

MODEL: 400-DC6N

When contacting MTU Onsite Energy please have the following information
available:

Serial Number: 309983

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Job: 309983-1-1

Job Start Date: 06/18/2009

Job Due Date: 06/29/2009

Part: FG845054

Rev: 00

Description: 400RGDC6N 400KW DOOSAN NATURAL GAS OPU 480V

PROCESSED BY JUSTIN W 05-15-09

Configuration Summary

BASE OPTIONS

Model: 400RDC6N,

Engine Model: Doosan (21.9L)

Generator Description: GENERATOR

GENERATOR 433/6220 1&14 12W

- PMG (DVR2000)

Voltage: 480 Volt 3 Phase 12w 60Hz,

Temperature Rise: 130 Deg,

Specifications: Standard Unit,

Cooling System: 40 Deg C Cooling System,

RATINGS

KW: 400,

KVA: 500,

P.F.: .8,

ELECTRICAL DRAWINGS:

AC Drawing: 819-M-17245, MUSTAFA K (05-26-09)

DC Drawing: 819-M-16316,

PP Drawing: 819-M-16317,

MECHANICAL DRAWINGS: KYLE P. 5-19-09

Dimensional Drawing: 400RDC6N(22L)OPU-MI-207

Sub-Base Tank Drawing: - N/A -,

Overall Dimensions: 150L x 68W x 80H

Checked By: ABW

CONTROL PANEL

Control Panel: DGC 2020 Control Panel,

Mounting Instructions: Control Panel Unit Mounted,

DGC Model: DGC 2020 Expanded Outputs Control Panel

Annunciator Panel: RDP-110 (SURFACE MTD)

CIRCUIT BREAKER

BREAKER 400A 3P 600V W/ACC 24VST

MTD & WIRED RSFG

- Note: All breaker accessories are wired to a terminal strip for customer connection.

OTHER COMPONENTS

Jacket Water Heater: -20 Deg F Block Heater (240V - 6000W),

Jacket Water Heater Mounting Instructions: Block Heater Mounted & Wired,

Jacket Water Heater Accessories: Isolation Valves (2),

Battery Configuration: BATTERY RACK & ACID

Battery Charger: FCA 24-10-2411UA

Battery Charger Mounting Instructions: Charger Mounted and AC-DC Wired,

TESTING

Unit Test Procedure: Standard Commercial Test,

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PAINT

Paint Color Selected: ANSI 61 Gray,

HOUSING

Housing Option: Open Power Unit,
Exhaust Grade: No Exhaust,

FUEL TANK/TRAILER

Sub-Base Fuel Tank/Trailer: No Tank or Trailer,

MISC

Vibrator Isolators:

SPRINGS TJC-790 (12)

Shipping Instructions: Ship Unit Wet (Fluids Installed),

NOTE: Warranty is charged seperately from unit and is not part of the total price.
Warranty Selected: 2 Yr/3000 Hr Basic Stdbby Limited Warranty (Std),

End Summary:

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RAW MATERIAL COMPONENTS:

Part Number	Required Qty		Description
35198	2.00	EA	VALVE BALL 3/4" NPT BRONZE W/TEFLON SEAT, USE AS STANDARD
39015	1.00	EA	LABEL "WARNING" 6" X 4" (UL) (UNIT MAY START AUTOMATICALLY)
39016	1.00	EA	LABEL "DANGER" 6" X 3 1/2" (UL)
40511	2.00	EA	RACK BATTERY UNIT MTD 23" OAL HOLDS 4D & 8D BATTERIES--SP
41711	3.00	EA	TRANSFORMER CURRENT 800:5 600V 12.5VA SEC--SP
43339	2.00	EA	CLAMP HOSE 4" TO 5 1/2" OD HEX HEAD WORM GEAR FASTENAL#62025
44324	1.00	EA	CLAMP MUFFLER 5"
75118	12.00	EA	MOUNT VIBE SPRING (TJC) 790 LBS TWO SPRING
47418	4.00	EA	NIPPLE PIPE 3/4" NPT X CLOSE SCHED 40 BLK IRON PIPE
47426	2.00	EA	ELBOW PIPE 3/4" NPT 90 DEG SCHED 40 BLK IRON PIPE
47427	1.00	EA	ELBOW PIPE 90 DEG 1" SCHED 40 THREADED
47530	1.00	EA	NIPPLE PIPE 1" NPT X CLOSE SCHED 40 THREADED
49238	1.00	EA	GROMMET RUBBER 11/2" I.D.X23/8" O.D.X3/8" THICK
49430	2.00	EA	STUD GROUND LUG CSA TD COMPRESSION L250 --SP--
49568	1.00	EA	GROMMET RUBBER 2-7/8 OD X 1-5/8 ID X 7/16 THICK
57060	2.00	EA	FITTING HOSE 3/4" ID HOSE BARB TO 3/4" NPT MALE
58330	8.00	FT	HOSE 3/4" ID 2 PLY GREEN STRIPE FOR COOLING SYSTEMS 50' LENTGH
69102	1.00	EA	BAR BUS COPPER 12 1/4"X4"X1/2" NEUTRAL FOR 1600-2000A BREAKERS
70782	1.00	EA	LABEL VOLTAGE REGULATOR ADJUST BLACK ON SILVER (UL)
71558	2.00	EA	LABEL - GROUND (UL)
72039	1.00	EA	TAG NOTICE: COOLING SYSTEM HAS BEEN FILLED W/50/50 WATER/ETH
72044	1.00	EA	TAG CAUTION CHECK OIL LEVEL BEFORE STARTING ENGINE
72047	1.00	EA	TAG DO NOT REMOVE TAG UNTIL WARRANTY REGISTRATION COMPLETE
72709	1.00	EA	LABEL "CAUTION" FOR LOW WATER LEVEL SHUTDOWN(SEE BELOW) (UL)
72928	4.00	EA	BRACKET LIFTING HOUSED/OPU SMALL BRACKETS
72961	6.00	EA	CLAMP HOSE 4 3/4" TO 6 1/2" OD HEX HEAD WORM GEAR fastenal#62028
73369	1.00	EA	LABEL "NOTICE" DISCONNECT BATTERY CABLES BEFORE WELDING
73799	1.00	EA	LABEL "NOTICE" SERVICE ACCESS DO NOT BLOCK WITH CONDUITS(UL)
73800	1.00	EA	LABEL "NOTICE" AC&DC CIRCUITS MUST BE RUN IN SEPARATE
74819	1.00	EA	BRACKET WATER HEATER MOUNTING FOR 3000-4000-5000W KIM HEATERS
75930	1.00	EA	BRACKET BREAKER ENCLOSURE SUPPORT 433 PSL FRAME GENERATOR
75977	12.00	EA	BOOT INSULATOR FOR SPADE TERMINAL (RED) USED ON UL2200 UNITS -SP
75985	1.00	EA	TAG WARNING!!! BATTERY MUST BE FULLY CHARGED PRIOR TO START
75993	1.00	EA	HEATER TANK 6000W 240V 1PH W/THERMOSTAT 100-120 DEG F (KIM)
75994	1.00	EA	COUPLING 1" NPT --ALUMINUM-- (USED ON KIM HORZ. WATER HTRS)
76020	3.00	EA	BAR BUS COPPER 5" X 5" X 1/4" USED ON 430FRAME GENERATOR TERMINAL BLOCK
76197	1.00	EA	LABEL "WARNING" 2" X 3" (UL) "UNIT STARTS AUTOMATICALLY"
76973	6.00	FT	FLEX FUEL TRACPIPE 2" --SP-- PURCHASED IN 150' REEL
76974	2.00	EA	FITTING TRACPIPE 2" --SP-- 2" MALE ADAPTER
77199	1.00	EA	REGULATOR VOLTAGE MAVC63-4D UL
77823	1.00	EA	DECAL "MADE IN THE USA"
77961	1.00	EA	SENSOR WATER LEVEL "LEVELPRO" 1/4" NPT -W/DELAY- (NEW)
79049	1.00	EA	SENDER TEMPERATURE 100-230 DEG F 1/8" NPT USE W/GAUGE 45974
79113	2.00	EA	FITTING HOSE 3/4 HOSE BARB TO 1" N.P.T. (SOCKETLESS)
80411	2.00	EA	BRACKET BATTERY HOLD DOWN BAR (USED W/ 40511 BATTERY RACK)
82657	1.00	EA	BOX OUTLET 430 FRAME GENERATOR TOP PANEL
82658	1.00	EA	COVER PLATE; DVR REGULATOR CUT-OUT

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82664	1.00	EA	BOX OUTLET 430 FRAME GENERATOR REAR PANEL
82665	1.00	EA	BOX OUTLET 430 FRAME GENERATOR ENGINE PANEL
82666	2.00	EA	BOX OUTLET 430 FRAME GENERATOR LEFT/ RIGHT PANEL
85237	1.00	EA	CHARGER BATTERY 24V 10A 120VAC SENS MODEL: FCA24-10-2411U
83389	1.00	EA	TAG "IMPORTANT" REFER TO INSTALLTION GUIDE PRIOR TO...
85911	1.00	EA	ADAPTER BASE MTD FUEL INLET 2" NPT (USE ON GTA8.3G2)
86639	1.00	EA	DOCUMENTATION MANUAL - MTU-C HARD COPY
76747	1.00	EA	GENERATOR 433/6220 SPECIAL SAE 1 FLYWHEEL 14 12W
86819	1.00	EA	ENGINE DOOSAN 21.9L 24V -PROTO SAE 1 FLYWHEEL 14 400KW
87005	1.00	EA	NAMEPLATE - BLANK GEN-SET (ANODIZED)
87052	1.00	EA	BRACKET BATTERY CHARGER MOUNTING FOR 10 AMP CHARGER -SP-
87053	1.00	EA	BRACKET BATTERY CHARGER SUPPORT ANGLE FOR 10 AMP CHARGER -SP-
87832	4.00	EA	MOUNT VIBE 1 1/4" NEOPRENE (REPLACES 46900) W/ 5/16-18 X 9/16" STUD FOR PANEL
88381	1.00	EA	BASE (150L X 68W X 10 RAIL) HSG-631 (400KW DOOSAN)
88476	1.00	EA	BELT GUARD (300KW & 400KW DOOSAN)
88478	1.00	EA	FLANGE DUCT FOR DOOSAN 400KW
88479	1.00	EA	HEADER "Y" EXHAUST (DOOSAN) 300KW-400KW
88495	1.00	EA	BRACKET; 400KW DOOSAN
89619	16.00	EA	OIL FOR WEIGHT CALCULATION ONLY
89620	27.00	EA	COOLANT (50-50 GLYCOL MIX) FOR WEIGHT CALCULATION ONLY
90191	1.00	EA	TUBE PLASTIC 1 1/2" DIA OD 4" LONG TO RODENT PROOF PANELS
47420	1.00	EA	NIPPLE PIPE 2"NPT X CLOSE SCHED 40 THREADED SP fastena#10270-06589
93275	1.00	EA	NIPPLE PIPE 2" NPT X 3" LG SCHED 40 BLK IRON THREADED
48670	1.00	EA	NIPPLE PIPE 2" NPT X 4" LG SCHED 40 THREADED SP
48671	1.00	EA	NIPPLE PIPE 2" NPT X 8" LG SCHED 40 THREADED
94094	8.00	EA	BOLT M12-1.5 X 20 SHCS
49816	8.00	EA	WASHER FLAT 1/2" (GOLD)
80440	4.00	EA	STRAP 3" LIFTING HOLE COVER (USED W/ 80425 COVER PLATE)
80425	4.00	EA	COVER BASE HOLE 3" (NEW STYLE) (USED W/ STRAP 80440)
46227	1.00	EA	SWITCH PRESSURE 20PSI 2P0 25A 1/4NP USED FOR HTR DISCONNECT
47191	20.00	FT	WIRE 10 AWG 90 DEG C BLACK TYPE THHN 600V STRANDED
47193	10.00	FT	WIRE 10 AWG 90 DEG C GREEN TYPE THHN
47404	1.00	EA	NIPPLE PIPE 1/4"NPT X CLOSE SCHED 40 BLK IRON PIPE
48530	1.00	EA	TEE PIPE 1/4" NPT SCHED 40 BLK IRON PIPE
47471	2.00	EA	FITTING HOSE ADAPTER #4 FLARE MALE TO 1/4" PIPE
49216	10.00	FT	CONDUIT FLEXIBLE 1/2" GREENFIELD LIGHT WALL
78682	10.00	FT	HOSE WIRE BRAID REINFORCED #4
78689	2.00	EA	FITTING HOSE #4 FEMALE SWIVEL 45DEG REUSABLE FOR WIRE BRAID
82197	1.00	EA	PLATE OIL PRESSURE DISCONNECT FOR (1)4000-6000W HEATER
86623	2.00	EA	CONNECTOR 90 DEGREE 1/2" FOR 1/2" FLEX CONDUIT
86624	2.00	EA	CONNECTOR STRAIGHT 1/2" FOR 1/2" FLEX CONDUIT
42828	3.00	EA	FUSE 10A 600V JX6-10
42820	1.00	EA	BLOCK FUSE 3 POLE 600 VOLT FOR 13/32" X 1 1/2" FUSES
73156	1.00	EA	BOX HANDY SCREW COVER 12X8X4 NO KNOCKOUTS
73512	1.00	EA	PMG KIT W/DVR2000 FOR NEW STYLE 430F GENERATORS
77943	1.00	EA	BOX COVER HANDY BOX USED W/DVR2000 (FITS HANDY BOX P/N 73156)
90093	2.00	EA	PLUG VENT - FINISHING 1.750 ID BLACK
83433	1.00	EA	PANEL REMOTE ANNUNCIATOR (MTU) (SURFACE) DGC-2020/1000/500
44981	1.00	EA	BREAKER 400A 600V 3P
44982	1.00	EA	ENCLOSURE BREAKER NEMA 1 TJ400S ORDER W/NEUTRAL BLOCK TNIA400
86478	1.00	EA	SHUNT TRIP CB 300-600A 24V -CORELINE- "TJ"

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75486	2.00	EA	BATTERY 12V COM-8DP ENGINE STARTING -BATTERY WET-
80592	1.00	EA	FLEX EXHAUST SS OAL 21" 5 1/16" SLV TO STD 8" FLG

Description: ASY CONTROL PANEL DGC 2020 (DOOSAN)

Part: FG845054 / 400RGDC6N 400KW DOOSAN
NATURAL GAS OPU 480V

RAW MATERIAL COMPONENTS:

Part Number	Required Qty		Description
86131	1.00	EA	MICROPROCESSOR DGC-2020 (MTU) "EXPANDED OUTPUT" UNIT
78963	1.00	EA	ENCLOSURE 45K & 50K --NEW-- BACK PLATE NOT INCLUDED
86498	1.00	EA	FACE PANEL 45K KDGC-2020 -STD- W/E-STOP NEW BELOW FOR NOTES
82248	1.00	EA	PLATE PANEL BACKING 45K/50K STD 45/50K PANEL BACKING PLATE
40218	1.00	EA	ALARM BUZZER 12-24VDC STD PANEL ALARM SONALERT
42806	2.00	EA	HOLDER FUSE 20A 1P PANEL MTG FITS TYPE AG FUSES--SP
73395	1.00	EA	KNOB PULL BLACK PHENOLIC THREADED INSERT 8-32
77832	1.00	EA	LATCH SLOTTED RECESS STYLE USED ON CONTROL PANELS FOR CSA
71116	1.00	EA	SWITCH E-STOP MAINTAINED 10A ILLUMINATED 1 NO & 1 NC
86494	1.00	EA	HARNESS WIRING PANEL KDGC-2020 STD PANEL HARNESS
76718	2.00	EA	LABEL "DANGER HIGH VOLTAGE" 1.125" X 1.875" (UL)
77365	1.00	EA	PROTECTOR TERMINAL STRIP SP FOR 45/50K PANELS
77828	2.00	EA	BEARING FLANGED PLAIN SLEEVE NONMETALLIC 1/4" ID
77829	2.00	EA	BOLT (FEMALE) SEX 10-24 1" LONG W/ 1/4" O.D. BARREL
77830	1.00	FT	ROD THREADED 10-24 UNC 11.75"L ZINC PLATED STEEL



100 Power Drive, Mankato, MN 56001
800-325-5450
A Tognum Group 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 ____		

GENSET 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 Online 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.

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?

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

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

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.

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 Chrg. 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



MTU Onsite Energy Corporation 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 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 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 two (2) years from invoice date or 3,000 hours of use, whichever is earlier. Accessories: Parts and labor for one (1) year from invoice date or 3,000 hours of use, whichever is earlier. The warranty period can be adjusted to the date of start-up if start-up is completed within twelve (12) months of invoice date. For a description of accessories and items excluded from this Limited Warranty, review the listings on the reverse side of this document.

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 to 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. Buyer must deliver the Product to Seller at its factory in Mankato, MN or other point designed by Seller. Buyer shall bear the full cost and risks involved in delivering the Product to Seller. 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.

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, contact MTU Onsite Energy, Attention: Service Department, 100 Power Drive, Mankato, MN 56001, (507) 625-7973.

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 roundtrip.
 - n. Any equipment not factory approved and engineered for use on MTU Onsite Energy products. This includes but is not limited to after market 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, 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 Owners 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.
 - 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.
 - bb. Any repair labor time that is determined to be excessive, e.g., two or more people performing a one-person job.
 - cc. Any expenses associated with investigating performance complaints in which no defect is found.
 - dd. Any associated costs for replacing components that are found not to be defective.
 - ee. 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 invoice date include but are not limited to:
 - a. Water heaters
 - b. Load banks
 - c. Tap changing switches
 - d. Day tank pumps and controls
 - e. Hand priming pumps
 - f. Oil leveler systems
 - g. Gas solenoid valves
 - h. Gas flex pipes
 - i. Cords, receptacles, and cord reels
 - j. Housing lights, space heaters, and associated equipment.

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TERMS & CONDITIONS

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.

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 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 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 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. Buyer must deliver the Product to Seller at its factory in Detroit, MI or other point designated by Seller. Buyer shall bear the full cost and risks involved in delivering the Product to Seller. 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.

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: Storage charges are applicable for equipment stored at MTU Onsite Energy for a period longer than 30 days from the date the product is ready for delivery and/or the date posted on the Delivery Notification Form, whichever occurs later.

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Operating Instructions

MANUAL START:

If the Engine-Generator Set is located in a closed space, start the ventilation fan or open the doors and windows to allow an ample supply of air to the unit.

- A. Place the generator circuit breaker in the **OPEN** position.
- B. Put the engine control in the **MANUAL / RUN** position.

NOTE: If the engine does not start, check the Operator's Manual.

MANUAL:

- C. Check the unit frequency. Speed should be 3 to 5 % of rated speed (60 Hz). If not, refer to Installation and Basic Operation Guide for governor adjustment.
- D. Check the unit AC voltage. (If the AC voltage is not reading correct, refer to the Operator's Manual for the proper procedure to adjust the voltage regulator to the rated voltage.)
- E. Check engine parameters, via gauges or by scrolling through the microprocessor control panel for proper readings.
- F. Close the generator circuit breaker.

The Engine-Generator Set is now ready to supply power to the load and will continue to supply power until the operator shuts down the set or an engine failure occurs.

MANUAL SHUTDOWN:

- A. Open the generator circuit breaker, move handle to the **DOWN** position.
- B. Put the engine control in the **OFF** position.
NOTE: Following daily service or other maintenance on generator set, place the engine control to desired operating mode. When desired operating mode is automatic, reset the generator circuit breaker by placing its handle in the **UP** position.

EMERGENCY STOP PUSH BUTTON: (OPTIONAL EQUIPMENT)

In case of emergency the operator may shutdown the generator set by pushing the red mushroom head button. If equipped, this is located in the lower right corner of the control panel. This will stop and lock out the generator set. The push button's red light will also turn on to indicate the generator was stopped, by initiating the emergency stop button. The red push button must be pulled out to reset the generator set and turn off the red indicating light. Place the engine control to the "OFF" position to reset the engine control before restarting the unit. Reset the main line circuit breaker before returning the generator set to "AUTOMATIC" operation.



AUTOMATIC OPERATIONS

For automatic operation the Engine-Generator Set will be controlled by the automatic transfer switch and the automatic engine control.

- A. For detailed operations of the transfer switch, refer to the Operations Manual supplied with the transfer switch.
- B. For detailed operations of the automatic engine control, refer to Operations Manual, supplied with the Genset.
 - I. Standby State
 - (a) Leave the engine control in the “AUTO” position.
 - (b) Leave the generator set circuit breaker in the “ON” position.
 - II. Power Fails
 - (a) The remote start contact in the transfer switch will close and complete a circuit to the automatic start control terminals marked “E” in the control panel.
 - (b) This will cause the engine to start and come up to speed and voltage, then transfer to the load to the Engine-Generator Set.
 - III. Power Returns
 - (a) The load transfers back to normal power after a time delay (if provided).
 - (b) The remote start contact in the transfer switch will open after a time delay (if provided), and the unit will shutdown and be ready for the next power failure.



WEEKLY CHECK LIST EXPLANATION

Rev. 20060728

- Date: - fill in the date of the inspection.
- Ambient Temp: - record outside or room air temperature.
- Oil Level: - record the level from the oil dipstick and the amount of oil added to engine if it was needed.
- Water Level: - record the level of the water in radiator and the amount of water added to radiator if it was needed.
- Heaters: - feel the block heater inlet and outlet hoses to make sure they are warm.
- Belts: - check belts to make sure they are tight.
You cannot hear loose belts over the unit noise.
Make sure the engine control is in the "OFF" position.
- Battery Charger: - visual inspection of charger to verify operation. If equipped with a dial meter verify charge rate. If equipped with LEDs verify LEDs lit. **Red** LED only indicates battery discharged, charging at "Bulk" rate. **Red & Green** LED only indicates charger charging at "Absorption" rate. **Green** LED only indicates "Float" rate, battery is fully charged.
- Battery Levels & Cables: - make sure batteries are full of water, cables are tight and battery posts are clean.
- Leaks: (Oil-Water-Fuel) - check all hoses and connections for dripping, tighten hose clamps if needed.
- Amps: - when the unit is running with load, record the amp reading.
- Volts: - when the unit is running with load, record the volt reading.
- Frequency: - when the unit is running with load, record the hertz reading.
- Oil Pressure: - when the unit is running with load, record the oil pressure.
- Water Temperature: - when the unit is running with load, record the water temperature reading once stabilized.
- BC Volts: - battery charger DC voltage reading.
- RTM: - running time meter total should be recorded before each test - this will allow you to determine if the unit has run since the last exercise.
- ATS: - automatic transfer switch should be filled in as "OK" if the test performed a load transfer properly.
- Mechanic: - should be initialed by the person doing the test.

[illegible]



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:** _____



Installation and Basic Operation Manual

MTU Onsite Energy Corporation
100 Power Drive, Mankato, MN 56001
Phone 800-325-5450 www.mtu-online.com
Installation_Basic_Manual_MTU_4-09

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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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.

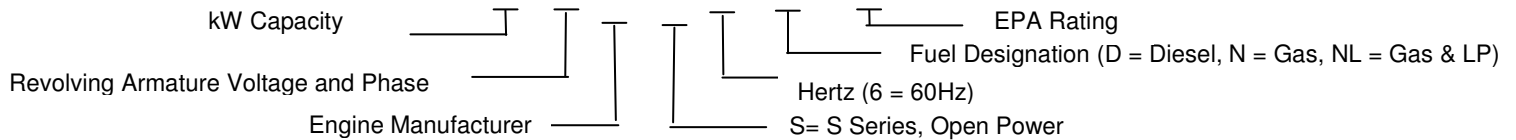
Model Designation: _____

Serial Number: _____

HOW TO READ MODEL NUMBERS

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

60 * J S 6 D T2





Forward

This Installation Guide provides general instructions for installing your MTU DD 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 DD 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 DD does not guarantee the result of any installation contained in this manual. Nor can MTU DD assume responsibility for any injury or damage to property. Persons engaging in installation do so entirely at their own risk.



Figures and Tables

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

Figure 1-1.....	Typical generator set installation
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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 Detroit Diesel Power Generation 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 1 pound (500 grams) 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:

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 100 psi or above. The tank pressures are regulated down. Vaporized LPG systems operate at pressures near 6 oz., 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 SHOCK

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.

1

General

When installed properly and according to applicable codes, your MTU DD 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

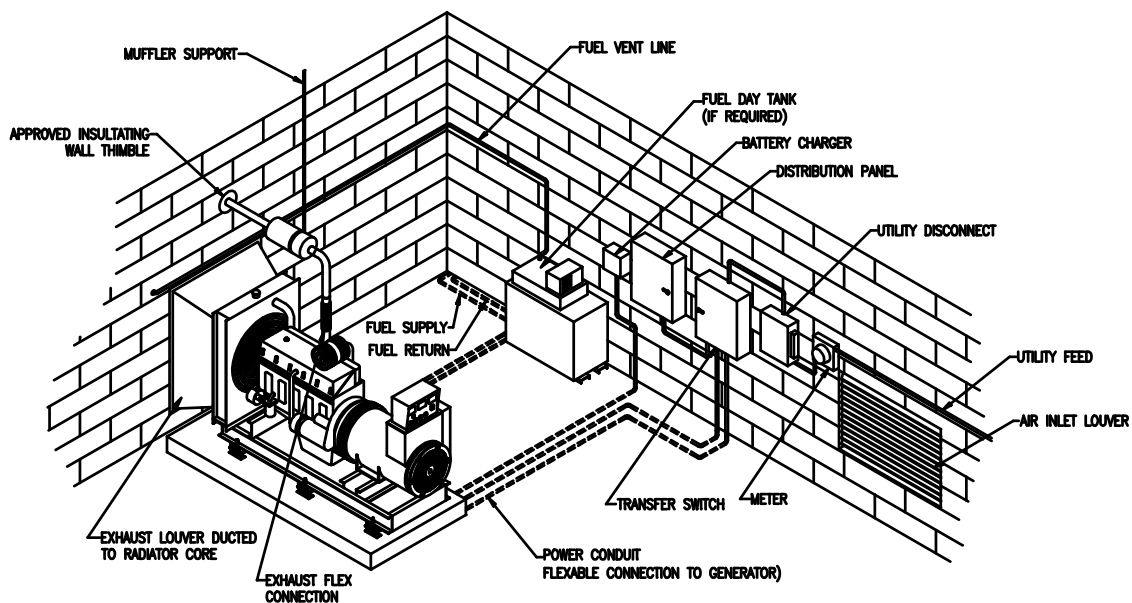


Figure 1-1: Typical generator set installation

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 DD 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.

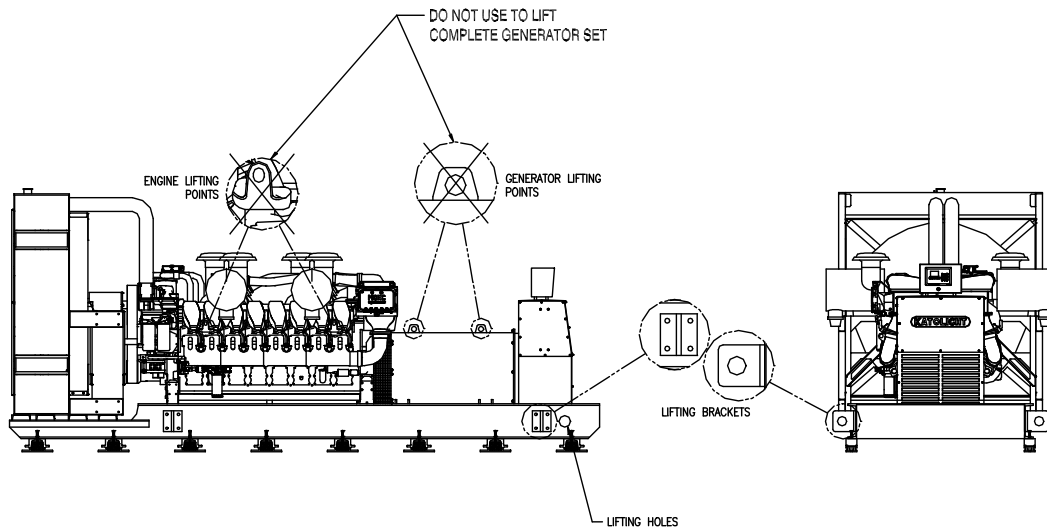


Figure 2-1: Lifting provisions

3

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 3 feet between an installed generator set and adjacent walls or other electrical equipment should be maintained on 3 sides of the generator set. Clearance of 5 feet 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 60 degrees, 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 32 degrees Fahrenheit.

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

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.

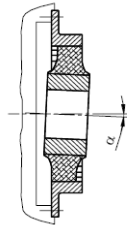
FIELD ALIGNMENT

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.

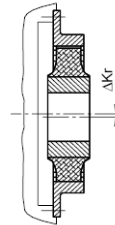
After final installation, the following measurements must be checked to confirm proper alignment as noted in the table and illustration below:

Measurement	Specification
Angular Displacement	Less than or equal to $.3^{\circ}$
Radial Displacement	Less than or equal to .059 inches
Axial Displacement	Less than or equal to .157 inches

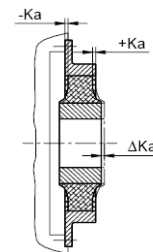
Angular Displacement



Radial Displacement



Axial Displacement



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.

NOTE: This effects S4000 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 2500 psi concrete reinforced with 8-gage wire mesh or number 6 reinforcing bars on 12-inch (30-cm) centers.

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

BASE	W_u
DEPTH =	$d * w * l$

Where W_u = engine-generator set weight in pounds
 d = concrete density (usually 145 lbs per cubic foot)
 w = foundation width in feet
 l = foundation length in feet

The inertia pad should be a minimum of 12 inches wider and 12 inches longer than the unit base. The inertia pad may be constructed higher than the floor level by 3 to 8 inches 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 8 to 10 inches 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.

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.

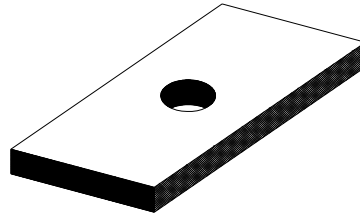


Figure 4-1: Typical pad type vibration

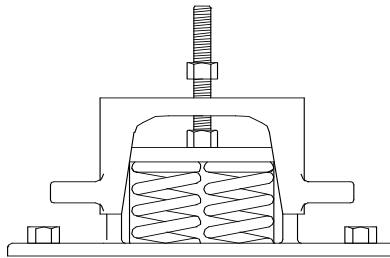


Figure 4-2: Spring mount vibration isolator

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

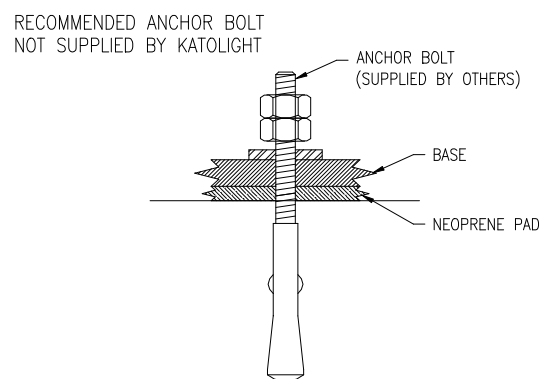


Figure 4-3: Recommended anchor bolt

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.

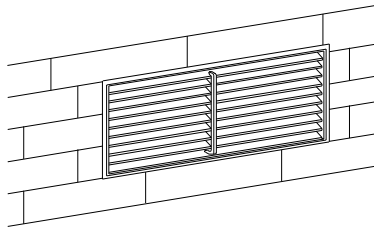


Figure 5-1: Typical center top pivoted louver

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.

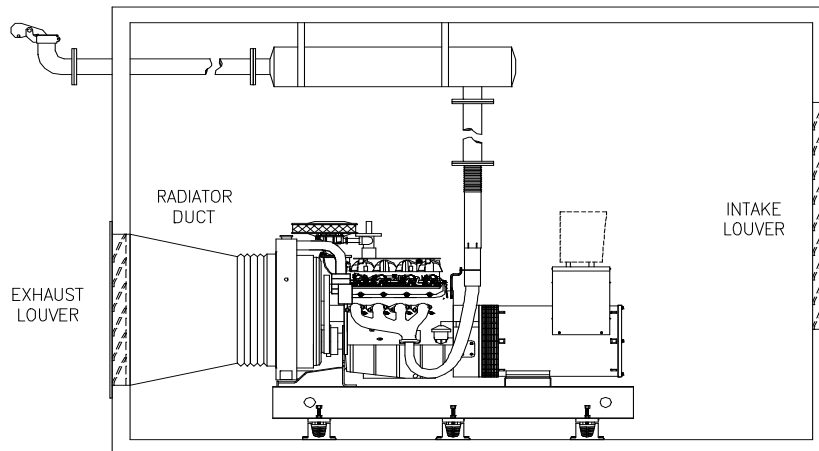


Figure 5-2: Typical installation with louvers

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 100°F. Allowable room air temperature rise is 20° to 30° F.

$$V = \frac{Q}{0.018 \cdot \Delta T}$$

Where V = Air flow through the engine-generator room (CFM)
 Q = Engine-generator set radiated heat (BTU/min)
 ΔT = Allowable room air temperature

Higher elevation installations will require increased airflow. Add 10% for each increase of 2500 feet. 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.

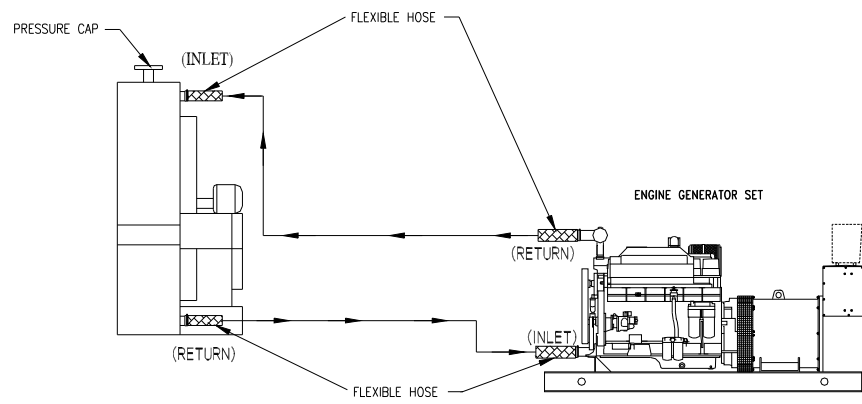


Figure 5-3: Typical remote radiator installation

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.

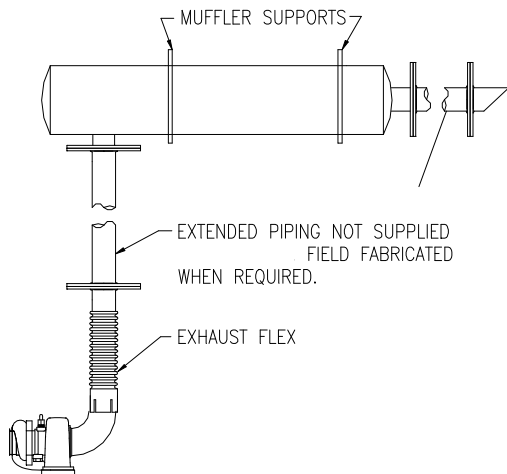


Figure 6-1: Typical side inlet exhaust

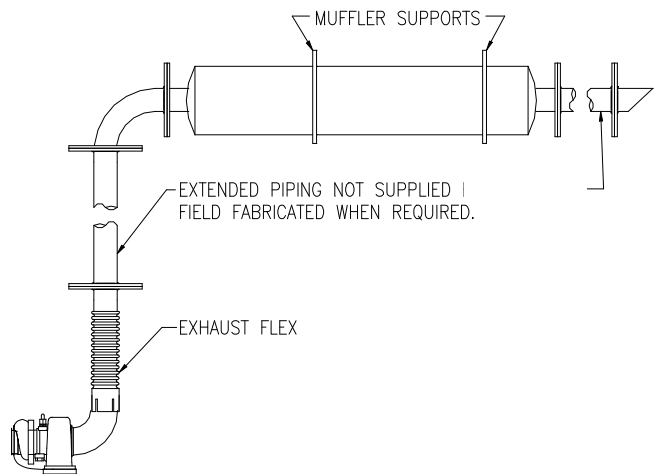


Figure 6-2: Typical end inlet exhaust

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.

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 DD 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.

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 800~F (427~C) to over 1200~F (649~C) for some engines, seamless stainless steel should be used for the flexible section.

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 (9) inches 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.

WALL THIMBLES

Approved wall thimbles should be constructed so that they extend at least (6) inches 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.

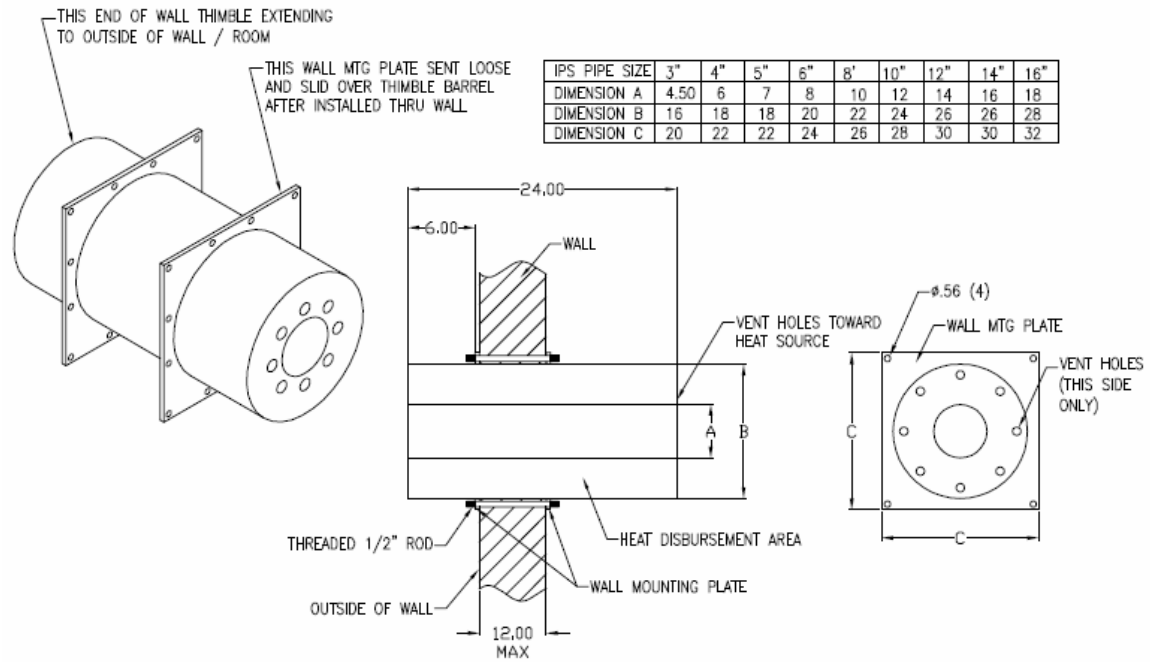


Figure 6-3: Wall thimble installation

TYPE OF FITTINGS (In Inches)	1-1/2	2	2-1/2	3	3-1/2	4	5	6	8	10	12
Standard Elbow (In Feet)	4.4	5.3	6.4	8.1	9.6	11	14	16	21	26	32
Long Rad. Elbow (In Feet)	2.8	3.5	4.2	5.2	6	7	9	11	14	17	20
Med. Rad. Elbow (In Feet)	3.6	4.6	5.4	6.8	8	9	12	14	18	22	26
Standard Tee (In Feet)	9.3	13	14	17	19	22	27	18	44	56	67

Table 6-1: Equivalent lengths of pipe fittings

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 5 feet 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 5 feet, a transfer pump is required. As a general rule, when static head and dynamic suction (horizontal head) exceed 6 inches hg (column mercury) 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 12 inches 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, (except for Cummins engines). 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 be 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.

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.

When installing the day tank for Cummins engines, make certain the tank is at, or slightly below, the level of the fuel filters to assure maintenance of fuel system prime. However, the top of the day tank must be below the injector drain connection of the engine.

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.

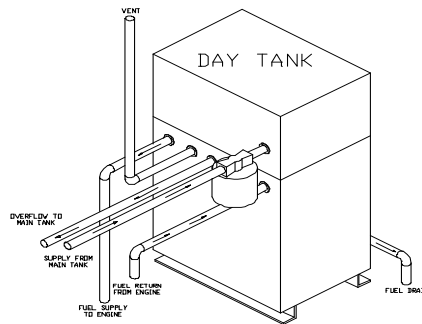


Figure 7-1: Fuel day tank

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 DD 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 DD 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 5000 feet or in cold weather (below 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.

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 1000 BTU per cubic foot, 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 20 psi maximum) is allowed inside the building. The vaporizer must be mounted below the level of the engine water pump and within 25 feet 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 7 to 11" of water column (4 to 6 ounces) 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 0.5" H₂O which allows for a normal amount of restriction from fittings.

Table 7-1, Gaseous Fuel Pipe Capacity, lists the capacity of various sizes and lengths of pipe. The capacity (in cubic feet per hour) is calculated using the specific gravity of 0.6 as base. A pressure drop of 0.5" (water column) is used to account for a nominal number of fittings and metering equipment in this table.

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 4 to 6 ounces per square inch.

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 DD 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 DD.

DETERMINING PIPE SIZE FOR GASEOUS FUEL SYSTEMS

1. Obtain the fuel consumption in cubic feet per hour 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
.65	Natural Gas	.962
1.00	Air	.775
1.50	Propane	.633
2.10	Butane	.535

3. Divide the fuel consumption from step 1 by the correction factor to obtain adjusted flow rate.
4. Determine length of pipe between the fuel source and generator set.
5. From table 6.1, 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 3 is encountered.
7. Move horizontally to the left column to determine the correct pipe size.

Iron Pipe Size (in.) Nominal	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	430	400	360	325	300	280	260
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

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 6.1 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

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 DD 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 DD generators.

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.

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 100 feet with No. 12AWG wire from the generator set control cabinet.

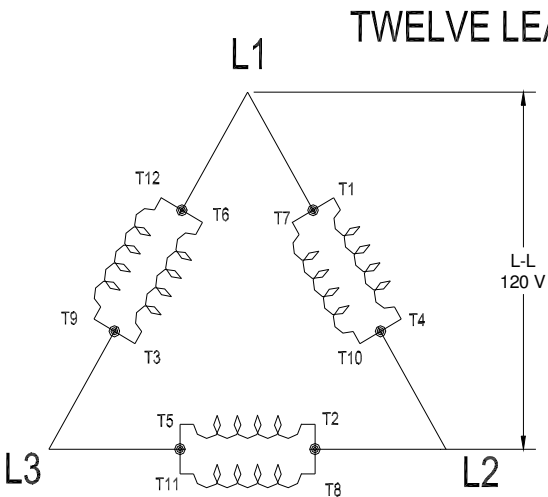
REMOTE/AUDIBLE ALARM

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.

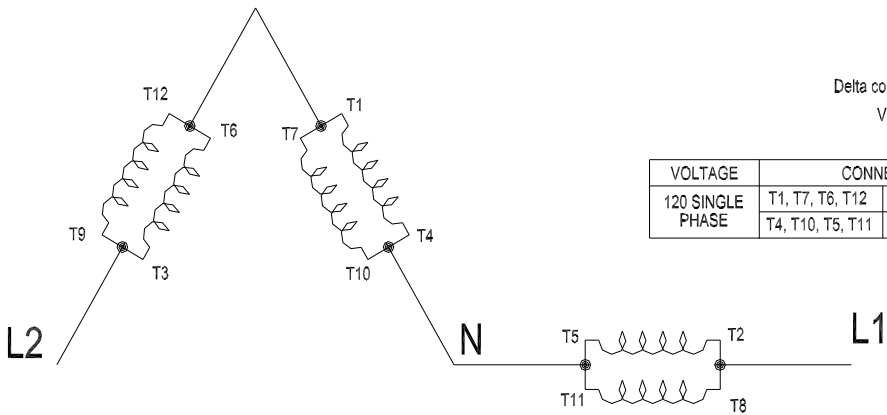
MTU DD suggests the louver motors be wired to a distribution panel on the load side of the automatic transfer switch. The louver motor control circuit is wired to “energized to run” contacts in the generator set control panel.



Delta connection with 12 lead generators only.
Voltages: 60 Hz 120v TO 139v
50 Hz 100v TO 120v

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

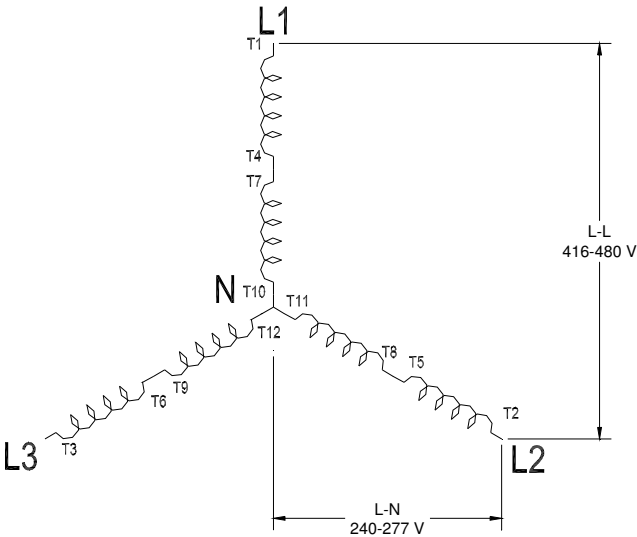
TWELVE LEAD ZIG-ZAG OR OPEN DELTA



Delta connection with 12 lead generators only.
Voltages: 60 Hz 120/240v single phase
50 Hz 110/220v single phase

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

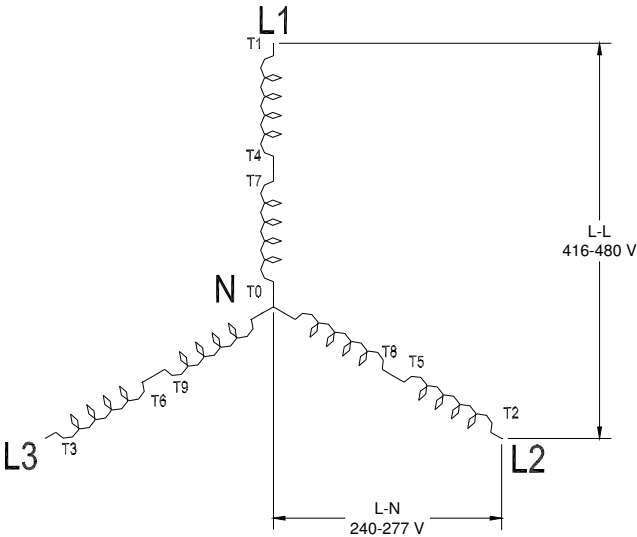
TWELVE LEAD SERIES WYE



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				

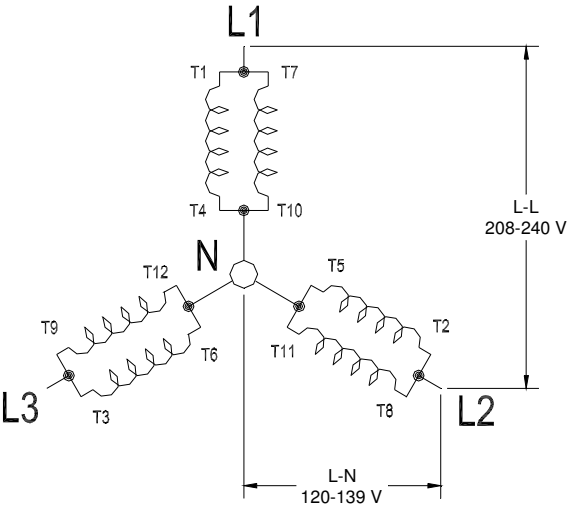
TEN LEAD SERIES WYE



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

VOLTAGE	CONNECT			L1	L2	L3	NEUTRAL
480-416 WYE	T10, T11, T12			T1	T2	T3	T0
	T4, T7	T5, T8	T6, T9				

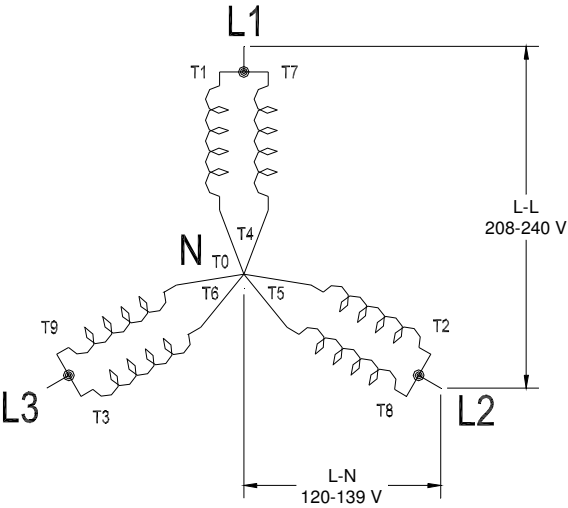
TWELVE LEAD PARALLEL WYE



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

VOLTAGE	CONNECT			L1	L2	L3	NEUTRAL
	T10, T11, T12	T4, T5, T6		T1	T2	T3	T10, T11, T12 T4, T5, T6

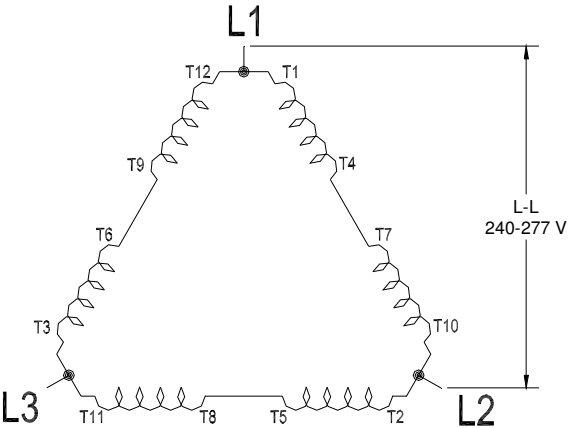
TEN LEAD PARALLEL WYE



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

VOLTAGE	CONNECT			L1	L2	L3	NEUTRAL
	T4, T5, T6, T0			T1	T2	T3	T4, T5, T6

TWELVE LEAD SERIES DELTA



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

VOLTAGE	CONNECT			L1	L2	L3
	T4, T7	T5, T8	T6, T9	T1	T2	T3

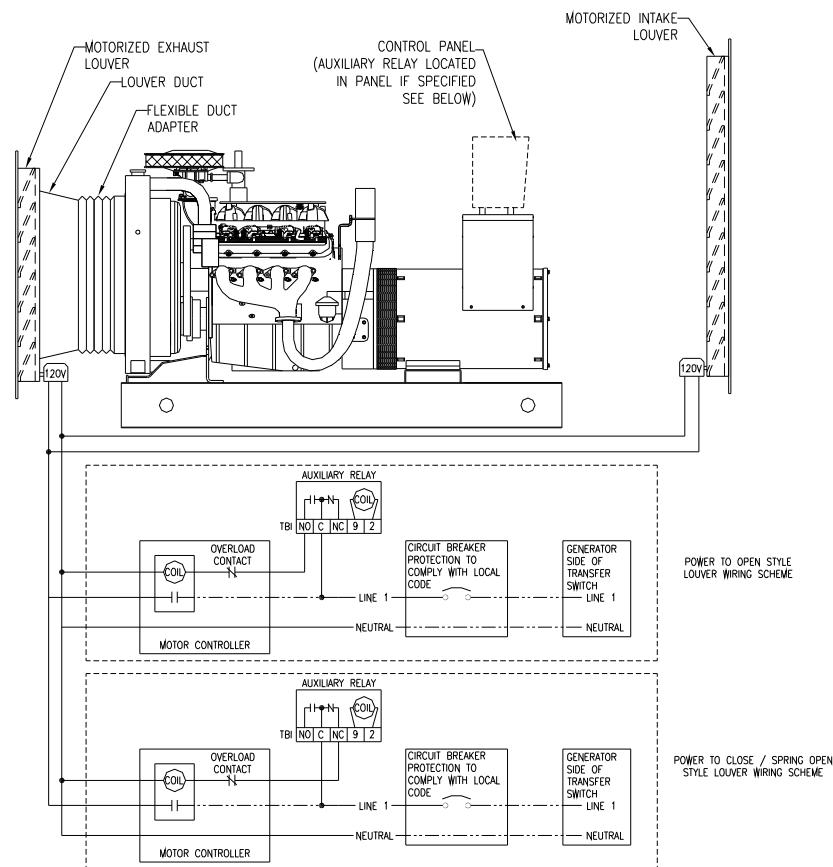


Figure 8-1: Suggested motorized louver wiring

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.

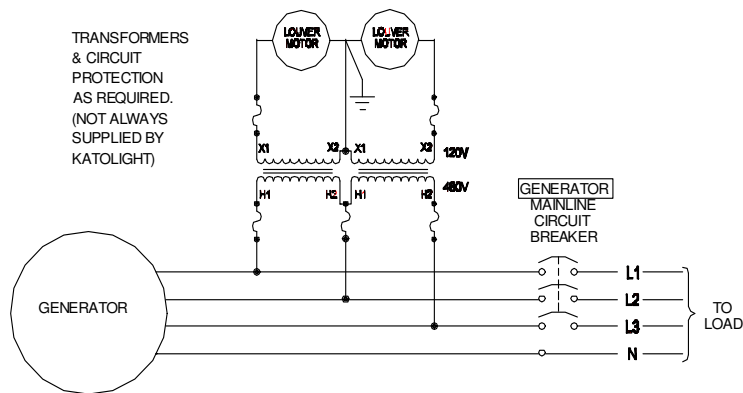


Figure 8-2: Optional motorized louver wiring

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 DD dealer for assistance. Service technicians are factory-trained and are capable of handling all of your service needs.

When contacting a MTU DD 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 DD 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.

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.	

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 a 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 DD 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 DD's control, you may incur an additional start-up charge at a later date.

Signature: _____ **Date:** _____

12

Operating Procedures

CAUTION

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 3 systems used to start the generator set. See Pages 8 – 14 for panel description and illustrations.

Starting at Control Panel

Move the RUN/OFF/AUTO switch on the control panel to the RUN position. This will activate the engine control system and the starting system. The starter will begin cranking and after a few seconds the engine should start. The starter will disconnect when the engine reaches a speed of 500-750 RPM. If the engine does not start, the starter will disengage at the end of the cranking cycle. MTU DD generator sets with the cycle cranking will crank for 10 seconds and then rest for 10 seconds until 5 cycles have been completed, then lock out on overcrank (fail to start). To clear an overcrank fault, place the RUN/OFF/AUTO switch in the OFF position. Wait 2 minutes for the starter motor to cool and then repeat the starting procedure. If the engine does not run after a second attempt at starting, refer to the **Troubleshooting** section.

Automatic Starting

Place the RUN/OFF/AUTO switch on the generator set control panel in the AUTO position if an automatic transfer switch is used. This allows the transfer switch to start the generator set if a power outage occurs and stop it when the power returns. **Be aware the genset could start at any time in the “AUTO” mode. Keep clear of all moving parts and be sure to turn switch to “OFF” position before servicing**

and disconnect the negative battery cable after disconnecting the battery charger circuit.

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. Exercise the generator set at least once a week for a minimum of 30 minutes with load so the engine reaches normal operating temperatures. 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.

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 DD Power Generation 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.

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 refer to the Replacement Parts manual for specific part information and ordering procedures. Please contact your nearest Distributor.

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 DD gensets 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 DD genset 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.

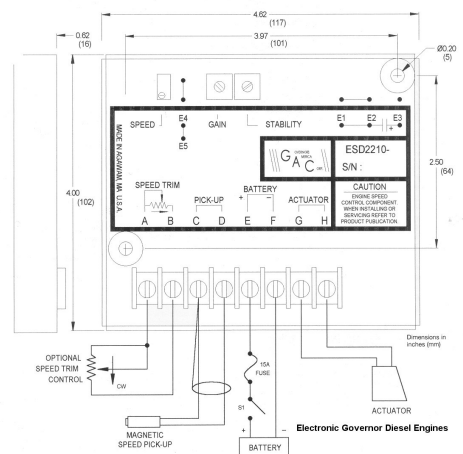


Figure 12-1: Standard GAC Governor Control

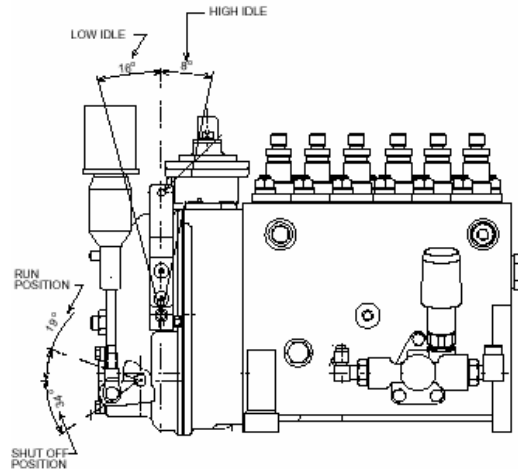


Figure 12-2: Standard Mechanical Governor for Diesel Engines

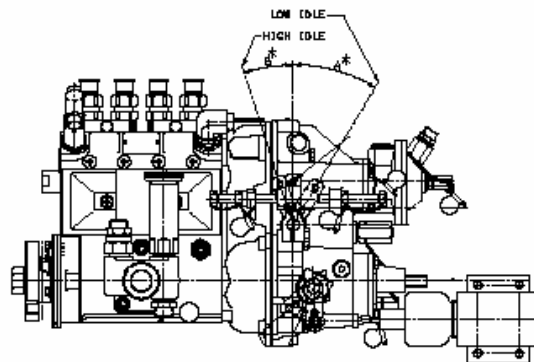


Figure 12-3: Standard Mechanical Governor for Diesel Engines

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.

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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. Place the RUN/OFF/AUTO switch in the OFF position 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

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.

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.

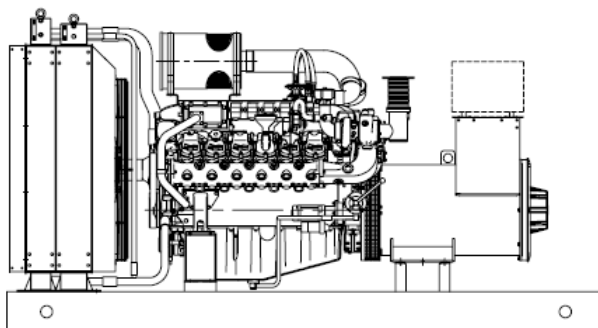
SYMPTOM As Indicated on Display Screen	CORRECTIVE ACTION
12. Engine will not crank.	Indicates possible fault with control or starting system. Check for the following conditions: • Fault lamp on. Correct fault and reset control. • Poor battery cable connections. Clean the battery cable terminals and tighten 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.

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.

400-DC6N

400 ekW 60 Hz Standby

208 - 600V



- Generator Set Tested to ISO 8528-5 For Transient Response
- UL2200, CSA Listing Offered
- All gen-sets are prototype and factory tested
- MTU Onsite Energy is a single source supplier
- Global Product Support
- 2 Year Standard Warranty
- Complete Range of Accessories
- Custom Design for any Application

21.9L Engine

- 21.9 Liter Displacement
- 4-Cycle

Permanent Magnet Generator (PMG) - Optional

- Brushless, Rotating Field
- 300% Short Circuit Capability
- 2/3 Pitch Windings

Digital Control Panel(s)

- UL Recognized, 
- Complete System Metering
- LCD Display

Cooling System

- Integral Set-mounted
- Engine Driven Fan

GEN-SET RATINGS

Voltage (L-L)	Phase	PF	Hz	Natural Gas Standby		skVA @ 30% voltage dip	Generator Model*	Temp Rise	Connection
				Amps	kW/kVA				
208v**	3	0.8	60	1388	400/500	830	433CSL6220	130°C/27°C	12 LEAD LOW WYE
240v**	3	0.8	60	1203	400/500	1100	433CSL6220	130°C/27°C	12 LEAD HI DELTA
480v**	3	0.8	60	601	400/500	1100	433CSL6220	130°C/27°C	12 LEAD HI WYE
600v**	3	0.8	60	481	400/500	C/F	432PSL6248	130°C/27°C	4 LEAD WYE

* The Generator Model Number identified in the table is for standard C Series Configuration. Consult the factory for alternate configuration.

** UL2200 Offered

STANDARD EQUIPMENT

ENGINE

- Air Cleaner
- Oil Pump
- Full Flow Oil Filter
- Jacket Water Pump
- Thermostat
- Exhaust Manifold – wet
- Blower Fan & Fan Drive
- Radiator - Unit Mounted
- Electric Starting Motor - 24V
- Governor – Electric Isochronous
- Base - Formed Steel
- SAE Flywheel & Bell Housing
- Charging Alternator - 24V
- Battery Box & Cables
- Flexible Fuel Connectors
- Flexible Exhaust Connection

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 our RDP-110 Remote Annunciator
- 16 Programmable Contact Inputs
- 7 contact outputs
- UL Recognized, 
- Event Recording
- IP 54 Front Panel Rating with Integrated Gasket

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 and Drip-proof
- Superior Voltage Waveform
- Digital, Solid State, Volts-per-hertz Regulator
- No Load to Full Load Regulation
- Brushless Alternator with Brushless Pilot Exciter
- 4 pole, Rotating Field
- 130°C Standby Temperature Rise
- 1 Bearing, Sealed
- Flexible Coupling
- Full Amortisseur Windings
- 125% Rotor Balancing
- 3-phase Voltage Sensing
- $\pm 1\%$ Voltage Regulation
- 3% Maximum Harmonic Content

APPLICATION DATA

Engine

Manufacturer:	Doosan	Rated RPM:	1800
Model:	GV222TIS	Engine Governor:	Woodward
Type:	4-Cycle	Max Power: Standby: bhp (kWm)	605 (457)
Arrangement:	V-12	Speed Regulation:	±.25%
Displacement: in. ³ (lit)	1,338 (21.9)	Frequency:	60 Hz
Bore: in. (cm)	5.04 (12.8)	Air Cleaner:	Dry
Stroke: in. (cm)	5.59 (14.2)		
Compression Ratio:	10.5:1		

Liquid Capacity (Lubrication)

Total oil system: gal (lit)	10.5 (40)
Engine Jacket water capacity: gal (lit)	11.62 (44)
System Coolant capacity: gal (lit)	C/F

Electrical

Electric volts DC:	24
Cold cranking Amps under 0°F (-17.8°C):	1200

Fuel Inlet

Fuel Supply Connection Size:	2" NPT
Fuel Supply Pressure:	
in. H ₂ O (mm H ₂ O)	10-20 (254-508)

Fuel Consumption

	Standby
100% Power Rating: cu ft/hr (lit/hr)	3,962 (112) *
75% Power Rating: cu ft/hr (lit/hr)	C/F
50% Power Rating: cu ft/hr (lit/hr)	C/F
* Estimated	

Cooling - Radiator System

	Standby
Ambient Capacity of Radiator: °F (°C)	C/F
Maximum Allowable Static Pressure	
on Radiator Exhaust: in. H ₂ O (kPa)	0.5 (0.12)
Water Pump	
Capacity: gal/min (lit/min)	169 (640)
After Cooler Pump	
Capacity: gal/min (lit/min)	90 (340)
Heat Rejection to	
Coolant: BTUM (kW)	25,762 (453)
Heat Rejection to	
After Cooler: BTUM (kW)	2,167 (38)

Air Requirements

	Standby
Aspirating: CFM (m ³ /min)	1,254.4 (35.5)
Air Flow Required	
for Radiator Cooled	
Unit: CFM (m ³ /min)	C/F

Exhaust System

	Standby
Gas Temp.(Stack): °F (°C)	959 (515)
Gas Volume at Stack	
Temp: CFM (m ³ /min)	2,028.3 (57.4)
Maximum Allowable	
Back Pressure: in. H ₂ O (kPa)	23.6 (5.87)

EMISSIONS DATA

	<u>NO_x</u>	<u>HC</u>	<u>CO</u>	<u>PM</u>
Natural Gas:	C/F	C/F	C/F	C/F
Liquid Propane:	C/F	C/F	C/F	C/F

All units are in g/hp-hr.

SOUND DATA

Standby Full Load

Standby No Load

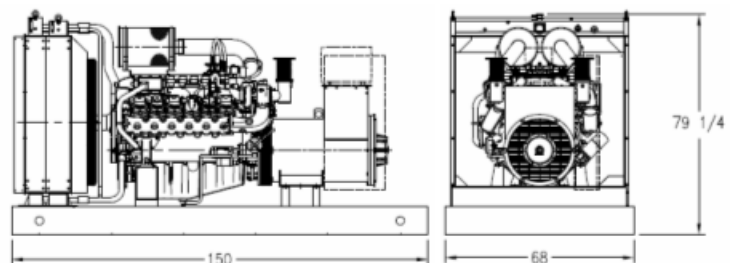
23 ft (7m) OPU w/ critical grade muffler (dBA)	C/F	C/F
23 ft (7m) Sound Attenuated Enclosure (dBA)	C/F	C/F

RATING DEFINITIONS and CONDITIONS

- Ambient capability factor at 984 ft (300m). Consult your local MTU Onsite Energy Power Generation Distributor for other altitudes.
- 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, AS 2789, and DIN 6271.
- Prime power ratings apply to installations where utility power is unavailable or unreliable. At varying load, the number of generator set operating hours is unlimited. A 10% overload capacity is available for one hour in twelve. Ratings are in accordance with ISO-8528/1, overload power in accordance with ISO-3046/1, BS 5514, AS 2789, and DIN 6271. For limited running time and base load ratings, consult the factory.
- Deration Factors:
Altitude: Max altitude 3,281 ft (1,000m).
Temperature: C/F

Weights & Dimensions

Length: in. (cm)	150 (381)
Width: in. (cm)	68 (172.7)
Height: in. (cm)	79.25 (201.2)
Weight (dry): lb. (kg)	6,773 (3,072)



Drawing above for illustration purposes only, based on standard open power 480 volt generator. Lengths may vary with other voltages.
*Do Not Use for Installation Design

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www.mtu-online.com

Operation & Maintenance Manual

GENERATOR NATURAL GAS ENGINE

GV158TIC

GV180TIC

GV222TIC

FOREWORD

This manual is designed to serve as a reference for DOOSAN Infracore (hereafter DOOSAN) customers and distributors who wish to gain basic product knowledge on DOOSAN **GV158TIC, GV180TIC, GV222TIC** natural gas generator engines.

These economical and high-performance natural gas engines (GV158TIC 8 cylinders) (GV180TIC 10 cylinders), (GV222TIC 12 cylinders) are 4 strokes and V-type have been so designed and manufactured to be used for the generator & power unit application. They meet all the requirements such as low noise, fuel economy, high engine speed and durability.

To maintain the engine in optimum condition and retain maximum performance for a long time, **CORRECT OPERATION** and **PROPER MAINTENANCE** are essential.

In this manual, the following symbols are used to indicate the type of service operations to be performed.

	Removal		Adjustment
	Installation		Cleaning
	Disassembly		Pay close attention-Important
	Reassembly		Tighten to specified torque
	Align the marks		Use special tools of manufacturer's
	Directional Indication		Lubricate with oil
	Inspection		Lubricate with grease
	Measurement		

During engine maintenance, please observe following instructions to prevent environmental damage;

- Take old oil to an old oil disposal point only.
- Ensure without fail that oil and diesel fuel will not get into the sea or rivers and canals or the ground.
- Treat undiluted anti-corrosion agents, antifreeze agents, filter element and cartridges as special waste.
- The regulations of the relevant local authorities are to be observed for the disposal of spent coolants and special waste.

If you have any question or recommendation in connection with this manual, please do not hesitate to contact our head office, dealers or authorized service shops.

For the last, the content of this maintenance instruction may be changed without notice for some quality improvement and please feel free to contact to our agents near by your location for any services. Thank you

DOOSAN Infracore Co., Ltd.
Sep. 2004

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1. Safety Regulations & Engine Specifications

1.1. General notes

Day-to-day use of power engines and the service products necessary for running them presents no problems if the persons occupied with their operation, maintenance and care are given suitable training and think as they work.

This summary is a compilation of the most important regulations, These are broken down into main sections which contain the information necessary for preventing injury to persons, damage to property and pollution. In addition to these regulations those dictated by the type of engine and its site are to be observed also.



IMPORTANT:

If despite all precautions, an accident occurs, in particular through contact with caustic acids, fuel penetrating the skin, scalding from oil, antifreeze being splashed in the eyes etc, consult a doctor immediately.

1.2. Handle compressed natural gas safety

Natural gas is highly flammable and explosive and may be extremely cold. The following cautions must be taken to avoid personal injury or engine damage

- Do not smoke when installing or servicing the engine or fuel system.
- Installation or servicing of natural gas equipment must only be conducted in well ventilated, natural gas compatible areas. Do not install or service equipment in an enclosed area where ignition sources are present without ensuring that an undetected gas leak may be safely vented without being ignited.
- Do not vent natural gas or permit leaks inside an enclosed area.

Bleed natural gas lines before installing or servicing any component connected to the fuel lines.



1.2.1. Avoid heating near pressurized fluid lines

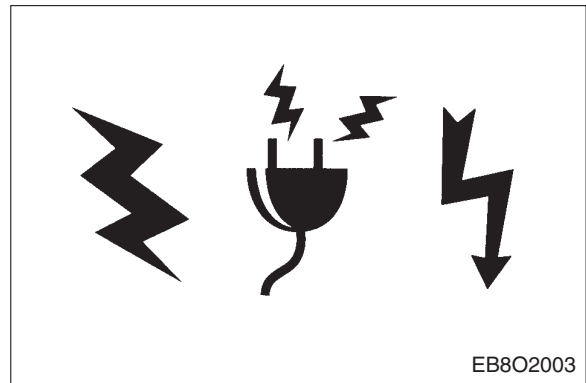
- Wear welding goggles and gloves when welding or using an acetylene torch.
- Insure a that metal shield separated the acetylene and oxygen which must be chained to a cart.
- Do not weld or heat areas near fuel tanks or fuel lines.



1.2.2. Venting an operable engine to relieve natural gas pressure

- To avoid personal injury an operable natural gas engine must be kept in a well ventilated area away from open flames and sparks.
- If the engine can run, use the following venting procedure to relieve the natural gas pressure downstream of the shutoff valve.

- 1) Shut off manual valves on natural gas supply tanks and main shutoff valve on natural gas fuel supply line.
- 2) Start engine and run until it stalls due to fuel starvation.
- 3) Check to make sure gauge pressure at point on the natural gas fuel line to be vented has been reduced to zero. If not, repeat step 1) Then repeat step 2).
- 4) Disconnect vehicle batteries using switch in battery compartment or by disconnecting battery ground cable.
- 5) Slightly loosen the NG fuel line fitting to be serviced in a well ventilated area to allow any remaining gas to vent.
- 6) Completely open the fitting that was slightly opened and allow to vent in a well ventilated area.



1.2.3. During commissioning, starting and operation



- This is the safety alert symbol. When you see this symbol in this manual, be alert to the potential for personal injury.



- Carefully read all safety message in this manual and on your safety signs. Be sure new equipment components and repair parts include the current safety signs.



- Avoid possible injury or death from runaway. Do not start engine by shorting across starter terminals.



- Prevent fires by keeping machine clean of accumulated trash, grease, fuel and debris.

- When the engine is running, do not get too close to the rotating parts.



- Do not touch the engine with bare hands when it is warm from operation risk of burns.



- Exhaust gases are toxic. If it is necessary to run an engine in an enclosed area, remove the exhaust gases from the area with an exhaust pipe extension. If you do not have an exhaust pipe extension, open the doors and get outside air into the area.



- Keep vicinity of engine free of oil and grease. Accidents caused by slipping can have serious consequences.

1.2.4. During maintenance and care



- Always carry out maintenance work when the engine is switched off. If the engine has to be maintained while it is running, e.g. changing the elements of change-over filters, remember that there is a risk of scalding. Do not get too close to rotating parts.

- Change the oil when the engine is warm from operation.



CAUTION:

There is a rise of burns and scalding. Do not touch oil drain plug or oil filters with bare hands.

- Take into account the amount of oil in the sump. Use a vessel of sufficient size to ensure that the oil will not overflow.

- Open the coolant circuit only when the engine has cooled down. If opening while the engine is still warm is unavoidable, comply with the instructions in the chapter "Maintenance and Care".

- Neither tighten up nor open pipes and hoses (lube oil circuit, coolant circuit and any additional hydraulic oil circuit) during the operation. The fluids which flow out can cause injury.



- Fuel is inflammable. Do not smoke or use naked lights in its vicinity. The tank must be filled only when the engine is switched off.



- When using compressed air, e.g. for cleaning the radiator, wear goggles.

- Keep service products (anti-freeze) only in containers which can not be confused with drinks containers.

- Comply with the manufacturer's instructions when handling batteries.

**CAUTION:**

Accumulator acid is toxic and caustic. Battery gases are explosive.

1.2.5. When carrying out checking, setting and repair work

- Checking, setting and repair work must be carried out by authorized personnel only.
- Use only tools which are in satisfactory condition. Worn open-end wrench slip. which could lead to Injury.
- When the engine is hanging on a crane, no-one must be allowed to stand or pass under it. Keep lifting gear in good condition.
- When working on parts which contain asbestos, comply with the notes.
- When checking spark plug do not put your hands under the electric.
- When working on the electrical system disconnect the battery earth cable first. Connect it up again last in prevent short circuits.

**1.2.6. To prevent damage to engine and premature wear**

- (1) If faults occur, find the cause immediately and have it eliminated in order to prevent more serious of damage.
- (2) Use only genuine DHIM spare parts. DHIM will accept no responsibility for damage resulting from the installation of other parts which are supposedly "just as good".
- (3) In addition to the above, note the following points.
 - Never let the engine run when dry, i.e. without lube oil or coolant.
 - Use only DHIM-approved service products (engine oil, anti-freeze and anticorrosion agent).
 - Have the engine maintained at the specified intervals.
 - Do not switch off the engine immediately when it is hot, but let it run without load for about 5 minutes so that temperature equalization can take place.
 - Never put cold coolant into an overheated engine. See "Maintenance and care".
 - Do not add so much engine oil that the oil level rises above the max. marking on the dipstick. Do not exceed the maximum permissible tilt of the engine. Serious damage to the engine may result if these instructions are not adhered to.
 - Always ensure that the testing and monitoring equipment (for battery charge, oil pressure, coolant temperature) function satisfactorily.
 - Do not let the raw water pump run dry, If there is a risk of frost, drain the pump when the engine is switched off.

1.2.7. To prevent pollution

(1) Engine oil, filter elements, fuel filters

- Take old oil only to an oil collection point.
- Take strict precautions to ensure that oil does not get into the drains or into the ground. The drinking water supply could be contaminated.
- Filter elements are classed as dangerous waste and must be treated as such.

(2) Coolant

- Treat undiluted anti-corrosion agent and / or antifreeze as dangerous waste.
- When disposing of spent coolant comply with the regulations of the relevant local authorities.

1.2.8. Notes on safety in handling used engine oil

Prolonged or repeated contact between the skin and any kind of engine oil decreases the skin. Drying, irritation or inflammation of the skin may therefore occur. Used engine oil also contains dangerous substances which have caused skin cancer in animal experiments. If the basic rules of hygiene and health and safety at work are observed, health risks are not to the expected as a result of handling used engine oil



Health precautions:

- Avoid prolonged or repeated skin contact with used engine oil.
- Protect your skin by means of suitable agents (creams etc.) or wear protective gloves.
- Clean skin which has been in contact with engine oil.
 - Wash thoroughly with soap and water, A nailbrush is an effective aid.
 - Certain products make it easier to clean your hands.
 - Do not use petrol, Diesel fuel, gas oil, thinners or solvents as washing agents.
- After washing apply a fatty skin cream to the skin.
- Change oil-soaked clothing and shoes.
- Do not put oily rags into your pockets.



Ensure that used engine oil is disposed of properly:

- Engine oil can endanger the water supply -

For this reason do not let engine oil get into the ground, waterways, the drains or the sewers. Violations are punishable.

Collect and dispose of used engine oil carefully. For information on collection points please contact the seller, the supplier or the local authorities.

1.2.9. General repair instructions



1. Before performing service operation, disconnect the grounding cable from the battery for reducing the chance of cable damage and burning due to short-circuiting.
2. Use covers for preventing the components from damage or pollution.
3. Engine oil and anti-freeze solution must be handled with reasonable care as they cause paint damage.
4. The use of proper tools and special tools where specified is important to efficient and reliable service operation.
5. Use genuine DAEWOO parts necessarily.
6. Used cotter pins, gaskets, O-rings, oil seals, lock washer and self-lock nuts should be discarded and new ones should be prepared for installation as normal function of the parts can not be maintained if these parts are reused.
7. To facilitate proper and smooth reassemble operation, keep disassembled parts neatly in groups. Keeping fixing bolts and nut separate is very important as they vary in hardness and design depending on position of installation.
8. Clean the parts before inspection or reassembly. Also clean oil ports, etc. using compressed air to make certain they are free from restrictions.
9. Lubricate rotating and sliding faces of parts with oil or grease before installation.
10. When necessary, use a sealer on gaskets to prevent leakage.
11. Carefully observe all specifications for bolts and nuts torques.
12. When service operation is completed, make a final check to be sure service has been done property.

1.3. Engine Specifications

1.3.1. Specification

Engine Model		GV158TIC	GV180TIC	GV222TIC
Items				
Engine type		Water-cooled, 4 cycle Vee type Turbo charged & intercooled		
Ignition system		Spark plug ignition		
Combustion chamber type		Open dish type		
Used fuel		NG(natural gas)		
Fuel supply system		Venturi mixer throttle valve type		
Cylinder liner type		Wet type, chromated or casting liner		
Timing gear system		Gear driven type		
No. of piston ring		2 Compression ring, 1 oil ring		
No. of cylinder-bore X stroke	(mm)	8 - 128 x 142	10 - 128 x 142	12 - 128 x 142
Total piston displacement	(cc)	14,618	18,273	21,927
Compression ratio		10.5 : 1		
Engine dimension (length X width X height)	(mm)	1,388 x 1,222 x 1,238	1,546 x 1,222 x 1,334	1,704 x 1,222 x 1,369
Engine weight	(kg)	950	1,175	1,509
Fuel injection order		1-5-7-2-6-3-4-8	1-6-5-10-2-7-3-8-4-9	1-12-5-8-3-10-6-7-2-11-4-9
Fuel ignition timing	Adjust angle	40° (B.T.D.C)		40° (B.T.D.C)
	Operate angle	14° (B.T.D.C)		12° (B.T.D.C)
Engine control system		ECM(engine control module) type		
Compression pressure (kg/cm ²)		16 (at 200 rpm)		
Intake and exhaust valve clearance (at cold)	(mm)	0.30/0.40		
Intake valve	Open at	24° (B.T.D.C)		
	Close at	36° (A.B.D.C)		
Exhaust valve	Open at	63° (B.B.D.C)		
	Close at	27° (A.T.D.C)		
Lubrication method		Pressurized circulation		
Oil pump type		Gear type driven by crank shaft		
Engine oil pressure	Low idle	0.8 ~ 1.4		
	High idle	3.0 ~ 4.8		
Oil filter type		Full-flow, cartridge type		
Lubricating oil capacity (max./min.)	(lit)	28/26	35/28	40/33
Oil cooler type		Water cooled		
Water pump type		Belt driven centrifugal type		
Cooling Method		Pressurized circulation		
Cooling water capacity (engine only)	(lit)	20	21	23
Thermostat type		Wax pallet type (71 ~ 85°C)		
Alternator voltage - capacity	(V - A)	24 - 45		
Starting Motor voltage - output	(V - kW)	24 - 6.6		
Fuel system	System	Air-Fuel mixer		
	Control	Throttle valve control		

Engine Model		GV158TIC	GV180TIC	GV222TIC
Items				
Ignition system	Ignition type	One coil per cylinder (no waste spark)		
	Spark plug	Iridium plug		
	Spark plug gap	0.39 ~ 0.4		
	Ignition coil	Inductive coil pack		
	Ignition timing adjustment	Controlled by ESC and ICM		
Control system	Control system	On-highway heavy-duty		
	Voltage (V)	24		
	Component	ESC, ICM, sensor, harness		
Turbo charger	Model	Holset HX35	Holset HX40	Holset HX50
	Type	Water cooled, Exhaust gas driving		
	Exhaust gas temperature (°C)	Max. 560		
Battery capacity	(V - AH)	24 - 200		

1.3.2. Engine Power

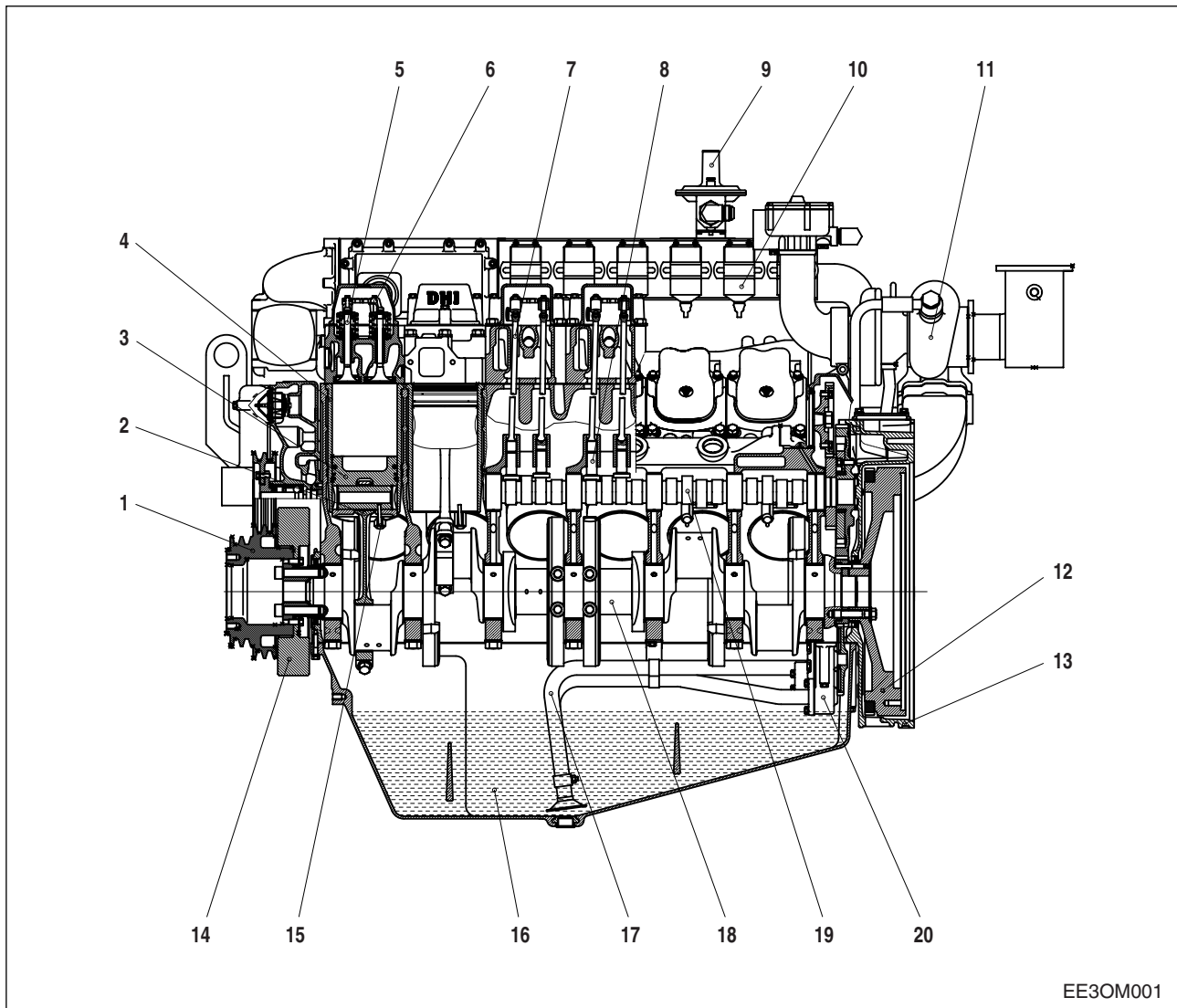
Production tolerance : $\pm 5\%$

Engine model		Condition		
		Stand-by	Prime	Continuous
GV158TIR	50 Hz (1,500 rpm)	253 kW (344 PS)	230 kW (313 PS)	207 kW (281 PS)
	60 Hz (1,800 rpm)	300 kW (408 PS)	270 kW (367 PS)	243 kW (330 PS)
GV158TIC	50 Hz (1,500 rpm)	-	230 kW (313 PS)	207 kW (281 PS)
	60 Hz (1,800 rpm)	-	270 kW (367 PS)	243 kW (330 PS)
GV180TIR	50 Hz (1,500 rpm)	319 kW (434 PS)	290 kW (394 PS)	261 kW (355 PS)
	60 Hz (1,800 rpm)	375 kW (510 PS)	340 kW (462 PS)	306 kW (416 PS)
GV180TIC	50 Hz (1,500 rpm)	-	290 kW (394 PS)	261 kW (355 PS)
	60 Hz (1,800 rpm)	-	340 kW (462 PS)	306 kW (416 PS)
GV222TIR	50 Hz (1,500 rpm)	385 kW (523 PS)	350 kW (476 PS)	315 kW (428 PS)
	60 Hz (1,800 rpm)	451 kW (613 PS)	410 kW (557 PS)	369 kW (502 PS)
GV222TIC	50 Hz (1,500 rpm)	-	350 kW (476 PS)	315 kW (428 PS)
	60 Hz (1,800 rpm)	-	410 kW (557 PS)	369 kW (502 PS)

Note : All data are based on operation without cooling fan at ISO 3046.

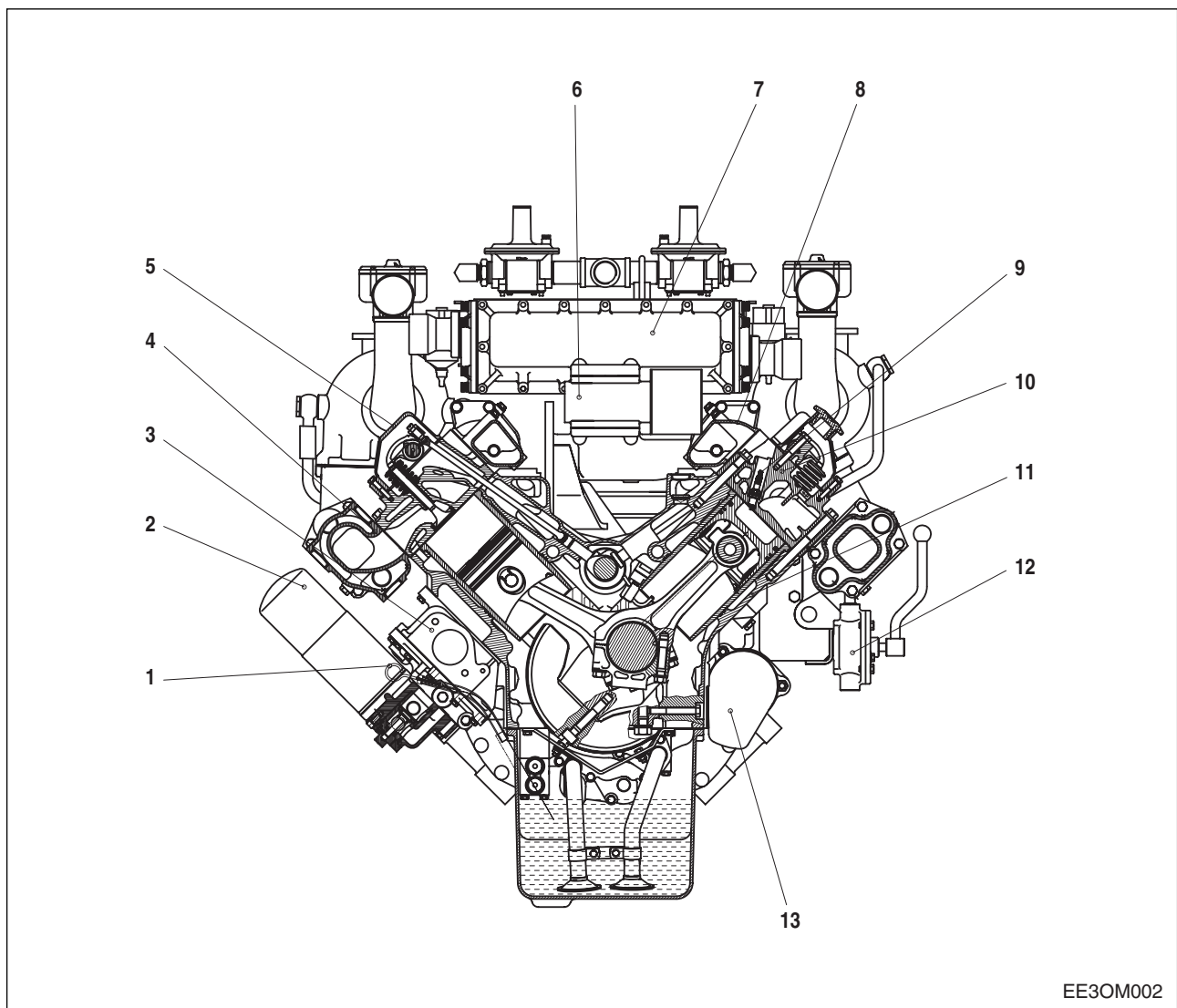
1.4. Engine Assembly

1.4.1. Engine Sectional View (longitudinal)



1. Crank shaft pulley	11. Turbo charger
2. Connecting rod	12. Flywheel
3. Piston	13. Fly wheel housing
4. Cylinder liner	14. Vibration damper
5. Valve	15. Oil spray nozzle
6. Rocker arm	16. Oil pan
7. Push rod	17. Oil suction pipe
8. Tappet	18. Crank shaft
9. Gas regulator	19. Cam shaft
10. Ignition coil	20. Oil pump

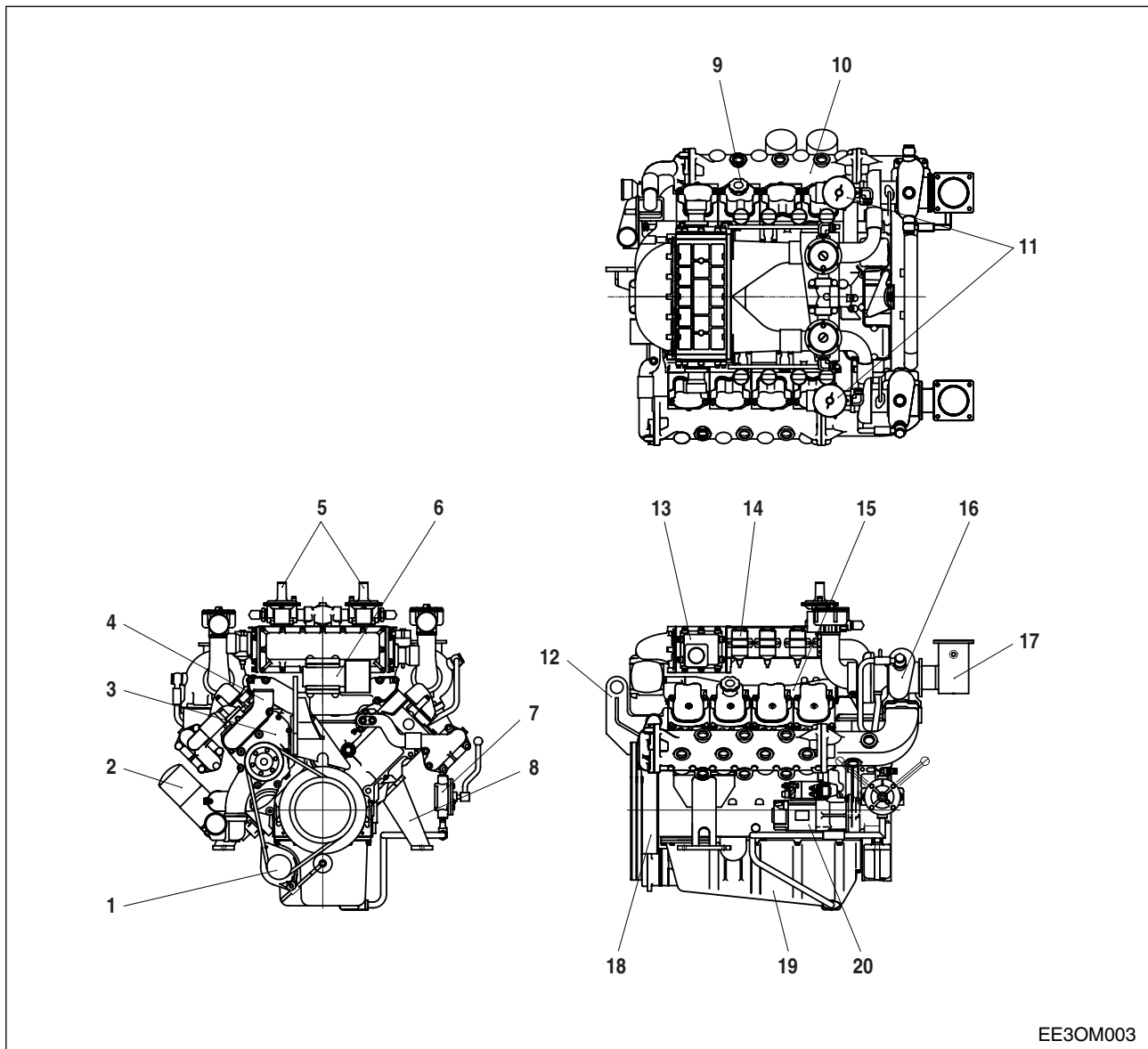
1.4.2. Engine Sectional View (cross)



1. Oil level gauge	8. Intake manifold
2. Oil filter	9. Spark plug
3. Oil cooler	10. Cylinder head
4. Exhaust manifold	11. Cylinder block
5. Cylinder head cover	12. Oil drain pump
6. Throttle valve	13. Starting motor
7. Inter cooler	

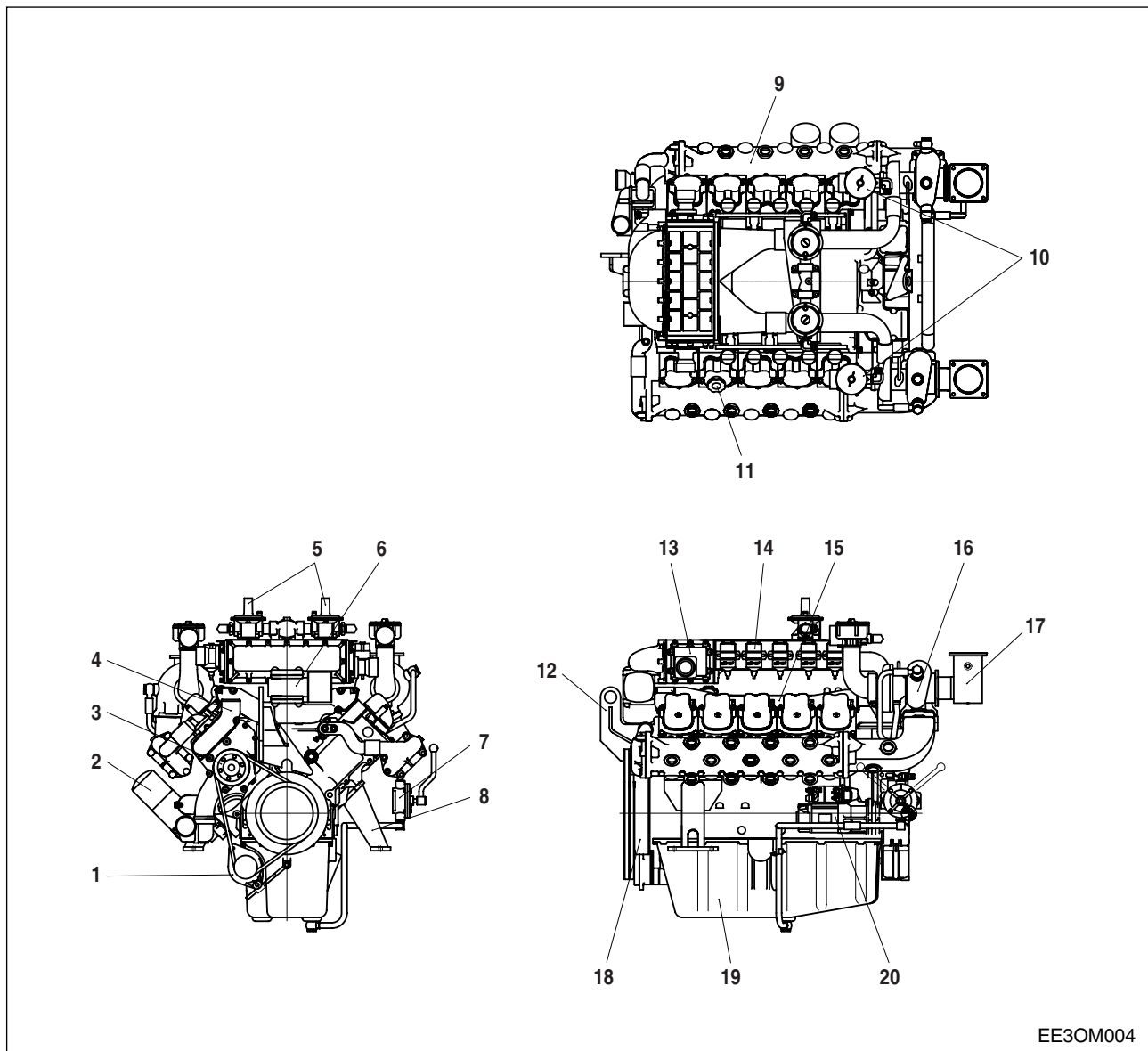
1.4.3. Engine Assembly Views

(1) GV158TIC



1. Alternator	11. Gas fuel mixer
2. Oil cooler & oil cooler	12. Lifting hook
3. Cooling water pump	13. Inter cooler
4. Water outlet	14. Ignition coil
5. Gas pressure regulator	15. Intake manifold
6. Throttle valve	16. Turbo charger
7. Oil drain pump	17. Exhaust elbow
8. Mounting bracket	18. Vibration damper
9. Oil filler cap	19. Oil pan
10. Exhaust manifold	20. Starting motor

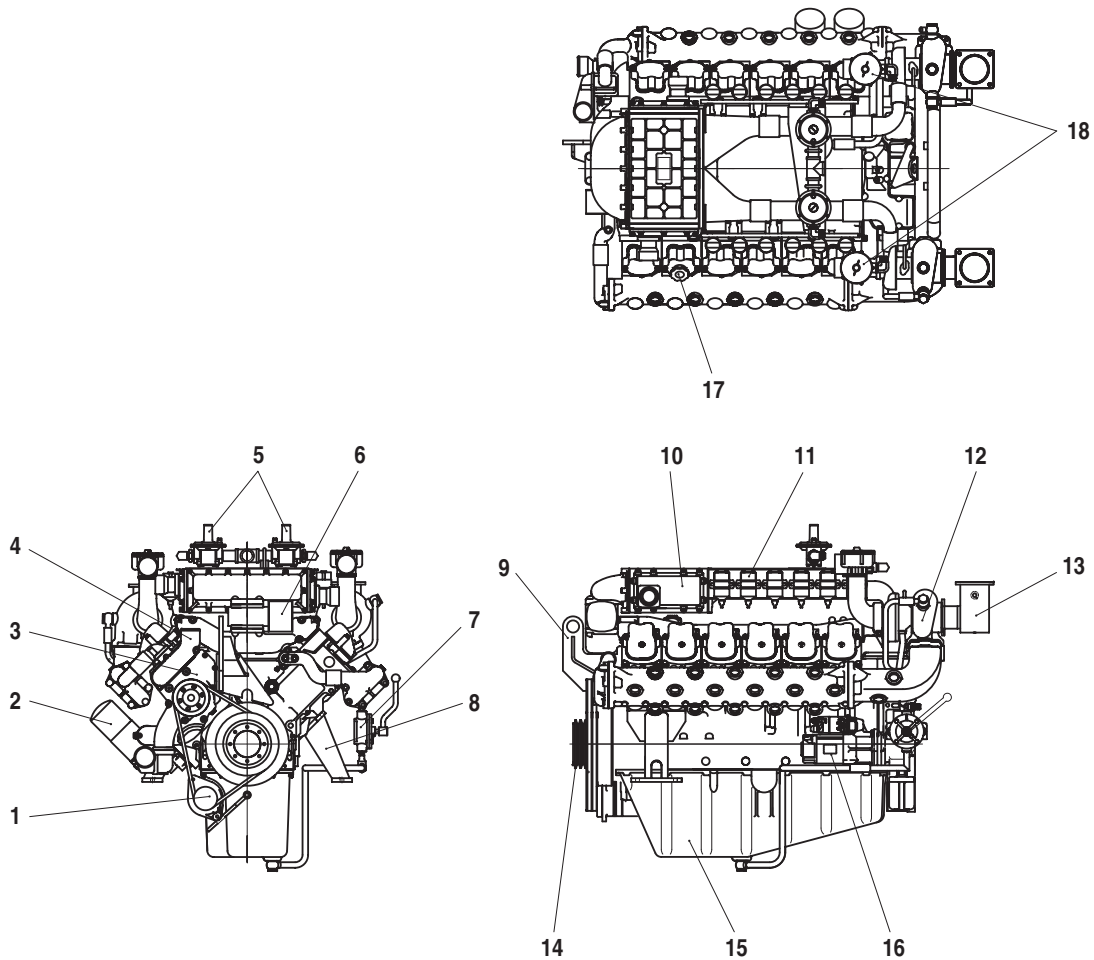
(2) GV180TIC



EE3OM004

1. Alternator	11. Gas fuel mixer
2. Oil cooler & oil cooler	12. Lifting hook
3. Cooling water pump	13. Inter cooler
4. Water outlet	14. Ignition coil
5. Gas pressure regulator	15. Intake manifold
6. Throttle valve	16. Turbo charger
7. Oil drain pump	17. Exhaust elbow
8. Mounting bracket	18. Vibration damper
9. Oil filler cap	19. Oil pan
10. Exhaust manifold	20. Starting motor

(3) GV222TIC



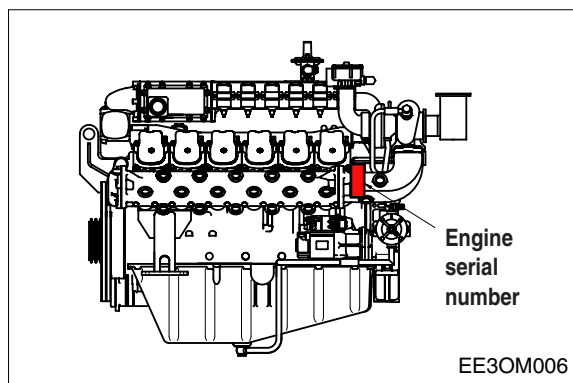
EE3OM005

1. Alternator	10. Inter cooler
2. Oil filter & cooler	11. Ignition coil
3. Cooling water pump	12. Turbo charger
4. Water outlet	13. Exhaust elbow
5. Gas pressure regulator	14. Crank shaft pulley
6. Throttle valve	15. Oil pan
7. Oil drain pump	16. Starting motor
8. Mounting bracket	17. Oil filler cap
9. Lifting hook	18. Gas fuel mixer

2. Technical Information

2.1. Engine model and serial number

- The engine model and serial number is located on the engine as illustrated.
- These numbers are required when requesting warranty and ordering parts. They are also referred to as engine model and serial number because of their location.



• Engine serial No. (example1 : GV158TIC)

EEZOD 4 00001

Serial No.
Production Year (2004)
Engine Model

• Engine serial No. (example1 : GV180TIC)

EESOA 4 00001

Serial No.
Production Year (2004)
Engine Model

• Engine serial No. (example1 : GV222TIC)

EEYOC 4 00001

Serial No.
Production Year (2004)
Engine Model

DAEWOO

MODEL		BORE	mm
SPEED	rpm	STROKE	mm
STAND-BY		VOLUME	cc
PRIME		YEAR	
SERIAL NUMBER			

DAEWOO HEAVY INDUSTRIES LTD.

EE3OM007

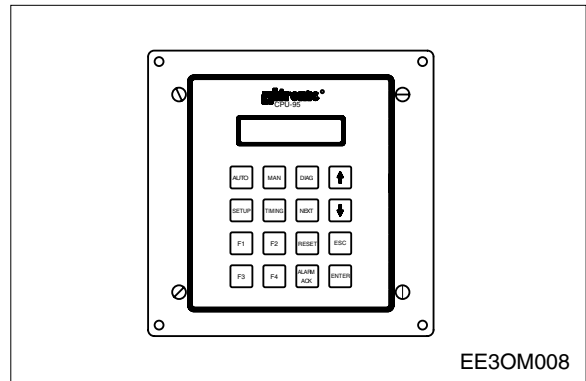
2.2. Diagnostic display module(CPU-95)

- The diagnostic display module is designed to operate in conjunction with a variety of display/control options.
- This facilitates the application of diagnostic display module systems to gas engines operating at varying stages of automation and sophistication.



CAUTION:

1. Do not connect or disconnect the diagnostic display module to/from the wiring harness without first removing the negative (-) battery cable from the battery.
2. Do not perform remove the inner parts of the Diagnostic display module.



2.3. Engine characteristic

The DAEWOO **GV158TIC**, **GV180TIC**, **GV22TIC** natural gas engine is an overhead valve, turbo charged, water-to-air charge cooled, electronically controlled engine

2.3.1. Design characteristic

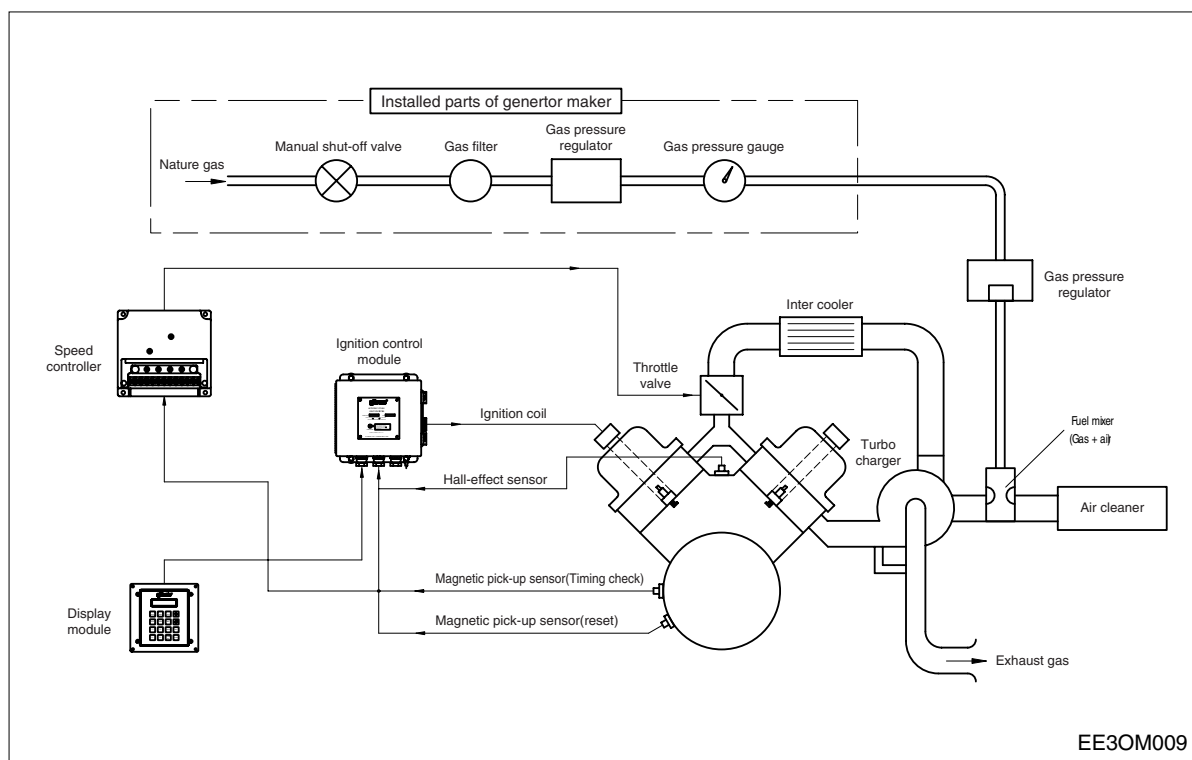
- Spark-ignited by the spark plug
- Electric engine control through the ECM(engine control module) system
- Turbocharger with a water cooled bearing-housing

2.3.2. Natural gas

- Natural gas is a clean burning fuel, and offers a low particulate emission. Natural gas is also a very economical fuel.
- From the gas producing areas in the country, the distribution companies and local utilities form a complex nation-wide-delivery-network that supplies natural gas for home and industry use. The network is highly developed and extended to all major population center in the country.

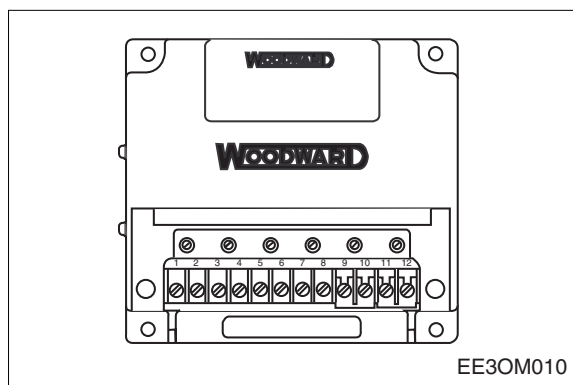
2.3.3. Engine ignition system

- This system changes the general combustion concept of the diesel engine. Specifically, it changes a compression-ignition diesel to a spark-ignited engine. However, this engine is unlike the typical generator engine that has spark plugs.
- The primary difference is this system uses a combustion concept. That is, excess air is mixed in with the combustion system. When combined with a gaseous fuel like natural gas, it allows greatly reduced emissions compared to diesel, plus high efficiencies and excellent high-performance.
- The GV158TIC, GV180TIC, GV222TIC engine is an integrated package featuring computer-controlled electronic engine system by the engine speed controller. This system controls fuel, ignition and speed, and has engine protection features.



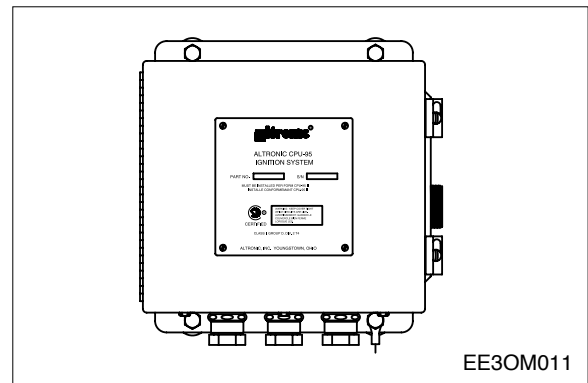
2.3.4. Engine speed controller : ESC

- The Engine Speed Control is designed to provide basic isochronous speed control for gas engines using the Flo-Tech Throttle.
- Engines with mechanical loads and generator loads are handled equally well.



2.3.5. Ignition control module : ICM

- This digital ignition system has been designed for application on nature gas fueled engines.
- This system is offers a variety of advanced control, emissions reduction, primary and spark diagnostics, self diagnostic serial communications and engine protection features.



2.3.6. Cylinder block

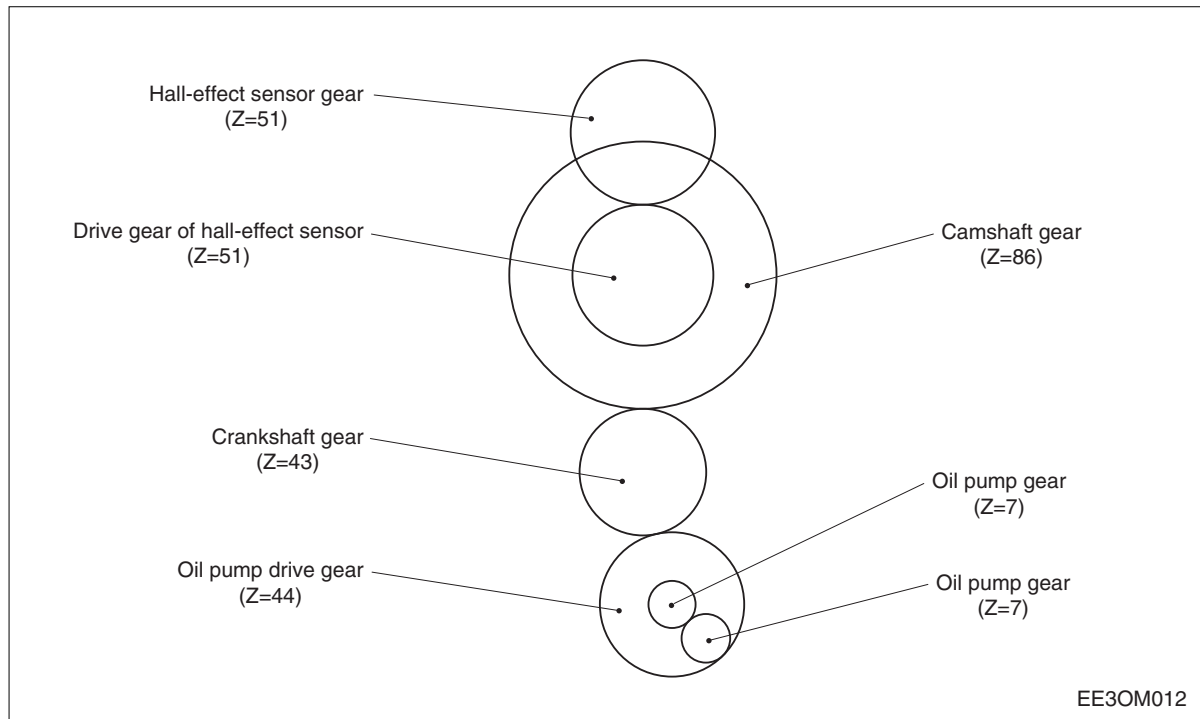
- The cylinder block is a single piece of alloy cast iron. To increase its stiffness, it is extended to a level below the crankshaft center line. The engine has replaceable wet cylinder liners and individual cylinder heads.

2.3.7. Piston, con-rod and crankshaft

- The forged crankshaft has screwed-on the balance weights. Radial seals with replaceable wearing rings on crankshaft and flywheel are provided to seal the crankcase penetrations.
- The connecting rods are die-forged, diagonally split and can be removed through the top of the cylinders together with the pistons. Crankshaft and connecting rods run in steel-backed lead bronze ready-to fit type bearings.

2.3.8. Engine timing

- Camshaft, oil pump and hall-effect sensor are driven by a gear train arranged at the flywheel end.

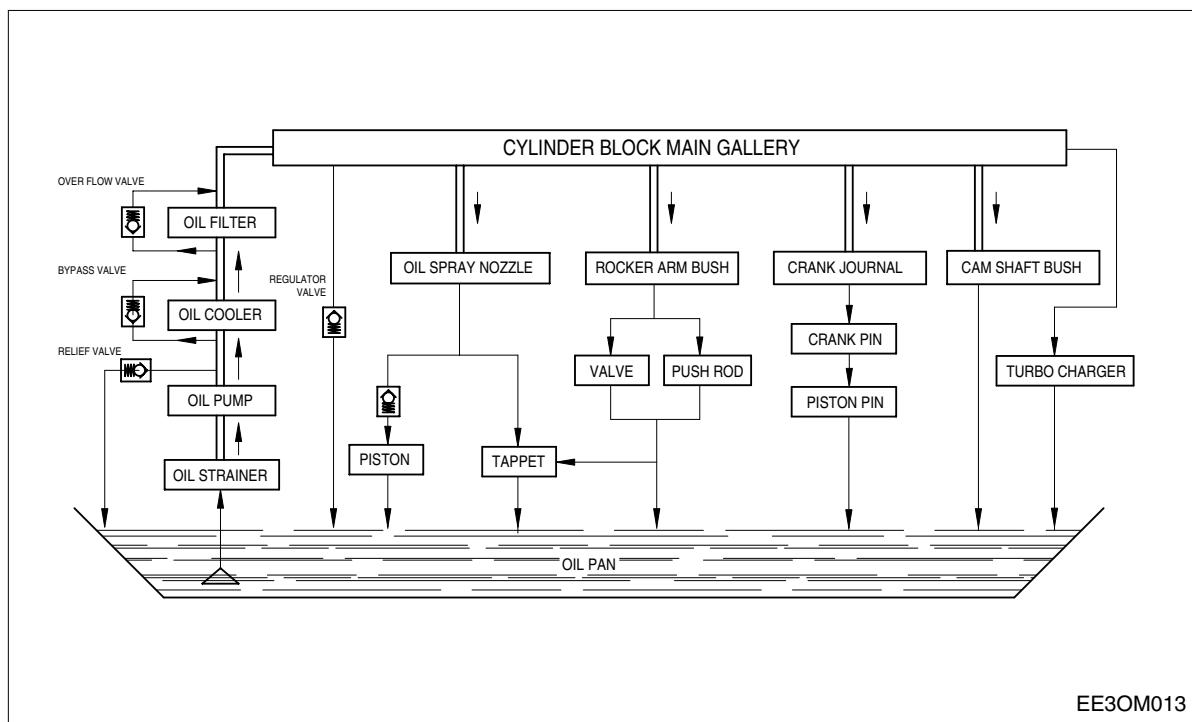


2.3.9. Valves

- The overhead valves are actuated via chilled cast iron tappets, push rods and rocker arms from the camshaft

2.3.10. Engine lubrication system

- The engine is equipped with force-feed lubrication. The pressure is produced by a gear pump whose drive gear is in direct mesh with the crankshaft gear at the flywheel end.
- The oil pump draws the oil from the oil sump and delivers it through the oil filter and oil cooler to the main distributor gallery and from there to the main bearings, big-end bearings and camshaft bearings as well as to the small-end bearings and the rocker arms.
- The turbocharger is also connected to the engine lubricating system. The cylinder walls and timing gears are splash-lubricated.
- Each cylinder has an oil jet provided for cooling the underside of the pistons. The lube oil is cleaned in a full-flow oil filter.



- Depending on the agreed extent of delivery and the design of the engine, the lube oil circuit can be equipped with oil pressure monitors (advance warning and cut-off function) which shut the engine down in the event of a sudden loss of pressure

2.3.11. Oil cooler

- An oil cooler is provided between the oil filter and the crankcase. This cooler is of the flat tube type with turbulence inserts and operated by the coolant

2.3.12. Engine oil



- Check oil level with the oil level gauge and replenish if necessary.
- Check the oil level with the engine cooled. If the engine is warm, allow time for 5 ~ 10 minutes for oil drain into the crankcase before checking oil level. The oil level must be between **Max.** and **Min.** lines on the gauge.
- Engine oil should be changed at the specified intervals. Oil in the oil filter cartridge should be changed simultaneously.

First oil change		After 50hr operation
Engine model	GV158TIC	every 200hr
	GV180TIC	
	GV222TIC	

- The following oils are also recommended

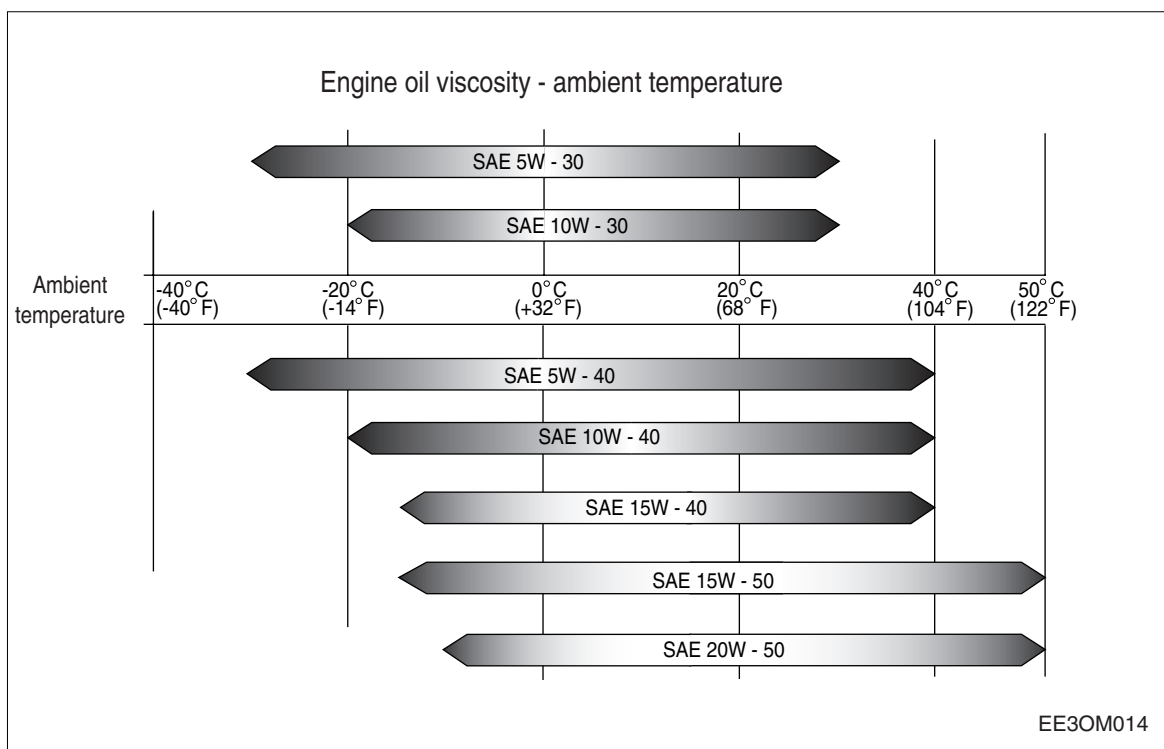
SAE No.	API No.	Sulfated ash content
15W40	above CD or CE	Bellow 0.5 %

Recommend oil : TOTAL LMG-405

Mobil Delvac super GEO 15W40

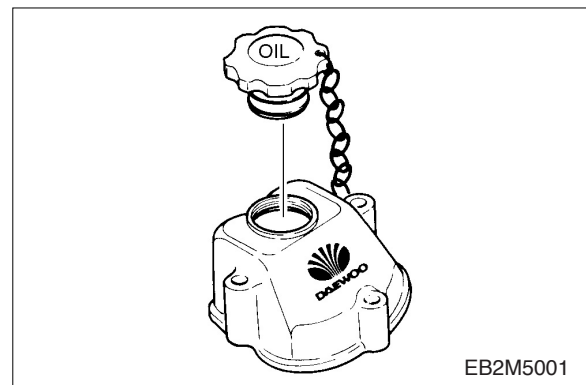
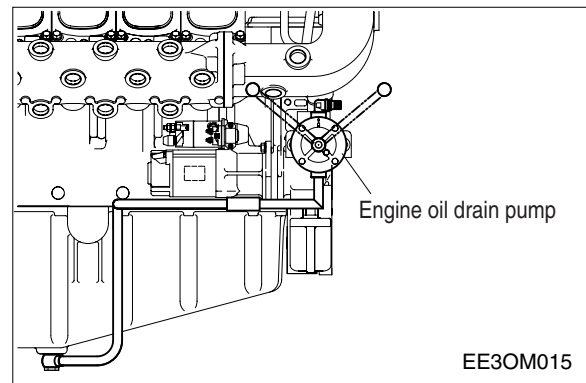
- Engine oil capacity

Engine oil capacity			
Engine model	in Oil pan		Total (lit)
	Max. (lit)	Min. (lit)	
GV158TIC	28	26	31
GV180TIC	35	28	38
GV222TIC	40	33	43



2.3.13. Exchanging of lubrication oil

- Engine oil and the oil filter are important factors affecting engine life. They affect ease of starting, fuel economy, combustion chamber deposits and engine wear.
- While the oil is still hot, discharge the sump oil by motion oil drain pump lever manually as figure.
- Refill new engine oil to the filler neck on the head cover in accordance with the oil capacity of the engine. Be careful about the mixing of dust or contaminator during the supplement of oil. Then confirm whether the oil level gauge indicates the vicinity of its maximum level.
- For a few minutes, operate the engine at idling in order to circulate oil through lubrication system. Thereafter shut down the engine. After waiting for about 10 minutes measure the quantity of oil and refill the additional oil if necessary.



2.3.14. Replacement of oil filter cartridge

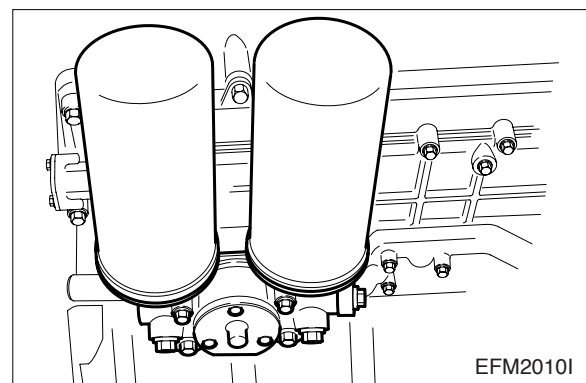
- Every time oil exchanges, replace the oil filter cartridge.
- Drain engine oil by loosening the drain plug on the filter head.



CAUTION:

Don't forget tightening the drain plug after having drained engine oil.

- Remove the oil filter by turning it counter-clockwise with a filter wrench.
- Wipe, clean the fitting face of the filter body and the oil filter body with a rag so that the new oil filter cartridge can be seated properly.
- Lightly oil the O-ring and turn the oil filter until O-ring is fitted against the seal face. And then turn it in addition by 3/4 ~1 turns further with hand or the filter wrench.

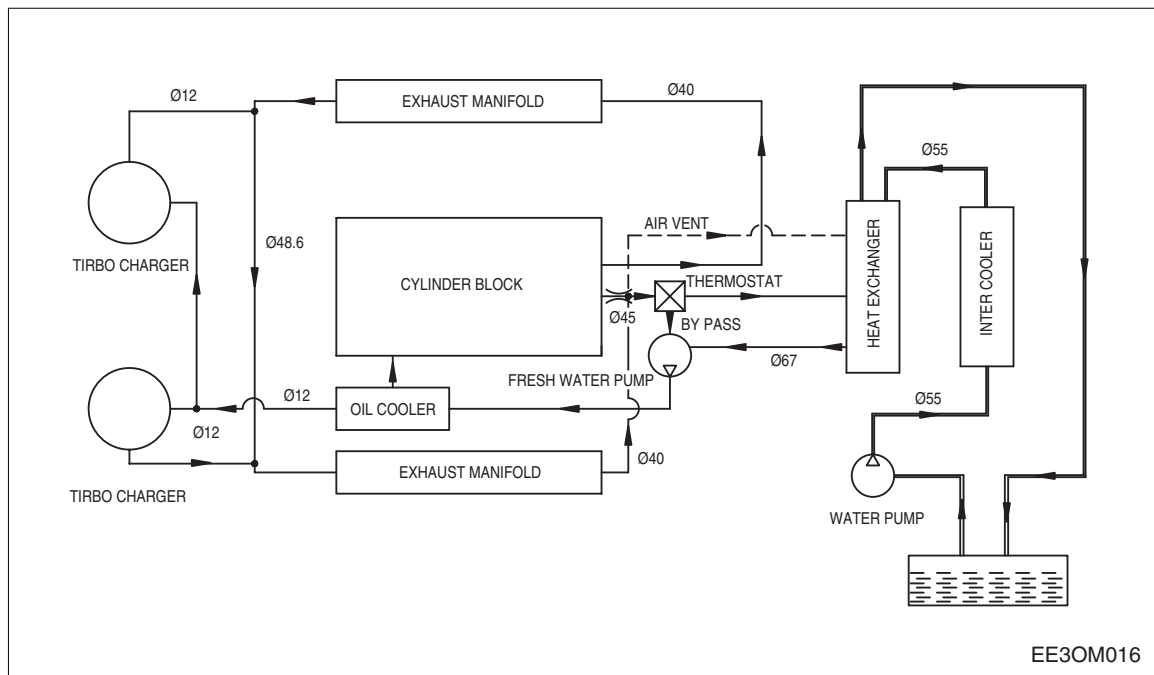


**NOTE:**

It is strongly advisable to use DAEWOO genuine oil filter cartridge for replacement.

2.3.15. Cooling System

- The engine has a liquid-cooling system. The water pump is a maintenance-free impeller pump driven by V-belts from the crankshaft pulley.
- Depending on the agreed extent of delivery and the design of the engine, the coolant circuit can be equipped with temperature monitors which, in the event of loss of coolant, shut the engine down.

**2.3.16. Cooling water**

- Regarding the cooling water that is to be used for engine, the soft water not the hard water must be used.
- The engine cooling water can be used diluting it with antifreezing solution 40% and the additive for rust prevention (DCA4) 3 ~ 5 %.
- The density of above solution and additive must be inspected every 500 hours to maintain it properly.

**NOTE:**

The proper density control of antifreezing solution and rust preventing additive will be able to prevent the rusting effectively and maintain the stable quality of engine.

For the improper control might give the fatal damage to the cooling water pump and cylinder liners, detail care is needed.

- Since **GV158TIC**, **GV180TIC**, **GV222TIC**(Engine of **D28** base engine) cylinder liner is wet type, particularly the cooling water control should be applied thoroughly.
- The density of antifreezing solution and additive for rust prevention is able to be confirmed by the cooling water test kit. (Fleetguard no. : **CC2602M** or DAEWOO no. : **60.99901-0038**)
- How to use the cooling water test kit
 - (1) When the cooling water temp. of engine is in the range of 10 ~ 55°C, loosen the plug for cooling water discharge and fill the plastic cup about a half.



NOTE:

In taking the cooling water sample, if the water in auxiliary tank were taken, it is hard to measure the accurate density. Take the cooling water sample necessarily loosening the cooling water discharge plug.

- (2) At the state of a test paper soaked in the sampled water, after taking the paper out through water agitation, shake off the water.
- (3) Wait for about 45 sec. till the color change of test paper.



NOTE:

However, it should not elapse longer than 75 sec, and if it did, the hue would change.

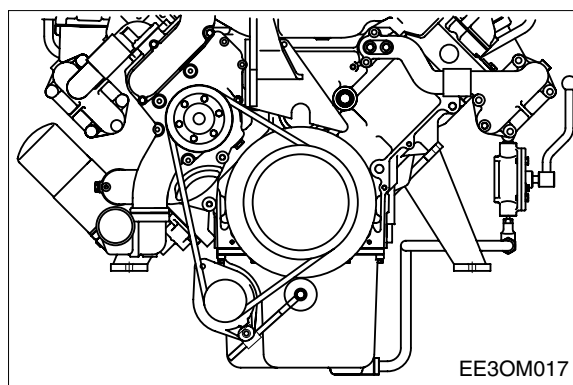
- (4) Make the numerical value by comparing the test paper which hue has changed with the color list of label on storage bottle.
- (5) By comparing the hue changed into yellowish green or so with the green color indication of test paper storage bottle, confirm the density. (Then, the density indication must be in the hue range of 33% to 50%).
- (6) The brown at the middle of test paper and the lower pink color indication represent the additive state for rust prevention, and the proper range is that the meeting numerical value of brown (vertical) and pink color (horizontal) locates in the range of 0.3 to 0.8 at the color list of label on the test paper storage bottle.
- (7) In case of less than 0.3, replenish the additive for rust prevention (DCA4), and in case of more than 0.8, pour out the cooling water about 50% and then readjust the density after refilling with clean fresh water.

- Amount of Anti-freeze in winter

Ambient Temperature (°C)	Cooling water (%)	Anti-freeze (%)
Over -10	85	15
-10	80	20
-15	73	27
-20	67	33
-25	60	40
-30	56	44
-40	50	50

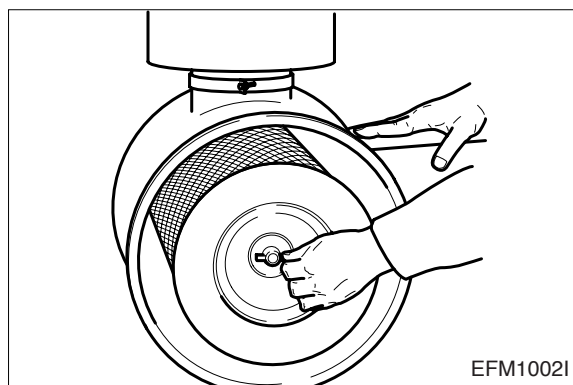
2.3.17. V-belt

- Use a V - belt of specified dimensions, and replace if damaged, frayed, or deteriorated.
- Check the V - belt for belt tension. If belt tension is lower than the specified limit, adjust the tension by relocating the alternator. (specified deflection: 10 ~ 15 mm when pressed down with thumb)



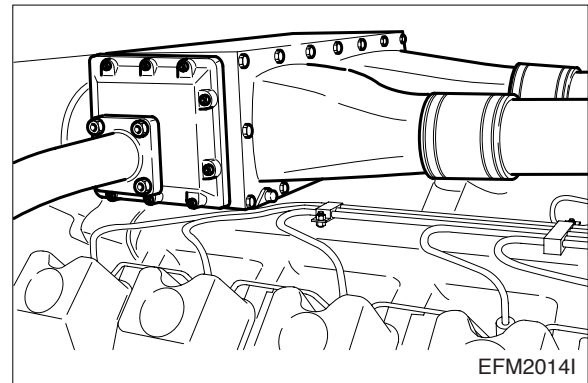
2.3.18. Air Cleaner

- Air cleaner is mounted on the engine to purify the air for combustion. The intervals at which the air cleaner requires servicing depend on the specific operating conditions encountered. Clogged air filters may cause black smoke and reduce power.
- A check should be made from time to time to see that the fastening elements securing the air cleaner to the intake manifold seal the connection tightly. Any ingress of unfiltered air is liable to cause a high rate of cylinder and piston wear.



2.3.19. Intercooler

- The intercooler is water to air type. The intercooler life and performance depends on the intake air condition greatly. Fouled air pollutes and clogs the air fins of intercooler. As a result of this, the engine output is decreased and engine malfunction is occurred.
- So you always check whether the intake air systems like air filter element are worn or polluted.



2.3.20. Valve Clearance Adjust Procedure



- After letting the #1 cylinder's piston come at the compression top dead center by turning the crankshaft, adjust the valve clearances.



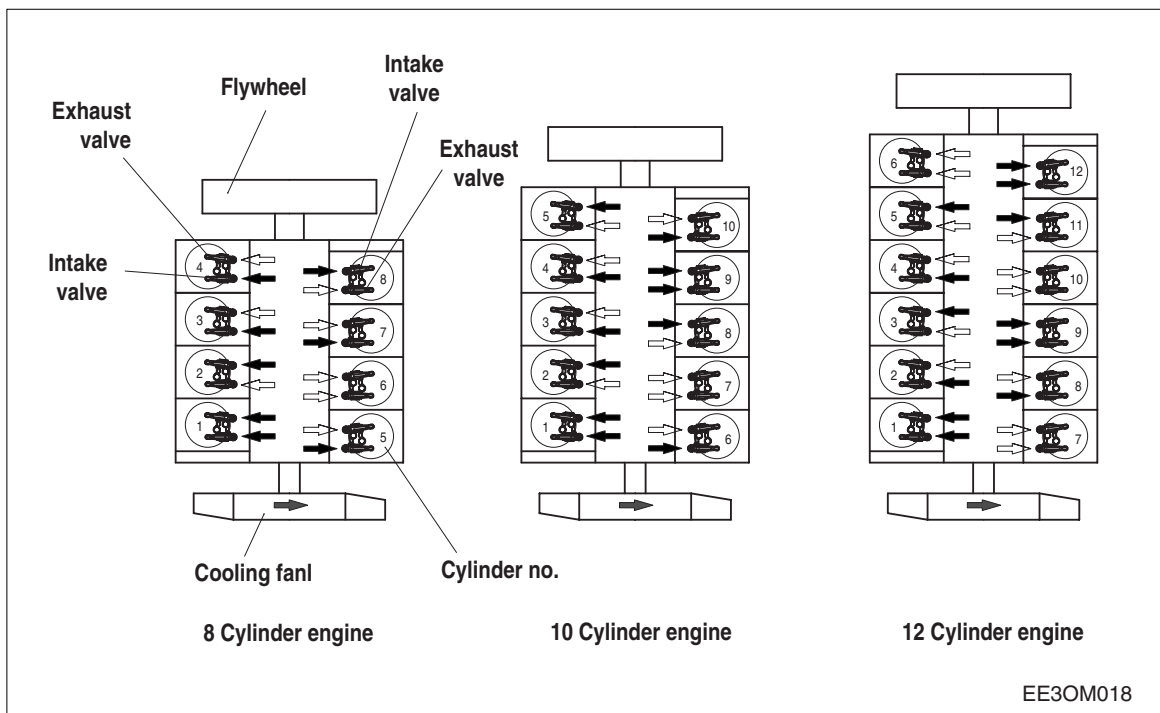
- Loosen the lock nuts of rocker arm adjusting screws and push the feeler gauge of specified value between a rocker arm and a valve stem and adjust the clearance with adjusting screw respectively and then tighten with the lock nut.
- As for the valve clearance, adjust it when in cold, as follows.

Model	Intake Valve	Exhaust Valve
GV158TIC GV180TIC GV222TIC	0.30 mm	0.40 mm

• Adjusting Sequence of Valve Clearance (1 Type)

- By cranking the engine, let #1 cylinder's valves overlap.
- In time, adjust the valve clearance corresponding to " ⇨ " of lower lists.
- In time, turning crankshaft one full turn, let the valves of #7 (10 cylinder engine) or #6 (8 cylinder engine and 12 cylinder engine) cylinder's valves overlap.
- Adjust the valve clearance corresponding to " ➡ " of lower lists.
- After reinsuring the valve clearances, retighten if necessary.

- No. 1 Cylinder is located at the side where cooling water pump was installed.



• Adjusting Sequence of Valve Clearance (2 Type)

Type 1 is the conventional and simple method, but if you have some problem to adjust your engine, please try type 2 sequence. This is a precision method, but it takes more time.

* 8 Cylinder Engine (GV158TIC)

Valve overlapping on cylinder (Intake & Exhaust valve)	1	5	7	2	6	3	4	8
Adjusting valves on cylinder (Intake & Exhaust valve)	6	3	4	8	1	5	7	2

* 10 Cylinder Engine (GV180TIC)

Valve overlapping on cylinder (Intake & Exhaust valve)	1	6	5	10	2	7	3	8	4	9
Adjusting valves on cylinder (Intake & Exhaust valve)	7	3	8	4	9	1	6	5	10	2

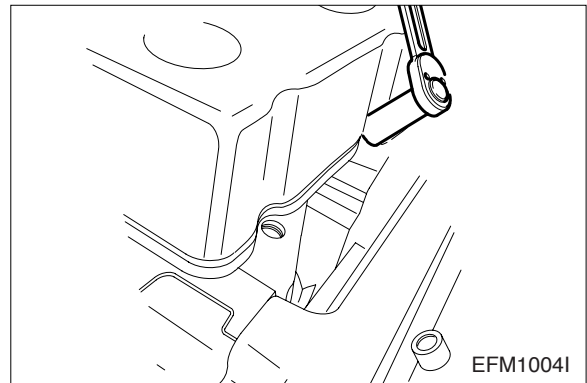
* 12 Cylinder Engine (GV222TIC)

Valve overlapping on cylinder (Intake & Exhaust valve)	1	12	5	8	3	10	6	7	2	11	4	9
Adjusting valves on cylinder (Intake & Exhaust valve)	6	7	2	11	4	9	1	12	5	8	3	10

2.3.21. Cylinder Compression Pressure



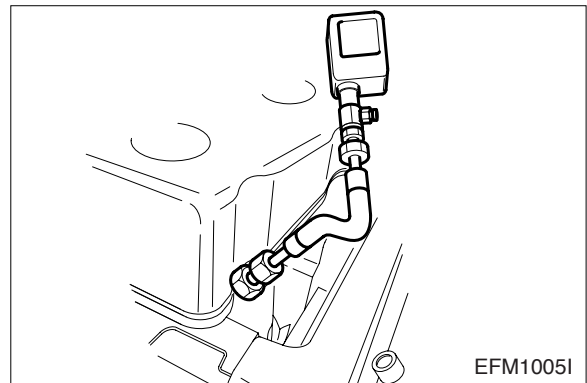
- Stop the engine after warming up, and take out the spark plug.



- Install the special tool (compression gauge adapter) at the spark plug hole, and connect the compression pressure gauge there.



Standard value	16kg/cm ² over
Limit value	13kg/cm ²
Difference between each cylinder	Within $\pm 10 \%$



- Condition : Water temperature 20°C,
Engine rotation 200rpm

2.3.22. Spark plug

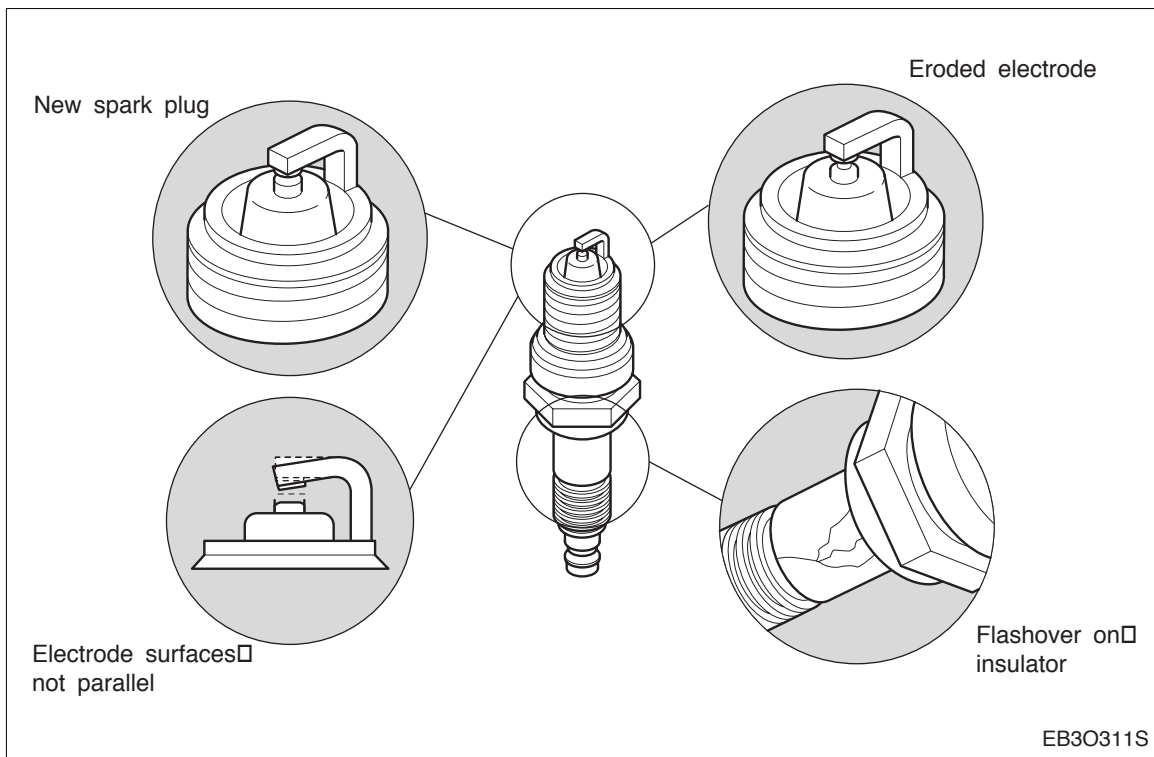
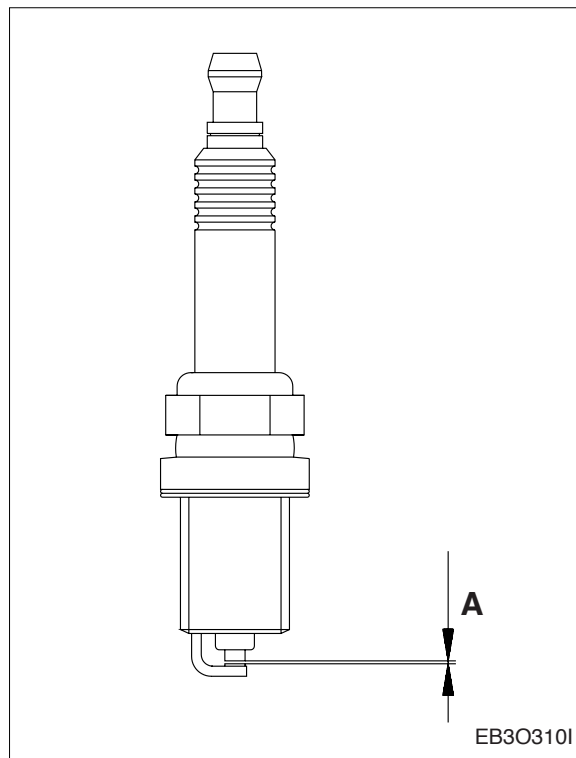


- Remove spark plug. Clean threads by hand with brush and solvent.
- Clean any deposits from electrode and Inspect insulator area
- Measure the spark plug distance at electrode position.(A)
- Replace spark plug if necessary.

	Standard
Distance(A)	0.39 ~ 0.40 mm

- Install spark plug.

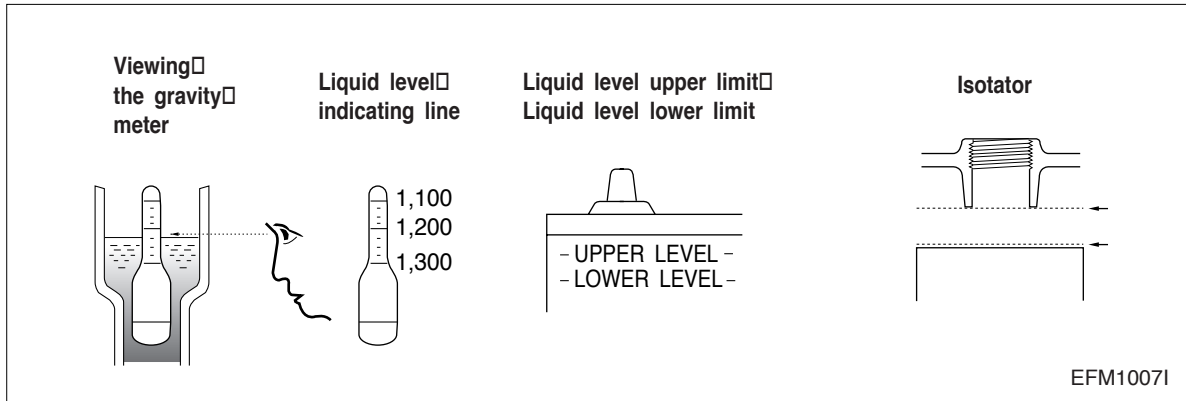
Torque	2.5 ~ 3.0 kg.m



2.3.23. Battery



- Inspect for any leakage of electrolytic solution owing to battery crack, and replace the battery in case of poor condition.
- Inspect for amount of electrolytic solution, and replenish if insufficient.
- Measure the gravity of electrolytic solution, if less than specified value (1.12 ~ 1.28), replenish.



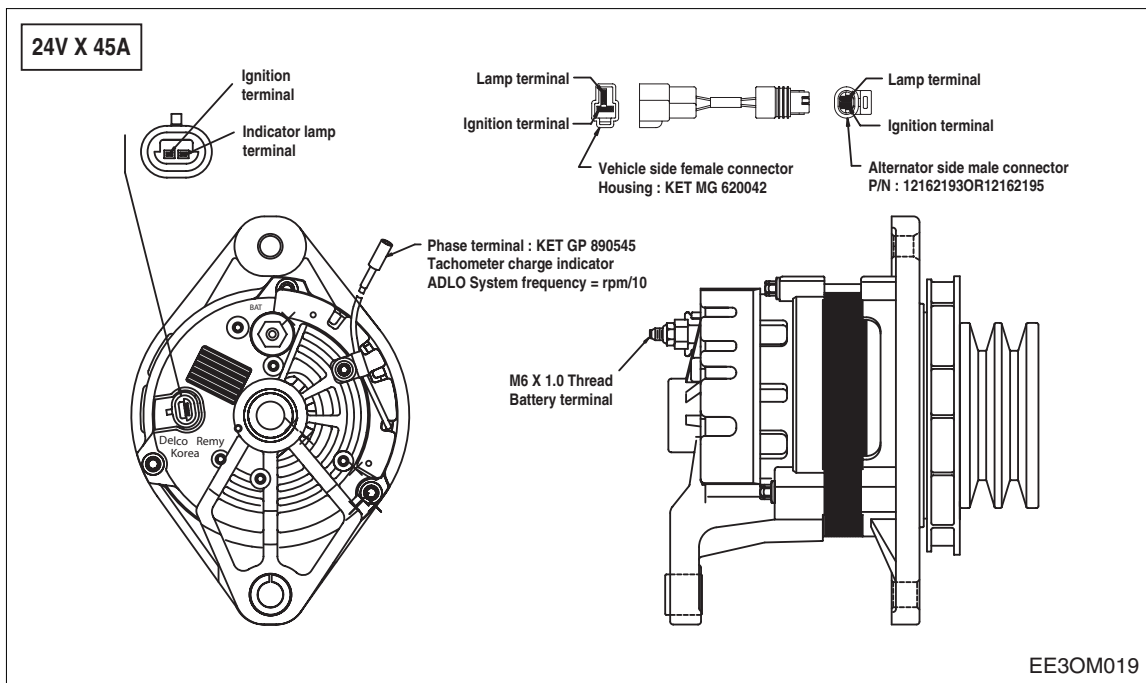
2.3.24. Turbocharger



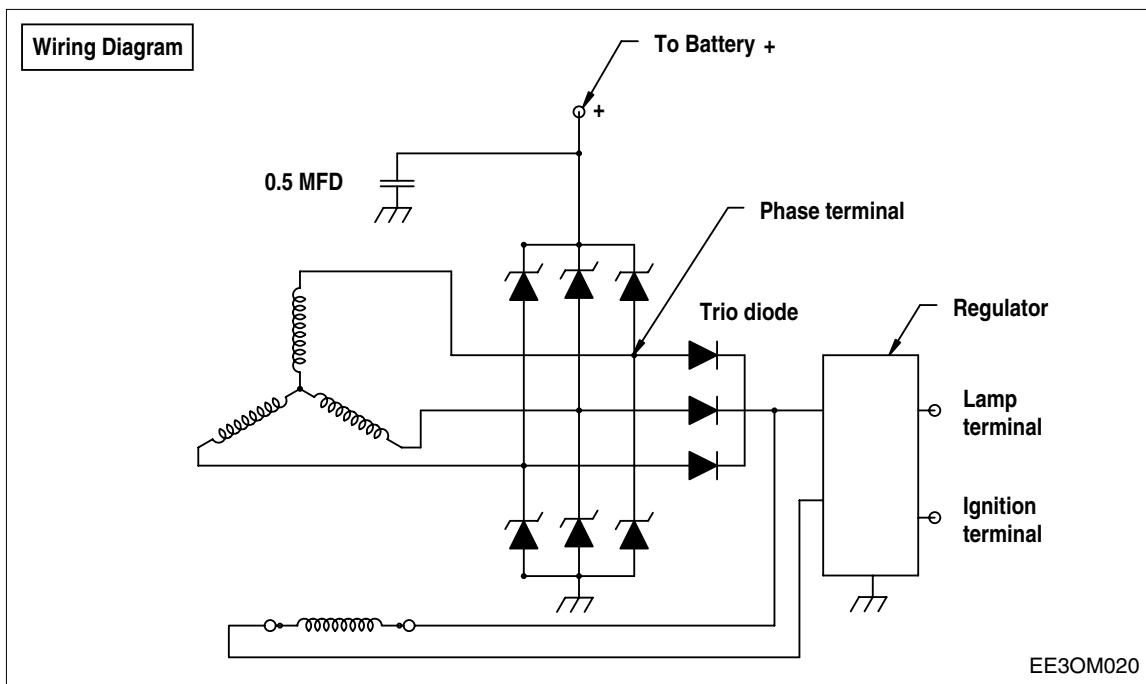
- The turbocharger needs not any special equipment.
- Every time of engine replacement, a leakage or clogging of oil pipes should be inspected. Air cleaner should be maintained carefully for not or foreign material not to get in. Periodic inspection should be applied on the compressed air and exhaust gas pipes, For leaking air will bring the overheat engine, an immediate repair must be done.
- During the operation that is surrounded by the dust and oil mixed air, frequent cleaning must be done on the impellers. Tear down the impeller casing (attention: be careful not to bend) and must clean with non-acid solvent solution. If necessary, use plastic scraper. If impeller is severely polluted, dip the impeller into solution and may be better to clean it with stiff brush. Then one thing to beware is to dip only impeller part and so do not support by impeller but bearing housing.

2.3.25. Alternator

- The alternator is fitted with integral silicon rectifiers. A transistorized regulator mounted on the alternator body interior limits the alternator voltage. The alternator should not be operated except with the regulator and battery connected in circuit to avoid damage to the rectifier and regulator.



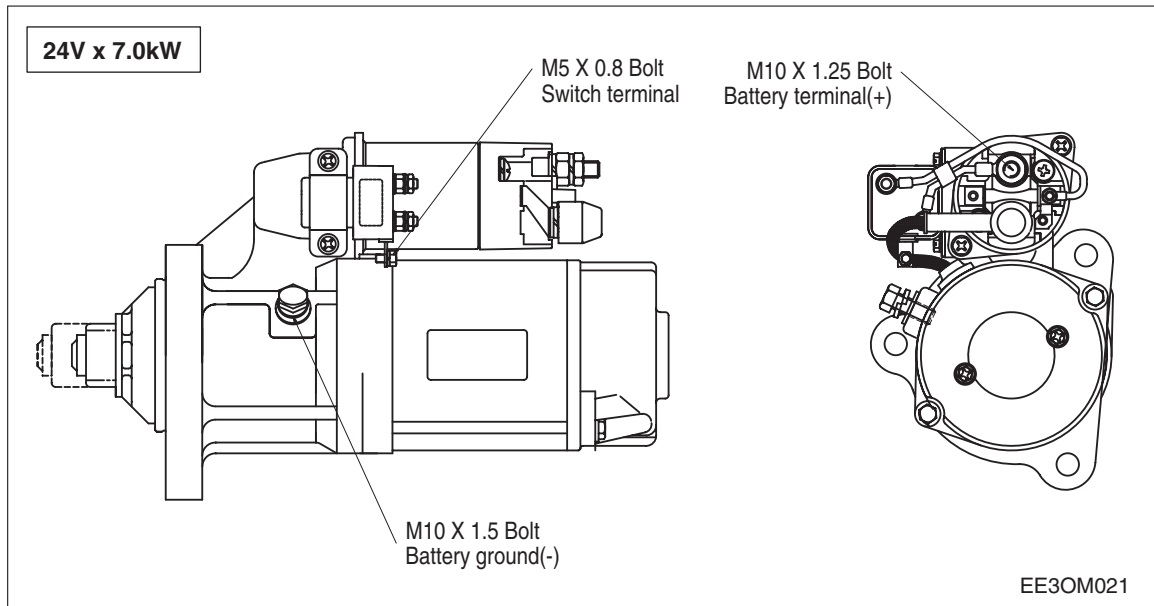
- The alternator is maintenance-free, nevertheless, it must be protected against dust and, above all, against moisture and water.



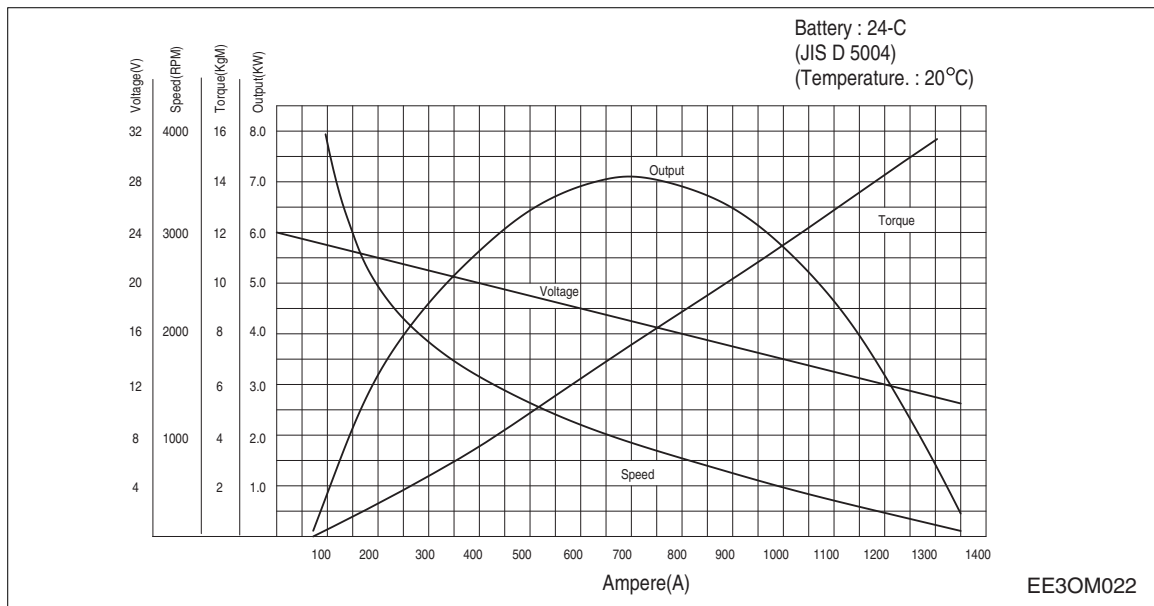
Operate the alternator according to the instructions given in the chapter.

2.3.26. Starting motor

- The sliding-gear starter motor is flanged to the rear of the flywheel housing on the left-hand side. As parts of every engine overhaul, the starter pinion and ring gear should be cleaned with a brush dipped in fuel and then a coat of grease should be applied again.

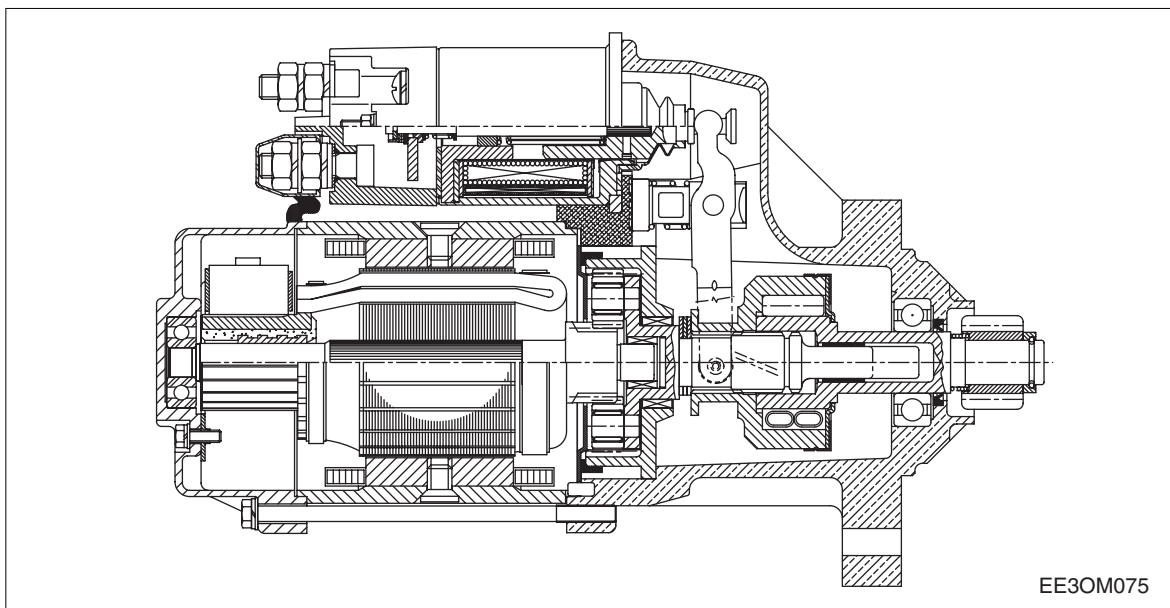


- Always protect starter motor against moisture



IMPORTANT:

Always disconnect the battery earth cable before starting work on the electrical system. Connect up the earth cable last, as there is otherwise a risk of short-circuits.



2.3.27. Precautions in use



- Pay attention to dropping the battery voltage capacity when they are left for long time even without use.
- As starting may not be done well sometime in cold winter season, do not try it to be continuous immediately but try to start again after waiting about 30 seconds.
- Prior to operating the gauge panel, make sure the polarity of battery once again (In majority of polarities, red side is "+" and black one is "-")
- On disassembling the gauge panel may be accompanied a risk of electrical shock, always work after pulling off the connector at rear side of it without fail.
- If the silver paper etc is used for connecting the cut-off fuse, because the excessive current might flow into the parts to damage, when fuse is cut off, after resolving the problem locating the cause, replace it with new fuse.
- Since battery has a danger of explosion by a heat, it must not be placed at the spot where generates a lot of heat.
- When engine is in stop, pull out the key always. Thus, a hazard of fire or wound due to wrong operation may not happen.
- In case of scrapping the batteries, observe the followings.



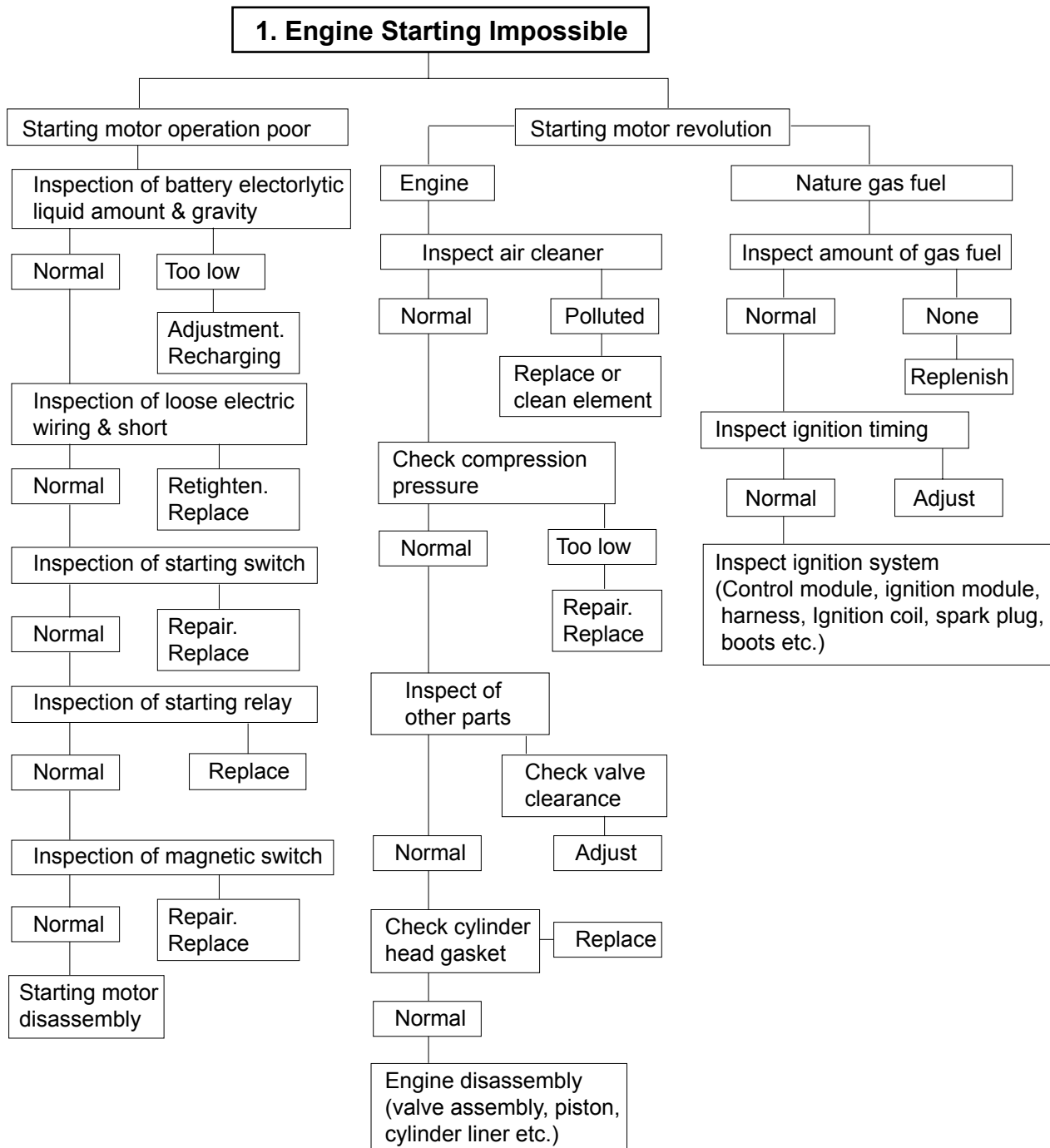
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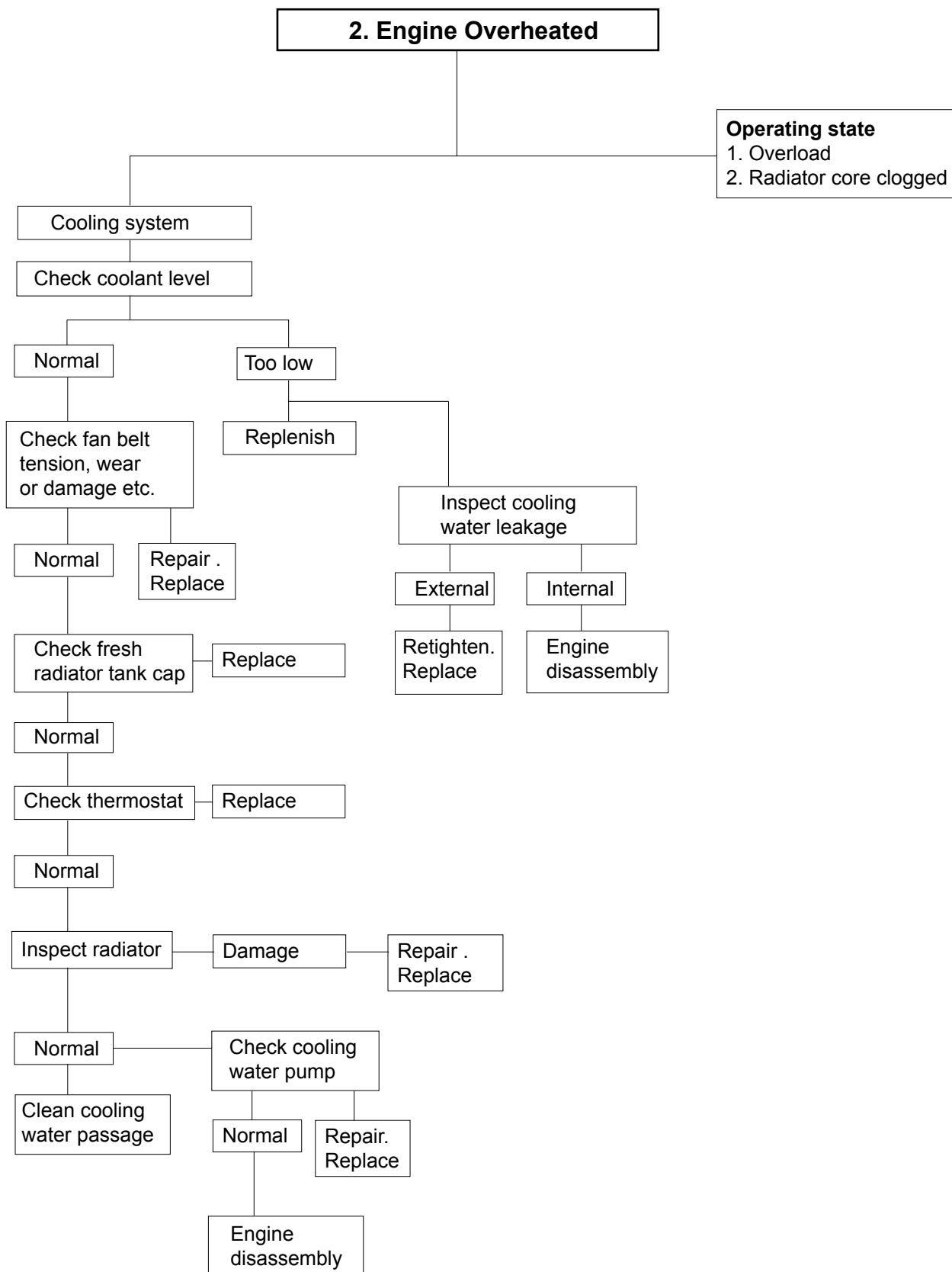
Do not throw it in the fire to scrap. It should not be thrown away into the places where are liable to cause the environmental pollution such as stream, river and mountain. Pack them as far as possible and dispose it as rubbish that is unable to use again.

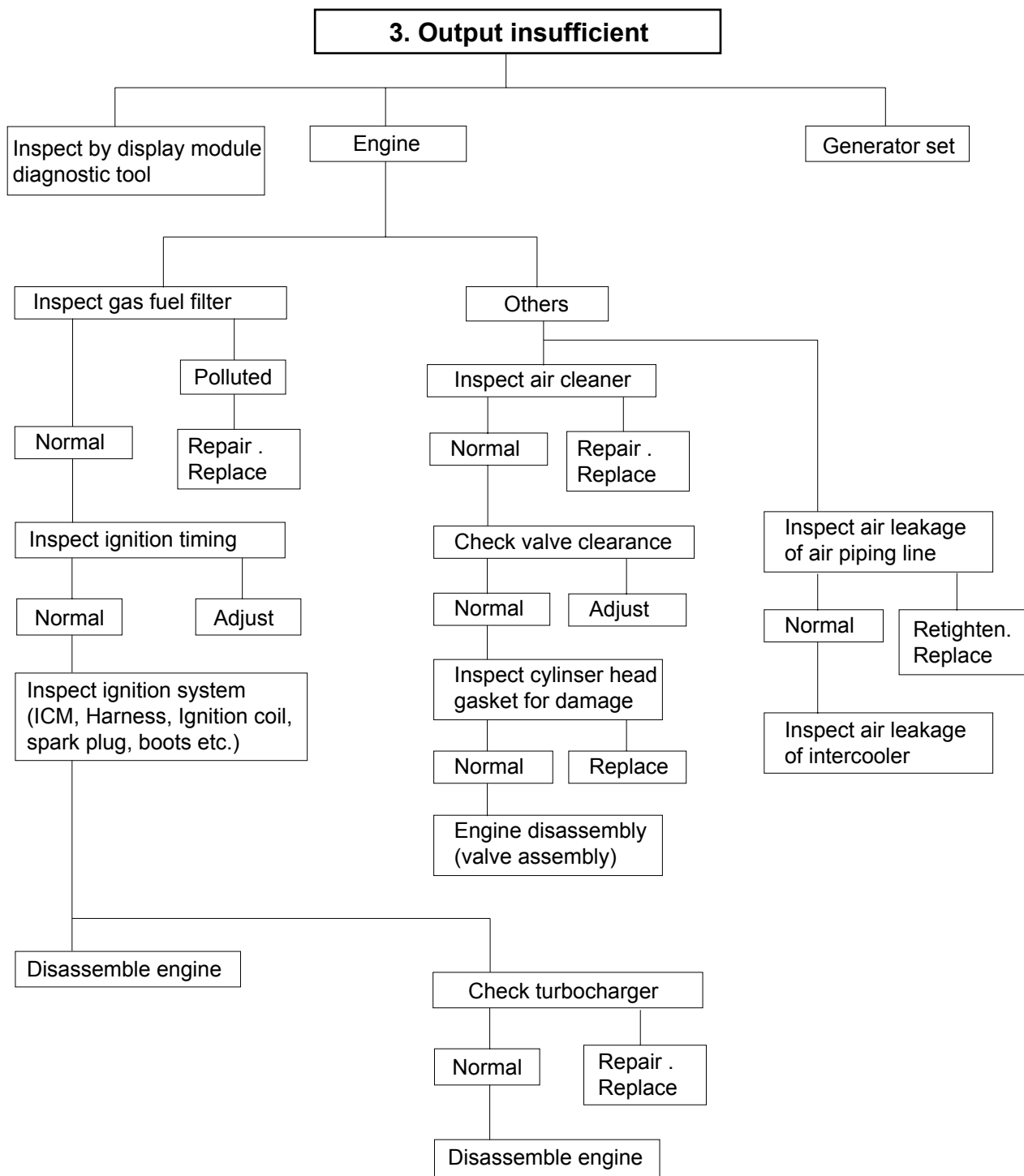
- DAEWOO will not be responsible to the problems that might be raised by the disassembling and structural change of this product without consultation.

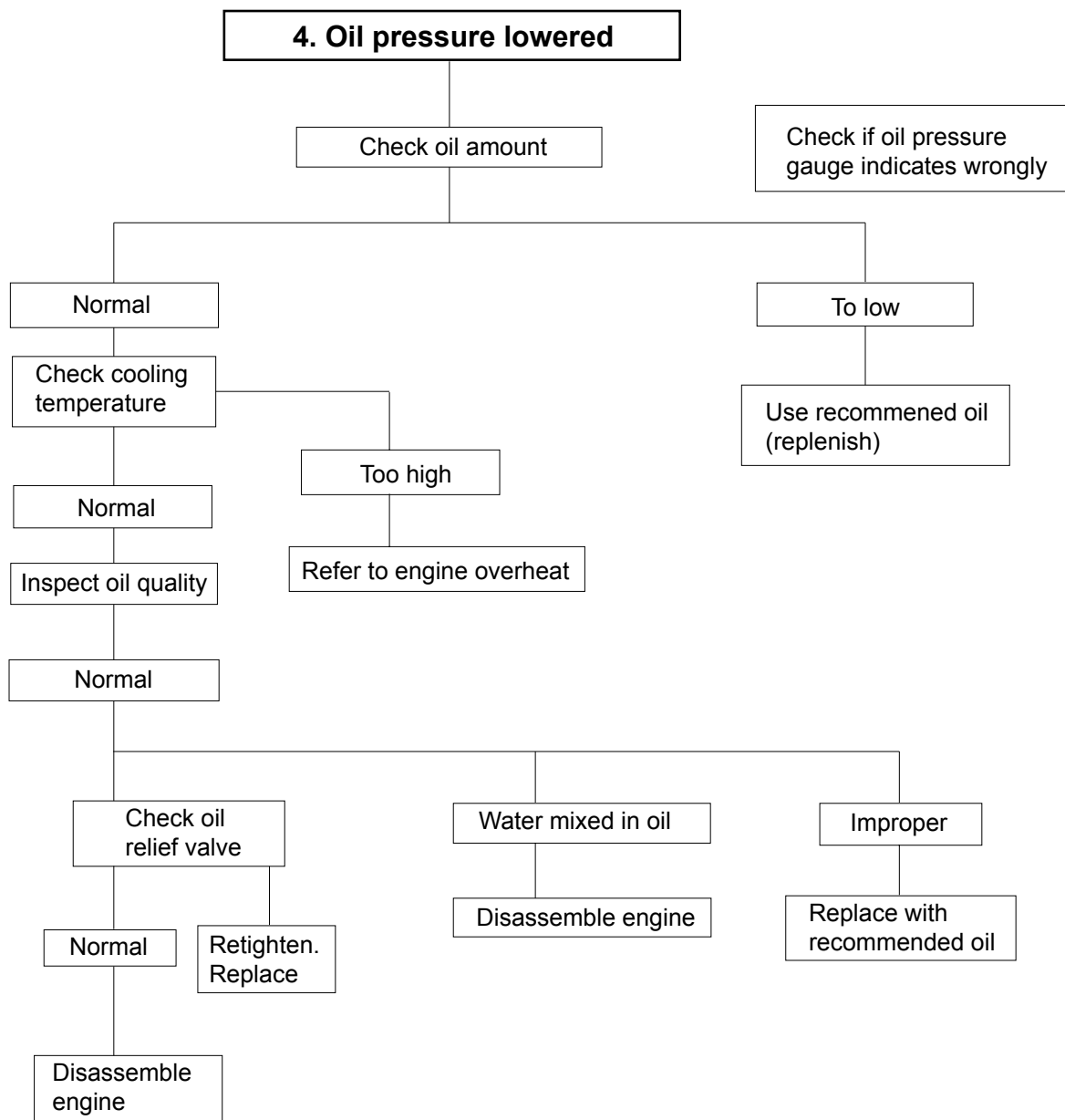
2.4. Diagnosis and Remedy

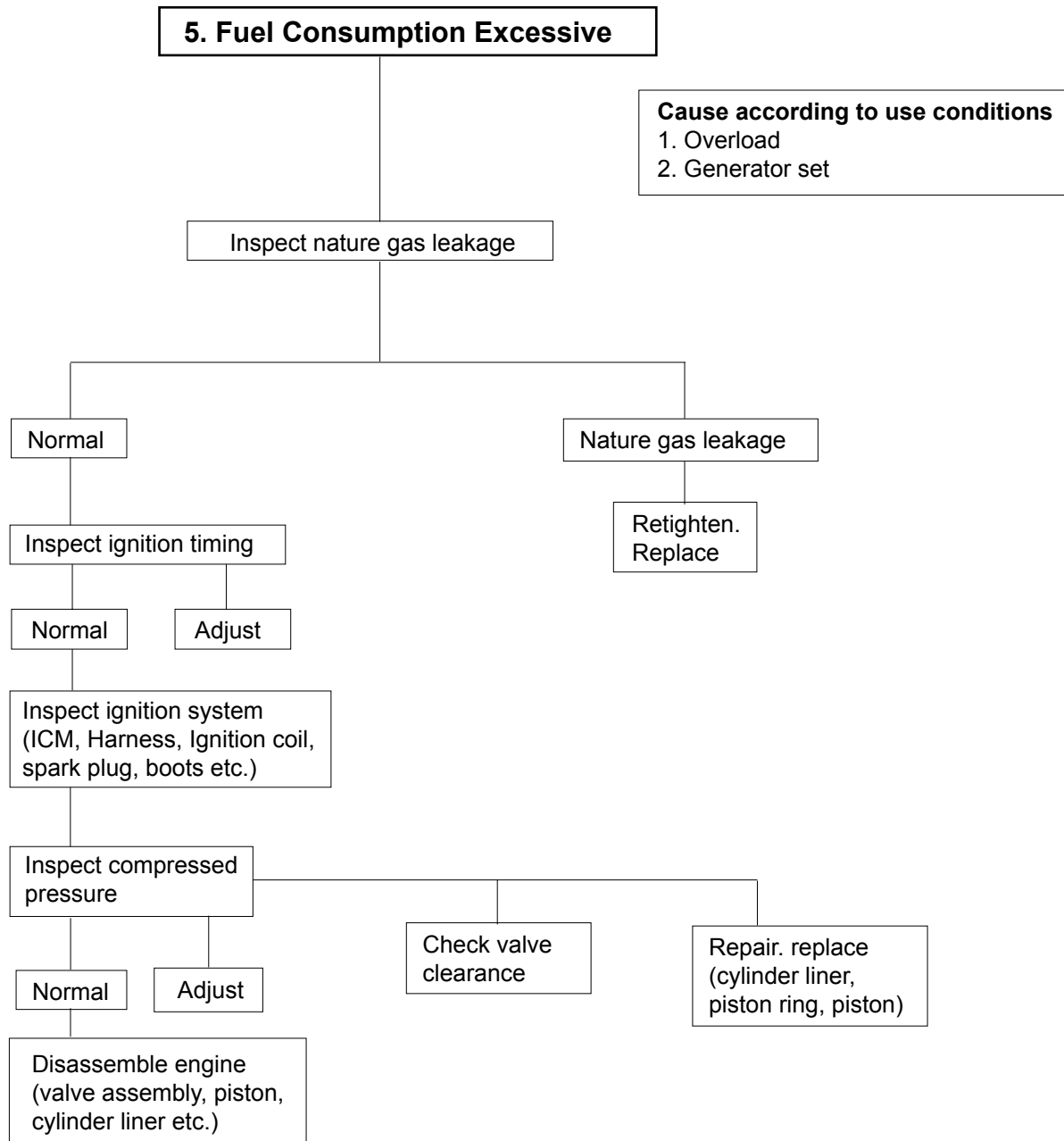
- The following description summarizes the probable cause of and remedy for general failure by item.
- Immediate countermeasures should be taken before a failure is inflamed if any symptom is detected.
- Inspect the electrical parts problem by the Display module.

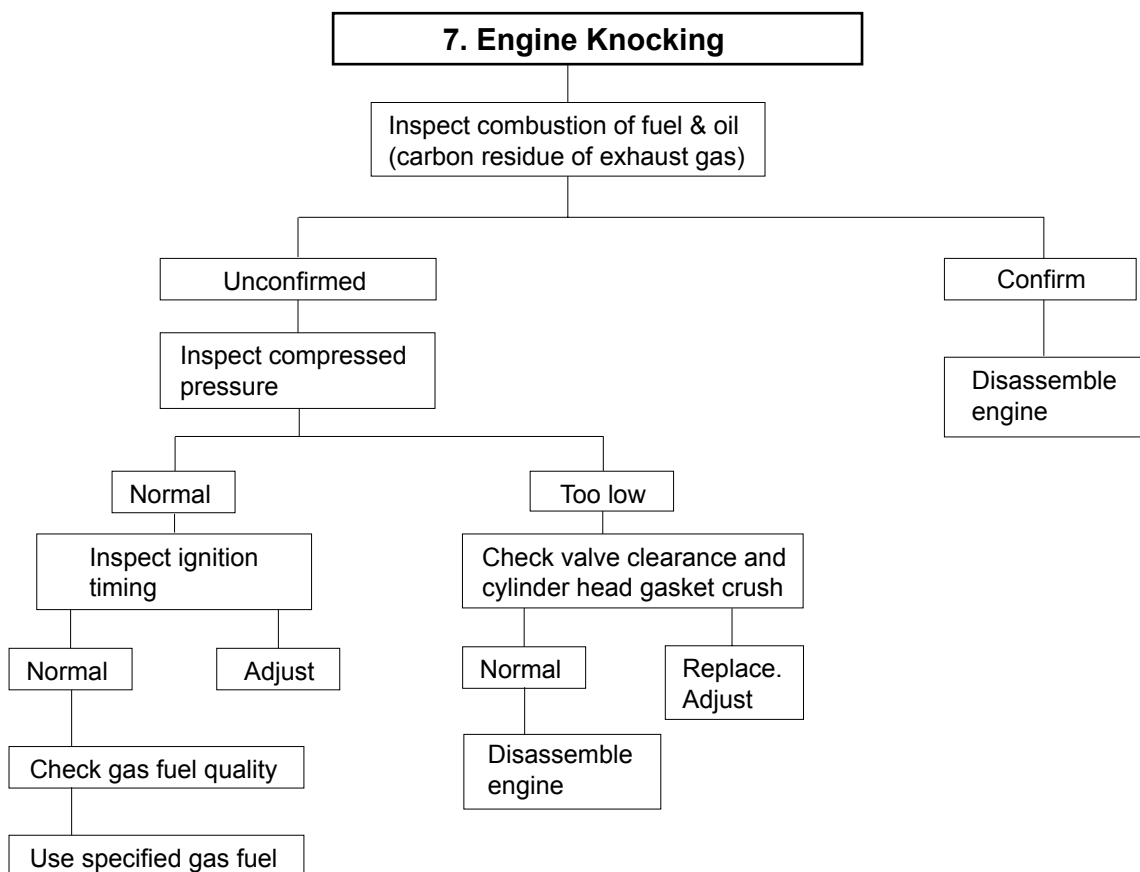
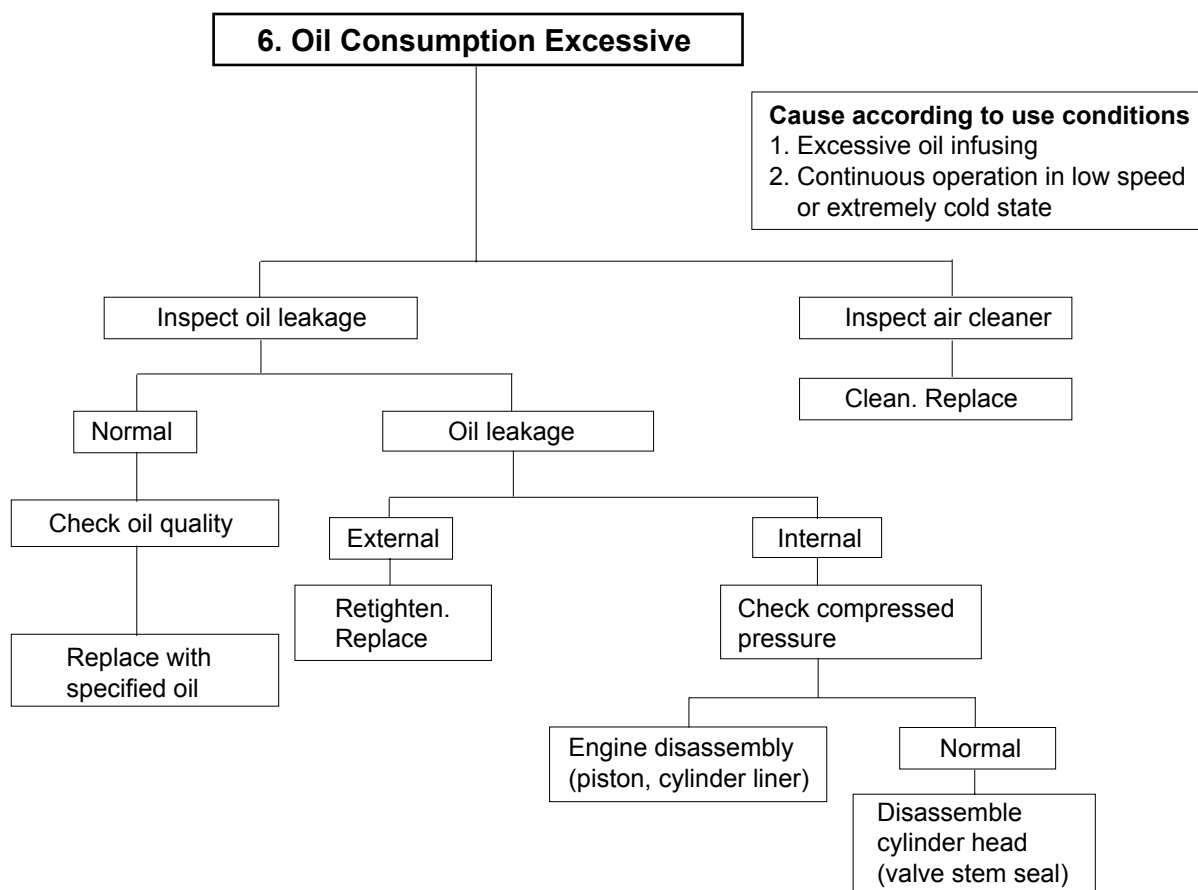


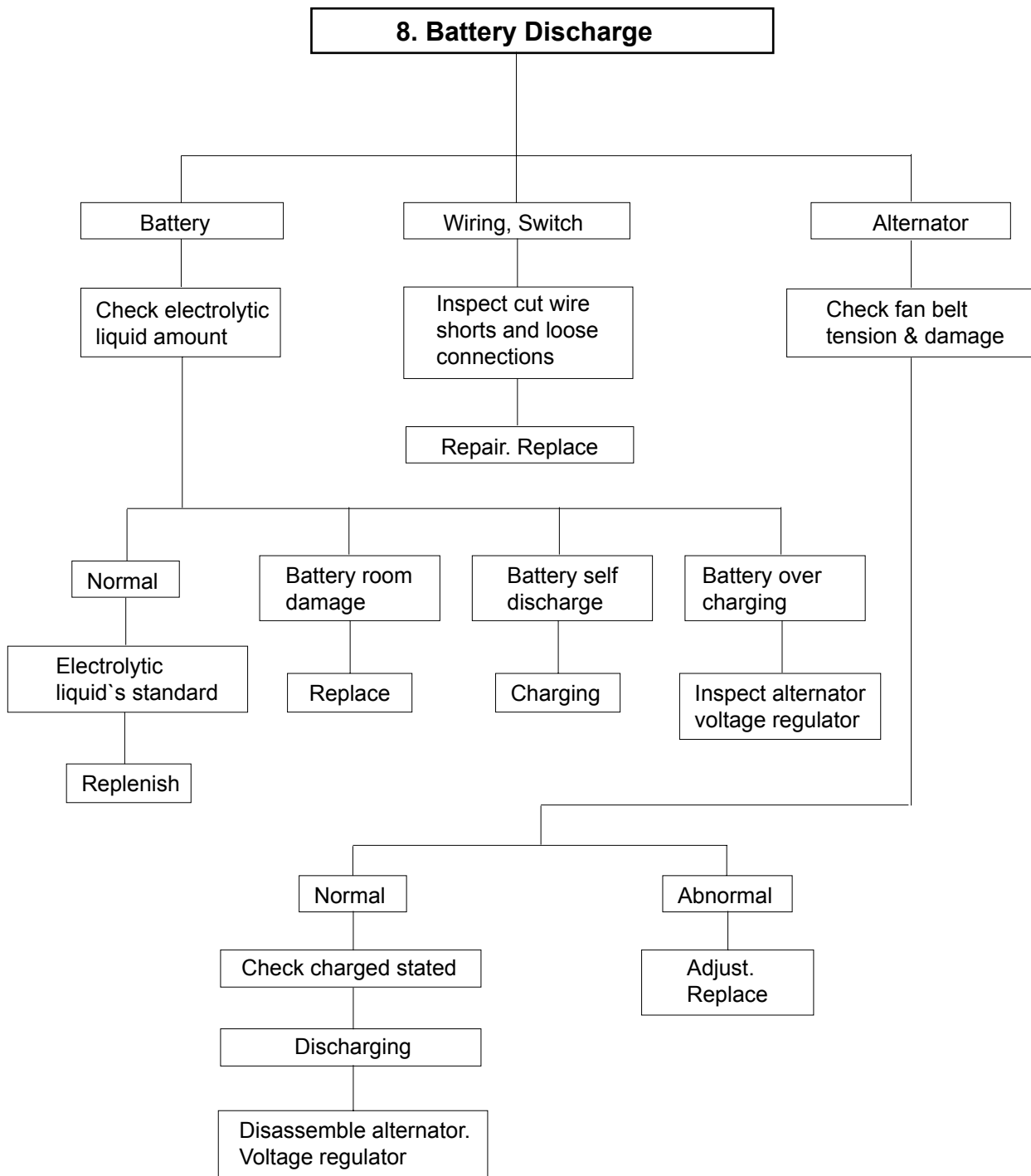












Condition	Causes	Remedies
1) Starting difficult (1) Compression pressure	- Valve's poor shut, stem distortion - Valve spring damage - Cylinder head gasket's leak - Wear of piston, piston ring or liner	Repair or replace Replace valve spring Replace gasket Adjust
2) Idle operation abnormal	Ignition timing incorrect	Adjust
3) Engine output insufficient (1) Continuous output Insufficient	- Valve clearance incorrect - Valve tightness poor - Cylinder head gasket's leak - Wear, stick, damage of piston ring - Ignition timing incorrect - Damage of spark plug & ignition coil - Air suction amount insufficient - Turbocharger poor	Adjust Repair Replace gasket Replace piston ring Adjust Adjust or replace Clean or replace air cleaner Repair or replace
(2) Output insufficient when in acceleration	- Compression pressure insufficient - Ignition timing incorrect - Damage of spark plug & ignition coil - Air intake amount insufficient	Disassemble engine Adjust Repair or replace Clean or replace air cleaner
4) Overheating	- Engine oil insufficient or poor - Cooling water insufficient - Fan belt loosened, worn, damaged - Cooling water pump's function lowered - Thermostat operation poor - Valve clearance incorrect - Exhaust system's resistance increased	Replenish or replace Replenish or replace Adjust or replace Repair or replace Replace Adjust Clean or replace
5) Engine noisy	For noises arise compositely such as rotating parts, lapping parts etc., there is necessity to search the cause of noises accurately.	
(1) Crankshaft	- As the wear of bearing or crankshaft progress, the oil clearances increase. - Lopsided wear of crankshaft - Oil supply insufficient due to oil passage clogging - Stuck bearing	Replace bearing & grind crankshaft Grind or replace Clean oil passage Replace bearing & grind
(2) Connecting rod and Connecting rod bearing	- Lopsided wear of con rod bearing - Lopsided wear of crank pin - Connecting rod distortion - Stuck bearing - Oil supply insufficiency as clogging at oil passage progresses	Replace bearing Grind crankshaft Repair or replace Replace & grind crankshaft Clean oil passage

Condition	Causes	Remedies
(3) Piston, piston pin & piston ring	• Piston clearance increase as the wear of piston and piston ring progresses • Wear of piston or piston pin • Stuck piston • Piston insertion poor • Piston ring damaged	Replace piston & piston ring Replace Replace piston Replace piston Replace piston
(4) Others	• Wear of crankshaft, thrust bearing • Camshaft end play increased • Idle gear end play increased • Timing gear backlash excessive • Valve clearance excessive • Abnormal wear of tappet, cam • Turbocharger inner part damaged	Replace thrust bearing Replace thrust plate Replace thrust washer Repair or replace Adjust valve clearance Replace tappet, cam Repair or replace
6) Oil Consumption Excessive		
(1) Oil level elevated	• Clearance between cylinder liner & piston • Wear of piston ring, ring groove • Piston ring's damage, stick, wear • Piston ring opening's disposition improper • Piston skirt part damaged or abnormal wear • Oil ring's oil return hole clogged • Oil ring's contact poor	Replace Replace piston, piston ring Replace piston ring Correct position Replace piston Replace piston ring Replace piston ring
(2) Oil level lowered	• Looseness of valve stem & guide • Wear of valve stem seal • Cylinder head gasket's leak	Replace in set Replace seal Replace gasket
(3) Oil leak	• Looseness of connection parts • Various parts' packing poor • Oil seal poor	Replace gasket, repair Replace packing Replace oil seal

2.5. Engine inspection

2.5.1. Stopping engine

- Cut off the main circuit breaker of the generator control panel. After checking the engine for any unusual condition at the idling speed, then press the stop button to stop the engine.

2.5.2. General engine inspection cycle

- In order to insure maximum, trouble-free engine performance at all times, regular inspection, adjustment and maintenance are vital.
 - Daily inspections in below figure should be checked every day.
 - The following maintenance details should be executed thoroughly at regular intervals.

○ : Check & adjust ● : Replace

Inspection Item		Daily	Every 50hrs	Every 200hrs	Every 500hrs	Every 1500hrs	Every 3000hrs	Remark
Cooling System	Check for leakage(hoses, clamp)	○						
	Check the water level	○						
	Adjust the V-belt tension	○						
	Change the coolant water							● 1 year
Lubrication System	Check for leakage	○						
	Check the oil level gauge	○						
	Change the lubricating oil		● 1st	●				Every 200hr
	Replace the oil filter cartridge		● 1st	●				Every 200hr
Intake & Exhaust System	Check the leakage for intercooler (hoses, clamp)	○				●		
	Check the air cleaner indicator	○						
	Check the air cleaner element and/or repair			○ clean	●			
	Clean the exhaust system						○	
Fuel System	Check the leakage fuel line	○						
	Check the fuel mixer							○ 1 year
	Check the throttle body							○ 1 year
	Check the speed controller							○ 1 year
	Check the gas pressure regulator							○ 1 year
Ignition System	Check the state of ignition timing							When necessary
	Check the spark plug					●	●	
	Check the ignition cable							● 1 year
	Check the ignition coil							○ 1 year
	Check the sensors (ignition or timing)	○						
Engine Adjust	Check the state of exhaust gas	○						
	Check the exhaust gas pressure							When necessary
	Check the battery charging	○						
	Check the compression pressure							When necessary
	Adjust Intake/Exhaust valve clearance				○			When necessary

2.5.3. Use of original parts for repair and replacement

- For engine is being mechanically harmonized with many parts, only when the original parts that the manufacture recommends to use is used, the engine trouble would be preventively maintained and capable to keep up the maximum performances.
- For the analogous parts not the original parts are poor in qualities and gives ill performances, it may rather bring early engine failure

3. DISASSEMBLY AND REASSEMBLY OF MAJOR COMPONENTS

3.1. Engine Disassembly



- Engine parts' disassembly procedures are as follows;

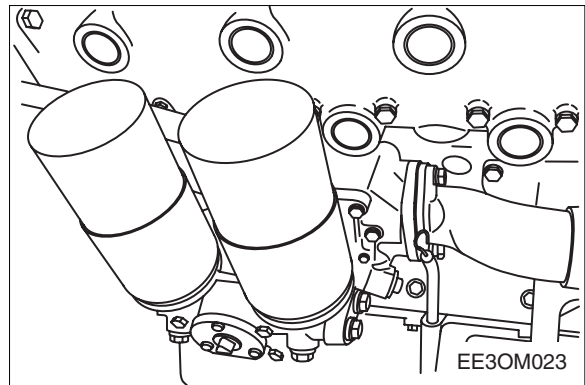
3.1.1. General precautions



- For the various tool storage before disassembly and parts storage after disassembly, the shelf for parts is prepared
- At the time of disassembly and reassembly, do the work with the naked and clean hand, and also the working place must be maintained clean
- The torn parts after disassembly must be kept not to collide each other.
- In disassembling, torn parts should be laid in disassembled order.
- Always close all the fuel valves before serving the system.

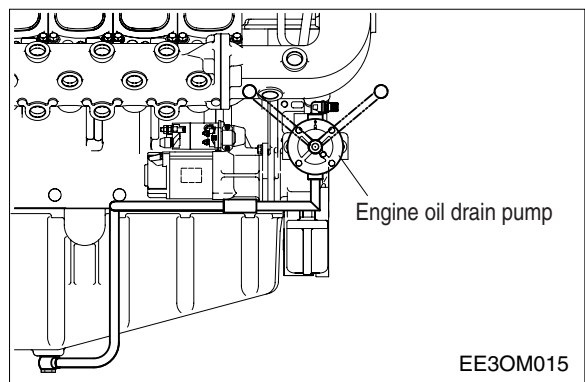
3.1.2. Oil level gauge

- Take out the oil level gauge.



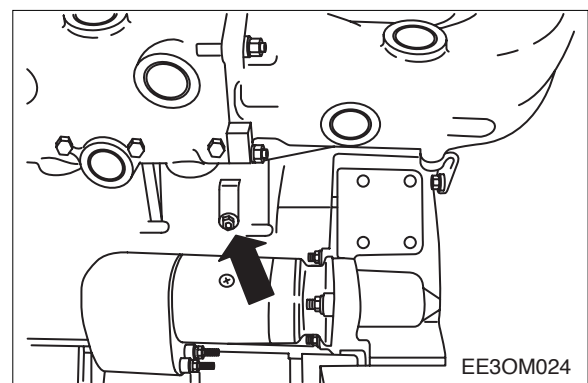
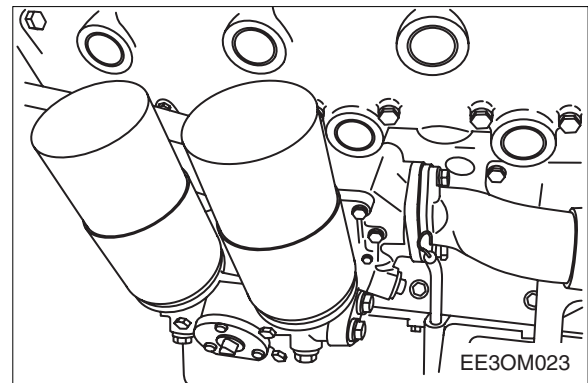
3.1.3. Engine oil

- Turn the valve opening and then move the oil drain pump lever as figure by hand, and let engine oil discharge into the prepared vessel



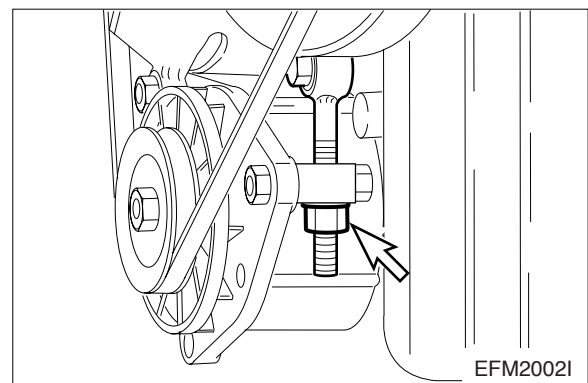
3.1.4. Cooling water

- Remove the cooling water drain plug from the cylinder block and oil cooler, various pipes, etc. and let the cooling water discharge into the prepared vessel.



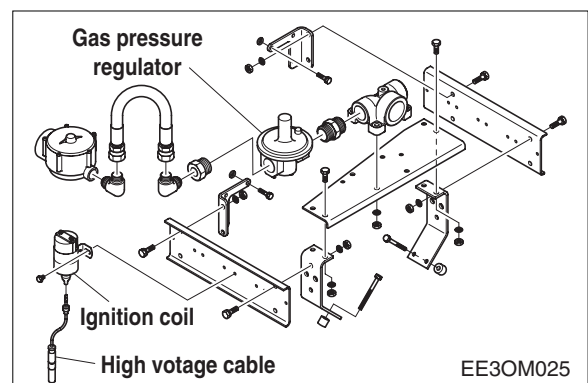
3.1.5. V-belt.

- Loosen the V-belt tension adjusting bolts, and remove the V-belt.



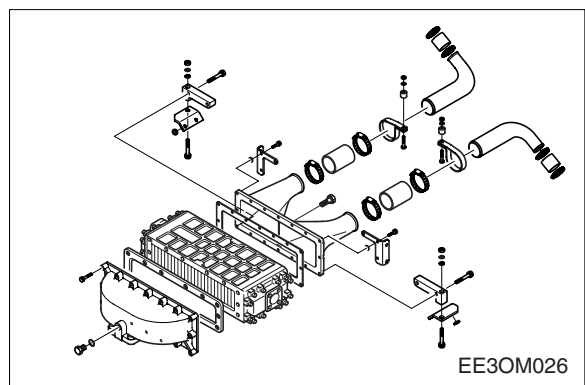
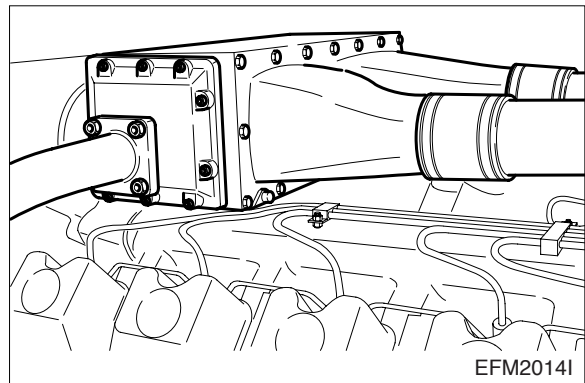
3.1.6. Ignition coil & gas pressure regulator

- Remove the high voltage cable by hand from each cylinder.
- Remove the gas pressure regulator fixing bolts and then tear down the gas pressure regulator and others parts.



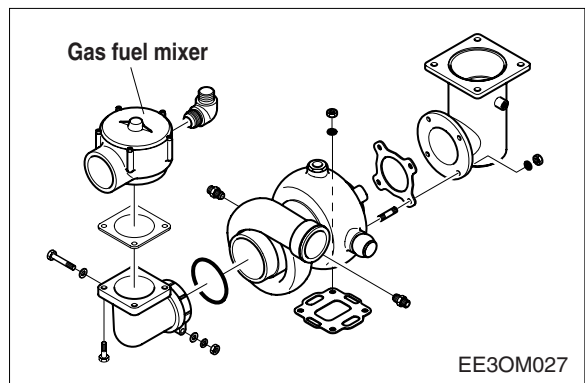
3.1.7. Intercooler

- Tear down the various hoses and air pipes from the inter cooler.
- Remove the intercooler fixing bolts and tear it down.



3.1.8. Turbocharger and gas fuel mixer

- Loosen the gas hose and air cleaner hose for connecting the gas fuel mixer.
- Loosen the clamp and fixing bolt for connecting the turbocharger and then tear down the air intake stake and gas fuel mixer.
- Remove the hollow screws of pipes for turbocharger and its discharge, and tear the pipes down.
- Remove the turbocharger fixing nuts and separate the turbocharger from the exhaust manifold.



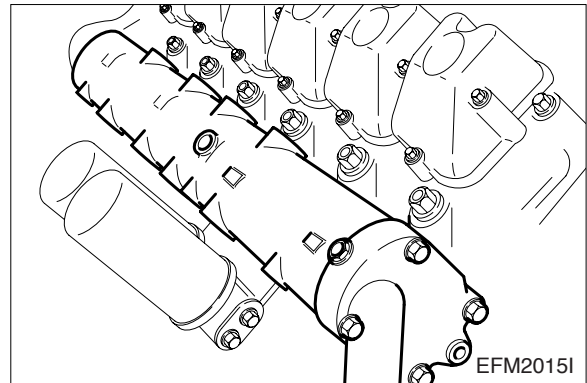
3.1.9. Exhaust manifold

- Remove the exhaust manifold fixing bolts and tear the manifold from the cylinder head.



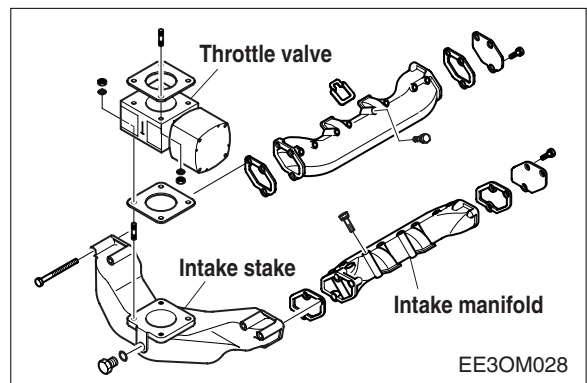
CAUTION:

Be careful not to drop the manifold because it is very heavy.



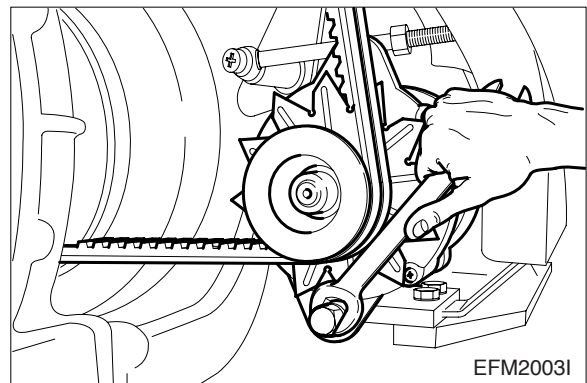
3.1.10. Intake manifold & throttle valve

- Remove the throttle valve fixing bolts and tear the throttle valve down from the intake stake.
- Remove the manifold fixing bolts and tear the manifold down from the cylinder head.



3.1.11. Alternator

- Remove the supporting guide piece for installing the alternator and the bracket bolts.
- Disassemble the alternator.



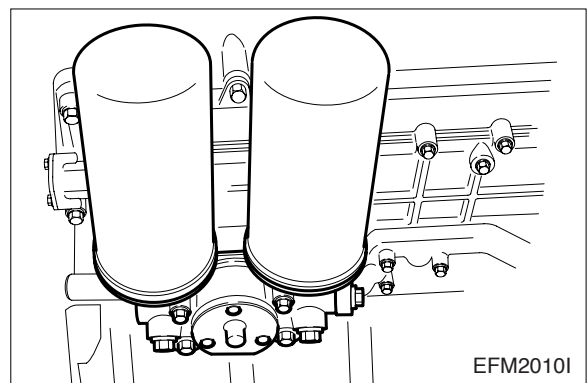
3.1.12. Oil filter



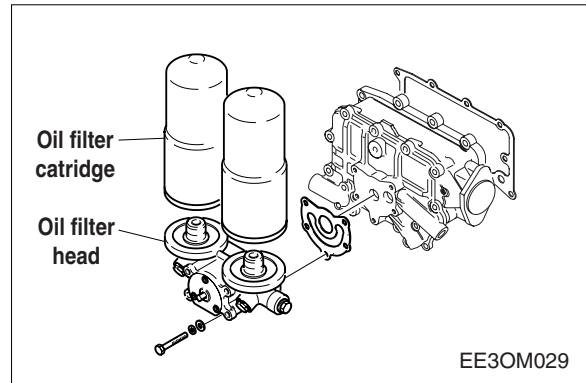
- Disassemble the oil filter cartridge with filter wrench by means of a filter wrench.



- Do not use again the cartridge removed after use.

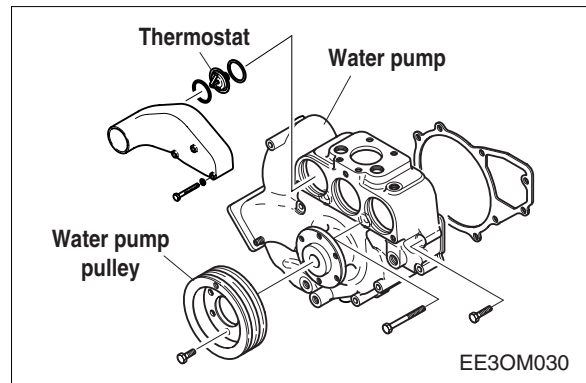


- Remove the oil filter head fixing bolts and disassemble the filter head



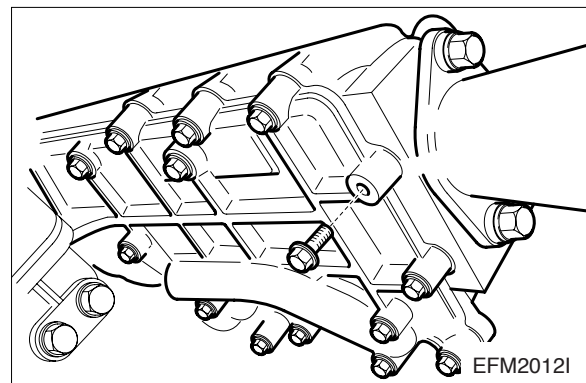
3.1.13. Cooling water pump

- Loosen the various hose clamps for the connections.
- Remove the cooling water discharging pipe and disassemble the thermostat.
- Remove the cooling water pump fixing bolts and disassemble the cooling water pump.

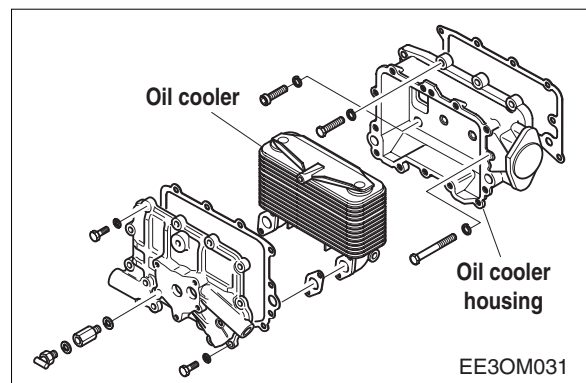


3.1.14. Oil cooler

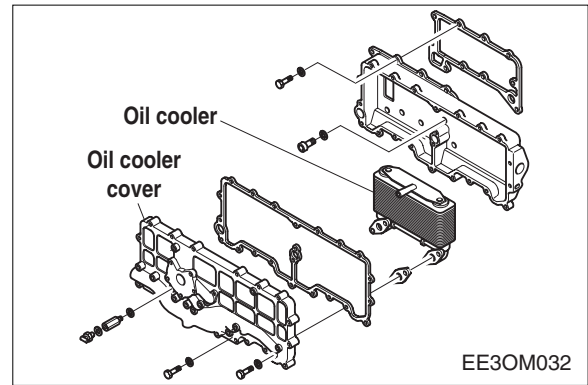
- By removing the plug screw of cooling water discharge port, the cooling water is discharged.
- Remove the oil cooler cover fixing bolts and disassemble the oil cooler.



- By removing the cooler housing fixing bolts and disassemble the oil cooler housing from the cylinder block.

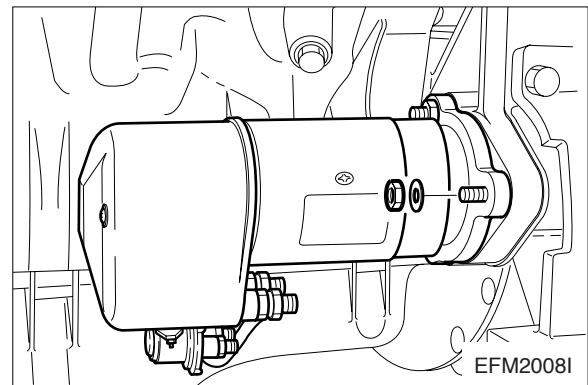


- Remove the oil cooler insert fixing bolts, and then disassemble the cooler insert.



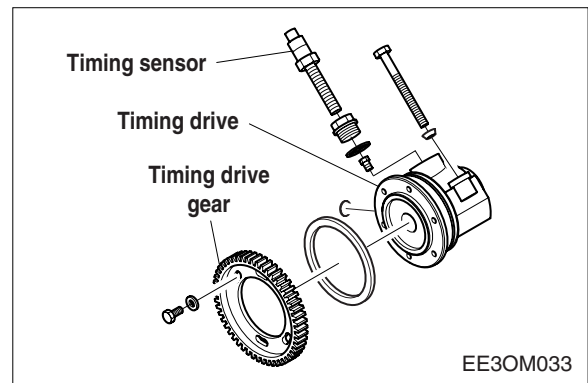
3.1.15. Starting motor

- Remove the starting motor fixing nuts and disassemble the starting motor.



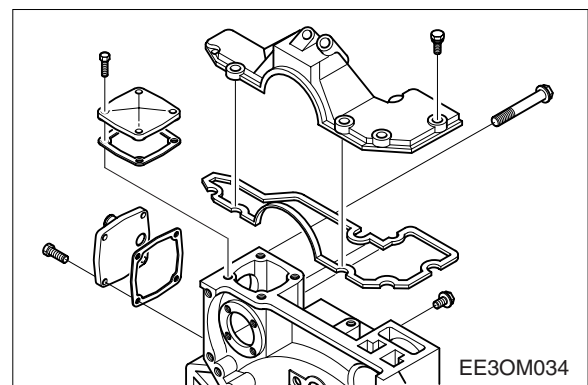
3.1.16. Timing drive & sensor

- Remove the timing drive fixing bolts and disassemble the timing drive and timing sensor.



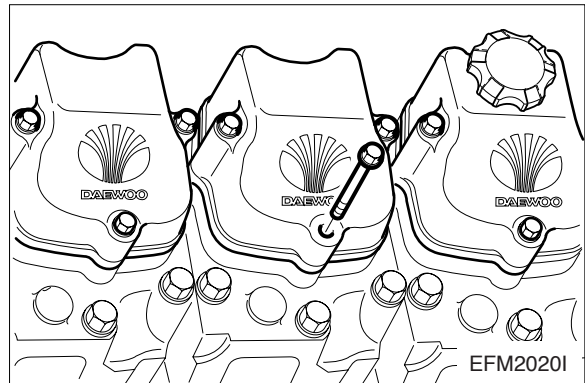
3.1.17. Flywheel housing cover

- Separate the side cover.
- Disassemble the flywheel housing cover.



3.1.18. Cylinder head cover

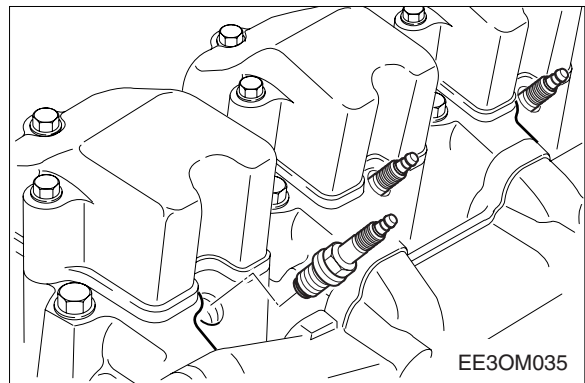
- Remove the fixing bolts and tear the cylinder head cover down



3.1.19. Spark plug

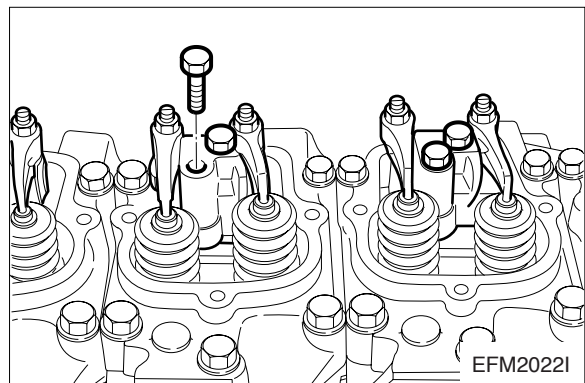


- By means of a long impact tool, loosen the spark plug and take it out.



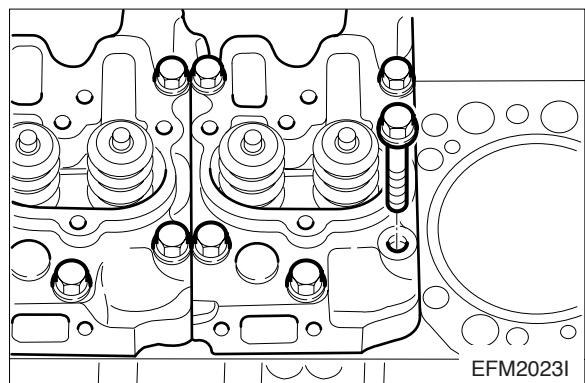
3.1.20. Rocker arm

- Remove the rocker arm bracket fixing bolts and take the rocker arm assembly out.
- Pull out the push rod.



3.1.21. Cylinder head

- Loosen the cylinder head fixing bolts in the reverse order of assembling, and remove them all and then take the cylinder head out.
- Remove the cylinder head gasket and scrap it.
- Eliminate the residue from the cylinder head face and cylinder block face.



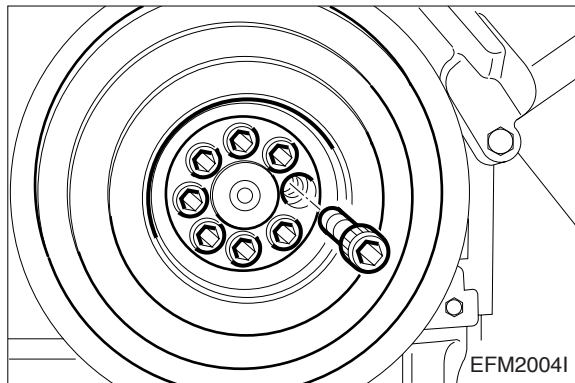


Notes:

Be careful not to damage the cylinder head face where its gasket contacts.

3.1.22. Vibration damper

- Remove the fixing bolts for crankshaft pulley in reverse order of assembling and disassemble the crankshaft pulley and vibration damper.

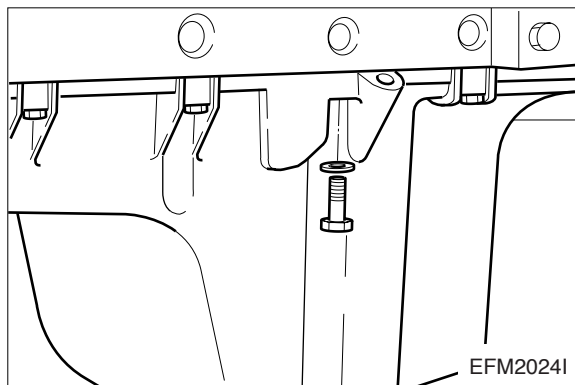


3.1.23. Oil pan

- Remove the oil pan fixing bolts and separate the pan.

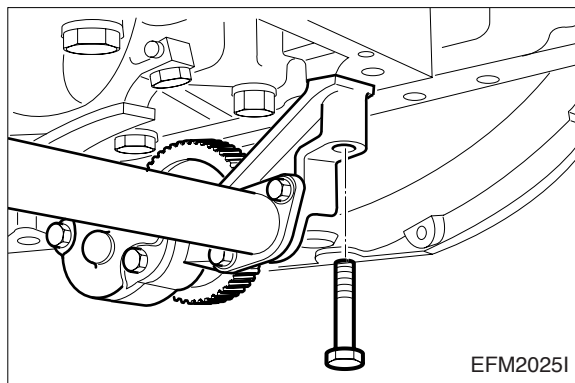


- Remove the oil pan gasket and scrap it.



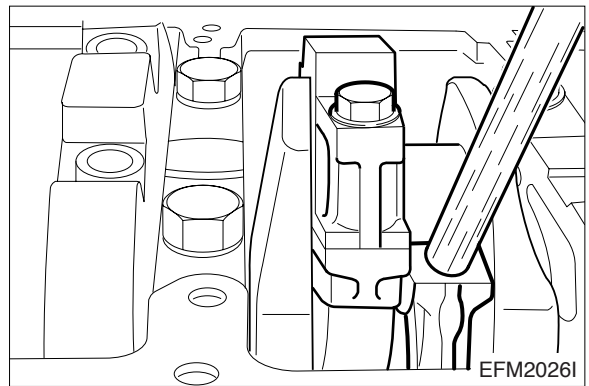
3.1.24. Oil pump

- Remove the oil suction pipe fixing bolts and tear them down.
- Remove the oil relief valve fixing bolts and take them out.
- Remove the oil pump fixing bolts and separate it.



3.1.25. Piston

- Remove the connecting rod cap bolts in the reverse order of assembling and follow the similar method as in the cylinder head bolt removal.
- Tapping the upper and lower connecting rod caps lightly with an urethane hammer, separate them and take the bearings out.
- By pushing the piston assembly with a wooden bar toward the cylinder head's direction remove the piston.

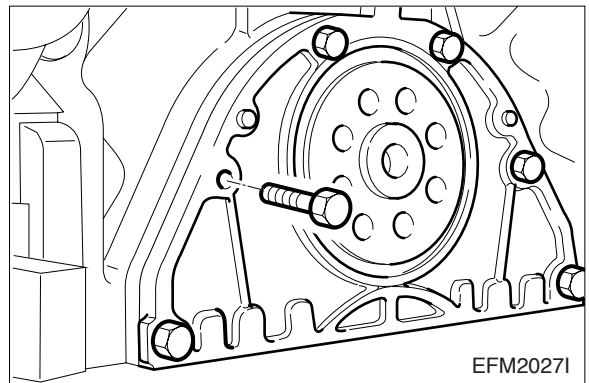


Notes:

- Be careful for the removed pistons not to collide each other or with the other parts.
- At the storage of pistons, maintain them in the order of cylinders. (In order for connecting rod caps not to mix one another, temporarily assemble them to the corresponding connecting rods.)

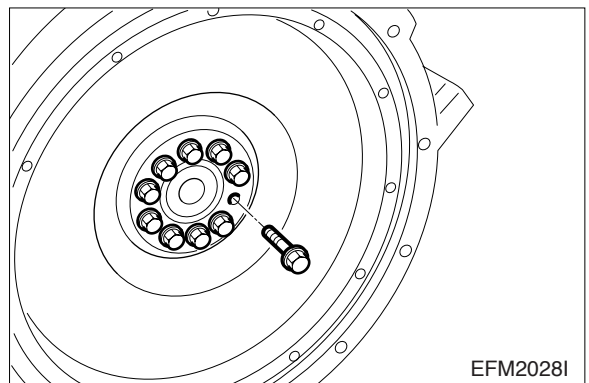
3.1.26. Front oil seal holder

- Remove the oil seal holder fixing bolts and tear down.
- Remove the oil seal and gasket from the oil seal holder and scrap them.



3.1.27. Fly wheel

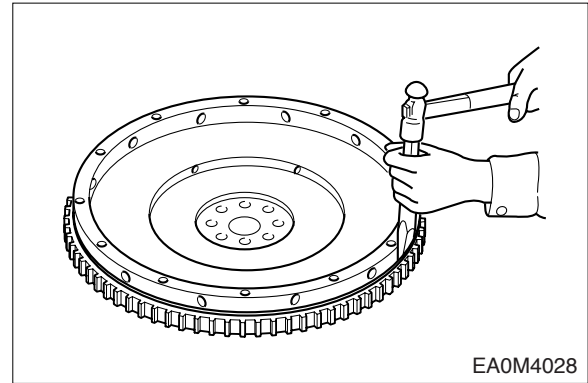
- Remove the flywheel fixing bolts in the order of disassembling and remove the flywheel.



- Remove the flywheel ring gear.
 - Heat the ring gear evenly with a gas burner (up to 200°C) to invite volumetric expansion.
 - Tapping around the edges of the ring gear with a hammer and brass bar to remove it.

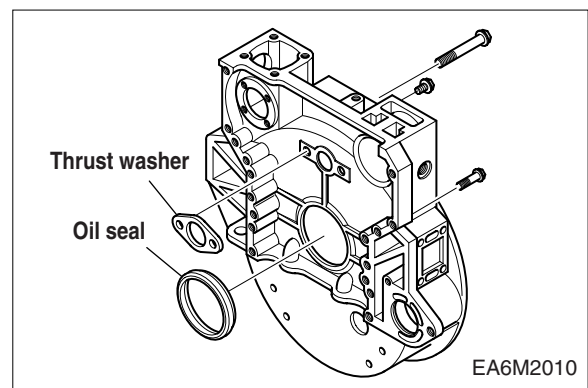


CAUTION:
Do not damage the flywheel.



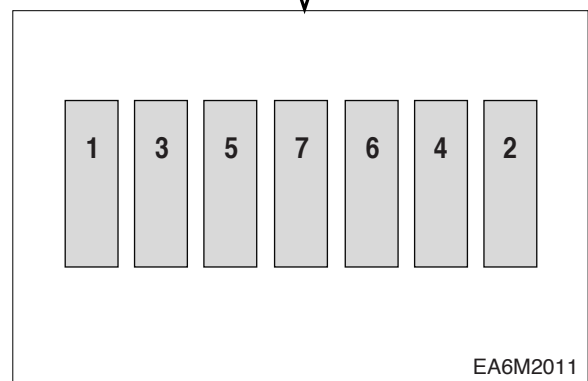
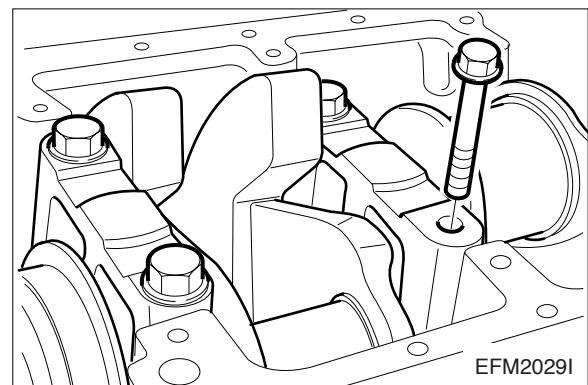
3.1.28. Flywheel housing

- Remove the flywheel housing fixing bolts and take them out.
- Remove the oil seal from the flywheel housing.



3.1.29. Crank shaft

- Remove the bolts from bearing caps.
- Remove the main bearing cap fixing bolts in the reverse order of assembling.
- Maintain the removed bearing caps in the order of cylinders.
- Temporarily install the bolts at the both side of crankshaft, and lift the shaft with a rope.





Notes:

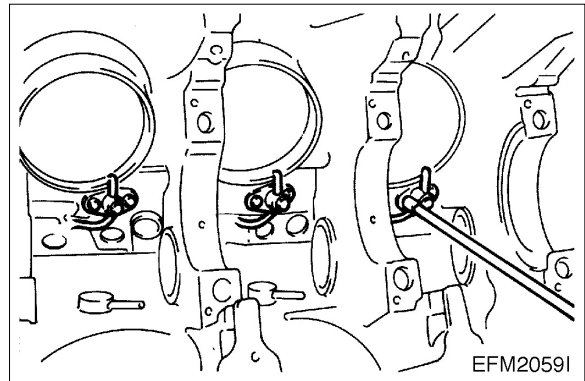
Do not mingle with the metal bearings and bearing caps randomly. To prevent mixing, temporarily assemble the metal bearings to the corresponding bearing caps in turn.

3.1.30. Camshaft and tappet

- Pull out the tappets from the cylinder block.
- Remove the camshaft being careful not to damage the camshaft and its bearings.

3.1.31. Oil spray nozzle

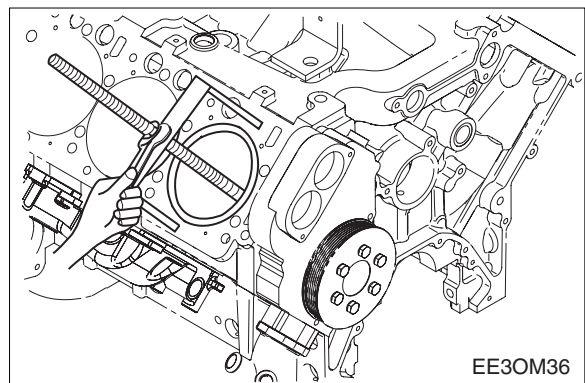
- Remove the oil injection nozzle fixing bolts and tear down the oil injection nozzles.



3.1.32. Cylinder liner



- By means of a special tool(Extractor), pull out the liner from the cylinder block.



3.2. Measurement and Inspection of Major Parts

3.2.1. Cleaning and inspection of cylinder block



- Clean the cylinder block and inspect it for any crack or damaged.



- Inspect the oil passage and water passage for any clog and erosion.
- By performing the hydraulic test, inspect for any leaks. With plugging the water and oil passages of cylinder block, put in the air of 5 kg/cm² pressure in the Inlet port of cylinder block and then soak the cylinder block in the water for about 1 minute to check for any leaks. (water temperature: 70°C)
- Inspect the cylinder block's camshaft bush to any damage and the alignment of oil supply holes and if abnormal, replace it.

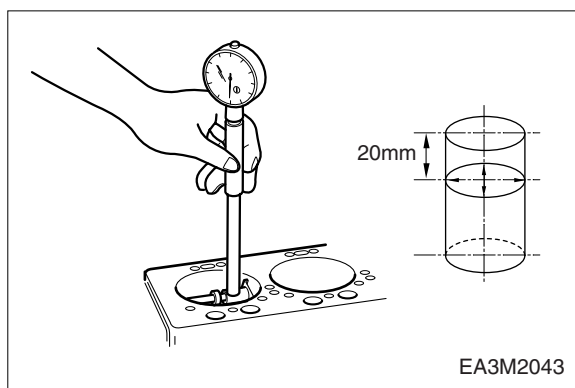
3.2.2. Cylinder liner measurement



- Assemble the cylinder liner at the cylinder block and measure inner diameters at upper, middle, lower 3 levels by 45° interval and calculate the average values after eliminating the max. and min. values.



- If the measured values are very close to the limit value or beyond, replace it.



Liner inner dia.	Standard	Limit
	ø127.990~ø128.010 mm	0.15 mm

3.2.3. Cylinder head

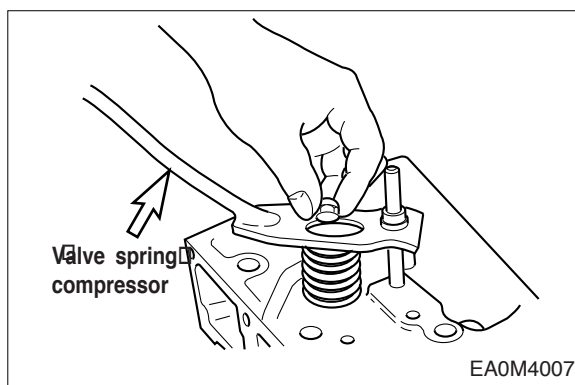
1) Cylinder head disassembly



- Be careful for the cylinder head gasket contacting surface of cylinder head not to be damaged.



- Remove the cotter pin pressing the valve spring by means of a special tool.
- Take out the valve stem seal.
- Pull out the intake and exhaust valves.



3.2.4. Spark plug

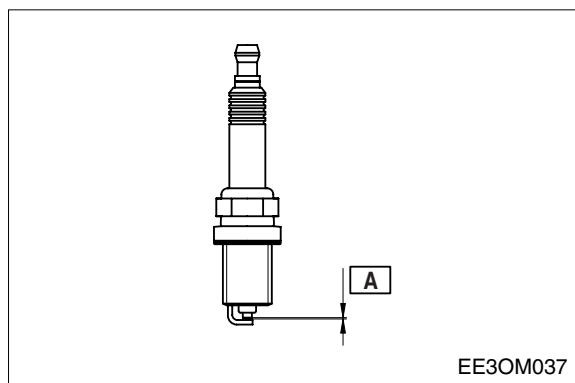


- Remove spark plug. Clean threads by hand with brush and solvent.



- Clean any deposits from electrode and inspect insulator area
- Measure the spark plug distance at electrode position.(A)
- Correct or replace the spark plug if necessary.

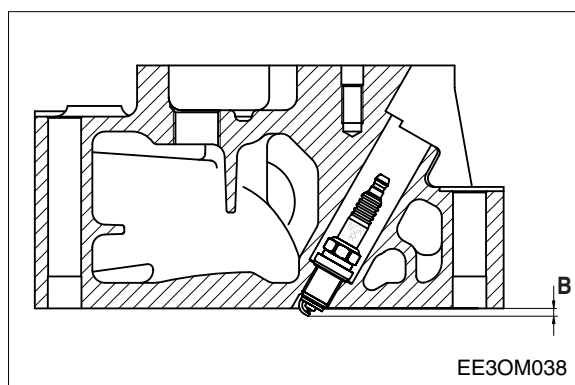
Standard(A)	0.39 ~ 0.40 mm



- Insert the spark plug into cylinder head and measure distance(B)

Torque	3.6 ~ 4.1 kg.m

Standard(B)	3.38 ~ 3.76 mm



3.2.5. Inspection and measurement of cylinder head

1) Damage check



- Inspect the cylinder head for any crack or damage.



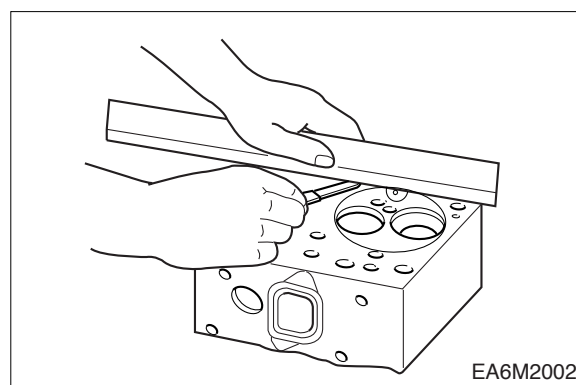
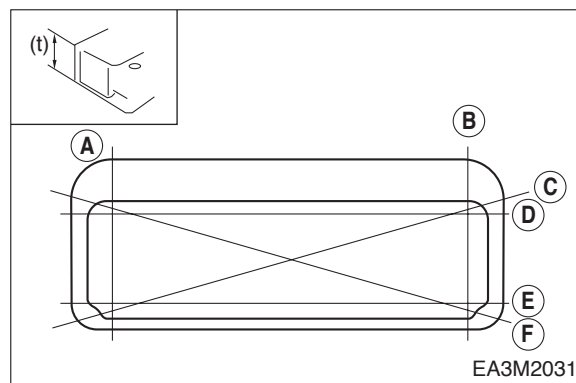
- Eliminate the carbon residue and gasket piece from the cylinder head lower face thoroughly. Then be careful for the valve seat not to be damaged.
- The cracks or damages that are difficult to search may be inspected by a hydraulic test or a magnetic powder test. (Hydraulic test is same as for cylinder block.)

2) Distortion



- Measure the flatness degree (any distortion) of cylinder head. Even beyond the limit value of maintenance, it may be corrected by grinding. (if more than limit value of use, replace it.)

Warpage	Standard	Limit
	0.05 mm or less	0.2 mm



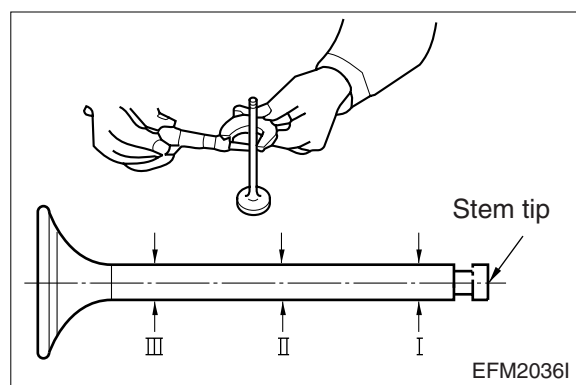
3.2.6. Inspection and measurement of valve and valve guide

1) Valve



- After cleaning the valves with clean diesel oil, measure the valve stem's outside diameter at upper, middle, and lower to determine the wears and when the wear limit is more than allowable limit, replace the valves.

Valve	Standard	Limit
Intake	$\phi 11.969 \sim \phi 11.980$ mm	$\phi 11.830$ mm
Exhaust	$\phi 11.969 \sim \phi 11.980$ mm	$\phi 11.830$ mm



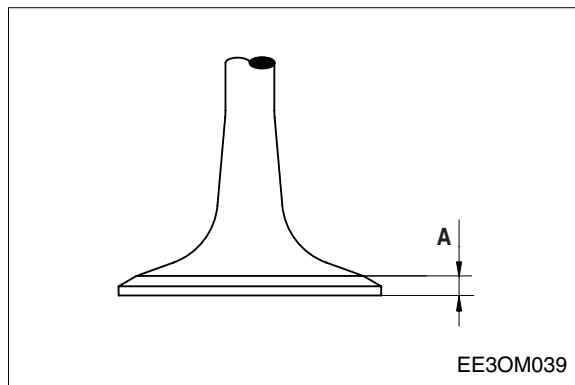


- Inspect the scratch and wear of valve stem seal contacting face, and if necessary correct with the grinding paper but if severe replace it.



- If valve head thickness (A) becomes less than 1.6mm for intake and 1.3mm for exhaust, replace the valve.

Valve	Standard	Limit
Intake(A)	2.6 ~ 3.0 mm	1.6 mm
Exhaust(B)	1.9 ~ 2.3 mm	1.3 mm

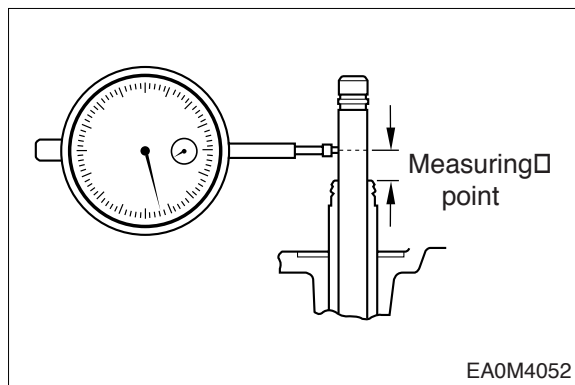


2) Valve guide



- Insert the valve into valve guide and measure the clearance between valve and valve guide by the shaking degree of valve. If the clearance is bigger, measure the valve and then replace the more worn cylinder head.

Valve	Standard	Limit
Intake	0.020 ~ 0.049 mm	0.20 mm
Exhaust	0.045 ~ 0.074 mm	0.25 mm



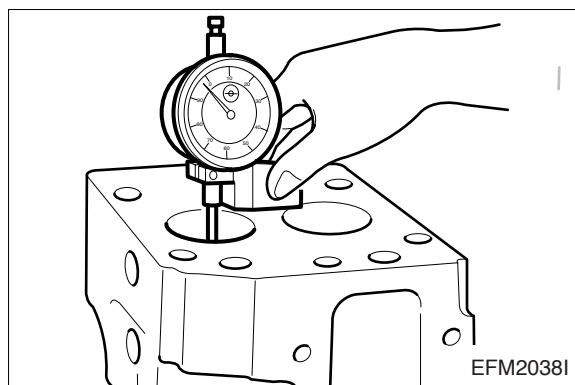
3) Valve seat



- Assemble the valves at the cylinder head and using the measuring instrument from the lower face, measure the projection amount of valve. If the measured value is more than the use limit, replace the valve or cylinder head.

< Valve seat thickness >

Standard	Limit
0.65 ~ 0.95 mm	2.5 mm



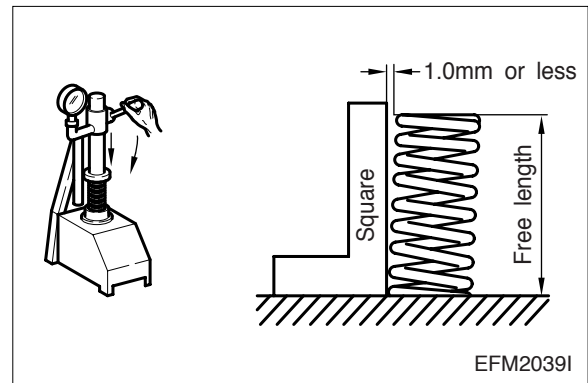
3.2.7. Valve spring



- Inspect the outlook of valve spring and if necessary replace it.



- By means of spring tester, measure the tension and free length.
- Measure the perpendicularity of valve spring.
- In case that the measured value exceeds the limit value, replace it.



< Perpendicularity regular >

Inside Spring	Free length	65.5 mm
	When given a regular load (15 ~ 17 kg)	46.3 mm
Outside Spring	Free length	64 mm
	When given a regular load (37 ~ 41 kg)	46.3 mm

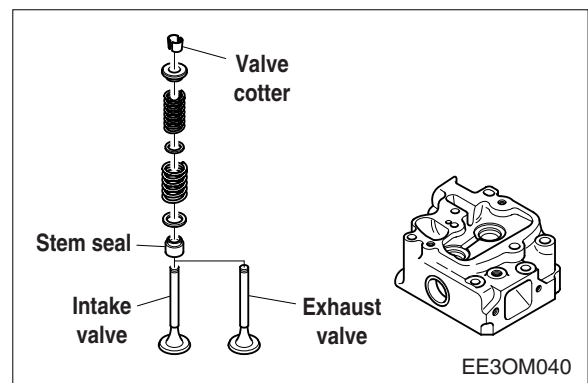
3.2.8. Assembling cylinder head



- Clean the cylinder head thoroughly.
- Coat the valve stems and valve guides with engine oil and assemble the valves.



- Replace the valve stem seals with new ones and insert the stem seals to the valve guides of cylinder head with a special tool. (Be careful for the valve stem seals not to be damaged.)

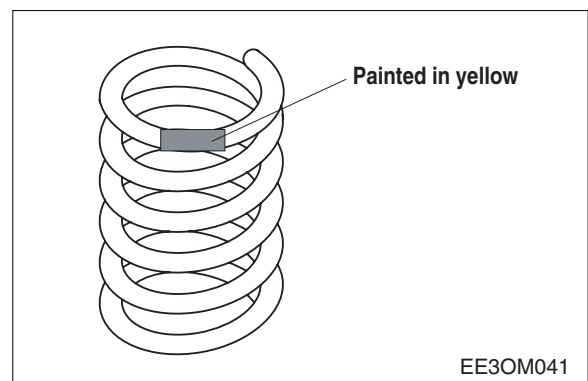


- Install the valve spring washer to valve guide.
- After putting on the inside, outside spring, install the valve spring seat on them.



NOTE:

Install the valve spring seat with "TOP" (painted in yellow) side up.

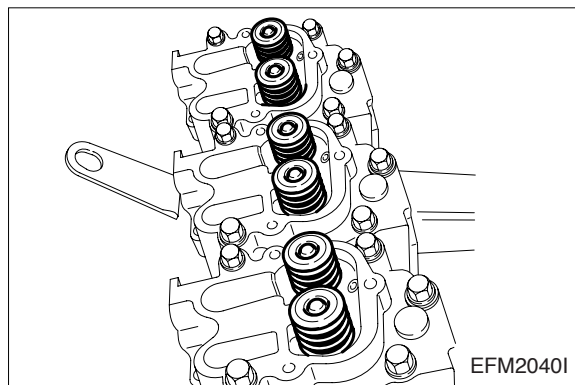




- Pressing the spring down with a special tool, assemble by inserting the valve cotter.



- After the valve is assembled, inspect the valve tapping it lightly with an urethane hammer if accurate assembling was done.

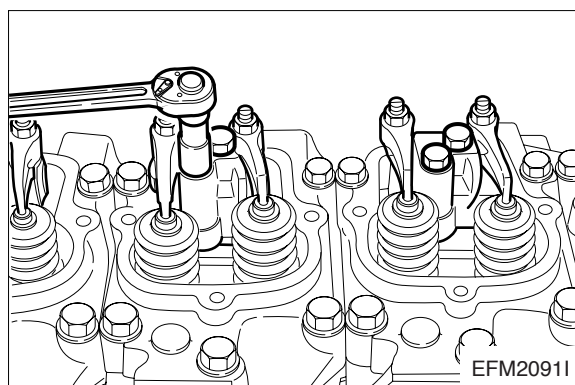


3.2.9. Rocker arm

1) Rocker arm disassembling



- Remove the snap rings in both ends of rocker arm with a pair of pliers.
- Tear down washer, rocker arm.
- Disassemble the rocker arm bush by means of a press.

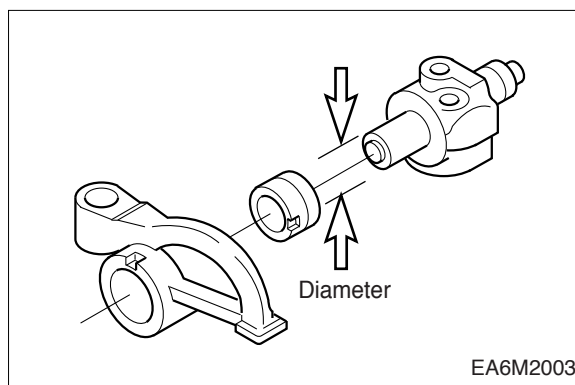


2) Inspection rocker arm bracket



- Measure the outer diameter of rocker arm bracket with outside micrometer at the position that the rocker arm is installed, and in case that it exceeds the limit value, replace.

	Standard	Limit
Bush inner dia.	$\phi 25.005 \sim \phi 25.035$ mm	$\phi 25.055$ mm
Shaft outer dia.	$\phi 24.967 \sim \phi 24.990$ mm	$\phi 24.837$ mm
Clearance	$0.015 \sim 0.068$ mm	0.25 mm



- Inspect the rocker arm surface that contacts with the valve stem for any scratch, step wear and correct the minor degree of wear with an oil stone or the fine grinding paper and replace if they are severe.

3.2.10. Tappet and push rod



- By means of outside micrometer, measure the outer diameter of tappet and replace the severe ones.

Tappet clearance	Standard	Limit
	0.035 ~ 0.077 mm	0.25 mm



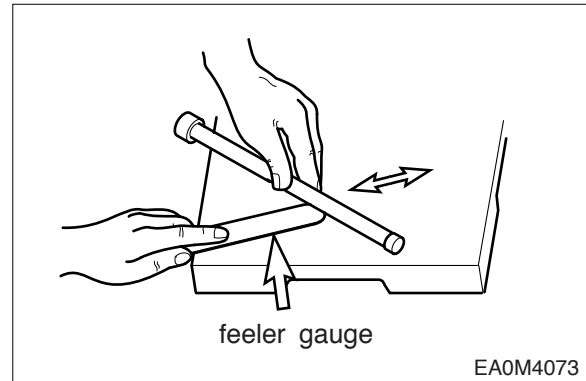
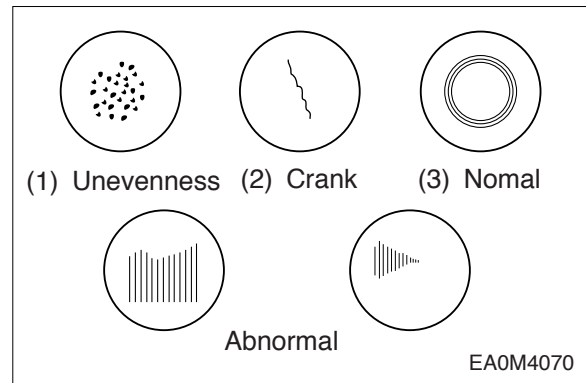
- By inspecting the tappet surface that contacts with the camshaft's cam for any crack and scratch etc., and if the degree is small, correct them with an oil stone or the grinding paper but if severe replace them.



- Place the push rod on the surface plate and rolling it, Inspect the curving degree with a clearance gauge and if abnormal, replace it.

< Run-out >

Limit	0.3 mm or less

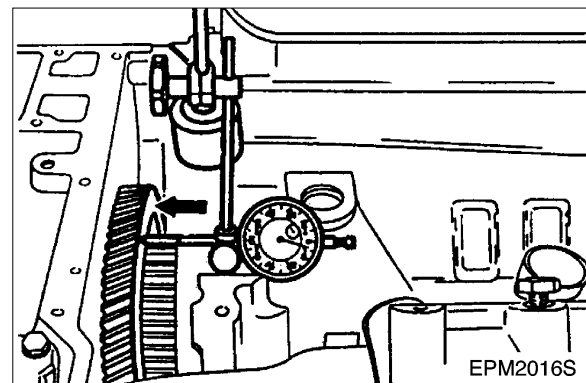


- Inspect the oil passages of rocker arm and rocker arm bracket for any clogs and reassemble them in the reverse order of disassembling after thorough cleaning.

3.2.11. Cam shaft

1) Axial end play

- Push the camshaft toward the pulley side.
- Place a dial gauge onto the camshaft gear.

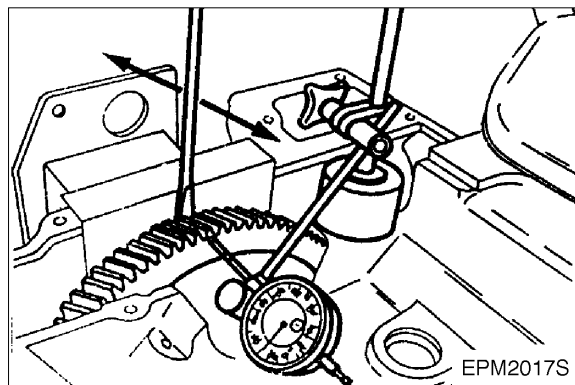




- Measure the camshaft's axial end play, moving the camshaft gear by means of a driver.

Limit	0.2 ~ 0.9 mm

- If excessive end play, assemble it by means of other thrust washer.



EPM2017S

2) Inspection and measurement



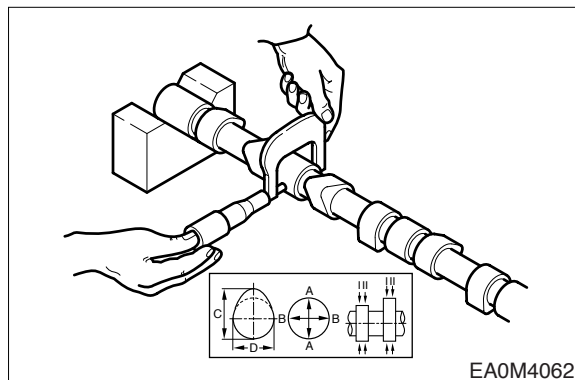
- With inspecting the cam surface for any damage with naked eyes and correct any minor scratch by means of an oil stone grinding and if severe, replace it.

3) Cam lobe height



- Use a micrometer to measure the cam lobe height and journal diameter.
- If the measured number is less than the specified limit, the camshaft must be replaced.

	Standard	Limit
Cam lobe height(C)	47.7 mm	46.5 mm
Cam journal diameter(A,B)	∅ 56.0 mm	∅ 55.6 mm



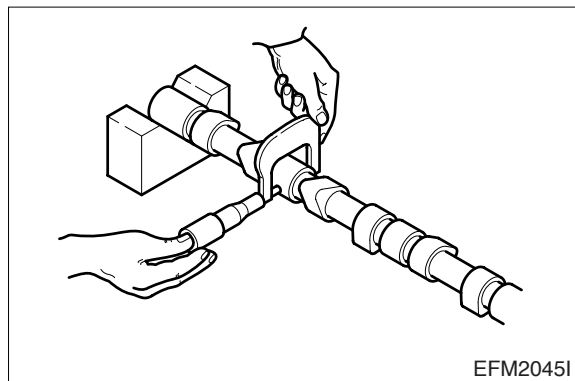
EA0M4062

4) Cam journal diameter



- By means of outside micrometer, measure the camshaft journal.

Standard	∅ 69.91 ~ ∅ 69.94 mm



EFM2045I

5) Cam bearing diameter

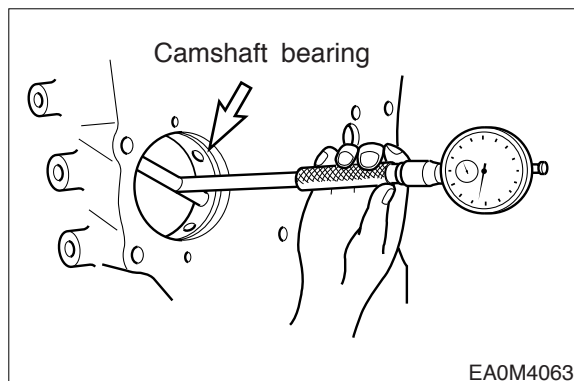


- Measure the camshaft bush inside diameter with a cylinder gauge and by comparing the inside and outside diameters, replace if abnormal.

Standard	$\phi 70.077 \sim \phi 70.061 \text{ mm}$

- Clearance between camshaft outside diameter and bush inner diameter of cylinder block.

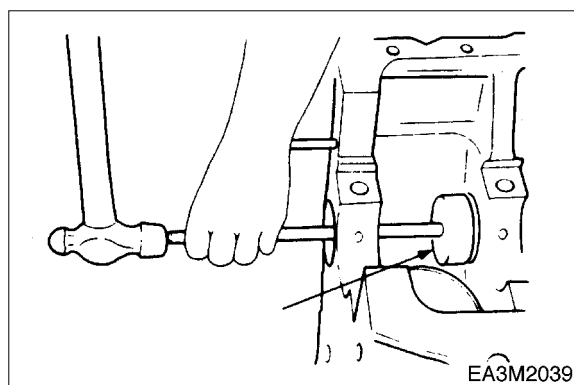
Standard	Limit
0.060 ~ 0.120 mm	0.18 mm



6) Camshaft bearing replacement



- Remover, installer

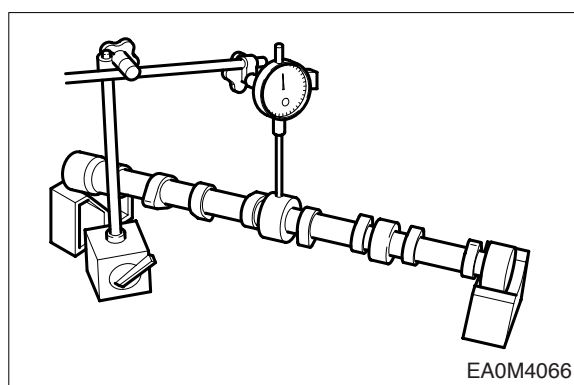


7) Camshaft run-out



- With placing the camshaft on the 2ea of V-blocks, and inspect the run-out of the camshaft, adjust or replace the severe one.

Standard	0.1 mm



3.2.12. Crank shaft

1) Inspection and measurement



- Inspect for any scratch or damage with naked eyes, and grind to the undersize according to the damaged degree and use the undersized bearing.
- Inspect for any crack by means of magnetic powder and color check, and replace the cracked ones.

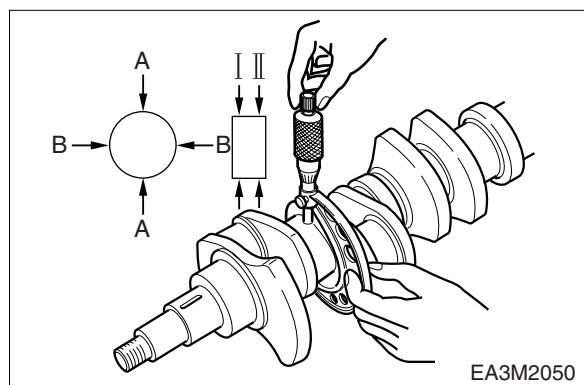
2) Journal and pin diameter



- With outside micrometer, measure the outside diameter of crank journal and crank pin at the direction and position of the figure shown and take the wear.

< Crankshaft journal outside diameter >

Standard	$\phi 103.98 \sim \phi 104.00 \text{ mm}$

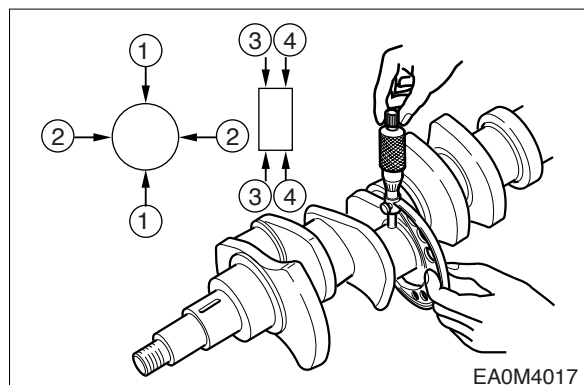


< Crankshaft pin outside diameter >

Standard	$\phi 89.98 \sim \phi 90.00 \text{ mm}$



- In case that the lopsided wear is more than the limit value, grind to the undersize, and use the undersized bearing.



< Kinds of bearings for undersize >

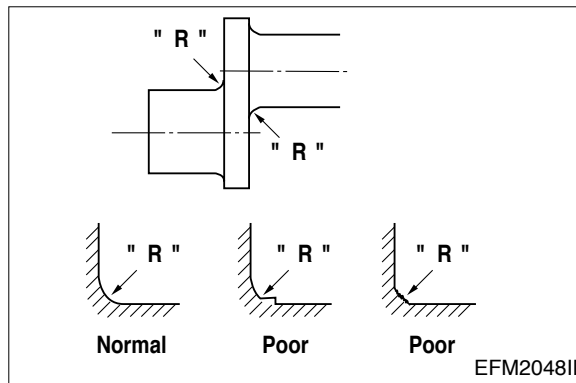
- Standard
- 0.25 (Inside diameter 0.25mm less than standard)
- 0.50 (Inside diameter 0.50mm less than standard)
- 0.75 (Inside diameter 0.75mm less than standard)
- 1.00 (Inside diameter 1.00mm less than standard)



- There are 4 kinds as above, and the crankshaft also can be used by regrounding as above.

< "R part" standard value >

- (a) Crank pin "R part" : $4.0 \begin{smallmatrix} 0 \\ -0.5 \end{smallmatrix}$
- (b) Crank journal "R part" : $4.0 \begin{smallmatrix} 0 \\ -0.5 \end{smallmatrix}$



NOTE:

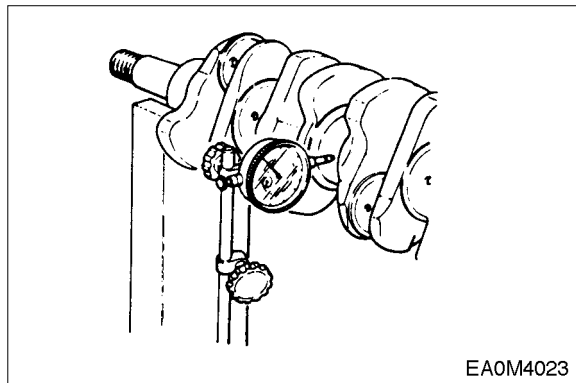
In case of crankshaft regrounding, the "R part" at the end of bearing must accurately be ground without fail and should avoid any processed jaw or coarse surface.

3) Run out of crankshaft



- Place the crankshaft on the V-block.
- Place the dial gauge on the surface plate and measure the run out of crankshaft rotating the crankshaft.

Standard	Limit
0.06 mm	0.4 mm



4) Inspection on crankshaft bearing and connecting rod bearing

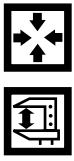


- Inspect the crankshaft bearing and connecting rod bearing for any damages such as lop-sided wear, scratch etc. and if abnormal, replace it.



- Inspect the oil clearance between the crankshaft and bearing.

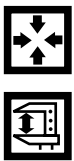
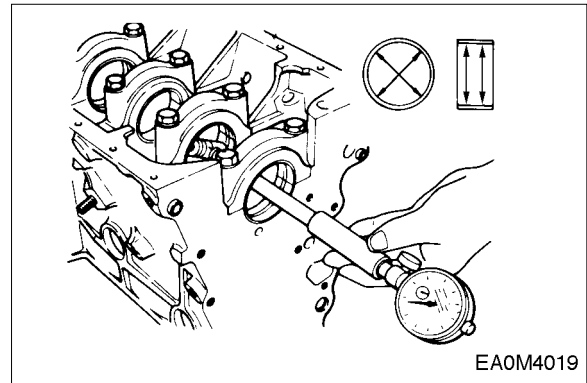
a) How to utilize the cylinder gauge



- Assemble the main bearing at the cylinder block and after tightening the bearing cap at the specified torque, measure the inside diameter.

Journal bearing nominal diameter	∅ 104 mm

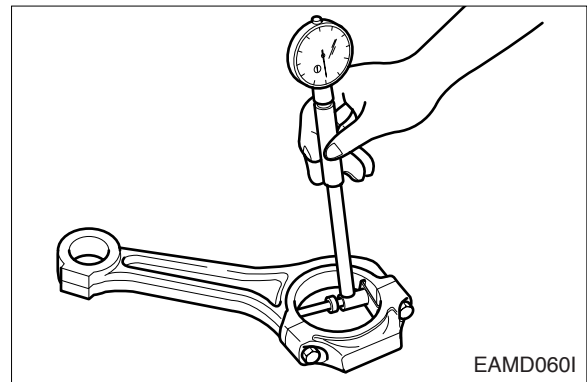
Bearing cap bolt torque	Initial 30 kg.m + angle 90°



- Assemble the bearing at the bigger end of connecting rod, and after tightening the bearing cap at the specified torque, measure the inside diameter.

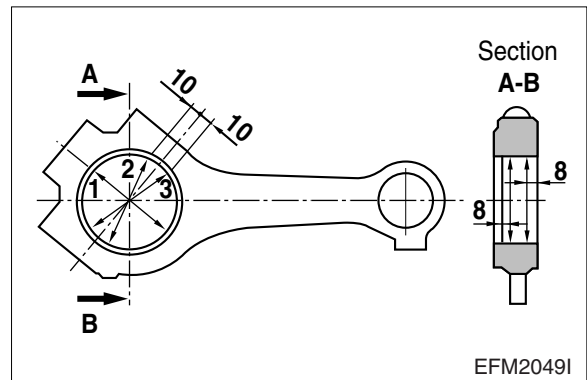
Connecting rod bearing journal diameter	∅ 90 mm

Connecting rod bolt torque	Initial 10 kg.m + angle 90°



- Crankshaft pin and bearing clearance value exceeds the limit value, grind the crankshaft journal and pin and then use the undersized bearing.

Standard	Limit
0.066 ~ 0.132 mm	0.166 mm



b) How to utilize plastic gauge



- Install the crankshaft in the cylinder block and place the plastic gauge on the crankshaft journal and pin at axial direction and then after tightening the bearing cap at the specified torque and again after tearing apart the bearing cap, measure the flatten plastic gauge thickness by pick it up. This is the oil clearance.
- With the same points, the oil clearance of connecting rod also can be measured.

5) End play

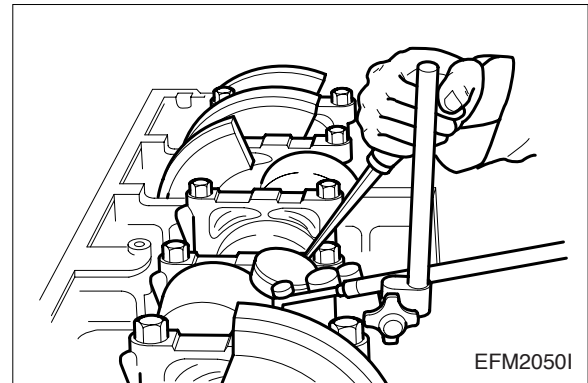


- Assemble the crankshaft in the cylinder block.



- Install the dial gauge, and measure the end play of crankshaft by pushing the crankshaft to axial direction.

Standard	Limit
0.190 ~ 0.322 mm	0.452 mm



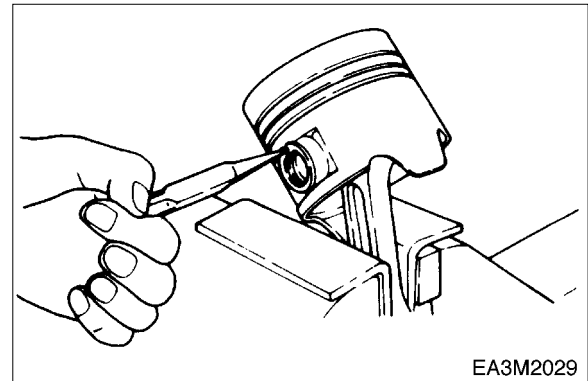
3.2.13. Piston

1) Piston disassembling



- Pull out the snap ring for piston pin and with a pair of snap ring pliers.

- With a round bar, remove the piston pin.



- With a pair of pliers, remove the piston rings.



- Clean the piston thoroughly.



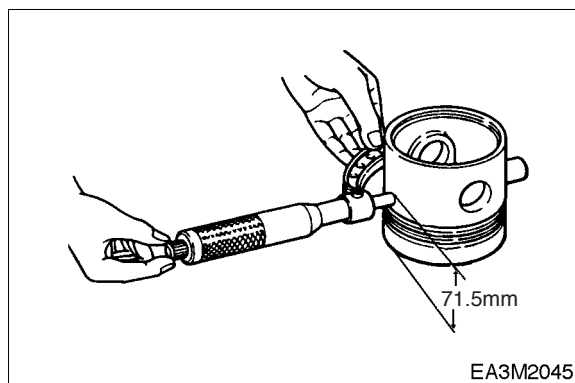
2) Piston inspection



- With naked eyes, inspect the piston for any wear, crack and scratch and particularly inspect carefully at the ring grooves for any wear.



- With the outside micrometer, measure the piston's outside diameter the measuring position is 71.5mm from the piston lower end, and the direction of measurement must be perpendicular to the piston pin direction.



Standard	$\phi 127.739 \sim \phi 127.757 \text{ mm}$

- By comparing the measured value of the piston outside diameter with the cylinder liner inside diameter, the bigger clearance is replaced.

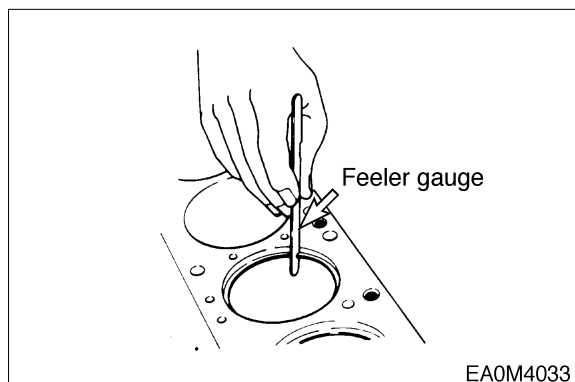
3) Piston ring and ring groove



- In case of piston ring's wear, damage or engine overhaul, replace piston rings.



- Insert the piston ring at the cylinder liner's upper part perpendicularly.
- With a feeler gauge, measure the gap clearance of piston ring.
- If the measured value exceeds the limit value, replace it.



< Piston ring gap >

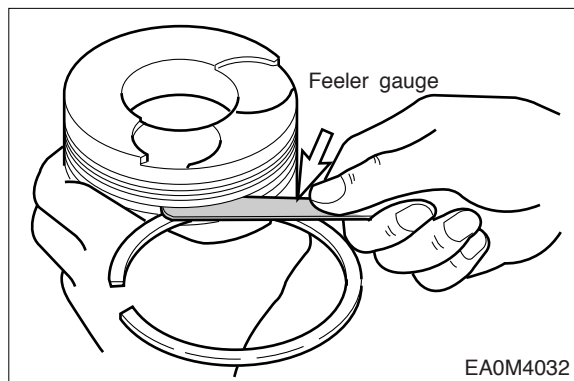
Division	Standard	Limit
Top ring	0.35 ~ 0.55 mm	1.5 mm
2nd ring	0.40 ~ 0.60 mm	1.5 mm
Oil ring	0.35 ~ 0.55 mm	1.5 mm

4) Piston side clearance

- Assemble the piston ring at the piston.
- Measure the each ring's side clearance and if the measured value exceeds the limit value, replace rings or piston.

< Piston side clearance >

Division	Specified value	Limit value
Top ring	0.35 ~ 0.55 mm	1.5 mm
2nd ring	0.050 ~ 0.082 mm	1.5 mm
Oil ring	0.030 ~ 0.062 mm	1.5 mm

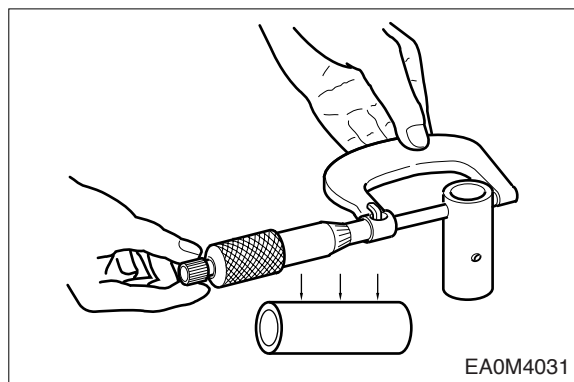


5) Piston pin



- With the outside micrometer, measure the piston pin's outside diameter and if the value is same as the use limit value or less, replace it.

Standard	Limit
$\phi 45.994 \sim \phi 46.000$ mm	$\phi 45.983$ mm or less

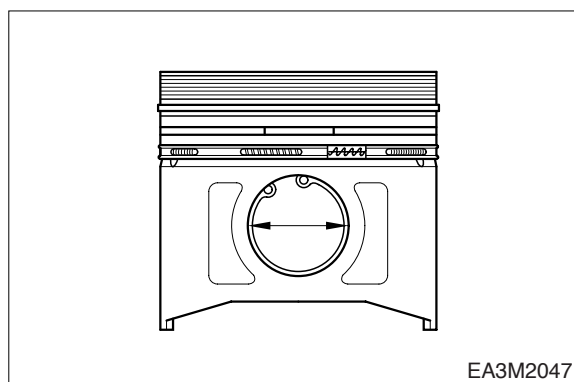


6) Piston pin and connecting rod bush clearance



- Inspect the clearance between the piston pin and the connecting rod bush, if it is more than the use limit value, replace either one that is more severe.

Limit	0.003 ~ 0.015 mm

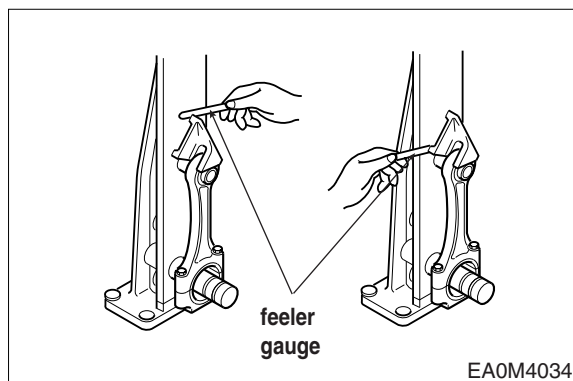


7) Connecting rod



- Inspect and measure the bigger end bearing hole and the smaller end bearing hole with respect to the parallelness and if abnormal, replace the rod.

Standard	Limit
0.02 mm	0.2 mm



8) Piston reassembling

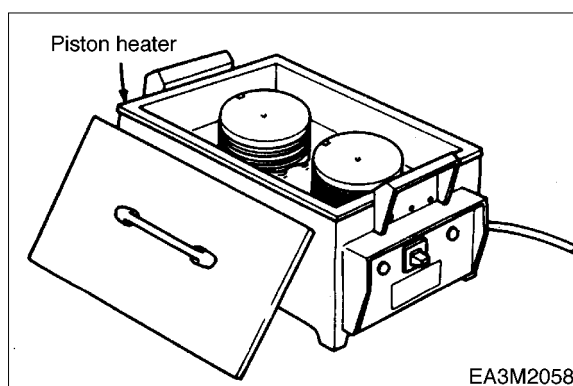


- After heating the piston at the piston heater for about 5 min (120 ~ 150°C), by aligning the piston pin hole with the pin hole of connecting rod's smaller end, insert the oil coated piston pin.



NOTE:

Confirm the direction of connecting rod and assemble.



- With the snap ring plier, insert the piston pin snap ring.
- With confirming the upper side indication of piston ring, after assembling the ring in the piston ring groove, inspect if the movement of ring is smooth.
- Keep in order of the assembled piston as the cylinder No. turn.

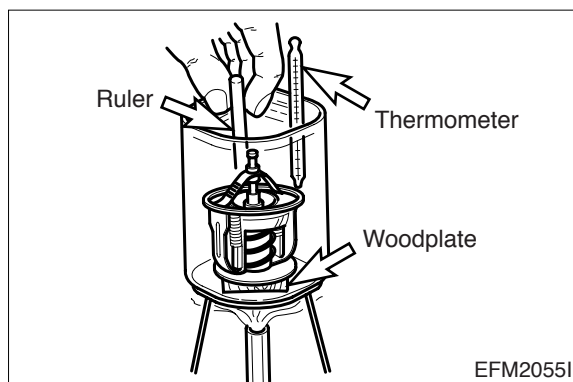
3.2.14. Thermostat



- Inspect the wax case and spring for any damage.
- With putting the water temperature gauge into water and heating the water at the indirect method, when the water temp reaches to 71°C, the valve begin to open and fully open when it reaches to 85°C.



- Measure the valve opening temperature and the valve full opening temperature and inspect if the valve lift is more than 8mm and if abnormal, replace it.



3.3. Engine Reassembly

3.3.1. Preparation and precaution before and after engine reassembly



- Clean all the parts thoroughly and also clean thoroughly by blowing into each passage of oil and cooling water.



- Disposition the various special and general tools for assembling in order.
- In order to coat the lapping parts with engine oil, prepare the clean engine oil.
- Prepare the sub-material such as an adhesive etc.
- Use three bond as an adhesive in the engine oil system and use silicone in the cooling system.
- Scrap the used gasket and seal ring, consumable parts etc. and replace with new ones.
- Tighten the various bolts in the specified tightening torque, and also according to the tightening order but the excessive torque must be avoided.
- Inspect if the movement of engine is smooth after assembling.
- After completion of assembling, whether various bolts are loose or not should necessarily be insured.
- Make sure that there is any missing parts or insufficient parts after full completion of assembling. Work only with clean hands.
- Before serving any fuel system component make certain that the fuel lines are fully closed and the fuel line pressure properly relieved.

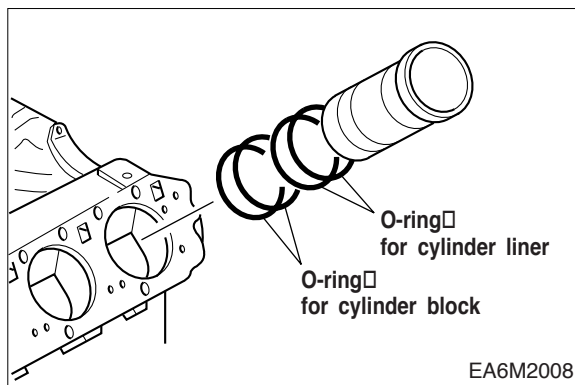
3.3.2. Cylinder liner



- Replace O-ring with new one without fail and at the upper side, insert to the cylinder liner, but at the lower side, to the cylinder block.



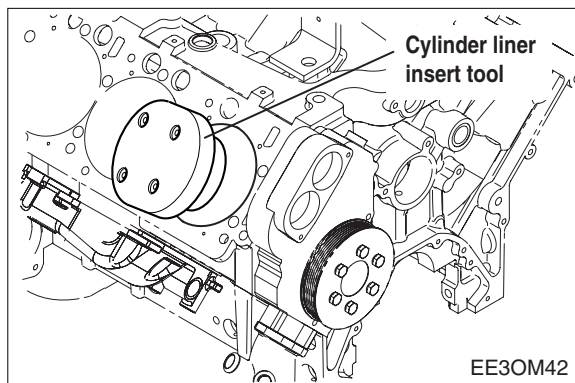
- Coat the joint parts where O-ring contacts with oil.



- After slipping the cylinder liner smoothly into the cylinder block, press it in being careful for O-ring not to damage.



- After completion of assembling the cylinder liner, confirm no leaks with 4 kg/cm² hydraulic test.



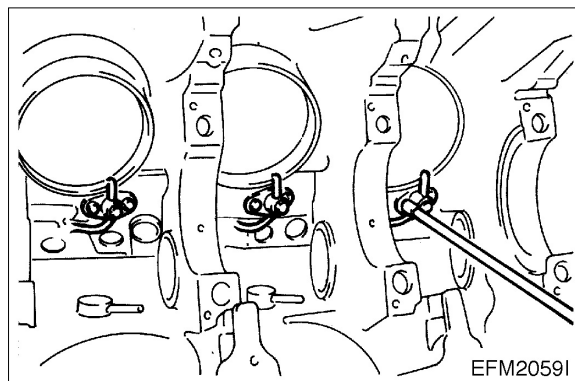
3.3.3. Oil spray nozzle

- Tighten the oil injection nozzle flange with hollow screws.



- Assemble the oil injection nozzle with the fixing bolts.

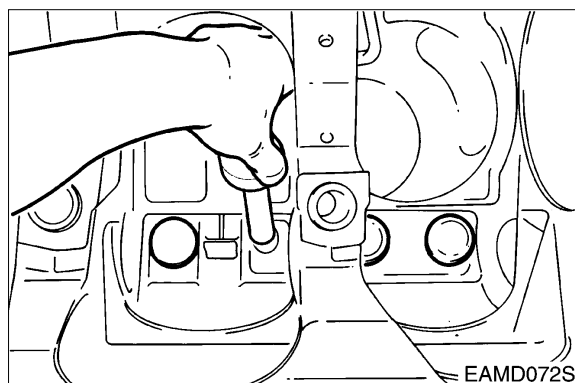
Torque	Hollow screw	7 kg.m
	Fixing bolt	1.2 kg.m



3.3.4. Tappet



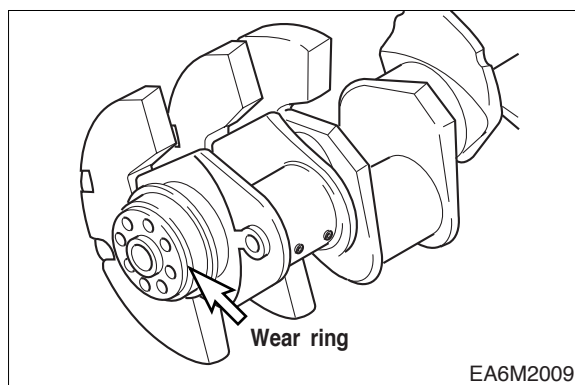
- Coat the tappet wholly clean oil and push in the tappet hole of the cylinder block.



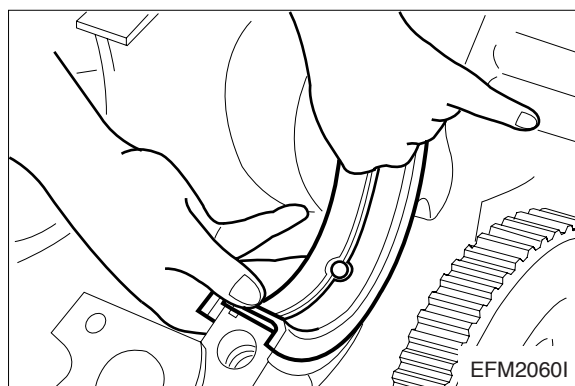
3.3.5. Crank shaft



- Put the wear ring into the heater to heat it up to 150 ~ 200°C level, push it over the crankshaft by means of a jig.



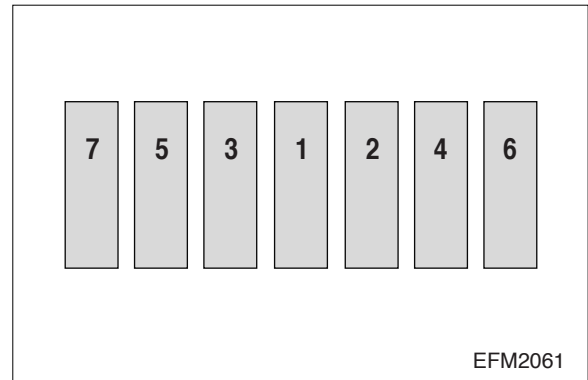
- Assemble the main bearing to the cylinder block and coat it with engine oil. Then assemble the bearing that has a hole to the cylinder block side and one that has no hole to the bearing cap and be careful not to change.



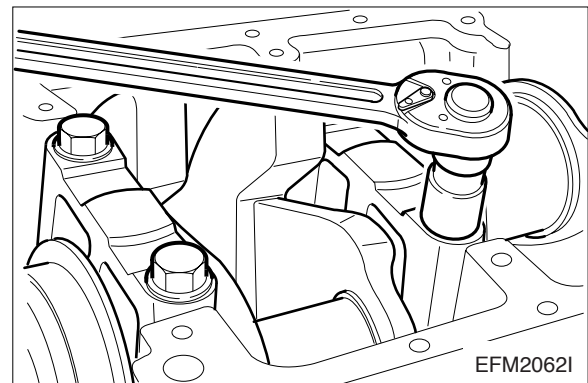
- Assemble temporarily one bolt each at both bolt holes and by connecting the wire to the bolts, lift it with crane or chain block and put down on the cylinder block carefully.



- Coat the crankshaft journal and pin parts with engine oil, and after fitting the main bearing into the bearing cap and assemble it to the cylinder block making sure of the number in order not to change the bearing cap.



- Coat the bearing cap bolt and its bolt seat part with engine oil necessarily and according to the tightening order, tighten them with 30kg.m and with rotating angle method ($90^{\circ} +10^{\circ}$) and tightening order are as follows.



< Bearing cap bolt's tightening order >

- (1) **First step** : Coat the bolts with engine oil.
- (2) **Second step** : Screw down 1 ~ 2 threads.
- (3) **Third step** : Tighten with about 15kg.m by wrench.
- (4) **Fourth step** : Tighten with about 25kg.m by torque wrench.
- (5) **Fifth step** : Tighten with 30kg.m by torque wrench.
- (6) **Sixth step** : Tighten with final rotating angle method $90^{\circ} +10^{\circ}$.

However, according to above tightening order, tighten step by step.



- Inspect if the crank shaft's rotation is smooth.
- Assemble the crankshaft gear on the crankshaft and coat a white paint mark on "1" part in order to find easily.

3.3.6. Cam shaft

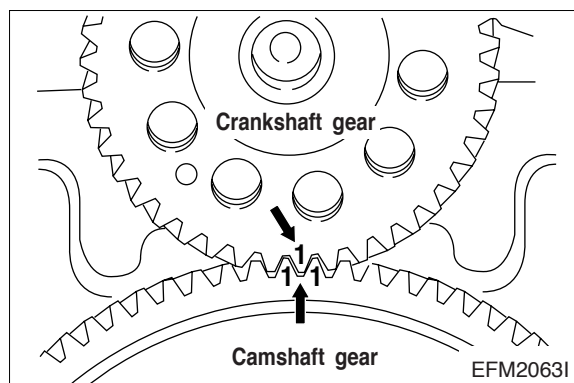


- Coat the cam bush of cylinder block and camshaft with engine oil.

- Assemble the cam bush and camshaft for them not to be damaged.



- Assemble the crankshaft gear and the camshaft gear making sure that the gear marks on both gears are aligned together.

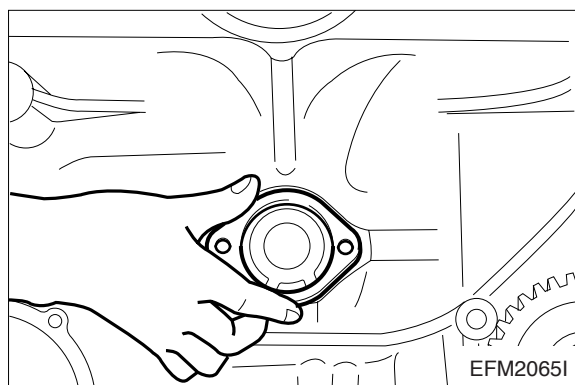


3.3.7. Flywheel housing

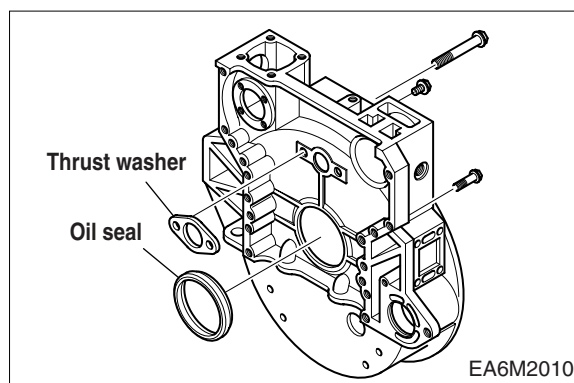


- Coat the thrust washer fixing bolt with an adhesive and tighten it with specified torque.

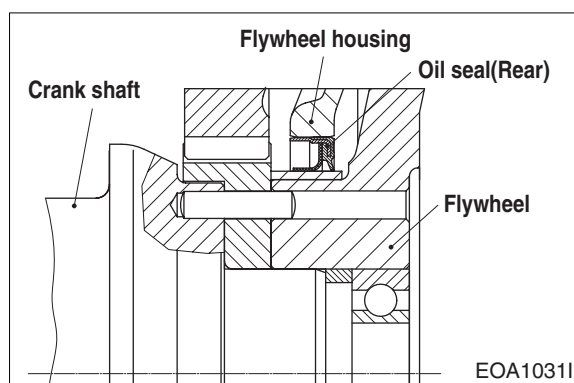
Torque	4 kg.m



- Coat the oil seal (P.T.F.E.) with lubricating oil and assemble the oil seal carefully for it not to deviate or be damaged by means of special tool. (Mandrel for assembling).



- Attach the gasket on the surface of cylinder block where the flywheel housing is to be installed. (In order to prevent the gasket slip down, coat a grease on the cylinder block surface.)
- Temporarily assemble 2ea of guide bolts for installing the flywheel housing to the cylinder block.





- After fitting the flywheel housing holes to the guide pins and engage temporarily 2 ~ 3 threads of fixing bolts, and according to the tightening order (zigzag method) tighten them in the specified torque.

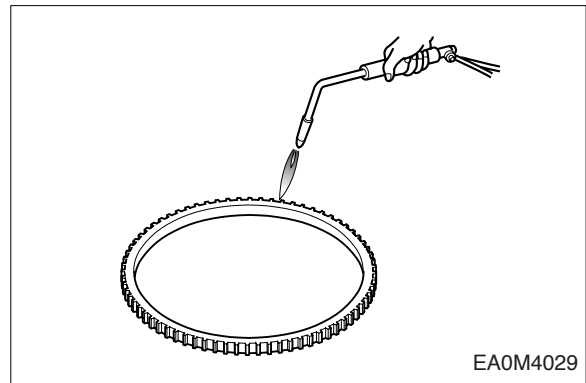
Torque	M12 x 1.5	10 kg.m
	M10	7.5 kg.m

3.3.8. Flywheel

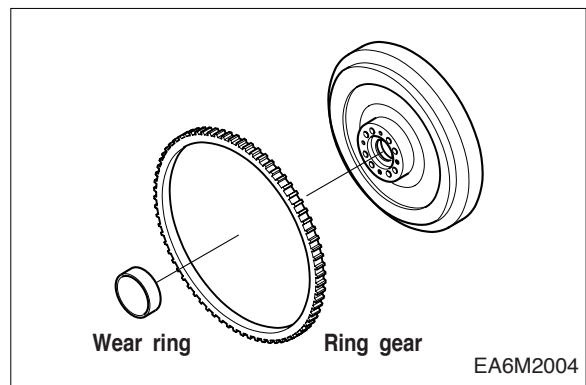
- Installation of flywheel ring gear with a gas burner, heat the ring gear evenly until heat expansion takes place, then install it using a hammer.



- Do not allow the temperature of the ring gear to exceed 200°C (390°F).
- By means of mandrel, assemble pilot bearing to the flywheel.

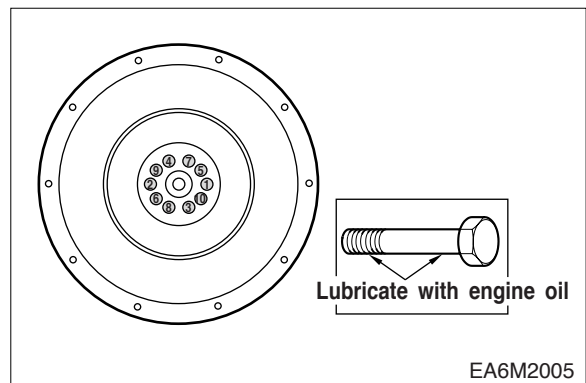


- By means of mandrel, press in the wear ring at the backward face.
- Install two guide bolts for installing the flywheel to the crankshaft.



- After letting the guide pin insert through the flywheel holes and engaging the fixing bolts by 2 ~ 3 threads temporarily, tighten them to the specified torque according to lightening order. (Zigzag order)

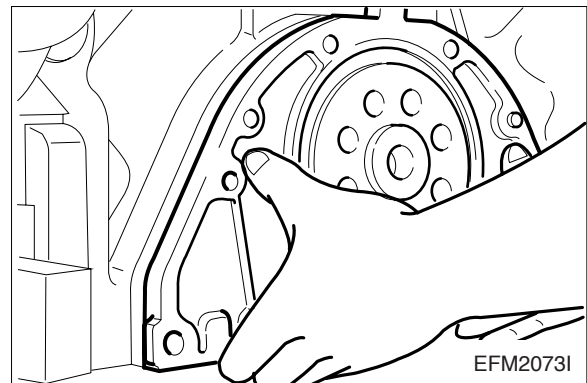
Torque	26 kg.m



3.3.9. Front oil seal holder



- After placing the oil seal in the oil holder hole properly, press it in with a mandrel. (Be careful for oil seal must not be damaged.)
- Attach a gasket at the oil seal holder.

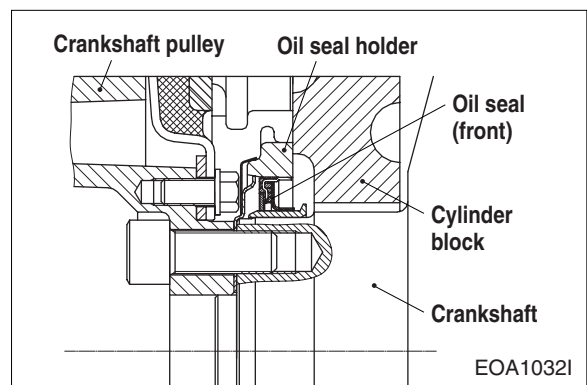


- Align the dowel pin with the oil seal holder dowel hole and assemble them by tapping lightly the dowel pin part with an urethane hammer when in assembling, take care not to hurt the oil seal by the crankshaft.



NOTE:

Without coating the oil seal with oil or lubricant, assemble it in the dry state.



- Tighten the fixing bolts in the zigzag method.

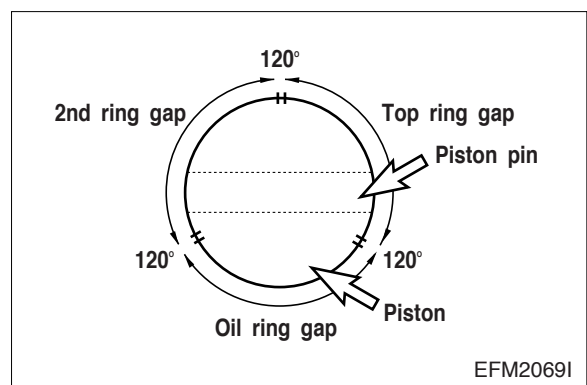
3.3.10. Piston



- Line up the piston assembly in the order of cylinders and fit the bearings to the connecting rods and bearing caps. However, take care not to swap between the connecting rods and bearing caps.



- Coat the pistons and connecting rod bearings sufficiently with clean engine oil.





- By means of a special tool, insert the piston rings and adjust the angles between the ring gaps at 120°.



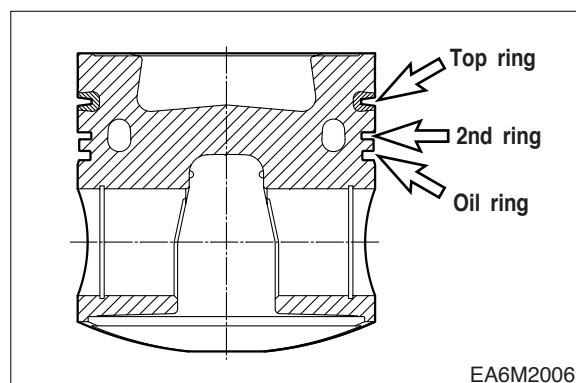
- Push in the piston with hands or wooden bar into cylinder. (Be careful for piston and rings not be damaged.)
- Pushing the piston down, rotate the crankshaft about 180° and fit the bearing cap to the connecting rod.



- Coat the tap parts of connecting rod bolts and their seats with engine oil, and after engaging 2 ~ 3 threads of bolts primarily rind then tighten them



to the specified torque. (10 kg.m + 90° +10°)



< Connecting rod bolt tightening order >

- (1) **First step** : Coat the bolts with engine oil.
- (2) **Second step** : Engage 2 ~ 3 threads by hands.
- (3) **Third step** : Tighten to about 7kg.m with wrench.
- (4) **Fourth step** : By means of torque wrench tighten to 10 kg.m.
- (5) **Fifth step** : Finally assemble by means of rotation angle method 90° +10°.

However, according to above tightening order, tighten step by step.

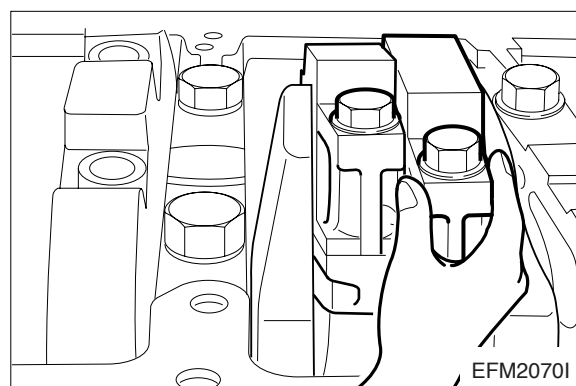
* Standard length of bolt and use limit:

- From head seat to bolt tip

Standard length	Use Limit
67.5 ^{+0.3} mm	69 mm



- By moving the connecting rod bearing cap by hands, make sure if there is any play in left and right.
- With the same method as above, assemble in each cylinder rotating the crankshaft.



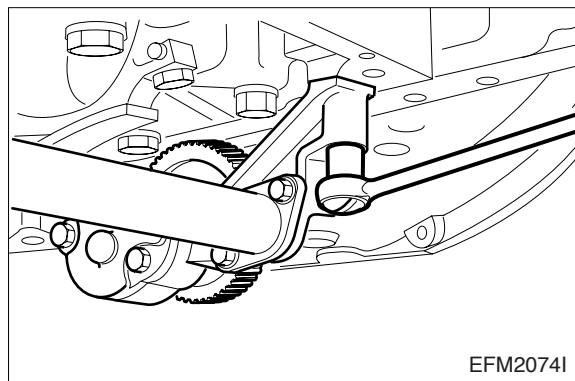
3.3.11. Oil pump

- Put the oil pump at the place to be installed on the cylinder block.
- Attach a gasket at the surface of oil pump where the pressure regulating valve is to be installed and place the regulating valve on a gasket.



- Assemble the oil pump by tightening the fixing bolts.

Torque	2.2 kg.m



EFM2074I

- Attach a gasket at the surface of the oil pump where the oil suction pipe is to be installed, and install the oil suction pipe by tightening the fixing bolts.



- Assemble the pipe bracket on the cylinder block side with bolts.

Torque	2.2 kg.m

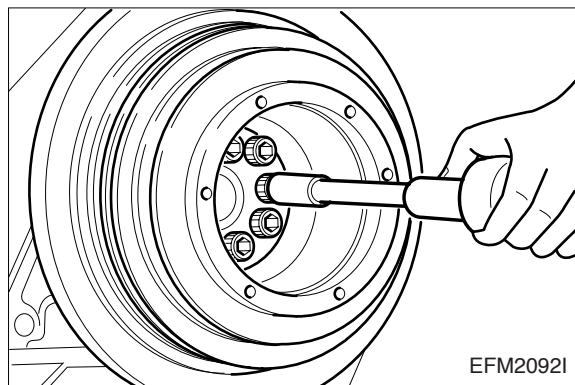
3.3.12. Vibration damper

- Assemble the vibration damper tightening firstly by the crankshaft pulley and the fixing bolts.



- Insert the crankshaft pulley assembly to the crankshaft and tighten the fixing bolts in the method of zigzag to the specified torque.

Torque	Vibration damper & pulley	6 kg.m
	Crank shaft pulley	21 kg.m



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3.3.13. Oil pan



- Clean thoroughly the gasket that is projecting at the junction parts of front oil seal holder and flywheel housing of cylinder block's lower face with a scraper.

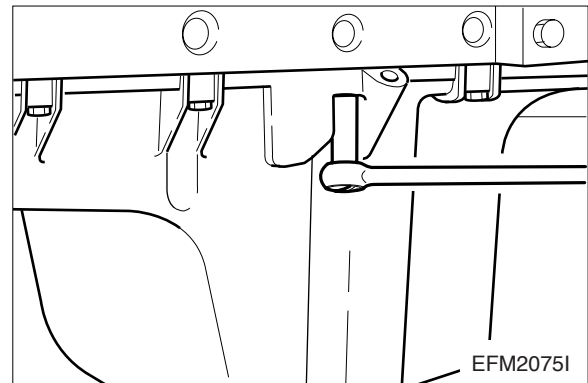


- In the process of gasket removal, be careful for the gasket pieces not to get into the engine inside.

- Attach a gasket to the cylinder block.
- Install the oil pan and tighten the fixing bolts. Then takes care not to squeeze out the gasket.



- Install the guide tube and insert the oil level gauge.



Torque	2.2 kg.m

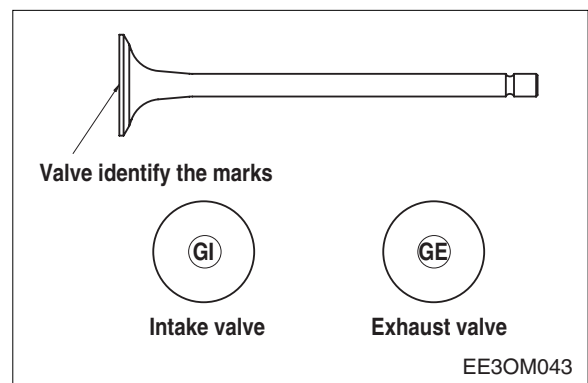
3.3.14. Intake and exhaust valve



- Identify the marks of "GI" and "GE" impressed on the valve head before assembling the valve with the valve head.



- With a valve stem seal fitting jig, assemble the valve stem seal with the valve guide.



3.3.15. Cylinder head

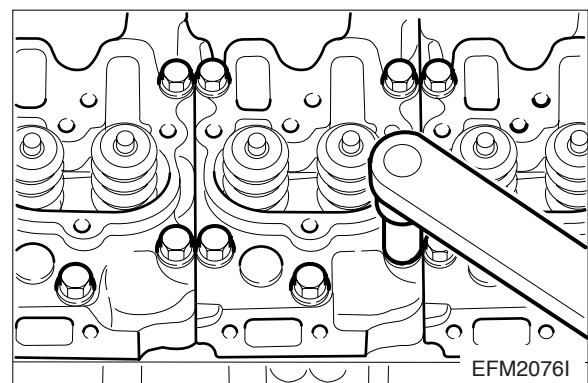


- Blow the cylinder head bolt holes with compressed air to remove the foreign material cleanly.

- Wipe off cleanly the junction part of cylinder block's head gasket.



- After confirming whether there is foreign material or not necessarily, if there is, remove it.
- Assemble a gasket fitting with the fixing pin of cylinder block.
- Position the cylinder head assembly on the cylinder block aligning with its dowel pin. (Take care not to damage the head gasket.)

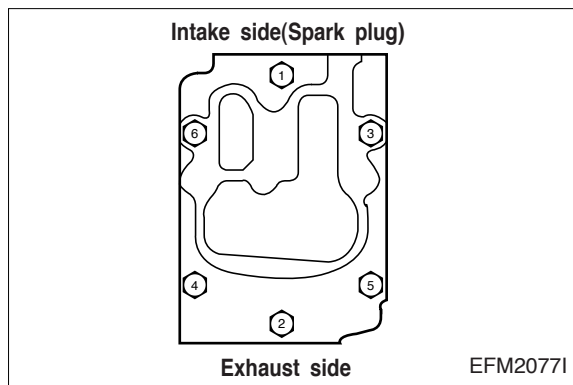




- Coat the cylinder head bolts with engine oil and tighten them to the specified torque according to step by step.



- However, prior to tightening the bolts, with a long steel rule, the parallelness between the cylinder heads must be adjusted.



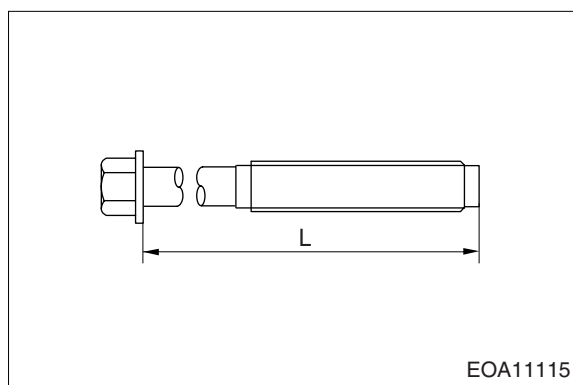
< Cylinder head bolts tightening order >

- (1) First step : Coat bolts with engine oil.
- (2) Second step : Tighten temporarily 1 ~ 2 threads by hands.
- (3) Third step : Tighten to about 8kg.m with a wrench.
- (4) Forth step : Tighten to 15kg.m with a torque wrench.
- (5) Fifth step : Rotate 90° by rotation angle method.
- (6) Sixth step : Finally tighten additionally rotating 90°.

* Standard length of bolt and use limit:

- From the head seat face to tip

Bolt no.	Standard length	Use limit
3, 6	168 mm	171 mm
2, 4, 5	144 mm	147 mm
1	109 mm	112 mm



CAUTION:

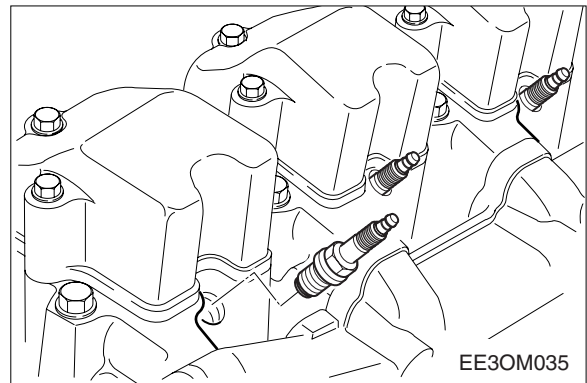
Take care for the foreign material not to get into the cylinder head suction passages.

3.3.16. Spark plug



- Put the spark plug hole of cylinder head and after inserting the spark plug assembly into it, tighten to assemble.

Torque	2.5 ~ 3.0 kg.m



3.3.17. Rocker arm

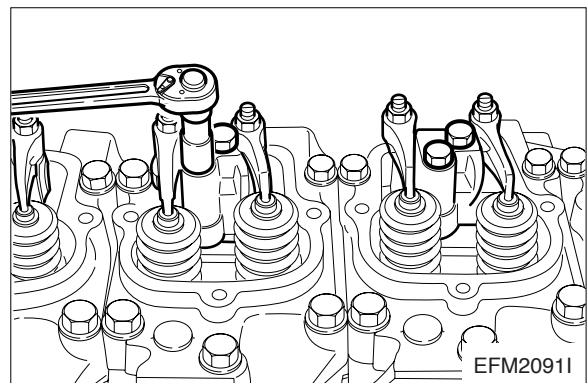


- Coat the push rod with engine oil and put it into the push rod hole.



- Position the rocker arm assembly on the cylinder head and tighten the fixing bolts to the specified tightening torque.

Torque	6.5 kg.m



- Adjust the valve clearance. Regarding the adjustment, refer to the regular maintenance part.

3.3.18. Timing drive & sensor

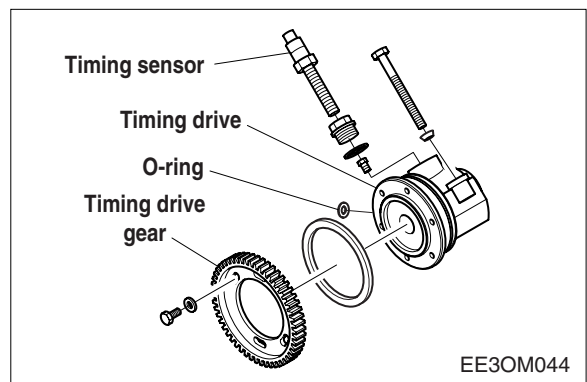


- Attach an O-ring to the cylinder block and install the timing drive on the cylinder block and then tighten the fixing bolts.

Torque	6.5 kg.m



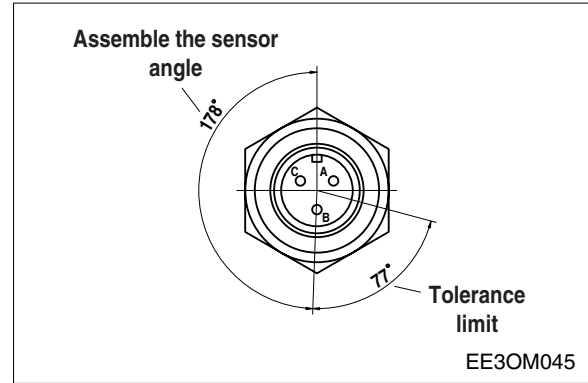
- Install the timing sensor on the timing drive and rotate (CW) the timing sensor. (Be careful for sensor magnet not to be broken)





- Until the end of it reach on trigger magnet and reverse rotate (CCW) the timing sensor for 255°(gap 1.0 mm) and then fix lock nut.

Timing sensor gap	0.7 ~ 1.0 mm (178° ~ 255°)

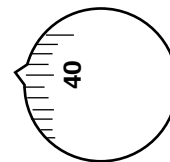
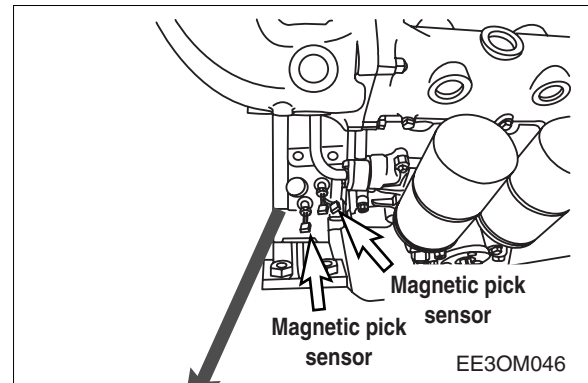


3.3.19. Ignition timing angle check & adjustment

1) Check ignition timing angle

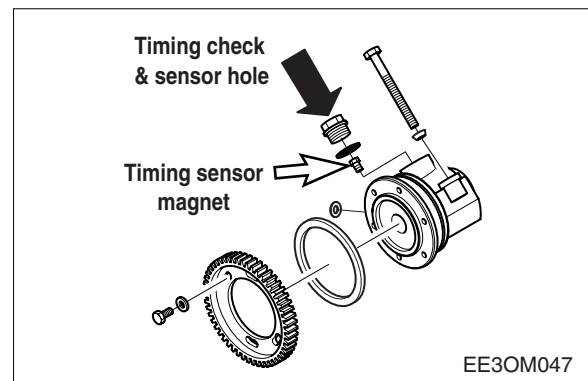


- Turning crankshaft, let the valves of #7 (10 cylinder engine) or #6 (8 cylinder engine and 12 cylinder engine) cylinder's valves overlap.
- Rotate the flywheel to the opposite direction about 30°(in order to remove a back lash) and then rotate in normal direction to set the flywheel timing angle and effect-hole sensor magnet position.



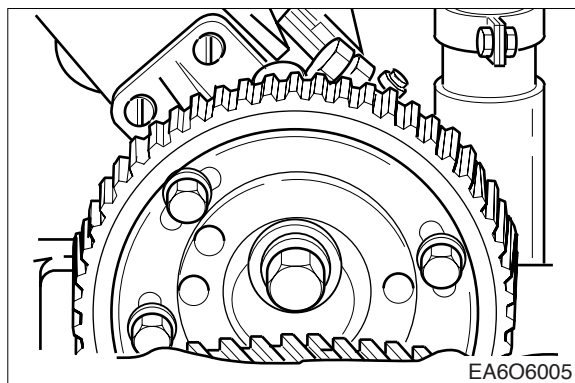
- If not aligned, the start of effect-hole sensor setting has to be corrected.

Engine model	GV158TIC	GV180TIC	GV222TIC
Adjusting angle of ignition timing(BTDC)	40°	40°	40°
Operating angle of ignition timing(BTDC)	14°	14°	12°



2) Adjust ignition timing angle

- Remove the effect-hole sensor drive gear cover.
- Correct start of effect-hole sensor setting by turning the drive gear flange in the oblong holes of the drive gear.
- Mark sure after every adjustment that fastening bolts are carefully tightened.
- Check start of effect-hole sensor setting once more.

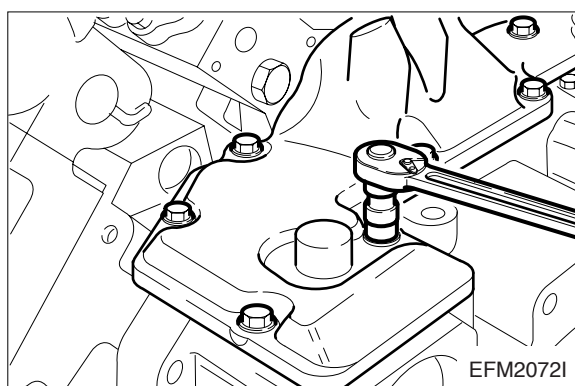


3.3.20. Flywheel housing cover

- Attach a gasket to the flywheel housing cover.
- Install the flywheel housing cover and tighten the fixing bolts by the zigzag method.

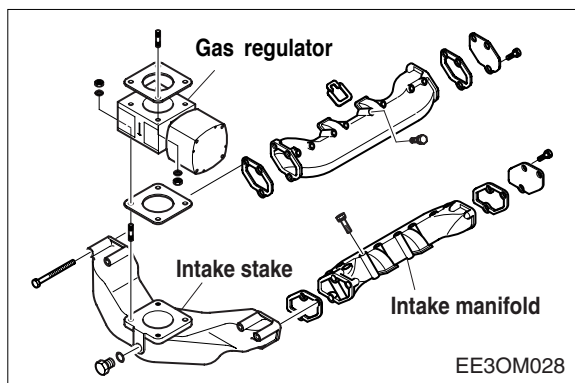


Torque	2.2 kg.m



3.3.21. Intake manifold & gas regulator

- Attach a new gasket to the cylinder head side.
- Assemble the intake manifold by tightening the fixing bolts.
- Attach a gasket to the inlet flange and assemble by tightening the fixing bolts.
- Attach a gasket to the equalizing pipe and gas regulator that connects the intake manifolds of both sides and assemble both manifolds by tightening the fixing bolts.



CAUTION:

Check assembled after the all engine parts install and tighten fuel line. Open fuel line valve and check for leaks using soapy water or commercial leak detector.

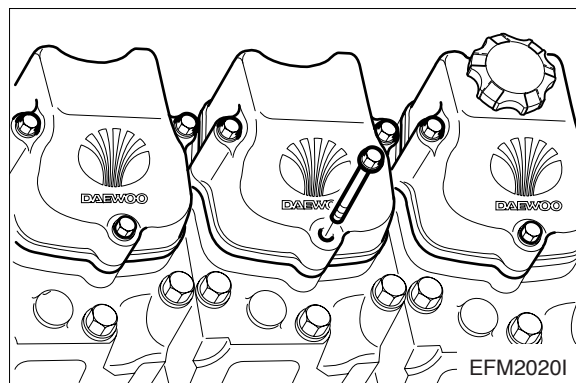
3.3.22. Cylinder head cover

- Attach a new gasket on the surface of cylinder head where the cover is to be installed.



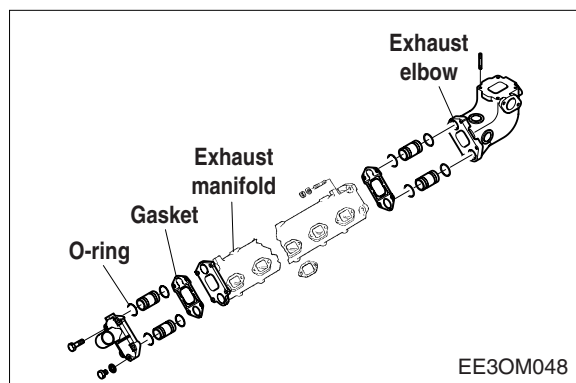
- Assemble the cylinder head cover by tightening the fixing bolts.
- Insert the oil filler cap.

Torque	2.2 kg.m



3.3.23. Exhaust manifold

- Prior to assembling the exhaust manifold, attach a gasket firstly to the cover and exhaust elbow pipe and assemble them tightening the bolts evenly as the right figure.



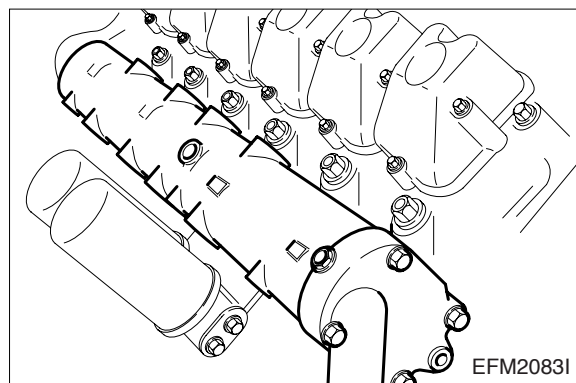
- Attach new gaskets to the exhaust manifold and then assemble the exhaust manifold with the fixing bolts.

Torque	5.0 kg.m



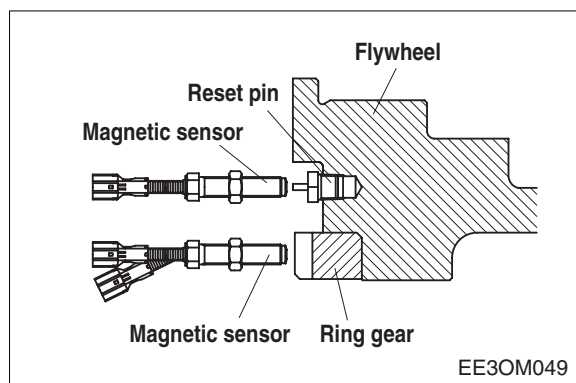
CAUTION:

Be careful not to drop the manifold because it is very heavy.



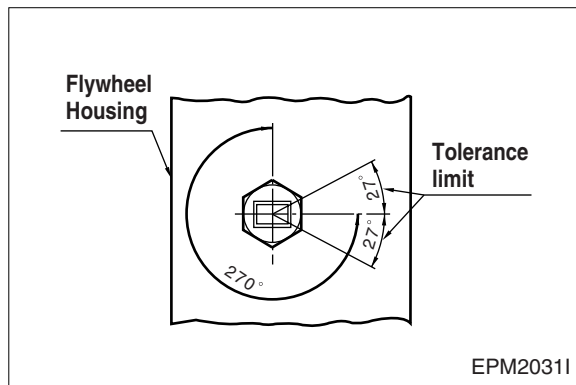
3.3.24. Reset & magnetic pick-up sensor

- Move the lock nut to hexagonal side of sensor completely.
- Rotate (CW) the Magnetic pick-up sensor on fly wheel housing, until the end of it reach on flywheel ring gear and/or reset pin.





- Rotate (CCW) the Magnetic pick-up sensor for 270°(gap 1.0 mm) and fix lock nut.
- Tolerance limit is 27°.(gap ± 0.1 mm)

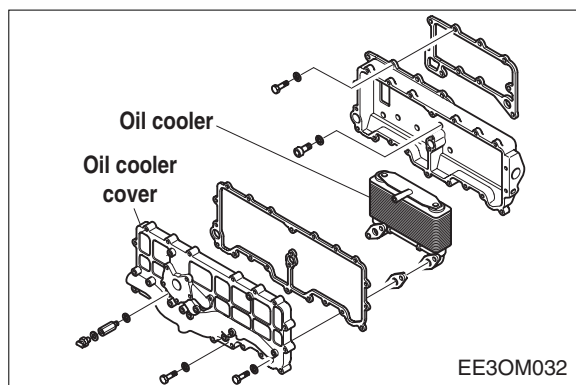
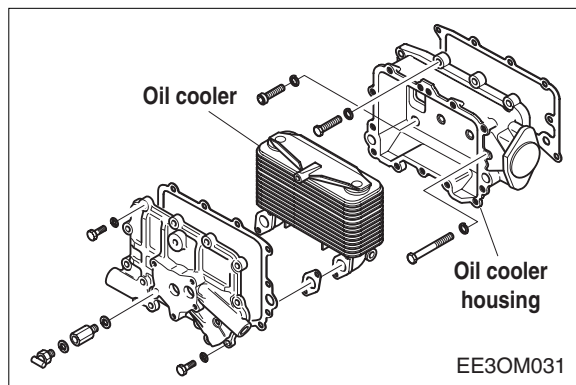
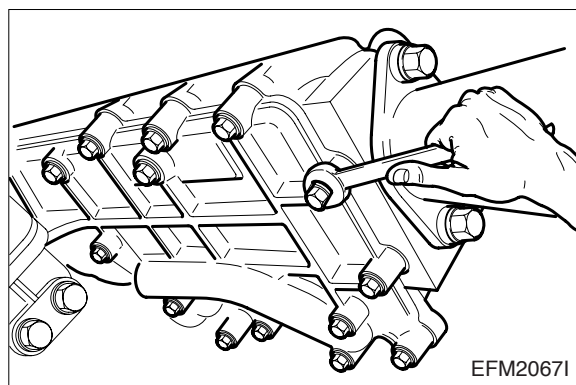


3.3.25. Oil cooler

- Attach a gasket on the surface in the oil cooler housing where the oil cooler is installed.
- Tighten the oil cooler with fixing bolts.
- Install the oil cooler assembly by tightening the fixing bolts in the zigzag order.



Torque	2.2 kg.m



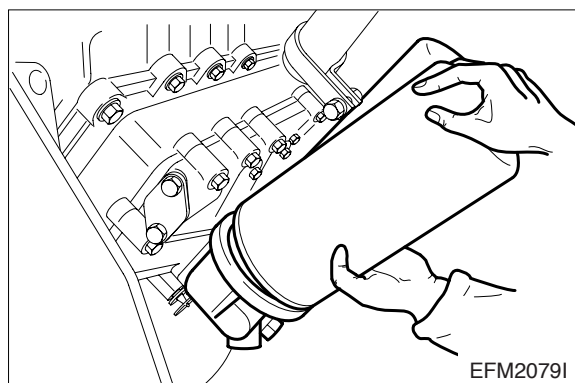
3.3.26. Oil filter

- Attach the oil filter gasket on the oil cooler.



- Install the filter head on the oil cooler and then tighten bolts in a diagonal sequence.

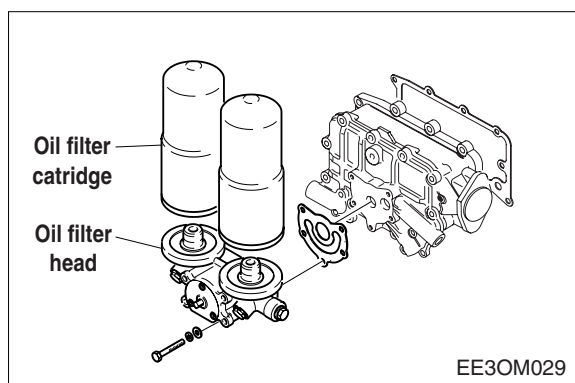
Torque	2.2 kg.m



- Lubricate the cartridge gasket and spin filter until gasket contacts oil filter head, then tighten additional 3/4 to 1 turn.



- Start engine and check for leaks.



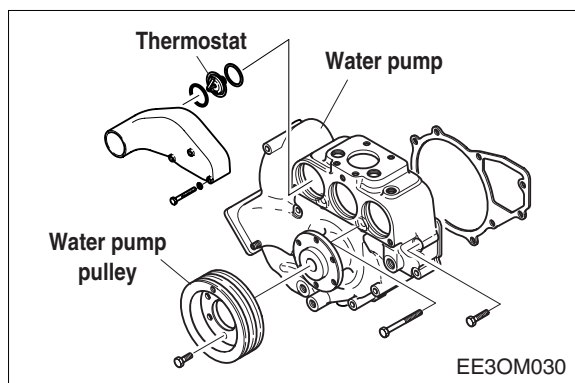
3.3.27. Cooling water pump

- Attach a gasket at the cooling water pump. (at cylinder block side)



- Assemble the cooling water pump by tightening the fixing bolts. (zigzag method)

Torque	Water pump	4.4 kg.m
	Water pump pulley	4.4 kg.m



- Insert the thermostat of cooling water pump.
- Insert the O-ring to the thermostat and assemble the cooling water pipes by tightening the fixing bolts.

Thermostat torque	2.2 kg.m

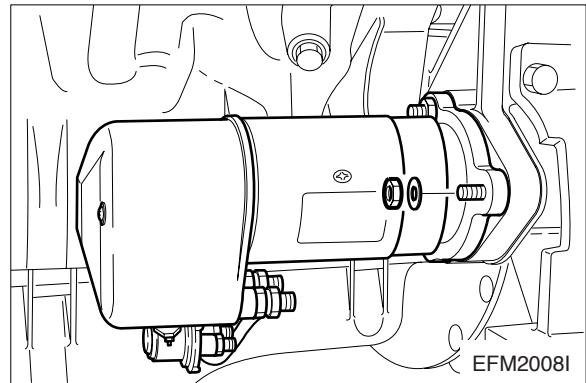
3.3.28. Starting motor

- Install stud bolts at the bolt holes on the flywheel housing for installing the starter.



- Insert the starter into the flywheel housing and tighten the fixing bolts.

Torque	8 kg.m



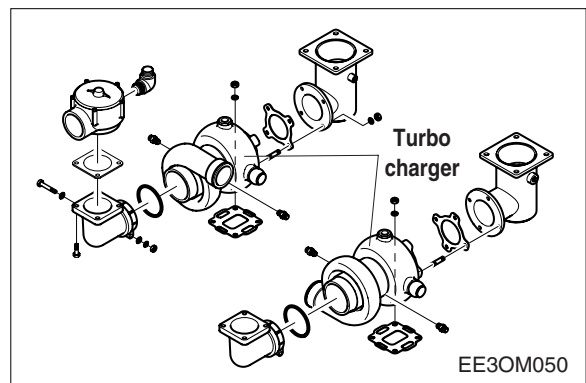
3.3.29. Turbo charger



- Attach a gasket to the exhaust elbow and assemble the turbocharger with fixing bolts.

Torque	4.4 kg.m

- Attach a gasket on the oil supply pipe and assemble the pipe with the fixing bolts.
- Attach a gasket on the oil discharge pipe and assemble the pipe by tightening the bolts.
- At the same method as above, both sides are assembled.



CAUTION:

Check assembled after the all engine parts install and tighten fuel line.

Open fuel line valve and check for leaks using soapy water or commercial leak detector.

3.3.30. Gas fuel mixer

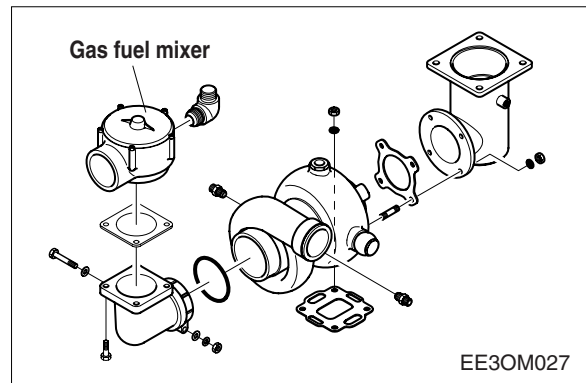
- Attach a gasket to the intake elbow and assemble the gas fuel mixer with fixing bolts.
- At the same method as above, both sides are assembled.



CAUTION:

Check assembled after the all engine parts install and tighten fuel line.

Open fuel line valve and check for leaks using soapy water or commercial leak detector.



3.3.31. Inter cooler

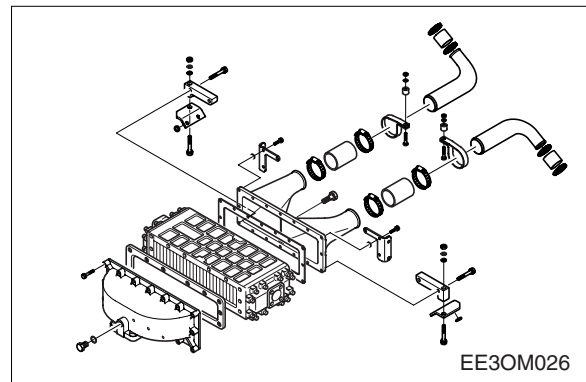
- After assembling the intercooler fixing bracket on the intake manifold and then assemble the intercooler with the fixing bolts.
- Assemble the various hoses and pipes.



CAUTION:

Check assembled after the all engine parts install and tighten fuel line.

Open fuel line valve and check for leaks using soapy water or commercial leak detector.



3.3.32. Ignition coil & gas pressure regulator

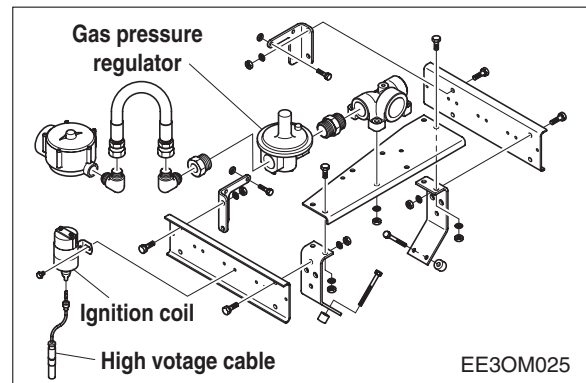
- Attach a bracket to the intake manifold and assemble the gas pressure regulator with fixing bolts.
- Assemble the ignition coil and high voltage cable.



CAUTION:

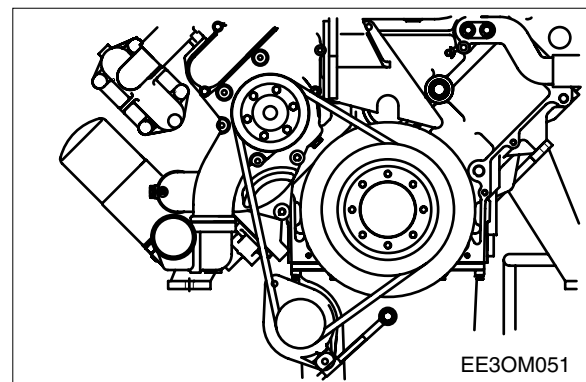
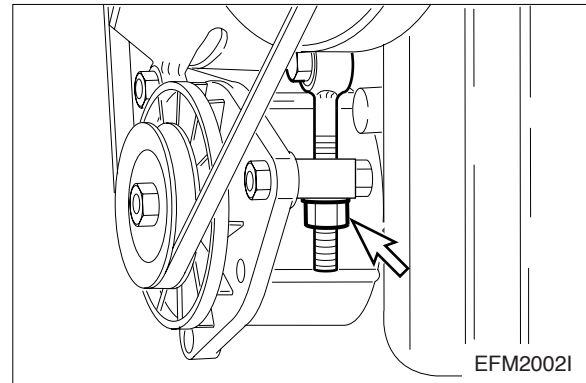
Check assembled after the all engine parts install and tighten fuel line.

Open fuel line valve and check for leaks using soapy water or commercial leak detector.



3.3.33. Alternator

- Assemble the alternator bracket to the lower part of cylinder block by tightening the fixing bolts.
- Install the alternator supporting plate (belt tension plate) to the oil pan by means of bolts.
- Assemble the alternator to the bracket and supporting plate tightening the bolts.
- Connect the crankshaft pulley and the alternator pulley and water pump pulley with V-belts by inserting them into the respective pulleys.
- Adjust the driving belt tension by regulating the alternator supporting plane. (Belt tension adjusting bolts: 10mm ~ 15mm by pushing with thumb)



3.4. Starting and Trial Operation

3.4.1. Preparations for breaking-in



- Fill of new engine oil through the oil filler cap.
- When measuring the oil level with the oil level gauge with the engine mounted, the oil level must indicate about 10mm above the max. line.
- Connect water hoses and fill up cooling water.
- Connect the fuel hoses to the fuel tank and to top(radiator or surge tank).
- Check the air bleeding of the fuel system.
- Connect the electrical systems such as starter, air heater, etc. with power source.

3.4.2. Operation of a new engine (Break-In)

Because the sliding surfaces of a new engine are not lapped enough, the oil film can be destroyed easily by overload or overspeed and the engine life-time may be shortened.

Therefore the following things must be obeyed by all means.

Up to the first 50 hours

- Engine should be run at fast idling until the temperature of the engine becomes normal operating condition.
- Overload or continuous high speed operation should be avoided.
- High speed operation with no load should be prevented.
- Abrupt start and stop of the engine should be avoided.
- Engine speed must be under 70% of its maximum speed.
- Maintenance and inspection must be accomplished thoroughly.

3.4.3. Check points for break-in

During the break-in (the initial running of the engine) period, be particularly observant as follows:

- a) Check engine oil level frequently. Maintain oil level in the safe range, between the "min." and "max." marks on dipstick.



NOTE:

If you have a problem getting a good oil level reading on dipstick, rotate dipstick 180° and re-insert for check.

- b) Watch the oil pressure warning lamp. If the lamp blinks, it may be the oil pick-up screen is not covered with oil. Check oil dipstick. Add oil to the oil pan, if required. Do not overfill. If level is correct and the status still exists, see your DEALER for possible switch or oil pump and line malfunction.



NOTE:

Oil pressure will rise as RPM increases, and fall as RPM decreases. In addition, cold oil will generally show higher oil pressure for any specific RPM than hot oil. Both of these conditions reflect normal engine operation.

- c) Watch the engine water temperature gauge and be sure there is proper water circulation. The water temperature gauge needle will fluctuate if water level in expansion tank is too low. At the end of the break-in period, remove break-in oil and replace the oil filter. Fill oil pan with recommended engine oil. Refer to following table.

Engine model	Engine oil capacity			Recommend oil	
	in Oil pan		Total (lit)	API No.	Sulfated ash content
	Max. (lit)	Min. (lit)			
GV158TIC	28	26	31	SAE 15W40 above CD or CE	Bellow 0.5%
GV180TIC	35	28	38		
GV222TIC	40	33	43		

Recommend oil : TOTAL LMG-405

Mobil Delvac super GEO 15W40

3.5. Speed controller setting

3.5.1. Installation checks



Do the checks in the order indicated. Terminal numbers in this chapter refer to the speed controller. (4.3. Speed controller)

- 1) Check that all electrical connections are correctly made and terminal screws tightened, the magnetic pickup is properly installed and the jam nut tightened, and the fuel valve and drain line are securely fastened and correctly installed.
- 2) Do not start the engine now. Turn on governor power. Check the battery voltage at terminals 1(+) and 2(-). It must be from 18 to 32Vdc.
- 3) If a signal generator is available : Attach the output to terminals 5 and 6, leaving the magnet pick-up connections off. Set the signal-generator output between 2 and 10 Vrms. If a signal generator is not available, proceed to step 8.
- 4) Set the signal-generator frequency to about half of idle speed. Close the **IDLE/RATED** switch. Turn the signal generator and governor power on. The voltage across terminals 3 and 4 should measure about 5Vdc (**START FUEL LIMIT** must be fully clockwise).
- 5) Set the signal generator for magnet pick-up frequency at rated speed. Close the **IDLE/RATED** switch. Set the external speed trim pot (if used) at mid position. Observe the output from terminals 3 and 4.
 - a) If the output is at max-fuel position (about 5Vdc), slowly turn the rated-speed potentiometer counterclockwise until the signal just begins to move to minimum.
 - b) If the output is at minimum, slowly turn the rated-speed potentiometer clockwise until the signal just begins to move to maximum.
 - c) Continue to adjust the rated-speed pot very slowly, trying to stop the signal between minimum and maximum. Stop adjusting when the signal moves slowly. It will not be possible to stop the motion. The rated-speed reference is now set very close to desired speed.
- 6) Open the **IDLE/RATED** switch. Set the signal generator for magnet pick-up frequency at idle speed. (Preset the idle speed only after presetting rated speed.)
 - a) If the signal is at maximum-fuel position, slowly turn the idle-speed potentiometer counterclockwise until the signal begins to move to minimum.
 - b) If the signal is at minimum, slowly turn the idle-speed potentiometer clockwise until the signal just begins to move to maximum.
- 7) Continue to adjust the idle-speed pot very slowly, trying to stop the signal between minimum and maximum. Stop adjusting when the signal moves slowly. It will not be possible to stop the signal. The idle-speed reference is now set very close to desired idle speed.
- 8) **If a signal generator is not available** : turn the rated speed pot fully counterclockwise. Turn the idle-speed pot fully clockwise. Remove the magnet pick-up wires from the speed control and measure resistance across the magnet pick-up wires. If the resistance is correct replace the connection.

3.5.2. Initial pre-start settings

In case the newly installed the speed controller does not control engine speed, be prepared to bellows sequence.

1) Rated Speed

If **RATED SPEED** was not set with a signal generator, set the **RATED SPEED** potentiometer to minimum (fully counterclockwise). Set the external speed trim, if used, to mid-position.

2) Stability

Set the **RATED** and **IDLE STABILITY** potentiometers to mid position.

3) Gain

Set the **RATED** and **IDLE GAIN** potentiometers to mid position.

4) Idle Speed

If **IDLE SPEED** was not set with a signal generator, set the **IDLE SPEED** potentiometer at maximum (fully clockwise).

5) Start Fuel Limit

Set the **START FUEL LIMIT** pot at mid point (maximum is fully clockwise).

6) Close the circuit between terminals 9 and 10 (Close for rated).

3.5.3. Start-up and stable adjustments

Prepare to start the engine. Read this entire chapter before attempting to start the engine. Interrelated problems can occur, and an understanding of all possibilities is needed before using a control for the first time.



CAUTION:

To protect against possible injury, loss of life, and/or property damage when starting the engine, turbine, or other type of prime mover, be prepared to make an emergency shutdown to protect against runaway or overspeed should the fuel control(s), the driving mechanism(s), or the control device(s) fail.

1) Adjust for stable operation

Read the following paragraphs before attempting initial engine start up. Dynamics must be quickly adjusted after initial start up.

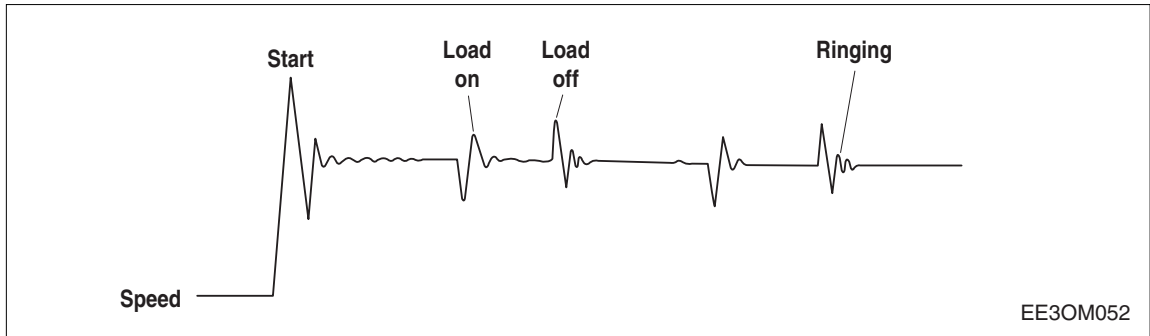
2) Immediately after the initial start up, it will be necessary to adjust the governor for stable operation. Idle and Rated dynamics are completely separate. In most cases the idle speed has been preset at maximum (fully clockwise) and Rated Speed is selected. In many cases the selection of rated speed will not indicate a desire for rated dynamics, which will be used when the engine is loaded. Idle dynamics may be selected and adjusted while rated speed is selected.

- 3) If the engine is hunting at a rapid rate, slowly decrease the **GAIN** (turn the potentiometer counterclockwise) until performance is stable.
- 4) If the engine is hunting at a slow rate, increase the **STABILITY** (turn the potentiometer clockwise) until the engine stabilizes. If increasing the **STABILITY** potentiometer does not stabilize the engine, it also may be necessary to slowly decrease the **GAIN** (turn the potentiometer counterclockwise).
 - a) Start cranking the engine. If the signal from terminals 3 and 4 does not show a positive voltage (2 to 6 Vdc) check the magnetic pick-up sensor.
 - b) Minimum voltage required from the magnetic pick-up sensor to operate the electronic control is 1.0 Vrms, measured at cranking speed or the lowest controlling speed. Measure the voltage while cranking with the speed sensor connected to the control. Be sure to prevent the engine from starting.
- 5) If the engine stops, it indicates a magnetic pick-up problem. The magnetic pick-up must produce a minimum of 1 Vac rms to activate the control. Failure to produce the minimum signal can be caused by improper magnetic pick-up installation, selection of an incorrect gear, improper wiring between the magnetic pick-up and the control, or a defective magnetic pick-up.
- 6) With the engine running and stable, slowly increase the rated-speed setting with the **RATED SPEED** pot until the desired rated speed is reached.
- 7) Dynamic adjustment
The object of the **GAIN** and **STABILITY** potentiometer adjustments is to obtain the optimum, or desired, stable engine-speed response.
- 8) Increasing the setting of the **GAIN** potentiometer provides faster transient response (decreases the amount of speed change from a sudden change in load).
To achieve the best response, slowly increase the **GAIN** (turn the potentiometer clockwise) until the engine becomes slightly unstable, then slowly turn the **GAIN** back counterclockwise as necessary to stabilize engine speed.
- 9) Step load the engine to make sure the engine returns to the proper speed with little overshoot or undershoot of the speed setting. (To reduce overshoot, increase the **STABILITY** setting by turning the potentiometer clockwise).
- 10) Increasing the **STABILITY** clockwise will require decreasing the **GAIN** (turning the **GAIN** potentiometer counterclockwise) to maintain stable operation.
- 11) If the engine is slow in returning to the proper speed, decrease the **STABILITY** by turning the potentiometer counterclockwise.
- 12) **Low idle speed adjustment** : The engine should be at rated speed with the **IDLE SPEED** potentiometer set at maximum (fully clockwise). Open the external **CLOSE FOR RATED** contact.

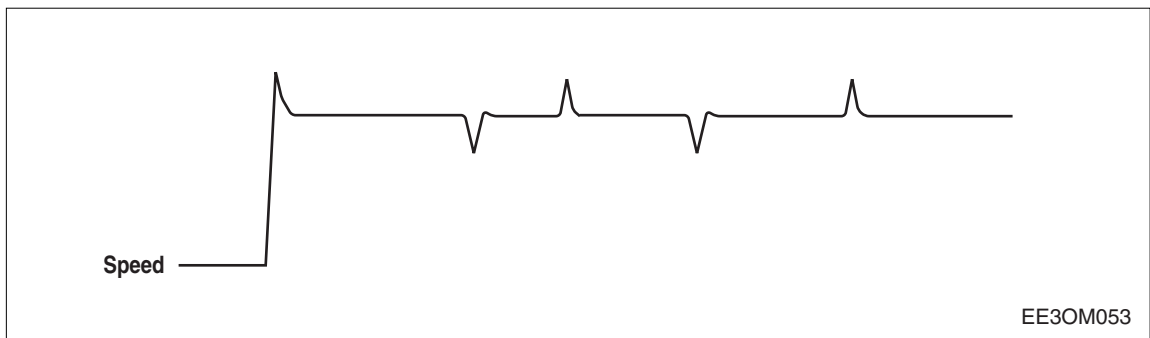
13) Decrease the **IDLE SPEED** (turn the potentiometer counterclockwise) until the desired idle speed is reached. It may be necessary to adjust the idle dynamics to maintain stability as speed is lowered.

14) Dynamic Adjustment

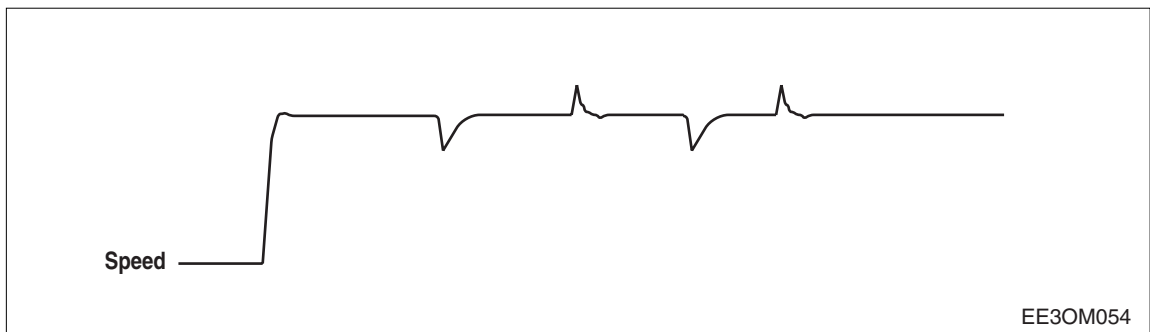
a) Gain is too high and stability too low. There are secondary overshoots on transients and large overshoots on starts (under damped)



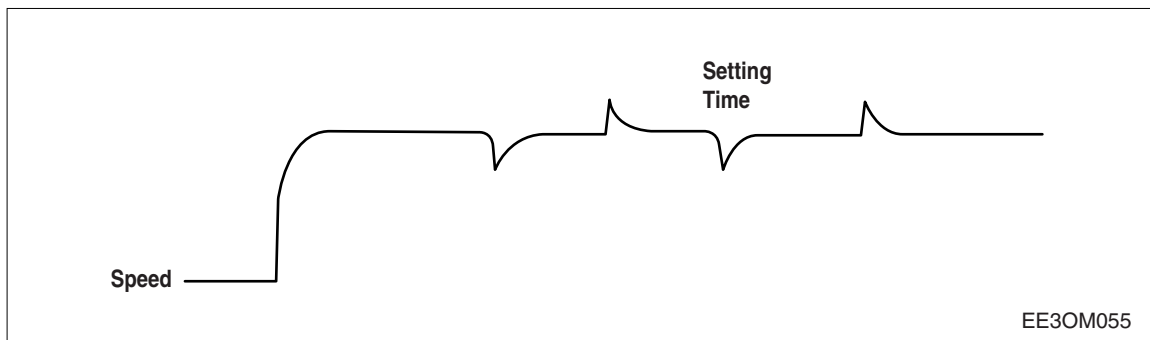
b) Optimum performance on load transients with slight overshoot on starts (optimum damping)



c) Optimum performance on start with slight time extension of load transients (optimum damping)



d) Stability too high, long time to settle to rated speed (over damped)



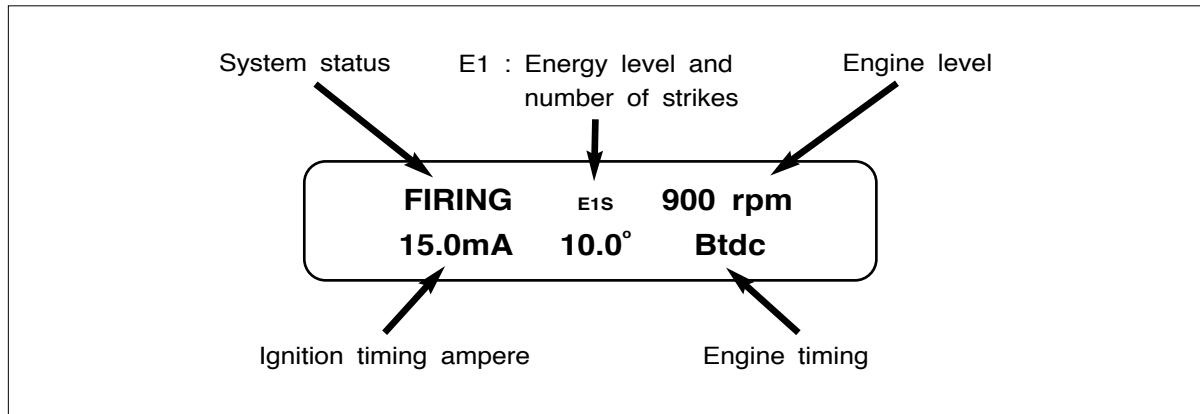
- 15) If idle dynamics were selected on initial start-up, it will now be necessary to set rated dynamics. Load the engine, then select rated dynamics.
- 16) Engine response will change as the engine warms up. It may be necessary to tune dynamics after warm-up. It may be necessary to compromise optimum control dynamics with a cold engine in order to have optimum dynamics when the engine is at operating temperature.
- 17) The **START FUEL LIMIT** was set at a point that allowed the cold engine to start during initial start up procedures. If **START FUEL LIMIT** is to be used, it should now be adjusted after engine stability and response rates are correctly adjusted.
- a) Adjusting the **START FUEL LIMIT** counterclockwise will prevent the fuel valve from delivering a maximum amount of fuel to the injectors until the selected speed (Idle or Rated) is reached. Adjust for desired engine performance during start up. The Start Fuel Limit must be set high enough to allow the engine to reach the selected speed.
- b) The **START FUEL LIMIT** should be adjusted from counterclockwise to obtain the desired characteristics while starting the engine. There may be differences in startup characteristics of cold and hot engines.

3.6. Display module

3.6.1. Display module system



The Display module, typically mounted in an engine control panel or other enclosure off the engine, offers users comprehensive display and control functionality. It features a two-line, backlit, alphanumeric display, in conjunction with a front accessible, sealed membrane keypad and gives users access to critical operating, setup, and diagnostic information.



3.6.2. Typical system diagnostics

- 1) Engine overspeed has been reached with the maximum observed speed displayed.
- 2) Indicative of a condition where an incorrect number of gear tooth pulses have been received between reset events. Often the result of an improperly gapped magnetic pickup or a damaged ring gear.
- 3) This diagnostic is flagged when zero gear tooth pulses are between two reset pulses. An open, shorted, or damaged magnetic pickup cable is typically the source of this fault.
- 4) Diagnostic faulted when too many gear tooth pulses are received without detection of reset pulse. An open, shorted, or damaged magnetic pickup cable is also typically the source of this fault.

ENGINE OVERSPEED
1800 rpm

RING-GEAR FAULT
160 TEETH READ

GT PICK-UP FAULT
MISSING PULSES

RS PICK-UP FAULT
MISSING PULSES

- 5) No Hall-effect pickup (4-cycle indicator) signal has been detected or it is improperly synchronized with the reset pickup.

**HE PICK-UP FAULT
MISSING / / NO - SYNC**

- 6) The expected 4 ~ 20mA control signal used for timing control is either below 2mA or above 22mA. Annunciated when timing control loop is either not present or out of range.

**CURRENT LOOP
OUT OF RANGE**

Timing control sensor ampere	4 ~ 20 mA

3.6.3. Patented primary and secondary diagnostic

- 1) Indicates the ignition system has detected an open circuit on output "A" ; usually the result of faulty wiring or a failed coil.

**PRIMARY OPEN
A**

- 2) A short circuit condition detected on output "B" ; may be the result of an improperly wired coil or a short to ground inside the conduit.

**PRIMARY SHORT
B**

- 3) A low voltage demand condition on output "C" ; typically indicates a shorted spark plug or secondary wire.

**LO SPARK VOLT.
C**

- 4) A high voltage demand condition detected on output "D" ; generally encountered when spark plugs become worn and require replacement.

**HI SPARK VOLT.
D**

- 5) No secondary spark on output "E" ; indicates disconnected secondary lead or voltage demand exceeding the coil's output.

**NO SEC. SPARK
E**

6) Output "**F**" is indicating that its monitored spark voltage demand is dramatically lower than the average of the cylinders. This indicates potentially an overly rich air/fuel mixture, a short in the secondary wiring, or perhaps an improperly gapped spark plug.

LO FROM ENGINE
F

7) A high spark voltage demand than that seen the other engine power cylinders has been detected on output "**K**". This may also be related to air/fuel ratio or the condition of the secondary wiring and/or spark plugs.

HI FROM ENGINE
K

3.6.4. Understanding the home screen

1) The **READY** message is displayed when the ignition is ready for the engine to crank for starting.

READY 0rpm
15.0mA **10.0°** **Btdc**

2) Once the engine begins turning, the **SYNCING** message is displayed while the ignition system verifies signals from the engine pickups.

SYNCING 155rpm
15.0mA **10.0°** **Btdc**

3) The **FIRING** message is displayed when the ignition begins firing. Additional data is provided on this screen to describe the selected mode of operation for the ignition. The energy mode (E1, E2, E3) and the single-strike / multi-strike type (S or M) are described in the middle of the upper line in small characters.

FIRING E1S **1000rpm**
15.0mA **10.0°** **Btdc**

4) The **STALLED** message is displayed when a loss of rotation is detected after the ignition is firing and neither a Shutdown or Fault has occurred. This signifies that the engine has stopped without any detected cause from the ignition system.

STALLED 0rpm
15.0mA **10.0°** **Btdc**

5) The **WARNING** message will supersede all of the above home screens if a diagnostic warning condition is present. When a diagnostic warning exists, a View Diagnostics message will flash on the bottom line of the display.

a) The Ignition Module will continue to operate under a warning condition while alerting the operator of a potential problem in several ways: by turning on the Alarm LED in the Ignition Module and by changing the state of the Alarm Out switch (switch opens).

b) The Display Module will display the Warning message. The various types of diagnostic warnings are described in section.

WARNING	1000rpm
15.0mA	10.0° Btdc

WARNING	1000rpm
VIEW	DIAGNOSTICS

6) The **FAULT** message will supersede all of the above home screens if a diagnostic fault condition is present.

a) When a diagnostic fault exists, a View Diagnostics message will flash on the bottom line of the display.

b) The ignition system will stop operating under a fault condition and will alert the operator to the problem in several ways: by changing the state of the Fire Confirm Out switch (switch opens), by turning on the alarm LED inside the Ignition Module, by changing the state of the Alarm Out switch (switch opens), by changing the state of the Fault Out switch (switch opens), and by displaying the Fault message.

c) The various types of diagnostic faults are described in section.

FAULT	0rpm
15.0mA	10.0° Btdc

FAULT	0rpm
VIEW	DIAGNOSTICS

7) The **SHUTDOWN** screen will supersede all other home displays if the logic level shutdown input of the Ignition Module or the G-Lead of the output primary connector is grounded or was previously grounded and the engine has not stopped rotating.

a) This screen indicates that the ignition is not firing because a shutdown input was triggered to shutdown the engine. If a diagnostic fault or warning exists while the ignition is in shutdown, a View Diagnostics message will flash on the bottom line of the display.

b) The Fire Confirm Out switch will change state (switch opens) and the other outputs will function as described above based on the existence of faults or warnings.

SHUTDOWN	0rpm
15.0mA	10.0° Btdc

SHUTDOWN	0rpm
VIEW	DIAGNOSTICS

8) The following types of screens can be viewed by pressing enter to start and next to advance.

- GV158TIC

H4A160 . FS100#001
UNIT 791950-16

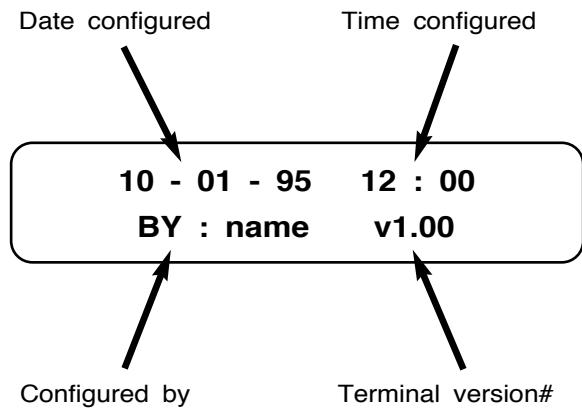
- GV180TIC

J4H160 . FS100#001
UNIT 791950-16

- GV222TIC

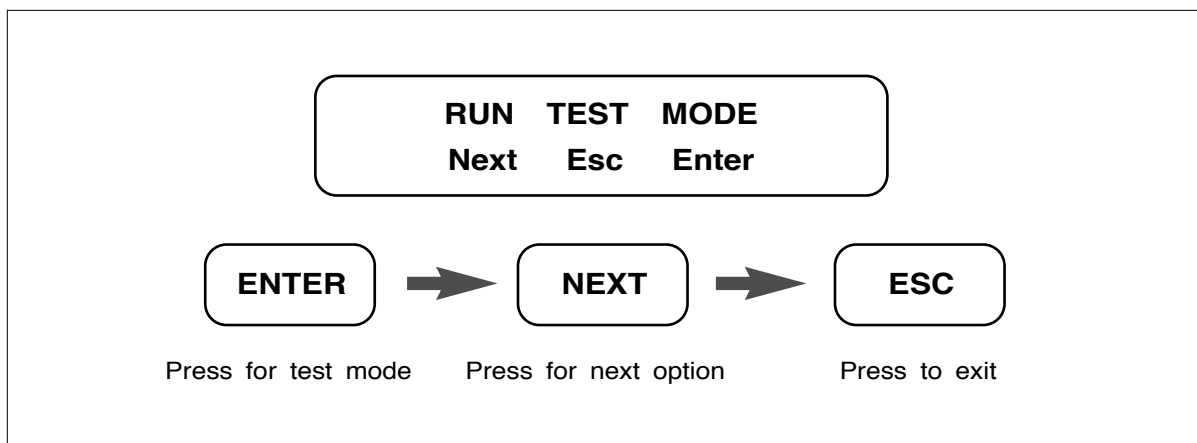
L4B160 . FS100#001
UNIT 791950-16

- H : Represents the engine model
(H:GV158TIC, J:GV180TIC, L:GV222TIC)
- 4 : 4-cycle engine
- A : Represents the Altronic pattern code
(A:GV158TIC, H:GV180TIC, B:GV222TIC)
- 160 : Represents the number of gear teeth
or holes to be sensed
- FS100#001 : Special pattern code
- UNIT 791950 -16 : Ignition module no.



3.6.5. Ignition state checks

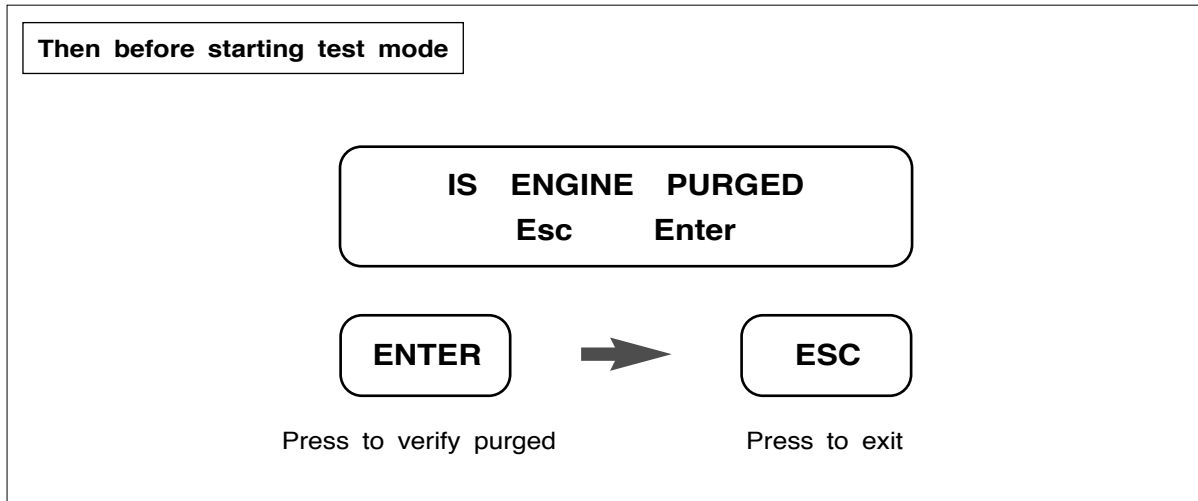
- 1) The last setup screen permits the operator to enter an ignition test mode. This test mode can fire all outputs in rotation, or individual outputs at a slow rate. This feature can be used to troubleshoot primary wiring and operation. Test mode will terminate if rotation of the engine is sensed. Diagnostic features do not function while in test mode.



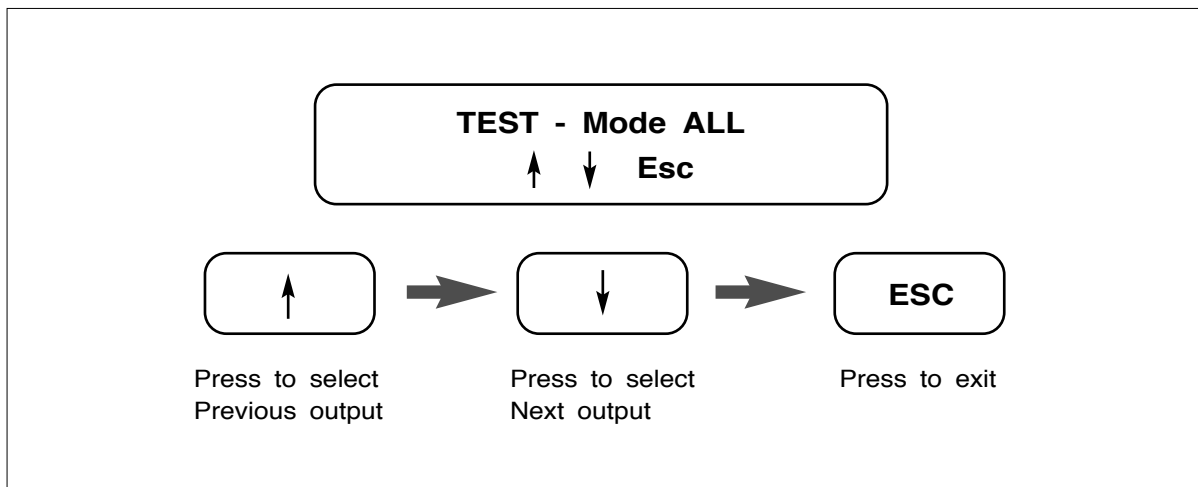


CAUTION:

The operator must fully purge the engine of combustible mixtures prior to selecting the test mode operation. Pressing the enter key again is a confirmation of this action.



- 2) Then the test mode screen indicates that the ignition is firing and permits the operator to select the output to be fired.



3.6.6. Ignition control module diagnostics

- 1) A diagnostic fault represents the most severe classification of problems. The presence of a diagnostic fault will inhibit the ignition from firing. When a fault is detected several things will occur:
 - a) The ignition will stop firing.
 - b) The Fire Confirm Out switch will open.
 - c) The Fault Out switch will open.
 - d) The Alarm Out switch will open.
 - e) The Alarm LED in the ignition unit will turn on.
 - f) The home status will read Fault, and the bottom line will flash View Diagnostics.



NOTE:

Diagnostic FAULTS will supersede diagnostic WARNINGS.

FAULT 0rpm
VIEW DIAGNOSTICS

- 2) A diagnostic warning represents the least severe classification of problems. The ignition will continue to fire in the presence of a diagnostic warning. When a warning is detected, several things will occur:
 - a) The Alarm Out switch will open.
 - b) The Alarm LED in the ignition unit will turn on.
 - e) The home status will read **WARNING**, and the bottom line will flash View Diagnostics.

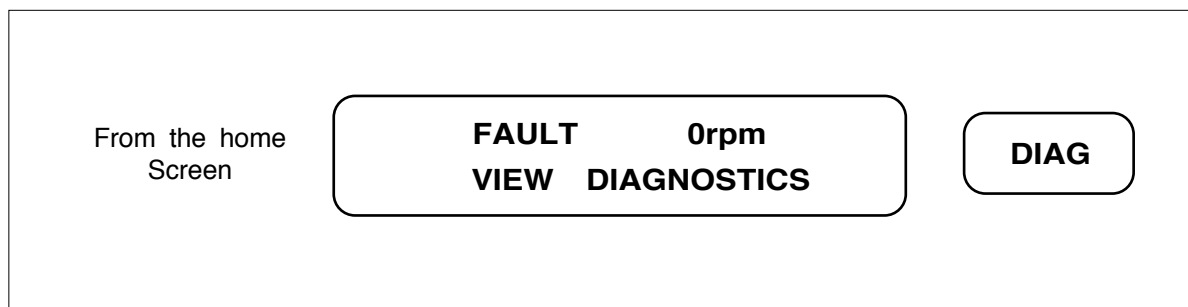
WARNING 3000rpm
VIEW DIAGNOSTICS

- 3) If the Alarm Out switch is being used to turn on an audible alarm or flasher, the user can acknowledge the alarm as described below.

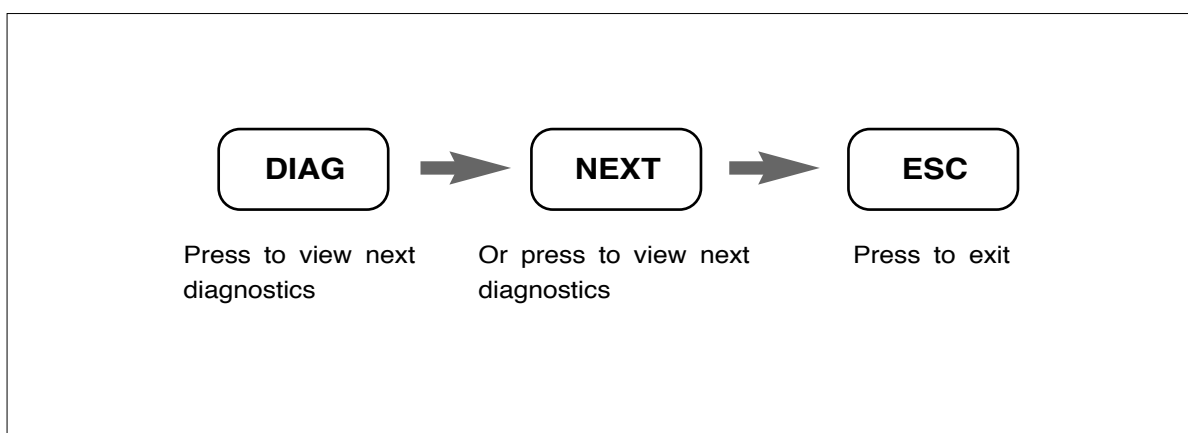
ALARM
ACK

- 4) Acknowledgment of the alarm results in the following until a reset is commanded or until another fault or warning may occur.
 - a) The Alarm Out switch will return to its closed position.
 - b) The Alarm LED will flash to indicate that an alarm is present but acknowledged.

- 5) When a fault or warning is present, the operator can display the actual cause of the diagnostic as depicted below.

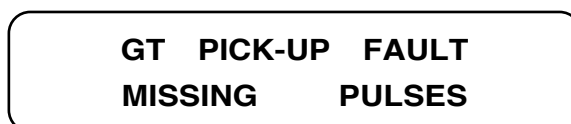


- 6) Then from the diagnostic description screens use the following keys.

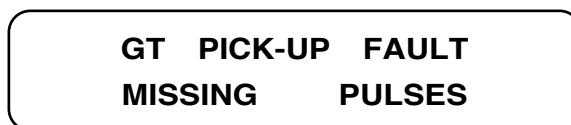


- 7) Diagnostic Fault screens, in order of display priority, are described below.

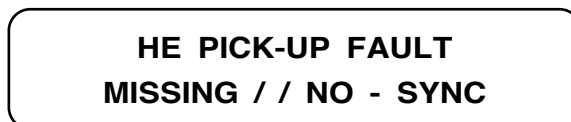
- a) When zero gear-tooth pluses are seen between two reset pluses.



- b) When too many gear-tooth pluses are seen without a reset pluses.



- c) When there are no hall-effect pickup pluses or when the pick-ups are not synchronized.



- d) When too many or too few gear-tooth pluses are seen between reset pluses. The received number or pluses is displayed.



e) When the engine speed exceeds the overspeed setpoint. Maximum observed speed is also displayed.

ENGINE OVERSPEED
1023 RPM

f) When the check-sum of microprocessor firmware cannot be verified. Unit requires service.

BOTTOM BOARD uP
CHECKSUM FAILED

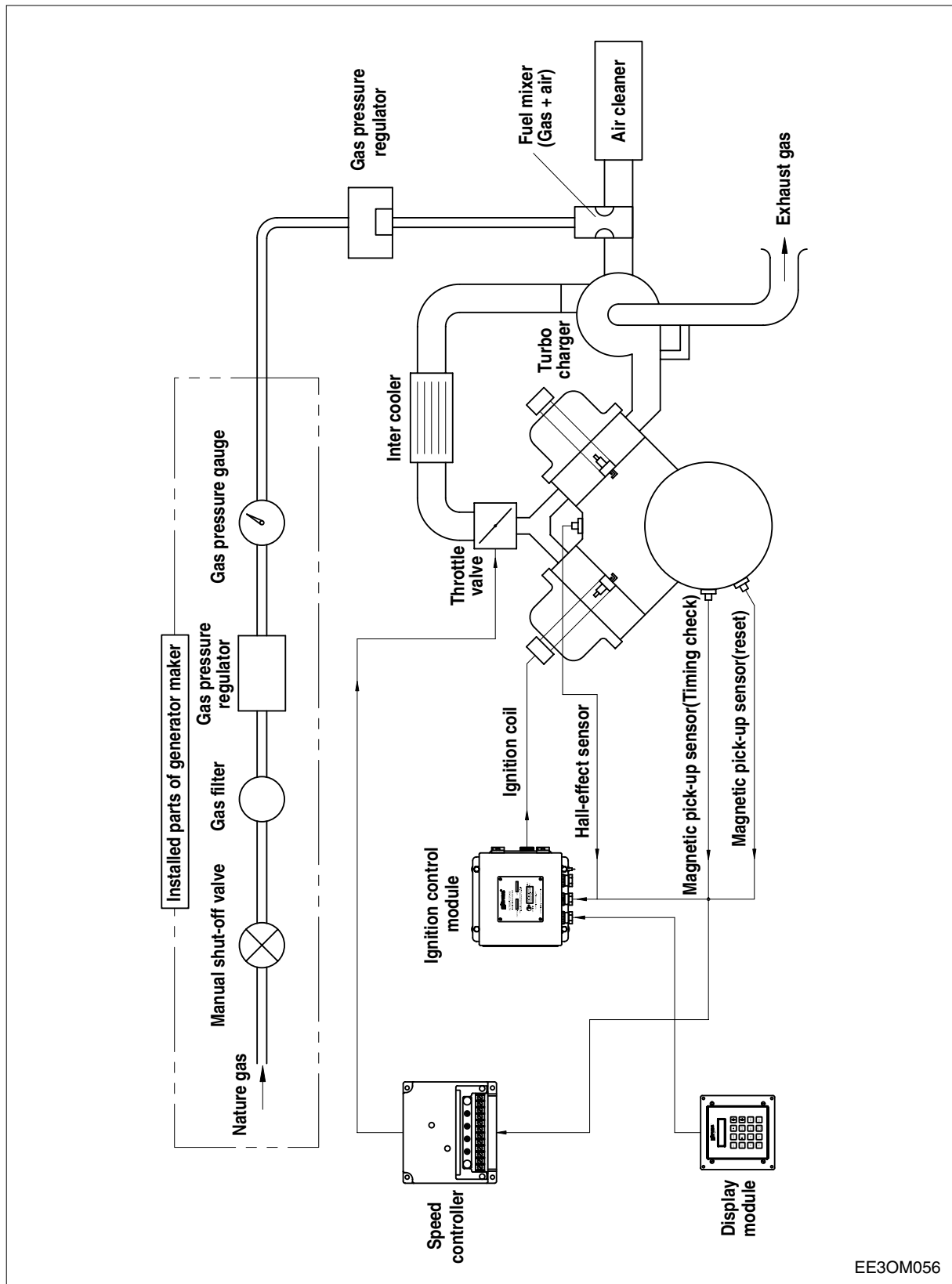
3.7. Diagnosis and remedies of trouble causes

- Prior to asking for repair, please check the following items

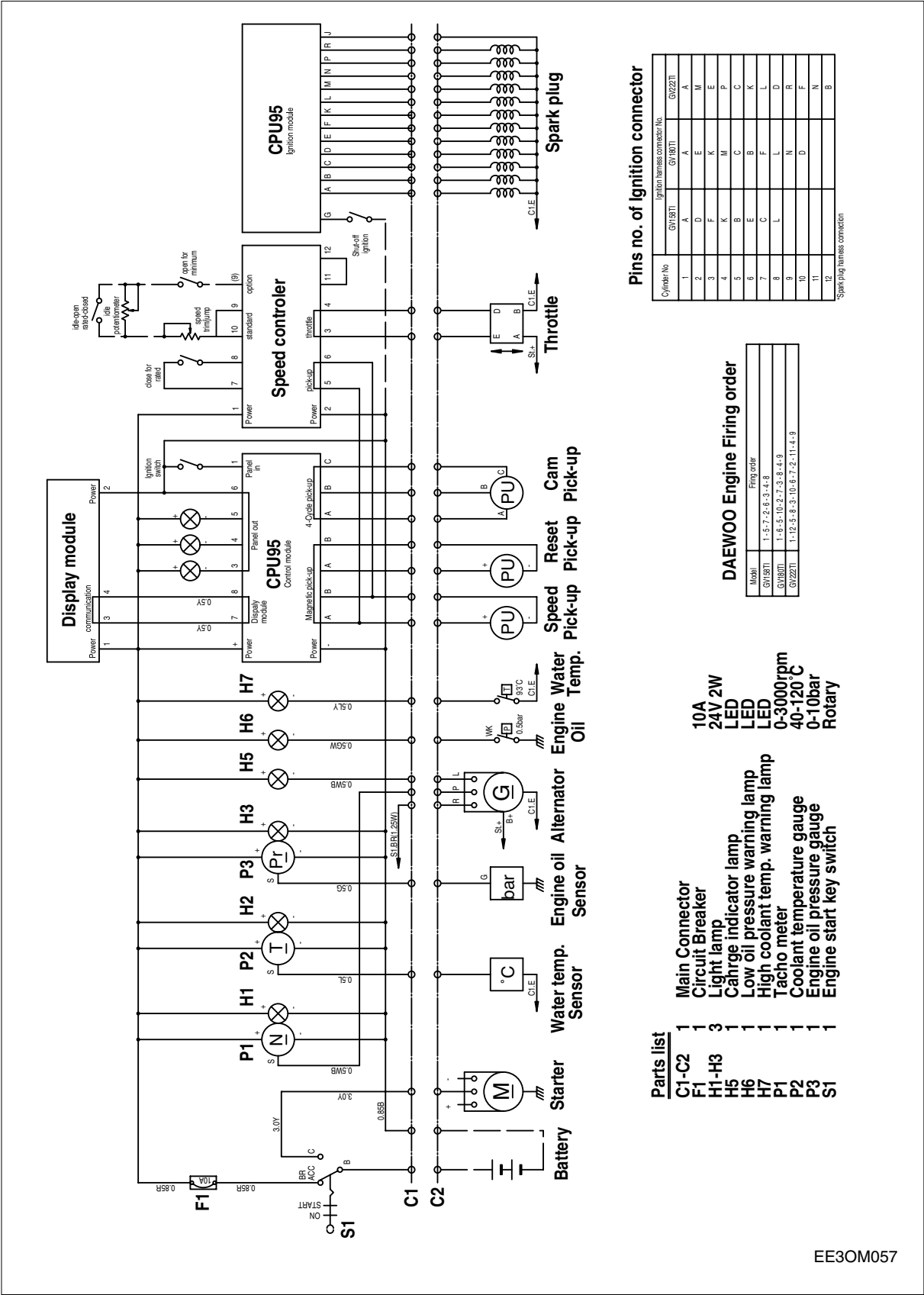
Generated Problem	Inspection Items	Inspecting Position
Starting failure, starting motor not rotate	◆ Confirm connector that connects electric wiring to gauge panel if it is correctly connected ◆ Confirm connection of electric wiring and batteries if it is connected correctly. ◆ Confirm connection of electric wiring and starting motor if it is connected correctly.	backward of gauge panel Battery terminal Starting motor terminal
Starting motor rotates but starting fail	◆ Make sure that fuel quantity is sufficient.	Fuel tank
Engine revolution meter not operates	◆ Confirm connector that connects wiring and gauge panel if it is correctly connected. ◆ Check if terminal resistance of tacho sensor is pulled out	Backward of gauge panel Tacho sensor terminal
Cooling water temp. gauge fails	◆ Confirm connector that connects wiring and gauge panel if it is correctly connected. ◆ Confirm connector of cooling temp sensor if it is correctly connected.	backward of gauge panel Cooling water pipe
Engine oil pressure gauge not operate	◆ Confirm connector that is connected to engine oil pressure sensing sensor if it is pulled out.	Side of oil filter
Charging abnormality warning lamp lights continuously	◆ Confirm that the electric wiring terminal that is connected to generator's L terminal if it is pulled out and touched to engine body.	Alternator terminal
Though engine stopped, engine revolution meter works continuously	◆ Characteristics of engine revolution meter is so designed that it may slowly drop down, and so it's not trouble.	Starting key
Cooling water temp. gauge and engine revolution meter not operate simultaneously.	◆ Confirm if the present position of start switch is at ACC. ◆ For power source of gauge panel goes from starting key, if the start key is at OFF, though engine is running, gauge panel does not move. ◆ Confirm connector that connects wiring and gauge panel if it is correctly connected. ◆ Confirm if connector that connected to solenoid and wiring is pulled out.	backward of gauge panel
Though engine switch is pushed, it does not stall.	◆ Confirm if the cable that connects electric governor and injection pump is cut.	Electric governor

4. ELECTRICAL EQUIPMENT

4.1. Gas fuel circuit



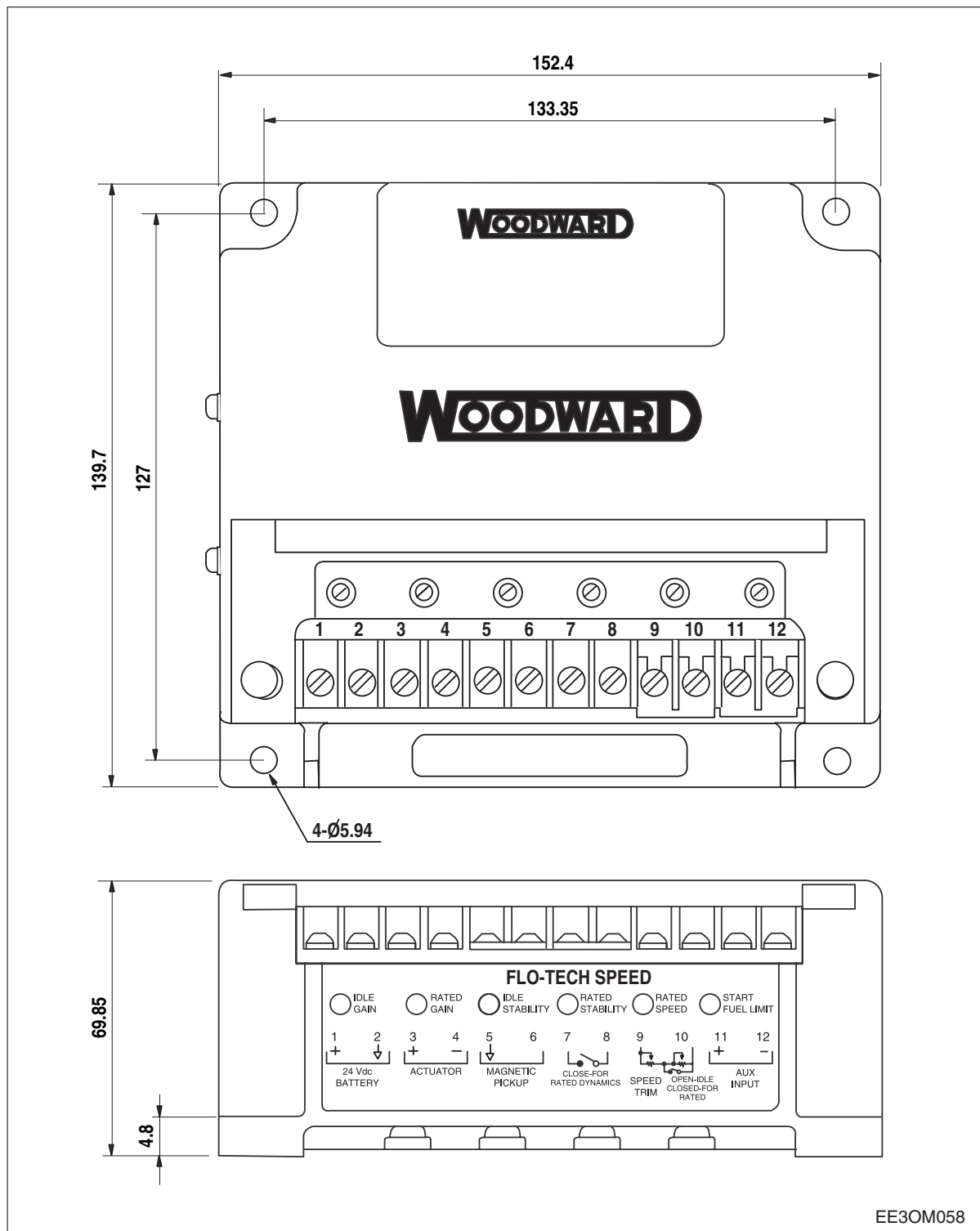
4.2. Electrical wiring diagram



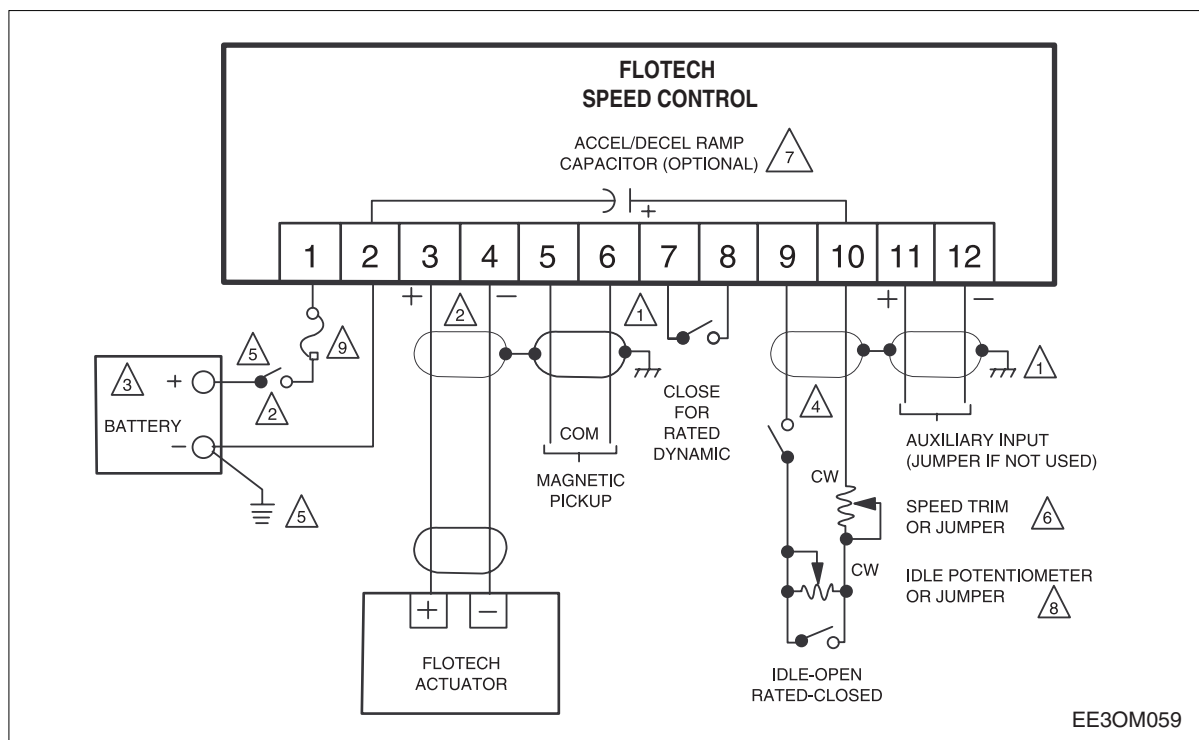
4.3. Speed controller

4.3.1. Speed controller description

- The Speed Controller is designed to provide basic isochronous speed control for gas engines.
- Engines with mechanical loads and generator loads are handled equally well.



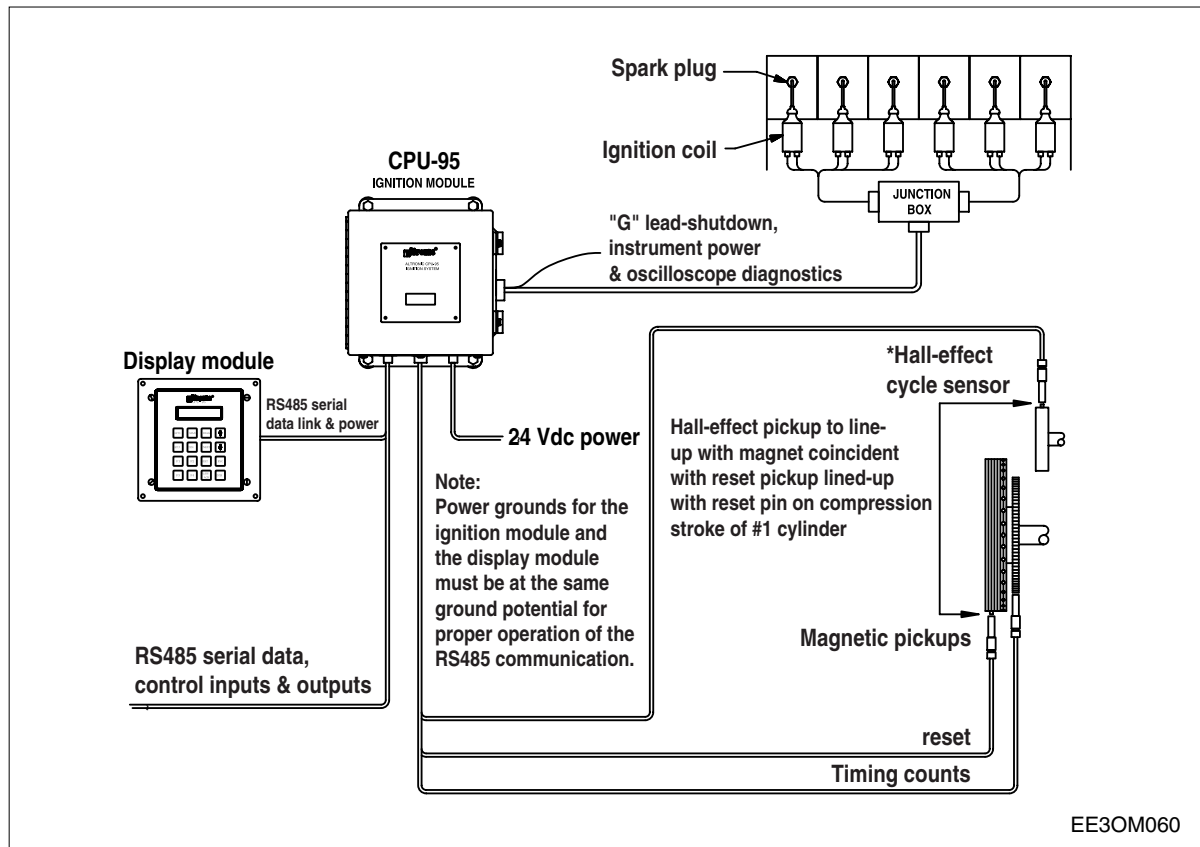
4.3.2. Speed controller circuit



- 1 : Shield wires to be twisted pairs with shield grounded at one end only.
- 2 : No. 18AWG or 20AWG standard wire. Must be as short as possible. 50ft. maximum wire length for 20AWG wire. 80ft. maximum wire length for 18AWG wire.
- 3 : Use 24 volt system.
- 4 : Open for minimum fuel.
- 5 : For positive ground systems, switch and fuse to be located in series with battery (-) and terminal 2. Positive terminal becomes chassis ground. Leads from battery to terminals 1 & 2 must be direct and not pass through distribution points.
- 6 : Approximate speed change with trim potentiometer
 - ◆ $\pm 2.5\%$ using a $1K\Omega$ potentiometer
 - ◆ $\pm 5\%$ using a $2K\Omega$ potentiometer
- 7 : About one second ramp time per $50\mu F$. Capacitor specifications : $200\mu F$ maximum, 15WVdc minimum. 15WVdc maximum. Less than $30\mu A$ DC leakage current over temperature range.
- 8 : Idle range about 25% to 100% rated using 50K potentiometer.
- 9 : Use a 1 amp fuse(3 AWG)

4.4. Ignition controller

4.4.1. Ignition controller circuit



a) Display module

- Displays operating mode, rpm, timing, status
- Displays diagnostic fault messages
- 24Vdc nominal input power
- Digital input(MISC)
- 4-20mA input for timing control
- Digital output, alarm or overspeed via RS485

b) RS485 serial data, control inputs and outputs

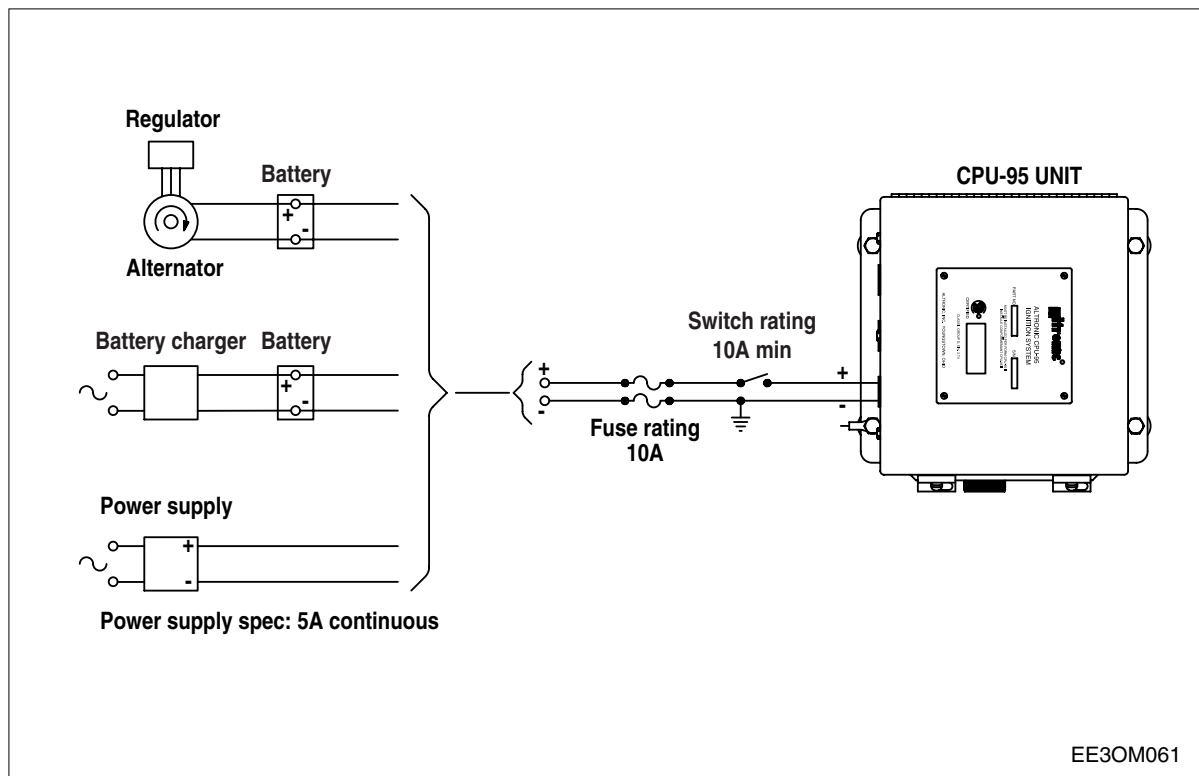
- RS485 serial communications from P.C.
- Low voltage shutdown input
- Miscellaneous input
- Alarm output switch
- Fault output switch
- Fire confirm output switch



NOTE:

RS485 serial communications & MISC. input to either display module or P.C., not both at same time.

4.4.2. DC power hookup of ignition system



- **Operating voltage requirements**

Starting	20 VDC min.
Running	24 ~ 28 VDC

- **Dimensions of cable**

* It is recommended that each system be connected separately back to the power source.
Determine the wire size required.

Distance in Cm	Minimum wire size	Distance in Cm	Minimum wire size
up to 762	16 AWG	2,012 - 3,048	10 AWG
793 - 1,219	14 AWG	3,079 - 4,877	8 AWG
1,250 - 1,981	12 AWG		

- **Dimensions of cable**

* If multiple units are powered from a source located in a separate building, Determine the wire size required between the power source and the engine room. Create a common power hookup point in the engine room, Then use determine the wire size required from this common point to each ignition module.

Distance in Cm	Minimum wire size	Distance in Cm	Minimum wire size
790 - 1,220	14 AWG	3,080 - 4,880	8 AWG
1,250 - 1,980	12 AWG	4,910 - 7,620	6 AWG
2,010 - 3,050	10 AWG	7,650 - 12,190	4 AWG

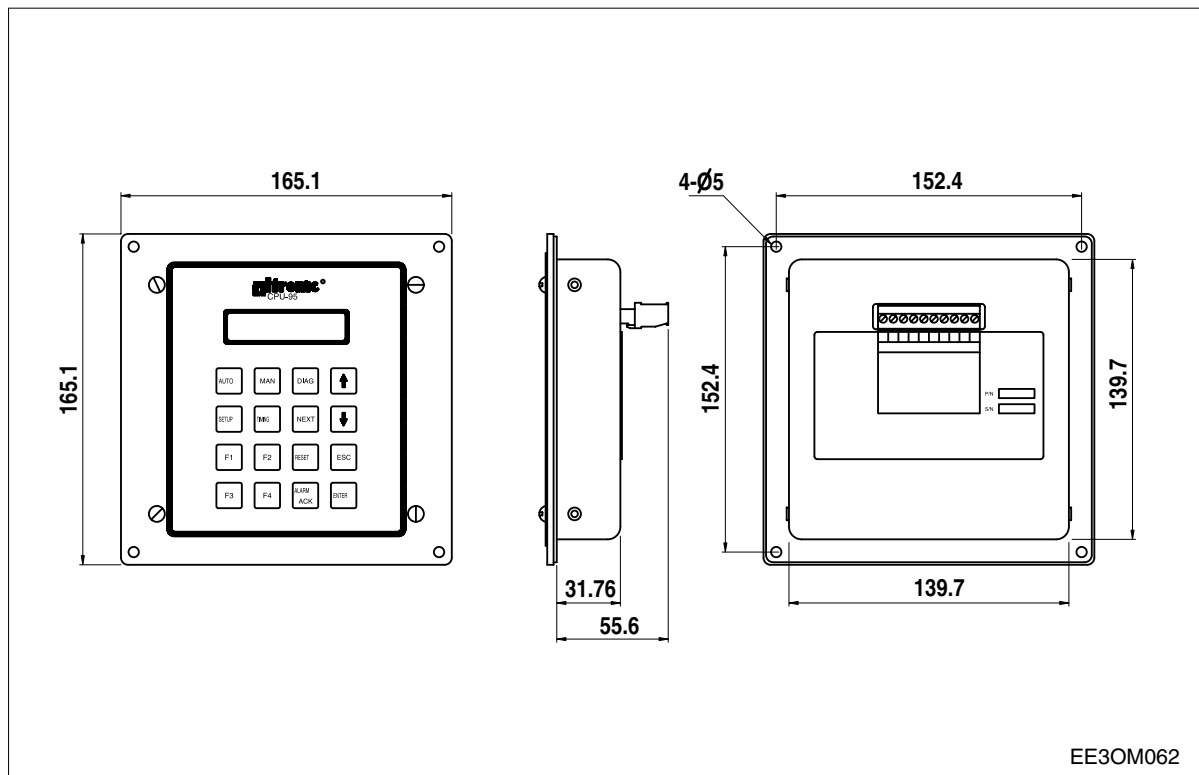


NOTE:

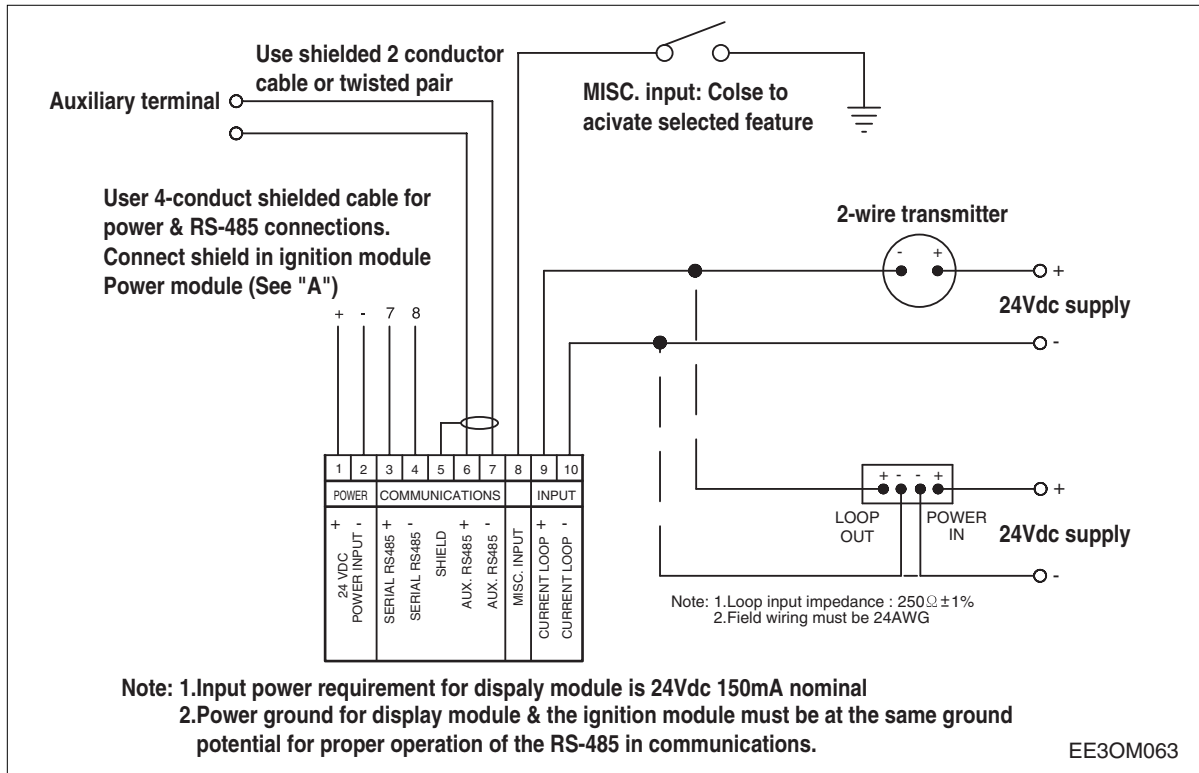
above 12,190Cm use multiple pairs of wires from the power source to the engine room

4.4.3. Display module

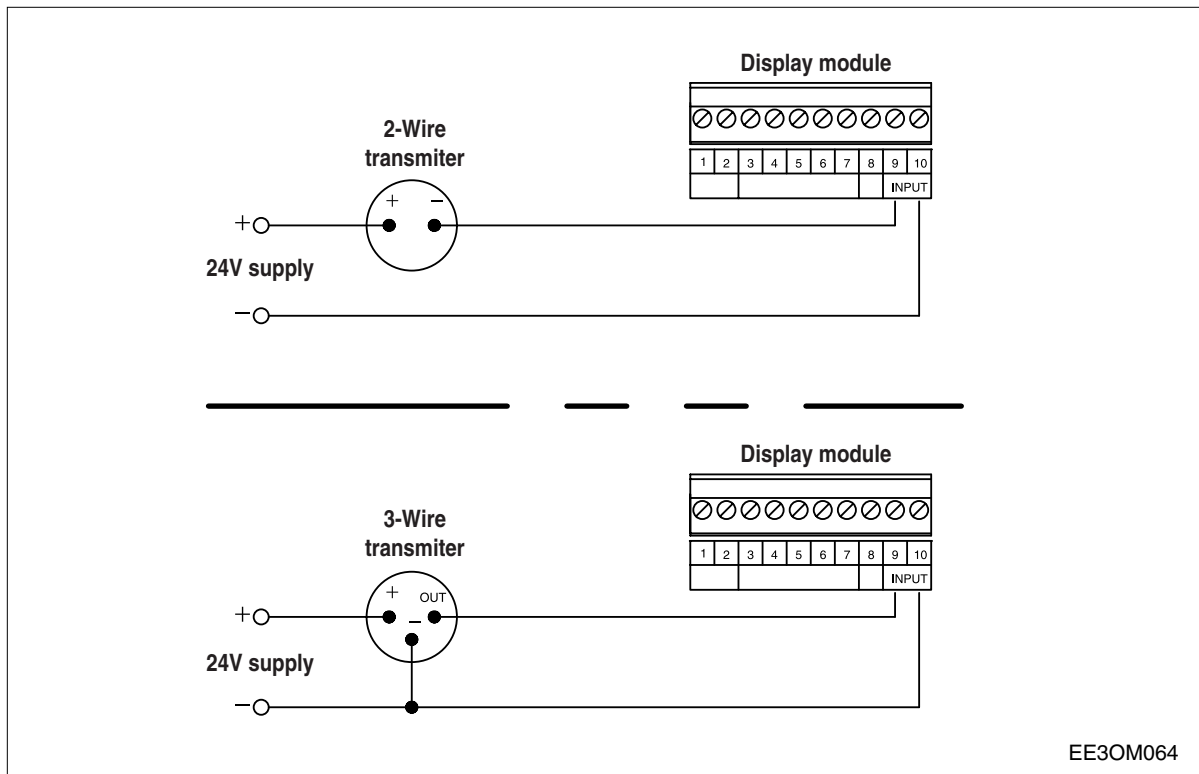
1) Feature of display module



2) Display module circuit



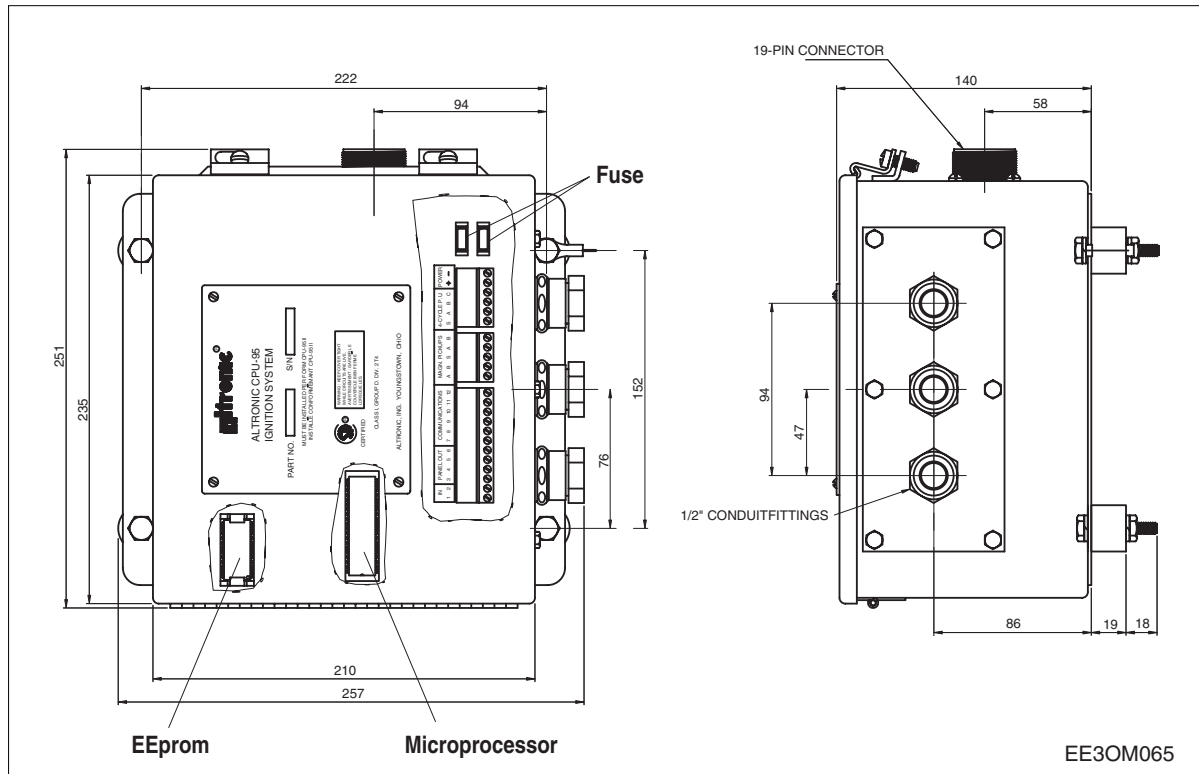
3) Voltage supply of display module



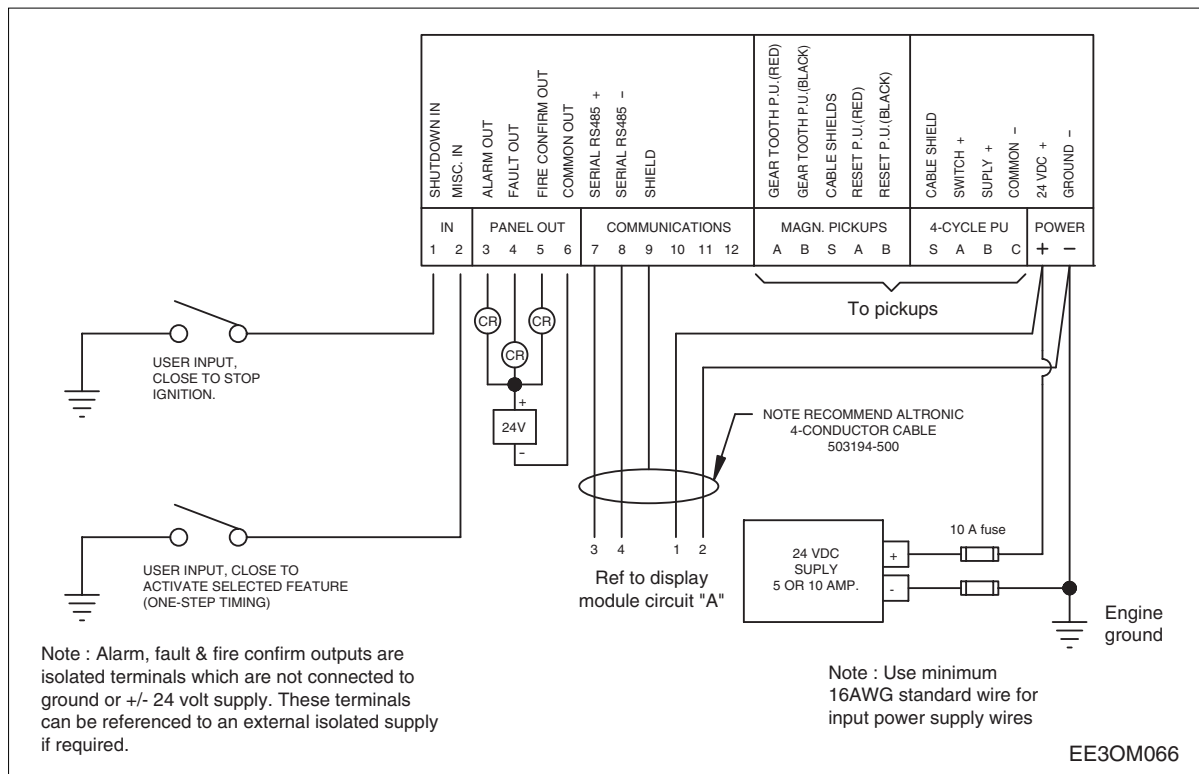
Note : 1. Loop input impedance : $250\Omega \pm 1\%$
2. Field wiring must be 24AWG

4.5. Ignition control module

4.5.1. Ignition control module views

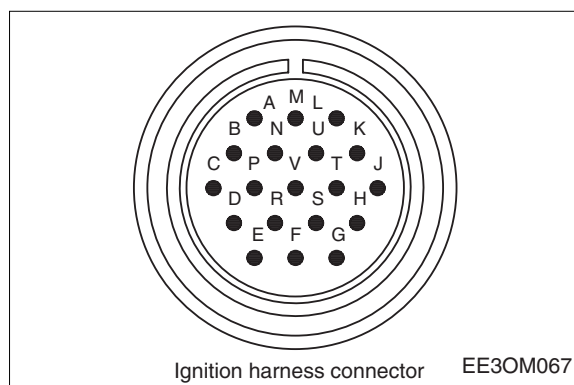


4.5.2. Ignition control circuit



4.5.3. Ignition harness connector

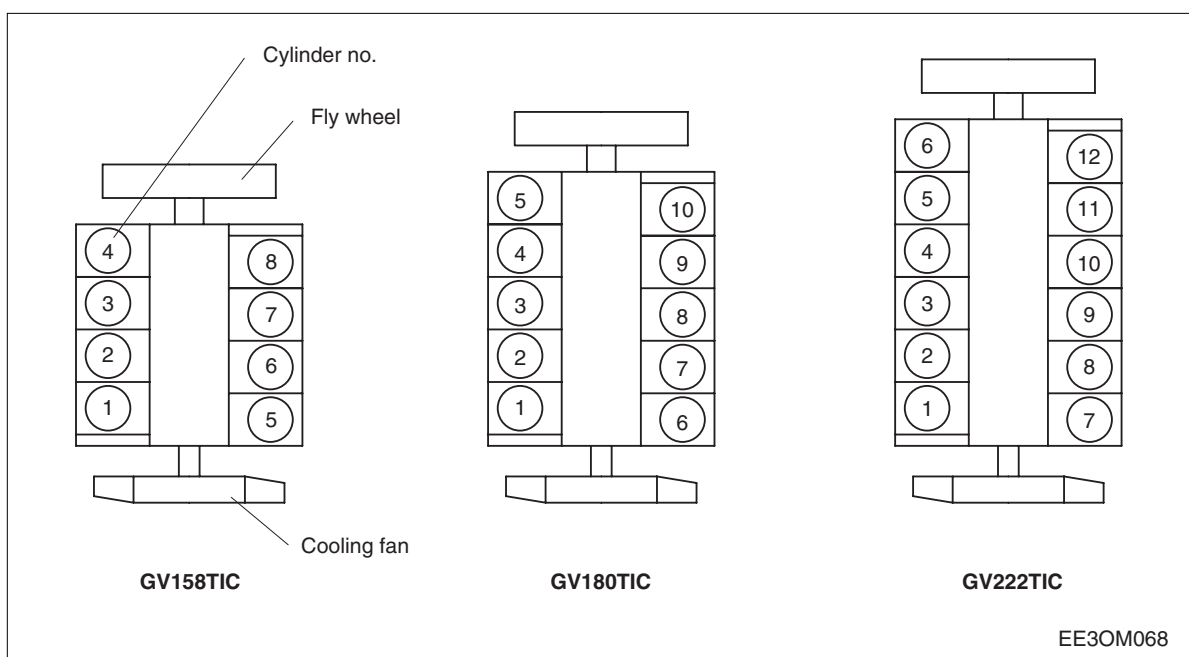
Cylinder no.	Connector pin no. of ignition harness		
	GV158TIC	GV180TIC	GV222TIC
1	A	A	A
2	D	E	M
3	F	K	E
4	K	M	P
5	B	C	C
6	E	B	K
7	C	F	L
8	L	L	D
9	-	N	R
10	-	D	F
11	-	-	N
12	-	-	B
GND	G	G	G
Off to GND	J	J	J



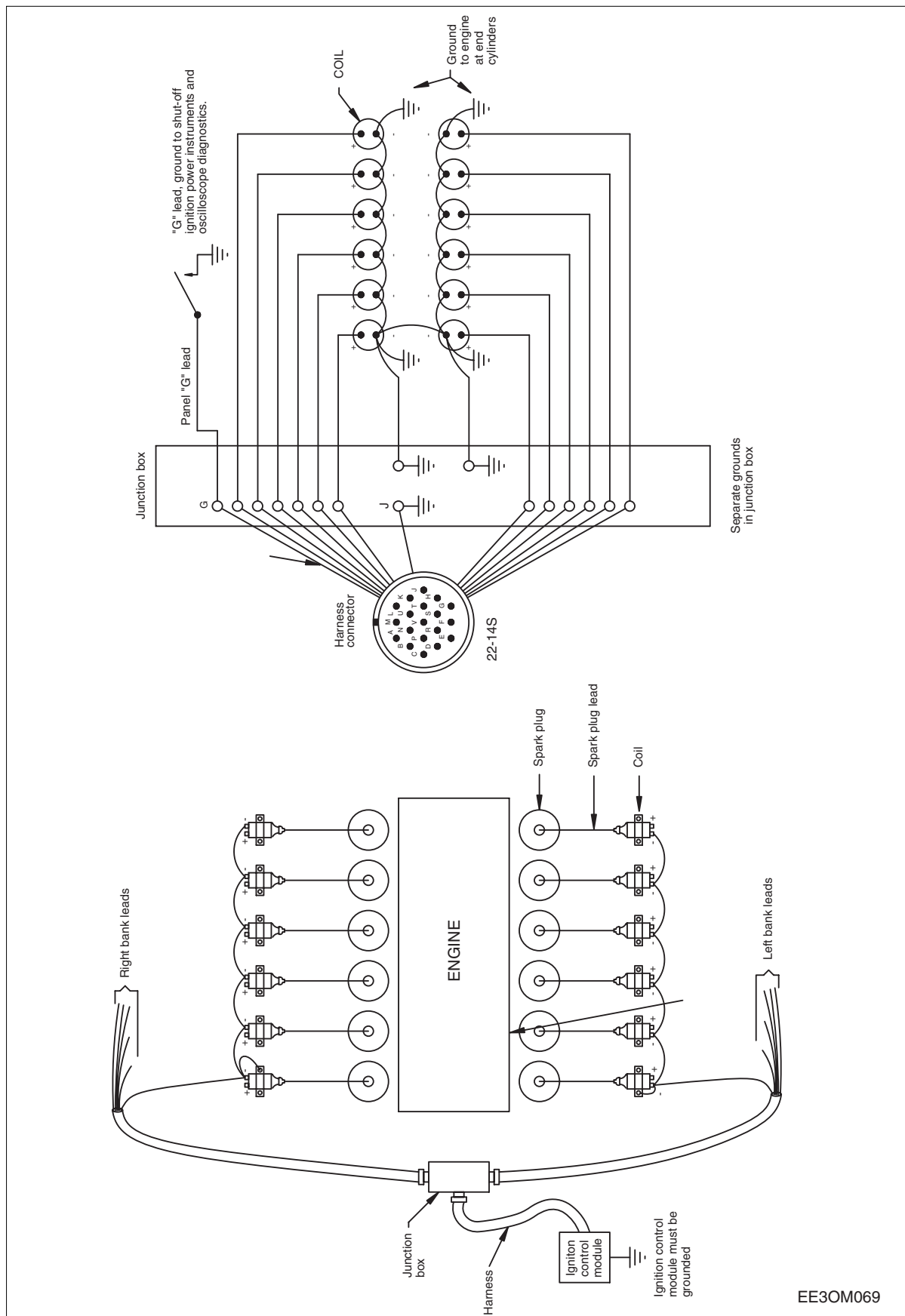
4.5.4. Ignition harness connector

Engine model	Firing order
GV158TIC	1-5-7-2-6-3-4-8
GV180TIC	1-6-5-10-2-7-3-8-4-9
GV222TIC	1-12-5-8-3-10-6-7-2-11-4-9

4.5.5. Engine cylinder no.



4.5.6. Ignition system



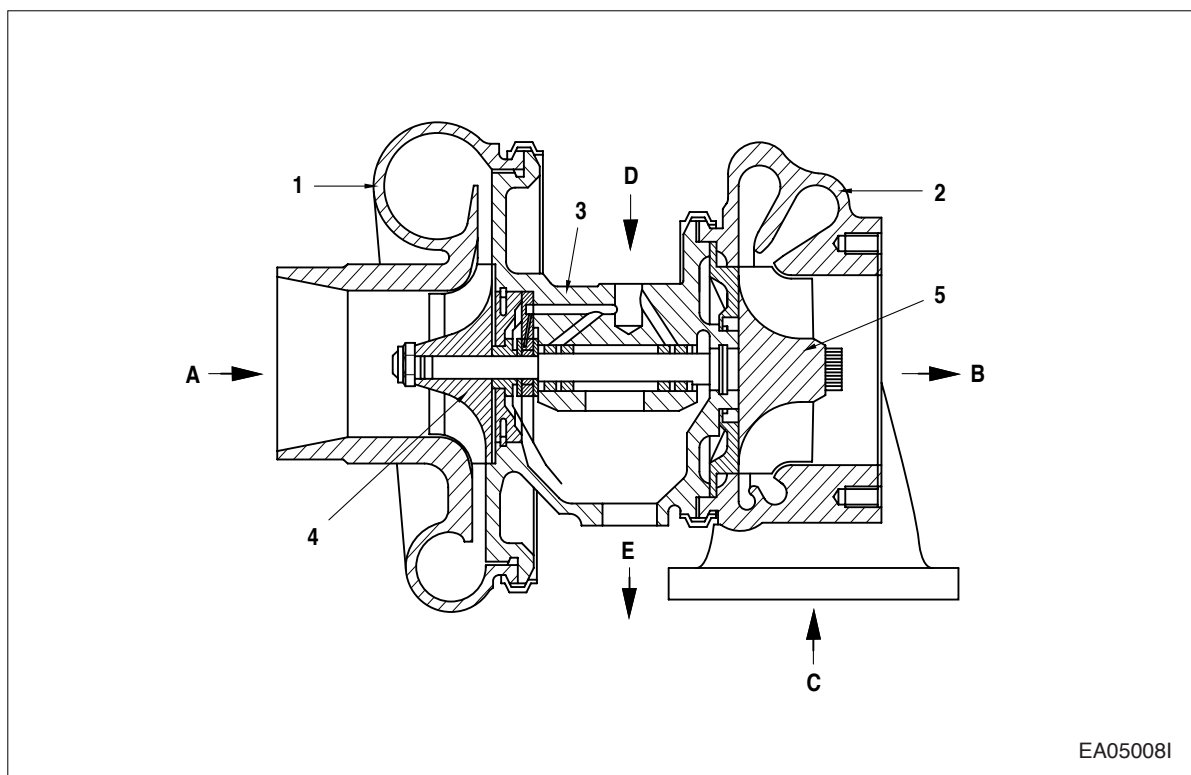
5. MAINTENANCE OF MAJOR PARTS

5.1. Turbo charger

5.1.1. Main data and specification

Generator engine	GV158TI	GV180TI	GV222TI
Turbocharger model	HOLSET HX35	HOLSET HX40	HOLSET HX50
Rated revolution(rpm)	80,000	80,000	60,000
Intake air quality(m ³ /sec)	0.28	0.35	0.43
Compression efficiency(%)	77	75.0	76
Compression ratio	1.8	2.0	1.66
Weight	14 kg	14 kg	14 kg

5.1.2. Operating principle



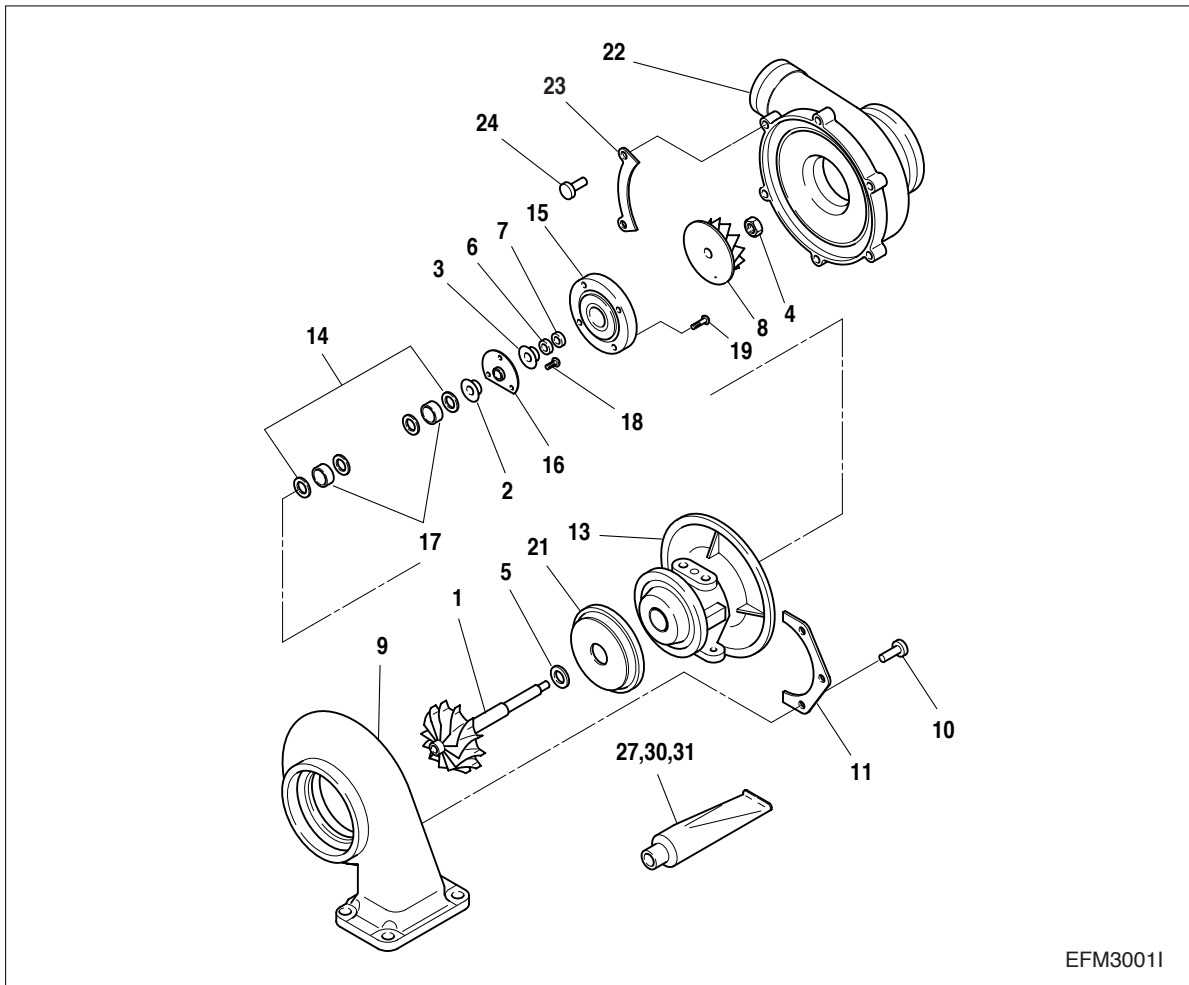
1. Impeller casing
2. Turbine housing
3. Bearing casing
4. Impeller
5. Turbine

- A. Air inlet
- B. Gas outlet
- C. Gas inlet
- D. Oil supply
- E. Oil return

5.1.3. Construction



Make sure that servicing should be performed at the professional maintenance shop as authorized by HOLSET or DAEWOO Company.

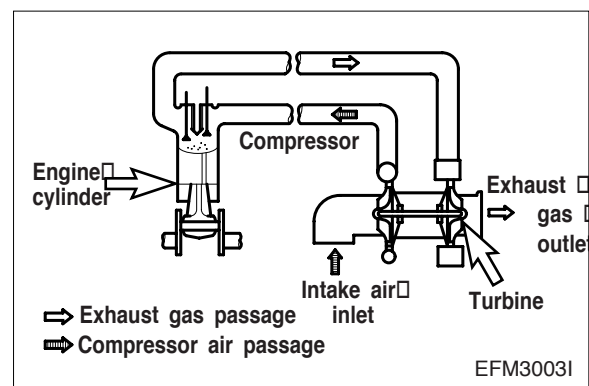
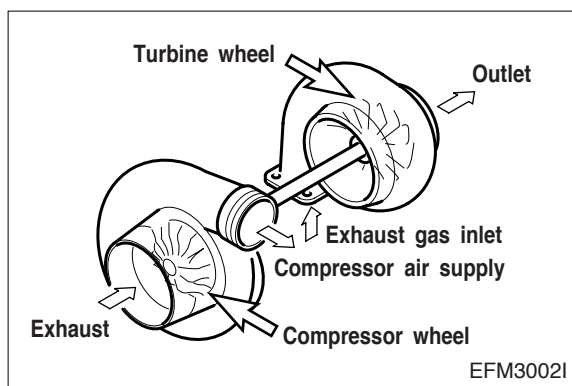


EFM30011

1. Turbine shaft	15. Seal plate
2. Thrust bush	16. Thrust bearing
3. Oil shut off	17. Journal bearing
4. Fixing nut	18. Screw
5. Seal ring	19. Screw
6. Seal ring	21. Heat dissipater
7. Seal ring	22. Compressor housing
8. Compressor wing wheel	23. Clamp
9. Turbine housing	24. Bolt
10. Bolt	27. Liquid gasket
11. Clamp	30. Loctite
13. Bearing housing	31. Liquid anti-burn agents
14. Retainer ring	

5.1.4. General information

- The engine output depends upon the supplied fuel quantity and the engine efficiency. In order to transform into the effective work of engine by burning the supplied fuel fully, the sufficient air to burn the fuel should be supplied to the cylinder.
- Therefore, the engine output is essentially determined by the size of the cylinder, and for if the air is supplied to the given volume of cylinder with the air being compressed, the air quantity in the cylinder will increase as much to result in that it may burn more fuel. the output will also be able to increase.
- Supplying the air by compressing like this into the engine cylinder is called as supercharging, and super charging by means of exhaust gas energy that discharges to the atmosphere is called as the turbocharging.



5.1.5. Function

1) Turbine

- The exhaust gas that is discharged from combustion chamber passes through turbine housing conveying an energy to turbine wings to give the rotating power, This is called as the turbine and in order not to influence a bad effect at bearing part, there are the seal ring and heat dissipater.

2) Compressor

- It is connected to the same shaft with the turbine to make a revolving assembly, and receive the revolving force of turbine, and sends air to the suction manifold by suctioning and compressing it. This is called as the compressor.

3) Bearing

- Thrust bearing force is applied to the turbine wheel and an arrangement is made for the shaft not to shift.
- Journal bearing (floating bearing) is adopted and it forms the double oil films at the inner and outer surfaces in comparison to the general stationary type so that the bearing may be able to rotate independently and consequently the double layers of films act as the damper to make the slipping speed on the bearing surface less than the rotating speed of shaft so that the dynamic stability may be obtained.

4) Sealing at compressor shaft

- In order for the compressed intake air and lubricating oil not to leak, a seal plate and a seal ring are made to the double structures.

5.1.6. How to handle the engine

1) Precautions for operation of the engine

Operation following items must be observed at the starting, operation and stop of engine.

Operation	Caution	Reason
At starting	1) Inspect oil quantity 2) After confirming that oil pressure rises by starting engine with starter (until the pointer of oil pressure gauge moves or pressure indicating lamp operates), the starting must be done. 3) In case that oil, oil filter and lubricating system's part are replaced or engine was stalled for long time (more than a week), and in case of operation under cold weather, loosen the oil pipe connecting parts of turbocharger inlet, and operate the starting motor until oil comes out the connecting parts. Care must be paid that after the confirming above, retighten the pipe connecting parts without fail, and proceed with the normal starting.	2) If engine is started quickly, of course beginning with every parts of engine, for it revolves without oil that is to reach to the turbocharger, the bearing's abnormal wear or stuck may be caused. 3) In case that engine stalled for long time and of cold weather, the fluidity of oil may be get worse.
Immediately After starting	1) Perform idling operation for about 5 min. immediately after engine starting. 2) Various inspections must insure that there are no leakage of oil, gas and air.	1) Sudden load at time soon after engine starting and at the state when turbocharger did not yet reach to smooth revolution, if abrupt load is applied to engine, some parts where oil did still not reach may cause a burn to be stuck. 2) If there are the leakage of oil, gas, air, particularly oil, for the oil pressure lowers, it causes a burn of bearing to be stuck.
During operation	Following items must be confirmed. 1) Oil pressure at idling : 0.9 ~ 3.0 bar at full load : 3.0 ~ 6.5 bar	1) If the pressure is too low, abnormal wear or stuck may be caused. Or if too high, the oil leak may be generated.

Operation	Caution	Reason
During operation	2) When abnormal noises and vibration are generated, slow down the revolution and must stop it to investigate the causes.	2) If the engine operation were continued with abnormal noises and vibration, it causes the engine trouble that can not be repaired or some other troubles.
At stop	1) At stopping the engine, perform the idling operation for 5min. and then stop it.	1) After heavy load operation, if the engine were stopped suddenly, the heat would be conducted to bearing parts from red hot turbine wings that would result in burning the oil to cause the stuck bearing metal and revolving shaft.

5.1.7. Routine inspection and maintenance

- Since the state of turbocharger depends largely on the state of engine maintenance, to perform the specified keep up thoroughly is needed.

1) Air intake system

- System in the intake air system, care must be taken to the air cleaner. In case of oil passing type air cleaner, if the oil level is lower than the specified value, the cleaning efficiency get worse, if higher, the sucked oil pollutes a case.
- Particularly, for if the rotor were polluted, the balance adjusted precisely would be deviated to cause a vibration that may cause the stuck or abnormal wear by loading large force to the bearing, the perfect air cleaner must always be used.
- In case of dry type filter, according to the indication of a dust indicator, cleaning must be done to make the intake air resistance as small as possible.

2) Exhaust system

- In exhaust system, a care must be taken to the gas leak and the stuck prevention. If exhaust gas leaks from the exhaust pipe and turbocharger etc., for the super charging effect will be lowered, the installed states of various parts must be paid with careful attention.
- Since the parts that reach to high temperature during operation such as the turbine room use the anti-heat nuts, a care must be paid not to mix with the general nuts and at the same time, bolt stuck preventing paint should be coated on the nut for the designated places.

3) Lubricating system

- In the lubricating system, a care must be paid to the oil quality and oil element replacement cycle.
- For the oil deterioration of turbocharger equipped engine, needless to speak of engine assembly itself, influences badly to the turbocharger too, the specified engine oil should used.

5.1.8. Periodical servicing

The turbocharger assembly must be inspected periodically.

1) Rotating condition of the rotor and checking tips

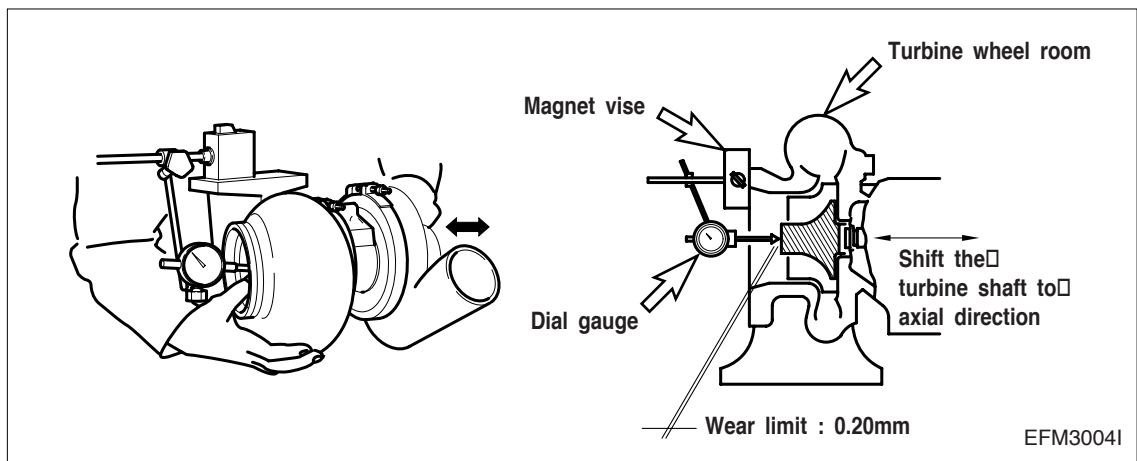
- Inspection on the revolving state of rotor is performed according to abnormal noises.
- In case of using an acoustic bar, touch the turbocharger housing with a tip of bar and raise the engine revolution slowly. Then, in case that high sound is heard by every 2 ~ 3 sec. continuously, for there should be the possibility to be abnormal metal and rotor, replace or repair the turbocharger.

2) Measuring rotor clearance

- Disassemble the turbocharger from the engine and should inspect the end plays in axial and circumference direction.
- In case of disassembling the turbocharger, the oil inlet and outlet should necessarily be sealed with a tape.

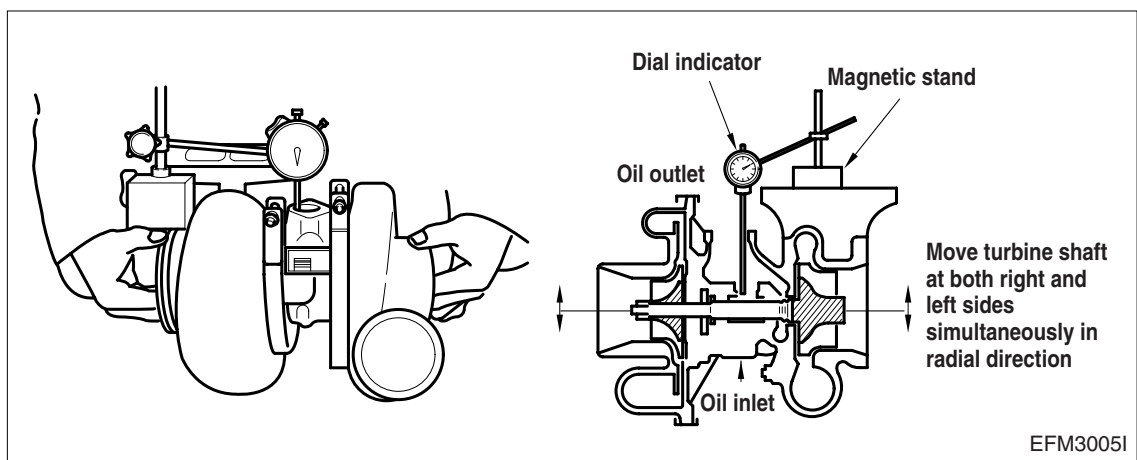
a) Rotor axial direction end play

- Wear limit : 0.20mm



b) Rotor's circumference direction end play.

- Wear limit : 0.65mm



- c) In case that the end plays to axial and circumference directions, replace or repair the turbocharger.

3) Overhaul and cleaning points

- Be sure to dismantle the turbocharger from the engine before cleaning.
- Also, make sure to seal the oil inlet and outlet with tape or similar.

4) Precautions for turbocharger reassembly

- When in assembling the turbocharger or the handling after assembling should work observing the following precautions necessarily.
- Particularly, precise care should be taken for foreign material not to get into the turbocharger.

a) Lubricating system



- Prior to assembling it into the engine, fill new oil into oil Inlet and turning turbine shaft with hand, lubricate journal and thrust bearing.
- Clean the pipe and oil outlet pipe between engine and oil inlet, and confirm if there is
- In order for oil not to leak from various connections, assemble securely.

b) Air intake system



- Confirm if there is any foreign material inside the air intake system.
- Assemble securely the air intake duct and air cleaner so that the connections from them may not leak an air.

c) Exhaust system

- Confirm if there is any foreign material in the exhaust system.
- Bolts and nuts must be made of anti-heat steel and in assembling, care should be taken not use the general nuts and coat the bolts and nuts with the anti-stuck agents at the same time.
- Assemble securely for gas not to leak from various connecting parts of exhaust pipes.

5.1.9. Trouble cause diagnosis and remedy

Condition	Causes	Remedies
1. Exhaust gas excessive	1) Air cleaner elements clogged 2) Air Inlet port clogged 3) Air leaks from air intake system 4) Turbocharger impossible to rotate due to stuck 5) Turbine wing's contact 6) Piping deformation or clogging of exhaust system	Replace or clean Inspect or repair Inspect or repair Overhaul and repair or replace Overhaul and repair or replace Inspect and repair
2. White smoke excessive	1) Oil leaks into turbine and compressor. 2) Seal ring's abnormal wear or damage	Overhaul and repair or replace Overhaul and repair or replace
3. Output lowered	1) Gas leak from various parts of exhaust system 2) Air cleaner's elements clogged 3) Turbocharger's pollution or damage 4) Air leaks from discharge part of compressor side	Inspect and repair Replace or clean Overhaul and repair or replace Inspect and repair
4. Abnormal noises or vibrations	1) Revolving parts' contact 2) Revolving imbalance of rotor 3) Stuck 4) Various connections loose	Overhaul and repair or replace Overhaul and repair or replace Overhaul and repair or replace Inspect and repair

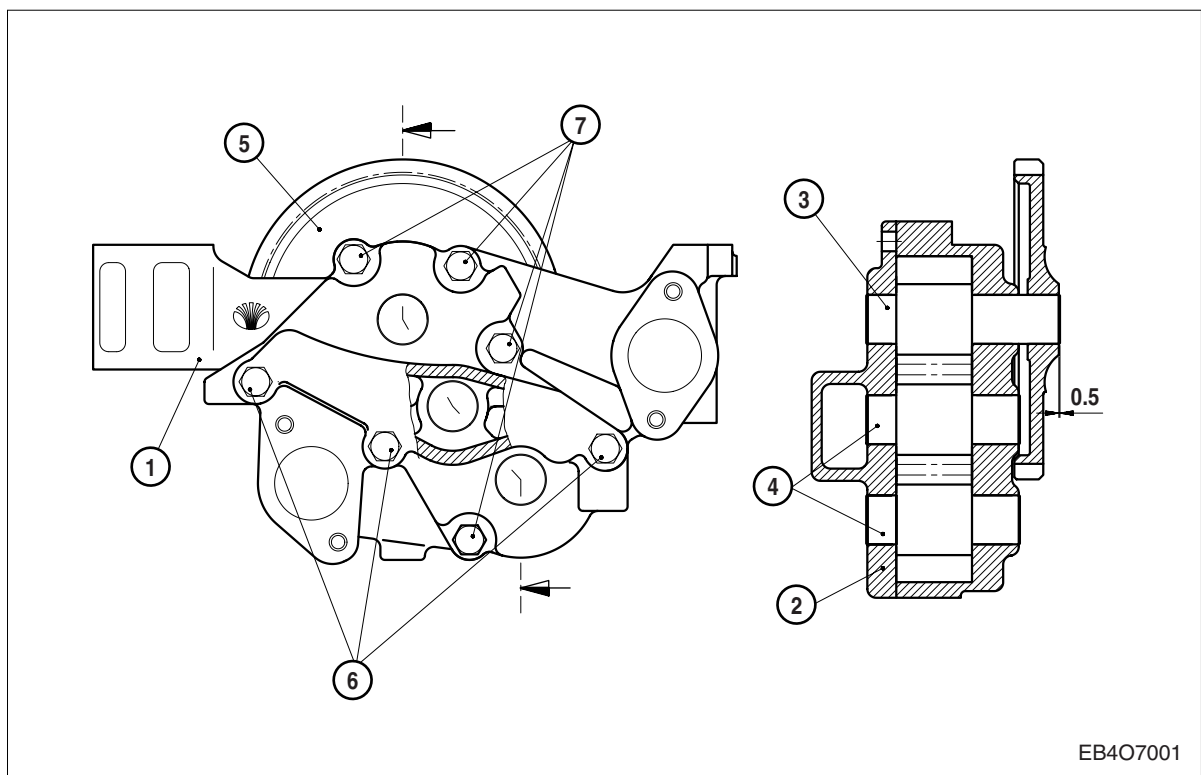
5.2. Lubricating System

- Lubricating oil pumped by the gear oil pump in the oil pan is filtrated in the oil filter. This filtrated oil passed on the oil cooler and next the main oil gallery of the cylinder block where is distributed to lubricate the various sliding parts and turbocharger etc also in order to ensure normal engine performance.

5.2.1. Specifications

Item	Specifications	Item	Specifications
Lubricating system	Forced pressure circulation	Oil filter type	Full flow
Oil pump type	Gear type	Filter element type	Cartridge type
Relief valve opening pressure	10 $\pm$ 0.1 kg/cm ²	Bypass valve opening pressure	2.5 $\pm$ 0.5 kg/cm ²
Bypass for oil cooler opening pressure	5 $\pm$ 0.5 kg/cm ²	Bypass for entire oil filter valve opening pressure	4.0~4.8 kg/cm ²
Adjusting valve for spray nozzle opening pressure	1.5~1.8 kg/cm ²		

5.2.2. Oil pump

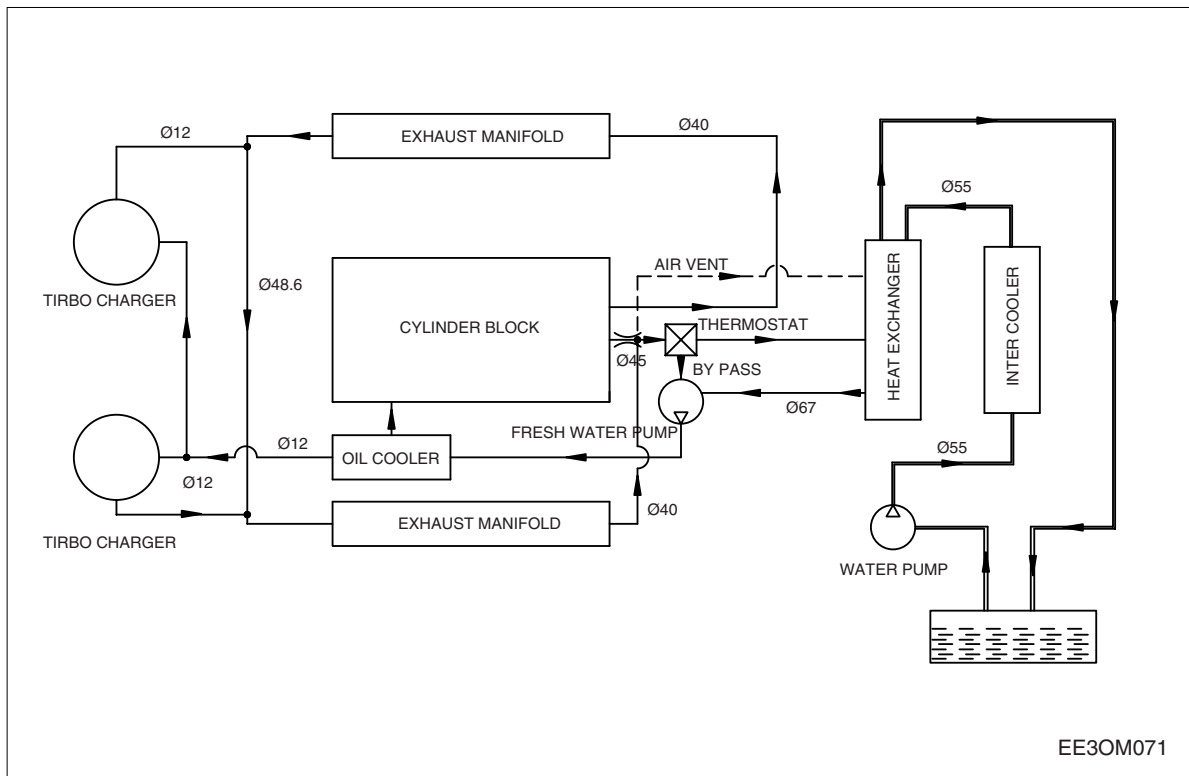


1. Oil pump housing
2. Cover
3. Oil pump gear

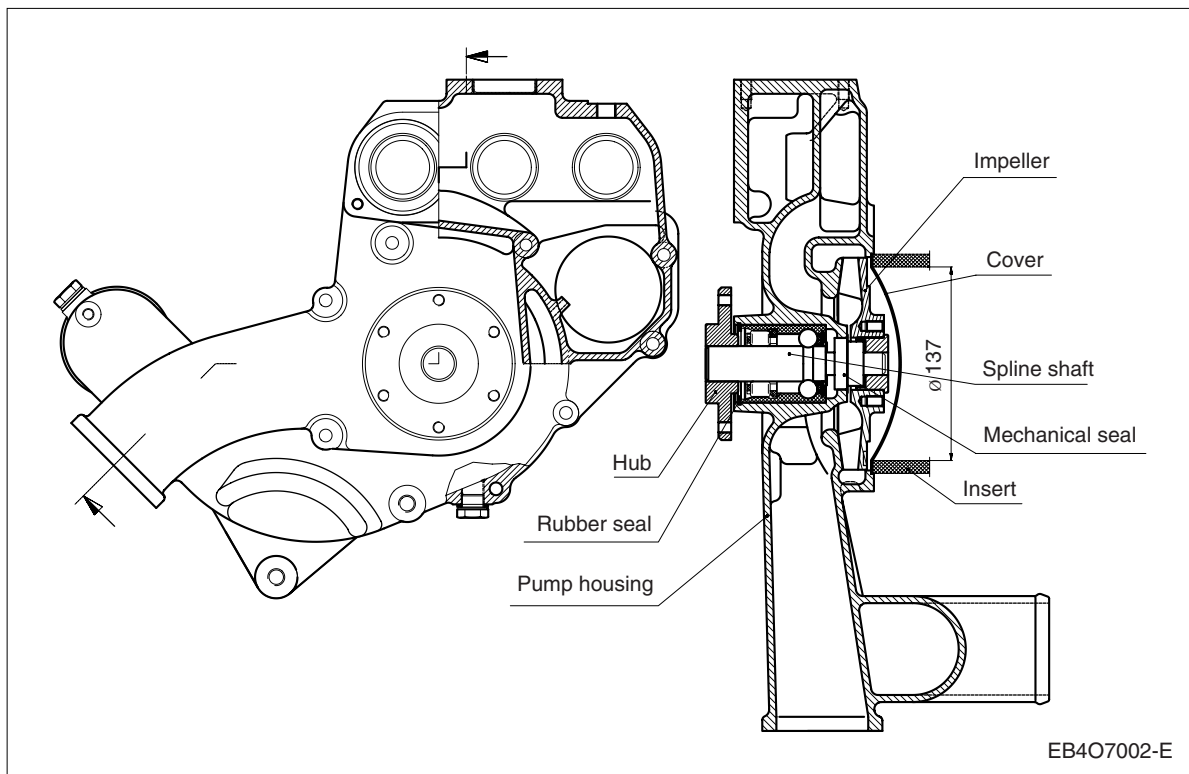
4. Oil pump gear
5. Oil pump drive gear
- 6,7. Hex bolt

5.3. Cooling system

- The engine has a liquid-cooling system. The water pump is a maintenance-free impeller pump driven by v-belts from the crankshaft pulley.



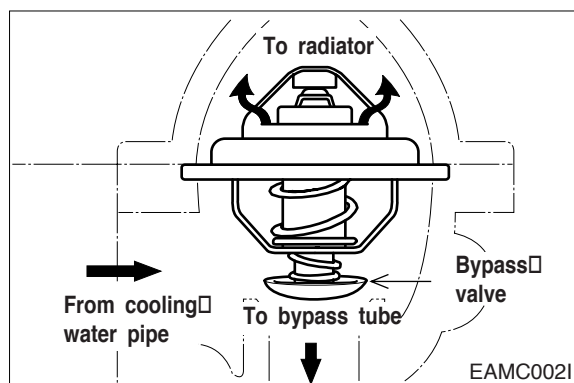
5.3.1. Cooling water pump



5.4. Thermostat

5.4.1. General descriptions and main data

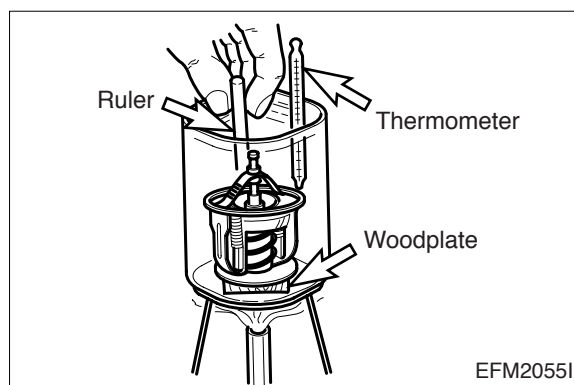
- The thermostat maintains a constant temperature of coolant (90 ~ 95°C) and improves thermal efficiency of the engine by preventing heat loss.
- Namely, when the temperature of coolant is low, the thermostat valve is closed to make the coolant bypass to directly enter the water pump; when the coolant temperature rises to open wide the thermostat valve, the bypass circuit is closed and the water passage to the radiator is opened so that the coolant is forced to flow into the radiator.



Item	Specifications
Type	Wax-pallet type
Open at	71°C
Open wide at	85°C
Valve lift	8 mm or more

5.4.2. Inspecting

- Check the wax pallet and spring for damage.
- Put the thermostat in a container of water, then heat the water slowly and check temperature with a thermometer. If the valve lift is 0.1 mm (starting to open) at temperature of 71°C and 8 mm or more (opening wide) at temperature of 85°C, the thermostat is normal.



5.4.3. Replacing thermostat and precautions for handling

- Precautions for handling

The wax pellet type thermostat does not react as quickly as bellows type one to a variation of temperature of coolant. Such relatively slow reaction is mainly due to the large heat capacity of the wax pellet type thermostat. Therefore, to avoid a sharp rise of coolant temperature, it is essential to idle the engine sufficiently before running it. In cold weather, do not run the engine at overload or overspeed it immediately after starting off.

- When draining out or replenishing coolant, doing it slowly so that air is bleed sufficiently from the entire cooling system.

- Replacing thermostat

If the thermostat is detected defective, replace with a new one.

5.4.4. Diagnostics and troubleshooting

Complaints	Possible causes	Corrections
1. Engine over-heating	• Lack of coolant • Radiator cap pressure valve spring weakened • Fan belt loosened or broken • Fan belt fouled with oil • Thermostat inoperative • Water pump defective • Restrictions in water passages due to deposit of scales • Ignition timing incorrect • Restriction in radiator core • Gases leaking into water jacket due to broken cylinder head gasket	• Replenish coolant • Replace cap • Adjust or replace fan belt • Replace fan belt • Replace thermostat • Repair or replace • Clean radiator and water passages • Adjust ignition timing correctly • Clean exterior of radiator • Replace cylinder head gasket
2. Engine over-cooling	• Thermostat inoperative • Ambient temperature too low	• Replace thermostat • Install radiator curtain
3. Lack of coolant	• Radiator leaky • Radiator hoses loosely connected or damaged • Radiator cap valve spring weakened • Water pump leaky • Cylinder head gasket leaky • Cylinder head or cylinder block cracked	• Correct or replace • Retighten clamps or replace hoses • Replace cap • Repair or replace • Replace cylinder head gasket • Replace cylinder head or block
4. Cooling system noisy	• Water pump bearing defective • Fan out of balance • Fan belt defective	• Replace bearing • Replace fan • Replace fan belt

5.5. V - Belts

- The tension of the belts should be checked after every 2,000 hours of operation.

5.5.1. Change the belts if necessary

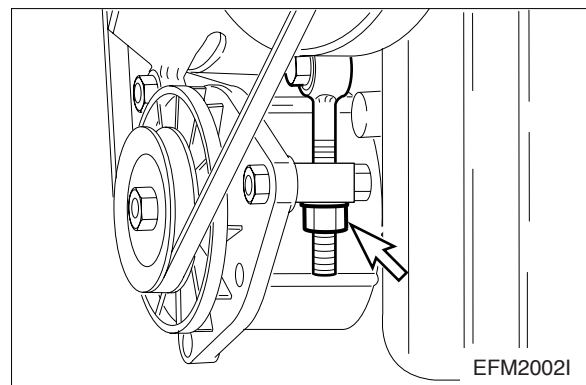
- If in the case of a multiple belt drive, wear or differing tensions are found, always replace the complete set of belts.

5.5.2. Checking condition

- Check belts for cracks, oil, overheating and wear.

5.5.3. Testing by hand

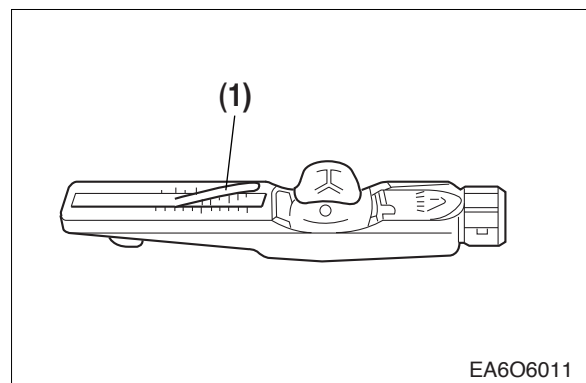
- By the finger-pressure the belt is pressed by 10-15mm between the pulleys in normal condition. (Pressed mid-way between the belt pulleys)
- A more precise check of the V-belt tension is possible only by using a V-belt tension tester.



5.5.4. Measuring tension

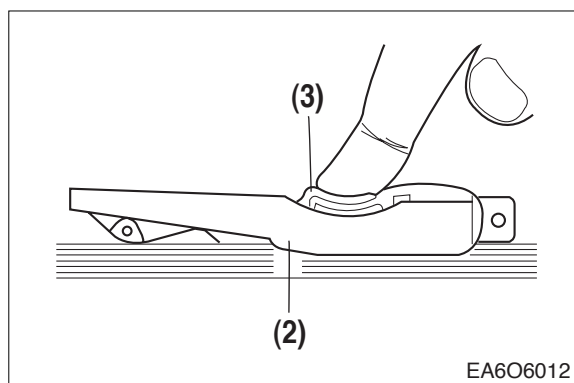
a) Lower indicator arm (1) into the scale.

- Apply tester to belt at a point midway between two pulleys so that edge of contact surface (2) is flush with the V-belt.
- Slowly depress pad (3) until the spring can be heard to disengage. This will cause the indicator to move upwards.
- If pressure is maintained after the spring has disengaged a false reading will be obtained!



b) Reading of tension

- Read of the tensioning force of the belt at the point where the top surface of the indicator arm (1) intersects with the scale.
- Before taking readings make ensure that the indicator arm remains in its position.



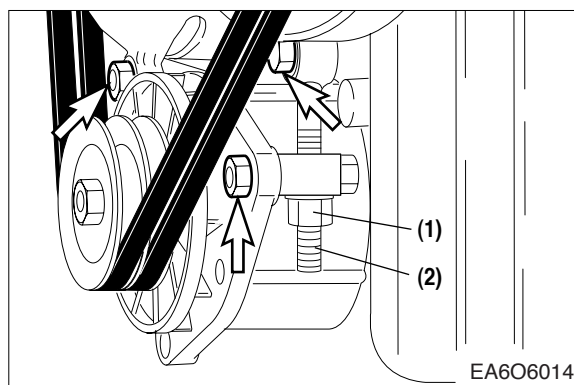
- V-belt tension

Type	Drive belt width	Tensioning forces on the tester		
		new installation		When servicing after long running time
		instrallation	After 10 min. running time	
M	9.5 mm	50 kg	45 kg	40 kg
A *	11.8 mm	55 kg	50 kg	45 kg
B	15.5 mm	75 kg	70 kg	60 kg
C	20.2 mm	75 kg	70 kg	60 kg

* : Adopted in GV158TIC, GV180TIC, GV222TIC engine

5.5.5. Tensioning and changing belts

- Loosen fixing bolts and nuts.
- Adjust the alternator until belts have correct tensions.
- Retighten fixing bolts and nuts.
- To change the belts loosen fixing bolts and nuts. Then push the alternator toward water pump pulley by hand.



5.6. Air Intake System

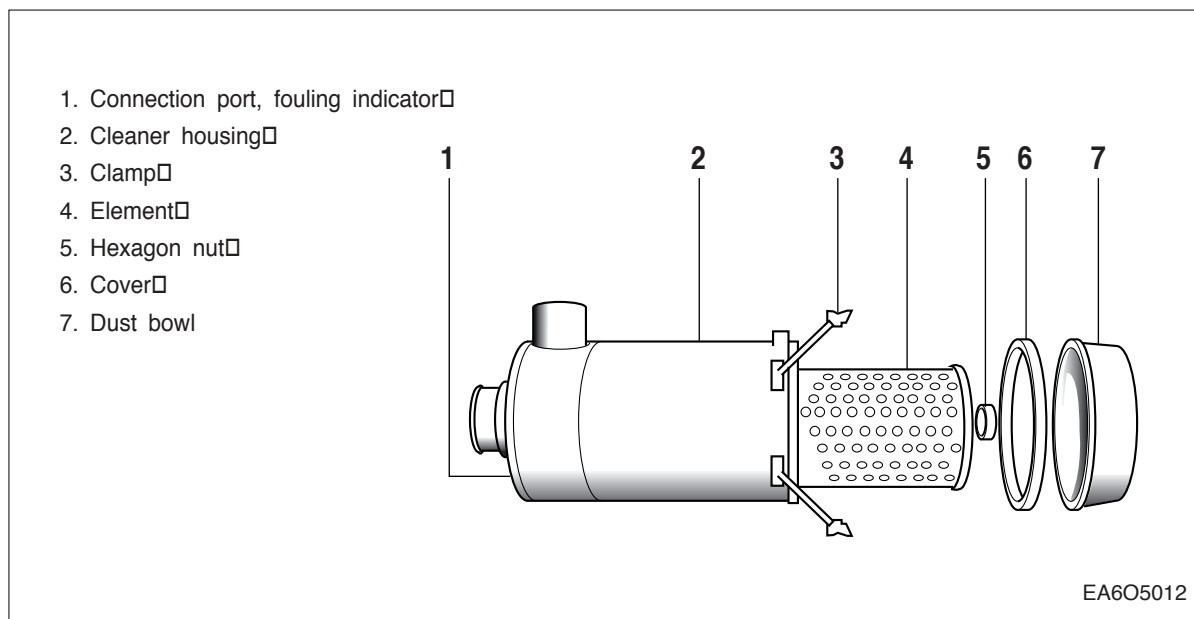
5.6.1. Maintenance

(Only when engine is switched off)

Empty the dust bowl (7) regularly. The bowl should never be filled more than halfway with dust. On slipping off the two clamps (3), the dust bowl can be removed. Take off the cover (6) of the dust bowl and empty.

Be careful to assemble cover and bowl correctly.

There is a recess in the cover rim and a lug on the collector which should register. Where the filter is installed horizontally, watch for "top" mark on cleaner bowl.



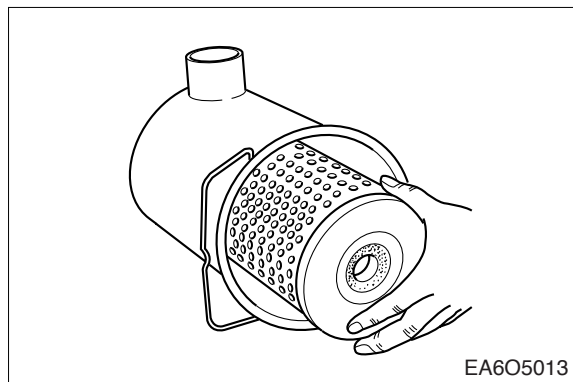
5.6.2. Changing filter element

- On removing the hexagon nut, take out the dirty cartridge and renew or clean.
- Wipe the cleaner housing with a damp cloth, in particular the sealing surface for the element.



NOTE:

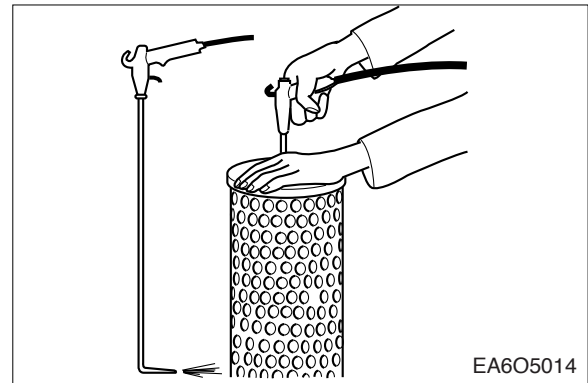
Do not allow dirt to get into the clean air end.



5.6.3. Cleaning filter elements

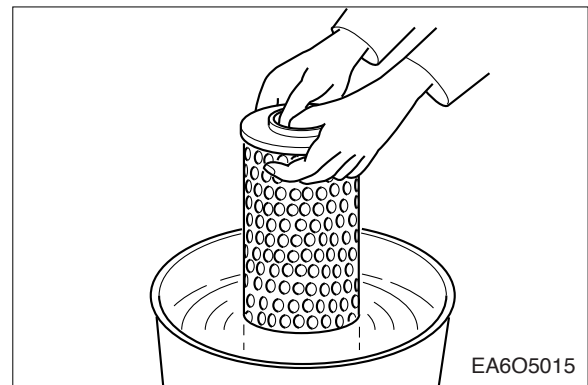
- **By compressed air (wear goggles)**

- For the purpose, the air gun should be fitted with a nozzle extension which is bent 90° at the discharge end and which is long enough to reach down inside to the bottom of the element.
- Moving the air gun up and down, blow out the element from the inside (maximum 500kPa - 5 bar) until no more dust comes out of the filter pleats.



- **By washing**

- Before washing, the element should be precleaned by means of compressed air, as described above.
- Then allow the element to soak in lukewarm washing solvent for 10 minutes, and then move it to and for in the solvent for about 5 minutes.
- Rinse thoroughly in clean water, shake out and allow drying at room temperature. The cartridge must be dry before it is reinstalled.
- Never use steam sprayers, petrol (gasoline), alkalis or hot liquids etc. to clean the filter elements.

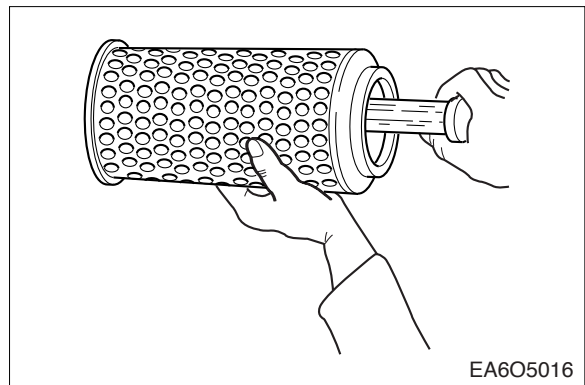


- **Knocking out dirt by hand**

- In emergencies, when no compressed air or cleaning agent is available, it is possible to clean the filter cartridge provisionally by hitting the end disk of the cartridge with the ball of one's thumb.
- Under no circumstances should the element be hit with a hard object or knocked against a hard surface to loosen dirt deposits.

• **Checking the filter cartridge**

- Before reinstalling the cartridge, it must be checked for damage e.g. to the paper pleats and rubber gaskets, or for bulges and dents etc. in the metal jacket.
- Cracks and holes in the paper pleating can be established by inspecting the cartridge with a flashlight.
- Damaged cartridges should not be reused under any circumstances. In cases of doubt, discard the cartridge and install a new one.



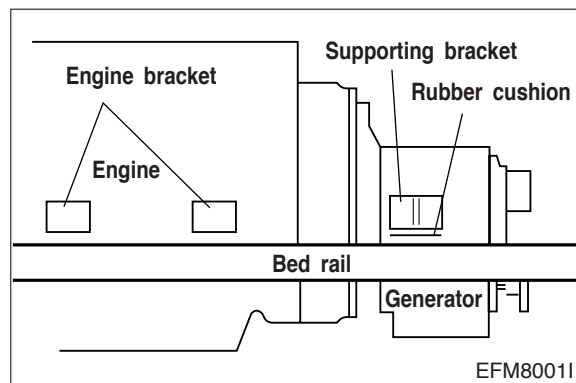
6. ENGINE INSTALLATION

6.1. Installing

- The center alignment of engine and Generator set is the most important factor for the extension of performance and life. Although aligning the center perfectly and accurately requires only few minutes, it is able to prevent unnecessary mechanical trouble at the future.

6.1.1. Bed rail

- At the installation of Generator set's bed rail, use steel.
- If the bed rail is strong enough, the center alignment of engine with Generator gets worse so that the excessive vibration may occur.



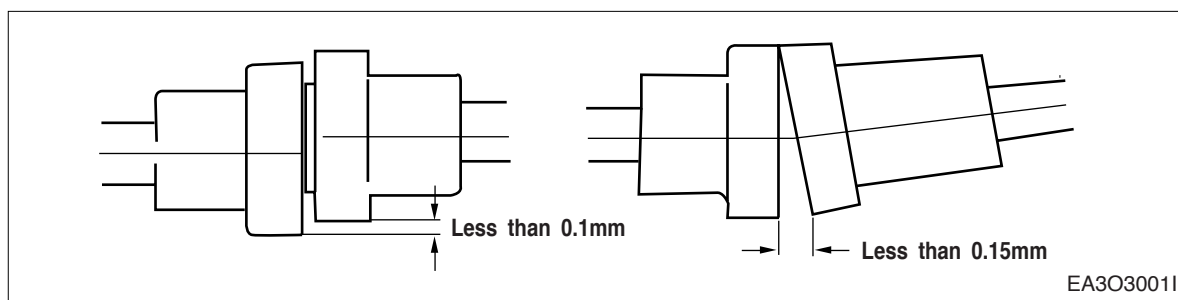
6.1.2. Supporting

- As in the engine installation, the supporting brackets are used even at the installation of Generator.
- The bracket must be solidly fixed at the Generator installing platform and the bed rail.

6.1.3. Aligning center

- The center alignment of engine and Generator is the most important factor for the extension of life cycle.
- Output shaft flange and opponent side flange of Generator should be aligned in their centers horizontal and parallel direction
- The adjustment between flange surfaces at the lower part should maintain less than 0.15 mm when the upper part's surfaces just meet and the deviation around the circumference should be maintained within 0.1 mm as following figure.

Surface (TIR)	Less than 0.15 mm
Center (TIR)	Less than 0.1 mm



- For bed rail is apt to deform for 6 months after initial performance, adjusting the center should be checked after 1 ~ 2 months.

6.2. Inspection prior to installation

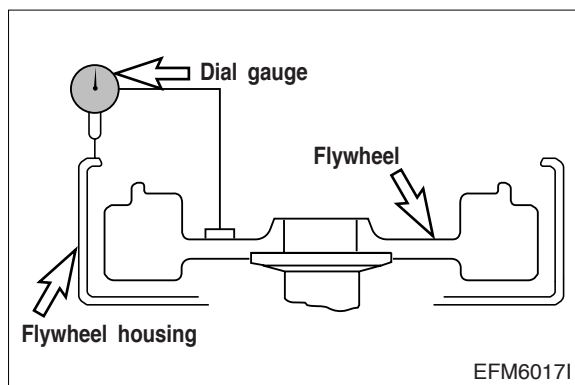
6.2.1. Inspection Prior to Installation



- Measure the correctness of flywheel and flywheel housing. Prior to inspection, clean the flywheel and flywheel housing.

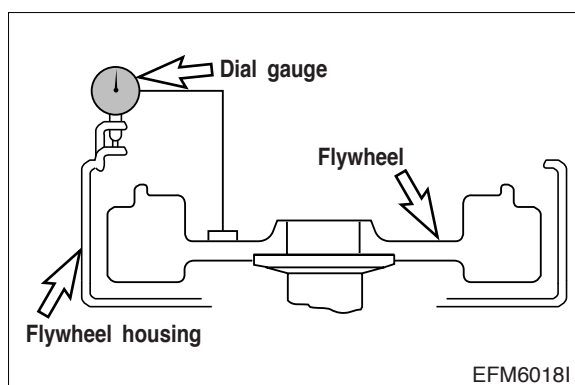
1) Measuring flywheel housing

- Measure the flywheel housing surface and install the dial gauge (1/1,000) at the flywheel so as to be vertical to the flywheel housing, and let the gauge stem to contact to the flange.
- Rotate the flywheel, and measure the surface error of flywheel housing flange. The surface error should not exceed 0.2mm.



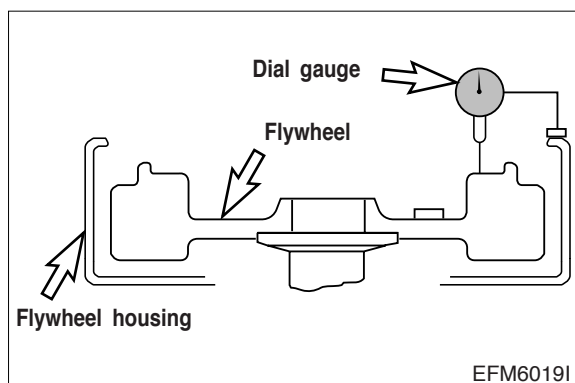
2) Measuring bore of flywheel housing

- Attach the gauge as above so that the gauge stem may contact the flywheel housing bore as the right figure.
- Measure the eccentrics of flywheel housing bore by rotating the flywheel. The eccentrics should not exceed 0.2 mm.



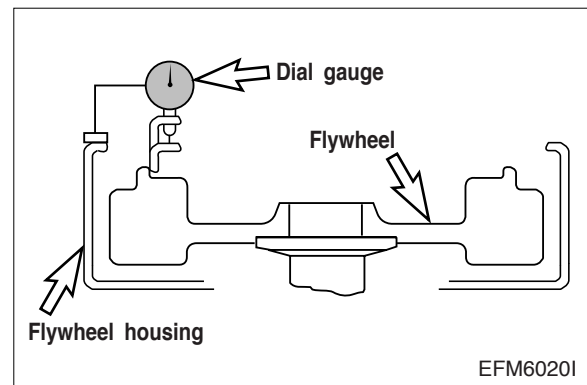
3) Measuring deformation of flywheel installing surface

- Fix the dial gauge to the flywheel housing so as for the gauge stem to be vertical to the surface to be installed.
- The deviation quantity should not exceed 0.127 mm/inch.



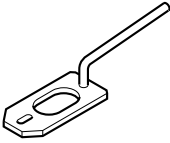
4) Measuring pilot bore of flywheel

- Install the gauge as below so as for the gauge stem to contact to the pilot bore of the surface to be installed.
- The eccentrics of the pilot bore of flywheel should not exceed 0.127mm at maximum.



7. SPECIAL TOOL LIST

No.	Part No.	Figure	Tool Name	Remark
1	EF.120-029	A technical drawing of a cylindrical oil seal insert with a central shaft and a flange.	Oil seal insert Assembly (RR)	
2	EF.120-183	A technical drawing of a cylindrical tool with a textured, knurled section in the middle.	Valve stern oil seal installer	
3	EF-123-193	A technical drawing of a long, thin cylindrical adapter with a threaded end.	Cylinder pressure tester adapter	
4	EF.120-031	A technical drawing of a simple cylindrical piston sleeve.	Piston sleeve	GV only
	EF.120-208	A technical drawing of a piston sleeve with a clamping mechanism.		All engine
5	EF.120-028	A technical drawing of a circular cylinder liner insert with four mounting holes.	Cylinder liner insert	
6	T7621010E	A technical drawing of a long-handled plier with a pointed tip.	Piston ring plier	
7	60.99901-0027	A technical drawing of a feeler gauge with multiple blades of varying thicknesses.	Feeler gauge	
8	T7610001E	A technical drawing of a standard snap ring plier.	Snap ring plier	

No.	Part No.	Figure	Tool Name	Remark
9	EF.123.-065		Valve spring presser	

APPENDIX

• Standard table of tightening torque

Specification	Screw	Strength	Tightening Torque kg-m
Cylinder block bearing cap			
- main bolt	M18 x 2	12.9	Initial 30 kg-m + rotating angle 90°
- side bolt	M12 x 1.5	10.9	8
Flywheel housing			
- tightening bolt	M12 x 1.5	10.9	10
- cover bolt	M10	12.9	7.5
	M8	8.8	2.2
Counter weight	M16 x 1.5	10.9	Initial 10 kg-m + rotating angle 90°
Crank pulley	M16 x 1.5	10.9	21
Vibration damper	M10	10.9	6
Flywheel	M16 x 1.5	12.9	26
Cooling fan	M8	8.8	2.2
Connecting rod cap	M16 x 1.5	10.9	Initial 10 kg-m + rotating angle 90°
Cylinder head	M15 x 2	12.9	8 kg.m + 15 kg.m +angle 90° + angle 90°
Cylinder head cover	M8	8.8	2.2
Ignition plug	M14 x 1.25	-	3.6 ~ 4.1
Cam shaft timer	M10	10.9	9
Rocker arm bracket	M10	10.9	6.5
Lock nut(adjusting screw)	M12 x 1	8.8	5
Oil pump cover	M8	8.8	2.2
Oil pump	M8	8.8	2.2
Oil cooler	M12	10.9	5
Oil pan	M8	8.8	2.2
Oil pan plug	M26 x 1.5	-	8
Exhaust manifold	M10	10.9	5.0
Intake manifold	M8	8.8	2.2
Starting motor	M12 x 1.5	8	8
Alternator bracket	M14	8.8	12
Oil pressure switch	PT1/8	-	2
Water temperature switch	M14	8.8	2

• Tightening torque for plug screw

Diameter x pitch	M10x1.0	M12x1.5	M14x1.5	M16x1.5	M18x1.5	M22x1.5	M26x1.5	M30x1.5
Torque (kg.m)	5.0	5.0	8.0	8.0	10.0	12.0	12.0	15.0

• **Tightening torque for hollow screw(4-hole)**

Material	M8	M10	M12	M14	M16	M18	M22	M26	M30	M38
SM25C	-	1.6	2.5	3.5	4.5	5.5	9.0	13.0	18.0	30.0
SUM22L*	0.8	1.8	3.0	4.0	5.5	6.5	11.0	16.0	20.0	35.0
STS304	0.8	1.8	3.0	4.0	5.5	6.5	11.0	16.0	20.0	35.0

* : Adopted in DAEWOO engine

• **Standard bolt tightening torque table**

Refer to the following table for bolts other then described above

Diameter x pitch (mm)	Degree of strength										
	3.6	4.6	4.8	5.6	5.8	6.6	6.8	6.9	8.8	10.9	12.9
	(4A)	(4D)	(4S)	(5D)	(5S)	(6D)	(6S)	(6G)	(8G)	(10K)	(12K)
	Limit value for elasticity (kg/mm ²)										
	20	24	32	30	40	36	48	54	64	90	108
Tightening torque (kg.m)											
M5	0.15	0.16	0.25	0.22	0.31	0.28	0.43	0.48	0.5	0.75	0.9
M6	0.28	0.30	0.45	0.4	0.55	0.47	0.77	0.85	0.9	1.25	0.5
M7	0.43	0.46	0.7	0.63	0.83	0.78	1.2	1.3	1.4	1.95	2.35
M8	0.7	0.75	1.1	1	1.4	1.25	1.9	2.1	2.2	3.1	3.8
M8x1	0.73	0.8	1.2	1.1	1.5	1.34	2.1	2.3	2.4	3.35	4.1
M10	1.35	1.4	2.2	1.9	2.7	2.35	3.7	4.2	4.4	6.2	7.4
M10x1	1.5	1.6	2.5	2.1	3.1	2.8	4.3	4.9	5	7	8.4
M12	2.4	2.5	3.7	3.3	4.7	4.2	6.3	7.2	7.5	10.5	12.5
M12x1.5	2.55	2.7	4	3.5	5	4.6	6.8	7.7	8	11.2	13.4
M14	3.7	3.9	6	5.2	7.5	7	10	11.5	12	17	20
M14x1.5	4.1	4.3	6.6	5.7	8.3	7.5	11.1	12.5	13	18.5	22
M16	5.6	6	9	8	11.5	10.5	17.9	18.5	18	26	31
M16x1.5	6.2	6.5	9.7	8.6	12.5	11.3	17	19.5	20	28	33
M18	7.8	8.3	12.5	11	16	14.5	21	24.2	25	36	43
M18x1.5	9.1	9.5	14.5	12.5	18.5	16.7	24.5	27.5	28	41	49
M20	11.5	12	18	16	22	19	31.5	35	36	51	60
M20x1.5	12.8	13.5	20.5	18	25	22.5	35	39.5	41	58	68
M22	15.5	16	24.5	21	30	26	42	46	49	67	75
M22x1.5	17	18.5	28	24	34	29	47	52	56	75	85
M24	20.5	21.5	33	27	40	34	55	58	63	82	92
M24x1.5	23	25	37	31	45	38	61	67	74	93	103

Others :

1. The above torque rating have been determined to 70% or so of the limit value for bolt elasticity.
2. Tension is calculated by multiplying tensile strength by cross section of thread.
3. Special screws should be tightened to 85% or so of the standard value.

For example, a screw coated with MoS2 should be tightened to 60% or so of the standard value.

• **Engine assembly tolerance**

(unit : mm)

	Items	Specifications	Remarks
Cylinder block	Inside dia. of liner forced in joint part (upper part)	$\phi 145.800 \sim \phi 145.840$	$\phi 145.8$ H7
	Inside dia. of liner forced in joint part (lower part)	$\phi 144.500 \sim \phi 144.540$	$\phi 144.5$ H7
	Inside dia. of liner color forced in part	$\phi 153.900 \sim \phi 154.150$	$\phi 153.9$ H11
	Liner colored surface depth	9.97 ~ 9.99	
Cylinder liner	Outside dia.of liner forced in joint part(upper)	$\phi 145.741 \sim \phi 145.786$	$\phi 145.8$ g6
	Outside dia. of liner forced in joint part(lower)	$\phi 144.432 \sim \phi 144.457$	$\phi 144.5$ f6
	Outside dia. of liner color part	$\phi 153.65 \sim \phi 153.75$	$\phi 153.8$
	Liner collar height	10.03 ~ 10.05	
	Liner forced in joint part (upper)	0.014 ~ 0.099	
	Liner forced in joint part (lower)	0.043 ~ 0.108	
	Liner collar part clearance	0.150 ~ 0.500	
	Inside dia. of liner	$\phi 127.990 \sim \phi 128.010$	$\phi 128 \pm 0.01$
	Liner's roundness & columness (upper)	0.01	from top up to 168mm
	Liner's roundness & columness (lower)	0.015	from bottom up to 85mm
	Liner's projection	0.04 ~ 0.08	measure at 4 place
Piston	Outside diameter of piston	$\phi 127.739 \sim \phi 127.757$	measure 71.5mm part from bottom(long length)
	Inside diameter of piston pin	$\phi 46.003 \sim \phi 46.009$	
	Max. allowable weight per engine	50g	
	1st ring groove width	3.5	
	2nd ring groove width	3.040 ~ 3.060	
	Oil ring home width	4.020 ~ 4.040	
Piston ring	1st ring height (thickness)	3.5	
	2nd ring height (thickness)	2.978 ~ 2.990	
	Oil ring height (thickness)	3.97 ~ 3.99	
	1st ring axial direction clearance	-	
	2nd ring axial direction clearance	0.050 ~ 0.082	
	Oil ring axial direction clearance	0.030 ~ 0.070	
	1st ring end part clearance	0.35 ~ 0.55	
	2nd ring end part clearance	0.40 ~ 0.60	
	Oil ring end part clearance	0.40 ~ 0.70	
Piston pin	Piston pin's outside diameter	$\phi 45.994 \sim \phi 46.000$	
	Clearance between piston pin & pin hole	0.003 ~ 0.015	
Connecting rod	Con rod small end part width	38.070 ~ 39.000	
	Con rod large end part width	35.341 ~ 35.380	35.5 C8
	Con rod cap	32.800 ~ 33.100	32.8+0.3
	Con rod axial direction clearance	0.240 ~ 0.392	
	Con rod small end part axial direction clearance	0.064 ~ 0.126	
	Con rod bush oil clearance	0.055 ~ 0.071	
	Con rod small end inside diameter (w/h bush)	$\phi 46.055 \sim \phi 46.065$	

(unit : mm)

	Items	Specifications	Remarks
Connecting rod	Con rod small end inside diameter (w/o bush)	$\Phi 50.600 \sim \Phi 50.630$	$\Phi 50.6$ H7
	Con rod bush's diameter	$\Phi 50.670 \sim \Phi 50.700$	
	Tightness	0.04 ~ 0.10	
	Con rod large end part's inside diameter	$\Phi 95.000 \sim \Phi 95.022$	$\Phi 95$ H6
	Con rod bearing spread (MIBA)	0.5 ~ 1.4	
	Con rod max. weight tolerance per engine	50g	
	Perpendicularity of large end inside diameter	0.035	reference to con -rod side face
	Large end part's inside roundness & columness	0.01	
	Large end part's inside straightness	0.005	
	Parallelness of small end inside with large end	0.02	
Crank shaft	Bearing housing diameter	$\Phi 111.000 \sim \Phi 111.022$	$\Phi 111$ H7
	Maximum shaking	$\Phi 0.05$	
	Main bearing journal diameter		
	Standard	$\Phi 103.98 \sim \Phi 104.00$	
	Undersize 0.10	$\Phi 103.88 \sim \Phi 103.90$	
	Undersize 0.25	$\Phi 103.73 \sim \Phi 103.75$	
	Undersize 0.50	$\Phi 103.48 \sim \Phi 103.50$	
	Undersize 0.75	$\Phi 103.23 \sim \Phi 103.25$	
	Undersize 1.00	$\Phi 102.98 \sim \Phi 103.00$	
	Thrust bearing journal width		
	Standard	38.000 ~38.062	38H9
	Undersize 1, 2	38.500 ~38.562	
	Undersize 3, 4	39.000 ~39.062	
	Con rod bearing journal diameter		
	Standard	$\Phi 89.98 \sim \Phi 90.00$	
	Undersize 0.10	$\Phi 89.88 \sim \Phi 89.90$	
	Undersize 0.25	$\Phi 89.73 \sim \Phi 89.75$	
	Undersize 0.50	$\Phi 89.48 \sim \Phi 89.50$	
	Undersize 0.75	$\Phi 89.23 \sim \Phi 89.25$	
	Undersize 1.00	$\Phi 89.98 \sim \Phi 89.00$	
	Main bearing journal's roundness	0.01	
	Main bearing journal's parallelness	0.005	
	Medium main bearing journal's shake	0.06	no 1, no 5 support
	Wear ring press in part's journal diameter	$\Phi 99.985 \sim \Phi 100.020$	$\Phi 100$ j7
	Wear ring's inside diameter	$\Phi 99.9907 \sim \Phi 99.942$	$\Phi 100$ S7
	Overlap	0.043 ~ 0.113	
	Thrust bearing width		
	Standard	37.74 ~ 37.81	
	Oversize	38.24 ~ 38.31	
	Oversize	38.74 ~ 38.81	

(unit : mm)

	Items	Specifications	Remarks
Crank shaft	Crankshaft's axial direction's clearance	0.190 ~ 0.322	
	Main bearing thickness		
	Standard	3.460 ~ 3.472	
	Oversize 0.10	3.510 ~ 3.522	
	Oversize 0.25	3.585 ~ 3.597	
	Oversize 0.50	3.710 ~ 3.722	
	Oversize 0.75	3.835 ~ 3.847	
	Oversize 1.00	3.960 ~ 3.972	
	Main bearing oil gap	0.066 ~ 0.132	
Flywheel	Main bearing spread	0.3 ~ 1.2	
	Thrust bearing's spread	0.3 ~ 1.2	
	Ring Gear assembly part's Outside diameter	$\phi 432.490 \sim \phi 432.645$	
	Ring gear inside diameter	$\phi 432.000 \sim \phi 432.155$	
	Overlap	0.335 ~ 0.645	
	Heat fitting temp. (°C)	200 ~ 230	
Cylinder head & valve	Allowable shaking amount after assembly	0.5	
	Outside diameter after reassembly used ring	$\phi 114.980 \sim \phi 115.015$	
	Head gasket thickness (after tightening bolts)	1.205 ~ 1.295	
	Cylinder head height	113.9 ~ 114.0	
	Cylinder head seal surface roughness	max. 16 μ	
	Valve projecting amount	- 0.65 ~ - 0.95	
	Exhaust valve		
	Stem diameter	$\phi 11.945 \sim \phi 11.955$	
	Radius direction clearance	0.045 ~ 0.073	
	Seat angle	45°	
	Head diameter	$\phi 50.9 \sim \phi 51.1$	
	"H" thickness of valve head	1.9 ~ 2.3	
	Valve seat part diameter of head	$\phi 53.00 \sim \phi 53.03$	
	Outside diameter of valve seat	$\phi 53.10 \sim \phi 53.11$	
	Intake valve		
	Stem diameter	$\phi 11.969 \sim \phi 11.980$	
	Radius direction clearance	0.020 ~ 0.049	
	Seat angle	30°	
	Head diameter	$\phi 57.85 \sim \phi 58.15$	
	"H" thickness of valve head	2.6 ~ 3.0	
	Valve seat part diameter of head	$\phi 61.00 \sim \phi 61.03$	$\phi 61$ H7
	Outside dia. of valve seat	$\phi 61.10 \sim \phi 61.11$	
	Depth of head's valve seat assembly part	12.5 ~ 12.6	
	Valve guide inside diameter	$\phi 12.000 \sim \phi 12.018$	$\phi 12$ H7
	Valve guide's inside diameter of head	$\phi 18.000 \sim \phi 18.018$	$\phi 18$ H7
	Valve guide's outside diameter	$\phi 18.028 \sim \phi 18.046$	$\phi 18.25$ S7
	Valve guide assembly locking piece	0.010 ~ 0.046	
	Valve seat's shaking	0.04	reference to valve guide

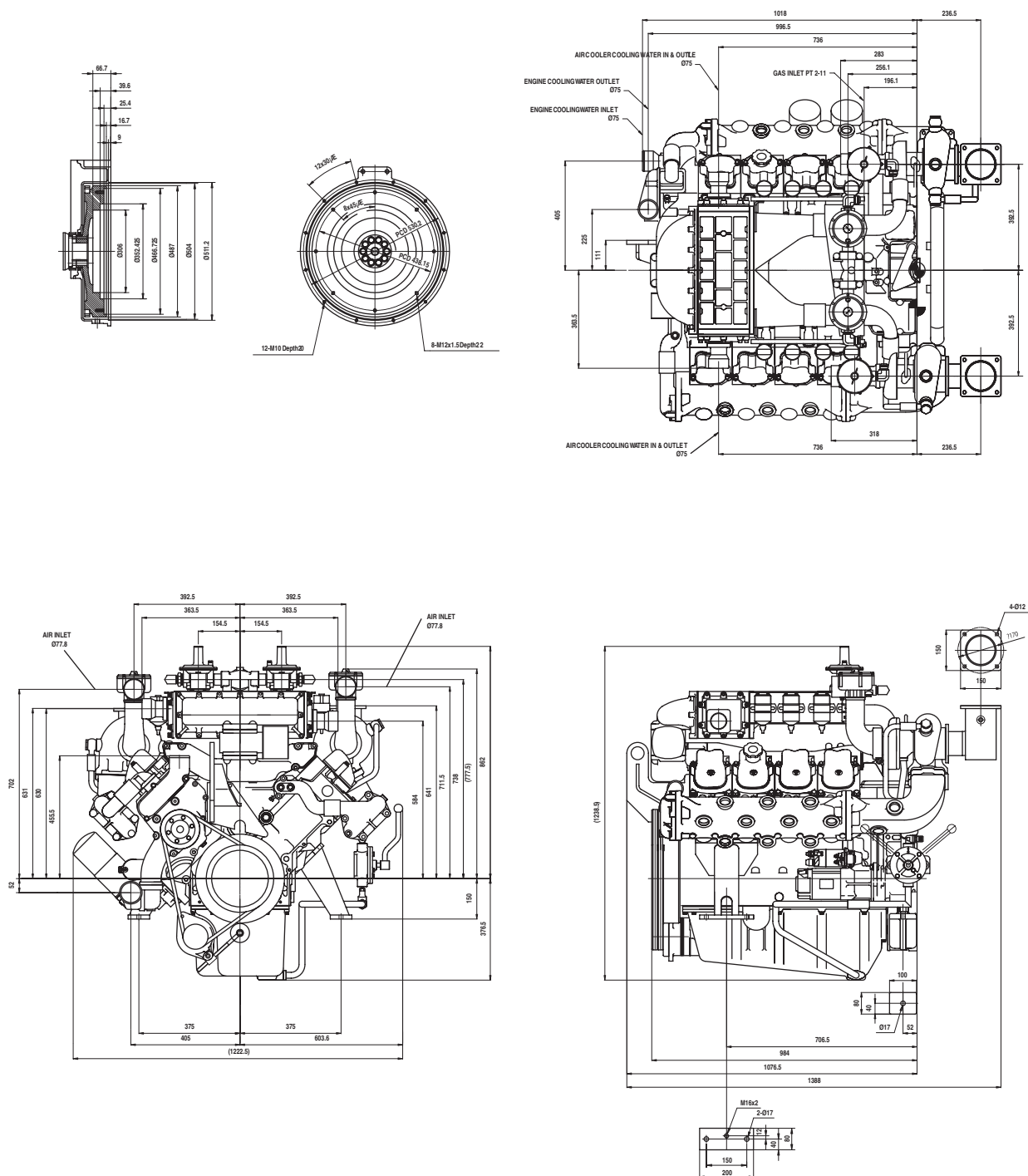
(unit : mm)

	Items	Specifications	Remarks
Valve spring	Valve lift	14.1	
	Projecting amount of valve guide	17.1 ~ 17.5	Above valve spring
	Free length of inside spring	72.43	
	Spring load of inside spring	15 ~ 17 kg	at 46.3 mm
	Spring load of inside spring	27 ~ 32 kg	at 32.3 mm
	Free length of outside spring	68.17	
	Spring load of outside spring	37 ~ 41 kg	at 46.3 mm
	Spring load of outside spring	66.5 ~ 76.5 kg	at 32.8 mm
Timing	Rocker arm bush's inside diameter	$\phi 25.005 \sim \phi 25.035$	when assembled
	Rocker arm bearing journal's diameter	$\phi 24.967 \sim \phi 24.990$	
	Bearing's clearance	0.015 ~ 0.068	
	Push rod's shaking	0.3	
	Valve tappet ass'y part's inside dia. of block	$\phi 20.000 \sim \phi 20.021$	
	Push rod's outside diameter	$\phi 19.944 \sim \phi 19.965$	$\phi 20$ H7
	Tappet clearance	0.035 ~ 0.077	
	Bush assembly's inside diameter of block	$\phi 70.077 \sim \phi 70.061$	
	Camshaft diameter	$\phi 69.910 \sim \phi 69.940$	$\phi 70$ e7
	Camshaft bearing oil gap	0.060 ~ 0.120	
	Camshaft axial direction play	0.20 ~ 0.90	
	Backlash (crank gear-camshaft gear)	0.118 ~ 0.242	
	Backlash (driving gear - injection pump gear)	0.102 ~ 0.338	
	Intake valve clearance	0.30	
	Exhaust valve clearance	0.40	
Engine lubricating system	Oil pressure at idling	0.9 ~ 3.0 bar	
	Oil pressure at rated speed operation	3.0 ~ 6.5 bar	
	Oil temperature	less than 110°C	
	Instantaneous allowable temperature	max. 100°C	
	Bypass valve opening pressure	1.8 ~ 2.4 bar	
	Pressure regulating valve of oil pump	8.5 ~ 10 bar	
	Spray nozzle		
	Operating pressure	1.6 ~ 1.9 bar	
	Crossing pressure	1.3 ~ 1.6 bar	
	Tip diameter	$\phi 2$	
	Backlash (crankshaft gear-oil pump drive gear)	0.10 ~ 0.45	
	Oil pump housing's depth/gear width	43.000 ~ 43.039	43 H8
		42.910 ~ 42.950	43 e8
	Oil pump housing axial play	0.050 ~ 0.128	
Engine cooling system	Cooling water pump shaft diameter	$\phi 21.930 \sim \phi 21.950$	
	Bearing gap	0.050 ~ 0.091	
	Impeller clearance (impeller - body)	1.0 ~ 1.5	
	Thermostat Operating temperature (°C)	71°C	

(unit : mm)

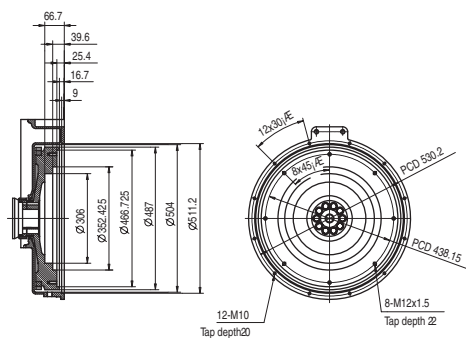
	Items	Specifications	Remarks
Inspection on compressed pressure	Good Need up keep Allowable max pressure difference between cylinders	above 16 bar bellow 13 bar 4 bar	
Fuel igni- tion sys- tem	Ignition plug clearance project ignition plug from cylinder head low sur- face	0.38 ~ 0.40 3.38 ~ 3.76	

- **GV158TIC Engine assembly**

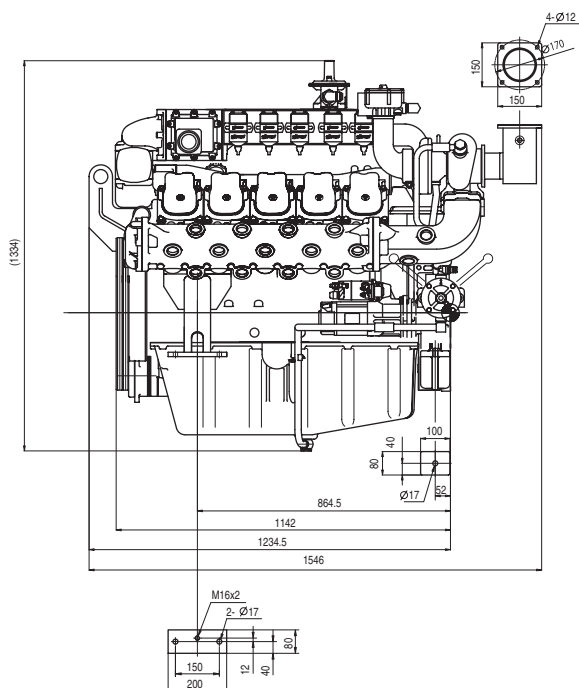
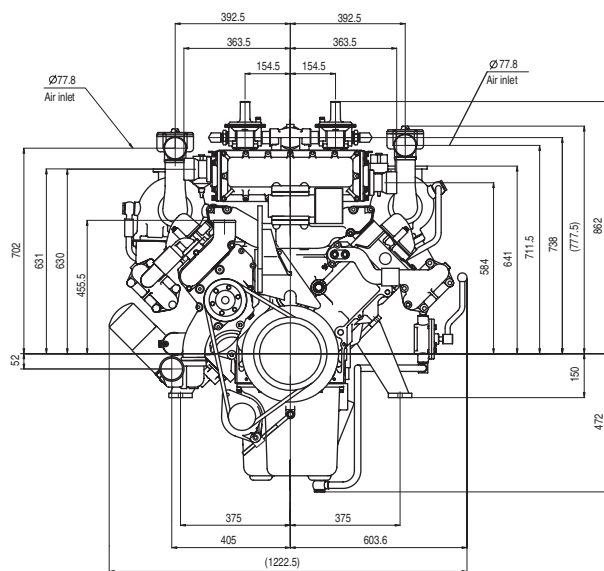
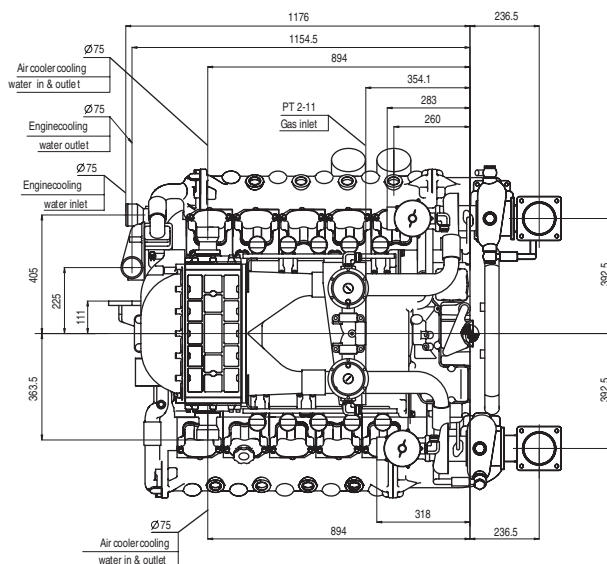


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• GV180TIC Engine assembly

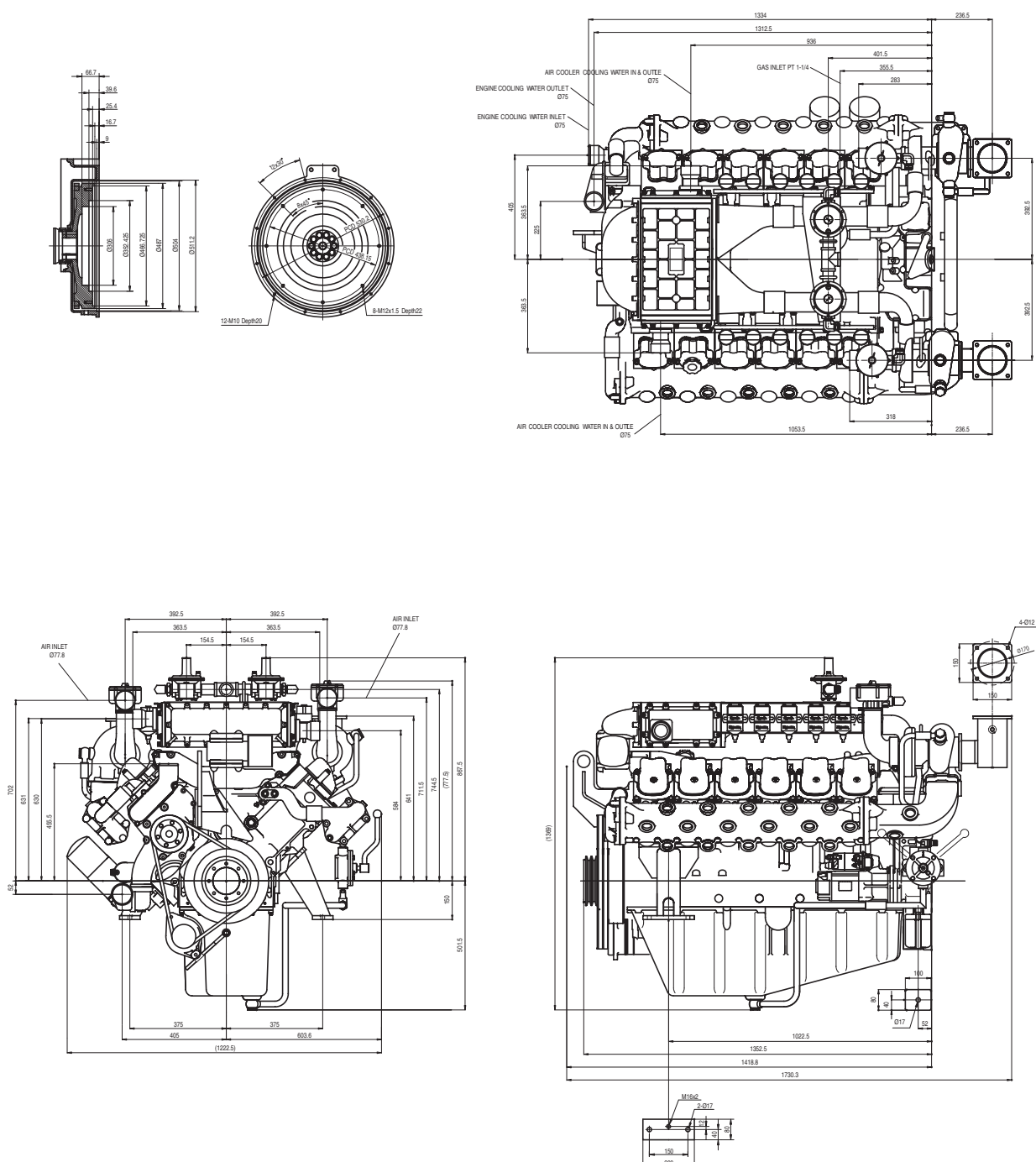


Power train



EE3OM073

- **GV222TIC Engine assembly**



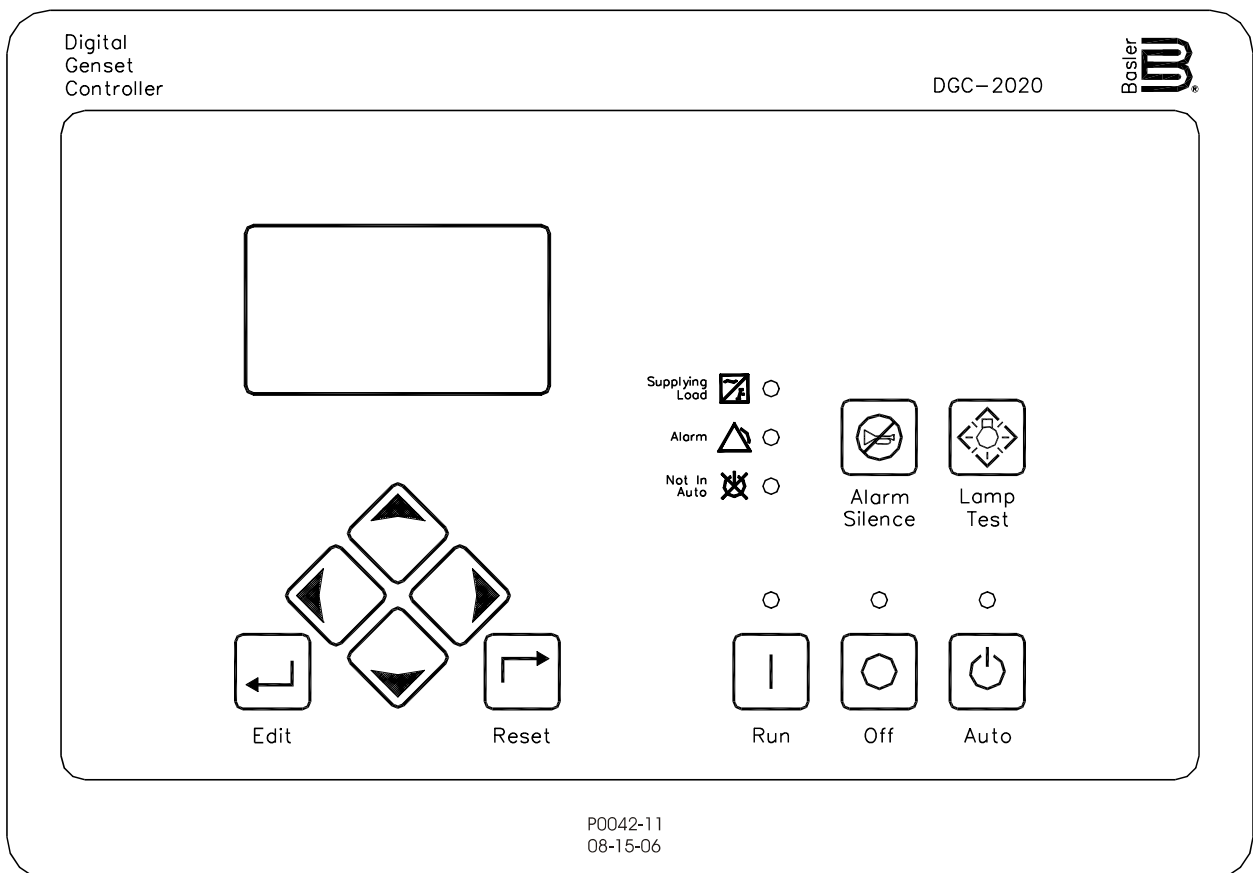
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INSTRUCTION MANUAL

FOR

DIGITAL GENSET CONTROLLER

DGC-2020



B Basler Electric

Publication: 9400200990
Revision: K 01/09

INTRODUCTION

This instruction manual provides information about the operation and installation of the DGC-2020 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
- 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

WARNING!

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

NOTES

DGC-2020 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 DGC-2020.

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 DGC-2020 utilizes password protection that guards against unauthorized changing of DGC-2020 settings. The default passwords are listed below.

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

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January 2009

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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.

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REVISION HISTORY

The following information provides a historical summary of the changes made to this instruction manual (9400200990), BESTCOMSPlus software, firmware package, and hardware of the DGC-2020.

Manual Revision and Date	Change
K, 01/09	- Updated manual to support firmware version 1.08.01 changes and BESTCOMSPlus version 2.03.00 changes. (See firmware and BESTCOMSPlus 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, <i>AEM-2020 (Analog Expansion Module)</i>. - Added information for Automatic Generator Detection in Section 4. - Improved CANbus 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, <i>Maintenance and Troubleshooting</i>. - Added <i>Synchronizer Operation</i> under <i>Breaker Management</i> in Section 3. - Improved <i>Communication</i> in Section 4. - Added Bits 6 through 10 to register 44822 in Appendix B. - Added Appendix C, <i>Tuning PID Settings</i>.
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, <i>CEM-2020 (Contact Expansion Module)</i>.
G, 11/07	- Added Section 8, <i>LSM-2020 (Load Share Module)</i>. - Updated HMI screens layout in Section 2. - Added BESTCOMSPlus Multigen Management screens.
F, 08/07	Updated manual to support firmware version 1.02.00 changes and BESTCOMSPlus version 1.03.00 changes. (See firmware and BESTCOMSPlus history below for details.)
E, 05/07	- Added description of <i>Clock Setup</i> screen in BESTCOMSPlus. - Updated several BESTCOMSPlus screen shots. - Increased Low Coolant Temp Pre-Alarm range to 30 - 150°F.
D, 03/07	- Removed International Modem option from <i>Style Chart</i> in Section 1. - Added coverage of part numbers 9400200105 and 9400200106.
C, 02/07	- Added <i>Event Recording</i> in Section 3, <i>Functional Description</i>. - Minor text edits throughout manual.
B, 11/06	Initial release

BESTCOMSPlus Version and Date	Change
2.03.00, 01/09	• Added Export to File feature. • Added settings for Phase Toggle and Initializing Messages on <i>General Settings, Front Panel HMI</i> screen. • Re-arranged <i>CANbus Setup</i> screen and added <i>ECU Setup</i> screen under <i>Communications</i>. • Added settings for 51-3 element under <i>Generator Protection, Current</i>. • Added setting for Off Mode Cooldown on <i>System Parameters, System Settings</i> screen. • Added <i>Remote Module Setup</i> screen under <i>System Parameters</i>. • Added <i>Remote LSM Inputs</i> settings and metering screens under <i>Programmable Inputs</i>. • Added settings to <i>Bias Control</i> screens for Var/PF control. • Added kVar A, B, C, and Total to <i>Power</i> and <i>Summary</i> metering screens. • Re-arranged MTU metering screens. • Added <i>MTU Status</i> screen and <i>MTU Engine Status</i> screen. • Added BESTlogic+ Input Objects for Configurable Elements, Configurable Protection, Front Panel Buttons, PF Mode Active, Pre Start Input, and Run Input. • Added BESTlogic+ Pre-Alarms for Checksum Fail and CEM Hardware Mismatch. • Added BESTlogic+ Elements for 51-3, COOLSTOPREQ, COOLDOWNREQ, EXTSTARTDEL, PRESTARTOUT, RUNOUTPUT, STARTDELBYP, and STARTOUTPUT. • Added Relay Control settings on <i>System Parameters, System Settings</i> screen. • Added support for CEM-2020H.
2.01.00, 07/08	• 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, 04/08	• Added settings for CEM-2020.
1.04.01, 12/07	• Added settings for LSM-2020.
1.03.00, 08/07	• Added/Updated screens to support firmware version 1.02.00. (See firmware history below 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 <i>Clock Setup</i> 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

Firmware Package Version and Date	Change
1.08.01, 01/09	• 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 <i>CANbus Setup</i> screens and added <i>ECU Setup</i> screens on front panel HMI. • Added support for CEM-2020H.
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 Version and Date	Change
P, 01/09	• Release firmware package 1.08.01 and BESTCOMSPlus 2.03.00.
N, 09/08	• Release firmware package 1.07.02.
M, 07/08	• Release firmware package 1.06.00 and BESTCOMSPlus 2.01.00.
L, 04/08	• Release firmware package 1.05.00 and BESTCOMSPlus 2.00.01.
K, 01/08	• Added definition of emergency stop input terminals.
J, 12/07	• Release firmware package 1.04.00 and BESTCOMSPlus 1.04.01.
H, 12/07	• Switched LCD heater types for manufacturability.
G, 08/07	• Release firmware package 1.03.00 and BESTCOMSPlus 1.03.00.
F, 04/07	• Release BESTCOMSPlus 1.02.00.
E, 03/07	• Release 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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SECTION 1 • GENERAL INFORMATION

DESCRIPTION

The DGC-2020 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 DGC-2020 operation. Basler Electric communication software (BESTCOMSPlus) allows units to be easily customized for each application. Because of the low sensing burden in the DGC-2020, 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.

FEATURES

DGC-2020 Digital Genset Controllers have the following features:

- Local and Remote Generator Control
- Engine and Generator Protection
- Programmable Analog Engine Senders
- ECU Communications via SAE J1939
- 16 Programmable Contact Inputs
- Programmable Logic
- Automatic Transfer Switch Control (Mains Failure)
- Automatic Generator Configuration Detection
- Integrated RS485
- Auto Synchronizing
- Exercise Timer
- Additional modules available to expand the capabilities of the DGC-2020

FUNCTIONS

DGC-2020 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 and phase imbalance protection is available as an option. Each generator protection function has an adjustable pickup and time delay setting. Sixteen inverse time curves enable the DGC-2020 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

DGC-2020 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 DGC-2020 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 DGC-2020 has the ability to detect a mains failure via a single-phase Bus input. A mains failure is established when any one of the following conditions are met:

- Bus voltage falls below dead bus threshold
- Bus voltage unstable due to overvoltage or undervoltage
- Bus voltage unstable due to overfrequency or underfrequency

At this time, the DGC-2020 will start the genset and when ready, apply power to the load via the genset. The DGC-2020 implements open transitions to and from the mains. When the mains returns and is considered stable, the DGC-2020 will transfer the load back to the mains.

Communication

Standard DGC-2020 communication features include a standard USB port and SAE J1939 interface. Optional communication features include a dial-out modem and RS-485 communication port. BESTCOMSPlus can communicate with the DGC-2020 through Ethernet via an optional LSM-2020 (Load Share Module). Contact Basler Electric for ordering information.

USB Port

A USB communication port can be used with BESTCOMSPlus software to quickly configure a DGC-2020 with the desired settings or retrieve metering values and event log records.

CANbus Interface

A CANbus interface provides high-speed communication between the DGC-2020 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 CANbus 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 DGC-2020 and may be obtained using BESTCOMSPlus software.
- MTU Protocol - A DGC-2020 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 DGC-2020 tracks and displays the active fault codes issued by the MTU engine ECU.

Dial-Out Modem

The optional dial-out modem enables remote control, monitoring, and setting of the DGC-2020. When an alarm or pre-alarm condition occurs, the DGC-2020 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 DGC-2020 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 DGC-2020. The AEM-2020 communicates with the DGC-2020 through a CANbus interface. Refer to Section 10, *AEM-2020 (Analog Expansion Module)*, for more information.

CEM-2020 (CONTACT EXPANSION MODULE)

The optional CEM-2020 provides 10 additional contact inputs and 24 additional output contacts to the DGC-2020. The CEM-2020 communicates with the DGC-2020 through a CANbus interface. Refer to Section 9, *CEM-2020 (Contact Expansion Module)*, for more information.

LSM-2020 (LOAD SHARE MODULE)

The optional LSM-2020 in conjunction with the DGC-2020 provides load sharing between governors through an analog load share line. The LSM-2020 communicates through an Ethernet port and provides access to the DGC-2020 via Ethernet. Refer to Section 8, *LSM-2020 (Load Share Module)*, for more information.

STYLE AND PART NUMBERS

Style Number

Standard-order DGC-2020 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 DGC-2020 style number identification chart.

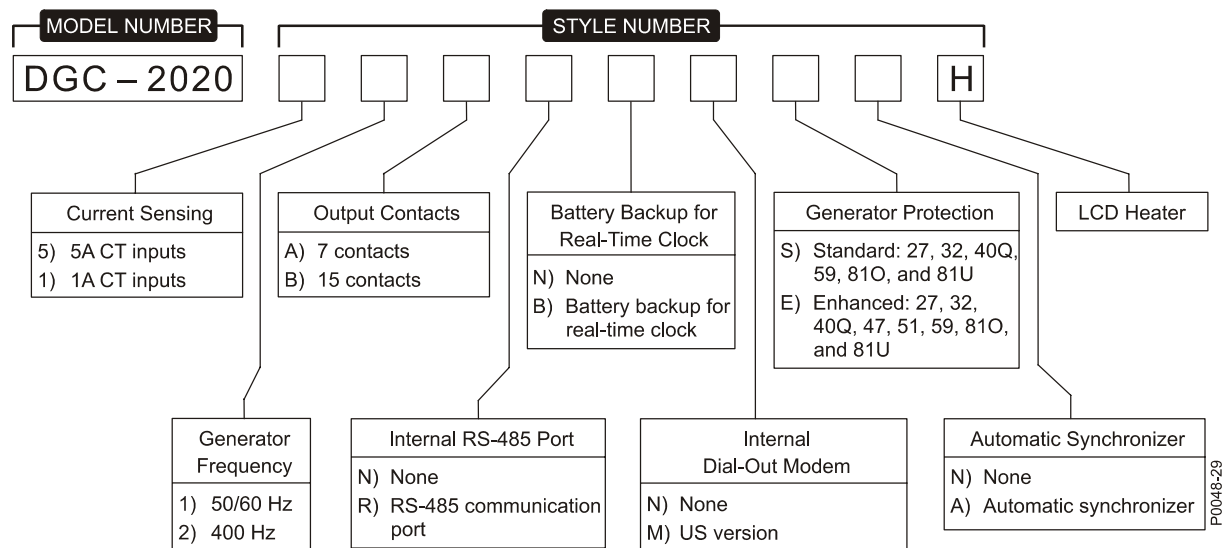


Figure 1-1. DGC-2020 Style Chart

For example, if a DGC-2020 style number were **51BNBMEAH**, 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
- M** Internal dial-out modem—US version
- E** Enhanced generator protection (undervoltage, reverse power, loss of excitation, phase imbalance, overcurrent, overvoltage, overfrequency, and underfrequency)
- A** Auto-synchronizer
- H** LCD heater

Part Numbers

A ten-digit part number specifies the electrical characteristics and operational features of special-order DGC-2020 controllers. Table 1-1 lists the special-order DGC-2020 controllers available along with descriptions of their operating features.

Table 1-1. Special-Order DGC-2020 Controllers

Part Number	Style Number	Special Features
9400200105	51ANBNSNH001	cURus recognized for use in hazardous locations.
9400200106	11ANBNSNH001	

SPECIFICATIONS

Operating Power

Nominal:	12 or 24 Vdc
Range:	6 to 32 Vdc (Withstands cranking ride-through down to 6 Vdc for 500 ms.)
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.

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

Configuration:	Line-to-line or line-to-neutral
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:	45 (A-phase) 43 (B-phase)

Contact Sensing

Contact sensing inputs include 1 emergency stop input and 16 programmable inputs. The emergency stop input accepts normally closed, dry contacts. All programmable inputs accept normally open, dry contacts.

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.

Fuel Level Sensing

Resistance Range:	33 to 240 Ω nominal
Terminals:	9, 11 (sender common)

Coolant Temperature Sensing

Resistance Range:	62.6 to 637.5 Ω nominal
Terminals:	10, 11 (sender common)

Oil Pressure Sensing

Resistance Range:	34 to 240 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)

Output Contacts

Fuel Solenoid, Engine Crank, and Pre-Start Relays

Rating: 30 Adc at 28 Vdc—make, break, and carry *

Terminals	
Fuel Solenoid:	RUN – NO, COM
Pre-Start:	PRE – NO, COM
Crank:	START – NO, COM

Programmable Relays (12)

Rating: 2 Adc at 30 Vdc—make, break, and carry

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)

* Contact rating is reduced to 3 A for part numbers 9400200105 and 9400200106 when used in a hazardous location.

† The number of programmable output contacts provided is determined by the output contacts character of the DGC-2020 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 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 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: $\pm 3\%$ 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 $+70^{\circ}\text{C}$.

Power Factor

Metering Range:	0.2 leading to 0.2 lagging
Calculation Method:	$PF = P \text{ (3-phase average)} \div S \text{ (3-phase average)}$
Accuracy:	± 0.02 *

* Applies when temperature is between -40°C to $+70^{\circ}\text{C}$.

Real Power

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

Measurement/Calculation Methods

Total:	$PF \times \text{Total kVA}$
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: $\pm 3\%$ 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 $+70^{\circ}\text{C}$.

Oil Pressure

Metering Range:	0 to 145 psi or 0 to 1,000 kPa
Accuracy:	$\pm 3\%$ of actual indication or ± 2 psi or ± 12 kPa (subject to accuracy of sender)
Display Resolution:	1 psi or 1 kPa

Coolant Temperature

Metering Range:	32 to 410°F or 0 to 204°C
Accuracy:	$\pm 3\%$ of actual indication or $\pm 2^{\circ}$ (subject to accuracy of sender)

Battery Voltage

Metering Range:	6 to 32 Vdc
Accuracy:	$\pm 3\%$ of actual indication or ± 0.2 Vdc
Display Resolution:	0.1 Vdc

Engine RPM

Metering Range:	0 to 4,500 rpm
Accuracy: *	$\pm 2\%$ 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 h
Update Interval:	6 min
Accuracy:	$\pm 1\%$ of actual indication or ± 12 min
Display Resolution:	1/10 hour

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 h
Update Interval:	6 min
Accuracy:	±1% or actual indication or ±12 min
Display Resolution:	1/10 hour

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 576 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

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%
Pickup Increment:	0.1%
Hysteresis Range:	1 to 10%
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%
Pickup Increment:	0.1%
Hysteresis Range:	1 to 10%
Hysteresis Increment:	0.1%
Activation Delay Range:	0 to 30 s
Activation Delay Increment:	0.1 s

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, <i>Time Overcurrent Characteristic Curves</i>

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

Logic Timers

Range:	0 to 10 s
Increment:	0.1 s
Accuracy:	±15 ms

Communication Interface

USB

Specification Compatibility:	USB 2.0
Data Transfer Speed:	9600 baud
Connector Type:	Mini-B jack

RS-485 (Optional)

Baud:	9600
Data Bits:	8
Parity:	None
Stop Bits:	1
Terminals:	14 (A), 13 (B), and 12 (shield)

CANbus

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)

NOTES

- 1.) If the DGC-2020 is providing one end of the J1939 bus, a 120 Ω terminating resistor should be installed across terminals 48 (CANL) and 49 (CANH).
- 2.) If the DGC-2020 is not part of the J1939 bus, the stub connecting the DGC-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 DGC-2020.

Modem (Optional)

Connector Type:	RJ-11 jack

Real-Time Clock

Clock has leap year and selectable daylight saving time correction. Backup capacitor and optional backup battery sustain timekeeping during losses of DGC-2020 operating power.

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

Clock Holdup

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

NOTE

Failure to replace the battery with Basler Electric P/N 38526 may void the warranty.

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 DGC-2020 is to be operated in a salt-fog environment. Salt-fog is known to be conductive and may short-circuit the battery.

Type Tests

Shock and Vibration:	EN60068-2-6
Dielectric Strength:	IEC 255-5
Impulse:	EN60664-1
Transients:	EN61000-4-4
Static Discharge:	EN61000-4-2

Shock

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" DA for 2.5 min.
52 to 500 to 52 Hz:	5 G peak for 7.5 min.

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 DGC-2020 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 DGC-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 Section 1 of this manual.

Ignition System

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

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
Salt Fog:	ASTM B 17-73, IEC 68-2-11
Ingress Protection:	IEC IP54 for front panel

UL/CSA Approval

“cURus” recognized to UL Standard 508 & CSA Standard C22.2 No. 14.
CSA certified to CSA C22.2 No. 14.

CAUTION

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

Part Numbers 9400200105 and 9400200106

“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 - T4.

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

WARNING! - EXPLOSION HAZARD

(9400200105 and 9400200106 only)

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.

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: 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 DGC-2020 human-machine interface (HMI). DGC-2020 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 DGC-2020. Table 2-1 lists the call-outs of Figure 2-1 along with a description of each HMI component.

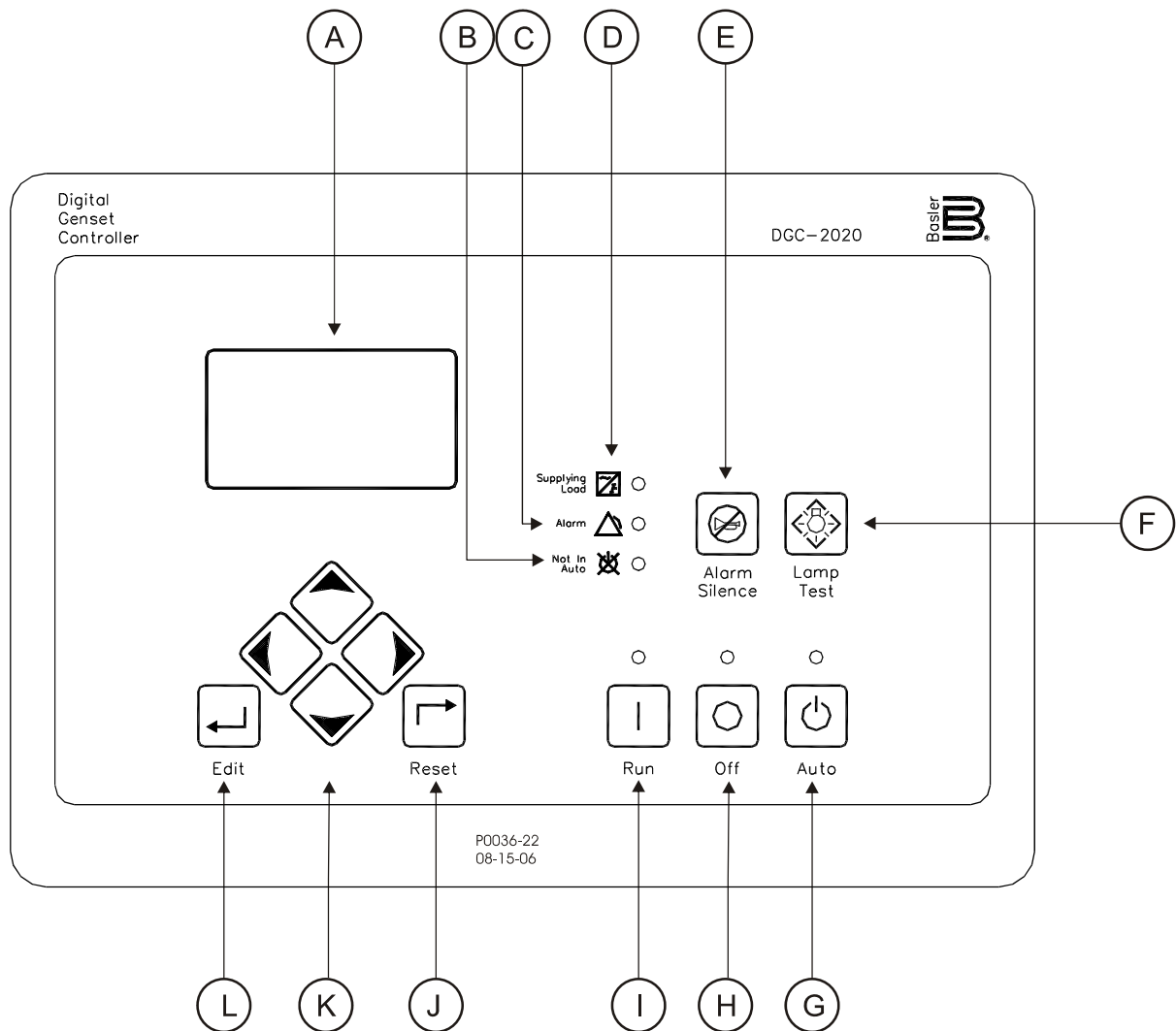


Figure 2-1. Front Panel HMI

Table 2-1. Front Panel HMI Descriptions

Locator	Description
A	<i>Liquid Crystal Display.</i> 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	<i>Not in Auto Indicator.</i> This red LED lights when the DGC-2020 is not operating in Auto mode.
C	<i>Alarm Indicator.</i> This red LED lights continuously during alarm conditions and flashes during pre-alarm conditions.
D	<i>Supplying Load Indicator.</i> This green LED lights when the generator current is greater than EPS threshold current.
E	<i>Alarm Silence Pushbutton.</i> Pressing this button opens the relay output programmed as the horn output.
F	<i>Lamp Test Pushbutton.</i> Pressing this button tests the DGC-2020 indicators by exercising all LCD pixels and lighting all LEDs.
G	<i>Auto Pushbutton and Mode Indicator.</i> Pressing the Auto button places the DGC-2020 in Auto mode. The green Auto mode LED lights when Auto mode is active.
H	<i>Off Pushbutton and Mode Indicator.</i> Pressing this button places the DGC-2020 in Off mode. The red Off mode LED lights when the DGC-2020 is in Off mode.
I	<i>Run Pushbutton and Mode Indicator.</i> Pressing this button places the DGC-2020 in Run mode. The green Run mode LED lights when Run mode is active.
J	<i>Reset Pushbutton.</i> This button is pressed to cancel a settings editing session and discard any settings changes. When pressed, this button also resets the Breaker Management Pre-Alarms.
K	<i>Arrow Pushbuttons.</i> 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	<i>Edit Pushbutton.</i> Pressing this button starts an editing session and enables changes to DGC-2020 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 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.

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
- 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 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)	• GEN Hz
• BLANK (Shows nothing on this line)	• GEN PF
• OIL P	• KWH
• TEMP	• GEN IA
• BATT V	• GEN IB
• RPM	• GEN IC
• RPM SRC	• KW A
• FUEL	• KW B
• RUN HRS	• KW C
• GEN VAB	• KW TOT
• GEN VBC	• KVA A
• GEN VCA	• KVA B
• GEN VAN	• KVA C
• GEN VBN	• KVA TOT
• GEN VCN	• ALG_IN_X (X = 1 to 8) (with AEM-2020)
• BUS Hz	• RTD_IN_X (X = 1 to 8) (with AEM-2020)
• BUS V	• THRM_CPL_X (X = 1 to 2) (with AEM-2020)

Sleep Mode

Sleep mode serves as a power saving feature. If the DGC-2020 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 DGC-2020 resumes normal display operation when any front panel button is pressed or the genset is started remotely via the ATS input. The DGC-2020 will not go to sleep while in an Alarm state. If needed, Sleep mode can be permanently disabled via BESTCOMSPlus 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 and SETTINGS. 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.

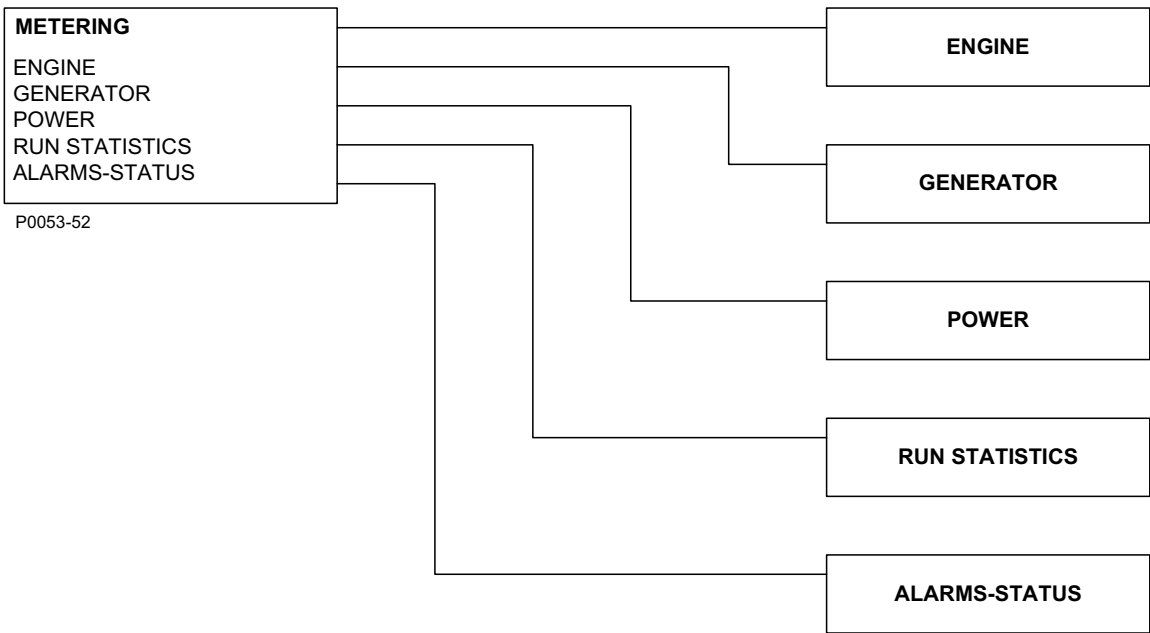


Figure 2-2. Metering Screen Branches

ENGINE
• OIL PRESSURE • COOLAND TMP • BATTERY VOLT • RPM • SPEED SRC • FUEL LEVEL • ENGINE LOAD • COOLANT LEVL • TOTAL RUN TM • HRS TO MAINT
GENERATOR
• GEN VAB • GEN VBC • GEN VCA • GEN VAN • GEN VBN • GEN VCN • GEN FREQ • GEN AMPS A • GEN AMPS B • GEN AMPS C

- BUS V
- BUS FREQ
- SYNCHRONIZER

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

RUN STATISTICS

- **CUMULATIVE**
 - CUMULATIVE
 - START
 - # STARTS
 - HRS TO MAINT
 - KW-HRS
 - TOTAL RUN TIME
 - HOURS
 - MINUTES
 - 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**
- **PRE-ALARMS**
- **MTU FAULT CODES** (Visible when ECU is configured for MTU MDEC, MTU ADEC, or MTU ECU7.)
- **MTU STATUS** (Visible when ECU is configured for MTU MDEC, MTU ADEC, or MTU ECU7.)
- **STATUS**
 - EPS SUPP. LOAD
 - GEN BREAKER
 - MAINS BREAKER
 - GRND DELTA O-RIDE
 - GEN DEAD
 - GEN STABLE
 - GEN FAILED
 - BUS DEAD
 - BUS STABLE
 - BUS FAILED
 - EXT START DEL
 - START DEL BYPASS
 - COOLDN REQ
 - COOL STOP REQ
 - OFF MODE COOLDN
- **INPUTS**
 - INPUT X (X = 1 to 16, (17 to 26 optional))
- **OUTPUTS**
 - OUTPUT X (X = 1 to 4, (5 to 36 optional))
- **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)
 - 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)
- **ANALOG STATUS**
- **CONF ELEMENTS**
- **CONF PROT STATUS**
- **EVENT LOG**
 - EVENT
 - 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
- **J1939 DATA** (Visible when ECU is configured for Standard or Volvo Penta.)
- **J1939 ENGINE CONFIG** (Visible when ECU is configured for Standard or Volvo Penta.)
- **J1939 ACTIVE DTC** (Visible when any ECU type is selected.)
- **J1939 PREV DTC** (Visible when any ECU type is selected.)

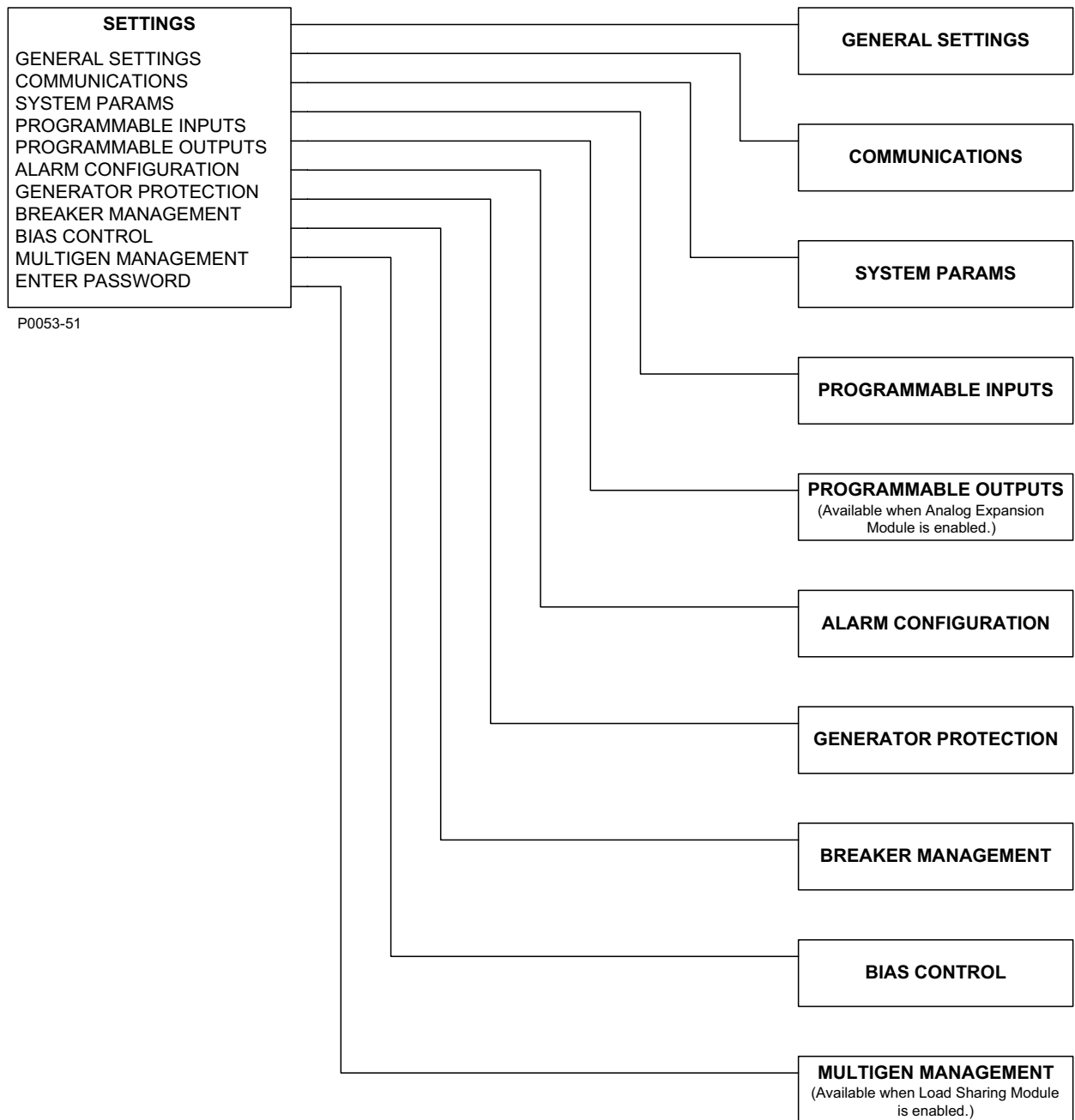


Figure 2-3. Settings Screen Branches

GENERAL SETTINGS	
• FRONT PANEL HMI	○ SUMMARY VIEW ○ SCROLL DELAY ○ PH TOG DELAY ○ LCD CONTRAST ○ SLEEP MODE ○ LANGUAGE ○ CONFIGURABLE METERING
• CONFIGURE DATE/TIME	○ YEAR ○ MONTH ○ DAY ○ HOURS ○ MINUTES ○ SECONDS

- UTC OFFSET
- DST ENABLED
- **VIEW DATE/TIME**
- **VERSION INFO**
 - FIRMWARE VERSION
 - BOOT CODE VERSION
 - SERIAL NUMBER
 - PART NUMBER
 - MODEL NUMBER
 - LANGUAGE VERSION
 - LANGUAGE PART NUM

COMMUNICATIONS

- **CANBUS SETUP**
 - CANBUS SETUP
 - CANBUS ENABLE
 - DTC ENABLE (Visible when CANBUS is enabled.)
 - CANBUS ADDR (Visible when CANBUS is enabled.)
 - ECU OPT SLCT (Visible when CANBUS is enabled.)
 - ECU PULSING (Visible when CANBUS is enabled.)
 - ENG SHTDN TM (Visible when CANBUS is enabled.)
 - PLS CYCL TM (Visible when CANBUS is enabled.)
 - ECU SET TM (Visible when CANBUS is enabled.)
 - RESP TIMEOUT (Visible when CANBUS is enabled.)
 - ECU SETUP (Visible when CANBUS is enabled.)
 - ECU CONF
 - SPEED SELECT PRIMARY (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.)
 - SPD DMAND SRC (Visible when ECU is configured for MTU MDEC.)
 - ENGINE RPM (Visible when ECU is configured for MTU MDEC.)
 - SPEED SETUP (Visible when ECU is configured for MTU ADEC or MTU ECU7.)
 - SPD DMAND SRC
 - ENGNE RPM
 - TEST OVRSPED
 - SPEED UP (Visible when ECU is configured for MTU ECU7.)
 - SPEED DN (Visible when ECU is configured for MTU ECU7.)
 - SPD DMD LIMIT (Visible when ECU is configured for MTU ECU7.)
 - INCREASE IDLE (Visible when ECU is configured for MTU ECU7.)
 - ECU SETUP (Visible when ECU is configured for MTU ADEC or ECU7.)
 - TRIP RESET
 - INT OIL PRIME
 - GOV PRM SW (Visible when ECU is configured for MTU ADEC.)
 - ENG STRT PRIME (Visible when ECU is configured for MTU ECU7.)
 - FAN OVERRIDE (Visible when ECU is configured for MTU ECU7.)
 - MODE SWITCH (Visible when ECU is configured for MTU ECU7.)
 - GOV PARAM SET (Visible when ECU is configured for MTU ECU7.)
 - CAN RATING SW 1 (Visible when ECU is configured for MTU ECU7.)
 - CAN RATING SW 2 (Visible when ECU is configured for MTU ECU7.)
 - DIS CYL CUT 1 (Visible when ECU is configured for MTU ECU7.)
 - DID CYL CUT 2 (Visible when ECU is configured for MTU ECU7.)
- **RS485 SETUP**
 - COMM BAUD
 - COMM PARITY
 - MODBUS ADDR

SYSTEM PARAMS

- **SYSTEM SETTINGS**
 - GEN CONNECT
 - AUTO CONFIG DETECT
 - ENABLE
 - LOW LINE THRESH
 - 1-PH THRESH
 - RATED KW
 - RATED VOLTS

- RATED FREQ
- RATED RPM
- COOLDWN TIME
- OFF MODE COOLDN
- EPS
 - EPS THRESHLD
 - LOW LINE OVERRIDE
 - SCALE FACTOR
- FUEL LVL TYP
- SYSTEM UNITS
- BATTERY VOLT
- FLYWHL TEETH
- SPEED SOURCE
- MAINT RESET
- NFPA LEVEL
- HORN
- 1 PHASE O-RIDE (Visible when 1 PHASE O-RIDE INPUT is selected.)
- RATED PF
- POWER UP DELAY
- RELAY CONTROL
 - START
 - RUN
 - PRESTART
- **REMOTE MODULE SETUP**
 - LSM SETUP
 - LSM ENABLE
 - CANBUS ADDRESS (Visible when LSM-2020 is enabled.)
 - 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
 - CEM SETUP
 - ENABLE
 - OUTPUTS (Visible when CEM-2020 is enabled.)
 - CANBUS 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
 - CAN DEBUG MENU (Visible when CEM-2020 is enabled.)
 - DGC TO CEM BP
 - CEM TO DGC BP

- AEM SETUP
 - ENABLE
 - CANBUS ADDR (Visible when AEM-2020 is enabled.)
 - VERSION INFO (Visible when AEM-2020 is enabled.)
 - FIRMWARE VERSION
 - BOOT CODE VERSION
 - SERIAL NUMBER
 - PART NUMBER
 - MODEL NUMBER
 - BUILD DATE
 - AEM DEBUG MENU (Visible when AEM-2020 is enabled.)
 - DGC TO AEM BP
 - AEM TO DGC BP
 - ANALOG INPUTS
 - SCALED
 - RAW
 - THERMAL INPUTS
 - SCALED
 - RAW
 - ANALOG OUTPUTS
 - SCALED
 - RAW
- **CRANK SETTINGS**
 - DISCNCT LMIT
 - PRECRNK DELY
 - PRESTRT CNTCT
 - STYLE
 - # CYCLES
 - CYCLE TIME
 - PRESTART REST CONFIG
 - 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
 - BUS PT PRI V
 - BUS PT SEC V
- **ENGINE STATISTICS**
 - START YEAR
 - START MONTH
 - START DAY
 - # STARTS
 - HRS TO MAINT
 - KW-HRS
 - TOTAL HRS
 - LOADED HRS
 - UNLOADED HRS

- **CONFIGURABLE INPUTS**

- INPUT X (X = 1 to 26)
 - ALARM CONFIG
 - ACTIVATN DLY
 - RECOGNITION

- **PROG FUNCTIONS**

- AUTO XFER SWITCH
 - INPUT
 - RECOGNITION (Visible when an INPUT is selected.)
- 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 PHASE AC O-RIDE
 - INPUT
 - RECOGNITION (Visible when an INPUT is selected.)
- BATT CHRG FAIL
 - INPUT
 - RECOGNITION (Visible when an INPUT is selected.)
- LOW COOL LEVEL
 - INPUT
 - RECOGNITION (Visible when an INPUT is selected.)
- FUEL LEAK DETECT
 - INPUT
 - RECOGNITION (Visible when an INPUT is selected.)

- **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
 - ALARM CONFIG
 - UNDER 1
 - THRESHOLD
 - ALARM CONFIG
 - UNDER 2
 - THRESHOLD
 - ALARM CONFIG
 - ARMING DELAY
 - THR1 ACT DLY
 - THR2 ACT DLY
 - HYSTERESIS
 - OOR ALM CFG

- **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
- 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

PROGRAMMABLE OUTPUTS (Visible when AEM-2020 is enabled)

- **ANALOG OUTPUTS**
 - 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

ALARM CONFIGURATION

- **PRE-ALARMS**
 - HIGH COOLANT TEMP
 - ENABLE
 - THRESHOLD
 - LOW COOLANT TEMP
 - ENABLE
 - THRESHOLD
 - LOW OIL PRESSURE
 - ENABLE
 - THRESHOLD
 - LOW FUEL LEVEL
 - ENABLE
 - THRESHOLD
 - ENGINE OVERLOAD
 - ENABLE
 - THRESHOLD

- 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
- CHECKSUM FAIL
 - ENABLE
- ACTIVE DTC (Visible when DTC is enabled.)
 - ENABLE
- ECU COMMS FAIL (Visible when CANBUS is enabled.)
 - ENABLE
- COOLANT LEVEL (Visible when CANBUS 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
- **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 CANbus in enabled.)
 - ENABLE
 - THRESHOLD

NOTE

The HIGH COOLANT TEMP and LOW OIL PRESSURE alarms have an ARMING DLY 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
 - 3 / 1 PHASE SETTINGS
 - PICKUP
 - HYSTERESIS
 - TIME DELAY
 - FREQ INHIBIT
 - ALARM CONFIG

- **59 OVERVOLTAGE**

- 59-1 / 59-2
 - LOW LINE SF
 - 3 / 1 PHASE SETTINGS
 - PICKUP
 - HYSTERESIS
 - TIME DELAY
 - ALARM CONFIG

- **47 PHASE IMBALANCE (Optional)**

- PICKUP
- HYSTERESIS TIME DELAY
- ALARM CONFIG

- **81 O/U FREQUENCY**

- UNDERFREQUENCY
 - INHIBIT VOLTS
 - PICKUP
 - HYSTERESIS
 - TIME DELAY
 - ALARM CONFIG
- OVERFREQUENCY
 - PICKUP HYSTERESIS
 - TIME DELAY
 - ALARM CONFIG

- **51 OVERCURRENT (Optional)**

- 51-1 / 51-2 / 51-3
 - LOW LINE OVERRIDE
 - SCALE FACTOR
 - 3 / 1 PHASE SETTINGS
 - PICKUP
 - TIME DIAL

- CURVE
 - ALARM CONFIG
- **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

BREAKER MANAGEMENT

- **BREAKER HARDWARE**
 - MAINS FAIL TRANSFER
 - ENABLE
 - RETURN DELAY
 - TRANSFER DELAY
 - MAX TRANSFER TIME
 - CLOSE WAIT TIME
 - TIME
 - GEN BREAKER
 - CONTINUOUS
 - CLOSING TIME
 - DEAD BUS CL ENBL
 - MAINS BREAKER
 - CONFIGURED
 - CONTINUOUS (Visible when Configured.)
 - CLOSING TIME (Visible when Configured.)
- **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
 - 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
 - BUS FAILED
 - TIME DELAY
- **SYNCHRONIZER**
 - TYPE
 - SLIP FREQ

- REGUL OFFSET
- CLOSING ANGLE
- VG>VB
- TIME DELAY
- FAIL DELAY

BIAS CONTROL

• AVR BIAS CONTROL

- 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
- 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.)
- OUTPUT (Visible when LSM-2020 is enabled.)
 - TYPE
- VOLT CTRL GAINS (Visible when LSM-2020 is enabled and OUTPUT TYPE = ANALOG.)
 - KP
 - KI
 - KD
 - TD
 - LOOP GAIN

• GOV BIAS CONTROL

- CONTACT (Visible when LSM-2020 is disabled or when LSM-2020 is enabled and OUTPUT TYPE = CONTACT.)
 - TYPE
- SPEED TRIM
 - ENABLE
 - 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.)
 - SETPOINT
- KW CTRL
 - LOAD CTRL ENABLE (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.)

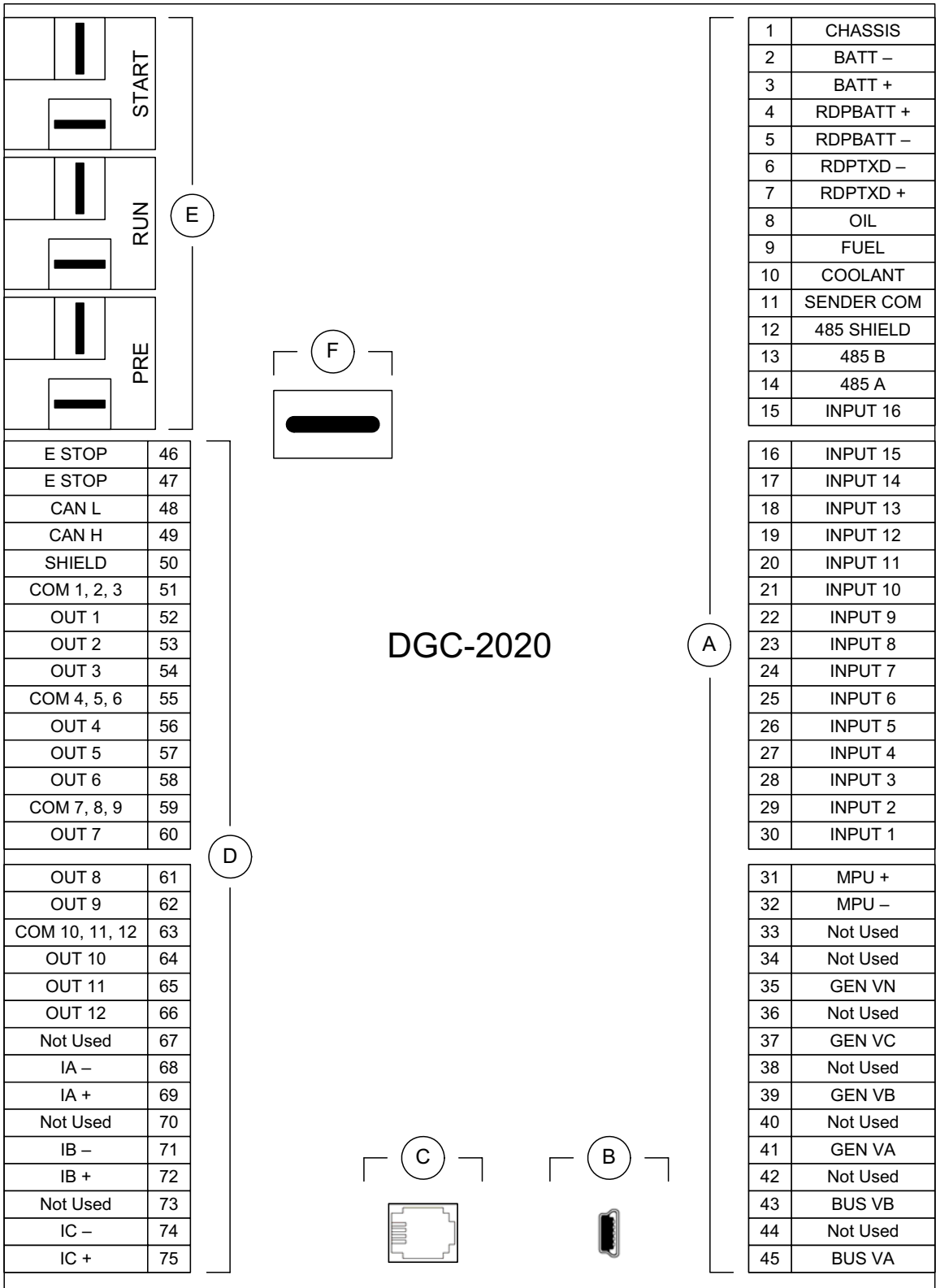
- BL ALG MAX (Visible when LSM-2020 is enabled.)
 - BL ALG MIN (Visible when LSM-2020 is enabled.)
 - BRKR OPEN PT (Visible when LSM-2020 is enabled.)
- OUTPUT (Visible when LSM-2020 is enabled.)
 - TYPE
- **CONTROL DEBUG (Visible when LSM-2020 in enabled.)**

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
- **NETWORK CONFIG**
 - EXP SEQ ID X (X = 1 TO 16)

REAR PANEL

All DGC-2020 terminals and connectors are located on the rear panel. Rear panel terminals and connectors are illustrated in Figure 2-4. (To show the terminals and connectors, Figure 2-4 shows the DGC-2020 with the rear cover removed.) Table 2-2 lists the call-outs of Figure 2-4 along with a description of each connector type.



P0055-28

Figure 2-4. Rear Panel

Table 2-2. Rear Panel HMI Descriptions

Locator	Description
A, D	The majority of external, DGC-2020 wiring is terminated at 15-position connectors with compression terminals. These connectors plug into headers on the DGC-2020. 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.
B	The mini-B USB socket mates with a standard USB cable and is used with a PC running BESTCOMSPPlus software for local communication with the DGC-2020.
C	DGC-2020 controllers with an optional, internal, dial-out modem connect to a telephone line through a USOC RJ-11 jack.
E	Connections to the DGC-2020 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	An optional battery backup for the real-time clock is available when ordering. See Section 7, <i>Maintenance and Troubleshooting</i> , for instructions on replacing the battery. Failure to replace the battery with Basler Electric P/N 38526 may void the warranty.

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SECTION 3 • FUNCTIONAL DESCRIPTION

INTRODUCTION

This section describes how the DGC-2020 functions. A detailed description of each function block is provided in the paragraphs under the heading of DGC-2020 Function Blocks.

DGC-2020 operating and metering features are described in Section 4, *BESTCOMSPPlus Software*.

DGC-2020 FUNCTION BLOCKS

To ease understanding, DGC-2020 functions are illustrated in the block diagram of Figure 3-1. The following paragraphs describe each function in detail.

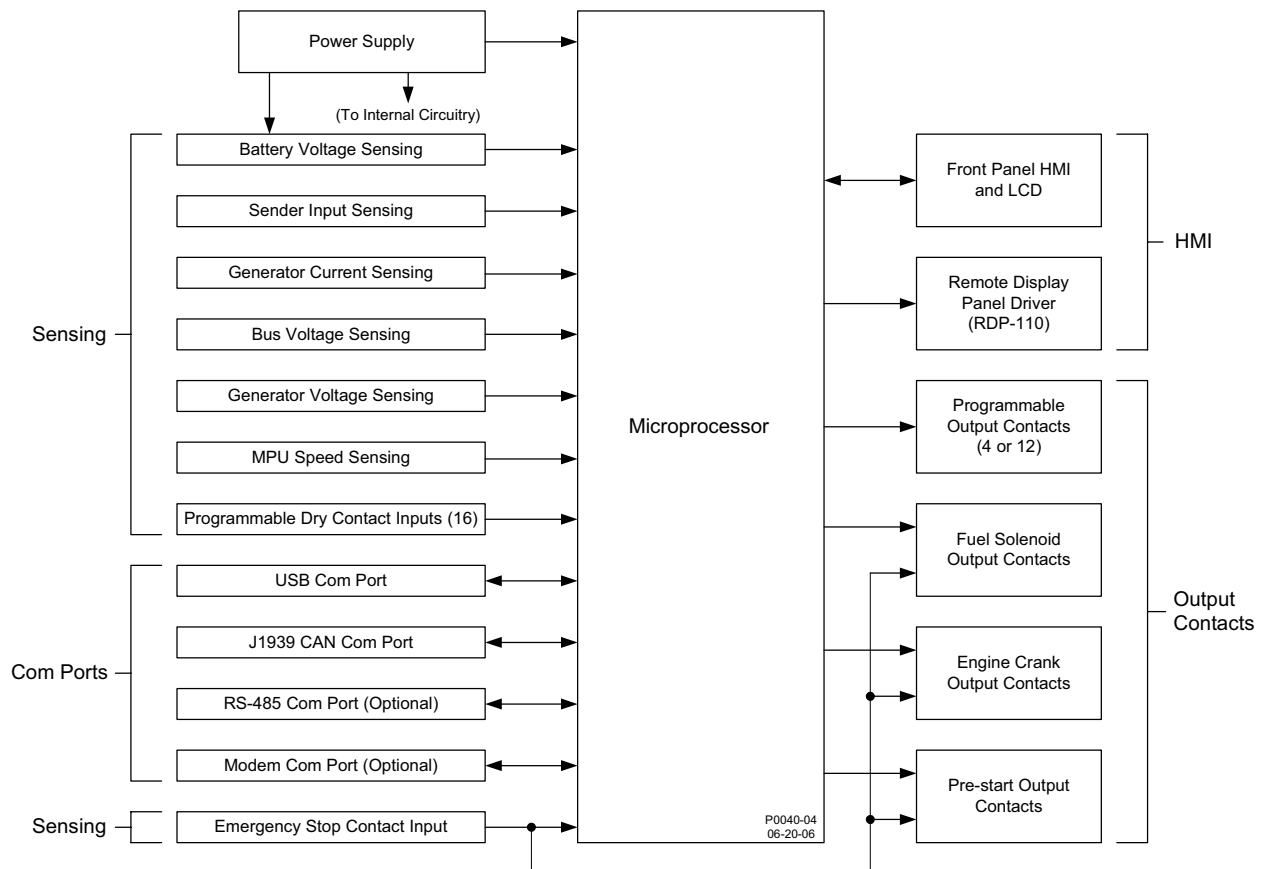


Figure 3-1. Function Block Diagram

Power Supply

The internal, switch-mode power supply uses the applied battery voltage to generate operating power for the internal circuitry of the DGC-2020. 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 DGC-2020 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 DGC-2020 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. Sensing voltage is applied to terminals 45 (A-phase) and 43 (B-phase).

Current Sensing Inputs

Generator currents are sensed and scaled to values suitable for use by the internal circuitry.

DGC-2020 controllers with 1 ampere current sensing (style number 1xxxxxxx) accept a maximum current value of 1 Aac. DGC-2020 controllers with 5 ampere current sensing (style number 5xxxxxxx) 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 DGC-2020 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, *BESTCOMSPlus 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 DGC-2020 to indicate a failed sender. Oil pressure senders that are compatible with the DGC-2020 include Datcon model 02505-00, Isspro model R8919, and Stewart-Warner models 411K and 411M. Other senders may also be used. BESTCOMSPlus software allows for the programming of sender characteristics. See Section 4, *BESTCOMSPlus 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 DGC-2020 to indicate a failed sender. Coolant temperature senders that are compatible with the DGC-2020 include Datcon model 02019-00, Faria model TS4042, Isspro model R8959, and Stewart-Warner model 334P. Other senders may be used. BESTCOMSPlus software allows for the programming of sender characteristics. See Section 4, *BESTCOMSPlus 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 DGC-2020 to indicate a failed sender. Fuel level senders that are compatible with the DGC-2020 include Isspro model R8925. Other senders may be used. BESTCOMSPlus software allows for the programming of sender characteristics. See Section 4, *BESTCOMSPlus Software*, for more information.

Fuel level sender connections are made at terminals 9 and 11 (sender common).

Speed Signal Inputs

The DGC-2020 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 DGC-2020 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 DGC-2020 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 DGC-2020 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 normally open, Form A contacts. A contact is connected between a programmable input and the negative side of the battery. Through BESTCOMSPlus, 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 DGC-2020/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 DGC-2020 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 DGC-2020 meets the requirements of NFPA Standard 110. The RDP-110 uses a dedicated, four-terminal interface with the DGC-2020. The RDP-110 communicates with the DGC-2020 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

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 DGC-2020 as *None*, *Alarm*, or *Pre-Alarm*. See Section 4, *BESTCOMSPlus*, *Programmable Inputs*, *Programmable Functions*, for more information. The light on the RDP-110 will turn on when the input that is assigned to the programmable function is closed, whether the function is configured as *None*, *Alarm*, or *Pre-Alarm*.

Additionally, the RDP-110 indicates when the DGC-2020 is not operating in Auto mode and when the generator is supplying load. For more information about the RDP-110, request product bulletin SNE.

RDP-110 communication connections are made at DGC-2020 terminals 6 (RDP TXD-) and 7 (RDP TXD+). RDP-110 operating power is supplied at DGC-2020 terminals 4 (RDP BATT+) and 5 (RDP BATT-).

Communication Ports

DGC-2020 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 BESTCOMSPlus software. The DGC-2020 is connected to a PC using a standard USB cable. BESTCOMSPlus is a Windows® based communication software package that is supplied with the DGC-2020. A detailed description of BESTCOMSPlus is provided in Section 4, *BESTCOMSPlus Software*.

CANbus

A Control Area Network (CAN) is a standard interface that enables communication between multiple controllers on a common network using a standard message protocol. DGC-2020 controllers have a CANbus interface that supports the SAE J1939 protocol and the MTU protocol.

Applications using an engine-driven generator set controlled by a DGC-2020 may also have an Engine Control Unit (ECU). The CANbus interface allows the ECU and DGC-2020 to communicate. The ECU reports operating information to the DGC-2020 through the CANbus interface. Operating parameters and diagnostic information, if supported by the ECU, are decoded and displayed for monitoring.

The primary use of the CANbus 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 DGC-2020 CANbus interface. These parameters are transmitted via the CANbus 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.

CANbus interface connections are made at 48 (CAN L), 49 (CAN H), and 50 (SHIELD).

Table 3-1. ECU Parameters Obtained from CANbus Interface

ECU Parameter	Metric Units	English Units	Update Rate	Decimal Place	* SPN
Actual engine percent torque	%	%	engine speed dependent	none	513
Air filter differential pressure	kPa	psi	500 ms	100 th	107
Air inlet temperature	kPa	°F	1 s	none	172
Ambient air temperature	°C	°F	1 s	10 th	171
Barometric pressure	kPa	psi	1 s	10 th	108
Battery voltage	Vdc	Vdc	1 s	10 th	168
Boost pressure	kPa	psi	500 ms	none	102
Coolant level	%	%	500 ms	10 th	111
Coolant pressure	kPa	psi	500 ms	10 th	109
Engine coolant temperature	°C	°F	1 s	none	110
Engine intercooler temperature	°C	°F	1 s	none	52
Engine oil level	%	%	500 ms	10 th	98
Engine oil pressure	kPa	psi	500 ms	10 th	100
Engine oil temperature	°C	°F	1 s	10 th	175
Engine speed	rpm	rpm	engine speed dependent	none	190
Exhaust gas temperature	°C	°F	500 ms	10 th	173
Fuel delivery pressure	kPa	psi	500 ms	10 th	94
Fuel rate	liter/hr	gal/hr	100 ms	100 th	183
Fuel temperature	°C	°F	1 s	none	174
Injection control pressure	MPa	psi	500 ms	none	164
Injector metering rail pressure	MPa	psi	500 ms	none	157
Intake manifold temperature	°C	°F	500 ms	none	105
Percent load at current rpm	%	%	50 ms	none	92
Switched battery voltage (at ECU)	Vdc	Vdc	1 s	10 th	158
Throttle (accelerator pedal) position	%	%	50 ms	10 th	91
Total engine hours	hours	hours	requested 1.5 s	100 th	247

ECU Parameter	Metric Units	English Units	Update Rate	Decimal Place	* SPN
Total fuel used	liters	gallons	requested 1.5 s	none	250
Trip fuel	liters	gallons	requested 1.5 s	none	182

* SPN is suspect parameter number.

Table 3-2. Engine Configuration Parameters Obtained from CANbus Interface

ECU Parameter	Metric Units	English Units	Update Rate	Decimal Place	* SPN
Engine speed at high idle point 6	rpm	rpm	5 s	none	532
Engine speed at idle point 1	rpm	rpm	5 s	none	188
Engine speed at point 2	rpm	rpm	5 s	none	528
Engine speed at point 3	rpm	rpm	5 s	none	529
Engine speed at point 4	rpm	rpm	5 s	none	530
Engine speed at point 5	rpm	rpm	5 s	none	531
Gain (Kp) of endspeed governor	%/rpm	%/rpm	5 s	100 th	545
Maximum momentary engine override speed point 7	rpm	rpm	5 s	none	533
Maximum momentary engine override time limit	seconds	seconds	5 s	10 th	534
Percent torque at idle point 1	%	%	5 s	none	539
Percent torque at point 2	%	%	5 s	none	540
Percent torque at point 3	%	%	5 s	none	541
Percent torque at point 4	%	%	5 s	none	542
Percent torque at point 5	%	%	5 s	none	543
Reference engine torque	N•m	ft-lb	5 s	none	544
Requested speed control range lower limit	rpm	rpm	5 s	none	535
Requested speed control range upper limit	rpm	rpm	5 s	none	536
Requested torque control range lower limit	%	%	5 s	none	537
Requested torque control range upper limit	%	%	5 s	none	538

* SPN is suspect parameter number.

CAUTION

When the CANbus is enabled, the DGC-2020 will ignore the following sender inputs: oil pressure, coolant temperature, and magnetic pickup.

Diagnostic Trouble Codes (DTCs)

The DGC-2020 obtains diagnostic engine information from a compatible engine control unit (ECU). The DGC-2020 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 3-3 lists the diagnostic information that the DGC-2020 obtains over the CANbus interface.

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.

Table 3-3. Diagnostic Information Obtained Over the CANbus 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

MTU Fault Codes

A DGC-2020 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 BESTCOMSPPlus 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 DGC-2020 does not have descriptive information about a fault number that was received, the fault description will display as "NO TEXT AVAILABLE". For more detailed information, refer to your MTU documentation.

3, L1 T-FUEL	82, RAIL PRES HI	177, AL LIFEDATA RI
4, L2 T-FUEL	89, ENG SPEED LOW	180, CAN1 NODE LOST
5, L1 T-CHRG AIR	90, IDLE SPEED LOW	181, CAN2 NODE LOST
6, L2 T-CHRG AIR	91, RUNUP SPEED LOW	182, CAN WRONG PARAMS
8, RAIL PRES LOW	92, START SPEED LOW	183, CAN NO PU-DATA
9, L1 T-INTERCOOLER	93, PREHT TMP. LIM 2	184, CAN PUDATA EE-FL
10, L2 T-INTERCOOLER	94, PREHT TMP. LIM 1	185, CAN LESS MAILBXS
15, L1 P-LUBE OIL	95, PRIMING FAULT	186, CAN1 BUS OFF
16, L2 P-LUBE OIL	99, DUMMY FAULT	187, CAN1 ERROR PASSV
19, L1 T-EXHAUST A	100, EDM NOT VALID	188, CAN2 BUS OFF
21, L1 T-EXHAUST B	101, IDM NOT VALID	189, CAN2 ERROR PASSV
23, L1 COOLANT LEVEL	102, INVLD FUEL CNS 1	201, SD T-COOLANT
24, L2 COOLANT LEVEL	103, INVLD FUEL CNS 2	202, SD T-FUEL
30, ENGINE OVERSPEED	104, OP HRS1 INVALID	203, SD T-CHARGE AIR
31, CHRGR1 OVERSPD 1	105, OP HRS2 INVALID	205, SD T-CLNT INTERC
32, CHRGR1 OVERSPD 2	106, ERR REC1 INVALID	208, SD P-CHARGE AIR
33, L1 P-FUELFLT DIF	107, ERR REC2 INVALID	211, SD P-LUBE OIL
44, L1 LEVEL INTRCLR	118, L1 SPPLY VOLT LO	214, SD P-CRANKCASE
45, L2 LEVEL INTRCLR	119, L2 SPPLY VOLT LO	215, SD P-RAIL FUEL
51, L1 T-LUBE OIL	120, L1 SPPLY VOLT HI	216, SD T-LUBE OIL
52, L2 T-LUBE OIL	121, L2 SPPLY VOLT HI	219, SD T-INTAKE AIR
57, L1 P-COOLANT	122, L1 T-ELECTRONIC	220, SD COOLANT LEVEL
58, L2 P-COOLANT	134, 15V POSECU DEFCT	222, SD LVL LKG FUEL
63, L1 P-CRANKCASE	136, 15V NEGECU DEFCT	223, SD LVL INTERCLR
65, L1 P-FUEL	137, L1 5V BUFFR TEST	229, SD ENG SPD SNSRS
66, L2 P-FUEL	138, SENSOR PWR DEFCT	230, SD CRANKSHFT SPD
67, L1 T-COOLANT	139, L1 TE BUFFR TEST	231, SD CAMSHAFT SPD
68, L2 T-COOLANT	140, TE BUF ECU DEFCT	240, SD P-FUEL
69, L1 T-EXTERN 1	142, BANK1ECU DEFECT	245, SD POWER SUPPLY
70, L2 T-EXTERN 1	144, BANK2ECU DEFECT	246, SD T-ELECTRONIC
71, L1 T-EXTERN 2	145, 15V GOODECU DFCT	249, SD CAN STOP
72, L2 T-EXTERN 2	147, AD-TST1ECU DEFCT	250, SD CAN SPD DEMND
73, L1 P-EXTERN 1	149, AD-TST2ECU DEFCT	251, SD CAN UP/DOWN
74, L2 P-EXTERN 1	151, AD-TST3ECU DEFCT	252, SD CAN NOTCH POS
75, L1 P-EXTERN 2	163, SD AUX 2	253, SD CAN OVERRIDE
76, L2 P-EXTERN 2	170, MI MODULE FAIL	254, SD CAN TST OVRSP
77, LIN EXT CLNT LEV	171, MI NOT ACTIVE	260, SD 15V POS SPPLY
78, LIN INTERCLR LEV	172, TBO EXPIRED	261, SD 15V NEG SPPLY
79, L BIN-EXTERN 3	173, MODL WRITE LIMIT	262, SD 5V BUFFR TEST
80, L BIN-EXTERN 4	176, AL LIFEDATA NA	263, SD TE BUFFR TEST
81, RAIL LEAKAGE		264, SD BANK 1 TEST

265, SD BANK 2 TEST	323, WIRING CYLNDR A3	364, STP PWR STG 2
266, SD SPD DEMAND AN	324, WIRING CYLNDR A4	365, STOP MV-WIRING
267, SD SPDTEST BNCH	325, WIRING CYLNDR A5	381, TRAN OUT1 PLNT DEF
269, SD LOAD PLS ANLG	326, WIRING CYLNDR A6	382, TRAN OUT2 PLNT DEF
270, SD SPD DEMAND	327, WIRING CYLNDR A7	383, TRAN OUT3 PLNT DEF
271, SD T-EXTERN 1	328, WIRING CYLNDR A8	384, TRAN OUT4 PLNT DEF
272, SD T-EXTERN 2	329, WIRING CYLNDR A9	385, TRAN OUT5 PLNT DEF
273, SD P-EXTERN 1	330, WIRING CYLNDR A10	386, TRAN OUT6 PLNT DEF
274, SD P-EXTERN 2	331, WIRING CYLNDR B1	390, AL MCR EXCEEDED
275, MD EXT.CLNT LVL	332, WIRING CYLNDR B2	399, INTERFACE ECU
276, MD INTERCLER LVL	333, WIRING CYLNDR B3	400, AL OPN LD DIGIN 1
277, MISDATA BIN-EXT3	334, WIRING CYLNDR B4	401, AL OPN LD DIGIN 2
278, MISDATA BIN-EXT4	335, WIRING CYLNDR B5	402, AL OPN LD DIGIN 3
279, SD CANRES TRIPFL	336, WIRING CYLNDR B6	403, AL OPN LD DIGIN 4
280, SD CAN ALRM RST	337, WIRING CYLNDR B7	404, AL OPN LD DIGIN 5
281, SD ADTEST1 SPPLY	338, WIRING CYLNDR B8	405, AL OPN LD DIGIN 6
282, SD ADTEST2 SPPLY	339, WIRING CYLNDR B9	406, AL OPN LD DIGIN 7
283, SD ADTEST3 SPPLY	340, WIRING CYLNDR B10	407, AL OPN LD DIGIN 8
284, SD CAN LAMP TEST	341, OPN LD CYLNDR A1	408, AL OPN LD DIGIN 9
301, TIMING CYLNDR A1	342, OPN LD CYLNDR A2	410, LO U-PDU
302, TIMING CYLNDR A2	343, OPN LD CYLNDR A3	411, LOLO U-PDU
303, TIMING CYLNDR A3	344, OPN LD CYLNDR A4	412, HI U-PDU
304, TIMING CYLNDR A4	345, OPN LD CYLNDR A5	413, HIHI U-PDU
305, TIMING CYLNDR A5	346, OPN LD CYLNDR A6	434, SD P-AUX 1
306, TIMING CYLNDR A6	347, OPN LD CYLNDR A7	444, SL U-PDU
307, TIMING CYLNDR A7	348, OPN LD CYLNDR A8	450, SD IDLE-END TRQ
308, TIMING CYLNDR A8	349, OPN LD CYLNDR A9	454, SS PWR RED ACT
309, TIMING CYLNDR A9	350, OPN LD CYLNDR A10	468, SD T-AUX 1
310, TIMING CYLNDR A10	351, OPN LD CYLNDR B1	469, SD AUX 1
311, TIMING CYLNDR B1	352, OPN LD CYLNDR B2	470, SD T-ECU
312, TIMING CYLNDR B2	353, OPN LD CYLNDR B3	471, SD COIL CURRENT
313, TIMING CYLNDR B3	354, OPN LD CYLNDR B4	472, AL STOP SD
314, TIMING CYLNDR B4	355, OPN LD CYLNDR B5	474, AL WIRING FO
315, TIMING CYLNDR B5	356, OPN LD CYLNDR B6	475, AL CR TRIG ENG ST
316, TIMING CYLNDR B6	357, OPN LD CYLNDR B7	476, AL CR INIT ERR
317, TIMING CYLNDR B7	358, OPN LD CYLNDR B8	478, AL COMB ALM YEL
318, TIMING CYLNDR B8	359, OPN LD CYLNDR B9	479, AL COMB ALM RED
319, TIMING CYLNDR B9	360, OPN LD CYLNDR B10	480, AL EXT ENG PROT
320, TIMING CYLNDR B10	361, PWR STG FL 1	555, AL CALL MTU FS
321, WIRING CYLNDR A1	362, PWR STG FL 2	
322, WIRING CYLNDR A2	363, STP PWR STG 1	

RS-485 (Optional)

DGC-2020 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 DGC-2020 are listed and defined in Appendix B, *Modbus Communication*. RS-485 port connections are made at DGC-2020 terminals 14 (485A), 13 (485B), and 12 (485 SHIELD).

Modem (Optional)

When equipped with the optional, internal, dial-out modem, the DGC-2020 can be connected to a standard telephone line through its RJ-11 jack. The modem enables the DGC-2020 to dial up to four pager telephone numbers and annunciate conditions selected by the user. These conditions include any DGC-2020 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 DGC-2020. 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 Pre-Start, Crank, and Fuel outputs open. When the Emergency Stop input is closed, all output contacts operate normally.

DGC-2020 output contacts include Pre-Start, Crank, Fuel, and up to 12 standard programmable outputs. Additional output contacts can be accommodated with a CEM-2020 (Contact Expansion Module).

Pre-Start

This output closes to energize the engine glow plugs. The Pre-Start output can be programmed to close up to 30 seconds prior to engine cranking. The Pre-Start 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 Pre-Start can be set to Off, On, or Preheat Before Crank. 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.

Pre-Start output connections are made through terminals located on the Pre-Start relay.

Crank

This output closes when engine cranking is initiated by the DGC-2020 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 1 to 60 seconds.

Crank output connections are made through terminals located on the Crank relay.

Fuel

This output closes when engine cranking is initiated by the DGC-2020. The Fuel output remains closed until an off command or emergency stop command is received.

Fuel output connections are made through terminals located on the Fuel relay.

Programmable

DGC-2020 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 DGC-2020 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 DGC-2020 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 DGC-2020 may be started automatically or “self-start” from an automatic starting feature listed in the following paragraphs. If the DGC-2020 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 BESTCOMSPlus. 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.

BREAKER MANAGEMENT

Introduction

The DGC-2020 is capable of controlling the generator breaker and the mains breaker. Once it is determined that a valid breaker request is available, the DGC-2020 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. BESTCOMSPlus 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+ 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 BESTCOMSPlus or the front panel HMI.
- Logic Request - generated from the PLC (programmable logic controller).

The type of response given for a local request depends on the operating mode of the DGC-2020.

RUN Mode

When in RUN mode, the generator and mains breakers can be closed manually using contact inputs or the breaker buttons on the BESTCOMSPlus *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 the PLC. The generator breaker can be manually controlled using contact inputs and outputs or the breaker buttons on the BESTCOMSPlus *Control* screen.

Breaker Operation

The DGC-2020 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 BESTCOMSPlus. If only the generator breaker is configured (mains breaker not configured) the DGC-2020 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 DGC-2020 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 DGC-2020 will close the generator breaker after verifying that both sides of the generator breaker are stable and the DGC-2020 is synchronizing.

Before the mains breaker can be closed, it must be configured in BESTCOMSPlus. If both the mains and the generator breakers are configured and open, the DGC-2020 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 DGC-2020 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 DGC-2020 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 BESTCOMSPlus is used to set the output contact type to pulses or continuous.

If the breaker does not seem to operate properly, refer to Section 7, *Maintenance and Troubleshooting*.

Synchronizer Operation

The synchronizer acts to align the generator voltage and frequency with that of the bus inputs when the DGC-2020 desires to close the generator to a live, stable bus. Several situations must exist before the synchronizer function will begin to execute:

- The DGC-2020 must include the synchronizer option
- The generator voltage must be stable
- The bus voltage must be stable
- The DGC-2020 must be in the process of initiating a breaker close

Breaker close sources are:

- The DGC-2020 itself when the automatic transfer (ATS) feature is enabled
- The DGC-2020 itself when the Run with Load logic element receives a Start pulse in the programmable logic.
- The DGC-2020 itself when started from a Demand Start as part of demand start/stop and sequencing.
- The DGC-2020 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 DGC-2020 is in AUTO mode. Only the Manual Breaker Close Input Contacts can initiate a breaker closure when the DGC-2020 is in RUN mode.

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.

The best way to tell if the synchronizer is active is to disable the speed trim function, then when it is desired to synchronize check for raise and/or lower pulses coming from the DGC-2020 if the governor or AVR bias control output type is contact, or to 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. 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 the synchronizer does not seem to operate properly, refer to Section 7, *Maintenance and Troubleshooting*.

EVENT RECORDING

An event log retains history of system events in nonvolatile memory. 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 DGC-2020. 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 are retained in the event log.

BESTCOMSPlus can be used to view and/or 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, the 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 3-4 lists all possible event strings (as shown in the event log).

Table 3-4. 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
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
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
ALT WIRE TMP HI P	Alternator Wiring Temp High	Pre-Alarm

Event String	Event Description	Event Type
ATS INPUT CLOSED	ATS Input	Status
AUTO RESTART	Automatic Restart in Progress	Status
AUTO RESTART FAIL A	Automatic Restart Fail	Alarm
BATT CHRG FAIL A	Battery Charger Fail	Alarm
BATT CHRG FAIL P	Battery Charger Fail	Pre-Alarm
BATT OVERVOLT P	Battery Overvoltage	Pre-Alarm
BATTLE OVERRIDE	Battle Override	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 (X = 1 to 8)	Configurable Protection X (X = 1 to 8)	Status
CONF PROT X A (X = 1 to 8)	Configurable Protection X (X = 1 to 8)	Alarm
CONF PROT X P (X = 1 to 8)	Configurable Protection X (X = 1 to 8)	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
DEMAND START	Demand Start Request	Status
DEMAND STOP	Demand Stop Request	Status
DGC HEARTBEAT FAIL P	DGC 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
ECU SHUTDOWN A	ECU Shutdown	Alarm
EMERGENCY STOP A	Emergency Stop	Alarm
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
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 FAIL	Fuel Level Sender Fail	Status
FUEL LEVL SENDR A	Fuel Level Sender Fail	Alarm
FUEL LEVL SENDR P	Fuel Level Sender Fail	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

Event String	Event Description	Event Type
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 PRESSURE IN 1 P	High Pressure Input 1	Pre-Alarm
HI PRESSURE IN 2 P	High Pressure Input 2	Pre-Alarm
HI ECU VOLTS A	High ECU Supply Voltage	Alarm
HI EXHAUST A T P	High Exhaust Temp A	Pre-Alarm
HI EXHAUSE B T P	High Exhaust Temp B	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 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 TERMPERATURE A	High Oil Temp	Alarm
HIGH OIL TEMPERATURE P	High Oil Temp	Pre-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 FUEL DLV PRESSURE A	Low Fuel Delivery Pressure	Alarm
LO ECU VOLTS P	Low ECU Supply Voltage	Pre-Alarm
LO SUPPLY VOLTS P	Low Voltage Supply	Pre-Alarm
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
LOSS REM COMS P	Loss of Remote Module Communication	Pre-Alarm
LOST ECU COMM A	Loss of ECU Communication	Alarm

Event String	Event Description	Event Type
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 Inter-gen Communications Failure	Pre-Alarm
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
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
OVERSPEED A	Overspeed	Alarm
OVERSPEED A	Overspeed	Alarm
PRIMING FAULT P	Priming Fault	Pre-Alarm
PROT SHUTDOWN	Protective Shutdown	Status
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

Event String	Event Description	Event Type
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 A (X = 1 to 8)	User Configurable Analog Input X Out of Range (X = 1 to 8)	Alarm
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
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
SCREEN ERROR	Screen Error	Status
RUNUP SPD LO P	Run Up Speed Low	Pre-Alarm
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
WEAK BATTERY P	Weak Battery	Pre-Alarm

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SECTION 4 • BESTCOMSPlus SOFTWARE

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SECTION 4 • BESTCOMSPlus SOFTWARE

INTRODUCTION

BESTCOMSPlus is a Windows®-based, PC application that provides a user-friendly, graphical user interface (GUI) for use with Basler Electric communicating products. The name BESTCOMSPlus is an acronym that stands for Basler Electric Software Tool for Communications, Operations, Maintenance, and Settings.

BESTCOMSPlus provides the user with a point-and-click means to set and monitor the DGC-2020. The capabilities of BESTCOMSPlus make the configuration of one or several DGC-2020 controllers fast and efficient. A primary advantage of BESTCOMSPlus is that a settings scheme can be created, saved as a file, and then uploaded to the DGC-2020 at the user's convenience.

BESTCOMSPlus uses plug-ins allowing the user to manage several different Basler Electric products. The DGC-2020 is a plug-in for BESTCOMSPlus and must be activated before use.

The DGC-2020 plug-in opens inside the BESTCOMSPlus main shell with the same default logic scheme that is shipped with the DGC-2020. 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+ Programmable Logic is used to program DGC-2020 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 DGC-2020 plug-in with BESTCOMSPlus.

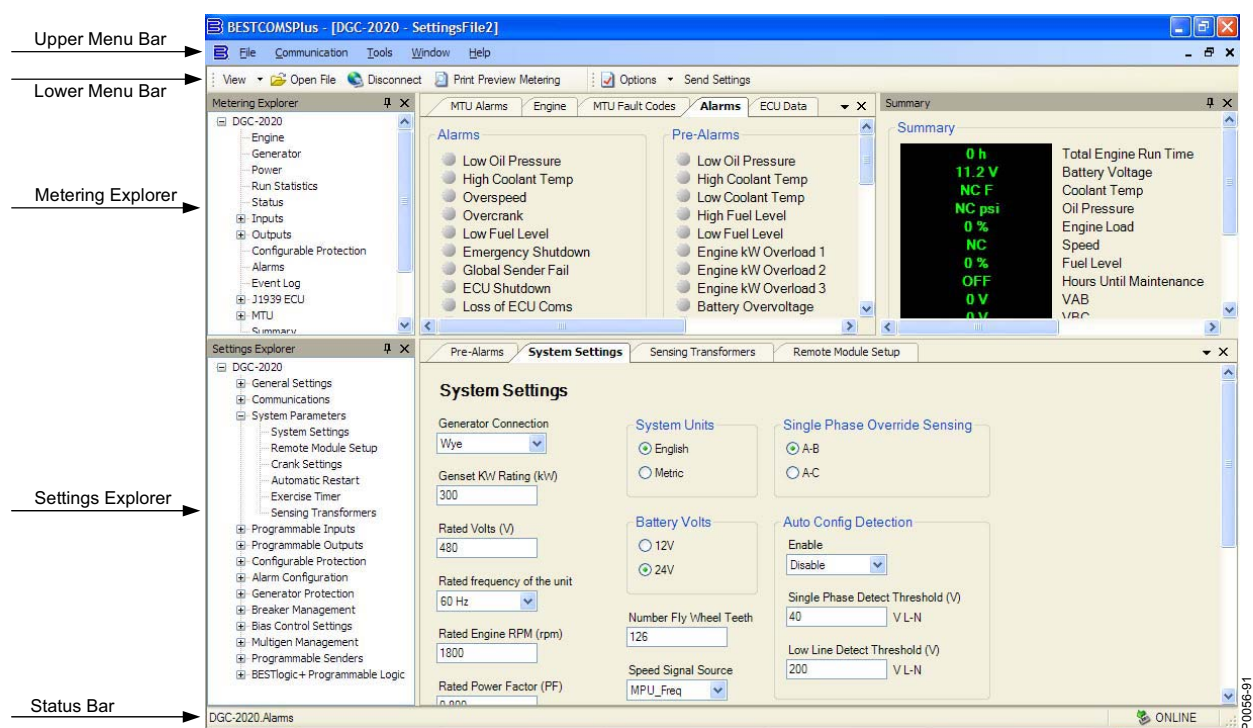


Figure 4-1. Typical User Interface Components

INSTALLATION

BESTCOMSPlus software is built on the Microsoft® .NET Framework. The setup utility that installs BESTCOMSPlus on your PC also installs the DGC-2020 plug-in and the .NET Framework (if not already installed). BESTCOMSPlus operates with IBM-compatible personal computers (PCs) using Windows® 2000, Windows® XP, and Windows® Vista. Microsoft® Internet Explorer 5.01 or later must be installed on your PC before installing BESTCOMSPlus. System requirements for the .NET Framework and BESTCOMSPlus are listed in Table 4-1.

Table 4-1. System Requirements for BESTCOMSPlus and the .NET Framework

Component	Requirement
Processor	400 MHz
RAM	128 MB
Hard Drive	25 MB (if .NET Framework is already installed on PC.)
	250 MB (if .NET Framework is not already installed on PC.)

In order to install and run BESTCOMSPlus, a Windows user must have administrator rights. A Windows user with limited rights may not be permitted to save files in certain folders.

Installing BESTCOMSPlus

NOTE

Do not connect USB cable until setup completes successfully. Connecting USB cable before setup is complete may result in unwanted or unexpected errors.

1. Insert the BESTCOMSPlus CD-ROM into the PC CD-ROM drive.
2. When the BESTCOMSPlus Setup and Documentation CD menu appears, click the Install button for the BESTCOMSPlus application. The setup utility automatically installs BESTCOMSPlus, the .NET Framework (if not already installed), and the DGC-2020 plug-in for BESTCOMSPlus on your PC.

When BESTCOMSPlus 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, when clicked, starts BESTCOMSPlus.

STARTUP AND ACTIVATION

Starting BESTCOMSPlus

To start BESTCOMSPlus, click the *Start* button, *Programs*, *Basler Electric*, and then the *BESTCOMSPlus* icon. During initial startup, the *BESTCOMSPlus Select Language* screen is displayed (Figure 4-2). You can select to have this screen displayed each time BESTCOMSPlus 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 later be accessed by selecting *Tools* and *Select Language* from the menu bar.

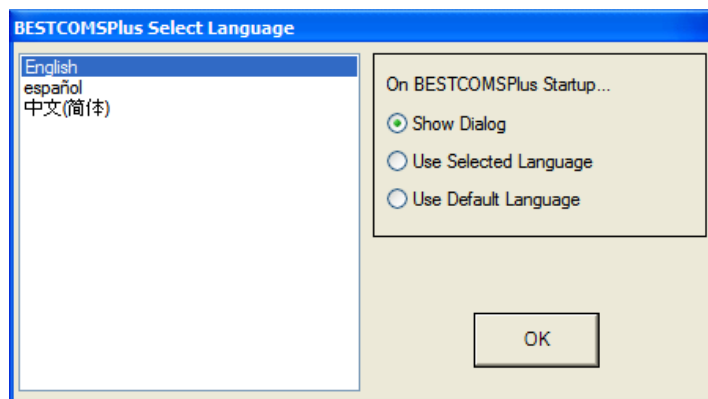


Figure 4-2. BESTCOMSPlus Select Language

The BESTCOMSPlus splash screen is shown for a brief time. See Figure 4-3.



Figure 4-3. Splash Screen

The BESTCOMSPlus platform window opens. If a DGC-2020 is connected, select *New Connection* from the *Communication* pull-down menu and select *DGC-2020*. See Figure 4-4. The DGC-2020 plug-in is automatically activated after connecting to a DGC-2020.

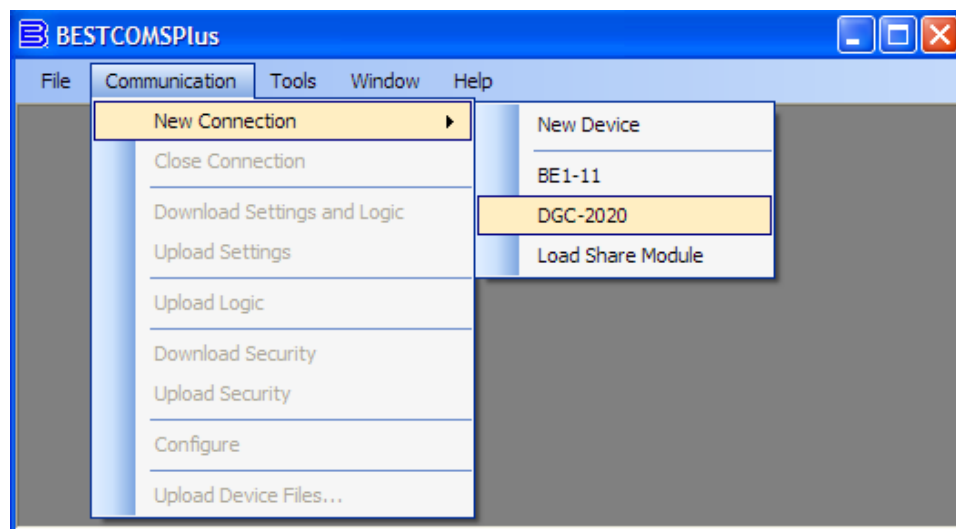


Figure 4-4. Communication Pull-Down Menu

If a DGC-2020 is not connected, select *New* from the *File* pull-down and select *DGC-2020*.

Activating the DGC-2020 Plug-In

The DGC-2020 plug-in must be activated before it can be used to set up a DGC-2020 product. If the DGC-2020 plug-in has already been activated, skip to *Communication*.

Requesting an Activation Key

When initially running the DGC-2020 plug-in, the *Activate Device* pop-up will appear. You must contact Basler Electric for an activation key before you can activate the DGC-2020 plug-in. You may request an activation key through email or the Basler Electric website. Click on either the *Website* or *Email* button.

Click on the *Activate* button when you are ready to enter the activation key you received from Basler Electric. The *Device Needs Activated* pop-up will appear. Refer to Figure 4-5.

Entering an Activation Key

Select the device 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 on the *Activate* button to continue. The *Device Needs Activated* screen is also found by selecting *Activate Device* from the *Tools* pull-down menu of the BESTCOMSPlus main shell.

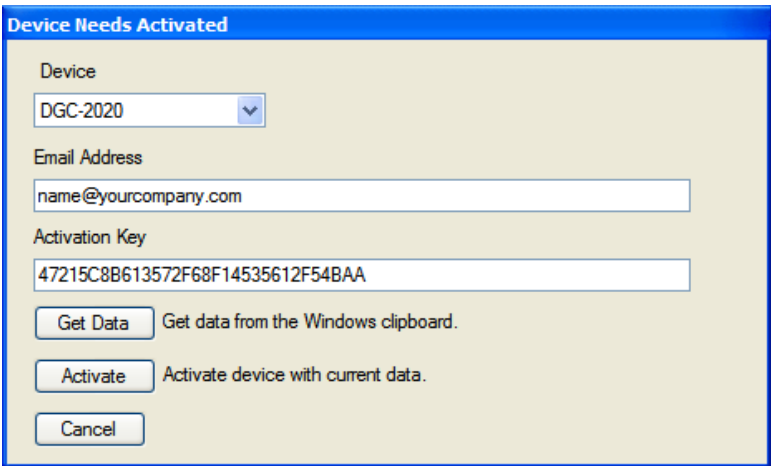


Figure 4-5. Device Needs Activated

COMMUNICATION

If connecting to the DGC-2020 through the USB or modem port, click *Communication* on the menu bar, followed by *New Connection* and *DGC-2020* as shown in Figure 4-6. The *DGC-2020 Connection* screen shown in Figure 4-7 will appear. If Ethernet communication is desired, skip to *Ethernet Communication*.

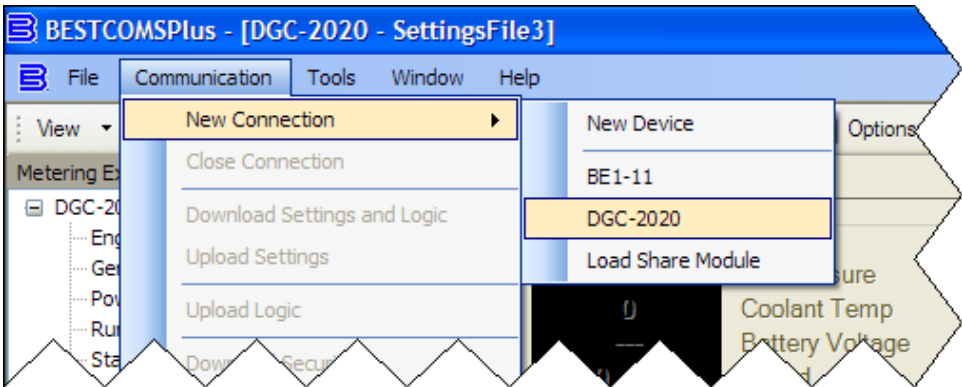


Figure 4-6. Communication, New Connection, DGC-2020

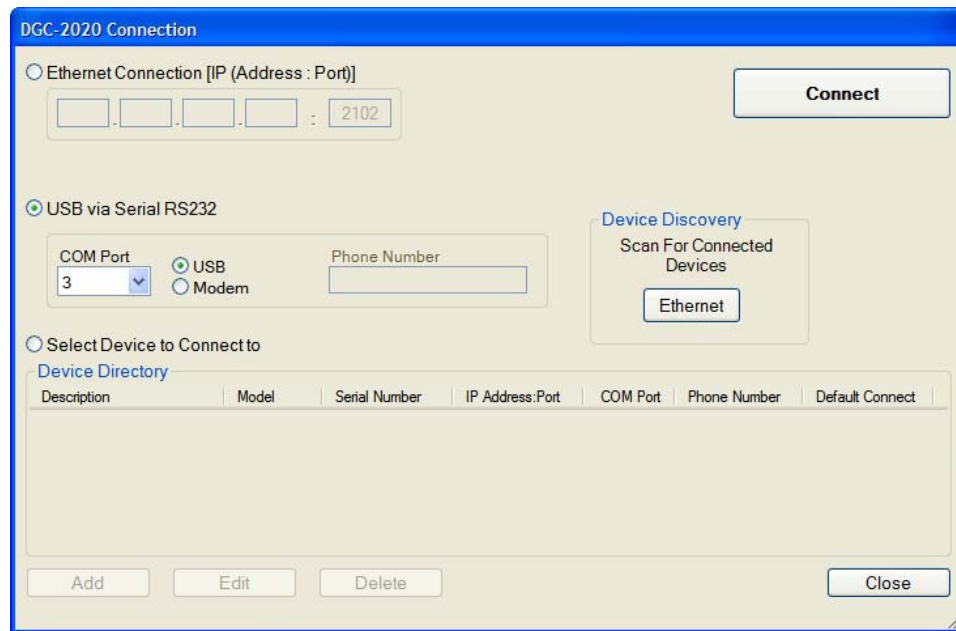


Figure 4-7. DGC-2020 Connection

USB Communication

If connecting to the DGC-2020 through a USB cable, select *USB via Serial RS232*, *USB*, and enter *COM Port*. The USB drivers are installed automatically during the BESTCOMSPlus installation process. To select the correct *COM Port*, open 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 DGC-2020 and the USB cable is connected before opening the Device Manager. See Figure 4-8.

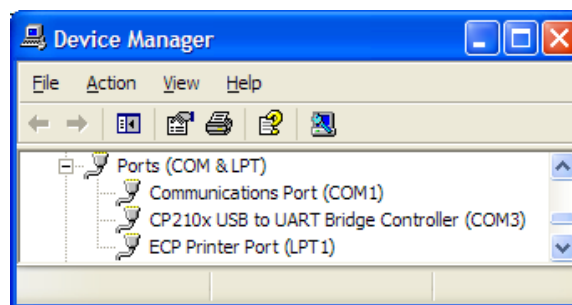


Figure 4-8. Windows® Device Manager

Installing the USB Driver if Automatic Installation Fails

To install the USB driver for the DGC-2020:

1. Apply operating power to the DGC-2020 and wait for the boot sequence to complete.
2. Plug the proper end of the USB cable into the PC and the other end into the DGC-2020.
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 BESTCOMSPlus into the PC CD-ROM drive.
7. Browse to the \driver folder on the CD-ROM and select *Next* to continue.

When installation of the driver is complete, you may be asked to restart your computer.

Modem Communication

If connecting to the DGC-2020 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*.

Ethernet Communication

Communication with the DGC-2020 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. The settings are configured through the DGC-2020 and sent to the LSM-2020 over the CANbus interface. The following procedure is used to configure LSM-2020 network settings and connect to the DGC-2020 through Ethernet via an LSM-2020.

1. Navigate to the *Settings, System Params, System Settings, LSM Setup* screen on the front panel HMI and verify that the LSM-2020 is enabled with the correct CANbus address so that the DGC-2020 and LSM-2020 are properly linked together. If a USB connection to the DGC-2020 is active, the LSM-2020 enable setting and CANbus address can be found by using the Settings Explorer in BESTCOMSPlus to open the *System Parameters, System Settings* tree branch as shown in Figure 4-20. The DGC-2020 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 DGC-2020.
2. Connect to the DGC-2020 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 4-9 will appear.

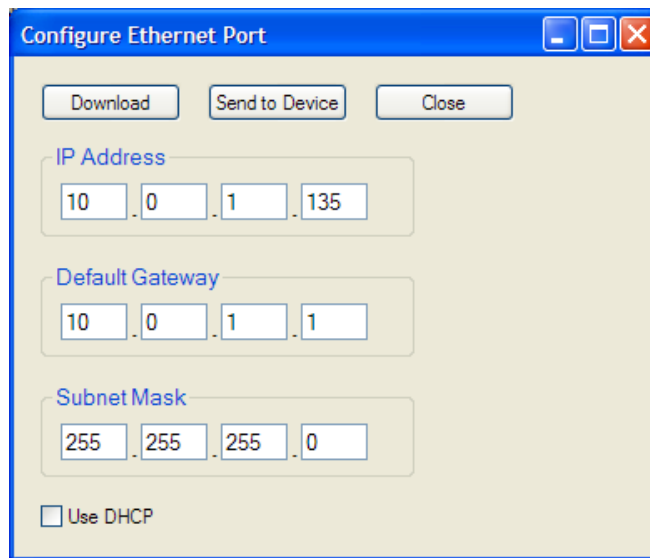


Figure 4-9. Configure Ethernet Port

Configurable options include:

<i>IP Address:</i>	Internet Protocol Address to be used by the LSM-2020.
<i>Default Gateway:</i>	Default host to send data destined for a host not on the network subnet.
<i>Subnet Mask:</i>	Mask used to determine the range of the current network subnet.
<i>Use DHCP:</i>	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 may 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* may 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 DGC-2020. Verify that the downloaded settings match the previously sent settings.
5. Connection to the DGC-2020 can be made through Ethernet via an LSM-2020 with properly configured network settings. When making a new connection to the DGC-2020, the *Ethernet Connection* option shown in Figure 4-7 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.

NOTE

The PC running BESTCOMSPlus software must be correctly configured 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.

NOTE

Microsoft Windows 2000 and XP SP1 contain a potential bug that may prevent device discovery from functioning properly. This issue may present itself if the PC running BESTCOMSPlus has more than one network interface card. See Microsoft® KB article 827536 for more information.

NOTE

Firmware updates to the LSM-2020 are made through the Ethernet port. Firmware updates to the DGC-2020 are only available through the USB port of the DGC-2020.

Establishing Communication

Communication between BESTCOMSPlus and the DGC-2020 is established by clicking on the *Connect* button on the *DGC-2020 Connection* screen (see Figure 4-7) or by clicking on the *Connect* button on the lower menu bar of the main BESTCOMSPlus 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, BESTCOMSPlus will automatically read all settings and logic from the DGC-2020 and load them into BESTCOMSPlus memory. See Figure 4-10.

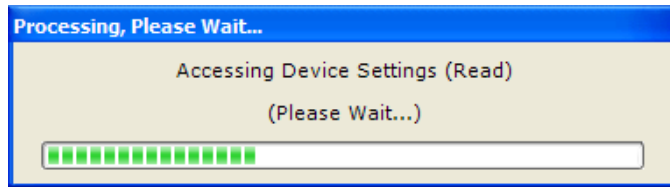


Figure 4-10. Processing, Please Wait...

MENU BARS

The menu bars are located near the top of the BESTCOMSPlus 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, setup communications, 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 BESTCOMSPlus views, open a settings file, connect/disconnect, preview metering printout, switch to live mode, and send a settings file to the DGC-2020.

Upper Menu Bar (BESTCOMSPlus Shell)

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 Preview Preview a settings file printout
- Print To File..... Save as rich text file type (*.rtf)
- Print..... Print 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 BESTCOMSPlus program

Communication

- New Connection Choose new device or DGC-2020
- Close Connection Close communication connection
- Download Settings and Logic..... Download operational and logic settings from the device
- Upload Settings Upload operational settings to the device
- Upload Logic Upload logic settings to the device
- Download Security Download security settings from the device
- Upload Security Upload security settings to the device
- Upload Device Files Upload a device package (firmware/language module)

Tools

- Check For Updates Check for BESTCOMSPlus updates via the internet
- Select Language Select BESTCOMSPlus language
- Activate Device Activate the product instance (DGC-2020 plug-in)
- Set File Password Password protect a settings file
- Compare Settings Files..... Compare settings files
- View Event Log View the BESTCOMSPlus event log
- Clear Event Log Clear the BESTCOMSPlus 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

- About..... View general, detailed build, and system information

Lower Menu Bar (DGC-2020 Plug-In)

View

This clickable icon allows you to view the Metering Panel, Settings Panel, or Show Settings Information.

Open File

This clickable icon is used to open a saved settings file.

Connect/Disconnect

When clicked, the *DGC-2020 Connection* screen opens allowing the user to connect via USB or a modem. This button is also used to disconnect from the device.

Print Preview Metering

Clicking on this icon will bring up the *Print Preview* screen where a preview of the Metering printout is shown. Click on the printer icon to send to a printer.

Options

When clicked, a drop-down list appears. *Live Mode Settings* puts BESTCOMSPlus in *Live* mode where settings are automatically sent to the device in real time as they are changed.

Send Settings

This button is used when BESTCOMSPlus is not operating in Live Mode. Click on this button after making a setting change to send the modified setting to the DGC-2020.

SETTINGS EXPLORER

The Settings Explorer is a convenient tool within BESTCOMSPlus used to navigate through the various settings screens of the DGC-2020 plug-in as listed in the following paragraphs.

Logic setup will be necessary after making certain setting changes. For more information, refer to Section 5, *BESTlogic+ Programmable Logic*.

DGC-2020 AND SYSTEM PARAMETERS

Prior to use, the DGC-2020 must be configured for operation in the intended application. The description of these configuration settings is 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+ Programmable Logic

NOTE

In the following descriptions, superscript letters (e.g., setting^x) mark words and phrases relating to DGC-2020 settings. Each letter references settings illustrated in BESTCOMSPlus. Lettered notes at the end of each group of descriptions provide the range and increment for each setting.

GENERAL SETTINGS

General DGC-2020 settings consist of settings controlling the HMI display and indicators. Additional general settings include style number configuration, DGC-2020 identification, DGC-2020 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 DGC-2020 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 BESTCOMSPlus.

Specific language modules can be uploaded into the DGC-2020. When the language module upload is complete, use the Language^C selector to select the correct language.

When Scrolling Screen is enabled^D, the front panel summary screen will scroll through the list of Scrolling Screen Items^E. The Scrolling Screen Delay^F 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^G 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^H are displayed on the initial boot screen of the DGC-2020.

BESTCOMSPlus front panel HMI settings are illustrated in Figure 4-11.

Front Panel HMI

LCD Contrast Value: 80 ^A

Front Panel Sleep Mode: ☐ Disable ☒ Enable ^B

Language Selection: English ^C

Scrolling Screen Enable: Disable ^D

Scrolling Screen Delay (s): 5 ^F

Phase Toggle Delay (s): 0 ^G

Initializing Message 1: DGC-2020 ^H

Initializing Message 2: ^I

Configurable HMI Summary Settings ^E

Scrolling Screen Item 1: Oil Pressure	Scrolling Screen Item 9: Gen VBC	Scrolling Screen Item 17: Gen KwH
Scrolling Screen Item 2: Coolant Temp	Scrolling Screen Item 10: Gen VCA	Scrolling Screen Item 18: Gen IA
Scrolling Screen Item 3: Battery Volts	Scrolling Screen Item 11: Gen VAN	Scrolling Screen Item 19: Gen IB
Scrolling Screen Item 4: RPM	Scrolling Screen Item 12: Gen VBN	Scrolling Screen Item 20: Gen IC
Scrolling Screen Item 5: RPM Source	Scrolling Screen Item 13: Gen VCN	
Scrolling Screen Item 6: Fuel Level	Scrolling Screen Item 14: Bus Freq	
Scrolling Screen Item 7: Run Time	Scrolling Screen Item 15: Bus Volts	
Scrolling Screen Item 8: Gen VAB	Scrolling Screen Item 16: Gen Freq	

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Figure 4-11. Front Panel HMI Settings

^A LCD Contrast Value: Adjustable from 0 to 100 (maximum contrast) in increments of 1.

^B Front Panel Sleep Mode: Enable or Disable.

^C Language: English, Chinese, or Spanish.

^D Scrolling Screen Enable: Enable or Disable.

^E Configurable HMI Summary Settings: Select Scrolling Screen Item 1 through 20.

^F Scrolling Screen Delay: Adjustable from 1 to 120 s in 1 s increments.

^G Phase Toggle Delay: Adjustable from 0 to 20 s in 1 s increments.

^H Initializing Message 1: Accepts an alphanumeric string of up to 16 characters. Displayed on the second line of the initial boot screen.

^I 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 BESTCOMSPlus is communicating with a DGC-2020, the style number of the DGC-2020 is automatically displayed on the BESTCOMSPlus Style Number tab.

When configuring DGC-2020 settings off-line, the style number for the unit to be configured can be entered into BESTCOMSPlus to enable configuration of the required settings.

BESTCOMSPlus style number selections and definitions are illustrated in Figure 4-12.

Figure 4-12. DGC-2020 Style Chart Selections and Definitions

Device Info

Information about a DGC-2020, LSM-2020 (Load Share Module), and CEM-2020 (Contact Expansion Module) can be obtained when communicating with BESTCOMSPlus.

DGC-2020

Information about a DGC-2020 communicating with BESTCOMSPlus can be obtained on the Device Info tab of BESTCOMSPlus.

Select application version^A when configuring DGC-2020 settings off-line. When on-line, read-only information includes the application version^B, boot code version^C, application build^D, serial number^E, application part number^F, model number^G, Language Module Version^H, and Language Module Part Number^I.

Site-specific information for the DGC-2020 can be assigned by the user. This label includes a device name.

Load Share Module

Information about an LSM-2020 communicating with BESTCOMSPlus can also be obtained on the Device Info tab of BESTCOMSPlus.

When on-line, read-only information includes the application version^K, boot code version^L, application build^M, serial number^N, application part number^O, and model number^P. The *Refresh* button^Q is used to refresh the screen after connecting an optional LSM-2020.

Contact Expansion Module

Information about a CEM-2020 communicating with BESTCOMSPlus can also be obtained on the Device Info tab of BESTCOMSPlus.

When on-line, read-only information includes the application version^R, boot code version^S, application build^T, serial number^U, application part number^V, and model number^W. The *Refresh* button^X is used to update the screen after connecting an optional CEM-2020.

BESTCOMSPlus device information values and settings are illustrated in Figure 4-13.

Analog Expansion Module

Information about an AEM-2020 communicating with BESTCOMSPlus can also be obtained on the Device Info tab of BESTCOMSPlus.

When on-line, read-only information includes the application version^Y, boot code version^Z, application build^{AA}, serial number^{BB}, application part number^{CC}, and model number^{DD}. The *Refresh* button^{EE} is used to update the screen after connecting an optional AEM-2020.

BESTCOMSPlus device information values and settings are illustrated in Figure 4-13.

Device Info

Application Version Number >=1.05.00 A	Application Part Number 9400201020 F
Application Version 1.05.00 B	Model Number DGC-2020 G
Boot Code Version 1.00.00 C	Language Module Version 3.00.00 H
Application Build 2008-02-14 D	Language Module Part Number 9400201021 I
Serial Number [Empty] E	

Identification

Unit Name String DGC-2020 J

Load Share Module

Application Version [Empty] K	Serial Number [Empty] N
Boot Code Version [Empty] L	Application Part Number [Empty] O
Application Build YYYY-MM-DD M	Model Number [Empty] P
Refresh Q	

Contact Expansion Module

Application Version [Empty] R	Serial Number [Empty] U
Boot Code Version [Empty] S	Application Part Number [Empty] V
Application Build YYYY-MM-DD T	Model Number [Empty] W
Refresh X	

Analog Expansion Module

Application Version [Empty] Y	Serial Number [Empty] BB
Boot Code Version [Empty] Z	Application Part Number [Empty] CC
Application Build YYYY-MM-DD AA	Model Number [Empty] DD
Refresh EE	

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Figure 4-13. Device Info Values and Settings

^A *Application Version*: When configuring DGC-2020 settings off-line, the application version for the unit to be configured must be selected. Select <1.00.07, <=1.00.07 & >1.01.00, >=1.01.00 & <1.02.00, or >=1.02.00.

^B *Application Version*: Read-only value obtained when BESTCOMSPlus is communicating with the DGC-2020.

- ^C *Boot Code Version*: Read-only value obtained when BESTCOMSPlus is communicating with the DGC-2020.
- ^D *Application Build*: Read-only value obtained when BESTCOMSPlus is communicating with the DGC-2020.
- ^E *Serial Number*: Read-only value obtained when BESTCOMSPlus is communicating with the DGC-2020.
- ^F *Application Part Number*: Read-only value obtained when BESTCOMSPlus is communicating with the DGC-2020.
- ^G *Model Number*: Read-only value obtained when BESTCOMSPlus is communicating with the DGC-2020.
- ^H *Language Module Version*: Read-only value obtained when BESTCOMSPlus is communicating with the DGC-2020.
- ^I *Language Module Part Number*: Read-only value obtained when BESTCOMSPlus is communicating with the DGC-2020.
- ^J *Device Name*: Accepts an alphanumeric character string of up to 16 characters.
- ^K *Application Version*: Read-only value obtained when BESTCOMSPlus is communicating with an optional LSM-2020.
- ^L *Boot Code Version*: Read-only value obtained when BESTCOMSPlus is communicating with an optional LSM-2020.
- ^M *Application Build*: Read-only value obtained when BESTCOMSPlus is communicating with an optional LSM-2020.
- ^N *Serial Number*: Read-only value obtained when BESTCOMSPlus is communicating with an optional LSM-2020.
- ^O *Application Part Number*: Read-only value obtained when BESTCOMSPlus is communicating with an optional LSM-2020.
- ^P *Model Number*: Read-only value obtained when BESTCOMSPlus is communicating with an optional LSM-2020.
- ^Q *Refresh*: Clicking this button will refresh the screen after connecting an optional LSM-2020.
- ^R *Application Version*: Read-only value obtained when BESTCOMSPlus is communicating with an optional CEM-2020.
- ^S *Boot Code Version*: Read-only value obtained when BESTCOMSPlus is communicating with an optional CEM-2020.
- ^T *Application Build*: Read-only value obtained when BESTCOMSPlus is communicating with an optional CEM-2020.
- ^U *Serial Number*: Read-only value obtained when BESTCOMSPlus is communicating with an optional CEM-2020.
- ^V *Application Part Number*: Read-only value obtained when BESTCOMSPlus is communicating with an optional CEM-2020.
- ^W *Model Number*: Read-only value obtained when BESTCOMSPlus is communicating with an optional CEM-2020.
- ^X *Refresh*: Clicking this button will refresh the screen after connecting an optional CEM-2020.
- ^Y *Application Version*: Read-only value obtained when BESTCOMSPlus is communicating with an optional AEM-2020.
- ^Z *Boot Code Version*: Read-only value obtained when BESTCOMSPlus is communicating with an optional AEM-2020.
- ^{AA} *Application Build*: Read-only value obtained when BESTCOMSPlus is communicating with an optional AEM-2020.
- ^{BB} *Serial Number*: Read-only value obtained when BESTCOMSPlus is communicating with an optional AEM-2020.
- ^{CC} *Application Part Number*: Read-only value obtained when BESTCOMSPlus is communicating with an optional AEM-2020.
- ^{DD} *Model Number*: Read-only value obtained when BESTCOMSPlus is communicating with an optional AEM-2020.
- ^{EE} *Refresh*: Clicking this button will refresh the screen after connecting an optional AEM-2020.

Device Security Setup

Password protection guards against unauthorized changing of DGC-2020 settings. DGC-2020 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
 - Pre-Crank Time Delay
 - Reset of Maintenance Interval
 - All controls on the Control screen available via the Metering Explorer in BESTCOMSPlus

Changing Passwords

Passwords can be changed only after communication between the PC and DGC-2020 is established. Changes to passwords are made through the *Device Security Setup* screen. Use the Settings Explorer in BESTCOMSPlus 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. Figure 4-14 illustrates the *Device Security Setup* screen with all three of the access levels 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.

Access Level	Password
OEM	OEM
Operator	OP
Settings	SET

Selected User Information

Access Level: Settings

Password: SET

Save Password

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Figure 4-14. Device Security Setup

^A *Access Level/Password:* Read-only value obtained when BESTCOMSPlus is communicating with the DGC-2020.

^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.

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. See Figure 4-15.

Figure 4-15. 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).

COMMUNICATIONS

DGC-2020 communication settings include setup parameters for CANbus, ECU, modem, and RS-485 communication.

CANbus Setup

The DGC-2020 CANbus interface provides high-speed communication between the DGC-2020 and the engine control unit (ECU) on an electronically controlled engine. When ECU support is enabled^A, the DGC-2020 will ignore the analog coolant temperature, oil pressure, and engine speed inputs and rely upon the ECU for these parameters. The DGC-2020 will also stop calculating engine run time and begin using the run time recorded by the ECU.

When enabled^B, the DGC-2020 will receive and retain unsolicited diagnostic trouble codes (DTCs) from an ECU with DTC capabilities.

A DGC-2020 operating on a CANbus network is identified by a unique address number^C.

In applications where the ECU is not continuously powered, the DGC-2020 has provisions for applying power to the ECU and pulsing the ECU to update its engine monitoring data. Either the DGC-2020 Fuel Solenoid or Pre-Start relay output can be used to apply power to the ECU^D. If the Pre-Start contact is

selected, the Fuel Solenoid 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^E may be disabled.

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 DGC-2020 Solution

The DGC-2020 resolves ECU limitations by using four timers:

- **Engine Shutdown.**^F 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 DGC-2020 pulses, the ECU will not start the engine.
- **Pulse Cycle Time.**^G The time in minutes that the controller waits before pulsing.
- **Settling Time.**^H 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.**^I The time in seconds to attempt communication with the ECU when the DGC-2020 is in the pulsing state or connecting state.

Figure 4-16. CANbus Setup

^A **Enable ECU Support:** Check box to enable ECU support.

^B **Enable DTC Support:** Check box to enable DTC support.

^C **CANbus Address:** Accepts an address number from 0 to 253 in increments of 1.

^D **Output Select:** Fuel Contact or Pre-start Contact.

^E **Pulsing:** Enable or Disable.

^F **Engine Shutdown:** Adjustable from 1 to 60 s in 1 s increments.

^G **Pulse Cycle Time:** Adjustable from 1 to 60 s in 1 s increments.

^H **Settling Time:** Adjustable from 5,500 to 30,000 ms in 1 ms increments.

^I **Response Timeout:** Adjustable from 1 to 60 s in 1 s increments.

ECU Setup

The DGC-2020 can be configured for Standard, Volvo Penta*, MTU MDEC, MTU ADEC, or MTU ECU7^A. Configuring the DGC-2020 for Volvo Penta necessitates the configuration of two additional settings: Speed Select and Accelerator Position. The Speed Select setting^B 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^C 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 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 DGC-2020 operating power is cycled.

If the engine is configured as MTU MDEC, the configuration of the following settings is necessary:

- MDEC Module Type^D
- Speed Demand Switch^E
- Engine RPM^F

If the engine is configured as MTU ADEC, the configuration of the following settings is necessary:

- Speed Demand Switch^E - Specifies speed demand source for the MTU engine ECU.
- Engine RPM^F - Requested engine RPM when speed demand source is analog CAN for an MTU ECU.
- Overspeed Test^G - Temporarily drives an MTU ECU into overspeed for testing overspeed.
- Governor Param Switch Over^H - Specifies which governor parameters an MTU ECU should use.
- Trip Reset^I - Resets trip information such as trip fuel used, trip hours, trip idle time, etc.
- Int Oil Prime^J - Causes an MTU ECU engine to perform an internal lubrication cycle.

If the engine is configured as MTU ECU7, the configuration of the following settings is necessary:

- Speed Demand Switch^E - Specifies speed demand source for the MTU engine ECU.
- Engine RPM^F - Requested engine RPM when speed demand source is analog CAN for an MTU ECU.
- Overspeed Test^G - Temporarily drives an MTU ECU into overspeed for testing overspeed.
- Speed Up^K - Increases speed of the MTU ECU.
- Speed Down^L - Decreases speed of the MTU ECU.
- Speed Demand Limit^M - Turns the speed demand limit on or off.
- Increased Idle^N - Sets the MTU ECU idle.
- Trip Reset^I - Resets trip information such as trip fuel used, trip hours, trip idle time, etc.
- Int Oil Prime^J - Causes an MTU ECU engine to perform an internal lubrication cycle.
- Engine Start Prime^O - Turns the engine start prime on or off.
- Fan Override^P - Turns the fan override on or off.
- Mode Switch^Q - Turns the mode switch on or off.
- Governor Param Switch Over^H - Specifies which governor parameters an MTU ECU should use.
- Governor Param Set Select^R - Sets the governor parameter set select.
- CAN Rating Switch 1 & 2^S - Turns the CAN rating switch 1 & 2 on or off.
- Cylinder Cutout Disable 1 & 2^T - Turns the cylinder cutout disable 1 & 2 on or off.

*The Volvo Penta ECU configuration is applicable only to the EDC3 and EMS2 models of Volvo Penta engine controllers.

Figure 4-17. ECU Setup

- ^A *ECU Type*: Standard, Volvo Penta, MTU MDEC, MTU ADEC, or MTU ECU7.
- ^B *Speed Select*: Primary or Secondary.
- ^C *Accelerator Position*: Adjustable from 0 to 100% in 1% increments.
- ^D *MDEC Module Type*: CAN Module 201, 302, 303, or 304.
- ^E *Speed Demand Switch*: Analog CAN, Up Down ECU, Up Down CAN, Analog ECU, Frequency, No CAN Demand.
- ^F *Engine RPM*: Adjustable from 1,400 to 2,000 in increments of 1.
- ^G *Overspeed Test*: Off or On.
- ^H *Governor Param Switch Over*: Off or On.
- ^I *Trip Reset*: Press to set.
- ^J *Int Oil Prime*: Press to set.
- ^K *Speed Up*: Press to set.
- ^L *Speed Down*: Press to set.
- ^M *Speed Demand Limit*: Off or On.
- ^N *Increased Idle*: 0 to 1,000 in increments of 1.
- ^O *Engine Start Prime*: Off or On.
- ^P *Fan Override*: Off or On.
- ^Q *Mode Switch*: Off or On.
- ^R *Governor Param Set Select*: 0 to 1,000 in increments of 1.
- ^S *CAN Rating Switch 1 & 2*: Off or On.
- ^T *Cylinder Cutout Disable 1 & 2*: Off or On.

Modem Setup (Optional)

DGC-2020 controllers with style number xxxxxMxxx are equipped with an internal telephone modem that has dial-in and dial-out capability. The modem gives the DGC-2020 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
- 81O Trip Pre-Alarm
- 81U Trip Pre-Alarm
- AEM Comm Failure
- Auto Restart Failure Alarm
- Auxiliary Input X Closed (X = 1 to 16)
- AVR Output Limit
- Battery Charger Fail Status
- Battery Overvoltage Pre-Alarm
- CEM Comm Failure
- Config Element X Status (X = 1 to 8)
- Coolant Temp Sender Fail Alarm
- Coolant Temp Sender Fail Pre-Alarm
- Cooldown Timer Active
- Duplicate AEM Pre-Alarm
- Duplicate CEM Pre-Alarm
- Duplicate LSM Pre-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 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
- 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)
- Weak Battery Voltage Pre-Alarm

Dial-Out

The DGC-2020 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 may be specified.

The message string sent by the DGC-2020 can be limited to a length supported by the receiving pagers^E. If a message to be transmitted by the DGC-2020 exceeds the pager message limit, the DGC-2020 will make multiple calls to transmit the complete message.

Dial-out messages are sent by the DGC-2020 at a user-defined interval^F. This interval gives an operator the opportunity to dial into the DGC-2020. A second user-defined interval^G determines how frequently dial-out attempts are made following a dial-out failure.

Dial-In

When the DGC-2020 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.

Figure 4-18. 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 may be selected.

^H **Rings for Modem Answer:** Adjustable from 1 to 9 in increments of 1.

RS-485 Setup (Optional)

DGC-2020 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, and port address^C. Fixed RS-485 port settings include the number of data bits (8) and stop bits (1).

Modbus register values for the DGC-2020 are listed and defined in Appendix B, *Modbus Communication*.

BESTCOMSPlus RS-485 port settings are illustrated in Figure 4-19.

The image shows a software window titled "RS485 Setup". It contains three configuration fields: "Baud Rate" with a dropdown menu set to "9600 Baud" and a small box labeled "A"; "Parity" with a dropdown menu set to "No Parity" and a small box labeled "B"; and "Modbus Address" with a text input field containing "125" and a small box labeled "C". The window has a light beige background and a thin border. In the bottom right corner, the text "P0042-08" is visible.

Figure 4-19. RS-485 Setup

^A **Baud Rate:** A value of 1200, 2400, 4800, or 9600 may be selected.

^B **Parity:** No Parity, Odd Parity, or Even Parity.

^C **Modbus Address:** A value of 1 to 247 may be entered in increments of 1.

SYSTEM PARAMETERS

System parameters configure the DGC-2020 for operation with a specific application and are divided into three categories: system, engine cranking, and sensing transformers.

System Settings

The following settings are used to configure the DGC-2020 for operation with a specific genset application.

Genset Electrical Parameters

Genset electrical parameters used by the DGC-2020 include the genset connection type, power rating, and voltage rating.

Genset connection types^A accommodated by the DGC-2020 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).

The DGC-2020 is compatible with gensets having power ratings^B up to 9,999 kW and voltage ratings^C up to 9,999 Vac.

The 32 and 40Q protection functions use the Rated Power Factor setting^D when determining pickup.

Engine Speed Measurement

The DGC-2020 can be configured to detect engine speed^E from a magnetic pickup (MPU), the genset frequency, or both the MPU and genset frequency.

When engine speed is obtained from the genset frequency, the DGC-2020 uses the rated (nominal) genset frequency^F and nominal rpm rating^G when calculating engine rpm.

When engine speed is obtained from an MPU, the DGC-2020 uses the nominal rpm rating^F and the number of flywheel teeth^H 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 DGC-2020 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 DGC-2020 to receive the engine speed data sent by the ECU via the SAE J1939 protocol.

Engine Cooldown

After a genset's load is removed, the DGC-2020 can ensure proper engine and turbocharger cooldown by maintaining engine operation for a user-specified duration^I. The cooldown time delay is initiated for any one of the following conditions:

- Genset load is removed and engine shutdown is permitted
- Auto transfer switch (ATS) opens while operating in Auto mode
- Remote shutdown is initiated

Off Mode Cooldown

When Off Mode Cooldown^I is enabled, pressing the DGC-2020 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^J. 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+ or BESTCOMSPlus 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.

After a genset's load is removed, the DGC-2020 can ensure proper engine and turbocharger cooldown by maintaining engine operation for a user-specified duration. The cooldown time delay is initiated for any one of the following conditions:

- Genset load is removed and engine shutdown is permitted
- Auto transfer switch (ATS) opens while operating in Auto mode
- Remote shutdown is initiated

EPS Threshold

Indication that the emergency power system is supplying load is determined by a user-adjustable threshold setting^K expressed as a percentage of the genset CT (nominal) primary rating.

The Low Line Scale Factor setting^L is used to automatically adjust the EPS threshold settings in applications that may utilize more than one type of genset connections. The scale factor setting is implemented when the DGC-2020 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 settings. For example, if a scale factor contact input is received by the DGC-2020 and the scale factor setting is 2.000, the threshold setting will be doubled (2.000 x PU).

Measurement/Metering Units

The user can configure the DGC-2020 to display and report engine oil pressure and coolant temperature in English or metric units of measure^M.

Battery Voltage

The nominal voltage^N of the starter battery is used by the DGC-2020 to detect and annunciate battery overvoltage and low or weak battery voltage.

NFPA Compliance Level

The DGC-2020 can be used in an application requiring compliance with NFPA Standard 110. Levels 1 and 2 of Standard 110 are supported^O. Selecting level 1 or 2 affects DGC-2020 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

Horn

An output contact configured (through programmable logic) to energize a horn^P can be enabled and disabled through BESTCOMSPlus or at the DGC-2020 front panel.

Single-Phase Override

The DGC-2020 will switch to single-phase voltage sensing^Q when a contact input (programmed as a single-phase override input) is received. Either A-to-B or A-to-C sensing can be selected.

Fuel Level Function

This setting^R 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 BESTCOMSPlus.

Power Up Delay

In some cases, the ECU takes longer than the DGC-2020 to power up. The power up delay setting^S is used to delay the initial pulsing of the ECU for data on DGC-2020 power up.

Auto Config Detection

When enabled^T, this feature allows the generator to automatically detect whether the unit is in the configured three-phase configuration, a single-phase AB configuration, or a single-phase AC configuration based on line to neutral (L-N) voltage measurements. Upon starting the genset, the configuration of the generator will be automatically detected and the metering and generator protection will be adjusted accordingly by automatically setting Single Phase Override, Single Phase AC Sense Override, and Low Line Override programmable functions as indicated by the detected Line to Neutral voltages. There is a one-second “debounce” in the detection to prevent the DGC-2020 from bouncing between detected configurations. When the DGC-2020 is in the OFF mode or the engine is not running, the Automatic Configuration Detection is disabled and the DGC-2020 will be assumed to be in the last valid automatically detected configuration.

It is recommended that the Single Phase Override, Single Phase AC Sense Override, and Low Line Override programmable functions not be mapped to contact inputs when Automatic Configuration Detection is enabled.

Single Phase Detection Threshold.^U 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 DGC-2020 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 Detection Threshold.^V 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 DGC-2020 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 Detection Generator Connection.^W 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.

Relay Control

The default operational setting for the Start^X, Run^Y, and Prestart^Z 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+.

BESTCOMSPlus system settings (DGC-2020, System Parameters, System Settings) are illustrated in Figure 4-20.

System Settings

Generator Connection: Wye A

Genset kW Rating (kW): 300 B

Rated Volts (V): 480 C

Rated frequency of the unit: 60 Hz F

Rated Engine RPM (rpm): 1800 G

Rated Power Factor (PF): 0.800 D

Off Mode Cool Down Enable: Disable I

No Load Cool Down Time (min): 0 J

Fuel Level Function: Fuel Lvl R

EPS Supplying Load: EPS Threshold (% of CT Pri): 3 K

Low Line Scale Factor: 1.000 L

System Units: English M

Battery Volts: 24V N

Number Fly Wheel Teeth: 126 H

Speed Signal Source: MPU_Freq E

Power Up Delay (s): 1 S

Horn: Enable P

NFPA Level: Zero O

Single Phase Override Sensing: A-B Q

Auto Config Detection: Enable: Disable T

Single Phase Detect Threshold (V): 40 V-L-L U

Low Line Detect Threshold (V): 200 V-L-L V

Single Phase Detect Generator Connection: A-B W

Relay Control: Start: Predefined X

Run: Predefined Y

Prestart: Predefined Z

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Figure 4-20. System Settings

- ^A Generator Connection: Delta, Wye, 1-Phase A-B, 1-Phase A-C, or Grounded Delta.
- ^B Genset kW Rating: Adjustable from 5 to 9,999 kW in 1 kW increments.
- ^C Rated Volts: Adjustable from 1 to 999 Vac in 1 Vac increments.
- ^D Rated Power Factor: Adjustable from -1 to +1 in increments of 0.001.
- ^E Speed Signal Source: MPU, Gen Freq, or MPU Freq.
- ^F Rated Frequency: 50/60 or 400 Hz.
- ^G Rated Engine RPM: Adjustable from 750 to 3,600 rpm in 1 rpm increments.
- ^H Number Fly Wheel Teeth: Adjustable from 50 to 500 in increments of 1.
- ^I Off Mode Cool Down Enable: Enable or Disable.
- ^J No Load Cool Down Time: Adjustable from 0 to 60 minutes in 1 minute increments.
- ^K EPS Current Threshold: Adjustable from 3 to 10% of the CT primary rating in 1% increments.
- ^L Low Line Scale Factor: Adjustable from 0 to 3.000 in increments of 0.001.
- ^M System Units: English or Metric.
- ^N Battery Volts: 12 or 24 Vdc.
- ^O NFPA Level: 0 disables NFPA compliance, 1 enables Level 1 NFPA compliance, 2 enables Level 2.
- ^P Horn: Enable or Disable.
- ^Q Single Phase Override Sensing: A-B or A-C.
- ^R Fuel Level Function: Disable, Fuel Lvl, Natural Gas, or Liquid Propane.
- ^S Power Up Delay: Adjustable from 0 to 60 seconds in 1 second increments.
- ^T Auto Config Detection: Enable or Disable.
- ^U Single Phase Detect Threshold: Adjustable from 0 to 480 V in 1 V increments.
- ^V Low Line Detect Threshold: Adjustable from 0 to 480 V in 1 V increments.
- ^W Single Phase Detection Generator Connection: A-B or A-C.
- ^X Start: Predefined or Programmable.
- ^Y Run: Predefined or Programmable.
- ^Z Prestart: Predefined or Programmable.

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.

Contact Expansion Module

A J1939 Address^C must be entered when the optional CEM-2020 is enabled^D. Select number of CEM-2020 outputs^E.

Analog Expansion Module

A J1939 Address^F must be entered when the optional AEM-2020 is enabled^G.

BESTCOMSPlus system settings (DGC-2020, System Parameters, Remote Module Setup) are illustrated in Figure 4-21.

Remote Module Setup

Load Share Module

☐ Disable **B**

☒ Enable

LSM J1939 Address

235 **A**

Contact Expansion Module

☐ Disable **D**

☒ Enable

CEM J1939 Address

236 **C**

CEM Outputs

18 Outputs **E**

Analog Expansion Module

☐ Disable **G**

☒ Enable

AEM J1939 Address

237 **F**

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Figure 4-21. Remote Module Setup

^A LSM J1939 Address: Adjustable from 1 to 253 in increments of 1.

^B Load Share Module: Enable or Disable.

^C CEM J1939 Address: Adjustable from 1 to 253 in increments of 1.

^D Contact Expansion Module: Enable or Disable.

^E CEM Outputs: 18 Outputs or 24 Outputs.

^F AEM J1939 Address: Adjustable from 1 to 253 in increments of 1.

^G Analog Expansion Module: Enable or Disable.

Crank Settings

The DGC-2020 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 of the same duration. Continuous cranking^D provides a single, extended engine-starting attempt.

The DGC-2020 uses the engine speed signal (supplied by a magnetic pickup (MPU) or the generator frequency) and the Crank Disconnect Limit setting^E 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^F, 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^G.

The Pre-Start can be configured^H 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^I 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^J, the starter will be disconnected from the engine.

BESTCOMSPlus engine cranking settings (DGC-2020, System Parameters, Crank Settings) are illustrated in Figure 4-22.

Figure 4-22. Engine 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 seconds in 1 second increments.

^D Continuous Crank Time: Adjustable from 5 to 60 seconds in 1 second increments. Controllers configured for NFPA compliance have a 1 to 45 second range.

^E Crank Disconnect Limit: Adjustable from 10 to 100% of nominal engine speed.

^F Pre-Crank Delay: Adjustable from 0 to 30 seconds in 1 second increments.

^G Pre-Start Contact Configuration: Open After Disconnect or Closed While Running.

^H Prestart Rest Configuration: Off During Rest, On During Rest, or Preheat Before Crank.

^I Oil Pressure Crank Disconnect Enable: Disable or Enable.

^J Crank Disconnect Pressure (psi): Adjustable from 3 to 150 psi in increments of 1 psi.

Automatic Restart

If the DGC-2020 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.

BESTCOMSPlus automatic restart settings (DGC-2020, System Parameters, Automatic Restart) are illustrated in Figure 4-23.

Figure 4-23. Automatic Restart Settings

^A Auto Restart Enable: Enable or Disable.

^B Auto Restart Interval: Adjustable from 0.5 to 30 minutes in 0.5 minute 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 may 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 DGC-2020 will close its GEN breaker during the RUN time.

Contact inputs and outputs can be assigned to the function. Refer to Section 5, *BESTlogic+ Programmable Logic*, for more information.

BESTCOMSPlus exercise timer settings (DGC-2020, System Parameters, Exercise Timer) are illustrated in Figure 4-24.

Exercise Timer

Mode: Monthly A

Start Day Of Month: 1 B

Start Day Of Week: Sunday C

Start Hour: 12 D

Start Minute: 30 E

Run Period Hours: 5 F

Run Period Minutes: 30 G

☐ Run with Load H

P0050-36

Figure 4-24. Exercise Timer Settings

^A Mode: Monthly, Weekly, or Daily.

^B Start Day Of Month: Adjustable from 1 to 31 in 1 day increments.

^C Start Day Of Week: Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, or Saturday.

^D Start Hour: Adjustable from 0 to 23 in 1 hour increments.

^E Start Minute: Adjustable from 0 to 59 in 1 minute increments.

^F Run Period Hours: Adjustable from 0 to 23 in 1 hour increments.

^G Run Period Minutes: Adjustable from 0 to 59 in 1 minute increments.

^H Run with Load: Enable or Disable.

Sensing Transformers

Three sets of transformer settings configure the DGC-2020 for operation with a specific system. These settings, along with the generator voltage, generator current, and bus voltage detected by the DGC-2020, enable the DGC-2020 to accurately meter system values, offer generator protection, and synchronize the generator with the bus (style number xxxxxxxA only).

Generator PT Settings

The generator PT settings establish the nominal primary^A (generator side) and secondary^B (DGC-2020 side) voltage levels at the generator voltage-sensing transformer.

Generator CT Setting

The generator CT setting^C 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 of the controller. A DGC-2020 with a style number of 1xxxxxxx uses a nominal CT secondary rating of 1 Aac. A DGC-2020 with a style number of 5xxxxxxx uses a nominal CT secondary rating of 5 Aac.

Bus Transformer Settings

Primary and secondary bus transformer ratings are used by the automatic transfer switch function, which monitors a single-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^D establishes the nominal voltage present at phases A and C of the bus. The secondary setting^E establishes the nominal voltage seen at the bus voltage input of the DGC-2020.

BESTCOMSPlus sensing transformer settings (DGC-2020, System Parameters, Sensing Transformers) are illustrated in Figure 4-25.

Sensing Transformers

Sensing Transformers

Generator PT

Gen PT Primary Volts (V)
480 A

Gen PT Secondary Volts (V)
480 B

Bus PT

Bus PT Primary Volts (V)
480 D

Bus PT Secondary Volts (V)
480 E

Generator CT

Gen CT Primary Amps (A)
500 C

P0053-98

Figure 4-25. Sensing Transformers Parameters

^A Gen PT Primary Volts: Adjustable from 1 to 9999 Vac in 1 Vac increments.

^B Gen PT Secondary Volts: Adjustable from 1 to 480 Vac in 1 Vac increments.

^C Gen CT Primary Amps: Adjustable from 1 to 5,000 Aac in 1 Aac increments.

^D Bus PT Primary Volts: Adjustable from 1 to 9999 Vac in 1 Vac increments.

^E Bus PT Secondary Volts: Adjustable from 1 to 480 Vac in 1 Vac increments.

PROGRAMMABLE INPUTS

DGC-2020 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 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 while the engine is running only.

Contact input status is available in BESTlogic+ Programmable Logic when “None” is selected for Alarm Configuration.

BESTCOMSPlus settings for contact inputs (DGC-2020, Programmable Inputs, Contact Inputs) are illustrated in Figure 4-26.

The screenshot shows a window titled "Contact Inputs" with a reference number "P0053-68" in the top right corner. It contains six input configuration panels, labeled Input #1 through Input #6. Each panel includes the following fields:

- Input #1:** Alarm Configuration (None), Activation Delay (0), Label Text (INPUT_1), Contact Recognition (Always).
- Input #2:** Alarm Configuration (None), Activation Delay (0), Label Text (INPUT_2), Contact Recognition (Always).
- Input #3:** Alarm Configuration (None), Activation Delay (0), Label Text (INPUT_3), Contact Recognition (Always).
- Input #4:** Alarm Configuration (None), Activation Delay (0), Label Text (INPUT_4), Contact Recognition (Always).
- Input #5:** Alarm Configuration (None), Activation Delay (0), Label Text (INPUT_5), Contact Recognition (Always).
- Input #6:** Alarm Configuration (None), Activation Delay (0), Label Text (INPUT_6), Contact Recognition (Always).

Figure 4-26. Contact Inputs Settings

^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 (A-B or A-C). (Note: Applies only when the Single-Phase Override (A-C) input is not invoked.)
- Single-Phase Override (A-C)^F - 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^G - When the selected input is invoked, a user selectable pre-alarm or alarm is annunciated after the activation delay.
- Low Coolant Level^H - When the selected input is invoked, a user selectable pre-alarm or alarm is annunciated after the activation delay.
- Fuel Leak Detect^I - 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+ Programmable Logic when "None" is selected.

BESTCOMSPlus settings for programmable functions (DGC-2020, Programmable Inputs, Programmable Functions) are illustrated in Figure 4-27.

Programmable Functions

Function	Input	Contact Recognition	Alarm Configuration	Activation Delay (s)
Auto Transfer Switch (A)	None	Always		
Grounded Delta Override (B)	None	Always		
Battle Override (C)	None	Always		
Low Line Override (D)	None	Always		
Single Phase Override (E)	None	Always		
Single Phase AC Override (F)	None	Always		
Battery Charger Fail (G)	None	Always	None	0
Low Coolant Level (H)	None	Always	None	0
Fuel Leak Detect (I)	None	Always	None	0

P0050-50

Figure 4-27. Programmable Functions Settings

- ^A **Auto Transfer Switch Input:** Select Input (None, 1-16) and Contact Recognition (Always or While Engine Running Only).
- ^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 AC Override:** Select Input (None, 1-16) and Contact Recognition (Always or While Engine Running Only).
- ^G **Battery Charger Fail:** Select Input (None, 1-16), Alarm Configuration (None, Alarm, Pre-Alarm), Activation Delay (s) (0 to 300 in increments of 1), and Contact Recognition (Always or While Engine Running Only).
- ^H **Low Coolant Level:** Select Input (None, 1-16), Alarm Configuration (None, Alarm, Pre-Alarm), Activation Delay (s) (0 to 300 in increments of 1), and Contact Recognition (Always or While Engine Running Only).
- ^I **Fuel Leak Detect:** Select Input (None, 1-16), Alarm Configuration (None, Alarm, Pre-Alarm), Activation Delay (s) (0 to 300 in increments of 1), and Contact Recognition (Always or While Engine Running Only).

Remote LSM Inputs

An optional LSM-2020 (Load Share Module) provides one configurable^A contact 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.

BESTCOMSPlus settings for the remote LSM input (DGC-2020, Programmable Inputs, Remote LSM Inputs) are illustrated in Figure 4-29.

Figure 4-28. Remote LSM Inputs Settings

^A *Input Type*: Voltage or Current.

^B *Min/Max Input Voltage*: Adjustable from 0 to 10 volts 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.

Remote contact input status is available in BESTlogic+ Programmable Logic when “None” is selected for Alarm Configuration.

BESTCOMSPlus settings for remote contact inputs (DGC-2020, Programmable Inputs, Remote Contact Inputs) are illustrated in Figure 4-29.

Figure 4-29. Remote Contact Inputs Settings

^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. A user-adjustable arming delay^D disables analog input recognition during engine startup. 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.

A remote analog input is disabled when Alarm Configuration is set to “None”. Remote analog input status is available in BESTlogic+ Programmable Logic when “Status Only” is selected.

BESTCOMSPlus settings for remote analog inputs (DGC-2020, Programmable Inputs, Remote Analog Inputs) are illustrated in Figure 4-30. Remote Analog Input #1 is shown.

Remote Analog Input #1

Label Text: ANALOG_INPUT_1 ^A

Arming Delay (s): 0 ^D

Hysteresis (%): 2.0 ^C

Out Of Range Alarm Type: None ^E

Input Type: Voltage ^B

Ranges

Param Min: -9999.0 ^F

Min Input Current (mA): 4.0 ^G

Min Input Voltage (V): 0.0 ^H

Param Max: 9999.0 ^I

Max Input Current (mA): 20.0 ^J

Max Input Voltage (V): 10.0 ^K

Threshold #1

Under Threshold: 0.0 ^M

Over Threshold: 0.0 ^M

Activation Delay (s): 0 ^N

Alarm Configuration: None ^L

Alarm Configuration: None ^L

Threshold #2

Under Threshold: 0.0 ^M

Over Threshold: 0.0 ^M

Activation Delay (s): 0 ^N

Alarm Configuration: None ^L

Alarm Configuration: None ^L

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Figure 4-30. Remote Analog Inputs Settings

^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 percent in increments of 0.1%.

^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: -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 1 V increments.

^I Parm Max: -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 1 V increments.

^L *Alarm Configuration*: None, Alarm, Pre-Alarm, or Status Only.

^M *Threshold*: -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. A user-adjustable arming delay^D disables RTD input recognition during engine startup. 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.

A remote RTD input is disabled when Alarm Configuration is set to “None”. Remote RTD input status is available in BESTlogic+ Programmable Logic when “Status Only” is selected.

BESTCOMSPlus settings for remote RTD inputs (DGC-2020, Programmable Inputs, Remote RTD Inputs) are illustrated in Figure 4-31. Remote RTD Input #1 is shown.

Remote RTD Input #1

Label Text: RTD_INPUT_1 ^A

Arming Delay (s): 0 ^D

Hysteresis (%): 2.0 ^B

Out Of Range Alarm Type: None ^E

RTD Type: 100 Ohm Platinum ^C

Threshold #1

Under

Threshold (F): 0 ^G

Alarm Configuration: None ^F

Over

Threshold (F): 0 ^G

Alarm Configuration: None ^F

Activation Delay (s): 0 ^H

Threshold #2

Under

Threshold (F): 0 ^G

Alarm Configuration: None ^F

Over

Threshold (F): 0 ^G

Alarm Configuration: None ^F

Activation Delay (s): 0 ^H

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Figure 4-31. Remote RTD Inputs Settings

^A *Label Text*: An alphanumeric character string with a maximum of 16 characters.

^B *Hysteresis*: Adjustable from 0 to 100 percent in increments of 0.1%.

^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*: -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. A user-adjustable arming delay^C disables thermocouple input recognition during engine startup.

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”. Remote thermocouple input status is available in BESTlogic+ Programmable Logic when “Status Only” is selected.

BESTCOMSPlus settings for remote thermocouple inputs (DGC-2020, Programmable Inputs, Remote Thermocouple Inputs) are illustrated in Figure 4-32. Remote Thermocouple Input #1 is shown.

Remote Thermocouple Input #1

Label Text: THERM_CPL_1 ^A Arming Delay (s): 0 ^C

Hysteresis (%): 2.0 ^B

Threshold #1

Under: Threshold (F): 32 ^E Alarm Configuration: None ^D

Over: Threshold (F): 32 ^E Alarm Configuration: None ^D Activation Delay (s): 0 ^F

Threshold #2

Under: Threshold (F): 32 ^E Alarm Configuration: None ^D

Over: Threshold (F): 32 ^E Alarm Configuration: None ^D Activation Delay (s): 0 ^F

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Figure 4-32. Remote Thermocouple Inputs Settings

^A Label Text: An alphanumeric character string with a maximum of 16 characters.

^B Hysteresis: Adjustable from 0 to 100 percent in increments of 0.1%.

^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: 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

DGC-2020 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^A.

BESTCOMSPlus settings for contact outputs (DGC-2020, Programmable Outputs, Contact Outputs) are illustrated in Figure 4-33.

Figure 4-33. Contact Outputs Settings

^A *Label Text*: An alphanumeric character string with a maximum of 16 characters.

Configurable Elements

Each of the 8 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.

Elements can be recognized^D always or while the engine is running only.

Configurable element status is available in BESTlogic+ Programmable Logic when “None” is selected for Alarm Configuration.

BESTCOMSPlus settings for the elements (DGC-2020, Programmable Outputs, Configurable Elements) are illustrated in Figure 4-34.

Figure 4-34. Configurable Elements Settings

^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.

BESTCOMSPlus settings for remote contact inputs (DGC-2020, Programmable Outputs, Remote Contact Outputs) are illustrated in Figure 4-35.

Figure 4-35. Remote Contact Outputs Settings

^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 Input Current^F or Min Input Voltage^G and Param Max^H correlates to Max Input Current^I or Max Input Voltage^J.

A remote analog output is disabled when Alarm Configuration is set to “None”. Remote analog output status is available in BESTlogic+ Programmable Logic when “Status Only” is selected.

BESTCOMSPlus settings for remote analog outputs (DGC-2020, Programmable Inputs, Remote Analog Outputs) are illustrated in Figure 4-36. Remote Analog Output #1 is shown.

Figure 4-36. Remote Analog Outputs Settings

^A *Param Selection:* Oil Pressure, Battery Temp, Coolant 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, Analog Input 1-8, RTD Input 1-8, or Thermocouple Input 1-2.

^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*: –9999.0 to +9999.0 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 1 V increments.
^H *Param Max*: –9999.0 to +9999.0 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 1 V increments.

CONFIGURABLE PROTECTION

Configurable protection can be used when the standard protection available with the DGC-2020 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. 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”. Configurable Protection status is available in BESTlogic+ Programmable Logic when “Status Only” is selected.

BESTCOMSPlus settings for configurable protection (DGC-2020, Programmable Outputs, Configurable Protection) are illustrated in Figure 4-37. Configurable Protection #1 is shown.

Figure 4-37. Configurable Protection Settings

- ^A *Label Text*: An alphanumeric character string with a maximum of 16 characters.
^B *Param Selection*: Oil Pressure, Battery Temp, Coolant 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, Analog Input 1-8, RTD Input 1-8, or Thermocouple Input 1-2.
^C *Arming Delay*: Adjustable from 0 to 300 s in 1 s increments.
^D *Hysteresis*: Adjustable from 0 to 1,000 percent in increments of 1%.

^E *Alarm Configuration*: None, Alarm, Pre-Alarm, or Status Only.

^F *Threshold*: -99,999,900 to 99,999,900 in increments of 1.

^G *Activation Delay*: Adjustable from 0 to 300 s in 1 s increments.

ALARM CONFIGURATION

DGC-2020 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:

- Pre-Alarms
- Alarms
- Sender Fail

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 pre-alarms other than weak battery, all displayed annunciations are reset automatically. 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.

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 DGC-2020 pre-alarm is described in the following paragraphs. Pre-alarms may be enabled and adjusted in BESTCOMSPlus or through the front panel HMI.

BESTCOMSPlus pre-alarm settings (DGC-2020, Alarm Configuration, Pre-Alarms) are illustrated in Figure 4-38.

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 BESTCOMSPlus System Settings tab (DGC-2020, 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 BESTCOMSPlus System Settings tab (DGC-2020, 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 fixed threshold setting. If enabled, a battery overvoltage pre-alarm occurs when the battery voltage increases above the threshold setting.

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 DGC-2020 maintenance timer counts

down to zero from the threshold time setting. The maintenance interval pre-alarm can be reset through the DGC-2020 front panel or by using BESTCOMSPlus.

To reset the maintenance interval pre-alarm through the DGC-2020 front panel, navigate to the SETTINGS->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 BESTCOMSPlus, 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 BESTCOMSPlus System Settings tab (DGC-2020, System Parameters, System Settings). The hysteresis setting functions as a pre-alarm dropout by preventing rapid switching of the alarm annunciation.

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.

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 60 seconds.

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.

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.

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 annunciated when the engine oil pressure decreases below the threshold setting for a fixed duration of 10 seconds.

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 DGC-2020 detects a communication problem in the J1939 interface linking the DGC-2020 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 may be enabled to announce the presence of a condition that is causing a DTC to be sent from the ECU to the DGC-2020.

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 DGC-2020 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 DGC-2020 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 DGC-2020 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 may 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 BESTCOMSPlus if needed.
2. If the problem still exists, reload the firmware file with BESTCOMSPlus.
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 may occur after changing firmware versions through BESTCOMSPlus. 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.

Pre-Alarms

High Fuel Level ☒ Disable Threshold (%) 90 Activation Delay (s) 0 ☐ Enable		Low Fuel Level ☒ Disable Threshold (%) 25 ☐ Enable	
Low Battery Voltage ☒ Disable Threshold (V) 20.0 Activation Delay (s) 10 ☐ Enable		High Coolant Temp ☐ Disable Threshold (F) 250 ☒ Enable	
Weak Battery Voltage ☒ Disable Threshold (V) 15.0 Activation Delay (s) 2 ☐ Enable		Low Coolant Temp ☒ Disable Threshold (F) 50 ☐ Enable	
Battery Overvoltage ☒ Disable Threshold (V) 30.0 ☐ Enable		ECU Coms Fail ☒ Disable ☐ Enable	Coolant Level ☒ Disable Threshold (%) 50 ☐ Enable
Maintenance Interval ☒ Disable Threshold (h) 500 ☐ Enable		Active DTC ☒ Disable ☐ Enable	Low Oil Pressure ☐ Disable Threshold (psi) 25 ☒ Enable
Engine kW Overload 1 ☒ Disable ☐ Enable Three Phase Threshold (%) 105 Three Phase Hysteresis (%) 1 Single Phase Threshold (%) 105 Single Phase Hysteresis (%) 1 Low Line Scale Factor 1.000		Engine kW Overload 2 ☒ Disable ☐ Enable Three Phase Threshold (%) 105 Three Phase Hysteresis (%) 1 Single Phase Threshold (%) 105 Single Phase Hysteresis (%) 1 Low Line Scale Factor 1.000	
		Engine kW Overload 3 ☒ Disable ☐ Enable Three Phase Threshold (%) 105 Three Phase Hysteresis (%) 1 Single Phase Threshold (%) 105 Single Phase Hysteresis (%) 1 Low Line Scale Factor 1.000	
AVR Bias Output Limit ☐ Disable Activation Delay (s) 10 ☒ Enable		Intergenset Comm Failure ☐ Disable ☒ Enable	
GOV Bias Output Limit ☐ Disable Activation Delay (s) 10 ☒ Enable		ID Missing ☐ Disable ☒ Enable	
CEM Comm Failure ☐ Disable ☒ Enable		ID Repeat ☐ Disable ☒ Enable	
		Checksum Failure ☐ Disable ☒ Enable	

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Figure 4-38. Pre-Alarms Configuration

^A **High Fuel Level:** Enable or Disable, threshold is adjustable from 0 to 150% in 1 % increments.

^B **Low Battery Voltage:** Enable or Disable, threshold is adjustable from 6 to 12 Vdc (12 Vdc battery) or 12 to 24 Vdc (24 Vdc battery) in 0.1 Vdc increments. Activation delay is adjustable from 1 to 10 s in 1 s increments.

^C **Weak Battery Voltage:** Enable or Disable, threshold is adjustable from 4 to 8 Vdc (12 Vdc battery) or 8 to 16 Vdc (24 Vdc battery) in 0.1 Vdc increments. Activation time delay is adjustable from 1 to 10 s in 1 s increments.

^D **Battery Overvoltage:** Enable or Disable, threshold is adjustable from 12 to 32 Vdc in 0.1 increments.

^E **Maintenance Interval:** Enable or Disable, threshold is adjustable from 0 to 5,000 h in 1 h increments.

^F *Engine kW Overload*: Enable or Disable, threshold is adjustable from 95 to 140% 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 35 to 150°F or 2 to 65°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 3 to 150 psi or 21 to 1,034 kPa in 7 psi or kPa increments. Activation time delay is fixed at 10 s.

^L *ECU Coms Fail*: 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 seconds in 1 second increments.

^O *GOV Bias Output Limit*: Enable or Disable, activation delay is adjustable from 1 to 15 seconds in 1 second 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.

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 DGC-2020 is set to Off mode.

Each DGC-2020 alarm is described in the following paragraphs. Alarms may be enabled and adjusted in BESTCOMSPlus or through the front panel HMI.

BESTCOMSPlus alarm settings (DGC-2020, Alarm Configuration, Alarms) are illustrated in Figure 4-39.

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 instantaneously 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.

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 instantaneously 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.

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.

Note: ECU Support must be enabled on the *Communications, CANbus Setup* screen before this alarm can be configured.

The image shows a software interface titled "Alarms" with five configuration sections. Each section has an "Enable" radio button (selected) and a "Disable" radio button. The sections are:

- High Coolant Temp** (labeled A): Threshold (F) is 275, Arming Delay (s) is 60.
- Low Oil Pressure** (labeled B): Threshold (psi) is 15, Arming Delay (s) is 10.
- Overspeed** (labeled C): Threshold (%) is 110, Activation Delay (ms) is 50.
- Low Fuel Level** (labeled D): Threshold (%) is 2, Activation Delay (s) is 30.
- Low Coolant Level** (labeled E): Threshold (%) is 25.

 The bottom right corner of the screen displays the code "P0053-79".

Figure 4-39. Alarms Configuration

^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 3 to 150 psi or 21 to 1,034 kPa in 7 psi or 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 DGC-2020 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 DGC-2020 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.

BESTCOMSPlus settings for the sender fail functions (DGC-2020, Alarm Configuration, Sender Fail) are illustrated in Figure 4-40.

Figure 4-40. Sender Fail Configuration

^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. DGC-2020 controllers with style number xxxxxxSxx offer standard protection consisting of undervoltage (27), overvoltage (59), overfrequency (81O), underfrequency (81U), reverse power (32), 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) and time overcurrent (51) elements.

The description of generator protection is organized as follows:

- Voltage (27, 59, 47)
- Frequency (81)
- Reverse Power (32)
- Loss of Excitation (40Q)
- Overcurrent (51)

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 (DGC-2020). When a single-phase override contact input is received, the DGC-2020 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 may utilize more than one type of genset connections. The scale factor setting is implemented when the DGC-2020 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 DGC-2020 and the scale factor setting is 2.000, the pickup setting will be doubled ($2.000 \times \text{PU}$).

The element is disabled when Alarm Configuration is set to “None”. Element status is available in BESTlogic+ Programmable Logic when “Status Only” is selected.

BESTCOMSPlus voltage protection settings (DGC-2020, Generator Protection, Voltage, Undervoltage) are illustrated in Figure 4-41. The 27-1 element is shown.

Figure 4-41. Undervoltage Protection Settings

^A *Pickup*: Adjustable from 70 to 576 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 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 to 3.000 in increments of 0.001.

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 (DGC-2020). When a single-phase override contact input is received, the DGC-2020 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 may utilize more than one type of genset connections. The scale factor setting is implemented when the DGC-2020 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 DGC-2020 and the scale factor setting is 2.000, the pickup setting will be doubled ($2.000 \times \text{PU}$).

The element is disabled when Alarm Configuration is set to “None”. Element status is available in BESTlogic+ Programmable Logic when “Status Only” is selected.

BESTCOMSPlus voltage protection settings (DGC-2020, Generator Protection, Voltage, Overvoltage) are illustrated in Figure 4-42. The 59-1 element is shown.

Overvoltage

59-1 Element

Low Line Scale Factor: 1.000 (E)

3 Phase

Pickup (V): 125 (A) V L-L

Hysteresis (V): 2 (D)

Activation Delay (s): 1.0 (B)

Alarm Configuration: None (C)

Single Phase

Pickup (V): 125 (A) V L-L

Hysteresis (V): 2 (D)

Activation Delay (s): 1.0 (B)

Alarm Configuration: None (C)

P0055-02

Figure 4-42. Overvoltage Protection Settings

- ^A **Pickup:** Adjustable from 70 to 576 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 60 Vac in 1 Vac increments.
- ^E **Low Line Scale Factor:** Adjustable from 0 to 3.000 in increments of 0.001.

Phase Imbalance (47)

DGC-2020 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 (DGC-2020). 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.

The element is disabled when Alarm Configuration is set to “None”. Element status is available in BESTlogic+ Programmable Logic when “Status Only” is selected.

BESTCOMSPlus voltage protection settings (DGC-2020, Generator Protection, Voltage, Phase Imbalance) are illustrated in Figure 4-43.

Phase Imbalance

47 Element

Pickup (V): 5 (A)

Hysteresis (V): 1 (D)

Activation Delay (s): 1.0 (B)

Alarm Configuration: None (C)

P0050-40

Figure 4-43. Phase Imbalance Protection Settings

- ^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.

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+ Programmable Logic when “Status Only” is selected.

BESTCOMSPlus frequency protection settings (DGC-2020, Generator Protection, Frequency) are illustrated in Figure 4-44.

Figure 4-44. Frequency Protection Settings

^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 65 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.

Reverse Power Protection (32)

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 CT secondary side (DGC-2020). When a single-phase override contact input is received by the DGC-2020, the reverse power protection settings automatically switch from the three-phase settings to the single-phase reverse power protection settings. The 32 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 32 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+ Programmable Logic when “Status Only” is selected.

BESTCOMSPlus reverse power protection settings (DGC-2020, Generator Protection, Reverse Power) are illustrated in Figure 4-45.

Reverse Power

32 Element

3 Phase

Pickup (%) A

Hysteresis (%) D

Activation Delay (s) B

Alarm Configuration C

Single Phase

Pickup (%) A

Hysteresis (%) D

Activation Delay (s) B

Alarm Configuration C

P0050-42

Figure 4-45. Reverse Power Protection Settings

^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 CT secondary side (DGC-2020). When a single-phase override contact input is received by the DGC-2020, 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 4-46.

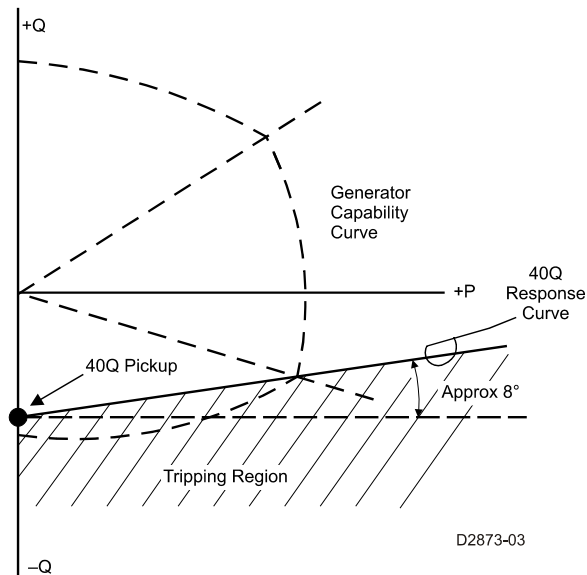


Figure 4-46. Generator Capability Curve vs. 40Q Response

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 DGC-2020 for the approximate tripping region is given by:

$$\text{Tripping Region} = 40\text{Q Pickup} + (1/8) * ((\text{Actual Watts} * 100)/\text{Rated var})$$

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+ Programmable Logic when “Status Only” is selected.

BESTCOMSPlus loss of excitation protection settings (DGC-2020, Generator Protection, Loss of Excitation) are illustrated in Figure 4-47.

Loss of Excitation (40Q)	
3 Phase	Single Phase
Pickup (%) 0 A	Pickup (%) 0 A
Hysteresis (%) 1 D	Hysteresis (%) 1 D
Activation Delay (s) 1 B	Activation Delay (s) 1 B
Alarm Configuration None v C	Alarm Configuration None v C

P0050-43

Figure 4-47. Loss of Excitation Protection Settings

^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 (DGC-2020). When a single-phase override contact input is received by the DGC-2020, 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) 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 BESTCOMSPlus, 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
- A, standard inverse
- B, very inverse
- C, extremely inverse
- D, definite
- E1, extremely inverse
- E2, extremely inverse
- G, long inverse
- I1, inverse
- I2, inverse
- I2, inverse
- L1, long inverse
- L2, long inverse
- M, moderately inverse
- 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 may utilize more than one type of genset connections. The scale factor setting is implemented when the DGC-2020 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 DGC-2020 and the scale factor setting is 2.000, the pickup setting will be doubled ($2.000 \times \text{PU}$).

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+ Programmable Logic when "Status Only" is selected.

BESTCOMSPlus overcurrent protection settings (DGC-2020, Generator Protection, Overcurrent) are illustrated in Figure 4-48. The 51-1 element is shown.

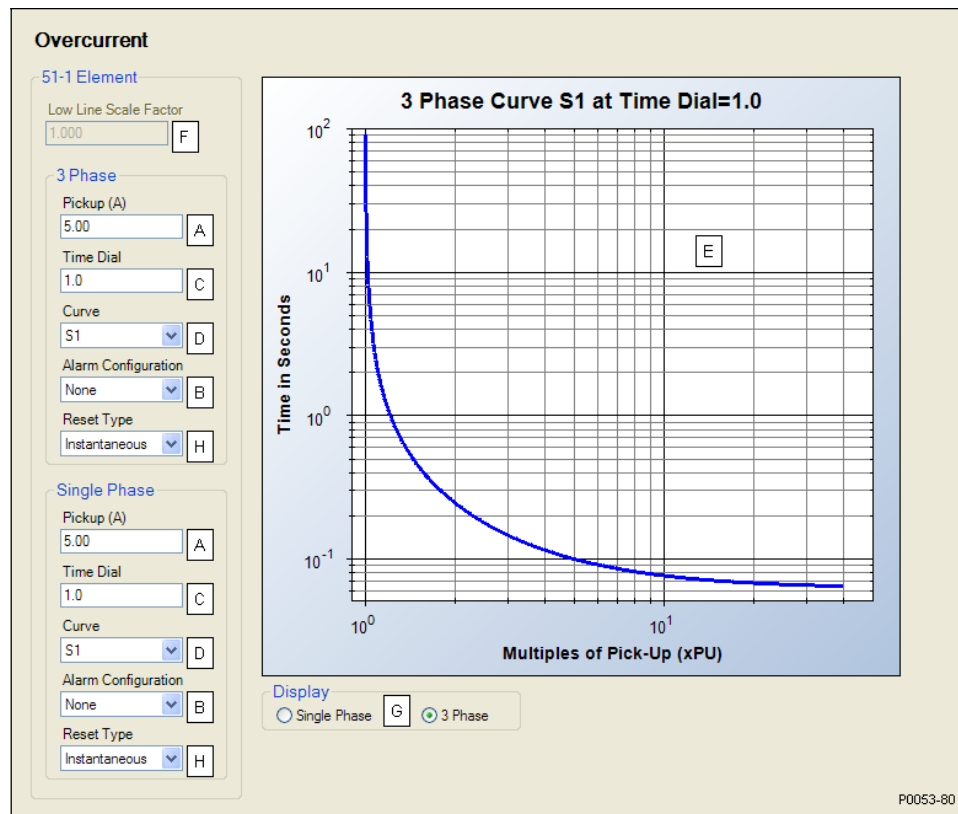


Figure 4-48. Overcurrent Protection Settings

- ^A **Pickup:** Adjustable from 0.9 to 7.75 Aac for 5 Aac current sensing (style number 5xxxxxxx) or 0.18 to 1.18 Aac for 1 Aac current sensing (style number 1xxxxxxx).
- ^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, S1, S2, V1, or V2.
- ^E **Overcurrent Pickup Curve.**
- ^F **Low Line Scale Factor:** Adjustable from 0 to 3.000 in 0.001 increments.
- ^G **Display:** 1 Phase or 3 Phase.
- ^H **Reset Type:** Instantaneous or Integrating.

BREAKER MANAGEMENT

DGC-2020 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
- Bus Condition Detection
- Synchronizer

Breaker Hardware

By default, one (generator) breaker is enabled^A for control and monitoring by the DGC-2020. In applications requiring control of a generator breaker and mains breaker, a second (mains) breaker can be enabled^B and configured.

When two breakers are configured (enabled), the DGC-2020 can be enabled to automatically transfer load power from the mains to the genset during a mains failure^C. This feature also enables the DGC-2020 to transfer the load back to the mains once mains power is restored. Settings include a transfer delay^D, return delay^E, and max transfer time^F.

Breakers controlled by pulse or continuous inputs are supported^G. Separate settings for each breaker's open^H and close^I pulse widths are provided.

During synchronization of the generator with the bus (Anticipatory mode only), the DGC-2020 uses the breaker closing time^J to calculate the optimum time to close the breaker.

When a close command is issued, the DGC-2020 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^K. Typically, this parameter is set to be longer than twice the breaker closing time.

The dead bus close enable setting^L 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.

BESTCOMSPlus breaker hardware settings (DGC-2020, Breaker Management, Breaker Hardware) are illustrated in Figure 4-49.

Breaker Hardware

Mains Fail

Mains Fail Transfer

☒ Disable **C**

☐ Enable

Mains Fail Transfer Delay (s) **D**

Mains Fail Return Delay (s) **E**

Mains Fail Max Transfer Time (s) **F**

Gen and Mains Breaker

Breaker Close Wait Time (s) **K**

Generator Breaker Hardware

Gen Breaker

☐ Not Configured **A**

☒ Configured

Open Pulse Time (s) **H**

Close Pulse Time (s) **I**

Contact Type

☐ Pulse **G**

☒ Continuous

Breaker Closing Time (ms) **J**

Dead Bus Close Enable

☒ Disable **L**

☐ Enable

Mains Breaker Hardware

Mains Breaker

☒ Not Configured **B**

☐ Configured

Open Pulse Time (s) **H**

Close Pulse Time (s) **I**

Contact Type

☐ Pulse **G**

☒ Continuous

Breaker Closing Time (ms) **J**

P0052-46

Figure 4-49. Breaker Hardware Settings

^A Generator Breaker: Configured, NOT Configured.

^B Mains Breaker: Configured or NOT Configured.

^C Mains Fail Transfer: Enable or Disable. This setting does not apply when generator frequency is 400Hz.

^D Mains Fail Transfer Delay: Adjustable from 1 to 300 s in 1 s increments. This specifies the delay between detection of failed mains to initiation of the transfer to the generator.

^E *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.

^F *Mains Fail Max Transfer Time*: Adjustable from 10 to 120 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 DGC-2020. 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.

^G *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.

^H *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 $\geq$ the Breaker Closing Time setting.

^I *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 $\geq$ the Breaker Closing Time setting.

^J *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.

^K *Breaker Close Wait Time*: Adjustable from 0.1 to 600 s in 0.1 s increments. This specifies the amount of time the DGC-2020 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 DGC-2020.

^L *Dead Bus Close Enable*: Enable or Disable.

Bus Condition Detection

DGC-2020 detection of dead bus voltages (for dead bus breaker closure) is controlled by a Dead Bus Threshold setting^A and a Dead Bus Activation Delay setting^B. A dead bus is recognized when the voltage decreases below the threshold setting for the duration of the time delay setting.

Before the DGC-2020 initiates a breaker closure, the generator and mains voltages must be stable. The DGC-2020 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 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^G. Breaker closure is not considered if the voltage conditions do not meet the stability pickup and dropout settings for the duration of the Bus Failed Activation Delay^H setting.

The Bus Stable and Gen Stable overvoltage and undervoltage detection elements have the low line scale factor^I applied to them to enhance versatility for reconfigurable machines.

NOTE

Voltage threshold and pickup settings on the Bus Condition Detection screen are entered in primary values (generator side of VT).

BESTCOMSPlus bus condition detection settings (DGC-2020, Breaker Management, Bus Condition Detection) are illustrated in Figure 4-50.

Bus Condition Detection

Generator Sensing

Gen Condition Settings

Dead Bus Threshold (V) **A** Dead Bus Activation Delay (s) **B**

Bus Stable Activation Delay (s) **G** Bus Failed Activation Delay (s) **H**

Low Line Scale Factor **I**

Gen Stable Overvoltage Settings **C** **Gen Stable Undervoltage Settings** **D**

Pickup (V) V L-L Dropout (V) Pickup (V) V L-L Dropout (V)

Gen Stable Overfrequency Settings **E** **Gen Stable Underfrequency Settings** **F**

Pickup (Hz) Dropout (Hz) Pickup (Hz) Dropout (Hz)

Bus Sensing

Bus Condition Settings

Dead Bus Threshold (V) **A** Dead Bus Activation Delay (s) **B**

Bus Stable Activation Delay (s) **G** Bus Failed Activation Delay (s) **H**

Low Line Scale Factor **I**

Bus Stable Overvoltage Settings **C** **Bus Stable Undervoltage Settings** **D**

Pickup (V) V L-L Dropout (V) Pickup (V) V L-L Dropout (V)

Bus Stable Overfrequency Settings **E** **Bus Stable Underfrequency Settings** **F**

Pickup (Hz) Dropout (Hz) Pickup (Hz) Dropout (Hz)

P0053-96

Figure 4-50. Bus Condition Detection Settings

^A Dead Bus Threshold: Adjustable from 0 to 4,800 Vac in 1 Vac increments.

^B Dead Bus Time Delay: Adjustable from 0.1 to 600 s in 0.1 s increments.

^C Gen and Bus Stable Overvoltage Pickup and Dropout: Adjustable from 10 to 1,200 Vac in 1 Vac increments.

^D Gen and Bus Stable Undervoltage Pickup and Dropout: Adjustable from 10 to 12,000 Vac in 1 Vac increments.

^E Gen and 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 x1xxxxxx).

^F Gen and 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 x1xxxxxx).

^G Bus Stable Activation Delay: Adjustable from 0.1 to 600 in 1 second increments.

^H Bus Failed Activation Delay: Adjustable from 0.1 to 600 in 1 second increments.

^I Low Line Scale Factor: Adjustable from 0 to 3 in increments of 0.001.

Automatic Synchronizer (Optional)

Two methods of generator synchronization are offered: phase lock loop and anticipatory^A. In both methods, the DGC-2020 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 DGC-2020 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.

BESTCOMSPlus automatic synchronizer settings (DGC-2020, Breaker Management, Synchronizer) are illustrated in Figure 4-51.

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. To minimize the impact on the bus during synchronization, the Fgen>Fbus setting^C 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 DGC-2020 will drive the generator frequency higher than the bus frequency before closing the breaker. The breaker closing angle setting^D 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^E.

Voltage Correction

Generator voltage correction is defined by the regulation offset setting^F. 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^G is enabled, the DGC-2020 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^H. 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.

NOTE

If the generator frequency is 400 Hz, the settings on the Synchronizer screen do NOT apply. In this case, BESTCOMSPlus will not allow these settings to be changed.

Figure 4-51. Synchronizer Settings

^A Sync Type: Phase Lock Loop or Anticipatory.

^B Slip Frequency: Adjustable from 0.05 to 0.5 Hz in 0.05 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 Fgen>Fbus: Enable or Disable.

^D *Breaker Closing Angle*: Adjustable from 3 to 20° in 1 ° increments. If Phase Lock Loop synchronization is selected, this specifies the maximum acceptable slip angle under which a breaker close command can be issued.

^E *Sync Activation Delay*: Adjustable from 0.1 to 0.8 seconds in 0.1s increments.

^F *Regulation Offset*: Adjustable from 2 to 15% of nominal generator voltage in 0.5% increments. This specifies the voltage acceptance window for the synchronization function.

^G *Vgen>Vbus*: Enable or Disable.

^H *Sync Fail Activation Delay*: Adjustable from 0.1 to 600 in 0.1 s increments. This is the amount of time the DGC-2020 will allow the synchronizer to attempt to synchronize the generator to the bus before annunciating a Synch 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 DGC-2020.

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 DGC-2020 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 DGC-2020 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 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^E, integral gain^F, derivative gain^G, derivative filter constant^H, and loop gain^I 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+. If Var/PF control is enabled, the generator breaker is closed, the generator is stable, and the Parallel to Mains logic element is TRUE, the Var/PF controller will become active. Whenever these conditions are not TRUE, the Var/PF controller is disabled, and the machine will operate in voltage droop.

When control^J is enabled and the control mode^K is set to Var, the Var setpoint can be derived from either a user setting or an analog input. The DGC-2020 calculates an operating kVar setpoint based on the kVar setpoint source setting^L. When this is set to User Setting, the operating kVar setpoint is equal to the configured kVar setpoint^M. When the kVar setpoint source setting^L 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^N and kVar analog min^O.

When control mode^J is set to PF, the PF setpoint can be derived either from a user setting or from an analog input. The DGC-2020 calculates an operating PF setpoint based on the PF setpoint source setting^P. When this is set to User Setting, the operating PF setpoint is equal to the configured PF setpoint^Q. When the PF setpoint source setting^P 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^R and PF analog min^S.

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^T, integral gain^U, derivative gain^V, derivative filter constant^W, and loop gain^X 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^Y. Voltage droop mode is entered any time the generator breaker is open. Voltage

droop is also the mode when the generator breaker is closed if kW load sharing is disabled. If it is desired to disable voltage droop, set the droop percentage to 0. The voltage droop gain setting^Z 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 may 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^{AA} 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.

BESTCOMSPlus AVR bias control settings (DGC-2020, Bias Control Settings, AVR Bias Control Settings) are illustrated in Figure 4-52.

AVR Bias Control Settings

Bias Control Output Type: A

Bias Control Contact Type: B

Correction Pulse Width (s): C

Correction Pulse Interval (s): D

Voltage

Kp Proportional Gain: E

Ki Integral Gain: F

Kd Derivative Gain: G

Td Derivative Filter Constant: H

Kg Loop Gain: I

Var / PF

Control Enable: J

Control Mode: K

Kp Proportional Gain: T

Ki Integral Gain: U

Kd Derivative Gain: V

Td Derivative Filter Constant: W

Kg Loop Gain: X

Droop Percentage (%): Y

Voltage Droop Gain: Z

Ramp Rate (%/s): AA

kVar Setpoint (%): M

kVar Setpoint Source: L

kVar Analog Max (%): N

kVar Analog Min (%): O

PF Setpoint Source: P

(- Leading / + Lagging)

PF Setpoint: Q

PF Analog Max: R

PF Analog Min: S

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Figure 4-52. 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 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 Control: Disable or Enable.

^K Control Mode: Var Control or PF Control.

^L kVar Setpoint Source: User Setting, LSM Analog Input 1, or Analog Inputs 1-8.

^M kVar Setpoint: Adjustable from -100 to 100 percent in 0.1 % increments.

^N kVar Analog Max: Adjustable from 0 to 100 percent in 0.1 % increments.

^O kVar Analog Min: Adjustable from 0 to 100 percent in 0.1 % increments.

^P PF Setpoint Source: User Setting, LSM Analog Input 1, or Analog Inputs 1-8.

^Q PF Setpoint: Adjustable from -0.60 to 0.60 in increments of 0.01.

^R PF Analog Max: Adjustable from -0.60 to 0.60 in increments of 0.01.

^S PF Analog Min: Adjustable from -0.60 to 0.60 in increments of 0.01.

^T Proportional Gain (Kp): Adjustable from 0 to 1,000 in increments of 0.001.

^U Integral Gain (Ki): Adjustable from 0 to 1,000 in increments of 0.001.

^V Derivative Gain (Kd): Adjustable from 0 to 1,000 in increments of 0.001.

^W Derivative Filter Constant (Td): Adjustable from 0 to 1 in increments of 0.001.

^X Loop Gain (Kg): Adjustable from 0 to 1,000 in increments of 0.001.

^Y Droop Percentage: Adjustable from 0 to 10 percent in 0.001 % increments.

^Z Voltage Droop Gain: Adjustable from 0 to 1,000 in increments of 0.001.

^{AA} Ramp Rate: Adjustable from 0 to 100 percent/second in 0.1 %/s increments.

Governor Bias Control Settings

The bias control output type^A should be set to contact when operating without an optional LSM-2020.

The DGC-2020 adjusts the generator voltage and frequency by issuing speed correction signals to the generator governor. Correction signals are issued in the form of DGC-2020 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. 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 may 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 may conflict, resulting in unpredictable load sharing and system frequency.

BESTCOMSPlus governor bias control settings (DGC-2020, Bias Control Settings, Governor Bias Control Settings) are illustrated in Figure 4-53.

kW Control - Real Power Control Settings

When enabled^L, the DGC-2020, used in conjunction with an optional LSM-2020, can accomplish kW sharing between similarly equipped generators. kW control is disabled when an optional LSM-2020 is not connected.

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^M, integral gain^N, derivative gain^O, derivative filter constant^P, and loop gain^Q 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^R. 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^S 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 may 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^T 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.

When User Setting is selected for the base load level source^U, the base load level setting^V 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+ 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 DGC-2020 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^W and baseload analog min^X.

When the unit unloads, the generator breaker will open when the power generated by the unit falls below the breaker open setpoint^Y.

Figure 4-53. 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 Load Control Enabled: Enable or Disable.
- ^M Proportional Gain (Kp): Adjustable from 0 to 1,000 in increments of 0.001.
- ^N Integral Gain (Ki): Adjustable from 0 to 1,000 in increments of 0.001.
- ^O Derivative Gain (Kd): Adjustable from 0 to 1,000 in increments of 0.001.

- ^P *Derivative Filter Constant (Td)*: Adjustable from 0 to 1 in increments of 0.001.
^Q *Loop Gain (Kg)*: Adjustable from 1 to 1,000 in increments of 0.001.
^R *Droop Percentage*: Adjustable from 0 to 10 percent in 0.001 % increments.
^S *Speed Droop Gain*: Adjustable from 0 to 1,000 in increments of 0.001.
^T *Ramp Rate*: Adjustable from 0 to 100 percent/second in 0.1 %/s increments.
^U *Base Load Level Source*: User Setting, LSM Analog Input 1, or Analog Inputs 1-8.
^V *Base Load Level*: Adjustable from 0 to 100 percent in 1 % increments.
^W *Baseload Analog Max*: Adjustable from 0 to 100 percent in 0.1 % increments.
^X *Baseload Analog Min*: Adjustable from 0 to 100 percent in 0.1% increments.
^Y *Breaker Open Setpoint*: Adjustable from 0 to 1,000 in increments of 1.

MULTIGEN MANAGEMENT

This group of settings is used when an optional LSM-2020 (Load Share Module) is connected to the DGC-2020. 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.

BESTCOMSPlus AVR output settings (DGC-2020, Multigen Management, AVR Output) are illustrated in Figure 4-54.

Figure 4-54. AVR Output Settings

- ^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 0.1 V increments.
^F *Max Output Voltage*: Adjustable from –10 to +10 V in 0.1 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.

BESTCOMSPlus governor output settings (DGC-2020, Multigen Management, Governor Output) are illustrated in Figure 4-55.

Governor Output

Output Type: Voltage A

Response: Increasing B

Min Output Current (mA): 4 C

Max Output Current (mA): 20 D

Min Output Voltage (V): -10 E

Max Output Voltage (V): 10 F

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Figure 4-55. Governor Output Settings

- ^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 0.1 V increments.
- ^F **Max Output Voltage:** Adjustable from –10 to +10 V in 0.1 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.

BESTCOMSPlus load share output settings (DGC-2020, Multigen Management, Load Share Output are illustrated in Figure 4-56.

Load Share Output

Max Voltage (V): 0 A

Min Voltage (V): 0 B

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Figure 4-56. Load Share Output

- ^A **Max Voltage:** Adjustable from –10 to +10 V in 0.1 V increments.
- ^B **Min Voltage:** Adjustable from –10 to +10 V in 0.1 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.

BESTCOMSPlus demand start/stop settings (DGC-2020, Multigen Management, Demand Start/Stop) are illustrated in Figure 4-57.

Figure 4-57. 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 seconds 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 seconds 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.

BESTCOMSPlus generator sequencing settings (DGC-2020, Multigen Management) are illustrated in Figure 4-58.

The available sequencing modes are defined in the following paragraphs.

Disabled

This is the only mode that may 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.

Generator Sequencing

Mode
Smallest Unit ID First [A]

Sequencing ID
0 [D]

Max Gen Start Time Sec (s)
60 [B]

Max Gen Stop Time Sec (s)
60 [C]

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Figure 4-58. 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 seconds in 1 s increments.

^C **Max Gen Stop Time:** Adjustable from 1 to 3,000 seconds in 1 s increments.

^D **Sequencing ID:** Adjustable from 0 to 255 in increments of 1.

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 BESTCOMSPlus 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 BESTCOMSPlus metering screen.

BESTCOMSPlus network configuration settings (DGC-2020, Multigen Management, Network Configuration) are illustrated in Figure 4-59.

Network Configuration

Expected Seq Id 1	Expected Seq Id 9
0 A	0
Expected Seq Id 2	Expected Seq Id 10
0	0
Expected Seq Id 3	Expected Seq Id 11
0	0
Expected Seq Id 4	Expected Seq Id 12
0	0
Expected Seq Id 5	Expected Seq Id 13
0	0
Expected Seq Id 6	Expected Seq Id 14
0	0
Expected Seq Id 7	Expected Seq Id 15
0	0
Expected Seq Id 8	Expected Seq Id 16
0	0

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Figure 4-59. Network Configuration Settings

^A Expected Seq Id: Adjustable from 0 to 255.

PROGRAMMABLE SENDERS

The sender inputs of the DGC-2020 can be customized to obtain maximum accuracy from the coolant temperature, oil pressure, and fuel level senders.

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)^B, 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 BESTCOMSPlus, which can be printed^D.

Sender curve points configured in BESTCOMSPlus can be saved in the configuration file^E. The data for all three senders is automatically saved with the DGC-2020 configuration file.

Any changes made in BESTCOMSPlus to the sender points, can be reverted to the factory-default values^F. A new settings file can also be created^G.

BESTCOMSPlus programmable sender settings (DGC-2020, Programmable Senders, Coolant Temperature, Oil Pressure, or Percent Fuel Level) are illustrated in Figure 4-60. (The contents and layout of each BESTCOMSPlus programmable sender screen is identical; only the coolant temperature sender screen is illustrated here.)

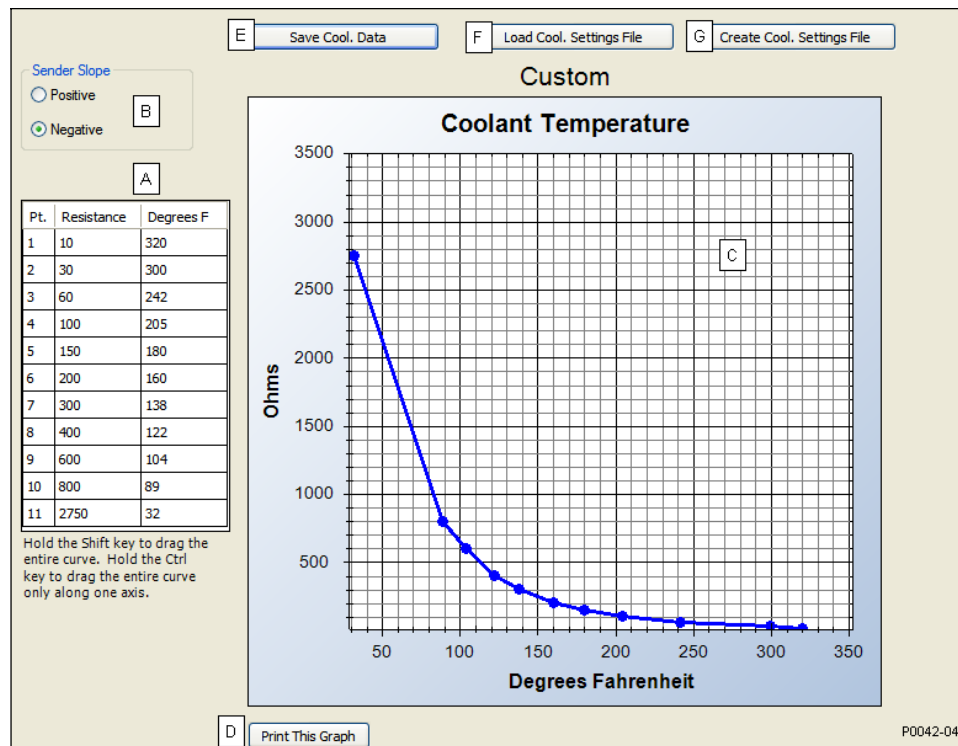


Figure 4-60. Programmable Senders Settings

- ^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+ PROGRAMMABLE LOGIC

BESTlogic+ Programmable Logic is used to set all logic functions in the DGC-2020. For detailed information on using BESTlogic+, refer to Section 5, *BESTlogic+ Programmable Logic*.

Logic Timers

Refer to Section 5, *BESTlogic+ Programmable Logic*, for information on using logic timers.

FILE MANAGEMENT

These paragraphs describe file management of settings files, firmware files, and language module files.

Settings Files

These paragraphs describe the tasks of opening, uploading, downloading, saving, printing, and comparing of settings files. When opening, uploading, downloading, or saving a settings file, operational settings, as well as BESTlogic+ settings are combined together as a whole. When printing a settings file, only the operational settings are shown. There is a separate print option available on the BESTlogic+ Programmable Logic screen for printing BESTlogic+ settings. For information on solely uploading or downloading BESTlogic+ settings, refer to Section 5, *BESTlogic+ Programmable Logic*.

A settings file conversion is required when DGC-2020 firmware has been changed so that the settings file is compatible with the firmware. For information on converting settings files, see *Converting Settings Files*, later in this section.

Opening a Settings File

To open a new instance of a settings file into BESTCOMSPlus, 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 open it and the file settings have been brought into a new instance in BESTCOMSPlus. You may also open a file, by clicking on the *Open File* icon on the lower menu bar. When done in this manner, you will be asked to upload the settings and logic from the file to the current device. You may choose *Yes* or *No*. The settings in the current instance will be overwritten.

Uploading a Settings File

To upload a settings file to the DGC-2020, you must first open the file through BESTCOMSPlus or create the file using BESTCOMSPlus. Then pull down the *Communication* menu and select *Upload Settings*. You are prompted to enter the password. If the password is correct, the upload begins and the progress bar is shown.

Downloading a Settings File

To download a settings file from the DGC-2020, you must pull down the *Communication* menu and select *Download Settings*. If the settings in your BESTCOMSPlus have changed, a dialog box will open asking you if want to save the current settings changes. You may choose *Yes* or *No*. After you have taken the required action to save or not save the current settings, the downloading is executed.

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. Select the *Save* button to complete the save.

Printing a Settings File

To view a preview of the printout, select *Print Preview* from the *File* pull-down menu. 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 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

BESTCOMSPlus has the ability to compare two different settings files. To use this feature, pull down the *Tools* menu and select *Compare Settings Files*. The *BESTCOMSPlus Settings Compare Setup* dialog box appears (Figure 4-61). Select the location of the first file to compare under *Left Settings Source* and select the location of the second file to compare 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 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.

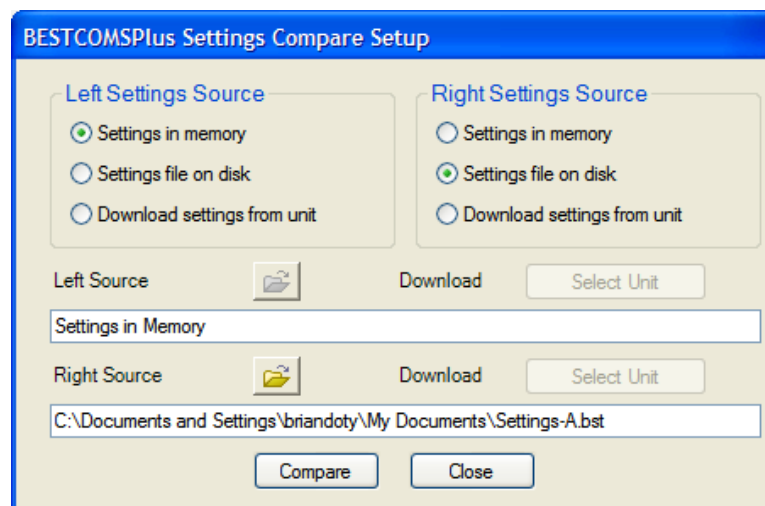


Figure 4-61. BESTCOMSPlus Settings Compare Setup

A dialog box will appear and notify you if any differences were found. The *BESTCOMSPlus Settings Compare* dialog box (Figure 4-62) is displayed where you can view all settings (*Show All Settings*), view only the differences (*Show Settings Difference(s)*), view all logic (*Show All Logic Paths*), or view only logic differences (*Show Logic Path Difference(s)*). Select *Close* when finished.

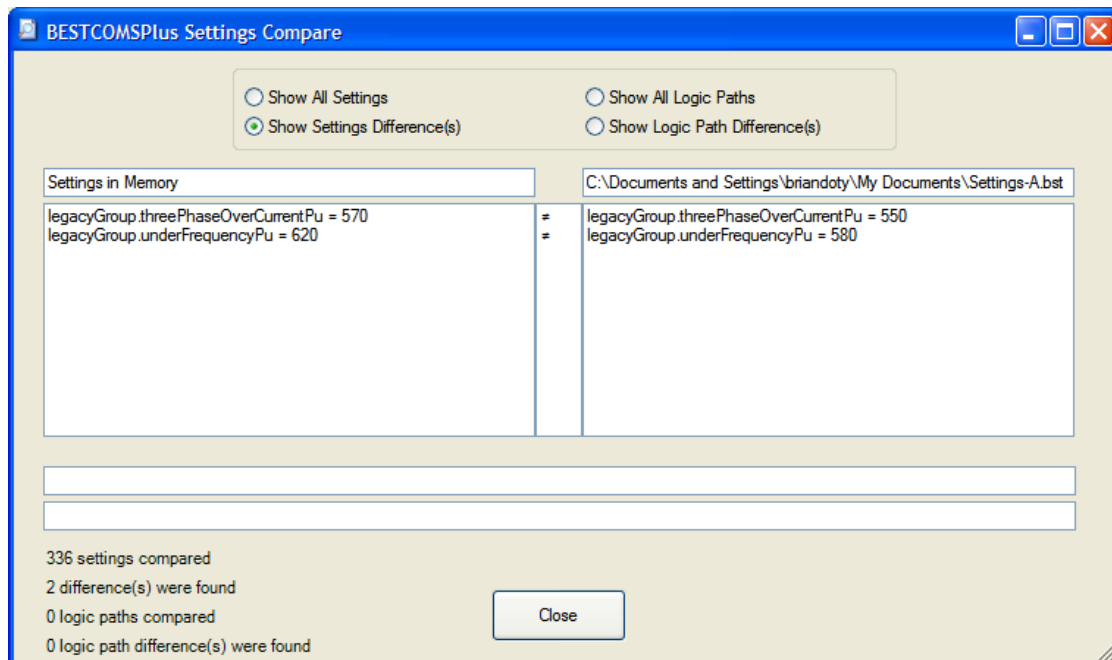


Figure 4-62. *BESTCOMSPlus Settings Compare*

Upgrading Firmware in DGC-2020 and Expansion Modules

A device package contains firmware and a language module. Embedded firmware is the operating program that controls the actions of the DGC-2020. The DGC-2020 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 DGC-2020 functionality may 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 DGC-2020. The DGC-2020 stores the language module in nonvolatile flash memory; the language module contains all language translations for the DGC-2020. The language module can be reprogrammed through the communications port. In general, any time a firmware upgrade is made to the DGC-2020, the language module should be uploaded as well.

The DGC-2020 may be used in conjunction with several expansion modules that expand the DGC-2020 capabilities. DGC-2020 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

If power is lost or communication is interrupted during file transfer to the DGC-2020, the DGC-2020 will cease operating and will not recover automatically.

CAUTION

The order in which the components are upgraded is critical. Assuming a system of a DGC-2020 and expansion modules is in a state where the DGC-2020 is communicating with all of the system expansion modules, **the expansion modules must be upgraded before the DGC-2020**. This is required because the DGC-2020 must be able to communicate to the expansion module before the DGC-2020 can send firmware to it. If the DGC-2020 were upgraded first, and the new firmware included a change in the DGC-2020 to expansion module communication protocol, it is possible that the expansion modules could no longer communicate with the upgraded DGC-2020. Without communications between the DGC-2020 and the expansion modules, upgrading the expansion modules is not possible.

Upgrading Firmware in Expansion Modules

The following procedure is used to upgrade firmware in DGC-2020 expansion modules. This must be completed before upgrading firmware in the DGC-2020. If no expansion modules are present, proceed to *Upgrading Firmware in the DGC-2020*.

1. Place the DGC-2020 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 DGC-2020 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->SYSTEM SETTINGS screen.
3. Verify that the DGC-2020 and all associated expansion modules are communicating. This can be verified by examining the pre-alarm status using the Metering Explorer in BESTCOMSPlus or from 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 DGC-2020 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 4-63) 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.

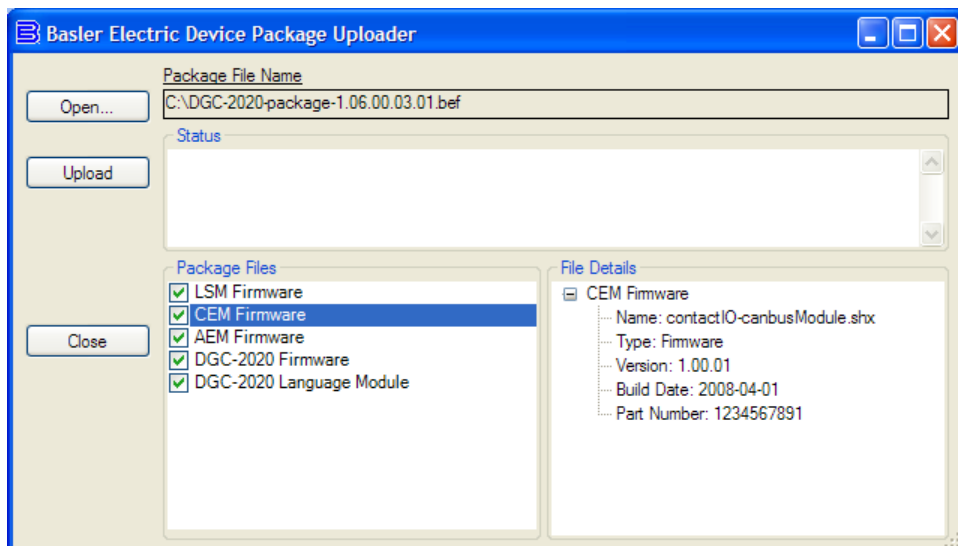


Figure 4-63. Basler Electric Device Package Uploader

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 4-64.

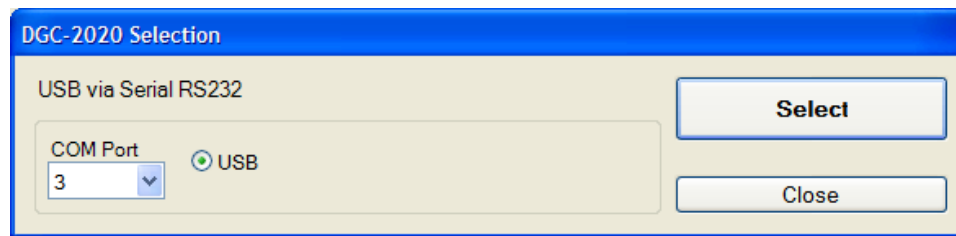


Figure 4-64. DGC-2020 Selection

10. The *Processing, Please Wait...* screen is displayed as file(s) are uploaded. See Figure 4-65.

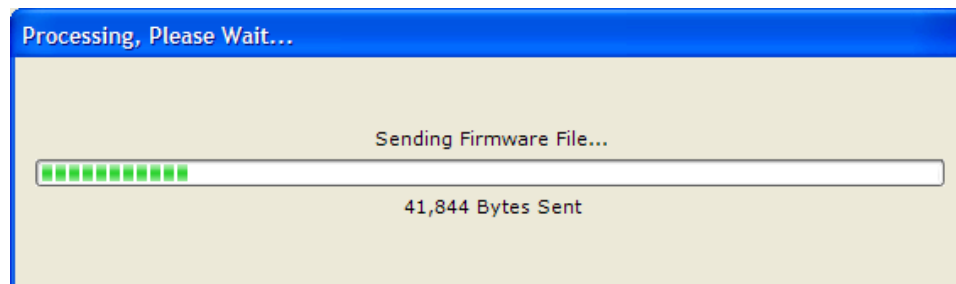


Figure 4-65. Processing, Please Wait...

11. After file(s) have been uploaded, click the *Close* button on the *Basler Electric Device Package Uploader* screen and disconnect communication to the DGC-2020.

Upgrading Firmware in the DGC-2020

Two scenarios are presented: (A) Upgrade DGC-2020 firmware and then load a settings file created with an earlier firmware version, and (B) Save settings file from DGC-2020, upgrade DGC-2020 firmware, and then load settings file back into the DGC-2020.

A. Upgrade DGC-2020 firmware and then load a settings file created with an earlier firmware version.

1. Upgrade the DGC-2020 firmware and language module.
 - a. Connect to the DGC-2020 with BESTCOMSPlus. Check the firmware Application Version on the GENERAL SETTINGS-> DEVICE INFO screen.
 - b. If the firmware Application Version is greater than or equal to 1.00.00, proceed to the next step. If it is less than 1.01.00 (i.e. it is of the form 1.00.zz, where zz is a 2-digit number), then the language selection setting of the DGC-2020 must be set to *English* before initiating the firmware upgrade. This is accomplished by selecting *English* on the GENERAL SETTINGS->FRONT PANEL HMI->LANGUAGE SELECTION screen. **Failure to perform this step may result in incorrect operation of the DGC-2020.**
 - c. Select *Upload Device Files* from the *Communication* pull-down menu. You do not have to be connected to the DGC-2020 at this time. Save settings when prompted, if desired.
 - d. 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.)
 - e. 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.

- f. Click the *Upload* button and follow the instructions that appear to begin the upgrade process.
- g. After the upload is complete, disconnect communication to the DGC-2020.

NOTE

If the front panel HMI becomes blank and all LEDs are flashing, cycle power to the DGC-2020 and restart the upgrade procedure starting with step A.1.c. You will not be asked to save settings this time.

2. Modify the Application Version in the desired settings file to be compatible with the DGC-2020 Application Version.
 - a. Open the desired settings file into BESTCOMSPlus.
 - b. Change the Application Version in the settings file to the setting that matches the Application Version of the unit. The Application Version is what was noted during the upload process (A1e above), or can be obtained through the DGC-2020 front panel on the SETTINGS->GENERAL SETTINGS->VERSION INFO->FIRMWARE VERSION screen
 - c. When the number is changed, the *Application Version Number Changed* screen will appear which indicates any settings that it must change because of the version change. These settings should be checked for accuracy after the application version number has been changed.
 - d. After changing the Application Version, save the settings file with a new name by selecting *Save As* from the *File* pull-down menu.
3. Modify the programmable logic in the desired settings file to be compatible with the DGC-2020 Application Version.
 - a. Open the programmable logic. The logic is accessible under SETTINGS->BESTLOGIC+ PROGRAMMABLE LOGIC.
 - b. Examine the logic scheme by scrolling up/down through the entire logic diagram. Delete any logic elements that have a red X through them; they are invalid elements for the version and style number of the DGC-2020 that is being configured in this settings file. Delete or complete any incomplete logic; all component inputs must be connected to something, or the components must be deleted.
 - c. If you have made no logic changes, make a change now by clicking on any component and moving it slightly. BESTCOMSPlus will sense that the logic has changed.
 - d. Save the Logic Scheme by clicking on *Save* on the BESTLogic+ Programmable Logic toolbar.
 - e. Save the settings file again after logic modifications are complete. The file name need not be changed from the name given to it when it was saved after the Application Version was changed.
4. Examine and correct any changes to settings when Application Version was changed.
 - a. If the changes were not examined when the Application Version was made, they should be examined prior to loading the settings file into the DGC-2020.
 - b. Use the BESTCOMSPlus Settings Compare tool to compare the settings file from "Before" the application version change to the version "After" the Application Version change.
 - c. The BESTCOMSPlus Settings Compare tool is found by selecting *Compare Settings Files* from the *Tools* pull-down menu.
 - d. Select the 2 files to compare and check *Show All Settings Differences*.
 - e. Correct any settings in the "After" file to their correct values.
 - f. After finishing all corrections, save the settings file again. The file name need not be changed from the name given to it when it was saved after the Application Version was changed.

5. Load the new settings file into the DGC-2020.
 - a. Disconnect communication from the DGC-2020.
 - b. Close all settings files.
 - c. From the File pull-down menu, select *New, DGC-2020*.
 - d. Connect to the DGC-2020.
 - e. Once all settings have been read from the DGC-2020, open the new settings file by selecting the file with File, *Open File* in the BESTCOMSPlus menu.
 - f. When BESTCOMSPlus asks if you wish to upload settings and logic to the device, click Yes.
 - g. The settings should go into the DGC-2020 successfully.
 - h. If you are receiving upload failures and indications that the logic is incompatible with the firmware version, check that the DGC-2020 style number in the saved file matches that of the DGC-2020 into which the file is being uploaded. The style number in the settings file is found under GENERAL SETTINGS->STYLE NUMBER in BESTCOMSPlus.
 - i. If the style number of the settings file does not match that of the DGC-2020 into which it is to be loaded, disconnect from the DGC-2020, then modify the style number in the settings file. Then repeat the steps in the sections titled *Modify the Programmable logic in the desired settings file to be compatible with the DGC-2020 Application version* and *Load the New Settings File into the DGC-2020*.
- B. Save settings file from DGC-2020, upgrade DGC-2020 firmware, and then load settings file back into the DGC-2020.
 1. Download settings from the DGC-2020.
 - a. Connect to the DGC-2020.
 - b. After all settings and logic have been downloaded from the DGC-2020 into BESTCOMSPlus, save the settings by selecting *Save As* from the File pull-down menu.
 - c. BESTCOMSPlus gives the option of entering additional info and file properties. Enter the information as desired and click OK.
 - d. Assign a file name and save the file in a location that is available for later retrieval.
 2. Upgrade the DGC-2020 firmware and language module.
 - a. Follow the steps in the section labeled *Upgrade the DGC-2020 firmware and language module* (A1 above).
 3. Modify the Application Version in the desired settings file to be compatible with the DGC-2020 Application Version.
 - a. Follow the steps in the section labeled *Modify the Application Version in the desired settings file to be compatible with the DGC-2020 Application Version* (A2 above).
 4. Modify the programmable logic in the desired settings file to be compatible with the DGC-2020 Application Version.
 - a. Follow the steps in the section labeled *Modify the programmable logic in the desired settings file to be compatible with the DGC-2020 Application Version* (A3 above).
 5. Examine and correct any changes to settings when Application Version was changed.
 - a. Follow the steps in the section labeled *Examine and correct any changes to settings when Application Version was changed* (A4 above).
 6. Load the new settings file into the DGC-2020.
 - a. Follow the steps in the section labeled *Load the new settings file into the DGC-2020* (A5 above).

METERING EXPLORER

The Metering Explorer is a convenient tool within BESTCOMSPlus used to navigate through the following metering screens of the DGC-2020 plug-in.

- 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
- 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 4-66. Table 4-2 explains the call-outs on Figure 4-66.

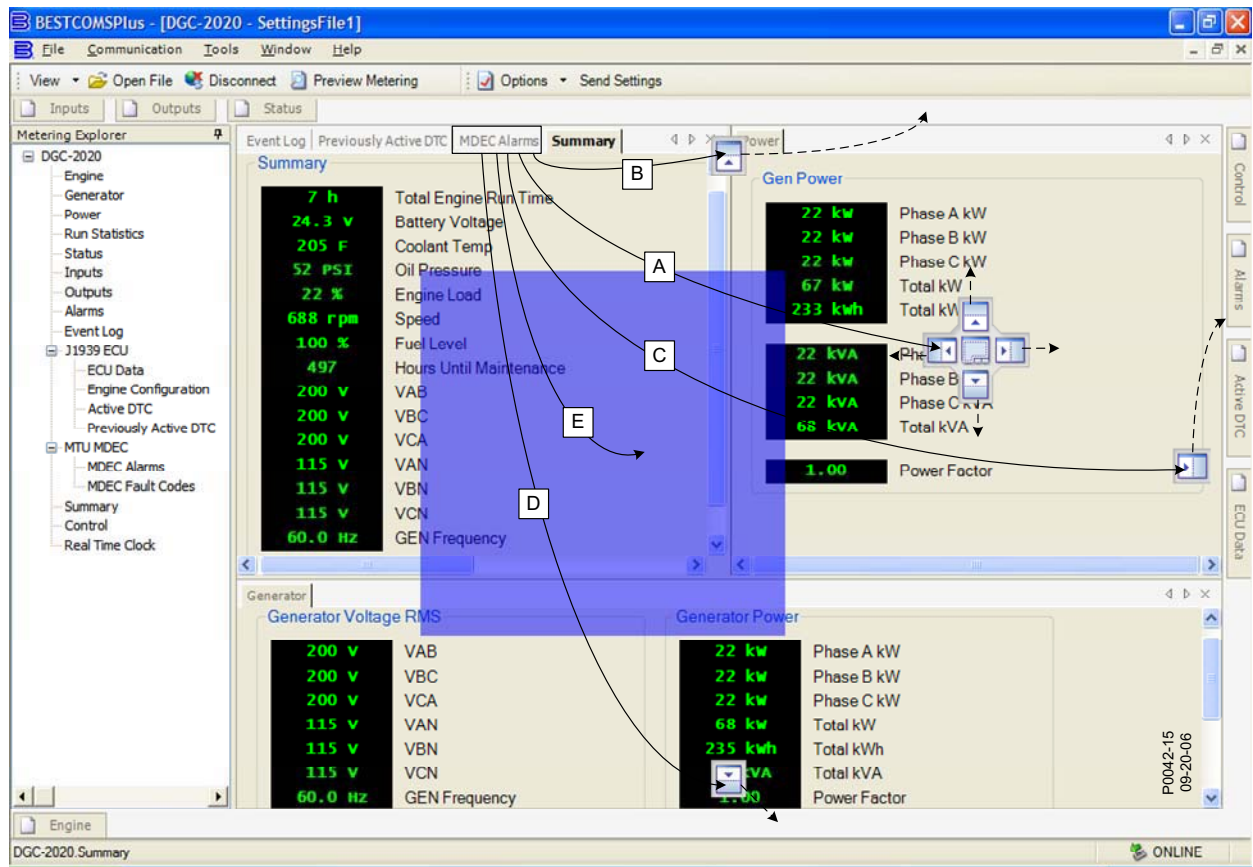
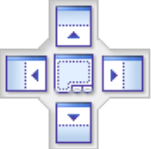


Figure 4-66. Metering, Docking Options

Table 4-2. Explanation of Call-Outs on Figure 4-66

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 may also be dragged to one of the arrow boxes used for docking.

Engine

This screen provides information and metering of engine components. Refer to Figure 4-67.

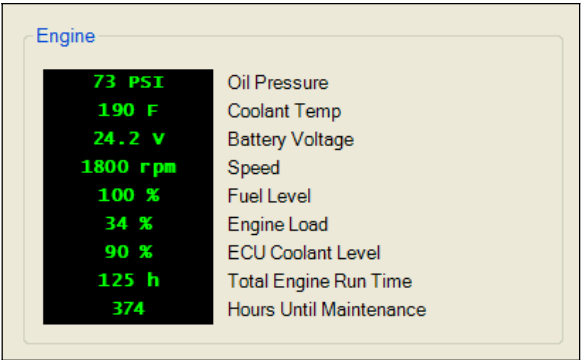


Figure 4-67. Metering, Engine

Generator

This screen provides metering of generator voltages and currents. Refer to Figure 4-68.

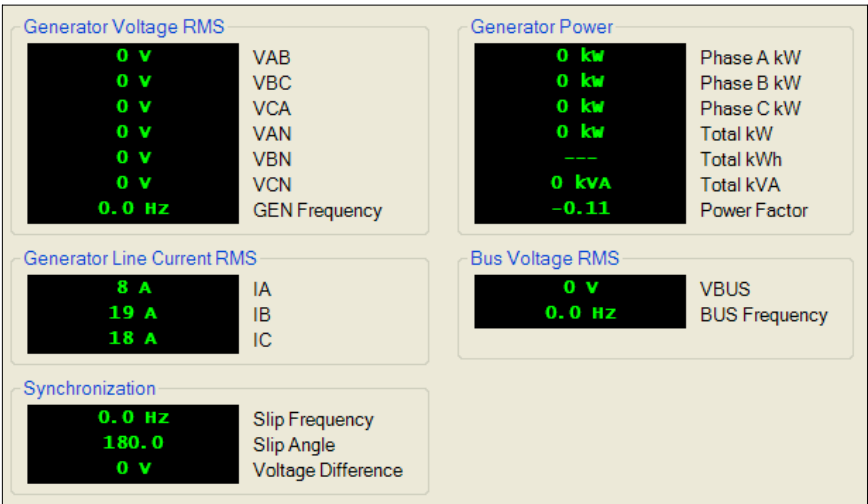


Figure 4-68. Metering, Generator

Power

This screen provides metering of generator power and power factor. Refer to Figure 4-69.



Figure 4-69. Metering, Power

Bias Control

This screen provides Var/PF mode status and operating levels. Refer to Figure 4-70.

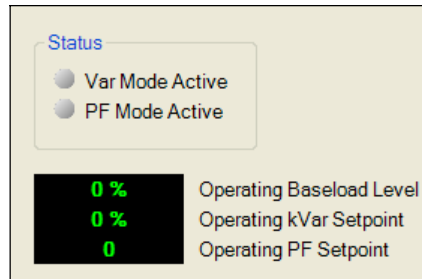


Figure 4-70. Metering, Bias Control

Run Statistics

This screen provides Cumulative Run Statistics, Session Run Statistics, and Commission Date. Refer to Figure 4-71. The maintenance interval can be reset through this screen.

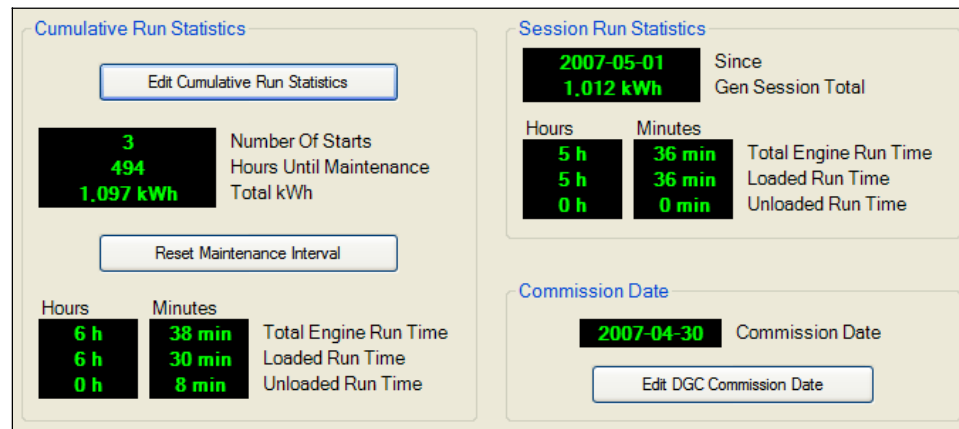


Figure 4-71. Metering, Run Statistics

Status

This screen indicates status of breakers, modes, and switches. The status is TRUE when the corresponding LED is red. Refer to Figure 4-72.

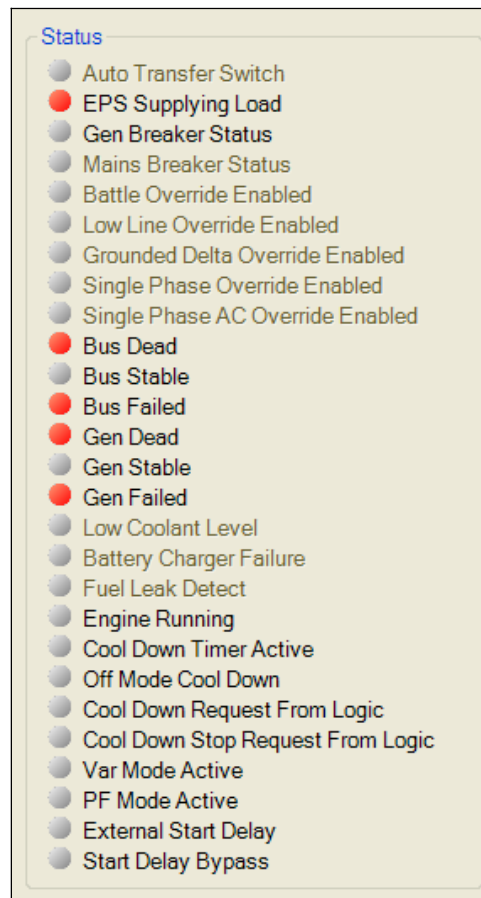


Figure 4-72. Metering, Status

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 4-73.

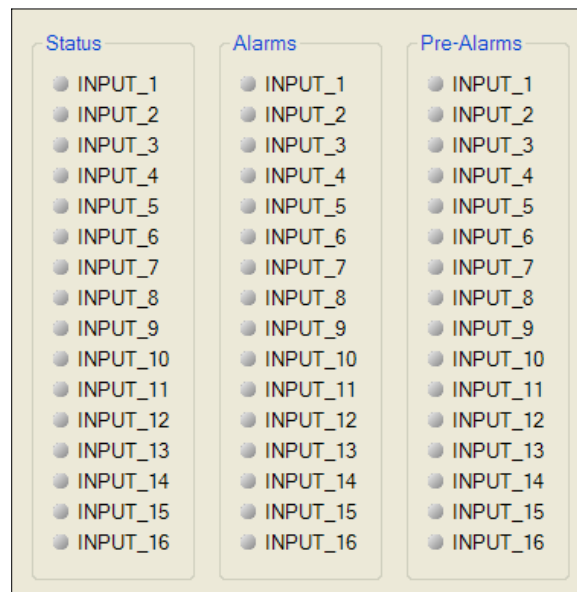


Figure 4-73. Metering, Inputs, Contact Inputs

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 4-74.



Figure 4-74. 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 4-75.

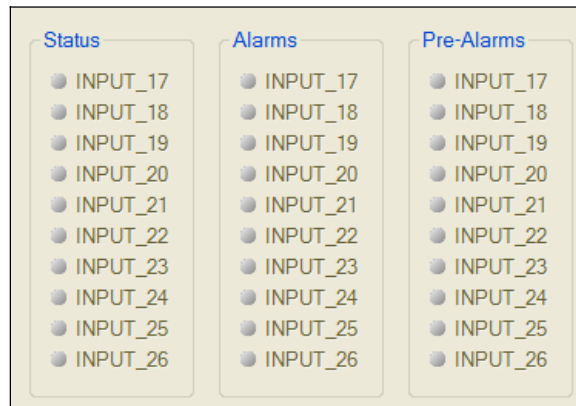


Figure 4-75. Metering, Inputs, Remote Contact Inputs

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 4-76. Remote Analog Input #1 is shown.

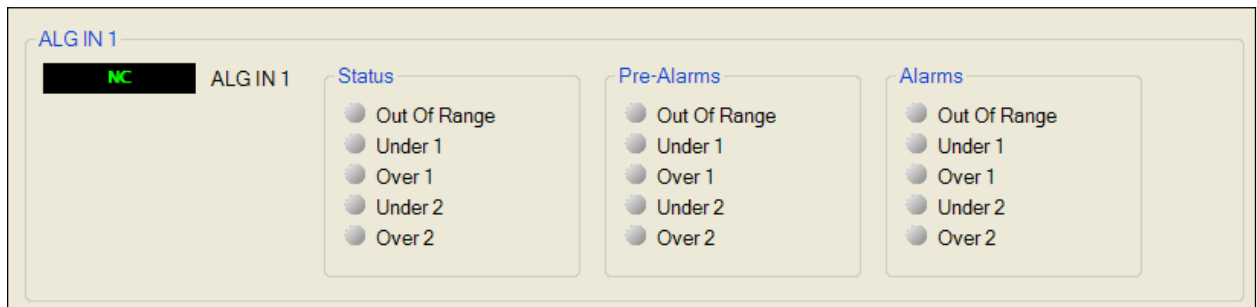


Figure 4-76. Metering, Inputs, Remote Analog Inputs

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 4-77. Remote RTD Input #1 is shown.

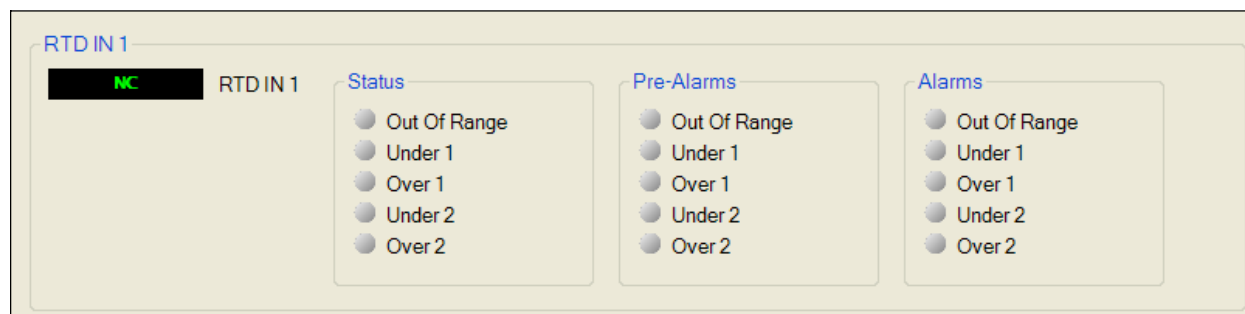


Figure 4-77. Metering, Inputs, Remote RTD Inputs

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 4-78. Remote Thermocouple Input #1 is shown.

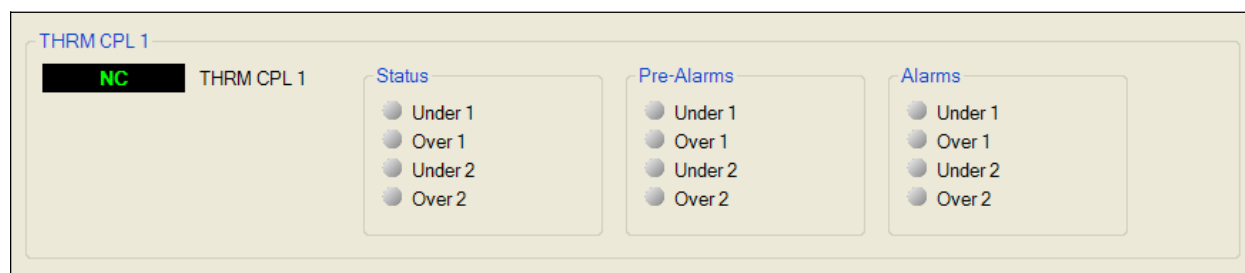


Figure 4-78. Metering, Inputs, Remote Thermocouple Inputs

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. Refer to Figure 4-78.

Figure 4-79. Metering, Inputs, Remote Analog Input Values

The *Calibrate* button shown in Figure 4-79 opens the Analog Input Temperature Calibration screen shown in Figure 4-80. This screen is used to calibrate RTD inputs 1 through 8 and thermocouple inputs 1 and 2.

Figure 4-80. Analog Input Temperature Calibration

Outputs

Contact Outputs

This screen indicates the status of contact outputs. The status is TRUE when the corresponding LED is green. Refer to Figure 4-81.

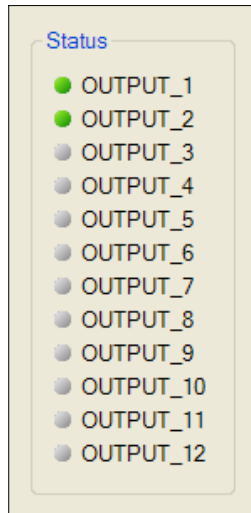


Figure 4-81. Metering, Outputs, Contact Outputs

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 4-82.

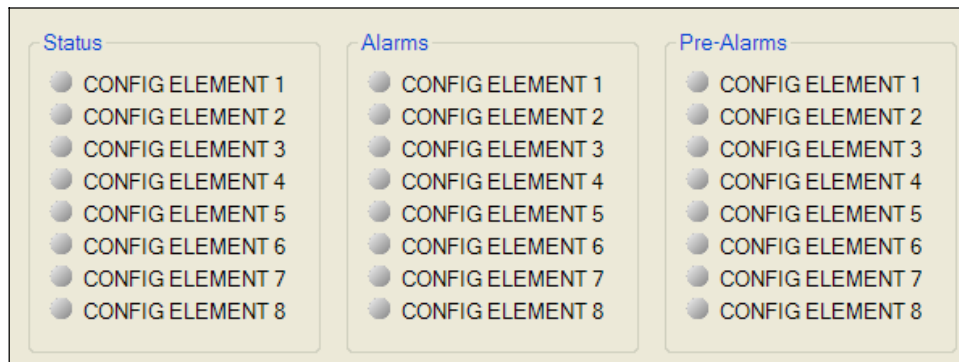


Figure 4-82. Metering, Outputs, Configurable Elements

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 4-83.

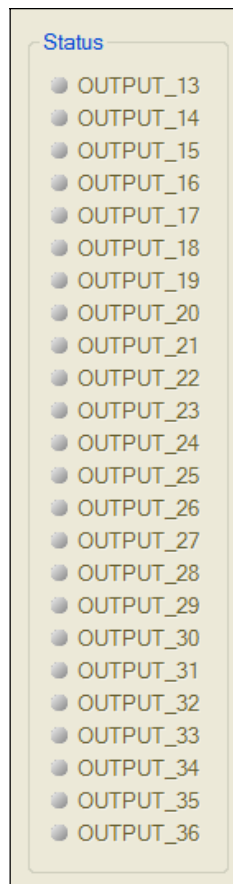


Figure 4-83. Metering, Outputs, Remote Contact Outputs

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 4-84.

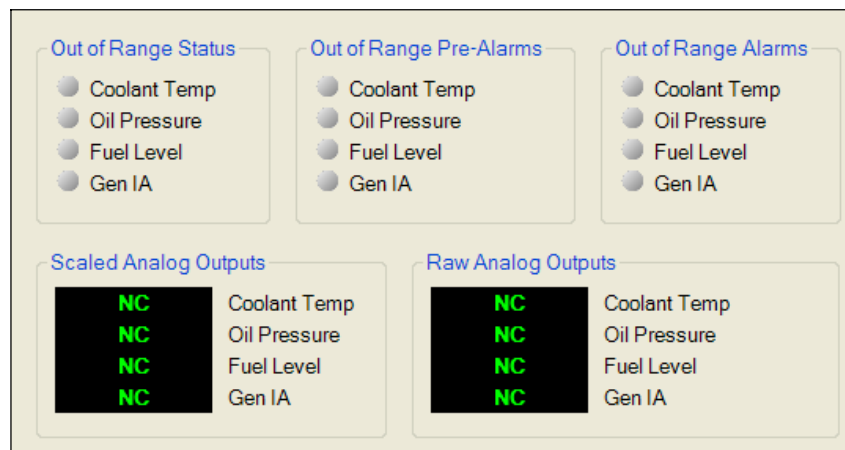


Figure 4-84. Metering, Outputs, Remote Analog Outputs

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 DGC-2020 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 4-85.

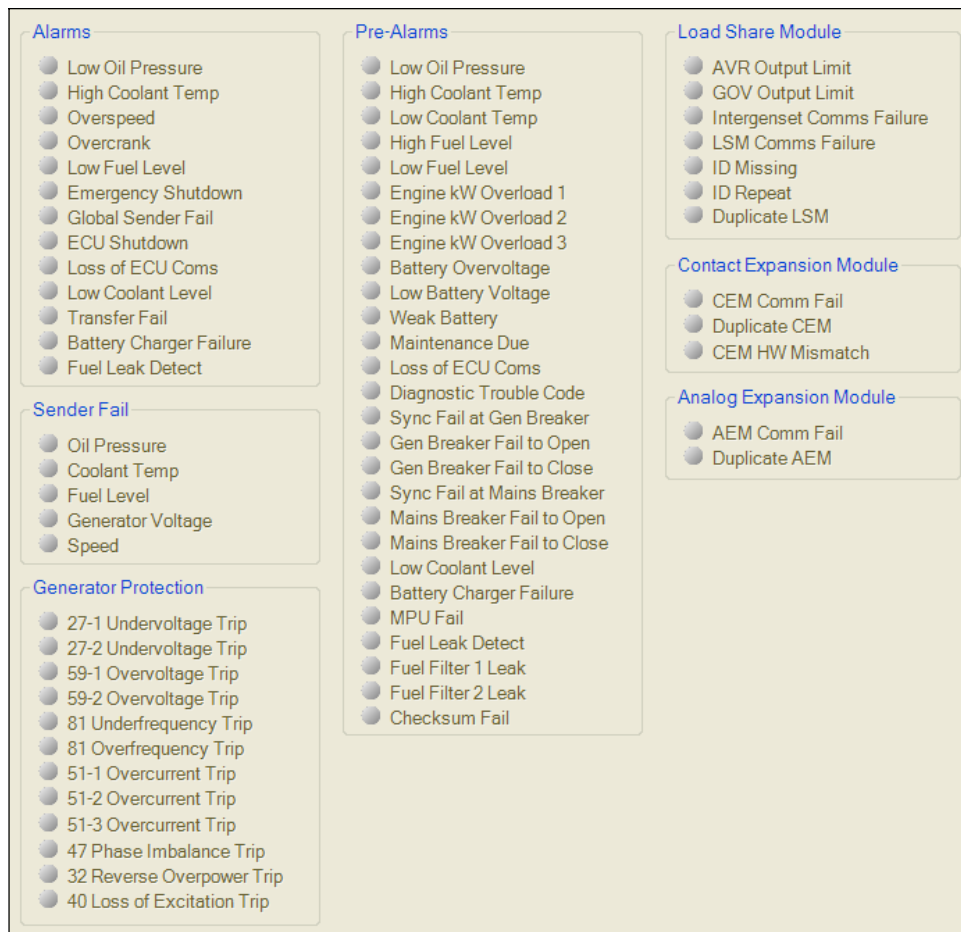


Figure 4-85. Metering, Alarms

Event Log

The event log provides a historical record of event occurrences detected by the DGC-2020. It is saved in nonvolatile memory so that it 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 DGC-2020. 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 BESTCOMSPlus 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 DGC-2020. The *Clear* button gives the user the option of clearing selected or all event logs. Refer to Figure 4-86.

Options Download Clear					
Event ID	Description	Occurrence	Date	Eng Hrs (H:m)	
13	GLBL SNDR FAIL A	2	2007-12-04 16:38:44	1:52	
14	SPD SNDR FAIL A	2	2007-12-04 16:38:44	1:52	
24	LOW OIL PRES P	26	2007-12-04 16:21:31	1:35	
9	SPD SNDR FAIL	4	2007-12-04 16:21:30	1:35	
10	MPU FAIL P	4	2007-12-04 16:21:30	1:35	
3	ENGINE RUNNING	99	2007-12-04 16:21:21	1:35	
3	ENGINE RUNNING	98	2007-12-04 16:21:07	1:35	
3	ENGINE RUNNING	97	2007-12-04 16:21:02	1:35	
3	ENGINE RUNNING	96	2007-12-04 16:20:37	1:35	
24	LOW OIL PRES P	25	2007-12-04 16:20:20	1:35	
9	SPD SNDR FAIL	3	2007-12-04 16:20:19	1:35	
10	MPU FAIL P	3	2007-12-04 16:20:19	1:35	
3	ENGINE RUNNING	95	2007-12-04 16:20:09	1:35	
3	ENGINE RUNNING	94	2007-12-04 16:19:28	1:35	
18	CEM COMM FAIL P	33	2007-12-04 16:19:27	1:35	
25	EMERGENCY STOP A	32	2007-12-04 16:19:07	1:35	
25	EMERGENCY STOP A	31	2007-12-04 14:49:28	1:35	
18	CEM COMM FAIL P	32	2007-12-04 14:49:05	1:35	

Figure 4-86. Metering, Event Log, Sorted by Date

When viewed with BESTCOMSPlus, 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 4-86 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 4-87, 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 4-86.

Options Download Clear					
Event ID	Description	Occurrence	Date	Eng Hrs (H:m)	
6	LSM HEARTBEAT FAIL P	50	2007-11-29 12:49:15	0:0	
6	LSM HEARTBEAT FAIL P	51	2007-11-29 12:49:38	0:0	
7	LSM GOV OUT LMT P	1	2007-11-15 18:12:59	0:13	
8	LOW COOL TMP P	1	2007-11-16 10:33:28	0:19	
8	LOW COOL TMP P	2	2007-11-26 10:47:40	0:0	
8	LOW COOL TMP P	3	2007-11-26 10:47:50	0:0	
8	LOW COOL TMP P	4	2007-11-26 11:12:23	0:0	
9	SPD SNDR FAIL	1	2007-11-16 16:44:39	0:0	
9	SPD SNDR FAIL	2	2007-11-19 14:33:53	358:0	
9	SPD SNDR FAIL	3	2007-12-04 16:20:19	1:35	
9	SPD SNDR FAIL	4	2007-12-04 16:21:30	1:35	
10	MPU FAIL P	1	2007-11-16 16:44:39	0:0	
10	MPU FAIL P	2	2007-11-19 14:33:59	358:0	

Figure 4-87. Metering, Event Log, Sorted by Event ID

J1939 ECU

The ECU reports operating information to the DGC-2020 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 4-88.

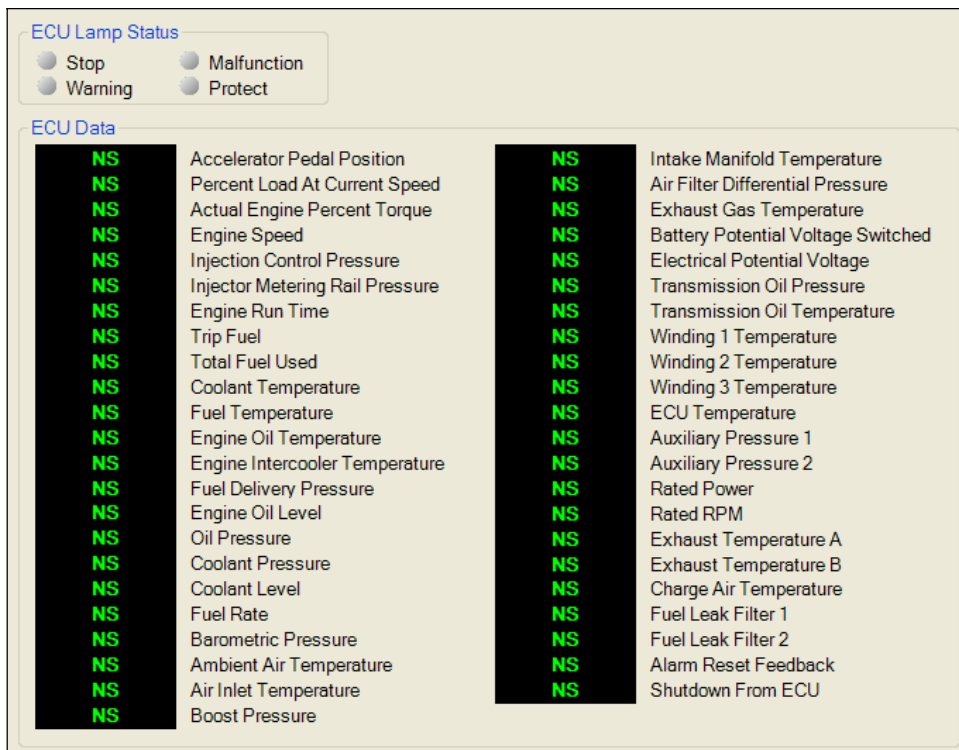


Figure 4-88. Metering, ECU Data

Engine Configuration

This screen displays Engine Configuration. Refer to Figure 4-89.

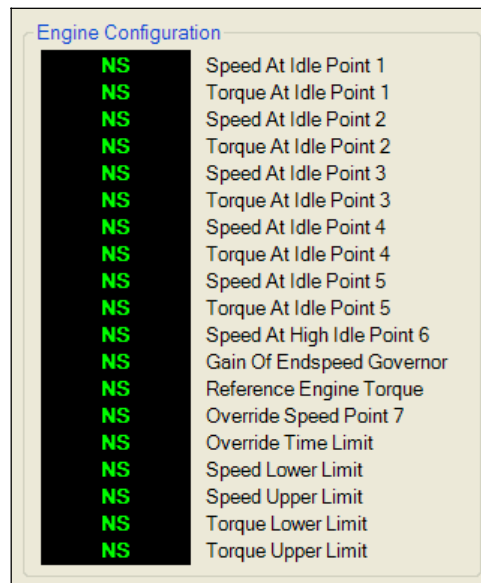


Figure 4-89. Metering, Engine Configuration

Active DTC and Previously Active DTC

This screen is used for viewing, downloading, and clearing DTC (Diagnostic Trouble Codes). Refer to Figure 4-90.

Options		Download		Clear
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 4-90. Metering, Download DTC

MTU

The MTU reports operating information to the DGC-2020 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 Alarms and MTU Pre-Alarms are reported on this screen. The status is TRUE when the corresponding LED is red. Refer to Figure 4-91.

MTU Alarms

☐ High Charge Air Temperature
☐ Low Oil Pressure
☐ High Oil Temperature
☐ Overspeed
☐ High Coolant Temperature
☐ Combined Red
☐ Low Aftercooler Coolant Level
☐ High ECU Supply Voltage
☐ Low Fuel Delivery Pressure

MTU Pre-Alarms

☐ High ECU Temperature
☐ High Voltage Supply
☐ High Oil Temperature
☐ Engine Speed Too Low
☐ High Intercooler Temperature
☐ Low ECU Supply Voltage
☐ High Charge Air Temperature
☐ High Exhaust Temp A
☐ High Coolant Temperature
☐ High Exhaust Temp B
☐ Shutdown Override
☐ High Fuel Temp
☐ High Fuel Rail Pressure
☐ Low Charge Air Coolant Level
☐ Priming Fault
☐ Low Fuel Rail Pressure
☐ Start Speed Low
☐ Low Coolant Level
☐ Runup Speed Low
☐ Low Charge Air Pressure
☐ Idle Speed Low
☐ Low Fuel Delivery Pressure
☐ Alternator Winding Temp
☐ Low Oil Pressure
☐ High Day Tank
☐ Combined Yellow
☐ Low Day Tank
☐ ECU Faulty
☐ High Storage Tank
☐ Speed Demand Fail
☐ Low Storage Tank
☐ Low Voltage Supply

☐ High Pressure Input 1
☐ High Pressure Input 2
☐ High Temp Coil 1
☐ High Temp Coil 2
☐ High Temp Coil 3
☐ High Ambient Temp
☐ Overspeed Test On
☐ High Fuel Filter Diff Pressure

Figure 4-91. Metering, MTU Alarms

MTU Fault Codes

MTU Fault Codes can be viewed and downloaded on this screen. Refer to Figure 4-92.

Options		Download	
Fault ID	Fault Codes	Description	
1	4	NO TEXT AVAILABLE	
2	201	SD T-COOLANT	

Figure 4-92. Metering, MTU Fault Codes

MTU Status

MTU Status is reported on this screen. The status is TRUE when the corresponding LED is red. Refer to Figure 4-93.

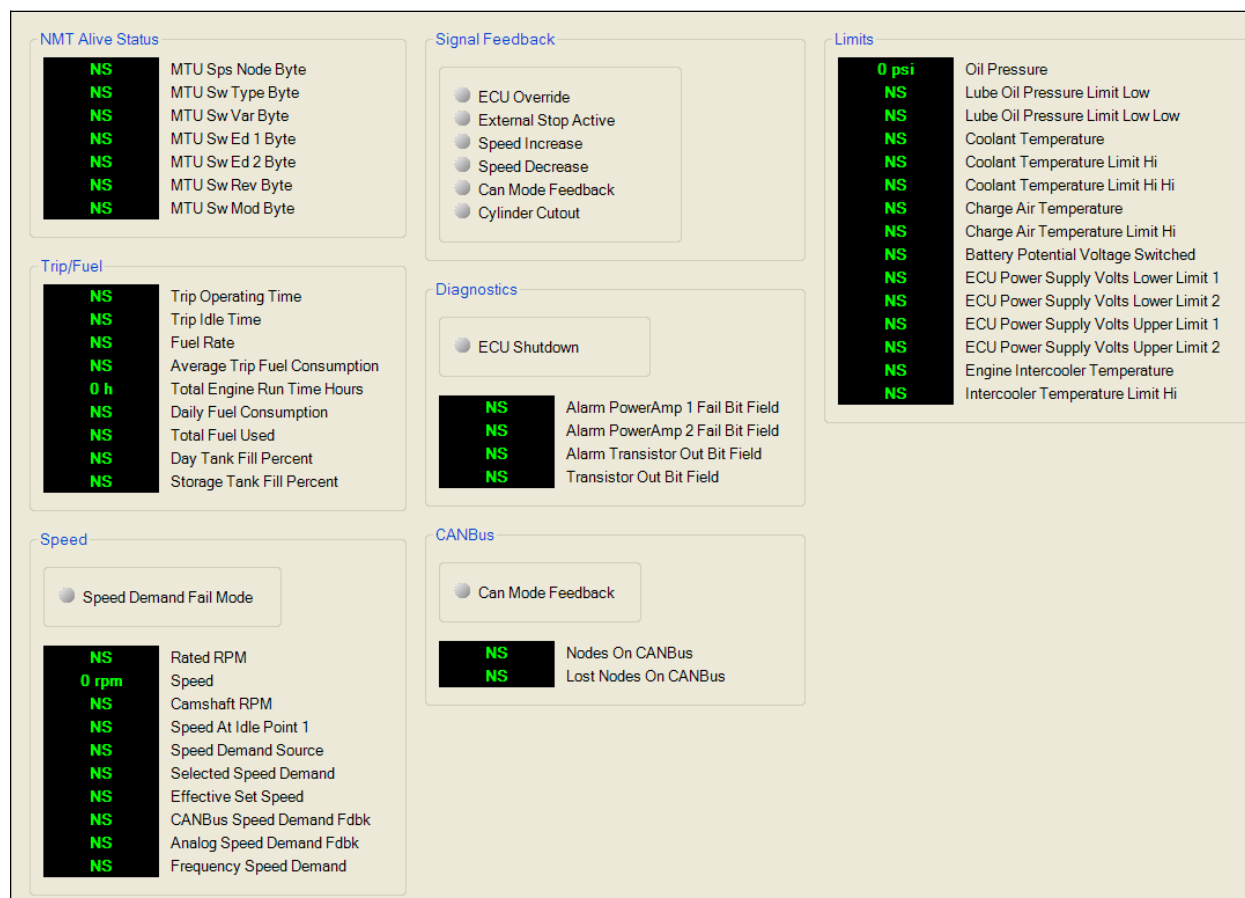


Figure 4-93. Metering, MTU Status

MTU Engine Status

MTU Engine Status is reported on this screen. The status is TRUE when the corresponding LED is red. Refer to Figure 4-95.

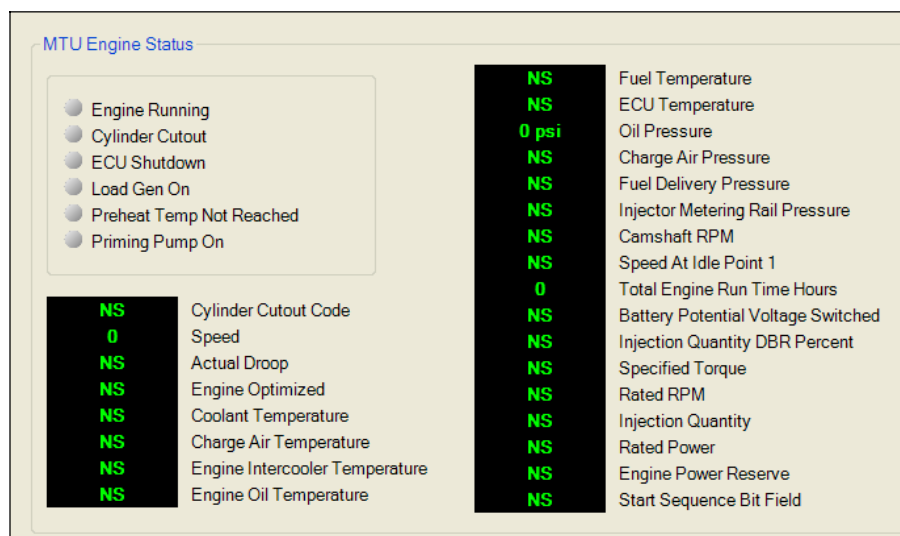


Figure 4-94. Metering, MTU Engine Status

Summary

This screen displays a metering summary. Refer to Figure 4-95.

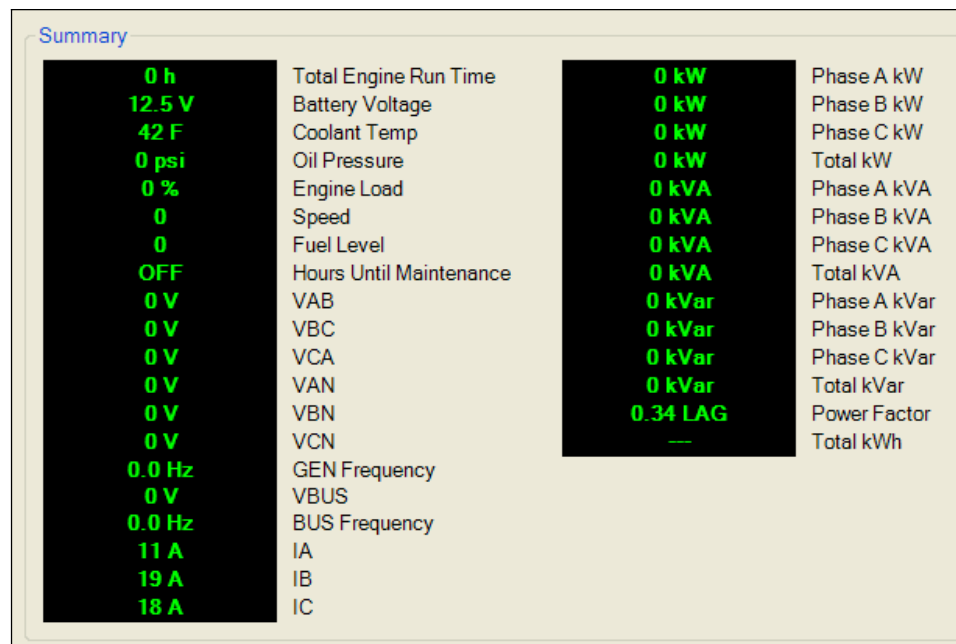


Figure 4-95. Metering, Summary

Control

Controls for stopping/starting the engine, controls for opening/closing breakers, and controls for opening/closing switches are accessed through the *Control* branch.

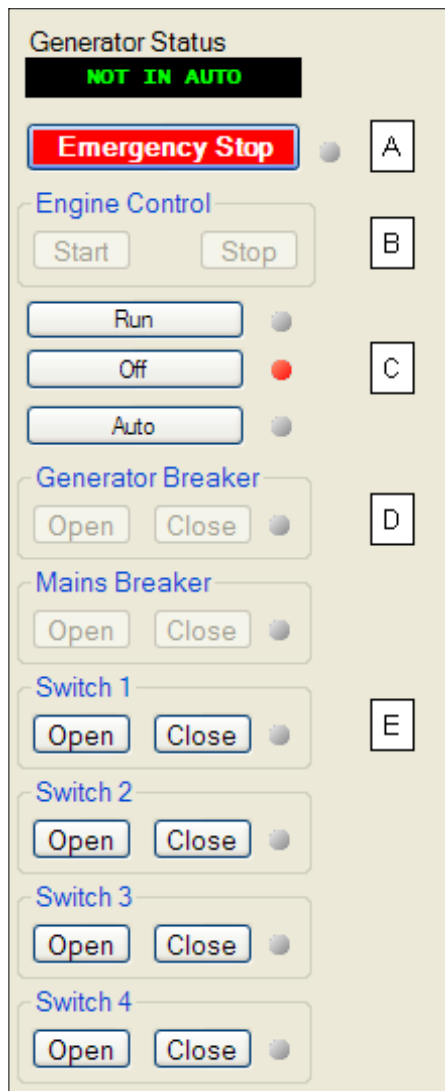


Figure 4-96. Metering, Control

The following controls are available by using the Metering Explorer in BESTCOMSPlus to open the *Control* branch. Refer to Figure 4-96.

- 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 BESTCOMSPlus in *Live* mode, these buttons will interact with the DGC-2020 in real time.

Real Time Clock

Settings for Date and Time are made here. Refer to Figure 4-97.

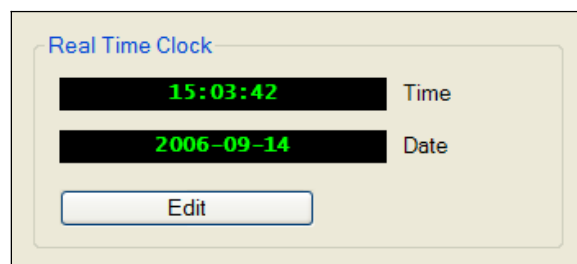


Figure 4-97. Metering, Real Time Clock

Generator Network Status

This screen (Figure 4-98) displays the detected 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 DGC-2020 and actively communicating to the generator network. The *Options* button is used to copy or save the list of sequencing IDs. The *Download* button refreshes the list of sequencing IDs.

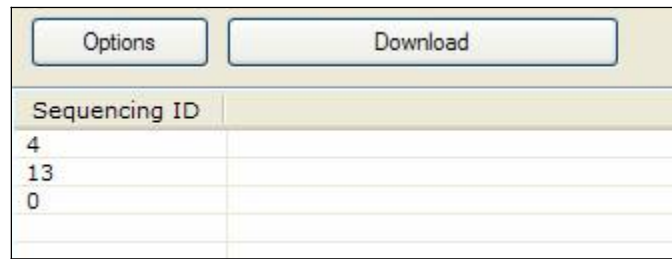


Figure 4-98. Metering, Generator Network Status

UPDATING BESTCOMSPlus SOFTWARE

Future enhancements to DGC-2020 functionality may make firmware updates desirable. Enhancements to DGC-2020 firmware typically coincide with enhancements to the DGC-2020 plug-in for BESTCOMSPlus. When a DGC-2020 is updated with the latest version of firmware, the latest version of the DGC-2020 plug-in for BESTCOMSPlus should also be obtained.

If you obtained a CD-ROM containing firmware from Basler Electric, then that CD-ROM will also contain the corresponding version of the DGC-2020 plug-in with BESTCOMSPlus software. The DGC-2020 plug-in with BESTCOMSPlus can also be downloaded from the Basler Electric website (<http://www.basler.com>). An outline form can be completed to obtain a password for downloading the software from the Basler Electric web site. BESTCOMSPlus also has a built in tool that will check for program updates if you are connected to the World Wide Web. The *Check for Updates* tool is located in the *Tools* drop-down menu.

CONVERTING SETTINGS FILES

A settings file conversion is required when DGC-2020 firmware has been changed. To make the settings file compatible with the firmware, perform the following:

1. Using BESTCOMSPlus, open the settings file to be converted from the top menu bar via *File, Open*. Do not connect to the DGC-2020 at this time.
2. Working offline, use the Settings Explorer to open the *Device Info* screen. Click on the pull-down menu under *Application Version* and select the version of firmware that the DGC-2020 holds.
3. Use the Settings Explorer to open the *BESTlogic+ Programmable Logic* screen. Verify that the three status LEDs located in the lower right corner are green indicating that the logic is ready to be saved to a file. If all three status LEDs are not green, click on the *Save* button located on the BESTlogic+ toolbar, correct any logic diagram errors, and then click *Save* again. Note that this step saves the logic in BESTCOMSPlus memory, not to a file.
4. It is recommended to save the old settings file. From the top menu bar select *File, Save As*, and enter a name for the new settings file.
5. Connect to the DGC-2020 and upload the new settings file.

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SECTION 5 • BESTlogic+ PROGRAMMABLE LOGIC

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SECTION 5 • BESTlogic+ PROGRAMMABLE LOGIC

INTRODUCTION

BESTlogic+ Programmable Logic is a programming method used for managing the input, output, protection, control, monitoring, and reporting capabilities of Basler Electric's DGC-2020 Digital Genset Controller. Each DGC-2020 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+. BESTlogic+ equations entered and saved in the DGC-2020 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 DGC-2020 is called a logic scheme.

One default active logic scheme is pre-loaded into the DGC-2020. This scheme is configured for a typical protection and control application and virtually eliminates the need for "start-from-scratch" programming. BESTCOMSPlus can be used to open a logic scheme that was previously saved as a file and upload it to the DGC-2020. The default logic scheme can also be customized to suit your application. Detailed information about logic schemes is provided later in this section.

BESTlogic+ 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 a DGC-2020. Detailed information about operating settings is provided in Section 3, *Functional Description*.

OVERVIEW OF BESTlogic+

BESTlogic+ settings are made through BESTCOMSPlus. Use the Settings Explorer to open the *BESTlogic+ Programmable Logic* tree branch as shown in Figure 5-1.

The *BESTlogic+ Programmable Logic* screen contains a logic library for opening and saving logic files, tools for creating and editing logic documents, and protection settings.

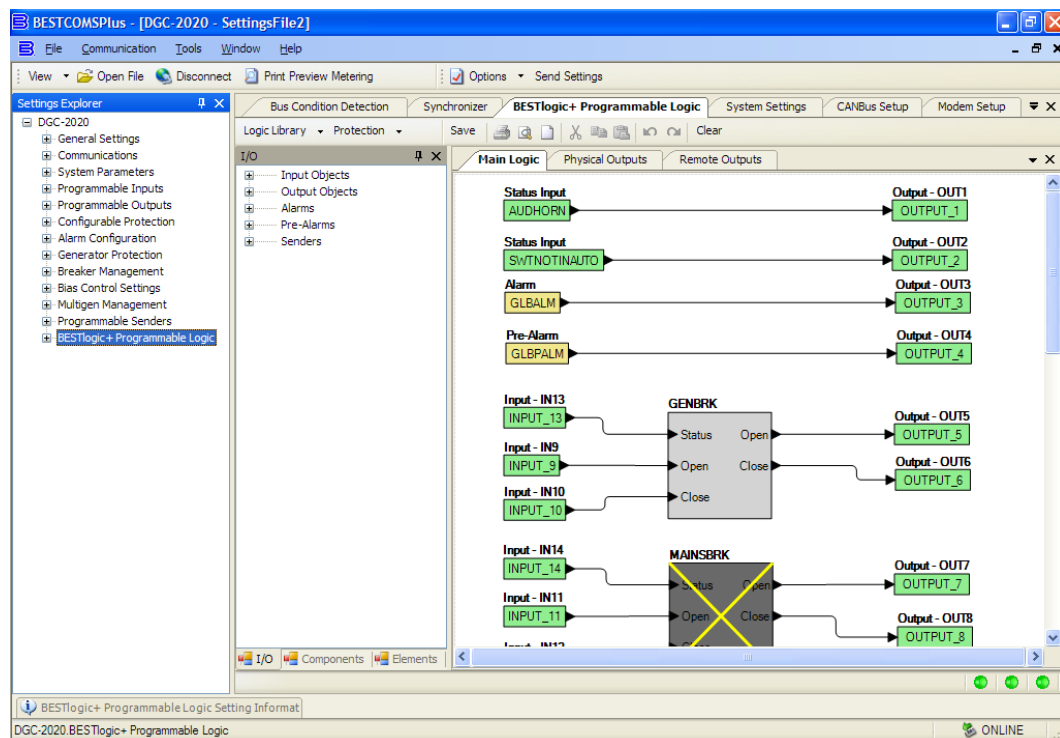


Figure 5-1. BESTlogic+ Programmable Logic Tree Branch

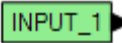
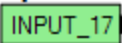
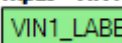
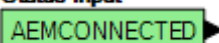
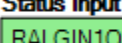
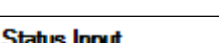
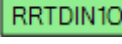
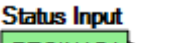
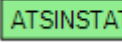
BESTlogic+ Composition

There are three main groups of objects used for programming BESTlogic+. These groups are *I/O*, *Components*, and *Elements*. For details on how these objects are used to program BESTlogic+, see the paragraphs on *Programming BESTlogic+*.

I/O

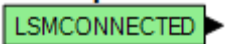
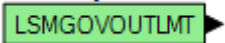
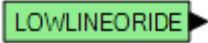
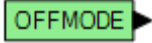
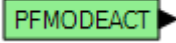
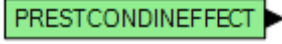
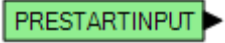
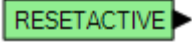
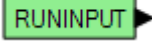
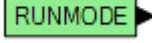
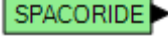
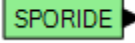
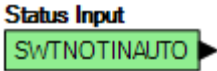
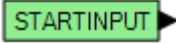
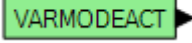
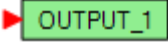
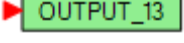
This group contains Input Objects, Output Objects, Alarms, Pre-Alarms, and Senders. Table 5-1 lists the names and descriptions of the objects in the I/O group.

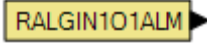
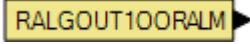
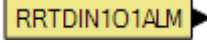
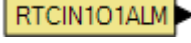
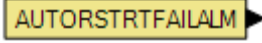
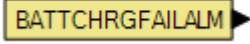
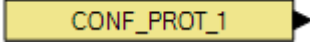
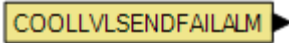
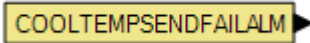
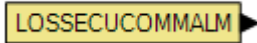
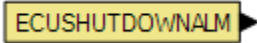
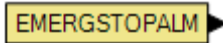
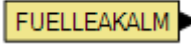
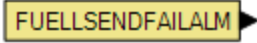
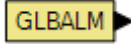
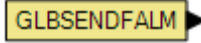
Table 5-1. I/O Group, Names and Descriptions

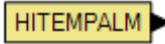
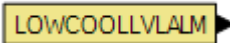
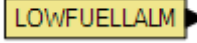
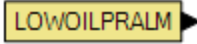
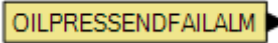
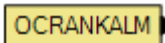
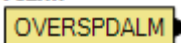
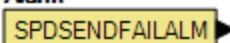
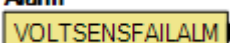
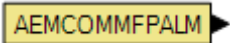
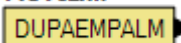
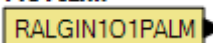
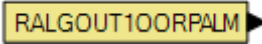
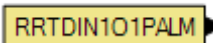
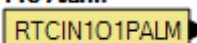
Name	Description	Symbol
Input Objects		
Logic 0	Always FALSE (Low).	
Logic 1	Always TRUE (High).	
<i>Physical Inputs</i> IN1 - IN16	TRUE when Physical Input x is active.	Input - IN1 
<i>Remote Inputs</i> IN17 - IN26	True when Remote Input x is active. (Available when an optional CEM-2020 is connected.)	Input - IN17 
<i>Virtual Inputs</i> VIN1 - VIN4	TRUE when Virtual Input x is active.	Input - VIN1 
<i>Status Input</i> Analog Expansion Module	Analog Expansion Module Connected. TRUE when an optional AEM-2020 is connected to the DGC-2020.	Status Input 
<i>Analog Expansion Module</i> 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 
<i>Analog Expansion Module</i> 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 
<i>Analog Expansion Module</i> 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 
<i>Analog Expansion Module</i> 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 
<i>Status Input</i> ATS Input	TRUE when the ATS (Auto Transfer Switch) input is TRUE.	Status Input 
<i>Status Input</i> Audible Horn	TRUE when the Audible Horn is active.	Status Input 
<i>Status Input</i> Auto Mode	TRUE when the DGC-2020 is in Auto Mode.	Status Input 

Name	Description	Symbol
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 BATTCRGFAIL 
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 Stable	TRUE when the Bus Stable condition settings have been exceeded.	Status Input BUSSTABLE 
Status Input Configurable Elements 1-8	TRUE when the Configurable Element x logic output is TRUE.	Status Input CONFIGELEMENT1 
Status Input Configurable Protection 1-8	TRUE when the Configurable Protection x Over Threshold #1 is TRUE.	Status Input - CONFPROT101 CONF_PROT_1 
Status Input Configurable Protection 1-8	TRUE when the Configurable Protection x Over Threshold #2 is TRUE.	Status Input - CONFPROT102 CONF_PROT_1 
Status Input Configurable Protection 1-8	TRUE when the Configurable Protection x Under Threshold #1 is TRUE.	Status Input - CONFPROT101 CONF_PROT_1 
Status Input Configurable Protection 1-8	TRUE when the Configurable Protection x Under Threshold #2 is TRUE.	Status Input - CONFPROT102 CONF_PROT_1 
Status Input Contact Expansion Module	Contact Expansion Module Connected. TRUE when an optional CEM-2020 is connected to the DGC-2020.	Status Input CEMCONNECTED 
Status Input Cool Down Timer Active	TRUE when the Cool Down Timer is timing out.	Status Input CDOWNTMRACT 
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 

Name	Description	Symbol
Status Input Front Panel Buttons	TRUE while the <i>EDIT</i> front panel button is pressed.	Status Input EDITBUTTON 
Status Input Front Panel Buttons	TRUE while the <i>LAMP TEST</i> front panel button is pressed.	Status Input LAMPBUTTON 
Status Input Front Panel Buttons	TRUE while the <i>LEFT</i> front panel button is pressed.	Status Input LEFTBUTTON 
Status Input Front Panel Buttons	TRUE while the <i>OFF</i> front panel button is pressed.	Status Input OFFBUTTON 
Status Input Front Panel Buttons	TRUE while the <i>RESET</i> front panel button is pressed.	Status Input RESETBUTTON 
Status Input Front Panel Buttons	TRUE while the <i>RIGHT</i> front panel button is pressed.	Status Input RIGHTBUTTON 
Status Input Front Panel Buttons	TRUE while the <i>RUN</i> front panel button is pressed.	Status Input RUNBUTTON 
Status Input Front Panel Buttons	TRUE while the <i>ALARM SILENCE</i> front panel button is pressed.	Status Input SILENCEBUTTON 
Status Input Front Panel Buttons	TRUE while the <i>UP</i> 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 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 Generator Stable	TRUE when the Gen Stable condition settings have been exceeded.	Status Input GENSTABLE 
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 Load Share Module	Load Share Module AVR Output Limit. TRUE when the LSM-2020 AVR Output Limit settings have been exceeded.	Status Input LSMAVROUTLMT 

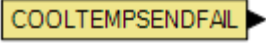
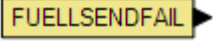
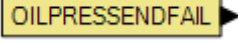
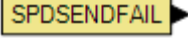
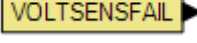
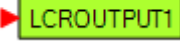
Name	Description	Symbol
<i>Status Input</i> Load Share Module	Load Share Module Connected. TRUE when an optional LSM-2020 is connected to the DGC-2020.	Status Input 
<i>Status Input</i> Load Share Module	Load Share Module Governor Output Limit. TRUE when the LSM-2020 Governor Output Limit settings have been exceeded.	Status Input 
<i>Status Input</i> Low Line Override	TRUE when the Low Line Override input is TRUE.	Status Input 
<i>Status Input</i> Off Mode	TRUE when the DGC-2020 is in Off Mode.	Status Input 
<i>Status Input</i> PF Mode Active	TRUE when PF mode is active.	Status Input 
<i>Status Input</i> Pre Start Condition in Effect	TRUE while in the Pre Start state.	Status Input 
<i>Status Input</i> Pre Start Input	TRUE when the DGC-2020 is indicating that the Pre Start relay should be closed.	Status Input 
<i>Status Input</i> Reset Active	TRUE while the Reset button on the HMI is pressed.	Status Input 
<i>Status Input</i> Run Input	TRUE when the DGC-2020 is indicating that the Run Input should be closed.	Status Input 
<i>Status Input</i> Run Mode	TRUE when the DGC-2020 is in Run Mode.	Status Input 
<i>Status Input</i> Single Phase AC Sensing Override	TRUE when the Single Phase AC Override input is TRUE.	Status Input 
<i>Status Input</i> Single Phase Connection Override	TRUE when the Single Phase Override input is TRUE.	Status Input 
<i>Status Input</i> Switch not in Auto	TRUE when the DGC-2020 is not in Auto Mode.	Status Input 
<i>Status Input</i> Start Input	TRUE when the DGC-2020 is indicating that the Start relay should be closed to start the engine.	Status Input 
<i>Status Input</i> VAR Mode Active	TRUE when Var mode is active.	Status Input 
Output Objects		
<i>Physical Outputs</i> OUT1 - OUTx	Physical Outputs 1 through 7 (style xxAxxxxx) or 1 through 15 (style xxBxxxxx).	Output - OUT1 
<i>Remote Outputs</i> OUT13 - OUT36	Remote Outputs 13 through 36. (Available when an optional CEM-2020 is connected.)	Output - OUT13 

Name	Description	Symbol
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 
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 
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 
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 
Auto Restart Fail	TRUE after the Automatic Restart function fails to restart the generator.	Alarm 
Battery Charger Fail	TRUE when the Battery Charger Fail function is configured as an Alarm and the activation delay has expired.	Alarm 
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 - CONFPROT101ALM 
Coolant Level Sender Fail	TRUE when a low coolant level error status code is received from the ECU. CANbus must be enabled.	Alarm 
Coolant Temp Sender Fail	TRUE when the Coolant Temp Sender Fail is configured as an Alarm and the activation delay has expired.	Alarm 
ECU Comm Loss	TRUE when communication to ECU has been lost.	Alarm 
ECU Shutdown	TRUE when ECU has Shutdown the engine.	Alarm 
Emergency Stop	TRUE when the Emergency Stop button has been pressed.	Alarm 
Fuel Leak	TRUE when the Fuel Leak Detect function is configured as an Alarm and the activation delay has expired.	Alarm 
Fuel Level Sender Fail	TRUE when the Fuel Level Sender Fail is configured as an Alarm and the activation delay has expired.	Alarm 
Global Alarm	TRUE when one or more Alarms are set.	Alarm 
Global Sender Fail	TRUE when one or more of the Sender Fails are configured as Alarms and are TRUE.	Sender Fail 

Name	Description	Symbol
Hi Coolant Temp	TRUE when the High Coolant Temp Alarm settings have been exceeded.	Alarm 
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 
Low Fuel Level	TRUE when the Low Fuel Level Alarm settings have been exceeded.	Alarm 
Low Oil Pressure	TRUE when the Low Oil Pressure Alarm settings have been exceeded.	Alarm 
Oil Pressure Sender Fail	TRUE when the Oil Pressure Sender Fail is configured as an Alarm and the activation delay has expired.	Alarm 
Overcrank	TRUE when an Overcrank condition exists.	Alarm 
Overspeed	TRUE when the Overspeed Alarm settings have been exceeded.	Alarm 
Speed Sender Fail	TRUE when the Speed Sender Fail activation delay has expired.	Alarm 
Voltage Sensing Fail	TRUE when the Voltage Sensing Fail is configured as an Alarm and the activation delay has expired.	Alarm 
Pre-Alarms		
<i>Analog Expansion Module</i> Analog Expansion Module Comm Fail	TRUE when communication from the AEM-2020 to the DGC-2020 has been lost.	Pre-Alarm 
<i>Analog Expansion Module</i> Multiple Analog Expansion Modules Detected	TRUE when more than one AEM-2020 is connected.	Pre-Alarm 
<i>Analog Expansion Module</i> 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 
<i>Analog Expansion Module</i> 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 
<i>Analog Expansion Module</i> 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 
<i>Analog Expansion Module</i> 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 

Name	Description	Symbol
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, <i>BESTCOMSPlus Software, Alarm Configuration, Pre-Alarms</i> , 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 DGC-2020 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 <i>System Parameters, Remote Module Setup</i> screen in BESTCOMSPlus.	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 
Diag Trouble Code	TRUE when a Diagnostic Trouble Code exists.	Pre-Alarm DIAGTRBCODEPALM 
ECU Com 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 
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 FUELSENDFAILPALM 
Global Pre-Alarm	TRUE when one or more Pre-Alarms are set.	Pre-Alarm GLBPALM 

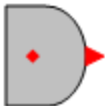
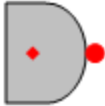
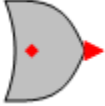
Name	Description	Symbol
Hi Coolant Temp	TRUE when the High Coolant Temp Pre-Alarm threshold has been exceeded.	Pre-Alarm HITEMPPALM 
High Fuel Level	TRUE when the High Fuel Level Pre-Alarm settings have been exceeded.	Pre-Alarm HIFUELLPALM 
Intergenset Comm Fail	TRUE when an individual generator detects 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 DGC-2020 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 
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 <i>Network Configuration</i> 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 <i>Network Configuration</i> 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 

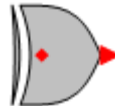
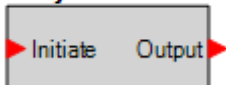
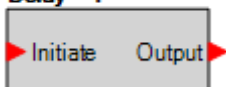
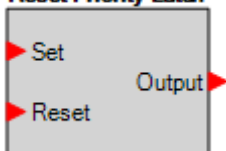
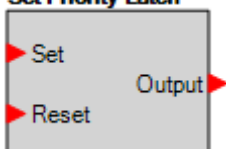
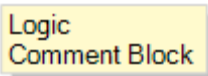
Name	Description	Symbol
Senders		
Coolant Temp Sender Fail	TRUE when the Coolant Temp Sender Fail is configured as either a Pre-Alarm or Alarm and the activation delay has expired.	Sender Fail 
Fuel Level Sender Fail	TRUE when the Fuel Level Sender Fail is configured as either a Pre-Alarm or Alarm and the activation delay has expired.	Sender Fail 
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 
Speed Sender Fail	TRUE when the Speed Sender Fail activation delay has expired.	Sender Fail 
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 
Logic Control Relays		
<i>Inputs</i> Input 1-16	Additional logic inputs. TRUE when the associated Logic Control Relay Output is TRUE.	LCR Input 
<i>Outputs</i> Output 1-16	Additional logic outputs.	LCR Output 

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

Name	Description	Symbol										
Logic Gates												
AND	<table><tr><td>Input</td><td>Output</td></tr><tr><td>0 0</td><td>0</td></tr><tr><td>0 1</td><td>0</td></tr><tr><td>1 0</td><td>0</td></tr><tr><td>1 1</td><td>1</td></tr></table>	Input	Output	0 0	0	0 1	0	1 0	0	1 1	1	
Input	Output											
0 0	0											
0 1	0											
1 0	0											
1 1	1											
NAND	<table><tr><td>Input</td><td>Output</td></tr><tr><td>0 0</td><td>1</td></tr><tr><td>0 1</td><td>1</td></tr><tr><td>1 0</td><td>1</td></tr><tr><td>1 1</td><td>0</td></tr></table>	Input	Output	0 0	1	0 1	1	1 0	1	1 1	0	
Input	Output											
0 0	1											
0 1	1											
1 0	1											
1 1	0											
OR	<table><tr><td>Input</td><td>Output</td></tr><tr><td>0 0</td><td>0</td></tr><tr><td>0 1</td><td>1</td></tr><tr><td>1 0</td><td>1</td></tr><tr><td>1 1</td><td>1</td></tr></table>	Input	Output	0 0	0	0 1	1	1 0	1	1 1	1	
Input	Output											
0 0	0											
0 1	1											
1 0	1											
1 1	1											
NOR	<table><tr><td>Input</td><td>Output</td></tr><tr><td>0 0</td><td>1</td></tr><tr><td>0 1</td><td>0</td></tr><tr><td>1 0</td><td>0</td></tr><tr><td>1 1</td><td>0</td></tr></table>	Input	Output	0 0	1	0 1	0	1 0	0	1 1	0	
Input	Output											
0 0	1											
0 1	0											
1 0	0											
1 1	0											

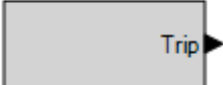
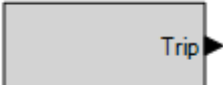
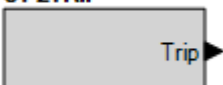
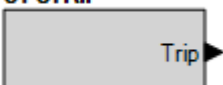
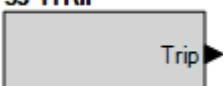
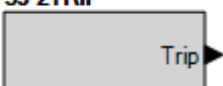
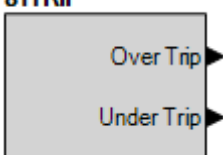
Name	Description	Symbol										
XOR	<table><tr><th>Input</th><th>Output</th></tr><tr><td>0 0</td><td>0</td></tr><tr><td>0 1</td><td>1</td></tr><tr><td>1 0</td><td>1</td></tr><tr><td>1 1</td><td>0</td></tr></table>	Input	Output	0 0	0	0 1	1	1 0	1	1 1	0	
Input	Output											
0 0	0											
0 1	1											
1 0	1											
1 1	0											
XNOR	<table><tr><th>Input</th><th>Output</th></tr><tr><td>0 0</td><td>1</td></tr><tr><td>0 1</td><td>0</td></tr><tr><td>1 0</td><td>0</td></tr><tr><td>1 1</td><td>1</td></tr></table>	Input	Output	0 0	1	0 1	0	1 0	0	1 1	1	
Input	Output											
0 0	1											
0 1	0											
1 0	0											
1 1	1											
NOT (INVERTER)	<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>	Input	Output	0	1	1	0					
Input	Output											
0	1											
1	0											
Pickup and Dropout Timers												
Drop Out Timer	Used to set a delay in the logic.	Drop Out Timer (1) TIMER_1 Delay = 1 										
Pickup Up Timer	Used to set a delay in the logic.	Pick Up Timer (1) TIMER_1 Delay = 1 										
Latches												
Reset Priority Latch	A positive going edge on the Set input sets the latch, as long as the Reset input is false. A positive edge on the Reset input will clear the latch.	Reset Priority Latch 										
Set Priority Latch	A positive going edge on the Set input sets the latch. A positive going edge on the Reset input will clear the latch, as long as the Set input is false.	Set Priority Latch 										
Other												
Comment Block	Enter user comments.											

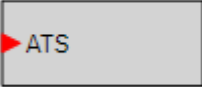
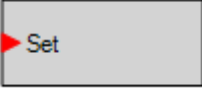
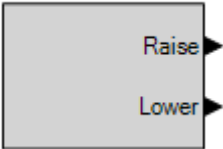
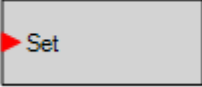
Elements

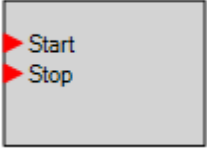
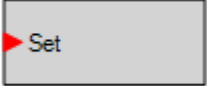
This group contains elements for the 51, 27, 47, 59, 81, 32, and 40. It also contains elements for Generator Breaker, AVR Raise/Lower, Governor Raise/Lower, Logic Alarm, Logic Pre-Alarm, Modem, Configurable Elements, AUTO Mode, OFF Mode, RUN Mode, Parallel to Mains, and Run with Load.

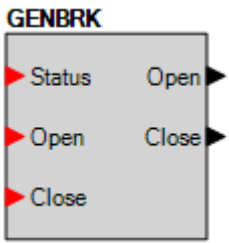
Table 5-3 lists the names and descriptions of the elements in the *Elements* group.

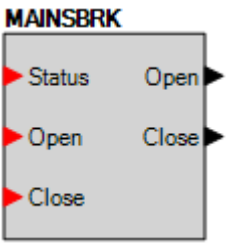
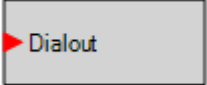
Table 5-3. Elements Group, Names and Descriptions

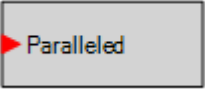
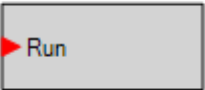
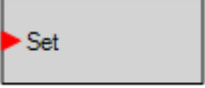
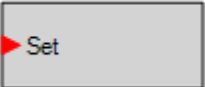
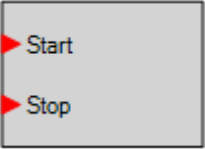
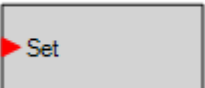
Name	Description	Symbol
Protection		
27-1TRIP	TRUE when the 27-1 undervoltage is in a TRIP condition. Connect to another logic block input.	27-1TRIP 
27-2TRIP	TRUE when the 27-2 undervoltage is in a TRIP condition. Connect to another logic block input.	27-2TRIP 
32TRIP	TRUE when the 32 reverse power is in a TRIP condition. Connect to another logic block input.	32TRIP 
40TRIP	TRUE when the 40Q loss of excitation is in a TRIP condition. Connect to another logic block input.	40TRIP 
47TRIP (Optional)	TRUE when the 47 phase imbalance is in a TRIP condition. Connect to another logic block input.	47TRIP 
51-1TRIP (Optional)	TRUE when the 51-1 overcurrent is in a TRIP condition. Connect to another logic block input.	51-1TRIP 
51-2TRIP (Optional)	TRUE when the 51-2 overcurrent is in a TRIP condition. Connect to another logic block input.	51-2TRIP 
51-3TRIP (Optional)	TRUE when the 51-3 overcurrent is in a TRIP condition. Connect to another logic block input.	51-3TRIP 
59-1TRIP	TRUE when the 59-1 overvoltage is in a TRIP condition. Connect to another logic block input.	59-1TRIP 
59-2TRIP	TRUE when the 59-2 overvoltage is in a TRIP condition. Connect to another logic block input.	59-2TRIP 
81TRIP	TRUE when the 81 frequency is in a TRIP condition. Connect to another logic block input.	81TRIP 

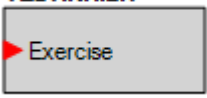
Name	Description	Symbol
Other		
ATS	When this logic element is TRUE, and the DGC-2020 is in AUTO mode, the generator will run. This can be used in place of the ATS programmable function if it is desired to generate the ATS signal as a combination of programmable logic rather than a simple contact input. 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 DGC 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 DGC is in AUTO mode, the generator will cool down and stop.	ATS 
AUTOMODE	When this input is TRUE, and the DGC-2020 is in OFF mode, the DGC-2020 will switch to AUTO mode. This is a pulsed input. It does not need to be held after the desired mode switch has occurred.	AUTOMODE 
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.	AVR 
CONFELMNTX (X = 1 to 8)	Configurable elements (CONFELMNT1-8) are connected to the logic scheme as outputs. These elements are configurable in BESTCOMSPlus under <i>Programmable Outputs, Configurable Elements</i> . 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 DGC-2020 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 DGC-2020's.	CONFELMNT1 CONFIG_ELEMENT_1 
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.	COOLSTOPREQ 

Name	Description	Symbol
COOLDOWNREQ	<u>RUN Mode</u> 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. <u>AUTO Mode</u> 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.	
ENGINE RUN	The Start input starts the generator. No load is applied. The breaker remains open. The Stop input stops the generator. The DGC-2020 only responds to this logic element when in AUTO mode.	
EXTSTARTDEL	If the Set input is TRUE while the DGC-2020 is in the Pre Start state, the DGC-2020 will remain in the Pre Start state until the Set input is FALSE.	

Name	Description	Symbol
GENBRK	This element is used to connect the breaker open and close output signals from the DGC-2020 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> <i>Status:</i> This input allows a contact input to be mapped that will provide breaker status feedback to the DGC-2020. 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. <i>Open:</i> 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 DGC-2020 is in RUN or AUTO mode, the breaker will open. <i>Close:</i> 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 DGC-2020 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 DGC-2020 will synchronize the generator to the bus, and then close the breaker. If the synchronizer option is not available, the DGC-2020 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 DGC-2020 that will be used to drive the breaker. <i>Open:</i> This output is pulsed TRUE (closes the output contact it is mapped to) when the DGC-2020 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. <i>Close:</i> This output is pulsed TRUE (closes the output contact it is mapped to) when the DGC-2020 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.	
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.	
LOGICALM	When this input is TRUE, the DGC-2020 goes into an Alarm condition.	
LOGICPALM	When this input is TRUE, the DGC-2020 goes into a Pre-alarm condition.	

Name	Description	Symbol
MAINSBRK	This element is used to connect the breaker open and close output signals from the DGC-2020 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 is configured on the <i>Breaker Hardware</i> screen via the <i>Breaker Management</i> tree branch. <u>Inputs</u> <i>Status</i>: This input allows a contact input to be mapped that will provide breaker status feedback to the DGC-2020. 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. <i>Open</i>: 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 DGC-2020 is in RUN or AUTO mode, the breaker will open. <i>Close</i>: 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 DGC-2020 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 DGC-2020 will synchronize the generator to the bus, and then close the breaker. If the synchronizer option is not available, the DGC-2020 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 DGC-2020 that will be used to drive the breaker. <i>Open</i>: This output is pulsed TRUE (closes the output contact it is mapped to) when the DGC-2020 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. <i>Close</i>: This output is pulsed TRUE (closes the output contact it is mapped to) when the DGC-2020 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.	
MODEM (Optional)	Connect the input to the output of another logic block. When TRUE, the Modem will dial out.	
OFFMODE	When this input is TRUE, the DGC-2020 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 DGC-2020 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 <i>Governor Bias Control Settings</i> 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 <i>AVR Bias Control Settings</i> 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 <i>AVR Bias Control Settings</i> screen. When Var/PF control is not active or not enabled, the voltage controller can be set up to implement voltage droop.	PARTOMAINS 
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 DGC-2020. When the "Predefined" functionality is selected, the relay will not respond to this element.	PRESTARTOUT 
RUNINHIBIT	When this logic element is TRUE, the DGC-2020 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 <u>any</u> condition in effect which will cause the generator to run, the DGC-2020 will start and run the generator.	RUNINHIBIT 
RUNMODE	When this input is TRUE, and the DGC-2020 is in OFF mode, the DGC-2020 will switch to RUN mode. This is a pulsed input. It does not need to be held after the desired mode switch has occurred.	RUNMODE 
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 DGC-2020. When the "Predefined" functionality is selected, the relay will not respond to this element.	RUNOUTPUT 
RUNWLOAD	The Start input starts the generator and closes the Gen breaker. The Stop input stops the generator and opens the Gen breaker. The DGC-2020 only responds to this logic element when in AUTO mode.	RUNWLOAD 
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 ECO, to control the pre start interval.	STARTDELBYP 

Name	Description	Symbol
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 DGC-2020. When the "Predefined" functionality is selected, the relay will not respond to this element.	
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 DGC-2020 will start and run the generator for the duration of the exercise period.	

LOGIC SCHEMES

A logic scheme is a group of logic variables written in equation form that defines the operation of a DGC-2020 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 Basler Electric DGC-2020's 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 DGC-2020 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 BESTCOMSPlus 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 DGC-2020

To retrieve settings from the DGC-2020, the DGC-2020 must be connected to a computer through a communications port. Once the necessary connections are made, settings can be downloaded from the DGC-2020 by selecting *Download Settings* on the Communication pull-down menu.

Sending a Logic Scheme to the DGC-2020

To send settings to the DGC-2020, the DGC-2020 must be connected to a computer through a communications port. Once the necessary connections are made, settings can be uploaded to the DGC-2020 by selecting *Upload Settings* on the Communication pull-down menu.

CAUTION

Always remove the DGC-2020 from service prior to changing or modifying the active logic scheme. Attempting to modify a logic scheme while the DGC-2020 is in service could generate unexpected or unwanted outputs.

CAUTION

Modifying a logic scheme in BESTCOMSPlus does not automatically make that scheme active in the DGC-2020. The modified scheme must be uploaded into the DGC-2020. See the paragraphs on *Sending and Retrieving Logic Schemes* later in this section.

PROGRAMMING BESTlogic+

BESTCOMSPlus is used to program BESTlogic+. Using BESTCOMSPlus is analogous to physically attaching wire between discrete DGC-2020 terminals. To program BESTlogic+, use the Settings Explorer within BESTCOMSPlus to open the *BESTlogic+ 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 element is disabled, it will have a yellow X on it. To enable the element, navigate to the settings page for that element.

The view of the Main Logic, Physical Outputs, and Remote Outputs can be automatically arranged by clicking the right mouse button on the window and selecting *Auto-Layout*.

The following must be met before BESTCOMSPlus will allow logic to be uploaded to the DGC-2020:

- 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 five 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 ten 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.
- At all levels there can only be 64 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+ 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)	Yellow	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 BESTCOMSPlus to open the *BESTlogic+ 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 0.0 to 1800.0 seconds in 0.1-second increments.

Next, open the *Components* tab inside the BESTlogic+ 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.

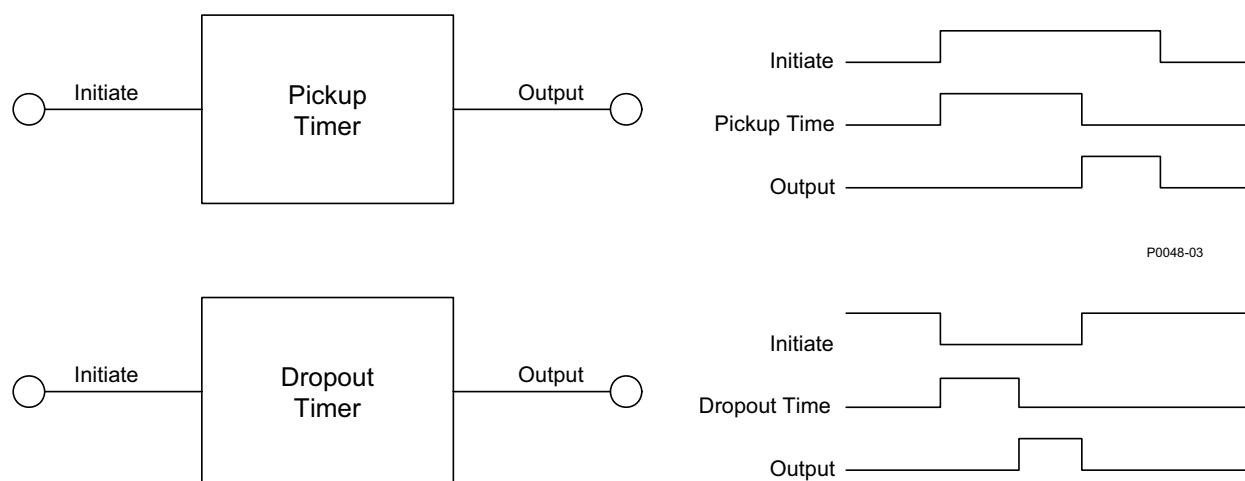


Figure 5-2. Pickup and Dropout Timer Logic Blocks

BESTlogic+ FILE MANAGEMENT

To manage BESTlogic+ files, use the Settings Explorer to open the *BESTlogic+ Programmable Logic* tree branch. The BESTlogic+ Programmable Logic toolbar is used to manage BESTlogic+ files. Refer to Figure 5-3. For information on Settings Files management, refer to Section 4, *BESTCOMSPlus Software*.



Figure 5-3. BESTlogic+ Programmable Logic Toolbar

Saving a BESTlogic+ File

After programming BESTlogic+ settings, click on the Save button to save the settings to memory.

Before the new BESTlogic+ settings can be uploaded to the DGC-2020, you must select Save from the *File* pull-down menu located at the top of the BESTCOMSPlus main shell. This step will save both the BESTlogic+ settings and the operating settings to a file.

The user also has the option to save the BESTlogic+ settings to a unique file that contains only BESTlogic+ 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+ File

To open a saved BESTlogic+ file, click on the *Logic Library* drop-down button on the BESTlogic+ 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+ 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+ File

To upload a BESTlogic+ file to the DGC-2020, you must first open the file through BESTCOMSPlus or create the file using BESTCOMSPlus. Then pull down the *Communication* menu and select *Upload Logic*.

Downloading a BESTlogic+ File

To download a BESTlogic+ file from the DGC-2020, you must pull down the *Communication* menu and select *Download Logic*. If the logic in your BESTCOMSPlus 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+ File

To view a preview of the printout, click on the *Print Preview* icon located on the BESTlogic+ 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+ 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+ 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+ EXAMPLES

Example 1 - AVR Logic Block Connections

Figure 5-4 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.

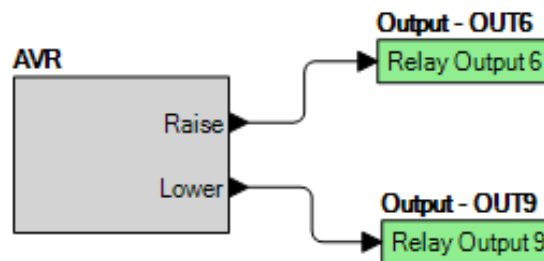


Figure 5-4. Example 1 - AVR Logic Block Connections

Example 2 - AND Gate Connections

Figure 5-5 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.

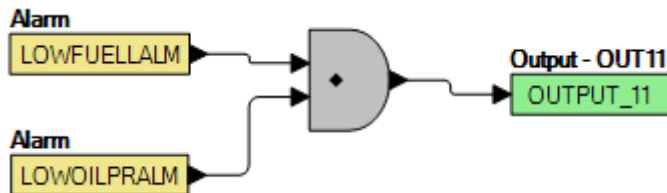


Figure 5-5. Example 2 - AND Gate Connections

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 DGC-2020 is in RUN mode (RUN Mode TRUE). Refer to Figure 5-6.

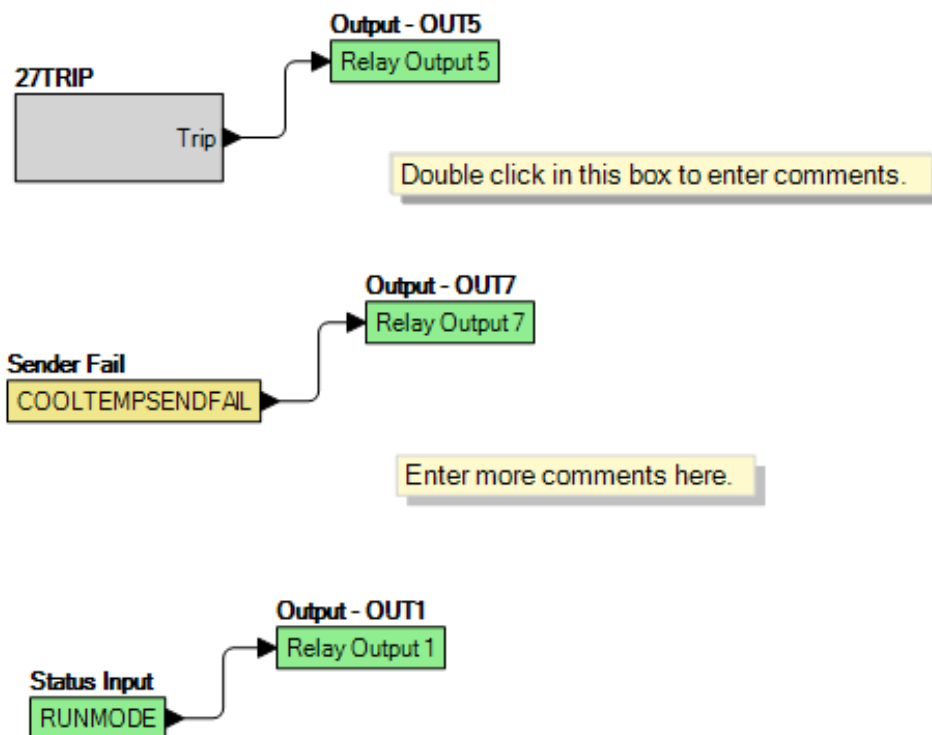


Figure 5-6. Example 3 - Multiple Logic Connections

SECTION 6 • INSTALLATION

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SECTION 6 • INSTALLATION

GENERAL

DGC-2020 controllers are delivered in sturdy cartons to prevent shipping damage. Upon receipt of a system, 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 the Basler Electric regional sales office, your sales representative, or a sales representative at Basler Electric, Highland, Illinois USA.

If the device is not installed immediately, store it in the original shipping package in a moisture- and dust-free environment.

PRODUCT REGISTRATION

Registering with Basler Electric enables you to receive important information updates on your product plus new product announcements. Register your product by directing your web browser to www.basler.com.

HARDWARE

DGC-2020 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. DGC-2020 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 measurement of 10.75 inches has a tolerance of +0.01/-0.01 inches. The horizontal measurement of 10.25 inches has a tolerance of +0.04/-0 inches. The vertical measurement of 7.25 inches has a tolerance of +0.01/-0.01 inches. The vertical measurement of 6.75 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.

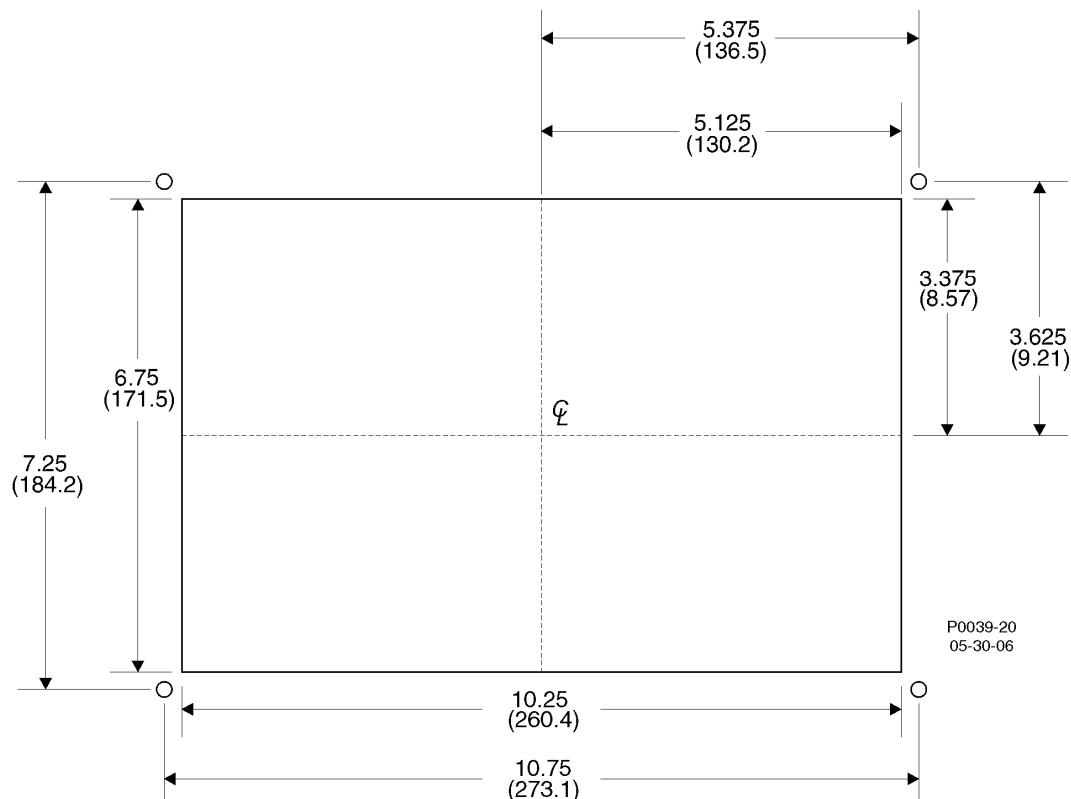


Figure 6-1. Panel Cutting and Drilling Dimensions

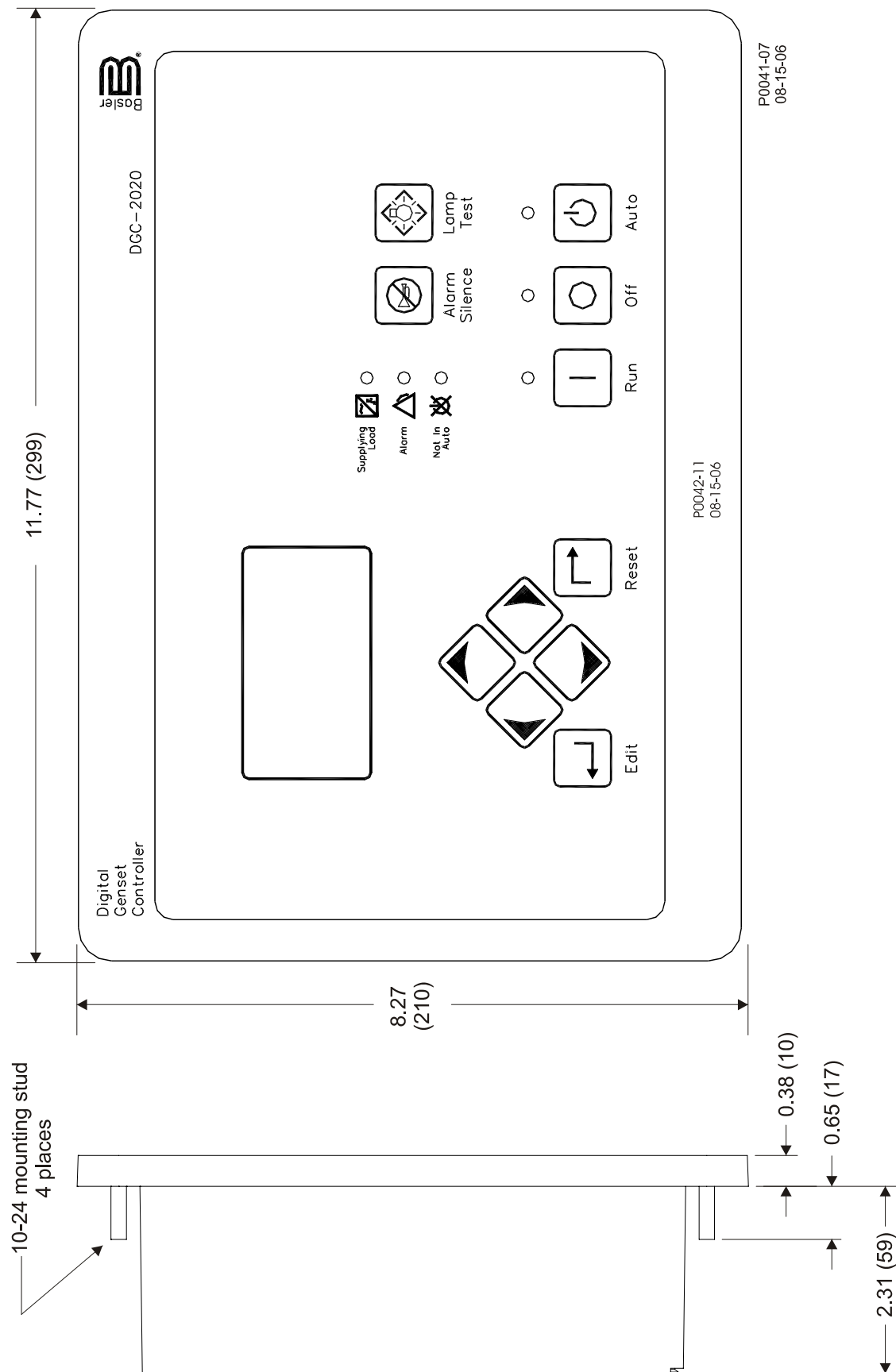


Figure 6-2. Overall Dimensions

CONNECTIONS

DGC-2020 connections are dependent on the application. Incorrect wiring may result in damage to the controller.

NOTE

Be sure that the DGC-2020 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 DGC-2020 will not operate.

Terminations

All DGC-2020 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. Controllers equipped with the optional, internal dial-out modem have an additional RJ-11 jack.

The mini-B USB socket mates with a standard USB cable and provides local communication between the DGC-2020 and a PC running BESTCOMSPlus software.

The majority of DGC-2020 connections are made with 15-position connectors with screw-down compression terminals. These connectors plug into headers on the DGC-2020. 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 4 inch-pounds (0.45 N•m).

Connections to the DGC-2020 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.

DGC-2020 terminal groups are described in the following paragraphs.

Operating Power

The DGC-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 DGC-2020 will not operate. Operating power terminals are listed in Table 6-1.

It is recommended that a fuse be added for additional protection for the wiring to the battery input of the DGC-2020. A Bussmann ABC-7 fuse or equivalent will help prevent wire damage and nuisance trips due to initial power supply inrush current.

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 DGC-2020 has sensing inputs for A-phase, B-phase, and C-phase generator current. Depending on the style number, a DGC-2020 will have a nominal sensing current rating of 1 Aac or 5 Aac. A style number of 1xxxxxxx indicates 1 Aac nominal current sensing and a style number of 5xxxxxxx 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 DGC-2020 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, a DGC-2020 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 DGC-2020 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 DGC-2020 senses A-phase and B-phase bus voltage. Bus voltage sensing terminals are listed in Table 6-4.

Table 6-4. Bus Voltage Sensing Terminals

Terminal	Description
43 (BUS VB)	B-phase bus voltage sensing input
45 (BUS VA)	A-phase bus voltage sensing input

Analog Engine Sender Inputs

Inputs are provided for oil pressure, fuel level, and coolant temperature senders.

Oil pressure senders that are compatible with the DGC-2020 include Datacon 02505-00, Isspro model R8919, and Stewart-Warner models 279BF, 279C, 411K, and 411M. Other senders may be used.

Compatible fuel level senders include Isspro model R8925. Other senders may be used.

Coolant temperature senders that are compatible with the DGC-2020 include Datacon 02019-00, Faria TS4042, Isspro model R8959 and Stewart-Warner model 334-P. Other senders may be used.

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 short-circuit across the input is removed. The ESTOP can be up to 75 ft away from the DGC-2020 using a maximum wire length of 150 ft. Emergency stop input terminals are listed in Table 6-6.

Table 6-6. Emergency Stop Input Terminals

Terminal	Description
46 (ESTOP)	Emergency stop contact input
47 (ESTOP)	

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 6-3, alleviates potential problems.

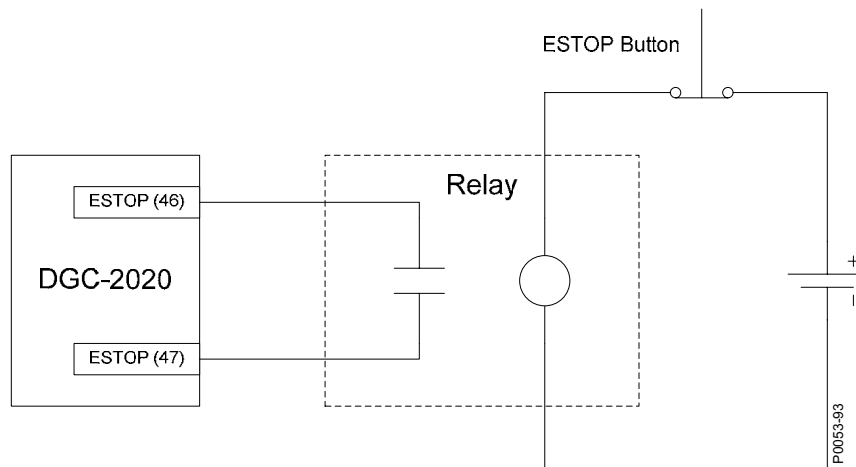


Figure 6-3. Interposing Relay Diagram

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.

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 DGC-2020 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 DGC-2020, either 4 or 12 sets of programmable output contacts are provided. Four programmable outputs are provided on DGC-2020 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 BESTCOMSPPlus software. The DGC-2020 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 (DGC-2020 termination).

RS-485 Communication Port

DGC-2020 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

CANbus Interface

These terminals provide communication using the SAE J1939 protocol or the MTU protocol and provide high-speed communication between the DGC-2020 and an MTU engine ECU on an electronically controlled engine. Connections between the MTU engine ECU and DGC-2020 should be made with twisted-pair, shielded cable. CANbus interface terminals are listed in Table 6-11. Refer to Figure 6-4 and Figure 6-5.

Table 6-11. CANbus Interface Terminals

Terminal	Description
48 (CAN L)	CAN low connection
49 (CAN H)	CAN high connection
50 (SHIELD)	CAN drain connection

NOTES

- 1.) If the DGC-2020 is providing one end of the J1939 bus, a 120 Ω terminating resistor should be installed across terminals 48 (CANL) and 49 (CANH).
- 2.) If the DGC-2020 is not part of the J1939 bus, the stub connecting the DGC-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 DGC-2020.

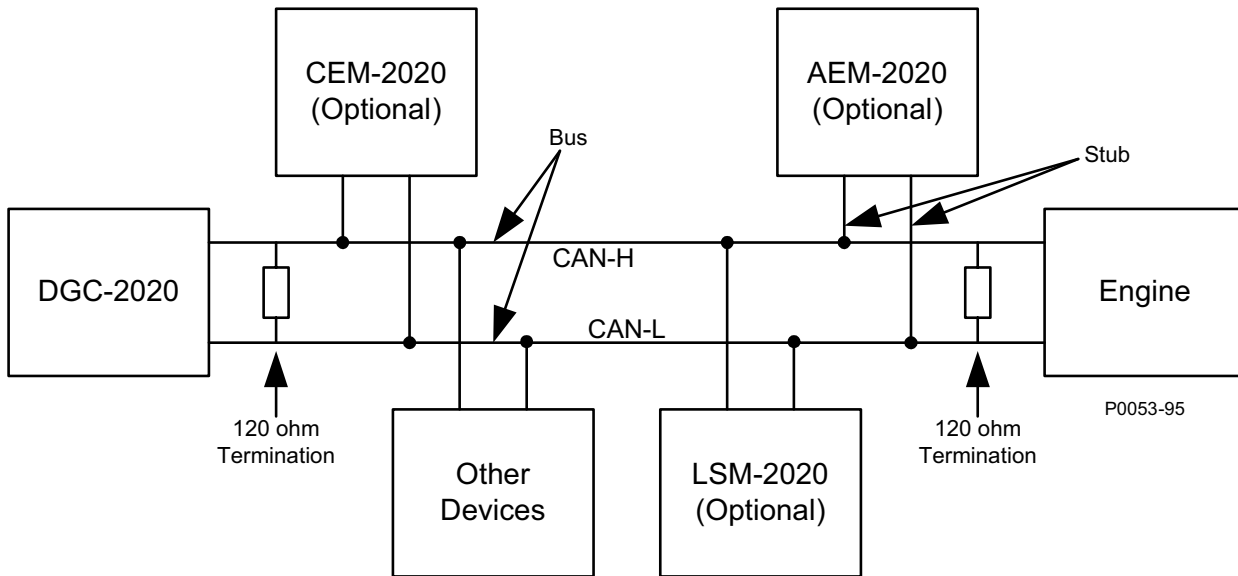


Figure 6-4. CANbus Interface with DGC-2020 providing One End of the Bus

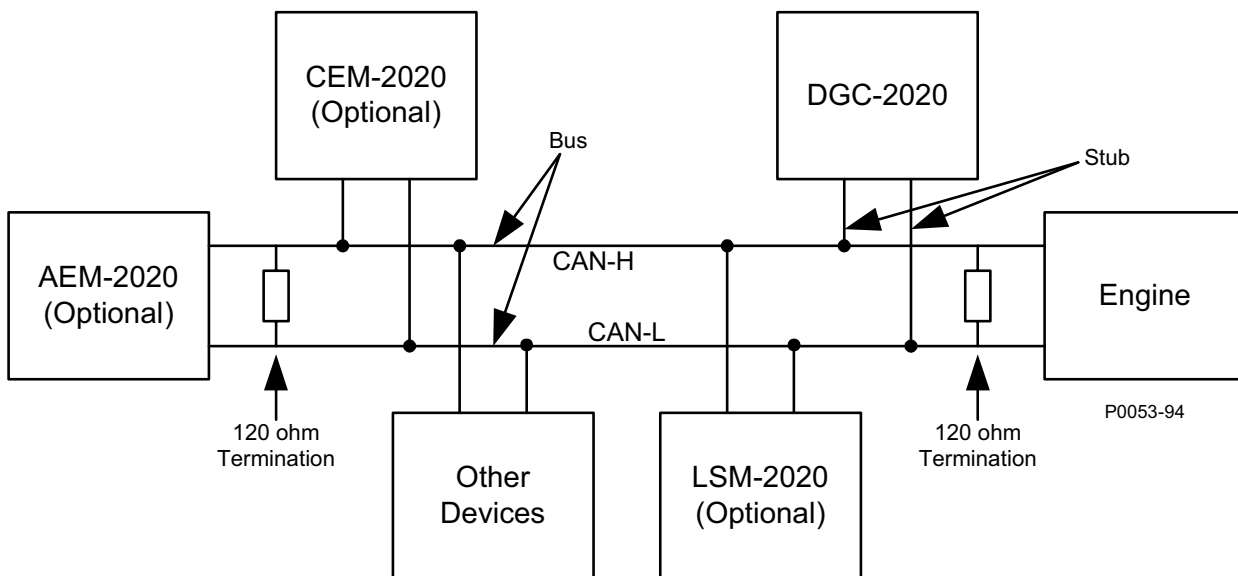


Figure 6-5. CANbus Interface with Optional AEM-2020 providing One End of the Bus

Dial-Out Modem

DGC-2020 controllers with style number xxxxxMxxx have an internal modem with dial-in, dial-out capability. The DGC-2020 connects to a standard-device telephone line through a USOC RJ-11C jack.

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 DGC-2020 and RDP-110. Twisted-pair conductors are recommended for connecting the communication terminals of the DGC-2020 and RDP-110.

Table 6-12 lists the DGC-2020 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

Connections for typical applications including 3-Phase Wye (Figure 6-6), 3-Phase Delta (Figure 6-7), Single-Phase A-B (Figure 6-8), and Single-Phase A-C (Figure 6-9) are shown on the following pages.

3-Phase Wye Connections for Typical Applications

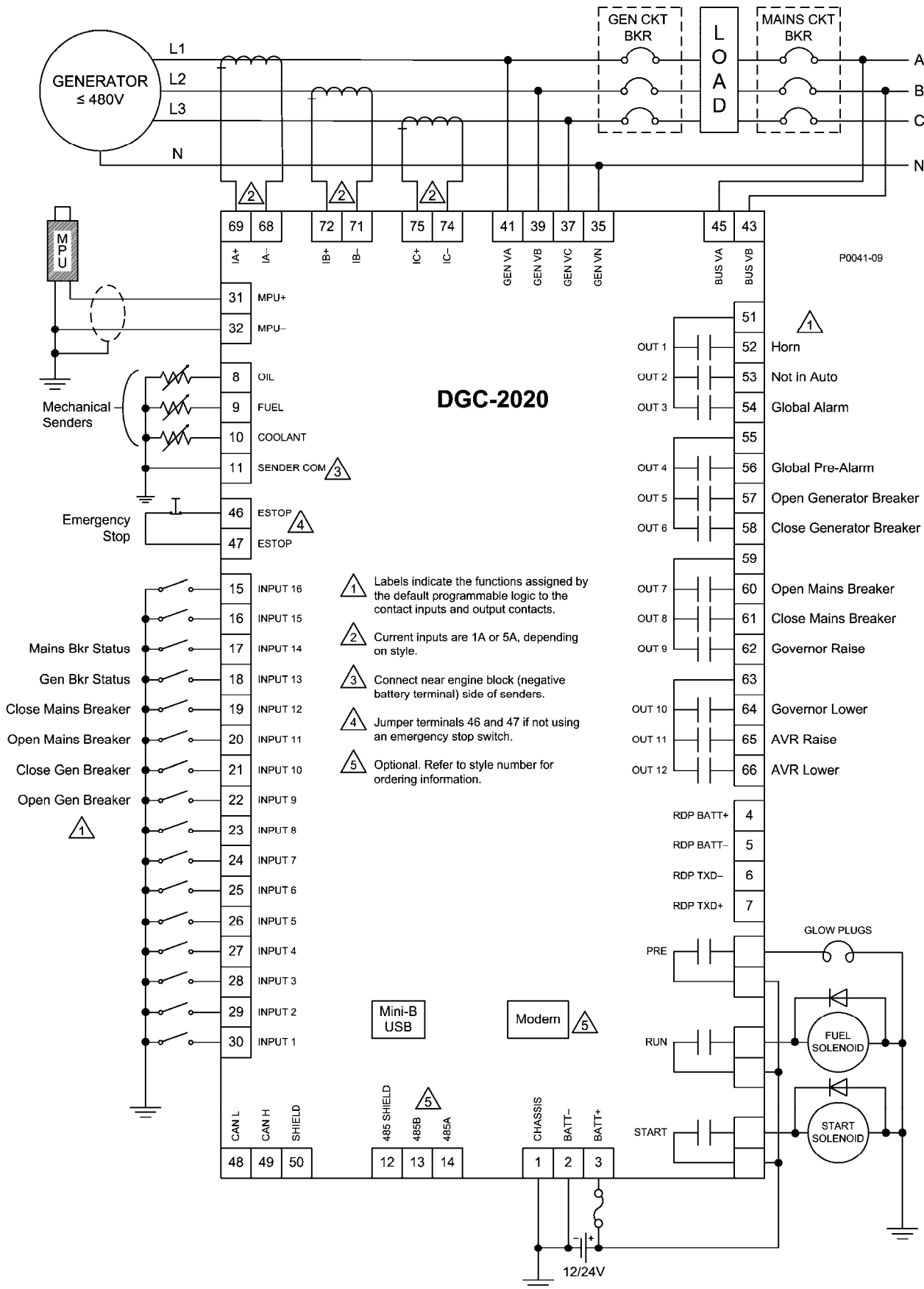


Figure 6-6. 3-Phase Wye Connections for Typical Applications

3-Phase Delta Connections for Typical Applications

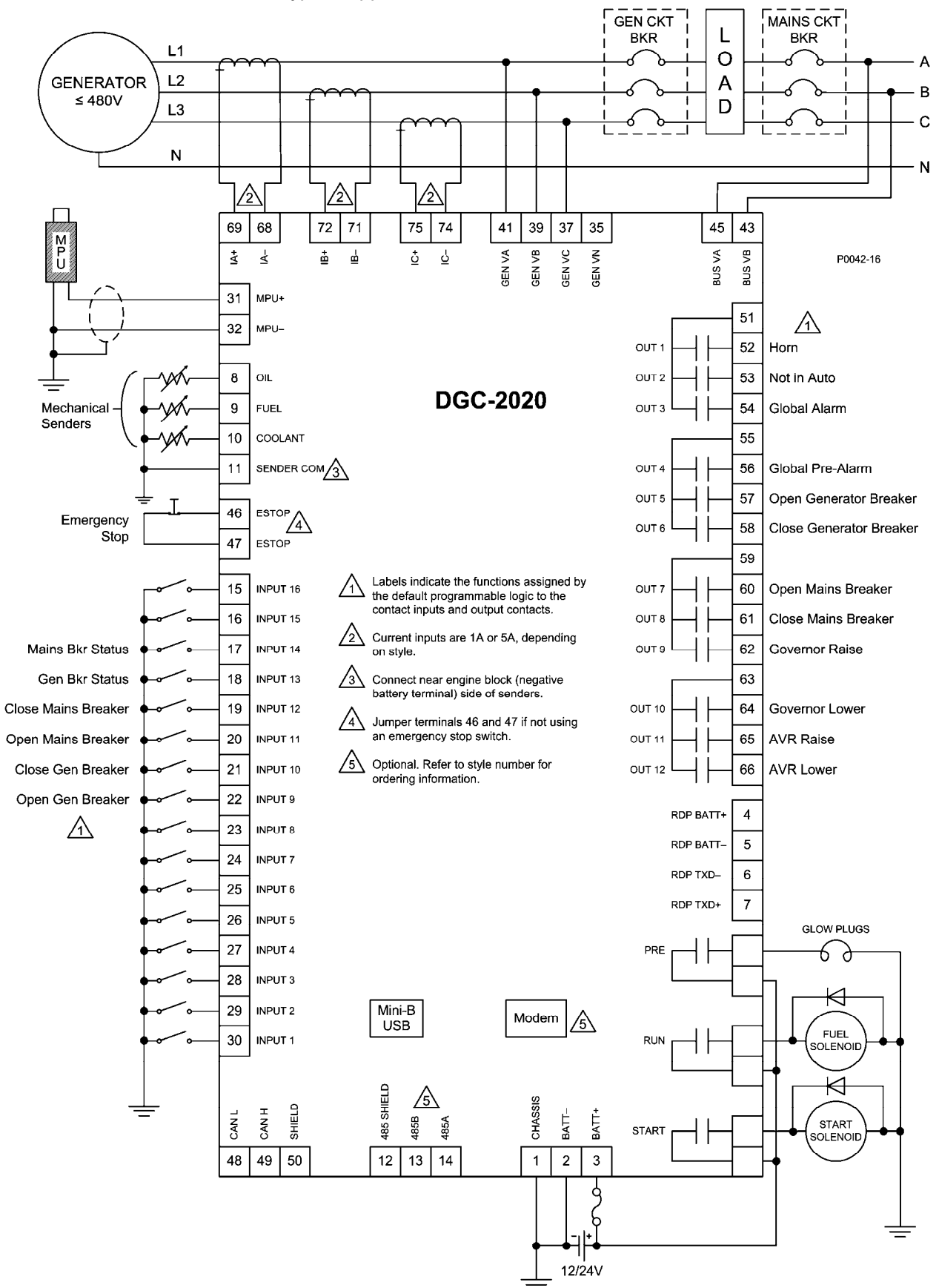


Figure 6-7. 3-Phase Delta Connections for Typical Applications

Single-Phase A-B Connections for Typical Applications

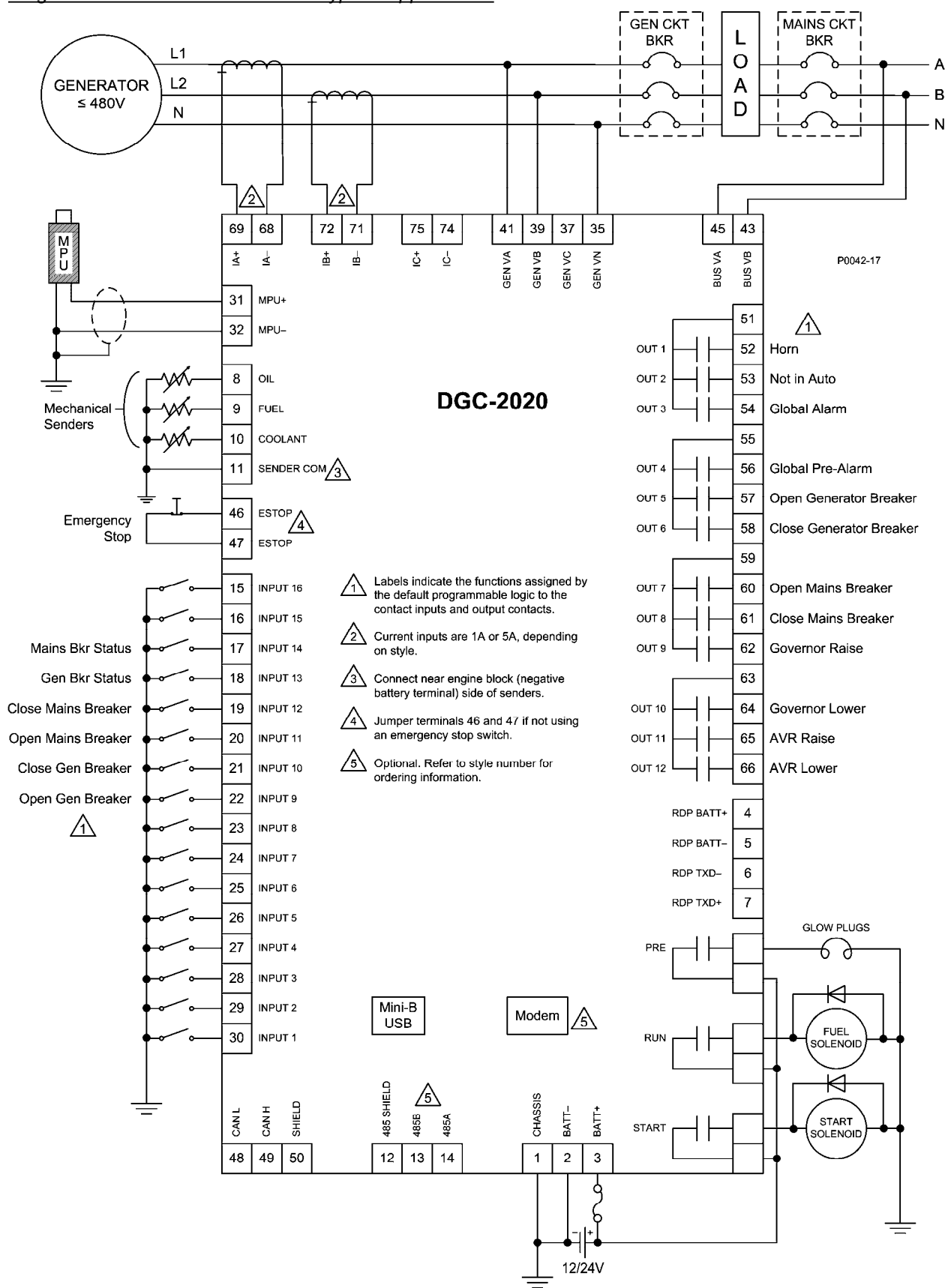


Figure 6-8. Single-Phase A-B Connections for Typical Applications

Single-Phase A-C Connections for Typical Applications

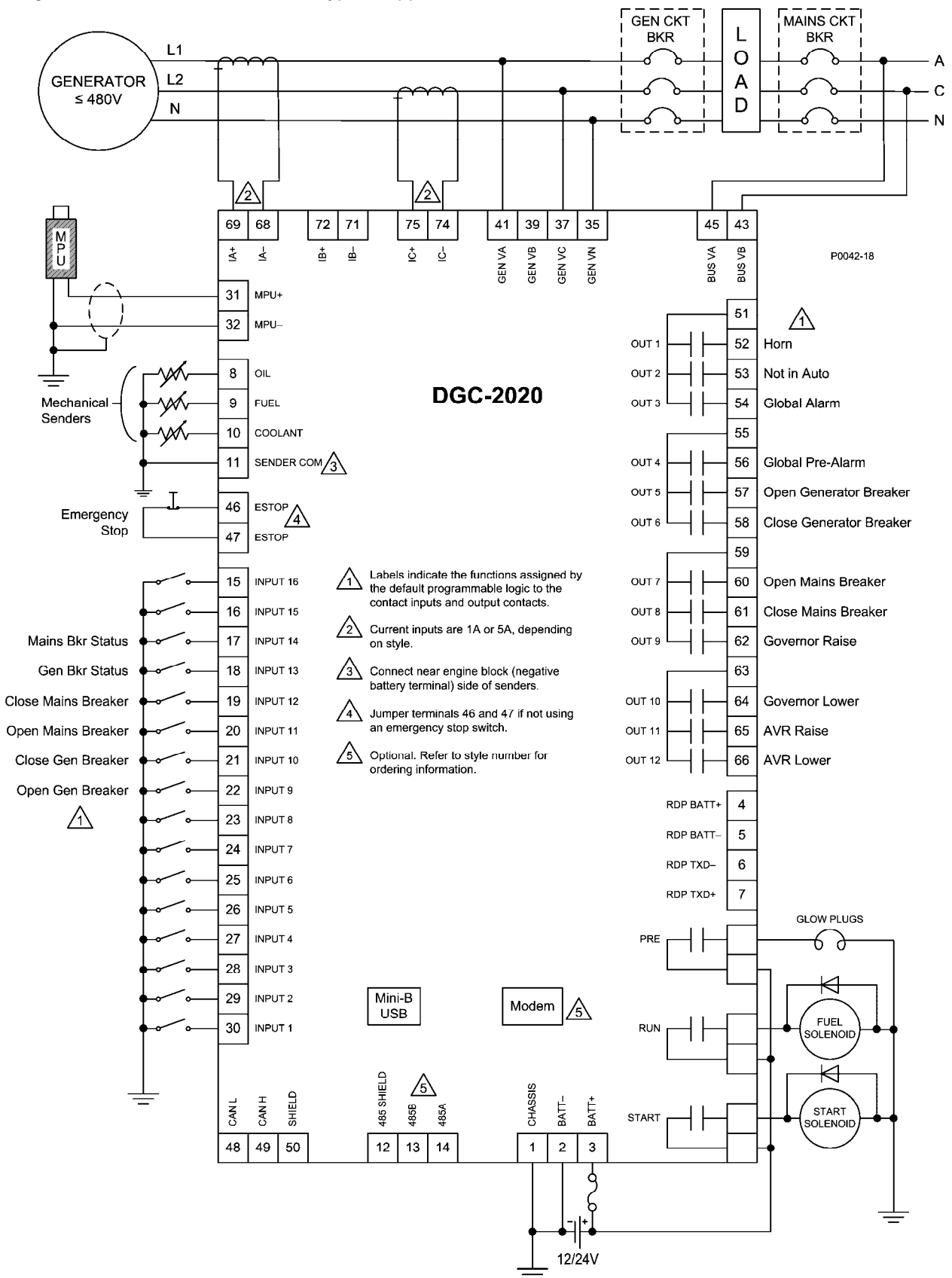


Figure 6-9. Single-Phase A-C Connections for Typical Applications

Connections for Volvo Penta EDC III Applications

Engines equipped with Volvo Penta EDC III controllers can receive engine control commands (such as start and stop) from the DGC-2020 through the SAE J1939 communication interface. To invoke this feature, the EDC III must receive a J1939 message containing engine control information within one second of waking (exiting sleep mode). If the EDC III does not receive an engine control message within the prescribed time, it will enter the stand-alone mode and ignore any J1939 control messages. If this occurs, the EDC III must be forced back into sleep mode by pressing the auxiliary stop pushbutton on the engine or by momentarily disconnecting EDC power.

The interconnection diagrams of Figures 6-10 through 6-13 illustrate the DGC-2020 and EDC III connections that allow the DGC-2020 to awaken the EDC III and start the engine, or simply acquire engine status information. Wake-up of the EDC III is initiated by using the DGC-2020 RUN output contacts to apply battery power to the EDC. To stop the engine, the DGC-2020 sends a sleep command through the J1939 interface to the EDC III and opens the RUN output contacts. This causes the EDC to stop the engine and enter the sleep mode.

In order for the DGC-2020 to communicate with the EDC III, two DGC-2020 settings must be changed from their default values.

- The J1939 address of the DGC-2020 must be set at 17.
- The engine start/stop configuration setting must be set for Volvo Penta.

Both settings are configured on the *CANbus Setup* screen of BESTCOMSPlus. Section 4, *BESTCOMSPlus Software* has information about adjusting DGC-2020 settings through BESTCOMSPlus.

Figure 6-10. 3-Phase Wye Connections for Volvo Penta EDC III Applications



3-Phase Delta Connections for Volvo Penta EDC III Applications

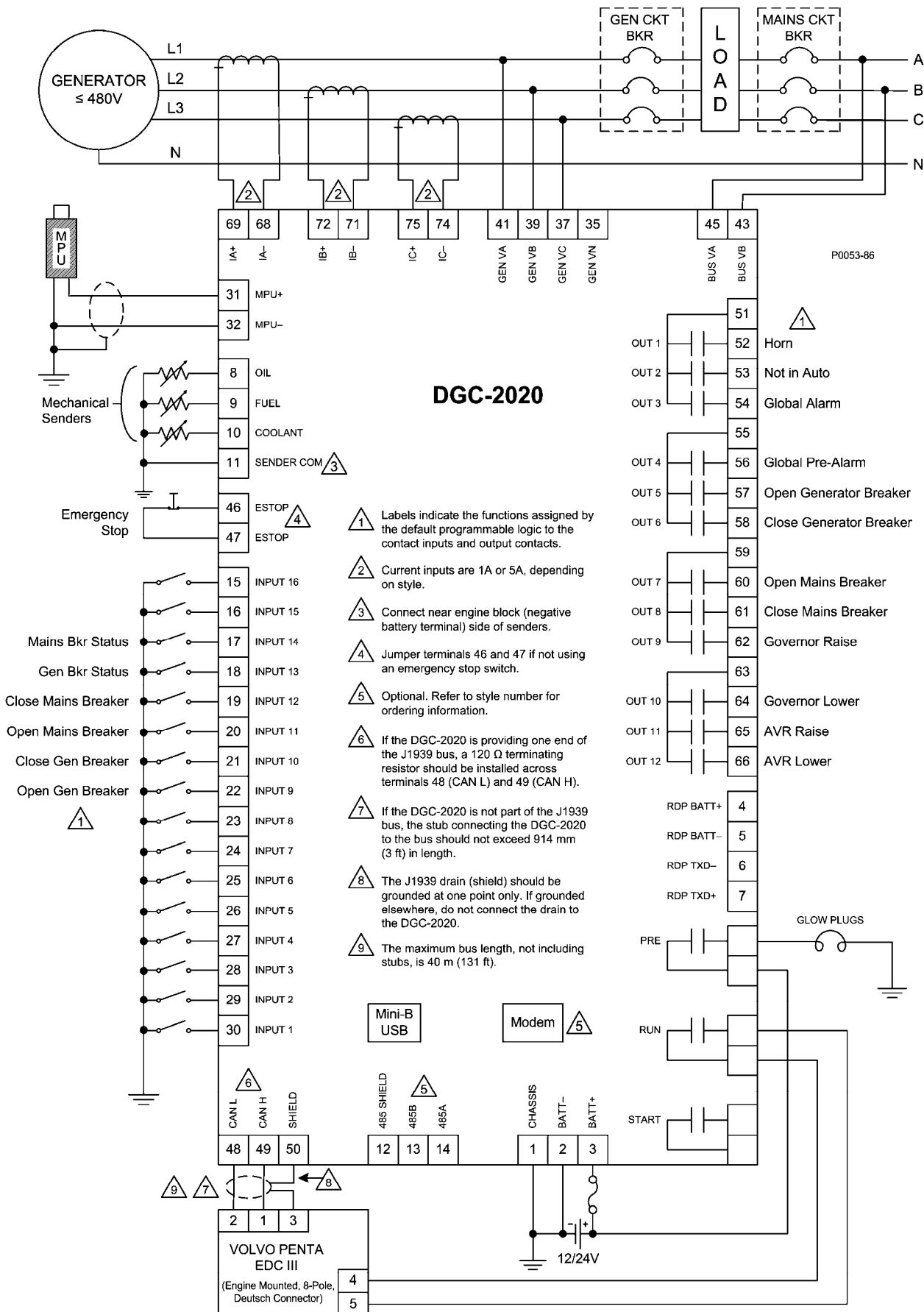


Figure 6-11. 3-Phase Delta Connections for Volvo Penta EDC III Applications

Single-Phase A-B Connections for Volvo Penta EDC III Applications

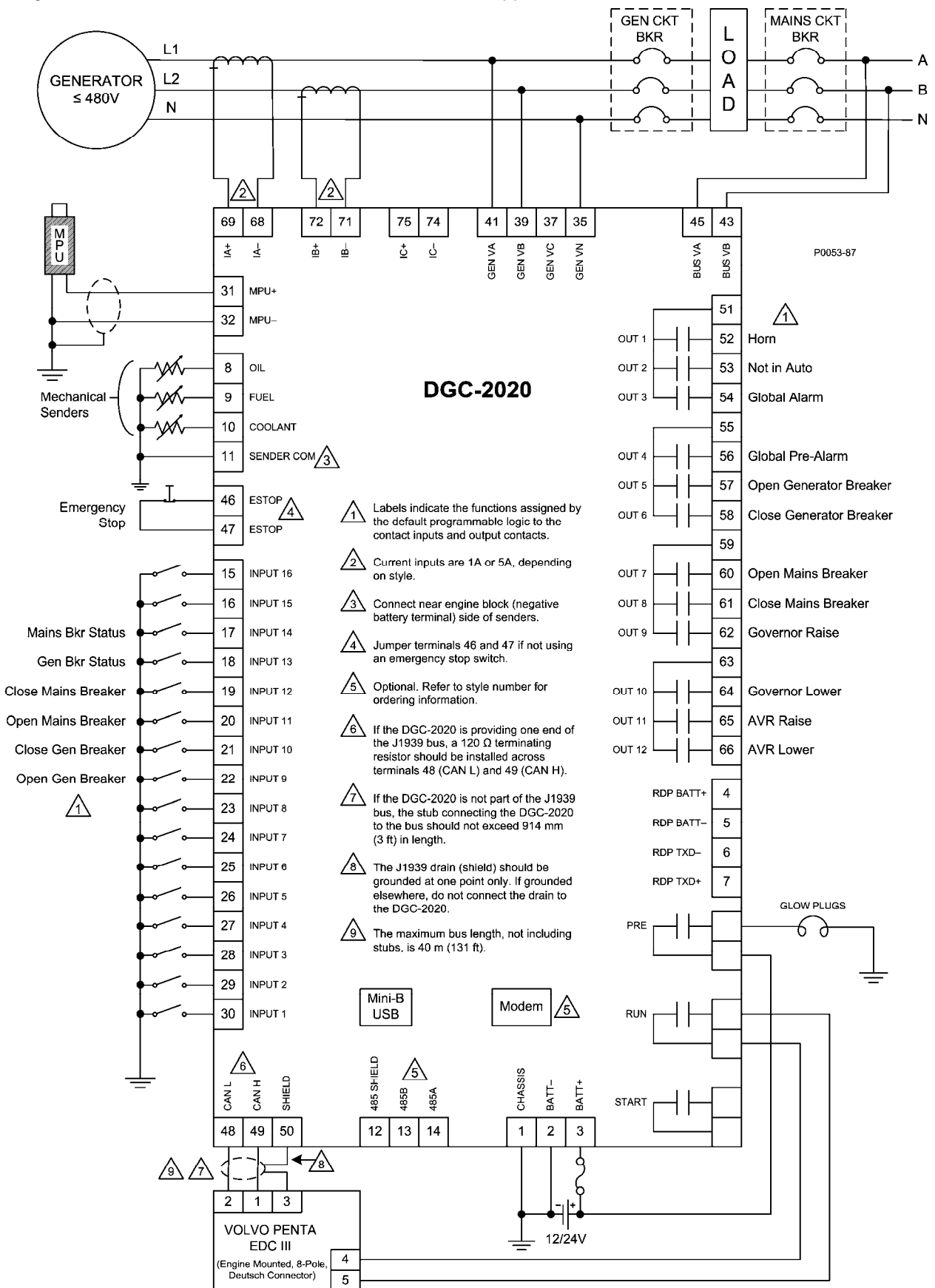


Figure 6-12. Single-Phase A-B Connections for Volvo Penta EDC III Applications

Single-Phase A-C Connections for Volvo Penta EDC III Applications

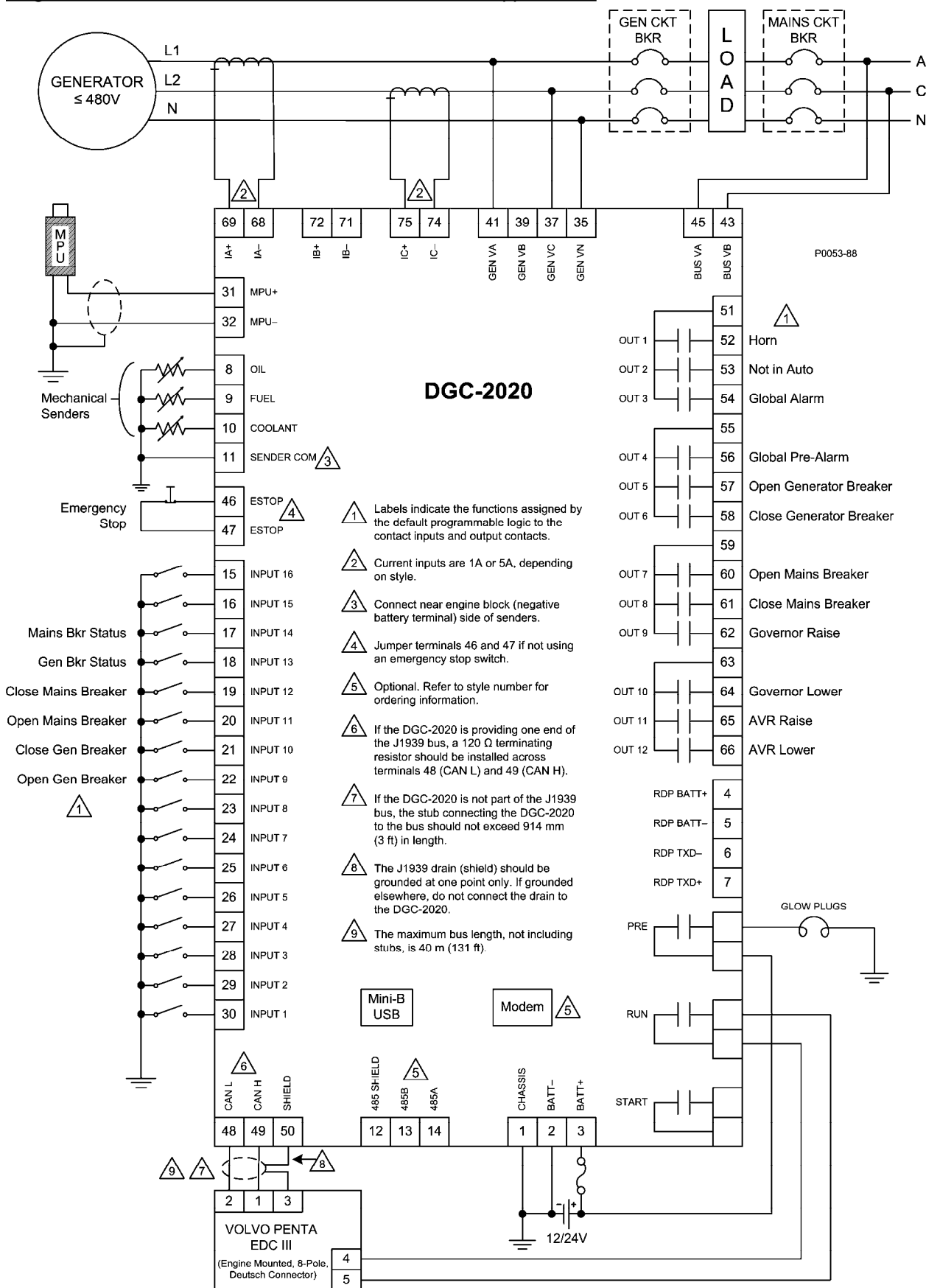


Figure 6-13. Single-Phase A-C Connections for Volvo Penta EDC III Applications

Connections for MTU MDEC ECU Applications

MTU MDEC ECUs, supplied on some Detroit Diesel engines, can receive engine control commands from the DGC-2020 and transmit engine operating status information to the DGC-2020 through the SAE J1939 communication interface.

In order for the DGC-2020 to communicate with the MTU MDEC ECU, ECU support must be enabled on the CANbus Setup screen of BESTCOMSPlus and "MTU MDEC" must be selected as the engine configuration. The appropriate ECU module type, speed demand source, and engine rpm must also be selected.

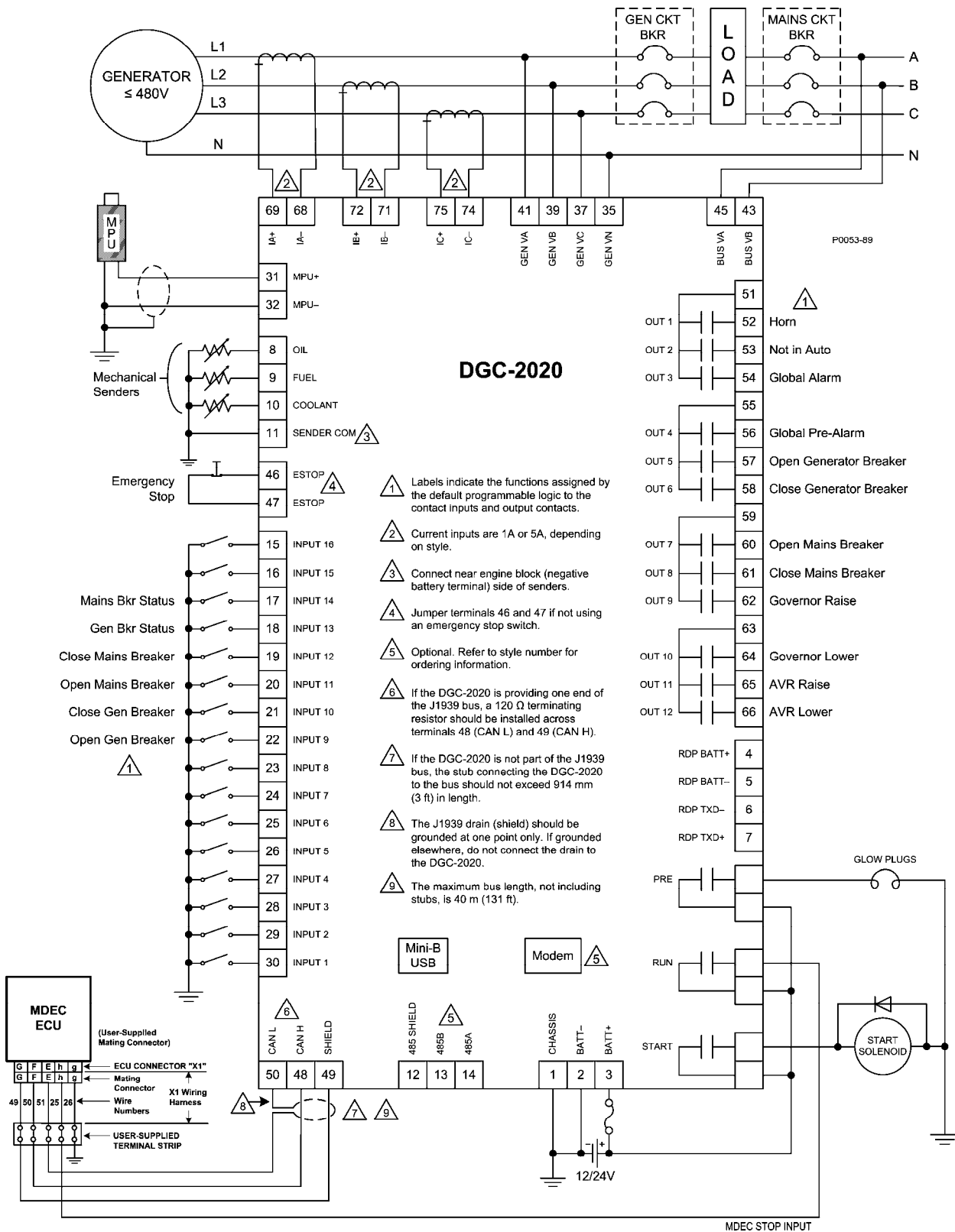
The MTU MDEC ECU must be configured properly in order for CANbus communication to function correctly. The parameters listed in Table 6-13 must be configured in the ECU with the MTU service tool. Contact Detroit Diesel if ECU reconfiguration is required and your facility is not equipped to perform this task.

Table 6-13. MTU MDEC ECU Configuration Parameters

MTU Parameter Number	Parameter Name	Description and Value
200	CANbus Interface Config Param	Set to 898 – Indicates one CANbus with PIMS
201.01	CANbus Monitor Nodes 1–16	Binary value indicating which communication devices are on the CANbus network. If a binary representation of this parameter's value does not have the bit set corresponding to a value of 00100000, take the value in this register, add 32 to it, and rewrite it to the register to set the bit. This informs the MTU MDEC ECU that a third part controller resides on the CANbus.
156.19	CANbus Speed Demand Switch Active	Set to 1 – This is necessary only if it is desired to set the engine speed demand source and speed demand from the DGC-2020. This capability may be blocked by setting the parameter to 0.

The interconnection diagrams of Figures 6-14 through 6-17 illustrate DGC-2020 and MTU MDEC ECU connections for four types of generator sensing configurations.

3-Phase Wye Connections for MTU MDEC ECU Applications



3-Phase Delta Connections for MTU MDEC ECU Applications

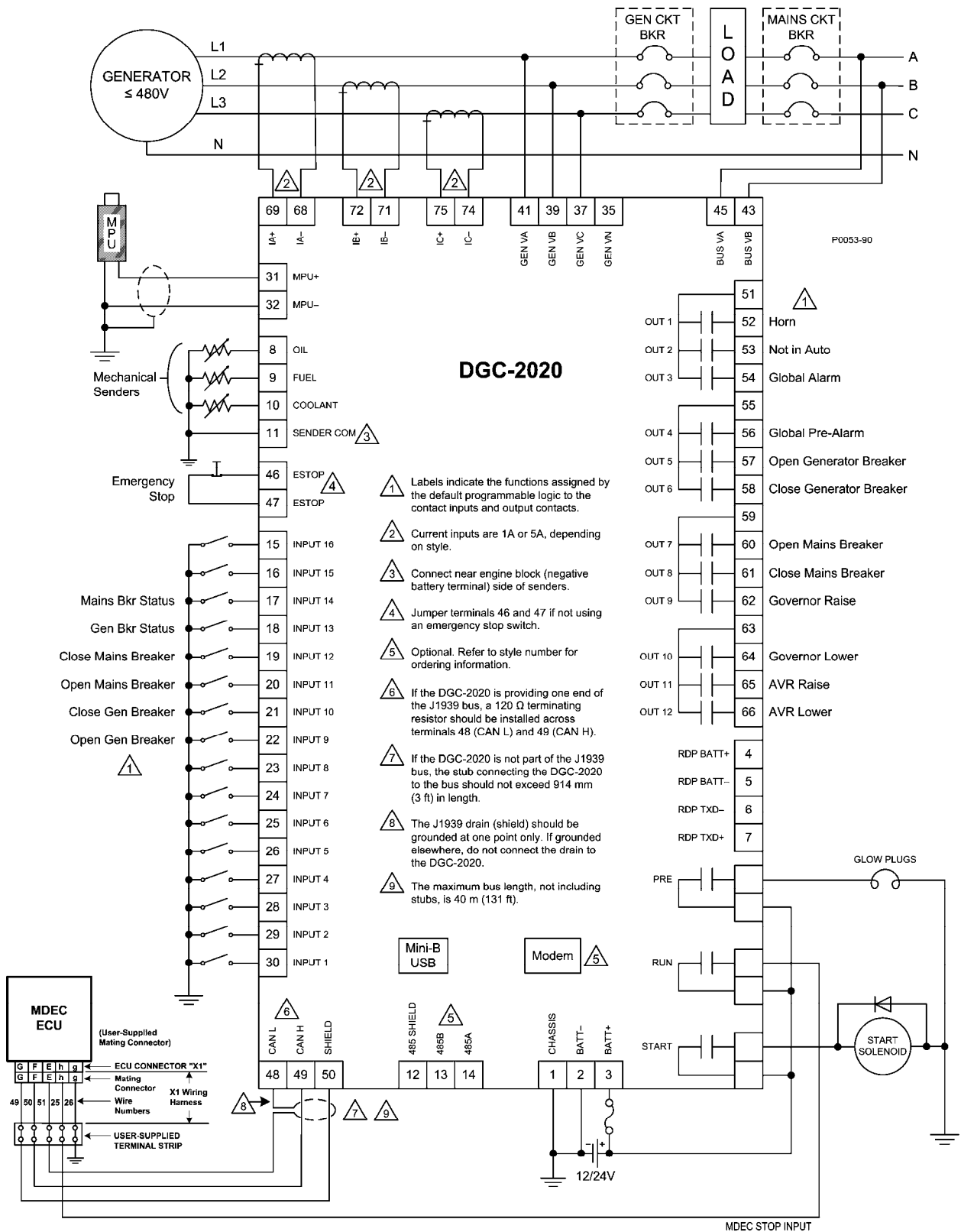


Figure 6-15. 3-Phase Delta Connections for MTU MDEC ECU Applications

Single-Phase A-B Connections for MTU MDEC ECU Applications

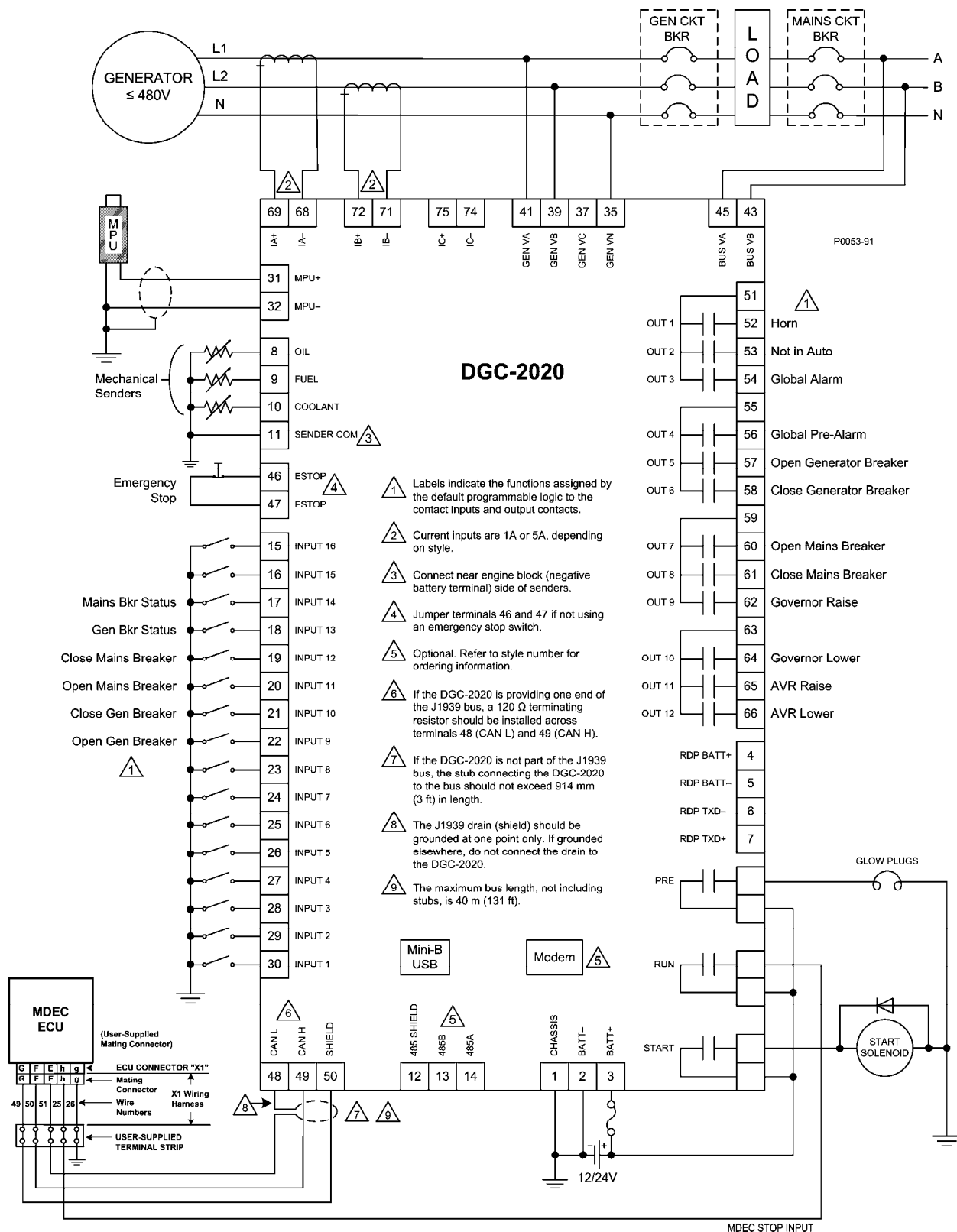


Figure 6-16. Single-Phase A-B Connections for MTU MDEC ECU Applications

Single-Phase A-C Connections for MTU MDEC ECU Applications

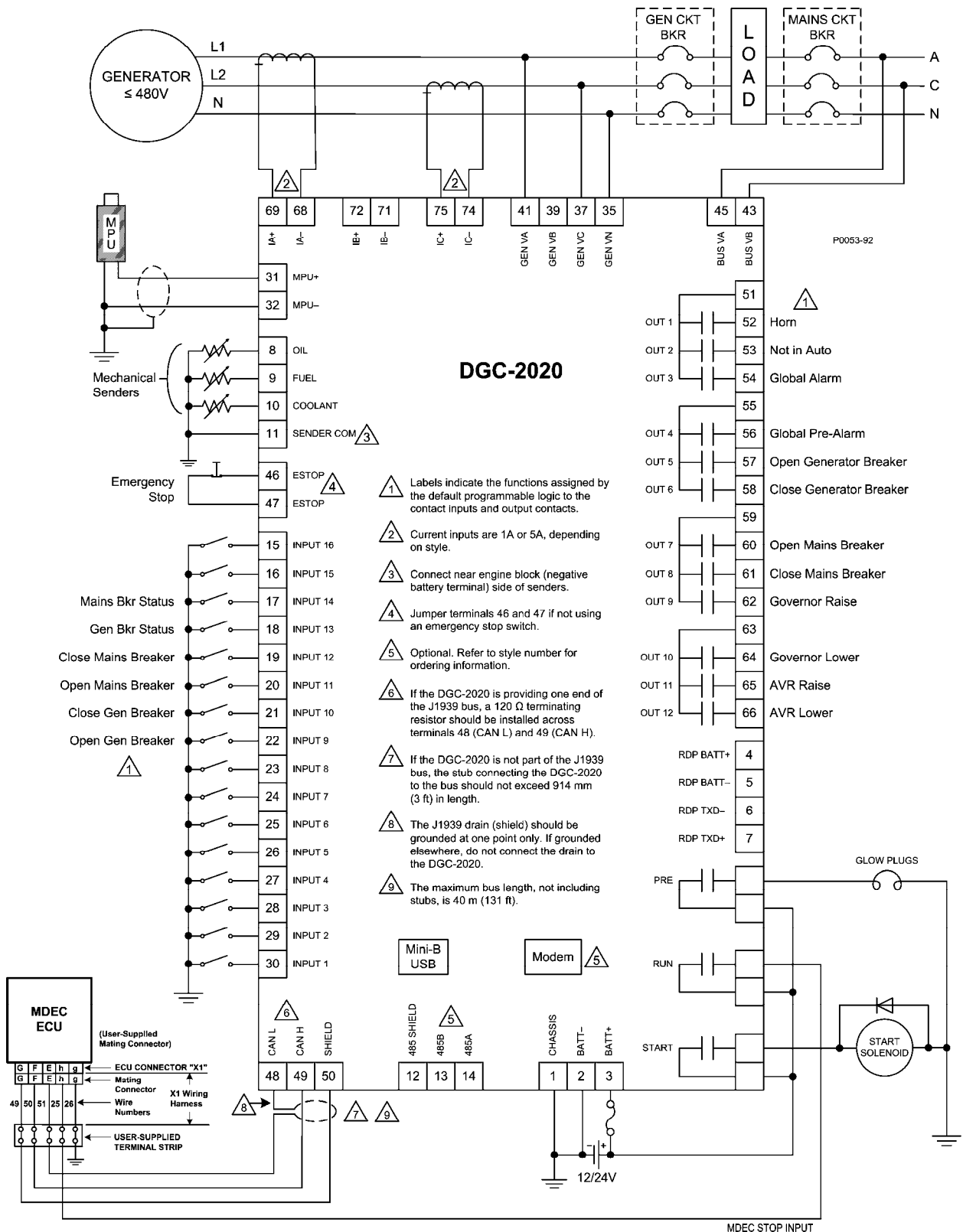


Figure 6-17. Single-Phase A-C Connections for MTU MDEC ECU Applications

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 DGC-2020. These modules interface to the DGC-2020 via CANbus, thus the CANBUS terminals are the only common connections (Figure 6-18) between the DGC-2020, AEM-2020, CEM-2020, and LSM-2020. Refer to Section 8, *LSM-2020 (Load Share Module)*, for independent LSM-2020 connections. Refer to Section 9, *CEM-2020 (Contact Expansion Module)*, for independent CEM-2020 connections. Refer to Section 10, *AEM-2020 (Analog Expansion Module)*, for independent AEM-2020 connections. Refer to *Connections, CANbus Interface*, in this section for details on DGC-2020 CANbus connections.

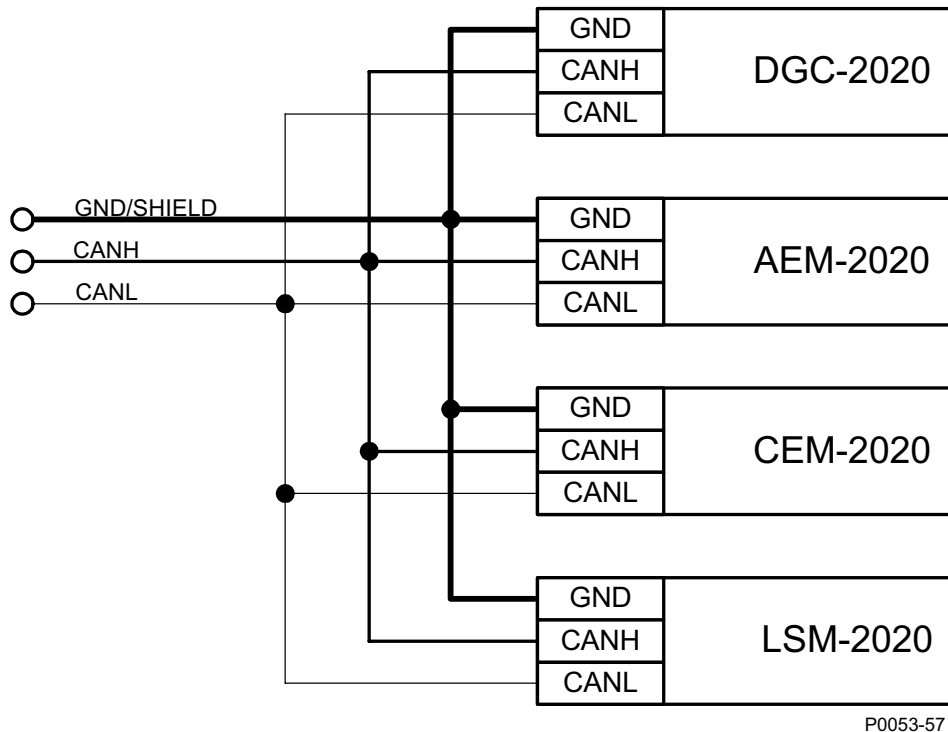


Figure 6-18. DGC-2020, AEM-2020, CEM-2020, LSM-2020 CANbus Connections

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 DGC-2020 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 7, *Maintenance and Troubleshooting*.

SECTION 7 • MAINTENANCE AND TROUBLESHOOTING

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SECTION 7 • MAINTENANCE AND TROUBLESHOOTING

MAINTENANCE

Preventative maintenance consists of periodic replacement of the backup battery (optional) and periodically checking that the connections between the DGC-2020 and the system are clean and tight. DGC-2020 units 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.

Backup Battery for the Real Time Clock

The backup battery for the real time clock is an option available for the DGC-2020 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 DGC-2020 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 Basler Electric to order a new battery, Basler Electric P/N 38526.

Battery access is located on the rear side of the DGC-2020.

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 DGC-2020 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 with Basler Electric P/N 38526 may void the warranty.

TROUBLESHOOTING

If you do not get the results that you expect from the DGC-2020, 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 DGC-2020 are set up properly. For more information, refer to Section 4, *BESTCOMSPlus Software, Communication*.

- 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*.

CANbus 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 CANbus 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, and verify that any stubs from the main bus do not exceed 3 meters 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 DGC-2020 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 DGC 2020 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 DGC-2020 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 DGC-2020 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. Confirm the nominal frequency setting.
- Step 4. Verify that the prime mover governor is operating properly.
- Step 5. Verify that the measured frequency of the voltage at the MPU input (31 and 32) is correct.
- Step 6. 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 DGC-2020.

Generator Breaker and Mains Breaker

Generator Breaker Will Not Close to a Dead Bus

- Step 1: Verify that breaker close request is being initiated. Initiate a generator breaker close request by one of the methods listed in Section 3, *Functional Description, Breaker Management*.
- Step 2: Navigate to the SETTINGS->BREAKER MANAGEMENT->BREAKER HARDWARE->GEN BREAKER screen and set DEAD BUS CL ENBL to ENABLE.
- Step 3: 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 BESTCOMSPlus 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 the bus status is DEAD. Check status by using the Metering Explorer in BESTCOMSPlus 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 5: Verify the wiring to the breaker from the DGC-2020. 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 BESTCOMSPlus, 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: Verify that breaker close request is being initiated. Initiate a generator breaker close request using one of the methods listed in Section 3, *Functional Description, Breaker Management*.
- Step 2: 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 BESTCOMSPlus 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 3: 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 BESTCOMSPlus 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 4: Verify the synchronizer is operating properly; refer to the synchronizer portion of the troubleshooting steps.
- Step 5: Verify the wiring to the breaker from the DGC-2020. 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 BESTCOMSPlus, 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: Verify the wiring to the breaker from the DGC-2020. 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 BESTCOMSPlus, 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 DGC-2020. Check status using the Metering Explorer in BESTCOMSPlus and verify that the MAINS FAIL status LED is lit when the power on the DGC-2020 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 DGC-2020. 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 BESTCOMSPlus, 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 DGC-2020. Check status using the Metering Explorer in BESTCOMSPlus and verify that the MAINS STABLE status LED is lit when the power on the DGC-2020 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 DGC-2020. 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 BESTCOMSPlus, 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 DGC-2020 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 DGC-2020 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 Exploring in BESTCOMSPlus 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 DGC-2020 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 DGC-2020 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 DGC-2020.

Synchronizer Does Not Lower Engine Speed Allowing Alignment of Bus and Generator

- Step 1: 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 Reduce 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 OUTPUT. If the bias is current based, you can force a fixed current by setting the Governor Output Voltage 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 ANALOG 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->MULTIGENMANAGEMENT->AVR ANALOG OUTPUT.

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 ANALOG 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 ANALOG OUTPUT screen and set VOLT RESPONSE to DECREASING.

SECTION 8 • LSM-2020 (LOAD SHARE MODULE)

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SECTION 8 • LSM-2020 (LOAD SHARE MODULE)

GENERAL INFORMATION

The LSM-2020 is a remote auxiliary device that interfaces to the DGC-2020 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 Load Share Line.

FEATURES

LSM-2020s have the following features:

- A Ramping Function to load and unload generators smoothly
- Communications via Ethernet or CANbus
- Demand Start/Stop and Generator Sequencing
- KW Load Control
- KW Load Sharing via analog 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 mA
Terminals:	P2-7 (IN+), P2-8 (IN–), P2-9 (V+)

Analog Outputs

Burden Data:	4-20 mA = 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')

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

CANbus

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

Rear-panel RJ-45 connector provides remote communications via BESTCOMSPlus to the LSM-2020 and to the DGC-2020 that the module is connected to.

Type: 10/100BASE-T

Industrial Ethernet devices designed to comply with IEC 61000-4 series of specifications are recommended.

Type Tests

Shock

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 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 Section 8 of this manual.

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

"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 - T4.

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: 1.45 lb (657 g)
Dimensions: See *Installation* later in this section.

FUNCTIONAL DESCRIPTION

Load Share Overview

A generator is paralleled with other generators on an island system, which is not connected to the utility. The generator shares load with other generators on the system via the load share line. The load share line of a generator is driven in proportion to the per unitized kW generation of the generator. The voltage at the junction of all load share lines is proportional to the per unitized average power generation of the system. For example, if the load share line operating voltage is 0 to 3 volts, and the measured voltage at the intersection point is 2 volts, the system is at 2/3 of its kW capacity. The generator uses the measured load share line input value to calculate per unitized average load level, and uses that as the setpoint for its kW controller.

A generator has a set of contacts that physically disconnects it from the load share line circuit. These contacts are open whenever the unit's generator breaker is open.

If a unit or set of units is paralleled to the utility, they derive their setting from the Mains Parallel Power Level setting, and disregard the load share line input.

Settings are provided to allow a generator to make a bumpless transition onto the system that is participating in load sharing. A bumpless transition is also achieved when the generator is brought offline.

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 BESTCOMSPlus to open the *Programmable Input, LSM Input* screen. To set the LSM Analog Input as the control source, use the Settings Explorer in BESTCOMSPlus 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.

CANbus

A Control Area Network (CAN) is a standard interface that enables communication between the LSM-2020 and the DGC-2020.

Ethernet Port

An Ethernet port provides communications via BESTCOMSPlus to the LSM-2020 and to the DGC-2020 that the module is connected to. Ethernet communication between LSM-2020s allows for generator sequencing on an islanded system. Firmware updates to the LSM-2020 are made through the Ethernet port. Firmware updates to the DGC-2020 are only available through the USB port of the DGC-2020. Refer to Section 4, *BESTCOMSPlus*, for information on configuring Ethernet communication and updating firmware in the DGC-2020.

Industrial Ethernet devices designed to comply with IEC 61000-4 series of specifications are recommended.

BESTCOMSPlus SOFTWARE

BESTCOMSPlus provides the user with a point-and-click means to set and monitor the LSM-2020. Installation and operation of BESTCOMSPlus is described in Section 4, *BESTCOMSPlus Software*.

LSM-2020 Plugin for BESTCOMSPlus

The setup utility that installs BESTCOMSPlus 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 DGC-2020 plugin for BESTCOMSPlus. 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 BESTCOMSPlus can be obtained on the Device Info tab of BESTCOMSPlus.

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.

BESTCOMSPlus device information values and settings are illustrated in Figure 8-1.

Device Info
P0052-40

Application Version
 A ▼

Application Version

Boot Code Version

Application Build
 D

Serial Number
 E

Application Part Number
 F

Model Number
 G

Figure 8-1. 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 BESTCOMSPlus. 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 BESTCOMSPlus to open the *General Settings, Device Security Setup* screen. See Figure 8-2.

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 8-2. 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-2020's 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 the Basler Electric regional sales office, your sales representative, or a sales representative at Basler Electric, Highland, Illinois USA.

If the device is not installed immediately, store it in the original shipping package in a moisture- and dust-free environment.

Product Registration

Registering with Basler Electric enables you to receive important information updates on your product plus new product announcements. Register your product by directing your web browser to www.basler.com.

Mounting

LSM-2020's are contained in an encapsulated plastic case and may be mounted in any convenient position. The construction of a LSM-2020 is durable enough to mount directly on a genset using UNF 1/4-20 or equivalent 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 8-3 for LSM-2020 overall dimensions. All dimensions are shown in inches with millimeters in parenthesis.

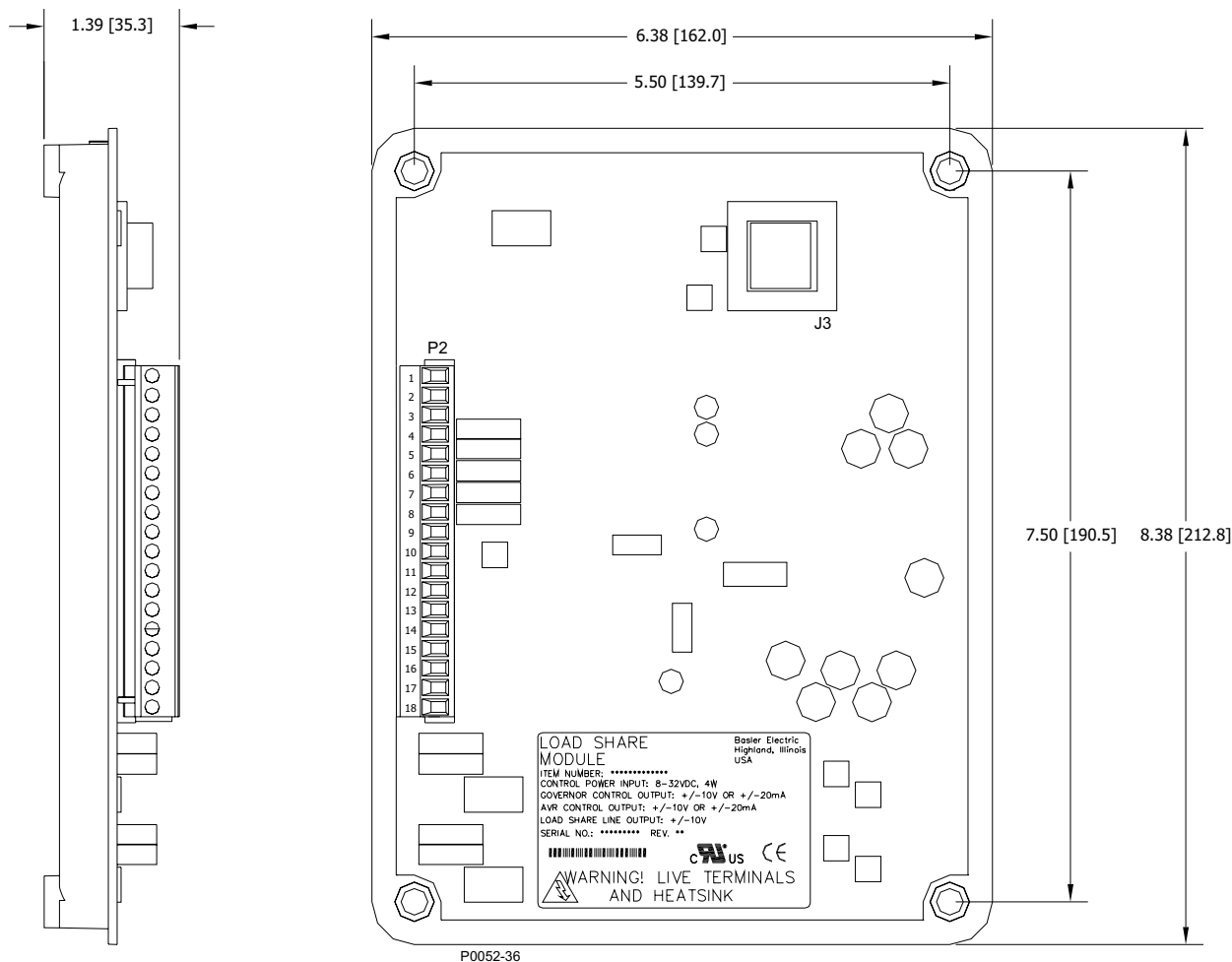


Figure 8-3. LSM-200 Overall Dimensions

Connections

LSM-200 connections are dependent on the application. Incorrect wiring may result in damage to the module.

NOTE

Operating power from the battery must be of the correct polarity. Although reverse polarity will not cause damage, the LSM-200 will not operate.

Be sure that the LSM-200 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-200 and a PC running BESTCOMSPlus software. This allows for setting of the LSM-200 and for the DGC-2020 that the module is connected to.

LSM-200 connections are made with an 18-position connector with screw-down compression terminals. This connector plugs into a header on the LSM-200. The connector and header have a dovetailed edge that ensures proper connector orientation. The connector and header are uniquely keyed to ensure that the connector mates only with the correct header. Connector screw terminals accept a maximum wire size of 12 AWG. Maximum screw torque is 4 inch-pounds (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 8-1.

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 8-1. 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

Analog Inputs

These inputs can be used for var, PF, or kW control. Analog input terminals are listed in Table 8-2.

Table 8-2. 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.

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 8-3.

Table 8-3. 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
P2-5 (LS-)	Load share line negative
P2-4 (LS')	Provides additional landing point for external resistor

CANbus Interface

These terminals provide communication using the SAE J1939 protocol and provide high-speed communication between the LSM-2020 and the DGC-2020. Connections between the LSM-2020 and DGC-2020 should be made with twisted-pair, shielded cable. CANbus interface terminals are listed in Table 8-4. Refer to Figure 8-4 and Figure 8-5.

Table 8-4. CANbus 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 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.

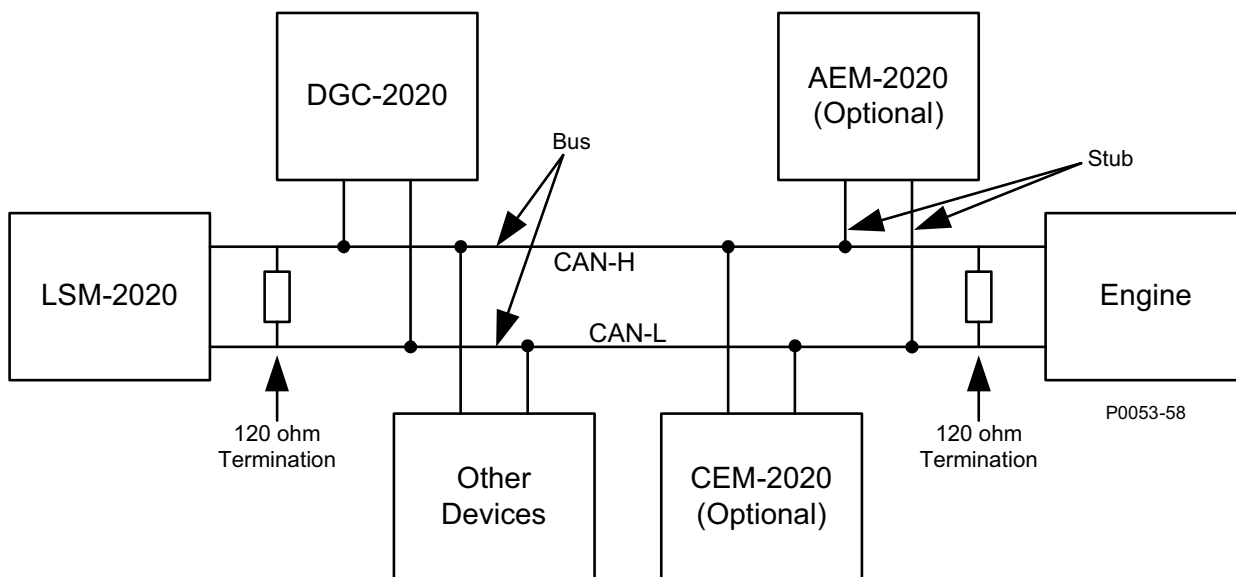


Figure 8-4. CANbus Interface with LSM-2020 providing One End of the Bus

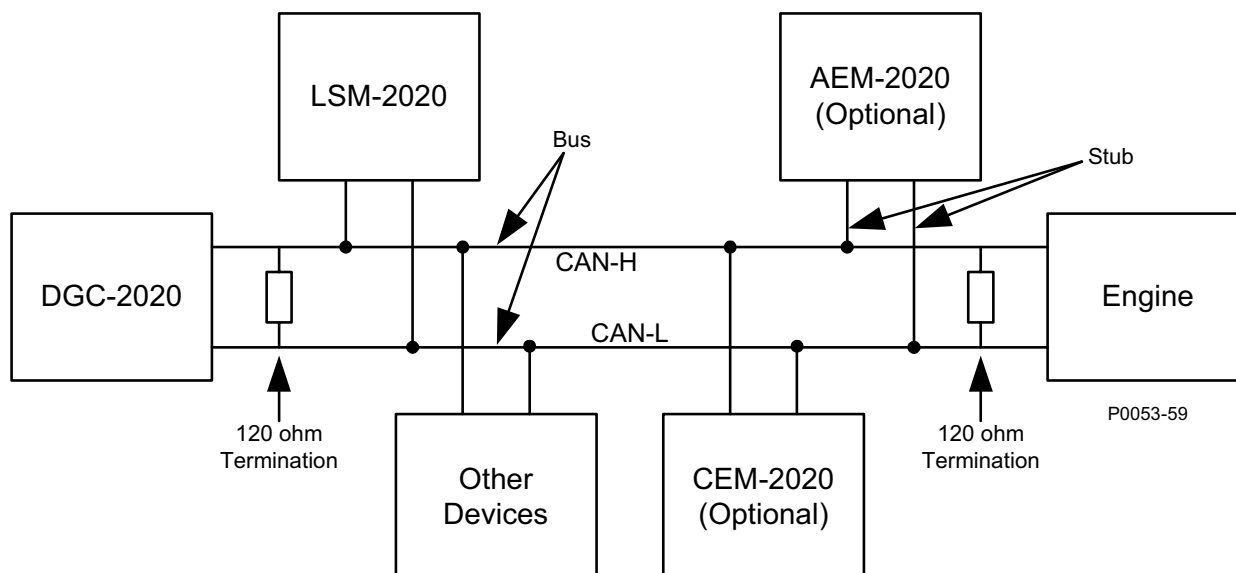


Figure 8-5. CANbus Interface with DGC-2020 providing One End of the Bus

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 8-6 illustrates typical LSM-2020 connections. Figure 8-7 illustrates a typical interconnection of two systems tied together via separate Load Share Modules.

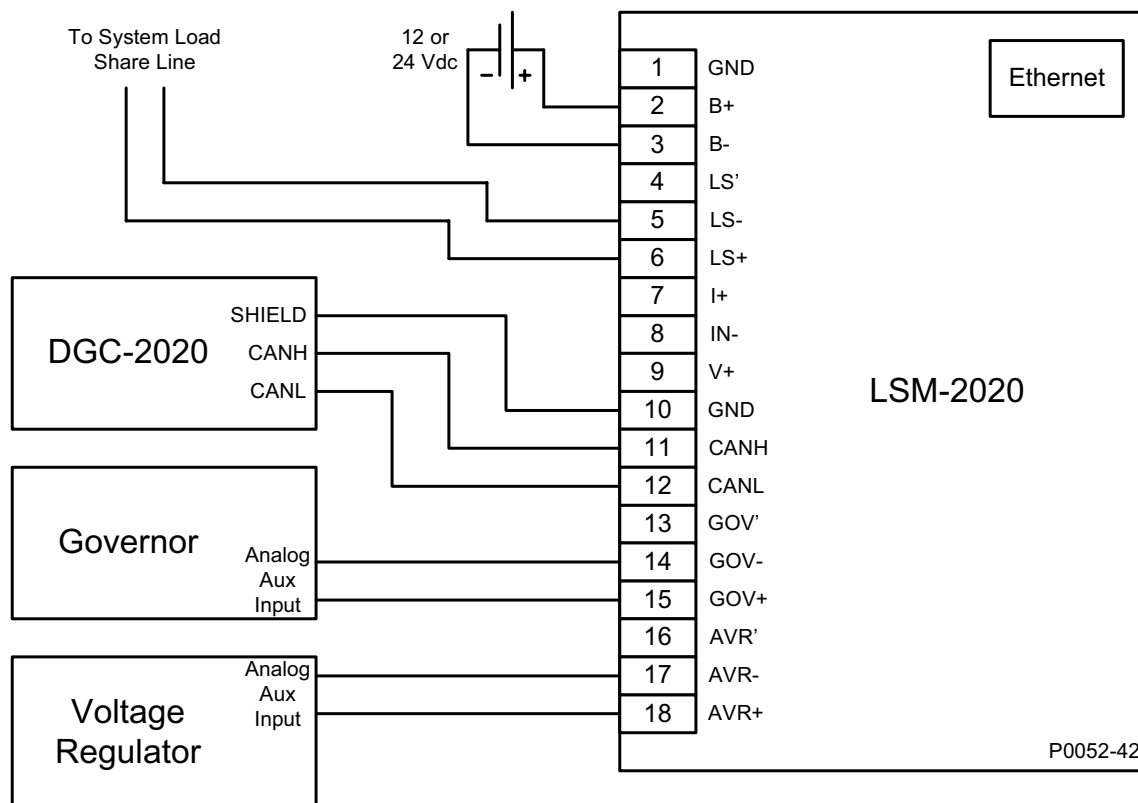


Figure 8-6. Typical LSM-2020 Connections

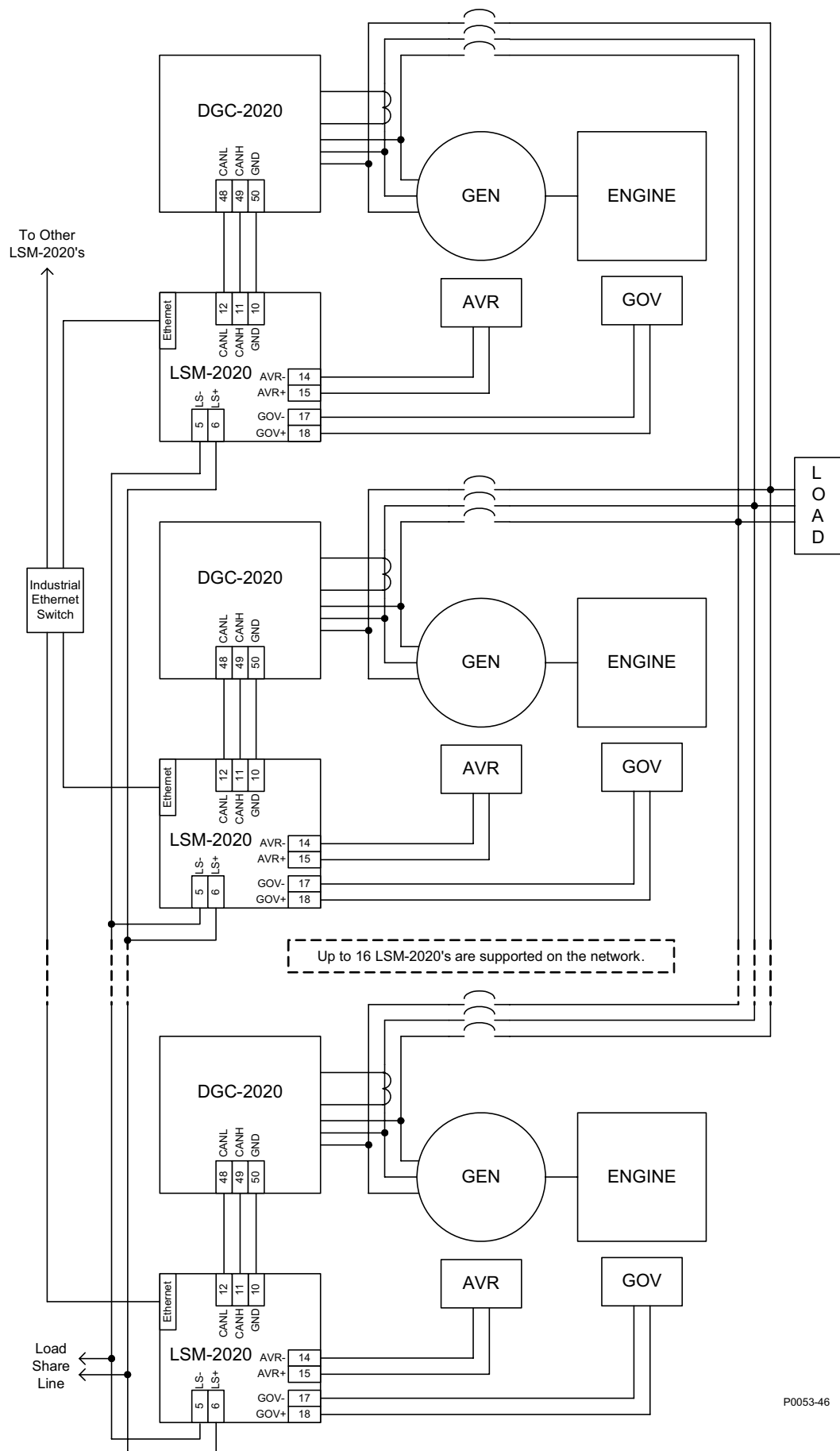


Figure 8-7. Typical LSM-2020 Interconnection Diagram

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 8-8 illustrates connections using the additional AVR' terminal as a landing point.

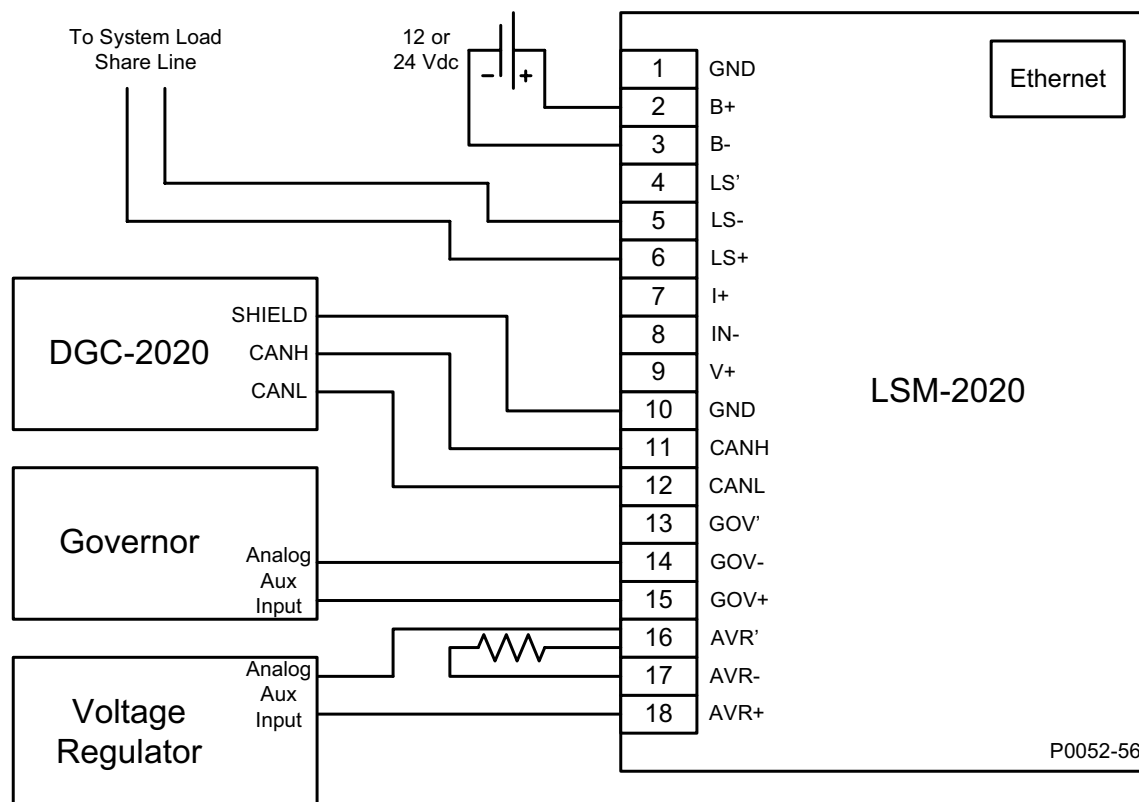


Figure 8-8. Connections using the AVR' Terminal

APPLICATION

Interfacing an External Control Device with a DGC-2020 – LSM-2020 System

In some cases, it may be necessary to interface an external device, such as a synchronizer, to a DGC-2020 – LSM-2020 system where the LSM controls the bias inputs to the AVR and governor. This can be done by placing the bias output of the LSM and the bias output of the external device in series. If the output of the LSM is connected in series with the bias output of the external synchronizer as shown in Figure 8-9, 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 a DGC-2020 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 DGC-2020 and the generator's breaker is closed, the DGC-2020 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.

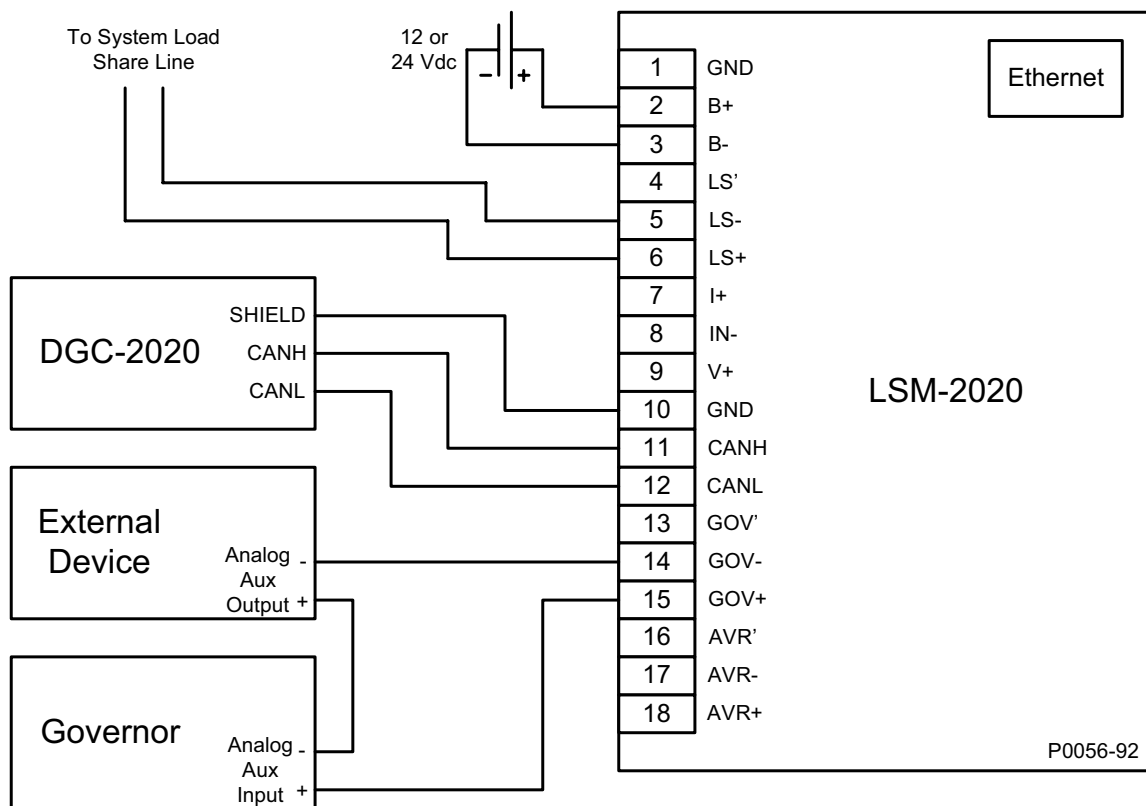


Figure 8-9. External Control Device with DGC-2020 – LSM-2020 System

MAINTENANCE

Preventive maintenance consists of periodically checking that the connections between the LSM-2020 and the system are clean and tight. LSM-2020's 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 9 • CEM-2020 (CONTACT EXPANSION MODULE)

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SECTION 9 • CEM-2020 (CONTACT EXPANSION MODULE)

GENERAL INFORMATION

The optional CEM-2020 is a remote auxiliary device that provides additional DGC-2020 contact inputs and outputs.

FEATURES

CEM-2020s have the following features:

- 10 Contact Inputs
- 24 Output Contacts
- Functionality of Inputs and Outputs assigned by BESTLogic+ programmable logic
- Communications via CANbus

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:	14 W

Contact Inputs

The CEM-2020 contains 10 programmable inputs that accept normally open and normally closed, dry contacts.

Time from a CEM-2020 input going high to:

Shutdown the generator via an alarm:	700 ms max
Close a relay on board the DGC-2020:	300 ms max

Output Contacts

Ratings

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

CANbus

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

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 $+130^{\circ}\text{C}$), vibration tests (of 5 to 50 G at $+25^{\circ}\text{C}$), and temperature/vibration tests (tested at 10 to 20 G over a temperature range of -60°C to $+100^{\circ}\text{C}$). 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 Section 9 of this manual.

Environment

Temperature

Operating: -40 to $+70^{\circ}\text{C}$ (-40 to $+158^{\circ}\text{F}$)

Storage: -40 to $+85^{\circ}\text{C}$ (-40 to $+185^{\circ}\text{F}$)

Humidity: IEC 68-2-38

UL Approval

“cURus” recognized to UL Standard 508 & CSA 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: 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 DGC-2020.

Output Contacts

The CEM-2020 provides 24 programmable output contacts with the same functionality as the output contacts on the DGC-2020. Outputs 13 through 24 can carry 1 A. Outputs 25 through 36 can carry 4 A.

Communications

CANbus

A Control Area Network (CAN) is a standard interface that enables communication between the CEM-2020 and the DGC-2020.

BESTCOMSPlus SOFTWARE

BESTCOMSPlus provides the user with a point-and-click means to set and monitor the Contact Expansion Module. Installation and operation of BESTCOMSPlus 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 the Basler Electric regional sales office, your sales representative, or a sales representative at Basler Electric, Highland, Illinois USA.

If the device is not installed immediately, store it in the original shipping package in a moisture- and dust-free environment.

Product Registration

Registering with Basler Electric enables you to receive important information updates on your product plus new product announcements. Register your product by directing your web browser to www.basler.com.

Mounting

Contact Expansion Modules are contained in an encapsulated 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 UNF ¼-20 or equivalent 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 9-1 for CEM-2020 overall dimensions. All dimensions are shown in inches with millimeters in parenthesis.

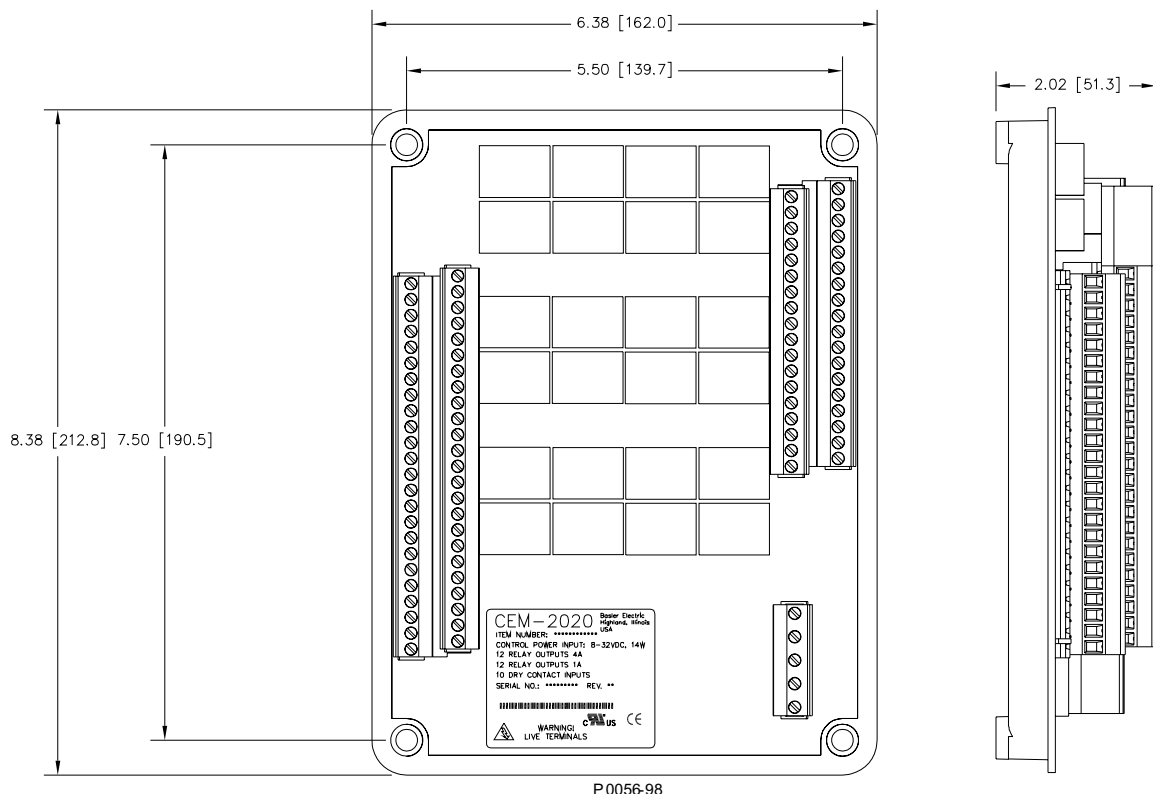


Figure 9-1. CEM-2020 Overall Dimensions

Contact Expansion Module connections are dependent on the application. Incorrect wiring may result in damage to the module.

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.

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. The connectors and headers are uniquely keyed to ensure that the connectors mate only with the correct headers. Connector screw terminals accept a maximum wire size of 12 AWG. Maximum screw torque is 5 inch-pounds (0.56 N•m).

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 9-1.

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.

Terminal	Description
P1-  (SHIELD)	Chassis ground connection
P1- – (BATT–)	Negative side of operating power input
P1- + (BATT+)	Positive side of operating power input

The CEM-2020 (Figure 9-2) has 10 contact inputs and 24 output contacts.

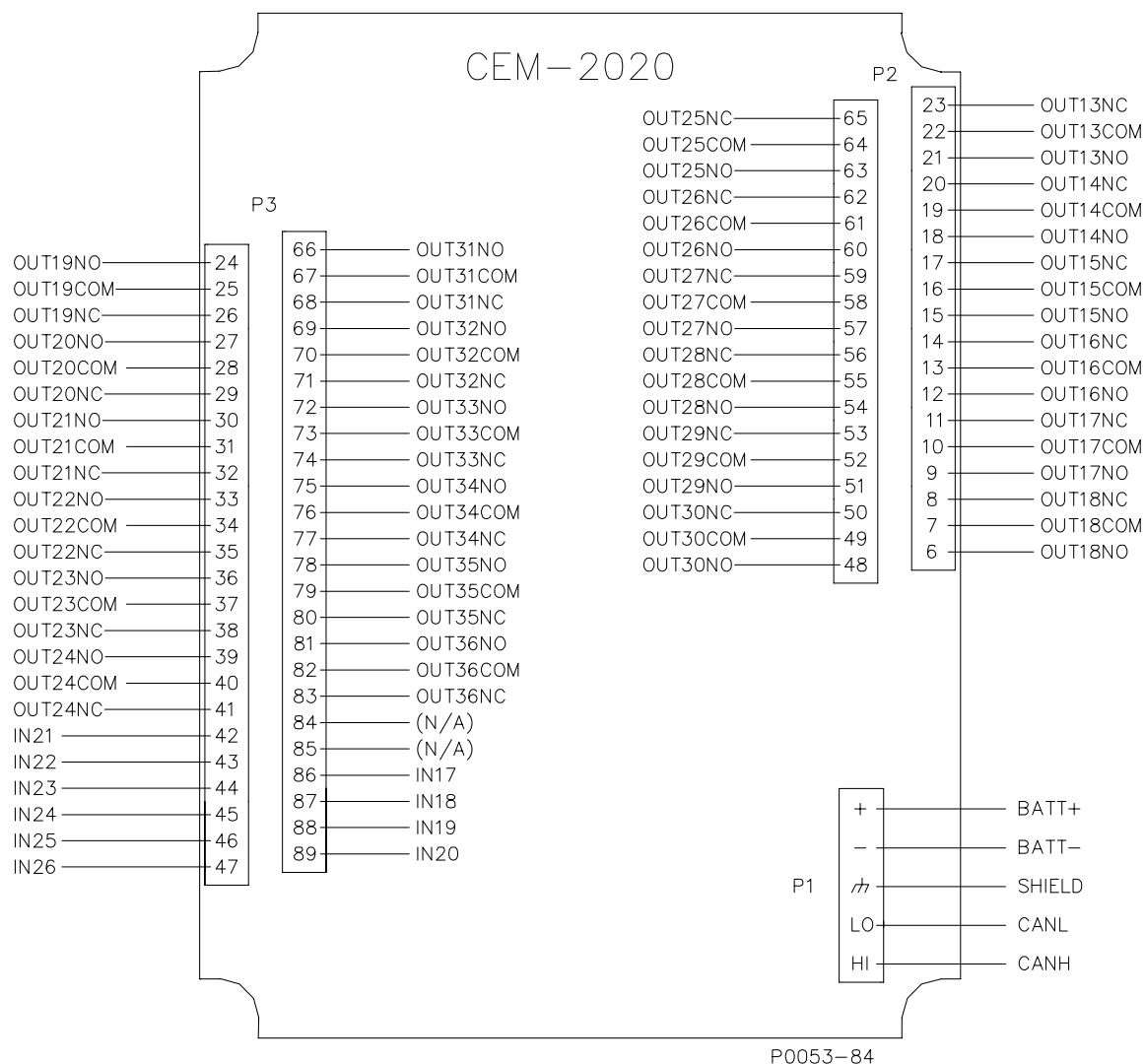


Figure 9-2. CEM-2020 Input Contact and Output Contact Terminals

CANbus Interface

These terminals provide communication using the SAE J1939 protocol and provide high-speed communication between the Contact Expansion Module and the DGC-2020. Connections between the CEM-2020 and DGC-2020 should be made with twisted-pair, shielded cable. CANbus interface terminals are listed in Table 9-2. Refer to Figure 9-3 and Figure 9-4.

Table 9-2. CANbus 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 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.

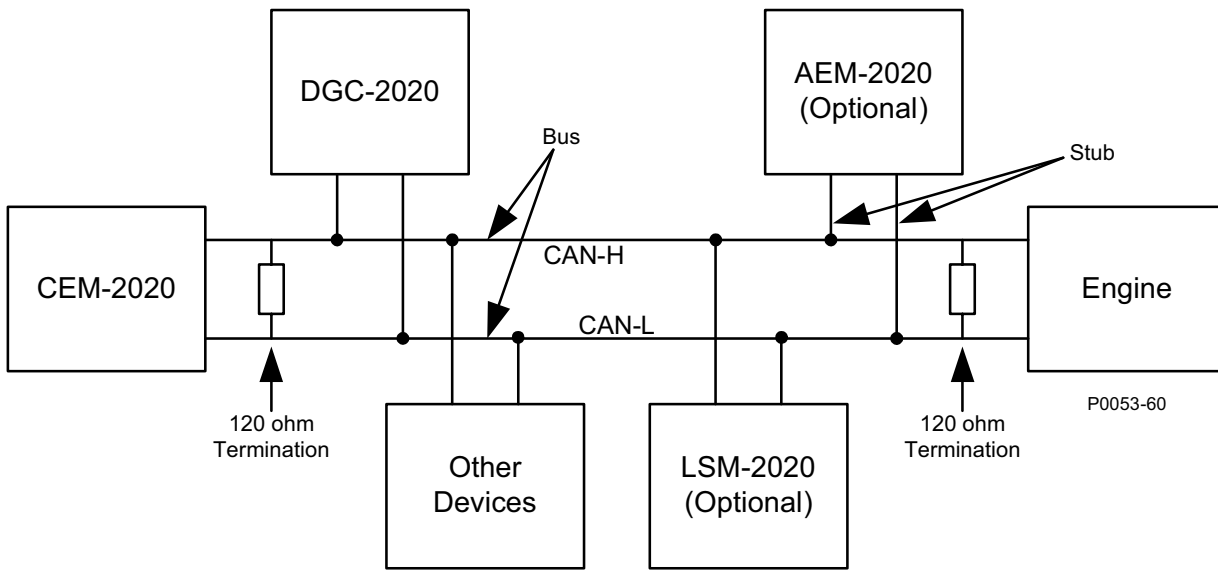


Figure 9-3. CANbus Interface with CEM-2020 providing One End of the Bus

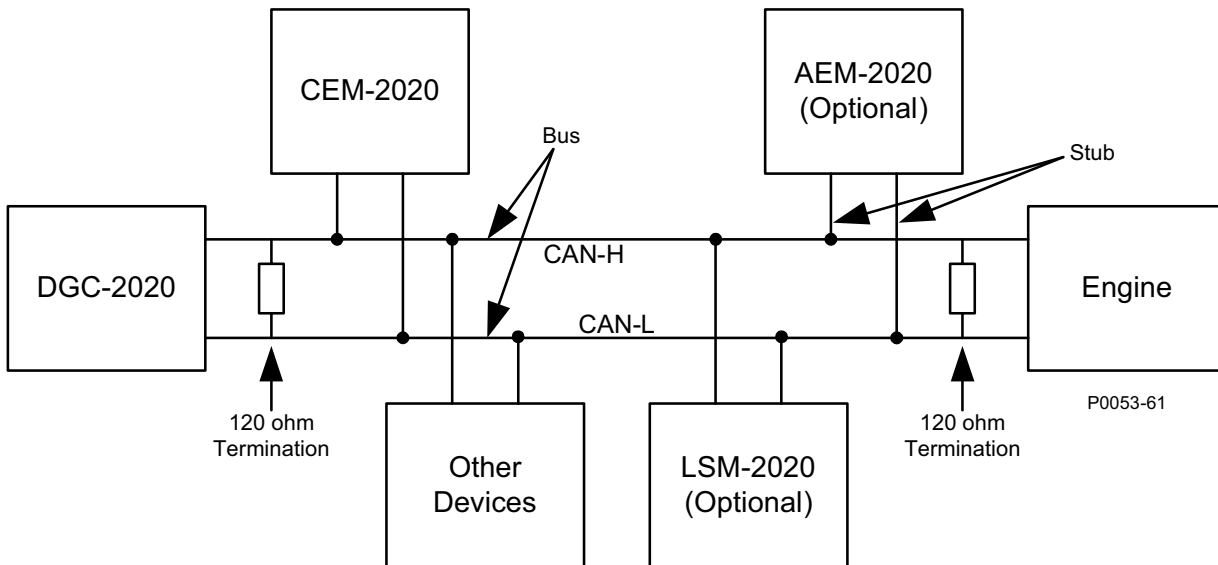


Figure 9-4. CANbus Interface with DGC-2020 providing One End of the Bus

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.

SECTION 10 • AEM-2020 (ANALOG EXPANSION MODULE)

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SECTION 10 • AEM-2020 (ANALOG EXPANSION MODULE)

GENERAL INFORMATION

The optional AEM-2020 is a remote auxiliary device that provides additional DGC-2020 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+ programmable logic
- Communications via CANbus

SPECIFICATIONS

Operating Power

Nominal: 12 or 24 Vdc
Range: 8 to 32 Vdc (Withstands cranking ride-through down to 6 Vdc for 500 ms.)

Analog Inputs

The AEM-2020 contains eight programmable analog inputs.

Rating: 4 to 20 mA or 0 to 10 Vdc (user-selectable)

RTD Inputs

The AEM-2020 contains eight programmable RTD inputs.

Rating: 100 Ω Platinum or 10 Ω Copper (user-selectable)
Setting Range: -50 to $+250^{\circ}\text{C}$ or -58 to $+482^{\circ}\text{F}$
Accuracy (10 Ω Copper): $\pm 0.044 \Omega @ 25^{\circ}\text{C}$, $\pm 0.005 \Omega/^{\circ}\text{C}$ drift over ambient temperature
Accuracy (100 Ω Platinum): $\pm 0.39 \Omega @ 25^{\circ}\text{C}$, $\pm 0.047 \Omega/^{\circ}\text{C}$ drift over ambient temperature

Thermocouple Inputs

The AEM-2020 contains two thermocouple inputs.

Rating: 2 K Type Thermocouples
Setting Range: 0 to $1,375^{\circ}\text{C}$ or 0 to $2,507^{\circ}\text{F}$
Display Range: Ambient to $1,375^{\circ}\text{C}$ or Ambient to $2,507^{\circ}\text{F}$
Accuracy: $\pm 40 \mu\text{V} @ 25^{\circ}\text{C}$, $\pm 5 \mu\text{V}/^{\circ}\text{C}$ drift over ambient temperature

Analog Outputs

The AEM-2020 contains four programmable analog outputs.

Rating: 4 to 20 mA or 0 to 10 Vdc (user-selectable)

Communication Interface

CANbus

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

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 $+130^{\circ}\text{C}$), vibration tests (of 5 to 50 G at $+25^{\circ}\text{C}$), and temperature/vibration tests (tested at 10 to 20 G over a temperature range of -60°C to $+100^{\circ}\text{C}$). 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 Section 10 of this manual.

Environment

Temperature

Operating:	-40 to $+70^{\circ}\text{C}$ (-40 to $+158^{\circ}\text{F}$)
Storage:	-40 to $+85^{\circ}\text{C}$ (-40 to $+185^{\circ}\text{F}$)

Humidity:	IEC 68-2-38

UL Approval

"cURus" recognized to UL Standard 508 & CSA Standard C22.2 No.14

"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 - T4.

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:	1.80 lb (816 g)
Dimensions:	See <i>Installation</i> 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 mA 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. When enabled, an out of range alarm alerts the user of an open or damaged thermocouple input wire. 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 mA 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

CANbus

A Control Area Network (CAN) is a standard interface that enables communication between the AEM-2020 and the DGC-2020.

BESTCOMSPlus SOFTWARE

BESTCOMSPlus provides the user with a point-and-click means to set and monitor the Analog Expansion Module. Installation and operation of BESTCOMSPlus 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 the Basler Electric regional sales office, your sales representative, or a sales representative at Basler Electric, Highland, Illinois USA.

If the device is not installed immediately, store it in the original shipping package in a moisture- and dust-free environment.

Product Registration

Registering with Basler Electric enables you to receive important information updates on your product plus new product announcements. Register your product by directing your web browser to www.basler.com.

Mounting

Analog Expansion Modules are contained in an encapsulated plastic case and may be mounted in any convenient position. The construction of a Analog Expansion Module is durable enough to mount directly on a genset using UNF ¼-20 or equivalent 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 AEM-2020 overall dimensions. All dimensions are shown in inches with millimeters in parenthesis.

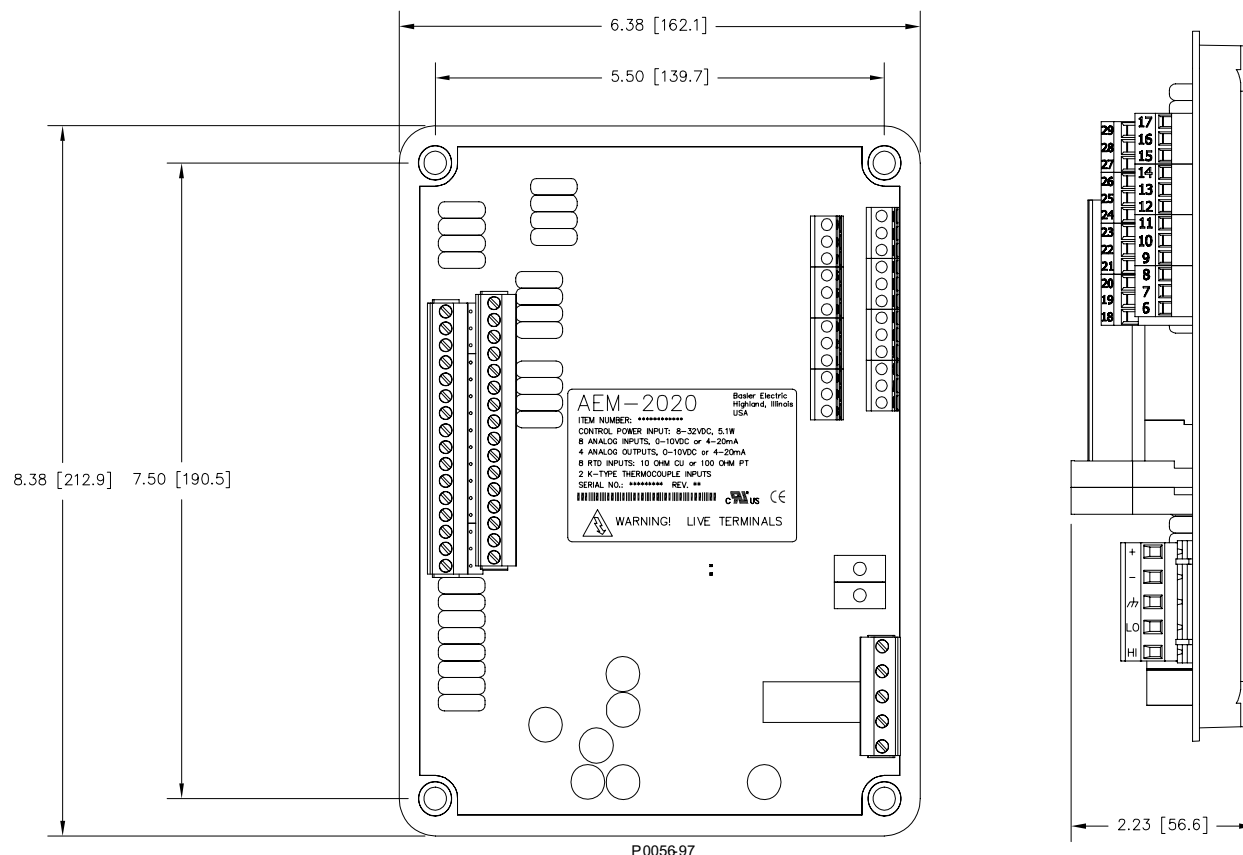


Figure 10-1. AEM-2020 Overall Dimensions

Connections

Analog Expansion Module connections are dependent on the application. Incorrect wiring may result in damage to the module.

NOTE

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. 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. 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 10-1.

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 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

AEM-2020 Inputs and Outputs

Input and output terminals are shown in Figure 10-2 and listed in Table 10-2.

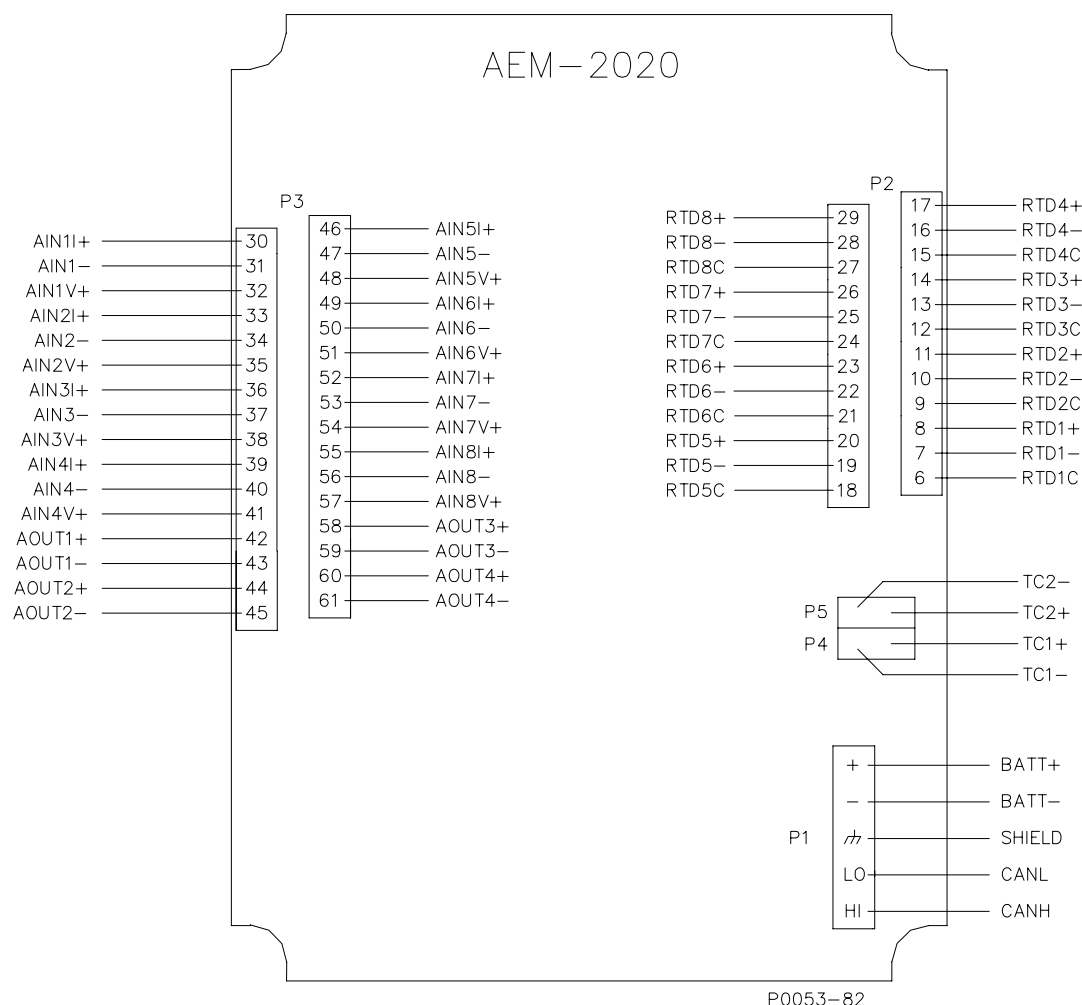


Figure 10-2. Input and Output Terminals

Table 10-2. Input and Output Terminals

Connector	Description
P1	Operating Power and CANbus
P2	RTD Inputs 1 - 8
P3	Analog Inputs 1 - 8 and Analog Outputs 1 - 4
P4	Thermocouple 1 Input
P5	Thermocouple 2 Input

External RTD Input Connections

External 2-wire RTD input connections are shown in Figure 10-3. Figure 10-4 shows external 3-wire RTD input connections.

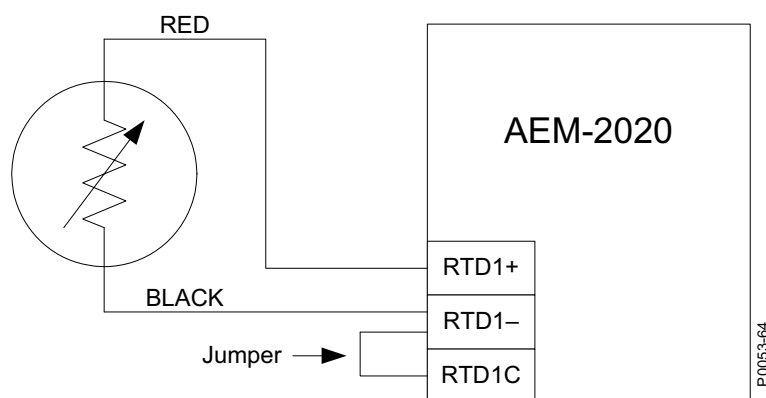


Figure 10-3. External Two-Wire RTD Input Connections

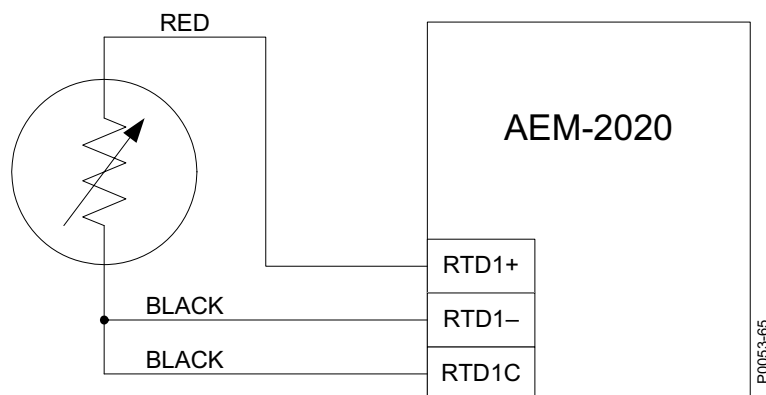


Figure 10-4. External Three-Wire RTD Input Connections

CANbus Interface

These terminals provide communication using the SAE J1939 protocol and provide high-speed communication between the Analog Expansion Module and the DGC-2020. Connections between the AEM-2020 and DGC-2020 should be made with twisted-pair, shielded cable. CANbus interface terminals are listed in Table 10-3. Refer to Figure 10-5 and Figure 10-6.

Table 10-3. CANbus 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 AEM-2020 is providing one end of the J1939 bus, a 120 Ω 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.

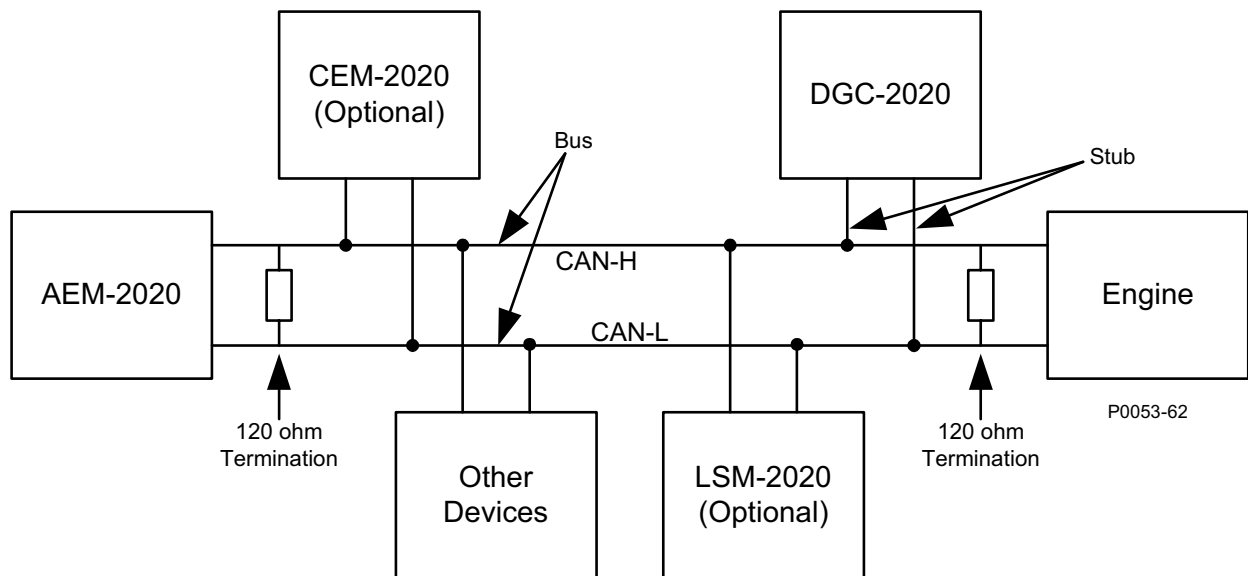


Figure 10-5. CANbus Interface with AEM-2020 providing One End of the Bus

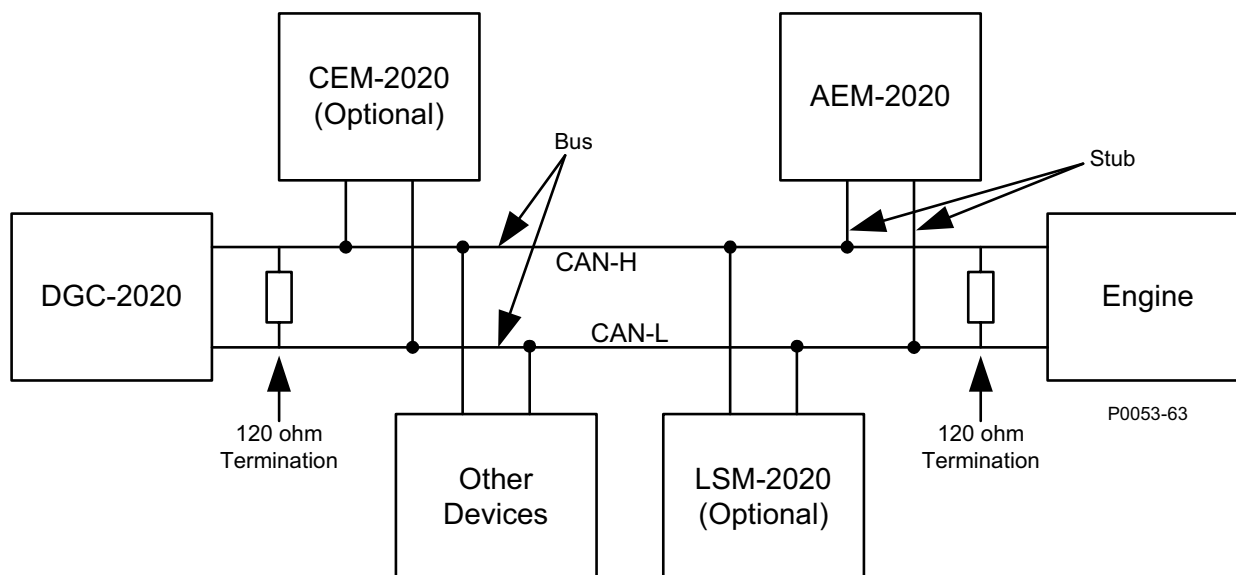


Figure 10-6. CANbus Interface with DGC-2020 providing One End of the Bus

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, Basler Electric recommends that no repair procedures be attempted by anyone other than Basler Electric personnel.

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 DGC-2020 (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 and one fixed time function can be selected. Characteristic curves for the inverse and definite time functions are defined by the following equation:

$$T_T = \frac{AD}{M^N - C} + BD + K \quad \text{Equation A-1}$$

$$T_R = \frac{RD}{|M^2 - 1|} \quad \text{Equation A-2}$$

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 Standard C37.112-1996.

* 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.

Table A-1. 51 Time Characteristic Curve Constants

Curve Selection	Curve Name	Trip Characteristic Constants					Reset
		A	B	C	N	K	R
S1	S, S1, Short Inverse	0.2663	0.03393	1.0000	1.2969	0.0280	0.5000
S2	S2, Short Inverse	0.0286	0.02080	1.0000	0.9844	0.0280	0.0940
L1	L, L1, Long Inverse	5.6143	2.18592	1.0000	1.0000	0.0280	15.750
L2	L2, Long Inverse	2.3955	0.00000	1.0000	0.3125	0.0280	7.8001
D	D, Definite Time	0.4797	0.21359	1.0000	1.5625	0.0280	0.8750
M	M, Moderately Inverse	0.3022	0.12840	1.0000	0.5000	0.0280	1.7500
I1	I, I1, Inverse Time	8.9341	0.17966	1.0000	2.0938	0.0280	9.0000
I2	I2, Inverse Time	0.2747	0.10426	1.0000	0.4375	0.0280	0.8868
V1	V, V1, Very Inverse	5.4678	0.10814	1.0000	2.0469	0.0280	5.5000
V2	V2, Very Inverse	4.4309	0.09910	1.0000	1.9531	0.0280	5.8231
E1	E, E1Extremely Inverse	7.7624	0.02758	1.0000	2.0938	0.0280	7.7500
E2	E2, Extremely Inverse	4.9883	0.01290	1.0000	2.0469	0.0280	4.7742
A	A, Standard Inverse	0.01414	0.00000	1.0000	0.0200	0.0280	2.0000
B	B, Very Inverse (I^2t)	1.4636	0.00000	1.0000	1.0469	0.0280	3.2500
C	C, Extremely Inverse (I^2t)	8.2506	0.00000	1.0000	2.0469	0.0280	8.0000
G	G, Long Time Inverse (I^2t)	12.1212	0.00000	1.0000	1.0000	0.0280	29.0000
F	Fixed Time *	0.0000	1.00000	0.0000	0.0000	0.0280	1.0000

* Curve F has a fixed delay of one second times the Time Dial setting.

TIME OVERCURRENT CHARACTERISTIC CURVE GRAPHS

Figures A-1 through A-16 illustrate the characteristic curves of the DGC-2020. 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.

Table A-2. Characteristic Curve Cross-Reference

Curve	Curve Name	Similar To
S1	S, S1, Short Inverse	ABB CO-2
S2	S2, Short Inverse	GE IAC-55
L1	L, L1, Long Inverse	ABB CO-5
L2	L2, Long Inverse	GE IAC-66
D	D, Definite Time	ABB CO-6
M	M, Moderately Inverse	ABB CO-7
I1	I, I1, Inverse Time	ABB CO-8
I2	I2, Inverse Time	GE IAC-51
V1	V, V1, Very Inverse	ABB CO-9
V2	V2, Very Inverse	GE IAC-53
E1	E, E1, Extremely Inverse	ABB CO-11
E2	E2, Extremely Inverse	GE IAC-77
A	A, Standard Inverse	BS, IEC Standard Inverse
B	B, Very Inverse (I^2t)	BS, IEC Very Inverse (I^2t)
C	C, Extremely Inverse (I^2t)	BS, IEC Extremely Inverse (I^2t)
G	G, Long Time Inverse (I^2t)	BS, IEC Long Time Inverse (I^2t)
F	Fixed Time	N/A

Time Dial Setting Cross-Reference

Although the time characteristic curve shapes have been optimized for the DGC-2020, the DGC-2020 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 DGC-2020.

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 DGC-2020 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 DGC-2020 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											
S, 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
L, 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
I, 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
V, 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
E, 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

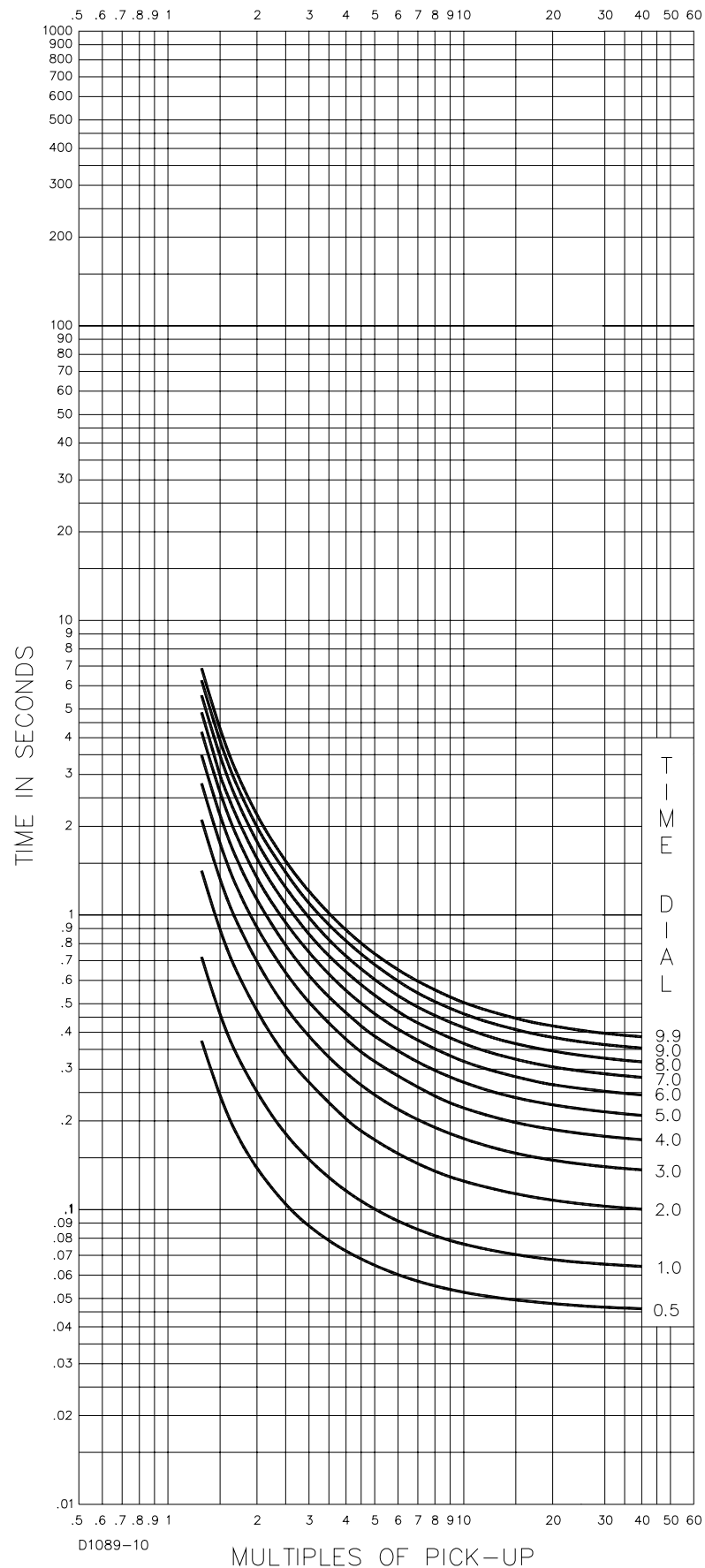


Figure A-1. Time Characteristic Curve S, S1, Short Inverse (Similar to ABB CO-2)

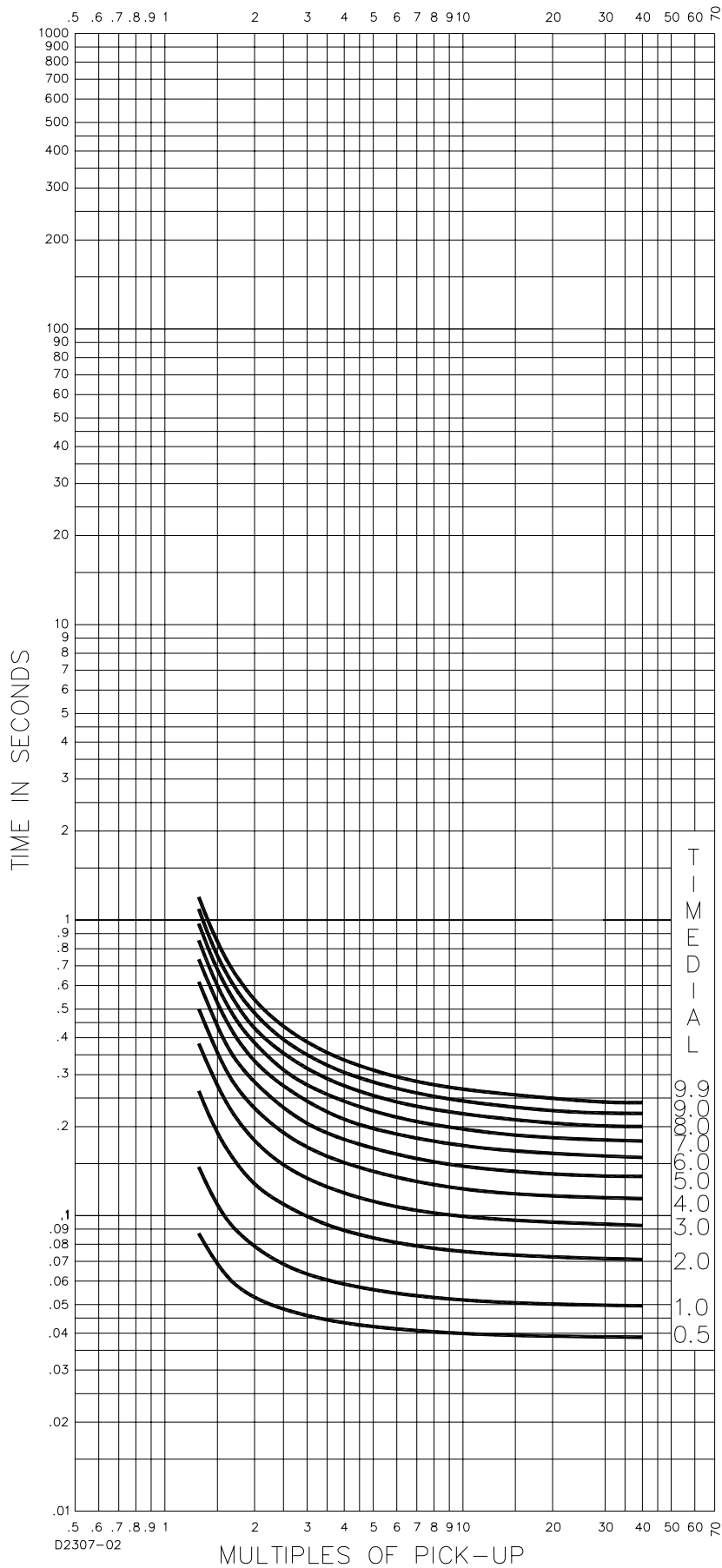


Figure A-2. Time Characteristic Curve S2, Short Inverse (Similar To GE IAC-55)

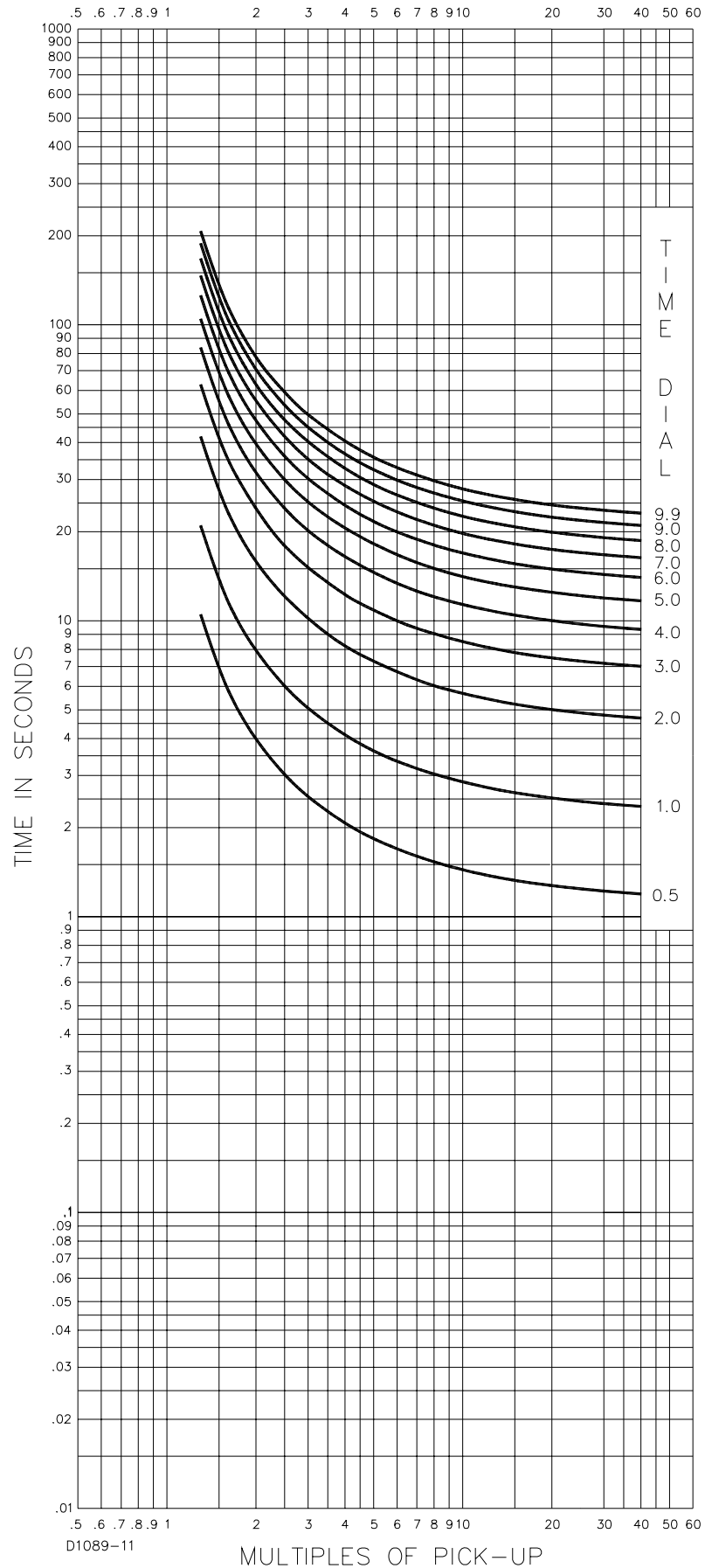


Figure A-3. Time Characteristic Curve L, L1, Long Inverse (Similar to ABB CO-5)

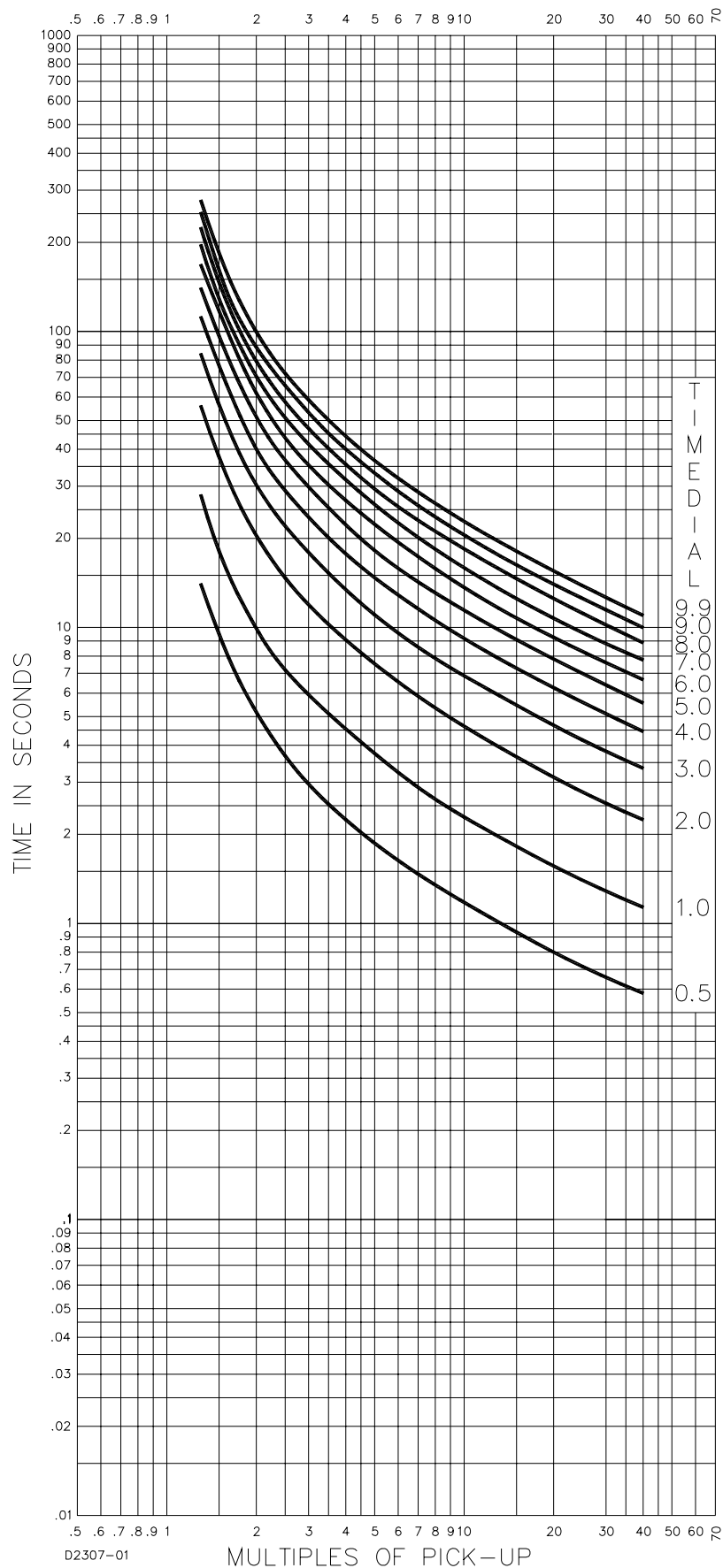


Figure A-4. Time Characteristic Curve L2, Long Inverse (Similar To GE IAC-66)

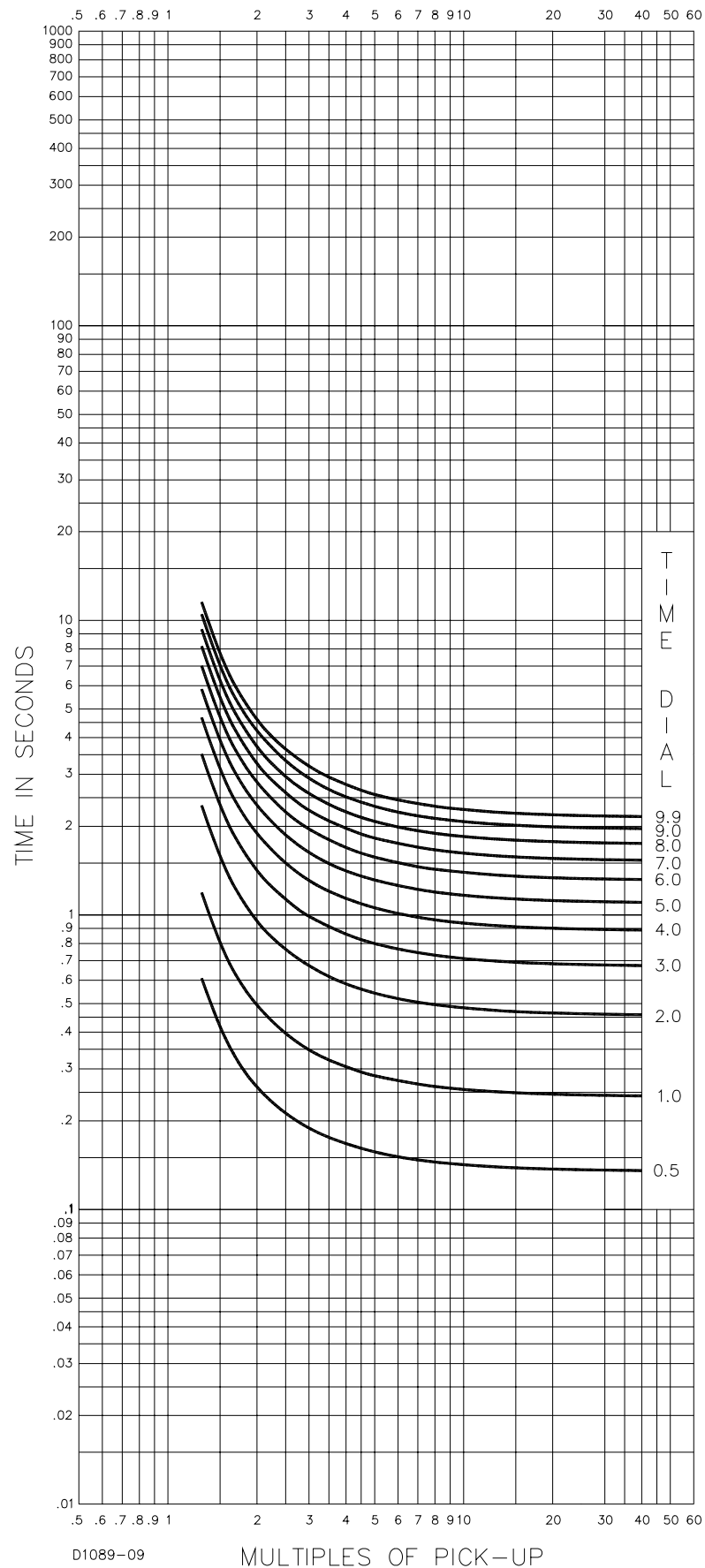


Figure A-5. Time Characteristic Curve D, Definite Time (Similar To ABB CO-6)

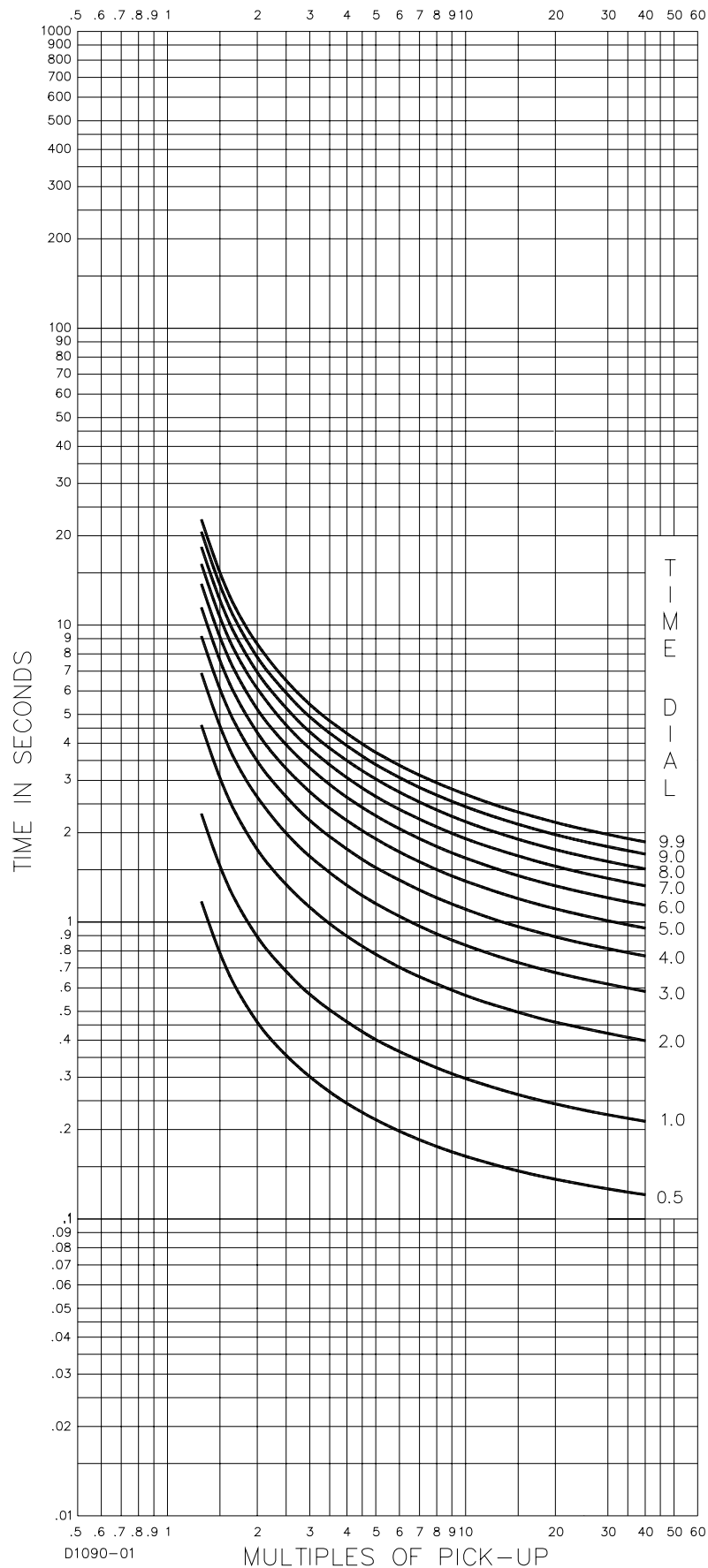


Figure A-6. Time Characteristic Curve M, Moderately Inverse (Similar to ABB CO-7)

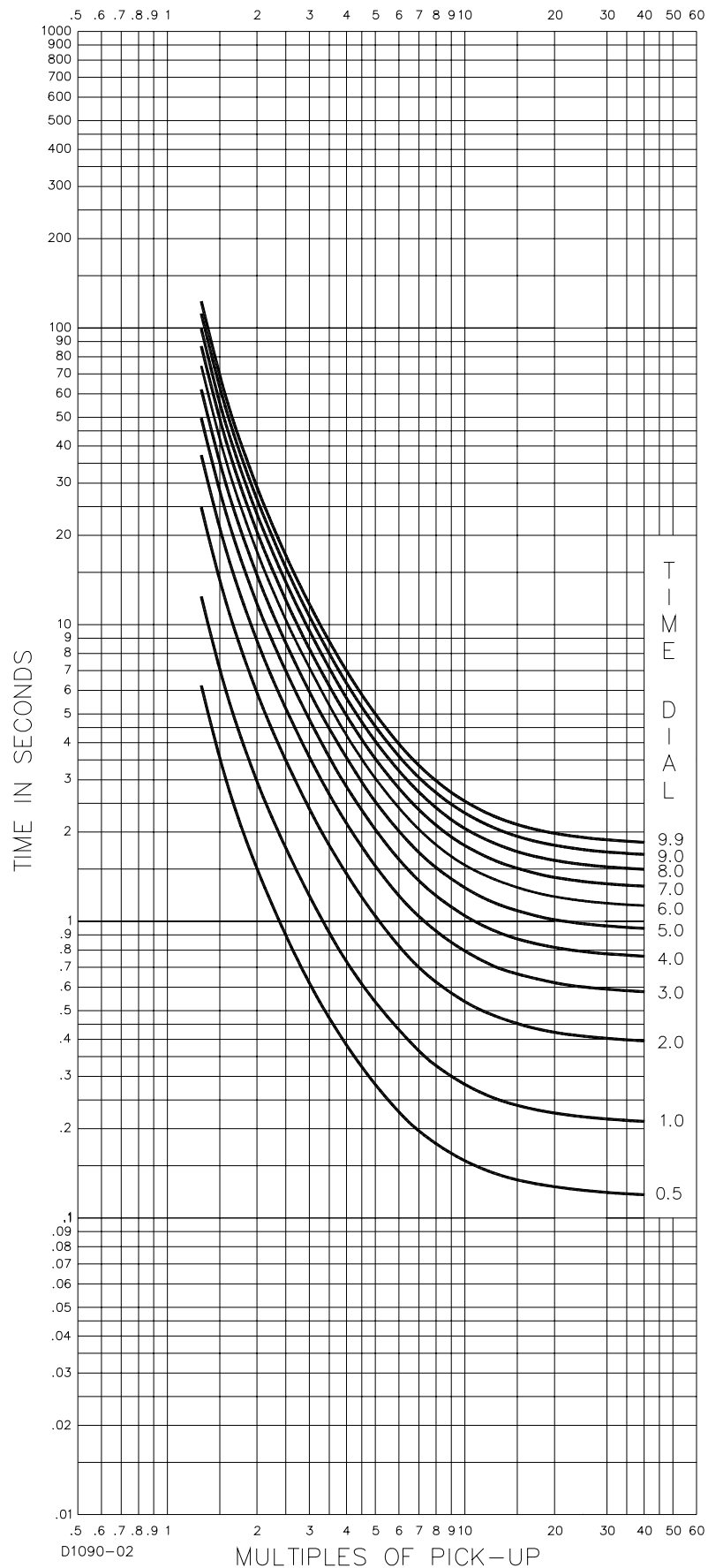


Figure A-7. Time Characteristic Curve I, I1, Inverse Time (Similar to ABB CO-8)

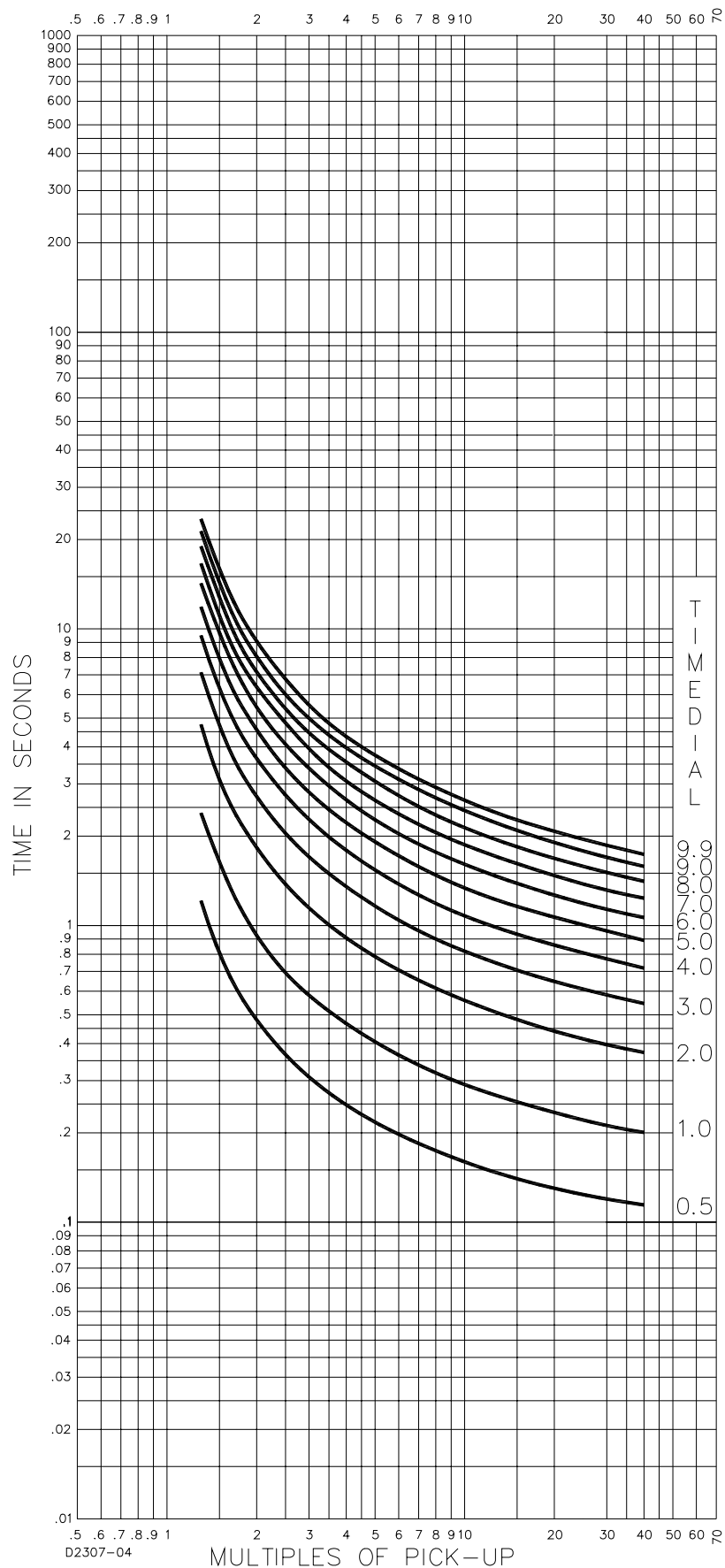


Figure A-8. Time Characteristic Curve I2, Inverse Time (Similar to GE IAC-51)

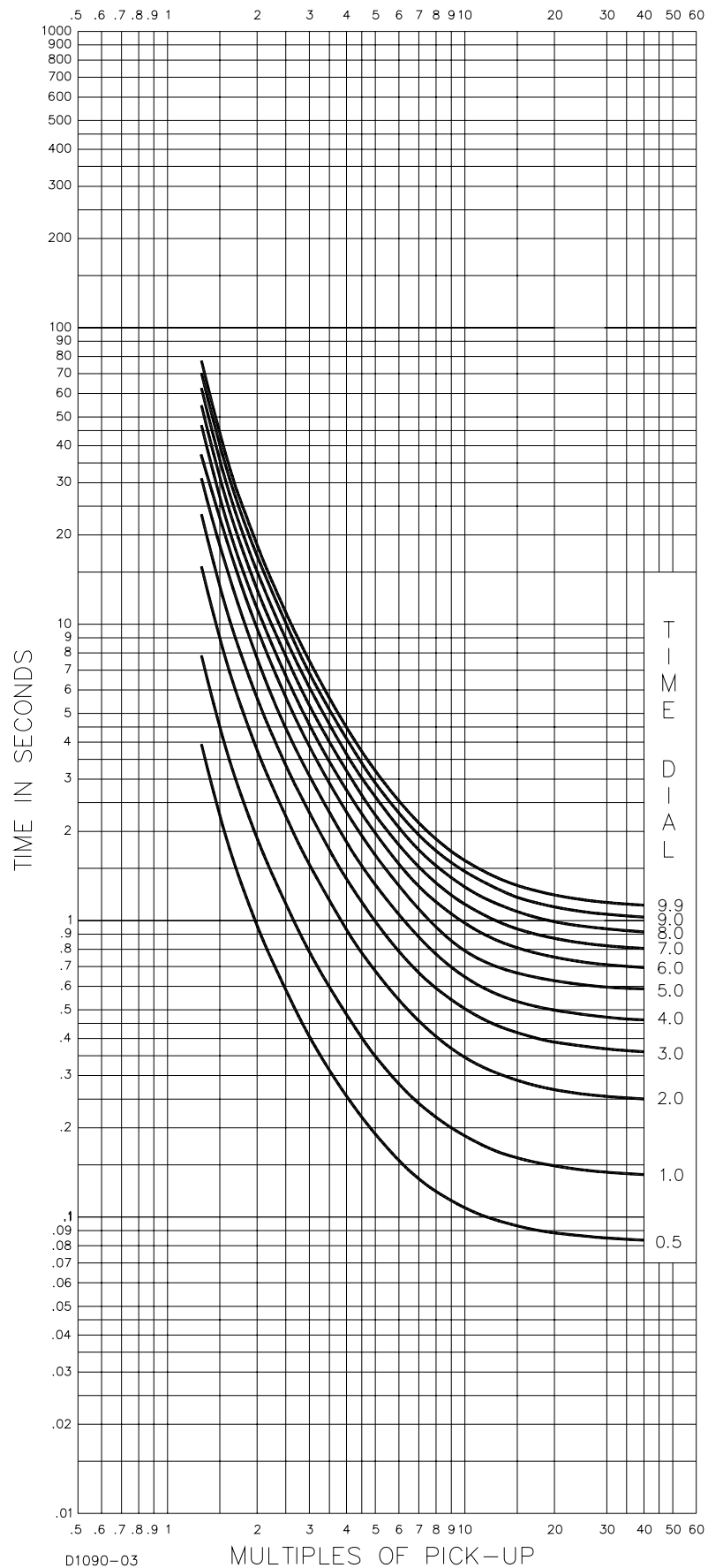


Figure A-9. Time Characteristic Curve V, V1, Very Inverse (Similar to ABB CO-9)

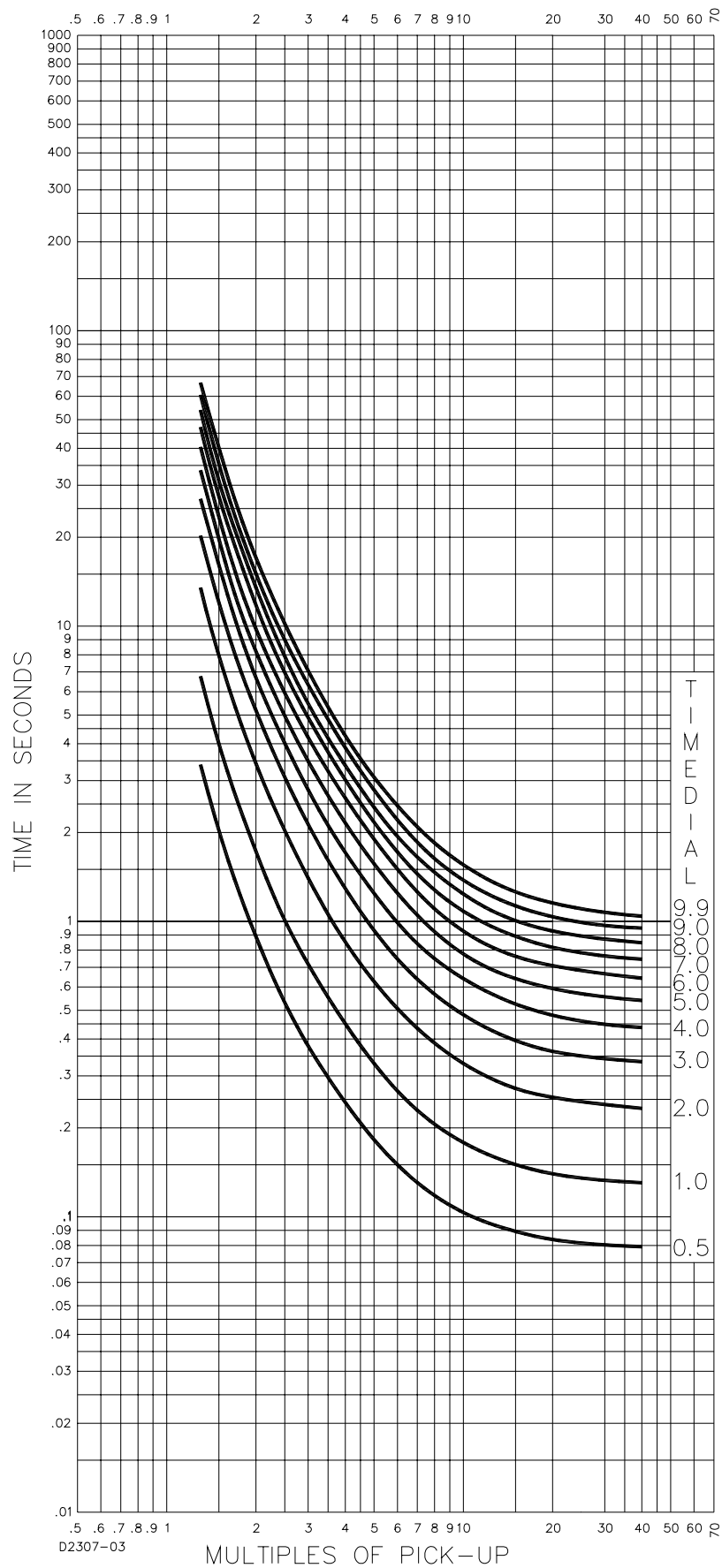


Figure A-10. Time Characteristic Curve V2, Very Inverse (Similar to GE IAC-53)

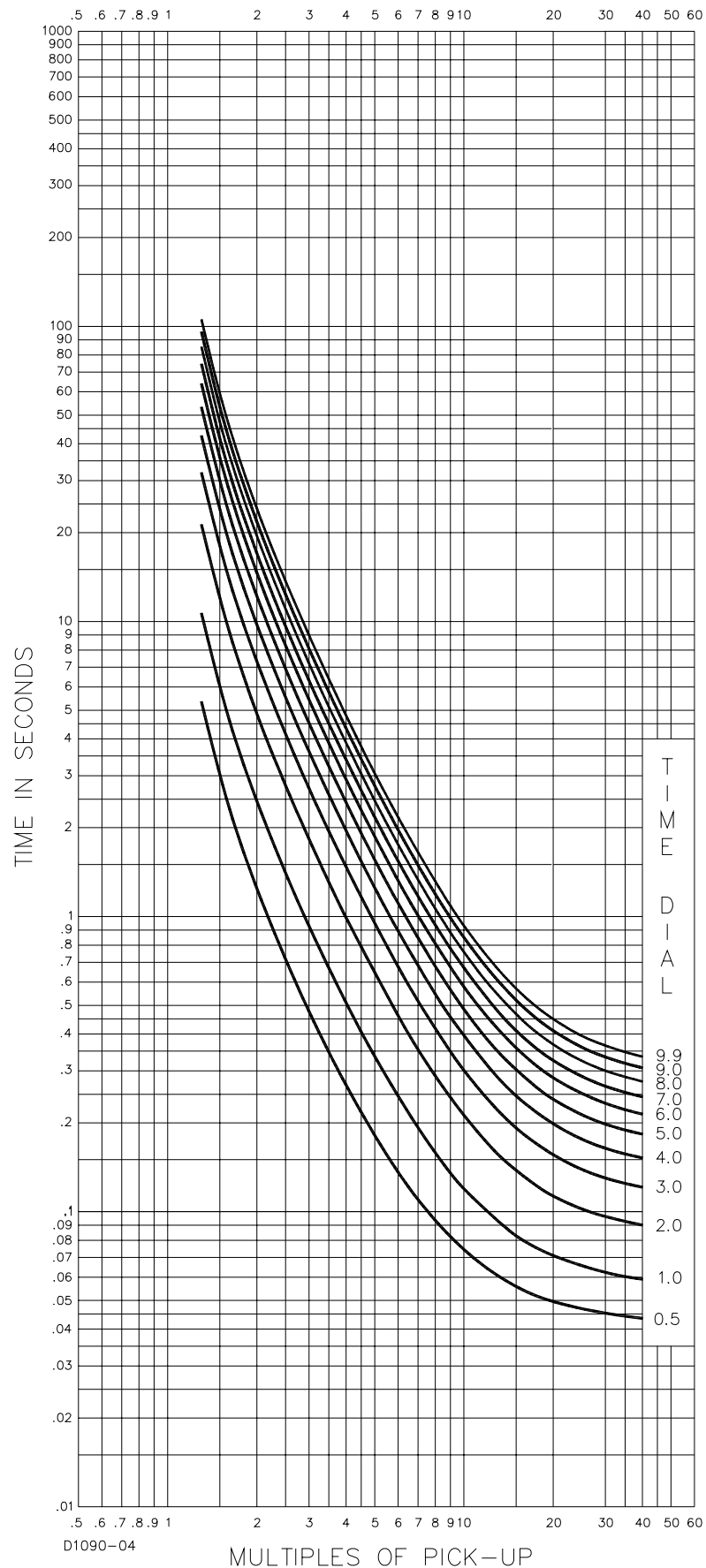


Figure A-11. Time Characteristic Curve E, E1, Extremely Inverse (Similar to ABB CO-11)

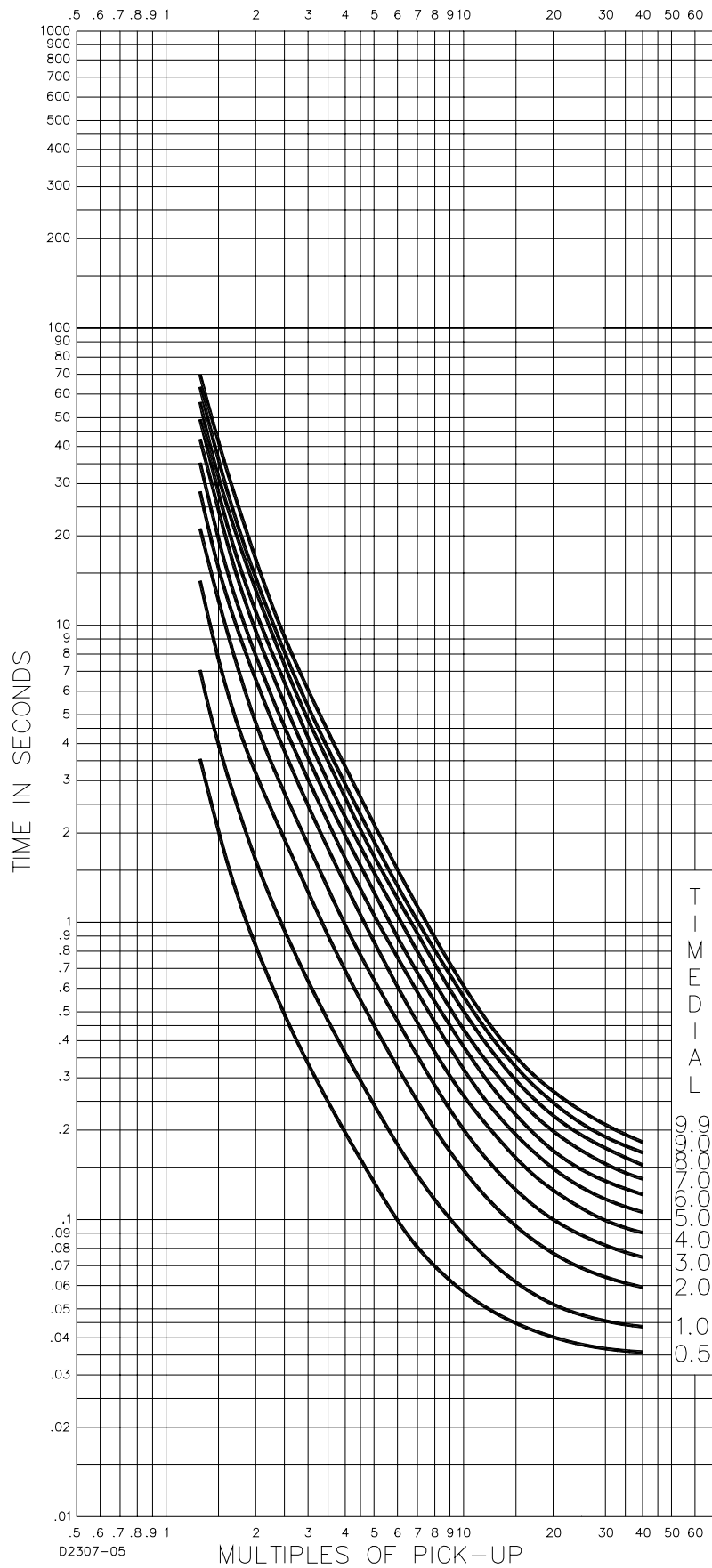


Figure A-12. Time Characteristic Curve E2, Extremely Inverse (Similar to GE IAC-77)

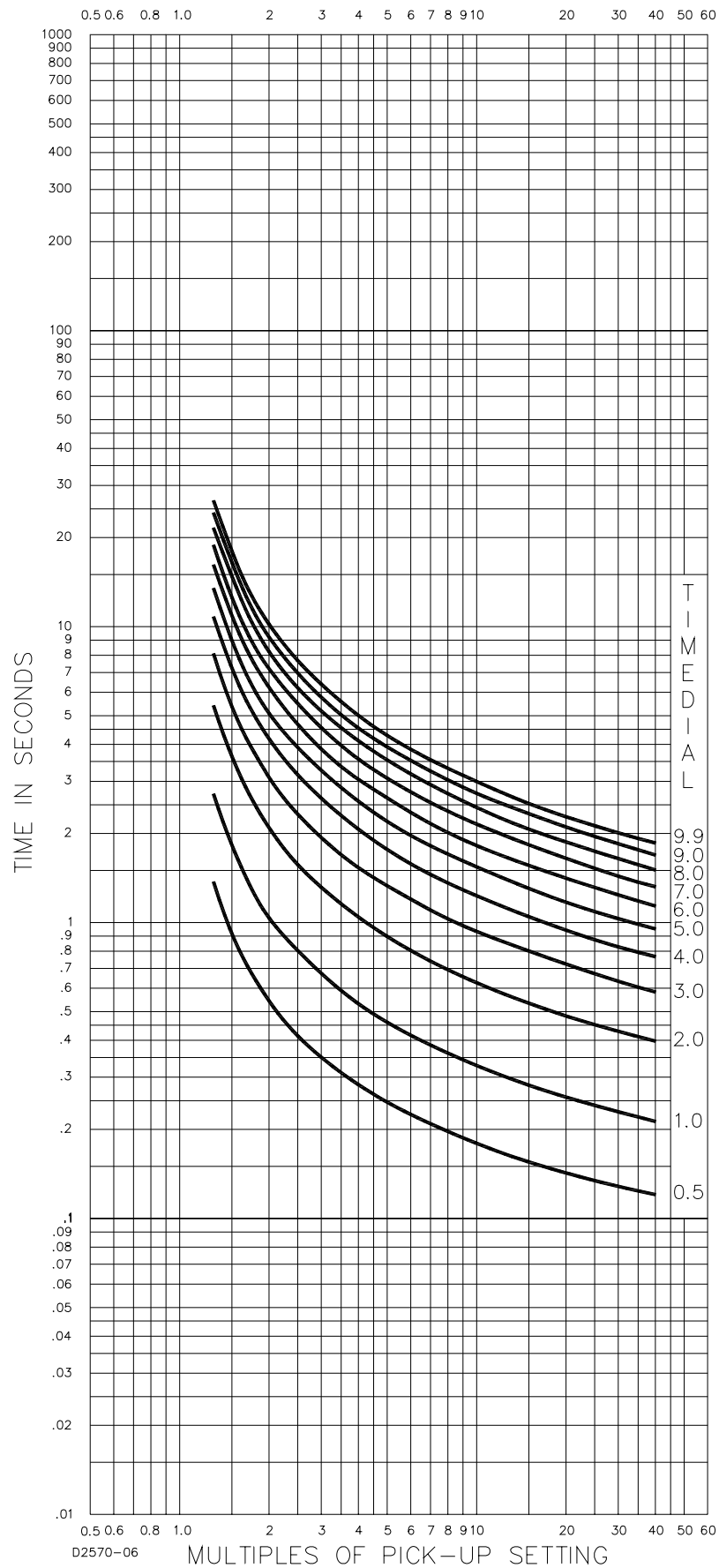


Figure A-13. Time Characteristic Curve A, Standard Inverse

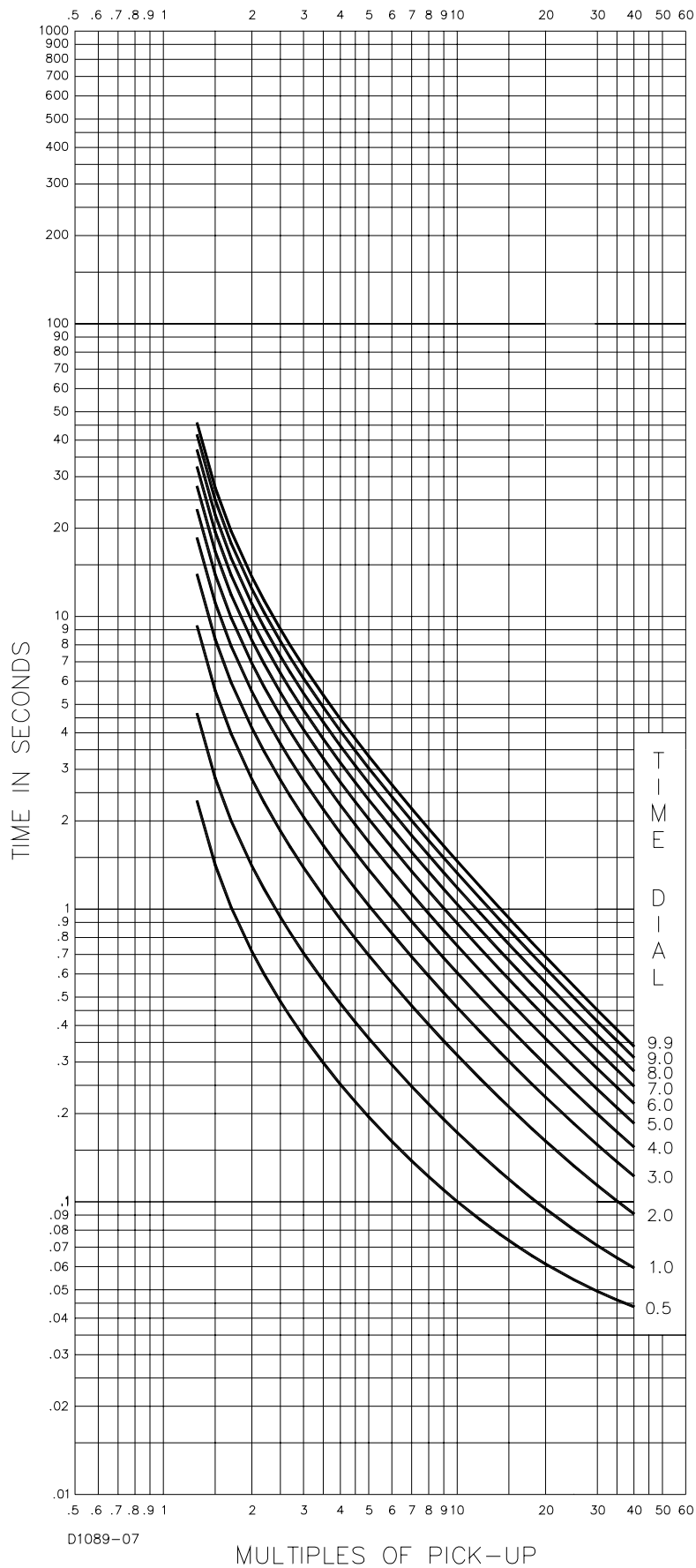


Figure A-14. Time Characteristic Curve B, Very Inverse

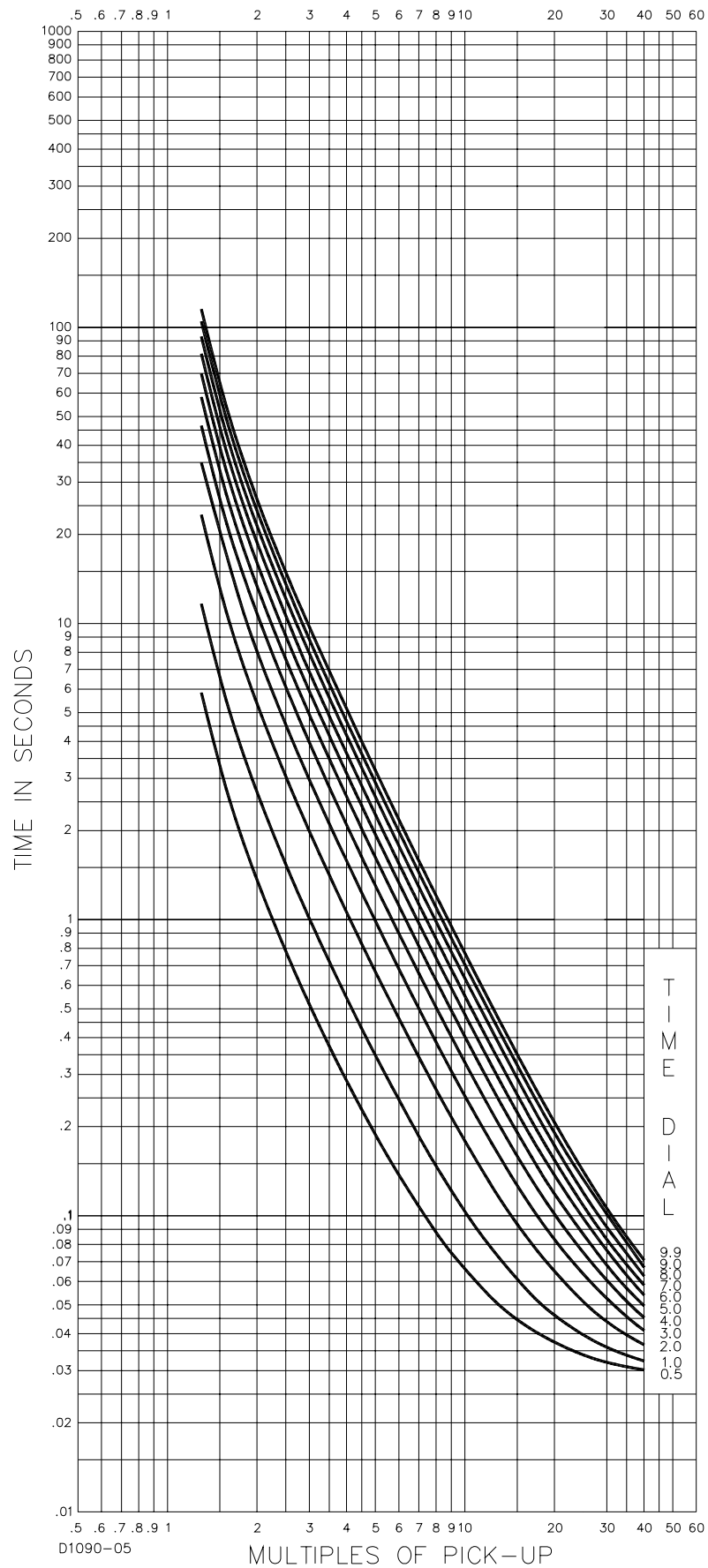


Figure A-15. Time Characteristic Curve C, Extremely Inverse

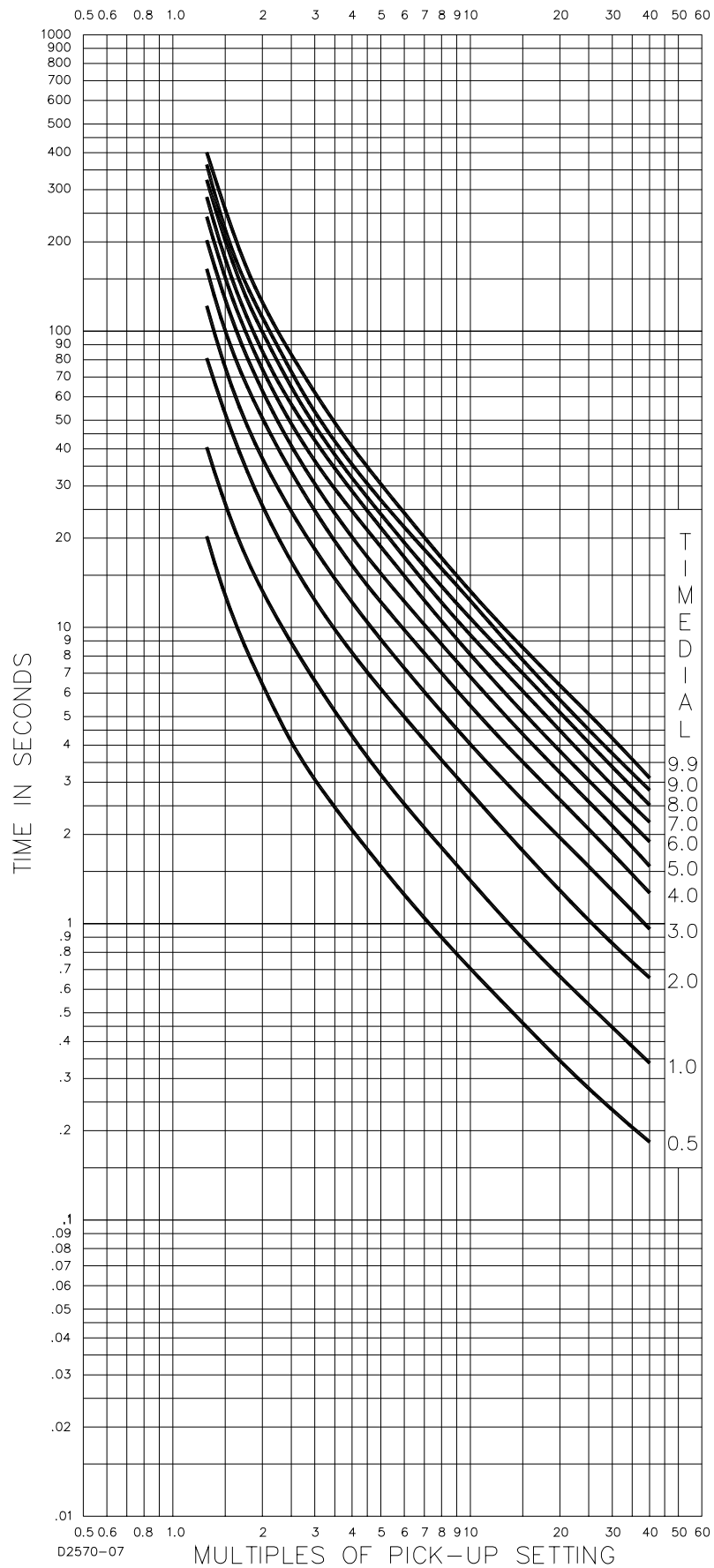


Figure A-16. Time Characteristic Curve G, Long Time Inverse

APPENDIX B • MODBUS™ COMMUNICATION

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APPENDIX B • MODBUS™ COMMUNICATION

INTRODUCTION

General Overview

An optional feature of the DGC-2020 performs Modbus communications by emulating a subset of the Modicon 984 Programmable Controller. This document describes the Modbus communications protocol employed by the DGC-2020 and how to exchange information with the DGC-2020 over a Modbus network.

The DGC-2020 maps all parameters into the Modicon 984 Holding Register address space (4XXXX). Refer to *MAPPING - DGC 2020 Parameters into MODICON ADDRESS SPACE* in this section. The 40XXX registers are identical to the data that was present in the DGC-500 and DGC-1000 products. This allows the DGC-2020 to work seamlessly in Modbus applications where it is replacing a DGC-500 or DGC-1000. The 42XXX registers contain all information included in the DGC-2020 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 DGC-2020 via Modbus protocol. This will allow the exchange of setup information and measured data between a Modbus Master Station and the DGC-2020.

The DGC-2020 data supported for remote access is listed in *MAPPING - DGC 2020 Parameters into MODICON ADDRESS SPACE* in this section.

DETAILED DESCRIPTION OF DGC-2020 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 DGC-2020 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 DGC-2020.

Query / Response Message Structure:

- Device Address
- Function Code
- Eight-Bit Data Bytes
- Error Check

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 DGC-2020 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 DGC-2020 supported baud rates are 9600, 4800, 2400, and 1200.

Message Framing / Timing Considerations

When receiving a message, the DGC-2020 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 DGC-2020 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 a DGC-2020 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 DGC-2020 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 DGC-2020 MESSAGE DEFINITION

Device Address

The DGC-2020 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 DGC-2020s will not respond to the broadcast query.

Function Code and Data Block

The DGC-2020 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 DGC-2020 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

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) DGC-2020 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 unallowed 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) DGC-2020 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 unallowed 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:

<u>Holding Register</u>	<u>Value</u>
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:

<u>Holding Register</u>	<u>Value</u>
K (Hi Byte)	hex 12
K (Lo Byte)	hex 34

The same byte alignments are required to write.

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:

<u>Holding Register</u>	<u>Value</u>
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.

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 8.43×10^{-37} to 3.38×10^{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:

<u>Holding Register</u>	<u>Value</u>
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 DGC-2020 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 - DGC-2020 PARAMETERS INTO MODICON ADDRESS SPACE

Table Conventions

Table B-3 uses the conventions outlined in this section.

The “Data Format” column uses the following abbreviations:

- DP - Double Precision
- TP - Triple Precision
- FP - Floating Point

Data formatted in Double Precision uses a 2-register group designated (a) and (b) and is defined as follows:

- Register (a) - 2 hi-order bytes
- Register (b) - 2 lo-order bytes

Data formatted in Triple Precision uses a 3 register group designated (a), (b) and (x). It is defined as follows:

- Register (a) - 2 hi-order bytes
- Register (b) - 2 mid-order bytes
- Register (x) - 2 lo-order bytes

Other register groups using the (a), (b), etc. designators are an ordered data group of consecutive ASCII characters or data bytes.

Legacy Parameter Table

The DGC-2020 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.

Table B-3. Legacy Parameter Table

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	0-1	R W	0 =Stop 1 =Start	
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	

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
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		.1 Volts DC
40052	Pre-alarm Activation Time Delay	1-10	R W		Seconds
WEAK BATTERY VOLTAGE PRE-ALARM					
40053	Enable	0-1	R W	0 =Off 1 =On	
40054	Threshold	40-80 (12V) 80-160 (24V)	R W		.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 PARAMETERS					
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	1=MPU 2=ALT 3=GEN 4=NONE	
40081	Sender Failure Alarm Code	individual bits are 0 or 1	R	b0=High Coolant Temperature b1=Oil Pressure b2 Fuel Level b3=Generator Voltage Sensing b4=Magnetic Pick-up b5-b7 not used	

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
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	
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		.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

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
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
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		.01
40133	Frequency		R		.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				
GENERATOR MONITOR - Continuation					
40140	Power Factor State	0-3	R	0= +LAG 1= -LEAD 2= -LAG 3= +LEAD	
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. aux. input 4. */	
40274	BESTCOMS 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		

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40287-97	RESERVED				
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	Half of a set of DTC data as defined in SAE J1939-73	
40301	Active DTC Number 16 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40302	Active DTC Number 15 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40303	Active DTC Number 15 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40304	Active DTC Number 14 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40305	Active DTC Number 14 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40306	Active DTC Number 13 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40307	Active DTC Number 13 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40308	Active DTC Number 12 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40309	Active DTC Number 12 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40310	Active DTC Number 11 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40311	Active DTC Number 11 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40312	Active DTC Number 10 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40313	Active DTC Number 10 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40314	Active DTC Number 9 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40315	Active DTC Number 9 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40316	Active DTC Number 8 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40317	Active DTC Number 8 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40318	Active DTC Number 7 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40319	Active DTC Number 7 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40320	Active DTC Number 6 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40321	Active DTC Number 6 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40322	Active DTC Number 5 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40323	Active DTC Number 5 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40324	Active DTC Number 4 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40325	Active DTC Number 4 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40326	Active DTC Number 3 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40327	Active DTC Number 3 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40328	Active DTC Number 2 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40329	Active DTC Number 2 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40330	Active DTC Number 1 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40331	Active DTC Number 1 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40332	Previous DTC Number 1 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40333	Previous DTC Number 1 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40334	Previous DTC Number 2 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40335	Previous DTC Number 2 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40336	Previous DTC Number 3 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40337	Previous DTC Number 3 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40338	Previous DTC Number 4 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40339	Previous DTC Number 4 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40340	Previous DTC Number 5 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40341	Previous DTC Number 5 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40342	Previous DTC Number 6 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40343	Previous DTC Number 6 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40344	Previous DTC Number 7 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40345	Previous DTC Number 7 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40346	Previous DTC Number 8 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40347	Previous DTC Number 8 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40348	Previous DTC Number 9 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40349	Previous DTC Number 9 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40350	Previous DTC Number 10 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40351	Previous DTC Number 10 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40352	Previous DTC Number 11 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40353	Previous DTC Number 11 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40354	Previous DTC Number 12 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40355	Previous DTC Number 12 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40356	Previous DTC Number 13 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40357	Previous DTC Number 13 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40358	Previous DTC Number 14 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40359	Previous DTC Number 14 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40360	Previous DTC Number 15 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40361	Previous DTC Number 15 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40362	Previous DTC Number 16 – Lower Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
40363	Previous DTC Number 16 – Upper Two Bytes	0-65535	R	Half of a set of DTC data as defined in SAE J1939-73	
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	

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 <u>3-Bit Status Flag Values:</u> 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		

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40388	CANbus ECU Configuration	0-65535	R W	0 = Not configured; 1 = Volvo Penta EDC3; 2 = MTU MDEC 3 = MTU ADEC	
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 Pressure2		R		
40426	Injector Metering Rail Pressure2	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	
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	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 4 kPa/bit gain, 0 kPa offset	

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
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)	
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 Point1	0 to 8031.875 rpm	R	Raw ECU Parameter Data 0.125 rpm/bit, 0 rpm offset	
40456	Torque At Idle Point1	0 to 125%	R	Raw ECU Parameter Data 1%/bit gain, -125% offset	
40457	Speed At Idle Point2	0 to 8031.875 rpm	R	Raw ECU Parameter Data 0.125 rpm/bit, 0 rpm offset	
40458	Torque At Idle Point2	0 to 125%	R	Raw ECU Parameter Data 1%/bit gain, -125% offset	
40459	Speed At Idle Point3	0 to 8031.875 rpm	R	Raw ECU Parameter Data 0.125 rpm/bit, 0 rpm offset	
40460	Torque At Idle Point3	0 to 125%	R	Raw ECU Parameter Data 1%/bit gain, -125% offset	
40461	Speed At Idle Point4	0 to 8031.875 rpm	R	Raw ECU Parameter Data 0.125 rpm/bit, 0 rpm offset	
40462	Torque At Idle Point4	0 to 125%	R	Raw ECU Parameter Data 1%/bit gain, -125% offset	
40463	Speed At Idle Point5	0 to 8031.875 rpm	R	Raw ECU Parameter Data 0.125 rpm/bit, 0 rpm offset	
40464	Torque At Idle Point5	0 to 125%	R	Raw ECU Parameter Data 1%/bit gain, -125% offset	
40465	Speed At High Idle Point6	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	

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
40468	Override Speed Point7	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	
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. aux. input 4. */	/* b7 =

Holding Register	Parameter	Range	Read/Write Supported	Data Format	Units
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	
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
CANbus 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	

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	

Current Parameter Table

The DGC-2020 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	R	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	Synchronizer Mode	Int32	N/A	N/A	RW	0 = Off Mode 1 = Auto Mode
42028	Slip Frequency	Int32	CentiHertz	Centi	RW	10 - 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	Int32	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

Register	Description	Type	Units	Scaling Factor	R/W	Range
42052	Mains Breaker Status	Int32	N/A	N/A	R	0 = Open 1 = Closed
42054-60	RESERVED					
42062	Dead Bus Close Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
42064-248	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
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

Register	Description	Type	Units	Scaling Factor	R/W	Range
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	Int32	DeciHertz	Deci	RW	470 - 4400
42370-498	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

Register	Description	Type	Units	Scaling Factor	R/W	Range
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	1 - 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 - 3
42820	Bus Stable Low Line Scale Factor	Float	N/A	N/A	RW	0 - 3
42822-3432	FUTURE USE					

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
43450-498	FUTURE USE	Int32		N/A	RW	

System Configuration and Status

Register	Description	Type	Units	Scaling Factor	R/W	Range
43500	Rated Volts	Float	Volt	N/A	RW	1 - 99999

Register	Description	Type	Units	Scaling Factor	R/W	Range
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
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	50 - 500

Register	Description	Type	Units	Scaling Factor	R/W	Range
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
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	Int32	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

Register	Description	Type	Units	Scaling Factor	R/W	Range
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 - 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	N/A	RW	3 - 150
43634	Crank Disconnect Pressure in KPA	UInt32	Kpa	N/A	RW	21 - 1034
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
43642	Single Phase Detect Threshold	Int32	Volt	N/A	RW	0 - 480
43644-748	FUTURE USE					

Control

Register	Description	Type	Units	Scaling Factor	R/W	Range
43750	Emergency Stop	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
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
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	RESERVED					
43774	Virtual Input 1 Close	Int32	N/A	N/A	RW	0 = Disable 1 = Enable

Register	Description	Type	Units	Scaling Factor	R/W	Range
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
43792-4006	FUTURE USE					

Communication

Register	Description	Type	Units	Scaling Factor	R/W	Range
44008-48	RESERVED					
44050	DHCP Enabled	UInt32	N/A	N/A	R	0 = Disabled 1 = Enabled
44052	Active IP Address	UInt32	N/A	N/A	R	0 - 4294967295
44054	Gateway IP Address	UInt32	N/A	N/A	R	0 - 4294967295
44056	Subnet Mask	UInt32	N/A	N/A	R	0 - 4294967295
44058-064	RESERVED					
44066-248	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 - 300
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
44256	3 Phase Overcurrent Alarm Configuration (51-1)	UInt32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
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 - 300

Register	Description	Type	Units	Scaling Factor	R/W	Range
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
44264	1 Phase Overcurrent Alarm Configuration (51-1)	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
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
44272	3 Phase Undervoltage Pickup (27-1)	Uint32	Volt	N/A	RW	70 - 576
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
44280	1 Phase Undervoltage Pickup (27-1)	Uint32	Volt	N/A	RW	70 - 576
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
44288	3 Phase Overvoltage Pickup (59-1)	Uint32	Volt	N/A	RW	70 - 576
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
44294	1 Phase Overvoltage Pickup (59-1)	Uint32	Volt	N/A	RW	70 - 576
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
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

Register	Description	Type	Units	Scaling Factor	R/W	Range
44306	Underfrequency Alarm Configuration	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
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
44314	Overcurrent Low Line Scale Factor (51-1)	Float	N/A	N/A	RW	0 - 3
44316	Overvoltage Low Line Scale Factor (59-1)	Float	N/A	N/A	RW	0 - 3
44318	Undervoltage Low Line Scale Factor (27-1)	Float	N/A	N/A	RW	0 - 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 - 300
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
44326	3 Phase Overcurrent Alarm Configuration (51-2)	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
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 - 300
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
44334	1 Phase Overcurrent Alarm Configuration (51-2)	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
44336	3 Phase Undervoltage Pickup (27-2)	Uint32	Volt	N/A	RW	70 - 576

Register	Description	Type	Units	Scaling Factor	R/W	Range
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
44344	1 Phase Undervoltage Pickup (27-2)	Uint32	Volt	N/A	RW	70 - 576
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
44352	3 Phase Overvoltage Pickup (59-2)	Uint32	Volt	N/A	RW	70 - 576
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
44358	1 Phase Overvoltage Pickup (59-2)	Uint32	Volt	N/A	RW	70 - 576
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
44364	Overcurrent Low Line Scale Factor (51-2)	Float	N/A	N/A	RW	0 - 3
44366	Overvoltage Low Line Scale Factor (59-2)	Float	N/A	N/A	RW	0 - 3
44368	Undervoltage Low Line Scale Factor (27-2)	Float	N/A	N/A	RW	0 - 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
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	Uint32	DeciPercent	Deci	RW	(-500) - 50
44394	3 Phase Reverse Power Activation Delay	Uint32	Decisecond	Deci	RW	0 - 300

Register	Description	Type	Units	Scaling Factor	R/W	Range
44396	3 Phase Reverse Power Alarm Configuration	Uint32	N/A	N/A	RW	0 = None 1 = Alarm 2 = Pre-Alarm
44398	3 Phase Reverse Power Hysteresis	Int32	DeciPercent	Deci	RW	10 - 100
44400	1 Phase Reverse Power Pickup	Uint32	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
44406	1 Phase Reverse Power Hysteresis	Int32	DeciPercent	Deci	RW	10 - 100
44408	3 Phase Loss of Excitation Pickup	Uint32	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
44414	3 Phase Loss of Excitation Hysteresis	Int32	DeciPercent	Deci	RW	10 - 100
44416	1 Phase Loss of Excitation Pickup	Uint32	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
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
44432-498	FUTURE USE					

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	N/A	RW	3 - 150
44512	Metric Low Oil Press. Alarm Threshold	Int32	Kpa	N/A	RW	21 - 1034
44514	Low Oil Press. Alarm Arming Delay	Uint32	Second	N/A	RW	5 - 15

Register	Description	Type	Units	Scaling Factor	R/W	Range
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 - 150
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 - 100
44542	High Fuel Level Pre-Alarm Enable	Int32	N/A	N/A	RW	0 = Disable 1 = Enable
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 - 240
44554	Low Battery Pre-Alarm Activation Delay	Uint32	Second	N/A	RW	1 - 10
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 - 160
44560	Weak Battery Pre-Alarm Activation Delay	Uint32	Second	N/A	RW	1 - 10
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	N/A	RW	3 - 150
44568	Metric Low Oil Press. Pre-Alarm Threshold	Int32	Kpa	N/A	RW	21 - 1034
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	95 - 140
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

Register	Description	Type	Units	Scaling Factor	R/W	Range
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	95 - 140
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 - 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	95 - 140
44606	Engine Overload 2 Pre-Alarm 3 Phase Hysteresis	Int32	Percent	N/A	RW	1 - 10
44608	Engine Overload 2 Pre-Alarm 1 Phase Threshold	Int32	Percent	N/A	RW	95 - 140
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 - 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	95 - 140
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	95 - 140
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 - 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

Register	Description	Type	Units	Scaling Factor	R/W	Range
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
44648-748	RESERVED					

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
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	(-128) - 127
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 - 255
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

Register	Description	Type	Units	Scaling Factor	R/W	Range
44812	Alarm Metering	Int32	N/A	N/A	R	Bit 0 = Overspeed Bit 1 = Hi Coolant Temp Bit 2 = Low Oil Pressure Bit 3 = Low Fuel Level Bit 4 = Global Sender Fail Bit 5 = Loss of ECU Comms Bit 6 = Overcrank Bit 7 = Emergency Shutdown Bit 8 = Loss of ECU Shutdown Bit 9 = ECU Low Coolant Level
44814	Pre-Alarm Metering	Int32	N/A	N/A	R	Bit 0 = Hi Coolant Temp Bit 1 = Low Oil Pressure Bit 2 = Low Fuel Level Bit 3 = Low Coolant Temp Bit 4 = Low Battery Voltage Bit 5 = Weak Battery Bit 6 = Battery Overvoltage Bit 7 = Maintenance Due Bit 8 = Loss of ECU Comms Bit 9 = Diagnostic Trouble Code Bit 10 = Engine kW Overload Bit 11 = Loss of Rem. Mod. Com Bit 12 = High Fuel Level Bit 13 = Sync Fail at Gen Brkr Bit 14 = Gen Brkr Fail to Close Bit 15 = Gen Brkr Fail to Open Bit 16 = Sync Fail at Mains Brkr Bit 17 = Mains Brkr Fail to Close Bit 18 = Mains Brkr Fail to Open
44816	MTU Alarm Metering	Int32	N/A	N/A	R	Bit 0 = High Charge Air Temp Bit 1 = High Oil Temp Bit 2 = High Coolant Temp Bit 3 = Low Aftcr cooler Cool. Level Bit 4 = Low Fuel Delivery Press. Bit 5 = Low Oil Pressure Bit 6 = Overspeed Bit 7 = Combined Red
44818	MTU Pre-Alarm Metering	Int32	N/A	N/A	R	Bit 0 = High ECU Temp. Bit 1 = High Oil Temp. Bit 2 = High Intercooler Temp. Bit 3 = High Charge Air Temp. Bit 4 = High Coolant Temp. Bit 5 = Shutdown Override Bit 6 = High Fuel Rail Press. Bit 7 = Low Fuel Rail Press. Bit 8 = Low Coolant Level Bit 9 = Low Charge Air Press. Bit 10 = Low Fuel Delivery Press. Bit 11 = Low Oil Press. Bit 12 = Combined Yellow
44820	Sender Fail Alarm Metering	Int32	N/A	N/A	R	Bit 0 = Speed Bit 1 = Oil Pressure Bit 2 = Coolant Temp Bit 3 = Fuel Level Bit 4 = Generator Voltage
44822	Protection Alarm Metering	Int32	N/A	N/A	R	Bit 0 = 51-1 Overcurrent Bit 1 = 47 Phase Imbalance Bit 2 = 27-1 Undervoltage Bit 3 = 59-1 Overvoltage Bit 4 = 81 Overfrequency Bit 5 = 81 Underfrequency Bit 6 = 51-2 Overcurrent Bit 7 = 27-2 Undervoltage Bit 8 = 59-2 Overvoltage Bit 9 = 32 Reverse Power Bit 10 = 40Q Loss of Excitation
44824-26	FUTURE USE					

Register	Description	Type	Units	Scaling Factor	R/W	Range
44828	Local Input Metering	Int32	N/A	N/A	R	Bit 0 = Input 1 Bit 1 = Input 2 Bit 2 = Input 3 Bit 3 = Input 4 Bit 4 = Input 5 Bit 5 = Input 6 Bit 6 = Input 7 Bit 7 = Input 8 Bit 8 = Input 9 Bit 9 = Input 10 Bit 10 = Input 11 Bit 11 = Input 12 Bit 12 = Input 13 Bit 13 = Input 14 Bit 14 = Input 15 Bit 15 = Input 16
44830	Local Output Metering	Int32	N/A	N/A	R	Bit 0 = Output 1 Bit 1 = Output 2 Bit 2 = Output 3 Bit 3 = Output 4 Bit 4 = Output 5 Bit 5 = Output 6 Bit 6 = Output 7 Bit 7 = Output 8 Bit 8 = Output 9 Bit 9 = Output 10 Bit 10 = Output 11 Bit 11 = Output 12
44832	Status Metering	Int32	N/A	N/A	R	Bit 0 = EPS Supplying Load Bit 1 = Single Phase Override Bit 2 = Single Phase AC Override Bit 3 = Low Line Override Bit 4 = Auto Transfer Switch Bit 5 = Battle Override Bit 6 = Grounded Delta Override Bit 7 = Mains Breaker Closed Bit 8 = Gen Breaker Closed Bit 9 = Bus Dead Bit 10 = Bus Stable Bit 11 = Bus Failed Bit 12 = Gen Dead Bit 13 = Gen Stable Bit 14 = Gen Failed Bit 15 = Low Coolant Level Bit 16 = Battery Charger Failure Bit 17 = Fuel Leak Detect Bit 18 = Engine Running Bit 19 = Cooldown Timer Active
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

Register	Description	Type	Units	Scaling Factor	R/W	Range
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
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
44882-918	FUTURE USE					
44920-48	RESERVED					
44950	Global Alarm	UInt32	N/A	N/A	R	0 = No system alarms in effect 1 = System alarm(s) in effect
44952	Global Pre-Alarm	UInt32	N/A	N/A	R	0 = No system pre-alarms in effect 1 = System pre-alarm(s) in effect
44954	Local Configurable Inputs Pre-Alarm Bits	Int32	N/A	N/A	R	Bit 0 = Input 1 Bit 1 = Input 2 Bit 2 = Input 3 Bit 3 = Input 4 Bit 4 = Input 5 Bit 5 = Input 6 Bit 6 = Input 7 Bit 7 = Input 8 Bit 8 = Input 9 Bit 9 = Input 10 Bit 10 = Input 11 Bit 11 = Input 12 Bit 12 = Input 13 Bit 13 = Input 14 Bit 14 = Input 15 Bit 15 = Input 16

Register	Description	Type	Units	Scaling Factor	R/W	Range
44956	Local Configurable Inputs Alarm Bits	Int32	N/A	N/A	R	Bit 0 = Input 1 Bit 1 = Input 2 Bit 2 = Input 3 Bit 3 = Input 4 Bit 4 = Input 5 Bit 5 = Input 6 Bit 6 = Input 7 Bit 7 = Input 8 Bit 8 = Input 9 Bit 9 = Input 10 Bit 10 = Input 11 Bit 11 = Input 12 Bit 12 = Input 13 Bit 13 = Input 14 Bit 14 = Input 15 Bit 15 = Input 16
44958	Configurable Elements Status Bits	Int32	N/A	N/A	R	Bit 0 = Config Element 1 Bit 1 = Config Element 2 Bit 2 = Config Element 3 Bit 3 = Config Element 4 Bit 4 = Config Element 5 Bit 5 = Config Element 6 Bit 6 = Config Element 7 Bit 7 = Config Element 8
44960	Configurable Elements Pre-Alarm Bits	Int32	N/A	N/A	R	Bit 0 = Config Element 1 Bit 1 = Config Element 2 Bit 2 = Config Element 3 Bit 3 = Config Element 4 Bit 4 = Config Element 5 Bit 5 = Config Element 6 Bit 6 = Config Element 7 Bit 7 = Config Element 8
44962	Configurable Elements Alarm Bits	Int32	N/A	N/A	R	Bit 0 = Config Element 1 Bit 1 = Config Element 2 Bit 2 = Config Element 3 Bit 3 = Config Element 4 Bit 4 = Config Element 5 Bit 5 = Config Element 6 Bit 6 = Config Element 7 Bit 7 = Config Element 8
44964	Remote Inputs Status Bits	Int32	N/A	N/A	R	Bit 0 = Remote Input 17 Bit 1 = Remote Input 18 Bit 2 = Remote Input 19 Bit 3 = Remote Input 20 Bit 4 = Remote Input 21 Bit 5 = Remote Input 22 Bit 6 = Remote Input 23 Bit 7 = Remote Input 24 Bit 8 = Remote Input 25 Bit 9 = Remote Input 26

Register	Description	Type	Units	Scaling Factor	R/W	Range
44966	Remote Outputs Status Bits	Int32	N/A	N/A	R	Bit 0 = Remote Output 13 Bit 1 = Remote Output 14 Bit 2 = Remote Output 15 Bit 3 = Remote Output 16 Bit 4 = Remote Output 17 Bit 5 = Remote Output 18 Bit 6 = Remote Output 19 Bit 7 = Remote Output 20 Bit 8 = Remote Output 21 Bit 9 = Remote Output 22 Bit 10 = Remote Output 23 Bit 11 = Remote Output 24 Bit 12 = Remote Output 25 Bit 13 = Remote Output 26 Bit 14 = Remote Output 27 Bit 15 = Remote Output 28 Bit 16 = Remote Output 29 Bit 17 = Remote Output 30 Bit 18 = Remote Output 31 Bit 19 = Remote Output 32 Bit 20 = Remote Output 33 Bit 21 = Remote Output 34 Bit 22 = Remote Output 35 Bit 23 = Remote Output 36
44968	CEM Alarm Bits	UInt32	N/A	N/A	R	Bit 0 = CEM Comm Fail Bit 1 = Duplicate CEM Bit 2 = CEM Hardware Mismatch
44970	Remote Configurable Inputs Pre-Alarm Bits	UInt32	N/A	N/A	R	Bit 0 = Remote Input 17 Bit 1 = Remote Input 18 Bit 2 = Remote Input 19 Bit 3 = Remote Input 20 Bit 4 = Remote Input 21 Bit 5 = Remote Input 22 Bit 6 = Remote Input 23 Bit 7 = Remote Input 24 Bit 8 = Remote Input 25 Bit 9 = Remote Input 26
44972	Remote Configurable Inputs Alarm Bits	UInt32	N/A	N/A	R	Bit 0 = Remote Input 17 Bit 1 = Remote Input 18 Bit 2 = Remote Input 19 Bit 3 = Remote Input 20 Bit 4 = Remote Input 21 Bit 5 = Remote Input 22 Bit 6 = Remote Input 23 Bit 7 = Remote Input 24 Bit 8 = Remote Input 25 Bit 9 = Remote Input 26
44974	AEM Alarm Bits	UInt32	N/A	N/A	R	Bit 0 = AEM Comm Fail Bit 1 = Duplicate AEM
44976-84	RESERVED					
44986	Generator Frequency	Int32	N/A	Deci	R	0 - 4400
44988	Bus Frequency	Int32	N/A	Deci	R	0 - 440
44990	Power Factor	Int32	N/A	Centi	R	(-100) - 100
44992-99	RESERVED					
45000	ECU Lamp Status	Int32	N/A	N/A	R	Bit 24 = Malfunction Bit 27 = Stop Bit 28 = Warning Bit 31 = Protect
45002	Number of DTC's	Int32	N/A	N/A	R	(-32768) - 32767
45004-490	RESERVED					
45500	Analog Input 1 Metering Value	Int32	DeciUnit	Deci	R	(-99990) - 99990
45502	Analog Input 2 Metering Value	Int32	DeciUnit	Deci	R	(-99990) - 99990

Register	Description	Type	Units	Scaling Factor	R/W	Range
45504	Analog Input 3 Metering Value	Int32	DeciUnit	Deci	R	(-99990) - 99990
45506	Analog Input 4 Metering Value	Int32	DeciUnit	Deci	R	(-99990) - 99990
45508	Analog Input 5 Metering Value	Int32	DeciUnit	Deci	R	(-99990) - 99990
45510	Analog Input 6 Metering Value	Int32	DeciUnit	Deci	R	(-99990) - 99990
45512	Analog Input 7 Metering Value	Int32	DeciUnit	Deci	R	(-99990) - 99990
45514	Analog Input 8 Metering Value	Int32	DeciUnit	Deci	R	(-99990) - 99990
45516	RTD Input 1 Metering Value	Int32	CentiDeg F	Centi	R	(-9999999) - 9999999
45518	RTD Input 2 Metering Value	Int32	CentiDeg F	Centi	R	(-9999999) - 9999999
45520	RTD Input 3 Metering Value	Int32	CentiDeg F	Centi	R	(-9999999) - 9999999
45522	RTD Input 4 Metering Value	Int32	CentiDeg F	Centi	R	(-9999999) - 9999999
45524	RTD Input 5 Metering Value	Int32	CentiDeg F	Centi	R	(-9999999) - 9999999
45526	RTD Input 6 Metering Value	Int32	CentiDeg F	Centi	R	(-9999999) - 9999999
45528	RTD Input 7 Metering Value	Int32	CentiDeg F	Centi	R	(-9999999) - 9999999
45530	RTD Input 8 Metering Value	Int32	CentiDeg F	Centi	R	(-9999999) - 9999999
45532	Thermocouple Input 1 Metering Value	Int32	CentiDeg F	Centi	R	(-9999999) - 9999999
45534	Thermocouple Input 2 Metering Value	Int32	CentiDeg F	Centi	R	(-9999999) - 9999999
45536	AEM Input Threshold Status Bits Reg 1	UInt32	N/A	N/A	R	Bit 0 = Analog Input 1 Out of Range Bit 1 = Analog Input 1 Over 1 Bit 2 = Analog Input 1 Over 2 Bit 3 = Analog Input 1 Under 1 Bit 4 = Analog Input 1 Under 2 Bit 5 = Analog Input 2 Out of Range Bit 6 = Analog Input 2 Over 1 Bit 7 = Analog Input 2 Over 2 Bit 8 = Analog Input 2 Under 1 Bit 9 = Analog Input 2 Under 2 Bit 10 = Analog Input 3 Out of Range Bit 11 = Analog Input 3 Over 1 Bit 12 = Analog Input 3 Over 2 Bit 13 = Analog Input 3 Under 1 Bit 14 = Analog Input 3 Under 2 Bit 15 = Analog Input 4 Out of Range Bit 16 = Analog Input 4 Over 1 Bit 17 = Analog Input 4 Over 2 Bit 18 = Analog Input 4 Under 1 Bit 19 = Analog Input 4 Under 2 Bit 20 = Analog Input 5 Out of Range Bit 21 = Analog Input 5 Over 1 Bit 22 = Analog Input 5 Over 2 Bit 23 = Analog Input 5 Under 1 Bit 24 = Analog Input 5 Under 2 Bit 25 = Analog Input 6 Out of Range Bit 26 = Analog Input 6 Over 1 Bit 27 = Analog Input 6 Over 2 Bit 28 = Analog Input 6 Under 1 Bit 29 = Analog Input 6 Under 2

Register	Description	Type	Units	Scaling Factor	R/W	Range
45538	AEM Input Threshold Status Bits Reg 2	Uint32	N/A	N/A	R	Bit 0 = Analog Input 7 Out of Range Bit 1 = Analog Input 7 Over 1 Bit 2 = Analog Input 7 Over 2 Bit 3 = Analog Input 7 Under 1 Bit 4 = Analog Input 7 Under 2 Bit 5 = Analog Input 8 Out of Range Bit 6 = Analog Input 8 Over 1 Bit 7 = Analog Input 8 Over 2 Bit 8 = Analog Input 8 Under 1 Bit 9 = Analog Input 8 Under 2 Bit 10 = RTD Input 1 Out of Range Bit 11 = RTD Input 1 Over 1 Bit 12 = RTD Input 1 Over 2 Bit 13 = RTD Input 1 Under 1 Bit 14 = RTD Input 1 Under 2 Bit 15 = RTD Input 2 Out of Range Bit 16 = RTD Input 2 Over 1 Bit 17 = RTD Input 2 Over 2 Bit 18 = RTD Input 2 Under 1 Bit 19 = RTD Input 2 Under 2 Bit 20 = RTD Input 3 Out of Range Bit 21 = RTD Input 3 Over 1 Bit 22 = RTD Input 3 Over 2 Bit 23 = RTD Input 3 Under 1 Bit 24 = RTD Input 3 Under 2 Bit 25 = RTD Input 4 Out of Range Bit 26 = RTD Input 4 Over 1 Bit 27 = RTD Input 4 Over 2 Bit 28 = RTD Input 4 Under 1 Bit 29 = RTD Input 4 Under 2
45540	AEM Input Threshold Status Bits Reg 3	Uint32	N/A	N/A	R	Bit 0 = RTD Input 5 Out of Range Bit 1 = RTD Input 5 Over 1 Bit 2 = RTD Input 5 Over 2 Bit 3 = RTD Input 5 Under 1 Bit 4 = RTD Input 5 Under 2 Bit 5 = RTD Input 6 Out of Range Bit 6 = RTD Input 6 Over 1 Bit 7 = RTD Input 6 Over 2 Bit 8 = RTD Input 6 Under 1 Bit 9 = RTD Input 6 Under 2 Bit 10 = RTD Input 7 Out of Range Bit 11 = RTD Input 7 Over 1 Bit 12 = RTD Input 7 Over 2 Bit 13 = RTD Input 7 Under 1 Bit 14 = RTD Input 7 Under 2 Bit 15 = RTD Input 8 Out of Range Bit 16 = RTD Input 8 Over 1 Bit 17 = RTD Input 8 Over 2 Bit 18 = RTD Input 8 Under 1 Bit 19 = RTD Input 8 Under 2 Bit 20 = Thermocouple 1 Out of Range Bit 21 = Thermocouple 1 Over 1 Bit 22 = Thermocouple 1 Over 2 Bit 23 = Thermocouple 1 Under 1 Bit 24 = Thermocouple 1 Under 2 Bit 25 = Thermocouple 2 Out of Range Bit 26 = Thermocouple 2 Over 1 Bit 27 = Thermocouple 2 Over 2 Bit 28 = Thermocouple 2 Under 1 Bit 29 = Thermocouple 2 Under 2
45542	AEM Input Threshold Status Bits Reg 4	Uint32	N/A	N/A	R	Bit 0 = Analog Output 1 Out of Range Bit 1 = Analog Output 2 Out of Range Bit 2 = Analog Output 3 Out of Range Bit 3 = Analog Output 4 Out of Range

Register	Description	Type	Units	Scaling Factor	R/W	Range
45544	AEM Input Threshold Alarm Bits Reg 1	Uint32	N/A	N/A	R	Bit 0 = Analog Input 1 Out of Range Bit 1 = Analog Input 1 Over 1 Bit 2 = Analog Input 1 Over 2 Bit 3 = Analog Input 1 Under 1 Bit 4 = Analog Input 1 Under 2 Bit 5 = Analog Input 2 Out of Range Bit 6 = Analog Input 2 Over 1 Bit 7 = Analog Input 2 Over 2 Bit 8 = Analog Input 2 Under 1 Bit 9 = Analog Input 2 Under 2 Bit 10 = Analog Input 3 Out of Range Bit 11 = Analog Input 3 Over 1 Bit 12 = Analog Input 3 Over 2 Bit 13 = Analog Input 3 Under 1 Bit 14 = Analog Input 3 Under 2 Bit 15 = Analog Input 4 Out of Range Bit 16 = Analog Input 4 Over 1 Bit 17 = Analog Input 4 Over 2 Bit 18 = Analog Input 4 Under 1 Bit 19 = Analog Input 4 Under 2 Bit 20 = Analog Input 5 Out of Range Bit 21 = Analog Input 5 Over 1 Bit 22 = Analog Input 5 Over 2 Bit 23 = Analog Input 5 Under 1 Bit 24 = Analog Input 5 Under 2 Bit 25 = Analog Input 6 Out of Range Bit 26 = Analog Input 6 Over 1 Bit 27 = Analog Input 6 Over 2 Bit 28 = Analog Input 6 Under 1 Bit 29 = Analog Input 6 Under 2
45546	AEM Input Threshold Alarm Bits Reg 2	Uint32	N/A	N/A	R	Bit 0 = Analog Input 7 Out of Range Bit 1 = Analog Input 7 Over 1 Bit 2 = Analog Input 7 Over 2 Bit 3 = Analog Input 7 Under 1 Bit 4 = Analog Input 7 Under 2 Bit 5 = Analog Input 8 Out of Range Bit 6 = Analog Input 8 Over 1 Bit 7 = Analog Input 8 Over 2 Bit 8 = Analog Input 8 Under 1 Bit 9 = Analog Input 8 Under 2 Bit 10 = RTD Input 1 Out of Range Bit 11 = RTD Input 1 Over 1 Bit 12 = RTD Input 1 Over 2 Bit 13 = RTD Input 1 Under 1 Bit 14 = RTD Input 1 Under 2 Bit 15 = RTD Input 2 Out of Range Bit 16 = RTD Input 2 Over 1 Bit 17 = RTD Input 2 Over 2 Bit 18 = RTD Input 2 Under 1 Bit 19 = RTD Input 2 Under 2 Bit 20 = RTD Input 3 Out of Range Bit 21 = RTD Input 3 Over 1 Bit 22 = RTD Input 3 Over 2 Bit 23 = RTD Input 3 Under 1 Bit 24 = RTD Input 3 Under 2 Bit 25 = RTD Input 4 Out of Range Bit 26 = RTD Input 4 Over 1 Bit 27 = RTD Input 4 Over 2 Bit 28 = RTD Input 4 Under 1 Bit 29 = RTD Input 4 Under 2

Register	Description	Type	Units	Scaling Factor	R/W	Range
45548	AEM Input Threshold Alarm Bits Reg 3	Uint32	N/A	N/A	R	Bit 0 = RTD Input 5 Out of Range Bit 1 = RTD Input 5 Over 1 Bit 2 = RTD Input 5 Over 2 Bit 3 = RTD Input 5 Under 1 Bit 4 = RTD Input 5 Under 2 Bit 5 = RTD Input 6 Out of Range Bit 6 = RTD Input 6 Over 1 Bit 7 = RTD Input 6 Over 2 Bit 8 = RTD Input 6 Under 1 Bit 9 = RTD Input 6 Under 2 Bit 10 = RTD Input 7 Out of Range Bit 11 = RTD Input 7 Over 1 Bit 12 = RTD Input 7 Over 2 Bit 13 = RTD Input 7 Under 1 Bit 14 = RTD Input 7 Under 2 Bit 15 = RTD Input 8 Out of Range Bit 16 = RTD Input 8 Over 1 Bit 17 = RTD Input 8 Over 2 Bit 18 = RTD Input 8 Under 1 Bit 19 = RTD Input 8 Under 2 Bit 20 = Thermocouple 1 Out of Range Bit 21 = Thermocouple 1 Over 1 Bit 22 = Thermocouple 1 Over 2 Bit 23 = Thermocouple 1 Under 1 Bit 24 = Thermocouple 1 Under 2 Bit 25 = Thermocouple 2 Out of Range Bit 26 = Thermocouple 2 Over 1 Bit 27 = Thermocouple 2 Over 2 Bit 28 = Thermocouple 2 Under 1 Bit 29 = Thermocouple 2 Under 2
45550	AEM Input Threshold Alarm Bits Reg 4	Uint32	N/A	N/A	R	Bit 0 = Analog Output 1 Out of Range Bit 1 = Analog Output 2 Out of Range Bit 2 = Analog Output 3 Out of Range Bit 3 = Analog Output 4 Out of Range
45552	AEM Input Threshold Pre-Alarm Bits Reg 1	Uint32	N/A	N/A	R	Bit 0 = Analog Input 1 Out of Range Bit 1 = Analog Input 1 Over 1 Bit 2 = Analog Input 1 Over 2 Bit 3 = Analog Input 1 Under 1 Bit 4 = Analog Input 1 Under 2 Bit 5 = Analog Input 2 Out of Range Bit 6 = Analog Input 2 Over 1 Bit 7 = Analog Input 2 Over 2 Bit 8 = Analog Input 2 Under 1 Bit 9 = Analog Input 2 Under 2 Bit 10 = Analog Input 3 Out of Range Bit 11 = Analog Input 3 Over 1 Bit 12 = Analog Input 3 Over 2 Bit 13 = Analog Input 3 Under 1 Bit 14 = Analog Input 3 Under 2 Bit 15 = Analog Input 4 Out of Range Bit 16 = Analog Input 4 Over 1 Bit 17 = Analog Input 4 Over 2 Bit 18 = Analog Input 4 Under 1 Bit 19 = Analog Input 4 Under 2 Bit 20 = Analog Input 5 Out of Range Bit 21 = Analog Input 5 Over 1 Bit 22 = Analog Input 5 Over 2 Bit 23 = Analog Input 5 Under 1 Bit 24 = Analog Input 5 Under 2 Bit 25 = Analog Input 6 Out of Range Bit 26 = Analog Input 6 Over 1 Bit 27 = Analog Input 6 Over 2 Bit 28 = Analog Input 6 Under 1 Bit 29 = Analog Input 6 Under 2

Register	Description	Type	Units	Scaling Factor	R/W	Range
45554	AEM Input Threshold Pre-Alarm Bits Reg 2	Uint32	N/A	N/A	R	Bit 0 = Analog Input 7 Out of Range Bit 1 = Analog Input 7 Over 1 Bit 2 = Analog Input 7 Over 2 Bit 3 = Analog Input 7 Under 1 Bit 4 = Analog Input 7 Under 2 Bit 5 = Analog Input 8 Out of Range Bit 6 = Analog Input 8 Over 1 Bit 7 = Analog Input 8 Over 2 Bit 8 = Analog Input 8 Under 1 Bit 9 = Analog Input 8 Under 2 Bit 10 = RTD Input 1 Out of Range Bit 11 = RTD Input 1 Over 1 Bit 12 = RTD Input 1 Over 2 Bit 13 = RTD Input 1 Under 1 Bit 14 = RTD Input 1 Under 2 Bit 15 = RTD Input 2 Out of Range Bit 16 = RTD Input 2 Over 1 Bit 17 = RTD Input 2 Over 2 Bit 18 = RTD Input 2 Under 1 Bit 19 = RTD Input 2 Under 2 Bit 20 = RTD Input 3 Out of Range Bit 21 = RTD Input 3 Over 1 Bit 22 = RTD Input 3 Over 2 Bit 23 = RTD Input 3 Under 1 Bit 24 = RTD Input 3 Under 2 Bit 25 = RTD Input 4 Out of Range Bit 26 = RTD Input 4 Over 1 Bit 27 = RTD Input 4 Over 2 Bit 28 = RTD Input 4 Under 1 Bit 29 = RTD Input 4 Under 2
45556	AEM Input Threshold Pre-Alarm Bits Reg 3	Uint32	N/A	N/A	R	Bit 0 = RTD Input 5 Out of Range Bit 1 = RTD Input 5 Over 1 Bit 2 = RTD Input 5 Over 2 Bit 3 = RTD Input 5 Under 1 Bit 4 = RTD Input 5 Under 2 Bit 5 = RTD Input 6 Out of Range Bit 6 = RTD Input 6 Over 1 Bit 7 = RTD Input 6 Over 2 Bit 8 = RTD Input 6 Under 1 Bit 9 = RTD Input 6 Under 2 Bit 10 = RTD Input 7 Out of Range Bit 11 = RTD Input 7 Over 1 Bit 12 = RTD Input 7 Over 2 Bit 13 = RTD Input 7 Under 1 Bit 14 = RTD Input 7 Under 2 Bit 15 = RTD Input 8 Out of Range Bit 16 = RTD Input 8 Over 1 Bit 17 = RTD Input 8 Over 2 Bit 18 = RTD Input 8 Under 1 Bit 19 = RTD Input 8 Under 2 Bit 20 = Thermocouple 1 Out of Range Bit 21 = Thermocouple 1 Over 1 Bit 22 = Thermocouple 1 Over 2 Bit 23 = Thermocouple 1 Under 1 Bit 24 = Thermocouple 1 Under 2 Bit 25 = Thermocouple 2 Out of Range Bit 26 = Thermocouple 2 Over 1 Bit 27 = Thermocouple 2 Over 2 Bit 28 = Thermocouple 2 Under 1 Bit 29 = Thermocouple 2 Under 2
45558	AEM Input Threshold Pre-Alarm Bits Reg 4	Uint32	N/A	N/A	R	Bit 0 = Analog Output 1 Out of Range Bit 1 = Analog Output 2 Out of Range Bit 2 = Analog Output 3 Out of Range Bit 3 = Analog Output 4 Out of Range
45560	Analog Output 1 Metering Value	Int32	CentiUnit	Centi	R	(-999990) - 999990

Register	Description	Type	Units	Scaling Factor	R/W	Range
45562	Analog Output 2 Metering Value	Int32	CentiUnit	Centi	R	(-999990) - 999990
45564	Analog Output 3 Metering Value	Int32	CentiUnit	Centi	R	(-999990) - 999990
45566	Analog Output 4 Metering Value	Int32	CentiUnit	Centi	R	(-999990) - 999990
45568	Configurable Protection Threshold Status Bits	UInt32	N/A	N/A	R	Bit 0 = Conf Protection 1 Over 1 Bit 1 = Conf Protection 1 Over 2 Bit 2 = Conf Protection 1 Under 1 Bit 3 = Conf Protection 1 Under 2 Bit 4 = Conf Protection 2 Over 1 Bit 5 = Conf Protection 2 Over 2 Bit 6 = Conf Protection 2 Under 1 Bit 7 = Conf Protection 2 Under 2 Bit 8 = Conf Protection 3 Over 1 Bit 9 = Conf Protection 3 Over 2 Bit 10 = Conf Protection 3 Under 1 Bit 11 = Conf Protection 3 Under 2 Bit 12 = Conf Protection 4 Over 1 Bit 13 = Conf Protection 4 Over 2 Bit 14 = Conf Protection 4 Under 1 Bit 15 = Conf Protection 4 Under 2 Bit 16 = Conf Protection 5 Over 1 Bit 17 = Conf Protection 5 Over 2 Bit 18 = Conf Protection 5 Under 1 Bit 19 = Conf Protection 5 Under 2 Bit 20 = Conf Protection 6 Over 1 Bit 21 = Conf Protection 6 Over 2 Bit 22 = Conf Protection 6 Under 1 Bit 23 = Conf Protection 6 Under 2 Bit 24 = Conf Protection 7 Over 1 Bit 25 = Conf Protection 7 Over 2 Bit 26 = Conf Protection 7 Under 1 Bit 27 = Conf Protection 7 Under 2 Bit 28 = Conf Protection 8 Over 1 Bit 29 = Conf Protection 8 Over 2 Bit 30 = Conf Protection 8 Under 1 Bit 31 = Conf Protection 8 Under 2

Register	Description	Type	Units	Scaling Factor	R/W	Range
45570	Configurable Protection Alarm Bits	Uint32	N/A	N/A	R	Bit 0 = Conf Protection 1 Over 1 Bit 1 = Conf Protection 1 Over 2 Bit 2 = Conf Protection 1 Under 1 Bit 3 = Conf Protection 1 Under 2 Bit 4 = Conf Protection 2 Over 1 Bit 5 = Conf Protection 2 Over 2 Bit 6 = Conf Protection 2 Under 1 Bit 7 = Conf Protection 2 Under 2 Bit 8 = Conf Protection 3 Over 1 Bit 9 = Conf Protection 3 Over 2 Bit 10 = Conf Protection 3 Under 1 Bit 11 = Conf Protection 3 Under 2 Bit 12 = Conf Protection 4 Over 1 Bit 13 = Conf Protection 4 Over 2 Bit 14 = Conf Protection 4 Under 1 Bit 15 = Conf Protection 4 Under 2 Bit 16 = Conf Protection 5 Over 1 Bit 17 = Conf Protection 5 Over 2 Bit 18 = Conf Protection 5 Under 1 Bit 19 = Conf Protection 5 Under 2 Bit 20 = Conf Protection 6 Over 1 Bit 21 = Conf Protection 6 Over 2 Bit 22 = Conf Protection 6 Under 1 Bit 23 = Conf Protection 6 Under 2 Bit 24 = Conf Protection 7 Over 1 Bit 25 = Conf Protection 7 Over 2 Bit 26 = Conf Protection 7 Under 1 Bit 27 = Conf Protection 7 Under 2 Bit 28 = Conf Protection 8 Over 1 Bit 29 = Conf Protection 8 Over 2 Bit 30 = Conf Protection 8 Under 1 Bit 31 = Conf Protection 8 Under 2
45572	Configurable Protection Pre-Alarm Bits	Uint32	N/A	N/A	R	Bit 0 = Conf Protection 1 Over 1 Bit 1 = Conf Protection 1 Over 2 Bit 2 = Conf Protection 1 Under 1 Bit 3 = Conf Protection 1 Under 2 Bit 4 = Conf Protection 2 Over 1 Bit 5 = Conf Protection 2 Over 2 Bit 6 = Conf Protection 2 Under 1 Bit 7 = Conf Protection 2 Under 2 Bit 8 = Conf Protection 3 Over 1 Bit 9 = Conf Protection 3 Over 2 Bit 10 = Conf Protection 3 Under 1 Bit 11 = Conf Protection 3 Under 2 Bit 12 = Conf Protection 4 Over 1 Bit 13 = Conf Protection 4 Over 2 Bit 14 = Conf Protection 4 Under 1 Bit 15 = Conf Protection 4 Under 2 Bit 16 = Conf Protection 5 Over 1 Bit 17 = Conf Protection 5 Over 2 Bit 18 = Conf Protection 5 Under 1 Bit 19 = Conf Protection 5 Under 2 Bit 20 = Conf Protection 6 Over 1 Bit 21 = Conf Protection 6 Over 2 Bit 22 = Conf Protection 6 Under 1 Bit 23 = Conf Protection 6 Under 2 Bit 24 = Conf Protection 7 Over 1 Bit 25 = Conf Protection 7 Over 2 Bit 26 = Conf Protection 7 Under 1 Bit 27 = Conf Protection 7 Under 2 Bit 28 = Conf Protection 8 Over 1 Bit 29 = Conf Protection 8 Over 2 Bit 30 = Conf Protection 8 Under 1 Bit 31 = Conf Protection 8 Under 2
45574	Gen Kvar A	Int32	KiloVAr	N/A	R	(-2147483648) - 2147483647

Register	Description	Type	Units	Scaling Factor	R/W	Range
45576	Gen Kvar B	Int32	KiloVAr	N/A	R	(-2147483648) - 2147483647
45578	Gen Kvar C	Int32	KiloVAr	N/A	R	(-2147483648) - 2147483647
45580	Gen Kvar Total	Int32	KiloVAr	N/A	R	(-2147483648) - 2147483647
45582-749	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	UInt32	N/A	N/A	RW	0 = Stop 1 = Start
45756	Test Buttons Image	UInt32	N/A	N/A	RW	0 - 255
45758	Reserved					
45760	Reserved					
45762	Embedded Code Version Number	UInt32	N/A	N/A	R	
45764	Boot Code Version Number	UInt32	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	
45770-999	FUTURE USE					
46000	J1939-Transmission Oil Pressure	UInt32	Raw ECU Parameter Data 16 kPa/bit gain, 0 kPa offset		R	0 to +4000 kPa (0 to 580 psi)
46002	J1939-Transmission Oil Temp	UInt32	Raw ECU Parameter Data 0.03125 °C/bit gain, -273 °C offset		R	-273 to +1735.0 °C (-459.4 to 3155.0 °F)
46004	J1939-Winding 1 Temp	UInt32	Raw ECU Parameter Data 1 °C/bit gain, -40 °C offset		R	-40 to +210 °C (-40 to 410 °F)
46006	J1939-Winding 2 Temp	UInt32	Raw ECU Parameter Data 1 °C/bit gain, -40 °C offset		R	-40 to +210 °C (-40 to 410 °F)
46008	J1939-Winding 3 Temp	UInt32	Raw ECU Parameter Data 1 °C/bit gain, -40 °C offset		R	-40 to +210 °C (-40 to 410 °F)
46010	J1939-ECU Temp	UInt32	Raw ECU Parameter Data 0.03125 °C/bit gain, -273 °C offset		R	-273 to +273 °C (-459 to 523 °F)
46012	J1939-Aux Pressure 1	UInt32	Raw ECU Parameter Data 16 kPa/bit gain, 0 kPa offset		R	0 to 4000 kPa
46014	J1939-Aux Pressure 2	UInt32	Raw ECU Parameter Data 16 kPa/bit gain, 0 kPa offset		R	0 to 4000 kPa
46016	J1939-Rated Power	UInt32	Raw ECU Parameter Data 0 to 32 127.5 kW (0 to 43 083.7 hp)		R	0.5 kW/bit, 0 kW offset (0.67 hp/bit, 0 hp offset)

Register	Description	Type	Units	Scaling Factor	R/W	Range
46018	J1939-Rated RPM	Uint32	Raw ECU Parameter Data 0 to 8031.875 rpm		R	0.125 rpm/bit, 0 offset
46020	J1939-Exhaust Temp A	Uint32	Raw ECU Parameter Data 0.03125 °C/bit gain, -273 °C offset		R	-273 to +1735.0 °C (-459.4 to 3155.0 °F)
46022	J1939-Exhaust Temp B	Uint32	Raw ECU Parameter Data 0.03125 °C/bit gain, -273 °C offset		R	-273 to +1735.0 °C (-459.4 to 3155.0 °F)
46024	J1939-Charge Air Temp	Uint32	Raw ECU Parameter Data 0.03125 °C/bit gain, -273 °C offset		R	0.03125 °C/bit gain, -273 °C offset -273 to +1735.0 °C (-459.4 to 3155.0 °F)
46026	J1939-ADEC ECU Error Code	Uint32	Raw ECU Parameter Data 0 to 64255		R	No Scale Or Offset
46028	J1939-ADEC Selected Speed Demand	Uint32	Raw ECU Parameter Data 0 to 8031.875 rpm		R	0.125 rpm/bit, gain 0 offset
46030	J1939-ADEC Effective Set Speed	Uint32	Raw ECU Parameter Data 0 to 8031.875 rpm		R	0.125 rpm/bit, gain 0 offset
46032	J1939-ADEC CANbus Speed Demand	Uint32	Raw ECU Parameter Data 0 to 8031.875 rpm		R	0.125 rpm/bit, gain 0 offset
46034	J1939-ADEC Analog Speed Demand	Uint32	Raw ECU Parameter Data 0 to 8031.875 rpm		R	0.125 rpm/bit, gain 0 offset
46036	J1939-ADEC Speed Demand Source	Uint32	Raw ECU Parameter Data 0 to 4294967295		R	No Scale or Offset
46038	J1939-ADEC Specified Torque	Uint32	Raw ECU Parameter Data 0 to 64255 Nm		R	1 Nm per bit
46040	J1939-ADEC Engine Optimized	Uint32	Raw ECU Parameter Data 0 to 64255		R	No Scale or Offset
46042	J1939-ADEC Current P Degree	Uint32	Raw ECU Parameter Data 0 to 160.6375%		R	.0025 % per bit, 0 Offset
46044	J1939-ADEC Day Tank Fill Percent	Uint32	Raw ECU Parameter Data 0 to 100%		R	0.4 % per bit, 0 offset
46046	J1939-ADEC Storage Tank Fill Percent	Uint32	Raw ECU Parameter Data 0 to 100%		R	0.4 % per bit, 0 offset
46048	J1939-ADEC Injection Quantity	Uint32	Raw ECU Parameter Data mm ³		R	0.1 mm ³ per bit, 0 offset
46050	J1939-ADEC Engine Power Reserve	Uint32	Raw ECU Parameter Data		R	.001% per bit, 0 offset

Register	Description	Type	Units	Scaling Factor	R/W	Range
46052	J1939-ADEC Cylinder Cutout Code	Uint32	Raw ECU Parameter Data		R	No Scale or Offset
46054	J1939-ADEC Start Sequence Bit Field	Uint32	Raw ECU Parameter Data		R	No Scale or Offset
46056	J1939-ADEC P Lube Oil Limit LO	Uint32	Raw ECU Parameter Data		R	0.01 mbar per bit, 0 offset
46058	J1939-ADEC P Lube Oil Limit LO LO	Uint32	Raw ECU Parameter Data		R	0.01 mbar per bit, 0 offset
46060	J1939-ADEC P Charge Air Pressure	Uint32	Raw ECU Parameter Data		R	0.01 mbar per bit, 0 offset
46062	J1939-ADEC AL Power Amp 1 Fail Bit Fld	Uint32	Raw ECU Parameter Data		R	No Scale or Offset
46064	J1939-ADEC AL Power Amp 1 Fail Bit Fld	Uint32	Raw ECU Parameter Data		R	No Scale or Offset
46066	J1939-ADEC AL Transistor Out Bit FI	Uint32	Raw ECU Parameter Data		R	No Scale or Offset
46068	J1939-ADEC Camshaft RPM	Uint32	Raw ECU Parameter Data		R	0.1 rpm per bit, 0 offset
46070	J1939-ADEC Daily Fuel Consumption	Uint32	Raw ECU Parameter Data		R	.0001 m³ per bit, 0 offset
46072	J1939-ADEC Frequency Speed Demand.	Uint32	Raw ECU Parameter Data		R	.0001 m³ per bit, 0 offset
46074	J1939-ADEC Average Trip Fuel Consumption	Uint32	Raw ECU Parameter Data		R	.001 l/h per bit, 0 offset
46076	J1939-ADEC Injection Quantity DBR Pct	Uint32	Raw ECU Parameter Data		R	.01 % per bit, 0 offset
46078	J1939-ADEC Actual Droop	Uint32	Raw ECU Parameter Data		R	.0001 % per bit, 0 offset
46080	J1939-ADEC Nodes On CANbus	Uint32	Raw ECU Parameter Data		R	No Scale or Offset
46082	J1939-ADEC Lost Nodes on CANbus	Uint32	Raw ECU Parameter Data		R	No Scale or Offset
46084	J1939-ADEC Trip Operating Time	Uint32	Raw ECU Parameter Data		R	1 hour per bit, 0 offset
46086	J1939-ADEC Transistor Out Bit Field	Uint32	Raw ECU Parameter Data		R	No Scale or Offset
46088	J1939-ADEC L1L ECU Power Supply Volts	Uint32	Raw ECU Parameter Data		R	.001 V per bit, 0 offset
46090	J1939-ADEC L2L ECU Power Supply Volts	Uint32	Raw ECU Parameter Data		R	001 V per bit, 0 offset
46092	J939-ADEC U1LECU Power Supply Volts	Uint32	Raw ECU Parameter Data		R	001 V per bit, 0 offset
46094	J1939-ADEC U2L ECU Power Supply Volts	Uint32	Raw ECU Parameter Data		R	001 V per bit, 0 offset
46096	J1939-ADEC Trip Idle Time	Uint32	Raw ECU Parameter Data		R	1 second per bit, 0 offset
46098	J1939-ADEC T Coolant Limit Hi	Uint32	Raw ECU Parameter Data		R	.01 Degree C per bit, 0 offset
46100	J1939-ADEC T Coolant Limit Hi Hi	Uint32	Raw ECU Parameter Data		R	01 Degree C per bit, 0 offset
46102	J1939-ADEC T Charge Air Limit Hi	Uint32	Raw ECU Parameter Data		R	01 Degree C per bit, 0 offset

Register	Description	Type	Units	Scaling Factor	R/W	Range
46104	J1939-ADEC T Intercooler Limit Hi	Uint32	Raw ECU Parameter Data		R	01 Degree C per bit, 0 offset
46106	J1939-MTU Sps Node	Uint32	Raw ECU Parameter Data		R	No Scale Or Offset
46108	J1939-MTU Sw Type	Uint32	Raw ECU Parameter Data		R	No Scale Or Offset
46110	J1939-MTU Sw Var	Uint32	Raw ECU Parameter Data		R	No Scale Or Offset
46112	J1939-MTU Sw Ed 1	Uint32	Raw ECU Parameter Data		R	No Scale Or Offset
46114	J1939-MTU Sw Ed2	Uint32	Raw ECU Parameter Data		R	No Scale Or Offset
46116	J1939-MTU Rev	Uint32	Raw ECU Parameter Data 0 to 127		R	No Scale Or Offset
46118	J1939-MTU Sw Mod	Uint32	Raw ECU Parameter Data 0 to 127		R	No Scale Or Offset

APPENDIX C • TUNING PID SETTINGS

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APPENDIX C • TUNING PID SETTINGS

INTRODUCTION

The LSM-2020 (Load Share Module) and DGC-2020 utilize three controllers to accomplish synchronization, load sharing, and speed trim functions. The controllers are a speed controller, a voltage controller, and a kW load controller. The voltage and speed controller are in effect when the DGC-2020 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, the load share controller controls the kW output of the machine to share equally on a percentage basis with the other generators on the bus. All generators participating in load sharing are connected together with load share lines which are used to communicate analog load share information between the machines.

When the generator is paralleled to the 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 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 load control could cause the system frequency to drift, and speed trim can be employed to counteract the drift. The drift can occur due to inaccuracies in measured KW vs. desired KW, since KW measurement accuracy is around 3%.

The load share module utilizes PID (Proportional, Integral, Derivative) Control to accomplish 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 setpoint and eliminates the residual steady-state error that occurs with a proportional only controller. Larger K_i implies steady state errors are eliminated quicker. The trade-off 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 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.

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

Voltage Controller Tuning Procedure

The voltage controller is tuned prior to the speed controller. Set all gains in voltage controller, speed controller, and KW load controller to 0. Start the generator and close the breaker onto some load.

The voltage controller is only active during synchronization when the DGC-2020 is trying to close the generator breaker. In order to tune it, a variable AC voltage source must be connected across the bus input of the DGC-2020. The generator must be started, then a breaker close sequence initiated by applying a breaker close pulse to a discrete contact input to cause the synchronizer to become active. In addition the *Breaker Close Wait Time* parameter and the *Sync Fail Activation Delay* should be set to a large value such as 120 seconds or more. This will allow the voltage controller to run for a long enough time to get meaningful response information.

If the synchronizer times out during the tuning process resulting in a synchronizer fail pre-alarm or a breaker close failure occurs while tuning, press the *Reset* button on the front of the DGC-2020 to clear the associated pre-alarm, then issue a breaker open pulse to a discrete contact input. The synchronizer is now reset, so a pulse can be applied to the breaker close discrete contact input to restart the synchronizer. Tuning can resume at this point.

KP - Proportional Gain

Set an initial value of 1 for KP.

Each time KP is set, disturb the system by changing the voltage on the bus input of the DGC-2020 so that the DGC-2020 will try to follow it. Verify that the generator's output approaches the new value in a stable manner. Since KI is zero at this point, there may be some small difference between the generator's output and the bus it is trying to follow. The important thing is that the generator's output behaves in a stable manner. If it is not stable, lower the value of KP and repeat.

Repeat this procedure, raising KP until the system is unstable, and then lower it to half the value where instability is first attained.

If it is not possible to obtain stable voltage operation, it may be necessary to reduce the control gains in the voltage regulator that has its analog bias input driven by the LSM-2020.

KI - Integral Gain

Set the initial value of KI to be a tenth of the value set for KP.

After setting a value for KI, disturb the system by changing the voltage on the bus input of the DGC-2020 so that the DGC-2020 will try to follow it. Verify that the DGC-2020 controls the voltage to go to the new value in a stable manner. If it is not stable, lower the value of KI and repeat.

Repeat this procedure, raising KI until the system is unstable, and then lower it to half the value where instability is first attained.

KD - Derivative Gain

If the performance with KP and KI alone is satisfactory, you may stop here. Otherwise, KD, the derivative controller gain, can be used in conjunction with TD, the noise filter constant, to reduce overshoot obtained with the PI control. Setting KD and TD is an iterative process. Start with small values of KD such as 0.1 or half the KI value, whichever is less.

TD is the constant of the low pass filter which filters the controller input if high frequency interference presents a problem when derivative control is employed. TD ranges from 0 to 1. TD=0 is no filtering. TD=1 is heaviest filtering.

Tuning of KD can be achieved through the following steps. First set TD=0 to eliminate filtering. Raise speed KD and check for stability. Each time KD is raised, disturb the system by changing the voltage on the bus input of the DGC-2020 so that the DGC-2020 will try to follow it. Verify that the DGC-2020 controls the voltage to go to the new value in a stable manner. Raise KD 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, set TD to 0.001 and see if the noise induced behavior is reduced. Raise TD until desired reduction of noise behavior is achieved. Once KD has been set, tune KD again. TD ranges from 0 to 1 with an increment of 0.001. TD=0 is no filtering, TD=1 is heaviest filtering. If noise again appears to be a problem, adjust TD until desired behavior is achieved, and then retune KD.

Var/PF Controller Tuning Procedure

Once desired voltage controller performance is obtained, the Var/PF controller can be tuned. Set all gains in the Var/PF controller to 0, 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.

KP - Proportional Gain

Set an initial value of $KP = 1$ in the Var/PF Controller. Set the control mode to Var control.

Set KP 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, cut Kp in half and try again. Assuming operation appears stable, change the Var setpoint in 10% steps and check for stable operation. Since KI is zero at this point, there may be some small error. The important thing is that stable var control is achieved.

Raise KP and repeat the test until unstable operation occurs. Then lower KP to half the value where unstable operation was first 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 that has its bias input driven by the LSM-2020.

KI - Integral Gain

Set the initial value of KI to be a tenth of the value set for KP.

Each time KI 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 KI and repeat the test.

Repeat this procedure, raising KI until the system is unstable, and then lower it to half the value where instability is first attained.

KD - Derivative Gain

If the performance with KP and KI alone is satisfactory, you may stop here. Otherwise, KD, the derivative controller gain, can be used in conjunction with TD, the noise filter constant, to reduce overshoot obtained with the PI control. Setting KD and TD is an iterative process. Start with small values of KD such as 0.1 or half the KI value, whichever is less.

TD is the constant of the low pass filter, which filters the controller input if high frequency interference presents a problem when derivative control is employed. TD ranges from 0 to 1. TD=0 is no filtering, TD=1 is heaviest filtering.

Tuning of KD can be achieved through the following steps. Raise KD, 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 KD 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, raise TD and tune KD again. TD ranges from 0 to 1. TD=0 is no filtering, TD=1 is heaviest filtering.

If high frequency noise seems to be entering the system, set TD to 0.001 and see if the noise induced behavior is reduced. Raise TD until desired reduction of noise behavior is achieved. Once TD has been set, tune KD again. TD ranges from 0 to 1 with an increment of 0.001. TD=0 is no filtering, TD=1 is heaviest filtering. If noise again appears to be a problem, adjust TD until desired behavior is achieved, then retune KD.

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 gains in both speed controller and kW load controller to 0. Start the generator and close the breaker onto some load.

KP - Proportional Gain

Set an initial value of 1 for KP.

Each time KP is set, manually displace the governor lever if possible and see that control is regained in a stable manner. If the governor cannot be perturbed in this manner, execute step responses by changing the speed trim set point and check that the generator's output approaches the new value in a stable manner. Since KI is zero at this point, there may be some small 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 KP and repeat.

Repeat this procedure, raising KP until the system is unstable, and then lower it to half the value where instability is first attained.

If it is not possible to obtain stable speed operation, it may be necessary to reduce the control gains in the governor that has its analog bias input driven by the LSM-2020.

KI - Integral Gain

Set the initial value of KI to be a tenth of the value set for KP.

Each time KI is set, manually displace the governor lever or change the speed trim set point and verify that control is regained in a stable manner. If the system is not stable, lower KI and repeat.

Repeat this procedure, raising KI until the system is unstable, and then lower it to half the value where instability is first attained.

KD - Derivative Gain

If the performance with KP and KI alone is satisfactory, you may stop here. Otherwise, KD, the derivative controller gain, can be used in conjunction with TD, the noise filter constant, to reduce overshoot obtained with the PI control. Setting KD and TD is an iterative process. Start with small values of KD such as 0.1 or half the KI value, whichever is less.

TD is the constant of the low pass filter which filters the controller input if high frequency interference presents a problem when derivative control is employed. TD ranges from 0 to 1. TD=0 is no filtering. TD=1 is heaviest filtering.

Tuning of KD can be achieved through the following steps. First set TD=0 to eliminate filtering. Raise speed KD and check for stability. Each time KD is raised, manually displace the governor lever or change the speed trim set point and see that control is regained in a stable manner. Raise KD 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, set TD to 0.001 and see if the noise induced behavior is reduced. Raise TD until desired reduction of noise behavior is achieved. Once TD has been set, tune KD again. TD ranges from 0 to 1 with an increment of 0.001. TD=0 is no filtering, TD=1 is heaviest filtering. If noise again appears to be a problem, adjust TD until desired behavior is achieved, and then retune KD.

kW Load Controller Tuning Procedure

Once desired voltage and speed controller performance is obtained, the kW load controller can be tuned. Set all gains in kW load controller to 0.

KP - Proportional Gain

Set an initial value of 1 for KP.

Close the breaker onto a load. Parallel a second generator with the unit being tuned and check for stable load sharing. Then open the generator breaker on the second generator and check that the unit being tuned is still stable. Since KI is zero at this point, there may be some small error in the load sharing. The important thing is that stable load sharing is achieved.

Raise KP and repeat the test until unstable operation occurs. Lower KP to half the value where unstable operation was first attained.

If it is not possible to obtain stable kW operation, it may be necessary to reduce the control gains in the governor that has its analog bias input driven by the LSM-2020.

KI - Integral Gain

Set the initial value of KI to be a tenth of the value set for KP.

Each time KI is set, parallel a second generator with the unit being tuned, and check for stable load sharing then open the generator breaker on the second generator and check that the unit being tuned is still stable. If the system is not stable, lower KI and repeat the test.

Repeat this procedure, raising KI until the system is unstable, and then lower it to half the value where instability is first attained.

KD - Derivative Gain

If the performance with KP and KI alone is satisfactory, you may stop here. Otherwise, KD, the derivative controller gain, can be used in conjunction with TD, the noise filter constant, to reduce overshoot obtained with the PI control. Setting KD and TD is an iterative process. Start with small values of KD such as 0.1 or half the KI value, whichever is less.

TD is the constant of the low pass filter which filters the controller input if high frequency interference presents a problem when derivative control is employed. TD ranges from 0 to 1. TD=0 is no filtering, TD=1 is heaviest filtering.

Tuning of KD can be achieved through the following steps. Raise load control KD and check for stability. Each time KD is raised, parallel another generator with the unit being tuned, and check for stable load sharing. Then drop the second generator and check that the unit being tuned is still stable. Raise KD 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, raise TD and tune KD again. TD ranges from 0 to 1. TD=0 is no filtering, TD=1 is heaviest filtering.

If high frequency noise seems to be entering the system, set TD to 0.001 and see if the noise induced behavior is reduced. Raise TD until desired reduction of noise behavior is achieved. Once TD has been set, tune KD again. TD ranges from 0 to 1 with an increment of 0.001. TD=0 is no filtering, TD=1 is heaviest filtering. If noise again appears to be a problem, adjust TD until desired behavior is achieved, then retune KD.

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 you need to use.
- 2) Once the criteria of step 1 have been established, tune a unit so that you can parallel 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. You shouldn't need to change them unless you get trips or need to change load sharing characteristics.
- 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 you need to modify settings for a particular machine type, 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 you will ever get one set of numbers that will work for all machines, but it is probable that you may end up with 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.

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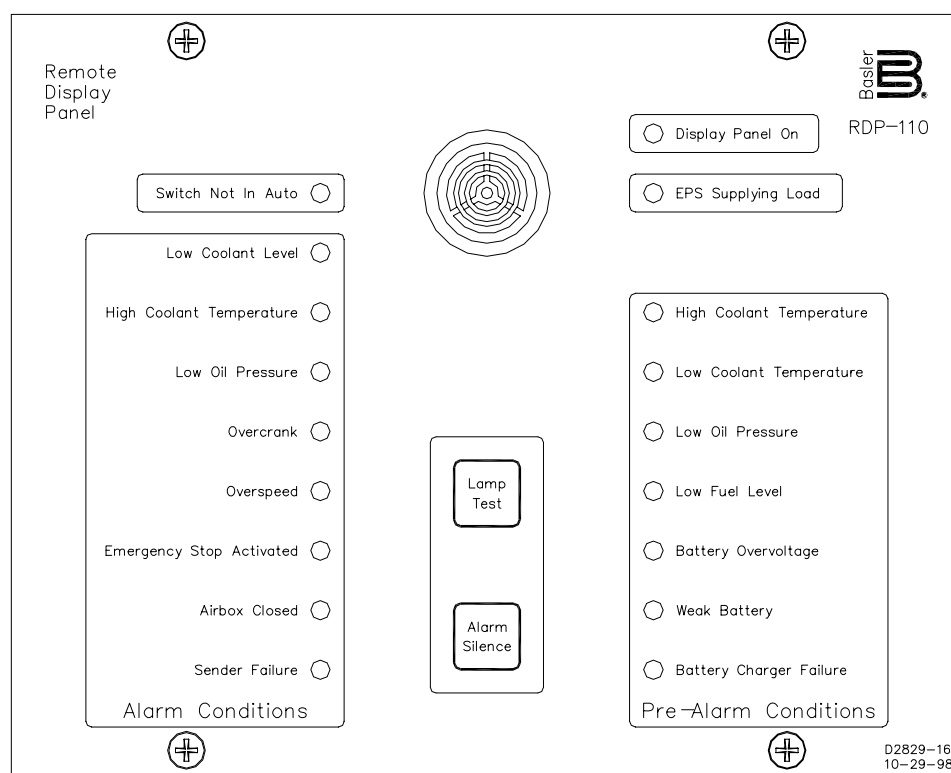
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INSTRUCTION MANUAL

FOR

REMOTE DISPLAY PANEL

RDP-110



B Basler Electric

Publication: 9318100990
Revision: E 06/07

INTRODUCTION

This instruction manual provides information about the operation and installation of the RDP-110 Remote Display Panel. To accomplish this, the following information is provided:

- General Information and Specifications
- Human-Machine Interface
- Functional Description
- Installation
- Testing

WARNING!

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

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Printed in USA

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June 2007

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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.

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REVISION HISTORY

The following information provides a historical summary of the changes made to this instruction manual (9318100990). Revisions are listed in reverse chronological order.

Manual Revision and Date	Change
E, 06/07	• Updated style chart to include DGC-2020 compatibility. • Added manual part number and revision to footers. • Updated manual to current style used.
D, 04/02	• Added UL and CSA documentation to Section 1. • Updated Figure 2-3 to reflect UL and CSA logos.
C, 01/00	• Added DGC front panel drawing and description to Section 2. • Updated Figure 4-2 to reflect DGC-1000 connections.
B, 07/99	• Added style chart and related information to Section 1. • Corrected controls and indicators on page 2-1 to reflect the changes to the style chart for RDP-110 X2 and RDP-110 X1. • Clarified the display functions for the airbox closed alarm on page 1-1. • Replaced airbox closed alarm on page 5-2 with factor selectable LED.
A, 10/98	• Deleted surface mount and flush mount part numbers from Section 1. • Replaced part numbers for surface and flush mount with “RDP-110-S and RDP-110-P.” • Added “maximum length 4,000 feet” to Figure 4-2. • Added new Section 6, <i>Manual Change Information</i>.
—, 06/98	• Initial release

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SECTION 1 • GENERAL INFORMATION

DESCRIPTION

RDP-110 Remote Display Panels use microprocessor-based technology to provide remote annunciation of engine-generator status. The RDP-110 is designed to be used in conjunction with the Basler DGC-2020, 500, 1000, and 2000 to provide installations with NFPA 110 Level 1 and Level 2 compliance. Microprocessor-based technology allows the use of serial communications for quick and simple connection to the DGC-2020, 500, 1000, and 2000. RS-485 compatible signals insure noise immunity over long distances. This combination of features in the RDP-110 yields significant savings in installation and setup costs.

FEATURES

RDP-110 Remote Display Panels have the following features:

- Packaged in metal cases for improved electromagnetic compatibility
- Designed for use in harsh environments
- Resistant to high moisture, salt fog, humidity, dust, dirt, and chemical contaminants
- Resistant to the entrance of insects and rodents
- Suitable for semi-flush mounting or surface (projection) mounting
- Suitable for controlling isolated generating systems or paralleled generating systems
- Serial communications with the DGC-2020, 500, 1000, and 2000 for easy installation

STYLE CHART

Operational features of the RDP-110 Remote Display Panel are defined by a combination of letters and numbers that constitute the device's style number shown in Figure 1-1. The style number of each unit is displayed in the upper right hand corner on the right side of the case.

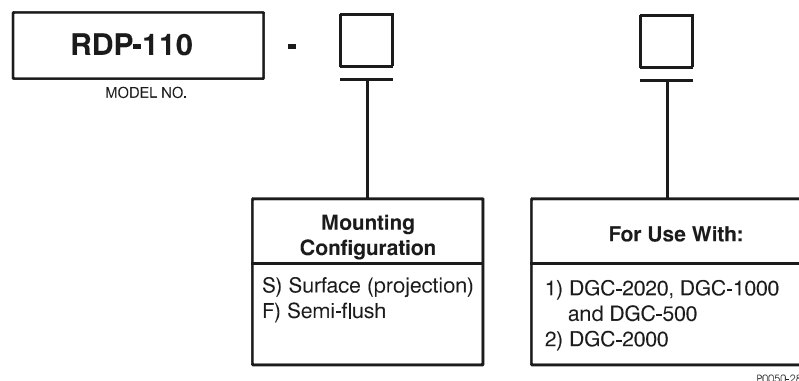


Figure 1-1. Style Chart

Style Number Example

The style number identification chart defines the electrical characteristics and operation features included in the RDP-110 Remote Display Panel. For example, if the style number were RDP-110 S1, the device would have the following

RDP-110

(S) Surface (Projection) Mounting

(1) For use with DGC-2020, DGC-1000, and DGC-500

FUNCTIONS

RDP-110 remote display panel displays the following functions:

- Switch Not in Auto Alarm
- Low Coolant Level Alarm
- High Coolant Temperature Alarm
- Low Oil Pressure Alarm
- Overcrank Alarm
- Overspeed Alarm
- Emergency Stop Alarm
- Airbox Closed Alarm for RDP-110 X2 or fuel leak/Sender failure for RDP-110 X1.
- Sender Failure Alarm
- Display Panel On LED
- Emergency System Supplying Load LED
- High Coolant Temperature Pre-alarm
- Low Coolant Temperature Pre-alarm
- Low Oil Pressure Pre-alarm
- Low Fuel Level Pre-alarm
- Battery Overvoltage Pre-alarm
- Weak Battery Pre-alarm
- Battery Charger Failure Pre-alarm

SPECIFICATIONS

RDP-110 Remote Display Panels have the following specifications.

Electrical

Power Input

DC Range	8 to 32 Vdc, 2 watts maximum
AC Range	84 to 144 Vac, 5 VA maximum

Hardware

Communication Port

Interface	
RS-485	Used to communicate with DGC-2020, 500, 1000, and 2000

Isolation

1800 Vdc for one minute between chassis ground and ac voltage input. 700 Vdc for one minute between any of the following groups

- Chassis ground
- Battery and 485 terminals
- AC voltage inputs

Radio Frequency Interference (RFI)

Type tested using a 5 watt, hand-held transceiver operating at random frequencies centered around 144 and 440 megahertz with the antenna located within 6 inches (15 centimeters) of the device in both vertical and horizontal planes

Environment

Operating Temperature Range	-40°C to 70°C (-40°F to 158°F)
Storage Temperature Range	-40°C to 85°C (-40°F to 185°F)

Salt Fog

Qualified to ASTM-117B-1989 with the device unpowered for the 100 hour test duration

Vibration

The device withstands 2 g in each of three mutually perpendicular planes, swept over the range of 10 to 500 hertz for a total of six sweeps, 15 minutes each sweep, without structural damage or degradation of performance

Shock

15 G

UL Recognition

UL recognized per Standard 508, UL File Number E97035.

CSA Certification

CSA certified per Standard CAN/CSA-C22.2 Number 14-95, CSA File Number LR23-23131.

Weight

3 kilograms (6.6 pounds)

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SECTION 2 • HUMAN-MACHINE INTERFACE

GENERAL

This section provides a description of the RDP-110 Remote Display Panel human machine interface (HMI).

CONTROLS AND INDICATORS

Figure 2-1 shows the front panel HMI for an RDP-110 X1 (DGC-2020, 500, and 1000), Figure 2-2 shows the front panel HMI for an RDP-110 X2 (DGC-2000). Descriptions in Table 2-1 refer to call outs in Figure 2-1 and 2-2.

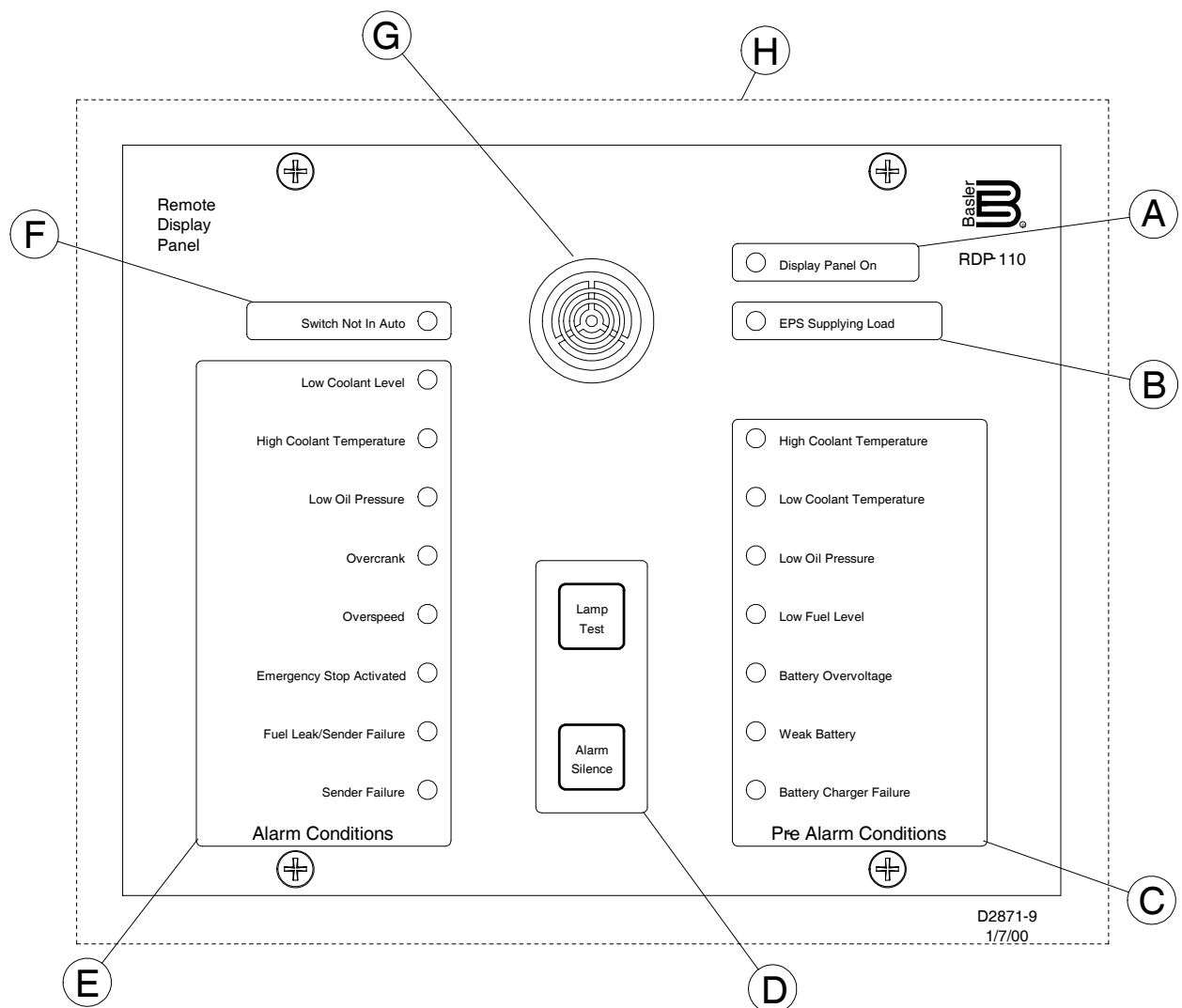


Figure 2-1. RDP-110 Front Panel (DGC-2020, 500, and 1000 Versions)

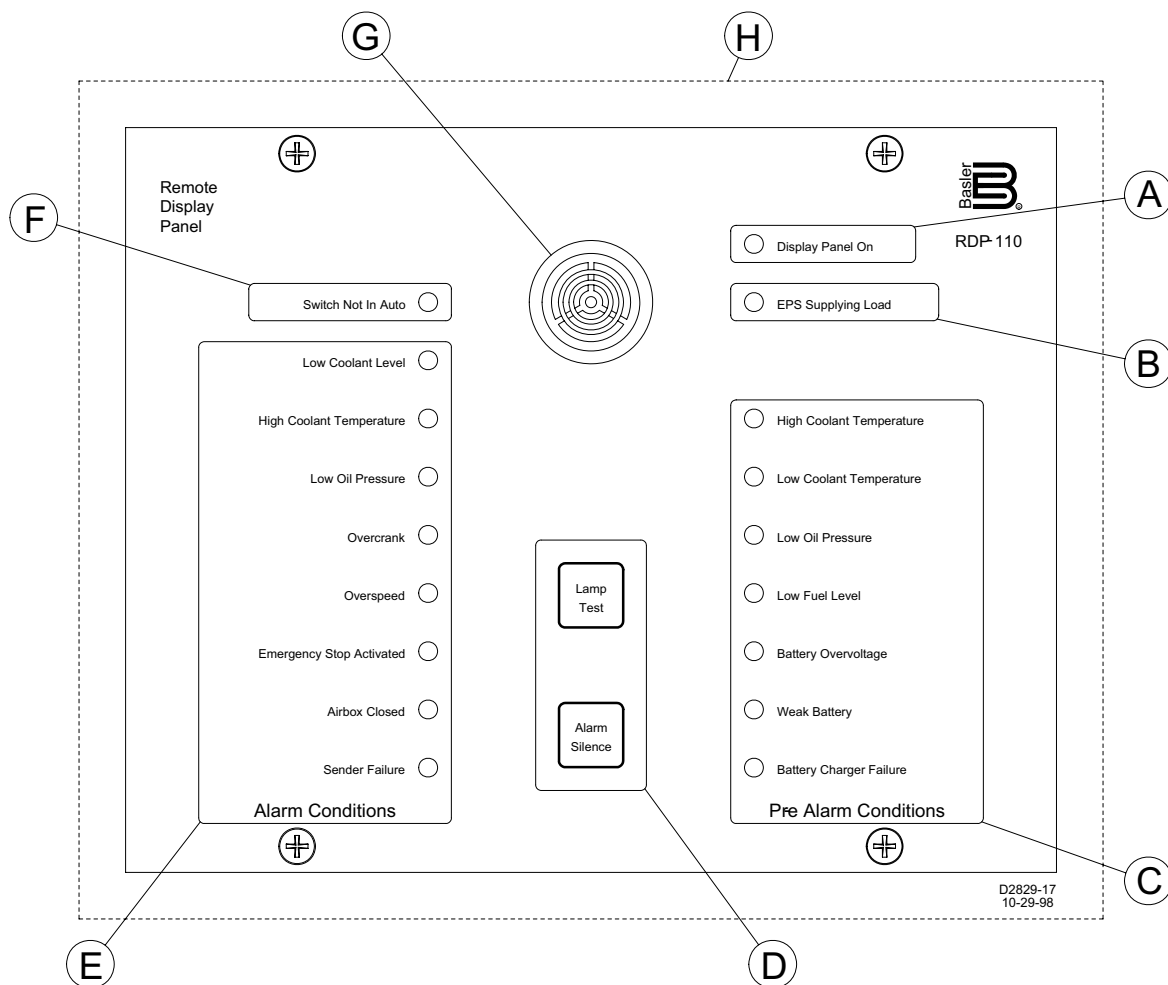


Figure 2-2. RDP-110 Front Panel (DGC-2000 Version)

Table 2-1. RDP-110 HMI (Controls and Indicators)

A	Green LED illuminates when power is applied to the RDP-110.
B	Green LED turns ON when the generator is supplying more than two percent of rated current.
C	Pre-Alarm Conditions - Yellow LED illuminates when the high coolant temperature pre-alarm setting is exceeded. - Yellow LED illuminates when the low coolant temperature pre-alarm setting is exceeded. - Yellow LED illuminates when the low oil pressure pre-alarm setting is exceeded. - Yellow LED illuminates when the low fuel level pre-alarm setting is exceeded. - Yellow LED illuminates when the battery overvoltage pre-alarm setting is exceeded. - Yellow LED illuminates when the weak battery pre-alarm setting is exceeded. - Yellow LED illuminates when the battery charger failure contact has closed.
D	Pushbuttons Lamp Test Pushbutton exercises the audible alarm and tests all LED's. Alarm Silence Pushbutton silences the audible alarm.

E Alarm Conditions

- Red LED illuminates when a low coolant level has occurred.
- Red LED illuminates when the high coolant temperature alarm setting is exceeded.
- Red LED illuminates when the low oil pressure alarm setting is exceeded.
- Red LED illuminates when the overcrank setting is exceeded.
- Red LED illuminates when the overspeed setting is exceeded.
- Red LED illuminates when the emergency stop is activated.
- Red LED illuminates when the airbox damper contact is closed.
- Red LED illuminates when the Fuel Leak/Sender Failure is detected (DGC-2020, 500, and 1000) or Airbox is closed (DGC-2000).
- Red LED illuminates when a sender failure is detected.

F Red LED illuminates when the DGC is not in AUTO.

G Audible alarm annunciates when DGC is not in AUTO and when alarms and Pre-alarms occur.

H Dashed line indicates the front panel outside edges when flush mounted.

RDP-110 CONNECTIONS

Compression type terminal strips make wiring the RDP-110 a simple task. It is necessary to remove the front panel to access the printed circuit board and terminal strips. These terminal strips connections accept one #10 or two #14 AWG wires or smaller. These operations are made even easier by user friendly labeling of the terminal strips on the printed circuit board. Once wired, these connectors can be quickly disconnected to facilitate RDP-110 replacement for out of circuit testing or maintenance. Each connector is keyed to prevent improper connections. Figure 2-3 shows the RDP-110 rear panel terminal connections.

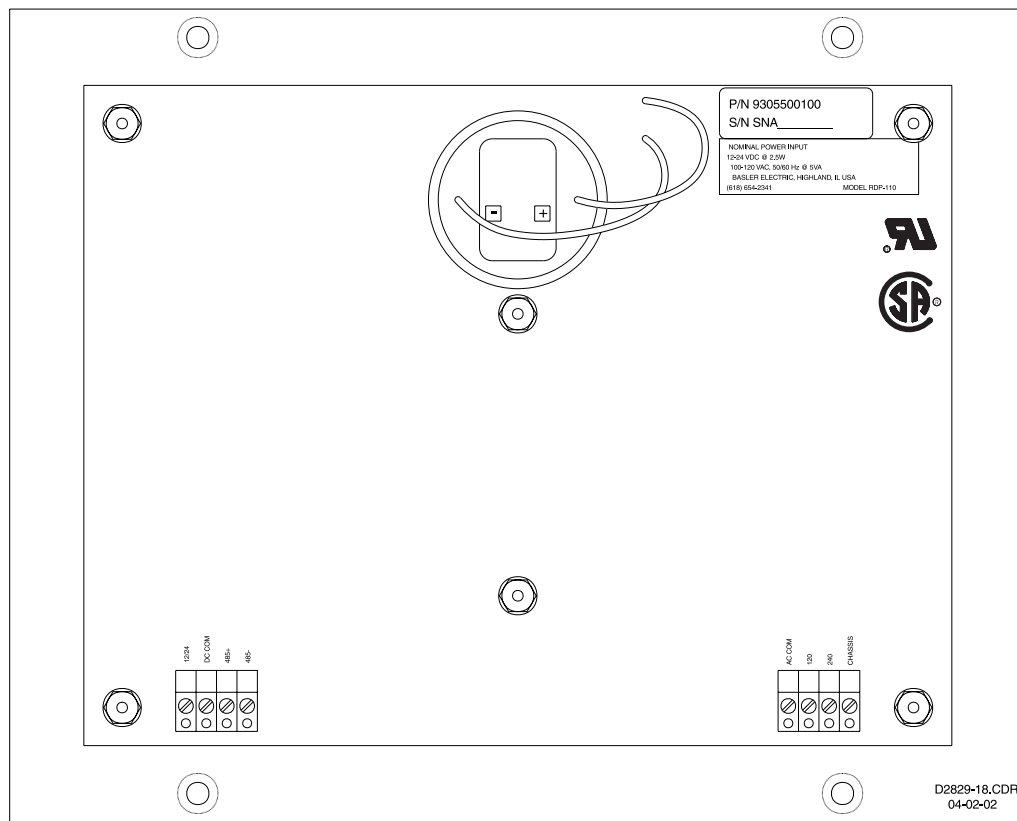


Figure 2-3. RDP-110 Remote Display Panel with Front Panel Removed

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SECTION 3 • FUNCTIONAL DESCRIPTION

GENERAL

RDP-110 Remote Display Panels use microprocessor-based technology to provide remote annunciation of various engine and generator parameters. Refer to the following paragraphs for the RDP-110 functional description.

Circuit functional description is divided into *Inputs*, *Microprocessor*, *Outputs*, and *Software*. Circuit functions illustrated in Figure 3-1 are described in the following paragraphs.

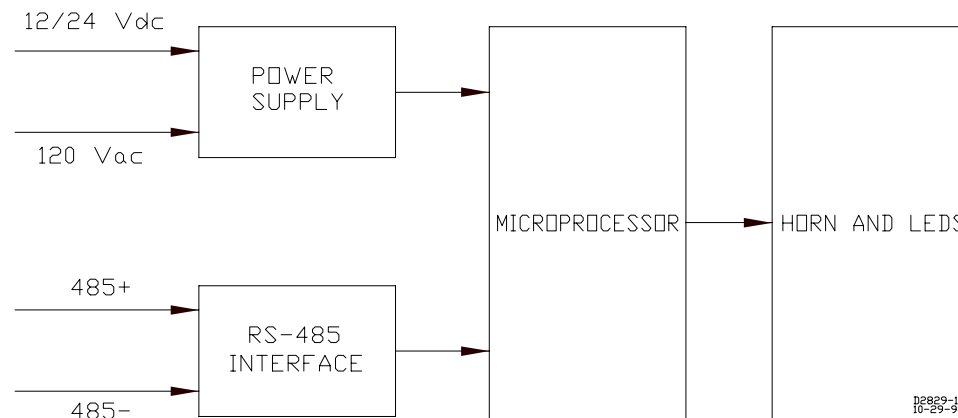


Figure 3-1. RDP-110 Functional Block Diagram

INPUTS

There are three types of inputs to the RDP-110 Display panel. They are:

- Operating (battery) dc power
- Operating (ac) power
- Serial interface

The following paragraphs describe these inputs.

Battery Operating Voltage

Required operating voltage is a nominal 12 or 24 Vdc. Operating voltage may be in the range of 8 to 32 Vdc. An internal switching power supply uses this battery voltage or a rectified and filtered signal from the ac input to generate +5 Vdc. The two power inputs (ac and dc) are isolated from each other and may be applied simultaneously.

AC Operating Voltage

Required operating voltage is a nominal 100/120 Vac 50/60 hertz. Operating voltage may be in the range of 80 to 144 Vac. An internal switching power supply uses this ac input voltage or the battery input voltage to generate +5 Vdc. The two power inputs (ac and dc) are isolated from each other and may be applied simultaneously.

RS-485 Interface

The differential RS-485 input signal is converted to a single-ended signal suitable for use by the microprocessor.

MICROPROCESSOR

Software programmed in the programmable read-only memory (PROM) controls the overall functionality of the device and makes all decisions based on programming and system inputs. Random access memory and electrically erasable memory are also provided on the microprocessor.

SOFTWARE

Software embedded in the RDP-110 controls all aspects of device functionality. This includes power-up initialization, front panel set-up, configuration, and serial communications input monitoring. When power is first applied, the RDP-110 initiates a power-up sequence. The embedded software and the on-board memory are checked, all functions are activated, and input monitoring begins.

Normal Mode

Normal mode displays the alarms and pre-alarms on the RDP-110 front panel. Pressing the front panel **Lamp Test** pushbutton activates the audible alarm and turns on all LEDs. Pressing the **Alarm Silence** pushbutton silences the audible alarm. After the alarm has been silenced only another alarm or pre-alarm will cause the audible alarm to re-activate. LED indicators can only be reset by resetting the DGC locally.

SECTION 4 • INSTALLATION

GENERAL

RDP-110 Remote Display Panels are delivered in sturdy cartons to prevent shipping damages. Upon receipt of the unit, check for damage, and if there is evidence of such, immediately file a claim with the carrier and notify the Basler Electric Regional Sales Office, your Sales Representative or Sales Representative at Basler Electric, Highland, Illinois.

If the remote display is not installed immediately, store it in the original shipping package in a moisture and dust free environment.

HARDWARE

RDP-110 panels are packaged in NEMA 1 metal cases for improved electromagnetic compatibility and are suitable for either semi-flush mounting or surface (projection) mounting. The metal case is resistant to moisture, salt fog, humidity, dust, dirt, and chemical contaminants. It also inhibits insect and rodent entrance.

MOUNTING

Figure 4-1 provides the overall dimensions, cutout dimensions, and drilling pattern diagram for mounting RDP-110 units. Part numbers for flush mount and projection mount units are as follows:

- Surface (projection) mount units RDP-110-S
- Semi-Flush mount units RDP-110-F

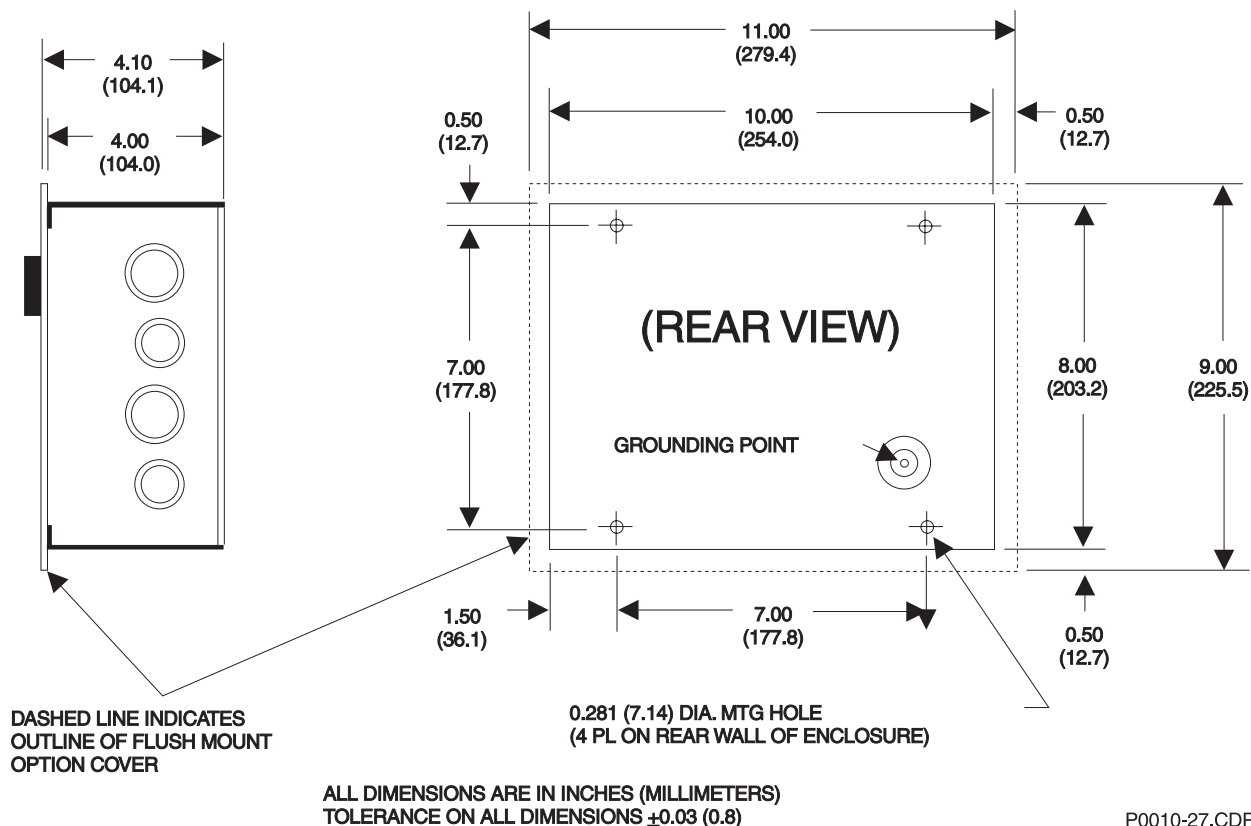


Figure 4-1. RDP-110 Rear and Side View, Overall Dimensions and Drilling Pattern Diagram

CONNECTIONS

CAUTION

Be sure the controller battery input polarity is wired correctly. Reverse polarity battery power will not allow the unit to be DC powered. Incorrect wiring may result in damage to the remote display.

NOTE

Be sure the remote display panel is hard-wired to earth ground with no smaller than 16 AWG copper wire attached to the chassis terminal on the rear of the remote display. An additional ground connection is on the conduit box.

Except as noted above, connections should be made with minimum wire size of 20 AWG. Be sure to use the correct input power for the power supply. Figure 4-2 is a typical connection diagram.

Each RDP-110 internally terminates the RS-485 connection with a 100-ohm resistance. Connecting multiple remote display panels may require modification of this terminating impedance. The internal terminating resistance can be eliminated by removing R65 from the printed circuit board. R65 is located in the lower left corner near the RS-485 terminal strip. Consult the EIA-RS-485 standard for a complete discussion.

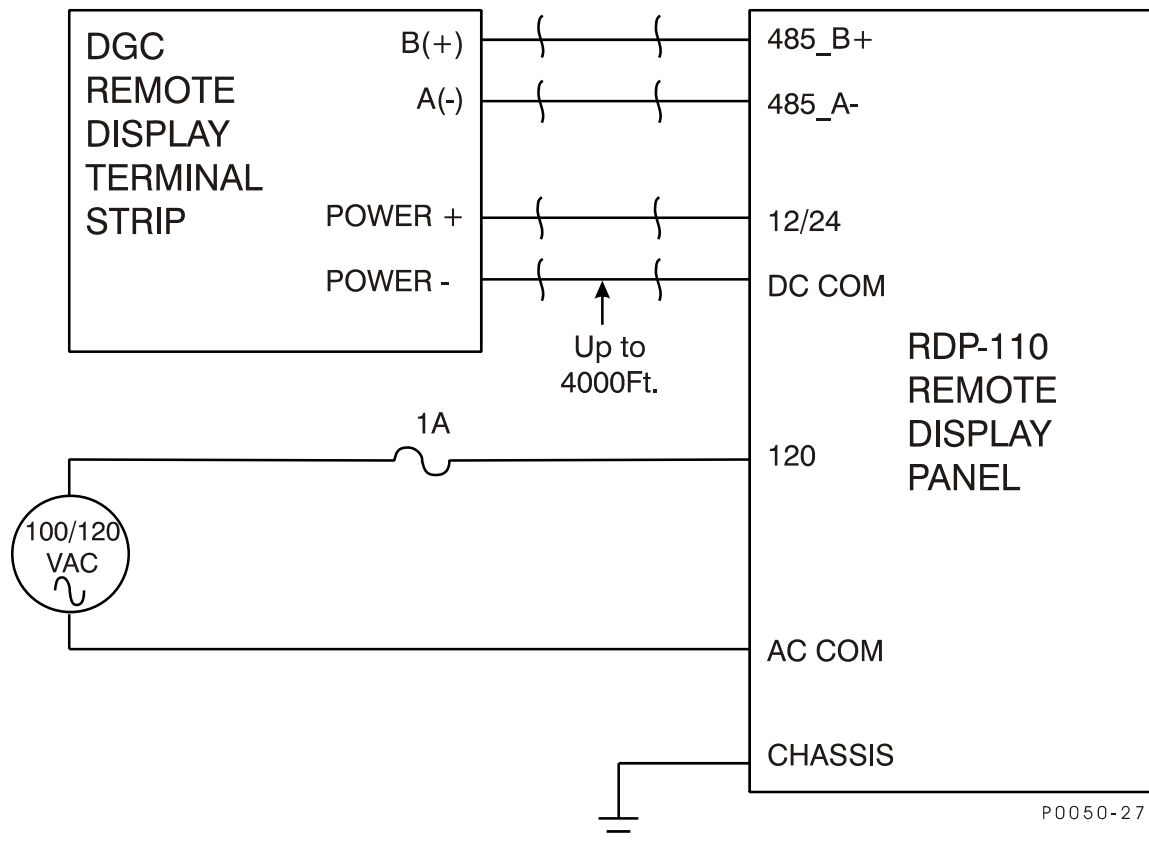


Figure 4-2. RDP-110 Typical Connection Diagram

SECTION 5 • TESTING

INTRODUCTION

This section provides a procedure for testing the RDP-110 using the built-in field test mode.

EQUIPMENT REQUIRED

The following equipment or suitable substitute is required.

- DC power supply, 24 volts
- 2 each, one ampere fuses
- Voltage source, 50/60 hertz, 100/120 volts
- Signal generator, 10.0 hertz, 5 volts peak to peak, square wave

FUNCTIONAL TEST PROCEDURE

To functional test the RDP-110, perform the following the steps.

Step 1. Connect the test setup as shown in Figure 5-1.

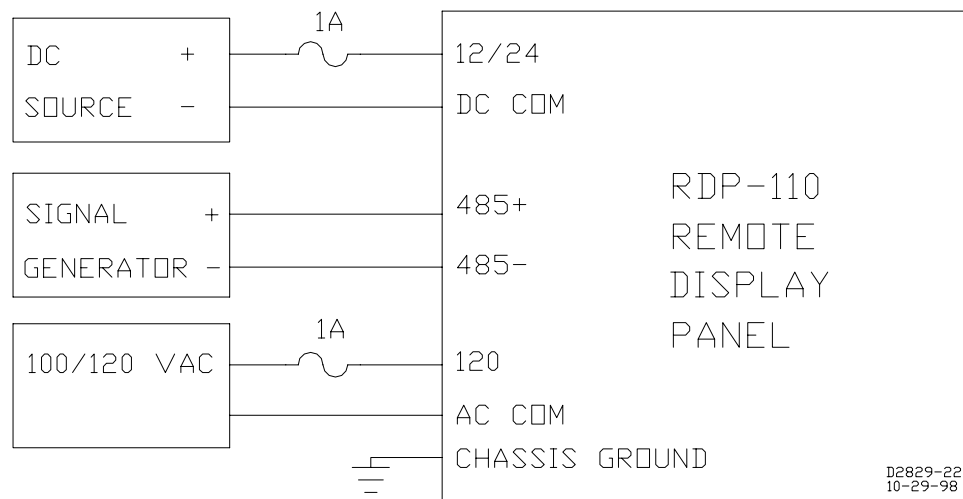


Figure 5-1. Test Set Diagram

- Step 2. Apply dc power.
- Step 3. The Display Panel On LED should turn on.
- Step 4. Press and hold the Lamp Test pushbutton.
- Step 5. The alarm should sound and all LED's should turn on.
- Step 6. Release the pushbutton and the alarm and LED'S should turn off.
- Step 7. Apply the 10 hertz signal.
- Step 8. Press and release the Lamp Test pushbutton.

Step 9. Each LED and the horn should annunciate in the following order before repeating:

- Switch Not in Auto
- Low Coolant Level Alarm
- High Coolant Temperature Alarm
- Low Oil Pressure Alarm
- Overcrank Alarm
- Overspeed Alarm
- Emergency Stop Activated Alarm
- Factory selectable LED
- Sender Failure Alarm
- EPS Supplying Load
- High Coolant Temperature Pre-alarm
- Low Coolant Temperature Pre-alarm
- Low oil Pressure Pre-alarm
- Low Fuel Level Pre-alarm
- Battery Overvoltage Pre-alarm
- Weak Battery Pre-alarm
- Battery Charger Failure Pre-alarm
- Audible Alarm

Step 10. Press and release the Alarm Silence pushbutton.

Step 11. The cycling indicators should stop when the Alarm Silence pushbutton is pressed.

Step 12. Remove the 10 Hz source and the DC power input.

Step 13. Repeat the above test procedure with AC power applied instead of the DC power.

This completes the field test procedures.



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DESCRIPTION

These solenoid valves are designed to control the flow of fuel gases in industrial and commercial gas burner systems. The valves are suitable for mainline, pilot line and venting applications. Burner construction valves, suffix “B”, are designed to handle liquefied petroleum gases (propane) in both the liquid and gaseous states. Series 8030, 8040, 8044, and 8262 valves are direct acting constructions. Series 8042, 8043, 8210, 8214, and 8215 valves are internal pilot operated constructions.

SPECIFICATIONS

Solenoid Enclosures: Valves listed in this series have a Red-Hat metal Type I general purpose junction box housing with (2) 7/8” knock-outs for 1/2” conduit connection (designated by the “JB” prefix in catalog numbers) or Red-Hat II molded epoxy solenoids. Red-Hat II solenoids are identified by the change letter “G” in the catalog numbers (e.g., 8210G74) and are shown in red.

Coils: Continuous duty molded class F or H as listed.

Standard Enclosures:

- Red-Hat Type I general purpose.
- Red-Hat II Types 1, 2, 3, 3S, 4 and 4X combination general purpose with watertight with 1/2” conduit hub.

Optional Enclosures:

- Red-Hat Type 3R rainproof. To order, add prefix “R” to the catalog number.
- Red-Hat Types 3, 4, 7 and 9 combinations explosion proof and water tight. To order add prefix “EF” to catalog number. (Except for Series 8214, and catalog number 8215A40, 8215A90 and 8215B93.)
- Red-Hat II Types 3, 3S, 4, 4X, 6, 6P, 7 and 9 combination explosion proof and water tight. To order, add prefix “EF” to the catalog number.
- **Electrical:** Standard Voltages – 24, 120, 240 volt, AC, 60 Hz except where noted otherwise. For DC voltages – 12, 24 volts DC.
- **Valve Parts in Contact with Fluids:** Body-aluminum or brass as listed, stainless steel (300 Series) available at 1/2”, 3/4” and 1” NPT pipe sizes.
 - ◆ Consult Factory.
 - ◆ Seals, Diaphragms and Discs – Buna N
 - ◆ Disc Holder – nylon (10.1 watt Normally Open Only)
 - ◆ Core Guide – Acetal, except suffix “B” valves which use brass
 - ◆ Rider Rings – Filled Teflon®
 - ◆ Core and Plugnut – 430F s.s.
 - ◆ Springs – 302 s.s
 - ◆ Shading coil – copper
 - ◆ Plug – Zinc plated steel

Gas Solenoid Valves



Ordering Information:

Important: We must have catalog number, voltage and hertz. Use strainers with solenoid valves. Red-Hat valves requiring CSA must be ordered with CSA suffix to cover special marking and handling. Red-Hat II valves are provided with CSA approval marking as standard.

Constr. Ref.	H	L	P	T	W
46	6-13/16	6-5/32	5-15/32	2-7/32	5-3/8
47	6-13/16	6-5/32	5-15/32	2-7/32	5-3/8

Pipe Size (ins.)	Orifice Size (ins.)	Cr Flow Factor	Operating Pressure Differential (psi)		Fluid and Ambient Temp °F		Standard Solenoid Enclosure Red-Hat Type I Red-Hat Type II 1, 2,3,3S,4&4X		Gas Capacity	Approval Listings						Watt Rating/ Class of Coil Insulation
			Min	Max	Min	Max	Cat. #	Const Ref #		Btu/Hr	UL	F M	CSA	CGA 3.9	CGA 6.5	AGA Z21.21
NORMALLY CLOSED (Closed when de-energized) Aluminum Body with Buna “N” Seating																
3/8	¾	3.4	0	5	-40	125	8214G10	8	183,000	0	0	0	0	0	0	17.1/F
½	¾	4.4	0	5	-40	125	8214G20	9	238,500	0	0	0	0	0	0	17.1/F
¾	¾ 1-5/8	5.1 11	0	5	-40	125	8214G30 JB821435	10 46	247,500 580,000	0 0	0 (2)	0 0	0 0	0 0	0 0	17.1/F 20/F
1	1-5/8	21	0	5	-40	125	JB821450	46	1,119,000	0	(2)	0	0	0	0	20/F
1-1/4	1-5/8	32	0	5	-40	125	JB821460	47	1,730,000	0	(2)	0	0	0	0	20/F
1-1/2	1-5/8	35	0	5	-40	125	JB821470	47	1,900,000	0	(2)	0	0	0	0	20/F
2	2-3/32	60	0	5	-40	125	JB821480	48	2,800,000	0	(2)	0	0	0	0	20/F

NPT	VOLTAGE	P/N	NPT	VOLTAGE	P/N
3/4	12	46013	3/4	24	46049
1	12	46021	1	24	46048
1 1/2	12	46010	1 1/2	24	46050
2	12	46029	2	24	46027

For support or information, call us at 800-325-5450 or visit us at www.mtu-online.com

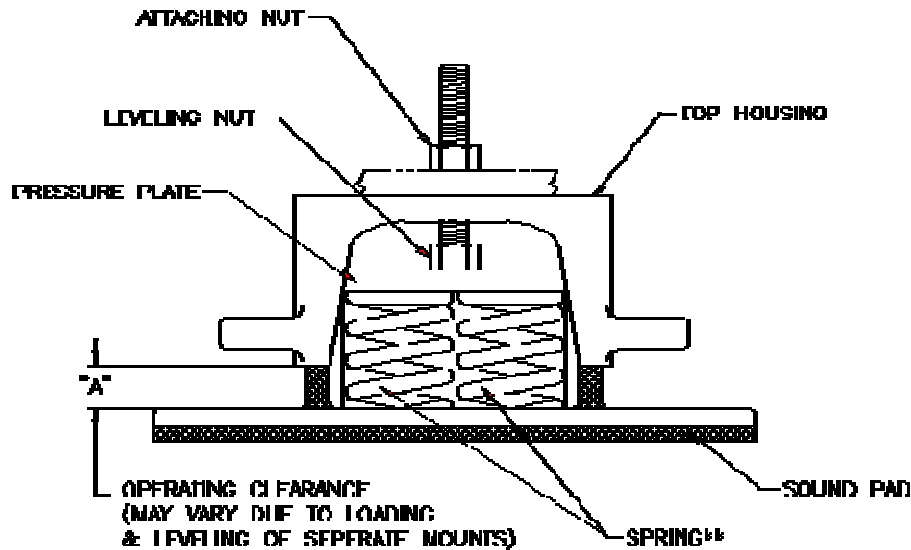
Materials and specifications subject to change without notice.

MTU Onsite Energy Corporation / 100 Power Drive / Mankato, MN 56001 / USA / A Tognum Group Company

Serial Number: 309983 - Page 600

Spring Isolators

Installation and Adjustment Procedure



DESCRIPTION

1. Locate all mounts with base plate to within 1/4" of common place (shim or grout as necessary)
2. Remove attaching nuts. Lower equipment on top of mounts. Top and bottom housing should be checked for proper alignment after loading. DO NOT HAMMER MOUNTS. If mounts are not aligned, raise equipment and shift mount to proper location
3. Anchor isolator to floor using slotted anchor holes
4. Turn leveling nut to contact pressure plate on each mount. By turning nuts equally on all mounts, equipment load is transferred to springs. Turn nuts one turn each until operating clearance "A" is obtained.
5. If equipment is not level at this time, additional turning of bolts at low end will raise corner to level. Tighten lock nut.

Spring coils may be as close as 1/16" and are still sized and adjusted properly.

For support or information, call us at 800-325-5450 or visit us at www.mtu-online.com

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Spring_Isolator_Procedures_Spec

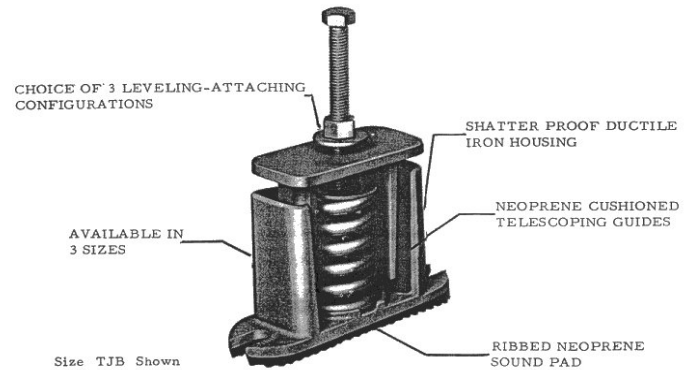
Spring Isolator

Type TJ Shatter Proof Ductile Iron



HIGHLIGHTS

- ◆ Protection for:
 - Compressors
 - Pumps
 - Blowers
 - Boilers
 - Generators
 - Air Handling Units
 - Mills



DIMENSIONS

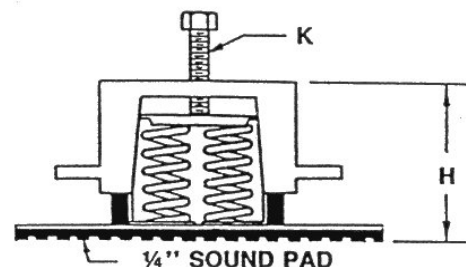
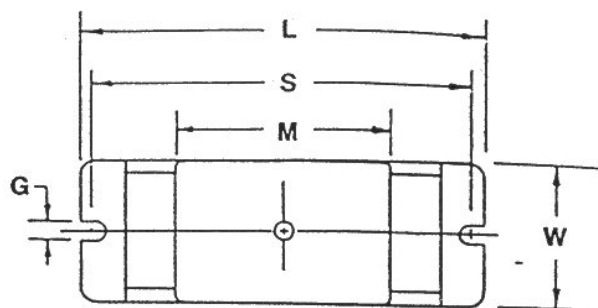
Dimensions (inches)

Size	L	W	S	G	K	M	H*	H**
B	6 7/8	2 1/16	6	9/16	1/2	4 1/2	5 1/2	6
C	13	2 3/8	12	5/8	5/8	7	5 3/4	6 1/2
E	13 1/4	4 5/8	12	11/16	5/8	7	5 3/4	6 1/2

H* Minimum free height T attaching

H** Minimum free height U & V attaching

Operating height may equal free height depending on load and adjustment



Spring Isolator

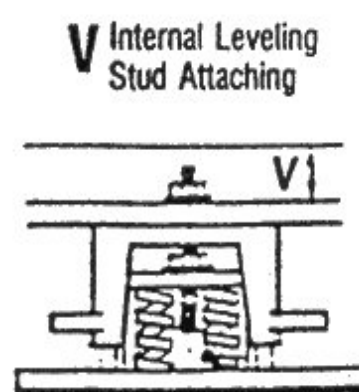
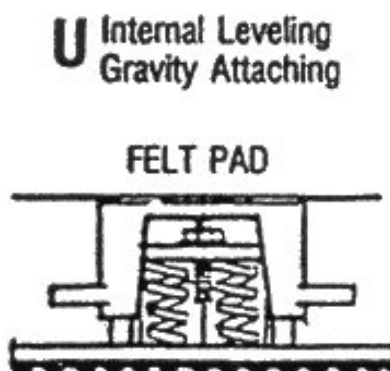
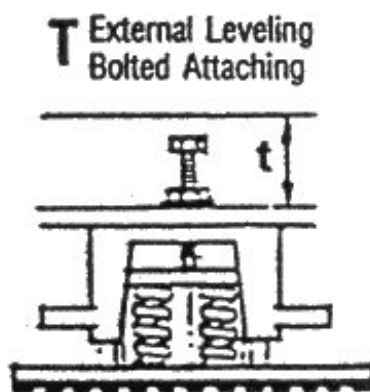
Type TJ Shatter Proof Ductile Iron



▶ SPECIFICATIONS

Load Rating-Deflection Rating-Spring Constant								
Size TJB (1 spring)			Size TJC (2 springs)			Size TJE (4 springs)		
Mount No. Max. Load (lbs)	Max. Defl. (ins)	Spring Rate (lbs/ins)	Mount No. Max. Load (lbs)	Max. Defl. (ins)	Spring Rate (lbs/ins)	Mount No. Max. Load (lbs)	Max. Defl. (ins)	Spring Rate (lbs/ins)
TJB 21	1.13	18	TJC 42	1.13	36	TJE 84	1.13	72
TJB 55	1.13	49	TJC 110	1.13	98	TJE 220	1.13	196
TJB 79	1.13	70	TJC 158	1.13	140	TJE 316	1.13	280
TJB 106	1.13	94	TJC 212	1.13	188	TJE 452	1.13	376
TJB 120	2.3	52	TJC 240	2.3	104	TJE 480	2.3	208
TJB 152	2.0	76	TJC 304	2.0	152	TJE 608	2.0	304
TJB 201	1.7	118	TJC 402	1.7	236	TJE 804	1.7	472
TJB 244	1.13	216	TJC 488	1.13	432	TJE 976	1.13	864
TJB 296	1.6	185	TJC 592	1.6	370	TJE 1184	1.6	740
TJB 318	1.13	281	TJC 636	1.13	562	TJE 1272	1.13	1124
TJB 395	1.8	220	TJC 790	1.8	440	TJE 1580	1.8	880
TJB 511	1.5	341	TJC 1022	1.5	682	TJE 2044	1.5	1364
TJB 715	1.3	550	TJC 1430	1.3	1100	TJE 2860	1.3	2200
TJB 1060	1.0	1060	TJC 2120	1.0	2120	TJE 4240	1.0	4240
TJB 1520	.78	1950	TJC 3040	.78	3900	TJE 6080	.78	7800
TJB 1650	.64	2580	TJC 3300	.64	5160	TJE 6600	.64	10320
TJB 1960	.78	2515	TJC 3920	.78	5030	TJE 7840	.78	10060

For assistance: Our staff of engineers stands ready to help you select isolators for your particular application.



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GE Industrial Systems

General Electric TJJ Circuit Breaker Manual Packet

Packet includes:

- Instructions.....GET-2279K
- Accessories (Optional)
 - Shunt Trip.....GEH-3435
 - Aux. Contacts.....GEH-3321
 - Bell Alarm.....GEH-3320





Molded Case Circuit Breakers

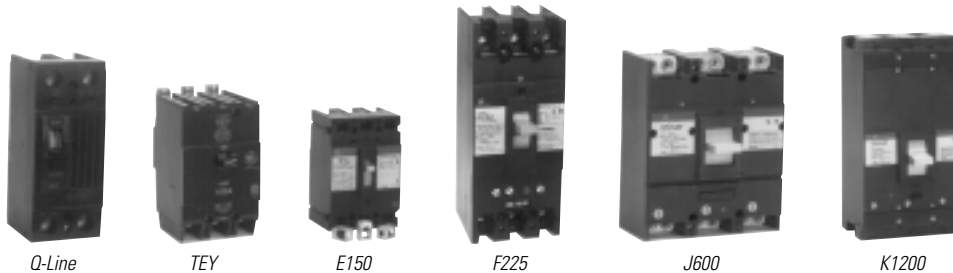
Application and Selection





The GE Family of Molded Case Circuit Breakers

From 10-1200 Amperes



Application Flexibility

In switchboards, motor control centers and lighting, power and customized control panelboards, General Electric molded case circuit breakers are used to provide reliable circuit protection. Molded case circuit breakers in individual enclosures are also used in numerous applications.

Minimum Downtime

Downtime is reduced and fuse replacement is eliminated with circuit breakers. In case of overload or short circuit, the breaker trips, opening the circuit and protecting the conductors. When normal conditions are restored, the breaker can be closed ("ON") again.

Trip-Free Mechanism

The breaker's trip-free mechanism opens the breaker contacts under overload or short circuit conditions, even with the breaker handle held in the ON position.

Eliminates Single-Phasing

Circuit breakers eliminate single-phasing. When an overload or short circuit occurs on any one conductor, a common trip bar simultaneously disconnects all three conductors of a three-phase circuit.

Easy System Upgrading

With General Electric circuit breakers, the circuit can be uprated, even after the breaker has been installed. Interchangeable trips provide a wide range of ratings within the same frame size.

Accessory Functions

Application flexibility of molded case circuit breakers is enhanced by a breaker accessory line. Remote closing or opening, undervoltage protection, indication of "tripped" condition at a remote location, electrical or mechanical interlocking, automatic reclosing, and primary or sequential operation are some of the functions practical with accessories.

Space Savings

Space savings can be an important factor in selecting General Electric molded case circuit breakers as equipment components. Higher rated breakers in particular, offer major space economies over fused switches.

Interrupting Ability

Interrupting ratings of General Electric molded case circuit breakers are based on actual short circuit tests. Breakers are rated for RMS symmetrical ac amperes and for maximum dc amperes.

Standards and Specifications

General Electric molded case circuit breakers meet standards established by Underwriters' Laboratories, National Electric Manufacturers Association, Federal Specifications, Institute of Electronic Engineers, National Electric Code and General Electric Company's own high quality standards.



Rugged, Dependable Construction

Circuit Breaker Frame

- **Molded case** is molded from high-mechanical and high-dielectric strength engineered plastic.
- **Trip indication** is shown by handle position midway between ON and OFF. To reset the trip mechanism, move the handle to extreme OFF, then to ON position.
- **Quick-make, quick-break, trip-free mechanism** minimizes arcing during breaker operation. Contacts cannot be “teased” into position. Trip-free mechanism is independent of manual handle control. The breaker trips under short circuit or overload, even though the operating handle is held in ON position.
- **Verifier “Twist-to-Trip” and “Push-to-Trip”** mechanically simulates over-current tripping through actuation of linkages not operated by the ON-OFF handle. Experience has shown that thermal magnetic circuit breakers in industrial applications better maintain their original protective characteristics when regularly exercised.
- **Common-trip bar** assures instant disconnect of all conductors when an overload or short circuit occurs on any one conductor in the circuit, or an accessory trip device operates.
- **Silver alloy contacts** combine the conductive properties of silver with other elements for clean, positive electrical contacting. Pitting and burning are minimized for longer contact life.
- **Arc chutes** of heat-absorbing, insulating material and metal grid plates quickly “extinguish” arcs.
- **UL listed lugs** for copper or aluminum cable, at full frame rating. Easy access and simple, straight-in wiring.

Thermal Magnetic Trip System

- **Front-adjustable magnetic trip** provides instantaneous trip in event of short circuit. Any current surge above the trip setting produces a magnetic field which instantly actuates the trip mechanism and opens the circuit.
- **Thermal trip** provides protection against sustained overloads. A bi-metallic element reacts time-wise in inverse proportion to the current. If a circuit is overloaded, heat resulting from excessive current flow causes the bi-metal to bend, actuating the trip mechanism to open the circuit.
- **Interchangeable trip units** (for frames over 150 ampere rating) simplify stocking and reduce inventory requirements. Field interchangeability assures maximum flexibility.

Electronic Trip System

- **Front adjustable programming functions (Power+ 4, MicroVersaTrip Plus)** provide a high degree of flexibility and convenience in making and checking settings.
- **Long-time pick up indication** is illuminated whenever the breaker is experiencing an overload condition. The light is extinguished by removing the overload or tripping the breaker.
- **Glass epoxy printed circuit boards with epoxy conformal coating** over all assembled components provide long life with error free operation.
- **Switch contacts and board interconnectors** provide corrosion resistance and long product life.
- **Neutral current sensor connections** located between the breaker lugs allow panelboard mounting of breakers without special fillers or increased panel space.
- **Fault trip indicators** for overload, short circuit, and ground fault are available for local indication.



Thermal Magnetic and Solid State Trip Types

Spectra RMS™ circuit breakers with digital rms-sensing electronic trip units provide many features and benefits not offered by thermal magnetic breakers (refer to GET-7002).

Thermal magnetic trip units are available in all GE molded case circuit breakers from Q Line through K frame. Solid state trip units may be alternatively selected for J and K frame circuit breakers. Additionally, non-automatic circuit interrupters, or molded case switches, are available. These interrupters have no automatic overload or short circuit trip elements. They are used for manual switching and isolation.

Enclosure Compensated Thermal Trip: 40°C

An enclosure compensated thermal trip is constructed to permit an enclosed circuit breaker in a 25°C room ambient to carry 100% of its nameplate current *intermittently* and 80% of its nameplate current *continuously* when cabled with conductor sized per the UL 489 standard (see Figure 29.1).

The thermal trip action is accomplished by a bimetallic strip. The movement of the bimetal and thus tripping is proportional to the current — high current fast response, low current slow response. This action provides a time delay which prevents service interruptions from normal inrush currents or temporary overloads. Continuous overloads will cause the bimetal to deflect sufficiently to release the latch and open the breaker contacts. However, the bimetal is also sensitive to ambient temperatures. If the room ambient is above or below 25°C, or the enclosure is warmer than normal, the breaker rating will vary inversely to the temperature: higher ambient-lower current, lower ambient-higher current. Enclosure compensation is furnished on Q-Line, TEB, TEY, TB-1, TED 277 volt and TED 480 volt circuit breakers.

Ambient Temperature Compensated Thermal Trip: 10° TO 50°C

An ambient compensating or “Ambient Compensated” thermal trip is the same as an enclosure compensated trip with one notable exception. It has a reduced sensitivity to changes in ambient temperature. In an ambient compensating thermal trip an additional bimetal is added to the circuit breaker. This bimetal responds to breaker ambient and modifies the characteristics of the current sensing bimetal to compensate for ambient temperature changes.

Ambient compensating thermal trips are provided as standard in all 600 volt thermal-magnetic molded case circuit breakers.

Adjustable Magnetic Trip — F225, J600, K1200 and TEC, TEMPL, TFC, TJC, TKC, TFL, THLC-2, THLC-4, TLB4

An electromagnet which partially surrounds the bimetal is used to provide instantaneous trip in the event of a short circuit. The high current creates a strong magnetic field attracting the armature and instantaneously releasing the trip latch in the same manner as the bimetal does on overload.

For short circuit protection, the adjustable magnetic trip provides high, low and intermediate trip settings.

Solid State Trip: -20° TO +55°C

Solid state MicroVersaTrip® Plus trip units meet the same standards as thermal trip units. Complete circuit breakers equipped with MicroVersaTrip Plus trip units are rated to carry 100% of their current sensor rating intermittently and 80% continuously in a 40°C breaker ambient. Some MicroVersaTrip Plus equipped breakers are rated to carry 100% continuously and are so marked.

In addition to the protection of conductors as required by codes and standards, MicroVersaTrip Plus can be set to provide protection for equipment such as motors, generators, or transformers and provide improved distribution system selectivity.

Figure 4.1
Operation of Thermal-Mag Trip Units

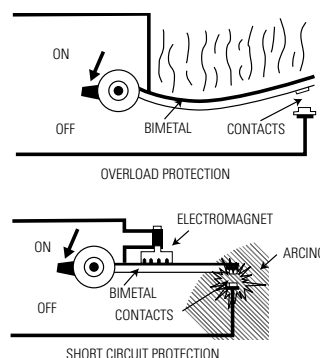




Table 5.1
Breaker Trip Types

	Breaker Type	Trip Type
Q-Line	All	Non-Interchangeable
TEY-100	TEY	Non-Interchangeable
E150	TEB TED THED Hi-Break	Non-Interchangeable Non-Interchangeable Non-Interchangeable
F225	TFJ TFK THFK Hi-Break	Non-Interchangeable Interchangeable Interchangeable
J600	TJJ TJK THJK Hi-Break TJ4V TJH4V Hi-Break TJH Hi-Break MVT Plus	Non-Interchangeable Interchangeable Interchangeable Non-Interchangeable Non-Interchangeable Interchangeable (Rating Plug ①)
K1200	TKM-800 TKM-1200 THKM Hi-Break TK4V TKH Hi-Break MVT Plus	Interchangeable Interchangeable Interchangeable Non-Interchangeable Interchangeable (Rating Plug ①)
Hi-I.C.	TEL, TEML② TFL② TJL4V Hi-I.C. TJL Hi-I.C. MVT Plus TKL4V Hi-I.C. TKL Hi-I.C. MVT Plus TLB-2② TLB-4②	Non-Interchangeable Non-Interchangeable Non-Interchangeable Interchangeable (Rating Plug ①) Non-Interchangeable Interchangeable (Rating Plug ①) Non-Interchangeable Non-Interchangeable
Current Limiting	THLC-1② THLC-2② THLC-4②	Non-Interchangeable Non-Interchangeable Non-Interchangeable
Tri-Break (fused)	TB-1 TB-4 TB-6 TB-8	Non-Interchangeable Non-Interchangeable Non-Interchangeable Non-Interchangeable

① MicroVersaTrip® Plus incorporates trip units with field replaceable rating plugs providing ease of changing ratings within frame size and sensor rating, with minimum downtime. See Table 5.2 for rating plug selection.

② Obsolete type.

Table 5.2
J/K Rating Plug Selection

Frame Type	Sensor Rating (Amps)	Current Rating (Amps)
J400	150	60, 80, 100, 125, 150
J400	400	150, 200, 225, 250, 300, 400
J600	600	300, 400, 450, 500, 600
K800	800	300, 400, 500, 600, 700, 800
K1200	1200	600, 800, 1000, 1200



Trip Unit Ratings Molded Case Circuit Breakers

Table 6.1
Trip Unit Ratings

Type	Reverse Feed		Trip Unit Type	Trip Unit Ratings (Amperes)	Instantaneous Type
Q-Line (THQB, L, C)	Yes		Non-interchangeable	10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110 ^① , 125 ^①	Fixed
TEY	Yes		Non-interchangeable	15, 20, 30, 40, 50, 60, 70, 80, 90, 100	Fixed
E150	Yes		Non-interchangeable	10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 110, 125, 150	Fixed
TEL ^②	Yes		Non-interchangeable	15, 20, 25, 30, 35, 40, 50, 50, 60, 70, 80, 90, 100, 125, 150	Fixed
THLC-1 ^②	Yes		Non-interchangeable	15, 20, 30, 40, 50, 60, 70, 80, 90, 100, 125, 150	Fixed
TB-1	No		Non-interchangeable	15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100	Fixed
TQD	Yes		Non-interchangeable	100, 125, 150, 175, 200, 225	Fixed
F225	TFJ	Yes	Non-interchangeable	70, 80, 90, 100, 110, 125, 150, 175, 200, 225	Adjustable
	TFK	No	Interchangeable		
TFL ^②	Yes		Non-interchangeable	70, 80, 90, 100, 125, 150, 175, 200, 225	Adjustable
THLC-2 ^②	Yes		Non-interchangeable	125, 150, 175, 200, 225	Adjustable
TJD	Yes		Non-interchangeable	250, 300, 350, 400	Fixed
J400	TJJ	Yes	Non-interchangeable	125, 150, 175, 200, 225, 250, 300, 350, 400	Adjustable
	TJK	No	Interchangeable		
J600	No		Interchangeable	250, 300, 350, 400, 450, 500, 600	Adjustable
TLB-4 ^②	Yes		Non-interchangeable	250, 300, 350, 400	Adjustable
THLC-4 ^②	Yes		Non-interchangeable	250, 300, 350, 400	Adjustable
TB-4	No		Non-interchangeable	125, 150, 175, 200, 225, 250, 300, 350, 400	Adjustable
TB-6	No		Non-interchangeable	300, 350, 400, 500, 600	Adjustable
K800	No		Interchangeable	300, 350, 400, 450, 500, 600, 700, 800	Adjustable
K1200	No		Interchangeable	600, 700, 800, 1000, 1200	Adjustable
TB-8	No		Non-interchangeable	600, 700, 800	Adjustable

① THQL only (2 pole).

② Obsolete type.



Accessories

Undervoltage Protection



The Undervoltage Release instantaneously trips the breaker when voltage drops to 35-70% of normal rating. The device retrips the breaker if it is closed before normal voltage is restored.

Standard duty and heavy-duty types are available.



Time Delay Unit — for use with UVR. This unit prevents nuisance tripping due to momentary loss of voltage.

A separate, externally mounted unit has 120 volt ac input and 125 volt dc output with delay adjustable from .1 to .5 seconds. It is used in conjunction with 125-volt dc undervoltage release, which must be ordered separately.

Bell Alarm



A bell alarm actuates a warning signal or other circuitry when the breaker is tripped under overload, short circuit, shunt trip, undervoltage trip, and 3 coil shunt trip conditions. Not actuated during normal ON-OFF operation.

Motor Operator for Remote "On-Off"

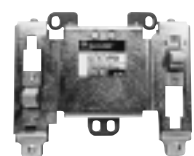


A motor-operated mechanism can open, close, or reset a breaker remotely. This convenient attachment mounts integrally with the breaker, without modification to the breaker or its handle. Just lift the cover of the accessory mechanism to operate the breaker manually. Breaker ON-OFF is indicated in the operating mechanism cover.

Mechanical Interlocking



Mechanical interlocks permit only one of two interconnected circuit breakers in a switchboard to be on at a time. Both circuit breakers can be OFF at the same time.



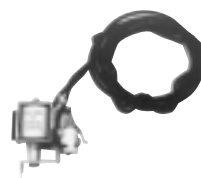
The walking beam interlock interconnects two circuit breakers from the rear, making it ideal for use in applications where a dead front would make it impossible to mount a mechanism on the face of the breaker.



The face mounted interlock interconnects the handles of two circuit breakers. This makes it possible to use the interlock with a motor operator.

Shunt Trip for Remote Tripping

Standard



A Shunt Trip Device can be used to trip and open a breaker by remote control. When the breaker opens, the shunt trip coil circuit is de-energized by means of an auxiliary switch. They meet UL requirements for operation at 55% of rated voltage for use on ground fault systems.

Three-coil (Blown Fuse Detector)

(not illustrated)

This provides single-phase protection for fused circuit breaker combinations, factory installed only.

It mounts in right pole for TEB, TED, and in left pole for TFK, TJK, TKM. Installed internally similar to standard shunt trip with leads connected across the fuses, it trips the breaker when a fuse blows or if the breaker is closed under load with a fuse open and fits all breaker types including molded case switches. Suitable for system voltages 208 to 600 volts ac.

Auxiliary Switch

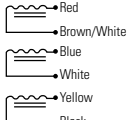


An auxiliary switch can be used to operate other accessories, indicating lights, relays, automatic reset, etc. It is available with one to four SPDT (form C) elements for flexibility. Switches open and close as the breaker is either manually or remotely tripped or turned OFF.



Molded Case Circuit Breakers

Accessory Data

Breaker Type	Bell Alarm Switch			Auxiliary Switch ^③ or Shunt Trip			Undervoltage Release			Blown Fuse Trip Device			Combination Accessories			Total Number of Accessories Within Any One Circuit Breaker	
	Mounting Pole			Inst. Sheet GEH-	Mounting Pole		Inst. Sheet GEH-	Mounting Pole		Inst. Sheet GEH-	Mounting Pole		Inst. Sheet GEH-				
	L	C	R		L	R		L	R		L	R					
Q-Line					UL ^⑧		N/A									One only	
TQD, THQD						UL										One only	
E150, TEB, TEC, TED, THED, TEL, TEMPL, TB1 ^② , THLC-1	UL ^①	—	UL	4576 5402	UL ^①	UL	3418 Aux. 3416 S.T. 5403 Aux. 5401 S.T.	—	UL	3417 5400	—	UL ^⑤	3434	—	—	—	2-pole circuit breaker — any one 3-pole circuit breaker — any two except UVR and 3-coil shunt trip
F225 ^⑥ , TFC, TFJ, TFK, THFK, TFL, TLB-2, TLB-4 THLC-4	—	—	UL ^⑤ ⑥	4620 5406	UL	UL	4653 5406	UL	UL	4653 5406	UL ^⑤	—	4622	—	—		Any two
J600 TJC, TJD, TJJ, TJK, THJK, TB4 ^② , TBC4 ^②	—	UL ^⑤	—	3320	UL	UL	3321 Aux. 3435 S.T.		UL	5407	UL ^⑤	—	3346	—	—	—	Any two plus bell alarm
K1200 TKC, TKM, THKM, TB6 ^② , TBC6 ^② , TB8, TBC8		UL ^⑤	—	4305	UL	UL	3321 Aux. 3344 S.T.		UL	5408	UL ^⑤	—	3346	—	—	—	Any two plus bell alarm
MicroVersaTrip™ 4 and RMS-9, TJ4V, THJ4V, TJL4V, TK4V, TKL4V, TJH, TJL, TKH, TKL	—	UL	—	4626 4663	—	UL	4623 Aux. 4623 S.T.	—	UL	4623	—	UL	4624 ^⑦	—	UL	4323	Any one plus bell alarm. UL Listed for field installation except bell alarm
Accessory Lead ^⑨ Color Coding	 Bell Alarm Switch			Auxiliary Switch  Shunt Trip 			 Undervoltage Release						Same as individual accessories			All accessory contacts shown with the circuit breaker in tripped position. ^⑩	

① Left pole mounting not available for 2 pole TEB, TED.

② UL listed at 200,000 AIC without internal accessories. 100,000 AIC with internally mounted accessories.

③ 600 volts AC auxiliary switches are not UL listed.

④ Formerly green.

⑤ Not available with lead exit from the back of breaker.

⑥ UL listed interrupting capacity with accessories: 10K AIC at 600 volts, AC, 22K AIC at 480 volts AC, 22K AIC at 240 volts AC.

⑦ Maximum available short circuit application is 85,000 sym rms A.

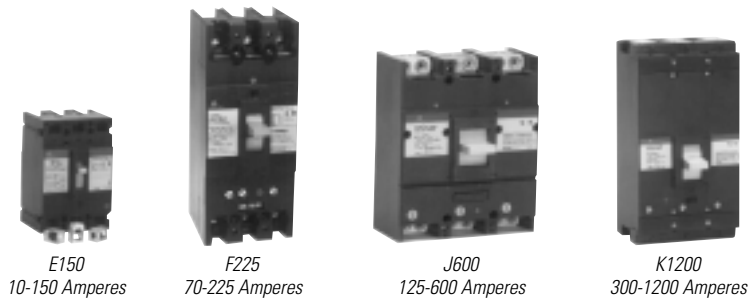
⑧ Accessory mounts in a one-inch frame and increases overall breaker size by one pole added to left side.

⑨ Leads are #18 AWG 125°C Vulkene® insulated.

⑩ Auxiliary switch is activated in both OFF and tripped positions.



Application Data – Molded Case Circuit Breakers



Molded case circuit breakers are circuit protective devices that primarily perform two functions: (1) manual switching operation to open and close a circuit by means of a toggle handle and (2) automatic opening of the circuit under sustained overload and/or short circuit conditions. Circuit breakers inherently provide the automatic protective function of opening the circuit under abnormal sustained overload, or short circuit conditions, without the use of fuses. When a circuit breaker opens to clear a fault, the toggle handle goes to a TRIPPED position midway between the ON and OFF positions, thus clearly indicating that a circuit breaker has opened. When the cause of the fault has been removed, the circuit breaker can again be closed simply by moving the toggle handle to the RESET position, and then moving the handle to the ON position.

Circuit breakers have an advantage over fusible elements. A fault on one pole of a multi-pole breaker actuates a common trip bar that opens all poles simultaneously, thus avoiding single phasing a motor circuit, as could occur in a fusible device. Molded case circuit breakers are “trip free” in construction. This means that the circuit breaker contacts cannot be held closed against a fault condition. Molded case circuit breakers are designed to protect insulated conductors against unsafe overheating that would ultimately damage the insulation and conductor.

Thermal-magnetic molded case circuit breakers are not designed to provide motor running overload protection. This function is normally performed by overload relays supplied in manual or magnetic motor starters. However, for infrequently started motors, MicroVersaTrip Plus equipped molded case circuit breakers can be used to provide motor overload, overcurrent, and ground fault protection.

Molded case circuit breakers meet UL Standard 489 covering “Molded Case Circuit Breakers, Molded Case Switches, and Circuit Breaker Enclosures.”

UL Standard 489 makes provision for two classes of products — UL Standard rated and UL 100 percent rated. The basis of these ratings for molded case and insulated case circuit breakers is as follows:

A. Standard rated under UL 489

1. Circuit breakers are rated to carry 100 percent of their nameplate current continuously in free air at 25°C when cabled per Table 31.1.
2. Enclosed circuit breakers are rated to carry 100 percent of their nameplate current intermittently (up to 3 hours maximum) and 80 percent continuously, with the enclosure in a 25°C ambient, and cabled per Table 32.1.
3. Group mounted circuit breakers may require derating of the circuit breaker and cable in room ambient temperatures other than 25°C and with cable other than specified in Table 32.1.



B. 100-percent rated under UL489

1. Circuit breakers are rated to carry 100 percent of their nameplate current continuously in an enclosure with ventilation and volume as specified on the device in a room ambient of 25°C when cabled as specified in Table 31.1 using 90°C insulation, sized to 75°C ampacity.
2. Room ambient temperatures other than 25°C, cable other than specified in Table 31.1, or enclosure volume and/or ventilation other than specified on the devices may require derating of the system.

100% Rated Circuit Breakers

Frame Type	Catalog Number	
	100% 65kAIC	100% Hi-Break®
J600	TJL1SS	TJH1SS
	TJL3SS	TJH3SS
	TJL4SS	TJH4SS
	TJL6SS	TJH6SS
K1200	TKL8SS	TKH8SS
	TKL12SS	TKH12SS

Standards and References

Underwriters Laboratories

UL 489 Branch Circuit and Service Circuit Breakers

Order from UL Publications Stock, 333 Pfingsten Road, Northbrook, Illinois 60062.

Federal Specifications

WC-375 Circuit Breaker, Molded Case; Branch Circuit and Service

National Electrical Code (NEC) (NFPA 70)

Latest Issue

Order from National Fire Protection Association, One Batterymarch Park, Quincy, Ma. 02269.

Inspection and Testing

The need for inspection of molded case breakers will vary depending on operating conditions. Suggested inspection and testing is defined in NEMA AB 4-1996, "Guidelines for inspection and preventive maintenance of molded case circuit breakers used in commerical and industrial applications."

In Making Connections with Aluminum Wire Refer to GEH-3445.

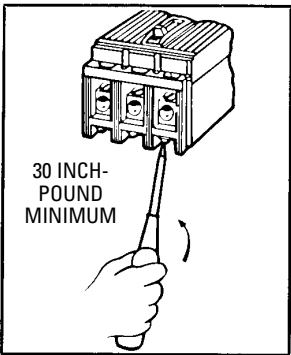
NOTE: When using aluminum wire, use a joint compound recommended by the wire manufacturer.

Lug Mounting Torque Values

GEJ-4654

TCAL12, 12A, 15, TC012

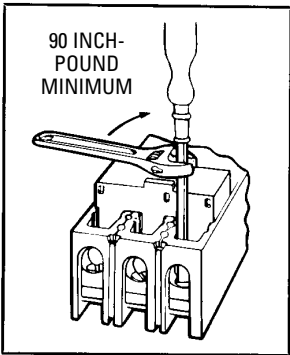
Mounting Lugs for E150 Line
Lugs must be securely fastened to terminal straps. Lugs are mounted at the factory with a torque wrench set at 30 inch-pounds minimum.



GEJ-4639

TCAL24, TC024, TCAL25, TC026, TCAL27

Mounting Lugs for F225 Line
Lugs must be securely fastened to terminal straps. Lugs are mounted at the factory torqued to 90 inch-pounds minimum.

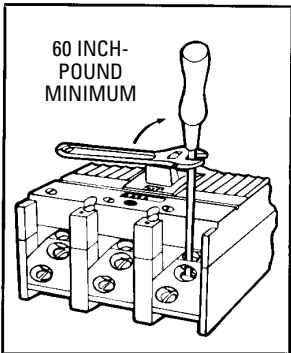


Suggested method for attachment or removal is illustrated.

GEJ-4655

TCAL43, TCAL63, TC043, TC063, TCAL47

Mounting Lugs for J600 Line
Lugs must be securely fastened to terminal straps. Lugs are mounted at the factory torqued to 60 inch-pounds minimum.

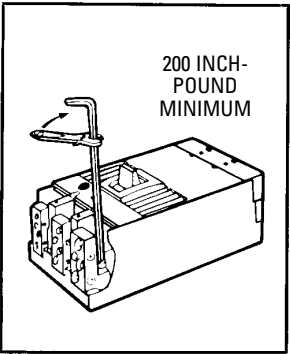


Suggested method for attachment or removal is illustrated.

GEJ-4656

TCAL41, TCAL61, TCAL81, TCAL91, TCAL121, TCAL131, TCAL122, TC041, TC061, TC081A, TC0121, TC0131, TC091

Mounting Lugs for K1200 Line
Lugs must be securely fastened to terminal straps. Lugs, when factory installed, are torqued to 200 inch-pounds minimum.



Suggested method for attachment or removal is illustrated.

Cable Connector (Wiring Lug) Torque Values

All Type THQP, THQL, THQB, THQC (including ground fault circuit breakers) and all TEB, TEC, TED, THED and TB1 circuit breakers and molded case switches are marked with the appropriate lug tightening torque values.

All other circuit breakers employ lugs with screws having an internal hexagonal socket with dimesnion "across the flats" of 1/4, 5/16 or 3/8 inch. The following table gives the recommended cable tightening torque for these lugs.

Socket Size (Across Flats)	Recommended Tightening Torque (inch-pounds)	Circuit Breaker Types
1/4	200	TQD, TQDL
5/16	275	TFJ/K, TJJ/K/D/C, TJ-V, TB4
3/8	375	TKM/C-TKOV, TB6/TB8



Molded-Case Circuit Breakers

Shunt Trip Accessory for Types TJC, TJD, TJJ, TJK, THJK, TB4, & TBC4

NOTE: UL listing is voided when the circuit breaker is modified to add an accessory.

Description

A Shunt Trip accessory is installed in a circuit breaker to allow electrical tripping of the breaker from a remote location. As shown in Figure 1, it consists of a solenoid whose core is attached to a spring-biased latch. When the control circuit is closed at the remote contacts, the solenoid is energized, which releases the latch. This allows the shaft and plunger to move the breaker trip bar and trip the breaker. A cut-off switch opens the solenoid coil electrical circuit when the breaker contacts open. The solenoid coil carries only momentary current and is not rated for continuous duty.

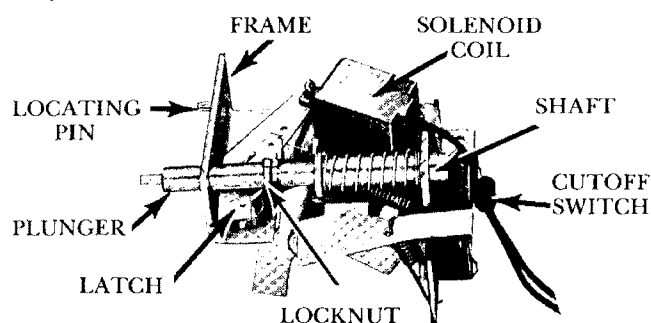


Figure 1. Shunt Trip accessory (unit shown for right pole installation).

The Shunt Trip must be ordered for either right pole or left pole installation. The catalog numbers for the various voltage applications are listed in Tables 1 and 2.

Catalog Number	Voltage Rating	Peak Inrush Current, A
TJKSTA7R or L	12 Vdc	4.8
TJKSTA8R or L	24 Vdc	4.6
TJKSTA9R or L	48 Vdc	2.4
TJKSTA12R or L	120 Vac	1.0
	125 Vdc	1.0
	240 Vac	1.9
TJKSTA11R or L	250 Vdc	0.4
TJKSTA13R or L	480 Vac	1.5
	600 Vac	1.9

Table 1. Catalog numbers and electrical ratings for the Shunt Trip accessory for breaker types TJC, TJD, TJJ, TJK, and THJK.

Catalog Number	Voltage Rating	Peak Inrush Current, A
TB4STA7R or L	12 Vdc	4.3
TB4STA8R or L	24 Vdc	4.6
TB4STA9R or L	48 Vdc	2.4
TB4STA12R or L	120 Vac	1.9
	125 Vdc	1.0
	240 Vac	1.9
TB4STA11R or L	250 Vdc	0.4
TB4STA13R or L	480 Vac	1.9
	600 Vac	1.9

Table 1. Catalog numbers and electrical ratings for the Shunt Trip accessory for breaker types TB4 and TBC4.

The Shunt Trip fastens to the breaker base and occupies the space next to the operating mechanism of the breaker, as shown in Figure 2. The spring-loaded plunger extends through a knockout in the trip unit case to operate the trip bar and does not interfere with the normal tripping action of the trip unit.

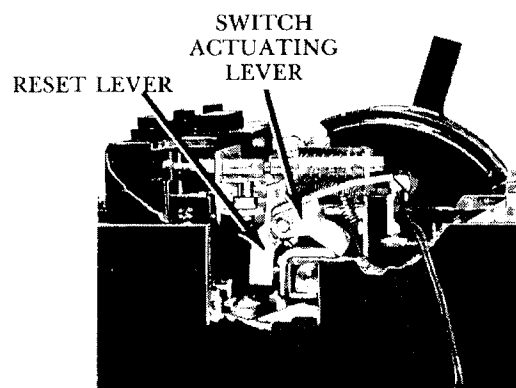


Figure 2. Shunt Trip installed in breaker (cutaway view of right pole installation).

A different style of plunger is used in the Shunt Trip, beginning with breakers and trip units built in week 49, 1996 (date code J649=). For breakers and trip units built before this date, use plunger style "A" in Figure 3. For breakers and trip units built during or after week 49, use plunger style "B." Refer to the breaker bar-code label or the trip unit face to determine the date of manufacture. The date code appears as a letter followed by three digits and an additional symbol. For instance, J649= indicates the manufacturing plant (J), the year (6), the week (49), and the decade (= indicates 90s).

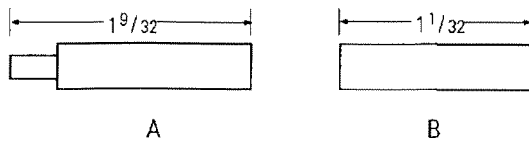


Figure 3. New- and old-style Shunt Trip plungers.

After installation, two leads (minimum of 24 inches long) are brought out through the side of the breaker case. (Accessories with leads brought out through the back of the breaker are available factory installed.) The external control circuit, consisting of normally open switch or relay contacts and connections to a control power source, must be supplied by the user.

Installation

CAUTION: The circuit breaker must be completely de-energized and disconnected from the electrical circuit before the Shunt Trip accessory is installed in the breaker. This is mandatory, since the breaker must be in the ON position to install these accessories.

ATTENTION: Il faut que le disjoncteur soit complètement désamorcé et débranché du circuit électrique avant que l'accessoire du déclenchement shunt soit installé dans le disjoncteur. Ceci est obligatoire, étant donné que le disjoncteur doit être en position "On" pour faire l'installation de ces accessoires.

CAUTION: Circuit breakers and accessories should be handled, inspected, installed, and removed by qualified personnel only and in accordance with these instructions and with accepted safety precautions.

ATTENTION: Seul un personnel qualifié et suivant ces directives ainsi que les mesures de précautions nécessaires devrait manipuler, inspecter installer et enlever les disjoncteurs et les accessoires.

Use the following procedure to install the Shunt Trip accessory in a circuit breaker.

1. **De-energize breaker.** Ensure that the circuit breaker is de-energized and disconnected from the circuit.
2. **Remove cover.** Remove the four cover mounting screws, then remove the cover from the breaker. Do not remove the trip unit.
3. **Drill hole in breaker.** From the back of the breaker, drill a 0.125-inch hole on the pole where the Shunt Trip is to be installed, as illustrated in Figure 4. Use the spotting hole closest to the trip unit for locating the drill.
4. **Remove knockout.** Being careful not to eject chips into the trip unit case, drive a small screwdriver through the knockout groove, shown in Figure 4, in several places. Gently pry outward to remove the knockout. Clean all chips from the

LOCATION OF
.125 HOLE
(DRILL FROM BACK)

LOCATING
HOLE

KNOCKOUT
GROOVE

SLOT COVER
HERE TO BRING
LEADS OUT THE SIDE

Figure 4. Inside of the breaker, showing the locations of the knockout, locating hole, drilled hole, and wire slot.

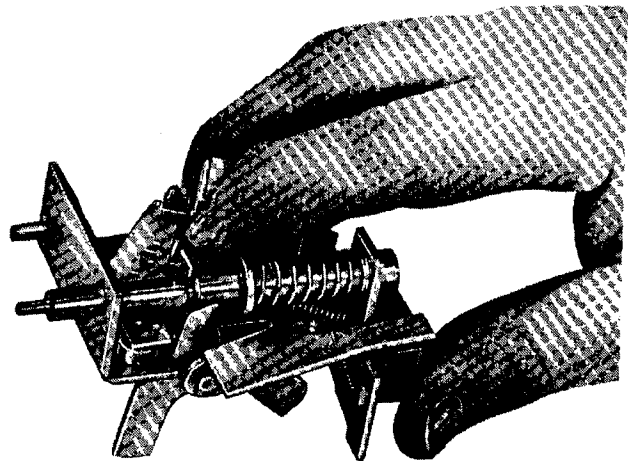


Figure 5. Holding the Shunt Trip for assembly (unit shown for right pole installation).

breaker case. Move the breaker handle to the ON position. Note that some trip units may have rectangular knockouts that are removed by inserting a screwdriver in the slot and prying upward.

5. **Ready unit for installation.** Ensure that the threaded portion of the shaft is screwed all the way into the plunger. Grasp the Shunt Trip as shown in Figure 5, pulling the plunger back beyond the latching point.
6. **Install the Shunt Trip.** Holding the Shunt Trip accessory as shown in Figure 5, insert the

plunger through the knockout removed in Step 4, and the locating pin, shown in Figure 1, into the locating hole, shown in Figure 4. Set the unit in place so that the accessory mounting hole is on top of the hole drilled in Step 3. The actuating lever of the Shunt Trip and the reset lever of the trip unit must be positioned with respect to the circuit breaker crossbar as shown in Figure 2.

7. **Secure unit.** Fasten the Shunt Trip accessory firmly in place using the 1-inch self-tapping screw and lock washer supplied, as shown in Figure 6.

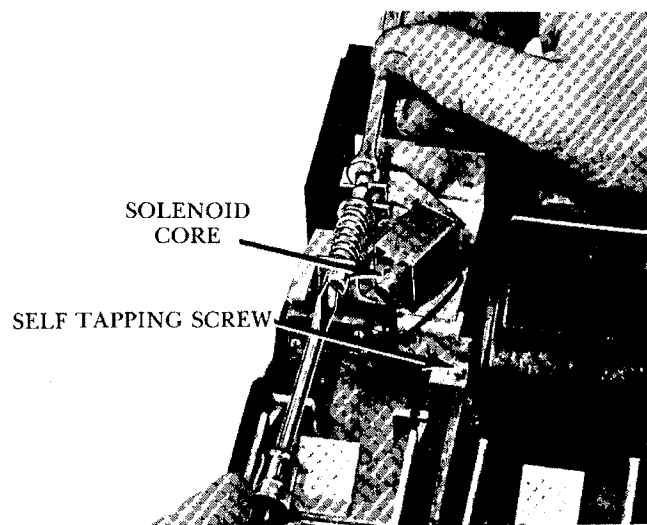
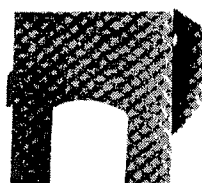


Figure 6. Shunt Trip accessory installed in the breaker (right pole installation shown).

8. **File slot for leads.** To bring the accessory leads out the side of the breaker, file openings in the breaker cover at any point between $3\frac{21}{32}$ " to $5\frac{3}{4}$ " from the trip end of the breaker, as shown in Figure 4. Note that accessories with leads brought out the back of the breaker are available factory installed.
9. **Installation in Type TB4 Circuit Breakers.** When installing a Shunt Trip in a Type TB4 breaker, place barrier A, illustrated in Figure 7, between the phase barrier and the rib in the base, as shown in Figure 8. Place barrier B in the slots next to the handle.

CAUTION: The circuit breaker and accessory must be completely de-energized and disconnected from electrical circuits before adjustments are made. To ensure optimum performance, it is necessary to adjust the Shunt Trip to compensate for manufacturing variations in the breaker. These adjustments were already made if the Shunt Trip was installed at the factory.



BARRIER "A"



BARRIER "B"

Figure 7. Two barriers installed with the Shunt Trip in Type TB4 circuit breakers.

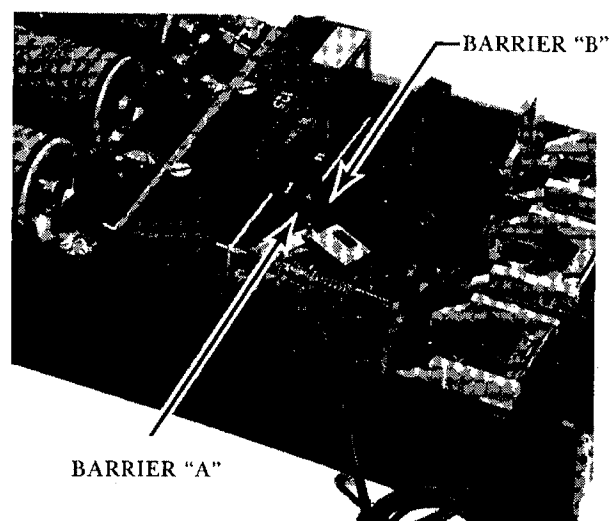


Figure 8. Installing the barriers in a Type TB4 breaker.

ATTENTION: Il faut que le disjoncteur et l'accessoire soient complètement désamorcés et débranchés des circuits électriques avant que ne soient apportés des ajustements. Afin d'assurer une performance optimale, il faut ajuster le déclenchement shunt pour compenser les variations de fabrications du disjoncteur. Ces ajustements ont déjà été faits si le déclenchement shunt a été installé à l'usine.

10. **Adjustments.** With the circuit breaker in the ON position and the accessory de-energized, unlatch the Shunt Trip by pushing the core through the solenoid. Turn the slotted end of the plunger, while holding the other end with a wrench, as shown in Figure 6. Turn the screwdriver counter-clockwise until the breaker trips, then continue for two additional turns.

To prevent loss of adjustment due to vibration, tighten the lock nut, shown in Figure 1, against the plunger to 6 in-lb torque.

11. **Mechanical Checkout.**

- Relatch the Shunt Trip and turn the breaker ON.

- Check the cutoff switch actuator to ensure that it does not touch the switch button. The actuator should depress the switch button completely with the breaker in the OFF position.
 - Being careful to keep fingers clear of the breaker contact arms, depress the solenoid core completely into the solenoid. The breaker should trip; if it does not, repeat the adjustment.
- 12. Replace cover.** Replace the breaker cover, taking care that the strain-relief ties or disks are placed one on each side of the hole in the cover.

These instructions do not cover all details or variations in equipment nor do they provide for every possible contingency that may be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise that are not covered sufficiently for the purchaser's purposes, the matter should be referred to the GE Company.



GE Electrical Distribution & Control

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GEH-3435I 1296

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Auxiliary Switch Accessories

For J 600 Line (TJK),
K 1200 Line (TKM)
And TB4, TB6 And
TB8 Circuit Breakers

General

Circuit breakers and components should be handled, inspected, installed or removed by qualified personnel in accordance with accepted safety procedures.

Auxiliary switch accessories are installed in circuit breakers to operate relay, control, or indicating light circuits simultaneously with the operation of the breaker.

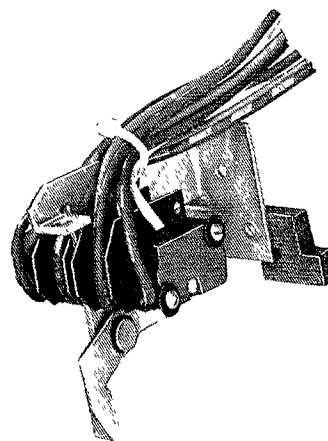
The position of the circuit breaker main contacts is indicated by closed or open auxiliary switch contacts as follows:

Normally-open, "A" contacts—open when the breaker is open or tripped, closed when the breaker is closed.

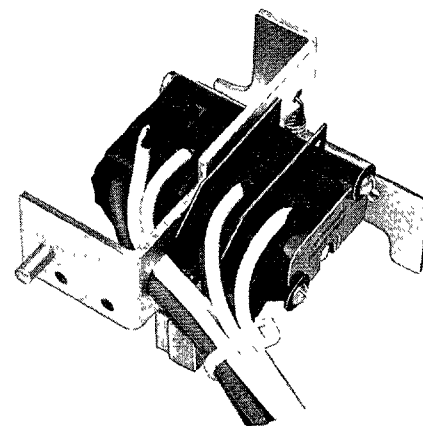
Normally-closed, "B" contacts—closed when the breaker is open or tripped, open when the breaker is closed.

Auxiliary switches for TJK or TKM circuit breaker consist of one to four "AB" elements (Figure 1). Each "AB" element is one 3-terminal, single-pole, double-throw switch with 3 color-coded wire leads connected to the switch terminals and brought out through the circuit breaker case, extending a minimum of 24 inches outside the breaker. An "AB" switch element can be used in an auxiliary circuit as a single "A" contact, using only the red and white leads, or a single "B" contact, using only the brown/white and white leads. It can also be used as both an "A" contact and a "B" contact, using all three leads, provided a common connection in the auxiliary circuit wiring between the "A" and "B" contacts is permissible.

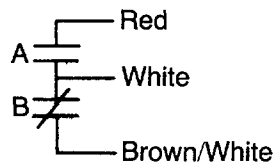
The auxiliary switch assembly is left- or right-pole mounted. It is fastened to the circuit breaker base and occupies the space adjacent to the operating mechanism. An auxiliary switch does not interfere with the operation of the trip unit or operating mechanism.



K 1200 Line Breaker



J 600 Line Breaker



Elements Schematic

Figure 1 Auxiliary Switch With Four AB Elements

Auxiliary Switch Accessories

Installation—J 600 Line Breaker Figure 2

CAUTION: The breaker must be completely de-energized and disconnected from the electrical circuit, when the auxiliary switch is being installed. This is mandatory because the breaker must be in the ON position while the accessory is being installed.

Auxiliary Switch Kits

Cat No Add L or R suffix for left or right-pole mounting		Number of Switch Elements	Maximum Ampere Rating Switch Element
For 240 volts AC	For 600 volts AC		
FOR J 600 LINE BREAKERS			
TJKASA2AB1	TJKASA6AB1	1	6A at rated voltage 1/4A at 250 volts DC 1/2A at 125 volts DC
TJKASA2AB2	TJKASA6AB2	2	
TJKASA2AB3	TJKASA6AB3	3	
TJKAST2AB4	TJKASA6AB4	4	
FOR K 1200 LINE BREAKERS			
TKMAAS2AB1	TKMAAS6AB1	1	6A at rated voltage 1/4A at 250 volts DC 1/2A at 125 volts DC
TKMAAS2AB2	TKMAAS6AB2	2	
TKMAAS2AB3	TKMAAS6AB3	3	
TKMAAS2AB4	TKMAAS6AB4	4	

Keep hands clear of mechanism at all times.

1. Remove cover from breaker by unscrewing eight cover screws. Do not remove the trip unit.
2. Be sure the circuit breaker is de-energized or removed from the circuit. With 0.125 diameter drill, drill through hole on the pole where accessory is to be installed. This hole should be drilled from the front or back of the breaker; use one of the spotting holes between pole units which is located 5³/₈" from the load end of the breaker (See Figure 3.)
3. Set switch in place, inserting locating pin into locating hole. Align the accessory mounting hole with hole drilled in step 2.
4. Fasten the accessory firmly in place with 1" × #6 self-tapping screw and lock washer (supplied).
5. To bring the accessory leads out the side of the breaker, file necessary openings in the breaker cover at any point 2¹/₂" to 3¹/₄" from the load end of the breaker.

NOTE: UL listing is voided when the circuit breaker is modified to add an accessory.

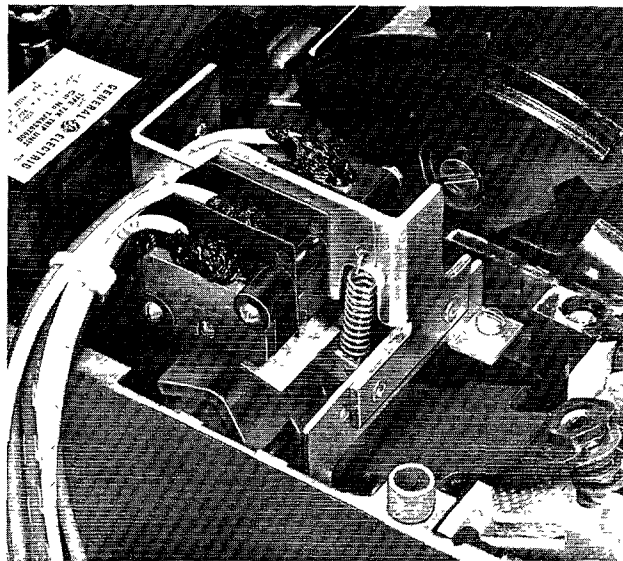


Figure 2 Auxiliary Switch installed in J 600 Case Breaker

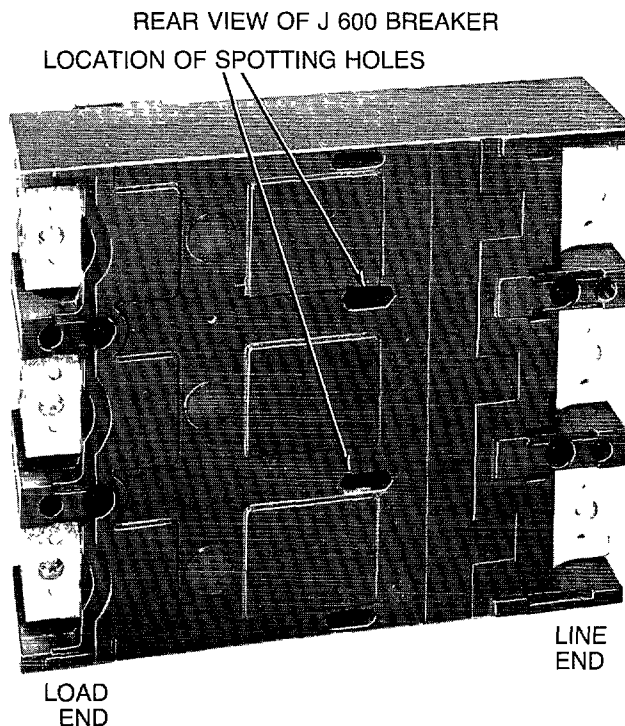


Figure 3 Spotting Holes Location

Installation—K 1200 Line Breaker Figure 4

Keep hands clear of mechanism at all times.

1. Remove the breaker cover by unscrewing the four cover screws. (Cover screws are those closest to the breaker handle.)
2. Locate the mounting bracket on the trip unit case. Fasten firmly in place (See Figure 5).
3. With $\frac{1}{4} \times 8-32$ accessory mounting screw in mounting hole, set the accessory in place. Phenolic support must sit in groove in the circuit breaker's molded base. Fasten firmly in place.
4. To bring the accessory leads out of the side of the breaker, file the necessary openings on accessory pole of the breaker cover, $4\frac{3}{4}$ to $5\frac{1}{4}$ inches from the load end of the cover. Care should be taken in forming the bundle of leads so that no wires interfere with the white trip button. Remove the load lug cover when making the measurement.

NOTE: UL listing is voided when the circuit breaker is modified to add an accessory.

Check for proper operation of The accessory after installation.

Mechanical Check:

With the breaker open, check to be sure that the switch actuator does not depress the switch buttons. Switch buttons are depressed when the breaker is closed.

Electrical Check:

Check for continuity to see that:

"A" contacts (red and white leads) are open when the breaker is open or tripped, and closed when the breaker is closed; "B" contacts (brown/white and white leads) are closed when the breaker is open or tripped; and open when the breaker is closed.

For future identification of the respective "AB" elements after the breaker cover is replaced, the leads associated with each "AB" switch element should be marked or taped together during the continuity check.

Replace the circuit breaker cover (arrange leads through the side opening), taking care that loops and ties or restraining discs are inside the breaker cover, and wire tie or disc is outside the breaker cover. Tighten the cover screw. The breaker is now ready for mounting.

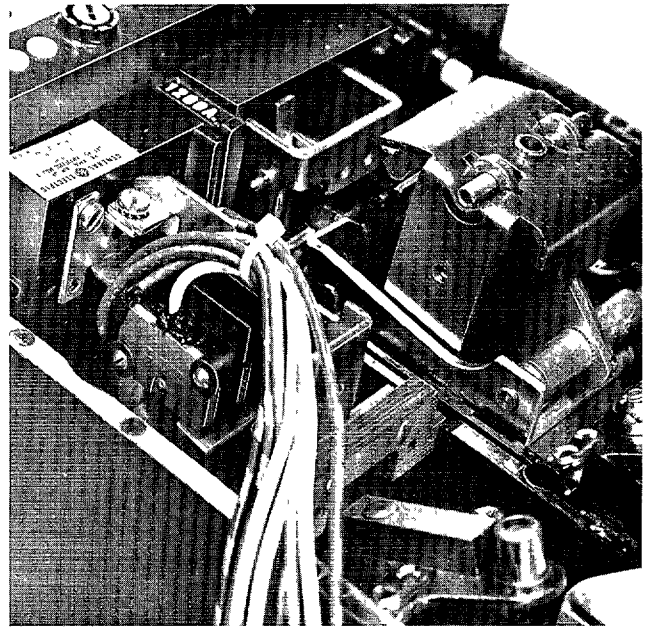


Figure 4 Auxiliary Switch installed in
K 1200 Molded Case Breaker.

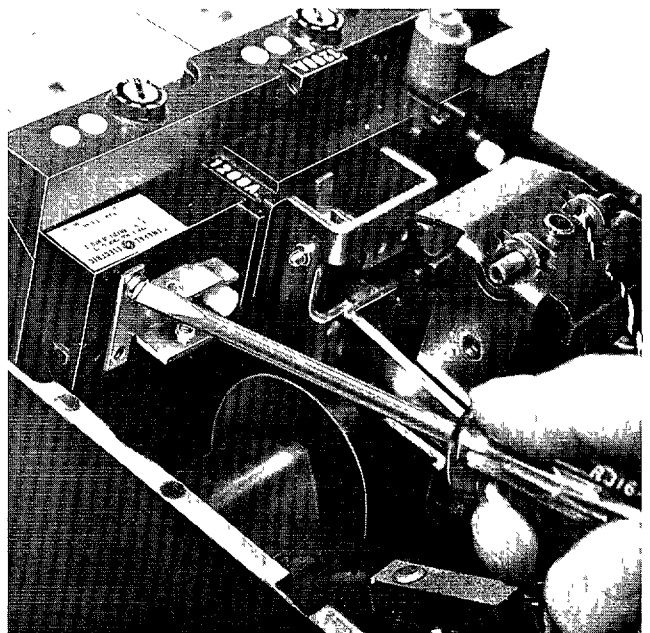


Figure 5 Mounting Bracket on TKMA trip unit

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

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Outside the U.S. write Construction Equipment Export Operation
411 Theodore Fremd Ave., Rye, NY 10580
GEH-3321G 1185 PSA

GENERAL  **ELECTRIC**



Bell Alarm Switch Accessory

For Types TJJ, TJK, THJK, TJS, TJSS, TJR, THJR, TB4

NOTE: UL listing is voided when the circuit breaker is modified to add an accessory. UL label must be destroyed.

Breaker Type	Bell Alarm Kit Cat. No.	Max. Volts	Max. Amperes
J 600 Line	TJKBAAL	240 VAC	5A

DESCRIPTION

The bell alarm device contains a single pole, double-throw switch which is actuated by the breaker trigger. Thus, only when the breaker is tripped due to over current condition, will this switch function and either close or open a circuit as desired. *For center pole mounting only.*

INSTALLATION

WARNING: The circuit breaker must be completely de-energized and disconnected from the circuit when accessories are installed.

1. Remove the circuit breaker cover (Figure 2).
2. With the breaker *tripped*, hold the handle as far as possible toward ON and install the breaker mounting bracket on the *right-hand* breaker mechanism frame (Figure 3).

KIT

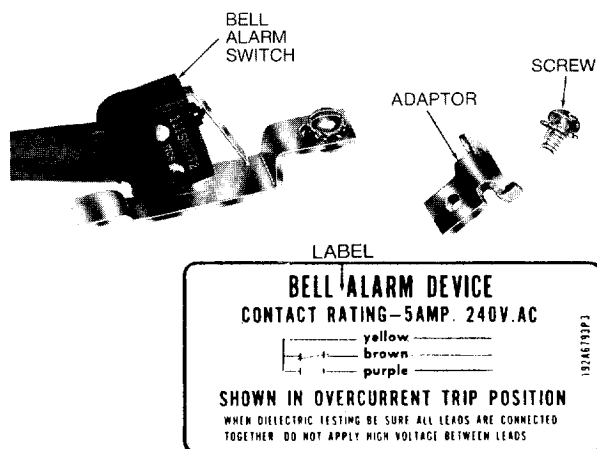


Figure 1

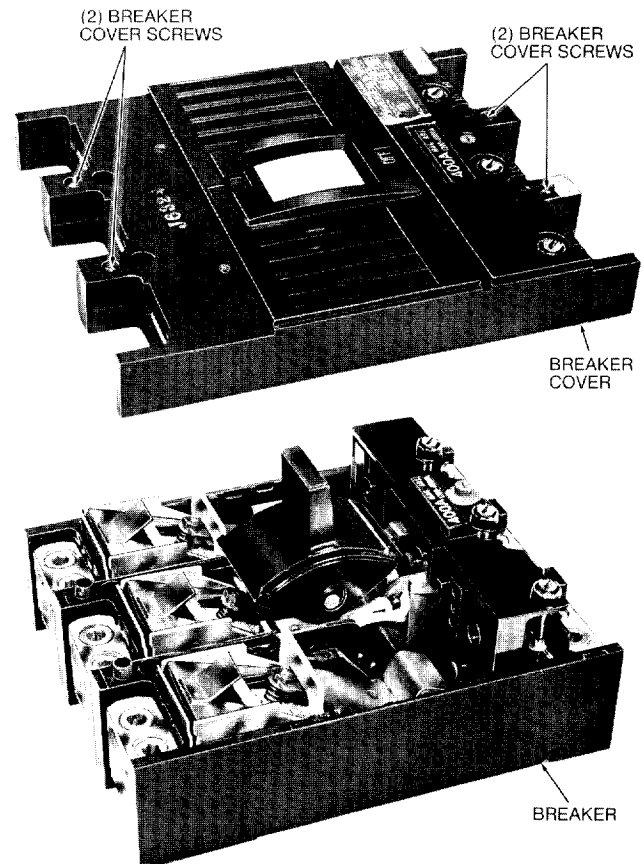


Figure 2

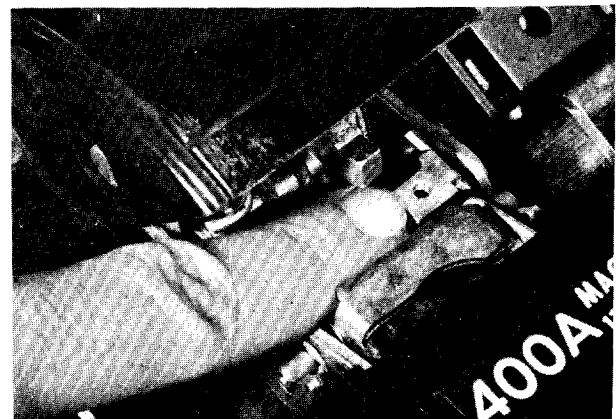


Figure 3

3. Hold the breaker handle toward ON (*breaker tripped*), and insert the bell alarm tab into the slot of the breaker mechanism frame (Figure 4).
4. Hold the breaker handle toward ON and start the screw in the bell alarm switch base into the tapped hole in the mounting bracket. **DO NOT TIGHTEN SCREW.**
5. Reset the breaker, and move handle to ON.
6. Use a screwdriver to slide the bell alarm switch against the breaker trigger, until the switch actuator is depressed to within 1/64 to 1/16 inch of the switch body (Figure 5). Tighten the screw.
7. Leads can be brought out through the left side of the breaker. File lead-out slots in the left side of the breaker cover approximately 3½ inches from the load end of the breaker. (Figure 6)
8. Bring bell alarm switch leads over latch pin through the lead-out slots. Be careful to avoid wedging leads in the breaker mechanism.
9. Trip the breaker, using "twist-to-trip" button.
10. Replace the breaker cover, taking care that strain relief ties or discs are placed one on each side of hole in cover. Proceed with electrical-mechanical check.

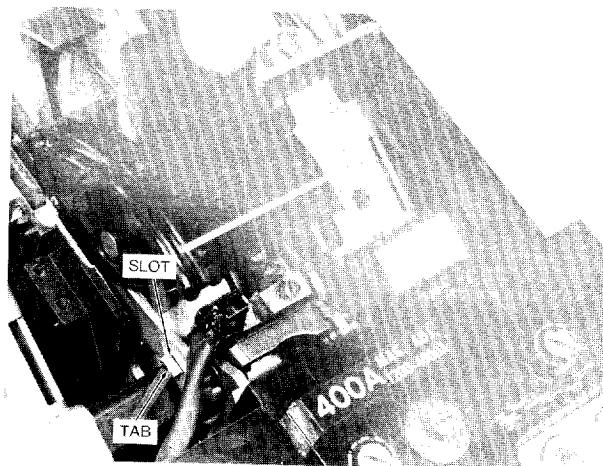


Figure 4

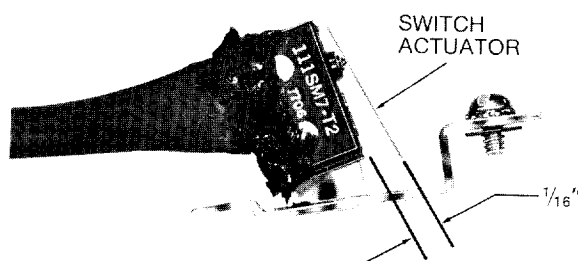
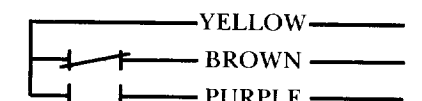


Figure 5

ELECTRO-MECHANICAL TESTS

With breaker still in the tripped position, circuit between accessory leads colored YELLOW and BROWN should be CLOSED, and between YELLOW and PURPLE should be OPEN. If it is not, check to see that switch actuator has been sufficiently depressed. If not, correct as follows:

- a. Reset breaker mechanism.
- b. Readjust switch per step 6.
- c. Trip breaker to check adjustment.



Bell Alarm Device

(Shown in breaker, tripped condition)

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the GE Company.

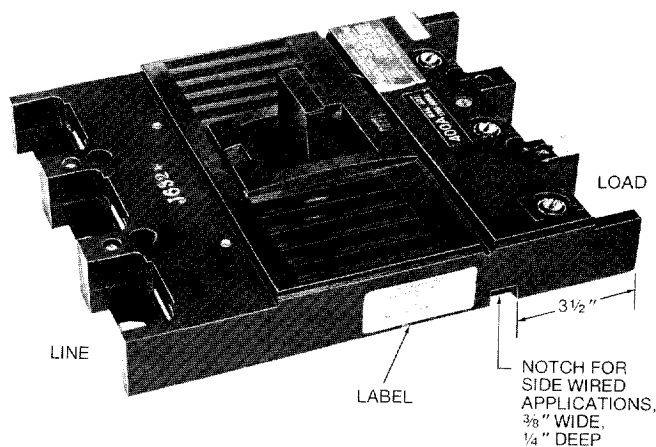


Figure 6



GE Electrical Distribution & Control

General Electric Company
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GEH-3320D 0289 PS

MAGNAPLUS[®] GENERATOR

280–430 Frame Installation, Operation, and Maintenance Manual



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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

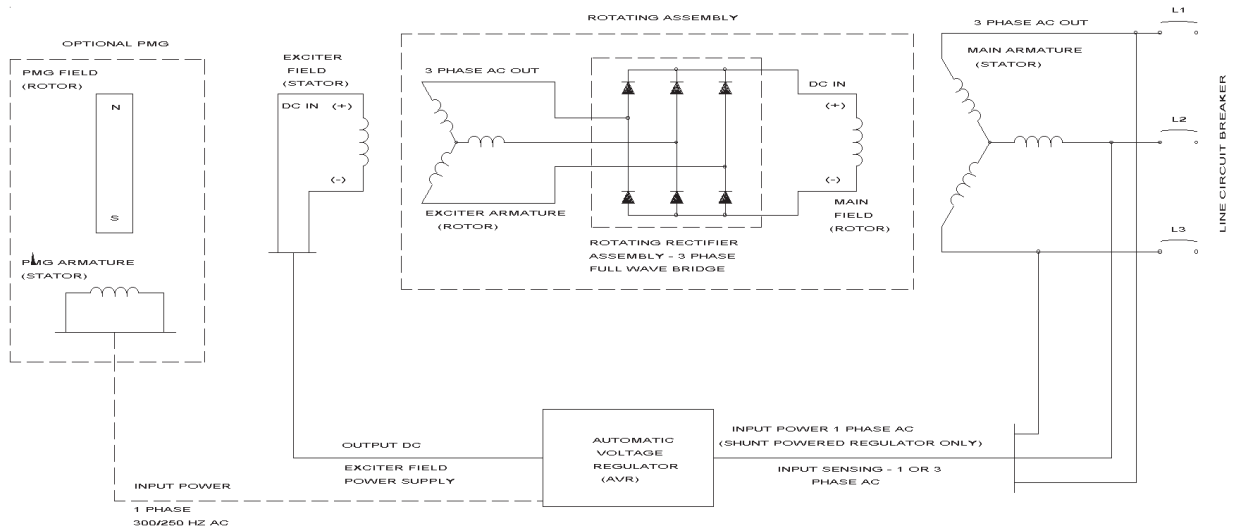


FIGURE 1 -- MagnaPLUS® Circuit Diagram

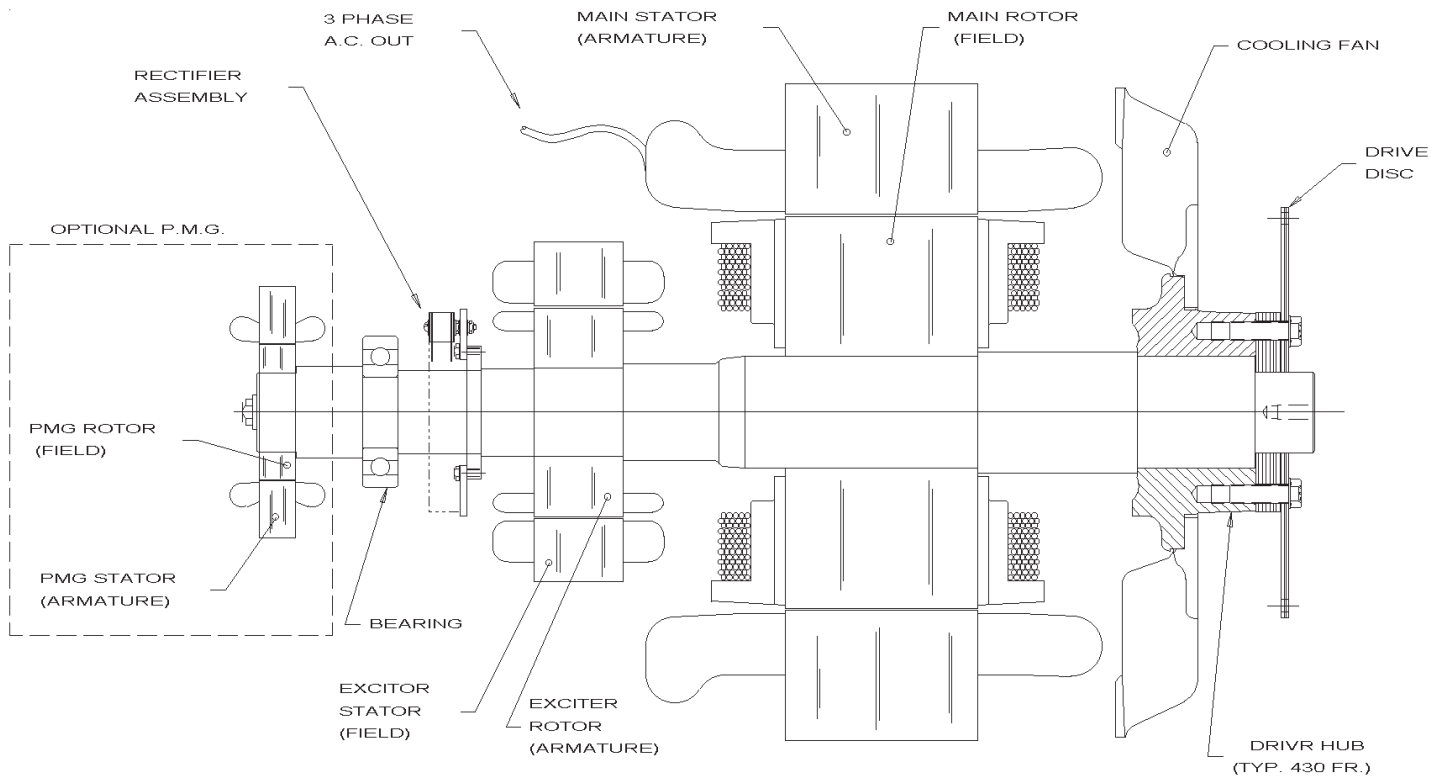


FIGURE 2 -- Typical MagnaPLUS® Layout Diagram

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.

⚠ 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 contact 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.

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).

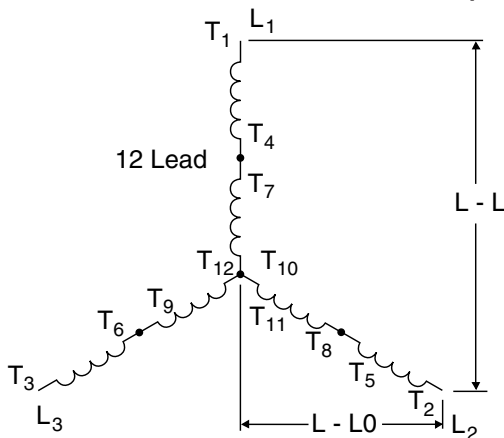
Refer to the connection diagram supplied with the generator and / or the proper diagrams shown in this manual. Install all inter component and external wiring in accordance with national and local electrical codes. The neutral in the following connection diagrams shown below may be either grounded (earthed) 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.

WIRING CONNECTIONS

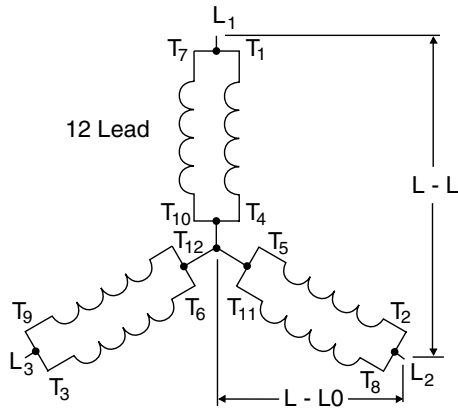
Wiring of the generator and accessories should be done in accordance with good electrical practices. Follow government, industry and association standards.

HIGH (SERIES) WYE CONNECTION



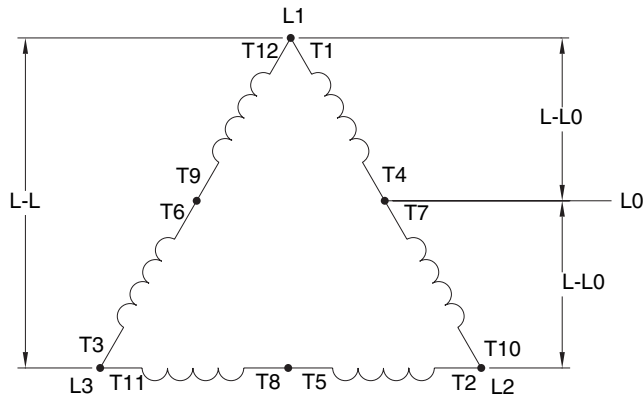
VOLTAGE (HIGH WYE)		
Hz	L-L	L-Lo
60	380	219
	416	240
	440	254
	460	266
	480	277
50	380	219
	400	231
	415	240
	440	254

LOW (PARALLEL) WYE CONNECTION



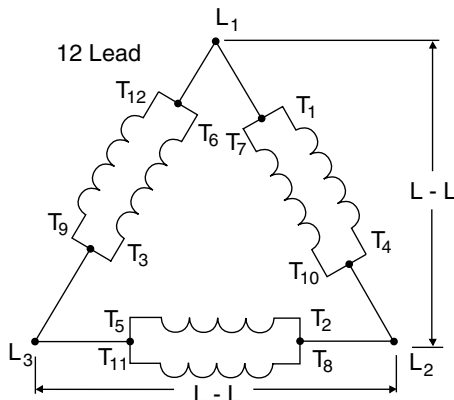
VOLTAGE (LOW WYE)		
Hz	L-L	L-L0
60	190	110
	208	120
	220	127
	230	133
	240	139
50	190	110
	200	115
	208	120
	220	127

HIGH (SERIES) DELTA CONNECTION



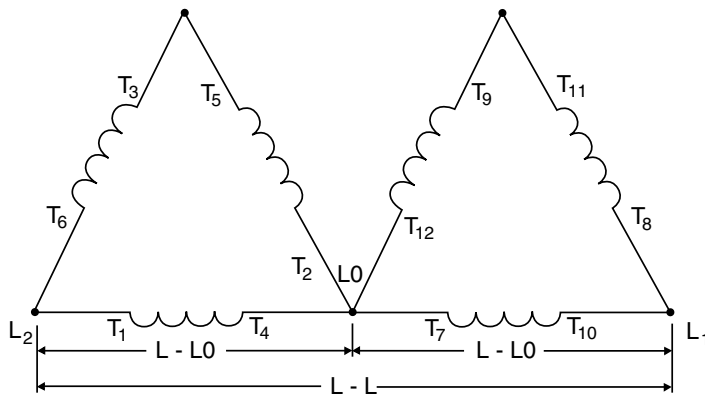
VOLTAGE (HIGH DELTA)		
Hz	L-L	L-L0
60	240	120
	277	139
50	200	100
	220	110
	240	120

LOW (PARALLEL) DELTA CONNECTION



VOLTAGE (LOW DELTA)	
Hz	L-L
60	110
	120
50	100
	110

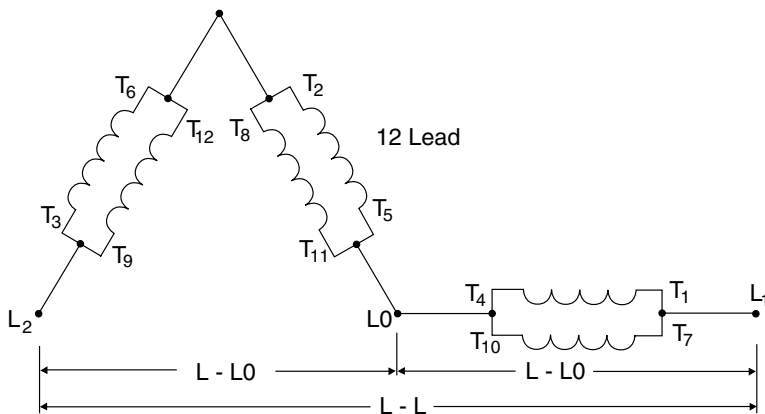
DOUBLE DELTA -- SINGLE PHASE CONNECTION



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.

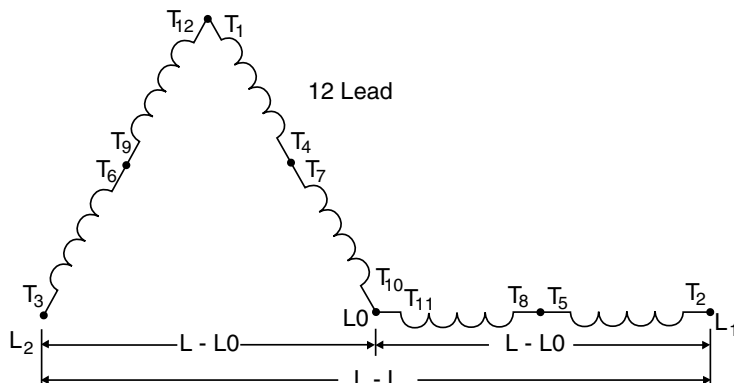
LOW ZIG ZAG -- SINGLE PHASE (PARALLEL) CONNECTION



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.

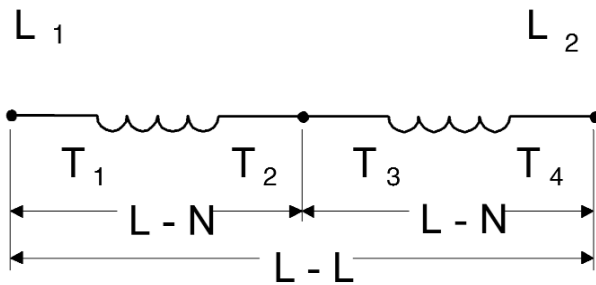
HIGH ZIG ZAG -- SINGLE PHASE (SERIES) CONNECTION



VOLTAGE (LOW ZIGZAG)		
Hz	L-L	L-LO
60	480	240

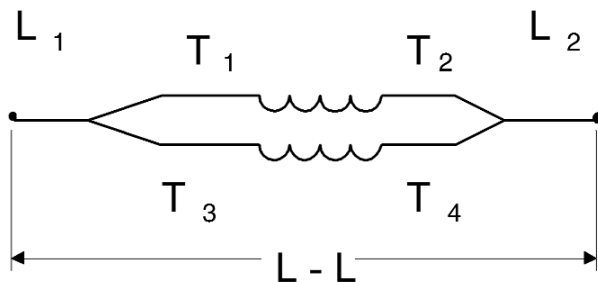
Note: Single phase KW/KVA ratings are approximately equal to 50% of the generator's three phase ratings.

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.

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).



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.



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

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.



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.

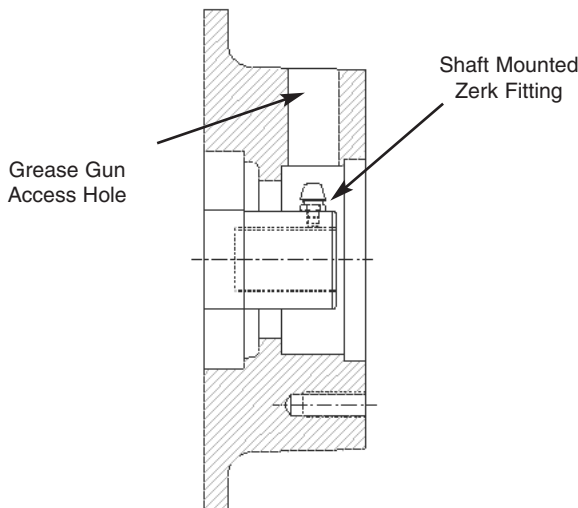


Figure 3--Drive End Bearing Bracket

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 generator's 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.

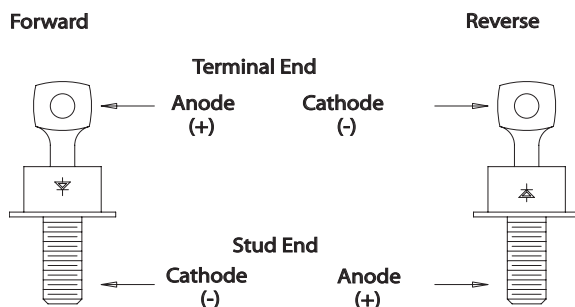


FIGURE 4: DIODE POLARITY

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.



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

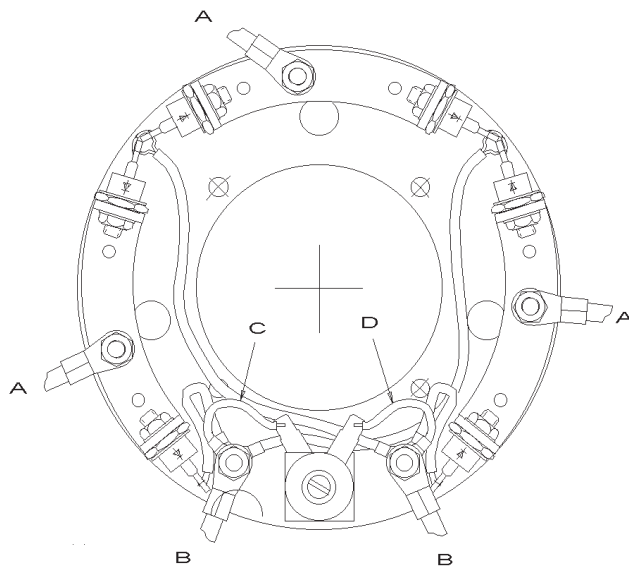
Using a bearing puller, remove the existing bearing. It is strongly recommended that the bearing be replaced any time the it is removed from the shaft. **ALWAYS** install the same type and size bearing that was supplied as original equipment. Order by part number from the parts list, and include the 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

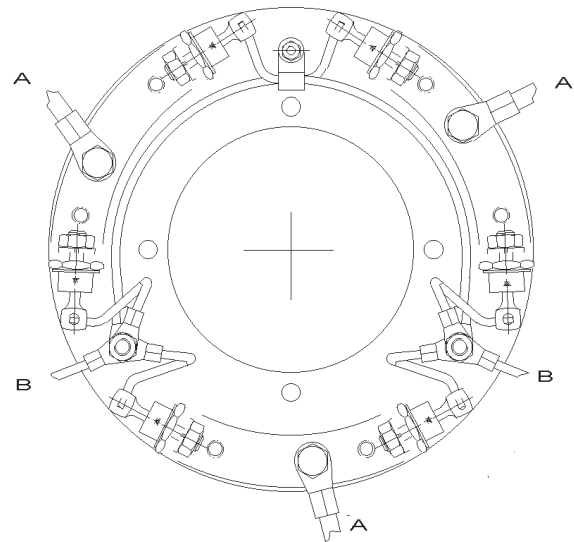
The rectifier assembly cannot be removed until the opposite drive end bearing bracket and bearing have been removed (see bearing removal procedure). Remove the three exciter rotor leads from the heat sinks and the two main rotor leads from the main rotor posts (see Figures 5). Remove the screws securing 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.



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.



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.

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.



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.

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

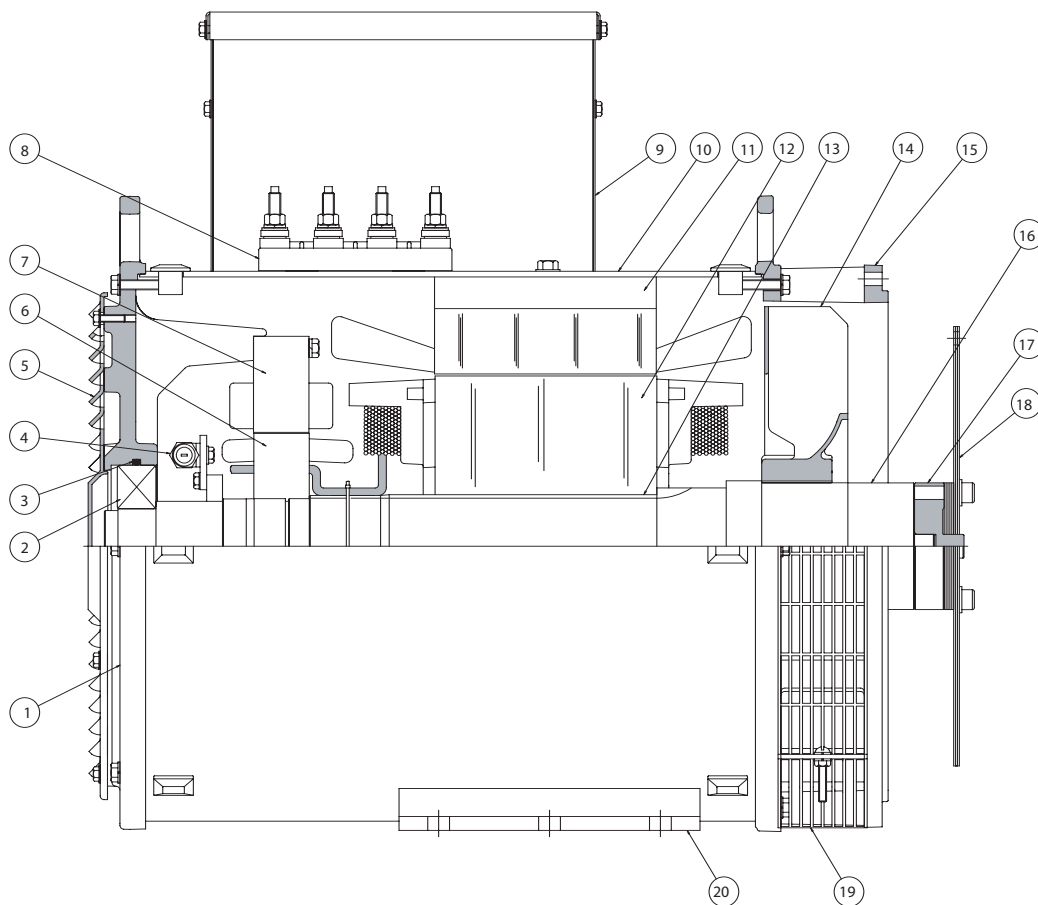
MODEL	GENERATOR RESISTANCE		EXCITER FIELD NO LOAD VOLTS 480 V / 60 HZ
	STATOR*	ROTOR	
281PSL1500	4.20	.400	11.0
281PSL1501	4.15	.400	11.0
281CSL1502	0.47	0.72	6.40
281PSL1502	3.20	.439	9.0
282PSL1703	1.07	0.34	14.70
282CSL1504	1.24	0.80	6.20
282PSL1704	1.07	0.34	14.70
282CSL1505	0.87	0.90	5.80
282PSL1705	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

DEDICATED SINGLE PHASE	GENERATOR RESISTANCE		EXCITER FIELD NO LOAD VOLTS 480 V / 60 HZ
	STATOR	ROTOR	
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

* Stator resistance measured line to line in a high wye connection.

PARTS LIST – SINGLE BEARING

Typical Generator Cross Section

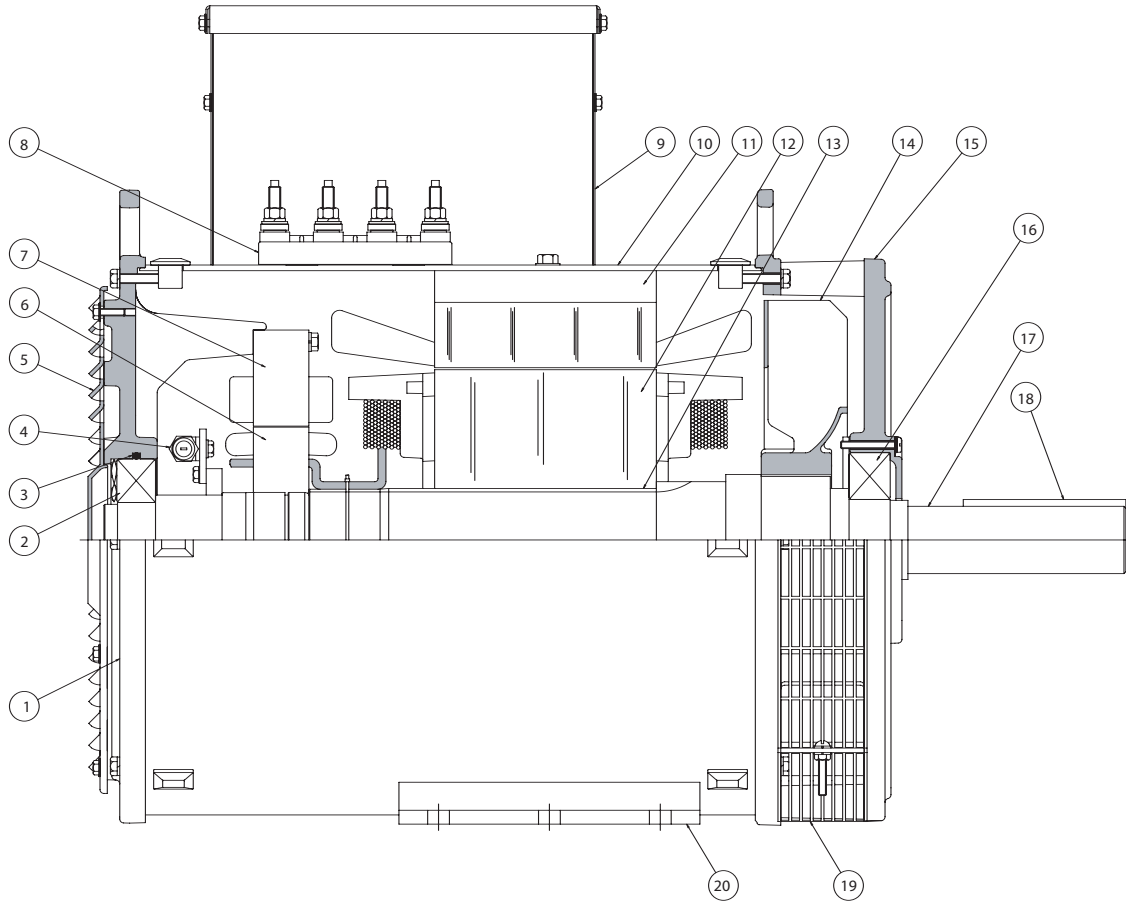


Reference Number	Part Name	Reference Number	Part Name
1	End Bracket (under end cover 360 & 430 frames)	11	Main Stator
2	Bearing	12	Main Rotor
3	O-ring (280 and 360 frame only)	13	Rotor Integral Keyway
4	Rectifier Assembly	14	Fan
5	Air Intake Cover	15	Mounting Adapter (SAE)
6	Exciter Rotor	16	Shaft
7	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.

PARTS LIST – DUAL BEARING

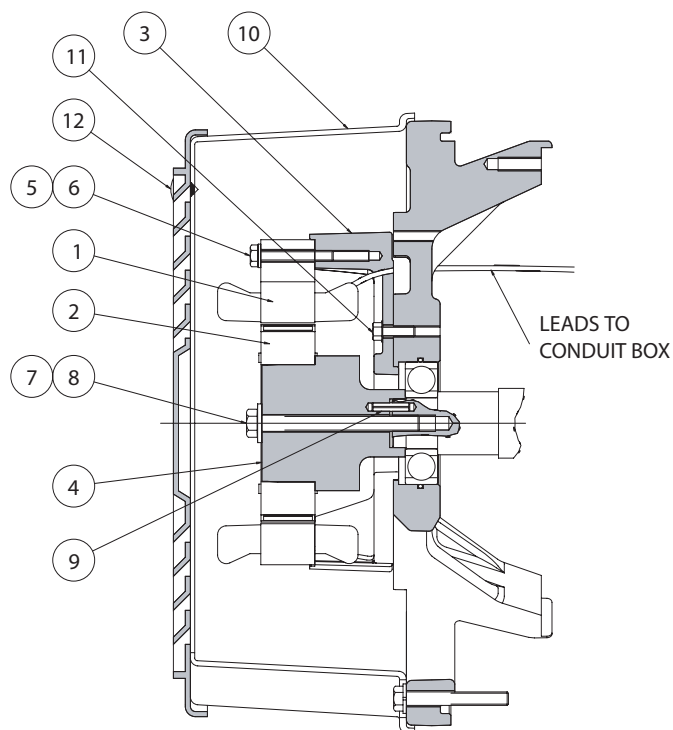
Typical Generator Cross Section



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

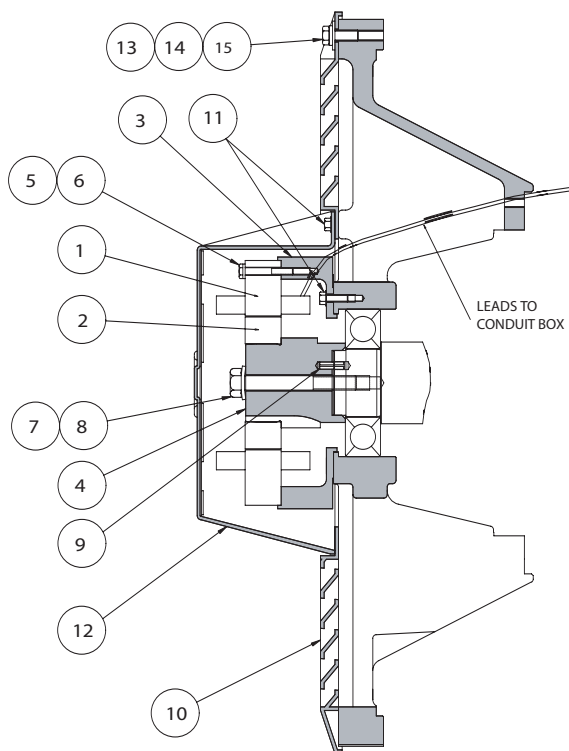
Note: Illustration above is a 360 frame MagnaPLUS®. Other Frame sizes are typical. Optional PMG not shown. The generator model and serial numbers are required when ordering parts.

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



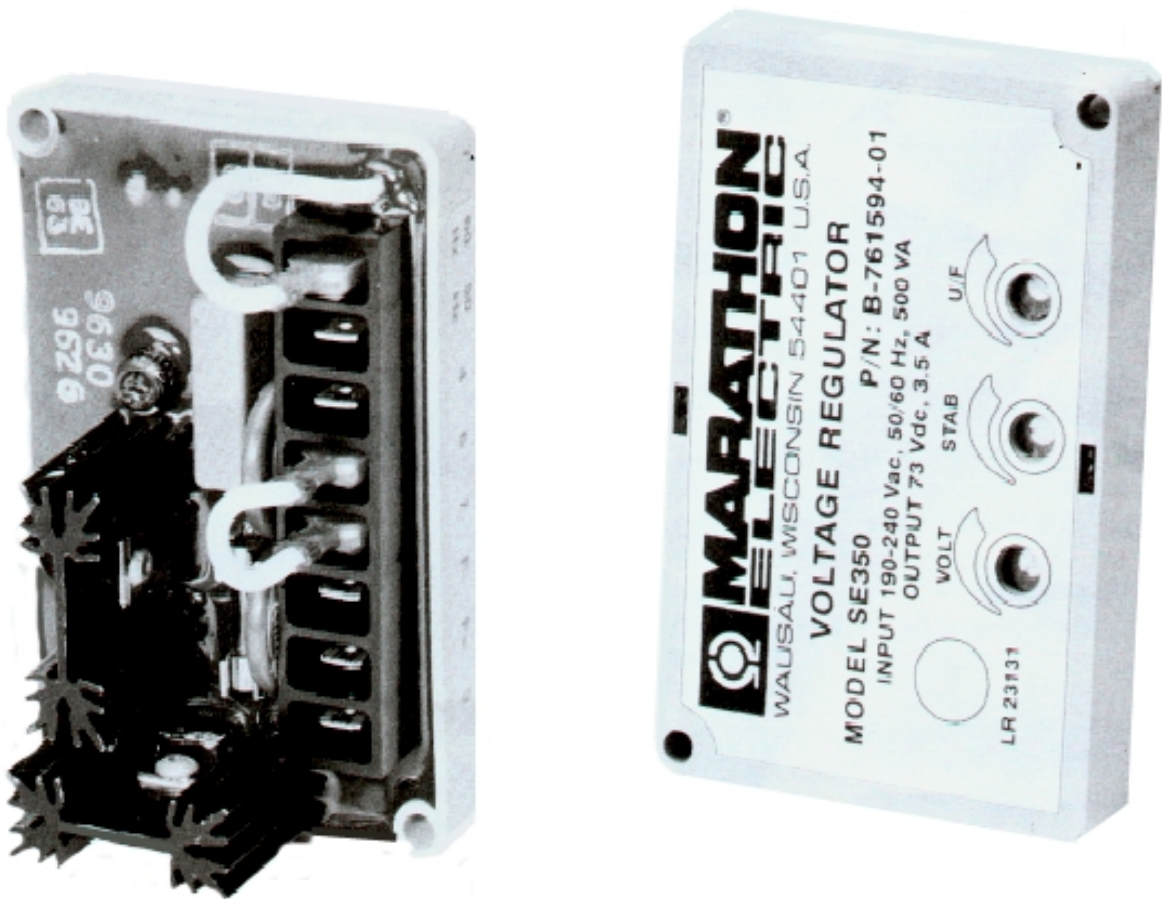
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Wausau, WI 54402-8003 USA
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SE350

VOLTAGE REGULATOR

INSTRUCTION MANUAL



MARATHON ELECTRIC®
A Subsidiary of Regal-Beloit Corporation

INTRODUCTION

The SE350 voltage regulator is an encapsulated electronic voltage regulator that controls the output of a brushless AC generator by regulating the current into the exciter field.

SPECIFICATION	SE350 REGULATOR
Sensing & Power Input	190-240 Vac
Burden	500 VA
Output Power- Continuous	73 Vdc at 3.5 Adc (255w)
Output Power - Forcing(240 Vac Input Power)	105 Vdc at 5 Adc (525w)
Regulation	1 .0%
Remote Voltage Adjustment Range	± 10% with 2000 ohm rheostat ± 5% with 1000 ohm rheostat
Frequency Compensation	Adjustable
Roll off frequency	54-61 Hz for 60 Hz 45-51 Hz for 50 Hz
Operation	Weight 6.5 oz.
Operating Temperature	- 40°C to + 60°C
Storage Temperature	- 65°C to + 85°C
Power Dissipation	8 watts maximum
Size	3.94" L X 2.66" W X 2.20" H
Voltage Buildup	Internal provisions for automatic voltage build up from generator residual voltage as low as 10 Vac.
EMI Suppression	Internal Electromagnetic Interference Filter (EMI Filter)

WARNING

**TO PREVENT PERSONAL INJURY OR EQUIPMENT DAMAGE
ONLY QUALIFIED PERSONNEL SHOULD
INSTALL, OPERATE, OR SERVICE THIS DEVICE.**

**CAUTION: DO NOT megger or high-pot the generator with the regulator connected.
DO NOT high-pot the regulator.**

The SE350 voltage regulator can be mounted in any plane, following are mounting dimensions.

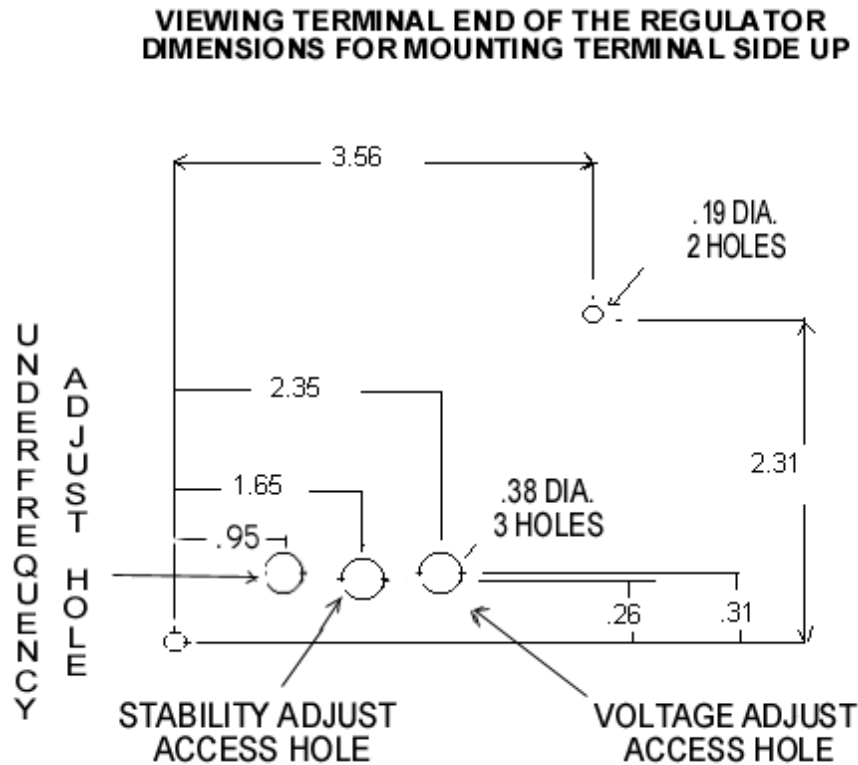


FIGURE 1

FUSE

A 4 Amp, 250 V, 5 X 20 mm fuse is supplied with the regulator (Part A-527066). It can be located on the rear face of the voltage regulator.

EXCITER POWER CIRCUIT

Connect the regulator wire F+ to the generator F+ or F1 field terminal.
Connect the regulator wire F- to the generator F- or F2 field terminal.
See Figure 2 for typical connection diagram

SENSING/POWER INPUT CIRCUIT

Input power and sensing is achieved through terminals 3 and 4.
The voltage input requirement of the SE350 is 190 to 240 Vac. See Figure 2

**INTERCONNECTION DIAGRAM
FOR 416-480 VOLT OR 208-240 VOLT
WYE CONNECTED GENERATOR**

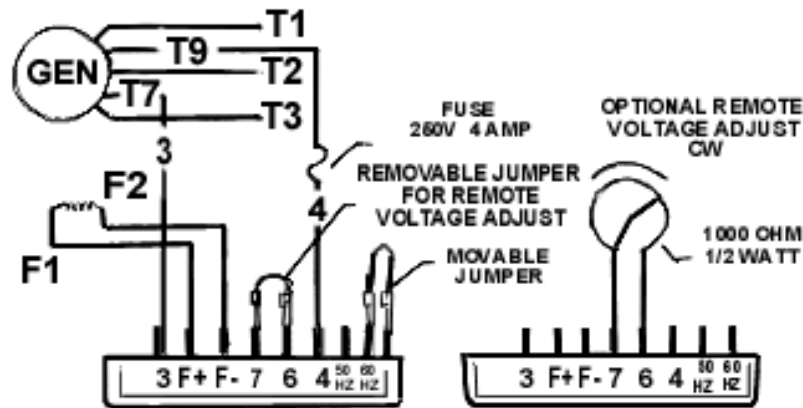


FIGURE 2

VOLTAGE ADJUST

The screwdriver adjustable potentiometer adjusts the generator output voltage. Adjustment clockwise increases the generator output voltage.

When using a remote voltage adjust rheostat, remove the jumper wire across terminals 6 and 7 and install a 2000 ohm 1/2 watt (minimum) rheostat. This will give $\pm 10\%$ voltage variation from the nominal. (For $\pm 5\%$ voltage variation use a 1000 ohm 1/2 watt rheostat). See Figure 2.

STABILITY ADJUST

System stability is the ability of the generator to respond to load transients. Decreasing the stability makes the generator less sluggish and faster to respond to load transients. If the stability of the regulator is decreased too much, the generator will tend to hunt under steady state conditions.

The screwdriver adjustable potentiometer adjusts the system stability. Adjustment clockwise increases the stability. Increasing the stability increases the response time of the generator. Conversely, decreasing the stability decreases the response time of the generator.

V/HZ ROLL-OFF FREQUENCY SELECTION

The roll off point is the frequency where the generator voltage starts to decrease. This reduces the Kilowatt load to the engine, which allows the engine to recover in speed under any load transient condition. Use jumper to select 50 HZ or 60 Hz. The screwdriver adjustable potentiometer sets the roll-off frequency from 54-61 Hz in the 60 Hz setting or from 45-51 Hz in the 50 Hz setting.

The SE350 has the roll-off point preset to 58 Hz in the 60 Hz mode and 48 Hz in the 50 Hz mode. To change the roll-off point, adjust engine speed to the desired rated speed. (50 or 60 Hz). Set the voltage to the desired setting at rated speed. Adjust engine speed to the desired roll-off point. Turn the potentiometer counterclockwise until the voltage starts to drop off. Then adjust the potentiometer clockwise until the voltage returns to rated voltage. Re-adjust engine speed to rated speed.

PRELIMINARY SET-UP

Ensure the voltage regulator is correctly connected to the generator. Refer to the specific connection diagram supplied with the generator.

Set the regulator voltage adjust to full counter-clockwise (minimum voltage level).

Set the remote voltage adjust (if used) to the center position.

Set the stability control full clockwise (maximum stability level).

Connect the positive lead of a 100 V D.C. voltmeter to F1 and the negative lead of the voltmeter to F2 or use an appropriate AC voltmeter on the generator output leads.

SYSTEM START-UP

Start and run the generator at no load and rated speed. The generator voltage should build up to a minimum level. (Actual level is dependent upon connection). If it does not build up, refer to field flashing section in generator manual.

Slowly adjust the voltage control until the generator voltage reaches the nominal value. If used, adjust the remote voltage rheostat to set the generator voltage to the exact value desired.

Turn the stability adjust counter-clockwise until instability is shown on either of the voltmeters mentioned in the “PRELIMINARY SET-UP” section. With the system operating in an unstable condition, slowly adjust the stability control clockwise until generator stability is reached.

Interrupt regulator power for a short time (approximately 1-2 seconds).

If the generator remains stable, no further adjustment is necessary. If the generator does not remain stable, increase the stability slightly and interrupt regulator power again.

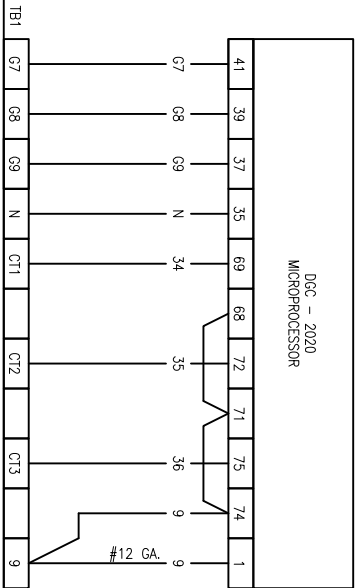
This procedure should be repeated until system stability is reached and maintained.

TROUBLESHOOTING

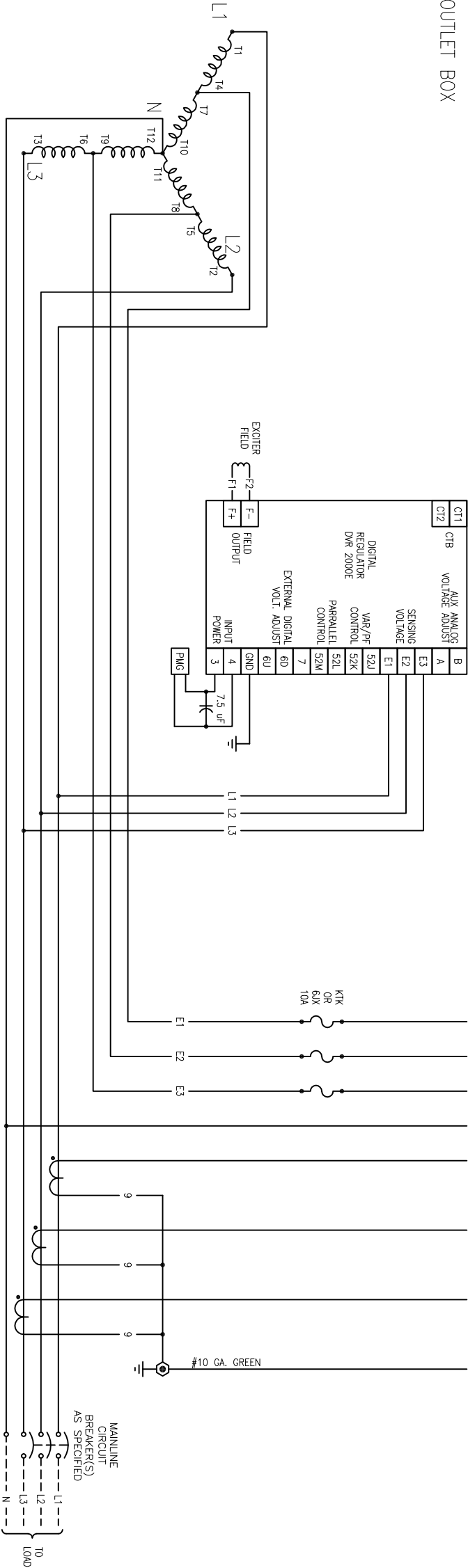
Symptom	Cause	Action
Residual Voltage -No Output	Residual voltage at regulator power input wires 3 & 4 below 10 V ac.	Check wiring diagram for proper connections. Flash generator field. Refer to field flashing section in generator manual.
	Acceleration time to rated speed too long.	Reduce acceleration time. Interrupt power input to regulator after achieving rated speed.
	Field leads F1, F2 not connected.	Connect field leads F1, F2.
	Power input leads not connected.	Connect power-input leads 3,4.
	Blown or missing fuse.	Replace fuse.
	Defective regulator.	Replace regulator.
Output Voltage Low	Defective generator.	Consult generator manual.
	Incorrect connections.	Check wiring diagram for proper connections.
	Voltages adjust turned down.	Rotate voltages adjust CW until desired voltage is reached.
	Remote voltage adjust is turned down.	Rotate remote voltages adjust CW until desired voltage is reached.
Output Voltage High	Defective regulator.	Replace regulator.
	Voltages adjust turned too high.	Rotate voltages adjust CCW until desired voltage is reached.
Output Voltage High - No Adjustment	Remote voltage adjust is turned too high.	Rotate remote voltages adjust CCW until desired voltage is reached.
	Defective regulator.	Replace regulator.
Remote Voltage Adjust Operates Backwards	Voltages adjust wire backwards.	Reverse the wiring of the remote voltage adjust.
Generator Output Voltage Hunting	Stability adjusts not set properly.	Rotate the stability adjusts in a CW direction until hunting stops.
Poor Regulation	Defective regulator.	Replace regulator.

CONTROL PANEL

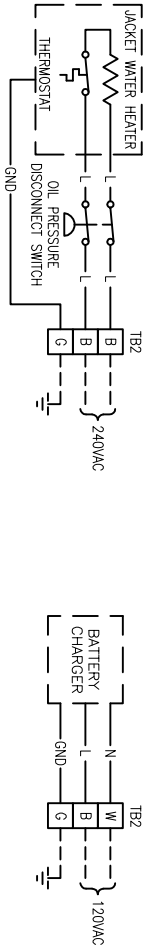
- LEGEND
- DGC - DGC-2020 CONTROLLER
 - GND - GROUND
 - PMG - PERMANENT MAGNET GENERATOR
 - TB1 - TERMINAL BLOCK 1 (CONTROL PANEL)
 - TB2 - TERMINAL BLOCK 2 (BREAKER ENCLOSURE)



GENERATOR OUTLET BOX



CUSTOMER CONNECTIONS



NOTES:
1. SHORT DASHED LINES (-----) INDICATE CUSTOMER CONNECTION OR OPTIONAL EQUIPMENT.

REV

REVISION DESCRIPTION

DATE

BY

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****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: NA

GENERATOR: 12 WIRE

REGULATOR: DVR-2000E

CONTROL PANEL: DGC-2020

VOLTAGE: 480/277 3ø

GOVERNOR: NA

AC DIAGRAM

DATE: 05-26-07

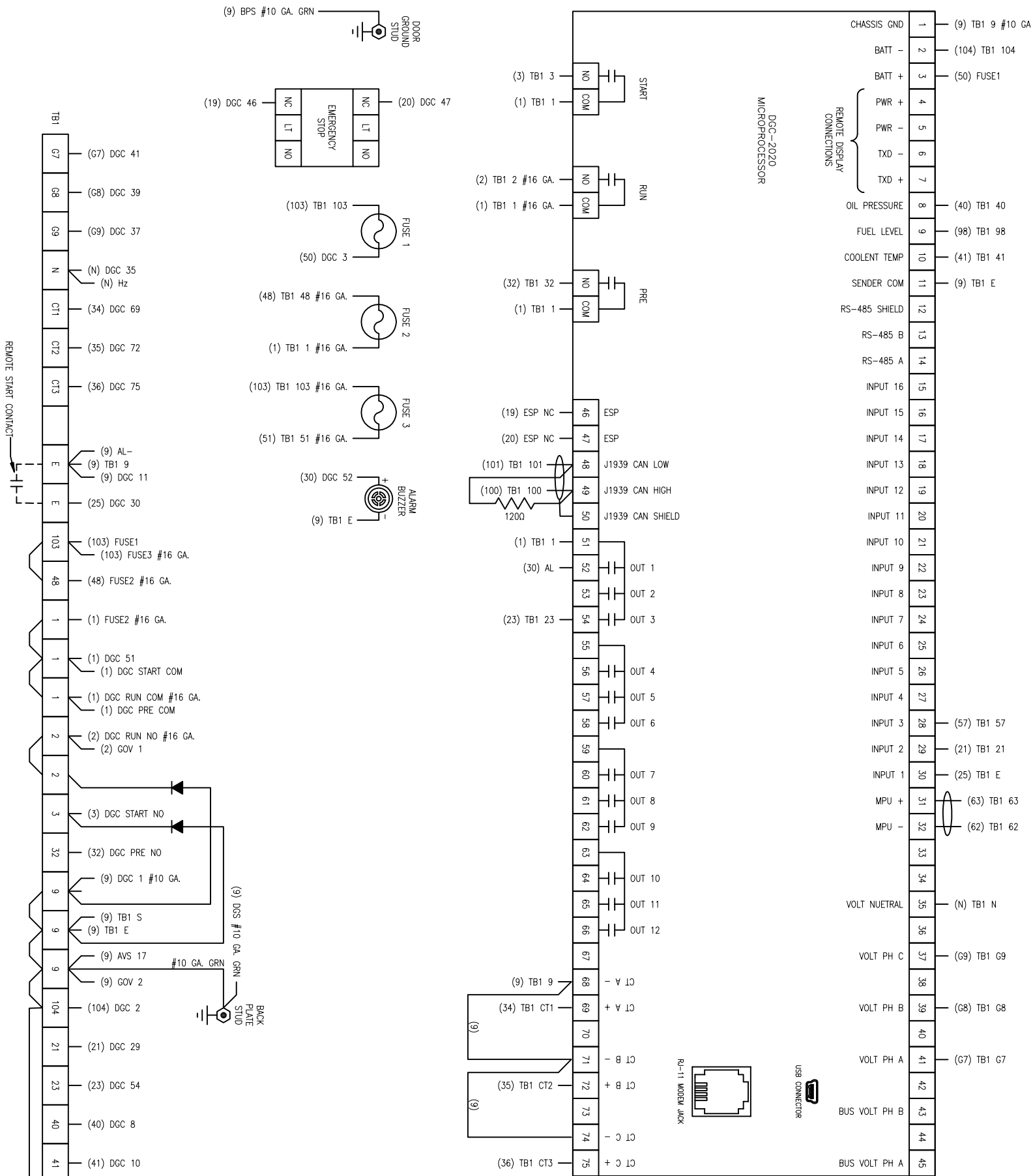
DRAWING SIZE: B-SIZE

DRAWN BY: MK

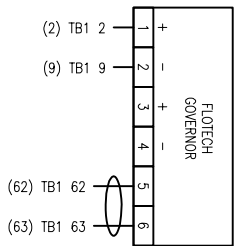
SHEET: 1 OF 1

819-M-17245

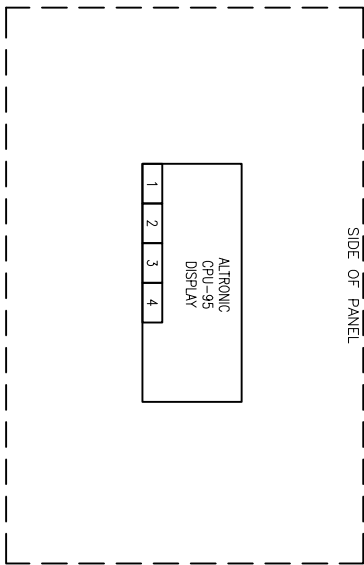
PANEL DOOR



PANEL BACK



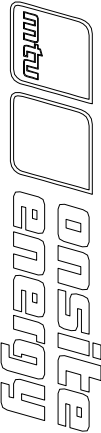
LEGEND	
AL	ALARM BUZZER
BPS	BACK PLATE STUD
DGC	DGC-2020 CONTROLLER
DGS	DOOR GROUND STUD
ESP	EMERGENCY STOP PUSHBUTTON
GOV	GOVERNOR
TB1	TERMINAL BOARD 1



NOTE:

1. FUSE 1 (CONTROLLER) ABC 5 AMP.
2. FUSE 2 (PANEL) ABC 15 AMP.
3. FUSE 3 (IGNITION) ABC 10 AMP.
4. ALL WIRE NUMBERS ARE IN PARENTHESES.
5. USE #20GA WIRE ON ALL DEVICES UNLESS OTHERWISE SPECIFIED.

1	REMOVE GUAGES & 24 RELAY PKG CHANGED DGC 11 TO TB1 E	3-4-09	RWA
REV	REVISION DESCRIPTION	DATE	BY



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****SPECIAL NOTE****

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ENGINE: DOOSAN	GV222
GENERATOR: NA	
REGULATOR: NA	
CONTROL PANEL: DGC-2	
VOLTAGE: 12VDC	
GOVERNOR: FLOTECH	

P P DIAGRAM

DATE: 1-15-09	DRAWING SIZE: B-SIZE
DRAWN BY: RWA	SHEET: 1 OF 2

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