is not connected, kW control is disabled.

kW control is accomplished with a PID controller that controls the speed bias signal from the LSM-2020 to the speed governor. The controller adjusts the bias output to drive the error between desired kW generation and measured kW generation to zero.

Settings are provided for proportional gain[Q], integral gain[R], derivative gain[S], derivative filter constant[T], loop gain[U], and Parallel To Mains Gain[V] of the PID controller.

The percent speed droop to be used when the unit is in droop mode is determined by the droop percentage setting[W]. Speed droop mode is entered any time the generator breaker is open. Speed droop is also the mode when the generator breaker is closed if kW load sharing is disabled. If it is desired to disable speed droop, set the droop percentage to 0. The speed droop gain setting[X] determines the gain factor applied to the speed droop percentage to compensate for governor differences and achieve desired droop performance. In order to test the operation of droop, the unit must be loaded to full load and the resulting generator speed should be compared to the desired droop. If it is not possible to load the unit to full load, the droop test can be performed at partial load. The expected speed is determined by the following equation.

Expected rpm reduction in droop - (actual load/machine capacity) ∗ (droop percentage/100) ∗ rated speed.

If the actual rpm drop does not match the expected value, calculate the error by dividing the expected drop by the actual drop, and putting the result in as the droop gain.

Ramp rate[Y] is defined as the rate, in percentage of machine capacity, at which the machine will ramp up its real power when loading or coming online. The machine also uses this rate to unload prior to cooling down. If a machine is the only machine online, ramping will not be in effect.

After ramping a generator's kW output, to bring it online or offline, overshoot may occur. The likeliness of kW overshoot increases as the ramp rate increases. Typically, overshoot is reduced by lowering the ramp rate to the slowest possible setting. If overshoot is still a problem, the Ramp Overshoot Reduction[Z] setting can be used. A setting of 0% overshoot reduction results in no change to the amount of overshoot. A setting of 100% provides maximum overshoot reduction. Ramp Overshoot Reduction must be tuned to the optimal level. Too little reduction may result in overshoot while too much reduction may result in undershoot.

When User Setting is selected for the base load level source[AA], the base load level setting[BB] determines the percent of machine capacity at which the kW controller will regulate if the generator is paralleled to the utility. If paralleled to the utility, the Parallel to Mains logic element in BESTlogic*Plus* must be driven by logic or a contact input. If parallel to utility operation is undertaken and the Parallel to Mains logic element is not implemented, the MGC-2000 Series will remain in kW load share and will either move toward operation at 100% of capacity or 0 capacity resulting in damage to the machine or system.

When the base load level source is configured for LSM-2020 input or an AEM-2020 input, the operating kW controller set point is calculated based on the specific analog input. Parameters are available for baseload analog max[CC] and baseload analog min[DD].

When the unit unloads, the generator breaker will open when the power generated by the unit falls below the breaker open setpoint[EE].

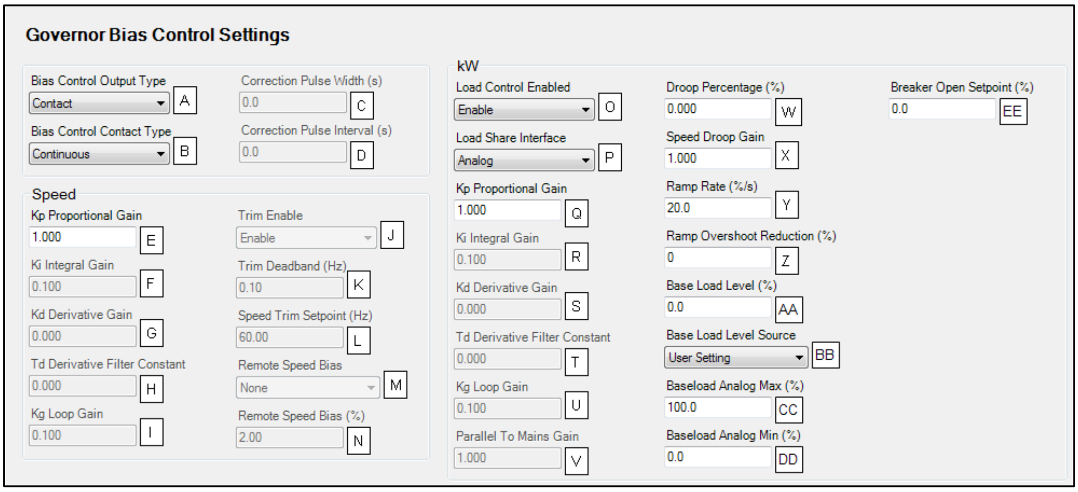

Figure 4-68. Governor Bias Control Settings

[A] *Bias Control Output Type:* Contact or Analog.
[B] *Bias Control Contact Type:* Continuous or Proportional.
[C] *Correction Pulse Width:* Adjustable from 0 to 99.9 s in 0.1 s increments.
[D] *Correction Pulse Interval:* Adjustable from 0 to 99.9 s in 0.1 s increments.
[E] *Proportional Gain (Kp):* Adjustable from 0 to 1,000 in increments of 0.001.
[F] *Integral Gain (Ki):* Adjustable from 0 to 1,000 in increments of 0.001.
[G] *Derivative Gain (Kd):* Adjustable from 0 to 1,000 in increments of 0.001.
[H] *Derivative Filter Constant (Td):* Adjustable from 0 to 1 in increments of 0.001.
[I] *Loop Gain (Kg):* Adjustable from 0 to 1,000 in increments of 0.001.
[J] *Speed Trim Enable:* Enable or Disable.
[K] *Speed Trim Setpoint:* Adjustable from 47 to 440 Hz in 0.01 Hz increments.
[L] *Trim Deadband:* Adjustable from 0 to 2 percent in increments of 0.1
[M] *Remote Speed Bias:* User Setting, LSM Analog Input 1, or ALG IN 1 through ALG IN 8.
[N] *Remote Speed Bias (%):* Adjustable from 0 to 5%, in increments of 0.01.
[O] *Load Control Enabled:* Enable or Disable.
[P] *Load Share Interface:* Analog or Ethernet
[Q] *Proportional Gain (Kp):* Adjustable from 0 to 1,000 in increments of 0.001.
[R] *Integral Gain (Ki):* Adjustable from 0 to 1,000 in increments of 0.001.
[S] *Derivative Gain (Kd):* Adjustable from 0 to 1,000 in increments of 0.001.
[T] *Derivative Filter Constant (Td):* Adjustable from 0 to 1 in increments of 0.001.
[U] *Loop Gain (Kg):* Adjustable from 1 to 1,000 in increments of 0.001.
[V] *Parallel To Mains Gain:* Adjustable from 0 to 1,000 in increments of 0.001.
[W] *Droop Percentage:* Adjustable from 0 to 10 percent in 0.001% increments.
[X] *Speed Droop Gain:* Adjustable from 0 to 1,000 in increments of 0.001.
[Y] *Ramp Rate:* Adjustable from 0 to 100 percent/second in 0.1%/s increments.
[Z] *Ramp Overshoot Reduction:* Adjustable from 0 to 100% in increments of 1.
[AA] *Base Load Level Source:* User Setting, LSM Analog Input 1, or Analog Inputs 1-8.
[BB] *Base Load Level:* Adjustable from 0 to 100% in 1% increments.
[CC] *Baseload Analog Max:* Adjustable from 0 to 100% in 0.1% increments.
[DD] *Baseload Analog Min:* Adjustable from 0 to 100% in 0.1% increments.
[EE] *Breaker Open Setpoint:* Adjustable from 0 to 100% in 0.1% increments.

Multigen Management

This group of settings is used when an optional LSM-2020 (Load Share Module) is connected to the MGC-2000 Series. Multigen management settings consist of settings for AVR output, governor output, load share output, demand start/stop, generator sequencing, and network configuration.

AVR Output

The AVR output[A] of the LSM-2020 is used to change the voltage setpoint of the generator. If the response[B] is set for increasing, an increased bias will cause higher voltage. If the response[B] is set for decreasing, an increased bias will cause lower voltage. Settings are provided for minimum output current[C], maximum output current[D], minimum output voltage[E], and maximum output voltage[F].

The BESTCOMS*Plus* AVR Output screen is illustrated in Figure 4-69.

Figure 4-69. AVR Output

[A] *Output Type:* Voltage or Current.
[B] *Response:* Increasing or Decreasing.
[C] *Min Output Current:* Adjustable from 4 to 20 mA in 0.1 mA increments.
[D] *Max Output Current:* Adjustable from 4 to 20 mA in 0.1 mA increments.
[E] *Min Output Voltage:* Adjustable from –10 to +10 V in 0.01 V increments.
[F] *Max Output Voltage:* Adjustable from –10 to +10 V in 0.01 V increments.

Governor Output

The governor output[A] of the LSM-2020 is used to change the speed setpoint of the generator. If the response[B] is set for increasing, an increased bias will cause faster speed. If the response[B] is set for decreasing, an increased bias will cause slower speed. Settings are provided for minimum output current[C], maximum output current[D], minimum output voltage[E], and maximum output voltage[F].

The BESTCOMS*Plus* Governor Output screen is illustrated in Figure 4-70.

Figure 4-70. Governor Output

[A] *Output Type:* Voltage or Current.
[B] *Response:* Increasing or Decreasing.
[C] *Min Output Current:* Adjustable from 4 to 20 mA in 0.1 mA increments.
[D] *Max Output Current:* Adjustable from 4 to 20 mA in 0.1 mA increments.
[E] *Min Output Voltage:* Adjustable from –10 to +10 V in 0.01 V increments.
[F] *Max Output Voltage:* Adjustable from –10 to +10 V in 0.01 V increments.

Load Share Output

The generator uses the measured load share output to calculate per unitized average load level, and uses that as the set point for its kW controller. Settings are provided for maximum voltage[A] and minimum voltage[B].

The BESTCOMS*Plus* Load Share Output screen is illustrated in Figure 4-71.

Figure 4-71. Load Share Output

[A] *Max Voltage:* Adjustable from –10 to +10 V in 0.01 V increments.
[B] *Min Voltage:* Adjustable from –10 to +10 V in 0.01 V increments.

Demand Start/Stop

When enabled[A], Demand Start/Stop (DSS) issues start and stop requests based on per unitized system load. The primary function of DSS is to provide start and stop request information to the sequencing handler. Generator sequencing must be enabled in order for Demand Start/Stop to function. If system load is above a set level[B] and the corresponding start level timeout[C] has been exceeded, a corresponding start request is issued. If system load is below the delayed stop level[D] and the stop timeout[E] has been exceeded, a stop request is issued.

The BESTCOMS*Plus* Demand Start/Stop screen is illustrated in Figure 4-72.

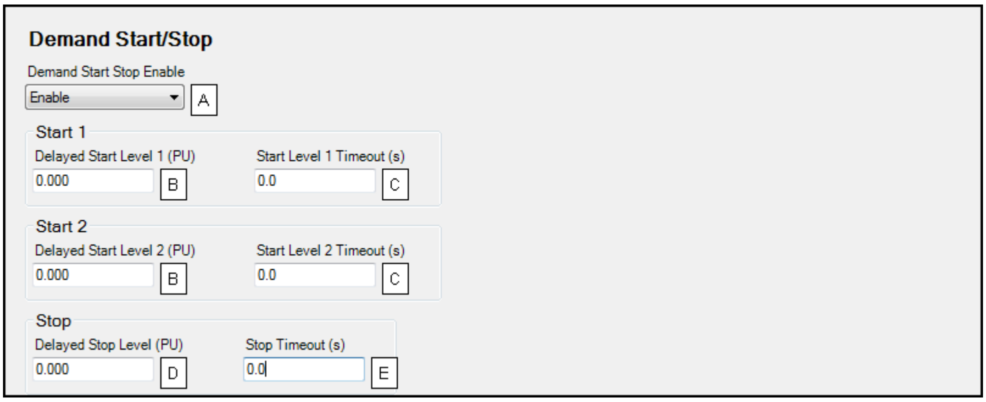

Figure 4-72. Demand Start/Stop

[A] *Demand Start Stop Enable:* Enable or Disable.
[B] *Delayed Start Level:* Adjustable from 0 to 1 in increments of 0.001.
[C] *Start Level Timeout:* Adjustable from 0 to 600 s in 0.1 s increments.
[D] *Delayed Stop Level:* Adjustable from 0 to 1 in increments of 0.001.
[E] *Stop Timeout:* Adjustable from 0 to 600 s in 0.1 s increments.

Generator Sequencing

Enabling sequencing on a networked group of load share units allows these units to manage load by starting and stopping appropriate units based on a factor of load demand and available capacity. The mode[A] of operation is used to determine the order in which each generator in a group will contribute to the systems power production upon a demand start/stop request. The maximum start time[B] setting defines the time to wait after a start request before demand start/stop can request the next priority unit to start. The maximum stop time[C] defines the time to wait after a demand start/stop request before the next unit responds to a demand start/stop request.

Each LSM-2020 maintains its own start/stop status with respect to sequencing. When there is a change to generator sequencing mode on any one unit, this change will propagate to all connected units that are not in the disabled mode. All units on the network are notified of this mode change via the system. A unit is available for sequencing if it is in auto mode and its sequencing mode is other than disabled.

If two or more units have the same sorting order parameter, the sequencing ID[D] will be used to determine which unit has priority. For example, if the sequencing mode is set for largest size first and both are 100 kW machines, the unit with the lower sequencing ID will be given priority. In the event that both units have the same sequencing ID, the unit with the lower unit ID (based on the Mac address) will be given priority.

If a unit fails to sequence on, the next generator in the sequence will be requested. The generator that previously failed will be requested again in the next sequence cycle.

The last machine can be shut down if there is no load on the system by enabling Allow Last Unit Shutdown[E].

The BESTCOMS*Plus* Generator Sequencing screen is illustrated in Figure 4-73.

The available sequencing modes are defined in the following paragraphs.

Disabled

This is the only mode that can coexist with a different mode on a networked system. A unit configured as disabled does not participate in sequenced starting and stopping and does not respond to demand start/stop requests.

Staggered Service Time

If this mode is selected, units will seek to sort the start priority of all non-disabled networked units in ascending order of service hours remaining. In this configuration, a network of units will respond to a demand start request by starting the unit with the least number of service hours remaining first. If a unit is down to zero service hours remaining, it is moved to the lowest start priority position. In the event that two or more units have matching service hours remaining, the unit with the lowest sequencing ID is assigned highest start priority. Units in Auto Run mode with the highest number of service hours remaining respond to demand stop requests first.

Balanced Service Time

If this mode is selected, units will seek to sort the start priority of all non-disabled networked units in ascending order of service hours remaining. In this configuration, a network of units will respond to a demand start request by starting the unit with the greatest number of service hours remaining first. In the event that two or more units have matching service hours remaining, the unit with the lowest sequencing ID is assigned highest start priority. Units in Auto Run mode with the lowest number of service hours remaining respond to demand stop requests first.

Largest Size First

If this mode is selected, units will seek to sort the start priority of all non-disabled networked units in descending order of real load capacity. In this configuration, a network of units will respond to a demand start request by starting the unit with the largest load capacity first. In the event that two or more units have matching capacities, the unit with the lowest sequencing ID is assigned highest start priority. The stopping order will be the reverse of the starting order.

Smallest Size First

If this mode is selected, units will seek to sort the start priority of all non-disabled networked units in ascending order of real load capacity. In this configuration, a network of units will respond to a demand start request by starting the unit with the smallest load capacity first. In the event that two or more units have matching capacities, the unit with the lowest sequencing ID is assigned highest start priority. The stopping order will be the reverse of the starting order.

Smallest Unit ID

If this mode is selected, units will seek to sort the start priority of all non-disabled networked units in ascending order according to the sequencing ID. In this configuration, a network of units will respond to a demand start request by starting the unit with the smallest sequencing ID. Units must have unique sequencing IDs to be part of a network. The stopping order will be the reverse of the starting order.

Adopt System Mode

If this mode is selected, units will first check to see if a consistent mode is present on the currently networked controllers. If a consistent mode is found, that mode is adopted. If a consistent mode is not found, the unit enters a mode mismatch state. If a mode mismatch occurs, verify that all machines on the network are configured for the same generator sequencing mode.

Figure 4-73. Generator Sequencing

[A] *Mode:* Disabled, Staggered Service Time, Balanced Service Time, Largest Size First, Smallest Size first, Smallest Unit ID First, or Adopt System Mode.
[B] *Max Gen Start Time:* Adjustable from 1 to 3,000 s in 1 s increments.
[C] *Max Gen Stop Time:* Adjustable from 1 to 3,000 s in 1 s increments.
[D] *Sequencing ID:* Adjustable from 0 to 255 in increments of 1.
[E] *Allow Last Unit Shutdown:* Enable or Disable.

Network Configuration

The sequencing ID of the unit being programmed and the sequencing IDs of all other units on a networked system should be entered in the expected sequence ID table[A]. If the state of any unit changes to offline and the ID Missing pre-alarm is enabled, an ID Missing pre-alarm appears on the front panel HMI and BESTCOMS*Plus* metering screen. If an expected sequence ID is detected on two or more units and the ID Repeat pre-alarm is enabled, an ID Repeat pre-alarm appears on the front panel HMI and the BESTCOMS*Plus* metering screen.

The BESTCOMS*Plus* Network Configuration screen is illustrated in Figure 4-74.

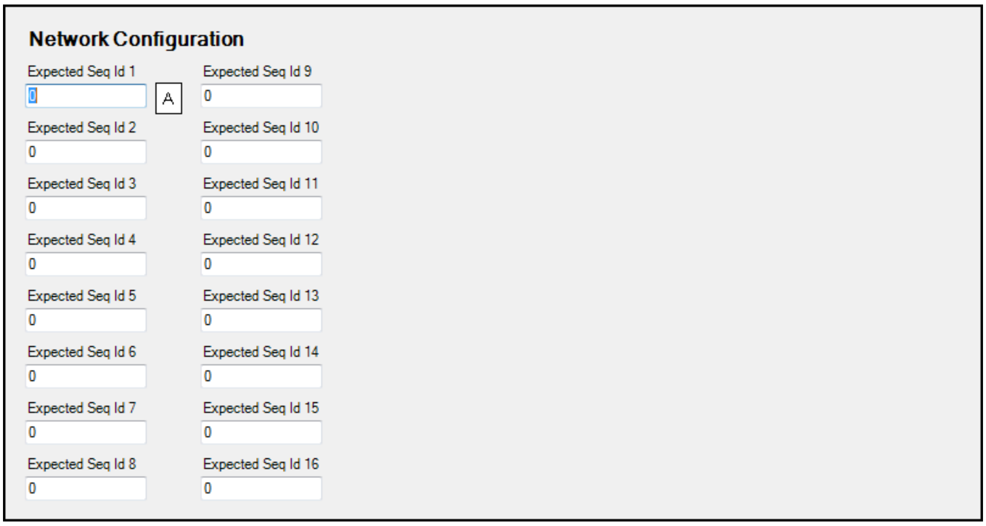

Figure 4-74. Network Configuration

[A] *Expected Seq Id:* Adjustable from 0 to 255.

Programmable Senders

The sender inputs of the MGC-2000 Series can be customized to obtain maximum accuracy from the coolant temperature, oil pressure, and fuel level senders.

TIM-ID: 0000099917 - 001

The characteristic curve of each sender input can be configured with up to 11 points[A]. Each point can be assigned a resistance input value and a corresponding temperature (coolant temperature sender), pressure (oil pressure sender), or percentage (fuel level sender) value. A sender slope setting[B] automatically orders the values in the resistance column according to whether the sender requires a negative or positive slope. Sender curve points are automatically plotted on a curve[C] in BESTCOMS*Plus*, which can be printed[D].

Sender curve points configured in BESTCOMS*Plus* can be saved in the configuration file[E]. The data for all three senders is automatically saved with the MGC-2000 Series configuration file.

Any changes made in BESTCOMS*Plus* to the sender points, can be reverted to the factory-default values[F]. A new settings file can also be created[G].

The BESTCOMS*Plus* Coolant Temperature programmable sender screen is illustrated in Figure 4-75. (The contents and layout of each BESTCOMS*Plus* programmable sender screen is identical.)

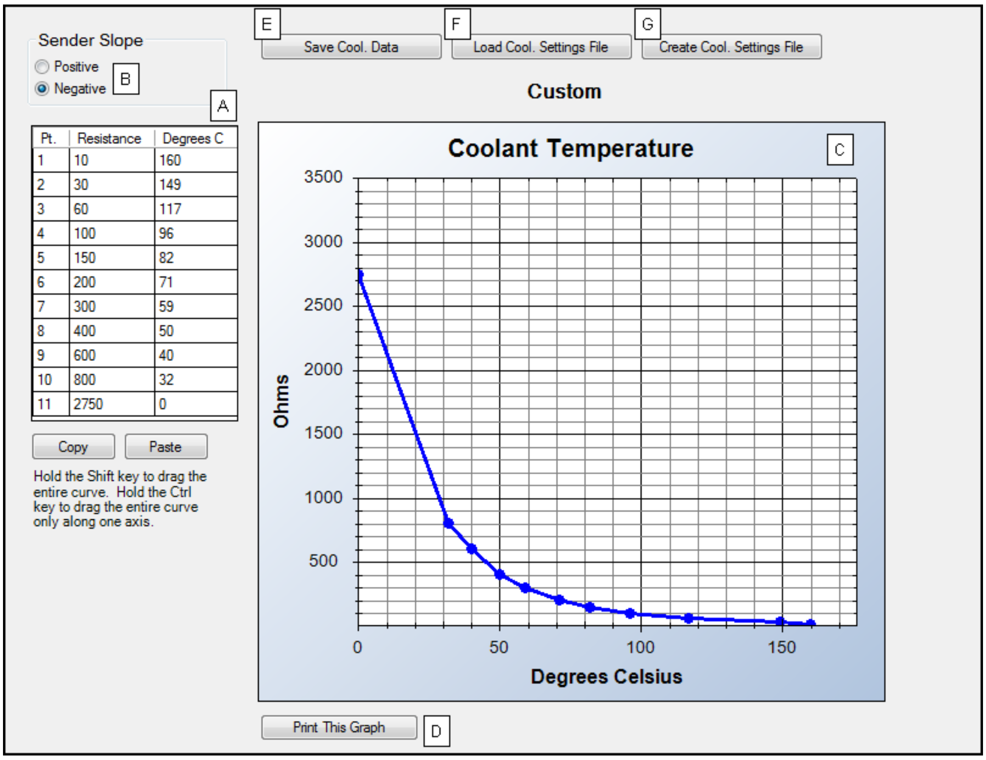

Figure 4-75. Coolant Temperature

[A] *Sender Points:* Accepts up to 11 user-defined sender resistance points.
[B] *Sender Slope:* Positive or Negative causes sender points to be sorted and displayed accordingly.
[C] *Sender Point Curve:* Automatic plot of sender points data.
[D] *Print This Graph:* Click to print sender point curve.
[E] *Save Cool. Data:* Click to save file containing sender point data.
[F] *Load Cool. Settings File:* Click to clear all user-defined sender data and revert to the factory-default values.
[G] *Create Cool. Settings File:* Click to create a new settings file by entering sender point data.

BESTlogic™Plus Programmable Logic

BESTlogic*Plus* Programmable Logic is used to set all logic functions in the MGC-2000 Series. For detailed information on using BESTlogic*Plus*, refer to Section 5, *BESTlogicPlus Programmable Logic.*

Logic Timers

Refer to Section 5, *BESTlogicPlus Programmable Logic,* for information on using logic timers.

Settings File Management

A settings file contains all MGC-2000 Series settings including logic. A settings file assumes a file extension of "∗.bst" or "∗.bstx". It is possible to save the logic only as a separate logic library file on the *BESTlogicPlus Programmable Logic* screen. This is helpful when similar logic is required for several devices. A logic library file assumes a file extension of "∗.bsl" or "∗.bslx". It is important to note that settings and logic can be uploaded to the device separately or together, but are always downloaded together. For more information on settings file management, refer to Section 3, *BESTCOMSPlus*. For more information on logic files, refer to Section 5, *BESTlogicPlus Programmable Logic*.

> **NOTE**
>
> Beginning with BESTCOMS*Plus* version 2.06.01, settings files are saved as "∗.bstx". Settings files opened with the previous "∗.bst" extension will be converted to "∗.bstx" when saved. A settings file with the "∗.bstx" extension can only be opened with BESTCOMS*Plus* version 2.06.01 and later.

Opening a Settings File

To open an MGC-2000 Series settings file with BESTCOMS*Plus*, pull down the *File* menu and choose *Open*. The *Open* dialog box appears. This dialog box allows you to use normal Windows techniques to select the file that you want to open. Select the file and choose *Open*. You can also open a file by clicking on the *Open File* button on the lower menu bar. If connected to a device, you will be asked to upload the settings and logic from the file to the current device. If you choose *Yes*, the settings displayed in BESTCOMSPlus will be overwritten with the settings of the opened file.

Saving a Settings File

Select *Save* or *Save As* from the *File* pull-down menu. A dialog box pops up allowing you to enter a filename and location to save the file. Select the *Save* button to complete the save.

Upload Settings and/or Logic to Device

To upload a settings file to the MGC-2000 Series, open the file through BESTCOMS*Plus* or create the file using BESTCOMS*Plus*. Then pull down the *Communication* menu and select *Upload Settings and Logic to Device.* If you want to upload operational settings without logic, select *Upload Settings to Device*. If you want to upload logic without operational settings, select *Upload Logic to Device*. You are prompted to enter the password. The default password is "OEM". If the password is correct, the upload begins and the progress bar is shown.

Download Settings and Logic from Device

To download settings and logic from the MGC-2000 Series, pull down the *Communication* menu and select *Download Settings and Logic from Device*. If the settings in BESTCOMS*Plus* have changed, a dialog box will open asking if you want to save the current settings changes. You can choose *Yes* or *No*. After you have taken the required action to save or discard the current settings, downloading begins. BESTCOMS*Plus* will read all settings and logic from the MGC-2000 Series and load them into BESTCOMS*Plus* memory.

Printing a Settings File

To view a preview of the settings printout, select *Print Preview* from the *File* pull-down menu. To print the settings, select the printer icon in the upper left corner of the *Print Preview* screen.

You can skip the print preview and go directly to print by pulling down the *File* menu and selecting *Print*. A dialog box, *Print* opens with the typical Windows choice to setup the properties of printer. Execute this command, as necessary, and then select *Print*.

Comparing Settings Files

BESTCOMS*Plus* has the ability to compare two settings files. To compare files, pull down the *Tools* menu and select *Compare Settings Files*. The *BESTCOMSPlus Settings Compare Setup* dialog box appears (Figure 4-76). Select the location of the first file under *Left Settings Source* and select the location of the second file under *Right Settings Source*. If you are comparing a settings file located on your PC hard drive or portable media, click the folder button and navigate to the file. If you want to compare settings

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downloaded from a unit, click the *Select Unit* button to set up the communication port. Click the *Compare* button to compare the selected settings files.

A dialog box will appear and notify you if any differences were found. The *BESTCOMSPlus Settings Compare* dialog box (Figure 4-77) is displayed where you can view all settings (*Show All Settings*), view only the differences (*Show Settings Differences*), view all logic *(Show All Logic Paths),* or view only logic differences *(Show Logic Path Differences).* Select *Close* when finished.

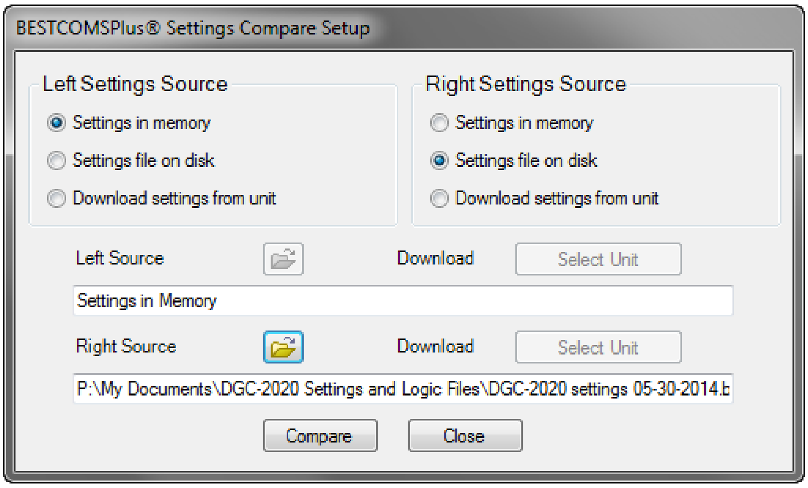

Figure 4-76. BESTCOMSPlus Settings Compare Setup

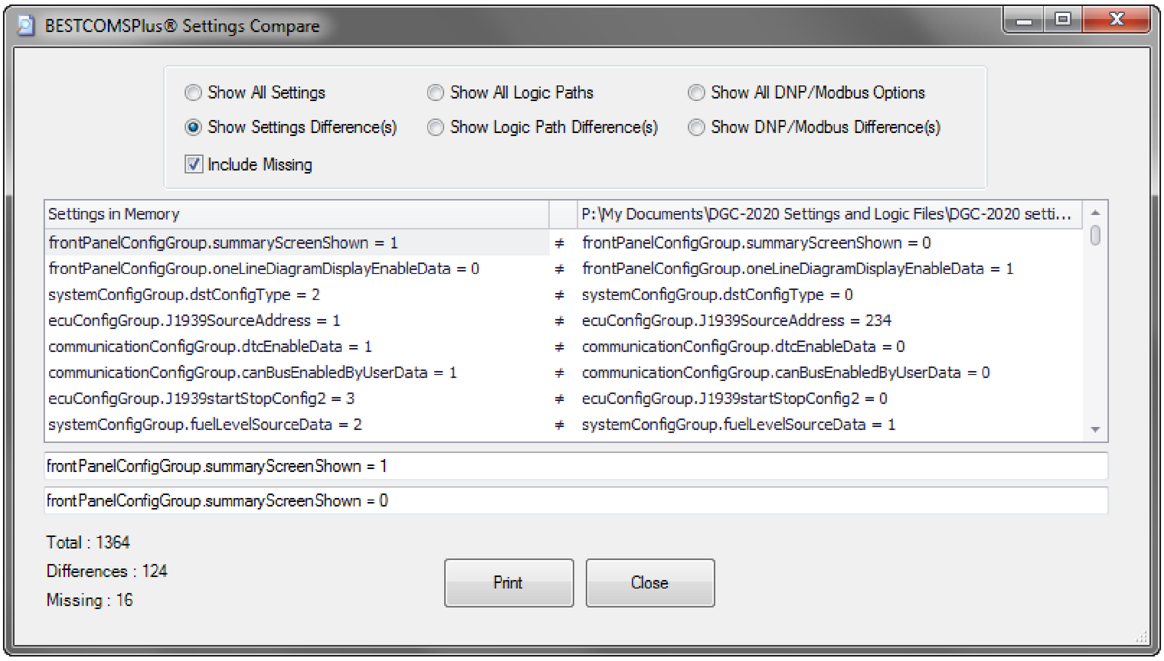

Figure 4-77. BESTCOMSPlus Settings Compare

Upgrading Firmware in the MGC-2000 Series and Expansion Modules

> **NOTE**
>
> The latest version of BESTCOMS*Plus* software should be downloaded from the Basler Electric website and installed before performing a firmware upgrade.

A device package contains firmware and a language module. Embedded firmware is the operating program that controls the actions of the MGC-2000 Series. The MGC-2000 Series stores firmware in nonvolatile flash memory that can be reprogrammed through the communication ports. It is not necessary to replace EPROM chips when updating the firmware with a newer version.

Future enhancements to the MGC-2000 Series functionality will make a firmware update desirable. Because default settings are loaded when DGC-2020 firmware is updated, your settings should be saved in a file prior to upgrading firmware.

The language of the front panel LCD can be changed by uploading a different language module into the MGC-2000 Series. The MGC-2000 Series stores the language module in nonvolatile flash memory; the language module contains all language translations for the MGC-2000 Series. The language module can be reprogrammed through the communications port. In general, any time a firmware upgrade is made to the MGC-2000 Series, the language module should be uploaded as well.

The MGC-2000 Series can be used in conjunction with several expansion modules that expand the MGC-2000 Series capabilities. MGC-2000 Series expansion modules include LSM-2020, CEM-2020, and AEM-2020. When upgrading the firmware in any component of this system, the firmware in ALL of the components of the system should be upgraded to ensure compatibility of communications between the various components.

CAUTION

The order in which the components are upgraded is critical. Assuming a system of an MGC-2000 Series and expansion modules is in a state where the MGC-2000 Series is communicating with all of the system expansion modules, **the expansion modules must be upgraded before the MGC-2000 Series.** This is required because the MGC-2000 Series must be able to communicate to the expansion module before the MGC-2000 Series can send firmware to it. If the MGC-2000 Series were upgraded first, and the new firmware included a change in the MGC-2000 Series to expansion module communication protocol, it is possible that the expansion modules could no longer communicate with the upgraded MGC-2000 Series. Without communications between the MGC-2000 Series and the expansion modules, upgrading the expansion modules is not possible.

NOTE

If power is lost or communication is interrupted during file transfer to the MGC-2000 Series, the MGC-2000 Series will cease operating and will not recover automatically. If this occurs or if the front panel HMI becomes blank and all LEDs are flashing at a 2-second rate, the MGC-2000 Series will not have valid firmware installed and the firmware must be uploaded again. To accomplish this, cycle power to the MGC-2000 Series and activate the MGC-2000 Series plugin in BESTCOMS*Plus*. Select *Upload Device Files* from the *Communication* pull-down menu and proceed normally.

Upgrading Firmware in Expansion Modules

The following procedure is used to upgrade firmware in MGC-2000 Series expansion modules. This must be completed before upgrading firmware in the MGC-2000 Series. If no expansion modules are present, proceed to *Upgrading Firmware in the MGC-2000 Series.*

1. Place the MGC-2000 Series in OFF mode. This can be accomplished by clicking the *Off* button on the *Control* screen inside the Metering Explorer or by pressing the *Off* button on the MGC-2000 Series front panel.
2. Enable the expansion modules that are present in the system. If they have not already been enabled, enable the expansion modules on the SETTINGS > SYSTEM PARAMETERS > REMOTE MODULE SETUP screen.
3. Verify that the MGC-2000 Series and all associated expansion modules are communicating. This can be verified by examining the pre-alarm status using the Metering Explorer in BESTCOMS*Plus* or from

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the front panel by navigating to METERING > ALARMS-STATUS > PRE-ALARMS. There should be no *Loss of Comms* pre-alarms in the pre-alarm status when communications are functioning properly.

4. Connect to the MGC-2000 Series through the USB port if not already connected. Firmware upgrades cannot be accomplished through the Ethernet port, with the exception of the LSM-2020.
5. Select *Upload Device Files* from the Communication pull-down menu.
6. You will be asked to save the current settings file. Select *Yes* or *No*.
7. When the *Basler Electric Device Package Uploader* screen (Figure 4-78) appears, click on the *Open* button to browse for the device package you have received from Basler Electric. The *Package Files* along with *File Details* are listed. Place a check in the boxes next to the individual files you want to upload.

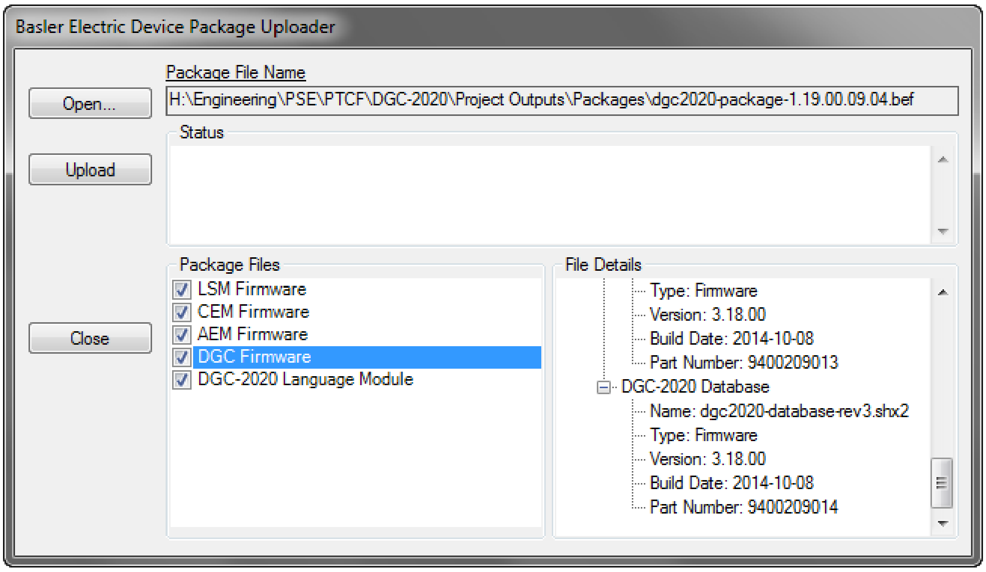


Figure 4-78. Basler Electric Device Package Uploader

8. Click on the *Upload* button and the *Proceed with Device Upload* screen will appear. Select *Yes* or *No*.
9. After selecting *Yes*, the *DGC-2020 Selection* screen will appear. Select the communication port to begin upload. Firmware updating is only possible locally through the USB port. Refer to Figure 4-79.

Figure 4-79. DGC-2020 Selection

10. The *Processing, Please Wait…* screen is displayed as file(s) are uploaded. See Figure 4-80.

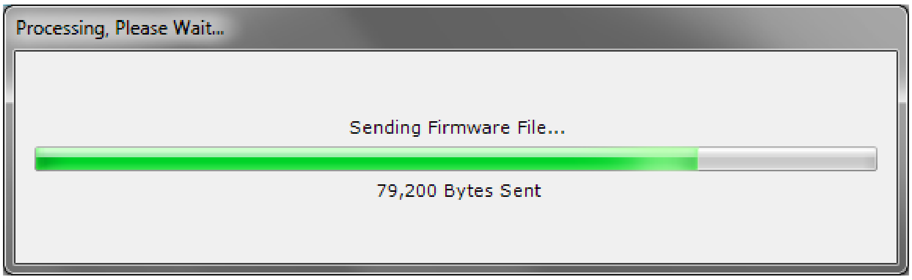


Figure 4-80. Processing, Please Wait…

11. After file(s) have been uploaded, click the *Close* button on the *Basler Electric Device Package Uploader* screen and disconnect communication to the MGC-2000 Series.

Upgrading Firmware in the MGC-2000 Series

A. Upgrade DGC-2020 firmware and then load a saved settings file.

1. Upgrade the DGC-2020 firmware and language module.
    a. Connect to the MGC-2000 Series with BESTCOMS*Plus*. Check the firmware Application Version on the GENERAL SETTINGS > VERSION INFO >DGC-2020 screen.
    b. Select *Upload Device Files* from the *Communication* pull-down menu. You do not have to be connected to the MGC-2000 Series at this time. Save settings when prompted, if desired.
    c. Open the desired device package file (****DGC-2020-*****_xxyyzz.bef, where **** may be additional descriptive text of varying length, and xx.yy.zz is the version number of the device package file.)
    d. Check the boxes for *DGC-2020 Firmware* and *DGC-2020 Language Module.* Note the version number of the DGC-2020 firmware; this is the version that will be used to set the Application Version in the settings file in a later step. This is NOT the same as the version of the package file that is contained in the fields xx.yy.zz in the package file name.
    e. Click the *Upload* button and follow the instructions that appear to begin the upgrade process.
    f. After the upload is complete, disconnect communication to the MGC-2000 Series.
2. Load the saved settings file into the MGC-2000 Series.
    a. Close all settings files.
    b. From the *File* pull-down menu, select *New*, *DGC-2020*.
    c. Connect to the MGC-2000 Series.
    d. Once all settings have been read from the MGC-2000 Series, open the saved settings file by selecting the file with *File, Open File* in the BESTCOMS*Plus* menu.
    e. When BESTCOMS*Plus* asks if you wish to upload settings and logic to the device, click *Yes*.
    f. If you are receiving upload failures and indications that the logic is incompatible with the firmware version, check that the MGC-2000 Series style number in the saved file matches that of the MGC-2000 Series into which the file is being uploaded. The style number in the settings file is found under GENERAL SETTINGS > STYLE NUMBER in BESTCOMS*Plus*.
    g. If the style number of the settings file does not match that of the MGC-2000 Series into which it is to be loaded, disconnect from the MGC-2000 Series, then modify the style number in the settings file. Then repeat the steps titled *Load the Settings File into the DGC-2020.*

NOTE

If the settings file was saved with a previous version of firmware, BESTCOMS*Plus* will automatically perform a settings file conversion to make the settings file compatible with the new firmware.

Metering Explorer

The Metering Explorer is a convenient tool within BESTCOMS*Plus* used to navigate through the following metering screens of the MGC-2000 Series plugin.

- Engine
- Generator
- Power
- Bias Control
- Run Statistics
- Status
- Inputs
    - Contact Inputs
    - Remote LSM Inputs
    - Remote Contact Inputs
    - Remote Analog Inputs
    - Remote RTD Inputs
    - Remote Thermocouple Inputs
    - Remote Analog Input Values
    - Logic Control Relays
- Outputs
    - Contact Outputs
    - Configurable Elements
    - Remote Contact Outputs
    - Remote Analog Outputs
- Configurable Protection
- Alarms
- Event Log
- J1939 ECU
    - ECU Data
    - Engine Configuration
    - Active DTC
    - Previously Active DTC
- MTU
    - MTU Alarms
    - MTU Fault Codes
    - MTU Status
    - MTU Engine Status
- Summary
- Control
- Real Time Clock
- Generator Network Status

The Metering Explorer has a "Docking" feature allowing the user to arrange and dock metering screens. A blue transparent square representing the screen being moved, seven arrow buttons, and a tabs button appear when holding down the left mouse button on a metering tab and dragging it out. See Figure 4-81. Table 4-8 explains the call-outs on Figure 4-81.

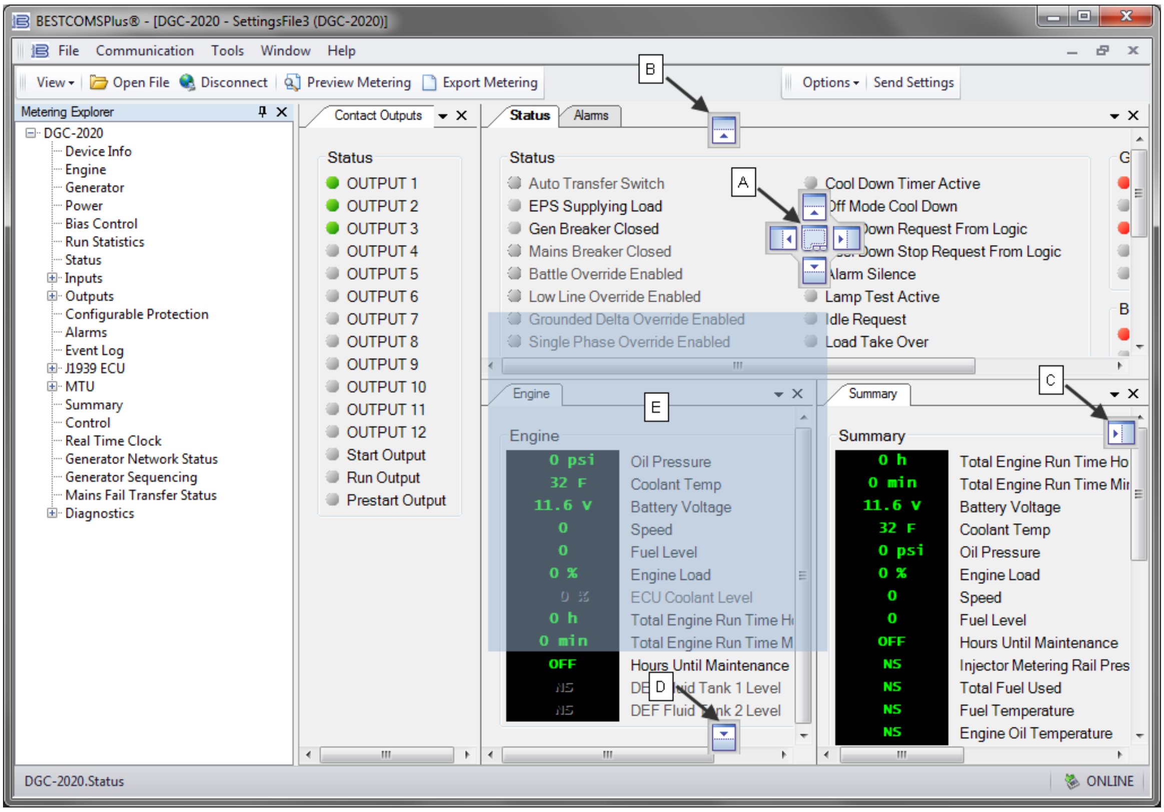
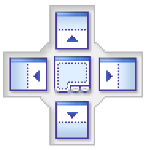
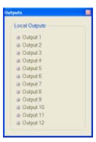


Figure 4-81. Metering, Docking Options

Table 4-8. Explanation of Call-Outs on Figure 4-81

Call-Out	Symbol	Explanation
A		Holding the left mouse button down on a metering tab and dragging it to one of the four arrow boxes will place it inside the selected window on the location selected. To place the metering tab as a tab inside the selected window, drop it on the tabs button in the center of the arrow buttons.
B		Holding the left mouse button down on a metering tab and dragging it to this arrow box will place it across the top of the screen. Click on the (thumbtack) to dock it on the top bar. To display a screen that is docked, simply use the mouse to hover the pointer over the tab on the top bar.
C		Holding the left mouse button down on a metering tab and dragging it to this arrow box will place it across the side of the screen. Click on the (thumbtack) to dock it on the side bar. To display a screen that is docked, simply use the mouse to hover the pointer over the tab on the side bar.
D		Holding the left mouse button down on a metering tab and dragging it to this arrow box will place it across the bottom of the screen. Click on the (thumbtack) to dock it on the bottom bar. To display a screen that is docked, simply use the mouse to hover the pointer over the tab on the bottom bar.
E		Holding the left mouse button down on a metering tab and dragging it to anywhere other than an arrow box will place it as a floating metering screen. This floating screen can later be closed by clicking on the in the upper right corner. It can also be dragged to one of the arrow boxes used for docking.

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Engine

This screen provides information and metering of engine components. Refer to Figure 4-82.

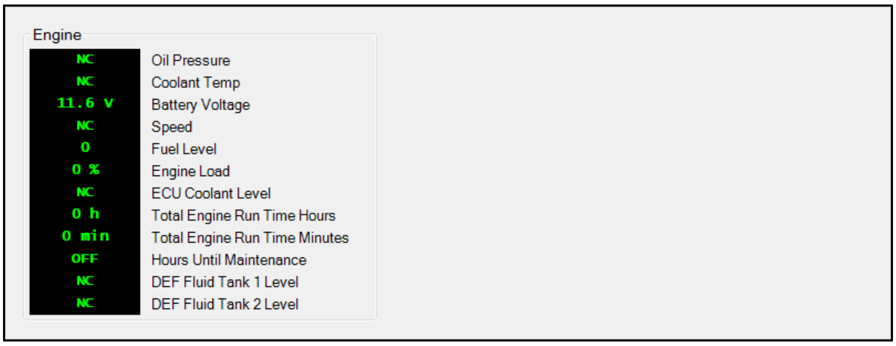

Figure 4-82. Metering, Engine

Generator

This screen provides metering of generator voltages and currents. Refer to Figure 4-83.

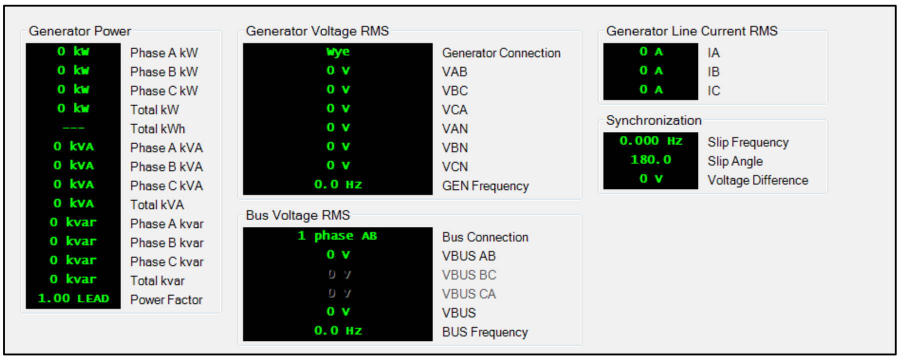

Figure 4-83. Metering, Generator

Power

This screen provides metering of generator power and power factor. Refer to Figure 4-84.

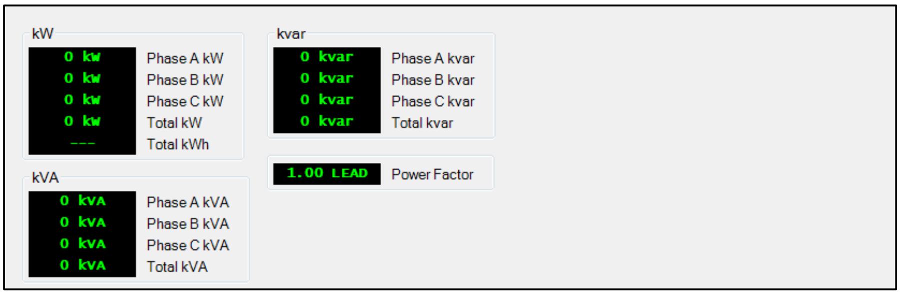

Figure 4-84. Metering, Power

Bias Control

This screen provides var/PF mode status and operating levels. Refer to Figure 4-85.

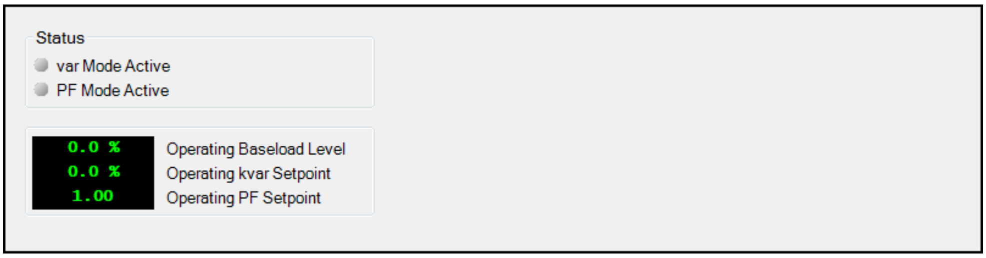

Figure 4-85. Metering, Bias Control

Run Statistics

This screen provides Cumulative Run Statistics, Session Run Statistics, and Commission Date. Refer to Figure 4-86.

The Hours Until Maintenance pre-alarm is configured on the Pre-Alarms screen in the Settings Explorer. The Hours Until Maintenance field will display "OFF" when the Maintenance Interval pre-alarm is disabled. Clicking Reset Maintenance Interval resets the Hours Until Maintenance to the value set for the Maintenance Interval pre-alarm on the Pre-Alarms screen in the Settings Explorer.

To change the commission date, click *Edit DGC Commission Date.* The DGC Commission Date dialog box appears. Enter the new commission date and click *Upload Data to Device.* Click *Close*. Note that the Commission Date field on the BESTCOMS*Plus* screen updates after the *Close* button is clicked.

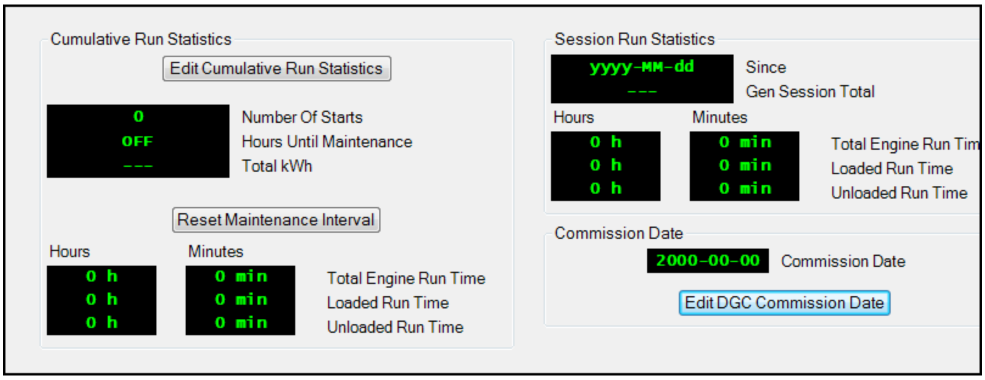

Figure 4-86. Metering, Run Statistics

Status

This screen indicates status of breakers, modes, switches, and I/O connection status. The status is TRUE when the corresponding LED is red. Refer to Figure 4-87.

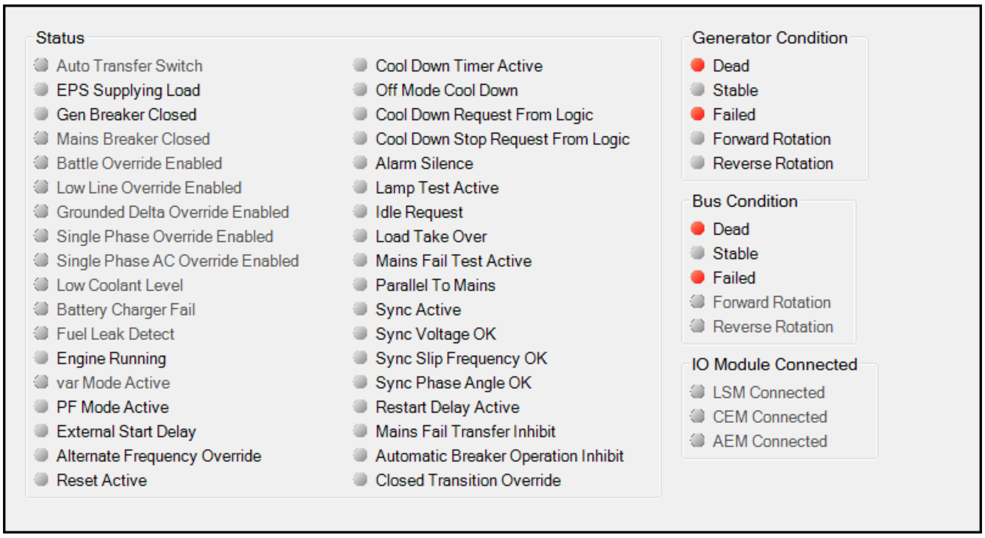

Figure 4-87. Metering, Status

Inputs

Contact Inputs

This screen indicates the status of contact inputs, contact input alarms, and contact input pre-alarms. The status is TRUE when the corresponding LED is red. Refer to Figure 4-88.

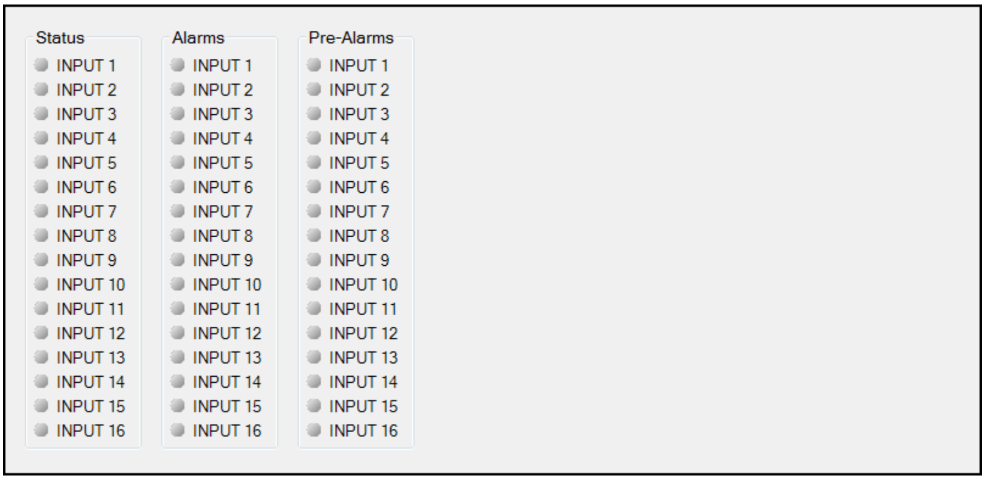

Figure 4-88. Metering, Inputs, Contact Inputs

Remote LSM Inputs

When an optional LSM-2020 (Load Share Module) is connected, the value of the analog inputs is displayed on this screen. Voltage is displayed when the input is configured for voltage and current is displayed when the input is configured for current. Refer to Figure 4-89.

Figure 4-89. Metering, Inputs, Remote LSM Inputs

Remote Contact Inputs

When an optional CEM-2020 (Contact Expansion Module) is connected, the status of the remote contact inputs, configurable remote contact input alarms, and remote contact input pre-alarms are shown on this screen. The status is TRUE when the corresponding LED is red. Refer to Figure 4-90.

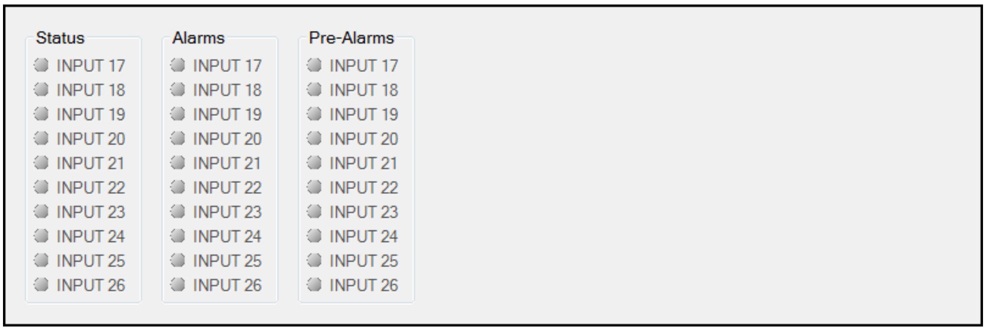

Figure 4-90. Metering, Inputs, Remote Contact Inputs

Remote Analog Inputs

When an optional AEM-2020 (Analog Expansion Module) is connected, the status of the remote analog inputs, remote analog input alarms, and remote analog input pre-alarms are shown on this screen. The status is TRUE when the corresponding LED is red. Refer to Figure 4-91. Remote Analog Input #1 is shown.

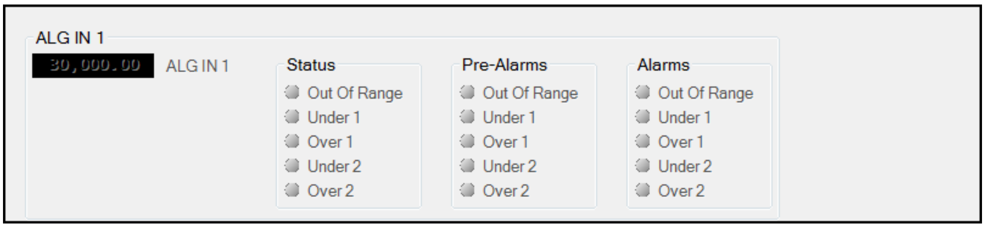

Figure 4-91. Metering, Inputs, Remote Analog Inputs

Remote RTD Inputs

When an optional AEM-2020 (Analog Expansion Module) is connected, the status of the remote RTD inputs, remote RTD input alarms, and remote RTD input pre-alarms are shown on this screen. The status is TRUE when the corresponding LED is red. Refer to Figure 4-92. Remote RTD Input #1 is shown.

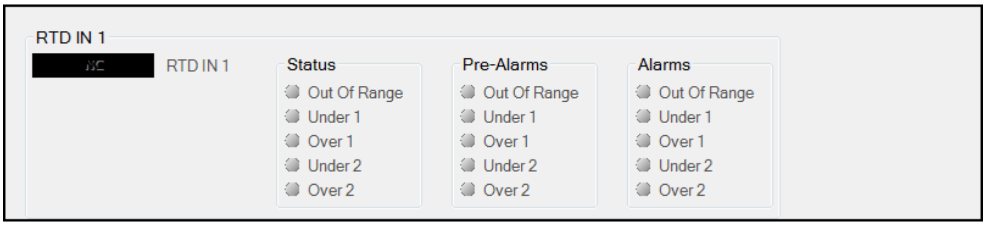

Figure 4-92. Metering, Inputs, Remote RTD Inputs

Remote Thermocouple Inputs

When an optional AEM-2020 (Analog Expansion Module) is connected, the status of the remote thermocouple inputs, remote thermocouple input alarms, and remote thermocouple input pre-alarms are shown on this screen. The status is TRUE when the corresponding LED is red. Refer to Figure 4-93. Remote Thermocouple Input #1 is shown.

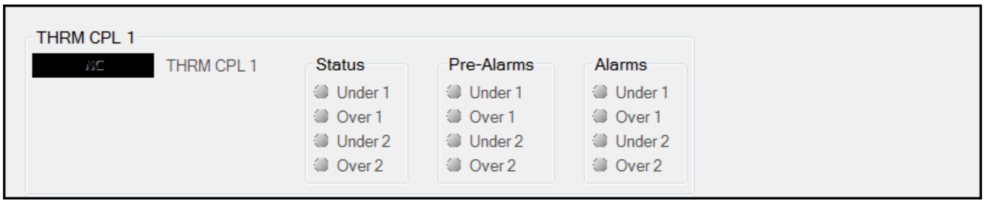

Figure 4-93. Metering, Inputs, Remote Thermocouple Inputs

Remote Analog Input Values

When an optional AEM-2020 (Analog Expansion Module) is connected, the values of the scaled analog inputs, raw analog inputs, RTD input temperatures, raw RTD inputs, thermocouple input temperatures, and raw thermocouple inputs are shown on this screen.

For each analog input, the raw metered input value is displayed along with the scaled metered input value. This is useful for checking if the AEM-2020 is seeing a valid raw input value (i.e. the raw 0 to 10 V voltage input or 4 to 20 mA current input). The scaled value is the raw input scaled up to the range specified by the Parameter Minimum and Parameter Maximum value parameters in the Remote Analog Input settings. Refer to Figure 4-93.

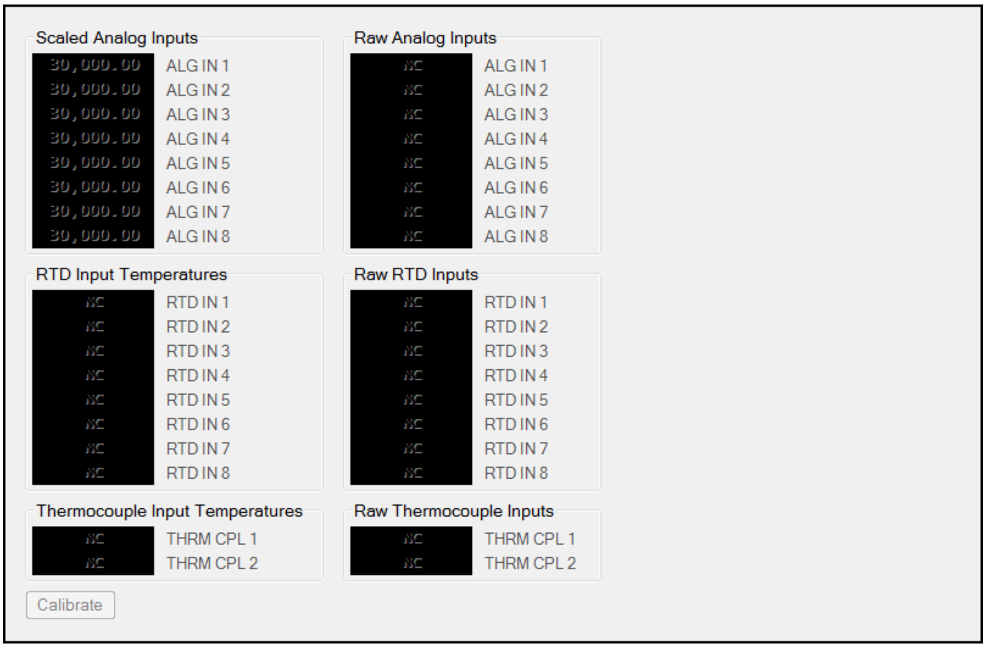

Figure 4-94. Metering, Inputs, Remote Analog Input Values

The *Calibrate* button shown on the Remote Analog Input Values screen opens the Analog Input Temperature Calibration screen shown in Figure 4-95. This screen is used to calibrate RTD inputs 1 through 8 and thermocouple inputs 1 and 2.

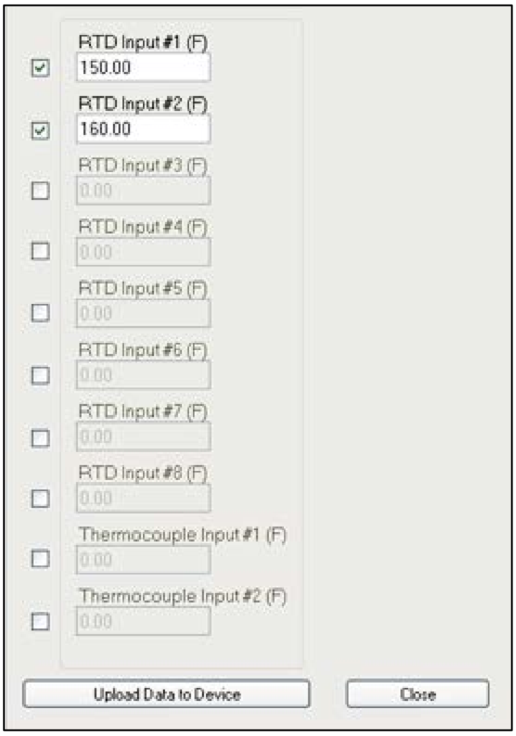

Figure 4-95. Analog Input Temperature Calibration

Logic Control Relays

Logic Control Relays

This screen indicates the status of logic control relays. The status is TRUE when the corresponding LED is green. Refer to Figure 4-96.

Figure 4-96. Metering, Outputs, Logic Control Relays

Outputs

Contact Outputs

This screen indicates the status of contact outputs. The status is TRUE when the corresponding LED is green. Refer to Figure 4-97.

Figure 4-97. Metering, Outputs, Contact Outputs

Configurable Elements

This screen indicates the status of configurable elements. It also indicates alarms and pre-alarms of configurable elements. The status is TRUE when the corresponding LED is green. Refer to Figure 4-98.

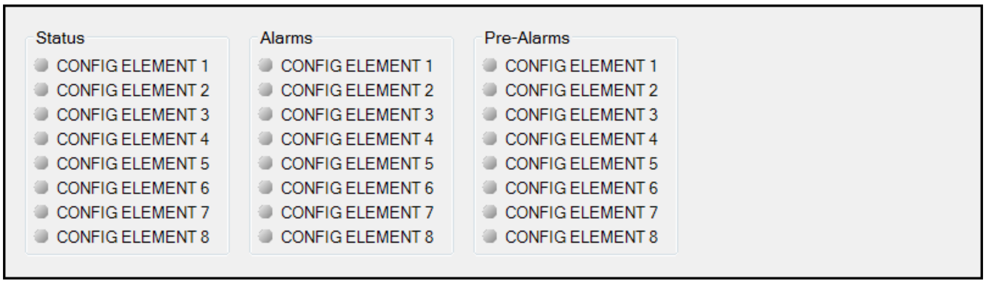

Figure 4-98. Metering, Outputs, Configurable Elements

Remote Contact Outputs

When an optional CEM-2020 (Contact Expansion Module) is connected, the status of the remote contact outputs is shown on this screen. The status is TRUE when the corresponding LED is green. Refer to Figure 4-99.

Figure 4-99. Metering, Outputs, Remote Contact Outputs

Remote Analog Outputs

When an optional AEM-2020 (Analog Expansion Module) is connected, the status of the remote analog outputs, scaled analog output values, and raw analog output values are shown on this screen. The status is TRUE when the corresponding LED is red.

Refer to Figure 4-100.

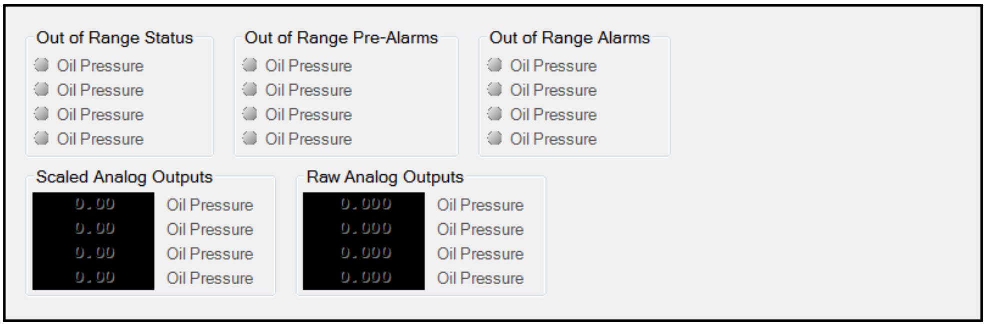

Figure 4-100. Metering, Outputs, Remote Analog Outputs

Configurable Protection

This screen indicates the status of configurable protection. The status is TRUE when the corresponding LED is green. Refer to Figure 4-101.

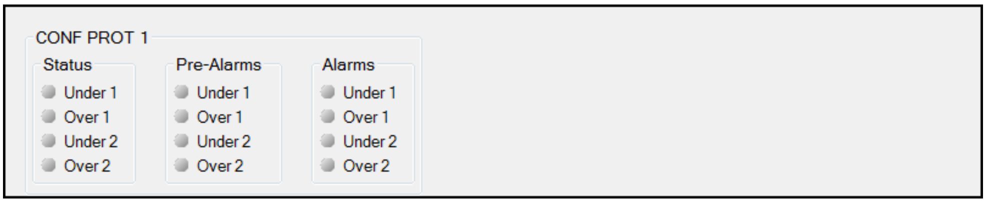

Figure 4-101. Metering, Configurable Protection

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Alarms

This screen indicates the status of Alarms, Pre-Alarms, Sender Fail, and Generator Protection. The status is TRUE when the corresponding LED is red. Alarms and pre-alarms are reset when the MGC-2000 Series is set to the Off mode. The Sync Fail at Gen Breaker, Gen Breaker Fail to Open, Gen Breaker Fail to Close, Sync Fail at Mains Breaker, Mains Breaker Fail to Open, and Mains Breaker Fail to Close pre-alarms can be reset by pressing the *Reset* key on the front panel HMI. Refer to Figure 4-102.

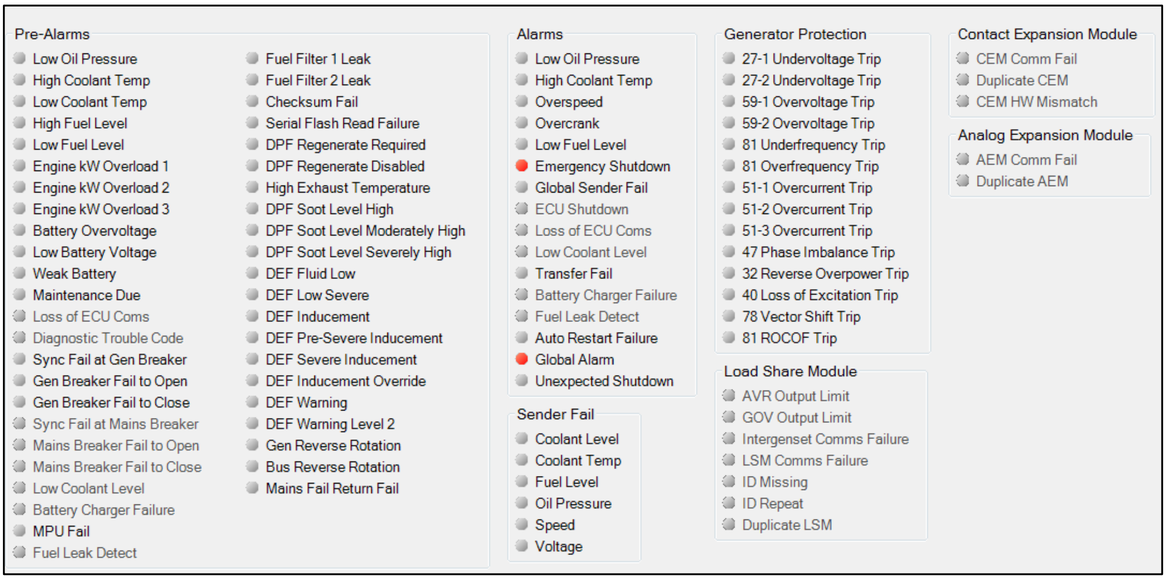
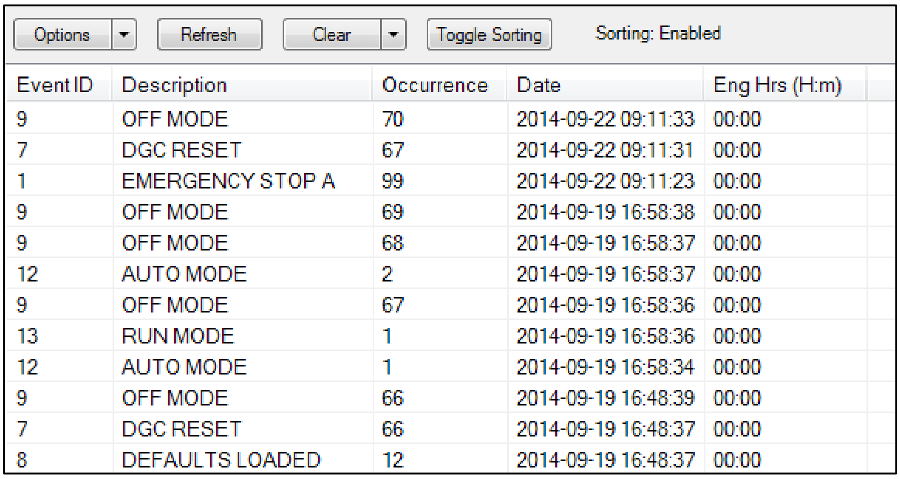


Figure 4-102. Metering, Alarms

Event Log

The event log provides a historical record of event occurrences detected by the MGC-2000 Series. It is saved in nonvolatile memory so that is will not be affected if power is removed. Thirty event records are retained and each record contains a time stamp of the first and last event occurrence, and the number of occurrences for each event. In addition, each record contains details of the time, date, and engine hours for the most recent 30 occurrences of the event. The number of occurrences stops incrementing at 99. If an event occurs which is of a type that differs from those in the 30 records in memory, the record that has the oldest “last” event occurrence is removed from the log, and the new category takes its place. Since 30 event records with up to 99 occurrences each are retained in memory, a history of nearly 3,000 specific events are retained in the MGC-2000 Series. Detailed occurrence information is retained for the most recent 30 occurrences of each event record, and there are 30 event records; thus the time, date and engine hours details for up to 900 specific event occurrences is retained in the event log.

The user can download the event log data into BESTCOMS*Plus* for viewing, and then save the event logs as files. The *Options* button is used to save the entire event log to a file, or to save the list to the computer clipboard making it available for insertion into other software applications. It is possible to copy a portion of the log to the computer clipboard by selecting the desired portion with the mouse then using the Options->Copy Selection feature. The *Download* button refreshes the event log list by performing a fresh download of the list from the MGC-2000 Series. The *Clear* button gives the user the option of clearing selected or all event logs. Refer to Figure 4-103.

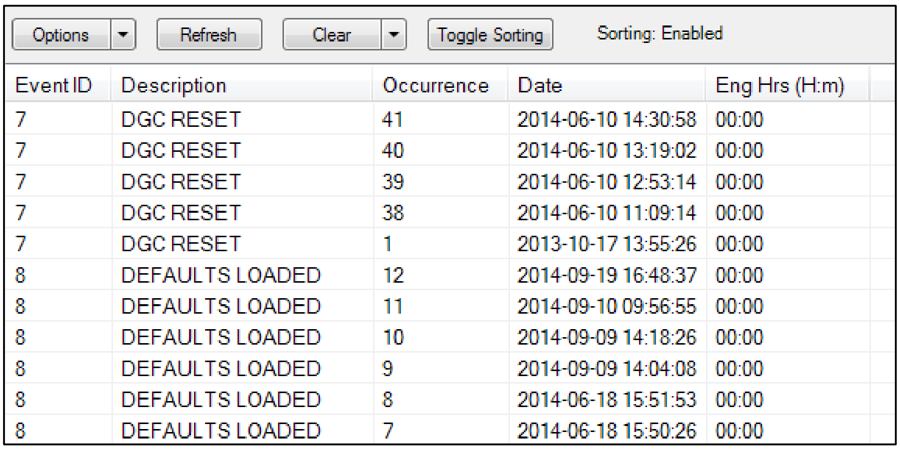


Options | Refresh | Clear | Toggle Sorting | Sorting: Enabled

Event ID	Description	Occurrence	Date	Eng Hrs (H:m)
9	OFF MODE	70	2014-09-22 09:11:33	00:00
7	DGC RESET	67	2014-09-22 09:11:31	00:00
1	EMERGENCY STOP A	99	2014-09-22 09:11:23	00:00
9	OFF MODE	69	2014-09-19 16:58:38	00:00
9	OFF MODE	68	2014-09-19 16:58:37	00:00
12	AUTO MODE	2	2014-09-19 16:58:37	00:00
9	OFF MODE	67	2014-09-19 16:58:36	00:00
13	RUN MODE	1	2014-09-19 16:58:36	00:00
12	AUTO MODE	1	2014-09-19 16:58:34	00:00
9	OFF MODE	66	2014-09-19 16:48:39	00:00
7	DGC RESET	66	2014-09-19 16:48:37	00:00
8	DEFAULTS LOADED	12	2014-09-19 16:48:37	00:00

Figure 4-103. Metering, Event Log, Sorted by Date

When viewed with BESTCOMS*Plus*, the event log can be sorted by Event ID, Description, Occurrence, Date, or Engine Hours. Selecting event log sorted by Date yields a list of all event occurrences in sequential order. This is a view that one would see in a typical “sequence of events” type of event log. Figure 4-103 shows the sequential list resulting from sorting by Date. Sorting by engine hours also results in a sequential list, where the sequence is in terms of engine hours rather than calendar date and time.
Selecting sorting by Event ID or Description allows one to view all the occurrences of a particular event type in their order of occurrence. In this view, one can see at a glance the times and dates of the occurrences of one type of event. For example, from Figure 4-104, if one wanted to know when all occurrences of Speed Sender Failures occurred, the information readily available without having to sift through all the occurrences of unrelated events as would have to be done in a rolling log implementation. This is apparent in Figure 4-103.



Options | Refresh | Clear | Toggle Sorting | Sorting: Enabled

Event ID	Description	Occurrence	Date	Eng Hrs (H:m)
7	DGC RESET	41	2014-06-10 14:30:58	00:00
7	DGC RESET	40	2014-06-10 13:19:02	00:00
7	DGC RESET	39	2014-06-10 12:53:14	00:00
7	DGC RESET	38	2014-06-10 11:09:14	00:00
7	DGC RESET	1	2013-10-17 13:55:26	00:00
8	DEFAULTS LOADED	12	2014-09-19 16:48:37	00:00
8	DEFAULTS LOADED	11	2014-09-10 09:56:55	00:00
8	DEFAULTS LOADED	10	2014-09-09 14:18:26	00:00
8	DEFAULTS LOADED	9	2014-09-09 14:04:08	00:00
8	DEFAULTS LOADED	8	2014-06-18 15:51:53	00:00
8	DEFAULTS LOADED	7	2014-06-18 15:50:26	00:00

Figure 4-104. Metering, Event Log, Sorted by Event ID

J1939 ECU

The ECU reports operating information to the MGC-2000 Series through the CANBus interface when the ECU is configured for Volvo Penta. Operating parameters and diagnostic information, if supported by the ECU, are decoded and displayed on these screens.

ECU Data

This screen displays ECU Lamp Status and ECU Data. The status is TRUE when the corresponding LED is red. Refer to Figure 4-105.

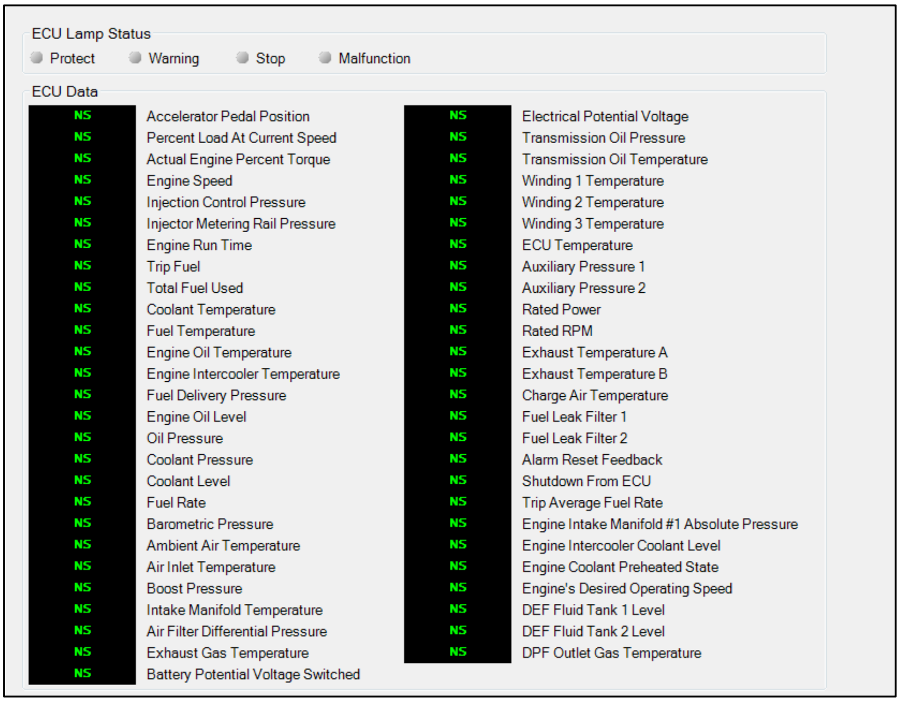


Figure 4-105. Metering, ECU Data

Engine Configuration

This screen displays Engine Configuration. Refer to Figure 4-106.

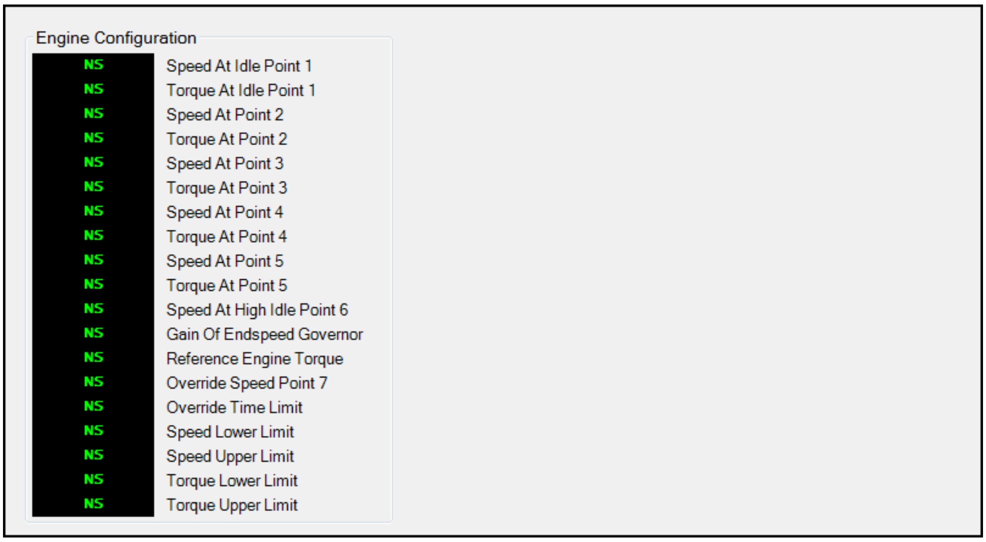
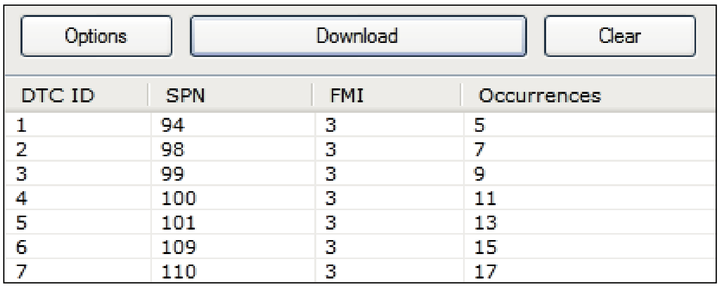


Figure 4-106. Metering, Engine Configuration

Active DTC and Previously Active DTC

This screen is used for viewing, downloading, and clearing DTC (Diagnostic Trouble Codes). Refer to Figure 4-107.



DTC ID	SPN	FMI	Occurrences
1	94	3	5
2	98	3	7
3	99	3	9
4	100	3	11
5	101	3	13
6	109	3	15
7	110	3	17

Figure 4-107. Metering, Download DTC

MTU

The MTU reports operating information to the MGC-2000 Series through the CANBus interface when the ECU is configured for MTU. Operating parameters and diagnostic information, if supported by the MTU, are decoded and displayed on these screens.

MTU Alarms

MTU fault codes are displayed in a scrolling window. MTU Alarms and MTU Pre-Alarms are also reported on this screen. The status is TRUE when the corresponding LED is red. Refer to Figure 4-108.

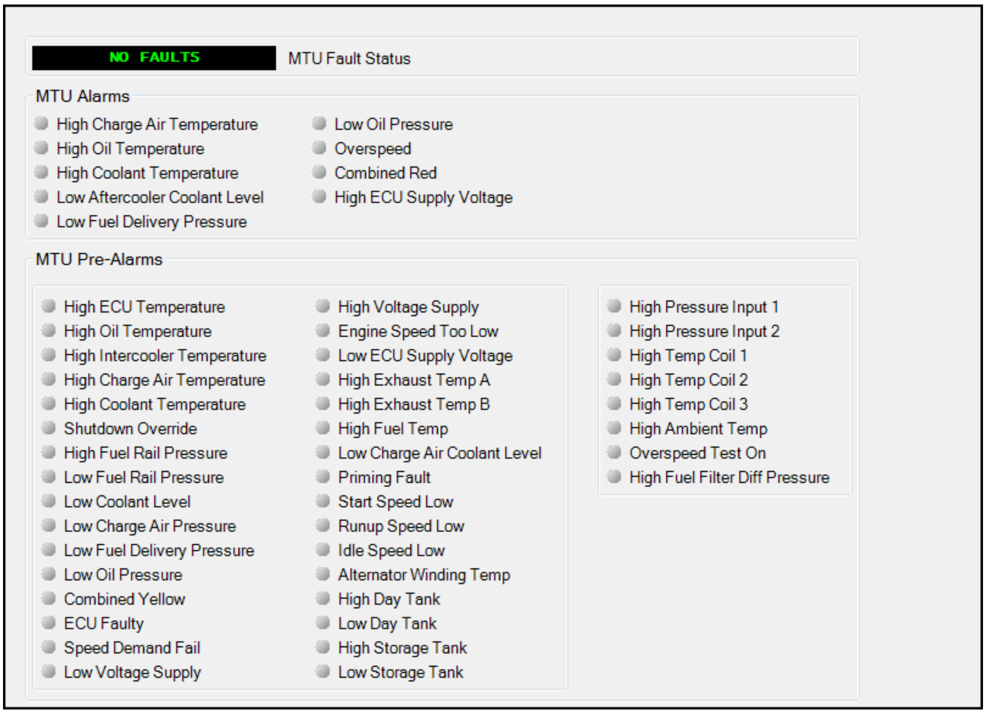
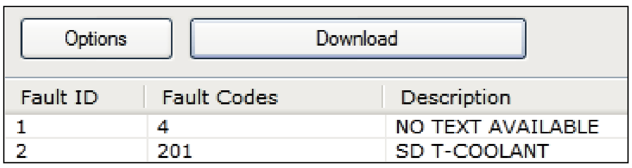


Figure 4-108. Metering, MTU Alarms

MTU Fault Codes

MTU Fault Codes can be viewed and downloaded on this screen. Refer to Figure 4-109.



Fault ID	Fault Codes	Description
1	4	NO TEXT AVAILABLE
2	201	SD T-COOLANT

Figure 4-109. Metering, MTU Fault Codes

TIM-ID: 0000099917 - 001

MTU Status

MTU Status is reported on this screen. The status is TRUE when the corresponding LED is red. Refer to Figure 4-110.

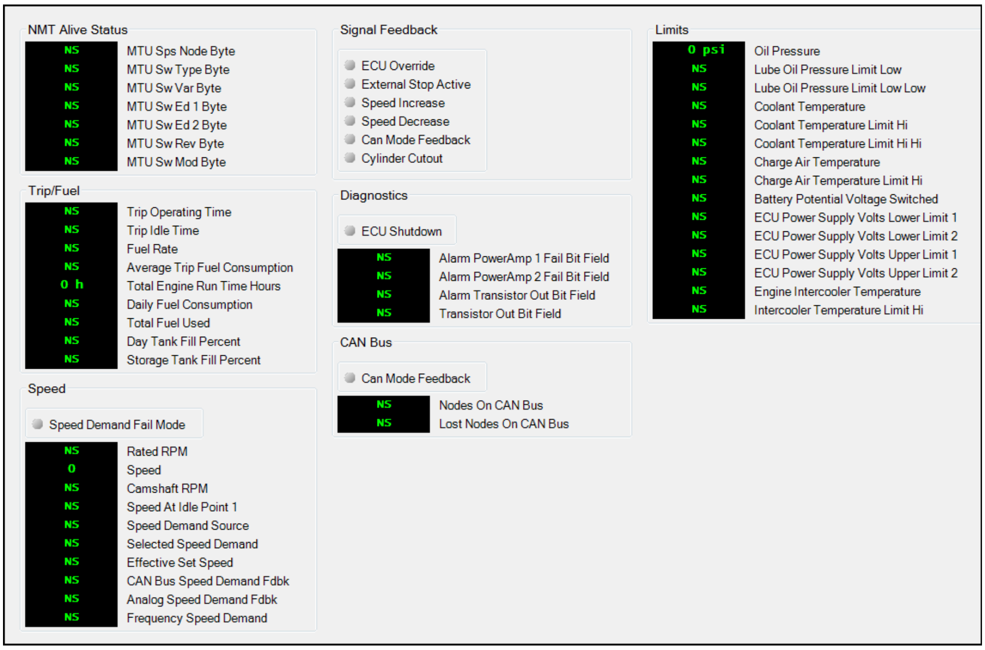


Figure 4-110. Metering, MTU Status

MTU Engine Status

MTU Engine Status is reported on this screen. The status is TRUE when the corresponding LED is red. Refer to Figure 4-111.

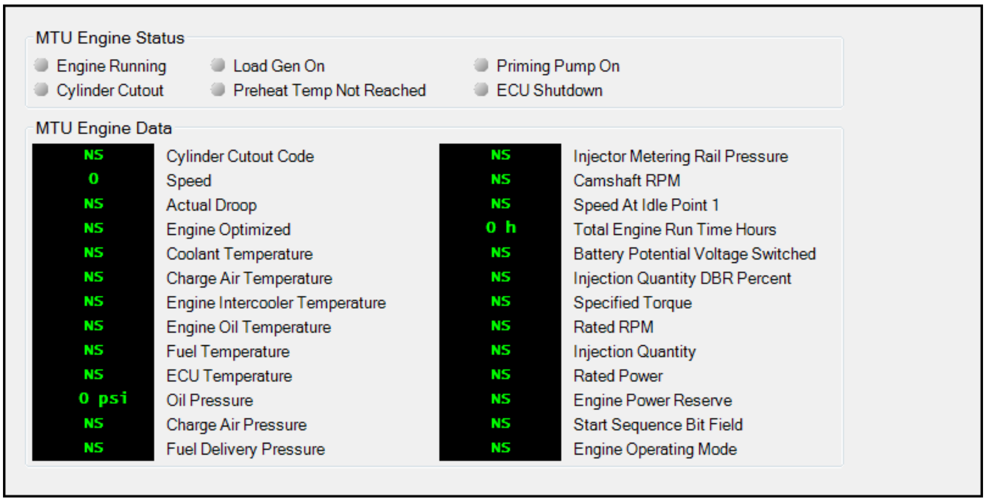


Figure 4-111. Metering, MTU Engine Status

Summary

This screen displays a metering summary. Refer to Figure 4-112.

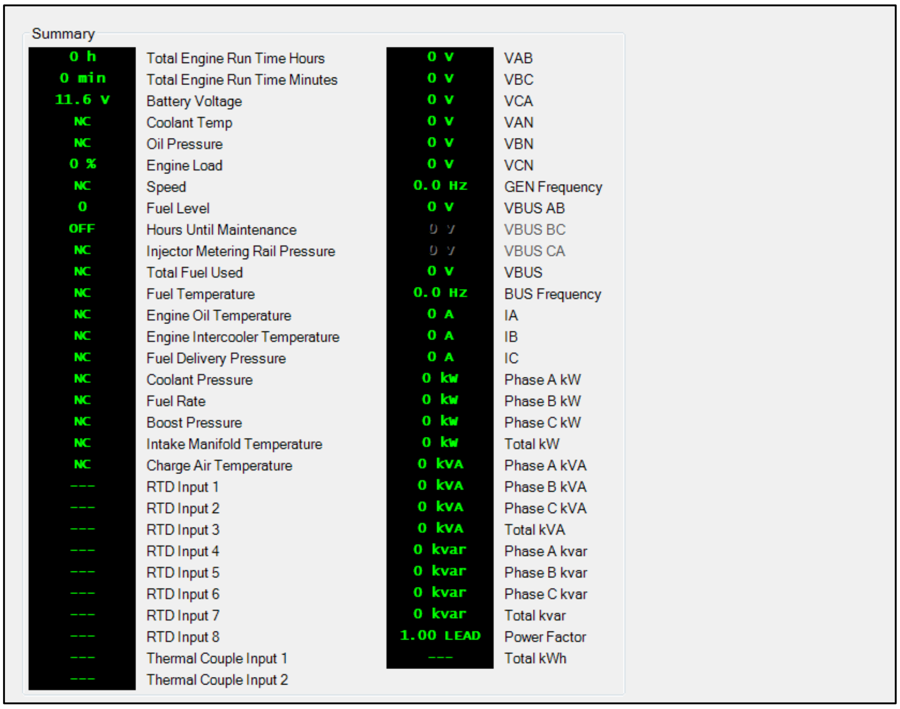


Figure 4-112. Metering, Summary

Control

Controls for stopping/starting the engine, controls for opening/closing breakers, and controls for opening/closing switches are accessed through the *Control* branch.

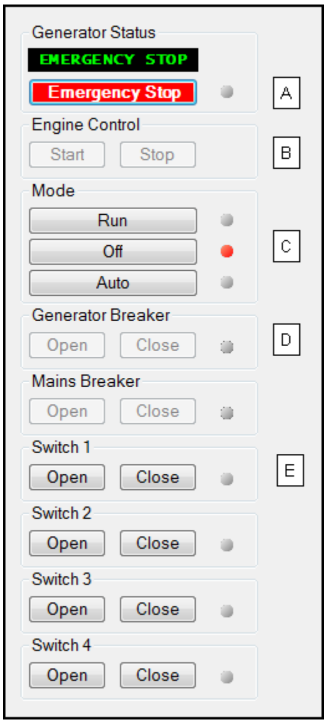


Figure 4-113. Metering, Control

The following controls are available by using the Metering Explorer in BESTCOMS*Plus* to open the *Control* branch. Refer to Figure 4-113.

A. The user has control to stop the generator in case of emergency by clicking on the *Emergency Stop* button.

B. The engine can be started and stopped by clicking on the *Start* and *Stop* buttons.

C. The engine can be set to Run, Auto, or Off.

D. There are controls for opening and closing the generator breaker and mains breaker. The breaker is open when the corresponding LED is green and closed when red.

E. Switches 1 through 4 can be opened or closed by clicking on the *Open* or *Close* buttons. The switch is closed when the corresponding LED is red.

When running BESTCOMS*Plus* in *Live* mode, these buttons will interact with the MGC-2000 Series in real time.

Real Time Clock

Settings for Date and Time are made here. Refer to Figure 4-114.

Figure 4-114. Metering, Real Time Clock

Generator Network Status

This screen (Figure 4-115) displays the designated system manager, total number of units, number of units on line, system online kW capacity, system total kW capacity, system generated kW, system generated kW percent, system total generated kvar, and sequencing IDs of the LSM-2020's on the network. This can only be accomplished when an optional LSM-2020 (Load Share Module) is connected to the MGC-2000 Series and actively communicating to the generator network.

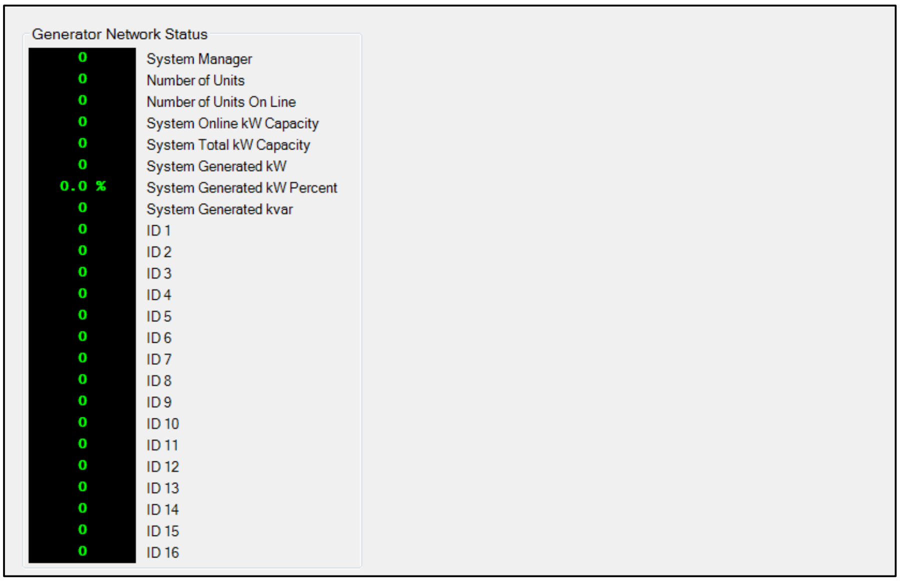


Figure 4-115. Metering, Generator Network Status

Generator Sequencing

This screen (Figure 4-116) displays the sequencing status of the generator network. The start/stop threshold, start/stop time delay, actual watt demand, and current sequencing mode are shown. Also, the sequencing ID numbers of the unit currently being monitored, the next unit to start/stop, and the unit designated as the system manager are indicated.

Figure 4-116. Metering, Generator Sequencing

Mains Fail Transfer Status

The Mains Fail Transfer Status screen displays the Mains Fail Transfer State and any timers relevant to the mains fail transfer process. These parameters are listed below.

Mains Fail Transfer State: The different mains fail transfer states are described below.

Power From Mains: Power is being supplied to the load from the mains bus.

Transfer Timer Active: Transfer Delay timer is actively counting.

Transferring to Gens: Load is being transferred to the generator bus.

Power From Gens: Power is being supplied to the load from the generator bus.

Return Timer Active: Return Delay timer is actively counting.

Transferring to Mains: Load is being transferred to the mains bus.

Disabled: MGC-2000 Series is in the OFF or RUN operating mode or in the alarm state.

Remaining Transfer Delay: Displays the current timer value in seconds.

Remaining Return Delay: Displays the current timer value in seconds.

Remaining Max Parallel Time: Displays the current timer value in seconds.

Remaining Max Transfer Time: Displays the current timer value in seconds.

Remaining Open Transition Delay Time: Displays the current timer value in seconds.

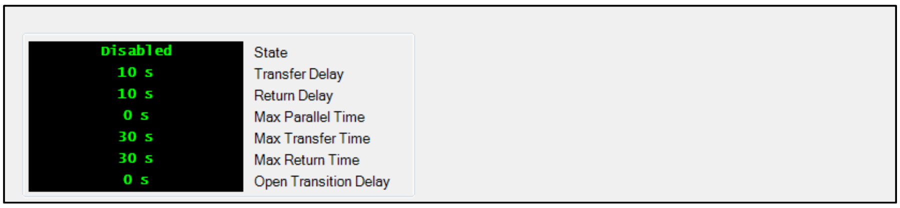


Figure 4-117. Metering, Mains Fail Transfer Status

Diagnostics

Diagnostics provide metering for kW and var control and load share parameters.

Control

Figure 4-118 illustrates the BESTCOMS*Plus Control* screen.

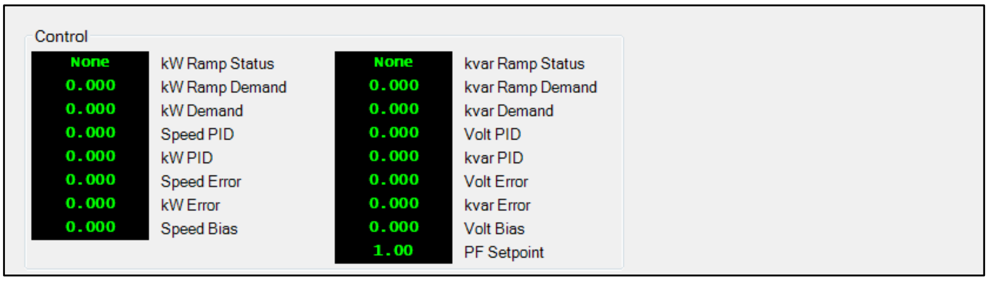


Figure 4-118. Metering Explorer, Diagnostics, Control Screen

Load Share

Figure 4-119 illustrates the BESTCOMS*Plus* Load Share screen.

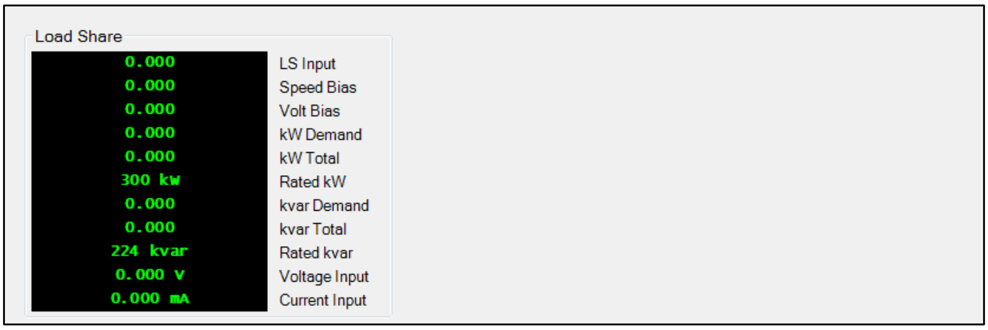


Figure 4-119. Metering Explorer, Diagnostics, Load Share Screen

BESTCOMS*Plus*® Updates

Ongoing MGC-2000 Series functionality enhancements may make future DGC-2020 firmware updates desirable. Enhancements to DGC-2020 firmware typically coincide with enhancements to the MGC-2000 Series plugin for BESTCOMS*Plus*. When an MGC-2000 Series is updated with the latest version of firmware, the latest version of BESTCOMS*Plus* should also be obtained.

- If you obtained a CD-ROM containing a firmware update from Basler Electric, then that CD-ROM will also contain the corresponding version of BESTCOMS*Plus* software.
- You can check for BESTCOMS*Plus* updates by visiting www.basler.com.
- You can use the manual "check for updates" function in BESTCOMS*Plus* to ensure that the latest version is installed by selecting *Check for Updates* in the *Help* drop-down menu. (An internet connection is required.)

Auto Export Metering

The auto export metering function automatically exports metering data over a user-defined period when an MGC-2000 Series connection is active. The user specifies the *Number of Exports* and the *Interval* between each export. Enter a filename for the metering data and a folder in which to save. The first export is performed immediately after clicking the *Start* button. Click the *Filter* button to select specific metering screens. Figure 4-120 illustrates the *Auto Export Metering* screen.

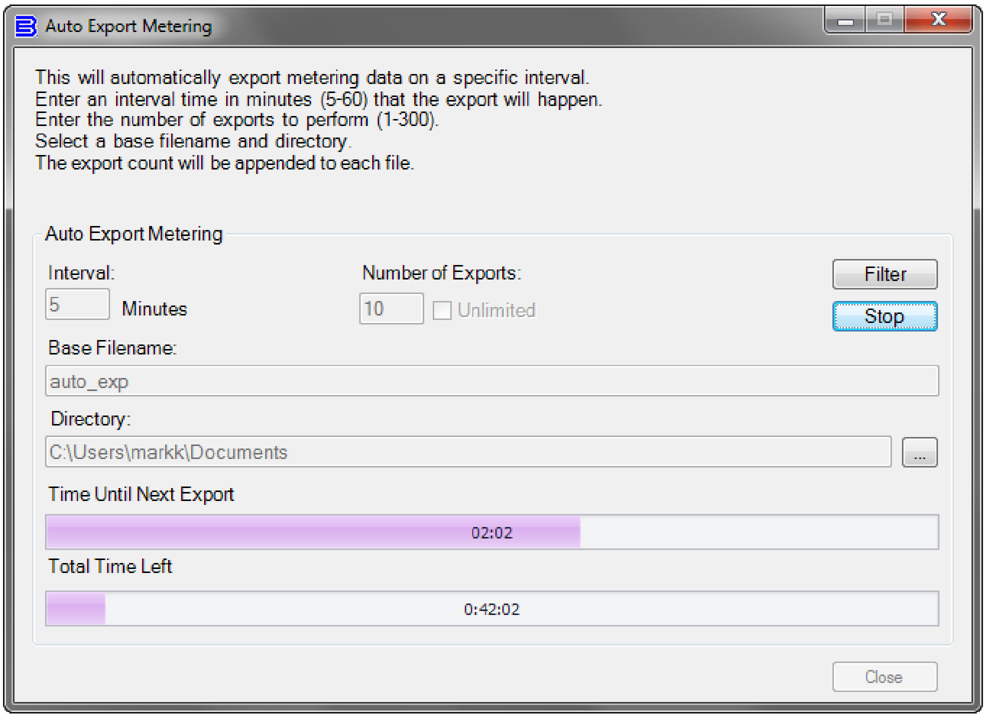


Figure 4-120. Auto Export Metering

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SECTION 5 • BESTlogic™*Plus* PROGRAMMABLE LOGIC

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SECTION 5 • BESTlogic™*Plus* PROGRAMMABLE LOGIC

Introduction

BESTlogic™*Plus* Programmable Logic is a programming method used for managing the input, output, protection, control, monitoring, and reporting capabilities of MTU Onsite Energy's MGC-2000 Series Digital Genset Controller. Each MGC-2000 Series has multiple, self-contained logic blocks that have all of the inputs and outputs of its discrete component counterpart. Each independent logic block interacts with control inputs and hardware outputs based on logic variables defined in equation form with BESTlogic*Plus*. BESTlogic*Plus* equations entered and saved in the MGC-2000 Series system's nonvolatile memory integrate (electronically wire) the selected or enabled protection and control blocks with control inputs and hardware outputs. A group of logic equations defining the logic of the MGC-2000 Series is called a logic scheme.

One default active logic scheme is pre-loaded into the MGC-2000 Series. This scheme is configured for a typical protection and control application and virtually eliminates the need for "start-from-scratch" programming. BESTCOMS*Plus*® can be used to open a logic scheme that was previously saved as a file and upload it to the MGC-2000 Series. The default logic scheme can also be customized to suit your application. Detailed information about logic schemes is provided later in this section.

BESTlogic*Plus* is not used to define the operating settings (modes, pickup thresholds, and time delays) of the individual protection and control functions. Operating settings and logic settings are interdependent but separately programmed functions. Changing logic settings is similar to rewiring a panel and is separate and distinct from making the operating settings that control the pickup thresholds and time delays of an MGC-2000 Series. Detailed information about operating settings is provided in Section 4, *BESTCOMSPlus® Software*.

Overview of BESTlogic™Plus

Use BESTCOMSPlus to make BESTlogic*Plus* settings. Use the Settings Explorer to open the *BESTlogicPlus Programmable Logic* tree branch as shown in Figure 5-1.

The *BESTlogicPlus Programmable Logic* screen contains a logic library for opening and saving logic files, tools for creating and editing logic documents, and protection settings.

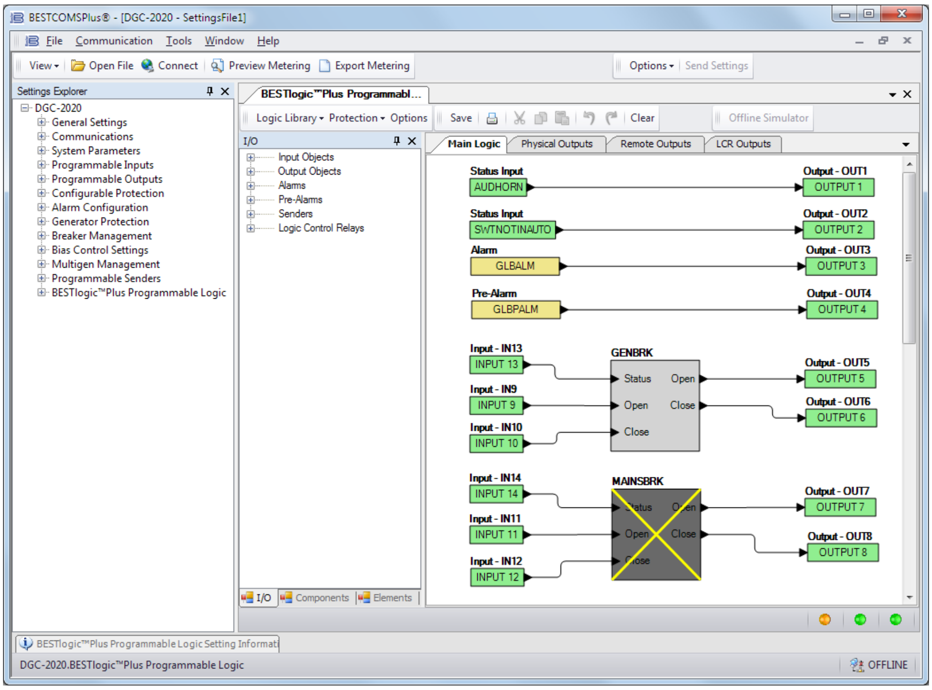

Figure 5-1. BESTlogicPlus Programmable Logic Tree Branch

BESTlogic™Plus Composition

There are three main groups of objects used for programming BESTlogic*Plus*. These groups are *I/O, Components,* and *Elements.* For details on how these objects are used to program BESTlogic*Plus*, see the paragraphs on *Programming BESTlogicPlus.*

I/O

This group contains Input Objects, Output Objects, Alarms, Pre-Alarms, Senders, and Logic Control Relays. Table 5-1 lists the names and descriptions of the objects in the *I/O* group.

Table 5-1. I/O Group, Names and Descriptions

Name	Description	Symbol
Input Objects		
Logic 0	Always false (Low).	Fixed 0
Logic 1	Always true (High).	Fixed 1
Physical Inputs IN1 - IN16	True when Physical Input x is active.	Input - IN1 INPUT 1
Remote Inputs IN17 - IN26	True when Remote Input x is active. (Available when an optional CEM-2020 is connected.)	Input - IN17 INPUT 17
Virtual Inputs VIN1 - VIN4	True when Virtual Input x is active.	Input - VIN1 VIN1
Status Input Alarm Silence	True when the Alarm Silence logic element is true or the Alarm Silence button is pressed on the front panel.	Status Input ALARMSILENCEIN
Status Input Alternate Frequency Override	True when the Alternate Frequency Override logic element is true.	Status Input ALTFREQOVERIN
Status Input Analog Expansion Module	Analog Expansion Module Connected. True when an optional AEM-2020 is connected to the MGC-2000 Series.	Status Input AEMCONNECTED
Analog Expansion Module Remote Analog Inputs 1-8	True when Over 1, Over 2, Under 1, Under 2, or Out of Range is configured as Status Only and the threshold has been exceeded. (Over 1 shown.)	Status Input - RALGIN1O1 ALG IN 1
Analog Expansion Module Remote Analog Outputs 1-4	True when the analog output connection is open and the Out of Range Alarm Configuration is set to Status Only.	Status Input - RALGOUT1OOR Oil Pressure
Analog Expansion Module Remote RTD Inputs 1-8	True when Over 1, Over 2, Under 1, Under 2, or Out of Range is configured as Status Only and the threshold has been exceeded. (Over 1 shown.)	Status Input - RRTDIN1O1 RTD IN 1
Analog Expansion Module Remote Thermocouple Inputs 1-2	True when Over 1, Over 2, Under 1, Under 2, or Out of Range is configured as Status Only and the threshold has been exceeded. (Over 1 shown.)	Status Input - RTCIN1O1 THRM CPL 1

Name	Description	Symbol
Status Input ATS Input	True when the ATS (Auto Transfer Switch) input is true or the ATS logic element is true.	Status Input ATSINSTATUS
Status Input Audible Horn	True when the Audible Horn is active.	Status Input AUDHORN
Status Input Auto Mode	True when the MGC-2000 Series is in Auto Mode or the Auto Mode logic element is true.	Status Input AUTOMODE
Status Input Auto Restart	True when the Automatic Restart function is active.	Status Input AUTORESTART
Status Input Battery Charger Fail	True when the Battery Charger Fail input is true.	Status Input BATTCHRGFAIL
Status Input Battle Override	True when the Battle Override input is true.	Status Input BATTLORIDE
Status Input Bus Dead	True when the Bus Dead condition settings have been exceeded.	Status Input BUSDEAD
Status Input Bus Fail	True when the Bus Fail condition settings have been exceeded.	Status Input BUSFAIL
Status Input Bus Forward Rotation	True when the sensed bus phase rotation matches the bus phase rotation specified in the system settings.	Status Input BUSFORWARDROTATIONSTATUS
Status Input Bus Reverse Rotation	True when the sensed bus phase rotation differs from the bus phase rotation specified in the system settings.	Status Input BUSREVERSEROTATIONSTATUS
Status Input Bus Stable	True when the Bus Stable condition settings have been exceeded.	Status Input BUSSTABLE
Status Input *CANBus Bus Off*	True when the CANBus bus is off.	Status Input CANBUSBUSOFF
Status Input *CANBus Error Passive*	True when a passive error is annunciated by the CANBus.	Status Input CANBUSERRORPASSIVE
Status Input Configurable Elements 1-8	True when the Configurable Element x logic element is true.	Status Input CONFIGELEMENT1
Status Input Configurable Protection 1-8	True when the Configurable Protection x Over Threshold #1 is true. (Over 1 shown.)	Status Input - CONFPROT101 CONF PROT 1
Status Input Contact Expansion Module	Contact Expansion Module Connected. True when an optional CEM-2020 is connected to the MGC-2000 Series.	Status Input CEMCONNECTED

Name	Description	Symbol
Status Input Cool Down Timer Active	True when the Cool Down Timer is timing out. The Cool Down Timer is true under two circumstances: 1. The unit is in auto and ATS is removed, causing the MGC-2000 Series to go into a cooldown state. 2. The engine is running (in RUN or AUTO mode with ATS applied) and the load has been removed (i.e. the EPSSUPLOAD status input is false due to small load). If the load is reapplied, the Cool Down Timer stops and resets, and it will restart when the load is removed the next time.	Status Input CDOWNTMRACT
Status Input DPF Lamp Command	True when DPF lamp is lit. This status input mimics the state of the DPF lamp. It remains true when the DPF lamp is constantly lit and toggles true and false at a rate of 1 Hz when DPF lamp is blinking.	Status Input DPFLAMPCOMMAND
Status Input Emergency Stop	True when the Emergency Stop button has been pressed.	Status Input EMERGSTOP
Status Input Engine Running	True while the Engine is Running.	Status Input ENGRUNNING
Status Input EPS Supplying Load	True while the EPS is supplying load.	Status Input EPSSUPLOAD
Status Input Front Panel Buttons	True while the *AUTO* front panel button is pressed.	Status Input AUTOBUTTON
Status Input Front Panel Buttons	True while the *DOWN* front panel button is pressed.	Status Input DOWNBUTTON
Status Input Front Panel Buttons	True while the *EDIT* front panel button is pressed.	Status Input EDITBUTTON
Status Input Front Panel Buttons	True while the *LAMP TEST* front panel button is pressed.	Status Input LAMPBUTTON
Status Input Front Panel Buttons	True while the *LEFT* front panel button is pressed.	Status Input LEFTBUTTON
Status Input Front Panel Buttons	True while the *OFF* front panel button is pressed.	Status Input OFFBUTTON
Status Input Front Panel Buttons	True while the *RESET* front panel button is pressed.	Status Input RESETBUTTON
Status Input Front Panel Buttons	True while the *RIGHT* front panel button is pressed.	Status Input RIGHTBUTTON
Status Input Front Panel Buttons	True while the *RUN* front panel button is pressed.	Status Input RUNBUTTON
Status Input Front Panel Buttons	True while the *ALARM SILENCE* front panel button is pressed.	Status Input SILENCEBUTTON

Name	Description	Symbol
Status Input Front Panel Buttons	True while the *UP* front panel button is pressed.	Status Input UPBUTTON
Status Input Fuel Leak	True when the Fuel Leak Detect input is true.	Status Input FUELLEAK
Status Input Generator Breaker Status	True when the generator breaker is closed.	Status Input GENBREAKERSTATUS
Status Input Generator Dead	True when the Gen Dead condition settings have been exceeded.	Status Input GENDEAD
Status Input Generator Fail	True when the Gen Fail condition settings have been exceeded.	Status Input GENFAIL
Status Input Gen Forward Rotation	True when the sensed generator phase rotation matches the generator phase rotation specified in the system settings.	Status Input GENFORWARDROTATIONSTATUS
Status Input Gen Reverse Rotation	True when the sensed generator phase rotation differs from the generator phase rotation specified in the system settings.	Status Input GENREVERSEROTATIONSTATUS
Status Input Generator Stable	True when the Gen Stable condition settings have been exceeded.	Status Input GENSTABLE
Status Input Generator Protection	True when the 27-1 element is tripped.	Status Input 27-1UNDRVLTTRIPSTATUS
Status Input Generator Protection	True when the 27-2 element is tripped.	Status Input 27-2UNDRVLTTRIPSTATUS
Status Input Generator Protection	True when the 59-1 element is tripped.	Status Input 59-1OVOLTTRIPSTATUS
Status Input Generator Protection	True when the 59-2 element is tripped.	Status Input 59-2OVOLTTRIPSTATUS
Status Input Generator Protection	True when the 32 element is tripped.	Status Input 32REVPWRTRIPSTATUS
Status Input Generator Protection	True when the 40 element is tripped.	Status Input 40LOSSEXCTRIPSTATUS
Status Input Generator Protection	True when the 47 element is tripped.	Status Input 47PH_IMBTRIPSTATUS
Status Input Generator Protection	True when the 51-1 element is tripped.	Status Input 51-1OCURRTRIPSTATUS
Status Input Generator Protection	True when the 51-2 element is tripped.	Status Input 51-2OCURRTRIPSTATUS
Status Input Generator Protection	True when the 51-3 element is tripped.	Status Input 51-3OCURRTRIPSTATUS

Name	Description	Symbol
Status Input Generator Protection	True when the 78 element is tripped.	Status Input 78VECSHFTTRIPSTATUS
Status Input Generator Protection	True when the 81 ROCOF element is tripped.	Status Input 81ROCOFTRIPSTATUS
Status Input Generator Protection	True when the 81 Over element is tripped.	Status Input 81OFRQTRIPSTATUS
Status Input Generator Protection	True when the 81 Under element is tripped.	Status Input 81UFRQTRIPSTATUS
Status Input Generator Test Loaded	True when the Exercise Timer has started the generator and run with load is selected.	Status Input GENTESTLOADED
Status Input Generator Test	True when the Exercise Timer has started the generator.	Status Input GENTEST
Status Input Global Low Coolant Level	True when the Low Coolant Level input is true.	Status Input GLBLOWCOOLLVL
Status Input Ground Delta Override	True when the Grounded Delta Override input is true.	Status Input GNDDLTAORIDE
Status Input Idle Request	True when the Idle Request logic element is true.	Status Input IDLEREQUESTIN
Status Input In Alarm State	True when the MGC-2000 Series is in the alarm state.	Status Input INALARMSTATE
Status Input In Connecting State	True when the MGC-2000 Series is in the connecting state.	Status Input INCONNECTINGSTATE
Status Input In Cooling State	True when the MGC-2000 Series is in the cooling state.	Status Input INCOOLINGSTATE
Status Input In Cranking State	True when the MGC-2000 Series is in the cranking state.	Status Input INCRANKINGSTATE
Status Input In Disconnect State	True when the MGC-2000 Series is in the disconnect state.	Status Input INDISCONNECTSTATE
Status Input In Prestart State	True when the MGC-2000 Series is in the pre-start state.	Status Input INPRESTARTSTATE
Status Input In Pulsing State	True when the MGC-2000 Series is in the pulsing state.	Status Input INPULSINGSTATE
Status Input In Ready State	True when the MGC-2000 Series is in the ready state.	Status Input INREADYSTATE
Status Input In Resting State	True when the MGC-2000 Series is in the resting state.	Status Input INRESTINGSTATE
Status Input In Running State	True when the MGC-2000 Series is in the running state.	Status Input INRUNNINGSTATE

Name	Description	Symbol
Status Input Lamp Test	True when the Lamp Test logic element is true or the Lamp Test button is pressed on the front panel.	Status Input LAMPTESTIN
Status Input Load Share Module	Load Share Module AVR Output Limit. True when the LSM-2020 AVR Output Limit settings have been exceeded.	Status Input LSMAVROUTLMT
Status Input Load Share Module	Load Share Module Connected. True when an optional LSM-2020 is connected to the MGC-2000 Series.	Status Input LSMCONNECTED
Status Input Load Share Module	Load Share Module Governor Output Limit. True when the LSM-2020 Governor Output Limit settings have been exceeded.	Status Input LSMGOVOUTLMT
Status Input Load Take Over	True when the Load Take Over logic element is true.	Status Input LOADTAKEOVERIN
Status Input Low Line Override	True when the Low Line Override input is true.	Status Input LOWLINEORIDE
Status Input Mains Breaker Status	True when the mains breaker is closed.	Status Input MAINSBREAKERSTATUS
Status Input Mains Fail Test	True when the Mains Fail Test logic element is true.	Status Input MAINSFAILIN
Status Input Mains Fail Transfer Complete	True when the MGC-2000 Series is configured for mains fail transfers and has successfully transferred to the generator from the utility. It remains true until the utility power is deemed good and the MGC-2000 Series transfers the load back to utility power.	Status Input MAINSFLTRCOMPLETE
Status Input Off Mode	True when the MGC-2000 Series is in Off Mode or the Off Mode logic element is true.	Status Input OFFMODE
Status Input Off Mode Cooldown	True when the MGC-2000 Series is in Off Mode and cooling down.	Status Input OFFMODECOOL
Status Input Parallel To Mains	True when the Parallel To Mains logic element is true, indicating that the generator is operating in parallel with the utility.	Status Input PARTOMAINS
Status Input PF Mode Active	True when PF mode is active.	Status Input PFMODEACT
Status Input Pre Start Condition in Effect	True while in the Pre Start state.	Status Input PRESTCONDINEFFECT
Status Input Pre Start Input	True when the MGC-2000 Series is indicating that the Pre Start relay should be closed.	Status Input PRESTARTINPUT
Status Input Reset Active	True when the Reset logic element is true or when the Reset key on the front panel is pressed.	Status Input RESETACTIVE
Status Input Restart Delay Active	True when the restart delay is currently active.	Status Input RESTARTDELAYACTIVE

Name	Description	Symbol
Status Input Run Input	True when the MGC-2000 Series is indicating that the Run relay should be closed.	Status Input RUNINPUT
Status Input Run Mode	True when the MGC-2000 Series is in Run Mode or the Run Mode logic element is true.	Status Input RUNMODE
Status Input Single Phase AC Sensing Override	True when the Single Phase AC Override input is true.	Status Input SPACORIDE
Status Input Single Phase Connection Override	True when the Single Phase Override input is true.	Status Input SPORIDE
Status Input Start Input	True when the MGC-2000 Series is indicating that the Start relay should be closed to start the engine.	Status Input STARTINPUT
Status Input Switch not in Auto	True when the MGC-2000 Series is not in Auto Mode.	Status Input SWTNOTINAUTO
Status Input Sync Active	True when the auto synchronizer is active to align the generator input and bus input voltages and phases.	Status Input SYNC ACTIVE
Status Input Sync Breaker Close OK	True when the auto synchronizer is running and determines that the voltage difference between bus and generator voltages, slip frequency, and phase angle are within specified limits so that it is okay to issue a breaker close command.	Status Input SYNC BRKCL OK
Status Input Sync Phase Angle OK	True when the auto synchronizer is running and the phase angle between the bus voltage input and the generator voltage input are within the limits indicated by the phase angle setting for phase lock synchronization, or the calculated advance angle for anticipatory synchronization.	Status Input SYNC PH ANG OK
Status Input Sync Slip Frequency OK	True when the auto synchronizer is running and the slip frequency between the bus voltage input and the generator voltage input are within the limits indicated by the slip frequency setting.	Status Input SYNC SLIP FREQ OK
Status Input Sync Voltage OK	True when the auto synchronizer is running and the voltage difference between the bus voltage input and the generator voltage input are within the limits indicated by the voltage window setting.	Status Input SYNC VOLT OK
Status Input Unloading State	True when the MGC-2000 Series is operating in parallel with other generators or is in parallel to the utility and the MGC-2000 Series is reducing the kW output of the generator prior to opening the generator breaker.	Status Input UNLDSTATE
Status Input var Mode Active	True when var mode is active.	Status Input VARMODEACT
Output Objects		
Physical Outputs OUT1 - OUTx	Physical Outputs 1 through 7 (style xxAxxxxxx) or 1 through 15 (style xxBxxxxxx).	Output - OUT1 OUTPUT 1

Name	Description	Symbol
Remote Outputs OUT13 - OUT36	Remote Outputs 13 through 36. (Available when an optional CEM-2020 is connected.)	Output - OUT13 OUTPUT 13
Alarms		
Analog Expansion Module Remote Analog Inputs 1-8	True when Over 1, Over 2, Under 1, Under 2, or Out of Range is configured as an alarm and the threshold has been exceeded. (Over 1 shown.)	Alarm - RALGIN1O1ALM ALG IN 1
Analog Expansion Module Remote Analog Outputs 1-4	True when the analog output connection is open and the Out of Range Alarm Configuration is set to Alarm.	Alarm - RALGOUT1OORALM Oil Pressure
Analog Expansion Module Remote RTD Inputs 1-8	True when Over 1, Over 2, Under 1, Under 2, or Out of Range is configured as an alarm and the threshold has been exceeded. (Over 1 shown.)	Alarm - RRTDIN1O1ALM RTD IN 1
Analog Expansion Module Remote Thermocouple Inputs 1-2	True when Over 1, Over 2, Under 1, Under 2, or Out of Range is configured as an alarm and the threshold has been exceeded. (Over 1 shown.)	Alarm - RTCIN1O1ALM THRM CPL 1
Auto Restart Fail	True after the Automatic Restart function fails to restart the generator.	Alarm AUTORSTRTFAILALM
Battery Charger Fail	True when the Battery Charger Fail function is configured as an alarm and the activation delay has expired.	Alarm BATTCHRGFAILALM
Configurable Protection Protection 1-8	True when Over 1, Over 2, Under 1, or Under 2 is configured as an alarm and the threshold has been exceeded. (Over 1 shown.)	Alarm - CONFPROT1O1ALM CONF PROT 1
Coolant Level Sender Fail	True when a low coolant level error status code is received from the ECU. CANBus must be enabled.	Alarm COOLLVLSENDFAILALM
Coolant Temp Sender Fail	True when the Coolant Temp Sender Fail is configured as an alarm and the activation delay has expired.	Alarm COOLTEMPSENDFAILALM
ECU Comm Loss	True when communication to ECU has been lost.	Alarm LOSSECUCOMMALM
ECU Shutdown	True when ECU has shut down the engine.	Alarm ECUSHUTDOWNALM
Emergency Stop	True when the Emergency Stop button has been pressed.	Alarm EMERGSTOPALM
Fuel Leak	True when the Fuel Leak Detect function is configured as an alarm and the activation delay has expired.	Alarm FUELLEAKALM
Fuel Level Sender Fail	True when the Fuel Level Sender Fail is configured as an alarm and the activation delay has expired.	Alarm FUELLSENDFAILALM

Name	Description	Symbol
Generator Protection 27-1	True when the 27-1 element is configured as an alarm and has tripped.	Alarm 27-1UNDRVLTALM
Generator Protection 27-2	True when the 27-2 element is configured as an alarm and has tripped.	Alarm 27-2UNDRVLTALM
Generator Protection 59-1	True when the 59-1 element is configured as an alarm and has tripped.	Alarm 59-1OVOLTALM
Generator Protection 59-2	True when the 59-2 element is configured as an alarm and has tripped.	Alarm 59-2OVOLTALM
Generator Protection 32	True when the 32 element is configured as an alarm and has tripped.	Alarm 32REVPWRALM
Generator Protection 40	True when the 40 element is configured as an alarm and has tripped.	Alarm 40LOSSEXCALM
Generator Protection 47	True when the 47 element is configured as an alarm and has tripped.	Alarm 47PH_IMBLALM
Generator Protection 51-1	True when the 51-1 element is configured as an alarm and has tripped.	Alarm 51-1OCURRALM
Generator Protection 51-2	True when the 51-2 element is configured as an alarm and has tripped.	Alarm 51-2OCURRALM
Generator Protection 51-3	True when the 51-3 element is configured as an alarm and has tripped.	Alarm 51-3OCURRALM
Generator Protection 78	True when the 78 element is configured as an alarm and has tripped.	Alarm 78VECSHFTALM
Generator Protection 81 ROC DF/DT	True when the 81 ROC DF/DT element is configured as an alarm and has tripped.	Alarm 81ROCOFALM
Generator Protection 81 Over	True when the 81 Over element is configured as an alarm and has tripped.	Alarm 81OFRQALM
Generator Protection 81 Under	True when the 81 Under element is configured as an alarm and has tripped.	Alarm 81UFRQALM
Global Alarm	True when one or more alarms are set.	Alarm GLBALM
Global Sender Fail	True when one or more of the Sender Fails are configured as alarms and are true.	Sender Fail GLBSENDFALM
Hi Coolant Temp	True when the High Coolant Temp Alarm settings have been exceeded.	Alarm HITEMPALM

Name	Description	Symbol
Low Coolant Level	True when the Low Coolant Level function is configured as an alarm and the activation delay has expired. In addition, true when CANBus is enabled and the Low Coolant Level Alarm threshold has been exceeded.	Alarm LOWCOOLLVLALM
Low Fuel Level	True when the Low Fuel Level Alarm settings have been exceeded.	Alarm LOWFUELLALM
Low Oil Pressure	True when the Low Oil Pressure Alarm settings have been exceeded.	Alarm LOWOILPRALM
Oil Pressure Sender Fail	True when the Oil Pressure Sender Fail is configured as an alarm and the activation delay has expired.	Alarm OILPRESSENDFAILALM
Overcrank	True when an Overcrank condition exists.	Alarm OCRANKALM
Overspeed	True when the Overspeed Alarm settings have been exceeded.	Alarm OVERSPDALM
Speed Sender Fail	True when the Speed Sender Fail activation delay has expired.	Alarm SPDSENDFAILALM
Unexpected Shutdown	True when the metered engine speed (RPM) unexpectedly drops to 0 while the engine is running.	Alarm UNEXPECTEDSHUTDNALM
Voltage Sensing Fail	True when the Voltage Sensing Fail is configured as an alarm and the activation delay has expired.	Alarm VOLTSENSFAILALM
Pre-Alarms		
Analog Expansion Module Analog Expansion Module Comm Fail	True when communication from the AEM-2020 to the MGC-2000 Series has been lost.	Pre-Alarm AEMCOMMFPALM
Analog Expansion Module Multiple Analog Expansion Modules Detected	True when more than one AEM-2020 is connected.	Pre-Alarm DUPAEMPALM
Analog Expansion Module Remote Analog Inputs 1-8	True when Over 1, Over 2, Under 1, Under 2, or Out of Range is configured as a pre-alarm and the threshold has been exceeded. (Over 1 shown.)	Pre-Alarm - RALGIN1O1PALM ALG IN 1
Analog Expansion Module Remote Analog Outputs 1-4	True when the analog output connection is open and the Out of Range Alarm Configuration is set to pre-alarm.	Pre-Alarm - RALGOUT1OORPALM Oil Pressure

Name	Description	Symbol
Analog Expansion Module Remote RTD Inputs 1-8	True when Over 1, Over 2, Under 1, Under 2, or Out of Range is configured as a pre-alarm and the threshold has been exceeded. (Over 1 shown.)	Pre-Alarm - RRTDIN1O1PALM RTD IN 1
Analog Expansion Module Remote Thermocouple Inputs 1-2	True when Over 1, Over 2, Under 1, or Under 2 is configured as a pre-alarm and the threshold has been exceeded. (Over 1 shown.)	Pre-Alarm - RTCIN1O1PALM THRM CPL 1
Battery Charger Fail	True when the Battery Charger Fail function is configured as a pre-alarm and the activation delay has expired.	Pre-Alarm BATTCHRGFAILPALM
Battery Overvoltage	True when the Battery Overvoltage pre-alarm threshold has been exceeded.	Pre-Alarm BATOVOLTPALM
Checksum Failure	True when some of the user settings or firmware code has been corrupted. Refer to Section 4, *BESTCOMSPlus® Software, Alarm Configuration, Pre-Alarms,* for more details.	Pre-Alarm CHECKSUMFAILPALM
Configurable Protection Protection 1-8	True when Over 1, Over 2, Under 1, or Under 2 is configured as a pre-alarm and the threshold has been exceeded. (Over 1 shown.)	Pre-Alarm - CONFPROT1O1PALM CONF PROT 1
Contact Expansion Module Multiple Contact Expansion Modules Connected	True when more than one CEM-2020 is connected.	Pre-Alarm DUPCEMPALM
Contact Expansion Module Contact Expansion Module Comm Fail	True when communication from the CEM-2020 to the MGC-2000 Series has been lost.	Pre-Alarm CEMCOMMFPALM
Contact Expansion Module Contact Expansion Modules Hardware Mismatch	True when the connected CEM-2020 does not have the same number of outputs as defined on the *System Parameters, Remote Module Setup* screen in BESTCOMS*Plus*.	Pre-Alarm CEMHWMISMATCHPALM
Coolant Temp Sender Fail	True when the Coolant Temp Sender Fail is configured as a pre-alarm and the activation delay has expired.	Pre-Alarm COOLTEMPSENDFAILPALM
DEF Fluid Low	True when the engine ECU reports via CANBus that the Diesel Exhaust Fluid (DEF) is at a level between 8 and 23%.	Pre-Alarm DEFLOWPALM

Name	Description	Symbol
DEF Inducement	This is the lowest level of inducement not to operate the engine when Diesel Exhaust Fluid (DEF) is low or of poor quality or there is a problem with the Exhaust After Treatment System (EATS). The engine is operating in a reduced power mode. Eventually the level of inducement will be increased unless the problem with the DEF or malfunction in the EATS is corrected.	Pre-Alarm DEFENGINEDERATEPALM
DEF Inducement Override	This pre-alarm indicates a temporary override of inducement not to operation the engine. This is set by the ECU and is not a user setting.	Pre-Alarm DEFINDUCEOVERRIDEPALM
DEF Low Severe	True when the engine ECU reports via CAN bus that Diesel Exhaust Fluid (DEF) is at a level below 8%.	Pre-Alarm DEFEMPTYPALM
DEF Pre-severe Inducement	This pre-alarm indicates a high level of inducement not to operate the engine due to low or poor quality Diesel Exhaust Fluid (DEF), or a malfunction in the Exhaust After Treatment System (EATS). The engine may operate in a reduced power mode, or for a limited time, after which it will enter a state of severe inducement unless the problem with the DEF or malfunction in the EATS is corrected.	Pre-Alarm DEFPRESEVEREINDUCEPALM
DEF Severe Inducement	This pre-alarm indicates the highest level of inducement not to operate the engine due to low or poor quality Diesel Exhaust Fluid (DEF), or a malfunction in the Exhaust After Treatment System (EATS). The engine may operate in a reduced power mode, or for a limited time, or may be prevented from starting by the ECU until the problem is corrected. A service tool may be required to restart the engine.	Pre-Alarm DEFSEVEREINDUCEPALM
Diag Trouble Code	True when a Diagnostic Trouble Code exists.	Pre-Alarm DIAGTRBCODEPALM
DPF Regenerate Disabled	True when the Diesel Particulate Filter (DPF) lamp status broadcast over CAN bus indicates that DPF regeneration is inhibited.	Pre-Alarm DPFREGENDISABLDPALM
DPF Regenerate Required	True when the Diesel Particulate Filter (DPF) lamp status broadcast over CAN bus indicates that DPF regeneration is required.	Pre-Alarm DPFREGENREQPALM
DPF Soot Level High	True when the engine ECU reports via CAN bus that Diesel Particulate Filter (DPF) soot level is high.	Pre-Alarm DPFSOOTHIPALM
DPF Soot Level Moderately High	True when Diesel Particulate Filter (DPF) lamp status (yellow warning) broadcast over CAN bus indicates that the soot level is moderately high.	Pre-Alarm DPFSOOTMODHIPALM
DPF Soot Level Severely High	True when Diesel Particulate Filter (DPF) lamp status (red warning) broadcast over CAN bus indicates that the soot level is severely high.	Pre-Alarm DPFSOOTEXTHIPALM
ECU Comm Loss	True when communication to ECU has been lost.	Pre-Alarm LOSSECUCOMMPALM
Engine kW Over Load 1	True when the Engine kW Overload 1 Pre-Alarm settings have been exceeded.	Pre-Alarm ENGKWOVRLD1PALM
Engine kW Over Load 2	True when the Engine kW Overload 2 Pre-Alarm settings have been exceeded.	Pre-Alarm ENGKWOVRLD2PALM

Name	Description	Symbol
Engine kW Over Load 3	True when the Engine kW Overload 3 Pre-Alarm settings have been exceeded.	Pre-Alarm ENGKWOVRLD3PALM
Fuel Leak	True when the Fuel Leak Detect function is configured as a pre-alarm and the activation delay has expired.	Pre-Alarm FUELLEAKPALM
Fuel Level Sender Fail	True when the Fuel Level Sender Fail is configured as a pre-alarm and the activation delay has expired.	Pre-Alarm FUELLSENDFAILPALM
Generator Breaker Close Fail	True when a generator breaker close fail pre-alarm occurs. The pre-alarm occurs when the MGC-2000 Series has issued a generator breaker close output but does not receive a generator breaker status input that indicates the breaker has closed before the breaker close wait time has expired.	Pre-Alarm GENBRKCLOSEFAIL
Generator Breaker Open Fail	True when a generator breaker open fail pre-alarm occurs. The pre-alarm occurs when the MGC-2000 Series has issued a generator breaker open output but does not receive a generator breaker status input that indicates the breaker has opened before the breaker close wait time has expired.	Pre-Alarm GENBRKOPENFAIL
Generator Breaker Sync Fail	True when a generator breaker sync fail pre-alarm occurs. The pre-alarm occurs when the synchronizer is running and attempting to close the generator breaker but the sync fail activation delay expires prior to achieving breaker closure.	Pre-Alarm GENBRKSYNCFAIL
Generator Protection 27-1	True when the 27-1 element is configured as a pre-alarm and has tripped.	Pre-Alarm 27-1UNDRVLTPALM
Generator Protection 27-2	True when the 27-2 element is configured as a pre-alarm and has tripped.	Pre-Alarm 27-2UNDRVLTPALM
Generator Protection 59-1	True when the 59-1 element is configured as a pre-alarm and has tripped.	Pre-Alarm 59-1OVOLTPALM
Generator Protection 59-2	True when the 59-2 element is configured as a pre-alarm and has tripped.	Pre-Alarm 59-2OVOLTPALM
Generator Protection 32	True when the 32 element is configured as a pre-alarm and has tripped.	Pre-Alarm 32REVPWRPALM
Generator Protection 40	True when the 40 element is configured as a pre-alarm and has tripped.	Pre-Alarm 40LOSSEXCPALM
Generator Protection 47	True when the 47 element is configured as a pre-alarm and has tripped.	Pre-Alarm 47PH_IMBPALM
Generator Protection 51-1	True when the 51-1 element is configured as a pre-alarm and has tripped.	Pre-Alarm 51-1OCURRPALM
Generator Protection 51-2	True when the 51-2 element is configured as a pre-alarm and has tripped.	Pre-Alarm 51-2OCURRPALM
Generator Protection 51-3	True when the 51-3 element is configured as a pre-alarm and has tripped.	Pre-Alarm 51-3OCURRPALM

Name	Description	Symbol
Generator Protection 78	True when the 78 element is configured as a pre-alarm and has tripped.	Pre-Alarm 78VECSHIFTPALM
Generator Protection 81 ROC DF/DT	True when the 81 ROC DF/DT element is configured as a pre-alarm and has tripped.	Pre-Alarm 81ROCOFPALM
Generator Protection 81 Over	True when the 81 Over element is configured as a pre-alarm and has tripped.	Pre-Alarm 81OFRQPALM
Generator Protection 81 Under	True when the 81 Under element is configured as a pre-alarm and has tripped.	Pre-Alarm 81UFRQPALM
Global Pre-Alarm	True when one or more pre-alarms are set.	Pre-Alarm GLBPALM
Hi Coolant Temp	True when the High Coolant Temp Pre-Alarm threshold has been exceeded.	Pre-Alarm HITEMPPALM
High Exhaust Temperature	True when Diesel Particulate Filter (DPF) lamp status broadcast over CANBus indicates high exhaust temperature.	Pre-Alarm HIGHEXHTEMPPALM
High Fuel Level	True when the High Fuel Level Pre-Alarm settings have been exceeded.	Pre-Alarm HIFUELLPALM
Intergenset Comm Fail	True when an individual generator detects that it had been connected to a generator network, but has lost the connection.	Pre-Alarm INTERGENCOMFPALM
Load Share Module Load Share Module Comm Fail	True when communication from the LSM-2020 to the MGC-2000 Series has been lost.	Pre-Alarm LSMCOMMFPALM
Load Share Module Multiple Load Share Modules Detected	True when more than one LSM-2020 is connected.	Pre-Alarm DUPLSMPALM
Low Battery Voltage	True when the Low Battery Voltage Pre-Alarm settings have been exceeded.	Pre-Alarm LOWBATVPALM
Low Coolant Level	True when the Low Coolant Level function is configured as a pre-alarm and the activation delay has expired. In addition, true when CANBus is enabled and the Low Coolant Level Pre-Alarm threshold has been exceeded.	Pre-Alarm LOWCOOLLVLPALM
Low Coolant Temp	True when the Low Coolant Temp Pre-Alarm threshold has been exceeded.	Pre-Alarm LOWTEMPPALM
Low Fuel Level	True when the Low Fuel Level Pre-Alarm threshold has been exceeded.	Pre-Alarm LOWFUELLPALM
Low Oil Pressure	True when the Low Oil Pressure Pre-Alarm threshold has been exceeded.	Pre-Alarm LOWOILPRPALM

Name	Description	Symbol
Mains Breaker Close Fail	True when a mains breaker close fail pre-alarm occurs. The pre-alarm occurs when the MGC-2000 Series has issued a mains breaker close output but does not receive a mains breaker status input that indicates the breaker has closed before the breaker close wait time has expired.	Pre-Alarm MAINBRKCLOSEFAIL
Mains Breaker Open Fail	True when a mains breaker open fail pre-alarm occurs. The pre-alarm occurs when the MGC-2000 Series has issued a mains breaker open output but does not receive a mains breaker status input that indicates the breaker has opened before the breaker close wait time has expired.	Pre-Alarm MAINBRKOPENFAIL
Mains Breaker Sync Fail	True when a mains breaker sync fail pre-alarm has occurred. The pre-alarm occurs when the synchronizer is running and attempting to close the mains breaker but the sync fail activation delay expires prior to achieving breaker closure.	Pre-Alarm MAINBRKSYNCFAIL
Mains Fail Return Failed	True when a mains fail return fail pre-alarm has occurred. The pre-alarm occurs when the MGC-2000 Series is attempting to transfer from generator power to mains power after mains returns, but has not returned to the mains from the generator before the Mains Fail Return Delay has expired.	Pre-Alarm MAINSFAILRETURNFAIL
Mains Fail Transfer Failed	True when a mains fail transfer fail pre-alarm occurs. The pre-alarm occurs when the MGC-2000 Series is configured for mains fail transfers, but has not transferred to the generator from the utility before the Mains Fail Max Transfer Time has expired. It remains true until the pre-alarm is cleared by pressing the *Reset* button on the front panel.	Pre-Alarm MAINSFLTRFAIL
Maintenance Interval	True when the Maintenance Interval Pre-Alarm threshold has been exceeded.	Pre-Alarm MAINTINTPALM
MPU Fail	True when the MPU has failed.	Pre-Alarm MPUFAILPALM
Network ID Missing Error	True if an expected sequence ID of an optional LSM-2020 is not detected on the network. Expected sequence IDs are entered on the *Network Configuration* screen.	Pre-Alarm IDMISSINGPALM
Network ID Repeat Error	True if two or more optional LSM-2020's report the same expected sequence ID. Expected sequence IDs are entered on the *Network Configuration* screen.	Pre-Alarm IDREPEATPALM
Oil Pressure Sender Fail	True when the Oil Pressure Sender Fail is configured as a pre-alarm and the activation delay has expired.	Pre-Alarm OILPRESSENDFAILPALM
Voltage Sensing Fail	True when the Voltage Sensing Fail is configured as a pre-alarm and the activation delay has expired.	Pre-Alarm VOLTSENSFAILPALM
Weak Battery	True when the Weak Battery Voltage Pre-Alarm settings have been exceeded.	Pre-Alarm WEAKBATPALM

Senders

Name	Description	Symbol
Coolant Temp Sender Fail	True when the Coolant Temp Sender Fail is configured as either a pre-alarm or alarm and the activation delay has expired.	Sender Fail COOLTEMPSENDFAIL
Fuel Level Sender Fail	True when the Fuel Level Sender Fail is configured as either a pre-alarm or alarm and the activation delay has expired.	Sender Fail FUELLSENDFAIL
Oil Pressure Sender Fail	True when the Oil Pressure Sender Fail is configured as either a pre-alarm or alarm and the activation delay has expired.	Sender Fail OILPRESSENDFAIL
Speed Sender Fail	True when the Speed Sender Fail activation delay has expired.	Sender Fail SPDSENDFAIL
Voltage Sensing Fail	True when the Voltage Sensing Fail is configured as either a pre-alarm or alarm and the activation delay has expired.	Sender Fail VOLTSENSFAIL
Logic Control Relays		
The logic control relays (LCR) consist of LCR outputs and LCR inputs. You can use the output to terminate the “output” end of a logic network, and then use the corresponding input as an input to logic elsewhere in the logic scheme. When a given LCR output is true the corresponding LCR input is true. In other words, when LCR Output N (N being a number from 1 to 16) becomes true, then LCR Input N is true also. If you get a “too many logic levels” error while building a logic network, LCR outputs and inputs can be used as a solution to this problem. Place an LCR output on the end of the partial logic network and then use the corresponding LCR input to build more logic than was previously possible.		
Inputs Input 1-16	See description above.	LCR Input LCRINPUT1
Outputs Output 1-16	See description above.	LCR Output LCROUTPUT1

Components

This group contains Logic Gates, Pickup and Dropout Timers, Latches, and Comment Blocks. Table 5-2 lists the names and descriptions of the objects in the *Components* group.

Table 5-2. Components Group, Names and Descriptions

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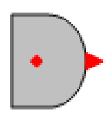
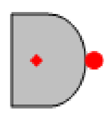
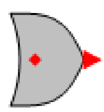
<tr><th>Name</th><th>Description</th><th>Symbol</th></tr>
<tr><td colspan="3">Logic Gates</td></tr>
<tr><td>AND</td><td><table><tr><th colspan="2">Input</th><th>Output</th></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>1</td></tr></table></td><td></td></tr>
<tr><td>NAND</td><td><table><tr><th colspan="2">Input</th><th>Output</th></tr><tr><td>0</td><td>0</td><td>1</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td></tr></table></td><td></td></tr>
<tr><td>OR</td><td><table><tr><th colspan="2">Input</th><th>Output</th></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>1</td></tr></table></td><td></td></tr>
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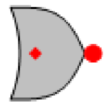
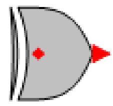
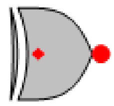
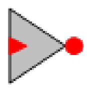
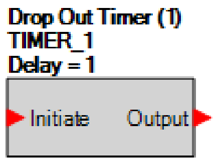
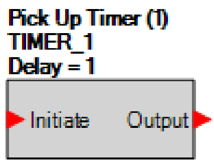
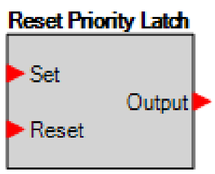
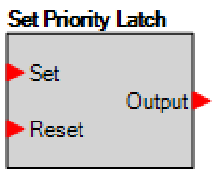
<table>
<tr><th>Name</th><th>Description</th><th>Symbol</th></tr>
<tr><td>NOR</td><td><table><tr><th colspan="2">Input</th><th>Output</th></tr><tr><td>0</td><td>0</td><td>1</td></tr><tr><td>0</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>0</td></tr></table></td><td></td></tr>
<tr><td>XOR</td><td><table><tr><th colspan="2">Input</th><th>Output</th></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td></tr></table></td><td></td></tr>
<tr><td>XNOR</td><td><table><tr><th colspan="2">Input</th><th>Output</th></tr><tr><td>0</td><td>0</td><td>1</td></tr><tr><td>0</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>1</td></tr></table></td><td></td></tr>
<tr><td>NOT
(INVERTER)</td><td><table><tr><th>Input</th><th>Output</th></tr><tr><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td></tr></table></td><td></td></tr>
<tr><td colspan="3">Pickup and Dropout Timers</td></tr>
<tr><td>Drop Out Timer</td><td>Used to set a delay in the logic.
For more information, refer to Programming BESTlogicPlus, Pickup and Dropout Timers, later in this section.</td><td></td></tr>
<tr><td>Pickup Up Timer</td><td>Used to set a delay in the logic.
For more information, refer to Programming BESTlogicPlus, Pickup and Dropout Timers, later in this section.</td><td></td></tr>
<tr><td colspan="3">Latches</td></tr>
<tr><td>Reset Priority Latch</td><td>When the Set input is on and the Reset input is off, the latch will go to the SET (ON) state. When the Reset input is on and the Set input is off, the latch will go to the RESET (OFF) state. If both the Set and Reset inputs are on at the same time, a reset priority latch will go to the RESET (OFF) state.</td><td></td></tr>
<tr><td>Set Priority Latch</td><td>When the Set input is on and the Reset input is off, the latch will go to the SET (ON) state. When the Reset input is on and the Set input is off, the latch will go to the RESET (OFF) state. If both the Set and Reset inputs are on at the same time, a set priority latch will go to the SET (ON) state.</td><td></td></tr>
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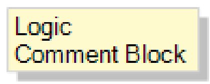
<tr><td colspan="3">Other</td></tr>
<tr><td>Comment Block</td><td>Enter user comments.</td><td></td></tr>
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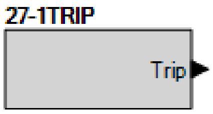
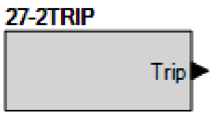
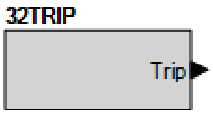
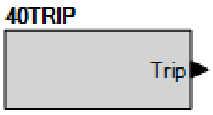
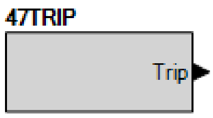
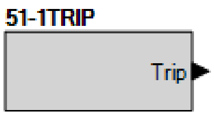
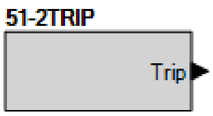
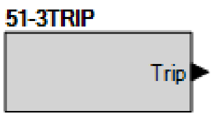
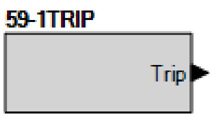
TIM-ID: 0000099917 - 001

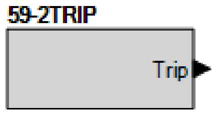
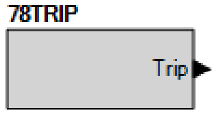
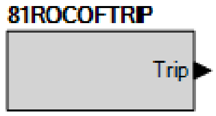
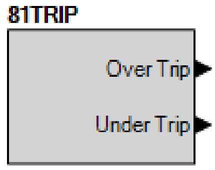
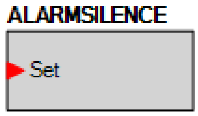
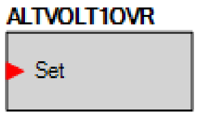
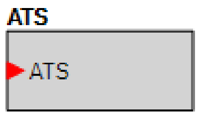
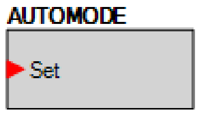
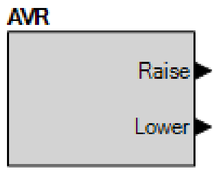
Elements

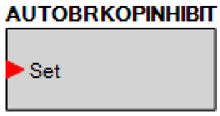
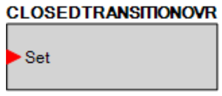
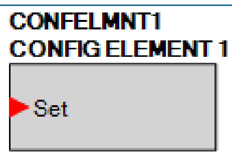
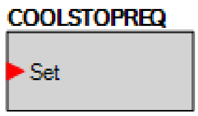
This group contains elements for the 27, 32, 40, 47, 51, 59, 78, 81, and ROCOF. It also contains elements for Generator Breaker, Mains Breaker, AVR Raise/Lower, Governor Raise/Lower, Logic Alarm, Logic Pre-Alarm, Modem, Configurable Elements, AUTO Mode, OFF Mode, RUN Mode, Parallel to Mains, Run with Load, Engine Run, ATS, Run Inhibit, Test Inhibit, Pre-Start Output, Start Output, Run Output, Cool Stop Request, Cool Down Request, External Start Delay, Start Delay Bypass, Alternate Frequency Override, Alternate Voltage Takeover, Load Takeover, MTU Speed Demand Switch, Mains Fail Test, Reset From, Alarm Silence, Lamp Test, Idle Request, Sequenced System Startup, Low Fuel Pre-Alarm, Diesel Particulate Filter Manual Regeneration, Diesel Particulate Filter Regeneration Inhibit, Emergency Stop, Speed Raise, and Speed Lower.

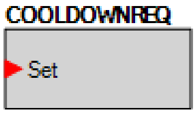
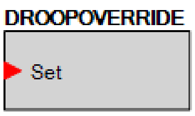
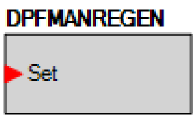
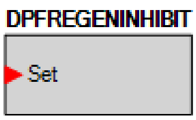
Table 5-3 lists the names and descriptions of the elements in the *Elements* group.

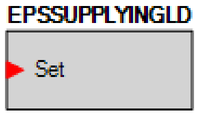
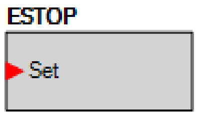
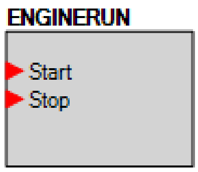
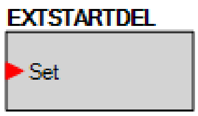
Table 5-3. Elements Group, Names and Descriptions

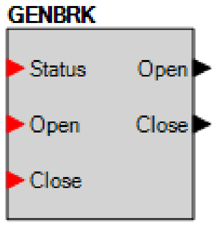
Name	Description	Symbol
Protection		
27-1TRIP	True when the 27-1 undervoltage is in a TRIP condition. Connect to another logic block input.	
27-2TRIP	True when the 27-2 undervoltage is in a TRIP condition. Connect to another logic block input.	
32TRIP	True when the 32 reverse power is in a TRIP condition. Connect to another logic block input.	
40TRIP	True when the 40Q loss of excitation is in a TRIP condition. Connect to another logic block input.	
47TRIP (Optional)	True when the 47 phase imbalance is in a TRIP condition. Connect to another logic block input.	
51-1TRIP (Optional)	True when the 51-1 overcurrent is in a TRIP condition. Connect to another logic block input.	
51-2TRIP (Optional)	True when the 51-2 overcurrent is in a TRIP condition. Connect to another logic block input.	
51-3TRIP (Optional)	True when the 51-3 overcurrent is in a TRIP condition. Connect to another logic block input.	
59-1TRIP	True when the 59-1 overvoltage is in a TRIP condition. Connect to another logic block input.	

Name	Description	Symbol
59-2TRIP	True when the 59-2 overvoltage is in a TRIP condition. Connect to another logic block input.	
78TRIP	True when the 78 vector shift is in a TRIP condition. Connect to another logic block input.	
81ROCOFTRIP	True when the 81 ROCOF is in a TRIP condition. Connect to another logic block input.	
81TRIP	True when the 81 frequency is in a TRIP condition. Connect to another logic block input.	
Other		
ALARMSILENCE	The alarm will be silenced when this element is true. The alarm can also be silenced by pressing the Alarm Silence button on the front panel of the MGC-2000 Series.	
ALTFREQOVER	When this logic element is true, protection and bus condition detection is forced to operate at the Alternate Frequency instead of the Rated Frequency.	
ALTVOLTXOVR (X = 1 to 4)	When this logic element is true and the voltage trim setpoint source is set for Trim Voltage, the alternate voltage setting becomes the active set point for the voltage trim controller.	
ATS	When this logic element is true, and the MGC-2000 Series is in AUTO mode, the generator will run. This can be used in place of the ATS programmable function if it is desired to generate the ATS signal as a combination of programmable logic rather than a simple contact input. If either the ATS logic element is true <u>or</u> the contact mapped to the ATS programmable function is true, <u>and</u> the MGC-2000 Series is in AUTO mode, the generator will run. If <u>both</u> the ATS logic element <u>and</u> the ATS programmable function are false, and the MGC-2000 Series is in AUTO mode, the generator will cool down and stop.	
AUTOMODE	When this input is true, and the MGC-2000 Series is in OFF mode, the MGC-2000 Series will switch to AUTO mode. This is a pulsed input. It does not need to be held after the desired mode switch has occurred.	
AVR	Can be connected to inputs of other logic blocks. When the AVR is being raised, the Raise output is true. When being lowered, the Lower output is true.	

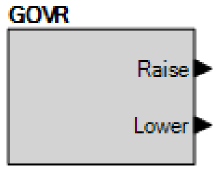
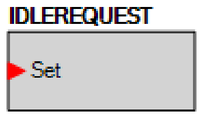
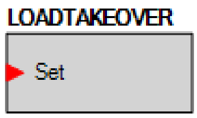
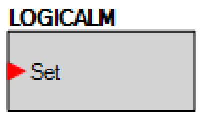
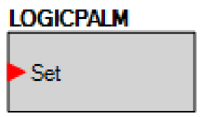
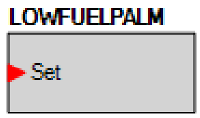
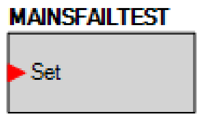
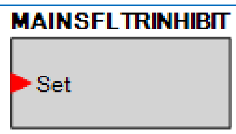
Name	Description	Symbol
AUTOBRKOP-INHIBIT	Automatic breaker operation is inhibited when the Set input is true.	
CLOSED-TRANSITIONOVR	All mains fail transfers are forced to be closed transitions, even if *Mains Fail Transfer Type* is set to *Open*, when the Set input is true.	
CONFELMNTX (X = 1 to 8)	Configurable elements (CONFELMNT1-8) are connected to the logic scheme as outputs. These elements are configurable in BESTCOMS*Plus* under *Programmable Outputs, Configurable Elements.* The user can assign a string of up to 16 characters, configure whether the element should generate an alarm or pre-alarm. If used for alarm or pre-alarm, the user's text is what will appear in the alarm or pre-alarm annunciation and in the MGC-2000 Series event log. In addition, the configurable element status can be used to generate modem dial outs which display the user's text on modem equipped MGC-2000 Series.	
COOLSTOPREQ	<u>RUN Mode</u> If the unit is in RUN mode when the Cool Stop Request is received, the unit will unload, open its breaker, and go into a cooldown cycle. While in the cooldown cycle, the unit will display “COOL & STOP REQ” in addition to displaying the cooldown timer. After the cooldown timer expires, the unit will go to OFF mode. The Cool Stop Request must be removed before the unit can be run again. If the Cool Stop Request is removed during the cooldown process, the unit will remain running. Furthermore, if a condition occurs that normally causes the unit to close its breaker in RUN mode, the unit will close its breaker and reload. <u>AUTO Mode</u> If the unit is in AUTO mode when the Cool Stop Request is received, all conditions that would normally cause the unit to run in AUTO mode are cleared. Since all conditions that cause the unit to run have been removed, the unit goes into a cooldown cycle. While in the cooldown cycle, the unit will display “COOL & STOP REQ” in addition to displaying the cooldown timer. After the cooldown timer expires, the unit will shut down, remaining in AUTO. The Cool Stop Request must be removed before the unit can be run again. If the Cool Stop Request is removed during the cooldown process and some condition that would normally cause the unit to run in AUTO mode is true, the unit will remain running. Furthermore, if a condition occurs that normally causes the unit to close its breaker, the unit will close its breaker and reload.	

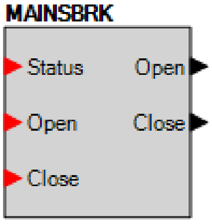
Name	Description	Symbol
COOLDOWNREQ	RUN Mode If the unit is in RUN mode when the Cool Down Request is received, the unit is forced to unload and open its breaker and then go into a cooldown cycle. While in the cool down cycle, the unit will display “COOLDOWN REQ” in addition to displaying the cooldown timer. After the cooldown timer expires, the unit will remain running in RUN mode. The Cool Down Request must be removed before the breaker can be closed again; this element blocks breaker closures. If the Cool Down Request is removed during the cool down process, the unit will remain running in RUN mode. Furthermore, if a condition occurs that normally causes the unit to close its breaker in RUN mode, the unit will close its breaker and reload. AUTO Mode If the unit is in AUTO mode and the Cool Down Request is received, the unit is forced to unload and open its breaker and go into a cooldown cycle. While in the cooldown cycle, the unit will display “COOLDOWN REQ” in addition to displaying the cooldown timer. After the cool down timer expires, the unit will remain running in AUTO mode, unless there are no conditions that cause the unit to run in AUTO mode, in which case it will shut down and remain in AUTO mode. The Cool Down Request must be removed before the breaker can be closed again; this element blocks breaker closures. If the Cool Down Request is removed during the cool down process and some condition that would normally cause the unit to run in AUTO mode is true, the unit will remain running in AUTO mode. Furthermore, if a condition occurs that normally causes the unit to close its breaker, the unit will close its breaker and reload.	
DROOPOVERRIDE	When the droop override logic element is true, the speed and voltage trim functions are disabled. The machine operates in speed droop and voltage droop to accomplish kW and kvar sharing. This is useful when it is desired to operate a system in droop rather than isochronous load sharing.	
DPFMANREGEN	Diesel Particulate Filter Regeneration is forced manually when the Set input is true.	
DPFREGENINHIBIT	Diesel Particulate Filter Regeneration is inhibited when the Set input is true.	

Name	Description	Symbol
EPSSUPPLYINGLD	When this element is true and the generator is deemed stable, the EPS Supplying Load LED, on the front panel, is illuminated. Under normal operation, the MGC-2000 Series indicates that it is supplying load when the generator is deemed stable and the generator current is above a percentage of CT primary current (typically 3%). The generator current requirement for supplying load indication may be bypassed by setting this element true. This is useful for testing purposes or in cases where the generator supplies load at a current level which falls below the requirement. A cool-down cycle is performed when the MGC-2000 Series is in auto mode, is indicating that it is supplying load (whether driven by logic or generator current), and the ATS input is removed.	
ESTOP	When this element is true, an Emergency Shutdown alarm is annunciated and the Emergency Stop LED on the RDP-110 is illuminated.	
ENGINERUN	The Start input starts the generator. No load is applied. The breaker remains open. The Stop input stops the generator. The MGC-2000 Series only responds to this logic element when in AUTO mode.	
EXTSTARTDEL	If the Set input is true while the MGC-2000 Series is in the Pre Start state, the MGC-2000 Series will remain in the Pre Start state until the Set input is false.	

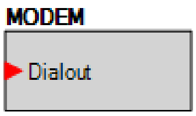
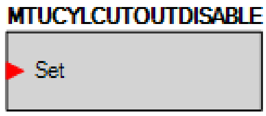
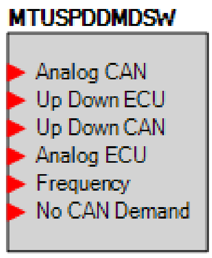
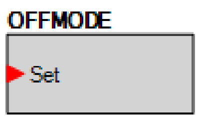
<table>
<tr><th>Name</th><th>Description</th><th>Symbol</th></tr>
<tr>
<td>GENBRK</td>
<td>
This element is used to connect the breaker open and close output signals from the MGC-2000 Series to physical output contacts to open and close the generator breaker, and map breaker status feedback to a contact input. In addition, contact inputs can be mapped to allow switches to be implemented to manually initiate breaker open and close requests.
<u>Inputs</u>
Status: This input allows a contact input to be mapped that will provide breaker status feedback to the MGC-2000 Series. When the contact input is closed, the breaker is indicated to be closed. When the contact input is open, the breaker is indicated to be open.
Open: This input allows a contact input to be mapped that can be used to initiate a manual breaker open request. When this input is pulsed closed while the MGC-2000 Series is in RUN or AUTO mode, the breaker will open.
Close: This input allows a contact input to be mapped that can be used to initiate a manual breaker close request. When this input is pulsed and the MGC-2000 Series is in AUTO or RUN mode, and the generator is stable, a close request will be initiated. If the Dead Bus Close Enable parameter is true, and the bus is dead, the breaker will close. If the bus is stable, the MGC-2000 Series will synchronize the generator to the bus, and then close the breaker. If the synchronizer option is not available, the MGC-2000 Series can still close the breaker if some external means is employed to synchronize the generator to the bus.
<u>Outputs</u>
The outputs must be mapped to the contact outputs of the MGC-2000 Series that will be used to drive the breaker.
Open: This output is pulsed true (closes the output contact it is mapped to) when the MGC-2000 Series is providing a signal to the breaker to open. It will be a pulse if the Breaker Output Contact Type is set to Pulse on the Breaker Hardware screen under Breaker Management in the Settings Explorer, and the length is determined by the Open Pulse Time. It will be a constant output if the Generator Breaker Hardware Contact Type is set to continuous. Note the pulse time must be set long enough for the breaker to actually open before the pulse is removed.
Close: This output is pulsed true (closes the output contact it is mapped to) when the MGC-2000 Series is providing a signal to the breaker to close. It will be a pulse if the Breaker Output Contact Type is set to Pulse on the Breaker Hardware screen under Breaker Management in the Settings Explorer, and the length is determined by the Open Pulse Time. It will be a constant output if the Generator Breaker Hardware Contact Type is set to continuous. Note the pulse time must be set long enough for the breaker to actually open before the pulse is removed.
NOTE
When using the MGC-2000 Series synchronizer, it is recommended that local MGC-2000 Series relay outputs be used for breaker closing commands to minimize the possibility of closures outside of desired breaker closing angles.
If remote (CEM-2020) outputs are to be used for breaker close commands, it is recommended that the anticipatory synchronizer type be used, and the breaker close wait time be adjusted to account for possible CEM-2020 output delays (typically 50 ms) to achieve desired breaker closing angles.
</td>
<td>


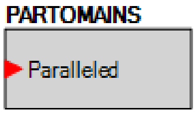
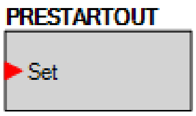
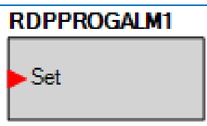
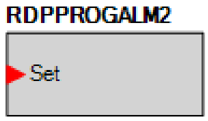
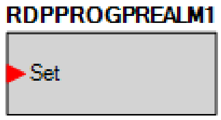
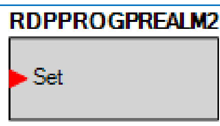
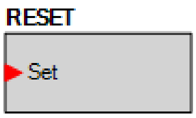
</td>
</tr>
</table>

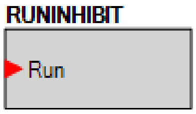
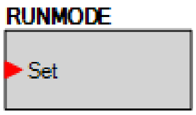
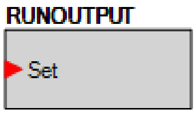
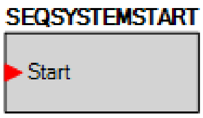
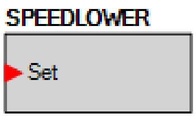
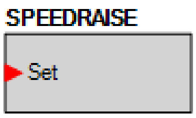
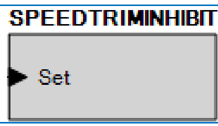
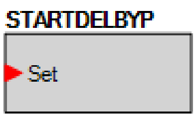
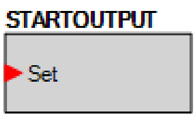
Name	Description	Symbol
GOVR	Can be connected to inputs of other logic blocks. When the Governor is being raised, the Raise output is true. When being lowered, the Lower output is true.	
IDLEREQUEST	When this element is true, the MGC-2000 Series will send an idle request to the engine ECU on J1939 engines that are equipped to receive such a request. At this time, only Volvo and Cummins are implemented. If the engine is not equipped to respond to idle requests, or the engine is not one of the listed J1939 engine types, this will have no effect.	
LAMPTEST	The lamp test will be performed when this element is true. The lamp test can also be accomplished by pressing the Lamp Test button on the front panel of the MGC-2000 Series.	
LOADTAKEOVER	When this logic element is true, the generator is forced to start, assume load, and disconnect from the mains, either in a closed or open transition. The Parallel to Mains logic element must be true any time the generator is in parallel with the utility. Parallel transitions to and from the mains will not operate properly if the Parallel to Mains logic element is not set correctly.	
LOGICALM	When this input is true, the MGC-2000 Series goes into an alarm condition.	
LOGICPALM	When this input is true, the MGC-2000 Series goes into a Pre-alarm condition.	
LOWFUELPALM	When this element is true, a Low Fuel Pre-Alarm is annunciated and the Low Fuel Level LED on the RDP-110 is illuminated.	
MAINSFAILTEST	When this element is true, the MGC-2000 Series will exercise its mains fail transfer function exactly as it would if the mains were to fail on a mains fail machine. This can be used as a test of the mains fail transfer capability of the unit without having to cause a true mains failure.	
MAINSFLTRINHIBIT	The mains fail transfer function is inhibited when the Set input is true.	

Name	Description	Symbol
MAINSBRK	This element is used to connect the breaker open and close output signals from the MGC-2000 Series to physical output contacts to open and close the mains breaker and map breaker status feedback to a contact input. In addition, contact inputs can be mapped to allow switches to be implemented to manually initiate breaker open and close requests. This element is only available when the Mains Breaker Hardware in configured on the *Breaker Hardware* screen via the *Breaker Management* tree branch. <u>Inputs</u> *Status:* This input allows a contact input to be mapped that will provide breaker status feedback to the MGC-2000 Series. When the contact input is closed, the breaker is indicated to be closed. When the contact input is open, the breaker is indicated to be open. *Open:* This input allows a contact input to be mapped that can be used to initiate a manual breaker open request. When this input is pulsed closed while the MGC-2000 Series is in RUN or AUTO mode, the breaker will open. *Close:* This input allows a contact input to be mapped that can be used to initiate a manual breaker close request. When this input is pulsed and the MGC-2000 Series is in AUTO or RUN mode, and the generator is stable, a close request will be initiated. If the Dead Bus Close Enable parameter is true, and the bus is dead, the breaker will close. If the bus is stable, the MGC-2000 Series will synchronize the generator to the bus, and then close the breaker. If the synchronizer option is not available, the MGC-2000 Series can still close the breaker if some external means is employed to synchronize the generator to the bus. <u>Outputs</u> The outputs must be mapped to the contact outputs of the MGC-2000 Series that will be used to drive the breaker. *Open:* This output is pulsed true (closes the output contact it is mapped to) when the MGC-2000 Series is providing a signal to the breaker to open. It will be a pulse if the Breaker Output Contact Type is set to Pulse on the Breaker Hardware screen under Breaker Management in the Settings Explorer, and the length is determined by the Open Pulse Time. It will be a constant output if the Mains Breaker Hardware Contact Type is set to continuous. Note the pulse time must be set long enough for the breaker to actually open before the pulse is removed. *Close:* This output is pulsed true (closes the output contact it is mapped to) when the MGC-2000 Series is providing a signal to the breaker to close. It will be a pulse if the Breaker Output Contact Type is set to Pulse on the Breaker Hardware screen under Breaker Management in the Settings Explorer, and the length is determined by the Open Pulse Time. It will be a constant output if the Mains Breaker Hardware Contact Type is set to continuous. Note the pulse time must be set long enough for the breaker to actually open before the pulse is removed. **NOTE** When using the MGC-2000 Series synchronizer, it is recommended that local MGC-2000 Series relay outputs be used for breaker closing commands to minimize the possibility of closures outside of desired breaker closing angles. If remote (CEM-2020) outputs are to be used for breaker close commands, it is recommended that the anticipatory synchronizer type be used, and the breaker close wait time be adjusted to account for possible CEM-2020 output delays (typically 50 ms) to achieve desired breaker closing angles.	

TIM-ID: 0000099917 - 001

Name	Description	Symbol
MODEM (Optional)	Connect the input to the output of another logic block. When true, the modem dials out.	
MTUCYLCUTOUT-DISABLE (MTU Cylinder Cutout Disable)	When this logic element is true, Cylinder Cutout Disable 1 and Cylinder Cutout Disable 2 are both sent to the engine ECU with true status. When this logic element is false, Cylinder Cutout Disable 1 and Cylinder Cutout Disable 2 are sent to the engine ECU with states set by the values programmed for the Cylinder Cutout Disable 1 and Cylinder Cutout Disable 2 MGC-2000 Series settings which are configured on the ECU Setup screen in BESTCOMS*Plus*.	
MTUSPDDMDSW	This logic element can be used to specify the Speed Demand Source parameter value that is sent to an MTU Engine ECU. When no input is true, the value sent to the engine ECU is the value specified in the Speed Demand Source setting in the ECU configuration setting. If an input on this logic element is true, the selected Speed Demand Source will be sent rather than the value specified by the Speed Demand Source setting. If multiple inputs are true at the same time, the input that is closest to the top of the logic element symbol will specify the Speed Demand Source parameter value that is sent to the ECU. Analog CAN: This input configures the MTU ECU to accept speed bias requests over J1939 CANBus from the MGC-2000 Series. Up Down ECU: This input configures the MTU ECU to accept speed raise/lower commands via contact inputs on the ECU. Up Down CAN: This input configures the MTU ECU to accept speed raise/lower commands via communications over J1939 CAN bus. Analog ECU: This input configures the MTU ECU to accept speed bias via bias voltage input connections on the ECU. Frequency: This configures the MTU ECU to accept speed commands via a frequency signal input on the ECU. The mapping of input signal frequency to machine speed is configured in a curve within the engine ECU. No CAN Demand: This input configures the MTU ECU to disregard all speed requests or speed raise/lower requests from J1939 CAN bus.	
OFFMODE	When this input is true, the MGC-2000 Series will switch to OFF mode. This is a pulsed input. It does not need to be held after the desired mode switch has occurred.	

Name	Description	Symbol
PARTOMAINS	Setting this logic element to true indicates to the MGC-2000 Series that it is paralleled to a utility. When paralleled to the utility, the kW controller will regulate the machine's kW output at the Base Load Level (%) that is set on the *Governor Bias Control Settings* screen, where the Base Load Level is in percent of machines rated kW. Otherwise, the kW controller will implement kW load sharing when part of a load sharing system. If a load sharing system is not implemented, the speed controller can be set up to implement speed droop. When paralleled to the utility, the var/PF controller will regulate the machine's reactive power output according to the control mode setting. If the control mode is var Controller, the output will be regulated to the kvar Setpoint (%) that is set on the AVR *Bias Control Settings* screen, where the kvar Setpoint (%) is in percentage of the machines rated kvar. If the control mode is PF Control, the reactive power output is regulated to a level that maintains the machines power factor at the value specified by the PF setting on the AVR *Bias Control Settings* screen. When var/PF control is not active or not enabled, the voltage controller can be set up to implement voltage droop.	
PRESTARTOUT	This element is used to drive the prestart output relay from logic when the Prestart Output Relay configuration is set to "Programmable". When the Prestart Output Relay configuration is set to "Programmable", the prestart relay will not close unless logic is used to drive this element. When the Prestart Output Relay configuration is set to "Predefined", the prestart relay is closed according to the predefined prestart functionality of the MGC-2000 Series. When the "Predefined" functionality is selected, the relay will not respond to this element.	
RDPPROGALM1	When true, this element illuminates the *Fuel Leak/Sender Failure* LED on the Remote Display Panel RDP-110. When this element is connected in logic, it overrides all other commands to the LED. Otherwise, the LED operates as normal.	
RDPPROGALM2	When true, this element illuminates the *Sender Failure* LED on the Remote Display Panel RDP-110. When this element is connected in logic, it overrides all other commands to the LED. Otherwise, the LED operates as normal.	
RDPPROGPREALM1	When true, this element illuminates the *Battery Overvoltage* LED on the Remote Display Panel RDP-110. When this element is connected in logic, it overrides all other commands to the LED. Otherwise, the LED operates as normal.	
RDPPROGPREALM2	When true, this element illuminates the *Battery Charger Failure* LED on the Remote Display Panel RDP-110. When this element is connected in logic, it overrides all other commands to the LED. Otherwise, the LED operates as normal.	
RESET	Reset will be active when this element is true. Reset can also be accomplished by pressing the Reset button on the front panel of the MGC-2000 Series.	

Name	Description	Symbol
RUNINHIBIT	When this logic element is true, the MGC-2000 Series is prevented from starting and running the generator, regardless of any condition that would normally cause the generator to run. If this element is false and there is any condition in effect which will cause the generator to run, the MGC-2000 Series will start and run the generator.	
RUNMODE	When this input is true, and the MGC-2000 Series is in OFF mode, the MGC-2000 Series will switch to RUN mode. This is a pulsed input. It does not need to be held after the desired mode switch has occurred.	
RUNOUTPUT	This element is used to drive the run output relay from logic when the Run Output Relay configuration is set to “Programmable”. When the Run Output Relay configuration is set to “Programmable”, the run relay will not close unless logic is used to drive this element. When the Run Output Relay configuration is set to “Predefined”, the run relay is closed according to the predefined run functionality of the MGC-2000 Series. When the “Predefined” functionality is selected, the relay will not respond to this element.	
RUNWLOAD	The Start input starts the generator and closes the Gen breaker. The Stop input stops the generator and opens the Gen breaker. The MGC-2000 Series only responds to this logic element when in AUTO mode.	
SEQSYSTEMSTART	When true, this element starts a sequenced system when no machines are running. This starts the first unit in a multiple unit system based on the sequencing criterion.	
SPEEDLOWER	This element lowers the speed setting of the MGC-2000 Series by up to 2 rpm per second. After the speed has not been lowered for 30 seconds, the modified speed is saved to nonvolatile memory.	
SPEEDRAISE	This element raises the speed setting of the MGC-2000 Series by up to 2 rpm per second. After the speed has not been raised for 30 seconds, the modified speed is saved to nonvolatile memory.	
SPEEDTRIMINHIBIT	When true, this element inhibits operation of the MGC-2000 Series speed trim PID controller. For example, speed trim is not desired in multiple generator systems during start up synchronization until the generators are stable.	
STARTDELBYP	This element allows the Pre Start state to be skipped based on logic. For example, a start delay may not be necessary when the engine is warm. This also allows an external device, such as an ECU, to control the pre start interval.	
STARTOUTPUT	This element is used to drive the start output relay from logic when the Start Output Relay configuration is set to “Programmable”. When the Start Output Relay configuration is set to “Programmable”, the start relay will not close unless logic is used to drive this element. When the Start Output Relay configuration is set to “Predefined”, the start relay is closed according to the predefined start functionality of the MGC-2000 Series. When the “Predefined” functionality is selected, the relay will not respond to this element.	

Name	Description	Symbol
STOPKVARRAMP	The Stop kvar Ramp logic element, when true, causes the generator to freeze the ramping of kvar and maintain a constant output.	STOPKVARRAMP Set
STOPKWRAMP	The Stop kW Ramp logic element, when true, causes the generator to freeze the ramping of kW and maintain a constant output.	STOPKWRAMP Set
TESTINHIBIT	When this logic element is true, the generator exercise timer cannot start the generator. If the TESTINHIBIT logic function is false during an exercise period, or transitions from true to false at any time during an exercise period, the MGC-2000 Series will start and run the generator for the duration of the exercise period.	TESTINHIBIT Exercise
VOLTAGETRIM INHIBIT	When true, this element inhibits operation of the MGC-2000 Series voltage trim PID controller. For example, voltage trim is not desired in multiple generator systems during start up synchronization until the generators are stable.	VOLTTRIMINHIBIT Set

Logic Schemes

A logic scheme is a group of logic variables written in equation form that defines the operation of an MGC-2000 Series Digital Genset Controller. Each logic scheme is given a unique name. This gives you the ability to select a specific scheme and be confident that the selected scheme is in operation. One logic scheme is configured for typical control applications and is the default active logic scheme. Only one logic scheme can be active at a given time. In most applications, preprogrammed logic schemes eliminate the need for custom programming. Preprogrammed logic schemes may provide more inputs, outputs, or features than are needed for a particular application. This is because a preprogrammed scheme is designed for a large number of applications with no special programming required. Unneeded logic block outputs may be left open to disable a function or a function block can be disabled through operating settings.

When a custom logic scheme is required, programming time is reduced by modifying the default logic scheme.

The Active Logic Scheme

Digital Genset Controllers must have an active logic scheme in order to function. All MGC-2000 Series controllers are delivered with a default, active logic scheme pre-loaded in memory. If the function block configuration and output logic of the default logic scheme meets the requirements of your application, then only the operating settings (power system parameters and threshold settings) need to be adjusted before placing the MGC-2000 Series in service.

Copying and Renaming Preprogrammed Logic Schemes

Copying a saved logic scheme to the active logic (*Logic Name*) and assigning a unique name is accomplished by loading the saved logic scheme into BESTCOMS*Plus* and then typing over the logic scheme's name. Changes are not activated until the new settings have been saved and uploaded to the device.

Sending and Retrieving Logic Schemes

Retrieving a Logic Scheme from the MGC-2000 Series

To retrieve settings from the MGC-2000 Series, the MGC-2000 Series must be connected to a computer through a communications port. Once the necessary connections are made, settings can be downloaded from the MGC-2000 Series by selecting *Download Settings and Logic* on the *Communication* pull-down menu.

Sending a Logic Scheme to the MGC-2000 Series

To send settings to the MGC-2000 Series, the MGC-2000 Series must be connected to a computer through a communications port. Once the necessary connections are made, settings can be uploaded to the MGC-2000 Series by selecting *Upload Settings and Logic* on the *Communication* pull-down menu.

CAUTION
Always remove the MGC-2000 Series from service prior to changing or modifying the active logic scheme. Attempting to modify a logic scheme while the MGC-2000 Series is in service could generate unexpected or unwanted outputs. Modifying a logic scheme in BESTCOMS*Plus* does not automatically make that scheme active in the MGC-2000 Series. The modified scheme must be uploaded into the MGC-2000 Series.

Programming BESTlogic™ Plus

Use BESTCOMS*Plus* to program BESTlogic*Plus*. Using BESTCOMS*Plus* is analogous to physically attaching wire between discrete MGC-2000 Series terminals. To program BESTlogic*Plus*, use the Settings Explorer within BESTCOMS*Plus* to open the *BESTlogicPlus Programmable Logic* tree branch as shown in Figure *5-1*.

The drag and drop method is used to connect a variable or series of variables to the logic inputs, outputs, components, and elements. To draw a wire/link from port to port (triangles), click the left mouse button on a port, pull the wire onto another port, and release the left mouse button. A red port indicates that a connection to the port is required or missing. A black port indicates that a connection to the port is not required. Drawing wires/links from input to input or output to output is not allowed. Only one wire/link can be connected to any one output. If the proximity of the endpoint of the wire/link is not exact, it may attach to an unintended port.

If an object or element is disabled, it will have a yellow X on it. To enable the element, navigate to the settings page for that element. A red X indicates that an object or element is not available per the style number of the MGC-2000 Series.

The view of the Main Logic, Physical Outputs, Remote Outputs, and LCR Outputs can be automatically arranged by clicking the right mouse button on the window and selecting *Auto-Layout.*

The following must be met before BESTCOMS*Plus* will allow logic to be uploaded to the MGC-2000 Series:

- A minimum of two inputs and a maximum of four inputs on any multi-port (AND, OR, NAND, NOR, XOR, and XNOR) gate.
- A maximum of nine logic levels for any particular path. A path being an input block or an output side of an element block through gates to an output block or an input side of an element block. This is to include any OR gates on the Physical Output or Remote Output tab/pages, but not the matched pairs of Physical Output blocks or Remote Output blocks.
- Only 30 gates per logic level. All output blocks and input sides of element blocks are at the maximum logic level of the diagram. All gates are pushed forward/upwards in logic levels and buffered to reach the final output block or element block if needed. A maximum of 150 gates allowed per diagram.
- At all levels there can only be 96 used link/wired or endpoints. Endpoints being inputs, outputs, both sides of element blocks.

Three status LEDs are located in the lower right corner of the BESTlogic*Plus* window. These LEDs show the *Logic Save Status*, *Logic Diagram Status*, and *Logic Layer Status*. Table 5-4 defines the colors for each LED.

Table 5-4. Status LEDs

LED	Color	Definition
Logic Save Status (Left LED)	Orange	Logic has changed since last save.
	Green	Logic has NOT changed since last save.

Logic Diagram Status (Center LED)	Red	Requirements NOT met as listed above.
	Green	Requirements met as listed above.
Logic Layer Status (Right LED)	Red	Requirements NOT met as listed above.
	Green	Requirements met as listed above.

Pickup and Dropout Timers

A pickup timer produces a true output when the elapsed time is greater than or equal to the Pickup Time setting after a false to true transition occurs on the Initiate input from the connected logic. Whenever the Initiate input status transitions to false, the output transitions to false immediately.

A drop out timer produces a true output when the elapsed time is greater than or equal to the Dropout Time setting after a true to false transition occurs on the Initiate input from the connected logic. Whenever the Initiate input transitions to true, the output transitions to false immediately.

Refer to Figure 5-2, *Pickup and Dropout Logic Timer Blocks.*

To program logic timer settings, use the Settings Explorer within BESTCOMS*Plus* to open the *BESTlogicPlus Programmable Logic/Logic Timers* tree branch. Enter a *Name* label that you want to appear on the timer logic block. The *Time Delay* value range is 0 to 250 hours in 1 hour increments, 0 to 250 minutes in 1 minute increments, or 0 to 1,800 seconds in 0.1 second increments.

Next, open the *Components* tab inside the BESTlogic*Plus* window and drag a timer onto the program grid. Right click on the timer to select the timer you want to use that was previously set on the *Logic Timers* tree branch. The *Logic Timer Properties Dialog Box* will appear. Select the timer you want to use.

Timing accuracy is ±15 milliseconds.

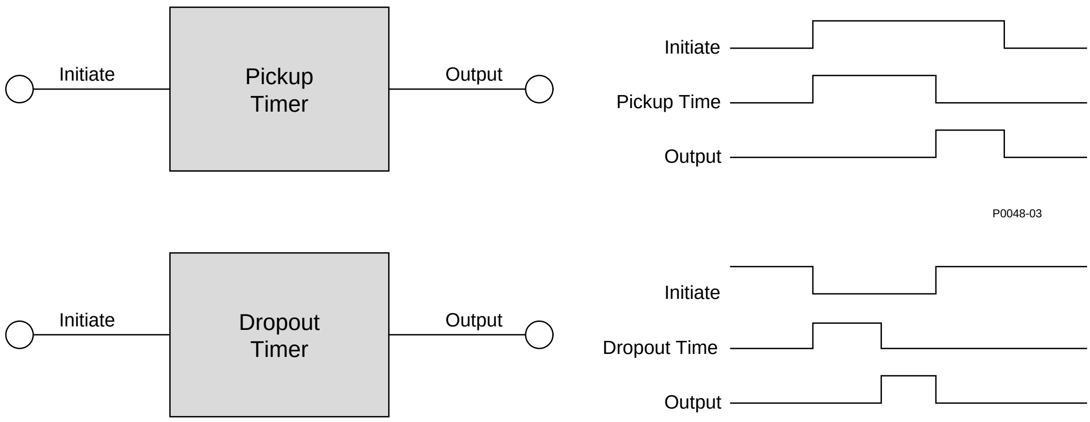


Figure 5-2. Pickup and Dropout Timer Logic Blocks

Offline Logic Simulator

The offline logic simulator allows you to change the state of various logic elements to illustrate how that state travels through the system. Before running the logic simulator, you must click the Save button on the BESTlogic*Plus* toolbar to save the logic to memory. Changes to the logic (other than changing the state) are disabled when the simulator is enabled. Colors are selected by clicking the Options button on the BESTlogic*Plus* toolbar. By default, Logic 0 is red and Logic 1 is green. Using your mouse, double-click on a logic element to change its state.

An example of the offline logic simulator is shown in Figure 5-3. Output 1 is Logic 0 (red) when Virtual Switch 1 is Logic 0 (red) and Fixed 1 is Logic 1 (green).

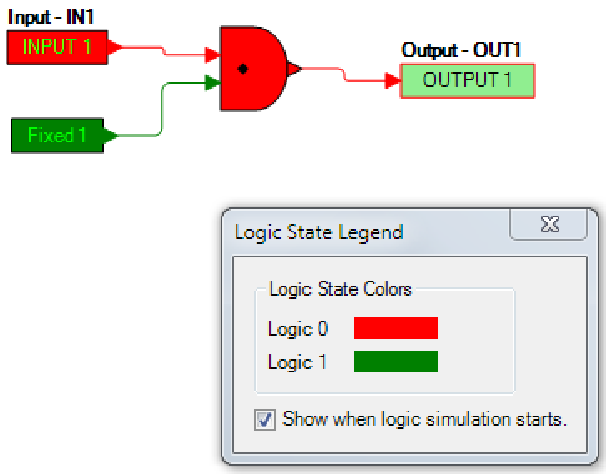


Figure 5-3. Offline Logic Simulator Example

BESTlogic™Plus File Management

To manage BESTlogic*Plus* files, use the Settings Explorer to open the *BESTlogicPlus Programmable Logic* tree branch. Use the BESTlogic*Plus* Programmable Logic toolbar to manage BESTlogic*Plus* files. Refer to Figure 5-4. For information on Settings Files management, refer to Section 4, *BESTCOMSPlus® Software.*

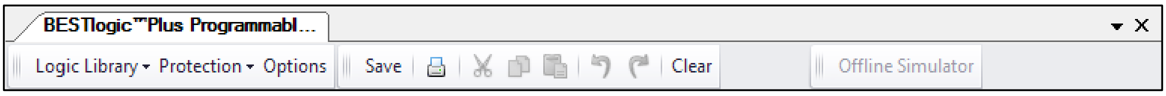


Figure 5-4. BESTlogicPlus Programmable Logic Toolbar

Saving a BESTlogic™Plus File

After programming BESTlogic*Plus* settings, click on the *Save* button to save the settings to memory.

Before the new BESTlogic*Plus* settings can be uploaded to the MGC-2000 Series, you must select *Save* from the *File* pull-down menu located at the top of the BESTCOMS*Plus* main shell. This step will save both the BESTlogic*Plus* settings and the operating settings to a file.

The user also has the option to save the BESTlogic*Plus* settings to a unique file that contains only BESTlogic*Plus* settings. Click on the *Logic Library* drop-down button and select *Save Logic Library File.* Use normal Windows® techniques to browse to the folder where you want to save the file and enter a filename to save as.

Opening a BESTlogic™Plus File

To open a saved BESTlogic*Plus* file, click on the *Logic Library* drop-down button on the BESTlogic*Plus* Programmable Logic toolbar and select *Open Logic Library File.* Use normal Windows techniques to browse to the folder where the file is located.

Protecting a BESTlogic™Plus File

Objects in a logic diagram can be locked so that when the logic document is protected these objects cannot be changed. Locking and protecting is useful when sending logic files to other personnel to be modified. The locked object(s) cannot be changed. To view the lock status of the object(s), select *Show Lock Status* from the *Protection* drop-down menu. To lock object(s), use the mouse to select object(s) to be locked. Right click on the selected object(s) and select *Lock Object(s).* The gold colored padlock next to the object(s) will change from an open to a locked state. To protect a logic document, select *Protect Logic Document* from the *Protection* drop-down button. A password is optional.

Uploading a BESTlogic™Plus File

To upload a BESTlogic*Plus* file to the MGC-2000 Series, you must first open the file through BESTCOMS*Plus* or create the file using BESTCOMS*Plus*. Then pull down the *Communication* menu and select *Upload Logic.*

Downloading a BESTlogic™Plus File

To download a BESTlogic*Plus* file from the MGC-2000 Series, you must pull down the *Communication* menu and select *Download Logic*. If the logic in your BESTCOMS*Plus* has changed, a dialog box will open asking you if want to save the current logic changes. You may choose *Yes* or *No*. After you have taken the required action to save or not save the current logic, the downloading is executed.

Printing a BESTlogic™Plus File

To view a preview of the printout, click on the *Print Preview* icon located on the BESTlogic*Plus* Programmable Logic toolbar. If you wish to print to a printer, select the printer icon in the upper left corner of the *Print Preview* screen.

You may skip the print preview and go directly to print by clicking on the *Printer* icon on the BESTlogic*Plus* Programmable Logic toolbar. A dialog box, *Select Views to Print* opens allowing you to check which views you would like to print. Next, the *Print* dialog box opens with the typical Windows choice to setup the properties of printer. Execute this command, as necessary, and then select *Print*.

A *Page Setup* icon is also provided on the BESTlogic*Plus* Programmable Logic toolbar allowing you to select *Paper Size, Paper Source, Orientation,* and *Margins.*

Clearing the On-Screen Logic Diagram

Click on the *Clear* button to clear the on-screen logic diagram and start over.

BESTlogic™Plus Examples

Example 1 - AVR Logic Block Connections

Figure 5-5 illustrates the AVR logic block and two output logic blocks. Output 6 is active while the AVR is being raised and Output 9 is active while the AVR is being lowered.

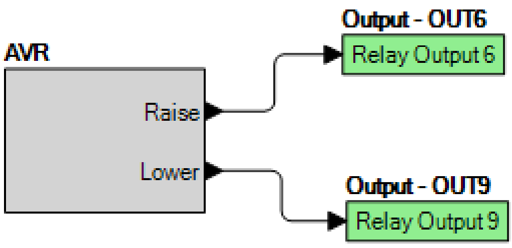


Figure 5-5. Example 1 - AVR Logic Block Connections

Example 2 - AND Gate Connections

Figure 5-6 illustrates a typical AND gate connection. In this example, Output 11 will become active when the Low Fuel alarm AND the Low Oil Pressure alarm are true.

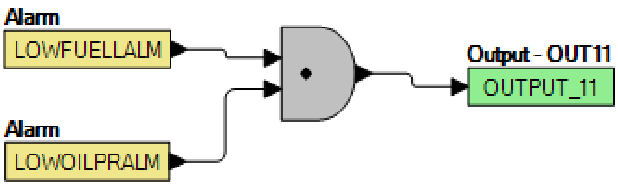


Figure 5-6. Example 2 - AND Gate Connections

Example 3 - Multiple Logic Connections

In this example, there are two comment boxes, which may be placed on the logic diagram. Double-click a comment box to modify the inside text. Output 5 will become true when the 27TRIP is TRUE. Output 7 will become true when the Cool Temp Sender Fail is true. Output 1 will become true when the MGC-2000 Series is in RUN mode (RUN Mode true). Refer to Figure 5-7.

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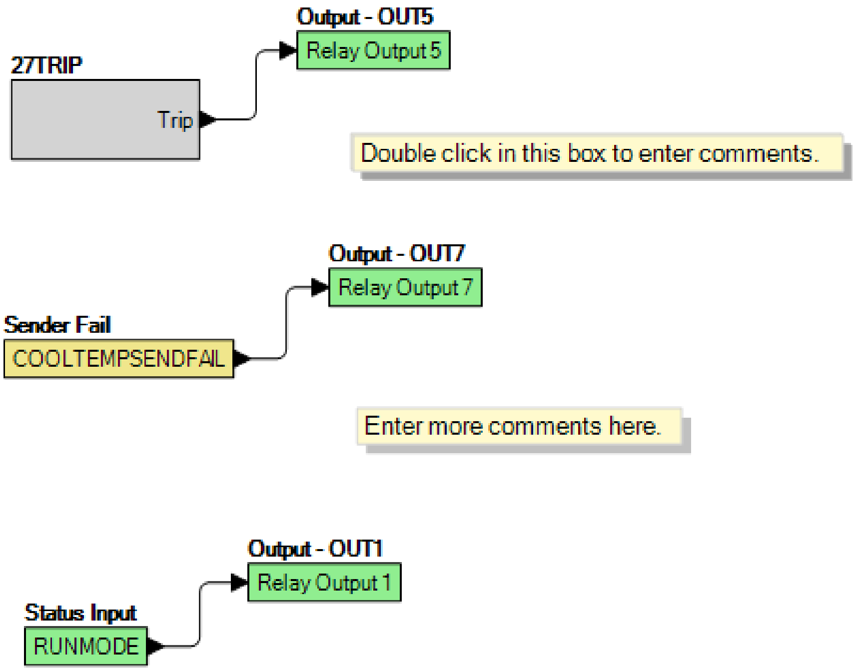

Figure 5-7. Example 3 - Multiple Logic Connections

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SECTION 6 • INSTALLATION

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SECTION 6 • INSTALLATION

General

MGC-2000 Series controllers are delivered in sturdy cartons to prevent shipping damage. Upon receipt of a unit, check the part number against the requisition and packing list for agreement. Inspect for damage, and if there is evidence of such, immediately file a claim with the carrier and notify MTU Onsite Energy.

If the device is not installed immediately, store it in the original shipping package in a moisture- and dust-free environment.

Hardware

MGC-2000 Series controllers are packaged for mounting in any top-mount enclosure. The front panel is resistant to moisture, salt fog, humidity, dust, dirt, and chemical contaminants. MGC-2000 Series controllers are mounted using the four permanently attached 10-24 studs. The torque applied to the mounting hardware should not exceed 25 inch-pounds (2.8 Newton meters).

Mounting

Panel cutting and drilling dimensions are shown in Figure 6-1. The horizontal drilling measurement of 10.75 inches has a tolerance of +0.01/–0.01 inches. The horizontal cutout measurement of 10.38 inches has a tolerance of +0.04/-0 inches. The vertical drilling measurement of 7.25 inches has a tolerance of +0.01/-0.01 inches. The vertical cutout measurement of 6.88 inches has a tolerance of +0.04/-0. Overall dimensions are shown in Figure 6-2. All dimensions are shown in inches with millimeters in parenthesis.

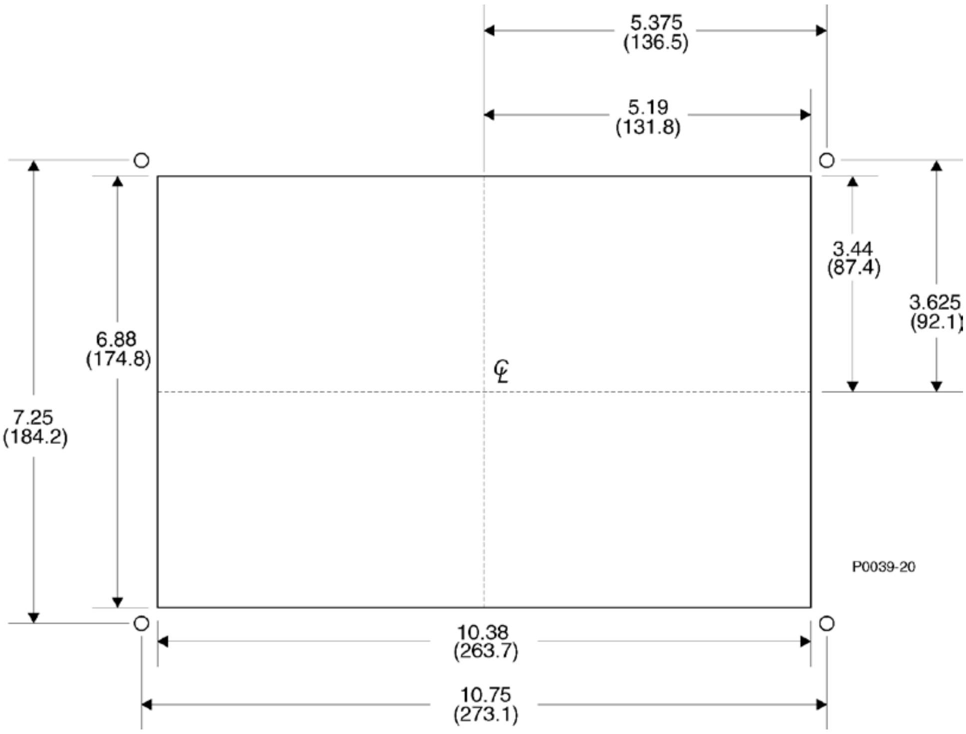

Figure 6-1. Panel Cutting and Drilling Dimensions

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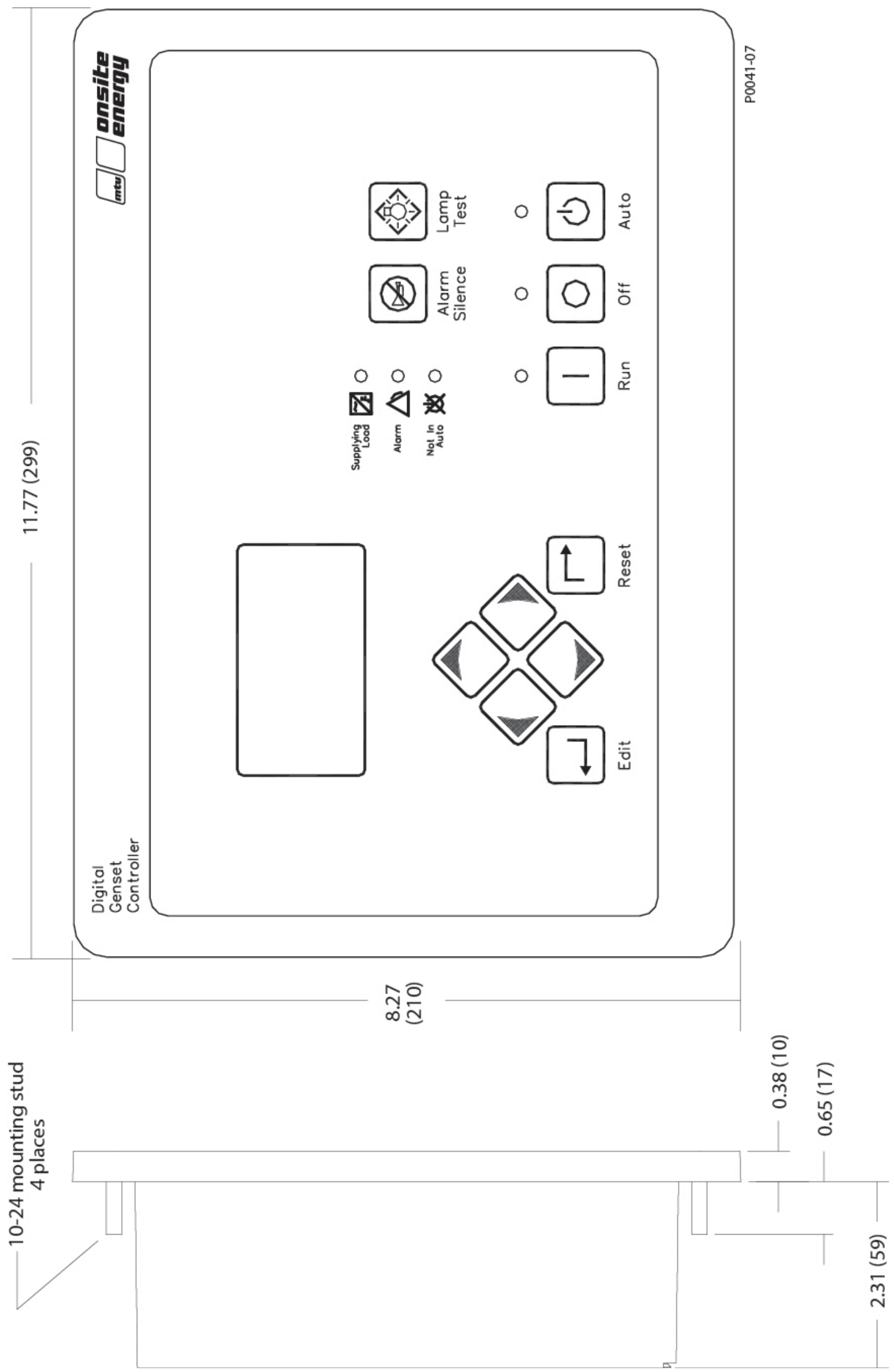

Figure 6-2. Overall Dimensions

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Connections

MGC-2000 Series connections are dependent on the application. Incorrect wiring may result in damage to the controller.

> **NOTES**
>
> Be sure that the MGC-2000 Series is hard-wired to earth ground with no smaller than 12 AWG copper wire attached to the chassis ground terminal (terminal 1) on the rear of the controller.
>
> Operating power from the battery must be of the correct polarity. Although reverse polarity will not cause damage, the MGC-2000 Series will not operate.
>
> For the MGC-2000 Series to correctly meter power factor, the generator must be rotating clockwise (A-B-C).

Terminations

All MGC-2000 Series terminals are located on the rear panel of the controller. There are three types of interface terminals: a mini-B USB socket, plug-in connectors with screw-down compression terminals, and quarter-inch, male, quick-connect terminals. MGC-2000 Series hardware version 3 controllers with style number xxxxxExxx are equipped with an RS-232 port. This port allows communication with an external, user-supplied modem with dial-in and dial-out capability. MGC-2000 Series hardware versions 1 and 2 with style number xxxxxMxxx are equipped with an internal modem with dial-in and dial-out capability.

The mini-B USB socket mates with a standard USB cable and provides local communication between the MGC-2000 Series and a PC running BESTCOMS*Plus*® software.

The majority of MGC-2000 Series connections are made with 15-position connectors with screw-down compression terminals. These connectors plug into headers on the MGC-2000 Series. The connectors and headers have a dovetailed edge that ensures proper connector orientation. Each connector and header is uniquely keyed to ensure that a connector mates only with the correct header. Connector screw terminals accept a maximum wire size of 12 AWG. Maximum screw torque is four inch-pounds (0.45 N•m).

Connections to the MGC-2000 Series starter, fuel solenoid, and glow plug output contacts are made directly to each relay through quarter-inch, male, quick-connect terminals. Amp part numbers 154718-3 (positive-lock receptacle) and 154719-1 (nylon housing) are the recommended components for making connections at these terminals.

MGC-2000 Series terminal groups are described in the following paragraphs.

Operating Power

The MGC-2000 Series operating power input accepts either 12 Vdc or 24 Vdc and tolerates voltage over the range of 6 to 32 Vdc. Operating power must be of the correct polarity. Although reverse polarity will not cause damage, the MGC-2000 Series will not operate. Operating power terminals are listed in Table 6-1.

To follow UL guidelines, a 5A maximum, 32 Vdc supplementary fuse must be implemented in the battery input circuit to the MGC-2000 Series.

Table 6-1. Operating Power Terminals

Terminal	Description
1 (CHASSIS)	Chassis ground connection
2 (BATT–)	Negative side of operating power input
3 (BATT+)	Positive side of operating power input

Generator Current Sensing

The MGC-2000 Series has sensing inputs for A-phase, B-phase, and C-phase generator current. Depending on the style number, an MGC-2000 Series will have a nominal sensing current rating of 1 Aac or 5 Aac. A style number of 1xxxxxxxx indicates 1 Aac nominal current sensing and a style number of 5xxxxxxxx indicates 5 Aac nominal current sensing. Generator current sensing terminals are listed in Table 6-2.

Table 6-2. Generator Current Sensing Terminals

Terminal	Description
68 (IA–)	A-phase current sensing input
69 (IA+)	
71 (IB–)	B-phase current sensing input
72 (IB+)	
74 (IC–)	C-phase current sensing input
75 (IC+)	

NOTE

Unused current sensing inputs should be shorted to minimize noise pickup.

Generator Voltage Sensing

The MGC-2000 Series accepts either line-to-line or line-to-neutral generator sensing voltage over the range of 12 to 576 volts, rms line-to-line. Depending on the style number, an MGC-2000 Series will have a nominal generator frequency rating of 50/60 hertz or 400 hertz. A style number of x1xxxxxxx indicates 50/60 hertz generator voltage and a style number of x2xxxxxxx indicates 400-hertz generator voltage. Generator voltage sensing terminals are listed in Table 6-3.

Table 6-3. Generator Voltage Sensing Terminals

Terminal	Description
35 (GEN VN)	Neutral generator voltage sensing input
37 (GEN VC)	C-phase generator voltage sensing input
39 (GEN VB)	B-phase generator voltage sensing input
41 (GEN VA)	A-phase generator voltage sensing input

Bus Voltage Sensing

Sensing of bus voltage enables the MGC-2000 Series to detect failures of the mains (utility). Controllers with style number xxxxxxxAx use bus voltage sensing to perform automatic synchronization of the generator with the bus (style number xxxxxxxAx only). The MGC-2000 Series senses single- or three-phase bus voltage. Three-phase bus input is available to MGC-2000 Series hardware version 3 only.

For hardware version 3, sensing voltage is applied to terminals 76 (A-phase), 78 (B-phase), and 80 (C-phase). For hardware versions 1 and 2, sensing voltage is applied to terminals 45 (A-phase) and 43 (B-phase). In version 3 hardware, terminal 45 is internally tied to 76 and terminal 43 is internally tied to 78. This accommodates the use of connectors wired for legacy MGC-2000 Series versions. Bus voltage sensing terminals are listed in Table 6-4.

Table 6-4. Bus Voltage Sensing Terminals

Terminal	Description
76, 45 (BUS VA)	A-phase bus voltage sensing input
78, 43 (BUS VB)	B-phase bus voltage sensing input
80 (BUS VC)	C-phase bus voltage sensing input

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Analog Engine Sender Inputs

Inputs are provided for oil pressure, fuel level, and coolant temperature senders.

Sender input terminals are listed in Table 6-5.

Table 6-5. Sender Input Terminals

Terminal	Description
8 (OIL)	Oil pressure sender input
9 (FUEL)	Fuel level sender input
10 (COOLANT)	Coolant temperature sender input
11 (SENDER COM)	Sender return terminal

Emergency Stop Input

The emergency stop input is intended for use with a normally closed switch and recognizes an emergency stop input when the connection from terminal 46 (ESTOP) to ground is removed. See Figure 6-3. The ESTOP can be up to 75 ft (22 m) away from the MGC-2000 Series using a maximum wire length of 150 ft (45 m). Emergency stop input terminals are listed in Table 6-6. Terminal 47 is only used in the *Optional Wiring Method* below.

Table 6-6. Emergency Stop Input Terminals

Terminal	Description
46 (ESTOP)	Emergency stop contact input
47 (ESTOP)	

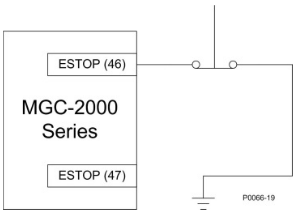

Figure 6-3. Emergency Stop Input Connections

NOTE

Units with a board number (located on back of the unit) lower than 9400201139 may experience problems associated with ESTOP wire lengths greater than 2 feet (0.6 m). An interposing relay, connected as shown in Figure 6-6, alleviates potential problems.

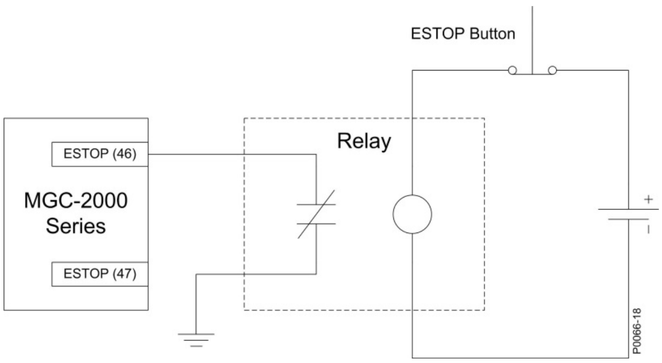

Figure 6-4. Interposing Relay Diagram

The relay is the type that when the coil is NOT energized, the contacts are open. When the coil is energized, the relay contacts are closed. The ESTOP button is normally closed (i.e. closed when it is NOT pushed). The relay coil is always energized when the ESTOP switch is closed (NOT pushed), so relay contacts are closed in normal operation. When the ESTOP button is pushed, the ESTOP switch opens, so relay contacts open, shutting down the unit.

Optional ESTOP Wiring Method

The following describes an optional wiring method for the emergency stop input. This method is no longer preferred. The emergency stop input is intended for use with a normally closed switch and recognizes an emergency stop input when the short-circuit across the input is removed. See Figure 6-5. The ESTOP can be up to 75 ft (22 m) away from the MGC-2000 Series using a maximum wire length of 150 ft (45 m). Emergency stop input terminals are listed in Table 6-6.

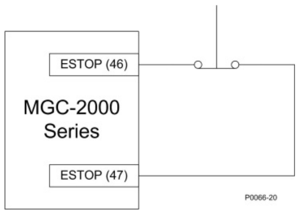

Figure 6-5. Emergency Stop Input Connections (Optional Wiring Method)

NOTE

Units with a board number (located on back of the unit) lower than 9400201139 may experience problems associated with ESTOP wire lengths greater than 2 feet (0.6 m). An interposing relay, connected as shown in Figure 6-6, alleviates potential problems.

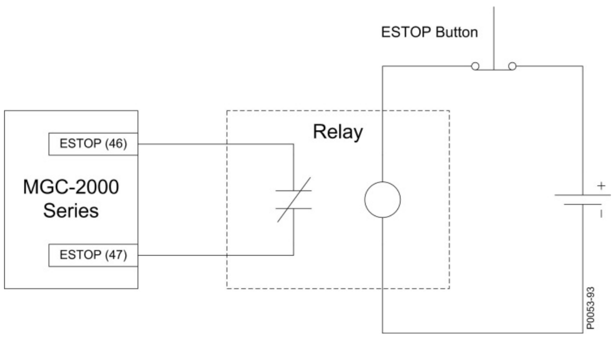

Figure 6-6. Interposing Relay Diagram (Optional ESTOP Wiring Method)

The relay is the type that when the coil is NOT energized, the contacts are open. When the coil is energized, the relay contacts are closed. The ESTOP button is normally closed (i.e. closed when it is NOT pushed). The relay coil is always energized when the ESTOP switch is closed (NOT pushed), so relay contacts are closed in normal operation. When the ESTOP button is pushed, the ESTOP switch opens, so relay contacts open, shutting down the unit.

Magnetic Pickup Input

The magnetic pickup input accepts a speed signal over the range of 3 to 35 volts peak and 32 to 10,000 hertz. Magnetic pickup input terminals are listed in Table 6-7.

Table 6-7. Magnetic Pickup Input Terminals

Terminal	Description
31 (MPU+)	Magnetic pickup positive input
32 (MPU–)	Magnetic pickup return input

Contact Sensing Inputs

Contact sensing inputs consist of 1 emergency stop input and 16 programmable inputs.

The programmable inputs accept normally open, dry contacts. Terminal 2 (BATT–) serves as the common return line for the programmable inputs. Information about configuring the programmable inputs is provided in Section 4, *BESTCOMSPlus® Software*.

Contact sensing input terminals are listed in Table 6-8.

Table 6-8. Contact Sensing Inputs

Terminal	Description
2 (BATT–)	Common return line for programmable contact inputs
15 (INPUT 16)	Programmable contact input 16
16 (INPUT 15)	Programmable contact input 15
17 (INPUT 14)	Programmable contact input 14
18 (INPUT 13)	Programmable contact input 13
19 (INPUT 12)	Programmable contact input 12
20 (INPUT 11)	Programmable contact input 11
21 (INPUT 10)	Programmable contact input 10
22 (INPUT 9)	Programmable contact input 9
23 (INPUT 8)	Programmable contact input 8
24 (INPUT 7)	Programmable contact input 7
25 (INPUT 6)	Programmable contact input 6
26 (INPUT 5)	Programmable contact input 5
27 (INPUT 4)	Programmable contact input 4
28 (INPUT 3)	Programmable contact input 3
29 (INPUT 2)	Programmable contact input 2
30 (INPUT 1)	Programmable contact input 1

Output Contacts

The MGC-2000 Series has three sets of fixed-function output contacts: Pre, Start, and Run. The Pre contacts supply battery power to the engine glow plugs, the Start contacts supply power to the start solenoid, and the Run contacts supply power to the fuel solenoid. Connections to the three sets of contacts are made directly at each relay using female, quarter-inch, quick-connect terminals. Amp part numbers 154718-3 (positive-lock receptacle) and 154719-1 (nylon housing) are the recommended components for making connections at each relay. For the location of the Pre, Start, and Run relays refer to Figure 2-2.

Depending on the style number of the MGC-2000 Series, either 4 or 12 sets of programmable output contacts are provided. Four programmable outputs are provided on MGC-2000 Series controllers with a style number of xxAxxxxxx. Twelve programmable outputs are provided on controllers with a style number of xxBxxxxxx. Programmable output contact terminals are listed in Table 6-9.

Table 6-9. Programmable Output Contact Terminals

Terminal	Description
51 (COM 1, 2, 3)	Common connection for outputs 1, 2, and 3

52 (OUT 1)	Programmable output 1
53 (OUT 2)	Programmable output 2
54 (OUT 3)	Programmable output 3
55 (COM 4, 5, 6)	Common connection for outputs 4, 5, and 6
56 (OUT 4)	Programmable output 4
57 (OUT 5)	Programmable output 5
58 (OUT 6)	Programmable output 6
59 (COM 7, 8, 9)	Common connection for outputs 7, 8, and 9
60 (OUT 7)	Programmable output 7
61 (OUT 8)	Programmable output 8
62 (OUT 9)	Programmable output 9
63 (COM 10, 11, 12)	Common connection for outputs 10, 11, and 12
64 (OUT 10)	Programmable output 10
65 (OUT 11)	Programmable output 11
66 (OUT 12)	Programmable output 12

USB Interface

A mini-B USB socket enables local communication with a PC running BESTCOMS*Plus* software. The MGC-2000 Series is connected to a PC using a standard USB cable equipped with a type A plug on one end (PC termination) and a mini-B plug on the other end (MGC-2000 Series termination).

RS-485 Communication Port

MGC-2000 Series0 controllers with the optional RS-485 communication port (style number xxxRxxxxx) are equipped for polled communication over a Modbus™ network. Twisted-pair, shielded cable is recommended for RS-485 port connections. RS-485 communication port terminals are listed in Table 6-10.

Table 6-10. RS-485 Communication Port Terminals

Terminal	Description
12 (485 SHIELD)	Shield connection for RS-485 cable
13 (485B)	RS-485 send/receive B connection
14 (485A)	RS-485 send/receive A connection

CAN Bus Interface

These terminals provide communication using the SAE J1939 protocol or the MTU protocol and provide high-speed communication between the MGC-2000 Series and an MTU engine ECU on an electronically controlled engine. Connections between the MTU engine ECU and MGC-2000 Series should be made with twisted-pair, shielded cable. CAN bus interface terminals are listed in Table 6-11. Refer to Figure 6-7 and Figure 6-8.

Table 6-11. CAN Bus Interface Terminals

Terminal	Description
48 (CAN L)	CAN low connection
49 (CAN H)	CAN high connection
50 (SHIELD)	CAN drain connection

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NOTES

1. If the MGC-2000 Series is providing one end of the J1939 bus, a 120 Ω, ½ watt terminating resistor should be installed across terminals 48 (CANL) and 49 (CANH).
2. If the MGC-2000 Series is not part of the J1939 bus, the stub connecting the MGC-2000 Series to the bus should not exceed 914 mm (3 ft) in length.
3. The maximum bus length, not including stubs, is 40 m (131 ft).
4. The J1939 drain (shield) should be grounded at one point only. If grounded elsewhere, do not connect the drain to the MGC-2000 Series.

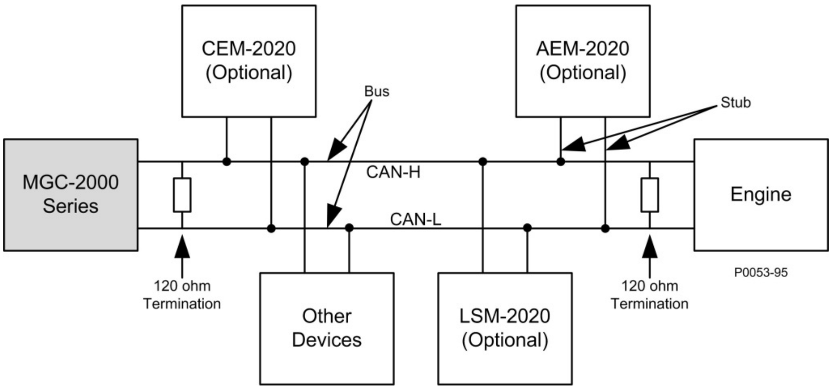

Figure 6-7. CAN Bus Interface with MGC-2000 Series providing One End of the Bus

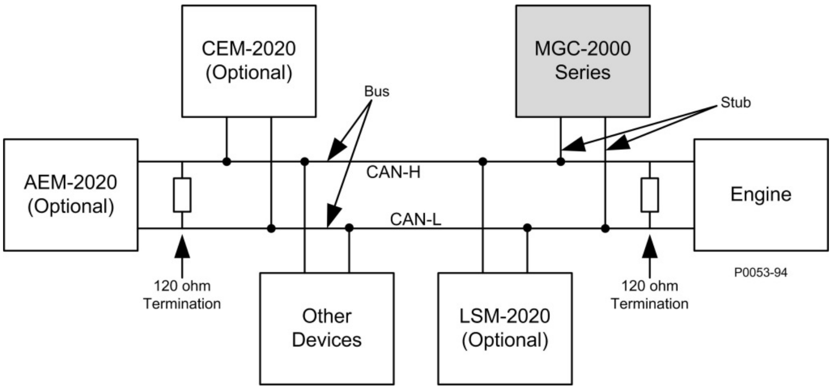

Figure 6-8. CAN Bus Interface with Optional AEM-2020 providing One End of the Bus

Modem

MGC-2000 Series hardware version 3 controllers with style number xxxxxExxx are equipped with an RS-232 port. This port allows communication with an external, user-supplied modem with dial-in and dial-out capability. MGC-2000 Series hardware versions 1 and 2 with style number xxxxxMxxx are equipped with an internal modem with dial-in and dial-out capability. The modem connects to a standard-device telephone line through a USOC RJ-11C jack.

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RDP-110 Connections

Terminals are provided for connection with the optional RDP-110 remote display panel. These terminals provide dc operating power to the RDP-110 and enable communication between the MGC-2000 Series and RDP-110. Twisted-pair conductors are recommended for connecting the communication terminals of the MGC-2000 Series and RDP-110. Communication may become unreliable if the connection wires exceed 4,000 feet.

Table 6-12 lists the MGC-2000 Series terminals that connect to the RDP-110.

Table 6-12. RDP-110 Interface Terminals

Terminal	Connects To:
4 (RDP BATT+)	RDP-110 terminal 12/24
5 (RDP BATT–)	RDP-110 terminal DC COM
6 (RDP TXD–)	RDP-110 terminal 485–
7 (RDP TXD+)	RDP-110 485+

Connections for Typical Applications

Connection diagrams for typical applications are shown on the following pages. See Table 6-13 for a diagram cross-reference.

Table 6-13. Typical Connection Diagram Cross-Reference

Connection Type	Hardware Version 3	Hardware Versions 1 and 2
Three-phase Wye	Figure 6-9, page 6-11	Figure 6-13, page 6-15
Three-Phase Delta	Figure 6-10, page 6-12	Figure 6-14, page 6-16
Single-Phase A-B	Figure 6-11, page 6-13	Figure 6-15, page 6-17
Single-Phase A-C	Figure 6-12, page 6-14	Figure 6-16, page 6-18

Three-Phase Wye Connections for Typical Applications

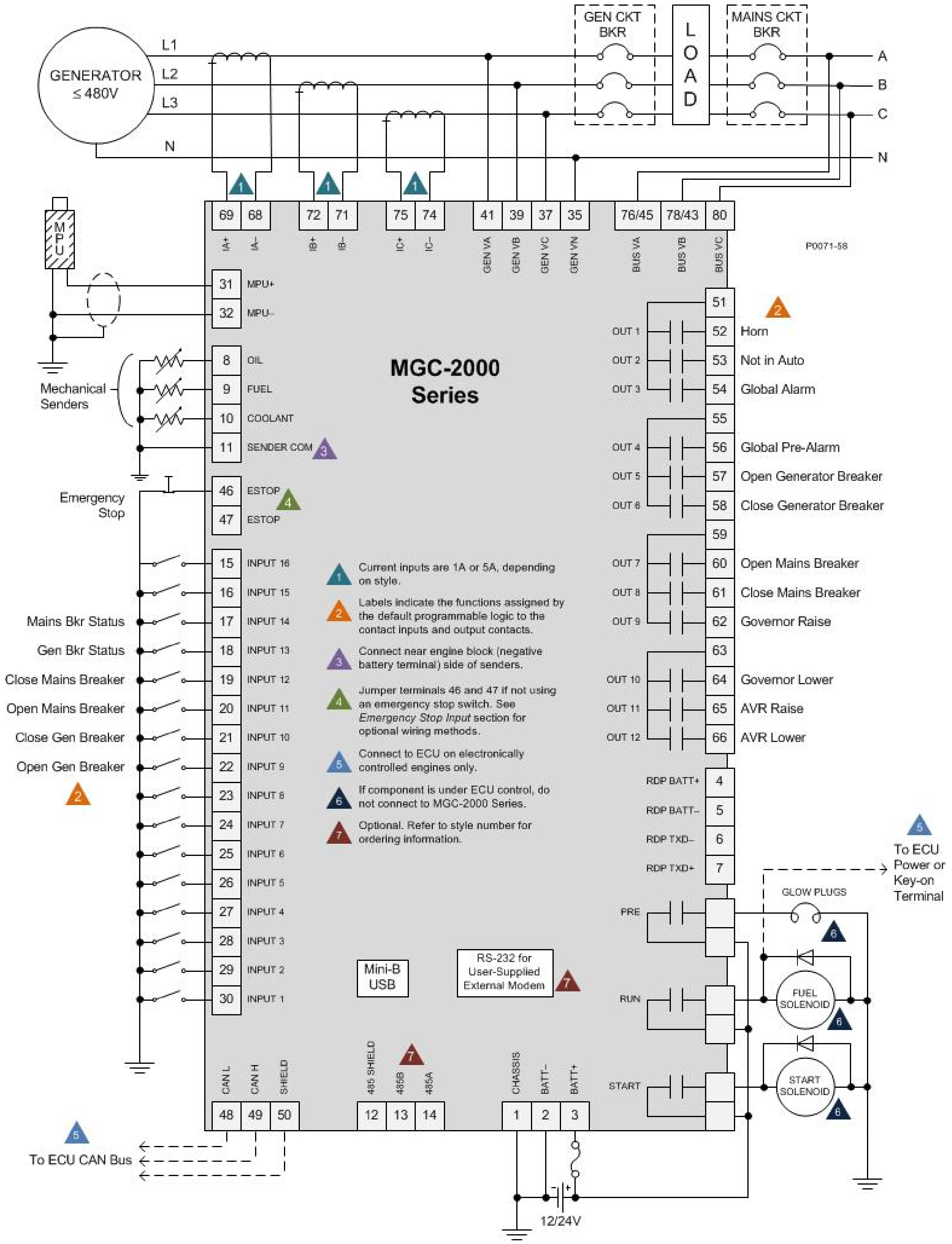

Figure 6-9. Three-Phase Wye Connections for Typical Applications (Hardware Version 3)

Three-Phase Delta Connections for Typical Applications

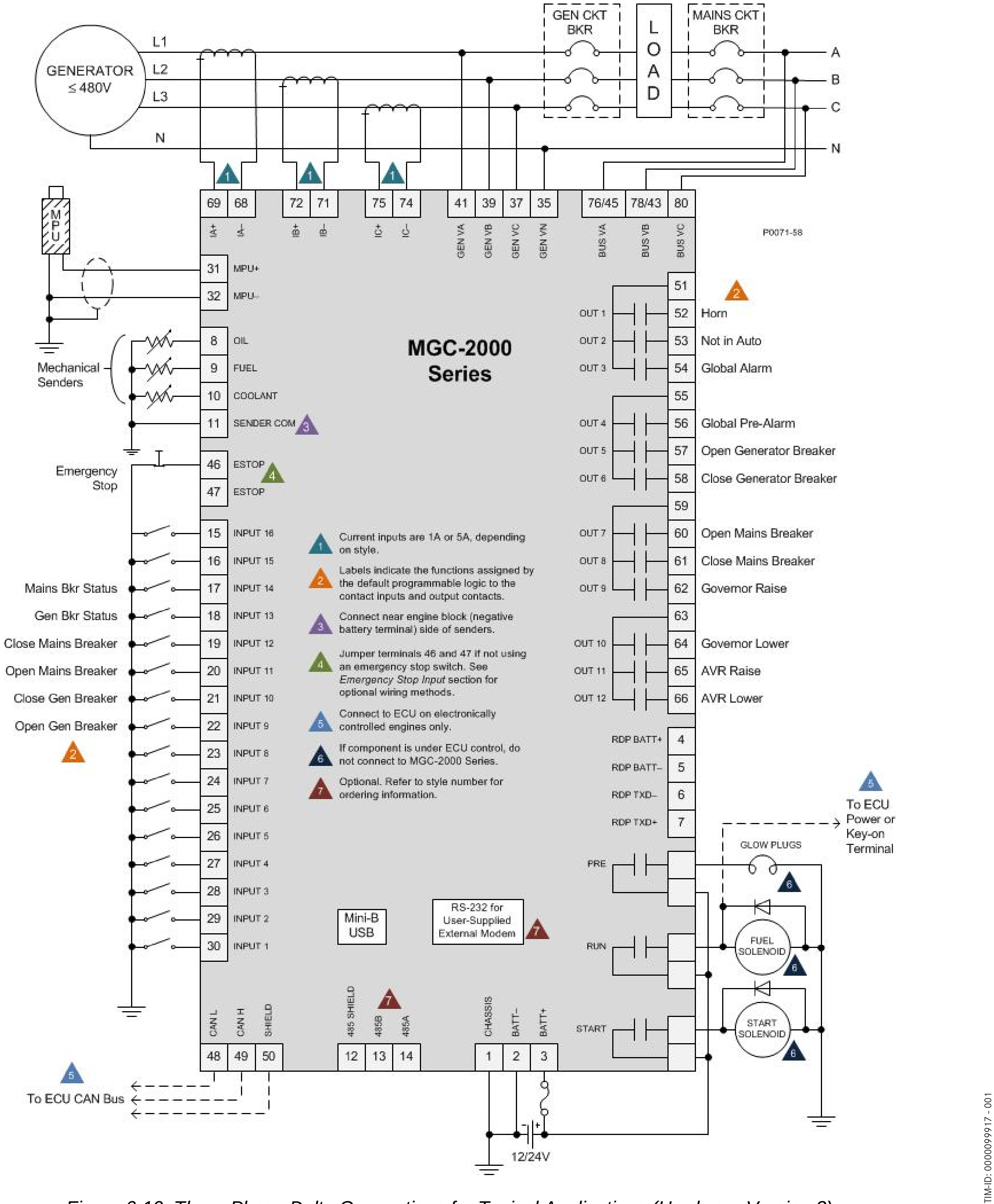

Figure 6-10. Three-Phase Delta Connections for Typical Applications (Hardware Version 3)

Single-Phase A-B Connections for Typical Applications

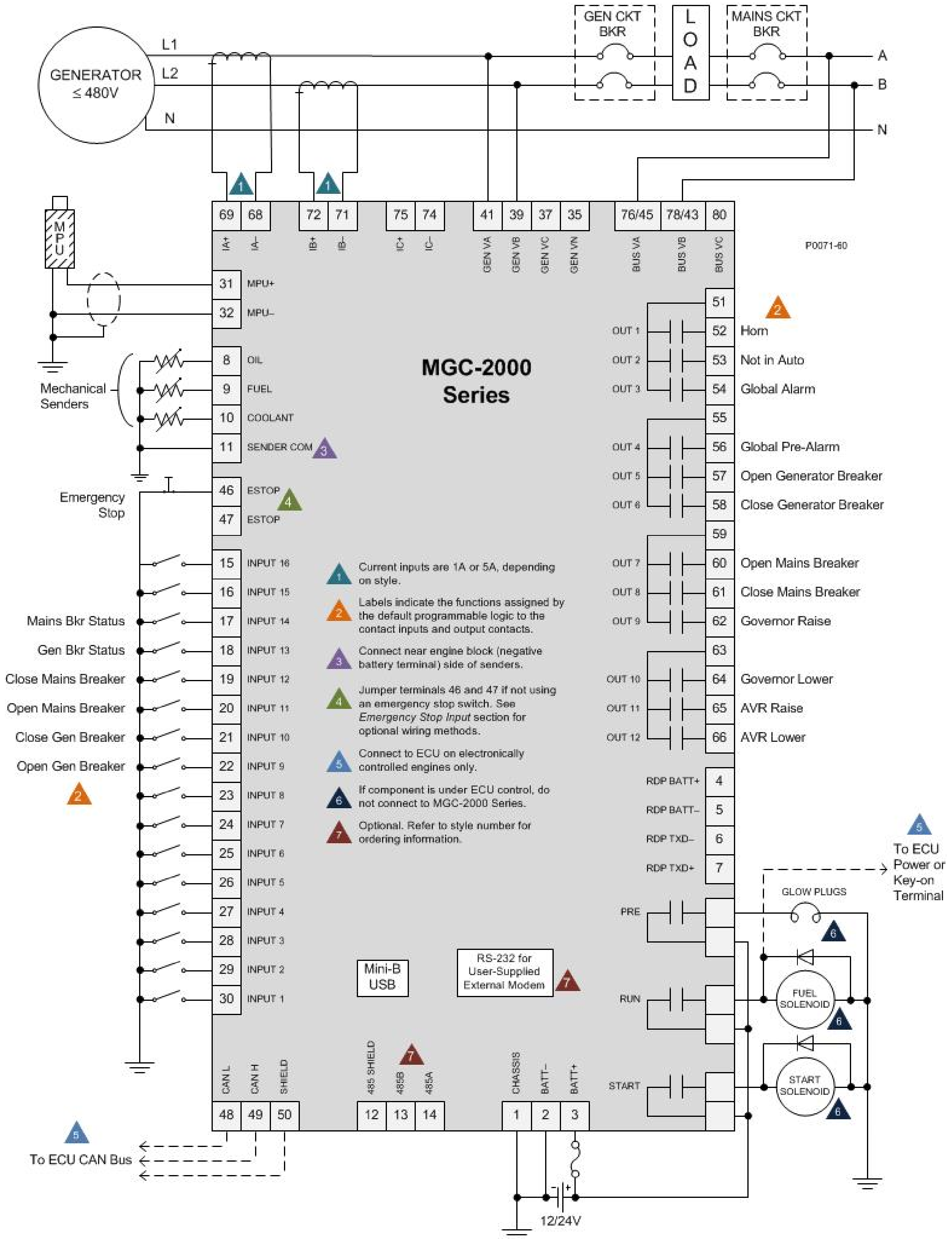

Figure 6-11. Single-Phase A-B Connections for Typical Applications (Hardware Version 3)

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Single-Phase A-C Connections for Typical Applications

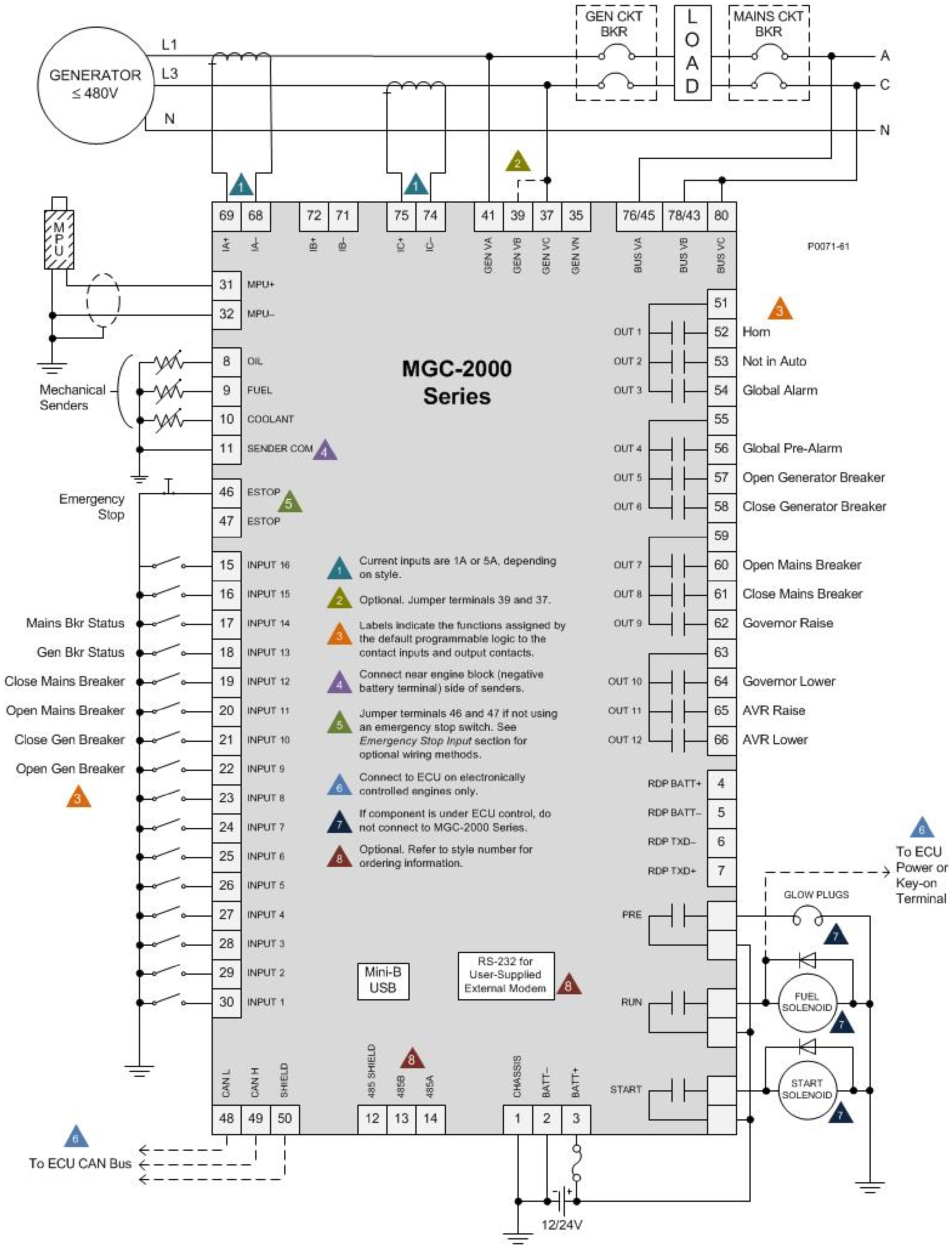

Figure 6-12. Single-Phase A-C Connections for Typical Applications (Hardware Version 3)

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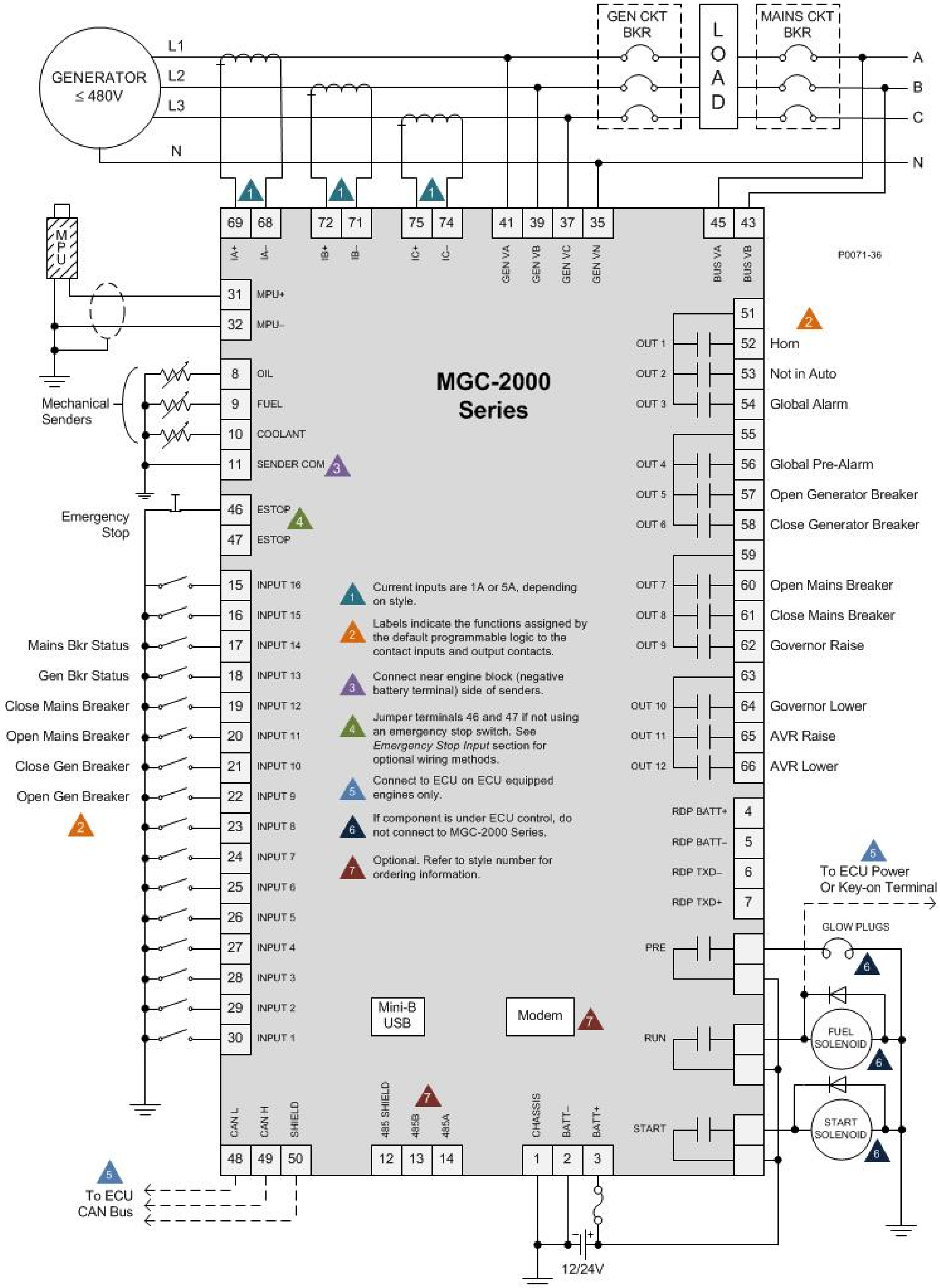

Figure 6-13. Three-Phase Wye Connections for Typical Applications (Hardware Versions 1 and 2)

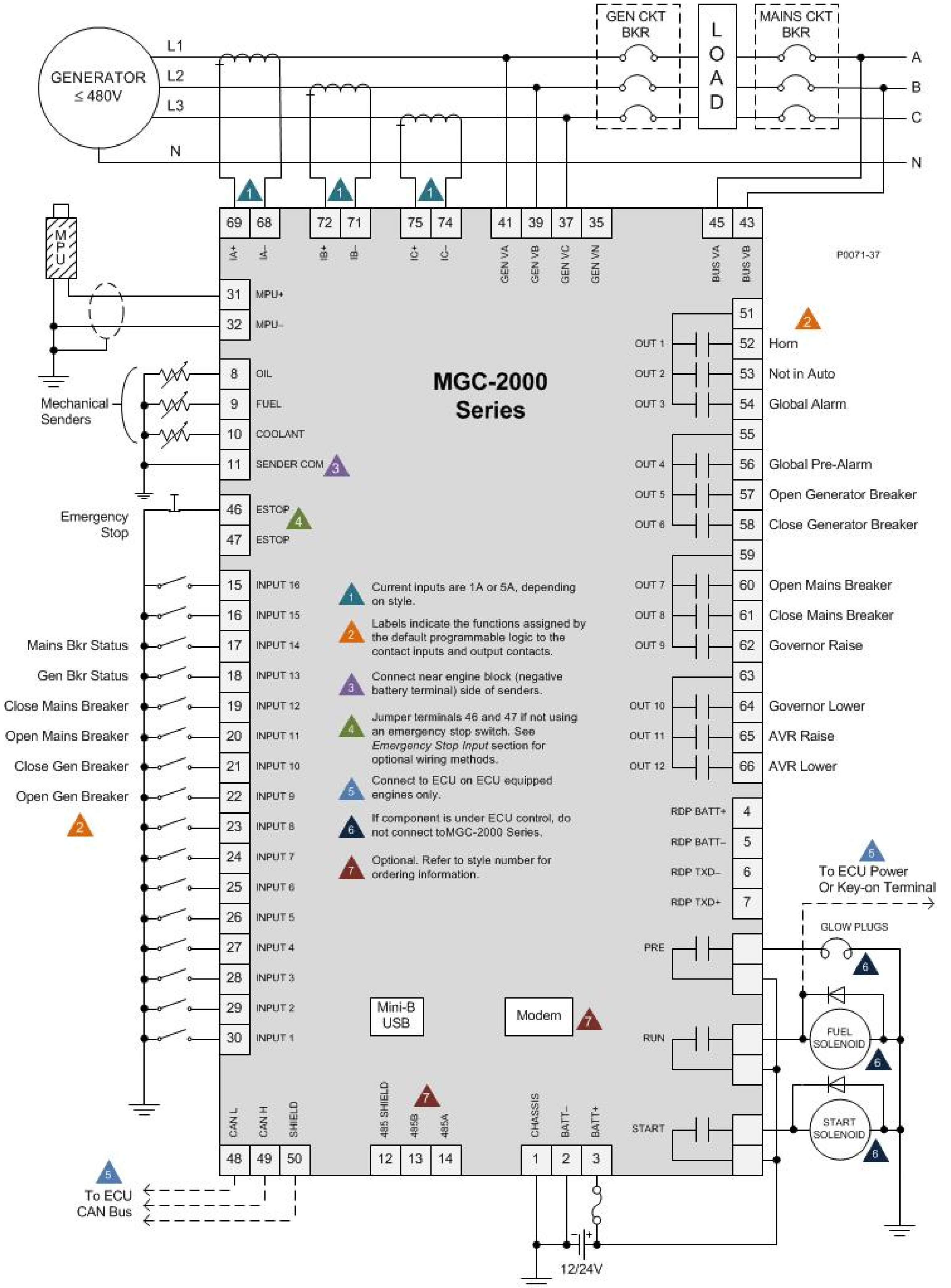

Figure 6-14. Three-Phase Delta Connections for Typical Applications (Hardware Versions 1 and 2)

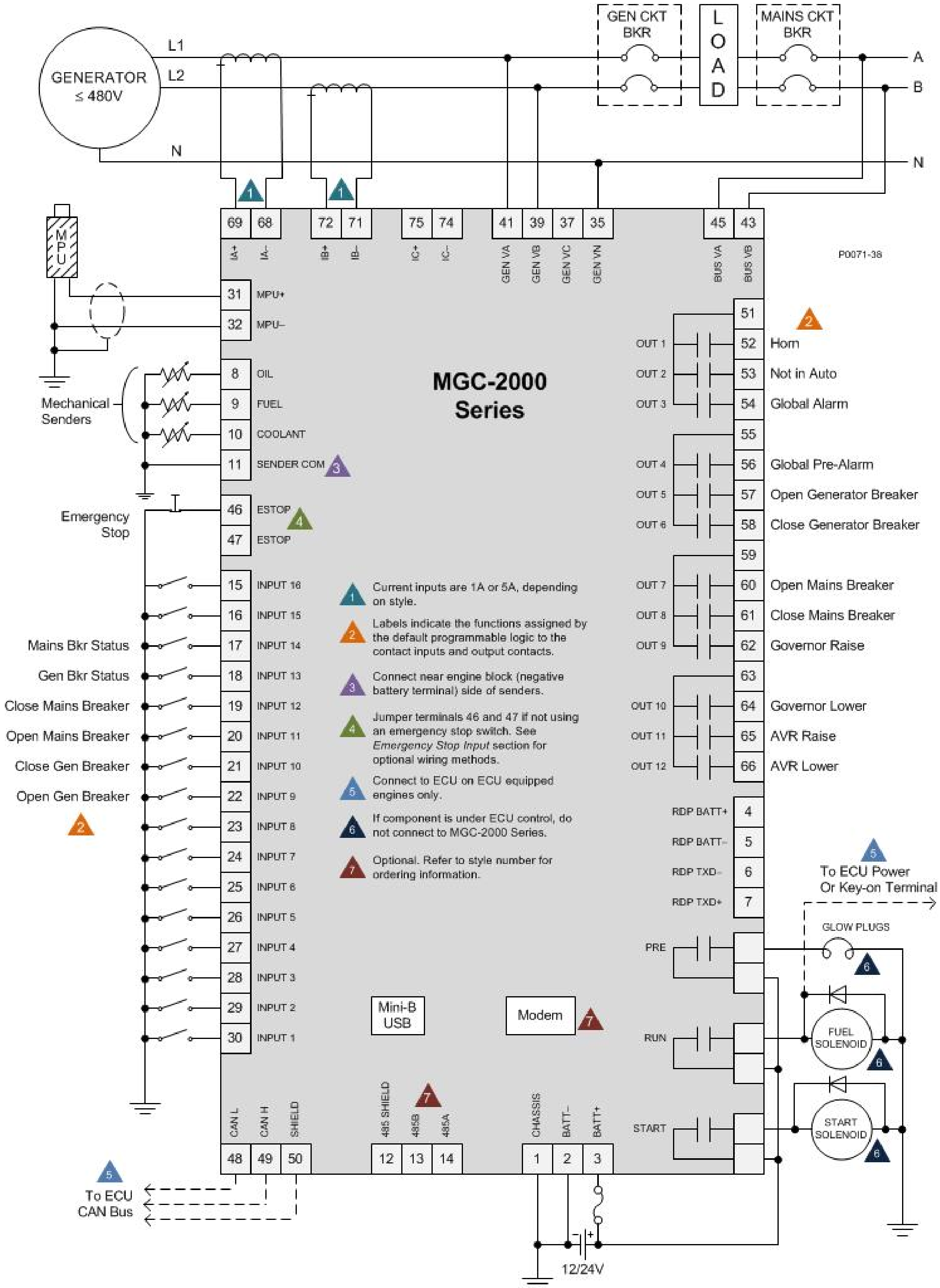

Figure 6-15. Single-Phase A-B Connections for Typical Applications (Hardware Versions 1 and 2)

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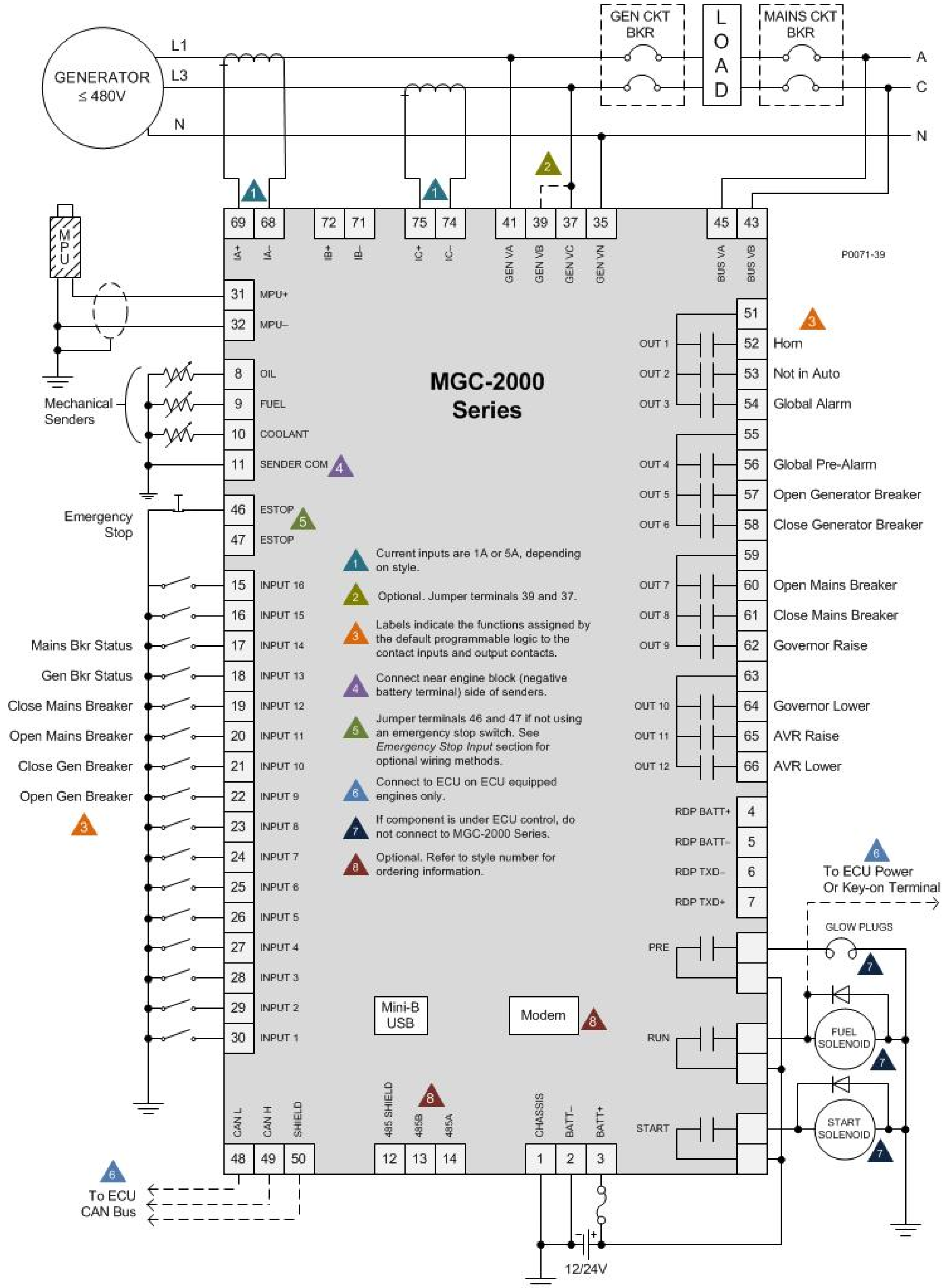

Figure 6-16. Single-Phase A-C Connections for Typical Applications (Hardware Versions 1 and 2)

Connections with AEM-2020, CEM-2020, and LSM-2020

The AEM-2020 (Analog Expansion Module), CEM-2020 (Contact Expansion Module), and LSM-2020 (Load Share Module) are optional modules that may be installed with the MGC-2000 Series. These modules interface to the MGC-2000 Series via CAN bus, thus the CAN bus terminals are the only common connections (Figure 6-17) between the MGC-2000 Series, AEM-2020, CEM-2020, and LSM-2020. Refer to Section 9, *LSM-2020 (Load Share Module),* for independent LSM-2020 connections. Refer to Section 10, *CEM-2020 (Contact Expansion Module),* for independent CEM-2020 connections. Refer to Section 11, *AEM-2020 (Analog Expansion Module),* for independent AEM-2020 connections. Refer to *Connections, CAN Bus Interface,* in this section for details on MGC-2000 Series CAN bus connections.

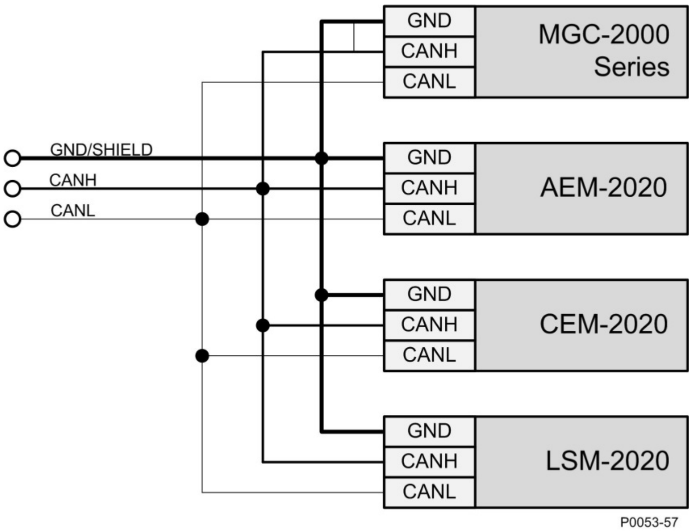

Figure 6-17. MGC-2000 Series, AEM-2020, CEM-2020, LSM-2020 CAN Bus Connections

Installation for CE Systems

For CE compliant systems, it may be required to route ac voltage and current sensing wires separately from other wires.

Installation in a Salt Fog Environment

If the MGC-2000 Series will be installed in a salt-fog environment, it is recommended that the backup battery for the real-time clock be removed. Salt fog is known to be conductive and may short-circuit the battery.

Information on removing the backup battery for the real-time clock can be found in Section 8, *Maintenance and Troubleshooting.*

SECTION 7 • SETUP

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SECTION 7 • SETUP

Introduction

The following paragraphs provide information for MGC-2000 Series initial setup, setting up MGC-2000 Series programmable inputs and outputs, generator and bus breaker control, synchronizer, setting up an MGC-2000 Series and LSM-2020 for a load sharing and kW control application, and mains fail transfer.

MGC-2000 Series Initial Setup

The MGC-2000 Series must be set up with parameters specific to the controlled machine in order to provide the desired machine control and protection. The following parameters must be configured prior to starting the machine. They are listed according to where they are found in BESTCOMS*Plus*® in the Settings Explorer. These parameters can also be set through the front panel of the MGC-2000 Series, but BESTCOMS*Plus*® is generally more convenient.

In BESTCOMS*Plus*®, if you are connected to the MGC-2000 Series and communicating with it, after changing settings you must click the *Send Settings* button in BESTCOMS*Plus*® to send the settings to the MGC-2000 Series. If you do not do this, or you do not save the modified settings to a settings file, setting information may be lost.

Initial Setup Required to Operate Unit

Once the following parameters are configured in the MGC-2000 Series, it should be possible to run the machine. Only those parameters required are presented in this discussion.

General Settings

Style Number

Connect BESTCOMS*Plus*® to the MGC-2000 Series. Check the style number of the MGC-2000 Series unit and verify that it has all the features required for the machine being configured. For example, if it is expected that the machine perform synchronization, the synchronizer option must exist in the style number. See Figure 7-1. Front Panel Navigation Path: SETTINGS > GENERAL SETTINGS > VERSION INFO > DGC-2020 > STYLE CODE

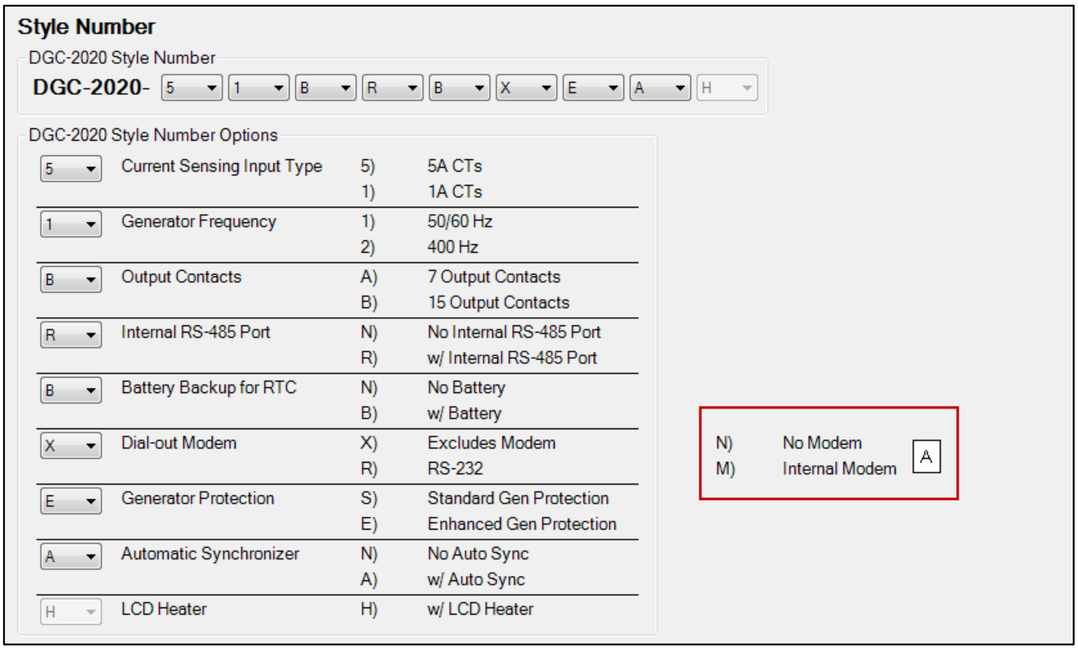

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Figure 7-1. Settings Explorer, General Settings, Style Number Screen

A MGC-2000 Series Dial-out modem options for hardware versions 1 and 2.

Communications

If the engine has an ECU (electronic control unit) and the MGC-2000 Series is to communicate with it, the communications must be set up.

CAN Bus Setup (Figure 7-2)

Front Panel Navigation Path: SETTINGS > COMMUNICATIONS > CAN Bus SETUP

1. Enable ECU Support - Set to Enabled for the MGC-2000 Series to communicate with the ECU.
2. Enable DTC (Diagnostic Trouble Code) Support - If the ECU is a J1939 ECU, enable DTC support. If the engine ECU does not support it, no diagnostic trouble codes will be logged by the MGC-2000 Series.
3. SPN Conversion Method - When this bit is a zero, the conversion method is indicated as version 4. The MGC-2000 Series will automatically set the conversion method to 4 when the CM bit is zero; this occurs for most engine types. However, if the CM bit is 1, indicating the SPN conversion method is NOT 4, the user will have to consult the engine manufacturer to learn the correct method of SPN conversion, and set the SPN Conversion Method setting in the MGC-2000 Series accordingly.
4. CAN Bus Address - This parameter sets a unique address number for the MGC-2000 Series operating on a CAN bus network. The CAN bus Address is set internally by the MGC-2000 Series when certain types of ECUs are selected on the ECU Setup screen, and in this case, the user-entered value does not apply.
5. ECU Contact Control - Output Select - Select whether the RUN output relay or the PRE (Prestart) output relay will close to give the ECU its “energize to run” signal. In some implementations, this relay may actually be providing ECU power.
6. ECU Contact Control - Pulsing Enable - Select if the ECU is not to be on line at all times. Often ECUs are allowed to go “off line” to conserve battery drain when the engine is not running. The MGC-2000 Series will “pulse” it periodically to force it to be active to allow the MGC-2000 Series to read data such as coolant temperature and coolant level. This is required if the MGC-2000 Series is to report low coolant temperature conditions (which may indicate a failure of a block heater), or low coolant level conditions (if a leak occurs while the machine is not running). Pulsing is also used to check the integrity of CAN bus communications when the machine is not running.
7. ECU Related Time Values - Engine Shut Down - Set this parameter for a value longer than the duration required to stop the engine after being shut down. The ECU is pulsed after this time expires. If the time is too short, the pulse may occur while the engine is still turning which could cause a brief re-start and possibly damage the flywheel and starter system.
8. ECU Related Time Values - Pulse Cycle Time - Set this parameter for the desired time between ECU pulse cycles.
9. ECU Related Time Values - Settling Time - This parameter is the duration of the “on line” time of the pulse cycle during which the MGC-2000 Series reads data from the ECU. The settling time should be set long enough so that any ECU parameters that require time to “settle down” after the ECU is on line can do so. Since the MGC-2000 Series may use some of the ECU data for alarm or pre-alarm annunciation, it is important that the data have time to settle.
10. ECU Related Time Values - Response Timeout - This setting defines the amount of time that the MGC-2000 Series will wait to receive data from the ECU during a pulse cycle or start attempt. If no data is received during this time in a pulse cycle, a LOSS OF ECU COMMS pre-alarm is annunciated. If no data is received in this time during an engine starting attempt, a LOSS OF ECU COMMS alarm is annunciated.

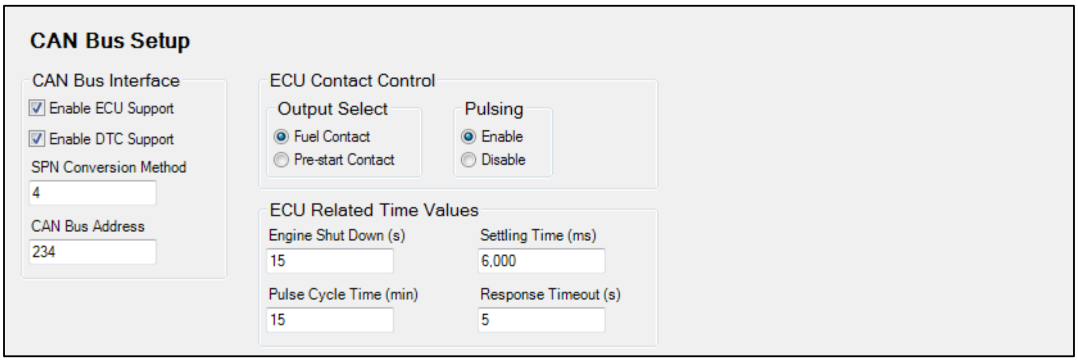

Figure 7-2. Settings Explorer, Communications, CAN Bus Setup Screen

ECU Setup (Figure 7-3)

Front Panel Navigation Path: SETTINGS > COMMUNICATIONS > CAN bus SETUP > ECU SETUP

1. ECU Type - For most engines, select *Standard*. However, there are exceptions. If your engine is a Volvo, select *Volvo-Penta*. If you have an MTU MDEC, ADEC, ECU-7/ECU8, GM/Doosan, Cummins, MTU Smart Connect, Scania, or John Deere, make the appropriate selection. Depending on the ECU type selected, some parameters may become enabled, allowing you to configure them for the specific engine. No modification of these parameters is required for the initial setup. Refer to the appropriate paragraphs in Section 4, *BESTCOMSPlus® Software*, for additional information.

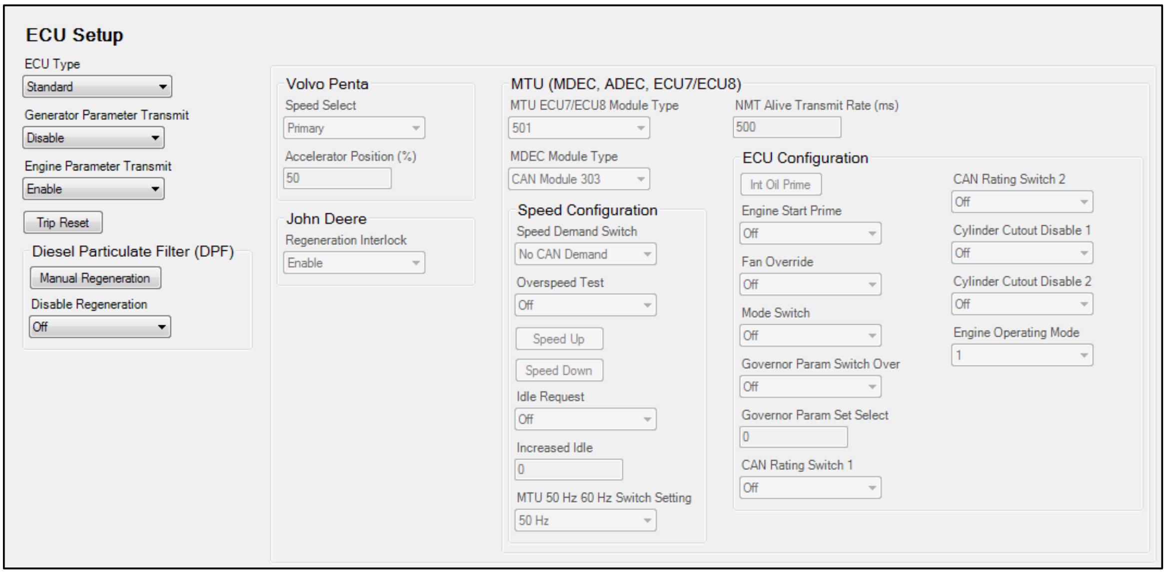

Figure 7-3. Settings Explorer, Communications, ECU Setup Screen

System Parameters

System Settings (Figure 7-4)

Front Panel Navigation Path: SETTINGS > SYSTEM PARAMS > SYSTEM SETTINGS

1. System Type - This setting is used with dead bus breaker close arbitration. For more information, refer to Section 3, *Functional Description, Dead Bus Breaker Close Arbitration.*
2. Fuel Level Function - This parameter selects the fuel type of the machine. If a fuel level sender is available in a tank, select *FUEL LVL*. If liquid propane or natural gas is used, set accordingly. Otherwise, select *Disable*. This informs the MGC-2000 Series to display N/A for fuel level on the overview screen.

   The use of a 0 – 10 Vdc or 4 – 20 mA transducer is possible when an Analog Expansion Module (AEM-2020) is connected. Use the Source setting to select the AEM-2020 analog input tied to the transducer.

   Set the maximum and minimum percentage range for the AEM-2020 analog inputs using the Maximum and Minimum percent settings. The maximum and minimum range of the AEM-2020 analog inputs are set separately. See *Programmable Inputs, Remote Analog Inputs*, below, for more information.
3. System Units - Select *English* or *Metric*.
4. Metric Pressure Units - Select *bar* or *kPa/MPa*.
5. Number of Flywheel Teeth - This setting defines the number of teeth on the flywheel for engines equipped with a magnetic pickup sensor (MPU) for engine speed detection.
6. Speed Signal Source - Select whether the rpm source for the MGC-2000 Series should be the magnetic pickup sensor (MPU), the generator frequency, or both (MPU-GEN). If MPU or generator frequency is selected as the rpm source, and the MGC-2000 Series cannot detect engine rpm, an MPU FAIL alarm will be announced. If MPU-GEN is selected as rpm source, if the MPU input does not provide valid speed information, the MGC-2000 Series will switch to generator frequency as the rpm source, annunciate an MPU FAIL pre-alarm, and continue running.

7. NFPA Level - Set this if NFPA level 1 or 2 compliance is required for the machine.

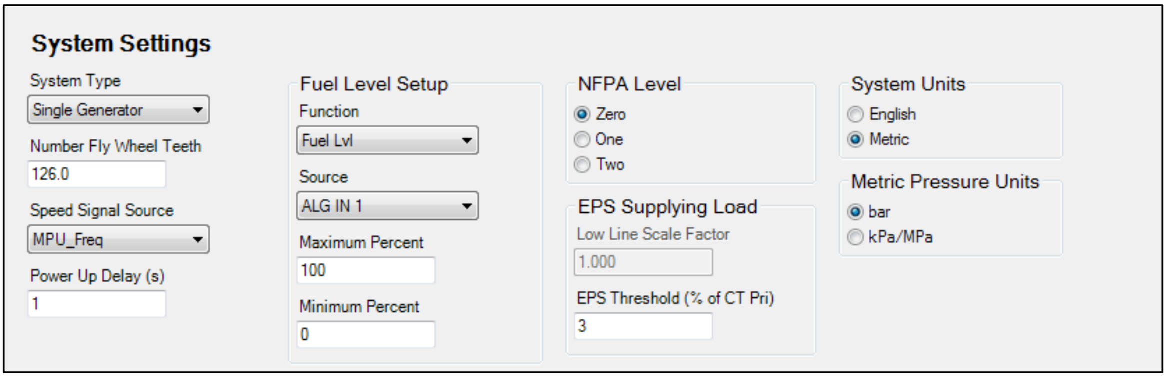

Figure 7-4. Settings Explorer, System Parameters, System Settings Screen

Rated Data (Figure 7-5) Note: Click the *Edit* button to change settings.
Front Panel Navigation Path: SETTINGS > SYSTEM PARAMS > SYSTEM SETTINGS

1. Generator Connection - Select *WYE, DELTA, 1 PHASE A-B, 1 PHASE A-C,* or *GROUNDED DELTA* etc. based on the generator configuration.
2. Genset kW Rating - This parameter defines the kW rating of the machine.
3. Rated Volts - This parameter defines the voltage rating of the machine.
4. Rated Frequency - This parameter defines the frequency rating of the machine.
5. Rated Engine RPM - This parameter defines the engine rpm rating of the machine.
6. Rated Power Factor - This parameter defines the power factor rating of the machine.
7. Battery Voltage - Select *12* or *24*.

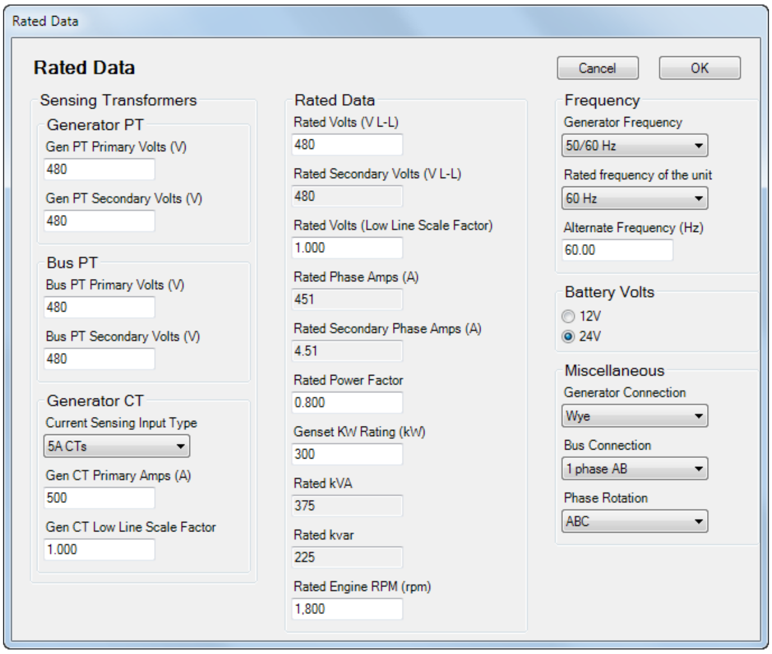

Figure 7-5. Settings Explorer, System Parameters, Rated Data

Remote Module Setup (Figure 7-6)
Front Panel Navigation Path: SETTINGS > SYSTEM PARAMS > REMOTE MODULE SETUP

This screen is used to enable any I/O modules that are to be used with the MGC-2000 Series. Refer to the appropriate sections in the MGC-2000 Series manual for more details regarding the individual I/O modules. Disable all if no modules are present.

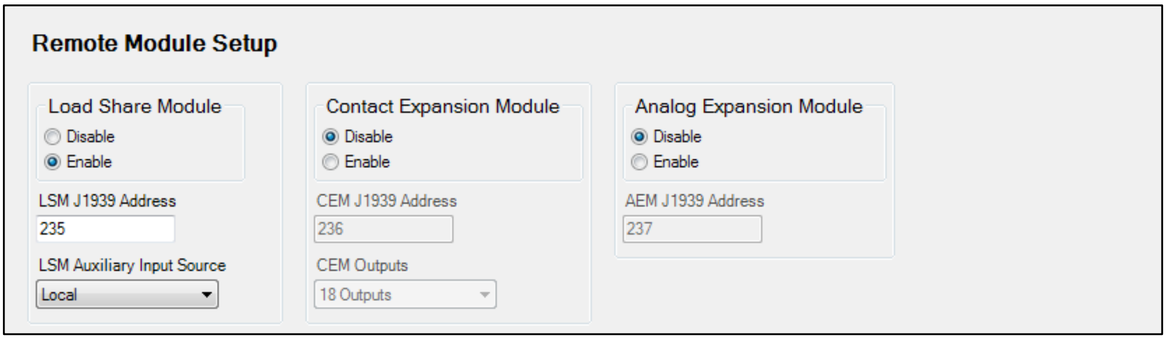

Figure 7-6. Settings Explorer, System Parameters, Remote Module Setup Screen

Crank Settings (Figure 7-7)
Front Panel Navigation Path: SETTINGS > SYSTEM PARAMS > CRANK SETTINGS

1. Crank Disconnect Limit - This parameter defines the engine rpm threshold in percentage of rated rpm at which engine cranking should cease.
2. Pre-Crank Delay - This setting specifies the amount of time for pre-cranking to occur. The PRE relay is closed during this time. This setting is typically used for engine preheating and/or pre-lubrication.
3. Prestart Contact Config - Select whether the PRE relay should remain closed after the engine starts, or if it should open.
4. Prestart Rest Configuration - There may be situations where it is desired to have the PRE relay closed during engine cranking but open for all or part of a crank resting cycle. Configure this accordingly. Refer to the appropriate paragraphs in Section 4, *BESTCOMSPlus® Software,* for additional information.
5. Oil Pressure Crank Disconnect - This setting provides an alternate method of determining conditions under which crank disconnect should occur. If the machine has no magnetic pick up (MPU) for rpm detection or a failed, MPU, and the MGC-2000 Series cannot read generator frequency to obtain rpm information, it will use oil pressure as criterion for crank disconnect. This will prevent long starter engagement if the engine starts but the MGC-2000 Series cannot determine engine speed for crank disconnect purposes.
6. Cranking Style - Select Cycle Cranking or Continuous Cranking.
    a. Cycle
        i. Number of Crank Cycles - This parameter defines the number of crank cycles if *Cycle* is selected as the crank style. Note if NFPA level 1 or 2 has been selected under SYSTEM PARAMETERS > NFPA LEVEL, this cannot be programmed; it is set to a fixed value to satisfy the NFPA compliance.
        ii. Crank Cycle Time: This parameter defines the length of the crank cycle if *Cycle* is selected as the crank style. Note if NFPA level 1 or 2 has been selected under SYSTEM PARAMETERS > FPA LEVEL, this cannot be programmed; it is set to a fixed value to satisfy the NFPA compliance.
        iii. Rest Time: This parameter defines the duration of the rest time if *Cycle* is selected as the crank style. Note if NFPA level 1 or 2 has been selected under SYSTEM PARAMETERS→NFPA LEVEL, this cannot be programmed; it is set to a fixed value to satisfy the NFPA compliance.
    b. Continuous
        i. Continuous Crank Time - This parameter defines the length of the crank cycle if *Continuous Cranking* is selected as the crank style.
7. Off Mode Cooldown Enable - When this setting is disabled, pushing the OFF button stops the unit immediately. When enabled, pushing the OFF button once will start a cool down cycle and the RUN LED will flash. The unit will complete the cool down cycle and stop in OFF mode. If the OFF button is pushed a second time, the unit stops immediately.
8. Restart Delay - This setting specifies the amount of time to delay restarting an engine after a normal shutdown. This setting is used to prevent stress from attempting to start while the engine is still spinning down.

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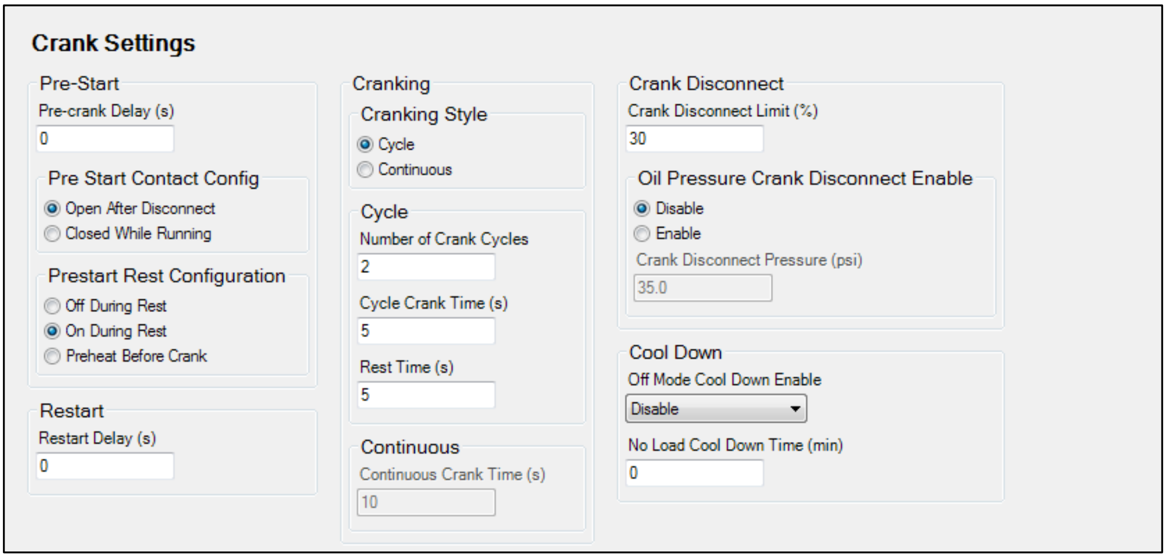

Figure 7-7. Settings Explorer, System Parameters, Crank Settings Screen

Sensing Transformers (Figure 7-8) Note: Click the *Rated Data* button to make changes.
Front Panel Navigation Path: SETTINGS > SYSTEM PARAMS > SENSING TRANS

1. Generator PT Primary Volts - This parameter defines the voltage of the potential transformer (PT) primary. If no PT is used, leave this parameter at its default value.
2. Generator PT Secondary Volts - This setting defines the voltage of the potential transformer (PT) secondary. The parameter must be less than 576 Vac because that is the maximum voltage that can be metered by the MGC-2000 Series voltage inputs. If no PT is used, leave this parameter at its default value.
3. Bus PT Primary Volts - This parameter defines the voltage of the potential transformer (PT) primary. If no PT is used, leave this parameter at its default value.
4. Bus PT Secondary Volts - This parameter defines the voltage of the potential transformer (PT) secondary. This must be less than 576 Vac because that is the maximum voltage that can be metered by the MGC-2000 Series voltage inputs. If no PT is used, leave this parameter at its default value.
5. Generator CT Primary Amps - This parameter defines the current transformer (CT) primary current in amps. The secondary must be 1A or 5A, and is determined by the MGC-2000 Series configuration as indicated in the MGC-2000 Series style code.
6. Gen CT Low Line Scale Factor - This setting is used to automatically adjust the Gen CT Primary Amps setting in applications that may utilize more than one type of genset connection.

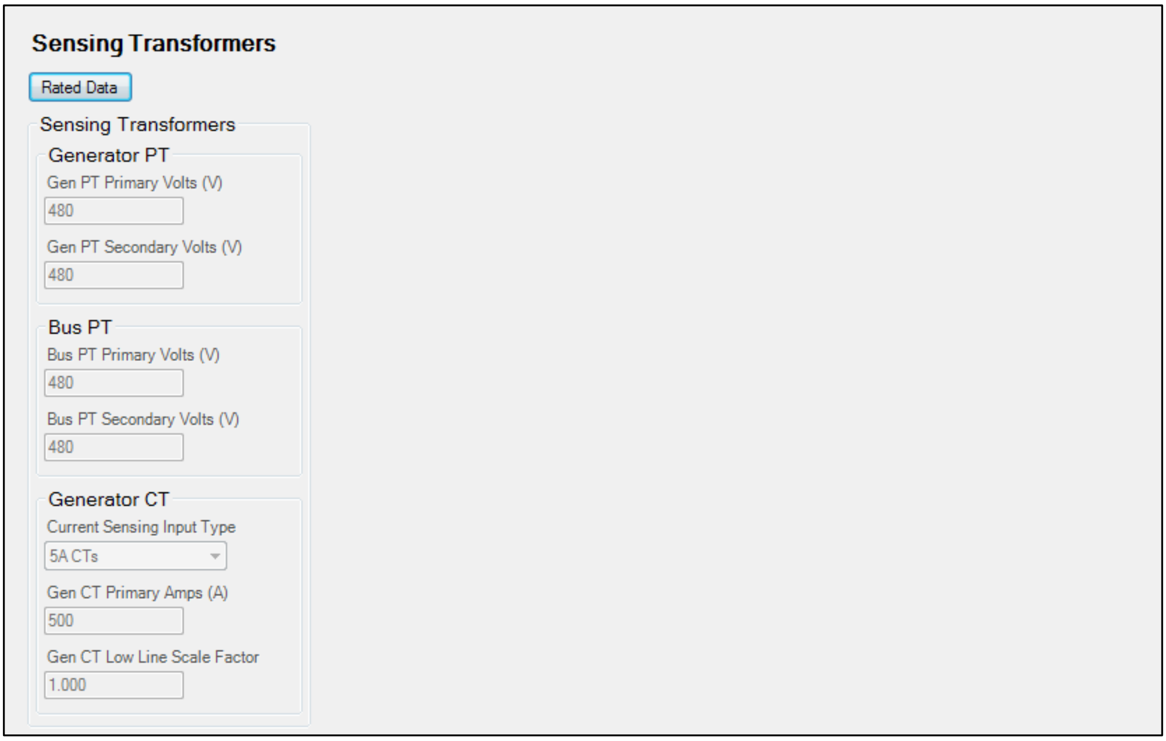

Figure 7-8. Settings Explorer, System Parameters, Sensing Transformers Screen

Relay Control

Front Panel Navigation Path: SETTINGS > SYSTEM PARAMS > RELAY CONTROL

These drop-down menus select the operating mode for the PRE, START, and RUN relays on the back of the MGC-2000 Series. In general, most machines will use preconfigured functionality; more advanced users may select programmable. Refer to the appropriate paragraphs in Section 4, *BESTCOMSPlus® Software,* for additional information. See Figure 7-9.

Figure 7-9. Settings Explorer, System Parameters, Relay Control Screen

Auto Config Detection

Front Panel Navigation Path: SETTINGS > SYSTEM PARAMS > AUTO CONFIG DETECT

If the machine connection type is not reconfigurable, disregard this setting. However, if a machine is reconfigurable, these parameters define how automatic detection of the generator connection type for some machines is accomplished. Refer to the appropriate paragraphs in Section 4, *BESTCOMSPlus® Software,* for additional information. See Figure 7-10.

Figure 7-10. Settings Explorer, System Parameters, Auto Config Detection Screen

Alarm Configuration

Horn Configuration (Figure 7-11)
Front Panel Navigation Path: SETTINGS > ALARM CONFIGURATION > HORN CONFIGURATION

1. Horn Enable - This setting enables or disables the output for the external alarm horn.
2. Not In Auto Horn Enable - This setting enables or disables the horn when not in auto mode.

Figure 7-11. Settings Explorer, Alarm Configuration, Horn Configuration Screen

Pre-Alarms
Front Panel Navigation Path: SETTINGS > ALARM CONFIGURATION > PRE-ALARMS

Examine each of the pre-alarms. Pre-alarm setup is not required to operate the machine, but is likely to be desired to provide warnings for machine protection. Enable any desired pre-alarms and enter an appropriate threshold. Set the activation delay where possible. The activation delay is the duration that a condition remains in effect before annunciating a pre-alarm. Refer to the appropriate paragraphs in Section 4, *BESTCOMSPlus® Software,* for additional information regarding pre-alarm configuration. See Figure 7-12.

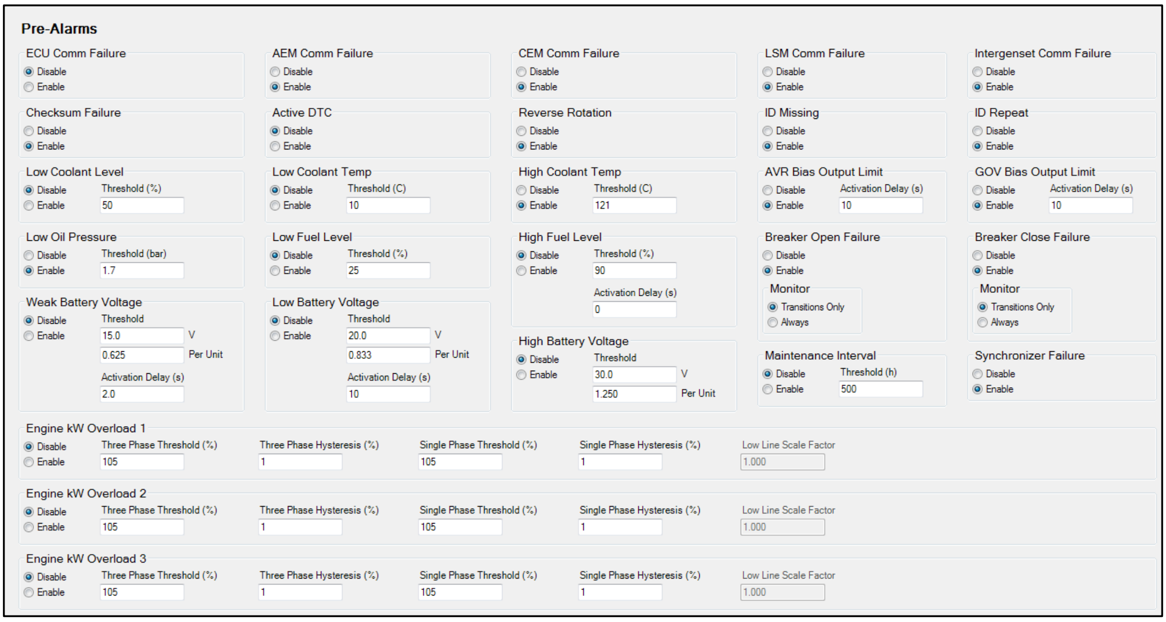

Figure 7-12. Settings Explorer, Alarm Configuration, Pre-Alarms Screen

Alarms

Front Panel Navigation Path: SETTINGS > ALARM CONFIGURATION > ALARMS

Examine each of the alarms. Alarm setup is not required to operate the machine, but is likely to be desired to provide shutdowns for machine protection. Enable any desired alarms and enter an appropriate threshold. Set the *Activation Delay* where possible. The activation delay is the duration that a condition remains in effect before annunciating an alarm. Refer to the appropriate paragraphs in Section 4, *BESTCOMSPlus® Software,* for additional information regarding alarm configuration. See Figure 7-13.

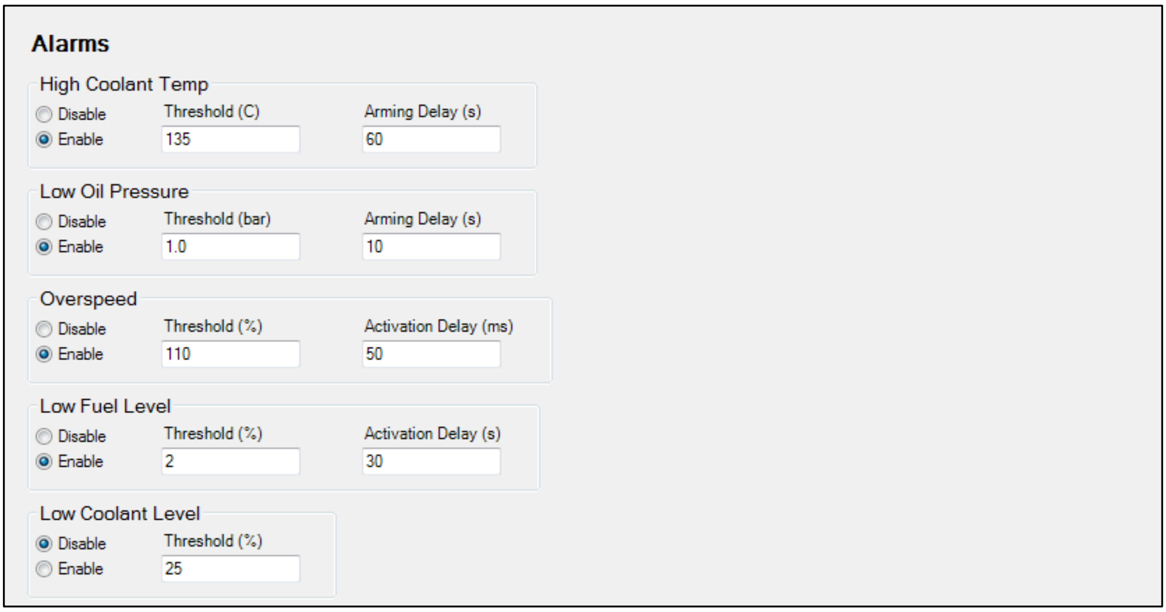

Figure 7-13. Settings Explorer, Alarm Configuration, Alarms Screen

Sender Fail

Front Panel Navigation Path: SETTINGS > ALARM CONFIGURATION > SENDER FAIL

Enable each sender type as desired by configuring it as an alarm or pre-alarm. Set an activation delay. The activation delay is the duration that the condition remains in effect before annunciating an alarm or pre-alarm. Refer to the appropriate paragraphs in Section 4, *BESTCOMSPlus® Software,* for additional information regarding sender fail configuration. If an MGC-2000 Series is receiving engine information

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from an engine ECU, the sender fail for coolant temperature and oil pressure do not need configured because they have no effect. They are appropriate for resistive senders only. See Figure 7-14.

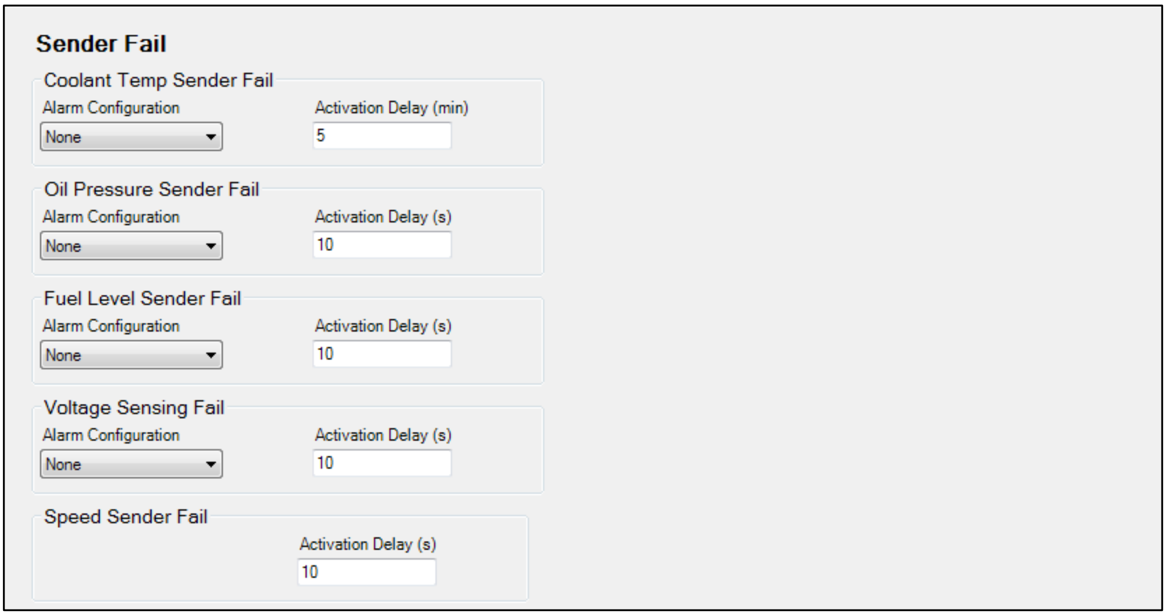


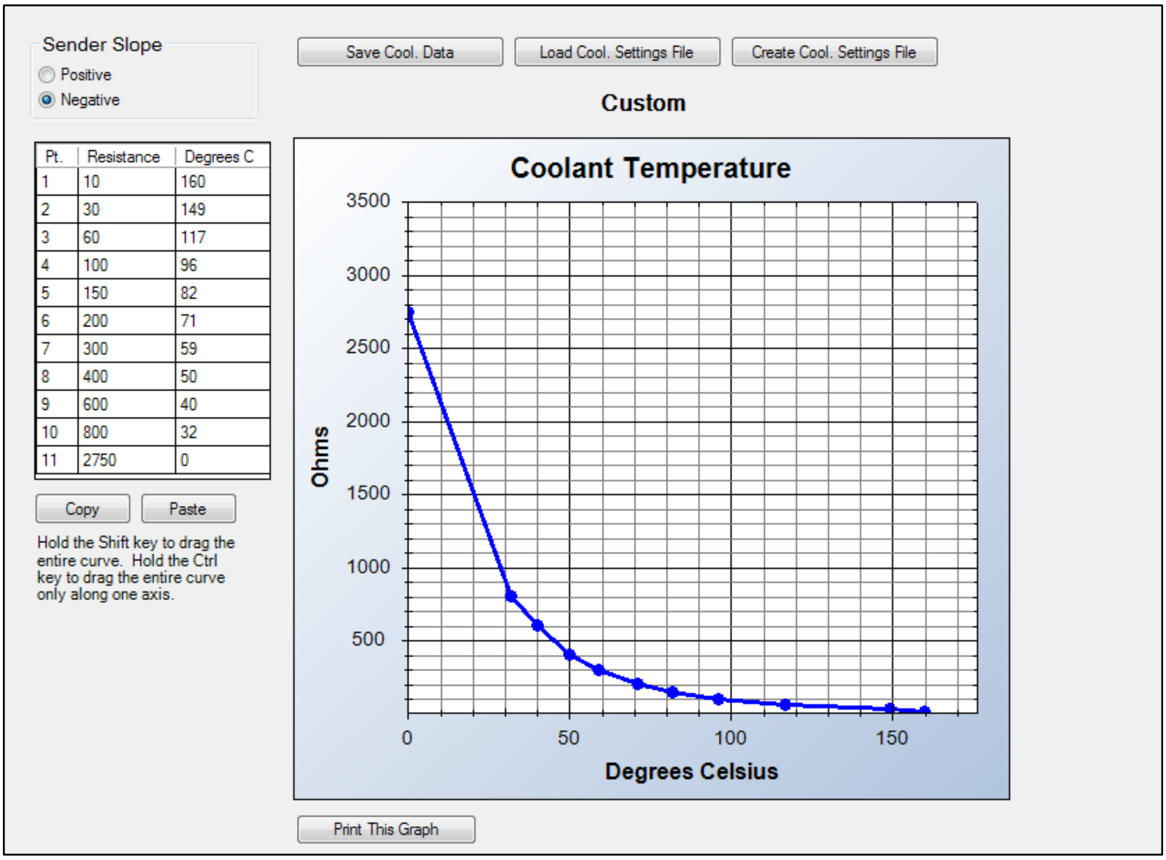
Figure 7-14. Settings Explorer, Alarm Configuration, Sender Fail Screen

Programmable Senders

If an MGC-2000 Series receives engine information from an engine ECU, the programmable sender parameters for the coolant temperature and oil pressure senders do not need to be configured because they have no effect. They are appropriate for resistive senders only.

Coolant Temperature (Figure 7-15)

1. The coolant temperature sender can be configured by selecting one of the sender types that come as a part of the BESTCOMS*Plus*® sender library by clicking on *Load Cool Settings File* and selecting the appropriate sender.
2. If no sender file matches the sender being used, the individual points that map resistance points to coolant temperature may be modified by setting numeric values in the table, or by dragging the points of the graph to the desired characteristic. Information on sender characteristics should be obtained from the sender manufacturer.
3. Select *Positive* or *Negative* sender slope as required for the desired sender graph.
4. Click *Save Cool Data* to save the data in the current settings file.
5. If you want to save newly entered sender data as a sender library file, click *Create Cool Settings File* and enter a file name and location to save the file.
6. Click the *Send Settings* button in BESTCOMS*Plus*® to send the sender settings to the MGC-2000 Series.



Pt.	Resistance	Degrees C
1	10	160
2	30	149
3	60	117
4	100	96
5	150	82
6	200	71
7	300	59
8	400	50
9	600	40
10	800	32
11	2750	0

Figure 7-15. Settings Explorer, Programmable Senders, Coolant Temperature Screen

Oil Pressure (Figure 7-16)

1. The oil pressure sender can be configured by selecting one of the sender types that come as a part of the BESTCOMS*Plus*® sender library by clicking on *Load Oil Settings File* and selecting the appropriate sender.
2. If no sender file matches the sender being used, the individual points that map resistance points to oil pressure may be modified by setting numeric values in the table, or dragging the points of the graph to the desired characteristic. Information on sender characteristics should be obtained from the sender manufacturer.
3. Select *Positive* or *Negative* sender slope as required for the desired sender graph.
4. Click *Save Oil Data* to save the data in the current settings file.
5. If you want to save newly entered sender data as a sender library file, click *Create Oil Settings File* and enter a file name and location to save the file.
6. Click the *Send Settings* button in BESTCOMS*Plus*® to send the sender settings to the MGC-2000 Series.

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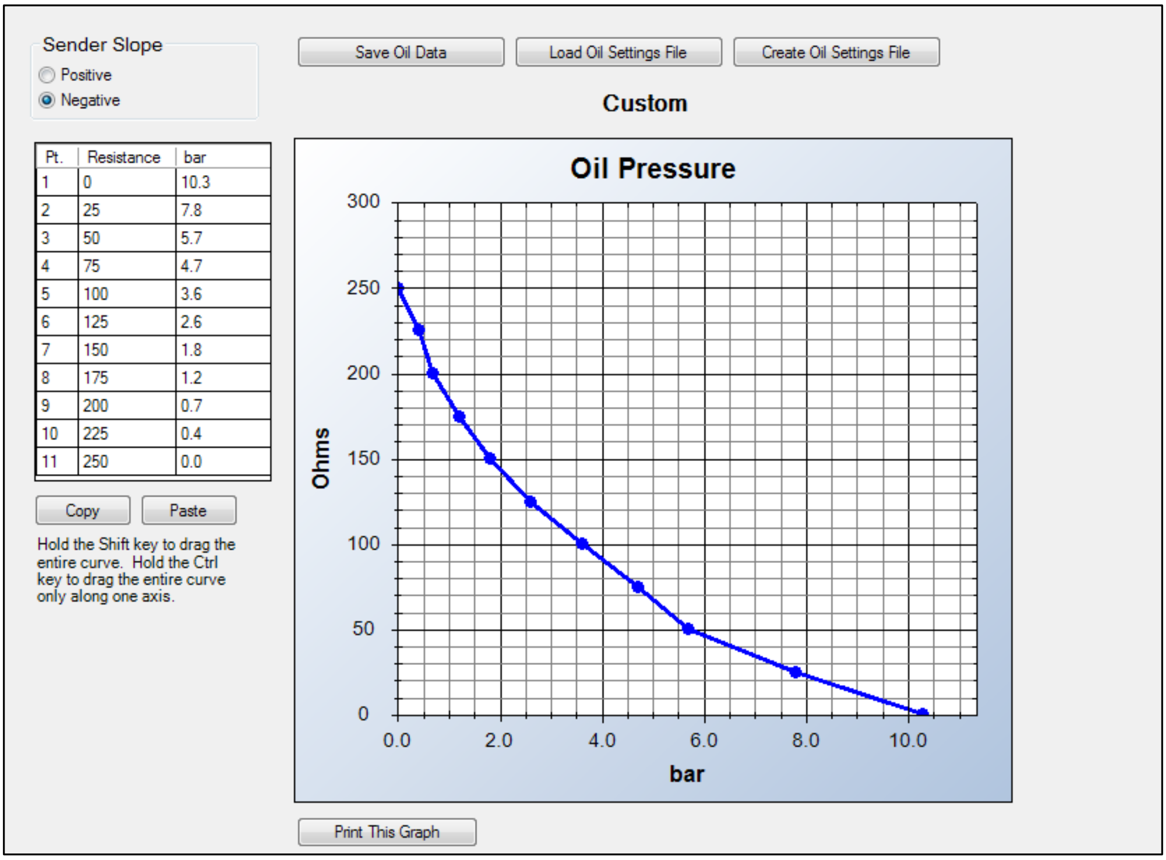

Figure 7-16. Settings Explorer, Programmable Senders, Oil Pressure Screen

Percent Fuel Level (Figure 7-17)

1. The percent fuel level sender is configured by selecting one of the sender types that come as a part of the BESTCOMS*Plus*® sender library by clicking on *Load Fuel Settings File* and selecting the appropriate sender.
2. If no sender file matches the sender being used, the individual points that map resistance points to fuel level may be modified by setting numeric values in the table, or dragging the points of the graph to the desired characteristic. Information on sender characteristics should be obtained from the sender manufacturer.
3. Select *Positive* or *Negative* sender slope as required for the desired sender graph.
4. Click *Save Fuel Data* to save the data in the current settings file.
5. If you want to save newly entered sender data as a sender library file, click *Create Fuel Settings File* and enter a file name and location to save the file.
6. Click the *Send Settings* button in BESTCOMS*Plus*® to send the sender settings to the MGC-2000 Series.

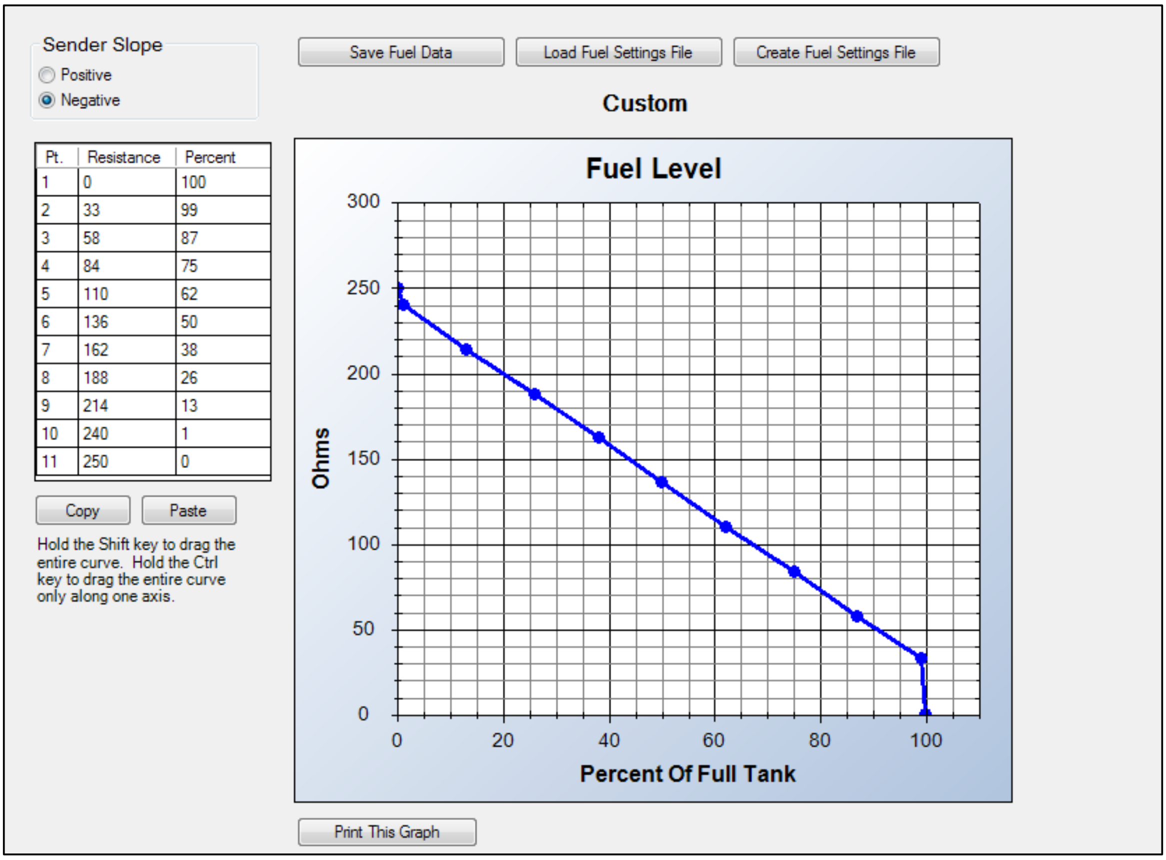

Figure 7-17. Settings Explorer, Programmable Senders, Fuel Level Screen

This completes the discussion of initial MGC-2000 Series setup parameters that are required prior to running a unit.

Initial Setup (Optional)

This section discusses some of the basic setup parameters that are not required to start and run the unit, but may be set up to further customize the MGC-2000 Series to the application. This discussion is not comprehensive; it presents some of the basic setup parameters. Advanced users can customize the MGC-2000 Series through the BESTlogic™*Plus* Programmable Logic, configurable inputs, configurable protection, configurable elements, and a numerous other features designed for MGC-2000 Series configurability.

The parameters are listed according to how they are listed in the Settings Explorer of BESTCOMS*Plus*®. These parameters can also be set from the front panel of the MGC-2000 Series.

General Settings

Front Panel HMI (Figure 7-18)
Front Panel Navigation Path: SETTINGS > GENERAL SETTINGS > FRONT PANEL HMI

1. LCD Contrast - Change this setting if the contrast needs adjusted.
2. Front Panel Sleep Mode - Select enable if desired. In sleep mode, the LEDs and LCD backlight turn off after 15 minutes of inactivity on the front panel to minimize battery drain.
3. Language Selection - Select the desired language.
4. Scrolling Screens - These settings are not accessible via the front panel. If a different overview screen for the front panel LCD is desired, specify the scrolling screens in which parameters are configured to appear on the front panel LCD display.
    a. Configure the *Configurable HMI Summary Settings.*
    b. Set the *Scrolling Screen Enable* to *Enable*.
    c. Set the *Scrolling Screen Scroll Delay* parameter to the desired value.

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5. Phase Toggle Delay - Set the phase toggle delay to a nonzero value if automatic scrolling through the phase information in the standard overview screen on the front panel is desired. If it is left at zero, scrolling through phase information is accomplished using the up and down arrow buttons.
6. Initializing Message 1 - This parameter defines the first line of text that appears on the front panel of the MGC-2000 Series as it is going through its power up and initializing sequence.
7. Initializing Message 2 - This parameter defines the second line of text that appears on the front panel of the MGC-2000 Series as it is going through its power up and initializing sequence.

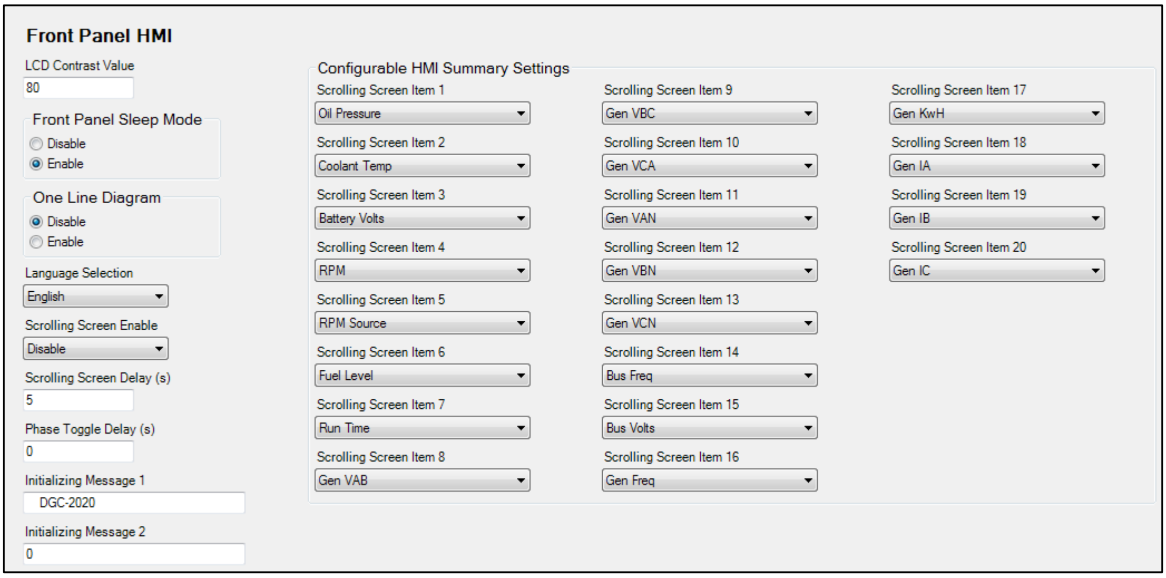

Figure 7-18. Settings Explorer, General Settings, Front Panel HMI Screen

Device Security Setup

If passwords other than default are desired, use BESTCOMS*Plus*® to connect to the MGC-2000 Series and change the passwords. Click on *Upload Security* from the *Communications* pull-down menu to load the new passwords. See Figure 7-19.

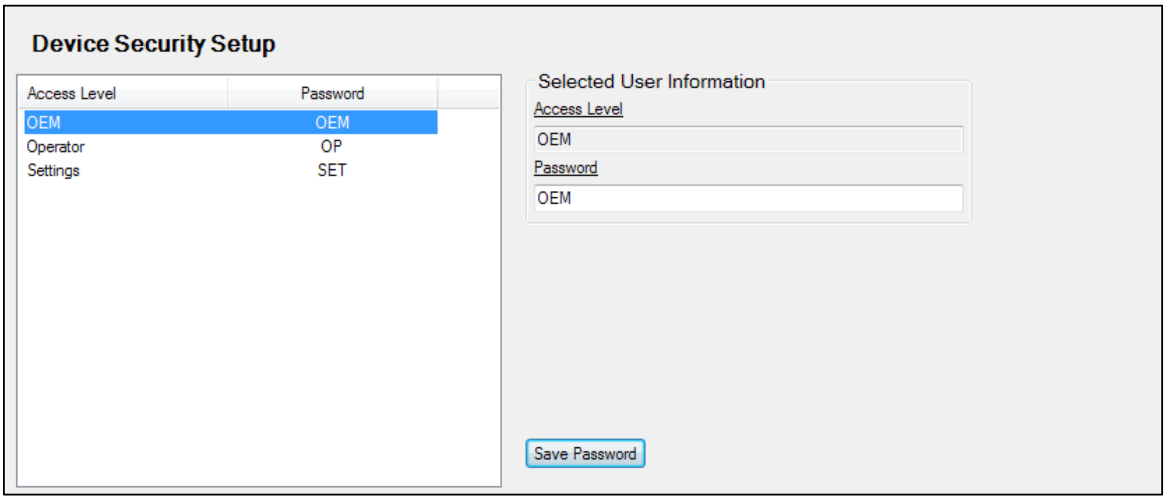

Figure 7-19. Settings Explorer, General Settings, Device Security Setup Screen

Clock Setup

Front Panel Navigation Path: SETTINGS > GENERAL SETTINGS > CONFIGURE DATE/TIME

Configure the date and time for the MGC-2000 Series. The daylight-savings time parameters are also configured on this screen. See Figure 7-20.

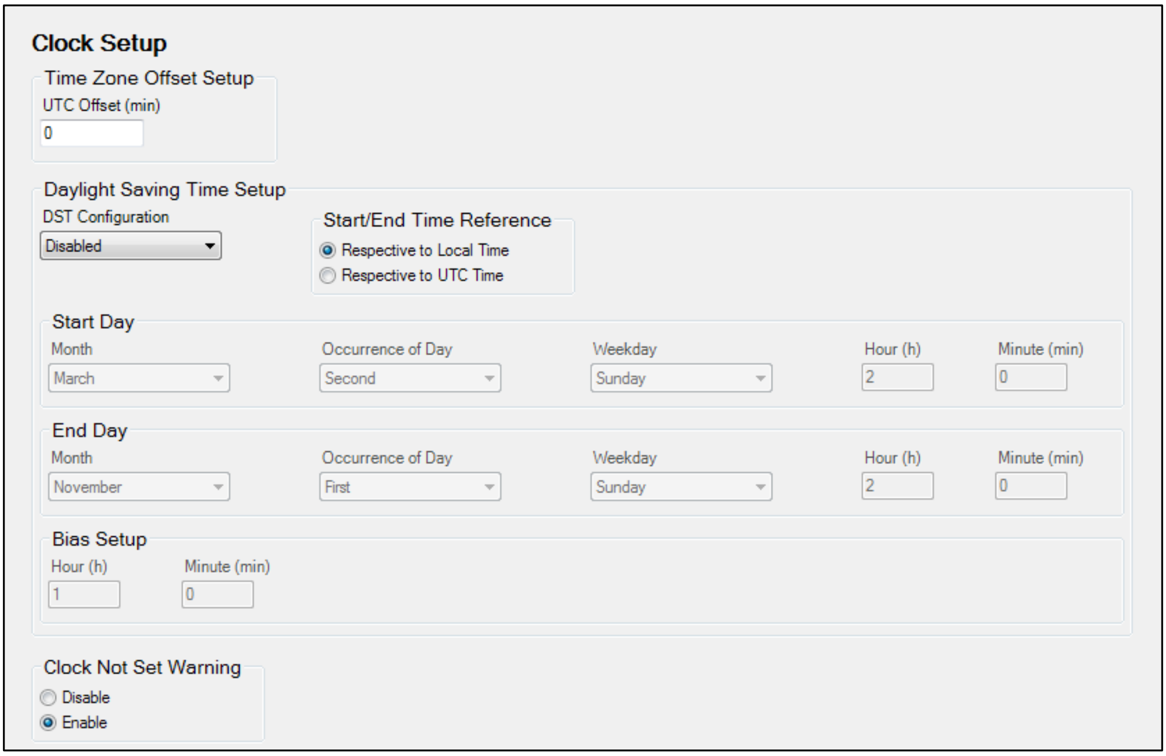

Figure 7-20. Settings Explorer, General Settings, Clock Setup Screen

This completes the discussion of optional MGC-2000 Series setup parameters. This discussion is not comprehensive; it presents some of the basic setup parameters. Advanced users can customize the MGC-2000 Series through the BESTlogic*Plus* Programmable Logic, configurable inputs, configurable protection, configurable elements, and numerous other features designed for MGC-2000 Series configurability.

Setting Up MGC-2000 Series Programmable Inputs and Outputs

The MGC-2000 Series along with the CEM-2020 (Contact Expansion Module) and AEM-2020 (Analog Expansion Module) provide a variety of programmable input and output capabilities. The MGC-2000 Series and the CEM-2020 include contact inputs that are configurable as pre-alarms or alarms and are available as inputs to BESTlogic*Plus* Programmable Logic. They also contain dry contact relay outputs, which are driven by the BESTlogic*Plus* Programmable Logic.

The AEM-2020 has eight analog inputs, eight resistive temperature device (RTD) inputs, two thermocouple inputs, and four analog outputs. Each analog input is configurable as a 4 to 20 mA current input or a 0 to 10 Vdc voltage input to accommodate most readily available industrial transducers; the RTD and thermocouple inputs are pre-configured for temperature measurement. Each analog, RTD, and/or thermocouple input can be programmed with a user adjustable range and assignable label along with up to four thresholds to implement protective schemes or BESTlogic*Plus* Programmable Logic programming utilizing the measured parameter. This allows for enhanced protection of the engine and generator, and protection of external devices.

The analog outputs can be configured as 4 to 20 mA current outputs or 0 to 10 Vdc voltage outputs. Each output can be mapped to metered parameters in the MGC-2000 Series to implement meter driver functionality, or provide signals for analog inputs of other equipment.

Instructions regarding configuration and setup of each type of programmable input and output are presented in the following paragraphs, along with instructions for enabling the expansion modules.

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Enable LSM-2020, CEM-2020, and AEM-2020

Front Panel Navigation Path: SETTINGS > SYSTEM PARAMS > REMOTE MODULE SETUP

The parameters for remote inputs and remote outputs are disabled and cannot be configured in BESTCOMS*Plus*® until after the appropriate module has been enabled. Thus, expansion modules connected to the MGC-2000 Series must be enabled before the associated parameters can be modified. See Figure 7-21.

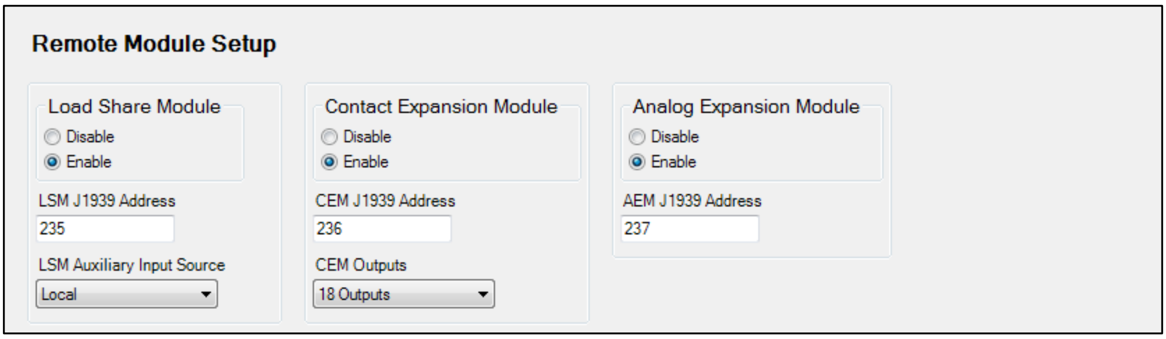

Figure 7-21. Settings Explorer, System Parameters, Remote Module Setup Screen

Configure the following parameters:

1. Load Share Module Enable/Disable - Select *Enable* if a load share module is present in the system.
2. LSM J1939 Address - Enter the J1939 address to be used by the LSM-2020. Normally this will not have to be changed unless the address is already in use elsewhere on the CAN bus network.
3. LSM Auxiliary Input Source – Select *Local* if locally measured input values are to be used. Select *System Manager* if the measured input values of the unit designated as the system manager are to be used.
4. Contact Expansion Module Enable/Disable - Select *Enable* if a contact expansion module is present in the system.
5. CEM J1939 Address - Set the J1939 address to be used by the CEM-2020. Normally this will not have to be changed unless the address is already in use elsewhere on the CAN bus network.
6. CEM Outputs - This setting defines the number of output relays on the CEM-2020. Select *18* or *24*. Refer to the style chart in Section 1, *General Information*, of the MGC-2000 Series instruction manual to determine if you have 18 or 24 output relays on the CEM-2020.

Programmable Inputs

The programmable inputs consist of:

- Contact inputs on the MGC-2000 Series.
- Programmable functions on the MGC-2000 Series. The programmable functions allow mapping of particular inputs to certain functions. For example, one can select an input for the ATS (Automatic Transfer Switch) input function, or a Low Fuel Level indication function.
- Remote LSM inputs on the LSM-2020. The LSM-2020 has one analog input.
- Remote contact inputs on the CEM-2020.
- Remote analog inputs on the AEM-2020.
- Remote RTD inputs on the AEM-2020.
- Remote thermocouple inputs on the AEM-2020.

Configuration Instructions

Configuring contact inputs on the MGC-2000 Series (See Figure 7-22.)
Front Panel Navigation Path: SETTINGS > PROGRAMMABLE INPUTS > CONFIGURABLE INPUTS

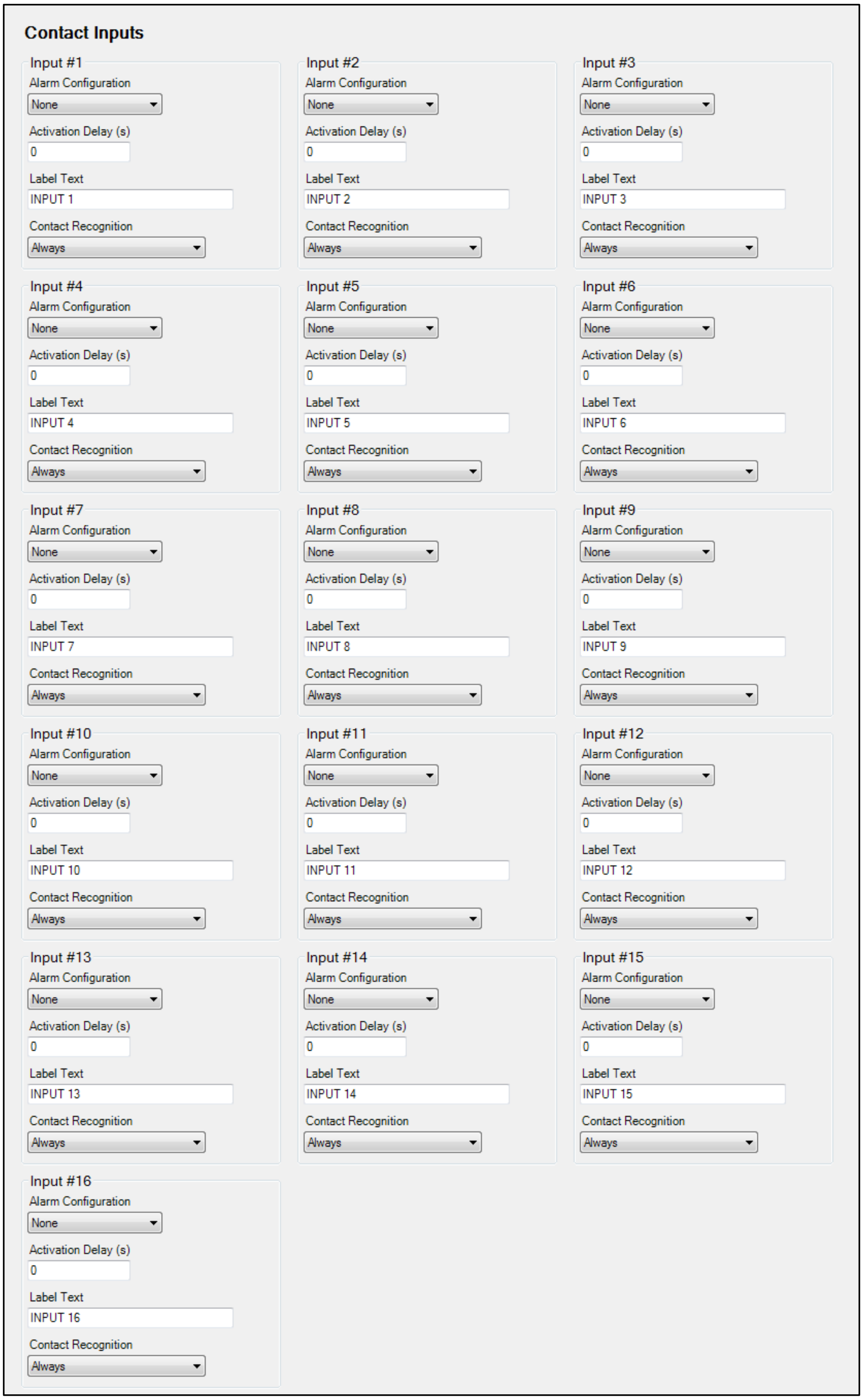

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Figure 7-22. Settings Explorer, Programmable Inputs, Contact Inputs Screen

For each contact input, configure the following parameters:

1. Alarm Configuration - Select *None, Alarm,* or *Pre-Alarm*. When an alarm occurs, the horn output annunciates with a constant beep and the engine shuts down. When a pre-alarm occurs, the horn output annunciates with an alternating on and off beep and the engine remains running. If *None* is selected, the input is status only. The status is available to BESTlogic*Plus* Programmable Logic regardless of *Alarm Configuration* setting.
2. Activation Delay - This parameter defines the duration that the input remains on before any annunciation occurs.
3. Label Text - Enter descriptive text that signifies the use of the input. This text appears next to the input in BESTlogic*Plus* Programmable Logic and in the event log if the input is configured as an alarm or pre-alarm.
4. Contact Recognition - Select whether the contact input should be recognized always, or only while the engine is running. For example, a switch closes when oil pressure is low while the engine is running. Such a switch would be closed when the engine is not running but a low oil pressure alarm or pre-alarm should not be annunciated unless the switch is closed while the engine is running. A selection of *While Engine Running Only* prevents spurious annunciation when the engine is not running.

Configurable Programmable Functions on the MGC-2000 Series (See Figure 7-23)
Front Panel Navigation Path: SETTINGS > PROGRAMMABLE INPUTS > PROG FUNCTIONS

Programmable functions are pre-defined functions in the MGC-2000 Series and are initiated by a contact input. An input must be mapped to a programmable function for that function to operate. Furthermore, some of the programmable functions can be configured as alarms or pre-alarms and cause annunciation to occur on the RDP-110 (Remote Display Panel).

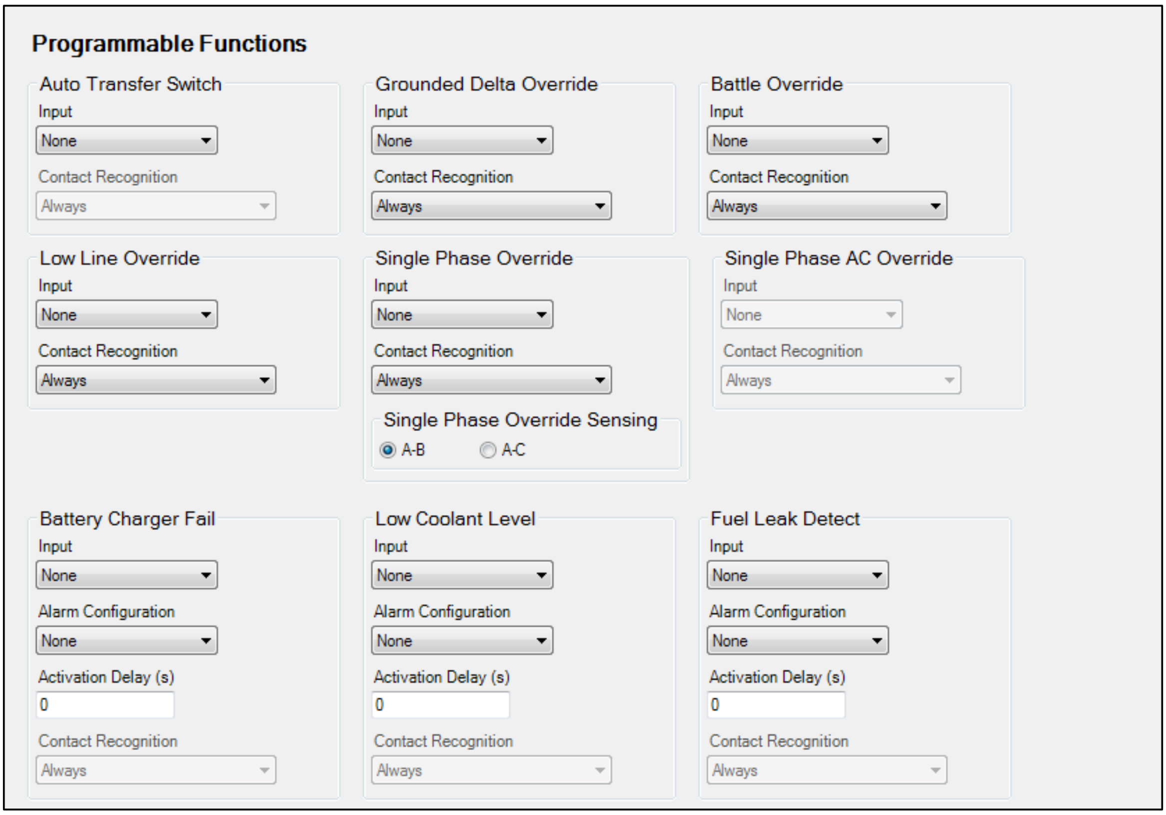

Figure 7-23. Settings Explorer, Programmable Inputs, Programmable Functions Screen

Configure the following parameters:

1. Auto Transfer Switch
    a. Input - This function is used to start the generator from a contact input when the MGC-2000 Series is in AUTO mode. Select the desired input or select *None* to disable the programmable function.
    b. Contact Recognition - Select *Always*.
2. Grounded Delta Override
    a. Input - If a reconfigurable machine will operate sometimes in a grounded delta configuration and sometimes in other configurations, select an input for this function to indicate to the MGC-2000 Series when the machine is in the grounded delta configuration. When the machine is grounded delta, the MGC-2000 Series will display line-to-neutral as well as line-to-line voltages. In normal delta, the line-to-neutral voltages are not displayed. Select *None* to disable the programmable function.
    b. Contact Recognition - Select *Always*.
3. Battle Override
    a. Input - Select an input for this function if a battle override initiated from a contact input is required. For some very critical applications, the ability to remove all system shutdowns may be a requirement. Selecting battle override will prevent all alarms from stopping the engine. Extreme caution should be taken before selecting this option as machine warranties can be voided if enabled. Select *None* to disable the programmable function.
    b. Contact Recognition - Select *Always*.
4. Low Line Override
    a. Input - If a reconfigurable machine will operate sometimes in a low line configuration machine and sometimes as high line, select an input for this function to indicate to the MGC-2000 Series that the machine is in low line operation. When this is in effect, the *Low Line Scale Factor* settings (found in various protection elements and bus stable/failed detection elements) will be applied to the metered parameter used for the protection. Select *None* to disable the programmable function.
    b. Contact Recognition - Select *Always*.
5. Single-Phase Override
    a. Input - If a reconfigurable machine operates sometimes in a single-phase configuration and sometimes as three-phase, select an input for this function to indicate to the MGC-2000 Series that the machine is in single-phase operation. When this is in effect, single-phase settings apply in the generator protection elements and only single-phase voltages and currents are displayed on the front panel. Select *None* to disable the programmable function.
    b. Contact Recognition - Select *Always*.
    c. Single-Phase Override Sensing - If the machine connection type is not reconfigurable, disregard this setting. However, if a machine is a reconfigurable machine, this setting defines how to interpret a single-phase override contact input. Refer to the appropriate paragraphs in Section 4, *BESTCOMSPlus® Software,* for additional information.
6. Single-Phase AC Override
    a. Input - If a reconfigurable machine operates sometimes in a single-phase AC (as opposed to single-phase AB) configuration and sometimes as a three-phase or single-phase AB configuration, select an input for this function to indicate to the MGC-2000 Series that the machine is in single-phase AC operation. When this is in effect and the single-phase override is in effect, single-phase settings apply in the generator protection elements and the metering uses phase C current and phase AC voltage for power factor calculations. Otherwise, phase A current and phase AB voltage are used for power factor calculations. Select *None* to disable the programmable function.
    b. Contact Recognition - Select *Always*.
7. Battery Charger Fail
    a. Input - Select an input for this function to indicate a battery charger failure. When this input is true, an alarm or pre-alarm will be annunciated based on alarm configuration, and the *Battery Charger Fail* indicator on the RDP-110 (Remote Display Panel) will illuminate. Select *None* to disable the programmable function.

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b. Alarm Configuration - Select *None, Alarm,* or *Pre-Alarm* for the desired behavior of this function. Regardless of the selection, the indicator on the RDP-110 will illuminate if an input has been assigned and the input is on.

c. Activation Delay - Set the delay for which the input must be true before the alarm or pre-alarm will be annunciated. This can be used to prevent “glitches” on the input from causing spurious annunciation.

8. Low Coolant Level

   a. Input - Select an input for this function to indicate a low coolant level. When this input is true, an alarm or pre-alarm is annunciated based on the alarm configuration, and the *Low Coolant Level* indicator on the RDP-110 (Remote Display Panel) will illuminate. Select *None* to disable the programmable function.

   b. Alarm Configuration - Select *None, Alarm,* or *Pre-Alarm* for the desired behavior of this function. Regardless of the selection, the indicator on the RDP-110 will illuminate if an input has been assigned and the input is on.

   c. Activation Delay - Set the delay for which the input must remain true before the alarm or pre-alarm is annunciated. This can be used to prevent “glitches” on the input from causing spurious annunciation.

9. Fuel Leak Detect

   a. Input - Select an input for this function to indicate when a fuel leakage condition has been detected. When this input is true, an alarm or pre-alarm is announced based on the alarm configuration and the *Fuel Leak* indicator on the RDP-110 (Remote Display Panel) will illuminate. Select *None* to disable the programmable function.

   b. Alarm Configuration - Select *None, Alarm,* or *Pre-Alarm* for the desired behavior of this function. Regardless of the selection, the indicator on the RDP-110 will illuminate if an input has been assigned and the input is on.

   c. Activation Delay - Set the delay for which the input must remain true before the alarm or pre-alarm will be annunciated. This can be used to prevent “glitches” on the input from causing spurious annunciation.

Configuring Remote LSM Inputs on the LSM-2020 (Load Share Module)
Front Panel Navigation Path: SETTINGS > PROGRAMMABLE INPUTS > LSM INPUTS

The LSM-2020 has one analog input. It is reserved for use with kW and/or kvar control and can be used as a source for the *kW Base Load (%)* setting, the *kvar Setpoint (%)* setting, or the *PF Setpoint* setting. However, the input type (4-20 mA or 0-10 Vdc) and the input range must be set on the *Remote LSM Inputs* screen in BESTCOMS*Plus*®. See Figure 7-24.

Figure 7-24. Settings Explorer, Programmable Inputs, Remote LSM Inputs Screen

The parameters to be configured are:

1. Input Type - Select *Voltage* for a 0-10 Vdc input or *Current* for a 4-20 mA current input.

2. Min Input Voltage (V) - This setting defines the minimum valid voltage expected from the transducer or device connected to the analog input. Voltage below this threshold will be limited to this value. The Min Input Voltage setting can be set only when *Voltage* is selected as the *Input Type*.

3. Max Input Voltage (V) - This setting defines the maximum valid voltage expected from the transducer or device connected to the analog input. Voltage above this threshold will be limited to this value. The Max Input Voltage setting can be set only when *Voltage* is selected as the *Input Type*.
4. Min Input Current (mA) - This setting defines the minimum valid current expected from the transducer or device connected to the analog input. Current below this threshold will be limited to this value. The Min Input Current setting can be set only when *Current* is selected as the *Input Type*.
5. Max Input Current (mA) - This setting defines the maximum valid current expected from the transducer or device connected to the analog input. Current above this threshold will be limited to this value. The Max Input Current can be set only when *Current* is selected as the *Input Type*.

Configuring Remote Contact Inputs on the CEM-2020 (See Figure 7-25)
Front Panel Navigation Path: SETTINGS > PROGRAMMABLE INPUTS > CONFIGURABLE INPUTS

The settings of this screen are disabled unless the CEM-2020 (Contact Expansion Module) has been enabled as previously explained.

For each contact input, configure the following parameters:

1. Alarm Configuration - Select an alarm configuration of *None, Alarm,* or *Pre-Alarm*. When an alarm occurs, the horn output annunciates with a constant beep and the engine shuts down. When a pre-alarm occurs, the horn output annunciates with an alternating on and off beep and the engine remains running. If *None* is selected, the input is status only. The status is available to BESTlogic*Plus* Programmable Logic regardless of the *Alarm Configuration* selection.
2. Activation Delay - This parameter defines how long the input remains on before any annunciation occurs.
3. Label Text - Enter descriptive text that signifies the use of the input. This text appears next to the input in BESTlogic*Plus* Programmable Logic and in the event log if the input is configured as an *Alarm* or *Pre-Alarm*.
4. Contact Recognition - Select whether the contact input should be recognized always, or only while the engine is running. For example, a switch closes when the oil pressure is low and the engine is running. This type of switch will be closed when the engine is not running and it should be blocked. However, a low oil pressure alarm or pre-alarm is annunciated when a low oil pressure occurs and the switch is closed while the engine is running. A selection of *While Engine Running Only* prevents spurious annunciation when the engine is not running.

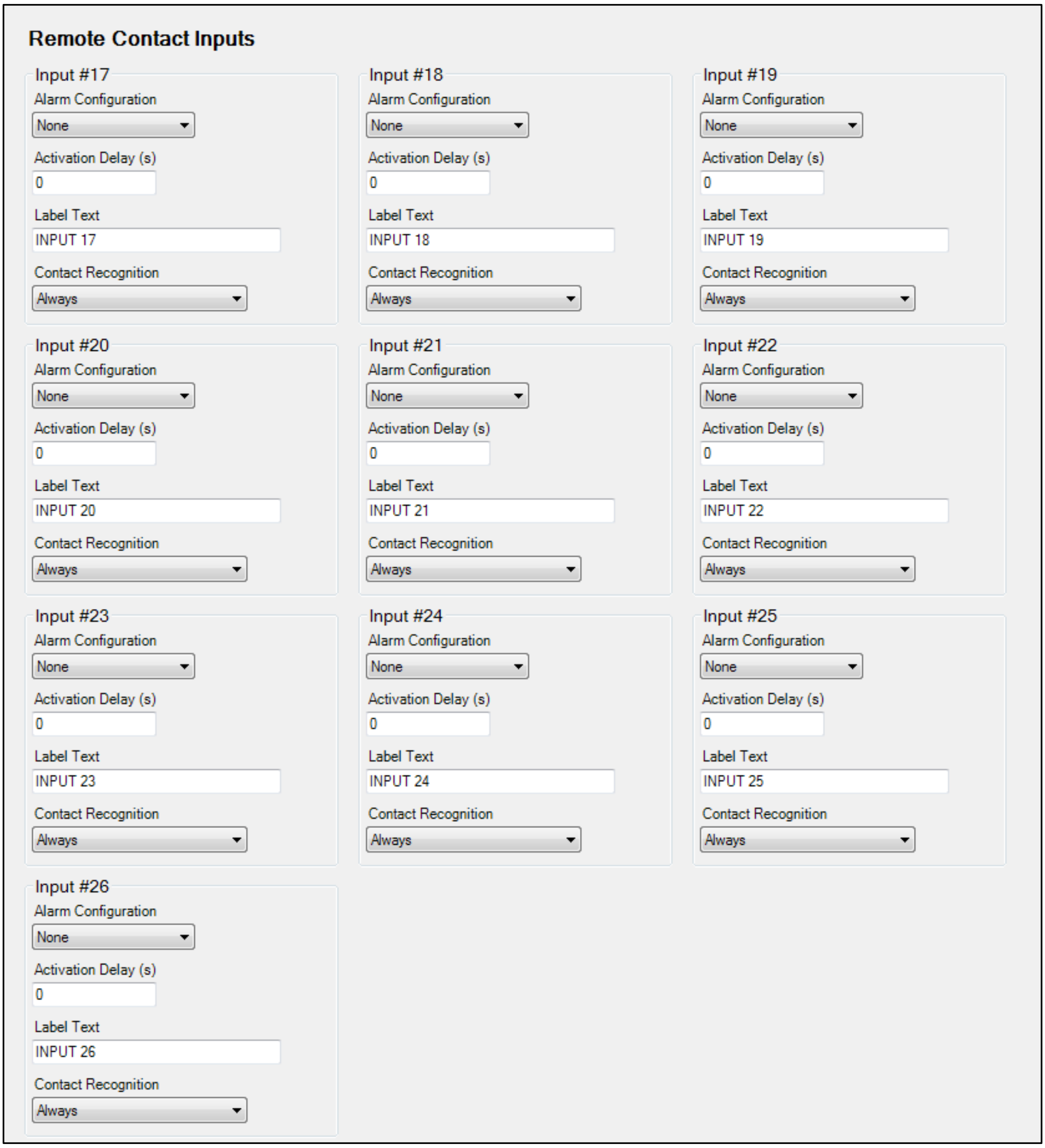

Figure 7-25. Settings Explorer, Programmable Inputs, Remote Contact Inputs Screen

Configuring Remote Analog Inputs on the AEM-2020
Front Panel Navigation Path: SETTINGS > PROGRAMMABLE INPUTS > ANALOG INPUTS

Each input is configured with a user-assignable string and parameter range to map the analog input signal range to a user-defined parameter range. Thus, external conditions are metered and displayed on the MGC-2000 Series. Each input is configured with up to four thresholds (two over thresholds and two under thresholds) which make their status available to BESTlogic*Plus* Programmable Logic. In addition, each threshold can trigger alarms or pre-alarms to protect the generator and associated equipment based on these measured external conditions. See Figure 7-26.

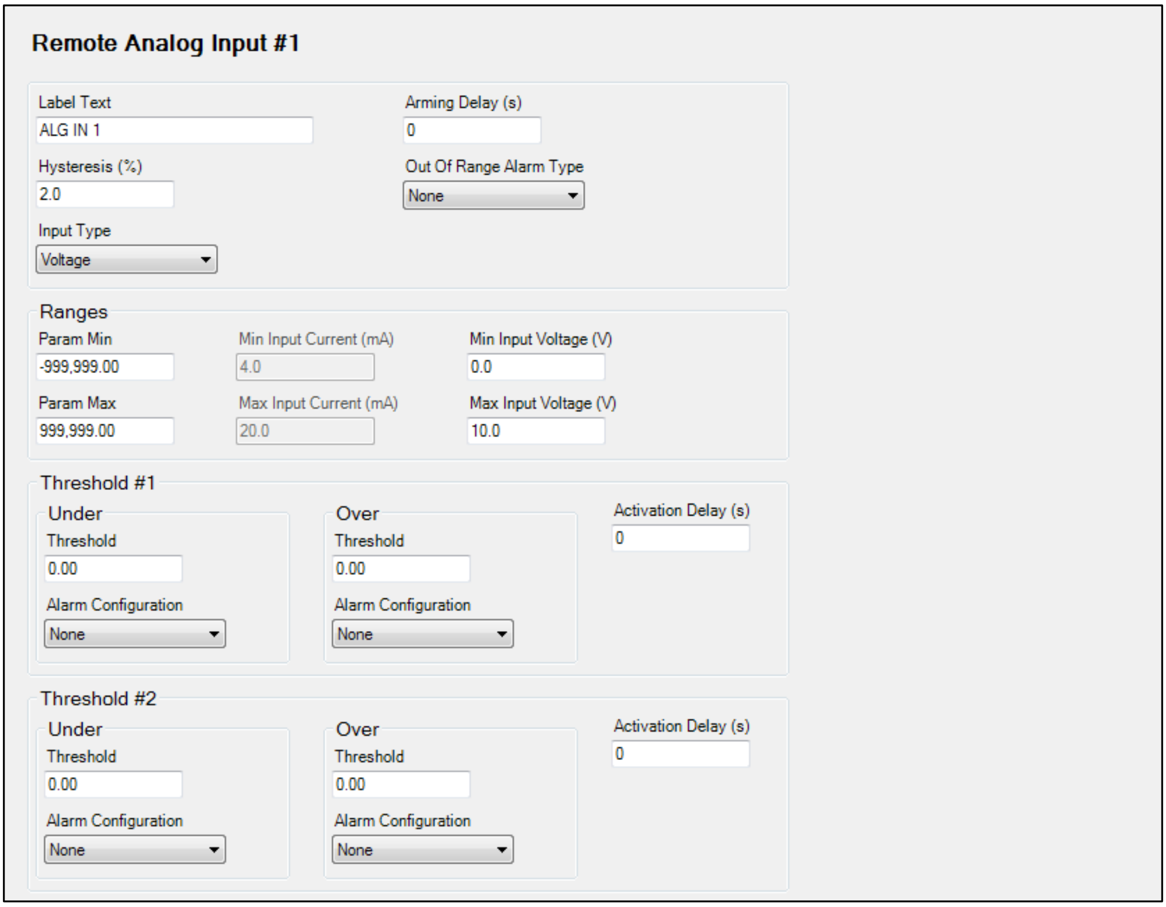

Figure 7-26. Settings Explorer, Programmable Inputs, Remote Analog Inputs Screen

Configure the following parameters:

1. Label Text - Enter descriptive text that signifies the use of the input. This text appears next to the threshold status and associated alarm and pre-alarm status in BESTlogic*Plus* Programmable Logic and in the event log if any of the input thresholds are configured as an *Alarm* or *Pre-Alarm*.
2. Hysteresis (%) - Enter a value for the desired hysteresis for threshold detection. This helps prevent intermittent detection of thresholds.
3. Input Type - Select *Voltage* for 0-10 Vdc inputs or *Current* for 4-20 mA current inputs.
4. Arming Delay - The *Arming Delay* is the wait time after engine startup, before input monitoring begins. Set the arming delay to zero if constant monitoring is desired, including while the engine is not running. Non-zero values direct the input to be monitored after the programmed time has elapsed after engine startup.
5. Out-of-Range Alarm Type - When the analog input falls outside of its programmed range (as determined by the *Min* and *Max Input* voltage or current settings) an out-of-range indication is annunciated. If *Alarm* or *Pre-Alarm* is selected, annunciation will occur. If *Status Only* is selected, the status will be available to BESTlogic*Plus* Programmable Logic but no annunciation will occur.
6. Parameter Minimum (Param Min) - This setting defines the value that the measured parameter assumes when the analog input is at its programmed minimum level. If the analog input is below its programmed minimum level, the measured parameter is limited to this *Parameter Minimum* setting. However, the raw analog input value displays the actual voltage or current measured at the analog input as long as it is within the voltage or current range detected by the input circuit.
7. Parameter Maximum (Param Max) - This setting defines the value that the measured parameter assumes when the analog input is at its programmed maximum level. If the analog input is above its programmed maximum level, the measured parameter is limited to this *Parameter Maximum* setting. However, the raw analog input value displays the actual voltage or current measured at the analog input as long as it is within the voltage or current range detected by the input circuit.

8. Min Input Current (mA) - This setting defines the minimum input current level expected for the input. When the input current falls below this level, the out-of-range condition is annunciated if it is configured as alarm or pre-alarm. If the *Input Type* is set for *Voltage,* this setting is disabled.
9. Max Input Current (mA) - This setting defines the maximum input current level expected for the input. When the input current rises above this level, the out-of-range condition is annunciated if it is configured as alarm or pre-alarm. If the *Input Type* is set for *Voltage*, this setting is disabled.
10. Min Input Voltage (V) - This setting defines the minimum input voltage level expected for the input. When the input falls below this level, the out-of-range condition is annunciated if it is configured as alarm or pre-alarm. If the *Input Type* is set for *Current*, this setting is disabled.
11. Max Input Voltage (V) - This setting defines the maximum input voltage level expected for the input. When the input rises above this level, the out-of-range condition is annunciated if it is configured as alarm or pre-alarm. If the *Input Type* is set for *Current*, this setting is disabled.

Four thresholds can be set for each analog input. There can be two “over” thresholds and two “under” thresholds. Each analog input can be configured as an *Alarm, Pre-Alarm,* or *as Status Only*. If any type other than *None* is selected, the threshold status is available to BESTlogic*Plus* Programmable Logic. This allows the user to set up an over and under pre-alarm threshold, and over and under alarm threshold.

An *Activation Delay* can be set for the thresholds. Over Threshold 1 and Under Threshold 1 share a common activation delay. Similarly, Over Threshold 2 and Under Threshold 2 share a second activation delay. See Figure 7-26.

12. Threshold 1
    a. Under Threshold - This parameter defines when Status, Alarm, or Pre-Alarm is annunciated.
    b. Under Threshold Alarm Configuration - Select *None* to disable, *Status Only* to make the threshold status available to BESTlogic*Plus* Programmable Logic, *Pre-Alarm* to annunciate a pre-alarm, or *Alarm* to annunciate an alarm.
    c. Over Threshold - This parameter defines when Status, Alarm, or Pre-Alarm is annunciated.
    d. Over Threshold Alarm Configuration - Select *None* to disable, *Status Only* to make the threshold status available to BESTlogic*Plus* Programmable Logic, *Pre-Alarm* to annunciate a pre-alarm, or *Alarm* to annunciate an alarm.
    e. Activation Delay(s) - This setting defines how long a Threshold 1 condition must be true before an alarm or pre-alarm is annunciated. This time is shared by both Over Threshold 1 and Under Threshold 1 detection.
13. Threshold 2
    f. Under Threshold - This parameter defines when Status, Alarm, or Pre-Alarm is annunciated.
    g. Under Threshold Alarm Configuration - Select *None* to disable, *Status Only* to make the threshold status available to BESTlogic*Plus* Programmable Logic, *Pre-Alarm* to annunciate a pre-alarm, or *Alarm* to annunciate an alarm.
    h. Over Threshold - This parameter defines when Status, Alarm, or Pre-Alarm annunciation is desired.
    i. Over Threshold Alarm Configuration - Select *None* to disable, *Status Only* to make the threshold status available to BESTlogic*Plus* Programmable Logic, *Pre-Alarm* to annunciate a pre-alarm, or *Alarm* to annunciate an alarm.
    j. Activation Delay(s) - This setting defines the duration that a Threshold 2 condition must be true before an alarm or pre-alarm is annunciated. This setting is shared by both Over Threshold 2 and Under Threshold 2 detection.

Configuring Remote RTD Inputs on the AEM-2020
Front Panel Navigation Path: SETTINGS > PROGRAMMABLE INPUTS > THERMAL INPUTS > RTD IN 1 to 8

Many of the settings for the Remote RTD Inputs are similar to the settings for Remote Analog Inputs. See Figure 7-27.

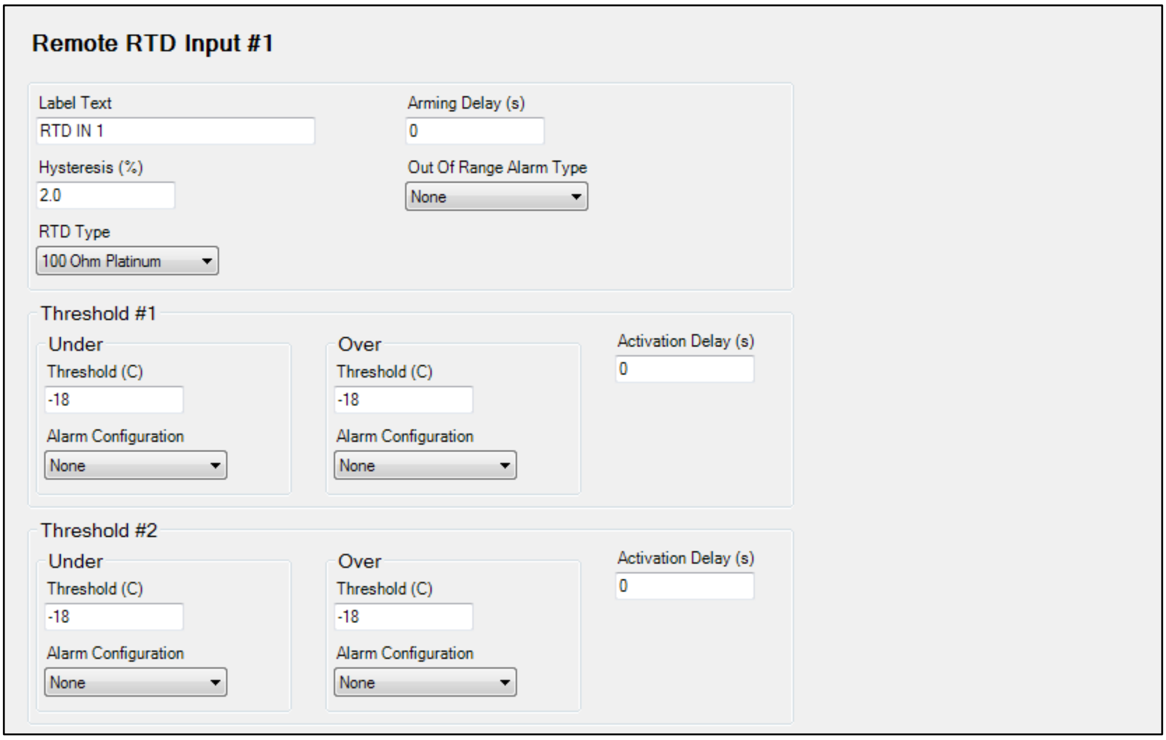

Figure 7-27. Settings Explorer, Programmable Inputs, Remote RTD Inputs Screen

Configure the following parameters:

1. Label Text - Enter descriptive text that signifies the use of the input. This text appears next to the threshold status and associated alarm and pre-alarm status in BESTlogic*Plus* Programmable Logic and in the event log if any of the input thresholds are configured as an *Alarm* or *Pre-Alarm*.
2. Hysteresis (%) - Enter a value for the desired hysteresis for threshold detection. This will help prevent intermittent detection of thresholds.
3. RTD Type - Select *100 Ohm Platinum* or *10 Ohm Copper* to match the RTD that is driving the input.
4. Arming Delay - The *Arming Delay* is the wait time after engine startup, before input monitoring begins. Set the arming delay to zero if constant monitoring desired, even when the engine is not running. Non-zero values direct the input to be monitored after the programmed time has elapsed after engine startup.
5. Out-of-Range Alarm Type - An out-of-range condition occurs when the MGC-2000 Series detects that the input is outside of the normal range of what is detected for the RTD type. Primarily this provides indication of an open or shorted RTD circuit. If *Alarm* or *Pre-Alarm* is selected, annunciation will occur. If *Status Only* is selected, the status is available to BESTlogic*Plus* Programmable Logic but annunciation will not occur.
6. Threshold 1 and Threshold 2 - These settings are identical to those for the Remote Analog Inputs. Refer to the setup instructions in the paragraphs titled *Configuring Remote Analog Inputs on the AEM-2020* to configure these thresholds.

Configuring Remote Thermocouple Inputs on the AEM-2020

Many settings for the Remote Thermocouple Inputs are similar to the settings for Remote Analog Inputs. See Figure 7-28.

Front Panel Navigation Path: SETTINGS > PROGRAMMABLE INPUTS > THERMAL INPUTS > THRM CPL 1 and 2

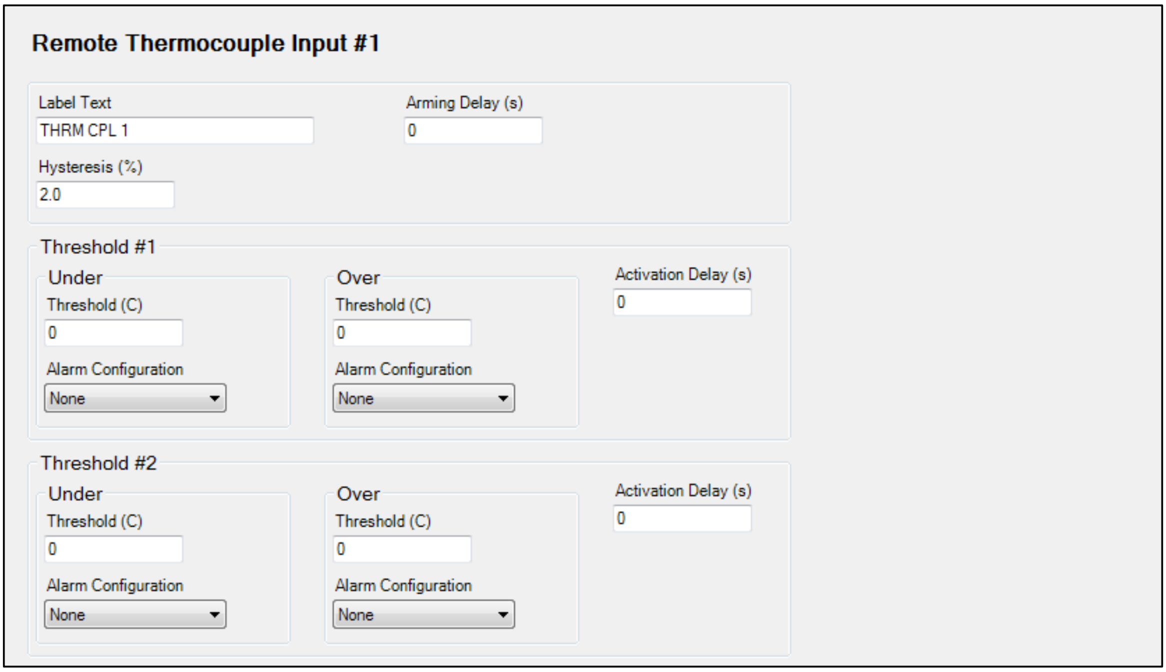

Figure 7-28. Settings Explorer, Programmable Inputs, Remote Thermocouple Inputs Screen

Configure the following parameters:

1. Label Text - Enter descriptive text that signifies the use of the input. This text appears next to the input status and associated alarm and pre-alarm status in BESTlogic*Plus* Programmable Logic and in the event log when the input thresholds are configured as an *Alarm* or *Pre-Alarm*.
2. Hysteresis (%) - Enter a value for the desired hysteresis for threshold detection. Hysteresis helps prevent intermittent detection of thresholds.
3. Arming Delay - The arming delay is the wait time after engine startup, before input monitoring begins. Set the arming delay to zero if constant monitoring is desired, even when the engine is not running. Non-zero values cause input monitoring after the programmed time has elapsed after engine startup.
4. Threshold 1 and Threshold 2 - These settings are identical to those for Remote Analog Inputs. Refer to the setup instructions in the paragraphs titled Configuring *Remote Analog Inputs on the AEM-2020* to configure these thresholds.

Programmable Outputs

The programmable outputs consist of:

- Contact outputs internal to the MGC-2000 Series
  - Programmable contact outputs
  - Run relay, Pre-Start relay, and Start relay outputs
- Remote contact outputs on the CEM-2020
- Remote analog outputs on the AEM-2020
- Configurable elements in the MGC-2000 Series. Configurable elements allow one to take an output from BESTlogic*Plus* Programmable Logic and set it up as a pre-alarm or alarm condition, as well as an input for subsequent logic in the PLC program.

Configuring Contact Outputs on the MGC-2000 Series

Programmable Contact Outputs (See Figure 7-29)
Front Panel Navigation Path: SETTINGS > PROGRAMMABLE OUTPUTS > OUTPUTS

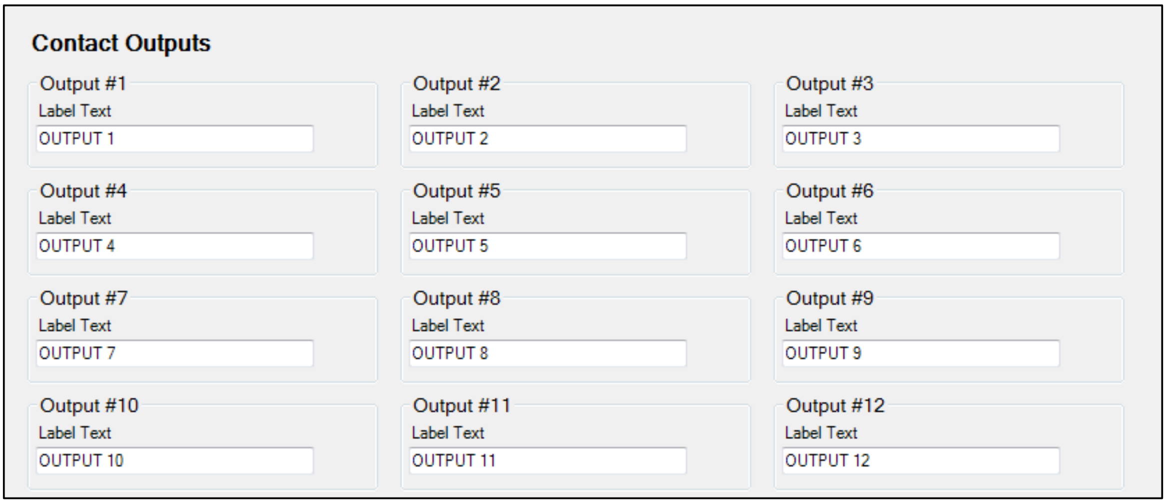

Figure 7-29. Settings Explorer, Programmable Outputs, Contact Outputs Screen

Each output can be programmed with a text label describing its use; this label appears in BESTlogic*Plus* Programmable Logic where the output is used to aid in program clarity and ease of programming.

Run Relay, Pre-Start Relay, and Start Relay
Front Panel Navigation Path: SETTINGS > SYSTEM PARAMS > RELAY CONTROL

In some systems, it may be beneficial to modify the standard functionality implemented by the MGC-2000 Series for the Run, Pre-Start, or Start relays. If your generator does not require a pre-start function, it may be desired to use the 30A relay assigned to it for other purposes. These relays can be configured in one of two ways. The first is to operate under their predefined functionality, making them a dedicated output. The second way is to select them to be programmable, in which case they become available to BESTlogic*Plus* Programmable Logic to be used in the same manner as the programmable relay outputs.

Figure 7-30 shows the *Relay Control* screen used to set the operation of these relays to predefined or programmable operation.

Figure 7-30. Settings Explorer, System Parameters, Relay Control Screen

For each relay (Start, Run, and Pre-Start), select whether it should use its predefined functionality or be made programmable.

When *Programmable* is selected for a relay, it becomes available to BESTlogic*Plus* Programmable Logic as a logic element. The elements are titled *Start Output, PreStart Out,* and *Run Output*. The predefined functionality is available as an input to the logic. If *Programmable* is selected as the relay control mode, connect the corresponding predefined input function to the relay and it functions as if *Predefined* were selected as its relay control type. However, other logic can be combined with it to create operation that is more versatile. If *Programmable* is selected for a relay, but it is not used in the logic, that relay will never close.

A logic example connecting the predefined inputs directly to the "programmable" relay outputs for all three relays is shown in Figure 7-31.

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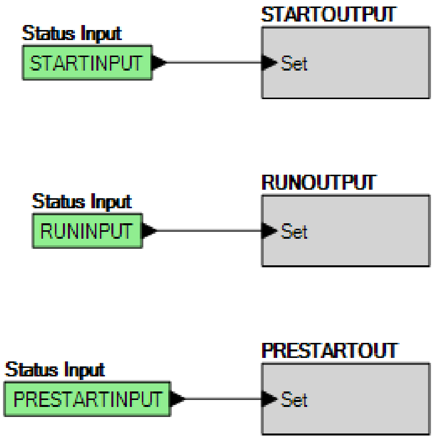

Figure 7-31. Logic Example of Programmable Relays

Setting Up Configurable Elements in the MGC-2000 Series.

Configurable elements are used with BESTlogic*Plus* Programmable Logic to allow a user to implement logic that causes an alarm or pre-alarm. This can be used to build protection that is not part of the standard protection in the MGC-2000 Series. See Figure 7-32.

Front Panel Navigation Path: SETTINGS > PROGRAMMABLE OUTPUTS > CONFIG ELEMENTS

The parameters for configurable elements are similar to those for programmable inputs. Set the following parameters for each configurable element:

1. Alarm Configuration - Select *None, Alarm,* or *Pre-Alarm*. When an alarm occurs, the horn annunciates with a constant high-pitched sound and the engine stops. When a pre-alarm occurs, the horn annunciates with an alternating on and off beep and the engine remains running. If *None* is selected, the element is status only. The status is available as an input to BESTlogic*Plus* Programmable Logic regardless of the setting of the *Alarm Configuration.*
2. Activation Delay - This setting defines the duration that the configurable element is true before alarm or pre-alarm annunciation.
3. Label Text - Enter descriptive text describing how the configurable element is used. This text appears next to the configurable element status in BESTlogic*Plus* Programmable Logic and in the event log if the *Alarm Configuration* is set as an *Alarm* or *Pre-Alarm*.
4. Contact Recognition - Select whether the configurable element is recognized always or only while the engine is running. A selection of *While Engine Running Only* prevents spurious annunciation when the engine is stopped.

For example, if the door of the generator room is opened a pre-alarm should occur to alert the control room that someone is in the generator room. In addition, suppose for safety reasons, any running machines should be stopped any time someone enters the generator room. Assume Input 5 is set up to indicate “DOOR OPEN” and it is configured as a *Pre-Alarm*. In BESTlogic*Plus* Programmable Logic, Input 5 could be ANDed with ENGINE RUNNING to drive Configurable Element 1, which is configured as an alarm. The logic diagram is shown in Figure 7-33.

Input 5, configured as a *Pre-Alarm*, triggers a pre-alarm if the door is opened whether the engine is running or stopped. Configurable Element 1, configured as an *Alarm*, triggers an alarm if the door is opened while the engine is running.

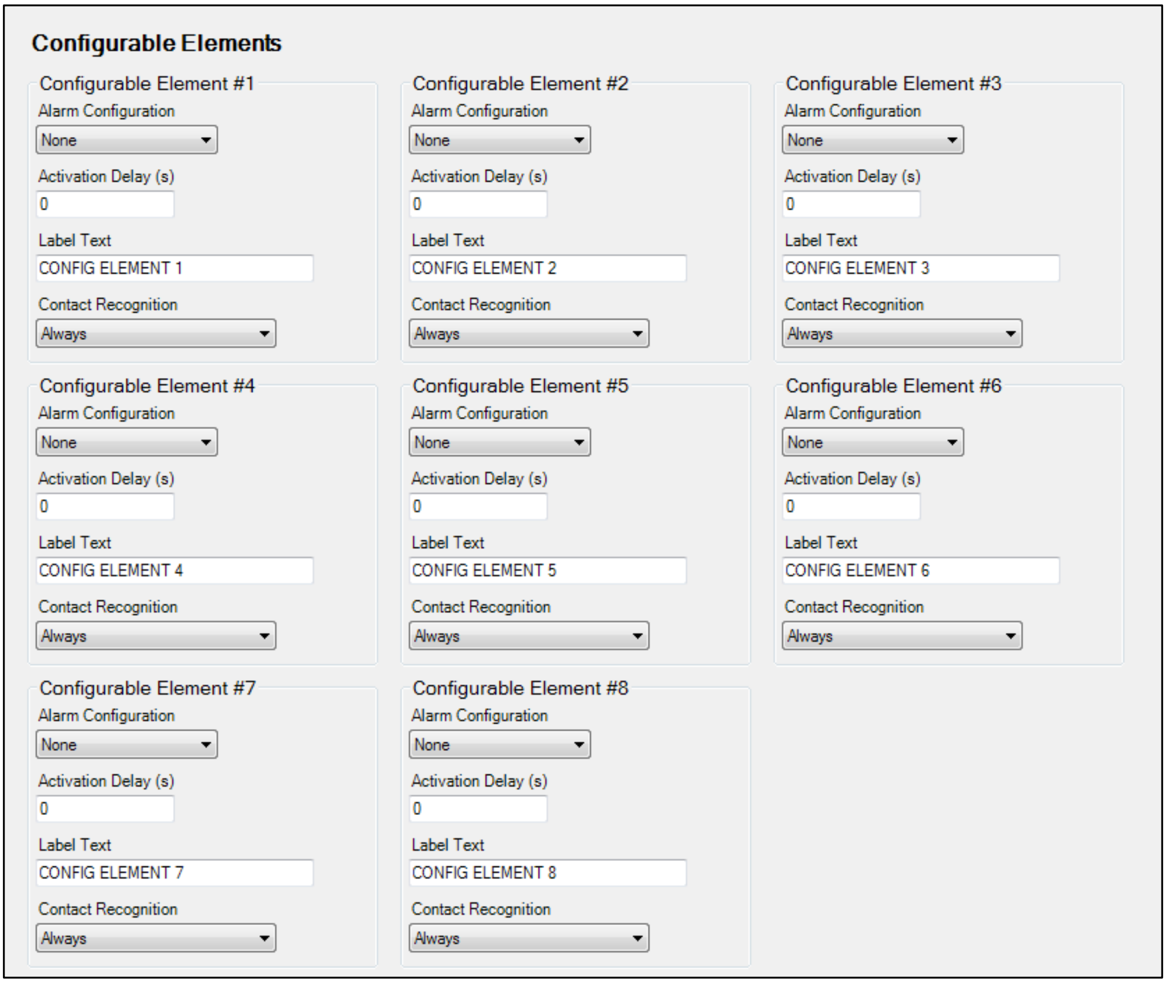

Figure 7-32. Settings Explorer, Programmable Outputs, Configurable Elements Screen

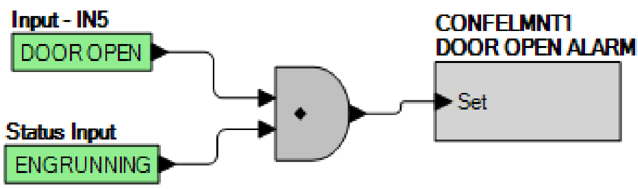

Figure 7-33. Using a Configurable Element Logic Diagram

Configuring Remote Contact Outputs on the CEM-2020 (See Figure 7-34)

Front Panel Navigation Path: SETTINGS > PROGRAMMABLE OUTPUTS > OUTPUTS

Each output can be programmed with a text label describing its use; this label appears in BESTlogic*Plus* Programmable Logic where the output is used to aid in program clarity and ease of programming.

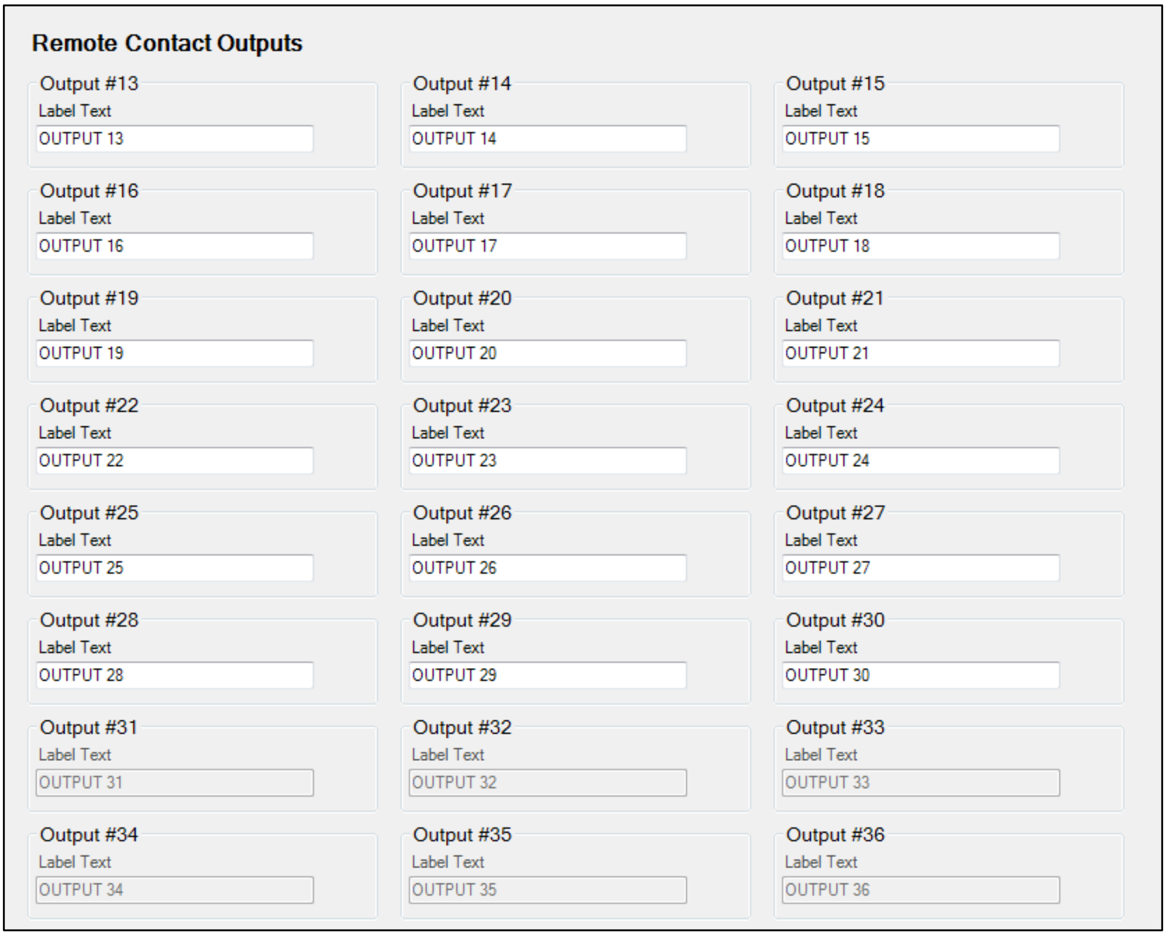

Figure 7-34. Settings Explorer, Programmable Outputs, Remote Contact Outputs Screen

Configuring Remote Analog Outputs on the AEM-2020

Front Panel Navigation Path: SETTINGS > PROGRAMMABLE OUTPUTS > ANALOG OUTPUTS

There are four remote analog outputs, each configured on its own screen in BESTCOMS*Plus*®. Parameters metered by the MGC-2000 Series are mapped to these outputs, enabling them to be used as meter drivers or they can drive analog inputs of external equipment. Ranges for the metered parameter and the analog output are set up so that when the metered parameter is at the minimum of the parameter range, the analog output is at the minimum of its output range. Similarly, when the metered parameter is at the maximum of the parameter range, the analog output is at the maximum of its output range. The parameters for Remote Analog Output 1 are shown in Figure 7-35.

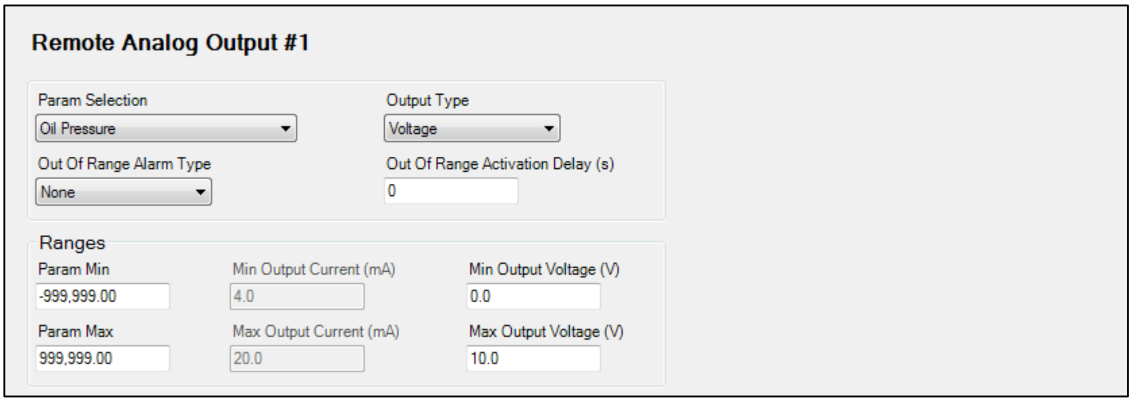

Figure 7-35. Settings Explorer, Programmable Outputs, Remote Analog Outputs Screen

Configure the following parameters:

1. Parameter Selection - This setting defines the metered parameter within the MGC-2000 Series (e.g. oil pressure, coolant temperature, etc.) that is assigned to drive the analog output. The parameter range and the output range are configured so that the range of the metered parameter is scaled to the range of the analog output. Thus, when the metered parameter is at the minimum of the parameter range, the analog output is at the minimum of its output range. Similarly, when the metered parameter is at the maximum of the parameter range, the analog output is at the maximum of its output range.
2. Output Type - Select *Voltage* or *Current* as the analog output type.
3. Out-of-Range Alarm Type - Select to annunciate an alarm or pre-alarm if the metered parameter is outside of the range assigned by the parameter minimum and parameter maximum settings.
4. Out-of-Range Alarm Activation Delay - This setting defines the time delay for which an out-of-range condition must be true before annunciating an *Alarm* or *Pre-Alarm*.
5. Parameter Minimum - This setting defines the minimum value that occurs on the parameter being metered.
6. Parameter Maximum - This setting defines the maximum value that occurs on the parameter being metered.
7. Min Output Current (mA) - If *Analog Output Type* is configured as *Current*, enter the output current level to be sourced when the metered parameter is at its minimum level. This setting is disabled when the output type is set to *Voltage*.
8. Max Output Current (mA) - If the *Analog Output Type* is configured as *Current,* enter the output current level to be sourced when the metered parameter is at its maximum level. This setting is disabled when the output type is set to *Voltage*.
9. Min Output Voltage (V) - If the *Analog Output Type* is configured as *Voltage*, enter the output voltage to be sourced when the metered parameter is at its minimum level. This setting is disabled when the output type is set to *Current*.
10. Max Output Voltage (V) - If the *Analog Output Type* is configured as *Voltage*, enter the output voltage level to be sourced when the metered parameter is at its maximum level. This setting is disabled when the output type is set to *Current*.

Generator and Bus Breaker Control

The MGC-2000 Series has the ability to automatically control the generator breaker. Users have the ability to control the breaker through physical inputs by using BESTlogic*Plus* programmable logic. Physical inputs can also be configured through logic to implement open and close commands for the generator breaker.

The MGC-2000 Series can automatically control the generator breaker under the following conditions.

- The unit is in AUTO and one of the following is true:
    1. The RUN WITH LOAD logic element is implemented in the logic and it is true.
    2. A Run session has been initiated by the exercise timer and the *Run With Load* check box in the generator exercise timer parameters is checked.
    3. Mains Fail Transfer is enabled and utility power has failed.

  The mains fail transfer is discussed in detail under *Mains Fail Transfer.*
- When the MGC-2000 Series controls a breaker, the following criteria must be satisfied for the generator breaker to change state:
    1. A breaker cannot be closed unless generator voltage is stable and bus voltage is stable or dead. A breaker will not close to a dead bus unless the *Dead Bus Close Enable* parameter found in BESTCOMS*Plus*® under SETTINGS EXPLORER→ BREAKER MANAGEMENT→ BREAKER HARDWARE is enabled.

       Front Panel Navigation Path: SETTINGS > BREAKER MANAGEMENT > BREAKER HARDWARE > GEN BREAKER
    2. A breaker will not change state if it receives conflicting commands. In other words, if an input is indicating an open command at the same time another input is indicating a close command, the breaker will not change state.

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Breaker status for a breaker is communicated to the MGC-2000 Series by having only the breaker element (either gen breaker or mains breaker) in the logic diagram and a physical input (contact from the breaker indicating breaker status) must be connected to the *Status* input of the breaker block.

Steps Required to Configure an MGC-2000 Series for Generator Breaker Control

1. Connect the MGC-2000 Series according to the appropriate figure in Section 6, *Installation* under *Connections* for the type of generator connection desired (WYE, DELTA, etc.).
2. Set up the basic system parameters that will govern engine operation and alarm and pre-alarm annunciation. Details can be found in the paragraphs titled *MGC-2000 Series Initial Setup*. Additional details of individual settings can be found in Section 4, *BESTCOMSPlus® Software*.
3. Configure the generator breaker parameters under SETTINGS EXPLORER > BREAKER MANAGEMENT > BREAKER HARDWARE. See Figure 7-36.

   Front Panel Navigation Path: SETTINGS > BREAKER MANAGEMENT > BREAKER HARDWARE > GEN BREAKER

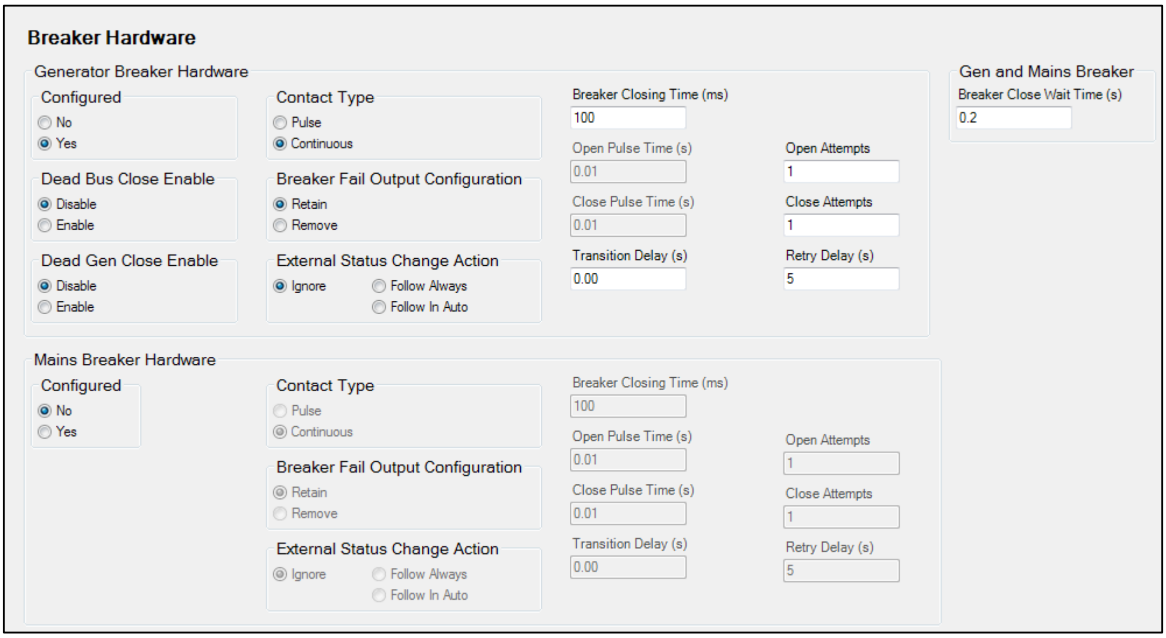

Figure 7-36. Settings Explorer, Breaker Management, Breaker Hardware Screen

   a. Breaker Close Wait Time. This is a time interval in which it is expected that the breaker will transition from open to closed or closed to open. If it does not change state within that time, either a Gen Breaker Close Fail or Gen Breaker Open Fail will be annunciated for generator breaker failures, and/or Mains Breaker Close Fail or Mains Breaker Open Fail will be annunciated for mains breaker failures.
   b. Generator Breaker.
      i. Enable Dead Bus Close if it is desired to close to a dead bus.
      ii. Set the contact type and pulse times if pulsed contacts are used.
      iii. Set the breaker close time. This is the time used by the anticipatory synchronizer to calculate the advance angle before 0 degrees slip angle that a breaker close command will be issued.
   c. Mains Breaker.
   d. Set the Mains Breaker as *Configured* if it is used, otherwise do not configure these settings.
      i. If the mains breaker is configured, set the contact type and pulse times if pulsed contacts are used.

ii. If the mains breaker is configured, set the breaker close time. This is the time used by the anticipatory synchronizer to calculate the advance angle at which a breaker close command will be issued.

4. Set up the Gen Breaker in BESTlogic*Plus* Programmable Logic under SETTINGS EXPLORER > BESTlogic*Plus* PROGRAMMABLE LOGIC. See Figure 7-37.

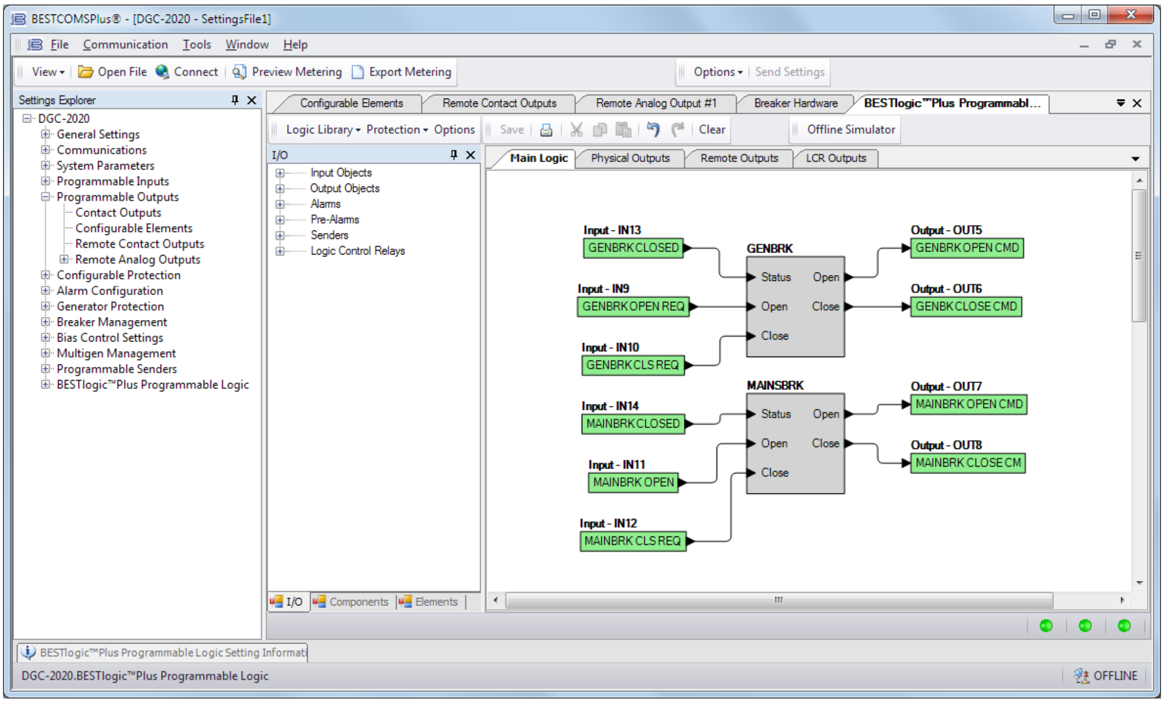

Figure 7-37. Settings Explorer, BESTlogicPlus Programmable Logic Settings

a. Generator Breaker

i. Drag the Gen Breaker element into the logic diagram.

ii. Connect the breaker element open and close output to the contact outputs that will drive the breaker.

iii. Connect the physical input or remote input that has the breaker status (closed if breaker is closed, open when breaker is open) to the *Status* input of the breaker element. This is the only way to indicate breaker status to the MGC-2000 Series.

iv. If it is desired to have physical inputs that can request breaker open and close commands, connect the desired inputs to the open and close command inputs of the breaker element. These inputs should be pulsed. If they both close at the same time, the breaker will not change state. If it is not desired to have inputs for breaker commands, connect a “Logic 0” input object to the open and close command inputs of the breaker block.

b. Mains Breaker (if configured)

i. Drag the Mains Breaker element into the logic diagram.

ii. Connect the breaker element open and close outputs to the contact outputs that will drive the breaker.

iii. Connect the physical input or remote input that has the breaker status (closed if breaker is closed, open when breaker is open) to the *Status* input of the breaker element. This is the only way to indicate breaker status to the MGC-2000 Series.

iv. If it is desired to have physical inputs that can request breaker open and close commands, connect the desired inputs to the open and close command inputs of the breaker element. Note these are to be pulsed inputs; if they are both closed at the same time, the breaker will not change state. If it is not desired to have inputs for

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breaker commands, connect a “Logic 0” input object to the open and close command inputs of the breaker block.

c. Click the *Save* button when the logic is complete.

d. From the *Communication* pull-down menu, select *Upload Logic* to load the logic into the MGC-2000 Series if you are connected to it, or save the settings file if you are working off line.

5. Set the parameters for detecting stable and failed bus and generator under SETTINGS EXPLORER > BREAKER MANAGEMENT > BUS CONDITION DETECTION.

Front Panel Navigation Path: SETTINGS > BREAKER MANAGEMENT > BUS CONDITION DETECT

a. Generator Sensing. See Figure 7-38.

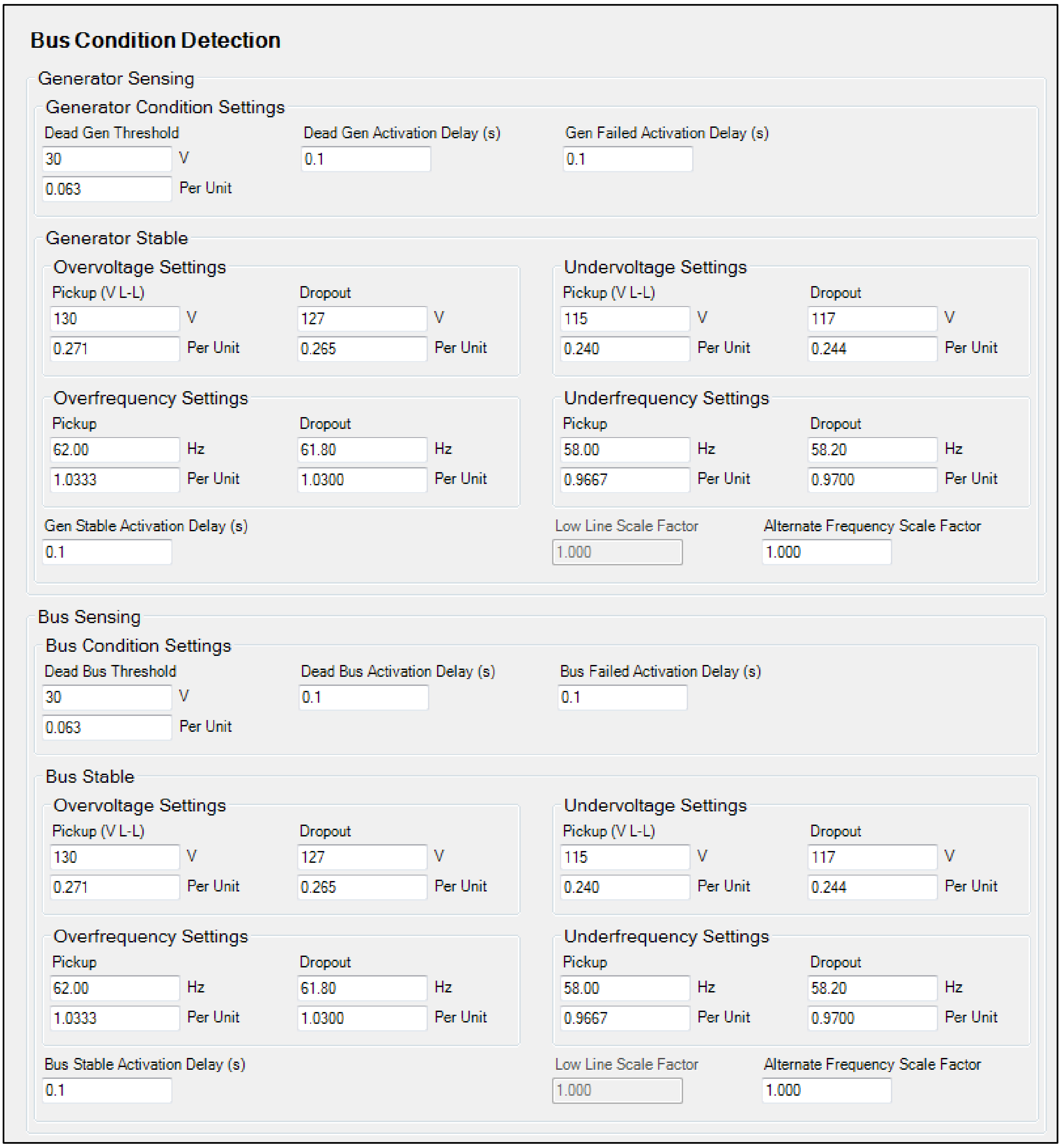

Figure 7-38. Settings Explorer, Breaker Management, Bus Condition Detection

i. Dead Bus Voltage Threshold and Activation Delay. When the voltage of the generator is below this threshold for the duration equal to the activation delay, the generator is deemed “Dead”.

ii. Gen Stable Over and Under Voltage thresholds and Over and Under Frequency thresholds and the Bus Stable and Bus Failed Activation Delay times. When the generator voltage and frequencies are within the specified ranges for the duration equal to the *Bus Stable Activation Delay*, the generator is deemed “Stable”. Otherwise, it is deemed “Failed”.

b. Bus Sensing. See Figure 7-38.

i. Dead Bus Voltage Threshold and Activation Delay. When the voltage of the bus is below this threshold for the duration equal to the activation delay, the bus is deemed “Dead”.

ii. Bus Stable Over and Under Voltage thresholds and Over and Under Frequency thresholds and the Bus Stable and Bus Failed Activation Delay times. When the bus voltage and frequencies are within the specified ranges for the duration equal to the *Bus Stable Activation Delay*, the bus is deemed “Stable”. Otherwise, it is deemed “Failed”.

CAUTION

The bus condition parameters are critical because they determine when a breaker can be closed. The generator breaker can be closed when any one of the following is true:

- The generator is stable and both breakers are open
- The generator is stable and the bus is stable
- The generator is stable, the bus is dead, and the dead bus close enable setting is set to enabled
- The generator is dead, the dead gen close enable setting is set to enabled, the bus is dead, and the dead bus close enable setting is set to enabled

The mains breaker can be closed only when the generator is stable and both breakers are open, or the generator is stable and the bus is stable.

6. Place the unit in AUTO. The unit is now configured for generator breaker control. It can be tested by driving the RUN WITH LOAD logic element true, or setting up the exercise timer for a loaded test, or by starting the unit in RUN or AUTO mode and giving it CLOSE and OPEN commands from the physical inputs if they are available for breaker control.

Synchronizer

Some applications require a generator set that is paralleled with other generators or a utility bus. In order to parallel the generator, the speed and the voltage of the generator must be properly matched to the source that the generator is being paralleled to. This is done by properly adjusting the generator’s speed control governor and automatic voltage regulator. Synchronization can be achieved manually by an operator or by the use of an automatic synchronizer.

The MGC-2000 Series digital genset controller has an integrated automatic synchronizer as an option to perform synchronization. The controller monitors the voltages, frequencies, and phase relationships of both the generator and the bus. It then sends a signal to the governor to increase or decrease the speed of the engine to match the frequency and match the generator phase angle to the bus phase angle. It will also send a signal to the voltage regulator to match the voltage levels. Once all of these conditions are met, the controller will send a breaker close signal to the generator circuit breaker.

There are two types of automatic synchronizers available. A phase lock type of automatic synchronizer controls the frequency of the generator and brings it into the predetermined phase angle window. After a time delay expires while in the window, the close signal is given to the generator circuit breaker. The anticipatory style of automatic synchronizer controls the slip frequency between the generator and the bus. The synchronizer calculates the timing of the closing signal to allow the generator breaker to be closed when the phase angle between the two sources is at 0 degrees. This calculation takes into account the slip rate, generator breaker closing time, and the phase angle difference.

In order to minimize the effects of I/O communications delays on synchronization, it is recommended that local I/O on the MGC-2000 Series, rather than remote I/O on the CEM-2020, be used for generator breaker open and close commands, generator breaker status, voltage raise and lower contacts, and speed raise and lower contacts.

Steps Required to Configure an MGC-2000 Series Automatic Synchronizer

The following steps describe how to configure the MGC-2000 Series automatic synchronizer using BESTCOMS*Plus*®:

1. Under the Settings Explorer, click on *General Settings* and then *Style Number*. Verify the unit you are communicating with has the *Automatic Synchronizer* option present. See Figure 7-39.

   Front Panel Navigation Path: SETTINGS > GENERAL SETTINGS > VERSION INFO > DGC-2020 > STYLE CODE

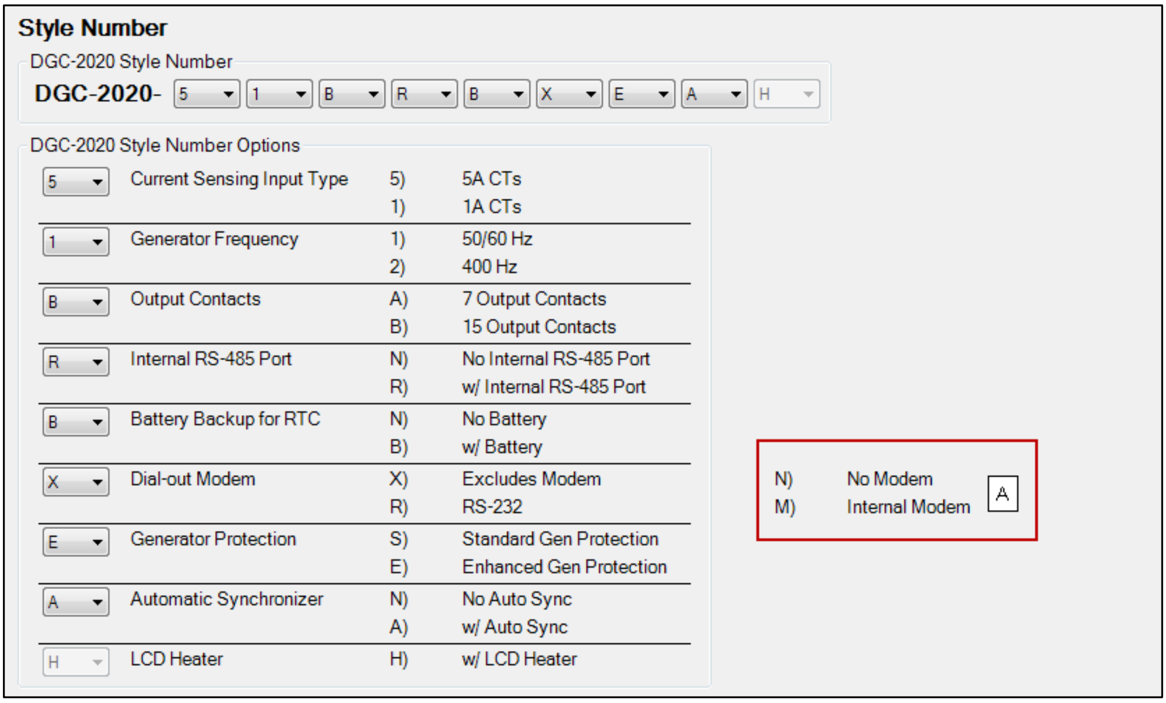

Figure 7-39. Settings Explorer, General Settings, Style Number Screen

[A] *MGC-2000 Series Dial-out modem options for hardware versions 1 and 2.*

2. If using a remote module to control the governor or voltage regulator i.e. LSM-2020 or CEM-2020, click on *System Parameters* then *Remote Module Setup*. Enable the applicable module. This step is not necessary if you are using the available contact outputs for AVR and governor control on the MGC-2000 Series. See Figure 7-40.

   Front Panel Navigation Path: SETTINGS > SYSTEM PARAMS > REMOTE MODULE SETUP

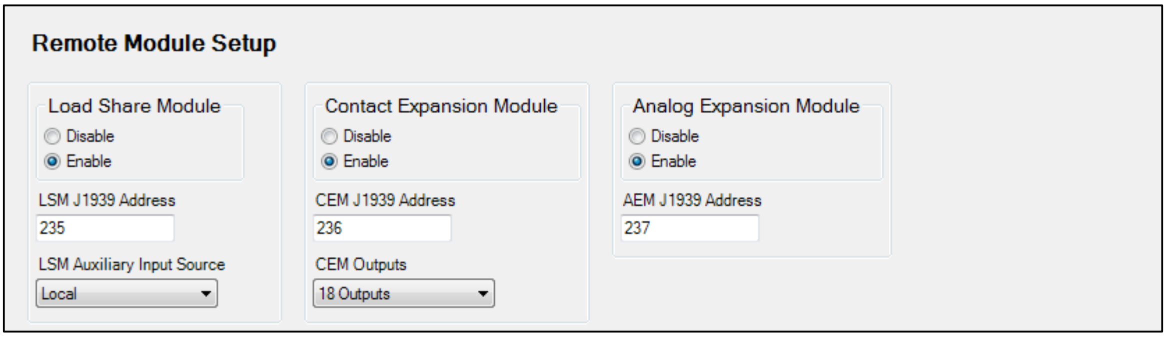

Figure 7-40. Settings Explorer, System Parameters, Remote Module Setup Screen

3. Next, click *Programmable Inputs*, then *Contact Inputs* to label the Breaker Status input (Input 13 is the default). See Figure 7-41.

   Front Panel Navigation Path: SETTINGS > PROGRAMMABLE INPUTS > CONFIGURABLE INPUTS

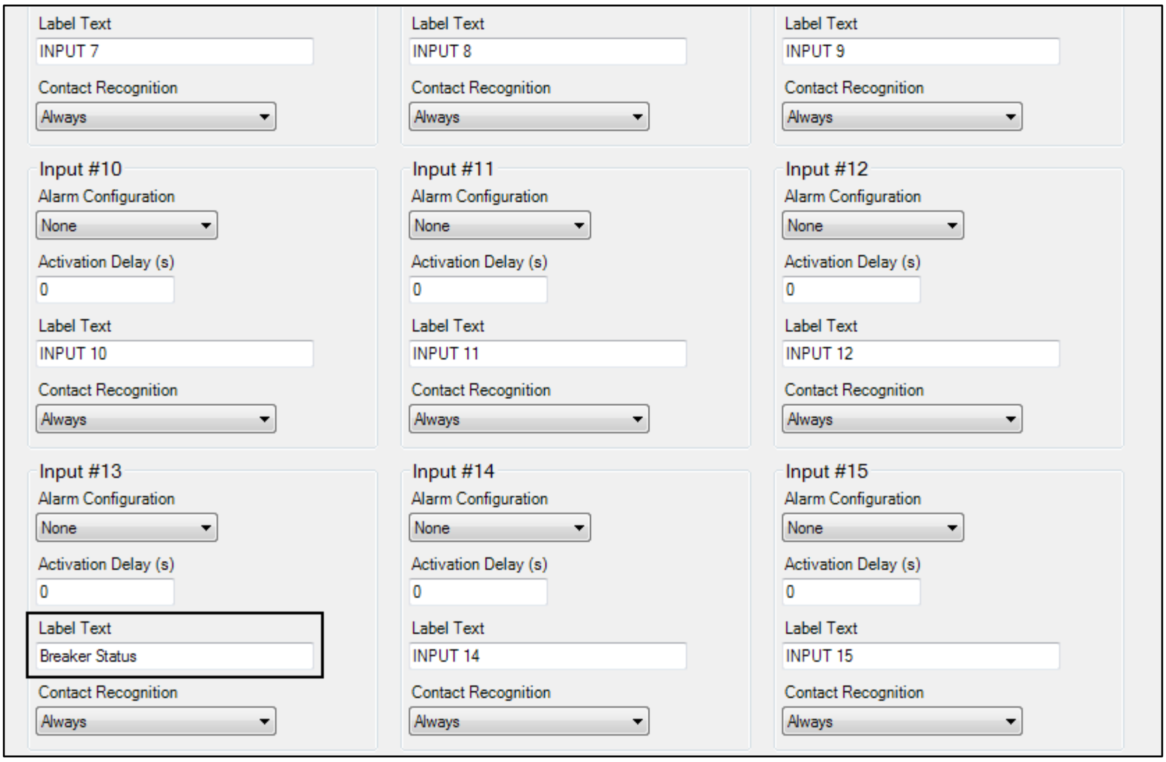

Figure 7-41. Settings Explorer, Programmable Inputs, Contact Inputs Screen

4. Click on *Programmable Outputs* then *Contact Outputs*. Select and label the appropriate outputs for Breaker Close (Output 5 is the default) and Breaker Open (Output 6 is the default). If using contact outputs on the MGC-2000 Series for Governor and Voltage Regulator control, the contact outputs can be labeled here as well. Default logic is Output 9 =GOV Raise, Output 10 = GOV Lower, Output 11 = AVR Raise, and Output 12 = AVR Lower. See Figure 7-42.

   Front Panel Navigation Path: SETTINGS > PROGRAMMABLE OUTPUTS > OUTPUTS

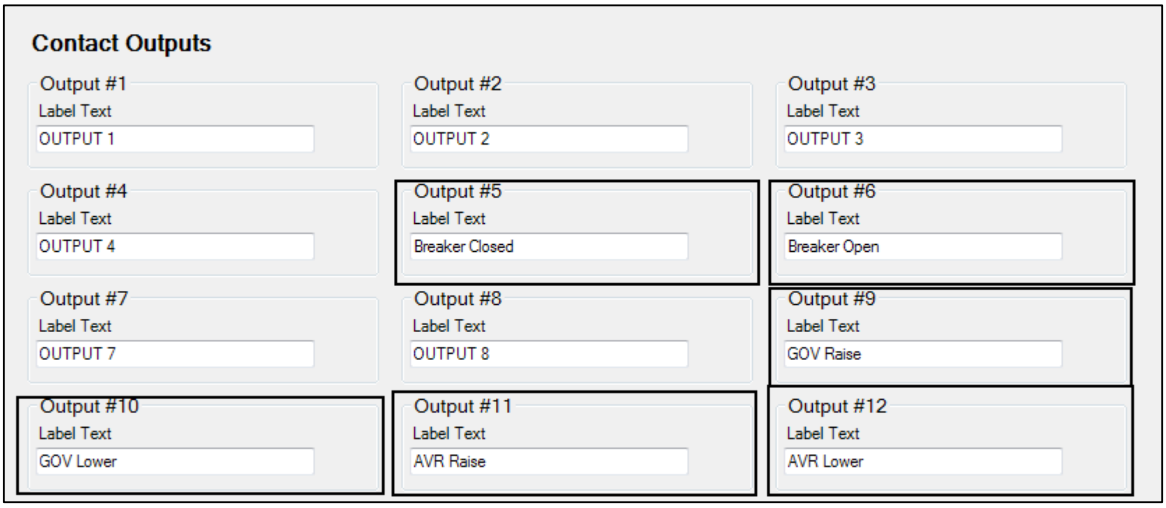

Figure 7-42. Settings Explorer, Programmable Outputs, Contact Outputs Screen

5. Click on *Breaker Management* then *Breaker Hardware*. On this screen, (Figure 7-43), enter the settings for the following parameters:

   Front Panel Navigation Path: SETTINGS > BREAKER MANAGEMENT > BREAKER HARDWARE

   a. Breaker Close Wait Time. This is an interval in which it is expected that the breaker will transition from open to closed or closed to open. If it does not change state within the specified time, either a Gen Breaker Close Fail or Gen Breaker Open Fail is annunciated as generator breaker failures, and/or Mains Breaker Close Fail or Mains Breaker Open Fail is annunciated as mains breaker failures.
   b. Generator Breaker:
      i. Enable the *Dead Bus Close Enable* parameter if it is desired to close to a dead bus.
      ii. Set the contact type and pulse times if pulsed contacts are used.
      iii. Set the breaker close time. This is the time used by the anticipatory synchronizer to calculate the advance angle before 0 degrees slip angle at which to issue the breaker close command.
   c. Mains Breaker (if configured):
      i. Set the mains breaker as configured if used otherwise leave it not configured.
      ii. If the mains breaker is configured, set the contact type and pulse times if pulsed contacts are used.
      iii. If the mains breaker is configured, set the breaker close time. This is the time used by the anticipatory synchronizer to calculate the advance angle before 0 degrees slip angle at which to issue the breaker close command.

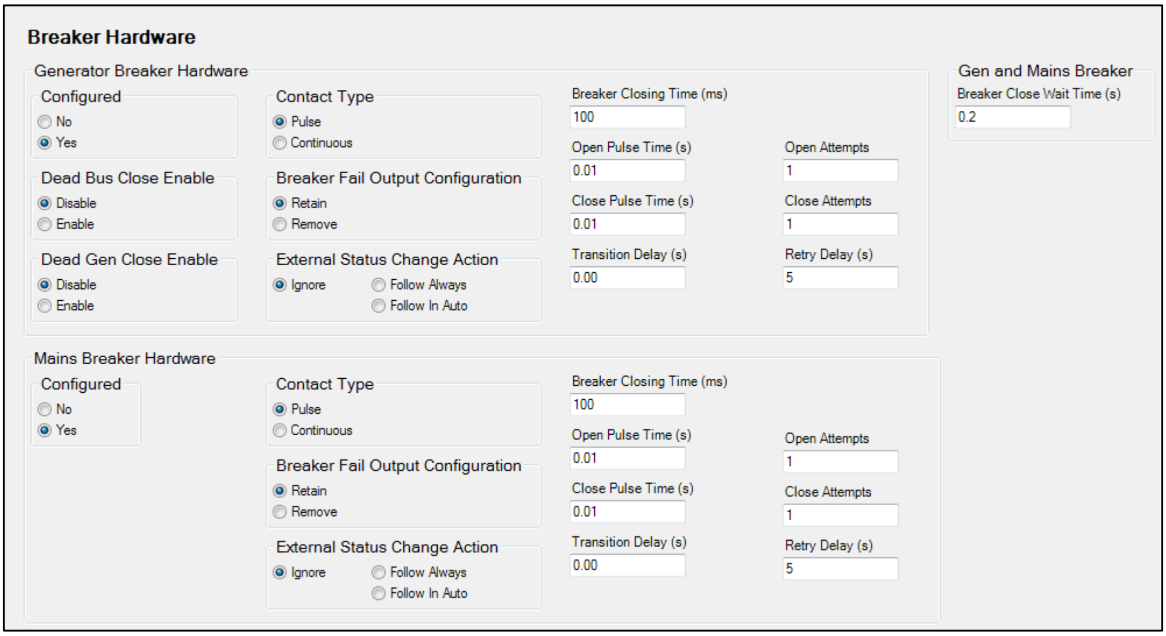

Figure 7-43. Settings Explorer, Breaker Management, Breaker Hardware Screen

6. Click on *Bus Condition Detection* under the *Breaker Management* portion of the Settings Explorer. This is where the parameters are set for detecting stable and failed bus and generator conditions. **The generator and bus condition parameters are critical since a breaker can be closed only when (1) the generator is stable and (2) the bus is either stable or dead**. See Figure 7-44.

   Front Panel Navigation Path: SETTINGS > BREAKER MANAGEMENT > BUS CONDITION DETECT

   a. Dead Bus Voltage Threshold and Activation Delay. When the voltage of either the generator or bus is below this threshold for the duration equal to the activation delay, the generator or bus is deemed "Dead".

   b. Gen Stable Over and Under Voltage Thresholds, and Over and Under Frequency Thresholds, and the Bus Stable and Bus Failed Activation Delay. When the generator voltage and frequencies are within the specified ranges for the duration equal to the Bus Stable Activation Delay, the generator is deemed "Stable". Otherwise it is deemed "Failed".

   c. Bus Stable Over and Under Voltage Thresholds and Over and Under Frequency Thresholds. When the bus input voltage and frequencies are within the specified ranges for the duration equal to the Bus Stable Activation Delay, the bus input is deemed "Stable". Otherwise it is deemed "Failed".

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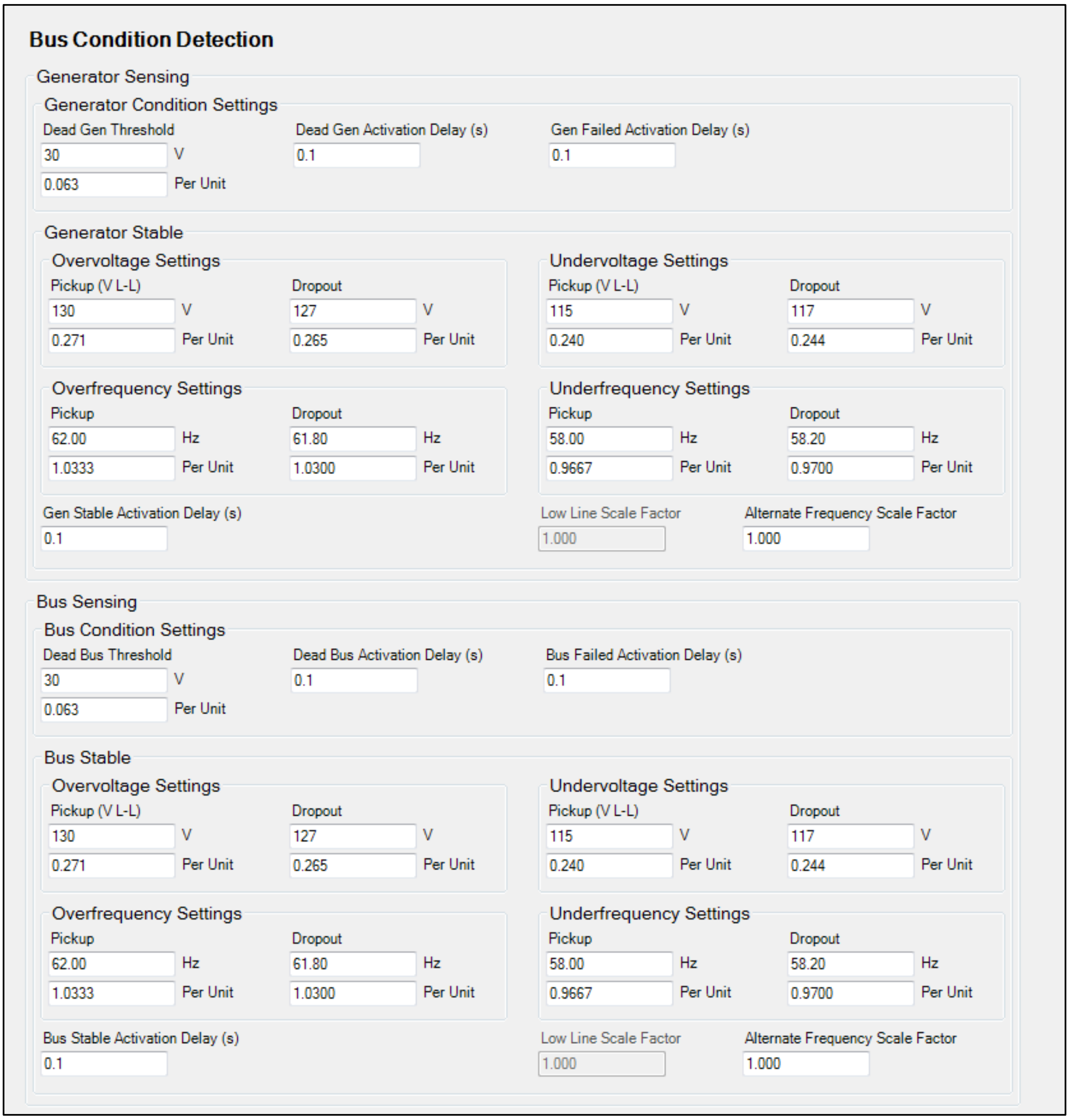

Figure 7-44. Settings Explorer, Breaker Management, Bus Condition Detection Screen

7. Next, click on *Synchronizer* under the *Breaker Management* section of the Settings Explorer. See Figure 7-45.

   Front Panel Navigation Path: SETTINGS > BREAKER MANAGEMENT > SYNCHRONIZER

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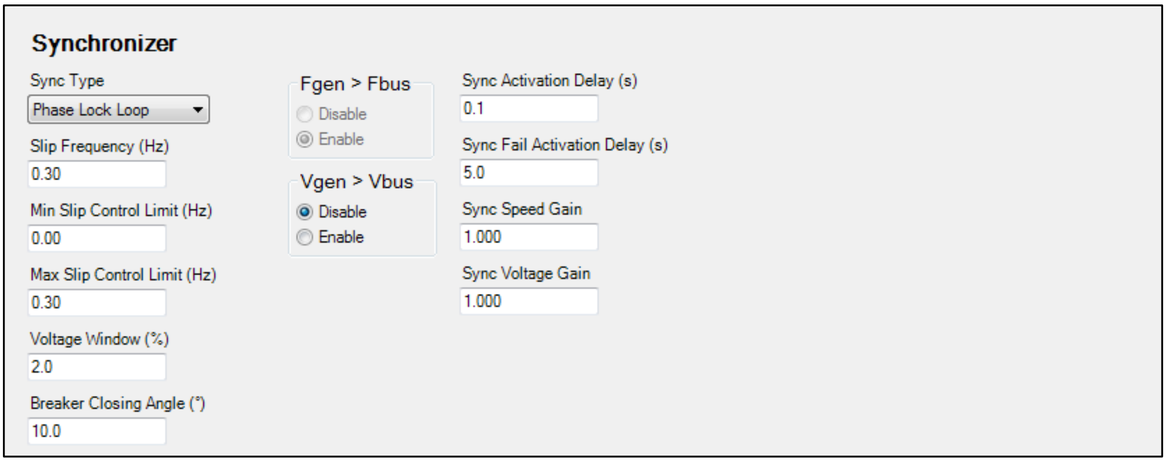

Figure 7-45. Settings Explorer, Breaker Management, Synchronizer Screen

<u>Anticipatory vs. Phase Lock Synchronizer</u>

If *Phase Lock Loop* synchronization is selected, the synchronizer will drive the angle between the generator and bus toward zero, and will drive the voltage between the generator and the bus so that the difference is less than the allowed difference set by the user.

If *Anticipatory* synchronization is selected, the synchronizer controls the slip frequency between the generator and the bus. The synchronizer calculates the timing of the closing signal that allows the generator breaker to be closed when the phase angle between the two sources is at 0 degrees. This calculation takes into account the slip rate, the generator breaker closing time, and the phase angle difference.

For either synchronizer type, you will need to enter settings for the following parameters:

a. Sync Type -Select either *Anticipatory* or *Phase Lock Loop* as the synchronizer type.

b. Slip Frequency - The slip frequency setting is the maximum slip frequency that is in effect for a breaker close to occur.

c. Voltage Window - The regulation offset is the maximum allowed percentage voltage difference between the generator and the bus that is in effect for a breaker close to occur. This is sometimes referred to as “voltage window”.

d. Min/Max Slip Control Limit - (Phase lock synchronizer only.) These settings provide continuous slip frequency control while in phase lock synchronization.

e. Breaker Close Angle - (Phase lock synchronizer only.) The breaker close angle is the maximum phase angle from the 0-degree phase angle that is in effect for a breaker close to occur. This is sometimes referred to as the “angle window” or “phase window”.

f. Sync Activation Delay - The Sync Activation Delay is the length of time that the conditions for synchronization must be met. Generator voltage and bus voltage must be within the acceptable range for the duration of the sync activation delay. Additionally, the following condition must be met when in Phase Lock mode. Generator and bus phase angles must be within the acceptable breaker closing angle range for the duration of the sync activation delay.

g. Sync Fail Delay - The sync fail delay is the maximum time allowed for synchronization to occur. If the sync fail delay expires before the breaker closure occurs, a Sync Fail pre-alarm is annunciated, and the synchronizer is reset. The synchronization attempt is aborted if the sync fail delay expires. This is set to allow ample time for synchronization and breaker closure to occur.

h. Gen Frequency > Bus Frequency - Enable gen frequency > bus frequency if desired. Enabling gen frequency > bus frequency will force kW to be pushed out of the generator when the breaker is closed.

i. Gen Voltage > Bus Voltage - Enable gen voltage > bus voltage if desired. Enabling gen voltage > bus voltage will ensure vars flow out of the generator when the breaker is closed.

8. Click on *Bias Control Settings* then *AVR Bias Control Settings* in the Settings Explorer. If using the MGC-2000 Series only, select *Contact* as the bias control output type. Then select either *Continuous* or *Proportional* as the bias control output type.

   If using the MGC-2000 Series in conjunction with an LSM-2020, you may choose to select *Analog* as the bias control output type. If this is chosen, you will also be required to enter gains and loop gains of the voltage PID controller. These settings may have to be adjusted to achieve the desired response from the voltage regulator. Controller tuning procedures may be found in Appendix C, *Tuning PID Settings*. See Figure 7-46.

   Front Panel Navigation Path: SETTINGS > BIAS CONTROL > AVR BIAS CONTROL

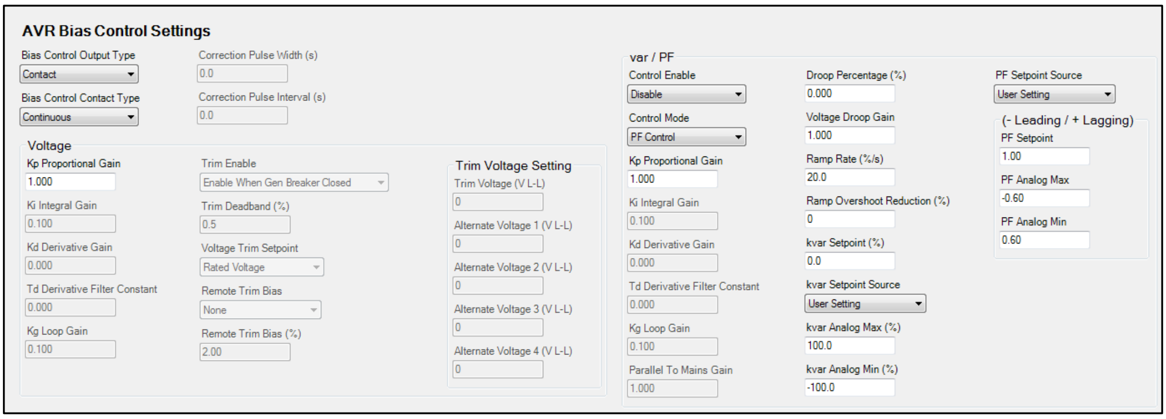

Figure 7-46. Settings Explorer, Bias Control Settings, AVR Bias Control Settings Screen

9. Next, click on the *Governor Bias Control Settings* screen. The parameters for the governor bias control are similar to those of the AVR bias control, and are set in a similar manner. Follow the same steps as for the AVR bias control setup. See Figure 7-47.

   Front Panel Navigation Path: SETTINGS > BIAS CONTROL > GOV BIAS CONTROL

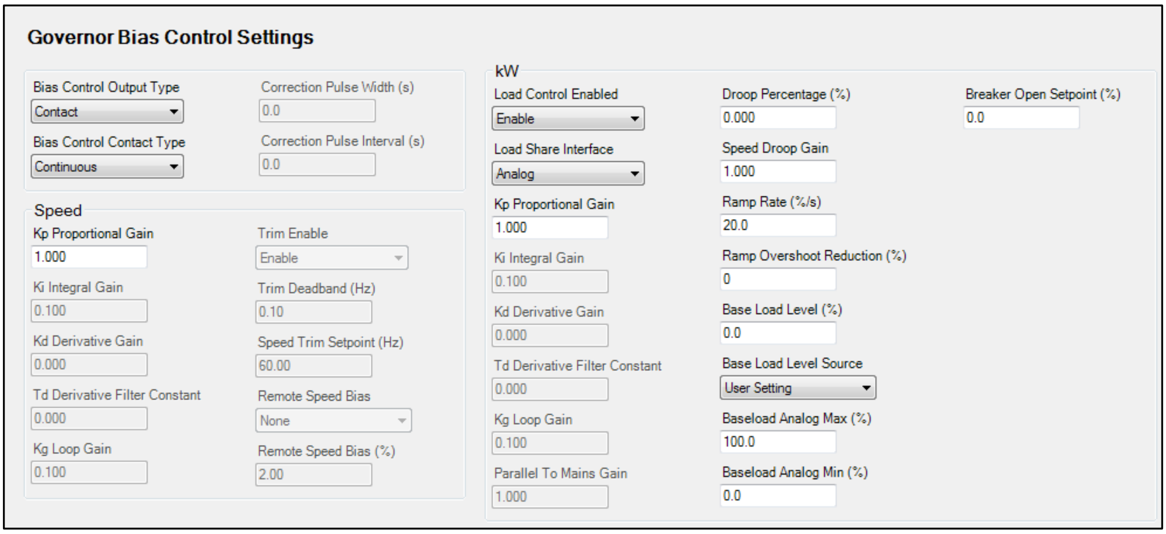

Figure 7-47. Settings Explorer, Bias Control Settings, Governor Bias Control Settings Screen

10. If using the LSM-2020 to control the voltage regulator with an analog signal, click on *Multigen Management* and then *AVR Output*. On this screen, you must select the bias output parameters and levels as required by your voltage regulator. See Figure 7-48.

    Front Panel Navigation Path: SETTINGS > MULTIGEN MANAGEMENT > AVR ANALOG OUTPUT

Figure 7-48. Settings Explorer, Multigen Management, AVR Output Screen

Settings should be entered for each of the following parameters when appropriate:

a. Output Type - Select whether the AVR bias signal should be *Voltage* or *Current*.

b. Response - Select *Increasing* or *Decreasing*. Increasing should be selected if an increase in the output parameter results in an increase of generator output voltage.

c. Min Output Current (mA) and Max Output Current (mA) - If the *Output Type* is *Current*, these parameters must be configured. Set the minimum and maximum current to a range equal to the voltage bias input range for the voltage regulator. The range on these parameters is 4 ma to 20 ma.

d. Min Output Voltage (V) and Max Output Voltage (V) - If the *Output Type* is *Voltage*, these parameters must be configured. Set the minimum and maximum voltage to a range equal to the voltage bias input range for the voltage regulator. The range on these parameters is –10V to +10V.

11. Next click on *Governor Output* and select the appropriate bias output parameters as required by the speed governor. These parameters are identical to those of the AVR output, and should be set in a similar manner. See Figure 7-49.

Front Panel Navigation Path: SETTINGS > MULTIGEN MANAGEMENT > GOV ANALOG OUTPUT

Figure 7-49. Settings Explorer, Multigen Management, Governor Output Screen

12. Set up programmable logic to allow the MGC-2000 Series to synchronize the generator and close the generator breaker. In the BESTlogic*Plus* Programmable Logic, click on the *Elements* tab and drag the Gen Breaker element into your main logic. See Figure 7-50.

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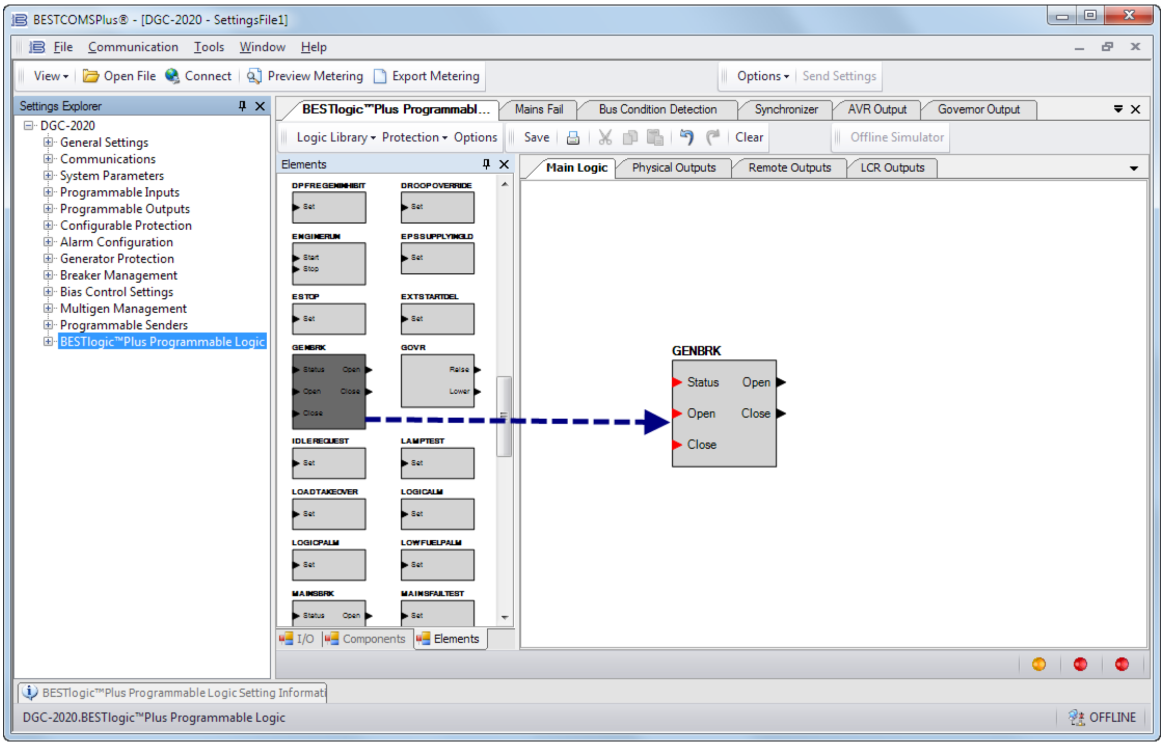

Figure 7-50. Settings Explorer, BESTlogicPlus Programmable Logic (Step 12)

13. Next, click on the *I/O* tab, drag the inputs assigned in step 3 above to the main logic, and connect them to the appropriate input or output of the Generator Breaker block. Note the “Open Gen Breaker” and “Close Gen Breaker” are inputs to the generator breaker block, and are used to request a breaker open or close through contact inputs. The “Gen 52 Open” and “Gen 52 Close” are outputs from the MGC-2000 Series to the physical breaker. The MGC-2000 Series opens or closes the generator breaker through these control signals. See Figure 7-51.

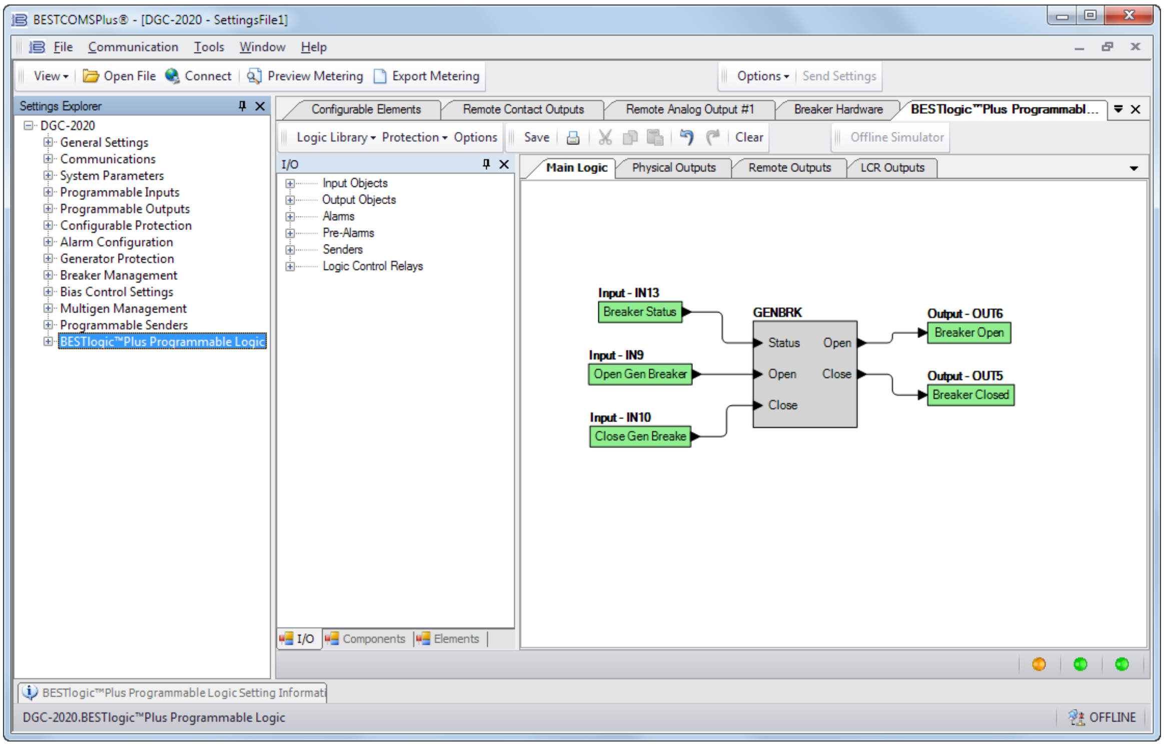

Figure 7-51. Settings Explorer, BESTlogicPlus Programmable Logic (Step 13)

14. If using the LSM-2020 to bias the voltage regulator and governor, no further setup is necessary. If using contact outputs, the output contacts should be set up to drive these functions. In the programmable logic, click on the *Elements* tab. Locate and drag the Governor and AVR logic blocks into the main logic. See Figure 7-52.

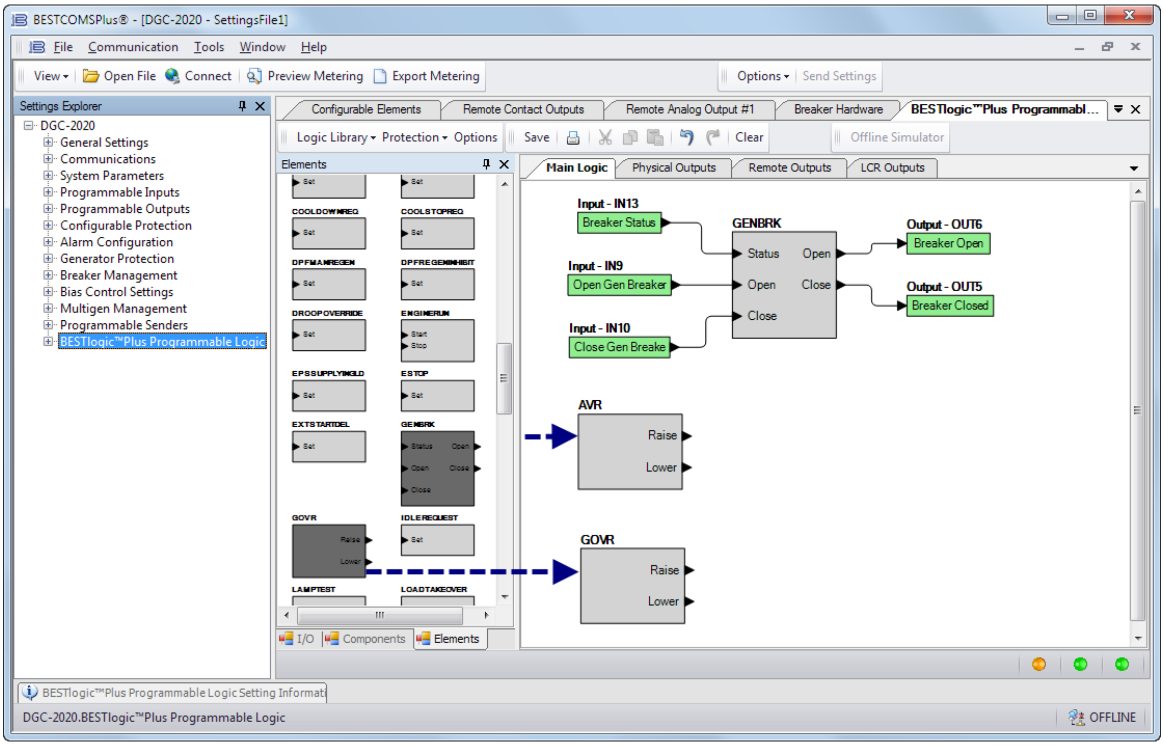

Figure 7-52. Settings Explorer, BESTlogicPlus Programmable Logic (Step 14)

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15. Next, click on the *I/O* tab and drag the selected output contacts into the main logic. Connect the Governor and AVR blocks to the appropriate outputs. This concludes implementation of the automatic synchronizer. See Figure 7-53.

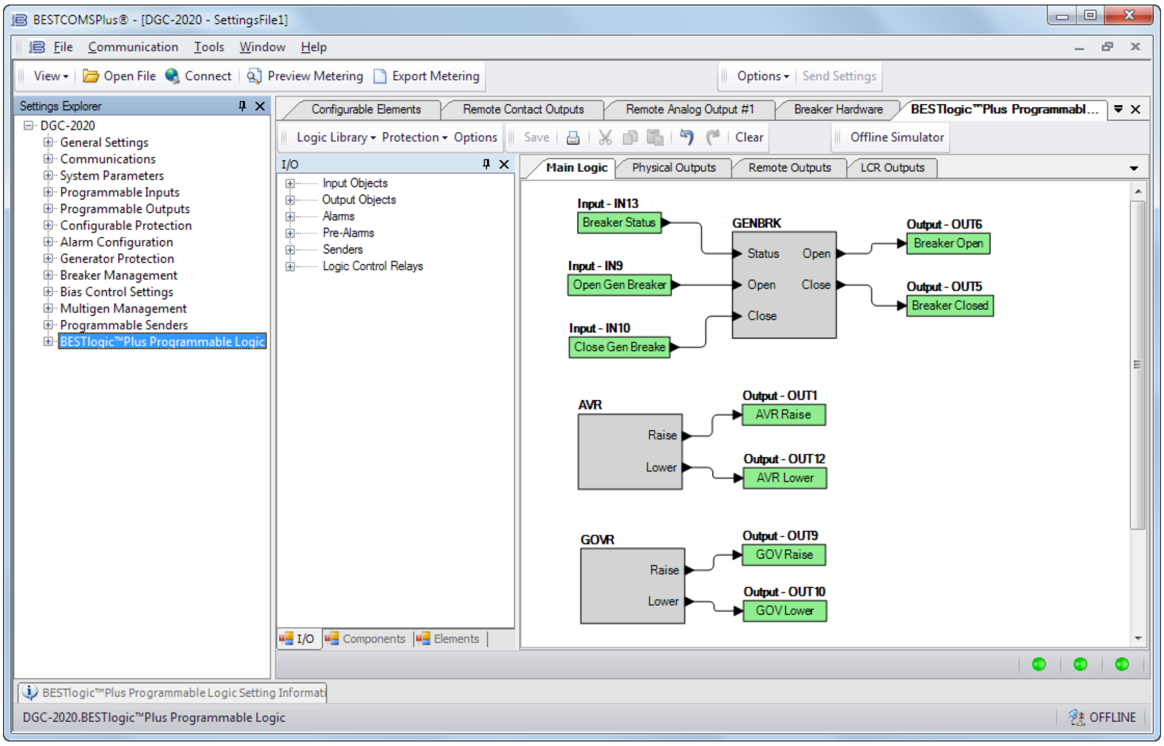

Figure 7-53. Settings Explorer, BESTlogicPlus Programmable Logic (Step 15)

Setting up an MGC-2000 Series and LSM-2020 for a Load Sharing and kW Control Application

The following paragraphs provide information and setup procedures for load sharing and kvar control using the MGC-2000 Series and LSM-2020.

Load Sharing Overview and Theory of Operation in the MGC-2000 Series

Load sharing is necessary when multiple generators are tied to a common bus driving a load and not connected to the utility; the generators are the only power source. Such a system is referred to as an “Islanded System”. Load sharing is accomplished by putting all of the governors in speed droop mode; however, when speed droop is employed, the system speed and frequency may not be maintained. As load increases, system speed drops. The throttles can be adjusted to resume desired speed, but if the load varies, it can be difficult to maintain the speed of the system. In systems where speed and frequency deviation is problematic, speed droop control is not the most appropriate load sharing method.

Isochronous (constant speed) load sharing can be accomplished using a system load share line. The load sharing electronics provide a bias to the governors’ analog bias inputs to implement sharing of kW among the machines. In such systems, all machines share load equally on a percentage of capacity basis. Furthermore, many load sharing devices include a speed trim feature, which actively controls the speed of each generator in the island system to maintain desired system frequency.

The heart of the load sharing system is the load share line. The voltage on the load share line will range between some minimum values, indicating the system is not loaded, to some maximum value, indicating the system is fully loaded. By measuring the load share line voltage, the user can determine the amount of system load. If the voltage is halfway between the minimum and maximum load share voltages, it is indicated that the average system load is 50 percent capacity.

Each load share device must drive the load share line with a voltage that is proportional to its percentage of load. The load share line outputs from all devices are connected together. Therefore, each load share device must contain an internal resistor between the voltage driver and the load share line output to limit the current from the voltage driver. The voltage on the connection point is the average of the load share line voltages contributed by each unit. This average voltage is proportional to the average percentage load of the machines.

The goal of a load sharing system is for all machines to share equally on a percentage of capacity basis. To accomplish this, each machine contains a load controller or kW controller, which provides regulation of the machine's kW output. The setting for each kW controller is derived from the system load share line voltage. The load share line voltage is measured, scaled, and fed back to the machine's kW controller. Thus, the setting for the kW controller is the average percentage load of the system. Thus, each machine's kW controller is driving the machine's kW output to a level equal to the average percentage kW load of the system. The result in a properly tuned system is that all machines share kW equally on a percentage of capacity basis.

While some newer systems replace the load share line using communication between the generators (inter-genset communications) many existing load share implementations use an analog load share line. Figure 7-54 shows a diagram of an analog load share line as presented in this document.

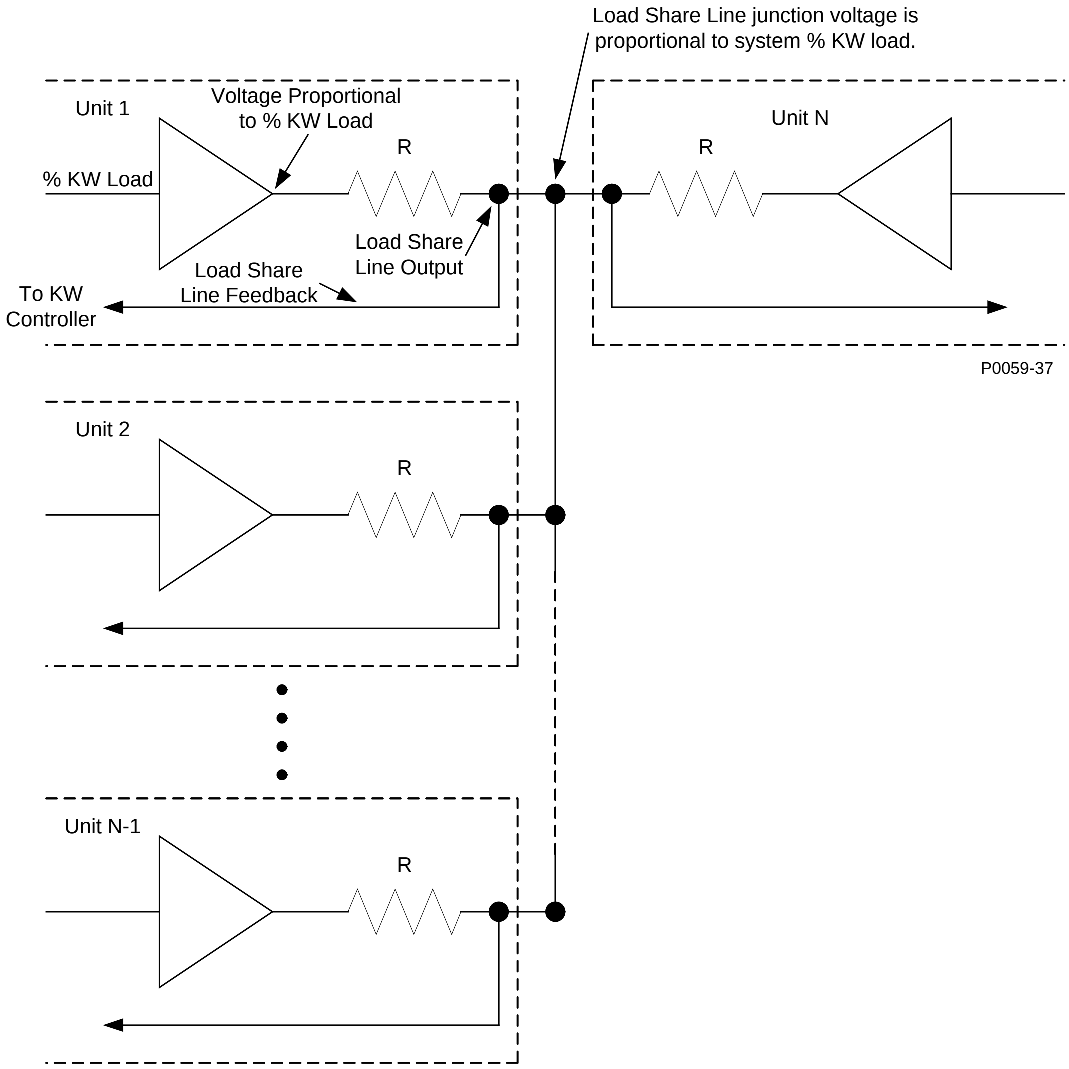

Figure 7-54. Load Share Line Implementation on a System of N Machines

If a unit or set of units is paralleled to the utility, they derive their kW control setting from the Base Load Level (%) setting, and disregard the load share line input. The Parallel to Mains (ParToMains) logic element in BESTlogic*Plus* Programmable Logic is used to indicate to the MGC-2000 Series that is it paralleled to the utility.

In short, when the generator breaker is open, the kW controller is disabled. When the generator breaker is closed and the unit is not paralleled to the utility, the kW controller's set point is derived from the load share line. When the generator breaker is closed and the machine is paralleled to the utility, the kW controller uses the Base Load Level (%) setting as its set point. Generator breaker status is communicated to the MGC-2000 Series through the status input on the generator breaker block in BESTlogic*Plus* Programmable Logic.

Settings are provided to allow a generator to ramp up its kW generation to minimize system disruption when it transitions onto a system that is load sharing. A similar ramp down transition is also implemented when the generator is brought off line.

Each load share module has a set of internal contacts that physically disconnects it from the load share line circuit when the generator is off line. These contacts are open whenever the unit's generator breaker is open.

kvar Control Overview and Theory of Operation in the MGC-2000 Series

The MGC-2000 Series and LSM-2020 can provide system kvar control. When the generator breaker is open, the unit operates in voltage droop mode. When the generator breaker is closed and the generator is part of an island system (the system is not paralleled to the utility), the unit shares kvar with the other machines in the system through intergenset communications. When the generator is paralleled to the utility, the kvar controller is enabled; either power factor or kvar control is implemented according to the VAR/PF control mode setting. Generator breaker status is communicated to the MGC-2000 Series through the status input on the generator breaker block in BESTlogic*Plus* Programmable Logic.

When var control mode is selected and the generator is paralleled to the utility, the kvar controller's set point is equal to the kvar Setpoint (%) setting. The setting is in units of percentage of the machine's rated kvar, which is calculated from the rated kW and rated Power Factor.

When power factor control mode is selected and the generator is paralleled to the utility, the var controller's set point is calculated as the percentage of rated kvar, which will maintain the power factor of the machine at the PF Setpoint setting. The Parallel to Mains (ParToMains) logic element in BESTlogic*Plus* Programmable Logic is used to indicate to the MGC-2000 Series that it is paralleled to the utility.

Setup of the MGC-2000 Series and the LSM-2020 for Load Sharing and/or kW Control

The setup of a load sharing and kW control system requires several steps:

1. Wire the MGC-2000 Series, LSM-2020, and any external devices that interact with the MGC-2000 Series or the LSM-2020.
2. Set all MGC-2000 Series settings related to Initial Machine Setup.
3. Configure MGC-2000 Series breaker control.
4. Configure the synchronizer function (if used).
5. Configure the parameters related to load sharing and kW control:
    a. Enable the load share module
    b. Configure the load share line voltage range
    c. Configure the AVR bias output voltage or current range and polarity
    d. Configure the governor bias output voltage or current range and polarity
    e. Configure the kW and speed control parameters
    f. Change the voltage and kvar control parameters
    g. Configure demand start/stop related parameters (if demand start/stop is used)
        i. Configure demand start/stop parameters
        ii. Configure generator sequencing parameters
        iii. Configure the generator network parameters
        iv. Configure the LSM-2020 Ethernet parameters
    h. Tune the kW, kvar, speed, and voltage controllers

Setup of some of these parameters are already covered in other sections of the MGC-2000 Series instruction manual; you will be directed to appropriate sections of this manual when this is the case. Detailed setup procedures are presented for those that are not addressed elsewhere.

Step by Step Setup Procedures

1. Wire the MGC-2000 Series, LSM-2020, and any external devices that interact with the MGC-2000 Series or the LSM-2020. Descriptions of MGC-2000 Series connections and diagrams showing typical wiring schemes for an MGC-2000 Series on a generator in various connection schemes (single-phase AB, single-phase AC, Wye, Delta, etc.) are found under *Connections*.

   Descriptions of the LSM-2020 connections and diagrams showing typical wiring schemes for connecting MGC-2000 Series and LSM-2020s on several machines which parallel together to form a load sharing system are found under *Installation* in Section 9, *LSM-2020 (Load Share Module)*.

2. Set all MGC-2000 Series settings related to Initial Machine Setup. Initial machine setup should be performed according to the paragraphs titled *MGC-2000 Series Initial Setup*.

3. Configure MGC-2000 Series breaker control. If the MGC-2000 Series is controlling the generator breaker in the system, it should be configured according to the paragraphs titled *Generator and Mains Breaker Control*. If the breaker is controlled by external switchgear, most of this may be omitted. However, it is still necessary to implement a contact input to the generator breaker block in the MGC-2000 Series BESTlogic*Plus* Programmable Logic to indicate generator breaker status to the MGC-2000 Series. The MGC-2000 Series will not load share or control kW or kvar unless it receives an indication that the generator breaker is closed.

4. Configure the synchronizer function. If the synchronizer option in the MGC-2000 Series is used to synchronize the MGC-2000 Series to the generator bus or to the utility, it should be configured according to the paragraphs titled *Synchronizer Setup*. If an external synchronizer is used for synchronization and the MGC-2000 Series load sharing is also configured, special wiring consideration is required to prevent both the LSM-2020 and the external synchronizer from trying to drive the AVR bias and the Governor bias at the same time. Examples of such wiring schemes are presented in the paragraphs titled *Interfacing an External Control Device with an MGC-2000 Series – LSM-2020 System* under *Application* in Section 9, *LSM-2020 (Load Share Module)*.

5. Configure the parameters related to load sharing and kW control.

   a. Enable the load share module. The load share module setup is found in BESTCOMS*Plus*® under SETTINGS EXPLORER→ DGC-2020→ SYSTEM SETTINGS→ REMOTE MODULE SETUP. See Figure 7-55.

      Front Panel Navigation Path: SETTINGS > SYSTEM PARAMS > REMOTE MODULE SETUP

      i. Enable the load share module by clicking *Enable* under the load share module settings.

      ii. LSM J1939 Address - Enter the J1939 address to be used by the LSM-2020. Normally this will not have to be changed unless the address is already in use elsewhere on the CAN bus network.

      iii. LSM Auxiliary Input Source - Select *Local* if locally measured input values are to be used. Select *System Manager* if the measured input values of the unit designated as the system manager are to be used.

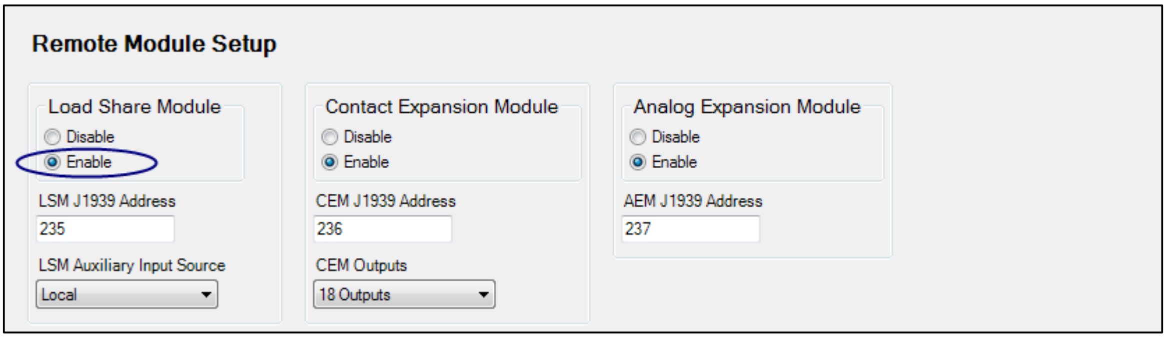

Figure 7-55. Settings Explorer, System Parameters, Remote Module Setup Screen

   b. Configure the load share line voltage range. If load sharing to equipment not produced by Basler Electric, the range of load share voltage utilized by the equipment must be determined. If the voltage range set up in the MGC-2000 Series does not match that of the devices, correct load sharing will not occur. If all devices are Basler Electric devices, a range of 0 to 10 V is a convenient range. The settings for the load share line voltage range are found in BESTCOMS*Plus*® under SETTINGS EXPLORER → DGC-2020 → MULTIGEN MANAGEMENT → LOAD SHARE OUTPUT. See Figure 7-56.

Front Panel Navigation Path: SETTINGS > MULTIGEN MANAGEMENT > LOAD SHARE LINE

Figure 7-56. Settings Explorer, Multigen Management, Load Share Output Screen

i. Max Voltage (V) - This setting defines the voltage value that represents 100% kW loading of the system.

ii. Min Voltage (V) - This setting defines the voltage that represents 0% loading or no loading of the system. Be careful not to interchange the min and max. If the min and max were interchanged on all machines, the system would probably work; otherwise, the machines configured correctly will try to motor those with min and max interchanged.

iii. Once the machine is set up and operating properly, the load share line voltage can be measured to determine system loading. If the voltage is 33% of the range above the minimum, the system is 33% loaded. If it is 75% above the minimum, the system is 75% loaded. This shows why a range of 0 to 10 volts is convenient. For example, multiply the voltage by 10 to determine the system percentage load. 7.5 volts is 75% load.

c. Configure the AVR bias output voltage or current range and polarity. Prior to this, the voltage or current range of the AVR bias input signal must be determined. If the programmed range does not match what is used by the AVR bias input, unpredictable or undesirable system behavior is likely to occur.

Settings for AVR bias output voltage or current range and polarity are found in BESTCOMS*Plus*® under SETTINGS EXPLORER→ DGC-2020→ MULTIGEN MANAGEMENT→ AVR OUTPUT. See Figure 7-57.

Front Panel Navigation Path: SETTINGS > MULTIGEN MANAGEMENT > AVR ANALOG OUTPUT

Figure 7-57. Settings Explorer, Multigen Management, AVR Output Screen

i. Output Type - Select *Voltage* or *Current*, depending on the output type.

ii. Response - Select *Increasing* if a higher level of bias causes the AVR to increase generator output voltage; select *Decreasing* if a higher level of bias causes the AVR to decrease generator output voltage.

iii. Min Output Current (mA) - This setting defines the minimum AVR bias current level if the bias *Output Type* is set to *Current*.

iv. Max Output Current (mA) - This setting defines the maximum AVR bias current level if the bias *Output Type* is set to *Current*.

v. Min Output Voltage (V) - This setting defines the minimum AVR bias voltage level if the bias *Output Type* is set to *Voltage*.

vi. Max Output Voltage (V) - This setting defines the maximum AVR bias voltage level if the bias *Output Type* is set to *Voltage*.

d. Configure the governor bias output voltage or current range and polarity.

Before this can be done, the voltage or current range of the governor bias input signal must be determined. If the programmed range does not match what is used by the governor bias input, unpredictable or undesired system behavior could occur.

Settings for Governor Bias Output voltage or current range and polarity are found in BESTCOMS*Plus*® under SETTINGS EXPLORER > DGC-2020 > MULTIGEN MANAGEMENT > GOVERNOR OUTPUT. See Figure 7-58.

Front Panel Navigation Path: SETTINGS > MULTIGEN MANAGEMENT > GOV ANALOG OUTPUT

i. Output Type - Select *Voltage* or *Current*, depending on the output type.

ii. Response - Select *Increasing* if a higher level of bias causes the governor to increase generator output voltage; select *Decreasing* if a higher level of bias causes the governor to decrease generator output voltage.

iii. Min Output Current (mA) - This setting defines the minimum governor bias current level if the bias *Output Type* is set to *Current*.

iv. Max Output Current (mA) - This setting defines the maximum governor bias current level if the bias *Output Type* is set to *Current*.

v. Min Output Voltage (V) - This setting defines the minimum governor bias voltage level if the bias *Output Type* is set to *Voltage*.

vi. Max Output Voltage (V) - This setting defines the maximum governor bias voltage level if the bias *Output Type* is set to *Voltage*.

Figure 7-58. Settings Explorer, Multigen Management, Governor Output Screen

e. Configure the kW and speed control parameters.

The settings for the kW and speed control parameters are found in BESTCOMS*Plus*® under SETTINGS EXPLORER > DGC-2020 > BIAS CONTROL SETTINGS > GOVERNOR BIAS CONTROL SETTINGS. See Figure 7-59.

Front Panel Navigation Path: SETTINGS > BIAS CONTROL > GOV BIAS CONTROL

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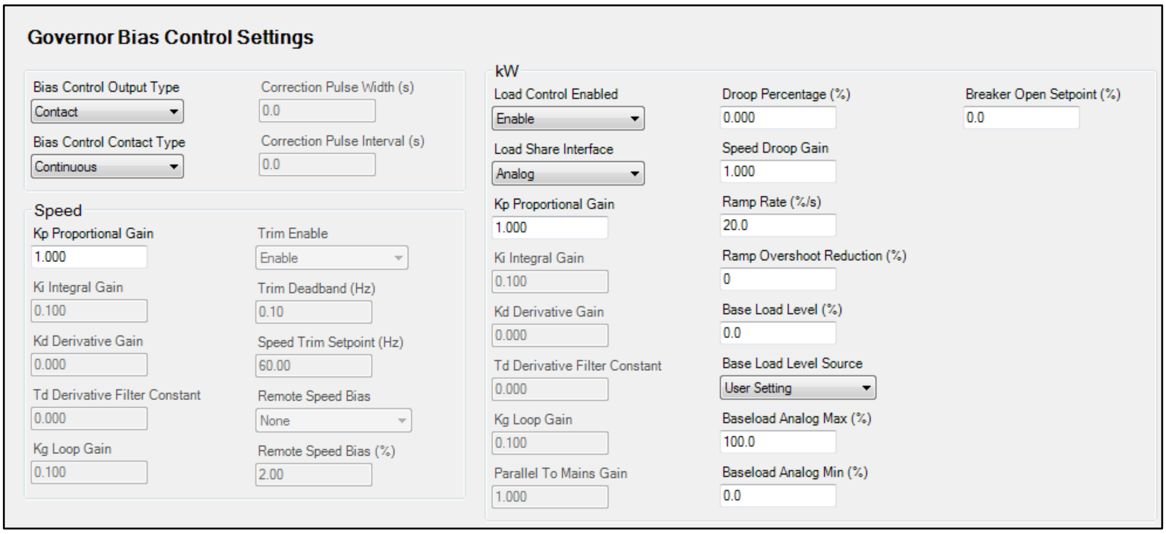

Figure 7-59. Settings Explorer, Bias Control Settings, Governor Bias Control Settings Screen

i. Bias Control Output Type - Select *Contact* or *Analog*, according to the machine's implementation.

ii. Bias Control Contact Type - Select *Continuous* or *Proportional*, depending on the contact output type. Proportional is a PWM based implementation. The duty cycle increases when more control output is required. This parameter cannot be programmed if the *Bias Control Output Type* is set to *Analog* since it is not applicable to analog outputs.

iii. Correction Pulse Interval - This parameter defines the duration in seconds between output pulses for proportional contact outputs. This parameter cannot be programmed if the *Bias Control Output Type* is set to *Analog* or the *Bias Control Contact Type* is set to *Continuous* since it is not applicable in either case. The pulse interval along with the pulse width specifies how often a new pulse occurs. The total time between pulses is the pulse width plus the pulse interval.

iv. Correction Pulse Width - Set the maximum width of a contact output pulse for proportional contact outputs. This is the maximum "On" time allowable for the proportional outputs. This parameter cannot be programmed if the *Bias Control Output Type* is set to *Analog* or the *Bias Control Contact Type* is set to *Continuous* since it is not applicable in either case.

v. Speed Trim Enable - Speed trim maintains the system at the speed trim set point when the generator breaker is closed and the generator is part of an islanded system, i.e. not paralleled to the utility. This maintains the frequency of the island system to compensate for speed deviations occurring from possible system "bumps" as machines go on and off the bus. It is generally recommended that speed trim be enabled. However, if an external speed POT is used for customer speed control, the speed trim function will maintain the speed trim set point regardless of the POT position. Effectively the speed POT is disabled.

   The speed controller is active under two sets of circumstances: (1) the synchronizer is active and biasing engine speed to accomplish alignment of the AC phases across the breaker that is being synchronized or (2) the generator breaker is closed and *Speed Trim Enable* is set to *Enabled* and the generator is NOT paralleled to the utility as indicated by the parallel to mains (ParToMains) logic element in BESTlogic*Plus* Programmable Logic.

vi. Speed Controller Gains (Kp, Ki, Kd, Td, Kg) - There are four Proportional - Integral - Derivative (PID) controllers involved when an MGC-2000 Series and LSM-2020 are used in a load sharing or load control system. The gains of the controllers involved with speed control are discussed below. Controller gains are configured as part of the controller tuning procedure. The tuning procedures for all PID controllers are presented in Appendix C, *Tuning PID Settings*. Controller tuning is performed after all other settings have been configured and is the last step in setting up an MGC-2000 Series and LSM-2020 for load sharing or load control.

The speed controller gains are:

(1) Speed Controller Kp - Proportional Gain

(2) Speed Controller Ki - Integral Gain

(3) Speed Controller Kd - Derivative Gain

(4) Speed Controller Td - Derivative filter time constant

(5) Speed Controller Kg - Loop Gain, must be nonzero for control to occur

vii. Speed Trim Setpoint (Hz) - When speed trim is enabled, the speed trim controller maintains system speed at the level specified by this setting.

viii. Speed Trim Deadband - When the difference between the measured speed and the speed trim set point is less than the trim dead band, the speed trim controller will treat this as zero error. If system operation appears "nervous" when speed trim is enabled, setting a nonzero dead band may result in smoother system operation. In addition, if machines do not appear to share kW equally when speed trim is enabled, setting a nonzero dead band will likely result in improved kW sharing.

ix. Remote Speed Bias - The Remote Speed Bias setting provides for biasing the speed of a group of generators on a bus, by as much as ±5%, for synchronizing to the utility. When the Remote Speed Bias setting is configured for the LSM-2020 input or an AEM-2020 input, the speed trim setpoint is calculated based on the specific analog input.

x. Remote Speed Bias (%) - The Remote Speed Bias (%) setting corresponds to the maximum and minimum analog input range.

xi. kW Load Control Enabled - Select *Enabled* when load sharing and kW control are required.

xii. kW Controller Gains (Kp, Ki, Kd, Td, Kg) - There are four Proportional - Integral - Derivative (PID) controllers involved when an MGC-2000 Series and LSM-2020 are used in a load sharing or load control system. The gains of the controllers involved with kW control are discussed below. All controller gains are configured as part of the controller tuning procedure. The tuning procedures for all PID controllers are presented in Appendix C, *Tuning PID Settings*. Controller tuning is performed after all other settings have been configured and is the last step in setting up an MGC-2000 Series and LSM-2020 for load sharing or load control.

The kW controller gains are:

(1) kW Controller Kp - Proportional Gain

(2) kW Controller Ki - Integral Gain

(3) kW Controller Kd - Derivative Gain

(4) kW Controller Td - Derivative filter time constant

(5) kW Controller Kg - Loop Gain, must be nonzero for control to occur

xiii. Droop Percentage (%) - This is the percentage of speed droop that is desired when the MGC-2000 Series is operating in speed droop mode. Setting this to the default setting of zero disables speed droop.

xiv. Speed Droop Gain - This gain factor is used to compensate for variations in governors and their tuning. After controller tuning has occurred, if a nonzero speed droop percentage is desired, set the value of droop percentage accordingly. Perform a test by exporting kW, and observe the speed droop. If the observed droop does not match the *Droop Percentage* setting, set the droop gain as a scale factor to achieve the desired droop. For instance, if the observed droop was only half of what is desired, set the droop gain to two. Then, the observed droop should correspond to the *Droop Percentage* Setting.

xv. Ramp Rate (%) - This rate is in terms of percentage of the machine's Rated kW at which the generator's kW output will ramp from 0 kW to the required kW demand level when the generator breaker is closed and the generator is paralleled to the utility. Paralleled to utility status is indicated to the MGC-2000 Series by the parallel to mains (ParToMains) logic element in BESTlogic*Plus* Programmable Logic. As an example, assume that the *Ramp Rate* is set at 10% per second. If the demand is 50% of the machine's capacity, and the generator breaker is closed to parallel the generator to the utility, it will take 5 seconds for the output to come up to the required level. If the demand is 80 percent, it will take 8 seconds to come up, etc. This is also the rate at which the machine will ramp down when going off line in a normal machine stop.

xvi. Base Load Level (%) - When the kW controller is active, this setting defines the level of the machines rated kW capacity that the MGC-2000 Series will regulate when the generator is paralleled to the utility as indicated by the parallel to mains (ParToMains) logic element in BESTlogic*Plus* Programmable Logic.

xvii. Base Load Level Source - The set point for the kW controller (when enabled) can either be the level set in the *Base Load Level (%)* setting, or it can be derived from an analog input on the LSM-2020 or AEM-2020 (Analog Expansion Module). Set this to *User Setting* or to an available analog input on the LSM-2020 or AEM-2020 as required for machine implementation.

xviii. Base Load Analog Max (%) - This setting defines the value of kW indicated when the *Base Load Level Source* is set to an analog input and the input is at its maximum. This parameter cannot be configured when *Base Load Level Source* is set for *User Setting*.

xix. Base Load Analog Min (%) - This setting is the value of kW indicated when the *Base Load Level Source* is set to an analog input and the input is at its minimum.

xx. Breaker Open Setpoint (%) - This setting specifies the maximum kW level at which the MGC-2000 Series will open the generator breaker after unloading prior to stopping the machine on a normal machine stop in AUTO mode.

f. Configure the voltage and kvar control parameters.

The settings for the voltage and kvar control parameters are found in BESTCOMS*Plus*® under SETTINGS EXPLORER > DGC-2020 > BIAS CONTROL SETTINGS > AVR BIAS CONTROL SETTINGS. See Figure 7-60.

Front Panel Navigation Path: SETTINGS > BIAS CONTROL > AVR BIAS CONTROL

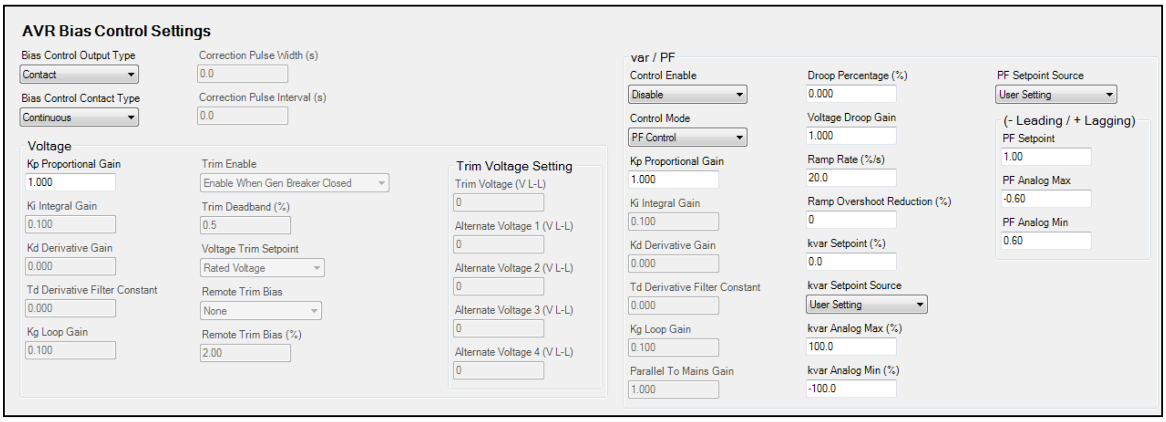

Figure 7-60. Settings Explorer, Bias Control Settings, AVR Bias Control Settings Screen

i. Bias Control Output Type - Select *Contact* or *Analog*, according to the machine's implementation.

ii. Bias Control Contact Type - Select *Continuous* or *Proportional*, depending on the contact output type. Proportional is a PWM based implementation. The duty cycle increases when more control output is required. This parameter cannot be programmed if the *Bias Control Output Type* is set to *Analog* since it is not applicable to analog outputs.

iii. Correction Pulse Interval - This setting defines the duration in seconds between output pulses for proportional contact outputs. This is the inverse of the frequency of the pulses. This parameter cannot be programmed if the *Bias Control Output Type* is set to *Analog* or the *Bias Control Contact Type* is set to *Continuous* since it is not applicable in either case.

iv. Correction Pulse Width - This setting defines the maximum width of a contact output pulse for proportional contact outputs. This is the maximum "On" time allowable for the proportional outputs. This parameter cannot be programmed if the *Bias Control Output Type* is set to *Analog* or the *Bias Control Contact Type* is set to *Continuous* since it is not applicable in either case.

v. Voltage Controller Gains (Kp, Ki, Kd, Td, Kg) - There are four Proportional - Integral - Derivative (PID) controllers involved when an MGC-2000 Series and LSM-2020 are used in a load sharing or load control system. The gains of the controllers involved with voltage control are discussed below. Controller gains are configured as part of the controller tuning procedure. The tuning procedures for all PID controllers are presented in Appendix C, *Tuning PID Settings*. Controller tuning is performed after all other settings have been configured and is the last step in setting up an MGC-2000 Series and LSM-2020 for load sharing or load control.

The voltage controller gains are:

(1) Voltage Controller Kp - Proportional Gain

(2) Voltage Controller Ki - Integral Gain

(3) Voltage Controller Kd - Derivative Gain

(4) Voltage Controller Td - Derivative filter time constant

(5) Voltage Controller Kg - Loop Gain, must be nonzero for control to occur

vi. Voltage Trim Deadband - The Voltage Trim error is calculated as the difference between the measured voltage and the voltage trim set point divided by the machine Rated Voltage. When this difference is less than the trim dead band setting, the voltage trim controller will treat this as zero error. If system operation appears "nervous" when voltage trim is enabled, setting a nonzero dead band may result in smoother system operation. In addition, if machines do not appear to share kvar equally when voltage trim is enabled, setting a nonzero dead band will likely result in improved kvar sharing.

vii. Remote Trim Bias - The remote trim bias setting selects an analog input to use as a bias to the voltage trim set point.

viii. Remote Trim Bias (%) - The remote trim bias (%) setting specifies the range, in percent, of the active voltage trim set point over which the voltage trim can be biased.

ix. Trim Voltage - The trim voltage setting defines the voltage trim value in volts.

x. Alternate Voltage 1 through 4 - The Alternate Voltage 1 through Alternate Voltage 4 settings define the voltage trim value when the corresponding Alternate Voltage Override logic element is true in BESTlogic*Plus* programmable logic.

xi. Var/PF Control Enable - Select *Enable* to turn on the kvar / Power Factor controller. Note that Var/PF control occurs only when the generator is paralleled to the utility as indicated by the parallel to mains (ParToMains) logic element in BESTlogic*Plus* Programmable Logic. When Var/PF control is enabled, the generator breaker is closed, and the generator is not paralleled to the utility as indicated by the Parallel To Mains logic element, the MGC-2000 Series will control the kvar to achieve kvar sharing with the other generators in the system through intergenset communications. When the generator breaker is open, the MGC-2000 Series will control the kvar to achieve voltage droop for kvar sharing.

xii. Control Mode - Select *Var Control* or *PF Control* as the control mode. The controller will operate in this mode when the generator is paralleled to the utility as indicated by the parallel to mains (ParToMains) logic element in BESTlogic*Plus* Programmable Logic.

xiii. Var/PF Controller Gains (Kp, Ki, Kd, Td, Kg) - There are four Proportional - Integral - Derivative (PID) controllers involved when an MGC-2000 Series and LSM-2020 are used in a load sharing or load control system. The gains of the controllers involved with Var/PF control are discussed below. Controller gains are configured as part of the controller tuning procedure. The tuning procedures for all PID controllers are presented in Appendix C, *Tuning PID Settings*. Controller tuning is performed after all

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other settings have been configured and is the last step in setting up an MGC-2000 Series and LSM-2020 for load sharing or load control.

The Var/PF controller gains are:

(1) Var/PF Controller Kp - Proportional Gain

(2) Var/PF Controller Ki - Integral Gain

(3) Var/PF Controller Kd - Derivative Gain

(4) Var/PF Controller Td - Derivative filter time constant

(5) Var/PF Controller Kg - Loop Gain, must be nonzero for control to occur

xiv. Droop Percentage (%) - This setting defines the percentage of voltage droop that is desired when the MGC-2000 Series is operating in voltage droop mode. The default setting of zero effectively disables voltage droop.

xv. Voltage Droop Gain - This gain factor is used to compensate for variations in AVRs and their tuning. After tuning the controller, if a nonzero voltage droop percentage is desired, set the value of droop percentage accordingly. Perform a test by exporting kvar, and observe the voltage droop. If the observed droop does not match the *Droop Percentage* setting, set the droop gain as a scale factor to achieve the desired droop. For instance, if the observed droop was only half what is desired, set the droop gain to two. Then, the observed droop should correspond to the *Droop Percentage* setting.

xvi. Ramp Rate (%) - This rate is in terms of percentage of the machine's Rated kvar Capacity (calculated from Rated kW and Rated Power Factor) at which the generator's kvar output will ramp from 0 kvar to the required kvar demand level when the generator breaker is closed and the generator is paralleled to the utility. Paralleled to utility status is indicated to the MGC-2000 Series by the parallel to mains (ParToMains) logic element in BESTlogic*Plus* Programmable Logic. As an example, assume the *Ramp Rate* is set at 10% per second. If the demand is 50% of the machine's capacity, and the generator breaker is closed to parallel the generator to the utility, it will take 5 seconds for the output to come up to the required level. If the demand is 80 percent, it will take 8 seconds to come up, etc. This is also the rate at which the machine will ramp down when going off line in a normal machine stop.

xvii. kvar Setpoint (%) - When the kvar controller is in Var Control Mode, this setting defines the level of the machine's Rated kvar Capacity (calculated from Rated kW and Rated Power Factor) that the MGC-2000 Series will regulate when the generator is paralleled to the utility as indicated by the parallel to mains (ParToMains) logic element in BESTlogic*Plus* Programmable Logic.

xviii. kvar Setpoint Source - The set point for the kvar controller when it is in kvar control mode can either be the level set in the *kvar Setpoint (%)* setting, or it can be derived from an analog input on the LSM-2020, or the AEM-2020 (Analog Expansion Module). Set this parameter to *User Setting* or to an available analog input on the LSM-2020 or AEM-2020 as required for machine implementation.

xix. kvar Analog Max (%) - This setting defines the value of kvar that is requested when the *kvar Setpoint Source* is set to an analog input and the input is at its maximum. This parameter cannot be configured when the *kvar Setpoint Source* is set for *User Setting*.

xx. kvar Analog Min (%) - This setting defines the value of kvar that is requested when the *kvar Setpoint Source* is set to an analog input and the input is at its minimum. This parameter cannot be configured when the *kvar Setpoint Source* is set for *User Setting*.

xxi. PF Setpoint Source - The set point for the kvar controller when it is in power factor control mode can either be the level set in the *PF Setpoint* setting, or it can be derived from an analog input on the LSM-2020, or the AEM-2020 (Analog Expansion Module). Set this to *User Setting* or to an available analog input on the LSM-2020 or AEM-2020 as required for the machine implementation.

xxii. PF Setpoint - The set point for the kvar controller when it is in power factor control mode and the *PF Setpoint Source* is set for *User Setting*. The MGC-2000 Series will maintain this power factor when the generator is paralleled to the utility as indicated by the parallel to mains (ParToMains) logic element in BESTlogic*Plus* Programmable Logic. Note that a negative setting is used to specify leading PF and a positive setting specifies lagging PF.

xxiii. PF Analog Max - This setting defines the value of PF that is requested when the *PF Setpoint Source* is set to an analog input and the input is at its maximum. This parameter cannot be configured when the *PF Setpoint Source* is set for *User Setting*. Note that a negative setting is used to specify leading PF and a positive setting specifies lagging PF.

xxiv. PF Analog Min - This setting defines the value of PF that is requested when the *PF Setpoint Source* is set to an analog input and the input is at its maximum. This parameter cannot be configured when the *PF Setpoint Source* is set for *User Setting*. Note that a negative setting is used to specify leading PF and a positive setting specifies lagging PF.

g. Configure Demand Start/Stop related parameters (if Demand Start/Stop is used)

i. Configure Demand Start/Stop parameters.

The Demand Start/Stop parameters are found in BESTCOMS*Plus*® under SETTINGS EXPLORER > DGC-2020 > MULTIGEN MANAGEMENT > DEMAND START/STOP. See Figure 7-61.

Front Panel Navigation Path: SETTINGS > MULTIGEN MANAGEMENT > DEMAND START STOP

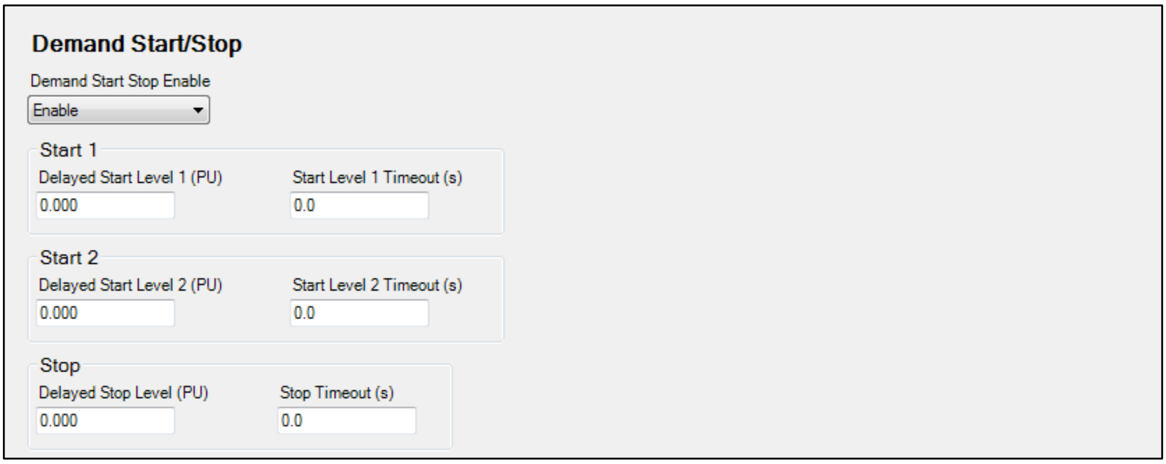

Figure 7-61. Settings Explorer, Multigen Management, Demand Start/Stop Screen

There are two demand start levels and timeouts. This allows the user to set up a lower system power level with a long timeout for normal generator starts, but if the system power level exceeds a higher level for a shorter time (e.g. a machine has an alarm shut down or some other abnormal system power phenomenon occurs) machines can be brought on quickly.

Set up the individual parameters according to:

(1) Demand Start/Stop Enable - Select *Enable* to turn on the demand start/stop functionality.

(2) Delayed Start Level 1 (PU) - This setting defines the level (in Per Unit) at which the sequence for starting another machine should occur. Once the *Start Level 1 Timeout* has expired, another machine will be started.

(3) Start Level 1 Timeout - Set setting defines the desired delay before starting a machine when the system per unit power level has exceeded *Delayed Start Level 1*.

(4) Delayed Start Level 2 (PU) - This setting defines the level (in Per Unit) at which the sequence for starting another machine should occur. Once the *Start Level 2 Timeout* has expired, another machine will be started.

(5) Start Level 2 Timeout - This setting defines the desired delay before starting a machine when the system per unit power level has exceeded *Delayed Start Level 2.*

(6) Delayed Stop Level (PU) - This setting defines the level (in Per Unit) at which the sequence for stopping another machine should occur. Once the *Stop Level Timeout* has expired, another machine will be shut down.

(7) Stop Level Timeout - This setting defines the desired delay before stopping a machine when the system per unit power level has been less than *Delayed Stop Level*.

ii. Configure Generator Sequencing parameters.

The Generator Sequencing parameters are found in BESTCOMS*Plus*® under SETTINGS EXPLORER > DGC-2020 > MULTIGEN MANAGEMENT > GENERATOR SEQUENCING. See Figure 7-62.

Front Panel Navigation Path: SETTINGS > MULTIGEN MANAGEMENT > SEQUENCING

Figure 7-62. Settings Explorer, Multigen Management, Generator Sequencing Screen

Set up the individual parameters according to:

(1) Mode - Select the desired generator-sequencing mode. Selections include *Disabled, Staggered Service Time, Balanced Service Time, Largest Size First, Smallest Size First, Smallest Unit ID First,* and *Adopt System Mode.*

When *Disabled*, the unit does not participate in sequencing. When any mode other than *Disabled* or *Adopt System Mode* is selected, all machines on the inter-genset communications network will switch to the newly programmed mode. If generator sequencing is being set up before an inter-genset communications network is in place, the same mode should be set for all machines. If a machine is added to the inter-genset communications network and *Adopt System Mode* is selected, the machine's sequencing mode will switch to the mode of the rest of the machines on the network.

(2) Sequence ID - Enter a number for sequence ID. The ID must be a unique non-zero number for each machine that is to participate in generator sequencing. Any machines with zero for a sequence ID will not participate in generator sequencing. In addition, machines with zero for a sequence ID will not be considered when network status is checked for the ID Missing and ID Repeat pre-alarms. These are discussed in detail in the paragraphs titled *Configure the Generator Network parameters* below.

(3) Max Gen Start Time (s) - This setting defines the maximum time in seconds that generator sequencing will allow for a machine to start. If a successful start does not occur within the allotted time, generator sequencing will move to the next machine in the priority order and try to start it. This should be set to allow ample time for a normal start to occur.

(4) Max Gen Stop Time (s) - This setting defines the maximum time in seconds that generator sequencing will allow for a machine to stop. If a successful stop

does not occur within the allotted time, generator sequencing will move to the next machine in the priority order and try to stop it. This should be set to allow ample time for a normal stop to occur.

(5) Allow Last Unit Shutdown - Set to enable or disable to allow the last unit to shut down if there is no load on the system.

iii. Configure the Generator Network parameters.

The Generator Network Configuration parameters are found in BESTCOMS*Plus*® under SETTINGS EXPLORER > DGC-2020 > MULTIGEN MANAGEMENT > NETWORK CONFIGURATION. See Figure 7-63.

Front Panel Navigation Path: SETTINGS > MULTIGEN MANAGEMENT > NETWORK CONFIG

Figure 7-63. Settings Explorer, Multigen Management, Network Configuration

These settings are the non-zero sequence IDs of all units that are on the inter-genset communications network. This allows the MGC-2000 Series to annunciate a pre-alarm if a machine is missing (ID Missing pre-alarm) or if an ID is repeated (ID Repeat pre-alarm) on the network. These pre-alarms help in diagnosing problems with the inter-genset communications network. If these pre-alarms are not desired, set all expected sequence IDs to zero. If you want to prevent the pre-alarm for a particular machine because it is off line, replace its sequence ID with zero in the *Expected Sequence ID* settings.

Set the number corresponding to the non-zero sequence ID of each machine participating in the inter-genset communications network. If you have N machines, put the non-zero sequence IDs for the N units into the first *N Expected Seq ID* setting positions. Additional *Expected Seq ID* positions should be set to zero.

It is likely that these pre-alarms will sound on multiple machines at the same time. If the cable falls out of a unit, all the units remaining on the network should annunciate ID Missing pre-alarms. In addition, the unit that the cable fell out of should annunciate the pre-alarm as well, since it does not see the IDs of the other machines in its network.

Network status can be viewed in BESTCOMS*Plus*® under METERING EXPLORER > GC-2020 > ENERATOR NETWORK STATUS.

iv. Configure the LSM-2020 Ethernet parameters.

Generators communicate with each other for demand start/stop functionality through inter-genset communications over the Ethernet ports on the LSM-2020s in the system. The *IP address, Subnet Mask,* and *Default Gateway* settings for each LSM-2020 must be configured in order for communication to occur. Instructions for configuring the LSM-2020 Ethernet parameters are found in the paragraphs titled *Ethernet Communications* under *Communications* in Section 4, *BESTCOMSPlus® Software*.

h. Tune the kW, kvar, speed, and voltage controllers.

Controller tuning is performed after all other settings have been configured and is the last step in setting up an MGC-2000 Series and LSM-2020 for load sharing or load control. There are four Proportional - Integral - Derivative (PID) controllers involved when an MGC-2000 Series and LSM-2020 are used in a load sharing or load control system. Each PID controller has settings for the following parameters: Kp, Ki, Kd, Td, and Kg. The controller parameters are configured as part of the controller tuning procedure. The tuning procedures for all PID controllers are presented in Appendix C, *Tuning PID Settings*.

Mains Fail Transfer

The MGC-2000 Series has an internal ATS feature which allows it to monitor the utility, and when the utility fails, opens the mains breaker, starts the generator, then closes the generator breaker to drive the load. When the utility returns and is deemed stable, it will return the load to the utility power. When using the mains fail transfer feature, the MGC-2000 Series will control the breakers to open and close them to achieve the transition from the utility to the generator. Physical inputs can be configured through logic to implement open and close commands for the generator and mains breakers.

Breaker status from a breaker is communicated to the MGC-2000 Series only by having the breaker element (either gen breaker or mains breaker) in the logic diagram and a physical input must be connected to the *Status* input of the breaker block.

When the MGC-2000 Series controls a breaker, the following criteria must be met for a breaker to change state:

1. A gen or mains breaker cannot be closed unless the generator voltage is stable, and the bus voltage is stable or dead. A breaker will not close to a dead bus unless the *Dead Bus Close Enable* parameter found in BESTCOMS*Plus®* under SETTINGS EXPLORER > BREAKER MANAGEMANT > BREAKER HARDWARE is enabled.
2. A breaker will not change state if it receives conflicting commands. In other words, if a physical input is indicating an open command the same time another physical input is indicating a close command, the breaker will not change state.

Steps Required to Configure an MGC-2000 Series for Mains Fail Transfer

1. Connect the MGC-2000 Series according to the appropriate figure in Section 6, *Installation* under *Connections* for the type of connection desired (WYE, DELTA, etc.).
2. Set up the system parameters that will govern engine operation and the alarm and pre-alarm annunciation. Details can be found in the paragraphs titled *MGC-2000 Series Initial Setup.* Additional details of individual settings can be found in Section 4, *BESTCOMSPlus® Software.*
3. Configure main and gen breaker parameters in BESTCOMS*Plus®* under SETTINGS EXPLORER > BREAKER MANAGEMENT > BREAKER HARDWARE. See Figure 7-64.

   Front Panel Navigation Path: SETTINGS > BREAKER MANAGEMENT > BREAKER HARDWARE

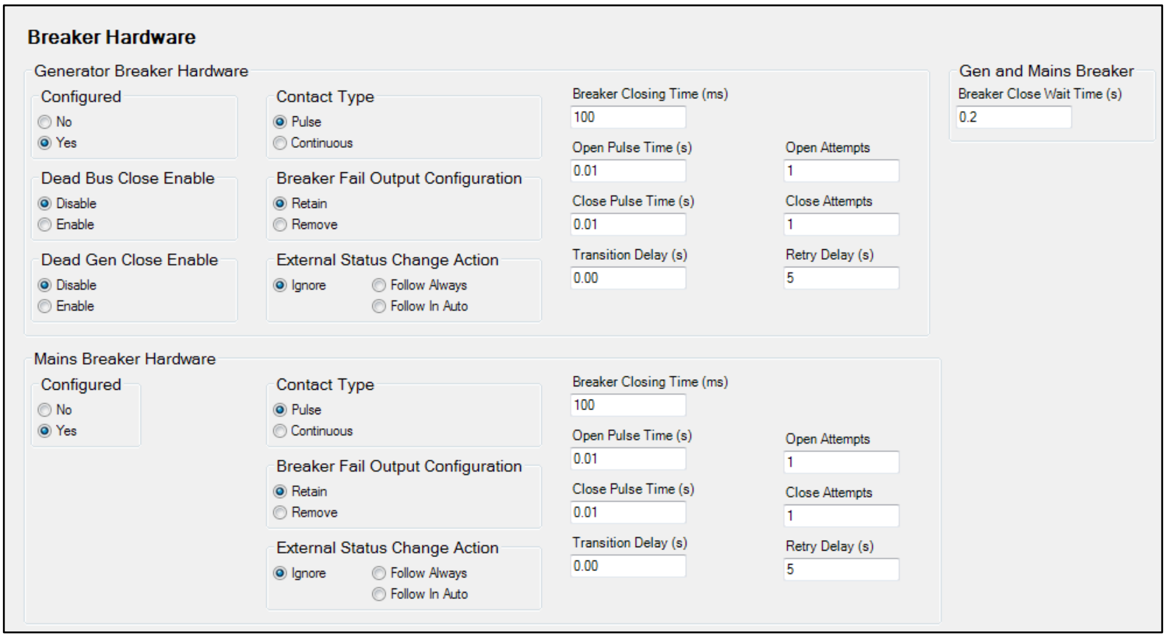

Figure 7-64. Settings Explorer, Breaker Management, Breaker Hardware Screen

a. Configure Mains Fail Transfer parameters in BESTCOMS*Plus* under SETTINGS EXPLORER > BREAKER MANAGEMENT > MAINS FAIL. See *Figure 7-65*.
Front Panel Navigation Path: SETTINGS > BREAKER MANAGEMENT > BREAKER HARDWARE > MAINS FAIL TRANSFER

   i. Enable Mains Fail Transfer

   ii. Enter the transfer and return delays

   iii. Enter the max transfer time. This is the maximum duration allowed for the transfer to be accomplished. If this time is exceeded, a mains fail transfer pre-alarm is annunciated.

   iv. Configure the Mains Fail Transfer Type setting for open or closed transitions. In open transitions, the generator is not connected directly to the utility at any time. In closed transitions, when transitioning the load from the generator to the utility, the generator will synchronize to the utility, close the mains breaker, then open the generator breaker when the generator has unloaded, or when the max parallel time has expired, whichever occurs first.

   v. Set the Max parallel Time if closed transitions are configured. This is the maximum amount of time that the generator is paralleled to the utility when the load is transitioned from the generator back to the utility power.

   vi. Set the In Phase Monitor setting to Enable or Disable if open transitions are selected. When enabled, the MGC-2000 Series initiates an open transition of the load from generator power back to utility power when an alignment phase angle between the generator and the utility passes through zero degrees. This can be less disruptive to certain types of load than transitioning at arbitrary phase angles.

b. Breaker Close Wait Time. (See Figure 7-64) This is a time interval in which it is expected that the breaker will transition from open to closed or closed to open. If it does not change state in that time, either a Gen Breaker Close Fail or Gen Breaker Open Fail is annunciated for Generator breaker failures, and/or Mains Breaker Close Fail or Mains Breaker Open Fail is annunciated for mains breaker failures.

c. Generator Breaker (See Figure 7-64)

   i. Set Dead Bus Close Enable to *Enabled*.

   ii. Select the contact type and enter pulse times if pulsed contacts are used.

iii. Enter the breaker close time. This time is used by the anticipatory synchronizer to calculate the advance angle before 0 degrees slip angle at which to issue the breaker close command.

d. Mains Breaker (See Figure 7-64)

i. Select *Configured* for the mains breaker.

ii. Select the contact type and enter pulse times if pulsed contacts are used.

iii. Enter the breaker close time. This time is used by the anticipatory synchronizer to calculate the advance angle before 0 degrees slip angle at which to issue the breaker close command.

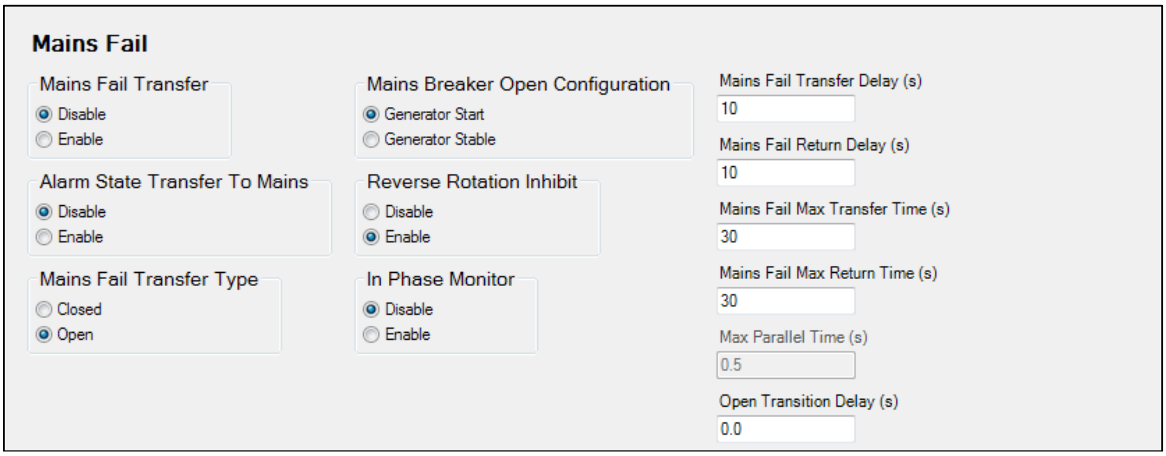

Figure 7-65. Settings Explorer, Breaker Management, Mains Fail Screen

4. Set up the Mains Breaker and Gen Breaker in BESTCOMS*Plus*® under Settings Explorer > BESTlogic*Plus* Programmable Logic. See Figure 7-66.

a. Mains Breaker

i. Drag the Mains Breaker element into the logic diagram.

ii. Connect the breaker element open and close outputs to the contact outputs that will drive the breaker.

iii. Connect the physical input or remote input that has the breaker status (closed if breaker is closed, open when breaker is open) to the *Status* input of the breaker element. This is the only way to indicate breaker status to the MGC-2000 Series.

iv. If it is desired to have physical inputs that can request breaker open and close commands, connect the desired inputs to the open and close command inputs of the breaker element. Note these are to be pulsed inputs; if they are both closed at the same time, the breaker will not change state. If it is not desired to have inputs for breaker commands, connect a “Logic 0” input object to the open and close command inputs of the breaker block.

b. Generator Breaker

i. Drag the Gen Breaker element into the logic diagram.

ii. Connect the breaker element open and close outputs to the contact outputs that will drive the breaker.

iii. Connect the physical input or remote input that has the breaker status (closed if breaker is closed, open when breaker is open) to the *Status* input of the breaker element. This is the only way to indicate breaker status to the MGC-2000 Series.

iv. If it is desired to have physical inputs that can request breaker open and close commands, connect the desired inputs to the open and close command inputs of the breaker element. Note these are to be pulsed inputs; if they are both closed at the same time, the breaker will not change state. If it is not desired to have inputs for breaker commands, connect a “Logic 0” input object to the open and close command inputs of the breaker block.

c. Click the *Save* button when the logic is complete.

d. From the *Communication* pull-down menu, select *Upload Logic* to load the logic into the MGC-2000 Series if connected, or save the settings to a file if working off line.

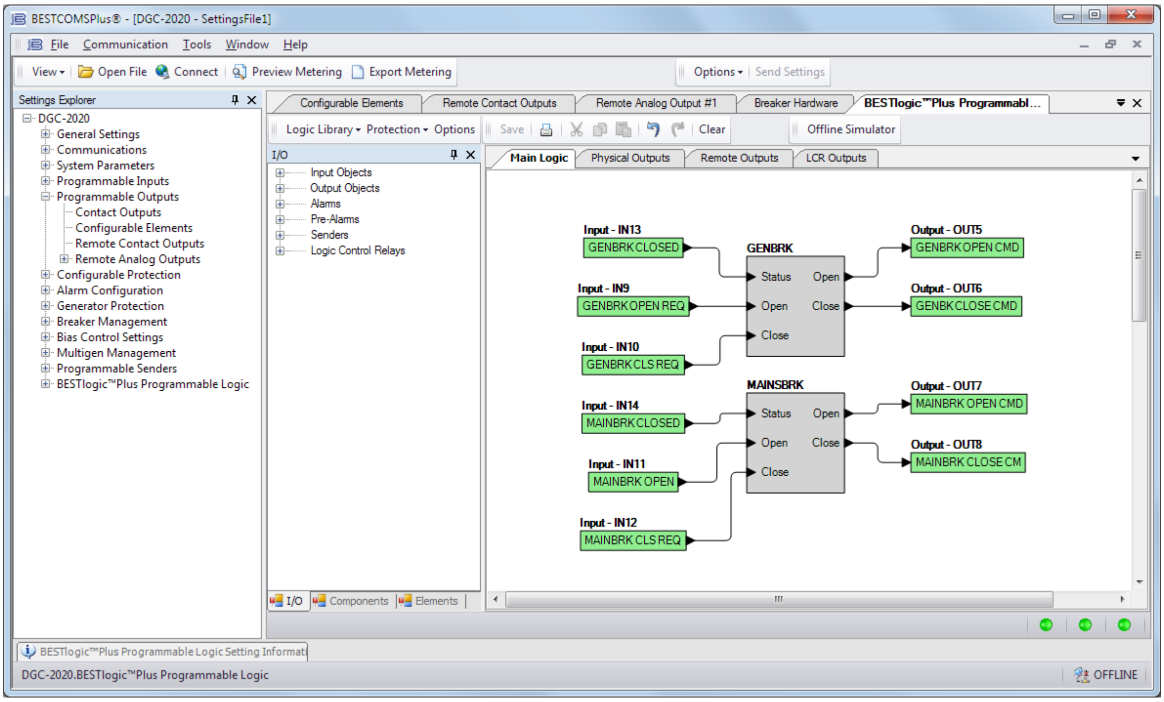

Figure 7-66. Settings Explorer, BESTlogicPlus Programmable Logic

5. Set the parameters for detecting stable and failed bus and generator under SETTINGS EXPLORER > BREAKER MANAGEMENT > BUS CONDITION DETECTION.

   a. Generator Sensing. See Figure 7-67.

      Front Panel Navigation Path: SETTINGS > BREAKER MANAGEMENT > BUS CONDITION DETECT

      i. Dead Bus Voltage Threshold and Activation Delay. When the voltage of either the generator or bus is below this threshold for the duration equal the activation delay, the generator or bus is deemed "Dead".

      ii. Gen Stable Over and Under Voltage Thresholds and Over and Under Frequency Thresholds and the Bus Stable and Bus Failed Activation Delay. When the generator voltage and frequencies are within the specified ranges for the duration equal to the Bus Stable Activation Delay, the generator is deemed "Stable". Otherwise it is deemed "Failed".

   b. Bus Sensing. See Figure 7-67.

      i. Bus Stable Over and Under Voltage Thresholds and Over and Under Frequency Thresholds. When the bus input voltage and frequencies are within the specified ranges for the duration equal to the *Bus Stable Activation Delay*, the bus input is deemed "Stable". Otherwise, it is deemed "Failed".

6. Place the unit in AUTO. The unit is now configured for mains fail transfer operation. It can be tested by removing the input to the bus input terminals, or temporarily modifying the bus condition parameter for the bus input to indicate the bus input has failed. After the mains fail transfer delay has expired, the mains breaker opens, the generator starts, and the gen breaker closes. When the bus is reapplied or the bus condition parameters are re-adjusted to indicate a stable bus input, after the mains fail return delay has expired, the unit opens the generator breaker, closes the mains breaker, cools down, and stops.

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CAUTION
The bus condition parameters are critical because they determine when a breaker can be closed. The generator breaker can be closed when any one of the following is true: • The generator is stable and both breakers are open • The generator is stable and the bus is stable • The generator is stable, the bus is dead, and the dead bus close enable setting is set to enabled • The generator is dead, the dead gen close enable setting is set to enabled, the bus is dead, and the dead bus close enable setting is set to enabled The mains breaker can be closed only when the generator is stable and both breakers are open, or the generator is stable and the bus is stable.

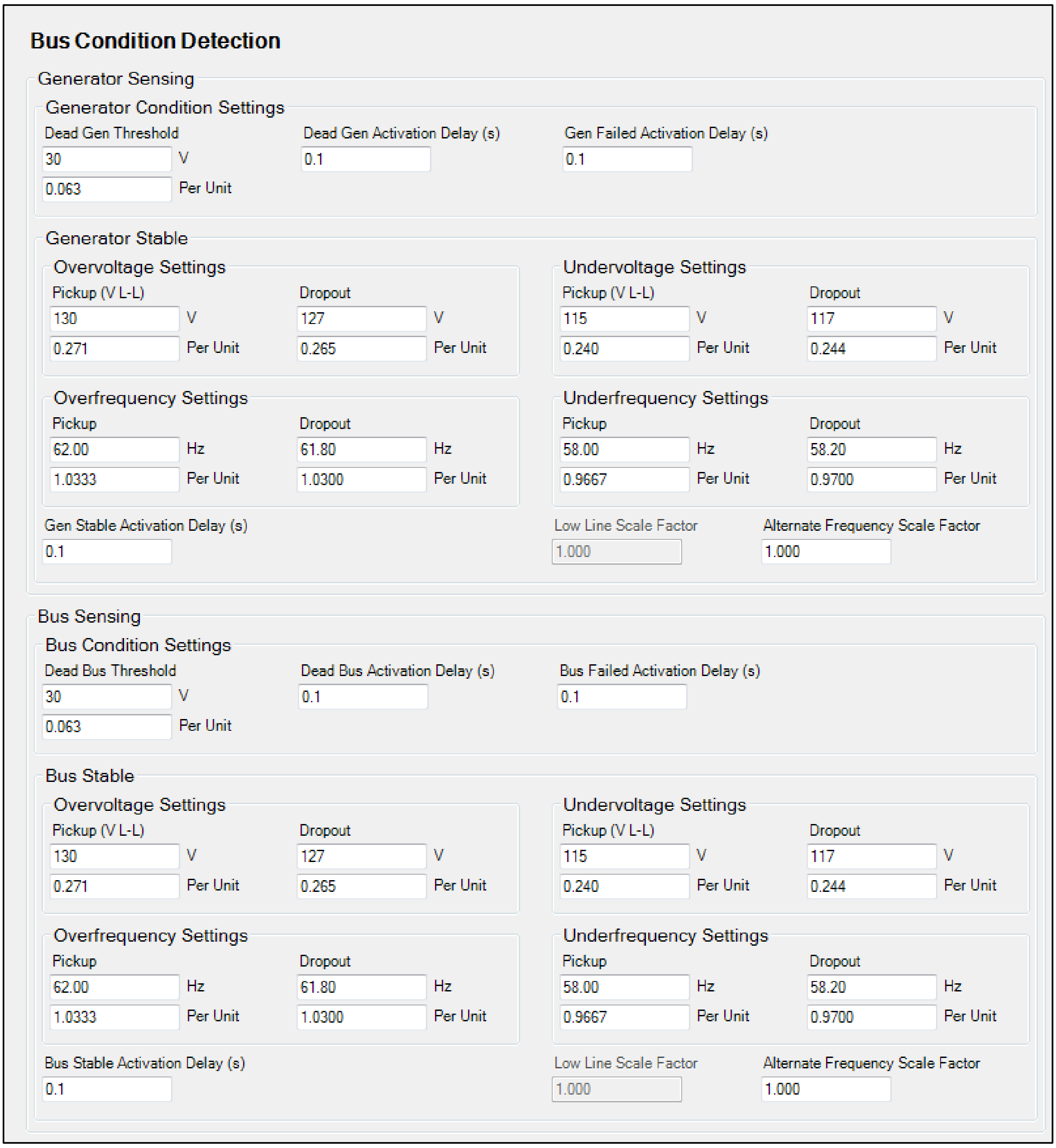

Figure 7-67. Settings Explorer, Breaker Management, Bus Condition Detection Screen

SECTION 8 • MAINTENANCE AND TROUBLESHOOTING

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SECTION 8 • MAINTENANCE AND TROUBLESHOOTING

Maintenance

Preventative maintenance consists of periodic replacement of the backup battery and periodically checking that the connections between the MGC-2000 Series and the system are clean and tight. MGC-2000 Series units are manufactured using state-of-the-art, surface-mount technology. As such, MTU Onsite Energy recommends that no repair procedures be attempted by anyone other than MTU Onsite Energy personnel.

Backup Battery for the Real Time Clock

The backup battery for the real time clock is a standard feature for the MGC-2000 Series Digital Genset Controller. A 3.0 Vdc, 195-mAh lithium battery (type Rayovac BR2032) is used to maintain clock function during loss of power supply voltage. In mobile substation and generator applications, the primary battery system that supplies the MGC-2000 Series power supply may be disconnected for extended periods (weeks, months) between uses. Without battery backup for the real time clock, clock functions will cease if battery input power is removed.

The backup battery has a life expectancy of approximately 10 years. After this time, you should contact MTU Onsite Energy to order a new battery, MTU Onsite Energy P/N 121826.

Battery access is located on the rear side of the MGC-2000 Series.

CAUTION
Replacement of the backup battery for the real-time clock should be performed only by qualified personnel. Do not short-circuit the battery, reverse battery polarity, or attempt to recharge the battery. Observe polarity markings on the battery socket while inserting a new battery. The battery polarity must be correct in order to provide backup for the real-time clock. It is recommended that the battery be removed if the MGC-2000 Series is to be operated in a salt-fog environment. Salt fog is known to be conductive and may short-circuit the battery.

NOTE
Failure to replace the battery appropriately may void the warranty. Contact MTU Onsite Energy for information on battery part #121826.

Troubleshooting

If you do not get the results that you expect from the MGC-2000 Series, first check the programmable settings for the appropriate function. Use the following troubleshooting procedures when difficulties are encountered in the operation of your genset control system.

Communications

Ethernet Port Does Not Operate Properly

Step 1. Verify that the proper port of your computer is being used. For more information, refer to Section 4, *BESTCOMSPlus® Software, Communication*.

Step 2. Verify the network configuration of the LSM-2020 and MGC-2000 Series are set up properly. For more information, refer to Section 4, *BESTCOMSPlus® Software, Communication.*

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Step 3. Verify that all Ethernet devices comply with IEC 61000-4 series of specifications for Industrial Ethernet Devices. Commercial devices are not recommended and may result in erratic network communications.

USB Port Does Not Operate Properly

Step 1. Verify that the proper port of your computer is being used. For more information, refer to Section 4, *BESTCOMSPlus® Software, Communication*.

CAN Bus Communication Does Not Operate Properly

Step 1: Verify that there is a 120-ohm termination resistor on each end of the bus section of the wiring, and that there are not any termination resistors at any node connections that are on stubs from the main bus.

Step 2: Check all CAN bus wiring for loose connections, and verify that the CAN H and CAN L wires have not gotten switched somewhere on the network.

Step 3: Verify that the cable length of the bus section of the wiring does not exceed 40 meters (131 feet), and verify that any stubs from the main bus do not exceed 3 meters (10 feet) in length.

Step 4: If the Engine ECU is a Volvo or MTU ECU, verify that the ECU Configuration setting is set to match the ECU configuration.

Inputs and Outputs

Programmable Inputs Do Not Operate as Expected

Step 1. Verify that all wiring is properly connected. Refer to Section 6, *Installation, Connections*.

Step 2. Confirm that the inputs are programmed properly.

Step 3. Ensure that the input at the MGC-2000 Series is actually connected to the BATT– terminal (2).

Programmable Outputs Do Not Operate as Expected

Step 1. Verify that all wiring is properly connected. Refer to Section 6, *Installation, Connections*.

Step 2. Confirm that the outputs are programmed properly.

Metering/Display

Incorrect Display of Battery Voltage, Coolant Temperature, Oil Pressure, or Fuel Level

Step 1. Verify that all wiring is properly connected. Refer to Section 6, *Installation, Connections.*

Step 2. Confirm that the SENDER COM terminal (11) is connected to the negative battery terminal and the engine-block side of the senders. Current from other devices sharing this connection can cause erroneous readings.

Step 3. If the displayed battery voltage is incorrect, ensure that the proper voltage is present between the BATT+ terminal (3) and the SENDER COM terminal (11).

Step 4. Verify that the correct senders are being used.

Step 5. Use a voltmeter connected between the BATT-terminal (2) and the SENDER COM terminal (11) on the MGC-2000 Series to verify that there is no voltage difference at any time. Any voltage differences may manifest themselves as erratic sender readings. Wiring should be corrected so that no differences exist.

Step 6: Check the sender wiring and isolate sender wiring from any of the AC wiring in the system. The sender wiring should be located away from any power AC wiring from the generator and any ignition wiring. Separate conduits should be used for sender wiring and any AC wiring.

Incorrect Display of Generator Voltage

Step 1. Verify that all wiring is properly connected. Refer to Section 6, *Installation, Connections*.

Step 2. Ensure that the proper voltage is present at the MGC-2000 Series voltage sensing inputs (41, 39, 37, and 35).

Step 3. Verify that the voltage transformer ratio and sensing configuration is correct.

Step 4. Confirm that the voltage sensing transformers are correct and properly installed.

Incorrect Measurement or Display of Generator Current

Step 1. Verify that all wiring is properly connected. Refer to Section 6, *Installation, Connections*.

Step 2. Ensure that the proper current is present at the MGC-2000 Series current sensing inputs 68/69, 71/72, and 74/75.

Step 3. Verify that the current sensing transformer ratios are correct.

Step 4. Confirm that the current sensing transformers are correct and properly installed.

Incorrect Display of Engine RPM

Step 1. Verify that all wiring is properly connected. Refer to Section 6, *Installation, Connections*.

Step 2. Verify that the flywheel teeth setting is correct.

Step 3. Verify that the prime mover governor is operating properly.

Step 4. Verify that the measured frequency of the voltage at the MPU input (31 and 32) is correct.

Step 5. If the MPU is shared with the governor, verify that the polarity of the MPU input to the governor matches the polarity of the MPU input to the MGC-2000 Series.

MGC-2000 Series Indicates Incorrect Power Factor

Check the rotation of the machine and the labeling of the A-B-C terminals. The machine must be rotating in clockwise (A-B-C) phase sequence for correct power factor metering. A power factor indication of 0.5 with resistive load present is a symptom of incorrect phase rotation.

LCD is Blank and all LEDs are Flashing at Approximately 2 Second Intervals

This indicates that the MGC-2000 Series does not detect that valid application firmware is installed. The unit is running its boot loader program, waiting to accept a firmware upload.

Step 1. Start BESTCOMS*Plus*®. Use the top pull-down menu and select FILE > NEW > DGC-2020.

Step 2. Select COMMUNICATIONS > UPLOAD DEVICE FILES and select the device package file that contains the firmware and language you want to upload.

Step 3. Check the boxes for DGC-2020 Firmware and DGC-2020 Language Module. Click the UPLOAD button to start the upload process.

Generator Breaker and Mains Breaker

Generator Breaker Will Not Close to a Dead Bus

Step 1: Review the description of how the generator breaker logic element functions contained in the GENBRK logic element description in Section 5, *BESTlogic*™Plus *Programmable Logic.*

Step 2: Review the section on breaker close requests in Section 3, *Functional Description, Breaker Management.*

Step 3: Navigate to the SETTINGS > BREAKER MANAGEMENT > BREAKER HARDWARE > GEN BREAKER screen and set DEAD BUS CL ENBL to ENABLE.

Step 4: Verify that the Generator status is stable. The breaker will not close if the generator status is not stable. Check status by using the Metering Explorer in BESTCOMS*Plus*® and verify that when the generator is running, the GEN STABLE status LED is lit. If necessary, modify the settings on the SETTINGS > BREAKER MANAGEMENT > BUS CONDITION DETECTION screen.

Step 5: Verify the bus status is DEAD. Check status by using the Metering Explorer in BESTCOMS*Plus*® and verify that when the generator is running, the BUS DEAD status LED is lit. If necessary, modify the settings on the SETTINGS > BREAKER MANAGEMENT > BUS CONDITION DETECTION screen.

Step 6: Verify the connections in BESTlogic*Plus* Programmable Logic to the generator breaker logic element. The *Status* input must be driven by an "A" or normally open contact from the generator breaker. The OPEN and CLOSE command inputs on the left side of the logic block are inputs for open and close commands. These can be wired to physical inputs if it is desired to have open and close command switches. If they are wired, they must either be pulsed inputs, or some logic must be employed so that the open and close command inputs are never driven at the same time. If these are both driven at the same time, the breaker is receiving open and

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close commands simultaneously. The breaker will not change state if it is being commanded to open and close at the same time.

Step 7: Verify the breaker is receiving a close command. Breaker close command sources are:

- The MGC-2000 Series itself when the automatic transfer (ATS) feature is enabled.
- The MGC-2000 Series itself when the RUN WITH LOAD logic element receives a *Start* pulse in the programmable logic.
- The MGC-2000 Series itself when started from a Demand Start as part of demand start/stop and sequencing.
- The MGC-2000 Series itself when started from the Exercise Timer and the Run with Load box is checked in the Generator Exerciser settings.
- Manual Breaker Close Input Contacts applied to the Open and Close inputs on the left side of the Generator Breaker logic element in the programmable logic.

Step 8: Verify the wiring to the breaker from the MGC-2000 Series. If it seems OK, you can do a manual close and open by modifying the programmable logic. Map some unused outputs to the OPEN and CLOSE outputs from the Gen Breaker Block in the programmable logic. Map a virtual switch to the logic output that would normally be the breaker close output. Map another virtual switch to the logic output that would normally be the breaker close output. Connect with BESTCOMS*Plus*®, and exercise the virtual switches using the Control panel located in the Metering Explorer. Never turn open and close on at the same time. This could damage the breaker and/or motor operator. If everything is working as expected, restore the logic to its original diagram.

Generator Breaker Will Not Close to a Live Bus

Step 1: Review the description of how the generator breaker logic element functions contained in the GENBRK logic element description in Section 5, *BESTlogicPlus Programmable Logic.*

Step 2: Review the section on breaker close requests in Section 3, *Functional Description, Breaker Management.*

Step 3: Verify that the Generator status is stable. The breaker will not close if the generator status is not stable. Check status using the Metering Explorer in BESTCOMS*Plus*® and verify that when the generator is running, the GEN STABLE status LED is lit. If necessary, modify the settings on the SETTINGS > BREAKER MANAGEMENT > BUS CONDITION DETECTION screen.

Step 4: Verify that the Bus status is stable. The breaker will not close if the bus is not stable, check status using the Metering Explorer in BESTCOMS*Plus*® and verify that when the generator is running, the BUS STABLE status LED is lit. If necessary, modify the settings on the SETTINGS > BREAKER MANAGEMENT > BUS CONDITION DETECTION screen.

Step 5: Verify the connections in BESTlogic*Plus* Programmable Logic to the generator breaker logic element. The *Status* input must be driven by an "A" or normally open contact from the generator breaker. The OPEN and CLOSE command inputs on the left side of the logic block are inputs for open and close commands. These can be wired to physical inputs if it is desired to have open and close command switches. If they are wired, they must either be pulsed inputs, or some logic must be employed so that the open and close command inputs are never driven at the same time. If these are both driven at the same time, the breaker is receiving open and close commands simultaneously. The breaker will not change state if it is being commanded to open and close at the same time.

Step 6: Verify the breaker is receiving a close command. Breaker close command sources are:

- The MGC-2000 Series itself when the automatic transfer (ATS) feature is enabled.
- The MGC-2000 Series itself when the RUN WITH LOAD logic element receives a *Start* pulse in the programmable logic.
- The MGC-2000 Series itself when started from a Demand Start as part of demand start/stop and sequencing.
- The MGC-2000 Series itself when started from the Exercise Timer and the Run with Load box is checked in the Generator Exerciser settings.
- Manual Breaker Close Input Contacts applied to the Open and Close inputs on the left side of the Generator Breaker logic element in the programmable logic.

Step 7: Verify the synchronizer is operating properly; refer to the synchronizer portion of the troubleshooting steps.

Step 8: Verify the wiring to the breaker from the MGC-2000 Series. If it seems OK, you can do a manual close and open by modifying the programmable logic. Map some unused outputs to the OPEN and CLOSE outputs from the Gen Breaker Block in the programmable logic. Map a virtual switch to the logic output that would normally be the breaker close output. Map another virtual switch to the logic output that would normally be the breaker close output. Connect with BESTCOMS*Plus*®, and exercise the virtual switches using the Control panel located in the Metering Explorer. Never turn open and close on at the same time. This could damage the breaker and/or motor operator. If everything is working as expected, restore the logic to its original diagram.

Generator Breaker Does Not Open When It Should

Step 1: Review the description of how the generator breaker logic element functions contained in the GENBRK logic element description in Section 5, *BESTlogicPlus Programmable Logic.*

Step 2: Review the section on breaker close requests in Section 3, *Functional Description, Breaker Management.*

Step 3: Verify the connections in BESTlogic*Plus* Programmable Logic to the generator breaker logic element. The *Status* input must be driven by an "A" or normally open contact from the generator breaker. The OPEN and CLOSE command inputs on the left side of the logic block are inputs for open and close commands. These can be wired to physical inputs if it is desired to have open and close command switches. If they are wired, they must either be pulsed inputs, or some logic must be employed so that the open and close command inputs are never driven at the same time. If these are both driven at the same time, the breaker is receiving open and close commands simultaneously. The breaker will not change state if it is being commanded to open and close at the same time.

Step 4: Verify the breaker is receiving a close command. Breaker close command sources are:

- The MGC-2000 Series itself when the automatic transfer (ATS) feature is enabled.
- The MGC-2000 Series itself when the RUN WITH LOAD logic element receives a *Start* pulse in the programmable logic.
- The MGC-2000 Series itself when started from a Demand Start as part of demand start/stop and sequencing.
- The MGC-2000 Series itself when started from the Exercise Timer and the *Run with Load* box is checked in the Generator Exerciser settings.
- Manual Breaker Close Input Contacts applied to the Open and Close inputs on the left side of the Generator Breaker logic element in the programmable logic.

Step 5: Verify the wiring to the breaker from the MGC-2000 Series. If it seems OK, you can do a manual close and open by modifying the programmable logic. Map some unused outputs to the OPEN and CLOSE outputs from the Gen Breaker Block in the programmable logic. Map a virtual switch to the logic output that would normally be the breaker close output. Map another virtual switch to the logic output that would normally be the breaker close output. Connect with BESTCOMS*Plus*®, and exercise the virtual switches using the Control panel located in the Metering Explorer. Never turn open and close on at the same time. This could damage the breaker and/or motor operator. If everything is working as expected, restore the logic to its original diagram.

Mains Breaker Does Not Open When Mains Fails

Step 1: Verify that a Mains Breaker has been configured by examining the settings on the SETTINGS > BREAKER MANAGEMENT > BREAKER HARDWARE screen.

Step 2: Verify the mains breaker has been correctly included in the programmable logic.

Step 3: Verify that the MAINS FAIL TRANSFER parameter is set to ENABLE on the SETTINGS > BREAKER MANAGEMENT > BREAKER HARDWARE screen.

Step 4: Verify that a failure of the mains is detected by the MGC-2000 Series. Check status using the Metering Explorer in BESTCOMS*Plus*® and verify that the MAINS FAIL status LED is lit when the power on the MGC-2000 Series bus voltage input is either out of voltage or frequency range. If necessary, modify the settings on the SETTINGS > BREAKER MANAGEMENT > BUS CONDITION DETECTION screen to achieve correct detection.

Step 5: Verify the wiring to the breaker from the MGC-2000 Series. If it seems OK, you can do a manual close and open by modifying the programmable logic. Map some unused outputs to the OPEN and CLOSE outputs from the Gen Breaker Block in the programmable logic. Map a

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virtual switch to the logic output that would normally be the breaker close output. Map another virtual switch to the logic output that would normally be the breaker close output. Connect with BESTCOMS*Plus*®, and exercise the virtual switches using the Control panel located in the Metering Explorer. Never turn open and close on at the same time. This could damage the breaker and/or motor operator. If everything is working as expected, restore the logic to its original diagram.

Mains Breaker Does Not Close After Mains Returns

Step 1: Verify that a Mains Breaker has been configured by examining the settings on the SETTINGS > BREAKER MANAGEMENT > BREAKER HARDWARE screen.

Step 2: Verify the mains breaker has been correctly included in the programmable logic.

Step 3: Verify that the MAINS FAIL TRANSFER parameter is set to ENABLE on the SETTINGS > BREAKER MANAGEMENT > BREAKER HARDWARE screen.

Step 4: Verify that stable mains power is detected by the MGC-2000 Series. Check status using the Metering Explorer in BESTCOMS*Plus*® and verify that the MAINS STABLE status LED is lit when the power on the MGC-2000 Series bus voltage input is good. If necessary, modify the settings on the SETTINGS > BREAKER MANAGEMENT > BUS CONDITION DETECTION screen to achieve correct detection.

Step 5: Verify the wiring to the breaker from the MGC-2000 Series. If it seems OK, you can do a manual close and open by modifying the programmable logic. Map some unused outputs to the OPEN and CLOSE outputs from the Gen Breaker Block in the programmable logic. Map a virtual switch to the logic output that would normally be the breaker close output. Map another virtual switch to the logic output that would normally be the breaker close output. Connect with BESTCOMS*Plus*®, and exercise the virtual switches using the Control panel located in the Metering Explorer. Never turn open and close on at the same time. This could damage the breaker and/or motor operator. If everything is working as expected, restore the logic to its original diagram.

Synchronizer

Determining if the Synchronizer is Active

Step 1: Disable the speed trim function.

Step 2: Initiate a breaker close request by one of the methods listed in Section 3, *Functional Description, Breaker Management.*

Step 3: Check for raise and/or lower pulses coming from the MGC-2000 Series if the governor or AVR bias control output type is contact.

Step 4: Check the governor and/or AVR bias analog outputs on the load share module with a volt meter if the governor or AVR bias control output type is analog.

Step 5: The voltages or raise/lower pulses should be changing when the synchronizer is active. If there are no raise/lower pulses, or if the analog bias voltages do not change, the synchronizer is not active.

Synchronizer Not Active

Step 1: Check style number to verify that the MGC-2000 Series has the synchronizer option. If the synchronizer option does not exist in the style number, you may contact Basler Electric and request a style number change.

Step 2: Check status using the Metering Explorer in BESTCOMS*Plus*® and verify that when the generator is running, the GEN STABLE status LED is lit and the BUS STABLE LED is lit. Adjust the Bus Condition Detection settings accordingly. The synchronizer will never activate if the Bus is Dead or Failed (i.e. not stable).

Step 3: Check that the MGC-2000 Series is trying to initiate a breaker closure. To determine the sources of breaker close requests, refer to Section 3, *Functional Description, Breaker Management.*

Synchronizer Active for a Short Time, Then Stops

Step 1: Check if a Sync Fail pre-alarm or a Breaker Close Fail pre-alarm is occurring or has occurred. The synchronizer stops acting when such a pre-alarm occurs. Press the *Off* button or the *Reset* button on the MGC-2000 Series front panel to clear these pre-alarms.

Step 2: Verify that the Sync Fail Activation delay is sufficiently long to allow the synchronizer to complete the synchronization process.

Step 3: Verify that the Breaker Close Wait time is not too short causing a pre-alarm to occur before the breaker closes when a breaker close is initiated by the MGC-2000 Series.

Synchronizer Does Not Lower Engine Speed Allowing Alignment of Bus and Generator

Step 1: Using the front panel HMI, navigate to the SETTINGS > MULTIGEN MANAGEMENT > GOV ANALOG OUTPUT screen and set SPD RESPONSE to DECREASING.

Synchronizer Does Not Raise Engine Speed Allowing Alignment of Bus and Generator

Step 1: Using the front panel HMI, navigate to the SETTINGS > MULTIGEN MANAGEMENT > GOV ANALOG OUTPUT screen and set SPD RESPONSE to DECREASING.

Synchronizer Does Not Lower the Generator Voltage to Achieve Matching of Bus and Generator Voltages

Step 1: Navigate to the SETTINGS > MULTIGEN MANAGEMENT > AVR ANALOG OUTPUT screen and set VOLT RESPONSE to DECREASING.

Synchronizer Does Not Raise Generator Voltage to Achieve Matching of Bus and Generator Voltages

Step 1: Navigate to the SETTINGS > MULTIGEN MANAGEMENT > AVR ANALOG OUTPUT screen and set VOLT RESPONSE to DECREASING.

Speed Bias

Engine Speed Does Not Change When Speed Bias Voltage Changes

Step 1: Verify that the engine speed will change when the speed bias changes. As a test, you can force a voltage on the speed bias output by setting the Min Output Voltage and Max Output Voltage to the same value by navigating to SETTINGS > MULTIGEN MANAGEMENT > GOV ANALOG OUPUT. If the bias is current based, you can force a fixed current by setting the Governor Output Current Minimum and Maximum to the same value by navigating to SETTINGS > MULTIGEN MANAGEMENT > GOV ANALOG OUTPUT.

If the speed still does not change when varying the bias:

- Verify that the governor or ECU is equipped and configured to accept bias inputs.
- Check connections to verify the wiring to the governor bias is correct.
- If you have an engine with an ECU, check ECU programming to verify it is set up to accept a speed bias input.

Engine Speed Decreases When Speed Bias is Increased

Step 1: Navigate to the SETTINGS > MULTIGEN MANAGEMENT > GOV ANALOG OUTPUT screen and set SPD RESPONSE to DECREASING.

Engine Speed Increases When Speed Bias is Decreased

Step 1: Navigate to the SETTINGS > MULTIGEN MANAGEMENT > GOV ANALOG OUTPUT screen and set SPD RESPONSE to DECREASING.

Voltage Bias

Generator Voltage Does Not Change When Voltage Bias Changes

Step 1: As a test, you can force a voltage on the AVR bias output by setting the Min Output Voltage and Max Output Voltage to the same value by navigating to SETTINGS > MULTIGEN MANAGEMENT > AVR OUTPUT. If the bias is current based, you can force a fixed current by setting the Min Output Current and Max Output Current to the same value by navigating to SETTINGS > MULTIGEN MANAGEMENT > AVR OUTPUT.

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If the voltage still does not change when varying the bias:

- Verify that the AVR is equipped and configured to accept bias inputs.
- Check connections to verify the wiring to the AVR bias is correct.
- If you have digital voltage regulator, verify it set up and programmed to accept a voltage bias input.

Generator Voltage Decreases When AVR Speed Bias is Increased

Step 1: Navigate to the SETTINGS > MULTIGEN MANAGEMENT > AVR OUTPUT screen and set VOLT RESPONSE to DECREASING.

Generator Voltage Increases When Speed Bias is Decreased

Step 1: Navigate to the SETTINGS > MULTIGEN MANAGEMENT > AVR OUTPUT screen and set VOLT RESPONSE to DECREASING.

Load Sharing

Generator Breaker Status is not being received by the MGC-2000 Series

Step 1: Close the generator breaker. Verify that the MGC-2000 Series sees the status indicating the generator breaker is closed. This is found on the front panel or in BESTCOMS*Plus*® under METERING > STATUS > GEN BREAKER.

Step 2: If the status is not correct, check the digital input status on the MGC-2000 Series through which the breaker status is fed by examining the input with BESTCOMS*Plus*® under METERING > INPUTS > CONTACT INPUTS or METERING > INPUTS > RE`MOTE CONTACT INPUTS.

Step 3: If the input status is correct, but the Gen Breaker status under METERING→STATUS is not, check the PLC logic, and verify that the Gen Breaker is fed into the MGC-2000 Series is tied in logic to the *Status* input on the Gen Breaker logic element.

Step 4: Make any corrections and re-check that the status is received correctly.

Generator Runs at Incorrect Speed when Generator Breaker is Closed

Step 1: Verify generator breaker status is being correctly received as described in *Generator Breaker Status is not being received by the MGC-2000 Series*. If the status is correct, proceed to the steps below.

Step 2: Check the range set for the LSM-2020 Governor Bias output by examining the Min. and Max. Output voltage or current settings under MULTIGEN MANAGEMENT→GOVERNOR BIAS OUTPUT. Verify that this range is valid for the governor or engine specified.

Step 3: Perform the tests in Step 1 of *Speed Bias* in this section to verify that setting the output to different values within its range causes engine speed to vary in the desired manner.

Step 4: Measure the voltage or current on the governor analog bias signal from the LSM-2020. This signal is found on terminals P2-14 (GOV–) and P2-15 (GOV+). If the output is at the midpoint of its range, the generator should run at rated speed.

Step 5: Check the SPEED BIAS parameter in the LSM DEBUG screen found on the front panel at SETTINGS > SYSTEM PARAMS > REMOTE MODULE SETUP > LSM SETUP > LOAD SHARE DEBUG. Check if the normalized value from the LSM DEBUG screen corresponds to the value measured at LSM-2020 terminals P2-14 (GOV–) and P2-15 (GOV+). If the normalized value is 0.00, the output should be in the midpoint of its range. If the normalized value is 1.00, the output should be in the maximum point of its range. If the normalized value is –1.00, the output should be in the minimum point of its range. Any other values are scaled within the range. If the normalized value and the measured output do not match up, either there are wiring errors, or some external device is driving the governor bias signal at the same time as the LSM-2020. Correct this conflicting situation if it exists.

Step 6: Check that the signal being measured at the LSM-2020 terminals P2-14 (GOV–) and P2-15 (GOV+) is carried to the actual governor bias inputs on the engine governor. Measurements should be the same as they were on the LSM-2020. If not, correct the wiring errors.

Step 7: Check if there are any relay contacts in the path between the LSM-2020 governor bias outputs and the engine governor's bias input. Any relay contacts that are used to switch load share lines, governor analog speed bias signals, or voltage regulator analog voltage bias signals must use a relay intended for low voltage, low current applications to preserve signal integrity. Signal relays, not power relays, must be used for this application. Verify the relay contacts are not affecting the signal.

Step 8: If speed trim is enabled, verify that the speed trim set point is at the correct value for desired operation.

Generators Do Not Share Load Equally

Step 1: Verify that load sharing is enabled in SETTINGS > BIAS CONTROL SETTINGS > GOVERNOR BIAS CONTROL SETTINGS > LOAD CONTROL ENABLED.

Step 2: Verify generator breaker status is being correctly received as described in *Generator Breaker Status is not being received by the MGC-2000 Series.* If the status is correct, proceed to Step 3.

Step 3: Check the Load Share Line operating voltage range by examining the Min. and Max. Voltage parameters found in BESTCOMS*Plus*® under SETTINGS > MULTIGEN MANAGEMENT > LOAD SHARE OUTPUT. The range must be the same for all machines in the load share system.

Step 4: Measure the Load Share line voltage at terminals P2-5 (LS–) and P2-6 (LS+) on the LSM-2020. The same voltage should be present on each LSM-2020. If not, correct any issues.

Step 5: Examine the FDBK VOLT on the front panel of the MGC-2000 Series under SETTINGS > SYSTEM PARAMS > REMOTE MODULE SETUP > LSM SETUP > LSM DEBUG. This is the voltage read from the load share lines by the MGC-2000 Series. Verify this voltage matches the voltage read with a voltmeter across LSM-2020 terminals P2-5 (LS–) and P2-6 (LS+). Verify the same FDBK VOLT is present on all the machines in the load share system. If they are not equal, examine the load share line wiring and correct any issues.

Step 6: Check if there are any contacts in the load share line path between the LSM-2020s. Any relay contacts that are used to switch load share lines, governor analog bias signals, or voltage regulator analog voltage bias signals must use a relay intended for low voltage, low current applications to preserve signal integrity. Signal relays, not power relays, must be used for this application. Verify the relay contacts are not affecting the signal.

Step 7: If there are still issues, disconnect the load share line from the LSM-2020. Run the single machine with load, and verify that it loads and unloads correctly, and runs at the correct speed. Repeat for each machine.

Step 8: Re-attach load share lines to all LSM-2020s that are part of the load sharing system. Run the SINGLE machine with load, and verify that it loads and unloads correctly, and runs at the correct speed. If the machine slows down when the generator breaker is closed, check the load share line voltage. It should be equal, on a normalized basis, to the normalized kW produced by the generator. As an example, if the generator is loaded to 50% capacity, the Load Share Line voltage should be at the midpoint of the range. If it is not, something is driving the load share line that should not be. The single unit should be the only device driving the load share lines.

Step 9: Disconnect the load share lines from each non-running machine and see if the speed of the running machine is correct. If a particular LSM-2020 on a non-running machine seems to affect the performance of the running machine, that LSM-2020 may be damaged such that the Load Share Line contacts are sticking, causing the LSM-2020 to drive the load share line even though the generator breaker is open. Tap the relays to see if the problem clears up. If so, a faulty LSM-2020 relay is indicated. Replace the LSM-2020, or wire in external contacts to remove the LSM-2020 from the load share system when the generator breaker is closed.

Step 10: If it appears that something is driving the load share line but it is not the LSM-2020 on one of the non-running units, search for an external device that is driving or loading down the load share lines.

Step 11: Repeat the preceding 3 steps for each machine.

Load Sharing Works Correctly, but a Single Unit Slows Down

With all units running, load sharing works correctly, but a single unit slows down after the generator breaker is closed.

Step 1: Disconnect the load share line from the LSM-2020. Run the single machine with load, and verify that it loads and unloads correctly, and runs at the correct speed. Repeat for each machine.

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Step 2: Re-attach load share lines to all LSM-2020s that are part of the load sharing system. Run the SINGLE machine with load, and verify that it loads and unloads correctly, and runs at the correct speed. If the machine slows down when the generator breaker is closed, check the load share line voltage. It should be equal, on a normalized basis, to the normalized kW produced by the generator. As an example, if the generator is loaded to 50% capacity, the Load Share Line voltage should be at the midpoint of the range. If it is not, something is driving the load share line that should not be. The single unit should be the only device driving the load share lines.

Step 3: Disconnect the load share lines from each non-running machine and see if the speed of the running machine is correct. If a particular LSM-2020 on a non-running machine seems to affect the performance of the running machine, that LSM-2020 may be damaged such that the Load Share Line contacts are sticking, causing the LSM-2020 to drive the load share line even though the generator breaker is open. Tap the relays to see if the problem clears up. If so, a faulty LSM-2020 relay is indicated. Replace the LSM-2020, or wire in external contacts to remove the LSM-2020 from the load share system when the generator breaker is closed.

Step 4: If it appears that something is driving the load share line but it is not the LSM-2020 on one of the non-running units, search for an external device that is driving or loading down the load share lines.

Step 5: Repeat the preceding 3 steps for each machine.

MGC-2000 Series Front Panel Debug Screens

There are several debug screens in the MGC-2000 Series that can be useful for debugging load sharing issues and I/O module related issues. The following debug screens are available: LOAD SHARE DEBUG, CONTROL DEBUG, CEM DEBUG, and AEM DEBUG.

LOAD SHARE DEBUG

This screen is useful for debugging load share related issues, and kW and var control related issues. It gives visibility into the parameters metered and controlled by the LSM-2020.

The LOAD SHARE DEBUG screen is located on the front panel at SETTINGS > SYSTEM PARAMS > REMOTE MODULE SETUP > LSM SETUP > LOAD SHARE DEBUG.

The following parameters are visible on the LOAD SHARE DEBUG screen:

- FDBK VOLT: Voltage the LSM-2020 sees on its load share line input. Terminals P2-5 (LS–) and P2-6 (LS+). This measurement is useful for debugging load share issues. Normally, all machines that have their generator breakers closed should measure the same voltage for FDBK VOLT. If this voltage differs, check for wiring errors, or problems with any relay contacts in the load share line wiring. Any relay contacts that are used to switch load share lines, governor analog speed bias signals, or voltage regulator analog bias signals must use a relay intended for low voltage, low current applications to preserve signal integrity. Signal relays, not power relays, must be used for this application.
- AUX VOLT: Voltage the LSM-2020 sees on its analog input. Terminals P2-8 (IN–) and P2-9 (V+).
- AUX CURRENT: Current the LSM-2020 sees on its analog input. Terminals P2-7 (IN+) and P2-8 (IN–).
- SPEED BIAS: This is the normalized value to which the LSM-2020 drives the governor analog bias output. If the value is –1.0, the output will be driven to the minimum value of the governor bias output range. If the value is 1.0, the output will be driven to the maximum value of the governor bias output range. If the value is 0.000, the output will be driven to the midpoint value (i.e. half way between maximum and minimum values) of the governor bias output range. If the generator breaker is open, or if the generator breaker is closed and speed trim and kW control are disabled, the output from the LSM-2020 will be the midpoint of the range, indicating the generator should run at rated speed. Any relay contacts that are used to switch load share lines, governor analog speed bias signals, or voltage regulator analog voltage bias signals must use a relay intended for low voltage, low current applications to preserve signal integrity. Signal relays, not power relays, must be used for this application.
- VOLT BIAS: This is the normalized value to which the LSM-2020 drives the voltage regulator analog bias output. If the value is –0.1, the output will be driven to the minimum value of the voltage regulator bias output range. If the value is 1.0, the output will be driven to the maximum value of the voltage regulator bias output range. If the value is 0.00, the output will be driven to

the midpoint value (i.e. half way between maximum and minimum values) of the voltage regulator bias output range. If the generator breaker is open, voltage trim and kvar control are disabled, so the output from the LSM-2020 will be the midpoint of the range, indicating the voltage regulator should operate at rated voltage. Any relay contacts that are used to switch load share lines, governor analog speed bias signal, or voltage regulator analog voltage bias signals must use a relays intended for low voltage, low current applications to preserve signal integrity. Signal relays, not power relays, must be used for this application.

- WATT DEMAND: This is the normalized kW demand requested by the LSM-2020. It is the desired amount of power that the generator produces. It is normalized such that 1.0 indicates the full kW capacity of the generator, 0.5 indicates 50% of the generator's capacity, etc. When the generator breaker is closed, and the kW controller is enabled, the WATT DEMAND indicates what level of power should be generated. In an island load share system, this will correspond to the value read on the load share lines. If the load share lines are at the 50% point of the load share voltage range, the WATT DEMAND will be 0.50. If the generator breaker is closed, and the PARALLEL TO MAINS logic element is true, the WATT DEMAND will be equal to the base load set point. When the generator breaker is open or the kW controller is disabled, the WATT DEMAND will always be equal to the value calculated from the voltage that the LSM-2020 sees on its load share line.
- kW TOTAL: This is the normalized kW being produced by the generator. 1.0 represents full machine capacity, 0.5 represents 50% of machine capacity, etc.
- RATED kW: This is the rated kW of the machine that should be equal to the RATED kW setting under SETTINGS > SYSTEM PARAMS > SYSTEM SETTINGS.
- var DEMAND: This is the normalized var demand requested by the LSM-2020. It is the desired amount of var that the generator should produce. It is normalized such that 1.0 indicates the full var capacity of the generator, 0.5 indicates 50% of the generator's capacity, etc. When the generator breaker is closed, and the var/PF controller is enabled, the var demand indicates what level of reactive power should be generated. If the generator breaker is closed, and the PARALLEL TO MAINS logic element is true, the var DEMAND will be equal to the kvar set point (%) if the controller is in var control mode, or will equal the var value that will maintain the machine Power Factor at the PF set point if the controller is in Power Factor mode. When the generator breaker is open or the var/PF controller is disabled, the var DEMAND will always be 0.0. When running with the generator breaker closed and the PARALLEL TO MAINS logic element is false (i.e. the generators are an islanded system), the var DEMAND will be 0.0 as well. The MGC-2000 Series runs in var DROOP when on an island system.
- kvar TOTAL: This is the normalized kvar being produced by the generator. 1.0 represents full machine capacity, 0.5 represents 50% of machine capacity, etc.
- RATED kvar: This is the calculated rated kvar of the machine, calculated from the Rated kW of the machine and the Rated Power Factor of the machine according to var is equal to the square root of ($VA^2 – WATT^2$).
- LSM_RT_BIN: LSM-2020 Real Time Binary Points. This is a 32-bit, bit packed number representing the binary points transmitted between the LSM-2020 and MGC-2000 Series. Debug at this level is not necessary.

CONTROL DEBUG

This screen is useful for debugging load share related issues, and kW and var control related issues. It gives visibility into the states of the kW, kvar, Speed Trim, and Voltage controllers in the MGC-2000 Series.

The CONTROL DEBUG screen is located on the front panel at SETTINGS > BIAS CONTROL > CONTROL DEBUG.

The following parameters are visible on the CONTROL DEBUG screen:

- kW RAMP: This indicates the current kW ramp direction as NONE, UP, or DOWN.
- kW RAMP DEMAND: This is the normalized kW demand that is ramped from the initial kW loading upon generator breaker closure to the desired kW set point. The rate at which the ramp occurs is set by the Ramp Rate (%) in the Governor Bias Control settings. Note the rate is in terms of percentage of machine capacity, it is not the time to ramp from zero up to the current desired kW level. Thus, at low loading it may appear that the ramp is skipped. If the system is

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loaded to only 10% and a unit is brought on line, and the ramp rate is 10% per second, it takes only one second to be up to 10% so the ramp time may be quite short.

- WATT DEMAND: This is the normalized requested kW demand on the generator. It is normalized such that 1.0 indicates the full kW capacity of the generator, 0.5 indicates 50% of the generator's capacity, etc. When the generator breaker is closed, and the kW controller is enabled, the WATT DEMAND indicates what level of power should be generated. In an island load share system, this will correspond to the normalized value read on the load share lines. If the load share lines are at the 50% point of the load share voltage range, the WATT DEMAND will be 0.5. If the generator breaker is closed, and the PARALLEL TO MAINS logic element is true, the WATT DEMAND will be equal to the base load set point. When the generator breaker is open or the kW controller is disabled, the WATT DEMAND will always be equal to the value calculated from the voltage that the LSM-2020 sees on its load share line.
- SPEED PID: This is the output value of the SPEED PID controller. It will normally range between –1.0 and 1.0, and will be zero any time the generator breaker is open, unless synchronization is in progress. If the Speed Trim is enabled, the SPEED PID will be nonzero when the generator breaker is closed if there is any difference between the machine speed and the Speed Trip Set Point parameter.
- kW PID: This is the output value of the kW PID controller. It will normally range between –1.0 and 1.0, and will be zero any time the generator breaker is open. If the kW Controller is enabled, the kW PID will be nonzero when the generator breaker is closed if there is any difference between the normalized kW generation and the WATT DEMAND value of the machine. If the kW controller is disabled, the kW PID will always be zero.
- SPEED ERR: This is the normalized difference between the measured generator frequency and the Speed Trip Set Point. A value of 1.0 means the difference is equal to the speed trip set point; a value of –1.0 means the difference is equal to the negative of the speed trim set point. When the generator breaker is open, or if Speed Trim is disabled, this will always be 0.000 unless synchronization is in progress. When speed trip is enabled, and the generator breaker is closed, this will typically be 0.000 or some relatively small number and move a small amount above and below 0.000 as the speed trim controller corrects for any speed errors.
- kW ERROR: This is the normalized difference between the measured generator kW generation and the WATT DEMAND described above. A value of 1.0 means the difference is equal to the Rated kW of the machine; a value of –1.0 means the difference is equal to the negative of the Rated kW of the machine. When the generator breaker is open, or if kW control is disabled, this will always be 0.000. When kW control is enabled, and the generator breaker is closed, this will typically be 0.000 or some relatively small number and move a small amount above and below 0.000 as the kW controller corrects for kW errors. If a load is added or dropped from the system, the error will be nonzero until the kW controller brings the kW generation to the desired level.
- SPEED BIAS: This is the normalized value to which the governor analog bias output of the LSM-2020 will be driven to accomplish desired kW and speed trim control. It is equal to the sum of the kW PID and the SPEED PID. If the value is –1.0, the speed bias output will be driven to the minimum value of the governor bias output range. If the value is 1.0, the output will be driven to the minimum value of the governor bias output range. If the value is 0.00, the output will be driven to the midpoint value (i.e. half way between maximum and minimum values) of the governor bias output range. If the generator breaker is open, or if the generator breaker is closed and speed trim and kW control are disabled, the SPEED BIAS value will be 0.00, driving the bias output to the midpoint of the governor bias output range indicating the generator should run at rated speed.
- PF SETPOINT: This is the power factor setpoint that will be used by the kvar controller when it is in the Power Factor regulation mode.
- kvar RAMP: This indicates the current kvar ramp direction as NONE, UP, or DOWN.
- var RAMP DEMAND: This is the normalized var demand that is ramped from the initial var loading upon generator breaker closure to the desired var output. The rate at which the ramp occurs is set by the Ramp Rate (%) parameter in the AVR Bias Control settings. Note the rate is in terms of percentage of machine capacity, it is not the time to ramp from zero up to the current desired var level. Thus, at low var loading it may appear that the ramp is skipped. If the system is loaded to only 10% and a unit is brought on line, and the load rate is 10% per second, it takes only one second to be up to 10% so the ramp time may be short.

- var DEMAND: This is the normalized requested kvar demand on the generator. It is normalized such that 1.0 indicates the full kvar capacity of the generator, 0.5 indicates 50% of the generator's capacity, etc. When the generator breaker is closed, and the var/PF controller is enabled, the var DEMAND indicates what level of reactive power should be generated. In an island load share system, this will be determined by the droop characteristics set by the Droop Percentage and Voltage Droop Gain parameters. If the generator breaker is closed, and the PARALLEL TO MAINS logic element is true, the var DEMAND will be equal to the kvar set point if the var/PF controller is in var mode or it will be calculated from the amount of kW being generated to maintain desired machine Power Factor when the var/PF controller is in Power Factor control mode. When the generator breaker is open, or the var/PF controller is disabled, the var DEMAND will be zero.
- VOLT PID: This is the current output value of the Voltage PID controller. It will normally range between –1.0 and 1.0, and will generally be zero at all times unless synchronization is in progress.
- kvar PID: This is the current output value of the kvar PID controller. It will normally range between –1.0 and 1.0, and will be zero any time the generator breaker is open. If the var/PF controller is enabled, the kvar PID will be nonzero when the generator breaker is closed if there is any difference between the normalized kvar generation and the var DEMAND value of the machine. If the var/PF controller is disabled, the kvar PID will always be zero.
- VOLT ERROR: This is the normalized difference between the measured generator voltage and the voltage to which the MGC-2000 Series is trying to synchronize. It will be 0.00 at all times except when the MGC-2000 Series is trying to synchronize its generator inputs to its bus input. When synchronizing, this will typically be 0.000 or some relatively small number and move a small amount above and below 0.000 as voltage controller corrects for any voltage errors.
- kvar ERROR: This is the normalized difference between the measured generator kvar generation and the var DEMAND described above. A value of 1.0 means the difference is equal to the Rated kvar of the machine; a value of –1.0 means the difference is equal to the negative of the Rated kvar of the machine. When the generator breaker is open, or if var/PF controller is disabled, this will always be 0.000. When var/PF control is enabled, and the generator breaker is closed, this will typically be 0.000 or some relatively small number and move a small amount above and below 0.000 as the var/PF controller corrects for var errors. If a reactive load is added or dropped from the system, the error will be nonzero until the var/PF controller brings the var generation to the desired level.
- VOLT BIAS: This is the normalized value to which the voltage regulator analog bias output of the LSM-2020 will be driven to accomplish desired kvar and Voltage control. It is equal to the sum of the VOLT PID and the kvar PID. If the value is –1.0, the voltage bias output will be driven to the minimum value of the voltage regulator analog bias output range. If the value is 1.0, the output will be driven to the maximum value of the voltage regulator analog bias output range. If the value is 0.000, the output will be driven to the midpoint value (i.e. half way between maximum and minimum values) of the voltage regulator analog bias output range. If the generator breaker is open, or if the generator breaker is closed and kvar control is disabled, the VOLT BIAS value will be 0.00, driving the bias output to the midpoint of the voltage regulator analog bias output range indicating the voltage regulator should operate the generator at rated voltage.

CEM DEBUG

This screen shows the binary data that is being sent between the CEM-2020 (Contact Expansion Module) and the MGC-2000 Series.

The CEM DEBUG screen is located on the front panel at SETTINGS > SYSTEM PARAMS > REMOTE MODULE SETUP > CEM SETUP > CEM DEBUG MENU.

The following parameters are visible on the CEM DEBUG screen:

- DGC TO CEM BP: MGC-2000 Series to CEM-2020 Binary Points. This is the status of the CEM-2020 output relays being transmitted from the MGC-2000 Series to the CEM-2020. This is a 32-bit, bit packed number representing the desired states of the CEM-2020 outputs. The left most bit is the first output, etc.
- CEM TO DGC BP: CEM-2020 to MGC-2000 Series Binary Points. This is the status of the CEM-2020 inputs being transmitted from the CEM-2020 to the MGC-2000 Series. This is a 32-bit, bit

packed number representing the metered states of the CEM-2020 inputs. The left most bit is the first input, etc.

AEM DEBUG

This screen shows the binary data that is being sent between the AEM-2020 (Analog Expansion Module) and the MGC-2000 Series.

The AEM DEBUG screen is located on the front panel at SETTINGS > SYSTEM PARAMS > REMOTE MODULE SETUP > AEM SETUP > AEM DEBUG MENU.

The following parameters are visible on the AEM DEBUG screen:

- DGC TO AEM BP: MGC-2000 Series to AEM-2020 Binary Points. This is a 32-bit, bit packed number representing the binary points transmitted from the MGC-2000 Series to the AEM-2020. Debug at this level is not necessary.
- AEM TO DGC BP: AEM-2020 to MGC-2000 Series Binary Points. This is a 32-bit, bit packed number representing the binary points transmitted from the AEM-2020 to the MGC-2000 Series. Debug at this level is not necessary.
- ANALOG INPUTS: For each analog input, the raw metered input value is displayed, and the scaled metered input value. This is useful to check if the AEM-2020 is seeing a valid raw input value (i.e. the raw 0 to 10 volt voltage input or 4 to 20 ma current input). The scaled value is the raw input scaled up to the range specified by the Parameter Minimum and Parameter Maximum value parameters in the Remote Analog Input settings.
- THERMAL INPUTS: For each RTD input, the resistance in ohms measured by the RTD input is displayed as well as the temperature calculated from the resistance measurement. For each thermocouple input, the voltage in millivolts is displayed as well as the temperature calculated from the resistance measurement.

SECTION 9 • LSM-2020 (LOAD SHARE MODULE)

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SECTION 9 • LSM-2020 (LOAD SHARE MODULE)

General Information

The LSM-2020 is a remote auxiliary device that interfaces to the MGC-2000 Series and provides analog outputs to the power system in the form of analog bias signals to the voltage regulator and speed governor. When the breaker is closed and Load Sharing is enabled, the LSM-2020 will share real power load proportionally with the other generators on the Analog or Ethernet Load Share Lines.

Refer to Section 7, *Setup*, for instructions on setting up an MGC-2000 Series and LSM-2020 for a load sharing and kW control application.

Features

LSM-2020s have the following features:

- A Ramping Function to load and unload generators smoothly
- Communications via Ethernet or CAN bus
- Demand Start/Stop and Generator Sequencing
- kW Load/var Control
- kW Load/var Sharing via analog and Ethernet load share lines

Specifications

Operating Power

Nominal.................................... 12 or 24 Vdc
Range .... 8 to 32 Vdc (Withstands cranking ride-through down to 6 Vdc for 500 ms.)
Maximum Consumption............ 4 W
Terminals................................. P2-3 (–), P2-2 (+), P2-1 (chassis ground)

Analog Inputs

Voltage Configuration .... 0-10 Vdc

Current Configuration .... 4-20 mAdc

Terminals................................. P2-7 (IN+), P2-8 (IN–), P2-9 (V+)

Burden

4 to 20 mAdc............................. 470 Ω maximum
±10 Vdc..................................... 9.65k Ω minimum

Analog Outputs

Burden Data.............................. 4-20 mAdc = 500 Ω maximum burden, ±10 Vdc = 667 Ω minimum burden

Voltage Regulator Bias Output

4-20 mA or ±10 Vdc isolated output signal. (Selectable in increments of 0.1.)

Isolated to 1,500 Vdc between outputs and ground

Terminals................................. P2-18 (AVR+), P2-17 (AVR–), P2-16 (AVR')

Governor Bias Output

4-20 mA, ±10 Vdc isolated output signal. (Selectable in increments of 0.1.)

Isolated to 500 Vdc between outputs and ground

Terminals................................. P2-15 (GOV+), P2-14 (GOV–), P2-13 (GOV')

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Load Share Line Output

0-10 Vdc isolated output signal. (Selectable in increments of 0.1 Vdc.

Isolated to 500 Vdc between outputs and ground

Terminals .... P2-6 (LS+), P2-5 (LS–), P2-4 (LS')

Communication Interface

CAN bus

Differential Bus Voltage .... 1.5 to 3 Vdc
Maximum Voltage .... –32 to +32 Vdc with respect to negative battery terminal
Communication Rate .... 250 kb/s
Terminals .... P2-12 (low), P2-11 (high), and P2-10 (shield)

Ethernet

Type 10/100BASE-T

Industrial Ethernet devices designed to comply with IEC 61000-4 series of specifications are recommended.

Type Tests

Shock

Withstands 15 G in 3 perpendicular planes.

Vibration

Swept over the following ranges for 12 sweeps in each of three mutually perpendicular planes with each 15-minute sweep consisting of the following:

5 to 29 to 5 Hz .... 1.5 G peak for 5 min.
29 to 52 to 29 Hz .... 0.036" Double Amplitude for 2.5 min.
52 to 500 to 52 Hz .... 5 G peak for 7.5 min.

Ignition System

Tested in closed proximity to an unshielded, unsuppressed Altronic DISN 800 ignition system.

HALT (Highly Accelerated Life Testing)

HALT is used by Basler Electric to prove that our products will provide the user with many years of reliable service. HALT subjects the device to extremes in temperature, shock, and vibration to simulate years of operation, but in a much shorter period. HALT allows Basler Electric to evaluate all possible design elements that will add to the life of this device. As an example of some of the extreme testing conditions, the LSM-2020 was subjected to temperature tests (tested over a temperature range of –80°C to +130°C), vibration tests (of 5 to 50 G at +25°C), and temperature/vibration tests (tested at 10 to 20 G over a temperature range of –60°C to +100°C). Combined temperature and vibration testing at these extremes proves that the LSM-2020 is expected to provide long-term operation in a rugged environment. Note that the vibration and temperature extremes listed in this paragraph are specific to HALT and do not reflect recommended operation levels. These operational ratings are included in this section.

Environment

Temperature
    Operating .... –40 to +70°C (–40 to +158°F)
    Storage .... –40 to +85°C (–40 to +185°F)
Humidity.................................... IEC 68-2-38

UL Approval

"cURus" recognized to UL Standard 508 & CSA Standard C22.2 No.14

CSA Certification

CSA certified to Standard C22.2 No. 14.

NFPA Compliance

Complies with NFPA Standard 110, *Standard for Emergency and Standby Power*.

CE Compliance

This product complies with the requirements of the following EC Directives:

- Low Voltage Devices (LVD) - 73/23/EEC as amended by 93/68/EEC
- Electromagnetic Compatibility (EMC) - 89/336/EEC as amended by 92/31/EEC and 93/68/EEC

This product conforms to the following Harmonized Standards:

- EN 50178:1997 - Electronic Equipment for use in Power Installations
- EN 61000-6-4:2001 - Electromagnetic Compatibility (EMC), Generic Standards, Emission Standard for Industrial Environments
- EN 61000-6-2:2001 - Electromagnetic Compatibility (EMC), Generic Standards, Immunity for Industrial Environments

Physical

Weight...................................... 1.45 lb (657 g)
Dimensions.............................. See *Installation* later in this section.

Functional Description

Analog Inputs

The analog inputs can be configured to accept voltage or current. These inputs can be used for var, PF, or kW control. The inputs are configured by using the Settings Explorer in BESTCOMS*Plus*® to open the *Programmable Input, LSM Input screen.* To set the LSM Analog Input as the control source, use the Settings Explorer in BESTCOMS*Plus*® to open the *Bias Control Settings* screens.

Analog Outputs

There are three analog outputs: AVR control, GOV control, and Load Share Line. Each output is described in the following paragraphs.

Output for Voltage Regulator Control

The AVR output provides remote control of the generator voltage setpoint.

Output for Governor Control

The GOV output provides remote control of the generator speed setpoint.

Load Share Line Output

The generator uses the measured LS (Load Share Line) output to calculate per unitized average load level, and uses that as the set point for its kW controller.

Generator Sequencing

Machines can be added or removed from the power system based on load demand. The following criteria should be considered before adding or removing a machine:

- Machine Priority
- Engine Run Time
- Machine Size
- kW% of the load/demand
- Out of Service machines

Communications

The LSM-2020 communication ports include CAN terminals and an Ethernet port.

CAN bus

A Control Area Network (CAN) is a standard interface that enables communication between the LSM-2020 and the MGC-2000 Series.

Ethernet Port

An Ethernet port provides both inter-genset communications and remote communications between a PC and the LSM-2020 or connected MGC-2000 Series via BESTCOMS*Plus*®. Ethernet communication between LSM-2020s allows for generator sequencing, load sharing, and kvar sharing on an islanded system. Firmware updates to the LSM-2020 are made through the Ethernet port. Firmware updates to the MGC-2000 Series are only available through the USB port of the MGC-2000 Series. Refer to Section 4,

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BESTCOMSPlus® Software, for information on configuring Ethernet communication and updating firmware in the MGC-2000 Series.

Industrial Ethernet devices designed to comply with IEC 61000-4 series of specifications are recommended.

To achieve Ethernet var sharing among machines in an islanded system, the following conditions must be met:

- Var/PF control must be enabled on the AVR Bias Control Settings screen
- A connection between the MGC-2000 Series and LSM-2020 must be established
- LSM-2020s must be connected to each other via Ethernet on the inter-genset communications network

BESTCOMSPlus® Software

BESTCOMS*Plus*® provides the user with a point-and-click means to set and monitor the LSM-2020. Installation and operation of BESTCOMS*Plus*® is described in Section 4, *BESTCOMSPlus® Software.*

LSM-2020 Plugin for BESTCOMS*Plus*®

The setup utility that installs BESTCOMS*Plus*® on your PC also installs the LSM-2020 plug-in. Refer to Section 4, *BESTCOMSPlus® Software,* for information on activating the plugin.

The LSM-2020 plugin is used to set device security and view device information such as firmware version and serial number.

LSM-2020 operational settings are found in the MGC-2000 Series plugin for BESTCOMS*Plus*®. Refer to Section 4, *BESTCOMSPlus® Software,* for a detailed description of each setting.

The LSM-2020 plugin has two screens: *Device Info* and *Device Security Setup.*

Device Info

Information about a LSM-2020 communicating with BESTCOMS*Plus*® can be obtained on the Device Info tab of BESTCOMS*Plus*®.

Select application version[A] when configuring LSM-2020 settings off-line. When on-line, read-only information includes application version[B], boot code version[C], application build[D], serial number[E], application part number[F], and model number[G].

BESTCOMS*Plus*® device information values and settings are illustrated in Figure 9-1.

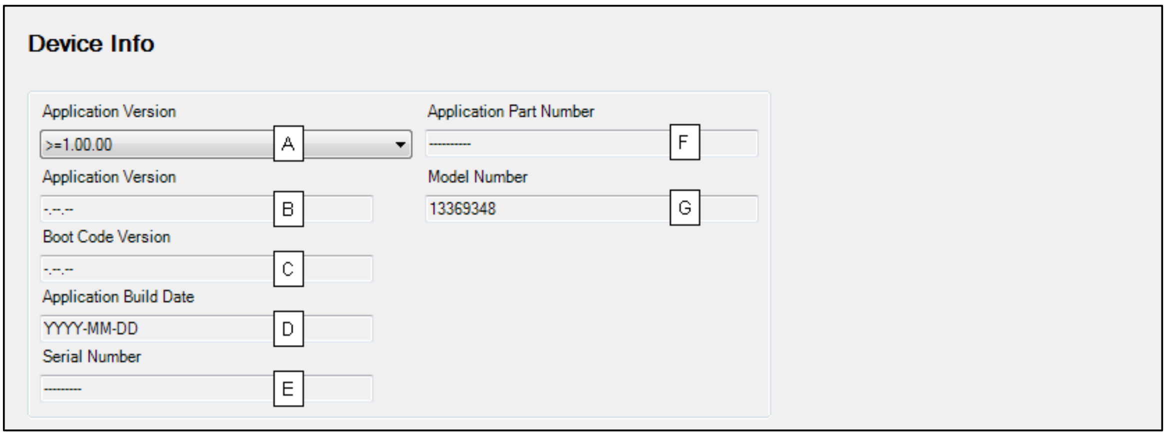

Figure 9-1. Device Info Screen

[A] *Application Version:* When configuring Load Share Module settings off-line, the application version for the unit to be configured must be selected.
[B] *Application Version:* Read-only value obtained when BESTCOMSPlus is communicating with the Load Share Module.
[C] *Boot Code Version:* Read-only value obtained when BESTCOMSPlus is communicating with the Load Share Module.

[D] *Application Build:* Read-only value obtained when BESTCOMSPlus is communicating with the Load Share Module.
[E] *Serial Number:* Read-only value obtained when BESTCOMSPlus is communicating with the Load Share Module.
[F] *Application Part Number:* Read-only value obtained when BESTCOMSPlus is communicating with the Load Share Module.
[G] *Model Number:* Read-only value obtained when BESTCOMSPlus is communicating with the Load Share Module.

Device Security Setup

Password protection guards against unauthorized changing of LSM-2020 communication settings. Passwords are case sensitive. *OEM Access* is the only level of password protection available. This password level allows access to all settings made using the LSM-2020 plugin for BESTCOMS*Plus*®. The default, OEM-access password is **OEM**.

Passwords can be changed only after communication between the PC and LSM-2020 is established. A change to the password is made through the *Device Security Setup* screen. Use the Settings Explorer in BESTCOMS*Plus*® to open the *General Settings, Device Security Setup* screen. See Figure 9-2.

A password is changed by clicking on the access level[A], entering the new password[B], and then clicking on the *Save Password* button[C].

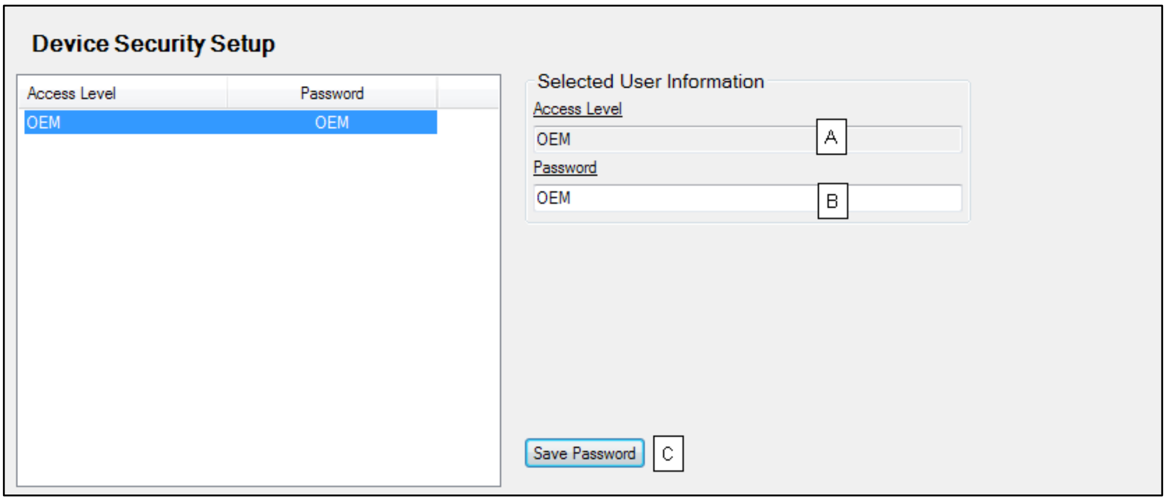

Figure 9-2. Device Security Setup Screen

[A] *Access Level/Password:* Read-only value obtained when BESTCOMSPlus is communicating with the Load Share Module.
[B] *Password:* Accepts an alphanumeric character string of up to 16 characters.
[C] *Save Password:* Clicking this button will save the password changes in BESTCOMSPlus memory.

Installation

LSM-2020s are delivered in sturdy cartons to prevent shipping damage. Upon receipt of a module, check the part number against the requisition and packing list for agreement. Inspect for damage, and if there is evidence of such, immediately file a claim with the carrier and notify MTU Onsite Energy.

If the device is not installed immediately, store it in the original shipping package in a moisture- and dust-free environment.

Mounting

LSM-2020's are contained in a potted plastic case and may be mounted in any convenient position. The construction of an LSM-2020 is durable enough to mount directly on a genset using ¼-inch hardware. Hardware selection should be based on any expected shipping/transportation and operating conditions. The torque applied to the mounting hardware should not exceed 65 in-lb (7.34 N•m).

See Figure 9-3 for LSM-2020 overall dimensions. All dimensions are shown in inches with millimeters in parenthesis.

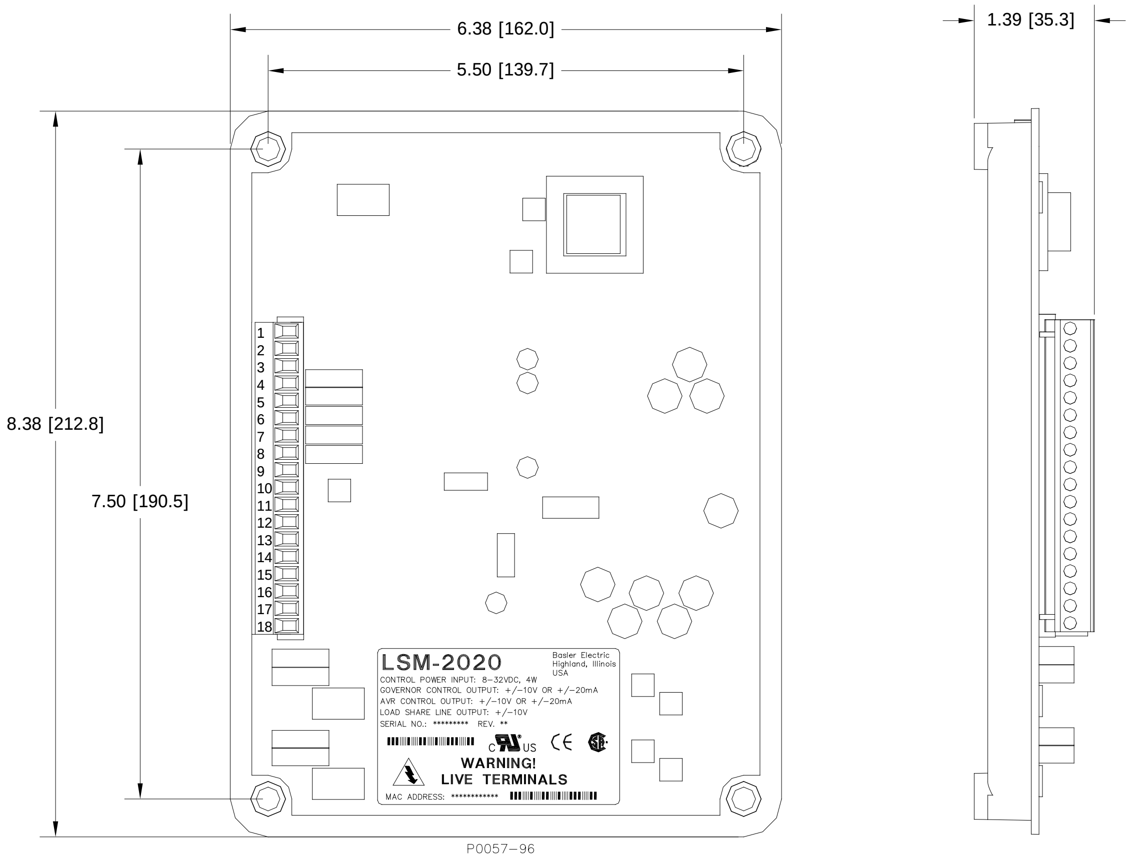

Figure 9-3. LSM-2020 Overall Dimensions

Connections

LSM-2020 connections are dependent on the application. Incorrect wiring may result in damage to the module.

> **NOTES**
>
> Operating power from the battery must be of the correct polarity. Although reverse polarity will not cause damage, the LSM-2020 will not operate.
>
> Be sure that the LSM-2020 is hard-wired to earth ground with no smaller than 12 AWG copper wire attached to the chassis ground terminal on the module.

Terminations

There are two types of interface terminals: plug-in connectors with screw-down compression terminals and an RJ-45 socket.

The RJ-45 socket mates with a standard Ethernet cable and provides local communication between the LSM-2020 and a PC running BESTCOMS*Plus*® software. This allows for setting of the LSM-2020 and for the MGC-2000 Series that the module is connected to.

LSM-2020 connections are made with an 18-position connector with screw-down compression terminals. This connector plugs into a header on the LSM-2020. The connector and header have a dovetailed edge that ensures proper connector orientation. Also, the connector and header are uniquely keyed to ensure that the connector mates only with the correct header.

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Caution

By mating conductors of dissimilar metals, galvanic corrosion could occur which may lead to signal loss.

Connectors and headers may contain tin- or gold-plated conductors. Tin-plated conductors are housed in a black plastic casing and gold-plated conductors are housed in an orange plastic casing. Mate connectors to headers of the same color only.

Connector screw terminals accept a maximum wire size of 12 AWG. Maximum screw torque is 4 in-lb (0.45 N•m).

Operating Power

The LSM-2020 operating power input accepts either 12 Vdc or 24 Vdc and tolerates voltage over the range of 6 to 32 Vdc. Operating power must be of the correct polarity. Although reverse polarity will not cause damage, the LSM-2020 will not operate. Operating power terminals are listed in Table 9-1.

It is recommended that a fuse be added for additional protection for the wiring to the battery input of the LSM-2020. A Bussmann ABC-7 fuse or equivalent is recommended.

Table 9-1. Operating Power Terminals

Terminal	Description
P2-1 (CHASSIS)	Chassis ground connection
P2-2 (BATT+)	Positive side of operating power input
P2-3 (BATT–)	Negative side of operating power input

Note

To comply with the requirements of EN 55011 (Radiated Emission), wiring connected to LSM-2020 terminals BATT+ and BATT– must be shielded. Shielding must be grounded at one end.

Analog Inputs

These inputs can be used for var, PF, or kW control. Analog input terminals are listed in Table 9-2. Current input connections are shown in Figure 9-4 and voltage input connections are shown in Figure 9-5.

Table 9-2. Analog Input Terminals

Terminal	Description
P2-9 (V+)	Voltage input used for var, PF, or kW control.
P2-8 (IN–)	Common for voltage or current.
P2-7 (I+)	Current input used for var, PF, or kW control.

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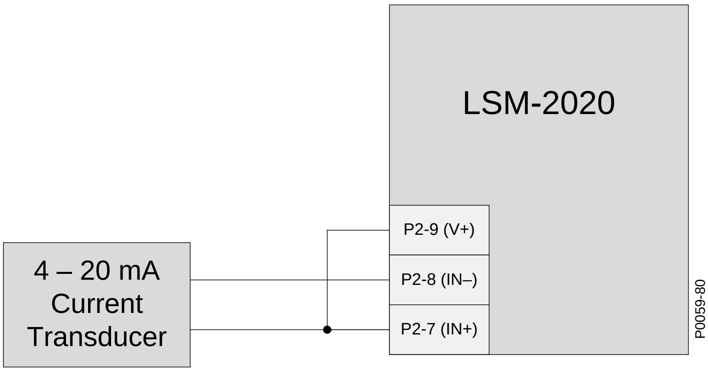

Figure 9-4. Analog Inputs - Current Input Connections

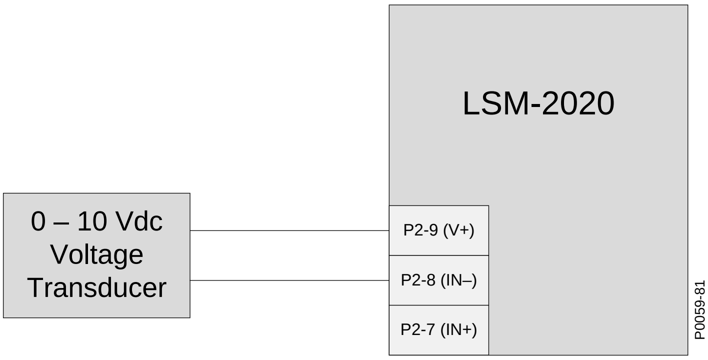

Figure 9-5. Analog Inputs - Voltage Input Connections

Analog Outputs

The LSM-2020 has three sets of analog output contacts: AVR control, GOV control, and Load Share Line. The AVR control output contacts provide remote control of the generator voltage setpoint. The GOV control output contacts provide remote control of the generator speed (RPM) setpoint. The generator uses the measured LS (Load Share Line) output to calculate the per unitized average load level, and uses that as the set point for its kW controller. Analog input terminals are listed in *Table 9-3*.

Note
To comply with the requirements of EN 61000-4-6 (RF Conducted Immunity), wiring connected to LSM-2020 terminals GOV+ and GOV– must be routed away from the LSM-2020 unit, making no contact with any part of it except the GOV+ and GOV– terminals. If this is not possible, the wiring must either be shielded or twisted pair. If shielding is used, it is not required to be grounded. If the wires are a twisted pair, two turns per inch are required.

Table 9-3. Analog Output Terminals

Terminal	Description
P2-18 (AVR+)	AVR control output positive
P2-17 (AVR–)	AVR control output negative
P2-16 (AVR’)	Provides additional landing point for external resistor
P2-15 (GOV+)	GOV control output positive
P2-14 (GOV–)	GOV control output negative
P2-13 (GOV’)	Provides additional landing point for external resistor
P2-6 (LS+)	Load share line positive

Terminal	Description
P2-5 (LS–)	Load share line negative
P2-4 (LS')	Provides additional landing point for external resistor

CAN bus Interface

These terminals provide communication using the SAE J1939 protocol and provide high-speed communication between the LSM-2020 and the MGC-2000 Series. Connections between the LSM-2020 and MGC-2000 Series should be made with twisted-pair, shielded cable. CAN bus interface terminals are listed in Table 9-4. Refer to Figure 9-6 and Figure 9-7.

Table 9-4. CAN bus Interface Terminals

Terminal	Description
P2-12 (CAN L)	CAN low connection (green wire)
P2-11 (CAN H)	CAN high connection (yellow wire)
P2-10 (SHIELD)	CAN drain connection

NOTES

1. If the LSM-2020 is providing one end of the J1939 bus, a 120 Ω, ½ watt terminating resistor should be installed across terminals P2-12 (CANL) and P2-11 (CANH).
2. If the LSM-2020 is not part of the J1939 bus, the stub connecting the LSM-2020 to the bus should not exceed 914 mm (3 ft) in length.
3. The maximum bus length, not including stubs, is 40 m (131 ft).
4. The J1939 drain (shield) should be grounded at one point only. If grounded elsewhere, do not connect the drain to the LSM-2020.

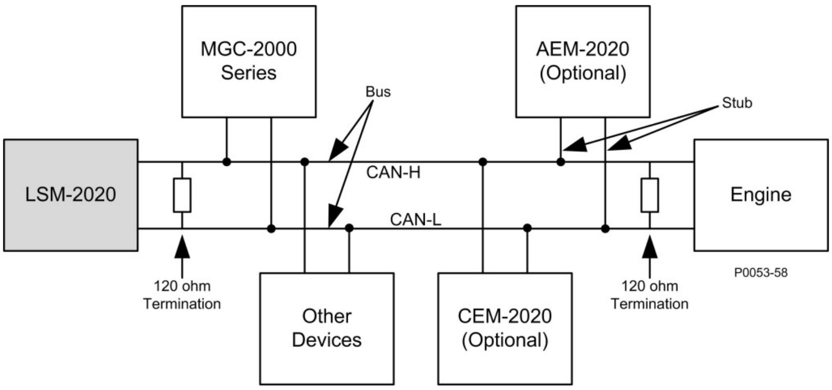

Figure 9-6. CAN bus Interface with LSM-2020 providing One End of the Bus

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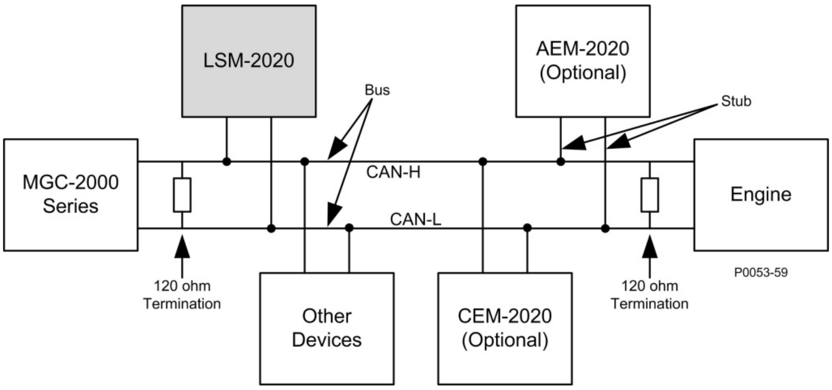

Figure 9-7. CAN bus Interface with MGC-2000 Series providing One End of the Bus

Ethernet Port

The LSM-2020 has Ethernet capability. The LSM-2020 connects to a PC through a RJ-45 jack (J3).

Industrial Ethernet devices designed to comply with IEC 61000-4 series of specifications are recommended.

Connections for Typical Applications

Figure 9-8 illustrates typical LSM-2020 connections. Figure 9-9 illustrates a typical interconnection of three systems tied together via separate Load Share Modules.

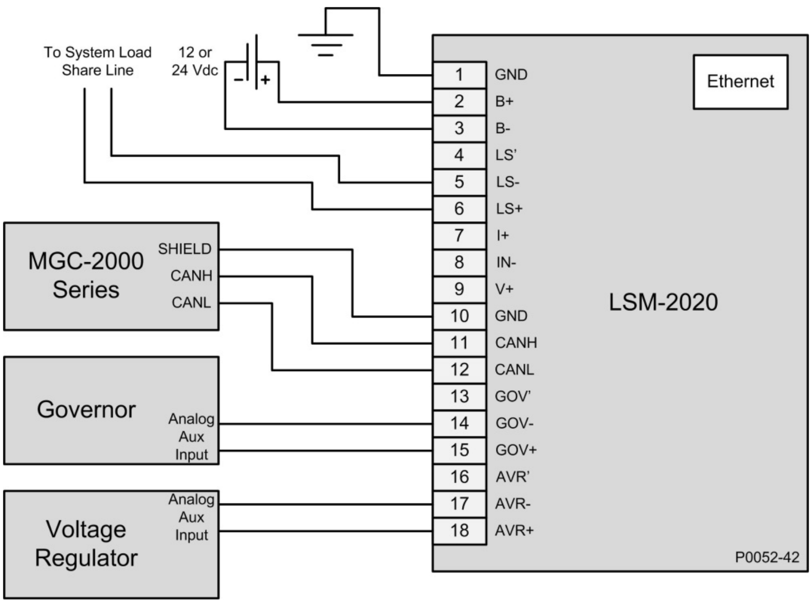

Figure 9-8. Typical LSM-2020 Connections

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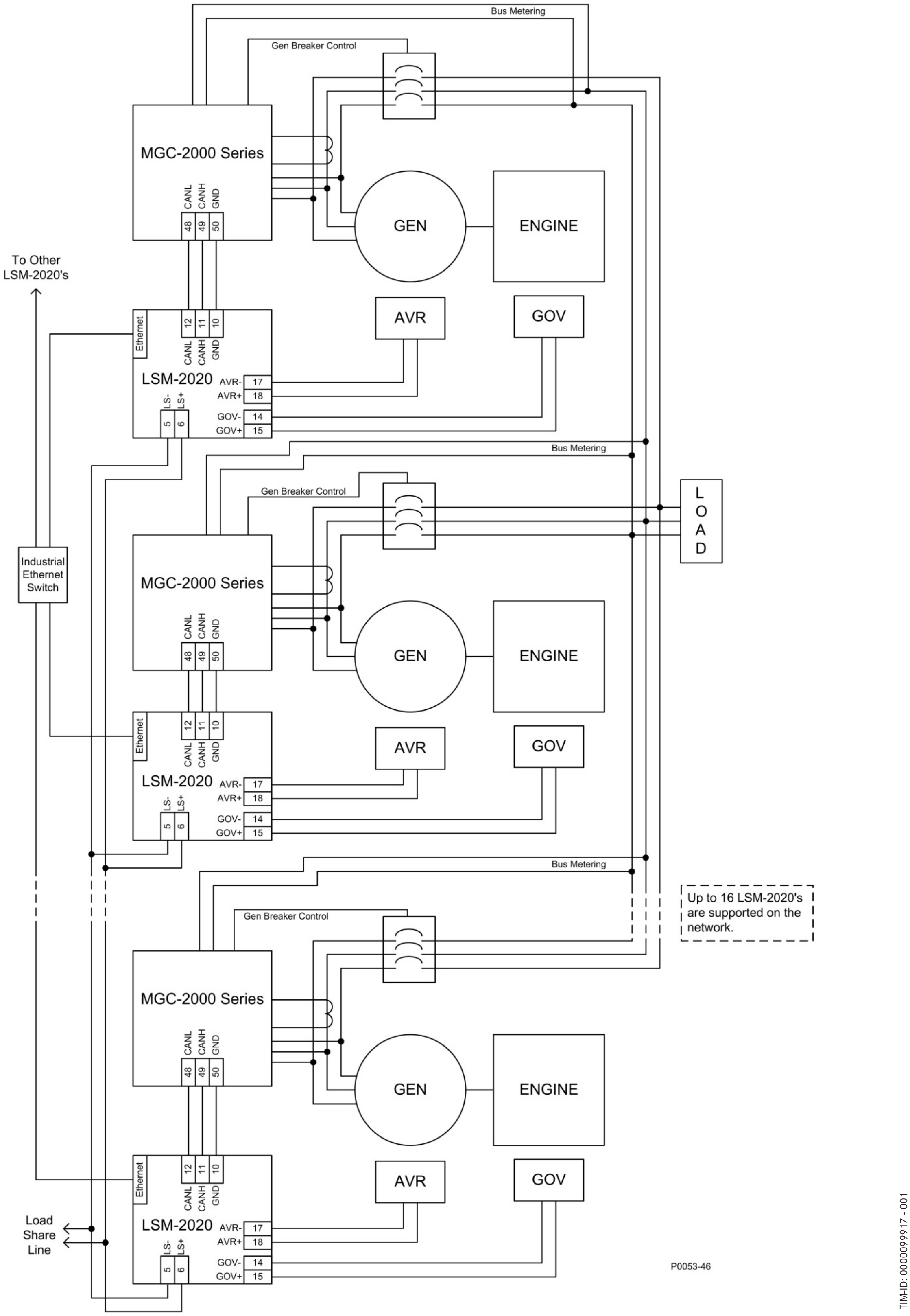

Figure 9-9. Typical LSM-2020 Interconnection Diagram

Connections using AVR', GOV', and LS'

Additional terminals provide a landing point to add series resistance to the GOV, AVR, and LS analog outputs. These terminals are not internally connected to the LSM-2020. Figure 9-10 illustrates connections using the additional AVR' terminal as a landing point.

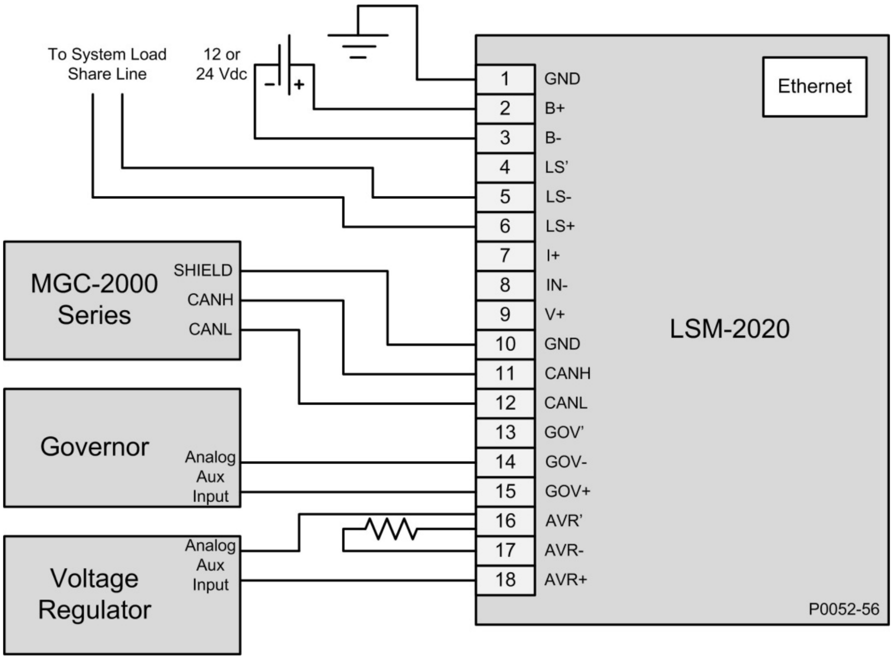

Figure 9-10. Connections using the AVR', GOV', and LS' Terminals

Application

Interfacing an External Control Device with an MGC-2000 Series – LSM-2020 System

Method 1

In some cases, it may be necessary to interface an external device, such as a synchronizer, to an MGC-2000 Series - LSM-2020 system where the LSM-2020 controls the analog bias inputs to the AVR and governor. If an external synchronizer is used in conjunction with the LSM-2020 to drive the governor analog speed bias signal, contacts that indicate generator breaker status can be used to switch the analog speed bias signal between the two devices as shown in Figure 9-11.

> **NOTE**
>
> Any relay contacts which are used to switch load share lines, governor analog speed bias signals, or voltage regulator analog voltage bias signals must use a relay intended for low voltage, low current applications to preserve signal integrity. Signal relays, not power relays, must be used for this application. It is recommended that relays having gold contacts are used.

The "A" contact is a normally open contact which is open when the generator breaker is open, and is closed when the generator breaker is closed. The "B" contact is a normally-closed contact that is closed when the generator breaker is open, and is open when the generator breaker is closed. The contact arrangement shown in Figure 9-11 gives the external device control of the analog speed bias signal when the generator breaker is open, and the LSM-2020 has control when the generator breaker is closed.

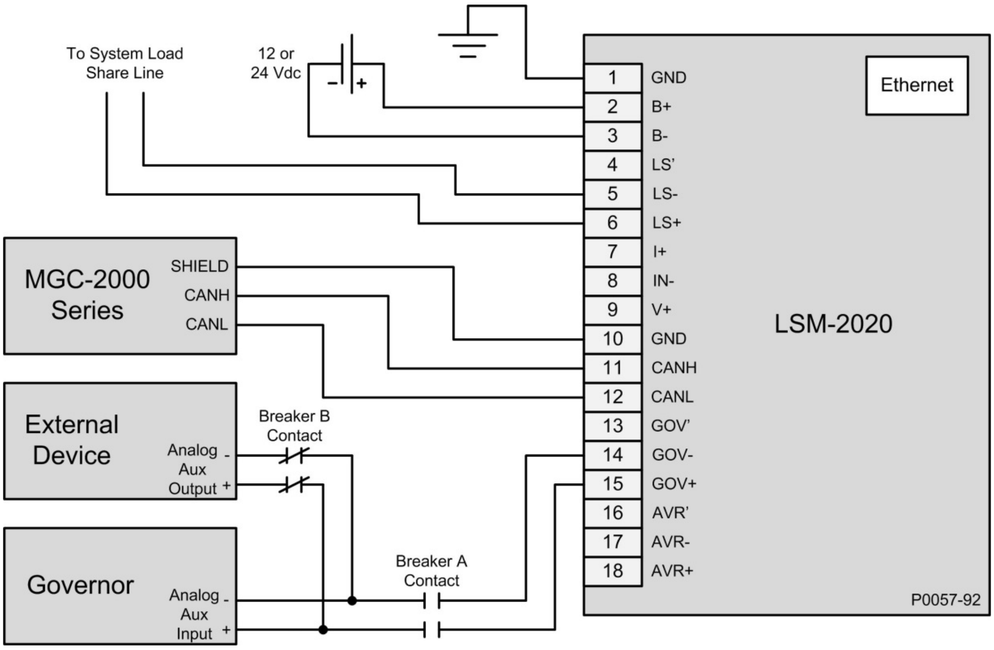

Figure 9-11. External Control Device with MGC-2000 Series — LSM-2020 System, Method 1

Method 2

An alternate method of interfacing the MGC-2000 Series and an external device to drive the governor bias voltage can be done by placing the bias output of the LSM-2020 and the bias output of the external device in series. If the output of the LSM-2020 is connected in series with the bias output of the external synchronizer as shown in Figure 9-12, both devices will be allowed to exercise control over the bias input of the governor.

Be sure the LSM and the external device are never in a situation where they oppose each other. Both devices should not be trying to exercise dynamic control at the same time. For example, an external synchronizer should only be used with an MGC-2000 Series that does not have the synchronizer option, or has the synchronizer function disabled.

In addition, be sure the analog voltage range limits of the governor or AVR inputs are not exceeded. Exceeding these limits may result in undesired system operation, or force a device into an error or fault state.

If it is desired to have raise/lower inputs to control speed, use a motor operated potentiometer, as the external device. Note that if speed trim is enabled in the MGC-2000 Series and the generator's breaker is closed, the MGC-2000 Series will drive the system to the speed trim setpoint regardless of the presence of the external device. When the generator breaker is open, speed trim is disabled, and the external device will control machine speed.

A similar arrangement may be used for the bias input of an AVR if an external device is required for voltage control.

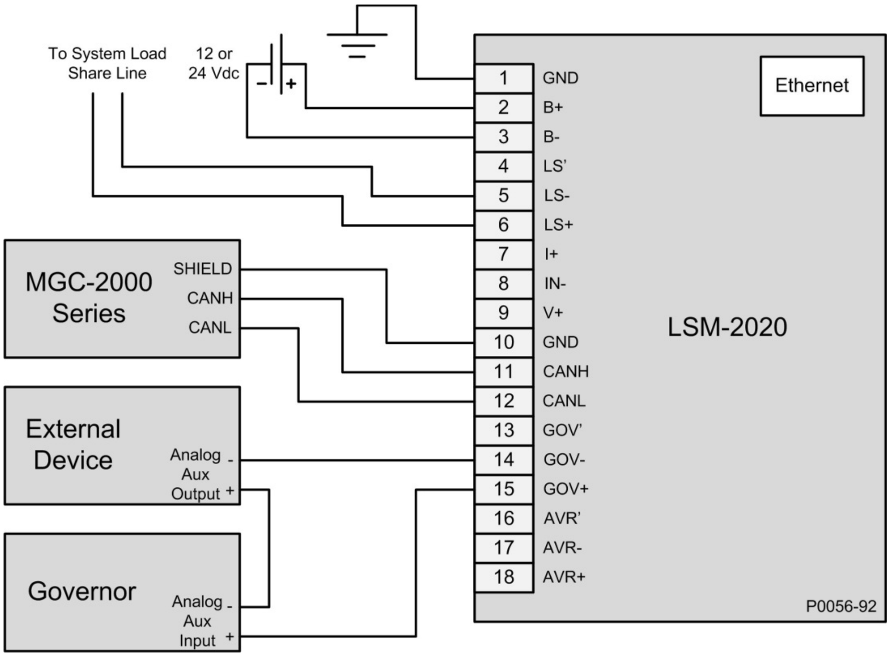

Figure 9-12. External Control Device with MGC-2000 Series — LSM-2020 System, Method 2

Maintenance

Preventive maintenance consists of periodically checking that the connections between the LSM-2020 and the system are clean and tight. LSM-2020s are manufactured using state-of-the-art surface-mount technology. As such, MTU Onsite Energy recommends that no repair procedures be attempted by anyone other than MTU Onsite Energy personnel.

SECTION 10 • CEM-2020 (CONTACT EXPANSION MODULE)

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SECTION 10 • CEM-2020 (CONTACT EXPANSION MODULE)

General Information

The optional CEM-2020 is a remote auxiliary device that provides additional MGC-2000 Series contact inputs and outputs. Two types of modules are available. The CEM-2020 provides 24 contact outputs.

Features

CEM-2020s have the following features:

- 10 Contact Inputs
- 24 Contact Outputs
- Functionality of Inputs and Outputs assigned by BESTlogic*Plus* programmable logic
- Communications via CAN bus

Specifications

Operating Power

Nominal.................................... 12 or 24 Vdc
Range .... 8 to 32 Vdc (Withstands cranking ride-through down to 6 Vdc for 500 ms)
Maximum Consumption
CEM-2020 .... 14 W

Contact Inputs

The CEM-2020 contains 10 programmable inputs that accept dry contacts.

Time from a CEM-2020 input application to:

Shutdown the generator via an alarm = 700 ms max
Close a relay on board the MGC-2000 Series = 300 ms max
Close a relay on board the CEM-2020 = 550 ms max

NOTES

A CEM-2020 contact input is true (on) if the input is connected to battery ground with a resistance of less than 200 ohms.

The maximum length of wire that can be accommodated depends on the resistance of the wire, and the resistance of the contacts of the device driving the input at the far end of the wire.

The maximum wire length can be calculated as follows:

L_{max} = (200 – R_{device})/(Resistance per Foot of Desired Wire)

Contact Outputs

Ratings
CEM-2020
Outputs 13 through 24.. 1 Adc at 30 Vdc, Form C, gold contacts
Outputs 25 through 36.. 4 Adc at 30 Vdc, Form C
Communication Interface

CAN Bus

Differential Bus Voltage .... 1.5 to 3 Vdc
Maximum Voltage .... –32 to +32 Vdc with respect to negative battery terminal
Communication Rate .... 250 kb/s

Type Tests

Shock

Withstands 15 G in 3 perpendicular planes.

Vibration

Swept over the following ranges for 12 sweeps in each of three mutually perpendicular planes with each 15-minute sweep consisting of the following:

5 to 29 to 5 Hz .... 1.5 G peak for 5 min.
29 to 52 to 29 Hz .... 0.036” Double Amplitude for 2.5 min.
52 to 500 to 52 Hz .... 5 G peak for 7.5 min.

Ignition System

Tested in closed proximity to an unshielded, unsuppressed Altronic DISN 800 ignition system.

HALT (Highly Accelerated Life Testing)

HALT is used by Basler Electric to prove that our products will provide the user with many years of reliable service. HALT subjects the device to extremes in temperature, shock, and vibration to simulate years of operation, but in a much shorter period span. HALT allows Basler Electric to evaluate all possible design elements that will add to the life of this device. As an example of some of the extreme testing conditions, the CEM-2020 was subjected to temperature tests (tested over a temperature range of –80°C to +130°C), vibration tests (of 5 to 50 G at +25°C), and temperature/vibration tests (tested at 10 to 20 G over a temperature range of –60°C to +100°C). Combined temperature and vibration testing at these extremes proves that the CEM-2020 is expected to provide long-term operation in a rugged environment. Note that the vibration and temperature extremes listed in this paragraph are specific to HALT and do not reflect recommended operation levels. These operational ratings are included in this section.

Environment

Temperature
  Operating............................ –40 to +70°C (–40 to +158°F)
  Storage............................... –40 to +85°C (–40 to +185°F)
Humidity.................................... IEC 68-2-38

UL Approval

“cURus” recognized to UL Standard 508 & CSA Standard C22.2 No. 14.

CSA Certification

CSA certified to Standard C22.2 No.14.

NFPA Compliance

Complies with NFPA Standard 110, *Standard for Emergency and Standby Power*.

CE Compliance

This product complies with the requirements of the following EC Directives:

- Low Voltage Directive (LVD) - 73/23/EEC as amended by 93/68/EEC
- Electromagnetic Compatibility (EMC) - 89/336/EEC as amended by 92/31/EEC and 93/68/EEC

This product conforms to the following Harmonized Standards:

- EN 50178:1997 - *Electronic Equipment for use in Power Installations*
- EN 61000-6-4:2001 - *Electromagnetic Compatibility (EMC), Generic Standards, Emission Standard for Industrial Environments*
- EN 61000-6-2:2001 - *Electromagnetic Compatibility (EMC), Generic Standards, Immunity for Industrial Environments*

Physical

Weight
CEM-2020 .... 2.25 lb (1.02 kg)
Dimensions .... See *Installation* later in this section.

Functional Description

Contact Inputs

The CEM-2020 provides 10 programmable contact inputs with the same functionality as the contact inputs on the MGC-2000 Series. The label text of each contact input is customizable.

Contact Outputs

CEM-2020

The CEM-2020 provides 24 programmable contact outputs with the same functionality as the contact outputs on the MGC-2000 Series. Outputs 13 through 24 can carry 1 A. Outputs 25 through 36 can carry 4 A. The label text of each contact output is customizable.

NOTES

When using the MGC-2000 Series synchronizer, it is recommended that local relay outputs on the MGC-2000 Series be used for breaker close commands to minimize the possibility of closures outside of desired breaker closing angles.

If remote (CEM-2020) outputs are to be used for breaker close commands, it is recommended that the anticipatory synchronizer type be used, and the breaker close wait time be adjusted to account for possible CEM-2020 output delays (typically 50 ms) to achieve desired breaker closing angles.

Communications

CAN Bus

A Control Area Network (CAN) is a standard interface that enables communication between the CEM-2020 and the MGC-2000 Series.

BESTCOMSPlus® Software

BESTCOMS*Plus*® provides the user with a point-and-click means to set and monitor the Contact Expansion Module. Installation and operation of BESTCOMS*Plus*® is described in Section 4, *BESTCOMSPlus® Software.*

Installation

Contact Expansion Modules are delivered in sturdy cartons to prevent shipping damage. Upon receipt of a module, check the part number against the requisition and packing list for agreement. Inspect for damage, and if there is evidence of such, immediately file a claim with the carrier and notify MTU Onsite Energy.

If the device is not installed immediately, store it in the original shipping package in a moisture- and dust-free environment.

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Mounting

Contact Expansion Modules are contained in a potted plastic case and may be mounted in any convenient position. The construction of a Contact Expansion Module is durable enough to mount directly on a genset using ¼-inch hardware. Hardware selection should be based on any expected shipping/transportation and operating conditions. The torque applied to the mounting hardware should not exceed 65 in-lb (7.34 N•m).

See Figure 10-1 for CEM-2020 overall dimensions. All dimensions are shown in inches with millimeters in parenthesis.

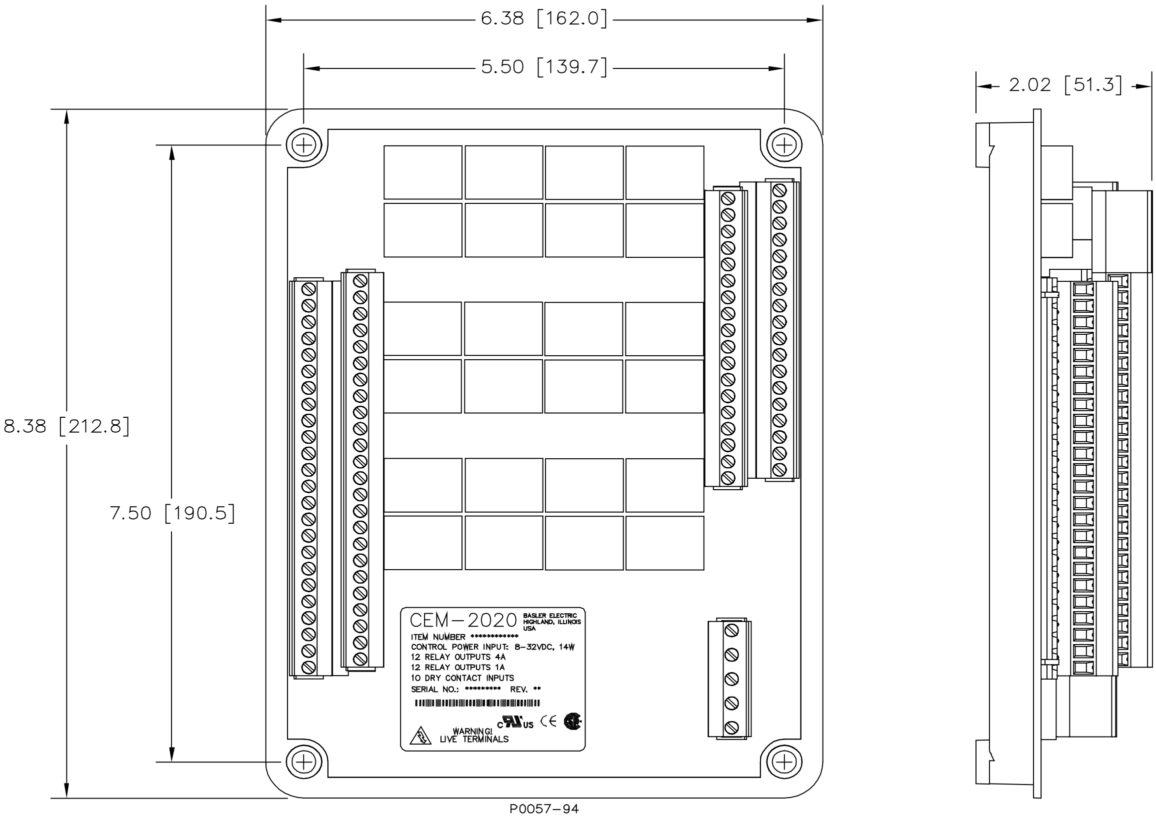

Figure 10-1. CEM-2020 Overall Dimensions

Connections

Contact Expansion Module connections are dependent on the application. Incorrect wiring may result in damage to the module.

NOTES

Operating power from the battery must be of the correct polarity. Although reverse polarity will not cause damage, the CEM-2020 will not operate.

Be sure that the CEM-2020 is hard-wired to earth ground with no smaller than 12 AWG copper wire attached to the chassis ground terminal on the module.

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Terminations

The terminal interface consists of plug-in connectors with screw-down compression terminals.

CEM-2020 connections are made with one 5-position connector, two 18-position connectors, and two 24-position connectors with screw-down compression terminals. These connectors plug into headers on the

CEM-2020. The connectors and headers have dovetailed edges that ensure proper connector orientation. Also, the connectors and headers are uniquely keyed to ensure that the connectors mate only with the correct headers.

Caution
By mating conductors of dissimilar metals, galvanic corrosion could occur which may lead to signal loss.

Connectors and headers may contain tin- or gold-plated conductors. Tin-plated conductors are housed in a black plastic casing and gold-plated conductors are housed in an orange plastic casing. Mate connectors to headers of the same color only.

Connector screw terminals accept a maximum wire size of 12 AWG. Maximum screw torque is 5 inch-pounds (0.56 N•m).

Operating Power

The Contact Expansion Module operating power input accepts either 12 Vdc or 24 Vdc and tolerates voltage over the range of 6 to 32 Vdc. Operating power must be of the correct polarity. Although reverse polarity will not cause damage, the CEM-2020 will not operate. Operating power terminals are listed in Table 10-1.

It is recommended that a fuse be added for additional protection for the wiring to the battery input of the Contact Expansion Module. A Bussmann ABC-7 fuse or equivalent is recommended.

Table 10-1. Operating Power Terminals

Terminal	Description
P1- ⏚ (SHIELD)	Chassis ground connection
P1- – (BATT–)	Negative side of operating power input
P1- + (BATT+)	Positive side of operating power input

Contact Inputs and Contact Outputs

The CEM-2020 (Figure 10-2) has 10 contact inputs and 24 contact outputs.

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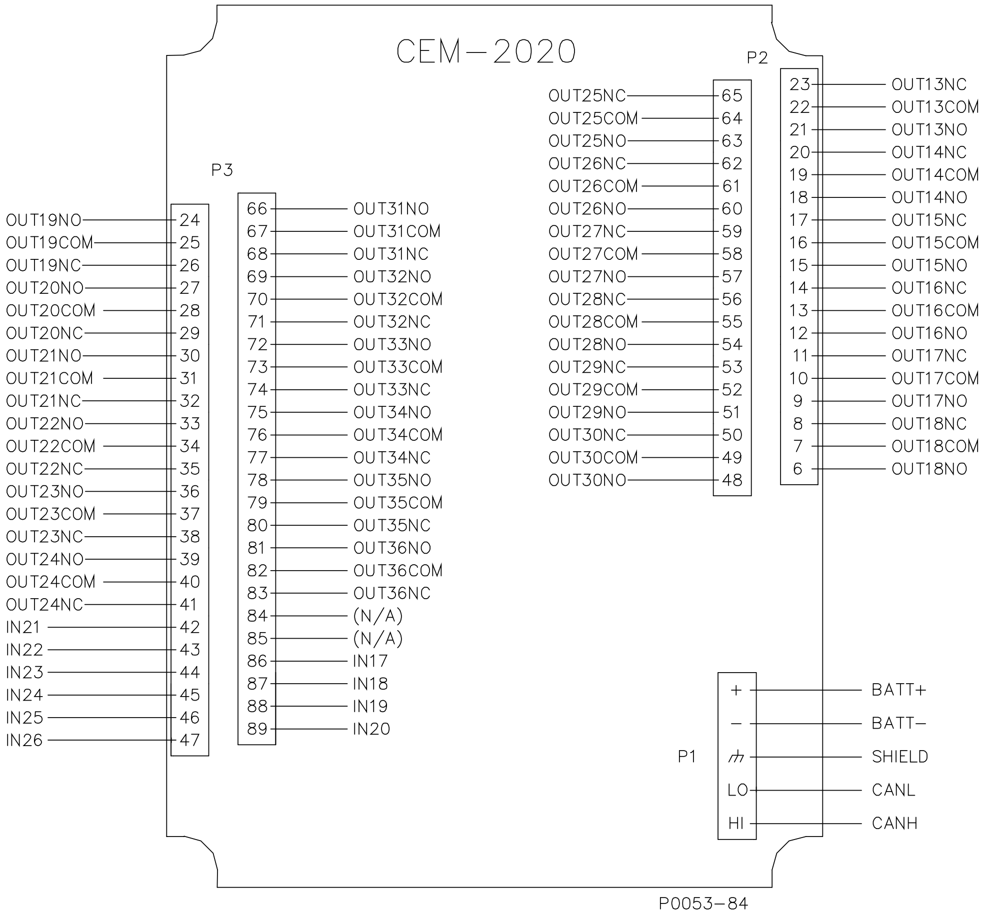

Figure 10-2. CEM-2020 Contact Input and Contact Output Terminals

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CAN Bus Interface

These terminals provide communication using the SAE J1939 protocol and provide high-speed communication between the Contact Expansion Module and the MGC-2000 Series. Connections between the CEM-2020 and MGC-2000 Series should be made with twisted-pair, shielded cable. CAN bus interface terminals are listed in Table 10-2. Refer to Figure 10-3 and Figure 10-4.

Table 10-2. CAN Bus Interface Terminals

Terminal	Description
P1- HI (CAN H)	CAN high connection (yellow wire)
P1- LO (CAN L)	CAN low connection (green wire)
P1- ⏚ (SHIELD)	CAN drain connection

NOTES

1. If the CEM-2020 is providing one end of the J1939 bus, a 120 Ω, ½ watt terminating resistor should be installed across terminals P1- LO (CANL) and P1- HI (CANH).
2. If the CEM-2020 is not part of the J1939 bus, the stub connecting the CEM-2020 to the bus should not exceed 914 mm (3 ft) in length.
3. The maximum bus length, not including stubs, is 40 m (131 ft).
4. The J1939 drain (shield) should be grounded at one point only. If grounded elsewhere, do not connect the drain to the CEM-2020.

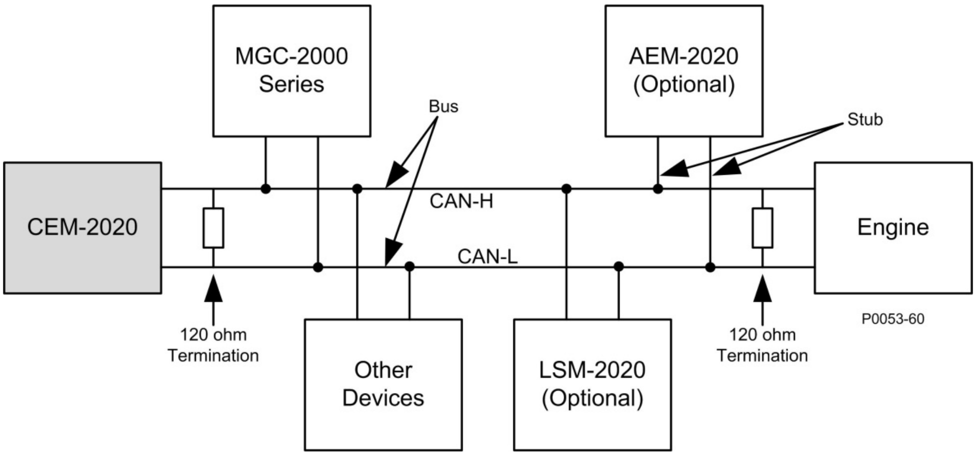

Figure 10-3. CAN Bus Interface with CEM-2020 providing One End of the Bus

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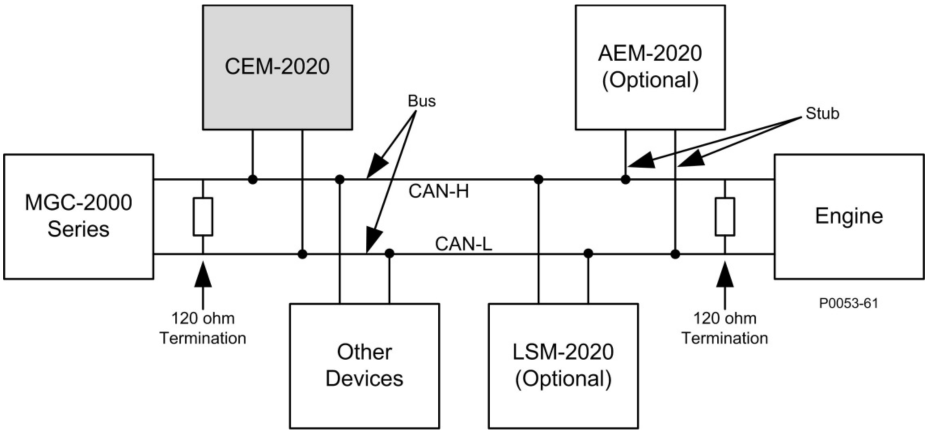

Figure 10-4. CAN Bus Interface with MGC-2000 Series providing One End of the Bus

Maintenance

Preventive maintenance consists of periodically checking that the connections between the CEM-2020 and the system are clean and tight. Contact Expansion Modules are manufactured using state-of-the-art surface-mount technology. As such, Basler Electric recommends that no repair procedures be attempted by anyone other than Basler Electric personnel.

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SECTION 11 • AEM-2020 (ANALOG EXPANSION MODULE)

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SECTION 11 • AEM-2020 (ANALOG EXPANSION MODULE)

General Information

The optional AEM-2020 is a remote auxiliary device that provides additional MGC-2000 Series analog inputs and outputs.

Features

AEM-2020s have the following features:

- 8 Analog Inputs
- 8 RTD Inputs
- 2 Thermocouple Inputs
- 4 Analog Outputs
- Functionality of Inputs and Outputs assigned by BESTlogic*Plus* programmable logic
- Communications via CAN bus

Specifications

Operating Power

Nominal.................................... 12 or 24 Vdc
Range .... 8 to 32 Vdc (Withstands cranking ride-through down to 6 Vdc for 500 ms.)
Maximum Consumption............ 5.1 W

Analog Inputs

The AEM-2020 contains eight programmable analog inputs.

Rating .... 4 to 20 mAdc or 0 to 10 Vdc (user-selectable)

Burden

4 to 20 mA.......................... 470 Ω maximum
±10 Vdc .... 9.65k Ω minimum

RTD Inputs

The AEM-2020 contains eight programmable RTD inputs.

Rating .... 100 Ω Platinum or 10 Ω Copper (user-selectable)
Setting Range........................... –50 to +250°C or –58 to +482°F
Accuracy (10 Ω Copper) .... ±0.044 Ω @ 25°C, ±0.005 Ω/°C drift over ambient temperature
Accuracy (100 Ω Platinum)........ ±0.39 Ω @ 25°C, ±0.047Ω/°C drift over ambient temperature

Thermocouple Inputs

The AEM-2020 contains two thermocouple inputs.

Rating .... 2 K Type Thermocouples
Setting Range........................... 0 to 1,375°C or 0 to 2,507°F
Display Range .... Ambient to 1,375°C or Ambient to 2,507°F
Accuracy.................................. ±40uV @ 25°C, ±5 uV/°C drift over ambient temperature

Analog Outputs

The AEM-2020 contains four programmable analog outputs.

Rating .... 4 to 20 mAdc or 0 to 10 Vdc (user-selectable)

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Communication Interface

CAN bus

Differential Bus Voltage .... 1.5 to 3 Vdc
Maximum Voltage .... –32 to +32 Vdc with respect to negative battery terminal
Communication Rate .... 250 kb/s

Type Tests

Shock

Withstands 15 G in 3 perpendicular planes.

Vibration

Swept over the following ranges for 12 sweeps in each of three mutually perpendicular planes with each 15-minute sweep consisting of the following:

5 to 29 to 5 Hz .... 1.5 G peak for 5 min.
29 to 52 to 29 Hz .... 0.036" Double Amplitude for 2.5 min.
52 to 500 to 52 Hz .... 5 G peak for 7.5 min.

Ignition System

Tested in closed proximity to an unshielded, unsuppressed Altronic DISN 800 ignition system.

HALT (Highly Accelerated Life Testing)

HALT is used by Basler Electric to prove that our products will provide the user with many years of reliable service. HALT subjects the device to extremes in temperature, shock, and vibration to simulate years of operation, but in a much shorter period span. HALT allows Basler Electric to evaluate all possible design elements that will add to the life of this device. As an example of some of the extreme testing conditions, the AEM-2020 was subjected to temperature tests (tested over a temperature range of –80°C to +130°C), vibration tests (of 5 to 50 G at +25°C), and temperature/vibration tests (tested at 10 to 20 G over a temperature range of –60°C to +100°C). Combined temperature and vibration testing at these extremes proves that the AEM-2020 is expected to provide long-term operation in a rugged environment. Note that the vibration and temperature extremes listed in this paragraph are specific to HALT and do not reflect recommended operation levels. These operational ratings are included in this section.

Environment

Temperature
    Operating............................ –40 to +70°C (–40 to +158°F)
    Storage............................... –40 to +85°C (–40 to +185°F)
Humidity.................................... IEC 68-2-38

UL Approval

"cURus" recognized to UL Standard 508 & CSA Standard C22.2 No.14

CSA Certification

CSA certified to Standard C22.2 No.14.

NFPA Compliance

Complies with NFPA Standard 110, *Standard for Emergency and Standby Power*.

CE Compliance

This product complies with the requirements of the following EC Directives:

- Low Voltage Directive (LVD) - 73/23/EEC as amended by 93/68/EEC
- Electromagnetic Compatibility (EMC) - 89/336/EEC as amended by 92/31/EEC and 93/68/EEC

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This product conforms to the following Harmonized Standards:

- EN 50178:1997 - *Electronic Equipment for use in Power Installations*
- EN 61000-6-4:2001 - *Electromagnetic Compatibility (EMC), Generic Standards, Emission Standard for Industrial Environments*
- EN 61000-6-2:2001 - *Electromagnetic Compatibility (EMC), Generic Standards, Immunity for Industrial Environments*

Physical

Weight....................................... 1.80 lb (816 g)
Dimensions .... See *Installation* later in this section.

Functional Description

A functional description of the AEM-2020's inputs and outputs is provided below.

Analog Inputs

The AEM-2020 provides eight analog inputs that are user-selectable for 4 to 20 mAdc or 0 to 10 Vdc. Each analog input has under/over thresholds that can be configured as status only, alarm, or pre-alarm. When enabled, an out of range alarm alerts the user of an open or damaged analog input wire. The label text of each analog input is customizable.

RTD Inputs

The AEM-2020 provides eight user-configurable RTD inputs for monitoring genset temperature. Each RTD input can be configured as status only, alarm, or pre-alarm to protect against high or low temperature conditions. When enabled, an out of range alarm alerts the user of an open or damaged RTD input wire. The label text of each RTD input is customizable.

Thermocouple Inputs

The AEM-2020 provides two thermocouple inputs for monitoring genset temperature. Each thermocouple input can be configured as status only, alarm, or pre-alarm to protect against high or low temperature conditions. The label text of each thermocouple input is customizable.

Analog Outputs

The AEM-2020 provides four analog outputs that are user-selectable for 4 to 20 mAdc or 0 to 10 Vdc. A wide selection of parameters including oil pressure, fuel level, generator voltage, and bus voltage can be configured as analog outputs. Refer to Section 4, *BESTCOMSPlus™ Software,* for a full list of parameter selections.

Communications

CAN Bus

A Control Area Network (CAN) is a standard interface that enables communication between the AEM-2020 and the MGC-2000 Series.

BESTCOMSPlus® Software

BESTCOMS*Plus®* provides the user with a point-and-click means to set and monitor the Analog Expansion Module. Installation and operation of BESTCOMS*Plus®* is described in Section 4, *BESTCOMSPlus® Software.*

Installation

Analog Expansion Modules are delivered in sturdy cartons to prevent shipping damage. Upon receipt of a module, check the part number against the requisition and packing list for agreement. Inspect for damage, and if there is evidence of such, immediately file a claim with the carrier and notify MTU Onsite Energy.

If the device is not installed immediately, store it in the original shipping package in a moisture- and dust-free environment.

Mounting

Analog Expansion Modules are contained in a potted plastic case and may be mounted in any convenient position. The construction of an Analog Expansion Module is durable enough to mount directly on a genset using ¼-inch hardware. Hardware selection should be based on any expected shipping/transportation and operating conditions. The torque applied to the mounting hardware should not exceed 65 in-lb (7.34 N•m).

See Figure 11-1 for AEM-2020 overall dimensions. All dimensions are shown in inches with millimeters in parenthesis.

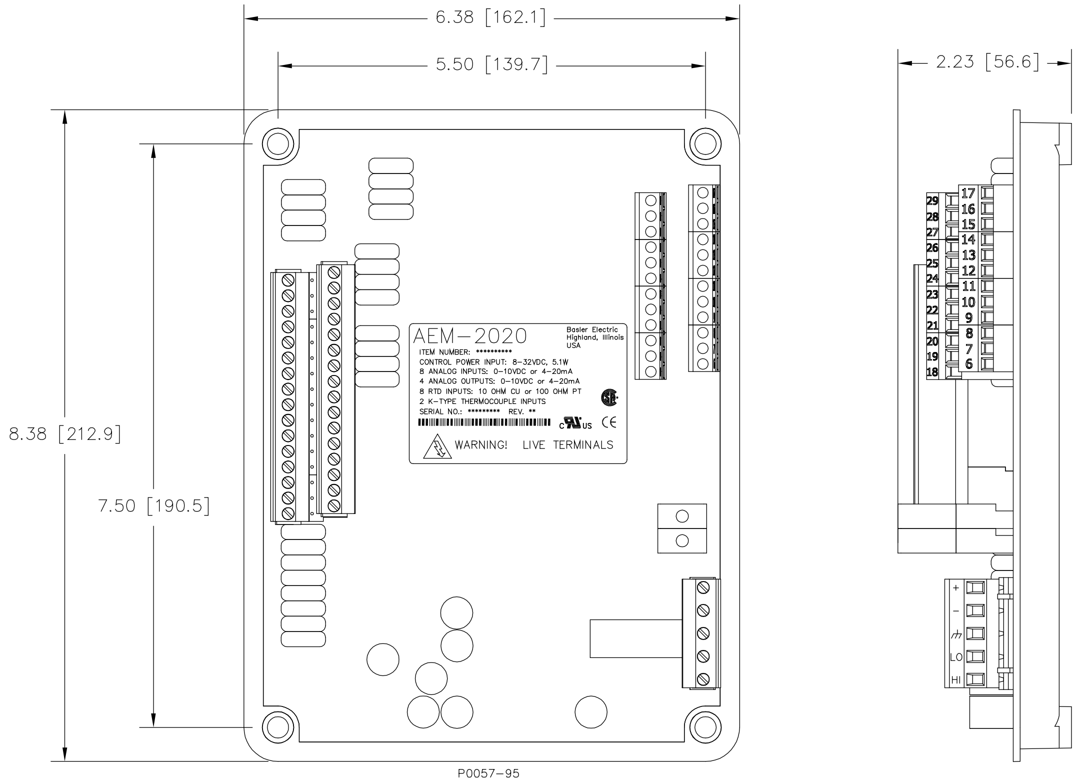

Figure 11-1. AEM-2020 Overall Dimensions

Connections

Analog Expansion Module connections are dependent on the application. Incorrect wiring may result in damage to the module.

> **NOTES**
>
> Operating power from the battery must be of the correct polarity. Although reverse polarity will not cause damage, the AEM-2020 will not operate.
>
> Be sure that the AEM-2020 is hard-wired to earth ground with no smaller than 12 AWG copper wire attached to the chassis ground terminal on the module.

Terminations

The terminal interface consists of both plug-in connectors and a permanently mounted connector with screw-down compression terminals.

AEM-2020 connections are made with one 5-position connector, two 12-position connectors, two 16-position connectors, and two 2-position thermocouple connectors. The 16, 5, and 2-position connectors plug into headers on the AEM-2020. The connectors and headers have dovetailed edges that ensure proper connector orientation. Also, the connectors and headers are uniquely keyed to ensure that the connectors mate only with the correct headers. The 12-position connector is not a plug-in connector and is mounted permanently to the board.

Caution
By mating conductors of dissimilar metals, galvanic corrosion could occur which may lead to signal loss.

Connectors and headers may contain tin- or gold-plated conductors. Tin-plated conductors are housed in a black plastic casing and gold-plated conductors are housed in an orange plastic casing. Mate connectors to headers of the same color only.

Connector screw terminals accept a maximum wire size of 12 AWG. Thermocouple connectors accept a maximum thermocouple wire diameter of 0.177 inches (4.5 mm). Maximum screw torque is 5 inch-pounds (0.56 N•m).

Operating Power

The Analog Expansion Module operating power input accepts either 12 Vdc or 24 Vdc and tolerates voltage over the range of 6 to 32 Vdc. Operating power must be of the correct polarity. Although reverse polarity will not cause damage, the AEM-2020 will not operate. Operating power terminals are listed in Table 11-1.

It is recommended that a fuse be added for additional protection for the wiring to the battery input of the Analog Expansion Module. A Bussmann ABC-7 fuse or equivalent is recommended.

Table 11-1. Operating Power Terminals

Terminal	Description
P1- ⏚ (SHIELD)	Chassis ground connection
P1- – (BATT–)	Negative side of operating power input
P1- + (BATT+)	Positive side of operating power input

AEM-2020 Inputs and Outputs

Input and output terminals are shown in Figure 11-2 and listed in Table 11-2.

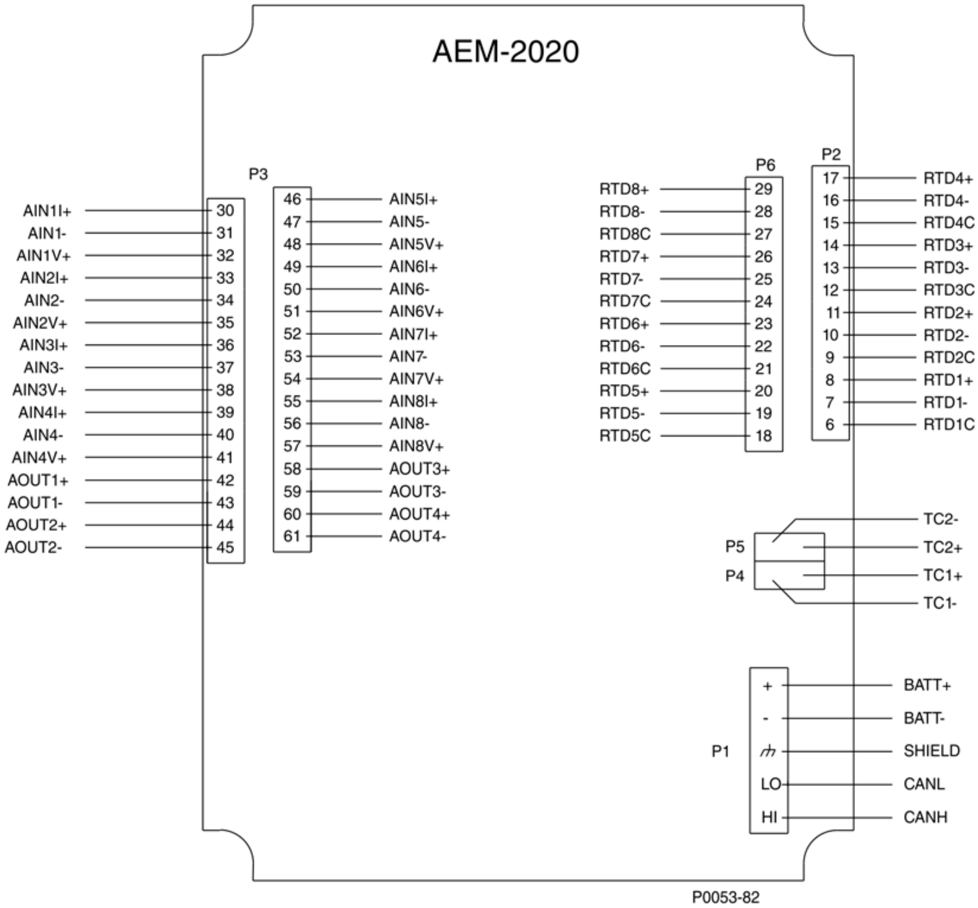

Figure 11-2. Input and Output Terminals

Table 11-2. Input and Output Terminals

Connector	Description
P1	Operating Power and CAN bus
P2	RTD Inputs 1 - 4
P3	Analog Inputs 1 - 8 and Analog Outputs 1 - 4
P4	Thermocouple 1 Input
P5	Thermocouple 2 Input
P6	RTD Inputs 5 - 8

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External Analog Input Connections

Voltage input connections are shown in Figure 11-3 and current input connections are shown in Figure 11-4. When using the current input, AIN V+ and AIN I+ must be tied together.

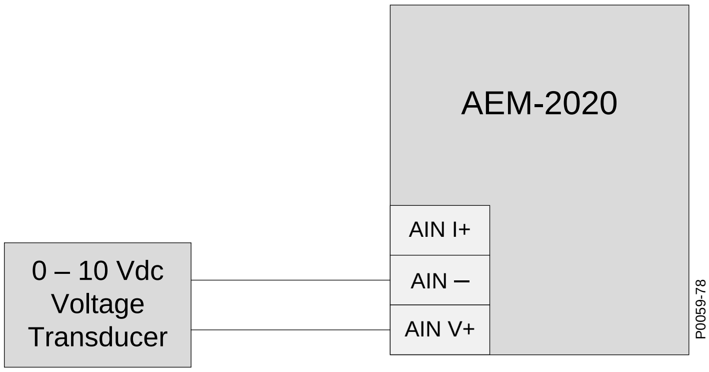

Figure 11-3. Analog Inputs - Voltage Input Connections

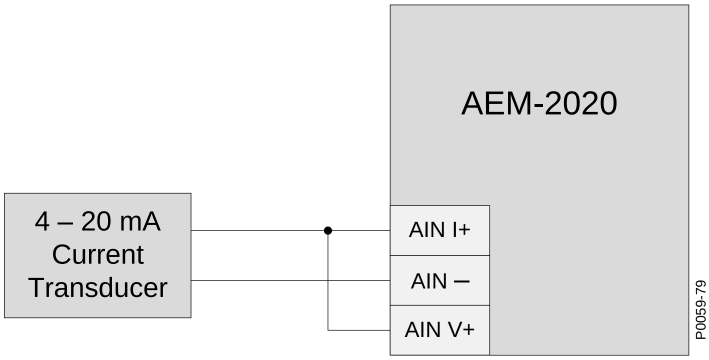

Figure 11-4. Analog Inputs - Current Input Connections

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External RTD Input Connections

External 2-wire RTD input connections are shown in Figure 11-5. Figure 11-6 shows external 3-wire RTD input connections.

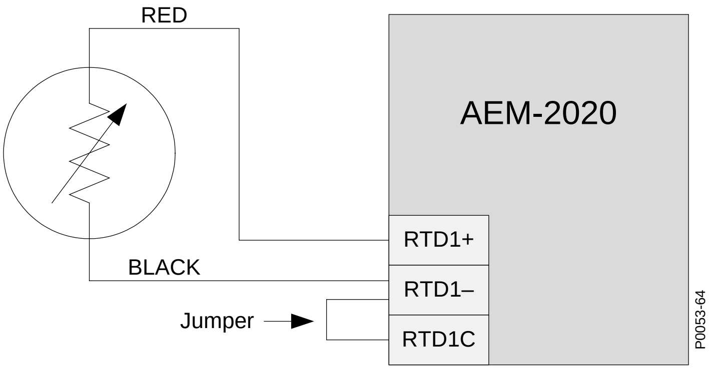

Figure 11-5. External Two-Wire RTD Input Connections

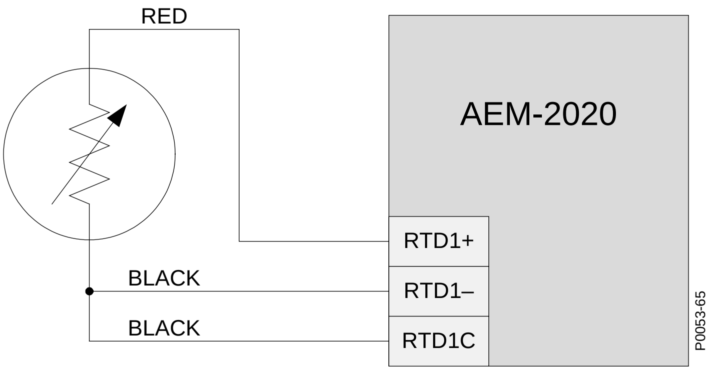

Figure 11-6. External Three-Wire RTD Input Connections

CAN Bus Interface

These terminals provide communication using the SAE J1939 protocol and provide high-speed communication between the Analog Expansion Module and the MGC-2000 Series. Connections between the AEM-2020 and MGC-2000 Series should be made with twisted-pair, shielded cable. CAN Bus interface terminals are listed in Table 11-3. Refer to Figure 11-7 and Figure 11-8.

Table 11-3. CAN Bus Interface Terminals

Terminal	Description
P1- HI (CAN H)	CAN high connection (yellow wire)
P1- LO (CAN L)	CAN low connection (green wire)
P1- ⏚ (SHIELD)	CAN drain connection

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NOTES

1. If the AEM-2020 is providing one end of the J1939 bus, a 120 Ω, ½ watt terminating resistor should be installed across terminals P1- LO (CANL) and P1- HI (CANH).
2. If the AEM-2020 is not part of the J1939 bus, the stub connecting the AEM-2020 to the bus should not exceed 914 mm (3 ft) in length.
3. The maximum bus length, not including stubs, is 40 m (131 ft).
4. The J1939 drain (shield) should be grounded at one point only. If grounded elsewhere, do not connect the drain to the AEM-2020.

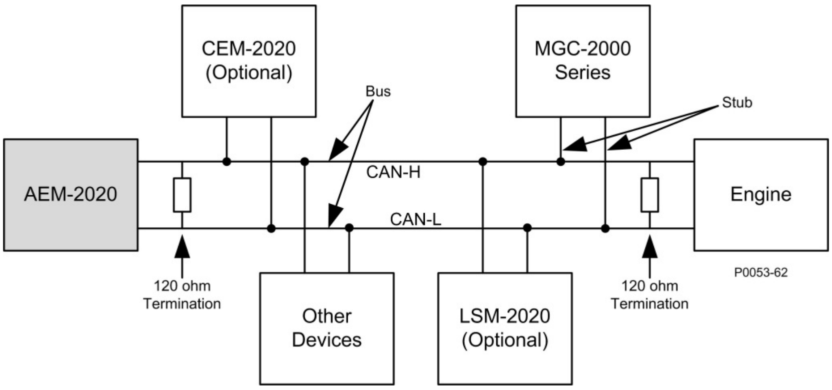

Figure 11-7. CAN Bus Interface with AEM-2020 providing One End of the Bus

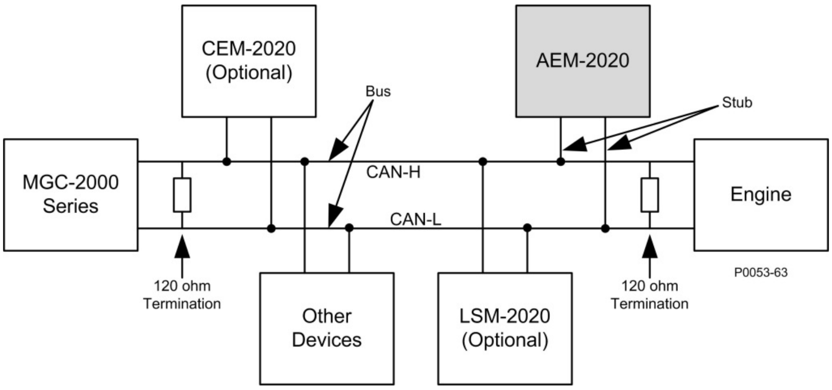

Figure 11-8. CAN Bus Interface with MGC-2000 Series providing One End of the Bus

Maintenance

Preventive maintenance consists of periodically checking that the connections between the AEM-2020 and the system are clean and tight. Analog Expansion Modules are manufactured using state-of-the-art surface-mount technology. As such, MTU Onsite Energy recommends that no repair procedures be attempted by anyone other than MTU Onsite Energy personnel.

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APPENDIX A • TIME OVERCURRENT CHARACTERISTIC CURVES

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APPENDIX A • TIME OVERCURRENT CHARACTERISTIC CURVES

Introduction

The inverse time overcurrent characteristic curves provided by the MGC-2000 Series (style xxxxxxExx only) closely emulate most of the common electromechanical, induction-disk, overcurrent relays sold in North America. To further improve proper relay coordination, selection of integrated reset or instantaneous reset characteristics is also provided.

Curve Specifications

Timing Accuracy:

Within ±500 milliseconds of indicated operating point.

Sixteen inverse time functions, one fixed time function, and one programmable time function can be selected. Characteristic curves for the inverse and definite time functions are defined by the following equation:

$$T_T = \frac{AD}{(M^N - C)^Q} + BD + K$$

Equation A-1

$$T_R = \frac{RD}{\left| M^2 - 1 \right|}$$

Equation A-2

T_T = Time to trip when $M \geq 1$

T_R = Time to reset if relay is set for integrating reset when $M < 1$. Otherwise, reset is 50 milliseconds or less

D = TIME DIAL setting (0.0 to 9.9) ∗

M = Multiple of PICKUP setting (0 to 40)

A, B, C, N, K = Constants for the particular curve

R = Constant defining the reset time

This equation complies with IEEE Std C37.112 - 1996 - *IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays*.

∗ Timing range is 0.0 to 7,200 seconds when the F (fixed) curve is selected.

Table A-1 lists time characteristic curve constants. See Figures A-1 through A-16 for graphs of the characteristics.

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Table A-1. 51 Time Characteristic Curve Constants

Curve Selection	Curve Name	Trip Characteristic Constants						Reset †
		A	B	C	N	K	Q	R
S1	Short Inverse	0.2663	0.03393	1	1.2969	0.028	1	0.5
S2	Short Inverse	0.0286	0.0208	1	0.9844	0.028	1	0.094
L1	Long Inverse	5.6143	2.18592	1	1	0.028	1	15.75
L2	Long Inverse	2.3955	0	1	0.3125	0.028	1	7.8001
D	Definite Time	0.4797	0.21359	1	1.5625	0.028	1	0.875
M	Moderately Inverse	0.3022	0.1284	1	0.5	0.028	1	1.75
I1	Inverse Time	8.9341	0.17966	1	2.0938	0.028	1	9
I2	Inverse Time	0.2747	0.10426	1	0.4375	0.028	1	0.8868
V1	Very Inverse	5.4678	0.10814	1	2.0469	0.028	1	5.5
V2	Very Inverse	4.4309	0.0991	1	1.9531	0.028	1	5.8231
E1	Extremely Inverse	7.7624	0.02758	1	2.0938	0.028	1	7.75
E2	Extremely Inverse	4.9883	0.0129	1	2.0469	0.028	1	4.7742
A	Standard Inverse	0.01414	0	1	0.02	0.028	1	2
B	Very Inverse (I^2t)	1.4636	0	1	1.0469	0.028	1	3.25
C	Extremely Inverse (I^2t)	8.2506	0	1	2.0469	0.028	1	8
G	Long Time Inverse (I^2t)	12.1212	0	1	1	0.028	1	29
F	Fixed Time ∗	0	1	0	0	0.028	1	1
P	User Programmable ‡	0 to 600	0 to 25	0 to 1	0.5 to 2.5	0.0280	1	0 to 30

∗ Curve F has a fixed delay of one second times the Time Dial setting.

† Instantaneous or integrating reset is selected on the *Overcurrent* setup screen in BESTCOMS*Plus*®.

‡ The programmable curve allows for four significant digits after the decimal place for every variable.

Time Overcurrent Characteristic Curve Graphs

Figures A-1 through A-16 illustrate the characteristic curves of the MGC-2000 Series. Table A-2 cross-references each curve to existing electromechanical relay characteristics. Equivalent time dial settings were calculated at a value of five times pickup.

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Table A-2. Characteristic Curve Cross-Reference

Curve	Curve Name	Similar To
S1	Short Inverse	ABB CO-2
S2	Short Inverse	GE IAC-55
L1	Long Inverse	ABB CO-5
L2	Long Inverse	GE IAC-66
D	Definite Time	ABB CO-6
M	Moderately Inverse	ABB CO-7
I1	Inverse Time	ABB CO-8
I2	Inverse Time	GE IAC-51
V1	Very Inverse	ABB CO-9
V2	Very Inverse	GE IAC-53
E1	Extremely Inverse	ABB CO-11
E2	Extremely Inverse	GE IAC-77
A	Standard Inverse	BS 142
B	Very Inverse (I^2t)	BS 142
C	Extremely Inverse (I^2t)	BS 142
G	Long Time Inverse (I^2t)	BS 142
F	Fixed Time	N/A
P	User Programmable	N/A

Time Dial Setting Cross-Reference

Although the time characteristic curve shapes have been optimized for the MGC-2000 Series, the MGC-2000 Series time dial settings are not identical to the settings of electromechanical induction disk overcurrent relays. Table A-3 helps you convert the time dial settings of induction disk relays to the equivalent setting for the MGC-2000 Series.

Using Table A-3

Cross-reference table values were obtained by inspection of published electromechanical time current characteristic curves. The time delay for a current of five times tap was entered into the time dial calculator function for each time dial setting. The equivalent MGC-2000 Series time dial setting was then entered into the cross-reference table.

If your electromechanical relay time dial setting is between the values provided in the table, it will be necessary to interpolate (estimate the correct intermediate value) between the electromechanical setting and the Basler Electric setting.

The MGC-2000 Series has a maximum time dial setting of 9.9. When the F (fixed) curve is selected, the maximum timing range is 7,200 seconds. The Basler Electric equivalent time dial setting for the electromechanical maximum setting is provided in the cross-reference table even if it exceeds 9.9. This allows interpolation as noted above.

Basler Electric time current characteristics are determined by a linear mathematical equation. The induction disk of an electromechanical relay has a certain degree of non linearity due to inertial and friction effects. For this reason, even though every effort has been made to provide characteristic curves with minimum deviation from the published electromechanical curves, slight deviations can exist between them.

In applications where the time coordination between curves is extremely close, we recommend that you choose the optimal time dial setting by inspection of the coordination study. In applications where coordination is tight, it is recommended that you retrofit your circuits with Basler Electric electronic relays to ensure high timing accuracy.

Table A-3 .Time Dial Setting Cross-Reference

Curve	Equivalent To	Electromechanical Relay Time Dial Setting											
		0.5	**1.0**	**2.0**	**3.0**	**4.0**	**5.0**	**6.0**	**7.0**	**8.0**	**9.0**	**10.0**	**11.0**
		Basler Electric Equivalent Time Dial Setting											
S1	ABB CO-2	0.3	0.8	1.7	2.4	3.4	4.2	5.0	5.8	6.7	7.7	8.6	9.7
L1	ABB CO-5	0.4	0.8	1.5	2.3	3.3	4.2	5.0	6.0	7.0	7.8	8.8	9.9
D	ABB CO-6	0.5	1.1	2.0	2.9	3.7	4.5	5.0	5.9	7.2	8.0	8.9	10.1
M	ABB CO-7	0.4	0.8	1.7	2.5	3.3	4.3	5.3	6.1	7.0	8.0	9.0	9.8
I1	ABB CO-8	0.3	0.7	1.5	2.3	3.2	4.0	5.0	5.8	6.8	7.6	8.7	10.0
V1	ABB CO-9	0.3	0.7	1.4	2.1	3.0	3.9	4.8	5.7	6.7	7.8	8.7	9.6
E1	ABB CO-11	0.3	0.7	1.5	2.4	3.2	4.2	5.0	5.7	6.6	7.8	8.5	10.3
I2	GE IAC-51	0.6	1.0	1.9	2.7	3.7	4.8	5.7	6.8	8.0	9.3	10.6	N/A
V2	GE IAC-53	0.4	0.8	1.6	2.4	3.4	4.3	5.1	6.3	7.2	8.4	9.6	N/A
S2	GE IAC-55	0.2	1.0	2.0	3.1	4.0	4.9	6.1	7.2	8.1	8.9	9.8	N/A
L2	GE IAC-66	0.4	0.9	1.8	2.7	3.9	4.9	6.3	7.2	8.5	9.7	10.9	N/A
E2	GE IAC-77	0.5	1.0	1.9	2.7	3.5	4.3	5.2	6.2	7.4	8.2	9.9	N/A

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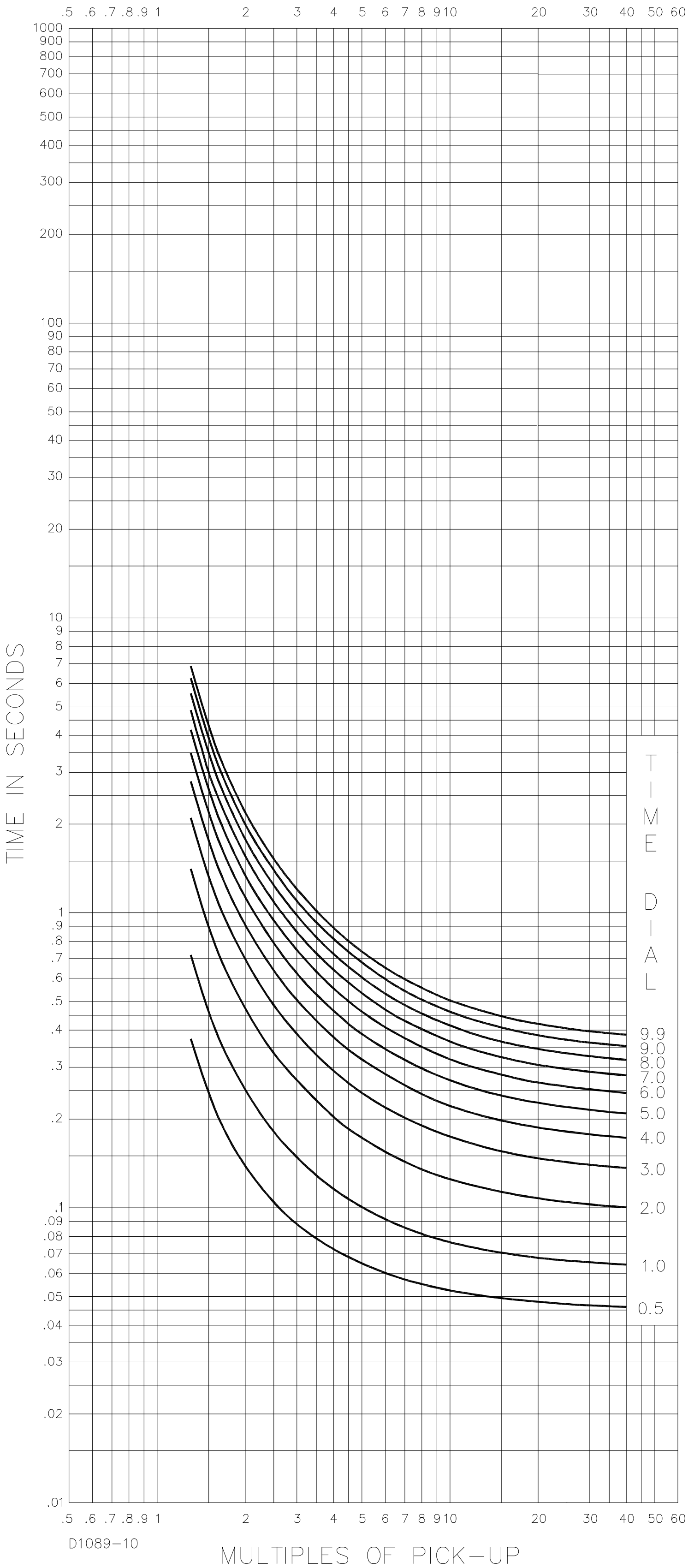

Figure A-1. Time Characteristic Curve S1, Short Inverse (Similar to ABB CO-2)

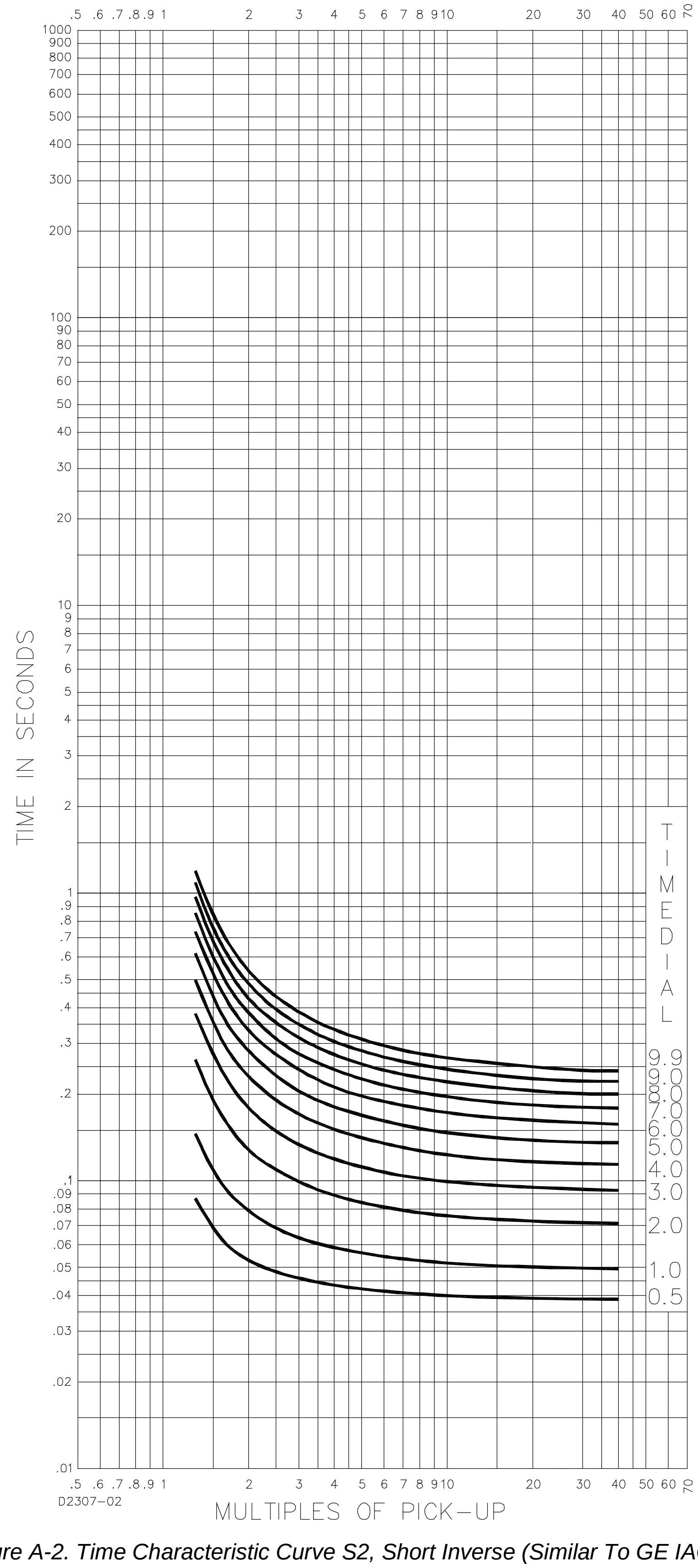

Figure A-2. Time Characteristic Curve S2, Short Inverse (Similar To GE IAC-55)

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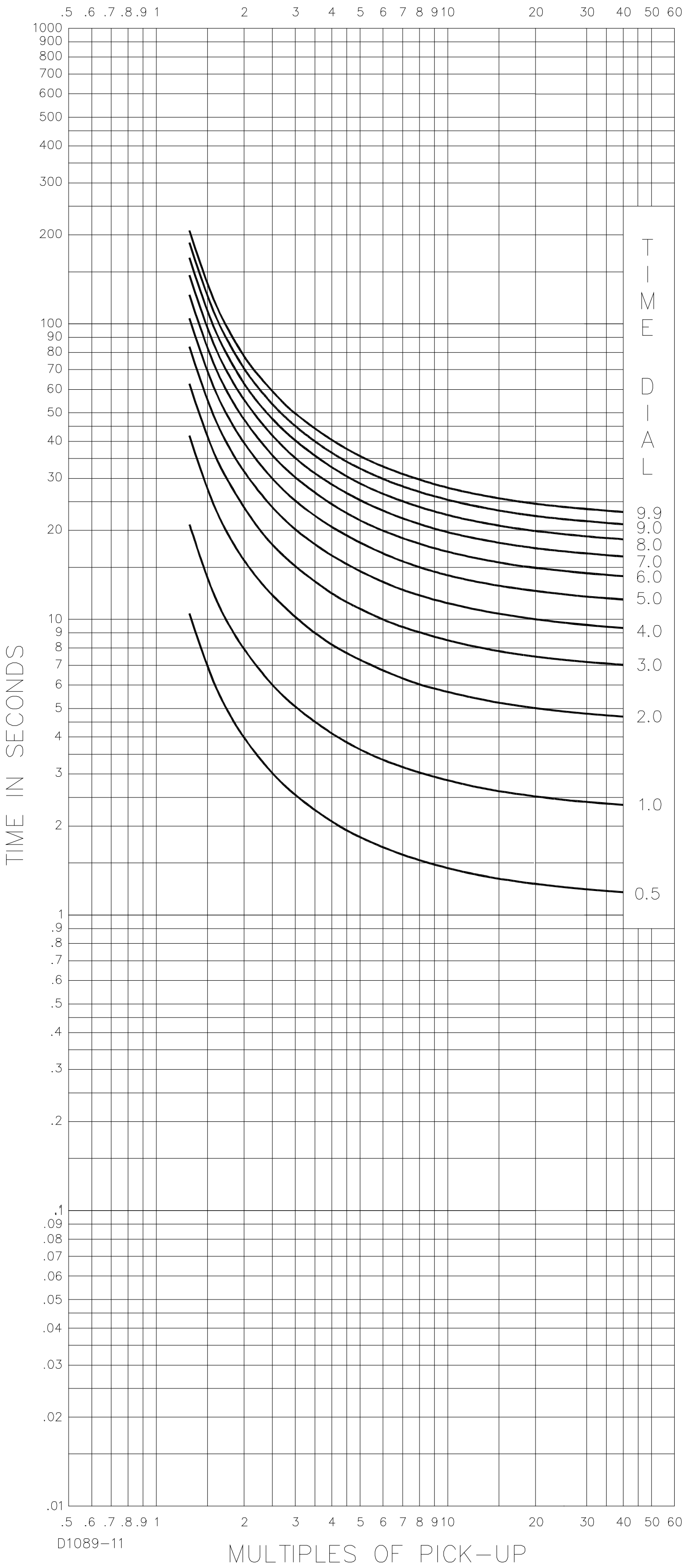

Figure A-3. Time Characteristic Curve L1, Long Inverse (Similar to ABB CO-5)

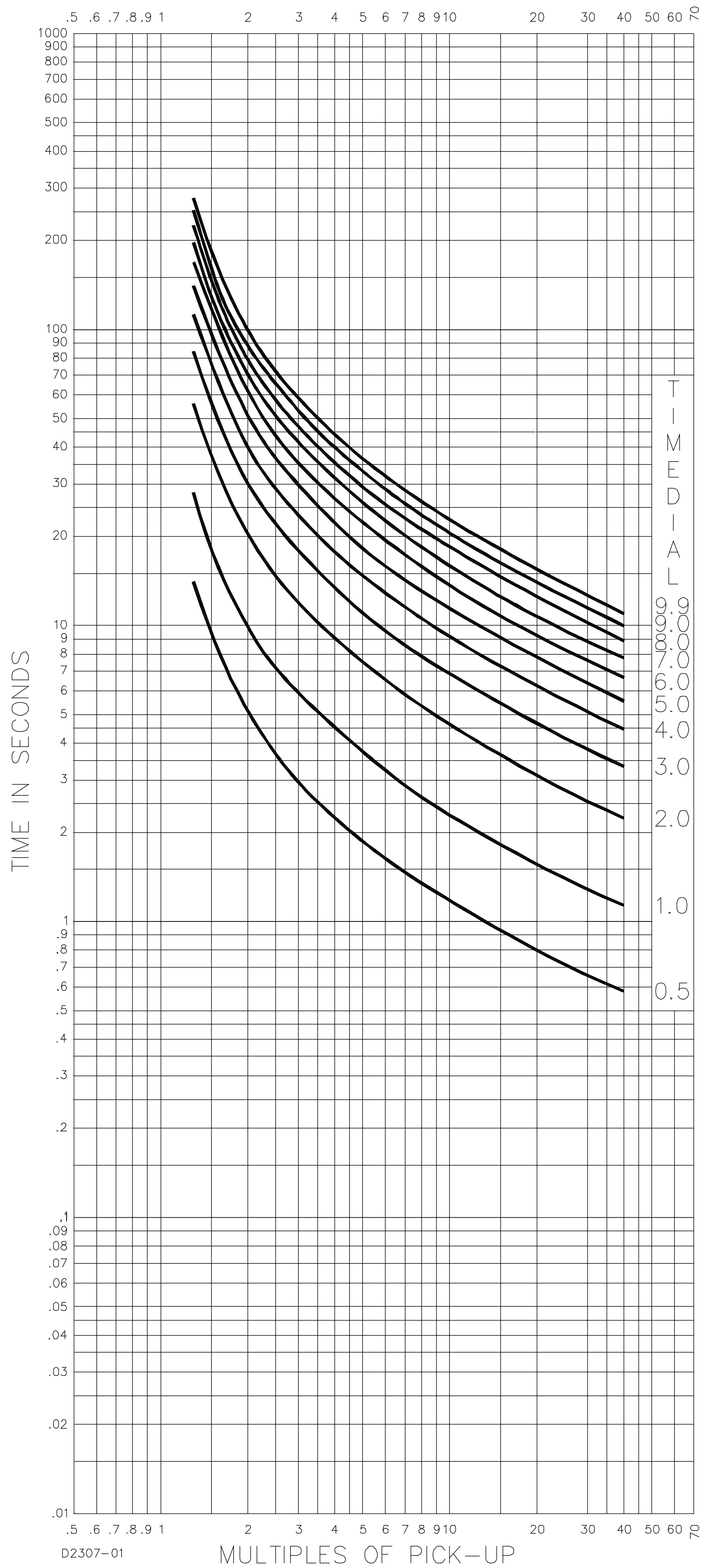

Figure A-4. Time Characteristic Curve L2, Long Inverse (Similar To GE IAC-66)

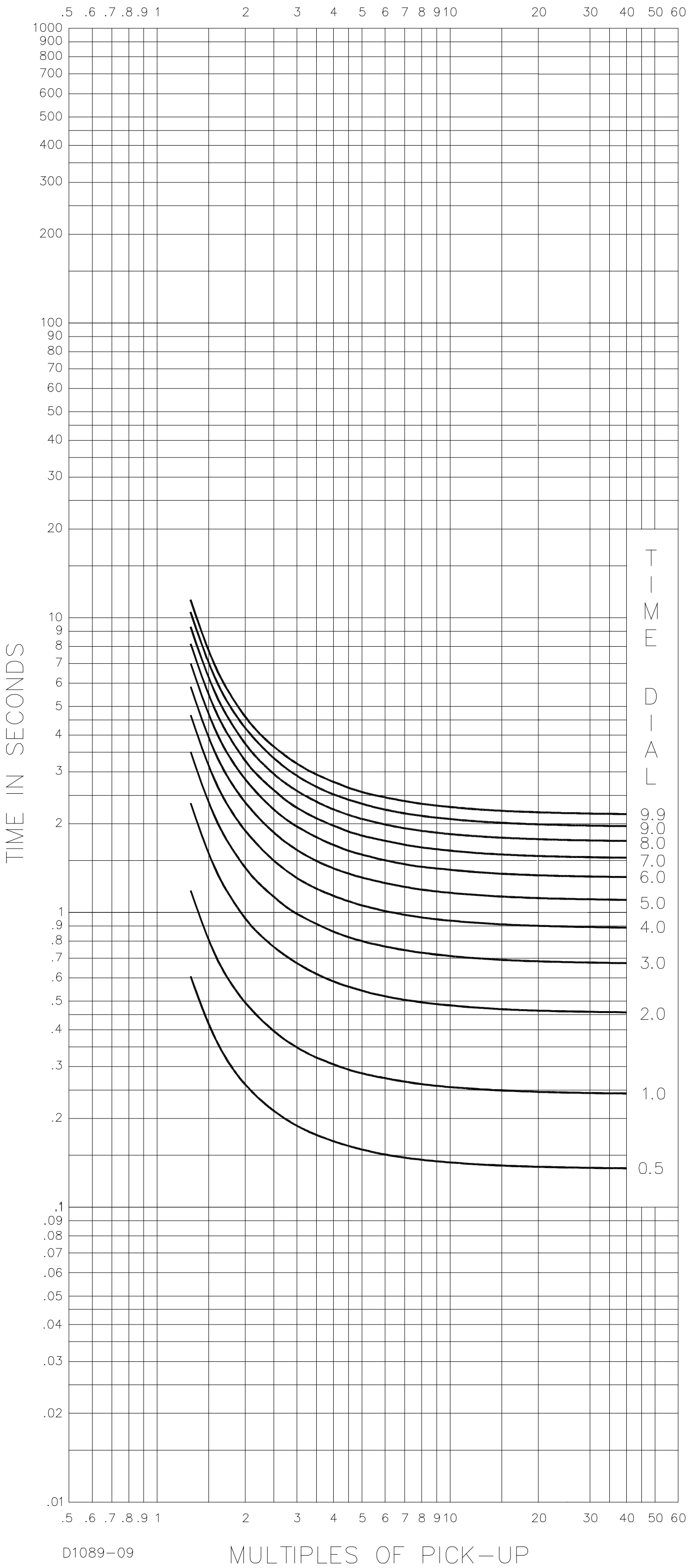

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Figure A-5. Time Characteristic Curve D, Definite Time (Similar To ABB CO-6)

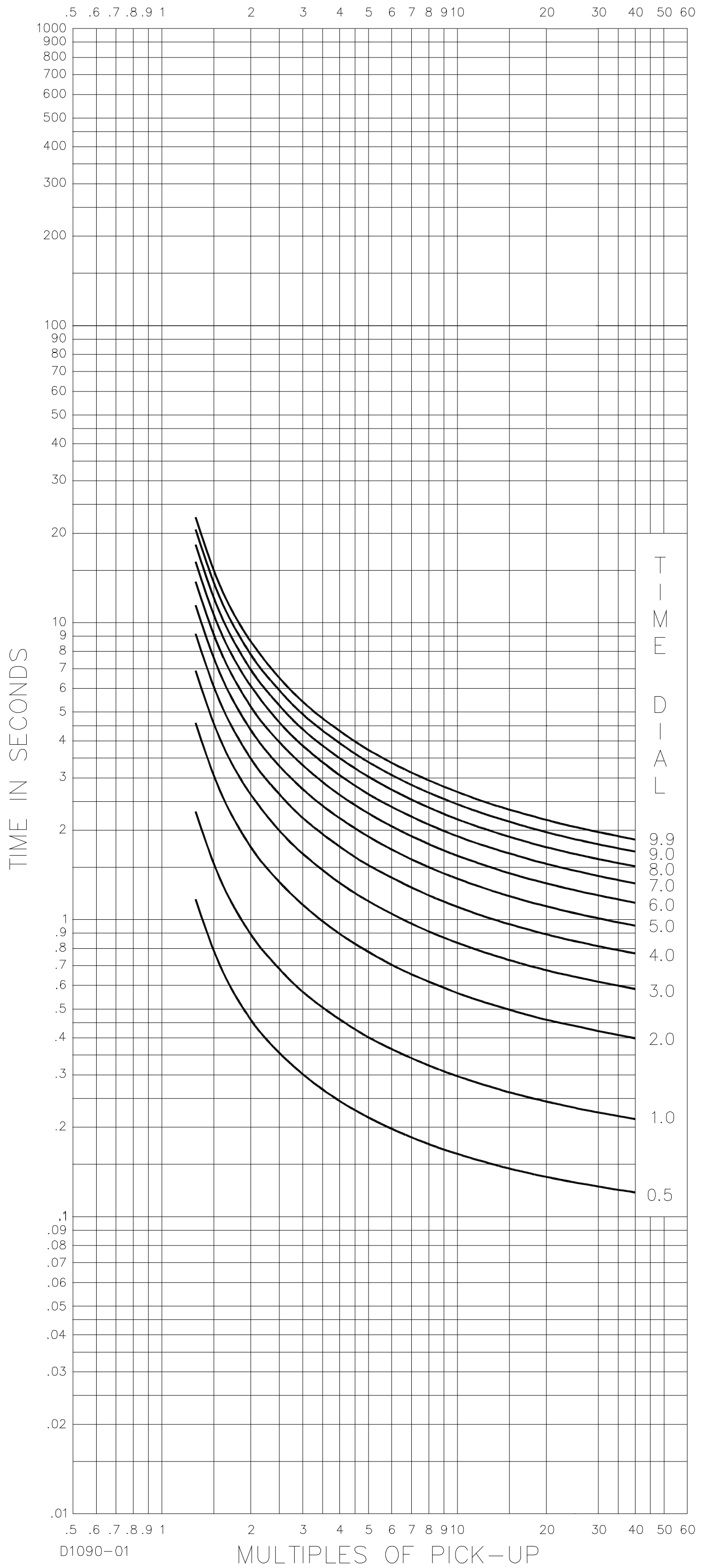

Figure A-6. Time Characteristic Curve M, Moderately Inverse (Similar to ABB CO-7)

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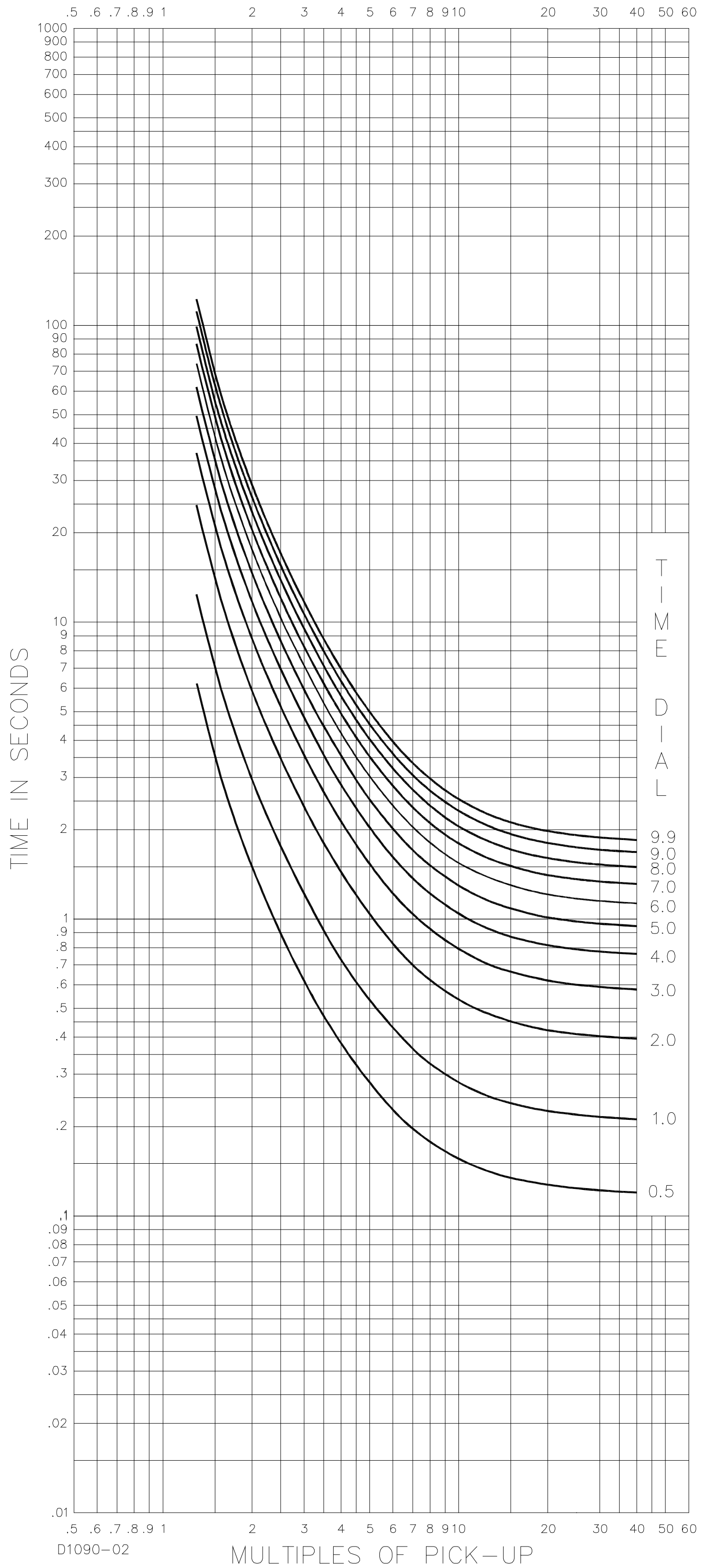

Figure A-7. Time Characteristic Curve I1, Inverse Time (Similar to ABB CO-8)

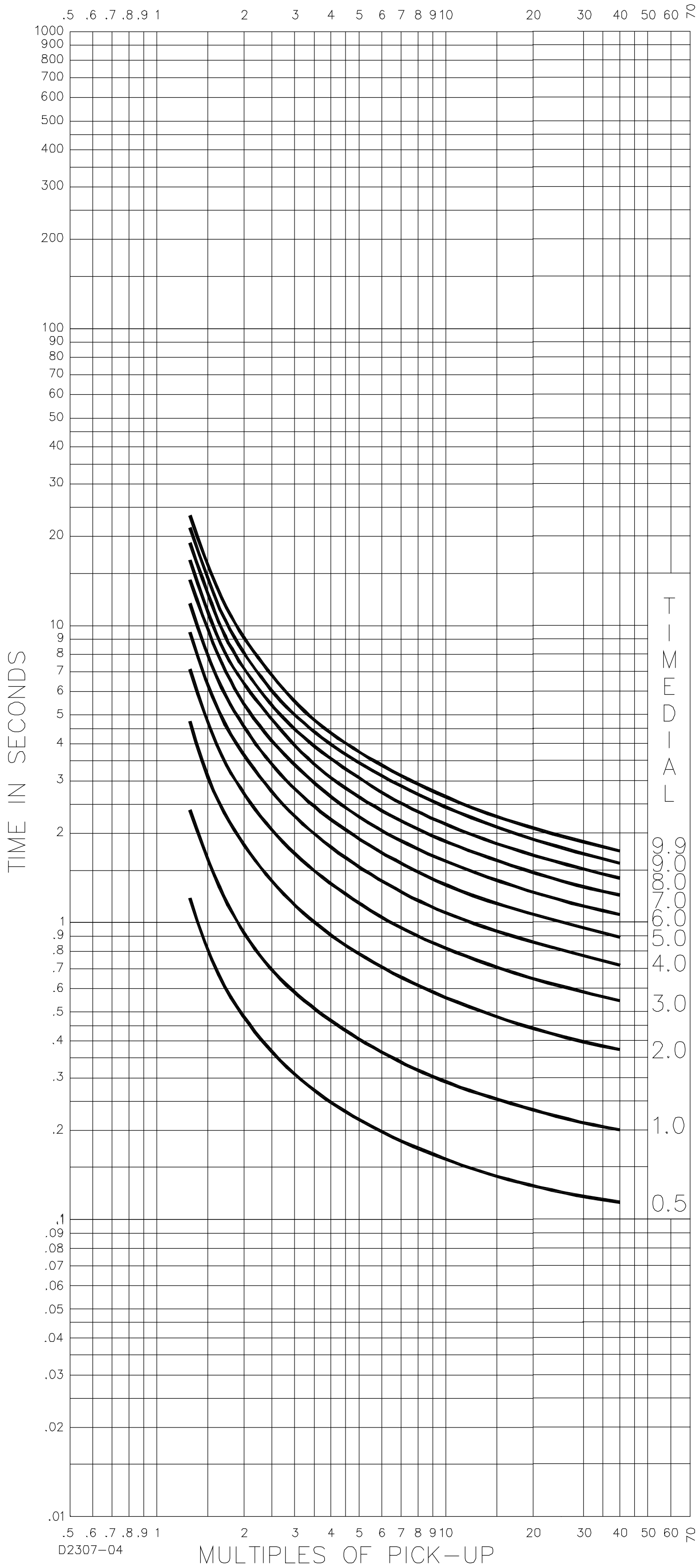

Figure A-8. Time Characteristic Curve I2, Inverse Time (Similar to GE IAC-51)

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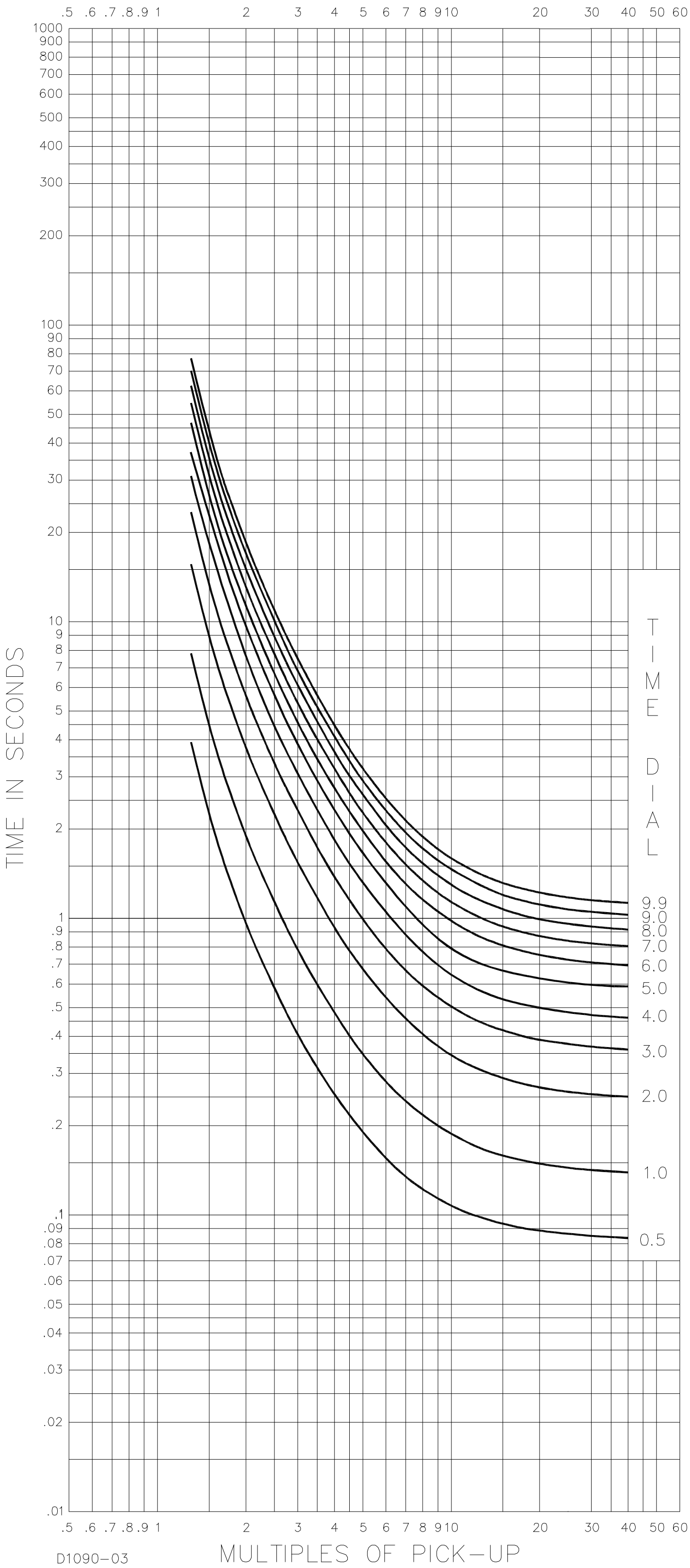

Figure A-9. Time Characteristic Curve V1, Very Inverse (Similar to ABB CO-9)

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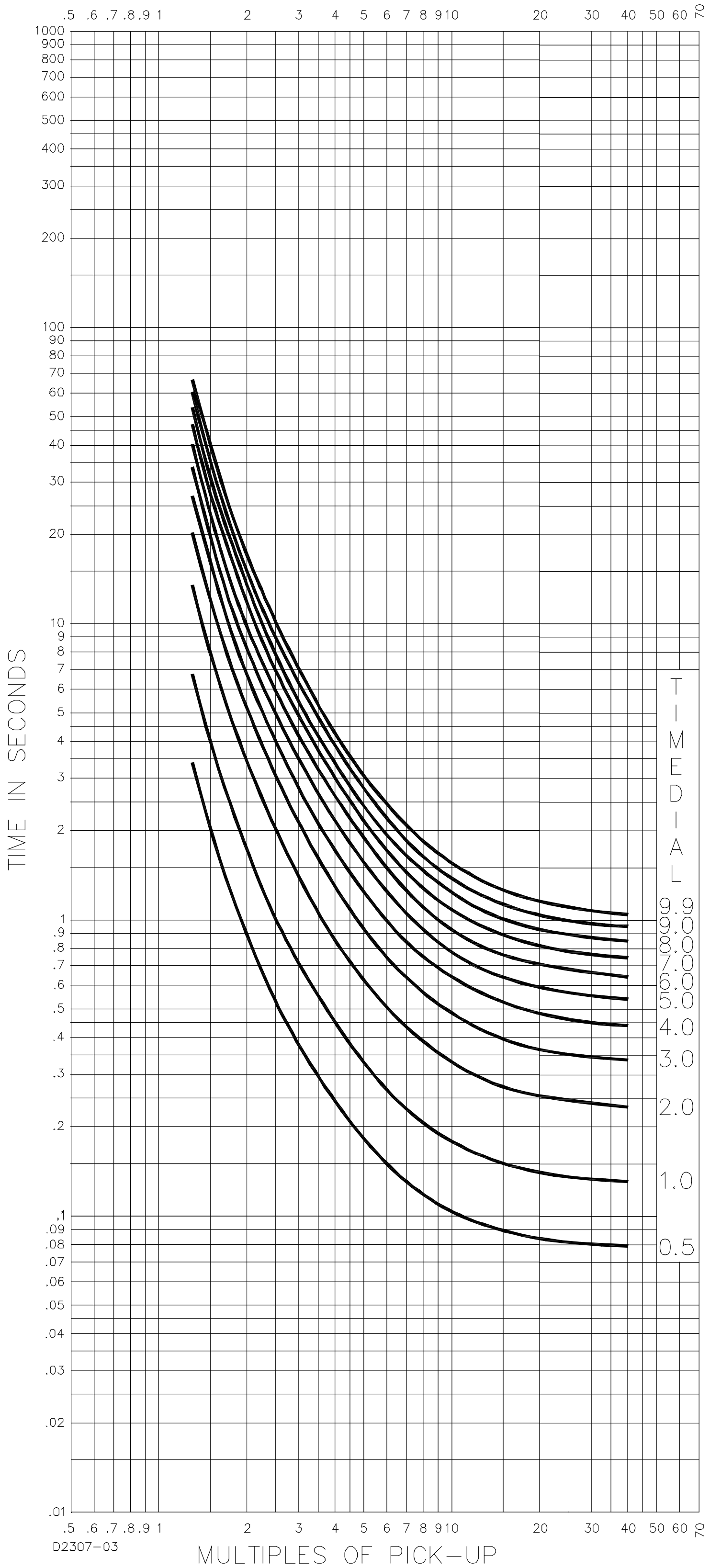

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Figure A-10. Time Characteristic Curve V2, Very Inverse (Similar to GE IAC-53)

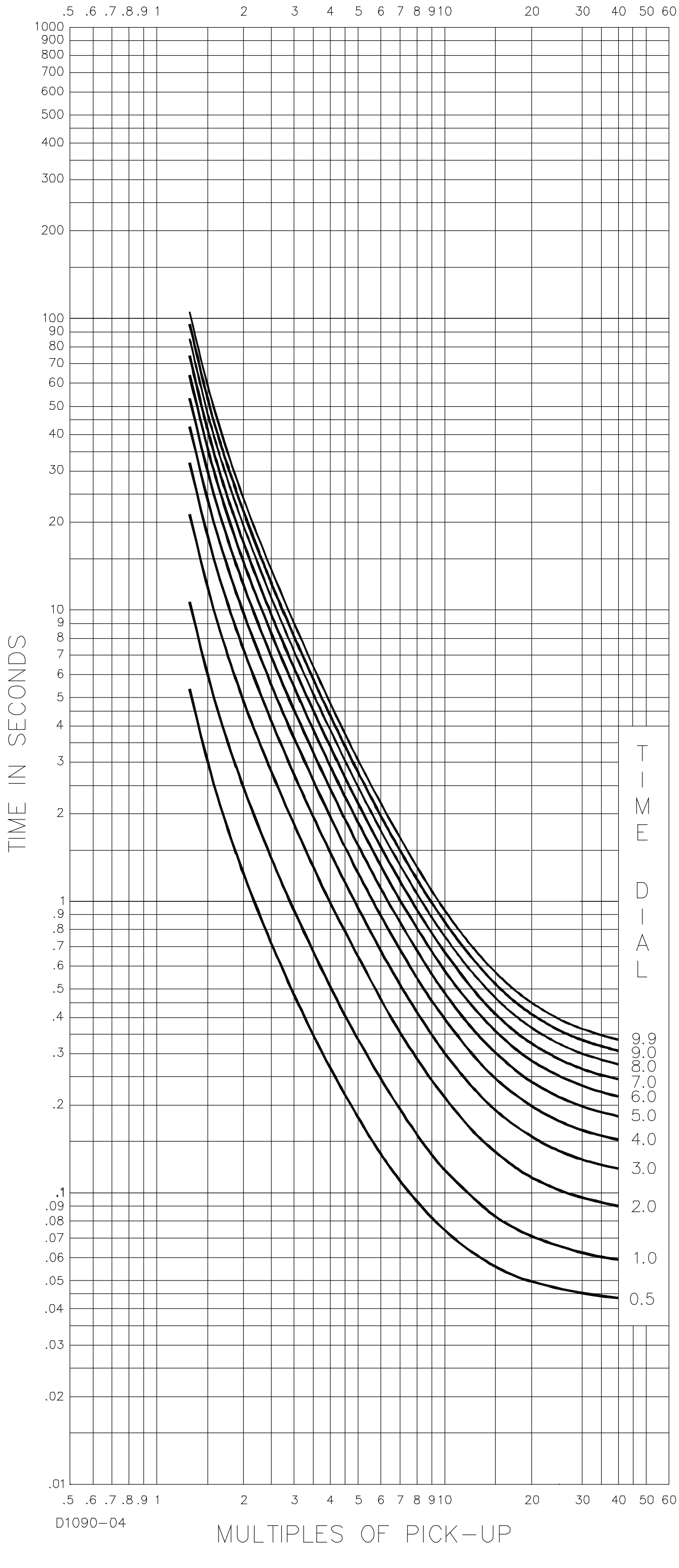

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Figure A-11. Time Characteristic Curve E1, Extremely Inverse (Similar to ABB CO-11)

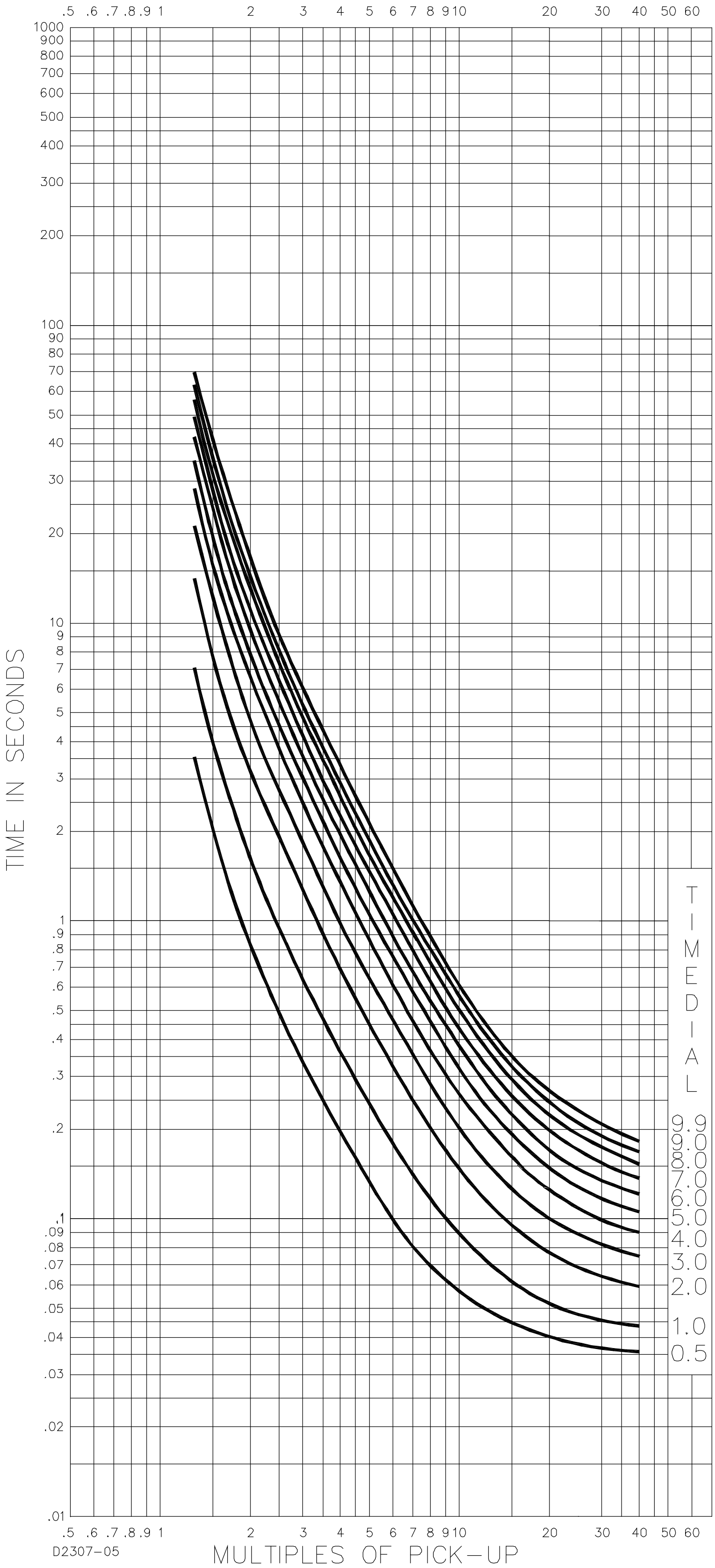

Figure A-12. Time Characteristic Curve E2, Extremely Inverse (Similar to GE IAC-77)

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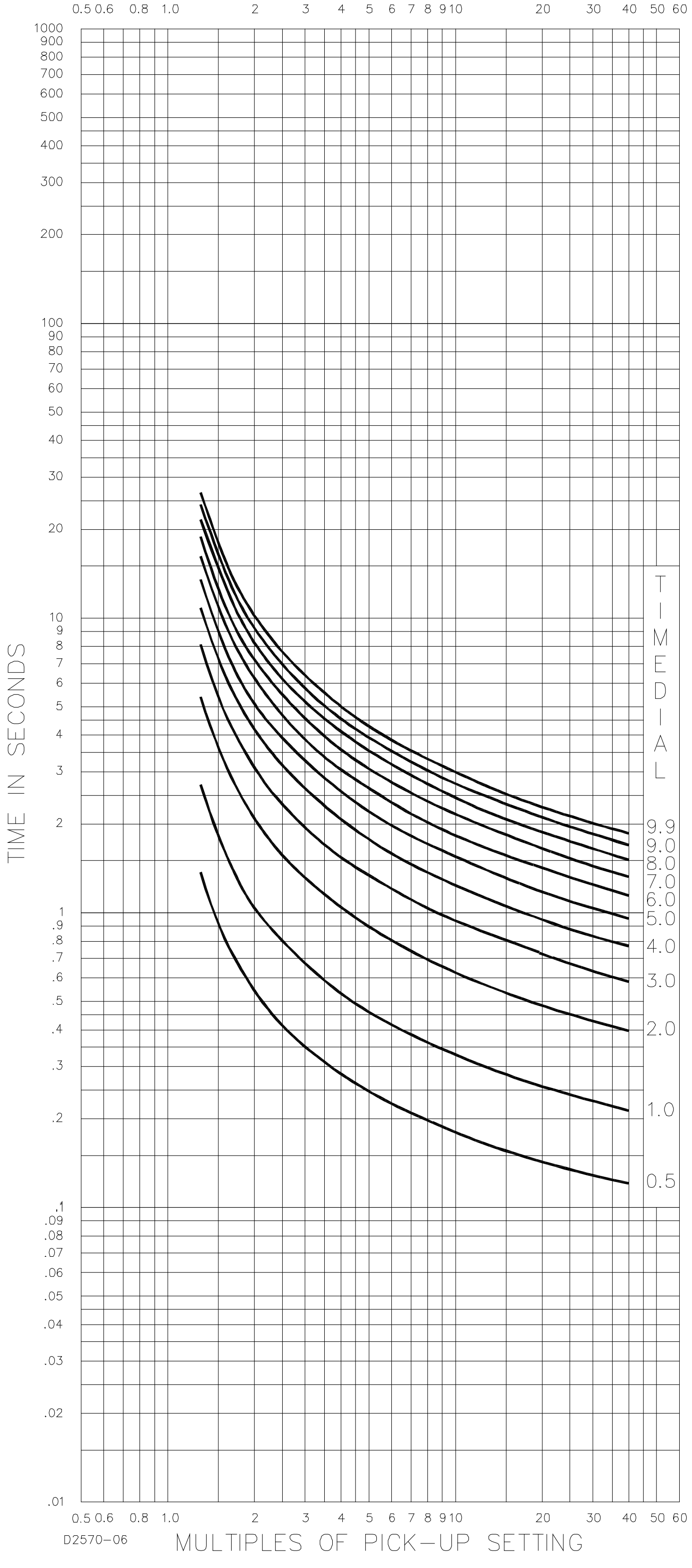

Figure A-13. Time Characteristic Curve A, Standard Inverse (BS 142)

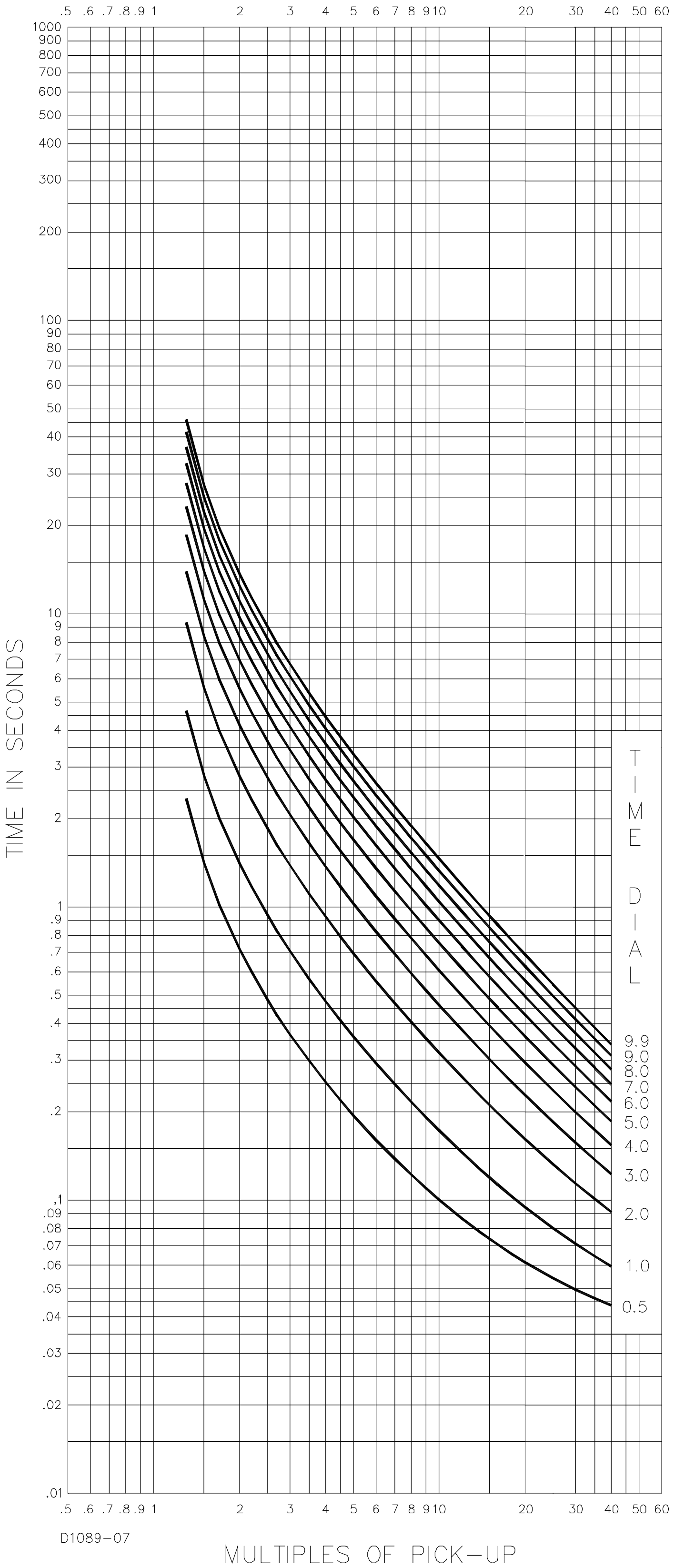

Figure A-14. Time Characteristic Curve B, Very Inverse (BS 142)

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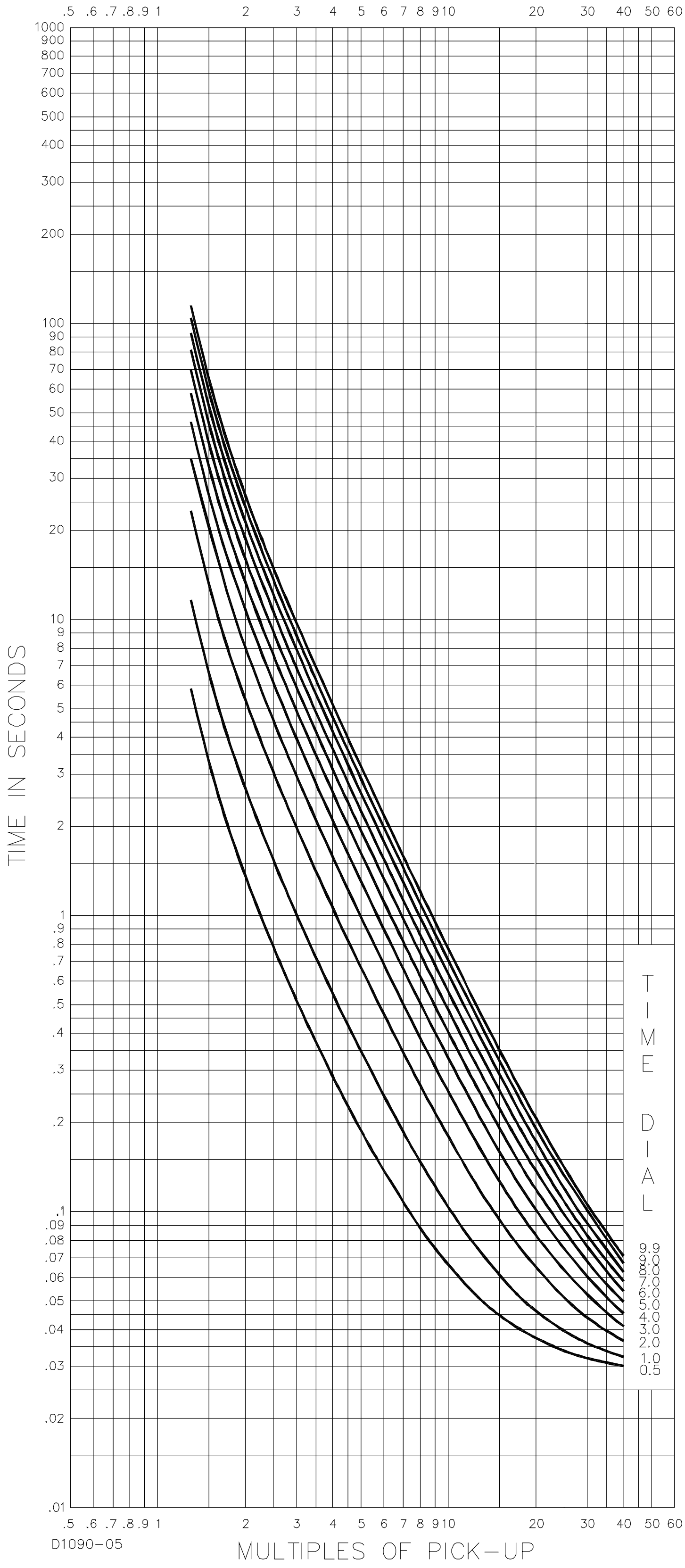

Figure A-15. Time Characteristic Curve C, Extremely Inverse (BS 142)

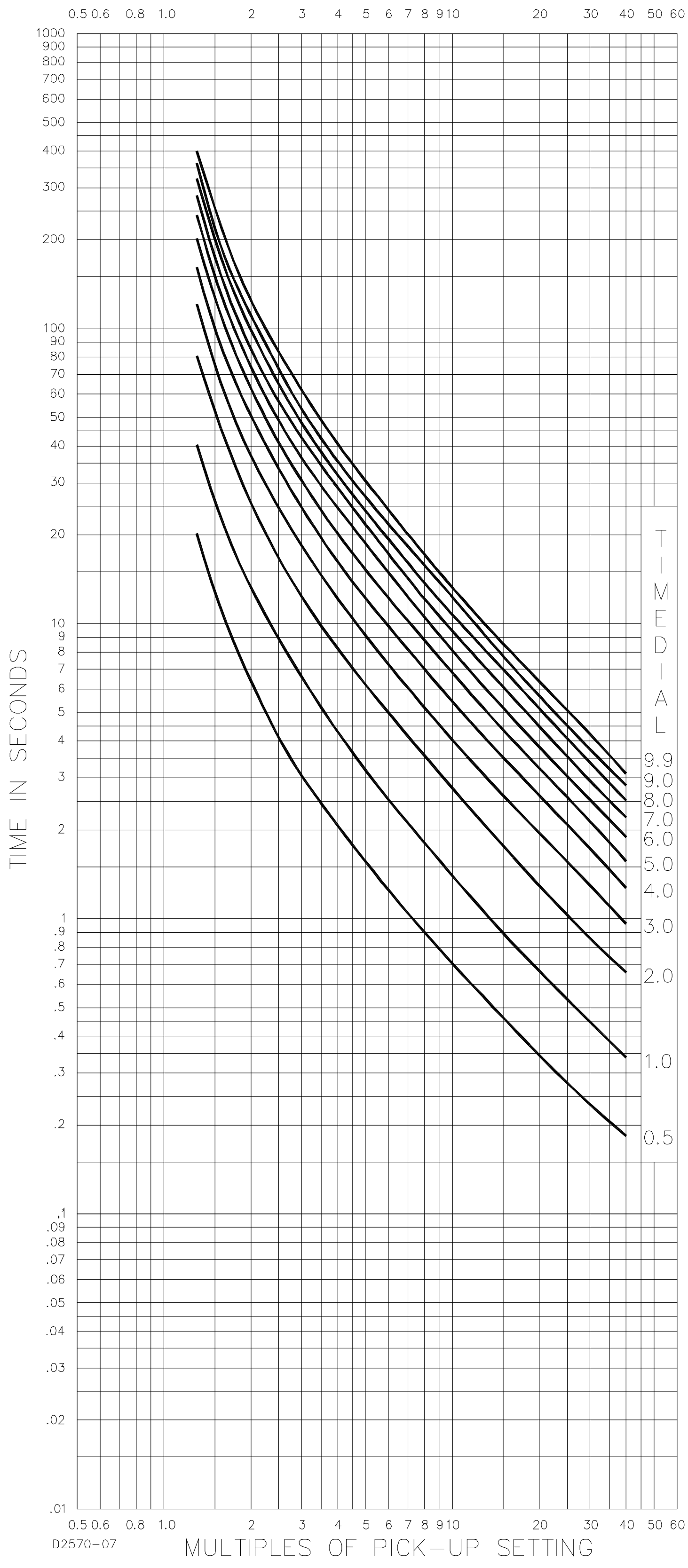

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Figure A-16. Time Characteristic Curve G, Long Time Inverse (BS 142)

APPENDIX B • MODBUS™ COMMUNICATION

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APPENDIX B • MODBUS™ COMMUNICATION

Introduction

General Overview

An optional feature of the MGC-2000 Series performs Modbus™ communications by emulating a subset of the Modicon 984 Programmable Controller. This document describes the Modbus communications protocol employed by the MGC-2000 Series and how to exchange information with the MGC-2000 Series over a Modbus network.

The MGC-2000 Series maps all parameters into the Modicon 984 Holding Register address space (4XXXX). Refer to *MAPPING - MGC-2000 Series Parameters into MODICON ADDRESS SPACE* in this section.

Note
For applications where an MGC-2000 Series is replacing a DGC-500, DGC-1000, or DGC-2000, registers 40000 - 41999 are identical to the data that was present in those products for a seamless transition. There is some overlap between the sets of registers which constitutes having two separate legacy register tables, one for both DGC-500 and DGC-1000 and another for MGC-2000 Series. The 42XXX registers contain all information included in the MGC-2000 Series and should be used for any new Modbus applications.

Intended Use of the Communications Protocol

This document provides the necessary information for 3rd party OEMs to develop in-house software to communicate with the MGC-2000 Series via Modbus protocol. This will allow the exchange of setup information and measured data between a Modbus Master Station and the MGC-2000 Series.

The MGC-2000 Series data supported for remote access is listed in *MAPPING - MGC-2000 Series Parameters into MODICON ADDRESS SPACE* in this section.

Detailed Description of MGC-2000 Series Modbus™ Protocol

Modbus™ Protocol Overview

Modbus communications use a master-slave technique in which only the master can initiate a transaction, called a query. The slave addressed by the query will respond by either supplying the requested data to the master or by performing the requested action. A slave device never initiates communications on the Modbus, and will always generate a response to the query unless certain error conditions occur. The MGC-2000 Series is designed to communicate on the Modbus only as a slave device.

A master can query slaves individually or query all slaves collectively by initiating a broadcast message. A slave does not send a response message to a broadcast query.

If a query requests actions unable to be performed by the slave, the slave response message will contain an Exception Response Code defining the error detected.

Query and response messages share the same message structure. Each message is comprised of four message fields: the Device Address, the Function Code, the Data Block, and the Error Check field. Subsequent sections in this document detail each message field and the corresponding functionality supported by the MGC-2000 Series.

Query / Response Message Structure:

- Device Address
- Function Code
- Eight-Bit Data Bytes
- Error Check

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Device Address Field

The Device Address field contains the unique Modbus address of the slave being queried. The addressed slave will repeat its address in the Device Address field of the response message. This field is 1 byte.

Function Code Field

The Function Code field in the Query message defines the action to be taken by the addressed slave. This field is echoed in the Response message, and will be altered by setting the MSB of the field to "1" if the response is an error response. This field is 1 byte.

Data Block Field

The query Data block contains additional information needed by the slave to perform the requested function. The response Data block contains data collected by the slave for the queried function. An error response will substitute an Exception Response Code for the Data Block. The length of this field varies with each query.

Error Check Field

The Error Check field provides a method for the slave to validate the integrity of the query message contents and allows the master to confirm the validity of response message contents. This field is 2 bytes.

Serial Transmission Details

A standard Modbus network offers 2 transmission modes for communication: ASCII or RTU. The MGC-2000 Series supports only the RTU (Remote Terminal Unit) mode.

Each 8-bit byte in a message contains two 4-bit hexadecimal characters. The message is transmitted in a continuous stream with the LSB of each byte of data transmitted first. Transmission of each 8-bit data byte occurs with 1 start bit and 1 stop bit. A ninth data bit is added when parity is selected. Parity checking is user-configurable to even, odd or none. The transmission baud rate is also user-configurable, and both parity and baud rate can be altered during real-time operation. If altered, the new baud rate and / or parity will not be enforced until the response message to the current query has completed. The MGC-2000 Series supported baud rates are 9600, 4800, 2400, and 1200.

Message Framing / Timing Considerations

When receiving a message, the MGC-2000 Series will allow maximum inter-byte latency up to 3.5 - 4.0 character times before considering the message complete.

Once a valid query is received, the MGC-2000 Series waits 10 msec. before responding.

Error Handling and Exception Responses

Any query received that contains a non-existent device address, a framing error or CRC error will be ignored - no response will be transmitted. Queries addressed to an MGC-2000 Series with an unsupported function code, unsupported register references, or illegal values in the data block will result in an error response message with an Exception Response Code. The Exception Response codes supported by the MGC-2000 Series are listed in Table B-1.

Table B-1. Exception Response Codes

Code	Name	Meaning
01	Illegal Function	The query Function/Subfunction Code is unsupported; query read of more than 125 registers; query preset of more than 100 registers
02	Illegal Data Address	A register referenced in the data block does not support queried read/write; query preset of a subset of a numerical register group.
03	Illegal Data Value	A preset register data block contains an incorrect number of bytes or one or more data values out of range.

Detailed MGC-2000 Series Message Definition

Device Address

The MGC-2000 Series Device Address can be any value in the Modbus protocol Device Address range (1 - 247). A query with a Device Address of 0 signifies a Broadcast message to all slaves - the connected MGC-2000 Series will not respond to the broadcast query.

Function Code and Data Block

The MGC-2000 Series maps all parameters into the Modicon 984 Holding Register address space (4XXXX) and supports the following Function Codes:

- Function 03 - Read Holding Registers
- Function 6 - Preset Single Register, Non-Broadcast & Broadcast
- Function 08, Subfunction 00 - Diagnostics: Return Query Data
- Function 16 - Preset Multiple Registers, Non-Broadcast & Broadcast

The only Broadcast query supported by the MGC-2000 Series is the Preset Multiple Registers query.

Read Holding Registers

Read Holding Registers - General

QUERY:

This query message requests a register or block of registers to be read. The data block contains the starting register address and the quantity of registers to be read. A register address of N will read Holding Register N+1.

Device Address	
Function Code	03 (hex)
Starting Address Hi	
Starting Address Lo	
No. of Registers Hi	
No. of Registers Lo	
CRC Error Check	

The number of registers cannot exceed 125 without causing an error response with Exception Code "Illegal Function".

Queries to read Write Only or unsupported registers result in an error response with Exception Code of “Illegal Data Address”.

RESPONSE:

The response message contains the data queried, respectively. The data block contains the block length in bytes followed by the data for each requested register. Attempting to read an unused register or a register which does not support read results in an error response with Exception Code of "Illegal Data Address".

Device Address	
Function Code	03 (hex)
Byte Count	
Data Hi	
Data Lo	
.	
.	
.	
Data Hi	
Data Lo	
CRC Error Check	

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Return Query Data

This query contains data to be returned (looped back) in the response. The response and query messages should be identical.

Device Address	
Function Code	08 (hex)
Subfunction Hi	00 (hex)
Subfunction Lo	00 (hex)
Data Hi	

Data Lo
CRC Error Check

Preset Multiple Registers, Non-Broadcast & Broadcast

Preset Multiple Registers - General

QUERY:

This query message requests a register or block of registers to be written. The data block contains the starting address and the quantity of registers to be written, followed by the Data Block byte count and data. A device address is 0 for a broadcast query.

A register address of N will write Holding Register N+1.

No query data will be written (non-broadcast or broadcast) if any of the following exceptions occur:

- Queries writing to Read Only or unsupported registers result in an error response with Exception Code of "Illegal Data Address".
- Queries attempting to write more than 100 registers cause an error response with Exception Code "Illegal Function".
- An incorrect Byte Count will result in an error response with Exception Code of "Illegal Data Value".
- There are several instances of registers that are grouped together (signified as DP or TP) to collectively represent a single numerical (vs. ASCII string) MGC-2000 Series parameter value. A query to write a subset of such a register group will result in an error response with Exception Code "Illegal Data Address".
- A query to write an unacceptable value (out of range) to a register results in an error response with Exception Code of "Illegal Data Value".

Device Address
Function Code 10 (hex)
Starting Address Hi
Starting Address Lo
No. of Registers Hi
No. of Registers Lo
Byte Count
Data Hi
Data Lo
.
.
.
Data Hi
Data Lo
CRC Error Check

RESPONSE:

The response message echoes the starting address and the number of registers. There is no response message when the query is broadcast.

Device Address	
Function Code	10 (hex)
Starting Address Hi	
Starting Address Lo	
No. of Registers Hi	
No. of Registers Lo	
CRC Error Check	

Preset Single Register, Non-Broadcast & Broadcast

QUERY:

This query message requests a register to be written. A device address is 0 for a broadcast query.

No query data will be written (non-broadcast or broadcast) if any of the following exceptions occur:

- Queries writing to Read Only or unsupported registers result in an error response with Exception Code of "Illegal Data Address".

- There are several instances of registers that are grouped together (signified as DP or TP) to collectively represent a single numerical (vs. ASCII string) MGC-2000 Series parameter value. A query to write a subset of such a register group will result in an error response with Exception Code “Illegal Data Address”.
- A query to write an unacceptable value (out of range) to a register results in an error response with Exception Code of “Illegal Data Value”.

Device Address	
Function Code	06 (hex)
Address Hi	
Address Lo	
Data Hi	
Data Lo	
CRC Error Check	

RESPONSE:

The response message echoes the address and the value written. There is no response message when the query is broadcast.

Device Address	
Function Code	06 (hex)
Address Hi	
Address Lo	
Data Hi	
Data Lo	
CRC Error Check	

Data Formats

Short Integer Data Format (INT8)

The Modbus short integer data format uses a single holding register to represent an 8 bit data value. The holding register high byte will always be zero.

Example: The value 132 represented in short integer format is hexadecimal 0x84. This number will read from a holding register as follows:

Holding Register		Value
K	(Hi Byte)	hex 00
K	(Lo Byte)	hex 84

The same byte alignments are required to write.

Integer Data Format (INT16)

The Modbus integer data format uses a single holding register to represent a 16-bit data value.

Example: The value 4660 represented in integer format is hexadecimal 0x1234. This number will read from a holding register as follows:

Holding Register		Value
K	(Hi Byte)	hex 12
K	(Lo Byte)	hex 34

The same byte alignments are required to write.

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Long Integer Data Format (INT32)

The Modbus long integer data format uses two consecutive holding registers to represent a 32-bit data value. The first register contains the low-order 16 bits and the second register contains the high-order 16 bits.

Example: The value 95,800 represented in long integer format is hexadecimal 0x00017638. This number will read from two consecutive holding registers as follows:

Holding Register	Value
K (Hi Byte)	hex 76
K (Lo Byte)	hex 38
K+1 (Hi Byte)	hex 00
K+1 (Lo Byte)	hex 01

The same byte alignments are required to write.

32-bit Bit-Mapped Parameter Mapping

The register arrangement for 32-bit bit-mapped parameters is illustrated in Figure B-1. The Alarm Metering registers (44812/44813) are shown as an example. In this example, Bit 25 is set indicating an Overcrank condition and Bit 17 is set indicating a Global Alarm.

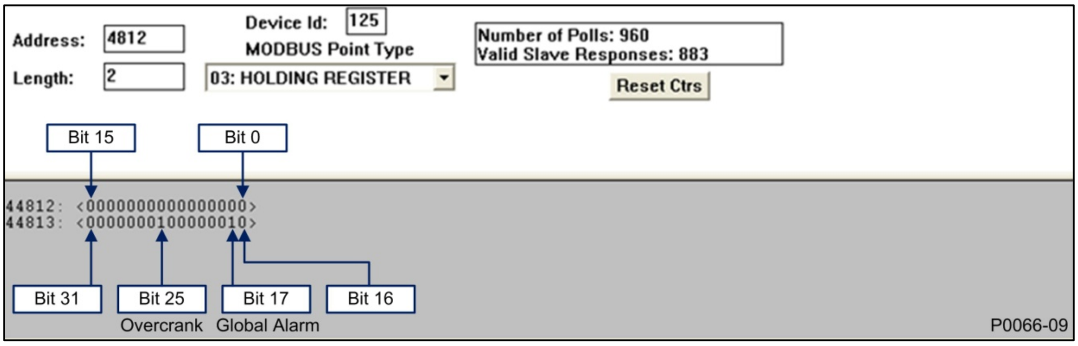

Figure B-1. 32-Bit Bit-Mapped Parameter Mapping

The Alarm Metering register bits are defined as follows:

- Bit 0 through Bit 16 = Not Used
- Bit 17 = Global Alarm
- Bit 18 = Auto Restart Failure
- Bit 19 = Fuel Leak Detect
- Bit 20 = Battery Charger Failure
- Bit 21 = Transfer Fail
- Bit 22 = Low Coolant Level
- Bit 23 = ECU Shutdown
- Bit 24 = Emergency Shutdown
- Bit 25 = Overcrank
- Bit 26 = Loss of ECU Comms
- Bit 27 = Global Sender Fail
- Bit 28 = Low Fuel Level
- Bit 29 = Low Oil Pressure
- Bit 30 = Hi Coolant Temp
- Bit 31 = Overspeed

Floating Point Data Format

The Modbus floating point data format uses two consecutive holding registers to represent a data value. The first register contains the low-order 16 bits of the following 32-bit format:

- MSB is the sign bit for the floating-point value (0 = positive).
- The next 8 bits are the exponent biased by 127 decimal.
- The 23 LSBs comprise the normalized mantissa. The most-significant bit of the mantissa is always assumed to be 1 and is not explicitly stored, yielding an effective precision of 24 bits.

The value of the floating-point number is obtained by multiplying the binary mantissa times two raised to the power of the unbiased exponent. The assumed bit of the binary mantissa has the value of 1.0, with the remaining 23 bits providing a fractional value. Table B-2 shows the floating-point format.

Table B-2. Floating Point Format

Sign	**Exponent + 127**	**Mantissa**
1 bit	8 bits	23 bits

The floating-point format allows for values ranging from approximately $8.43X10^{-37}$ to $3.38X10^{38}$. A floating-point value of all zeroes is the value zero. A floating-point value of all ones (not a number) signifies a value currently not applicable or disabled.

Example: The value 95,800 represented in floating point format is hexadecimal 47BB1C00. This number will read from two consecutive holding registers as follows:

Holding Register	Value
K (Hi Byte)	hex 1C
K (Lo Byte)	hex 00
K+1 (Hi Byte)	hex 47
K+1 (Lo Byte)	hex BB

The same byte alignments are required to write.

Double Precision Data Format (DP)

The Modbus Double Precision data format (DP) uses 2 consecutive registers to represent a data value. The first register contains the high-order 16 bits of double precision data, and is the actual data value / 10,000.

The second register contains the low-order 16 bits of double precision data, and is the actual data value modulus 10,000.

Triple Precision Data Format (TP)

The Modbus Triple Precision data format (TP) uses 3 consecutive registers to represent a data value. The first register contains the high-order 16 bits of triple precision data, and is the actual data value / 100,000,000. The modulus from this operation is divided by 10,000 to arrive at the value of the second register, and the modulus of this last operation is the value of the third register (the low-order 16 bits of triple precision).

Error Check

This field contains a 2-byte CRC value for transmission error detection. The master first calculates the CRC and appends it to the query message. The MGC-2000 Series recalculates the CRC value for the received query and performs a comparison to the query CRC value to determine if a transmission error has occurred. If so, no response message is generated. Otherwise, the slave calculates a new CRC value for the response message and appends it to the message for transmission.

Reference the "Modicon Modbus Protocol Reference Guide", PI-MBUS-300 Rev. E, pages 112 - 115 for an excellent explanation and implementation of the CRC-16 algorithm.

The CRC calculation is performed using all bytes of the Device Address, Function Code, and Data Block fields. A 16-bit CRC-register is initialized to all 1's. Then each 8-bit byte of the message is used in the following algorithm:

First, exclusive-OR the message byte with the low-order byte of the CRC-register. The result, stored in the CRC-register, will then be right-shifted 8 times. The CRC-register MSB is zero-filled with each shift. After each shift the CRC-register LSB is examined: if 1, the CRC-register is then exclusive-ORed with the fixed polynomial value A001 (hex) prior to the next shift. Once all bytes of the message have undergone the above algorithm, the CRC-register will contain the message CRC value to be placed in the Error Check field.

Interdependence of Preset Multiple Register Data

Preset Multiple Register data is collectively written only after the query has been determined to be legal, which includes a range-check of the entire data block. Therefore, data which must be written prior to other data must use a separate query. For example, a Preset Multiple Register Query of the entire Contiguous Write Block (40023-40055) to set the Battery Overvoltage Pre-alarm Threshold atop the 24V range and change the Battery Volts from 12V to 24V will fail. The change to 24V would occur simultaneously to setting the Pre-alarm Threshold, and the threshold value range-check will use the current 12V range.

Mapping - MGC-2000 Series Parameters into Modicon Address Space

Current Parameter Table

The MGC-2000 Series maps all non-legacy parameters into the Holding Register address space (42000 and above). Query address N will access the Holding Register N+1.

Breaker Management

Register	Description	Type	Units	Scaling Factor	R/W	Range
42000	Gen Breaker Configured	Int32	N/A	N/A	RW	0 = Not Configured 1 = Configured
42002	Gen Breaker Open Pulse Time	Int32	Centisecond	Centi	RW	1 - 80
42004	Gen Breaker Close Pulse Time	Int32	Centisecond	Centi	RW	1 - 80
42006	Gen Breaker Contact Type	Int32	N/A	N/A	RW	0 = Pulse 1 = Continuous
42008	Gen Breaker Close Time	Int32	Millisecond	N/A	RW	0 - 800
42010	RESERVED					
42012	Mains Breaker Configured	Int32	N/A	N/A	RW	0 = Not Configured 1 = Configured
42014	Mains Breaker Open Pulse Time	Int32	Centisecond	Centi	RW	1 - 80
42016	Mains Breaker Close Pulse Time	Int32	Centisecond	Centi	RW	1 - 80
42018	Mains Breaker Output Continuous	Int32	N/A	N/A	RW	0 = Pulse 1 = Continuous
42020	Mains Breaker Close Time	Int32	Millisecond	N/A	RW	0 - 800
42022	RESERVED					
42024	Synchronizer Type	Int32	N/A	N/A	RW	1 = Anticipatory 2 = Phase Lock Loop
42026	RESERVED					
42028	Slip Frequency	Int32	CentiHertz	Centi	RW	1 - 50
42030	Breaker Closing Angle	Int32	DeciDegree	Deci	RW	30 - 200
42032	Regulation Offset	Int32	DeciPercent	Deci	RW	20 - 150
42034	Vgen > Vbus	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
42036	Fgen > Fbus	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
42038-40	RESERVED					
42042	Breaker Close Wait Time	Float	Second	N/A	RW	0.1 - 600
42044	Sync Time Delay	Float	Second	N/A	RW	0.1 - 0.8
42046	Sync Fail Time Delay	Float	Second	N/A	RW	0.1 - 600
42048	Mains Fail Transfer Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
42050	Gen Breaker Status	Int32	N/A	N/A	R	0 = Open 1 = Closed
42052	Mains Breaker Status	Int32	N/A	N/A	R	0 = Open 1 = Closed
42054	Mains Fail Transfer Delay	Int32	Second	N/A	RW	0 - 300
42056	Mains Fail Return Delay	Int32	Second	N/A	RW	0 - 1800
42058	Mains Fail Max Transfer Time	Int32	Second	N/A	RW	1 - 120
42060	RESERVED					
42062	Dead Bus Close Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable

Register	Description	Type	Units	Scaling Factor	R/W	Range
42064	Sync Speed Gain	Float	N/A	N/A	RW	0.001 - 1000
42066	Sync Voltage Gain	Float	N/A	N/A	RW	0.001 - 1000
42068	Max Parallel Time	Int32	Second	Deci	RW	1 - 100000
42070	Mains Fail Transfer Type	Int32	N/A	N/A	RW	0 = Open 1 = Close
42072	In Phase Monitor Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
42074	Dead Gen Close Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
42076	RESERVED					
42078	Min Slip Control Limit	Int32	N/A	Centi	RW	0 - 200
42080	Max Slip Control Limit	Int32	N/A	Centi	RW	0 - 200
42082	Rev. Rotation Mains Fail Inhibit	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
42084	Gen Breaker External Status Change Action Data	Int32	N/A	N/A	RW	0 = Ignore 1 = Follow Always 2 = Follow In Auto
42086	Gen Breaker Fail Output Config Data	Int32	N/A	N/A	RW	0 = Retain 1 = Remove
42088	Mains Fail Mains Breaker Open Config Data	Int32	N/A	N/A	RW	0 = Generator Start 1 = Generator Stable
42090	Mains Fail Allow Transfer To Mains In Alarm State Data	Int32	N/A	N/A	RW	1 = Enable 2 = Disable
42092	Mains Breaker External Status Change Action Data	Int32	N/A	N/A	RW	0 = Ignore 1 = Follow Always 2 = Follow In Auto
42094	Mains Breaker Fail Output	Int32	N/A	N/A	RW	0 = Retain 1 = Remove
42096	Gen Breaker Transition Delay Data	Int32	Centisecond	Centi	RW	0 - 1000
42098	Mains Breaker Transition Delay Data	Int32	Centisecond	Centi	RW	0 - 1000
42100	Mains Breaker Open Attempts Data	Int32	N/A	N/A	RW	1 - 20
42102	Mains Breaker Close Attempts Data	Int32	N/A	N/A	RW	1 - 20
42104	Mains Breaker Retry Delay Data	Int32	Second	N/A	RW	0 - 1200
42106	Gen Breaker Open Attempts Data	Int32	N/A	N/A	RW	1 - 20
42108	Gen Breaker Close Attempts Data	Int32	N/A	N/A	RW	1 - 20
42110	Gen Breaker Retry Delay Data	Int32	Second	N/A	RW	10 - 3700
42112	Open Transition Delay Data	Int32	Decisecond	Deci	RW	0 - 36000
42114	Max Return Time Data	Int32	Second	N/A	RW	10 - 3700
42116-248	FUTURE USE					

Bias Control Settings

Register	Description	Type	Units	Scaling Factor	R/W	Range
42250	AVR Kp Proportional Gain	Float	N/A	N/A	RW	0 - 1000
42252	AVR Ki Integral Gain	Float	N/A	N/A	RW	0 - 1000
42254	AVR Kd Derivative Gain	Float	N/A	N/A	RW	0 - 1000
42256	AVR Td Filter Constant	Float	N/A	N/A	RW	0 - 1
42258	AVR Kg Loop Gain	Float	N/A	N/A	RW	0 - 1000
42260	AVR Windup Limit	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
42262	AVR Integrator Limit Plus	Float	N/A	N/A	RW	0 - 1000
42264	AVR Integrator Limit Minus	Float	N/A	N/A	RW	(-1000) - 0
42266	AVR Output Upper Limit	Float	N/A	N/A	RW	0 - 1000
42268	AVR Output Lower Limit	Float	N/A	N/A	RW	(-1000) - 0
42270	RESERVED					
42272	Governor Kp Proportional Gain	Float	N/A	N/A	RW	0 - 1000
42274	Governor Ki Integral Gain	Float	N/A	N/A	RW	0 - 1000
42276	Governor Kd Derivative Gain	Float	N/A	N/A	RW	0 - 1000

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Register	Description	Type	Units	Scaling Factor	R/W	Range
42278	Governor Td Filter Constant	Float	N/A	N/A	RW	0 - 1
42280	Governor Loop Gain	Float	N/A	N/A	RW	0 - 1000
42282	Governor Windup Limit	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
42284	Governor Integrator Limit Plus	Float	N/A	N/A	RW	0 - 1000
42286	Governor Integrator Limit Minus	Float	N/A	N/A	RW	(-1000) - 0
42288	Governor Output Upper Limit	Float	N/A	N/A	RW	0 - 1000
42290	Governor Output Lower Limit	Float	N/A	N/A	RW	(-1000) - 0
42292	RESERVED					
42294	kvar Kp	Float	N/A	N/A	RW	0 - 1000
42296	kvar Ki	Float	N/A	N/A	RW	0 - 1000
42298	kvar Kd	Float	N/A	N/A	RW	0 - 1000
42300	kvar Td	Float	N/A	N/A	RW	0 - 1
42302	kvar Loop Gain	Float	N/A	N/A	RW	0 - 1000
42304	kvar Windup Limit	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
42306	kvar Integrator Limit Plus	Float	N/A	N/A	RW	0 - 1000
42308	kvar Integrator Limit Minus	Float	N//A	N/A	RW	(-1000) - 0
42310	kvar Output Upper Limit	Float	N/A	N/A	RW	0 - 1000
42312	kvar Output Lower Limit	Float	N/A	N/A	RW	(-1000) - 0
42314	RESERVED					
42316	kW Kp	Float	N/A	N/A	RW	0 - 1000
42318	kW Ki	Float	N/A	N/A	RW	0 - 1000
42320	kW Kd	Float	N/A	N/A	RW	0 - 1000
42322	kW Td	Float	N/A	N/A	RW	0 - 1
42324	kW Loop Gain	Float	N/A	N/A	RW	0 - 1000
42326	kW Windup Limit	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
42328	kW Integrator Limit Plus	Float	N/A	N/A	RW	0 - 1000
42330	kW Integrator Limit Minus	Float	N/A	N/A	RW	(-1000) - 0
42332	kW Output Upper Limit	Float	N/A	N/A	RW	0 - 1000
42334	kW Output Lower Limit	Float	N/A	N/A	RW	(-1000) - 0
42336	RESERVED					
42338	Droop Percent	Float	Percent	N/A	RW	0 - 10
42340	Load Control	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
42342	kW Load Rate	Int32	N/A	Deci	RW	0 - 1000
42344	Breaker Open Setpoint	Int32	N/A	Deci	RW	0 - 1000
42346	AVR Bias Control Output Type	Int32	N/A	N/A	RW	0 = Contact 1 = Analog
42348	Governor Bias Control Output Type	Int32	N/A	N/A	RW	0 = Contact 1 = Analog
42350	Speed Droop Gain	Float	N/A	N/A	RW	0 - 1000
42352	Voltage Droop Gain	Float	N/A	N/A	RW	0 - 1000
42354	Speed Trim Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
42356	Voltage Trim Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
42358	Ramped Watt Demand Per Unit	Float	N/A	N/A	R	0 - 100
42360	Watt Demand Per Unit	Float	N/A	N/A	R	0 - 100
42362	Speed PID Output	Float	N/A	N/A	R	0 - 100
42364	kW PID Output	Float	N/A	N/A	R	0 - 100
42366	Volt PID Output	Float	N/A	N/A	R	0 - 100
42368	Speed Trim Setpoint	Uint32	DeciHertz	Centi	RW	4700 - 44000
42370	var Control Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
42372	kvar Load Rate	Uint32	N/A	Deci	RW	1 - 1000

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Register	Description	Type	Units	Scaling Factor	R/W	Range
42374	Base Load Level Source	Uint32	N/A	N/A	RW	0 = User Setting 1 = LSM Analog Input 1 2 = AEM Analog Input 1 3 = AEM Analog Input 2 4 = AEM Analog Input 3 5 = AEM Analog Input 4 6 = AEM Analog Input 5 7 = AEM Analog Input 6 8 = AEM Analog Input 7 9 = AEM Analog Input 8
42376	kVar Setpoint Source	Uint32	N/A	N/A	RW	0 = User Setting 1 = LSM Analog Input 1 2 = AEM Analog Input 1 3 = AEM Analog Input 2 4 = AEM Analog Input 3 5 = AEM Analog Input 4 6 = AEM Analog Input 5 7 = AEM Analog Input 6 8 = AEM Analog Input 7 9 = AEM Analog Input 8
42378	PF Setpoint Source	Uint32	N/A	N/A	RW	0 = User Setting 1 = LSM Analog Input 1 2 = AEM Analog Input 1 3 = AEM Analog Input 2 4 = AEM Analog Input 3 5 = AEM Analog Input 4 6 = AEM Analog Input 5 7 = AEM Analog Input 6 8 = AEM Analog Input 7 9 = AEM Analog Input 8
42380-84	RESERVED					
42386	Baseload Analog Max	Int32	Percent	Deci	RW	0 - 1000
42388	Baseload Analog Min	Int32	Percent	Deci	RW	0 - 1000
42390	kvar Analog Max	Int32	Percent	Deci	RW	(-1000) - 1000
42392	kvar Analog Min	Int32	Percent	Deci	RW	(-1000) - 1000
42394	PF Analog Max	Int32	N/A	Centi	RW	160 - 240
42396	PF Analog Min	Int32	N/A	Centi	RW	160 - 240
42398	var Droop Percentage	Float	Percent	N/A	RW	0 - 10
42400-06	RESERVED					
42408	Base Load Level	Float	Percent	N/A	RW	0 - 100

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Register	Description	Type	Units	Scaling Factor	R/W	Range
42410	kvar Setpoint	Float	Percent	N/A	RW	(-100) - 100
42412	PF Setpoint	Int32	N/A	Centi	RW	160 - 240
42414	var Control Mode	Int32	N/A	N/A	RW	0 = var Control 1 = PF Control
42416	Load Share Interface	Int32	N/A	N/A	RW	0 = Analog Load Share Line 1 = Ethernet Comms
42418	Remote Speed Bias Source	Int32	N/A	N/A	RW	0 = User Setting 1 = LSM Analog Input 1 2 = AEM Analog Input 1 3 = AEM Analog Input 2 4 = AEM Analog Input 3 5 = AEM Analog Input 4 6 = AEM Analog Input 5 7 = AEM Analog Input 6 8 = AEM Analog Input 7 9 = AEM Analog Input 8
42420	RESERVED					
42422	RESERVED					
42424	LSM Aux Input Source	Int32	N/A	N/A	RW	0 = LSM Local Aux Input 1 = LSM System Manager
42426	kW Ramp Status	Int32	N/A	N/A	R	0 = none 1 = up 2 = down
42428	kvar Ramp Status	Int32	N/A	N/A	R	0 = none 1 = up 2 = down
42430	Speed Trim Bias Range Percent x 100 Data	Int32	CentiPercent	Centi	RW	0 - 500
42432	kW Ramp Overshoot Reduction Percent Data	Int32	Percent	N/A	RW	0 - 100
42434	kvar Ramp Overshoot Reduction Percent Data	Int32	Percent	N/A	RW	0 - 100
42436	Speed Trim Deadband	Uint32	CentiHertz	Centi	RW	0 - 100
42438	Volt Trim Deadband	Uint32	DeciPercent	Deci	RW	0 - 20
42440	kW Parallel To Mains Gain	Float	N/A	N/A	RW	0 - 1000
42442	kvar Parallel To Mains Gain	Float	N/A	N/A	RW	0 - 1000
42444-498	FUTURE USE					

Pulse Outputs

Register	Description	Type	Units	Scaling Factor	R/W	Range
42500	AVR Correction Pulse Width	Int32	Decisecond	Deci	RW	0 - 999
42502	AVR Correction Pulse Interval	Int32	Decisecond	Deci	RW	0 - 999
42504	AVR Bias Contact Type	Int32	N/A	N/A	RW	0 = Continuous 1 = Proportional
42506	RESERVED					
42508	Governor Correction Pulse Width	Int32	Decisecond	Deci	RW	0 - 999
42510	Governor Correction Pulse Interval	Int32	Decisecond	Deci	RW	0 - 999
42512	Governor Bias Contact Type	Int32	Decisecond	Deci	RW	0 = Continuous 1 = Proportional
42514	RESERVED					
42516-748	FUTURE USE					

Bus Condition Detection

Register	Description	Type	Units	Scaling Factor	R/W	Range
42750	Gen Sensing Dead Bus Pickup	Int32	Volt	N/A	RW	0 - 4800
42752	Gen Sensing Dead Bus Time Delay	Int32	Decisecond	Deci	RW	1 - 6000
42754	RESERVED					
42756	Gen Sensing Stable Undervoltage Pickup	Int32	Volt	N/A	RW	10 - 99999
42758	Gen Sensing Stable Undervoltage Dropout	Int32	Volt	N/A	RW	10 - 99999
42760	Gen Sensing Stable Overvoltage	Int32	Volt	N/A	RW	10 - 99999
42762	Gen Sensing Stable Overvoltage Dropout	Int32	Volt	N/A	RW	10 - 99999
42764	Gen Sensing Stable Underfrequency Pickup	Int32	CentiHertz	Centi	RW	4600 - 6400
42766	Gen Sensing Stable Underfrequency Dropout	Int32	CentiHertz	Centi	RW	4600 - 6400
42768	Gen Sensing Stable Overfrequency Pickup	Int32	CentiHertz	Centi	RW	4600 - 6400
42770	Gen Sensing Stable Overfrequency Dropout	Int32	CentiHertz	Centi	RW	4600 - 6400
42772	Gen Sensing Fail Time Delay	Int32	Decisecond	Deci	RW	1 - 6000
42774	Gen Sensing Stable Time Delay	Int32	Decisecond	Deci	RW	1 - 6000
42776	RESERVED					
42778	Bus Sensing Dead Bus Pickup	Int32	Volt	N/A	RW	0 - 4800
42780	Bus Sensing Dead Bus Time Delay	Int32	Decisecond	Deci	RW	1 - 6000
42782	RESERVED					
42784	Bus Sensing Stable Undervoltage Pickup	Int32	Volt	N/A	RW	10 - 9999
42786	Bus Sensing Stable Undervoltage Dropout	Int32	Volt	N/A	RW	10 - 9999
42788	Bus Sensing Stable Overvoltage Pickup	Int32	Volt	N/A	RW	10 - 9999
42790	Bus Sensing Stable Overvoltage Dropout	Int32	Volt	N/A	RW	10 - 9999
42792	Bus Sensing Stable Underfrequency Pickup	Int32	CentiHertz	Centi	RW	4600 - 6400
42794	Bus Sensing Stable Underfrequency Dropout	Int32	CentiHertz	Centi	RW	4600 - 6400
42796	Bus Sensing Stable Overfrequency Pickup	Int32	CentiHertz	Centi	RW	4600 - 6400
42798	Bus Sensing Stable Overfrequency Dropout	Int32	CentiHertz	Centi	RW	4600 - 6400
42800	Bus Sensing Fail Time Delay	Int32	Decisecond	Deci	RW	1 - 6000
42802	Bus Sensing Stable Time Delay	Int32	Decisecond	Deci	RW	1 - 6000
42804	RESERVED					
42806	Gen Dead Status	Int32	N/A	N/A	R	0 - 1
42808	Gen Stable Status	Int32	N/A	N/A	R	0 - 1
42810	Gen Fail Status	Int32	N/A	N/A	R	0 - 1
42812	Bus Dead Status	Int32	N/A	N/A	R	0 - 1
42814	Bus Stable Status	Int32	N/A	N/A	R	0 - 1
42816	Bus Fail Status	Int32	N/A	N/A	R	0 - 1
42818	Gen Stable Low Line Scale Factor	Float	N/A	N/A	RW	0.001 - 3
42820	Bus Stable Low Line Scale Factor	Float	N/A	N/A	RW	0.001 - 3
42822	Gen Stable Alternate Frequency Scale Factor	Float	N/A	N/A	RW	0.001 - 100
42824	Bus Stable Alternate Frequency Scale Factor	Float	N/A	N/A	RW	0.001 - 100
42826-3250	FUTURE USE					
43252	User Configurable Input 1 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm
43254	User Configurable Input 1 Time Delay	Int32	Second	N/A	RW	0 - 300
43258	RESERVED					
43260	User Configurable Input 2 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm
43262	User Configurable Input 2 Time Delay	Int32	Second	N/A	RW	0 - 300
43266	RESERVED					
43268	User Configurable Input 3 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm
43270	User Configurable Input 3 Time Delay	Int32	Second	N/A	RW	0 - 300
43272-74	RESERVED					

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Register	Description	Type	Units	Scaling Factor	R/W	Range
43276	User Configurable Input 4 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm
43278	User Configurable Input 4 Time Delay	Int32	Second	N/A	RW	0 - 300
43282	RESERVED					
43284	User Configurable Input 5 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm
43286	User Configurable Input 5 Time Delay	Int32	Second	N/A	RW	0 - 300
43288-90	RESERVED					
43292	User Configurable Input 6 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm
43294	User Configurable Input 6 Time Delay	Int32	Second	N/A	RW	0 - 300
43298	RESERVED					
43300	User Configurable Input 7 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm
43302	User Configurable Input 7 Time Delay	Int32	Second	N/A	RW	0 - 300
43304-06	RESERVED					
43308	User Configurable Input 8 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm
43310	User Configurable Input 8 Time Delay	Int32	Second	N/A	RW	0 - 300
43312-14	RESERVED					
43316	User Configurable Input 9 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm
43318	User Configurable Input 9 Time Delay	Int32	Second	N/A	RW	0 - 300
43322	RESERVED					
43324	User Configurable Input 10 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm
43326	User Configurable Input 10 Time Delay	Int32	Second	N/A	RW	0 - 300
43328-30	RESERVED					
43332	User Configurable Input 11 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm
43334	User Configurable Input 11 Time Delay	Int32	Second	N/A	RW	0 - 300
43338	RESERVED					
43340	User Configurable Input 12 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm
43342	User Configurable Input 12 Time Delay	Int32	Second	N/A	RW	0 - 300
43344-46	RESERVED					
43348	User Configurable Input 13 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm
43350	User Configurable Input 13 Time Delay	Int32	Second	N/A	RW	0 - 300
43352-54	RESERVED					

Register	Description	Type	Units	Scaling Factor	R/W	Range
43356	User Configurable Input 14 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm
43358	User Configurable Input 14 Time Delay	Int32	Second	N/A	RW	0 - 300
43360-62	RESERVED					
43364	User Configurable Input 15 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm
43366	User Configurable Input 15 Time Delay	Int32	Second	N/A	RW	0 - 300
43368-70	RESERVED					
43372	User Configurable Input 16 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm
43374	User Configurable Input 16 Time Delay	Int32	Second	N/A	RW	0 - 300
43376-408	RESERVED					
43410	ATS Contact Input	Int32	N/A	N/A	RW	-1 = None 0 = Input 1 1 = Input 2 2 = Input 3 3 = Input 4 4 = Input 5 5 = Input 6 6 = Input 7 7 = Input 8 8 = Input 9 9 = Input 10 10 = Input 11 11 = Input 12 12 = Input 13 13 = Input 14 14 = Input 15 15 = Input 16
43412	RESERVED					
43414	Single Phase Connection Override Contact Input	Int32	N/A	N/A	RW	-1 = None 0 = Input 1 1 = Input 2 2 = Input 3 3 = Input 4 4 = Input 5 5 = Input 6 6 = Input 7 7 = Input 8 8 = Input 9 9 = Input 10 10 = Input 11 11 = Input 12 12 = Input 13 13 = Input 14 14 = Input 15 15 = Input 16
43416	RESERVED					

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Register	Description	Type	Units	Scaling Factor	R/W	Range
43418	Single Phase AC Sense Override Contact Input	Int32	N/A	N/A	RW	-1 = None 0 = Input 1 1 = Input 2 2 = Input 3 3 = Input 4 4 = Input 5 5 = Input 6 6 = Input 7 7 = Input 8 8 = Input 9 9 = Input 10 10 = Input 11 11 = Input 12 12 = Input 13 13 = Input 14 14 = Input 15 15 = Input 16
43420	RESERVED					
43422	High/Low Line Contact Input	Int32	N/A	N/A	RW	-1 = None 0 = Input 1 1 = Input 2 2 = Input 3 3 = Input 4 4 = Input 5 5 = Input 6 6 = Input 7 7 = Input 8 8 = Input 9 9 = Input 10 10 = Input 11 11 = Input 12 12 = Input 13 13 = Input 14 14 = Input 15 15 = Input 16
43424	RESERVED					
43426	Battle Override Contact Input	Int32	N/A	N/A	RW	-1 = None 0 = Input 1 1 = Input 2 2 = Input 3 3 = Input 4 4 = Input 5 5 = Input 6 6 = Input 7 7 = Input 8 8 = Input 9 9 = Input 10 10 = Input 11 11 = Input 12 12 = Input 13 13 = Input 14 14 = Input 15 15 = Input 16
43428	RESERVED					

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Register	Description	Type	Units	Scaling Factor	R/W	Range
43430	Grounded Delta Override Contact Input	Int32	N/A	N/A	RW	-1 = None 0 = Input 1 1 = Input 2 2 = Input 3 3 = Input 4 4 = Input 5 5 = Input 6 6 = Input 7 7 = Input 8 8 = Input 9 9 = Input 10 10 = Input 11 11 = Input 12 12 = Input 13 13 = Input 14 14 = Input 15 15 = Input 16
43432	RESERVED					

Senders

Register	Description	Type	Units	Scaling Factor	R/W	Range
43434	Coolant Temperature Sender Fail Configuration Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
43436	Coolant Temperature Sender Fail Activation Delay	Int32	Minute	N/A	RW	5 - 30
43438	Oil Pressure Sender Fail Configuration Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
43440	Oil Pressure Sender Fail Activation Delay	Int32	Second	N/A	RW	0 - 300
43442	Fuel Level Sender Fail Configuration Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
43444	Fuel Level Sender Fail Activation Delay	Int32	Second	N/A	RW	0 - 300
43446	Voltage Sensing Fail Configuration Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
43448	Voltage Sensing Fail Activation Delay	Int32	Second	N/A	RW	0 - 300
43450	Low Coolant Level Contact Input	Int32	N/A	N/A	RW	-1 = None 0 = Input 1 1 = Input 2 2 = Input 3 3 = Input 4 4 = Input 5 5 = Input 6 6 = Input 7 7 = Input 8 8 = Input 9 9 = Input 10 10 = Input 11 11 = Input 12 12 = Input 13 13 = Input 14 14 = Input 15 15 = Input 16
43452	Low Coolant Level Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
43454	Low Coolant Level Time Delay	Int32	Second	N/A	RW	0 - 300

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Register	Description	Type	Units	Scaling Factor	R/W	Range
43456	Battery Charge Failed Contact Input	Int32	N/A	N/A	RW	-1 = None 0 = Input 1 1 = Input 2 2 = Input 3 3 = Input 4 4 = Input 5 5 = Input 6 6 = Input 7 7 = Input 8 8 = Input 9 9 = Input 10 10 = Input 11 11 = Input 12 12 = Input 13 13 = Input 14 14 = Input 15 15 = Input 16
43458	Battery Charge Failed Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
43460	Battery Charge Failed Time Delay	Int32	Second	N/A	RW	0 - 300
43462	Fuel Leak Detect Contact Input	Int32	N/A	N/A	RW	-1 = None 0 = Input 1 1 = Input 2 2 = Input 3 3 = Input 4 4 = Input 5 5 = Input 6 6 = Input 7 7 = Input 8 8 = Input 9 9 = Input 10 10 = Input 11 11 = Input 12 12 = Input 13 13 = Input 14 14 = Input 15 15 = Input 16
43464	Fuel Leak Detect Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
43466	Fuel Leak Detect Time Delay	Int32	Second	N/A	RW	0 - 300
43468	User Configurable Input 1 Eng Run Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
43470	User Configurable Input 2 Eng Run Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
43472	User Configurable Input 3 Eng Run Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
43474	User Configurable Input 4 Eng Run Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
43476	User Configurable Input 5 Eng Run Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
43478	User Configurable Input 6 Eng Run Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only

Register	Description	Type	Units	Scaling Factor	R/W	Range
43480	User Configurable Input 7 Eng Run Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
43482	User Configurable Input 8 Eng Run Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
43484	User Configurable Input 9 Eng Run Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
43486	User Configurable Input 10 Eng Run Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
43488	User Configurable Input 11 Eng Run Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
43490	User Configurable Input 12 Eng Run Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
43492	User Configurable Input 13 Eng Run Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
43494	User Configurable Input 14 Eng Run Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
43496	User Configurable Input 15 Eng Run Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
43498	User Configurable Input 16 Eng Run Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only

System Configuration and Status

Register	Description	Type	Units	Scaling Factor	R/W	Range
43500	Rated Volts	Float	Volt	N/A	RW	1 - 99999
43502	Pre-Start Contact Config	Int32	N/A	N/A	RW	0 = Open After Disconnect 1 = Closed While Running
43504	System Units	Int32	N/A	N/A	RW	0 = English 1 = Metric
43506	Battery Volts	Int32	N/A	N/A	RW	0 = 12V 1 = 24V
43508	Off Mode Status	Int32	N/A	N/A	R	0 = Disable 1 = Enable
43510	Run Mode Status	Int32	N/A	N/A	R	0 = Disable 1 = Enable
43512	Auto Mode Status	Int32	N/A	N/A	R	0 = Disable 1 = Enable
43514	Virtual Input 1 Status	Int32	N/A	N/A	R	0 = Disable 1 = Enable
43516	Virtual Input 2 Status	Int32	N/A	N/A	R	0 = Disable 1 = Enable
43518	Virtual Input 3 Status	Int32	N/A	N/A	R	0 = Disable 1 = Enable
43520	Virtual Input 4 Status	Int32	N/A	N/A	R	0 = Disable 1 = Enable
43522	RTC Clock Hour	Int32	Hour	N/A	RW	0 - 23

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Register	Description	Type	Units	Scaling Factor	R/W	Range
43524	RTC Minute	Int32	Minute	N/A	RW	0 - 59
43526	RTC Second	Int32	Second	N/A	RW	0 - 59
43528	RTC Month	Int32	N/A	N/A	RW	1 - 12
43530	RTC Day	Int32	N/A	N/A	RW	1 - 31
43532	RTC Year	Int32	N/A	N/A	RW	0 - 99
43534	RTC DST Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
43536	Gen PT Primary	Int32	Volt	N/A	RW	1 - 99999
43538	Gen PT Secondary	Int32	Volt	N/A	RW	1 - 480
43540	Gen CT Primary	Int32	Amp	N/A	RW	1 - 9999
43542	Bus PT Primary	Int32	Volt	N/A	RW	1 - 99999
43544	Bus PT Secondary	Int32	Volt	N/A	RW	1 - 480
43546	Cranking Style	Uint32	N/A	N/A	RW	0 = Continuous 1 = Cycle
43548	Number of Crank Cycles	Uint32	N/A	N/A	RW	1 - 7
43550	Cycle Crank Time	Unit32	Second	N/A	RW	5 - 15
43552	Continuous Crank Time	Unit32	Second	N/A	RW	5 - 60
43554	Crank Disconnect Limit	Uint32	Percent	N/A	RW	10 - 100
43556	Pre Crank Delay	Uint32	Second	N/A	RW	0 - 30
43558	Configured Gen Connection	Uint32	N/A	N/A	RW	0 = Delta 1 = Wye 2 = 1-phase AB 3 = 1-phase AC 4 = Grounded Delta
43560	Gen Rated Frequency	Int32	Hertz	N/A	RW	0 = 50 Hz 1 = 60 Hz
43562	Rated kW	Uint32	kiloWatt	N/A	RW	5 - 9999
43564	Rated Engine RPM	Uint32	RPM	N/A	RW	750 - 3600
43566	No Load Cool Down Time	Uint32	Minute	N/A	RW	0 - 60
43568	EPS Current Threshold	Int32	PercentCTPri	N/A	RW	3 - 10
43570	Fuel Level Function	Uint32	N/A	N/A	RW	0 = Disable 1 = Fuel Lvl 2 = Natural Gas 3 = Propane
43572	Number Flywheel Teeth	Uint32	N/A	N/A	RW	1 - 500
43574	Speed Signal Source	Uint32	N/A	N/A	RW	1 = MPU 2 = Gen Freq 3 = MPU Freq
43576	NFPA Level	Uint32	N/A	N/A	RW	0 = Zero 1 = One 2 = Two
43578	Horn Enable	Int32	N/A	N/A	RW	0 = Disabled 1 = Enabled
43580	Single Phase Override Sensing	Uint32	N/A	N/A	RW	0 = AB 1 = AC
43582	RESERVED					
43584	LCD Contrast Value	Uint32	N/A	N/A	RW	0 - 100
43586	Front Panel Sleep Mode	Uint32	N/A	N/A	RW	0 = Disabled 1 = Enabled
43588	RESERVED					
43590	UTC Offset	Int32	Minute	N/A	RW	(-1440) - 1440
43592	DST Configuration	Int32	N/A	N/A	RW	0 = Disabled 1 = Floating 2 = Fixed
43594	Start/End Time Reference	Int32	N/A	N/A	RW	0 = Local Time 1 = UTC Time
43596	DST Bias Hours	Int32	N/A	N/A	RW	0 - 23
43598	DSP Bias Minutes	Int32	N/A	N/A	RW	0 - 59

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Register	Description	Type	Units	Scaling Factor	R/W	Range
43600	DST Start Month	Int32	N/A	N/A	RW	1 = January 2 = February 3 = March 4 = April 5 = May 6 = June 7 = July 8 = August 9 = September 10 = October 11 = November 12 = December
43602	DST Start Day	Int32	N/A	N/A	RW	1 - 31
43604	DST Start Week of Month	In32	N/A	N/A	RW	0 = First 1 = Second 2 = Third 3 = Fourth 4 = Last
43606	DST Start Day of Week	Int32	N/A	N/A	RW	0 = Sunday 1 = Monday 2 = Tuesday 3 = Wednesday 4 = Thursday 5 = Friday 6 = Saturday
43608	DST Start Hour	Int32	N/A	N/A	RW	0 - 23
43610	DST Start Minute	Int32	N/A	N/A	RW	0 - 59
43612	DST End Month	Int32	N/A	N/A	RW	1 = January 2 = February 3 = March 4 = April 5 = May 6 = June 7 = July 8 = August 9 = September 10 = October 11 = November 12 = December
43614	DST End Day	Int32	N/A	N/A	RW	1 - 31
43616	DST End Week of Month	Int32	N/A	N/A	RW	0 = First 1 = Second 2 = Third 3 = Fourth 4 = Last
43618	DST End Day of Week	Int32	N/A	N/A	RW	0 = Sunday 1 = Monday 2 = Tuesday 3 = Wednesday 4 = Thursday 5 = Friday 6 = Saturday
43620	DST End Hour	Int32	N/A	N/A	RW	0 - 23
43622	DST End Minute	Int32	N/A	N/A	RW	0 - 59
43624	EPS Low Line Scale Factor	Float	N/A	N/A	RW	0.001 - 3
43626	Rated Power Factor	Float	Power Factor	N/A	RW	(-1) - 1
43628	Prestart Rest Configuration	Int32	N/A	N/A	RW	0 = Off During Rest 1 = On During Rest 2 = Preheat before Crank
43630	Oil Pressure Crank Disconnect	UInt32	N/A	N/A	RW	0 = Disable 1 = Enable
43632	Crank Disconnect Pressure	Uint32	PSI	Deci	RW	29 - 1500
43634	Crank Disconnect Pressure in kPa	Uin32	kPa	Deci	RW	200 - 10345
43636	Power Up Delay	Uint32	Second	N/A	RW	0 - 60
43638	Auto Config Detect Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
43640	Low Line Detect Threshold	Int32	Volt	N/A	RW	0 - 480

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Register	Description	Type	Units	Scaling Factor	R/W	Range
43642	Single Phase Detect Threshold	Int32	Volt	N/A	RW	0 - 480
43644	Start Relay Control	Uint32	N/A	N/A	RW	0 = Predefined 1 = Programmable
43646	Run Relay Control	Uint32	N/A	N/A	RW	0 = Predefined 1 = Programmable
43648	Prestart Relay Control	Uint32	N/A	N/A	RW	0 = Predefined 1 = Programmable
43650	Single Phase Connect Generator Detection	Int32	N/A	N/A	RW	0 = A-B 1 = A-C
43652	Off Mode Cool Down Enable	Uint32	N/A	N/A	RW	0 = Disable 1 = Enable
43654	RESERVED					
43656	Not In Auto Horn Enable	Uint32	N/A	N/A	RW	0 = Disable 1 = Enable
43658	Clock Not Set Warning Enable	Uint32	N/A	N/A	RW	0 = Disable 1 = Enable
43660	Alternate Frequency	Int32	Hertz	Centi	RW	1000 - 45000
43662	Generator System Type	Int32	N/A	N/A	RW	0 = Single Generator 1 = Multiple Generator
43664	Gen CT Low Line Scale Factor	Float	N/A	N/A	RW	0.001 - 3
43666	Metric Pressure Units	Int32	N/A	N/A	RW	0 = Bar 1 = kPa
43668	System Units	Int32	N/A	N/A	RW	0 = English 1 = Metric
43670	Kpa bar Config Data	Int32	N/A	N/A	RW	0 = Bar 1 = Kpa
43672	Crank Disconnect Pressure Bar Data	Int32	Bar	Deci	RW	2 - 103
43674	RPM Bandwidth Data	Int32	N/A	N/A	RW	0 - 1000
43676	Number Flywheel Teeth	Uint32	N/A	Deci	RW	10 - 5000
43678	Phase Rotation	Int32	N/A	N/A	RW	0 = ACB 1 = ABC
43680	Restart Delay	Int32	Second	N/A	RW	0 - 120
43682	Configured Bus Connection	Uint32	N/A	N/A	RW	0 = Single Phase 1 = Three Phase
43684	Fuel Level Source	Int32	N/A	N/A	RW	1 – 9
43686	Fuel Level Percent Max	Int32	N/A	N/A	RW	0 – 150
43688	Fuel Level Percent Min	Int32	N/A	N/A	RW	0 – 150
43690	Cycle Rest Time	Uint32	Second	N/A	RW	5 - 15
43692	Rated Volts - Low Line Scale Factor Data	Float	N/A	N/A	RW	0.001 - 3
43694-748	FUTURE USE					

Control

Register	Description	Type	Units	Scaling Factor	R/W	Range
43750	Emergency Stop: Writing a 1 will toggle emergency stop from off to on. Writing a 1 again will toggle emergency stop from on to off	Int32	N/A	N/A	RW	1 = Toggle On/Off
43752	Remote Start	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
43754	Remote Stop	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
43756	Run Mode	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
43758	Off Mode	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
43760	Auto Mode	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
43762	Alarm Reset	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
43764	Gen Breaker Open	Int32	N/A	N/A	RW	0 = Disable 1 = Enable

Register	Description	Type	Units	Scaling Factor	R/W	Range
43766	Gen Breaker Close	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
43768	Mains Breaker Open	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
43770	Mains Breaker Close	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
43772	FUTURE USE					
43774	Virtual Input 1 Close	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
43776	Virtual Input 1 Open	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
43778	Virtual Input 2 Close	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
43780	Virtual Input 2 Open	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
43782	Virtual Input 3 Close	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
43784	Virtual Input 3 Open	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
43786	Virtual Input 4 Close	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
43788	Virtual Input 4 Open	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
43790	ESTOP Latch Status	Int32	N/A	N/A	R	0 = Disabled 1 = Enabled
43792	Gen Breaker Open	Int32	N/A	N/A	RW	1 = Operate (non-latching)
43794	Gen Breaker Close	Int32	N/A	N/A	RW	1 = Operate (non-latching)
43796	Mains Breaker Open	Int32	N/A	N/A	RW	1 = Operate (non-latching)
43798	Mains Breaker Close	Int32	N/A	N/A	RW	1 = Operate (non-latching)
43800-4006	FUTURE USE					

Communication

Register	Description	Type	Units	Scaling Factor	R/W	Range
44008	RESERVED					
44010-16	FUTURE USE					
44018	Modem Inter Dialout Activation Delay	Int32	Second	N/A	RW	0 = 15 1 = 30 2 = 60 3 = 120
44020	Modem Pager Buffer Limit	Int32	N/A	N/A	RW	0 = 80 Chars 1 = 120 Chars 2 = 160 Chars 3 = 200 Chars
44022	Modem Pager Coms Data Format	Int32	N/A	N/A	RW	0 = 8 bit, no parity 1 = 7 bit, even parity

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Register	Description	Type	Units	Scaling Factor	R/W	Range
44024-25	Modem Dialout Conditions 1	Uint32	N/A	N/A	RW	Bit 0 = Aux Input 5 Closed Bit 1 = Aux Input 4 Closed Bit 2 = Aux Input 3 Closed Bit 3 = Aux Input 2 Closed Bit 4 = Aux Input 1 Closed Bit 5 = Cooldown Timer Active Bit 6 = Switch Not In Auto Bit 7 = Scheduled Maintenance Pre-Alarm Bit 8 = Weak Battery Voltage Pre-Alarm Bit 9 = Low Battery Voltage Pre-Alarm Bit 10 = Low Oil Pressure Pre-Alarm Bit 11 = High Coolant Temp Pre-Alarm Bit 12 = kW Overload 1 Pre-Alarm Bit 13 = Battery Overvoltage Pre-Alarm Bit 14 = Fuel Level Sender Fail Pre-Alarm Bit 15 = Oil Pressure Sender Fail Pre-Alarm Bit 16 = Coolant Temp Sender Fail Pre-Alarm Bit 17 = Low Coolant Temp Pre-Alarm Bit 18 = High Fuel Pre-Alarm Bit 19 = Low Fuel Pre-Alarm Bit 20 = Overspeed Alarm Bit 21 = Emergency Stop Alarm Bit 22 = Overcrank Alarm Bit 23 = Low Coolant Level Status Bit 24 = Low Fuel Alarm Bit 25 = Loss of Gen Volt Sensing Alarm Bit 26 = MPU Speed Sender Fail Alarm Bit 27 = Fuel Level Sender Fail Alarm Bit 28 = Oil Pressure Sender Fail Alarm Bit 29 = Coolant Temp Sender Fail Alarm Bit 30 = Low Oil Pressure Alarm Bit 31 = High Coolant Temp Alarm
44026-27	Modem Dialout Conditions 2	Uint32	N/A	N/A	RW	Bit 0 = 59-2 Trip Alarm Bit 1 = 27-2 Trip Alarm Bit 2 = 51-2 Trip Alarm Bit 3 = Engine Running Bit 4 = Battery Charger Fail Status Bit 5 = Fuel Leak Detect Status Bit 6 = Transfer Fail Alarm Bit 7 = 81U Trip Pre-Alarm Bit 8 = 81O Trip Pre-Alarm Bit 9 = 59-1 Trip Pre-Alarm Bit 10 = 27-1 Trip Pre-Alarm Bit 11 = 47 Trip Pre-Alarm Bit 12 = 51-1 Trip Pre-Alarm Bit 13 = 81U Trip Alarm Bit 14 = 81O Trip Alarm Bit 15 = 59-1 Trip Alarm Bit 16 = 27-1 Trip Alarm Bit 17 = 47 Trip Alarm Bit 18 = 51-1 Trip Alarm Bit 19 = Loss of ECU Coms Pre-Alarm Bit 20 = Loss of ECU Coms Alarm Bit 21 = Aux Input 16 Closed Bit 22 = Aux Input 15 Closed Bit 23 = Aux Input 14 Closed Bit 24 = Aux Input 13 Closed Bit 25 = Aux Input 12 Closed Bit 26 = Aux Input 11 Closed Bit 27 = Aux Input 10 Closed Bit 28 = Aux Input 9 Closed Bit 29 = Aux Input 8 Closed Bit 30 = Aux Input 7 Closed Bit 31 = Aux Input 6 Closed
44028-30	RESERVED					
44032	CAN bus Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable

Register	Description	Type	Units	Scaling Factor	R/W	Range
44034	DTC Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44036	Rings for Modem Answer	Int32	N/A	N/A	RW	1 - 9
44038	Modem Offline Delay	Int32	Minute	N/A	RW	1 - 240
44040	Modbus Baud Rate	Int32	N/A	N/A	RW	0 = 9600 Baud 1 = 4800 Baud 2 = 2400 Baud 3 = 1200 Baud
44042	Modbus Parity	Int32	N/A	N/A	RW	0 = No Parity 1 = Odd Parity 2 = Even Parity
44044	Modbus Address	Int32	N/A	N/A	RW	1 - 247
44046-47	Modem Dialout Conditions 3	Uint32	N/A	N/A	RW	Bit 0 = 78 Vector Shift Trip Bit 1 = 51-3 Trip Pre-Alarm Bit 2 = 51-3 Trip Alarm Bit 3 = Duplicate AEM Bit 4 = AEM Comms Failure Bit 5 = Duplicate CEM Bit 6 = CEM Comms Failure Bit 7 = Duplicate LSM Bit 8 = Config Element 8 Status Bit 9 = Config Element 7 Status Bit 10 = Config Element 6 Status Bit 11 = Config Element 5 Status Bit 12 = Config Element 4 Status Bit 13 = Config Element 3 Status Bit 14 = Config Element 2 Status Bit 15 = Config Element 1 Status Bit 16 = ID Repeat Bit 17 = ID Missing Bit 18 = LSM Comms Failure Bit 19 = Intergenset Comms Failure Bit 20 = GOV Output Limit Bit 21 = AVR Output Limit Bit 22 = Auto Restart Fail Alarm Bit 23 = kW Overload 3 Pre-Alarm Bit 24 = kW Overload 2 Pre-Alarm Bit 25 = 40 Trip Pre-Alarm Bit 26 = 32 Trip Pre-Alarm Bit 27 = 59-2 Trip Pre-Alarm Bit 28 = 27-2 Trip Pre-Alarm Bit 29 = 51-2 Trip Pre-Alarm Bit 30 = 40 Trip Alarm Bit 31 = 32 Trip Alarm
44048	LSM-2020 Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44050	DHCP Enabled	Uint32	N/A	N/A	R	0 = Disabled 1 = Enabled
44052-56	RESERVED					
44058	CEM-2020 Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44060	RESERVED					
44062	AEM-2020 Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44064	CEM Outputs	Int32	N/A	N/A	RW	0 = 18 Outputs 1 = 24 Outputs

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Register	Description	Type	Units	Scaling Factor	R/W	Range
44066-67	Modem Dialout Conditions 4	Uint32	N/A	N/A	RW	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Common Pre-Alarm Bit 16 = Common Alarm Bit 17 = Unexpected Shutdown Alarm Bit 18 = ECU Shutdown Bit 19 = DEF Inducement Override Pre-Alarm Bit 20 = DEF Severe Inducement Pre-Alarm Bit 21 = DEF Pre-Severe Inducement Pre-Alarm Bit 22 = DEF Engine Derate Pre-Alarm Bit 23 = DEF Fluid Empty Pre-Alarm Bit 24 = DEF Fluid Low Pre-Alarm Bit 25 = DPF Soot Level Severely High Pre-Alarm Bit 26 = DPF Soot Level Moderately High Pre-Alarm Bit 27 = DPF Soot Level High Pre-Alarm Bit 28 = High Exhaust Temp Pre-Alarm Bit 29 = DPF Regeneration Inhibited Pre-Alarm Bit 30 = DPF Regeneration Required Pre-Alarm Bit 31 = 81 ROCOF DF/DT Trip
44068	Active IP Address	Uint32	N/A	N/A	R	0 - 4294967295
44070	Gateway IP Address	Uint32	N/A	N/A	R	0 - 4294967295
44072	Subnet Mask	Uint32	N/A	N/A	R	0 - 4294967295
44074-248	FUTURE USE					

Protection

Register	Description	Type	Units	Scaling Factor	R/W	Range
44250	3 Phase Overcurrent Pickup (51-1)	Uint32	CentiAmp	Centi	RW	18 - 775
44252	3 Phase Overcurrent Time Dial (51-1)	Uint32	DeciUnit	Deci	RW	0 - 72000
44254	3 Phase Overcurrent Curve (51-1)	Uint32	N/A	N/A	RW	0 = S1 Curve 1 = S2 Curve 2 = L1 Curve 3 = L2 Curve 4 = D Curve 5 = M Curve 6 = I1 Curve 7 = I2 Curve 8 = V1 Curve 9 = V2 Curve 10 = E1 Curve 11 = E2 Curve 12 = A Curve 13 = B Curve 14 = C Curve 15 = G Curve 16 = F Curve 17 = Programmable

Register	Description	Type	Units	Scaling Factor	R/W	Range
44256	3 Phase Overcurrent Alarm Configuration (51-1)	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44258	1 Phase Overcurrent Pickup (51-1)	Uint32	CentiAmp	Centi	RW	18 - 775
44260	1 Phase Overcurrent Time Dial (51-1)	Uint32	DeciUnit	Deci	RW	0 - 72000
44262	1 Phase Overcurrent Curve (51-1)	Uint32	N/A	N/A	RW	0 = S1 Curve 1 = S2 Curve 2 = L1 Curve 3 = L2 Curve 4 = D Curve 5 = M Curve 6 = I1 Curve 7 = I2 Curve 8 = V1 Curve 9 = V2 Curve 10 = E1 Curve 11 = E2 Curve 12 = A Curve 13 = B Curve 14 = C Curve 15 = G Curve 16 = F Curve 17 = Programmable
44264	1 Phase Overcurrent Alarm Configuration (51-1)	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44266	Phase Imbalance Pickup	Uint32	Volt	N/A	RW	5 - 100
44268	Phase Imbalance Activation Delay	Uint32	Decisecond	Deci	RW	0 - 300
44270	Phase Imbalance Alarm Configuration	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44272	3 Phase Undervoltage Pickup (27-1)	Uint32	Volt	N/A	RW	70 - 1000
44274	3 Phase Undervoltage Activation Delay (27-1)	Uint32	Decisecond	Deci	RW	0 - 300
44276	3 Phase Undervoltage Inhibit Frequency (27-1)	Uint32	Hertz	N/A	RW	20 - 400
44278	3 Phase Undervoltage Alarm Configuration (27-1)	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44280	1 Phase Undervoltage Pickup (27-1)	Uint32	Volt	N/A	RW	70 - 1000
44282	1 Phase Undervoltage Activation Delay (27-1)	Uint32	Decisecond	Deci	RW	0 - 300
44284	1 Phase Undervoltage Inhibit Frequency (27-1)	Uint32	Hertz	N/A	RW	20 - 400
44286	1 Phase Undervoltage Alarm Configuration (27-1)	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44288	3 Phase Overvoltage Pickup (59-1)	Uint32	Volt	N/A	RW	70 - 1000
44290	3 Phase Overvoltage Activation Delay (59-1)	Uint32	Decisecond	Deci	RW	0 - 300
44292	3 Phase Overvoltage Alarm Configuration (59-1)	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44294	1 Phase Overvoltage Pickup (59-1)	Uint32	Volt	N/A	RW	70 - 1000

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Register	Description	Type	Units	Scaling Factor	R/W	Range
44296	1 Phase Overvoltage Activation Delay (59-1)	Uint32	Decisecond	Deci	RW	0 - 300
44298	1 Phase Overvoltage Alarm Configuration (59-1)	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44300	Underfrequency Pickup	Uint32	DeciHertz	Deci	RW	450 - 4400
44302	Underfrequency Activation Delay	Uint32	Decisecond	Deci	RW	0 - 300
44304	Underfrequency Inhibit Voltage	Uint32	Volt	N/A	RW	70 - 576
44306	Underfrequency Alarm Configuration	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44308	Overfrequency Pickup	Uint32	DeciHertz	Deci	RW	450 - 4400
44310	Overfrequency Activation Delay	Uint32	Decisecond	Deci	RW	0 - 300
44312	Overfrequency Alarm Configuration	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44314	Overcurrent Low Line Scale Factor (51-1)	Float	N/A	N/A	RW	0.001 - 3
44316	Overvoltage Low Line Scale Factor (59-1)	Float	N/A	N/A	RW	0.001 - 3
44318	Undervoltage Low Line Scale Factor (27-1)	Float	N/A	N/A	RW	0.001 - 3
44320	3 Phase Overcurrent Pickup (51-2)	Uint32	CentiAmp	Centi	RW	18 - 775
44322	3 Phase Overcurrent Time Dial (51-2)	Uint32	DeciUnit	Deci	RW	0 - 72000
44324	3 Phase Overcurrent Curve (51-2)	Uint32	N/A	N/A	RW	0 = S1 Curve 1 = S2 Curve 2 = L1 Curve 3 = L2 Curve 4 = D Curve 5 = M Curve 6 = I1 Curve 7 = I2 Curve 8 = V1 Curve 9 = V2 Curve 10 = E1 Curve 11 = E2 Curve 12 = A Curve 13 = B Curve 14 = C Curve 15 = G Curve 16 = F Curve 17 = Programmable
44326	3 Phase Overcurrent Alarm Configuration (51-2)	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44328	1 Phase Overcurrent Pickup (51-2)	Uint32	CentiAmp	Centi	RW	18 - 775
44330	1 Phase Overcurrent Time Dial (51-2)	Uint32	DeciUnit	Deci	RW	0 - 72000

Register	Description	Type	Units	Scaling Factor	R/W	Range
44332	1 Phase Overcurrent Curve (51-2)	Uint32	N/A	N/A	RW	0 = S1 Curve 1 = S2 Curve 2 = L1 Curve 3 = L2 Curve 4 = D Curve 5 = M Curve 6 = I1 Curve 7 = I2 Curve 8 = V1 Curve 9 = V2 Curve 10 = E1 Curve 11 = E2 Curve 12 = A Curve 13 = B Curve 14 = C Curve 15 = G Curve 16 = F Curve 17 = Programmable
44334	1 Phase Overcurrent Alarm Configuration (51-2)	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44336	3 Phase Undervoltage Pickup (27-2)	Uint32	Volt	N/A	RW	70 - 1000
44338	3 Phase Undervoltage Activation Delay (27-2)	Uint32	Decisecond	Deci	RW	0 - 300
44340	3 Phase Undervoltage Inhibit Frequency (27-2)	Uint32	Hertz	N/A	RW	20 - 400
44342	3 Phase Undervoltage Alarm Configuration (27-2)	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44344	1 Phase Undervoltage Pickup (27-2)	Uint32	Volt	N/A	RW	70 - 1000
44346	1 Phase Undervoltage Activation Delay (27-2)	Uint32	Decisecond	Deci	RW	0 - 300
44348	1 Phase Undervoltage Inhibit Frequency (27-2)	Uint32	Hertz	N/A	RW	20 - 400
44350	1 Phase Undervoltage Alarm Configuration (27-2)	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44352	3 Phase Overvoltage Pickup (59-2)	Uint32	Volt	N/A	RW	70 - 1000
44354	3 Phase Overvoltage Activation Delay (59-2)	Uint32	Decisecond	Deci	RW	0 - 300
44356	3 Phase Overvoltage Alarm Configuration (59-2)	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44358	1 Phase Overvoltage Pickup (59-2)	Uint32	Volt	N/A	RW	70 - 1000
44360	1 Phase Overvoltage Activation Delay (59-2)	Uint32	Decisecond	Deci	RW	0 - 300
44362	1 Phase Overvoltage Alarm Configuration (59-2)	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44364	Overcurrent Low Line Scale Factor (51-2)	Float	N/A	N/A	RW	0.001 - 3
44366	Overvoltage Low Line Scale Factor (59-2)	Float	N/A	N/A	RW	0.001 - 3
44368	Undervoltage Low Line Scale Factor (27-2)	Float	N/A	N/A	RW	0.001 - 3
44370	Phase Imbalance Hysteresis	Uint32	Volt	N/A	RW	1 - 5
44372	3 Phase Undervoltage Hysteresis (27-1)	Uint32	Volt	N/A	RW	1 - 60

Register	Description	Type	Units	Scaling Factor	R/W	Range
44374	1 Phase Undervoltage Hysteresis (27-1)	Uint32	Volt	N/A	RW	1 - 60
44376	3 Phase Overvoltage Hysteresis (59-1)	Uint32	Volt	N/A	RW	1 - 60
44378	1 Phase Overvoltage Hysteresis (59-1)	Uint32	Volt	N/A	RW	1 - 60
44380	Underfrequency Hysteresis	Uint32	DeciHertz	Deci	RW	1 - 400
44382	Overfrequency Hysteresis	Uint32	DeciHertz	Deci	RW	1 - 400
44384	3 Phase Undervoltage Hysteresis (27-2)	Uint32	Volt	N/A	RW	1 - 60
44386	1 Phase Undervoltage Hysteresis (27-2)	Uint32	Volt	N/A	RW	1 - 60
44388	3 Phase Overvoltage Hysteresis (59-2)	Uint32	Volt	N/A	RW	1 - 60
44390	1 Phase Overvoltage Hysteresis (59-2)	Uint32	Volt	N/A	RW	1 - 60
44392	3 Phase Reverse Power Pickup	Int32	DeciPercent	Deci	RW	(-500) - 50
44394	3 Phase Reverse Power Activation Delay	Uint32	Decisecond	Deci	RW	0 - 300
44396	3 Phase Reverse Power Alarm Configuration	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44398	3 Phase Reverse Power Hysteresis	Int32	DeciPercent	Deci	RW	10 - 100
44400	1 Phase Reverse Power Pickup	Int32	DeciPercent	Deci	RW	(-500) - 50
44402	1 Phase Reverse Power Activation Delay	Uint32	Decisecond	Deci	RW	0 - 300
44404	1 Phase Reverse Power Alarm Configuration	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44406	1 Phase Reverse Power Hysteresis	Int32	DeciPercent	Deci	RW	10 - 100
44408	3 Phase Loss of Excitation Pickup	Int32	DeciPercent	Deci	RW	(-1500) - 0
44410	3 Phase Loss of Excitation Activation Delay	Uint32	Decisecond	Deci	RW	0 - 300
44412	3 Phase Loss of Excitation Alarm Configuration	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44414	3 Phase Loss of Excitation Hysteresis	Int32	DeciPercent	Deci	RW	10 - 100
44416	1 Phase Loss of Excitation Pickup	Int32	DeciPercent	Deci	RW	(-1500) - 0
44418	1 Phase Loss of Excitation Activation Delay	Uint32	Decisecond	Deci	RW	0 - 300
44420	1 Phase Loss of Excitation Alarm Configuration	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44422	1 Phase Loss of Excitation Hysteresis	Int32	DeciPercent	Deci	RW	10 - 100
44424	3 Phase Overcurrent Reset Type (51-1)	Int32	N/A	N/A	RW	0 = Instantaneous 1 = Integrating
44426	1 Phase Overcurrent Reset Type (51-1)	Int32	N/A	N/A	RW	0 = Instantaneous 1 = Integrating
44428	3 Phase Overcurrent Reset Type (51-2)	Int32	N/A	N/A	RW	0 = Instantaneous 1 = Integrating
44430	1 Phase Overcurrent Reset Type (51-2)	Int32	N/A	N/A	RW	0 = Instantaneous 1 = Integrating
44432	51-1 Curve Constant A	Float	N/A	N/A	RW	0 - 600
44434	51-1 Curve Constant B	Float	N/A	N/A	RW	0 - 25
44436	51-1 Curve Constant C	Float	N/A	N/A	RW	0 - 1

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Register	Description	Type	Units	Scaling Factor	R/W	Range
44438	51-1 Curve Constant N	Float	N/A	N/A	RW	0.5 - 2.5
44440	51-1 Curve Constant R	Float	N/A	N/A	RW	0 - 30
44442	51-2 Curve Constant A	Float	N/A	N/A	RW	0 - 600
44444	51-2 Curve Constant B	Float	N/A	N/A	RW	0 - 25
44446	51-2 Curve Constant C	Float	N/A	N/A	RW	0 - 1
44448	51-2 Curve Constant N	Float	N/A	N/A	RW	0.5 - 2.5
44450	51-2 Curve Constant R	Float	N/A	N/A	RW	0 - 30
44452	3 Phase Overcurrent Pickup (51-3)	Uint32	CentiAmp	Centi	RW	18 - 775
44454	3 Phase Overcurrent Time Dial (51-3)	Uint32	DeciUnit	Deci	RW	0 - 72000
44456	3 Phase Overcurrent Curve (51-3)	Uint32	N/A	N/A	RW	0 = S1 Curve 1 = S2 Curve 2 = L1 Curve 3 = L2 Curve 4 = D Curve 5 = M Curve 6 = I1 Curve 7 = I2 Curve 8 = V1 Curve 9 = V2 Curve 10 = E1 Curve 11 = E2 Curve 12 = A Curve 13 = B Curve 14 = C Curve 15 = G Curve 16 = F Curve 17 = Programmable
44458	3 Phase Overcurrent Alarm Configuration (51-3)	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44460	1 Phase Overcurrent Pickup (51-3)	Uint32	CentiAmp	Centi	RW	18 - 775
44462	1 Phase Overcurrent Time Dial (51-3)	Uint32	DeciUnit	Deci	RW	0 - 72000
44464	1 Phase Overcurrent Curve (51-3)	Uint32	N/A	N/A	RW	0 = S1 Curve 1 = S2 Curve 2 = L1 Curve 3 = L2 Curve 4 = D Curve 5 = M Curve 6 = I1 Curve 7 = I2 Curve 8 = V1 Curve 9 = V2 Curve 10 = E1 Curve 11 = E2 Curve 12 = A Curve 13 = B Curve 14 = C Curve 15 = G Curve 16 = F Curve 17 = Programmable
44466	1 Phase Overcurrent Alarm Configuration (51-3)	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44468	Overcurrent Low Line Scale Factor (51-3)	Float	N/A	N/A	RW	0.001 - 3
44470	3 Phase Overcurrent Reset Type (51-3)	Int32	N/A	N/A	RW	0 = Instantaneous 1 = Integrating
44472	1 Phase Overcurrent Reset Type (51-3)	Int32	N/A	N/A	RW	0 = Instantaneous 1 = Integrating
44474	51-3 Curve Constant A	Float	N/A	N/A	RW	0 - 600
44476	51-3 Curve Constant B	Float	N/A	N/A	RW	0 - 25
44478	51-3 Curve Constant C	Float	N/A	N/A	RW	0 - 1

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Register	Description	Type	Units	Scaling Factor	R/W	Range
44480	51-3 Curve Constant N	Float	N/A	N/A	RW	0.5 - 2.5
44482	51-3 Curve Constant R	Float	N/A	N/A	RW	0 - 30
44484	78 Vector Shift Alarm Config	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44486	78 Vector Shift Pickup	Int32	Degree	N/A	RW	2 - 90
44488	78 Open Mains Breaker on Trip	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44490	81 ROCOF Alarm Config	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
44492	81 ROCOF Pickup	Uint32	Hz/Second	Deci	RW	2 - 100
44494	81 ROCOF Activation Delay	Uint32	Second	Milli	RW	0 - 10000
44496	81 ROCOF Open Mains Breaker on Trip	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44498	Alternate Frequency Scale Factor	Float	N/A	N/A	RW	0.001 - 100

Alarms

Register	Description	Type	Units	Scaling Factor	R/W	Range
44500	High Coolant Temp Alarm Enable	Uint32	N/A	N/A	RW	0 = Disable 1 = Enable
44502	High Coolant Temp Alarm Threshold	Uint32	Deg F	N/A	RW	100 - 280
44504	Metric High Coolant Temp Alarm Threshold	Int32	Deg C	N/A	RW	38 - 138
44506	High Coolant Temp Alarm Activation Delay	Uint32	Second	N/A	RW	0 - 150
44508	Low Oil Press. Alarm Enable	Uint32	N/A	N/A	RW	0 = Disable 1 = Enable
44510	Low Oil Press. Alarm Threshold	Uint32	PSI	Deci	RW	29 - 1500
44512	Metric Low Oil Press. Alarm Threshold	Uint32	kPa	Deci	RW	200 - 10345
44514	Low Oil Press. Alarm Arming Delay	Uint32	Second	N/A	RW	5 - 60
44516	Overspeed Alarm Enable	Uint32	N/A	N/A	RW	0 = Disable 1 = Enable
44518	Overspeed Alarm Threshold	Uint32	Percent	N/A	RW	105 - 140
44520	Overspeed Alarm Activation Delay	Uint32	Millisecond	Milli	RW	0 - 500
44522	Low Fuel Level Alarm Enable	Uint32	N/A	N/A	RW	0 = Disable 1 = Enable
44524	Low Fuel Level Alarm Threshold	Uint32	Percent	N/A	RW	0 - 100
44526	Low Fuel Level Alarm Activation Delay	Int32	Second	N/A	RW	0 - 30
44528	High Coolant Temp Pre-Alarm Enable	Uint32	N/A	N/A	RW	0 = Disable 1 = Enable
44530	High Coolant Temp Pre-Alarm Threshold	Uint32	Deg F	N/A	RW	100 - 280
44532	Metric High Coolant Temp Pre-Alarm Threshold	Int32	Deg C	N/A	RW	38 - 138
44534	Low Coolant Temp Pre-Alarm Enable	Uint32	N/A	N/A	RW	0 = Disable 1 = Enable
44536	Low Coolant Temp Pre-Alarm Threshold	Uint32	Deg F	N/A	RW	35 - 151
44538	Metric Low Coolant Temp Pre-Alarm Threshold	Int32	Deg C	N/A	RW	2 - 66
44540	High Fuel Level Pre-Alarm Threshold	Int32	Percent	N/A	RW	0 - 150
44542	High Fuel Level Pre-Alarm Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable

Register	Description	Type	Units	Scaling Factor	R/W	Range
44544	High Fuel Level Pre-Alarm Activation Delay	Int32	Second	N/A	RW	0 - 30
44546	Low Fuel Level Pre-Alarm Enable	Uint32	N/A	N/A	RW	0 = Disable 1 = Enable
44548	Low Fuel Level Pre-Alarm Threshold	Uint32	Percent	N/A	RW	10 - 100
44550	Low Battery Pre-Alarm Enable	Uint32	N/A	N/A	RW	0 = Disable 1 = Enable
44552	Low Battery Pre-Alarm Threshold	Uint32	DeciVolt	Deci	RW	60 - 280
44554	Low Battery Pre-Alarm Activation Delay	Uint32	Second	N/A	RW	1 - 60
44556	Weak Battery Pre-Alarm Enable	Uint32	N/A	N/A	RW	0 = Disable 1 = Enable
44558	Weak Battery Pre-Alarm Threshold	Uint32	DeciVolt	Deci	RW	40 - 280
44560	Weak Battery Pre-Alarm Activation Delay	Uint32	Second	Deci	RW	0 - 100
44562	Battery Overvoltage Pre-Alarm Enable	Uint32	N/A	N/A	RW	0 = Disable 1 = Enable
44564	Low Oil Press. Pre-Alarm Enable	Uint32	N/A	N/A	RW	0 = Disable 1 = Enable
44566	Low Oil Press. Pre-Alarm Threshold	Uint32	PSI	Deci	RW	29 - 1500
44568	Metric Low Oil Press. Pre-Alarm Threshold	Int32	kPa	Deci	RW	20 - 10345
44570	Engine Overload 1 Pre-Alarm Enable	Uint32	N/A	N/A	RW	0 = Disable 1 = Enable
44572	Engine Overload 1 Pre-Alarm Threshold	Int32	Percent	N/A	RW	0 - 200
44574	ECU Comms Fail Pre-Alarm Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44576	Active DTC Pre-Alarm Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44578	Maintenance Interval Pre-Alarm Enable	Uint32	N/A	N/A	RW	0 = Disable 1 = Enable
44580	Maintenance Interval Pre-Alarm Threshold	Uint32	Hour	N/A	RW	0 - 5000
44582	Speed Sender Fail Activation Delay	Int32	Second	N/A	RW	0 - 300
44584	ECU Low Coolant Level Alarm Enable	Uint32	N/A	N/A	RW	0 = Disable 1 = Enable
44586	ECU Low Coolant Level Alarm Threshold	Uint32	Percent	N/A	RW	1 - 99
44588	ECU Low Coolant Level Pre-Alarm Enable	Uint32	N/A	N/A	RW	0 = Disable 1 = Enable
44590	ECU Low Coolant Level Pre-Alarm Threshold	Uint32	Percent	N/A	RW	1 - 99
44592	Battery Overvoltage Alarm Threshold	Int32	DeciVolt	Deci	RW	120 - 320
44594	Engine Overload 1 Pre-Alarm 3 Phase Hysteresis	Int32	DeciVolt	Deci	RW	1 - 10
44596	Engine Overload 1 Pre-Alarm 1 Phase Threshold	Int32	Percent	N/A	RW	0 - 200
44598	Engine Overload 1 Pre-Alarm 1 Phase Hysteresis	Int32	Percent	N/A	RW	1 - 10
44600	Engine Overload 1 Pre-Alarm 1 Phase Low Line Scale Factor	Float	N/A	N/A	RW	0.001 - 3
44602	Engine Overload 2 Pre-Alarm Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44604	Engine Overload 2 Pre-Alarm 3 Phase Threshold	Int32	Percent	N/A	RW	0 - 200
44606	Engine Overload 2 Pre-Alarm 3 Phase Hysteresis	Int32	Percent	N/A	RW	1 - 10

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Register	Description	Type	Units	Scaling Factor	R/W	Range
44608	Engine Overload 2 Pre-Alarm 1 Phase Threshold	Int32	Percent	N/A	RW	0 - 200
44610	Engine Overload 2 Pre-Alarm 1 Phase Hysteresis	Int32	Percent	N/A	RW	1 - 10
44612	Engine Overload 2 Pre-Alarm 1 Phase Low Line Scale Factor	Float	N/A	N/A	RW	0.001 - 3
44614	Engine Overload 3 Pre-Alarm Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44616	Engine Overload 3 Pre-Alarm 3 Phase Threshold	Int32	Percent	N/A	RW	0 - 200
44618	Engine Overload 3 Pre-Alarm 3 Phase Hysteresis	Int32	Percent	N/A	RW	1 - 10
44620	Engine Overload 3 Pre-Alarm 1 Phase Threshold	Int32	Percent	N/A	RW	0 - 200
44622	Engine Overload 3 Pre-Alarm 1 Phase Hysteresis	Int32	Percent	N/A	RW	1 - 10
44624	Engine Overload 3 Pre-Alarm 1 Phase Low Line Scale Factor	Float	N/A	N/A	RW	0.001 - 3
44626	LSM Comm Failure Pre-alarm Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44628	Intergenset Comm Failure Pre-alarm Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44630	AVR Bias Output Limit Pre-alarm Activation Delay	Int32	Second	N/A	RW	1 - 15
44632	AVR Bias Output Limit Pre-alarm Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44634	GOV Bias Output Limit Pre-alarm Activation Delay	Int32	Second	N/A	RW	1 - 15
44636	GOV Bias Output Limit Pre-alarm Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44638	ID Missing Pre-alarm Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44640	ID Repeat Pre-alarm Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44642	CEM Comm Failure Pre-alarm Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44644	AEM Comm Failure Pre-alarm Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44646	Checksum Failure Pre-alarm Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44648	Low Oil Pressure Alarm (metric pressure units is Bar)	Int32	Bar	Deci	RW	2 - 103
44650	Low Oil Pressure Pre-Alarm (metric pressure units is Bar)	Int32	Bar	Deci	RW	2 - 103
44652	Sync Fail Pre-alarm Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44654	Breaker Close Fail Pre-Alarm Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44656	Breaker Open Fail Pre-Alarm Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
44658	Breaker Close Fail Pre-Alarm Monitor	Int32	N/A	N/A	RW	0 = Transitions Only 1 = Always
44660	Breaker Open Fail Pre-Alarm Monitor	Int32	N/A	N/A	RW	0 = Transitions Only 1 = Always
44662	Reverse Rotation Pre-Alarm Enable	Uint32	N/A	N/A	RW	0 = Disable 1 = Enable
44664-748	FUTURE USE					

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Metering

Register	Description	Type	Units	Scaling Factor	R/W	Range
44750	Gen VAB Metering	Int32	Volt	N/A	R	(-2147483648) - 2147483647
44752	Gen VBC Metering	Int32	Volt	N/A	R	(-2147483648) - 2147483647
44754	Gen VCA Metering	Int32	Volt	N/A	R	(-2147483648) - 2147483647
44756	Gen VAN Metering	Int32	Volt	N/A	R	(-2147483648) - 2147483647

Register	Description	Type	Units	Scaling Factor	R/W	Range
44758	Gen VBN Metering	Int32	Volt	N/A	R	(-2147483648) - 2147483647
44760	Gen VCN Metering	Int32	Volt	N/A	R	(-2147483648) - 2147483647
44762	Bus Voltage Metering	Int32	Volt	N/A	R	(-2147483648) - 2147483647
44764	Gen IA Metering	Int32	Amp	N/A	R	(-32768) - 32767
44766	Gen IB Metering	Int32	Amp	N/A	R	(-32768) - 32767
44768	Gen IC Metering	Int32	Amp	N/A	R	(-32768) - 32767
44770	Gen kVA A Metering	Int32	KiloVA	N/A	R	(-2147483648) - 2147483647
44772	Gen kVA B Metering	Int32	KiloVA	N/A	R	(-2147483648) - 2147483647
44774	Gen kVA C Metering	Int32	KiloVA	N/A	R	(-2147483648) - 2147483647
44776	Gen kVA Total Metering	Int32	KiloVA	N/A	R	(-2147483648) - 2147483647
44778	Gen kW A Metering	Int32	KiloWatt	N/A	R	(-2147483648) - 2147483647
44780	Gen kW B Metering	Int32	KiloWatt	N/A	R	(-2147483648) - 2147483647
44782	Gen kW C Metering	Int32	KiloWatt	N/A	R	(-2147483648) - 2147483647
44784	Gen kW Total Metering	Int32	KiloWatt	N/A	R	(-2147483648) - 2147483647
44786	Power Factor Metering	Float	N/A	N/A	R	(-1) - 1
44788	Gen PF Lagging	Int32	N/A	N/A	R	0 = leading, 1 = lagging
44790	Gen Frequency Metering	Float	Hertz	N/A	R	45 - 440
44792	Bus Frequency Metering	Float	Hertz	N/A	R	45 - 440
44794	Active Speed Source	Uint32	N/A	N/A	R	0 = None 1 = MPU 2 = Gen Freq 4 = CAN bus
44796	Engine Speed Metering	Uint32	RPM	N/A	R	0 - 65535
44798	Engine Load Metering	Int32	Percent	N/A	R	(-32768) - 32767
44800	Coolant Temp. Metering	Int32	Deg F	N/A	R	(-32768) - 32767
44802	Oil Pressure Metering	Int32	PSI	N/A	R	(-32768) - 32767
44804	Battery Voltage Metering	Int32	DeciVolt	N/A	R	(-32768) - 32767
44806	Fuel Level Metering	Int32	N/A	N/A	R	(-32768) - 32767
44808	ECU Coolant Level Metering	Uint32	N/A	N/A	R	0 - 255
44810	Cool Down Time Remaining	Int32	Minute	N/A	R	(-128) - 127

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Register	Description	Type	Units	Scaling Factor	R/W	Range
44812-13	Alarm Metering	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Unexpected Shutdown Bit 17 = Global Alarm Bit 18 = Auto Restart Failure Bit 19 = Fuel Leak Detect Bit 20 = Battery Charger Failure Bit 21 = Transfer Fail Bit 22 = Low Coolant Level Bit 23 = ECU Shutdown Bit 24 = Emergency Shutdown Bit 25 = Overcrank Bit 26 = Loss of ECU Comms Bit 27 = Global Sender Fail Bit 28 = Low Fuel Level Bit 29 = Low Oil Pressure Bit 30 = Hi Coolant Temp Bit 31 = Overspeed
44814-15	Pre-Alarm Metering 1	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Serial Flash Read Failure Bit 3 = Checksum Fail Bit 4 = Global Pre-Alarm Bit 5 = Fuel Filter 2 Leak Bit 6 = Fuel Filter 1 Leak Bit 7 = Engine kW Overload 3 Bit 8 = Engine kW Overload 2 Bit 9 = MPU Fail Bit 10 = Fuel Leak Detect Bit 11 = Battery Charger Failure Bit 12 = Low Coolant Level Bit 13 = Mains Brkr Fail to Open Bit 14 = Mains Brkr Fail to Close Bit 15 = Sync Fail at Mains Brkr Bit 16 = Gen Brkr Fail to Open Bit 17 = Gen Brkr Fail to Close Bit 18 = Sync Fail at Gen Brkr Bit 19 = High Fuel Level Bit 20 = Loss of Rem. Mod. Com Bit 21 = Engine kW Overload Bit 22 = Diagnostic Trouble Code Bit 23 = Loss of ECU Comms Bit 24 = Maintenance Due Bit 25 = Battery Overvoltage Bit 26 = Weak Battery Bit 27 = Low Battery Voltage Bit 28 = Low Coolant Temp Bit 29 = Low Fuel Level Bit 30 = Low Oil Pressure Bit 31 = Hi Coolant Temp

Register	Description	Type	Units	Scaling Factor	R/W	Range
44816-17	MTU Alarm Metering	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = Not Used Bit 21 = Not Used Bit 22 = Not Used Bit 23 = High ECU Supply Bit 24 = Combined Red Bit 25 = Overspeed Bit 26 = Low Oil Pressure Bit 27 = Low Fuel Delivery Press. Bit 28 = Low Aftercooler Coolant Level Bit 29 = High Coolant Temp Bit 30 = High Oil Temp Bit 31 = High Charge Air Temp
44818-19	MTU Pre-Alarm Metering	Int32	N/A	N/A	R	Bit 0 = Low Storage Tank Bit 1 = High Storage Tank Bit 2 = Low Day Tank Bit 3 = High Day Tank Bit 4 = Alternator Winding Temp Bit 5 = Idle Speed Low Bit 6 = Run Up Speed Low Bit 7 = Start Speed Low Bit 8 = Priming Fault Bit 9 = Low Charge Air Coolant Level Bit 10 = High Fuel Temp. Bit 11 = High Exhaust Temp. B Bit 12 = High Exhaust Temp. A Bit 13 = Low ECU Supply Voltage Bit 14 = Engine Speed Too Low Bit 15 = High Voltage Supply Bit 16 = Low Voltage Supply Bit 17 = Speed Demand Fail Bit 18 = ECU Faulty Bit 19 = Combined Yellow Bit 20 = Low Oil Press. Bit 21 = Low Fuel Delivery Press. Bit 22 = Low Charge Air Press. Bit 23 = Low Coolant Level Bit 24 = Low Fuel Rail Press. Bit 25 = High Fuel Rail Press. Bit 26 = Shutdown Override Bit 27 = High Coolant Temp. Bit 28 = High Charge Air Temp. Bit 29 = High Intercooler Temp. Bit 30 = High Oil Temp. Bit 31 = High ECU Temp.

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Register	Description	Type	Units	Scaling Factor	R/W	Range
44820-21	Sender Fail Alarm Metering	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = Not Used Bit 21 = Not Used Bit 22 = Not Used Bit 23 = Not Used Bit 24 = Not Used Bit 25 = Not Used Bit 26 = Not Used Bit 27 = Generator Voltage Bit 28 = Fuel Level Bit 29 = Coolant Temp Bit 30 = Oil Pressure Bit 31 = Speed
44822	Gen Protect Status	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = 81 ROC DF/DT Trip Bit 19 = 78 Vector Shift Trip Bit 20 = 51-3 Overcurrent Bit 21 = 40Q Loss of Excitation Bit 22 = 32 Reverse Power Bit 23 = 59-2 Overvoltage Bit 24 = 27-2 Undervoltage Bit 25 = 51-2 Overcurrent Bit 26 = 81 Underfrequency Bit 27 = 81 Overfrequency Bit 28 = 59-1 Overvoltage Bit 29 = 27-1 Undervoltage Bit 30 = 47 Phase Imbalance Bit 31 = 51-1 Overcurrent

Register	Description	Type	Units	Scaling Factor	R/W	Range
44824	Gen Protect Pre-alarms	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = Not Used Bit 21 = Not Used Bit 22 = Not Used Bit 23 = Not Used Bit 24 = Not Used Bit 25 = Not Used Bit 26 = Gen Phase Imbalance Bit 27 = Gen Overcurrent Bit 28 = Gen Underfrequency Bit 29 = Gen Overfrequency Bit 30 = Gen Undervoltage Bit 31 = Gen Overvoltage
44826	Gen Protect Alarms	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = Not Used Bit 21 = Not Used Bit 22 = Not Used Bit 23 = Not Used Bit 24 = Not Used Bit 25 = Not Used Bit 26 = Gen Phase Imbalance Bit 27 = Gen Overcurrent Bit 28 = Gen Underfrequency Bit 29 = Gen Overfrequency Bit 30 = Gen Undervoltage Bit 31 = Gen Overvoltage

Register	Description	Type	Units	Scaling Factor	R/W	Range
44828-29	Local Input Metering	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Input 16 Bit 17 = Input 15 Bit 18 = Input 14 Bit 19 = Input 13 Bit 20 = Input 12 Bit 21 = Input 11 Bit 22 = Input 10 Bit 23 = Input 9 Bit 24 = Input 8 Bit 25 = Input 7 Bit 26 = Input 6 Bit 27 = Input 5 Bit 28 = Input 4 Bit 29 = Input 3 Bit 30 = Input 2 Bit 31 = Input 1
44830-31	Local Output Metering	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Pre Start Output Bit 18 = Run Output Bit 19 = Start Output Bit 20 = Output 12 Bit 21 = Output 11 Bit 22 = Output 10 Bit 23 = Output 9 Bit 24 = Output 8 Bit 25 = Output 7 Bit 26 = Output 6 Bit 27 = Output 5 Bit 28 = Output 4 Bit 29 = Output 3 Bit 30 = Output 2 Bit 31 = Output 1

Register	Description	Type	Units	Scaling Factor	R/W	Range
44832-33	Status Metering 1	Int32	N/A	N/A	R	Bit 0 = Idle Request Bit 1 = Lamp Test Bit 2 = Alarm Silence Bit 3 = Reset Bit 4 = Alternate Frequency Override Bit 5 = Start Delay Bypass Bit 6 = Cooldown and Stop Request from Logic Bit 7 = Cooldown Request from Logic Bit 8 = External Start Delay Bit 9 = Off Mode Cooldown Bit 10 = PF Mode Active Bit 11 = Var Mode Active Bit 12 = Cooldown Timer Active Bit 13 = Engine Running Bit 14 = Fuel Leak Detect Bit 15 = Battery Charger Failure Bit 16 = Low Coolant Level Bit 17 = Gen Failed Bit 18 = Gen Stable Bit 19 = Gen Dead Bit 20 = Bus Failed Bit 21 = Bus Stable Bit 22 = Bus Dead Bit 23 = Gen Breaker Closed Bit 24 = Mains Breaker Closed Bit 25 = Grounded Delta Override Bit 26 = Battle Override Bit 27 = Auto Transfer Switch Bit 28 = Low Line Override Bit 29 = Single Phase AC Override Bit 30 = Single Phase Override Bit 31 = EPS Supplying Load
44834	Hours Until Maintenance	Int32	N/A	N/A	RW	0 - 5000
44836	Cum. Total Engine Run Hrs.	Int32	Hour	N/A	R	0 - 99999
44838	Cum. Total Engine Run Min.	Int32	N/A	N/A	R	0 - 59
44840	Cum. Loaded Engine Run Hrs.	Int32	N/A	N/A	R	0 - 99999
44842	Cum. Loaded Engine Run Min.	Int32	N/A	N/A	R	0 - 59
44844	Cum. Unloaded Engine Run Hrs.	Int32	Hour	N/A	R	0 - 99999
44846	Cum. Unloaded Engine Run Min.	Int32	N/A	N/A	R	0 - 59
44848	Cum. Total kW-Hrs	Uint32	KiloWattHour	N/A	R	0 - 999999999
44850	Cum. Total kW-Mins	Uint32	KiloWattMinute	N/A	R	0 - 4294967295
44852	Commission Date Month	Uint32	N/A	N/A	RW	1 - 12
44854	Commission Date Day	Uint32	N/A	N/A	RW	1 - 31
44856	Commission Date Year	Uint32	N/A	N/A	RW	0 - 99
44858	Session Total Engine Run Hrs.	Int32	Hour	N/A	R	0 - 99999
44860	Session Total Engine Run Min.	Int32	N/A	N/A	R	0 - 59
44862	Session Loaded Engine Run Hrs.	Int32	Hour	N/A	R	0 - 99999
44864	Session Loaded Engine Run Min.	Int32	N/A	N/A	R	0 - 59
44866	Session Unloaded Engine Run Hrs.	Int32	Hour	N/A	R	0 - 99999

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Register	Description	Type	Units	Scaling Factor	R/W	Range
44868	Session Unloaded Engine Run Min.	Int32	N/A	N/A	R	0 - 59
44870	Session kW-Hrs	Int32	KiloWattHour	N/A	R	0 - 999999999
44872	Cumulative Number of Engine Starts	Uint32	N/A	N/A	RW	0 - 65535
44874	Session Start Date Month	Uint32	N/A	N/A	RW	1 - 12
44876	Session Start Date Day	Uint32	N/A	N/A	RW	1 - 31
44878	Session Start Date Year	Uint32	N/A	N/A	RW	0 - 99
44880	Generator Status	Uint32	N/A	N/A	R	0 = RESET State 1 = READY State 2 = CRANKING State 3 = RESTING State 4 = RUNNING State 5 = ALARM State 6 = PRESTART State 7 = COOLING State 8 = CONNECTING State 9 = DISCONNECT State 10 = PULSING State 11 = UNLOADING State
44882	Contact Status	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Input 16 Bit 13 = Input 15 Bit 14 = Input 14 Bit 15 = Input 13 Bit 16 = Input 12 Bit 17 = Input 11 Bit 18 = Input 10 Bit 19 = Input 9 Bit 20 = Input 8 Bit 21 = Input 7 Bit 22 = Input 6 Bit 23 = Input 5 Bit 24 = Input 4 Bit 25 = Input 3 Bit 26 = Input 2 Bit 27 = Input 1 Bit 28 = Reserved Bit 29 = Estop Bit 30 = Not Used Bit 31 = Not Used

Register	Description	Type	Units	Scaling Factor	R/W	Range
44884	Main and Aux Relay Image	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Output 16 Bit 13 = Output 15 Bit 14 = Output 14 Bit 15 = Output 13 Bit 16 = Output 12 Bit 17 = Output 11 Bit 18 = Output 10 Bit 19 = Output 9 Bit 20 = Output 8 Bit 21 = Output 7 Bit 22 = Output 6 Bit 23 = Output 5 Bit 24 = Output 4 Bit 25 = Output 3 Bit 26 = Output 2 Bit 27 = Output 1 Bit 28 = Reserved Bit 29 = Prestart Bit 30 = Run Bit 31 = Start
44886-918	RESERVED					
44920-32	FUTURE USE					

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Register	Description	Type	Units	Scaling Factor	R/W	Range
44934-35	Protection Alarm Metering	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = 81 ROC DF/DT Trip Bit 19 = 78 Vector Shift Trip Bit 20 = 51-3 Overcurrent Bit 21 = 40Q Loss of Excitation Bit 22 = 32 Reverse Power Bit 23 = 59-2 Overvoltage Bit 24 = 27-2 Undervoltage Bit 25 = 51-2 Overcurrent Bit 26 = 81 Underfrequency Bit 27 = 81 Overfrequency Bit 28 = 59-1 Overvoltage Bit 29 = 27-1 Undervoltage Bit 30 = 47 Phase Imbalance Bit 31 = 51-1 Overcurrent
44936	Cumulative Stats - Total Run Minutes	Uint32	Minute	N/A	RW	0 - 5999940
44938	Cumulative Stats - Loaded Run Minutes	Uint32	Minute	N/A	RW	0 - 5999940
44940	Cumulative Stats - Unloaded Run Minutes	Uint32	Minute	N/A	RW	0 - 5999940
44942	Run Stats - Total Run Minutes	Uint32	Minute	N/A	RW	0 - 5999940
44944	Run Stats - Loaded Run Minutes	Uint32	Minute	N/A	RW	0 - 5999940
44946	Run Stats - Unloaded Run Minutes	Uint32	Minute	N/A	RW	0 - 5999940

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Register	Description	Type	Units	Scaling Factor	R/W	Range
44948-49	LSM Alarm Bits	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = Not Used Bit 21 = Not Used Bit 22 = Not Used Bit 23 = Not Used Bit 24 = Not Used Bit 25 = Duplicate LSM Bit 26 = ID Repeat Bit 27 = ID Missing Bit 28 = LSM Comms Failure Bit 29 = Intergenset Comms Failure Bit 30 = GOV Output Limit Bit 31 = AVR Output Limit
44950	Global Alarm	Uint32	N/A	N/A	R	Bit 0 = No system alarms in effect Bit 1 = System alarm(s) in effect
44952	Global Pre-Alarm	Uint32	N/A	N/A	R	Bit 0 = No system pre-alarms in effect Bit 1 = System pre-alarm(s) in effect

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Register	Description	Type	Units	Scaling Factor	R/W	Range
44954-55	Local Configurable Inputs Pre-Alarm Bits	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Input 16 Bit 17 = Input 15 Bit 18 = Input 14 Bit 19 = Input 13 Bit 20 = Input 12 Bit 21 = Input 11 Bit 22 = Input 10 Bit 23 = Input 9 Bit 24 = Input 8 Bit 25 = Input 7 Bit 26 = Input 6 Bit 27 = Input 5 Bit 28 = Input 4 Bit 29 = Input 3 Bit 30 = Input 2 Bit 31 = Input 1
44956-57	Local Configurable Inputs Alarm Bits	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Input 16 Bit 17 = Input 15 Bit 18 = Input 14 Bit 19 = Input 13 Bit 20 = Input 12 Bit 21 = Input 11 Bit 22 = Input 10 Bit 23 = Input 9 Bit 24 = Input 8 Bit 25 = Input 7 Bit 26 = Input 6 Bit 27 = Input 5 Bit 28 = Input 4 Bit 29 = Input 3 Bit 30 = Input 2 Bit 31 = Input 1

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Register	Description	Type	Units	Scaling Factor	R/W	Range
44958-59	Configurable Elements Status Bits	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = Not Used Bit 21 = Not Used Bit 22 = Not Used Bit 23 = Not Used Bit 24 = Config Element 8 Bit 25 = Config Element 7 Bit 26 = Config Element 6 Bit 27 = Config Element 5 Bit 28 = Config Element 4 Bit 29 = Config Element 3 Bit 30 = Config Element 2 Bit 31 = Config Element 1
44960-61	Configurable Elements Pre-Alarm Bits	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = Not Used Bit 21 = Not Used Bit 22 = Not Used Bit 23 = Not Used Bit 24 = Config Element 8 Bit 25 = Config Element 7 Bit 26 = Config Element 6 Bit 27 = Config Element 5 Bit 28 = Config Element 4 Bit 29 = Config Element 3 Bit 30 = Config Element 2 Bit 31 = Config Element 1

Register	Description	Type	Units	Scaling Factor	R/W	Range
44962-63	Configurable Elements Alarm Bits	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = Not Used Bit 21 = Not Used Bit 22 = Not Used Bit 23 = Not Used Bit 24 = Config Element 8 Bit 25 = Config Element 7 Bit 26 = Config Element 6 Bit 27 = Config Element 5 Bit 28 = Config Element 4 Bit 29 = Config Element 3 Bit 30 = Config Element 2 Bit 31 = Config Element 1
44964-65	Remote Inputs Status Bits	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = Not Used Bit 21 = Not Used Bit 22 = Remote Input 26 Bit 23 = Remote Input 25 Bit 24 = Remote Input 24 Bit 25 = Remote Input 23 Bit 26 = Remote Input 22 Bit 27 = Remote Input 21 Bit 28 = Remote Input 20 Bit 29 = Remote Input 19 Bit 30 = Remote Input 18 Bit 31 = Remote Input 17

Register	Description	Type	Units	Scaling Factor	R/W	Range
44966-67	Remote Outputs Status Bits	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Remote Output 36 Bit 9 = Remote Output 35 Bit 10 = Remote Output 34 Bit 11 = Remote Output 33 Bit 12 = Remote Output 32 Bit 13 = Remote Output 31 Bit 14 = Remote Output 30 Bit 15 = Remote Output 29 Bit 16 = Remote Output 28 Bit 17 = Remote Output 27 Bit 18 = Remote Output 26 Bit 19 = Remote Output 25 Bit 20 = Remote Output 24 Bit 21 = Remote Output 23 Bit 22 = Remote Output 22 Bit 23 = Remote Output 21 Bit 24 = Remote Output 20 Bit 25 = Remote Output 19 Bit 26 = Remote Output 18 Bit 27 = Remote Output 17 Bit 28 = Remote Output 16 Bit 29 = Remote Output 15 Bit 30 = Remote Output 14 Bit 31 = Remote Output 13
44968-69	CEM Alarm Bits	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = Not Used Bit 21 = Not Used Bit 22 = Not Used Bit 23 = Not Used Bit 24 = Not Used Bit 25 = Not Used Bit 26 = Not Used Bit 27 = Not Used Bit 28 = Not Used Bit 29 = CEM Hardware Mismatch Bit 30 = Duplicate CEM Bit 31 = CEM Comm Fail

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Register	Description	Type	Units	Scaling Factor	R/W	Range
44970-71	Remote Configurable Inputs Pre-Alarm Bits	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = Not Used Bit 21 = Not Used Bit 22 = Remote Input 26 Bit 23 = Remote Input 25 Bit 24 = Remote Input 24 Bit 25 = Remote Input 23 Bit 26 = Remote Input 22 Bit 27 = Remote Input 21 Bit 28 = Remote Input 20 Bit 29 = Remote Input 19 Bit 30 = Remote Input 18 Bit 31 = Remote Input 17
44972-73	Remote Configurable Inputs Alarm Bits	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = Not Used Bit 21 = Not Used Bit 22 = Remote Input 26 Bit 23 = Remote Input 25 Bit 24 = Remote Input 24 Bit 25 = Remote Input 23 Bit 26 = Remote Input 22 Bit 27 = Remote Input 21 Bit 28 = Remote Input 20 Bit 29 = Remote Input 19 Bit 30 = Remote Input 18 Bit 31 = Remote Input 17

Register	Description	Type	Units	Scaling Factor	R/W	Range
44974-75	AEM Alarm Bits	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = Not Used Bit 21 = Not Used Bit 22 = Not Used Bit 23 = Not Used Bit 24 = Not Used Bit 25 = Not Used Bit 26 = Not Used Bit 27 = Not Used Bit 28 = Not Used Bit 29 = Not Used Bit 30 = Duplicate AEM Bit 31 = AEM Comm Fail
44976	Slip Frequency	Int32	Hertz	Centi	R	(-32768) - 32767
44978	Slip Angle	Int32	DeciUnit	Deci	R	(-32768) - 32767
44980	Voltage Difference	Int32	Volt	N/A	R	(-2147483648) - 2147483647

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Register	Description	Type	Units	Scaling Factor	R/W	Range
44982-83	MDEC Pre-Alarms	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = Not Used Bit 21 = Not Used Bit 22 = Not Used Bit 23 = Not Used Bit 24 = High Fuel Filter Diff Pressure Bit 25 = Overspeed Test On Bit 26 = Ambient Temp Bit 27 = High Temp Coil 3 Bit 28 = High Temp Coil 2 Bit 29 = High Temp Coil 1 Bit 30 = High Pressure Input 2 Bit 31 = High Pressure Input 1
44984-85	MTU Status	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = ECU Shutdown Bit 21 = Priming Pump ON Bit 22 = CAN Mode Feedback Bit 23 = Preheat Temp Not Reached Bit 24 = Load Gen On Bit 25 = Cylinder Cutout Bit 26 = Engine Running Bit 27 = Speed Decrease Bit 28 = Speed Increase Bit 29 = Speed Demand Fail Mode Bit 30 = External Stop Active Bit 31 = ECU Override

Register	Description	Type	Units	Scaling Factor	R/W	Range
44986	Generator Frequency	Int32	Hertz	Deci	R	0 - 4400
44988	Bus Frequency	Int32	Hertz	Deci	R	0 - 4400
44990	Power Factor	Int32	N/A	Centi	R	(-100) - 100
44992	Slip Frequency	Int32	N/A	Milli	R	(-450000) -450000
44994	Bus VAB	Int32	Volt	N/A	R	(-2147483648) – 2147483647
44996	Bus VBC	Int32	Volt	N/A	R	(-2147483648) – 2147483647
44998	Bus VCA	Int32	Volt	N/A	R	(-2147483648) – 2147483647
45000-01	ECU Lamp Status	Int32	N/A	N/A	R	Bit 0 = Protect Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Warning Bit 4 = Stop Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Malfunction Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = Not Used Bit 21 = Not Used Bit 22 = Not Used Bit 23 = Not Used Bit 24 = Not Used Bit 25 = Not Used Bit 26 = Not Used Bit 27 = Not Used Bit 28 = Not Used Bit 29 = Not Used Bit 30 = Not Used Bit 31 = Not Used
45002	Number of DTC's	Int32	N/A	N/A	R	(-32768) - 32767
45004-07	Reserved					

Register	Description	Type	Units	Scaling Factor	R/W	Range
45008	CAN Communications Diagnostics	Int32	N/A	N/A	R	Bit 0 = CAN ECU Offline Bit 1 = Active DTC Clear Fail Bit 2 = Previously Active DTC Clear Fail Bit 3 = DTC Values Changed Bit 4 = ECU Comms Failed Bit 5 = Not Used Bit 6 = Not Used Bit 7 = CAN Hardware Pass Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = Not Used Bit 21 = Not Used Bit 22 = Not Used Bit 23 = Not Used Bit 24 = Not Used Bit 25 = Not Used Bit 26 = Not Used Bit 27 = Not Used Bit 28 = Not Used Bit 29 = Not Used Bit 30 = Not Used Bit 31 = Not Used
45010	RESERVED					
45012	ECU Accelerator Pedal Position	Uint32	0.4%/bit gain, 0% offset	N/A	R	0 to 100%
45014	ECU Percent Load at Current Speed	Uint32	1%/bit gain, 0% offset	N/A	R	0 to 125%
45016	ECU Actual Engine Percent Torque	Uint32	1%/bit gain, -125% offset	N/A	R	0 to 125%
45018	ECU Engine Speed	Uint32	RPM (0.125rpm/bit gain)	N/A	R	0 to 8031.875 rpm
45020	ECU Injection Control Pressure	Uint32	1/256 MPa/bit, 0 Offset	N/A	R	0 to +251 MPa
45022	ECU Injector Metering Rail Pressure	Uint32	1/256 MPa/bit, 0 Offset	N/A	R	0 to +251 MPa
45024	ECU Engine Run Time	Uint32	0.05 h/bit gain, 0 h offset	N/A	R	0 to +210,554, 060.75 h
45026	ECU Trip Fuel	Uint32	0.5 L per bit gain, 0 L offset	N/A	R	0 to +2,105,540, 608 L
45028	ECU Total Fuel Used	Uint32	0.5 L per bit gain, 0 L offset	N/A	R	0 to +2,105,540, 608 L
45030	ECU Coolant Temperature	Uint32	1 °C/bit gain, -40 °C offset	N/A	R	-40 to +210 °C
45032	ECU Fuel Temperature	Uint32	1 °C/bit gain, -40 °C offset	N/A	R	-40 to +210 °C
45034	ECU Engine Oil Temperature	Uint32	0.03125 °C/bit gain, -273 °C offset	N/A	R	-273 to +1735.0 °C
45036	ECU Engine Intercooler Temperature	Uint32	1 °C/bit gain, -40 °C offset	N/A	R	-40 to +210 °C
45038	ECU Fuel Delivery Pressure	Uint32	4 kPa/bit gain, 0 kPa offset	N/A	R	0 to +1000 kPa
45040	ECU Engine Oil Level	Uint32	0.4 %/bit gain, 0 % offset	N/A	R	0 to +100 %
45042	ECU Oil Pressure	Uint32	4 kPa/bit gain, 0 kPa offset	N/A	R	0 to +1000 kPa

Register	Description	Type	Units	Scaling Factor	R/W	Range
45044	ECU Coolant Pressure	Uint32	2 kPa/bit gain, 0 kPa offset	N/A	R	0 to +500 kPa
45046	ECU Coolant Level	Uint32	0.4 %/bit gain, 0 % offset	N/A	R	0 to +100 %
45048	ECU Fuel Rate	Uint32	0.05 L/h per bit , 0 offset	N/A	R	0 to +3212.75 L/h
45050	ECU Barometric Pressure	Uint32	0.5 kPa/bit gain, 0 kPa offset	N/A	R	0 to +125 kPa
45052	ECU Ambient Air Temperature	Uint32	0.03125 °C/bit gain, -273 °C offset	N/A	R	-273 to +1735.0 °C
45054	ECU Air Inlet Temperature	Uint32	1 °C/bit gain, -40 °C offset	N/A	R	-40 to +210 °C
45056	ECU Boost Pressure	Uint32	2 kPa/bit gain, 0 kPa offset	N/A	R	0 to +500 kPa
45058	ECU Intake Manifold Temperature	Uint32	1 °C/bit gain, -40 °C offset	N/A	R	-40 to +210 °C
45060	ECU Air Filter Differential Pressure	Uint32	0.05 kPa/bit gain, 0 kPa offset	N/A	R	0 to +12.5 kPa
45062	ECU Exhaust Gas Temperature	Uint32	0.03125 °C/bit gain, -273 °C offset	N/A	R	-273 to +1735.0 °C
45064	ECU Electrical Potential Voltage	Uint32	0.05 V/bit gain, 0 V offset	N/A	R	0 to +3212.75 V
45066	ECU Battery Potential Voltage Switched	Uint32	0.05 V/bit gain, 0 V offset	N/A	R	0 to +3212.75 V
45068	ECU Speed at Idle Point 1	Uint32	0.125 rpm/bit, 0 rpm offset	N/A	R	0 to 8031.875 rpm
45070	ECU Torque at Idle Point 1	Uint32	1%/bit gain, -125% offset	N/A	R	0 to +125 %
45072	ECU Speed at Idle Point 2	Uint32	0.125 rpm/bit, 0 rpm offset	N/A	R	0 to 8031.875 rpm
45074	ECU Torque at Idle Point 2	Uint32	1%/bit gain, -125% offset	N/A	R	0 to +125 %
45076	ECU Speed at Idle Point 3	Uint32	0.125 rpm/bit, 0 rpm offset	N/A	R	0 to 8031.875 rpm
45078	ECU Torque at Idle Point 3	Uint32	1%/bit gain, -125% offset	N/A	R	0 to +125 %
45080	ECU Speed at Idle Point 4	Uint32	0.125 rpm/bit, 0 rpm offset	N/A	R	0 to 8031.875 rpm
45082	ECU Torque at Idle Point 4	Uint32	1%/bit gain, -125% offset	N/A	R	0 to +125 %
45084	ECU Speed at Idle Point 5	Uint32	0.125 rpm/bit, 0 rpm offset	N/A	R	0 to 8031.875 rpm
45086	ECU Torque at Idle Point 5	Uint32	1%/bit gain, -125% offset	N/A	R	0 to +125 %
45088	ECU Speed at High Idle Point 6	Uint32	0.125 rpm/bit, 0 rpm offset	N/A	R	0 to 8031.875 rpm
45090	ECU Gain of End Speed Governor	Uint32	0.0007813%ref trq/rpm per bit gain, 0 Offset	N/A	R	0 to 50.2 %/rpm
45092	ECU Reference Engine Torque	Uint32	1 Nm/bit gain, 0 Nm offset	N/A	R	0 to 64 255 Nm
45094	ECU Override Speed Point 7	Uint32	0.125 rpm/bit, 0 rpm offset	N/A	R	0 to 8031.875 rpm
45096	ECU Override Time Limit	Uint32	0.1 s/bit gain, 0 s offset	N/A	R	0 s to 25 s
45098	ECU Speed Lower Limit	Uint32	10 rpm/bit gain, 0 rpm offset	N/A	R	0 to 2500 rpm
45100	ECU Speed Upper Limit	Uint32	10 rpm/bit gain, 0 rpm offset	N/A	R	0 to 2500 rpm
45102	ECU Torque Lower Limit	Uint32	1%/bit gain, -125% offset	N/A	R	0 to 125%
45104	ECU Torque Upper Limit	Uint32	1%/bit gain, -125% offset	N/A	R	0 to 125%
45106	Active DTC 1	Uint32	N/A	N/A	R	Suppose the 32 bits of DTC Data is in Register N and N+1.
45108	Active DTC 2	Uint32	N/A	N/A	R	

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45110	Active DTC 3	Uint32	N/A	N/A	R	SPN = (Register N: Most Significant 3 bits * 65536) + (Register N+1: LS Byte * 256) + (Register N+1: MS Byte) FMI = Register N: Bits 8-12 Occurrence Count = Register N: Bits 0 through 6
45112	Active DTC 4	Uint32	N/A	N/A	R	
45114	Active DTC 5	Uint32	N/A	N/A	R	
45116	Active DTC 6	Uint32	N/A	N/A	R	
45118	Active DTC 7	Uint32	N/A	N/A	R	
45120	Active DTC 8	Uint32	N/A	N/A	R	
45122	Active DTC 9	Uint32	N/A	N/A	R	
45124	Active DTC 10	Uint32	N/A	N/A	R	
45126	Active DTC 11	Uint32	N/A	N/A	R	
45128	Active DTC 12	Uint32	N/A	N/A	R	
45130	Active DTC 13	Uint32	N/A	N/A	R	
45132	Active DTC 14	Uint32	N/A	N/A	R	
45134	Active DTC 15	Uint32	N/A	N/A	R	
45136	Active DTC 16	Uint32	N/A	N/A	R	
45138	Previously Active DTC 1	Uint32	N/A	N/A	R	
45140	Previously Active DTC 2	Uint32	N/A	N/A	R	
45142	Previously Active DTC 3	Uint32	N/A	N/A	R	
41544	Previously Active DTC 4	Uint32	N/A	N/A	R	
45146	Previously Active DTC 5	Uint32	N/A	N/A	R	
45148	Previously Active DTC 6	Uint32	N/A	N/A	R	
45150	Previously Active DTC 7	Uint32	N/A	N/A	R	
45152	Previously Active DTC 8	Uint32	N/A	N/A	R	
45154	Previously Active DTC 9	Uint32	N/A	N/A	R	
45156	Previously Active DTC 10	Uint32	N/A	N/A	R	
45158	Previously Active DTC 11	Uint32	N/A	N/A	R	
45160	Previously Active DTC 12	Uint32	N/A	N/A	R	
45162	Previously Active DTC 13	Uint32	N/A	N/A	R	
45164	Previously Active DTC 14	Uint32	N/A	N/A	R	
45166	Previously Active DTC 15	Uint32	N/A	N/A	R	
45168	Previously Active DTC 16	Uint32	N/A	N/A	R	
45170	Active DTC Count Data	Uint32	N/A	N/A	R	0 - 16
45172	Previously Active DTC Count Data	Uint32	N/A	N/A	R	0 - 16
45174	Active MTU Fault Code Count Data	Uint32	N/A	N/A	R	0 - 20
45176-248	RESERVED					
45250	CAN bus Enabled by User Data	Int32	N/A	N/A	RW	0 - 1
45252	DTC Enable Data	Int32	N/A	N/A	RW	0 - 1
45254	J1939 Source Address	Int32	N/A	N/A	RW	1 - 253
45256	ECU Control Output	Uint32	N/A	N/A	RW	0 = Fuel Relay Controls 1 - Preheat Relay Controls
45258	Pulsing Enable	Uint32	N/A	N/A	RW	1 = Enable 2 = Disable
45260	MDEC Module Type	Uint32	N/A	N/A	RW	1 = CAN Module 201 2 = CAN Module 302 3 = CAN Module 303 4 = CAN Module 304
45262	MDEC Speed Demand Source	Uint32	N/A	N/A	RW	0 = Analog CAN 1 = Up Down ECU 2 = Up Down CAN 3 = Analog ECU 4 = Frequency 5 = No CAN Demand

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45264	MDEC Engine RPM Request	Uint32	N/A	N/A	RW	1400 - 2000
45266	Volvo Accelerator Pedal Position	Uint32	N/A	N/A	RW	0 - 100
45268	Volvo RPM Select	Uint32	N/A	N/A	RW	0 = Primary 1 = Secondary
45270	J1939 Start Stop Config	Uint32	N/A	N/A	RW	0 = Standard 1 = Volvo Penta 2 = MTU MDEC 3 = MTU ADEC 4 = MTU ECU7 5 = GM 6 = Cummins 7 = MTU Smart Connect 8 = Scania 9 = John Deere
45272	ECU Settling Time	Uint32	Millisecond	Milli	RW	5500 - 30000
45274	ECU Pulse Cycle Time	Uint32	Minute	N/A	RW	1 - 60
45276	ECU Disconnect Time	Uint32	Second	N/A	RW	1 - 60
45278	ECU Connect Time	Uint32	Second	N/A	RW	1 - 60
45280	MTU Request Test Overspeed	Uint32	N/A	N/A	RW	0 = Off 1 = On
45282	MTU Governor Switchover Parameters	Uint32	N/A	N/A	RW	0 - 1
45284	MTU Intermittent Oil Prime Request	Uint32	N/A	N/A	RW	0 = Off 1 = On
45286	MTU Trip Info Reset Request	Uint32	N/A	N/A	RW	0 = Off 1 = On
45288	MTU Speed Increase	Uint32	N/A	N/A	RW	0 = Off 1 = On
45290	MTU Speed Decrease	Uint32	N/A	N/A	RW	0 = Off 1 = On
45292	MTU Speed Demand Limit Boolean	Uint32	N/A	N/A	RW	0 = Off 1 = On
45294	MTU Mode Switch	Uint32	N/A	N/A	RW	0 - 1000
45296	MTU Increased Idle	Uint32	N/A	N/A	RW	0 - 1000
45298	MTU Gov Param Set Select	Uint32	N/A	N/A	RW	0 = Off 1 = On
45300	MTU Fan Override	Uint32	N/A	N/A	RW	0 = Off 1 = On
45302	MTU Prime On Engine Start	Uint32	N/A	N/A	RW	0 = Off 1 = On
45304	MTU CAN Rating SW1	Uint32	N/A	N/A	RW	0 = Off 1 = On
45306	MTU CAN Rating SW2	Uint32	N/A	N/A	RW	0 = Off 1 = On
45308	MTU Disable Cylinder Cutout 1	Uint32	N/A	N/A	RW	0 = Off 1 = On
45310	MTU Cylinder Cutout 2	Uint32	N/A	N/A	RW	0 = Off 1 = On
45312	MTU ECU7 Module Type Data	Int32	N/A	N/A	RW	0 = Off 1 = On
45314	RESERVED					
45316	MTU NMT Alive Repeat Milliseconds	Int32	Millisecond	N/A	RW	100 - 500
45318	Generator Parameter Transmit Enable Data	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
45320	DPF Manual Regenerate Data	Int32	N/A	N/A	RW	0 = Off 1 = On
45322	DPF Regenerate Disable Data	Int32	N/A	N/A	RW	0 = Off 1 = On

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45324	J1939 Speed Torque Transmit Enable Data	Int32	N/A	N/A	RW	0 = Off 1 = On
45326	Engine Idle RPM Data	Int32	N/A	N/A	RW	100 - 2000
45328	Engine Parameter Transmit Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
45330	Requested MTU SMC ENG Operating Mode	Int32	N/A	N/A	RW	1 - 2
45332	SPN Conversion Method	Int32	N/A	N/A	RW	1 - 4
45334	John Deere Regeneration Interlock	Uint32	N/A	N/A	RW	0 = Disable 1 = Enable
45334-482	RESERVED					
45484	Volt Reg CAN bus Param Transmit Enable Data	Int32	N/A	N/A	RW	0 = None 1 = Marathon 2 = Basler 3 = J1939
45486	Volt Reg Primary Volt Setpoint in DeciVolts Data	Int32	DeciUnit	Deci	RW	1000 - 6000
45488	Volt Reg Alternate Volt Setpoint in DeciVolts Data	Int32	DeciUnit	Deci	RW	1000 - 6000
45490	Volt Reg Volt Adjust Bandwidth CentiVolts Data	Int32	CentiUnit	Centi	RW	0 - 3000
45492	Volt Reg Field Current in Milliamps Data	Int32	MilliUnit	Milli	RW	0 - 30000
45494	Volt Reg Primary UF Knee in DeciHertz Data	Int32	DeciUnit	Deci	RW	400 - 700
45496	Volt Reg Alternate UF Knee in DeciHertz Data	Int32	DeciUnit	Deci	RW	400 - 700
45498	Volt Reg Underfreq Slope in CentiUnits	Int32	CentiUnit	Centi	RW	100 - 500
45500	Analog Input 1 Metering Value	Int32	CentiUnit	Centi	R	(-100000000) – 99999900
45502	Analog Input 2 Metering Value	Int32	CentiUnit	Centi	R	(-100000000) – 99999900
45504	Analog Input 3 Metering Value	Int32	CentiUnit	Centi	R	(-100000000) – 99999900
45506	Analog Input 4 Metering Value	Int32	CentiUnit	Centi	R	(-100000000) – 99999900
45508	Analog Input 5 Metering Value	Int32	CentiUnit	Centi	R	(-100000000) – 99999900
45510	Analog Input 6 Metering Value	Int32	CentiUnit	Centi	R	(-100000000) – 99999900
45512	Analog Input 7 Metering Value	Int32	CentiUnit	Centi	R	(-100000000) – 99999900
45514	Analog Input 8 Metering Value	Int32	CentiUnit	Centi	R	(-100000000) – 99999900
45516	RTD Input 1 Metering Value	Int32	CentiDeg F	Centi	R	(-100000000) – 99999900
45518	RTD Input 2 Metering Value	Int32	CentiDeg F	Centi	R	(-100000000) – 99999900
45520	RTD Input 3 Metering Value	Int32	CentiDeg F	Centi	R	(-100000000) – 99999900
45522	RTD Input 4 Metering Value	Int32	CentiDeg F	Centi	R	(-100000000) – 99999900
45524	RTD Input 5 Metering Value	Int32	CentiDeg F	Centi	R	(-100000000) – 99999900
45526	RTD Input 6 Metering Value	Int32	CentiDeg F	Centi	R	(-100000000) – 99999900
45528	RTD Input 7 Metering Value	Int32	CentiDeg F	Centi	R	(-100000000) – 99999900

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45530	RTD Input 8 Metering Value	Int32	CentiDeg F	Centi	R	(-100000000) – 99999900
45532	Thermocouple Input 1 Metering Value	Int32	CentiDeg F	Centi	R	(-100000000) – 99999900
45534	Thermocouple Input 2 Metering Value	Int32	CentiDeg F	Centi	R	(-100000000) – 99999900
45536-37	AEM Input Threshold Status Bits Reg 1	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Analog Input 6 Under 2 Bit 3 = Analog Input 6 Under 1 Bit 4 = Analog Input 6 Over 2 Bit 5 = Analog Input 6 Over 1 Bit 6 = Analog Input 6 Out of Range Bit 7 = Analog Input 5 Under 2 Bit 8 = Analog Input 5 Under 1 Bit 9 = Analog Input 5 Over 2 Bit 10 = Analog Input 5 Over 1 Bit 11 = Analog Input 5 Out of Range Bit 12 = Analog Input 4 Under 2 Bit 13 = Analog Input 4 Under 1 Bit 14 = Analog Input 4 Over 2 Bit 15 = Analog Input 4 Over 1 Bit 16 = Analog Input 4 Out of Range Bit 17 = Analog Input 3 Under 2 Bit 18 = Analog Input 3 Under 1 Bit 19 = Analog Input 3 Over 2 Bit 20 = Analog Input 3 Over 1 Bit 21 = Analog Input 3 Out of Range Bit 22 = Analog Input 2 Under 2 Bit 23 = Analog Input 2 Under 1 Bit 24 = Analog Input 2 Over 2 Bit 25 = Analog Input 2 Over 1 Bit 26 = Analog Input 2 Out of Range Bit 27 = Analog Input 1 Under 2 Bit 28 = Analog Input 1 Under 1 Bit 29 = Analog Input 1 Over 2 Bit 30 = Analog Input 1 Over 1 Bit 31 = Analog Input 1 Out of Range

Register	Description	Type	Units	Scaling Factor	R/W	Range
45538-39	AEM Input Threshold Status Bits Reg 2	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = RTD Input 4 Under 2 Bit 3 = RTD Input 4 Under 1 Bit 4 = RTD Input 4 Over 2 Bit 5 = RTD Input 4 Over 1 Bit 6 = RTD Input 4 Out of Range Bit 7 = RTD Input 3 Under 2 Bit 8 = RTD Input 3 Under 1 Bit 9 = RTD Input 3 Over 2 Bit 10 = RTD Input 3 Over 1 Bit 11 = RTD Input 3 Out of Range Bit 12 = RTD Input 2 Under 2 Bit 13 = RTD Input 2 Under 1 Bit 14 = RTD Input 2 Over 2 Bit 15 = RTD Input 2 Over 1 Bit 16 = RTD Input 2 Out of Range Bit 17 = RTD Input 1 Under 2 Bit 18 = RTD Input 1 Under 1 Bit 19 = RTD Input 1 Over 2 Bit 20 = RTD Input 1 Over 1 Bit 21 = RTD Input 1 Out of Range Bit 22 = Analog Input 8 Under 2 Bit 23 = Analog Input 8 Under 1 Bit 24 = Analog Input 8 Over 2 Bit 25 = Analog Input 8 Over 1 Bit 26 = Analog Input 8 Out of Range Bit 27 = Analog Input 7 Under 2 Bit 28 = Analog Input 7 Under 1 Bit 29 = Analog Input 7 Over 2 Bit 30 = Analog Input 7 Over 1 Bit 31 = Analog Input 7 Out of Range

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45540-41	AEM Input Threshold Status Bits Reg 3	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Thermocouple 2 Under 2 Bit 3 = Thermocouple 2 Under 1 Bit 4 = Thermocouple 2 Over 2 Bit 5 = Thermocouple 2 Over 1 Bit 6 = Thermocouple 2 Out of Range Bit 7 = Thermocouple 1 Under 2 Bit 8 = Thermocouple 1 Under 1 Bit 9 = Thermocouple 1 Over 2 Bit 10 = Thermocouple 1 Over 1 Bit 11 = Thermocouple 1 Out of Range Bit 12 = RTD Input 8 Under 2 Bit 13 = RTD Input 8 Under 1 Bit 14 = RTD Input 8 Over 2 Bit 15 = RTD Input 8 Over 1 Bit 16 = RTD Input 8 Out of Range Bit 17 = RTD Input 7 Under 2 Bit 18 = RTD Input 7 Under 1 Bit 19 = RTD Input 7 Over 2 Bit 20 = RTD Input 7 Over 1 Bit 21 = RTD Input 7 Out of Range Bit 22 = RTD Input 6 Under 2 Bit 23 = RTD Input 6 Under 1 Bit 24 = RTD Input 6 Over 2 Bit 25 = RTD Input 6 Over 1 Bit 26 = RTD Input 6 Out of Range Bit 27 = RTD Input 5 Under 2 Bit 28 = RTD Input 5 Under 1 Bit 29= RTD Input 5 Over 2 Bit 30 = RTD Input 5 Over 1 Bit 31 = RTD Input 5 Out of Range

Register	Description	Type	Units	Scaling Factor	R/W	Range
45542-43	AEM Input Threshold Status Bits Reg 4	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = Not Used Bit 21 = Not Used Bit 22 = Not Used Bit 23 = Not Used Bit 24 = Not Used Bit 25 = Not Used Bit 26 = Not Used Bit 27 = Not Used Bit 28 = Analog Output 4 Out of Range Bit 29 = Analog Output 3 Out of Range Bit 30 = Analog Output 2 Out of Range Bit 31 = Analog Output 1 Out of Range

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45544-45	AEM Input Threshold Alarm Bits Reg 1	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Analog Input 6 Under 2 Bit 3 = Analog Input 6 Under 1 Bit 4 = Analog Input 6 Over 2 Bit 5 = Analog Input 6 Over 1 Bit 6 = Analog Input 6 Out of Range Bit 7 = Analog Input 5 Under 2 Bit 8 = Analog Input 5 Under 1 Bit 9 = Analog Input 5 Over 2 Bit 10 = Analog Input 5 Over 1 Bit 11 = Analog Input 5 Out of Range Bit 12 = Analog Input 4 Under 2 Bit 13 = Analog Input 4 Under 1 Bit 14 = Analog Input 4 Over 2 Bit 15 = Analog Input 4 Over 1 Bit 16 = Analog Input 4 Out of Range Bit 17 = Analog Input 3 Under 2 Bit 18 = Analog Input 3 Under 1 Bit 19 = Analog Input 3 Over 2 Bit 20 = Analog Input 3 Over 1 Bit 21 = Analog Input 3 Out of Range Bit 22 = Analog Input 2 Under 2 Bit 23 = Analog Input 2 Under 1 Bit 24 = Analog Input 2 Over 2 Bit 25 = Analog Input 2 Over 1 Bit 26 = Analog Input 2 Out of Range Bit 27 = Analog Input 1 Under 2 Bit 28 = Analog Input 1 Under 1 Bit 29 = Analog Input 1 Over 2 Bit 30 = Analog Input 1 Over 1 Bit 31 = Analog Input 1 Out of Range

Register	Description	Type	Units	Scaling Factor	R/W	Range
45546-47	AEM Input Threshold Alarm Bits Reg 2	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = RTD Input 4 Under 2 Bit 3 = RTD Input 4 Under 1 Bit 4 = RTD Input 4 Over 2 Bit 5 = RTD Input 4 Over 1 Bit 6 = RTD Input 4 Out of Range Bit 7 = RTD Input 3 Under 2 Bit 8 = RTD Input 3 Under 1 Bit 9 = RTD Input 3 Over 2 Bit 10 = RTD Input 3 Over 1 Bit 11 = RTD Input 3 Out of Range Bit 12 = RTD Input 2 Under 2 Bit 13 = RTD Input 2 Under 1 Bit 14 = RTD Input 2 Over 2 Bit 15 = RTD Input 2 Over 1 Bit 16 = RTD Input 2 Out of Range Bit 17 = RTD Input 1 Under 2 Bit 18 = RTD Input 1 Under 1 Bit 19 = RTD Input 1 Over 2 Bit 20 = RTD Input 1 Over 1 Bit 21 = RTD Input 1 Out of Range Bit 22 = Analog Input 8 Under 2 Bit 23 = Analog Input 8 Under 1 Bit 24 = Analog Input 8 Over 2 Bit 25 = Analog Input 8 Over 1 Bit 26 = Analog Input 8 Out of Range Bit 27 = Analog Input 7 Under 2 Bit 28 = Analog Input 7 Under 1 Bit 29 = Analog Input 7 Over 2 Bit 30 = Analog Input 7 Over 1 Bit 31 = Analog Input 7 Out of Range

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45548-49	AEM Input Threshold Alarm Bits Reg 3	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Thermocouple 2 Under 2 Bit 3 = Thermocouple 2 Under 1 Bit 4 = Thermocouple 2 Over 2 Bit 5 = Thermocouple 2 Over 1 Bit 6 = Thermocouple 2 Out of Range Bit 7 = Thermocouple 1 Under 2 Bit 8 = Thermocouple 1 Under 1 Bit 9 = Thermocouple 1 Over 2 Bit 10 = Thermocouple 1 Over 1 Bit 11 = Thermocouple 1 Out of Range Bit 12 = RTD Input 8 Under 2 Bit 13 = RTD Input 8 Under 1 Bit 14 = RTD Input 8 Over 2 Bit 15 = RTD Input 8 Over 1 Bit 16 = RTD Input 8 Out of Range Bit 17 = RTD Input 7 Under 2 Bit 18 = RTD Input 7 Under 1 Bit 19 = RTD Input 7 Over 2 Bit 20 = RTD Input 7 Over 1 Bit 21 = RTD Input 7 Out of Range Bit 22 = RTD Input 6 Under 2 Bit 23 = RTD Input 6 Under 1 Bit 24 = RTD Input 6 Over 2 Bit 25 = RTD Input 6 Over 1 Bit 26 = RTD Input 6 Out of Range Bit 27 = RTD Input 5 Under 2 Bit 28 = RTD Input 5 Under 1 Bit 29= RTD Input 5 Over 2 Bit 30 = RTD Input 5 Over 1 Bit 31 = RTD Input 5 Out of Range

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45550-51	AEM Input Threshold Alarm Bits Reg 4	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = Not Used Bit 21 = Not Used Bit 22 = Not Used Bit 23 = Not Used Bit 24 = Not Used Bit 25 = Not Used Bit 26 = Not Used Bit 27 = Not Used Bit 28 = Analog Output 4 Out of Range Bit 29 = Analog Output 3 Out of Range Bit 30 = Analog Output 2 Out of Range Bit 31 = Analog Output 1 Out of Range

Register	Description	Type	Units	Scaling Factor	R/W	Range
45552-53	AEM Input Threshold Pre-Alarm Bits Reg 1	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Analog Input 6 Under 2 Bit 3 = Analog Input 6 Under 1 Bit 4 = Analog Input 6 Over 2 Bit 5 = Analog Input 6 Over 1 Bit 6 = Analog Input 6 Out of Range Bit 7 = Analog Input 5 Under 2 Bit 8 = Analog Input 5 Under 1 Bit 9 = Analog Input 5 Over 2 Bit 10 = Analog Input 5 Over 1 Bit 11 = Analog Input 5 Out of Range Bit 12 = Analog Input 4 Under 2 Bit 13 = Analog Input 4 Under 1 Bit 14 = Analog Input 4 Over 2 Bit 15 = Analog Input 4 Over 1 Bit 16 = Analog Input 4 Out of Range Bit 17 = Analog Input 3 Under 2 Bit 18 = Analog Input 3 Under 1 Bit 19 = Analog Input 3 Over 2 Bit 20 = Analog Input 3 Over 1 Bit 21 = Analog Input 3 Out of Range Bit 22 = Analog Input 2 Under 2 Bit 23 = Analog Input 2 Under 1 Bit 24 = Analog Input 2 Over 2 Bit 25 = Analog Input 2 Over 1 Bit 26 = Analog Input 2 Out of Range Bit 27 = Analog Input 1 Under 2 Bit 28 = Analog Input 1 Under 1 Bit 29 = Analog Input 1 Over 2 Bit 30 = Analog Input 1 Over 1 Bit 31 = Analog Input 1 Out of Range

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45554-55	AEM Input Threshold Pre-Alarm Bits Reg 2	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = RTD Input 4 Under 2 Bit 3 = RTD Input 4 Under 1 Bit 4 = RTD Input 4 Over 2 Bit 5 = RTD Input 4 Over 1 Bit 6 = RTD Input 4 Out of Range Bit 7 = RTD Input 3 Under 2 Bit 8 = RTD Input 3 Under 1 Bit 9 = RTD Input 3 Over 2 Bit 10 = RTD Input 3 Over 1 Bit 11 = RTD Input 3 Out of Range Bit 12 = RTD Input 2 Under 2 Bit 13 = RTD Input 2 Under 1 Bit 14 = RTD Input 2 Over 2 Bit 15 = RTD Input 2 Over 1 Bit 16 = RTD Input 2 Out of Range Bit 17 = RTD Input 1 Under 2 Bit 18 = RTD Input 1 Under 1 Bit 19 = RTD Input 1 Over 2 Bit 20 = RTD Input 1 Over 1 Bit 21 = RTD Input 1 Out of Range Bit 22 = Analog Input 8 Under 2 Bit 23 = Analog Input 8 Under 1 Bit 24 = Analog Input 8 Over 2 Bit 25 = Analog Input 8 Over 1 Bit 26 = Analog Input 8 Out of Range Bit 27 = Analog Input 7 Under 2 Bit 28 = Analog Input 7 Under 1 Bit 29 = Analog Input 7 Over 2 Bit 30 = Analog Input 7 Over 1 Bit 31 = Analog Input 7 Out of Range

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45556-57	AEM Input Threshold Pre-Alarm Bits Reg 3	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Thermocouple 2 Under 2 Bit 3 = Thermocouple 2 Under 1 Bit 4 = Thermocouple 2 Over 2 Bit 5 = Thermocouple 2 Over 1 Bit 6 = Thermocouple 2 Out of Range Bit 7 = Thermocouple 1 Under 2 Bit 8 = Thermocouple 1 Under 1 Bit 9 = Thermocouple 1 Over 2 Bit 10 = Thermocouple 1 Over 1 Bit 11 = Thermocouple 1 Out of Range Bit 12 = RTD Input 8 Under 2 Bit 13 = RTD Input 8 Under 1 Bit 14 = RTD Input 8 Over 2 Bit 15 = RTD Input 8 Over 1 Bit 16 = RTD Input 8 Out of Range Bit 17 = RTD Input 7 Under 2 Bit 18 = RTD Input 7 Under 1 Bit 19 = RTD Input 7 Over 2 Bit 20 = RTD Input 7 Over 1 Bit 21 = RTD Input 7 Out of Range Bit 22 = RTD Input 6 Under 2 Bit 23 = RTD Input 6 Under 1 Bit 24 = RTD Input 6 Over 2 Bit 25 = RTD Input 6 Over 1 Bit 26 = RTD Input 6 Out of Range Bit 27 = RTD Input 5 Under 2 Bit 28 = RTD Input 5 Under 1 Bit 29= RTD Input 5 Over 2 Bit 30 = RTD Input 5 Over 1 Bit 31 = RTD Input 5 Out of Range

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45558-59	AEM Input Threshold Pre-Alarm Bits Reg 4	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = Not Used Bit 21 = Not Used Bit 22 = Not Used Bit 23 = Not Used Bit 24 = Not Used Bit 25 = Not Used Bit 26 = Not Used Bit 27 = Not Used Bit 28 = Analog Output 4 Out of Range Bit 29 = Analog Output 3 Out of Range Bit 30 = Analog Output 2 Out of Range Bit 31 = Analog Output 1 Out of Range
45560	Analog Output 1 Metering Value	Int32	CentiUnit	Centi	R	(-100000000) – 99999900
45562	Analog Output 2 Metering Value	Int32	CentiUnit	Centi	R	(-100000000) – 99999900
45564	Analog Output 3 Metering Value	Int32	CentiUnit	Centi	R	(-100000000) – 99999900
45566	Analog Output 4 Metering Value	Int32	CentiUnit	Centi	R	(-100000000) – 99999900

Register	Description	Type	Units	Scaling Factor	R/W	Range
45568-69	Configurable Protection Threshold Status Bits	Uint32	N/A	N/A	R	Bit 0 = Conf Protection 8 Under 2 Bit 1 = Conf Protection 8 Under 1 Bit 2 = Conf Protection 8 Over 2 Bit 3 = Conf Protection 8 Over 1 Bit 4 = Conf Protection 7 Under 2 Bit 5 = Conf Protection 7 Under 1 Bit 6 = Conf Protection 7 Over 2 Bit 7 = Conf Protection 7 Over 1 Bit 8 = Conf Protection 6 Under 2 Bit 9 = Conf Protection 6 Under 1 Bit 10 = Conf Protection 6 Over 2 Bit 11 = Conf Protection 6 Over 1 Bit 12 = Conf Protection 5 Under 2 Bit 13 = Conf Protection 5 Under 1 Bit 14 = Conf Protection 5 Over 2 Bit 15 = Conf Protection 5 Over 1 Bit 16 = Conf Protection 4 Under 2 Bit 17 = Conf Protection 4 Under 1 Bit 18 = Conf Protection 4 Over 2 Bit 19 = Conf Protection 4 Over 1 Bit 20 = Conf Protection 3 Under 2 Bit 21 = Conf Protection 3 Under 1 Bit 22 = Conf Protection 3 Over 2 Bit 23 = Conf Protection 3 Over 1 Bit 24 = Conf Protection 2 Under 2 Bit 25 = Conf Protection 2 Under 1 Bit 26 = Conf Protection 2 Over 2 Bit 27 = Conf Protection 2 Over 1 Bit 28 = Conf Protection 1 Under 2 Bit 29 = Conf Protection 1 Under 1 Bit 30 = Conf Protection 1 Over 2 Bit 31 = Conf Protection 1 Over 1
45570-71	Configurable Protection Alarm Bits	Uint32	N/A	N/A	R	Bit 0 = Conf Protection 8 Under 2 Bit 1 = Conf Protection 8 Under 1 Bit 2 = Conf Protection 8 Over 2 Bit 3 = Conf Protection 8 Over 1 Bit 4 = Conf Protection 7 Under 2 Bit 5 = Conf Protection 7 Under 1 Bit 6 = Conf Protection 7 Over 2 Bit 7 = Conf Protection 7 Over 1 Bit 8 = Conf Protection 6 Under 2 Bit 9 = Conf Protection 6 Under 1 Bit 10 = Conf Protection 6 Over 2 Bit 11 = Conf Protection 6 Over 1 Bit 12 = Conf Protection 5 Under 2 Bit 13 = Conf Protection 5 Under 1 Bit 14 = Conf Protection 5 Over 2 Bit 15 = Conf Protection 5 Over 1 Bit 16 = Conf Protection 4 Under 2 Bit 17 = Conf Protection 4 Under 1 Bit 18 = Conf Protection 4 Over 2 Bit 19 = Conf Protection 4 Over 1 Bit 20 = Conf Protection 3 Under 2 Bit 21 = Conf Protection 3 Under 1 Bit 22 = Conf Protection 3 Over 2 Bit 23 = Conf Protection 3 Over 1 Bit 24 = Conf Protection 2 Under 2 Bit 25 = Conf Protection 2 Under 1 Bit 26 = Conf Protection 2 Over 2 Bit 27 = Conf Protection 2 Over 1 Bit 28 = Conf Protection 1 Under 2 Bit 29 = Conf Protection 1 Under 1 Bit 30 = Conf Protection 1 Over 2 Bit 31 = Conf Protection 1 Over 1

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45572-73	Configurable Protection Pre-Alarm Bits	Uint32	N/A	N/A	R	Bit 0 = Conf Protection 8 Under 2 Bit 1 = Conf Protection 8 Under 1 Bit 2 = Conf Protection 8 Over 2 Bit 3 = Conf Protection 8 Over 1 Bit 4 = Conf Protection 7 Under 2 Bit 5 = Conf Protection 7 Under 1 Bit 6 = Conf Protection 7 Over 2 Bit 7 = Conf Protection 7 Over 1 Bit 8 = Conf Protection 6 Under 2 Bit 9 = Conf Protection 6 Under 1 Bit 10 = Conf Protection 6 Over 2 Bit 11 = Conf Protection 6 Over 1 Bit 12 = Conf Protection 5 Under 2 Bit 13 = Conf Protection 5 Under 1 Bit 14 = Conf Protection 5 Over 2 Bit 15 = Conf Protection 5 Over 1 Bit 16 = Conf Protection 4 Under 2 Bit 17 = Conf Protection 4 Under 1 Bit 18 = Conf Protection 4 Over 2 Bit 19 = Conf Protection 4 Over 1 Bit 20 = Conf Protection 3 Under 2 Bit 21 = Conf Protection 3 Under 1 Bit 22 = Conf Protection 3 Over 2 Bit 23 = Conf Protection 3 Over 1 Bit 24 = Conf Protection 2 Under 2 Bit 25 = Conf Protection 2 Under 1 Bit 26 = Conf Protection 2 Over 2 Bit 27 = Conf Protection 2 Over 1 Bit 28 = Conf Protection 1 Under 2 Bit 29 = Conf Protection 1 Under 1 Bit 30 = Conf Protection 1 Over 2 Bit 31 = Conf Protection 1 Over 1
45574	Gen Kvar A	Int32	kvar	N/A	R	(-2147483648) - 2147483647
45576	Gen Kvar B	Int32	kvar	N/A	R	(-2147483648) - 2147483647
45578	Gen Kvar C	Int32	kvar	N/A	R	(-2147483648) - 2147483647
45580	Gen Kvar Total	Int32	kvar	N/A	R	(-2147483648) - 2147483647
45582	FUTURE USE					

Register	Description	Type	Units	Scaling Factor	R/W	Range
45584-85	Logic Control Relay Status	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Logic Control Relay 16 Bit 17 = Logic Control Relay 15 Bit 18 = Logic Control Relay 14 Bit 19 = Logic Control Relay 13 Bit 20 = Logic Control Relay 12 Bit 21 = Logic Control Relay 11 Bit 22 = Logic Control Relay 10 Bit 23 = Logic Control Relay 9 Bit 24 = Logic Control Relay 8 Bit 25 = Logic Control Relay 7 Bit 26 = Logic Control Relay 6 Bit 27 = Logic Control Relay 5 Bit 28 = Logic Control Relay 4 Bit 29 = Logic Control Relay 3 Bit 30 = Logic Control Relay 2 Bit 31 = Logic Control Relay 1
45586-87	I/O Modules Connected	Uint32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Not Used Bit 19 = Not Used Bit 20 = Not Used Bit 21 = Not Used Bit 22 = Not Used Bit 23 = Not Used Bit 24 = Not Used Bit 25 = Not Used Bit 26 = Not Used Bit 27 = Not Used Bit 28 = Not Used Bit 29 = AEM Connected Bit 30 = CEM Connected Bit 31 = LSM Connected
45588	Max Vector Shift	Int32	N/A	Centi	R	0 - 100000
45590	Max DF/DT	Int32	N/A	Centi	R	0 - 100000

Register	Description	Type	Units	Scaling Factor	R/W	Range
45592	Current DF/DT	Int32	N/A	Centi	R	0 - 100000
45594-95	Status Metering 2	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Bus Reverse Rotation Bit 17 = Bus Forward Rotation Bit 18 = Gen Reverse Rotation Bit 19 = Gen Forward Rotation Bit 20 = Closed Transition Override Bit 21 = Auto Breaker Operation Inhibit Bit 22 = Mains Fail Transfer Inhibit Bit 23 = Restart Delay Active Bit 24 = Synchronizer Break Close OK Bit 25 = Synchronizer Angle OK Bit 26 = Synchronizer Slip Freq OK Bit 27 = Synchronizer Volt Match OK Bit 28 = Synchronizer Active Bit 29 = Parallel To Mains Bit 30 = Mains Fail Test Bit 31 = Take Over Load

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45596-97	Gen Protect Pre-Alarm Status	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = 81 ROC DF/DT Trip Bit 19 = 78 Vector Shift Trip Bit 20 = 51-3 Overcurrent Trip Bit 21 = 40 Loss of Excitation Trip Bit 22 = 32 Reverse Overpower Trip Bit 23 = 59-2 Overvoltage Trip Bit 24 = 27-2 Undervoltage Trip Bit 25 = 51-2 Overcurrent Trip Bit 26 = 81 Underfrequency Trip Bit 27 = 81 Overfrequency Trip Bit 28 = 59-1 Overvoltage Trip Bit 29 = 27-1 Undervoltage Trip Bit 30 = 47 Phase Imbalance Trip Bit 31 = 51-1 Overcurrent Trip
45598-99	Gen Protect Alarm Status	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = 81 ROC DF/DT Trip Bit 19 = 78 Vector Shift Trip Bit 20 = 51-3 Overcurrent Trip Bit 21 = 40 Loss of Excitation Trip Bit 22 = 32 Reverse Overpower Trip Bit 23 = 59-2 Overvoltage Trip Bit 24 = 27-2 Undervoltage Trip Bit 25 = 51-2 Overcurrent Trip Bit 26 = 81 Underfrequency Trip Bit 27 = 81 Overfrequency Trip Bit 28 = 59-1 Overvoltage Trip Bit 29 = 27-1 Undervoltage Trip Bit 30 = 47 Phase Imbalance Trip Bit 31 = 51-1 Overcurrent Trip

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45600-01	Pre-Alarm Metering 2	Int32	N/A	N/A	R	Bit 0 = Not Used Bit 1 = Not Used Bit 2 = Not Used Bit 3 = Not Used Bit 4 = Not Used Bit 5 = Not Used Bit 6 = Not Used Bit 7 = Not Used Bit 8 = Not Used Bit 9 = Not Used Bit 10 = Not Used Bit 11 = Not Used Bit 12 = Not Used Bit 13 = Not Used Bit 14 = Not Used Bit 15 = Not Used Bit 16 = Not Used Bit 17 = Not Used Bit 18 = Bus Reverse Rotation Bit 19 = Gen Reverse Rotation Bit 20 = DEF Inducement Override Bit 21 = DEF Severe Inducement Bit 22 = DEF Presevere Inducement Bit 23 = DEF Engine Derate Bit 24 = DEF Fluid Level Empty Bit 25 = DEF Fluid Level Low Bit 26 = DPF Soot Level Severely High Bit 27 = DPF Soot Level Moderately High Bit 28 = DPF Soot Level High Bit 29 = High Exhaust Temperature Bit 30 = DPF Regenerate Disabled Bit 31 = DPF Regenerate Required
45602	Operating Units Config Data	Int32	N/A	N/A	R	0 – 3
45604	kW Rate of Change Data	Int32	N/A	Centi	R	0 – 10000
45606	Generator Network System Manager Data	Int32	N/A	N/A	R	-1 – 255
45608	Generator Network Unit ID 1	Int32	N/A	N/A	R	-1 – 255
45610	Generator Network Unit ID 2	Int32	N/A	N/A	R	-1 – 255
45612	Generator Network Unit ID 3	Int32	N/A	N/A	R	-1 – 255
45614	Generator Network Unit ID 4	Int32	N/A	N/A	R	-1 – 255
45616	Generator Network Unit ID 5	Int32	N/A	N/A	R	-1 – 255
45618	Generator Network Unit ID 6	Int32	N/A	N/A	R	-1 – 255
45620	Generator Network Unit ID 7	Int32	N/A	N/A	R	-1 – 255
45622	Generator Network Unit ID 8	Int32	N/A	N/A	R	-1 – 255
45624	Generator Network Unit ID 9	Int32	N/A	N/A	R	-1 – 255
45626	Generator Network Unit ID 10	Int32	N/A	N/A	R	-1 – 255
45628	Generator Network Unit ID 11	Int32	N/A	N/A	R	-1 – 255
45630	Generator Network Unit ID 12	Int32	N/A	N/A	R	-1 – 255

Register	Description	Type	Units	Scaling Factor	R/W	Range
45632	Generator Network Unit ID 13	Int32	N/A	N/A	R	-1 – 255
45634	Generator Network Unit ID 14	Int32	N/A	N/A	R	-1 – 255
45636	Generator Network Unit ID 15	Int32	N/A	N/A	R	-1 – 255
45638	Generator Network Unit ID 16	Int32	N/A	N/A	R	-1 – 255
45640	Generator Network Number of Units	Int32	N/A	N/A	R	0 – 16
45642	LSM Input Data	Int32	CentiUnit	Centi	R	(-100000000) - 99999900
45644	Generator Network Number of Units Online	Int32	N/A	N/A	R	0 – 16
45646	Generator Network Total System kW Capacity	Int32	N/A	N/A	R	0 – 16777216
45648	Generator Network Total Generated kW	Int32	N/A	N/A	R	0 – 16777216
45650	Generator Network Total Generated kvar	Int32	N/A	N/A	R	0 – 16777216
45652	Sequencing Mode Feedback from LSM	Int32	N/A	N/A	R	-2147483648 – 2147483647
45654	Next Unit to Start from LSM	Int32	N/A	N/A	R	-1 – 255
45656	Next Unit to Stop from LSM	Int32	N/A	N/A	R	-1 – 255
45658	Start Timer 1 Sec from LSM	Int32	N/A	N/A	R	0 – 32767
45660	Start Timer 2 Sec from LSM	Int32	N/A	N/A	R	0 – 32767
45662	Stop Timer Sec from LSM	Int32	N/A	N/A	R	0 – 32767
45664	Gen Connection for Metering Data	Int32	N/A	N/A	R	0 = Delta 1 = Wye 2 = 1 phase AB 3 = 1 phase AC 4 = Grounded Delta
45666	Bus Connection for Metering Data	Int32	N/A	N/A	R	0 = 1 phase AB 1 = 3 phase 2 = 1 phase AC
45668	Gen Average Line to Line Voltage Data	Int32	N/A	N/A	R	-2147483648 - 2147483647
45670	Gen Average Line to Neutral Voltage Data	Int32	N/A	N/A	R	-2147483648 - 2147483647
45672	Gen Average Current Data	Int32	N/A	N/A	R	-2147483648 - 2147483647
45674	Remaining Transfer Delay Data	Int32	N/A	Sec x 67 to sec	R	-2147483648 - 2147483647
45676	Remaining Return Delay Data	Int32	N/A	Sec x 67 to sec	R	-2147483648 - 2147483647
45678	Remaining Max Transfer Time Data	Int32	N/A	Sec x 67 to sec	R	-2147483648 - 2147483647
45680	Remaining Max Parallel Time Data	Int32	N/A	Sec x 67 to sec	R	-2147483648 - 2147483647
45682	Remaining Open Transition Delay Data	Int32	N/A	Sec x 67 to sec	R	-2147483648 - 2147483647
45684	Remaining Max Return Time Data	Int32	N/A	Sec x 67 to sec	R	-2147483648 - 2147483647

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45686	Generator Network System Total kW Capacity Data	Int32	N/A	N/A	R	8388607
45688	Generator Network Total Generated kW Percent Data	Int32	DeciPercent	Deci	R	8388607
45690-748	FUTURE USE					
45750	Device Address	Int32	N/A	N/A	RW	(-128) - 127
45752	pc Emergency Stop	Uint32	N/A	N/A	RW	0 = Stop 1 = Start
45754	pc Relay Closed: Runs when in Auto mode	Uint32	N/A	N/A	RW	0 = Stop 1 = Start
45756	Test Buttons Image	Uint32	N/A	N/A	RW	0 - 255
45758-60	RESERVED					
45762	Embedded Code Version Number	Uint32	N/A	N/A	R	
45764	Boot Code Version Number	Int32	N/A	N/A	R	
45766	Model Number	Uint32	N/A	N/A	R	
45768	Embedded Code Part Number	Uint32	N/A	N/A	R	

Register	Description	Type	Units	Scaling Factor	R/W	Range
45770	Conf Prot 1 Param Select	Unit32	N/A	N/A	RW	0 = Oil Pressure 1 = Coolant Temp 2 = Battery Volts 3 = RPM 4 = Fuel Level 5 = Gen VAB 6 = Gen VBC 7 = Gen VCA 8 = Gen VAN 9 = Gen VBN 10 = Gen VCN 11 = Bus Freq 12 = Bus Volts 13 = Gen Freq 14 = Gen PF 15 = Gen IA 16 = Gen IB 17 = Gen IC 18 = kW A 19 = kW B 20 = kW C 21 = kW Total 22 = kVA A 23 = kVA B 24 = kVA C 25 = kVA Total 26 = Analog Input 1 27 = Analog Input 2 28 = Analog Input 3 29 = Analog Input 4 30 = Analog Input 5 31 = Analog Input 6 32 = Analog Input 7 33 = Analog Input 8 34 = RTD Input 1 35 = RTD Input 2 36 = RTD Input 3 37 = RTD Input 4 38 = RTD Input 5 39 = RTD Input 6 40 = RTD Input 7 41 = RTD Input 8 42 = Thermocouple 1 43 = Thermocouple 2 44 = Fuel Delivery Pressure 45 = kvar A 46 = kvar B 47 = kvar C 48 = kvar Total 49 = Injector Metering Rail Pressure 50 = Total Fuel Used 51 = Fuel Temperature 52 = Engine Oil Temperature 53 = Engine Intercooler Temperature 54 = Coolant Pressure 55 = Fuel Rate 56 = Boost Pressure 57 = Intake Manifold Temperature 58 = Charge Air Temperature 59 = Engine Percent Load 60 = Bus VAB 61 = Bus VBC 62 = Bus VCA 63 = kW Load Percent 64 = Number of Units Online 65 = System kW Capacity 66 = System Total Generated kW 67 = System Total Generated kvar
45772	Conf Prot 1 Hysteresis	Int32	Percent	Deci	RW	0 - 1000
45774	Conf Prot 1 Arming Delay	Int32	Second	N/A	RW	0 - 300
45776	Conf Prot 1 Threshold 1 Activation Delay	Int32	Second	N/A	RW	0 - 300

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45778	Conf Prot 1 Threshold 2 Activation Delay	Int32	Second	N/A	RW	0 - 300
45780	Conf Prot 1 Over 1 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45782	Conf Prot 1 Over 2 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45784	Conf Prot 1 Under 1 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45786	Conf Prot 1 Under 2 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45788	Conf Prot 1 Over 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45790	Conf Prot 1 Over 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45792	Conf Prot 1 Under 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45794	Conf Prot 1 Under 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45796	Conf Prot 2 Param Select	Unit32	N/A	N/A	RW	0 = Oil Pressure 1 = Coolant Temp 2 = Battery Volts 3 = RPM 4 = Fuel Level 5 = Gen VAB 6 = Gen VBC 7 = Gen VCA 8 = Gen VAN 9 = Gen VBN 10 = Gen VCN 11 = Bus Freq 12 = Bus Volts 13 = Gen Freq 14 = Gen PF 15 = Gen IA 16 = Gen IB 17 = Gen IC 18 = kW A 19 = kW B 20 = kW C 21 = kW Total 22 = kVA A 23 = kVA B 24 = kVA C 25 = kVA Total 26 = Analog Input 1 27 = Analog Input 2 28 = Analog Input 3 29 = Analog Input 4 30 = Analog Input 5 31 = Analog Input 6 32 = Analog Input 7 33 = Analog Input 8 34 = RTD Input 1 35 = RTD Input 2 36 = RTD Input 3 37 = RTD Input 4 38 = RTD Input 5 39 = RTD Input 6 40 = RTD Input 7 41 = RTD Input 8 42 = Thermocouple 1 43 = Thermocouple 2 44 = Fuel Delivery Pressure 45 = kvar A 46 = kvar B 47 = kvar C 48 = kvar Total 49 = Injector Metering Rail Pressure 50 = Total Fuel Used 51 = Fuel Temperature 52 = Engine Oil Temperature 53 = Engine Intercooler Temperature 54 = Coolant Pressure 55 = Fuel Rate 56 = Boost Pressure 57 = Intake Manifold Temperature 58 = Charge Air Temperature 59 = Engine Percent Load 60 = Bus VAB 61 = Bus VBC 62 = Bus VCA 63 = kW Load Percent 64 = Number of Units Online 65 = System kW Capacity 66 = System Total Generated kW 67 = System Total Generated kvar
45798	Conf Prot 2 Hysteresis	Int32	Percent	Deci	RW	0 - 1000
45800	Conf Prot 2 Arming Delay	Int32	Second	N/A	RW	0 - 300
45802	Conf Prot 2 Threshold 1 Activation Delay	Int32	Second	N/A	RW	0 - 300

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45804	Conf Prot 2 Threshold 2 Activation Delay	Int32	Second	N/A	RW	0 - 300
45806	Conf Prot 2 Over 1 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45808	Conf Prot 2 Over 2 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45810	Conf Prot 2 Under 1 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45812	Conf Prot 2 Under 2 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45814	Conf Prot 2 Over 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45816	Conf Prot 2 Over 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45818	Conf Prot 2 Under 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45820	Conf Prot 2 Under 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only

Register	Description	Type	Units	Scaling Factor	R/W	Range
45822	Conf Prot 3 Param Select	Uint32	N/A	N/A	RW	0 = Oil Pressure 1 = Coolant Temp 2 = Battery Volts 3 = RPM 4 = Fuel Level 5 = Gen VAB 6 = Gen VBC 7 = Gen VCA 8 = Gen VAN 9 = Gen VBN 10 = Gen VCN 11 = Bus Freq 12 = Bus Volts 13 = Gen Freq 14 = Gen PF 15 = Gen IA 16 = Gen IB 17 = Gen IC 18 = kW A 19 = kW B 20 = kW C 21 = kW Total 22 = kVA A 23 = kVA B 24 = kVA C 25 = kVA Total 26 = Analog Input 1 27 = Analog Input 2 28 = Analog Input 3 29 = Analog Input 4 30 = Analog Input 5 31 = Analog Input 6 32 = Analog Input 7 33 = Analog Input 8 34 = RTD Input 1 35 = RTD Input 2 36 = RTD Input 3 37 = RTD Input 4 38 = RTD Input 5 39 = RTD Input 6 40 = RTD Input 7 41 = RTD Input 8 42 = Thermocouple 1 43 = Thermocouple 2 44 = Fuel Delivery Pressure 45 = kvar A 46 = kvar B 47 = kvar C 48 = kvar Total 49 = Injector Metering Rail Pressure 50 = Total Fuel Used 51 = Fuel Temperature 52 = Engine Oil Temperature 53 = Engine Intercooler Temperature 54 = Coolant Pressure 55 = Fuel Rate 56 = Boost Pressure 57 = Intake Manifold Temperature 58 = Charge Air Temperature 59 = Engine Percent Load 60 = Bus VAB 61 = Bus VBC 62 = Bus VCA 63 = kW Load Percent 64 = Number of Units Online 65 = System kW Capacity 66 = System Total Generated kW 67 = System Total Generated kvar
45824	Conf Prot 3 Hysteresis	Int32	Percent	Deci	RW	1 - 1000
45826	Conf Prot 3 Arming Delay	Int32	Second	N/A	RW	0 - 300
45828	Conf Prot 3 Threshold 1 Activation Delay	Int32	Second	N/A	RW	0 - 300

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45830	Conf Prot 3 Threshold 2 Activation Delay	Int32	Second	N/A	RW	0 - 300
45832	Conf Prot 3 Over 1 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45834	Conf Prot 3 Over 2 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45836	Conf Prot 3 Under 1 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45838	Conf Prot 3 Under 2 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45840	Conf Prot 3 Over 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45842	Conf Prot 3 Over 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45844	Conf Prot 3 Under 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45846	Conf Prot 3 Under 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only

Register	Description	Type	Units	Scaling Factor	R/W	Range
45848	Conf Prot 4 Param Select	Uint32	N/A	N/A	RW	0 = Oil Pressure 1 = Coolant Temp 2 = Battery Volts 3 = RPM 4 = Fuel Level 5 = Gen VAB 6 = Gen VBC 7 = Gen VCA 8 = Gen VAN 9 = Gen VBN 10 = Gen VCN 11 = Bus Freq 12 = Bus Volts 13 = Gen Freq 14 = Gen PF 15 = Gen IA 16 = Gen IB 17 = Gen IC 18 = kW A 19 = kW B 20 = kW C 21 = kW Total 22 = kVA A 23 = kVA B 24 = kVA C 25 = kVA Total 26 = Analog Input 1 27 = Analog Input 2 28 = Analog Input 3 29 = Analog Input 4 30 = Analog Input 5 31 = Analog Input 6 32 = Analog Input 7 33 = Analog Input 8 34 = RTD Input 1 35 = RTD Input 2 36 = RTD Input 3 37 = RTD Input 4 38 = RTD Input 5 39 = RTD Input 6 40 = RTD Input 7 41 = RTD Input 8 42 = Thermocouple 1 43 = Thermocouple 2 44 = Fuel Delivery Pressure 45 = kvar A 46 = kvar B 47 = kvar C 48 = kvar Total 49 = Injector Metering Rail Pressure 50 = Total Fuel Used 51 = Fuel Temperature 52 = Engine Oil Temperature 53 = Engine Intercooler Temperature 54 = Coolant Pressure 55 = Fuel Rate 56 = Boost Pressure 57 = Intake Manifold Temperature 58 = Charge Air Temperature 59 = Engine Percent Load 60 = Bus VAB 61 = Bus VBC 62 = Bus VCA 63 = kW Load Percent 64 = Number of Units Online 65 = System kW Capacity 66 = System Total Generated kW 67 = System Total Generated kvar
45850	Conf Prot 4 Hysteresis	Int32	Percent	Deci	RW	1 - 1000
45852	Conf Prot 4 Arming Delay	Int32	Second	N/A	RW	0 - 300
45854	Conf Prot 4 Threshold 1 Activation Delay	Int32	Second	N/A	RW	0 - 300

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45856	Conf Prot 4 Threshold 2 Activation Delay	Int32	Second	N/A	RW	0 - 300
45858	Conf Prot 4 Over 1 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45860	Conf Prot 4 Over 2 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45862	Conf Prot 4 Under 1 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45864	Conf Prot 4 Under 2 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45866	Conf Prot 4 Over 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45868	Conf Prot 4 Over 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45870	Conf Prot 4 Under 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45872	Conf Prot 4 Under 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45874	Conf Prot 5 Param Select	Uint32	N/A	N/A	RW	0 = Oil Pressure 1 = Coolant Temp 2 = Battery Volts 3 = RPM 4 = Fuel Level 5 = Gen VAB 6 = Gen VBC 7 = Gen VCA 8 = Gen VAN 9 = Gen VBN 10 = Gen VCN 11 = Bus Freq 12 = Bus Volts 13 = Gen Freq 14 = Gen PF 15 = Gen IA 16 = Gen IB 17 = Gen IC 18 = kW A 19 = kW B 20 = kW C 21 = kW Total 22 = kVA A 23 = kVA B 24 = kVA C 25 = kVA Total 26 = Analog Input 1 27 = Analog Input 2 28 = Analog Input 3 29 = Analog Input 4 30 = Analog Input 5 31 = Analog Input 6 32 = Analog Input 7 33 = Analog Input 8 34 = RTD Input 1 35 = RTD Input 2 36 = RTD Input 3 37 = RTD Input 4 38 = RTD Input 5 39 = RTD Input 6 40 = RTD Input 7 41 = RTD Input 8 42 = Thermocouple 1 43 = Thermocouple 2 44 = Fuel Delivery Pressure 45 = kvar A 46 = kvar B 47 = kvar C 48 = kvar Total 49 = Injector Metering Rail Pressure 50 = Total Fuel Used 51 = Fuel Temperature 52 = Engine Oil Temperature 53 = Engine Intercooler Temperature 54 = Coolant Pressure 55 = Fuel Rate 56 = Boost Pressure 57 = Intake Manifold Temperature 58 = Charge Air Temperature 59 = Engine Percent Load 60 = Bus VAB 61 = Bus VBC 62 = Bus VCA 63 = kW Load Percent 64 = Number of Units Online 65 = System kW Capacity 66 = System Total Generated kW 67 = System Total Generated kvar
45876	Conf Prot 5 Hysteresis	Int32	Percent	Deci	RW	1 - 1000
45878	Conf Prot 5 Arming Delay	Int32	Second	N/A	RW	0 - 300
45880	Conf Prot 5 Threshold 1 Activation Delay	Int32	Second	N/A	RW	0 - 300

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45882	Conf Prot 5 Threshold 2 Activation Delay	Int32	Second	N/A	RW	0 - 300
45884	Conf Prot 5 Over 1 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45886	Conf Prot 5 Over 2 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45888	Conf Prot 5 Under 1 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45890	Conf Prot 5 Under 2 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45892	Conf Prot 5 Over 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45894	Conf Prot 5 Over 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45896	Conf Prot 5 Under 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45898	Conf Prot 5 Under 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only

Register	Description	Type	Units	Scaling Factor	R/W	Range
45900	Conf Prot 6 Param Select	Uint32	N/A	N/A	RW	0 = Oil Pressure 1 = Coolant Temp 2 = Battery Volts 3 = RPM 4 = Fuel Level 5 = Gen VAB 6 = Gen VBC 7 = Gen VCA 8 = Gen VAN 9 = Gen VBN 10 = Gen VCN 11 = Bus Freq 12 = Bus Volts 13 = Gen Freq 14 = Gen PF 15 = Gen IA 16 = Gen IB 17 = Gen IC 18 = kW A 19 = kW B 20 = kW C 21 = kW Total 22 = kVA A 23 = kVA B 24 = kVA C 25 = kVA Total 26 = Analog Input 1 27 = Analog Input 2 28 = Analog Input 3 29 = Analog Input 4 30 = Analog Input 5 31 = Analog Input 6 32 = Analog Input 7 33 = Analog Input 8 34 = RTD Input 1 35 = RTD Input 2 36 = RTD Input 3 37 = RTD Input 4 38 = RTD Input 5 39 = RTD Input 6 40 = RTD Input 7 41 = RTD Input 8 42 = Thermocouple 1 43 = Thermocouple 2 44 = Fuel Delivery Pressure 45 = kvar A 46 = kvar B 47 = kvar C 48 = kvar Total 49 = Injector Metering Rail Pressure 50 = Total Fuel Used 51 = Fuel Temperature 52 = Engine Oil Temperature 53 = Engine Intercooler Temperature 54 = Coolant Pressure 55 = Fuel Rate 56 = Boost Pressure 57 = Intake Manifold Temperature 58 = Charge Air Temperature 59 = Engine Percent Load 60 = Bus VAB 61 = Bus VBC 62 = Bus VCA 63 = kW Load Percent 64 = Number of Units Online 65 = System kW Capacity 66 = System Total Generated kW 67 = System Total Generated kvar
45902	Conf Prot 6 Hysteresis	Int32	Percent	Deci	RW	1 - 1000
45904	Conf Prot 6 Arming Delay	Int32	Second	N/A	RW	0 - 300
45906	Conf Prot 6 Threshold 1 Activation Delay	Int32	Second	N/A	RW	0 - 300

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45908	Conf Prot 6 Threshold 2 Activation Delay	Int32	Second	N/A	RW	0 - 300
45910	Conf Prot 6 Over 1 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45912	Conf Prot 6 Over 2 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45914	Conf Prot 6 Under 1 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45916	Conf Prot 6 Under 2 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45918	Conf Prot 6 Over 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45920	Conf Prot 6 Over 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45922	Conf Prot 6 Under 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45924	Conf Prot 6 Under 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only

Register	Description	Type	Units	Scaling Factor	R/W	Range
45926	Conf Prot 7 Param Select	Uint32	N/A	N/A	RW	0 = Oil Pressure 1 = Coolant Temp 2 = Battery Volts 3 = RPM 4 = Fuel Level 5 = Gen VAB 6 = Gen VBC 7 = Gen VCA 8 = Gen VAN 9 = Gen VBN 10 = Gen VCN 11 = Bus Freq 12 = Bus Volts 13 = Gen Freq 14 = Gen PF 15 = Gen IA 16 = Gen IB 17 = Gen IC 18 = kW A 19 = kW B 20 = kW C 21 = kW Total 22 = kVA A 23 = kVA B 24 = kVA C 25 = kVA Total 26 = Analog Input 1 27 = Analog Input 2 28 = Analog Input 3 29 = Analog Input 4 30 = Analog Input 5 31 = Analog Input 6 32 = Analog Input 7 33 = Analog Input 8 34 = RTD Input 1 35 = RTD Input 2 36 = RTD Input 3 37 = RTD Input 4 38 = RTD Input 5 39 = RTD Input 6 40 = RTD Input 7 41 = RTD Input 8 42 = Thermocouple 1 43 = Thermocouple 2 44 = Fuel Delivery Pressure 45 = kvar A 46 = kvar B 47 = kvar C 48 = kvar Total 49 = Injector Metering Rail Pressure 50 = Total Fuel Used 51 = Fuel Temperature 52 = Engine Oil Temperature 53 = Engine Intercooler Temperature 54 = Coolant Pressure 55 = Fuel Rate 56 = Boost Pressure 57 = Intake Manifold Temperature 58 = Charge Air Temperature 59 = Engine Percent Load 60 = Bus VAB 61 = Bus VBC 62 = Bus VCA 63 = kW Load Percent 64 = Number of Units Online 65 = System kW Capacity 66 = System Total Generated kW 67 = System Total Generated kvar
45928	Conf Prot 7 Hysteresis	Int32	Percent	Deci	RW	1 - 1000
45930	Conf Prot 7 Arming Delay	Int32	Second	N/A	RW	0 - 300
45932	Conf Prot 7 Threshold 1 Activation Delay	Int32	Second	N/A	RW	0 - 300

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45934	Conf Prot 7 Threshold 2 Activation Delay	Int32	Second	N/A	RW	0 - 300
45936	Conf Prot 7 Over 1 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45938	Conf Prot 7 Over 2 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45940	Conf Prot 7 Under 1 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45942	Conf Prot 7 Under 2 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45944	Conf Prot 7 Over 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45946	Conf Prot 7 Over 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45948	Conf Prot 7 Under 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45950	Conf Prot 7 Under 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only

Register	Description	Type	Units	Scaling Factor	R/W	Range
45952	Conf Prot 8 Param Select	Uint32	N/A	N/A	RW	0 = Oil Pressure 1 = Coolant Temp 2 = Battery Volts 3 = RPM 4 = Fuel Level 5 = Gen VAB 6 = Gen VBC 7 = Gen VCA 8 = Gen VAN 9 = Gen VBN 10 = Gen VCN 11 = Bus Freq 12 = Bus Volts 13 = Gen Freq 14 = Gen PF 15 = Gen IA 16 = Gen IB 17 = Gen IC 18 = kW A 19 = kW B 20 = kW C 21 = kW Total 22 = kVA A 23 = kVA B 24 = kVA C 25 = kVA Total 26 = Analog Input 1 27 = Analog Input 2 28 = Analog Input 3 29 = Analog Input 4 30 = Analog Input 5 31 = Analog Input 6 32 = Analog Input 7 33 = Analog Input 8 34 = RTD Input 1 35 = RTD Input 2 36 = RTD Input 3 37 = RTD Input 4 38 = RTD Input 5 39 = RTD Input 6 40 = RTD Input 7 41 = RTD Input 8 42 = Thermocouple 1 43 = Thermocouple 2 44 = Fuel Delivery Pressure 45 = kvar A 46 = kvar B 47 = kvar C 48 = kvar Total 49 = Injector Metering Rail Pressure 50 = Total Fuel Used 51 = Fuel Temperature 52 = Engine Oil Temperature 53 = Engine Intercooler Temperature 54 = Coolant Pressure 55 = Fuel Rate 56 = Boost Pressure 57 = Intake Manifold Temperature 58 = Charge Air Temperature 59 = Engine Percent Load 60 = Bus VAB 61 = Bus VBC 62 = Bus VCA 63 = kW Load Percent 64 = Number of Units Online 65 = System kW Capacity 66 = System Total Generated kW 67 = System Total Generated kvar
45954	Conf Prot 8 Hysteresis	Int32	Percent	Deci	RW	1 - 1000
45956	Conf Prot 8 Arming Delay	Int32	Second	N/A	RW	0 - 300
45958	Conf Prot 8 Threshold 1 Activation Delay	Int32	Second	N/A	RW	0 - 300

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Register	Description	Type	Units	Scaling Factor	R/W	Range
45960	Conf Prot 8 Threshold 2 Activation Delay	Int32	Second	N/A	RW	0 - 300
45962	Conf Prot 8 Over 1 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45964	Conf Prot 8 Over 2 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45966	Conf Prot 8 Under 1 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45968	Conf Prot 8 Under 2 Threshold	Int32	N/A	Centi	RW	(-99999900) - 99999900
45970	Conf Prot 8 Over 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45972	Conf Prot 8 Over 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45974	Conf Prot 8 Under 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45976	Conf Prot 8 Under 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
45978-999	FUTURE USE					
46000	J1939-Transmission Oil Pressure	Uint32	16 kPa/bit, 0 offset	N/A	R	0 to +4000 kPa (0 to 580 psi)
46002	J1939-Transmission Oil Temp	Uint32	.03125 Deg C/bit Offset -273 Deg C	N/A	R	−273 to +1735.0 °C (−459.4 to 3155.0 °F)
46004	J1939-Winding 1 Temp	Uint32	1 Deg C Per Bit Offset -40 Deg C	N/A	R	−40 to +210 °C (−40 to 410 °F)
46006	J1939-Winding 2 Temp	Uint32	1 Deg C Per Bit Offset -40 Deg C	N/A	R	−40 to +210 °C (−40 to 410 °F)
46008	J1939-Winding 3 Temp	Uint32	1 Deg C Per Bit Offset -40 Deg C	N/A	R	−40 to +210 °C (−40 to 410 °F)
46010	J1939-ECU Temp	Uint32	.03125 Deg C/bit Offset -273 Deg C	N/A	R	-273 to 1734.96875 degC
46012	J1939-Aux Pressure 1	Uint32	16 kPa/bit 0 Offset	N/A	R	0 to 4000 kPa
46014	J1939-Aux Pressure 2	Uint32	16 kPa/bit 0 Offset	N/A	R	0 to 4000 kPa
46016	J1939-Rated Power	Uint32	0.5 kW/bit 0 Offset	N/A	R	0 to 32,127.5 kW
46018	J1939-Rated RPM	Uint32	0.125 rpm/bit 0 Offset	N/A	R	0 to 8,031.875 rpm
46020	J1939-Exhaust Temp A	Uint32	.03125 Deg C/bit Offset -273 Deg C	N/A	R	-273 to 1734.96875 degC
46022	J1939-Exhaust Temp B	Uint32	.03125 Deg C/bit Offset -273 Deg C	N/A	R	-273 to 1734.96875 degC
46024	J1939-Charge Air Temp	Uint32	.03125 Deg C/bit Offset -273 Deg C	N/A	R	-273 to 1734.96875 degC
46026	J1939-ADEC ECU Error Code	Uint32	No Scale or Offset	N/A	R	0 - 65535
46028	J1939-ADEC Selected Speed Demand	Uint32	0.125 rpm/bit, 0 rpm offset	N/A	R	0 - 8031.875
46030	J1939-ADEC Effective Set Speed	Uint32	0.125 rpm/bit, 0 rpm offset	N/A	R	0 - 8031.875

Register	Description	Type	Units	Scaling Factor	R/W	Range
46032	J1939-ADEC CAN bus Speed Demand	Uint32	0.125 rpm/bit, 0 rpm offset	N/A	R	0 - 8031.875
46034	J1939-ADEC Analog Speed Demand	Uint32	0.125 rpm/bit, 0 rpm offset	N/A	R	0 - 8031.875
46036	J1939-ADEC Speed Demand Source	Uint32	0 = ANALOG_CAN, 1 = UP_DN_ECU, 2 = UP_DN_CAN, 3 = ANALOG_ECU, 5 = FREQUENCY, 7 = NO_CAN_DEMAND	N/A	R	0 - 7
46038	J1939-ADEC Specified Torque	Uint32	1 Nm/Bit, 0 Offset	N/A	R	0 to 64255 Nm
46040	J1939-ADEC Engine Optimized	Uint32	No Scale or Offset	N/A	R	0 - 64255
46042	J1939-ADEC Current P Degree	Uint32	0.0025%/Bit, 0 offset	N/A	R	0 to 160.7375%
46044	J1939-ADEC Day Tank Fill Percent	Uint32	0.4%/Bit, 0 offset	N/A	R	0 to 100%
46046	J1939-ADEC Storage Tank Fill Percent	Uint32	0.4%/Bit, 0 offset	N/A	R	0 - 4294967295
46048	J1939-ADEC Injection Quantity	Uint32	0.1 mm2 per bit	N/A	R	0 - 429496729.5
46050	J1939-ADEC Engine Power Reserve	Uint32	0.001% per bit	N/A	R	0 - 4294967.295
46052	J1939-ADEC Cylinder Cutout Code	Uint32	No Scale or Offset	N/A	R	0 - 4294967295
46054	J1939-ADEC Start Sequence Bit Field	Uint32	Bit Packed Data	N/A	R	0 - 4294967295
46056	J1939-ADEC P Lube Oil Limit LO	Uint32	binary on or off	N/A	R	0 - 1
46058	J1939-ADEC P Lube Oil Limit LO LO	Uint32	binary on or off	N/A	R	0 - 1
46060	J1939-ADEC P Charge Air Pressure	Uint32	.01 mbar/bit, 0 offset	N/A	R	0 - 42949672.5 mbar
45062	J1939-ADEC AL Power Amp 1 Fail Bit Fld	Uint32	Bit Packed Data	N/A	R	0 - 4294967295
46064	J1939-ADEC AL Power Amp 2 Fail Bit Fld	Uint32	Bit Packed Data	N/A	R	0 - 4294967295
46066	J1939-ADEC AL Transistor Out Bit Fl	Uint32	Bit Packed Data	N/A	R	0 - 4294967295
46068	J1939-ADEC Camshaft RPM	Uint32	0.1 rpm/bit, 0 offset	N/A	R	0 - 429496729.5 rpm
46070	J1939-ADEC Daily Fuel Consumption	Uint32	.0001 m3 per bit, 0 offset	N/A	R	0 - 429496.7295 m3
46072	J1939-ADEC Frequency Speed Demand.	Uint32	0.1 rpm/bit, 0 offset	N/A	R	0 - 429496729.5 rpm
46074	J1939-ADEC Average Trip Fuel Consumption	Uint32	0.001 L/h/bit, 0 offset	N/A	R	0 - 4294967.295 L/h
46076	J1939-ADEC Injection Quantity DBR Pct	Uint32	0,01% /bit, 0 offset	N/A	R	0 - 42949672.95 %
46078	J1939-ADEC Actual Droop	Uint32	0.001%/bit, 0 offset	N/A	R	0 - 4294967.295 %
46080	J1939-ADEC Nodes On CAN bus	Uint32	No Scale or Offset	N/A	R	0 - 4294967295
46082	J1939-ADEC Lost Nodes on CAN bus	Uint32	No Scale or Offset	N/A	R	0 - 4294967295
46084	J1939-ADEC Trip Operating Time	Uint32	No Scale or Offset	N/A	R	0 - 4294967295 h

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Register	Description	Type	Units	Scaling Factor	R/W	Range
46086	J1939-ADEC Transistor Out Bit Field	Uint32	Bit Packed Data	N/A	R	0 - 4294967295
46088	J1939-ADEC L1L ECU Power Supply Volts	Uint32	0.001 V/bit	N/A	R	0 - 4294967.295
46090	J1939-ADEC L2L ECU Power Supply Volts	Uint32	0.001 V/bit	N/A	R	0 - 4294967.295
46092	J939-ADEC U1LECU Power Supply Volts	Uint32	0.001 V/bit	N/A	R	0 - 4294967.295
46094	J1939-ADEC U2L ECU Power Supply Volts	Uint32	0.001 V/bit	N/A	R	0 - 4294967295
46096	J1939-ADEC Trip Idle Time	Uint32	1 sec per bit, 0 offset	N/A	R	0 - 4294967295 sec
46098	J1939-ADEC T Coolant Limit Hi	Uint32	0.01 Deg C/Bit, 0 offset	N/A	R	0 - 42949672.95
46100	J1939-ADEC T Coolant Limit Hi Hi	Uint32	0.01 Deg C/Bit, 0 offset	N/A	R	0 - 42949672.95
46102	J1939-ADEC T Charge Air Limit Hi	Uint32	0.01 Deg C/Bit, 0 offset	N/A	R	0 - 42949672.95
46104	J1939-ADEC T Intercooler Limit Hi	Uint32	0.01 Deg C/Bit, 0 offset	N/A	R	0 - 42949672.95
46106	J1939-MTU Sps Node	Uint32	No Scale or Offset	N/A	R	0 - 255
46108	J1939-MTU Sw Type	Uint32	No Scale or Offset	N/A	R	0 - 255
46110	J1939-MTU Sw Var	Uint32	No Scale or Offset	N/A	R	0 - 255
46112	J1939-MTU Sw Ed 1	Uint32	No Scale or Offset	N/A	R	0 - 255
46114	J1939-MTU Sw Ed2	Uint32	No Scale or Offset	N/A	R	0 - 255
46116	J1939-MTU Rev	Uint32	No Scale or Offset	N/A	R	0 - 255
46118	J1939-MTU Sw Mod	Uint32	No Scale or Offset	N/A	R	0 - 255
46120	J1939-ECU Protect Lamp Status Data	Uint32	Raw ECU Parameter Data	N/A	R	0 = Off 1 = On 2 = Slow Flash 3 = Fast Flash
46122	J1939-ECU Warning Lamp Status Data	Uint32	Raw ECU Parameter Data	N/A	R	0 = Off 1 = On 2 = Slow Flash 3 = Fast Flash
46124	J1939-ECU Red Stop Lamp Status Data	Uint32	Raw ECU Parameter Data	N/A	R	0 = Off 1 = On 2 = Slow Flash 3 = Fast Flash
46126	J1939-ECU Malfunction Status Data	Uint32	Raw ECU Parameter Data	N/A	R	0 = Off 1 = On 2 = Slow Flash 3 = Fast Flash
46128-248	RESERVED					
46250	PLC Timer 1 Seconds	Int32	Second	Deci	RW	0 - 18000
46252	PLC Timer 2 Seconds	Int32	Second	Deci	RW	0 - 18000
46254	PLC Timer 3 Seconds	Int32	Second	Deci	RW	0 - 18000
46256	PLC Timer 4 Seconds	Int32	Second	Deci	RW	0 - 18000
46258	PLC Timer 5 Seconds	Int32	Second	Deci	RW	0 - 18000
46260	PLC Timer 6 Seconds	Int32	Second	Deci	RW	0 - 18000

Register	Description	Type	Units	Scaling Factor	R/W	Range
46262	PLC Timer 7 Seconds	Int32	Second	Deci	RW	0 - 18000
46264	PLC Timer 8 Seconds	Int32	Second	Deci	RW	0 - 18000
46266	PLC Timer 9 Seconds	Int32	Second	Deci	RW	0 - 18000
46268	PLC Timer 10 Seconds	Int32	Second	Deci	RW	0 - 18000
46270	PLC Timer 1 Minutes	Uint32	Minute	N/A	RW	0 - 250
46272	PLC Timer 2 Minutes	Uint32	Minute	N/A	RW	0 - 250
46274	PLC Timer 3 Minutes	Uint32	Minute	N/A	RW	0 - 250
46276	PLC Timer 4 Minutes	Uint32	Minute	N/A	RW	0 - 250
46278	PLC Timer 5 Minutes	Uint32	Minute	N/A	RW	0 - 250
46280	PLC Timer 6 Minutes	Uint32	Minute	N/A	RW	0 - 250
46282	PLC Timer 7 Minutes	Uint32	Minute	N/A	RW	0 - 250
46284	PLC Timer 8 Minutes	Uint32	Minute	N/A	RW	0 - 250
46286	PLC Timer 9 Minutes	Uint32	Minute	N/A	RW	0 - 250
46288	PLC Timer 10 Minutes	Uint32	Minute	N/A	RW	0 - 250
46290	PLC Timer 1 Hours	Uint32	Hour	N/A	RW	0 - 250
46292	PLC Timer 2 Hours	Uint32	Hour	N/A	RW	0 - 250
46294	PLC Timer 3 Hours	Uint32	Hour	N/A	RW	0 - 250
46296	PLC Timer 4 Hours	Uint32	Hour	N/A	RW	0 - 250
46298	PLC Timer 5 Hours	Uint32	Hour	N/A	RW	0 - 250
46300	PLC Timer 6 Hours	Uint32	Hour	N/A	RW	0 - 250
46302	PLC Timer 7 Hours	Uint32	Hour	N/A	RW	0 - 250
46304	PLC Timer 8 Hours	Uint32	Hour	N/A	RW	0 - 250
46306	PLC Timer 9 Hours	Uint32	Hour	N/A	RW	0 - 250
46308	PLC Timer 10 Hours	Uint32	Hour	N/A	RW	0 - 250
46310	AEM Input 1 Max Voltage	Int32	DeciVolt	Deci	RW	0 - 100
46312	AEM Input 1 Max Current	Int32	Milliamp x 10	Deci	RW	40 - 200
46314	AEM Input 1 Min Voltage	Int32	DeciVolt	Deci	RW	0 - 100
46316	AEM Input 1 Min Current	Int32	Milliamp x 10	Deci	RW	40 - 200
46318	AEM Input 1 Param Max	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46320	AEM Input 1 Param Min	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46322	AEM Input 1 Hysteresis	Int32	Deci Percent	Deci	RW	0 – 1000
46324	AEM Input 1 Arming Delay	Int32	Second	N/A	RW	0 – 300
46326	AEM Input 1 Threshold 1 Activation Delay	Int32	Second	N/A	RW	0 – 300
46328	AEM Input 1 Threshold 2 Activation Delay	Int32	Second	N/A	RW	0 – 300
46330	AEM Input 1 Over 1 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46332	AEM Input 1Over 2 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46334	AEM Input 1 Under 1 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46336	AEM Input 1Under 2 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46338	AEM Input 1 Over 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46340	AEM Input 1 Over 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46342	AEM Input 1 Under 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only

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Register	Description	Type	Units	Scaling Factor	R/W	Range
46344	AEM Input 1 Under 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46346	AEM Input 1 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46348	AEM Input 2 Max Voltage	Int32	DeciVolt	Deci	RW	0 - 100
46350	AEM Input 2 Max Current	Int32	Milliamp x 10	Deci	RW	40 - 200
46352	AEM Input 2 Min Voltage	Int32	DeciVolt	Deci	RW	0 - 100
46354	AEM Input 2 Min Current	Int32	Milliamp x 10	Deci	RW	40 - 200
46356	AEM Input 2 Param Max	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46358	AEM Input 2 Param Min	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46360	AEM Input 2 Hysteresis	Int32	Deci Percent	Deci	RW	0 – 1000
46362	AEM Input 2 Arming Delay	Int32	Second	N/A	RW	0 – 300
46364	AEM Input 2 Threshold 1 Activation Delay	Int32	Second	N/A	RW	0 – 300
46366	AEM Input 2 Threshold 2 Activation Delay	Int32	Second	N/A	RW	0 – 300
46368	AEM Input 2 Over 1 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46370	AEM Input 2Over 2 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46372	AEM Input 2 Under 1 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46374	AEM Input 2Under 2 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46376	AEM Input 2 Over 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46378	AEM Input 2 Over 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46380	AEM Input 2 Under 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46382	AEM Input 2 Under 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46384	AEM Input 2 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46386	AEM Input 3 Max Voltage	Int32	DeciVolt	Deci	RW	0 - 100
46388	AEM Input 3 Max Current	Int32	Milliamp x 10	Deci	RW	40 - 200
46390	AEM Input 3 Min Voltage	Int32	DeciVolt	Deci	RW	0 - 100
46392	AEM Input 3 Min Current	Int32	Milliamp x 10	Deci	RW	40 - 200
46394	AEM Input 3 Param Max	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46396	AEM Input 3 Param Min	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46398	AEM Input 3 Hysteresis	Int32	Deci Percent	Deci	RW	0 – 1000

Register	Description	Type	Units	Scaling Factor	R/W	Range
46400	AEM Input 3 Arming Delay	Int32	Second	N/A	RW	0 – 300
46402	AEM Input 3 Threshold 1 Activation Delay	Int32	Second	N/A	RW	0 – 300
46404	AEM Input 3 Threshold 2 Activation Delay	Int32	Second	N/A	RW	0 – 300
46406	AEM Input 3 Over 1 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46408	AEM Input 3Over 2 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46410	AEM Input 3 Under 1 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46412	AEM Input 3Under 2 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46414	AEM Input 3 Over 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46416	AEM Input 3 Over 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46418	AEM Input 3 Under 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46420	AEM Input 3 Under 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46422	AEM Input 3 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46424	AEM Input 4 Max Voltage	Int32	DeciVolt	Deci	RW	0 - 100
46426	AEM Input 4 Max Current	Int32	Milliamp x 10	Deci	RW	40 - 200
46428	AEM Input 4 Min Voltage	Int32	DeciVolt	Deci	RW	0 - 100
46430	AEM Input 4 Min Current	Int32	Milliamp x 10	Deci	RW	40 - 200
46432	AEM Input 4 Param Max	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46434	AEM Input 4 Param Min	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46436	AEM Input 4 Hysteresis	Int32	Deci Percent	Deci	RW	0 – 1000
46438	AEM Input 4 Arming Delay	Int32	Second	N/A	RW	0 – 300
46440	AEM Input 4 Threshold 1 Activation Delay	Int32	Second	N/A	RW	0 – 300
46442	AEM Input 4 Threshold 2 Activation Delay	Int32	Second	N/A	RW	0 – 300
46444	AEM Input 4 Over 1 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46446	AEM Input 4Over 2 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46448	AEM Input 4 Under 1 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46450	AEM Input 4Under 2 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46452	AEM Input 4 Over 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only

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Register	Description	Type	Units	Scaling Factor	R/W	Range
46454	AEM Input 4 Over 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46456	AEM Input 4 Under 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46458	AEM Input 4 Under 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46460	AEM Input 4 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46462 - 46498	FUTURE USE					
46500	AEM Input 5 Max Voltage	Int32	DeciVolt	Deci	RW	0 - 100
46502	AEM Input 5 Max Current	Int32	Milliamp x 10	Deci	RW	40 - 200
46504	AEM Input 5 Min Voltage	Int32	DeciVolt	Deci	RW	0 - 100
46506	AEM Input 5 Min Current	Int32	Milliamp x 10	Deci	RW	40 - 200
46508	AEM Input 5 Param Max	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46510	AEM Input 5 Param Min	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46512	AEM Input 5 Hysteresis	Int32	Deci Percent	Deci	RW	0 – 1000
46514	AEM Input 5 Arming Delay	Int32	Second	N/A	RW	0 – 300
46516	AEM Input 5 Threshold 1 Activation Delay	Int32	Second	N/A	RW	0 – 300
46518	AEM Input 5 Threshold 2 Activation Delay	Int32	Second	N/A	RW	0 – 300
46520	AEM Input 5 Over 1 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46522	AEM Input 5Over 2 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46524	AEM Input 5 Under 1 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46526	AEM Input 5Under 2 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46528	AEM Input 5 Over 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46530	AEM Input 5 Over 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46532	AEM Input 5 Under 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46534	AEM Input 5 Under 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46536	AEM Input 5 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46538	AEM Input 6 Max Voltage	Int32	DeciVolt	Deci	RW	0 - 100

Register	Description	Type	Units	Scaling Factor	R/W	Range
46540	AEM Input 6 Max Current	Int32	Milliamp x 10	Deci	RW	40 - 200
46542	AEM Input 6 Min Voltage	Int32	DeciVolt	Deci	RW	0 - 100
46544	AEM Input 6 Min Current	Int32	Milliamp x 10	Deci	RW	40 - 200
46546	AEM Input 6 Param Max	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46548	AEM Input 6 Param Min	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46550	AEM Input 6 Hysteresis	Int32	Deci Percent	Deci	RW	0 – 1000
46552	AEM Input 6 Arming Delay	Int32	Second	N/A	RW	0 – 300
46554	AEM Input 6 Threshold 1 Activation Delay	Int32	Second	N/A	RW	0 – 300
46556	AEM Input 6 Threshold 2 Activation Delay	Int32	Second	N/A	RW	0 – 300
46558	AEM Input 6 Over 1 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46560	AEM Input 6Over 2 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46562	AEM Input 6 Under 1 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46564	AEM Input 6Under 2 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46566	AEM Input 6 Over 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46568	AEM Input 6 Over 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46570	AEM Input 6 Under 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46572	AEM Input 6 Under 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46574	AEM Input 6 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46576	AEM Input 7 Max Voltage	Int32	DeciVolt	Deci	RW	0 - 100
46578	AEM Input 7 Max Current	Int32	Milliamp x 10	Deci	RW	40 - 200
46580	AEM Input 7 Min Voltage	Int32	DeciVolt	Deci	RW	0 - 100
46582	AEM Input 7 Min Current	Int32	Milliamp x 10	Deci	RW	40 - 200
46584	AEM Input 7 Param Max	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46586	AEM Input 7 Param Min	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46588	AEM Input 7 Hysteresis	Int32	Deci Percent	Deci	RW	0 – 1000
46590	AEM Input 7 Arming Delay	Int32	Second	N/A	RW	0 – 300
46592	AEM Input 7 Threshold 1 Activation Delay	Int32	Second	N/A	RW	0 – 300
46594	AEM Input 7 Threshold 2 Activation Delay	Int32	Second	N/A	RW	0 – 300
46596	AEM Input 7 Over 1 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46598	AEM Input 7Over 2 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900

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Register	Description	Type	Units	Scaling Factor	R/W	Range
46600	AEM Input 7 Under 1 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46602	AEM Input 7Under 2 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46604	AEM Input 7 Over 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46606	AEM Input 7 Over 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46608	AEM Input 7 Under 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46610	AEM Input 7 Under 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46612	AEM Input 7 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46614	AEM Input 8 Max Voltage	Int32	DeciVolt	Deci	RW	0 - 100
46616	AEM Input 8 Max Current	Int32	Milliamp x 10	Deci	RW	40 - 200
46618	AEM Input 8 Min Voltage	Int32	DeciVolt	Deci	RW	0 - 100
46620	AEM Input 8 Min Current	Int32	Milliamp x 10	Deci	RW	40 - 200
46622	AEM Input 8 Param Max	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46624	AEM Input 8 Param Min	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46626	AEM Input 8 Hysteresis	Int32	Deci Percent	Deci	RW	0 – 1000
46628	AEM Input 8 Arming Delay	Int32	Second	N/A	RW	0 – 300
46630	AEM Input 8 Threshold 1 Activation Delay	Int32	Second	N/A	RW	0 – 300
46632	AEM Input 8 Threshold 2 Activation Delay	Int32	Second	N/A	RW	0 – 300
46634	AEM Input 8 Over 1 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46636	AEM Input 8Over 2 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46638	AEM Input 8 Under 1 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46640	AEM Input 8Under 2 Threshold	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46642	AEM Input 8 Over 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46644	AEM Input 8 Over 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46646	AEM Input 8 Under 1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46648	AEM Input 8 Under 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only

Register	Description	Type	Units	Scaling Factor	R/W	Range
46650	AEM Input 8 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46652	AEM Output 1 Max Voltage	Int32	DeciVolt	Deci	RW	0 – 100
46654	AEM Output 1 Max Current	Int32	Milliamp x 10	Deci	RW	40 – 200
46656	AEM Output 1 Min Voltage	Int32	DeciVolt	Deci	RW	0 – 100
46658	AEM Output 1 Min Current	Int32	Milliamp x 10	Deci	RW	40 – 200
46660	AEM Output 1 Param Max	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46662	AEM Output 1 Param Min	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900

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Register	Description	Type	Units	Scaling Factor	R/W	Range
46664	AEM Output 1 Param Selection	Uint32	N/A	N/A	RW	0 = Oil Pressure 1 = Coolant Temp 2 = Battery Volts 3 = RPM 4 = Fuel Level 5 = Gen VAB 6 = Gen VBC 7 = Gen VCA 8 = Gen VAN 9 = Gen VBN 10 = Gen VCN 11 = Bus Freq 12 = Bus Volts 13 = Gen Freq 14 = Gen PF 15 = Gen IA 16 = Gen IB 17 = Gen IC 18 = kW A 19 = kW B 20 = kW C 21 = kW Total 22 = kVA A 23 = kVA B 24 = kVA C 25 = kVA Total 26 = Analog Input 1 27 = Analog Input 2 28 = Analog Input 3 29 = Analog Input 4 30 = Analog Input 5 31 = Analog Input 6 32 = Analog Input 7 33 = Analog Input 8 34 = RTD Input 1 35 = RTD Input 2 36 = RTD Input 3 37 = RTD Input 4 38 = RTD Input 5 39 = RTD Input 6 40 = RTD Input 7 41 = RTD Input 8 42 = Thermocouple 1 43 = Thermocouple 2 44 = Fuel Delivery Pressure 45 = kvar A 46 = kvar B 47 = kvar C 48 = kvar Total 49 = Injector Metering Rail Pressure 50 = Total Fuel Used 51 = Fuel Temperature 52 = Engine Oil Temperature 53 = Engine Intercooler Temperature 54 = Coolant Pressure 55 = Fuel Rate 56 = Boost Pressure 57 = Intake Manifold Temperature 58 = Charge Air Temperature 59 = Engine Percent Load 60 = Bus VAB 61 = Bus VBC 62 = Bus VCA 63 = kW Load Percent 64 = Number of Units Online 65 = System kW Capacity 66 = System Total Generated kW 67 = System Total Generated kvar
46666	AEM Output 1 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46668	AEM Output 1 Out of Range Time Delay	Int32	Second	N/A	RW	0 – 300

Register	Description	Type	Units	Scaling Factor	R/W	Range
46670	AEM Output 2 Max Voltage	Int32	DeciVolt	Deci	RW	0 – 100
46672	AEM Output 2 Max Current	Int32	Milliamp x 10	Deci	RW	40 – 200
46674	AEM Output 2 Min Voltage	Int32	DeciVolt	Deci	RW	0 – 100
46676	AEM Output 2 Min Current	Int32	Milliamp x 10	Deci	RW	40 – 200
46678	AEM Output 2 Param Max	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46680	AEM Output 2 Param Min	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900

Register	Description	Type	Units	Scaling Factor	R/W	Range
46682	AEM Output 2 Param Selection	Uint32	N/A	N/A	RW	0 = Oil Pressure 1 = Coolant Temp 2 = Battery Volts 3 = RPM 4 = Fuel Level 5 = Gen VAB 6 = Gen VBC 7 = Gen VCA 8 = Gen VAN 9 = Gen VBN 10 = Gen VCN 11 = Bus Freq 12 = Bus Volts 13 = Gen Freq 14 = Gen PF 15 = Gen IA 16 = Gen IB 17 = Gen IC 18 = kW A 19 = kW B 20 = kW C 21 = kW Total 22 = kVA A 23 = kVA B 24 = kVA C 25 = kVA Total 26 = Analog Input 1 27 = Analog Input 2 28 = Analog Input 3 29 = Analog Input 4 30 = Analog Input 5 31 = Analog Input 6 32 = Analog Input 7 33 = Analog Input 8 34 = RTD Input 1 35 = RTD Input 2 36 = RTD Input 3 37 = RTD Input 4 38 = RTD Input 5 39 = RTD Input 6 40 = RTD Input 7 41 = RTD Input 8 42 = Thermocouple 1 43 = Thermocouple 2 44 = Fuel Delivery Pressure 45 = kvar A 46 = kvar B 47 = kvar C 48 = kvar Total 49 = Injector Metering Rail Pressure 50 = Total Fuel Used 51 = Fuel Temperature 52 = Engine Oil Temperature 53 = Engine Intercooler Temperature 54 = Coolant Pressure 55 = Fuel Rate 56 = Boost Pressure 57 = Intake Manifold Temperature 58 = Charge Air Temperature 59 = Engine Percent Load 60 = Bus VAB 61 = Bus VBC 62 = Bus VCA 63 = kW Load Percent 64 = Number of Units Online 65 = System kW Capacity 66 = System Total Generated kW 67 = System Total Generated kvar
46684	AEM Output 2 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46686	AEM Output 2 Out of Range Time Delay	Int32	Second	N/A	RW	0 – 300

Register	Description	Type	Units	Scaling Factor	R/W	Range
46688	AEM Output 3 Max Voltage	Int32	DeciVolt	Deci	RW	0 – 100
46690	AEM Output 3 Max Current	Int32	Milliamp x 10	Deci	RW	40 – 200
46692	AEM Output 3 Min Voltage	Int32	DeciVolt	Deci	RW	0 – 100
46694	AEM Output 3 Min Current	Int32	Milliamp x 10	Deci	RW	40 – 200
46696	AEM Output 3 Param Max	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46698	AEM Output 3 Param Min	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900

Register	Description	Type	Units	Scaling Factor	R/W	Range
46700	AEM Output 3 Param Selection	Uint32	N/A	N/A	RW	0 = Oil Pressure 1 = Coolant Temp 2 = Battery Volts 3 = RPM 4 = Fuel Level 5 = Gen VAB 6 = Gen VBC 7 = Gen VCA 8 = Gen VAN 9 = Gen VBN 10 = Gen VCN 11 = Bus Freq 12 = Bus Volts 13 = Gen Freq 14 = Gen PF 15 = Gen IA 16 = Gen IB 17 = Gen IC 18 = kW A 19 = kW B 20 = kW C 21 = kW Total 22 = kVA A 23 = kVA B 24 = kVA C 25 = kVA Total 26 = Analog Input 1 27 = Analog Input 2 28 = Analog Input 3 29 = Analog Input 4 30 = Analog Input 5 31 = Analog Input 6 32 = Analog Input 7 33 = Analog Input 8 34 = RTD Input 1 35 = RTD Input 2 36 = RTD Input 3 37 = RTD Input 4 38 = RTD Input 5 39 = RTD Input 6 40 = RTD Input 7 41 = RTD Input 8 42 = Thermocouple 1 43 = Thermocouple 2 44 = Fuel Delivery Pressure 45 = kvar A 46 = kvar B 47 = kvar C 48 = kvar Total 49 = Injector Metering Rail Pressure 50 = Total Fuel Used 51 = Fuel Temperature 52 = Engine Oil Temperature 53 = Engine Intercooler Temperature 54 = Coolant Pressure 55 = Fuel Rate 56 = Boost Pressure 57 = Intake Manifold Temperature 58 = Charge Air Temperature 59 = Engine Percent Load 60 = Bus VAB 61 = Bus VBC 62 = Bus VCA 63 = kW Load Percent 64 = Number of Units Online 65 = System kW Capacity 66 = System Total Generated kW 67 = System Total Generated kvar
46702	AEM Output 3 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46704	AEM Output 3 Out of Range Time Delay	Int32	Second	N/A	RW	0 – 300

Register	Description	Type	Units	Scaling Factor	R/W	Range
46706	AEM Output 4 Max Voltage	Int32	DeciVolt	Deci	RW	0 – 100
46708	AEM Output 4 Max Current	Int32	Milliamp x 10	Deci	RW	40 – 200
46710	AEM Output 4 Min Voltage	Int32	DeciVolt	Deci	RW	0 – 100
46712	AEM Output 4 Min Current	Int32	Milliamp x 10	Deci	RW	40 – 200
46714	AEM Output 4 Param Max	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900
46716	AEM Output 4 Param Min	Int32	Centi Unit	Centi	RW	(-100000000) – 99999900

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Register	Description	Type	Units	Scaling Factor	R/W	Range
46718	AEM Output 4 Param Selection	Uint32	N/A	N/A	RW	0 = Oil Pressure 1 = Coolant Temp 2 = Battery Volts 3 = RPM 4 = Fuel Level 5 = Gen VAB 6 = Gen VBC 7 = Gen VCA 8 = Gen VAN 9 = Gen VBN 10 = Gen VCN 11 = Bus Freq 12 = Bus Volts 13 = Gen Freq 14 = Gen PF 15 = Gen IA 16 = Gen IB 17 = Gen IC 18 = kW A 19 = kW B 20 = kW C 21 = kW Total 22 = kVA A 23 = kVA B 24 = kVA C 25 = kVA Total 26 = Analog Input 1 27 = Analog Input 2 28 = Analog Input 3 29 = Analog Input 4 30 = Analog Input 5 31 = Analog Input 6 32 = Analog Input 7 33 = Analog Input 8 34 = RTD Input 1 35 = RTD Input 2 36 = RTD Input 3 37 = RTD Input 4 38 = RTD Input 5 39 = RTD Input 6 40 = RTD Input 7 41 = RTD Input 8 42 = Thermocouple 1 43 = Thermocouple 2 44 = Fuel Delivery Pressure 45 = kvar A 46 = kvar B 47 = kvar C 48 = kvar Total 49 = Injector Metering Rail Pressure 50 = Total Fuel Used 51 = Fuel Temperature 52 = Engine Oil Temperature 53 = Engine Intercooler Temperature 54 = Coolant Pressure 55 = Fuel Rate 56 = Boost Pressure 57 = Intake Manifold Temperature 58 = Charge Air Temperature 59 = Engine Percent Load 60 = Bus VAB 61 = Bus VBC 62 = Bus VCA 63 = kW Load Percent 64 = Number of Units Online 65 = System kW Capacity 66 = System Total Generated kW 67 = System Total Generated kvar
46720	AEM Output 4 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm 3 = Status Only
46722	AEM Output 4 Out of Range Time Delay	Int32	Second	N/A	RW	0 – 300

Register	Description	Type	Units	Scaling Factor	R/W	Range
46724 - 46748	FUTURE USE					
46750	User Config Input 1 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46752	User Config Input 1 Time Delay	Int32	Second	N/A	RW	0 – 300
46754	User Config Input 1 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46756	User Config Input 2 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46758	User Config Input 2 Time Delay	Int32	Second	N/A	RW	0 – 300
46760	User Config Input 2 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46762	User Config Input 3 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46764	User Config Input 3 Time Delay	Int32	Second	N/A	RW	0 – 300
46766	User Config Input 3 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46768	User Config Input 4 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46770	User Config Input 4 Time Delay	Int32	Second	N/A	RW	0 – 300
46772	User Config Input 4 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46774	User Config Input 5 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46776	User Config Input 5 Time Delay	Int32	Second	N/A	RW	0 – 300
46778	User Config Input 5 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46780	User Config Input 6 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46782	User Config Input 6 Time Delay	Int32	Second	N/A	RW	0 – 300
46784	User Config Input 6 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46786	User Config Input 7 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46788	User Config Input 7 Time Delay	Int32	Second	N/A	RW	0 – 300
46790	User Config Input 7 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46792	User Config Input 8 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46794	User Config Input 8 Time Delay	Int32	Second	N/A	RW	0 – 300
46796	User Config Input 8 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46798	User Config Input 9 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46800	User Config Input 9 Time Delay	Int32	Second	N/A	RW	0 – 300

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Register	Description	Type	Units	Scaling Factor	R/W	Range
46802	User Config Input 9 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46804	User Config Input 10 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46806	User Config Input 10 Time Delay	Int32	Second	N/A	RW	0 – 300
46808	User Config Input 10 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46810	User Config Input 11 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46812	User Config Input 11 Time Delay	Int32	Second	N/A	RW	0 – 300
46814	User Config Input 11 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46816	User Config Input 12 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46818	User Config Input 12 Time Delay	Int32	Second	N/A	RW	0 – 300
46820	User Config Input 12 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46822	User Config Input 13 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46824	User Config Input 13 Time Delay	Int32	Second	N/A	RW	0 – 300
46826	User Config Input 13 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46828	User Config Input 14 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46830	User Config Input 14 Time Delay	Int32	Second	N/A	RW	0 – 300
46832	User Config Input 14 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46834	User Config Input 15 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46836	User Config Input 15 Time Delay	Int32	Second	N/A	RW	0 – 300
46838	User Config Input 15 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46840	User Config Input 16 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46842	User Config Input 16 Time Delay	Int32	Second	N/A	RW	0 – 300
46844	User Config Input 16 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46846	User Config Input 17 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46848	User Config Input 17 Time Delay	Int32	Second	N/A	RW	0 – 300
46850	User Config Input 17 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46852	User Config Input 18 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46854	User Config Input 18 Time Delay	Int32	Second	N/A	RW	0 – 300

Register	Description	Type	Units	Scaling Factor	R/W	Range
46856	User Config Input 18 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46858	User Config Input 19 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46860	User Config Input 19 Time Delay	Int32	Second	N/A	RW	0 – 300
46862	User Config Input 19 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46864	User Config Input 20 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46866	User Config Input 20 Time Delay	Int32	Second	N/A	RW	0 – 300
46868	User Config Input 20 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46870	User Config Input 21 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46872	User Config Input 21 Time Delay	Int32	Second	N/A	RW	0 – 300
46874	User Config Input 21 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46876	User Config Input 22 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46878	User Config Input 22 Time Delay	Int32	Second	N/A	RW	0 – 300
46880	User Config Input 22 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46882	User Config Input 23 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46884	User Config Input 23 Time Delay	Int32	Second	N/A	RW	0 – 300
46886	User Config Input 23 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46888	User Config Input 24 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46890	User Config Input 24 Time Delay	Int32	Second	N/A	RW	0 – 300
46892	User Config Input 24 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46894	User Config Input 25 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46896	User Config Input 25 Time Delay	Int32	Second	N/A	RW	0 – 300
46898	User Config Input 25 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46900	User Config Input 26 Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46902	User Config Input 26 Time Delay	Int32	Second	N/A	RW	0 – 300
46904	User Config Input 26 Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only

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Register	Description	Type	Units	Scaling Factor	R/W	Range
46906	ATS Contact Input	Int32	N/A	N/A	RW	-1 = None 0 = Input 1 1 = Input 2 2 = Input 3 3 = Input 4 4 = Input 5 5 = Input 6 6 = Input 7 7 = Input 8 8 = Input 9 9 = Input 10 10 = Input 11 11 = Input 12 12 = Input 13 13 = Input 14 14 = Input 15 15 = Input 16
46908	ATS Time Delay	Int32	Second	N/A	RW	0 – 300
46910	ATS Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46912	Battle Override Contact Input	Int32	N/A	N/A	RW	-1 = None 0 = Input 1 1 = Input 2 2 = Input 3 3 = Input 4 4 = Input 5 5 = Input 6 6 = Input 7 7 = Input 8 8 = Input 9 9 = Input 10 10 = Input 11 11 = Input 12 12 = Input 13 13 = Input 14 14 = Input 15 15 = Input 16
46914	Battle Override Time Delay	Int32	Second	N/A	RW	0 – 300
46916	Battle Override Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46918	Low Coolant Level Contact Input	Int32	N/A	N/A	RW	-1 = None 0 = Input 1 1 = Input 2 2 = Input 3 3 = Input 4 4 = Input 5 5 = Input 6 6 = Input 7 7 = Input 8 8 = Input 9 9 = Input 10 10 = Input 11 11 = Input 12 12 = Input 13 13 = Input 14 14 = Input 15 15 = Input 16
46920	Low Coolant Level Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46922	Low Coolant Level Time Delay	Int32	Second	N/A	RW	0 – 300
46924	Low Coolant Level Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only

Register	Description	Type	Units	Scaling Factor	R/W	Range
46926	Battery Charge Failed Contact Input	Int32	N/A	N/A	RW	-1 = None 0 = Input 1 1 = Input 2 2 = Input 3 3 = Input 4 4 = Input 5 5 = Input 6 6 = Input 7 7 = Input 8 8 = Input 9 9 = Input 10 10 = Input 11 11 = Input 12 12 = Input 13 13 = Input 14 14 = Input 15 15 = Input 16
46928	Battery Charge Failed Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46930	Battery Charge Failed Time Delay	Int32	Second	N/A	RW	0 – 300
46932	Battery Charge Failed Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46934	Fuel Leak Detect Contact Input	Int32	N/A	N/A	RW	-1 = None 0 = Input 1 1 = Input 2 2 = Input 3 3 = Input 4 4 = Input 5 5 = Input 6 6 = Input 7 7 = Input 8 8 = Input 9 9 = Input 10 10 = Input 11 11 = Input 12 12 = Input 13 13 = Input 14 14 = Input 15 15 = Input 16
46936	Fuel Leak Detect Config Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
46938	Fuel Leak Detect Time Delay	Int32	Second	N/A	RW	0 – 300
46940	Fuel Leak Detect Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46942	Single Phase Connection Override Contact Input	Int32	N/A	N/A	RW	-1 = None 0 = Input 1 1 = Input 2 2 = Input 3 3 = Input 4 4 = Input 5 5 = Input 6 6 = Input 7 7 = Input 8 8 = Input 9 9 = Input 10 10 = Input 11 11 = Input 12 12 = Input 13 13 = Input 14 14 = Input 15 15 = Input 16

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Register	Description	Type	Units	Scaling Factor	R/W	Range
46944	Single Phase Connection Override Time Delay	Int32	Second	N/A	RW	0 – 300
46946	Single Phase Connection Override Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46948	Single Phase AC Sense Override Contact Input	Int32	N/A	N/A	RW	-1 = None 0 = Input 1 1 = Input 2 2 = Input 3 3 = Input 4 4 = Input 5 5 = Input 6 6 = Input 7 7 = Input 8 8 = Input 9 9 = Input 10 10 = Input 11 11 = Input 12 12 = Input 13 13 = Input 14 14 = Input 15 15 = Input 16
46950	Single Phase AC Sense Override Time Delay	Int32	Second	N/A	RW	0 – 300
46952	Single Phase AC Sense Override Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46954	Hi/Lo Line Contact Input	Int32	N/A	N/A	RW	-1 = None 0 = Input 1 1 = Input 2 2 = Input 3 3 = Input 4 4 = Input 5 5 = Input 6 6 = Input 7 7 = Input 8 8 = Input 9 9 = Input 10 10 = Input 11 11 = Input 12 12 = Input 13 13 = Input 14 14 = Input 15 15 = Input 16
46956	Hi/Lo Line Time Delay	Int32	Second	N/A	RW	0 – 300
46958	Hi/Lo Line Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
46960	Grounded Delta Override Contact Input	Int32	N/A	N/A	RW	-1 = None 0 = Input 1 1 = Input 2 2 = Input 3 3 = Input 4 4 = Input 5 5 = Input 6 6 = Input 7 7 = Input 8 8 = Input 9 9 = Input 10 10 = Input 11 11 = Input 12 12 = Input 13 13 = Input 14 14 = Input 15 15 = Input 16

Register	Description	Type	Units	Scaling Factor	R/W	Range
46962	Grounded Delta Override Time Delay	Int32	Second	N/A	RW	0 – 300
46964	Grounded Delta Override Engine Running Only	Int32	N/A	N/A	RW	0 = Always 1 = While Engine Running Only
47000	AEM1 RTD1 Hysteresis	Int32	DeciPercent	Deci	RW	0 - 1000
47002	AEM1 RTD1 Arming Delay	Int32	Second	N/A	RW	0 - 300
47004	AEM1 RTD1 Threshold1 Activation Delay	Int32	Second	N/A	RW	0 - 300
47006	AEM1 RTD1 Threshold2 Activation Delay	Int32	Second	N/A	RW	0 - 2
47008	AEM1 RTD1 Over1 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47010	AEM1 RTD1 Over2 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47012	AEM1 RTD1 Under1 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47014	AEM1 RTD1 Under2 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47016	AEM1 RTD1 Over1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47018	AEM1 RTD1 Over2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47020	AEM1 RTD1 Under1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47022	AEM1 RTD1 Under2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47024	AEM1 RTD1 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47026	AEM1 RTD2 Hysteresis	Int32	DeciPercent	Deci	RW	0 - 1000
47028	AEM1 RTD2 Arming Delay	Int32	Second	N/A	RW	0 - 300
47030	AEM1 RTD2 Threshold1 Activation Delay	Int32	Second	N/A	RW	0 - 300
47032	AEM1 RTD2 Threshold2 Activation Delay	Int32	Second	N/A	RW	0 - 2
47034	AEM1 RTD2 Over1 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47036	AEM1 RTD2 Over2 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47038	AEM1 RTD2 Under1 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47040	AEM1 RTD2 Under2 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47042	AEM1 RTD2 Over1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47044	AEM1 RTD2 Over2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only

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Register	Description	Type	Units	Scaling Factor	R/W	Range
47046	AEM1 RTD2 Under1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47048	AEM1 RTD2 Under2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47050	AEM1 RTD2 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47052	AEM1 RTD3 Hysteresis	Int32	DeciPercent	Deci	RW	0 - 1000
47054	AEM1 RTD3 Arming Delay	Int32	Second	N/A	RW	0 - 300
47056	AEM1 RTD3 Threshold1 Activation Delay	Int32	Second	N/A	RW	0 - 300
47058	AEM1 RTD3 Threshold2 Activation Delay	Int32	Second	N/A	RW	0 - 2
47060	AEM1 RTD3 Over1 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47062	AEM1 RTD3 Over2 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47064	AEM1 RTD3 Under1 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47066	AEM1 RTD3 Under2 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47068	AEM1 RTD3 Over1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47070	AEM1 RTD3 Over2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47072	AEM1 RTD3 Under1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47074	AEM1 RTD3 Under2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47076	AEM1 RTD3 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47078	AEM1 RTD4 Hysteresis	Int32	DeciPercent	Deci	RW	0 - 1000
47080	AEM1 RTD4 Arming Delay	Int32	Second	N/A	RW	0 - 300
47082	AEM1 RTD4 Threshold1 Activation Delay	Int32	Second	N/A	RW	0 - 300
47084	AEM1 RTD4 Threshold2 Activation Delay	Int32	Second	N/A	RW	0 - 2
47086	AEM1 RTD4 Over1 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47088	AEM1 RTD4 Over2 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47090	AEM1 RTD4 Under1 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47092	AEM1 RTD4 Under2 Threshold	Int32	Deg F	N/A	RW	-58 - 482

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Register	Description	Type	Units	Scaling Factor	R/W	Range
47094	AEM1 RTD4 Over1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47096	AEM1 RTD4 Over2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47098	AEM1 RTD4 Under1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47100	AEM1 RTD4 Under2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47102	AEM1 RTD4 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47104	AEM1 RTD5 Hysteresis	Int32	DeciPercent	Deci	RW	0 - 1000
47106	AEM1 RTD5 Arming Delay	Int32	Second	N/A	RW	0 - 300
47108	AEM1 RTD5 Threshold1 Activation Delay	Int32	Second	N/A	RW	0 - 300
47110	AEM1 RTD5 Threshold2 Activation Delay	Int32	Second	N/A	RW	0 - 2
47112	AEM1 RTD5 Over1 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47114	AEM1 RTD5 Over2 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47116	AEM1 RTD5 Under1 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47118	AEM1 RTD5 Under2 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47120	AEM1 RTD5 Over1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47122	AEM1 RTD5 Over2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47124	AEM1 RTD5 Under1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47126	AEM1 RTD5 Under2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47128	AEM1 RTD5 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47130	AEM1 RTD6 Hysteresis	Int32	DeciPercent	Deci	RW	0 - 1000
47132	AEM1 RTD6 Arming Delay	Int32	Second	N/A	RW	0 - 300
47134	AEM1 RTD6 Threshold1 Activation Delay	Int32	Second	N/A	RW	0 - 300
47136	AEM1 RTD6 Threshold2 Activation Delay	Int32	Second	N/A	RW	0 - 2
47138	AEM1 RTD6 Over1 Threshold	Int32	Deg F	N/A	RW	-58 - 482

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Register	Description	Type	Units	Scaling Factor	R/W	Range
47140	AEM1 RTD6 Over2 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47142	AEM1 RTD6 Under1 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47144	AEM1 RTD6 Under2 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47146	AEM1 RTD6 Over1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47148	AEM1 RTD6 Over2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47150	AEM1 RTD6 Under1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47152	AEM1 RTD6 Under2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47154	AEM1 RTD6 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47156	AEM1 RTD7 Hysteresis	Int32	DeciPercent	Deci	RW	0 - 1000
47158	AEM1 RTD7 Arming Delay	Int32	Second	N/A	RW	0 - 300
47160	AEM1 RTD7 Threshold1 Activation Delay	Int32	Second	N/A	RW	0 - 300
47162	AEM1 RTD7 Threshold2 Activation Delay	Int32	Second	N/A	RW	0 - 2
47164	AEM1 RTD7 Over1 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47166	AEM1 RTD7 Over2 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47168	AEM1 RTD7 Under1 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47170	AEM1 RTD7 Under2 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47172	AEM1 RTD7 Over1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47174	AEM1 RTD7 Over2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47176	AEM1 RTD7 Under1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47178	AEM1 RTD7 Under2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47180	AEM1 RTD7 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47182	AEM1 RTD8 Hysteresis	Int32	DeciPercent	Deci	RW	0 - 1000
47184	AEM1 RTD8 Arming Delay	Int32	Second	N/A	RW	0 - 300

Register	Description	Type	Units	Scaling Factor	R/W	Range
47186	AEM1 RTD8 Threshold1 Activation Delay	Int32	Second	N/A	RW	0 - 300
47188	AEM1 RTD8 Threshold2 Activation Delay	Int32	Second	N/A	RW	0 - 2
47190	AEM1 RTD8 Over1 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47192	AEM1 RTD8 Over2 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47194	AEM1 RTD8 Under1 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47196	AEM1 RTD8 Under2 Threshold	Int32	Deg F	N/A	RW	-58 - 482
47198	AEM1 RTD8 Over1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47200	AEM1 RTD8 Over2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47202	AEM1 RTD8 Under1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47204	AEM1 RTD8 Under2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47206	AEM1 RTD8 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47208-48	RESERVED					
47250	AEM1 Thermocouple1 Hysteresis	Int32	DeciPercent	Deci	RW	0 - 1000
47252	AEM1 Thermocouple1 Arming Delay	Int32	Second	N/A	RW	0 - 300
47254	AEM1 Thermocouple1 Threshold1 Activation Delay	Int32	Second	N/A	RW	0 - 300
47256	AEM1 Thermocouple1 Threshold2 Activation Delay	Int32	Second	N/A	RW	0 - 300
47258	AEM1 Thermocouple1 Over1 Threshold	Int32	Deg F	N/A	RW	32 - 2507
47260	AEM1 Thermocouple1 Over2 Threshold	Int32	Deg F	N/A	RW	32 - 2507
47262	AEM1 Thermocouple1 Under1 Threshold	Int32	Deg F	N/A	RW	32 - 2507
47264	AEM1 Thermocouple1 Under2 Threshold	Int32	Deg F	N/A	RW	32 - 2507
47266	AEM1 Thermocouple1 Over1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47268	AEM1 Thermocouple1 Over2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47270	AEM1 Thermocouple1 Under1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only

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Register	Description	Type	Units	Scaling Factor	R/W	Range
47272	AEM1 Thermocouple1 Under 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47274	AEM1 Thermocouple1 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47276	AEM1 Thermocouple2 Hysteresis	Int32	DeciPercent	Deci	RW	0 - 1000
47278	AEM1 Thermocouple2 Arming Delay	Int32	Second	N/A	RW	0 - 300
47280	AEM1 Thermocouple2 Threshold1 Activation Delay	Int32	Second	N/A	RW	0 - 300
47282	AEM1 Thermocouple2 Threshold2 Activation Delay	Int32	Second	N/A	RW	0 - 300
47284	AEM1 Thermocouple2 Over1 Threshold	Int32	Deg F	N/A	RW	32 - 2507
47286	AEM1 Thermocouple2 Over2 Threshold	Int32	Deg F	N/A	RW	32 - 2507
47288	AEM1 Thermocouple2 Under1 Threshold	Int32	Deg F	N/A	RW	32 - 2507
47290	AEM1 Thermocouple2 Under2 Threshold	Int32	Deg F	N/A	RW	32 - 2507
47292	AEM1 Thermocouple2 Over1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47294	AEM1 Thermocouple2 Over2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47296	AEM1 Thermocouple2 Under1 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47298	AEM1 Thermocouple2 Under 2 Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only
47300	AEM1 Thermocouple2 Out of Range Alarm Type	Int32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-alarm 3 = Status Only

Legacy Parameter Table for DGC-500 and DGC-1000

The MGC-2000 Series maps all legacy parameters previously associated with the DGC-500 and DGC-1000 into the Holding Register address space (40000 to 41999). Query address N will access the Holding Register N+1. The Data Format is Integer type data unless identified otherwise in the Data Format column.

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40001-18	RESERVED				
PARAMETER SETTINGS					
40019	Emergency Stop	0-1	R W	0 =Off 1 =Stop	
40020	Remote Start / Stop: Runs when in Auto mode	0-1	R W	0 =Stop 1 =Start	

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40021-22	RESERVED				
SYSTEM PARAMETERS					
40023	Default Generator Connection	0-2	R W	0=3ph L-L 1=3ph L-N 2=1ph A-B	
40024	NFPA Level	0-2	R W	0=Off 1=Level 1 2=Level 2	
40025	RESERVED				
40026	Rated Engine RPM	750-3600	R W		RPM
40027	Number Flywheel Teeth	50-500	R W		
40028	Genset kW Rating	25-9999	R W		KWatt
40029	No Load Cool Down Time	0-60	R W		Minutes
GENERATOR PT PRIMARY					
40030	Voltage(a)	1-15000	R W	DP	VoltsAC x10000
40031	Voltage(b)		R W	DP	VoltsAC
GENERATOR PT SECONDARY					
40032	Voltage	1-480	R W		VoltsAC
GENERATOR CT PRIMARY					
40033	Current	1-5000	R W		AmpsAC
LOW FUEL ALARM					
40034	Enable	0-1	R W	0 =Off 1 =On	
40035	Threshold	2-50	R W		% Full Tank
LOW FUEL PRE-ALARM					
40036	Enable	0-1	R W	0 =Off 1 =On	
40037	Threshold	10-100	R W		% Full Tank
LOW COOLANT TEMP PRE-ALARM					
40038	Enable	0-1	R W	0 =Off 1 =On	
40039	Threshold	32-150	R W		Degrees F
BATTERY OVERVOLTAGE PRE-ALARM					
40040	Enable	0-1	R W	0 =Off 1 =On	
40041	RESERVED				
MAINTENANCE INTERVAL PRE-ALARM					
40042	Enable	0-1	R W	0 =Off 1 =On	
40043	Threshold	0-5000	R W		Hours
ENGINE KW OVERLOAD PRE-ALARM					
40044	Enable	0-1	R W	0 =Off 1 =On	
40045	Threshold	95-140	R W		% of Rated
HIGH COOLANT TEMP PRE-ALARM					
40046	Enable	0-1	R W	0 =Off 1 =On	
40047	Threshold	100-280	R W		Degrees F
LOW OIL PRESSURE PRE-ALARM					
40048	Enable	0-1	R W	0 =Off 1 =On	
40049	Threshold	3-100	R W		PSI
LOW BATTERY VOLTAGE PRE-ALARM					
40050	Enable	0-1	R W	0 =Off 1 =On	
40051	Threshold	60-120 (12V) 120-240 (24V)	R W		0.1 Volts DC
40052	Pre-alarm Activation Time Delay	1-10	R W		Seconds
WEAK BATTERY VOLTAGE PRE-ALARM					

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Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40053	Enable	0-1	R W	0 =Off 1 =On	
40054	Threshold	40-80 (12V) 80-160 (24V)	R W		0.1 VoltDC
40055	Pre-alarm Activation Time Delay	1-10	R W		Seconds
40056-59	RESERVED				
HIGH COOLANT TEMP ALARM					
40060	Enable	0-1	R W	0 =Off 1 =On	
40061	Threshold	100-280	R W		Degrees F
40062	Arming Delay after Crank Disconnect	60	R W		Seconds
LOW OIL PRESSURE ALARM					
40063	Enable	0-1	R W	0 =Off 1 =On	
40064	Threshold	3-100	R W		PSI
40065	Arming Delay after Crank Disconnect	5-15	R W		Seconds
OVERSPEED ALARM					
40066	Enable	0-1	R W	0 =Off 1 =On	
40067	Threshold	105-140	R W		% of Rated
40068	Alarm Activation Time Delay	0-500	R W		MilliSec
40069-71	RESERVED				
CRANKING PARAMETERES					
40072	Cranking Style	0-1	R W	0=Contin. 1=Cycle	
40073	Number of Crank Cycles	1-7	R W		
40074	Cycle Crank Time	5-15	R W		Seconds
40075	Continuous Crank Time	1-60	R W		Seconds
40076	Crank Disconnect Limit	10-100	R W		% of Rated
40077	Pre-crank Delay	0-30	R W		Seconds
SYSTEM MONITOR					
40078	Remaining Cooldown Time	0-60	R		Minutes
40079	RESERVED				
40080	Active Speed Signal Sources	1-4	R	0 = None 1 = MPU 2 = Gen Freq 4 = CAN Bus	
40081	Sender Failure Alarm Code	individual bits are 0 or 1	R	b0 = High Coolant Temperature b1 = Oil Pressure b2 = Fuel Level b3 = Magnetic Pick-up b4 = Generator Voltage Sensing b5 = Battery Charger Fail b6 = Coolant Level Sender Fail b7 not used	
40082	Alarm Codes	individual bits are 0 or 1	R	b0=High Coolant Temperature b1=Low Coolant Level b2=Low Fuel Level b3=Emergency Stop b4=Sender Failure b5=Over Crank b6=Over Speed b7=Low Oil Pressure Rev. 3.04 Added: b8 = CAN Fail	

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Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40083	Pre-Alarm Codes	individual bits are 0 or 1	R	b0=High Coolant Temperature b1=Low Coolant Temperature b2=Weak Battery b3=Low Battery b4=Battery Overvoltage b5=Battery Charger Fail b6=Maintenance Interval b7=Engine Overload Rev. 3.04 Added: b8 = DTC b9 = CAN Fail	
40084	Pre-Alarm Codes, Group 2	individual bits are 0 or 1	R	b0=Low Oil Pressure b1=Low Fuel Level b2=Magnetic Pick-up Fail b3=Fuel Level Sender Fail b4=Aux Input 1 b5=Aux Input 2 b6=Aux Input 3 b7=Aux Input 4	
40085	Engine Coolant Temperature		R		DegF
40086	Engine Oil Pressure		R		PSI
40087	Battery Voltage		R		0.1 VoltsDC
40088	Fuel Level		R		% Full Tank
40089	Time Remaining until Maintenance		R		Hours
40090	Accumulated Engine Runtime(a)		R W	DP	Minutes x 10000
40091	Accumulated Engine Runtime(b)		R W	DP	Minutes
40092	Not Currently Used		R W	DP	
40093	Not Currently Used		R W	DP	
40094	Engine Speed(a)		R	DP	RPM x10000
40095	Engine Speed(b)		R	DP	RPM
40096	Engine Load(a)		R	DP	
40097	Engine Load(b)		R	DP	% of Rated Load
GENERATOR MONITOR					
40098	Phase a-b RMS Voltage(a)		R	DP	RMS Volt x 10000
40099	Phase a-b RMS Voltage(b)		R	DP	RMS Volt
40100	Phase b-c RMS Voltage(a)		R	DP	RMS Volt x 10000
40101	Phase b-c RMS Voltage(b)		R	DP	RMS Volt
40102	Phase c-a RMS Voltage(a)		R	DP	RMS Volt x 10000
40103	Phase c-a RMS Voltage(b)		R	DP	RMS Volt
40104	Phase a-n RMS Voltage(a)		R	DP	RMS Volt x 10000
40105	Phase a-n RMS Voltage(b)		R	DP	RMS Volt
40106	Phase b-n RMS Voltage(a)		R	DP	RMS Volt x 10000
40107	Phase b-n RMS Voltage(b)		R	DP	RMS Volt
40108	Phase c-n RMS Voltage(a)		R	DP	RMS Volt x 10000
40109	Phase c-n RMS Voltage(b)		R	DP	RMS Volt
40110	Phase a RMS Current		R		RMS Amps
40111	Phase b RMS Current		R		RMS Amps
40112	Phase c RMS Current		R		RMS Amps
40113	Phase a Apparent Power(a)		R	DP	KVA x 10000
40114	Phase a Apparent Power(b)		R	DP	KVA
40115	Phase b Apparent Power(a)		R	DP	KVA x 10000
40116	Phase b Apparent Power(b)		R	DP	KVA
40117	Phase c Apparent Power(a)		R	DP	KVA x 10000
40118	Phase c Apparent Power(b)		R	DP	KVA
40119	3 Phase Apparent Power(a)		R	DP	KVA x 10000

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Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40120	3 Phase Apparent Power(b)		R	DP	KVA
40121	Phase a Power(a)		R	DP	KWatt x 10000
40122	Phase a Power(b)		R	DP	KWatt
40123	Phase b Power(a)		R	DP	KWatt x 10000
40124	Phase b Power(b)		R	DP	KWatt
40125	Phase c Power(a)		R	DP	KWatt x 10000
40126	Phase c Power(b)		R	DP	KWatt
40127	3 Phase power(a)		R	DP	KWatt x 10000
40128	3 Phase power(b)		R	DP	KWatt
40129	3 Phase Total kW-Hours(a)		R W	TP	KWH x 10000 x 10000
40130	3 Phase Total kW-Hours(b)		R W	TP	KWH x 10000
40131	3 Phase Total kW-Hours(x)		R W	TP	KWH
40132	Power Factor	0-100	R		0.01
40133	Frequency		R		0.1 Hertz
40134	Present Total kW-minutes (a)		R W	TP	kWm x 10000 x 10000
40135	Present Total kW-minutes (b)		R W	TP	kWm x 10000
40136	Present Total kW-minutes (c)		R W	TP	kWm
40137	Generator Speed Mode	individual bits are 0 or 1	R W	<u>active spd signals:</u> b0 =mag. pick-up or CAN's ECU engine's speed. b1 =generator	
40138-39	RESERVED				
40140	Power Factor State	0-3	R	0 = leading, 1 = lagging	
40141-272	RESERVED				
40273	Input Contacts States	individual bits are 0 or 1	R	b0 = coolant level, b1 = ATS, b2 = E-stop, b3 = charger failed, b4 = aux. input 1, b5 = aux. input 2, b6 = aux. input 3, b7 = aux. input 4. /* b7 = aux. input 4. */	
40274	BESTCOMS*Plus*® Test Buttons States	individual bits are 0 or 1	R W	b0 = button #1, b1 = button #2, b2 = button #3, b3 = button #4, b4-b7 are not used.	
40275-80	RESERVED				
40281	Embedded Code Version Number (a)	0-99	R		
40282	Embedded Code Version Number (b)	0-9999	R		
40283	Embedded Code Version Number (c)	0-9999	R		
40287-97	RESERVED				

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40298	Read Relay Image of both Main and Aux Output	individual bits are 0 or 1	R	Main is in lower byte and Aux is in upper byte. b0 = Aux Output 1, b1 = Aux Output 2, b2 = Aux Output 3, b3 = Aux Output 4, b4 = Aux Output 5, b5 = Aux Output 6, b6 = Aux Output 7, b7 = Aux Output 8. b8 = Master Start Relay, b9 = Fuel Solenoid Relay, b10 = PreHeat PreLube Relay, b11 = Alarm Relay, b12 = UNASSIGNED, b13 = Buzzer On, b14 = EPS Loaded Relay, b15 = PreAlarm Relay,	
40299	RESERVED				
J1939 DIAGNOSTIC TROUBLE CODES					
40300	Active DTC Number 16 – Lower Two Bytes	0-65535	R	Suppose the 32 bits of DTC Data is in Register N and N+1. SPN = (Register N: Most Significant 3 bits * 65536) + (Register N+1: LS Byte * 256) + (Register N+1: MS Byte) FMI = Register N: Bits 8-12 Occurrence Count = Register N: Bits 0 through 6	
40301	Active DTC Number 16 – Upper Two Bytes	0-65535	R		
40302	Active DTC Number 15 – Lower Two Bytes	0-65535	R		
40303	Active DTC Number 15 – Upper Two Bytes	0-65535	R		
40304	Active DTC Number 14 – Lower Two Bytes	0-65535	R		
40305	Active DTC Number 14 – Upper Two Bytes	0-65535	R		
40306	Active DTC Number 13 – Lower Two Bytes	0-65535	R		
40307	Active DTC Number 13 – Upper Two Bytes	0-65535	R		
40308	Active DTC Number 12 – Lower Two Bytes	0-65535	R		
40309	Active DTC Number 12 – Upper Two Bytes	0-65535	R		
40310	Active DTC Number 11 – Lower Two Bytes	0-65535	R		
40311	Active DTC Number 11 – Upper Two Bytes	0-65535	R		
40312	Active DTC Number 10 – Lower Two Bytes	0-65535	R		
40313	Active DTC Number 10 – Upper Two Bytes	0-65535	R		
40314	Active DTC Number 9 – Lower Two Bytes	0-65535	R		
40315	Active DTC Number 9 – Upper Two Bytes	0-65535	R		
40316	Active DTC Number 8 – Lower Two Bytes	0-65535	R		
40317	Active DTC Number 8 – Upper Two Bytes	0-65535	R		
40318	Active DTC Number 7 – Lower Two Bytes	0-65535	R		
40319	Active DTC Number 7 – Upper Two Bytes	0-65535	R		
40320	Active DTC Number 6 – Lower Two Bytes	0-65535	R		
40321	Active DTC Number 6 – Upper Two Bytes	0-65535	R		

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Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40322	Active DTC Number 5 – Lower Two Bytes	0-65535	R		
40323	Active DTC Number 5 – Upper Two Bytes	0-65535	R		
40324	Active DTC Number 4 – Lower Two Bytes	0-65535	R		
40325	Active DTC Number 4 – Upper Two Bytes	0-65535	R		
40326	Active DTC Number 3 – Lower Two Bytes	0-65535	R		
40327	Active DTC Number 3 – Upper Two Bytes	0-65535	R		
40328	Active DTC Number 2 – Lower Two Bytes	0-65535	R		
40329	Active DTC Number 2 – Upper Two Bytes	0-65535	R		
40330	Active DTC Number 1 – Lower Two Bytes	0-65535	R		
40331	Active DTC Number 1 – Upper Two Bytes	0-65535	R		
40332	Previous DTC Number 1 – Lower Two Bytes	0-65535	R	Suppose the 32 bits of DTC Data is in Register N and N+1. SPN = (Register N+1: Most Significant 3 bits * 65536) + (Register N: LS Byte * 256) + (Register N: MS Byte) FMI = Register N+1: Bits 8-12 Occurrence Count = Register N: Bits 0 through 6	
40333	Previous DTC Number 1 – Upper Two Bytes	0-65535	R		
40334	Previous DTC Number 2 – Lower Two Bytes	0-65535	R		
40335	Previous DTC Number 2 – Upper Two Bytes	0-65535	R		
40336	Previous DTC Number 3 – Lower Two Bytes	0-65535	R		
40337	Previous DTC Number 3 – Upper Two Bytes	0-65535	R		
40338	Previous DTC Number 4 – Lower Two Bytes	0-65535	R		
40339	Previous DTC Number 4 – Upper Two Bytes	0-65535	R		
40340	Previous DTC Number 5 – Lower Two Bytes	0-65535	R		
40341	Previous DTC Number 5 – Upper Two Bytes	0-65535	R		
40342	Previous DTC Number 6 – Lower Two Bytes	0-65535	R		
40343	Previous DTC Number 6 – Upper Two Bytes	0-65535	R		
40344	Previous DTC Number 7 – Lower Two Bytes	0-65535	R		
40345	Previous DTC Number 7 – Upper Two Bytes	0-65535	R		
40346	Previous DTC Number 8 – Lower Two Bytes	0-65535	R		
40347	Previous DTC Number 8 – Upper Two Bytes	0-65535	R		
40348	Previous DTC Number 9 – Lower Two Bytes	0-65535	R		
40349	Previous DTC Number 9 – Upper Two Bytes	0-65535	R		
40350	Previous DTC Number 10 – Lower Two Bytes	0-65535	R		
40351	Previous DTC Number 10 – Upper Two Bytes	0-65535	R		
40352	Previous DTC Number 11 – Lower Two Bytes	0-65535	R		
40353	Previous DTC Number 11 – Upper Two Bytes	0-65535	R		

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40354	Previous DTC Number 12 – Lower Two Bytes	0-65535	R		
40355	Previous DTC Number 12 – Upper Two Bytes	0-65535	R		
40356	Previous DTC Number 13 – Lower Two Bytes	0-65535	R		
40357	Previous DTC Number 13 – Upper Two Bytes	0-65535	R		
40358	Previous DTC Number 14 – Lower Two Bytes	0-65535	R		
40359	Previous DTC Number 14 – Upper Two Bytes	0-65535	R		
40360	Previous DTC Number 15 – Lower Two Bytes	0-65535	R		
40361	Previous DTC Number 15 – Upper Two Bytes	0-65535	R		
40362	Previous DTC Number 16 – Lower Two Bytes	0-65535	R		
40363	Previous DTC Number 16 – Upper Two Bytes	0-65535	R		
40364	RESERVED				
40365	RESERVED				
40366	RESERVED				
40367	RESERVED				
40368	DTC Lamp Status NOTE: Even bits are Always a Zero Value.	individual bits are 0 or 1	R	Active stored in upper byte – Previous stored in lower byte. b0 = 0, b1 = Protect Lamp, b2 = 0, b3 = Amber Warning Lamp, b4 = 0, b5 = Red Stop Lamp, b6 = 0, b7 = Malfunction Indicator Lamp, b8 = 0, b9 = Protect Lamp, b10 = 0, b11 = Amber Warning Lamp, b12 = 0, b13 = Red Stop Lamp, b14 = 0, b15 = Malfunction Indicator Lamp	
40369	Number of DTC's	0-65535	R	Active stored in upper byte – Previous stored in lower byte.	
40370	CAN Bus Results Register	individual bits are 0 or 1	R	b0 = CAN Comms. Fail, b1 = Active DTC Clear Fail, b2 = Previous DTC Clear Fail, b3 = DTC Values Changed, b4 = CAN Hardware Test Pass, b5 = UNASSIGNED, b6 = UNASSIGNED, b7 = UNASSIGNED,	
40371	CAN Related Parameter: Percent Coolant Level	0-100	R	Percent	

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Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40372	CAN Communications Diagnostics for use when CAN is enabled.	individual bits are 0 or 1	R	Bit 12 - .Engine Run Time Bit 11 – Data Failure Status Previous Active DTCs Cleared Bit 10 – Active DTCs Cleared Bit 9 - Previous Active DTCs Bit 8 - Current Active DTCs Bit 7 – Coolant Level Bit 6 - Oil Pressure Bit 5 - Coolant Temp Bit 4 - Engine Speed Bit 3 – Can Error Status tx err passive Bit 2 – Can Error Status rx err passive Bit 1 – Can Error Status driver sleep status Bit 0 – Can Error Status bus off	
40373	System Config	individual bits are 0 or 1	R W	Bit 0 – RUN Bit 1 – OFF Bit 2 – AUTO_RUN Bit 3 – AUTO_OFF Bit 4 – AUTO_ANY	
40374	System Status	0 - 10	R	0 = RESET 1 = READY 2 = CRANKING 3 = RESTING 4 = RUNNING 5 = ALARM 6 = PRESTART 7 = COOLING 8 = CONNECTING 9 = DISCONNECT 10 = PULSING 11 = UNLOADING	
40375	Used to display Value, NC, NS, NA, and SF		R	Bits 0-2: coolant level Bits 3-5: coolant temperature Bits 6-8: oil pressure Bits 9-11: engine speed Bits 12-14: engine run time Bit 15: NOT USED 3-Bit Status Flag Values: 000 for Valid Data 001 for No Comms 010 for Not Sent 011 for Not Supp 100 for Sender Error	
40380-81	FUTURE USE				
40382	MTU module type	1-4	R W	1 = module type 201 2 = module type 302 3 = module type 303 4 = module type 304	
40383	MTU speed demand switch	0-7	R W	0 = ANALOG_CAN 1 = UP_DN_ECU 2 = UP_DN_CAN 3 = ANALOG_ECU 5 = FREQUENCY 7 = NO_CAN_DEMAND	
40384	MTU RPM request for engine	1400-2000	R W		
40385	Volvo Accelerator Pedal Position (Trim)	0-100	R W	0 = Rated speed – 120rpm; 50 = Rated speed; 100 = Rated speed + 120rpm.	
40386	Volvo Engine RPM Select	0-1	R W	0 = Primary, 1 = Secondary.	
40387	J1939 source address for this unit	0-253	R W		
40388	CAN bus ECU Configuration	0-65535	R W	0 = Not configured; 1 = Volvo Penta EDC3; 2 = MTU MDEC 3 = MTU ADEC	

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40395	ECU Settling Time	0-65535	R W	milliseconds	
40396	ECU Pulse Cycle Time - The amount of time unit is to wait in OFF between Pulse Cycles.	0-65535	R W	minutes	
40397	ECU Disconnect Time - The amount of time ECU is kept powered off.	0-65535	R W	seconds	
40398	ECU Connect Time - The amount of time ECU is powered when connecting (unit tries to run). Also used for the Pulse duration time.	0-65535	R W	seconds	
40399-420	FUTURE USE				
J1939 DATA					
40421	Accelerator Pedal Position	0 to 100%	R	0.4%/bit gain, 0% offset	
40422	Percent Load At Current Speed	0 to 125%	R	1%/bit gain, 0% offset	
40423	Actual Engine Percent Torque	0 to 125%	R	1%/bit gain, -125% offset	
40424	Engine Speed	0 to 8031.875	R	RPM (0.125rpm/bit gain)	
40425	Injection Control Pressure	0 to +251 MPa	R	1/256 MPa/bit, 0 Offset	
40426	Injector Metering Rail Pressure	0 to +251 MPa (0 to 36 404 psi)	R	1/256 MPa/bit gain, 0 MPa offset	
40427	Engine Run Time	0 to +210,554, 060.75 h	R	0.05 h/bit gain, 0 h offset	
40428	Engine Run Time		R		
40429	Engine Run Time		R		
40430	Trip Fuel	Data Range: 0 to +2,105,540, 608 L	R	0.5 L per bit gain, 0 L offset	
40431	Trip Fuel		R		
40432	Trip Fuel		R		
40433	Total Fuel Used	Data Range: 0 to +2,105,540, 608 L	R	0.5 L per bit gain, 0 L offset	
40434	Total Fuel Used		R		
40435	Total Fuel Used		R		
40436	Coolant Temperature	-40 to +210 °C (-40 to 410 °F)	R	Raw ECU Parameter Data 1 °C/bit gain, -40 °C offset	
40437	Fuel Temperature	-40 to +210 °C (-40 to 410 °F)	R	Raw ECU Parameter Data 1 °C/bit gain, -40 °C offset	
40438	Engine Oil Temperature	-273 to +1735.0 °C (-459.4 to 3155.0 °F)	R	Raw ECU Parameter Data 0.03125 °C/bit gain, -273 °C offset	
40439	Engine Intercooler Temperature	-40 to +210 °C (-40 to 410 °F)	R	Raw ECU Parameter Data 1 °C/bit gain, -40 °C offset	
40440	Fuel Delivery Pressure	0 to +1000 kPa (0 to 145 psi)	R	Raw ECU Parameter Data 4 kPa/bit gain, 0 kPa offset	
40441	Engine Oil Level	0 to +100 %	R	Raw ECU Parameter Data 0.4 %/bit gain, 0 % offset	
40442	Engine Oil Pressure	0 to +1000 kPa (0 to 145 psi)	R	Raw ECU Parameter Data 4 kPa/bit gain, 0 kPa offset	
40443	Coolant Pressure	0 to +500 kPa (0 to 72.5 psi)	R	Raw ECU Parameter Data 2 kPa/bit gain, 0 kPa offset	
40444	Coolant Level	0 to +100 %	R	Raw ECU Parameter Data 0.4 %/bit gain, 0 % offset	
40445	Fuel Rate	0 to +3212.75 L/h	R	Raw ECU Parameter Data 0.05 L/h per bit gain, 0 L/h offset (13.9 x 10-6 L/s per bit)	

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40446	Barometric Pressure	0 to +125 kPa (0 to +18.1 psi)	R	Raw ECU Parameter Data 0.5 kPa/bit gain, 0 kPa offset	
40447	Ambient Air Temperature	-273 to +1735.0 °C (-459.4 to 3155.0 °F)	R	Raw ECU Parameter Data 0.03125 °C/bit gain, -273 °C offset	
40448	Air Inlet Temperature	-40 to +210 °C (-40 to 410 °F)	R	Raw ECU Parameter Data 1 °C/bit gain, -40 °C offset	
40449	Boost Pressure	0 to +500 kPa (0 to 72.5 psi)	R	Raw ECU Parameter Data 2 kPa/bit gain, 0 kPa offset	
40450	Intake Manifold Temperature	-40 to +210 °C (-40 to 410 °F)	R	Raw ECU Parameter Data 1 °C/bit gain, -40 °C offset	
40451	Air Filter Differential Pressure	0 to +12.5 kPa (0 to +1.8 psi)	R	Raw ECU Parameter Data 0.05 kPa/bit gain, 0 kPa offset	
40452	Exhaust Gas Temperature	-273 to +1735.0 °C (-459.4 to 3155.0 °F)	R	Raw ECU Parameter Data 0.03125 °C/bit gain, -273 °C offset	
40453	Electrical Potential Voltage	0 to +3212.75 V	R	Raw ECU Parameter Data 0.05 V/bit gain, 0 V offset	
40454	Battery Potential Voltage Switched	Data Range: 0 to +3212.75 V	R	Raw ECU Parameter Data 0.05 V/bit gain, 0 V offset	
40455	Speed At Idle Point 1	0 to 8031.875 rpm	R	Raw ECU Parameter Data 0.125 rpm/bit, 0 rpm offset	
40456	Torque At Idle Point 1	0 to 125%	R	Raw ECU Parameter Data 1%/bit gain, -125% offset	
40457	Speed At Idle Point 2	0 to 8031.875 rpm	R	Raw ECU Parameter Data 0.125 rpm/bit, 0 rpm offset	
40458	Torque At Idle Point 2	0 to 125%	R	Raw ECU Parameter Data 1%/bit gain, -125% offset	
40459	Speed At Idle Point 3	0 to 8031.875 rpm	R	Raw ECU Parameter Data 0.125 rpm/bit, 0 rpm offset	
40460	Torque At Idle Point 3	0 to 125%	R	Raw ECU Parameter Data 1%/bit gain, -125% offset	
40461	Speed At Idle Point 4	0 to 8031.875 rpm	R	Raw ECU Parameter Data 0.125 rpm/bit, 0 rpm offset	
40462	Torque At Idle Point 4	0 to 125%	R	Raw ECU Parameter Data 1%/bit gain, -125% offset	
40463	Speed At Idle Point 5	0 to 8031.875 rpm	R	Raw ECU Parameter Data 0.125 rpm/bit, 0 rpm offset	
40464	Torque At Idle Point 5	0 to 125%	R	Raw ECU Parameter Data 1%/bit gain, -125% offset	
40465	Speed At High Idle Point 6	0 to 8031.875 rpm	R	Raw ECU Parameter Data 0.125 rpm/bit, 0 rpm offset	
40466	Gain Of End speed governor	0 to 50.2 %/rpm	R	Raw ECU Parameter Data 0.0007813 % engine reference torque/rpm per bit gain (normalized), 0 %/rpm per bit offset	
40467	Reference Engine Torque	0 to 64 255 Nm	R	Raw ECU Parameter Data 1 Nm/bit gain, 0 Nm offset	
40468	Override Speed Point 7	0 to 8031.875 rpm	R	Raw ECU Parameter Data 0.125 rpm/bit, 0 rpm offset	
40469	Override Time Limit	0 s to 25 s	R	Raw ECU Parameter Data 0.1 s/bit gain, 0 s offset	
40470	Speed Lower Limit	0 to 2500 rpm	R	Raw ECU Parameter Data 10 rpm/bit gain, 0 rpm offset	

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40471	Speed Upper Limit	0 to 2500 rpm	R	Raw ECU Parameter Data 10 rpm/bit gain, 0 rpm offset	
40472	Torque Lower Limit	0 to 125%	R	Raw ECU Parameter Data 1%/bit gain, -125% offset	
40473	Torque Upper Limit	0 to 125%	R	Raw ECU Parameter Data 1%/bit gain, -125% offset	
40474	Crankcase Pressure	-250 to +251.99 kPa	R	Raw ECU Parameter Data 0.0078125 kPa/bit gain, -250 kPa offset	
40475	Oil Filter Diff. Pressure	0 to 125 kPa	R	Raw ECU Parameter Data 0.5 kPa/bit gain, 0 offset	
40476	Fuel Filter Diff. Pressure	0 to 500 kPa	R	Raw ECU Parameter Data 2 kPa/bit gain, 0 offset	
40477-82	FUTURE USE				
40493-99	FUTURE USE				
40500	DGC-2020 product series identifier	2020	R		
40501	Firmware Part Number - 2nd most significant digit. NOTE: The most significant digit is always 9, but is not mapped.	0 - 9	R		
40502	Firmware Part Number - 3rd-6th most significant digits	0000 - 9999	R		
40503	Firmware Part Number - four least significant digits	0000 - 9999	R		
40504	LED Status	individual bits are 0 or 1	R	Bits indicate status of LED's: b0 = RUN b1 = OFF b2 = AUTO b3 = ALARM b4 = LOAD b5 = NOT IN AUTO	
40507	Read Relay Image of both Main and Aux Output (Duplicate of 40298)	individual bits are 0 or 1	R	Main is in lower byte and Aux is in upper byte. b0 = Aux Output 1, b1 = Aux Output 2, b2 = Aux Output 3, b3 = Aux Output 4, b4 = Aux Output 5, b5 = Aux Output 6, b6 = Aux Output 7, b7 = Aux Output 8. b8 = Master Start Relay, b9 = Fuel Solenoid Relay, b10 = PreHeat PreLube Relay, b11 = Alarm Relay, b12 = UNASSIGNED, b13 = Buzzer On, b14 = EPS Loaded Relay, b15 = PreAlarm Relay,	
40508	Input Contacts States (Duplicate of 40273)	individual bits are 0 or 1	R	b0 = coolant level, b1 = ATS, b2 = E-stop, b3 = charger failed, b4 = aux. input 1, b5 = aux. input 2, b6 = aux. input 3, b7 = aux. input 4. /* b7 = aux. input 4. */	
40509-604	RESERVED				
OVERCURRENT					
40605	51 Pick-up – 3-phase	18-118, 90-775	R W	0.18-1.18 Aac for 1A CTs, 0.90-7.75 Aac for 5A CTs	

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Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40606	51 Time Dial – 3-phase	0-99, 0-300	R W	0.0-9.9 for 40607=0-15 (inverse), 0.0-30.0s for 40607=16 (fixed)	
40607	51 Curve – 3-phase	0-16	R W	0-15 for inverse, 16 for fixed	
40608	51 Alarm Config. – 3-phase	0-2	R W	0=None, 1=Pre-Alarm, 2=Alarm	
40609	51 Pick-up – 1-phase	18-118, 90-775	R W	0.18-1.18 Aac for 1A CTs, 0.90-7.75 Aac for 5A CTs	
40610	51 Time Dial – 1-phase	0-99, 0-300	R W	0.0-9.9 for 40607=0-15 (inverse), 0.0-30.0s for 40607=16 (fixed)	
40611	51 Curve – 1-phase	0-16	R W	0-15 for inverse, 16 for fixed	
40612	51 Alarm Config. – 1-phase	0-2	R W	0=None, 1=Pre-Alarm, 2=Alarm	
PHASE IMBALANCE					
40613	47 Pick-up	5-100	R W	Volts AC	
40614	47 Time Delay	0-300	R W	0.0-30.0 seconds	
40615	47 Alarm Configuration	0-2	R W	0=None, 1=Pre-Alarm, 2=Alarm	
UNDERVOLTAGE					
40616	27 Pick-up – 3-phase	70-576	R W	Volts AC	
40617	27 Time Delay – 3-phase	0-300	R W	0.0-30.0 seconds	
40618	27 Inhibit Frequency- 3-ph.	20-400	R W	Hertz	
40619	27 Alarm Config. – 3-phase	0-2	R W	0=None, 1=Pre-Alarm, 2=Alarm	
40620	27 Pick-up – 1-phase	70-576	R W	Volts AC	
40621	27 Time Delay – 1-phase	0-300	R W	0.0-30.0 seconds	
40622	27 Inhibit Frequency – 1-ph.	20-400	R W	Hertz	
40623	27 Alarm Config. – 1-phase	0-2	R W	0=None, 1=Pre-Alarm, 2=Alarm	
OVERVOLTAGE					
40624	59 Pick-up – 3-phase	70-576	R W	Volts AC	
40625	59 Time Delay – 3-phase	0-300	R W	0.0-30.0 seconds	
40626	59 Alarm Config. – 3-phase	0-2	R W	0=None, 1=Pre-Alarm, 2=Alarm	
40627	59 Pick-up – 1-phase	70-576	R W	Volts AC	
40628	59 Time Delay – 1-phase	0-300	R W	0.0-30.0 seconds	
40629	59 Alarm Config. – 1-phase	0-2	R W	0=None, 1=Pre-Alarm, 2=Alarm	
UNDERFREQUENCY					
40630	81U Pick-up	450-550, 550-650, 3600-4400	R W	45.0-55.0 Hz for 50-Hz config., 55.0-65.0 Hz for 60-Hz config., 360.0-440.0 Hz for 400-Hz unit	
40631	81U Time Delay	0-300	R W	0.0-30.0 seconds	
40632	81U Inhibit Voltage	70-576	R W	Volts AC	
40633	81U Alarm Configuration	0-2	R W	0=None, 1=Pre-Alarm, 2=Alarm	
OVERFREQUENCY					
40634	81O Pick-up	450-550, 550-650, 3600-4400	R W	45.0-55.0 Hz for 50-Hz config., 55.0-65.0 Hz for 60-Hz config., 360.0-440.0 Hz for 400-Hz unit	
40635	81O Time Delay	0-300	R W	0.0-30.0 seconds	
40636	81O Alarm Configuration	0-2	R W	0=None, 1=Pre-Alarm, 2=Alarm	
GENERATOR PROTECTION STATUS					
40637	Gen Protection Status (upper 16 bits)	0-65535	R	b16-b31 UNASSIGNED	
40638	Gen Protection Status (lower 16 bits)	0-65535	R	b0 = overvoltage trip, b1 = undervoltage trip, b2 = overfrequency trip, b3 = underfrequency trip, b4 = overcurrent trip, b5 = phase imbalance trip, b6-b15 UNASSIGNED	
40639	Gen Protection Pre-Alarms (upper 16 bits)	0-65535	R	b16-b31 UNASSIGNED	

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40640	Gen Protection Pre-Alarms (lower 16 bits)	0-65535	R	b0 = overvoltage pre-alarm, b1 = undervoltage pre-alarm, b2 = overfrequency pre-alarm, b3 = underfrequency pre-alarm, b4 = overcurrent pre-alarm, b5 = phase imbalance pre-alarm, b6-b15 UNASSIGNED	
40641	Gen Protection Alarms (upper 16 bits)	0-65535	R	b16-b31 UNASSIGNED	
40642	Gen Protection Alarms (lower 16 bits)	0-65535	R	b0 = overvoltage alarm, b1 = undervoltage alarm, b2 = overfrequency alarm, b3 = underfrequency alarm, b4 = overcurrent alarm, b5 = phase imbalance alarm, b6-b15 UNASSIGNED	
REAL TIME CLOCK					
40700	Hours	0-23	R W		
40701	Minutes	0-59	R W		
40702	Seconds	0-59	R W		
40703	Month	1-12	R W		
40704	Day	1-31	R W		
40705	Year		R W		
40706	Daylight Savings Time Enable	0-1	R W	0 = Off 1 = On	
40707-33	RESERVED				
RUN STATISTICS					
40734	Maintenance Interval Hours	0-5000	R W		hours
40735	Hours Until Maintenance	0-5000	R W		hours
40737	Commission Start Month	1-12	R W		month
40738	Commission Start Day	1-31	R W		day
40739	Commission Start Year	0-99	R W		year
40740-41	Cumulative Run Hours x 60	0-4294967295	R W	DP	hours
40742-43	Cumulative Loaded Run Hours x 60	0-4294967295	R W	DP	hours
40744-45	Cumulative Unloaded Run Hours x 60	0-4294967295	R W	DP	hours
40746	Start Count	0-65535	R W		
40747	Session Start Month	1-12	R W		month
40748	Session Start Day	1-31	R W		day
40749	Session Start Year	0-99	R W		year
40750-51	Session Run Hours x 60	0-4294967295	R W	DP	hours
40752-53	Session Loaded Run Hours x 60	0-4294967295	R W	DP	hours
40754-55	Session Unloaded Run Hours x 60	0-4294967295	R W	DP	hours
CAN bus ECU					
40758	ECU Control Output Select	0-1	R W	0 = fuel solenoid relay, 1 = pre-start relay	
40759	ECU Pulsing Enable	0-1	R W	0 = pulsing is enabled, 1 = pulsing is disabled	
40760	MDEC Alarms	0-65535	R	b0 = High Charge Air Temp, b1 = High Oil Temp, b2 = High Coolant Temp, b3 = Low Aftercooler Level, b4 = Low Fuel Delivery Press, b5 = Low Oil Press, b6 = Overspeed, b7 = Combined Red, b8-b15 UNASSIGNED	

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Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40761	MTU Pre-alarms	0-65535	R	b0 = High ECU Temp, b1 = High Oil Temp, b2 = High Intercooler Temp, b3 = High Charge Air Temp, b4 = High Coolant Temp, b5 = Shutdown Override, b6 = High Fuel Rail Press, b7 = Low Fuel Rail Press, b8 = Low Coolant Level, b9 = Low Charge Air Pressure, b10 = Low Fuel Deliv Pressure, b11 = Low Oil Pressure, b12 = Combined Yellow, b13-b15 UNASSIGNED	

Legacy Parameter Table for MGC-2000 Series

The MGC-2000 Series maps all legacy parameters previously associated with the MGC-2000 Series into the Holding Register address space (40000 to 41999). Some of these registers overlap the registers of the DGC-500 and DGC-1000 which constitutes a separate register table. Query address N will access the Holding Register N+1. The Data Format is Integer type data unless identified otherwise in the Data Format column.

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
PRODUCT ACCESS INFORMATION					
40252	<Reserved>				
40253	User Ltd Access Password(a)	'A'-'Z', 'a'-'z', '_', '0' - '9'	- W		
40254	User Ltd Access Password(b)		- W		
40255	User Ltd Access Password(c)		- W		
40256	User Ltd Access Password(d)		- W		
40257	<Reserved>				
40006	Front Panel Password(a)	All front panel pushbuttons except for RUN, OFF, AUTO	R -		
40007	Front Panel Password(b)		R -		
40008	Front Panel Password(c)		R -		
40009	Front Panel Password(d)		R -		
40010	<Reserved>				
40011	<Reserved>				
40012	<Reserved>				
40013	<Reserved>				
40014	User Ttl Access Password(a)	'A'-'Z', 'a'-'z', '_', '0'-'9'	- W		
40015	User Ttl Access Password(b)		- W		
40016	User Ttl Access Password(c)		- W		
40017	User Ttl Access Password(d)		- W		
40030	<Reserved>				
40031	Logoff	Data=Don't Care	- W		
40032	<Reserved>				
COMMUNICATION PARAMETERS					
40051	Comm Baud Rate	0	R W	0 =9600	Baud

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40052	Remote Delay Time	0-20	R W	0=Min. 1 =10 2 = 20 etc. 20 =200	MilliSec 10
40053	Comm Parity	0-2	R W	0 =None 1 =Odd 2 =Even	
40054	Device Address	1-247	R W		
40055	Modern Time Delay	0-9999	R W		Microseconds
40056	Embedded Code Version No.	100-9999	R -		Version No. x 100
PARAMETER SETTINGS					
40078	Remote (PC) Emergency Stop	0-1	- W	0 =Off 1 = Stop	
40079	Remote Start / Stop	0-1	- W	0 =Stop 1 =Start	
40080	<Reserved>				
40081	Settings Source	0-2	R W	0 =Factory 1 =OEM 2 =User	
40082	Save Settings	Data=Don't Care	- W		
40083	<Reserved>				
SYSTEM PARAMETERS					
40091	Generator Connection	0-2	R W	0=3ph L-L 1=3ph L-N 2=1ph A-B	
40092	NFPA Level	0-2	R W	0 =Off 1 =Level 1 2 =Level 2	
40093	Unit System	0-1	R W	0=English 1=Metric	
40094	Battery Volts	0-1	R W	0=12 VDC 1=24 VDC	
40095	Generator Frequency	0-1	R W	0=50 HZ 1=60 HZ	
40096	Rated Engine RPM	750-3600	R W		RPM
40097	Rated Engine RPM Minimum	750	R -		RPM
40098	Rated Engine RPM Maximum	3600	R -		RPM
40099	Rated Engine RPM Stepsize	50	R -		RPM
40100	Number Flywheel Teeth	50-500	R W		
40101	Number Flywheel Teeth Minimum	50	R -		
40102	Number Flywheel Teeth Maximum	500	R -		
40103	Number Flywheel Teeth Stepsize	1	R -		
40104	Genset KW Rating	25-9999	R W		KWatt
40105	Genset KW Rating Minimum	25	R -		KWatt
40106	Genset KW Rating Maximum	9999	R -		KWatt
40107	Genset KW Rating Stepsize	1	R -		KWatt
40108	No Load Cool Down Time	0-60	R W		Minutes
40109	No Load Cool Down Time Minimum	0	R -		Minutes
40110	No Load Cool Down Time Maximum	60	R -		Minutes
40111	No Load Cool Down Time Stepsize	5	R -		Minutes
40112	Alternator Frequency Rated	100-900	R W		Hertz
40113	Alternator Frequency Rated Minimum	100	R -		Hertz

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40114	Alternator Frequency Rated Maximum	900	R -		Hertz
40115	Alternator Frequency Rated Stepsize	1	R -		Hertz
GENERATOR PT PRIMARY					
40121	Voltage(a)	1-15000	R W	DP	VoltsAC x 10000
40122	Voltage(b)		R W	DP	VoltsAC
40123	Voltage Minimum(a)	1	R -	DP	VoltsAC x 10000
40124	Voltage Minimum(b)		R -	DP	VoltsAC
40125	Voltage Maximum(a)	15000	R -	DP	VoltsAC x 10000
40126	Voltage Maximum(b)		R -	DP	VoltsAC
40127	Voltage Stepsize(a)	1	R -	DP	VoltsAC x 10000
40128	Voltage Stepsize(b)		R -	DP	VoltsAC
GENERATOR PT SECONDARY					
40129	Voltage	1-480	R W		VoltsAC
40130	Voltage Minimum	1	R -		VoltsAC
40131	Voltage Maximum	480	R -		VoltsAC
40132	Voltage Stepsize	1	R -		VoltsAC
GENERATOR CT PRIMARY					
40133	Current	1-5000	R W		AmpsAC
40134	Current Minimum	1	R -		AmpsAC
40135	Current Maximum	5000	R -		AmpsAC
40136	Current Stepsize	1	R -		AmpsAC
BUS PT PRIMARY					
40141	Voltage(a)	1-15000	R W	DP	VoltsAC x 10000
40142	Voltage(b)		R W	DP	VoltsAC
40143	Voltage Minimum(a)	1	R -	DP	VoltsAC x 10000
40144	Voltage Minimum(b)		R -	DP	VoltsAC
40145	Voltage Maximum(a)	15000	R -	DP	VoltsAC x 10000
40146	Voltage Maximum(b)		R -	DP	VoltsAC
40147	Voltage Stepsize(a)	1	R -	DP	VoltsAC x 10000
40148	Voltage Stepsize(b)		R -	DP	VoltsAC
BUS PT SECONDARY					
40149	Voltage	1-480	R W		VoltsAC
40150	Voltage Minimum	1	R -		VoltsAC
40151	Voltage Maximum	480	R -		VoltsAC
40152	Voltage Stepsize	1	R -		VoltsAC
LOW FUEL PRE-ALARM					
40181	Enable	0-1	R W	0 =Off 1 =On	
40182	Threshold	10-100	R W		% Full Tank
40183	Minimum	10	R -		% Full Tank
40184	Maximum	100	R -		% Full Tank
40185	Stepsize	1	R -		% Full Tank
LOW COOL TEMP PRE-ALARM					
40186	Enable	0-1	R W	0 =Off 1 =On	
40187	Threshold	40-100	R W		DegF

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Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40188	Minimum	40	R -		DegF
40189	Maximum	100	R -		DegF
40190	Stepsize	1	R -		DegF
BATTERY OVERVOLTAGE PRE-ALARM					
40191	Enable	0-1	R W	0 =Off 1 =On	
40192	Threshold	140-160 (12V) 240-320 (24V)	R W		.1 VoltDC
40193	Minimum	140 / 240	R -		.1 VoltDC
40194	Maximum	160 / 320	R -		.1 VoltDC
40195	Stepsize	1	R -		.1 VoltDC
MAINTENANCE INTERVAL PRE-ALARM					
40196	Enable	0-1	R W	0 =Off 1 =On	
40197	Threshold	0-5000	R W		Hours
40198	Minimum	0	R -		Hours
40199	Maximum	5000	R -		Hours
40200	Stepsize	10	R -		Hours
ENGINE KW OVERLOAD PRE-ALARM					
40201	Enable	0-1	R W	0 =Off 1 =On	
40202	Threshold	95-140	R W		% of Rated
40203	Minimum	95	R -		% of Rated
40204	Maximum	140	R -		% of Rated
40205	Stepsize	1	R -		% of Rated
HIGH COOLANT TEMPERATURE PRE-ALARM					
40206	Enable	0-1	R W	0 =Off 1 =On	
40207	Threshold	100-280	R W		DegF
40208	Minimum	100	R -		DegF
40209	Maximum	280	R -		DegF
40210	Stepsize	1	R -		DegF
LOW OIL PRESSURE PRE-ALARM					
40211	Enable	0-1	R W	0 =Off 1 =On	
40212	Threshold	3-100	R W		PSI
40213	Minimum	3	R -		PSI
40214	Maximum	100	R -		PSI
40215	Stepsize	1	R -		PSI
LOW BATTERY VOLTAGE PRE-ALARM					
40216	Enable	0-1	R W	0 =Off 1 =On	
40217	Threshold	60-120 (12V) 120-240 (24V)	R W		.1 VoltDC
40218	Minimum	60 / 120	R -		.1 VoltDC
40219	Maximum	120 / 240	R -		.1 VoltDC
40220	Stepsize	1 (0.1 VDC)	R -		.1 VoltDC
40221	Pre-alarm Activation Time Delay	1-10	R W		Seconds
40222	Activation Time Delay Minimum	1	R -		Seconds
40223	Activation Time Delay Maximum	10	R -		Seconds
40224	Activation Time Delay Stepsize	1	R -		Seconds

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Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
WEAK BATTERY VOLTAGE PRE-ALARM					
40225	Enable	0-1	R W	0 =Off 1 =On	
40226	Threshold	40-80 (12V) 80-160 (24V)	R W		.1 VoltDC
40227	Minimum	40 / 80	R -		.1 VoltDC
40228	Maximum	80 / 160	R -		.1 VoltDC
40229	Stepsize	1 (0.1 VoltDC)	R -		.1 VoltDC
40230	Pre-alarm Activation Time Delay	1-10	R W		Seconds
40231	Activation Time Delay Minimum	1	R -		Seconds
40232	Activation Time Delay Maximum	10	R -		Seconds
40233	Activation Time Delay Stepsize	1	R -		Seconds
LOGON PASSWORD (40252-7)					
HIGH COOLANT TEMPERATURE ALARM					
40281	Enable	0-1	R W	0 =Off 1 =On	
40282	Shutdown Enable	0-1	R W	0 =Off 1 =On	
40283	Threshold	100-280	R W		DegF
40284	Minimum	100	R -		DegF
40285	Maximum	280	R -		DegF
40286	Stepsize	1	R -		DegF
40287	Arming Delay after Crank Disconnect	60	R W		Seconds
40288	Arming Delay Minimum	60	R -		Seconds
40289	Arming Delay Maximum	60	R -		Seconds
40290	Arming Delay Stepsize	0	R -		Seconds
LOW OIL PRESSURE ALARM					
40291	Enable	0-1	R W	0 =Off 1 =On	
40292	Shutdown Enable	0-1	R W	0 =Off 1 =On	
40293	Threshold	3-100	R W		PSI
40294	Minimum	3	R -		PSI
40295	Maximum	100	R -		PSI
40296	Stepsize	1	R -		PSI
40297	Arming Delay after Crank Disconnect	5-15	R W		Seconds
40298	Arming Delay Minimum	5	R -		Seconds
40299	Arming Delay Maximum	15	R -		Seconds
40300	Arming Delay Stepsize	1	R -		Seconds
OVERSPEED ALARM					
40301	Enable	0-1	R W	0 =Off 1 =On	
40302	Shutdown Enable	0-1	R W	0 =Off 1 =On	
40303	Threshold	105-140	R W		% of Rated
40304	Minimum	105	R -		% of Rated
40305	Maximum	140	R -		% of Rated
40306	Stepsize	1	R -		% of Rated
40307	Alarm Activation Time Delay	0-500	R W		MilliSec
40308	Activation Time Delay Minimum	0	R -		MilliSec

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40309	Activation Time Delay Maximum	500	R -		MilliSec
40310	Activation Time Delay Stepsize	10	R -		MilliSec
SENDER FAIL ALARMS					
40311	Coolant Temperature Sender Failure Alarm Enable	0-1	R W	0 =Off 1 =On	
40312	Oil Pressure Sender Failure Alarm Enable	0-1	R W	0 =Off 1 =On	
40314	Magnetic Pick-up Failure Alarm Enable	0-1	R W	0 =Off 1 =On	
40315	Loss of Generator Voltage Alarm Enable	0-1	R W	0 =Off 1 =On	
40316	Pre-alarm Buzzer Enable	0-1	R W	0 =Off 1 =On	
40317	Battery Charger Failure Pre-alarm Enable	0-1	R W	0 =Off 1 =On	
40318	Global Sender Failure Alarm Time Delay	1-10	R W		Seconds
40319	Coolant Temperature Sender Failure Alarm Activation Delay	5-30 (increment size of 5)	R W		Minutes
CRANKING PARAMETERS					
40351	Cranking Style	0-1	R W	0=Contin. 1=Cycle	
40352	Number of Crank Cycles	1-7	R W		
40353	Number of Crank Cycles Minimum	1	R -		
40354	Number of Crank Cycles Maximum	7	R -		
40355	Number of Crank Cycles Stepsize	1	R -		
40356	Cycle Crank Time	5-15	R W		Seconds
40357	Cycle Crank Time Minimum	5	R -		Seconds
40358	Cycle Crank Time Maximum	15	R -		Seconds
40359	Cycle Crank Time Stepsize	1	R -		Seconds
40360	Continuous Crank Time	1-60	R W		Seconds
40361	Continuous Crank Time Minimum	1	R -		Seconds
40362	Continuous Crank Time Maximum	60	R -		Seconds
40363	Continuous Crank Time Stepsize	1	R -		Seconds
40364	Crank Disconnect Limit	10-100	R W		% of Rated
40365	Crank Disconnect Limit Minimum	10	R -		% of Rated
40366	Crank Disconnect Limit Maximum	100	R -		% of Rated
40367	Crank Disconnect Limit Stepsize	1	R -		% of Rated
40368	Pre-crank Delay	0-30	R W		Seconds
40369	Pre-crank Delay Minimum	0	R -		Seconds
40370	Pre-crank Delay Maximum	30	R -		Seconds
40371	Pre-crank Delay Stepsize	1	R -		Seconds
40372	Pre-crank Contact after Disconnect	0-1	R W	0=Open 1=Closed	
SYSTEM MONITOR					
40374	Remaining Cooldown Time	0-60	R -		Minutes
40375	<Reserved>				

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Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40376	Active Speed Signal Sources	1-4	R -	1 =MPU 2 =ALT 3 =GEN 4 =NONE	
40377	Sender Failure Alarm Codes		R -	b0=Cool Temp b1=Oil Press b2 Reserved b3=Spd Signal b4=Gen Volt b5-b7 Not Used	
40378	Alarm Codes		R -	b0=Hi Cool Temp b1 Low Coolant Level b2=Airbox b3=E-Stop b4=Sender Fail b5=Over-crank b6=Over-speed b7=Low Oil Press	
40379	Pre-Alarm Codes		R -	b0=Hi Cool Temp b1=Low Cool Temp b2=Weak Batt b3=Low Batt b4 =Batt ov b5=Charger Fail b6=Service Due b7=kW Overload	
40380	Pre-Alarm Codes, Group 2		R -	b0=Low Oil Press b1=Low Fuel b2 Reserved b3 Reserved b4-b7 Not Used	
40381	Engine Coolant Temperature		R -		DegF
40382	Engine Oil Pressure		R -		PSI
40383	Battery Voltage		R -		.1 VoltDC
40384	Fuel Level		R -		% Full Tank
40385	Time Remaining until Maintenance		R -		Hours
40386	Accumulated Engine Runtime(a)		R -	DP	Minutes x 10000
40387	Accumulated Engine Runtime(b)		R -	DP	Minutes
40388	Accumulated Engine Runtime Warranty(a)		R W	DP	Minutes x 10000
40389	Accumulated Engine Runtime Warranty(b)		R W	DP	Minutes
40390	Engine Speed(a)		R -	DP	RPM x 10000
40391	Engine Speed(b)		R -	DP	RPM
40392	Engine Load(a)		R -	DP	%
40393	Engine Load(b)		R -	DP	%
GENERATOR MONITOR					
40394	Phase a-b RMS Voltage(a)		R -	DP	RMS Volt x10000
40395	Phase a-b RMS Voltage(b)		R -	DP	RMS Volt
40396	Phase b-c RMS Voltage(a)		R -	DP	RMS Volt x10000
40397	Phase b-c RMS Voltage(b)		R -	DP	RMS Volt
40398	Phase c-a RMS Voltage(a)		R -	DP	RMS Volt x10000
40399	Phase c-a RMS Voltage(b)		R -	DP	RMS Volt
40400	Phase a-n RMS Voltage(a)		R -	DP	RMS Volt x10000
40401	Phase a-n RMS Voltage(b)		R -	DP	RMS Volt
40402	Phase b-n RMS Voltage(a)		R -	DP	RMS Volt x10000

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40403	Phase b-n RMS Voltage(b)		R -	DP	RMS Volt
40404	Phase c-n RMS Voltage(a)		R -	DP	RMS Volt x10000
40405	Phase c-n RMS Voltage(b)		R -	DP	RMS Volt
40406	Bus RMS Voltage(a)		R -	DP	RMS Volt x10000
40407	Bus RMS Voltage(b)		R -	DP	RMS Volt
40408	Phase a RMS Current		R -		RMS Amps
40409	Phase b RMS Current		R -		RMS Amps
40410	Phase c RMS Current		R -		RMS Amps
40411	Phase a Apparent Power(a)		R -	DP	KVA x 10000
40412	Phase a Apparent Power(b)		R -	DP	KVA
40413	Phase b Apparent Power(a)		R -	DP	KVA x 10000
40414	Phase b Apparent Power(b)		R -	DP	KVA
40415	Phase c Apparent Power(a)		R -	DP	KVA x 10000
40416	Phase c Apparent Power(b)		R -	DP	KVA
40417	3 Phase Apparent Power(a)		R -	DP	KVA x 10000
40418	3 Phase Apparent Power(b)		R -	DP	KVA
40419	Phase a Power(a)		R -	DP	KWatt x 10000
40420	Phase a Power(b)		R -	DP	KWatt
40421	Phase b Power(a)		R -	DP	KWatt x 10000
40422	Phase b Power(b)		R -	DP	KWatt
40423	Phase c Power(a)		R -	DP	KWatt x 10000
40424	Phase c Power(b)		R -	DP	KWatt
40425	3 Phase power(a)		R -	DP	KWatt x 10000
40426	3 Phase power(b)		R -	DP	KWatt
40427	Total kW-Hours saved in EE (a)		R W	TP	KWH x 10000 x 10000
40428	Total kW-Hours saved in EE (b)		R W	TP	KWH x 10000
40429	Total kW-Hours saved in EE (x)		R W	TP	KWH
40430	Power Factor		R -		.01
40431	<Reserved>				
40432	<Reserved>				
40433	Generator Frequency		R -		.1 Hertz
40434	Bus Frequency		R -		.1 Hertz
40435	Total kW-Minutes since last save (a)		R -		kWm x 10000 x 10000
40436	Total kW-Minutes since last save (b)		R -		kWm x 10000
40437	Total kW-Minutes since last save (x)		R -		kWm
CONTIGUOUS WRITE BLOCK (REGROUPED PARAMETERS)					
40441	Generator Connection	0-2	R W	0=3ph L-L 1=3ph L-N 2=1ph A-B	
40442	NFPA Level	0-2	R W		
40443	Unit System	0-1	R W	0=English 1=Metric	
40444	Nominal Battery Voltage	0-1	R W	0=12 VDC 1=24 VDC	
40445	Generator Frequency	0-1	R W	0=50 HZ 1=60 HZ	
40446	Rated Engine RPM	750-3600	R W		RPM
40447	Number Flywheel Teeth	50-500	R W		
40448	Genset KW Rating	25-9999	R W		KWatt
40449	No Load Cool Down Time	0-60	R W		Minutes
40450	Alternator Frequency Rated	100-900	R W		Hertz

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Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40451	Generator Speed Mode	Individual Bits are 0 or 1	R W		Active Speed Signals b0=mag pick-up b1=generator b2=chg. alt. Gen. Phase Rotation b4=0 for A-B-C b4=1 for A-C-B Maintenance Timer b5=0 is active b5=1 to reset
GENERATOR PT PRIMARY					
40452	Voltage(a)	1-15000	R W	DP	VoltsAC x 10000
40453	Voltage(b)		R W	DP	VoltsAC
GENERATOR PT SECONDARY					
40454	Voltage	1-480	R W		VoltsAC
GENERATOR CT PRIMARY					
40455	Current	1-5000	R W		AmpsAC
40456	<Reserved>				
BUS PT PRIMARY					
40457	Voltage(a)	1-15000	R W	DP	VoltsAC x 10000
40458	Voltage(b)		R W	DP	VoltsAC
BUS PT SECONDARY					
40459	Voltage	1-480	R W		VoltsAC
LOW FUEL PRE-ALARM					
40460	Enable	0-1	R W	0 =Off 1 =On	
40461	Threshold	10-100	R W		% Full Tank
LOW COOL TEMP PRE-ALARM					
40462	Enable	0-1	R W	0 =Off 1 =On	
40463	Threshold	40-100	R W		DegF
BATTERY OVERVOLTAGE PRE-ALARM					
40464	Enable	0-1	R W	0 =Off 1 =On	
40465	Threshold	140-160 (12V) 240-320 (24V)	R W		.1 VoltDC
MAINTENANCE INTERVAL PRE-ALARM					
40466	Enable	0-1	R W	0 =Off 1 =On	
40467	Threshold	0-5000	R W		Hours
ENGINE KW OVERLOAD PRE-ALARM					
40468	Enable	0-1	R W	0 =Off 1 =On	
40469	Threshold	95-140	R W		% of Rated
HIGH COOLANT TEMPERATURE PRE-ALARM					
40470	Enable	0-1	R W	0 =Off 1 =On	
40471	Threshold	100-280	R W		DegF
LOW OIL PRESSURE PRE-ALARM					

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40472	Enable	0-1	R W	0 =Off 1 =On	
40473	Threshold	3-100	R W		PSI
LOW BATTERY VOLTAGE PRE-ALARM					
40474	Enable	0-1	R W	0 =Off 1 =On	
40475	Threshold	60-120 (12V) 120-240 (24V)	R W		.1 VoltDC
40476	Pre-alarm Activation Time Delay	1-10	R W		Seconds
WEAK BATTERY VOLTAGE PRE-ALARM					
40477	Enable	0-1	R W	0 =Off 1 =On	
40478	Threshold	40-80 (12V) 80-160 (24V)	R W		.1 VoltDC
40479	Pre-alarm Activation Time Delay	1-10	R W		Seconds
HIGH COOLANT TEMPERATURE ALARM					
40480	Enable	0-1	R W	0 =Off 1 =On	
40481	Shutdown Enable	0-1	R W	0 =Off 1 =On	
40482	Threshold	100-280	R W		DegF
40483	Arming Delay after Crank Disconnect	60	R W		Seconds
LOW OIL PRESSURE ALARM					
40484	Enable	0-1	R W	0 =Off 1 =On	
40485	Shutdown Enable	0-1	R W	0 =Off 1 =On	
40486	Threshold	3-100	R W		PSI
40487	Arming Delay after Crank Disconnect	5-15	R W		Seconds
OVERSPEED ALARM					
40488	Enable	0-1	R W	0 =Off 1 =On	
40489	Shutdown Enable	0-1	R W	0 =Off 1 =On	
40490	Threshold	105-140	R W		% of Rated
40491	Alarm Activation Time Delay	0-500	R W		MilliSec
SENDER FAIL ALARMS					
40492	Coolant Temperature Sender Failure Alarm Enable	0-1	R W	0 =Off 1 =On	
40493	Oil Pressure Sender Failure Alarm Enable	0-1	R W	0 =Off 1 =On	
40495	Magnetic Pick-up Failure Alarm Enable	0-1	R W	0 =Off 1 =On	
40496	Loss of Generator Voltage Alarm Enable	0-1	R W	0 =Off 1 =On	
40497	Pre-alarm Buzzer Enable	0-1	R W	0 =Off 1 =On	
40498	Battery Charger Failure Pre-alarm Enable	0-1	R W	0 =Off 1 =On	
40499	Global Sender Failure Alarm Time Delay	0-10	R W		Seconds
CRANKING PARAMETERS					
40500	Cranking Style	0-1	R W	0=Contin. 1=Cycle	
40501	Number of Crank Cycles	1-7	R W		
40502	Cycle Crank Time	5-15	R W		Seconds
40503	Continuous Crank Time	1-60	R W		Seconds

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Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40504	Crank Disconnect Limit	10-100	R W		% of Rated
40505	Pre-crank Delay	0-30	R W		Seconds
40506	Pre-crank Contact after Disconnect	0-1	R W	0=Open 1=Closed	
SYSTEM MONITOR					
40507	Accumulated Engine Runtime Warranty(a)		R W	DP	Minutes x 10000
40508	Accumulated Engine Runtime Warranty(b)		R W	DP	Minutes
CALIBRATION					
40509	Voltage Calibration A(a)		R W	DP	x 10000
40510	Voltage Calibration A(b)		R W	DP	x 1
40511	Voltage Calibration B(a)		R W	DP	x 10000
40512	Voltage Calibration B(b)		R W	DP	x 1
40513	Voltage Calibration C(a)		R W	DP	x 10000
40514	Voltage Calibration C(b)		R W	DP	x 1
40515	Voltage Calibration N(a)		R W	DP	x 10000
40516	Voltage Calibration N(b)		R W	DP	x 1
40517	Current Calibration A(a)		R W	DP	x 10000
40518	Current Calibration A(b)		R W	DP	x 1
40519	Current Calibration B(a)		R W	DP	x 10000
40520	Current Calibration B(b)		R W	DP	x 1
40521	Current Calibration C(a)		R W	DP	x 10000
40522	Current Calibration C(b)		R W	DP	x 1
40523	Current Calibration N(a)		R W	DP	x 10000
40524	Current Calibration N(b)		R W	DP	x 1
40525	Coolant Temperature 0(a)		R W	DP	x 10000
40526	Coolant Temperature 0(b)		R W	DP	x 1
40527	Coolant Temperature 1(a)		R W	DP	x 10000
40528	Coolant Temperature 1(b)		R W	DP	x 1
40529	Coolant Temperature 2(a)		R W	DP	x 10000
40530	Coolant Temperature 2(b)		R W	DP	x 1
40531	Coolant Temperature 3(a)		R W	DP	x 10000
40532	Coolant Temperature 3(b)		R W	DP	x 1
40533	Coolant Temperature 4(a)		R W	DP	x 10000
40534	Coolant Temperature 4(b)		R W	DP	x 1
40535	Coolant Temperature 5(a)		R W	DP	x 10000
40536	Coolant Temperature 5(b)		R W	DP	x 1
40537	Coolant Temperature 6(a)		R W	DP	x 10000
40538	Coolant Temperature 6(b)		R W	DP	x 1
40539	Coolant Temperature 7(a)		R W	DP	x 10000
40540	Coolant Temperature 7(b)		R W	DP	x 1
40541	Coolant Temperature 8(a)		R W	DP	x 10000
40542	Coolant Temperature 8(b)		R W	DP	x 1
40543	Coolant Temperature 9(a)		R W	DP	x 10000
40544	Coolant Temperature 9(b)		R W	DP	x 1
40545	Coolant Temperature 10(a)		R W	DP	x 10000
40546	Coolant Temperature 10(b)		R W	DP	x 1
40547	Coolant Temperature 11(a)		R W	DP	x 10000
40548	Coolant Temperature 11(b)		R W	DP	x 1
40549	Coolant Temperature 12(a)		R W	DP	x 10000
40550	Coolant Temperature 12(b)		R W	DP	x 1
40551	Coolant Temperature 13(a)		R W	DP	x 10000

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40552	Coolant Temperature 13(b)		R W	DP	x 1
40553	Oil Pressure 0(a)		R W	DP	x 10000
40554	Oil Pressure 0(b)		R W	DP	x 1
40555	Oil Pressure 1(a)		R W	DP	x 10000
40556	Oil Pressure 1(b)		R W	DP	x 1
40557	Oil Pressure 2(a)		R W	DP	x 10000
40558	Oil Pressure 2(b)		R W	DP	x 1
40559	Oil Pressure 3(a)		R W	DP	x 10000
40560	Oil Pressure 3(b)		R W	DP	x 1
40561	Oil Pressure 4(a)		R W	DP	x 10000
40562	Oil Pressure 4(b)		R W	DP	x 1
40563	Oil Pressure 5(a)		R W	DP	x 10000
40564	Oil Pressure 5(b)		R W	DP	x 1
40565	Oil Pressure 6(a)		R W	DP	x 10000
40566	Oil Pressure 6(b)		R W	DP	x 1
40567	Oil Pressure 7(a)		R W	DP	x 10000
40568	Oil Pressure 7(b)		R W	DP	x 1
40569	Oil Pressure 8(a)		R W	DP	x 10000
40570	Oil Pressure 8(b)		R W	DP	x 1
40571	Oil Pressure 9(a)		R W	DP	x 10000
40572	Oil Pressure 9(b)		R W	DP	x 1
40573	Oil Pressure 10(a)		R W	DP	x 10000
40574	Oil Pressure 10(b)		R W	DP	x 1
40575	Oil Pressure 11(a)		R W	DP	x 10000
40576	Oil Pressure 11(b)		R W	DP	x 1
40577	Oil Pressure 12(a)		R W	DP	x 10000
40578	Oil Pressure 12(b)		R W	DP	x 1
40579	Oil Pressure 13(a)		R W	DP	x 10000
40580	Oil Pressure 13(b)		R W	DP	x 1
SYSTEM MONITOR - Continuation					
40581	System Configuration	32, 64, 128	R W	32=AUTO 64=OFF 128=RUN	
40582	System State	0-5	R -	0=RESET 1=READY 2=CRANK 3=REST 4=RUN 5=ALARM	
CALIBRATION - Continuation					
40583	Phase angle (a)		R W	DP	
40584	Phase angle (b)		R W	DP	
GENERATOR MONITOR - Continuation					
40585	Power Factor State	0-3	R	0=+LAG 1=-LEAD 2=-LAG 3=+LEAD	

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APPENDIX C • TUNING PID SETTINGS

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APPENDIX C • TUNING PID SETTINGS

Introduction

The LSM-2020 (Load Share Module) and MGC-2000 Series utilize four controllers to accomplish synchronization, load sharing, reactive power sharing, speed trim, and voltage trim functions. The controllers are a voltage controller, a var/PF controller, a speed controller, and a kW load controller. The voltage and speed controllers are in effect when the MGC-2000 Series is synchronizing the generator to a bus. When synchronizing, these controllers adjust the speed and voltage output of the generator to match that of the bus. After the generator is paralleled to a bus that is not connected to utility power, the kW load controller controls the kW output of the machine to share real power equally on a percentage basis with the other generators on the bus. All generators participating in load sharing are connected together with analog load share lines or Ethernet inter-genset communications which are used to communicate load share information between the machines. When the generator is not paralleled to the utility, the var/PF controller utilizes inter-genset communications to accomplish reactive power sharing where each machine shares reactive power equally on a percentage basis with the other generators on the bus. When the generator is paralleled to the utility, the kW load controller causes the unit to produce wattage at a level equal to the base load set point. The var/PF controller can operate in either var or PF control mode when the generator is paralleled to the utility. When operating in var control mode, the machine will produce reactive power at a level equal to the kvar Setpoint setting. When in PF control mode, the var/PF controller will regulate the reactive power output of the machine to maintain the power factor specified by the PF Setpoint setting. The kW base load set point, the kvar set point, and the PF set point can be derived from either a user setting, or an analog input.

When the generator is paralleled to an islanded bus and load sharing is enabled, the speed trim function, if enabled in all machines on the bus, will ensure that the bus frequency is maintained at the frequency set by the speed trim setting. Speed trim is in effect only in the situation where the generator breaker is closed to an islanded bus and load control and speed trim are enabled. Speed trim is not in effect when the breaker is open, since the default mode when the breaker is open is droop, and speed trim would counteract droop. Speed trim is not in effect when the breaker is closed unless load control is enabled. When load control is enabled, it is possible that integral action in PID controller for kW Load control could cause the system frequency to drift, and speed trim can be employed to counteract the drift.

When the generator is paralleled to an islanded bus and the kvar controller is enabled to accomplish kvar sharing, the voltage trim function, if enabled in all machines on the bus, will ensure that the bus voltage of the system is maintained at a voltage equal to the Rated Voltage Setpoint of the machines. Voltage trim is in effect only in the situation where the generator breaker is closed to an islanded bus and kvar control and voltage trim are enabled. Voltage trim is not in effect when the breaker is open, since the default mode when the breaker is open is droop, and voltage trim would counteract droop. Voltage trim is not in effect when the breaker is closed unless kvar control is enabled. When kvar control is enabled, it is possible that integrator action in PID controller for kvar control could cause the system voltage to drift, and voltage trim can be employed to counteract the drift.

The load share module utilizes PID (Proportional, Integral, Derivative) Control to accomplish kW and kvar load sharing, speed control, and voltage control. A brief description of the three 3 main tuning parameters, and their effects on system behavior, is presented below.

- K_p - *Proportional Gain* - The proportional term makes a change to the output that is proportional to the current error value. The proportional response can be adjusted by multiplying the error by a constant K_p, called the proportional gain. Larger K_p typically means faster response since the larger the error, the larger the feedback to compensate. An excessively large proportional gain will lead to process instability.
- K_i - *Integral Gain* - The contribution from the integral term is proportional to both the magnitude of the error and the duration of the error. Some integral gain is required in order for the system to achieve zero steady-state error. The integral term (when added to the proportional term) accelerates the movement of the process towards the set point and eliminates the residual steady-state error that occurs with a proportional only controller. Larger K_i implies steady state errors are eliminated more quickly. The tradeoff is larger overshoot: any negative error integrated during transient response must be integrated away by positive error before reaching steady state.
- K_d - *Derivative Gain* - The derivative term slows the rate of change of the controller output and is used to reduce the magnitude of the overshoot produced by the integral component and improve the combined controller-process stability. However, differentiation of a signal amplifies noise in

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the signal, and thus, this term in the controller may be sensitive to noise in the error term, and can cause a process to become unstable if the noise and the derivative gain are sufficiently large. Larger K_d decreases overshoot, but slows down transient response and may lead to instability. In general K_d is not recommended in the MGC controllers unless testing shows that it benefits system performance.

Table C-1 shows the effects of increasing parameters.

Table C-1. Effects of Increasing Parameters

Parameter	Rise Time	Overshoot	Setting Time	Steady State Error
K_p	Decrease	Increase	Small Change	Decrease
K_i	Decrease	Increase	Increase	Eliminate
K_d	Small Change	Decrease	Decrease	None

Tuning Procedures

Prior to performing any controller tuning, it is strongly recommended that Generator Protection, in particular Reverse Power protection and Loss of Excitation protection, should be configured to protect the machine in case any reverse power or reverse var situations occur during the tuning process.

Voltage Controller Tuning Procedure

The voltage controller is tuned prior to the speed controller. Set all K_p, K_i, and K_d gains in the voltage controller, speed controller, kW load controller and var/PF controller to 0. Set the K_g values to 0.1.

The voltage controller is active during synchronization when the MGC-2000 Series is trying to close the generator breaker, and also when the generator breaker is closed and the generator is not paralleled to utility power and the voltage trim function is enabled. In order to tune the voltage controller, the unit is operated with the generator breaker closed and voltage trim enabled. We can then change the rated voltage of the machine to change the voltage controller set point and observe the response. Set the Voltage Trim function and the var/PF controller to enabled, and verify in logic that when the generator breaker is closed, the Parallel to mains logic element is not true. When the engine is running and the generator breaker is closed, the voltage controller should be operating to accomplish voltage trim, driving the system voltage to the level set by the Rated Voltage setting in the system ratings.

K_p - Proportional Gain

Each time K_p is set, we will modify the rated voltage setting in the Rated Data and observe how the generator output voltage responds to the change.

Set an initial value of 1 for K_p. Start the generator and close the generator breaker to the dead bus.

Verify that the generator's output approaches the Rated Voltage in a stable manner. Since K_i is zero at this point, there may be a difference between the generator's output and the Rated Voltage set point. The important thing is that the generator's output behaves in a stable manner. If it is not stable, lower the value of K_p and repeat.

Now modify the Rated Voltage setting to a level that is 3% to 5% higher than the initial setting. Verify that the generator's output approaches the new value in a stable manner. Set the Rated Voltage Setting back to its original value and observe the generator's output. Next, modify the Rated Voltage setting to a level that is 3% to 5% lower than the initial setting observe the generator output voltage. Finally, set the Rated Voltage back to its initial value, and observe the generator output voltage to verify it operates in a stable manner.

Repeat this procedure, raising K_p until the system begins to operate in an unstable manner, and then lower it back to the highest value where stable operation was achieved. Note that if the generator output is not coming very close to the set point value, it is often an indication that the value of K_p is too low.

If it is not possible to obtain stable voltage operation, it may be necessary to reduce the control gains in the voltage regulator which has its analog bias input driven by the LSM-2020.

K_i - Integral Gain

Set the initial value of K_i to be a tenth of the value set for K_p. Start the generator and close the generator breaker to the dead bus.

Next, modify the Rated Voltage setting to a level that is 3% to 5% higher than the initial setting. Verify that the generator's output approaches the new value in a stable manner. Set the Rated Voltage Setting back to its original value and observe the generator's output. Next, modify the Rated Voltage setting to a level that is 3% to 5% lower than the initial setting observe the generator output voltage. Finally, set the Rated Voltage back to its initial value, and observe the generator output voltage to verify it operates in a stable manner. If stable operation is not achievable, it may be necessary to lower the value for K_i. Repeat this procedure, raising K_i until the system is unstable, and then lower it to the highest value that achieved stable operation.

K_d - Derivative Gain

If the performance with K_p and K_i alone is satisfactory, it is recommended K_d be left at a value of zero. K_d can amplify noise in a system so it should be used with great care. Otherwise K_d, the derivative controller gain, can be used in conjunction with T_d, the noise filter constant, to reduce overshoot obtained with PI control. Setting K_d and T_d is an iterative process.

Tuning of K_d can be achieved through the following steps. Set an initial value of K_d that is $1/10^{th}$ the value of K_p or $1/10^{th}$ the value of K_i, whichever is smaller. Start the generator and close the generator breaker to the dead bus.

Modify the Rated Voltage setting to a level that is 3% to 5% higher than the initial setting. Verify that the generator's output approaches the new value in a stable manner. Set the Rated Voltage Setting back to its original value and observe the generator's output. Next, modify the Rated Voltage setting to a level that is 3% to 5% lower than the initial setting observe the generator output voltage. Finally, set the Rated Voltage back to its initial value, and observe the generator output voltage to verify it operates in a stable manner. Repeat with higher values of K_d until the system begins to be unstable, then enter half this value as the K_d gain.

If high frequency noise seems to be entering the system, T_d is the constant of the low pass filter which filters the controller input to reduce the effects of such interference when derivative control is employed. T_d ranges from 0 to 1 with an increment of 0.001. T_d=0 is no filtering, T_d=1 is heaviest filtering. If T_d adjustment is necessary, set T_d to 0.001 and see if the noise induced behavior is reduced. Raise T_d until desired reduction of noise behavior is achieved. Once T_d has been set, tune K_d again. If noise again appears to be a problem, adjust T_d until desired behavior is achieved, then retune K_d.

Speed Controller Tuning Procedure

The speed controller is tuned prior to the kW load controller. Set Load Control to enabled, and speed trim to enabled. Set all K_p, K_i, and K_d gains in both speed controller and kW load controller to 0. Set the K_g values to 0.1.

K_p - Proportional Gain

Set an initial value of 1 for K_p. Start the generator and close the breaker to the dead bus.

Each time K_p is set, execute step responses in the following manner to observe the machine's response to the change in the Speed Trim set point.

Next, modify the Speed Trim set point to a level that is one or two hertz higher than the initial setting. Verify that the generator's output frequency approaches the new value in a stable manner. Set the Speed Trim set point back to its original value and observe the generator's output frequency. Next, modify the Speed Trim set point to a level that is one or two hertz lower than the initial setting observe the generator output frequency. Finally, set the Speed Trim set point back to its initial value, and observe the generator frequency to verify it operates in a stable manner.

Since K_i is zero at this point, there may be some difference between the generator's output and the speed it is trying to reach. The important thing is that the generator's output behaves in a stable manner. If the system is unstable, lower K_p and repeat.

Repeat this procedure, raising K_p until the system begins to operate in an unstable manner, and then lower it back to the highest value where stable operation is attained. Note that if the generator output is not coming very close to the set point value, it is often an indication that the value of K_p is too low.

If it is not possible to obtain stable speed operation, it may be necessary to reduce the control gains in the governor which has its analog bias input driven by the LSM-2020.

K_i - Integral Gain

Set the initial value of K_i to be a tenth of the value set for K_p. Start the generator and close the breaker to the dead bus.

Next, modify the Speed Trim set point to a level that is one or two hertz higher than the initial setting. Verify that the generator's output frequency approaches the new value in a stable manner. Set the Speed Trim set point back to its original value and observe the generator's output frequency. Next, modify the Speed Trim set point to a level that is one or two hertz lower than the initial setting observe the generator output frequency. Finally, set the Speed Trim set point back to its initial value, and observe the generator output frequency to verify it operates in a stable manner. If stable operation is not achievable it may be necessary to lower the value for K_i. Repeat this procedure, raising K_i until the system is unstable, and then lower it to the highest value that achieved stable operation.

K_d - Derivative Gain

If the performance with K_p and K_i alone is satisfactory, it is recommended you leave K_d at a value of zero. K_d can amplify noise in a system so it should be used with great care. Otherwise K_d, the derivative controller gain, can be used in conjunction with T_d, the noise filter constant, to reduce overshoot obtained with P_i control. Setting K_d and Td is an iterative process which can be accomplished by performing the following steps.

Set an initial value of K_d that is 1/10th the value of K_p or 1/10th the value of K_i, whichever is smaller.

Modify the Speed Trim set point to a level that is one or two hertz higher than the initial setting. Verify that the generator's output approaches the new value in a stable manner. Set the Speed Trim set point back to its original value and observe the generator's output frequency. Next, modify the Speed Trim set point to a level that is one or two hertz lower than the initial setting observe the generator output frequency. Finally, set the Speed Trim set point back to its initial value, and observe the generator output frequency to verify it operates in a stable manner. Repeat with higher values of K_d until the system begins to be unstable, and then enter half this value as the K_d gain.

If high frequency noise seems to be entering the system, T_d is the constant of the low pass filter which filters the controller input to reduce the effects of such interference when derivative control is employed. T_d ranges from 0 to 1 with an increment of 0.001. T_d=0 is no filtering, T_d=1 is heaviest filtering. If T_d adjustment is necessary, set T_d to 0.001 and see if the noise induced behavior is reduced. Raise T_d until desired reduction of noise behavior is achieved. Once T_d has been set, tune K_d again. If noise again appears to be a problem, adjust T_d until desired behavior is achieved, then retune K_d.

var/PF Controller Tuning Procedure

Once desired voltage controller performance is obtained, the var/PF controller can be tuned. Two tuning methods are presented, one where the machine is paralleled to the utility to tune systems that are used for utility parallel operation and a second method where machines are paralleled together to tune systems employing island parallel operation.

var/PF Controller Tuning Procedure Using Parallel to Mains Operation

In Parallel to Mains operation the var/PF controller regulates the kvar output of the machine at a level specified by the kvar Setpoint % setting when the control mode is kvar control, or it regulates the kvar output to maintain the power factor specified by the PF Setpoint setting when the control mode is set to PF control.

Set the K_p, K_i, and K_d gains in the var/PF controller to 0. Set the K_g value to 0.1. Enable the var/PF controller, and set the control mode to Var Control. The generator must be paralleled to the utility (as indicated by the Parallel to Mains element in logic) in any of the tuning steps where the system is being tested for stable operation.

K_p - Proportional Gain

Set an initial value of K_p = 1 in the var/PF Controller. Enable the var/PF controller, and set the control mode to Var Control.

Set K_p on var/PF controller. Synchronize the generator to the utility so that var control becomes active. Verify that stable var control occurs. If the var control seems unstable, lower K_p and try again. Assuming operation appears stable, change the var setpoint in 10% steps and check for stable operation. Since K_i is zero at this point, there may be some error. Most importantly, verify that stable var control is achieved.

Raise K_p and repeat the test until unstable operation occurs. Then lower K_p to the highest value where stable operation was attained.

If it is not possible to obtain stable var controller operation, it may be necessary to reduce the control gains in the voltage regulator which has its bias input driven by the LSM-2020.

K_i - Integral Gain

Set the initial value of K_i to be a tenth of the value set for K_p.

Each time K_i is set, synchronize the generator to the utility so that var control becomes active. Check that operation appears stable. Change the var setpoint in 10% steps and check for stable operation. If the system is not stable, lower K_i and repeat the test.

Repeat this procedure, raising K_i until the system is unstable, and then lower it to the highest value for which stable operation is achieved.

K_d - Derivative Gain

If the performance with K_p and K_i alone is satisfactory, it is recommended K_d be left at a value of zero. K_d can amplify noise in a system so it should be used with great care. Otherwise K_d, the derivative controller gain, can be used in conjunction with T_d, the noise filter constant, to reduce overshoot obtained with PI control. Setting K_d and T_d is an iterative process. Start with small values of K_d such as $1/10^{th}$ the value of K_p or $1/10^{th}$ the value of K_i, whichever is smaller.

Tuning of K_d can be achieved through the following steps. Set an initial value of K_d, then synchronize the generator to the utility so that var control becomes active, and check for stability. Change the var setpoint in 10% steps and check for stable operation. Raise K_d, repeating the tests until the system is unstable, and then lower it to half the value where instability is first attained.

If high frequency noise seems to be entering the system, T_d is the constant of the low pass filter which filters the controller input to reduce the effects of such interference when derivative control is employed. T_d ranges from 0 to 1 with an increment of .001. T_d=0 is no filtering, T_d=1 is heaviest filtering. If T_d adjustment is necessary, set T_d to 0.001 and see if the noise induced behavior is reduced. Raise T_d until desired reduction of noise behavior is achieved. Once T_d has been set, tune K_d again. If noise again appears to be a problem, adjust T_d until desired behavior is achieved, then retune K_d.

var/PF Controller Tuning Procedure Using Multiple Machines in Island Parallel operation

In Island Parallel operation the var/PF controller regulates the kvar output of the machine to a level determined from inter-genset communications to accomplish kvar sharing with the other machines in the system. When properly tuned, the var/PF controller regulates the kvar output of the machine to a level equal to the average system kvar load, on a percentage of capacity basis. Thus, each machine will share kvar equally on a percentage of capacity basis.

The procedure below is written for the case where you have two machines that need to be tuned. Thus, any time a PID gain change is made, the change should be replicated in both machines before any testing for stability.

If a machine is available that is already tuned, but another one needs tuned against it, the following procedure still applies, except that PID values in the machine that have already been tuned should not be changed.

K_p - Proportional Gain

On both machines set the K_p, K_i, and K_d gains in var/PF controller to 0. Set the K_g value to 0.1. Set an initial value of 1 for K_p.

Close the breaker of the first machine onto a load. Parallel the second generator and check for stable kvar sharing between the two machines. Then, open the generator breaker on the second generator and check that both units are still stable. Since K_i is zero at this point, there may be some error in the kvar sharing. The important thing is to verify stable sharing is achieved. Repeat for various levels of kvar load if a means of varying kvar load is available.

Raise K_p in both machines and repeat the test until unstable operation occurs. Lower K_p to the highest value yielding stable operation. If one machine becomes unstable before the other as gains are raised, it may be necessary to do any further gain increases in only one machine. If the machines are not similar, you may end up with different gains in each machine. If it is not possible to obtain stable kvar sharing, it may be necessary to reduce the control gains in the AVR which has its analog bias input driven by the LSM-2020.

K_i - Integral Gain

Set the initial value of K_i to be a tenth of the value set for K_p in both machines.

Each time K_i is set in both machines, parallel the machines and check for stable kvar sharing. Then, open the generator breaker on the second generator and check that both units are still stable. If the system is not stable, lower K_i and repeat the test.

Repeat this procedure, raising K_i in both machines until the system is unstable, and then lower it to the highest value yielding stable operation.

Repeat for various levels of kvar load if a means of varying kvar load is available.

K_d-Derivative Gain

If the performance with K_p and K_i alone is satisfactory, it is recommended K_d be left at a value of zero. K_d can amplify noise in a system so it should be used with great care. Otherwise K_d, the derivative controller gain, can be used in conjunction with T_d, the noise filter constant, to reduce overshoot obtained with PI control. Setting K_d and T_d is an iterative process.

In both machines start with mall values of K_d that are 1/10th K_p or 1/10th K_i, whichever is smaller. Tuning of K_d can be achieved through the following steps. Set kvar control K_d in both machines, parallel them together, and check for stability. Then, drop the second generator and check that both units are still stable. Raise K_d in both machines until the system is unstable, and then lower it to half the value where instability is first attained. Test at various levels of kvar load if a means of varying kvar load is available.

If high frequency noise seems to be entering the system, T_d is the constant of the low pass filter which filters the controller input to reduce the effects of such interference when derivative control is employed. T_d ranges from 0 to 1 with an increment of 0.001. T_d=0 is no filtering, T_d=1 is heaviest filtering. If T_d adjustment is necessary, set T_d to 0.001 and see if the noise induced behavior is reduced. Raise T_d until desired reduction of noise behavior is achieved. Once T_d has been set, tune K_d again. If noise again appears to be a problem, adjust T_d until desired behavior is achieved, then retune K_d.

kW Load Controller Tuning Procedure

Once desired voltage and speed controller performance is obtained, the kW load controller can be tuned.

Two tuning methods are presented, one where the machine is paralleled to the utility to tune systems that are used for utility parallel operation and a second method where machines are paralleled together to tune systems employing island parallel operation.

kW Load Controller Tuning Procedure Using Parallel to Mains Operation

In Parallel to Mains operation the kW Load Controller regulates the kW output of the machine to the level of kW indicated by the Base Load Level setting.

Set the K_p, K_i, and K_d gains in the kW Load Controller to 0. Set the K_g value to 0.1. Enable the kW Load Controller. The generator must be paralleled to the utility (as indicated by the Parallel to Mains element in logic) in any of the tuning steps where the system is being tested for stable operation.

K_p - Proportional Gain

Set an initial value of K_p = 1 in the kW Load Controller.

Set K_p on kW Load Controller. Synchronize the generator to the utility so that kW control becomes active. Verify that stable kW control occurs. If the kW control seems unstable, lower K_p and try again. Assuming operation appears stable, change the base load setpoint in 10% steps and check for stable operation. Since K_i is zero at this point, there may be some error. Most importantly, verify stable kW control is achieved.

Raise K_p and repeat the test until unstable operation occurs. Then lower K_p to the highest value where stable operation was attained.

If it is not possible to obtain stable kW controller operation, it may be necessary to reduce the control gains in the engine governor which has its bias input driven by the LSM-2020.

K_i - Integral Gain

Set the initial value of K_i to be a tenth of the value set for K_p.

Each time K_i is set, synchronize the generator to the utility so that kW control becomes active. Check that operation appears stable. Change the base load setpoint in 10% steps and check for stable operation. If the system is not stable, lower K_i and repeat the test.

Repeat this procedure, raising K_i until the system is unstable, and then lower it to the highest value yielding stable operation.

K_d - Derivative Gain

If the performance with K_p and K_i alone is satisfactory, it is recommended K_d be left at a value of zero. K_d can amplify noise in a system so it should be used with great care. Otherwise K_d, the derivative controller gain, can be used in conjunction with T_d, the noise filter constant, to reduce overshoot obtained with P_i control. Setting K_d and T_d is an iterative process. Start with small values of K_d such as 1/10th the value of K_p or 1/10th the value of K_i, whichever is smaller.

Tuning of K_d can be achieved through the following steps. Set an initial value of K_d, then synchronize the generator to the utility so that kW control becomes active, and check for stability. Change the base load setpoint in 10% steps and check for stable operation. Raise K_d, repeating the tests until the system is unstable, and then lower it to half the value where instability is first attained.

If high frequency noise seems to be entering the system, T_d is the constant of the low pass filter which filters the controller input to reduce the effects of such interference when derivative control is employed. T_d ranges from 0 to 1 with an increment of 0.001. T_d=0 is no filtering, T_d=1 is heaviest filtering. If T_d adjustment is necessary, set T_d to 0.001 and see if the noise induced behavior is reduced. Raise T_d until desired reduction of noise behavior is achieved. Once T_d has been set, tune K_d again. If noise again appears to be a problem, adjust T_d until desired behavior is achieved, then retune K_d.

kW Load Controller Tuning Procedure Using Multiple Machines in Island Parallel Operation

In Island Parallel operation the kW Load Controller regulates the kW output of the machine to a level determined from the analog load share line or inter-genset communications to accomplish kW sharing with the other machines in the system. When properly tuned, the kW controller regulates the kW output of the machine to a level equal to the average system kW load, on a percentage of capacity basis. Thus, each machine will share kW equally on a percentage of capacity basis.

The procedure below is written for the case where two machines need to be tuned. Thus, any time a PID gain change is made, the change should be replicated in both machines before any testing for stability.
If a machine is available that is already tuned, but you need to tune another one against it, the following procedure still applies, except that PID values in the machine that has already been tuned should not be changed.

K_p - Proportional Gain

Disable the Speed Trim function in all machines when tuning the kW load controller gains.

On both machines set the K_p, K_i, and K_d gains in kW load controller to 0. Set the K_g value to 0.1. Set an initial value of 1 for K_p.

Close the breaker of the first machine onto a load. Parallel the second generator and check for stable load sharing between the two machines. Then open the generator breaker on the second generator and check that both units are still stable. Since K_i is zero at this point, there may be error in the load sharing. The important thing is to verify stable load sharing is achieved.

Raise K_p in both machines and repeat the test until unstable operation occurs. Lower K_p to the highest value yielding stable operation. If one machine becomes unstable before the other as gains are raised, it may be necessary to do any further gain increases in only one machine. If the machines are not similar, you may end up with different gains in each machine. If it is not possible to obtain stable kW operation, it may be necessary to reduce the control gains in the governor which has its analog bias input driven by the LSM-2020. Test at various levels of kW load if a means of varying kW load is available.

K_i - Integral Gain

Set the initial value of K_i to be a tenth of the value set for K_p in both machines.

Each time K_i is set in both machines, parallel the machines and check for stable load sharing then open the generator breaker on the second generator and check that both units are still stable. If the system is not stable, lower K_i and repeat the test. Test at various levels of kW load if a means of varying kW load is available. Repeat this procedure, raising K_i in both machines until the system is unstable, and then lower it to the highest value yielding stable operation.

K_d-Derivative Gain

If the performance with K_p and K_i alone is satisfactory, it is recommended K_d be left at a value of zero. K_d can amplify noise in a system so it should be used with great care. Otherwise K_d, the derivative controller gain, can be used in conjunction with T_d, the noise filter constant, to reduce overshoot obtained with PI

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control. Setting K_d and T_d is an iterative process. In both machines start with small values of K_d that are $1/10^{th}$ K_p or $1/10^{th}$ K_i, whichever is smaller.

Tuning of K_d can be achieved through the following steps. Set load control K_d in both machines, parallel them together, and check for stability. Then, drop the second generator and check that both units are still stable. Raise K_d in both machines until the system is unstable, and then lower it to half the value where instability is first attained. Test at various levels of kW load if a means of varying kW load is available.

If high frequency noise seems to be entering the system, T_d is the constant of the low pass filter which filters the controller input to reduce the effects of such interference when derivative control is employed. T_d ranges from 0 to 1 with an increment of 0.001. T_d=0 is no filtering, T_d=1 is heaviest filtering. If T_d adjustment is necessary, set T_d to 0.001 and see if the noise induced behavior is reduced. Raise T_d until desired reduction of noise behavior is achieved. Once T_d has been set, tune K_d again. If noise again appears to be a problem, adjust T_d until desired behavior is achieved, then retune K_d.

Generic Gains for Multiple Machine Types

The following method is suggested for determining generic gains for multiple machine types.

1) Decide what levels of reverse power and reverse var (loss of excitation) protection are needed.
2) Once the criteria of step 1 have been established, tune a unit so that one machine can be paralleled to another unit at no load and not cause any trips.
3) Parallel two machines onto a load, and verify that acceptable load sharing occurs.
4) Add and drop loads with machines paralleled to verify acceptable load sharing occurs, and no trips occur.
5) Once the settings are deemed “good”, save them as initial settings for a given machine configuration for all future jobs. The settings shouldn’t need changed unless there is tripping or load sharing characteristics need to be changed.
6) Test the units paralleled under no load and verify that no trips occur.
7) Parallel two machines onto a load, and verify that acceptable load sharing occurs.
8) Add and drop loads with machines paralleled to verify acceptable load sharing occurs and no trips occur.
9) If the settings for a particular machine type need to be modified, keep those settings to be used as initial settings for all future machines of that type.
10) Test every machine with steps 6, 7, and 8.

It is not expected that one set of numbers works for all machines, but it is probable to have 6 to 12 sets of settings that cover a wide range of machine sizes and engine manufacturers. However, once a set of gains has been determined for a particular machine type, the same gains should work in all identical machines.

APPENDIX D • MTU FAULT CODES

Introduction

MTU fault codes displayed by the MGC-2000 Series are listed in Table D-1.

Table D-1. MTU Fault Codes

Fault Code Number	String	Description
3	HI T FUEL	Fuel temperature too high (limit 1).
4	SS T FUEL	Fuel temperature too high (limit 2).
5	HI T CHRG AIR	Charge air temperature too high (limit 1).
6	SS T CHRG AIR	Air temperature too high (limit 2).
9	HI T INTERCOOLER	Coolant temperature of InterCooler too high (limit 1).
10	SS T INTERCOOLER	Coolant temperature of InterCooler too high (limit 2)
15	LO P LUBE OIL	Pressure of lube oil too low (limit 1).
16	SS P LUBE OIL	Pressure of lube oil too low (limit 2).
19	HI T EXHAUST A	Exhaust gas temperature (A-side) too high (limit 1).
20	SS T EXHAUST A	Exhaust gas temperature (A-side) too high (limit 2).
21	HIT T EXHAUST B	Exhaust gas temperature (B-side) too high (limit 1).
22	SS T EXHAUST B	Exhaust gas temperature (B-side) too high (limit 2).
23	LO COOLANT LEVEL	Coolant level too low (limit 1).
24	SS COOLANT LEVEL	Coolant level too low (limit 2).
25	HI P DIFF LUBE OIL	Differential pressure of oil filter too high (limit 1).
26	SS P DIFF LUBE OIL	Differential pressure of oil filter too high (limit 2).
27	HI LEVEL LEAKAGE FUEL	Level of leakage fuel too high (limit 1).
29	HI ETC IDLE SPD TOO HI	Idle speed of one of the switchable chargers too high.
30	SS ENGINE OVERSPEED	Engine overspeed (limit 2).
31	HI ETC1 OVERSPEED	Speed of basic charger too high (limit 1).
32	SS ETC1 OVERSPEED	Speed of basic charger too high (limit 2).
33	L1 P FUELFLT DIF	Differential pressure of fuel filter too high (limit 1).
36	HI ETC2 OVERSPEED	Speed of 1st switchable charger too high (limit 1).
37	SS ETC2 OVERSPEED	Speed of 1st switchable charger too high (limit 2).
38	AL ETC SPEED DEVIATION	Speed deviation between basic turbo charger and one of the switchable chargers.
39	AL ETC2 CUTIN FAIL	Switching of charger ETC2 failed.
44	LO LEVEL INTRCLR	Coolant level of intercooler too low (limit 1).
45	FAULT L2 LEVEL INTRCLR	Coolant level of intercooler too low (limit 2).
51	HI T LUBE OIL	Lube oil temperature too high (limit 1).
52	SS T LUBE OIL	Lube oil temperature too high (limit 2).
53	HI T INTAKE AIR	Air intake temperature high (Limit 1).
54	HIHI T INTAKE AIR	Air intake temperature high (Limit 2).
57	LO P COOLANT	Coolant pressure too low (limit 1).
58	SS P COOLANT	Coolant pressure too low (limit 2).
59	SS T COOLANT L3	Coolant temperature too high/too low (limit 3).
60	SS T COOLANT L4	Coolant temperature too high/too low (limit 4).
61	HI P ADCRANK CS L1	AdCrankCase pressure too high (Limit 1).
62	HI P ADCRANK CS L2	AdCrankCase pressure too high (Limit 2).
63	HI P CRANKCASE	Crankcase pressure too high (limit 1).
64	SS P CRANK CASE	Crankcase pressure too high (limit 2).
65	LO P FUEL	Fuel supply pressure too low (limit 1).

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Fault Code Number	String	Description
66	SS P FUEL	Fuel supply pressure too low (limit 2).
67	HI T COOLANT	Coolant temperature too high (limit 1).
68	SS T COOLANT	Coolant temperature too high (limit 2).
69	L1 T EXTERN 1	Limit 1, out of range.
70	L2 T EXTERN 1	Limit 2, out of range.
71	L1 T EXTERN 2	Limit 1, out of range.
72	L2 T EXTERN 2	Limit 2, out of range.
73	L1 P EXTERN 1	Limit 1, out of range.
74	L2 P EXTERN 1	Limit 2, out of range.
75	L1 P EXTERN 2	Limit 1, out of range.
76	L2 P EXTERN 2	Limit 2, out of range.
77	LIM EXT CLNT LEV	Binary signal 1 Plant active.
78	LIM INTERCLR LEV	Binary signal 2 Plant active.
79	L BIN EXTERN 3	Binary signal 3 Plant active.
80	L BIN EXTERN 4	Binary signal 4 Plant active.
81	AL RAIL LEAKAGE	Rail pressure gradient too low for Start or too high for Stop.
82	HI P FUEL COMON RAIL	Rail pressure > setpoint value.
83	LO P FUEL COMMON RAIL	Rail pressure < setpoint value.
85	HI T UMBLASSEN	'Umblasen' temperature too high (limit 1).
86	SS T UMBLASSEN	'Umblasen' temperature too high (limit 2).
89	SS SPEED TOO LOW	Engine is being stalled. The engine speed of the normally operating engine dropped below the limit from parameter 2.2500.027 Limit Engine Speed Low without any stop request. For safety reason the engine is stopped when this event occurs.
90	SS IDLE SPEED LOW	Idle speed not reached.
91	SS RELEASE SPEED LO	Acceleration speed not reached.
92	SS STARTER SPEED LO	Starter speed not reached.
93	SS PREHT TMP	Preheat temperature too low (limit 2).
94	LO PREHT TMP	Preheat temperature too low (limit 1).
95	AL PRELUBE FAULT	Prelubrication fault.
99	DUMMY FAULT	Dummy fault - this is not a real fault, but is used on some ECU's to test the fault reporting mechanism.
100	EDM NOT VALID	Checksum fault EDM.
101	IDM NOT VALID	Checksum fault IDM.
102	INVLD FUEL CNS 1	Fuel consumption counter detect.
103	INVLD FUEL CNS 2	Consumption monitoring 2 not valid.
104	ENG HRS INVALID 1	Engine Hours Counter defect.
105	ENG HRS INVALID 2	Checksum fault.
106	ERR REC1 INVALID	Checksum fault.
107	ERR REC2 INVALID	Checksum fault.
118	LO ECU SUPPLY VOLTS	Power supply voltage too low (limit 1).
119	LOLO ECU SUPPLY VOLTS	Power supply voltage too low (limit 2).
120	HI ECU SUPPLY VOLTS	Power supply voltage too high (limit 1).
121	HIHI ECU SUPPLY VOLTS	Power supply voltage too high (limit 2).
122	HI T ECU	Temperature of electronic too high (limit 1).
134	15v POSECU DEFCT	Internal electronic fault.
136	15V NEGECU DEFCT	Internal electronic fault.
137	L1 5V BUFFR TEST	Pressure-sensor fault, pressure-sensor wiring, or internal electronic fault.
138	SENSOR PWR DEFCT	Pressure-sensor fault, pressure-sensor wiring, or internal electronic fault.
139	L1 TE BUFFR TEST	Internal electronic fault.

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Fault Code Number	String	Description
140	TE BUF ECU DEFCT	Internal electronic fault.
141	AL POWER TOO HIGH	AL power too high.
142	MCR EXCEEDED 1 HR STR	AL MCR exceeded 1 hour.
143	BANK1 ECU DEFECT	Internal electronic fault.
144	BANK2 ECU DEFECT	Internal electronic fault.
145	15V GOODECU DFCT	Internal electronic fault.
147	AD TST1ECU DEFCT	Internal electronic fault.
149	AD TST2ECU DEFCT	Internal electronic fault.
151	AD TST3ECU DEFCT	Internal electronic fault.
170	MI MODULE FAIL	Module in maintenance indicator defect.
171	MI NOT ACTIVE	WI not active anymore.
172	TBO EXPIRED	TBO expired.
173	MODL WRITE LIMIT	EEPROM write limit reached.
176	AL LIFE DATA NA	No (fitting) LifeData-Backup-System is available within a delay time after ECU Reset.
177	AL LIFE DATA INCPLT	If the ADEC has to restore the LifeData from the backup-system and at least one checksum is wrong after the upload or the upload is incomplete, then this failure is set.
180	AL CAN1 NODE LOST	Connection to a node on CAN 1 lost.
181	AL CAN2 NODE LOST	Connection to a node on CAN 2 lost.
182	AL CAN WRONG PARAMS	Incorrect CAN parameter values have been entered.
183	AL CAN NO PU DATA	A CAN mode is selected which the communication is initialized aided of the PU data module. However, required PU data module is not present or is not valid.
184	AL CAN PUDATA ERR	During attempt to copy a received PU data module to Flash module, a program error occurred.
185	CAN LESS MAILBXS	CAN less mailboxes.
186	AL CAN1 BUS OFF	CAN controller 1 is in “Bus Off” state.
187	AL CAN1 ERR PASSV	CAN controller 1 has signaled a warning.
188	AL CAN2 BUS OFF	CAN controller 2 is in “Bus Off” state.
189	AL CAN2 ERROR PASSV	CAN controller 2 has signaled a warning.
190	AL EMU PARAM NO SUPPORT	EMU parameters are not supported.
198	AL COMB ALM YEL	Combined Yellow Alarm - a yellow alarm is a warning and does generally not result in engine shutdown.
201	SD T COOLANT	Coolant temperature-sensor defect.
202	SD T FUEL	Fuel temperature-sensor defect.
203	SD T CHARGE AIR	Charge air temperature-sensor defect.
205	SD T CLNT INTERC	Intercooler coolant temperature-sensor defect.
206	SD T EXHAUST A	Exhaust gas temperature-sensor on A-side defect.
207	SD T EXHAUST B	Exhaust gas temperature-sensor on B-side defect.
208	SD P CHARGE AIR	Charge air pressure-sensor defect.
211	SD P LUBE OIL	Lube oil pressure-sensor defect.
212	SD P COOLANT	Coolant pressure-sensor defect.
213	SD P COOLANT INTRCOOLR	Intercooler coolant pressure-sensor defect.
214	SD P CRANKCASE	Crankcase pressure-sensor defect.
215	SD P HD	Rail pressure-sensor defect.
216	SD T LUBE OIL	Lube oil temperature-sensor defect.
219	SD T INTAKE AIR	Intake air temperature-sensor defect.
220	SD COOLANT LEVEL	Sensor for coolant level defect.
221	SD P DIFF LUBE OIL	Sensor for differential pressure of lube oil defect.

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Fault Code Number	String	Description
222	SL LVL LKG FUEL	Sensor for leakage level of fuel defect.
223	SD LVL INTERCLR	Sensor for coolant level of intercooler defect.
227	SD PRE FILT P LUBE OIL	Pressure sensor for lube oil before filter defect.
228	SD P FL PRE FILTR	Sensor defect on the fuel pre-filter pressure sensor.
229	AL SD CAM STOP	Sensor of Camshaft defect and sensor of crankshaft defect before.
230	SD CRANKSHFT SPD	Sensor defect on crankshaft.
231	SD CAMSHAFT SPD	Sensor defect on camshaft.
232	SD CHARGER1 SPEED	Speed-sensor of basic charger defect.
233	SD CHARGER2 SPEED	Speed-sensor of switching charger defect.
239	SD P DIFF FUEL	Sensor defect in the fuel filter differential pressure sensor.
240	SD P FUEL	Fuel pressure-sensor defect.
241	SD T UMBLASSEN	Temperature-sensor of recirculated charge air defect.
242	SD T COOLANT R	Redundant coolant temperature-sensor defect.
244	SD P LUBE OIL R	Redundant pressure sensor for lube oil defect.
245	SD POWER SUPPLY	Internal ECU error.
246	SD T ELECTRONIC	Internal ECU fault.
249	SD CAN STOP	Missing data CAN.
250	SD CAN SPD DEMND	Missing data CAN.
251	SD CAN UP DOWN	Missing data CAN.
252	SD CAN NOTCH POS	Missing data CAN.
253	SD CAN OVERRIDE	Missing data CAN.
254	SD CAN TST OVRSP	Missing data CAN.
255	SD CAN ENGAGE SIG	Missing data CAN.
256	SD CAN CYL CUTOUT	Missing data CAN.
257	SD CAN LOCAL	Missing data CAN.
258	SD CAN RCS ENGAGE	Missing data CAN.
259	SD CAN RCS CYL CT	Missing data CAN.
260	SD 15V POS SPPLY	Internal ECU fault.
261	15V POS SPPLY	Internal ECU fault.
262	SD 5V BUFFR TEST	Internal ECU fault.
263	SD TE BUFFR TEST	Internal ECU fault.
264	SD BANK 1 TEST	Internal ECU fault.
265	SD BANK 2 TEST	Internal ECU fault.
266	SD SPD DEMAND AN	Analog speed demand defect.
267	SD SPDMTEST BNCH	Short circuit, cable breakage.
268	SD SPINUT	Analog spinning value defect.
269	SD LOAD ANLG FLT	Filtered analog load pulse signal not available.
270	SD FREQUENCY INPUT	Frequency input defect.
271	SD T EXTERN 1	Missing data CAN.
272	SD T EXTERN 2	Missing data CAN.
273	SD P EXTERN 1	Missing data CAN.
274	SD P EXTERN 2	Missing data CAN.
275	SD EXT CLNT LVL	Missing data CAN.
276	SD INTERCLER LVL	Missing data CAN.
277	SD BIN EXT3	Missing data CAN.
278	SD BIN EXT4	Missing data CAN.
279	SD CANRES TRIPFL	Missing data CAN.
280	SD CAN ALRM RST	Missing data CAN.
281	SD ADTEST1 SPPLY	Internal ECU fault.

Fault Code Number	String	Description
282	SD ADTEST 2 SPPLY	Internal ECU fault.
283	SD ADTEST3 SPPLY	Internal ECU fault.
284	SD CAN LAMP TEST	Missing data CAN.
285	SD CAN IDLE RQ SR	Missing data CAN.
286	SD CAN IDLE REQ	Missing data CAN.
287	SD CAN IDLE REQ	Missing data CAN.
288	SD CAN TRBOSW LCK	Missing data CAN.
301	TIMING CYLNDR A1	Error in timing of injector cylinder A1: timing value too low/high.
302	TIMING CYLNDR A2	Error in timing of injector cylinder A2: timing value too low/high.
303	TIMING CYLNDR A3	Error in timing of injector cylinder A3: timing value too low/high.
304	TIMING CYLNDR A4	Error in timing of injector cylinder A4: timing value too low/high.
305	TIMING CYLNDR A5	Error in timing of injector cylinder A5: timing value too low/high.
306	TIMING CYLNDR A6	Error in timing of injector cylinder A6: timing value too low/high.
307	TIMING CYLNDR A7	Error in timing of injector cylinder A7: timing value too low/high.
308	TIMING CYLNDR A8	Error in timing of injector cylinder A8: timing value too low/high.
309	TIMING CYLNDR A9	Error in timing of injector cylinder A9: timing value too low/high.
310	TIMING CYLNDR A10	Error in timing of injector cylinder A10: timing value too low/high.
311	TIMING CYLNDR B1	Error in timing of injector cylinder B1: timing value too low/high.
312	TIMING CYLNDR B2	Error in timing of injector cylinder B2: timing value too low/high.
313	TIMING CYLNDR B3	Error in timing of injector cylinder B3: timing value too low/high.
314	TIMING CYLNDR B4	Error in timing of injector cylinder B4: timing value too low/high.
315	TIMING CYLNDR B5	Error in timing of injector cylinder B5: timing value too low/high.
316	TIMING CYLNDR B6	Error in timing of injector cylinder B6: timing value too low/high.
317	TIMING CYLNDR B7	Error in timing of injector cylinder B7: timing value too low/high.
318	TIMING CYLNDR B8	Error in timing of injector cylinder B8: timing value too low/high.
319	TIMING CYLNDR B9	Error in timing of injector cylinder B9: timing value too low/high.
320	TIMING CYLNDR B10	Error in timing of injector cylinder B10: timing value too low/high.
321	WIRING CYLNDR A1	Short circuit in injector cable of cylinder A1.
322	WIRING CYLNDR A2	Short circuit in injector cable of cylinder A2.
323	WIRING CYLNDR A3	Short circuit in injector cable of cylinder A3.
324	WIRING CYLNDR A4	Short circuit in injector cable of cylinder A4.
325	WIRING CYLNDR A5	Short circuit in injector cable of cylinder A5.
326	WIRING CYLNDR A6	Short circuit in injector cable of cylinder A6.
327	WIRING CYLNDR A7	Short circuit in injector cable of cylinder A7.
328	WIRING CYLNDR A8	Short circuit in injector cable of cylinder A8.
329	WIRING CYLNDR A9	Short circuit in injector cable of cylinder A9.
330	WIRING CYLNDR A10	Short circuit in injector cable of cylinder A10.
331	WIRING CYLNDR B1	Short circuit in injector cable of cylinder B1.
332	WIRING CYLNDR B2	Short circuit in injector cable of cylinder B2.
333	WIRING CYLNDR B3	Short circuit in injector cable of cylinder B3.
334	WIRING CYLNDR B4	Short circuit in injector cable of cylinder B4.
335	WIRING CYLNDR B5	Short circuit in injector cable of cylinder B5.
336	WIRING CYLNDR B6	Short circuit in injector cable of cylinder B6.
337	WIRING CYLNDR B7	Short circuit in injector cable of cylinder B7.
338	WIRING CYLNDR B8	Short circuit in injector cable of cylinder B8.
339	WIRING CYLNDR B9	Short circuit in injector cable of cylinder B9.
340	WIRING CYLNDR B10	Short circuit in injector cable of cylinder B10.
341	OPN LD CYLNDR A1	Open load in injector cable of cylinder A1.
342	OPN LD CYLNDR A2	Open load in injector cable of cylinder A2.

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Fault Code Number	String	Description
343	OPN LD CYLNDR A3	Open load in injector cable of cylinder A3.
344	OPN LD CYLNDR A4	Open load in injector cable of cylinder A4.
345	OPN LD CYLNDR A5	Open load in injector cable of cylinder A5.
346	OPN LD CYLNDR A6	Open load in injector cable of cylinder A6.
347	OPN LD CYLNDR A7	Open load in injector cable of cylinder A7.
348	OPN LD CYLNDR A8	Open load in injector cable of cylinder A8.
349	OPN LD CYLNDR A9	Open load in injector cable of cylinder A9.
350	OPN LD CYLNDR A10	Open load in injector cable of cylinder A10.
351	OPN LD CYLNDR B1	Open load in injector cable of cylinder B1.
352	OPN LD CYLNDR B2	Open load in injector cable of cylinder B2.
353	OPN LD CYLNDR B3	Open load in injector cable of cylinder B3.
354	OPN LD CYLNDR B4	Open load in injector cable of cylinder B4.
355	OPN LD CYLNDR B5	Open load in injector cable of cylinder B5.
356	OPN LD CYLNDR B6	Open load in injector cable of cylinder B6.
357	OPN LD CYLNDR B7	Open load in injector cable of cylinder B7.
358	OPN LD CYLNDR B8	Open load in injector cable of cylinder B8.
359	OPN LD CYLNDR B9	Open load in injector cable of cylinder B9.
360	OPN LD CYLNDR B10	Open load in injector cable of cylinder B10.
361	AL POWER STAGE LOW	Internal error of electronic.
362	AL POWER STAGE HIGH	Internal error of electronic.
363	AL STOP POWER STAGE	Internal error of electronic.
364	AL STOP POWER STAGE 2	Internal error of electronic.
365	AL MV WIRING GND	Cable line error.
371	AL WIRING TO 1	Short circuit or open load on transistor output 1 (TO 1).
372	AL WIRING TO 2	Short circuit or open load on transistor output 2 (TO 2).
373	AL WIRING TO 3	Short circuit or open load on transistor output 3 (TO 3).
374	AL WIRING TO 4	Short circuit or open load on transistor output 4 (TO 4).
381	AL WIRING TOP 1	Short circuit or open load on transistor output plant 1 (TOP 1).
382	AL WIRING TOP 2	Short circuit or open load on transistor output plant 2 (TOP 2).
383	AL WIRING TOP 3	Short circuit or open load on transistor output plant 3 (TOP 3).
384	AL WIRING TOP 4	Short circuit or open load on transistor output plant 4 (TOP 4).
385	AL WIRING TOP 5	Short circuit or open load on transistor output plant 5 (TOP 5).
386	AL WIRING TOP 6	Short circuit or open load on transistor output plant 6 (TOP 6).
390	AL MCR EXCEEDED	DBR/MCR Function: MCR (Maximum Continuous Rating) in exceeded.
392	HI T COOLNT R	Redundant coolant temperature too high (limit 1).
393	SS T COOLNT R	Redundant coolant temperature too high (limit 2).
394	LO P LUBE OIL R	Redundant pressure of lube oil too low (limit 1).
395	SS P LUBE OIL R	Redundant pressure of lube oil too low (limit 2).
396	TD T COOLANT	Maximum deviation of T-Coolant sensors.
397	TD P LUBE OIL	Maximum deviation of P-Oil sensors.
399	AL INTERFACE ECU	Interface ECU.
400	AL OPN LD DIGIN 1	Open load on digital input 1.
401	AL OPN LD DIGIN 2	Open load on digital input 2.
402	AL OPN LD DIGIN 3	Open load on digital input 3.
403	AL OPN LD DIGIN 4	Open load on digital input 4.
404	AL OPN LD DIGIN 5	Open load on digital input 5.
405	AL OPN LD DIGIN 6	Open load on digital input 6.
406	AL OPN LD DIGIN 7	Open load on digital input 7.
407	AL OPN LD DIGIN 8	Open load on digital input 8.

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Fault Code Number	String	Description
408	AL OPN LD E STOP	Open load on input for emergency stop.
410	LO U PDU	Power driver voltage (injectors) too low (limit 1).
411	LOLO U PDU	Power driver voltage (injectors) too low (limit 2).
412	HI U PDU	Power driver voltage (injectors) too high (limit 1).
413	HIHI U PDU	Power driver voltage (injectors) too high (limit 2).
414	HI L WATER FUEL PREFILT	Water level of fuel prefilter too high (limit 1).
415	LO P COOLANT INTRCOOLR	Coolant pressure of InterCooler too low (limit 1).
416	SS P COOLANT INTRCOOLR	Coolant pressure of InterCooler too low (limit 2).
417	SD L WATER FUEL PREFILT	Water level-sensor of fuel prefilter defect.
418	SD INTAKE AIR B	Sensor defect of the Intake Air B temperature sensor.
419	SD PRE_ENG T COOL	Sensor defect in the Coolant Temperature Sensor before engine coolant intake.
420	AL L1 AUX 1	Input of Aux 1 injured limit 1.
421	AL L2 AUX 1	Input of Aux 1 injured limit 2.
422	SD T CHRG AIR B	Sensor defect in the Charge Air B Temperature Sensor.
423	LO P COOLANT DIFF	Low Coolant Differential Pressure.
424	AL L1 AUX 2	Auxiliary 2 Alarm Level 1 Alarm.
425	AL L2 AUX 2	Auxiliary 2 Alarm Level 2 Alarm.
426	SD AIR MASS A	Sensor defect in Air Mass Sensor A.
427	SD AIR MASS B	Sensor defect in Air Mass Sensor B.
428	AL L1 T AUX 1	Temperature input of Aux 1 injured limit 1.
429	HI P COOLANT	High Coolant Pressure.
430	LO PRE ENG P COOLNT	Low Pre-Engine Coolant Pressure (Limit 1).
431	SS PRE ENG P COOLNT	Low Pre-Engine Coolant Pressure (Limit 2).
432	AL L1 T AUX2	Auxiliary Temperature 2 Level 1 Alarm.
433	AL L2 T AUX2	Auxiliary Temperature 2 Level 2 Alarm.
434	HI PRE ENG T COOLNT	High Pre-Engine Coolant Temperature (Limit 1).
435	SS PRE ENG T COOLNT	High Pre-Engine Coolant Temperature (Limit 2).
436	AL L1 P AUX 2	Auxiliary Pressure 2 Level 1 Alarm.
437	AL L2 P AUX 2	Auxiliary Pressure 2 Level 2 Alarm.
438	LO P FUEL RAIL 2 STR	Low pressure on fuel rail 2.
439	HI P FUEL RAIL 2 STR	Hi pressure on fuel rail 2.
440	AL L1 P AUX 1	Pressure input of Aux 1 injured limit 1.
441	AL RAIL 2 LEAKAGE STR	Alarm fuel rail 2 leak detected.
442	AL L2 P AUX 1	Pressure input of Aux 1 injured limit 2.
443	HI P CHG MIX DIFF	High Charge Mix Differential Pressure.
444	SD U PDU	Sensor defect of Injector Power driver unit.
445	SD P AMBIENT AIR	Ambient air pressure-sensor defect.
446	SD P HD2	Sensor Defect In HD 2 Pressure Sensor.
447	HIHI P CHG MIX DIFF	Charge Mixture Differential Pressure High (Limit 2).
448	HI P CHARGE AIR	Pressure of charge air too high (limit 1).
449	SS P CHARGE AIR	Pressure of charge air too high (limit 2).
450	SD IDLE END TRQ IN	Input of Idle/End-Torque defect
451	HI T CHARGE MIX	High Charge Mixture Temperature (Limit 1).
452	HI HI T CHARGE MIX	High Charge Mixture Temperature (Limit 2).
453	LO T CHARGE MIX	Low Charge Mixture Temperature.
454	SS PWR RED ACT	Power Reduction is activated.
455	AL L1 AUX1 PLANT	Input of Aux 1 (plant) injured limit 1.

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Fault Code Number	String	Description
456	AL L2 AUX1 PLANT	Input of Aux 1 (plant) injured limit 2.
457	LO T INTAKE AIR	Low Intake Air Temperature (Limit 1).
458	LO LO T INTAKE AIR	Low Intake Air Temperature (Limit 2).
459	SD P CLNT B ENG	Sensor Defect In the Coolant Before Engine Pressure Sensor.
460	HI T EXHAUST EMU	Exhaust gas temperature of EMU too high (limit 1).
461	LO T EXHAUST EMU	Exhaust gas temperature of EMU too low (limit 1).
462	HI T COOLANT EMU	Coolant temperature of EMU injured limit 1.
463	SD AUX 2	Sensor defect on Aux 2.
464	SD P AUX 1	Analog input for pressure Aux 1 defect.
465	SD P AUX 2	Sensor Defect in the Auxiliary 2 Pressure Sensor.
466	SD T AUX 2	Sensor Defect in the Auxiliary 2 Temperature Sensor.
467	AL L2 T AUX 1	Temperature input of Aux 1 injured limit 2.
468	SD T AUX 1	Analog input for Temperature Aux 1 defect.
469	SD AUX 1	Analog input for Aux 1 defect.
470	SD T ECU	ECU temperature-sensor defect.
471	SD COIL CURRENT	Coil Current sensor defect.
472	AL STOP SD	Engine stop, because critical channel has sensor defect.
473	AL WIRING PWM CM2	Open load or short circuit on channel PWM CM2.
474	AL WIRING FREQ OUT	Open load or short circuit on frequency output (FO) channel.
475	AL CR TRIG ENG ST	Released in case of an engine stop in order to trigger the crash recorder.
476	AL CRASH REC ERR	Initial error of crash recorder.
477	WRT MISTK BIN VAL	Binary Data Write Error.
478	AL COMB ALM YEL	Combined Alarm YELLOW (Plant).
479	AL COMB ALM RED	Combined Alarm RED (Plant).
480	AL EXT ENG PROT	External Engine Protection function active.
481	SD COIL CURRENT 2	Sensor Defect In Coil Current 2 Sensor.
482	SD T EXHAUST C	Sensor Defect In Exhaust System C Temperature Sensor.
483	SD T EXHAUST D	Sensor Defect In Exhaust System D Temperature Sensor.
484	HI T EXHAUST C	High Exhaust C Temperature (Limit 1).
485	SS T EXHAUST C	High Exhaust C Temperature (Limit 2).
486	HI T EXHAUST D	High Exhaust D Temperature.
487	SS T EXHAUST D	Shutdown due to High Exhaust D Temperature.
488	HI ETC 3 OVERSPD	High Turbo Charger ETC 3 Overspeed (Limit 1).
489	SS ETC 3 OVERSPD	High Turbo Charger ETC 3 Overspeed (Limit 2).
490	HI ETC 4 OVERSPD	High Turbo Charger ETC 4 Overspeed (Limit 1).
491	SS ETC 4 OVERSPD	High Turbo Charger ETC 4 Overspeed (Limit 2).
492	HI ETC 4 CUTIN FAIL	High Turbo Charger ETC 4 Cut In Failure (Limit 1).
493	HI ETC 3 CUTIN FAIL	High Turbo Charger ETC 3 Cut In Failure (Limit 2).
494	SD THROTL A FDBK	Sensor Defect In Throttle A Feedback Sensor.
495	SD THROTL B FDBK	Sensor Defect In Throttle B Feedback Sensor.
496	SD P CHARGE MIX A	Sensor Defect In Charge Mix A Pressure Sensor.
497	SD P CHARGE MIX B	Sensor Defect In Charge Mix B Pressure Sensor.
498	SD P CHRG MIX DIFF	Sensor Defect In Charge Mix Differential Pressure Sensor.
499	SD P CHARGE MIX	Sensor Defect In Charge Mix Pressure Sensor.
500	AL WIRING POM STARTER 1	A wiring fault has been detected in the connection of starter 1 of POM.
501	AL WIRING POM STARTER 2	A wiring fault has been detected in the connection of starter 2 of POM.
502	AL OPEN LD POM ALTRNATR	An open load on POM's alternator output has been detected.

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Fault Code Number	String	Description
503	AL BATT NOT CHARGING	Battery is not being charged by alternator.
504	AL CAN POM NODE LOST	POM is missing on CAN bus.
505	AL NEW POM FOUND	New POM found.
506	AL LOW STARTER VOLTS	Battery voltage is too low for starting.
507	AL POM ERROR	A general POM error has been detected.
508	AL WRONG POM ID	POM sends a different identification number (ID) than expected.
509	AL CHECK POM FUSE	Check POM fuse.
510	AL OVERRIDE APPLIED	Override applied.
511	HIHI P CHG MIX A	Hi Charge Air Mix A Pressure (Limit 2).
512	HIHI P CHG MIX B	Hi Charge Air Mix B Pressure (Limit 2).
513	SD P COOLNT DIFF	Sensor Defect In Coolant Differential Pressure Sensor.
514	WRITE ERR FLASH	Write Error Occurred when writing data to Flash Memory.
515	STARTER NOT ENGAGED	Starter of POM could not be engaged.
516	OILNIVEAU CAL ERR	Remote Oil Level Watchman Calibration Error.
517	SD CHG MX PR THRT	Sensor Defect In Charge Pre-Throttle Mix Pressure Sensor.
518	SD THROT BYPASS FDBK	Sensor Defect In Throttle Feedback Bypass Sensor.
519	OIL LVL CAL ERROR	Oil Level Calibration Error.
520	SD P IN AIR AFT FLT A	Sensor Defect In Intake Air After Filter A Pressure Sensor.
521	SD P OIL MID VAL	Lube Oil Pressure Middle Value (Limit 2).
522	SD P IN AIR AFT FLT B	Sensor Defect In Intake Air After Filter B Pressure Sensor.
523	SD T COOL RED MIDVL	Coolant Temperature Mid value (Limit 2).
524	SS ENG OVRSPD MIDVL	Engine Speed Middle Value too high (Limit 2).
525	SD P LUBE OIL R2	Sensor Defect In Lube Oil Pressure (R2) Sensor.
526	SD T COOL OIL R2	Sensor Defect In Oil Coolant Temperature (R2) Sensor.
527	TD ENG SPD SNS DEV	Engine Speed Sensor Deviation.
528	SD ENG SPD SENSR 3	Sensor Defect in Engine Speed Third Sensor.
529	SS T COOL RED 2	Coolant Temperature Red 2 Alarm (Limit 2).
530	SS P LUBE OIL RED 2	Lube Oil Pressure Red 2 Alarm (Limit 2).
531	AL WIRING PWM CM1	PWM CM1 Wiring Issue.
532	AL WIRING PWM1	PWM 1 Wiring Issue.
533	AL WIRING PWM2	PWM 2 Wiring Issue.
534	HIHI POWER DIFF	Power Difference High (Limit 2).
535	LOLO POWER DIFF	Power Difference Low (Limit 2).
536	AL WIRING PWM1 CM1	PWM CM1 Wiring Issue.
537	SD P VNTRI DLTA SD A	Sensor Defect In Venture Side A Delta Pressure Sensor.
538	SD P VNTRI DLTA SD B	Sensor Defect In Venture Side B Delta Pressure Sensor.
539	SD P EGR VNTRI STATIC	Sensor Defect In EGR Venture Static Pressure Sensor.
540	SD T EGR	Sensor Defect In EGR Temperature Sensor.
541	AL L1 T EGR	EGR Temperature (Limit 1) Alarm.
542	AL L2 T EGR	EGR Temperature (Limit 2) Alarm.
543	MULTIPLE FDH SLAVES	There is more than one device which is configured as Backup for FDH-Functionality.
544	CONFIGURATION CHANGED	Gets active in case of changing system configuration e.g. by changing ECU- or SAM-Device. Remains until undo procedure or data is transferred by a valid maintenance case. Is cancelled automatically.
545	AL L1 P EXT PLNT1	External Plant 1 Pressure Alarm (Limit 1).
546	AL L1 P EXT PLNT2	External Plant 2 Pressure Alarm (Limit 1).

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Fault Code Number	String	Description
547	AL L1 T EXT PLNT1	External Plant 1 Temperature Alarm (Limit 1).
548	AL L1 T EXT PLNT2	External Plant 2 Temperature Alarm (Limit 1).
549	AL PWR CUTOFF DET	Power Cutoff Detected.
550	SS ENG OVRSP RED2	Engine Overspeed Red2 (Limit 1) Alarm.
551	SS ENG OVRSPD CAMSFT	Engine Overspeed Camshaft (Limit 1) Alarm.
552	AL GAS CTRL CHK FLT	Gas Control Check Fault Alarm.
553	AL AUX DEVICES FLT	Auxiliary Devices Alarm.
554	AL IGNITION FAULT	Ignition Fault Alarm.
555	AL CALL FIELD SERVICE	Gets active in case of completing a maintenance-case which manipulates Engine-Parameters. Remains also after switching on-off ECU until a valid release code is entered via Display- and Button-Control of SAM-Device. Release Code is available via Internet by a special procedure.
556	AL GAS VALVE FLT	Gas Valve Fault Alarm.
557	AL ENG SPD COLL. FLT	Engine Speed Collapse Fault Alarm.
558	AL WIRING PWM CM2	PWM CM2 Wiring Issue.
559	AL MIX THRT A FLT	Throttle A Mixture Fault Alarm.
560	AL MIX THRT B FLT	Throttle B Mixture Fault Alarm.
561	AL LIM EXT PLNT BIN1	External Plant Bin 1Limit Alarm.
562	AL LIM EXT PLNT BIN2	External Plant Bin 1Limit Alarm.
563	AL LIM EXT PLNT BIN3	External Plant Bin 1Limit Alarm.
564	AL LIM EXT PLNT BIN4	External Plant Bin 1Limit Alarm.
565	L1 P AFTER AIR FLT A	Intake A Air Pressure After Filter (Limit 1).
566	L2 P AFTER AIR FLT A	Intake A Air Pressure After Filter (Limit 2).
567	L1 P AFTER AIR FLT B	Intake B Air Pressure After Filter (Limit 1).
568	L2 P AFTER AIR FLT B	Intake B Air Pressure After Filter (Limit 2).
569	AL SAM MSG DATA FLT	SAM Module Missing Data Fault.
570	L1 CAN MAX TIMG RETRD	Maximum Timing Retard from CAN (Limit 1).
571	L2 CAN MAX TIMG RETRD	Maximum Timing Retard from CAN (Limit 2).
572	L3 CAN MAX TIMG RETRD	Maximum Timing Retard from CAN (Limit 3).
573	SD P DIFF STR VS VRD	Sensor Defect in Pressure Differential Sensor Pitot Tube vs. Pressure.
574	SD M AIR EGR BEF CLR	Sensor Defect In Air Mass Sensor before EGR Cooler.
575	SD M INTAKE AIR	Sensor Defect In Intake Air Mass Sensor.
576	AL ESCM OVERRIDE STR	Exceeding of the corrected current MCR - odr DBR/MCR value.
577	SD T LUBE OIL PAN	Sensor Defect In Oil Pan Lube Oil Temperature Sensor.
578	AL L1 T LUBOIL PAN	Lube Oil Pan Temperature (Limit 1).
579	AL MD CANRQ IDLE SPD	MD Idle Speed Request over Can Bus.
580	AL CAN SPD LIMIT	MD Speed Limitation From Can Bus.
581	AL PWM CM3	PWM CM3 Alarm.
582	AL EMERG STOP FL	Emergency Stop Failed Alarm.
583	AL BRKR CLOSED	Circuit Breaker Closed Alarm.
584	AL CAN STRTCLR FL	Start Clearance from Can Bus Fail Alarm.
585	AS MOTORSTRT BL	Engine Start Blocked Alarm.
586	LO P OIL REFILL PMP	Refill Pump Lower Oil Pressure.
587	AL WIRING PWM CM4	PWM CM4 Wiring Issue.
588	SD P OIL REFILL PUMP	Sensor Defect In Refill Pump Oil Pressure Sensor.
589	SD T EGR SIDE B	Side B EGR Temperature Alarm.
590	SD P DLTA EXHAUST A	Sensor Defect In Exhaust A Pressure Delta Sensor.
591	SD P EGRB VNTRI STATC	Sensor Defect In Side B EGR Venture Static Pressure Sensor.
592	AS P DLTA EXH B	Sensor Defect In Exhaust B Pressure Delta Sensor.
593	SD OIL T J1939	Sensor Defect in Lube Oil Pan Temperature Sensor.

Fault Code Number	String	Description
594	AL L1 PRV 1 DEFECT STR	Yellow alarm pressure relief valve first rail.
595	AL L2 PRV 1 DEFECT STR	Red alarm pressure relief valve first rail.
596	DEVELOP PR SET	Develop PR Set Alarm.
597	AL WIRING PWM CM5	PWM CM5 Wiring Issue.
598	AL L1 PRV 2 DEFECT STR	Yellow alarm pressure relief valve second rail.
599	AL L2 PRV 2 DEFECT STR	Red alarm pressure relief valve second rail.
600	SD T EXG A+B	Sensor Defect In Exhaust A Plus B Temperature Sensor.
601	SD ETC1 + EC2	Turbo Charger Speed Sensors 1 and 2 Faulty.
602	AK CAB ENG STRT LOCK	Engine Start Lock from Can Alarm.
603	SD AIR HUMIDITY	Sensor Defect In Air Humidity Sensor.
604	AL HUT CHGSPD MAX	HUT Speed Change Maximum Limit Alarm.
605	AL HUT DEV TOO HI	HUT DEV too high limit alarm.
606	AL DBL NODES LOST 1+2	Nodes Lost on Can1 and Can2 Alarm.
607	AL MD CAN STOP	MD Can Stop Alarm.
608	AL WIRING PWM CM6	PWM CM6 Wiring Issue.
609	AL WIRING PWM CM7	PWM CM7 Wiring Issue.
610	AL WIRING SUCK RESTRCT 1 STR	Open load or short circuit on PWM HP fuel control block channel.
611	AL WIRING SUCK RESTRCT 2 STR	Open load or short circuit on PWM HP fuel control block channel 2.
612	AL WIRING PRESS CTRL VLV 1 STR	Open load or short circuit on PWM pressure regulating valve channel.
613	AL WIRING PRESS CTRL VLV 2 STR	Open load or short circuit on PWM pressure regulating valve channel 2.
614	L1 P FUEL SEC FLTDIFF	Secondary Filter Fuel Pressure Limit 1 Alarm.
615	AL EIL PROTECTION STR	Alarm for Protection Module in response to faulty or manipulated EIL.
616	AL EIL ERROR STR	EIL Error.
617	LO ACTUAL HU VAL	HU Actual Value Low (Limit 1).
618	LOLO ACTUAL HU VAL	HU Actual Value Low (Limit 2).
619	HI ACTUAL HU VAL	HU Actual Value High (Limit 1).
620	HIHI ACTUAL HU VAL	HU Actual Value High (Limit 2).
621	LO NOX VALUE	NOX Value Low (Limit 1).
622	LOLO NOX VALUE	NOX Value Low (Limit 2).
623	HI NOX VALUE	NOX Value High (Limit 1).
624	HIHI NOX VALUE	NOX Value High (Limit 2).
625	SD P FUEL ADD SEC FLT	Sensor Defect in Pressure Sensor that meters Fuel Pressure Before supplemental Filter.
626	AL WIRING PWM CM8	PWM CM8 Wiring Issue.
627	AL WIRING PWM CM9	PWM CM9 Wiring Issue.
628	AL WIRING PWM CM10	PWM CM10 Wiring Issue.
629	EGR THOTTLE A DFCT	EGR Throttle EGR Defect.
630	EGR THOTTLE B DFCT	EGR Throttle EGR Defect.
631	AL BYPASS THROT DFCT	Bypass Throttle Defect.
632	AL DISPNS THRTL DFCT	Dispenser Throttle Defect.
633	SD P AMBAIR HDT2800	Sensor Defect in Ambient HD2800 Air Pressure Sensor.
634	SD T AMBAIR HDT2800	Sensor Defect in Ambient HD2800 Air Temperature Sensor.
635	SD H AMBAIR HDT2800	Sensor Defect in Ambient HD2800 Air Humidity Sensor.
636	SD OIL LVL J1939	Sensor Defect in J1939 Lube Oil Level Sensor.
637	SD OIL T J1939	Sensor Defect in J1939 Lube Oil Temperature Sensor.
638	AL WIRING PWM SIG1	PWM SIG1 Wiring Issue.

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Fault Code Number	String	Description
639	AL WIRING PWM SIG2	PWM SIG2 Wiring Issue.
640	SD SM NOX O2 FACTR	Sensor Defect In Smart NOX Oxidation Factor Sensor.
641	AS SYS WATCHDG RST	System Restart by Watchdog Detected.
642	SD ELCT ENG PWR AI2	Sensor Defect In Engine Power AI2 Electronic Sensor.
643	SP P FUEL BOF	Sensor Defect in BOF Fuel Pressure Sensor.
644	AL L1 P FUEL BOF	BOF Fuel Pressure Limit 1.
645	AL L2 P FUEL BOF	BOF Fuel Pressure Limit 2.
646	AL KNOCK INTNSTY	Knock Intensity Too High.
647	SD P EXH LAMBDA	Sensor Defect in Exhaust Lambda Pressure Sensor.
648	SD P CHRG AIR B	Sensor Defect In Charge Air B Pressure Sensor.
649	AL REQ ANGL THRT A	Throttle A Angle Alarm.
650	AL REQ ANGL THRT B	Throttle B Angle Alarm.
651	AL PREHT ERROR	Preheating Error Alarm.
652	AL GET COM LOST	GET Communications Lost.
653	AL IX92X COMM LOST	IC92X Communications Lost.
654	AL FSERIES COMM LOST	F Series Communications Lost.
655	AL TECJET COMM LOST	TECJET Communications Lost.
656	AL PROACT A COMM LST	PROACT A Communications Lost.
657	AL PROACT B COMM LST	PROACT B Communications Lost.
658	AL NOXA COMM LOST	NOX A Communications Lost.
659	AL NOXB COMM LOST	NOX B Communications Lost.
660	AL PHYTRNA COM LST	PHYTRON A Communications Lost.
661	AL PHYTRNB COM LST	PHYTRON B Communications Lost.
662	SD SMRT NOX HTR	Sensor Defect in Smart NOX Heater Element Sensor.
663	SD SMRT NOX CONC.	Sensor Defect in Smart NOX Concentration Sensor.
664	AL OIL REFILL ERR	Oil Refill Error.
665	AL GET YELLOW	GET Yellow Alarm.
666	AL IC92X YELLOW	IC92X Yellow Alarm.
667	AL FSERIES YELLOW	F Series Yellow Alarm.
668	AL TECJET YELLOW	TECJET Yellow Alarm.
669	AL PROACTA YELLOW	PROACT A Yellow Alarm.
670	AL PROACTB YELLOW	PROACT B Yellow Alarm.
671	AL NOXA YELLOW	NOX A Yellow Alarm.
672	AL NOXB YELLOW	NOX B Yellow Alarm.
673	AL PHYA YELLOW	PHYTRON A Yellow Alarm.
674	AL PHYB YELLOW	PHYTRON B Yellow Alarm.
675	AL GET RED	GET Red Alarm.
676	AL IC92X RED	IC92X Red Alarm.
677	AL FSERIES RED	F Series Red Alarm.
678	AL TECJET RED	TECJET Red Alarm.
679	AL PROACTA RED	PROACT A Red Alarm.
680	AL PROACTB RED	PROACT B Red Alarm.
681	AL NOXA RED	NOX A Red Alarm.
682	AL NOXB RED	NOX B Red Alarm.
683	AL PHYA RED	PHYTRON A Red Alarm.
684	AL PHYB RED	PHYTRON B Red Alarm.
685	AL LUBE OIL MIN	Lube Oil Minimum.
686	AL LUBE OIL MAX	Lube Oil Maximum.
687	AL LUBEOIL LVL SW	Lube Oil Level Switch is Faulty.

Fault Code Number	String	Description
688	LO OIL REFILL	Low Oil Refill.
689	HI OIL REFILL	High Oil Refill.
690	AL LUBEOIL LVL LO	Lube Oil Level Low.
691	HI LUBEOIL LVL REFILL	Lube Oil Refill Level High.
692	AL ECU PWR OFF ON REQ STR	ECU configuration changed, switch power off/on.
693	AL MB VALVE ERR	MB Valve Error.
694	SD T GAS	Sensor Defect in Gas Temperature Sensor.
695	AL EGR FAILURE	EGR Failure Alarm.
696	AL SMARTCONCT USB ERR STR	Alarm configuration parameter.
697	AL SMARTCONCT RS485 ERR STR	Alarm configuration parameter.
698	AL SD STOP BUTTON STR	Channel signals open load or internal error.
700	AL SD START BUTTON STR	Channel signals open load.
701	AL SD UP BUTTON STR	Channel signals open load.
702	AL SD DN BUTTON STR	Channel signals open load or internal error.
703	AL SD EXT SPEED DMD SW STR	Channel signals open load.
704	AL SD SPEED DMD INCREASE STR	Channel signals open load or internal error.
705	AL SD BINARY SPD DMD LMT STR	Channel signals open load or internal error.
706	AL SD DROOP 2 SWITCH STR	Channel signals open load or internal error.
707	AL SD FREQUENCY SWITCH STR	Channel signals open load or internal error.
709	AL SD OVERRIDE BUTTON STR	Channel signals open load or internal error.
710	AL SD ALARM RESET STR	Channel signals open load or internal error.
711	AL SD CYLINDER CUTOUT STR	Channel signals open load or internal error.
712	AL SD RQST BIN OUT TST STR	Channel signals open load or internal error.
713	AL SD EXT ENGINE PROTECTN STR	Channel signals open load or internal error.
714	AL SD PRELUBE SIGNAL STR	Channel signals open load.
715	AL SD EXT INC IDLE BIN STR	Channel signals open load.
716	AL SD EXT INC IDLE BIN BRK STR	Channel signals open load.
717	AL SD RQST PLANT DBR STR	Channel signals open load.
718	INTK AIR THRTL DFCT	Intake Air Throttle Defect.
719	AL T GAS L1	Gas Temperature Limit Alarm (Limit 1).
720	AL T GAS L2	Gas Temperature Limit Alarm (Limit 2).
721	AL T GAS L3	Gas Temperature Limit Alarm (Limit 3).
722	AL T GAS L4	Gas Temperature Limit Alarm (Limit 4).
723	SD T EXH BEF DOC A	Sensor Defect Exhaust Temperature Sensor before DOC.
724	SD T EXH BEF DPF A	Sensor Defect Exhaust Temperature Sensor before DPF.
725	SD T EXH AFTR DPF A	Sensor Defect Exhaust Temperature Sensor after DPF
726	SD P DELTA EXH DPF A	Sensor Defect in DPF Exhaust Pressure Delta Sensor.
727	L1 DELTA T_NT INTRCLR	NT Intercooler NT Temperature (Limit 1) Alarm.

Fault Code Number	String	Description
728	L2 DELTA T_NT INTRCLR	NT Intercooler NT Temperature (Limit 2) Alarm.
729	L1 T EXH BEF DOC	Exhaust Temperature Before DOC (Limit 1) Alarm.
730	L2 T EXH BEF DOC	Exhaust Temperature Before DOC (Limit 2) Alarm.
731	L2 T EXH BEF DOC	Exhaust Temperature Before DPF (Limit 1) Alarm.
732	L2 T EXH BEF DPF	Exhaust Temperature Before DPF (Limit 2) Alarm.
733	L1 T EXH AFTR DPF	Exhaust Temperature After DPF (Limit 1) Alarm.
734	L2 T EXH AFTR DPF	Exhaust Temperature After DPF (Limit 2) Alarm.
735	L1 P_DPF DIFF	DPF Exhaust Pressure Difference Alarm (Limit 1) Alarm.
736	L2 P_DPF DIFF	DPF Exhaust Pressure Difference Alarm (Limit 2) Alarm.
737	L1 P_DPF NORM DIFF	DPF Normal Difference Pressure (Limit 1) Alarm.
738	L2 P_DPF NORM DIFF	DPF Normal Difference Pressure (Limit 2) Alarm.
739	L3 P_DPF NORM DIFF	DPF Normal Difference Pressure (Limit 3) Alarm.
740	L4 P_DPF NORM DIFF	DPF Normal Difference Pressure (Limit 4) Alarm.
741	DPF RIGOROUS TM ABORT	DPF Rigorous TM Aborted Alarm.
742	DPF PER RIGOROUS TM	DPF Periodic Rigorous TM Alarm.
743	DPF RIG TM SUPPR	DPF Rigorous TM Suppressed Alarm.
744	DPF FLASH READ ERR	DPF Flash Memory Read Error Alarm.
745	AL EMISSN FLT	Emission Fault Alarm.
746	AL EMISSN FLT2	Emission Fault 2 Alarm.
747	SD P INTK AIRFLT DIFF	Sensor Defect in the Intake Air Filter Differential Pressure Sensor.
748	SD T EXH BEF SCR F1	Sensor Defect in Exhaust Temperature Sensor Before SCR Filter 1.
749	SD T EXH BEF SCR F2	Sensor Defect in Exhaust Temperature Sensor Before SCR Filter 2.
750	SD T EXH AFTR SCR F1	Sensor Defect in Exhaust Temperature Sensor Before SCR Filter 1.
751	SD T EXH AFTR SCR F2	Sensor Defect in Exhaust Temperature Sensor Before SCR Filter 2.
752	SD DEF TANK LVL	Sensor Defect in DEF Tank Level Sensor.
753	SD T RM TANK	Sensor Defect in RM Tank Temperature Sensor.
754	SD BOSCH LSU LMBDA SNS	Sensor Defect In Bosch LSU Lambda Sensor.
755	SELCTD MODE NOT VLD	Selected Mode Not Valid Alarm.
756	NO VLD MODE SW SGNL	No Valid Mode Switch Alarm.
757	AL LIM T COOL LT FAN	Coolant LT Fan Limit (Limit 1) Alarm.
758	DEF NOZZLE DAMG	DEF Nozzle Damage Alarm.
759	L1 T FUEL B ENGINE	Fuel Temperature Before Engine too high (Limit 1) Alarm.
760	L2 T FUEL B ENGINE	Fuel Temperature Before Engine too high (Limit 2) Alarm.
761	SD T FUEL B ENGINE	Sensor Defect In Sensor metering Fuel Temperature Before Engine Alarm.
762	AL SMRT CNCT LOST	Smart Connect Lost Alarm.
763	AL OL ASO FLP FDBK B	OL ASO Flap B Feedback Alarm.
764	ASO FLP B CLSD A FL	ASO Flap B Closed A Failed Alarm.
765	AL OL ASO FLP FDBK A	OL ASO Flap A Feedback Alarm.
766	ASO FLP A CLSD B FL	ASO Flap A Closed B Failed Alarm.
767	ASP FLAPS CLOSED	ASO Flaps Closed Alarm.
768	ST T EXH V HPTURBN A1	Sensor Defect In Exhaust V HP Turbine A1 Temperature Sensor.
769	SD T EXH AFTR ENG	Sensor Defect In Exhaust Temperature After Engine Sensor.
770	SD T SEA WATER PUMP	Sensor Defect In Sea Water After Pump Temperature Sensor.
771	SD T FUEL B	Sensor Defect In Fuel Temperature B Sensor.
772	SD LVL OIL REFILL TNK	Sensor Defect In Refill Tank Oil Level Sensor.
773	SD P FUEL RTN PATH	Sensor Defect In Return Path Fuel Pressure Sensor.
774	SD P FUEL BEFR ENG	Sensor Defect In Fuel Pressure Before Engine Sensor.
775	SD P SCHM AFT LVL PMP	Sensor Defect In After Level Pump Oil Pressure Sensor.
776	SD P SCHM AT HPPUMP A	Sensor Defect In Oil Pressure at HP Pump A Sensor.

Fault Code Number	String	Description
777	SD P SCHM AT HPPUMP B	Sensor Defect In Oil Pressure at HP Pump B Sensor.
778	ASO FLPS OPN FL TO CLS	ASO Flaps Open, Failed to Close Alarm.
779	WRONG NOX SNSR E1	NOX Sensor E1 Wrong Position Alarm.
780	WRONG NOX SNSR E2	NOX Sensor E2 Wrong Position Alarm.
781	WRONG NOX SNSR E3	NOX Sensor E3 Wrong Position Alarm.
782	SD P LUBOIL ETC A	Turbo Charger A Lube Oil Pressure Too High.
783	SD T EXH BEFR SCR F3	Sensor Defect In Before SCR Exhaust Temperature Sensor.
784	SD T EXH AFTR SCR F3	Sensor Defect In After SCR Exhaust Temperature Sensor.
785	L1 P OIL BEF HD PMP A	Oil Pressure Before HD PUMP A (Limit 1) Alarm.
786	L1 P OIL BEF HD PMP B	Oil Pressure Before HD PUMP B (Limit 1) Alarm.
787	L1 P OILNIV PUMP	Oil Pressure in Oil Niveaux Pump (Limit 1) Alarm.
788	ETC SPD FL DETECT	Turbo Charger Speed Failure Detected.
789	WRONG POS TMP SNS E1	Temperature Sensor E1 Wrong Position Alarm.
790	WRONG POS TMP SNS E2	Temperature Sensor E2 Wrong Position Alarm.
791	WRONG POS TMP SNS E3	Temperature Sensor E3 Wrong Position Alarm.
792	L1 P CHARGE AIR B	Charge Air B Pressure (Limit 1) Alarm.
793	L2 P CHARGE AIR B	Charge Air B Pressure (Limit 2) Alarm.
794	L1 P FL BEFR ENGN	Fuel Pressure Before Engine (Level 1) Alarm.
795	L1 P FUEL RTN	Fuel Pressure in Return Path (Limit 1) Alarm.
796	HI T CHARGE AIR B	High Charge Air B Temperature (Limit 1) Alarm.
797	HIHI T CHRG AIR B	High Charge Air B Temperature (Limit 2) Alarm.
798	L1T EXH BEF HPTRBN A1	Exhaust Temperature Before HP Turbine A1 (Limit 1) Alarm.
799	L2T EXH BEF HPTRBN A1	Exhaust Temperature Before HP Turbine A1 (Limit 2) Alarm.
800	L1 T EXH AFTR ENGINE	Exhaust Temperature After Engine (Limit 1) Alarm.
801	L1T RAW WATR AFTR PMP	Raw Water After Pump Temperature (Limit 1) Alarm.
802	L1T FUEL BEFR ENGINE	Fuel Temperature Before Engine (Limit 1) Alarm.
803	HI T FUEL B	High Fuel B Temperature (Limit 1) Alarm.
804	SS T FUEL B	High Fuel B Temperature (Limit 2) Alarm.
805	LO OIL LVL REFILL	Refill Oil Level Low Alarm.
806	SD CHARGR 3 SPD	Sensor Defect In Turbo Charger 3 Speed Sensor.
807	SD CHARGR 4 SPD	Sensor Defect In Turbo Charger 4 Speed Sensor.
808	SD CHARGR 5 SPD	Sensor Defect In Turbo Charger 5 Speed Sensor.
809	SD F1 NOX BEFOR SCR	Sensor Defect In F1 NOX Before SCR sensor.
810	NO COMS F1NOX BF SCR	Communications Lost with F1 NOX Before SCR sensor.
811	SD F1 NOX AFTR SCR	Sensor Defect In F1 NOX After SCR sensor.
812	NO COMS F1NOX AF SCR	F1 NOX After SCR Communications lost alarm.
813	SD F2 NOX BEFOR SCR	Sensor Defect In F2 NOX Before SCR sensor.
814	NO COMS F2NOX BF SCR	F2 NOX Before SCR Communications lost alarm.
815	SD F2 NOX AFTR SCR	Sensor Defect In F2 NOX After SCR sensor.
816	NO COMS F2NOX AF SCR	F2 NOX After SCR Communications lost alarm.
817	SD F3 NOX BEFOR SCR	Sensor Defect In F3 NOX Before SCR sensor.
818	NO COMS F3NOX BF SCR	F3 NOX Before SCR Communications lost alarm.
819	SD F3 NOX AFTR SCR	Sensor Defect In F3 NOX After SCR sensor.
820	NO COMS F3NOX AF SCR	F3 NOX After SCR Communications lost alarm.
821	HI ETC1 IDLE SPEED	Turbo Charger 1 Speed at Idle Too High.
822	HI ETC2 IDLE SPEED	Turbo Charger 2 Speed at Idle Too High.
823	HI ETC3 IDLE SPEED	Turbo Charger 3 Speed at Idle Too High.
824	HI ETC4 IDLE SPEED	Turbo Charger 4 Speed at Idle Too High.
825	HI ETC5 IDLE SPEED	Turbo Charger 5 Speed at Idle Too High.

Fault Code Number	String	Description
826	AL ETC1 SPD DEVTN	Turbo Charger 1 Speed Deviation.
827	AL ETC2 SPD DEVTN	Turbo Charger 2 Speed Deviation.
828	AL ETC3 SPD DEVTN	Turbo Charger 3 Speed Deviation.
829	AL ETC4 SPD DEVTN	Turbo Charger 4 Speed Deviation.
830	AL ETC5 SPD DEVTN	Turbo Charger 5 Speed Deviation.
831	AL ETC JOB ROTATN	Turbo Charger Job Rotation Alarm.
832	EIL DIFF ENG NUMBR	EIL Different Engine Number Alarm.
833	AL EMISSION WRN	Emission Warning Alarm.
834	AL GAS PATH WRN	Gas Path Warning Alarm.
835	AL GAST PATH FLT	Gas Path Fault Alarm.
836	AL SPEED DMD FAIL	Speed Demand Failure Alarm.
837	BYPASS VLV DEFCET	Bypass Valve Defect Alarm.
838	AL ASH VOLUME	Ash Volume Alarm.
839	ECU NT CLS ECO FLAP A	ASO Flap A not closed by ECU Alarm.
840	ECU NT CLS ECO FLAP B	ASO Flap B not closed by ECU Alarm.
841	SD P GASLN COM RL	Sensor Defect in Gasoline Common Rail Pressure Sensor.
842	AL ACT FL VLV POS L1	ACT Fuel Valve Position (Limit 1) Alarm.
843	SD T CHRG AIR BEF EGR	Sensor Defect in Charge Air Before EGR Temperature Sensor.
844	HI T CHRG AIR BEF EGR	Charge Air Before EGR High Temperature (Limit 1) Alarm.
845	HIHI T CHRGAIR BF EGR	Charge Air Before EGR High Temperature (Limit 2) Alarm.
846	HI T CHRG AIR DIFF AB	Charge Air Differential AB High Temperature (Limit 1) Alarm.
847	HIHI T CHRG AIR DF AB	Charge Air Differential AB High Temperature (Limit 2) Alarm.
848	AL REL HUMIDTY L1	Relative Humidity (Limit 1) Alarm.
849	AL IBT FUNCT ACTV	IBT Function Active Alarm.
850	SD ALIVE FIP	Sensor Defect in ALIVE FIP sensor.
851	AL EXT STRT HD HI	External Start and HD Too High Alarm.
852	MAX BLNK SH TM EXP	Max Blank Shot Time Expired Alarm.
853	HSB1 COMMS LOST	HSB1 Communications Lost Alarm.
854	HSB1 ACUTATR DEFCT	HSB1 Actuator Defect Alarm.
855	BYPASS THR2 DEFCT	Bypass Throttle 2 Defect Alarm.
856	SD P LUBOIL ETC B	Sensor Defect In Turbo Charger Oil Pressure Sensor.
857	NOX ATO1 SENSR DEFCT	NOX ATO 1 Sensor Defect Alarm.
858	L1 P LUBOIL ETC B	Turbo Charger B Oil Pressure Low (Limit 1).
859	HSB2 COMMS LOST	HSB2 Communications Lost Alarm.
860	HSB2 ACUTATR DEFCT	HSB2 Actuator Defect Alarm.
861	DEF IN PIPE S_ACT SYS	DEF in DEF Pipe in ACT system Alarm.
862	DEF TNK HT SNS_ACT SD	DEF Tank ACT Sensor Defect.
863	HSB3 COMMS LOST	HSB3 Communications Lost Alarm.
864	HSB3 ACUTATR DEFCT	HSB3 Actuator Defect Alarm.
865	HSB4 COMMS LOST	HSB4 Communications Lost Alarm.
866	HSB4 ACUTATR DEFCT	HSB4 Actuator Defect Alarm.
867	L1 P LUBOIL ETC A	Turbo Charger A Oil Pressure Low (Limit 1).
868	L2 P LUBOIL ETC A	Turbo Charger A Oil Pressure Low (Limit 2).
869	L2 P LUBOIL ETC B	Turbo Charger B Oil Pressure Low (Limit 2).
870	AL MB VLV DEFCT 2	MB Valve Defect 2 Alarm.
871	NOX ATO1 COMS LOST	NOX ATO 1 Communications Lost Alarm.
872	EGR A REF LEARN FAIL	EGR Reference Learning Algorithm Failure Alarm.
873	DEF TNK LVL EMPTY	DEF Tank Level Empty Alarm.
874	SCR FAIL	SCR Failure Alarm.

Fault Code Number	String	Description
875	ADBLUE TANK LOW	ADBLUE (DEF) Tank Level Low Alarm.
876	EGR B REF LEARN FAIL	EGR B Reference Learning Algorithm Failure Alarm.
877	BYP A REF LEARN FAIL	Bypass A Reference Learning Algorithm Failure Alarm.
878	BYPASS B FAST LRN FL	Bypass B Fast Learn Algorithm Failure Alarm.
879	DISPNSR REF LRN FL	Dispenser Reference Learn Algorithm Failure Alarm.
880	INTAKEAIR REF LRN FL	Intake Air Reference Learn Algorithm Failure Alarm.
881	AL UREA QLTY RELEASE	Urea Quality Release Alarm.
882	SCR F1 SU REVLTN RNG	SCR F1 SU Revolution Range Alarm.
883	SCR F2 SU REVLTN RNG	SCR F2 SU Revolution Range Alarm.
884	SCR F1 SU ADBLUE QNTY	SCR F1 SU ADBLUE Quantity.
885	SCR F2 SU ADBLUE QNTY	SCR F2 SU ADBLUE Quantity.
886	SCR ADBLUE PRESSR	SCR ADBLUE Pressure Alarm.
887	SCR SU PRIME REQUEST	SCR SU Priming Request Alarm.
888	SCR SU ADBLUE PRESSR	SCR SU ADBLUE Pressure Alarm.
889	SD T LUBEOIL ETC	Sensor Defect In Turbo Charger Oil Temperature Sensor.
890	L2 T LUBEOIL ETC	Lube Oil Temperature Too High (Limit 2).
891	AL TURNING ACTIVATED	Turning Activation Alarm.
892	FLO1 SPPLYUNT1 COM LS	Lost Communications with Air Flow 1 Supply Unit 1.
893	FLO1 SPPLYUNT2 COM LS	Lost Communications with Air Flow 1 Supply Unit 2.
894	FLO2 SPPLYUNT1 COM LS	Lost Communications with Air Flow 2 Supply Unit 1.
895	FLO2 SPPLYUNT2 COM LS	Lost Communications with Air Flow 2 Supply Unit 2.
896	FLO3 SPPLYUNT1 COM LS	Lost Communications with Air Flow 3 Supply Unit 1.
897	FLO3 SPPLYUNT2 COM LS	Lost Communications with Air Flow 3 Supply Unit 2.
898	TRICAN COMMS LOST	Communications Lost on TRICAN network.
899	OLT COMMS LOST	Communications to OLT Lost.
900	SCRF3 SU REV RNG	SCR F3 SU Revolution Range Alarm.
901	SCRF3 SU ADBLUE QTY	SCR F3 SU Adblue Quantity Low.
902	HI TCOOL CYL HEAD	High Cylinder Head Coolant Temperature (Limit 1).
903	SD TCOOL CYL HEAD	Sensor Defect in Cylinder Head Coolant Temperature Sensor.
904	SS TCOOL CYL HEAD	High Cylinder Head Coolant Temperature (Limit 2).
905	ADBLUE EXP CNS FL	ADBLUE Expected Consumption Failure Alarm.
906	ADBLUE BALANCE FL	ADBLUE Balance Failed Alarm.
907	NOX RAW EMISSN FL	NOX Raw Gas Emission Failed Alarm.
908	APPRCH NOX DOS STP FL	Approach NOX Dosing Stop Failed Alarm.
909	SCR TEXH BTW FLOWS FL	Exhaust Temperature Between SCR Flows Failed Alarm.
910	EXP TEXH BFR SCR FL	Expected Exhaust Temperature Before SCR Failure Alarm.
911	EXP TEXH AFT SCR FL	Expected Exhaust Temperature After SCR Failure Alarm.
912	SCR F1 TEXH BFR GRDNT	SCR F1 Exhaust Temperature Before Gradient Alarm.
913	SCR F2 TEXH BFR GRDNT	SCR F2 Exhaust Temperature Before Gradient Alarm.
914	SCR F3 TEXH BFR GRDNT	SCR F3 Exhaust Temperature Before Gradient Alarm.
915	SCR F1 TEXH AFT GRDNT	SCR F1 Exhaust Temperature After Gradient Alarm.
916	SCR F2 TEXH AFT GRDNT	SCR F2 Exhaust Temperature After Gradient Alarm.
917	SCR F3 TEXH AFT GRDNT	SCR F3 Exhaust Temperature After Gradient Alarm.
918	L1 T LUBEOIL ETC	Turbo Charger Lube Oil Temperature High (Limit 1).
919	ENERGY CNTR DEFCT	Energy Counter Defect Alarm.
920	L1 TEXH BFR SCRF1	Exhaust Temperature Before SCR F1 (Limit 1) Alarm.
921	L2 TEXH BFR SCRF1	Exhaust Temperature Before SCR F1 (Limit 2) Alarm.
922	L1 TEXH AFT SCRF1	Exhaust Temperature After SCR F1 (Limit 1) Alarm.
923	L2 TEXH AFT SCRF1	Exhaust Temperature After SCR F1 (Limit 2) Alarm.

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Fault Code Number	String	Description
924	L1 TEXH BFR SCRF2	Exhaust Temperature Before SCR F2 (Limit 1) Alarm.
925	L2 TEXH BFR SCRF2	Exhaust Temperature Before SCR F2 (Limit 2) Alarm.
926	L1 TEXH AFT SCRF2	Exhaust Temperature After SCR F2 (Limit 1) Alarm.
927	L2 TEXH AFT SCRF2	Exhaust Temperature After SCR F2 (Limit 2) Alarm.
928	L1 TEXH BFR SCRF3	Exhaust Temperature Before SCR F3 (Limit 1) Alarm.
929	L2 TEXH BFR SCRF3	Exhaust Temperature Before SCR F3 (Limit 2) Alarm.
930	L1 TEXH AFT SCRF3	Exhaust Temperature After SCR F3 (Limit 1) Alarm.
931	L2 TEXH AFT SCRF3	Exhaust Temperature After SCR F3 (Limit 2) Alarm.
932	AL MIC5 YELLOW	MIC 5 Yellow Alarm.
933	AL MIC5 RED	MIC 5 Red Alarm.
934	AL MIC5 COMM LOST	MIC 5 Comms Lost Alarm.
935	LO F1 TEXH BFR SCR	F1 Exhaust Temperature before SCR Too Low Alarm.
936	LO F2 TEXH BFR SCR	F2 Exhaust Temperature before SCR Too Low Alarm.
937	LO F3 TEXH BFR SCR	F3 Exhaust Temperature before SCR Too Low Alarm.
938	LO F1 TEXH AFT SCR	F1 Exhaust Temperature after SCR Too Low Alarm.
939	LO F2 TEXH AFT SCR	F2 Exhaust Temperature after SCR Too Low Alarm.
940	LO F3 TEXH AFT SCR	F3 Exhaust Temperature after SCR Too Low Alarm.
941	LO SCR OPRATING T	SCR Operating Temperature Too Low Alarm.
942	CATLY CONV LO F1	Catalytic Conversion Too Low F1 Alarm.
943	CATLY CONV LO F2	Catalytic Conversion Too Low F2 Alarm.
944	CATLY CONV LO F3	Catalytic Conversion Too Low F3 Alarm.
945	L1 L VOLTAGE ASO	Low ASO Voltage (Limit 1) Alarm.
946	L2 L VOLTAGE ASO	Low ASO Voltage (Limit 2) Alarm.
947	INVALD LSI CHANL CFG	Invalid LSI Channel Configuration Alarm.
948	AL ESI ACTIVATED	ESI Activated Alarm.
949	SD VOLTAGE ASO	Sensor Defect in ASO Voltage Sensor.
950	SCR SU FLT S EXST F1	SCR SU Fault S F1 Exists alarm.
951	ETC0 CUTIN FAIL	Turbo Charger 0 Cut In Failure.
952	ETC1 CUTIN FAIL	Turbo Charger 1 Cut In Failure.
953	LAMBDA VALUE INVALID	Lambda Value Invalid Alarm.
954	NOX VALUE INVALID	NOX Value Invalid Alarm.
955	THRML MANGMT ACTV	Thermal Management Active Alarm.
956	P5 CNTVAR LIM MN ACTV	P5 Control Variable Minimum Limit Active Alarm.
957	P5 CV MAX BOI MN ACT	P5 Control Variable Max BOI Minimum Active Alarm.
958	LMDA CTLVR LMT MN ACT	Lambda Control Variable Minimum Limit Active Alarm.
959	LMDA CV MX BOI MN ACT	Lambda Control Variable Max BOI Minimum Active Alarm.
960	NOXP5 MN BOI MX ACTV	NOX P5 Minimum BOI Maximum Active.
961	NOXP5 MX BOI MN ACTV	NOX P5 Maximum BOI Minimum Active.
962	GPS LMDA CV MAX ACTV	GPS Lambda Control Variable Maximum Active Alarm.
963	GPS P5 CV MAX ACTV	GPS P5 Control Variable Maximum Active Alarm.
964	GPS P5 CV MIN ACTV	GPS P5 Control Variable Minimum Active Alarm.
965	SCR SU FLT S EXIST F2	SCR SU Fault S F2 Exists Alarm.
966	SCR SU FLT S EXIST F3	SCR SU Fault S F3 Exists Alarm.
967	SCR SU PRIM REQ F1	SCR SU Priming Request F1 Alarm.
968	SCR SU PRIM REQ F2	SCR SU Priming Request F2 Alarm.
969	SCR SU PRIM REQ F3	SCR SU Priming Request F3 Alarm.
970	SD P EXHAUST	Sensor Defect in Exhaust Pressure Sensor.
971	COLD ENGINE ALARM	Cold Engine Alarm.
972	MIC5 SINGATURE DIFF	MIC5 Signature Difference Alarm.

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Fault Code Number	String	Description
973	AL CHECKSUM IIG	IIG Check Sum Alarm.
974	AL CAN3 BUS OFF	Can3 Bus Off Alarm.
975	CAN3 ERR PASSIVE	Can3 Error Passive Alarm.
976	AL CAN4 BUS OFF	Can4 Bus Off Alarm.
977	CAN4 ERR PASSIVE	Can4 Error Passive Alarm.
978	HI ETC5 OVERSPEED	Turbo Charger 5 Overspeed (Limit 1).
979	SS ETC5 OVERSPEED	Turbo Charger 5 Overspeed (Limit 2).
980	ADBLUE TEMP HI F1	ADBLUE (DEF) Temperature Too High F1 Alarm.
981	ADBLUE TEMP HI F2	ADBLUE (DEF) Temperature Too High F2 Alarm.
982	ADBLUE TEMP HI F3	ADBLUE (DEF) Temperature Too High F3 Alarm.
983	STOP ON TRIG CRSHRECR	Stop on Crash Recorder Trigger Alarm.
984	NOX ATO2 SNSR DEFCT	NOX ATO2 Sensor Defect Alarm.
985	NOX ATO2 SNS COM LOST	NOX ATO 2 Communications Lost Alarm.
1000	SD LVL DEF TNK B	Sensor Defect In DEF Tank B Level Sensor.
1001	SD LVL COOL WTR	Sensor Defect In Coolant Water Level Sensor.
1002	SD LVL HYD OIL	Sensor Defect In Hydraulic Oil Level Sensor.
1003	L1 LVL COOL WTR	Coolant Water Level (Limit 1) Alarm.
1004	L2 LVL COOL WTR	Coolant Water Level (Limit 2) Alarm.
1005	L1 LVL HYD OIL	Hydraulic Oil Level (Limit 1) Alarm.
1006	L2 LVL HYD OIL	Hydraulic Oil Level (Limit 2) Alarm.
1007	L1 LVL LUBEOIL J1939	J1939 Lube Oil Level (Limit 1) Alarm.
1008	L2 LVL LUBEOIL J1939	J1939 Lube Oil Level (Limit 2) Alarm.
1009	SD P FLTR MONITR	Sensor Defect In Fuel Filter Pressure Sensor.
1010	L1 P FLTR MONITR	Fuel Filter Pressure (Limit 1) Alarm.
1011	DEF TANK LVL LO	DEF Tank Level Low Alarm.
1012	MIC5 PARM DNLOAD ACTV	MIC5 Parameter Download Active Alarm.
1013	HI DELTA NOX AB	HI Delta NOX A-B (Limit 1) Alarm.
1014	HIHI DLTA NOX AB	HI Delta NOX A-B (Limit 2) Alarm.
1015	TTL BKDN NOX SNRS	NOX Sensors Total Breakdown alarm.
1016	REDUND LOSS NOX SNRS	NOX Sensors Redundancy Loss Alarm.
1017	HI DELTA P5 FOR NOX	High Delta P5 for NOX Alarm.
1018	F1 DEF CONSUMPT ERROR	F1 DEF Consumption Error Alarm.
1019	F1 DEF BALANCE ERROR	F1 DEF Balance Error Alarm.
1020	F1 RAW GAS EMSN ERROR	F1 Raw Gas Emission Error Alarm.
1021	F1 NOX ANNHRG ERROR	F1 NOX Approaching Error Condition Alarm.
1022	TEX BEF SCR BET F1&F2	Exhaust Temperature Before SCR Between F1 and F2 Alarm.
1023	TEX AFT SCR BET F1&F2	Exhaust Temperature After SCR Between F1 and F2 Alarm.
1024	LOLO P FUEL COMM RL A	Fuel Common Rail A Low Fuel Pressure (Limit 2) Alarm.
1025	LOLO P FUEL COMM RL B	Fuel Common Rail B Low Fuel Pressure (Limit 2) Alarm.
1026	IAP COMMS LOST	IAP Communications Lost Alarm.
1027	ENGN COLD ACTIV	Engine Cold Active Alarm.
1028	F1EXP TEX BFR SCR ERR	F1 Expected Exhaust Temperature Before SCR Error Alarm.
1029	IAP MISSNG ENERG DATA	IAP Missing Energization Data Error.
1030	LO P CRANK CASE	Low Crankcase Pressure (Limit 1) Alarm.
1031	LOLO P CRK CASE	Low Crankcase Pressure (Limit 2) Alarm.
1032	INJ DRIFT LMT1 CYL A1	Cylinder A1 Injector Drift Limit 1 Alarm.
1033	INJ DRIFT LMT1 CYL A2	Cylinder A2 Injector Drift Limit 1 Alarm.
1034	INJ DRIFT LMT1 CYL A3	Cylinder A3 Injector Drift Limit 1 Alarm.
1035	INJ DRIFT LMT1 CYL A4	Cylinder A4 Injector Drift Limit 1 Alarm.

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Fault Code Number	String	Description
1036	INJ DRIFT LMT1 CYL A5	Cylinder A5 Injector Drift Limit 1 Alarm.
1037	INJ DRIFT LMT1 CYL A6	Cylinder A6 Injector Drift Limit 1 Alarm.
1038	INJ DRIFT LMT1 CYL A7	Cylinder A7 Injector Drift Limit 1 Alarm.
1039	INJ DRIFT LMT1 CYL A8	Cylinder A8 Injector Drift Limit 1 Alarm.
1040	INJ DRIFT LMT1 CYL A9	Cylinder A9 Injector Drift Limit 1 Alarm.
1041	INJ DRFT LMT1 CYL A10	Cylinder A10 Injector Drift Limit 1 Alarm.
1042	INJ DRIFT LMT1 CYL B1	Cylinder B1 Injector Drift Limit 1 Alarm.
1043	INJ DRIFT LMT1 CYL B2	Cylinder B2 Injector Drift Limit 1 Alarm.
1044	INJ DRIFT LMT1 CYL B3	Cylinder B3 Injector Drift Limit 1 Alarm.
1045	INJ DRIFT LMT1 CYL B4	Cylinder B4 Injector Drift Limit 1 Alarm.
1046	INJ DRIFT LMT1 CYL B5	Cylinder B5 Injector Drift Limit 1 Alarm.
1047	INJ DRIFT LMT1 CYL B6	Cylinder B6 Injector Drift Limit 1 Alarm.
1048	INJ DRIFT LMT1 CYL B7	Cylinder B7 Injector Drift Limit 1 Alarm.
1049	INJ DRIFT LMT1 CYL B8	Cylinder B8 Injector Drift Limit 1 Alarm.
1050	INJ DRIFT LMT1 CYL B9	Cylinder B9 Injector Drift Limit 1 Alarm.
1051	INJ DRFT LMT1 CYL B10	Cylinder B10 Injector Drift Limit 1 Alarm.
1052	INJ DRIFT LMT2 CYL A1	Cylinder A1 Injector Drift Limit 2 Alarm.
1053	INJ DRIFT LMT2 CYL A2	Cylinder A2 Injector Drift Limit 2 Alarm.
1054	INJ DRIFT LMT2 CYL A3	Cylinder A3 Injector Drift Limit 2 Alarm.
1055	INJ DRIFT LMT2 CYL A4	Cylinder A4 Injector Drift Limit 2 Alarm.
1056	INJ DRIFT LMT2 CYL A5	Cylinder A5 Injector Drift Limit 2 Alarm.
1057	INJ DRIFT LMT2 CYL A6	Cylinder A6 Injector Drift Limit 2 Alarm.
1058	INJ DRIFT LMT2 CYL A7	Cylinder A7 Injector Drift Limit 2 Alarm.
1059	INJ DRIFT LMT2 CYL A8	Cylinder A8 Injector Drift Limit 2 Alarm.
1060	INJ DRIFT LMT2 CYL A9	Cylinder A9 Injector Drift Limit 2 Alarm.
1061	INJ DRFT LMT2 CYL A10	Cylinder A10 Injector Drift Limit 2 Alarm.
1062	INJ DRIFT LMT2 CYL B1	Cylinder B1 Injector Drift Limit 2 Alarm
1063	INJ DRIFT LMT2 CYL B2	Cylinder B2 Injector Drift Limit 2 Alarm.
1064	INJ DRIFT LMT2 CYL B3	Cylinder B3 Injector Drift Limit 2 Alarm.
1065	INJ DRIFT LMT2 CYL B4	Cylinder B4 Injector Drift Limit 2 Alarm.
1066	INJ DRIFT LMT2 CYL B5	Cylinder B5 Injector Drift Limit 2 Alarm.
1067	INJ DRIFT LMT2 CYL B6	Cylinder B6 Injector Drift Limit 2 Alarm.
1068	INJ DRIFT LMT2 CYL B7	Cylinder B7 Injector Drift Limit 2 Alarm.
1069	INJ DRIFT LMT2 CYL B8	Cylinder B8 Injector Drift Limit 2 Alarm.
1070	INJ DRIFT LMT2 CYL B9	Cylinder B9 Injector Drift Limit 2 Alarm.
1071	INJ DRFT LMT2 CYL B10	Cylinder B10 Injector Drift Limit 2 Alarm.
1072	F1EXP TEX AFT SCR ERR	F1 Expected Exhaust Temperature After SCR Error Alarm.
1073	F1GRD TEX BFR SCR ERR	F1 Exhaust Temperature Gradient Before SCR Error Alarm.
1074	F1GRD TEX AFT SCR ERR	F1 Exhaust Temperature Gradient After SCR Error Alarm.
1075	F1 T DEF TOO HI	F1 DEF Temperature Too High Alarm.
1076	LO F1 TEXH BFR SCR	F1 Exhaust Temperature before SCR Too Low Alarm.
1077	LO F1 TEXH AFT SCR	F1 Exhaust Temperature after SCR Too Low Alarm.
1078	F2 DEF CONSMPT ERR	F2 DEF Consumption Error Alarm.
1079	F2 DEF BALNC ERR	F2 DEF Balance Error Alarm.
1080	F2 RAW GAS EMISN ERR	F2 Raw Gas Emission Error Alarm.
1081	F2 NOX ANNHRG ERROR	F2 NOX Approaching Error Condition Alarm.
1082	F2EXP TEX BFR SCR ERR	F2 Expected Exhaust Temperature Before SCR Error Alarm.
1083	F2EXP TEX AFT SCR ERR	F2 Expected Exhaust Temperature After SCR Error Alarm.
1084	F2GRD TEX BFR SCR ERR	F2 Exhaust Temperature Gradient Before SCR Error Alarm.

Fault Code Number	String	Description
1085	F2GRD TEX AFT SCR ERR	F2 Exhaust Temperature Gradient After SCR Error Alarm.
1086	F2 T DEF TOO HI	F2 DEF Temperature Too High Alarm.
1087	LO F2 TEXH BFR SCR	F2 Exhaust Temperature before SCR Too Low Alarm.
1088	LO F2 TEXH AFT SCR	F2 Exhaust Temperature after SCR Too Low Alarm.

TIM-ID: 0000099917 - 001

APPENDIX E • EXHAUST TREATMENT

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APPENDIX E • EXHAUST TREATMENT

Diesel Particulate Filter (DPF)

In order to meet Tier 4 emission requirements, some engine manufacturers are applying Diesel Particulate Filters (DPF) to the exhaust system of the engine. A Diesel Particulate Filter traps particulate matter contained in diesel exhaust and prevents it from distributing into the air. The particulate matter is later burned off during a regeneration process.

The MGC-2000 Series communicates DPF control and status information to and from the engine ECU via J1939 communications in the form of various Parameter Group Numbers (PGN) and Suspect Parameter Numbers (SPN). These are summarized in the following paragraphs.

Regeneration

Regeneration is accomplished by operating the engine at elevated exhaust temperatures where the accumulated particulate is burned off. If, in normal operation, the engine can be loaded to a high enough level to achieve the elevated exhaust temperature, then regeneration can occur as a part of normal operation. This is known as *passive regeneration*.

High exhaust temperatures can also be accomplished by methods such as providing dampers in the exhaust stream or heating the exhaust through the burning of fuel. This is known as *active regeneration* since it is outside of normal engine operation.

Heavily loaded engines will seldom require active regeneration. A lightly loaded engine will likely undergo active regeneration when required.

DPF Control

DPF control information is sent from the MGC-2000 Series to the Engine ECU through PGN Number 57244 (0xE000). A manual regeneration request is sent using SPN 3696, Diesel Particulate Filter Regeneration Force Switch. Regeneration can be inhibited by SPN 3695, Diesel Particulate Filter Regeneration Inhibit Switch.

Manual Regeneration

The operator can force a regeneration cycle by turning on the Manual Regeneration setting found on the front panel under Settings→Communication→CAN bus Setup→ECU Setup→DPF Regenerate Setup. The parameter will remain on for a few seconds then go off. The ECU will respond to the momentary setting by logging the request to force a manual regeneration. A continuous request is not used because this can be problematic for some engine ECUs.

Manual regeneration can also be initiated by clicking the *Manual Regeneration* button on the ECU Setup screen in BESTCOMS*Plus*®. BESTlogic™*Plus* programmable logic can also be used to initiate manual regeneration by setting the DPF Manual Regeneration (DPFMANREGEN) logic element true.

Regeneration Inhibit

The operator can inhibit regeneration by turning on the DPF Regeneration Disable setting found on the ECU Setup screen in BESTCOMS*Plus*.

Regeneration can also be disabled by turning on the Disable Regeneration setting on the ECU Setup screen in BESTCOMS*Plus*.

BESTlogicPlus programmable logic can also be used to inhibit regeneration by setting the DPF Regeneration Inhibit (DPFREGENINHIBIT) logic element true.

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DPF Status and Pre-Alarms

The MGC-2000 Series receives DPF status information which is broadcast from the engine ECU in various Parameter Group Numbers (PGN) and Suspect Parameter Numbers (SPN). This information is displayed on the front panel and in BESTCOMS*Plus*, via DPF related pre-alarms. The J1939 parameters and the resulting MGC-2000 Series pre-alarms are summarized in the following paragraphs.

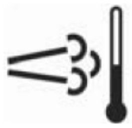
- PGN 64892 (0xFD7C) Diesel Particulate Filter Control 1
    - *SPN 3697, Diesel Particulate Filter Lamp Command*

      REGEN REQUIRED Pre-Alarm: When SPN 3697 has a value of 1 or 4 indicating the DPF lamp is on, the MGC-2000 Series will annunciate a pre-alarm with text of REGEN REQUIRED. The DPF symbol, shown to the right, will accompany the text when the pre-alarm appears on the MGC-2000 Series front panel.

    - *SPN 3698, Exhaust System High Temperature Lamp Command*

      HIGH EXHAUST TEMP Pre-Alarm: When SPN 3698 has a value of 1 indicating the high exhaust temperature lamp is on, the MGC-2000 Series will annunciate a pre-alarm with text of HIGH EXHAUST TEMP. The high exhaust temperature symbol, shown to the right, will accompany the text when the pre-alarm appears on the MGC-2000 Series front panel.

    - *SPN 3703 Diesel Particulate Filter Status*

      SPN 3703 indicates that regeneration is required at the lowest level, moderate level, or most severe level. The MGC-2000 Series uses this parameter for DPF Soot Level Pre-alarms which are described in the following paragraphs.

- DPF Soot Level Annunciation

  The MGC-2000 Series annunciates DPF Soot Level pre-alarms which are described in the following paragraphs.

    - SOOT LEVEL HIGH Pre-Alarm

      This pre-alarm is annunciated when one of the following occurs.

        - A DTC is received with SPN 3719 (Diesel Particulate Filter Soot Load Percent) with FMI = 15 (*Data Valid But Above Normal Operating Range Least Severe Level)*
        - SPN 3703 (Diesel Particulate Filter Status) is received with a value of 001 (*regeneration is needed – lowest level)*

      The pre-alarm text is SOOT LVL HI.

      The DPF symbol, shown to the right, accompanies the text when the pre-alarm appears on the MGC-2000 Series front panel.

    - SOOT LEVEL MODERATELY HIGH Pre-Alarm

      This pre-alarm is annunciated when one of the following occurs.

        - A DTC is received with SPN 3719 (Diesel Particulate Filter Soot Load Percent) with FMI = 16 (*Data Valid But Above Normal Operating Range Moderately Severe Level)*
        - SPN 3703 (Diesel Particulate Filter Status) is received with a value of 010 (*regeneration is needed – moderate level)*

      The pre-alarm text is SOOT LVL MOD HI.

      The DPF warning symbol, shown to the right, accompanies the text when the pre-alarm appears on the MGC-2000 Series front panel.

    - SOOT LEVEL EXTREMELY HIGH Pre-Alarm

      This pre-alarm is annunciated when one of the following occurs.

        - A DTC is received with SPN 3719 (Diesel Particulate Filter Soot Load Percent) with FMI = 0 (*Data Valid But Above Normal Operating Range Most Severe Level)*

- SPN 3703 (Diesel Particulate Filter Status) is received with a value of 011 (*regeneration is needed – highest level)*

The pre-alarm text is SOOT LVL EXT HI.

The DPF stop symbol, shown to the right, accompanies the text when the pre-alarm appears on the MGC-2000 Series front panel. If the DPF soot level reaches the most severe level, the engine ECU may shut the engine down, preventing it from running, or allow it to run, but at a reduced power level. The MGC-2000 Series only indicates a pre-alarm, it does not prevent the engine from running or cause operation at a reduced power level. However, the operator should be aware that the engine ECU or after treatment system may cause such behavior.

Exhaust After Treatment Systems (EATS)

In order to meet Tier 4 emission requirements, some engine manufacturers are adding Exhaust After Treatment Systems (EATS) which treat the engine exhaust within the exhaust system to reduce particulate matter and harmful contaminants prior to releasing the exhaust into the atmosphere. One such system uses urea-based Diesel Exhaust Fluid (DEF) catalyst which is combined with the exhaust gasses in the EATS to bring the emissions to acceptable levels.

The MGC-2000 Series meters EATS information from the engine ECU via J1939 CAN bus and displays the DEF level within the DEF tank(s), and also displays several pre-alarms related to the EATS system. Any DEF related pre-alarms annunciated on the front panel display the symbol used for DEF functions which is shown to the right.

Most systems will contain one DEF tank, while some may contain two tanks. The MGC-2000 Series front panel displays the level of DEF in each tank under Metering→Alarms-Status→J1939 Status→DEF Tank1 LVL% and Metering→Alarms-Status→J1939 Status→DEF Tank2 LVL%. The tank 1 level is sent from the ECU via SPN 1761 in J1939 PGN 65110 - After Treatment 1 Reagent Tank 1 Information. The tank 2 level is sent from the ECU via SPN 4367 in J1939 PGN 64829 - After Treatment 1 Reagent Tank 2 Information. The tank levels are expressed in units of percent.

Pre-Alarms

The ECU sends DEF level diagnostics to the MGC as SPNs 5245 and 5246 in PGN 65110 (the AT1TI PGN). SPN 5245 communicated DEF level diagnostics, whereas SPN 5246 communicates DEF inducement level status.

There are several pre-alarms related to the EATS which annunciate DEF level diagnostics and DEF inducement level status. They are always enabled and will annunciate when received from the engine ECU. Each of them contains the symbol for DEF functions when annunciated on the front panel; however it will not be displayed in BESTCOMS*Plus*. The pre-alarms are summarized in the following paragraphs.

- DEF FLUID LOW: This pre-alarm displays when SPN 5245 has a value of 1, indicating that the DEF tank level is low. The exact DEF levels which constitute a low DEF condition vary among manufacturers.
- DEF LOW SEVERE: This pre-alarm displays when SPN 5245 has a value of 4, indicating that the DEF tank level is severely low or empty. The exact DEF levels which constitute a severely low DEF condition vary among manufacturers. When this occurs and is not remedied, the engine ECU may enter a mode of inducement not to operate the engine where some of the conditions in the pre-alarms descriptions below may occur.
- DEF WARNING: This pre-alarm displays when SPN 5246 has a value of 1. This is the lowest level of warning which indicates the EATS is not functioning properly or DEF quality or level is insufficient for proper operation.
- DEF WARNING LVL2: This pre-alarm displays when SPN 5246 has a value of 2. This is a higher level of warning which indicates the EATS is not functioning properly or DEF quality or level is insufficient for proper operation. If the problem causing this warning is not corrected, the system will eventually enter the DEF inducement states. In these states, the engine power or operating speed may be derated depending on the engine manufacturer and engine application.
- DEF INDUCEMENT: This pre-alarm displays when SPN 5246 has a value of 3, indicating the first level of inducement. The engine power or operating speed may be derated at this level of inducement

depending on engine manufacturer and engine application. This is the lowest level of inducement and is caused by either the EATS not functioning properly or insufficient DEF quality or level for proper operation.

- DEF PRESEVERE INDUCEMENT: This pre-alarm displays when SPN 5246 has a value of 4, indicating the Pre-Severe Inducement level of inducement. This indicates that the engine has entered the second highest level of inducement not to operate. This is caused by either the EATS not functioning properly or insufficient DEF quality or level for proper operation. The engine power or operating speed may be derated at this level of inducement depending on engine manufacturer and engine application. The ECU will allow the engine to run for a limited time in this condition after which the engine will enter the severe inducement state.
- DEF SEVERE INDUCEMENT: This pre-alarm displays when SPN 5246 has a value of 5, indicating the Severe Inducement level of inducement. This is caused by either the EATS not functioning properly or insufficient DEF quality or level for proper operation. In this condition, the engine may either operate with reduced power or RPM or be shut down depending on manufacturer or engine application. The engine will remain at this level of inducement until the problem causing the inducement is resolved.
- DEF INDUCEMENT OVERRIDE: This pre-alarm displays when SPN 5246 has a value of 6, indicating the Temporary Override of inducement. This indicates DEF inducement is temporarily overridden. The engine may operate with reduced power, or for a limited time, after which time it may re-enter the SEVERE INDUCEMENT state.

TIM-ID: 0000099917 - 001

1.11 MTU Onsite Energy Gaseous Fuel System Data Sheet

GASEOUS FUEL SYSTEM

Fuel System Specifications Data Sheet

MTU Onsite Energy has developed a custom fuel system using common gaseous fuel system components that features a state-of-the-art Engine Control Module (ECM) which has the latest technology available incorporated.

As today's emissions regulations get stricter on engines, other solutions are necessary to comply. This is accomplished with the new MTU Onsite Energy gaseous generator sets by using a closed loop fuel system utilizing sequential ignition and after treatment (where required). This system is capable of detecting engine faults and protecting itself from harm while also alerting the user with a Malfunction Indicator Light (MIL) through the digital generator set controller. The ECM communicates with the controller to allow a fully integrated system sharing necessary information between components reducing additional sensors. The MTU Onsite Energy fuel system is adept to operating conditions and changes parameters based on its surroundings for variables such as barometric pressure and intake air temperature. Knock sensing is also a built-in function to the fuel system allowing peak power for the environmental conditions of the unit when this protection is deemed necessary.

The MTU Onsite Energy fuel system utilizes a Windows®-based interface for viewing the engine parameters along with diagnostic tools for determining component failures, allowing quick solutions in the field.

PRODUCT HIGHLIGHTS

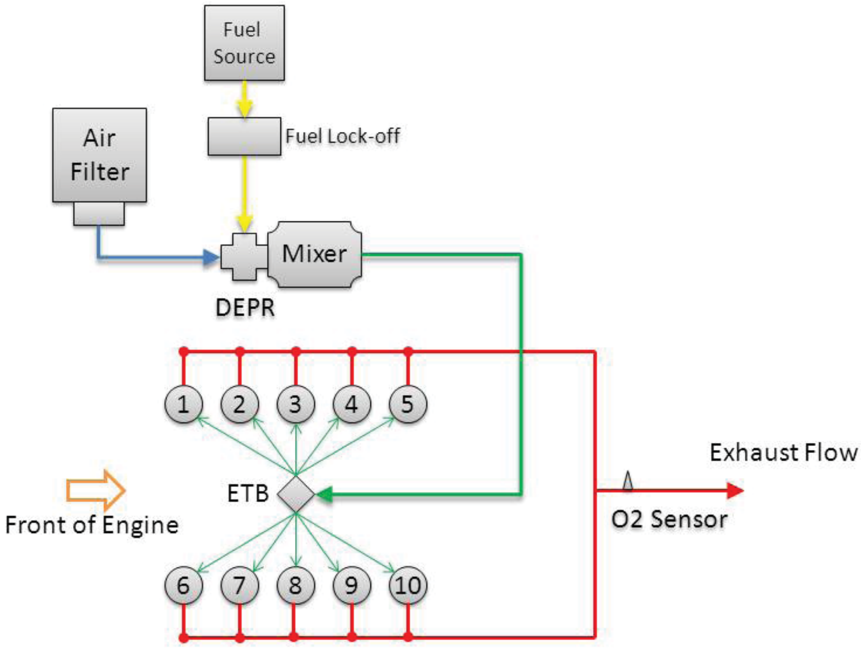
MTU Onsite Energy fuel system capabilities include (but are not limited to):

- CAN J-1939 for full communication with the digital generator set controller amongst other devices capable of reading CANBus signals
- Closed Loop Lambda Control for EPA Compliance
- Sequential Ignition System
- Electronic Governing
- Controls engines up to 10 cylinders
- Electronic Fuel Lock-Off Control
- Built-In Engine Data Logger
- Built-In Engine Protection from engine faults
- Every fuel system pre-programmed for single fuel operation on both NG or LPG fuel
- Active Knock Control (where applicable)

TIM-ID: 0000048902 - 006

GASEOUS FUEL SYSTEM

Fuel System Specifications Data Sheet



Fuel System Overview Diagram (10V shown)

**DEPR = Digital Electronic Pressure Regulator

FUEL SYSTEM
Single Valve Gas Solenoid Data Sheet

Internal pilot operated solenoid valve used to control the flow of fuel gases in generator systems. This compact valve design exceeds flow requirements and is also capable of withstanding temperatures as low as -40 °F.

DESCRIPTION

- Unique double disc design with overtravel provides redundant sealing for leak tight shutoff
- For on-off control of fuel gas
- ⅛" NPT pipe taps with plugs for routine testing

VALVE CONSTRUCTION

Valve Part Materials	
Body	Aluminum
Seals and Disc	NBR
Core Tube	305 Stainless Steel
Core Guide	Acetal
Rider Ring	PTFE
Core and Plugnut	430F Stainless Steel
Springs	302 Stainless Steel
Shading Coil	Copper
Pipe Plug	Zinc-Plated Steel

ELECTRICAL

Standard Coil and Class of Insulation	B
DC Watts	14.9

VALVE RESPONSE TIME

Opening Time	Less than 1 second
Closing Time	Less than 1 second

APPROVALS

UL Listed to standard 429 “Electrically Operated Valves” Guide YIOZ, File MP618 Safety Shutoff Valves.

CSA Certified to:
1. Standard C22.2 No. 139 “Electrically Operated Valves”, File 010381
2. Automatic Gas Valves Z21.21 (6.5), C/I, File 112872
3. Automatic Gas Safety Shutoff Valves (3.9), File 112872

NPT	Voltage	Part Number
¾"	12	SUA46013
1"	12	SUA46021
1 ½"	12	SUA86725
1 ½"	24	SUA87895
2"	24	SUA86726

TIM-ID: 0000048903 - 005

TIM-ID: 0000048903 - 005

1.13 Dual Valve Gas Solenoid Data Sheet

FUEL SYSTEM
Dual Valve Gas Solenoid Data Sheet

There are two primary types of valves. Valve 1 features two normally closed safety shutoff valves in one housing, as well as a maximum flow adjustment. Valve 2 features two normally closed safety shutoff valves with a gas pressure regulator in one housing. Both valve types are used in single and dual fuel systems to regulate the flow of gaseous fuels to generator systems, and are also fast opening and fast closing.

CERTIFICATIONS AND STANDARDS

All models are:
- CSA Certified
- UL Recognized

PART NUMBER LIST

12 Volt Systems	24 Volt Systems
SUA102426	SUA102427
SUA102428	SUA102429
	SUA97687

SPECIFICATIONS

	Valve 1	Valve 2
Part Numbers	SUA97687	SUA102426, SUA102427, SUA102428, and SUA102429
Gases	Natural Gas, Propane	Natural Gas, Propane
Maximum Operating Pressure	5 psi	5 psi
Maximum Close-Off Pressure	C/F	7 psi
Ambient Temperature	5 °F to 140 °F	-40 °F to 140 °F
Cycle Rate	C/F	60 Cycles/Hour
Operating Time	100% Duty Cycle	100% Duty Cycle
Valve Construction		
Housing	Aluminum, Steel	Aluminum, Steel
Seal on Valve Seats	NBR-based rubber	NBR-based rubber
Valve Response Time		
Opening Time	Less than 1 second	Less than 1 second
Closing Time	Less than 1 second	Less than 1 second

SUPPLEMENTAL HARDWARE

Valve	1 ½" Flange	2" Flange	Gas Pressure Switch
SUA97687	N/A	SUA97686	N/A
SUA102426	SUA91990	SUA91991	SUA91987
SUA102427	SUA91990	SUA91991	SUA91987
SUA102428	SUA91992	N/A	SUA91987
SUA102429	SUA91992	N/A	SUA91987

TIM-ID: 0000048904 - 005

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PowerPact™ H-, J-, and L-Frame Circuit Breakers

Catalog
0611CT1001

2012

Class 0611

CONTENTS

TIM-ID: 0000053623 - 002

SQUARE D
by Schneider Electric

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SQUARE D™ by Schneider Electric

PowerPact™ H-, J-, and L-Frame Circuit Breakers

TIM-ID: 0000053623 - 002

Section 1—Catalog Numbering

PowerPact with Micrologic™ Circuit Breakers

The PowerPact H-, J-, and L-frame circuit breakers are designed to protect electrical systems from damage caused by overloads and short circuits. H- and J-frame circuit breakers are available with either thermal-magnetic or Micrologic™ electronic trip units. L-frame circuit breakers are available with Micrologic electronic trip unit.

Direct Access to Energy Management

The new generation PowerPact with Micrologic circuit breakers set the standard with direct access to energy management. Integrated metering enhances their protective functions. For the first time, Schneider Electric™ users can monitor energy from 15 A to 3000 A, offering new performance in a remarkably compact device.

- Smart – A meter in every breaker
- Safe – Combines safety and performance in one compact device
- Simple – Easy to select, install, and use

Increased energy availability

Safety and Protection

Energy measurement and control

Catalog Numbering

– J L L 3 6 250 T – – – – –

Brand

- _ Square D™
- N Schneider Electric

Frame

- H H-Frame
- J J-Frame
- L L-Frame

Performance Level (kA) (See Table 1)

Terminations

- L Lugs Line/Load Side
- M Lugs Line Side
- P Lugs Load Side
- F Bus Bar
- A I-Line
- S Rear Connected
- N Plug-in
- D Drawout
- K Reverse I-Line

Poles

- 2 2P
- 3 3P
- 4 4P

Voltage

- 6 600 Vac

Amperage

- 060 60 A
- 100 100 A
- 150 150 A
- 250 250 A
- 400 400 A
- 600 600 A
- 000 Switch or Frame only

Trip Unit

Micrologic™ Electronic Trip Units

- U31 LI Standard Protection
- U33 LSI Standard Protection
- U43 LSI plus Ammeter
- U44 LSIG plus Ammeter
- U53 LSI plus Energy Management
- U54 LSIG plus Energy Management
- M37 Magnetic Only (L-Frame Only)
- M38 Motor Protector Circuit Breaker
- S40 400 A Molded Case Switch (L-Frame Automatic Switch)
- S60 600 A Molded Case Switch (L-Frame Automatic Switch)
- F40 400 A L-Frame Only (No Trip Unit)
- F60 600 A L-Frame Only (No Trip Unit)

Thermal-Magnetic Trip Units

- — Standard Fixed Trip Unit (Suitable for reverse connection)
- F06 60 A H-Frame Only (No trip unit)
- F15 150 A H-Frame Only (No trip unit)
- F25 250 A J-Frame Only (No trip unit)
- T Complete Circuit Breaker (Frame + removable trip unit)
- S15 150 A Molded Case Switch (H-Frame automatic switch)
- S17 175 A Molded Case Switch (J-Frame automatic switch)
- S25 250 A Molded Case Switch (J-Frame automatic switch)
- C 100% Rated Continuous Current Rating[1]
- M71 30 A H-Frame Motor Circuit Protector (MCP)
- M72 50 A H-Frame Motor Circuit Protector (MCP)
- M73 100 A H-Frame Motor Circuit Protector (MCP)
- M74 150 A H-Frame Motor Circuit Protector (MCP)
- M75 250 A J-Frame Motor Circuit Protector (MCP)
- D81 500 Vdc 150–175 A J-Frame Molded Case Circuit Breaker
- D82 500 Vdc 200–250 A J-Frame Molded Case Circuit Breaker
- R 100% Rated Continuous Current Rating Complete Circuit Breaker (Frame + removable trip unit)

1 100% ratings valid for:
3P H/J frame unit mount only
3P/4P L-frame 250 A and 400 A unit mount
3P L-frame 250 A and 400 A I-Line

I-Line™ Phasing

- — ABC (3P)
- 6 CBA (3P)
- 1 AB (2P)
- 2 AC (2P)
- 3 BA (2P)
- 4 BC (2P)
- 5 CA (2P)
- 6 CB (2P)

Accessory Suffix Code (See Table 2)

Table 1: Interrupting Rating

	UL/CSA/NOM					IEC 647-2 Icu/Ics					
	240 Vac	**480 Vac**	**600 Vac**	**250 Vdc[1]**	**500 Vdc[2]**	**220/240 Vac**	**380/440/415 Vac**	**500/525 Vac**	**690 Vac**	**250 Vdc[1]**	**500 Vdc[3]**
D	25 kA	18 kA	14 kA	20 kA	—	25/25 kA	18/18 kA	14/14 kA	—	20 kA	20 kA
G	65 kA	35 kA	18 kA	20 kA	20 kA	65/65 kA	35/35 kA	18/18 kA	—	20 kA	20 kA
J	100 kA	65 kA	25 kA	20 kA	—	100/100 kA	65/65 kA	25/25 kA	—	20 kA	20 kA
L	125 kA	100 kA	50 kA	20 kA	—	125/125 kA	100/100 kA	50/50 kA	—	20 kA	20 kA
R	200 kA	200 kA	100 kA	—	—	150 kA	125 kA	75 kA	20 kA	—	—

1 250 Vdc ratings only available with PowerPact H or J circuit breakers with thermal-magnetic trip units (not including MCP).
2 UL 500 Vdc ratings only available with PowerPact J circuit breakers with thermal-magnetic trip units (not including MCP).
3 IEC 500 Vdc rating only available on PowerPact J-frame circuit beakers.

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SQUARE D™ by Schneider Electric

Table 2: Factory Installed Accessory Suffix Codes (Building Sequence as Listed) and Field-Installable Kit Number

(1) Communication Networks[1]

Suffix	Description	Kit No.
EA	NSX Cord 1.3 m, V ≤ 480 V	S434201
EB	NSX Cord 3 m, V ≤ 480 V	S434202
ED	NSX Cord 1.3 m, V > 480 V	S434204
EE	NSX Cord 3 m, V > 480 V	S434303
EG[4]	BSCM + NSX Cord 1.3 m, V ≤ 480 V	S434201BS
EH[4]	BSCM + NSX Cord 3 m, V ≤ 480 V	S434202BS
EK[4]	BSCM + NSX Cord 1.3 m, V > 480 V	S434204BS
EL[4]	BSCM + NSX Cord 3 m, V > 480 V	S434303BS
EN	24 Vdc Power Supply Terminal Block	S434210

(2) Indication Contacts

Suffix	Description	Kit No.
V	SDX	S429532
	SDTAM (motor only trip units)	S429424

(3) Auxiliary Switch

Suffix	Contacts	Kit No.	Kit Qty.
AA	1A/1B Standard	S29450	1
AB	2A/2B Standard	S29450	2
AC	3A/3B Standard (L-frame only)	S29450	3
AE	1A/1B Low-Level	S29452	1
AF	2A/2B Low-Level	S29452	2
AG	3A/3B Low Level (L-frame only)	S29452	3

(4) Alarm/Overcurrent Trip Switch

Suffix	Switch	Kit No.	Kit Qty.
PowerPact L-Frame and PowerPact H/J-Frame with Micrologic™ 5/6 trip units			
BC	Alarm Switch	S29450	1
BH	Alarm Switch Low-Level	S29452	1
BD	Overcurrent Trip Switch, Standard SDE Actuator	S29450 S29451	1 1
BJ	Overcurrent Trip Switch, Low-Level SDE Actuator	S29452 S29451	1 1
BE	Alarm Switch and Overcurrent Trip Switch, Standard	S29450	2
BK	Alarm Switch and Overcurrent Trip Switch, Low-Level	S29452	2
PowerPact H/J-Frame with Thermal-Magnetic or Micrologic 1/2/3 trip units			
BC	Alarm Switch	S29450	1
BH	Alarm Switch Low-Level	S29452	1
BD	Overcurrent Trip Switch, Standard SDE Actuator	S29450 S29451	1 1
BJ	Overcurrent Trip Switch, Low-Level SDE Actuator	S29452 S29451	1 1
BE	Alarm Switch and Overcurrent Trip Switch, Standard SDE Actuator	S29450 S29451	2 1
BK	Alarm Switch and Overcurrent Trip Switch, Low-Level SDE Actuator	S29452 S29451	2 1

1 Except for 24 Vdc Power Supply Terminal Block, installation requires IFM (STRV00210) for Modbus communication and/or FDM (STRV00121) for external display
2 YH1 = all installed accessories but ZSI and ENCT
YH2 = ENCT and all installed accessories
YH3 = ZSI and all installed accessories
YH4 = ZSI, ENCT and all installed accessories
3 I-Line™ wire harness included for communication network accessories. Optional wire harness for unit mount requires YH1 suffix.
4 If using with a motor operator, requires Communicating Motor Operator (suffix NC).
5 Requires Micrologic trip unit U43, U44, U53, or U54 and communication accessories EG, EH, EK, or EL.

(5) Shunt Trip		(6) Undervoltage Release UVR		Voltage
Suffix	Kit No.	Suffix	Kit No.	
SK	S29384	UK	S29404	24 Vac
SL	S29385	UL	S29405	48 Vac
SA	S29386	UA	S29406	120 Vac
SD	S29387	UD	S29407	208/277 Vac
SH	S29388	UH	S29408	380/480 Vac
SJ	S29389	UJ	S29409	525/600 Vac
SN	S29382	UN	S29402	12 Vdc
SO	S29390	UO	S29410	24 Vdc
SU	S29391	UU	S29411	30 Vdc
SP	S29392	UP	S29412	48 Vdc
SV	S29383	UV	S29403	60 Vdc
SR	S29393	UR	S29413	125 Vdc
SS	S29394	US	S29414	250 Vdc

(6) Communicating Motor Operator[5]

Suffix	Voltage	H-Frame	J-Frame	L-Frame
NC	220/240 Vac	S429441	S431549	S432652

(7) Motor Operator

Suffix	Voltage	H-Frame	J-Frame	L-Frame
ML	48/60 Vac	S29440	S31548	S432639
MA	120 Vac	S29433	S31540	S432640
MD	277 Vac	S29434	S31541	S432641
MF	380/415 Vac	—	—	S432642
MH	440/480 Vac	S29435	S31542	S432647
MO	24/30 Vdc	S29436	S31543	S432643
MV	48/60 Vdc	S29437	S31544	S432644
MR	110/130 Vdc	S29438	S31545	S432645
MS	250 Vdc	S29439	S31546	S432646

(8) Rotary Handle

Suffix	Handle Type (color)	H/J-Frame	L-Frame
RD10	Direct Mount (black)	S29337	S32597
RD20	Direct Mount (red)	S29339	S32599
RE10	Extended Door Mount (black)	S29338	S32598
RT10	Telescoping (black)	S29343	S32603
RE20	Extended Door Mount (red)	S29340	S32600

(9) Wire Harnesses[2]

Suffix	Harness[2]	Kit No.
YH3	ZSI Wire Harness, H/J Frame	S434300
YH3	ZSI Wire Harness, L-Frame	S434301
YH2	ENCT Wire Harness	S434302
YH1	OF Wire Harness	S434500
YH1	SD/SDE Wire Harness	S434501
YH1	SDx/SDTAM Wire Harness	S434502
YH1	MN Wire Harness	S434503
YH1	MX Wire Harness	S434504
YH1	Motor Operator Wire Harness	S434506
YH1	Communicating Motor Operator Wire Harness	S434507
YH1[3]	NSX Wire Harness	S434508
YH4	ENCT and ZSI Wire Harnesses	—
YH1[3]	24 Vdc Power Supply Wire Harness	S434505

(10) Handle Padlocks

Suffix	Padlock Type	H/J-Frame	L-Frame
YP	Handle Padlock, ON or OFF	S29371	S32631
YQ	Handle Padlock, OFF Only	S37422	NJPAF

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Section 2—General Information

The PowerPact H-, J-, and L-frame circuit breakers are designed to protect electrical systems from damage caused by overloads and short circuits. H- and J-frame circuit breakers are available with either thermal-magnetic or Micrologic™ electronic trip units. L-frame circuit breakers are available with Micrologic electronic trip unit.

H- and J-frame circuit breakers with thermal-magnetic trip units contain individual thermal (overload) and instantaneous (short circuit) sensing elements in each pole. The amperage ratings of the thermal trip elements are calibrated at 104°F (40°C) free air ambient temperature. Per the National Electric Code® (NEC®) and the Canadian Electrical Code, standard circuit breakers may only be applied continuously at up to 80% of their rating. Circuit breakers rated for 100% operation are available but require specially-designed enclosures, copper lugs, and 194°F (90°C) rated wire.

Devices with the Micrologic electronic trip unit provide adjustable protection settings for greater system flexibility. In addition to electronic protection, Micrologic trip units allow users to monitor both energy and power. Through direct access to in-depth information and networking using open protocols, PowerPact circuit breakers with Micrologic trip units let operators optimize the management of their electrical installations. Far more than a circuit breaker, these circuit breakers are a measurement and communication tool ready to meet energy-efficiency needs through optimized power requirements, increased energy availability, and improved installation management.

Applications

PowerPact H-, J-, and L-frame circuit breakers offer high performance and a wide range of interchangeable trip units to protect most applications.

Electronic trip units provide highly accurate protection with wide setting ranges and can integrate measurement, metering and communication functions. They can be combined with the front display module (FDM121) to provide functions similar to a power meter.

Table 3: Applications

	Power Meter	PowerPact H-, J-, and L-frame circuit breakers equipped with Micrologic 5 / 6 trip units offer type A (ammeter) or E (energy) metering functions as well as communication capability. Using Micrologic trip unit sensors and intelligence, PowerPact H-, J-, and L-frame circuit breakers provide access to measurements of all the main electrical parameters on the built-in screen, on a dedicated front display module (FDM121) or through the communication network.
	Operating assistance	Integration of measurement functions provides operators with operating assistance functions including alarms tripped by user-selected measurement values, time-stamped event tables and histories, and maintenance indicators.
	Front display module	The main measurements can be read on the built-in screen of Micrologic 5 / 6 trip units. They can also be displayed on the equipment FDM121 along with pop-up windows signalling the main alarms.
	Communication Network	PowerPact H-, J-, and L-frame circuit breakers equipped with Micrologic 5 / 6 trip units provide communication capabilities. Simple RJ45 cables connect to a Modbus™ communication interface module.

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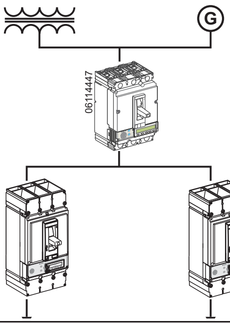
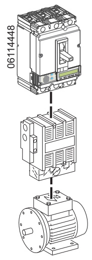
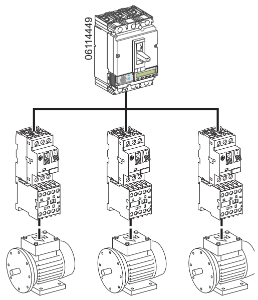
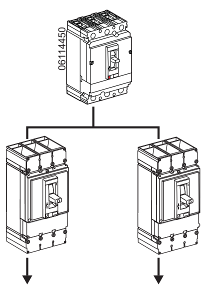
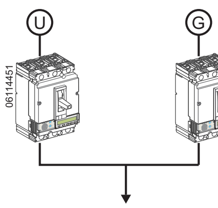
Table 3: Applications

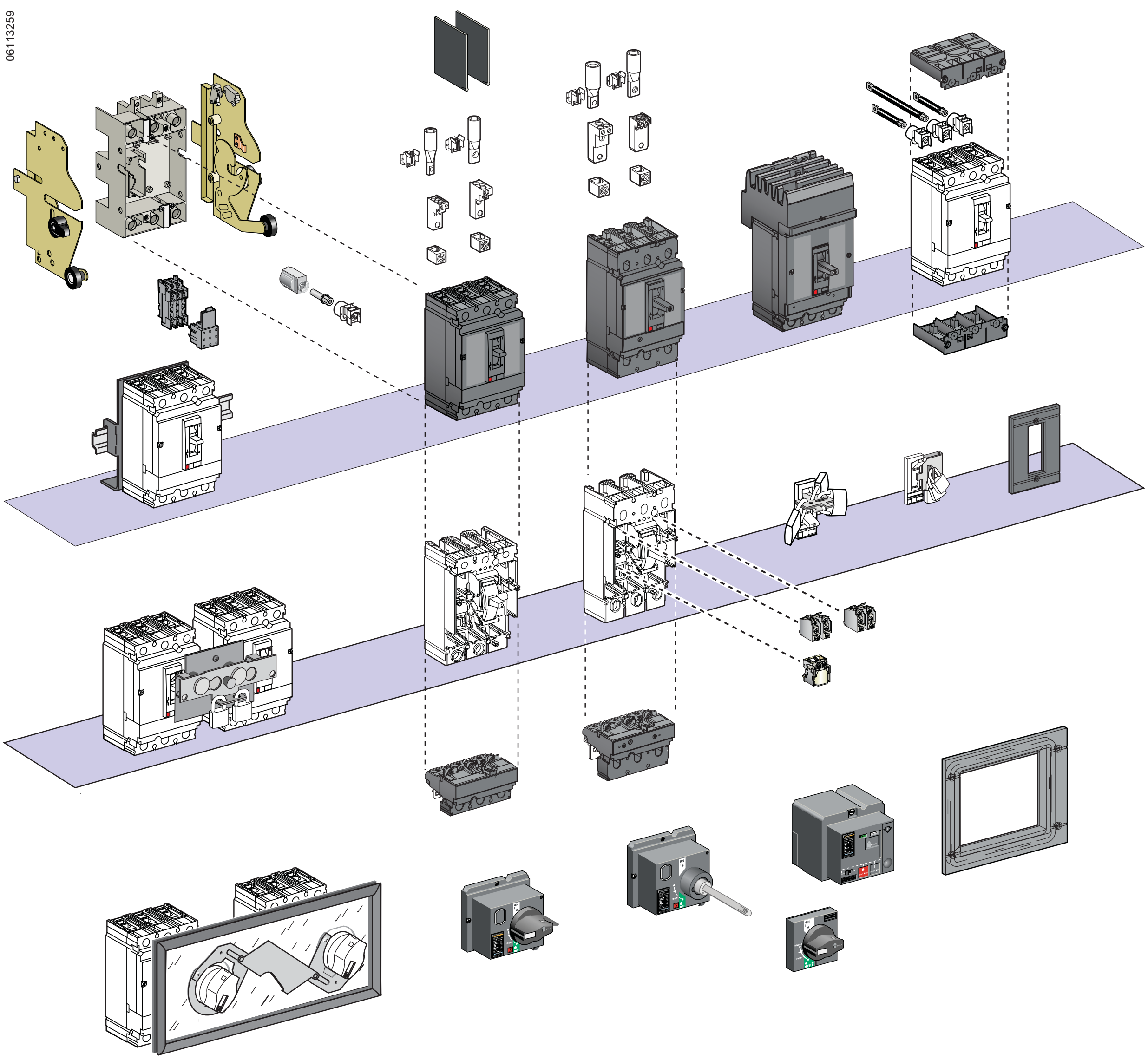
	Protection of distribution systems	The PowerPact H-, J-, and L-frame circuit breakers provide protection against short circuits and overloads for: • distribution systems supplied by transformers • distribution systems supplied by engine generator sets They are easily installed at all levels in distribution systems, from the main LV switchboard to the subdistribution boards and enclosures. All PowerPact circuit breakers can protect against insulation faults by adding an external Vigirex relay.
	Protection of motors	The PowerPact H-, J-, and L-frame circuit breakers include a number of versions to protect motor applications: • basic short-circuit protection with electronic instantaneous only MCP or the electronic Micrologic™ 1.3 M trip units, combined with a special overload relay to provide thermal protection • protection against overloads, short circuit and phase unbalance or loss with Micrologic 2 M trip units The exceptional limiting capacity of the PowerPact circuit breakers automatically provides coordination with the motor starter.
	Protection of special applications	The PowerPact H-, J-, and L-frame circuit breakers offer a number of version for special protection applications: • industrial control panels with: — compliance with international standards IEC 60947-2 and UL 508/CSA 22.2 N°14 —compliance with UL489 — installation in universal and functional enclosures • 400 Hz systems
	Control using automatic switches	An automatic switch version of PowerPact H-, J-, and L-frame circuit breakers is available for circuit control. All add-on functions for the circuit breakers may be combined with the basic automatic switch function, including motor operators. For information on other automatic switches, contact Schneider Electric™.
	Manual transfer systems	To ensure a continuous supply of power, some electrical installations are connected to two power systems: • the normal source, usually the utility (U) • a replacement source to supply the installation when the normal source is not available, generally from a generator (G) A mechanical and/or electrical interlocking system between two circuit breakers or automatic switches avoids all risk of parallel connection of the sources during switching. A system can be manual transfer mechanical device interlocking.

Flexible Configurations

The PowerPact H-, J- and L-frame circuit breakers may be configured with lugs, bus bar connections, rear connections, I-Line™, drawout cradle, or plug-in base.

Field Installable Accessories and Trip Units

Figure 1: Field Installable Accessories and Trip Units



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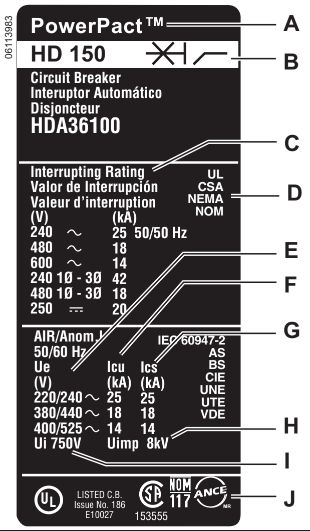
General Characteristics

Faceplate Label



Characteristics indicated on the faceplate label:

A. Circuit breaker type
B. Circuit breaker disconnector symbol
C. Performance levels
D. Standards
E. Ue: Operating voltage per IEC
F. Icu: Ultimate breaking capacity per IEC
G. Ics: Service breaking capacity per IEC
H. Uimp: Rated impulse withstand voltage per IEC
I. Ui: Insulation voltage per IEC
J. Certification marks

NOTE: When the circuit breaker is equipped with an extended rotary handle, the door must be opened to view the faceplate.

Codes and Standards

H-, J-, and L-frame circuit breakers, automatic switches and electronic motor circuit protectors are manufactured and tested in accordance with the following standards.

NOTE: Apply circuit breakers according to guidelines detailed in the National Electric Code (NEC) and other local wiring codes.

Table 4: Codes and Standards (Domestic)

PowerPact H-, J-, and L-Frame Circuit Breakers	H-, J-, and L-Frame Switches	PowerPact H-, J-, and L-Frame Motor Circuit Protectors
UL 489[1]	UL 489[3]	UL 508
IEC 60947-2	IEC 60947-3	IEC 60947-2
CSA C22.2 No. 5[2]	CSA C22.2 No. 5[4]	CSA C22.2 No. 14
Federal Specification W-C-375B/GEN	Federal Specification W-C-375B/GEN	NEMA AB1
NEMA AB1	NEMA AB1	CCC
NMX J-266	NMX J-266	CE Marking
CCC	CE Marking	
CE Marking		

1 PowerPact H- and J-frame circuit breakers are in UL File E10027. PowerPact L-frame circuit breakers are in UL File E63335.
2 PowerPact H- and J-frame circuit breakers are in CSA File LR40970. PowerPact L-frame circuit breakers are in CSA File 69561.
3 PowerPact H- and J-frame switches are in UL File E87159.
4 PowerPact H- and J-frame switches are in CSA File LR32390.

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Vibration

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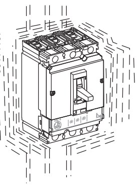

PowerPact H-, J-, and L-frame devices resist mechanical vibration.

Tests are carried out in compliance with standard UL489 SA and SB for the levels required by merchant-marine inspection organizations (Veritas, Lloyd's, etc.):

PowerPact H-, J-, and L-frame circuit breaker meet IEC 60068-2-6 for vibration:

- — 2.0 to 25.0 Hz and amplitude +/- 1.6 mm
- — 25.0 to 100 Hz acceleration +/- 4.0 g

Excessive vibration may cause tripping, breaks in connections or damage to mechanical parts.

Electromagnetic disturbances

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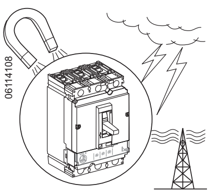

PowerPact H-, J-, and L-frame devices are protected against:

- overvoltages caused by circuit switching
- overvoltages caused by an atmospheric disturbances or by a distribution-system outage (such as from failure due to lightning)
- devices emitting radio waves (radios, walkie-talkies, radar, etc.)
- electrostatic discharges produced directly by users

PowerPact H-, J-, and L-frame devices have successfully passed the electromagnetic-compatibility tests (EMC) defined by the following international standards:

- IEC/EN 60947-2: Low-voltage switchgear and controlgear, part 2: Circuit breakers:
  - — Annex F: Immunity tests for circuit breakers with electronic protection
  - — Annex B: Immunity tests for residual current protection
- IEC/EN 61000-4-2: Electrostatic-discharge immunity tests
- IEC/EN 61000-4-3: Radiated, radio-frequency, electromagnetic-field immunity tests
- IEC/EN 61000-4-4: Electrical fast transient/burst immunity tests
- IEC/EN 61000-4-5: Surge immunity tests
- IEC/EN 61000-4-6: Immunity tests for conducted disturbances induced by radio frequency fields
- CISPR 11: Limits and methods of measurement of electromagnetic disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment.

These tests ensure that:

- no nuisance tripping occurs
- tripping times are respected

Tropicalization

The materials used in PowerPact circuit breakers will not support the growth of fungus and mold.

PowerPact circuit breakers have passed the test defined below for extreme atmospheric conditions.

Dry cold and dry heat:

- — IEC 68-2-1–dry cold at -55 °C
- — IEC 68-2-2–dry heat at +85° C

Damp heat (tropicalization)

- — IEC 68-2-30–damp heat (temperature + 55° C and relative humidity of 95%)
- — IEC 68-2-52 level 2–salt mist

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Special Ratings

The H-frame and J-frame circuit breakers also comply with the following special ratings:

- HACR rating
- SWD switch duty rating (applies only to 15 and 20 A / 277 Vac or less, 2P and 3P)
- HID high intensity discharge lighting rating (15–50 A)

The L-frame circuit breakers complies with the following special rating:

- HACR rating

Marine Ratings

UL Marine Listed/CSA Certified Circuit Breakers (UL489 Supplement SA)

The PowerPact H- and J-frame circuit breakers with thermal-magnetic trip units meet the UL 489 Supplement SA requirements for use on vessels of any length under or over 65 ft. (19.8 m). The PowerPact H-, J-, and L-frame circuit breakers with Micrologic™ electronic trip units meet the UL 489 Supplement SA for use on vessels over 65 ft. (19.8 m) in length. Marine circuit breakers must not use aluminum or aluminum alloys for terminal connections and must be calibrated at an ambient temperature of 104° F (40° C). Standard circuit breakers should not be specified or used in the place of marine rated circuit breakers.

Circuit breakers can be ordered with the Marine SA listing by adding the suffixes “LC” (copper lugs) and “YA” (marine) to the catalog number.

UL Naval Listed/CSA Certified Circuit Breakers (UL 489 Supplement SB)

The PowerPact H-, J-, and L-frame circuit breakers with Micrologic trip units meet the UL 489 Supplement SB requirements for use on naval vessels. These circuit breakers are subject to various vibration tests as described in UL 489 Supplement SB. Naval circuit breakers must not use aluminum or aluminum alloys for terminal connections and must be calibrated at an ambient temperature of 122° F (50° C). Standard circuit breakers should not be specified or used in the place of navel rated circuit breakers.

Circuit breakers can be ordered with the Naval SB listing by adding the suffixes “LC” (copper lugs) and “YA1” (naval) to the catalog number.

American Bureau of Shipping (ABS)

The PowerPact H-, J-, and L-Frame circuit breakers are certified to ABS-NVR (American Bureau of Shipping - Naval Vessel Rules), for use on Naval vessels.

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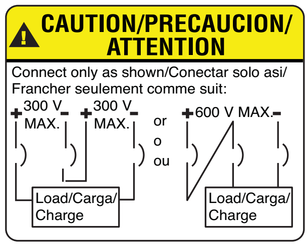
UL 489 SC Listed 500 Vdc Circuit Breakers

The UL Listed/CSA Certified thermal-magnetic J-Frame molded case circuit breakers are specifically designed for use on ungrounded dc systems having a maximum short-circuit voltage of 500 Vdc or a maximum floating (unloaded) voltage of 600 Vdc. The circuit breakers are suitable for use only with UPS (uninterruptable power supplies) and ungrounded systems. This two-level voltage rating allows these circuit breakers to be applied to battery sources having a short-circuit availability of 20,000 amperes at 500 Vdc.

These circuit breakers are UL Listed/CSA Certified for the interrupting ratings shown only if applied with three poles connected in series (series connection is external to circuit breaker). See diagram below.



Source = 600 Vdc max. (floating)
500 Vdc max. (loaded)

NOTE: Due to external series connection, I-Line™ circuit breakers are not available for this application.

Table 5: DC Molded Case Circuit Breakers

Ampere Rating	Circuit Breaker Cat. No.	Adjustable Magnetic Trip Range—DC Amperes		Performance Level @ 500 Vdc
		Low	High	
100 A	**JGL37100D81**	400	600	20 k AIR
125 A	**JGL37125D81**	400	600	
150 A	**JGL37150D81**	400	600	
175 A	**JGL37175D81**	400	600	
200 A	**JGL37200D82**	500	850	20 k AIR
225 A	**JGL37225D82**	500	850	
250 A	**JGL37250D82**	500	850	

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Table 6: Circuit Breakers

Circuit Breaker		**150 A H-Frame**					**250 A J-Frame**					**400 A L-Frame**					**600 A L-Frame**				
Circuit Breaker Type		HD	HG	HJ	HL	HR	JD	JG	JJ	JL	JR	LD	LG	LJ	LL	LR	LD	LG	LJ	LL	LR
Number of poles[1]		2, 3				3	2, 3				3	3, 4					3, 4				
Amperage Range (A)		15-150					70-250					70-400					200-600				
UL 489 Circuit Breaker Ratings																					
UL/CSA/NOM (kA rms)	240 Vac	25	65	100	125	200	25	65	100	125	200	25	65	100	125	200	25	65	100	125	200
	480 Vac	18	35	65	100	200	18	35	65	100	200	18	35	65	100	200	18	35	65	100	200
	600 Vac	14	18	25	50	100	14	18	25	50	100	14	18	25	50	100	14	18	25	50	100
	250 Vdc[2]	20	20	20	20	---	20	20	20	20	---	---	---	---	---	---	---	---	---	---	---
	500 Vdc[2, 3]	---	---	---	---	---	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---
IEC 947-2 Circuit Breaker Ratings																					
Ultimate breaking capacity (Icu) (kA rms)	220/240 Vac	25	65	100	125	150	25	65	100	125	150	25	65	100	125	150	25	65	100	125	150
	380/415 Vac	18	35	65	100	125	18	35	65	100	125	18	35	65	100	125	18	35	65	100	125
	440/480 Vac	18	35	65	100	125	18	35	65	100	125	18	35	65	100	125	18	35	65	100	125
	500/525 Vac	14	18	25	50	75	14	18	25	50	75	14	18	25	50	75	14	18	25	50	75[4]
	690 Vac	---	---	---	---	20	---	---	---	---	20	---	---	---	---	20	---	---	---	---	20
	250 Vdc[2]	---	---	---	---	---	20	20	20	20	---	---	---	---	---	---	---	---	---	---	---
	500 Vdc[2, 3]	---	---	---	---	---	20	20	20	20	---	---	---	---	---	---	---	---	---	---	---
Service breaking capacity (Ics)	% Icu	100%					100%					100%					100%				
Insulation Voltage	V_i	750 Vac					750 Vac					750 Vac					750 Vac				
Impulse Withstand Voltage	V_{imp}	8 kVac					8 kVac					8 kVac					8 kVac				
Operational Voltage	V_e	690 Vac					690 Vac					690 Vac					690 Vac				
Sensor Rating	I_n	150 A					250 A					400 A					600 A				
Utilization Category	---	A					A					A					A				
Operations (Open-Close Cycles)																					
Without Current		4000					5000					5000					5000				
With Current		4000					1000					1000					1000				
Protection and Measurements																					
Short-circuit protection	Magnetic only	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Overload/short-circuit protection	Thermal-magnetic	■	■	■	■	■	■	■	■	■	■	---	---	---	---	---	---	---	---	---	---
	Electronic	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	with neutral protection (Off-0.5-1-OSN)[5]	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	with ground fault protection	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	with zone selective interlocking (ZSI)[6]	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Display / I, V, f, P, E, THD measurements / interrupted-current measurement		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Options	Front display module (FDM121)	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Operating assistance	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Counters	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Histories and alarms	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Metering Com	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Device status/control com	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Dimensions / Weight / Connections																					
Dimensions 3P (Unit Mount) in. (mm)	Height	6.4 (163)					7.5 (191)					13.38 (340)					13.38 (340)				
	Width	4.1 (104)					4.1 (104)					5.51 (140)					5.51 (140)				
	Depth	3.4 (86)					3.4 (86)					4.33 (110)					4.33 (110)				
Weight 3P - lb. (Kg)		4.8 (2.2)					5.3 (2.4)					13.2 (6.0)					13.7 (6.2)				
Connections / Terminations	Unit Mount	■					■					■					■				
	I-Line™	■					■					■					■				
	Rear Connection	■					■					■					■				
	Plug-In	■					■					■					■				
	Drawout	■					■					■					■				
	Optional Lugs	■					■					■					■				

1 H and J-frame breakers with Micrologic™ trip units available only with 3P. The HJ, HL and the J-Frame 2P breakers are 3P modules.

2 DC not available with PowerPact H, J or L-frame circuit breakers with Micrologic trip units.

3 500 Vdc specific catalog numbers, ungrounded UPS systems only.

4 I_{cs} for 600 A L-frame circuit breaker at 525 V is 19 kA.

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SQUARE D™ by Schneider Electric

5 OSN: Over Sized Neutral protection for neutrals carrying high currents (e.g. 3rd harmonics).
6 ZSI using restraint wires.

PowerPact H-, J-, and L-frame Circuit Breaker Trip Units

Table 7: Micrologic™ Trip Unit Features

Features	Micrologic Trip Unit (X = Standard Feature, O = Available Option					
	Standard		Ammeter		Energy	
	3.2/3.3	3.2S/3.3S	5.2A/5.3A	6.2A/6.3A	5.2E/5.3E	6.2E/6.3E
LI	X					
LSI[1]		X	X		X	
LSIG/Ground Fault Trip[2]				X		X
Ground-Fault Alarm Trip				X		X
Current Settings Directly in Amperes	X	X	X	X	X	X
True RMS Sensing	X	X	X	X	X	X
UL Listed	X	X	X	X	X	X
Thermal Imaging	X	X	X	X	X	X
LED for Long-Time Pickup	X	X	X	X	X	X
LED for Long-Time Alarm	X	X	X	X	X	X
LED Green “Ready” Indicator	X	X	X	X	X	X
Up to 12 Alarms Used Together			X	X	X	X
Digital Ammeter			X	X	X	X
Zone-Selective Interlocking[3]			X	X	X	X
Communications	O	O	O	O	O	O
LCD Display			X	X	X	X
Front Display Module FDM121			O	O	O	O
Advanced User Interface			X	X	X	X
Neutral Protection			X	X	X	X
Contact Wear Indication[4]			X	X	X	X
Incremental Fine Tuning of Settings			X	X	X	X
Load Profile[4, 5]			X	X	X	X
Power Measurement					X	X
Power Quality Measurements					X	X

1 The LSI with 3.2S/3.3S trip units have fixed short time and long time delays.
2 Requires neutral current transformer on three-phase four-wire loads.
3 ZSI for H/J-frame devices is only IN. ZSI for L-frame devices is IN and OUT.
4 Indication available using the communication system only.
5 % of hours in 4 current ranges: 0–49%, 50–79%, 80–89%, and >90% I_n.

Thermal-Magnetic or Electronic Trip Unit?

Thermal-magnetic trip units (available on H- and J-frame circuit breakers only) protect against overcurrents and short-circuits using tried and true techniques. For applications requiring installation optimization and energy efficiency, electronic trip units offering more advanced protection functions combined with measurements.

Trip units using digital electronics are faster as well as more accurate. Wide setting ranges make installation upgrades easier. Designed with processing capabilities, Micrologic trip units can provide measurement information and device operating assistance. With this information, users can avoid or deal more effectively with disturbances and can play a more active role in system operation. They can manage the installation, anticipate events and plan any necessary servicing.

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Accurate Measurements for Complete Protection

PowerPact H-, J-, and L-frame circuit breakers devices offer excellent measurement accuracy from 15 amperes on up to the short-circuit currents. This is made possible by a new generation of current transformers combining “iron-core” sensors for self-powered electronics and “air core” sensors (Rogowski coils) for measurements. The protection functions are managed by an ASIC (Application Specific Integrated Circuit) component that is independent of the measurement functions. This independence ensures immunity to conducted and radiated disturbances and a high level of reliability.

Numerous Security Functions

Torque-limiting screws	The screws secure the trip unit to the circuit breaker. When the correct tightening torque is reached, the screw heads break off. Optimum tightening avoids any risk of temperature rise. A torque wrench is no longer required.
Easy and sure changing of trip units	All trip units are interchangeable, without wiring. A mechanical mismatch-protection system makes it impossible to mount a trip unit on a circuit breaker with a lower rating.
“Ready” LED for a continuous self-test	The LED on the front of the electronic trip units indicates the result of the self-test running continuously on the measurement system and the tripping release. As long as the green LED is flashing, the links between the CTs, the processing electronics and the tripping mechanism are operational. The circuit breaker is ready to protect. A minimum current of 15 to 50 A, depending on the device, is required for this indication function.
A patented dual adjustment system for protection functions.	Available on Micrologic™ 5 / 6 trip units, the system consists of: • an adjustment using rotary switches sets the maximum value • an adjustment using the keypad or made remotely, fine-tunes the setting. This setting may not exceed the first one. It can be read directly on the Micrologic trip unit screen, to within one ampere and a fraction of a second.

TIM-ID: 0000053623 - 002

Section 3—Circuit Breakers

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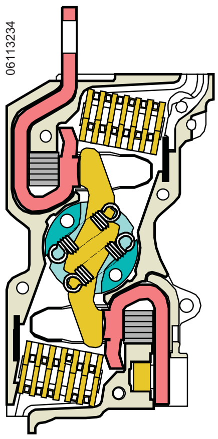

Dual-Break Rotating Contacts

All PowerPact H-, J-, and L-frame circuit breakers are equipped with dual-break rotating contacts that reduce the amount of peak current during a short circuit fault. This reduces the let-through currents and enhances equipment protection.

Reduced Let-Through Currents

The moving contact has the shape of an elongated "S" and rotates around a floating axis. The shape of the fixed and moving contacts are such that the repelling forces appear as soon as the circuit reaches approximately 15 times I_n.

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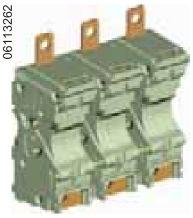

Due to the rotating movement, repulsion is rapid and the device greatly limits short-circuit currents, whatever the interrupting level of the unit (D, G, J or L). The fault current is extinguished before it can fully develop. Lower let-through currents provide less peak energy, reducing the required bus bar bracing, lowering enclosure pressure, and delivering improved series or combination ratings. See page 21 for UL Current Limiting labels.

High Ampere Interrupting Ratings (AIR)

Circuit breakers are available with interrupting ratings up to:

- 200 kA at 240 Vac delta
- 200 kA at 480 Vac delta
- 100 kA at 600 Vac delta.

See Table 1 for additional performance levels.

Internal Operating Mechanism

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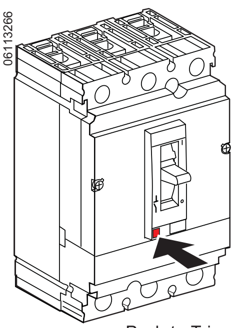

Push-to-Trip

PowerPact H-, J-, and L-frame circuit breakers have an over-center toggle mechanism providing quick-make, quick-break operation. The operating mechanism is also trip-free, which allows tripping even when the circuit breaker handle is held in the "ON" position.

Internal cross-bars provide common opening and closing of all poles with a single operating handle.

All PowerPact circuit breakers have an integral push-to-trip button in the cover to manually trip the circuit breaker. This should be used as part of a regular preventive maintenance program.

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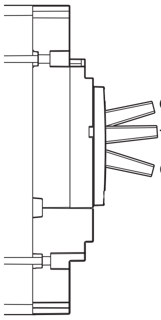
Handle Position Indication



The circuit breaker handle can assume any of three positions, ON, tripped or OFF as shown. The center tripped position provides positive visual indication that the circuit breaker has tripped.

The circuit breaker can be reset by first pushing the handle to the extreme “OFF” position. Power can then be restored to the load by pushing the handle to the “ON” position.

Circuit Breaker Ratings

The interrupting rating is the highest current at rated voltage the circuit breaker is designed to safely interrupt under standard test conditions. Circuit breakers must be selected with interrupting ratings equal to or greater than the available short-circuit current at the point where the circuit breaker is applied to the system (unless it is a branch device in a series rated combination). Interrupting ratings are shown on Table 6: Circuit Breakers on page 17 and on the faceplate label on the front of the circuit breaker.

Reverse Feeding of Circuit Breakers

The standard unit-mount H-, J-, and L-frame circuit breakers have sealed trip units and may be reverse fed. See Tables 12–13 and 24–29 for catalog numbers.

Circuit breakers with field-interchangeable trip units (designated by the suffix T and labeled “LINE” and “LOAD”) cannot be reverse fed. Neither can circuit breaker frames without terminations or trip units.

Current Limiting

The current limiting attributes of PowerPact H-, J-, and L-frame circuit breakers provide greater protection for downstream devices by limiting the let-through current in the event of a fault. The current-limiting capabilities of HJ/HL/HR, JJ/JL/JR, and LJ/LL/LR frame circuit breakers are documented with Underwriters Laboratories and Canadian Standards Association. These current-limiting circuit breakers ship with a label that identifies them as UL/CSA Current Limiting CIrcuit Breakers. (The HD/HG, JD/JG, and LD/LG circuit breakers do not carry the UL Current Limiting label)

The trip curves with let-through data are available in the trip curve section in this catalog.

Please note that as let-through curves for UL Listed/CSA Certified Current-Limiting Circuit Breakers, these curves are maximum let-through values.

100% Rated

Some models of the H-, J-, and L-frame circuit breakers are UL Listed/CSA Certified to be applied at up to 100% of their current rating. Because of the additional heat generated, the use of specially-designed enclosures, copper lugs on H- and J-frame circuit breakers, and 194°F (90°C) rated wire is required when applying circuit breakers at 100% of continuous current rating. (L-frame circuit breakers can use aluminum or copper lugs.) Markings on the circuit breaker indicate the minimum enclosure size and ventilation required. The 194°F (90°C) wire must be sized according to the ampacities of the 167°F (75°C) wire column in the NEC. Circuit breakers with 100% rating can also be used in applications requiring only standard (80%) continuous loading.

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100% ratings valid for:

- 3P H/J-frame unit mount construction only
- 3P/4P L-frame 250 A and 400 A unit mount construction
- 3P L-frame 250 A and 400 A I-Line™ construction

Corner Grounded Delta Ratings (1Ø-3Ø)

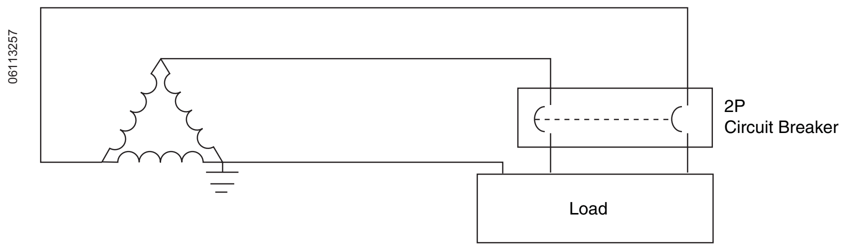
Circuit breakers suitable for corner-grounded circuits are marked 1Ø-3Ø. For additional information, refer to data bulletin 2700DB0202R2/09.

Table 8: Corner Grounded Delta Ratings (1Ø-3Ø)

	2P H-Frame					2P J-Frame				
	HD	HG	HJ[1]	HL[1]	HR[1]	JD[1]	JG[1]	JJ[1]	JL[1]	JR[1]
Ampere Rating (A)	15–150					150–250				
Voltage Rating (Vac)	240					240				
UL Interrupting Rating (kA)	42	42	65	100	200	42	42	65	100	200

[1] Built using 3P module

Figure 2: Three-Phase 240 Vac Corner-Grounded Delta System



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Special Applications

Protection of Industrial Control Panels

PowerPact H-, J-, and L-frame circuit breakers are also used in industrial control panels. They serve as an incoming devices or can be combined with contactors to protect motor feeders:

- compliance with worldwide standards including IEC 60947-2 and UL 508 / CSA C22.2 N°14
- overload and short-circuit protection
- installation in universal and functional type

PowerPact H-, J-, and L-frame circuit breakers equipped for motor protection functions as described in the following pages can be used in industrial control panels. The accessories for the PowerPact H-, J-, and L-frame circuit breakers are suitable for the special needs of these applications.

400 Hz Applications

Micrologic™ 3.2/3, 5.2/3 A or E and 6.2/3 with A or E measurement functions are suitable for 400 Hz. The use of electronics offers the advantage of greater operating stability when the frequency varies. However the units are still subject to temperature rise caused by the frequency.

The practical consequences are:

- limit settings: see the I_r derating table below
- the long-time, short-time and instantaneous pick-ups are not modified (see pages 58 or 60)
- the accuracy of the displayed measurements is 2% (class II).

Table 9: Thermal Derating Maximum I_r Setting

Circuit Breaker	Maximum Setting Coefficient	Max I_r Setting at 400 Hz
H-Frame, 100 A	1	100
J-Frame, 250 A	0.9	225
L-Frame, 400 A	0.8	320
L-Frame, 600 A	0.65	390

Auxiliary Switch (OF) in 400 Hz Networks

Table 10: Electrical Characteristics of Auxiliary Switches

Contact		Standard		Low Level	
Utilization cat. (IEC 60947-5-1)		AC12	AC15	AC12	AC15
Operational current	24 V	6 A	6 A	5 A	3 A
	40 V	6 A	6 A	5 A	3 A
	110 V	6 A	5 A	5 A	2.5 A
	200/240 V	6 A	4 A	5 A	2 A
	380/415 V	6 A	2 A	5 A	1.5 A

Shunt Trip (MX) or Undervoltage Trip (MN) Voltage Release at 400 Hz and 440 V

For circuit breakers on 400 Hz systems, only 125 Vdc undervoltage trip (MN) or shunt trip (MX) releases may be used. The release must be supplied by the 400 Hz system through a rectifier bridge (to be selected from the table below) and an additional resistor with characteristics depending on the system voltage.

Table 11: Rectifier Bridges for MN or MX Releases

Voltage	Rectifier	Additional Resistor
220/240 V	Thomson 110 BHz or General Instrument W06 or Semikron SKB at 1.2/1.3	4.2 kΩ-5 W
380/240 V	Semikron SKB at 1.2/1.3	10.7 kΩ-10 W

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H- and J-Frame Catalog Numbers

Unit-Mount Circuit Breaker Catalog Numbers

Table 12: PowerPact H-Frame 150 A Unit-Mount[1] Thermal-Magnetic Circuit Breakers (600 Vac, 250 Vdc) with Factory Sealed Trip Unit (Suitable for Reverse Connection)

Current Rating @ 40 C	Fixed AC Magnetic Trip		Interrupting Rating							
			D		G		J[2]		L[2]	
	Hold	Trip	Standard (80%) Rated	100% Rated[3]	Standard (80%) Rated	100% Rated[3]	Standard (80%) Rated	100% Rated[3]	Standard (80%) Rated	100% Rated[3]
H-Frame, 150 A, 2P, 600 Vac 50/60Hz, 250 Vdc[4]										
15 A	350 A	750 A	**HDL26015**	**HDL26015C**	**HGL26015**	**HGL26015C**	**HJL26015**	**HJL26015C**	**HLL26015**	**HLL26015C**
20 A	350 A	750 A	**HDL26020**	**HDL26020C**	**HGL26020**	**HGL26020C**	**HJL26020**	**HJL26020C**	**HLL26020**	**HLL26020C**
25 A	350 A	750 A	**HDL26025**	**HDL26025C**	**HGL26025**	**HGL26025C**	**HJL26025**	**HJL26025C**	**HLL26025**	**HLL26025C**
30 A	350 A	750 A	**HDL26030**	**HDL26030C**	**HGL26030**	**HGL26030C**	**HJL26030**	**HJL26030C**	**HLL26030**	**HLL26030C**
35 A	400 A	850 A	**HDL26035**	**HDL26035C**	**HGL26035**	**HGL26035C**	**HJL26035**	**HJL26035C**	**HLL26035**	**HLL26035C**
40 A	400 A	850 A	**HDL26040**	**HDL26040C**	**HGL26040**	**HGL26040C**	**HJL26040**	**HJL26040C**	**HLL26040**	**HLL26040C**
45 A	400 A	850 A	**HDL26045**	**HDL26045C**	**HGL26045**	**HGL26045C**	**HJL26045**	**HJL26045C**	**HLL26045**	**HLL26045C**
50 A	400 A	850 A	**HDL26050**	**HDL26050C**	**HGL26050**	**HGL26050C**	**HJL26050**	**HJL26050C**	**HLL26050**	**HLL26050C**
60 A	800 A	1450 A	**HDL26060**	**HDL26060C**	**HGL26060**	**HGL26060C**	**HJL26060**	**HJL26060C**	**HLL26060**	**HLL26060C**
70 A	800 A	1450 A	**HDL26070**	**HDL26070C**	**HGL26070**	**HGL26070C**	**HJL26070**	**HJL26070C**	**HLL26070**	**HLL26070C**
80 A	800 A	1450 A	**HDL26080**	**HDL26080C**	**HGL26080**	**HGL26080C**	**HJL26080**	**HJL26080C**	**HLL26080**	**HLL26080C**
90 A	800 A	1450 A	**HDL26090**	**HDL26090C**	**HGL26090**	**HGL26090C**	**HJL26090**	**HJL26090C**	**HLL26090**	**HLL26090C**
100 A	900 A	1700 A	**HDL26100**	**HDL26100C**	**HGL26100**	**HGL26100C**	**HJL26100**	**HJL26100C**	**HLL26100**	**HLL26100C**
110 A	900 A	1700 A	**HDL26110**	**HDL26110C**	**HGL26110**	**HGL26110C**	**HJL26110**	**HJL26110C**	**HLL26110**	**HLL26110C**
125 A	900 A	1700 A	**HDL26125**	**HDL26125C**	**HGL26125**	**HGL26125C**	**HJL26125**	**HJL26125C**	**HLL26125**	**HLL26125C**
150 A	900 A	1700 A	**HDL26150**	**HDL26150C**	**HGL26150**	**HGL26150C**	**HJL26150**	**HJL26150C**	**HLL26150**	**HLL26150C**
H-Frame, 150 A, 3P, 600 Vac 50/60Hz, 250 Vdc										
15 A	350 A	750 A	**HDL36015**	**HDL36015C**	**HGL36015**	**HGL36015C**	**HJL36015**	**HJL36015C**	**HLL36015**	**HLL36015C**
20 A	350 A	750 A	**HDL36020**	**HDL36020C**	**HGL36020**	**HGL36020C**	**HJL36020**	**HJL36020C**	**HLL36020**	**HLL36020C**
25 A	350 A	750 A	**HDL36025**	**HDL36025C**	**HGL36025**	**HGL36025C**	**HJL36025**	**HJL36025C**	**HLL36025**	**HLL36025C**
30 A	350 A	750 A	**HDL36030**	**HDL36030C**	**HGL36030**	**HGL36030C**	**HJL36030**	**HJL36030C**	**HLL36030**	**HLL36030C**
35 A	400 A	850 A	**HDL36035**	**HDL36035C**	**HGL36035**	**HGL36035C**	**HJL36035**	**HJL36035C**	**HLL36035**	**HLL36035C**
40 A	400 A	850 A	**HDL36040**	**HDL36040C**	**HGL36040**	**HGL36040C**	**HJL36040**	**HJL36040C**	**HLL36040**	**HLL36040C**
45 A	400 A	850 A	**HDL36045**	**HDL36045C**	**HGL36045**	**HGL36045C**	**HJL36045**	**HJL36045C**	**HLL36045**	**HLL36045C**
50 A	400 A	850 A	**HDL36050**	**HDL36050C**	**HGL36050**	**HGL36050C**	**HJL36050**	**HJL36050C**	**HLL36050**	**HLL36050C**
60 A	800 A	1450 A	**HDL36060**	**HDL36060C**	**HGL36060**	**HGL36060C**	**HJL36060**	**HJL36060C**	**HLL36060**	**HLL36060C**
70 A	800 A	1450 A	**HDL36070**	**HDL36070C**	**HGL36070**	**HGL36070C**	**HJL36070**	**HJL36070C**	**HLL36070**	**HLL36070C**
80 A	800 A	1450 A	**HDL36080**	**HDL36080C**	**HGL36080**	**HGL36080C**	**HJL36080**	**HJL36080C**	**HLL36080**	**HLL36080C**
90 A	800 A	1450 A	**HDL36090**	**HDL36090C**	**HGL36090**	**HGL36090C**	**HJL36090**	**HJL36090C**	**HLL36090**	**HLL36090C**
100 A	900 A	1700 A	**HDL36100**	**HDL36100C**	**HGL36100**	**HGL36100C**	**HJL36100**	**HJL36100C**	**HLL36100**	**HLL36100C**
110 A	900 A	1700 A	**HDL36110**	**HDL36110C**	**HGL36110**	**HGL36110C**	**HJL36110**	**HJL36110C**	**HLL36110**	**HLL36110C**
125 A	900 A	1700 A	**HDL36125**	**HDL36125C**	**HGL36125**	**HGL36125C**	**HJL36125**	**HJL36125C**	**HLL36125**	**HLL36125C**
150 A	900 A	1700 A	**HDL36150**	**HDL36150C**	**HGL36150**	**HGL36150C**	**HJL36150**	**HJL36150C**	**HLL36150**	**HLL36150C**

1 Standard Lug Kit: AL150HD Terminal Wire Range: 14–3/0 AWG Al or Cu
2 UL Listed/CSA Certified as current limiting circuit breakers.
3 100% rated circuit breakers have copper lugs and can be used with copper wire only.
4 HD and HG circuit breakers are true 2-pole construction.

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Table 13: PowerPact J-Frame 250 A Unit-Mount Thermal-Magnetic Circuit Breakers with Factory Sealed Trip Unit (Suitable for Reverse Connection)

Current Rating @ 40 C	Adjustable AC Magnetic Trip		Interrupting Rating									
			D		G		J[1]		L[1]		R[1]	
	Hold	Trip	Standard (80%) Rated	100% Rated[2]	Standard (80%) Rated	100% Rated[2]	Standard (80%) Rated	100% Rated[2]	Standard (80%) Rated	100% Rated[2]	Standard (80%) Rated	100% Rated[2]
J-Frame, 250 A, 2P, 600 Vac 50/60Hz, 250 Vdc												
150 A[3]	750 A	1500 A	**JDL26150**	**JDL26150C**	**JGL26150**	**JGL26150C**	**JJL26150**	**JJL26150C**	**JLL26150**	**JLL26150C**	—	—
175 A[3]	875 A	1750 A	**JDL26175**	**JDL26175C**	**JGL26175**	**JGL26175C**	**JJL26175**	**JJL26175C**	**JLL26175**	**JLL26175C**	—	—
200 A[4]	1000 A	2000 A	**JDL26200**	**JDL26200C**	**JGL26200**	**JGL26200C**	**JJL26200**	**JJL26200C**	**JLL26200**	**JLL26200C**	—	—
225 A[4]	1125 A	2250 A	**JDL26225**	**JDL26225C**	**JGL26225**	**JGL26225C**	**JJL26225**	**JJL26225C**	**JLL26225**	**JLL26225C**	—	—
250 A[4]	1250 A	2500 A	**JDL26250**	**JDL26250C**	**JGL26250**	**JGL26250C**	**JJL26250**	**JJL26250C**	**JLL26250**	**JLL26250C**	—	—
J-Frame, 250 A, 3P, 600 Vac 50/60Hz, 250 Vdc												
150 A[3]	750 A	1500 A	**JDL36150**	**JDL36150C**	**JGL36150**	**JGL36150C**	**JJL36150**	**JJL36150C**	**JLL36150**	**JLL36150C**	**JRL36150**	**JRL36150C**
175 A[3]	875 A	1750 A	**JDL36175**	**JDL36175C**	**JGL36175**	**JGL36175C**	**JJL36175**	**JJL36175C**	**JLL36175**	**JLL36175C**	**JRL36175**	**JRL36175C**
200 A[4]	1000 A	2000 A	**JDL36200**	**JDL36200C**	**JGL36200**	**JGL36200C**	**JJL36200**	**JJL36200C**	**JLL36200**	**JLL36200C**	**JRL36200**	**JRL36200C**
225 A[4]	1125 A	2250 A	**JDL36225**	**JDL36225C**	**JGL36225**	**JGL36225C**	**JJL36225**	**JJL36225C**	**JLL36225**	**JLL36225C**	**JRL36225**	**JRL36225C**
250 A[4]	1250 A	2500 A	**JDL36250**	**JDL36250C**	**JGL36250**	**JGL36250C**	**JJL36250**	**JJL36250C**	**JLL36250**	**JLL36250C**	**JRL36250**	**JRL36250C**

1 UL Listed/CSA Certified as current limiting circuit breakers.
2 100% rated circuit breakers have copper lugs and can be used with copper wire only.
3 Standard Lug Kit: AL175JD Terminal Wire Range: 4–4/0 AWG Al or Cu
4 Standard Lug Kit: AL250JD Terminal Wire Range: 3/0 AWG–350 kcmil Al or Cu

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Table 14: H-Frame 150 A and J-Frame 250 A Electronic Trip UL Rated Circuit Breakers (600 Vac, 50/60 Hz) With Factory Sealed Trip Unit Suitable for Reverse Connection

Electronic Trip Unit			Sensor Rating	Interrupting Rating				
Type	Function	Trip Unit		D	G	J[1]	L[2]	R[2]
Standard (80%) Rated Circuit Breakers, 3P								
Standard	LI	3.2[2]	60 A[3]	HDL36060U31X	HGL36060U31X	HJL36060U31X	HLL36060U31X	HRL36060U31X
			100 A[3]	HDL36100U31X	HGL36100U31X	HJL36100U31X	HLL36100U31X	HRL36100U31X
			150 A[3]	HDL36150U31X	HGL36150U31X	HJL36150U31X	HLL36150U31X	HRL36150U31X
			250 A[4]	JDL36250U31X	JGL36250U31X	JJL36250U31X	JLL36250U31X	JRL36250U31X
Standard	LSI	3.2S[2]	60 A[3]	HDL36060U33X	HGL36060U33X	HJL36060U33X	HLL36060U33X	HRL36060U33X
			100 A[3]	HDL36100U33X	HGL36100U33X	HJL36100U33X	HLL36100U33X	HRL36100U33X
			150 A[3]	HDL36150U33X	HGL36150U33X	HJL36150U33X	HLL36150U33X	HRL36150U33X
			250 A[4]	JDL36250U33X	JGL36250U33X	JJL36250U33X	JLL36250U33X	JRLL36250U33X
Ammeter	LSI	5.2A	60 A[3]	HDL36060U43X	HGL36060U43X	HJL36060U43X	HLL36060U43X	HRL36060U43X
			100 A[3]	HDL36100U43X	HGL36100U43X	HJL36100U43X	HLL36100U43X	HRL36100U43X
			150 A[3]	HDL36150U43X	HGL36150U43X	HJL36150U43X	HLL36150U43X	HRL36150U43X
			250 A[4]	JDL36250U43X	JGL36250U43X	JJL36250U43X	JLL36250U43X	JRL36250U43X
Energy	LSI	5.2E	60 A[3]	HDL36060U53X	HGL36060U53X	HJL36060U53X	HLL36060U53X	HRL36060U53X
			100 A[3]	HDL36100U53X	HGL36100U53X	HJL36100U53X	HLL36100U53X	HRL36100U53X
			150 A[3]	HDL36150U53X	HGL36150U53X	HJL36150U53X	HLL36150U53X	HRL36150U53X
			250 A[4]	JDL36250U53X	JGL36250U53X	JJL36250U53X	JLL36250U53X	JRL36250U53X
Ammeter	LSIG	6.2A	60 A[3]	HDL36060U44X	HGL36060U44X	HJL36060U44X	HLL36060U44X	HRL36060U44X
			100 A[3]	HDL36100U44X	HGL36100U44X	HJL36100U44X	HLL36100U44X	HRL36100U44X
			150 A[3]	HDL36150U44X	HGL36150U44X	HJL36150U44X	HLL36150U44X	HRL36150U44X
			250 A[4]	JDL36250U44X	JGL36250U44X	JJL36250U44X	JLL36250U44X	JRL36250U44X
Energy	LSIG	6.2E	60 A[3]	HDL36060U54X	HGL36060U54X	HJL36060U54X	HLL36060U54X	HRL36060U54X
			100 A[3]	HDL36100U54X	HGL36100U54X	HJL36100U54X	HLL36100U54X	HRL36100U54X
			150 A[3]	HDL36150U54X	HGL36150U54X	HJL36150U54X	HLL36150U54X	HRL36150U54X
			250 A[4]	JDL36250U54X	JGL36250U54X	JJL36250U54X	JLL36250U54X	JRL36250U54X
100% Rated Circuit Breakers, 3P[5]								
Standard	LI	3.2[2]	60 A[3]	HDL36060CU31X	HGL36060CU31X	HJL36060CU31X	HLL36060CU31X	HRL36060CU31X
			100 A[3]	HDL36100CU31X	HGL36100CU31X	HJL36100CU31X	HLL36100CU31X	HRL36100CU31X
			150 A[3]	HDL36150CU31X	HGL36150CU31X	HJL36150CU31X	HLL36150CU31X	HRL36150CU31X
			250 A[4]	JDL36250CU31X	JGL36250CU31X	JJL36250CU31X	JLL36250CU31X	JRL36250CU31X
Standard	LSI	3.2S[2]	60 A[3]	HDL36060CU33X	HGL36060CU33X	HJL36060CU33X	HLL36060CU33X	HRL36060CU33X
			100 A[3]	HDL36100CU33X	HGL36100CU33X	HJL36100CU33X	HLL36100CU33X	HRL36100CU33X
			150 A[3]	HDL36150CU33X	HGL36150CU33X	HJL36150CU33X	HLL36150CU33X	HRL36150CU33X
			250 A[4]	JDL36250CU33X	JGL36250CU33X	JJL36250CU33X	JLL36250CU33X	JRL36250CU33X
Ammeter	LSI	5.2A	60 A[3]	HDL36060CU43X	HGL36060CU43X	HJL36060CU43X	HLL36060CU43X	HRL36060CU43X
			100 A[3]	HDL36100CU43X	HGL36100CU43X	HJL36100CU43X	HLL36100CU43X	HRL36100CU43X
			150 A[3]	HDL36150CU43X	HGL36150CU43X	HJL36150CU43X	HLL36150CU43X	HRL36150CU43X
			250 A[4]	JDL36250CU43X	JGL36250CU43X	JJL36250CU43X	JLL36250CU43X	JRL36250CU43X
Energy	LSI	5.2E	60 A[3]	HDL36060CU53X	HGL36060CU53X	HJL36060CU53X	HLL36060CU53X	HRL36060CU53X
			100 A[3]	HDL36100CU53X	HGL36100CU53X	HJL36100CU53X	HLL36100CU53X	HRL36100CU53X
			150 A[3]	HDL36150CU53X	HGL36150CU53X	HJL36150CU53X	HLL36150CU53X	HRL36150CU53X
			250 A[4]	JDL36250CU53X	JGL36250CU53X	JJL36250CU53X	JLL36250CU53X	JRL36250CU53X

1 UL Listed/CSA Certified as current limiting circuit breakers.

2 3P circuit breakers with this trip unit can be used for 2P applications.

3 Standard Lug Kit: AL150HD Terminal Wire Range: 14–3/0 AWG Al or Cu

4 Standard Lug Kit: AL250JD Terminal Wire Range: 3/0 AWG–350 kcmil Al or Cu
For smaller wire range (4–4/0 AWG Al or Cu), replace the lug's wire binding screws with the larger binding screws provided.

5 100% rated circuit breakers have copper lugs and can be used with copper wire only.

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I-Line™ Circuit Breaker Catalog Numbers

Table 15: PowerPact H-Frame 150 A I-Line Thermal-Magnetic Circuit Breakers[1] with Factory Sealed Trip Unit (Suitable for Reverse Connection)[2]

Current Rating @ 40 C	Fixed AC Magnetic Trip		Interrupting Rating[3] Standard (80%) Rated			
	Hold	Trip	D	G	J[4]	L[4]
H-Frame, 150 A, 2P, 600 Vac 50/60Hz, 250 Vdc						
15 A	350 A	750 A	**HDA26015( )**	**HGA26015( )**	**HJA26015( )**	**HLA26015( )**
20 A	350 A	750 A	**HDA26020( )**	**HGA26020( )**	**HJA26020( )**	**HLA26020( )**
25 A	350 A	750 A	**HDA26025( )**	**HGA26025( )**	**HJA26025( )**	**HLA26025( )**
30 A	350 A	750 A	**HDA26030( )**	**HGA26030( )**	**HJA26030( )**	**HLA26030( )**
35 A	400 A	850 A	**HDA26035( )**	**HGA26035( )**	**HJA26035( )**	**HLA26035( )**
40 A	400 A	850 A	**HDA26040( )**	**HGA26040( )**	**HJA26040( )**	**HLA26040( )**
45 A	400 A	850 A	**HDA26045( )**	**HGA26045( )**	**HJA26045( )**	**HLA26045( )**
50 A	400 A	850 A	**HDA26050( )**	**HGA26050( )**	**HJA26050( )**	**HLA26050( )**
60 A	800 A	1450 A	**HDA26060( )**	**HGA26060( )**	**HJA26060( )**	**HLA26060( )**
70 A	800 A	1450 A	**HDA26070( )**	**HGA26070( )**	**HJA26070( )**	**HLA26070( )**
80 A	800 A	1450 A	**HDA26080( )**	**HGA26080( )**	**HJA26080( )**	**HLA26080( )**
90 A	800 A	1450 A	**HDA26090( )**	**HGA26090( )**	**HJA26090( )**	**HLA26090( )**
100 A	900 A	1700 A	**HDA26100( )**	**HGA26100( )**	**HJA26100( )**	**HLA26100( )**
110 A	900 A	1700 A	**HDA26110( )**	**HGA26110( )**	**HJA26110( )**	**HLA26110( )**
125 A	900 A	1700 A	**HDA26125( )**	**HGA26125( )**	**HJA26125( )**	**HLA26125( )**
150 A	900 A	1700 A	**HDA26150( )**	**HGA26150( )**	**HJA26150( )**	**HLA26150( )**
H-Frame, 150 A, 3P, 600 Vac 50/60Hz, 250 Vdc						
15 A	350 A	750 A	**HDA36015**	**HGA36015**	**HJA36015**	**HLA36015**
20 A	350 A	750 A	**HDA36020**	**HGA36020**	**HJA36020**	**HLA36020**
25 A	350 A	750 A	**HDA36025**	**HGA36025**	**HJA36025**	**HLA36025**
30 A	350 A	750 A	**HDA36030**	**HGA36030**	**HJA36030**	**HLA36030**
35 A	400 A	850 A	**HDA36035**	**HGA36035**	**HJA36035**	**HLA36035**
40 A	400 A	850 A	**HDA36040**	**HGA36040**	**HJA36040**	**HLA36040**
45 A	400 A	850 A	**HDA36045**	**HGA36045**	**HJA36045**	**HLA36045**
50 A	400 A	850 A	**HDA36050**	**HGA36050**	**HJA36050**	**HLA36050**
60 A	800 A	1450 A	**HDA36060**	**HGA36060**	**HJA36060**	**HLA36060**
70 A	800 A	1450 A	**HDA36070**	**HGA36070**	**HJA36070**	**HLA36070**
80 A	800 A	1450 A	**HDA36080**	**HGA36080**	**HJA36080**	**HLA36080**
90 A	800 A	1450 A	**HDA36090**	**HGA36090**	**HJA36090**	**HLA36090**
100 A	900 A	1700 A	**HDA36100**	**HGA36100**	**HJA36100**	**HLA36100**
110 A	900 A	1700 A	**HDA36110**	**HGA36110**	**HJA36110**	**HLA36110**
125 A	900 A	1700 A	**HDA36125**	**HGA36125**	**HJA36125**	**HLA36125**
150 A	900 A	1700 A	**HDA36150**	**HGA36150**	**HJA36150**	**HLA36150**

1 Standard Lug Kit: AL150HD Terminal Wire Range: 14–3/0 AWG Al or Cu
2 No 100% I-Line available.
3 () Indicates phasing. See “Catalog Numbering” on page 8.
4 UL Listed/CSA Certified as current limiting circuit breakers.

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Table 16: PowerPact J-Frame 250A I-Line™ Thermal-Magnetic Circuit Breakers with Factory Sealed Trip Unit (Suitable for Reverse Connection)[1]

Current Rating @ 40 C	Adjustable AC Magnetic Trip		Interrupting Rating[2] Standard (80%) Rated				
	Hold	Trip	D	G	J[3]	L[3]	R[3]
J-Frame, 250 A, 2P, 600 Vac 50/60Hz, 250 Vdc							
150 A[4]	750 A	1500 A	**JDA26150( )**	**JGA26150( )**	**JJA26150( )**	—	—
175 A[4]	875 A	1750 A	**JDA26175( )**	**JGA26175( )**	**JJA26175( )**	—	—
200 A[5]	1000 A	2000 A	**JDA26200( )**	**JGA26200( )**	**JJA26200( )**	—	—
225 A[5]	1125 A	2250 A	**JDA26225( )**	**JGA26225( )**	**JJA26225( )**	—	—
250 A[5]	1250 A	2500 A	**JDA26250( )**	**JGA26250( )**	**JJA26250( )**	—	—
J-Frame, 250 A, 3P, 600 Vac 50/60Hz, 250 Vdc							
150 A[4]	750 A	1500 A	**JDA36150**	**JGA36150**	**JJA36150**	**JLA36150**	**JRA36150**
175 A[4]	875 A	1750 A	**JDA36175**	**JGA36175**	**JJA36175**	**JLA36175**	**JRA36175**
200 A[5]	1000 A	2000 A	**JDA36200**	**JGA36200**	**JJA36200**	**JLA36200**	**JRA36200**
225 A[5]	1125 A	2250 A	**JDA36225**	**JGA36225**	**JJA36225**	**JLA36225**	**JRA36225**
250 A[5]	1250 A	2500 A	**JDA36250**	**JGA36250**	**JJA36250**	**JLA36250**	**JRA36250**

1 No 100% I-Line available.
2 () Indicates phasing. See “Catalog Numbering” on page 8.
3 UL Listed/CSA Certified as current limiting
4 Standard Lug Kit: AL175JD Terminal Wire Range: 4–4/0 AWG Al or Cu
5 Standard Lug Kit: AL250JD Terminal Wire Range: 3/0 AWG–350 kcmil Al or Cu

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Table 17: H-Frame 150 A and J-Frame 250 A I-Line™ Standard (80%) Rated Electronic Trip UL Rated Circuit Breakers (3P, 600 Vac, 50/60 Hz) With Factory Sealed Trip Unit Suitable for Reverse Connection [1]

Electronic Trip Unit			Sensor Rating	Interrupting Rating				
Type	Function	Trip Unit		D	G	J[2]	L[2]	R[2]
Standard	LI	3.2[3]	60 A[4]	HDA36060U31X	HGA36060U31X	HJA36060U31X	HLA36060U31X	HRA36060U31X
			100 A[4]	HDA36100U31X	HGA36100U31X	HJA36100U31X	HLA36100U31X	HRA36100U31X
			150 A[4]	HDA36150U31X	HGA36150U31X	HJA36150U31X	HLA36150U31	HRA36150U31
			250 A[3, 5]	JDA36250U31X	JGA36250U31X	JJA36250U31X	JLA36250U31X	JRA36250U31X
Standard	LSI	3.2S[3]	60 A[4]	HDA36060U33X	HGA36060U33X	HJA36060U33X	HLA36060U33X	HRA36060U33X
			100 A[4]	HDA36100U33X	HGA36100U33X	HJA36100U33X	HLA36100U33X	HRA36100U33X
			150 A[4]	HDA36150U33X	HGA36150U33X	HJA36150U33X	HLA36150U33X	HRA36150U33X
			250 A[3, 5]	JDA36250U33X	JGA36250U33X	JJA36250U33X	JLA36250U33X	JRA36250U33X
Ammeter	LSI	5.2A	60 A[4]	HDA36060U43X	HGA36060U43X(	HJA36060U43X	HLA36060U43X	HRA36060U43X
			100 A[4]	HDA36100U43X	HGA36100U43X	HJA36100U43X	HLA36100U43X	HRA36100U43X
			150 A[4]	HDA36150U43X	HGA36150U43X	HJA36150U43X	HLA36150U43X	HRA36150U43X
			250 A[3, 5]	JDA36250U43X	JGA36250U43X	JJA36250U43X	JLA36250U43X	JRA36250U43X
Energy	LSI	5.2E	60 A[4]	HDA36060U53X	HGA36060U53X	HJA36060U53X	HLA36060U53X	HRA36060U53X
			100 A[4]	HDA36100U53X	HGA36100U53X	HJA36100U53X	HLA36100U53X	HRA36100U53X
			150 A[4]	HDA36150U53X	HGA36150U53X	HJA36150U53X	HLA36150U53X	HRA36150U53X
			250 A[3, 5]	JDA36250U53X	JGA36250U53X	JJA36250U53X	JLA36250U53X	JRA36250U53X
Ammeter	LSIG	6.2A	60 A[4]	HDA36060U44X	HGA36060U44X	HJA36060U44X	HLA36060U44X	HRA36060U44X
			100 A[4]	HDA36100U44X	HGA36100U44X	HJA36100U44X	HLA36100U44X	HRA36100U44X
			150 A[4]	HDA36150U44X	HGA36150U44X	HJA36150U44X	HLA36150U44X	HRA36150U44X
			250 A[3, 5]	JDA36250U44X	JGA36250U44X	JJA36250U44X	JLA36250U44X	JRA36250U44X
Energy	LSIG	6.2E	60 A[4]	HDA36060U54X	HGA36060U54X	HJA36060U54X	HLA36060U54X	HRA36060U54X
			100 A[4]	HDA36100U54X	HGA36100U54X	HJA36100U54X	HLA36100U54X	HRA36100U54X
			150 A[4]	HDA36150U54X	HGA36150U54X	HJA36150U54X(	HLA36150U54X	HRA36150U54X
			250 A[3, 5]	JDA36250U54X	JGA36250U54X	JJA36250U54X	JLA36250U54X	JRA36250U54X

1 No 100% I-Line available.

2 UL Listed/CSA Certified as current limiting circuit breakers.

3 3P circuit breakers with this trip unit can be used for 2P applications.

4 Standard Lug Kit: AL150HD Terminal Wire Range: 14–3/0 AWG Al or Cu

5 Standard Lug Kit: AL250JD Terminal Wire Range: 3/0 AWG–350 kcmil Al or Cu
For smaller wire range (4–4/0 AWG Al or Cu), replace the lug's wire binding screws with the larger binding screws provided.

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Circuit Breakers with Field-Interchangeable Trip Units Catalog Numbers

Table 18: H-Frame 150 A Circuit Breaker Frame[1] with Field-Interchangeable Thermal-Magnetic Trip Units[2] (3P, 600 Vac, 250 Vdc)

Ampere Rating	Fixed AC Magnetic Trip		Interrupting Rating			
			D	G	J[3]	L[3]
	Hold	Trip	Cat. No.	Cat. No.	Cat. No.	Cat. No.
15 A	350 A	750 A	**HDL36015T**	**HGL36015T**	**HJL36015T**	**HLL36015T**
20 A	350 A	750 A	**HDL36020T**	**HGL36020T**	**HJL36020T**	**HLL36020T**
25 A	350 A	750 A	**HDL36025T**	**HGL36025T**	**HJL36025T**	**HLL36025T**
30 A	350 A	750 A	**HDL36030T**	**HGL36030T**	**HJL36030T**	**HLL36030T**
35 A	400 A	850 A	**HDL36035T**	**HGL36035T**	**HJL36035T**	**HLL36035T**
40 A	400 A	850 A	**HDL36040T**	**HGL36040T**	**HJL36040T**	**HLL36040T**
45 A	400 A	850 A	**HDL36045T**	**HGL36045T**	**HJL36045T**	**HLL36045T**
50 A	400 A	850 A	**HDL36050T**	**HGL36050T**	**HJL36050T**	**HLL36050T**
60 A	800 A	1450 A	**HDL36060T**	**HGL36060T**	**HJL36060T**	**HLL36060T**
70 A	800 A	1450 A	**HDL36070T**	**HGL36070T**	**HJL36070T**	**HLL36070T**
80 A	800 A	1450 A	**HDL36080T**	**HGL36080T**	**HJL36080T**	**HLL36080T**
90 A	800 A	1450 A	**HDL36090T**	**HGL36090T**	**HJL36090T**	**HLL36090T**
100 A	900 A	1700 A	**HDL36100T**	**HGL36100T**	**HJL36100T**	**HLL36100T**
110 A	900 A	1700 A	**HDL36110T**	**HGL36110T**	**HJL36110T**	**HLL36110T**
125 A	900 A	1700 A	**HDL36125T**	**HGL36125T**	**HJL36125T**	**HLL36125T**
150 A	900 A	1700 A	**HDL36150T**	**HGL36150T**	**HJL36150T**	**HLL36150T**

1 Standard Lug Kit: AL150HD Terminal Wire Range: 14–3/0 AWG Al or Cu

2 Circuit breakers will be labeled with Line and Load markings and are not suitable for reverse connections. Only available on standard (80%) rated 3P unit-mount circuit breakers. Not available in R interrupting rating. Not available with I-Line™ or Plug-In constructions.

3 UL Listed/CSA Certified as current limiting circuit breakers.

Table 19: J-Frame 250 A Circuit Breaker Frame with Field-Interchangeable Thermal-Magnetic Trip Units[1] (3P, 600 Vac, 250 Vdc)

Ampere Rating	Adjustable AC Magnetic Trip		Interrupting Rating			
			D	G	J[2]	L[3]
	Low	High	Cat. No.	Cat. No.	Cat. No.	Cat. No.
150 A[3]	750 A	1500 A	**JDL36150T**	**JGL36150T**	**JJL36150T**	**JLL36150T**
175 A[3]	875 A	1750 A	**JDL36175T**	**JGL36175T**	**JJL36175T**	**JLL36175T**
200 A[4]	1000 A	2000 A	**JDL36200T**	**JGL36200T**	**JJL36200T**	**JLL36200T**
225 A[4]	1125 A	2250 A	**JDL36225T**	**JGL36225T**	**JJL36225T**	**JLL36225T**
250 A[4]	1250 A	2500 A	**JDL36250T**	**JGL36250T**	**JJL36250T**	**JLL36250T**

1 Circuit breakers will be labeled with Line and Load markings and are not suitable for reverse connections. Only available on standard (80%) rated 3P unit-mount circuit breakers. Not available in R interrupting rating. Not available with I-Line™ or Plug-In constructions.

2 UL Listed/CSA Certified as current limiting circuit breakers.

3 Standard Lug Kit: AL175JD Terminal Wire Range: 4–4/0 AWG Al or Cu

4 Standard Lug Kit: AL250JD Terminal Wire Range: 3/0 AWG–350 kcmil Al or Cu

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Table 20: H-Frame 150 A and J-Frame 250 A 3P Circuit Breakers with Lugs and Field-Interchangeable Electronic Trip Units[1], [2] (Standard (80%) Rated, 600 Vac, 50/60 Hz)

Electronic Trip Unit			Sensor Size	Interrupting Rating			
Type	Function	Trip Unit		D	G	J[3]	L[3]
Standard	LI	3.2	60 A[4]	**HDL36060TU31X**	**HGL36060TU31X**	**HJL36060TU31X**	**HLL36060TU31X**
			100 A[4]	**HDL36100TU31X**	**HGL36100TU31X**	**HJL36100TU31X**	**HLL36100TU31X**
			150 A[4]	**HDL36150TU31X**	**HGL36150TU31X**	**HJL36150TU31X**	**HLL36150TU31X**
			250 A[5]	**JDL36250TU31X**	**JGL36250TU31X**	**JJL36250TU31X**	**JLL36250TU31X**
Standard	LSI	3.2S	60 A[4]	**HDL36060TU33X**	**HGL36060TU33X**	**HJL36060TU33X**	**HLL36060TU33X**
			100 A[4]	**HDL36100TU33X**	**HGL36100TU33X**	**HJL36100TU33X**	**HLL36100TU33X**
			150 A[4]	**HDL36150TU33X**	**HGL36150TU33X**	**HJL36150TU33X**	**HLL36150TU33X**
			250 A[5]	**JDL36250TU33X**	**JGL36250TU33X**	**JJL36250TU33X**	**JLL36250TU33X**
Ammeter	LSI	5.2A	60 A[4]	**HDL36060TU43X**	**HGL36060TU43X**	**HJL36060TU43X**	**HLL36060TU43X**
			100 A[4]	**HDL36100TU43X**	**HGL36100TU43X**	**HJL36100TU43X**	**HLL36100TU43X**
			150 A[4]	**HDL36150TU43X**	**HGL36150TU43X**	**HJL36150TU43X**	**HLL36150TU43X**
			250 A[5]	**JDL36250TU43X**	**JGL36250TU43X**	**JJL36250TU43X**	**JLL36250TU43X**
Energy	LSI	5.2E	60 A[4]	**HDL36060TU53X**	**HGL36060TU53X**	**HJL36060TU53X**	**HLL36060TU53X**
			100 A[4]	**HDL36100TU53X**	**HGL36100TU53X**	**HJL36100TU53X**	**HLL36100TU53X**
			150 A[4]	**HDL36150TU53X**	**HGL36150TU53X**	**HJL36150TU53X**	**HLL36150TU53X**
			250 A[5]	**JDL36250TU53X**	**JGL36250TU53X**	**JJL36250TU53X**	**JLL36250TU53X**
Ammeter	LSIG	6.2A	60 A[4]	**HDL36060TU44X**	**HGL36060TU44X**	**HJL36060TU44X**	**HLL36060TU44X**
			100 A[4]	**HDL36100TU44X**	**HGL36100TU44X**	**HJL36100TU44X**	**HLL36100TU44X**
			150 A[4]	**HDL36150TU44X**	**HGL36150TU44X**	**HJL36150TU44X**	**HLL36150TU44X**
			250 A[5]	**JDL36250TU44X**	**JGL36250TU44X**	**JJL36250TU44X**	**JLL36250TU44X**
Energy	LSIG	6.2E	60 A[4]	**HDL36060TU54X**	**HGL36060TU54X**	**HJL36060TU54X**	**HLL36060TU54X**
			100 A[4]	**HDL36100TU54X**	**HGL36100TU54X**	**HJL36100TU54X**	**HLL36100TU54X**
			150 A[4]	**HDL36150TU54X**	**HGL36150TU54X**	**HJL36150TU54X**	**HLL36150TU54X**
			250 A[5]	**JDL36250TU54X**	**JGL36250TU54X**	**JJL36250TU54X**	**JLL36250TU54X**

1 Circuit breakers will be labeled with Line and Load markings and are not suitable for reverse connections.
2 Only available on 3P unit-mount circuit breakers. Not available in R interrupting rating. Not available with I-Line™ or Plug-in constructions.
3 UL Listed/CSA Certified as current limiting circuit breakers.
4 Standard Lug Kit: AL150HD Terminal Wire Range: 14–3/0 AWG Al or C
5 Standard Lug Kit: AL250JD Terminal Wire Range: 3/0 AWG–350 kcmil Al or Cu
For smaller wire range (4–4/0 AWG Al or Cu), replace the lug's wire binding screws with the larger binding screws provided.

H-Frame Trip Unit

Table 21: H-Frame and J-Frame 3P Field-Installable Thermal-Magnetic Trip Units

15–60 A H-Frame		70–150 A H-Frame		150–250 A J-Frame	
Amperage	Cat. No.	Amperage	Cat. No.	Amperage	Cat. No.
15 A	**HT3015**	70 A	**HT3070**	150 A	**JT3150**
20 A	**HT3020**	80 A	**HT3080**	175 A	**JT3175**
25 A	**HT3025**	90 A	**HT3090**	200 A	**JT3200**
30 A	**HT3030**	100 A	**HT3100**	225 A	**JT3225**
35 A	**HT3035**	110 A	**HT3110**	250 A	**JT3250**
40 A	**HT3040**	125 A	**HT3125**	—	—
45 A	**HT3045**	150 A	**HT3150**	—	—
50 A	**HT3050**	—	—	—	—
60 A	**HT3060**	—	—	—	—

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Table 22: H-Frame and J-Frame 3P Field-Installable Micrologic™ Electronic Trip Units[1]

Electronic Trip Unit Type	Function	Trip Unit	Ampere Settings	Trip Unit Cat. No.
Standard	LI	3.2	15-20-25-30-35-40-45-50-60	**HE3060U31X**
			35-40-45-50-60-70-80-90-100	**HE3100U31X**
			50-60-70-80-90-100-110-125-150	**HE3150U31X**
			70-80-100-125-150-175-200-225-250	**JE3250U31X**
	LSI	3.2S	15-20-25-30-35-40-45-50-60	**HE3060U33X**
			35-40-45-50-60-70-80-90-100	**HE3100U33X**
			50-60-70-80-90-100-110-125-150	**HE3150U33X**
			70-80-100-125-150-175-200-225-250	**JE3250U33X**
Ammeter	LSI	5.2A	15–60	**HE3060U43X**
			35–100	**HE3100U43X**
			50–150	**HE3150U43X**
			70–250	**JE3250U43X**
	LSIG	6.2A	15–60	**HE3060U44X**
			35–100	**HE3100U44X**
			50–150	**HE3150U44X**
			70–250	**JE3250U44X**
Energy	LSI	5.2E	15–60	**HE3060U53X**
			35–100	**HE3100U53X**
			50–150	**HE3150U53X**
			70–250	**JE3250U53X**
	LSIG	6.2E	15–60	**HE3060U54X**
			35–100	**HE3100U54X**
			50–150	**HE3150U54X**
			70–250	**JE3250U54X**

1 Electronic trip units cannot be used for DC applications.

Table 23: H-Frame 150A and J-Frame 250 A 3P Basic Circuit Breaker Frame Without Terminations or Trip Unit (600 Vac, 250 Vdc[1])

Circuit Breaker Frame	Ampere Rating	Interrupting Rating D Cat. No.	G Cat. No.	J[2] Cat. No.	L[2] Cat. No.
H-Frame[3]	15–60 A	**HDF36000F06**	**HGF36000F06**	**HJF36000F06**	**HLF36000F06**
	70–150 A	**HDF36000F15**	**HGF36000F15**	**HJF36000F15**	**HLF36000F15**
J-Frame	150–250 A	**JDF36000F25**	**JGF36000F25**	**JJF36000F25**	**JLF36000F25**

1 Not suitable for reverse connection.
2 UL Listed/CSA Certified as current limiting circuit breakers.
3 Field-installable trip units must match frame ampere rating.

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L-Frame Circuit Breaker Catalog Numbers

Unit-Mount Circuit Breaker Catalog Numbers

Table 24: L-Frame 600 A Electronic Trip UL Rated 3P Circuit Breakers (600 Vac, 50/60 Hz) With Factory Sealed Trip Unit Suitable for Reverse Connection

Electronic Trip Unit			Sensor Rating	Interrupting Rating (2nd Letter of Catalog Number)				
Type	Function	Trip Unit		D	G	J[1]	L[1]	R[1]
Standard (80%) Rated, 600 Vac, 50/60 Hz								
Standard	LI	3.3[2]	250 A[3]	LDL36250U31X	LGL36250U31X	LJL36250U31X	LLL36250U31X	LRL36250U31X
			400 A[4]	LDL36400U31X	LGL36400U31X	LJL36400U31X	LLL36400U31X	LRL36400U31X
			600 A[4]	LDL36600U31X	LGL36600U31X	LJL36600U31X	LLL36600U31X	LRL36600U31X
Standard	LSI	3.3S[2]	250 A[3]	LDL36250U33X	LGL36250U33X	LJL36250U33X	LLL36250U33X	LRL36250U33X
			400 A[4]	LDL36400U33X	LGL36400U33X	LJL36400U33X	LLL36400U33X	LRL36400U33X
			600 A[4]	LDL36600U33X	LGL36600U33X	LJL36600U33X	LLL36600U33X	LRL36600U33X
Ammeter	LSI	5.3A	400 A[4]	LDL36400U43X	LGL36400U43X	LJL36400U43X	LLL36400U43X	LRL36400U43X
			600 A[4]	LDL36600U43X	LGL36600U43X	LJL36600U43X	LLL36600U43X	LRL36600U43X
Energy	LSI	5.3E	400 A[4]	LDL36400U53X	LGL36400U53X	LJL36400U53X	LLL36400U53X	LRL36400U53X
			600 A[4]	LDL36600U53X	LGL36600U53X	LJL36600U53X	LLL36600U53X	LRL36600U53X
Ammeter	LSIG	6.3A	400 A[4]	LDL36400U44X	LGL36400U44X	LJL36400U44X	LLL36400U44X	LRL36400U44X
			600 A[4]	LDL36600U44X	LGL36600U44X	LJL36600U44X	LLL36600U44X	LRL36600U44X
Energy	LSIG	6.3E	400 A[4]	LDL36400U54X	LGL36400U54X	LJL36400U54X	LLL36400U54X	LRL36400U54X
			600 A[4]	LDL36600U54X	LGL36600U54X	LJL36600U54X	LLL36600U54X	LRL36600U54X
100% Rated, 600 Vac, 50/60 Hz								
Standard	LI	3.3[2]	250 A[3]	LDL36250CU31X	LGL36250CU31X	LJL36250CU31X	LLL36250CU31X	LRL36250CU31X
			400 A[4]	LDL36400CU31X	LGL36400CU31X	LJL36400CU31X	LLL36400CU31X	LRL36400CU31X
Standard	LSI	3.3S[2]	250 A[3]	LDL36250CU33X	LGL36250CU33X	LJL36250CU33X	LLL36250CU33X	LRL36250CU33X
			400 A[4]	LDL36400CU33X	LGL36400CU33X	LJL3640C0U33X	LLL36400CU33X	LRL36400CU33X
Ammeter	LSI	5.3A	400 A[4]	LDL36400CU43X	LGL36400CU43X	LJL36400CU43X	LLL36400CU43X	LRL36400CU43X
Energy	LSI	5.3E	400 A[4]	LDL36400CU53X	LGL36400CU53X	LJL36400CU53X	LLL36400CU53X	LRL36400CU53X
Ammeter	LSIG	6.3A	400 A[4]	LDL36400CU44X	LGL36400CU44X	LJL36400CU44X	LLL36400CU44X	LRL36400CU44X
Energy	LSIG	6.3E	400 A[4]	LDL36400CU54X	LGL36400CU54X	LJL36400CU54X	LLL36400CU54X	LRL36400CU54X

1 UL Listed/CSA Certified as current limiting circuit breakers.
2 3P circuit breakers with this trip unit can be used for 2P applications.
3 Standard Lug Kit: AL400L61K3 Terminal Wire Range: (1) 2 AWG–600 kcmil Cu or (1) 2 AWG–500 kcmil Al
4 Standard Lug Kit: AL600LS52K3 Terminal Wire Range: (2) 2/0 AWG–500 kcmil Al/Cu

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Table 25: L-Frame 600 A Electronic Trip UL Rated 4P Circuit Breakers (600 Vac, 50/60 Hz) With Factory Sealed Trip Unit Suitable for Reverse Connection

Electronic Trip Unit			Sensor Rating	Interrupting Rating (2nd Letter of Catalog Number)				
Type	Function	Trip Unit		D	G	J[1]	L[1]	R[1]
Standard (80%) Rated, 600 Vac, 50/60 Hz								
Standard	LI	3.3	250 A[2]	**LDL46250U31X**	**LGL46250U31X**	**LJL46250U31X**	**LLL46250U31X**	**LRL46250U31X**
			400 A[3]	**LDL46400U31X**	**LGL46400U31X**	**LJL46400U31X**	**LLL46400U31X**	**LRL46400U31X**
			600 A[3]	**LDL46600U31X**	**LGL46600U31X**	**LJL46600U31X**	**LLL46600U31X**	**LRL46600U31X**
Standard	LSI	3.3S	250 A[2]	**LDL46250U33X**	**LGL46250U33X**	**LJL46250U33X**	**LLL46250U33X**	**LRL46250U33X**
			400 A[3]	**LDL46400U33X**	**LGL46400U33X**	**LJL46400U33X**	**LLL46400U33X**	**LRL46400U33X**
			600 A[3]	**LDL46600U33X**	**LGL46600U33X**	**LJL46600U33X**	**LLL46600U33X**	**LRL46600U33X**
Ammeter	LSI	5.3A	400 A[3]	**LDL46400U43X**	**LGL46400U43X**	**LJL46400U43X**	**LLL46400U43X**	**LRL46400U43X**
			600 A[3]	**LDL46600U43X**	**LGL46600U43X**	**LJL46600U43X**	**LLL46600U43X**	**LRL46600U43X**
Energy	LSI	5.3E	400 A[3]	**LDL46400U53X**	**LGL46400U53X**	**LJL46400U53X**	**LLL46400U53X**	**LRL46400U53X**
			600 A[3]	**LDL46600U53X**	**LGL46600U53X**	**LJL46600U53X**	**LLL46600U53X**	**LRL46600U53X**
Ammeter	LSIG	6.3A	400 A[3]	**LDL46400U44X**	**LGL46400U44X**	**LJL46400U44X**	**LLL46400U44X**	**LRL46400U44X**
			600 A[3]	**LDL46600U44X**	**LGL46600U44X**	**LJL46600U44X**	**LLL46600U44X**	**LRL46600U44X**
Energy	LSIG	6.3E	400 A[3]	**LDL46400U54X**	**LGL46400U54X**	**LJL46400U54X**	**LLL46400U54X**	**LRL46400U54X**
			600 A[3]	**LDL46600U54X**	**LGL46600U54X**	**LJL46600U54X**	**LLL46600U54X**	**LRL46600U54X**
100% Rated, 600 Vac, 50/60 Hz								
Standard	LI	3.3	250 A[2]	**LDL46250CU31X**	**LGL46250CU31X**	**LJL46250CU31X**	**LLL46250CU31X**	**LRL46250CU31X**
			400 A[3]	**LDL46400CU31X**	**LGL46400CU31X**	**LJL46400CU31X**	**LLL46400CU31X**	**LRL46400CU31X**
Standard	LSI	3.3S	250 A[2]	**LDL46250CU33X**	**LGL46250CU33X**	**LJL46250CU33X**	**LLL46250CU33X**	**LRL46250CU33X**
			400 A[3]	**LDL46400CU33X**	**LGL46400CU33X**	**LJL46400CU33X**	**LLL46400CU33X**	**LRL46400CU33X**
Ammeter	LSI	5.3A	400 A[3]	**LDL46400CU43X**	**LGL46400CU43X**	**LJL46400CU43X**	**LLL46400CU43X**	**LRL46400CU43X**
Energy	LSI	5.3E	400 A[3]	**LDL46400CU53X**	**LGL46400CU53X**	**LJL46400CU53X**	**LLL46400CU53X**	**LRL46400CU53X**
Ammeter	LSIG	6.3A	400 A[3]	**LDL46400CU44X**	**LGL46400CU44X**	**LJL46400CU44X**	**LLL46400CU44X**	**LRL46400CU44X**
Energy	LSIG	6.3E	400 A[3]	**LDL46400CU54X**	**LGL46400CU54X**	**LJL46400CU54X**	**LLL46400CU54X**	**LRL46400CU54X**

1 UL Listed/CSA Certified as current limiting circuit breakers.

2 Standard Lug Kit: AL400L61K4 Terminal Wire Range: (1) 2 AWG–600 kcmil Cu or (1) 2 AWG–500 kcmil Al

3 Standard Lug Kit: AL600LS52K4 Terminal Wire Range: (2) 2/0 AWG–500 kcmil Al/Cu

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I-Line™ Circuit Breaker Catalog Numbers

Table 26: L-Frame 600 A I-Line Standard (80%) Rated Electronic Trip UL Rated Circuit Breakers (600 Vac, 50/60 Hz) With Factory Sealed Trip Unit Suitable for Reverse Connection

Electronic Trip Unit			Sensor Rating	Interrupting Rating				
Type	Function	Trip Unit		D	G	J[1]	L[3]	R[3]
Standard	LI	3.3[2]	250 A[3]	LDA36250U31X	LGA36250U31X	LJA36250U31X	LLA36250U31X	LRA36250U31X
			400 A[4]	LDA36400U31X	LGA36400U31X	LJA36400U31X	LLA36400U31X	LRA36400U31X
			600 A[4]	LDA36600U31X	LGA36600U31X	LJA36600U31X	LLA36600U31X	LRA36600U31X
Standard	LSI	3.3S[2]	250 A[3]	LDA36250U33X	LGA36250U33X	LJA36250U33X	LLA36250U33X	LRA36250U33X
			400 A[4]	LDA36400U33X	LGA36400U33X	LJA36400U33X	LLA36400U33X	LRA36400U33X
			600 A[4]	LDA36600U33X	LGA36600U33X	LJA36600U33X	LLA36600U33X	LRA36600U33X
Ammeter	LSI	5.3A	400 A[44]	LDA36400U43X	LGA36400U43X	LJA36400U43X	LLA36400U43X	LRA36400U43X
			600 A[4]	LDA36600U43X	LGA36600U43X	LJA36600U43X	LLA36600U43X	LRA36600U43X
Energy	LSI	5.3E	400 A[4]	LDA36400U53X	LGA36400U53X	LJA36400U53X	LLA36400U53X	LRA36400U53X
			600 A[4]	LDA36600U53X	LGA36600U53X	LJA36600U53X	LLA36600U53X	LRA36600U53X
Ammeter	LSIG	6.3A	400 A[4]	LDA36400U44X	LGA36400U44X	LJA36400U44X	LLA36400U44X	LRA36400U44X
			600 A[4]	LDA36600U44X	LGA36600U44X	LJA36600U44X	LLA36600U44X	LRA36600U44X
Energy	LSIG	6.3E	400 A[4]	LDA36400U54X	LGA36400U54X	LJA36400U54X	LLA36400U54X	LRA36400U54X
			600 A[4]	LDA36600U54X	LGA36600U54X	LJA36600U54X	LLA36600U54X	LRA36600U54X

1 UL Listed/CSA Certified as current limiting circuit breakers.
2 3P circuit breakers with this trip unit can be used for 2P applications.
3 Standard Lug Kit: AL400L61K3 Terminal Wire Range: (1) 2 AWG–600 kcmil Cu or (1) 2 AWG–500 kcmil Al
4 Standard Lug Kit: AL600LS52K3 Terminal Wire Range: (2) 2/0 AWG–500 kcmil Al/Cu

Table 27: L-Frame 250 A and 400 A I-Line 100% Rated Electronic Trip UL Rated Circuit Breakers (600 Vac, 50/60 Hz) With Factory Sealed Trip Unit Suitable for Reverse Connection

Electronic Trip Unit			Sensor Rating	Interrupting Rating				
Type	Function	Trip Unit		D	G	J[1]	L[3]	R[3]
Standard	LI	3.3[2]	250 A[3]	LDA36250CU31X	LGA36250CU31X	LJA36250CU31X	LLA36250CU31X	LRA36250CU31X
			400 A[4]	LDA36400CU31X	LGA36400CU31X	LJA36400CU31X	LLA36400CU31X	LRA36400CU31X
Standard	LSI	3.3S[2]	250 A[3]	LDA36250CU33X	LGA36250CU33X	LJA36250CU33X	LLA36250CU33X	LRA36250CU33X
			400 A[4]	LDA36400CU33X	LGA36400CU33X	LJA36400CU33X	LLA36400CU33X	LRA36400CU33X
Ammeter	LSI	5.3A	400 A[4]	LDA36400CU43X	LGA36400CU43X	LJA36400CU43X	LLA36400CU43X	LRA36400CU43X
Energy	LSI	5.3E	400 A[4]	LDA36400CU53X	LGA36400CU53X	LJA36400CU53X	LLA36400CU53X	LRA36400CU53X
Ammeter	LSIG	6.3A	400 A[4]	LDA36400CU44X	LGA36400CU44X	LJA36400CU44X	LLA36400CU44X	LRA36400CU44X
Energy	LSIG	6.3E	400 A[4]	LDA36400CU54X	LGA36400CU54X	LJA36400CU54X	LLA36400CU54X	LRA36400CU54X

1 UL Listed/CSA Certified as current limiting circuit breakers.
2 3P circuit breakers with this trip unit can be used for 2P applications.
3 Standard Lug Kit: AL400L61K3 Terminal Wire Range: (1) 2 AWG–600 kcmil Cu or (1) 2 AWG–500 kcmil Al
4 Standard Lug Kit: AL600LS52K3 Terminal Wire Range: (2) 2/0 AWG–500 kcmil Al/Cu

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Circuit Breakers with Field-Interchangeable Trip Units Catalog Numbers

Table 28: L-Frame 3 Pole, 600 A Circuit Breakers with Lugs and Field-Interchangeable Electronic Trip Units (600 Vac, 50/60 Hz)[1, 2]

Electronic Trip Unit			Sensor Rating	Interrupting Rating			
Type	Function	Trip Unit		D	G	J [3]	L[3]
Standard (80% Rated), 600 Vac, 50/60 Hz							
Standard	LI	3.3	250 A[4]	LDL36250TU31X	LGL36250TU31X	LJL36250TU31X	LLL36250TU31X
			400 A[5]	LDL36400TU31X	LGL36400TU31X	LJL36400TU31X	LLL36400TU31X
			600 A[5]	LDL36600TU31X	LGL36600TU31X	LJL36600TU31X	LLL36600TU31X
Standard	LSI	3.3S	250 A[4]	LDL36250TU33X	LGL36250TU33X	LJL36250TU33X	LLL36250TU33X
			400 A[5]	LDL36400TU33X	LGL36400TU33X	LJL36400TU33X	LLL36400TU33X
			600 A[5]	LDL36600TU33X	LGL36600TU33X	LJL36600TU33X	LLL36600TU33X
Ammeter	LSI	5.3A	400 A[5]	LDL36400TU43X	LGL36400TU43X	LJL36400TU43X	LLL36400TU43X
			600 A[5]	LDL36600TU43X	LGL36600TU43X	LJL36600TU43X	LLL36600TU43X
Energy	LSI	5.3E	400 A[5]	LDL36400TU53X	LGL36400TU53X	LJL36400TU53X	LLL36400TU53X
			600 A[5]	LDL36600TU53X	LGL36600TU53X	LJL36600TU53X	LLL36600TU53X
Ammeter	LSIG	6.3A	400 A[5]	LDL36400TU44X	LGL36400TU44X	LJL36400TU44X	LLL36400TU44X
			600 A[5]	LDL36600TU44X	LGL36600TU44X	LJL36600TU44X	LLL36600TU44X
Energy	LSIG	6.3E	400 A[5]	LDL36400TU54X	LGL36400TU54X	LJL36400TU54X	LLL36400TU54X
			600 A[5]	LDL36600TU54X	LGL36600TU54X	LJL36600TU54X	LLL36600TU54X
100% Rated, 600 Vac, 50/60 Hz							
Standard	LI	3.3	250 A[4]	LDL36250RU31X	LGL36250RU31X	LJL36250RU31X	LLL36250RU31X
			400 A[5]	LDL36400RU31X	LGL36400RU31X	LJL36400RU31X	LLL36400RU31X
Standard	LSI	3.3S	250 A[4]	LDL36250RU33X	LGL36250RU33X	LJL36250RU33X	LLL36250RU33X
			400 A[5]	LDL36400RU33X	LGL36400RU33X	LJL36400RU33X	LLL36400RU33X
Ammeter	LSI	5.3A	400 A[5]	LDL36400RU43X	LGL36400RU43X	LJL36400RU43X	LLL36400RU43X
Energy	LSI	5.3E	400 A[5]	LDL36400RU53X	LGL36400RU53X	LJL36400RU53X	LLL36400RU53X
Ammeter	LSIG	6.3A	400 A[5]	LDL36400RU44X	LGL36400RU44X	LJL36400RU44X	LLL36400RU44X
Energy	LSIG	6.3E	400 A[5]	LDL36400RU54X	LGL36400RU54X	LJL36400RU54X	LLL36400RU54X

1 Circuit breakers will be labeled with Line and Load markings and are not suitable for reverse connections.
2 Only available on 3P unit-mount circuit breakers. Not available in R interrupting rating. Not available with I-Line™ or Plug-in constructions.
3 UL Listed/CSA Certified as current limiting circuit breakers.
4 Standard Lug Kit: AL400L61K3 Terminal Wire Range: (1) 2 AWG–600 kcmil Cu or (1) 2 AWG–500 kcmil Al
5 Standard Lug Kit: AL600LS52K3 Terminal Wire Range: (2) 2/0 AWG–500 kcmil Al/Cu

Table 29: L-Frame 600 A, 3 Pole, Basic Circuit Breaker Frame Without Terminations or Trip Units (600 Vac, 50/60 Hz)[1]

Ampere Rating	Interrupting Rating			
	D	G	J [2]	L[2]
250 A (70–250 A)	LDF36000F25	LGF36000F25	LJF36000F25	LLF36000F25
400 A (125–400 A)	LDF36000F40	LGF36000F40	LJF36000F40	LLF36000F40
600 A (200–600 A)	LDF36000F60	LGF36000F60	LJF36000F60	LLF36000F60

1 Not suitable for reverse connection.
2 UL Listed/CSA Certified as current limiting

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Table 30: L-Frame 3P Field-Installable Micrologic™ Electronic Trip Units

Electronic Trip Unit			Ampere Setting	Trip Unit Cat. No.
Type	Function	Trip Unit		
Standard	LI	3.3	70-80-100-125-150-175-200-225-250	**LE3250U31X**
			125-150-175-200-225-250-300-350-400	**LE3400U31X**
			200-225-250-300-350-400-450-500-600	**LE3600U31X**
	LSI	3.3S	70-80-100-125-150-175-200-225-250	**LE3250U33X**
			125-150-175-200-225-250-300-350-400	**LE3400U33X**
			200-225-250-300-350-400-450-500-600	**LE3600U33X**
Ammeter	LSI	5.3A	125–400	**LE3400U43X**
			200–600	**LE3600U43X**
	LSIG	6.3A	125–400	**LE3400U44X**
			200–600	**LE3600U44X**
Energy	LSI	5.3E	125–400	**LE3400U53X**
			200–600	**LE3600U53X**
	LSIG	6.3E	125–400	**LE3400U54X**
			200–600	**LE3600U54X**

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Section 4—Automatic Switches

Automatic Switch Functions

An automatic switch can be used to open and close a circuit under normal operating conditions. They are similar in construction to circuit breakers, except that the switches open instantaneously at a factory-set, non-adjustable trip point calibrated to protect only the molded case switch itself.

Molded case switches are intended for use as disconnect devices only. UL489 requires molded case switches to be protected by a circuit breaker or fuse of equivalent rating. Molded case switches are labeled with their appropriate withstand ratings. The withstand rating of a switch is defined as the maximum current at rated voltage that the molded case switch will withstand without damage when protected by a circuit breaker with an equal continuous current rating.

PowerPact H-, J-, and L-frame automatic switches are available in unit mount, I-Line™, plug-in and drawout versions. They use the same accessories and offer the same connection possibilities as the circuit-breaker versions. They may be interlocked with another switch or circuit breaker to form a source-changeover system.

Switches are Listed under UL file E103740 and Certified under CSA file LR88980.

Motor Operator

PowerPact H-, J-, and L-frame switches equipped with a motor operator module allow remote closing and opening.

Ground Fault Protection (H- and J-Frame Circuit Breakers Only)

An ELM or GFM module may be added to an automatic switch to monitor all leakage currents in the outgoing circuits of the equipment on which the automatic switch is installed. When the ELM or GFM module detects an earth-leakage current, the automatic switch interrupts the load current.

Automatic Switch Protection

The automatic switch can make and break its rated current. For an overload or a short-circuit, it must be protected by an upstream device, in compliance with installation standards. Due to their high-set instantaneous release PowerPact H-, J- and L-frame automatic switches are self-protected.

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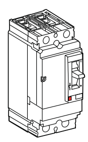
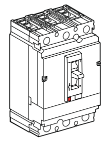
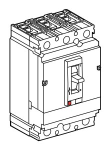
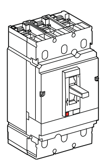
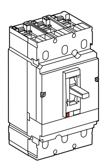
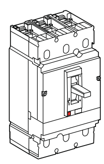
Specifications

Table 31: H-Frame Automatic Molded Case Switch Specifications

Frame			H-Frame			
Withstand Rating			"G"		"L"	
						
UL 489	Poles		2P	3P	2P1	3P
	Catalog Number	150 A	HGL26000S15	HGL3600S15	HLL26000S15	HLL36000S15
		175 A	—	—	—	—
		250 A	—	—	—	—
	Withstand Ratings	240 Vac	65 kA	65 kA	125 kA	125 kA
		480 Vac	35 kA	35 kA	100 kA	100 kA
		600 Vac	18 kA	18 kA	50 kA	50 kA
		250 Vdc	20 kA	20 kA	20 kA	20 kA
	AC Trip Point		2250 A	2250 A	2250 A	2250 A
IEC 60947-3	Rated Insulation Voltage		750 Vac	750 Vac	750 Vac	750 Vac
	Rated Impulse Withstand Voltage		8 kV	8 kV	8 kV	8 kV
	Rated Operational Voltage	ac	525 Vac	525 Vac	525 Vac	525 Vac
		dc	—	—	—	—

1 2P devices use a 3P switch frame with the center pole inoperative.

Table 32: J-Frame Automatic Molded Case Switch Specifications

Frame			J-Frame				
Withstand Rating			"G"		"L"		"R"
							
UL 489	Poles		2P1	3P	2P1	3P	3P
	Catalog Number	150 A	—	—	—	—	—
		175 A	JGL26000S17	JGL36000S17	JLL26000S17	JLL36000S17	JRL36000S17
		250 A	JGL26000S25	JGL36000S25	JLL26000S25	JLL36000S25	JRL36000S25
	Withstand Ratings	240 Vac	65 kA	65 kA	125 kA	125 kA	200 kA
		480 Vac	35 kA	35 kA	100 kA	100 kA	200 kA
		600 Vac	18 kA	18 kA	50 kA	50 kA	100 kA
		250 Vdc	20 kA	20 kA	20 kA	20 kA	20 kA
	AC Trip Point		3125 A	3125 A	3125 A	3125 A	3125 A
IEC 60947-3	Rated Insulation Voltage		750 Vac	750 Vac	750 Vac	750 Vac	750 Vac
	Rated Impulse Withstand Voltage		8 kV	8 kV	8 kV	8 kV	8 kV
	Rated Operational Voltage	ac	525 Vac	525 Vac	525 Vac	525 Vac	525 Vac
		dc	500 Vdc	500 Vdc	500 Vdc	500 Vdc	500 Vdc

1 2P devices use a 3P switch frame with the center pole inoperative.

Catalog Numbers

Table 33: PowerPact H-Frame and J-Frame 250 A Unit-Mount Automatic Molded Case Switches, 600 Vac with Factory Sealed Trip Unit (Suitable for Reverse Connection)

Ampere Rating	2-pole	3-pole	Withstand Rating 1			Trip Point	Standard Lug Kit Terminal Wire Range
	Cat. No.	Cat. No.	240 Vac	480 Vac	600 Vac		
G Withstand							
150 A	HGL26000S15[2]	HGL36000S15	65	35	18	2250 A	AL150HD #14–#3/0 AWG Al or Cu
175 A	JGL26000S17	JGL36000S17	65	35	18	3125 A	AL250JD #3/0–350 kcmil Al or Cu
250 A	JGL26000S25	JGL36000S25					
L Withstand							
150 A	HLL26000S15	HLL36000S15	125	100	50	2250 A	AL150HD #14–#3/0 AWG Al or Cu
175 A	JLL26000S17	JLL36000S17	125	100	50	3125 A	AL250JD #3/0–350 kcmil Al or Cu
250 A	JLL26000S25	JLL36000S25					
R Withstand							
175 A	—	JRL36000S17	200	200	100	3125 A	AL250JD #3/0–350 kcmil Al or Cu
250 A	—	JRL36000S25					

1 The withstand rating is the fault current, at rated voltage, that the molded case switch will withstand without damage when protected by a circuit breaker or fuse with an equal continuous current rating.

2 2-pole device with 3 in. (76 mm) mounting height, all other 2-pole circuit breakers use 3-pole switch 4.5 in. (114 mm) mounting height.

Table 34: PowerPact H-Frame and J-Frame I-Line™ Automatic Molded Case Switches, 600 Vac with Factory Sealed Trip Unit (Suitable for Reverse Connection)

Ampere Rating	2-pole	3-pole	Withstand Rating 1			Trip Point	Standard Lug Kit Terminal Wire Range
	Cat. No.	Cat. No.	240 Vac	480 Vac	600 Vac		
G Withstand							
150 A	HGA26000S15( )[2]	HGA36000S15	65	35	18	1300 A	AL150HD #14–#3/0 AWG Al or Cu
175 A	JGA26000S17( )	JGA36000S17	65	35	18	2500 A	AL250JD #3/0–350 kcmil Al or Cu
250 A	JGA26000S25( )	JGA36000S25					
L Withstand							
150 A	HLA26000S15( )	HLA36000S15	125	100	50	1300 A	AL150HD #14–#3/0 AWG Al or Cu
175 A	JLA26000S17( )	JLA36000S17	125	100	50	1300 A	AL250JD #3/0–350 kcmil Al or Cu
250 A	JLA26000S25( )	JLA36000S25				2500 A	
R Withstand							
175 A	JRA26000S17( )	JRA36000S17	200	200	100	3125A	AL250JD #3/0–350 kcmil Al or Cu
250 A	JRA26000S25( )	JRA36000S25					

1 The withstand rating is the fault current, at rated voltage, that the molded case switch will withstand without damage when protected by a circuit breaker or fuse with an equal continuous current rating.

2 2-pole device with 3 in. (76 mm) mounting height, all other 2-pole circuit breakers use 3-pole 4.5 in. (114 mm) mounting height.

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Table 35: PowerPact L-Frame 600 A Unit-Mount Automatic Molded Case Switches, 600 Vac

Ampere Rating	Poles[1]	Cat. No.	Withstand Rating [2]			Trip Point	Standard Lug Terminal Wire Range
			240 Vac	480 Vac	600 Vac		
Unit-Mount Automatic Molded Case Switches,							
G Withstand							
400 A	3P	**LGL36000S40X**	65 kA	35 kA	18 kA	4800 A	AL600LS52K3 (2) 2 AWG–500 kcmil Al/Cu
600 A		**LGL36000S60X**	65 kA	35 kA	18 kA	6600 A	
400 A	4P	**LGL46000S40X**	65 kA	35 kA	18 kA	4800 A	AL600LS52K4 (2) 2 AWG–500 kcmil Al/Cu
600 A		**LGL46000S60X**	65 kA	35 kA	18 kA	6600 A	
L Withstand							
400 A	3P	**LLL36000S40X**	125 kA	100 kA	50 kA	4800 A	AL600LS52K3 (2) 2 AWG–500 kcmil Al/Cu
600 A		**LLL36000S60X**	125 kA	100 kA	50 kA	6600 A	
400 A	4P	**LLL46000S40X**	125 kA	100 kA	50 kA	4800 A	AL600LS52K4 (2) 2 AWG–500 kcmil Al/Cu
600 A		**LLL46000S60X**	125 kA	100 kA	50 kA	6600 A	
R Withstand							
400 A	3P	**LRL36000S40X**	200 kA	200 kA	100 kA	4800 A	AL600LS52K3 (2) 2 AWG–500 kcmil Al/Cu
600 A		**LRL36000S60X**	200 kA	200 kA	100 kA	6600 A	
400 A	4P	**LRL46000S40X**	200 kA	200 kA	100 kA	4800 A	AL600LS52K4 (2) 2 AWG–500 kcmil Al/Cu
600 A		**LRL46000S60X**	200 kA	200 kA	100 kA	6600 A	
I-Line™ Circuit Breakers Automatic Molded Case Switches							
G Withstand							
400 A	3P	**LGA36000S40X**	65 kA	35 kA	18 kA	4800 A	AL600LF52K3 (2) 3/0 AWG–500 kcmil Al/Cu
600 A		**LGA36000S60X**	65 kA	35 kA	18 kA	6600 A	
L Withstand							
400 A	3P	**LLA36000S40X**	125 kA	100 kA	50 kA	4800 A	AL600LF52K3 (2) 3/0 AWG–500 kcmil Al/Cu
600 A		**LLA36000S60X**	125 kA	100 kA	50 kA	6600 A	
R Withstand							
400 A	3P	**LRA36000S40X**	200 kA	200 kA	100 kA	4800 A	AL600LF52K3 (2) 3/0 AWG–500 kcmil Al/Cu
600 A		**LRA36000S60X**	200 kA	200 kA	100 kA	6600 A	

1 4P circuit breaker available as bus connected, with lug configurations, and in plug-in, draw-out and rear-connected configurations.

2 The withstand rating is the fault current, at rated voltage, that the molded case switch will withstand without damage when protected by a circuit breaker or fuse with an equal continuous current rating.

Table 36: L-Frame Ratings and Withstand Ratings

			400 A	600 A
Number of Poles			3, 4	3, 4
Ampere Rating (A)			400	600
UL 489 Ratings				
Rated Voltage (V)			600	600
IEC 60947-3 ratings				
Rated Insulation Voltage (V)			750	750
Rated Impulse Withstand Voltage (kV)			8	8
Rated Operational Voltage	Ue	AC 50/60 Hz	525	525
Rated Operational Current	Ie	AC 525 V	400	600
Making Capacity (kA peak)			7.1	8.5
Short-Time Withstand Current (kA rms)	Icw	Icw (kA ms)	5	6
		Duration (s)	1	1

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Section 5—Motor Circuit Protection

General Information

The parameters to be considered for motor-feeder protection depend on:

- the application (type of machine driven, operating safety, frequency of operation, etc.)
- the level of continuity of service required by the load or the application
- the applicable standards for the protection of equipment.

The required electrical functions are:

- isolation
- switching, generally at high endurance levels
- protection against overloads and short-circuits, adapted to the motor
- additional special protection.

A motor branch circuit must comply with the requirements of standard UL508 concerning contactors and their protection:

- coordination of feeder components
- overload relay trip classes.

Motor Branch Circuit Protection Function

A motor branch circuit comprises a set of devices for motor protection and control, as well as for protection of the branch circuit itself.

Switching

The purpose is to control the motor (ON / OFF), either manually, automatically or remotely, taking into account overloads upon start-up and the long service life required. This function is provided by a contactor. When the coil of the contactor's electromagnet is energized, the contactor closes and establishes, through the poles, the circuit between the upstream supply and the motor, through the circuit breaker.

Basic Protection

- Short-circuit protection
  Detection and breaking, as quickly as possible, of high short-circuit currents to avoid damage to the installation. This function is provided by a circuit breaker.
- Overload protection
  Detection of overload currents and motor shutdown before temperature rise in the motor and conductors damages insulation. This function is provided by a circuit breaker or a separate motor overload relay.
- Phase unbalance or phase loss protection
  Phase unbalance or phase loss can cause temperature rise and braking torques that can lead to premature ageing of the motor. These effects are even greater during starting, therefore protection must be virtually immediate.

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Additional Electronic Protection

- Locked rotor
- Under-load
- Long starts and stalled rotor
- Insulation faults

Trip Class of a Overload Relay Device

The motor branch circuit includes thermal protection that may be built into the circuit breaker. The protection must have a trip class suited to motor starting. Depending on the application, the motor starting time varies from a few seconds (no-load start) to a few dozen seconds (high-inertia load).

Table 37: Trip Class of Overload Relays as a Function of Their FLA Setting

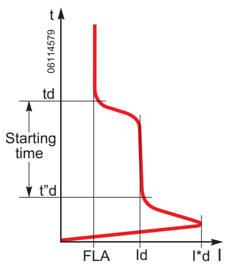
Class	1.05 FLA[1]	1.2 FLA[1]	1.5 FLA[2]	6.0 FLA[1]
5	t > 2 h	t < 2h	t < 2 mn	2 s < t ≤ 5 s
10	t > 2 h	t < 2h	t < 4 mn	4 s < t ≤ 10 s
20	t > 2 h	t < 2h	t < 8 mn	6 s < t ≤ 20 s

1 Time for a cold start (motor off and cold).

2 Time for warm start (motor running under normal conditions).

Example: In class 20, the motor must have finished starting within 20 seconds (6 to 20 s) for a starting current of 6 x FLA.

Asynchronous-Motor Starting Parameters



Typical motor-starting curve

The main parameters of direct on-line starting of three-phase asynchronous motors (90% of all applications) are listed below.

- FLA: Full load amperes
  This is the current drawn by the motor at full rated load.
- Id: locked rotor current
  This is the current drawn by the motor during starting, on average 6.0 x In for a duration of 5 to 30 seconds depending on the application. These values determine the trip class and any additional “long-start” protection devices that may be needed.
- Id: peak starting current
  This is the subtransient current during the first two half-waves when the system is energized, on the average 14 I_n for 10 to 15 ms (e.g. 1840 A peak).

The protection settings must effectively protect the motor, notably through a suitable overload relay trip class, but let the peak starting current through.

Motor-Feeder Solutions

PowerPact H-, J-, and L-frame circuit breakers motor circuit breakers are designed for motor-feeder solutions using:

- three devices, including an electronic MCP or 1.3 M instantaneous-only trip unit
- two devices including a 2 M electronic trip unit.

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PowerPact H-, J-, and L-Frame with Micrologic™ Trip Units Motor-Protection Range

PowerPact H-, J-, and L-frame circuit breakers with Micrologic trip units can be used to create motor-feeder solutions comprising two or three devices. The protection devices are designed for continuous duty at 104°F (40°C).

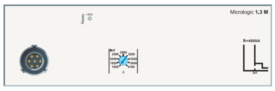
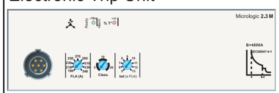
Three-device solutions

- 1 PowerPact circuit breaker with Micrologic 1.3 M trip unit
- 1 contactor
- overload relay

Two-device solutions

- 1 PowerPact circuit breaker with a Micrologic 2 M electronic trip unit.
- 1 contactor

Table 38: Motor Protection Specifications

Type of Motor Protection			3 Devices (Circuit Breaker + Contactor + Overload Relay)	2 Devices (Circuit Breaker + Contactor)
PowerPact H-, J-, or L-frame circuit breaker			PowerPact L-frame 400/600 A	PowerPact H-, J-, and L-Frame 100–600 A
	Type 2 coordination with		Contactor + overload relay	Contactor
Trip Unit	Type		Micrologic 1.3 M Electronic Trip Unit 	Micrologic 2 M Electronic Trip Unit 
Overload Relay	Separate		X	
	Built-in, Class	5		X
		10		X
		20		X
Protection functions of PowerPact H-, J-, and L-frame circuit breaker				
Short-circuits			X	X
Overloads				X
Special motor functions	Phase unbalance			X

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Electronic Motor Circuit Protectors (AC Only)

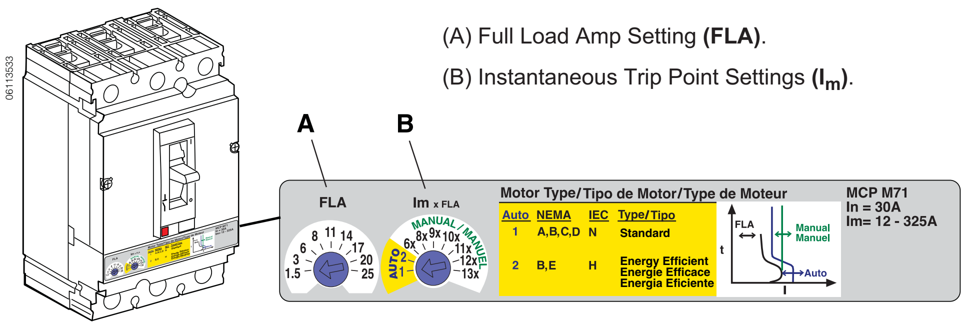
PowerPact H- and J-frame Electronic Motor Circuit Protectors (MCP) are instantaneous-trip circuit breakers. They are designed to offer short circuit protection and are National Electrical Code® (NEC®) compliant when installed as part of a combination controller having motor overload protection. MCP circuit breakers accept the same accessories and terminals as the equivalent thermal-magnetic circuit breakers. (See Section 3 for Accessories.)

The unique design of the PowerPact MCPs includes two rotary switches to allow quick setting adjustments based on the characteristics of the motor.

The first rotary switch allows for Full Load Amperes (FLA) adjustment across the range of the frame size.

The second rotary switch selects the type of motor protection based on Automatic 1 for Standard Efficiency or Automatic 2 for High Energy Efficient. When using the automatic settings the MCP microprocessor automatically adjusts the trip settings for both current and time to align with the start-up characteristic for the motor type, whether it is a standard or energy-efficient motor. This includes a dampening means to accommodate a transient motor in-rush current without nuisance tripping of the circuit breaker. Rotary switch 2 also allows for traditional motor protection from 8 to 13 times the selected FLA.

The MCP rotary switches are detented and allow the device to be set to specific trip values within a typical accuracy range of +/-5%.



(A) Full Load Amp Setting **(FLA)**.

(B) Instantaneous Trip Point Settings **(I_m)**.

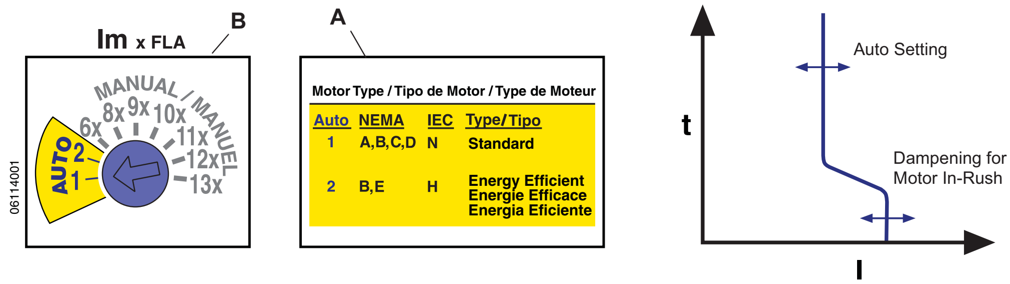
Full Load Amp Settings

1. Determine the motor's full-load current by referring to the nameplate on the motor.
2. Set the trip range by turning the FLA rotary switch to the setting closest to the motor's full load current.

Automatic Protection Settings

The MCP microprocessor automatically adjusts the trip settings for both current and time to align with the start-up characteristics for the motor type selected. This includes a dampening means to accommodate a transient motor in-rush current without nuisance tripping of the circuit breaker.

Figure 3: Automatic Protection Settings

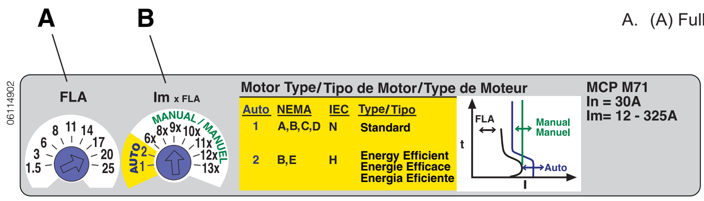


Manual Protection Settings

The manual settings may be adjusted to multiples of current based on the rotary switch setting for motor Full Load Amps (FLA).

$$\textbf{Instantaneous Trip Point} = (\text{FLA}) \times (I_m)$$

For example, if FLA rotary switch is set to 20 and I_m rotary switch is set to 9x, then the instantaneous trip point will be 180 A.



A. (A) Full Load Amp Setting **(FLA)**.

A. (B) Instantaneous Trip Point Settings **(I_m)**.

See Tables 44 thru 46 for more information.

Table 39: H- and J-Frame Electronic Motor Circuit Protectors (MCP)

Frame	Current	Full Load Amperes Range	Adjustable Instantaneous Trip Range	Suffix	J Interrupting (See SCCR Table Below)	L Interrupting (See SCCR Table Below)	R Interrupting
					Cat. No.	Cat. No.	Cat. No.
H-Frame	30 A	1.5–25 A	9–325 A	M71	HJL36030M71	HLL36030M71	HRL36030M71
	50 A	14–42 A	84–546 A	M72	HJL36050M72	HLL36050M72	HRL36050M72
	100 A	30–80 A	180–1040 A	M73	HJL36100M73	HLL36100M73	HRL36100M73
	150 A	58–130 A	348–1690 A	M74	HJL36150M74	HLL36150M74	HRL36150M74
J-Frame	250 A	114–217 A	684–2500 A	M75	JJL36250M75	JLL36250M75	JRL36250M75

- High Short Circuit Current Ratings (SCCR)

  The PowerPact MCP helps achieve the high UL508A Short Circuit Current Rating (SCCR) needed to meet NEC Article 409 requirements for industrial control panels. They deliver up to 100 kA at 480 Vac SCCR when used in combination with approved Square D™ NEMA or Schneider Electric™ IEC motor starters.

Table 40: Short Circuit Current Ratings (SCCR)

Contactor/Starter	J Interrupting			L Interrupting			R Interrupting		
	200–240 Vac	480 Vac	600 Vac	200–240 Vac	480 Vac	600 Vac	200–240 Vac	480 Vac	600 Vac
Tesys D-line and F-line	100 kA	65 kA	25 kA	100 kA	100 kA	50 kA	200 kA	200 kA	100 kA
NEMA Type S	100 kA	65 kA	25 kA	100 kA	100 kA	50 kA	200 kA	200 kA	100 kA

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Table 41: MCP Selection by HP Ratings of Induction-Type Squirrel-Cage and Wound-Rotor Motors

Horsepower Rating of Induction-Type Squirrel-Cage and Wound-Rotor Motors 3Ø 60 Hz					NEC Full Load Amperes	PowerPact H-Frame and J-Frame Electronic MCP	
Starter Size	200 Vac	230 Vac	480 Vac	575 Vac			
				1/2	0.9 A		
			1/2		1.1 A		
				3/4	1.3 A		
			3/4	1	1.7 A		
			1		2.1 A		
		1/2			2.2 A		
				1-1/2	2.4 A		
	1/2				2.5 A		
				2	2.7 A		
			1-1/2		3 A		
00		3/4			3.2 A		
			2		3.4 A		
	3/4				3.7 A		
				3	3.9 A	HJL36030M71 and HLL36030M71 1/2–10 hp	
		1			4.2 A		
	1				4.8 A		
			3		4.8 A		
		1-1/2			6 A		
				5	6.1 A		
		2			6.8 A		
	1-1/2				6.9 A		
			5		7.6 A		
	2				7.8 A		
0				7-1/2	9 A		
		3			9.6 A		
	3		7-1/2	10	11 A		
			10		14 A		
		5			15.2 A		
				15	17 A		
1	5				17.5 A		
			15		21 A		HJL36050M72 and HLL36050M72 10–25 hp
		7-1/2		20	22 A		
	7-1/2				25.3 A		
			20	25	27 A		
2		10			28 A		
				30	32 A		
	10				32.2 A		
			25		34 A		
			30		40 A		
				40	41 A	HJL36100M73 and HLL36100M73 15–50 hp	
		15			42 A		
	15				48.3 A		
3			40	50	52 A		
		20			54 A		
	20			60	62 A		
			50		65 A		
		25			68 A		
			60	75	77 A		
	25				78.2 A		HJL36150M74 and HLL36150M74 30–100 hp
		30			80 A		
	30				92 A		
4			75		96 A		
				100	99 A		
		40			104 A		
	40				120 A		
			100		124 A		
				125	125 A	JJL36250M75 and JLL36250M75 50–150 hp	
		50			130 A		
				150	144 A		
	50				150 A		
5		60			154 A		
			125		156 A		
	60				177.1 A		
			150		180 A		
		75		200	192 A		
	75				221 A		
			200		240 A		
		100			248 A		

Shaded area is not covered by J-frame electronic motor circuit protector.

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Micrologic™ 1.3 M Electronic Trip Units for Instantaneous Protection Only (L-Frame Circuit Breakers Only)

Micrologic 1.3 M trip units are used in 3-device motor-feeder solutions on PowerPact L-frame circuit breakers with performance levels G/J/L. They provide short-circuit protection for motors up to 250 kW at 400 V.

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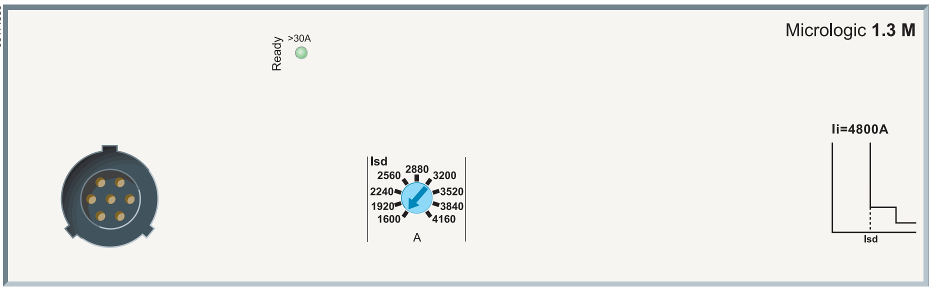

Micrologic 1.3 M trip units provide instantaneous protection only, using electronic technology. They are dedicated to 600 A 3-pole (3P 3D) circuit breakers or 4pole circuit breakers with detection on 3 poles (4P, 3D). They are especially used in 3-pole versions for motor protection, see Section 5—Motor Circuit Protection.

Circuit breakers equipped with Micrologic 1.3 M trip units, without thermal protection, are used in certain applications to replace automatic switches. Micrologic 1.3 M trip units are available on PowerPact L-frame circuit breakers only.

NOTE: All Micrologic trip units have a transparent, sealable cover that protects access to the adjustment rotary switches.

They also provide the benefits of electronic technology:

- accurate settings
- tests
- “Ready” LED.

Circuit breakers with a Micrologic 1.3 M trip unit are combined with a overload relay and a contactor.

Protection settings are made using a rotary switch.

Protection Version

3-pole (3P): 3-pole frame circuit breakers equipped with detection on all 3 poles.

Indications

The green “Ready” LED blinks slowly when the electronic trip unit is ready to provide protection. It indicates the trip unit is operating correctly.

NOTE: All the trip units have a transparent sealable cover that protects access to the adjustment rotary switches.

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Table 42: Micrologic™ 1.3 M Electronic Trip Unit

Rating: I_n at 104°F (40°C)[1]		400 A	600 A
Circuit Breaker	PowerPact L-frame	X	X
Short-time protection			
Pick-up (A) accuracy ±15%	I_{sd} There is a very short delay to let through motor starting currents	Adjustable directly in amps	
		9 settings: 2000-2400-2800-3200-3600-4000-4800 A	9 settings: 3000-3600-4200-4800-5400-6000-6600-7200 A
Time delay (ms)	t_{sd}	Non-adjustable	
	Non-tripping time Maximum break time	20 60	
Instantaneous protection			
Pick-up (A) accuracy ±15%	I_i non-adjustable	4800	7200
	Non-tripping time Maximum break time	0 30 ms	

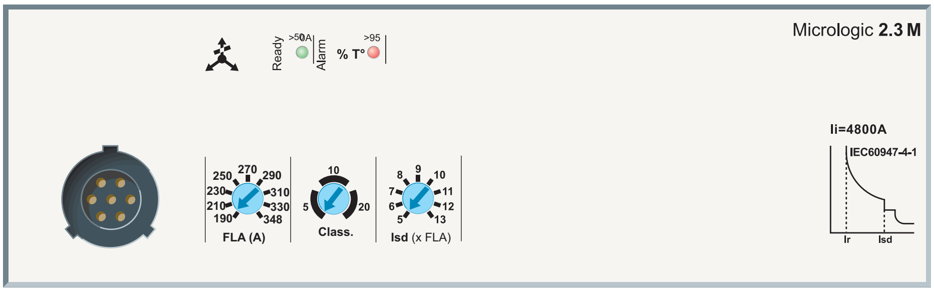
[1] Motor standards require operation at 104°F (40°C). Circuit-breaker ratings are derated to take this requirement into account

Micrologic 2.2 M and 2.3 M Electronic Trip Units

Micrologic 2.2 M and 2.3 M trip units provide built-in thermal and instantaneous protection. They are used in 2-device motor-feeder solutions on PowerPact H-, J-, and L-frame circuit breakers with performance levels J/L. They provide protection for motors up to 315 kW at 400 V against:

- short-circuits
- overloads with selection of a trip class (5, 10 or 20)
- phase unbalance.

06114582



Circuit breakers with a Micrologic 2.2 M/ 2.3 M trip unit include protection similar to an inverse-time overload relay. They are combined with a contactor.

Protection settings are made using a rotary switch.

Overloads (or Thermal Protection)

Long-time protection and trip class (FLA)

- Inverse-time thermal protection
- against overloads with adjustable pick-up FLA.
- Settings are made in amperes. The tripping curve for the long-time protection, which indicates the time delay tr before tripping, is defined by the selected trip class.

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Trip Class

- The class is selected as a function of the normal motor starting time.
  - Class 5: starting time less than 5 s
  - Class 10: starting time less than 10 s
  - Class 20: starting time less than 20 s
- For a given class, it is necessary to check that all motor-feeder components are sized to carry the 6 x FLA starting current without excessive temperature rise during the time corresponding to the class.

Short-Circuits

Short-time protection (I_{sd})

- Provides protection with an adjustable pick-up I_{sd}.
- There is a very short delay to let through motor starting currents.

Non-adjustable instantaneous protection (I_i)

- Instantaneous protection with non-adjustable pick-up I_i.

Phase Unbalance or Phase Loss (I_{unbal})

- This function opens the circuit breaker if a phase unbalance occurs:
  - that is greater than the 30% fixed pick-up I_{unbal}
  - following the non-adjustable time delay t_{unbal} equal to:
    • 0.7 s during starting
    • 4 s during normal operation
- Phase loss is an extreme case of phase unbalance and leads to tripping under the same conditions

Indications

Front indications

- The green “Ready” LED blinks slowly when the electronic trip unit is ready to provide protection. It indicates the trip unit is operating correctly.
- Red alarm LED for motor operation goes ON when the thermal image of the rotor and stator is greater than 95% of the permissible temperature rise.

Remote indications using SDTAM module

- PowerPact H-, J-, and L-frame devices with a Micrologic™ 2 M trip unit can be equipped with an SDTAM module dedicated to motor applications for:
  - a contact to indicate circuit-breaker overload
  - a contact to open the contactor. In the event of a phase unbalance or overload, this output is activated 400 ms before circuit-breaker tripping to open the contactor and avoid circuit breaker tripping
- This module takes the place of the shunt trip (MN)/undervoltage trip (MX) coils and an auxiliary switch (OF) contact

SDTAM remote indication relay module with its terminal block.

Note: All the trip units have a transparent sealable cover that protects access to the adjustment rotary switches.

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Table 43: Micrologic™ 2.2 M and 2.3 M Electronic Trip Unit

Rating: I_n at 104°F (40°C)[1]			30 A	50 A	100 A	150 A	250 A	400 A	600 A		
Circuit Breaker	PowerPact H-frame		X	X	X	X	—	—	—		
	PowerPact J-frame		—	—	—	—	X	—	—		
	PowerPact L-frame		—	—	—	—	—	X	X		
Overloads (or Thermal Protection): Long-Time Protection and Trip Class											
Pick-Up (A) Tripping between 1.05 and 1.20 FLA	**FLA**		**Value depending on trip unit rating (I_n) and setting on rotary switch**								
	I_n = 30 A	FLA =	14	16	18	20	21	22	23	24	25
	I_n = 50 A	FLA =	14	17	21	24	27	29	32	36	42
	I_n = 100 A	FLA =	30	35	41	45	51	56	63	71	80
	I_n = 150 A	FLA =	58	71	78	86	91	97	110	119	130
	I_n = 250 A	FLA =	114	137	145	155	163	172	181	210	217
	I_n = 400 A	FLA =	190	210	230	250	270	290	310	330	348
	I_n = 600 A	FLA =	312	338	364	390	416	442	468	484	520
Time Delay											
Trip Class			5	10	20						
Time Delay (s) Depending on selected trip class	t_r	1.5 x FLA	120	240	480	For warm start					
		6 x FLA	6.5	13.5	26	For cold start					
		7.2 x FLA	5	10	20	For cold start					
S Short Circuits: Short-time protection with fixed time delay											
Pick-up (A) accuracy ±15%	I_{sd} = FLA x		5	6	7	8	9	10	11	12	13
Time delay (ms)	t_{sd}		Non-adjustable								
	Non-tripping time		20								
	Maximum break time		60								
I Short Circuit: Non-adjustable instantaneous protection											
Pick-up (A) accuracy ±15%	I_i non-adjustable		450	750	1500	2250	3750	4800	7200		
Time delay (ms)	Non-tripping time		0								
	Maximum break time		30 ms								
Phase unbalance or phase loss											
Pick-up (A) accuracy ±20%	I_{unbal} in % average current[2]		30%								
Time delay (ms)	Non-adjustable		0.7 s during starting 4 s during normal operation								

1 Motor standards require operation at 104°F (40°C). Circuit-breaker ratings are derated to take this requirement into account.

2 The unbalance measurement takes into account the most unbalanced phase with respect to the average current.

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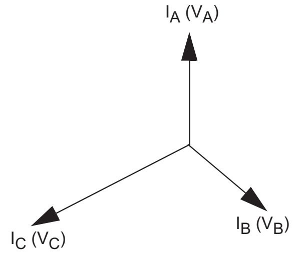
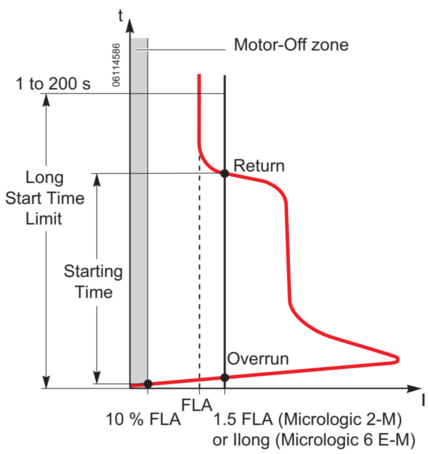
Additional Technical Characteristics

Table 44: Additional Technical Characteristics



Unbalance of Phase Currents and Voltages



Motor Starting and Long Starts

Phase unbalance	An unbalance in three-phase systems occurs when the three voltages are not equal in amplitude and/or not displaced 120° with respect to each other. It is generally due to single-phase loads that are incorrectly distributed throughout the system and unbalance the voltages between the phases. These unbalances create negative current components that cause braking torques and temperature rise in asynchronous machines, thus leading to premature ageing.
Phase loss	Phase loss is a special case of phase unbalance. • During normal operation, it produces the effects mentioned above and tripping must occur after four seconds. • During starting, the absence of a phase may cause motor reversing, i.e. it is the load that determines the direction of rotation. This requires virtually immediate tripping (0.7 seconds). Starting time in compliance with the class (Micrologic™ 2 M) For normal motor starting, Micrologic 2 M checks the conditions below with respect to the thermal-protection (long-time) pick-up FLA: • current > 10% x FLA (motor-off limit) • overrun of 1.5 x FLA threshold, then return below this threshold before the end of a 10 s time delay. If either of these conditions is not met, the thermal protection trips the device after a maximum time equal to that of the selected class. Pick-up FLA must have been set to the current indicated on the motor rating plate.
Starting time in compliance with the class (Micrologic 2 M)	For normal motor starting, Micrologic 2 M checks the conditions below with respect to the thermal-protection (long-time) pick-up FLA: • current > 10% x FLA (motor-off limit) • overrun of 1.5 x FLA threshold, then return below this threshold before the end of a 10 s time delay If either of these conditions is not met, the thermal protection trips the device after a maximum time equal to that of the selected class. Pick-up FLA must have been set to the current indicated on the motor rating plate.

Table 45: L-Frame Electronic Trip Unit Magnetic Only 3 Pole, 600 Vac, 50/60 Hz—Three Device Solutions[1]

Sensor Rating		Trip Unit	Adjustable[2] Trip Range (A)	G-Interrupting Cat. No.	J-Interrupting Cat. No.	L-Interrupting Cat. No.	R-Interrupting Cat. No.
PowerPact L-Frame	400	1.3 M	500–1200%	LGL36400M37X	LJL36400M37X	LLL36400M37X	LRL36400M37X
	600		500–1200%	LGL36600M37X	LJL36600M37X	LLL36600M37X	LRL36600M37X

1 Three-device solutions are the traditional solutions: motor circuit protector plus motor starter plus overload relay.
2 UL magnetic trip tolerances are -20%/+30% from the nominal values shown.

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Table 46: H-Frame (150 A), J-Frame (250 A) and L-Frame (600 A) Electronic Motor Protector Circuit Breakers (UL Ratings)—Two Device Solutions[1]

Electronic Trip Unit Type	Frame	Sensor Rating	Trip Unit	Full Load Amperes Range (FLA)	I_{sd} (x FLA)	G Interrupting Cat. No.	J Interrupting Cat. No.	L Interrupting Cat. No.	R Interrupting Cat. No.
Standard[2]	H-Frame	30	2.2 M	14–25	5-13 x FLA	HGL36030M38X	HJL36030M38X	HLL36030M38X	HRL36030M38X
		50		14–42	5-13 x FLA	HGL36050M38X	HJL36050M38X	HLL36050M38X	HRL36050M38X
		100		30–80	5-13 x FLA	HGL36100M38X	HJL36100M38X	HLL36100M38X	HRL36100M38X
		150		58–130	5-13 x FLA	HGL36150M38X	HJL36150M38X	HLL36150M38X	HRL36150M38X
	J-Frame	250		114–217	5-13 x FLA	JGL36250M38X	JJL36250M38X	JLL36250M38X	JRL36250M38X
	L-Frame	400	2.3 M	190–348	5-13 x FLA	LGL36400M38X	LJL36400M38X	LLL36400M38X	LRL36400M38X
		600		312–520	5-13 x FLA	LGL36600M38X	LJL36600M38X	LLL36600M38X	LRL36600M38X

1 Two-device solutions (these electronic motor protector circuit breakers include short circuit and overload protection)
—1 electronic motor circuit protector with a Micrologic™ 2.2 M electronic trip unit, plus
—1 contactor

2 The standard trip unit offers Class 5, 10 and 20 and phase unbalance or phase loss protection.

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Section 6—Trip Units

Available Trip Units

- PowerPact H-, J-, and L-Frame circuit breakers offer a range of thermal-magnetic and Micrologic™ electronic trip units in interchangeable cases. Thermal-magnetic trip units are designed to open automatically under overload or short circuit. H-frame and J-frame thermal-magnetic circuit breakers contain individual thermal (overload) and instantaneous (short circuit) sensing elements in each pole.
- Micrologic electronic trip units provide intelligent operation, with wide setting ranges make installation upgrades easier. Designed with processing capabilities, Micrologic trip units can provide measurement information and device operating assistance to supply all of the information required to manage the electrical installation and optimize energy use.

  Micrologic trip units offer excellent measurement accuracy, using a new generation of current transformers combining “iron-core” sensors for self-powered electronics and “air-core” sensors (Rogowski coils) for measurements. The protection functions are managed by an ASIC component that is independent of the measurement functions. This independence ensures immunity to conducted and radiated disturbances and a high level of reliability.

  An LED on the front of the electronic trip units indicates the result of the self-test running continuously on the measurement system and the tripping release. When the green LED is flashing, the links between the CTs, the processing electronics and the Mitop release are operational. The circuit breaker is ready to protect. A minimum current of 15 to 50 A, depending on the device, is required for this function.

  The dual adjustment for protection functions on Micrologic 5 / 6 consists of:

  — an adjustment using rotary switches sets the maximum value

  — an adjustment, made using the keypad or remotely, fine-tunes the setting. This setting may not exceed the first one. It can be read directly on the Micrologic screen, to within one ampere and a fraction of a second.

NOTE: All the trip units have a transparent sealable cover that protects access to the adjustment rotary switches.

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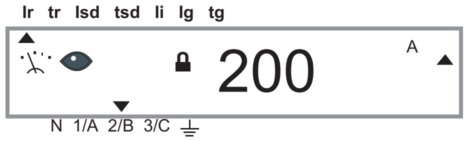
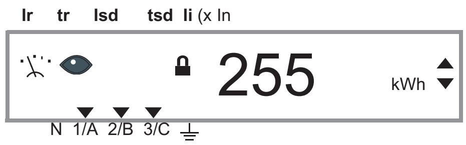
Table 47: Understanding the Names of Micrologic™ Electronic Trip Units

	Protection	Frame	Measurements	Applications
	1: I 3: LI or LSI 5: LSI 6: LSIG	H- and J-frame 	A: Ammeter 	DIstribution or M: Motors
	L: Long time S: Short time I: Instantaneous G: Ground fault	L-frame 	E: Energy 	
Examples				
Micrologic 1.3 M Trip Unit	Instantaneous only	400 or 600 A		Motor
Micrologic 3.3 Trip Unit	LI	250, 400, or 600 A		Distribution
Micrologic 3.2S Trip Unit	LSI	60, 100, 150, or 250 A		Distribution
Micrologic 5.2A Trip Unit	LSI—Ammeter	60, 100, 150, or 250 A		Distribution

For Micrologic trip unit features, see table 7 on page 18.

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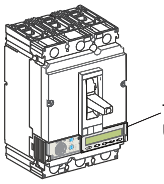
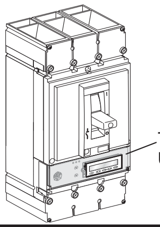
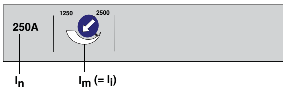
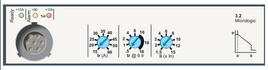
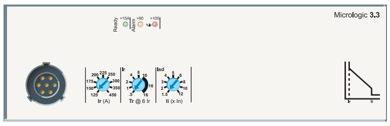
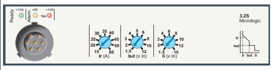
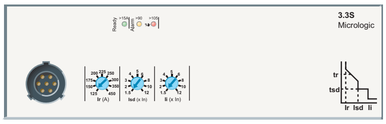
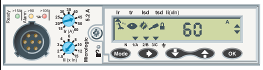
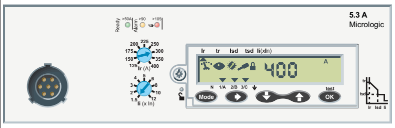
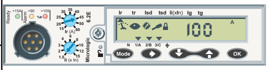
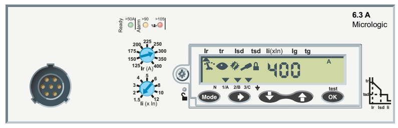
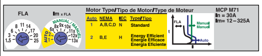
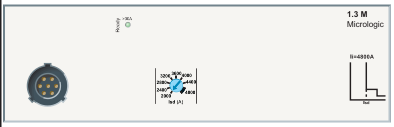
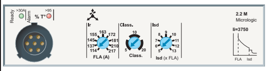
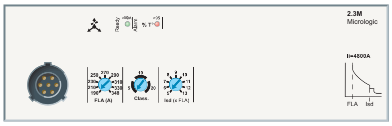
Table 48: Trip Unit Availability

Trip Unit Type	Trip Unit	H-, J-Frame	Trip Unit	L-Frame
				
Distribution Protection Thermal-Magnetic	T-M		N/A	
Distribution Protection LI	Micrologic™ 3.2		Micrologic 3.3	
Distribution Protection LSI Fixed ST and LT delays	Micrologic 3.2S		Micrologic 3.3S	
Distribution Protection LSI + Ammeter	Micrologic 5.2 A		Micrologic 5.3 A	
Distribution Protection LSI + Energy Monitoring	Micrologic 5.2 E		Micrologic 5.3 E	
Distribution Protection LSIG + Ammeter	Micrologic 6.2 A		Micrologic 6.3 A	
Distribution Protection LSIG + Energy Monitoring	Micrologic 6.2 E		Micrologic 6.3 E	
Motor Circuit Protection Magnetic Only	M		N/A	
Motor Protection Micrologic 1 M	N/A		Micrologic 1.3M	
Motor Protection Micrologic 2 M	Micrologic 2.2 M		Micrologic 2.3 M	

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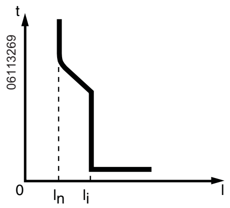
Protection of Distribution Systems

Thermal-Magnetic Trip Units

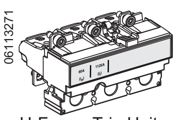
TM thermal-magnetic trip units can be used on PowerPact H and J-frame circuit breakers with interrupting levels D/G/J/L. Thermal-magnetic trip units are available in factory sealed or field-interchangeable constructions.



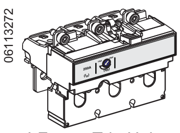
H-Frame Trip Curve

(I_n) Fixed threshold thermal protection against overload

(I_i) **Fixed** threshold instantaneous protection against short circuits



H-Frame Trip Unit



J-Frame Trip Unit

Table 49: H-Frame and J-Frame 3P Field-Installable Thermal-Magnetic Trip Unit

15–60 A H-Frame		70–150 A H-Frame		150–250 A J-Frame	
Amperage	**Cat. No.**	**Amperage**	**Cat. No.**	**Amperage**	**Cat. No.**
15 A	**HT3015**	70 A	**HT3070**	150 A	**JT3150**
20 A	**HT3020**	80 A	**HT3080**	175 A	**JT3175**
25 A	**HT3025**	90 A	**HT3090**	200 A	**JT3200**
30 A	**HT3030**	100 A	**HT3100**	225 A	**JT3225**
35 A	**HT3035**	110 A	**HT3110**	250 A	**JT3250**
40 A	**HT3040**	125 A	**HT3125**	—	—
45 A	**HT3045**	150 A	**HT3150**	—	—
50 A	**HT3050**	—	—	—	—
60 A	**HT3060**	—	—	—	—

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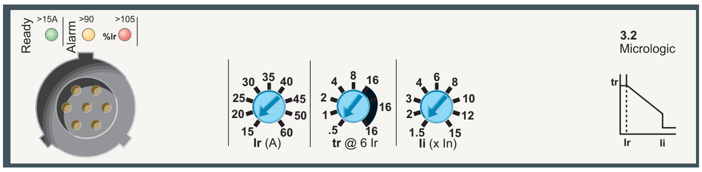
SQUARE D™ by Schneider Electric

Micrologic™ 3 Trip Units

Micrologic 3 trip units can be used on PowerPact H-, J-, and L-Frame circuit breakers with performance levels D/G/J/L.



They provide:

- standard protection of distribution cables
- indication of:
  - — overloads (using LEDs)
  - — overload tripping (using the SDx relay module).

Circuit breakers equipped with Micrologic 3 trip units can be used to protect distribution systems supplied by transformers.

Protection

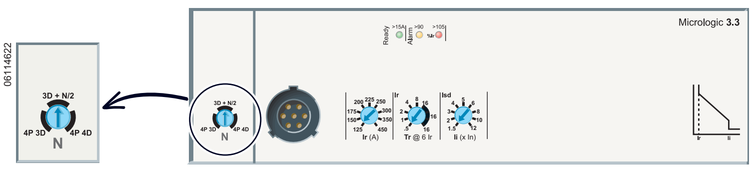
Settings are made using the adjustment rotary switches.

Overloads: Long time protection (I_r)

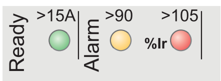
Inverse time protection against overloads with an adjustable current pick-up Ir set using a rotary switch and an adjustable time delay t_r.

Neutral protection

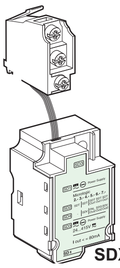
- On 3-pole L-frame circuit breakers, neutral protection is not possible.
- On four-pole L-frame circuit breakers, neutral protection may be set using a three-position switch:
  - — switch position 4P 3D: neutral unprotected
  - — switch position 4P 3D + N/2: neutral protection at half the value of the phase pick-up, (0.5 x Ir)
  - — switch position 4P 4D: neutral fully protected at I_r



Indicators



Front Indicators



SDX Module

Front indicators

- The green “Ready” LED blinks slowly when the electronic trip unit is ready to provide protection. It indicates the trip unit is operating correctly.
- Orange overload pre-alarm LED: steady on when I > 90% I_r
- Red overload LED: steady on when I > 105% I_r

Remote indicators

An overload trip signal can be remotely checked by installing an SDx relay module inside the circuit breaker. This module receives the signal from the Micrologic electronic trip unit through an optical link and makes it available on the terminal block. The signal is cleared when the circuit breaker is reclosed. See page 94.

Table 50: Micrologic™ 3 Trip Unit

Ratings	I_n at 104°F (40°C)[1]		60 A	100 A	150 A	250 A	400 A	600 A			
Circuit Breaker	H-frame		X	X	X						
	J-frame					X					
	L-frame					X	X	X			
Micrologic 3.2 / 3.3 trip units											
L Long-time protection											
Pick-Up (A) Tripping between 1.05 and 1.20 Ir	I_r		**Value depending on sensor rating (I_n) and setting on rotary switch**								
	I_n =60 A	I_r =	15	20	25	30	35	40	45	50	60
	I_n = 100 A	I_r =	35	40	45	50	60	70	80	90	100
	I_n = 150 A	I_r =	50	60	70	80	90	100	110	125	150
	I_n = 250 A	I_r =	70	80	100	125	150	175	200	225	250
	I_n = 400 A	I_r =	125	150	175	200	225	250	300	350	400
	I_n = 600 A	I_r =	200	225	250	300	350	400	450	500	600
Time Delay (s) Accuracy 0 to -20%	t_r		0.5	1	2	4	8	16			
		1.5 x I_r	15	25	50	100	200	400			
		6 x I_r	0.5	1	2	4	8	16			
		7.2 x I_r	0.35	0.7	1.4	2.8	5.5	11			
Thermal memory			20 minutes before and after tripping								
I Instantaneous											
Pick-up (A) accuracy ± 15%	I_i x	60 A	1.5	2	3	4	6	8	10	12	15
		100 A	1.5	2	3	4	6	8	10	12	15
		150 A	1.5	2	3	4	6	8	10	12	15
		250 A	1.5	2	3	4	5	6	8	10	12
		400 A	1.5	2	3	4	5	6	8	10	12
		600 A	1.5	2	3	4	5	6	8	10	11
	Non-tripping time Maximum break time		10 ms 50 ms for I > 1.5 Ii								
Micrologic 3.2S / 3.3S trip units											
L Long-time protection											
Pick-Up (A) Tripping between 1.05 and 1.20 Ir	I_r		**Value depending on sensor rating (I_n) and setting on rotary switch**								
	I_n =60 A	I_r =	15	20	25	30	35	40	45	50	60
	I_n = 100 A	I_r =	35	40	45	50	60	70	80	90	100
	I_n = 150 A	I_r =	50	60	70	80	90	100	110	125	150
	I_n = 250 A	I_r =	70	80	100	125	150	175	200	225	250
	I_n = 400 A	I_r =	125	150	175	200	225	250	300	350	400
	I_n = 600 A	I_r =	200	225	250	300	350	400	450	500	600
Time Delay (s) Accuracy 0 to -20%	t_r		non-adjustable								
		1.5 x I_r	400								
		6 x I_r	16								
		7.2 x I_r	11								
Thermal memory			20 minutes before and after tripping								
S Short-time protection											
Pick-up (A) accuracy ± 10%	I_{sd} - I_r x...		1.5	2	3	4	5	6	7	8	10
Time delay (ms)	t_{sd}		non-adjustable								
	Non-tripping time Maximum break time		20 80								
I Instantaneous											
Pick-up (A) accuracy ± 15%	I_i x I_n		1.5	2	3	4	6	8	10	12	15
	Non-tripping time Maximum break time		10 ms 50 ms for I > 1.5 Ii								

1 If the trip units are used in high-temperature environments, the Micrologic trip unit setting must take into account the thermal limitations of the circuit breaker. See the temperature derating information on page 126.

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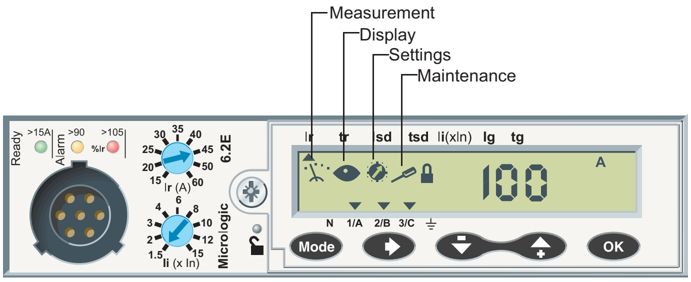
Micrologic™ 5 / 6 A or E Trip Units

Micrologic 5 / 6 A (Ammeter) or E (Energy) trip units can be used on PowerPact H-, J-, and L-frame circuit breakers with performance levels D, G, J, or L. They all have a front display module. They offer basic LSI protection (Micrologic 5 trip unit) or LSI and ground-fault protection G (Micrologic 6 trip unit). They also offer measurement, alarm and energy values.



The capabilities of Micrologic 5 / 6 A and E trip units come into full play with the front display module. When the two are connected using a simple cable with RJ45 connectors, the combination offers full Power Meter capabilities and all the measurements required to monitor the electrical installation.

	Measurements	**Operating and Maintenance Assistance**	**Communication Network**
Ammeter (Micrologic A Trip Unit)	Current measurements • Phase and neutral currents I_A, I_B, I_C, I_N • Average current of the 3 phases I_{avg} • Highest current of the three phases I_{max} • Ground-fault current Ig (Micrologic 6.2 / 6.3 A) trip units • Maximum and minimum current measured	Indicators, alarms and histories • Fault types • Alarms for high/low alarm thresholds linked to I measurements • Trip, alarm and operating histories • Time-stamped tables for settings and maximum current Maintenance indicators • Operation, trip and alarm counters • Operating hours counter • Contact wear • Load profile and thermal image	Modbus™ with add-on module
Energy (Micrologic E Trip Unit)	Current measurements • Phase and neutral currents I_A, I_B, I_C, I_N • Average current of the 3 phases I_{avg} • Highest current of the three phases I_{max} • Ground-fault current I_g (Micrologic 6.2 / 6.3 A trip units) • Maximum and minimum current measured • Current unbalance between phases Voltage measurements • Phase-to-phase (V) and phase-to-neutral (U) voltages • Average voltages V_{avg}, U_{avg} • Ph-Ph (V) and Ph-N (U) voltage unbalance Frequency measurements • Frequency (f) Power-quality indicators • Total harmonic distortion (THD) for current and voltage Power measurements • Active, reactive and apparent power, total and per phase • Power factor and cos φ Maximum and minimum • For all I, V, f, P, E measurements Demand current and power measurements • Demand values, total and per phase • Maximum demand Energy metering • Active, reactive and apparent energy, total and per phase	Indicators, alarms and histories • Fault types • Alarms for high/low thresholds linked to I, V, f, P, E measurements • Trip, alarm and operating histories • Time-stamped tables for settings and I, V, f, P, E maximum values Maintenance indicators • Operation, trip and alarm counters • Operating hours counter • Contact wear • Load profile and thermal image	Modbus with add-on module

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Power Requirements

The amount of current needed to power the trip unit is printed in the upper left hand corner of the trip unit by the Ready LED.

Table 51: Trip Unit Power Requirements

Frame		Power-Up Requirement
H-Frame, 60 A	60 A	> 15 A
	100 A	> 15 A
	150 A	> 30 A
J-Frame, 250A	250A	> 30 A
L-Frame, 600 A	400 A	> 50 A
	600 A	> 50 A

Protection

Settings can be adjusted in two ways, using the rotary switches and/or the keypad.

- The keypad can be used to make fine adjustments in 1 A steps below the maximum value defined by the setting on the rotary switch.
- Access to setting modifications using the keypad is protected by a locking function displayed on the screen and controlled by a microswitch.
- The lock is activated automatically if the keypad is not used for 5 minutes.
- Access to the microswitch is protected by a transparent, sealable cover.
- With the cover closed, it is still possible to display the various settings and measurements using the keypad.

Overloads: Long-Time Protection (I_r)

Inverse time protection against overloads with an adjustable current pick-up I_r is set using a rotary switch or the keypad for fine adjustments. The time delay t_r is set using the keypad.

Short-Circuits: Short-Time Protection (I_{sd})

Short-circuit protection with an adjustable pick-up I_{sd} and adjustable time delay t_{sd}, with the possibility of including a portion of an inverse time curve (I^2t On).

Short-Circuits: Instantaneous Protection (I_i)

Instantaneous protection with adjustable pick-up I_i.

Additional Ground Fault Protection (I_g) on Micrologic™ 6 Trip Units

Residual type ground-fault protection with an adjustable pick-up Ig and adjustable time delay tg. Possibility of including a portion of an inverse time curve (I^2t On).

Neutral Protection

- On 4-pole circuit breakers, this protection can be set using the keypad:
  - Off: neutral unprotected
  - 0.5: neutral protection at half the value of the phase pick-up (0.5 x Ir)
  - 1.0: neutral fully protected at Ir
  - OSN: Oversized neutral protection at 1.6 times the value of the phase pick-up.
    Used when there is a high level of 3rd order harmonics (or orders that are multiples of 3) that accumulate in the neutral and create a high current. In this case, the device must be limited to $I_r = 0.63 \times I_n$ for the maximum neutral protection setting of $1.6 \times I_r$.
- With 3-pole circuit breakers, the neutral can be protected by installing an external neutral sensor with the output (T1, T2) connected to the trip unit.

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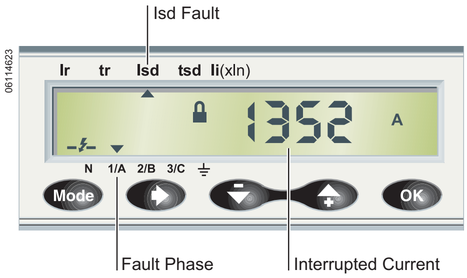
Zone Selective Interlocking (ZSI)

A ZSI terminal block may be used to interconnect a number of Micrologic™ trip units to provide zone selective interlocking for short-time (I_{sd}) and ground-fault (I_g) protection, without a time delay. For PowerPact H- and J-frame circuit breakers, the ZSI function is available only in relation to the upstream circuit breaker (ZSI out). For PowerPact L-frame circuit breakers, the ZSI function is available in relation to the upstream circuit breaker (ZSI out) and downstream circuit breakers (ZSI in).

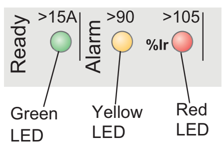
Display of Type of Fault.



Display of Interrupted Current.

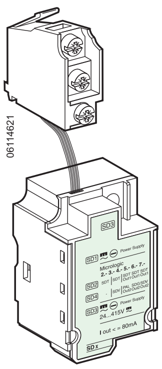
On a fault trip, the type of fault (I_r, I_{sd}, I_i, I_g), the phase concerned and the interrupted current are displayed. An external power supply is required.

Indicators



Front Indicators

- The green “Ready” LED blinks slowly when the electronic trip unit is ready to provide protection. It indicates the trip unit is operating correctly.
- Orange overload pre-alarm LED stays on when I > 90% Ir
- Red overload LED stays on when I > 105% Ir



SDx Module

Remote Indicators

An SDx relay module installed inside the circuit breaker can be used to remote the following information:

- overload trip
- overload prealarm (Micrologic 5 trip units) or ground fault trip (Micrologic 6 trip units).

This module receives the signal from the Micrologic electronic trip unit through an optical link and makes it available on the terminal block. The signal is cleared when the circuit breaker is closed. Note: all the trip units have a transparent sealable cover

These outputs can be reprogrammed to be assigned to other types of tripping or that protects access to the adjustment rotary switch. The module is described in detail in the section dealing with accessories.

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Table 52: Micrologic™ 5/6 Trip Unit

Ratings	I_n at 104°F (40°C)[1]	60 A	100 A	150 A	250 A	400 A	600 A
Circuit Breaker	H-frame	X	X	X			
	J-frame				X		
	L-frame					X	X

L Long-time protection

Pick-up (A) tripping between 1.05 and 1.20 Ir	I_r	rotary switch	Value depending on the trip unit rating (I_n) and setting on rotary switch								
	I_n = 60 A	I_r =	15	20	25	30	35	40	45	50	60
	I_n = 100 A	I_r =	35	40	45	50	60	70	80	90	100
	I_n = 150 A	I_r =	50	60	70	80	90	100	110	125	150
	I_n = 250 A	Ir =	70	80	100	125	150	175	200	225	250
	I_n = 400 A	Ir =	125	150	175	225	225	250	300	350	400
	I_n = 600 A	Ir =	200	225	250	350	300	400	450	500	600
		keypad setting	Fine adjustment in 1 A steps below maximum value set on rotary switch								
Time Delay (s) Accuracy 0 to -20%	tr =	keypad setting	0.5	1	2	4	8	16			
		1.5 x Ir	15	25	50	100	200	400			
		6 x Ir	0.5	1	2	4	8	16			
		7.2 x Ir	0.35	0.7	1.4	2.8	5.5	11			
Thermal memory			20 minutes before and after tripping								

S Short-time protection

Pick-up (A) accuracy ± 10%	I_{sd}	keypad setting	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
			Fine adjustment in 0.5 x I_r steps using the keypad																	

Time delay	t_{sd} =	Keypad setting	I^2t Off	0	0.1 s	0.2 s	0.3 s	0.4 s
			I^2t On	—	0.1 s	0.2 s	0.3 s	0.4 s
	Non-tripping time			20 ms	80 ms	140 ms	230 ms	350 ms
	Maximum break time			80 ms	140 ms	200 ms	320 ms	500 ms

I Instantaneous

Pick-up (A) accuracy ± 15%	$I_i = I_n$ x	Rotary Switch	60 A	1.5	2	.3	4	6	8	10	12	15
			100 A	1.5	2	.3	4	6	8	10	12	15
			150 A	1.5	2	.3	4	6	8	10	12	15
			250 A	1.5	2	.3	4	5	6	8	10	12
			400 A	1.5	2	.3	4	5	6	8	10	12
			600 A	1.5	2	.3	4	5	6	8	10	11
	Non-tripping time Maximum break time			10 ms 50 ms for I > li								

G Ground-fault protection - for Micrologic 6 A or E Trip Units

Pick-up (A) accuracy ± 10%	I_g	Keypad Setting																	
	I_n= 60 A	I_g =	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1		
	I_n= 100–600 A	I_g =	0.2	2.5	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1

Time delay (s)	t_g =	Keypad setting	I^2t Off	0	0.1	0.2	0.3	0.4
			I^2t On	—	0.1	0.2	0.3	0.4
	Non-tripping time			20	80	140	230	350
	Maximum break time			80	140	200	320	500
Test	I_g function			Built in				

1 If the trip units are used in high-temperature environments, the Micrologic trip unit setting must take into account the thermal limitations of the circuit breaker. See the temperature derating information on page 126.

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Table 53: Micrologic™ 3 Field-Installable Trip Units

Circuit Breaker				Trip Unit Type	Catalog No.
Frame	Standard	Poles	Rating		
H-frame	UL/CSA/NOM	3P	60 A	Micrologic 3.2	**HE3060U31X**
		3P	60 A	Micrologic 3.2S	**HE3060U33X**
		3P	100 A	Micrologic 3.2	**HE3100U31X**
		3P	100 A	Micrologic 3.2S	**HE3100U33X**
		3P	150 A	Micrologic 3.2	**HE3150U31X**
		3P	150 A	Micrologic 3.2S	**HE3150U33X**
J-Frame	UL/CSA/NOM	3P	250 A	Micrologic 3.2	**JE3250U31X**
		3P	250 A	Micrologic 3.2S	**JE3250U33X**
L-Frame	UL/CSA/NOM	3P	250 A	Micrologic 3.3	**LE3250U31X**
				Micrologic 3.3S	**LE3250U33X**
			400 A	Micrologic 3.3	**LE3400U31X**
				Micrologic 3.3S	**LE3400U33X**
			600 A	Micrologic 3.3	**LE3600U31X**
				Micrologic 3.3S	**LE3600U33X**
		4P	250 A	Micrologic 3.3	**LE4250U31X**
				Micrologic 3.3S	**LE4250U33X**
			400 A	Micrologic 3.3	**LE4400U31X**
				Micrologic 3.3S	**LE4400U33X**
			600 A	Micrologic 3.3	**LE4600U31X**
				Micrologic 3.3S	**LE4600U33X**

Table 54: Micrologic™ 5 and 6 Field-Installable Trip Units

Circuit Breaker				Trip Unit Type	Catalog No.
Frame	Standard	Poles	Rating		
H-frame	UL/CSA/NOM	3P	60 A	Micrologic 5.2 A	**HE3060U43X**
				Micrologic 6.2 A	**HE3060U44X**
				Micrologic 5.2 E	**HE3060U53X**
				Micrologic 6.2 E	**HE3060U54X**
			100 A	Micrologic 5.2 A	**HE3060U43X**
				Micrologic 6.2 A	**HE3100U44X**
				Micrologic 5.2 E	**HE3100U53X**
				Micrologic 6.2 E	**HE3100U54X**
			150 A	Micrologic 5.2 A	**HE3150U43X**
				Micrologic 6.2 A	**HE3150U44X**
				Micrologic 5.2 E	**HE3150U53X**
				Micrologic 6.2 E	**HE3150U54X**
J-Frame	UL/CSA/NOM	3P	250 A	Micrologic 5.2 A	**JE3250U43X**
				Micrologic 6.2 A	**JE3250U44X**
				Micrologic 5.2 E	**JE3250U53X**
				Micrologic 6.2 E	**JE3250U54X**
L-Frame	UL/CSA/NOM	3P	400 A	Micrologic 5.3 A	**LE3400U43X**
				Micrologic 6.3 A	**LE3400U44X**
				Micrologic 5.3 E	**LE3400U53X**
				Micrologic 6.3 E	**LE3400U54X**
			600 A	Micrologic 5.3 A	**LE3600U43X**
				Micrologic 6.3 A	**LE3600U44X**
				Micrologic 5.3 E	**LE3600U53X**
				Micrologic 6.3 E	**LE3600U54X**
	UL/CSA/NOM	4P	400 A	Micrologic 5.3 A	**LE4400U43X**
				Micrologic 6.3 A	**LE4400U44X**
				Micrologic 5.3 E	**LE4400U53X**
				Micrologic 6.3 E	**LE4400U54X**
			600 A	Micrologic 5.3 A	**LE4600U43X**
				Micrologic 6.3 A	**LE4600U44X**
				Micrologic 5.3 E	**LE4600U53X**
				Micrologic 6.3 E	**LE4600U54X**

Table 55: Micrologic Spare Parts

Description	Frame	Trip Unit	Catalog No.
LCD Display	H/J/L	Micrologic 5	**S429483**
		Micrologic 6	**S429484**
Trip Unit Cover-Transparent	H/J	Micrologic 3	**S429481**
	L		**S432461**
	H/J	Micrologic 5/6	**S429478**
	L		**S432459**
Trip Unit Wire Seal	H	Micrologic 3/5/6	**MICROTUSEAL**

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Power Meter Functions

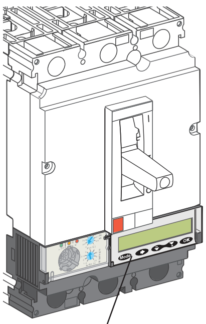
In addition to protection functions, Micrologic™ 5 / 6 trip units offer all the functions of Power Meter products as well as operating-assistance for the circuit breaker.

- display of settings
- measurement functions:
  - Ammeter (A)
  - Energy (E)
- alarms
- time-stamped histories and event tables
- maintenance indicator
- communication network.

Micrologic A and E trip unit measurement functions are made possible by the trip unit intelligence and the accuracy of the sensors. They are handled by a microprocessor that operates independent of protection functions.

Display

Micrologic Trip Unit LCD


Trip Unit LCD

The user can display all the protection settings and the main measurements on the LCD screen of the trip unit.

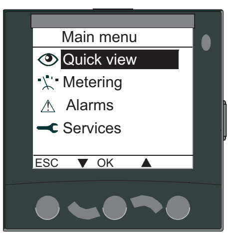
- Micrologic A trip unit: instantaneous rms current measurements
- Micrologic E trip unit: voltage, frequency and power measurements and energy metering, in addition to the measurements offered by Micrologic A

To make the display available under all conditions and increase operating comfort, an external power supply is recommended for Micrologic A trip unit. It is indispensable to:

- display faults and interrupted current measurements
- use all the functions of Micrologic E trip unit (such as metering of low power and energy values)
- ensure operation of the communication network.

The external power supply can be shared by several devices. For description, see page 79.

Front Display Module (FDM121)



FDM121 Display

An FDM121 can be connected to a Micrologic trip unit using a prefabricated cable to display all measurements on a screen. The result is a veritable 96 x 96 mm Power Meter.

In addition to the information displayed on the Micrologic trip unit LCD, the FDM121 screen shows demand, power quality and maximum/minimum values along with alarms, histories and maintenance indicators.

The FDM121 requires a 24 Vdc power supply. The Micrologic trip unit is supplied by the same power supply through the cable connecting it to the FDM.

PC Screen

When the Micrologic trip unit, with or without a front display module, is connected to a communication network, all information can be accessed using a PC with the appropriate software installed.

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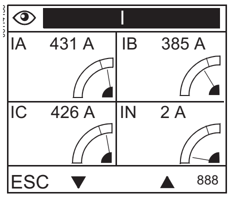
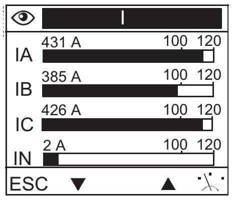
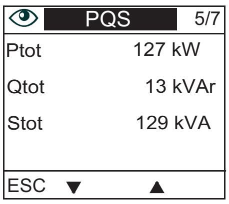
Measurements



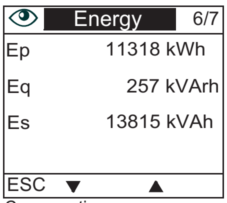
Current



Voltage



Power



Consumption

Instantaneous RMS Measurements

The Micrologic™ A and E trip units continuously display the RMS value of the highest current of the three phases and neutral (Imax). The navigation buttons can be used to scroll through the main measurements.

In the event of a fault trip, the current interrupted is memorized.

The Micrologic A trip unit measures phase, neutral, ground fault currents. The Micrologic E trip unit offers voltage, frequency and power measurements in addition to the measurements provided by Micrologic A trip unit.

Maximum / Minimum Values

Every instantaneous measurement provided by Micrologic A or E trip unit can be associated with a maximum/minimum. The maximum for the highest current of the three phases and neutral, the demand current and power can be reset using the trip unit keypad, the front display module or the communication network.

Energy Metering

The Micrologic E trip units also measures the energy consumed since the last reset of the meter. The active energy meter can be reset using the keypad and the front display module or the communication network.

Demand and Maximum Demand Values

Micrologic E trip units also calculates demand current and power values. These calculations can be made using a block or sliding interval that can be set from 5 to 60 minutes in steps of 1 minute. The window can be synchronized with a signal sent through the communication network. Whatever the calculation method, the calculated values can be recovered on a PC using the Modbus communication network.

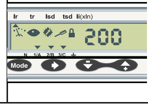
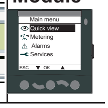
Ordinary spreadsheet software can be used to provide trend curves and forecasts based on this data. They will provide a basis for load shedding and reconnection operations used to adjust consumption to the subscribed power.

Power Quality

Micrologic E trip units calculate power quality indicators taking into account the presence of up to the 15th order, including the total harmonic distortion (THD) of unit. current and voltage.

NOTE: The front display module will display voltage and current phases as A/B/C instead of 1/2/3.

Table 56: Micrologic™ 5/6 Trip Units Integrated Power Meter Functions

			Type		Display	
			A	E	Trip Unit LCD 	Front Display Module 
Display of Protection Settings						
Pick-ups (A) and delays	All settings can be displayed	I_r, t_r, I_{sd}, t_{sd}, I_i, I_g, t_g	X	X	X	
Measurements						
Instantaneous rms measurements						
Currents (A)	Phase and neutral	I_A, I_B, I_C, I_N	X	X	X	X
	Average of phases	$Iavg = (I_A + I_B + I_C) / 3$	X	X	—	X
	Highest current of the 3 phases and neutral	Imax of I_A, I_B, I_C, I_N	X	X	X	X
	Ground fault (Micrologic 6 trip unit)	% Ig (pick-up setting)	X	X	X	X
	Current unbalance between phases	% Iavg	—	X	—	X
Voltage (V)	Phase-to-phase	V_{AB}, V_{BC}, V_{CA}	—	X	X	X
	Phase-to-neutral	U_{AN}, U_BN, U_{CN}	—	X	X	X
	Average of phase-to-phase voltages	$Vavg = (V_{AB} + V_{AC} + V_{BC}) / 3$	—	X	—	X
	Average of phase-to-neutral voltages	$Uavg = (U_{AN} + U_{BN} + U_{CN}) / 3$	—	X	—	X
	Ph-Ph and Ph-N voltage unbalance	% Vavg and% Uavg	—	X	—	X
	Phase sequence	1-2-3, 1-3-2	—	X	X	X
Frequency (Hz)	Power System	f	—	X	X	X
Power	Active (kW)	P, total/per phase	—	X	X	X
	Reactive (kVAR)	Q, total/per phase	—	X	X	X
	Apparent (kVA)	S, total/per phase	—	X	X	X
	Power factor and cos φ (fundamental)	PF and cos φ, total and per phase	—	X	—	X
Maximum, minimum (MAX/MIN)						
	Associated with instantaneous rms measurements	Reset with Micrologic trip unit or front display module	X	X	—	X
Energy metering						
Energy	Active (kWh), reactive (kVAR), apparent (kVA)	Total since last reset Absolute or signed mode[1]	—	X	X	X
Demand and maximum demand values						
Demand current (A)	Phases and neutral	Present value on the selected window	—	X	—	X
		Maximum demand since last reset	—	X	—	X
Demand power	Active (kWh), reactive (kVAR), apparent (kVA)	Present value on the selected window	—	X	—	X
		Maximum demand since last reset	—	X	—	X
Calculation window		Adjustable from 5 to 60 minutes in 1 minute steps	—	X	—	[2]
Power quality						
Total harmonic distortion THD (%)	Of voltage with respect to rms value	THDU, THDV of the Ph-Ph and Ph-N voltage	—	X	—	X
	Of current with respect to rms value	THDI of the phase current	—	X	—	X

1 Absolute mode: E absolute = E out + E in; Signed mode: E signed = E out - E in.

2 Available through the communication network only.

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Additional technical characteristics

Measurement accuracy of the entire measurement system, including the sensors:

- Current: +/- 1%
- Voltage: +/- 0.5%
- Power and energy: +/- 2%
- Frequency: +/- 0.1%.

Operating-Assistance Functions Characteristics

Micrologic™ Trip Unit Alarms with Time-Stamping

Alarm Types

The user can assign an alarm to all Micrologic A or E trip unit measurements or events:

- up to 12 alarms can be used together:
  - — two alarms are predefined and activated automatically:
    Micrologic 5 trip unit: overload (Ir)
    Micrologic 6 trip unit: overload (Ir) and ground fault (Ig)
  - — thresholds, priorities and time delays can be set for ten other alarms.
- the same measurement can be used for different alarms to precisely monitor certain values, e.g. the frequency or the voltage
- alarms can also be assigned to various states: phase lead/lag, four quadrants,
- phase sequence selection of display priorities, with screen displaying a window showing high priority alarm
- alarm time-stamping.

Alarm Settings

Alarms cannot be set using the keypad or the front display module. They are set through the communication network with the PC. Set-up includes the threshold, priority, activation delay before display and deactivation delay. It is also possible to reprogram the standard assignment for the two SDx relay outputs to user-selected alarms.

Alarm Reading

Remote alarm indicators

- reading on the front display module or on a PC through the communication network
- system remote indicators using SDx relay with two output contacts for alarms.
- Micrologic trip unit built-in LCD display.

Histories and Event Tables

Micrologic A and E trip unit have histories and event tables that are always active.

Three types of time-stamped histories

- Tripping due to overruns of I_r, I_{sd}, I_i, I_g: last 17 trips
- Alarms: last 10 alarms
- Operating events: last 10 events

Each history record is stored with:

- indicators in clear text in a number of user-selectable languages
- time-stamping: date and time of event
- status: pick-up / drop-out

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Two types of time-stamped event tables

- Protection settings
- Minimums / maximums

Display of alarms and tables

The time-stamped history and event tables may be displayed on a PC through the communication network.

Embedded memory

Micrologic™ A and E trip units have a non-volatile memory that saves all data on alarms, histories, event tables, counters and maintenance indicators even if power is lost.

Maintenance Indicators

Micrologic A and E trip units have indicators for, among others, the number of operating cycles, contact wear and operating times (operating hours counter) of the PowerPact H-, J-, and L-frame circuit breakers.

It is possible to assign an alarm to the operating cycle counter to plan maintenance. The various indicators can be used together with the trip histories to analyze the level of stresses the device has been subjected to. The information provided by the indicators cannot be displayed on the Micrologic trip unit LCD. It is displayed on the PC through the communication network.

Management of Installed Devices

Each circuit breaker equipped with a Micrologic 5 or 6 trip unit can be identified using the communication network:

- serial number
- firmware version
- hardware version
- device name assigned by the user.

This information together with that previously described provides a clear view of the state of the installed devices.

NOTE: Please refer to page 73 for more details on display formats.

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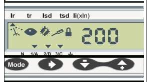
Table 57: Micrologic™ 5/6 Trip Units Operating Assistance Functions

			Type A	Type E	Display: Trip Unit LCD 	Display: Front Display Module 
Operating Assistance						
Personalized Alarms						
Settings	Up to 10 alarms assigned to all A and E measurements		X	X	—	[1]
	Phase lead/lag, four quadrants, phase sequence, display priority selection		—	X	—	[1]
Display	Alarms and tripping		X	X	—	[1]
Remote Indicators	Activation of two dedicated contacts on SDx module		X	X	—	[1]
Time-Stamped Histories						
Trips (last 17)	Cause of tripping (time-stamping with ms)	Ir, Isd, Ii (Micrologic 5, 6 Trip Unit)	X	X	—	[1]
		Ig (Micrologic 6 Trip Unit)	X	X	—	[1]
Alarms (last 10)			X	X	—	[1]
Operating events (last 10)	Event types	Modification of protection setting by rotary switch	—	X	—	[1]
		Opening of keypad lock	—	X	—	[1]
		Test using keypad	—	X	—	[1]
		Test using external tool	—	X	—	[1]
		Time setting (date and time)	—	X	—	[1]
		Reset for maximum, minimum and energy meter	X	X	X	X
Time Stamping	Presentation	Date and time, text, status	X	X	—	[1]
Time-Stamped Event Tables						
Protection settings	Setting modified (value displayed)	I_r t_r I_{sd} t_{sd} I_i I_g t_g	X	X	—	[1]
	Time-stamping	Date and time of modification	X	X	—	[1]
	Previous value	Value before modification	X	X	—	[1]
Min/Max	Values monitored	I_A I_B I_C I_N / I_A I_B I_C I_N Ii	X	X	—	[1]
	Time-stamping Previous value	Date and time of min/max record Min/max value	X	X	—	[1]
Maintenance Indicators						
Counter	Mechanical cycles[2] Electrical cycles[2] Trips Alarms Hours	Assignable to an alarm Assignable to an alarm One per type of trip One for each type of alarm Total operating time (hours)	X	X	—	[1]
Indicator	Contact wear	%	X X	X X	—	[1]
Load profile	Hours at different load levels	% of hours in four current ranges: 0–49% I_n, 50–79% I_n, 80–89% I_n and ≥ 90% I_n	X X	X X	—	[1]

1 Available through the communication network only.
2 The BSCM (page 78) is required for these functions.

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Additional technical characteristics:

- Contact wear
  Each time PowerPact H-, J-, and L-frame circuit breakers open, the Micrologic™ 5 / 6 trip unit measures the interrupted current and increments the contact-wear indicator as a function of the interrupted current, according to test results stored in memory. Breaking under normal load conditions results in a very slight increment. The indicator value may be read on the front display module. It provides an estimation of contact wear calculated on the basis of the cumulative forces affecting the circuit breaker. When the indicator reaches 80%, it is advised to replace the circuit breaker to ensure the availability of the protected equipment.
- Circuit breaker load profile
  Micrologic 5 / 6 trip units calculate the load profile of the circuit breaker protecting a load circuit. The profile indicates the percentage of the total operating time at four current levels (% of I_n):
  - — 0 to 49% I_n
  - — 50 to 79% I_n
  - — 80 to 89% I_n
  - — ≥ 90% I_n.
  - — This information can be used to optimize use of the protected devices or to plan ahead for expansion.

Motor Circuit Protectors (AC Only)

See Section 5 for information about PowerPact H-, J- and L-frame electronic motor circuit protectors (MCP) with trip units:

- Micrologic 1.3 M
- Micrologic 2 M

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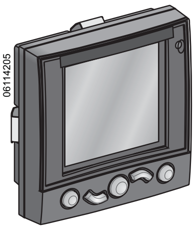
Section 7—Accessories for Micrologic™ Trip Units

Display Options

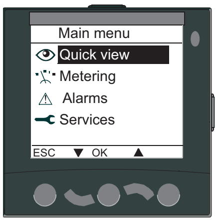
Front Display Module Functions (FDM121) (Micrologic 5 / 6 A or E Trip Units Only)



The front display module (FDM121) can be integrated in the PowerPact H-, J-, and L-frame circuit breaker system. It uses the sensors and processing capacity of the Micrologic trip unit to display measurements, demand, power quality and maximum/minimum values along with alarms, histories, and maintenance indicators.

It is easy to use and requires no special software or settings and is immediately operational when connected to the PowerPact H-, J-, and L-frame circuit breakers by a simple cable.

The FDM121 is a large display, but requires very little depth. The anti-glare graphic display screen is backlit for easy reading even under poor ambient lighting and at sharp angles.



FDM121 Display

Surface Mount Accessory

Table 58: Characteristics

Screen	Size	96 x 96 x 30 mm
	Installation	Requires 10 mm behind the door (or 20 mm when the 24 Vdc power supply connector is used).
	Backlighting	White
	Viewing Angle	Vertical ±60°, horizontal ±30°
	Resolution	High: excellent reading of graphic symbols.
Alarm LED	Flashing orange	Alarm pick-up
	Steady orange after operator reset	Alarm condition persists.
Operating temperature	14°F to 131°F (-10 °C to +55 °C).	
Certifications	UL, CSA, CE	
24 Vdc power supply	Tolerances 24 V -20% +10% (19.2 V to 26.4 V)	When the FDM121 is connected to the communication network, the 24 Vdc is supplied by the communication network wiring.
Power Requirements	40 mA, 24 Vdc	
Mounting	Standard door cut-out 92 x 92 mm. Attached using clips.	To avoid a cut-out in the door, a surface-mount accessory is available for surface mounting by drilling two 22 mm diameter holes.
Degree of protection	NEMA12 / IP54 in front.	NEMA12 / IP54 is maintained after mounting by using the supplied gasket during installation.

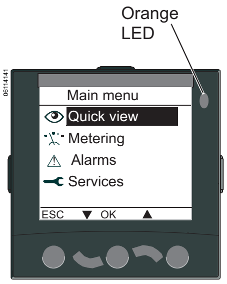
Mounting

The FDM121 is easily installed in equipment.

- Standard door cut-out 3.62 x 3.62 in. (92 x 92 mm).
- Attached using clips.

To avoid a cut-out in the door, an accessory is available for surface mounting by drilling only two 0.87 in. (22 mm) diameter holes.

The FDM121 degree of protection is NEMA12 / IP54 in front. NEMA12 / IP54 is maintained after mounting by using the supplied gasket during installation.



Display of Micrologic Trip Unit Measurements and Alarms

The FDM121 is intended to display Micrologic 5 / 6 trip unit measurements, alarms and operating information. It cannot be used to modify the protection settings. Measurements may be easily accessed through a menu.

All user-defined alarms are automatically displayed. The display mode depends on the priority level selected during alarm set-up:

- high priority: a pop-up window displays the time-stamped description of the alarm and the orange LED flashes
- medium priority: the orange Alarm LED goes steady on l
- low priority: no display on the screen.

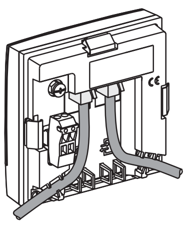
All faults resulting in a trip automatically produce a high-priority alarm, without any special settings required. In all cases, the alarm history is updated.

If power to the FDM121 fails, all information is stored in the Micrologic trip unit non-volatile memory. The data can be consulted using the communication network when power is restored.

Status Indications and Remote Control

When the circuit breaker is equipped with the BSCM module (page 78), the FDM121 display can also be used to view circuit breaker status conditions:

- Auxiliary switch (OF): ON/OFF
- Alarm switch (SD): trip indication
- Overcurrent trip switch (SDE): fault-trip indication (overload, short-circuit, ground fault)



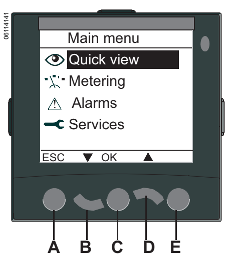
Electrical Connection

The FDM121 is equipped with:

- a 24 Vdc terminal block:
  - — plug-in type with 2 wire inputs per point for easy daisy-chaining
  - — power supply range of 24 V -20% (19.2 V) to 24 V +10% (26.4 V)
- two RJ45 jacks.

The Micrologic trip unit connects to the internal communication network terminal block on the PowerPact H-, J-, and L-frame circuit breakers using the pre-wired NSX cord. Connection to one of the RJ45 connectors on the FDM121 automatically establishes communication between the Micrologic trip unit and the FDM121 and supplies power to the Micrologic trip unit measurement functions.

When the second connector is not used, it must be fitted with a line terminator TRV00880.



Navigation

Five buttons are used for intuitive and fast navigation.

The “Context” button may be used to select the type of display (digital [text], bargraph, analog).

The user can select the display language (Chinese, English, French, German, Italian, Portuguese, Spanish, etc.) Other languages can be downloaded.

Screens

Main menu

When powered up, the FDM121 screen automatically displays the ON/OFF status of the device.

When not in use, the screen is not backlit. Backlighting can be activated by pressing one of the buttons. It goes off after 3 minutes.

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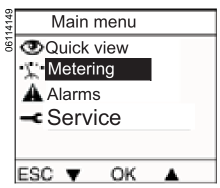
Quick view	Provides access to five screens that display a summary of essential operating information (I, U, f, P, E, THD, circuit breaker On / Off).
Metering	Used to display the measurement data (I, U-V, f, P, Q, S, E, THD, PF) with the corresponding min/max values.
Alarms	Displays active alarms and the alarm history
Services	Provides access to the operation counters, energy and maximum reset function, maintenance indicators, identification of modules connected to the internal bus and FDM121 internal settings (language, contrast, etc.)

Fast access to essential information:

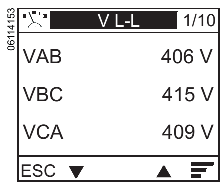
- "Quick view" provides access to five screens that display a summary of essential operating information (I, V, f, P, E, THD, circuit breaker On / Off).

Access to detailed information

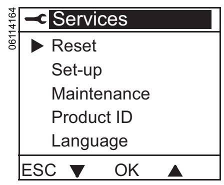
- "Metering" can be used to display the measurement data (I, U-V, f, P, Q, S, E, THD, PF) with the corresponding min/max values.
- Alarms displays active alarms and the alarm history
- Services provides access to the operation counters, energy and maximum reset function, maintenance indicators, identification of modules connected to the internal bus and FDM121 internal settings (language, contrast, etc.)



Quick View



Metering Sub-Menu



Services

Catalog Numbers

Table 59: Front Display Module Catalog Numbers

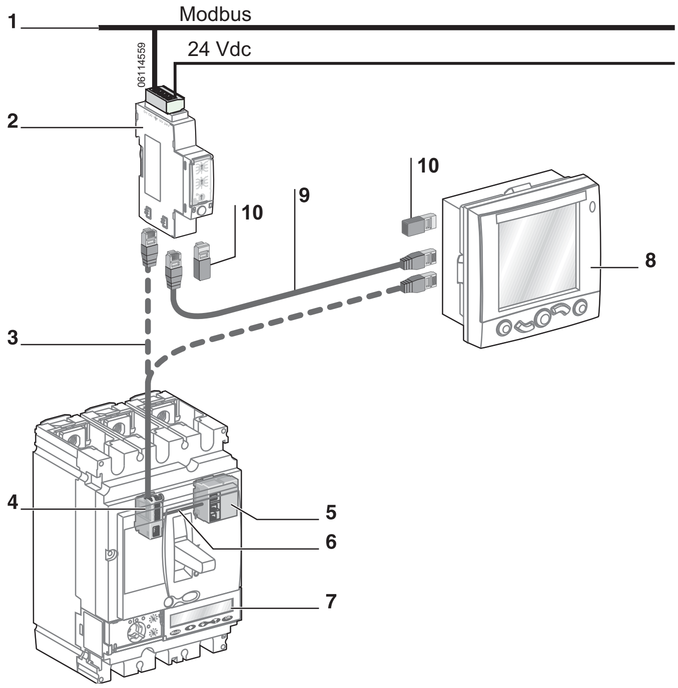
Description	Catalog No.
FDM121	**STRV00121**
FDM121 Mounting Accessory	**TRV00128**

Circuit Breaker Communication Network Options

All PowerPact H-, J-, and L-frame circuit breakers devices can be equipped with the communication function using a pre-wired connection system and a Modbus™ communication interface module. The interface module can be connected directly or through the front display module (FDM121).

The PowerPact H-, J-, and L-frame circuit breakers can be integrated in a Modbus communication network. Four functional levels can be used separately or combined to adapt to all supervision requirements.

Level	Function
Communication of status indications	Compatible with PowerPact H-, J- and L-frame circuit breakers and automatic switches. Use the BSCM module to access the following information: • ON/OFF position • trip indication • fault-trip indication
Communication of commands	Available on all circuit breakers and automatic switches with communicating motor operators, the remote control can be used to: • open • closed • reset
Communication of measurements with Micrologic 5 / 6 A or E trip unit	This level provides access to: • instantaneous and demand values • maximums/minimums • energy metering • demand current and power • power quality
Communication of operating assistance with Micrologic 5 / 6 A or E trip unit	This level also provides access to: • protection and alarm settings • time-stamped histories and event tables • maintenance indicators



PowerPact H-, J-, or L-frame circuit breaker is connected to the Modbus communication interface module (IFM) or front display module (FDM121) through the internal terminal block for the NSX cord.

The front display module is connected to the Modbus communication interface module by a communication cable with RJ45 connectors on both ends.

1. Modbus network
2. Modbus communication interface module
3. NSX cord
4. Internal terminal block for communication using the NSX cord
5. BSCM module
6. Prefabricated wiring
7. Micrologic trip unit
8. FDM121 display
9. RJ45 cable
10. Line terminator (for unused connectors, if applicable)

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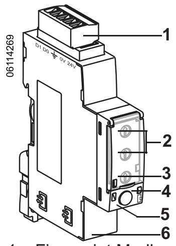
Modbus Communication Interface Module (IFM)



1. Five-point Modbus and 24 Vdc connector
2. Two Modbus address rotary switches (1 to 99)
3. Modbus traffic LED
4. Lock-out to disable writing to the trip unit
5. Test LED
6. Test button
7. Two connectors for RJ45 cable

Functions

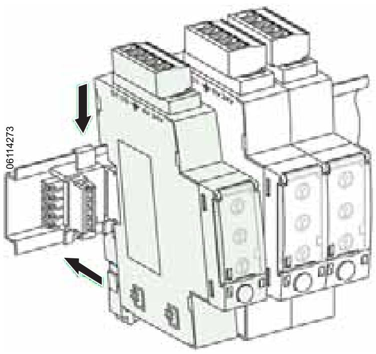
This module, required for connection to the network, contains the Modbus address (1 to 99) declared by the user using the two rotary switches in front. It automatically adapts (baud rate, parity) to the Modbus network in which it is installed.

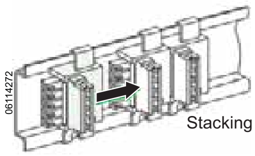
It is equipped with a lock-out switch to enable or disable operations involving writing to Micrologic trip unit, (such as reset, counter reset, setting modifications, device opening and closing commands).

There is a built-in test function to check the connections of the Modbus communication interface module with the Micrologic trip unit and front display module.

Mounting

The module is mounted on a DIN rail. A number of modules may be clipped one next to the other. For this, a stacking accessory (shown below) is available for fast clip-connection of both the Modbus link and the 24 Vdc supply.





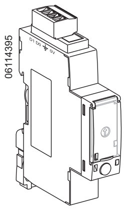
The Modbus communication interface module supplies 24 Vdc to the corresponding Micrologic trip unit, front display module, and BSCM module. Module power requirements is 60 mA / 24 Vdc.

Catalog Numbers

Table 60: IFM Catalog Numbers

Description	Catalog No.
Modbus Communication Interface Module (IFM)	**STRV00210**
Stacking Connectors for IFM (10)	**TRV00217**

Isolated Modus Repeater Module



Since Modbus interface modules (part number STRV00210) are not isolated, an isolated Modbus Repeater Module needs to be inserted between the Modbus network inside the equipment and the Modbus network outside the equipment.

Table 61: Catalog Number

Description	Catalog No.
Isolated Modbus Repeater Module	**STRV00211**

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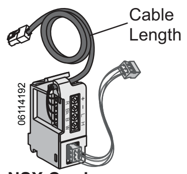
NSX Cord



NSX Cord,
V ≤ 480 V

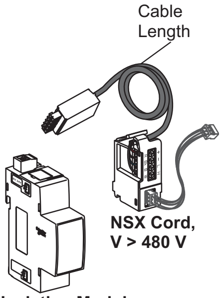
Micrologic trip units are connected to the Modbus communication interface module (IFM) or front display module through the internal terminal block for the NSX cord equipped with an RJ45 connector.

The NSX cord is available in two cable lengths:

- 4.27 ft (1.3 m)
- 9.84 ft (3 m)

Lengths up to 32.8 ft (10 m) are possible using extensions.

- For voltage V ≤ 480 V, available in 3 prefabricated lengths: 0.35 m, 1.3 m and 3 m.
- For voltages V > 480 V, a special 1.3 m cable with an insulation accessory is required.
- A set of cables with RJ45 connectors is available to adapt to different distances between devices.

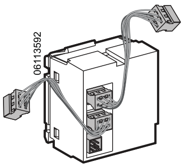


Isolation Module
for NSX Cord
with V > 480 V

Table 62: NSX Cord Catalog Numbers

Description	Catalog No.
NSX Cord 4.27 ft (1.3 m), V ≤ 480 V	**S434201**
NSX Cord 9.84 ft (3 m), V ≤ 480 V	**S434202**
NSX Cord 4.27 ft (1.3 m), V > 480 V	**S434204**
NSX Cord 9.84 ft (3 m), V > 480 V	**S434303**

Breaker Status and Control Module (BSCM)



Functions

The optional BSCM Breaker Status & Control Module is used to acquire device status indications and control the communicating remote-control function. It includes a memory used to manage the maintenance indicators.

Status indications

Indication of device status:
Auxiliary switch (OF), alarm switch (SD), and overcurrent trip switch (SDE).

Maintenance indicators

The BSCM manages the following indicators:

- mechanical operation counter
- electrical operation counter
- history of status indications.

It is possible to assign an alarm to the operation counters.

Controls

The BSCM can be used to carry out communicating remote control operations using the communicating motor operator (open, close and reset) in different modes (manual, auto).

Mounting

The BSCM can be installed on all PowerPact H-, J-, and L-frame circuit breakers and automatic switches with Micrologic trip units. It simply clips into the auxiliary contact slots. It occupies the slots of one auxiliary switch (OF) and one overcurrent trip switch (SDE). The BSCM is supplied with 24 Vdc power automatically through the NSX cord when the communication network is installed.

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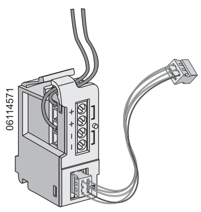
Catalog Numbers

Table 63: BSCM Catalog Numbers

Description	Catalog No.
Replacement BSCM	**S434205**
BSCM with NSX Cord 1.3 m, V ≤ 480 V	**S434201BS**
BSCM with NSX Cord 3 m, V ≤ 480 V	**S434202BS**
BSCM with NSX Cord 1.3 m, V > 480 V	**S434204BS**
BSCM with NSX Cord 3 m, V > 480 V	**S434303BS**

24 Vdc Power-Supply Terminal Block



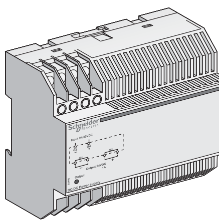
24 Vdc Terminal Block

The Micrologic 5/6 trip unit display is operational when current is flowing through the circuit breaker. To power the Micrologic 5/6 trip unit when the trip unit is not connected to an FDM121 or to the communication network, a 24 Vdc power-supply terminal block can be installed only on Micrologic 5/6 trip units. When used, it excludes connection of an NSX cord.

Table 64: 24 Vdc Catalog Number

Description	Catalog No.
24 Vdc Terminal Block Unit Mount	**S434210**

External 24 Vdc Power-Supply Module



External 24 Vdc
Power-Supply Module

An external 24 Vdc power supply is required for installation in a communication network, whatever the type of trip unit.

On installations without a communication network, the power supply is available as an option for Micrologic 5/6 trip units in order to:

- modify settings when the circuit breaker is open
- display measurements when the current flowing through the circuit breaker is low (15 to 50 A depending on the rating)
- maintain the display of the cause of tripping and interrupted current.

A single external 24 Vdc supply may be used for the entire network, depending on the number of devices in the communication network. The required characteristics are:

- output voltage: 24 Vdc ± 5%
- ripple: ± 1%

Table 65: Available External Power-Supply Modules (1 A)

Available External Power-Supply Modules		Input Voltage	Output Power	Cat. No.
Power supply	Vdc (±5%)	24–30	5 VA/5W	**685823**
		48–60		**685824**
		100–125		**685825**
	Vac (+10%, -15%)	110–130		**685826**
		200–240		**685827**
		380–415		**685829**

To determine the required output current of the 24 Vdc power supply, it is necessary to sum up the currents consumed by the different loads supplied:

Table 66: Power Requirements

Module	Typical Consumption 24 Vdc @ 68°F (20°C)	Maximum Consumption 19.2 Vdc @ 140°F (60°C)
Micrologic 5/6 trip units	30 mA	55 mA
BSCM	9 mA	15 mA
FDM121	21 mA	30 mA
IFM	21 mA	30 mA
Isolated Modbus Repeater Module	15 mA	19 mA

For installation recommendations, see page page 133

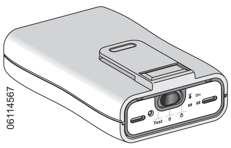
Battery Module

Battery Module

The battery module is a back-up supply for the external power-supply module. The input/output voltages are 24 Vdc and it can supply power for approximately three hours (100 mA).

Table 67: Battery Module

Description	Catalog No.
Battery Module	**685831**



Pocket Tester

Pocket Tester

The pocket tester connects to the Micrologic trip unit test connector. It powers up the Micrologic trip unit and the Ready LED. It supplies the screen, allows settings to be made using the keypad, and provides thermal imaging inhibit functions.

Table 68: Pocket Tester

Description	Catalog No.
Pocket Tester	**S434206**

The pocket tester runs off of two Alkaline AA batteries.

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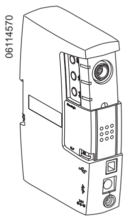
UST Test Adapter (UTA) Tester for Test and Maintenance



UTA Tester Module

The UTA Tester includes:

- configuration and maintenance module
- power supply (110–220 Vac / 50-60 Hz 24 Vdc - 1 A)
- special Micrologic cable for connection to the trip-unit test connector
- standard USB cable
- standard RJ45 cable
- user manual

Table 69: UTA Tester Catalog Numbers

Description	Catalog No.
UTA Tester (complete)	**STRV00910**
Spare 110-240 V power supply	**TRV00915**
Spare Micrologic cable	**TRV00917**
Spare UTA Tester Module	**STRV00911**
Bluetooth/Modbus Option for UTA Tester	**SVW3A8114**

Included in the UTA Tester, the UTA Tester module tests Micrologic trip unit operation and provides access to all parameters and settings. It connects to the Micrologic trip unit test connector and can operate in two modes.

- Stand-alone mode to:
  - — supply the Micrologic trip unit with power and check operation using the Ready LED
  - — Provides ground-fault inhibit and thermal memory inhibit
- PC mode, connected to a PC with a USB or Bluetooth link. This mode provides access to protection settings, alarm settings and readings of all indicators. Using the associated RSU software utility, it is possible to store, in a dedicated file for each device, all the data that can transferred to another device.
  This mode also offers operating-test functions:
  - — check on trip time delay (trip curve)
  - — check on non-tripping time (coordination)
  - — check on ZSI (Zone Selective Interlocking) function
  - — alarm simulation
  - — display of setting curves
  - — display of currents
  - — printing of test reports
  - — optional Bluetooth link (to PC).

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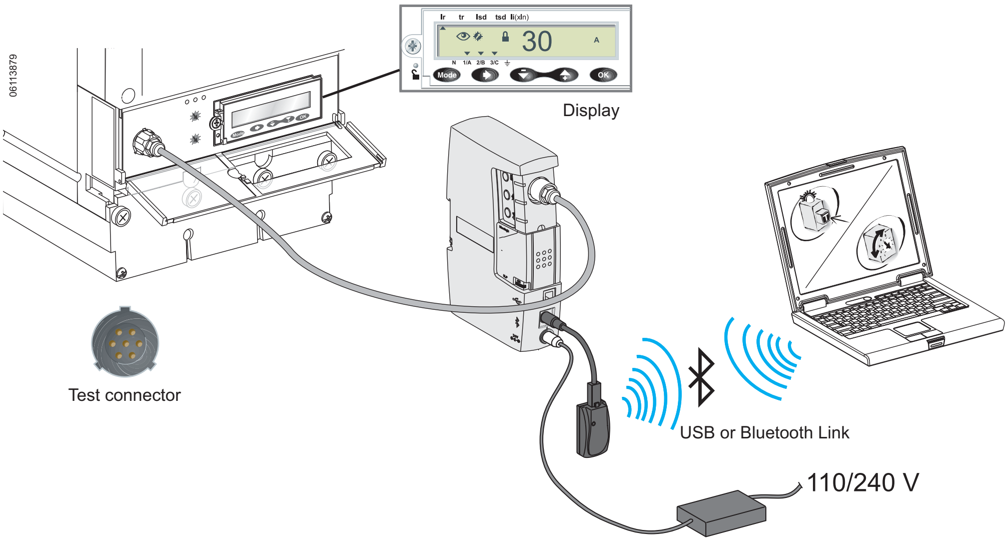
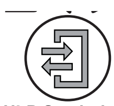


Universal Logic Plug System


ULP Symbol

The Universal Logic Plug (ULP) system allows the PowerPact H-, J- and L-frame circuit breakers to become metering and supervision tools to assist for energy efficiency. For easy connection of the different modules, the prefabricated cables are identified by a ULP symbol. The connection points on compatible modules are marked in the same manner.

Table 70: ULP Accessories Catalog Numbers

Description	Qty	Catalog No.
RJ45 connectors, female/female	10	**TRV00870**
ULP Line termination	10	**TRV00880**
RJ45/RJ45 male cord L= 0.3 m	10	**TRV00803**
RJ45/RJ45 male cord L= 0.6 m	10	**TRV00806**
RJ45/RJ45 male cord L = 1 m	5	**TRV00810**
RJ45/RJ45 male cord L = 2 m	5	**TRV00820**
RJ45/RJ45 male cord L = 3 m	5	**TRV00830**
RJ45/RJ45 male cord L = 5 m	1	**TRV00850**
Modbus Line Terminations	2	**VW3A8306DRC**

For more information about the ULP System, see page 132 or bulletin 48940-329-01, *ULP (Universal Logic Plug) Connection System—User Guide.*

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Circuit Breaker Communication Networks and Software

Modbus™ Communication Network

Modbus is the most widely used communication protocol in industrial networks. It operates in master-slave mode. The devices (slaves) communicate one after the other with a gateway (master).

Masterpact™ and PowerPact™ circuit breakers with Micrologic™ trip units, PowerLogic™ and Sepam™ products all operate with this protocol. A Modbus network is generally implemented on an LV or MV system. Micrologic trip units use the Modbus communication protocol, compatible with ION-Enterprise PowerLogic supervision systems.

Depending on the data monitored and the desired refresh rate, a Modbus network connected to a gateway can serve 4 to 16 devices. For larger installations, a number of Modbus networks can be connected to an Ethernet® network (TCP/IP/Modbus protocol) through their gateways.

The downloadable RSUsoftware application facilitates implementation of communication network functions.

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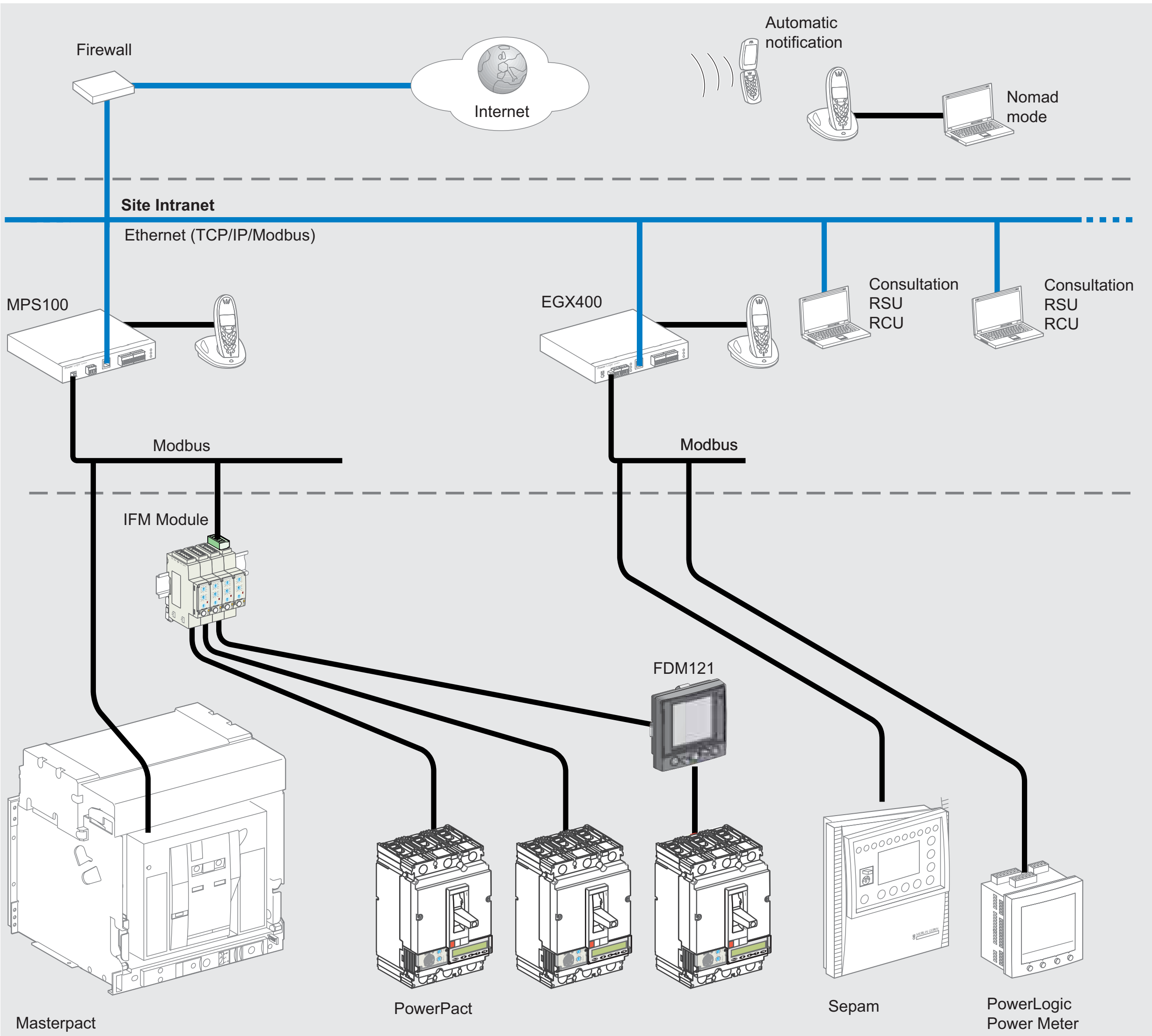

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Supervision Software

Schneider Electric™ electrical installation supervision, management and expert system software integrates PowerPact H-, J-, and L-frame electronic circuit breakers identification modules.

Types of Software

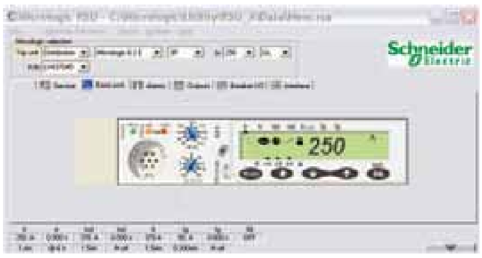
Micrologic trip unit communication network functions are designed to interface with software dedicated to electrical installations:

- installation supervision
- electrical installation supervision
- power system management: electrical engineering expert systems
- process control
- SCADA (Supervisory Control & Data Acquisition), EMS (Enterprise Management System) or BMS (Building Management System) type software.

Remote Setting Utility (RSU)

The downloadable Micrologic Trip Unit Utility, RSU, facilitates the implementation of communication network functions.

- The RSU is available to assist in starting up a communicating installation. The software can be downloaded from the Schneider Electric internet site.
- The “Live update” function enables immediate updating to obtain the most recent upgrades. These easy-to-use utilities include starting assistance and online help. They are compatible with Microsoft Windows 2000, XP, Vista and Windows 7.



RSU mini-supervision screen for current measurements.

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The RSU can be used to set the protection functions and alarms for each Masterpact™ and PowerPact device.

After connection to the network and entry of the circuit-breaker Modbus address, the software automatically detects the type of trip unit installed.

There are two possible operating modes. For each selected circuit breaker, the user can do the following.

Operating Mode	Operation	Description
Off-Line with the Software Disconnected from the Communication Network	Determine the protection settings	The settings are carried out on a screen that shows the front of the trip unit. The Micrologic trip unit setting rotary switches, keypad and screen are simulated for easy use of all Micrologic trip unit setting functions.
	Save and duplicate the protection settings	Each configuration created can be saved for subsequent device programming. It can also be duplicated and used as the basis for programming another circuit breaker.
On-Line with the Software Connected to the Network	Display the current settings The software displays the trip unit and provides access to all settings.	The software displays the trip unit and provides access to all settings.
	View the corresponding protection curves	A graphic curve module in the software displays the protection curve corresponding to the settings.
	Display the current settings Modify settings in a secure manner	There are different levels of security: — password: by default, it is the same for all devices, but can be differentiated for each device — locking of the Modbus communication interface module which must be unlocked before the corresponding device can be set remotely — maximum settings limited by the positions of the two rotary switches on the trip unit. These rotary switches, set by the user, determine the maximum settings that can be made using the communication network. Settings are modified by: — either direct, on-line setting of the protection settings on the screen — or by loading the settings prepared in off-line mode. This is possible only if the positions of the rotary switches allow the new settings. All manual settings made subsequently on the device have priority.
	Program alarms	Up to 12 alarms can be linked to measurements or events. two alarms are predefined and activated automatically: — Micrologic 5 trip unit: overload (Ir) — Micrologic 6 trip unit: overload (Ir) and ground fault (Ig) thresholds, priorities and time delays can be set for 10 other alarms. They may be selected from a list of 91 alarms
	Set the outputs of the SDx relays	This is required when the user wants to change the standard configuration and assign different signals to the 2 outputs of the SDx relay.

To download the RSU software (LV4ST100):

- go to www.schneider-electric.com and do a search for LV4ST100.
- Click on LV4ST100, then click Software/Firmware under Downloads menu, then download.

Gateway

The gateway has two functions:

- access to the company intranet (Ethernet) by converting Modbus frames to the TCP/IP/Modbus protocol
- optional web page server for the information from the devices.

Examples include EGX300 and EGX100.

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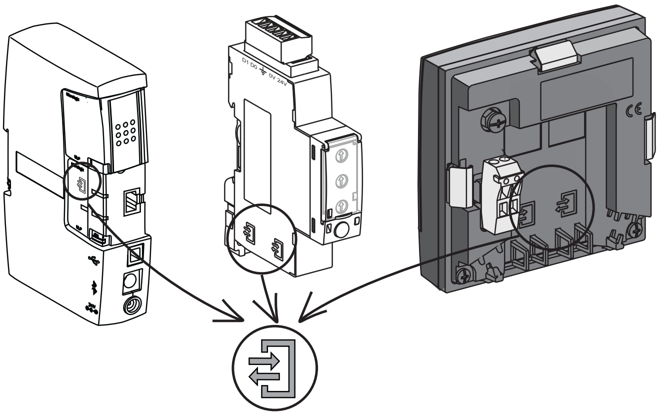
by Schneider Electric

Integration of PowerPact H-, J-, and L-frame Circuit Breakers

Micrologic trip unit communication network functions are designed to interface with software dedicated to electrical installations. PowerPact H-, J-, and L-frame circuit breakers are integrated using Modbus communication interface modules connected through FDM121 front display modules or NSX cords.

For easy connection of the different modules, the prefabricated cables are identified by ULP (Universal Logic Plug) symbols. The connection points on compatible modules are marked in the same manner.



Schneider Electric™ Solutions

Electrical Equipment Supervision using Gateways such as the EGX300 Web Servers

- A simple solution for customers who want to consult the main electrical parameters of installed devices without dedicated software.
- Up to 16 devices are connected using Modbus communication interface modules to an MPS100 or EGX300 Ethernet gateway integrating the functions of a web page server. The embedded Web pages can be easily configured with just a few mouse clicks. The information they provide is updated in real time.
- The Web pages can be consulted using a standard Web browser on a PC connected through Ethernet to the company Intranet or remotely using a modem. Automatic notification of alarms and threshold overruns is possible using e-mail or SMS (Short Message Service).

SMS Electrical Engineering Expert System Software

PowerLogic™ SMS is a family of web-enabled software products for high-end power-monitoring applications. It is designed for large power systems.

SMS products offer detailed analysis of electrical events, long-duration data logging and extensive, economical report-building capabilities (such as power usage monitoring and tariff management).

A wide variety of screens can be displayed in real time, including more than 50 tables, analogue meters, bargraphs, alarms logs with links to display waveforms and predefined reports on energy quality and service costs.

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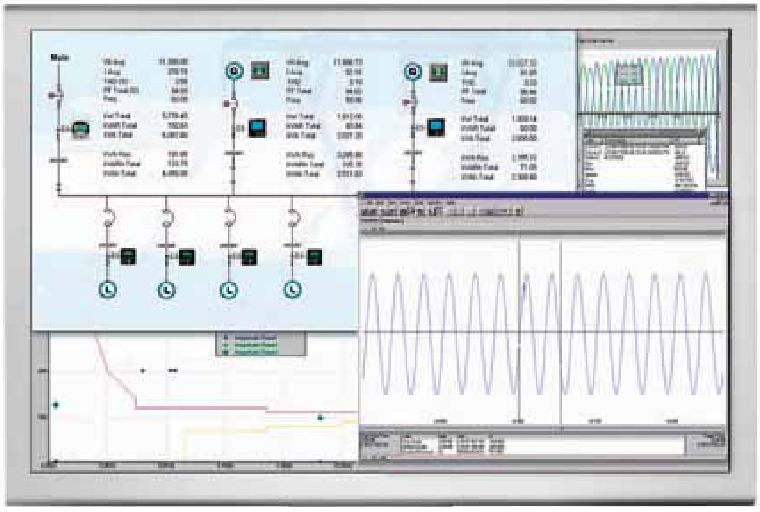
Electrical Installation Supervision using ION-Enterprise Software

- PowerLogic™ ION-Enterprise software is ideally suited to the supervision needs of small system applications, monitoring up to 32 devices.
- Installed on a PC under Windows, it represents a cost-effective and easy-to-implement power-monitoring solution that offers:
  - — automatic detection of compatible devices
  - — real-time monitoring of data including power requirements
  - — a report generator with a number of pre-defined reports that can be exported to
  - — Excel
  - — cost allocation
  - — time-stamped data-logging possibilities
  - — Modbus serial and Modbus TCP/IP compatible communication.



Other Software

PowerPact H-, J-, and L-frame devices can forward their measurement and operating information to special software integrating the electrical installation and other technical facilities:

- SCADA process control software: Vijeo CITECT
- BMS Building Management System software: Vista.

For more information, contact your local field office.

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External neutral current transformer

External Neutral Current Transformer (ENCT)

The external neutral current transformer is a sensor required for a three-pole circuit breaker in a system with a distributed neutral to measure the neutral current in order to:

- protect the neutral conductor
- protect against ground faults.

This current transformer can be connected to Micrologic 5 / 6 trip units. The transformer rating must be compatible with that of the circuit breaker.

Table 71: Current Transformers

Circuit Breaker	Rating	Catalog No.
H-Frame	60–100 A	**S429521**
	150 A	**S430562**
J-Frame	250 A	**S430563**
L-Frame	400–600 A	**S432575**

For installation recommendations, see page 132.

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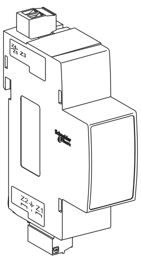
External Neutral Voltage Tap

External Neutral Voltage Tap (ENVT)

The external neutral voltage tap is required for Micrologic E power metering with a three-pole circuit breaker in a system with a distributed neutral. It is used to connect the neutral to the Micrologic trip unit to measure phase-to-neutral (Ph-N) voltages.

The ENVT is included with the Micrologic 5/6 electronic trip unit.



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Zone Selective Interlock (ZSI) Module

A ZSI terminal block may be used to interconnect a number of Micrologic trip units to provide zone selective interlocking for short-time (I_{sd}) and ground-fault (I_g) protection, without a time delay. For PowerPact H- and J-frame circuit breakers, the ZSI function is available only in relation to the upstream circuit breaker (ZSI out). For PowerPact L-frame circuit breakers, the ZSI function is available in relation to the upstream circuit breaker (ZSI out) and downstream circuit breakers (ZSI in)

Table 72: ZSI Catalog Number

Description	Catalog No.
ZSI Module	**S434212**

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I-Line™ Wiring Harness

Accessories installed in I-Line circuit breakers require the use of optional wiring harnesses (not provided). The wiring harness allows the accessory wiring to exit the circuit breaker through wiring channels in the side of the circuit breakers. Wire harnesses may also be used for unit-mount applications.

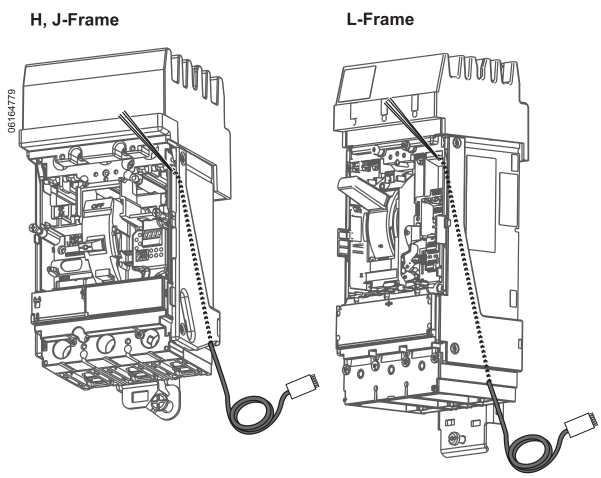

Table 73: Wiring Harness Catalog Numbers

Description	Catalog No.
Auxiliary Switch (OF) I-Line Wire Harness	**S434500**
Alarm Switch (SD)/Overcurrent Trip Switch (SDE) I-Line Wire Harness	**S434501**
SDx/SDTAM I-Line Wire Harness	**S434502**
Undervoltage Trip (MN) I-Line Wire Harness	**S434503**
Shunt Trip (MX) I-Line Wire Harness	**S434504**
24 Vdc Power Supply Terminal Block I-Line Wire Harness	**S434505**
Motor Operator (MT) I-Line Wire Harness	**S434506**
Communicating Motor Operator (MTc) I-Line Wire Harness	**S434507**
NSX Cord I-Line Wire Harness	**S434508**
ZSI (H/J-Frame, Out Only) I-Line Wire Harness	**S434300**
ZSI (L-Frame, In and Out) I-Line Wire Harness	**S434301**
ENCT I-Line Wire Harness	**S434302**

Section 8—Accessories and Auxiliaries

All PowerPact H-, J-, and L-frame circuit breakers and automatic switches have slots for the electrical auxiliaries

H- and J-Frame	L-Frame
• 4 indication contacts — 2 ON/OFF (auxiliary switches [OF1 and OF2]) — 1 trip indication (alarm switch [SD]) — 1 fault-trip indication (overcurrent trip switch [SDE]) • one remote-tripping release — either 1 undervoltage trip (MN) — or 1 shunt trip (MX)	• 5 indication contacts — 3 ON/OFF auxiliary switches (OF1, OF2, and OF3) — 1 trip indication (alarm switch [SD]) — 1 fault-trip indication (overcurrent trip switch [SDE]) • one remote-tripping release — either 1 undervoltage trip (MN) — or 1 shunt trip (MX)

Circuit breakers equipped with Micrologic™ trip units may be equipped with a fault-trip indication to identify the type of fault by installing

- one indication module with two outputs (see page 94)
  - either an SDx module with Micrologic 3.x / 5.x A or E / 6.x A or E
  - or an SDTAM module with Micrologic 2.x M.

  This module occupies the slots of one auxiliary switch (OF) contact and an undervoltage trip (MN)/shunt trip (MX).

All these auxiliaries may be installed with a motor operator.

Communication Network

Communication networks require specific auxiliaries.

Communication of status indications

- 1 BSCM module
- 1 NSX cord (internal terminal block) for both communication and 24 Vdc supply to the BSCM.

Communication of status conditions is compatible with a standard motor operator.

Communication of status indications and controls requires, in addition to the previous auxiliaries:

- 1 communicating motor operator connected to the BSCM.

Communication of measurements is available on Micrologic 5 / 6. The system consists of:

- 1 NSX cord (internal terminal block) for both communication and 24 Vdc supply to the Micrologic.

Communication of measurements is compatible with a standard or communicating motor operator.

Communication of status indications, controls and measurements is available on Micrologic 5 / 6. The system consists of:

- 1 BSCM module
- 1 NSX cord (internal terminal block) for both communication and 24 Vdc supply to the BSCM and the Micrologic
- 1 communicating motor operator connected to the BSCM.

Installation of SDx or SDTAM is compatible with communication network.

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Table 74: Standard Auxiliary Possibilities Based on Trip Unit

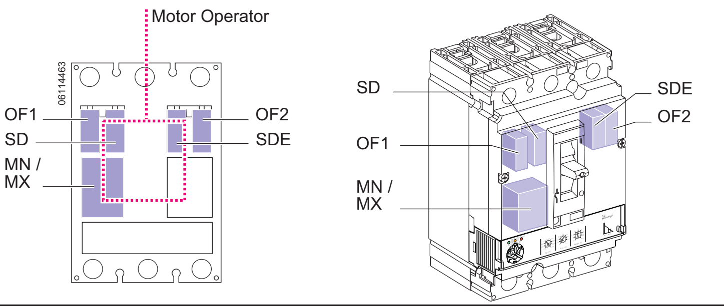
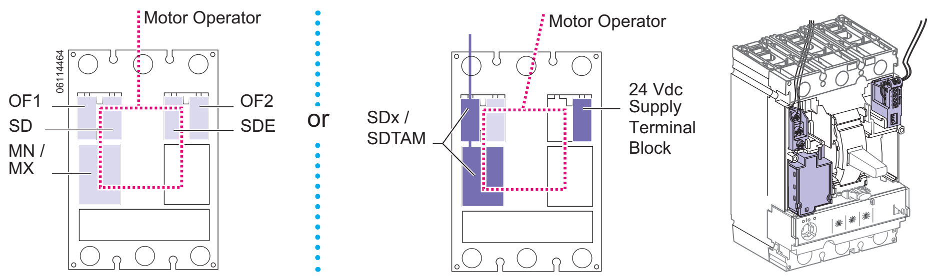
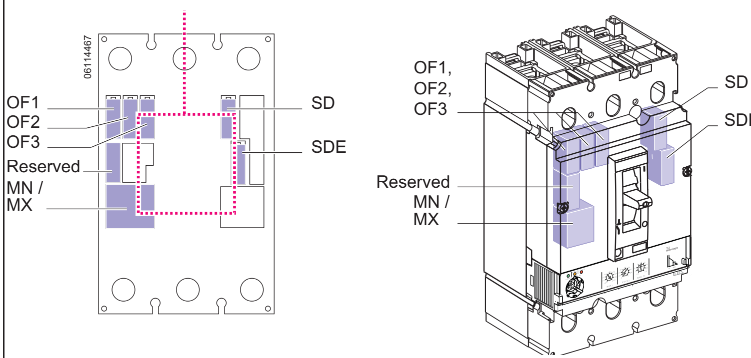
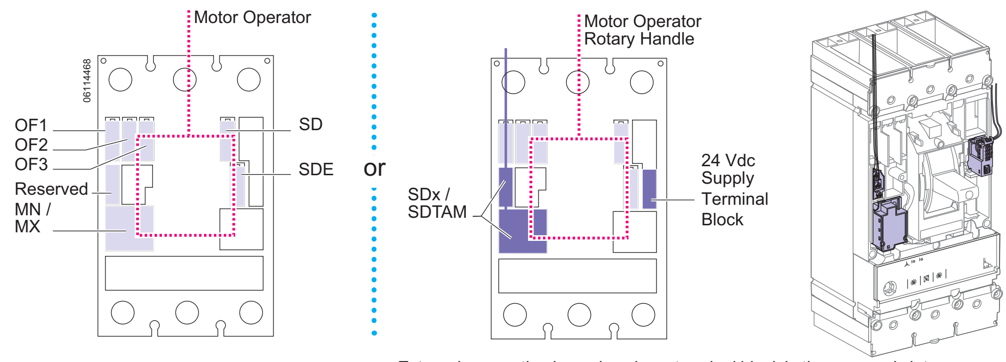
Type	Trip Unit	Auxiliary Possibilities
H-Frame J-Frame	Micrologic™ 3	
H-Frame J-Frame	Micrologic 5 Micrologic 6	 *The SDx or SDTAM uses the OF1 and MN/MX slots.* *External connection is made via a terminal block in the OF1 slot.* *The 24 Vdc supply provides for the Micrologic 5 / 6 display when the device is OFF or under low-load conditions.*
L-Frame	Micrologic 1.3 M Micrologic 3	
L-Frame	Micrologic 5 Micrologic 6	 *External connection is made using a terminal block in the reserved slot.* *The 24 V DC supply provides for the Micrologic 5 / 6 display when the device is OFF or under low-load conditions.*

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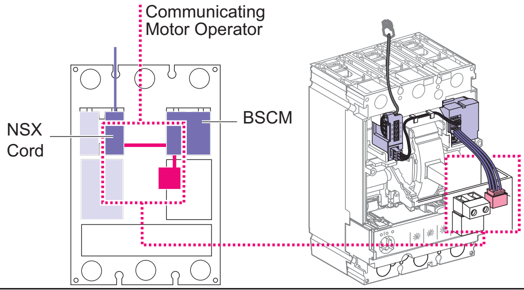
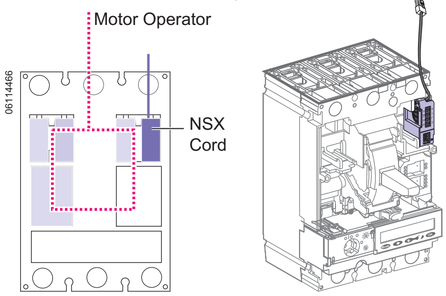
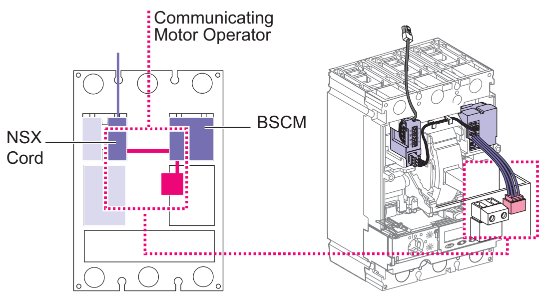
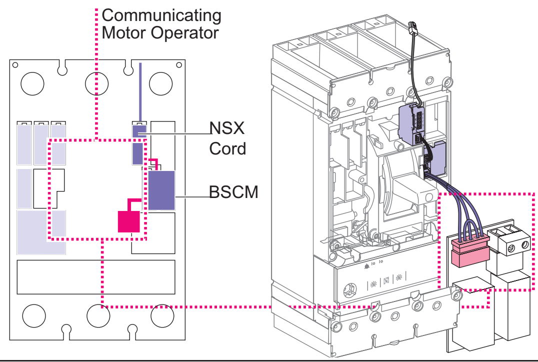
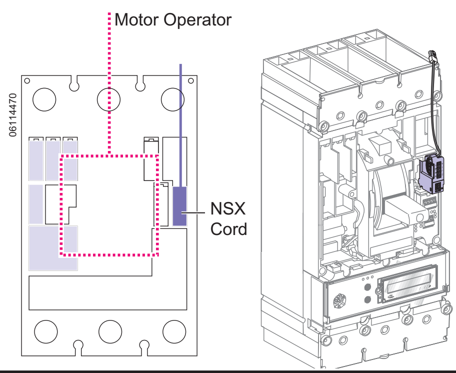
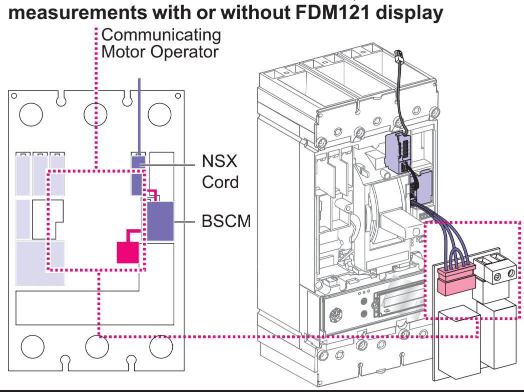
Table 75: Communication Network Auxiliary Possibilities Based on Trip Unit

Type	Trip Unit	Auxiliary Possibilities
H-Frame J-Frame	Micrologic™ 3	**Communication of status indications and controls** 
H-Frame J-Frame	Micrologic 5 Micrologic 6	**Communication of measurements with or without FDM121 display**  or **Communication of status indications, controls and measurements with or without FDM121 display** 
L-Frame	Micrologic 1.3 M Micrologic 3	**Communication of status indications and controls** 
L-Frame	Micrologic 5 Micrologic 6	**Communication of status indications**  or **Communication of status indications, controls and measurements with or without FDM121 display** 

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Accessory Connections

Electrical accessories are fitted with numbered terminal blocks for wires with the following maximum size:

- 16 AWG (1.5 mm^2) for auxiliary switches (OF1 or OF2), and shunt trip (MX) or undervoltage trip (MN)
- 14 AWG (2.5 mm^2) for the motor operator

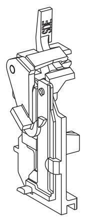
Auxiliary switch wiring exits fixed mounted devices through a knock-out in the front cover.

NOTE: See page 115 for plug-in and page 117 for drawout options.

Auxiliary and Alarm Indication Contacts

Auxiliary indication contacts provide remote information of the circuit breaker status and can thus be used for indications, electrical locking, relays, etc.

Auxiliary Switch (OF)/
Alarm Switch (SD)



Overcurrent Trip
Switch Actuator (SDE)

Table 76: Auxiliary and Alarm Indication Contacts

Applications	**Open/Closed—Auxiliary Switches (OF)** • Indicates the position of the circuit breaker contacts **Trip Indication—Alarm Switch (SD)** • Indicates that the circuit breaker has tripped due to an overload, short circuit or ground fault, the operation of a shunt trip or undervoltage trip or the “push-to-trip” button • Resets when the circuit breaker is reset **Overcurrent Trip Switch (SDE)** • Indicates that the circuit breaker has tripped due to an overload, short circuit or ground fault • Resets when the circuit breaker is reset The above switches are also available in low-level versions (with gold flash plating) capable of switching very low loads (e.g., for controlling PLCs or electronic circuits) **Rotary Handle Indicator: CAO (early-break) and CAF (early-make)** • Fitted in the rotary handle module (see page 102)
Installation & Connection	• The auxiliary switch (OF), alarm switch (SD), and overcurrent trip switch (SDE) indication contacts snap into cavities behind the front accessory cover of the circuit breaker. • One model serves for all indication functions depending on where it is fitted in the circuit breaker. • The overcurrent trip switch (SDE) in a circuit breaker equipped with a thermal-magnetic or Micrologic™ 1/2/3 trip unit requires the SDE actuator.
Standards	• The internal accessories comply with requirements of Underwriters Laboratories® Inc. (UL®). • UL 489 and Canadian Standard Association C22.2 No. 5-02 Standards. • All internal accessories are Listed for field installation per UL file E103955 and Certified under CSA file LR 69561. • Auxiliary indicator contacts comply with UL 489, CSA C22.2 No. 5-02 and IEC 60947-5 Standards. “Low-level” indicator contacts are not UL Recognized.

Table 77: Electrical Characteristics

Characteristic		Standard		Low-Level[1]	
Supplied as Standard (Form C)		4		4	
Maximum Number of Contacts		4		4	
Rated Thermal Current		6 A		5 A	
Maximum Load		100 mA at 24 V		1 mA at 4 V	
Operational Current		AC	DC	AC	DC
	24 V	6 A	6 A	5 A	5 A
	48 V	6 A	2.5 A	5 A	2.5 A
	110 V	6 A	0.6 A	5 A	0.6
	220/240 V	6 A	—	5 A	—
	250 V	—	0.6 A	5 A	0.3 A
	380/440 V	6 A	—	5 A	—
	480 V	6 A	—	5 A	—
	660/690 V	6 A	—	—	—

1 If the maximum voltage and current is exceeded, the low-level function of the switch will be lost but the switch will continue to function as a standard switch.

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Table 78: Auxiliary Switch Catalog Numbers

Contacts	Factory-Installed Suffix	Field-Installable Kit No.	Kit Qty.
1A/1B Standard	AA	**S29450**	1
2A/2B Standard	AB	**S29450**	2
1A/1B Low-Level (Gold)	AE	**S29482**	1
2A/2B Low-Level (Gold)	AF	**S29482**	2

Table 79: Alarm/Overcurrent Trip Switch Catalog Numbers

Suffix	Switch	Kit No.	Kit Qty.
PowerPact L-Frame PowerPact H/J-Frame with Micrologic™ 5/6 trip units			
BC	Alarm Switch	S29450	1
BH	Alarm Switch Low-Level	S29452	1
BD	Overcurrent Trip Switch Standard	S29450	1
BJ	Overcurrent Trip Switch Low-Level	S29452	1
BE	Alarm Switch and Overcurrent Trip Switch, Standard	S29450	2
BK	Alarm Switch and Overcurrent Trip Switch, Low-Level	S29452	2
PowerPact H/J-Frame with Thermal-Magnetic or Micrologic 1/2/3 trip units			
BC	Alarm Switch	S29450	1
BH	Alarm Switch, Low-Level	S29452	1
BD	Overcurrent Trip Switch, Standard SDE Actuator	S29450 S29451	1 1
BJ	Overcurrent Trip Switch, Low-Level SDE Actuator	S29452 S29451	1 1
BE	Alarm Switch and Overcurrent Trip Switch, Standard SDE Actuators	S29450 S29451	2 2
BK	Alarm Switch and Overcurrent Trip Switch, Low-Level SDE Actuators	S29452 S29451	2 2

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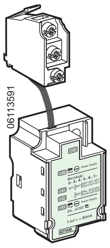
SDx and SDTAM Modules for Micrologic™

SDx and SDTAM are relay modules with two outputs. They send different signals depending on the type of fault. They may not be used together.

SDx Module



SDx module with terminal block.

The SDx module remotely monitors the trip or alarm conditions of PowerPact H-, J-, and L-frame circuit breakers equipped with electronic protection.

An SDx relay module installed inside the circuit breaker can be used to remote the overload trip signal.

This module receives the signal from the Micrologic electronic trip unit through an optical link and makes it available on the terminal block. The signal is cleared when the circuit breaker is closed. These outputs can be reprogrammed to be assigned to other types of tripping or alarm (see page 94).

The SDx module may be used in 400 Hz systems for voltages from 24 to 440V.

The SD2 output, available on all Micrologic trip units, corresponds to the overload-trip indication.

The SD4 output, available on Micrologic 5 / 6, is assigned to:

- overload pre-alarm (Micrologic 5)
- ground-fault trip indication (Micrologic 6)

These two outputs automatically reset when the device is closed (turned ON).

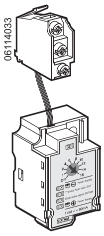
For Micrologic 5 / 6, the SD2 and SD4 outputs can be reprogrammed to be assigned to other types of tripping or alarm.

It is possible to assign a function output characteristics:

- latching with a time delay. Return to the initial state occurs at the end of the time delay
- permanent latching. Return to the initial state takes place through the communication function.

Static outputs: 24–415 V AC / Vdc; 80 mA max.

SDTAM Module



SDTAM module with terminal block.

The SDTAM module, linked to the contactor controller, opens the contactor when an overload or other motor fault occurs, thus avoiding opening of the circuit breaker. The SDTAM module is specifically for the motor-protection Micrologic trip units 2 M (2.2 M and 2.3 M).

Micrologic 2 M

The SD4 output opens the contactor 400 ms before normal circuit-breaker opening in the following cases:

- overload (long-time protection for the trip class)
- phase unbalance or phase loss

The SD2 output serves to memorize contactor opening by SDTAM.

Output characteristics

Output reset can be:

- manual by a pushbutton included in the wiring diagram
- automatic after an adjustable time delay (1 to 15 minutes) to take into account the motor-cooling time

Static outputs: 24–415 Vac / Vdc; 80 mA max. a (+) 24–415 V

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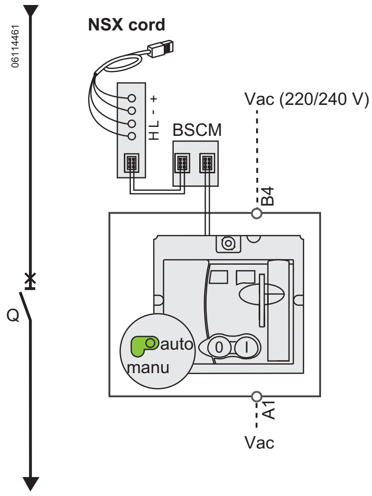

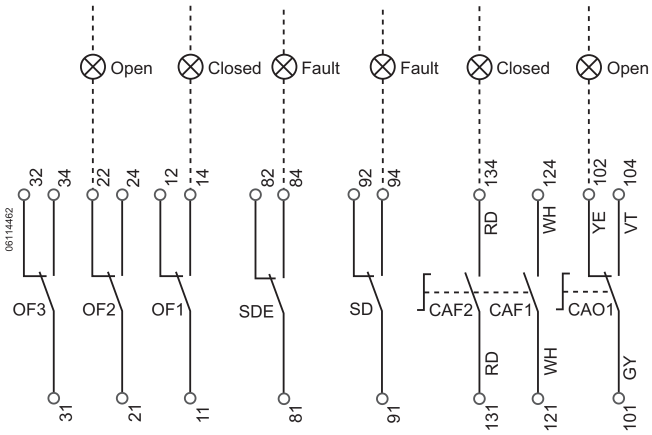

Schematic of the communicating motor operator .

Table 80: SDx and SDTAM Catalog Numbers

Contacts	Factory-Installed Suffix	Field-Installable Kit No.
SDx	V	**S429532**
SDTAM (motor trip units only)	V	**S429424**

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Shunt Trip (MX) and Undervoltage Trip (MN)

A voltage release can be used to trip the circuit breaker using a control signal.

Table 81: Shunt Trip and Undervoltage Trip

Applications	**Shunt Trip (MX)** • Trips the circuit breaker when the control voltage rises above 70% of its rated voltage • Impulse type ≥ 20 ms or maintained control signals • AC shunt trips are suitable for ground-fault protection when combined with a Class I ground-fault sensing element • Continuous duty rated coil **Undervoltage Trip (MN)** • Trips the circuit breaker when the control voltage drops below a tripping threshold • Drops out between 35% and 70% of the rated voltage • Continuous duty rated coil • Circuit breaker closing is possible only if the voltage exceeds 85% of the rated voltage. If an undervoltage condition exists, operation of the closing mechanism of the circuit breaker will not permit the main contacts to touch, even momentarily. This is commonly called “Kiss Free”.
Installation and Connection	• Accessories are common to H-, J-, and L-frame circuit breakers and snap into cavities under the front accessory cover of the circuit breaker • Each terminal may be connected by one 18–14 AWG (1.0–2.5 mm^2) stranded copper wire
Operation	• The circuit breaker must be reset locally after being tripped by shunt trip (MX) or undervoltage trip (MN) • Tripping by the shunt trip or undervoltage trip has priority over manual (or motor operator) closing; in the presence of a standing trip order such an action does not result in any closing, even temporarily, of the main contacts • Endurance: 50% of the rated mechanical endurance of the circuit breaker

Table 82: Electrical Characteristics

		AC	DC
Rated Voltage (V)		24, 48, 120, 208/277, 380/480, 525, 600	12, 24, 30, 48, 60, 125, 250
Power Requirements	Pickup (shunt trip)	< 10 VA	< 5 W
	Seal-in (undervoltage trip)	< 5 VA	< 5 W
Clearing Time (ms)		< 50	< 50

Table 83: Shunt Trip and Undervoltage Trip Suffix Codes and Kit Numbers

Voltage	Shunt Trip (MX)		Undervoltage Release (MN)	
	Factory-Installed Suffix	Field-Installable Kit No.	Factory-Installed Suffix	Field-Installable Kit No.
24 Vac	SK	**S29384**	UK	**S29404**
48 Vac	SL	**S29385**	UL	**S29405**
120 Vac	SA	**S29386**	UA	**S29406**
208/277 Vac	SD	**S29387**	UD	**S29407**
380/480 Vac	SH	**S29388**	UH	**S29408**
525/600 Vac	SJ	**S29389**	UJ	**S29409**
12 Vdc	SN	**S29382**	UN	**S29402**
24 Vdc	SO	**S29390**	UO	**S29410**
30 Vdc	SU	**S29391**	UU	**S29411**
48 Vdc	SP	**S29392**	UP	**S29412**
60 Vdc	SV	**S29383**	UV	**S29403**
125 Vdc	SR	**S29393**	UR	**S29413**
250 Vdc	SS	**S29394**	US	**S29414**

Table 84: Adjustable and Fixed Time Delay Units for Undervoltage Trip

Rated Voltage	Field-Installable Kit No.	
	Adjustable	Fixed
48 Vac/dc	S33680	S29426
100/130 Vac/dc	S33681	—
220/250 Vac/dc	S33682	S29427

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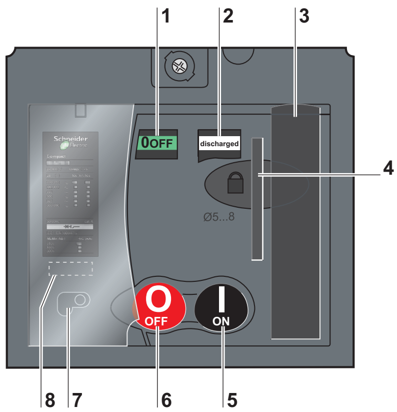
Motor Operator

The motor operator remotely operates the circuit breaker featuring easy and sure operation:

- All circuit breaker indications and information remain visible and accessible, including trip unit settings and circuit breaker connection
- Suitability for isolation is maintained and padlocking remains possible
- Double insulation front face



1. Contact position indicator (suitability for isolation)
2. Spring status indicator (charged, discharged)
3. Manual spring-charging handle
4. Keylock device (optional)
   Locking device (off position) using one to three padlocks, diameter 0.2–0.32 in. (5–8 mm), not supplied
5. ON push button
6. OFF push button
7. Manual/auto mode selection switch; the position of the switch can be indicated remotely
8. Operation counter

Applications:

- Local motor-driven operation, centralized operation, automatic distribution control
- Normal/standby manual transfer or switching to a replacement source to optimize energy costs
- Load shedding and reconnection to optimize energy costs
- Less than five cycle closing time for source synchronization

Installation and Connection

- All installations are available for H- and J-frame circuit breakers.
  All installations are available for L-frame circuit breakers except I-Line
- Connections of the motor operator module are to a built-in terminal block behind its front cover
- Stranded copper wire 14 AWG (2.5 mm^2)

Automatic Operation

The motor operator is connected in series with the overcurrent trip switch (SDE).

- ON and OFF by two impulse type or continuous control signals
- Depending on the wiring, resetting can be done locally, remotely or automatically
- Mandatory manual reset following tripping due to an electrical fault (with overcurrent trip switch)

Manual Operation

- Transfer to manual mode with possibility of remote mode indication
- ON and OFF by two push buttons
- Recharging of stored-energy system by pumping the lever
- Padlocking in off position

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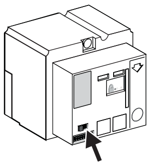

Table 85: Motor Operator Characteristics

Response Time (ms)	Opening		< 600
	Closing		< 80
Operating Frequency	cycles/minute max.		4
Power Requirements[1]	AC (VA)	Opening	≤500
		Closing	≤500
	DC (W)	Opening	≤500
		Closing	≤500

1 For H- and J-frame, the inrush current is 2x operating current for 10 ms.

Table 86: Motor Operator and Accessory Suffix Codes and Catalog Numbers

Device[1]	Control Voltage	Factory-Installed Suffix	Field-Installable Kit No.		
			H-Frame	J-Frame	L-Frame
Communicating Motor Operator	220/240 Vac 50/60 Hz	NC	**S429441**	**S431549**	**S432652**
Motor Operator	48/60 Vac 50/60 Hz	ML	**S29440**	**S31548**	**S432639**
	110/130 Vac 50/60 Hz	MA	**S29433**	**S31540**	**S432640**
	208/277 Vac 60 Hz	MD	**S29434**	**S31541**	**S432641**
	380/415 Vac 50/60 Hz	MF	—	—	**S432642**
	440/480 Vac 60 Hz	MH	**S29435**	**S31542**	**S432647**
	24/30 Vdc	MO	**S29436**	**S31543**	**S432643**
	48/60 Vdc	MV	**S29437**	**S31544**	**S432644**
	110/130 Vdc	MR	**S29438**	**S31545**	**S432645**
	250 Vdc	MS	**S29439**	**S31546**	**S432646**
Lock Mounting Hardware	—	—	—	—	**S32649**
Ronis Lock	—	—	**S41940**	**S41940**	**S41940**
Profalux Lock	—	—	**S42888**	**S42888**	**S42888**
Mounting Hardware with Ronis Lock	—	—	**S429449**	**S429449**	—
Operations Counter	—	—	—	—	**S32648**
Adapter for I-Line™ Circuit Breaker			**S37420**	**S37420**	—

1 For NSX cord (communication suffixes EA, EB, ED, and EE) any motor operator may be selected.
For BSCM + NSX cord (communication suffixes EB, EH, EK, and EL) only the communicating motor operator may be selected.

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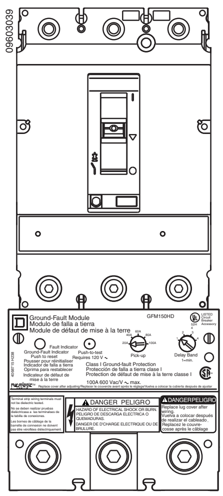
Add-On Ground-Fault Module (GFM) (H- and J-Frame Only)



J-Frame Circuit Breaker with GFM Installed

The Micrologic™ Ground-Fault Module (GFM) is a UL Listed/CSA Certified circuit breaker accessory which protects equipment from damage caused by ground faults. It is an add-on module which, when connected to a PowerPact H- or J-frame thermal-magnetic circuit breaker only, provides ground-fault sensing and ground-fault relay functions.

HD/JD ground-fault modules feature:

- Adjustable ground-fault pickup levels
- Adjustable ground-fault time delays
- Integral ground-fault push-to-test feature
- Ground-fault indicator (mechanical for local, contacts for remote)
- All GFMs are supplied for I-Line™ mounting as standard, easily convertible to unit mount by removing the I-Line bracket.
- Fault-powered (through the sensing current transformer) for electronics, shunt trip, and integral test feature. Meets NEC 230.95(C).
- A 12 Vdc shunt trip module (Catalog No. S29382) is required in the circuit breaker. This may be field installed or factory installed when the circuit breaker is ordered with an -SN suffix.
- UL 1053 – Ground-fault Sensing and Relaying Equipment

The GFM system requires the following:

- H-frame (15–150 A) or J-frame (150–250 A) molded case circuit breaker
- Shunt trip for circuit breaker (may be factory-installed or field-installed)
- Bus bar connection (terminal nut inserts) for OFF end of circuit breaker
- Optional neutral current transformer, catalog number GFM25CT (must be ordered for 4-wire applications).

Table 87: Ground-Fault Module

Catalog No.	Rating	Sensitivity	Time Delay (Approximate)
GFM150HD	150 A	20, 40, 60, 80, 100 A	0.2, 0.3, 0.4, 0.6 sec
GFM250JD	250 A	40, 80, 120, 160, 200 A	0.2, 0.3, 0.4, 0.6 sec

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Earth Leakage Module (ELM) (H- and J-Frame Only)


J-Frame Circuit Breaker with ELM Installed

The Earth Leakage Module (ELM) is an add-on module which, when connected to a PowerPact H- or J-frame MCCB, provides low-level ground-fault sensing and ground-fault relay functions.

Because these ELMs are highly sensitive (30 mA to 3 A), they provide much greater protection than GFMs (20 Amps to 200 Amps sensitivity). The ELMs provide greater protection of control circuits and other sensitive equipment. The associated circuit breaker must have a 48 Vdc shunt trip), which may be field-installed (kit S29392) or factory-installed (suffix –SP) in the H- or J-Frame circuit breaker.

The add-on Earth Leakage Module (ELM) features:

- Adjustable ground-fault pickup levels as low as 30 mA
- Adjustable ground-fault time delays from instantaneous to 500 msec (time delay can be applied to any setting)
- Integral ground fault push-to-test feature
- Ground-fault indicator; pop-up button for local status and contacts for remote indication (to be used only with the tripping option)
- All ELMs are supplied for I-Line™ mounting and are easily convertible to unit-mount by removing the I-Line mounting feet
- Three poles; 240 to 600 Vac maximum: 3-phase, 3-wire (no neutral) and 1-phase, 2-wire applications
- Line-power obtained through internal bus to provide power for electronics, shunt trip, and integral test feature
- A shunt trip is required in the circuit breaker; it may be field-installed or factory-installed in the PowerPact H and J circuit breakers.
- UL 1053 – Ground-fault Sensing and Relaying Equipment

Table 88: ELM Selection Chart [1]

Companion Circuit Breaker		Enclosure Space Required I-Line Equipment	Catalog No.	Pick-Up Adjustments	Ground-Fault Time Delay Adjustments
Prefix	Size				
HD, HG, HJ, HL	15–150 A	LA	**ELM150HD**	30 mA 100 mA 300 mA 1A 3A	Instantaneous 60 ms 100 ms 500 msec
JD, JG, JJ, JL	150–250 A	LA	**ELM250JD**		

1 At 250 A, the ELM250JD can be used with standard (80%) rated circuit breakers only.

Factory-Installed ELMs

The catalog number for circuit breakers with factory-installed ELM should include the special suffixes SP and VL or VM:

H D M 3 6 150 SP VL

where

- H = H-fame (or J = J-frame)
- D = D interruption level (or G, J or L)
- M = Lugs on ON end and terminal nuts on OFF end (required)
- SP = Factory-installed 48 Vdc shunt trip (S29392, required)
- VL= Earth Leakage Module (ELM) <150 A (H-frame) or
  VM = Earth Leakage Module (ELM) <250 A (J-frame)

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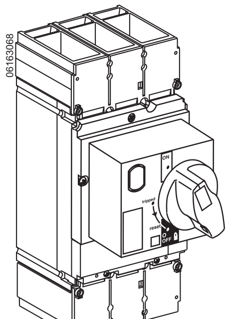
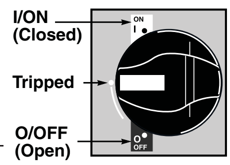
Rotary Operating Handles

Directly Mounted Rotary Operating Handles

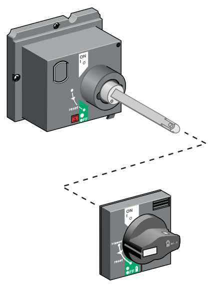


Directly Mounted Rotary Operating Handle

Installation	The directly mounted rotary operating handle replaces the circuit breaker front accessory cover (secured by screws).
Operation	The direct rotary handle maintains: • Suitability for isolation • Indication of three positions: I (ON), Tripped and O (OFF) • Access to the “push-to-trip” button • Visibility of, and access to, trip unit settings • The circuit breaker may be locked in the OFF position by using one to three padlocks (not supplied)
Models	• Standard with black handle • VDE type with red handle and yellow bezel for machine tool control
Variations	Accessories transform the standard direct rotary handle for the following situations: • Motor control centers (MCCs): – Opening of door prevented when circuit breaker is on – Closing of circuit breaker inhibited when door is open • Machine tool control; complies with CNOMO E03.81.501N; degree of protection IP54 • Early make or early break contacts may be installed into direct mount rotary handle
Standards	The directly-mounted rotary operating handle is UL Listed under file E103955 and CSA Certified under file LR 69561



Door-Mounted (Extended) Rotary Operating Handle



Door Mounted Rotary Operating Handle

Installation	The door-mounted (extended) rotary operating handle is made up of: • A unit that replaces the front accessory cover of the circuit breaker (secured by screws) • An assembly (handle and front plate) on the door that is always secured in the same position, whether the circuit breaker is installed vertically or horizontally • An adjustable extension shaft • The handle mechanism can be used in NEMA 3R and 12 enclosure applications
Operation	The door mounted operating handle makes it possible to operate circuit breakers installed in enclosure from the front. The door mounted operating handle maintains: • Suitability for isolation • Indication of the three positions OFF (O), ON (I) and tripped • Visibility of and access to trip unit settings when the door is open • Degree of protection: IP40 as per IEC 529 Defeatable interlock prevents opening of door when circuit breaker is on The circuit breaker may be locked in the off position by using one to three padlocks, padlock shackle diameter 0.19–0.31 in. (5–8 mm); padlocks are not supplied; locking prevents opening of the enclosure door
Shaft Length	The shaft length is the distance between the back of the circuit breaker and the door: • Minimum shaft length is 7.4 (185 mm) • Maximum shaft length is 24 in. (600 mm) • Extended shaft length must be adjusted
Models	• Standard with black handle • VDE type with red handle and yellow bezel for machine tool control
Variations	For drawout configurations, the extended rotary handle is also available with a telescopic shaft containing two stable positions
Standards	The door-mounted rotary operating handle is UL Listed under file E103955 and CSA Certified under file LR 69561

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Table 89: Rotary Operated Handles

Device		Description	H- and J-Frame Factory Installed Suffix	H- and J-Frame Field Installable Kit No.	L-Frame Factory Installed Suffix	L-Frame Field Installable Kit No.
Direct Mounted	Standard Handle Black	Handle only	RD10	S29337	RD10	S32597
	Standard Black Handle with	One early-break switch	RD12	S29337 + S29345	RD12	S32597 + S32605
		Two early-make switches	RD13	S29337 + S29346	RD13	S32597 + S29346
	Red handle on yellow bezel	Handle Only	RD20	S29339	RD20	S32599
		One early-break switch	RD22	S29339 + S29345	RD22	S32599 + S32605
		Two early-make switches	RD23	S29339 + S29346	RD23	S32599 + S29346
	MCC Conversion Accessory		—	S429341	—	S32606
	CNOMO Conversion Accessory		—	S29342	—	S32602
Door Mounted	Standard black handle	Handle Only	RE10	S29338	RE10	S32598
	Standard Black Handle with:	Two early make switches	RE13	S29338 + S29345	RE13	S32598 + S32605
	Red handle on yellow bezel	Handle Only	RE20	S29340	RE20	S32600
Telescoping			RT10	S29343	RT10	S32603
Accessories	Key lock adapter		—	S429344	—	S32604
	Key locks	Ronis 1351.500	—	S41940	—	S41940
		Profalux KS5 B24 D4Z	—	S42888	—	S42888
		2 Ronis keylocks with 1 key	—	S41950	—	S41950
		2 Profalux keylocks with 1 key	—	S42878	—	S42878
	Indication Auxiliary Switch	One early-break switch	—	S29345	—	S32605
		Two early-make switches	—	S29346	—	S29346

Class 9421 NEMA Door Mounted Rotary Operating Handles

Installation	The extended rotary operating handle is made up of: • A mounting plate that provides a rotary actuator for a standard toggle circuit breaker • Handle assemblies available for NEMA 3, 3R, 4, and 4X • Available in standard or short (3 in.) handle assemblies
Operation	The door mounted operating handle makes it possible to operate circuit breakers installed in enclosure from the front. Provides ON (I) and OFF (O) indication The circuit breaker may be locked in the off position
Shaft Length	The shaft length is the distance between the back of the circuit breaker and the door: • Minimum mounting depth is 5.5 in. (138 mm) • Maximum mounting depth is 10.75 in. (273 mm) with standard shaft • Maximum mounting depth is 21.3 in. (543 mm) with long shaft

H- and J-Frame Class 9421 Door-Mounted Operating Mechanism

Description	Catalog No.
Standard Shaft Kit	**9421LJ1**
Long Shaft Kit	**9421LJ4**

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PowerPact™ H-, J-, and L-Frame Circuit Breakers
Accessories and Auxiliaries

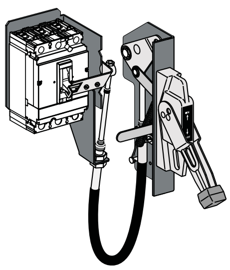
Table 90: H- and J-Frame Component Parts

Description		Catalog No.
Standard Handle Assembly	Type 1, 3R, 12	**9421LH6**
	NEMA Type 3 and 4, Painted	**9421LH46**
	NEMA Type 3 and 4, Chrome Plated	**9421LC46**
Operating Mechanism	Includes Lockout	**9421LJ7**
Standard Shaft	Support Bracket Not Required	**9421LS8**
Long Shaft	Support Bracket Included	**9421LS13**

Table 91: L-Frame NEMA Door-Mounted Rotary Operated Handles

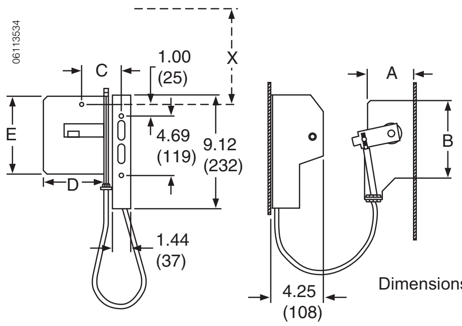
Handle Type	Poles	Operating Mechanism Included in Kit	Mounting Depth Min–Max	Kit Number
Painted 6 in.	3	9421LS8 and 9421LC46	7-1/4 to 12-1/16 in. (184 to 306 mm)	**9421LD1**
		9421LS13 and 9421LH46	7-1/4 to 22-5/8 in. (184 to 575 mm)	**9421LD4**

Class 9422 Cable Operating Handle



Flange-mounted handle cable operating mechanism is for use with Class 9422 Type A handle operators especially designed for tall, deep enclosures where placement flexibility is required.

Applications	• The cable operator maintains: Suitability for isolation Indication of three positions: O (OFF), I (ON) and tripped Access to push-to-test • The circuit breaker may be locked in the off position by one to three padlocks • Door can be locked closed due to interlocking features of the handle operator
Installation	• Handle is mounted on flange of enclosure using specified mounting dimensions while circuit breaker and operating mechanism are mounted to inside of enclosure using two screws • Cable lengths available in 3-, 5- or 10-foot lengths to accommodate a variety of mounting locations Handles are available in painted NEMA 1, 3, 3R, 4 (sheet steel) and 12 ratings or chrome (NEMA 4, 4x)



Refer to NEC Article 430-10 for minimum dimension X from circuit breaker top mounting hole to wall or barrier to ensure adequate wire bending space.

Note: Bend radius in cable must never be less than 6 in. (152 mm). Electrical clearances must be maintained between cable and live electrical parts.

Dimensions: in. [mm]

Table 92: Class 9422 Cable Operating Mechanisms and A1 Handles

Description		H- and J-Frame Kit Number	L-Frame Kit Number
Cable Mechanism Length	36 in. (914 mm)	**9422CSF30**	**9422CSJ30**
	60 in (1524 mm)	**9422CSF50**	**9422CSJ50**
	84 in. (2134 m)	**9422CSF70**	—
	120 in. (3048 mm)	**9422CSF10**	**9422CSJ10**
A1 painted flange handle		—	**9422A1**
Operating Mechanism Only		—	**9422RSI**

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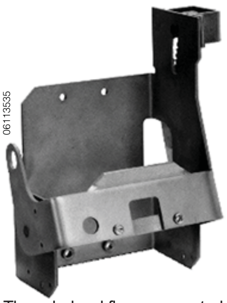
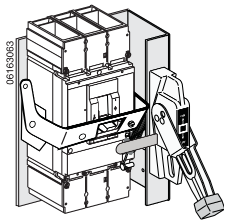
Class 9422 Flange-Mounted Variable-Depth Operating Mechanism



Threaded-rod flange-mounted variable depth operating mechanism

Designed for installation in custom built control enclosures where main or branch circuit protective devices are required.

- All circuit breaker operating mechanisms are suitable for either right- or left-hand flange mounting, convertible on the job.
- H- and J-frame variable mounting depth range: 5.88–17.75 in. (149–451 mm).
- H- and J-frame operating mechanism 9422RQ1 does not include handle mechanism.



Designed for installation in custom-built control enclosures where main or branch circuit protective devices are required. All circuit breaker operating mechanisms are suitable for either right- or left-hand flange mounting, convertible in the field.

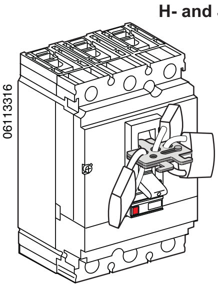
Table 93: L-Frame Flange-Mounted Operating Mechanism

Description	Depth	Kit Number
Variable Depth Mechanism	9.00–17.75 in. (229–451 mm)	**9422RSI**

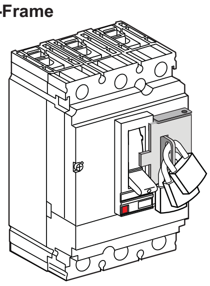
Locking Systems

Padlocking systems can receive up to three padlocks with diameters of 0.19–0.31 in. (5–8 mm); padlocks not supplied.

H- and J-Frame

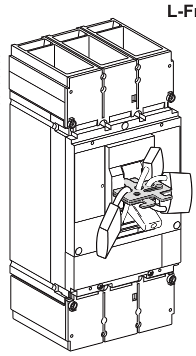


Removable Attachment

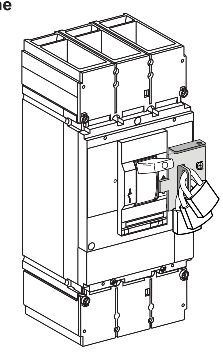


Fixed Padlock Attachment

L-Frame



Removable Attachment



Fixed Padlock Attachment

Table 94: Device Locking, Interlocking Options

Device	Description		Field-Installed Cat. No.	
			H- and J-Frame	L-Frame
Handle Padlocking Device[1]	Removable (lock OFF only)		S29370	S29370
	Fixed (lock OFF or ON)		S29371	S32631
	Fixed (lock OFF only)[2]		S37422	NJPAF
Key Locking	Provision and 2 locks keyed alike	Ronis	—	S41950
		Profalux	—	S42878

1 Rotary handles and motor operators have integral padlocking capability.

2 Not available in HD or HG 2P modules.

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Manual Mechanical Interlocking Systems

Some installations use two power supply sources to counter any temporary loss in the main supply. A mechanical interlocking system is required to safely switch between the two sources. The replacement source can be a generator set or another network.

Managing multiple power sources can be controlled manually by mechanical interlocks.

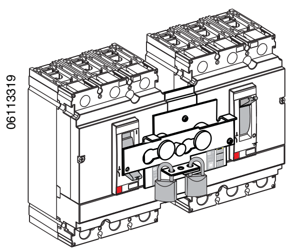
The mechanical interlocking system is made up of:

- two H-, J-, or L-frame devices (circuit breakers or switches) controlled manually
- mechanical interlocking, which prevents handle movement from the Off position while the other device is in the On position.

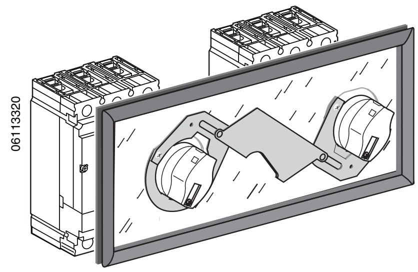
Since it is controlled manually by a maintenance technician, switchover time from the normal source to the replacement source can vary.

Figure 4: Interlocking Systems

H- and J-Frame

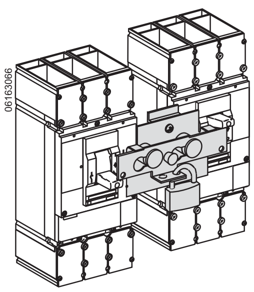


Interlocking with Toggle Control (S29354)

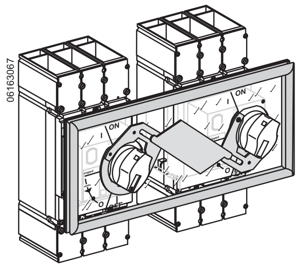


Interlocking with Rotary Handles (S29369)

L-Frame



Interlocking with Toggle Control (S32614)



Interlocking with Rotary Handles (S32621)

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Interlocking of Circuit Breakers With Toggle Control

Two devices can be interlocked using this system. Two identical interlocking systems can be used to interlock three devices installed side by side.

Authorized positions:

- one device closed (ON), the others open (OFF)
- all devices open (OFF)

The system is locked using one or two padlocks (shackle diameter 0.19–0.31 in. [5 to 8 mm]). This system can be expanded to more than three devices.

There are two interlocking-system models:

- one for PowerPact H- and J-frame circuit breakers
- one for PowerPact L-frame circuit breakers

All toggle-controlled unit-mount or plug-in PowerPact H-, J-, and L-frame circuit breakers and automatic switches of the same frame size can be interlocked. The devices must be either all unit-mount or all plug-in versions. Interlocking is not available for I-Line™ constructions.

The toggle interlock system can receive one or two padlocks with diameters of 0.19–0.31 in. (5–8 mm). Both interlocked circuit breakers must be unit-mount or both plug-in. Two sliding interlocking bars can be used to interlock three circuit breakers installed side-by-side, in which case one circuit breaker is in the ON (I) position and the two others in the OFF (O) position. (Kit S29354. Not available for 2P HD and HG devices.)

Interlocking of Two Devices with Rotary Handles

Interlocking involves padlocking the rotary handles on two devices which may be either circuit breakers or automatic switches.

Authorized positions:

- one device closed (ON), the other open (OFF)
- both devices open (OFF).

The system is locked using up to three padlocks (shackle diameter 0.19–0.31 in. [5 to 8 mm]).

There are two interlocking-system models:

- one for PowerPact H- and J-frame circuit breakers
- one for PowerPact L-frame circuit breakers

All rotary-handle unit-mount or plug-in PowerPact H-, J-, and L-frame circuit breakers and automatic switches of the same frame size can be interlocked. The devices must be either all unit-mount or all plug-in versions. Interlocking is not available for I-Line constructions

The rotary handles are padlocked with the devices in the OFF (I) position. The interlock mechanism inhibits the two devices from being closed (ON/I) at the same time, but allows for both devices to be open (OFF/O) simultaneously. (Kit S29369. Not available for 2P HD and HG devices.)

Table 95: Interlocking Accessories

Accessory	Means	Kit Number	
		H-, J-Frame	L-Frame
Interlocking (UL listed)	Mechanical for circuit breakers with rotary handles[1]	S29369	S32621
	Mechanical for circuit breakers with toggles[1]	S29354	S32614

1 Not available in HD or HG 2P modules.

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Interlocking Devices using Keylocks (Captive Keys)

Interlocking using keylocks makes it possible to interlock two or more devices that are physically distant or that have very different characteristics, for example medium-voltage and low-voltage devices or a PowerPact H-, J-, and L-frame circuit breaker and automatic switch.

Each device is equipped with an identical keylock and the key is captive on the closed (ON) device. A single key is available for all devices. It is necessary to first open (OFF position) the device with the key before the key can be withdrawn and used to close another device.

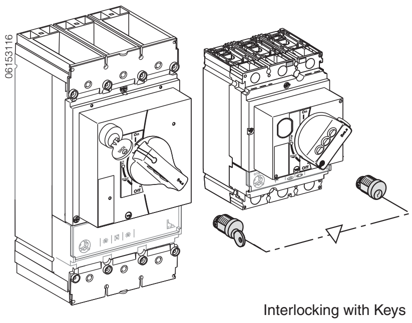
All rotary-handle PowerPact H-, J-, and L-frame circuit breakers and automatic switches can be interlocked between each other or with any other device equipped with the same type of keylock.

For circuit breakers equipped with rotary handles or a motor operator. Interlocking with keys may be easily implemented by equipping each of the circuit breakers, either unit-mount or drawout, with a directly mounted rotary operating handle and a standard keylock, with only one key for the two keylocks. This solution enables interlocking between two circuit breakers that are geographically distant or that have significantly different characteristics.

Use:

- A keylock adapter (one required for each circuit breaker)
- Two identical keylocks with a single key

See Table 89 for more information.



Interlocking with Keys

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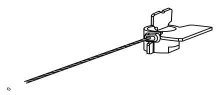
Sealing Accessory



The sealing accessory kits includes the elements required to fit seals to prevent:

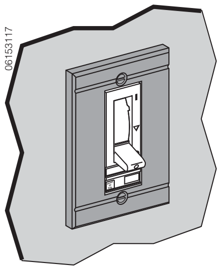
- Front accessory cover removal
- Rotary handle removal
- Opening of the motor operator
- Access to accessories
- Access to trip unit settings
- Access to ground-fault protection settings
- Trip unit removal
- Terminal cover removal
- Access to power connections

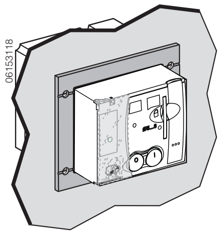
Table 96: Sealing Accessory Kits

Description	Kit No.	Qty.
Trip Unit Sealing Accessory Kit	**MICROTUSEAL**	6
Front Cover Screws Sealing Accessory Kit	**S29375**	6

Front-Panel Escutcheons

- For unit-mount or plug-in installation
- Front-panel escutcheons for toggle handles secures to the panel from the front
- Front-panel escutcheons for motor-operated or rotary-operating handle secures to the panel by four screws from the front





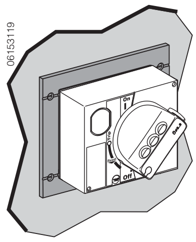


Table 97: Front-Panel Escutcheons

Description	Kit Number	
	H-, J-Frame	L-Frame
Front Panel Escutcheon for Toggle Circuit Breakers	**S29315**	**32556**
Front Panel Escutcheon for Rotary Handle, Motor Operator or Extended Escutcheon	**S29317**	**S32558**

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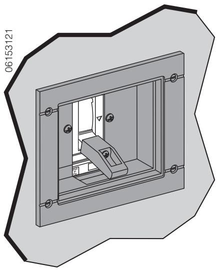
Toggle Collars (For Drawout Mounting)



Toggle collars make it possible to maintain degrees of protection regardless of the circuit breaker position (connected, disconnected):

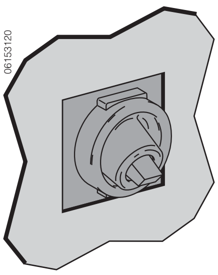
- Front panel escutcheons are required (identical to those for rotary handle and ammeter module)
- Toggle collars are secured by two screws on the circuit breaker
- Front panel escutcheons are secured on the enclosure
- Toggle extension is supplied with the toggle collar

Front panel escutcheons for motor operator and rotary operating handles are the same as for the unit-mount circuit breakers.

Table 98: Toggle Collars

Description	H-, J-Frame Kit Number	L-Frame Kit Number
Toggle Collar	**S29284**	**S32534**

Toggle Boot



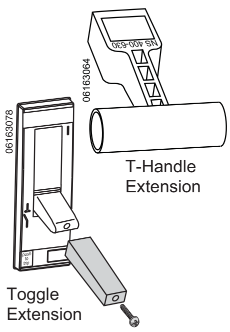
- NEMA 1, 2, 3, 3R protection
- Fits on front of circuit breaker

Table 99: Toggle Boot

Description	Kit Number	
	H-, J-Frame[1]	L-Frame
Toggle Boot	**S29319**	**S32560**

1 Not available for HD and HG 2P modules

Handle Extension



Designed to extend the circuit breaker handle for easier manual circuit breaker operation.

Table 100: Handle Extensions

Description	Qty.	Kit Number	
		H-, J-Frame	L-Frame
T-Handle Extension (Temporary)	1	—	**32595**
Toggle Extension (Fixed)	5	**S29313**	**S432553**

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05/2012
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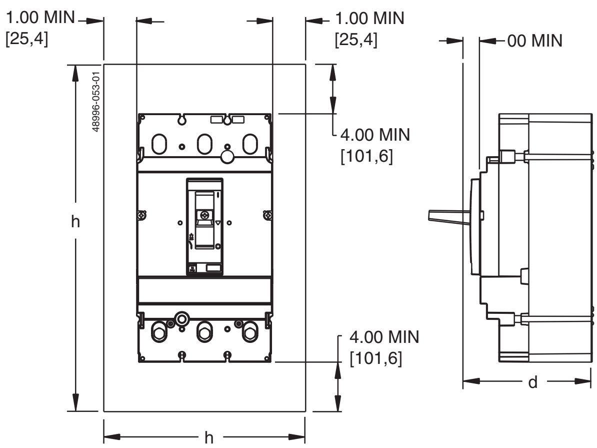
Circuit Breaker Enclosures and Enclosure Accessories

- Square D™ brand circuit breaker enclosures are UL Listed/CSA Certified and are suitable for use as service entrance equipment, except as footnoted.
- The short circuit rating of an enclosed circuit breaker is equal to the rating of the circuit breaker installed, except as footnoted.
- Circuit breakers are ordered and shipped separately for field installation.

Table 101: Enclosure Dimensions



Circuit Breaker	Amperage	Enclosure Dimensions (h x w x d)	
		Standard (80%)	100% Rated
H-Frame	15–150 A	18.13 x 8.63 x 4.13 in. (461 x 219 x 105 mm)	62 x 14 x 22.5 in. (1575 x 356 x 572 mm)
J-Frame	150–250 A	28.5 x 12.38 x 5.38 in. (724 x 314 x 137 mm)	62 x 14 x 22.5 in. (1575 x 356 x 572 mm)
L-Frame	250–600 A	40.5 x 13.75 x 4.33 in. (1030 x 350 x 110 mm)	40.5 x 13.75 x 4.33 in. (1030 x 350 x 110 mm)

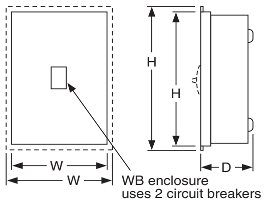
Table 102: Circuit Breaker Enclosure Catalog Numbers

Circuit Breaker			Enclosure Cat. No.				
Cat. No. Prefix	Rating	Poles	NEMA 1 Flush	NEMA 1 Surface	NEMA 3R[1]	NEMA 4, 4X, 5, 3, 3R Stainless Steel	NEMA 12/3R, 5 (Without Knockouts)[2]
HDL,HGL,HJL,HLL	15–150 A	2, 3	J250F	J250S	J250R	J250DS	J250AWK
JDL,JGL,JJL,JLL	150–250 A	2, 3					
HDL	15–100 A	3	—	HD100S[3, 4, 5]	—	—	—
JDL	150–250 A	3	—	JD250S[3, 5, 6]	—	—	—

1 Enclosures with NRB or RB suffix have provisions for 3/4 in. through 2-1/2 in. bolt-on hubs in top endwall. Enclosures with R suffix have blank endwalls and require field cut opening.
2 Suitable for rainproof NEMA 3R application by removing drain screw from bottom endwall.
3 Copper wire only
4 Maximum short circuit current rating is 25 kA, 240 Vac
5 Order service ground kit PKOGTA2 if required.
6 Maximum short circuit current rating is 18 kA, 480 Vac.

Table 103: Dimensions

Cat. No.	Approximate Dimension						
	Series	H		W		D	
HD100S	A01	17.00 in.	431.8 mm	7.90 in.	200.7 mm	4.75 in.	120.7 mm
J250F	A01	32.40 in.	823 mm	15.40 in.	391 mm	6.00 in.	152 mm
J250S	A01	31.36 in.	797 mm	14.36 in.	365 mm	6.00 in.	152 mm
J250R	A01	31.05 in.	789 mm	14.47 in.	368 mm	6.28 in.	160 mm
J250DS	A01	32.26 in.	819 mm	9.72 in.	247 mm	7.94 in.	202 mm
J250AWK	A01	32.26 in.	819 mm	9.72 in.	247 mm	7.94 in.	202 mm



NEMA Type 1

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Table 104: Insulated Grounded Neutral Assembly

Circuit Breaker		Neutral Assembly For Use With		Terminal Lug Data—Total Available (Line plus Load) AWG/kcmil
Cat. No. Prefix	Ampere Rating	NEMA 1 & 3R	NEMA 4, 4X, 5, 12 & 12K	
		Cat. No.	Cat. No.	
HDL,HGL,HJL,HLL	15–100 A	**SN100FA**	**SN100FA**	(4) 14–1/0 Cu or (4) 12–1/0 Al
HDL,HGL,HJL,HLL	125–150 A	**SN400LA**	**SN400LA**	(2) 1–600 or (4) 1–250 Al/Cu, plus (2) 4–300 Al/Cu
JDL,JGL,JJL,JLL	150–250 A	**SN400LA**	**SN400LA**	(2) 1–600 or (4) 1–250 Al/Cu, plus (2) 4–300 Al/Cu

Table 105: Service Ground Kits

Circuit Breaker Cat. No. Prefix	Ground Bar Cat. No.	Number of Terminals	Conductors Per Terminal	Wire Range
HDL,HGL,HJL,HLL, JDL,JGL,JJL,JLL	PKOGTJ250	2	1	6 AWG–300 kcmil Al/Cu

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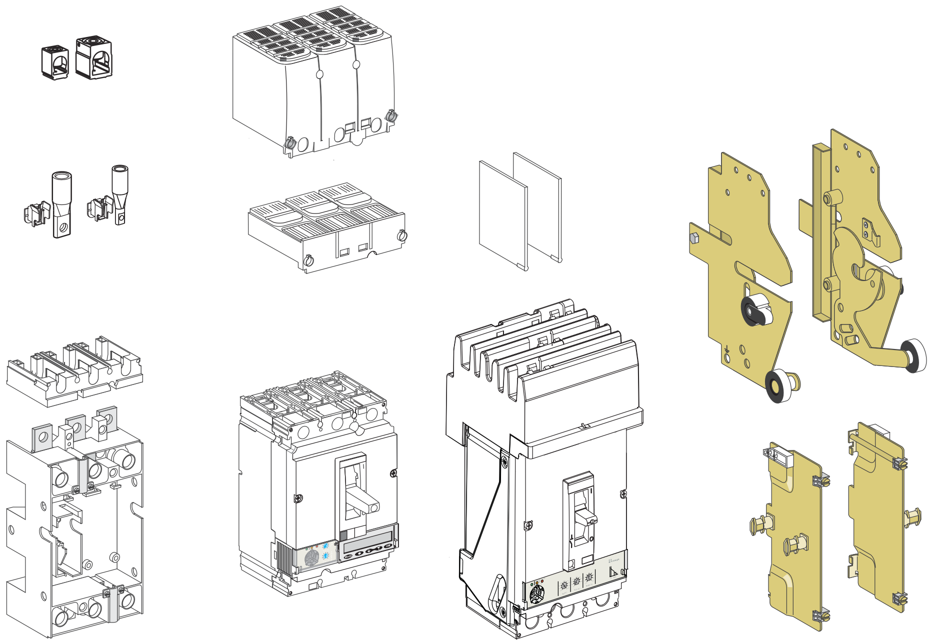
Section 9—Circuit Breaker Mounting and Connections



Mounting Configurations

The PowerPact H-, J-, and L-frame circuit breakers are available in a variety of configurations.

Table 106: Mounting Options

Termination Letter	Poles		Options Code Suffix	
	H-, J-Frame	L-Frame		
A = I-Line™	3 Pole Only	3 Pole Only	For factory-installed terminations, place termination letter in the third block of the circuit breaker catalog number. L G D 3 6 4 0 0 E 2 0 H J 0 0 Termination No. Options Code	(N, and D Terminations Only)
F = Bus Bar	3 Pole Only	3 or 4 Pole		H = Plug-In or Drawout
L = Lugs on Both Ends	3 Pole Only	3 or 4 Pole		J = No Stationary part
M = Lugs ON End	3 Pole Only	3 or 4 Pole		0 = No Switches
P = Lugs OFF End	3 Pole Only	3or 4 Pole		0 = No Shutters
N = Plug-In	3 Pole Only	3 or 4 Pole		
D = Drawout	3 Pole Only	3 or 4 Pole		
S = Rear Connection	3 Pole Only	3 or 4 Pole		

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Refer to circuit breaker installation bulletin before installing circuit breaker, accessories, or wiring.

SQUARE D by Schneider Electric

Unit-Mount Circuit Breakers

The standard lugs can be removed for the installation of compression-type lugs or bus connections. All lugs are UL Listed/CSA Certified for their proper application and marked for use with aluminum and copper (Al/Cu) or copper only (Cu) conductors. Lugs suitable for copper and aluminum conductors are made of tin-plated aluminum.

Mounting

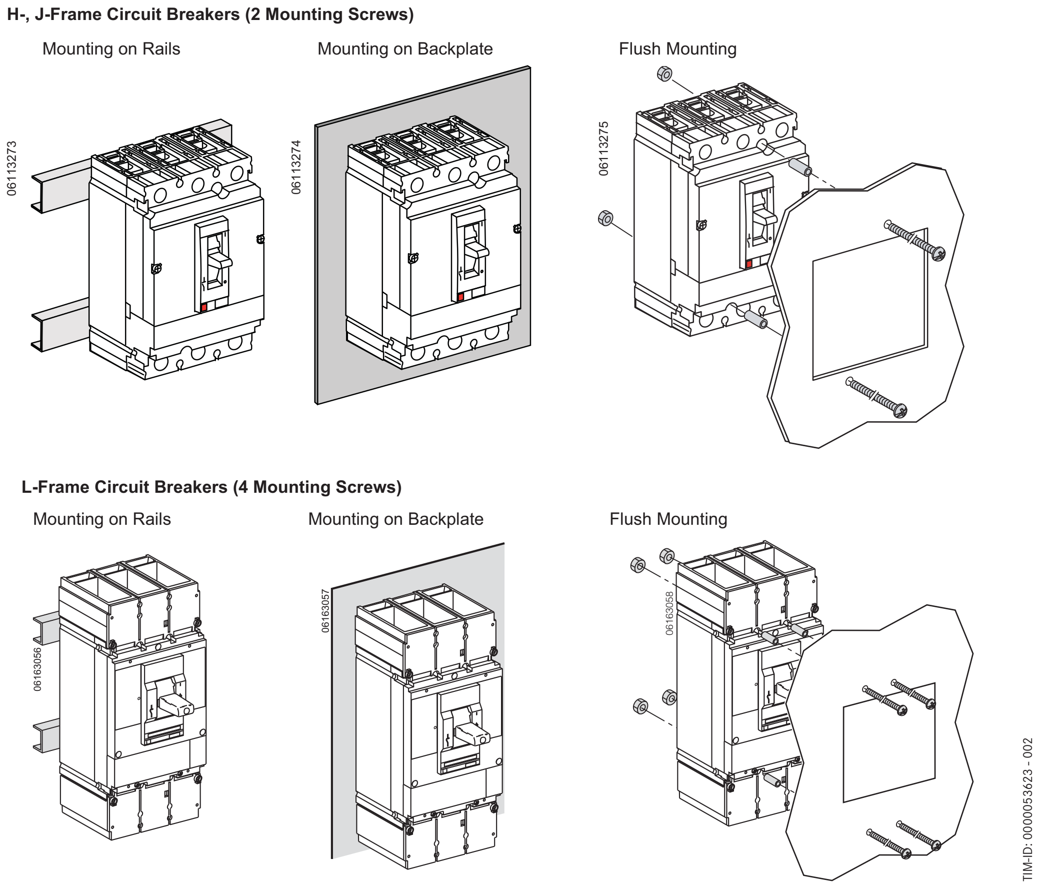
H-, J-, and L-frame circuit breakers may be mounted vertically, horizontally or flat on their back without any derating of characteristics.

Unit-mount H- and J-frame circuit breakers are supplied with two mounting screws, unit-mount L-frame circuit breakers are supplied with four mounting screws. These mounting screws are inserted through mounting holes molded into the circuit breaker case and threaded into the mounting enclosure, rails or through the panel door for flush mounting.

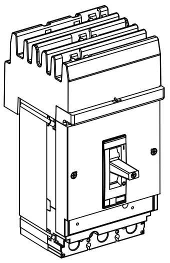
A DIN rail mounting bracket (catalog no. S29305) is available for the H- and J-frame circuit breakers.

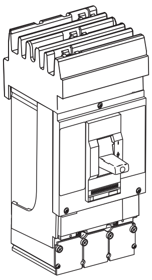
NOTE: DIN rail mounting is not compatible with motor operated applications.

Figure 5: Unit-Mounting Options



I-Line™ Circuit breakers





PowerPact H-, J-, and L-frame circuit breakers are available in I-Line construction for easy installation and removal in I-Line applications.

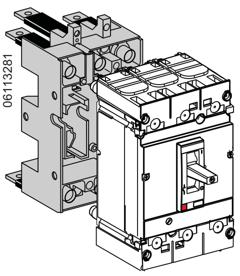
I-Line circuit breakers use “blow-on” type line side connectors. In case of a short circuit, increased magnetic flux causes the plug-on connectors of the circuit breaker to tighten their grasp on the bus bars. The I-Line connectors and circuit breaker mounting bracket are integral parts of I-Line circuit breakers and cannot be removed or replaced. I-Line circuit breakers come with mechanical load side lugs, or optional terminal nut to connect to bus bars or to compression (crimp) lugs.

.

Table 107: Phase Options—Example HDA36150

Phase Option Number	Phase Connection	2P Example	3P Example
1	AB	**HDA261501**	—
2	AC	**HDA261502**	—
3	BA	**HDA261503**	—
4	BC	**HDA261504**	—
5	CA	**HDA261505**	—
6	CB	**HDA261506**	—
Standard	ABC	—	**HDA36150**
6	CBA	—	**HDA361506**

Plug-In Circuit Breaker Mounting



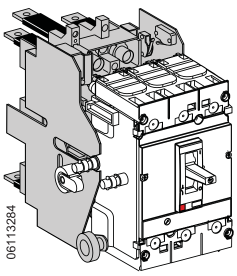
Plug-In Mounting

The plug-in base is mounted through a panel. The plug-in configuration makes it possible to:

- Extract and/or rapidly replace the circuit breaker without having to touch connections
- Allow for addition of future circuits at a later date

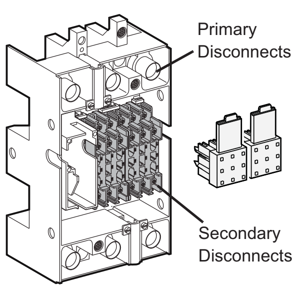
When the circuit breaker is in the connected position, the primary voltage is fed through the circuit breaker by means of multiple finger disconnects. Control voltage of internal accessories is provided through secondary disconnects.

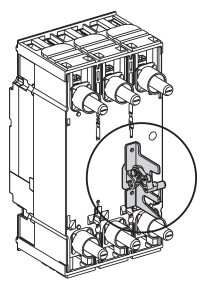
Parts of a Plug-In Configuration



Drawout Mounting

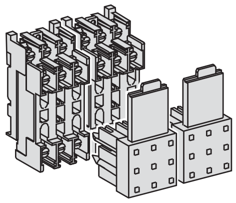
- Plug-in Base: The plug-in base provides mounting through a front panel or mounting on rails.
- Disconnects: Provides both primary and secondary disconnect to the circuit breaker.
- Safety Trip Interlock: The safety trip causes automatic tripping if the circuit breaker is ON before engaging or withdrawing it; the safety trip does not prevent the circuit breaker operation, even when the circuit breaker is disconnected.
- Plug-in Base: The plug-in base provides mounting through a front panel or mounting on rails.
- Mandatory short terminal shields





Safety Trip Interlock Mounted on Back of Circuit Breaker

PowerPact™ H-, J-, and L-Frame Circuit Breakers
Circuit Breaker Mounting and Connections

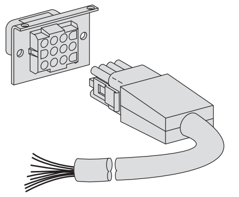


Disconnecting Blocks

Accessory circuits exit the circuit breaker using one to three secondary disconnecting blocks (nine wires each). Circuit breaker connection wires for the options installed with trip unit STR53UP exit through the automatic secondary disconnecting blocks. These are made up of:

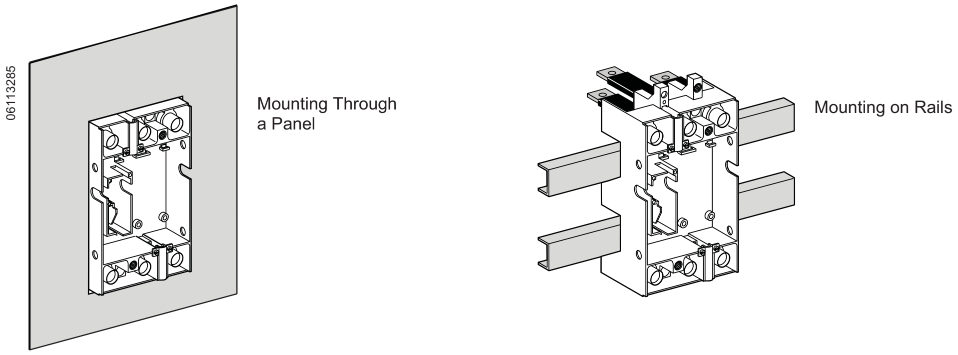
- A moving part connected to the circuit breaker through a support (one support per circuit breaker)
- A fixed part mounted on the plug-in base, equipped with connectors for wire up to 14 AWG (2.5 mm^2)

For test purposes, circuit breakers may be equipped with one to three manual auxiliary connectors, which allow the auxiliaries to remain connected when in the “disconnected” position.



Manual Auxiliary Connector

Figure 6: Plug-In Base (Mounting Options)



The L-frame plug-in mounting is Listed under UL file E113555 and Certified under CSA file LR 69561.

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Drawout Mounting

The cradle is made up of two side plates installed on the plug-in base and two other plates mounted on the circuit breaker.

The drawout mounting provides all of the functions of the plug-in base, plus:

- Disconnected position—the power circuit is disconnected, the circuit breaker is simply withdrawn and may still be operated (on, off, push-to-trip)
- Circuit breaker may be locked using 1 to 3 padlocks, diameter 0.19 to 0.31 inch (5–8 mm), to prevent connection
- Auxiliaries can be tested using manual auxiliary connector

Drawout mounting is on a backplate:

- Through a front panel or on rails
- Horizontally or vertically

Accessories for drawout circuit breakers:

- *Auxiliary indicator contacts indicator contacts* for installation on the fixed part of the cradle, indicating the "connected" and "disconnected" position
- *Toggle collar* for circuit breakers with toggle through front panel, intended to maintain the degree of protections whatever the position of the circuit breakers (supplied with a toggle extension)
- *Keylock* which can be used to
  - — Prevent insertion for connection
  - — Lock the circuit breaker in the connected or disconnected position
- *Telescopic shaft* for extended rotary handles
- *Control voltage,* which is provided through automatic secondary disconnect in the connected position only. Electrical accessories can be tested in the disconnected position with an external wiring harness.

The drawout-mounted cradle is listed under UL file E113555 and certified under CSA file LR69561.

Figure 7: Drawout Mounting Positions

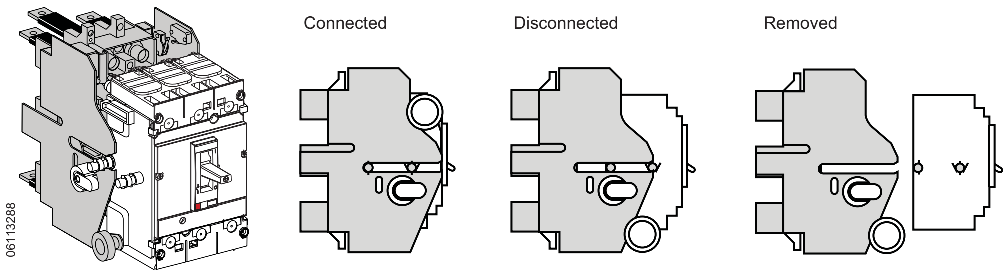

Table 108: Plug-In and Drawout Mountings for H- and J-Frame Circuit Breakers (3P or 2P in a 3P module)

Description			Factory Installed Suffix	Field-Installed Cat. No.
Complete Factory-Assembled Circuit Breakers	Plug-in base shipped with circuit breaker		N	—
	Drawout cradle shipped with circuit breaker		D	—
Special Order Options for Plug-In and Drawout Circuit Breakers	Plug-In Base	Circuit breaker Only	HJ00	
		Plug-in base kit		**S29278**
	Drawout Cradle	Circuit breaker only	HJ00	
		Plug-in base kit		**S29278**
		Cradle side plates (fixed part of chassis)		**S29282**
		Circuit breaker side plates (moving part of chassis)		**S29283**
Accessories for Plug-In and Drawout	H-Frame Shutter Kit (set of two)			**S37442**
	J-Frame Shutter Kit (set of two)			**S37443**
	Secondary Disconnect Blocks	Fixed part 9-wire connector (mounted on base)		**S29273**
		Moving part 9-wire connector (mounted on circuit breaker)		**S29274**
		Support for 2-moving connectors		**S29275**
	Extended escutcheon with extended toggle collar			**S29284**
	Two position indicating switches (connected/disconnected)			**S29287**
	Short Terminal Covers			**29321**

Table 109: Plug-In and Drawout Mountings for L-Frame Circuit Breakers

Description		Poles	Plug-in Mounting			Drawout Mounting		
			Factory Installed Suffix	Field-Installed		Factory Installed Suffix	Field-Installed	
				Qty	Kit. No.		Qty	Kit. No.
Kit (stationary and moving parts)		3	N		—	D		—
		4	N		—	D		—
Stationary Part	Plug-in base	3			**S32514**			**S32514**
		4			**S32515**			**S32515**
	Fixed part of chassis							**S32532**
Moving Part	Circuit breaker only		HJ00			HJ00		
	Moving part of chassis							**S32533**
	Short terminal covers	3		2x[1]	**S32562**		2x[1]	**S32562**
		4		2x[1]	**S32563**		2x[1]	**S32563**

1 Order two of kit.

Handle Escutcheon

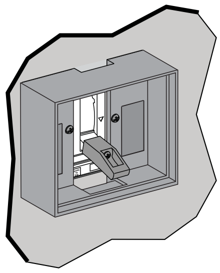

Table 110: Plug-In and Drawout Accessories

Plug-In and Drawout Accessories			Field-Installed Kit No.	
			H-, J-Frame	L-Frame
Secondary Disconnecting Blocks[1]	Fixed Part	9-Wire Connector	**S29273**	**S29273**
	Moving Part	9-Wire Connector	**S29274**	**S32523**
		Support for Moving Connectors	2x[2] **S29275**	3x[3] **S32525**
Manual Auxiliary Connector	9-Wire Connector for Disconnected Operation		—	**S29272**
Shutter	Two Shutters for Plug-In Base		**29271**	**32521**
Classic Accessories	Extended Escutcheon for Toggle Collar		**S29284**	**S32534**
	Locking Device (Key Lock is Not Included)		**S29286**	**S29286**
	Two Position Indicator Contacts (Connected/Disconnected)		**S29287**	**S29287**

1 Included when electrical accessories are factory installed.
2 Order two of kit.
3 Order three of kit.

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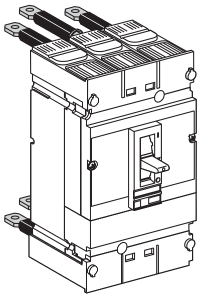
Connection

Rear Connection



For connection of bus bars or cables with compression lugs. Rear connections are easily installed on the circuit breaker terminals. The same connection may be installed flat, edgewise or at a 45° angle. All combinations are possible. The circuit breaker is mounted on a backplate.

One Long and Two Short

Four Positions Possible for Each Connector

Horizontal

Vertical

45° Angle

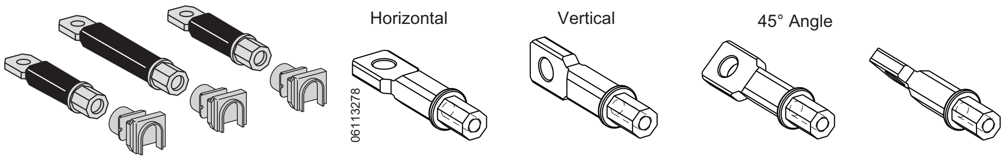


Table 111: Rear Connections

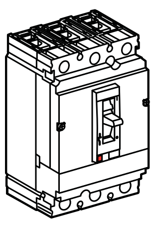
Device	Description	H-Frame Poles	H-Frame Factory-Installed Termination No.	H-Frame Field-Installable Cat. No.	J-Frame Poles	J-Frame Factory-Installed Termination No.	J-Frame Field-Installed Cat. No.	L-Frame Poles	L-Frame Factory-Installed Termination No.	L-Frame Field-Installed Cat. No.
Mixed Rear Connection Kit[1]		2	S	—	2	S	—	3	S	S32477
		3	S	S37432	3	S	S37437	4	S	S32478
Consisting of:	Short rear connections (set of 2)	2 or 3	—	2x[2] S37433	2 or 3	—	2x[2] S37438	3	—	2x[2,3] S432475
	Long rear connections (set of 2)		—	S37434		—	S37439[4]		—	2x[3] S432476
	Short terminal cover (3P)	3	—	S37436	3	—	S37440	3	—	2x[5] S32562
	Short terminal cover (4P)	4	—	—	—	—	—	4	—	2x[5] S32563

1 Kit contains four short rear connections, two long rear connections (four long rear connections for 4P), hardware and two terminal covers.
2 Order two kits (two in kit x two kits for total of four)
3 Parts only, no hardware is included. See Table 112, below.
4 For use with 3P circuit breakers only.
5 Order two kits (kit contains only one terminal cover, two terminal covers are required per circuit breaker).

Table 112: L-Frame Rear Connection Hardware

Description	Cat. No.
Set of 4 M10 x 25 terminal screws and washers for one side.	**S36967**

Mechanical Lugs



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Unit-mount H-, J-, and L-frame circuit breakers can be ordered with mechanical line and load side lugs. The standard lugs can be removed for the installation of compression-type lugs or bus connections. All lugs are UL Listed/CSA Certified for their proper application and marked for use with aluminum and copper (Al/Cu) or copper only (Cu) conductors. Lugs suitable for copper and aluminum conductors are made of tin-plated aluminum. Lugs suitable for use with copper conductors only are made of copper.

Mechanical Lugs for the H- and J-frame circuit breakers lay on top of the circuit breaker terminals and can be installed without the use of any tools. The lugs are held in place with snap features built into the insulating retainer and are secured with the clamp force applied to the wire binding screw.

Mechanical lugs are sold either factory installed or as field installable kits.

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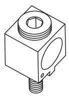
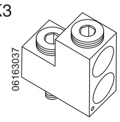
Table 113: Mechanical Lug Kits for H-Frame and J-Frame Circuit Breakers

	Circuit Breaker Application				Number of Wires Per Lug and Wire Range	Kit Cat. No.	Qty Per Kit
	Standard	Ampere Rating	Optional	Ampere Rating			
Al Lugs for Use with Al or Cu Wire	HD, HG, HJ, HL	15–150 A			(1) 14–3/0 AWG Al or Cu	**AL150HD**	3
	JD, JG, JJ, JL	150–175 A			(1) 4-4/0 AWG Al or Cu	**AL175JD**	3
	JD, JG, JJ, JL	200–250 A	JD,JG,JJ,JL	150–175 A	(1) 3/0–350 kcmil Al or Cu	**AL250JD**	3
Cu Lugs for Use with Cu Wire Only			HD,HG,HJ,HL	15–150 A	(1) 14–2/0 AWG Cu	**CU150HD**	3
			JD,JG,JJ,JL	150–250 A	(1) 1/0–300 kcmil Cu	**CU250JD**	3
Control Wire Terminal for H-frame lug kit						**S37423**	2
Control Wire Terminal for J-frame lug kit						**S37424**	2

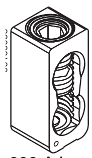
Table 114: Mechanical Lug Kits for L-Frame Circuit Breakers[1]



400 A Lug
AL400L6IK3



600 A Lug
AL600LS52K3



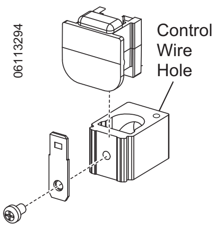
600 A Lug
AL600LF52K3

	Circuit Breaker Application				Number of Wires Per Lug and Wire Range[2]	Kit Cat. No.	Qty Per Kit	Type of Termina l Shield[3]
	Ampere Rating	Poles	Unit Mount	I-Line™				
Al Lugs for Use with Al or Cu Wire	250	3	X	X	(1) 2 AWG–500 kcmil Al	**AL400L61K3**	3	Short
		4	X	—	(1) 2 AWG–600 kcmil Cu	**AL400L61K4**	4	Short
	400/600	3	X	—	(2) 2/0 AWG–500 kcmil Al or Cu	**AL600LS52K3**	3	Medium
		4	X	—		**AL600LS52K4**	4	Medium
	400/600	3	X	X	(2) 3/0 AWG–500 kcmil Al or Cu	**AL600LF52K3**	3	Short
Cu Lugs for Use with Cu Wire Only	250/400	3	X	X	(1) 2 AWG–500 kcmil Al	**CU400L61K3**	3	Short
		4	X	—	(1) 2 AWG–600 kcmil Cu	**CU400L61K4**	4	Short
	400/600	3	X	—	(1) 2/0 AWG–500 kcmil Al or Cu	**CU600LS52K3**	3	Medium
		4	X	—		**CU600LS52K4**	4	Medium
	400/600	3	X	X	(1) 3/0 AWG–500 kcmil Al or Cu	**CU600LF52K3**	3	Short

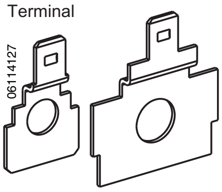
1 For lug pack information, see Figure 31 on page 157.
2 For control wire installation, use an 8-32 x 1/4 in. screw (not provided) into tapped control wire hole in lower left hand corner of lug.
3 For terminal shield dimensions, see Figure 31 on page 157.

Voltage Takeoff (Control Wire Terminals) for Mechanical Lugs and Terminal Nuts

Mechanical Lug Control Wire Terminal



Busbar Control Wire Terminal



Powerpact H- and J-Frame mechanical lugs may be equipped with a separate control wire termination. The kit is available factory installed or as a field installable kit. The adaptor is secured underneath the lug and has a tab extension suitable for attachment of a 0.250 inch slip-on connector.

All L-frame mechanical lugs are pre-tapped for control wires. For control wire installation, use an 8-32 x 1/4 in. screw (not provided) into tapped control wire hole in lower left hand corner of the lug.

Fully insulated type connectors must be used to prevent live parts from extending into the wiring gutter area.

Table 115: Control Wire Terminals

Description	Frame	Cat. No.	Qty Per Kit
Mechanical Lugs			
Control Wire Terminal for H-Frame Lugs	HD/HG/HJ/HL	**S37423**	2
Control Wire Terminal for J-Frame Lugs	JD/JG/JJ/JL	**S37424**	2
Busbar Connection			
Control Wire Terminal for H-Frame Terminal Nut	HD/HG/HJ/HL	**S37429**	2
Control Wire Terminal for J-Frame Terminal Nut	JD/JG/JJ/JL	**S37430**	2
Control Tap takeoff	L-Frame	**29348**	2

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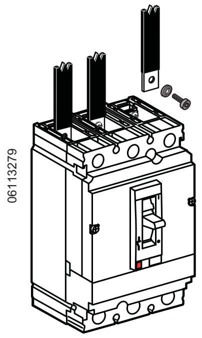
Bus-Bar Connections



The H-, J- and L-frame circuit breakers may be equipped with captive nuts and screws for direct connection to bars or to compression (crimp) lugs

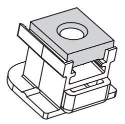
For H- and J-frame, these are readily field-installable, simply by removing the mechanical lug and replacing with the appropriate terminal nut inset described in Table 116. They are also available factory-installed, using the Product Selector or by using the catalog suffixes below.

For L-frame, the mechanical lug can be removed, leaving the threaded nut insert intact. This configuration may be ordered with the suffixes described below. Connection hardware (terminal screws) must be ordered as in table 116.

Table 116: Factory-Installed Terminal Nut Inserts for Bus or Crimp Lug Connection

Cat. No. Termination (Position 4)	Special Terminations Options	Description
F		Terminal nut insert on both ends; no lugs either end
M		Terminal nut insert on OFF end; lugs on ON end only
P		Terminal nut insert on ON end; lugs on OFF end only
A	-TA	I-Line™ on ON end; English terminal nuts on OFF end[1]
A	-TB	I-Line on ON end; Metric terminal nuts on OFF end[1]
F, M, or P	-TW	For -F-, Metric terminal nuts on both ends[1]
F, M, or P	-TX	For -M, lugs on ON end; Metric terminal nuts on OFF end For -P, Metric terminal nuts on ON end; lugs on OFF end

1 For H- and J-frame only. L-frame terminal nuts are metric only.



Terminal Nut Insert

Table 117: Terminal Nuts for Bus Bar Connection of H-Frame and J-Frame Circuit Breakers

Description[1]	Frame	Tap	Cat. No.	Qty Per Kit	Torque
H-Frame Terminal Nut Insert–English	HD/HG/HJ/HL	1/4-20	**S37425**	2	80–90 lb-in (9–10.2 N•m)
H-Frame Terminal Nut Insert–English	HD/HG/HJ/HL	1/4-20	**S37444**	3	
H-Frame Terminal Nut Insert–Metric	HD/HG/HJ/HL	M6	**S37426**	2	
J-Frame Terminal Nut Insert–English	JD/JG/JJ/JL	1/4-20	**S37427**	2	80–90 lb-in (9–10.2 N•m)
J-Frame Terminal Nut Insert–English	JD/JG/JJ/JL	1/4-20	**S37445**	3	
J-Frame Terminal Nut Insert–Metric	JD/JG/JJ/JL	M8	**S37428**	2	

1 Screws not included.

Table 118: Bar Dimensions

Dimension	H-Frame	J-Frame	L-Frame
A	0.250 in. (6.4 mm)	0.3125 in. (7.9 mm)	0.4 in. (10 mm)
B	0.125–0.375 in. (3.2–9.5 mm)	0.125–0.375 in. (3.2–.5 mm)	0.11–0.39 in. (3–10 mm)
C	0.50 in. (12.7 mm)	0.50–0.75 in. (12.7–1.1 mm)	1.35 in. (32 mm)
D	0.3 in. (7.6 mm)	0.625 in. (15.9 mm)	<0.51 in. 13 mm)
E	0.3 in. (7.6 mm)	0.375 in. (9.5 mm)	0.64 in. (16 mm)

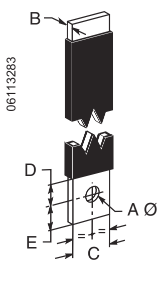


Table 119: L-Frame Bus Bar Connections Hardware

Description	Cat. No.
Set of 4 M10 x 25 terminal screws and washers for one side.	**S36967**

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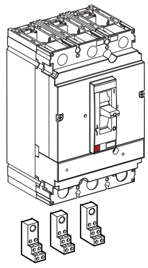
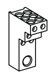
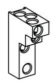
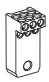
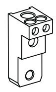
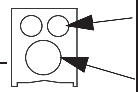
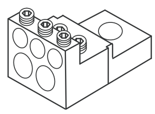
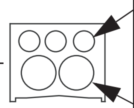
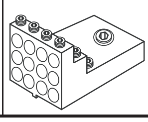
Power Distribution Connectors


06113295

The power distribution connectors (PDC) can be used for multiple load wire connections on one circuit breaker. Use in place of standard distribution blocks to save space and time. Field installable kit includes tin-plated aluminum lug, connectors, and required mounting hardware.

- For use on load end of circuit breaker only
- For use in UL 508 Industrial Control applications
- For use in UL 1995/CSA C22.2 No. 236 heating and cooling equipment
- For copper wire only

Table 120: Power Distribution Connectors

Frame		Kit Number	Qty per Kit	Wires per Terminal	Wire Range	Wire Binding Screw Torque
H-Frame	06113296 	**PDC6HD6**	1	6	8–6 AWG (10–16 mm2)	25 lb-in (2.8 N•m)
					14–10 AWG (2.5–6 mm2)	20 lb-in (2.3 N•m)
	06113297 	**PDC3HD2**	1	3	2 AWG (35 mm2)	40 lb-in (4.5 N•m)
					14–3 AWG (2.5–35 mm2)	35 lb-in (4.0 N•m)
J-Frame	06113298 	**PDC6JD4**	1	6	8–4 AWG (10–25 mm2)	35 lb-in (4.0 N•m)
					14–10 AWG (2.5–6 mm2)	20 lb-in (2.3 N•m)
	06113299 	**PDC3JD20**	1	3 total 2 	14–6 AWG Cu (2.5–16 mm2) or 4–1 AWG Cu (25–50 mm2)	35 lb-in (4.0 N•m) 40 lb-in (4.5 N•m)
				and 1	3–2/0 AWG Cu (35–70 mm2)	50 lb-in (5.6 N•m)
L-Frame		**PDC5DG20L3** [1]	3	5 total 3 	4–1 AWG (25–50 mm2) or 14–6 AWG (2.5–16 mm2)	40 lb-in (4.5 N•m) 35 lb-in (4.0 N•m)
				and 2	3–2/0 AWG (35–70 mm2)	50 lb-in (5.6 N•m)
		**PDC12DG4L3** [1]	3	12	8–4 AWG (10–25 mm2)	35 lb-in (4.0 N•m)
					14–10 AWG (2.5–6 mm2)	20 lb-in (2.3 N•m)

[1] Kit includes terminal shield.

See Table 123 for the phase barriers for power distribution connectors.

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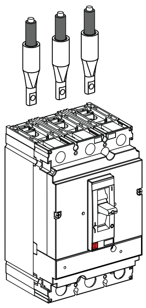
Compression Lugs


06113300

Both copper and aluminum compression lug kits are available for the H-, J-, and L-frame circuit breakers. Each kit contains required insulators and all mounting hardware. Compression lugs require the long lug cover pack, see Figure 31 on page 157.

Table 121: Compression Lug Kits for Al/Cu Connectors

Circuit Breaker	Lug Kit	Rating @ 75 C		Poles	Wires per Lug	Wire Range	Lugs per Terminal	Lugs per Kit
		Al	Cu					
Al/Cu Connectors								
H-Frame	**YA060HD**	≤ 60 A	≤ 60 A	3	1	6–2 AWG Cu or Al (16–35 mm^2)	1	3
	YA150HD	≤ 150 A	≤ 150 A	3	1	1/0–4/0 AWG Cu or Al (50–95 mm^2)	1	3
J-Frame	**YA150JD**	≤ 200 A	≤ 200 A	3	1	1–3/0 AWG Cu or Al (50–95 mm^2)	2	3
	YA250J35	≤ 250 A	≤ 250 A	3	1	3/0 AWG–350 kcmil Cu or Al (95–185 mm^2)	2	3
L-Frame	**YA400L31K3**	230 A	285 A	3	1	4-300 kcmil Al/Cu (25–150 mm^2)	1	3
	YA600L32K3	460 A	570 A	3	2	4-300 kcmil A/Cu (25–150 mm^2)	2	6
	YA400L51K3	310 A	380 A	3	1	2/0-500 kcmil A/Cu (70–240 mm^2)	1	3
	YA600L52K3	620 A	760 A	3	2	2/0-500 kcmil Al/Cu (70–240 mm^2)	2	6
	YA400L71K3	385 A	475 A	3	1	500-750 kcmil A (240–400 mm^2)l 500 kcmil Cu (240 mm^2)	1	3
	YA600L32K4	460 A	570 A	4	2	4-300 kcmil A/Cu (25–150 mm^2)	1	8
	YA400L51K4	310 A	380 A	4	1	2/0-500 kcmil Al/Cu (70–240 mm^2)	2	4
	YA600L52K4	620 A	760 A	4	2	2/0-500 kcmil Al/Cu (70–240 mm^2)	1	8
	YA400L71K4	385 A	475 A	4	1	500-750 kcmil Al (240–400 mm^2) 500 kcmil Cu (240 mm^2)	2	4

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Table 122: Compression Lug Kits for Cu Connectors

Circuit Breaker	Lug Kit	Rating @ 75 C		Poles	Wires per Lug	Wire Range	Lugs per Terminal	Lugs per Kit
		Al	Cu					
H-Frame	**CYA060HD**	—	≤ 60 A	3	1	6–1/0 AWG Cu (16–50 mm^2)	1	3
	CYA150HD	—	≤ 150 A	3	1	4–2/0 AWG Cu (25–70 mm^2)	1	3
J-Frame	**CYA150JD**	—	≤ 150 A	3	1	4–2/0 AWG Cu (25–70 mm^2)	2	3
	CYA250J3	—	≤ 250 A	3	1	2/0 AWG–300 kcmil Cu (70–185 mm^2)	2	3
L-Frame	**CYA400L31K3**	—	285 A	3	1	2/0-300 kcmil Cu (70–150 mm^2)	1	3
	CYA600L32K3	—	570 A	3	2	2/0-300 kcmil Cu (70–150 mm^2)	2	6
	CYA400L51K3	—	380A	3	1	250-500 kcmil Cu (150–240 mm^2)	1	3
	CYA600L52K3	—	760A	3	2	250-500 kcmil Cu (150–240 mm^2)	2	6
	CYA400L71K3	—	475 A	3	1	500-750 kcmil Al (240–400 mm^2) 500 kcmil Cu (240 mm^2)	1	3
	CYA400L31K4	—	285A	4	1	2/0-300 kcmil Cu (70–150 mm^2)	1	4
	CYA600L32K4	—	570 A	4	2	2/0-300 kcmil Cu (70–150 mm^2)	2	8
	CYA400L51K4	—	380 A	4	1	250-500 kcmil Cu (150–240 mm^2)	1	4
	CYA600L52K4	—	760 A	4	2	250-500 kcmil Cu (150–240 mm^2)	2	8

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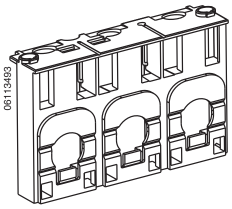
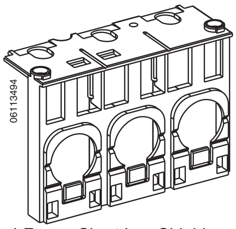
Terminal Shields



H-Frame Short Lug Shield



J-Frame Short Lug Shield

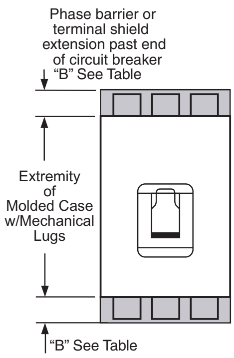


Table 123: Terminal Shields and Phase Barriers

Used With	Description				Dimension B (in.)	Cat. No.	Qty Per Kit
H- and J-Frame Mechanical Lugs	Short Lug Shield	Frame	Max. Wire Size				
		H-Frame 60 A	3 AWG		0.50	S37446	1
		H-Frame 150 A	3/0 AWG		0.50	S37447	1
		J-Frame	350 kcmil		0.24	S37448	1
H- and J-Frame Power Distribution Connectors and Compression Lugs		Compatible with:					
		PDC	Compression Lugs				
			Aluminum	Copper			
	H-Frame Long Lug Shield	PDC6HD6	YA060HD	CYA060HD	2.24	S37449	1
		PDC3HD2	YA150HD	CYA150HD			
	J-Frame Long Lug Shield	PDC6JD4	YA150JD	CYA150JD	1.68	S37450	1
		PDC3JD2		CYA250J3			

NOTE: L-frame terminal shields are shipped with the mechanical lug kits, see Table 114.

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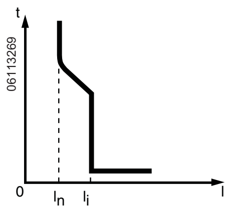
Section 10—Installation Recommendations

Operating conditions

Temperature Derating

- PowerPact H-, J-, and L-frame circuit breakers may be used between -13°F and 158°F (-25 °C and +70 °C). For temperatures higher than 104° F (40° C°) inside the enclosure, devices must be derated.
- Circuit breakers should be put into service under normal ambient, operating-temperature conditions.
- The permissible storage-temperature range for PowerPact H-, J-, and L-frame circuit breakers in the original packing is -58°F[1] and 185°F (-50 °C[1] and +85 °C).



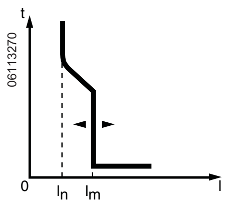
H-Frame Trip Curve

(I_n) Fixed threshold thermal protection against overload
(I_i) **Fixed** threshold instantaneous protection against short circuits

Table 124: Temperature Derating for H-Frame Trip Unit Thermal Protection—Long-Time

Temperature[1]		Rating (A) I_n															
°C	°F																
-10	14	23	30	38	46	53	60	68	76	88	103	112	123	137	160	180	221
0	32	21	28	36	43	49	56	63	71	83	97	107	117	131	151	171	207
10	50	20	26	33	40	46	52	59	66	77	90	101	111	126	141	161	194
20	68	18	24	31	37	42	48	54	62	72	84	96	105	120	132	152	180
30	86	17	22	28	34	39	44	50	56	66	77	88	98	110	121	139	165
40	104	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**125**	**150**
50	122	12	17	21	25	30	34	38	43	53	62	72	80	86	95	109	131
60	140	9	14	17	20	24	28	31	35	46	53	63	70	72	80	93	111

1 Shaded areas indicate temperature rerated values, non-shaded areas inside an enclosure are standard circuit breaker ampere ratings at 104° F (40° C°).



J-Frame Trip Unit

(I_n) Fixed threshold thermal protection against overload
(I_m) Adjustable instantaneous protection against short circuits

Table 125: Temperature Derating for J-Frame Trip Unit Thermal Protection—Long-Time

Temperature[1]		Rating (A) I_n				
°C	°F					
-10	14	221	264	289	330	377
0	32	207	247	273	310	354
10	50	194	230	256	290	330
20	68	180	213	240	270	307
30	86	165	194	220	248	279
40	104	**150**	**175**	**200**	**225**	**250**
50	122	131	150	176	193	214
60	140	111	124	151	160	177

1 Shaded areas indicate temperature rerated values, non-shaded areas are standard circuit breaker ampere ratings at 104° F (40° C°).

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1 -40°F (-40 °C) for Micrologic™ trip units with an LCD screen.

PowerPact H-, J- and L-Frame Circuit Breakers Equipped with Electronic Trip Units

Electronic trip units are not affected by variations in temperature. If the trip units are used in high-temperature environments, the Micrologic™ trip unit setting must nevertheless take into account the temperature limits of the circuit breaker.

Changes in temperature do not affect measurements by electronic trip units.

- The built-in CT sensors with Rogowski coils measure the current.
- The control electronics compare the value of the current to the settings defined for 104°F (40°C).

Because temperature has no effect on the CT measurements, the tripping thresholds do not need to be modified.

However, the temperature rise caused by the flow of current combined with the ambient temperature increases the temperature of the device. To avoid reaching the thermal withstand value, it is necessary to limit the current flowing through the device, that is the maximum I_r setting as a function of the temperature.

The table below indicates the maximum long-time (LT) protection setting I_r (A) depending on the ambient temperature.

Table 126: Derating Circuit Breakers with Micrologic Trip Units

Type of Device	Rating	Temperature						
		104°F (40°C)	113°F (45°C)	122°F (50°C)	131°F (55°C)	140°F (60°C)	149°F (65°C)	158°F (70°C)
H-Frame								
Unit-mount, plug-in or drawout	60 A	No derating						
	100 A	No derating						
	150 A	No derating						
J-Frame								
Unit-mount	250	250	250	250	245	237	230	225
Plug-in or drawout	250	250	245	237	230	225	220	215
L-Frame								
Unit-mount	400	400	400	400	390	380	370	360
Plug-in or drawout	400	400	390	380	370	360	350	340
Unit-mount	600	600	600	600	585	570	550	535
Plug-in or drawout	600	570	550	535	520	505	490	475

Example. A unit-mount PowerPact L-frame circuit breaker equipped with a Micrologic can have a maximum I_r setting of:

- 400 A up to 122°F (50 °C)
- 380 A up to 140°F (60 °C)

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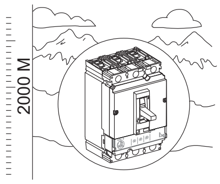
Altitude derating



Altitude does not significantly affect the characteristics of PowerPact H-, J-, and L-frame circuit breakers circuit breakers up to 6560 ft (2000 m). Above this altitude, it is necessary to take into account the decrease in the dielectric strength and cooling capacity of air.

The following table gives the corrections to be applied for altitudes above 6560 ft (2000 m). The breaking capacities remain unchanged.

Table 127: Altitude Derating

Altitude		6560 ft (2000 m)	9840 ft (3000 m)	13120 ft (4000 m)	16400 ft (5000 m)
Dielectric withstand voltage		3000 V	2500 V	2100 V	1800 V
Insulation voltage	V_i	800 V	700 V	600 V	500 V
Maximum operational voltage	V_e	690 V	590 V	520 V	460 V
Average current capacity (A) at 104°F (40°C)	I_n x	1 0.	0.96	0.93	0.9

400 Hz Derating

Application of H- and J-frame circuit breakers at frequencies above 60 Hz requires that special consideration be given to the effects of high frequency on the circuit breaker characteristics. Thermal and instantaneous operations must be treated separately.

At frequencies below 60 Hz, the thermal derating of PowerPact H and J-frame circuit breakers is negligible. However, at frequencies above 60 Hz, thermal derating is required.

One of the most common high frequency applications is at 400 Hz.

Table 128: 400 Hz Derating

Circuit Breaker	400 Hz Derating Multiplier
H-Frame	0.95
J-Frame	0.90
L-Frame, 400 A	0.80
L-Frame, 600 A	0.65

For more information, refer to Data Bulletin 0100DB0101, *Determining Current Carrying Capacity in Special Applications*.

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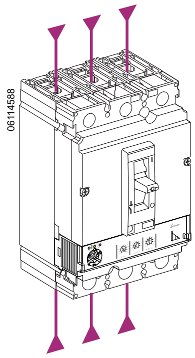
Installation in Equipment

Power from the Top or Bottom



PowerPact H-, J-, and L-frame circuit breakers with factory-sealed trip units can be supplied from either the top or the bottom without any reduction in performance. This capability facilitates connection when installed in end-use equipment.

All connection and insulation accessories can be used on circuit breakers supplied either from the top or bottom.

Weight

The table below presents the weights of the circuit breakers and the main accessories, which must be summed to obtain the total weight. The values are valid for all performance categories.

Table 129: Weights

Type of Device		Circuit Breakers	Base	Cradle	Motor Operator
H-frame, 100 A	2P	3.95 lb (1.79 kg)	1.75 lb (0.8 kg)	4.85 lb (2.2 kg)	2.65 lb (1.2 kg)
	3P	4.52 lb (2.05 kg)	1.75 lb (0.8 kg)	4.85 lb (2.2 kg)	2.65 lb (1.2 kg)
H-frame, 150 A	2P	4.08 lb (1.85 kg)	1.75 lb (0.8 kg)	4.85 lb (2.2 kg)	2.65 lb (1.2 kg)
	3P	4.85 lb (2.2 kg)	1.75 lb (0.8 kg)	4.85 lb (2.2 kg)	2.65 lb (1.2 kg)
J-frame, 250 A	3P	5.29 lb (2.4 kg)	1.75 lb (0.8 kg)	4.85 lb (2.2 kg)	2.65 lb (1.2 kg)
L-frame, 600 A	3P	13.65 lb (6.19 kg)	5.29 lb (2.4 kg)	4.85 lb (2.2 kg)	6.17 lb (2.8 kg)
	4P	17.92 lb (8.13 kg)	6.17 lb (2.8 kg)	4.85 lb (2.2 kg)	6.17 lb (2.8 kg)

Safety Clearances and Minimum Distances

General Rules

When installing a circuit breaker, minimum distances (safety clearances) must be maintained between the device and panels, bars and other protection devices installed nearby. These distances, which depend on the voltage, are defined by tests carried out in accordance with UL standards.

If installation is not checked by type tests, it is also necessary to:

- use insulated bars for circuit-breaker connections
- segregate the busbars using phase barriers

For PowerPact H-, J-, and L-frame devices, terminal shields and interphase barriers are recommended and may be mandatory depending on the operating voltage of the device and type of installation (unit-mount, drawout, etc.).

Power Connections

The table below indicates the connection requirements for PowerPact H-, J-, and L-frame devices to ensure insulation of live parts for the various types of connection.

- unit-mount devices with front connection or rear connection
- plug-in or drawout devices.

Connection accessories such as crimp lugs, terminal extensions (straight, right-angle, double-L and 45°) and spreaders are supplied with interphase barriers. Long terminal shields provide a degree of protection of IP40 (ingress).

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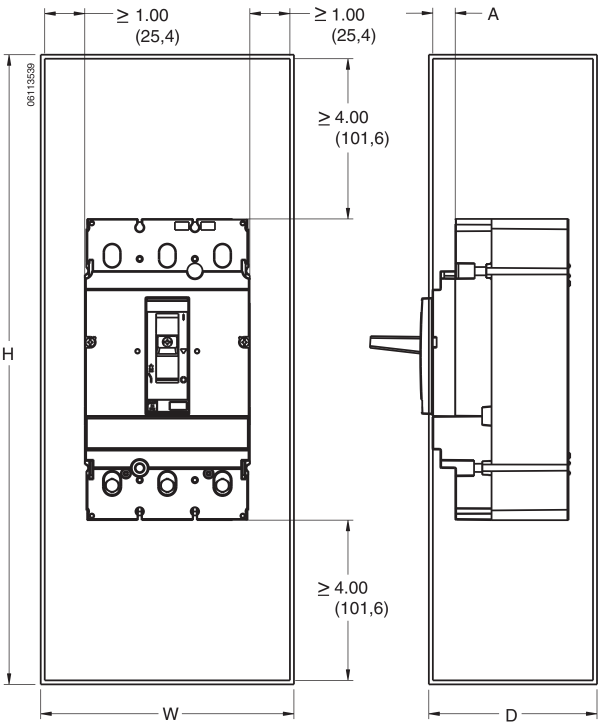
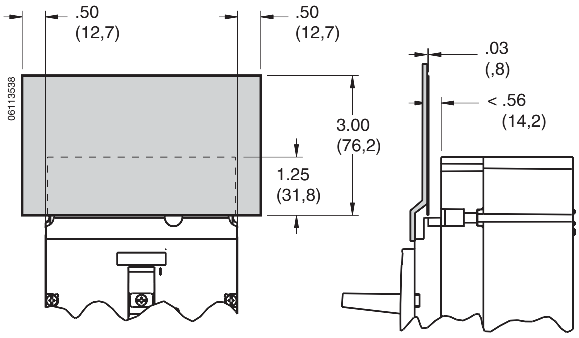
Safety Clearance

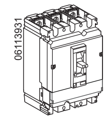
H- and J-Frame Safety Clearances

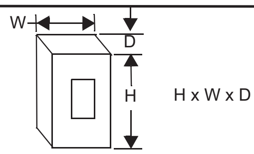


Fiber Insulating Plate



Enclosure Dimensions





		Standard (80%) Rated	100% Rated
HD/HG/ HJ/HL	15–150 A	18.13 x 8.63 x 4.13 in. (461 x 219 x 105 mm)	62 x 22.5 x14 in. (572 x 1575 x 356 mm)
JD/JG/ JJ/JL	150–250 A	28.5 x 12.38 x 5.38 in. (724 x 314 x 137 mm)	62 x 22.5 x14 in. (572 x 1575 x 356 mm)

If dimension A < 0.56 in., attach fiber insulating plate, not provided, to enclosure cover.

Table 130: Minimum Safety Clearances

Operating Voltage	Clearance						
	Between Devices	Between Device and Sheet Metal					
		Painted Sheet Metal			Bare Sheet Metal		
V ≤ 440 V for devices equipped with:							
• No accessories	0	0	30	30	5	40	40
• Interphase barriers	0	0	0	0	0	0	0
• Long terminal shields	0	0	0	0	0	0	0
440 < V ≤ 600 for devices equipped with:							
• Interphase barriers[1]	0	0	0	0	20	10	10
• Long terminal shields	0	0	0	0	10	10	10
V > 600 V for devices equipped with:							
• Long terminal shields	0	10	50	50	20	100	100

[1] Only for J-frame devices

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Clearances with Respect to Live Bare Busbars

Table 131: Minimum Safety Clearances to Bare Busbars

Operating Voltage	Clearances to Live Bare Busbars[1]			
	Spacing ≤ 60 mm		Spacing > 60 mm	
V ≤ 440 V	350	350	80	80
440 V < V ≤ 600 V	350	350	120	120

1 These clearances can be reduced for special installations as long as the configuration is checked by tests.

Control Wiring

Remote Tripping by Undervoltage Trip (MN) or Shunt Trip (MX)

Power requirements are approximately:

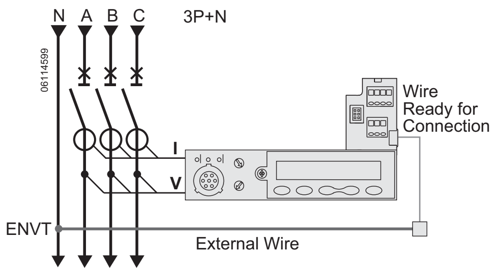
- 30 VA for pick-up of the undervoltage trip (MN) and shunt trip (MX)
- 300–500 VA for the motor operator.

Table 132: Recommended Maximum Cable Lengths[1]

Power Supply Voltage (Vdc)		12 Vdc		24 Vdc		48 Vdc	
Cable cross-section		16 AWG (1.5 mm²)	14 AWG (2.5mm²)	16 AWG (1.5 mm²)	14 AWG (2.5mm²)	16 AWG (1.5 mm²)	14 AWG (2.5mm²)
Undervoltage Trip (MN)	V source 100%	49 ft (15 m)	—	525 ft (160 m)	—	2100 ft (640 m)	—
	V source 85%	23 ft (7 m)	—	131 ft (40 m)	—	525 ft (160 m)	—
Shunt Trip (MX)	V source 100%	197 ft (60 m)	—	787 ft (240 m)	—	3150 ft (960 m)	—
	V source 85%	98 ft (30 m)	—	394 ft (120 m)	—	1575 ft (480 m)	—
Motor Operator	V source 100%		—	33 ft (10 m)	16 m)	213 ft (65 m)	361 ft (110 m)
	V source 85%	—	—	6.6 ft (2 m)	4 m)	56 ft (17 m)	82 ft (25 m)

1 the indicated length is that of each of the two wires.

External Neutral Voltage Tap (ENVT)



External neutral voltage tap (ENVT)

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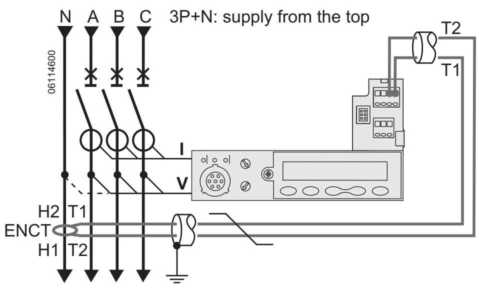
This connection is required for accurate power measurements on 3-pole circuit breakers equipped with Micrologic™ 5 / 6 E trip units in installations with a distributed neutral. It can be used to measure phase-neutral voltages and calculate power using the 3 wattmeter method.

PowerPact H-, J-, and L-frame 3-pole circuit breakers come with a wire installed on the device for the connection to the ENVT. This wire is equipped with a connector for connection to an external wire with:

- cross-sectional area of 18–14 AWG (1 mm² to 2.5 mm²)
- maximum length of 32.8 ft (10 m).

SQUARE D by Schneider Electric

External Neutral Current Transformer (ENCT)



This connection is required to protect the neutral on 3-pole circuit breakers equipped with Micrologic™ 5 / 6 A or E trip units in installations with a distributed neutral. For Micrologic 6 A or E, it is required for ground-fault protection.

The ENCT is connected in the same way for unit-mount, plug-in or drawout devices:

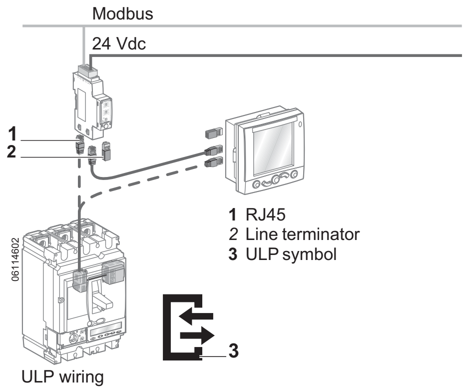
- unit-mount devices are connected using terminals T1 and T2 of the internal terminal block.
- plug-in and drawout devices are not connected using the auxiliary terminals.

The wires must be connected/disconnected inside the devices using terminals T1 and T2.

The ENCT must be connected to the Micrologic trip unit by a shielded twisted pair. The shielding should be connected to the enclosure earth only at the CT end, no more than 12 in. (30 cm) from the CT.

- the power connections of the CT to the neutral (H2 and H1) must be made in the same way for power supply from the top or the bottom (see figure). Make sure they are not reversed for devices with power supply from the bottom.
- cross-sectional area of 22–16 AWG (0.4 mm² to 1.5 mm²)
- maximum length of 32.8 ft (10 m).

ULP Connection System Between Micrologic, FDM121 Module and Modbus™ Interface



1 RJ45
2 Line terminator
3 ULP symbol

ULP connection system.

The ULP (Universal Logic Plug) wiring system used by H-, J- and L-frame circuit breakers for connection through the Modbus network requires neither tools nor settings. The prefabricated cables are used for both data transfer and distribution of 24 Vdc power. Connectors on each component are identified by ULP symbols, ensuring total compatibility between each component.

A line terminator must be fitted to all components with an unused RJ45 connector.

Table 133: Available Cables

Cable	Available Lengths
NSX cord for connection of the internal terminal block to the Modbus interface or the FDM121 display using an RJ45 connector.	4.27 ft (1.3 m)
	9.84 ft (3 m)
ULP cables with RJ45 connectors at each end for the other connections between ULP wiring components For greater distances, two cables can be interconnected using the RJ45 female/ female connector. Maximum length of 32.8 ft (10 m) between 2 modules and 98.4 ft (30 m) in all.	0.98 ft (0.3 m)
	1.97 ft (0.6 m)
	3.28 ft (1 m)
	2.56 ft (2 m)
	9.84 ft (3 m)
	16.4 ft (5 m)

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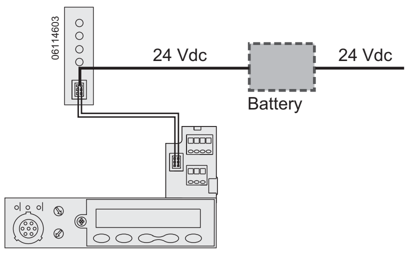
24 Vdc Power Supply Module

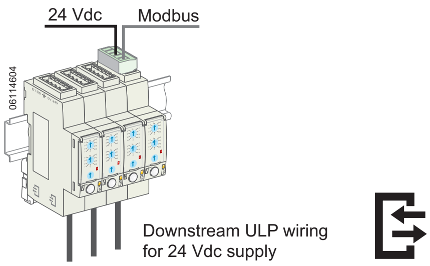
An external 24 Vdc power supply is required for installations with communication networks, regardless of the type of trip unit.

On installations without communication networks, the power supply is available as an option for Micrologic™ 5/6 to:

- modify settings when the circuit breaker is open (OFF position)
- display measurements when the current flowing through the circuit breaker is low
- maintain the display of the cause of tripping



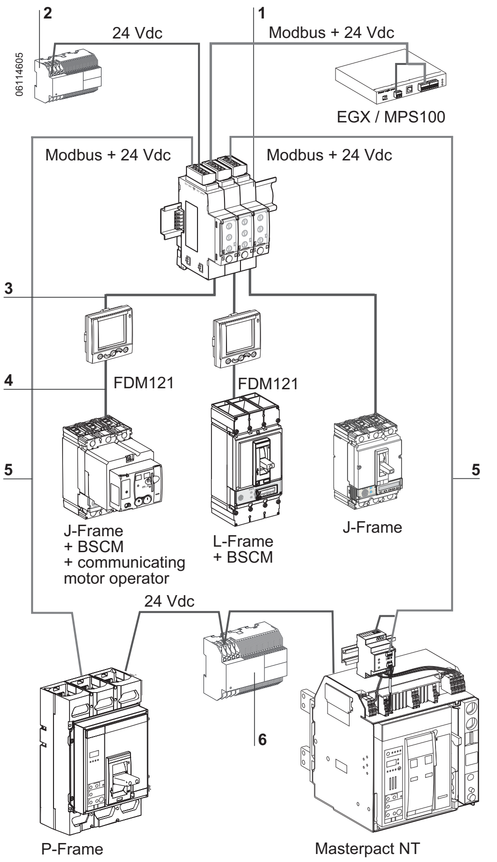
Power supply, without the Communication function, using the terminal block with a backup battery.



Power supply, with the communication function, using the Modbus interface.

To determine power requirements of devices, see page 80.

Wiring



1 Modbus interface module with connection accessory.
2 24 Vdc power supply of Micrologic for Powerpact H-, J-, and L-Frame communication modules.
3 ULP cord.
4 NSX cord.
5 Modbus cable + 24 Vdc part no. 50965 (Schneider Electric) recommended or part no. 7895A (Belden).
6 24 Vdc power supply of Micrologic for PowerPact M-Frame/ Masterpact circuit breakers.

Micrologic™ 5 or 6 Without the Communication Function

The external 24 Vdc supply is connected through the circuit breaker terminal block.

Use of a 24 Vdc battery provides backup power for approximate 3 hours (100 mA) in the event of an interruption in the external supply.

Micrologic 5 or 6 With the Communication Function

The external 24 Vdc supply is connected through the Modbus interface using a five-pin connector, including two for the power supply. Stacking accessories (see page 77) can be used to supply a number of interfaces by fast clip-on connection.

The 24 Vdc power is distributed downstream by the ULP (Universal Logic Plug) communication cables with RJ45 connectors. This system ensures both data transfer and power distribution to the connected modules.

Recommendations for 24 Vdc Wiring

Do not connect the positive terminal to ground

- Do not connect the negative terminal to ground.
- The maximum length for each conductor (+/-) is 33 ft (10 m).
- For connection distances greater than ten metres, the plus and minus conductors of the 24 Vdc supply must be twisted to improve EMC.
- The 24 Vdc conductors must cross the power cables perpendicularly. If this is difficult or impossible, the plus and minus conductors must be twisted.

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Modbus

Each PowerPact H-, J-, and L-frame circuit breaker equipped with Micrologic™ 5/6 and an FDM121 display is connected to the Modbus network using the Modbus com module. Connection of all the circuit breakers and other Modbus devices in the equipment to a Modbus bus is made much easier by using a Modbus RJ45 junction block installed in the equipment.

Recommendations for Modbus Wiring:

- The shielding may be grounded on one end only
- The conductors must be twisted to improve immunity (EMC)
- The Modbus conductors must cross the power cables perpendicularly

Example.

A unit-mount PowerPact L-frame circuit breaker with a Micrologic trip unit can have a maximum I_r setting of:

- 400 A up to 122°F (50 °C)
- 380 A up to 140°F (60 °C)

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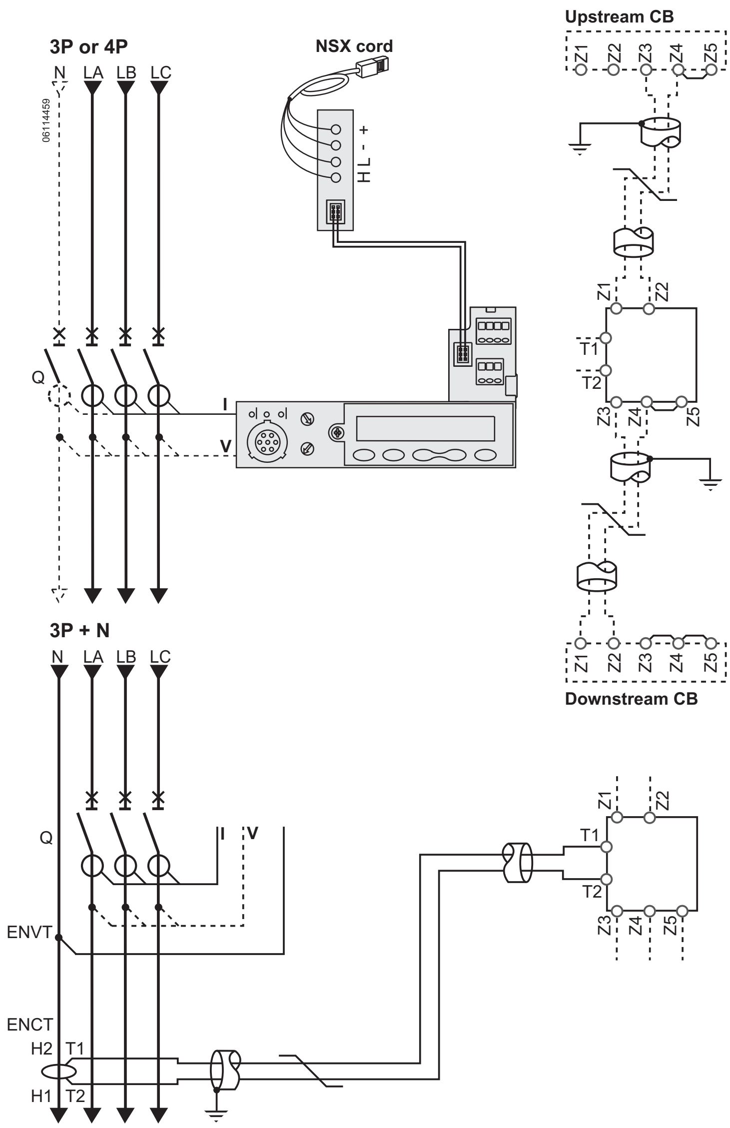
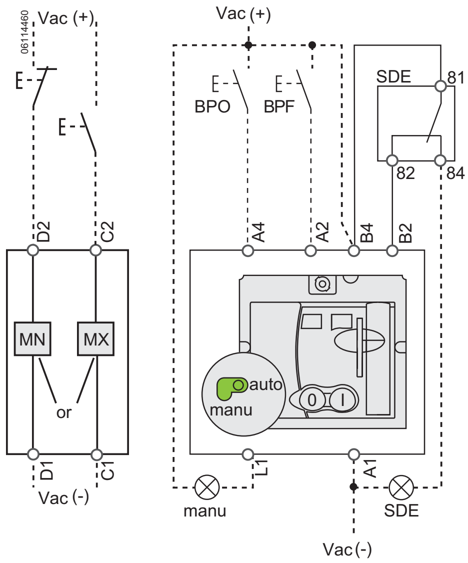
Section 11—Wiring Diagrams

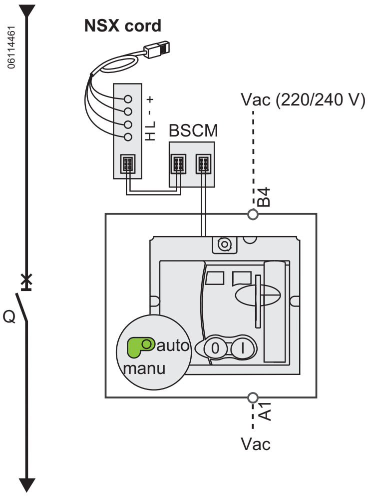
Unit-Mount Circuit Breakers

Power	Micrologic™ Trip Unit[1]	Remote Operation





Motor Operator



Schematic of the communicating motor operator .

Communicating Motor Operator

Continued on next page

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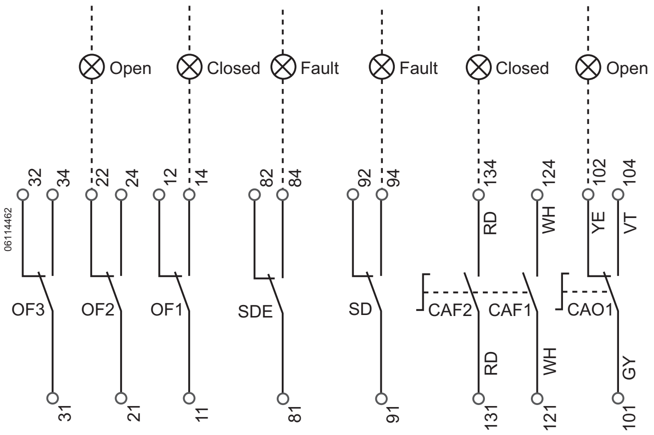
Unit-Mount Circuit Breakers *(continued)*

Indication Contacts



The diagram is shown with circuits de-energized, relays in normal position, and all devices open, connected, and charged.
Terminal connections shown as O must be connected by the customer.

Micrologic™ Trip Unit A or E

A/E	Communication H (WH), L(BL): data -(BK), +(RD): 24 Vdc power supply
A/E	ZSI (Zone Selective Interlocking) Z1: ZSI OUT SOURCE Z2: ZSI OUT Z3: ZSI IN SOURCE Z4: ZSI IN ST (short time) Z5: ZSI IN GF (ground fault) (Z3, Z4, and Z5 for L-frame circuit breaker only)
A/E	ENCT: External Neutral Current Transformer: -Shielded cable with 1 twisted pair (T1, T2) -Shielding earthed at CT end only Connection L = 12 in. (30 cm) max. -Maximum length of 33 ft (10 m) -Cable size of 22 AWG -Recommended cable: Belden 9451SB or equivalent
E	ENVT: External Neutral Voltage Tap for Connection to the Neutral using a 3P Circuit Breaker

Color Code for Auxiliary Wiring

RD: Red	VI: Violet
WH: White	GY: Gray
YE: Yellow	OR: Orange
BK: Black	BL: Blue
GN: Green	

Remote Operation

MN	Undervoltage Release
or	
MX	Shunt Release
Motor Operator	
A4	Opening Order
A2	Closing Order
B4, A1	Power Supply to Motor Operator
L1	Manual Position (manu)
B2	Overcurrent Trip Switch Interlocking (mandatory for correct operation)
BPO	Opening Pushbutton
BPF	Closing Pushbutton
Communicating Motor Operator	
B4, A1	Motor Operator Power Supply
BSCM	Breaker Status and Control Module

Indication Contacts

OF2/OF1	Device ON/OFF Auxiliary Switches
OF3	Device ON/OFF Auxiliary Switches (L-Frame)
SDE	Overcurrent Trip Switch (short-circuit, overload, ground fault, earth leakage)
SD	Alarm Switch
CAF2/CAF1	Early-Make Contact (rotary handle only)
CAO1	Early-Break Contact (rotary handle only)

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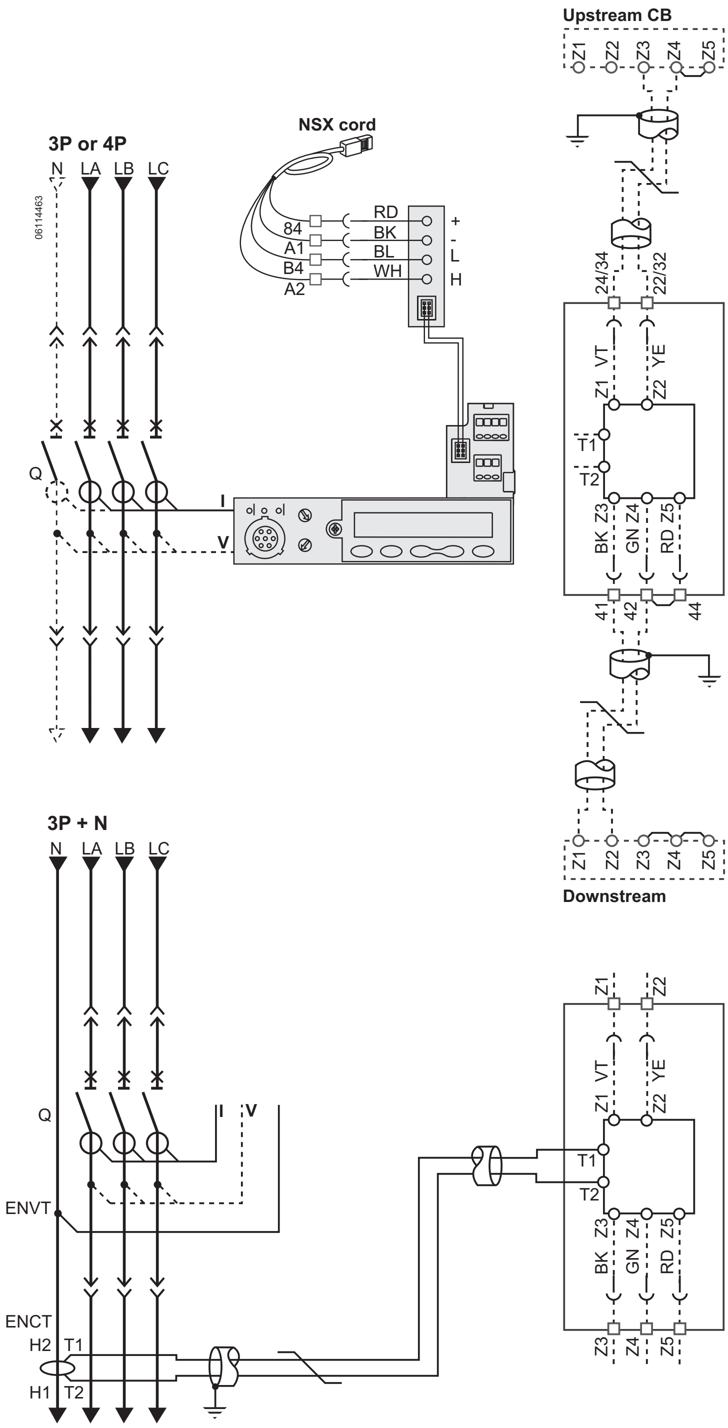
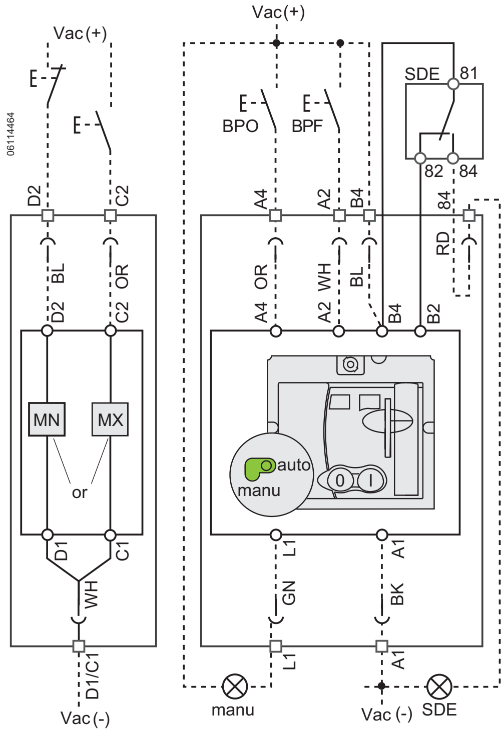
SQUARE D by Schneider Electric

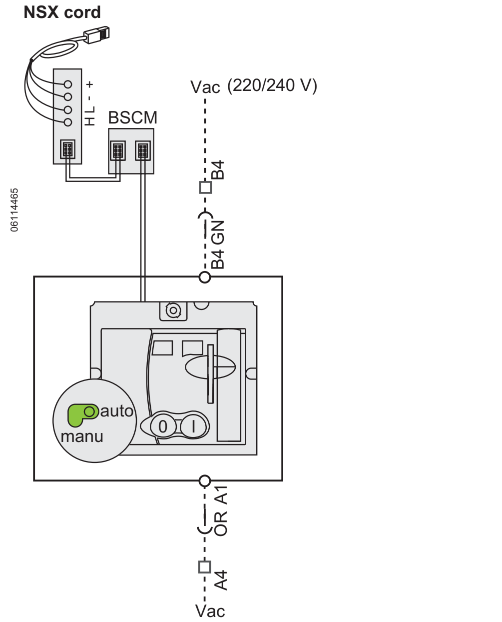
Plug-In and Drawout Circuit Breakers

Power	Micrologic™ Trip Unit[1]	Remote Operation





Motor Operator



Communicating Motor Operator

Continued on next page

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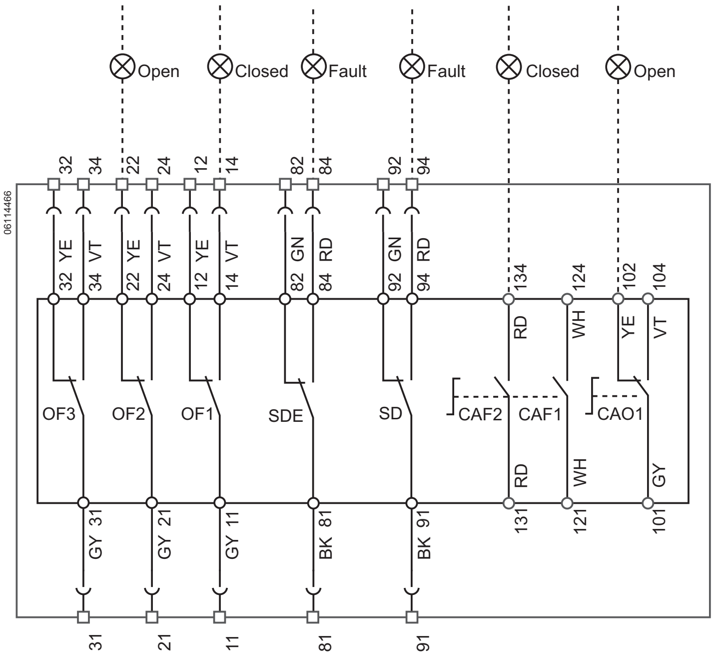
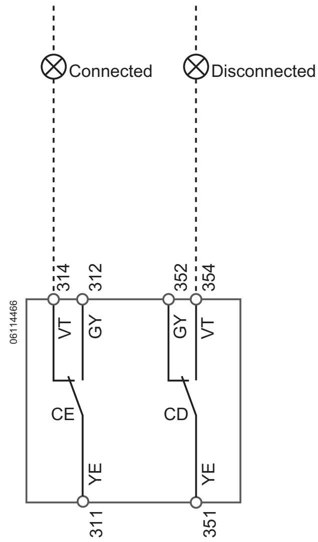
Plug-In and Drawout Circuit Breakers *(continued)*

Indication Contacts	Carriage Switches





The diagram is shown with circuits de-energized, relays in normal position, and all devices open, connected, and charged.

Terminal connections shown as ☐ and O must be connected by the customer.

Micrologic™ Trip Unit A or E	
A/E	Communication H (WH), L(BL): data -(BK), +(RD): 24 Vdc power supply
A/E	ZSI (Zone Selective Interlocking) Z1: ZSI OUT SOURCE Z2: ZSI OUT Z3: ZSI IN SOURCE Z4: ZSI IN ST (short time) Z5: ZSI IN GF (ground fault) (Z3, Z4, and Z5 for L-frame circuit breaker only)
A/E	ENCT: External Neutral Current Transformer: -Shielded cable with 1 twisted pair (T1, T2) -Shielding earthed at CT end only Connection L = 12 in. (30 cm) max. -Maximum length of 33 ft (10 m) -Cable size of 22 AWG -Recommended cable: Belden 9451SB or equivalent
E	ENVT: External Neutral Voltage Tap for Connection to the Neutral using a 3P Circuit Breaker

Color Code for Auxiliary Wiring	
RD: Red	VI: Violet
WH: White	GY: Gray
YE: Yellow	OR: Orange
BK: Black	BL: Blue
GN: Green	

Remote Operation	
MN	Undervoltage Release
or	
MX	Shunt Release
Motor Operator	
A4	Opening Order
A2	Closing Order
B4, A1	Power Supply to Motor Operator
L1	Manual Position (manu)
B2	Overcurrent Trip Switch Interlocking (mandatory for correct operation)
BPO	Opening Pushbutton
BP	Closing Pushbutton
Communicating Motor Operator	
B4, A1	Motor Operator Power Supply
BSCM	Breaker Status and Control Module

Indication Contacts	
OF2/OF1	Device ON/OFF Auxiliary Switches
OF3	Device ON/OFF Auxiliary Switches (L-Frame)
SDE	Overcurrent Trip Switch (short-circuit, overload, ground fault, earth leakage)
SD	Alarm Switch
CAF2/CAF1	Early-Make Contact (rotary handle only)
CAO1	Early-Break Contact (rotary handle only)

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SQUARE D™ by Schneider Electric

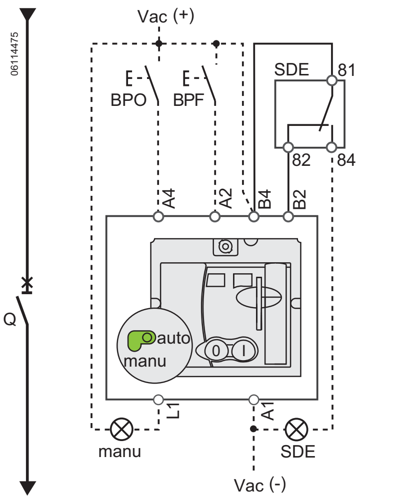
Motor Operator

NOTE: The diagram is shown with circuits de-energized, relays in normal position, and all devices open, connected, and charged.

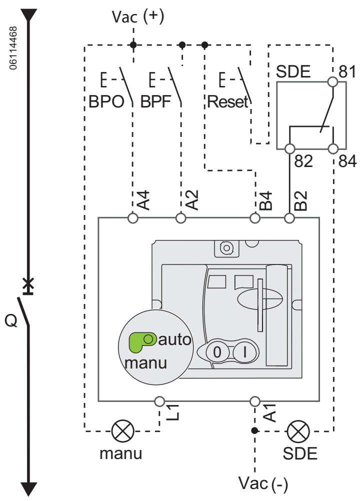
After tripping initiated by the “Push to trip” button, the undervoltage release (MN), or the shunt release (MX), device can be reset automatically, remotely, or manually.

Following tripping due to an electrical fault, reset must be carried out manually.

Motor Operator with Automatic Reset



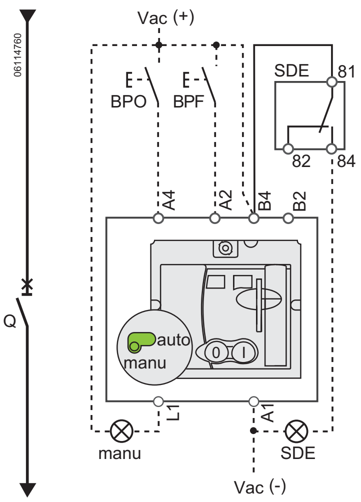
Motor Operator with Remote Reset



Symbols

Q:	Circuit Breaker
A4:	Opening Order
A2:	Closing Order
B4, A1:	Motor Operator Power Supply
L1:	Manual Position (manu)
B2:	Overcurrent Trip Switch Interlocking (mandatory for correct operation)
BPO:	Opening Pushbutton
BPF:	Closing Pushbutton
SDE:	Fault-Trip Indication Contact (short-circuit, overload, ground fault, earth leakage)

Motor Operator with Manual Reset



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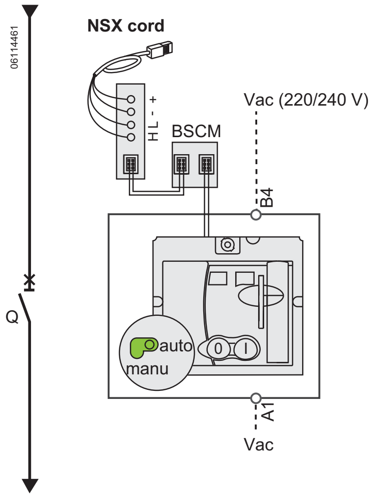
Motor Operator *(continued)*

Symbols

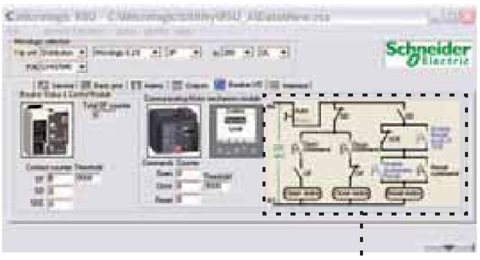
Q: Circuit Breaker
B4, A1: Motor Operator Power Supply
BSCM: Breaker Status and Control Module

Communicating Motor Operator

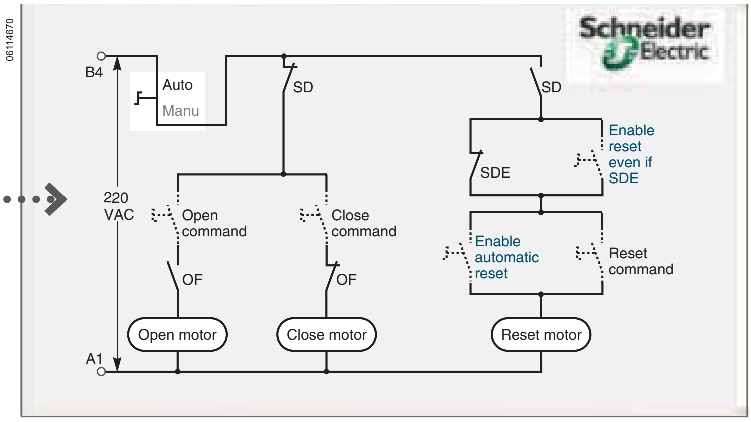


Schematic of the communicating motor operator .

RSU Screen for Communicating Motor Operator



RSU utility setup screen for the communicating motor operator



Single-line diagram of communicating motor operator

Opening, closing and reset orders are transmitted through the communication network. The “Enable automatic reset” and “Enable reset even if SDE” parameters must be set using the RSU software using the screen by clicking the blue text.

“Auto/Manu” is a switch on the front of the motor operator.

Terminal connections shown as O must be connected by the customer.

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SQUARE D™ by Schneider Electric

SDx Module with Micrologic™ Trip Unit

NOTE: The diagram is shown with circuits de-energized, relays in normal position, and all devices open, connected, and charged.

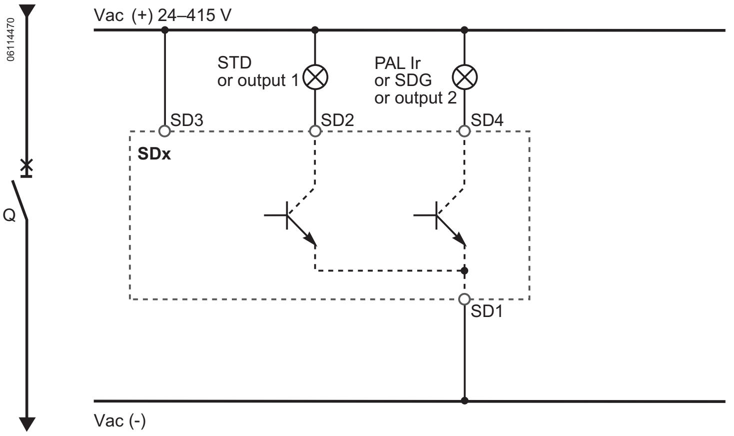
Symbols

SD1, SD3: SDx Module Power Supply
SD2: Output 1 (80 mA max.)
SD4: Output 2 (80 mA max.)

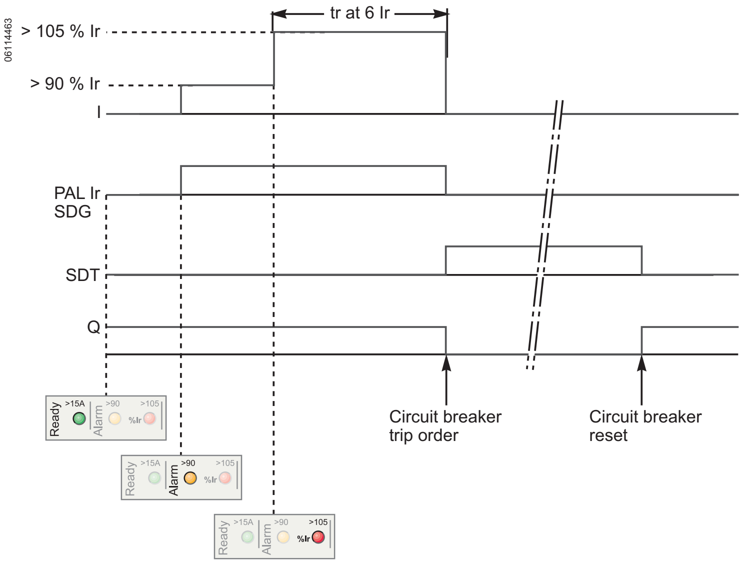
	SD2	SD4
Micrologic 3	SDT	—
Micrologic 5	SDT or Output 1	PAL Ir or Output 2
Micrologic 6	SDT or Output 1	SDG or Output 2

Terminal connections shown as O must be connected by the customer.

Connection



Operation



I: Charge Current
PAL Ir: Thermal Overload Pre-Alarm
SDG: Ground-Fault Signal
SDT: Thermal-Fault Signal
Q: Circuit Breaker

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SQUARE D by Schneider Electric

SDTAM Module with Micrologic™ M Trip Unit

NOTE: The diagram is shown with circuits de-energized, relays in normal position, and all devices open, connected, and charged.

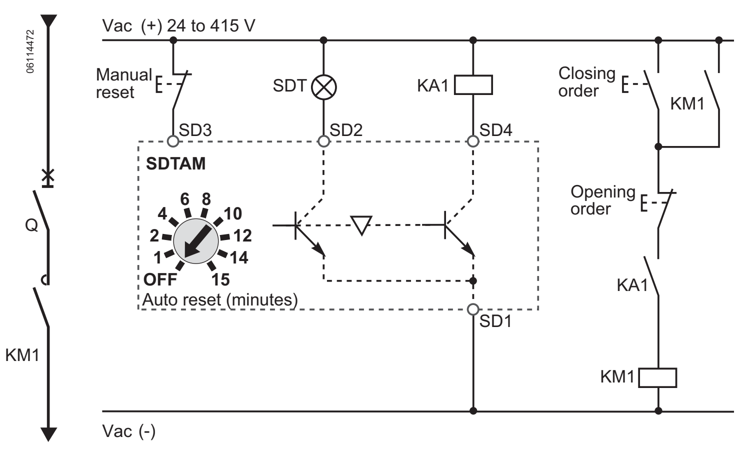
Symbols

SD1, SD3:	SDTAM Module Power Supply
SD2:	Thermal Fault Signal (80 mA max.)
SD4:	Contactor Control Output (80 mA max.)

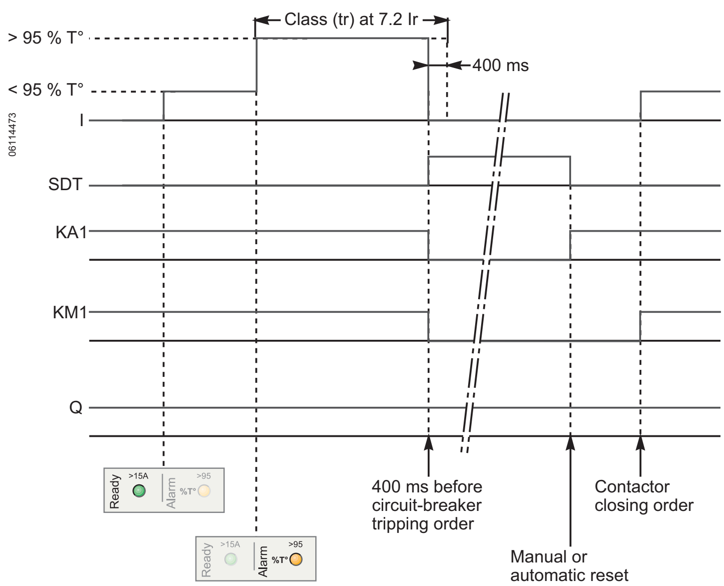
	SD2	SD4
Micrologic 2 M	SDT	KA1

Terminal connections shown as O must be connected by the customer.

Connection



Operation



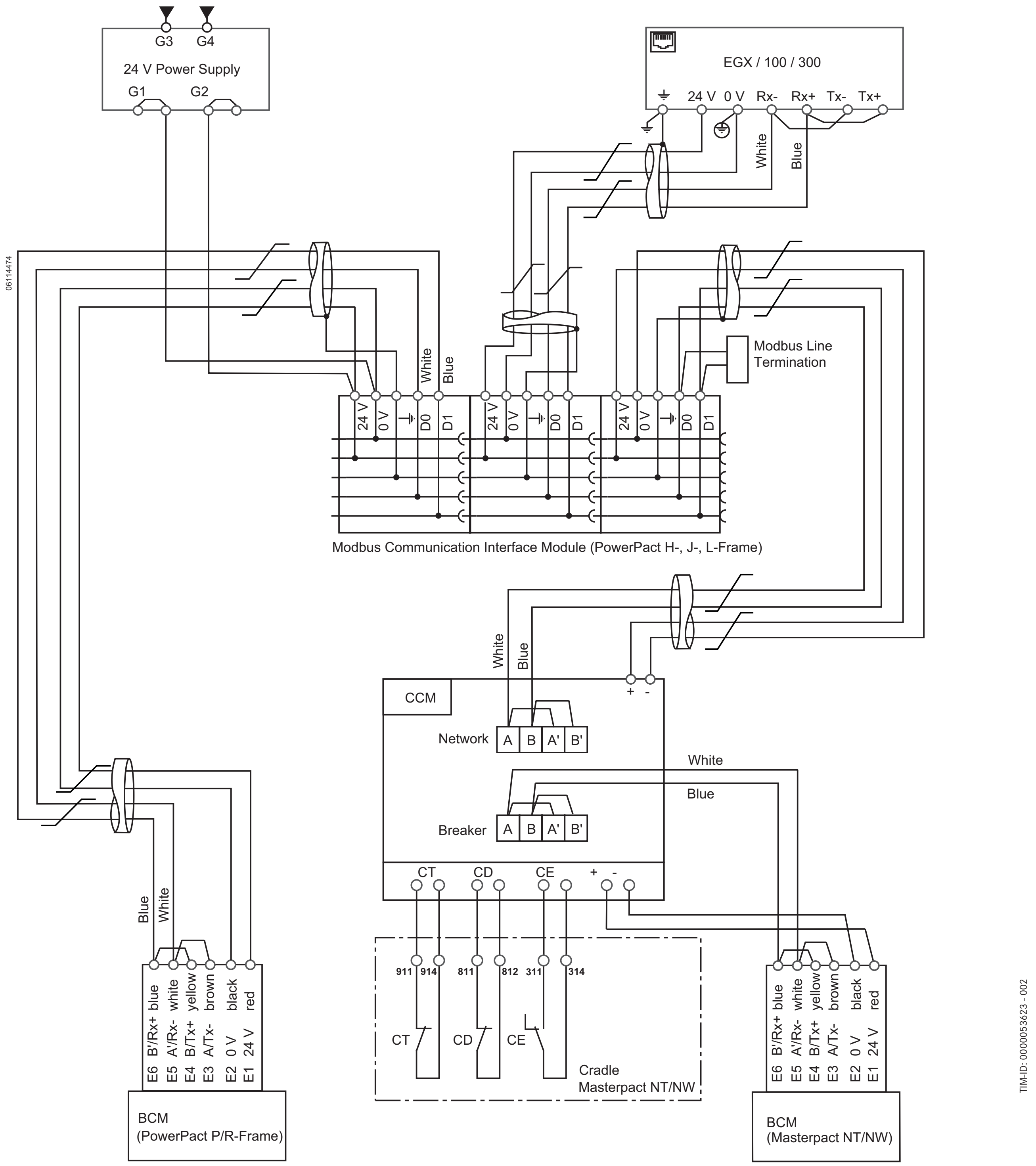
I:	Charge Current
SDT:	Thermal Fault Signal
KA1:	Auxiliary Relay (RBN or RTBT Relay)
KM1:	Motor Contactor
Q:	Circuit Breaker

TIM-ID: 0000053623 - 002

Modbus™ Module

Detailed connection of the circuit breakers on communication network Modbus

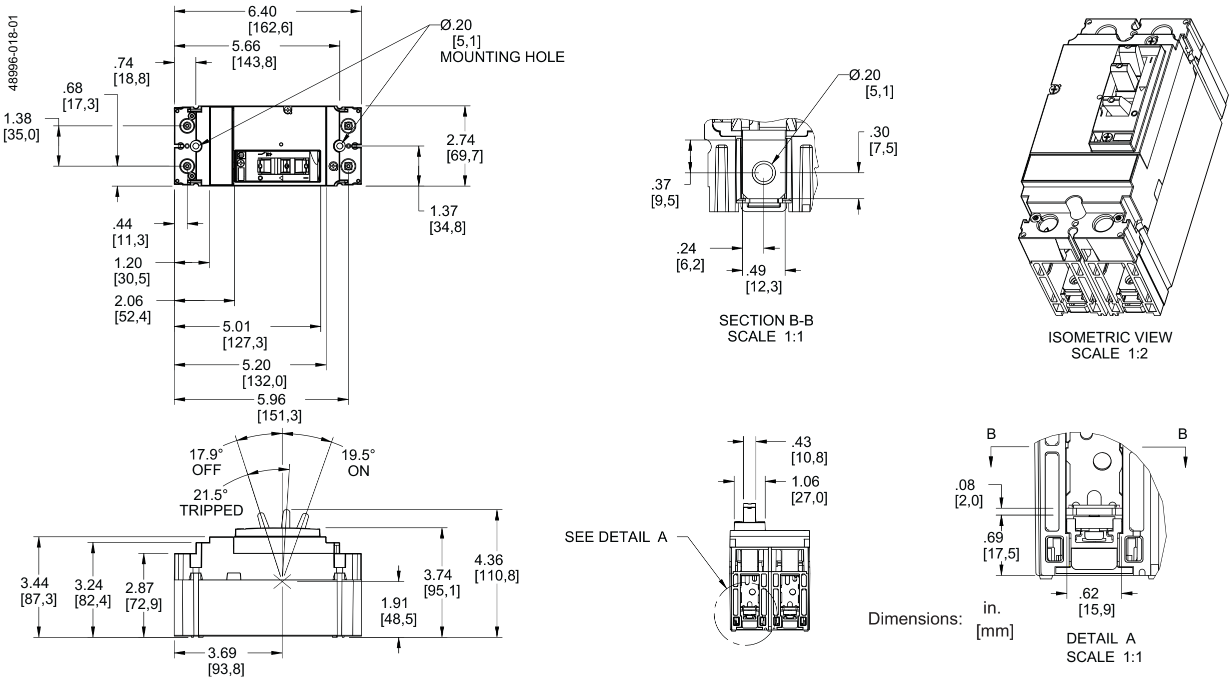
Connection



Section 12—Dimensions

PowerPact H-Frame Circuit Breakers

Figure 8: 15–150 A Bus Bar PowerPact H-Frame 2P HD/HG Thermal-Magnetic Only Circuit Breaker



TIM-ID: 0000053623 - 002

SQUARE D™ by Schneider Electric

Figure 9: 15–150 A Unit Mount PowerPact H-Frame 2P HD/HG Thermal-Magnetic Only Circuit Breaker

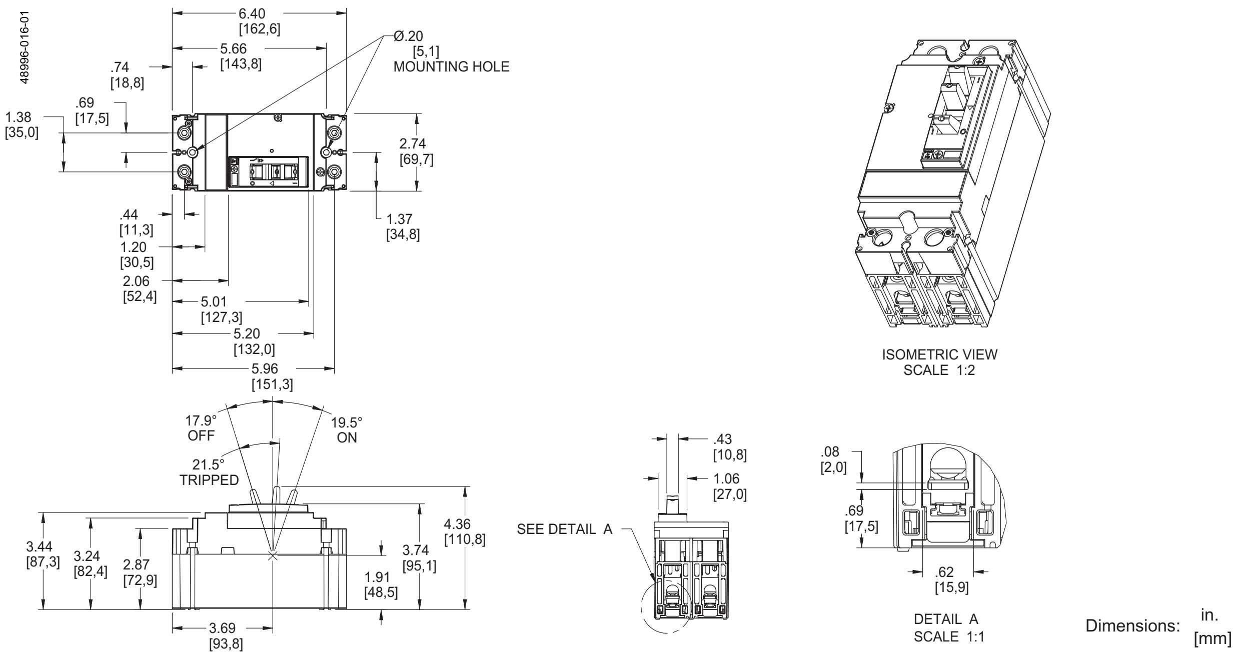
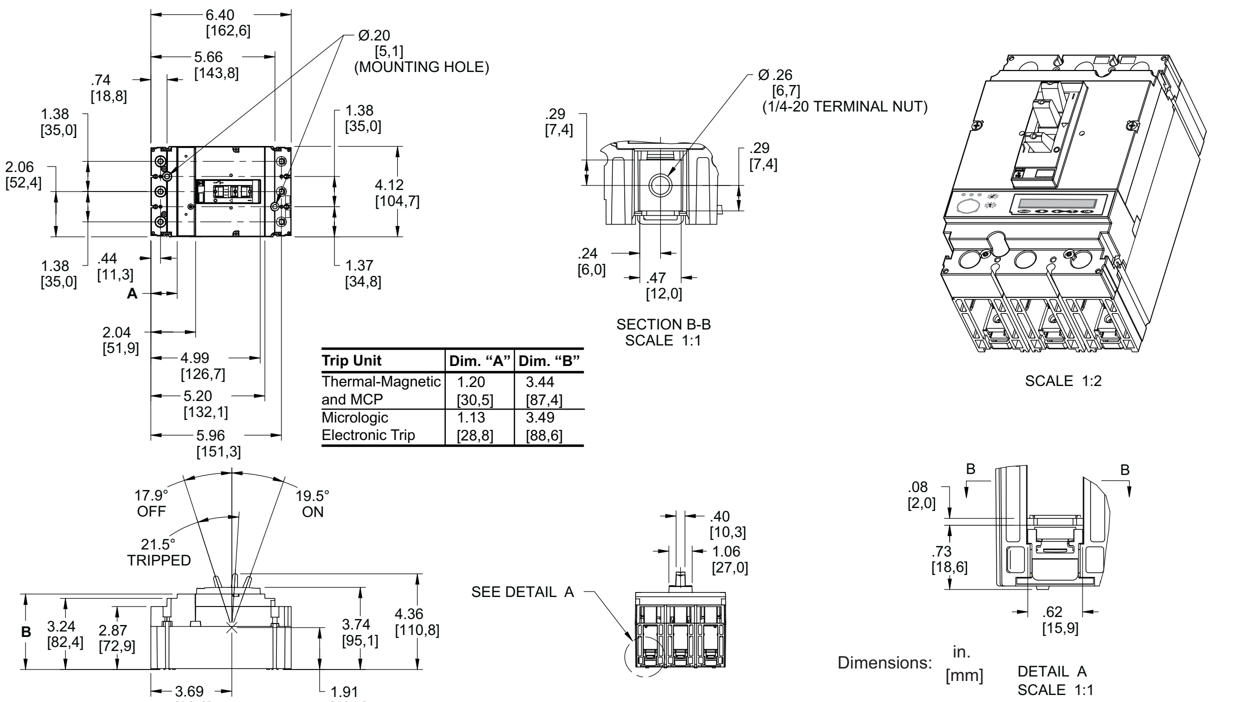


Figure 10: 15–150 A Bus Bar PowerPact H-Frame 3P Circuit Breaker



Trip Unit	Dim. "A"	Dim. "B"
Thermal-Magnetic and MCP	1.20 [30,5]	3.44 [87,4]
Micrologic Electronic Trip	1.13 [28,8]	3.49 [88,6]

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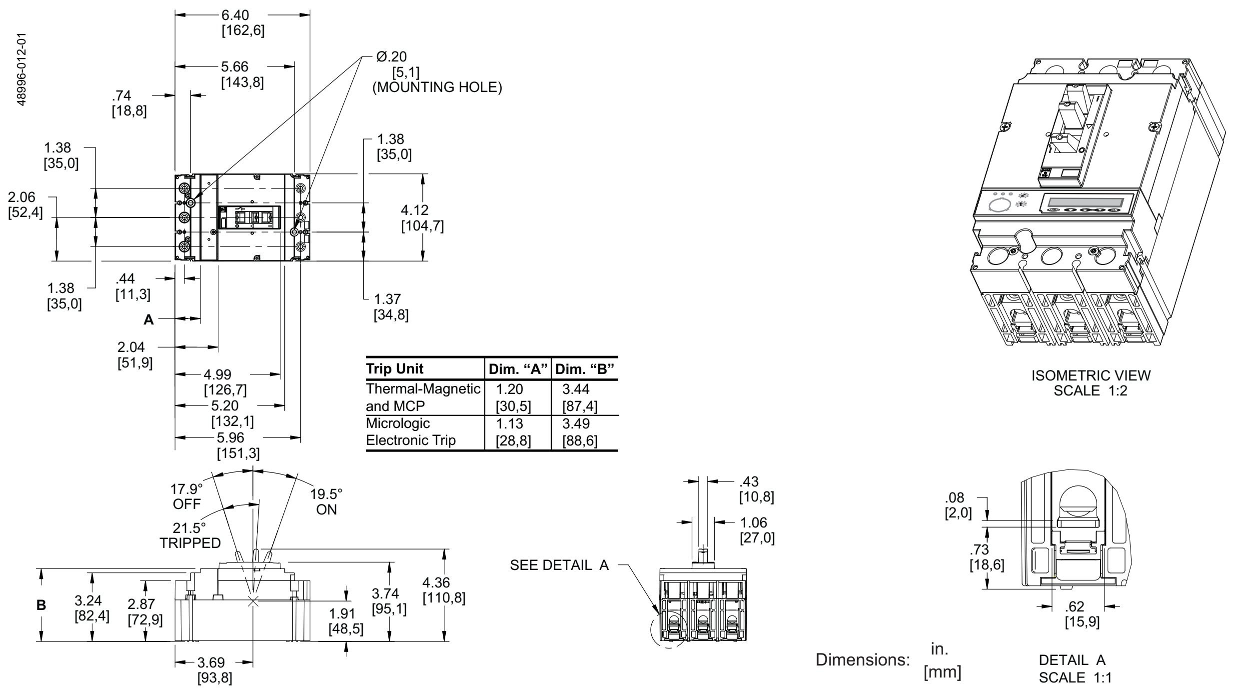
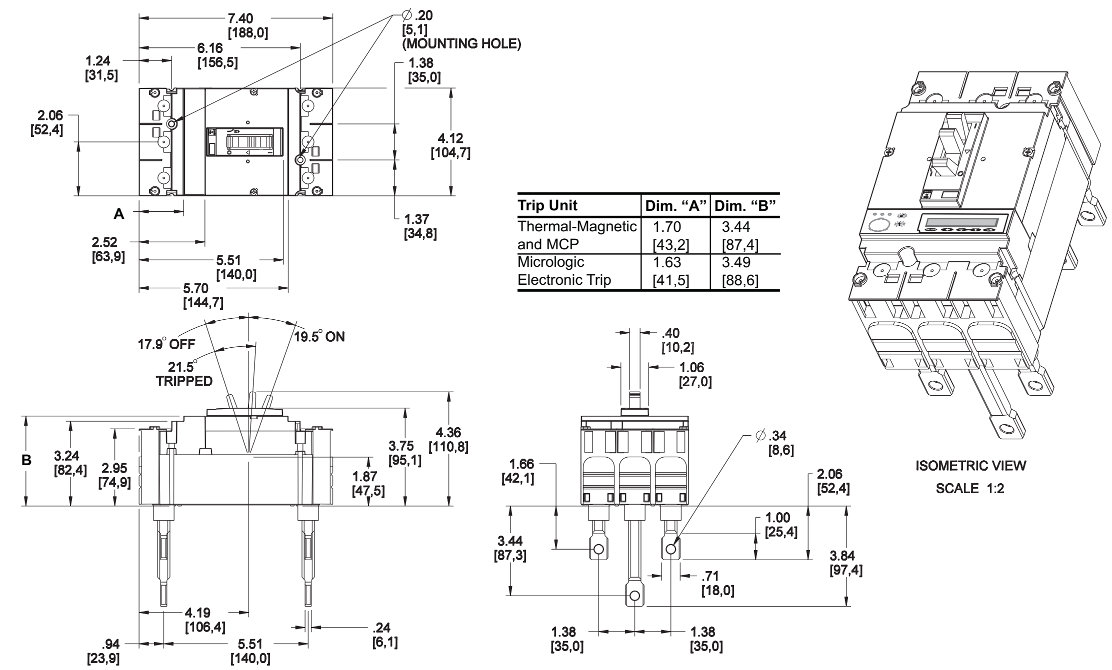
Figure 11: 15–150 A Lug-Lug PowerPact H-Frame 3P Circuit Breaker



Trip Unit	Dim. "A"	Dim. "B"
Thermal-Magnetic and MCP	1.20 [30,5]	3.44 [87,4]
Micrologic Electronic Trip	1.13 [28,8]	3.49 [88,6]

Figure 12: 15–150 A Rear Connected PowerPact H-Frame 3P Circuit Breaker



Trip Unit	Dim. "A"	Dim. "B"
Thermal-Magnetic and MCP	1.70 [43,2]	3.44 [87,4]
Micrologic Electronic Trip	1.63 [41,5]	3.49 [88,6]

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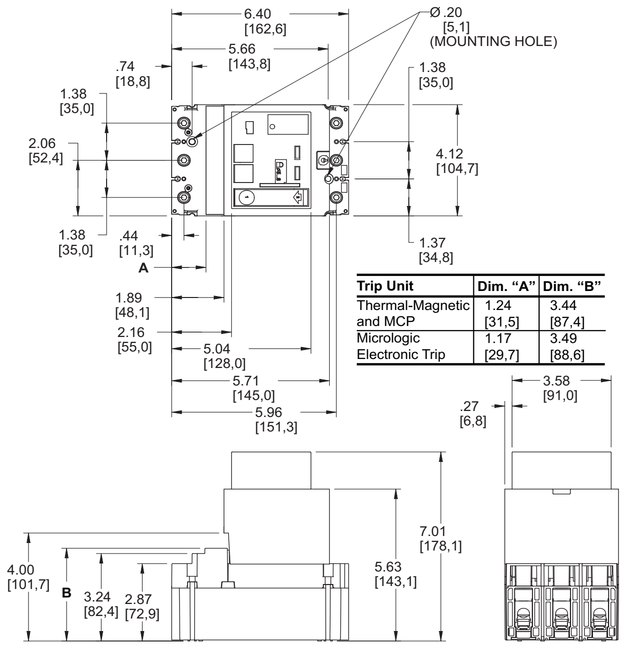
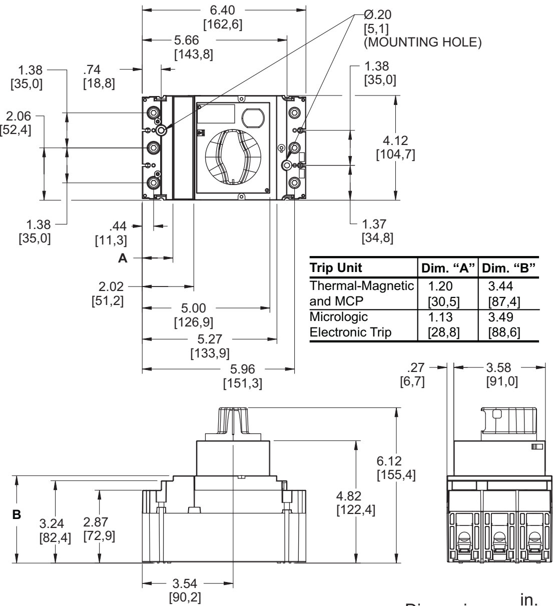
Figure 13: Motor Operator Detail (PowerPact H-Frame Circuit Breaker)



Trip Unit	Dim. "A"	Dim. "B"
Thermal-Magnetic and MCP	1.24 [31,5]	3.44 [87,4]
Micrologic Electronic Trip	1.17 [29,7]	3.49 [88,6]

Figure 14: Rotary Handle Detail (PowerPact H-Frame Circuit Breaker)



Trip Unit	Dim. "A"	Dim. "B"
Thermal-Magnetic and MCP	1.20 [30,5]	3.44 [87,4]
Micrologic Electronic Trip	1.13 [28,8]	3.49 [88,6]

Dimensions: in. [mm]

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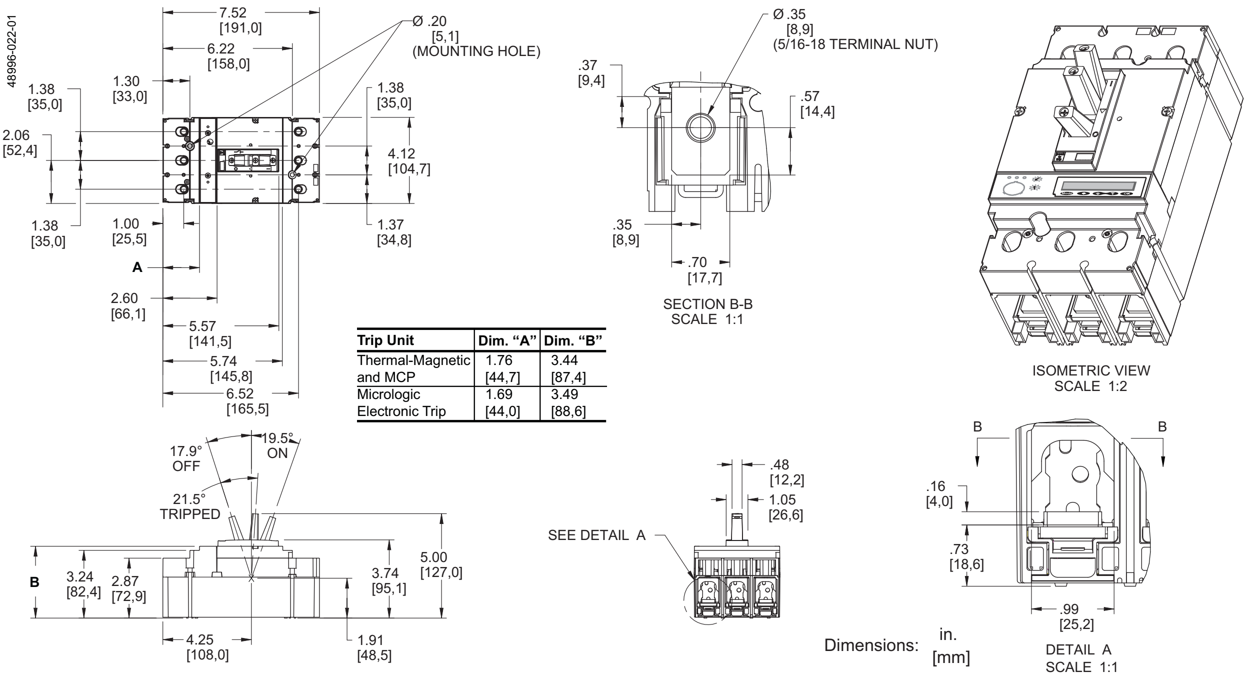
SQUARE D™ by Schneider Electric

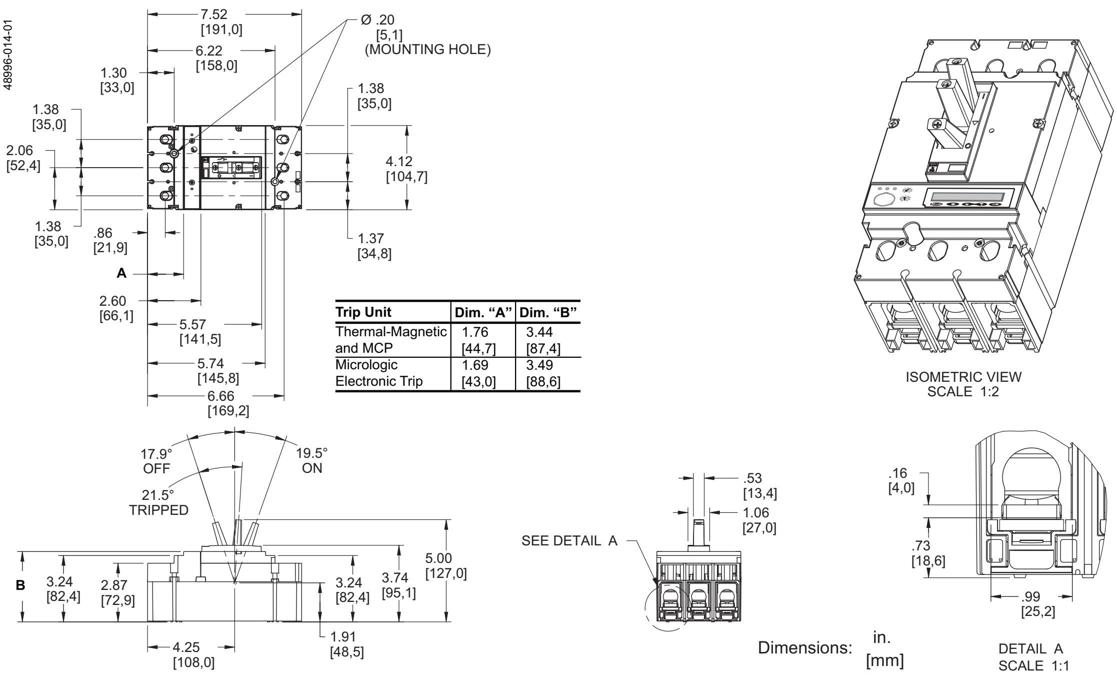
PowerPact J-Frame Circuit Breakers

Figure 15: 150–250 A Bus Bar PowerPact J-Frame 3P Circuit Breaker



Trip Unit	Dim. "A"	Dim. "B"
Thermal-Magnetic and MCP	1.76 [44,7]	3.44 [87,4]
Micrologic Electronic Trip	1.69 [44,0]	3.49 [88,6]

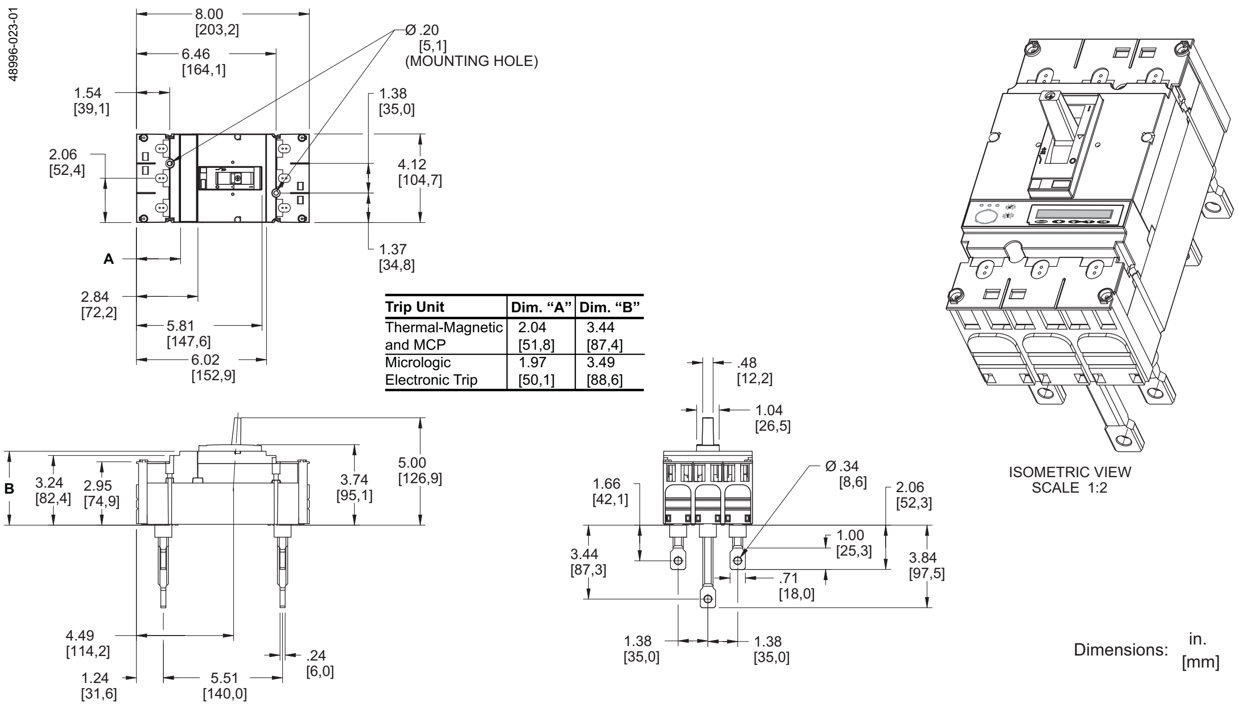
Figure 16: 150–250 A Lug-Lug PowerPact J-Frame 3P Circuit Breaker



Trip Unit	Dim. "A"	Dim. "B"
Thermal-Magnetic and MCP	1.76 [44,7]	3.44 [87,4]
Micrologic Electronic Trip	1.69 [43,0]	3.49 [88,6]

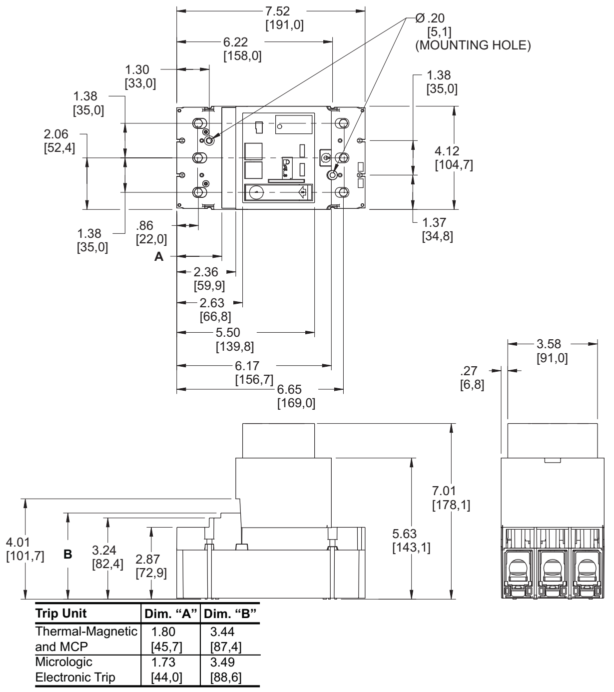
TIM-ID: 0000053623 - 002

Figure 17: 150–250 A Rear Connected PowerPact J-Frame 3P Circuit Breaker



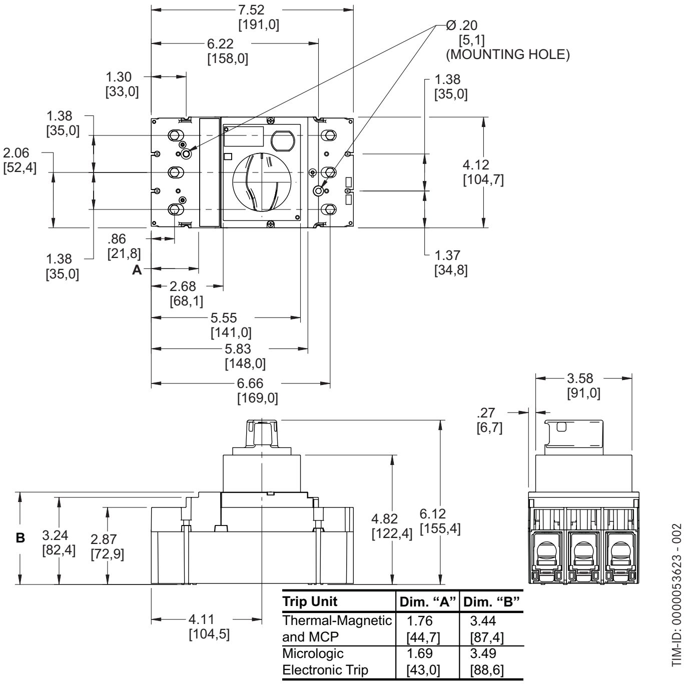
Trip Unit	Dim. "A"	Dim. "B"
Thermal-Magnetic and MCP	2.04 [51,8]	3.44 [87,4]
Micrologic Electronic Trip	1.97 [50,1]	3.49 [88,6]

Figure 18: Motor Operator Detail (PowerPact J-Frame Circuit Breaker)



Trip Unit	Dim. "A"	Dim. "B"
Thermal-Magnetic and MCP	1.80 [45,7]	3.44 [87,4]
Micrologic Electronic Trip	1.73 [44,0]	3.49 [88,6]

Figure 19: Rotary Handle Detail (PowerPact J-Frame Circuit Breaker)



Trip Unit	Dim. "A"	Dim. "B"
Thermal-Magnetic and MCP	1.76 [44,7]	3.44 [87,4]
Micrologic Electronic Trip	1.69 [43,0]	3.49 [88,6]

Dimensions: in. [mm]

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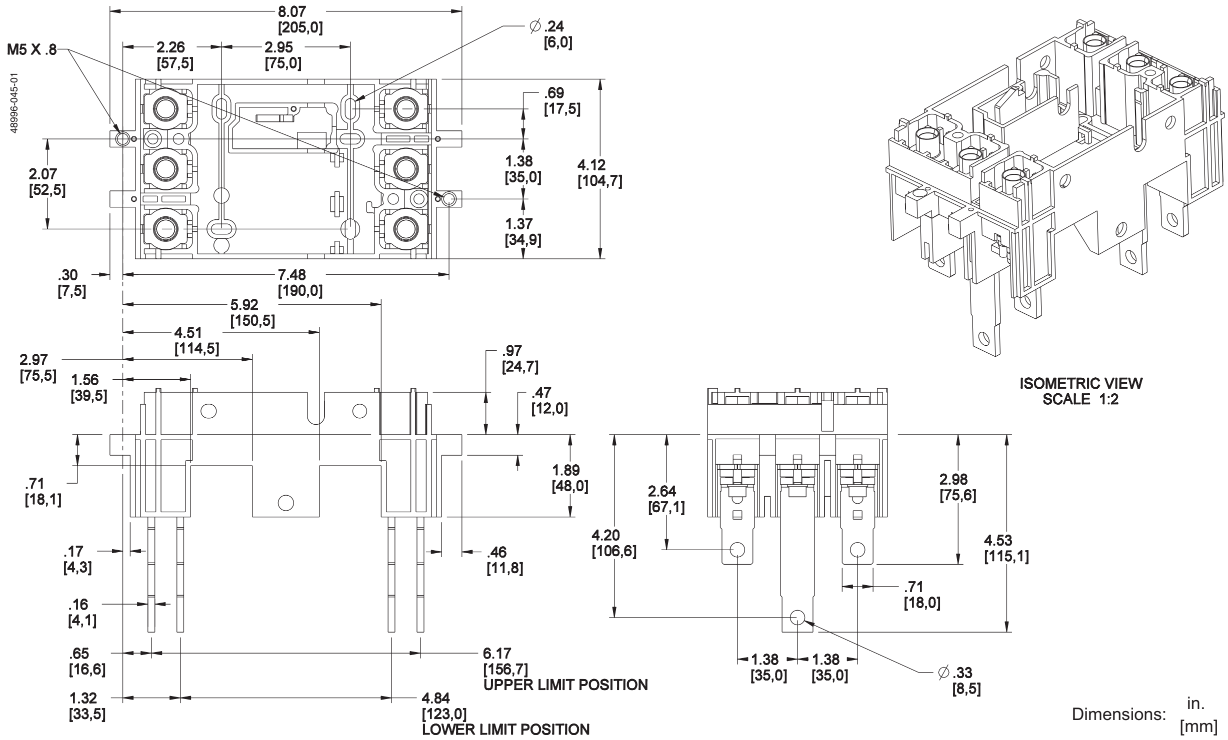
SQUARE D by Schneider Electric

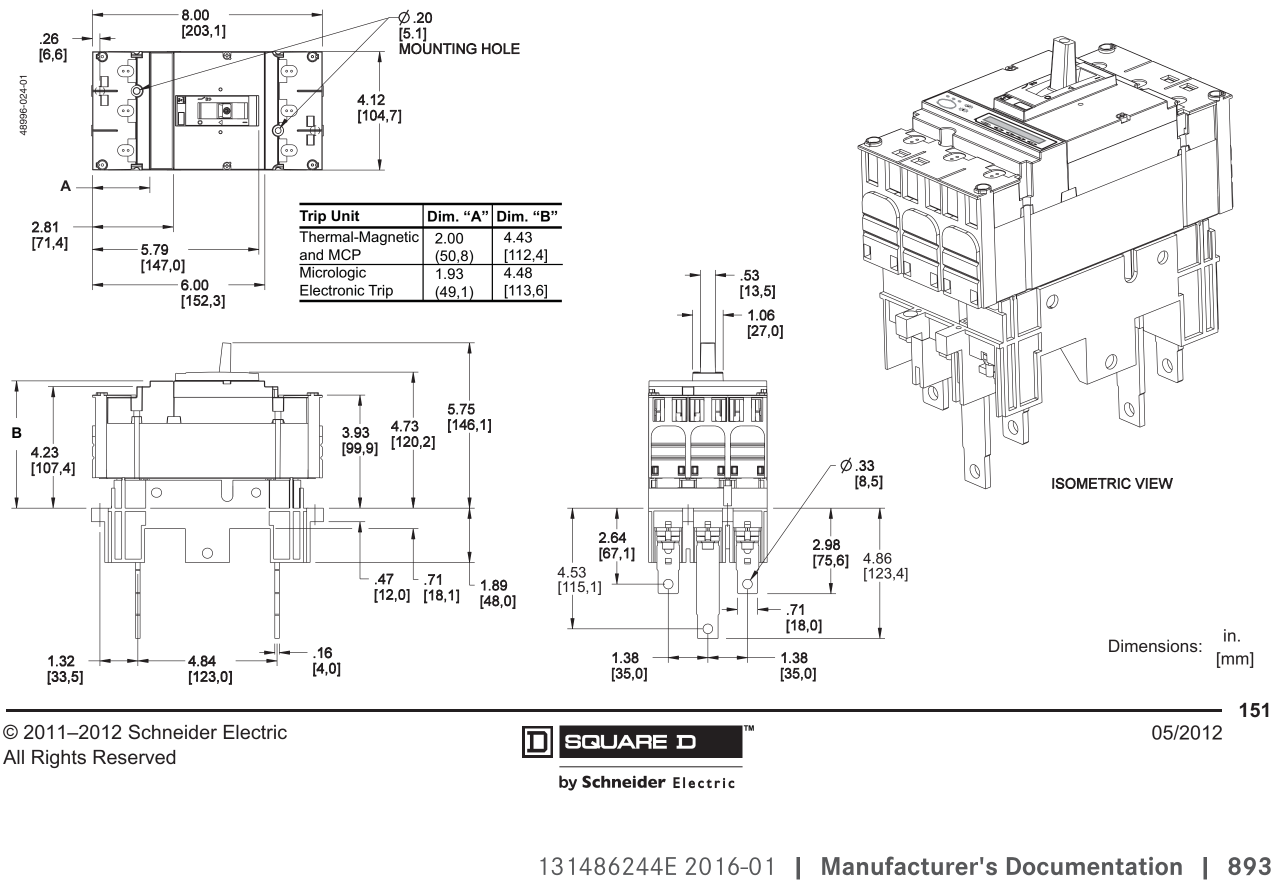
PowerPact H- and J-Frame Plug-In Circuit Breakers

Figure 20: 15–250 A PowerPact H- and J-Frame 3P Circuit Breaker Plug-In Base



Dimensions: in. [mm]

Figure 21: 15–250 A PowerPact H- and J-Frame Plug-In 3P Circuit Breaker



Trip Unit	Dim. "A"	Dim. "B"
Thermal-Magnetic and MCP	2.00 (50,8)	4.43 [112,4]
Micrologic Electronic Trip	1.93 (49,1)	4.48 [113,6]

Dimensions: in. [mm]

PowerPact H- and J-Frame Drawout Circuit Breakers

Figure 22: 15–250 A PowerPact H- and J-Frame 3P Circuit Breaker Cradle

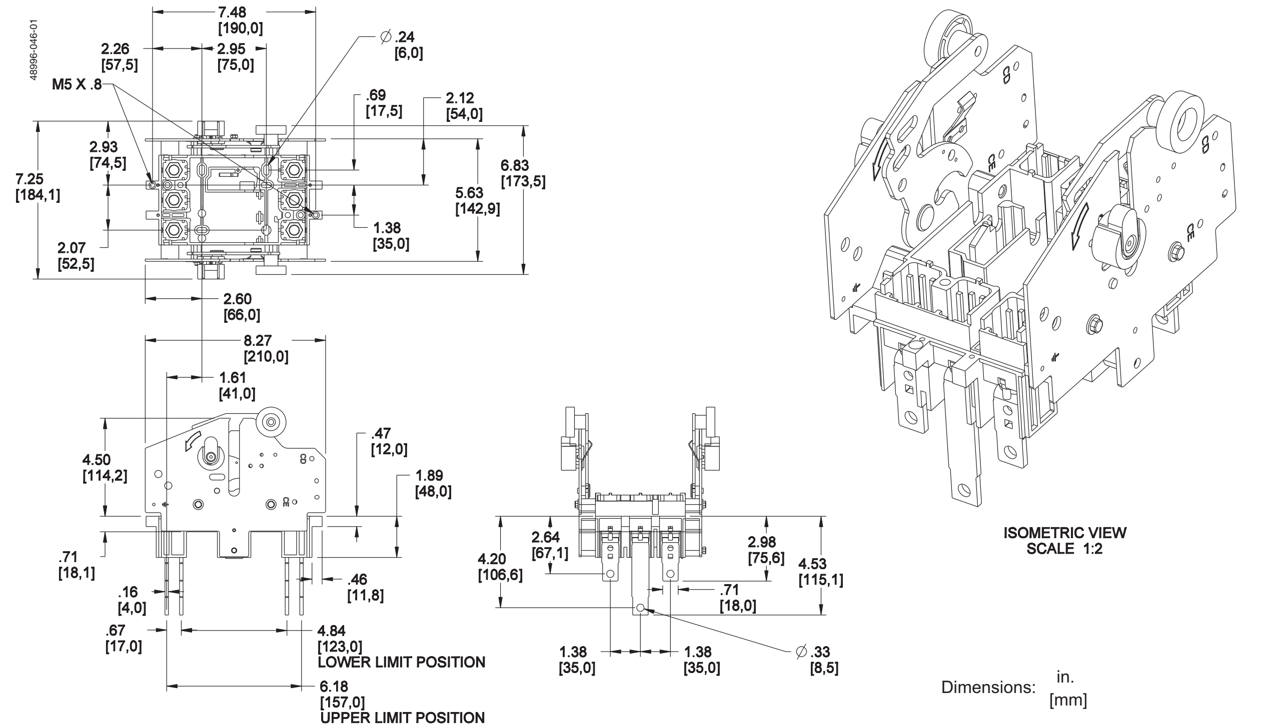
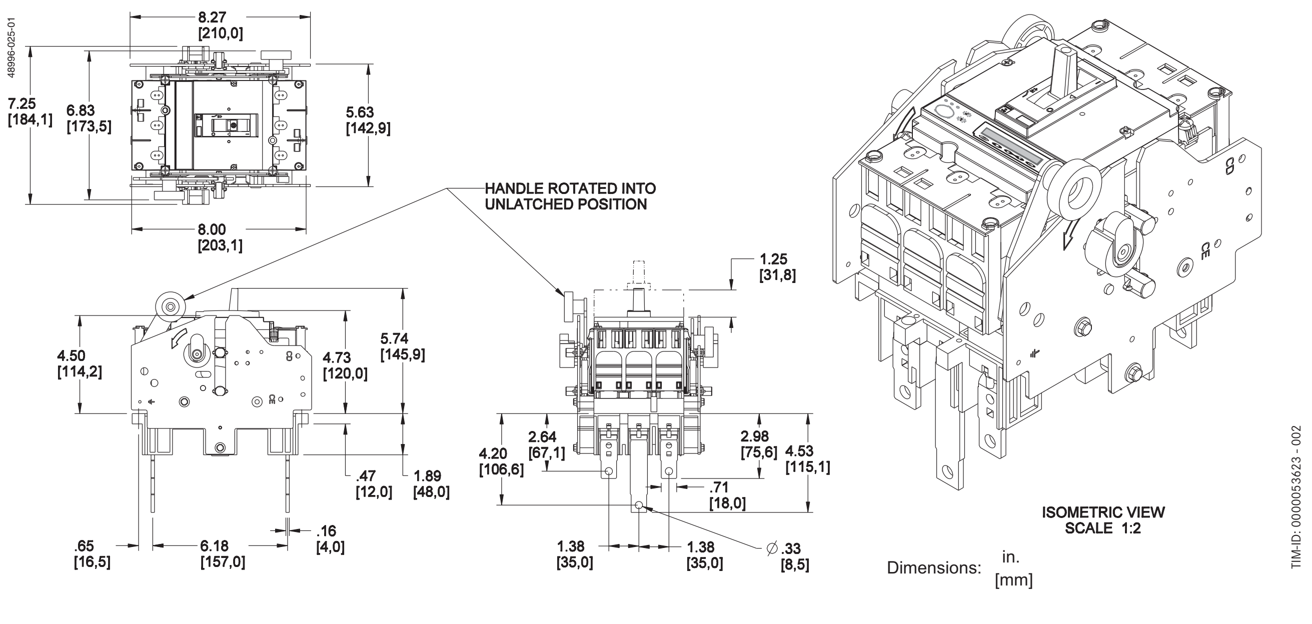


Figure 23: 15–250 A PowerPact H- and J-Frame Drawout 3P Circuit Breaker



PowerPact H- and J-Frame Circuit Breaker Mounting

Figure 24: PowerPact H-Frame 2P HD/HG Thermal-Magnetic Only Circuit Breaker

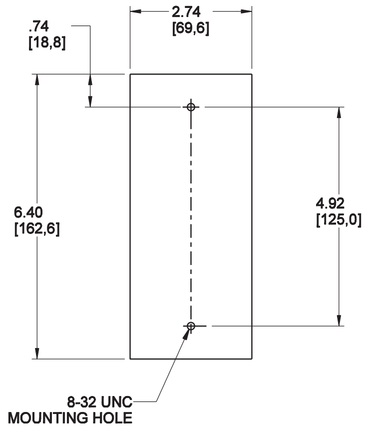
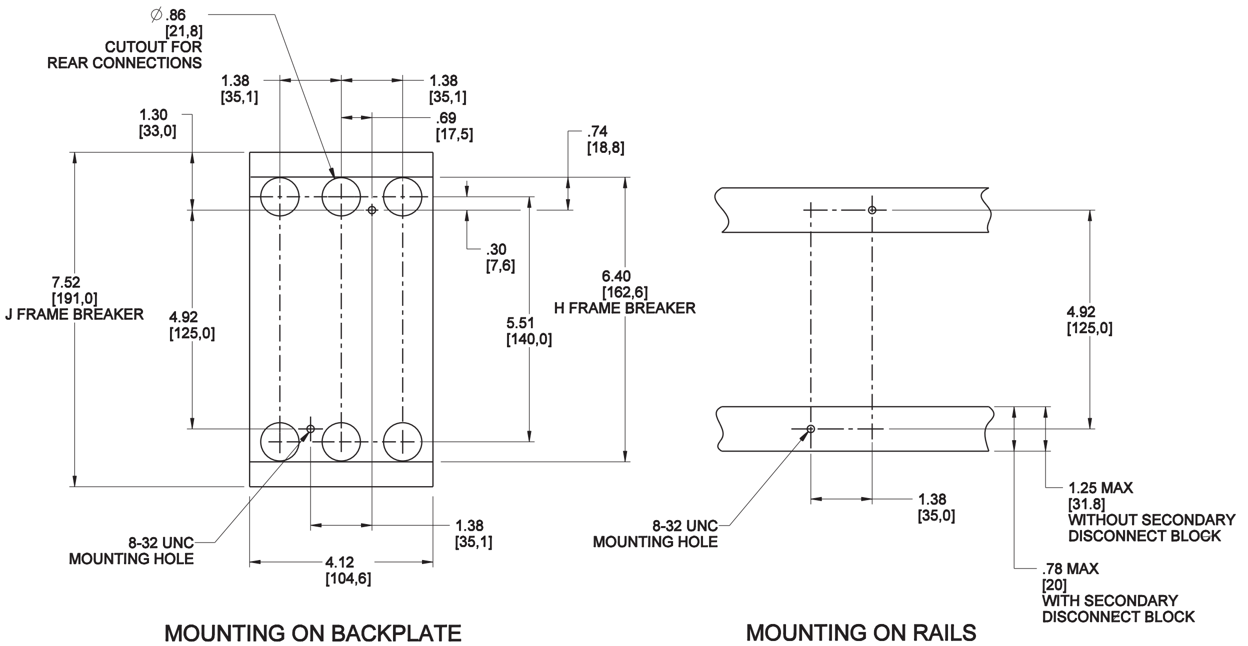


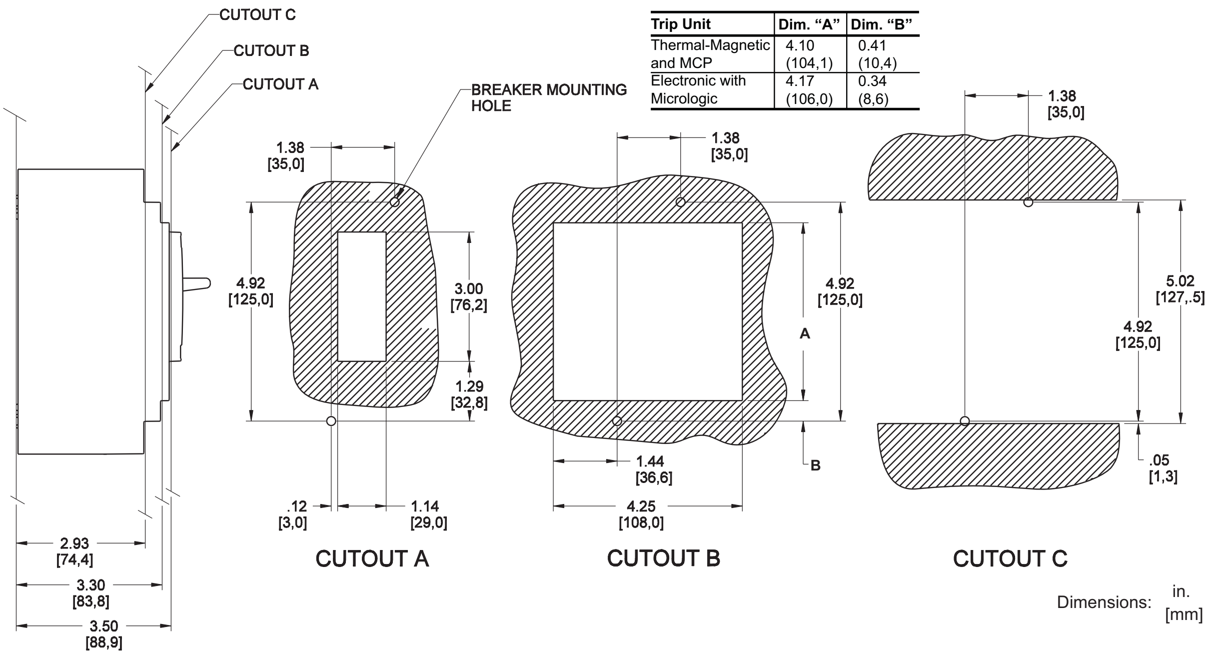
Figure 25: PowerPact H- and J-Frame 3P Circuit Breaker



TIM-ID: 0000053623 - 002

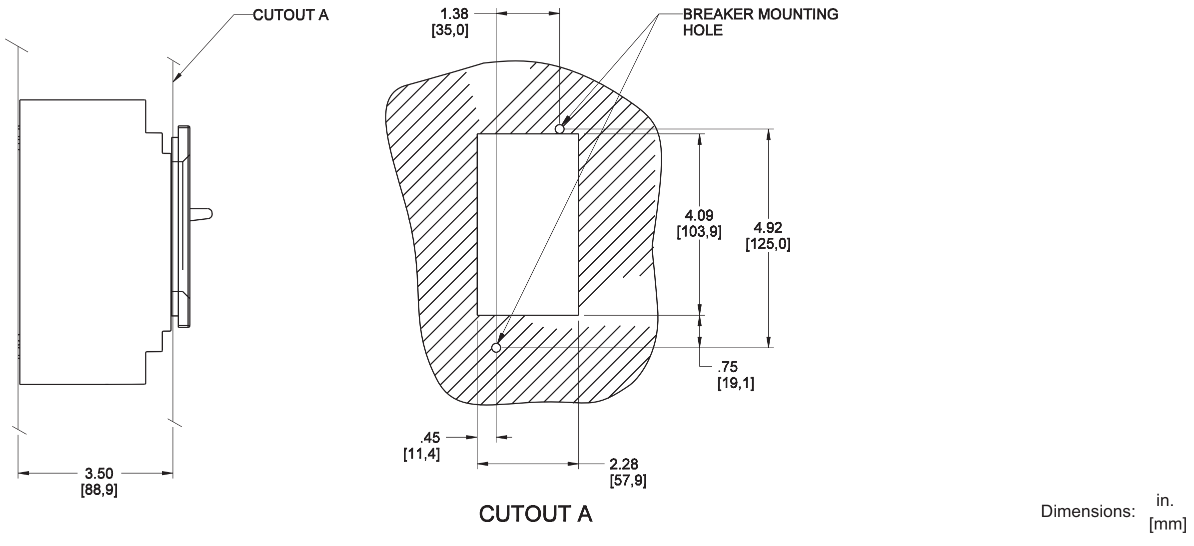
PowerPact H- and J-Frame Circuit Breaker Door Cutouts

Figure 26: PowerPact H- and J-Frame Circuit Breaker Toggle Handle Door Cutout



Trip Unit	Dim. "A"	Dim. "B"
Thermal-Magnetic and MCP	4.10 (104,1)	0.41 (10,4)
Electronic with Micrologic	4.17 (106,0)	0.34 (8,6)

Figure 27: PowerPact H- and J-Frame Circuit Breaker Toggle Handle With Escutcheon Door Cutout



TIM-ID: 0000053623 - 002

Figure 28: PowerPact H- and J-Frame Circuit Breaker Fixed Rotary Handle Cutout

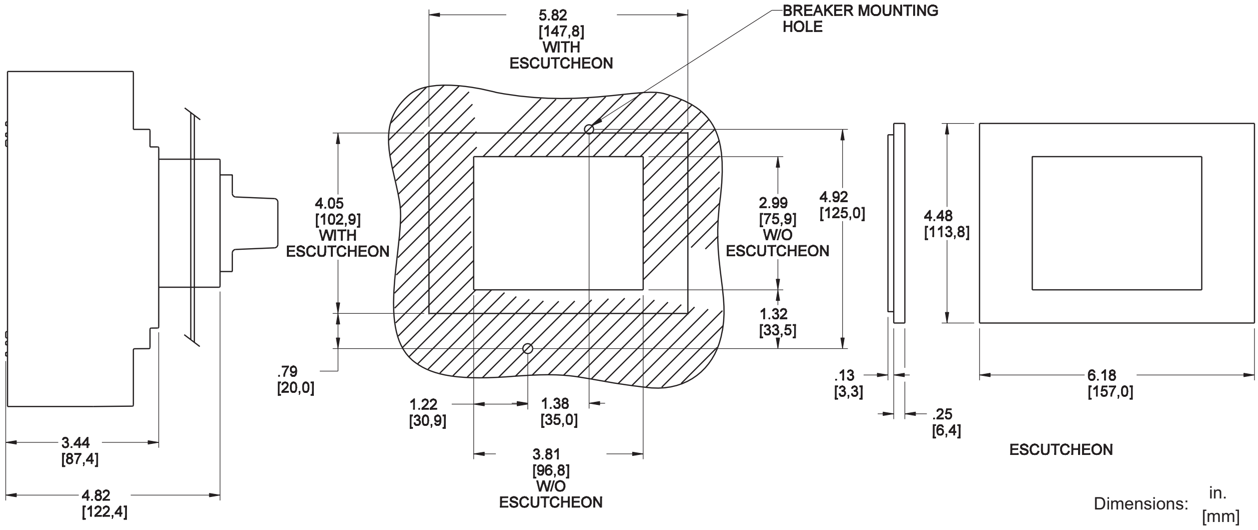
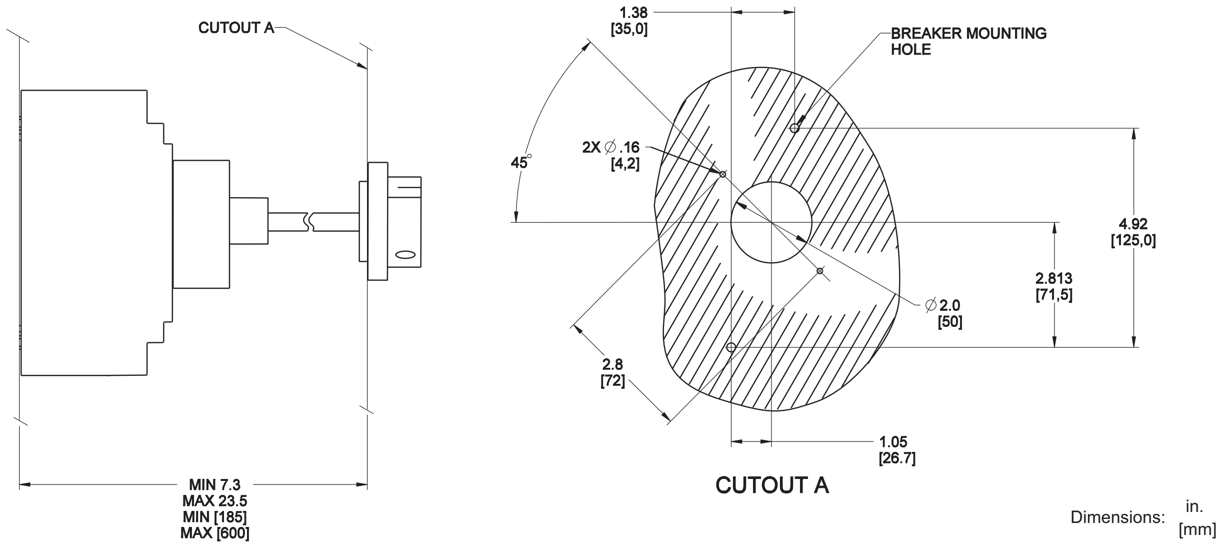


Figure 29: PowerPact H- and J-Frame Circuit Breaker Door Mounted Rotary Handle Cutout



TIM-ID: 0000053623 - 002

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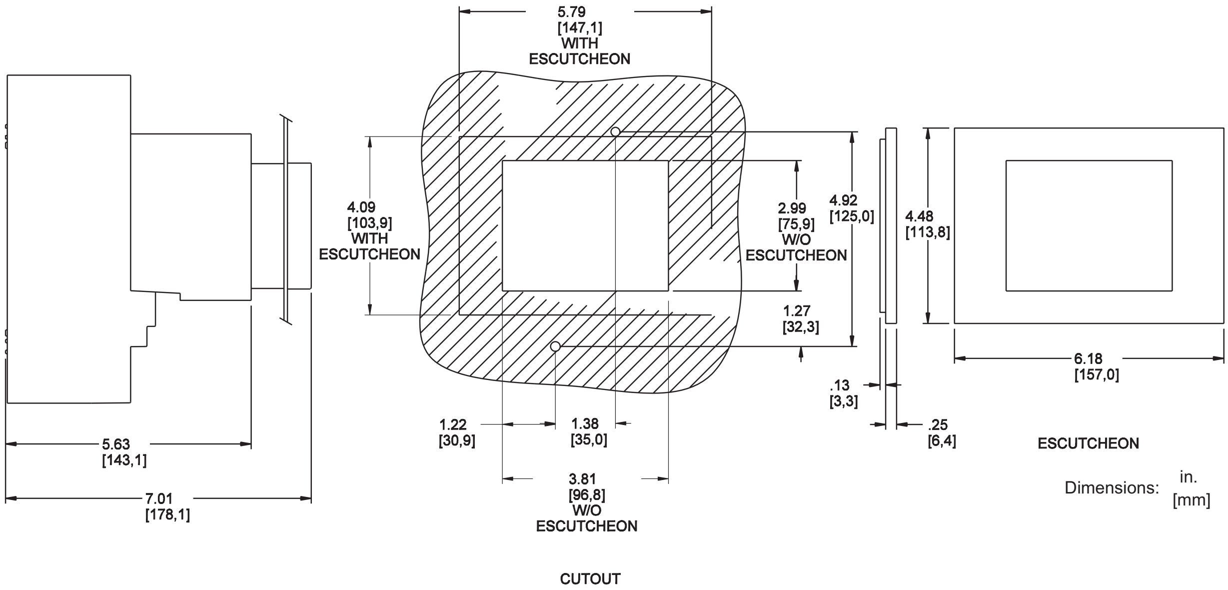
Figure 30: PowerPact H- and J-Frame Circuit Breaker Motor Operator Cutout



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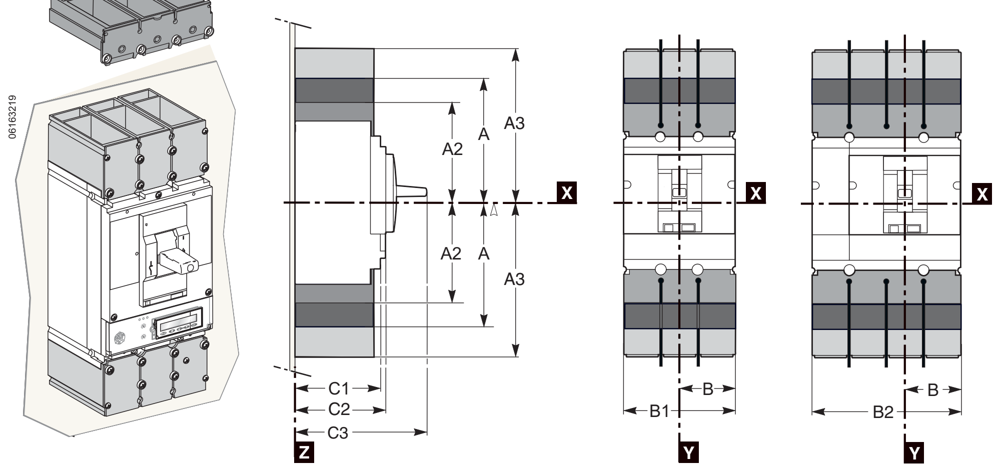
PowerPact L-Frame Circuit Breakers

Figure 31: PowerPact L-Frame Fixed Mounted Electronic Trip Circuit Breaker



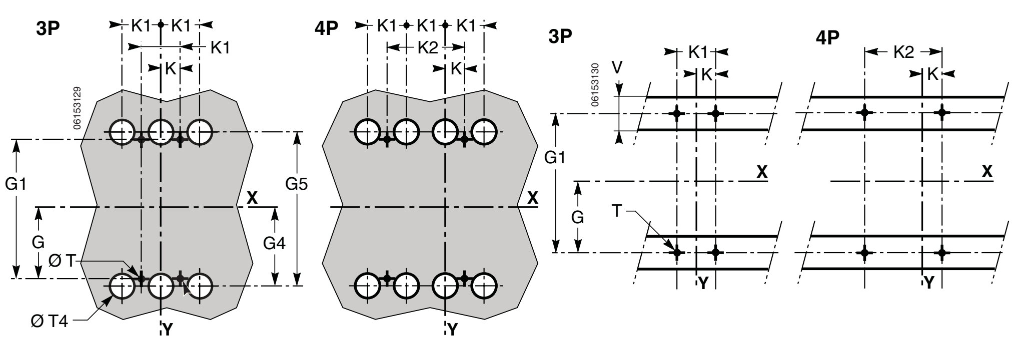
A2 = Short lug pack
AL400L61K3
AL400L61K4
CU400L61K3
CU400L61K4
AL600LF52K3
CU600LF5283

A = Medium lug pack
AL600LS52K3
AL600LS52K4
CU600LS52K3
CU600LS52K4

A3 = Long lug pack
Compression Lug Kits

	A	A2	A3	B	B1	B2	C1	C2	C3
inch	6.69	5.65	7.87	2.76	5.51	7.28	3.76	4.33	6.61
mm	170	143.5	200	70	140	185	105	110	168

Figure 32: PowerPact L-Frame Circuit Breaker Mounting



	G	G1	G4	G5	K[1]	K1	K2	T	T4[2]	U[3]
inch	3.93	7.87	4.46	8.93	0.88	1.77	3.54	0.23	1.25	1.38
mm	100	200	113.5	227	22.5	45	90	6	32	35

1 For 2 pole circuit breaker, the middle holes are not required.

2 For rear connected circuit breakers only.

3 V is ≤ 78 in. (20 mm) on C-frame circuit breakers with secondary disconnecting blocks.

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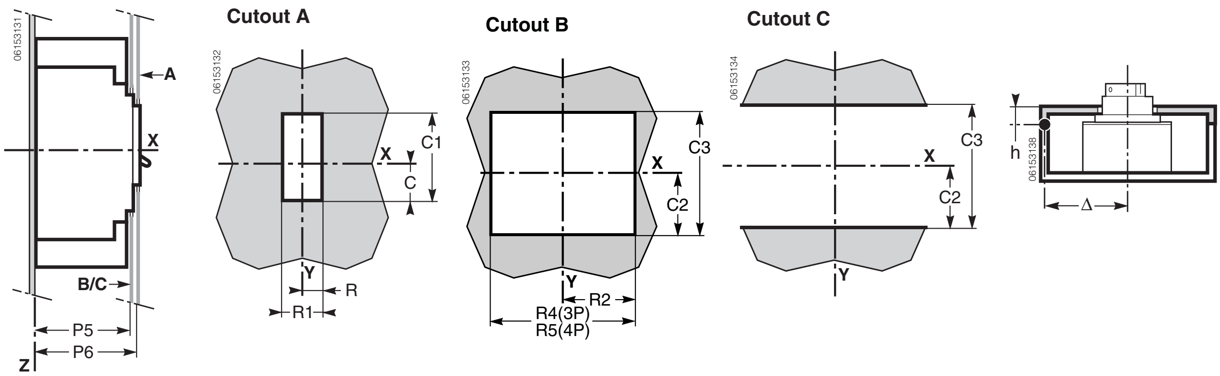
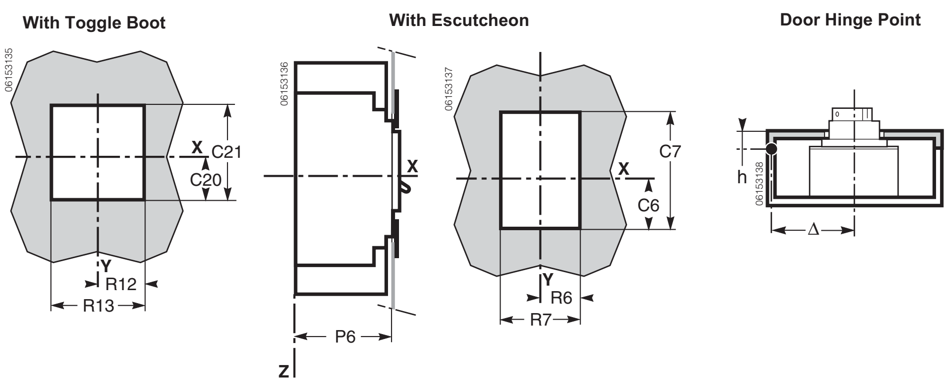
Figure 33: Front Panel Cutouts for PowerPact L-Frame Fixed or Plug-In Circuit Breakers



	C	C1	C2	C3	P5	P6	R	R1	R2	R4	R5	Δ
inch	1.63	4.56	3.64	7.24	4.21	4.40	1.24	2.48	2.81	5.62	7.40	3.93 + (5 x h)
mm	41.5	116	92.5	184	107	112	31.5	63	71.5	143	188	100 + (5 x h)

Figure 34: PowerPact L-Frame Circuit Breaker Front Panel Cutouts for Toggle Boot and Escutcheon

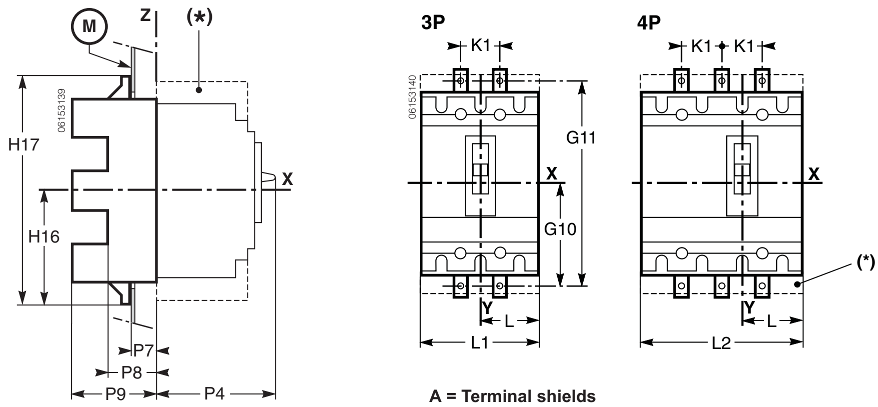


	C6	C7	C20	C21	P6	R6	R7	R12	R13	Δ
inch	2.2	6	1.83	5.00	4.40	3.5	7	2.48	4.96	3.93 + (5 x h)
mm	56.5	155	46.5	126	112	90	180	63	126	100 + (5 x h)

TIM-ID: 0000053623 - 002

PowerPact L-Frame Plug-In and Drawout Mounting

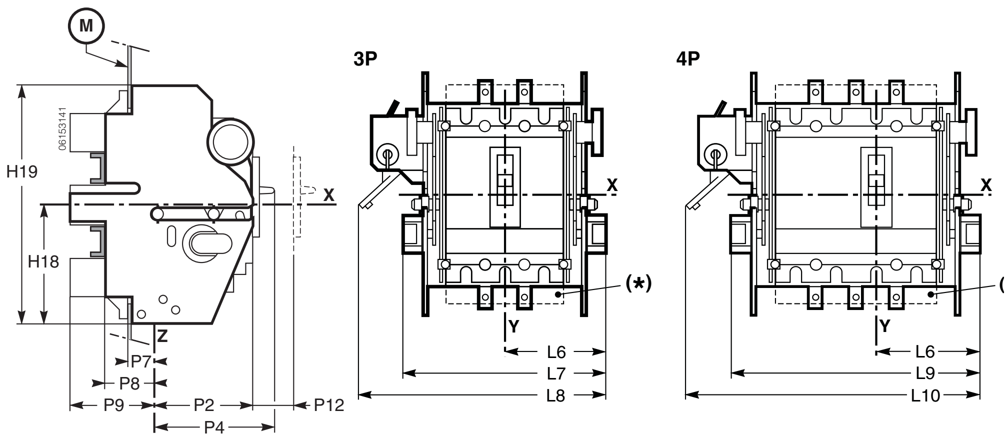
Figure 35: PowerPact L-Frame Plug-In Circuit Breaker (On Base)



A = Terminal shields
M = Through front panel

	G10	G11	H16	H17	K1	L	L1	L2	P4	P7	P8	P9
inch	5.90	11.8	6.20	12.40	1.77	2.75	5.51	7.28	6.61	1.06	1.77	3.93
mm	150	300	157.5	315	45	70	140	185	168	27	45	100

Figure 36: PowerPact L-Frame Drawout Circuit Breaker (on Cradle)



M = Through front panel

	H18	H19	L6	L7	L8	L10	P2	P4	P7	P8	P9	P12	L9
inch	5.51	11.02	4.33	8.66	98.46	11.61	4.33	6.61	1.06	1.77	3.93	1.25	10.43
mm	140	280	110	220	250	295	110	168	27	45	100	32	265

TIM-ID: 0000053623 - 002

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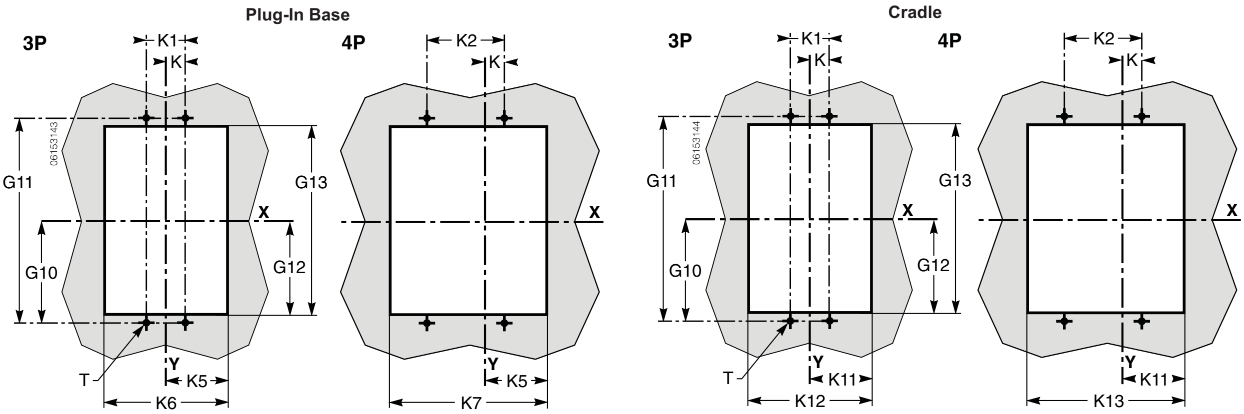
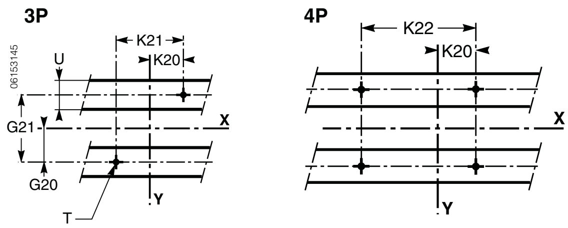
Figure 37: PowerPact L-Frame Circuit Breaker Mounting Through a Backplate



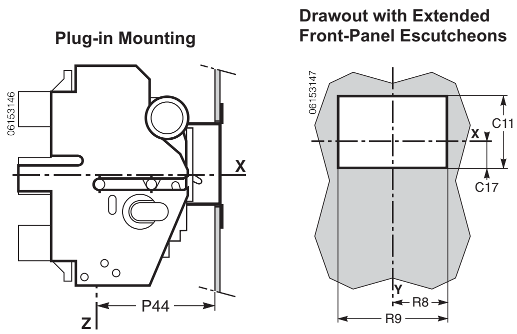
	G10	G11	G12	G13	K	K1	K2	K5	K6	K7	K11	K12	K13
inch	5.90	11.8	5.39	10.7	0.88	1.77	3.54	2.81	2.81	7.4	7.40	3.60	8.98
mm	150	300	137	274	22.5	45	90	71.5	143	188	91.5	183	228

Figure 38: PowerPact L-Frame Circuit Breaker Mounting on Rails (Plug-In Base or Cradle)



	G20	G21	K20	K21	K22	T
inch	2.95	5.90	8.97	1.96	5.71	0.24
mm	75	150	50	100	145	6

Figure 39: PowerPact L-Frame Circuit Breaker Front-Panel Cutouts

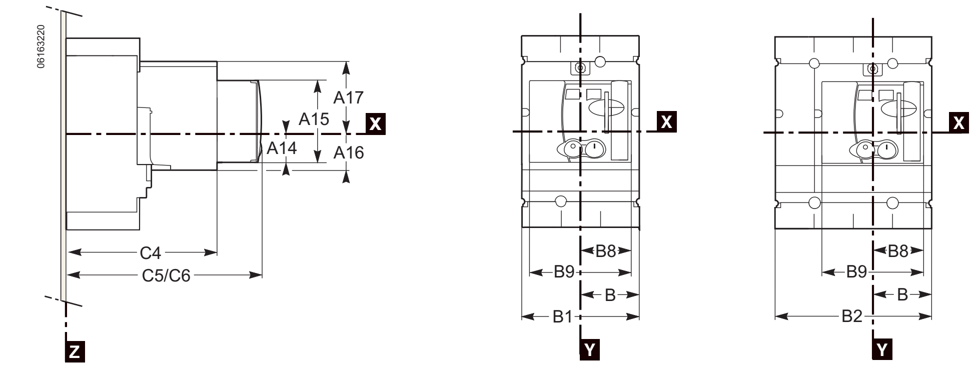


	C11	C17	P44	R8	R9
inch	6.10	2.22	5.78	3.54	7.08
mm	155	56.5	147	90	180

TIM-ID: 0000053623 - 002

PowerPact L-Frame Circuit Breaker Handles and Handle Operators

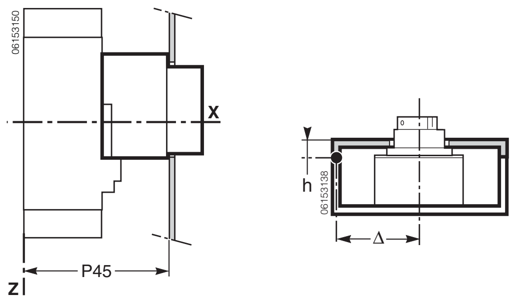
Figure 40: PowerPact L-Frame Circuit Breaker Motor Operators



C5: without keylock
C6: with keylock

	A14	A15	A16	A17	B	B1	B2	B8	B9	C4	C5	C6	D1
inch	1.57	4.84	2.05	3.94	2.76	5.51	7.28	2.42	4.84	8.46	10.08	10.16	3.94
mm	40	123	52	100	70	140	185	61.5	123	215	256	258	100

Figure 41: PowerPact L-Frame Circuit Breaker Motor Operator Front-Panel Cutouts



	C22	C23	P45	R14	R15	Δ
inch	1.63	4.96	8.54	2.53	5.08	3.93 + (5 x h)
mm	41.5	126	217	64.5	129	100 + (5 x h)

TIM-ID: 0000053623 - 002

Figure 42: PowerPact L-Frame Circuit Breaker Cable-Operating Handles

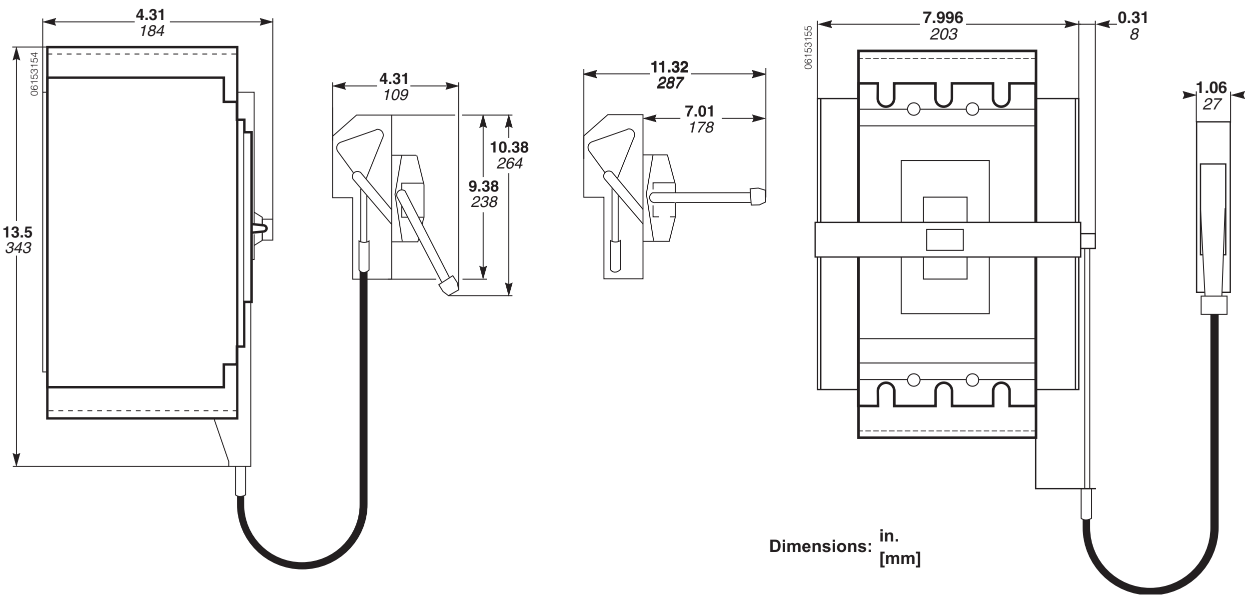
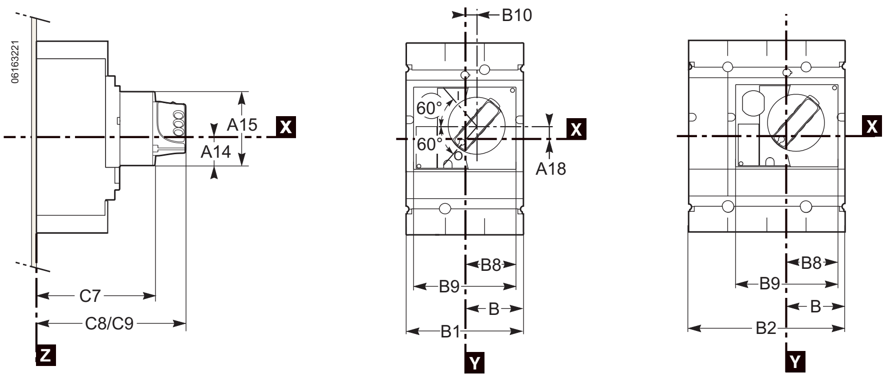


Figure 43: PowerPact L-Frame Circuit Breaker Rotary-Operating Handles

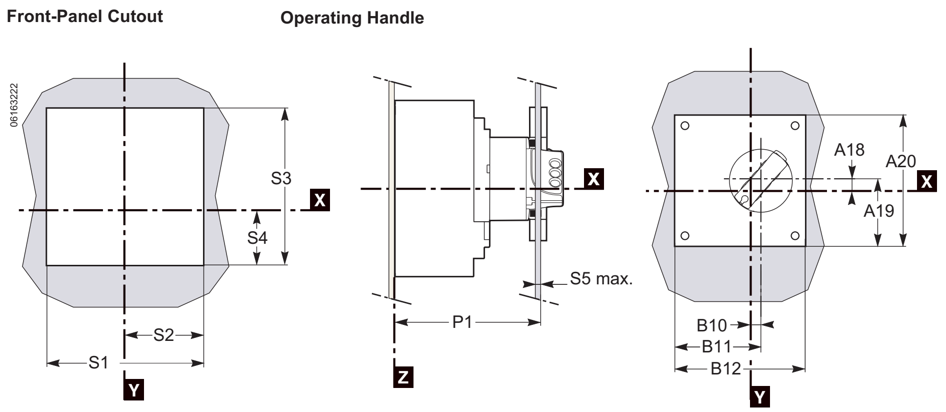


C8: without keylock
C9: with keylock

	A14	A15	A18	B	B1	B2	B8	B9	B10	C7	C8	C9	D1
inch	1.57	4.84	0.97	2.76	5.51	7.28	2.42	4.84	0.20	5.71	7.05	7.40	3.94
mm	40	123	24.6	70	140	185	61.5	123	5	145	179	188	100

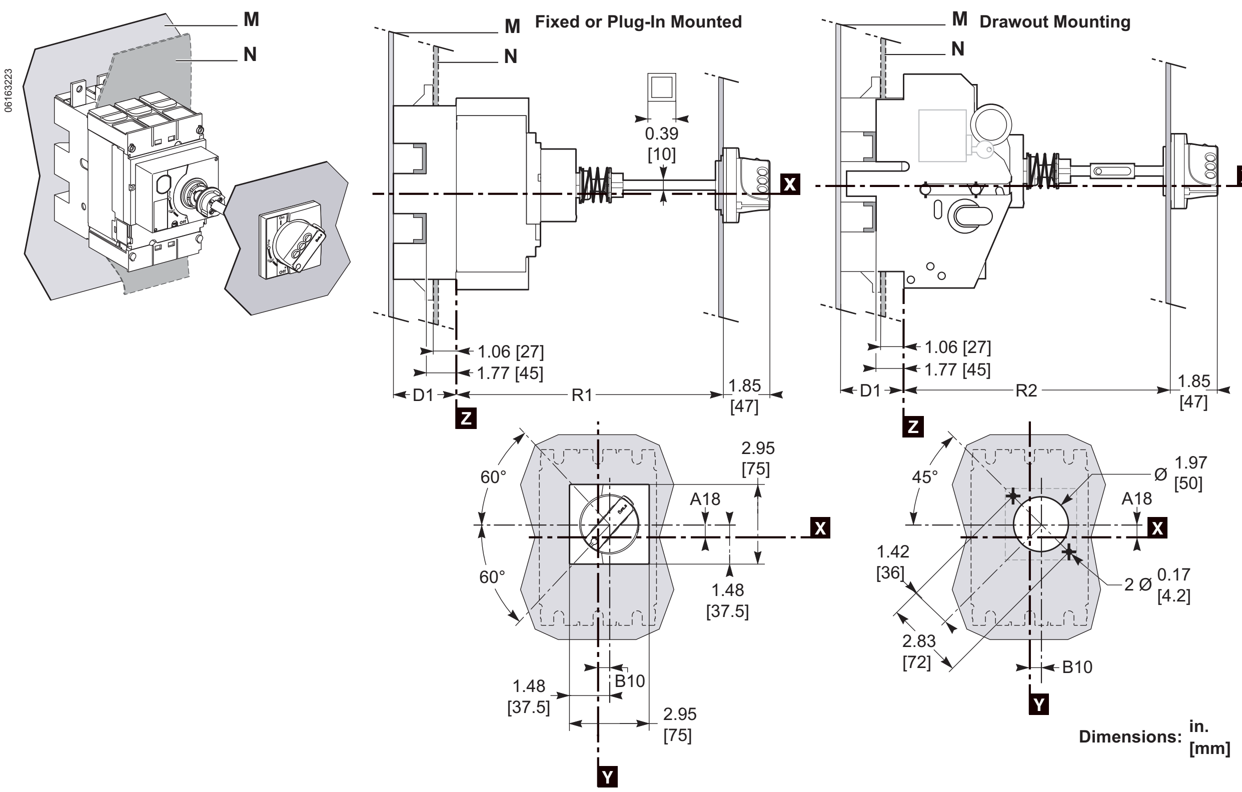
TIM-ID: 0000053623 - 002

Figure 44: PowerPact L-Frame Motor-Control Center Circuit Breaker Direct Rotary-Operating Handle



	A18	A19	A20	B10	B11	B12	P1	S1	S2	S3	S4	S5
inch	0.97	3.27	6.30	0.20	3.35	6.30	5.87	5.71	2.95	5.71	2.01	0.04–0.12
mm	24.6	83	160	5	85	160	149	145	75	145	51	1–3

Figure 45: PowerPact L-Frame Circuit Breaker Extended Rotary Handle Mounting



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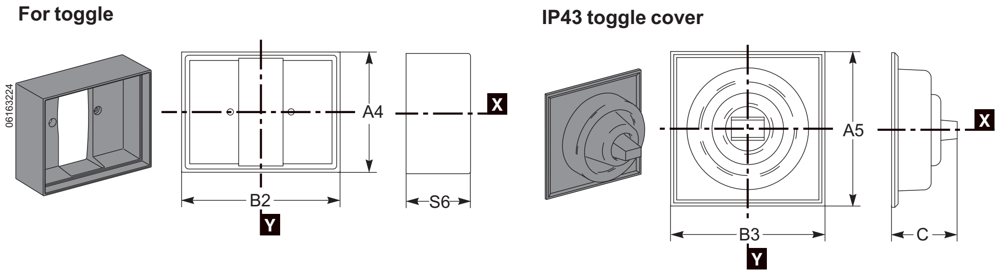
	R1 min	R1 max	R2 min	R2 max	A18	B10	D1
inch	7.68	23.62	10.71	23.62	0.97	0.20	3.94
mm	195	600	272	600	24.6	5	100

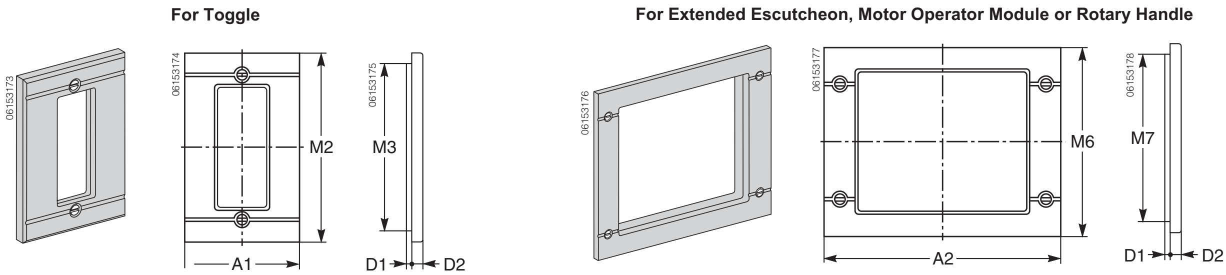
L-Frame Circuit Breaker Front Accessories

Figure 46: PowerPact L-Frame Circuit Breaker Extended Escutcheons



	A4	A5	B2	B3	C	S6
inch	4.82	5.43	4.82	5.43	2.36	1.38
mm	122.5	134	122.5	134	60	35

Figure 47: PowerPact L-Frame Circuit Breaker Front-Panel Escutcheons

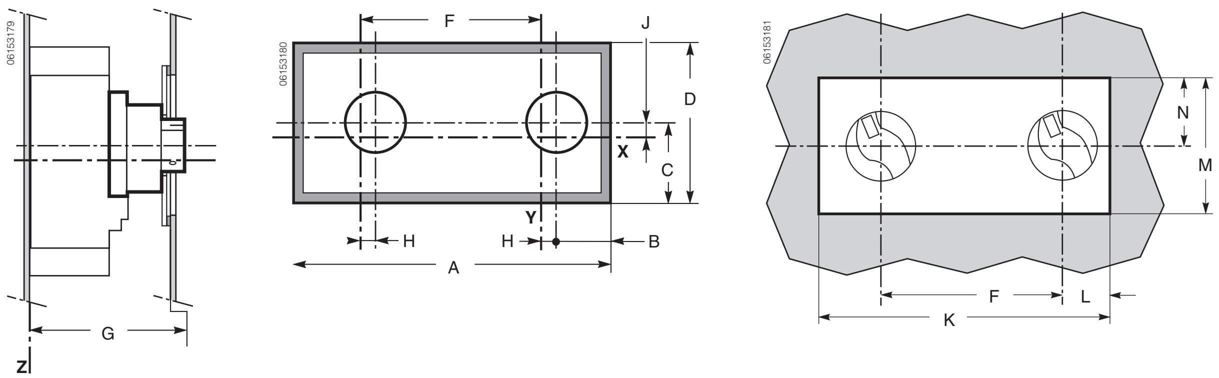


	A1	A2	D1	D2	M2	M3	M6	M7
inch	4.01	7.44	0.13	0.25	6.10	5.59	6.45	5.94
mm	102	189	3.5	6.5	115	142	164	151

TIM-ID: 0000053623 - 002

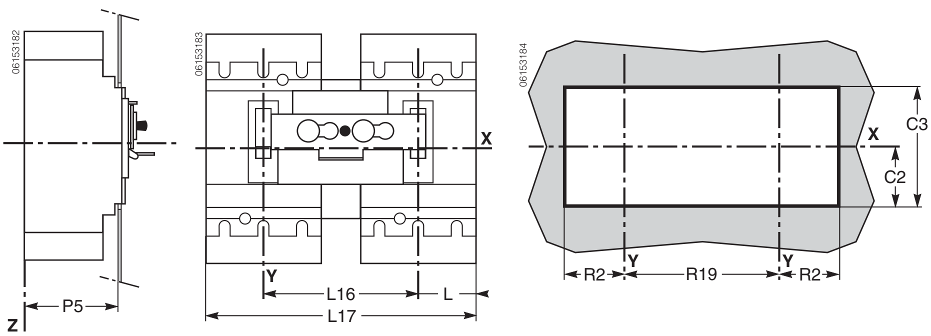
PowerPact L-Frame Circuit Breaker Interlocking Systems

Figure 48: PowerPact L-Frame Circuit Breaker Interlocking Systems with Rotary-Operating Handles



	A	B	C	D	F	G	H	J	K	L	M	N
inch	16.38	4.53	3.94	7.87	8.27	6.18	0.20	0.97	15.20	3.94	6.89	2.93
mm	416	115	100	200	210	157	5	24.6	386	100	175	74.5

Figure 49: PowerPact L-Frame Circuit Breaker Interlocking Systems with Toggle Handles



	C2	C3	L	L16	L17	R2	R19	P5
inch	3.64	7.24	2.75	7.28	12.79	2.81	7.28	4.21
mm	92.5	184	70	185	325	71.5	185	107

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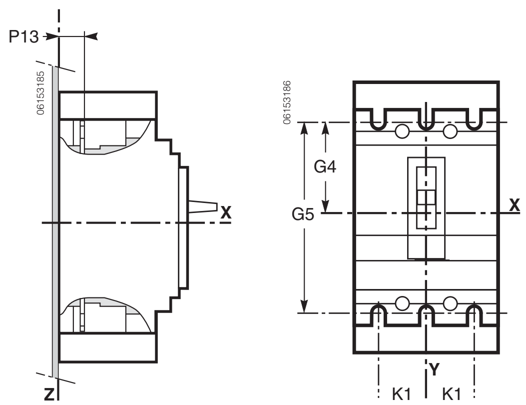
PowerPact L-Frame Circuit Breaker Connectors

Figure 50: PowerPact L-Frame Circuit Breaker Fixed-Mounted Connections



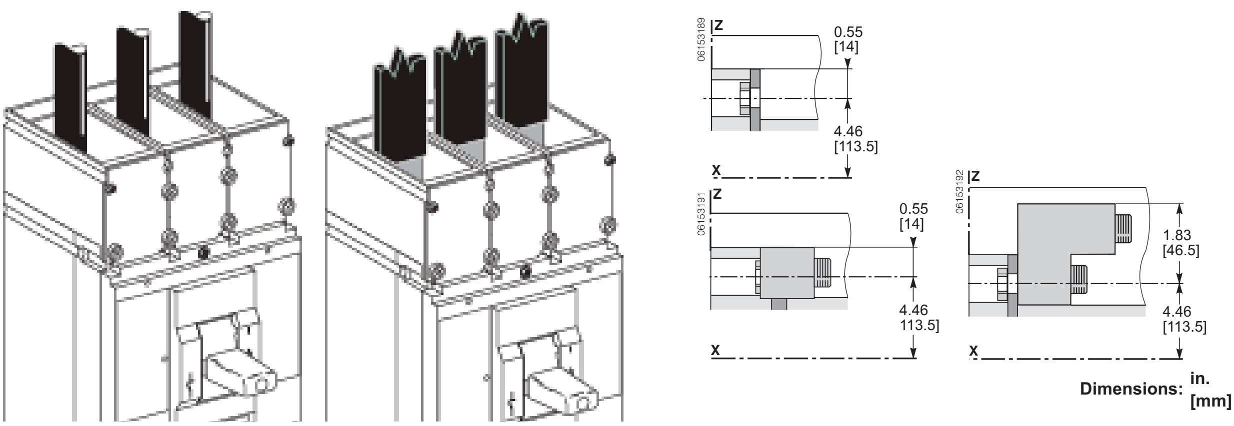
	G4	G5	K1	P13
inch	4.46	8.93	1.77	1.02
mm	113.5	227	45	526

Figure 51: PowerPact L-Frame Circuit Breaker Front Connections

Front Connections

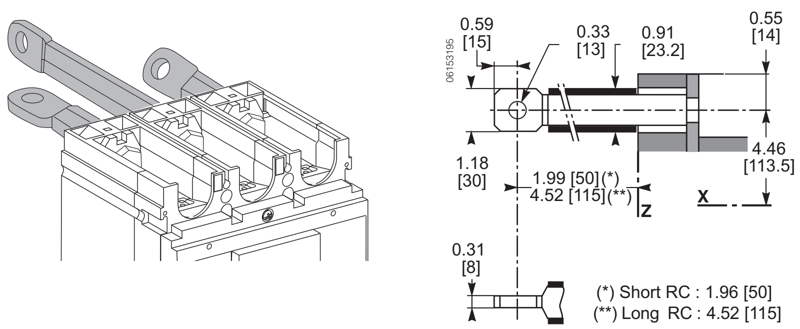
Bus Bar Connection

M10 Screws



Dimensions: in. [mm]

Figure 52: PowerPact L-Frame Circuit Breaker Rear Connections

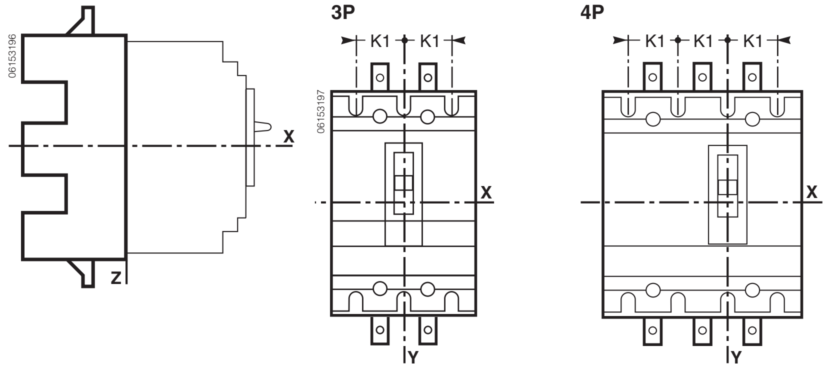


(*) Short RC : 1.96 [50]
(**) Long RC : 4.52 [115]

Dimensions: in. [mm]

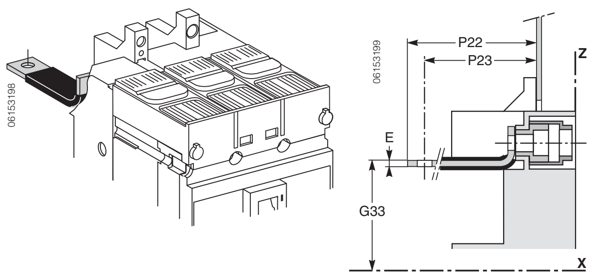
TIM-ID: 0000053623 - 002

Figure 53: PowerPact L-Frame Circuit Breaker Plug-In or Drawout Mounting Connections



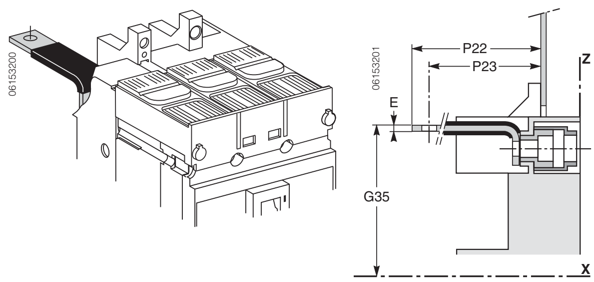
	K1
inch	1.77
mm	45

Figure 54: PowerPact L-Frame Circuit Breaker Rear Connections Fitted at Lower Limit



	E	G33	P22	P23
inch	0.23	4.09	4.50–7.14	3.93–6.57
mm	6	104	114.5–181.5	100–167

Figure 55: PowerPact L-Frame Circuit Breaker Rear Connections Fitted at Upper Limit



	E	G35	P22	P23
inch	0.23	5.07	4.50–7.14	3.93–6.57
mm	6	129	114.5–181.5	100–167

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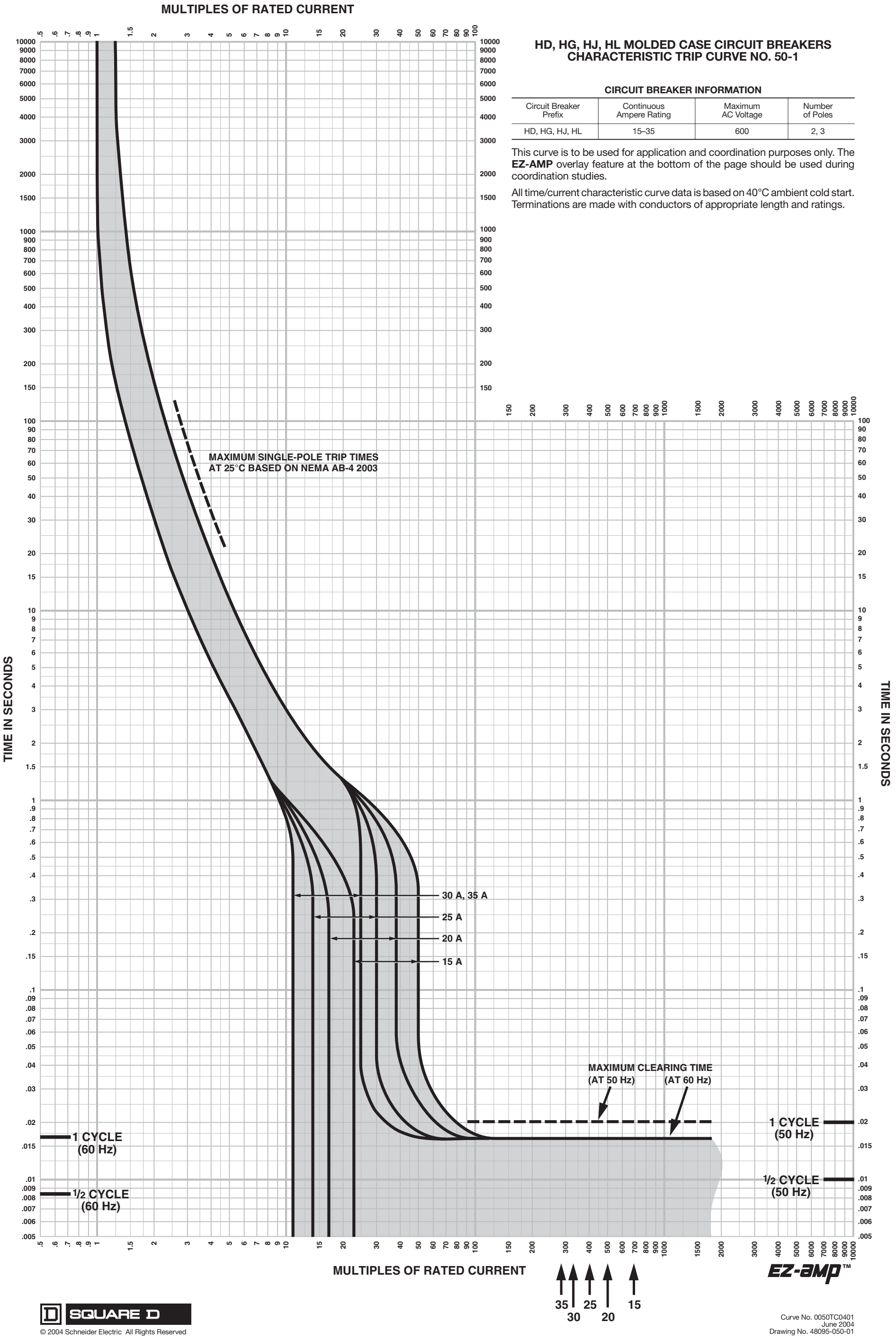
Section 13—Trip Curves

PowerPact H- and J-Frame Thermal-Magnetic Trip Circuit Breakers

Figure 56: H-Frame 15–35 A (HD, HG, HJ, and HL) Thermal-Magnetic Trip



HD, HG, HJ, HL MOLDED CASE CIRCUIT BREAKERS
CHARACTERISTIC TRIP CURVE NO. 50-1

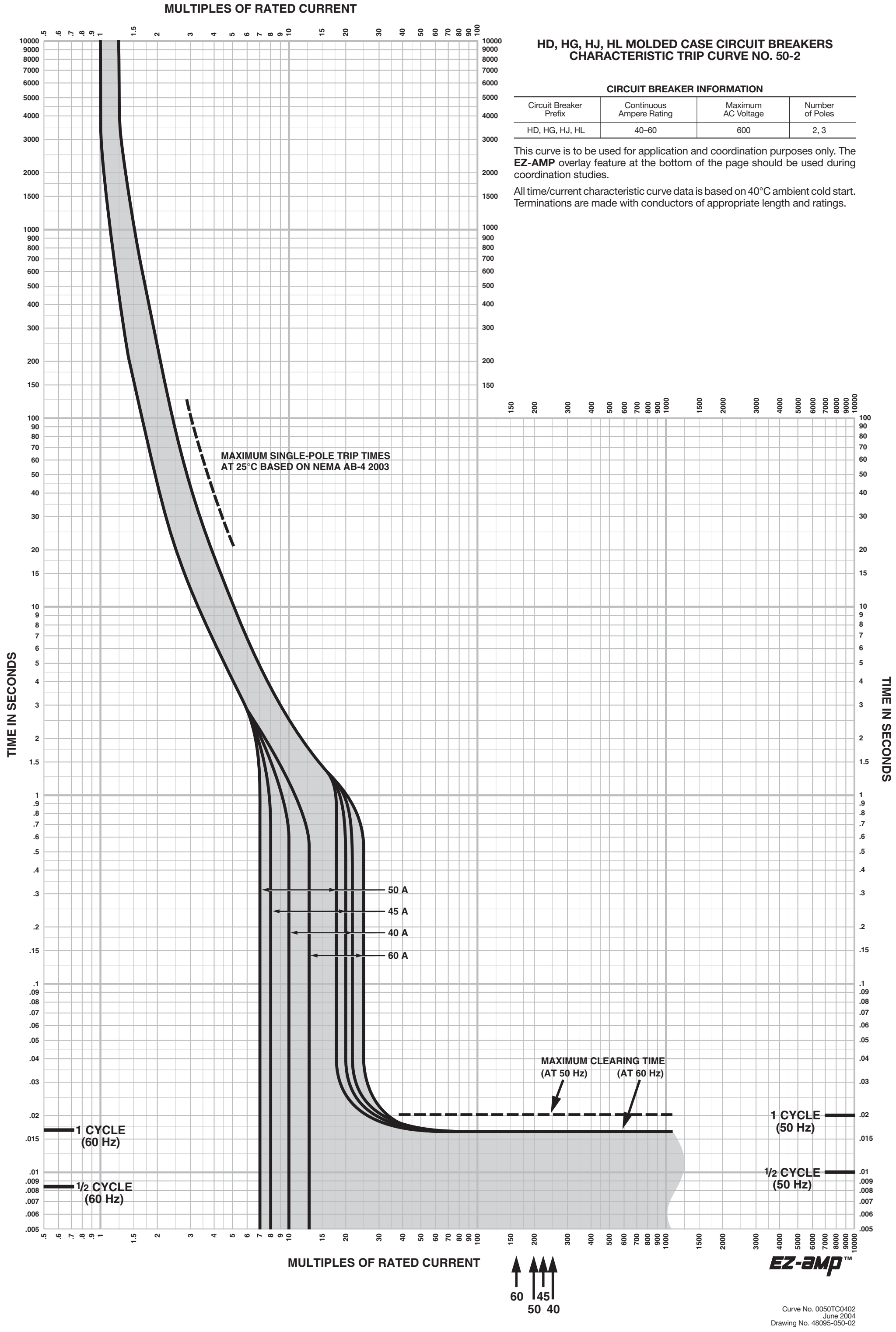
CIRCUIT BREAKER INFORMATION

Circuit Breaker Prefix	Continuous Ampere Rating	Maximum AC Voltage	Number of Poles
HD, HG, HJ, HL	15–35	600	2, 3

This curve is to be used for application and coordination purposes only. The **EZ-AMP** overlay feature at the bottom of the page should be used during coordination studies.

All time/current characteristic curve data is based on 40°C ambient cold start. Terminations are made with conductors of appropriate length and ratings.

Figure 57: H-Frame 40–60 A (HD, HG, HJ, and HL) Thermal-Magnetic Trip



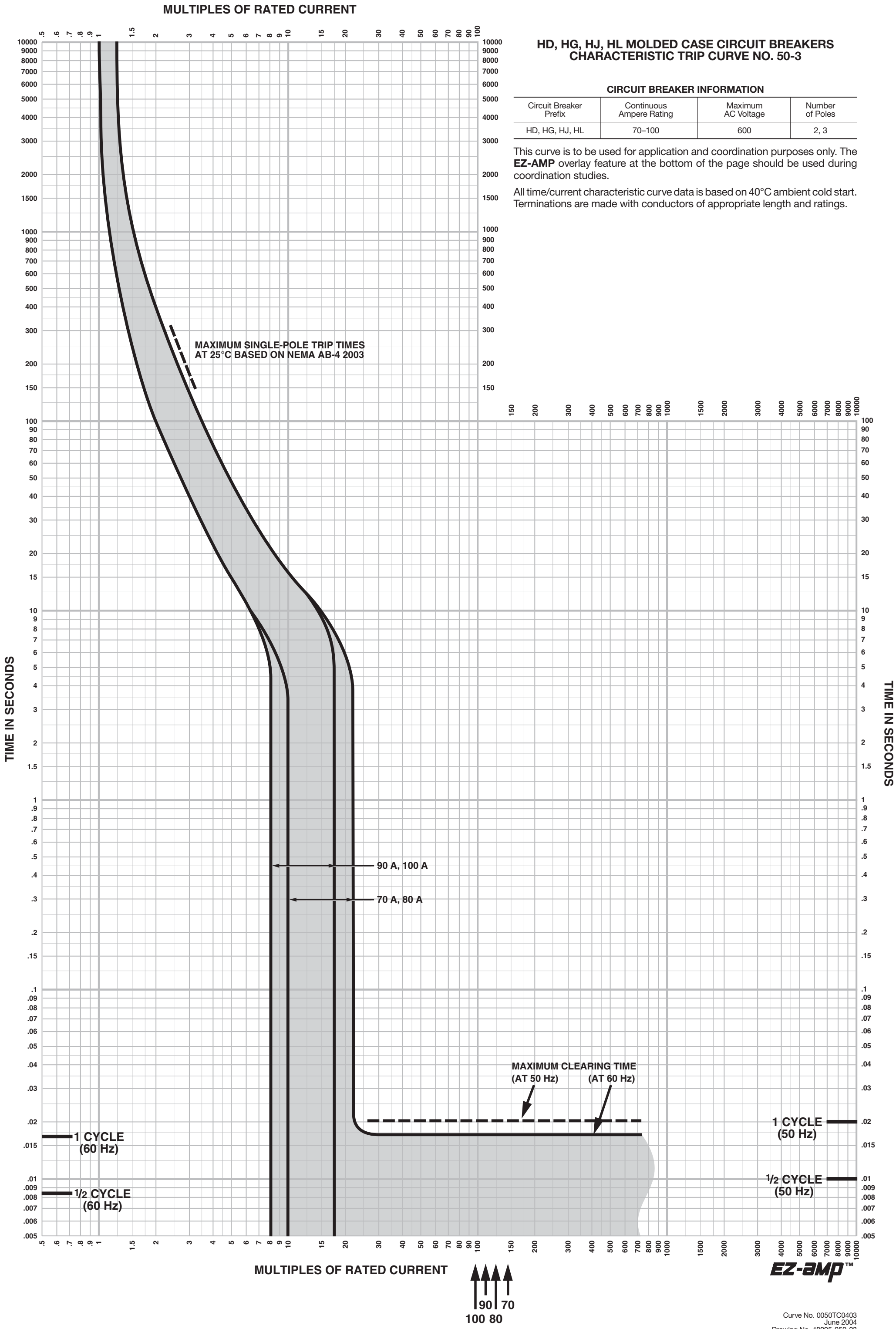
Circuit Breaker Prefix	Continuous Ampere Rating	Maximum AC Voltage	Number of Poles
HD, HG, HJ, HL	40–60	600	2, 3

This curve is to be used for application and coordination purposes only. The **EZ-AMP** overlay feature at the bottom of the page should be used during coordination studies.

All time/current characteristic curve data is based on 40°C ambient cold start. Terminations are made with conductors of appropriate length and ratings.

TIM-ID: 0000053623 - 002

Figure 58: H-Frame 70–100 A (HD, HG, HJ, and HL) Thermal-Magnetic Trip



**HD, HG, HJ, HL MOLDED CASE CIRCUIT BREAKERS
CHARACTERISTIC TRIP CURVE NO. 50-3**

CIRCUIT BREAKER INFORMATION

Circuit Breaker Prefix	Continuous Ampere Rating	Maximum AC Voltage	Number of Poles
HD, HG, HJ, HL	70–100	600	2, 3

This curve is to be used for application and coordination purposes only. The **EZ-AMP** overlay feature at the bottom of the page should be used during coordination studies.

All time/current characteristic curve data is based on 40°C ambient cold start. Terminations are made with conductors of appropriate length and ratings.

Curve No. 0050TC0403
June 2004
Drawing No. 48095-050-03

TIM-ID: 0000053623 - 002

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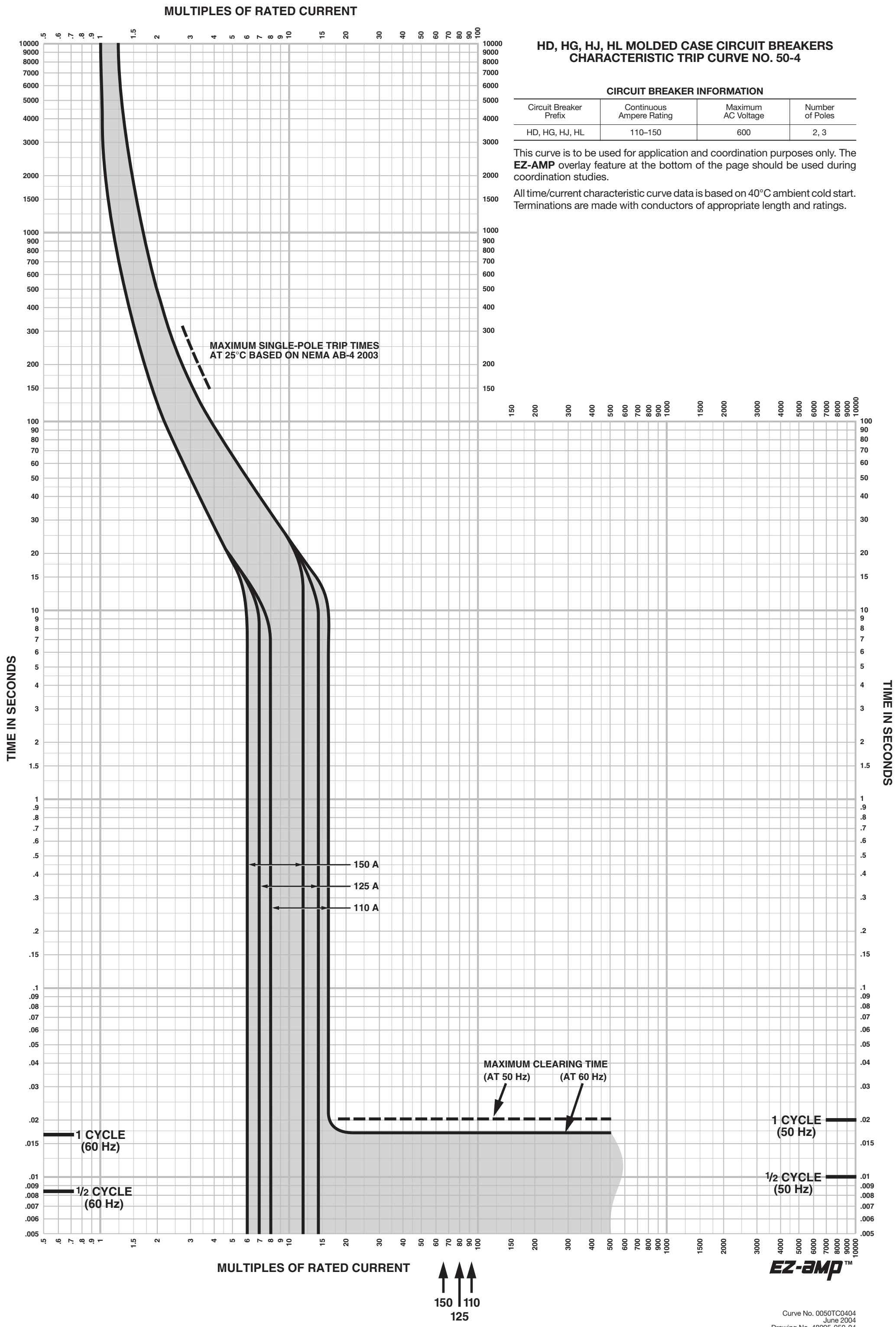
Figure 59: H-Frame 110–150 A (HD, HG, HJ, and HL) Thermal-Magnetic Trip



HD, HG, HJ, HL MOLDED CASE CIRCUIT BREAKERS
CHARACTERISTIC TRIP CURVE NO. 50-4

CIRCUIT BREAKER INFORMATION

Circuit Breaker Prefix	Continuous Ampere Rating	Maximum AC Voltage	Number of Poles
HD, HG, HJ, HL	110–150	600	2, 3

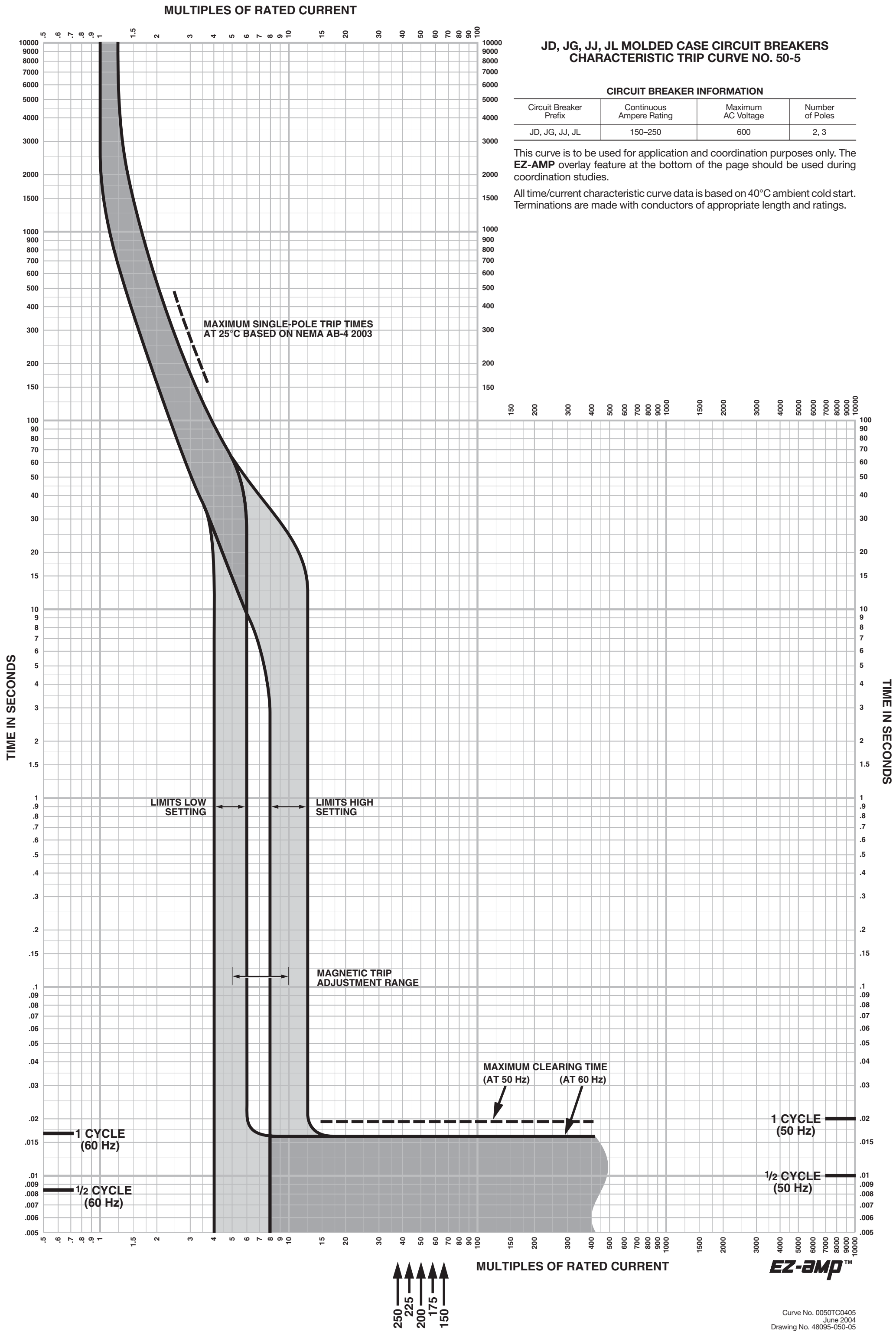
This curve is to be used for application and coordination purposes only. The **EZ-AMP** overlay feature at the bottom of the page should be used during coordination studies.

All time/current characteristic curve data is based on 40°C ambient cold start. Terminations are made with conductors of appropriate length and ratings.

Curve No. 0050TC0404
June 2004
Drawing No. 48095-050-04

TIM-ID: 0000053623 - 002

Figure 60: J-Frame 150–250 A (JD, JG, JJ, and JL) Thermal-Magnetic Trip



JD, JG, JJ, JL MOLDED CASE CIRCUIT BREAKERS
CHARACTERISTIC TRIP CURVE NO. 50-5

CIRCUIT BREAKER INFORMATION

Circuit Breaker Prefix	Continuous Ampere Rating	Maximum AC Voltage	Number of Poles
JD, JG, JJ, JL	150–250	600	2, 3

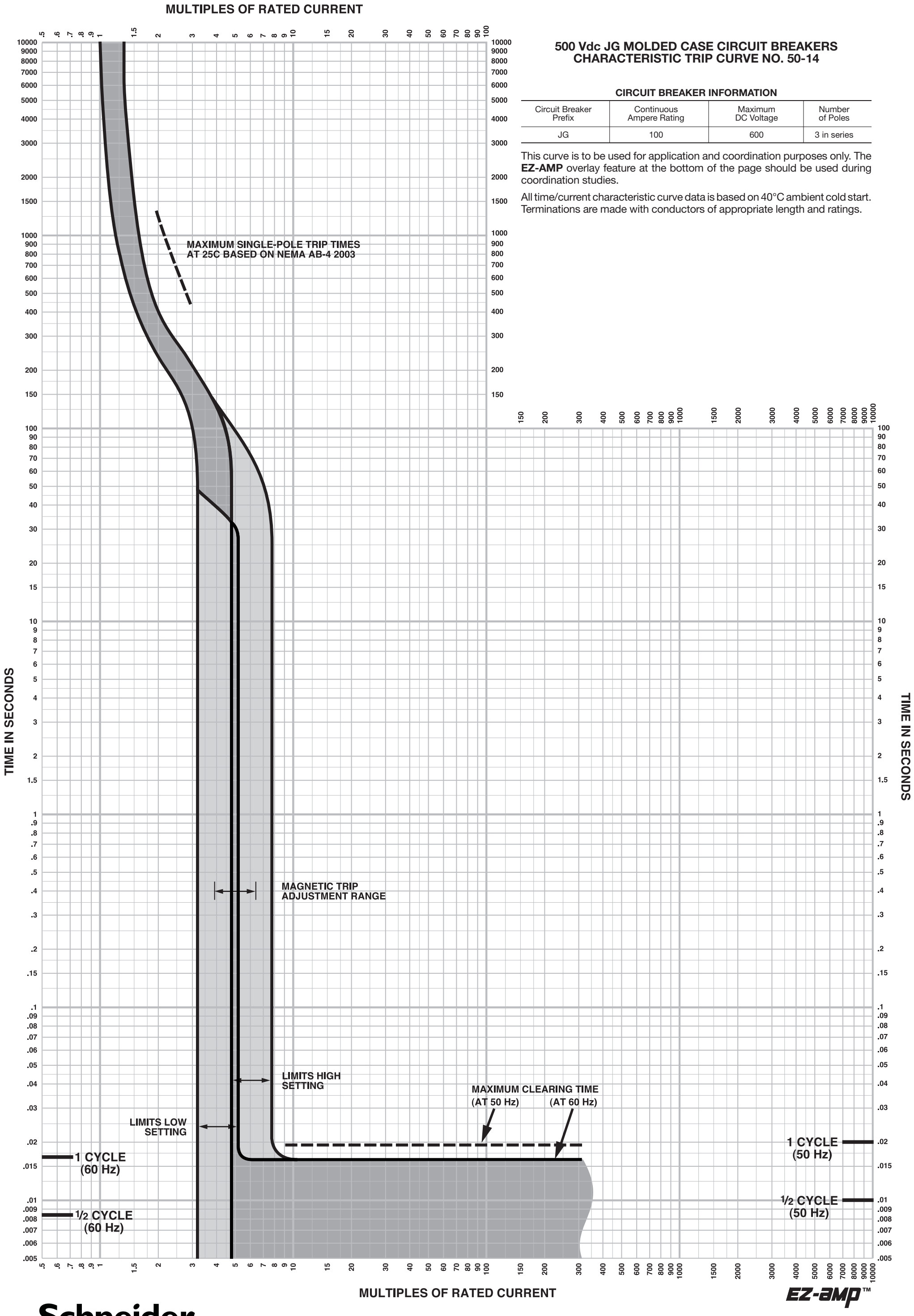
This curve is to be used for application and coordination purposes only. The **EZ-AMP** overlay feature at the bottom of the page should be used during coordination studies.

All time/current characteristic curve data is based on 40°C ambient cold start. Terminations are made with conductors of appropriate length and ratings.

Curve No. 0050TC0405
June 2004
Drawing No. 48095-050-05

TIM-ID: 0000053623 - 002

Figure 61: J-Frame 100 A (JG) 500 Vdc Thermal-Magnetic 500 Trip



500 Vdc JG MOLDED CASE CIRCUIT BREAKERS
CHARACTERISTIC TRIP CURVE NO. 50-14

CIRCUIT BREAKER INFORMATION

Circuit Breaker Prefix	Continuous Ampere Rating	Maximum DC Voltage	Number of Poles
JG	100	600	3 in series

This curve is to be used for application and coordination purposes only. The **EZ-AMP** overlay feature at the bottom of the page should be used during coordination studies.

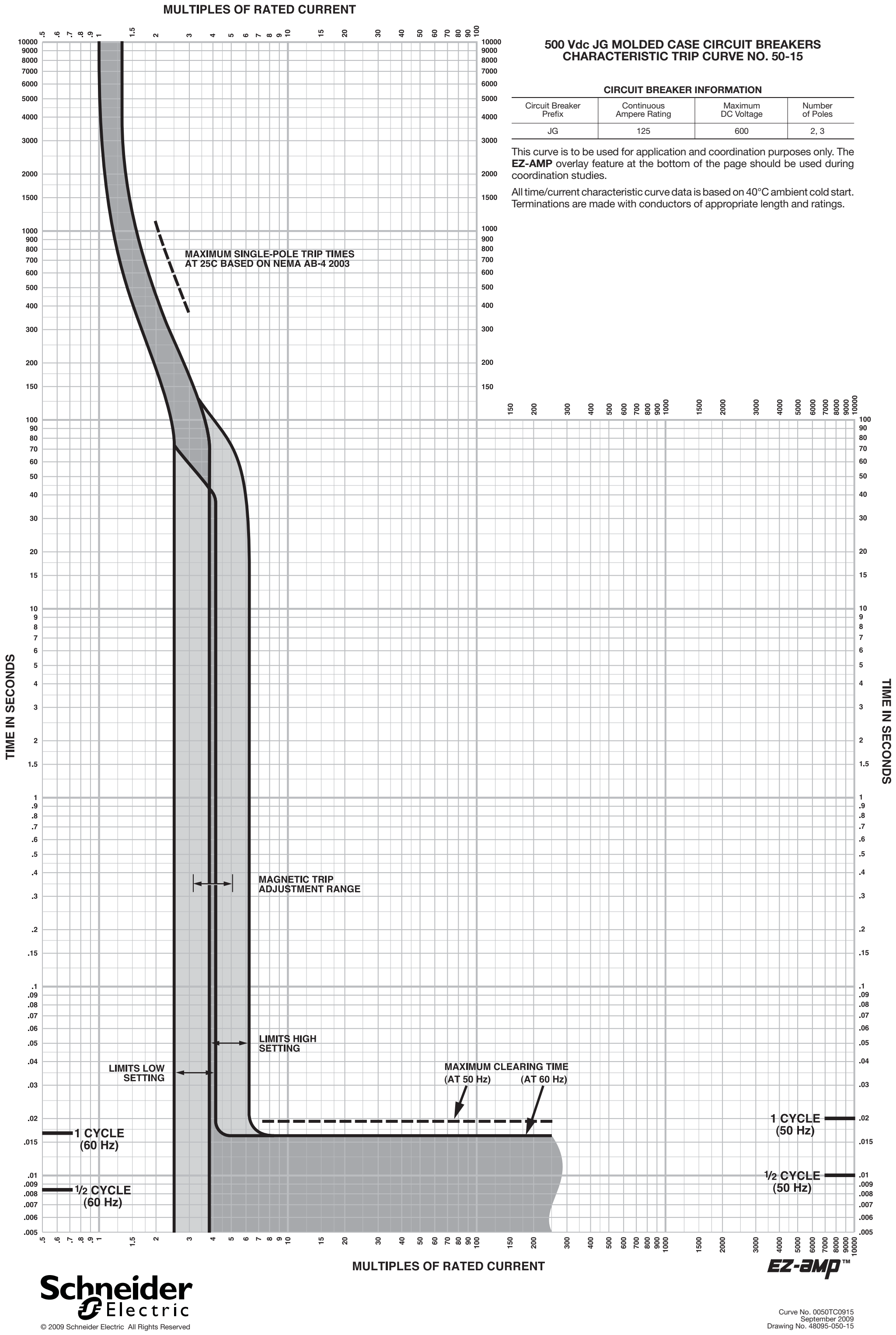
All time/current characteristic curve data is based on 40°C ambient cold start. Terminations are made with conductors of appropriate length and ratings.

TIM-ID: 0000053623 - 002

Schneider Electric

Curve No. 0050TC0914
September 2009
Drawing No. 48095-050-14

Figure 62: J-Frame 125 A (JG) 500 Vdc Thermal-Magnetic Trip



500 Vdc JG MOLDED CASE CIRCUIT BREAKERS CHARACTERISTIC TRIP CURVE NO. 50-15

CIRCUIT BREAKER INFORMATION

Circuit Breaker Prefix	Continuous Ampere Rating	Maximum DC Voltage	Number of Poles
JG	125	600	2, 3

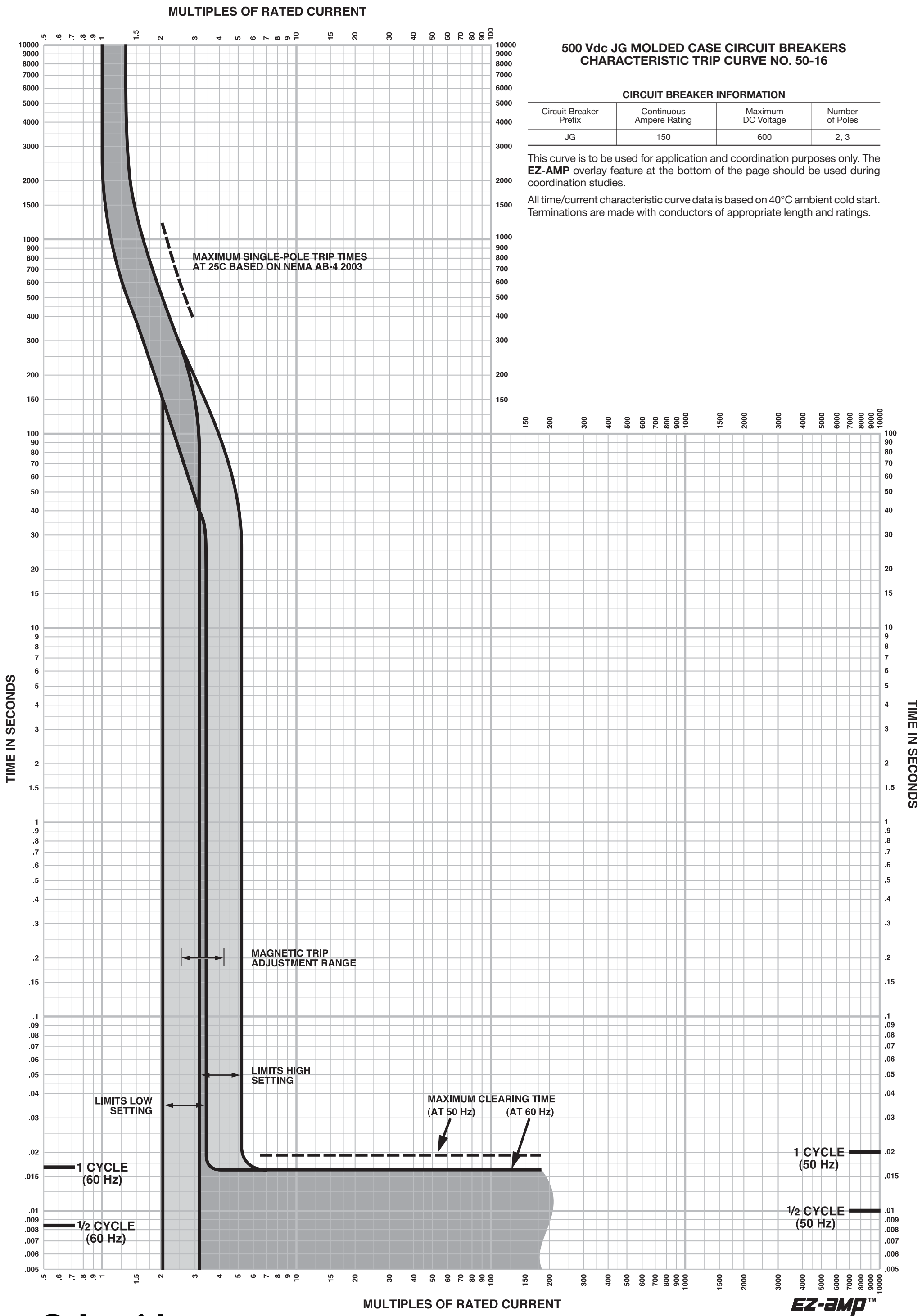
This curve is to be used for application and coordination purposes only. The **EZ-AMP** overlay feature at the bottom of the page should be used during coordination studies.

All time/current characteristic curve data is based on 40°C ambient cold start. Terminations are made with conductors of appropriate length and ratings.

TIM-ID: 0000053623 - 002

SQUARE D by Schneider Electric

Figure 63: J-Frame 150 A (JG) 500 Vdc Thermal-Magnetic Trip



500 Vdc JG MOLDED CASE CIRCUIT BREAKERS
CHARACTERISTIC TRIP CURVE NO. 50-16

CIRCUIT BREAKER INFORMATION

Circuit Breaker Prefix	Continuous Ampere Rating	Maximum DC Voltage	Number of Poles
JG	150	600	2, 3

This curve is to be used for application and coordination purposes only. The **EZ-AMP** overlay feature at the bottom of the page should be used during coordination studies.

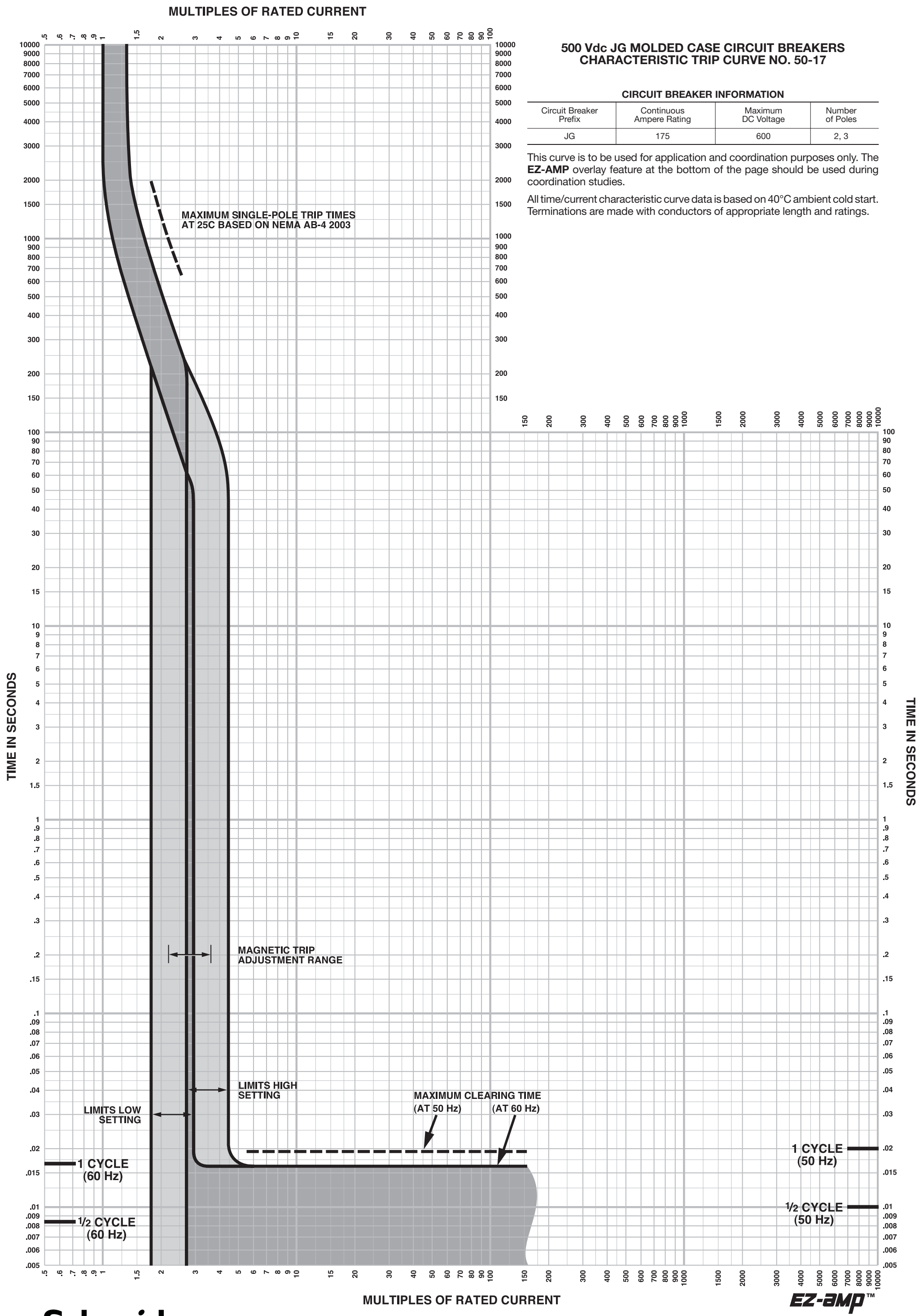
All time/current characteristic curve data is based on 40°C ambient cold start. Terminations are made with conductors of appropriate length and ratings.

TIM-ID: 0000053623 - 002

Schneider Electric

Curve No. 0050TC0916
September 2009
Drawing No. 48095-050-16

Figure 64: J-Frame 175 A (JG) 500 Vdc Thermal-Magnetic Trip



500 Vdc JG MOLDED CASE CIRCUIT BREAKERS CHARACTERISTIC TRIP CURVE NO. 50-17

CIRCUIT BREAKER INFORMATION

Circuit Breaker Prefix	Continuous Ampere Rating	Maximum DC Voltage	Number of Poles
JG	175	600	2, 3

This curve is to be used for application and coordination purposes only. The **EZ-AMP** overlay feature at the bottom of the page should be used during coordination studies.

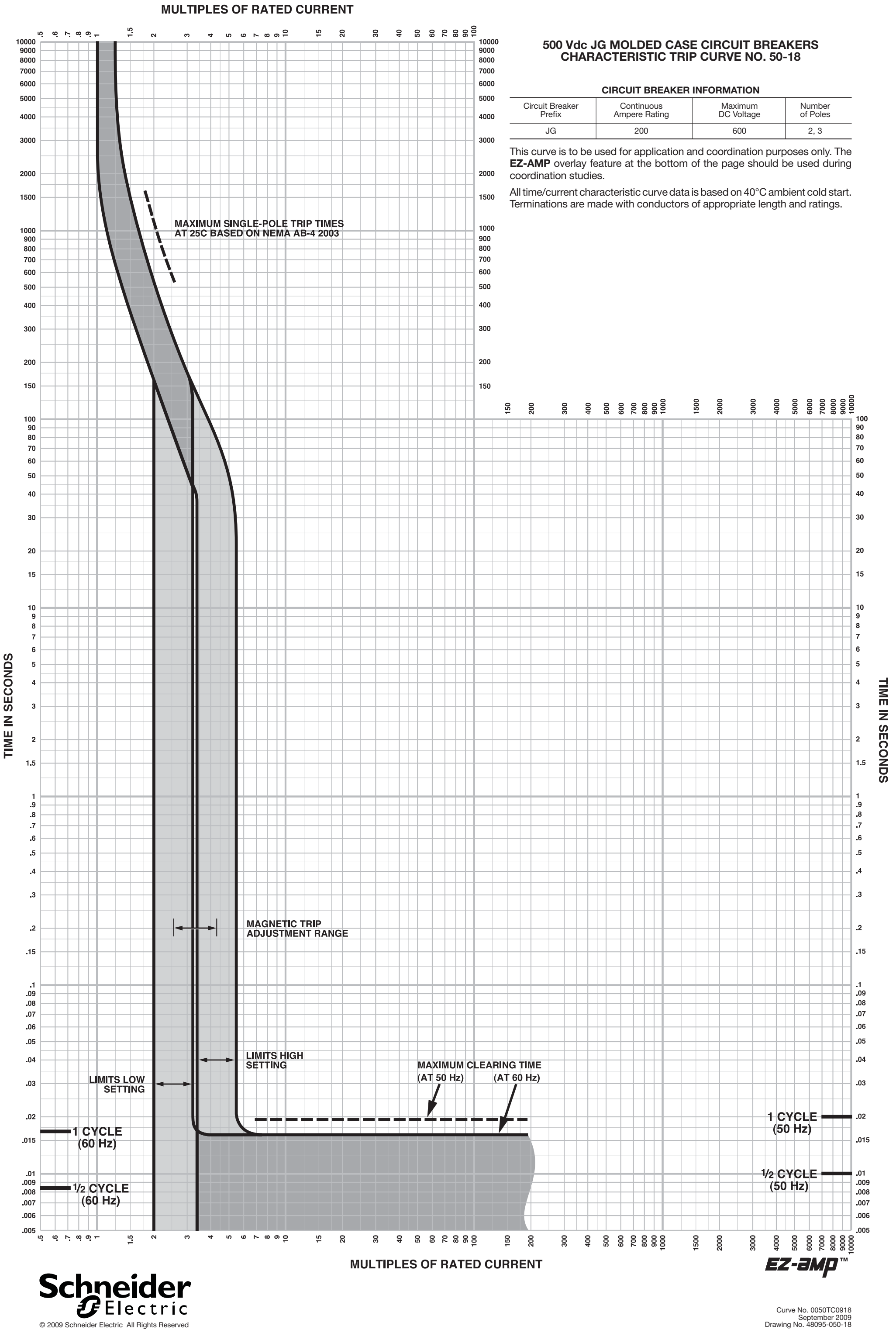
All time/current characteristic curve data is based on 40°C ambient cold start. Terminations are made with conductors of appropriate length and ratings.

Schneider Electric

Curve No. 0050TC0917
September 2009
Drawing No. 48095-050-17

TIM-ID: 0000053623 - 002

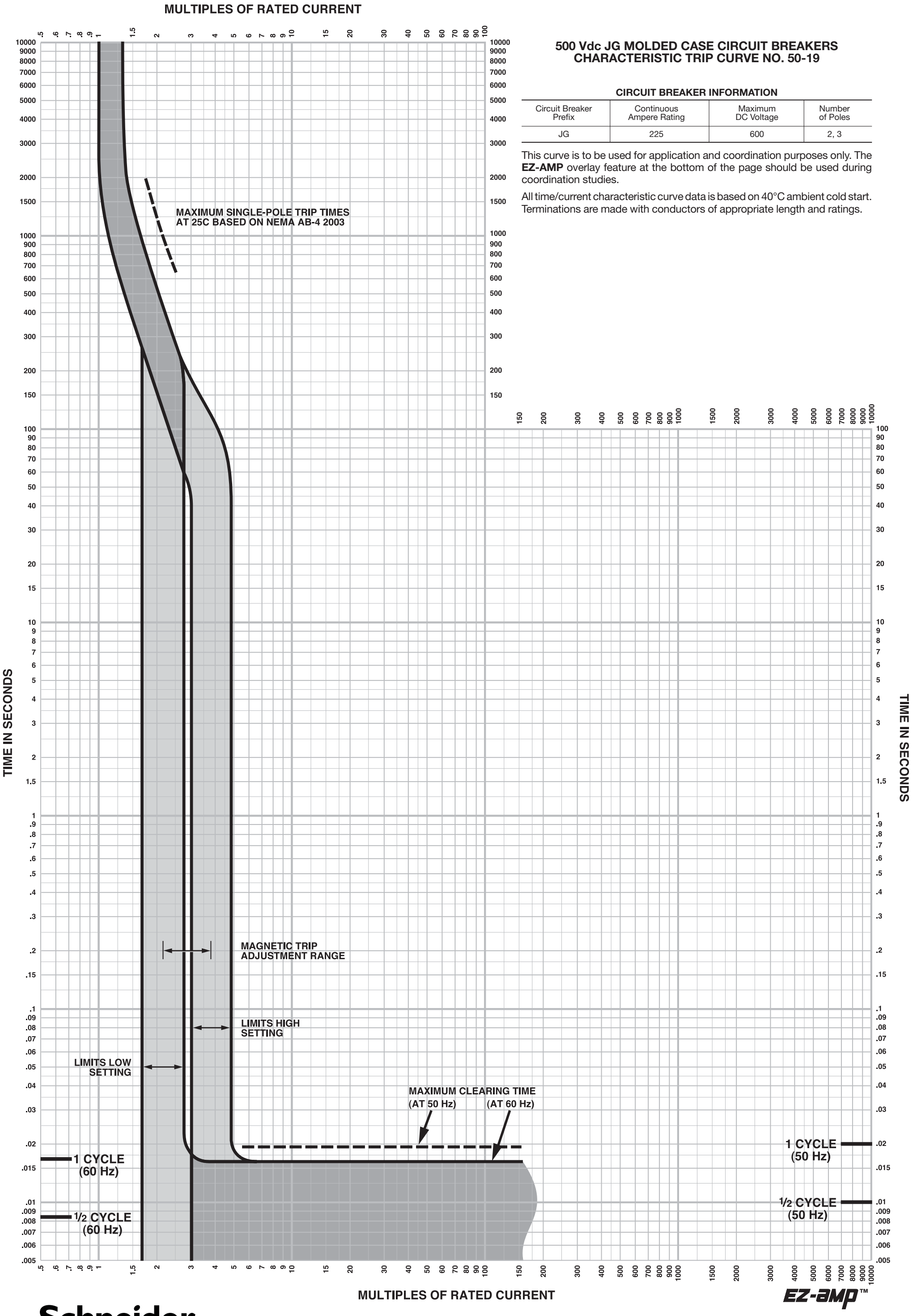
Figure 65: J-Frame 200 A (JG) 500 Vdc Thermal-Magnetic Trip



TIM-ID: 0000053623 - 002

SQUARE D™ by Schneider Electric

Figure 66: J-Frame 225 A (JG) 500 Vdc Thermal-Magnetic Trip



CIRCUIT BREAKER INFORMATION

Circuit Breaker Prefix	Continuous Ampere Rating	Maximum DC Voltage	Number of Poles
JG	225	600	2, 3

This curve is to be used for application and coordination purposes only. The **EZ-AMP** overlay feature at the bottom of the page should be used during coordination studies.

All time/current characteristic curve data is based on 40°C ambient cold start. Terminations are made with conductors of appropriate length and ratings.

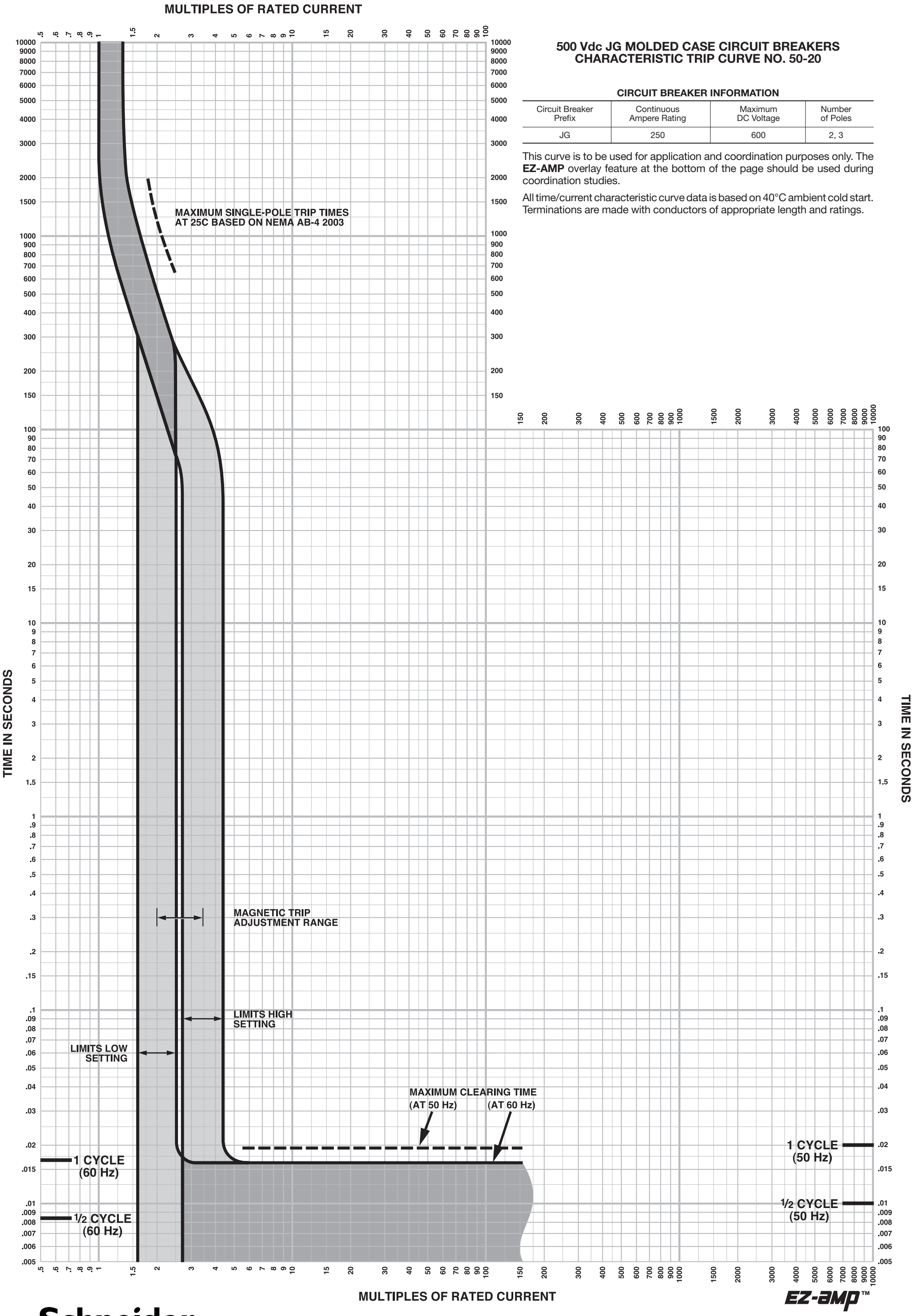
Schneider Electric

Curve No. 0050TC0919
September 2009
Drawing No. 48095-050-19

TIM-ID: 0000053623 - 002

SQUARE D™ by Schneider Electric

Figure 67: J-Frame 250 A (JG) 500 Vdc Thermal-Magnetic Trip



500 Vdc JG MOLDED CASE CIRCUIT BREAKERS
CHARACTERISTIC TRIP CURVE NO. 50-20

CIRCUIT BREAKER INFORMATION

Circuit Breaker Prefix	Continuous Ampere Rating	Maximum DC Voltage	Number of Poles
JG	250	600	2, 3

This curve is to be used for application and coordination purposes only. The **EZ-AMP** overlay feature at the bottom of the page should be used during coordination studies.

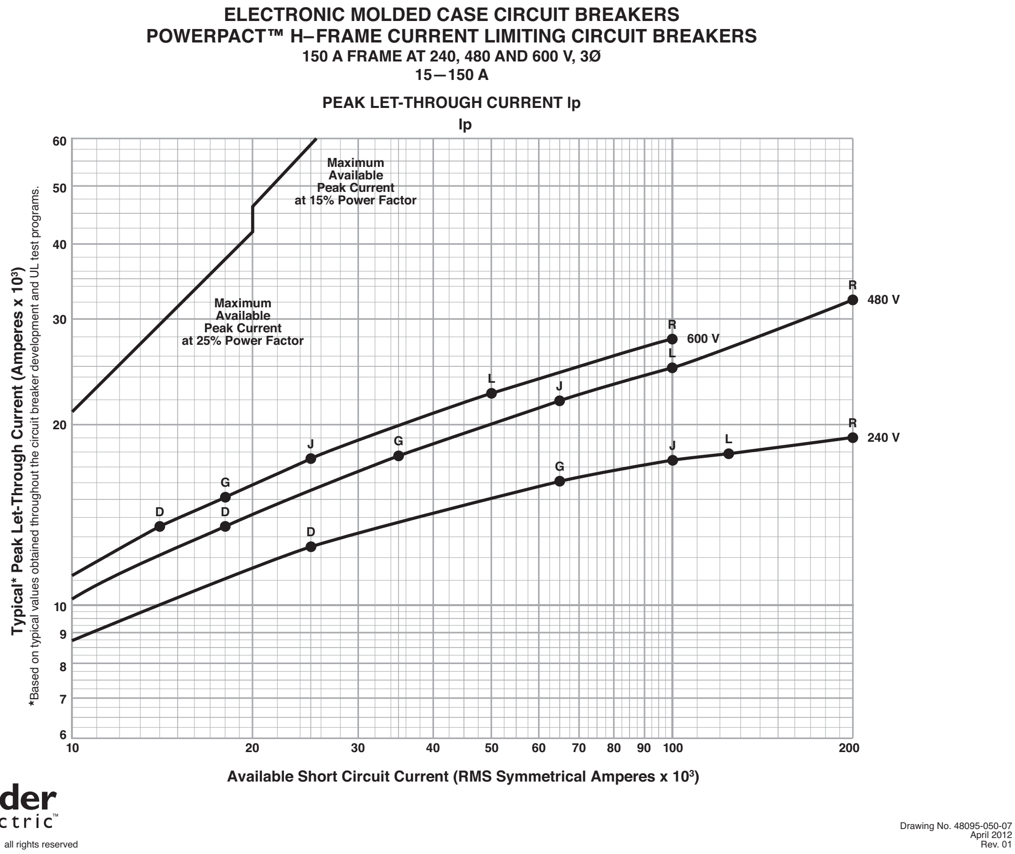
All time/current characteristic curve data is based on 40°C ambient cold start. Terminations are made with conductors of appropriate length and ratings.

TIM-ID: 0000053623 - 002

Schneider Electric

Curve No. 0050TC0920
September 2009
Drawing No. 48095-050-20

Figure 68: H-Frame 150 A Typical Peak Let-Through Curves



TIM-ID: 0000053623 - 002

Figure 69: H-Frame 150 A Typical I^2t Let-Through Curves

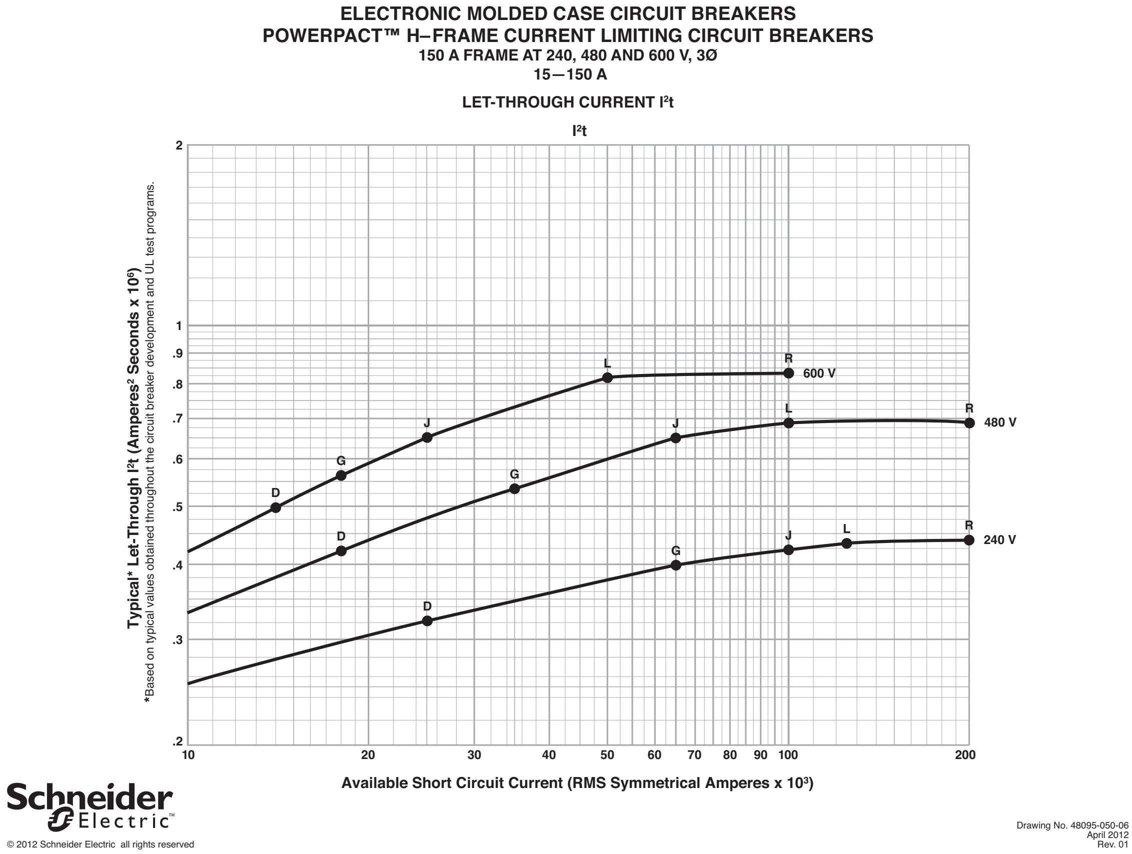
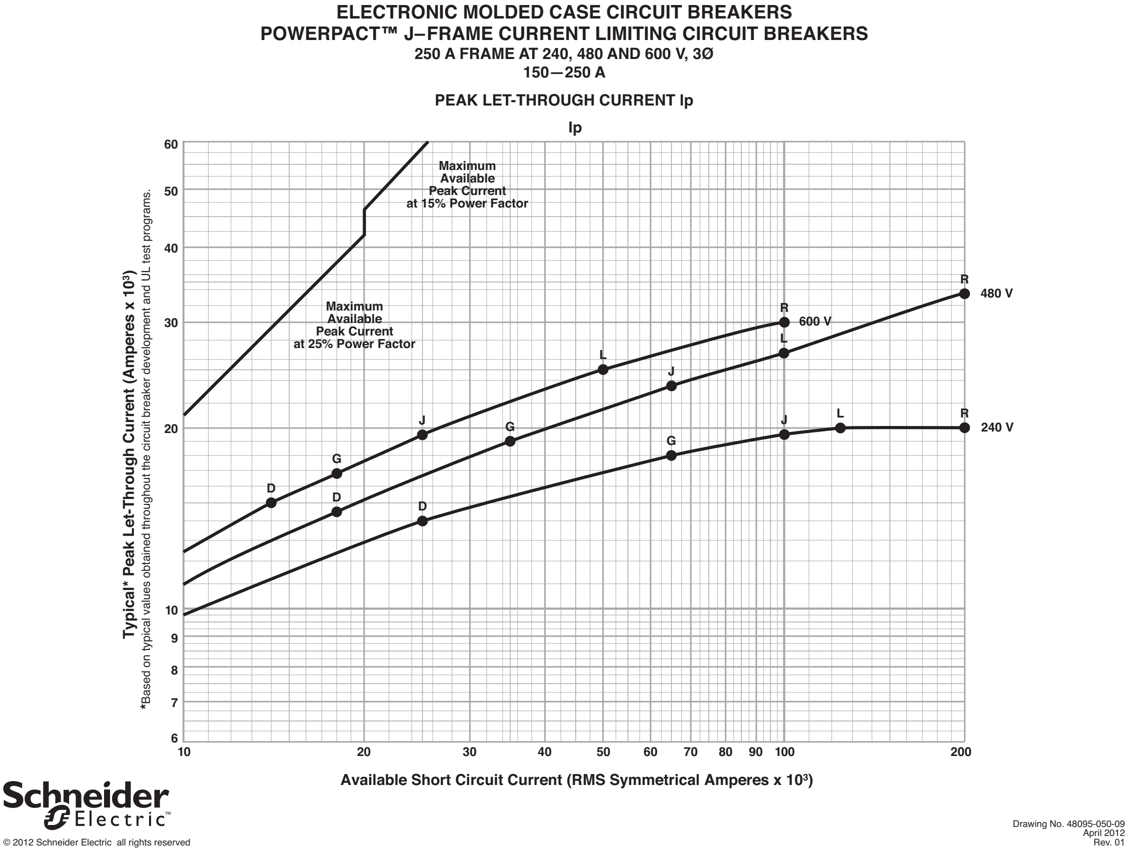
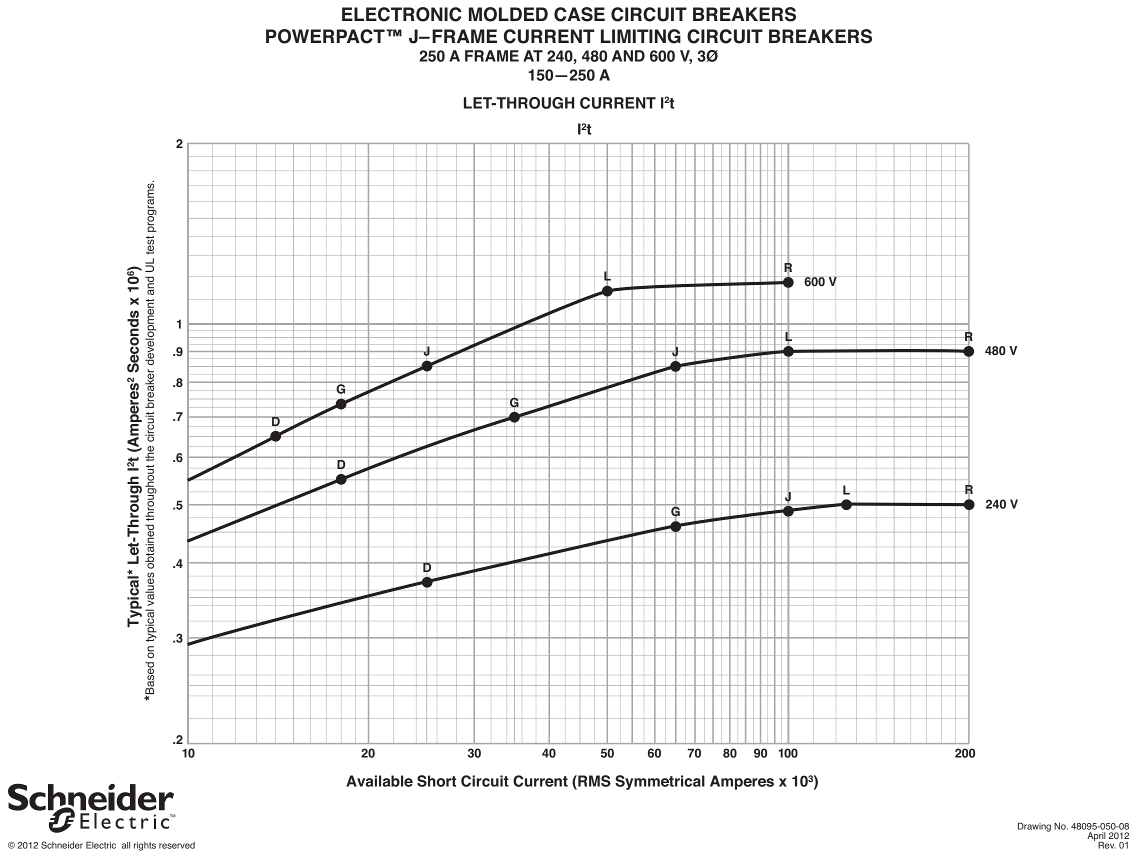


Figure 70: J-Frame 250 A Typical Peak Let-Through Curves



TIM-ID: 0000053623 - 002

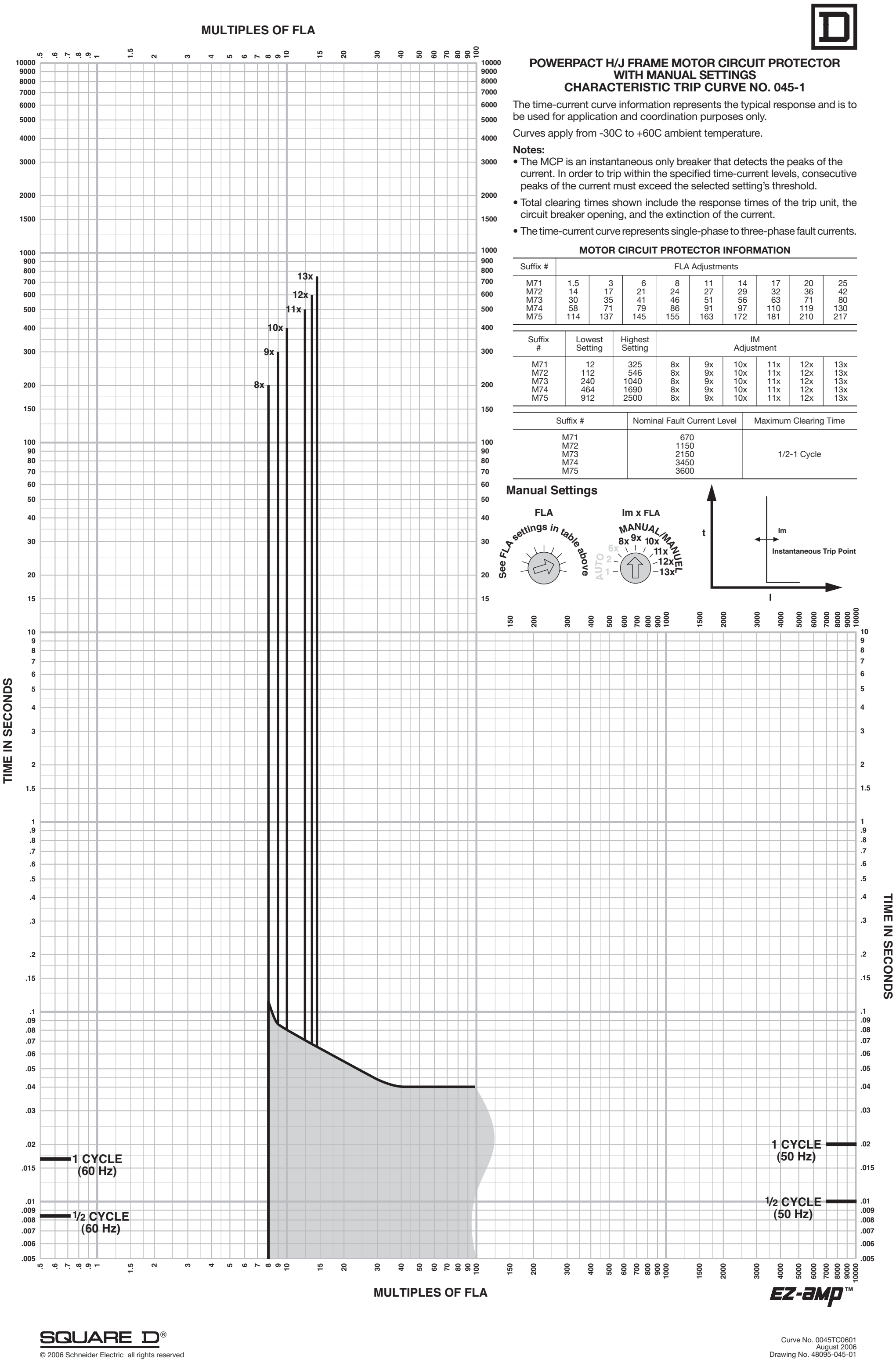
Figure 71: J-Frame 250 A Typical I²t Let-Through Curves



TIM-ID: 0000053623 - 002

SQUARE D by Schneider Electric

Figure 72: H- and J-Frame Motor Circuit Protector



POWERPACT H/J FRAME MOTOR CIRCUIT PROTECTOR WITH MANUAL SETTINGS CHARACTERISTIC TRIP CURVE NO. 045-1

The time-current curve information represents the typical response and is to be used for application and coordination purposes only.

Curves apply from -30C to +60C ambient temperature.

Notes:
- The MCP is an instantaneous only breaker that detects the peaks of the current. In order to trip within the specified time-current levels, consecutive peaks of the current must exceed the selected setting's threshold.
- Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.
- The time-current curve represents single-phase to three-phase fault currents.

MOTOR CIRCUIT PROTECTOR INFORMATION

Suffix #	FLA Adjustments								
M71	1.5	3	6	8	11	14	17	20	25
M72	14	17	21	24	27	29	32	36	42
M73	30	35	41	46	51	56	63	71	80
M74	58	71	79	86	91	97	110	119	130
M75	114	137	145	155	163	172	181	210	217

Suffix #	Lowest Setting	Highest Setting	IM Adjustment					
M71	12	325	8x	9x	10x	11x	12x	13x
M72	112	546	8x	9x	10x	11x	12x	13x
M73	240	1040	8x	9x	10x	11x	12x	13x
M74	464	1690	8x	9x	10x	11x	12x	13x
M75	912	2500	8x	9x	10x	11x	12x	13x

Suffix #	Nominal Fault Current Level	Maximum Clearing Time
M71	670	1/2-1 Cycle
M72	1150	
M73	2150	
M74	3450	
M75	3600	

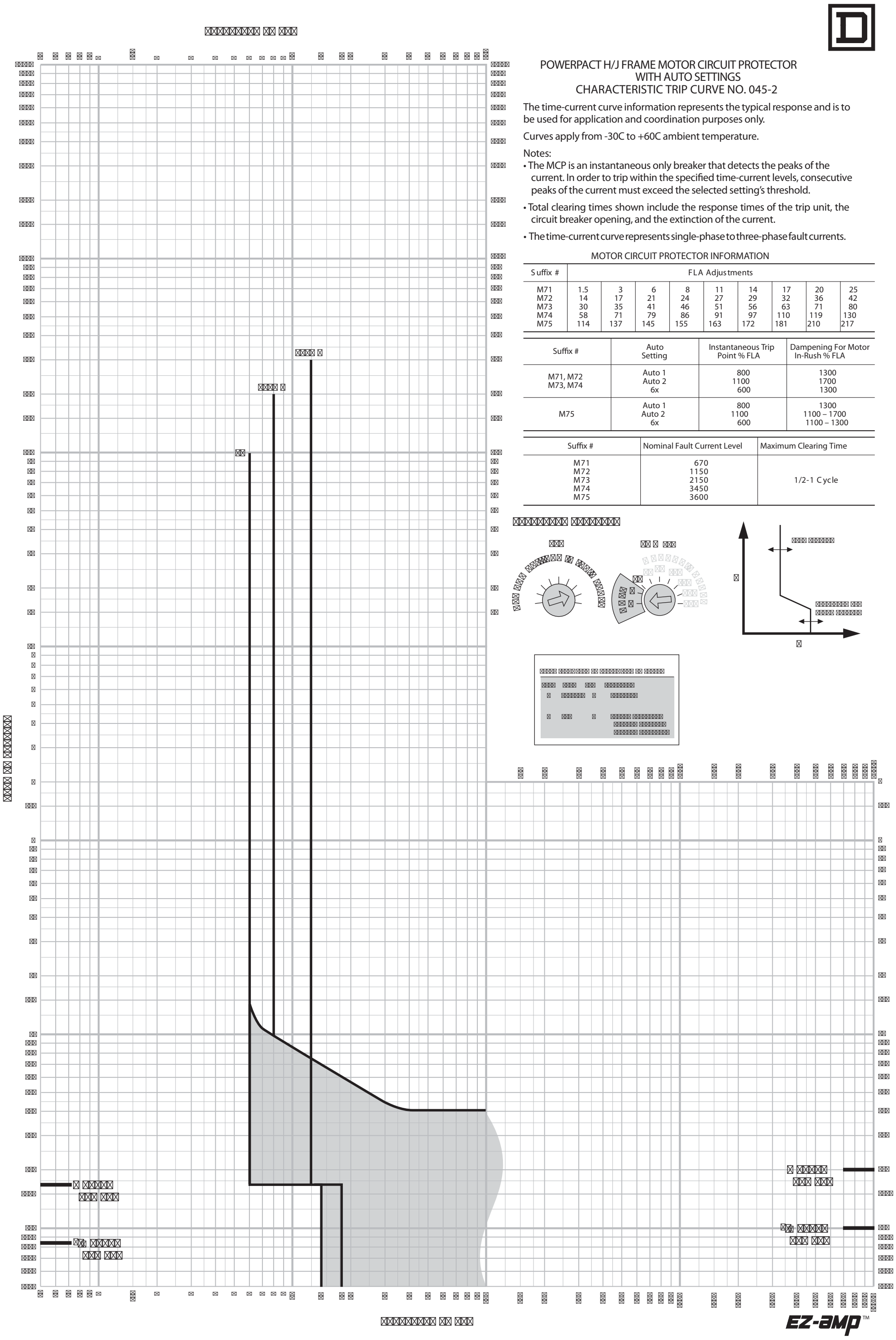
TIM-ID: 0000053623 - 002

SQUARE D by Schneider Electric

TIM-ID: 0000053623 - 002

SQUARE D™ by Schneider Electric

Figure 73: H- and J-Frame Motor Circuit Protector



POWERPACT H/J FRAME MOTOR CIRCUIT PROTECTOR
WITH AUTO SETTINGS
CHARACTERISTIC TRIP CURVE NO. 045-2

The time-current curve information represents the typical response and is to be used for application and coordination purposes only.

Curves apply from -30C to +60C ambient temperature.

Notes:

- The MCP is an instantaneous only breaker that detects the peaks of the current. In order to trip within the specified time-current levels, consecutive peaks of the current must exceed the selected setting's threshold.
- Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.
- The time-current curve represents single-phase to three-phase fault currents.

MOTOR CIRCUIT PROTECTOR INFORMATION

Suffix #	FLA Adjustments								
M71	1.5	3	6	8	11	14	17	20	25
M72	14	17	21	24	27	29	32	36	42
M73	30	35	41	46	51	56	63	71	80
M74	58	71	79	86	91	97	110	119	130
M75	114	137	145	155	163	172	181	210	217

Suffix #	Auto Setting	Instantaneous Trip Point % FLA	Dampening For Motor In-Rush % FLA
M71, M72 M73, M74	Auto 1 Auto 2 6x	800 1100 600	1300 1700 1300
M75	Auto 1 Auto 2 6x	800 1100 600	1300 1100 – 1700 1100 – 1300

Suffix #	Nominal Fault Current Level	Maximum Clearing Time
M71 M72 M73 M74 M75	670 1150 2150 3450 3600	1/2-1 Cycle

SQUARE D

Curve No. 0045TC0602
August 2006
Drawing No. 48095-045-02

TIM-ID: 0000053623 - 002

SQUARE D™ by Schneider Electric

Figure 74: H-Frame UL Listed Current-Limiting Circuit Breaker

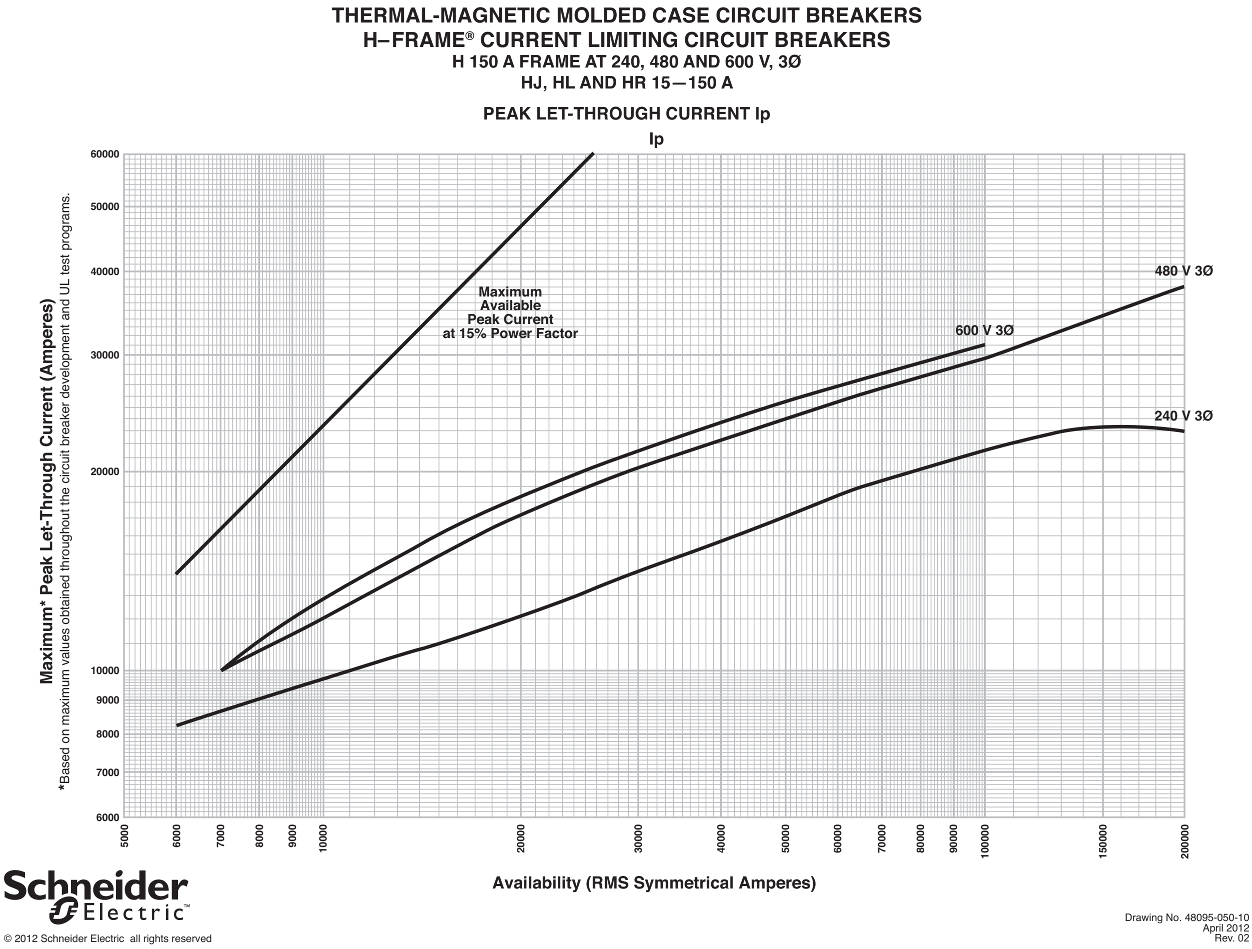
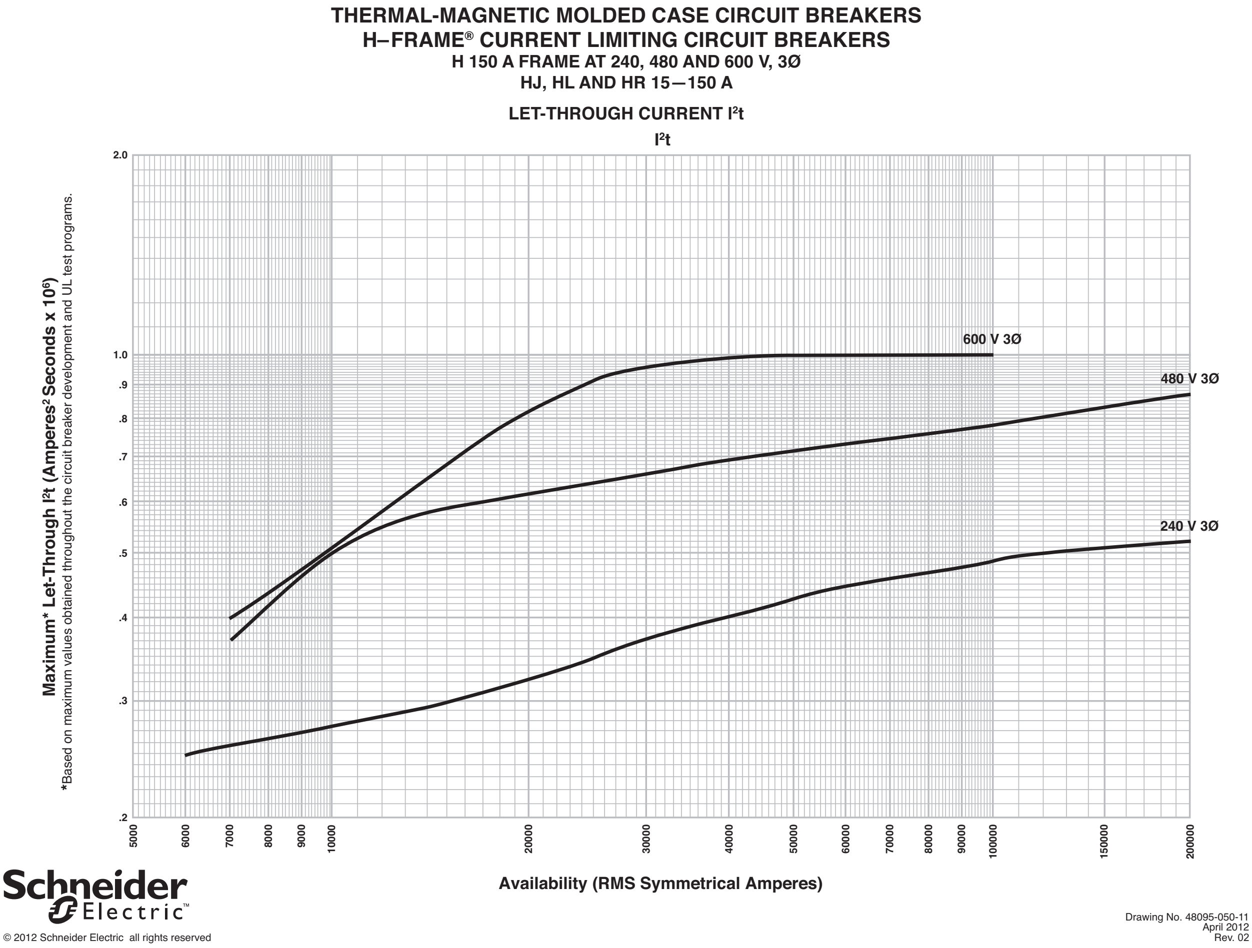
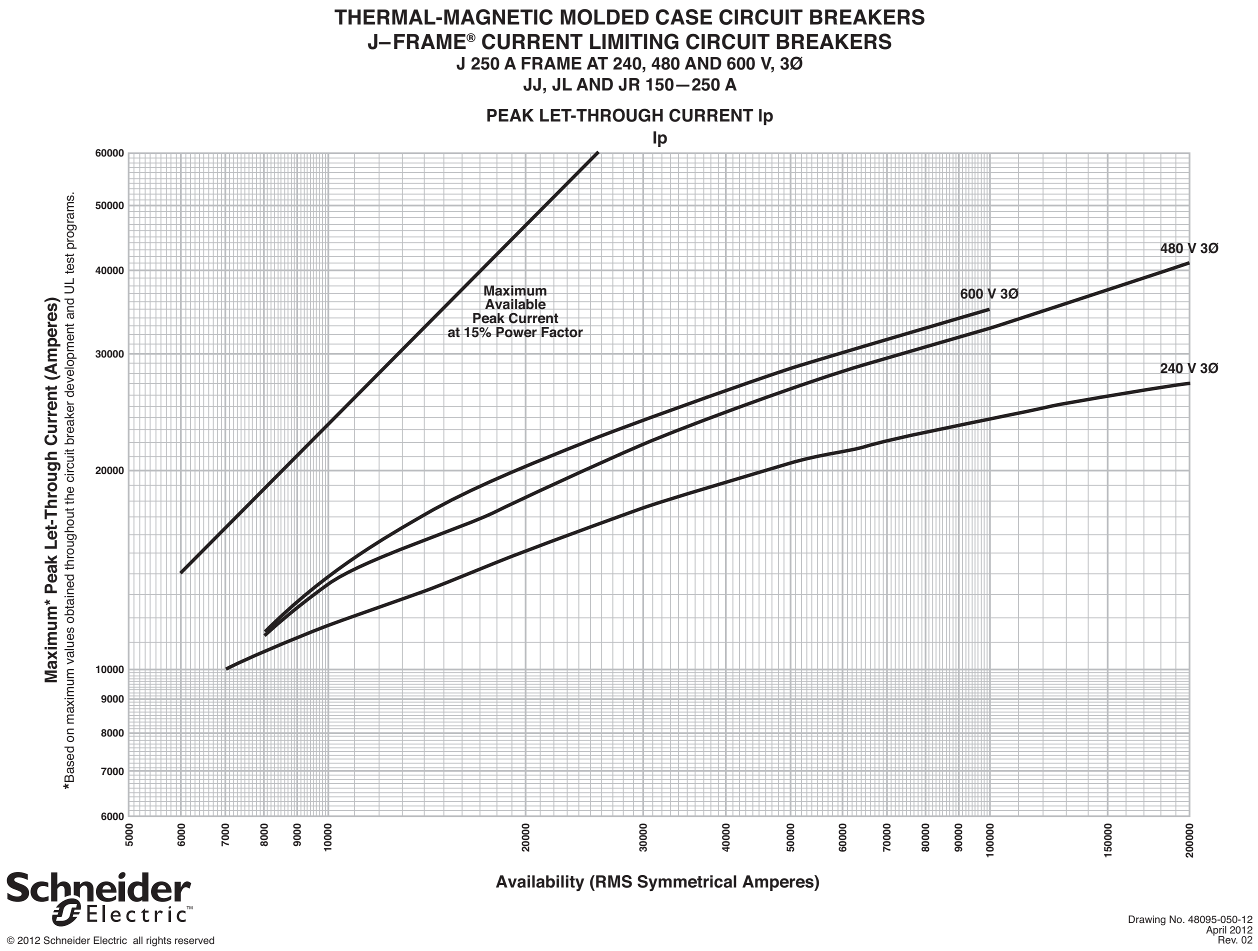


Figure 75: H-Frame UL Listed Current-Limiting Circuit Breaker



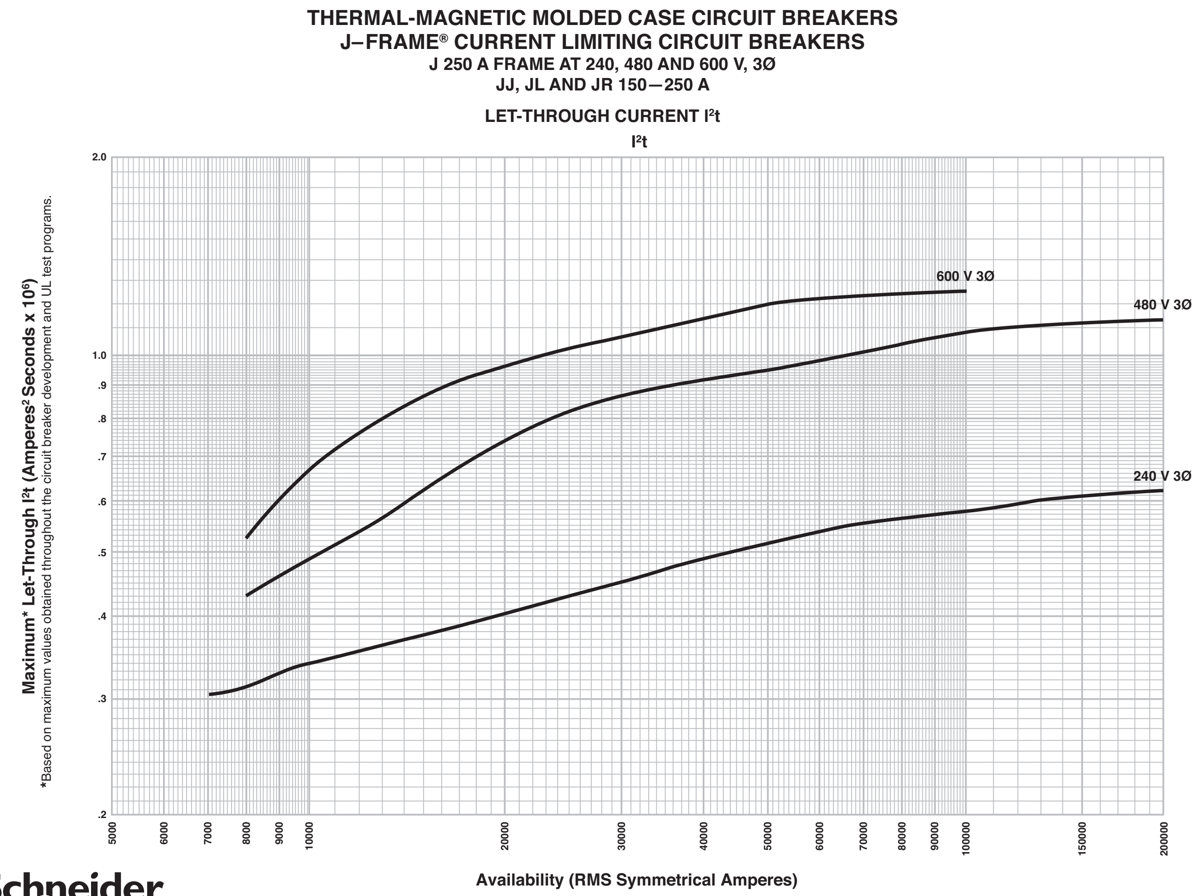
TIM-ID: 0000053623 - 002

Figure 76: J-Frame UL Listed Current -Limiting Circuit Breaker



TIM-ID: 0000053623 - 002

Figure 77: J-Frame UL Listed Current-Limiting Circuit Breaker



Drawing No. 48095-050-13
April 2012
Rev. 02

TIM-ID: 0000053623 - 002

Figure 78: Ground Fault Module GFM150HD Trip Curve

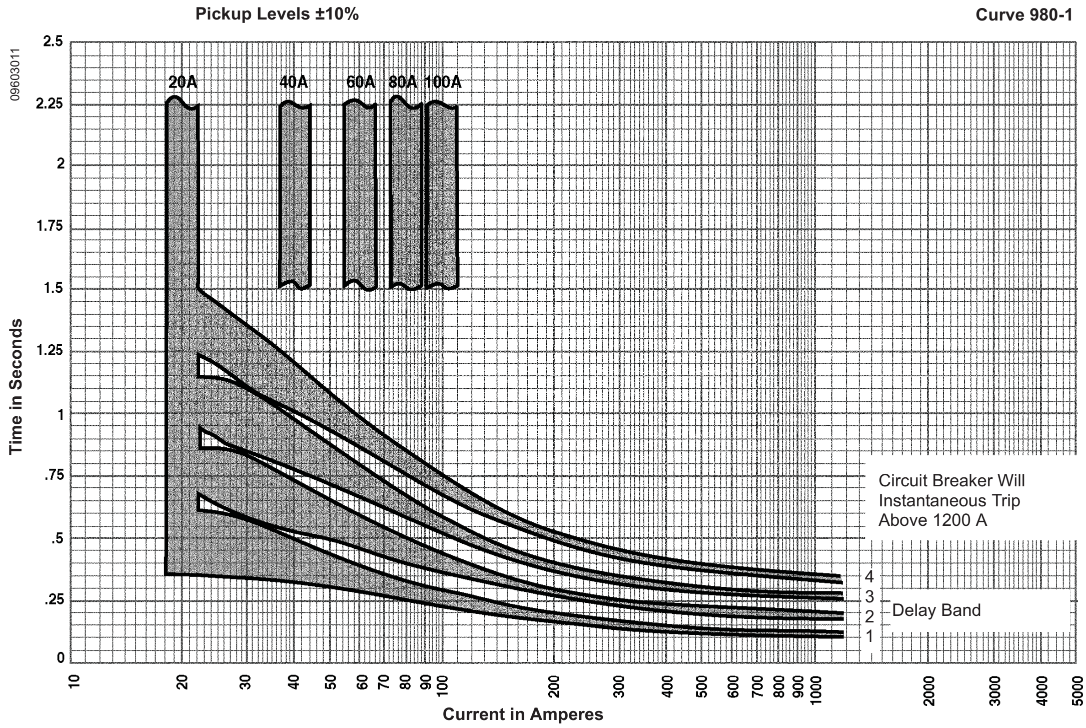
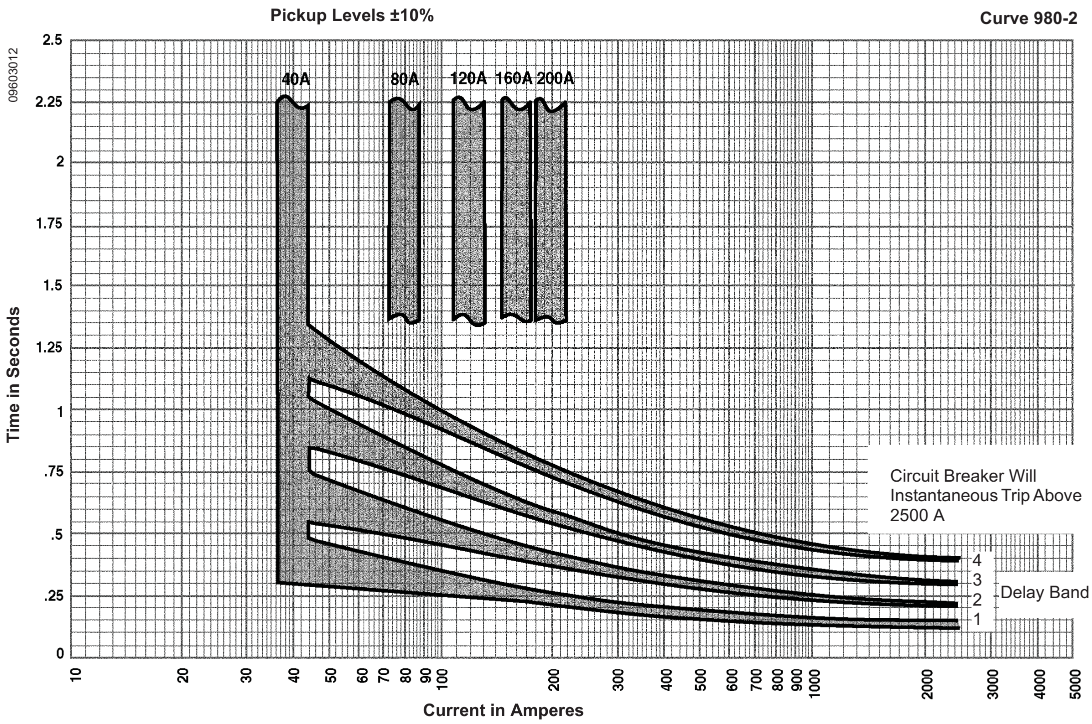


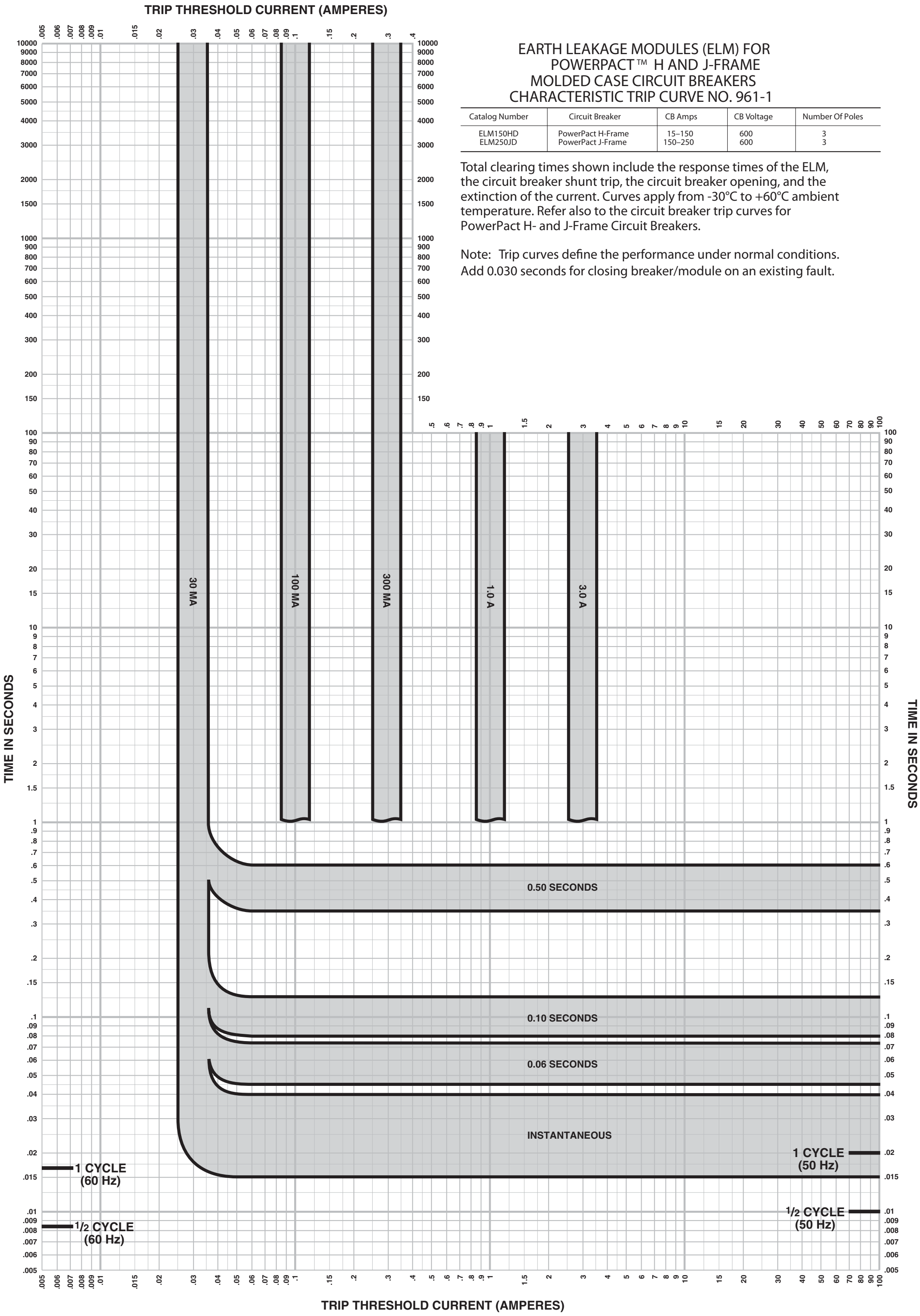
Figure 79: Ground Fault Module GFM250JD Trip Curve



TIM-ID: 0000053623 - 002

SQUARE D by Schneider Electric
05/2012

Figure 80: Earth Leakage Module Trip Curve



EARTH LEAKAGE MODULES (ELM) FOR POWERPACT™ H AND J-FRAME MOLDED CASE CIRCUIT BREAKERS CHARACTERISTIC TRIP CURVE NO. 961-1

Catalog Number	Circuit Breaker	CB Amps	CB Voltage	Number Of Poles
ELM150HD	PowerPact H-Frame	15–150	600	3
ELM250JD	PowerPact J-Frame	150–250	600	3

Total clearing times shown include the response times of the ELM, the circuit breaker shunt trip, the circuit breaker opening, and the extinction of the current. Curves apply from -30°C to +60°C ambient temperature. Refer also to the circuit breaker trip curves for PowerPact H- and J-Frame Circuit Breakers.

Note: Trip curves define the performance under normal conditions. Add 0.030 seconds for closing breaker/module on an existing fault.

TIM-ID: 0000053623 - 002

PowerPact H- and J-Frame Thermal-Magnetic Trip MCP Instantaneous Trip Points

Table 134: M71 Instantaneous Trip Points

		Automatic Setting (A)		Manual Adjustment (A)						
	I_m Setting	1	2	6x	8x	9x	10x	11x	12x	13x
Motor Type	NEMA	A, B, C, D	B, E	(FLA) x (I_m)						
	IEC	N	H							
FLA	1.5	12	16.5	9	12	13.5	15	16.5	18	19.5
	3	24	33	18	24	27	30	33	36	39
	6	48	66	36	48	54	60	66	72	78
	8	64	88	48	64	72	80	88	96	104
	11	88	121	66	88	99	110	121	132	143
	14	112	154	84	112	126	140	154	168	182
	17	136	187	102	136	153	170	187	204	221
	20	160	220	120	160	180	200	220	240	260
	25	200	275	150	200	225	250	275	300	325
Dampening for motor in-rush (% FLA)		1300%	1700%	1300%	—					

Table 135: M72 Instantaneous Trip Points

		Automatic Setting (A)[1]		Manual Adjustment (A)[1]						
	I_m Setting	1	2	6x	8x	9x	10x	11x	12x	13x
Motor Type	NEMA	A, B, C, D	B, E	(FLA) x (I_m)						
	IEC	N	H							
FLA	14	112	154	84	112	126	140	154	168	182
	17	136	187	102	136	153	170	187	204	221
	21	168	231	126	168	189	210	231	252	273
	24	192	264	144	192	216	240	264	288	312
	27	216	297	162	216	243	270	297	324	351
	29	232	319	174	232	261	290	319	348	377
	32	256	352	192	256	288	320	352	384	416
	36	288	396	216	288	324	360	396	432	468
	42	336	462	252	336	378	420	462	504	546
Dampening for motor in-rush (% FLA)		1300%	1700%	1300%	—					

1 ± 5% of nominal amperage shown above

TIM-ID: 0000053623 - 002

Table 136: M73 Instantaneous Trip Points

		Automatic Setting (A)[1]		Manual Adjustment (A)[1]						
	I_m Setting	1	2	6x	8x	9x	10x	11x	12x	13x
Motor Type	NEMA	A, B, C, D	B, E	(FLA) x (I_m)						
	IEC	N	H							
FLA	30	240	330	180	240	270	300	330	360	390
	35	280	385	210	280	315	350	385	420	455
	41	328	451	246	328	369	410	451	492	533
	46	368	506	276	368	414	460	506	552	598
	51	408	561	306	408	459	510	561	612	663
	56	448	616	336	448	504	560	616	672	728
	63	504	693	378	504	567	630	693	756	819
	71	568	781	426	568	639	710	781	852	923
	80	640	880	480	640	720	800	880	960	1040
Dampening for motor in-rush (% FLA)		1300%	1700%	1300%	—					

1 ± 5% of nominal amperage shown above

Table 137: M74 Instantaneous Trip Points

		Automatic Setting (A)[1]		Manual Adjustment (A)[1]						
	I_m Setting	1	2	6x	8x	9x	10x	11x	12x	13x
Motor Type	NEMA	A, B, C, D	B, E	(FLA) x (I_m)						
	IEC	N	H							
FLA	58	464	638	348	464	522	580	638	696	754
	71	568	781	426	568	639	710	781	852	923
	79	632	869	474	632	711	790	869	948	1027
	86	688	946	516	688	774	860	946	1032	1118
	91	728	1001	546	728	819	910	1001	1092	1183
	97	776	1067	582	776	873	970	1067	1164	1261
	110	880	1210	660	880	990	1100	1210	1320	1430
	119	952	1309	714	952	1071	1190	1309	1428	1547
	130	1040	1430	780	1040	1170	1300	1430	1560	1690
Dampening for motor in-rush (% FLA)		1300%	1700%	1300%	—					

1 ± 5% of nominal amperage shown above

Table 138: M75 Instantaneous Trip Points

		Automatic Setting (A)[1]		Manual Adjustment (A)[1]						
	I_m Setting	1	2	6x	8x	9x	10x	11x	12x	13x
Motor Type	NEMA	A, B, C, D	B, E	(FLA) x (I_m)						
	IEC	N	H							
FLA	114	912	1254	684	912	1026	1140	1254	1368	1482
	137	1096	1507	822	1096	1233	1370	1507	1644	1781
	145	1160	1595	870	1160	1305	1450	1595	1740	1885
	155	1240	1705	930	1240	1395	1550	1705	1860	2015
	163	1304	1793	978	1304	1467	1630	1793	1956	2119
	172	1376	1892	1032	1376	1548	1720	1892	2064	2236
	181	1448	1991	1086	1448	1629	1810	1991	2172	2353
	210	1680	2310	1260	1680	1890	2100	2310	2500 [2]	2500 [2]
	217	1736	2387	1302	1736	1953	2170	2387	2500 [2]	2500 [2]
Dampening for motor in-rush (% FLA)		1100–1300%	1100–1700%	1100–1300%	—					

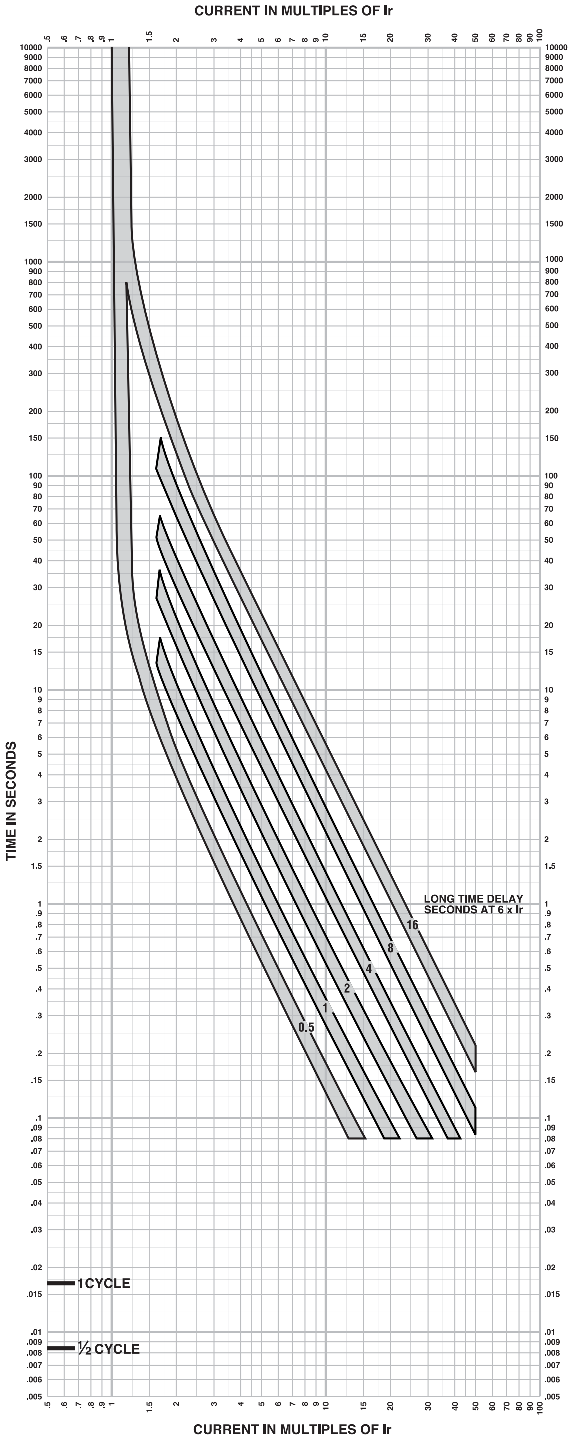
1 ± 5% of nominal amperage shown above
2 2500 A maximum instantaneous trip point

TIM-ID: 0000053623 - 002

SQUARE D by Schneider Electric

PowerPact H-Frame Electronic Trip Circuit Breakers— 60 A/100 A/150 A Frame

Figure 81: Micrologic™ 3.2 Electronic Trip Unit Long Time Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 3.2 Long Time Trip Curve
60A, 100A, 150A H-Frame

The time-current curve information is to be used for application and coordination purposes only.

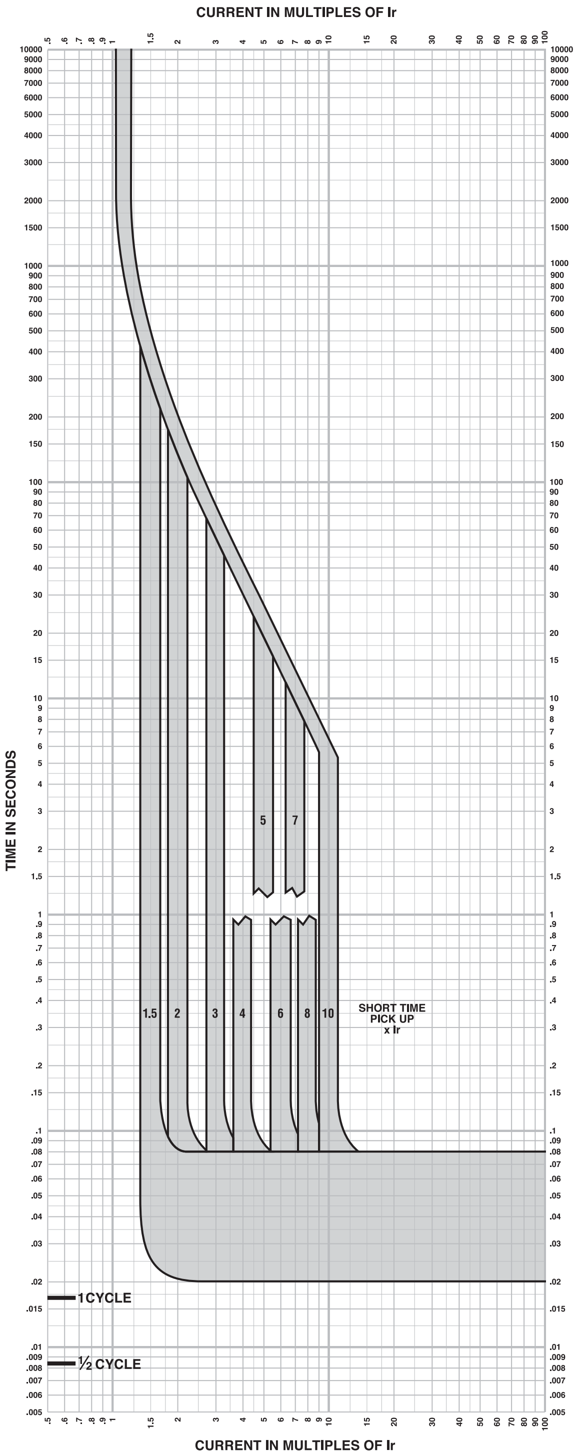
Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

TIM-ID: 0000053623 - 002

Figure 82: Micrologic™ 3.2S Electronic Trip Unit Long Time / Short Time Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 3.2S Long Time/
Short Time Trip Curve
60A, 100A, 150A H-Frame

The time-current curve information is to be used for application and coordination purposes only.

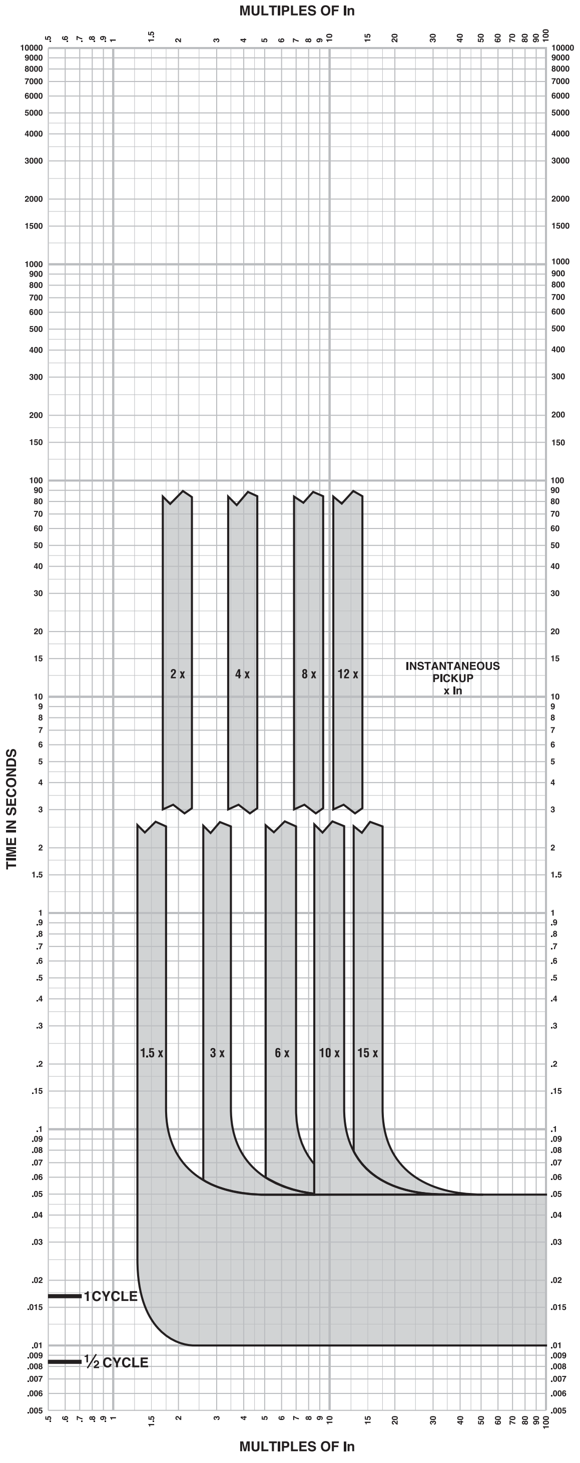
Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35°C to +70°C (-31°F to +158°F) ambient temperature.

TIM-ID: 0000053623 - 002

Figure 83: Micrologic™ 3.2/3.2S/5.2A/5.2E/6.2A/6.2E Electronic Trip Unit Instantaneous Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 3.2/3.2S/5.2A or E/6.2A or E
Instantaneous Trip Curve
60A, 100A, 150A H-Frame

The time-current curve information is to be used for application and coordination purposes only.

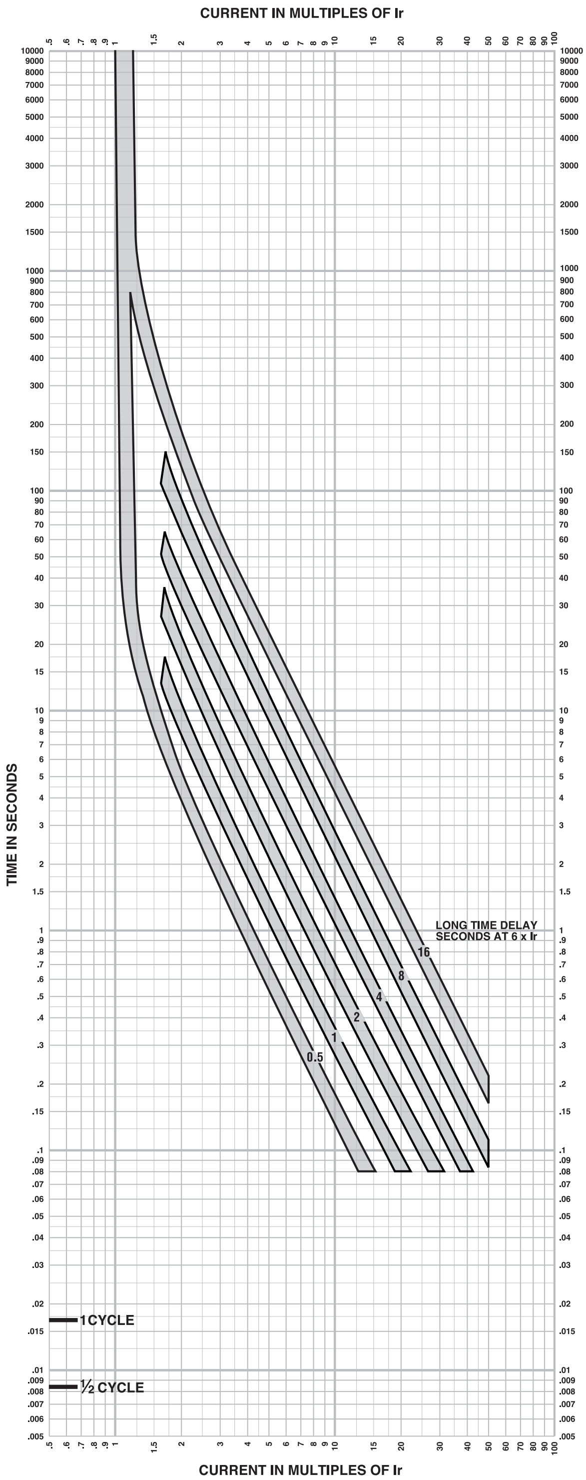
Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.
3. In = Maximum dial setting of Ir.
   60A H-Frame: In = 60A = Max Ir setting
   100A H-Frame: In = 100A = Max Ir setting
   150A H-Frame: In = 150A = Max Ir setting

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

TIM-ID: 0000053623 - 002

Figure 84: Micrologic™ 5.2A/5.2E/6.2A/6.2E Electronic Trip Unit Long Time Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 5.2A or E/6.2A or E
Long Time Trip Curve
60A, 100A, 150A H-Frame

The time-current curve information is to be used for application and coordination purposes only.

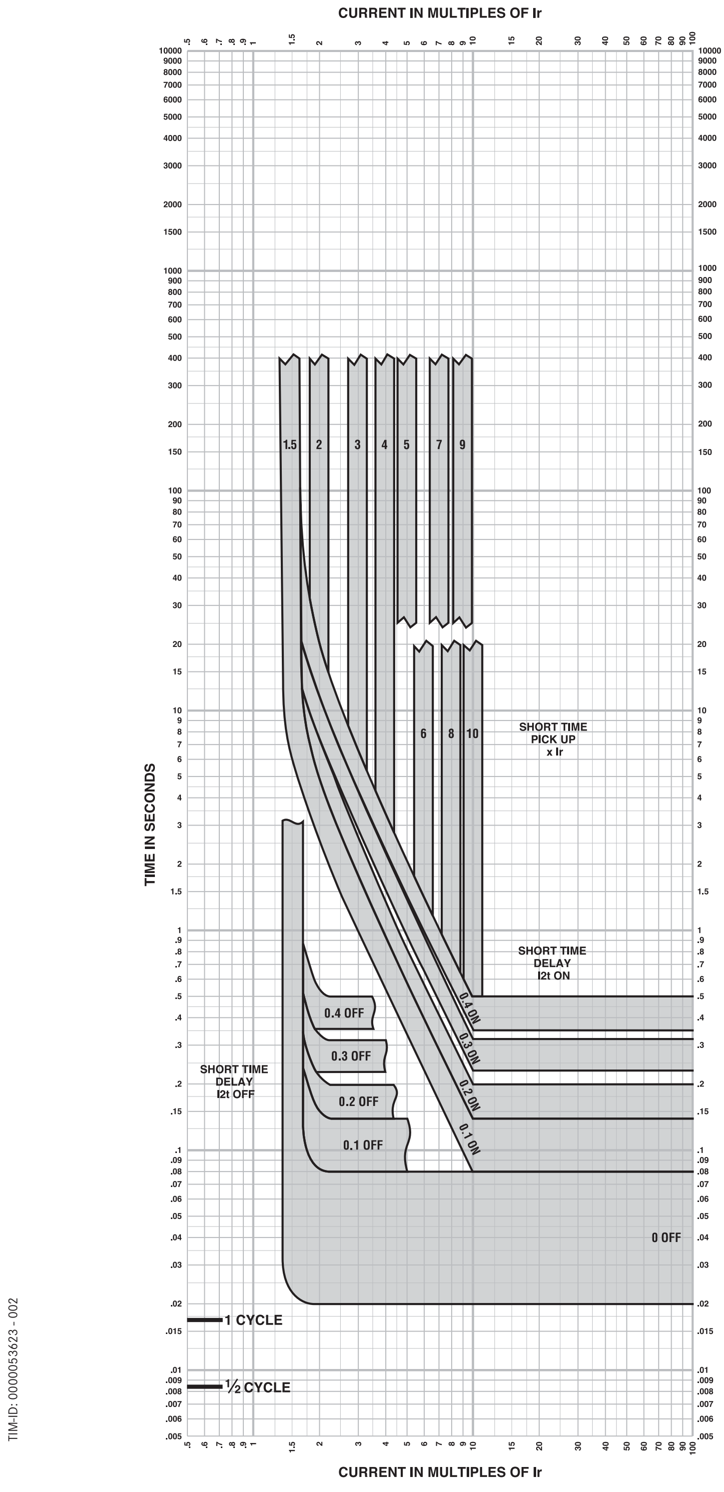
Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35°C to +70°C (-31°F to +158°F) ambient temperature.

TIM-ID: 0000053623 - 002

Figure 85: Micrologic™ 5.2A/5.2E/6.2A/6.2E Electronic Trip Unit Short Time Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 5.2A or E/6.2A or E
Short Time Trip Curve
60A, 100A, 150A H-Frame

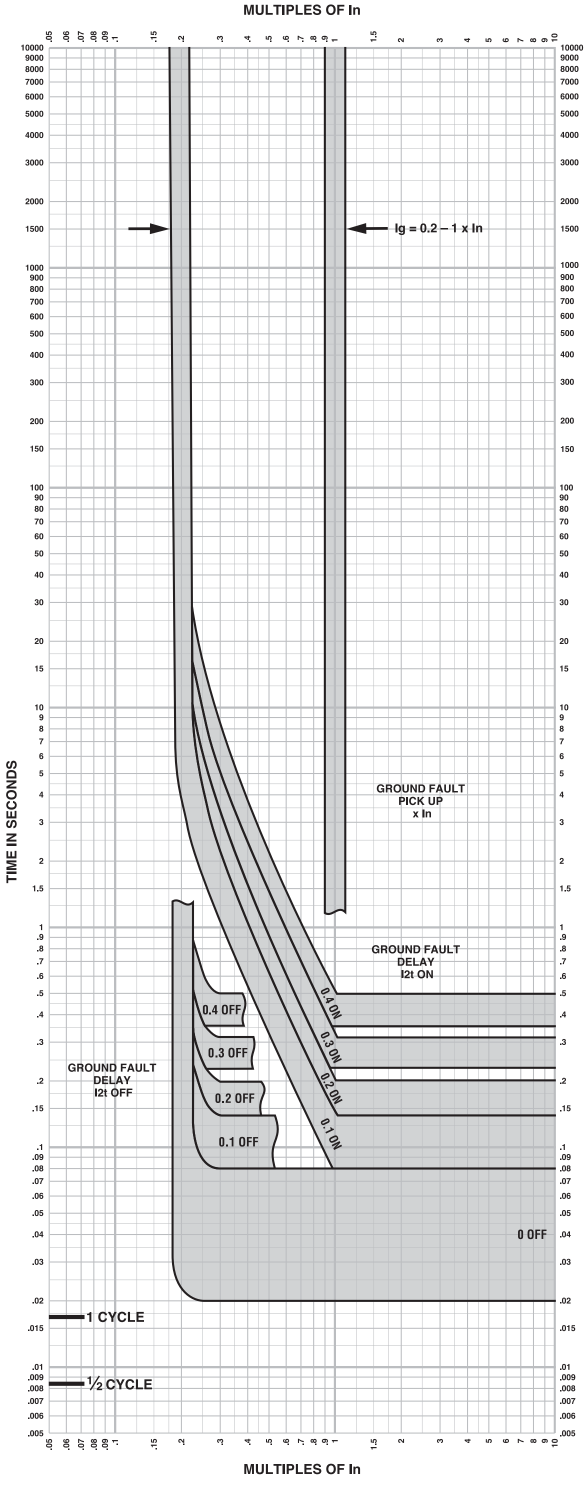
The time-current curve information is to be used for application and coordination purposes only.

Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

Figure 86: Micrologic™ 6.2A/6.2E Electronic Trip Unit Ground Fault Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 6.2A or E
Ground Fault Trip Curve
100A, 150A H-Frame

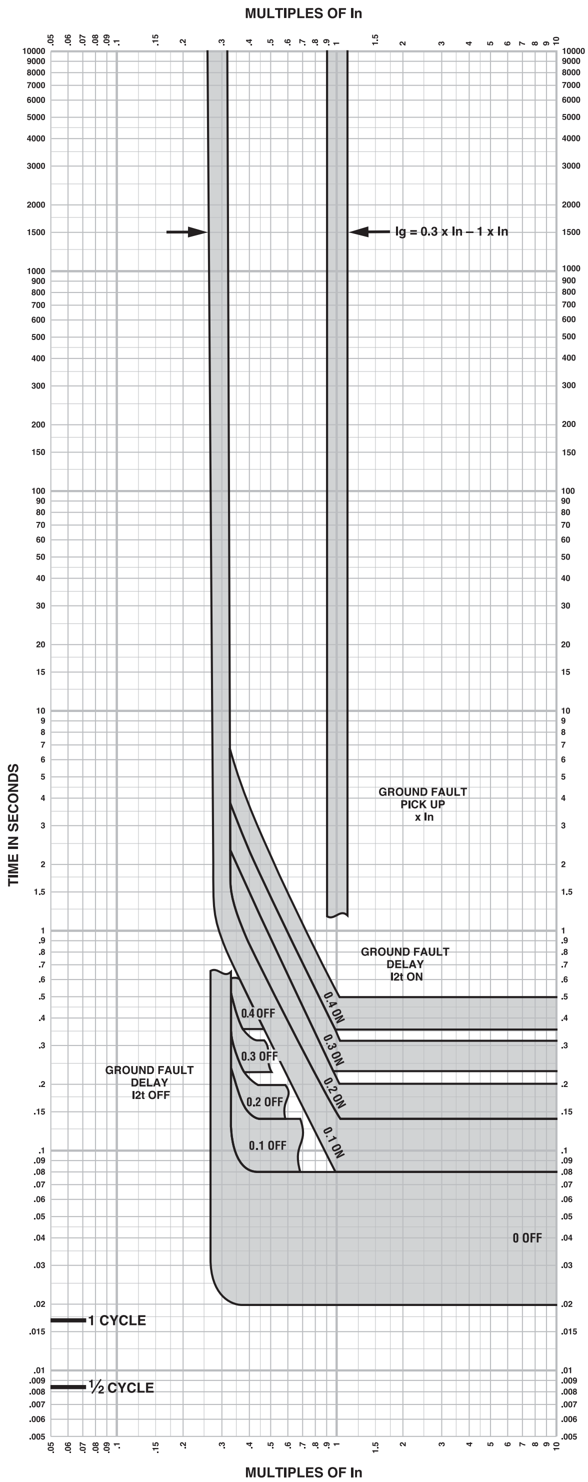
The time-current curve information is to be used for application and coordination purposes only.

1. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

TIM-ID: 0000053623 - 002

Figure 87: Micrologic™ 6.2A/6.2E Electronic Trip Unit Ground Fault Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 6.2A or E
Ground Fault Trip Curve
60A H-Frame

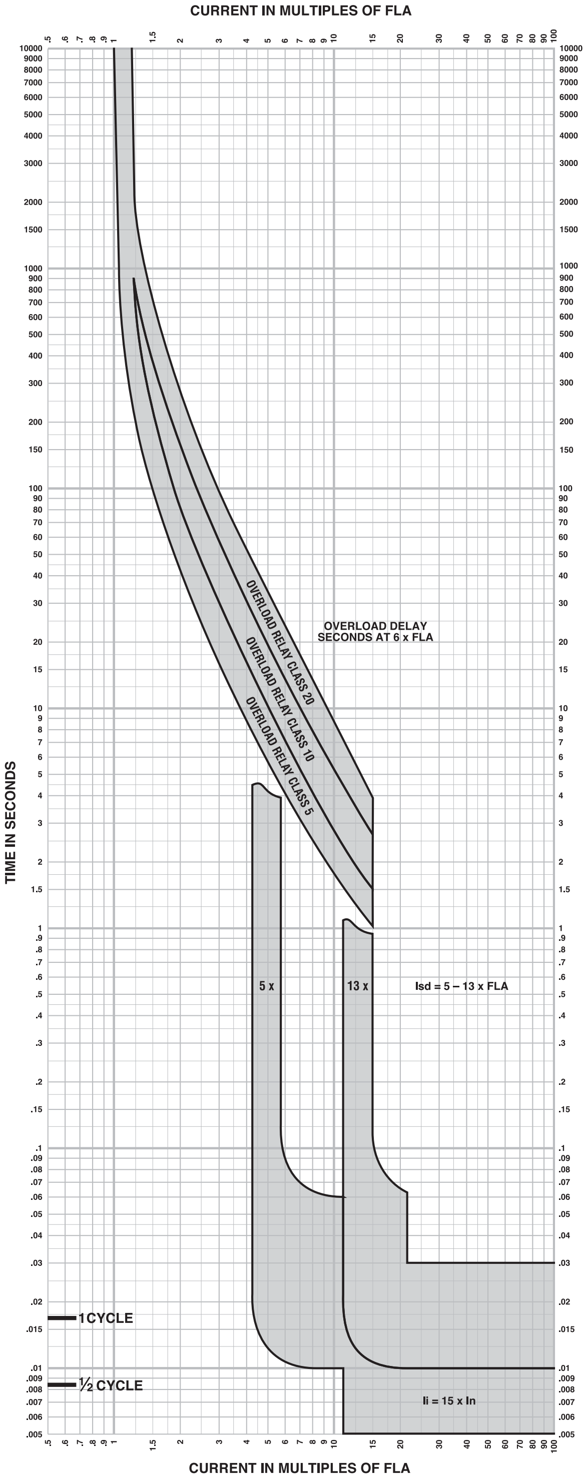
The time-current curve information is to be used for application and coordination purposes only.

1. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

TIM-ID: 0000053623 - 002

Figure 88: Micrologic™ 2.2 M Electronic Trip Unit Overload Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 2.2M Overload Trip Curve
30A, 50A, 100A, 150A H-Frame, 250A J-Frame

The time-current curve information is to be used for application and coordination purposes only.

Notes:

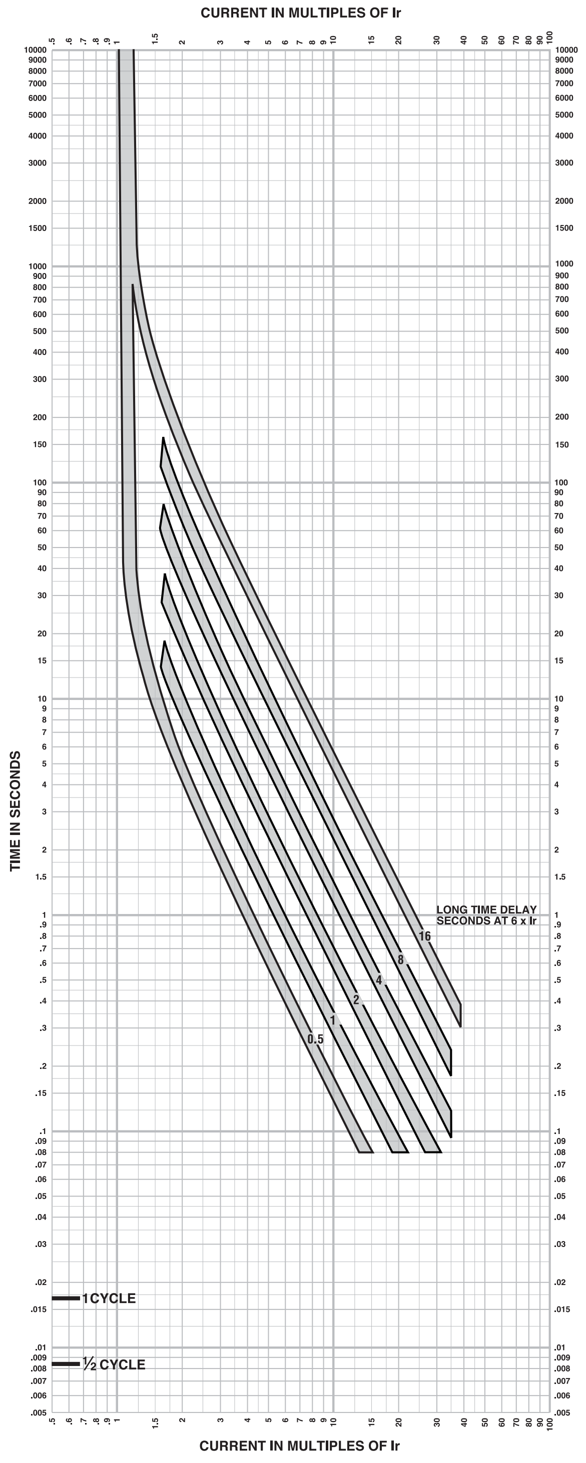
1. If overload still exists past overload relay delay, MCP will open 0.4 seconds later.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.
3. Isd minimum and maximum only shown.
4. Ii = 15 x In
   In = 30A, 50A, 100A, 150A, 250A
   MCP will trip <30ms at 15 x In

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

TIM-ID: 0000053623 - 002

J-Frame Electronic Trip Circuit Breakers—250 A Frame

Figure 89: Micrologic™ 3.2 Electronic Trip Unit Long-Time Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 3.2 Long Time Trip Curve
250A J-Frame

The time-current curve information is to be used for application and coordination purposes only.

Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

TIM-ID: 0000053623 - 002

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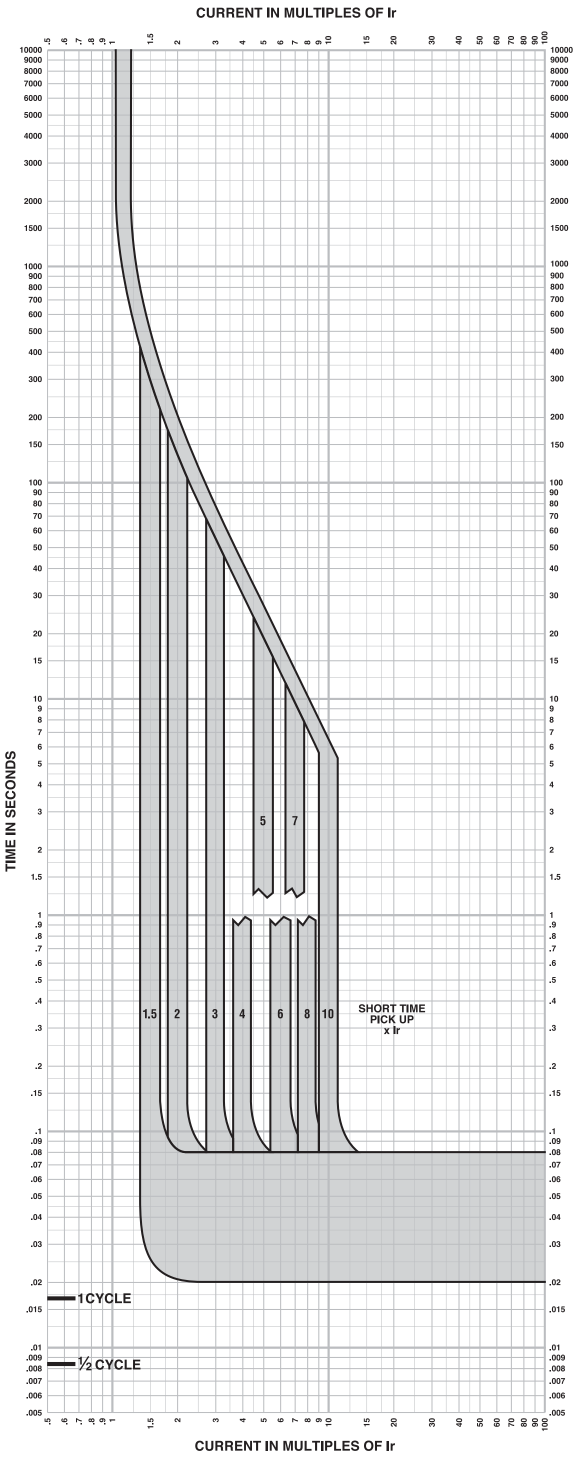
Figure 90: Micrologic™ 3.2S Electronic Trip Unit Long Time / Short Time Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 3.2S Long Time/
Short Time Trip Curve
250A J-Frame

The time-current curve information is to be used for application and coordination purposes only.

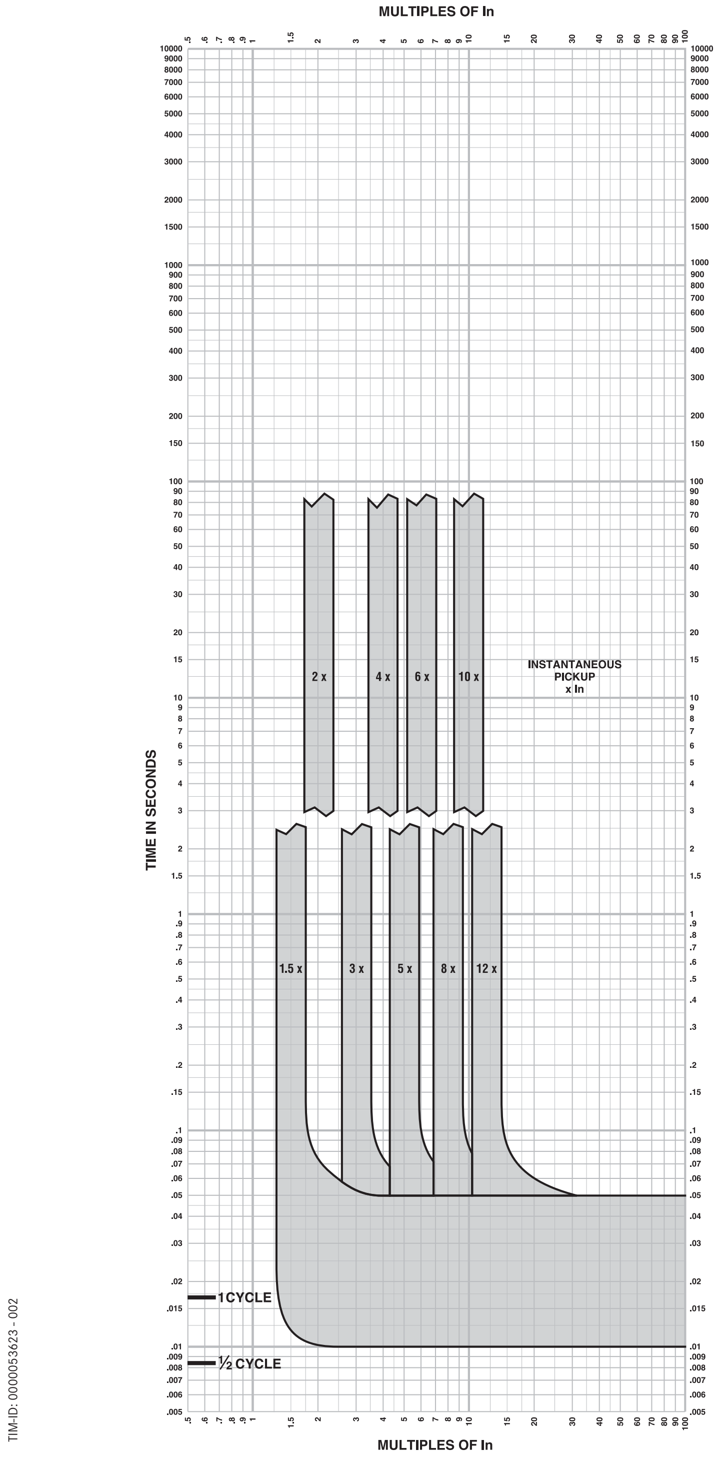
Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

TIM-ID: 0000053623 - 002

Figure 91: Micrologic™ 3.2/3.2S/5.2A/5.2E/6.2A/6.2E Electronic Trip Curve Instantaneous Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 3.2/3.2S/5.2A or E/6.2A or E
Instantaneous Trip Curve
250A J-Frame

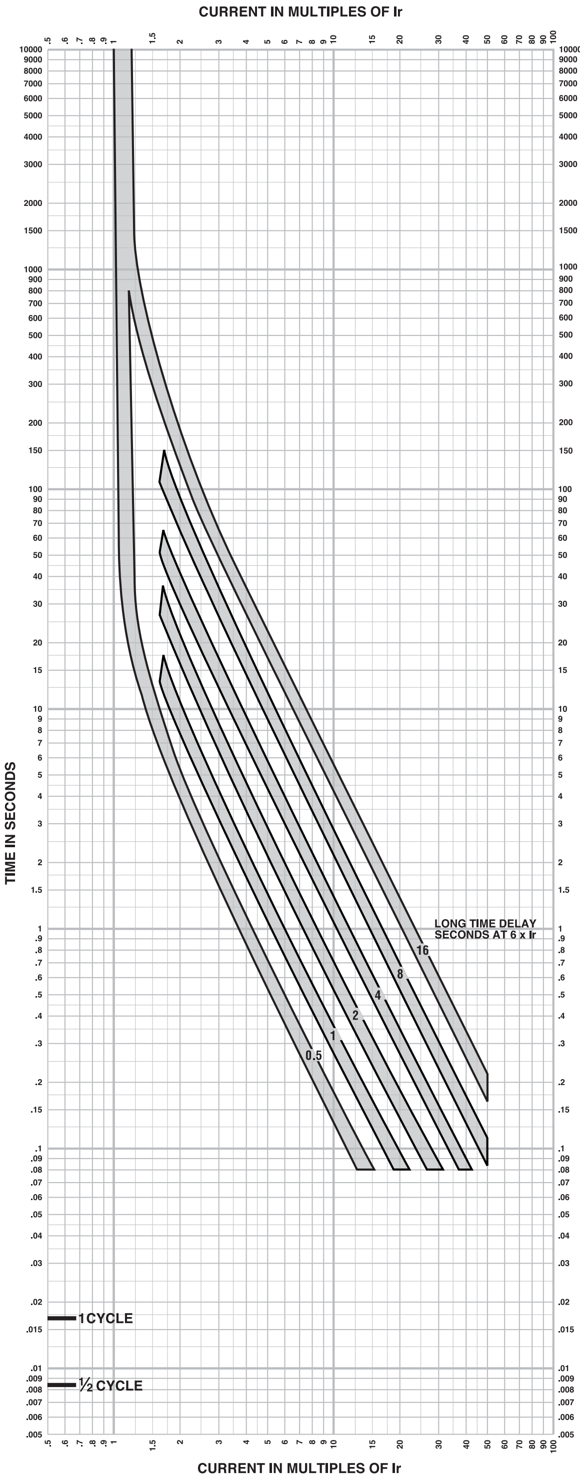
The time-current curve information is to be used for application and coordination purposes only.

Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.
3. In = Maximum dial setting of Ir.
   250A J-Frame: In = 250A = Max Ir setting

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

Figure 92: Micrologic™ 5.2A/5.2E/6.2A/6.2E Electronic Trip Unit Long Time Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 5.2A or E/6.2A or E
Long Time Trip Curve
250A J-Frame

The time-current curve information is to be used for application and coordination purposes only.

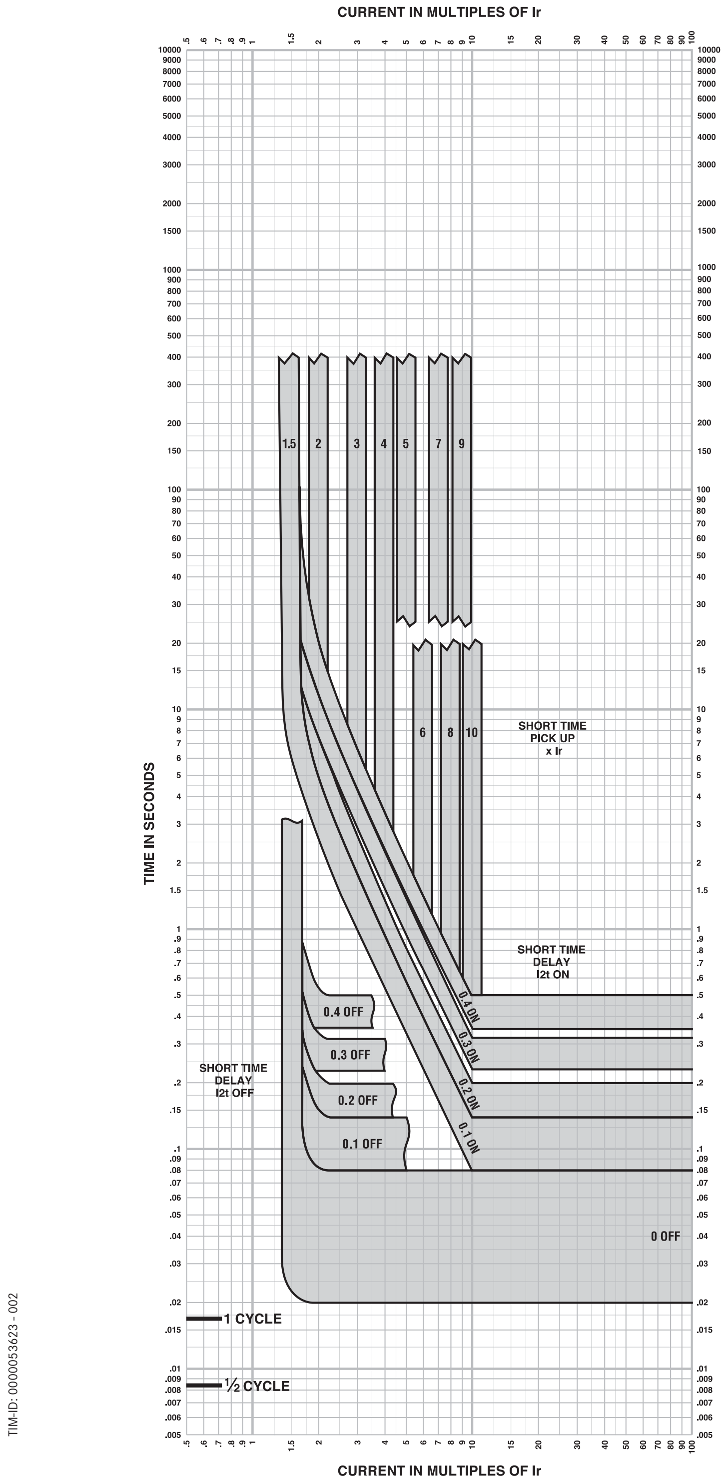
Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35°C to +70°C (-31°F to +158°F) ambient temperature.

TIM-ID: 0000053623 - 002

Figure 93: Micrologic™ 5.2A/5.2E/6.2A/6.2E Electronic Trip Unit Short Time Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 5.2A or E/6.2A or E
Short Time Trip Curve
250A J-Frame

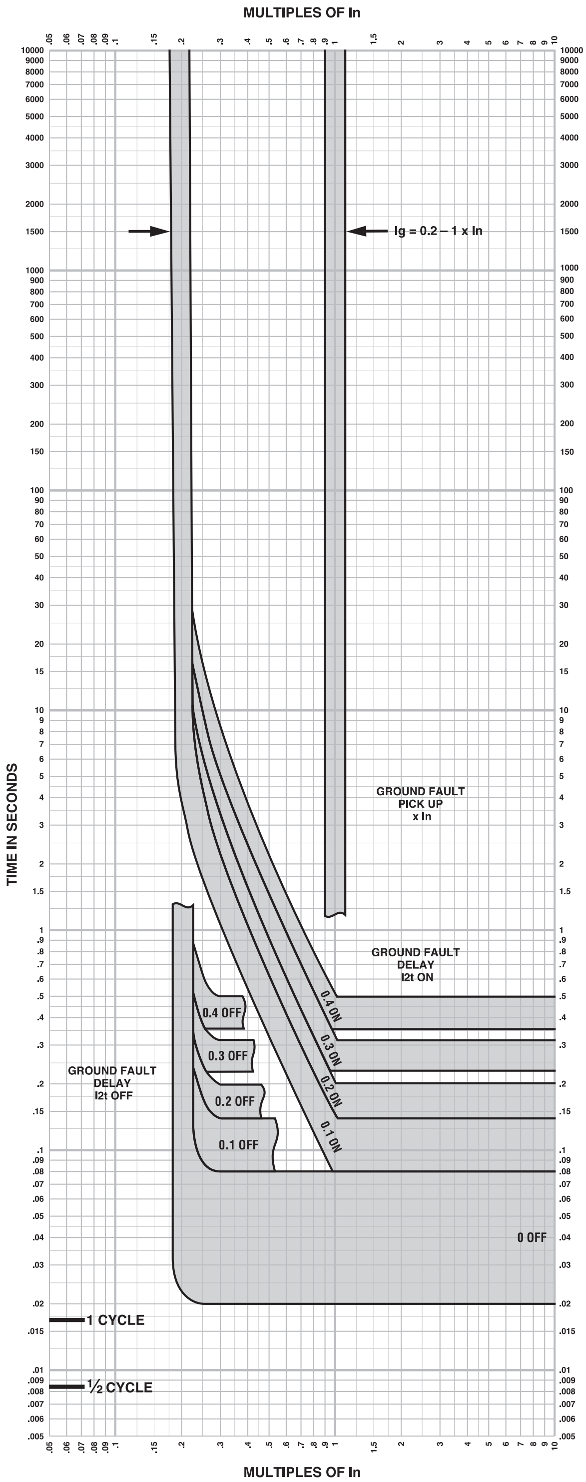
The time-current curve information is to be used for application and coordination purposes only.

Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

Figure 94: Micrologic™ 6.2A/6.2E Electronic Trip Unit Ground Fault Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 6.2A or E
Ground Fault Trip Curve
250A J-Frame

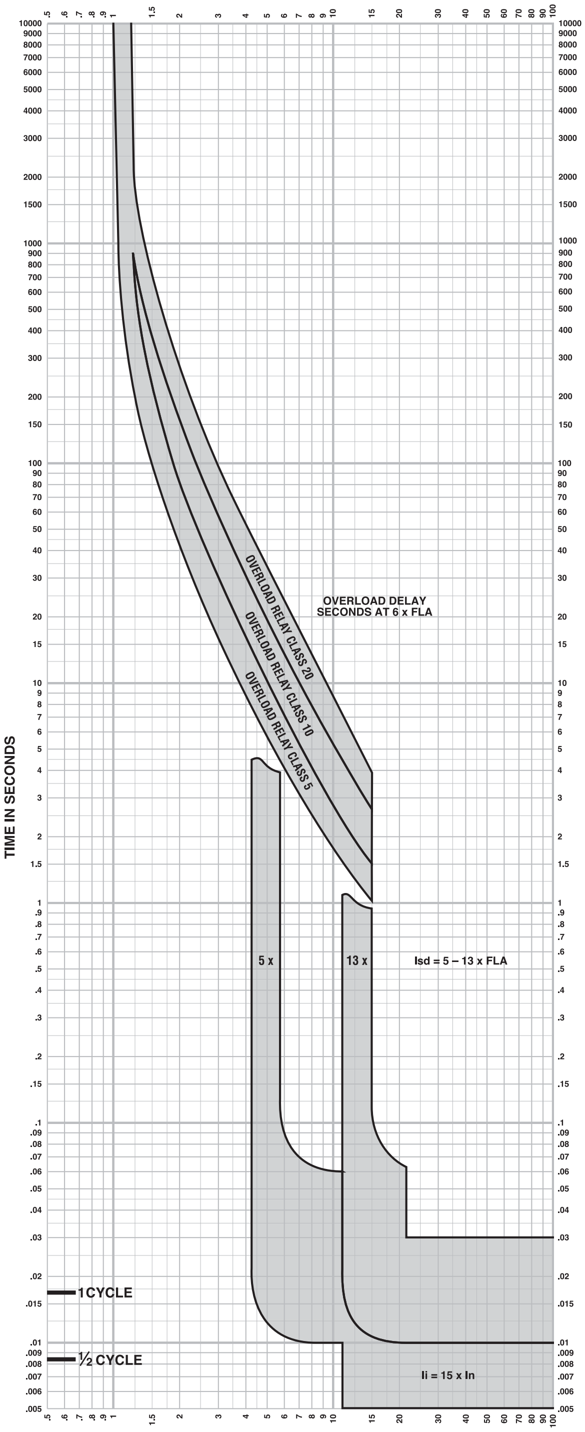
The time-current curve information is to be used for application and coordination purposes only.

1. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

TIM-ID: 0000053623 - 002

Figure 95: Micrologic™ 2.2 M Electronic Trip Unit Overload Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 2.2M Overload Trip Curve
30A, 50A, 100A, 150A H-Frame, 250A J-Frame

The time-current curve information is to be used for application and coordination purposes only.

Notes:

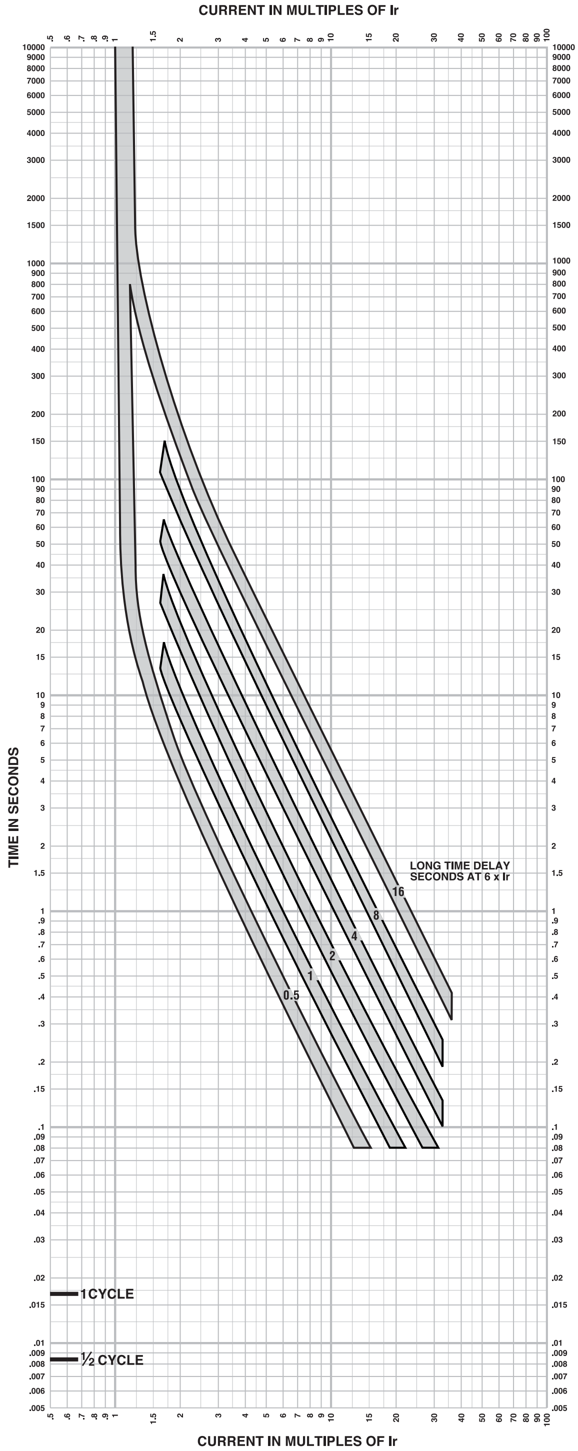
1. If overload still exists past overload relay delay, MCP will open 0.4 seconds later.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.
3. Isd minimum and maximum only shown.
4. Ii = 15 x In
   In = 30A, 50A, 100A, 150A, 250A
   MCP will trip <30ms at 15 x In

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

TIM-ID: 0000053623 - 002

PowerPact L-Frame Electronic Trip Circuit Breakers—250 A/400 A/600 A Frame

Figure 96: Micrologic™ 3.3 Electronic Trip Unit Long Time Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 3.3 Long Time Trip Curve
250A, 400A L-Frame

The time-current curve information is to be used for application and coordination purposes only.

Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

TIM-ID: 0000053623 - 002

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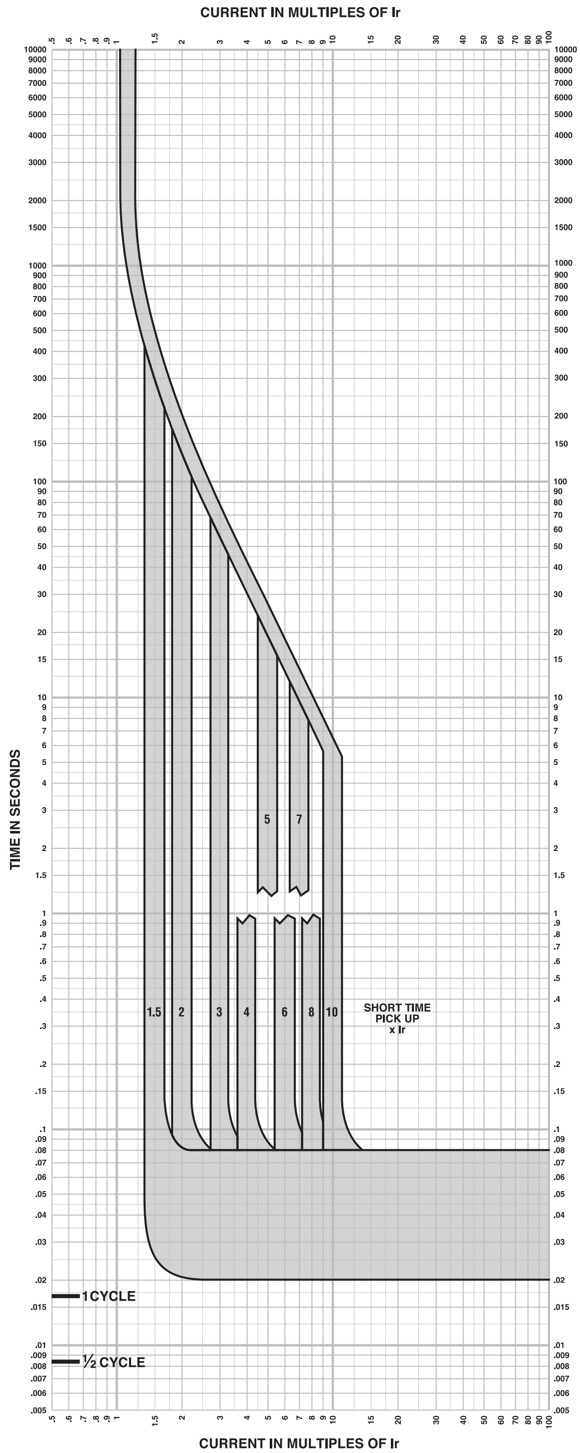
Figure 97: Micrologic™ 3.3S Electronic Trip Unit Long Time/Short Time Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 3.3S Long Time/
Short Time Trip Curve
250A, 400A L-Frame

The time-current curve information is to be used for application and coordination purposes only.

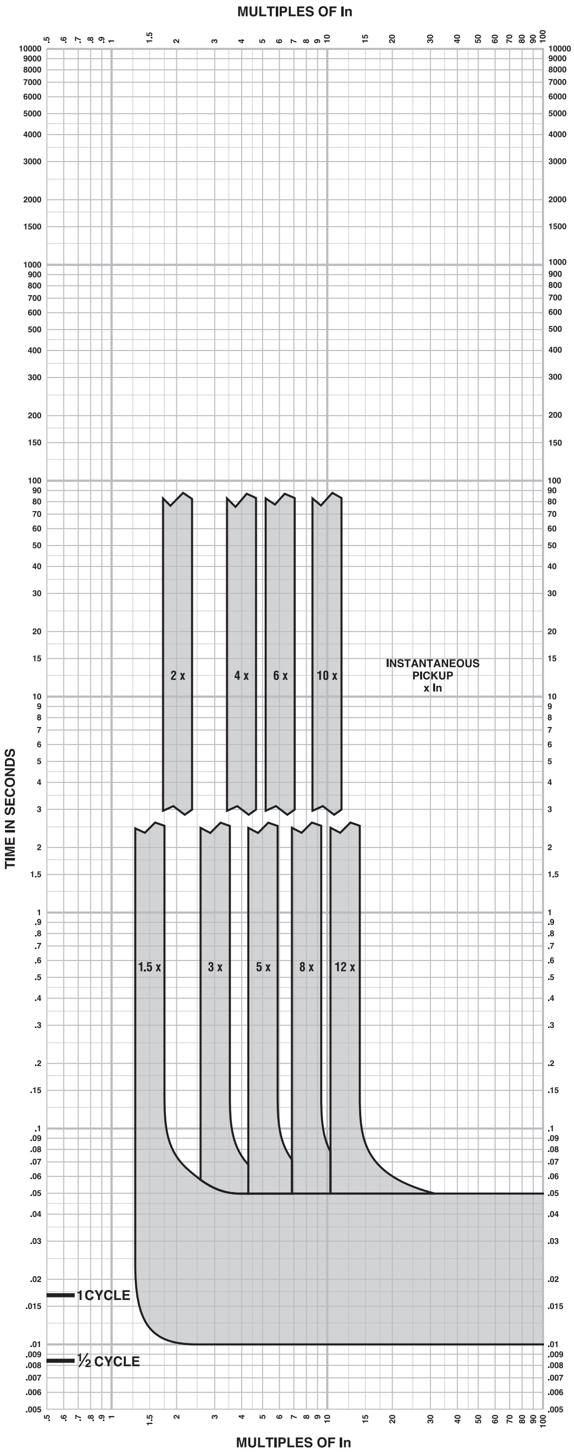
Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

TIM-ID: 0000053623 - 002

Figure 98: Micrologic™ 3.3/3.3S Electronic Trip Unit Instantaneous Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 3.3/3.3S
Instantaneous Trip Curve
250A L-Frame

The time-current curve information is to be used for application and coordination purposes only.

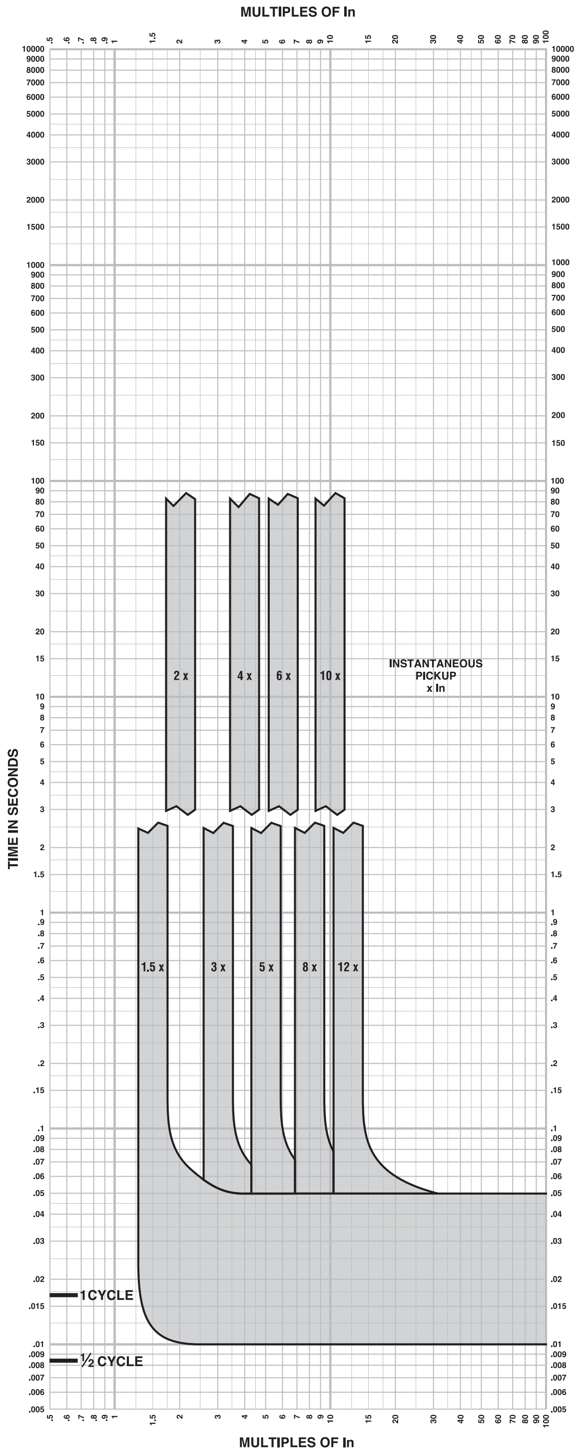
Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.
3. In = Maximum dial setting of Ir.
   250A L-Frame: In = 250A = Max Ir setting

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

TIM-ID: 0000053623 - 002

Figure 99: Micrologic™ 3.3/3.3S/5.3A/5.3E/6.3A/6.3E Electronic Trip Unit Instantaneous Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 3.3/3.3S/5.3A or E/6.3A or E
Instantaneous Trip Curve
400A L-Frame

The time-current curve information is to be used for application and coordination purposes only.

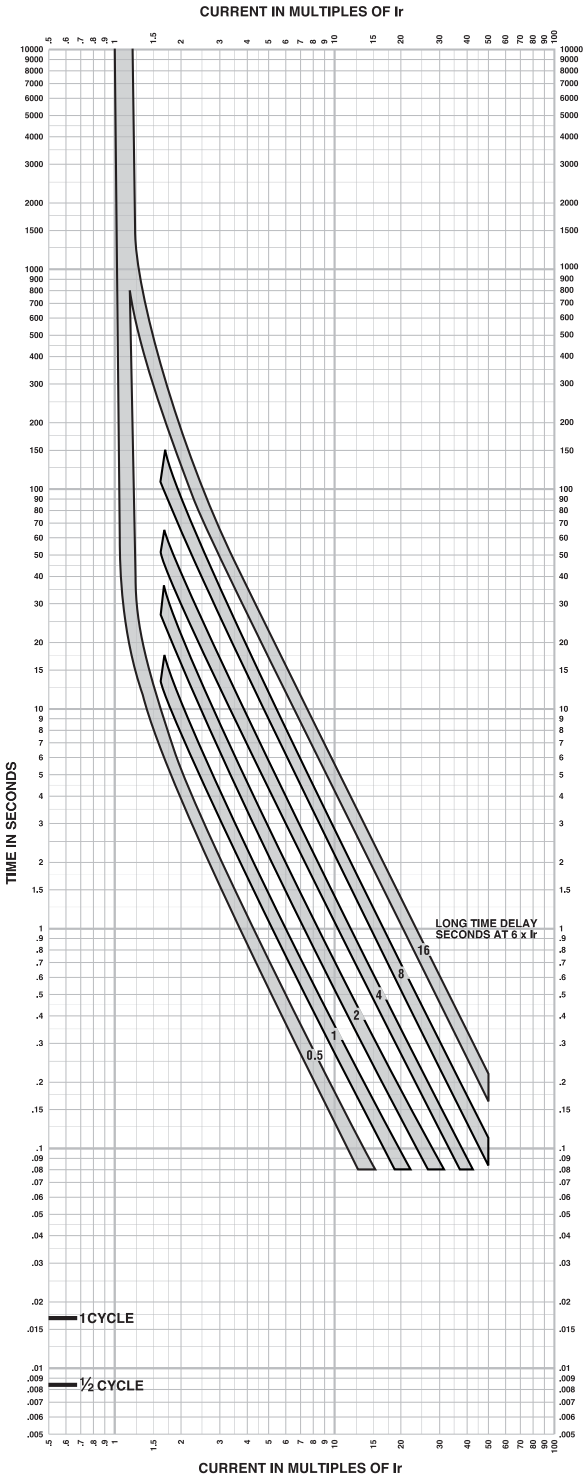
Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.
3. In = Maximum dial setting of Ir.
   400A L-Frame: In = 400A = Max Ir setting

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

TIM-ID: 0000053623 - 002

Figure 100: Micrologic™ 5.3A/5.3E/6.3A/6.3E Electronic Trip Unit Long Time Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 5.3A or E/6.3A or E
Long Time Trip Curve
400A L-Frame

The time-current curve information is to be used for application and coordination purposes only.

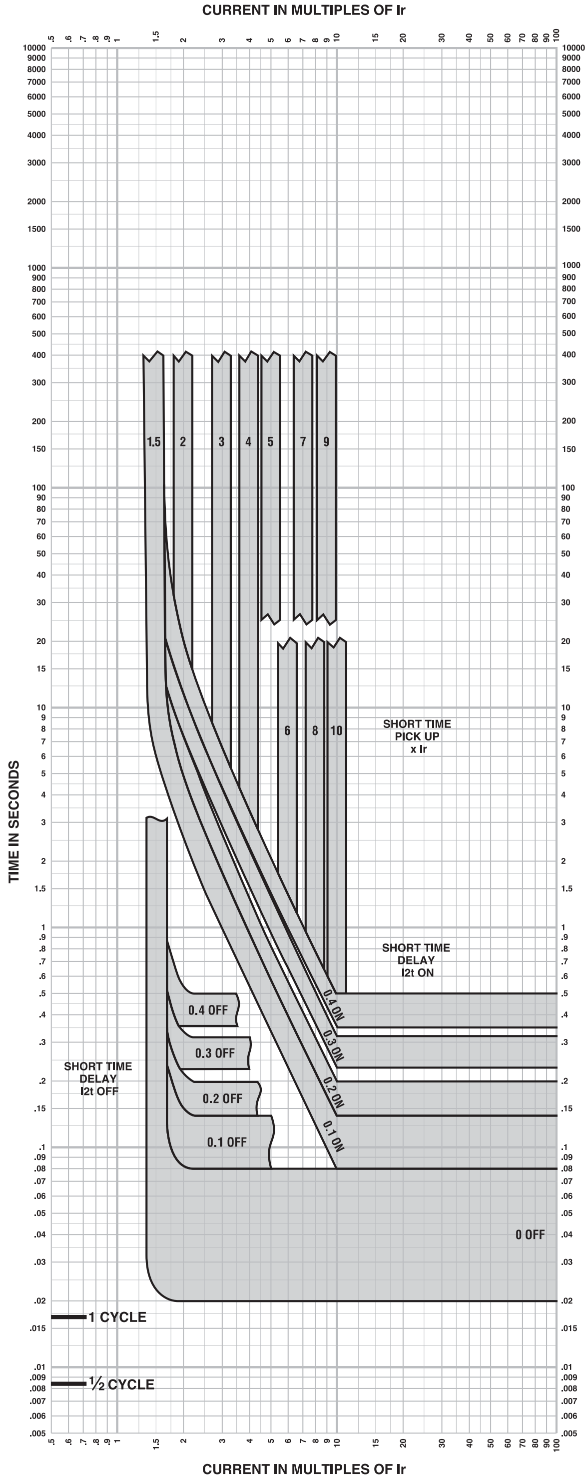
Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

TIM-ID: 0000053623 - 002

Figure 101: Micrologic™ 5.3A/5.3E/6.3A/6.3E Electronic Trip Unit Short Time Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 5.3A or E/6.3A or E
Short Time Trip Curve
400A L-Frame

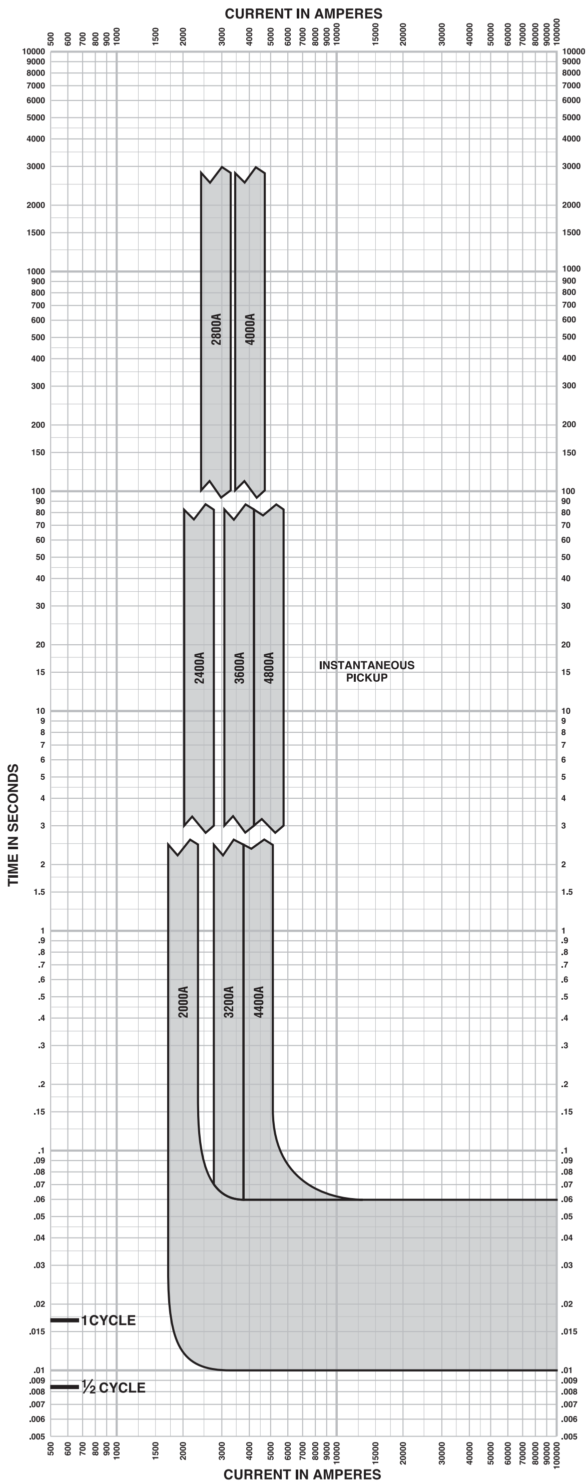
The time-current curve information is to be used for application and coordination purposes only.

Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

Figure 102: Micrologic™ 1.3 M Electronic Trip Unit Instantaneous Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 1.3M Instantaneous Trip Curve
400A L-Frame

The time-current curve information is to be used for application and coordination purposes only.

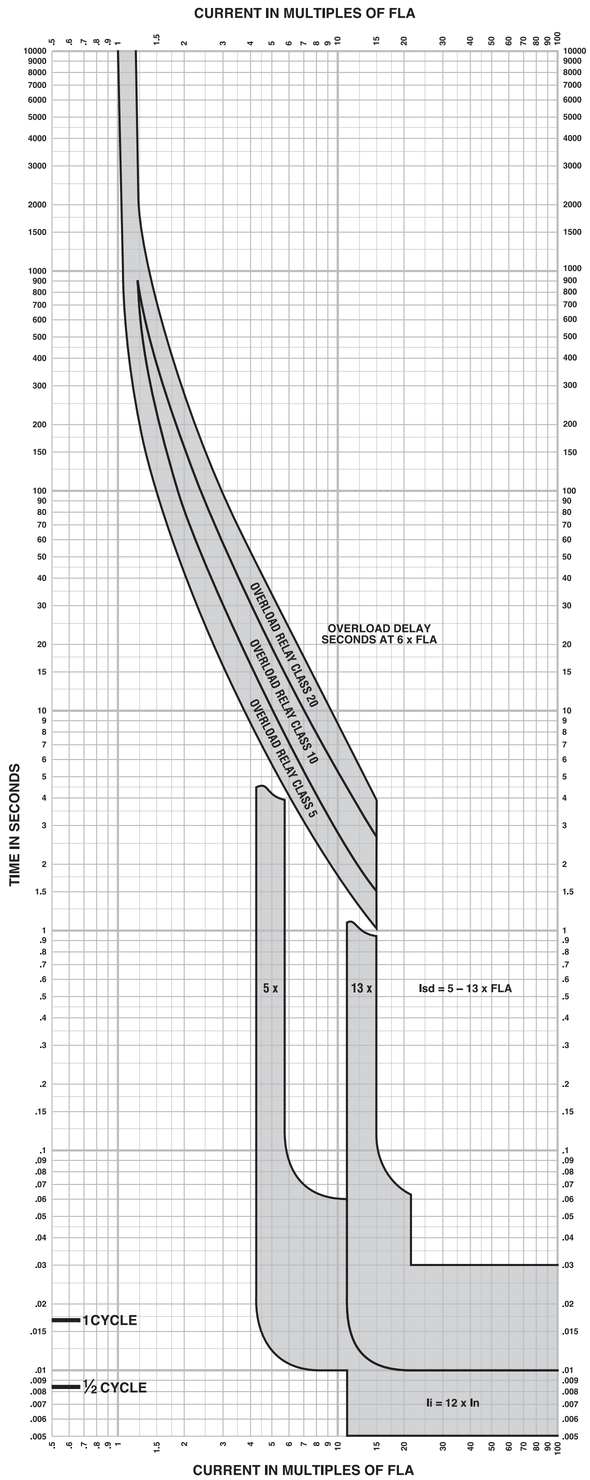
Notes:

1. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

TIM-ID: 0000053623 - 002

Figure 103: Micrologic™ 2.3 M Electronic Trip Unit Overload Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 2.3M Overload Trip Curve
400A, 600A L-Frame

The time-current curve information is to be used for application and coordination purposes only.

Notes:

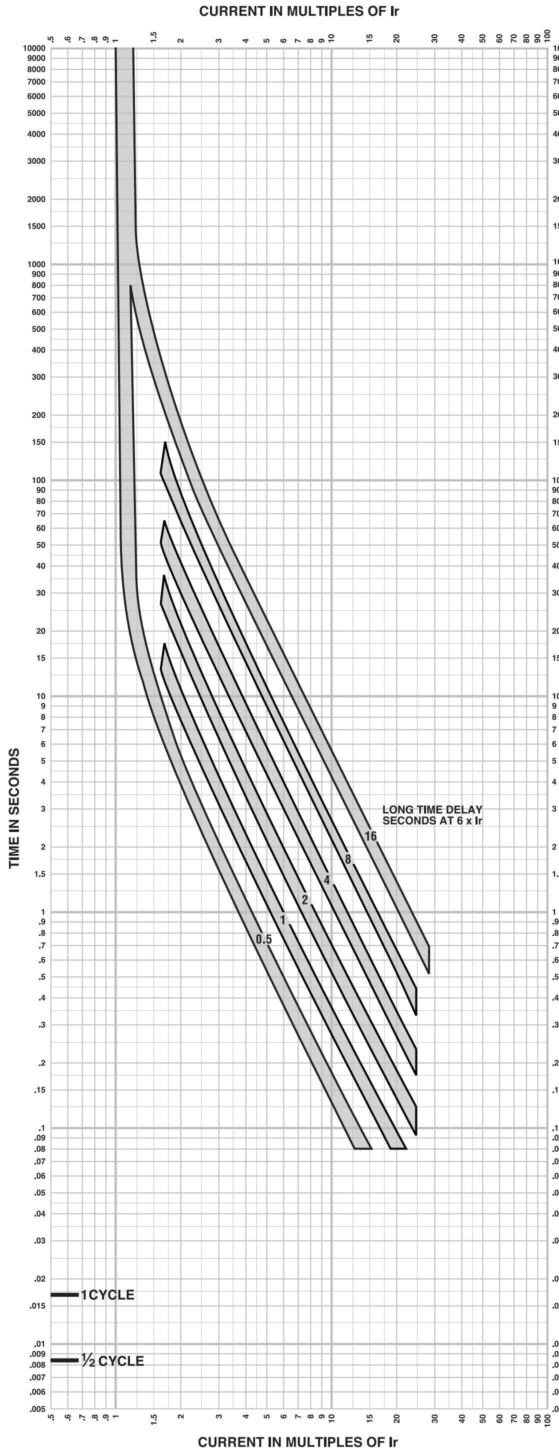
1. If overload still exists past overload relay delay, MCP will open 0.4 seconds later.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.
3. Isd minimum and maximum only shown.
4. Ii = 12 x In
   In = 400A, 600A
   MCP will trip <30ms at 12 x In

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

TIM-ID: 0000053623 - 002

SQUARE D by Schneider Electric

Figure 104: Micrologic™ 3.3 Electronic Trip Unit Long Time Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 3.3 Long Time Trip Curve
600A L-Frame

The time-current curve information is to be used for application and coordination purposes only.

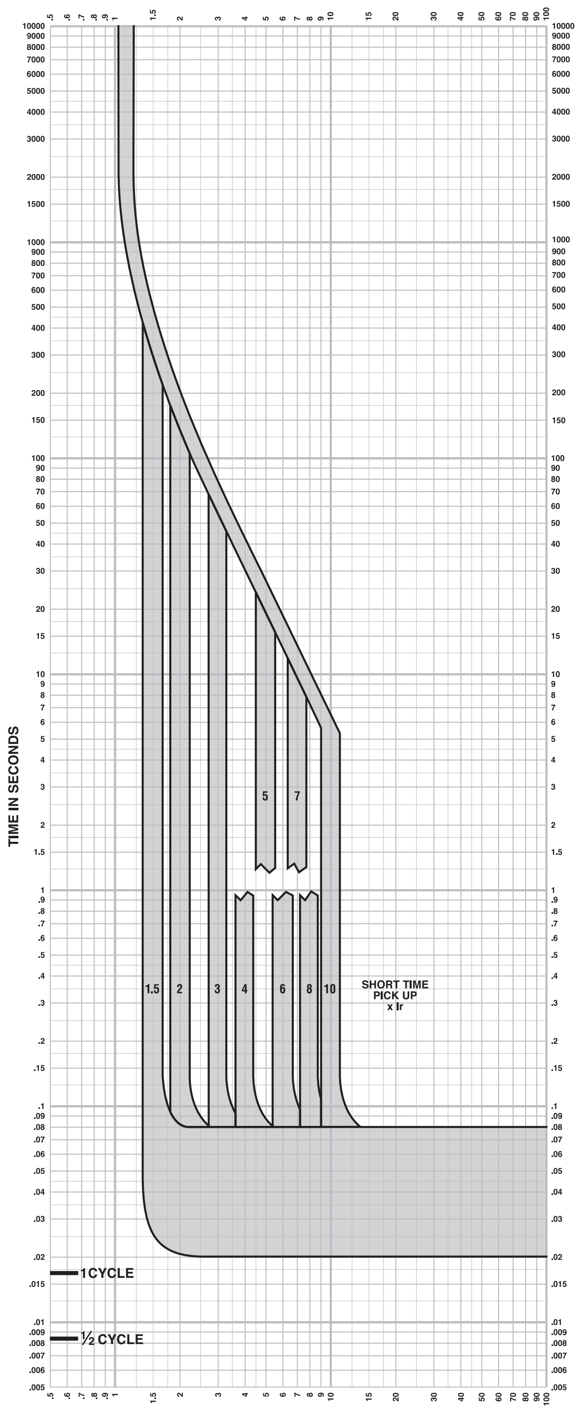
Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

TIM-ID: 0000053623 - 002

Figure 105: Micrologic™ 3.3S Electronic Trip Unit Long Time/Short Time Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 3.3S Long Time/
Short Time Trip Curve
600A L-Frame

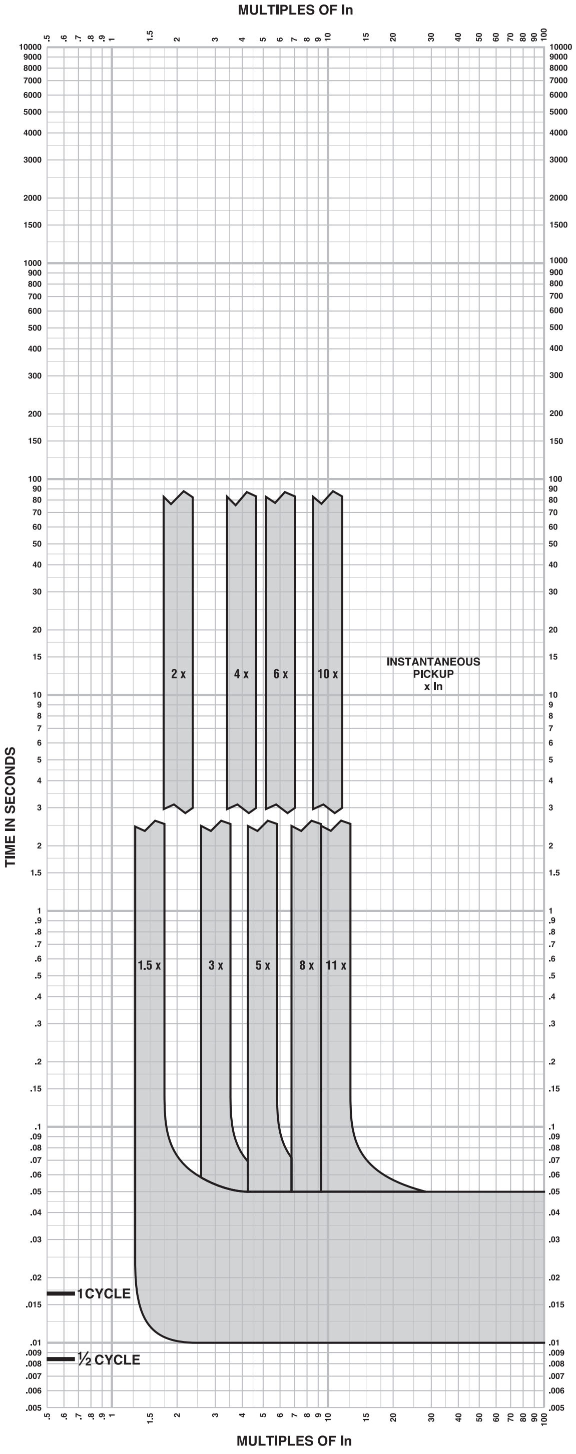
The time-current curve information is to be used for application and coordination purposes only.

Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

Figure 106: Micrologic™ 3.3/3.3S/5.3A/5.3E/6.3A/6.3E Electronic Trip Unit Instantaneous Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 3.3/3.3S/5.3A or E/6.3A or E
Instantaneous Trip Curve
600A L-Frame

The time-current curve information is to be used for application and coordination purposes only.

Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.
3. In = Maximum dial setting of Ir.
   600A L-Frame: In = 600A = Max Ir setting

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

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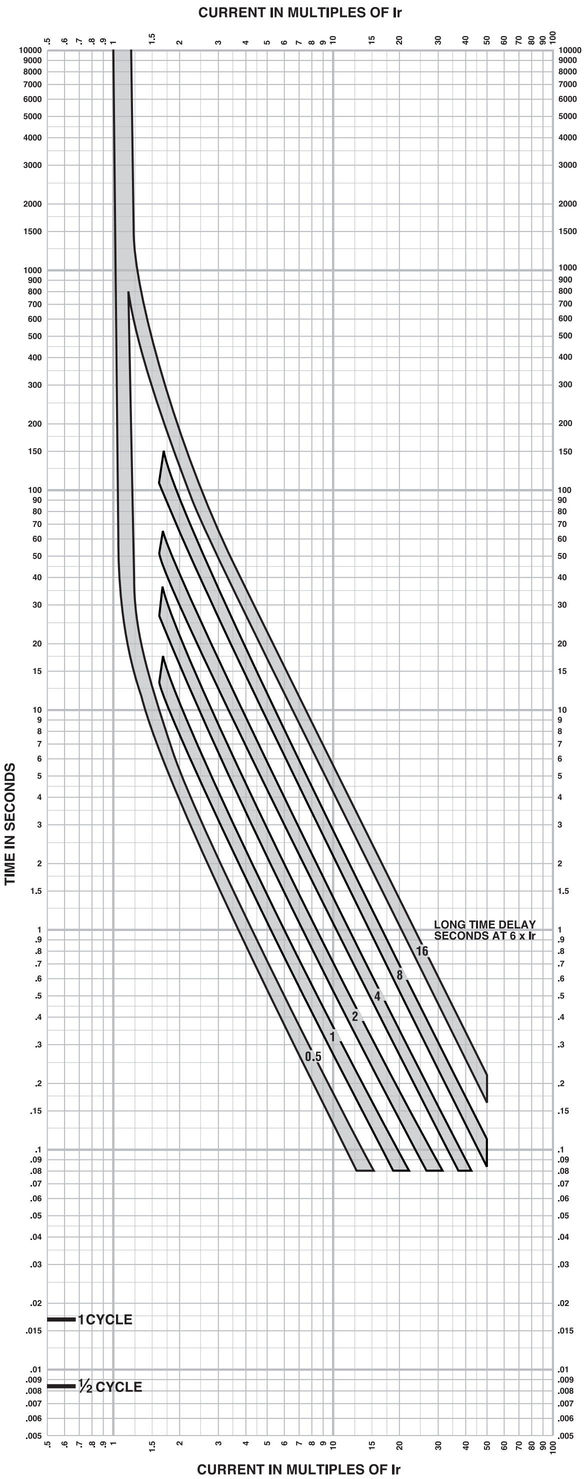
Figure 107: Micrologic™ 5.3A/5.3E/6.3A/6.3E Electronic Trip Unit Long Time Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 5.3A or E/6.3A or E
Long Time Trip Curve
600A L-Frame

The time-current curve information is to be used for application and coordination purposes only.

Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35°C to +70°C (-31°F to +158°F) ambient temperature.

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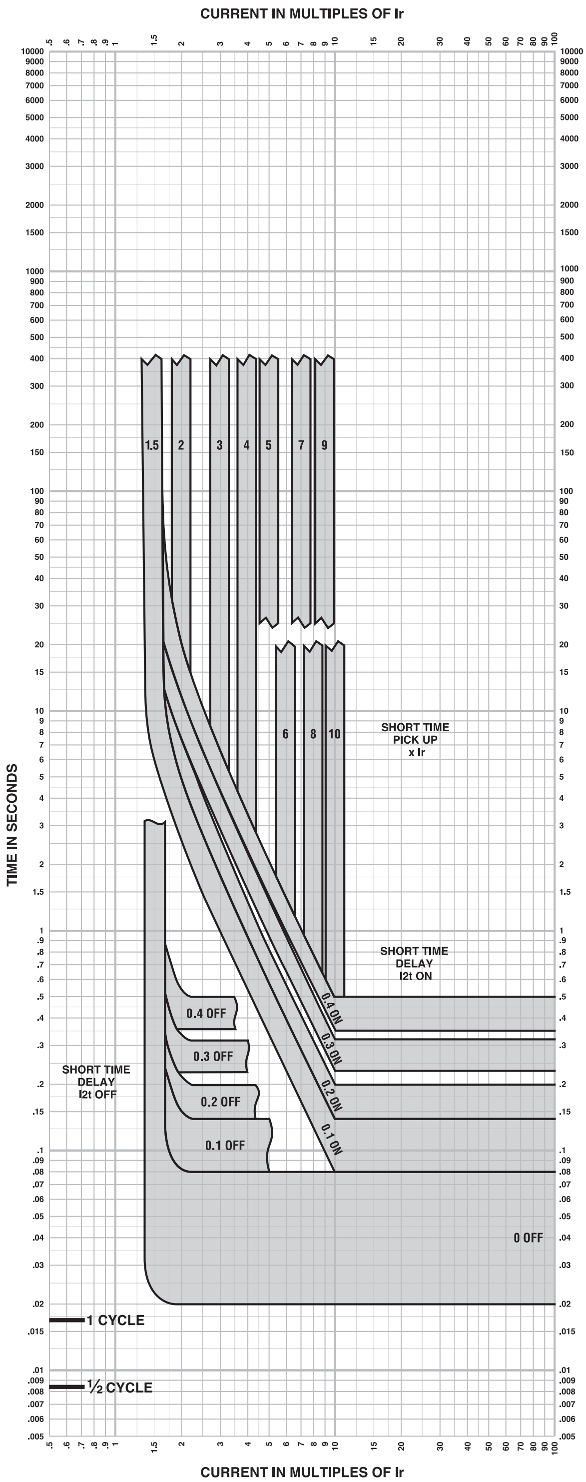
Figure 108: Micrologic™ 5.3A/5.3E/6.3A/6.3E Electronic Trip Unit Short Time Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 5.3A or E/6.3A or E
Short Time Trip Curve
600A L-Frame

The time-current curve information is to be used for application and coordination purposes only.

Notes:

1. There is a thermal-imaging effect that can act to shorten the long-time delay. The thermal imaging effect comes into play if a current above the long-time delay pickup value exists for a time and then is cleared by the tripping of a downstream device or the circuit breaker itself. A subsequent overload will cause the circuit breaker to trip in a shorter time than normal. The amount of time delay reduction is inverse to the amount of time that has elapsed since the previous overload. Approximately 20 minutes is required between overloads to completely reset thermal-imaging.
2. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

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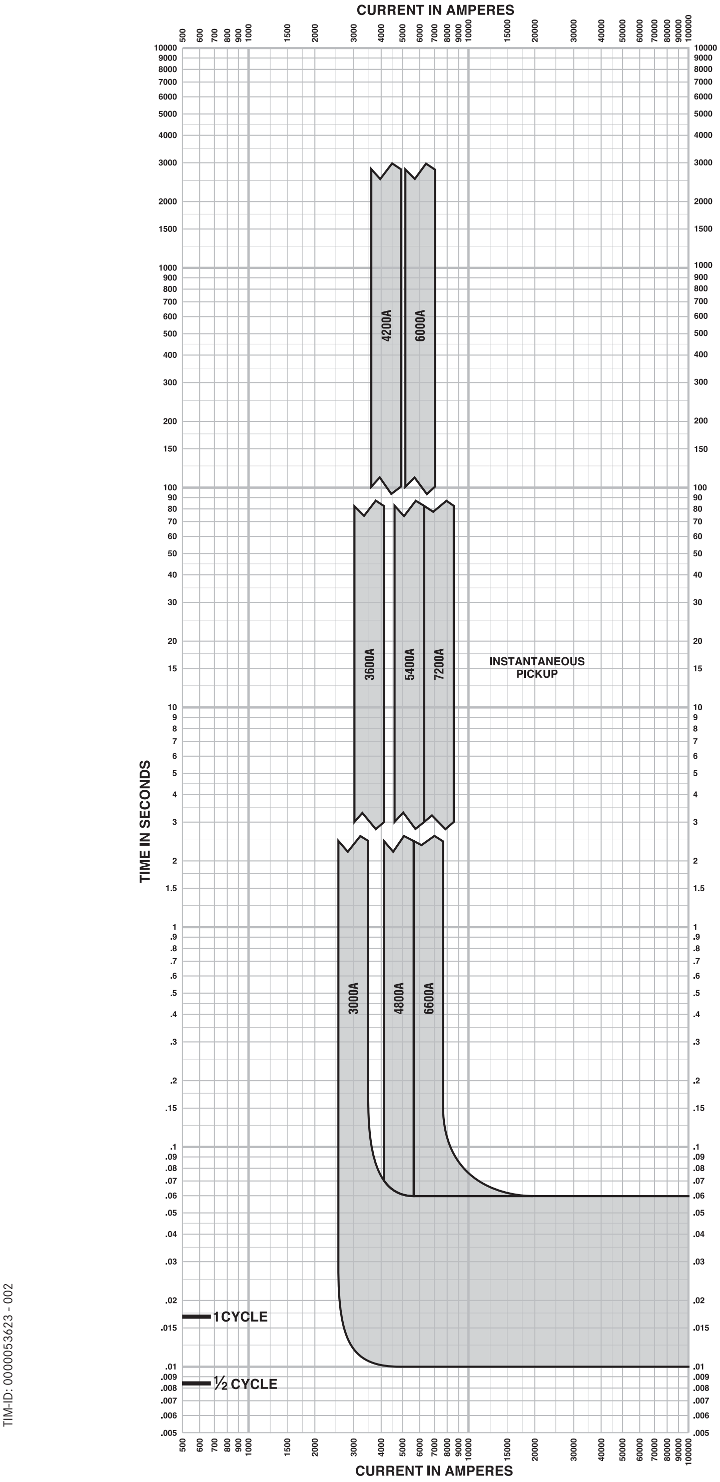
Figure 109: Micrologic™ 1.3 M Electronic Trip Unit Instantaneous Trip Curve



MICROLOGIC™ ELECTRONIC TRIP UNITS
Micrologic™ 1.3M Instantaneous Trip Curve
600A L-Frame

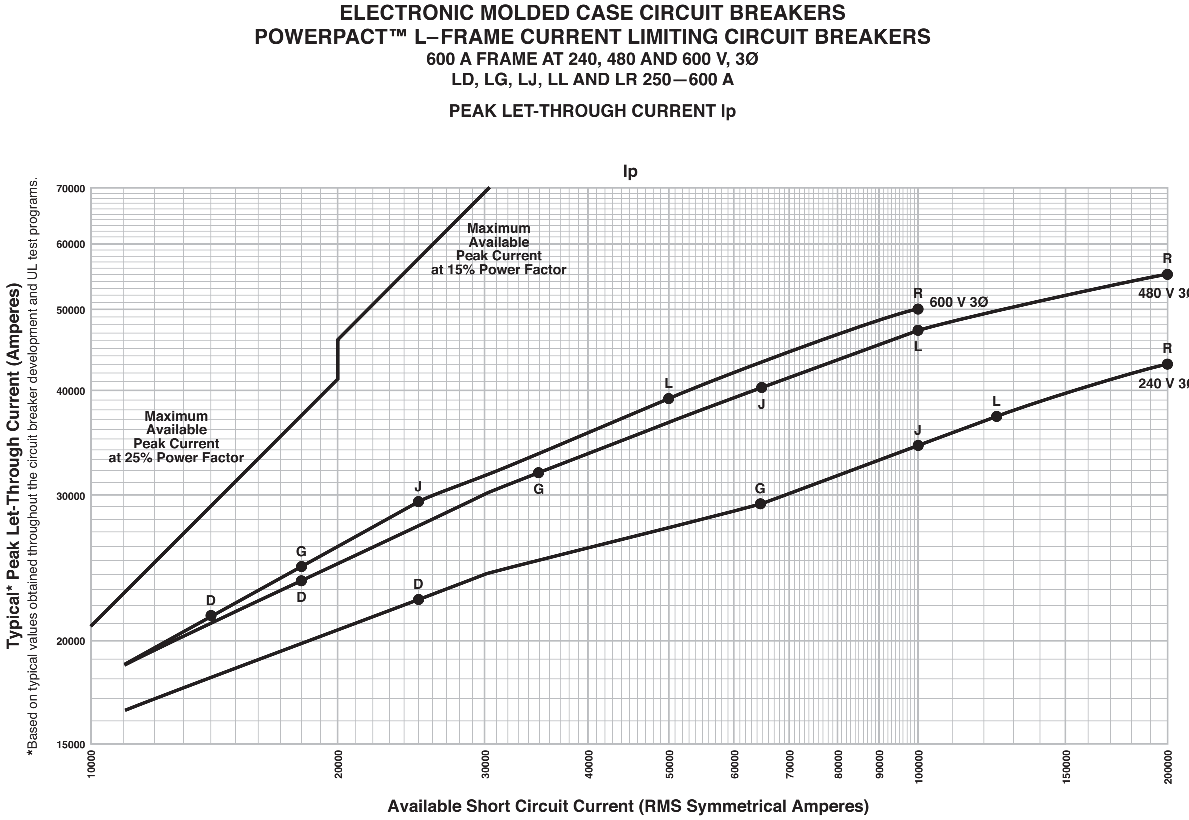
The time-current curve information is to be used for application and coordination purposes only.

Notes:

1. Total clearing times shown include the response times of the trip unit, the circuit breaker opening, and the extinction of the current.

Curves apply from -35ºC to +70ºC (-31ºF to +158ºF) ambient temperature.

Figure 110: L-Frame 600 A Typical Peak Let-Through Curves



TIM-ID: 0000053623 - 002

Figure 111: L-Frame 600 A Typical I^2t Let-Through Curves

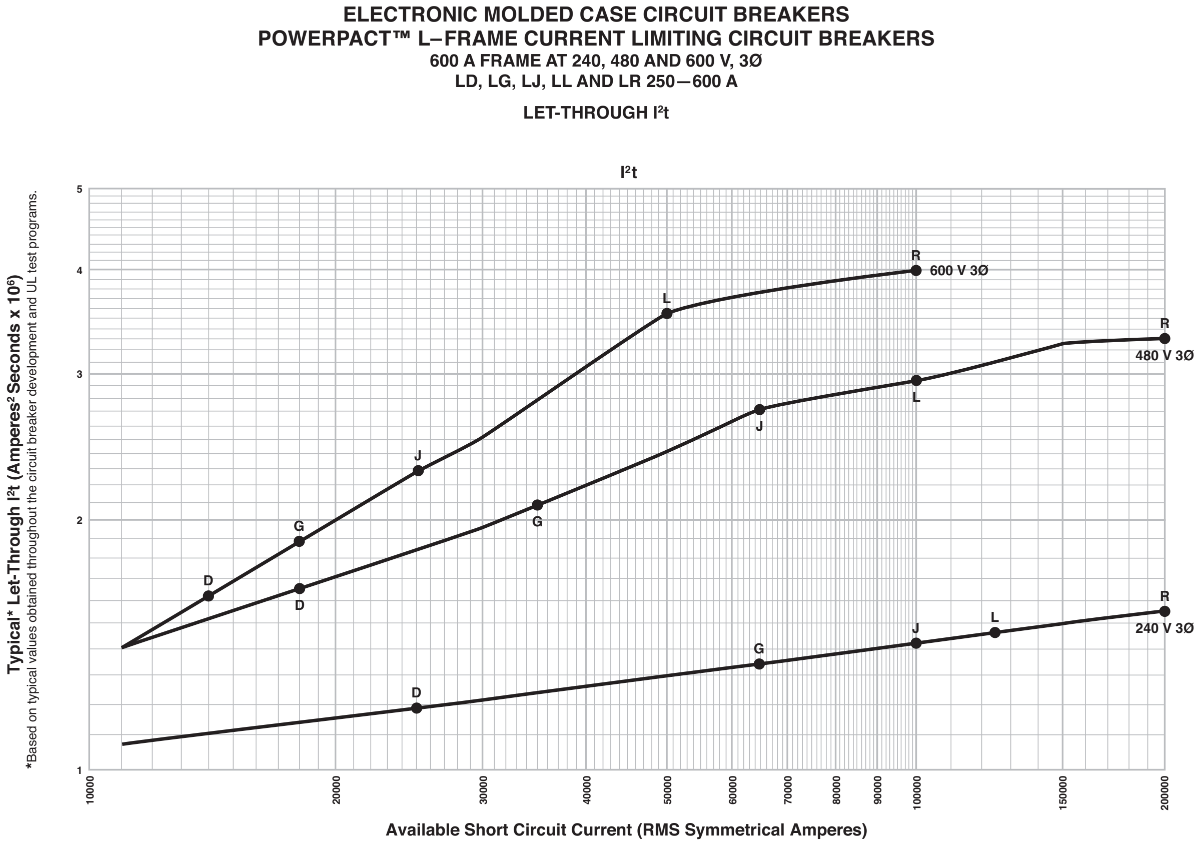


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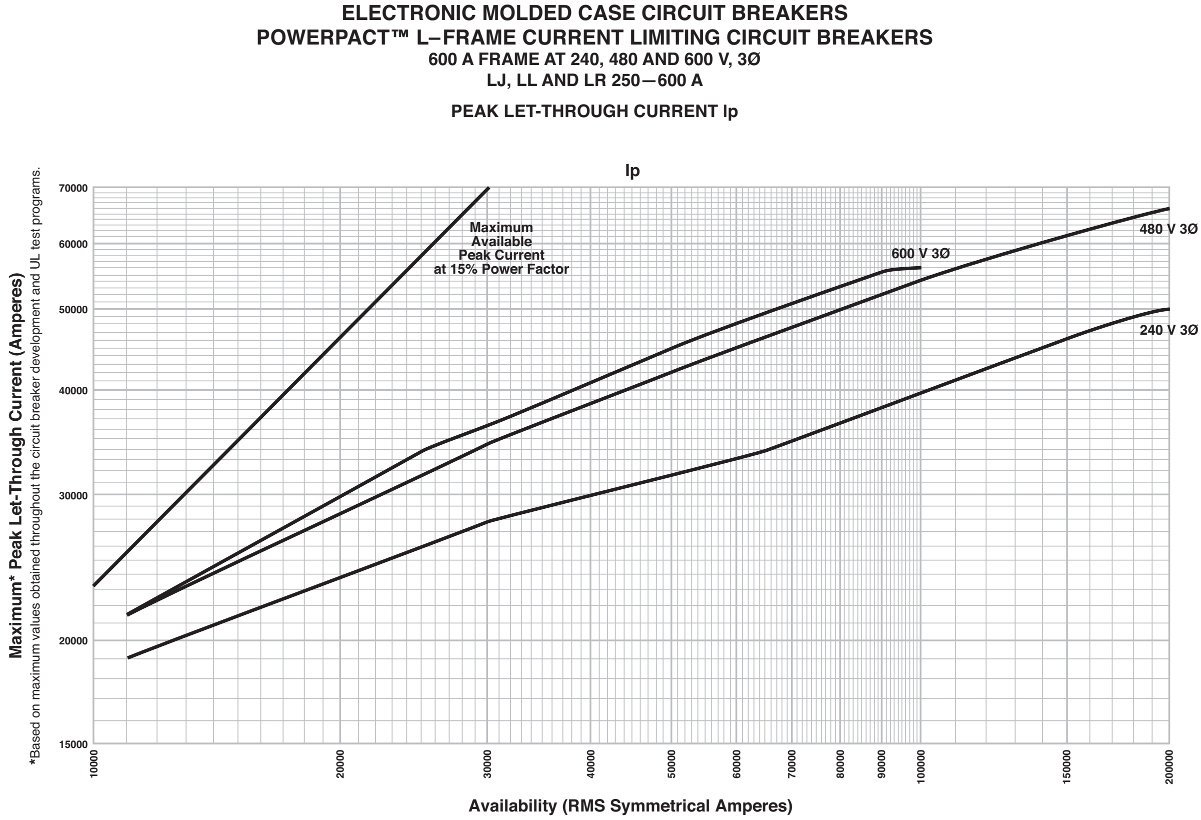
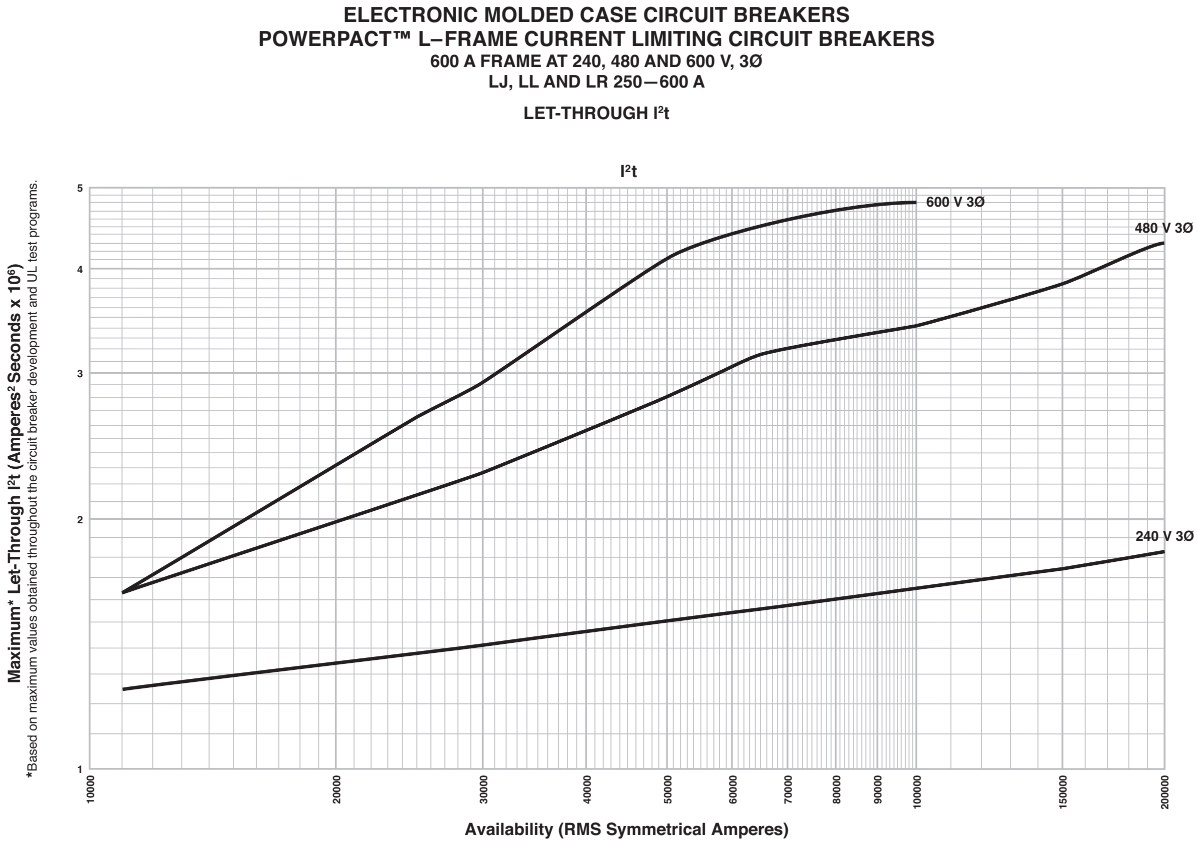
Figure 112: L-Frame UL Listed Current-Limiting Circuit Breaker



TIM-ID: 0000053623 - 002

Figure 113: L-Frame UL Listed Current-Limiting Circuit Breaker



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Catalog Numbers

SQUARE D
by Schneider Electric

PowerPact™ H-, J-, and L-Frame Circuit Breakers
Catalog Numbers

TIM-ID: 0000053623 - 002

SQUARE D by Schneider Electric

PowerPact™ H-, J-, and L-Frame Circuit Breakers
Catalog Numbers

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SQUARE D™
by Schneider Electric

Glossary

accessory = An electrical or mechanical device that performs a secondary or minor function apart from overcurrent protection.

accessory cover = A removable cover on the front of a circuit breaker behind which are mounted the trip unit and all electrical accessories.

adjustable rating plug = A component which plugs into the trip unit, establishing the ampere rating of the circuit breaker

AIC = Amperes interrupting capacity.

AIR = See *amperes interrupting rating*.

alarm switch (bell alarm) = See *overcurrent trip switch*.

ambient temperature rating = Temperature at which the continuous current rating (handle rating) of a circuit breaker is based; the temperature of the air immediately surrounding the circuit breaker which can affect the thermal (overload) tripping characteristics of thermal-magnetic circuit breakers. Electronic trip circuit breakers, however, are insensitive to normal (-10° to 50°C) ambient conditions.

ammeter (local current meter) = A module that mounts directly to the circuit breaker trip unit and reports RMS phase and ground-fault current values as seen by the trip unit. Current values are displayed one phase at a time.

ampacity = The current, in amperes, that a conductor or circuit breaker can carry continuously under the conditions of use without exceeding its temperature rating.

ampere = The equivalent of one coulomb per second or the steady current produced by one volt applied across a resistance of one ohm.

amperes interrupting rating = The highest current at rated voltage that an overcurrent protective device is intended to interrupt under specified test conditions (NEC).

ANCE (National Association of Standardization and Certification for the Electrical Sector) = The standards and certification agency accredited by the Mexican government.

ANSI® = American National Standards Institute.

automatic molded case switch = A switch with construction similar to a molded case circuit breaker except that the switch opens only instantaneously at a non-adjustable trip point calibrated to protect only the molded case switch itself.

auxiliary switch = A switch mechanically operated by the main device for signaling, interlocking, or other purposes.

bell alarm = A mechanically-operated switch used to indicate the main contact position of a circuit breaker, which indicates when a circuit breaker has tripped. Also see *overcurrent trip switch*.

BPFE = See *electrical closing push button*.

branch circuit = The circuit between the final overcurrent device protecting the circuit and the outlet(s).

BCM = See *circuit breaker communications module*.

Canadian Standards Association® (CSA®) = Canadian product safety testing and certification organization.

carriage= See *cradle*.

CCM = See *cradle communication module*.

CD = See *cell switch*.

CDM = See *mechanical operation counter*.

CE = See *cell switch*.

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cell switch = A switch which indicates the position of a drawout circuit breaker in relation to the cradle.

— **CD** = Disconnected position cell switch.

— **CE** = Connected position cell switch.

— **CT** = Test position cell switch.

CH = A spring-charged contact inside of the spring charging motor on insulated-case and low-voltage power circuit breakers.

charging handle= See *spring charging handle.*

circuit breaker = A device designed to open and close a circuit by non-automatic means and to open the circuit automatically on an overcurrent without damage to itself when properly applied within its rating.

circuit breaker communications module (BCM) = A module which, when installed in a circuit breaker, receives and transmits information on the communication network.

circuit breaker frame = (1) The circuit breaker housing which contains the current carrying components, the current sensing components, and the tripping and operating mechanism. (2) That portion of an interchangeable trip molded case circuit breaker remaining when the interchangeable trip unit is removed.

close button = A button for manually closing the main contacts after the closing springs are charged.

close button cover = A cover which fits over the close button and blocks access to it. Access to the close button may be permitted through the use of a tool or rod inserted through a small hole in the front of the close button cover.

closing coil (shunt close) = A coil which closes the circuit breaker electrically using an external voltage source when a specified voltage is applied across the coil.

coil clearing switch = A mechanically-operated switch in series with the coil of a shunt trip device which breaks the coil current when the circuit breaker opens.

communication network = A network allowing the flow of information between electrical components, comprised of programmable controller interface units, protocol software and modems.

conductor = A substance or body that allows a current of electricity to pass continuously along it.

continuous current rating (handle rating) (ampere rating) = The designated RMS alternating or direct current in amperes which a device or assembly will carry continuously in free air without tripping or exceeding temperature limits.

continuous load = A load where the maximum current on the circuit is expected to continue.

cradle communications module (CCM) = An external module which allows addressing of the cradle and retention of the address when the drawout circuit breaker is in the disconnected position and which is used to transmit information about the position of the circuit breaker in the cradle to the communication network.

cradle compartment = A compartment containing all connectors, shields, adapters, barriers, spreaders, shutters, keys and interlocking devices for a drawout circuit breaker.

CSA® = See *Canadian Standards Association.*

CT = Current transformer. See also *cell switch*.

current path (of a circuit breaker) = The current-carrying conductors within a circuit breaker between, and including, line and load terminations.

current transformer (current sensor) (CT) = An instrument to measure current, encircling a conductor carrying the current to be measured or controlled.

demand metering = The metering of power or current demand seen by a circuit breaker. It is calculated over a fixed or sliding time window that can be programmed from five to 60 minutes. Depending on the contract signed with the power supplier, specific programming makes it possible to avoid or minimize the cost of overrunning the subscribed power. Maximum demand values are systematically stored and time stamped.

disconnecting contacts = See *main disconnecting contacts* and *secondary disconnecting contacts*.

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drawout circuit breaker = An assembly of a circuit breaker and a supporting structure (cradle) so constructed that the circuit breaker is supported and can be moved to either the main circuit connected or disconnected position without removing connections or mounting supports.

drawout mechanism = A mechanism which engages the drawout cradle assembly and draws the circuit breaker into or out of the equipment. The drawout mechanism includes the drawout mechanism shaft, drawout levering device arms and a drawout position indicator.

drawout position indicator = An indicating means which shows the position of the circuit breaker in the drawout structure.

drawout access cover (drawout shaft cover) = A shutter which allows or restricts access to the drawout shaft.

electrical closing push button (BPFE) = A push button used to electrically close a circuit breaker using a shunt close with communication option. This takes into account all safety functions that are part of the control and monitoring system of the installation.

electrical operator (motor operator) = An electrical device used to open and close a circuit breaker or switch and reset a circuit breaker. See also *spring charging motor*.

electronic trip circuit breaker = A circuit breaker which uses current sensors and electronic circuitry to sense, measure and respond to current levels.

fixed-mounted circuit breaker = A circuit breaker so mounted that it cannot be removed without removing primary and sometimes secondary connections and/or mounting supports.

frame size = The largest ampere rating available in a group of circuit breakers of similar physical configuration.

frequency = The number of cycles per second for an alternating current system.

frequency rating = The range of frequencies within which a product can be applied.

ground fault = An unintentional current path, through ground, back to the source.

ground-fault delay = The length of time the circuit breaker trip unit will delay before initiating a trip signal to the circuit breaker after a ground fault has been detected.

ground-fault module = An electronic accessory used in combination with thermal-magnetic circuit breakers to provide branch circuit ground-fault protection and ground-fault indication.

ground-fault pickup = The level of ground-fault current at which the trip system begins timing.

handle rating = Continuous current rating.

IDMTL = Long-time delay curve which can be varied in slope to enhance selectivity.

IEC® = International Electrotechnical Commission.

IEEE® = Institute of Electrical and Electronics Engineers.

Ig = See *ground-fault pickup.*

Ii = See *instantaneous pickup.*

In = See *sensor rating.*

individually-mounted circuit breaker = A circuit breaker so mounted that it cannot be removed without removing primary and sometimes secondary connections and/or mounting supports.

instantaneous pickup = The current level at which the circuit breaker will trip with no intentional time delay.

instantaneous trip = A qualifying term indicating that no delay is purposely introduced in the tripping action of the circuit breaker during short-circuit conditions.

insulated case circuit breaker (ICCB) = UL Standard 489 Listed non-fused molded case circuit breakers which utilize a two-step stored energy closing mechanism, electronic trip system and drawout construction.

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integral ground-fault protection for equipment = Equipment ground-fault protection on grounded neutral systems provided by components internal to the circuit breaker.

interchangeable trip unit = A trip unit which can be interchanged by a user among circuit breaker frames of the same design.

interrupting rating = The highest current at rated voltage available at the incoming terminals of the circuit breaker. When the circuit breaker can be used at more than one voltage, the interrupting rating will be shown on the circuit breaker for each voltage level. The interrupting rating of a circuit breaker must be equal to or greater than the available short-circuit current at the point at which the circuit breaker is applied to the system.

inverse time = A qualifying term indicating there is purposely introduced a delay in the tripping action of the circuit breaker, which delay decreases as the magnitude of the current increases.

I_r = See *long-time pickup.*

I_{sd} = See *short-time pickup.*

I^2t = See *let-through current.*

I^2 t IN (I^2 t ON) = An inverse time delay characteristic.

I^2 t OUT (I^2 t OFF) = A constant time delay characteristic.

latch check switch = A mechanically-operated switch which senses if the trip latch is reset.

let-through current = The peak current (measured in amperes) which passes through an overcurrent protective device during an interruption.

let-through I^2t = An expression related to energy (measured in ampere-squared seconds) which passes through an overcurrent protective device during an interruption.

LI = A combination of adjustable trip functions including long-time ampere rating, long-time delay, and instantaneous pickup.

lifting adapter = A device used with a crane, chain block or an optional lifting mechanism supplied with switchgear for removing and installing a drawout circuit breaker or fuse truck.

LIG = A combination of adjustable trip functions including long-time ampere rating, long-time delay, instantaneous pickup, ground-fault pickup and ground-fault delay.

limit switch = A switch mechanically operated by a device.

local current meter = An ammeter installed as part of the trip unit.

long-time ampere rating = An adjustment which, in combination with the installed rating plug, establishes the continuous current rating of a full-function electronic trip circuit breaker.

long-time delay = The length of time the circuit breaker will carry a sustained overcurrent (greater than the long-time pickup) before initiating a trip signal.

long-time pickup = The current level at which the circuit breaker long-time delay function begins timing.

low voltage power circuit breaker (LVPCB) = A circuit breaker tested to the ANSI C37 Standards with a two-step stored-energy mechanism, an electronic trip system, and drawout construction.

LS = A combination of adjustable trip functions including long-time ampere rating, long-time delay, short-time pickup, short-time delay and a defeatable instantaneous pickup.

LSG = A combination of adjustable trip functions including long-time ampere rating, long-time delay, short-time pickup, short-time delay, defeatable instantaneous pickup, ground-fault pickup and ground-fault delay.

LSI = A combination of adjustable trip functions including long-time ampere rating, long-time delay, short-time pickup, short-time delay and defeatable instantaneous pickup.

LSIG = A combination of adjustable trip functions including long-time ampere rating, long-time delay, short-time pickup, short-time delay, defeatable instantaneous pickup, ground-fault pickup and ground-fault delay.

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main disconnecting contacts = Spring-loaded and self-aligning contact on the rear of a drawout circuit breaker that provide positive electrical contact when the circuit breaker is in the connected position.

Masterpact™ = The family of universal power circuit breakers including insulated case circuit breakers and low-voltage power circuit breakers.

MCH = See *spring-charging motor.*

MDGF = Modified differential ground-fault system.

manual charging handle = A manually-operated handle which charges the circuit breaker closing springs.

mechanical operation counter (CDM) = A mechanical device which indicates the total number of circuit breaker operating cycles.

Micrologic™ = The family of electronic trip systems available on molded case circuit breakers, insulated case circuit breakers and low-voltage power circuit breakers.

miniature circuit breaker (MCB) = A small circuit breaker which is assembled as an integral unit in a supportive and enclosed housing of insulating material, rated 150 A or less and used in 120 V, 120/240 V, 240 V and 480Y/277 V ac systems and dc systems up to 125 Vdc.

MN = See *undervoltage release.*

Modbus™ communication network = A communication network comprised of programmable controller interface units, protocol software and modems.

molded case circuit breaker (MCCB) = A circuit breaker which is assembled as an integral unit in a supportive and enclosed housing of insulating material, generally 20 to 3000 A in size and used in systems up to 600 Vac and 500 Vdc.

motor circuit protector = A recognized component of construction similar to a circuit breaker except with no thermal elements so that it provides short-circuit protection only.

MX = See *shunt trip.*

National Association of Standardization and Certification for the Electrical Sector = See *ANCE.*

neutral current transformer = A current transformer which encircles the neutral conductor; required on circuit breakers with ground-fault protection, when applied on a grounded system.

NMX® (Norma Mexicana X) = Listing mark indicating certification to non-mandatory Mexican safety standards.

NOM = Listing mark indicating certification to mandatory Mexican safety standards

OF = See *auxiliary switch.*

open/closed indicator = An indicating means which displays the position (open or closed) of the main contacts.

operating mechanism = An internal mechanical system which opens and closes the circuit breaker contacts.

OTS = Overcurrent trip switch (alarm switch, bell alarm). A mechanical switch that operates when the circuit breaker is tripped by the trip system.

overcurrent = Any current in excess of the rated continuous current of equipment or the ampacity of a conductor.

overcurrent mechanism = An internal mechanical system which trips the circuit breaker during an overcurrent.

overcurrent trip element = A device which detects an overcurrent and transmits the energy necessary to open the circuit automatically (UL only).

overcurrent trip switch (SDE) = A mechanically-operated switch which indicates when a circuit breaker has tripped due to overcurrent conditions.

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overload delay = The length of time the circuit breaker will carry a sustained low-level overcurrent before initiating a trip signal.

peak current sensing = A method of determining the current by means of detecting the current peaks.

peak let-through current = The maximum peak current flowing in a circuit during an overcurrent condition.

PF = A switch used to indicate a circuit breaker is ready to close.

phase barrier = A barrier which provides phase-to-phase or phase-to-ground isolation.

PowerLogic™ = The family of electronic circuit monitoring systems available on molded case circuit breakers, insulated case circuit breakers and low-voltage power circuit breakers.

Power-Zone™ = The family of low-voltage and medium-voltage switchgear.

programmable contact module (M6C and M2C) = A programmable module which indicates the type of fault and the instantaneous and delayed threshold overruns. It may be programmed with instantaneous return to the initial state, without return to the initial state, or with return to the initial state following a delay.

primary disconnect contacts = An electrical plug-on connector in the main current path between the drawout components and the cradle mounted in the equipment.

push-to-close button = A button for manually closing the main contacts after the closing springs are charged.

push-to-open button = A button for manually opening the circuit breaker.

push-to-trip button = A button for manually tripping the circuit breaker.

racking device shutter = See *drawout shaft cover*.

racking interlock = An interlock to prevent racking of a drawout circuit breaker when the enclosure door is open by not allowing the racking crank to be inserted into the circuit breaker.

rating plug = A component which plugs into the full-function electronic trip unit, establishing the maximum continuous current rating of the circuit breaker.

remote reset after fault (RES) = A component which resets the overcurrent trip switch (SDE) and the mechanical operator after tripping.

RES = See *remote reset after fault*.

residual ground-fault sensing = A means of providing equipment ground-fault protection utilizing sensors on each individual phase.

restraint interface module (RIM) = A component which allows zone-selective interlocking communication between Square D™ full-function electronic trip systems, add-on ground-fault modules and zero-sequence ground-fault relays.

RIM = Restraint interface module.

RMS = Root-mean-square.

RMS current sensing = A method of determining the true RMS current of sinusoidal and non-sinusoidal waveforms by sampling the current waveform a number of times per cycle, then calculating the true RMS value.

safety shutter = A device that closes to block access to the main disconnects when the circuit breaker is in the disconnected, test or withdrawn position.

SDE = See *overcurrent trip switch.*

secondary disconnect contacts = An electrical plug-on connector in the secondary (control) circuit between a drawout circuit breaker and its cradle in the equipment.

sensor = The current sensing element within the circuit breaker which provides the sensing function for that circuit breaker.

sensor plug = A component used with a Micrologic™ trip system to set the sensor size of a circuit breaker.

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sensor size = Maximum ampere rating possible for a specific circuit breaker, based on the size of the current sensor inside the circuit breaker. Sensor size is less than or equal to frame size.

SGR = Source ground return system.

short-circuit delay (STD) = The length of time the circuit breaker will carry a short circuit (current greater than the short-circuit pickup) before initiating a trip signal.

short-circuit pickup = The current level at which the circuit breaker short-circuit delay function begins timing.

short-time delay = The length of time the circuit breaker will carry a short circuit (current greater than the short-time pickup) before initiating a trip signal.

short-time pickup = The current level at which the circuit breaker short-time delay function begins timing.

shunt close (closing coil) (XF) = An accessory which closes the circuit breaker from a remote location using an external voltage source.

shunt trip (MX) = An accessory which trips the circuit breaker from a remote location using an external voltage source.

spring-charging handle = A handle located on the front of the circuit breaker used to manually charge the stored energy mechanism.

spring charging motor = A motor which electrically charges the stored energy closing spring(s).

STD = Short-time delay.

stored energy mechanism (SEM) = A spring mechanism that is compressed or “charged” and then released or “discharged” to close the circuit breaker.

terminal block = The connections for control wiring.

tg = See *ground-fault delay.*

thermal imaging = A trip unit function that accurately maps the heating and cooling effects of load behavior on rated conductors to provide thermal protection without nuisance tripping.

thermal-magnetic circuit breaker = A general purpose term for circuit breakers that use bimetals and electromagnetic assemblies to provide both thermal and magnetic overcurrent protection.

thermal memory = Provides continuous temperature rise status of the wiring for a period of time both before and after the device trips. This allows the circuit breaker to respond to a series of overload conditions which would otherwise go undetected.

t_r = See *long-time delay.*

t_{sd} = See *short-time delay.*

two-step stored energy mechanism = See *stored energy mechanism*.

transformer = A static device with primary winding, connected in series with the conductor (bus) carrying the current to be measured or controlled within the switchgear.

trip button = See *push-to-trip button*.

trip curve = A graphical representation of the response of a circuit breaker to current over a period of time.

trip indicator = A module that mounts directly to the circuit breaker trip unit that displays whether the circuit breaker tripped due to an overload, a short-circuit or a ground-fault condition.

trip indicator reset = A button on the trip indicator module used to reset the trip indicator.

trip system = A system which consists of a Micrologic™ trip unit and current transformers.

trip unit = A programmable device which measures and times current flowing through the circuit breaker and initiates a trip signal when appropriate.

UL® = See *Underwriters Laboratories Inc.*

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undervoltage trip (MN, UVR) = An accessory which trips the circuit breaker automatically when the monitored circuit voltage falls below a predetermined percentage of its specified value.

Underwriters Laboratories Inc.® (UL®) = An independent, not-for-profit standards development, product safety testing and certification organization.

unit-mount circuit breaker = A circuit breaker mounted such that it cannot be removed without removing primary and sometimes secondary connections or mounting supports.

withstand rating = The level of RMS symmetrical current that a circuit breaker can carry with the contacts in a closed position for a stated period of time–usually stated in cycles.

zero-blind time = Metering method used by the Micrologic™ H trip unit where a dedicated metering data chain is separate from the protection data chain so that a greater number of data samples can be used for metering. This increases the number of samples taken per time period, which in turn gives the H trip unit a higher degree of metering accuracy.

zero-sequence ground-fault sensing = A means of providing equipment ground-fault protection utilizing an external sensor (surrounding all phase and neutral conductors).

zone-selective interlocking (ZSI) = A communication capability between electronic trip systems and ground-fault relays which permits a short circuit or ground fault to be isolated and cleared by the nearest upstream device with no intentional time delay.

ZSI = Zone-selective interlocking.

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05/2012

SQUARE D CIRCUIT BREAKERS

Ground Fault Protection Field Test Instructions

TIM-ID: 0000091348 - 001

SQUARE D CIRCUIT BREAKERS
Ground Fault Protection Field Test Instructions

SCOPE
MTU Onsite Energy offers several solutions for Equipment Ground Fault Protection, depending on model, series, or configuration. This document applies to the following factory-installed Square D electronic trip circuit breakers with integral ground fault protection. Other instructions are available for ground fault protection integral to the MGC-3000 Series engine generator controller or for GE circuit breakers with ground fault protection if equipped.

Square D circuit breakers covered by these instructions:
- H-Frame with GFM150HD ground fault module
- J-Frame with GFM250JD ground fault module
- L-Frame with Micrologic 6.3A trip unit
- P-Frame with Micrologic 6.0A or 6.0P trip unit
- R-Frame with Micrologic 6.0A or 6.0P trip unit
- NW-Frame with Micrologic 6.0A or 6.0P trip unit

An external neutral current transformer (CT) is also required and is usually factory installed in the generator outlet box or circuit breaker enclosure, or it may be shipped loose for field installation.

INTRODUCTION
Paragraph 230-95(c) of NFPA 70, National Electrical Code, requires that ground fault protection systems for equipment be performance tested when first installed.

Square D recommends testing be done:
- when the equipment is installed at its permanent location.
- yearly as part of annual maintenance or after each unintentional operation of the overcurrent protective device.
- if the distribution system is altered in any way.

Field testing simulates a ground fault greater than the highest pickup setting on the module. The module then triggers the ground fault shunt trip, tripping the circuit breaker.

Field testing determines that:
- installation is correct.
- ground fault protection system is operational.

Field testing is not a check of the calibration of any sensing relay.

Before testing, review instruction manual included with the ground fault module. Testing must be conducted and evaluated by qualified personnel.

⚠	**HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH** • Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices. See NFPA 70E. • This equipment must be installed and serviced only by qualified electrical personnel. • Turn off all power supplying this equipment before working on or inside the equipment. • Always use a properly rated voltage sensing device to confirm power is off. • Replace all devices, doors, and covers before turning on power to this equipment.

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SQUARE D CIRCUIT BREAKERS

Ground Fault Protection Field Test Instructions

INSPECTION (AT INSTALLATION ONLY)

1. Turn off all power supplying this equipment before working on or inside equipment.
2. Remove the neutral disconnect link on switchboard to isolate neutral of the wiring system from both supply and ground.
3. With circuit breaker in off position, measure insulation resistance of neutral to ground to ensure no ground connections exist downstream (load side).
4. Visually inspect wiring. Confirm that the grounding connection at the service equipment is upstream (line side) of the circuit breaker neutral CT and that a neutral connection exists from the supply transformer to the service equipment.
5. Reconnect all neutral and ground connections.

GROUND FAULT TEST

H-Frame with GFM150HD and J-Frame with GFM250JD Ground Fault Modules

⚠	**HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH** • Turn off all power supplying this equipment before connecting temporary power source. • Do not touch terminals 7 or 8 when the temporary power source is connected and turned on.

NOTE: If ground fault test circuit is not connected to 120 VAC power source, connect a temporary 120 VAC power source to the test circuit.

1. Turn off all power supplying this equipment before connecting temporary power source.
2. Remove lug cover (Figure 1, A).
3. Connect 120 VAC 50/60 Hz 60 VA supply to terminals 7 and 8 (Figure 1, B).
4. Replace lug cover.

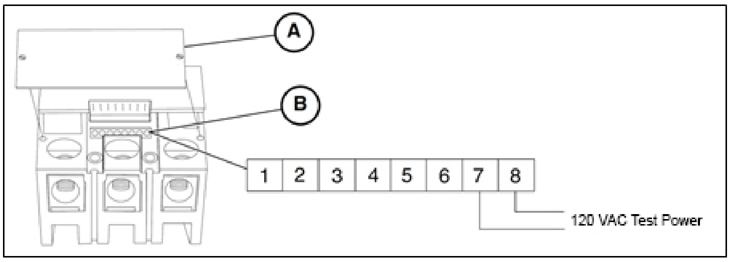

Figure 1: Lug cover for access to terminals 7 and 8

5. Turn 120 VAC ground fault test power on.
6. Test ground fault system. If circuit breaker does not trip, contact the local field office.
   a) Depress **Push-to-test** Button (Figure 2, A).
   b) Circuit breaker will trip and red indicator button will pop up. Press **indicator** button to reset (Figure 2, B).

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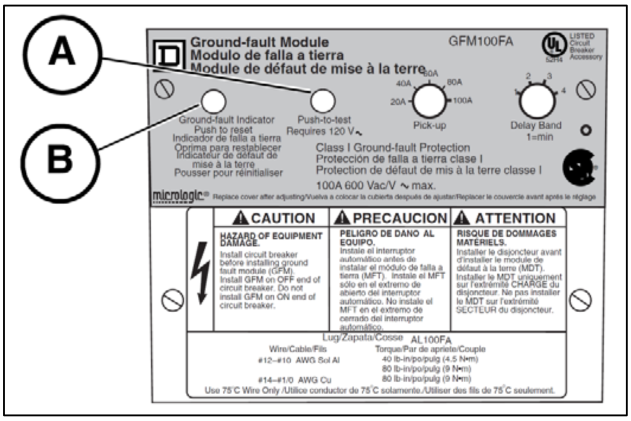


Figure 2: Lug cover for access to terminals 7 and 8

NOTE: If using a temporary 120 VAC power source to test the circuit, turn it off, and then disconnect it.

7. Remove lug cover (Figure 3, C).
8. Disconnect 120 VAC power supply to terminals 7 and 8 (Figure 3, D).
9. Replace lug cover.

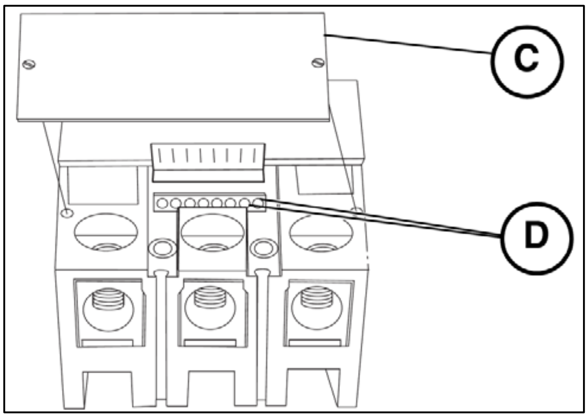


Figure 3: Lug cover for access to terminals 7 and 8

10. Record the results in Table 2.

L-Frame with Micrologic 6.3A Trip Unit

1. Perform the ground fault protection test on the keypad of the Micrologic trip unit. Use this test to check the trip unit's electronic tripping function.

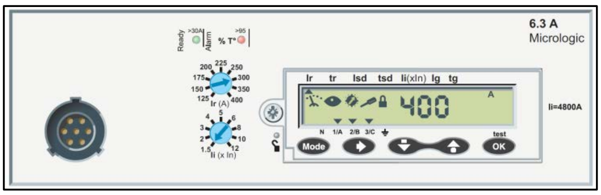


Figure 4: Lug cover for access to terminals 7 and 8

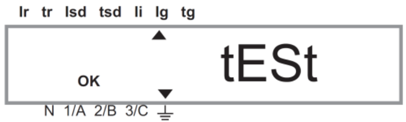
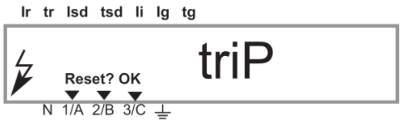
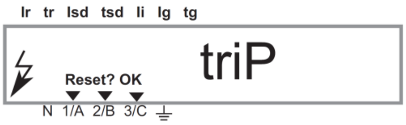
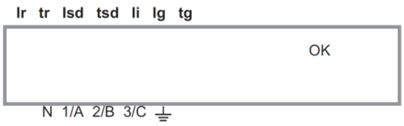
Step	Readout Value	Action	Display
1	Current in most heavily loaded phase	• Access the ground fault protection test function by pressing OK. • The tESt pictogram appears and the OK pictogram blinks.	
2	Peak demand with Reset option showing	• Prompt the ground fault protection test by pressing OK. The ground fault protection trip screen is displayed.	
3	Reset option lit	• Acknowledge the ground fault trip screen by pressing OK. • The Reset OK pictogram blinks.	
4	OK	• Confirm by pressing OK again. • The confirmation OK displays for two seconds.	

Table 1: L-Frame Micrologic 6.3A Test Sequence

11. Record the results in Table 2.

P-Frame, R-Frame, and NW-Frame with Micrologic 6.0A or 6.0P Trip Units

With the trip unit powered and the circuit breaker closed, test the equipment ground fault trip function. The trip unit is powered if:

- Circuit breaker is on and has more than 150 V of load voltage on two phases (circuit breaker is closed or bottom fed).
- The Full-Function or Hand-Held Test Kit is connected and on.
- The 24 Vdc external power supply is connected.
- An external voltage tap is installed and voltage of more than 150 V is present on two phases.

1. To test the trip function, press the ground fault test button (Figure 5, A). Circuit breaker will trip and the trip unit ground fault indicator light will come on.

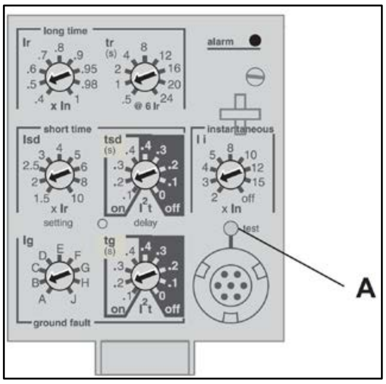


Figure 5: Micrologic 6.0A Trip Unit

2. Record the results in Table 2.

NOTE: If a complete check of the ground fault system is necessary, use primary injection testing. If the system has multiple sources and/or requires field connections at the job site, use primary injection testing.

Date	Ground Fault Settings	Test Results	Signature

Table 2: Ground Fault Test Record

REFERENCE PUBLICATIONS

Frame	Square D Publication No.	Description
H-Frame J-Frame	48041-088-01	GFM150HD and GFM250JD Ground-Fault Modules with Micrologic Trip System – Instruction Bulletin
	48040-757-04	Field Test Procedure for Micrologic Ground-Fault Module
L-Frame	48940-312-01	Micrologic 5 and 6 Electronic Trip Units for PowerPact H-, J-, L-Frame Circuit Breakers – User Guide
	S1A78233	PowerPact™ L-Frame Electronic Trip Circuit Breaker Installation – Instruction Bulletin
	48940-306-01	PowerPact™ and Compact External Neutral Current Transformer (ENCT) Instruction Bulletin
P-Frame R-Frame	48049-137-05	Micrologic 5.0P and 6.0P Electronic Trip Units v PLogic-2002-AA and Later – Instruction Bulletin
	48049-148-05	P-Frame and NS630b-NS1600 Circuit Breakers – Instruction Bulletin
	8049-243-04	PowerPact™ R-Frame and NS1600b-NS3200 Circuit Breakers – Instruction Bulletin
	48049-273-04	Neutral Current transformers for Masterpact® NT, P-Frame, and NS630b-NS1600 Circuit Breakers – Instruction Bulletin
	48049-222-04	Neutral Current Transformers for Masterpact NW, R-Frame, and NS1600-NS3200 Circuit Breakers – Instruction Bulletin
NW-Frame	HRB28361	Masterpact NW Low-Voltage Power/Insulated Case Circuit Breaker Installation – Instruction Bulletin
	06131B1202	Maintenance Guide for Masterpact NT and NW Circuit Breakers – Instruction Bulletin
	48049-222-04	Neutral Current Transformers for Masterpact NE, R-Frame, and NS1600b-MS3200 Circuit Breakers – Instruction Bulletin

MAGNAPLUS® GENERATOR

280–430 Frame
Installation, Operation, and Maintenance Manual

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MARATHON ELECTRIC
GENERATORS
A REGAL-BELOIT COMPANY

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CONTENTS

SAFETY

PLEASE REMEMBER SAFETY FIRST. If you are not sure of the instructions or procedures contained herein, seek qualified help before continuing.

This service manual emphasizes the safety precautions necessary during the installation, operation, and maintenance of your MagnaPLUS® generator. Each section of this manual has caution and warning messages. These messages are for your safety, and the safety of the equipment involved. If any of these cautions or warnings are not readily understood, seek clarification from qualified personnel before proceeding.

Before any service work is done, disconnect all power sources and lock out all controls to prevent an unexpected start up of the generator set driver. Proper grounding (earthing) of the generator frame and distribution system in compliance with local and national electrical codes and specific site requirements must be provided. These safety precautions are necessary to prevent potential serious personal injury, or even death.

The hazards associated with lifting or moving your MagnaPLUS® generator are pointed out in the installation and maintenance sections. Incorrect lifting or moving can result in personal injury or damage to the unit.

Prior to start up of the unit ensure that all generator leads are properly connected to the generator link board located inside the connection box. Always assume that there will be voltage present at the generator terminals whenever the generator's shaft is rotating, and proceed accordingly. Residual voltage is present at the generator terminals and at the automatic voltage regulator panel connections even with the regulator fuse removed. Caution must be exercised, or serious injury or death can result.

This manual is not intended to be a substitute for properly trained personnel. Installation and repairs should only be attempted by qualified, trained people. The cautions and warnings point out known conditions and situations that are potentially hazardous. Each installation may well create its own set of hazards.

When in doubt, ask. Questions are much easier to handle than mistakes caused by a misunderstanding of the information presented in this manual.

RECEIVING AND STORAGE

RECEIVING AND STORAGE

Upon receipt of the generator, it is recommended that it be carefully examined for possible shipping damage. The generator was given to the freight carrier in good condition; thus, the carrier is responsible for the product from the factory dock to the destination. Any damage should be noted on the freight bill before accepting the shipment. Any claims for damage must be promptly filed with the delivering carrier.

UNPACKING AND HANDLING

Carefully read all instruction tags shipped with the unit. When lifting, attach an overhead crane to the lifting lug(s) on the generator frame. Apply lifting forces in a vertical direction. When transporting single bearing generators, the generator’s rotor must be adequately supported to prevent damage.

WARNING

THE LIFTING LUG(S) ON THE GENERATOR ARE DESIGNED TO SUPPORT THE GENERATOR ONLY. DO NOT LIFT A COMPLETE GENERATOR AND DRIVER ASSEMBLY BY MEANS OF LIFTING LUG(S) ON THE GENERATOR. PERSONAL INJURY OR EQUIPMENT DAMAGE MAY RESULT.

STORAGE

In the event that the generator is not immediately installed on its prime mover, it is recommended that the unit be stored indoors in a clean, dry area which is not subject to rapid changes in temperature and humidity. If the generator is stored for a long period of time, the generator should be tested, cleaned and dried as required before being put into service. See the maintenance section of this manual for further information. If the unit has been stored in an area where it has been subject to vibration, it is recommended that the bearing(s) be inspected and replaced as necessary.

PRINCIPLES OF OPERATION

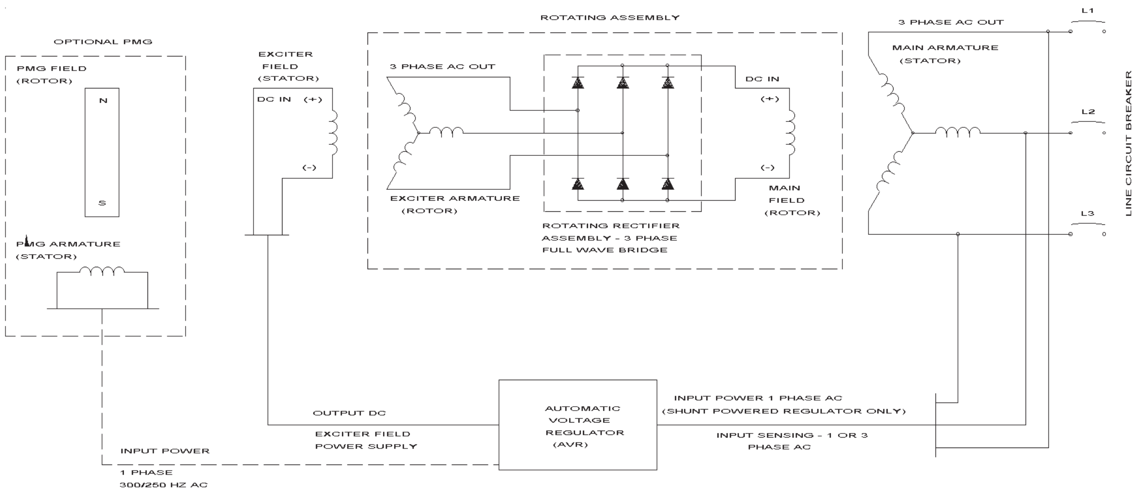

FIGURE 1 -- MagnaPLUS® Circuit Diagram

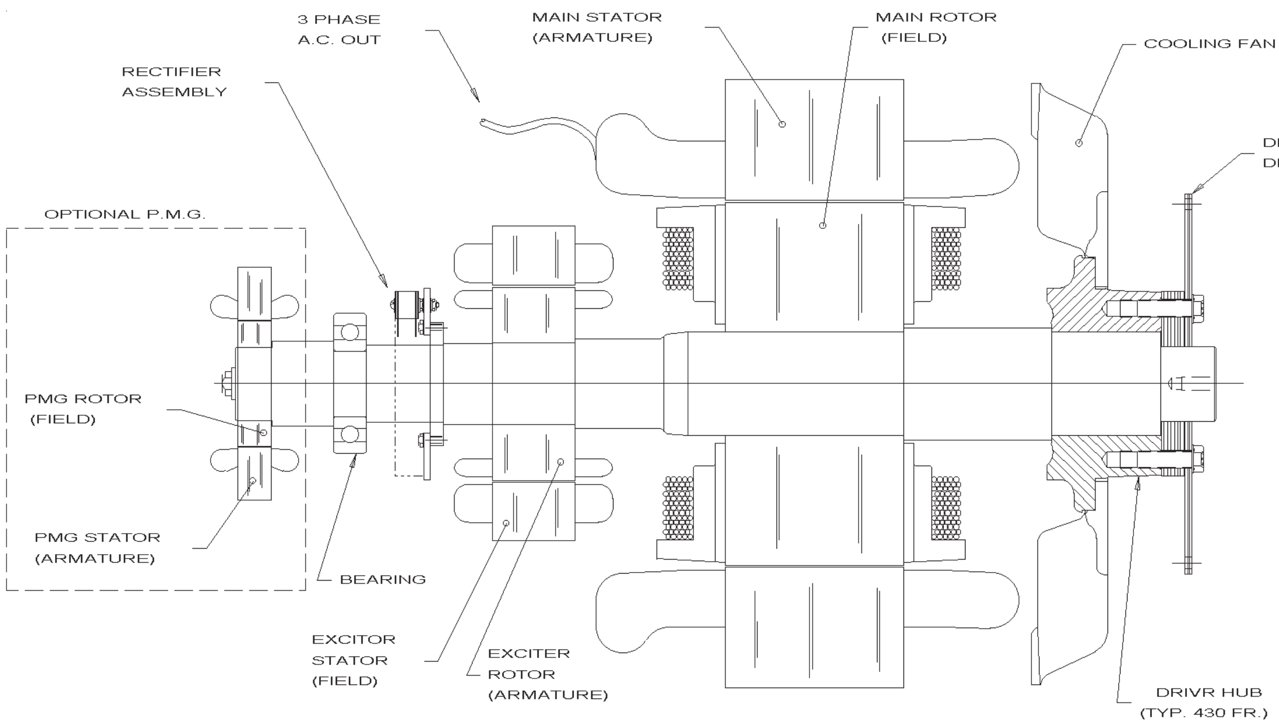

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FIGURE 2 -- Typical MagnaPLUS® Layout Diagram

PRINCIPLE OF OPERATION

MagnaPLUS® generators are brushless, self excited, externally voltage regulated, synchronous AC generator. The generator is made up of six major components: main stator (armature), main rotor (field), exciter stator (field), exciter rotor (armature), rectifier assembly, and voltage regulator. In understanding the above terminology, note the following: stators are stationary, rotors rotate, a field is a DC electrical input, and an armature is an AC electrical output. These system components are electrically interconnected as shown in Figure 1 and physically located as shown in Figure 2.

The generator's exciter consists of a stationary field and a rotating armature. The stationary field (exciter stator) is designed to be the primary source of the generator's residual magnetism. This residual magnetism allows the exciter rotor (armature) to produce AC voltage even when the exciter stator (field) is not powered. This AC voltage is rectified to DC by the rotating rectifier assembly and fed directly to the main rotor (field). As the generator shaft continues to rotate, the main rotor (field) induces a voltage into the generator's main stator (armature). At rated speed, the main stator's voltage produced by the residual magnetism of the exciter allows the automatic voltage regulator to function. The regulator provides voltage to the exciter field resulting in a build-up of generator terminal voltage. This system of using residual magnetism eliminates the need for a special field flashing circuit in the regulator. After the generator has established the initial residual voltage, the regulator provides a controlled DC field voltage to the exciter stator resulting in a controlled generator terminal voltage.

Voltage Regulation

In the standard configuration (shunt excited), the automatic voltage regulator receives both its input power and voltage sensing from the generator's output terminals (See Figure 1). With the optional PMG configuration, the regulator receives input power from the PMG. The regulator automatically monitors the generator's output voltage against an internal reference set point and provides the necessary DC output voltage to the exciter field required to maintain constant generator terminal voltage. The generator's terminal voltage is changed by adjusting the regulator's reference set point. Consult the regulator manual for specific adjustment and operating instructions.

MOTOR STARTING

When a motor is started, a large surge of current is drawn by the motor. This starting current is equivalent to the motors locked rotor or stall current and is 5 to 10 times normal full load current. When the generator supplies this in-rush of starting current, the generator voltage dips temporarily. If the motor is too large for the generator, the generator's voltage dips greater than 30 percent. This may result in the motor starter de-energizing or the motor stalling. MagnaPlus® generators generally supply .3 to .4 horsepower per generator KW in motor starting capability. For specific data contact Marathon Electric.

PARALLEL OPERATION

All MagnaPlus® generators are built with 2/3 pitch main stator windings and full amortisseur (damper) windings. These features make the MagnaPlus® generators suitable for parallel operation when equipped with the proper voltage regulators and voltage regulator accessories. Consult with the factory for further information relative to parallel operations.

NONLINEAR LOADING

Solid state electronic control devices (variable frequency drives, precision motor controls, battery chargers, etc.) utilize electronic switching circuits (thyristors, SCRs, Diodes, etc.). These switching circuits introduce high frequency harmonics which distort the normal wave form of the generator. This creates additional heat in the generator windings and may cause the generator to over-heat. Problems which can occur are not limited to the generator. Poor wave shape may adversely effect various loads connected to the generator. Consult Marathon Electric for further information relative to nonlinear loads.

INSTALLATION

PREPARATION FOR USE

Although the generator has been carefully inspected and tested in operation prior to shipment from the factory, it is recommended that the generator be thoroughly inspected. Check all bolts for tightness and examine the insulation on lead wires for chafing prior to proceeding with installation. Remove all shipping tapes, bags, skids and rotor support blocking. For two bearing units, rotate the shaft by hand to ensure that it rotates smoothly without binding.

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⚠WARNING

DISABLE AND LOCKOUT ANY ENGINE CRANKING DEVICES BEFORE ATTEMPTING TO INSTALL OR SERVICE THE GENERATOR. FOR ELECTRIC START SETS, DISCONNECT THE CRANKING BATTERY. FOR AIR START, DISCONNECT THE AIR SUPPLY. FOR MOTOR GENERATOR SETS, OPEN THE POWER SUPPLY TO THE DRIVE MOTOR. FAILURE TO COMPLY WITH THESE SAFETY PROCEDURES COULD RESULT IN SEVERE PERSONAL INJURY OR EQUIPMENT DAMAGE.

NEVER "BAR OVER" THE ENGINE GENERATOR SET USING THE GENERATOR'S FAN. THE FAN IS NOT DESIGNED FOR THIS PURPOSE. BARRING OVER THE SET WITH THE FAN COULD DAMAGE THE FAN AND RESULT IN PERSONAL INJURY OR EQUIPMENT DAMAGE.

GENERATOR MOUNTING

Single Bearing Units.

Single bearing units are provided with an SAE flywheel housing adapter flange and flexible drive discs. Coupling the generator's shaft to the engine flywheel is accomplished with special steel drive discs bolted to the shaft. In addition to the drive discs, there may be a hub spacer, spacer discs, or a combination of hub spacer and spacer discs inserted between the drive discs and the shaft to achieve the proper shaft extension ("G" dimension per SAE J620c). Holes are provided in the periphery of the coupling discs which correspond to tapped holes in the prime mover's flywheel. The outside diameter of the drive discs fit in a rabbet in the flywheel so that concentricity is assured.

Grade 8 place bolts and hardened washers are recommended to mount the drive discs to the flywheel. DO NOT USE SPLIT TYPE LOCK WASHERS. Split lock washers when biting into the drive disc cause stress risers which may result in the disc fracturing.

The SAE flywheel housing adapter ring and the engine flywheel housing are designed to match each other with no further alignment necessary. Use grade 5 or greater mounting bolts. MagnaPLUS® generator frames are constructed with two or three bolt holes per foot. The feet should be shimmed where necessary to obtain solid contract with the sub-base. With the frame securely bolted to the engine flywheel housing, there is no side thrust or pull on the generator frame, thus no real need to secure the feet with more than one bolt per foot.

GENERATOR MOUNTING

Two Bearing Generators -- Direct Drive

Two bearing generators are provided with a keyed shaft extension. For direct drive generators, the assembler furnishes a flexible coupling which is installed between the driver and the generator's shaft. Aligning the generator and its driver as accurately as possible will reduce vibration, increase bearing life, and ensure minimum coupling wear. It may be necessary to shim the generator feet for proper support and alignment. Secure the feet of the generator with grade 5 or greater bolts through the holes provided in the mounting feet. Consult the coupling manufacturer's instructions for alignment specifications and procedures.

GENERATOR MOUNTING

Two Bearing Units -- Belt Driven

Two bearing MagnaPLUS® generators can be belt driven provided belts are sized and applied correctly. Please refer to your supplier of belts and sheaves for correct sizing and tensioning specifications. A bearing life calculation should be performed. Marathon Electric recommends a minimum B-10 life of 40,000 hours. If cog type belts are used, a vibration may be introduced which could lead to premature failure of the bearings.

HYDRAULIC DRIVE WITH SHAFT SPLINE

Two Bearing Units

All 280 PDL MagnaPLUS® two bearing hydraulic drive generators are equipped with a Zerk grease fitting mounted in the drive end of the shaft. Prior to assembly to the hydraulic drive motor, lightly coat the hydraulic drive motor shaft, and/or grease the generator spline per the greasing instructions in the MAINTENANCE section, page 12. **DO NOT assemble the generator to the hydraulic drive motor with the spline dry.**

END PLAY TESTING

Refer to the engine manual for recommended end play specifications and measurement procedures. If end play is not to specification, it is an indication that the generator shaft is not moving freely in the assembly, and normal life of the thrust bearing could be impaired. Probable causes of this problem are:

1. Improper seating of drive discs in the flywheel resulting in misalignment.

2. Improper mating of generator frame to engine flywheel housing resulting in misalignment.

3. Improper "G" dimension per SAE J620c on either the engine or generator.

TORSIONAL VIBRATION

Torsional vibrations are generated in all rotating shaft systems. In some cases, the amplitude of these vibrations at critical speeds may cause damage to either the generator, its driver, or both. It is therefore necessary to examine the torsional vibration effect on the entire rotating system. IT IS THE RESPONSIBILITY OF THE GENERATOR SET ASSEMBLER TO ASSURE THE TORSIONAL COMPATIBILITY OF THE GENERATOR AND ITS DRIVER. Drawings showing pertinent dimensions and weights of the rotating assembly will be supplied by Marathon Electric upon request.

ENVIRONMENTAL CONSIDERATIONS

The MagnaPLUS® generator is designed for heavy duty industrial applications; however, dirt, moisture, heat and vibration are enemies of rotating electrical machinery. Excessive exposure to the elements may shorten generator life. The temperature of the cooling air entering the intake openings of the generator should not exceed the ambient temperature shown on the generator's nameplate. Generators intended for outdoor application should be protected with housings having adequate ventilation. Although the standard insulation systems are moisture and humidity resistant, space heaters are recommended for extreme conditions. If the generator is to be installed in an area where blowing sand and dust are present, the enclosure should be fitted with filters. Filters reduce erosion on the generator's insulation by blocking high velocity abrasive particles generated by the flow of cooling air through the generator. Consult the factory for appropriate filters and generator deratings required.

WIRING CONNECTIONS

Wiring of the generator and accessories should be done in accordance with good electrical practices. Follow government, industry and association standards.

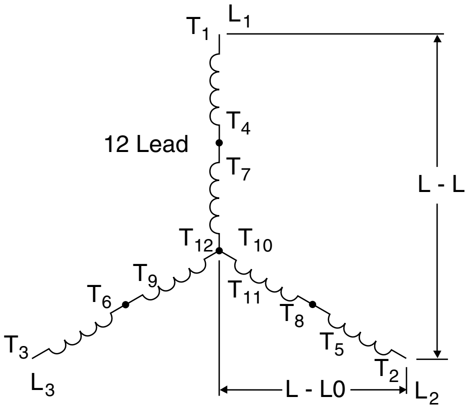
The generator conduit box construction allows cable entry from multiple sides. A hole saw or other appropriate tool may be used to provide for conduit entrance. Protect the interior of the generator from shavings when drilling or sawing. An approved connector must be used in conjunction with the conduit. To minimize the transmission of vibration, it is essential that flexible conduit be used for all electrical entrance to the generator conduit box.

All MagnaPLUS® generators are equipped with link boards (terminal strips) for both internal and external connections. All connections made to the studs of the link board should be made with high quality ring terminals. Ring terminal sizes are: 6 mm (280 Series Frames) and 10 mm (360 and 430 Series Frames). Torque link board connections to the following specifications: 280 frame -- 5.4 NM (4 Ft Lb); 360 & 430 frame -- 27 NM (20 Ft Lb).

Refer to the connection diagram supplied with the generator and / or the proper diagrams shown in this manual. Install all inter component and external wiring in accordance with national and local electrical codes. The neutral in the following connection diagrams shown below may be either grounded (earthed) or left above ground potential (floating). See national and local codes and / or the system distribution wiring schematic diagram for the proper connection of the neutral.

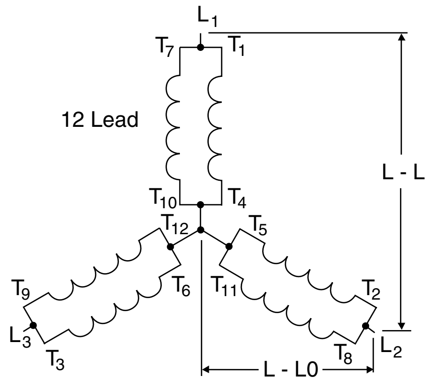
The following connection diagrams are shown for twelve lead generators. Ten lead generators have the same terminal designations except for leads T10, T11, and T12. These three leads are internally connected inside the generator and brought out as a single lead (T0). Ten lead generators can only be connected in a wye configuration.

HIGH (SERIES) WYE CONNECTION



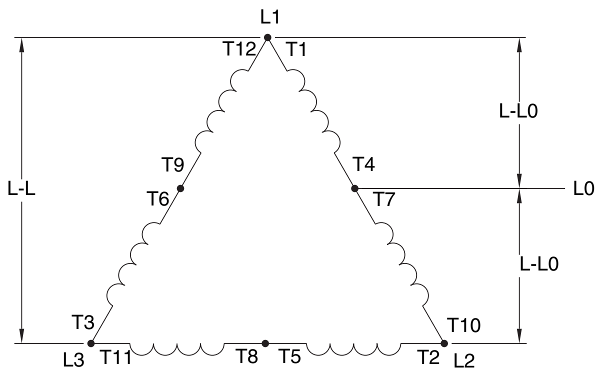
VOLTAGE (HIGH WYE)		
Hz	**L-L**	**L-Lo**
60	380	219
	416	240
	440	254
	460	266
	480	277
50	380	219
	400	231
	415	240
	440	254

LOW (PARALLEL) WYE CONNECTION



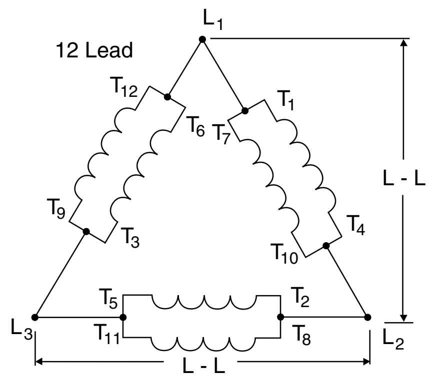
VOLTAGE (LOW WYE)		
Hz	**L-L**	**L-L0**
60	190	110
	208	120
	220	127
	230	133
	240	139
50	190	110
	200	115
	208	120
	220	127

HIGH (SERIES) DELTA CONNECTION



VOLTAGE (HIGH DELTA)		
Hz	**L-L**	**L-L0**
60	240	120
	277	139
50	200	100
	220	110
	240	120

LOW (PARALLEL) DELTA CONNECTION



VOLTAGE (LOW DELTA)	
Hz	**L-L**
60	110
	120
50	100
	110

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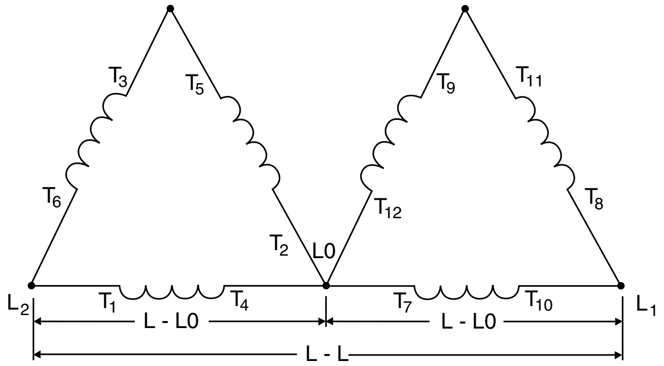
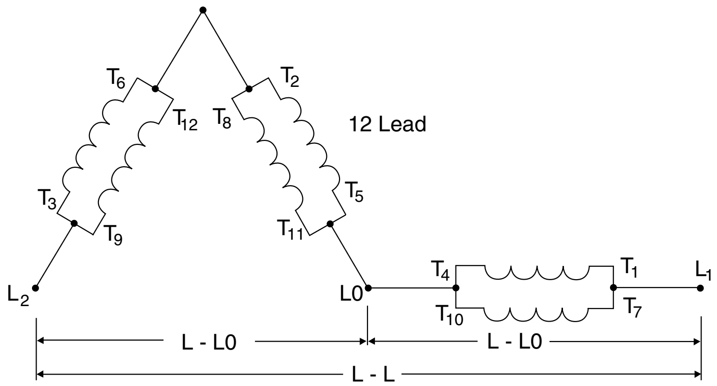
DOUBLE DELTA -- SINGLE PHASE CONNECTION



VOLTAGE (DOUBLE DELTA)		
Hz	L-L	L-LO
60	200	100
	220	110
	240	120
50	220	110

Note: Single phase KW/KVA ratings are approximately equal to 50% of the generator's three phase ratings.

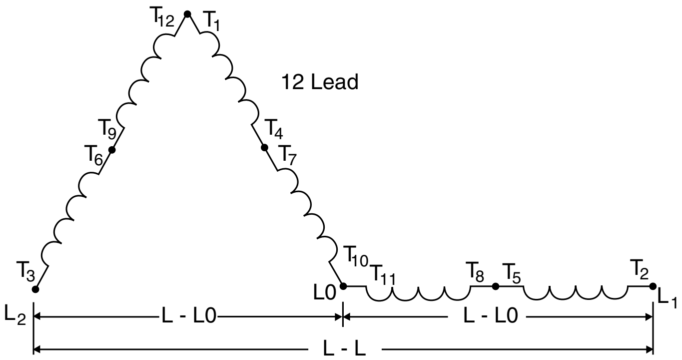
LOW ZIG ZAG -- SINGLE PHASE (PARALLEL) CONNECTION



VOLTAGE (LOW ZIGZAG)		
Hz	L-L	L-LO
60	200	100
	220	110
	240	120
50	220	110

Note: Single phase KW/KVA ratings are approximately equal to 50% of the generator's three phase ratings.

HIGH ZIG ZAG -- SINGLE PHASE (SERIES) CONNECTION



VOLTAGE (LOW ZIGZAG)		
Hz	L-L	L-L0
60	480	240

Note: Single phase KW/KVA ratings are approximately equal to 50% of the generator's three phase ratings.

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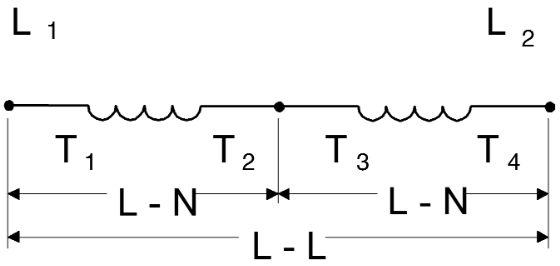
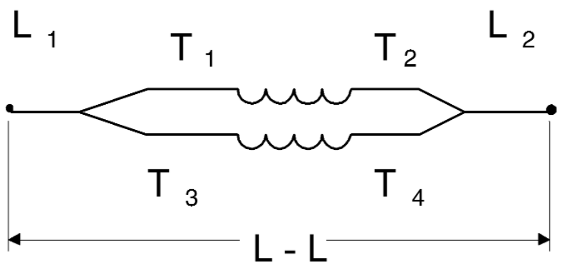
DEDICATED SINGLE PHASE CONNECTION
HIGH VOLTAGE - SERIES CONNECTED



VOLTAGE (DEDICATED)		
Hz	**L-L**	**L-N**
60	240	120
	220	110
50	220	110
	200	100

SINGLE PHASE CONNECTION - SINGLE VOLTAGE PARALLEL



VOLTAGE	
	L-L
60 HZ	120
50 HZ	110

Note: For 120 volt only service. Use an AVC63-4A or a VR63-4C voltage regulator to replace the standard SE350 regulator.

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OPERATION

PRE-START INSPECTION

Before starting the generator for the first time, the following inspection checks are recommended:

1. A visual inspection should be made for any loose parts, bad connections, or foreign materials.
2. Bar the set over by hand for at least 2 revolutions to be sure that there is no interference and that the set turns freely. If the set does not turn freely, check for clearance in the generator and exciter air gap.
3. Check all wiring against the proper connection diagrams, and ensure that all connections and terminations are tight and properly insulated.
4. Verify that all equipment is properly grounded (earthed).

> **⚠WARNING**
>
> **MAGNAPLUS® GENERATORS MAY HAVE VOLTAGE PRESENT AT THE LEAD TERMINALS WHEN THE SHAFT IS ROTATING. DO NOT PERMIT OPERATION OF THE GENERATOR UNTIL ALL LEADS HAVE BEEN CONNECTED AND INSULATED. FAILURE TO DO THIS MAY RESULT IN PERSONAL INJURY OR EQUIPMENT DAMAGE.**

5. Clear the surrounding area of any materials that could be drawn into the generator.
6. Check all fasteners for tightness.
7. Check all access plates, covers, screens and guards. If they have been removed for assembly or inspection, reinstall and check for security.
8. Review all prime mover prestart up instructions, and ensure that all recommended steps and procedures have been followed.
9. Remove any masking materials affixed during painting. Inspect the generator, prime mover, and any accessory equipment to ensure that nameplates, and all safety warning / caution signs and decals provided with the equipment are in place and clearly visible.

   Note: It is strongly recommended that the authority having jurisdiction over the installation site be consulted to determine if any additional warning or caution notices, or additional safety devices are required by local codes / standards. Any such required notices or devices should be installed prior to initial startup.

START-UP

The following procedure should be followed when starting the generator set for the first time.

1. The generator output must be disconnected from the load. Be sure that the main circuit breaker or fused disconnect is in the open position.
2. Open the input power to the automatic voltage regulator. Remove the fuse or disconnect and insulate one of the regulator input power leads. (See separate regulator manual)
3. Verify that all prime mover start-up procedures have been followed.
4. If the unit is provided with space heaters, ensure that they are de energized. In some installations, a set of auxiliary contacts on the main circuit breaker or transfer switch will automatically open the space heater circuit when the generator is connected to the load.
5. Start the prime mover, and adjust it for proper speed. See generator nameplate.
6. The purpose of this initial test with the regulator out of the circuit is to detect any wiring mistakes without exposing the unit to undue risk. Check all line to line and line to neutral voltages for balanced voltage. If voltages are balanced, shut down the set and reconnect the regulator. If voltages are unbalanced, shut down the equipment and check for improper wiring. If the problem persists, consult the factory.

   With the regulator de energized, the residual voltage should be 10 - 25% of rated value. It is recommended that this residual voltage and driver RPM be recorded for use as a future troubleshooting benchmark.

> **⚠WARNING**
>
> **THE FOLLOWING TEST MUST BE CONDUCTED BY QUALIFIED ELECTRICAL PERSONNEL. LETHAL VOLTAGE MAY BE PRESENT AT BOTH THE GENERATOR AND VOLTAGE REGULATOR TERMINALS DURING THIS PROCEDURE. CAUTION MUST BE EXERCISED NOT TO COME INTO PERSONAL CONTACT WITH LIVE TERMINALS, LINKS, OR STUDS. SERIOUS INJURY OR DEATH COULD RESULT.**

7. Start the set and adjust the terminal voltage to the desired value by means of the regulator voltage adjustment. If the regulator is equipped with a stability adjustment, follow the instructions in the regulator manual to adjust the stability. Again, check all line to line and line to neutral voltages for balance. It is

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recommended practice to record the no load excitation (DC voltage to the exciter stator), generator terminal voltage, and driver speed as a benchmark for future troubleshooting.

8. Close the main circuit breaker to the load.

9. Monitor the generator output current to verify that it is at or below nameplate value.

10. Check generator speed (frequency) under load. Adjust as necessary. (Refer to prime mover or governor manuals)

SHUTDOWN PROCEDURE

There are no specific instructions for shutting down the generator; however, several good practices should be observed to prolong equipment life.

1. It is advisable to disconnect all loads (open main circuit breaker or disconnect) prior to shutdown. This is especially important if loads can be damaged by low voltage or low frequency conditions during generator "coast down".

2. Isolate all conditions that could apply voltage to the generator terminals while the generator is at rest. Failure to comply could result in personnel injury or equipment damage.

3. If the unit is equipped with space heaters, verify that the heater circuit is energized.

MAINTENANCE

The following maintenance procedures should be followed to ensure long equipment life and satisfactory performance. Maintenance intervals will depend upon operating conditions.

1. Routinely check intake and exhaust air screens to ensure that they are clean and free of debris. Clogged intake air screens will reduce cooling air flow and result in higher operating temperatures. This will reduce generator life and may result in generator damage.

2. All MagnaPLUS® generators are equipped with double shielded ball bearings lubricated for the life of the bearing. Every 1,000 hours check the bearing(s) for smooth, quiet operation. For continuous duty generators, recommended practice is to replace the bearing during major overhauls of the engine.

3. Periodically inspect the unit for any buildup of contamination (dirt, oil, etc.) on the windings. If the wound components have become coated with heavy concentrations of oil and grime, the unit should be disassembled and thoroughly cleaned. This operation is not one that can be accomplished effectively on site, but rather one that should be conducted by an authorized service center equipped with the appropriate apparatus and solvents necessary to properly clean and dry the generator.

WARNING

THE FOLLOWING TEST MUST BE CONDUCTED BY QUALIFIED ELECTRICAL PERSONNEL. LETHAL VOLTAGE MAY BE PRESENT AT BOTH THE GENERATOR AND VOLTAGE REGULATOR TERMINALS DURING THIS PROCEDURE. CAUTION MUST BE EXERCISED NOT TO COME INTO PERSONAL CONTACT WITH LIVE TERMINALS, LINKS, OR STUDS. SERIOUS INJURY OR DEATH COULD RESULT.

4. Every 2,000 operating hours or in conjunction with scheduled engine maintenance, check the DC no load excitation voltage per item #7 in the startup procedure. Compare this voltage with the value recorded during initial startup. If this value of no load excitation voltage is markedly higher than the bench mark reading, it is an indication of problems in either the exciter, main field, or the rotating rectifier assembly. Ensure that RPM is the same as initial test.

5. Monitor and record insulation resistance with a 500 volt mega-ohm meter. The minimum acceptable reading is 2 mega-ohms. If the reading drops below the minimum, the generator should be cleaned and dried at an authorized service shop. Consult Marathon Electric for more information.

DRYING WINDINGS

Generators in service may inadvertently have their windings exposed to splashing or sprayed water. Units that have been in transit or storage for long periods of time may be subjected to extreme temperature and moisture changes causing excessive condensation. Regardless of the source of moisture, wet windings should be thoroughly dried out before operating the unit. If this precaution is not taken, serious damage to the generator can result. The following procedures may be utilized in drying the generator's windings. The method selected will be influenced by winding wetness and situation limitations.

Space Heaters

An electric heater may have been supplied with the generator. When energized from a power source other than the generator, the heater will gradually dry the generator. This process can be accelerated by enclosing the unit with a covering and inserting additional heating units. A hole should be left at the top of the covering to permit the escape of moisture. Care should be taken not to overheat various accessory equipment mounted with the generator.

Forced Air

Another method to dry the generator is to run the set with no excitation (see startup procedure item #2). The natural flow of ambient air through the generator will tend to dry the windings. This method can be accelerated by adding a source of heat at the air intake to the generator. Heat at point of entry should not exceed 80 C (180° F).

HYDRAULIC DRIVE GENERATORS, SHAFT SPLINE LUBRICATION

The shaft spline should be greased prior to initial assembly to the driver, and every three (3) months to reduce maintenance, and prolong the life of the spline coupling per the following procedure:

1. Material: Molybdenum Disulfide - sometimes referred to as “Molly Grease.”

2. Turn the rotor assembly so that the Zerk fitting is in line with the access hole in the top of the drive end bearing bracket as illustrated in Figure 3.

3. Using a hand held grease gun with a solid coupling, apply a small amount of grease into the fitting. DO NOT OVER GREASE. Limit the amount of grease to one (1) trigger pull of the grease gun.

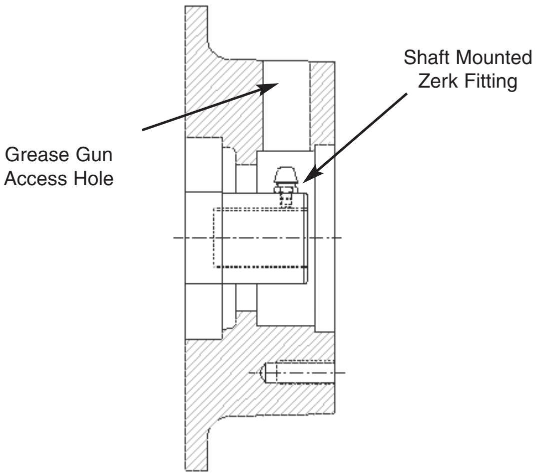


Figure 3--Drive End Bearing Bracket

TESTING

Visual Inspection

Remove covers and look for any obvious problems: burnt windings, loose connections, broken wires, frayed insulation, cracked brackets, missing hardware, etc. Check for foreign objects which may have been drawn into the generator. Verify that the generator’s air gaps (main rotor and exciter) are free from obstructions. If possible, rotate the generator manually to ensure free rotation. Never “bar over” the engine generator set using the generator fan.

⚠WARNING

THE FOLLOWING TEST MUST BE CONDUCTED BY QUALIFIED ELECTRICAL PERSONNEL. LETHAL VOLTAGE MAY BE PRESENT AT BOTH THE GENERATOR AND VOLTAGE REGULATOR TERMINALS DURING THIS PROCEDURE. CAUTION MUST BE EXERCISED NOT TO COME INTO PERSONAL CONTACT WITH LIVE TERMINALS, LINKS, OR STUDS. SERIOUS INJURY OR DEATH COULD RESULT.

CONSTANT EXCITATION TEST (12V BATTERY TEST)

The generator “no load” voltage is dependent on exciter input voltage and generator speed. With the generator operating at rated speed and 12 volts dc applied to the exciter field, the generators terminal voltage will be near rated value.

1. Shutdown the generator set and connect a voltmeter on the generator terminals.

2. Disconnect the regulator’s F+ (F1) and F- (F2) leads and connect them to a 12V battery. Caution should be taken to ensure that the battery is not exposed to any potential arcing.

3. With no load on the generator (main breaker open) run the generator at rated speed. Measure the generator’s terminal voltage and compare this value with values recorded during installation.

If voltage readings are normal, the main generator and excitation are operating properly. Troubleshooting should continue with the regulator. If readings are not normal the problem is in the generator. Continue testing diodes, surge suppressor, and windings.

Continuity / Resistance Test

The generator has four components which can be checked using an ohm meter: exciter stator, exciter rotor, main stator and main rotor. Each of these components are comprised of various windings which form a complete electrical path of relatively low resistance. Using an ohm meter measure the loop resistance of each component. Compare these measured values with the values listed in the specification section of this manual. Note that very small resistance values require precision equipment to make accurate measurements; however, a standard ohm meter will provide a good indication of winding continuity.

Insulation Test

Insulation resistance is a measure of the integrity of the insulating materials that separate the electrical windings from the generator’s steel core. This resistance can degrade over time or be degraded by contaminants: dust, dirt, oil, grease, and especially moisture. Most winding failures are due to a breakdown in the insulation system. In many cases, low insulation resistance is caused by moisture collected when the generator is shutdown

Insulation resistance is measured with a megger (mega-ohm meter). A megger measures insulation resistance by placing 500 volts between the winding and the frame of the generator. Caution must be taken to remove all electronic devices (regulators, diodes, surge protectors, capacitors, protective relays, etc.) from the winding circuit before checking the insulation. Winding insulation can be checked on the main stator, main rotor, exciter stator, and exciter rotor. Minimum resistance is 2 mega-ohms. If the winding resistance is low it must be dried (see maintenance section) or repaired.

DIODE TESTING

If the generator is close coupled to an engine, it may be necessary to "bar over" the engine in order to gain access to a given area of the rectifier assembly. NEVER use the generator's fan as a fulcrum to accomplish this. Use the engine manufacturer's recommended practice to manually turn over the engine. To prevent possible injury to personnel, and damage to the equipment, ensure that the engine cannot start during this procedure.

Remove the two main rotor leads and the three exciter rotor leads from the rectifier assembly (Figure 5). The rectifier assembly is now electrically isolated from the generator. The diodes remain mounted and the diode leads remain connected to the terminal posts. Using an ohmmeter or a battery light continuity tester, place one test probe on the diode lead terminal post. In succession, touch the other test probe to the lead screw hole in each heat sink. Reverse the probes and repeat the procedure. You have now tested the three diodes connected to this terminal post in both the forward and reverse direction. Repeat the procedure using the other diode terminal post.

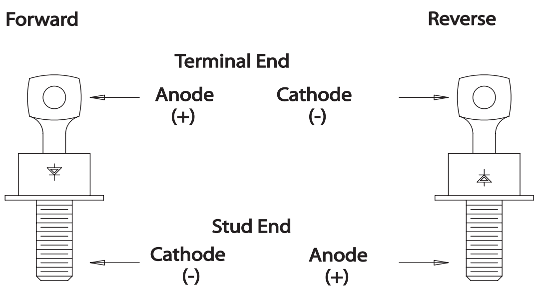


FIGURE 4: DIODE POLARITY

When the positive test probe is connected to the diode's anode and the negative test probe is connected to the diode's cathode (forward biased), the diode will switch on and conduct electricity (Figure 4). This is observed by a low resistance reading when using an ohm meter or the lighting of the bulb when using a battery light continuity tester. Reversing the test leads (reverse biased) will result in the diode switching off and no electricity will be conducted. The results of these tests should indicate one of three conditions:

1. **Good diode:** Will have a much greater resistance in one direction than the other. Typical reverse biased resistance will be 30,000 ohms or greater, while forward biased resistance will be less than 10 ohms. The battery light tester will have the light "on" in one direction and "off" in the other.

2. **Shorted condition:** Ohmmeter reading will be zero, or very low in both directions. The continuity tester will have the light "on" in both directions.

3. **Open condition:** Ohmmeter will have a maximum (infinity) reading in both directions. Continuity tester light will be off in both directions.

Diode failure after a 25 hour "run in" period is generally traceable to external causes such as a lightning strike, reverse current, line voltage spikes, etc. All 6 diodes are essentially in the same circuit. When a diode is stressed to failure, there is no easy method to determine remaining life in the other diodes. To avoid possible continued failures, it is recommended that the entire rectifier assembly be replaced rather than replacing individual diodes.

SERVICE

GENERAL

The service procedures given in this section are those which can reasonably be conducted on-site with a minimum number of special tools and equipment. All service procedures should be conducted by qualified maintenance personnel. Replacement parts may be ordered through an authorized service center or directly from the factory.

FIELD FLASHING

Restoring Residual Magnetism
(not applicable on PMG equipped generators)

To restore residual magnetism to the generator, connect a 12 volt battery to the exciter field while the generator using the following procedure:

1. Shutdown the generator set. Remove the exciter field leads F+ and F from the regulator.

⚠CAUTION

Failure to remove the exciter field leads from the automatic voltage regulator during flashing procedures may destroy the regulator.

2. Connect the F+ and F- leads to the battery's corresponding positive and negative terminals. This should be done using an appropriate length of lead wire to separate the battery from the point of connection (batteries may explode when exposed to an electric arc). After 3 to 5 seconds, remove the F- lead. An inductive arc should result. If no arc is drawn, repeat the procedure.

3. Reconnect the F+ and F- leads to the regulator. Restart the generator and verify that terminal voltage is developed. If terminal voltage does not develop, repeat the field flashing procedure and / or consult the trouble shooting section.

BEARING REMOVAL

Prior to performing this operation, it is suggested that the alternator's shaft be rotated until two of the main rotor poles are in a vertical position. Once the bearing bracket is backed out, the rotor will drop on the main stator core. Having the rotor in this position will limit the amount of rotor drop to that of the air gap. Visually inspect the bearing bore for damage or wear. If worn or damaged, replace prior to reassemble.

Opposite Drive End Bearing Bracket Removal.
Prior to proceeding with bracket removal, disconnect exciter field leads F+ and F- from the automatic voltage regulator and ensure that they are free to move when the bearing bracket is removed. Remove the bearing bracket retaining bolts. Using a pair of screw drivers, wedge the bracket off the frame. After approximately 1/8 inch, the bracket will clear the locating register on the frame and will drop until the rotor is resting on the main stator core. Continue to pull the bracket free from the bearing. Visually inspect the bearing bore and o-ring (if equipped) for damage or wear. If worn or damaged, repair or replace prior to reassembly.

Drive End Bearing Bracket Removal,
Two Bearing Units.
Remove any drive arrangement from the generator shaft extension. Remove the bearing lock ring retaining screws. There is no o-ring in the drive end bearing bracket. The shaft extension must be supported before proceeding further. A hoist and sling, jack, or some other means of support with a capacity of 2 tons should be used.

Remove the bearing bracket retaining cap screws. Using a flat bladed screw driver or chisel, pry the bracket back from the frame. After approximately 1/8 inch, the bracket will clear the locating register on the frame. Lower the shaft extension until the rotor is resting on the main stator core. Continue to pull the bracket free from the bearing. Visually inspect the bearing bore for damage or wear. If worn or damaged, sleeve or replace prior to reassembly.

Reassembly note: Before the bearing bracket is seated against the frame, a threaded rod may be used to help align the inner bearing cap with the bearing bracket.

BEARING REPLACEMENT

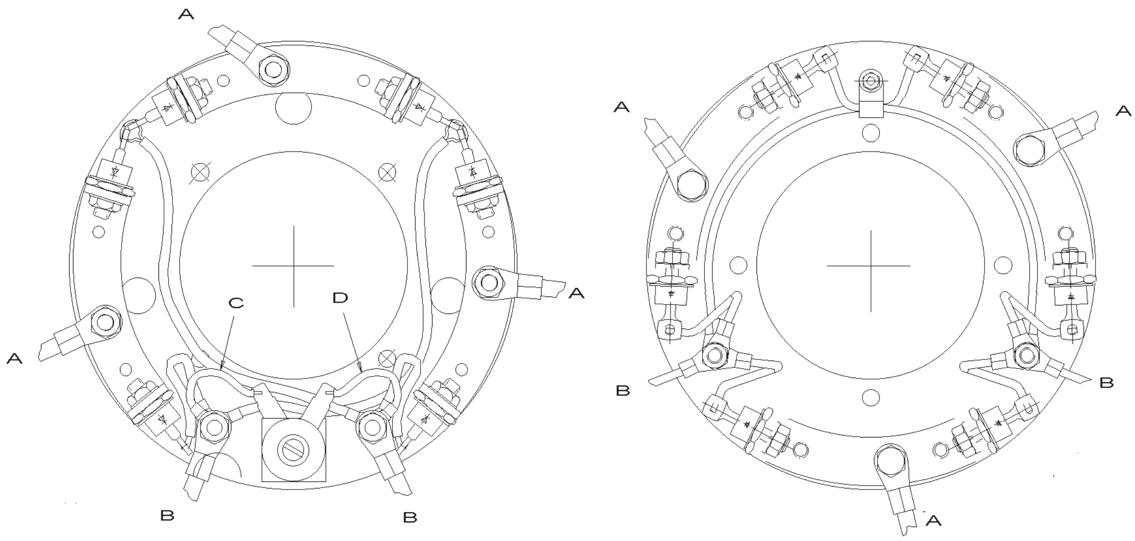
Using a bearing puller, remove the existing bearing. It is strongly recommended that the bearing be replaced any time the it is removed from the shaft. **ALWAYS** install the same type and size bearing that was supplied as original equipment. Order by part number from the parts list, and include the unit serial number and part number when ordering. Heat the bearing to a maximum of 100°C (212°F) in an oven. Apply a thin coat of clean lubricating oil to the press fit area of the rotor shaft. Using suitable heat resistant gloves, install the bearing over the end of the shaft until it seats against the shaft shoulder. The bearing should slide on the shaft and be seated without excessive force. Should the bearing bind on the shaft prior to being seated against the shoulder, a piece of tubing slightly larger than the press fit area can be used to drive the bearing to its final position. Using light taps with a soft mallet, apply pressure to the inner race only.

RECTIFIER ASSEMBLY REMOVAL

The rectifier assembly cannot be removed until the opposite drive end bearing bracket and bearing have been removed (see bearing removal procedure). Remove the three exciter rotor leads from the heat sinks and the two main rotor leads from the main rotor posts (see Figures 5). Remove the screws securing the rectifier assembly and pull the assembly free from the shaft.

DIODE REPLACEMENT

Prior to installing a replacement diode on the heat sink, apply a thin film of conductive heat sink compound around the base of the diode (do not coat the threads). When installing a diode on the heat sink, care should be taken not to over torque the retaining nut which could cause damage to the device. Torque to 28 pound inches. If not damaged, the existing diode lead wire may be unsoldered from the failed diode, and resoldered on the replacement.



430 FRAME 280 / 360 FRAME
A - Exciter Rotor Lead, B - Main Rotor Lead, C - Red (+) Suppressor Lead, D - Black (-) Suppressor Lead

FIGURE 5: ROTATING RECTIFIER ASSEMBLY

RETURNED GOODS

Contact Marathon Electric Manufacturing Corporation for authorization before returning any product. We can not be responsible for any items returned without authorization.

⚠CAUTION

Single bearing generators must have their rotor assembly properly secured to prevent damage during transit to the factory, or to an authorized service center.

TROUBLESHOOTING

This section is intended to suggest a systematic approach to locating and correcting generator malfunctions. The section is arranged according to the symptoms of the problem. The steps have been arranged in an attempt to do the easy checks first and prevent further damage when troubleshooting a disabled machine.

The first step of troubleshooting is to gather as much information as is possible from operating personnel and individuals present during the failure. Typical information includes: how long the unit had been operating; what loads were on line; weather conditions; protective equipment that did or did not function. In addition, information as to the operating condition of the generator's prime mover is vital. Has the prime mover been maintaining constant speed? If not, have there been extended periods of under speed operation? Has the prime mover experienced an over-speed condition? If yes, what was the maximum speed, and how long did the unit operate at that elevated speed?

The generator speed should be maintained at rated nameplate value during all operating tests. The frequency of the generator depends upon rotational speed. Most regulators used with MagnaPLUS® generators have built in under frequency protection such that if the speed is reduced more than 5%, the voltage will drop off rather rapidly with further reductions in speed.

⚠WARNING

HIGH VOLTAGES MAY BE PRESENT AT THE GENERATOR'S TERMINALS WHEN THE UNIT IS RUNNING. SOME ACCESSORY EQUIPMENT SUCH AS SPACE HEATERS MAY BE ENERGIZED FROM AN OUTSIDE POWER SOURCE WHEN THE UNIT IS AT REST. TOOLS, EQUIPMENT, CLOTHING AND YOUR BODY MUST BE KEPT CLEAR OF ROTATING PARTS AND ELECTRICAL CONNECTIONS. SPECIAL PRECAUTIONS MUST BE TAKEN DURING TROUBLESHOOTING SINCE PROTECTIVE COVERS AND SAFETY DEVICES MAY BE REMOVED OR DISABLED TO GAIN ACCESS AND PERFORM TESTS. BE CAREFUL. SERIOUS PERSONAL INJURY OR DEATH CAN RESULT FROM THESE HAZARDS. CONSULT QUALIFIED PERSONNEL WITH ANY QUESTIONS.

GENERATOR PRODUCES NO VOLTAGE

CAUSE	CHECK AND REMEDY
Voltmeter off or defective	Check voltage with a separate meter at the generator terminals.
Incorrect or defective connections	Verify generator connections. See drawings supplied with the generator or lead connection diagrams in this manual. Inspect all wiring for loose connections, open circuits, grounds, and short circuits.
Loss of residual	Flash the field. Refer to field flashing in the service section. If the generator is equipped with a PMG, field flashing is not necessary -- check regulator fuse and input power from the PMG.
Defective diodes, suppressor, or windings	Test the generator using the 12 volt battery test as specified in the testing section. If the results indicate generator problems, perform insulation, continuity, and diode tests as specified in the testing section.
Regulator protection operating	Adjust regulator. Consult regulator manual.
Regulator inoperative	Adjust or replace regulator. Consult regulator manual.

GENERATOR PRODUCES LOW VOLTAGE, NO LOAD

CAUSE	CHECK AND REMEDY
Underspeed operation	Check speed using a tachometer or frequency meter.
Voltmeter off or defective	Check voltage with a separate meter at the generator terminals.
Incorrect or defective connections	Verify generator connections. See drawings supplied with the generator or lead connection diagrams in this manual. Inspect all wiring for grounds, open circuits and short circuits.
Loss of regulator power	Check regulator fuse and input power. Input power is produced by the generator's residual voltage or from an optional PMG.
Regulator adjustment	Adjust regulator settings. Consult regulator manual.
Regulator incorrectly connected	Review the generator connection diagram or reference the regulator manual.
Defective diodes, suppressor, or windings	Test the generator using the 12 volt battery test as specified in the testing section. If the results indicate generator problems, perform insulation, continuity, and diode tests as specified in the testing section.
Regulator inoperative	Adjust or replace regulator. Consult regulator manual.

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GENERATOR PRODUCES LOW VOLTAGE WHEN LOAD APPLIED

CAUSE	CHECK AND REMEDY
Excessive load	Reduce load. The load on each leg should be evenly balanced, and rated current should not be exceeded on any leg.
Large motor starting or low load power factor	Motor starting currents are too large for the generator. When starting multiple motors, sequence the motors and start the largest motors first. Reduce lagging power factor load.
Driver speed droop or belt slip	Check driver. If belt driven, check belt tension. Check under frequency setting on regulator. Under frequency voltage roll-off may be activated.
Reactive droop	If the generator is equipped for parallel operation, some droop is normal as reactive load increases. When operating as a single unit, the parallel CT can be shorted to eliminate this effect. Refer to Regulator manual.
Line drop	If voltage is proper at generator terminals but low at load terminals, increase external wire size.
Defective diodes, suppressor, or windings	Test the generator using the 12 volt battery test as specified in the testing section. If the results indicate generator problems, perform insulation, continuity, and diode tests as specified in the testing section.

GENERATOR PRODUCES FLUCTUATING VOLTAGE

CAUSE	CHECK AND REMEDY
Fluctuating engine speed	Check engine and governor systems for malfunctions. Check load for fluctuation.
Regulator stability	Adjust Regulator stability. Refer to Regulator manual.
Regulator external rheostat	Replace defective or worn rheostat. Use shielded cable to minimize electrical noise.
Defective rectifier assembly	Check assembly for loose connections. Test the diodes as specified in the test section.
Loose terminal or load connections	Improve connections both mechanically and electrically.
Defective regulator	Replace regulator.

GENERATOR PRODUCES HIGH VOLTAGE

CAUSE	CHECK AND REMEDY
Faulty metering	Check voltage with separate meter at generator terminals.
Incorrect connections	Verify generator connections. Refer to drawings supplied with the generator or connection diagrams in this manual.
Regulator adjustments	Adjust regulator. Consult regulator manual.
Leading power factor	Check the power factor of the load. If power factor is leading, change load configuration. Excessive leading power factor (capacitors) can cause voltage to climb out of control.
Incorrect regulator connection	Verify regulator voltage sensing is connected correctly. Consult regulator manual.
Defective regulator	Replace regulator.

GENERATOR BUILDS VOLTAGE FROM STARTUP, THEN GOES TO LOW (RESIDUAL) VOLTAGE

CAUSE	CHECK AND REMEDY
Regulator protective circuit operating	Check indicators on regulator. Correct problems and adjust regulator as is required. Refer to regulator manual.

GENERATOR IS OVERHEATING

CAUSE	CHECK AND REMEDY
Generator is overloaded	Reduce load. Check with ammeter and compare with nameplate rating.
Clogged ventilating screens	Clean air passages.
High room temperature or altitude	Improve ventilation or reduce load.
Insufficient circulation of cooling air	Generator location and enclosure design must provide adequate air flow and minimize recirculation of hot air.
Unbalanced load	The load on each leg should be as evenly balanced as possible and should not exceed rated current on any one leg.

GENERATOR PRODUCES MECHANICAL NOISE

CAUSE	CHECK AND REMEDY
Defective bearing	Replace bearing.
Loose or misaligned coupling	Tighten, realign, or replace coupling.
Belt slap or loose guards	Check belt tensioning. Check belt guard fasteners.

EQUIPMENT RUNS NORMALLY ON UTILITY POWER, BUT WILL NOT RUN ON GENERATOR SET

CAUSE	CHECK AND REMEDY
Distorted voltage waveform	Analyze load. Excessive SCR (thyristor) loading will cause distortion. Some equipment may be sensitive to distorted waveforms. Refer to Marathon Electric..
Improper generator voltage or frequency	Check name plates of devices comprising the load. Compare required voltage and frequency with that of the generator. Adjust driver speed and/or generator voltage as necessary to match generator output to load requirements.

CAUTION

Compare required voltage, frequency, and KVA with generator nameplate to ensure adequate generator capacity. If in doubt, consult Marathon Electric for information regarding generator capacity.

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SPECIFICATIONS

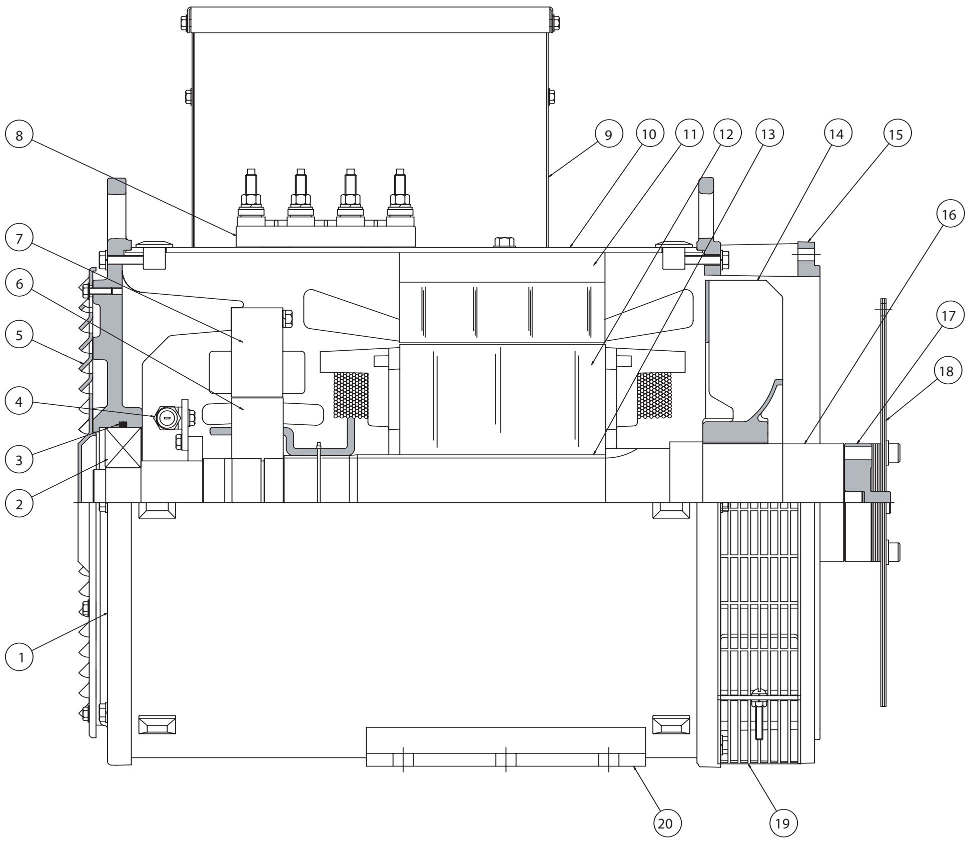
MODEL / FRAME SIZE	EXCITER RESISTANCE STATOR	ROTOR
281, 282, 283, 284, 285, 286, 287	18.0	.120
361, 362, 363 -- three phase	23.5	.120
361, 362, 363 -- dedicated single phase	23.0	.135
431, 432, 433 -- three phase	18.5	.120
431, 432 -- dedicated single phase	18.0	.105

MODEL	GENERATOR RESISTANCE STATOR*	ROTOR	EXCITER FIELD NO LOAD VOLTS 480 V / 60 HZ
281PSL1500	4.20	.400	11.0
281PSL1501	4.15	.400	11.0
281CSL1502	0.47	0.72	6.40
281PSL1502	3.20	.439	9.0
282PSL1703	1.07	0.34	14.70
282CSL1504	1.24	0.80	6.20
282PSL1704	1.07	0.34	14.70
282CSL1505	0.87	0.90	5.80
282PSL1705	0.74	0.37	14.35
283CSL1506	0.54	1.00	8.20
283PSL1706	0.45	0.40	12.95
283CSL1507	0.44	1.18	9.20
283PSL1707	0.39	0.46	11.20
284CSL1508	0.29	1.36	10.00
284PSL1708	0.27	0.52	14.18
284CSL1542	0.27	1.36	8.30
284PSL1742	0.22	0.54	14.00
285PSL1700	0.20	0.58	11.90
286PSL1701	0.14	0.72	10.68
287PSL1702	0.12	0.79	10.9
361CSL1600	.381	.750	11.8
361CSL1601	.264	.810	12.5
361CSL1602	.181	.990	14.1
362CSL1604	.138	1.05	12.2
362CSL1606	.098	1.20	10.8
363CSL1607	.069	1.37	12.2
431CSL6202	.021	.811	15.1
431CSL6204	.048	.637	13.6
431CSL6206	.037	.679	13.82
431CSL6208	.013	.715	12.20
432PSL6210	.021	.811	15.1
432PSL6212	.023	.866	14.1
433PSL6216	.012	1.067	16.2
433PSL6220	.012	.974	15.6

* Stator resistance measured line to line in a high wye connection.

DEDICATED SINGLE PHASE	GENERATOR RESISTANCE STATOR	ROTOR	EXCITER FIELD NO LOAD VOLTS 480 V / 60 HZ
281PSL1500	4.20	.400	11.0
281CSL1513	0.47	0.72	4.3
281PSL1511	1.420	.381	8.3
281PSL1512	1.106	.395	8.1
281PSL1513	.632	.430	8.7
282CSL1515	0.21	0.82	6.2
282PSL1714	0.19	0.35	13.0
282PSL1715	0.19	0.35	13.0
282PSL1716	0.11	0.36	12.4
283CSL1517	0.08	1.14	12.7
283PSL1717	0.5	0.41	11.8
283PSL1718	0.07	0.46	10.1
284CSL1518	0.06	1.41	12.5
284CSL1550	0.05	1.48	16
284PSL1750	0.05	0.55	11.1
285PSL1711	0.04	0.58	11.0
286PSL1712	0.03	0.71	9.7
287PSL1713	0.02	0.78	12.3
361PSL1611	.070	.750	17.5
361PSL1612	.043	.857	16.1
361CSL1613	.037	.926	13.6
362CSL1615	.019	1.20	17.0
363CSL1617	.012	1.35	23.0
431PSL6222	.025	.516	9.9
431PSL6224	.013	.615	13.8
431PSL6226	.009	.643	15.1
432PSL6228	.007	.852	11.2

PARTS LIST – SINGLE BEARING
Typical Generator Cross Section



Reference Number	Part Name	Reference Number	Part Name
1	End Bracket (under end cover 360 & 430 frames)	11	Main Stator
2	Bearing	12	Main Rotor
3	O-ring (280 and 360 frame only)	13	Rotor Integral Keyway
4	Rectifier Assembly	14	Fan
5	Air Intake Cover	15	Mounting Adapter (SAE)
6	Exciter Rotor	16	Shaft
7	Exciter Stator	17	Drive Hub
8	Link Board (terminal block)	18	Drive Disk (SAE)
9	Conduit Box	19	Exhaust Screen (drip cover not shown)
10	Generator Frame	20	Mounting Base

Note: Illustration above is a 360 frame MagnaPLUS®. Other Frame sizes are typical. Optional PMG not shown. The generator model and serial numbers are required when ordering parts.

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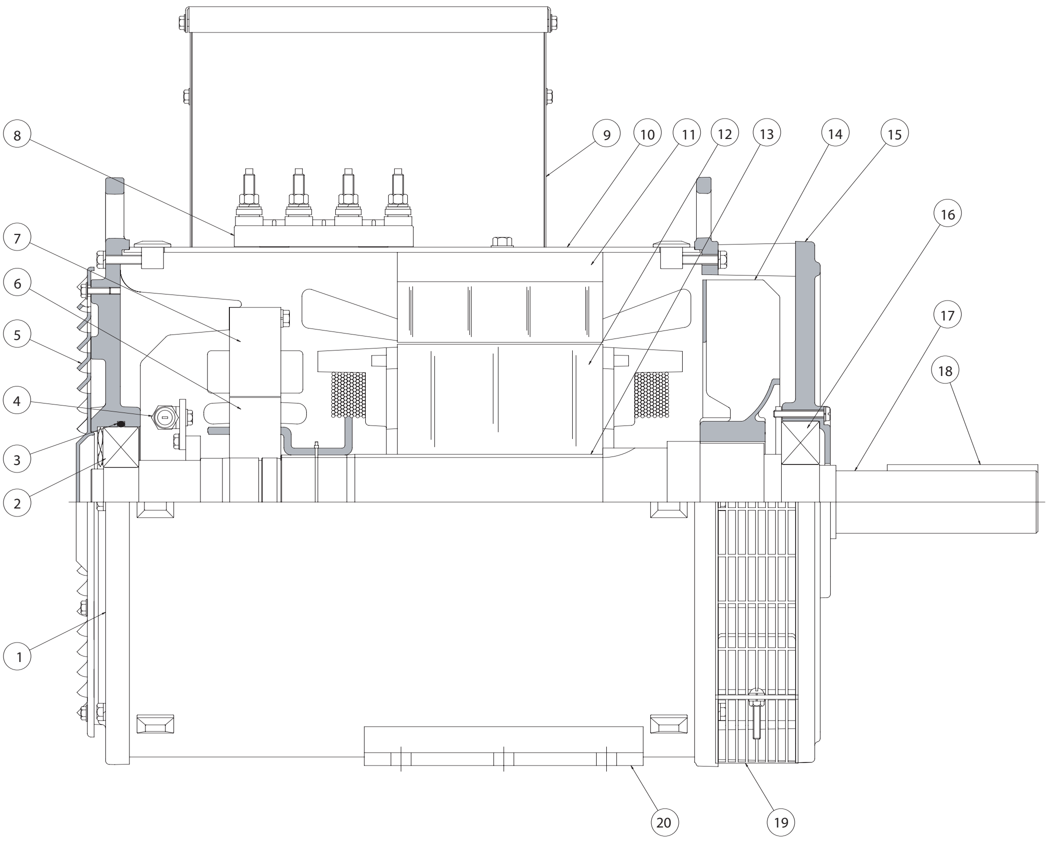
PARTS LIST – DUAL BEARING
Typical Generator Cross Section



Reference Number	Part Name	Reference Number	Part Name
1	End Bracket (under end cover 360 & 430 frames)	11	Main Stator
2	Bearing (nondrive end)	12	Main Rotor
3	O-ring (280 and 360 frame only)	13	Rotor Integral Keyway
4	Rectifier Assembly	14	Fan
5	Air Intake Cover	15	End Bracket (drive end)
6	Exciter Rotor	16	Bearing (drive end)
7	Exciter Stator	17	Shaft
8	Link Board (terminal block)	18	Key
9	Conduit Box	19	Exhaust Screen (drip cover not shown)
10	Generator Frame	20	Mounting Base

Note: Illustration above is a 360 frame MagnaPLUS®. Other Frame sizes are typical. Optional PMG not shown. The generator model and serial numbers are required when ordering parts.

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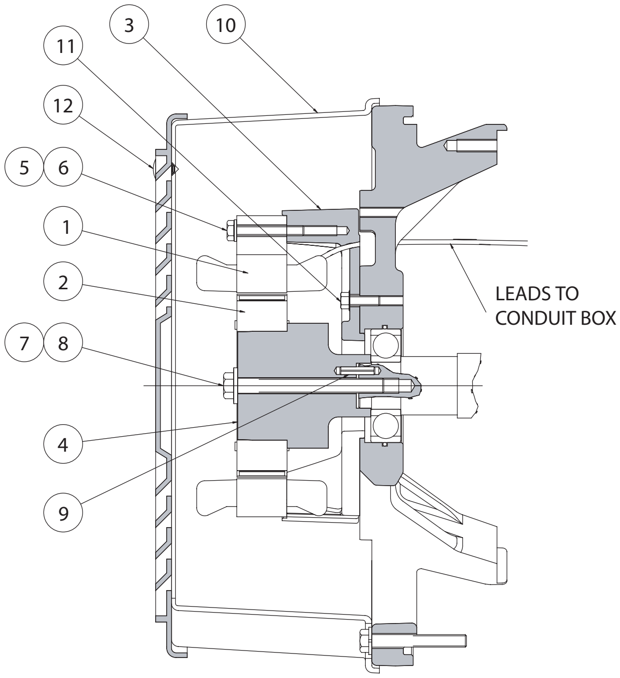
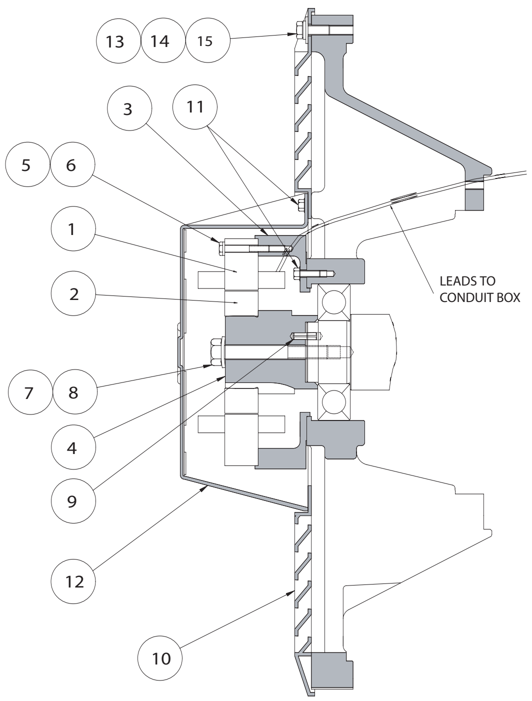
PARTS LIST – PMG GENERATORS



Typical 280 and 360 Frame Add-On PMG

Item	Description	Qty
1	PMG Stator Assembly	1
2	PMG Rotor Assembly	1
3	Stator Adaptor	1
4	Shaft, PMG rotor	1
5	Screw, Hex Hd Flg Lock 1/4 - 20	4
6	Washer, Belleville - 1/4	4
7	Hex Hd Cap Screw, 1/2 - 13 x 4"	1
8	Washer, Belleville - 1/2	4
9	Roll Pin 0.25 x .88	1
10	Drip Cover - PMG Add-on	1
11	Screw, Hex Hd Flg Lock 1/4-20	4
12	Pushpin	4



Typical 430 Frame Add-On PMG

Item	Description	Qty
1	PMG Stator Assembly	1
2	PMG Rotor Assembly	1
3	Stator Adaptor	1
4	Shaft, PMG rotor	1
5	Screw, Hex Hd Flg Lock 1/4 - 20	4
6	Washer, Belleville, 1/4	4
7	Hex Hd Cap Screw, 1/2 - 13 x 4"	1
8	Washer, Belleville, 1/2	1
9	Roll Pin 0.25 x .88	1
10	Air Intake - PMG Add-on	1
11	Screw, Hex Hd Flg Lock 1/4 - 20	4
12	PMG Cover	1
13	Hex Hd Cap Screw, 3/8 - 16	6
14	Washer, flat - 3/8	6
15	Washer, split lock - 3/8	6

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MARATHON ELECTRIC
GENERATORS
A REGAL-BELOIT COMPANY

Marathon Electric Mfg. Corp.
P.O. Box 8003
Wausau, WI 54402-8003 USA
Phone: 715.675.3359
Fax: 715.675.8026
www.marathonelectric.com

Printed in USA
SB504 05/06

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5481J/10K/5-06/ML/BH

INSTRUCTIONS

Basler Electric
Phone: +1 618.654.2341
Route 143, Box 269
Highland IL 62249 USA

FOR
ANALOG VOLTAGE CONTROLLER
Model AVC63-4 (P/N 9166800136)
Model AVC63-4D (P/N 9166800134)

Power Systems Group
Fax: +1 618.654.2351
www.basler.com
info@basler.com

INTRODUCTION

AVC63-4 and AVC63-4D analog voltage controllers regulate voltage on 50 or 60 hertz brushless generators. The controllers include frequency compensation, over-excitation shutdown, solid-state buildup circuitry, and EMI filtering.

AVC63-4 adjustment potentiometers are located on the terminals and components side of the controller (see Figure 1). AVC63-4D adjustment potentiometers are accessed through the controller front panel (see Figure 2).

SPECIFICATIONS

Output Power

Maximum Continuous:	4 Adc at 63 Vdc (252 W)
One Minute Forcing:	7 Adc at 100 Vdc (700 W) with 240Vac power input

Exciter Field DC Resistance

15 to 100 Ω

Input Power

Range:	190 - 240 Vac, ±10%, single-phase
Frequency:	50/60 Hz, ±10%
Burden:	500 VA

Sensing Input

190 to 240 Vac, single-phase, 50/60 Hz, ±10%, common with ac power input

Voltage Adjustment Range

171 to 264 Vac

Regulation Accuracy

Better than ±1.0%, no-load to full-load

Response Time

Less than 1.5 cycles for ±5% changes is sensing voltage

EMI Suppression

Internal electromagnetic interference (EMI) filtering

Overexcitation Shutdown

Field voltage shuts down after time delay if exciter field voltage exceeds 100 Vdc, ±5%. (See *Overexcitation Shutdown* for inverse time delay curve and description.)

Voltage Buildup

Automatic voltage buildup occurs for residual generator voltages as low as 6 Vac.

Power Dissipation

8 W maximum

Temperature

Operating:	–40 to 140°F (–40 to 60°C)
Storage:	–85 to 185°F (–65 to 85°C)

Vibration

2 to 27 Hz:	1.3 G
27 to 52 Hz:	0.036 inches, double-amplitude
52 to 1000 Hz:	5 G

Shock

Withstands up to 20 G in each of three mutually perpendicular axes.

Weight

8 oz (220 g) net

Agency Certification

UL recognized and CSA certified

CONTROLS

AVC63-4 and AVC63-4D controls consist of jumpers and screwdriver-adjusted potentiometers.

Jumpers

Two jumpers connect to the controller terminals: the Corner Frequency jumper and the Voltage Adjust Rheostat jumper. These jumpers are shown in Figure 3.

Corner Frequency Jumper

Analog voltage controllers are delivered with the Corner Frequency Jumper set for 60 hertz operation. This gives a corner frequency of 55 hertz. For 50 hertz operation and a corner frequency of 45 hertz, the Corner Frequency jumper must be moved to the 50 Hz terminal.

Voltage Adjust Rheostat Jumper

Analog voltage controllers are delivered with the Voltage Adjust Rheostat jumper connected across terminals 6 and 7. This enables adjustment of the generator output voltage through the controller's internal Voltage Control potentiometer. Clockwise rotation of the voltage control increases generator voltage.

If remote adjustment of the generator output is desired, the Voltage Adjust Rheostat jumper must be replaced with a user-supplied rheostat. A 1000 ohm, ½-watt rheostat will provide adequate voltage adjustment range for most applications. Figure 8 shows the proper remote rheostat connections.

Potentiometer Controls

AVC63-4 potentiometer controls are located on the components and terminals side of the controller and are shown in Figure 1. AVC63-4D potentiometer controls are accessible through the controller front panel and are shown in Figure 2.

INPUT POWER/SENSING INPUT

Power for the exciter field and analog voltage controller is derived from the generator output. The acceptable power input range is 171 to 264 Vac and is connected to terminals 3 and 4. Connect wiring as shown in the interconnection diagram of Figure 8.

EXCITER FIELD POWER CIRCUIT

Controller terminal F+ is connected to the brushless exciter field positive terminal and controller terminal F– is connected to the brushless exciter field negative terminal.

CAUTION

The exciter field dc resistance must be 15 Ω or greater and less than 100 Ω.

If the exciter field dc resistance is less than 15 Ω and the full-load field current does not exceed the maximum continuous current rating of the controller, a resistor of

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sufficient wattage must be added in series with the field to increase the total resistance to 15 Ω.

FREQUENCY COMPENSATION

The frequency compensation feature improves system load pickup performance by restraining voltage recovery until the frequency has also started to recover. Figures 4 and 5 illustrate the underfrequency characteristics of the AVC63-4 and AVC63-4D.

The corner frequency range is set for 50 hertz or 60 hertz by connecting the Corner Frequency jumper to the appropriate terminal. Refer to *Controls, Jumpers* for details about selecting the corner frequency range.

The corner frequency setting is adjusted by the Underfrequency control (potentiometer). Clockwise rotation of the Underfrequency control increases the corner frequency and counterclockwise rotation decreases the corner frequency. If user adjustment of this factory-set potentiometer is desired, follow the *Preliminary Setup* and *System Startup* procedures.

OVEREXCITATION SHUTDOWN

The overexcitation shutdown feature removes controller output power, after a time delay, if the exciter field voltage exceeds 100 Vdc, ±5%. The time delay is inversely proportional to the magnitude of the detected overvoltage—up to 135 Vdc. Beyond 140 Vdc, the field voltage is removed after approximately 2 seconds. Figure 6 shows the over-excitation shutdown time delay characteristic curves.

Once the output power is removed, the controller can be reset by decreasing the input voltage to less than 10 Vac for two seconds, minimum. This can be achieved by stopping the prime mover or by interrupting the controller input power with a reset switch.

INSTALLATION

Mounting

The AVC63-4 and AVC63-4D controllers may be mounted on the generator in any convenient position. Figure 7 shows the outline dimensions and drilling locations. Dimensions are shown in inches with millimeters in parenthesis.

The recommended mounting hardware is two #8 or M4 screws torqued to 9 inch-pounds (0.9 newton meters). Nylon-lined locking nuts are recommended when installing the controller with loose hardware.

Connections

AVC63-4 and AVC63-4D controller terminals consist of quarter-inch, quick-connect tabs.

Figure 8 shows a typical interconnection diagram for the AVC63-4 and AVC63-4D controllers.

OPERATING PROCEDURES

The following procedures provide instructions for adjusting the AVC63-4 and AVC63-4D controllers. Symptoms caused by certain generator system problems or a faulty controller are included along with suggested remedies.

CAUTION
Meggers and high-potential test equipment must not be used. Use of such equipment could damage the semiconductors contained in the controller.

Preliminary Setup

Complete the following steps before proceeding with system startup.

1. Verify that the analog voltage controller specifications conform with the requirements of the generator system.
2. Ensure that the controller jumpers are positioned as follows.
   a. If a remote voltage adjust rheostat will not be used, ensure that the Voltage Adjust Rheostat jumper is connected across terminals 6 and 7.
   b. If a 55 hertz corner frequency for a 60 hertz system is desired, connect the Corner Frequency jumper to the 60 Hz terminal. If a 45 hertz corner frequency for a 50 hertz system is desired, connect the Corner Frequency jumper to the 50 Hz terminal.
3. Ensure that the connections between the generator system and the controller are correct.
4. Install the fuses as shown in Figure 8.
5. Set the controller's Voltage control fully counter-clockwise and the remote voltage adjust rheostat (if used) to the centered position.
6. Adjust the controller's Stability control fully clockwise. This provides the most stability and the slowest response.
7. If user adjustment of the Underfrequency control is required, start with the potentiometer adjusted to the fully counterclockwise position. Then, slowly adjust the potentiometer clockwise to set.

System Startup

NOTE
All voltage readings are to be taken with an average-reading voltmeter.

1. Perform the steps under *Preliminary Setup*.
2. Start the prime mover and bring it up to rated speed. Generator voltage should build up. If it does not build up, perform the steps under *Field Flashing*.
3. Slowly adjust the controller's Voltage control (or remote voltage adjust rheostat) until the generator voltage reaches the nominal level.

   If the voltage does not build up to the rated level:
   a. Check the generator output for excessive load or a short-circuit.
   b. If a minimal residual of 6 volts is not present, perform the steps under *Field Flashing*.
4. Apply and remove the generator load to verify stability.

   If the generator responds too slowly or hunts (oscillates):
   a. Check the generator output for excessive load or a short-circuit. Adjust the controller's Stability control with no load applied.
   b. Check the stability of the governor system.
5. Check regulation under normal operating conditions.

   If the regulation is poor:
   a. Verify that the prime mover is operating at rated speed.
   b. Verify that the voltmeter is connected to the same point as the controller sensing.
   c. Use an average-sensing voltmeter (not an rms-sensing voltmeter).
6. Verify the corner frequency setting by slowly reducing the generator frequency until the generator output voltage just starts to decrease.

If adjustment of the corner frequency is required:

a. Rotate the Underfrequency control fully counter-clockwise.

b. Reduce the generator frequency from nominal (either 50 Hz or 60 Hz) to the desired corner frequency.

c. Slowly adjust the Underfrequency control clockwise until the generator output voltage just starts to decrease.

Field Flashing

When the controller is operated with the generator for the first time, the polarity of the field's residual magnetism may not be correct or the magnitude may not be high enough. If generator voltage does not increase after startup, stop the prime mover and perform the following steps.

1. With the prime mover at rest, connect a dc source in series with a 3 to 5 Ω limiting resistor to the field's positive (F+) and negative (F–) terminals. The dc source should not be grounded and should not have an output greater than 12 Vdc.
2. Apply the dc voltage for approximately 3 seconds, then remove it.
3. With controller terminals 3 and 4 disconnected, start the prime mover and measure the voltage at the generator output terminals.
4. If the voltage is greater than 6 Vac, voltage buildup should be successful and controller terminals 3 and 4 can be reconnected. If less than 6 Vac is measured, repeat steps 1 through 3. If repeating these steps does not result in generator voltage buildup, contact Basler Electric.

OPERATIONAL TEST

1. Connect the analog voltage controller as shown in Figure 9. Do not apply power. Ensure that the light bulbs are rated for 120 volts and less than 100 watts.
2. Adjust the controller's Voltage control and remote voltage adjust rheostat (if used) fully counterclockwise.
3. Apply 240 Vac, 60 Hz power to the controller. The light bulbs should flash momentarily.
4. Slowly adjust the controller's Voltage control clockwise.

Results

1. Before minimum luminance is reached, the light bulbs should attain maximum luminance to signify the regulation point.
2. At the regulation point, a small change in the Voltage control or remote voltage adjust rheostat position should turn the light bulbs on or off.

CONTROLLER DIFFERENCES

Previous versions of the AVC63-4 controller, sold prior to mid-2003, are slightly different in appearance and control adjustment.

Your controller version can be determined by the location of the heat sinks. Figure 10 shows the heat sink location on the previous and current version of the AVC63-4.

Adjustment of the Underfrequency Control is different on previous versions of the AVC63-4. When adjusting the Underfrequency Control on previous versions, clockwise rotation decreases the corner frequency and counter-clockwise rotation increases the corner frequency. References to the rotation of the Underfrequency control in this publication should be reversed when adjusting the corner frequency on previous versions of the AVC63-4.

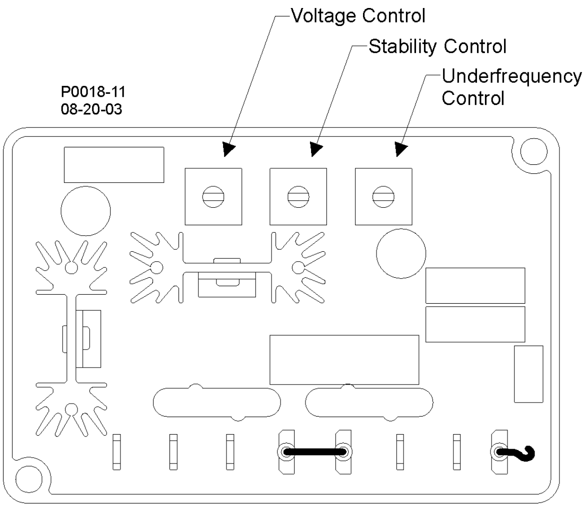

Figure 1. AVC63-4 Potentiometer Control Locations

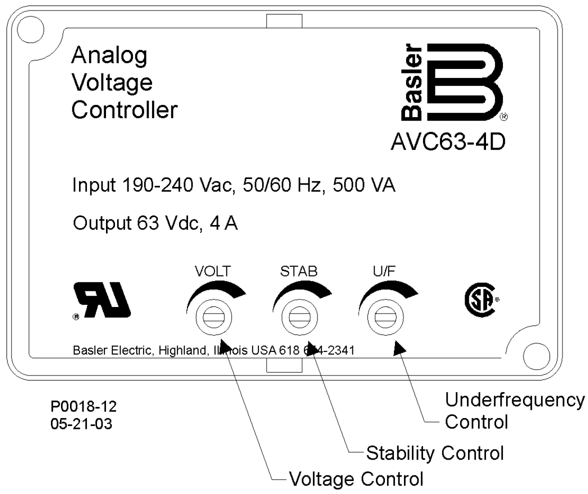

Figure 2. AVC63-4D Potentiometer Control Locations

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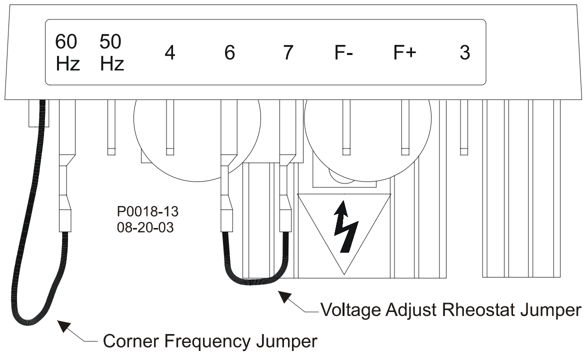


Figure 3. Jumper Locations

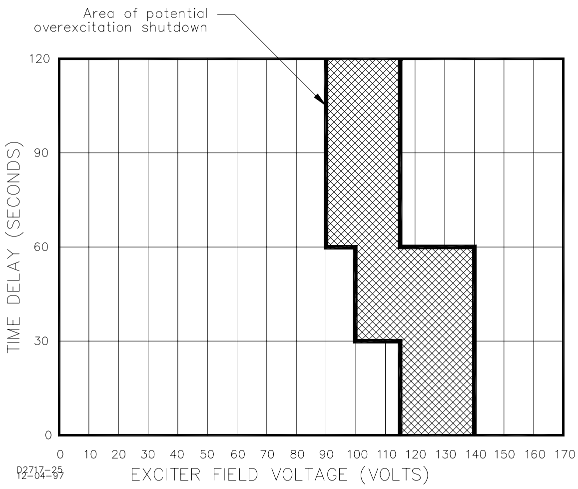


Figure 6. Overexcitation Shutdown Time Delay Characteristic

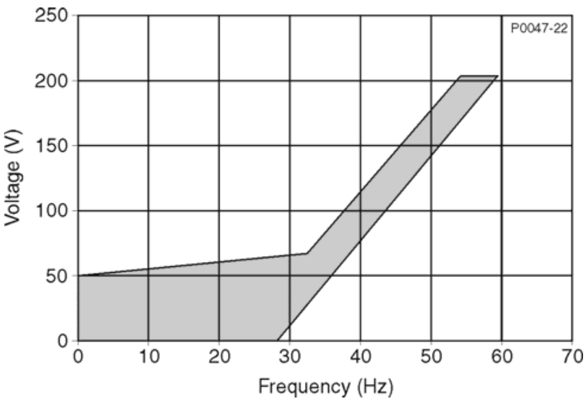


Figure 4. Frequency Compensation Characteristic - 60 Hz

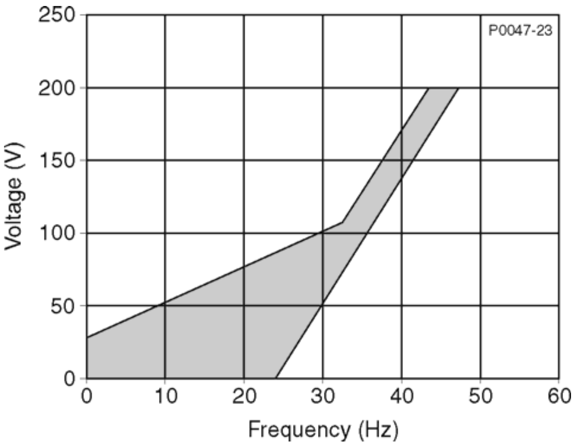
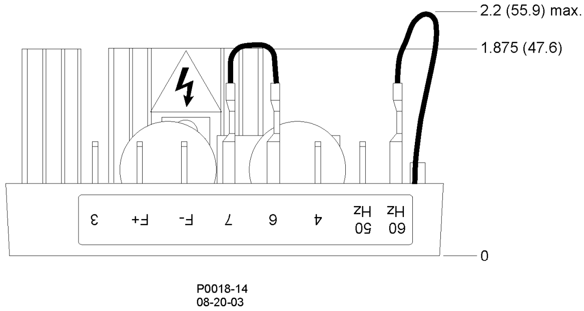
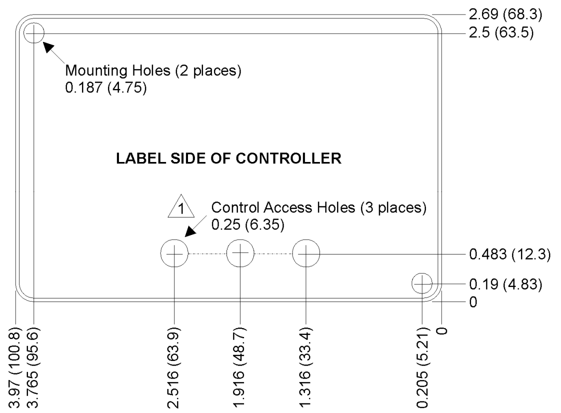


Figure 5. Frequency Compensation Characteristic - 50 Hz





1 Control access hole locations apply to AVC63-4D only.

Figure 7. Outline and Drilling Dimensions

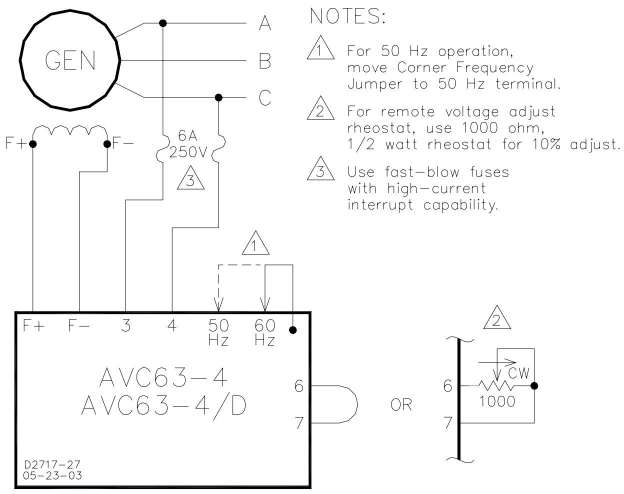


Figure 8. Typical Interconnection, 208/240 V Nominal

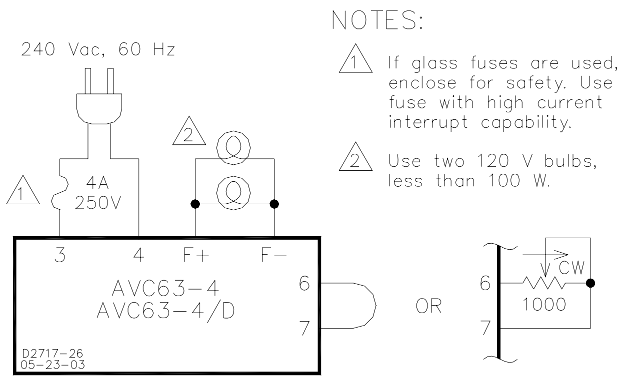


Figure 9. Operational Test Diagram

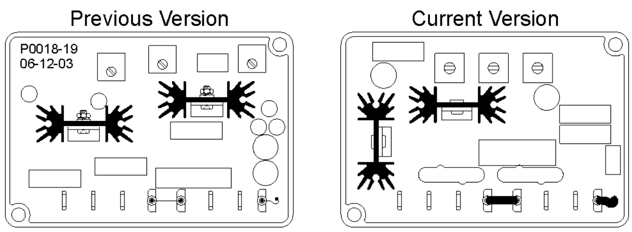


Figure 10. Controller Version Heat Sink Locations

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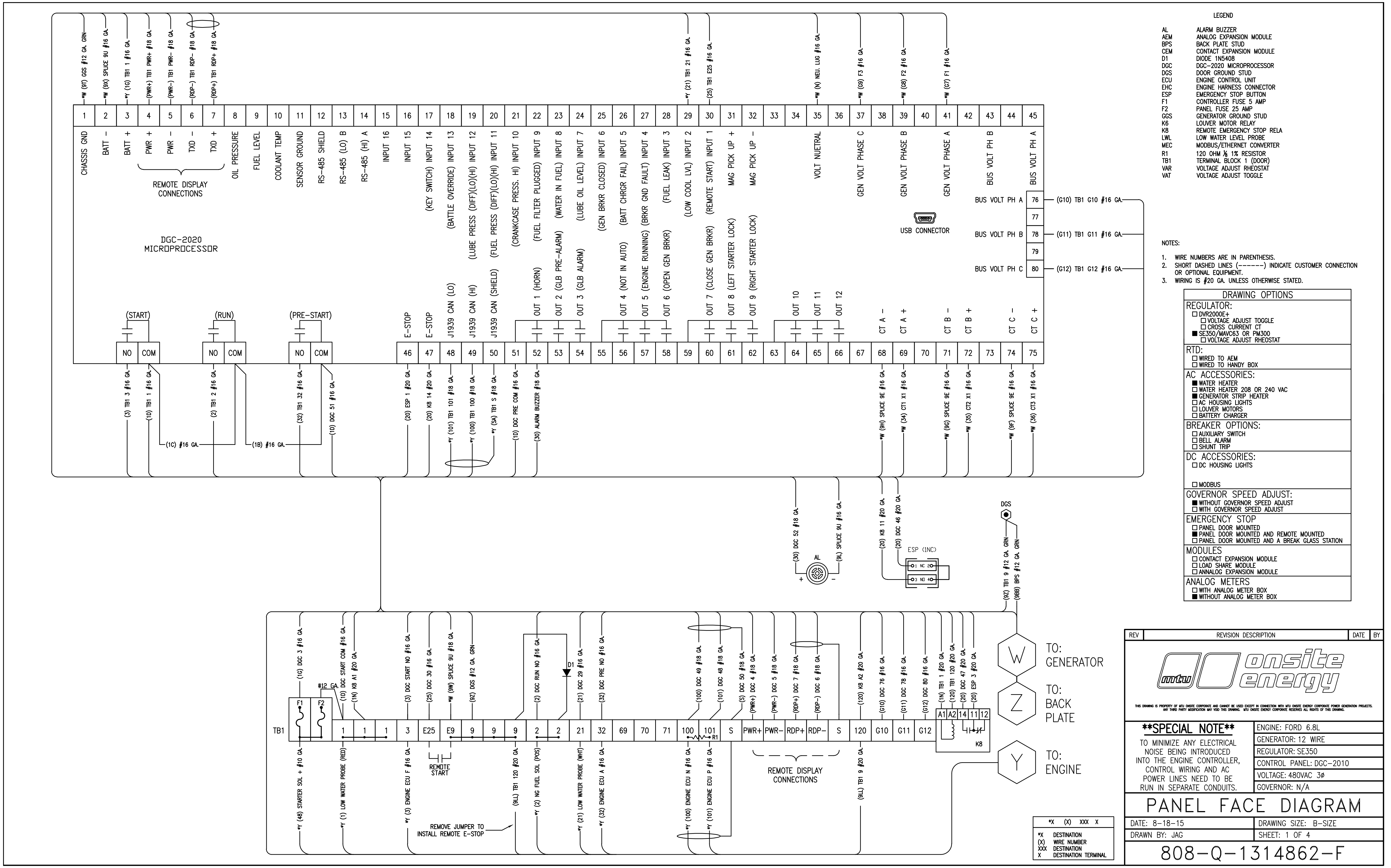
NOTES

2 Drawings

2.1 Panel Front 808-Q-1314862-F



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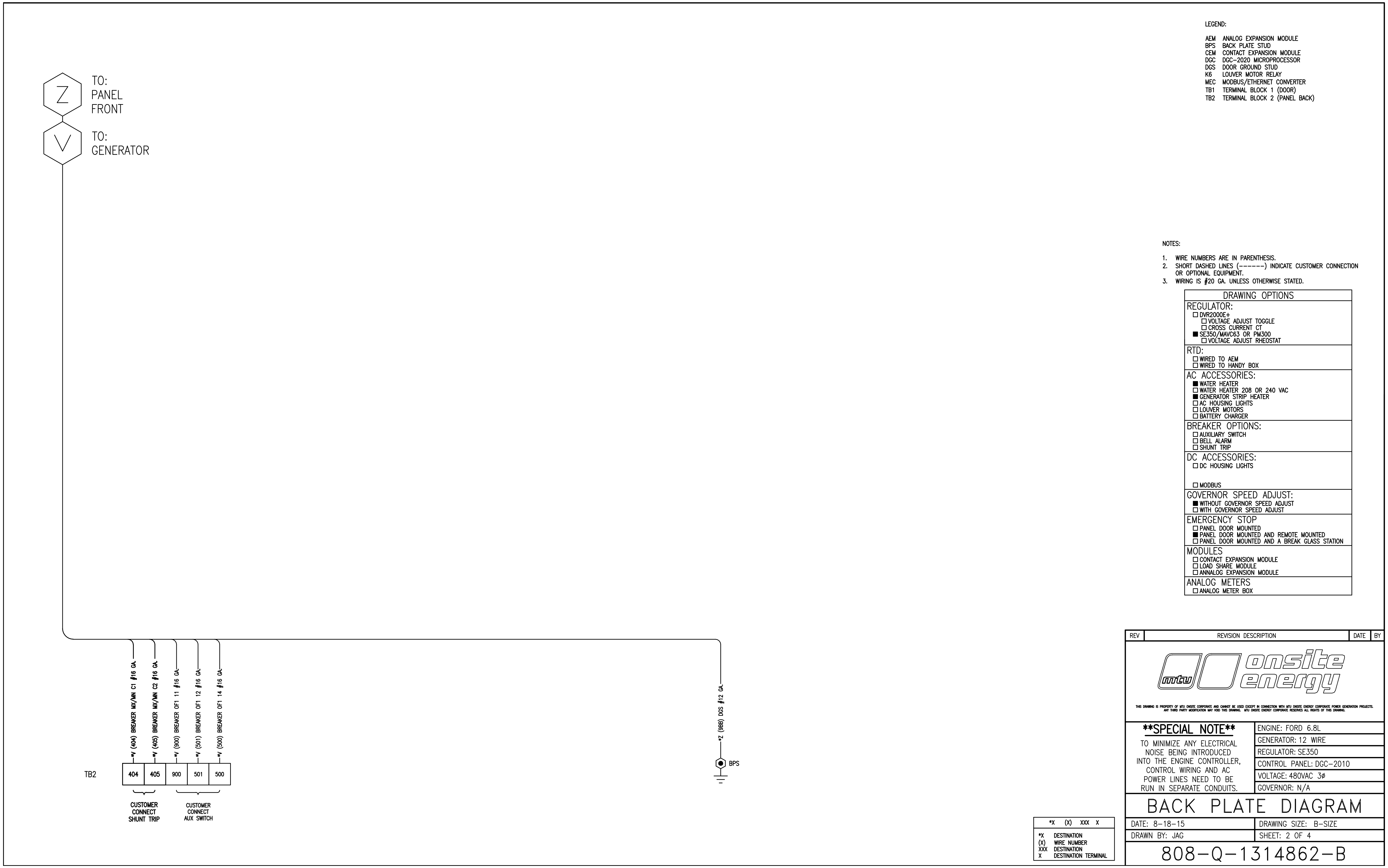
2.2 Panel Back 808-Q-1314862-B



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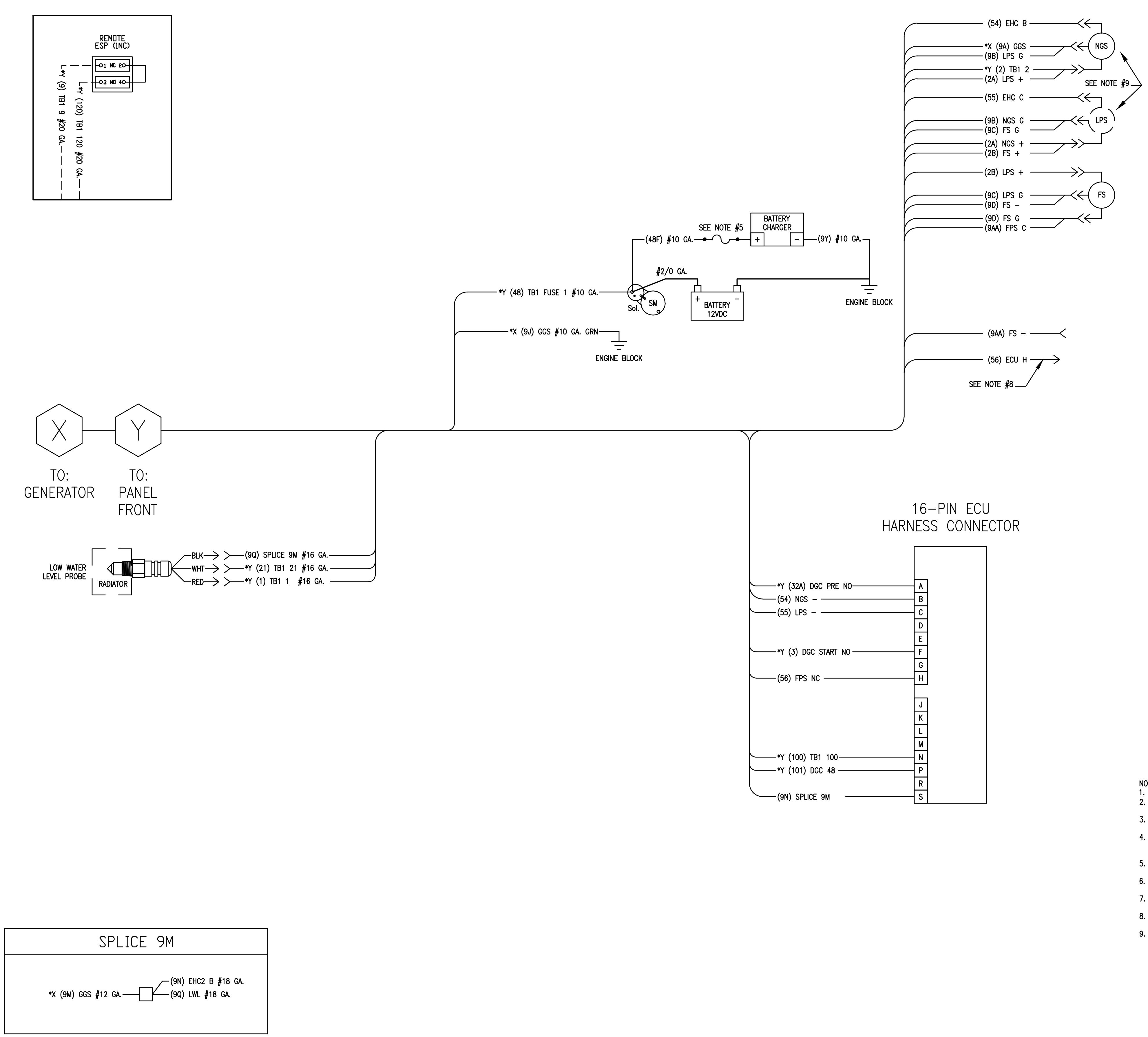
2.3 Engine 808-Q-1314862-E



LEGEND

BC	BATTERY CHARGER
BPS	BACK PLATE STUD
DGC	DGC−2020 MICROPROCESSOR
DGS	DOOR GROUND STUD
DLC	DATA LINK CONNECTOR
ECU	ENGINE CONTROL UNIT
EHC2	ENGINE HARNESS CONNECTOR
FLS	FUEL LEAK SWITCH
FS	FUEL SOLENOID
GGS	GENERATOR GROUND STUD
K6	LOUVER MOTOR RELAY
K8	REMOTE EMERGENCY STOP RELAY
LPS	LP GAS SOLENOID
LWL	LOW WATER LEVEL PROBE
NGS	NATURAL GAS FUEL SOLENOID
TB1	TERMINAL BLOCK 1
TB2	TERMINAL BLOCK 2 (PANEL BACK)
SM	STARTER MOTOR

NOTES:

1. WIRE NUMBERS ARE IN PARENTHESIS.
2. SHORT DASHED LINES (−−−−−−) INDICATE CUSTOMER CONNECTION OR OPTIONAL EQUIPMENT.
3. WIRING IS #20 GA. UNLESS OTHERWISE STATED.

DRAWING OPTIONS

REGULATOR:
- ☐ DVR2000E+
  - ☐ VOLTAGE ADJUST TOGGLE
  - ☐ CROSS CURRENT CT
- ■ SE350/MAVC63 OR PM300
  - ☐ VOLTAGE ADJUST RHEOSTAT

RTD'S:
- ☐ WIRED TO AEM
- ☐ WIRED TO HANDY BOX

AC ACCESSORIES:
- ■ WATER HEATER
- ☐ WATER HEATER 208 OR 240 VAC
- ■ GENERATOR STRIP HEATER
- ☐ AC HOUSING LIGHTS
- ☐ LOUVER MOTORS
- ☐ BATTERY CHARGER

BREAKER OPTIONS:
- ☐ AUXILIARY SWITCH
- ☐ BELL ALARM
- ☐ SHUNT TRIP

DC ACCESSORIES:
- ☐ DC HOUSING LIGHTS
- ☐ MODBUS

GOVERNOR SPEED ADJUST:
- ■ WITHOUT GOVERNOR SPEED ADJUST
- ☐ WITH GOVERNOR SPEED ADJUST

EMERGENCY STOP:
- ☐ PANEL DOOR MOUNTED
- ■ PANEL DOOR MOUNTED AND REMOTE MOUNTED
- ☐ PANEL DOOR MOUNTED AND A BREAK GLASS STATION

MODULES:
- ☐ CONTACT EXPANSION MODULE
- ☐ LOAD SHARE MODULE
- ☐ ANNALOG EXPANSION MODULE

ANALOG METERS
- ☐ ANALOG METER BOX

NOTES:
1. WIRE NUMBERS ARE IN PARENTHESIS.
2. SHORT DASHED LINES (−−−−−−) INDICATE CUSTOMER CONNECTION OR OPTIONAL EQUIPMENT.
3. BATTERY CHARGER FUSE ONLY WHEN REQUIRED OR SUPPLIED BY CHARGER MANUFACTURER.
4. FUEL LEVEL GUAGE SENDER REQUIREMENTS
   33 OHMS = FULL
   240 OHMS = EMPTY
5. BATTERY CHARGER FUSE ONLY WHEN SUPPLIED OR REQUIRED BY CHARGER MANUFACTURER.
6. AUX SWITCH CONTACTS ARE SHOWN WHEN THE BREAKER IS IN THE OPEN POSITION.
7. BELL ALARM CONTACTS ARE SHOWN IN THE NON−TRIPPED POSITION.
8. WIRED TO GROUND IF UNIT IS LP LIQUID OR VAPOR. UNWIRED IF UNIT IS NATURAL GAS.
9. ONE OF THESE TWO FUEL SOLENOIDS IS FACTORY INSTALLED ON SINGLE FUEL APPLICATIONS:
   A.) NATURAL GAS FUEL SOLENOID NOT REQUIRED ON LP FUEL UNITS. B.) LP FUEL SOLENOID NOT REQUIRED ON NATURAL GAS FUEL UNITS

*X (X) XXX X

*X	DESTINATION
(X)	WIRE NUMBER
XXX	DESTINATION
X	DESTINATION TERMINAL

REV	REVISION DESCRIPTION	DATE	BY

mtu onsite energy

SPECIAL NOTE

TO MINIMIZE ANY ELECTRICAL NOISE BEING INTRODUCED INTO THE ENGINE CONTROLLER, CONTROL WIRING AND AC POWER LINES NEED TO BE RUN IN SEPARATE CONDUITS.

ENGINE: FORD 6.8L
GENERATOR: 12 WIRE
REGULATOR: SE350
CONTROL PANEL: DGC−2010
VOLTAGE: 480VAC 3Ø
GOVERNOR: N/A

ENGINE DIAGRAM

DATE: 8−18−15	DRAWING SIZE: B−SIZE
DRAWN BY: JAG	SHEET: 4 OF 4

808−Q−1314862−E

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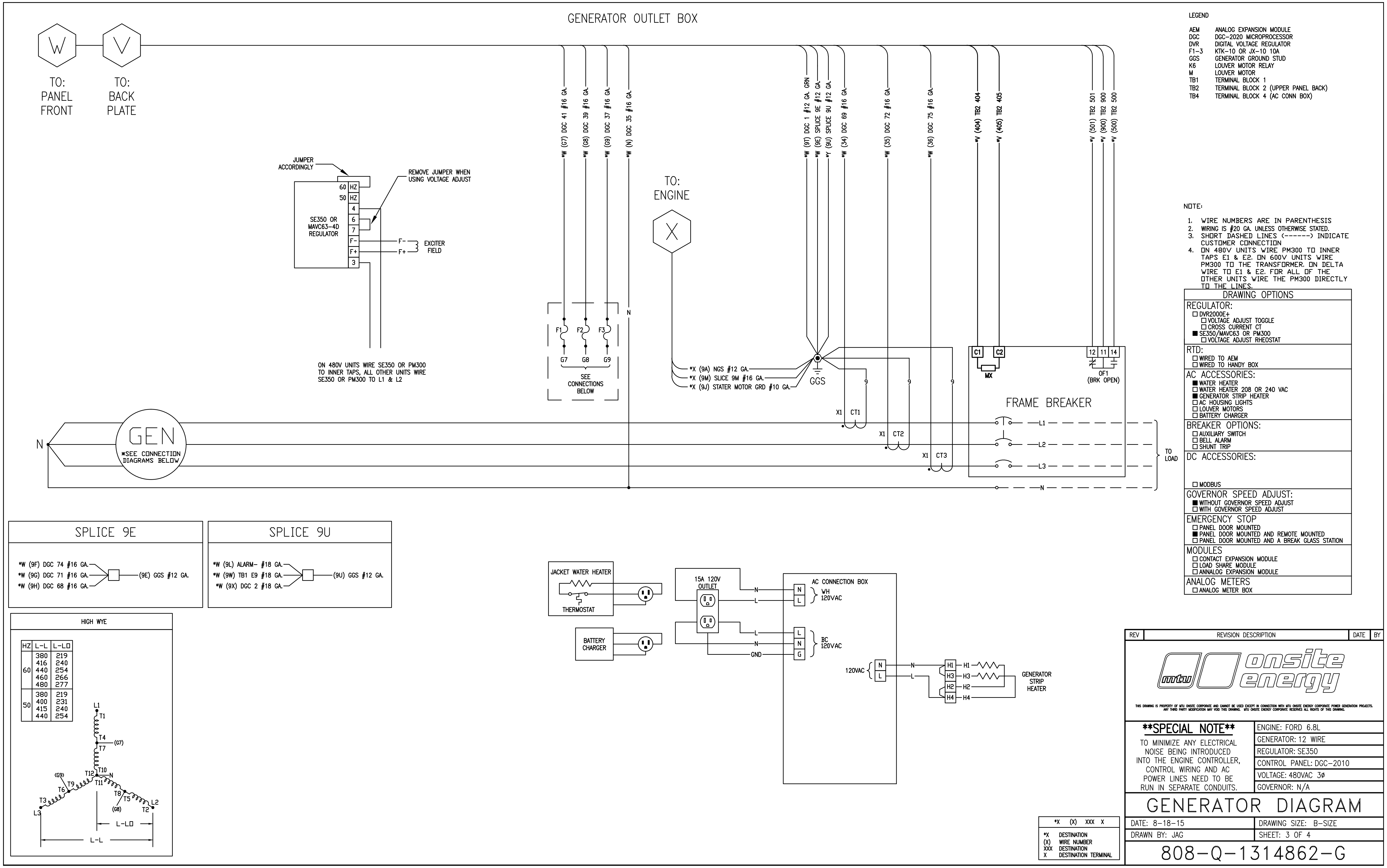
TIM-ID: 0000104695 - 001

2.4 Generator 808-Q-1314862-G



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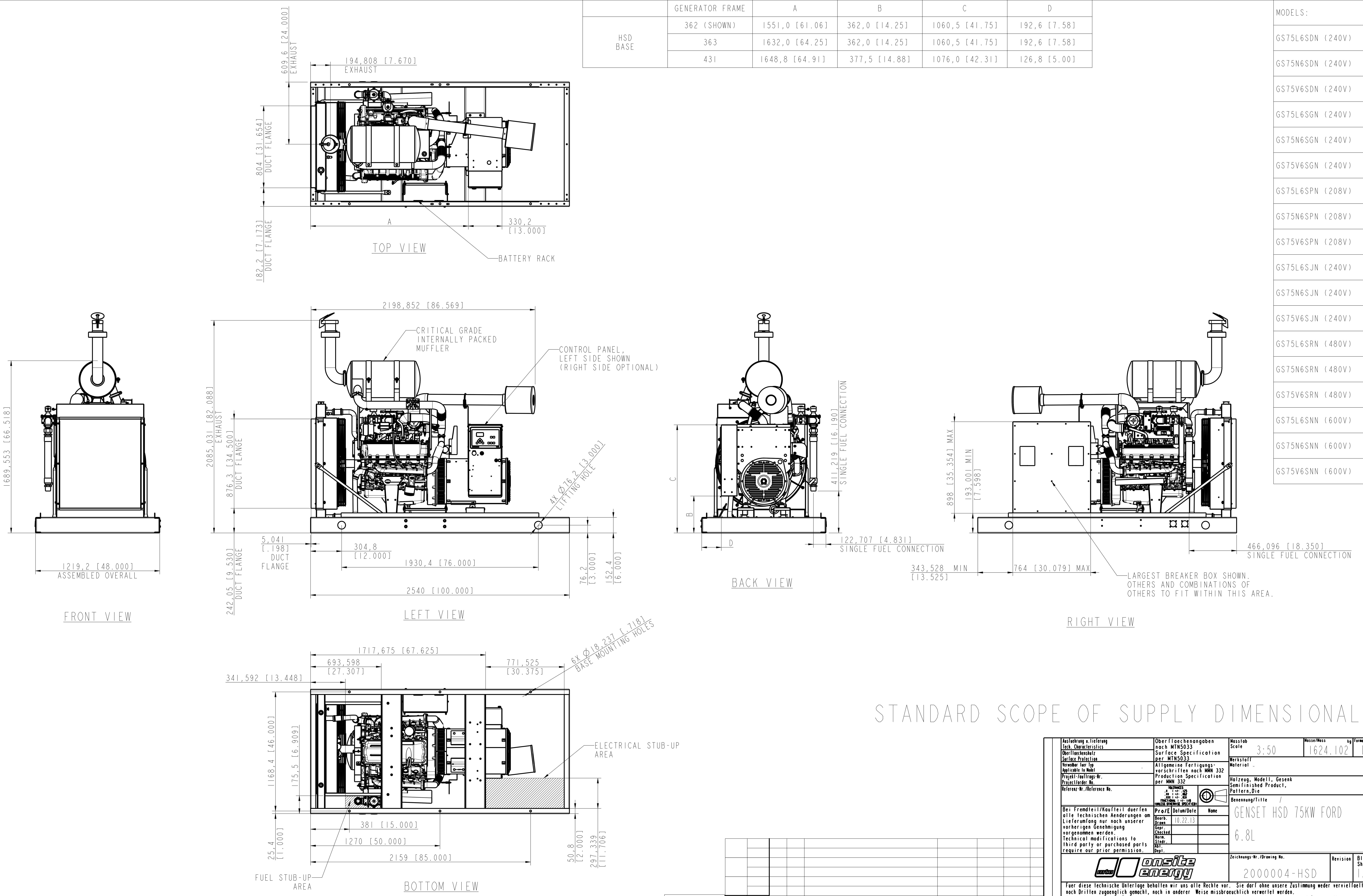
TIM-ID: 0000104704 - 001

GENERATOR FRAME		A	B	C	D
HSD BASE	362 (SHOWN)	1551,0 [61.06]	362,0 [14.25]	1060,5 [41.75]	192,6 [7.58]
	363	1632,0 [64.25]	362,0 [14.25]	1060,5 [41.75]	192,6 [7.58]
	431	1648,8 [64.91]	377,5 [14.88]	1076,0 [42.31]	126,8 [5.00]

MODELS:
GS75L6SDN (240V)
GS75N6SDN (240V)
GS75V6SDN (240V)
GS75L6SGN (240V)
GS75N6SGN (240V)
GS75V6SGN (240V)
GS75L6SPN (208V)
GS75N6SPN (208V)
GS75V6SPN (208V)
GS75L6SJN (240V)
GS75N6SJN (240V)
GS75V6SJN (240V)
GS75L6SRN (480V)
GS75N6SRN (480V)
GS75V6SRN (480V)
GS75L6SNN (600V)
GS75N6SNN (600V)
GS75V6SNN (600V)



STANDARD SCOPE OF SUPPLY DIMENSIONAL

Ausfuehrung u. Lieferung / Tech. Characteristics	Oberflaechenangaben nach MTN5033 / Surface Specification per MTN5033
Oberflaechenschutz / Surface Protection	Allgemeine Fertigungsvorschriften nach MMN 332 / Production Specification per MMN 332
Verwendbar fuer Typ / Applicable to Model	
Projekt-/Auftrags-Nr. / Project/order No.	
Referenz-Nr./Reference No.	

Massstab / Scale: 3:50 — Masse/Mass kg: 1624.102 — Format/Size: D

Werkstoff / Material: .

Halbzeug, Modell, Gesenk / Semifinished Product, Pattern, Die

Benennung/Title: GENSET HSD 75KW FORD 6.8L

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Pro/E	Datum/Date	Name
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Gepr. Checked		
Norm. Stndr.		
Abt. Dept.		

onsite energy

Zeichnungs-Nr./Drawing No.: 2000004-HSD — Revision: — Blatt Sheet: 1/8

Aufgeführte Normen / Relevant Standards	Passmass / Fit	Abmass in / Deviation in	Buchst. / Rev. Ltr.	Anzahl / Frequency	Aenderung/Revision	Aenderungs-Nr. / Revision Notice No.	Datum / Date	Name	Gepr. / Check.

TIM-ID: 0000098985 - 001

	GENERATOR FRAME	A	B
HSD BASE	362 (SHOWN)	392,1 [15.44]	152,4 [6.00]
	363	311,1 [12.25]	152,4 [6.00]
	431	285,5 [11.25]	111,3 [4.38]

OPTIONAL SCOPE OF SUPPLY DIMENSIONAL

Ausfuehrung u. lieferung / Tech. Characteristics	Oberflaechenangaben nach MTN5033 / Surface Specification per MTN5033
Oberflaechenshutz / Surface Protection	
Verwedbar fuer Typ / Applicable to Model	Allgemeine Fertigungs-vorschriften nach MMN 332 / Production Specification per MMN 332
Projekt-/auftrags-Nr. / Project/order No.	
Referenz-Nr./Reference No.	TOLERANCES .X : +/- .125 .XX : +/- .062 .XXX : +/- .031 FRACTIONAL : +/- 1/8 (UNLESS OTHERWISE SPECIFIED)

Masstab / Scale: 3:50
Masse/Mass kg: 1624.102
Format/Size: D
Werkstoff / Material: -
Halzeug, Modell, Gesenk / Semifinished Product, Pattern, Die
Benennung/Title: GENSET HSD 75KW FORD 6.8L

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Bearb. Drawn	10.22.13	
Gepr. Checked		
Norm. Stndr.		
Abt. Dept.		

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Zeichnungs-Nr./Drawing No.: 2000004-HSD
Revision:
Blatt / Sheet: 2/8

Aufgeführte Normen / Relevant Standards	Passmass / Fit	Abmass in Deviation in	Buchst. / Rev. Ltr.	Hauf. / Frequency	Aenderung/Revision	Aenderungs-Nr. / Revision Notice No.	Datum / Date	Name	Gepr. / Check.

TIM-ID: 0000098985 - 001

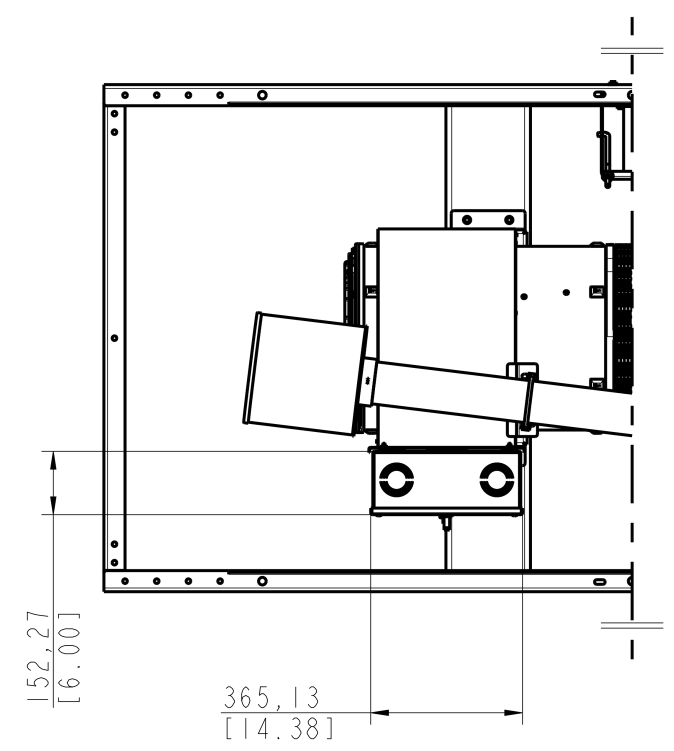
20-250 AMP - SQUARE D, H- & J-FRAME BREAKER

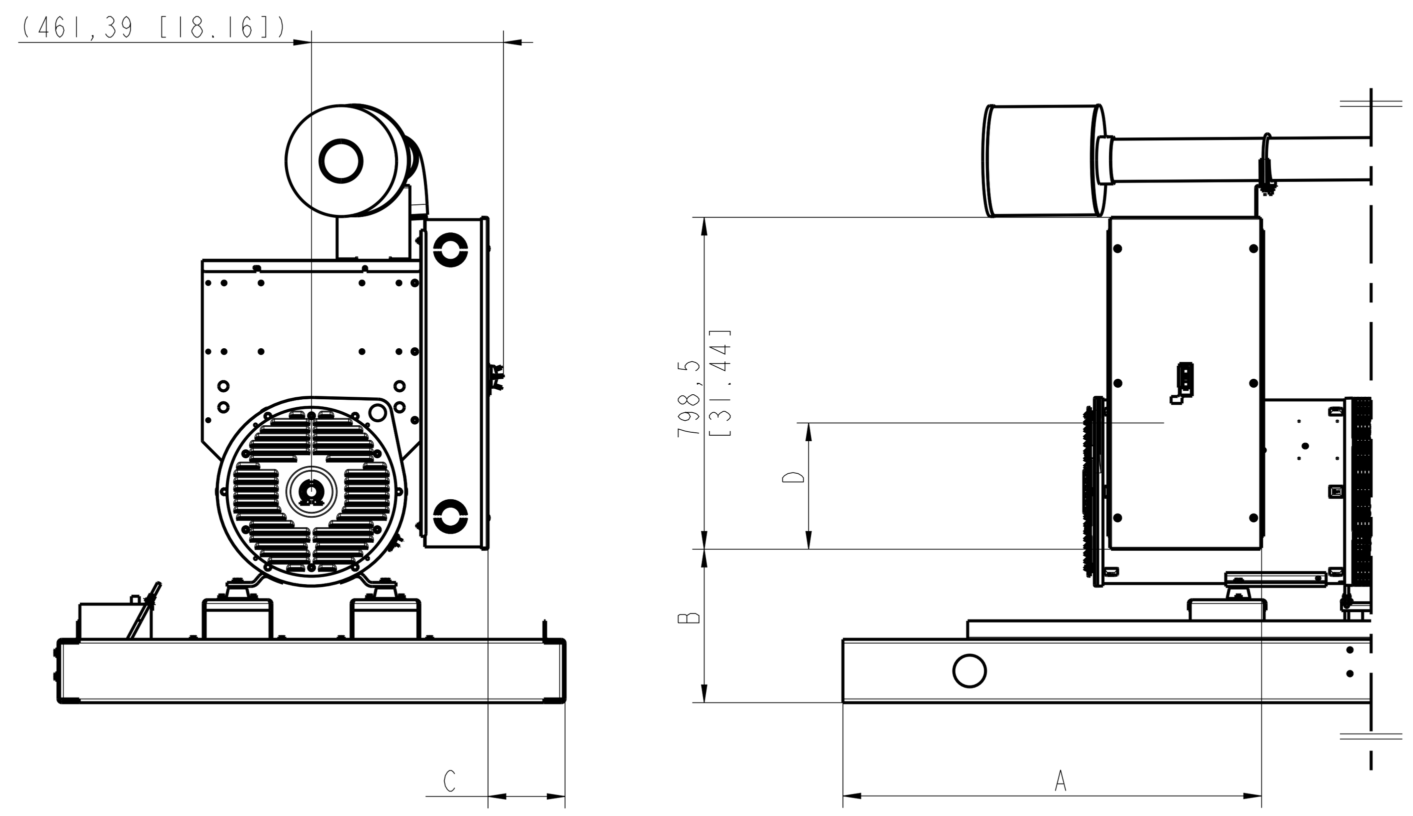
	GENERATOR FRAME	A	B	C
HSD BASE	362 (SHOWN)	1006,6 [39.63]	369,2 [14.53]	185,2 [7.29]
	363	923,5 [36.36]	369,2 [14.53]	185,2 [7.29]
	431	863,3 [33.99]	392,2 [15.44]	119,4 [4.70]

RIGHT SIDE SHOWN, LEFT SIDE OPTIONAL

600V ONLY

20-250 AMP - SQUARE D H- & J-FRAME BREAKER BOTTOM CONNECTION LUGS	
CIRCUIT BREAKER	D
H-FRAME	318,01 [12.52]
J-FRAME	303,77 [11.96]





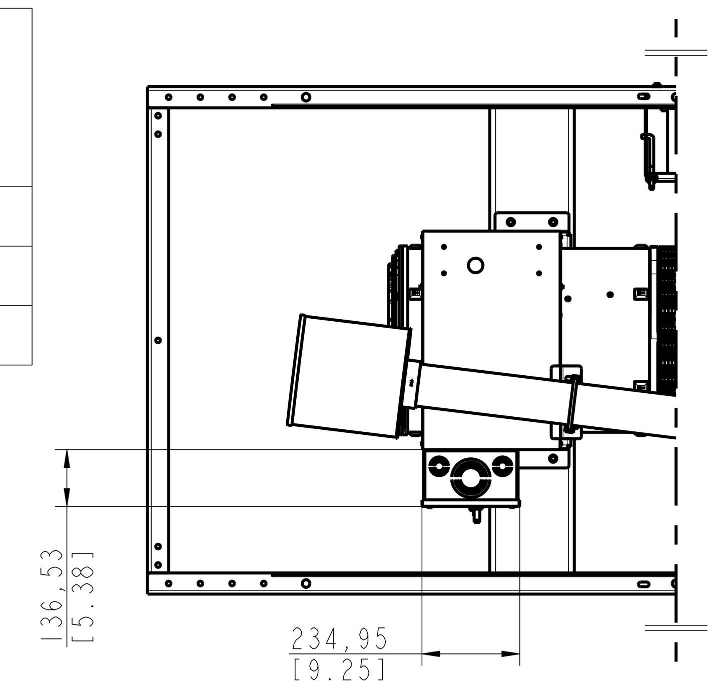
20-250 AMP - SQUARE D, H- & J-FRAME BREAKER

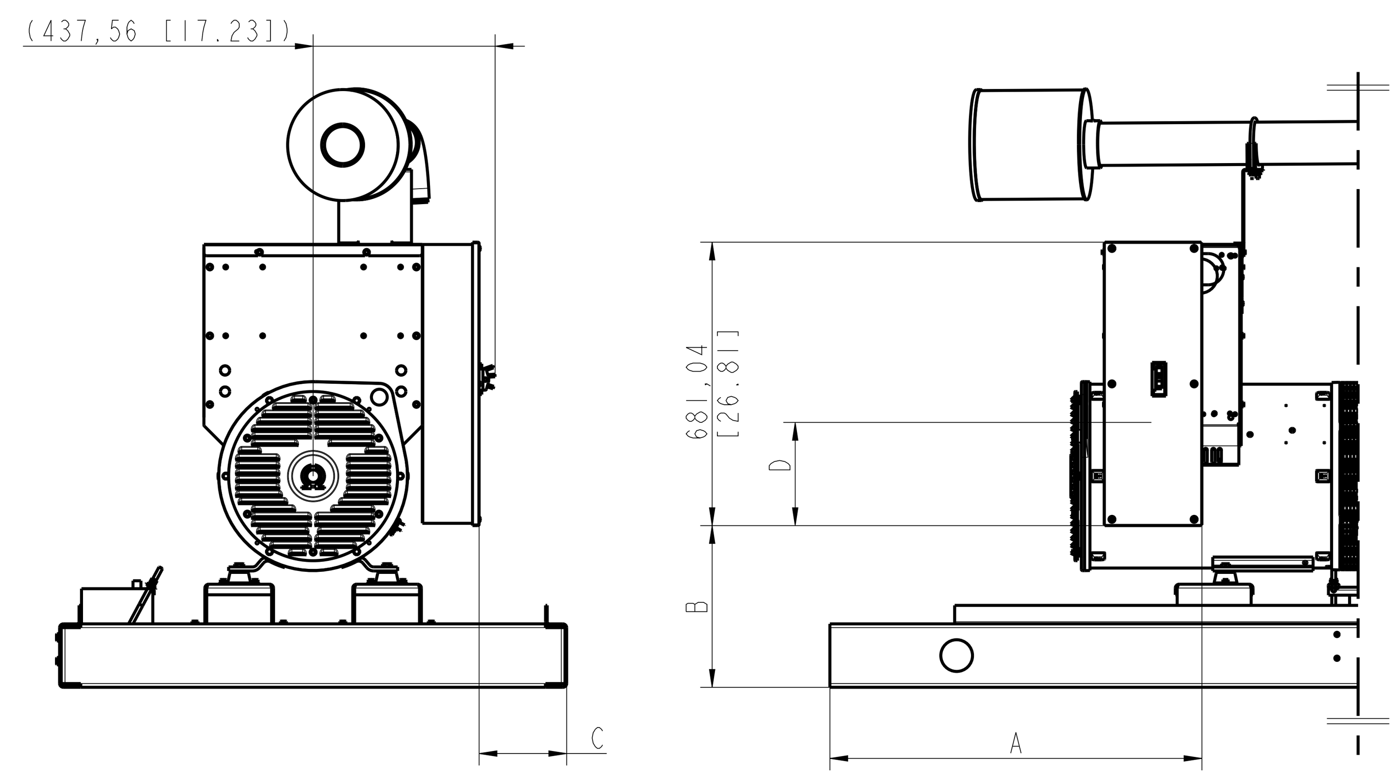
	GENERATOR FRAME	A	B	C
HSD BASE	362 (SHOWN)	894,4 [35.21]	386,6 [15.25]	207,8 [8.18]
	363	811,4 [31.94]	386,6 [15.25]	207,8 [8.18]
	431	751,1 [29.57]	410,5 [16.16]	142,1 [5.59]

RIGHT SIDE SHOWN, LEFT SIDE OPTIONAL

UP TO 480V ONLY

20-250 AMP - SQUARE D H- & J-FRAME BREAKER BOTTOM CONNECTION LUGS	
CIRCUIT BREAKER	D
H-FRAME	262,1 [10.32]
J-FRAME	247,9 [9.76]





300-350 AMP - SQUARE D, LA/LD/P/M-FRAME BREAKER

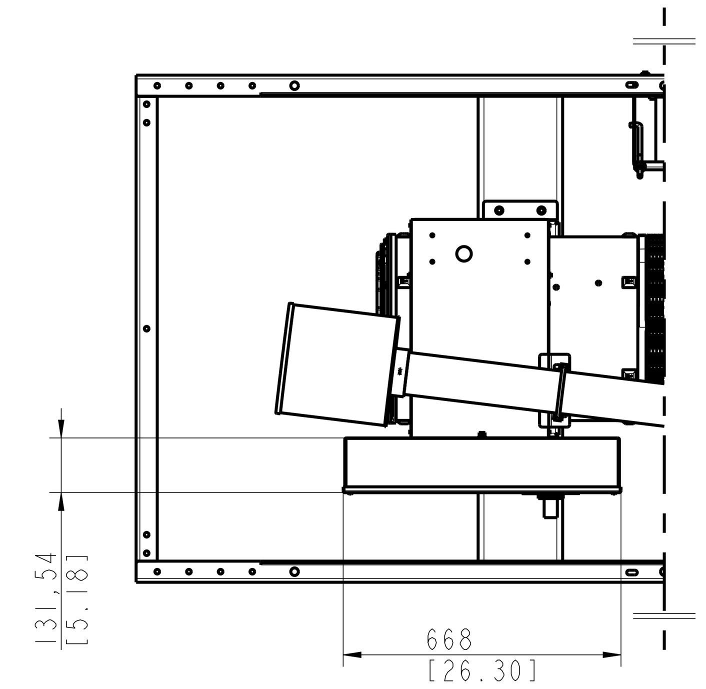
	GENERATOR FRAME	A	B	C
HSD BASE	362 (SHOWN)	1165,8 [45.90]	213,5 [8.38]	215,4 [8.48]
	363	1082,8 [42.63]	213,5 [8.38]	215,4 [8.48]
	431	1053,7 [41.48]	200,7 [7.90]	149,7 [5.89]

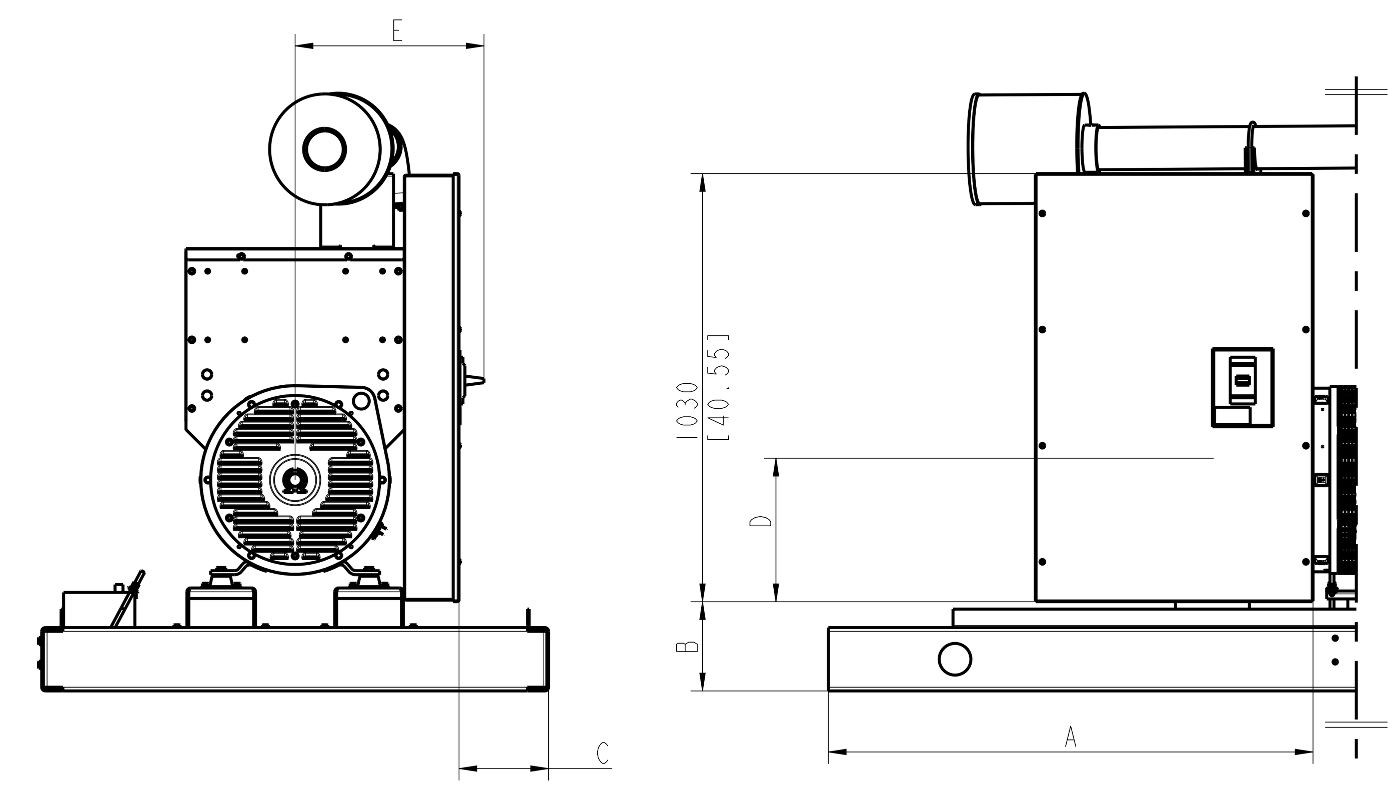
RIGHT SIDE SHOWN, LEFT SIDE OPTIONAL

ALL VOLTAGES

300-350 AMP - SQUARE D LD- & P-FRAME BREAKER BOTTOM CONNECTION LUGS	
CIRCUIT BREAKER	D
LD-FRAME	345,08 [13.59]
P-FRAME	351,79 [13.85]

300-350 AMP - SQUARE D LD- & P-FRAME BREAKER BREAKER DIMENSION	
CIRCUIT BREAKER	E
LD-FRAME	454,17 [17.88]
P-FRAME	479,29 [18.87]





SINGLE BREAKER OPTIONS

Ausfuehrung u. lieferung / Tech. Characteristics	Oberflaechenangaben nach MTN5033 / Surface Specification per MTN5033	Masstab / Scale: 7:100	Masse/Mass kg: 1624.102 — Format/Size: D
Oberflaechenshutz / Surface Protection			
Verwedbar fuer Typ / Applicable to Model: -	Allgemeine Fertigungsvorschriften nach MMN 332 / Production Specification per MMN 332	Werkstoff / Material: -	
Projekt-/auftrags-Nr. / Project/order No.		Halzeug, Modell, Gesenk / Semifinished Product, Pattern, Die	
Referenz-Nr./Reference No.	TOLERANCES .X : +/- .125 .XX : +/- .062 .XXX : +/- .031 FRACTIONAL : +/- 1/8 (UNLESS OTHERWISE SPECIFIED)	Benennung/Title: GENSET HSD 75KW FORD 6.8L	

Pro/E	Datum/Date	Name
Bearb. Drawn	10.22.13	
Gepr. Checked		
Norm. Stndr.		
Abt. Dept.		

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Zeichnungs-Nr./Drawing No.: 2000004-HSD | Revision: | Blatt Sheet: 3/8

Aufgeführte Normen / Relevant Standards	Passmass Fit	Abmass in Deviation in	Buchst. Rev.Ltr.	Summ vor Frequency	Aenderung/Revision	Aenderungs-Nr. Revision Notice No.	Datum Date	Name	Gepr. Check.

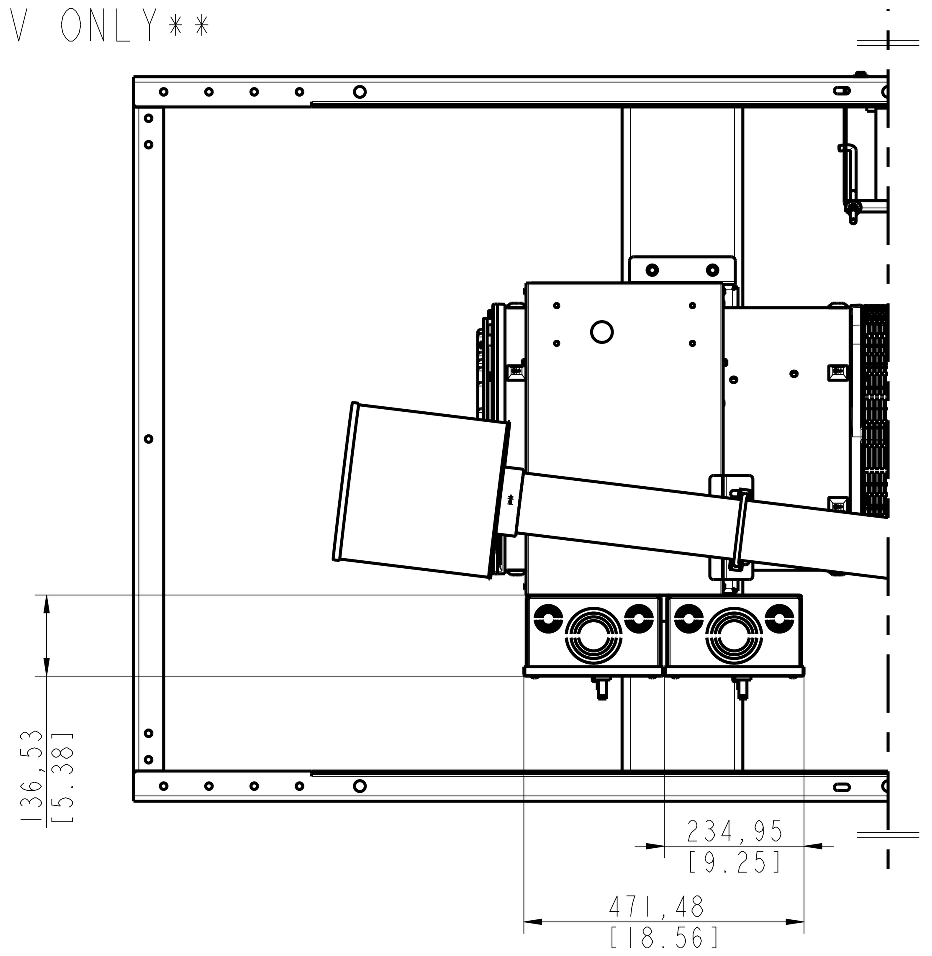
TIM-ID: 0000098985 - 001

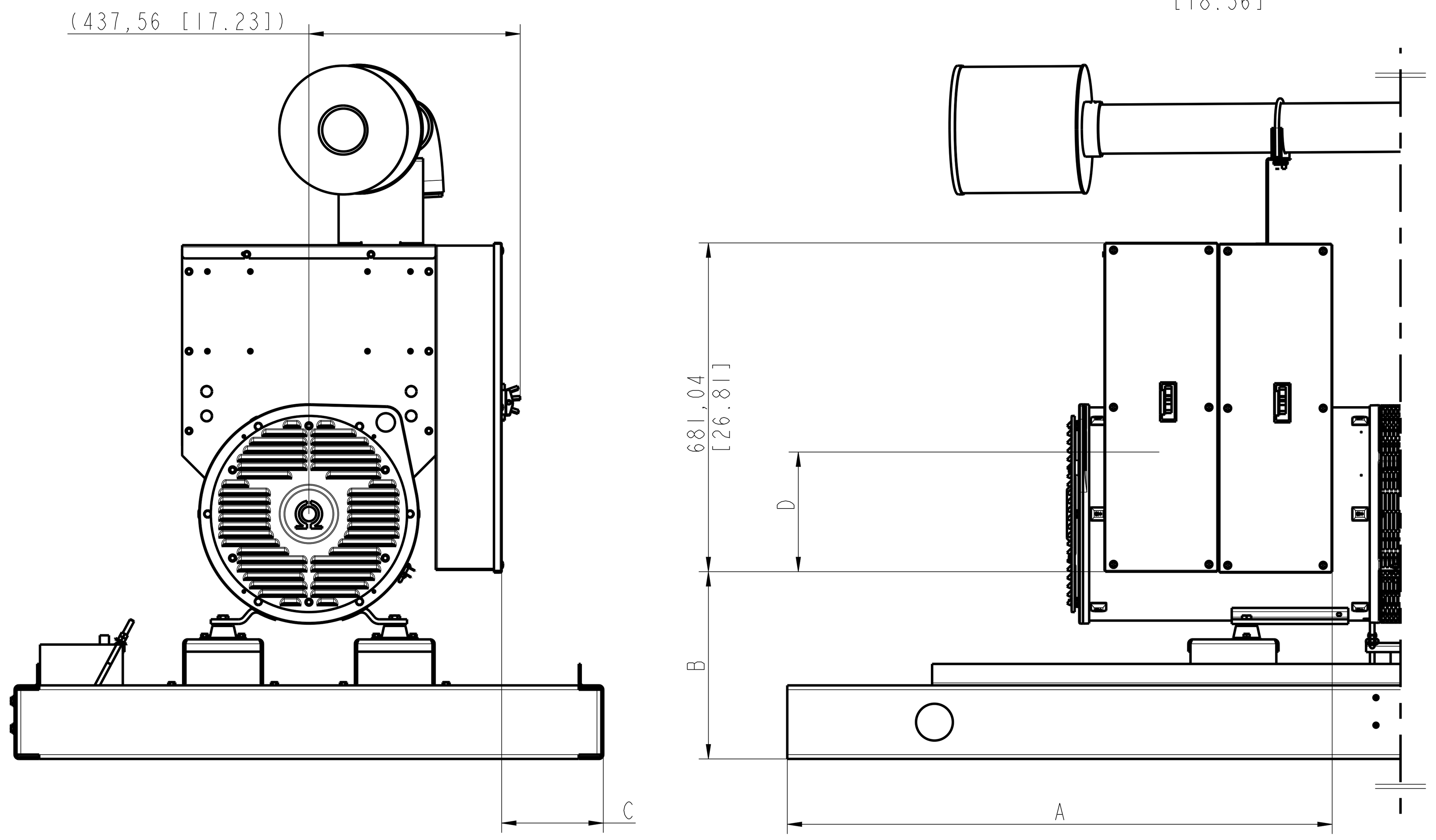
DUAL 20-250 AMP, H- & J-FRAME BREAKER				
	GENERATOR FRAME	A	B	C
HSD BASE	362 (SHOWN)	1131 [44.53]	386,6 [15.25]	207,8 [8.18]
	363	1048 [41.26]	386,6 [15.25]	207,8 [8.18]
	431	987,7 [38.89]	410,5 [16.16]	142,1 [5.59]

RIGHT SIDE SHOWN, LEFT SIDE OPTIONAL

UP TO 480V ONLY

20-250 AMP - SQUARE D H- & J-FRAME BREAKER BOTTOM CONNECTION LUGS	
CIRCUIT BREAKER	D
H-FRAME	262,1 [10.32]
J-FRAME	247,9 [9.76]





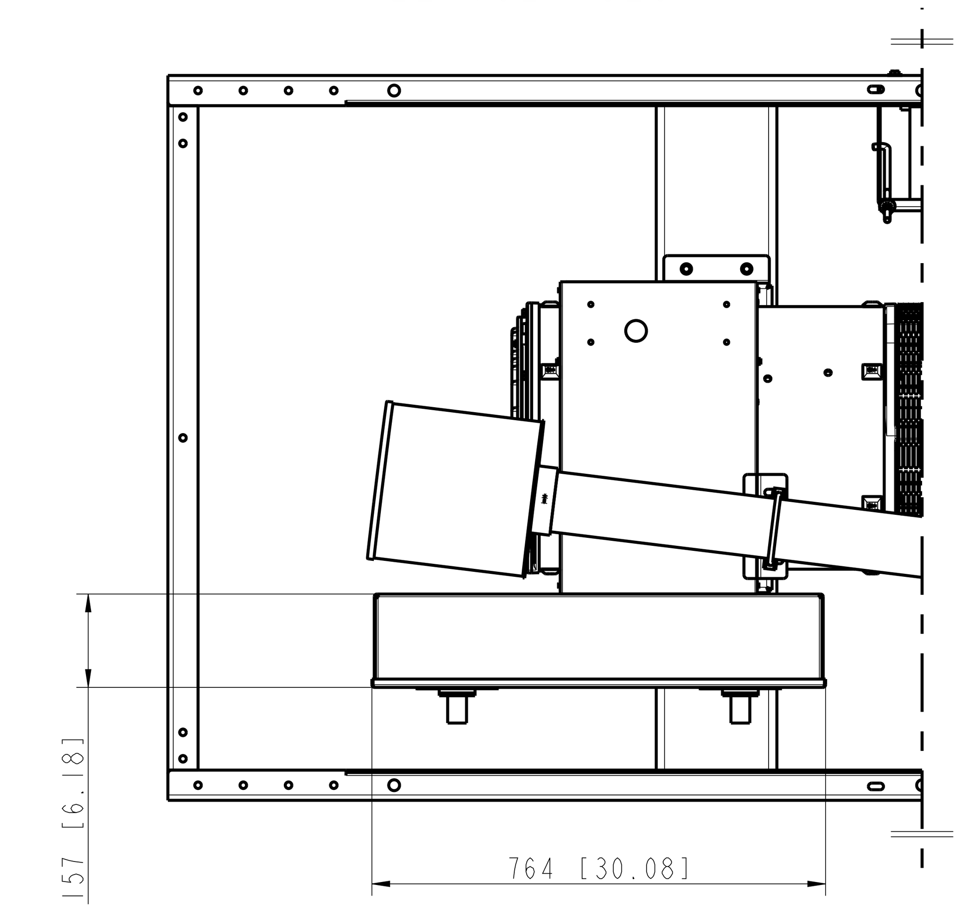
DUAL 300-350 AMP, LA/LD/P/M-FRAME BREAKER				
	GENERATOR FRAME	A	B	C
HSD BASE	362 (SHOWN)	1107,5 [43.60]	193 [7.60]	190 [7.48]
	363	1105,5 [43.52]	193 [7.60]	190 [7.48]
	431	1084,1 [42.68]	216,9 [8.54]	124,3 [4.89]

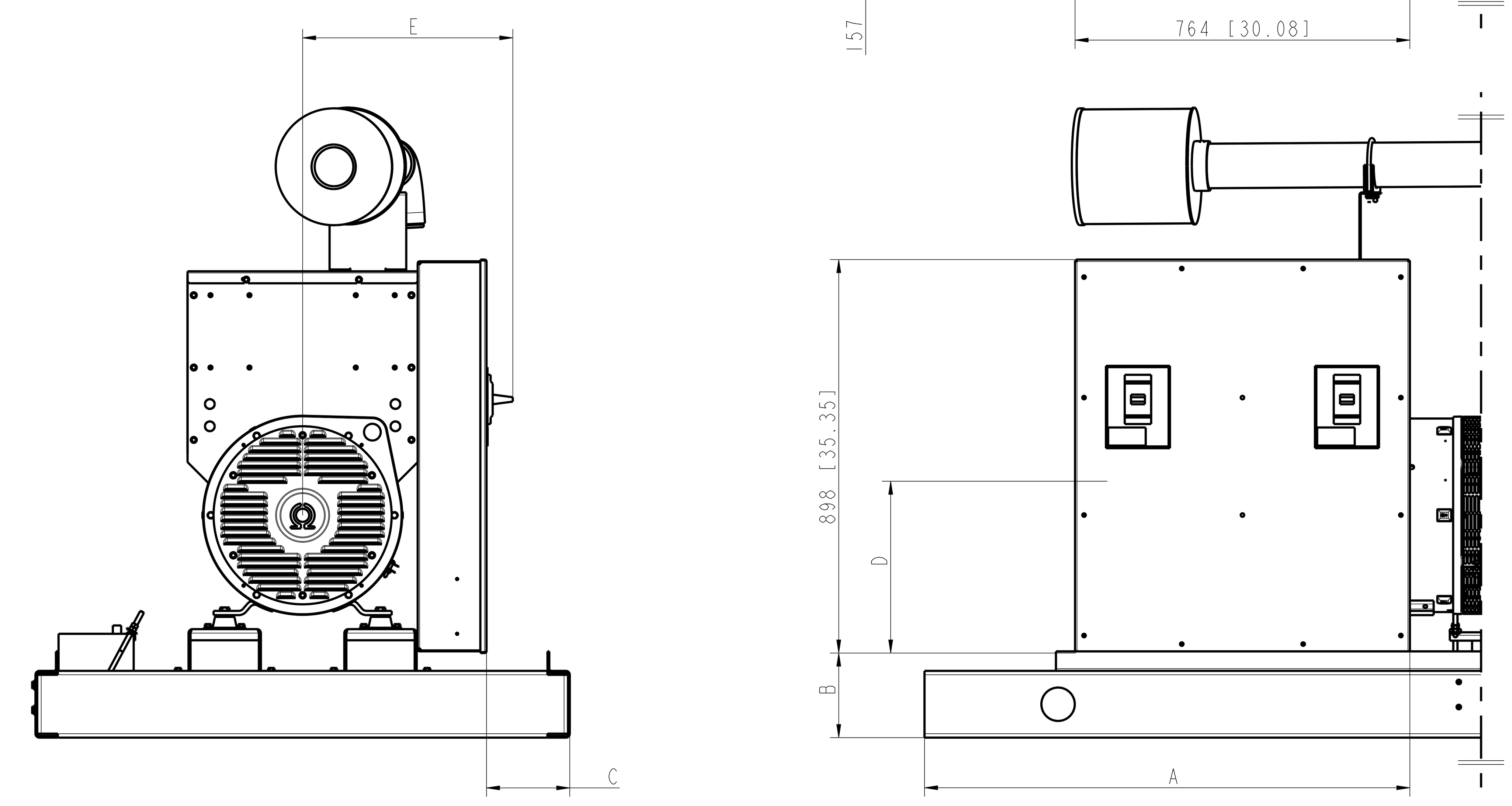
300-350 AMP - SQUARE D LD- & P-FRAME BREAKER BOTTOM CONNECTION LUGS	
CIRCUIT BREAKER	D
LD-FRAME	392,14 [15.44]
P-FRAME	398,78 [15.70]

300-350 AMP - SQUARE D LD- & P-FRAME BREAKER BREAKER DIMENSION	
CIRCUIT BREAKER	E
LD-FRAME	479,57 [18.88]
P-FRAME	504,70 [19.87]

RIGHT SIDE SHOWN, LEFT SIDE OPTIONAL

ALL VOLTAGES





DUAL BREAKER OPTIONS

Ausfuehrung u. lieferung Tech. Characteristics	Oberflaechenangaben nach MTN5033 Surface Specification per MTN5033
Oberflaechenshutz Surface Protection	
Verwedbar fuer Typ Applicable to Model	Allgemeine Fertigungs-vorschriften nach MMN 332 Production Specification per MMN 332
Projekt-/auftrags-Nr. Project/order No.	
Referenz-Nr./Reference No.	TOLERANCES .X : +/- .125 .XX : +/- .062 .XXX : +/- .031 FRACTIONAL : +/- 1/8 (UNLESS OTHERWISE SPECIFIED)

Masstab Scale: 1:10 | Masse/Mass kg: 1624.102 | Format/Size: D

Werkstoff Material: -

Halzeug, Modell, Gesenk Semifinished Product, Pattern, Die

Benennung/Title: GENSET HSD 75KW FORD 6.8L

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Zeichnungs-Nr./Drawing No.: 2000004-HSD | Revision | Blatt Sheet: 4/8

Aufgeführte Normen Relevant Standards	Passmass Fit	Abmass in Deviation in	Buchst. Rev.Ltr.	Summ' vor Frequency	Aenderung/Revision	Aenderungs-Nr. Revision Notice No.	Datum Date	Name	Gepr. Check.

TIM-ID: 0000098985 - 001

125-250 AMP J-FRAME & 300-400 AMP LA/LD/P/M-FRAME BREAKER					
	GENERATOR FRAME	A	B	C1	C2
HSD BASE	362 (SHOWN)	1060,5 [41.75]	180,5 [7.12]	210,5 [8.29]	207,8 [8.18]
	363	1060,5 [41.75]	180,5 [7.12]	210,5 [8.29]	207,8 [8.18]
	431	1191,9 [46.93]	204,4 [8.05]	144,8 [5.70]	142,1 [5.59]

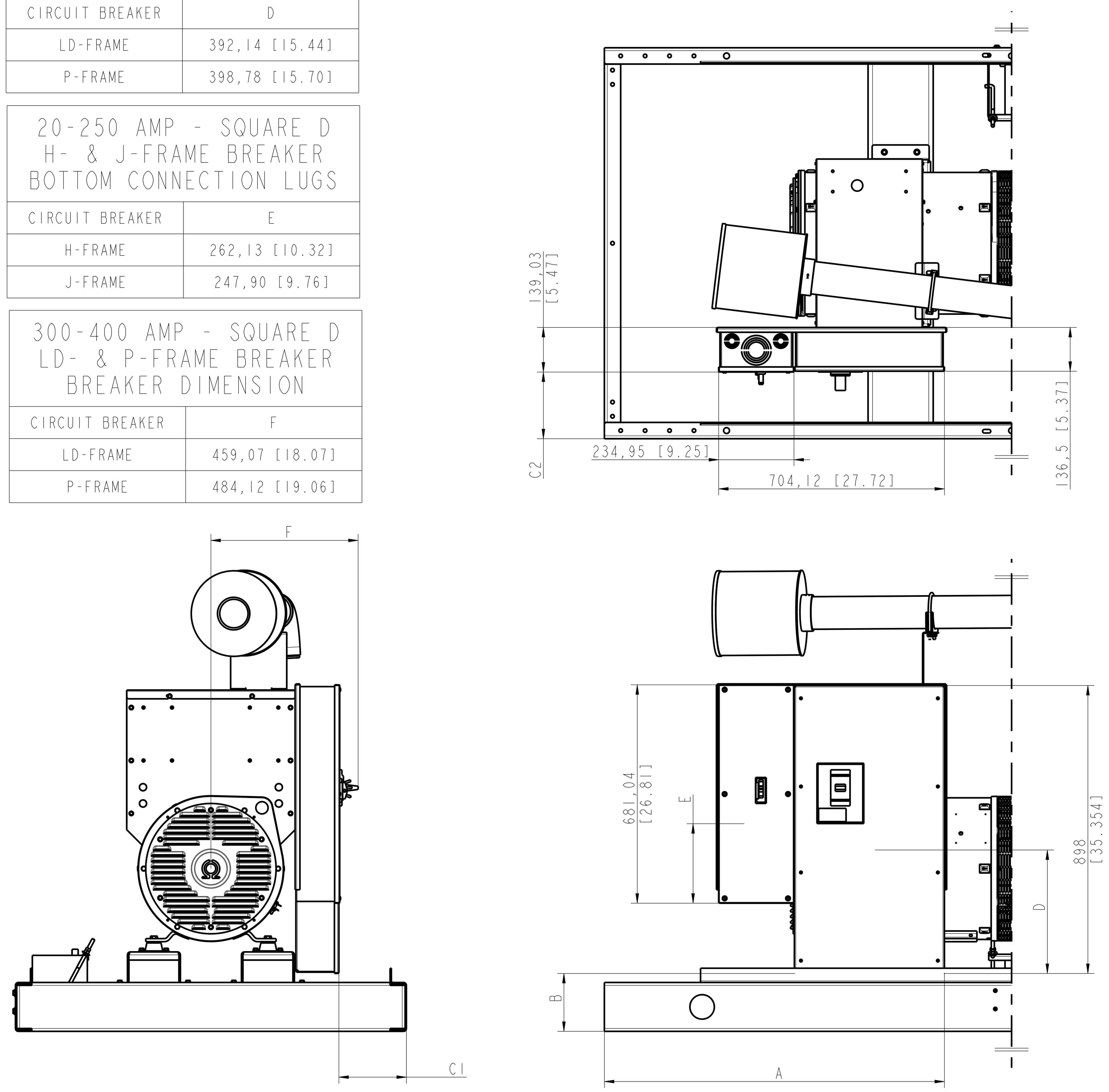
300-400 AMP - SQUARE D LD- & P-FRAME BREAKER BOTTOM CONNECTION LUGS	
CIRCUIT BREAKER	D
LD-FRAME	392,14 [15.44]
P-FRAME	398,78 [15.70]

20-250 AMP - SQUARE D H- & J-FRAME BREAKER BOTTOM CONNECTION LUGS	
CIRCUIT BREAKER	E
H-FRAME	262,13 [10.32]
J-FRAME	247,90 [9.76]

300-400 AMP - SQUARE D LD- & P-FRAME BREAKER BREAKER DIMENSION	
CIRCUIT BREAKER	F
LD-FRAME	459,07 [18.07]
P-FRAME	484,12 [19.06]

RIGHT SIDE SHOWN, LEFT SIDE OPTIONAL

UP TO 480V ONLY



DUAL BREAKER OPTIONS

Aufgeführte Normen Relevant Standards	Passmass Fit	Abmass in Deviation in	Buchst. Rev.Ltr.	Nummer Frequency	Aenderung/Revision	Aenderungs-Nr. Revision Notice No.	Datum Date	Name	Gepr. Check.

Ausfuehrung u.Lieferung Tech. Characteristics	Oberflaechenangaben nach MTN5033 Surface Specification per MTN5033	Masstab Scale 1:10	Masse/Mass kg 1624.102 · Format/Size D
Oberflaechenshutz Surface Protection		Werkstoff Material -	
Verwedbar fuer Typ Applicable to Model -	Allgemeine Fertigungs-vorschriften nach MMN 332 Production Specification per MMN 332		
Projekt-/auftrags-Nr. Project/order No.		Halzeug, Modell, Gesenk Semifinished Product, Pattern,Die	
Referenz-Nr./Reference No.	TOLERANCES .X : +/- .125 .XX : +/- .062 .XXX : +/- .031 FRACTIONAL : +/- 1/8 (UNLESS OTHERWISE SPECIFIED)	Benennung/Title / GENSET HSD 75KW FORD 6.8L	
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onsite energy		Zeichnungs-Nr./Drawing No. 2000004-HSD	Revision · Blatt Sheet 5/8

TIM-ID: 0000098985 - 001


TOP VIEW
194,808 [7.670]
FRONT VIEW
EXHAUST TUBE Ø4.00" O.D.
885 [34.843]
237,4 [9.346]
228,75 [9.006]
806,45 [31.750]
1219,2 [48.000]
LEFT VIEW
165,275 [6.507]
1076,325 [42.375]
4X INTAKE SCREEN
282,575 [11.125]
1334,25 [52.530]
1136 [44.724]
AIR OUT
304,8 [12.000]
1930,4 [76.000]
(304,8) [12.000]
2540 [100.000]
152,4 [6.000]
4X DOORS
BACK VIEW
1278,232 [50.324]
611,6 [24.079]
AIR IN
AIR IN
1909,953 [75.195]
2085,031 [82.088]
NOTES:
1) STANDARD ENCLOSURE: STEEL 150 MPH RATED (SHOWN)
2) OPTIONAL ENCLOSURES: ALUMINUM 150 MPH RATED
3) ENCLOSURES DIMENSIONALLY IDENTICAL FROM EXTERIOR.
HOUSING DIMENSIONAL
Ausfuehrung u.lieferung Tech. Characteristics
Oberflaechenshutz Surface Protection
Verwedbar fuer Typ Applicable to Model
Projekt-/auftrags-Nr. Project/order No.
Referenz-Nr./Reference No.
Oberflaechenangaben nach MTN5033 Surface Specification per MTN5033
Allgemeine Fertigungs-vorschriften nach MMN 332 Production Specification per MMN 332
TOLERANCES .X : +/- .125 .XX : +/- .062 .XXX : +/- .031 FRACTIONAL : +/- 1/8 (UNLESS OTHERWISE SPECIFIED)
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Norm. Stndr.
Abt. Dept.
Masstab Scale 1:10
Masse/Mass kg 1624.102
Format/Size D
Werkstoff Material
Halzeug, Modell, Gesenk Semifinished Product, Pattern,Die
Benennung/Title
GENSET HSD 75KW FORD 6.8L
onsite energy
Zeichnungs-Nr./Drawing No. 2000004-HSD
Revision
Blatt Sheet 6/8
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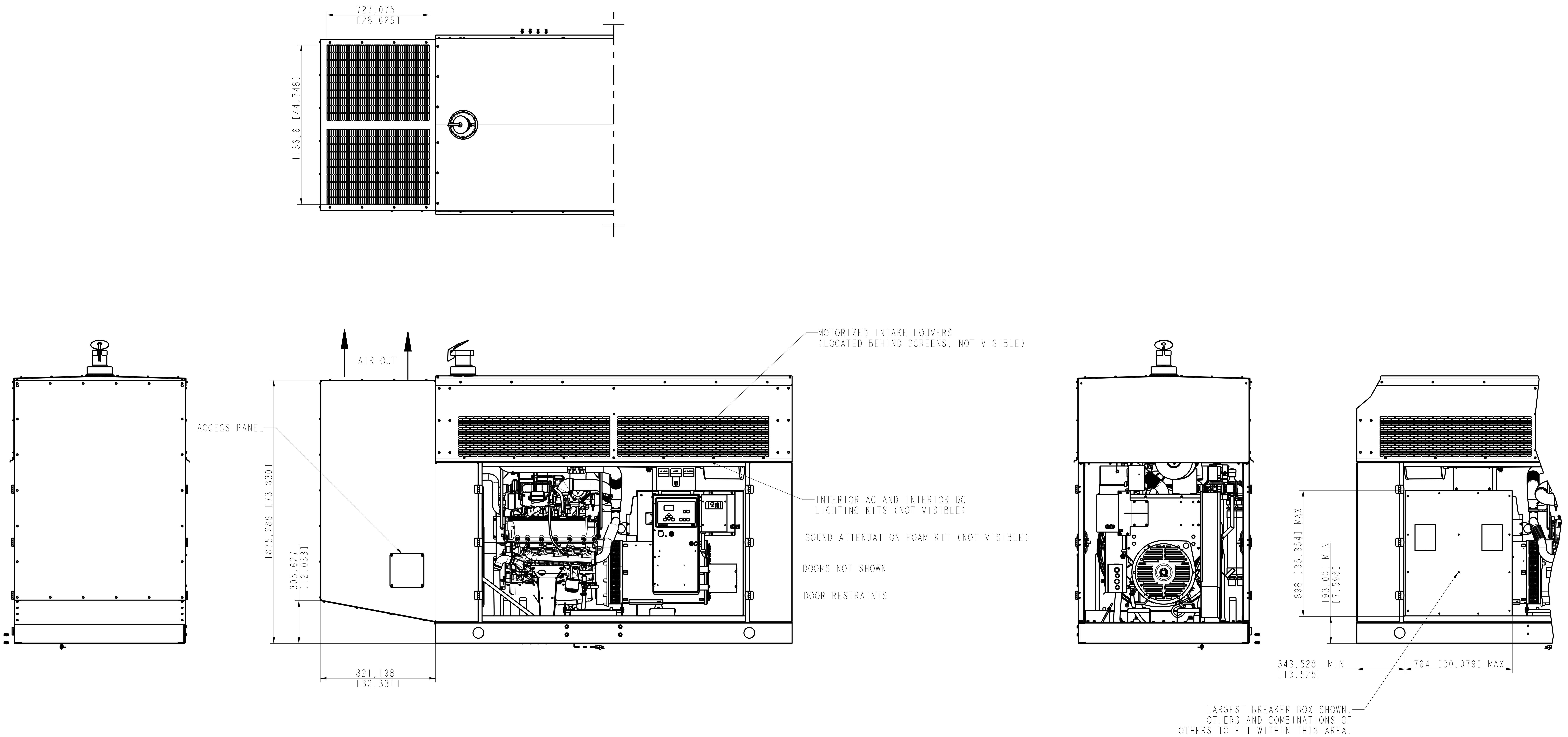
Aufgeführte Normen Relevant Standards
Passmass Fit
Aenderung/Revision
Aenderungs-Nr. Revision Notice No.
Datum Date
Name
Gepr. Check.

TIM-ID: 0000098985 - 001



EXHAUST SCOOP

HOUSING OPTIONS
DIMENSIONAL

Ausfuehrung u.lieferung Tech. Characteristics	Oberflaechenangaben nach MTN5033 Surface Specification per MTN5033	Masstab Scale 7:100	Masse/Mass kg 1624.102	Format/Size D
Oberflaechenshutz Surface Protection		Werkstoff Material _		
Verwedbar fuer Typ Applicable to Model -	Allgemeine Fertigungs-vorschriften nach MMN 332 Production Specification per MMN 332	Halzeug, Modell, Gesenk Semifinished Product, Pattern,Die		
Projekt-/auftrags-Nr. Project/order No.				
Referenz-Nr./Reference No.	TOLERANCES .X : +/- .125 .XX : +/- .062 .XXX : +/- .031 FRACTIONAL : +/- 1/8 (UNLESS OTHERWISE SPECIFIED)	Benennung/Title / GENSET HSD 75KW FORD 6.8L		

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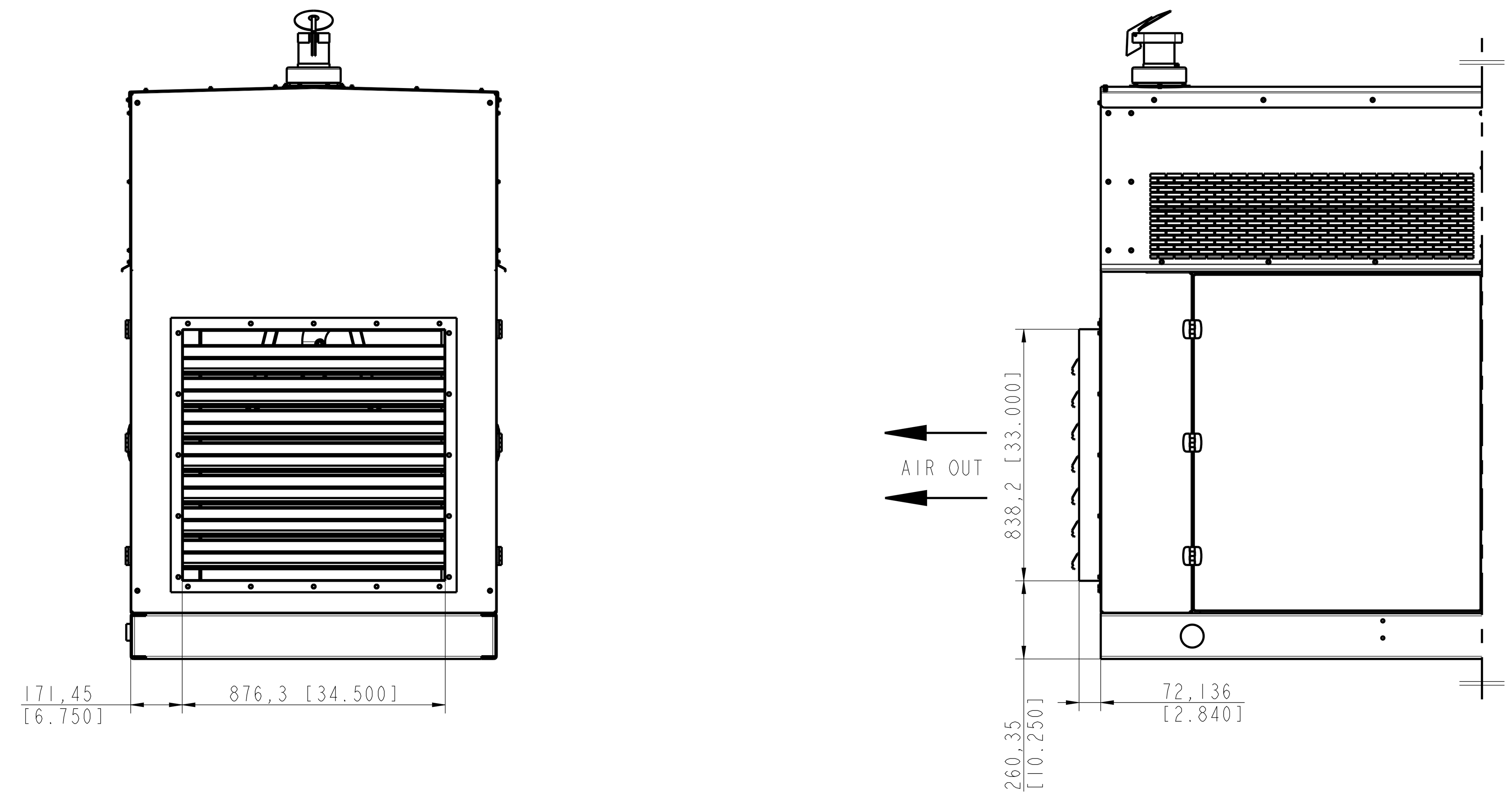
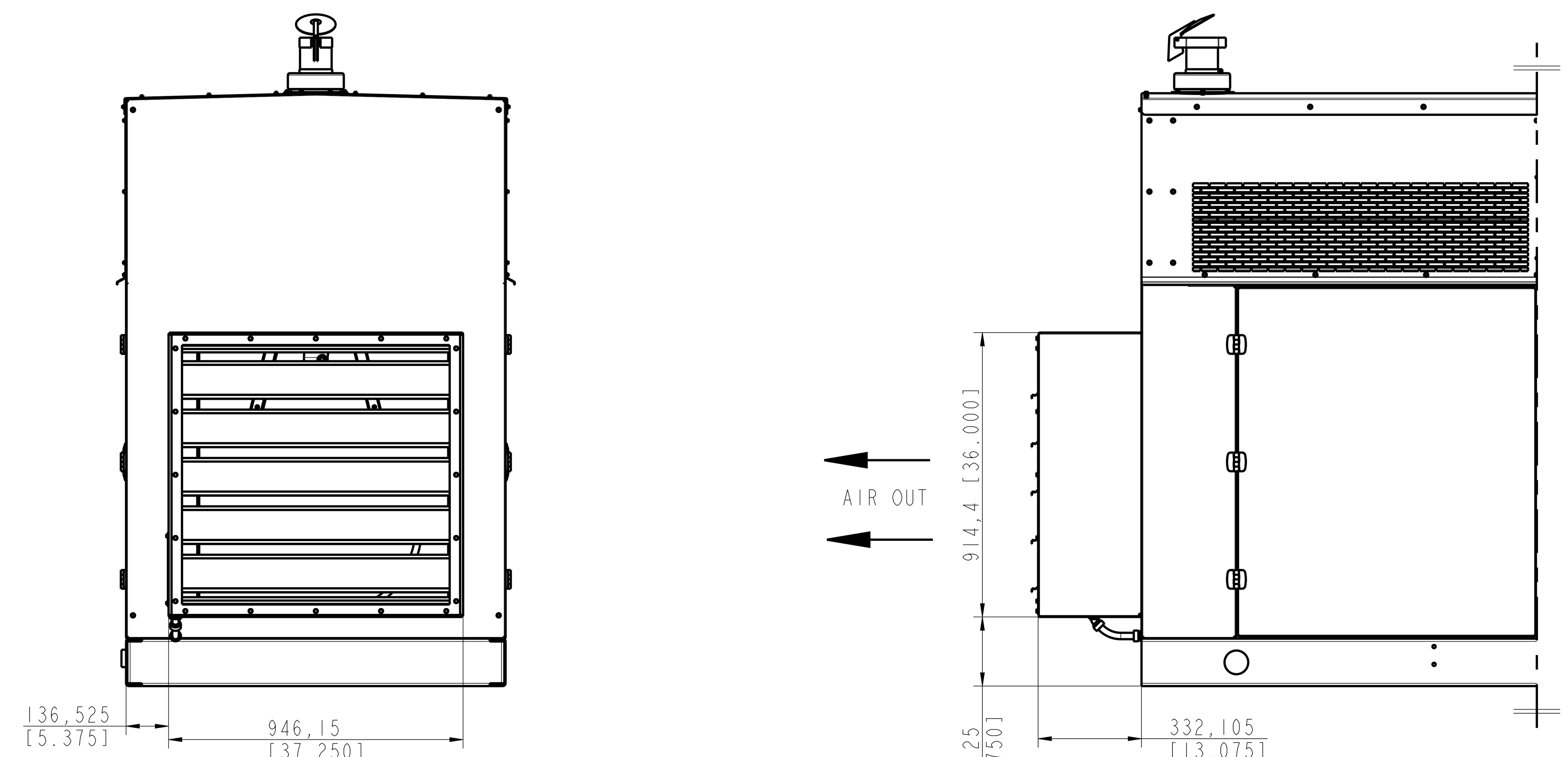
Zeichnungs-Nr./Drawing No.	Revision	Blatt Sheet
2000004-HSD		7/8

Aufgeführte Normen Relevant Standards	Passmass Fit	Abmass in Deviation µm	Buchst. Rev.Ltr.	Komml vor Frequency	Aenderung/Revision	Aenderungs-Nr. Revision Notice No.	Datum Date	Name	Gepr. Check.

TIM-ID: 0000098985 - 001



GRAVITY EXHAUST
LOUVER



MOTORIZED EXHAUST
LOUVER

HOUSING OPTIONS
DIMENSIONAL

Ausfuehrung u.lieferung / Tech. Characteristics	Oberflaechenangaben nach MTN5033 / Surface Specification per MTN5033	Masstab / Scale: 7:100	Masse/Mass kg: 1624.102 · Format/Size: D
Oberflaechenshutz / Surface Protection		Werkstoff / Material: -	
Verwedbar fuer Typ / Applicable to Model: -	Allgemeine Fertigungs-vorschriften nach MMN 332 / Production Specification per MMN 332		
Projekt-/auftrags-Nr. / Project/order No.		Halzeug, Modell, Gesenk / Semifinished Product, Pattern, Die	
Referenz-Nr./Reference No.	TOLERANCES .X : +/- .125, .XX : +/- .062, .XXX : +/- .031, FRACTIONAL : +/- 1/8 (UNLESS OTHERWISE SPECIFIED)	Benennung/Title: GENSET HSD 75KW FORD 6.8L	
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Aufgeführte Normen / Relevant Standards	Passmass / Fit	Abmass in / Deviation in	Buchst. / Rev.Ltr.	Summ vor / Frequency	Aenderung/Revision	Aenderungs-Nr. / Revision Notice No.	Datum / Date	Name	Gepr. / Check.

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