Service

Marine Generator Sets

Models:

13- 40EKOZD
11- 35EFKOZD

Controller:

Decision-Maker® 3500

KOHLER®

TP-6953 7/19f

Product Identification Information

Product identification numbers determine service parts. Record the product identification numbers in the spaces below immediately after unpacking the products so that the numbers are readily available for future reference. Record field-installed kit numbers after installing the kits.

Generator Set Identification Numbers

Record the product identification numbers from the generator set nameplate(s).

Model Designation ______________________________

Specification Number ____________________________

Serial Number __________________________________

Accessory Number	Accessory Description

Engine Identification

Record the product identification information from the engine nameplate.

Manufacturer __________________________________

Model Designation ______________________________

Serial Number __________________________________

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Table of Contents

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. To prevent accidents be aware of potential dangers and act safely. Read and follow all safety precautions and instructions. SAVE THESE INSTRUCTIONS.

This manual has several types of safety precautions and instructions: Danger, Warning, Caution, and Notice.

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***.

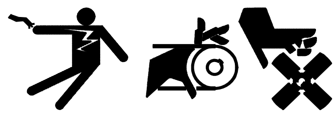
NOTICE

Notice communicates installation, operation, or maintenance information that is safety related but not hazard related.

Safety decals affixed to the equipment in prominent places alert the operator or service technician to potential hazards and explain how to act safely. The decals are shown throughout this publication to improve operator recognition. Replace missing or damaged decals.

Accidental Starting

WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

Engine Backfire/Flash Fire

WARNING

Risk of fire.
Can cause severe injury or death.

Do not smoke or permit flames or sparks near fuels or the fuel system.

Servicing the fuel system. A flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the fuel injection system, fuel line, fuel filter, fuel pump, or other potential sources of spilled fuels or fuel vapors. Catch fuels in an approved container when removing the fuel line or fuel system.

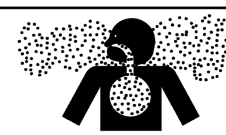
Servicing the air cleaner. A sudden backfire can cause severe injury or death. Do not operate the generator set with the air cleaner/silencer removed.

Combustible materials. A sudden flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the generator set. Keep the compartment and the generator set clean and free of debris to minimize the risk of fire. Catch fuels in an approved container. Wipe up spilled fuels and engine oil.

Combustible materials. A fire can cause severe injury or death. Generator set engine fuels and fuel vapors are flammable and explosive. Handle these materials carefully to minimize the risk of fire or explosion. Equip the compartment or nearby area with a fully charged fire extinguisher. Select a fire extinguisher rated ABC or BC for electrical fires or as recommended by the local fire code or an authorized agency. Train all personnel on fire extinguisher operation and fire prevention procedures.

Exhaust System

WARNING



Carbon monoxide.
Can cause severe nausea, fainting, or death.

The exhaust system must be leakproof and routinely inspected.

Carbon monoxide symptoms. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is a poisonous gas present in exhaust gases. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Carbon monoxide poisoning symptoms include but are not limited to the following:

- Light-headedness, dizziness
- Physical fatigue, weakness in joints and muscles
- Sleepiness, mental fatigue, inability to concentrate or speak clearly, blurred vision
- Stomachache, vomiting, nausea

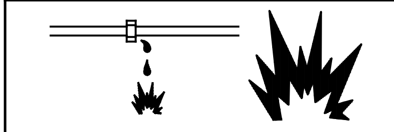
If experiencing any of these symptoms and carbon monoxide poisoning is possible, seek fresh air immediately and remain active. Do not sit, lie down, or fall asleep. Alert others to the possibility of carbon monoxide poisoning. Seek medical attention if the condition of affected persons does not improve within minutes of breathing fresh air.

Inspecting the exhaust system. Carbon monoxide can cause severe nausea, fainting, or death. For the safety of the craft's occupants, install a carbon monoxide detector. Never operate the generator set without a functioning carbon monoxide detector. Inspect the detector before each generator set use.

Operating the generator set. Carbon monoxide can cause severe nausea, fainting, or death. Be especially careful if operating the generator set when moored or anchored under calm conditions because gases may accumulate. If operating the generator set dockside, moor the craft so that the exhaust discharges on the lee side (the side sheltered from the wind). Always be aware of others, making sure your exhaust is directed away from other boats and buildings.

Fuel System

WARNING



Explosive fuel vapors.
Can cause severe injury or death.

Use extreme care when handling, storing, and using fuels.

The fuel system. Explosive fuel vapors can cause severe injury or death. Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

Draining the fuel system. Explosive fuel vapors can cause severe injury or death. Spilled fuel can cause an explosion. Use a container to catch fuel when draining the fuel system. Wipe up spilled fuel after draining the system.

Hazardous Noise

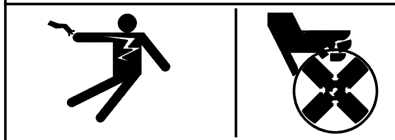
CAUTION

Hazardous noise.
Can cause hearing loss.

Never operate the generator set without a muffler or with a faulty exhaust system.

Hazardous Voltage/ Moving Parts

WARNING



Hazardous voltage. Moving parts.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Disconnecting the electrical load. Hazardous voltage can cause severe injury or death. Disconnect the generator set from the load by turning off the line circuit breaker or by disconnecting the generator set output leads from the transfer switch and heavily taping the ends of the leads. High voltage transferred to the load during testing may cause personal injury and equipment damage. Do not use the safeguard circuit breaker in place of the line circuit breaker. The safeguard circuit breaker does not disconnect the generator set from the load.

High voltage test. Hazardous voltage can cause severe injury or death. Follow the instructions of the test equipment manufacturer when performing high-voltage tests on the rotor or stator. An improper test procedure can damage equipment or lead to generator set failure.

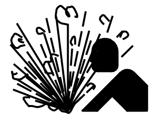
Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

Electrical backfeed to the utility. Hazardous backfeed voltage can cause severe injury or death. Connect the generator set to the building/marina electrical system only through an approved device and after the building/marina main switch is turned off. Backfeed connections can cause severe injury or death to utility personnel working on power lines and/or personnel near the work area. Some states and localities prohibit unauthorized connection to the utility electrical system. Install a ship-to-shore transfer switch to prevent interconnection of the generator set power and shore power.

Testing live electrical circuits. Hazardous voltage or current can cause severe injury or death. Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment manufacturer when performing voltage tests. Observe the following precautions when performing voltage tests: (1) Remove all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Do not touch the enclosure or components inside the enclosure. (4) Be prepared for the system to operate automatically.
(600 volts and under)

Hot Parts

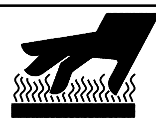
WARNING



Hot coolant and steam.
Can cause severe injury or death.

Before removing the pressure cap, stop the generator set and allow it to cool. Then loosen the pressure cap to relieve pressure.

WARNING



Hot engine and exhaust system.
Can cause severe injury or death.

Do not work on the generator set until it cools.

Servicing the alternator. Hot parts can cause severe injury or death. Avoid touching the alternator field or exciter armature. When shorted, the alternator field and exciter armature become hot enough to cause severe burns.

Notice

NOTICE

Fuse replacement. Replace fuses with fuses of the same ampere rating and type (for example: 3AB or 314, ceramic). Do not substitute clear glass-type fuses for ceramic fuses. Refer to the wiring diagram when the ampere rating is unknown or questionable.

NOTICE

Saltwater damage. Saltwater quickly deteriorates metals. Wipe up saltwater on and around the generator set and remove salt deposits from metal surfaces.

Notes

Introduction

This manual provides troubleshooting and repair instructions for 13- 40EKOZD and 11- 35EFKOZD model generator sets (4-lead and 12-lead), controller, and accessories.

Refer to the engine service manual for generator set engine service information.

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

Read this manual and carefully follow all procedures and safety precautions to ensure proper equipment operation and to avoid bodily injury. Read and follow the Safety Precautions and Instructions section at the beginning of this manual. Keep this manual with the equipment for future reference.

The equipment service requirements are very important to safe and efficient operation. Inspect the parts often and perform required service at the prescribed intervals. Maintenance work must be performed by appropriately skilled and suitably-trained maintenance personnel familiar with generator set operation and service.

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Service Assistance

For professional advice on generator set power requirements and conscientious service, please contact your nearest Kohler distributor or dealer.

- Visit the Kohler Co. website at KOHLERPower.com.
- Look at the labels and decals on your Kohler product or review the appropriate literature or documents included with the product.
- Call toll free in the US and Canada 1-800-544-2444.
- Outside the US and Canada, call the nearest regional office.

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List of Related Literature

Figure 1 identifies related literature available for the generator sets covered in this manual. Only trained and qualified personnel should install or service the generator set.

Literature Type	Models			
	13EKOZD and 11EFKOZD (1 Phase)	**13EKOZD and 11EFKOZD (3 Phase)**	**15EKOZD and 13EFKOZD (1 Phase)**	**15EKOZD and 13EFKOZD (3 Phase)**
Specification Sheet	G2-171	G2-182	G2-173	G2-172
Installation Manual	TP-6952			
Operation Manual	TP-6951			
Parts Catalog*	TP-6954			
Service Manual (Engine)	TP-6939			
Service Manual (Generator)	TP-6953			
SiteTech™ Software Operation Manual	TP-6701			
Modbus® Communications Protocol Operation Manual	TP-6113			

Literature Type	20EKOZD and 17.5EFKOZD (1 Phase)	20EKOZD and 16.5EFKOZD (3 Phase)	23EKOZD and 20EFKOZD (1 Phase)	23EKOZD and 19.5EFKOZD (3 Phase)
Specification Sheet	G2-174	G2-175	G2-176	G2-177
Installation Manual	TP-6952			
Operation Manual	TP-6951			
Parts Catalog*	TP-6954			
Service Manual (Engine)	TP-6939			
Service Manual (Generator)	TP-6953			
SiteTech™ Software Operation Manual	TP-6701			
Modbus® Communications Protocol Operation Manual	TP-6113			

Literature Type	14EKOZD and 12EFKOZD (1 Phase)	14EKOZD and 12EFKOZD (3 Phase)	16EKOZD and 13.5EFKOZD (1 Phase)	16EKOZD and 13.5EFKOZD (3 Phase)
Specification Sheet	G2-185	G2-186	G2-187	G2-188
Installation Manual	TP-7045			
Operation Manual	TP-7044			
Parts Catalog*	TP-6954			
Service Manual (Engine)	TP-6939			
Service Manual (Generator)	TP-6953			
SiteTech™ Software Operation Manual	TP-6701			
Modbus® Communications Protocol Operation Manual	TP-6113			

Literature Type	21EKOZD and 18EFKOZD (1 Phase)	21EKOZD and 17EFKOZD (3 Phase)	24EKOZD and 20.5EFKOZD (1 Phase)	24EKOZD and 20.5EFKOZD (3 Phase)
Specification Sheet	G2-189	G2-190	G2-191	G2-192
Installation Manual	TP-7045			
Operation Manual	TP-7044			
Parts Catalog*	TP-6954			
Service Manual (Engine)	TP-6939			
Service Manual (Generator)	TP-6953			
SiteTech™ Software Operation Manual	TP-6701			
Modbus® Communications Protocol Operation Manual	TP-6113			

* Includes generator and engine information.

Literature Type	Models			
	32EKOZD and 28EFKOZD (1 Phase)	**32EKOZD and 28EFKOZD (3 Phase)**	**40EKOZD and 35EFKOZD (1 Phase)**	**40EKOZD and 35EFKOZD (3 Phase)**
Specification Sheet	G2-194	G2-195	G2-196	G2-197
Installation Manual	TP-7045			
Operation Manual	TP-7044			
Parts Catalog*	TP-6954			
Service Manual (Engine)	TP-6916			
Kohler KDI Special Tools Manuals	TP-7105, TP-7083, and TP-7084			
Service Manual (Generator)	TP-6953			
SiteTech™ Software Operation Manual	TP-6701			
Modbus® Communications Protocol Operation Manual	TP-6113			

* Includes generator and engine information.

Figure 1 Generator Set Literature

Notes

1.1 General

This manual covers maintenance, troubleshooting, and repair of the alternating current marine generator sets listed in Figure 1-1. Consult the generator set nameplate for specific generator set ratings.

60 Hz Models	Voltage	Hz	Ph
13EKOZD and 14EKOZD	120 120/240	60	1
13EKOZD and 14EKOZD	120/208 120/240 127/220 139/240 277/480	60	3
15EKOZD and 16EKOZD	120 120/240	60	1
15EKOZD and 16EKOZD	120/208 120/240 127/220 139/240 277/480	60	3
20EKOZD and 21EKOZD	120 120/240	60	1
20EKOZD and 21EKOZD	120/208 120/240 127/220 139/240 277/480	60	3
23EKOZD and 24EKOZD	120 120/240	60	1
23EKOZD and 24EKOZD	120/208 120/240 127/220 139/240 277/480	60	3
32EKOZD and 40EKOZD	120/240	60	1
32EKOZD and 40EKOZD	120/208 120/240 127/220 139/240 277/480	60	3

50 Hz Models	Voltage	Hz	Ph
11EFKOZD and 12EFKOZD	230 240	50	1
11EFKOZD and 12EFKOZD	110/190 115/230 120/208 230/400 240/416 220/380	50	3
13EFKOZD and 13.5EFKOZD	230 240	50	1
13EFKOZD and 13.5EFKOZD	110/190 115/230 120/208 230/400 240/416 220/380	50	3
17.5EFKOZD and 18EFKOZD	230 240	50	1
16.5EFKOZD and 17EFKOZD	110/190 115/230 120/208 230/400 240/416 220/380	50	3
20EFKOZD and 20.5EFKOZD	230 240	50	1
19.5EFKOZD and 20.5EFKOZD	110/190 115/230 120/208 230/400 240/416 220/380	50	3
28EFKOZD and 35EFKOZD	230 240	50	1
28EFKOZD and 35EFKOZD	110/190 110/220 120/208 230/400 240/416 220/380	50	3

Figure 1-1 Generator Model Coverage

The 13EKOZD/11EFKOZD and 14EKOZD/12EFKOZD (single- and three-phase) models are powered by a three-cylinder, water-cooled, four-cycle diesel engine with a heat exchanger.

The 15EKOZD/13EFKOZD and 16EKOZD/13.5EFKOZD (single- and three-phase) models are powered by a three-cylinder, water-cooled, four-cycle diesel engine with a heat exchanger.

The 20EKOZD/16.5/17.5EFKOZD, 21EKOZD/17/18EFKOZD, 23EKOZD/19.5/20EFKOZD, 24EKOZD/20.5EFKOZD (single- and three-phase) models are powered by a four-cylinder, water-cooled, four-cycle diesel engine with a heat exchanger.

The 32/40EKOZD and 28/35EFKOZD (single- and three-phase) models are powered by a four-cylinder, water-cooled, four-cycle turbocharged diesel engine with a heat exchanger.

Heat exchanger cooling consists of a heat exchanger with a coolant recovery tank, thermostat, rubber impeller seawater pump, centrifugal type engine circulating pump, water-cooled exhaust manifold, and an exhaust mixer.

Kohler Co. develops all Kohler® marine generator set ratings using accepted reference conditions of 25°C (77°F) and pressure of 29.2 in. Hg dry barometer. ISO 3046 and ISO 8528-1 include reference conditions and output calculations. Obtain the technical information bulletin on ratings guidelines (TIB-101) for complete ratings definitions.

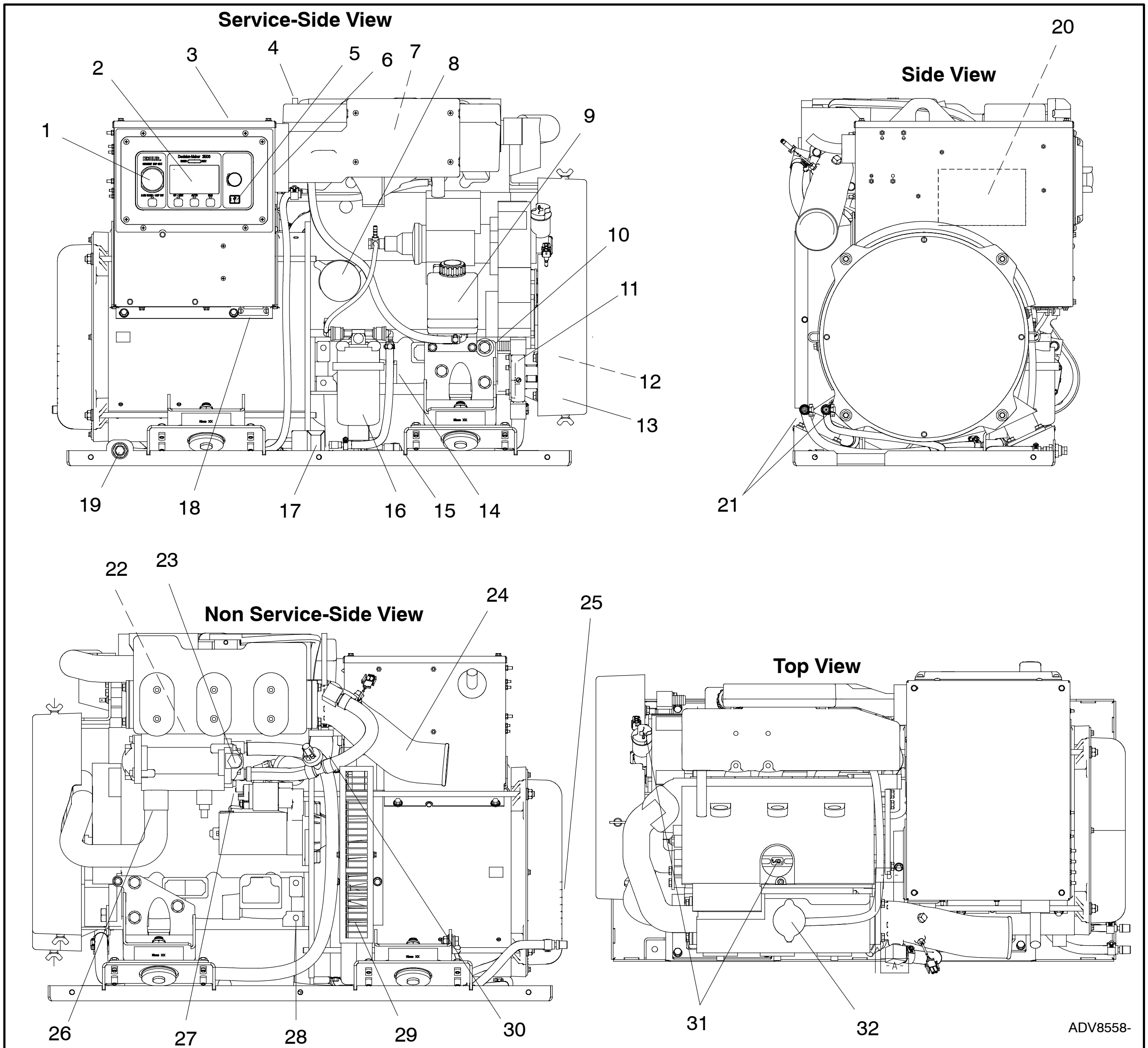
Read this manual, then carefully follow all service recommendations. See Figure 1-2 for identification and location of components.

1.2 Engine

Generator Model	13EKOZD/ 11EFKOZD and 14EKOZD/ 12EFKOZD (1 & 3 Ph.)	15EKOZD/ 13EFKOZD and 16EKOZD/ 13.5EFKOZD (1 & 3Ph.)	20EKOZD/ 17.5EFKOZD and 21EKOZD/ 18EFKOZD (1 Ph.)	20EKOZD/ 16.5EFKOZD and 21EKOZD/ 17EFKOZD (3 Ph.)	23EKOZD/ 20EFKOZD and 24EKOZD/ 20.5EFKOZD (1 Ph.)	23EKOZD/ 19.5EFKOZD and 24EKOZD/ 20.5EFKOZD (3 Ph.)
Number of cylinders	3		4			
Type	4 cycle, naturally aspirated					
Governor	Mechanical					
Engine firing order (#1 cylinder on flywheel end or alternator end)	1-3-2		1-3-4-2			
Direction of rotation (as viewed from flywheel)	Counterclockwise					
Combustion system	Direct injection					
Bore x stroke, mm (in.)	88 x 102 (3.46 x 4.02)					
Displacement L (CID)	1.9 (114)		2.5 (151)			
Compression ratio	17:1					
Max. power at rated rpm, HP 60/50 Hz	24.7/25.5		38.7/34.1			
RPM 60/50 Hz	1800/1500		1800/1500			
Lubrication system	Pressurized oil system with oil pump					
Lube oil capacity, w/filter L (U.S. qts.)	8.7 (9.2)		11 (11.6)			
Oil recommendation	API: CI-4, CH-4, CG-4 class SAE: 10W-40/5W-40					
Fuel recommendation	EN 590 for EU - ASTM D975-09 20/23EKOZD and 21/24EKOZD 60 Hz Models Only: Use fuel with a sulfur content less than 400ppm.					
Fuel shutoff solenoid	Electric					
Fuel pump	Electric					
Max. recommended fuel pump lift, m (ft.)	1.2 (4)					
Battery voltage	12 or 24 volts					
Battery charging module	8 amp 12/24 volt (original GM77373) 8 amp 12 volt (revised GM105398) 8 amp 24 volt (revised GM105399)					
Battery recommendation (minimum)	650 CCA @ 0°F					
Starter motor	2 kW, 12 volt 2.5 kW, 24 volt					
Recommended coolant	50% ethylene glycol; 50% clean, softened water					
Coolant capacity, approx. L (U.S. qts.) add 0.24 L (8 oz.) for coolant recovery tank	5.2 (5.53)		4.4 (4.6)			
Thermostat, opening temp. °C (°F)	79 (174)					
High exhaust temperature shutdown, °C (°F)	60 (140)					
Pressure cap rating, kPa (psi)	95 (13.7)					

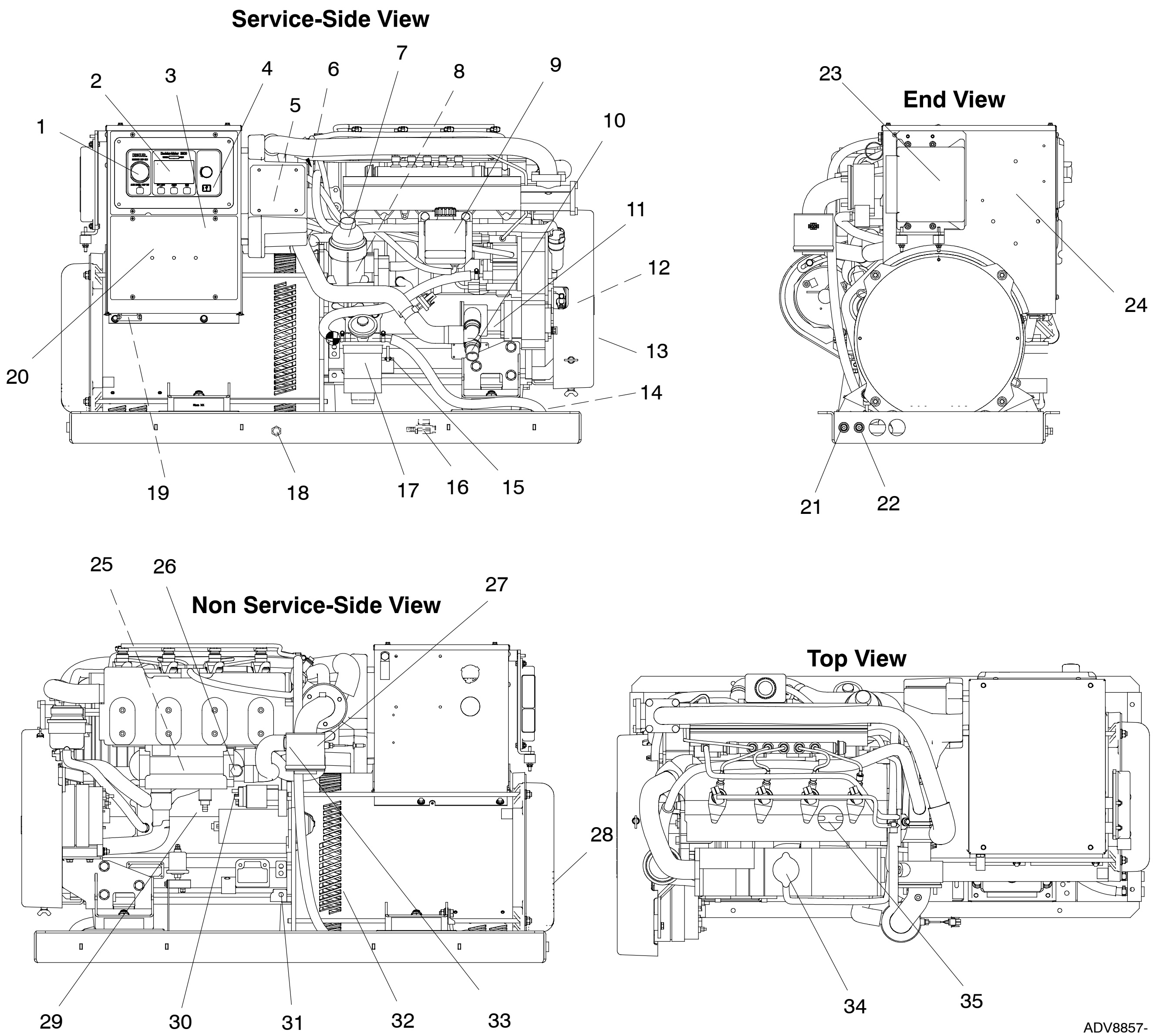
Generator Model	32EKOZD/ 28EFKOZD (1 & 3 Ph.)	40EKOZD/ 35EFKOZD (1 & 3 Ph.)
Number of cylinders	4	
Type	4 cycle, turbocharged	4 cycle, turbocharged, charge air cooled
Governor	Electronic	
Engine firing order (#1 cylinder on flywheel end or alternator end)	1-3-4-2	
Direction of rotation (as viewed from flywheel)	Counterclockwise	
Combustion system	Direct injection	
Bore x stroke, mm (in.)	88 x 102 (3.46 x 4.02)	
Displacement L (CID)	2.48 (151.5)	
Compression ratio	17:1	
Max. power at rated rpm, HP 60/50 Hz	52.4/46.9	65.7/57.6
RPM 60/50 Hz	1800/1500	
Lubrication system	Pressurized oil system with oil pump	
Lube oil capacity, w/filter L (U.S. qts.)	10.5 (11.0)	10.5 (11.0)
Oil recommendation	API: CJ-4 class SAE: $\geq$ -25°C (-13°F): 5W-30 < -25°C (-13°F): 0W-30 ACEA: E6-E7-E9	
Fuel recommendation	EN 590 for EU - ASTM D975-09 Use ultra low sulfur diesel fuel with a sulfur content less than 15 ppm.	
Fuel shutoff solenoid	Electric	
Fuel pump	Electric	
Max. recommended fuel pump lift, m (ft.)	1.2 (4)	
Battery voltage	12 or 24 volts	
Battery charging alternator	72 amp @ 12 volts 40 amp @ 24 volts	
Battery recommendation (minimum)	1000 CCA @ 0°F	
Starter motor	2 kW, 12 volt 2.5 kW, 24 volt	
Recommended coolant	50% ethylene glycol; 50% clean, softened water	
Coolant capacity, approx. L (U.S. qts.) add 0.24 L (8 oz.) for coolant recovery tank	7 (7.4)	
Thermostat, opening temp. °C (°F)	79 (174)	
High exhaust temperature shutdown, °C (°F)	60 (140)	
Pressure cap rating, kPa (psi)	95 (13.7)	

1.3 Service Views



1. Emergency stop
2. Decision-Maker® 3500 controller
3. Nameplate (on top of controller)
4. Lifting eye
5. USB port
6. EGR lamp (on side of junction box) 20/23EKOZD and 21/24EKOZD (60 Hz) models only
7. Air filter (13/15/20/23EKOZD and 11/13/16.5/17.5/19.5/20EFKOZD models only)
8. Oil filter
9. Coolant overflow bottle
10. Seawater inlet
11. Seawater pump
12. V-belt
13. Belt guard
14. Oil check/dipstick
15. Oil drain valve
16. Fuel filter
17. Fuel pump
18. Customer load lead connection
19. Oil drain
20. Optional circuit breaker location (opposite side of junction box)
21. Fuel supply and return (fuel lines are coiled and tied to unit when shipped)
22. Heat exchanger internal to exhaust manifold
23. Anticorrosion zinc anode
24. Mixing elbow (water outlet/exhaust outlet)
25. Alternator cooling air inlet
26. Engine coolant drain (remove hose clamp)
27. Battery positive (+) connection
28. Battery negative (-) connection
29. Air outlet
30. Seawater drain (remove hose clamp)
31. Oil fill
32. Coolant fill/coolant overflow tube

Figure 1-2 Service Views—Typical (13- 24EKOZD and 11- 20.5EFKOZD Models)



1. Emergency stop
2. Decision-Maker® 3500 controller
3. Nameplate (on front of junction box)
4. USB port
5. Air filter element
6. Lifting eye
7. Oil filter cartridge cover
8. Oil filter cartridge
9. Coolant overflow bottle
10. Seawater inlet
11. Seawater pump
12. V-belt (battery charging alternator)
13. Belt guard
14. Fuel pump
15. Oil check/dipstick
16. Oil drain valve (on engine)
17. Fuel filter
18. Oil drain
19. Customer load lead connection
20. Optional circuit breaker location
21. Fuel return connection
22. Fuel supply connection
23. ECU
24. Location for 24- to 12-volt converter, if equipped
25. Heat exchanger internal to exhaust manifold
26. Anticorrosion zinc anode
27. Water cooled exhaust outlet
28. Alternator cooling air inlet
29. Engine coolant drain
30. Battery positive (+) connection
31. Battery negative (-) connection
32. Alternator air outlet
33. Seawater drain (remove hose clamp)
34. Coolant fill/coolant overflow tube
35. Oil fill

Figure 1-3 Service Views—Typical (32- 40EKOZD and 28- 35EFKOZD Models)

1.4 Introduction

The specification sheets for each generator set provide specific alternator and engine information. Refer to the respective specification sheet for data not supplied in this manual. Consult the generator set operation manual, installation manual, engine operation manual, and engine service manual for additional specifications.

Voltage regulation is provided by the generator set controller. Refer to the Operation Manual for additional voltage regulator information.

1.5 Wound-Field Alternator Concept—13-32EKOZD and 11-28EFKOZD Models

The alternator is identified with one of the following designations: 4D_ or 4E_. Example: Gen. Model 4D3.1. The first alpha character (D) identifies the alternator family.

These generator sets utilize a wound-field alternator to produce AC voltage. Upon activation of the generator master switch, DC current from the battery magnetizes the rotor (field). When the magnetized rotor rotates within the stator windings, an electrical voltage develops within the stator. As engine speed and generator output increase, the voltage regulator feeds rectified stator output current to the rotor through the exciter to increase the strength of the rotor field. As the rotor field increases in strength, generator output also increases.

The voltage regulator (integrated in the controller) monitors the generator output voltage through leads A and B (for 1-phase models) and leads A, B, and C (for 3-phase models). The duty cycle of the pulse width modulator (PWM) signal to the activator board adjusts the exciter field current changing the main field current to meet load requirements. See Figure 1-4 and Figure 1-5.

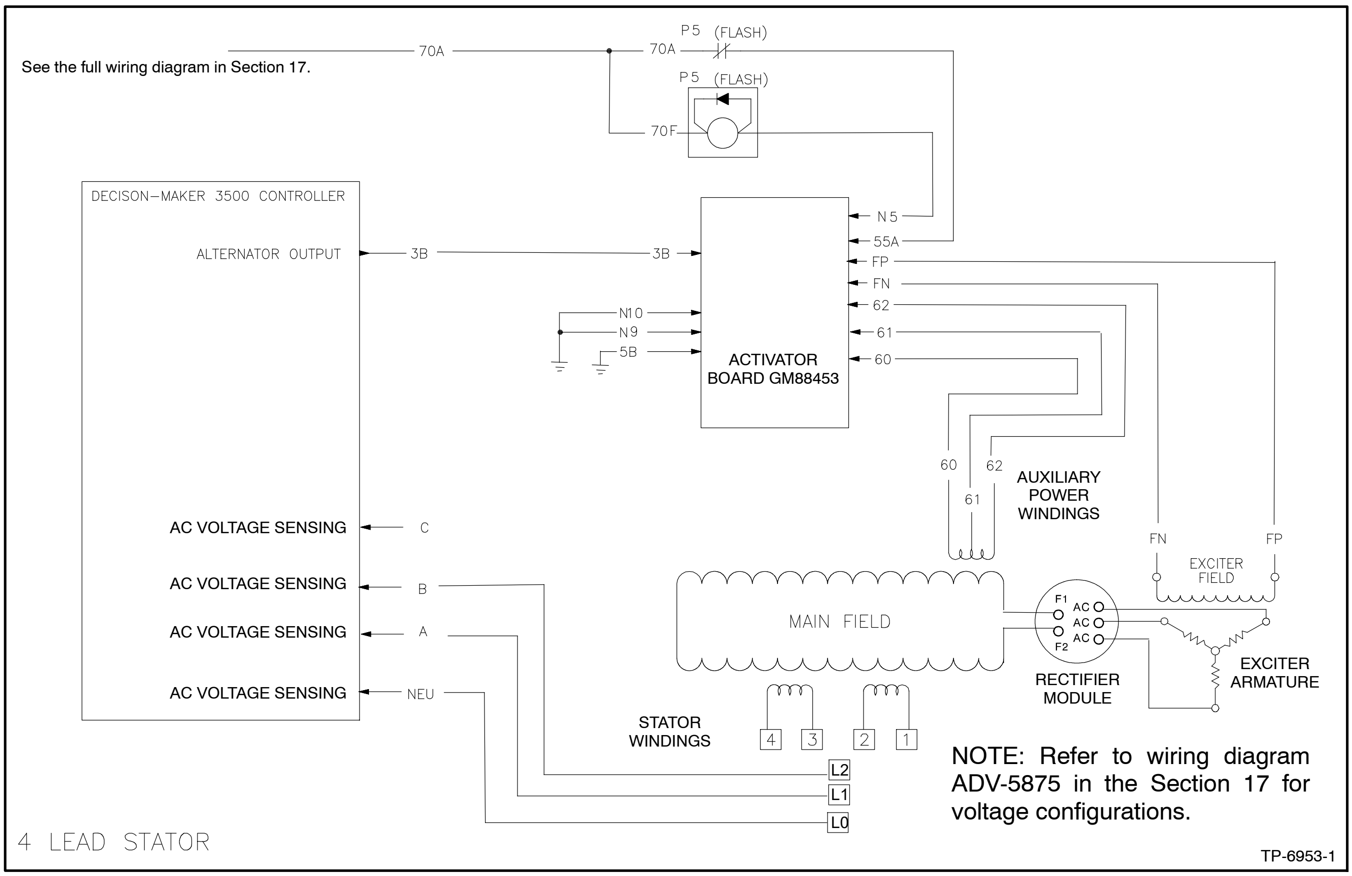


Figure 1-4 4-Lead Brushed Alternator Schematic (13-32EKOZD and 11-28EFKOZD Models)

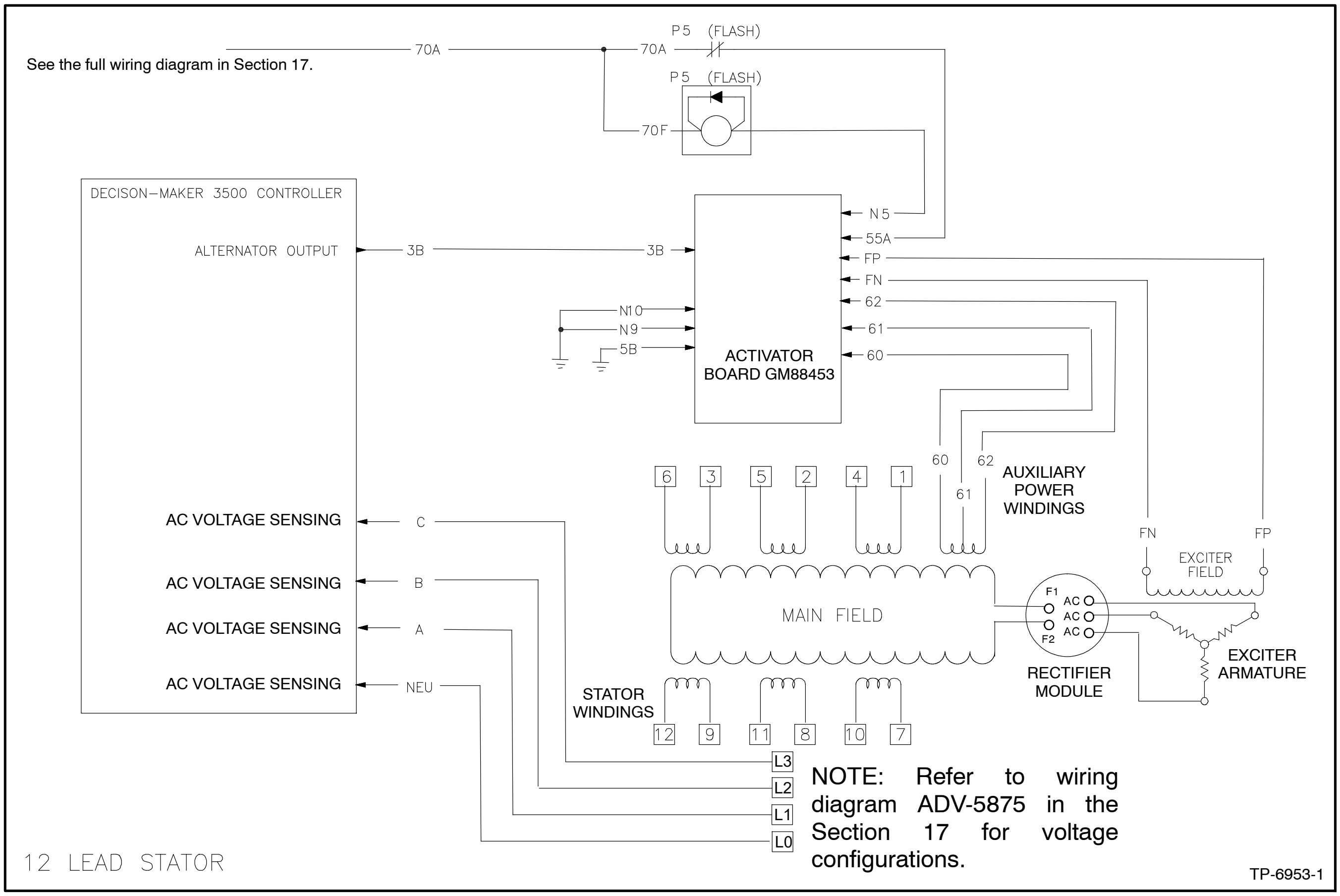


Figure 1-5 12-Lead Brushless Alternator Schematic (13- 32EKOZD and 11- 28EFKOZD Models)

When a large motor is connected to the alternator, the output voltage will decrease suddenly (due to the increased requirements of the motor load). The voltage regulator increases the current target (transmitted through a PWM signal on 3B and 5B) to respond to the change in the output voltage, which causes the activator board to apply full auxiliary winding voltage to the exciter field until it reaches the new target current. As the exciter field current increases, the rotor field current starts to increase, causing the output voltage of the alternator to start to recover. As the motor speed increases, the current draw to the motor decreases, resulting in a decrease of the alternator load.

When a short circuit condition occurs on the output of the alternator, the output voltage will go to 0 volts and the voltage regulator will set a 100% PWM output duty cycle in an effort to recover the voltage to rated. This causes the activator to apply full auxiliary winding voltage (about 160 VDC) to the exciter field until the exciter field current reaches 7.8 amps DC (when it decreases the voltage applied to maintain 7.8 amps DC on the exciter field). The high current in the exciter field applies a maximum voltage across the rotor field, driving it toward a maximum current. The current supplied to the fault will increase as the rotor field current increases, but the initial short circuit current is supplied by stored energy in the alternator. The initial current spike is due to stored energy in the alternator.

When a large load is removed from the alternator, the output voltage of that alternator increases and the voltage regulator decreases the duty cycle of the PWM signal to the activator board. This causes the activator board to turn off the voltage to the exciter field until the current reaches the new target. The exciter armature generates voltage until the exciter field current reaches 0 amps, causing the rotor field current to increase for a short time after the load is removed. After the exciter field current reaches 0 amps, the output voltage of the alternator decreases until it decays to the target voltage, when the voltage regulator increases the PWM duty cycle again and the activator applies full voltage to the exciter field until the current matches the target set by the PWM signal (when it decreases the voltage to maintain the target current).

1.6 Permanent Magnet Alternator Concept—40EKOZD and 35EFKOZD Models

A permanent magnet alternator is identified with one of the following designations: 4P_X, 4Q_X, 4R_X, 4S_X, or 4T_X, and 4UA_. Example: Gen. Model 4S12X. The first alpha character (S) identifies the alternator family. If the last character is an X, it denotes a Fast-Response™ X alternator.

The generator set has a rotating-field alternator with a smaller rotating-armature alternator turned by a common shaft. The main rotating-field alternator supplies current to load circuits while the rotating-armature (exciter) alternator supplies DC to excite the main alternator's field.

The generator set has a 4-pole, rotating-field with brushless, permanent magnet alternator excitation system. The PM system provides short-circuit excitation current up to 300% at 60 Hz (approximately 275% at 50 Hz) for a minimum of 10 seconds to allow selective circuit breaker tripping.

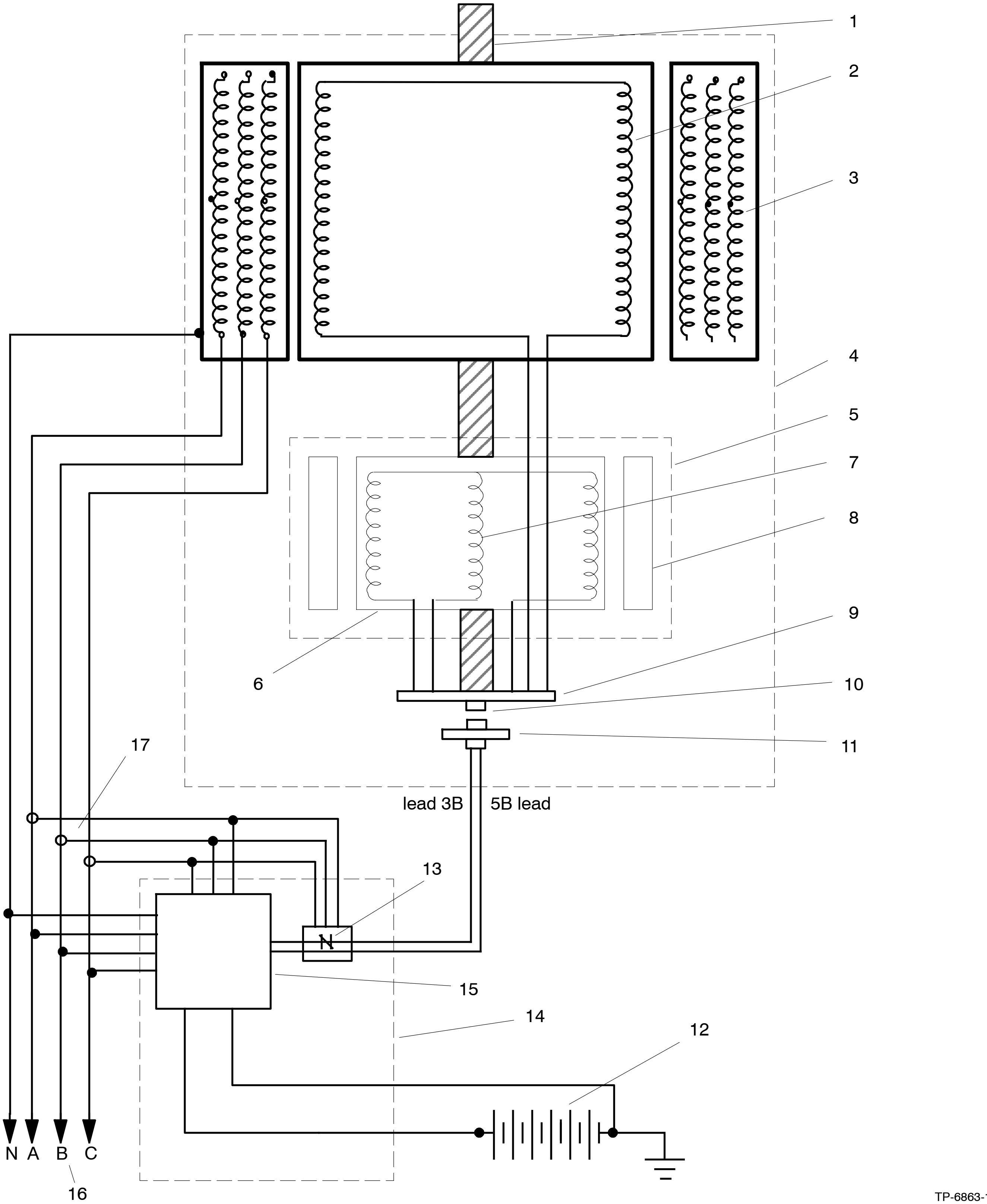
The alternator excitation system uses a permanent, magnet exciter with a silicon controlled rectifier (SCR) assembly which controls the amount of DC current fed to the alternator field. This type of system uses a voltage regulator (located within the Decision-Maker® 3500 controller) which provides a signal to control the SCR assembly through an optical coupling. The voltage regulator monitors engine speed and alternator output voltage to turn a stationary light emitting diode (LED) on or off, according to engine speed and output voltage. The LED is mounted on the end bracket opposite a photo transistor board which rotates on the shaft. The photo transistor picks up the signal from the LED and tells the SCR assembly to turn on or off, depending upon the need, as dictated by the voltage regulator. See Figure 1-6.

The voltage recovery period of this type of alternator is several times faster than the conventionally wound field brushless alternator because it does not have to contend with the inductance of the exciter field. It also has better recovery characteristics than the static excited machine because it is not dependent upon the generator set output voltage for excitation power. Possibly the greatest advantage of this type machine is its inherent ability to support short-circuit current and allow system coordination for tripping downstream branch circuit breakers.

The alternator system delivers exciter current to the main field within 0.05 seconds of a change in load demand.

1.6.1 Short Circuit Performance

When a short circuit occurs in the load circuit(s) being served, output voltage drops and amperage momentarily rises to 600%-1000% of the generator set's rated current until the short is removed. The SCR assembly sends full exciter power to the main field. The alternator then sustains up to 300% of its rated current. Sustained high current will cause correspondingly rated load circuit fuses/breakers to trip. The *controller alternator protection* feature serves to collapse the alternator's main field in the event of a sustained heavy overload or short circuit.



1. Rotor shaft
2. Rotor field windings (rotor assembly)
3. Stator main windings (stator assembly)
4. Alternator assembly
5. Exciter assembly
6. Exciter armature (connected to rotor)
7. Exciter armature windings
8. Exciter field magnets
9. FRX activator/photo transistor board
10. Photo transistor
11. LED optic board
12. Engine starting battery
13. Alternator protection (controller)
14. Generator set controller
15. AC voltage regulator (controller)
16. AC output leads
17. Current sensing

Figure 1-6 Alternator Schematic (40EKOZD and 35EFKOZD Models)

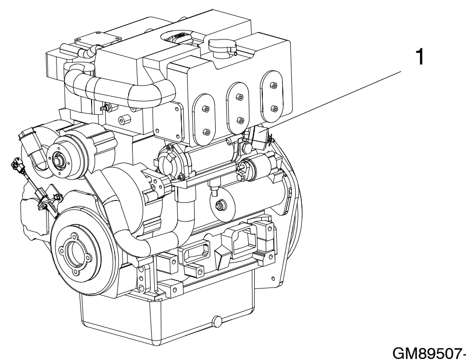
1.7 Electrical Values (13-32EKOZD/11-28EFKOZD Models)

Component Specification (12-Lead)	13EKOZD/ 11EFKOZD and 14EKOZD/ 12EFKOZD 4D3.1	15EKOZD/ 13EFKOZD and 16EKOZD/ 13.5EFKOZD 4D3.8	20EKOZD/ 16.5EFKOZD and 21EKOZD/ 17EFKOZD 4D4.2	23EKOZD/ 19.5EFKOZD and 24EKOZD/ 20.5EFKOZD 4D5.0	32EKOZD and 28EFKOZD 4D8.3
Hot exciter field winding voltage/amperage readings at rated voltage					
No load (63 Hz)—volts/amps	6/0.7	8/1.2	7/1.0	7/0.9	7/0.9
Full load (60 Hz)—volts/amps	26/3.4	38/4.8	30/4.0	25/3.5	30/2.7
No load (50 Hz)—volts/amps	7/0.8	10/1.4	8/1.0	8/1.0	8/1.0
Exciter field winding resistance (cold)—ohms @ 20°C (68°F)	5.8				7.2
Exciter armature resistance (cold)—ohms (line-to-line)	0.5	0.5	0.5	0.6	0.6
Main field (rotor) resistance (cold)—ohms @ 20°C (68°F)	3.2	3.5	3.6	4.0	5.3
Stator output voltages with separately excited generator, using 12-volt battery (60 Hz only)					
1-4, 2-5, 3-6, 7-10, 8-11, 9-12—volts	>150				
60-61—volts	>150				
60-62—volts	>150				
Cold stator resistance					
1-4, 2-5, 3-6, 7-10, 8-11, 9-12—ohms	0.20	0.12	0.09	0.09	0.04
60-61—ohms	1.1	0.5	0.47	0.7	0.5
60-62—ohms	2.2	1.0	1.1	1.4	1.0
Component Specification (4-Lead)	**13EKOZD/ 11EFKOZD and 14EKOZD/ 12EFKOZD 4E3.1**	**15EKOZD/ 13EFKOZD and 16EKOZD/ 13.5EFKOZD 4E3.8**	**20EKOZD/ 17.5EFKOZD and 21EKOZD/ 18EFKOZD 4E4.2**	**23EKOZD/ 20EFKOZD and 24EKOZD/ 20.5EFKOZD 4E5.0b**	**32EKOZD and 28EFKOZD 4E8.3**
Hot exciter field winding voltage/amperage readings at rated voltage					
No load (63 Hz)—volts/amps	5.7/0.8	5.7/0.8	5.9/1.0	9/1.2	9/1.1
Full load (60 Hz)—volts/amps	19/2.6	26/3.4	30/4.0	17/1.8	20/2.5
No load (50 Hz)—volts/amps	13/1.7	13/1.7	13/2.1	19/2.5	19/2.3
Exciter field winding resistance (cold)—ohms @ 20°C (68°F)	5.8				7.2
Exciter armature resistance (cold)—ohms (line-to-line)	0.5	0.5	0.5	0.73	0.6
Main field (rotor) resistance (cold)—ohms @ 20°C (68°F)	3.2	3.5	3.6	4.0	5.3
Stator output voltages with separately excited generator, using 12-volt battery (60 Hz only)					
1-2, 3-4—volts	>150				
60-61—volts	>150				
60-62—volts	>150				
Cold stator resistance					
1-2, 3-4—ohms	0.15	0.14	0.13	0.12	0.06
60-61—ohms	1.1	0.5	0.44	0.7	0.5
60-62—ohms	2.2	1.0	1.1	1.4	1.0

1.8 Electrical Values (40EKOZD and 35EFKOZD Models)

Generator Models->	40EKOZD/ 35EFKOZD 3 Phase (Alternator Model 4P7BX)	40EKOZD/ 35EFKOZD 1 Phase (Alternator Model 4Q7BX)
Component Specification	**Cold Resistance Value (in ohms)**	
Stator windings, 12 lead	0.069	-
Stator windings, 4 lead	-	0.025
Rotor windings	5.65	5.65
Exciter armature windings	0.8	0.8

1.9 Oil Pressure Sender (OPS)

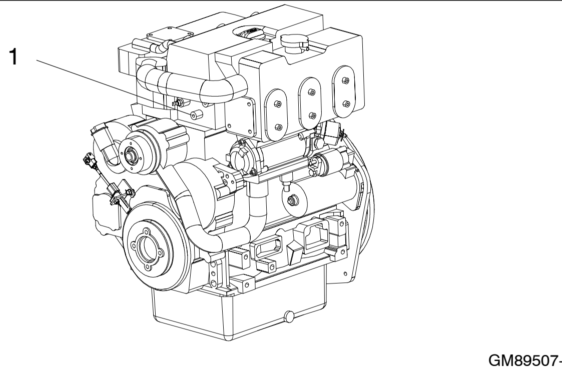


1. Oil pressure sender

Figure 1-7 Oil Pressure Sender Location, Typical

Sender P/N	Value A	Value B
343473	240 +2.5/- 10.5 ohms at 0 psi	33.5 +10.5/- 7.5 ohms at 100 psi
GM96251	240 ohms at 0 psi	33 ohms at 100 psi
GM102100	240 ohms at 0 psi	33 ohms at 100 psi

1.10 Coolant Temperature Sender (CTS)



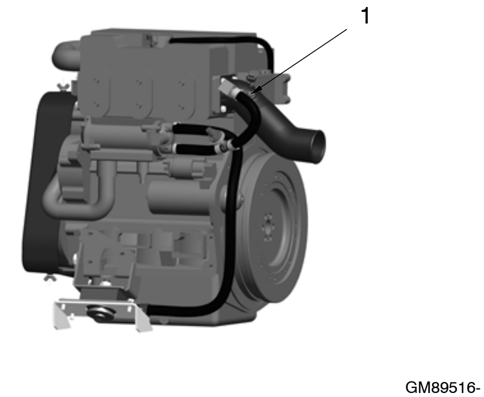
1. Coolant temperature sender

Figure 1-8 Coolant Temperature Sender Location, Typical

Note: For 32/40EKOZD and 28/35EFKOZD models, consult the Engine Service Manual for CTS information. See the List of Related Literature found at the beginning of this manual for the publication number.

Sender P/N	Value A	Value B
GM94527	927 ±113 ohms at 25°C (77°F)	54 ±5 ohms at 104.4°C (220°F)

1.11 Exhaust Temperature Sender (ETS)



1. Exhaust temperature sender

Figure 1-9 Exhaust Temperature Sender Location, Typical

Sender P/N	Shutdown at
GM93708	60°C (140°F)

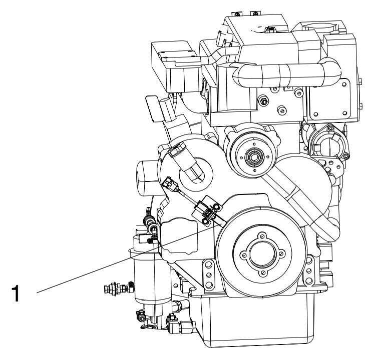
1.12 Low Seawater Pressure Switch (LWP)

1. Low seawater pressure switch

Figure 1-10 Low Seawater Pressure Switch Location

Switch P/N	Value A	Value B
GM30263	3.4 ±2 kPa	0.5 ±0.3 psi

1.13 Magnetic Pickup Sensor (13-24EKOZD/11-20.5EFKOZD Models)



1. Magnetic pickup sensor

Figure 1-11 Magnetic Pickup Sensor Location

Sensor P/N	Resistance	Operating Gap
GM92350	1 k Ohms ±10% @ 20°C (68°C)	1 mm (0.039 in.)

Note: For 32/40EKOZD and 28/35EFKOZD models, consult the Engine Service Manual for speed sensor information. See the List of Related Literature found at the beginning of this manual for the publication number.

1.14 Alternator Torque Values and Assembly Specifications

Use the torque values shown below during alternator assembly. For assembly torque values not shown, use the guidelines in Appendix C, General Torque Specifications.

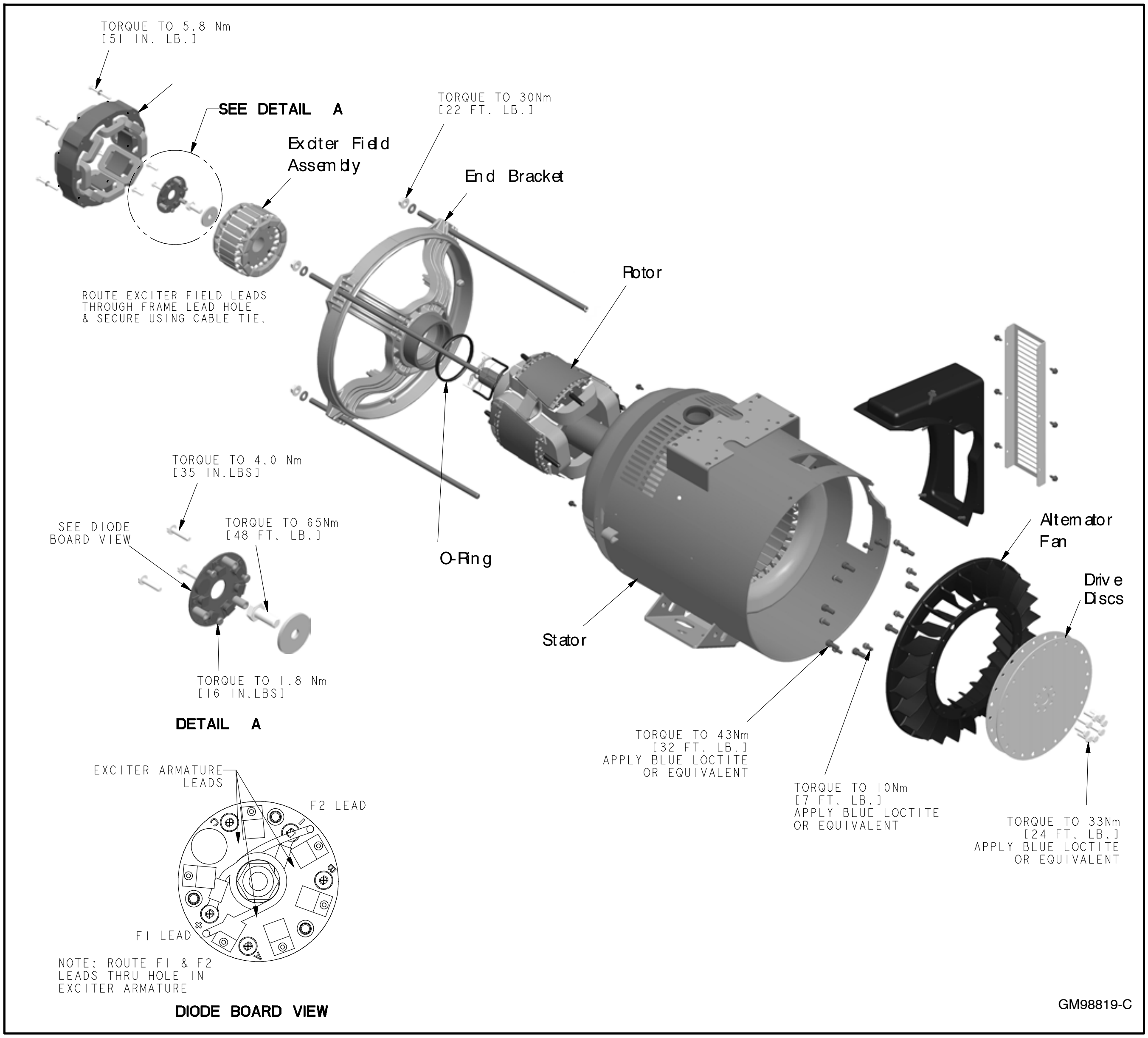


Figure 2 Alternator Assembly Torque Specs—13-24EKOZD and 11-20.5EFKOZD Models (Parts Shown May Vary Slightly Between Models)

Loctite® is a registered trademark of the Henkel Corporation.

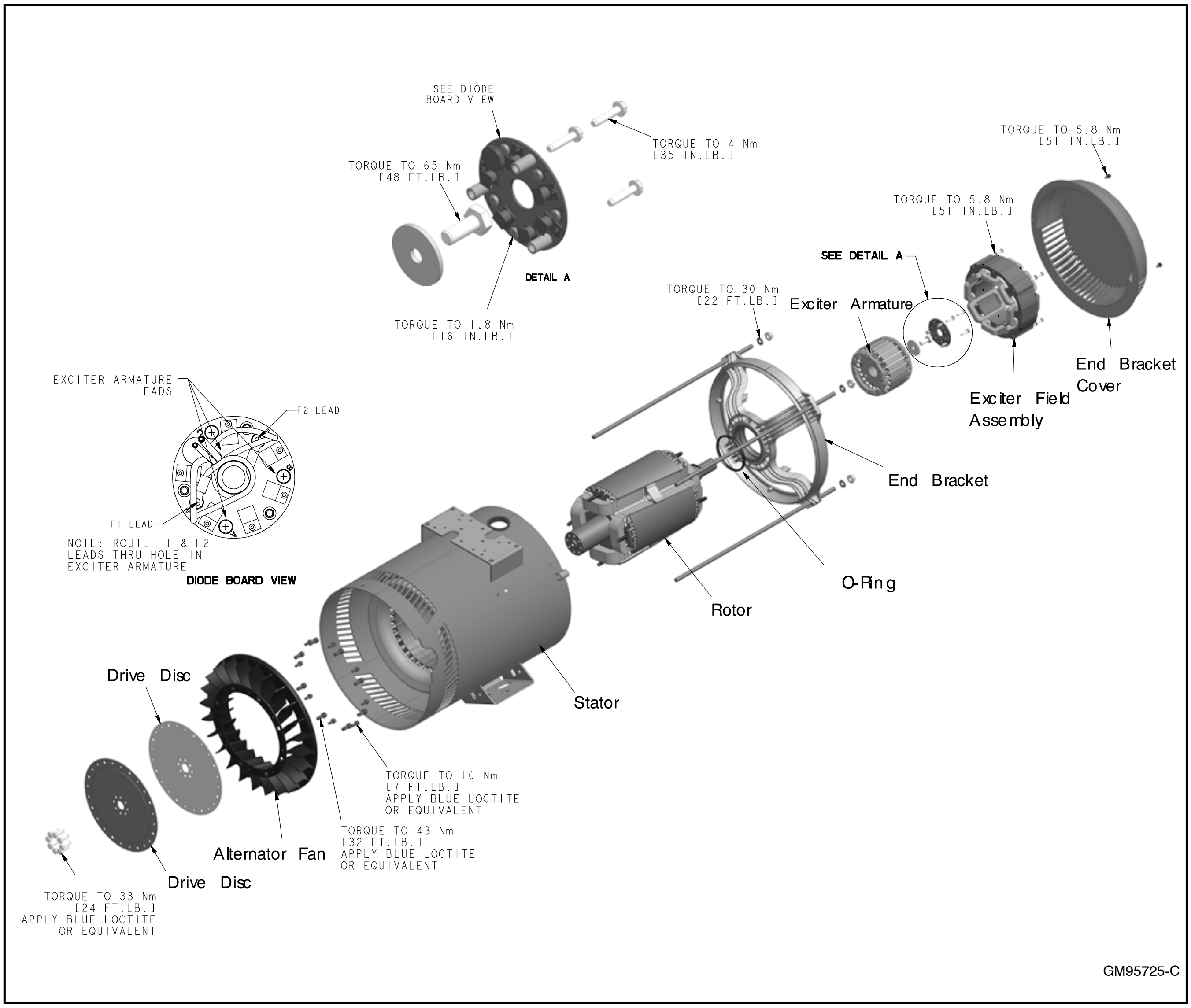


Figure 1-12 Alternator Assembly Torque Specs—32EKOZD/28EFKOZD Models
(Parts Shown May Vary Slightly Between Models)

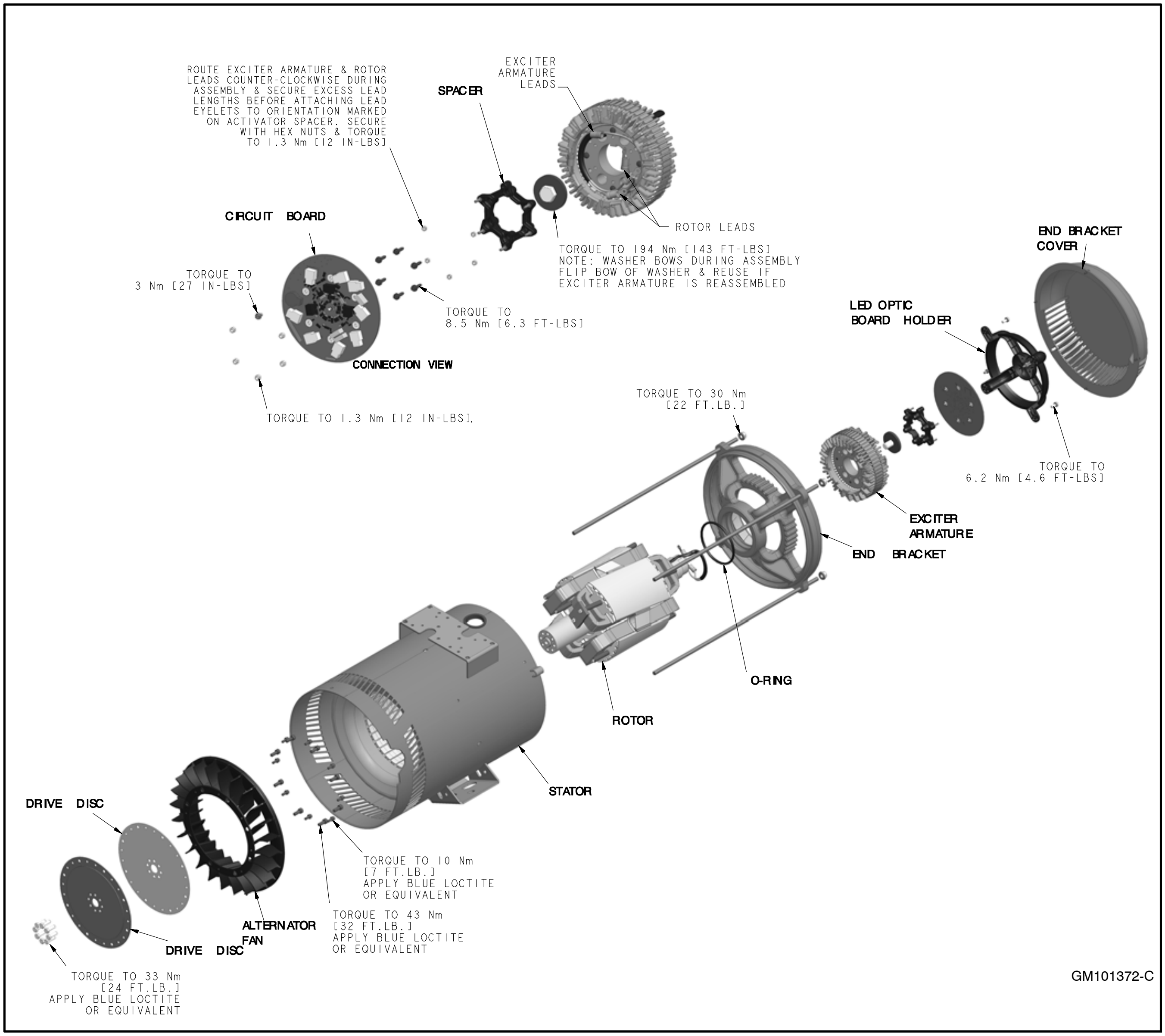


Figure 1-13 Alternator Assembly Torque Specs—40EKOZD/35EFKOZD Models (Parts Shown May Vary Slightly Between Models)

1.15 Introduction

This service manual provides controller and accessory troubleshooting and repair information for the following controller:

- Decision-Maker® 3500

The following illustration identifies the controller.

1.16 Controller Identification and Features

1.16.1 Decision-Maker® 3500

- **AC Output Voltage Regulator Adjustment.** The voltage adjustment provides a maximum adjustment of ±10% of the system voltage.
- **Adjustable Engine Run Speed.** Set engine speed slightly higher or lower than nominal (+49 to -50 RPM) for passive synchronization.
- **Alarm Silence.** The controller can be set up to silence the alarm horn only when in the AUTO mode for NFPA-110 application or Always for user convenience.
- **Alternator Protection.** The controller provides generator set overload and short circuit protection matched to each alternator for the particular voltage/phase configuration.
- **Automatic Restart.** The controller automatic restart feature initiates the start routine and recrank after a failed start attempt.
- **Cyclic Cranking.** The controller has programmable cyclic cranking.
- **ECM Diagnostics.** The controller displays engine ECM fault code descriptions to help in engine troubleshooting.
- **Engine Start Aid.** The configurable starting aid feature provides customized control for an optional engine starting aid.
- **Event Logging.** The controller keeps a record (up to 1000 entries) for warning and shutdown faults. This fault information becomes a stored record of system events and can be reset.
- **Generator Management.** Programmable generator management based on manual selection, fuel level, or run time to optimize fuel usage, noise, maintenance, etc.
- **Historical Data Logging.** Total number of successful starts of the generator is recorded and displayed.
- **Integrated Hybrid Voltage Regulator.** The voltage regulator provides ±0.5% no-load to full-load RMS voltage regulation with three-phase sensing.
- **Lamp Test.** Press the alarm silence/lamp test button to verify functionality of the indicator lights.
- **LCD Display.** Backlit LCD display with integral heater and adjustable contrast for viewing in varying temperatures and lighting conditions.
- **Load Management.** Dynamic load add/shed, based on the present load and available capacity based on the number of generator sets on the bus.
- **Measurement Units.** The controller provides selection of English or metric displays.
- **Power Metering.** Controller graphical display provides voltage, current, power factor, kW, kVA, and kVAR.
- **Programming Access (USB).** Provides software upgrades and diagnostics with PC software tools.
- **Remote Reset.** The remote reset function supports acknowledging and resetting faults and allows restarting of the generator set without going to the master control switch off/reset position.
- **Run Time Hourmeter.** The generator set run time is displayed.
- **Time Delay Engine Cooldown (TDEC).** The TDEC provides a time delay before the generator set shuts down.
- **Time Delay Engine Start (TDES).** The TDES provides a time delay before the generator set starts.
- **Voltage Selection Menu.** This menu provides the capability of quickly switching generator output voltage. Requires initial activation using SiteTech™ software. NOTE: Generator set output leads may require reconnection.
- **Paralleling Functions:**
  - Bus sensing
  - First on logic
  - Synchronizing
  - Communication based isochronous load sharing
  - Droop load sharing
  - External controlled load sharing via analog bias signals

1.17 Decision-Maker® 3500 with Integral Voltage Regulator

The voltage regulator is integral to the controller and uses a patented hybrid voltage regulator design to provide ±0.5% no-load to full-load regulation using root-mean-square (RMS) voltage sensing.

The voltage regulator features three-phase sensing and supports both 12- and 24-volt engine electrical systems.

- The Decision-Maker® 3500 graphical display and pushbutton/rotary dial provide access to data. A five-line, 35-characters per line LCD display provides complete and concise information include gain, ramp rate, reactive droop, VAR control (P, I, D gains), and PF control (P, I, D gains).
- The controller supports Modbus®.

Voltage Regulation Menu

- Voltage adjustment, ±10% of system voltage
- V/Hz cut-in, 42-62 Hz
- Underfrequency unload slope, 0-10% of system voltage
- Reactive droop, 0.0-20%
- Voltage regulator gain adjust, 1-255
- Startup ramp rate, 5.0% to 100.0%/sec

Generator Set Calibration Menu

- L1-L2 volts
- L2-L3 volts (3-phase)
- L3-L1 volts (3-phase)
- L1-N volts
- L2-N volts
- L3-N volts (3-phase)
- Gen L1 current
- Gen L2 current
- Gen L3 current (3-phase)
- Bus L1-L2 volts
- Bus L2-L3 volts (3-phase)
- Bus L3-L1 volts (3-phase)

Modbus® is a registered trademark of Schneider Electric.

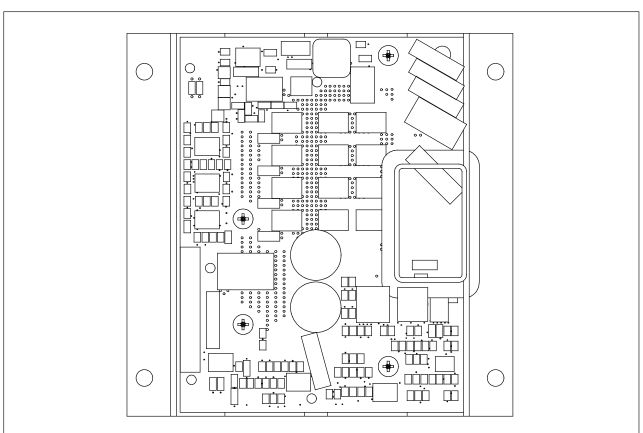
1.17.1 Specifications and Features

Specification/Feature	Voltage Regulator Type Integral with Decision-Maker® 3500
Integrated Voltage Regulator	Patented Hybrid Design
Status and Shutdown Indicators	LEDs and Graphical LCD Display
Operating Temperature	- 40°C to 70°C (- 40°F to 158°F)
Storage Temperature	- 40°C to 85°C (- 40°F to 185°F)
Humidity Withstand	5- 95% Condensing
Salt Spray Tolerance	5% Salt Spray per ASTM-B-117-90
Circuit Protection	Solid-State, Redundant Software and Fuses
Sensing, Nominal	100- 600 V (L-L), 50- 60 Hz
Sensing Mode	RMS, Single- or 3-Phase
Input Requirements	8- 36 VDC
Continuous Output	5 VDC @ 100 mA max. 5.0 ADC with GM88453 Activator Board
Maximum Forcing Output	5 VDC @100 mA max. 7.8 ADC with GM88453 Activator Board
Transition Frequency	42.0- 62.0 Hz
Exciter Field Resistance	4- 30 Ohms with GM88453 Activator Board
No-Load to Full-Load Voltage Regulation	±0.5%
Thermal Drift	<0.5% (- 40°C to 70°C) [- 40°F to 158°F] Range
Response Time	Less than 5mS
System Voltage Adjust Range	±10%
Voltage Adjustment	Controller Menu Knob
Remote Voltage Adjustment	0.5- 4.5 VDC (±10%) Bias Input
Paralleling Capability	Reactive Droop plus Load Share and Control
VAR/PF Control Input	VAR Control Mode, PF Control Mode, System VAR Control, System PF Control

1.17.2 Integral Voltage Regulator

Adjustment	Digital Display	Range Setting	Default Selection
Voltage Adjustment	Voltage Adjust	±10% of System Voltage	System Voltage
V/Hz Cut-in	V/Hz Setpoint	42 to 62 Hz	1.0 Hz Below Nominal Frequency
Underfrequency Unload Slope	V/Hz Slope	0- 10% of System Voltage (Volts per Cycle)	5% of Rated Voltage per Cycle
Reactive Droop	Volt Droop @ 100% kVAR	0.0% to 20% of System Voltage	1% of System Voltage
Voltage Regulator Gain Adjust	Voltage Gain Adjust	1 to 255	128
Startup Voltage Ramp Rate	Startup Ramp Rate	5.0% to 100.0%/Sec	25%/Sec

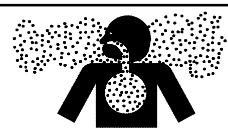
1.17.3 Activator Board GM88453 (13- 32EKOZD/11- 28EFKOZD Models)



- Interfaces between the controller and alternator assembly using rotor field leads, auxiliary power windings, and optic board leads.
- Allows the Decision-Maker® controller the ability to control a wound-field alternator using the same control signal as the Fast Response™ alternator.
- Permits the generator set controller to control the current to the exciter field of a wound-field excited alternator.
- Contains two isolated relay driver outputs (RDO) rated at 250 mA. Provides RDO outputs indicating a field over-excitation condition and that the alternator is supplying voltage to the activator.

2.1 Prestart Checklist

⚠ WARNING



Carbon monoxide.
Can cause severe nausea, fainting, or death.

The exhaust system must be leakproof and routinely inspected.

Operating the generator set. Carbon monoxide can cause severe nausea, fainting, or death. Be especially careful if operating the generator set when moored or anchored under calm conditions because gases may accumulate. If operating the generator set dockside, moor the craft so that the exhaust discharges on the lee side (the side sheltered from the wind). Always be aware of others, making sure your exhaust is directed away from other boats and buildings.

To ensure continued satisfactory operation perform the following checks or inspections before or at each startup, as designated, and at the intervals specified in the service schedule. In addition, some checks require verification after the unit starts.

Air Cleaner, if equipped. 13/15/20/23/32/40EKOZD and 11/13/16.5/17.5/19.5/20/28/35EFKOZD Models: Check for a clean and installed air cleaner element to prevent unfiltered air from entering the engine.

Air Inlets. Check for clean and unobstructed air inlets.

Air Shrouding. Check for securely installed and positioned air shrouding.

Battery. Check for tight battery connections. Consult the battery manufacturer's instructions regarding battery care and maintenance.

Coolant Level. Check the coolant level according to the cooling system maintenance information.

Note: Block heater damage. The block heater will fail if the energized heater element is not immersed in coolant. Fill the cooling system before turning on the block heater. Run the engine until it is warm, and refill the radiator to purge the air from the system before energizing the block heater.

Drive Belts. Check the belt condition and tension of the water pump and battery charging alternator belt.

Exhaust System. Check for exhaust leaks and blockages. Check the silencer and piping condition and check for tight exhaust system connections.

Inspect the exhaust system components (exhaust manifold, mixing elbow, exhaust line, hose clamps, silencer, and exhaust outlet) for cracks, leaks, and corrosion.

- Check the hoses for softness, cracks, leaks, or dents. Replace the hoses as needed.
- Check for corroded or broken metal parts and replace them as needed.
- Check for loose, corroded, or missing clamps. Tighten or replace the hose clamps as needed.
- Check that the exhaust outlet is unobstructed.
- Visually inspect for exhaust leaks *(blowby)*. Check for carbon or soot residue on exhaust components. Carbon and soot residue indicates an exhaust leak. Seal leaks as needed.
- Ensure that the carbon monoxide detector(s) is (1) in the craft, (2) functional, and (3) energized whenever the generator set operates.

For your safety: Never operate the generator set without a functioning carbon monoxide detector(s) for your safety and the safety of others on your vessel.

Fuel Level. Check the fuel level and keep the tank(s) full to ensure adequate fuel supply.

Oil Level. Maintain the oil level at or near, not over, the full mark on the dipstick.

Operating Area. Check for obstructions that could block the flow of cooling air. Keep the air intake area clean. Do not leave rags, tools, or debris on or near the generator set.

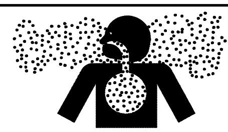
Seawater Pump Priming. Prime the seawater pump before initial startup. To prime the pump: (1) close the seacock, (2) remove the hose from the water-filter outlet, (3) fill the hose and seawater pump with clean water, (4) reconnect the hose to the water filter outlet, and (5) open the seacock. Confirm seawater pump operation on startup as indicated by water discharge from the exhaust outlet.

2.2 Marine Inspection

Kohler Co. recommends that all boat owners have their vessels inspected at the start of each boating season by the US Coast Guard, the local Coast Guard Auxiliary, or local state agency.

Kohler Co. also recommends having the generator's exhaust system inspected at the start of each boating season by an authorized Kohler® distributor/dealer. Repair any problems identified before operating the generator set.

WARNING



Carbon monoxide.
Can cause severe nausea, fainting, or death.

The exhaust system must be leakproof and routinely inspected.

Carbon monoxide symptoms. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is a poisonous gas present in exhaust gases. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Carbon monoxide poisoning symptoms include but are not limited to the following:

- Light-headedness, dizziness
- Physical fatigue, weakness in joints and muscles
- Sleepiness, mental fatigue, inability to concentrate or speak clearly, blurred vision
- Stomachache, vomiting, nausea

If experiencing any of these symptoms and carbon monoxide poisoning is possible, seek fresh air immediately and remain active. Do not sit, lie down, or fall asleep. Alert others to the possibility of carbon monoxide poisoning. Seek medical attention if the condition of affected persons does not improve within minutes of breathing fresh air.

Inspecting the exhaust system. Carbon monoxide can cause severe nausea, fainting, or death. For the safety of the craft's occupants, install a carbon monoxide detector. Never operate the generator set without a functioning carbon monoxide detector. Inspect the detector before each generator set use.

Operating the generator set. Carbon monoxide can cause severe nausea, fainting, or death. Be especially careful if operating the generator set when moored or anchored under calm conditions because gases may accumulate. If operating the generator set dockside, moor the craft so that the exhaust discharges on the lee side (the side sheltered from the wind). Always be aware of others, making sure your exhaust is directed away from other boats and buildings.

2.3 Angular Limits During Operation

See Figure 2-1 for angular operation limits.

13-24EKOZD/11-20.5EFKOZD Models	
Instant Operation (up to 1 min.)	**Intermittent Operation (up to 30 min.)**
35°	25°
32-40EKOZD/28-35EFKOZD Models	
Intermittent Operation (up to 1 min.)	**Continuous Operation**
35°	25°

Figure 2-1 Angular Limits During Operation

2.4 Operation in European Union Member Countries

This generator set is specifically intended and approved for operation below the deck in the engine compartment. Operation above the deck and/or outdoors would constitute a violation of European Union Directive 2000/14/EC noise emission standard.

2.5 Load Profile

Whenever operating the generator set, Kohler Co. recommends maintaining the minimum load profile indicated in Figure 2-2. Maintaining the load profile prevents corrosion formation on internal engine components when they're exposed to the breakdown of exhaust gases. Extended light loading may result in engine "wet stacking."

Min. Load Requirement	**Ideal Load Requirement**
30% load	70% load or more

Figure 2-2 Load Profile

Unburned Fuel (Wet Stacking) occurs when water/fuel vapor condenses in the exhaust system. At normal combustion temperatures, water stays vaporized but at low combustion temperatures, it condenses back to a liquid. When running the generator set under normal loads (30% load or more) for long periods of time, diesel exhaust stays hot enough to prevent water/fuel vapor from condensing. Conversely, if the generator set is subjected to light loads (30% or less) for long periods of time, water/fuel vapors accumulate and may result in the following conditions to develop:

- Cylinder wall glazing
- Fuel on water
- Crankcase oil dilution
- Wet stacking

Note: Consult the engine manufacturer's guidelines for more details on unburned fuel and wet stacking.

The operator should perform all of the prestart checks. Start the generator set according to the starting procedure in the controller section of this manual. While the generator set is operating, listen for a smooth-running engine and visually inspect the generator set for fluid or exhaust leaks.

2.6 Controller Operation

Note: Opening seacock. Before starting the generator set, open the seacock to allow cooling water passage. Failure to do so could damage the seawater pump impeller and cause serious engine overheating damage.

Note: Transfer switch. Check that the marine ship-to-shore transfer switch, if equipped, is in the ship position.

Note: If the generator set does not start after 3 crank attempts (an overcrank fault occurs):
1) Close the seacock.
2) Completely drain the water from the exhaust system at the silencer's drain plug.
3) Do not attempt generator set restart.
4) Contact an authorized Kohler® distributor/dealer.
A water-filled exhaust piping and silencer may further hinder generator starting and cause seawater entry into the engine cylinders through the exhaust valves. Water ingested into the engine may cause major engine damage that the Kohler Co. warranty does not cover.

The controller operation includes several types of starting and stopping functions as detailed below. The controller buttons, lamps, and alarm horn functions are summarized in Figure 2-3.

There are three primary modes of operation, selected by pressing the respective buttons:

- **OFF**
- **RUN**
- **AUTO** (Standby Mode)

When the OFF button is pressed, the generator set is in OFF or goes to OFF and will not start. When the RUN button is pressed, the generator set starts and runs until the OFF or AUTO button is pressed or until a fault is received. When the AUTO button is pressed, the generator set enters the Standby Mode (STANDBY-RUNNING or STANDBY-OFF depending upon the start signal).

- **OFF.** If the generator set was previously running, pressing the OFF button immediately shuts off the generator set, with no engine cooldown. The generator set remains off and will not respond to a remote start signal.
- **RUN—Local Start.** A single generator set starts. No other generator sets in the system will start (or stop).
- **AUTO—Standby or System Ready**. The generator set is waiting for a start signal. The generator set will start and run when a start signal is received via a remote start, local auto-start, or communications-based start.

  All generator sets in the system (connected by PGEN and in Standby Mode by pressing AUTO) will start when any one of the generator sets receives a start signal.

  Any generator set in the system not in AUTO will not start.

  If Generator Management is on, some generator sets may shutdown after a period of time.

  With removal of the start signal, all generator sets will shutdown with the appropriate engine cooldown.
- **AUTO-RUN** (Press AUTO and RUN together for a system start signal). All generator sets in the system start and run, close to bus, synchronize, parallel, share load, etc. Some generator sets may shut down after a period of time (indicated by Generator Management) but they remain in Standby Mode ready to start and run if needed.
- **AUTO-OFF** (Press AUTO and OFF together to remove a system start signal, if AUTO-RUN is active). All generator sets in the system open their breakers, enter engine cooldown, shut down, and enter Standby Mode. Closing the remote start contacts accomplishes nothing. Generator sets in the system will enter Standby Mode.

Start Signal

A start signal includes the following:

- Remote start signal via contacts 3 and 4. An ATS (used during a power outage, exercise period, etc.) or a remote panel used in the vessel take precedence over all other start signals.
- System Start (AUTO-START). Press AUTO and RUN simultaneously to send a start signal.
- Communications-based start message from SiteTech™ or a CAN-based remote panel.

Hardwired contacts (remote start contacts 3 and 4) have priority over all other start signals. If the remote start contacts are activated, the generator sets in the system that are in AUTO, will start and run. If the generator sets were already running, they will remain running but the original source of that start signal will be ignored. The contacts now have control.

Stop Signal

A stop signal includes the following:

- Removal of start signal via contacts 3 and 4. An ATS (used during a power outage, exercise period, etc.) or a remote panel used in the vessel take precedence over all other start signals.
- System Stop (AUTO-OFF). Press AUTO and OFF simultaneously to send a stop signal to cancel the system start. NOTE: This will not do anything if the system start is not active. Press AUTO and OFF on any controller in the system.
- Communications-based stop message from SiteTech™ or a CAN-based remote panel.

Engine Cooldown

Cooldown is a state where the generator is running at no load to allow hot engine components time to cool slowly before the engine is stopped. In paralleling applications, this occurs with the circuit breaker open.

When the generator set is running in AUTO mode (AUTO-RUN), an engine cooldown cycle begins when the remote start input is deactivated. Also, if stopping due to a stop signal, a cooldown cycle begins.

If the Cooldown Override is disabled (OFF) in the Generator Configuration Menu, coolant temperature is ignored. The generator will enter cooldown when the start signal is removed, only if the engine control switch is in AUTO. The engine will run for a period of time equal to the Cooldown Delay parameter setting, regardless of the coolant temperature.

If the Cooldown Override is enabled (ON) in the Generator Configuration Menu, coolant temperature will be considered for cooldown. The generator will enter cooldown when the start signal is removed, only if the engine control switch is in AUTO. The engine will run until the coolant temperature is below the Engine Cooled Down parameter setting, or until the Cooldown Delay has expired.

The cooldown cycle lasts for some predetermined amount of time. The cooldown delay is an adjustable parameter. The Engine Cooled Down temperature is not adjustable.

Note: No engine cooldown cycle occurs if the OFF button is pressed or if a fault occurs. The shutdown is immediate. If possible, run the generator set without load for 5 minutes to ensure adequate engine cooldown.

Note: The alarm horn sounds and the Not-In-Auto Warning display appears whenever the generator set is not in the AUTO mode.

Note: The transient start/stop function of the controller prevents accidental cranking of the rotating engine. The generator set stops and recranks when the OFF/RESET button is momentarily pressed and then the RUN button is pressed.

Note: The controller provides up to 30 seconds of programmable cyclic cranking and up to 60 seconds rest with up to 6 cycles. The default setting is 15 seconds cranking and 15 seconds rest for 3 cycles. Make cyclic cranking adjustments using SiteTech™ software.

Button Mode	Generator Set Status	Fault Lamp	Alarm Horn	Alarm Silence Button	Alarm Horn Lamp	Controller Display
AUTO	Off	—	Off	—	—	Scrolling Overview Menu Only
	On (or Cranking)	—	Off	—	—	
	Running and then Off	Red	On	—	—	Shutdown Message
			Off	Pressed	Yellow	
OFF/RESET	Off	Yellow	On	—	—	Not In Auto Warning
			Off	Pressed	Yellow	
RUN (unit fails to start)	Off (or Cranking)	Yellow	On	—	—	Not in Auto Warning
			Off	Pressed	Yellow	
	Off	Red	On	—	—	Locked Rotor Shutdown (or other shutdown message)
			Off	Pressed	Yellow	
RUN (unit starts)	Off (or Cranking)	Yellow	On	—	—	Not in Auto Warming
	On		Off	Pressed	Yellow	
	Running and then Off	Red	On	—	—	Shutdown Message
			Off	Pressed	Yellow	

Figure 2-3 Button Function Summary

2.6.1 Battle Mode

Battle Mode, if enabled in the personality, prevents the controller from stopping due to any fault but overspeed and emergency stop. The faults are displayed on the controller user interface but do not stop the generator set.

2.6.2 Emergency Stop

Use the controller emergency stop switch for immediate emergency shutdown.

The emergency stop switch bypasses the time delay engine cooldown and immediately shuts down the generator set.

Note: Use the emergency stop switch(es) for emergency shutdowns only. Use the generator set OFF/RESET button for normal shutdowns.

The controller fault lamp lights and the unit shuts down when the local emergency stop switch activates.

Use the following procedure to reset the generator set after shutdown by a local or remote emergency stop switch. Refer to Section 2.6.8, Controller Resetting procedure, to restart the generator set following a fault shutdown.

1. Investigate and correct the cause of the emergency stop.
2. Reset the controller emergency stop switch by pulling the switch dial outward.
3. Press the generator set OFF/RESET button.
4. After resetting all faults using the controller reset procedure in Section 2.6.8, press the generator set RUN and/or AUTO button to restart the generator set. The generator set will not crank until the reset procedure completes.

2.6.3 System Status Lamps

The (OFF/RESET- AUTO- RUN) buttons indicate the status condition with an integrated lamp at the button.

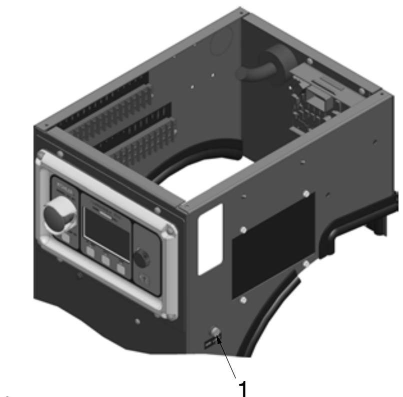
The lamp illuminates on the AUTO (automatic start) button indicating the system senses no faults and the unit is ready to start by remote command.

The lamp illuminates on the OFF/RESET button indicating the generator set is stopped.

The lamp illuminates on the RUN button indicating the generator set is cranking or running from a local command.

Only one of the three button lamps will illuminate at any given time.

2.6.4 Exhaust Gas Recirculation (EGR) Lamp



1. EGR lamp

Figure 2-4 EGR Lamp (20/23EKOZD and 21/24EKOZD 60 Hz Models Only)

The EGR lamp is located on the side of the junction box for 20/23EKOZD and 21/24EKOZD 60 Hz models only. See Figure 2-4. Under normal operation, the light illuminates for approximately 1 second at startup to indicate that power is available to the EGR and then, the light goes out. If the light pulses (blinks) more than one time, verify that the ECU module is properly connected and verify that the EGR valve is properly connected. If all connections are good and the light continues to pulse (blink), see Figure 2-5 or contact an authorized Kohler distributor/dealer for service.

Item	Error	Number of Blinks*
Input Pulse Width Modulator (PWM)	PWM Missing	1 Blink
EGR Valve Sensor	No Signal	2 Blinks
	EGR Valve Not Lifting	3 Blinks
	EGR Valve Not Closing	4 Blinks
Valve Over Current	Over Current	5 Blinks

* The number of each blink occurs for approx. 500 milliseconds, the EGR lamp goes off for approx. 3 seconds, and then it repeats.

Figure 2-5 EGR Lamp Blink Code (20/23EKOZD and 21/24EKOZD 60 Hz Models Only)

2.6.5 System Fault Warning Lamp with Digital Displays

The system FAULT lamp glows yellow and the alarm horn sounds indicating a warning fault but does not shut down the generator set. The fault lamp illuminates yellow and the alarm horn sounds when the fuel tank level on diesel-fueled models approaches empty. This fault requires an optional low fuel level switch for the lamp to function. See Section 2.6.8, Controller Resetting procedure, for instructions on resetting a system warning.

When the system warning lamp is on and no message displays, rotate the dial to the Active Events menu. Press the dial to view messages. Rotate the dial to view additional messages. Press the OFF button to return to the main menu. When the system warning continues, it may lead to a fault and cause a system shutdown.

Use the Silence Alarm button to silence the alarm horn at the operator's discretion.

If the controller is setup for an NFPA 110 application, press the AUTO button before silencing the alarm horn. The alarm horn cannot be silenced unless the button is in the AUTO mode. See 2.6.7 Status and Notice Digital Displays for more information.

AC Sensing Lost (controller in RUN or AUTO and voltage was never present). The fault lamp illuminates yellow and the alarm horn sounds when the controller does not detect the nominal generator set AC output voltage after crank disconnect.

Auxiliary Input. The fault lamp illuminates yellow and the alarm horn sounds when an auxiliary digital or analog input signals the controller. The digital inputs do not function during the first 30 seconds after startup. Use SiteTech™ software to define inputs as shutdowns or warnings.

Average Current High. The fault lamp illuminates yellow and the alarm horn sounds when the generator encounters excessive load or a downstream fault. The output breaker trips. The available sustained fault current of the generator can be obtained from the per-unit transient reactance of the generator and the system voltage and power.

Average Generator Voltage High. The fault lamp illuminates yellow and the alarm horn sounds when the generator encounters an over voltage condition. This condition can be caused by a loss of sensing wire, a winding failure, voltage regulator failure, etc. The output breaker trips. The generator may continue to produce excessive voltage until it is shut down.

Average Generator Voltage Low. The fault lamp illuminates yellow and the alarm horn sounds when the generator encounters an under voltage condition. This condition can be caused by a loss of a diode on the rectifier bridge, sensing problem, a winding failure, voltage regulator failure, etc. The output breaker trips. The generator may continue to produce insufficient voltage until it is shut down.

Battery Charger Fault. The fault lamp illuminates yellow and the alarm horn sounds when the battery charger malfunctions. This fault feature requires an optional battery charger with a malfunction output for the lamp to function.

Cabinet Intrusion. The fault lamp illuminates yellow and the alarm horn sounds when the door to the unit was opened.

Common Warning. The fault lamp illuminates yellow and the alarm horn sounds when the controller is signaled by a common warning. Use SiteTech™ software to activate the common warning. The common warning comprises all of the warnings under a single alert.

Critically High Fuel Level (diesel-powered models only). The fault lamp illuminates yellow and the alarm horn sounds when the fuel tank level on diesel models approaches full. This fault requires an optional critical high fuel switch and fuel tank for the lamp to function.

ECM Diagnostics (Multiple Engine Inputs). The fault lamp illuminates yellow and the alarm horn sounds when ECM diagnostics signals the controller. The specific display (xxxxx) will be a brief message or fault code that is engine manufacturer dependant. The engine literature provides the fault code description and further information.

Failure to Synchronize. The fault lamp illuminates yellow and the alarm horn sounds when the generator set does not successfully synchronize to the live bus within the time delay as defined in the synchronizing setup menu. The controller will continue attempting to synchronize to the bus after the time delay expires and the warning occurs. Generator Management will start another generator set if this warning occurs.

Fuel Tank Leak. The fault lamp illuminates yellow and the alarm horn sounds when the fuel tank signals a leak of the inner tank. This fault requires an optional fuel tank leak switch for the lamp to function.

Generator Frequency High. The fault lamp illuminates yellow and the alarm horn sounds when the generator has an overfrequency condition. The output breaker trips. This condition can be caused by various mechanical failures (loss of speed signal to ECU, improperly controlled or inadvertent injection of gaseous fuel etc.).

Generator Frequency Low. The fault lamp illuminates yellow and the alarm horn sounds when the generator has an underfrequency condition. The output breaker trips.

Generator Total Real Power High. The fault lamp illuminates yellow and the alarm horn sounds when the generator encounters excessive load or a downstream fault. The output breaker trips.

Generator Total Real Power Low. The fault lamp illuminates yellow and the alarm horn sounds when the generator is no longer producing power (loss of fuel, bearing failure, fuel system failure, ECU problem, or speed bias connection failure on non-ECM engines). The output breaker trips.

Ground Fault Input. The fault lamp illuminates yellow and the alarm horn sounds when a user-supplied ground fault detector signals the controller.

High Battery Voltage. The fault lamp illuminates yellow and the alarm horn sounds when the battery voltage rises above the preset level for more than 10 seconds. Figure 2-6 shows high battery voltage specifications. The high battery voltage feature monitors the battery and battery charging system in the generator set operating and off modes.

Engine Electrical System Voltage	High Battery Voltage Range	High Battery Voltage Default Setting
12	13.2- 16.2	15
24	26.4- 32.4	30

Figure 2-6 High Battery Voltage Specs

High Coolant Temperature. The fault lamp illuminates yellow and the alarm horn sounds when the engine coolant temperature approaches the shutdown range. The high coolant temperature warning does not function during the preset inhibit time delay period after startup.

High Fail To Close Delay. The fault lamp illuminates yellow and the alarm horn sounds when the circuit breaker did not close within the allocated breaker closure time.

High Fail To Open Delay. The fault lamp illuminates yellow and the alarm horn sounds when the circuit breaker did not open as quickly as the controller expected.

High Fuel Level (diesel-powered models only). The fault lamp illuminates yellow and the alarm horn sounds when the fuel tank level on diesel models approaches near full. This fault requires an optional high fuel switch and fuel tank for the lamp to function.

High Genset System Frequency. The fault lamp illuminates yellow and the alarm horn sounds when another generator in the paralleling system has a lower system frequency than this generator. The local display shows System Frequency, FMI: High.

High Genset System Voltage. The fault lamp illuminates yellow and the alarm horn sounds when another generator in the paralleling system has a lower system voltage than this generator. The local display shows System Voltage, FMI: High.

High Intake Air Temperature. The fault lamp illuminates yellow and the alarm horn sounds when the engine intake air temperature approaches the shutdown range.

High Lube Oil Temperature. The fault lamp illuminates yellow and the alarm horn sounds when the engine high oil temperature approaches the shutdown range.

High Max. Close Attempts The fault lamp illuminates yellow and the alarm horn sounds when the circuit breaker did not close, even after the controller attempted to close it as many times as specified by the max. close attempts.

Invalid Generator Management Enabled. The fault lamp illuminates yellow and the alarm horn sounds when the generator management has been disabled because the generator management configuration of this generator does not match the generator management configuration of another generator that is connected to the same PGEN network. The local display shows Generator Management.

Invalid Genset Voltage Phase Connection. The fault lamp illuminates yellow and the alarm horn sounds when another generator in the paralleling system has a different phase connection than this generator. The local display shows System Phase.

Low Battery Voltage. The fault lamp illuminates yellow and the alarm horn sounds when the battery voltage drops below a preset level for more than 90 seconds.

Engine Electrical System Voltage	Low Battery Voltage Range	Low Battery Voltage Default Setting
12	9.6- 12.6	12
24	19.2- 25.2	24

Figure 2-7 Low Battery Voltage Specs

The low battery voltage feature monitors the battery and battery charging system in the generator set operating and off modes. The controller logic inhibits the low battery voltage warning during the crank cycle.

Low Coolant Temperature. The fault lamp illuminates yellow and the alarm horn sounds when the engine coolant temperature is low. The low coolant temperature warning does not function during the preset inhibit time delay period after startup.

Low Cranking Voltage. The fault lamp illuminates yellow and the alarm horn sounds when the battery voltage drops below 60% of the nominal voltage (12 or 24 VDC) for more than 6 seconds during the crank cycle.

Low Engine Oil Level. The fault lamp illuminates yellow and the alarm horn sounds because of low engine oil level. This fault feature requires an optional low engine oil level sensor for the lamp to function.

Low Fuel Level. The fault lamp illuminates yellow and the alarm horn sounds when the fuel tank level on diesel-fueled models approaches empty. This fault requires an optional low fuel level switch for the lamp to function.

Low Fuel Pressure. The fault lamp illuminates yellow and the alarm horn sounds when low fuel pressure occurs. This fault requires an optional low fuel pressure switch for the lamp to function.

Low Genset System Frequency. The fault lamp illuminates yellow and the alarm horn sounds when another generator in the paralleling system has a higher system frequency than this generator. The local display shows System Frequency, FMI: Low.

Low Genset System Voltage. The fault lamp illuminates yellow and the alarm horn sounds when another generator in the paralleling system has a higher system voltage than this generator. The local display shows System Voltage, FMI: Low.

Low Oil Pressure. The fault lamp illuminates yellow and the alarm horn sounds when the engine oil pressure approaches the shutdown range. The low oil pressure warning does not function during first the 30 seconds after startup.

Not in Auto (Generator Master Control Switches). The fault lamp illuminates yellow and the alarm horn sounds when the generator set button is in the RUN or OFF/RESET mode.

Option Board 2X Communication Loss. The fault lamp illuminates yellow and the alarm horn sounds when the communication with option board 2X (A, B, or C) has been lost.

Reserve Oil Empty. The fault lamp illuminates yellow and the alarm horn sounds when the oil makeup kit level has dropped below a threshold.

Speed Sensor Fault. The fault lamp illuminates yellow and the alarm horn sounds when the speed signal is absent for one second while the generator set runs.

Total Reactive Power Low. The fault lamp illuminates yellow and the alarm horn sounds when the generator has a loss of field condition due to insufficient reactive load production to support real load. The output breaker trips.

2.6.6 System Fault Shutdown Lamp With Digital Displays

The system FAULT lamp glows red, the alarm horn sounds, and the unit shuts down to indicate a fault shutdown under the following conditions. See Section 2.6.8, Controller Resetting procedure, for information on resetting a system shutdown.

Note: Always identify and correct the cause of a fault shutdown before resetting the controller.

When the system shutdown lamp is on and no message displays, rotate the dial to the Active Events menu. Press the dial to view messages. Rotate the dial to view additional messages. Press the OFF button to return to the main menu.

Use the Alarm Off button to silence the alarm horn at the operator's discretion. If the controller is setup for an NFPA 110 application, press the AUTO button before silencing the alarm horn. The alarm horn cannot be silenced unless the button is in the AUTO mode. See Section 2.6.7 Status and Notice Digital Displays.

AC Sensing Lost (controller in AUTO and voltage was previously present). The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the controller does not detect the nominal generator set AC output voltage for more than 3 seconds after crank disconnect.

Alternator Protection. The fault lamp illuminates red and the unit shuts down because of an alternator overload or short circuit. See Appendix D, Alternator Protection in the Generator Operation Manual for more information.

Auxiliary Input (Shutdown). The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when an auxiliary digital or analog inputs signals the controller. The digital inputs do not function during the first 30 seconds after startup. Use SiteTech™ software to define inputs as shutdowns or warnings.

Common Fault. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the controller is signaled by a common fault. Use SiteTech™ software to activate the common fault shutdown. The common fault comprises of any combination of the fault shutdowns under a single alert.

Coolant Temperature Open Circuit. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the engine coolant temperature sender circuit is open.

ECM Communications Loss. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the ECM communication link is disrupted.

ECM Diagnostics (Multiple Engine Inputs). The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when ECM diagnostics signals the controller. The specific display (xxxxx) will be a brief message or fault code that is engine manufacturer dependant. The engine literature provides the fault code description and further information.

ECM Model Mismatch. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the controller detects an error with the ECM model.

Electrical Metering Communication Loss. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the metering to the controller communication link is disrupted.

Emergency Stop. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the local or optional remote emergency stop switch activates.

Fuel Tank Leak. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the fuel tank signals a leak of the inner tank. This fault requires an optional fuel tank leak switch for the lamp to function.

Generator Total Real Power High. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the generator set supplies more than 102% of the rated standby output kW (or 112% of the rated prime power output kW) for more than 60 seconds.

High Coolant Temperature. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down because of high engine coolant temperature. The high coolant temperature shutdown does not function during the preset inhibit time delay period after startup.

Note: The high engine temperature shutdown function and the low coolant level shutdown function are independent. A low coolant level condition may not activate the high engine temperature switch.

High Engine Speed. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down immediately when the governed frequency on 50 and 60 Hz models exceeds the over speed setting.

High Exhaust Temperature. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down immediately when the engine exhaust temperature exceeds the default setting.

High Intake Air Temperature. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down because of high intake air temperature. The shutdown occurs 5 seconds after the engine intake air reaches the temperature shutdown range. The engine intake air temperature shutdown does not function during the first 30 seconds after startup.

High Generator Frequency. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the frequency is above the overfrequency setting. See Figure 2-8.

Overfrequency Setting Range	Time Delay	Overfrequency Default Setting
102%- 140% of nominal	10 sec.	110% of nominal

Figure 2-8 Overfrequency Specs

High Generator Voltage (Each Phase). The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the voltage exceeds the overvoltage setting for the preset time delay period. See Figure 2-9 for overvoltage specifications.

Note: Overvoltage can damage sensitive equipment in less than one second. Install separate overvoltage protection on online equipment requiring faster than 2-second shutdown.

Overvoltage Setting Range	Time Delay Range	Overvoltage Default Setting
105%- 135% of nominal	2- 10 sec.	120% at 2 sec.

Figure 2-9 Overvoltage Specs

High Lube Oil Temperature. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down because of high engine oil temperature. The shutdown occurs 5 seconds after the engine oil reaches the temperature shutdown range. The high engine oil temperature shutdown does not function during the first 30 seconds after startup.

Locked Rotor (failed to crank). If none of the speed sensing inputs show engine rotation within the preset time delay of initiating engine cranking, the ignition and crank circuits turn off for the preset period and the cycle repeats. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down after the second cycle of the preset period of cranking.

Low Coolant Level. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down because of low coolant level. Shutdown occurs 5 seconds after low coolant level is detected.

Low Engine Oil Level. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down because of low engine oil level. This fault feature requires an optional low engine oil level sensor for the lamp to function.

Low Engine Speed. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down immediately when the governed frequency on 50 and 60 Hz models drops below the under speed setting.

Low Fuel Level (diesel-powered models only). The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the fuel tank level on diesel-fueled models approaches empty. This fault requires an optional low fuel level switch for the lamp to function.

Low Fuel Pressure. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when low fuel pressure occurs. This fault requires an optional low fuel pressure switch for the lamp to function.

Low Generator Frequency. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the frequency drops below the underfrequency setting. See Figure 2-10 for underfrequency specifications.

Underfreq. Setting Range	Time Delay	Underfrequency Default Setting
80%- 95% of nominal	10 sec. (short term) 60 sec. (long term)	90% of nominal

Figure 2-10 Underfrequency Specs

Low Generator Voltage (Each Phase). The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the voltage drops below the undervoltage setting for the time delay period. See Figure 2-11 for undervoltage specifications

Undervoltage Setting Range	Time Delay Range	Undervoltage Default Setting
70%- 95% of nominal	5- 30 sec.	80% of nominal at 10 sec.

Figure 2-11 Undervoltage Specs

Low Oil Pressure. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down because of low oil pressure. The shutdown occurs 5 seconds after the low pressure condition is detected. The low oil pressure shutdown does not function during first the 30 seconds after startup.

Low Seawater Pressure. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down after a loss of seawater pressure is detected.

Max. Alternator Current Low. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when Alternator Protection Configuration in the personality profile is not correct. The controller may need a new personality profile. Check the voltage, frequency, and connection settings. Consult your local authorized distributor.

Oil Pressure Open Circuit. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the engine oil pressure sender circuit is open for more than 5 seconds.

Overcrank. The fault lamp illuminates red, the alarm horn sounds, and cranking stops when the unit does not start within the defined cranking period. See Section 2.6 for cyclic crank specifications.

Note: The controller is equipped with an automatic restart function. When speed drops below 25 Hz (750 rpm) while the engine is running, the unit attempts to recrank. The unit then follows the cyclic cranking cycle and, when the engine fails to start, will shut down on an overcrank fault condition.

Run Relay Coil Overload. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the current draw on the 70 wire from the controller has exceeded 40 amps or has exceeded 10 amps for at least 10 ms.

Starter Relay Coil Overload. The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the current draw on the 71 wire from the controller has exceeded 40 amps or has exceeded 10 amps for at least 10 ms.

Trip to Shutdown Delay The fault lamp illuminates red, the alarm horn sounds, and the unit shuts down when the generator is stopped if the circuit breaker has tripped for a Protective Relay function, and the trip to shutdown time delay has expired. This delay allows mitigation of problem conditions without engine shutdown. If the delay expires, it is presumed no successful action was taken in the allotted time.

2.6.7 Status and Notice Digital Displays

Warnings and shutdown faults appear on the digital display under the Active Events menu and become part of the event history. Beyond the warnings and shutdowns there are several events which also appear on the digital display under the Active Events menu. Status is an event that is not an alert but is part of the event history. Notice is an alert that is not part of the event history.

The controller allows a selected number of changes by the user for setting up the controller application which are covered in this section.

Alarm Horn Silence. This status message indicates whether the alarm horn can be silenced in any button mode (OFF/RESET- AUTO- RUN) or requires the AUTO button be pressed first compliant per NFPA 110. Use SiteTech™ software to change this setting. See Section 2.6.8, Controller Resetting procedure, for information on resetting the system.

The local display shows *Alarm Silence: Always* when the alarm horn can be silenced with the master control buttons in any position (default setting).

The local display shows *Alarm Silence: Auto Only* when the alarm horn can be silenced only when in the AUTO mode. The correct reset sequence requires pressing the OFF/RESET button, then pressing the AUTO button, and then pressing the ALARM SILENCE button.

Close Breaker. This notice message indicates that the controller is attempting to close the circuit breaker (a close command is being sent to the circuit breaker). This notice only appears in paralleling applications (where the bus sensing is connected to the bus side of the paralleling breaker).

Contactor. This notice message indicates that the controller wants to be connected to the paralleling bus. If a contactor is used for paralleling, this output controls it. This notice only appears in paralleling applications (where the bus sensing is connected to the bus side of the paralleling breaker).

Emergency Power System (EPS) Supplying Load. This notice message indicates when the generator set supplies more than 1% of the rated standby output current.

Engine Cooldown (Delay) Active. This notice message indicates that the delay for engine cooldown is active where the generator set will continue to run after the OFF/RESET button is pressed. The unit will continue to run until the time delay times out.

Engine Start Aid Active. This notice message indicates that the start aid is active and will energize an engine equipped preheat or ether system during the crank cycle. Use SiteTech™ software to set up this feature.

Engine Started. This status indicates that the generator set start circuit is closed allowing the engine to crank and run.

Engine Stopped. This status indicates that the generator set start circuit is open causing the engine to shut down.

Generator Running. This notice indicates that the generator set has started and is running.

Load Priority # Shed. This status message indicates the digital output for load priority # (1, 2, 3, 4, 5, or 6) shed is active (contacts closed), indicating the 1st, 2nd, 3rd, 4th, 5^{th,} or 6th priority load shed has been activated.

Remote Start. This notice indicates that the generator set start circuit was closed from a remote location allowing the engine to crank and run. The remote location is typically a set of contacts on a transfer switch or remote start switch.

Remove Breaker Trip. This notice message indicates that the controller considers the breaker to be safe to close. The breaker may be closed or preparing to close when this notice is displayed. This notice only appears in paralleling applications (where the bus sensing is connected to the bus side of the paralleling breaker).

Run Button Acknowledged. This notice message indicates that the RUN button on the controller has been pushed.

System Ready. This status indicates that the generator set is in the AUTO mode and available to start if the start circuit is closed.

2.6.8 Controller Resetting (Following System Shutdown or Warning)

Use the following procedure to restart the generator set after a system shutdown or to clear a warning lamp condition. This procedure includes the resetting of the optional remote annunciator.

Refer to Section 2.6.2, Emergency Stop, to reset the generator set after an emergency stop.

1. Disconnect the generator set load using the line circuit breaker or automatic transfer switch.
2. Correct the cause of the fault shutdown or warning. See the Safety Precautions and Instructions section of this manual before proceeding.

Note: Always identify and correct the cause of a fault shutdown before resetting the controller.

3. Reset the fault by pressing the OFF/RESET button.
4. Start the generator set by pressing the generator set OFF/RESET button and then press the RUN button.

   When equipped, the remote annunciator alarm horn sounds. Press the ALARM SILENCE/LAMP TEST button to stop the alarm horn. The lamp turns off.
5. Test operate the generator set to verify correction of the shutdown cause by pressing the RUN button.
6. Press the generator set OFF/RESET button to stop the generator set.
7. Press the generator set AUTO button.
8. Silence the controller alarm horn by pressing the ALARM SILENCE button.
9. Reconnect the generator set load via the line circuit breaker or automatic transfer switch.
10. When equipped, the remote annunciator alarm horn sounds. Press the ALARM SILENCE/LAMP TEST button to stop the alarm horn. The alarm silenced lamp turns on if the alarm is silenced.

2.6.9 Controller Bootloader Mode Function

If the Decision-Maker® 3500 controller display does not boot upon applying battery, but the blue LED flashes, follow the steps below to power up the controller in bootloader mode:

1. With the battery disconnected, press and hold the OFF/RESET button.
2. With the OFF/RESET button still held, connect battery power. The display will remain blank but the OFF/RESET LED will slowly blink.
3. Connect Kohler SiteTech™ and upload current firmware to the controller. The display will now power up.
4. Use Kohler SiteTech™ to determine if the appropriate unit model is identified in the Genset Info menu. If not, re-apply the generator personality profile.

2.7 Menu Displays

The Menu Summary List and Figure 2-12 provide a quick reference to the digital display data. Some digital display data may not be identical to your display due to generator set application differences. The closed bullet items represent main level data and the open bullet items are sub-level data. The Menu Summary List indicates items that are user selectable. Use SiteTech™ software for changing programmable information.

Menu Summary List (Legend: ● First level submenu, ○ second level submenu, ◇ third level submenu)

Metering Menu

- **Generator Metering**
  - L1-L2 VOLTS: ###V
  - L2-L3 VOLTS: ###V
  - L3-L1 VOLTS: ###V
  - AVG GEN VOLTAGE L-L: ###V
  - GEN FREQUENCY: ##.#Hz
  - L1-L0 VOLTS: ###V
  - L2-L0 VOLTS: ###V
  - L3-L0 VOLTS: ###V
  - AVG GEN VOLTAGE L-N: ###V
  - GEN FREQUENCY: ##.#Hz
  - L1 CURRENT: ###A
  - L2 CURRENT: ###A
  - L3 CURRENT: ###A
  - AVG CURRENT: ###A
  - GEN FREQUENCY: ##.#Hz
  - L1 POWER: ####W
  - L2 POWER: ####W
  - L3 POWER: ####W
  - TOTAL POWER: ####.#kW
  - GEN % OF RATED kW: ###%
  - L1 REACTIVE POWER: ####VAR
  - L2 REACTIVE POWER: ####VAR
  - L3 REACTIVE POWER: ####VAR
  - TOTAL REACTIVE POWER: ####VAR
  - L1 APPARENT POWER: ####VA
  - L2 APPARENT POWER: ####VA
  - L3 APPARENT POWER: ####VA
  - TOTAL APPARENT PWR: ####VA
  - GEN % OF RATED kVA: ###%
  - L1 PF: #.##
  - L2 PF: #.##
  - L3 PF: #.##
  - TOTAL PF: #.##
  - GEN PHASE ROTATION: ###
- **Engine Metering**
  - ENGINE SPEED: ####RPM
  - ECM BATTERY VOLTAGE: ##.#VDC
  - GEN BATTERY VOLTAGE: ##.#VDC
  - GENSET CONTROLLER TEMP: ###°F
  - OIL PRESSURE: ###PSI
  - OIL TEMPERATURE: ###°F
  - COOLANT TEMPERATURE: ###°F
  - COOLANT PRESSURE: ###PSI
  - FUEL LEVEL: ###%
  - FUEL PRESSURE: ###PSI
  - FUEL TEMPERATURE: ###°F
  - FUEL RATE: ###GAL/h (*shown if available from ECM*)
  - FUEL USED LAST RUN: ###GAL (*shown if available from ECM*)
  - CRANKCASE PRESSURE: ###PSI
  - INTAKE AIR PRESSURE: ###PSI
  - INTAKE AIR TEMP: ###°F
- **Battery X Meter**

  Note: *This menu option does not apply to marine generator sets.*
  - STATUS: (IDLING/STANDBY/ CHARGING/ BATT FAIL/CHRGR FAIL/ NOT AVAILABLE)
  - OUTPUT VOLTAGE: ##.#VDC
  - OUTPUT CURRENT: ##.#A
  - CHARGER STATE: IDLE/BULK/ ABSORB/FLOAT/EQUAL/REFRESH/ RECOVER/NA
  - CHARGER TEMP: ###°F
  - REDUCED OUTPUT ACTIVE: YES/NO
  - TEMP COMPENSATION ACTIVE: YES/NO
  - SOFTWARE VER.: XXXXXXXXXXXX
- **Overview**
  - GENERATOR STATUS
    - AVG GEN VOLTAGE L-L: ###V
    - AVG CURRENT: ###A
    - GEN FREQUENCY: ##.#Hz
  - ENGINE STATUS
    - COOLANT TEMPERATURE: ###°F
    - OIL PRESSURE: ###PSI
    - GEN BATTERY VOLTAGE: ##.#V
  - SYSTEM STATUS
    - FUEL PRESSURE: ###PSI
    - TOTAL POWER: ####kW
    - TOTAL RUN TIME: #####.#hrs
- **Paralleling Metering**
  - CONNECTED TO BUS: TRUE/FALSE
  - AVG BUS VOLTAGE L-L: ###.#V
  - AVG GEN VOLTAGE L-L: ###.#V
  - BUS FREQUENCY: ##.##Hz
  - GEN FREQUENCY: ##.##Hz
  - BUS TOTAL POWER: #####.#kW
  - BUS % OF RATED kW: ###%
  - BUS % OF RATED kVAR: ###%

Generator Information Menu

- **Generator Information**
  - TOTAL RUN TIME: #####.#hrs
  - HOURS LOADED: #####hrs
  - HOURS UNLOADED: #####hrs
  - kW HOURS: #####kWh
  - OPERATING HOURS: ######hrs
  - TOTAL # OF STARTS: ########
  - LAST MAINTENANCE: ##/##/####
  - OP HRS SINCE MAINT: ####hrs
  - STARTS SINCE MAINT: ###
  - ENG HRS SINCE MAINT: ####hrs
  - LOADED SINCE MAINT: ####hrs
  - UNLOADED SINCE MAINT: ####hrs
  - kW HRS SINCE MAINT: ####kWh
  - RESET MAINT RECORDS: YES/NO*
  - LAST START: ##/##/####
  - LAST RUN LENGTH: ####hrs
  - CTRL SERIAL #: XXXXXXXXX
  - SOFTWARE VER.: XXXXXXXXX
  - ECM SERIAL #: XXXXXXXXX
  - GENSET MODEL #: XXXXXXXXX
  - GENSET SPEC. #: XXXXXXXXX
  - GENSET SERIAL #: XXXXXXXXX
  - ALT. PART #: XXXXXXXXX
  - ENGINE PART #: XXXXXXXXX
  - ENGINE MODEL #: XXXXXXXXX
  - ENGINE SERIAL #: XXXXXXXXX
- **Event History**
  - GENERATOR EVENT HISTORY
    ##/##/#### (Date) ##:##.##XX (Time)
    DEVICE EVENT: ###
    STATUS/FAULT/NOTICE/WARNING
    EVENT X OF Y
  - ENGINE EVENT LOG
    SPN: ####
    FMI: ##
    OCCURRENCE COUNT: ###
    EVENT X OF Y

Generator Information Menu (Continued)

- **Configuration**
  - GENERATOR CONFIGURATION
    - OPERATING MODE: (STANDBY/PRIME)
    - APPLICATION TYPE: (NONE/MARINE/ MOBILE/STANDBY/PRIME)
    - SYSTEM VOLTAGE L-L: ###V*
    - SYSTEM FREQUENCY: ##.#Hz*
    - SYSTEM PHASE: (SINGLE/SINGLE DOG/THREE-WYE/THREE- DELTA)*
    - RATED ENGINE SPEED: ####RPM
    - ENGINE SPEED ADJUSTMENT: *
    - ADJUSTED ENGINE RUN SPEED: ####RPM
    - kW RATING: ####kW
    - kVA RATING: #####kVA
    - RATED CURRENT: ###A
    - BATTERY VOLTAGE: ##VDC*
    - POWER ECM: ON/OFF*
    - ENGINE START DELAY: ##s*
    - STARTING AID DELAY: ##s*
    - CRANK ON DELAY: ##s*
    - CRANK PAUSE DELAY: ##s*
    - ENGINE WARMED UP: ###°F
    - ENGINE COOLED DOWN: ###°F
    - COOLDOWN DELAY: ##s*
    - COOLDOWN OVERRIDE: ON/OFF*
    - FUEL TYPE: (NATURAL GAS/LP/ GASOLINE/DIESEL/UNKNOWN)*
    - CRANK CYCLES LIMIT: ##*
    - NFPA DEFAULTS: ON/OFF*
    - EMERGENCY BATTLEMODE: ON/OFF*
    - POWER UP IN AUTO: ON/OFF*
    - NOT IN AUTO WARN ENABLE: ON/OFF*
    - AUX FAULT DELAY: ##s*
    - AUX FAULT INHIBIT DELAY: ##s*
  - PROTECTION CONFIGURATION
    - OVERVOLTAGE: ###%*
    - OVERVOLTAGE: ###.#V
    - OVERVOLTAGE DELAY: ##s*
    - UNDERVOLTAGE: ##%*
    - UNDERVOLTAGE: ##.#V
    - UNDERVOLTAGE DELAY: ##s*
    - OVERFREQUENCY: ##%*
    - OVERFREQUENCY: ##.#Hz
    - UNDERFREQUENCY: ##%*
    - UNDERFREQUENCY: ##.#Hz
    - OVERSPEED: ##.#%*
    - OVERSPEED: ##.#Hz
    - OVERSPEED: ####RPM
    - LOW BATTERY VOLTAGE: ###%*
    - LOW BATTERY VOLTAGE: ##.#VDC
    - HIGH BATTERY VOLTAGE: ###%*
    - HIGH BATTERY VOLTAGE: ##.#VDC
  - BATT X BASIC CONFIG

    Note: *This menu option does not apply to marine generator sets.*
    - BATTERY TOPOLOGY: (DEFAULT/ VRLA/ AGM/GEL/NiCd*
    - CHARGER SYSTEM VOLTAGE: 12VDC/24VDC*
    - AUTO EQUALIZE ENABLED: ON/OFF*
    - TEMP COMPENSATION ENABLED: ON/OFF*
    - ABSORPTION TERMINATION: #.##A (+/- 0.05)*
    - BULK VOLTAGE: ##.##VDC (+/- 0.05)*
    - ABSORPTION VOLTAGE: ##.##VDC (+/- 0.05) *
    - FLOAT VOLTAGE: ##.##VDC (+/- 0.05)*
    - MANUAL EQUALIZE ACTIVE: YES/NO*
    - CUSTOM PROFILE ENABLED: ON/OFF*
    - TEMP COMPENSATION SLOPE: ##mV/C*
    - EQUALIZE VOLTAGE: ##.##VDC (+/- 0.05)*
    - MAX ABSORPTION TIME: ###MIN*
    - MAX BULK TIME: ###MIN*
    - BULK STATE RETURN: ##.##V (+/- 0.05)*

* User-Defined (changeable) Menu Displays. Use SiteTech™ software to change other settings including User-Defined Menu Displays.

Generator Information Menu (Continued)

- **Voltage Regulation**
  - AVG GEN VOLTAGE L-L: ###.#V
  - VOLTAGE ADJUST: ###.#V*
  - TARGET VOLTAGE: ###.#V
  - L1-L2 VOLTS: ###.#V
  - L2-L3 VOLTS: ###.#V
  - L3-L1 VOLTS: ###.#V
  - GEN FREQUENCY: ##.#Hz
  - V/Hz SETPOINT: ##.#Hz*
  - V/Hz SLOPE: ##%/Hz*
  - VOLT DROOP AT 100% kVAR: ##.#%*
  - VOLTAGE GAIN ADJUST: ###*
  - START UP RAMP RATE: ###.#%/s*
  - RESET REG. DEFAULTS: YES/NO*
- **Paralleling Operation**
  - PARALLELING SETUP
    - DEAD BUS LEVEL: ##.#%*
    - VOLTAGE OK PICKUP: ##.#%*
    - VOLTAGE OK DROPOUT: ##.#%*
    - FREQUENCY OK PICKUP: ##.#Hz*
    - FREQUENCY OK DROPOUT: ##.#Hz*
    - VOLTS-Hz OK DELAY: ##.#s*
    - FIRST ON DELAY: ##.#s*
    - FAIL TO OPEN DELAY: ##s*
    - FAIL TO CLOSE DELAY: ##s*
    - RECLOSE DELAY: ##.#s*
    - MAX CLOSE ATTEMPTS: ###*
    - CB CRNT FAULT LIMIT: ###.#%*
    - CB CRNT FAULT DELAY: ##.#s*
    - CB PHASE FAULT LIMIT: ##.#°*
    - CB PHASE FAULT DELAY: ##.#s*
    - kW RAMP RATE: ##.#%/s*
    - kW DISCONNECT LEVEL: ##.#%*
    - TRIMS ENABLE: ON/OFF*
    - LOAD ENABLE: ON/OFF*
    - SYSTEM LOAD CONTROL: ON/OFF*
    - SYSTEM SYNC CONTROL: ON/OFF*
    - STAND ALONE MODE: ON/OFF*
    - SYNC MODE IN AUTO: (INVALID/OFF/PASSIVE/CHECK/ ACTIVE/DEAD FIELD)*
    - SYNC MODE IN RUN: (INVALID/OFF/PASSIVE/CHECK/ ACTIVE/DEAD FIELD)*
  - SYNCHRONIZING SETUP
    - SYNC MODE IN RUN: (INVALID/OFF/PASSIVE/CHECK/ ACTIVE/DEAD FIELD)*
    - SYNC MODE IN AUTO: (INVALID/OFF/PASSIVE/CHECK/ ACTIVE/DEAD FIELD)*
    - CONNECTED TO BUS: TRUE/FALSE
    - VOLTS-Hz OK: TRUE/FALSE
    - IN SYNC: TRUE/FALSE
    - VOLTAGE MATCHED: TRUE/FALSE
    - VOLTAGE MATCH WINDOW: ##.#%*
    - AVG BUS VOLTAGE L-L: ###.#V
    - AVG GEN VOLTAGE L-L: ###.#V
    - VOLTAGE MATCH P GAIN: ##.##*
    - VOLTAGE MATCH I GAIN: ##.##*
    - VOLTAGE MATCH D GAIN: ##.##*
    - VOLTAGE BIAS: ###.##
    - FREQUENCY MATCHED: TRUE/FALSE
    - FREQUENCY WINDOW: #.#Hz*
    - BUS FREQUENCY: ##.##Hz
    - GEN FREQUENCY: ##.##Hz
    - FREQ MATCH P GAIN: ##.##*
    - FREQ MATCH I GAIN: ##.##*
    - FREQ MATCH D GAIN: ##.##*
    - SPEED BIAS: ###.##
    - PHASE MATCHED: TRUE/FALSE

Generator Information Menu (Continued)

    - PHASE MATCH WINDOW: ##.#°*
    - PHASE DIFFERENCE: ###.#°
    - PHASE MATCH P GAIN: ##.##*
    - PHASE MATCH I GAIN: ##.##*
    - PHASE MATCH D GAIN: ##.##*
    - SPEED BIAS: ###.##
    - DWELL TIME: ##.#s*
    - DWELL TIME REMAINING: ##.#s
    - FAIL TO SYNC TIME: ####s*
    - SYNC TIME REMAINING: ####s
    - BUS PHASE ROTATION: DISABLED/A-B-C/C-B-A
    - GEN PHASE ROTATION: DISABLED/A-B-C/C-B-A
  - SHARING SETUP
    - BUS % OF RATED kW: ###.##%
    - GEN % OF RATED kW: ###.##%
    - kW SHARING P GAIN: ##.##*
    - kW SHARING I GAIN: ##.##*
    - kW SHARING D GAIN: ##.##*
    - SPEED BIAS: ###.##
    - SYSTEM FREQUENCY: ##.#Hz
    - GEN FREQUENCY: ##.#Hz
    - FREQ TRIM P GAIN: ##.##*
    - FREQ TRIM I GAIN: ##.##*
    - FREQ TRIM D GAIN: ##.##*
    - SPEED BIAS: ###.##
    - FREQ DROOP AT 100% kW: ##.#%*
    - BUS % OF RATED kVAR: ###.##%
    - GEN % OF RATED kVAR: ###.##%
    - kVAR SHARING P GAIN: ##.##*
    - kVAR SHARING I GAIN: ##.##*
    - kVAR SHARING D GAIN: ##.##*
    - VOLTAGE BIAS: ###.##
    - SYSTEM VOLTAGE L-L: ###.#V
    - AVG GEN VOLTAGE L-L: ###.#V
    - VOLT TRIM P GAIN: ##.##*
    - VOLT TRIM I GAIN: ##.##*
    - VOLT TRIM D GAIN: ##.##*
    - VOLTAGE BIAS: ###.##
    - VOLT DROOP AT 100% kVAR: ##.#%*
  - PROTECTIVE RELAY SETUP
    - OVER POWER TRIP: ###.#%*
    - OVER POWER DELAY: ##.#s*
    - REVERSE POWER TRIP: ###.#%*
    - REVERSE POWER DELAY: ##.#s*
    - OVER VOLTAGE TRIP: ###.#%*
    - OVER VOLTAGE DELAY: ##.#s*
    - UNDER VOLTAGE TRIP: ###.#%*
    - UNDER VOLTAGE DELAY: ##.#s*
    - OVER FREQ TRIP: ###.#%*
    - OVER FREQ DELAY: ##.#s*
    - UNDER FREQ TRIP: ###.#%*
    - UNDER FREQ DELAY: ##.#s*
    - REVERSE VAR TRIP: ###.#%*
    - REVERSE VAR DELAY: ##.#s*
    - OVER CURRENT TRIP: ###.#%*
    - OVER CURRENT DELAY: ##.#s*
    - TRIP TO SHTDWN DELAY: #####s*
  - GENERATOR MANAGEMENT
    - GEN MANAGEMENT MODE: (INVALID/MANUAL FIXED/RUN TIME/FUEL LEVEL)*
    - GEN MANAGEMENT: ON/OFF*
    - GEN MANAGEMENT ORDER: #* *will revert to previous setting in run time or fuel level mode.*
    - START CAPACITY: ###.#%*
    - START DELAY: ####s*
    - STOP CAPACITY: ###.#%*
    - STOP DELAY: ####s*
    - TOTAL BUS CAPACITY: #####kW
    - BUS TOTAL POWER: #####kW
    - START kW: #####kW
    - STOP kW: #####kW
    - START ACCUMULATOR: #####

Generator Information Menu (Continued)

    - STOP ACCUMULATOR: #####
    - RUN TIME THRESHOLD: ###.#hrs* *only if in Run Time Management*
    - TOTAL RUN TIME: #######.#hrs
    - FUEL LEVEL THRESHOLD: ##.#%* *only if in Fuel Level Management*
    - FUEL LEVEL: ###.#%
    - STABLE DELAY: ####s*
    - MINIMUM GENS ONLINE: ##*
    - MIN LOADS ADDED: ##*
    - STOPPED BY GEN MGMT: TRUE/FALSE
  - LOAD CONTROL
    - GEN MAX % CAP: ###.#%*
    - GEN OVERLOAD %: ###.#%*

Controller Configuration Menu

- **Controller Configuration**
  - LANGUAGE: English*
  - UNITS: Metric/English*
  - TIME FORMAT: Hr 12/Hr 24*
  - DATE FORMAT: Month Date Year/ Date Month Year*
  - DATE: ##/##/####*
  - TIME: ##:## XM*
  - CONTRAST: ###*
  - ALARM SILENCE: ALWAYS/AUTO ONLY*
- **Communication Setup**
  - MODBUS BAUD RATE: OFF/9600 b/s/ 19200 b/s/38400 b/s/57600 b/s/ 115200 b/s*
  - MODBUS ADDRESS: ##*
  - PGEN BAUD RATE: OFF/9600 b/s/ 19200 b/s/38400 b/s/57600 b/s/ 115200 b/s
  - PGEN NODE ID: ##
  - PGEN NODES ONLINE: ##
  - PGEN NODES OFFLINE: ##
- **Calibration**

When the line is highlighted, hold the knob down to enable the calibration capability.

  - GEN L1-L0 VOLTS: ###.#V*
  - GEN L2-L0 VOLTS: ###.#V*
  - GEN L3-L0 VOLTS: ###.#V*
  - GEN L1-L2 VOLTS: ###.#V*
  - GEN L2-L3 VOLTS: ###.#V*
  - GEN L3-L1 VOLTS: ###.#V*
  - GEN L1 CURRENT: ###.#A*
  - GEN L2 CURRENT: ###.#A*
  - GEN L3 CURRENT: ###.#A*
  - BUS L1-L2 VOLTS: ###.#V*
  - BUS L2-L3 VOLTS: ###.#V*
  - BUS L3-L1 VOLTS: ###.#V*
  - RESET GEN VOLT METER: YES/NO*
  - RESET GEN AMP METER: YES/NO*
  - RESET BUS VOLT METER: YES/NO*
  - RESET ALL METERS: YES/NO*

* User-Defined (changeable) Menu Displays. Use SiteTech™ software to change other settings including User-Defined Menu Displays.

I/O Menu

- **Resistive Input**

Analog Input 0:1
Analog Input 0:2
Analog Input 0:3
Analog Input 0:4
Analog Input 0:5
Analog Input 0:6

- DESCRIPTION: (*function by default unless modified via SiteTech*)
- MEASUREMENT: ###.#Ohms
- EVENT: *
- INPUT ENABLED: ON/OFF*
- SENSOR TYPE: *
- LOW PROTECTIVE INHIBIT: ##s*
- LOW WARNING: ON/OFF*
- LOW WARNING LIMIT: *
- LOW WARNING DELAY: ##s*
- LOW SHUTDOWN: ON/OFF*
- LOW SHUTDOWN LIMIT: *
- LOW SHUTDOWN DELAY: ##s*
- HIGH PROTECTIVE INHIBIT: ##s*
- HIGH WARNING: ON/OFF*
- HIGH WARNING LIMIT: *
- HIGH WARNING DELAY: ##s*
- HIGH SHUTDOWN: ON/OFF*
- HIGH SHUTDOWN LIMIT: *
- HIGH SHUTDOWN DELAY: ##s*

I/O Menu (Continued)

- **Digital Input**

Digital Input 0:1
Digital Input 0:2
Digital Input 0:3
Digital Input 0:4
Digital Input 0:5
Digital Input 0:6

- DESCRIPTION: (*function by default unless modified via SiteTech*)
- STATUS: ACTIVE/INACTIVE
- FUNCTION: *
- EVENT: *
- LOGIC: ACTIVE ON/ACTIVE OFF *
- ENABLED: ON/OFF*
- INHIBIT TIME: ##s*
- DELAY TIME: ##s*

- **Digital Output**

Digital Output 0:1
Digital Output 0:2
Digital Output 0:3
Digital Output 0:4
Digital Output 1:1
(Note: Only displayed if the 15-Relay Dry Contact Kit is installed.)
...

- DESCRIPTION: *(function by default unless modified via SiteTech*)
- STATUS: ACTIVE/INACTIVE
- FUNCTION: *
- EVENT: *
- LOGIC: ACTIVE ON/ACTIVE OFF*

Active Events Menu

Rotate the dial to view Active Events:
Warnings
Shutdowns
Statuses
Notices

Press the OFF button to return to the main menu.

* User-Defined (changeable) Menu Displays. Use SiteTech™ software to change other settings including User-Defined Menu Displays.

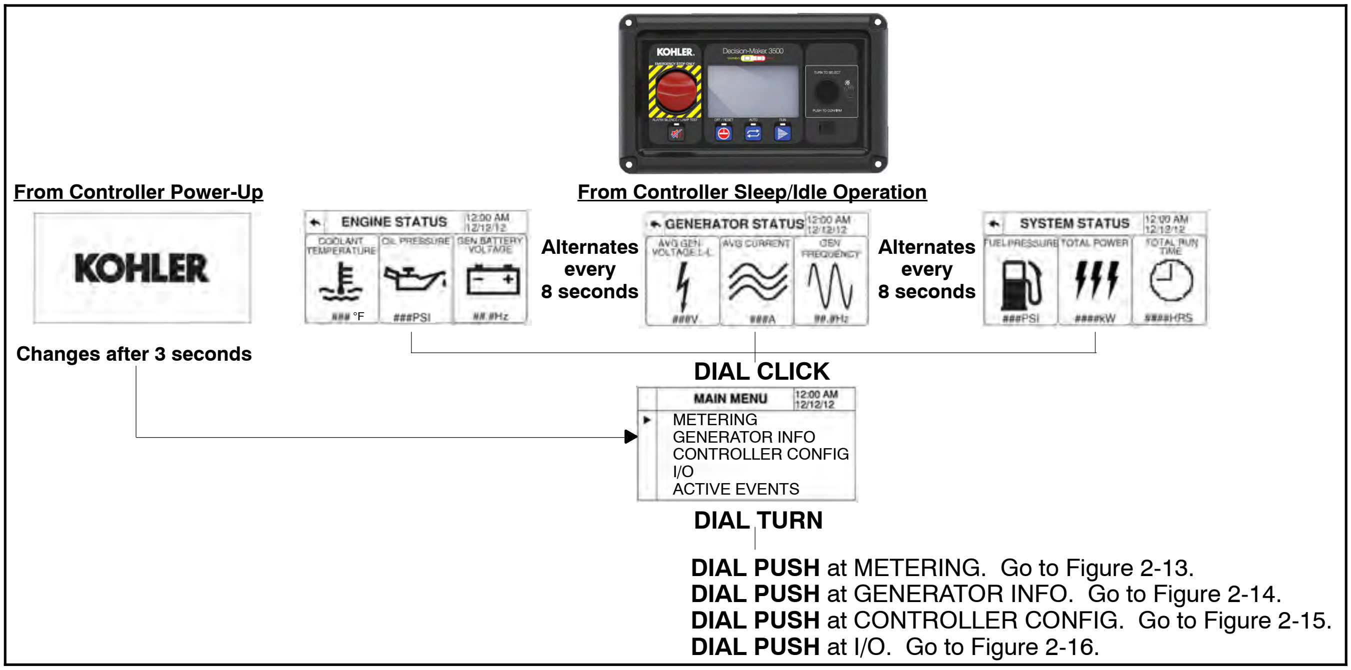


Figure 2-12 Decision-Maker 3500 Controller Information Menu Structure

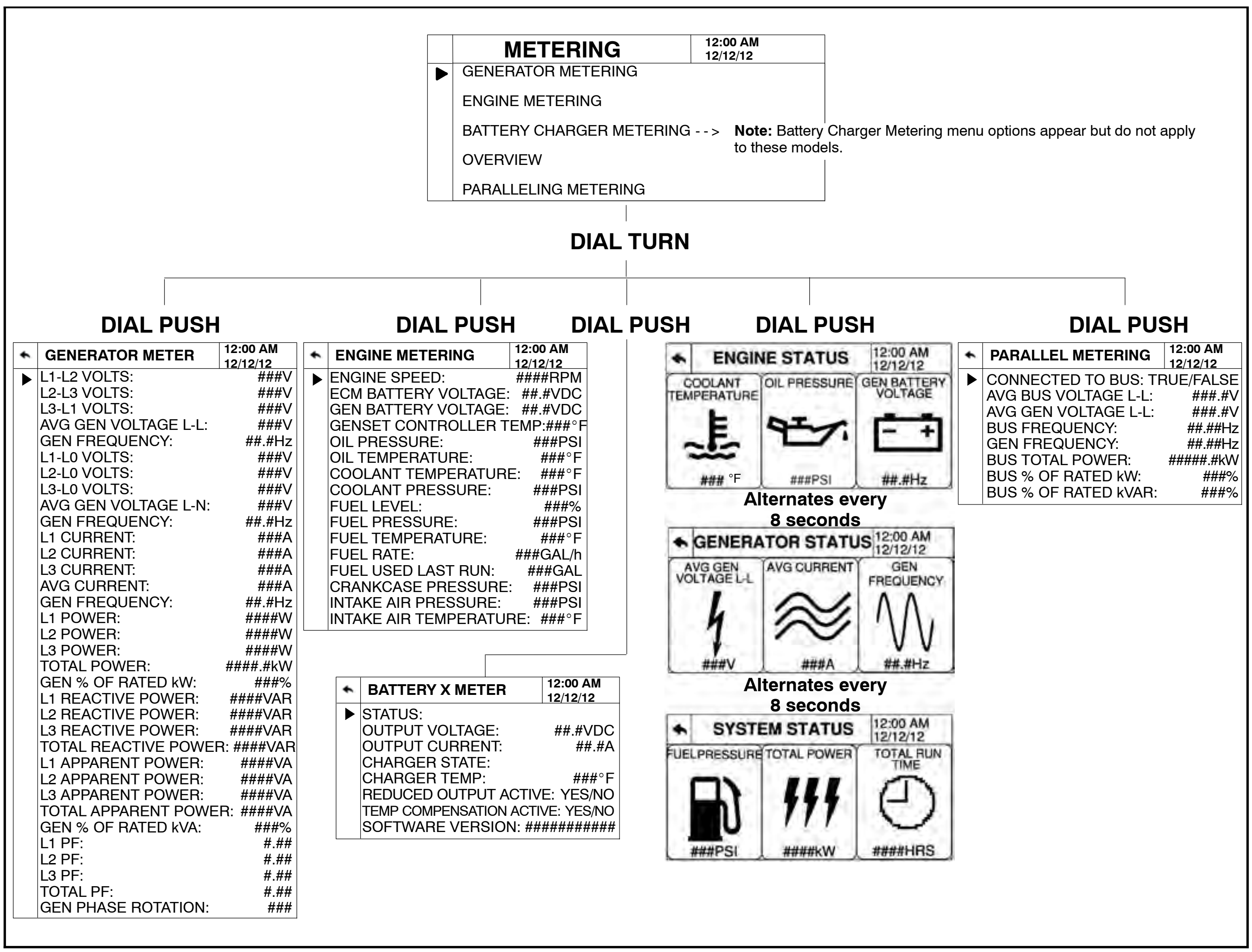


Figure 2-13 Metering Menu

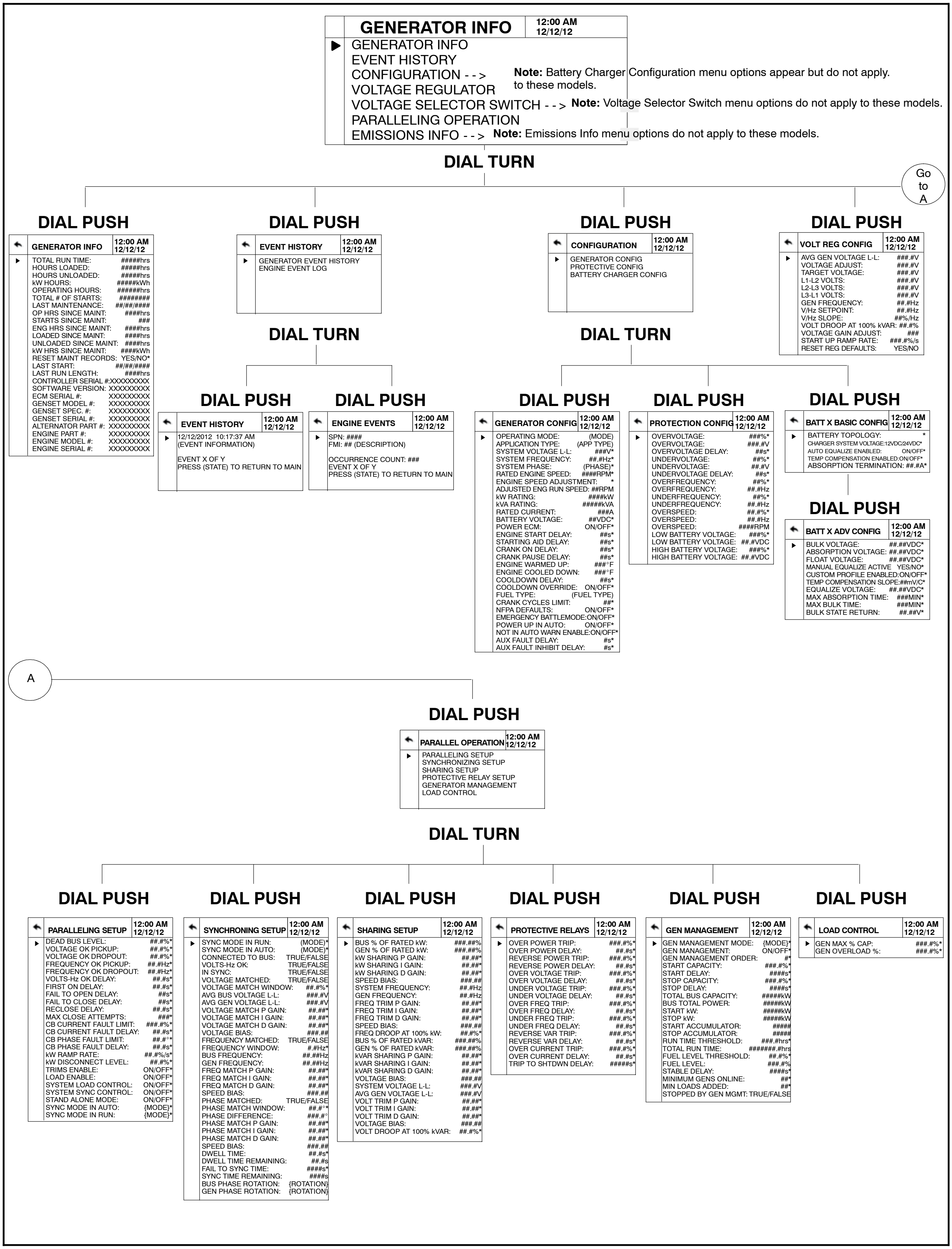


Figure 2-14 Generator Information Menu

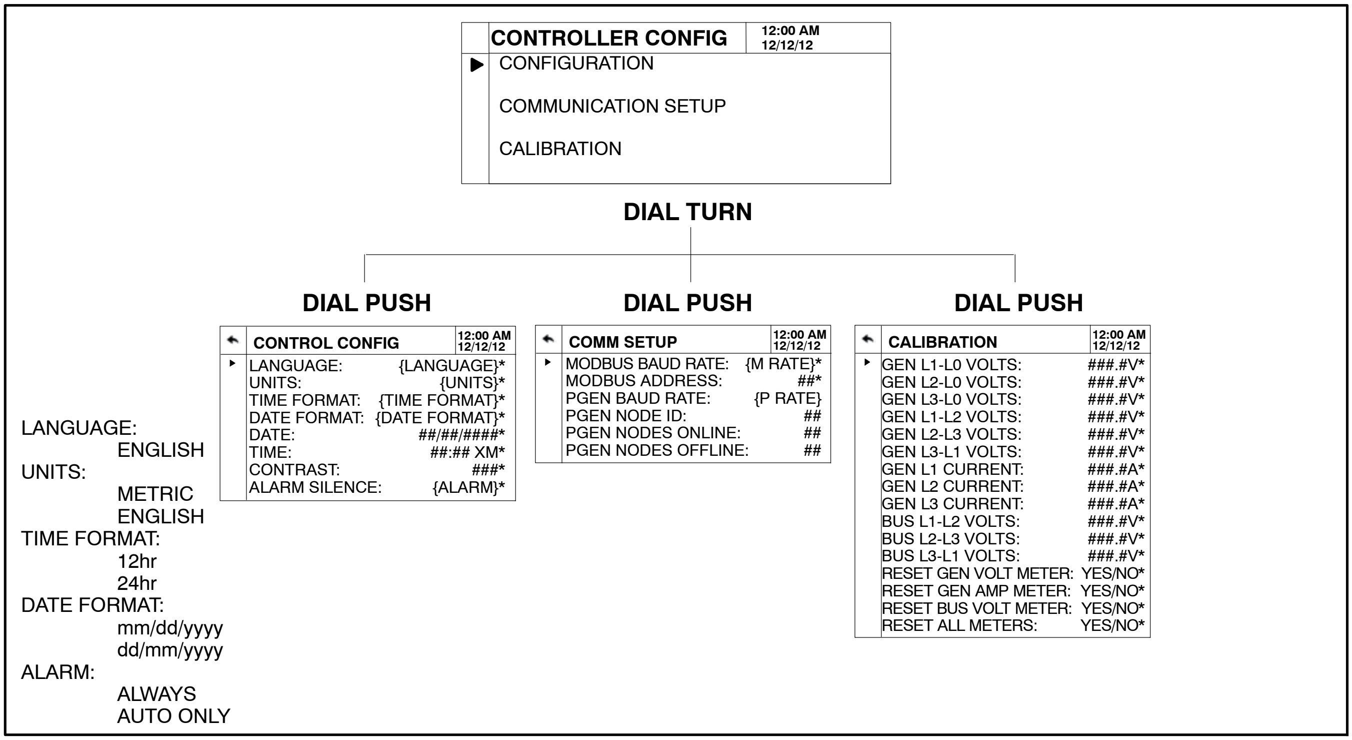


Figure 2-15 Controller Configuration Menu

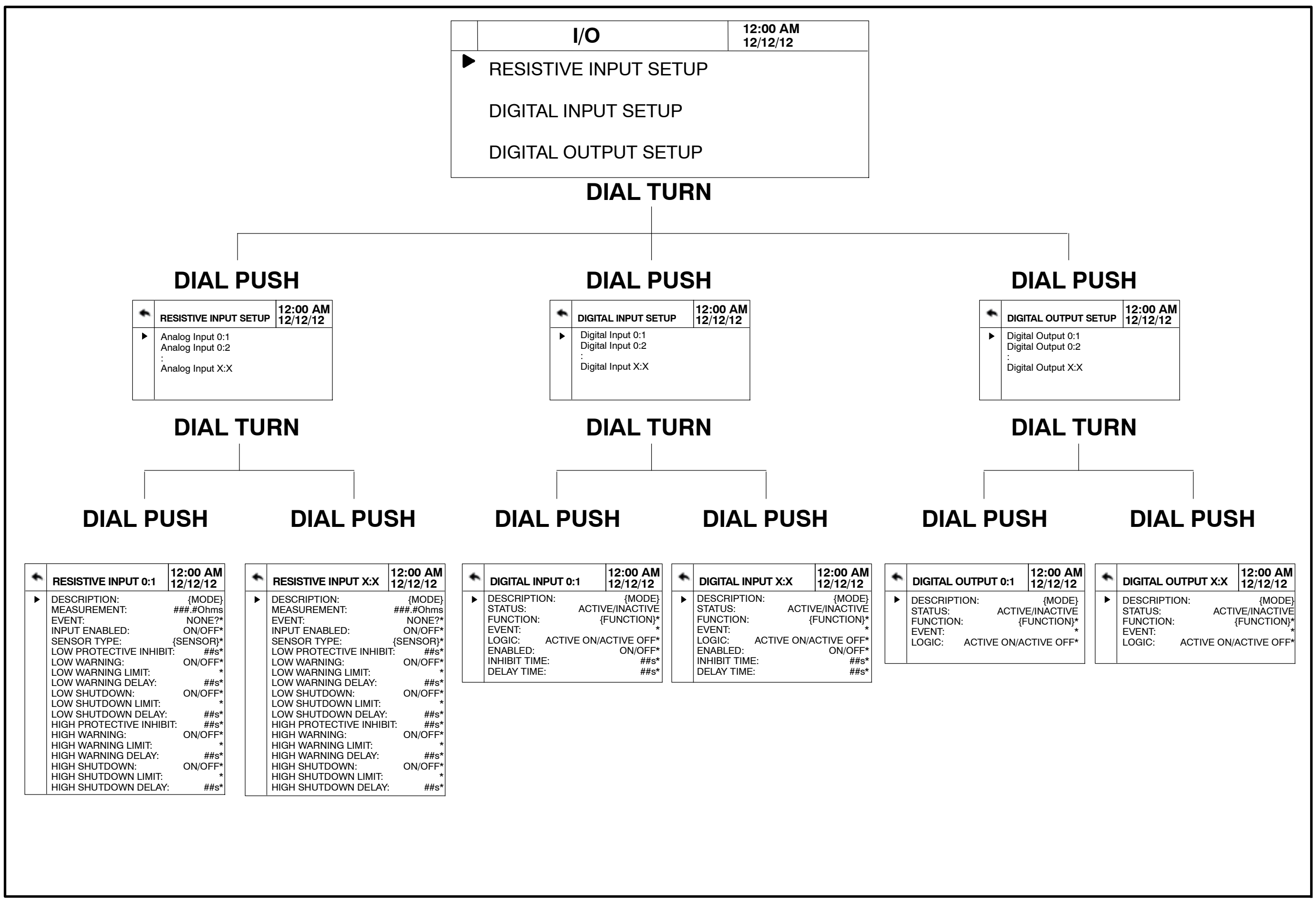


Figure 2-16 I/O Menu

2.8 Monitoring and Programming Setup

The user programmer can access the controller data with the controller digital display or a personal computer (PC) with optional SiteTech™ software to monitor and/or program. Access the controller system with a PC using a USB cable with a mini USB plug. Refer to the Introduction, List of Related Materials for related software literature.

While this manual focuses on data access through the controller pushbutton/rotary selector dial and display, most data entries require input using a PC for initial setup. The PC entries typically include alpha characters such as digital input descriptions.

2.8.1 PC Communications

Communicate between a PC and the generator set controller logic using USB communication protocol. The PC connections require optional SiteTech™ software. Contact your authorized distributor/dealer for assistance.

Local Single Connection

A PC connects to the USB port of the generator set controller using a mini USB connector. See Figure 2-17.

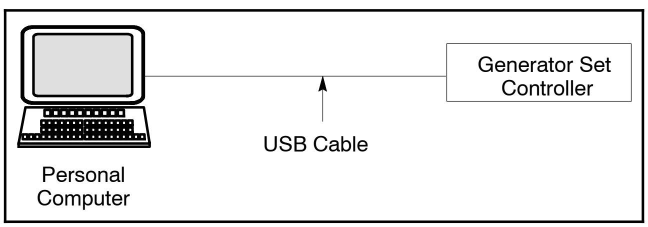


Figure 2-17 Local Single Connection

Remote Single Connection

A modem connects a PC to a single device. The PC communicates with the device via telephone line or an ethernet network. See Figure 2-18.

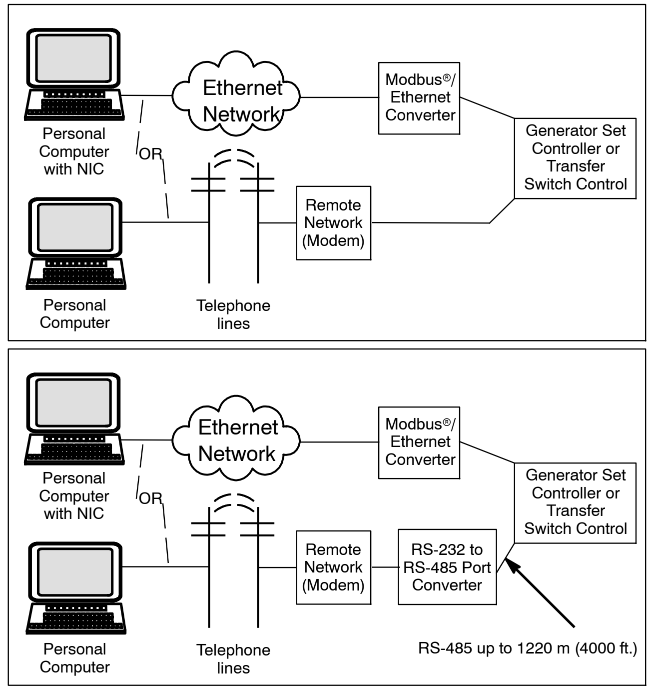


Figure 2-18 Remote Single Connections

2.8.2 Modbus® Communications

The controller communicates using Modbus® as a slave connection with the Modbus® master initiating the communication. The controller seeks the system and alternator parameters and diagnostic information then responds back to the Modbus® master. In addition, the controller accepts information to alter controller parameters including generator set starting and stopping. See Figure 2-19. Refer to the List of Related Materials for available Modbus® literature.

Note: Only one Modbus® master can be connected to the controller. Examples include the remote serial annunciator and switchgear applications.

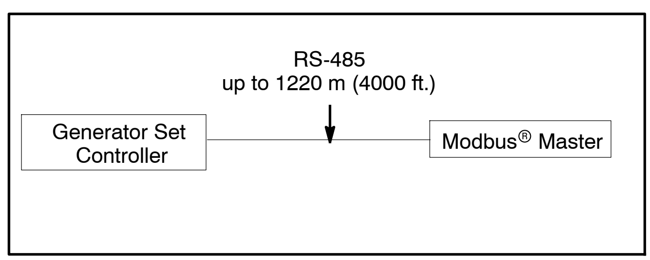


Figure 2-19 Modbus® Connections

Modbus® is a registered trademark of Schneider Electric.

Inhibit Time Delay. The inhibit time delay is the time period following crank disconnect during which the generator set stabilizes and the controller does not detect a fault or status event. Select the desired inhibit time delay from 0 to 60 seconds. A setting of 0 means the warning is monitored continuously, even if not running.

TIme Delay (Shutdown or Warning). The time delay follows the inhibit time delay. The time delay is the time period between when the controller first detects a fault or status event and the controller warning or shutdown lamp illuminates. The delay prevents nuisance alarms. Select the desired time delay from 0 to 60 seconds.

Section 2.8.3 and Section 2.8.4 contain warnings and faults with ranges and time delays including items that do not have user adjustments.

Note: The engine ECM may limit the crank cycle even if the controller is set to a longer time period.

2.8.3 Warning Parameter Default Setting

Figure 2-20 lists default settings for common warnings.

Fault Condition	Sensing Mechanism	Warning Condition	When Active	Inhibit Time	Time Delay	Display Cleared On
Low oil pressure pre-alarm	Pressure sender	20 psi	Running	Crank disconnect + 30 sec.	0 sec.	Warning removal, generator off
High coolant temperature	Temperature sender	225° F	ON	Crank disconnect + 30 sec.	0 sec.	Warning removal, generator off
Low cranking voltage	Battery analog input	Vbat < 60% of nominal	Cranking	Cranking.	3 sec.	Next good crank or system reset
Low battery voltage (12V)	Battery analog input	< 11 V	Continuous, not cranking	0, Always	60 sec.	Warning removed
High battery voltage (12V)	Battery analog input	> 16 V	Continuous, not cranking	0, Always	60 sec.	Warning removed
Low battery voltage (24V)	Battery analog input	< 22 V	Continuous, not cranking	0, Always	60 sec.	Warning removed
High battery voltage (24V)	Battery analog input	> 30 V	Continuous, not cranking	0, Always	60 sec.	Warning removed
Battery charger fault	Digital input from charger	Input closed	Continuous	0, Always	1 sec.	Warning removed
Low fuel	Digital input from fuel switch	Input closed	Continuous	0, Always	10 sec.	Warning removed
Low coolant temperature	Digital input	Input closed	Continuous	0, Always	10 sec.	Warning removed
Not in auto	Mode switch	Mode not in auto	Continuous	0, Always	0 sec.	Warning removed

Figure 2-20 Warning Parameter Default Table

2.8.4 Fault Parameter Default Setting

Figure 2-21 lists default settings for common faults.

Fault Condition	Sensing Mechanism	Fault Condition	When Active	Inhibit Time	Time Delay	Display Cleared On
E-Stop	E-Stop switch input	Input open	Continuous	0, Always	1 sec.	Fault removal and reset
Locked rotor	ECM	No rotation	Cranking	Cranking	3 sec.	Reset
Overcrank	Speed sensor or ECM	3 cycles	Cranking	Cranking	15 sec.	Reset
ECM communication loss	CAN input	No CAN communication	Cranking and running	1 sec.	1 sec.	Reset
Auxiliary fault	Digital input from customer device	Input closed	Continuous	0, Always	2 sec.	Removal of input and reset
Under frequency long term	Metering software	> 1 Hz below nominal	ON	Crank disconnect + 10 sec.	60 sec.	Reset
Under frequency short term	Metering software	< 90% of nominal	ON	Crank disconnect + 10 sec.	10 sec.	Reset
Over frequency	Metering software	> 110% of nominal	ON	Crank disconnect + 10 sec.	10 sec.	Reset
Over voltage	Metering software	> 120% of nominal	ON	Crank disconnect	2 sec.	Reset
Under voltage	Metering software	< 80% of nominal	ON	Crank disconnect	10 sec.	Reset
Low oil pressure	Analog input and/or ECM	12 psi	ON	Crank disconnect + 30 sec. or ECM	5 sec. or ECM	Reset
Overspeed	ECM	> 115% of nominal	ON	Crank disconnect	0.3 sec.	Reset
High coolant temperature	Analog input and/or ECM	230° F	ON	Crank disconnect	5 sec.	Reset
Low coolant level (optional)	Digital input	Low coolant level	ON	30 sec.	5 sec.	Fault removal and reset
Low coolant level in radiator (optional)	Analog input	Low coolant level	Continuous	0, Always	10 sec.	Fault removal and reset
High oil temp (optional)	Digital input	High temperature (275° F)	ON	30 sec.	5 sec.	Fault removal and reset
Low oil level (optional)	Digital input	Low oil level	ON	30 sec.	5 sec.	Fault removal and reset
Fuel leak (3rd party doublewall fuel lines) (optional)	Digital input	Fuel leak	ON	30 sec.	5 sec.	Fault removal and reset
High exhaust temperature	Analog input	High exhaust temperature	Running	5 sec.	5 sec.	Fault removal and reset
Low seawater pressure	Digital input	Low seawater pressure	Running	30 sec.	5 sec..	Fault removal and reset

Fault Condition	Sensing Mechanism	Fault Condition	When Active	Inhibit Time	Time Delay	Display Cleared On
Intake air temperature	ECM	Engine specific. Consult engine specifications.	Running	ECM	ECM	ECM
Fuel return temperature	ECM	100°C	Running	ECM	ECM	ECM
AC sensing loss	Integral voltage metering	No AC voltage at controller	Running	10 sec.	3 sec.	
Alternator protection	CTs and integral metering	Exceeding alternator protection curve	Running	Crank Disconnect		
ECM model mismatch	CAN parameter file	ECM comms don't match	Prior to crank			
Run relay coil overload	Internal hardware and software	Relay coil exceeds max. current	Running	0	0	Fault removal and reset
Sensor supply voltage	CAN (John Deere only)	ECM	Running	ECM	ECM	
Starter relay coil overload	Internal hardware and software		Cranking	Cranking		

Figure 2-21 Fault Parameter Default Table

2.9 Controller Parameters

The controller parameters list is an overview of the various features and functions of the controller. Certain features function only when optional accessories are connected.

Note: Use Kohler® SiteTech™ software and a personal computer connected to the controller's USB port to configure the controller parameters. See TP-6701, SiteTech Software Operation Manual, for instructions.

Parameter List

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Identity				
Vendor	None			
Product	None			
Firmware Version	None		*Software Version: XXXXXXXX*	
Engine Metering				
Engine Speed	None	R/min	*Engine Speed: ####RPM*	The speed at which the engine is presently running
Engine Oil Pressure	None	kPa	*Oil Pressure: ###PSI*	
Engine Coolant Temperature	None	°C	*Coolant Temperature: ### °F*	
Engine Oil Level	None	%		
Engine Coolant Level	None	%		
Engine Fuel Level	None	%		
Battery Voltage	None	V	*Gen Battery Voltage: ##.#VDC*	The battery voltage as measured by the controller
Fuel Temperature	None	°C	*Fuel Temperature: ### °F*	
Fuel Pressure	None	kPa	*Fuel Pressure: ###PSI*	
Fuel Rate	None	L/h	*Fuel Rate: ###GAL/h*	
Fuel Used Last Run	Not supported for these models.			
Coolant Pressure	None	kPa	*Coolant Pressure: ###PSI*	
Lube Oil Temperature	None	°C	*Oil Temperature: ### °F*	
Crankcase Pressure	Not supported for these models.			
Genset Controller Temperature	None	°C		
Battery Voltage From ECM	None	V	*ECM Battery Voltage: ##.#VDC*	The battery voltage as reported by the ECM
Exhaust Temperature	Not supported for these models.			
Exhaust Pressure				
Intake Air Temperature	None	°C	*Intake Air Temperature: ### °F*	
Intake Air Pressure	None	kPa	*Intake Air Pressure: ###PSI*	
Engine Low Oil Pressure Switch	None			
Engine Oil Level Switch	None			
Engine High Coolant Temperature Switch	None			
Engine Low Coolant Temperature Switch	None			
Engine Low Fuel Level Switch	None			
Engine Seawater Pressure	None	kPa		
Engine Governor Target Speed	None	R/min		
Engine Speed Governor				
Engine Speed Adjustment	Always			The target engine speed setting
Adjusted Engine Run Speed	Always		*Adjusted Engine Run Speed: ####RPM*	
Generator Metering				Metered values for each phase
Generator Rotation Actual	None		*Gen Phase Rotation: Disabled/A-B-C/C-B-A*	
Generator Current Lead/Lag L1	None			
Generator Current Lead/Lag L2	None			
Generator Current Lead/Lag L3	None			
Generator Current Total Lead/Lag	None			
Generator Power Factor L1	None		*LI PF: #.##*	
Generator Power Factor L2	None		*L2 PF: #.##*	
Generator Power Factor L3	None		*L3 PF: #.##*	
Generator Total Power Factor	None		*Total PF: #.##*	
Generator Apparent Power L1	None	VA	*L1 Apparent Power: ####VA*	
Generator Apparent Power L2	None	VA	*L2 Apparent Power: ####VA*	
Generator Apparent Power L3	None	VA	*L3 Apparent Power: ####VA*	
Generator Total Apparent Power	None	VA	*Total Apparent Power: ####VA*	
Generator Percent Of Rated Apparent Power	None	%		
Generator Reactive Power L1	None	VAR	*L1 Reactive Power: ####VAR*	
Generator Reactive Power L2	None	VAR	*L2 Reactive Power: ####VAR*	
Generator Reactive Power L3	None	VAR	*L3 Reactive Power: ####VAR*	
Generator Total Reactive Power	None	VAR	*Total Reactive Power: ####VAR*	
Generator Percent Of Rated Reactive Power	None	%	*Gen % of Rated kVA: ###%*	
Generator Voltage L1-L2	None	V	*L1-L2 Volts: ###V*	

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Generator Voltage L2-L3	None	V	*L2-L3 Volts: ###V*	
Generator Voltage L3-L1	None	V	*L3-L1 Volts: ###V*	
Generator Voltage Average Line To Line	None	V	*AVG Gen Voltage L-L: ###V*	
Generator Voltage L1-N	None	V	*L1-L0 Volts: ###V*	
Generator Voltage L2-N	None	V	*L2-L0 Volts: ###V*	
Generator Voltage L3-N	None	V	*L3-L0 Volts: ###V*	
Generator Voltage Average Line To Neutral	None	V	*AVG Gen Voltage L-N: ###V*	
Generator Current L1	None	A	*L1 Current: ###A*	
Generator Current L2	None	A	*L2 Current: ###A*	
Generator Current L3	None	A	*L3 Current: ###A*	
Generator Current Average	None	A	*AVG Current: ###A*	
Generator Phase Angle AB To L2-L3	None	°		
Generator Phase Angle AB To L3-L1	None	°		
Generator Phase Angle Voltage A To Current L1	None	°		
Generator Phase Angle Voltage B To Current L2	None	°		
Generator Phase Angle Voltage C To Current L3	None	°		
AC Frequency	None	Hz	*Gen Frequency: ##.#Hz*	
Generator Percent Of Rated Real Power	None	%	*Gen % of Rated kW: ###%*	
Generator Real Power L1	None	W	*L1 Power: ####W*	
Generator Real Power L2	None	W	*L2 Power: ####W*	
Generator Real Power L3	None	W	*L3 Power: ####W*	
Generator Total Real Power	None	W	*Total Power: ####W*	
Bus Metering				
Bus Voltage L1-L2	None	V		
Bus Voltage L2-L3	None	V		
Bus Voltage L3-L1	None	V		
Bus Voltage Average Line To Line	None	V	*AVG Bus Voltage L-L: ###.#V*	
Bus Total Real Power	None	kW		
Bus Total Real Power Percentage	None	%		
Bus Total Reactive Power Percentage	None	%		
Bus Frequency	None	Hz	*Bus Frequency: ##.##Hz*	
Bus Rotation Actual	None		*Bus Phase Rotation: Disabled/A-B-C/C-B-A*	
Phase Angle Generator Voltage AB Bus Voltage L1-L2	None	°	*Phase Difference: ###.#°*	
Speed Bias 2	Not supported for these models.			
Voltage Bias 2				
Bus Phase Angle AB To L2-L3	None	°		
Bus Phase Angle AB To L3-L1	None	°		
Genset Info				
Genset Model Number	Locked		*Genset Model #: XXXXXXXXX*	
Genset Spec Number	Locked		*Genset Spec #: XXXXXXXXX*	
Genset Serial Number	Locked		*Genset Serial #: XXXXXXXXX*	
Alternator Part Number	Locked		*Alternator Part #: XXXXXXXXX*	
Genset Controller Serial Number	None		*Controller Serial #: XXXXXXX*	
Engine Part Number	Not supported for these models.			
Engine Model Number	Locked		*Engine Model #: XXXXXXXXX*	
Engine Serial Number	Not supported for these models.			
ECM Serial Number				
Genset State	None			The present state of the genset
Master Switch Position	None			
Genset Run Time				
Genset Controller Clock Time	Always		*Time: ##:## XM* *Date: ##/##/####*	The present time on the controller system clock
Genset Controller Total Operation Time	None	h	*Operating Hours: ######hrs*	The total number of hours that power has been applied to the genset controller
Engine Total Run Time	None	h	*Total Run Time: #####hrs*	The total number of hours that the engine has been running

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Engine Total Run Time Loaded	None	h	*Hours Loaded: #####hrs*	The total number of hours that the engine has been running while supplying more than 1% of rated genset load
Engine Total Run Time Unloaded	None	h	*Hours Unloaded: #####hrs*	The total number of hours that the engine has been running while supplying less than 1% of rated genset load
Engine Total Number Of Starts	None		*Total # of Starts: ########*	The total number of times that the engine was started via the genset controller
Genset Total Energy	None	kW-h	*kW Hours: #####kWh*	The total amount of energy that the genset has produced
Engine Maintenance Period Hours	Always	h		The number of hours between engine maintenance requirement
Genset Date Time Of Last Maintenance	None		*Last Maintenance: ##/##/####*	The time on the controller system clock when the last maintenance was performed
Engine Run Time At Reset Maintenance	None	h		The total number of hours that the engine had been running when the last maintenance was performed
Engine Run Time Until Maintenance	None	h		The total number of engine run hours that remain before engine maintenance is required
Genset Controller Hours Of Operation Since Maintenance	None	h	*Op Hrs Since Maint: ####hrs*	The number of hours that power has been applied to the genset controller since maintenance was performed
Engine Run Time Since Maintenance	None	h	*Eng Hrs Since Maint: ####hrs*	The number of hours that the engine has been running since maintenance was performed
Engine Run Time Loaded Since Maintenance	None	h	*Loaded Since Maint: ####hrs*	The number of hours that the engine has been running while supplying more than 1% of rated genset load, since maintenance was performed
Engine Run Time Unloaded Since Maintenance	None	h	*Unloaded Since Maint: ####hrs*	The total number of hours that the engine has been running while supplying less than 1% of rated genset load, since maintenance was performed
Engine Number Of Starts Since Maintenance	None		*Starts Since Maint: ###*	The number of times that the engine was started via the genset controller, since maintenance was performed
Genset Energy Since Maintenance	None	kW-h	*kW Hrs Since Maint: ####kWh*	The amount of energy that genset has produced since maintenance was performed
Engine Last Start Time	None		*Last Start: ##/##/####*	The date and time that the engine was last started via the genset controller
Last Run Length	None	h	*Last Run Length: ####hrs*	The length of time that the engine ran the last time it was started via the genset controller

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Genset Controller Date Format	Always		*Date Format: Month Date Year/Date Month Year*	
Genset Controller Time Format	Always		*Time Format: Hr 12/Hr 24*	
Genset Personality Profile				
Ecm Model	Locked			
Maximum Alternator Current	None	A		Used by thermal protection algorithm
Engine Number Of Flywheel Teeth	Locked			The number of teeth on the engine flywheel
Engine Warmed Up Temperature	Locked	°C	*Engine Warmed Up: ### °F*	The engine is warmed up enough to be loaded
Engine Cooled Down Temperature	Locked	°C	*Engine Cooled Down: ### °F*	The engine is cool enough to be turned off
Engine Crank Disconnect Speed	Locked	R/min		The engine speed that the starter will be disengaged
Engine Idle Speed	Locked	R/min		The engine speed when in idle mode
Engine Run Speed	Stopped	R/min	*Rated Engine Speed: ####RPM*	The normal operating speed of the engine
Engine Coolant Temperature Protectives Enabled	Locked			
Engine Low Coolant Temperature Inhibit Delay	Not supported for these models.			
Engine High Coolant Temperature Inhibit Delay	Locked	s		The time, after crank disconnect, before the protectives are monitored; if 0, protectives are monitored even when the engine is stopped
Engine Low Coolant Temperature Warning Delay	Locked	s		
Engine High Coolant Temperature Warning Delay	Locked	s		
Engine Low Coolant Temperature Shutdown Delay	Locked	s		
Engine High Coolant Temperature Shutdown Delay	Locked	s		
Engine Low Coolant Temperature Warning Limit	Locked	°C		
Engine High Coolant Temperature Warning Limit	Locked	°C		
Engine Low Coolant Temperature Shutdown Limit	Locked	°C		
Engine High Coolant Temperature Shutdown Limit	Locked	°C		
Engine Coolant Temperature Deadband	Locked	°C		
Personality Alternator Manufacturer	Locked			
Personality Alternator Toc Time Constant	Locked	s		
Personality Alternator Number Of Poles	Locked			
Personality Alternator Type	Locked			
Personality Fixed Voltage 50Hz	Locked	V		
Personality Power Rating Single Phase 50Hz 10PF	Locked	kW		
Personality Power Rating Single Phase 50Hz 8PF	Not supported for these models.			
Personality Power Rating Fixed Volt 50Hz	Locked	kW		
Personality Power Rating 50Hz 220 440	Locked	kW		
Personality Power Rating 50Hz 208 415	Locked	kW		
Personality Power Rating 50Hz 200 400	Locked	kW		
Personality Power Rating 50Hz 190 380	Locked	kW		
Personality Power Rating 50Hz 173 346	Locked	kW		
Personality Power Rating 50Hz Delta	Locked	kW		
Personality Fixed Voltage 60Hz	Locked	V		
Personality Power Rating Single Phase 60Hz 10PF	Locked	kW		
Personality Power Rating Single Phase 60Hz 8PF	Not supported for these models.			
Personality Power Rating Fixed Volt 60Hz	Locked	kW		
Personality Power Rating 60Hz 240 480	Locked	kW		
Personality Power Rating 60Hz 230 460	Locked	kW		
Personality Power Rating 60Hz 220 440	Locked	kW		
Personality Power Rating 60Hz 208 416	Locked	kW		
Personality Power Rating 60Hz 190 380	Locked	kW		
Personality Power Rating 60Hz Delta	Locked	kW		
Personality Installed Options	Locked			
Gen Rating 1 Fuel Type	Locked			
Gen Rating 1 50HZ 1Ph	Locked	kW		
Gen Rating 1 50HZ Wye 173 346	Locked	kW		

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Gen Rating 1 50HZ Wye 190 380	Locked	kW		
Gen Rating 1 50HZ Wye 200 400	Locked	kW		
Gen Rating 1 50HZ Wye 208 415	Locked	kW		
Gen Rating 1 50HZ Wye 220 440	Locked	kW		
Gen Rating 1 50Hz Delta	Locked	kW		
Gen Rating 1 Fixed Voltage 50Hz	Locked	V		
Gen Rating 1 Fixed Voltage KW 50Hz	Locked	kW		
Gen Rating 1 60HZ 1Ph	Locked	kW		
Gen Rating 1 60HZ Wye 190 380	Locked	kW		
Gen Rating 1 60HZ Wye 208 416	Locked	kW		
Gen Rating 1 60HZ Wye 220 440	Locked	kW		
Gen Rating 1 60HZ Wye 230 460	Locked	kW		
Gen Rating 1 60HZ Wye 240 480	Locked	kW		
Gen Rating 1 60Hz Delta	Locked	kW		
Gen Rating 1 Fixed Voltage 60Hz	Locked	V		
Gen Rating 1 Fixed Voltage KW 60Hz	Locked	kW		
Gen Rating 2 Fuel Type	Locked			
Gen Rating 2 50HZ 1Ph	Locked	kW		
Gen Rating 2 50HZ Wye 173 346	Locked	kW		
Gen Rating 2 50HZ Wye 190 380	Locked	kW		
Gen Rating 2 50HZ Wye 200 400	Locked	kW		
Gen Rating 2 50HZ Wye 208 415	Locked	kW		
Gen Rating 2 50HZ Wye 220 440	Locked	kW		
Gen Rating 2 50Hz Delta	Locked	kW		
Gen Rating 2 Fixed Voltage 50Hz	Locked	V		
Gen Rating 2 Fixed Voltage KW 50Hz	Locked	kW		
Gen Rating 2 60HZ 1Ph	Locked	kW		
Gen Rating 2 60HZ Wye 190 380	Locked	kW		
Gen Rating 2 60HZ Wye 208 416	Locked	kW		
Gen Rating 2 60HZ Wye 220 440	Locked	kW		
Gen Rating 2 60HZ Wye 230 460	Locked	kW		
Gen Rating 2 60HZ Wye 240 480	Locked	kW		
Gen Rating 2 60Hz Delta	Locked	kW		
Gen Rating 2 Fixed Voltage 60Hz	Locked	V		
Gen Rating 2 Fixed Voltage KW 60Hz	Locked	kW		
Freq Match P Gain Scaler	Locked			
Freq Match I Gain Scaler	Locked			
Freq Match D Gain Scaler	Locked			
Volt Match P Gain Scaler	Locked			
Volt Match I Gain Scaler	Locked			
Volt Match D Gain Scaler	Locked			
Phase Match P Gain Scaler	Locked			
Phase Match I Gain Scaler	Locked			
Phase Match D Gain Scaler	Locked			
Real Power P Gain Scaler	Locked			
Real Power I Gain Scaler	Locked			
Real Power D Gain Scaler	Locked			
Torque Share P Gain Scaler	Locked			
Torque Share I Gain Scaler	Locked			
Torque Share D Gain Scaler	Locked			
Freq Trim P Gain Scaler	Locked			
Freq Trim I Gain Scaler	Locked			
Freq Trim D Gain Scaler	Locked			
Reactive Power P Gain Scaler	Locked			
Reactive Power I Gain Scaler	Locked			
Reactive Power D Gain Scaler	Locked			
Volt Trim P Gain Scaler	Locked			
Volt Trim I Gain Scaler	Locked			
Volt Trim D Gain Scaler	Locked			

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Voltage Selector Switch				
Voltage Selector Switch Position	Not supported for these models.			
Voltage Selector Switch Max Positions				
Voltage Selector Switch Position 1 Voltage				
Voltage Selector Switch Position 1 Frequency				
Voltage Selector Switch Position 1 Voltage Phase Connection				
Voltage Selector Switch Position 2 Voltage				
Voltage Selector Switch Position 2 Frequency				
Voltage Selector Switch Position 2 Voltage Phase Connection				
Voltage Selector Switch Position 3 Voltage				
Voltage Selector Switch Position 3 Frequency				
Voltage Selector Switch Position 3 Voltage Phase Connection				
Genset System Configuration				
Genset System Voltage	Stopped	V	*System Voltage L-L: ###V*	The generator operating voltage
Genset System Frequency	Stopped	Hz	*System Frequency: ##.#Hz*	The generator operating frequency
Genset Voltage Phase Connection	Stopped		*System Phase: Single/Single Dog/Three-Wye/ Three-Delta*	The generator number of phases (single or three)
Genset Power Rating	Locked	kW	*kW Rating: ####kW*	The generator operating power rating in kW
Genset Apparent Power Rating	Stopped	kVA		The generator operating apparent power rating in kVA
Genset Rated Current	None	A	*Rated Current: ###A*	Calculated from power rating, voltage, and connection
Genset System Battery Voltage	Stopped	V	*Battery Voltage: ##V*	The generator operating battery voltage
Prime Power Application	Locked		*Operating Mode: Standby/Prime*	Indicates whether the generator set is in a prime power application
Current Transformer Ratio	Locked			
Local Start Mode	Not supported for these models.			
Measurement System	Always		*Units: Metric/English*	Indicates whether to use the English or Metric measurements system for display of parameter values and their units
Alarm Silence Always Allowed	Always		*Alarm Silence: Always/Auto Only*	When true, the alarm can be silenced when the controller is in any state; when false, the alarm can only be silenced in the Auto state
NFPA 110 Enabled	Always		*NFPA Defaults: On/Off*	Indicates whether NFPA110 defaults are enabled
Cool Down Temperature Override	Always		*Cooldown Override: On/Off*	Indicates whether the engine's cooled-down parameter should be overridden during the time delay
Oil Sensor Type	Stopped			Indicates the type of oil sensor
Public CAN Protocol	Not supported for these models.			
Display Contrast	Always		*Contrast: ###*	
Using Voltage Selector Switch	Stopped			
Genset System Language	Always		*Language: English*	
Genset Maximum Percent Capacity	Always	%		
Generator Overloaded Percent	Always	%		
Under Frequency Shed Level	Always	%		
Base Load Add Time	Always	s		
Base Over Load Shed Time	Always	s		
Base Under Frequency Shed Time	Always	s		

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Genset Fuel Type	Stopped		*Fuel Type: Natural Gas/LP/ Gasoline/Diesel/ Unknown*	
Battle Mode	Always		*Emergency Battlemode: On/Off*	
ECM Powered Mode	Stopped			Indicates whether the ECM Power is turned on
Genset Application	Locked		*Application Type: None/Marine/ Mobile/Standby/Prime*	
Genset Calibration				
Calibration Factor Voltage L1-L2	Always		*Gen L1-L2 Volts: ###.#V*	
Calibration Factor Voltage L2-L3	Always		*Gen L2-L3 Volts: ###.#V*	
Calibration Factor Voltage L3-L1	Always		*Gen L3-L1 Volts: ###.#V*	
Calibration Factor Voltage L1-N	Always		*Gen L1-L0 Volts: ###.#V*	
Calibration Factor Voltage L2-N	Always		*Gen L2-L0 Volts: ###.#V*	
Calibration Factor Voltage L3- N	Always		*Gen L3-L0 Volts: ###.#V*	
Calibration Factor Current L1	Always		*Gen L1 Current: ###.#A*	
Calibration Factor Current L2	Always		*Gen L2 Current: ###.#A*	
Calibration Factor Current L3	Always		*Gen L3 Current: ###.#A*	
Bus Calibration Factor Voltage L1-L2	Always		*Bus L1-L2 Volts: ###.#V*	
Bus Calibration Factor Voltage L2-L3	Always		*Bus L2-L3 Volts: ###.#V*	
Bus Calibration Factor Voltage L3-L1	Always		*Bus L3-L1 Volts: ###.#V*	
Voltage Regulator				
Voltage Regulator Average Voltage Adjustment	Always	V	*Voltage Adjust: ###.#V*	The target voltage setting
Voltage Regulator Volts Per Hertz Slope	Always	%	*V/Hz Slope: ##%/Hz*	The ratio of volts/hertz ramping
Voltage Regulator Volts Per Hertz Cut In Frequency	Always	Hz	*V/Hz Setpoint: ##.#Hz*	The frequency that the Volts Per Hertz feature is activated
Voltage Regulator Gain	Always		*Voltage Gain Adjust: ###*	Provides adjustment to the sensitivity of the voltage regulator
Voltage Regulator Stability Adjust	Always			Controls damping to provide stable voltage during transients and steady-state operation
Voltage Regulator Firmware Version	Not supported for these models.			
Voltage Regulator Target Voltage	None	V	*Target Voltage: ###.#V*	
Voltage Regulator Normal Ramp Rate	Always	%/s	*Start Up Ramp Rate: ###.#%/s*	
Engine Timing				
Engine Idle Duration	Always	s		The length of time for the engine idle mode
Engine Restart Delay	Always	s		The length of time to wait before attempting to restart the engine when engine rotation cannot be determined
Engine Start Delay	Always	s	*Engine Start Delay: ##s*	The length of time to wait before attempting to start the engine after a remote start command is received
Engine ECM Start Delay	Always	s		The length of time to wait before engaging the starter after the ECM has been powered
Engine Cool Down Delay	Always	s	*Cooldown Delay: ##s*	The length of time to wait before stopping the engine after a remote stop command is received (unless the low temperature delay applies)
Engine Start Aid Delay	Always	s	*Starting Aid Delay: ##s*	The length of time to turn the starting aid output on before attempting to start the engine
Engine Crank On Delay	Always	s	*Crank On Delay: ##s*	The length of time for the on-period of the crank cycle

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Engine Crank Pause Delay	Always	s	*Crank Pause Delay: ##s*	The length of time for the off-period of the crank cycle
Engine Number Of Crank Cycles	Stopped		*Crank Cycles Limit: ##*	The number of crank cycles before an over crank fault is indicated
Genset Protection				
After Crank Disconnect Fault Inhibit Delay	Not supported for these models.			
Genset Low Battery Voltage Warning Delay	None	s		
Genset High Battery Voltage Warning Delay	None	s		
Genset Low Battery Voltage Warning Limit	Always	%		Percentage of System Battery Voltage that the battery voltage must drop below for a Low Battery voltage condition to be indicated
Genset High Battery Voltage Warning Limit	Always	%		Percentage of System Battery Voltage that the battery voltage must exceed for a High Battery voltage condition to be indicated
Genset Battery Low Cranking Voltage Warning Delay	None	s		
Genset Battery Low Cranking Voltage Warning Limit	None	%		Percentage of System Battery Voltage that the battery voltage must drop below during cranking for a Low Cranking Battery condition to be indicated
Engine Protection				
Engine Low Coolant Level Shutdown Delay	None	s		
Engine Low Oil Pressure Warning Delay	Locked	s		
Engine Low Oil Pressure Shutdown Delay	Locked	s		
Engine Locked Rotor Shutdown Delay	Always	s		The length of time for the starter to be engaged with no engine rotation detected, before a fault is indicated
ECM Communication Loss Shutdown Delay	Not supported for these models.			
Genset Low Engine Speed Shutdown Limit	Always	%		Percentage of nominal engine speed that the engine must drop below for an under speed condition to be indicated
Genset High Engine Speed Shutdown Limit	Always	%		Percentage of nominal engine speed that the engine must exceed for an overspeed condition to be indicated
Engine Oil Pressure Protectives Enabled	Locked			
Engine Low Oil Pressure Inhibit Delay	Locked	s		The time, after crank disconnect, before the protectives are monitored; if 0, protectives are monitored even when the engine is stopped
Engine Low Oil Pressure Warning Limit	Locked	kPa		
Engine Low Oil Pressure Shutdown Limit	Locked	kPa		
Engine Oil Pressure Deadband	Locked	kPa		
Generator Protection				
Loss Of AC Sensing Shutdown Delay	None	s		
Genset Low Voltage Shutdown Delay	Always	s	*Undervoltage Delay: ##s*	The time that the generator voltage must be in an under voltage condition before a fault is indicated
Genset High Voltage Shutdown Delay	Always	s	*Overvoltage Delay: ##s*	The time that the generator voltage must be in an over voltage condition before a fault is indicated

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Genset Low Voltage Shutdown Limit	Always	%	*Undervoltage: ##%*	Percentage of System Voltage that the generator voltage must drop below for an under voltage condition to be indicated
Genset High Voltage Shutdown Limit	Always	%	*Overvoltage: ##%*	Percentage of System Voltage that the generator voltage must exceed for an over voltage condition to be indicated
Genset Short Term Low Frequency Shutdown Delay	None	s		
Genset Long Term Low Frequency Shutdown Delay	None	s		
Genset High Frequency Shutdown Delay	None	s		
Genset Low Frequency Shutdown Limit	Always	%	*Underfrequency: ##%*	Percentage of System Frequency that the generator frequency must drop below for an under frequency condition to be indicated
Genset High Frequency Shutdown Limit	Always	%	*Overfrequency: ##%*	Percentage of System Frequency that the generator frequency must exceed for an over frequency condition to be indicated
Programmable Digital Input				
Digital Input Board Number	None		*I/O Board Number: X*	Indicates board number this IO point is located on
Digital Input Io Number	None			Indicates the point number, of this IO type on this board, for this configuration
Digital Input Status	None			The current value of the input (scaled to the units of the function ID)
Digital Input Enabled	Always		*Enabled: On/Off*	Indicates whether this input is enabled
Digital Input Logic	Always			The type of switch that is connected to the input, where "normal" refers to the non-activated state
Digital Input Function	Always		*Function:*	Indicates the functionality of this IO point
Digital Input Event	Always		*Event:*	The parameter ID defining the function for this input
Digital Input Delay	Always	s	*Delay Time: ##s*	The time that the input must be active before a status change is indicated
Digital Input Inhibit Delay	Always	s	*Inhibit Time: ##s*	The time that the input must be active before a status change is indicated
Digital Input Description	Always		*Description:*	A user-defined description of this IO point
Programmable Digital Output				
Digital Output Board Number	None		*I/O Board Number: X*	Indicates board number this IO point is located on
Digital Output Io Number	Not supported for these models.			
Digital Output Status				
Digital Output Enabled				
Digital Output Logic				
Digital Output Function				
Digital Output Event				
Digital Output Description				

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Programmable Analog Resistive Input				
Analog Resistive Input Board Number	Not supported for these models.			
Analog Resistive Input Io Number				
Analog Resistive Input Metered Value				
Analog Resistive Input Metered Relative Value				
Analog Resistive Input Enabled				
Analog Resistive Input Switch Logic				
Analog Resistive Input Function				
Analog Resistive Input Protectives Enabled				
Analog Resistive Input Event				
Analog Resistive Input Sensor				
Analog Resistive Input Low Protective Inhibit Delay				
Analog Resistive Input High Protective Inhibit Delay				
Analog Resistive Input Delay				
Analog Resistive Input Inhibit Delay				
Analog Resistive Input Normal Delay				
Analog Resistive Input Low Warning Delay				
Analog Resistive Input Critically Low Warning Delay				
Analog Resistive Input High Warning Delay				
Analog Resistive Input Critically High Warning Delay				
Analog Resistive Input Low Shutdown Delay				
Analog Resistive Input High Shutdown Delay				
Analog Resistive Input Low Warning Limit				
Analog Resistive Input Critically Low Warning Limit				
Analog Resistive Input Low Shutdown Limit				
Analog Resistive Input High Warning Limit				
Analog Resistive Input Critically High Warning Limit				
Analog Resistive Input High Shutdown Limit				
Analog Resistive Input Deadband				
Analog Resistive Input Relative Upper Range Limit				
Analog Resistive Input Relative Lower Range Limit				
Analog Resistive Input Relative Range Limit Deadband				
Analog Resistive Input Relative Range High Limit Inhibit Time				
Analog Resistive Input Relative Range Low Limit Inhibit Time				
Analog Resistive Input Relative Range Limit Delay				
Analog Resistive Input Description				
Programmable Analog Voltage Input				
Analog Voltage Input Board Number	Not supported for these models.			
Analog Voltage Input Io Number				
Analog Voltage Input Metered Value				
Analog Voltage Input Metered Relative Value				
Analog Voltage Input Enabled				
Analog Voltage Input Switch Logic				
Analog Voltage Input Function				
Analog Voltage Input Protectives Enabled				
Analog Voltage Input Event				
Analog Voltage Input Sensor				
Analog Voltage Input Low Protective Inhibit Delay				
Analog Voltage Input High Protective Inhibit Delay				
Analog Voltage Input Delay				
Analog Voltage Input Inhibit Delay				
Analog Voltage Input Normal Delay				
Analog Voltage Input Low Warning Delay				
Analog Voltage Input Critically Low Warning Delay				
Analog Voltage Input High Warning Delay				
Analog Voltage Input Critically High Warning Delay				
Analog Voltage Input Low Shutdown Delay				
Analog Voltage Input High Shutdown Delay				
Analog Voltage Input Low Warning Limit				
Analog Voltage Input Critically Low Warning Limit				
Analog Voltage Input Low Shutdown Limit				
Analog Voltage Input High Warning Limit				

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Analog Voltage Input Critically High Warning Limit	Not supported for these models.			
Analog Voltage Input High Shutdown Limit				
Analog Voltage Input Deadband				
Analog Voltage Input Relative Upper Range Limit				
Analog Voltage Input Relative Lower Range Limit				
Analog Voltage Input Relative Range Limit Deadband				
Analog Voltage Input Relative Range High Limit Inhibit Time				
Analog Voltage Input Relative Range Low Limit Inhibit Time				
Analog Voltage Input Relative Range Limit Delay				
Analog Voltage Input Description				
Protective Relays				
PR Over Power Trip	Always	%	*Over Power Trip: ###.#%*	Percent of rated power
PR Over Power Time Delay	Always	s	*Over Power Delay: ##.#s*	
PR Reverse Power Trip	Always	%	*Reverse Power Trip: ###.#%*	Percent of rated power
PR Reverse Power Time Delay	Always	s	*Reverse Power Delay: ##.#s*	
PR Over Voltage Trip	Always	%	*Over Voltage Trip: ###.#%*	Percent of rated voltage
PR Over Voltage Time Delay	Always	s	*Over Voltage Delay: ##.#s*	
PR Under Voltage Trip	Always	%	*Under Voltage Trip: ###.#%*	Percent of rated voltage
PR Under Voltage Time Delay	Always	s	*Under Voltage Delay: ##.#s*	
PR Over Frequency Trip	Always	%	*Over Freq Trip: ###.#%*	Percent of rated frequency
PR Over Frequency Time Delay	Always	s	*Over Freq Delay: ##.#s*	
PR Under Frequency Trip	Always	%	*Under Freq Trip: ###.#%*	Percent of rated frequency
PR Under Frequency Time Delay	Always	s	*Under Freq Delay: ##.#s*	
PR Reverse Var Trip	Always	%	*Reverse VAR Trip: ###.#%*	Percent of rated reactive power (PR Loss Of Field)
PR Reverse Var Time Delay	Always	s	*Reverse VAR Delay: ##.#s*	
PR Over Current VR Trip	Always	%	*Over Current Trip: ###.#%*	Percent of maximum current
PR Over Current VR Time Delay	Always	s	*Over Current Delay: ##.#s*	
Breaker Trip To Shutdown Time Delay	Always	s	*Trip to Shtdwn Delay: #####s*	
Synchronization Control				
Voltage Match Window	Always	%	*Voltage Match Window: ##.#%*	Percent of rated voltage
Sync Frequency Window	Always	Hz	*Frequency Window: #.#Hz*	
Phase Match Window	Always	°	*Phase Match Window: ##.# °*	
Dwell Time	Always	s	*Dwell Time: ##.#s*	
Fail To Sync Delay	Always	s	*Fail to Sync Time: ####s*	
Breaker Reclose Time	Always	s	*Reclose Delay: ##.#s*	
Breaker Close Attempts	Always		*Max Close Attempts: ###*	
First On Close Delay	Always	s	*First On Delay: ##.#s*	
Circuit Breaker Current Fault Limit	Always	%	*CB Current Fault Limit: ###.#%*	10 = 1.0%

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Circuit Breaker Current Fault Delay	Always	s	*CB Current Fault Delay: ##.#s*	10 = 1.0 Sec
Volts Hertz Okay Time Delay	Always	s	*Volts-Hz OK Delay: ##.#s*	
Sync Mode In Auto	Always		*Sync Mode in Auto: Invalid/Off/Passive/Check/ Active/Dead Field*	
Sync Mode In Run	Always		*Sync Mode in Run: Invalid/Off/Passive/Check/ Active/Dead Field*	
Circuit Breaker Phase Angle Fault Limit	Always	°	*CB Phase Fault Limit: ##.# °*	
Circuit Breaker Phase Angle Fault Delay	Always	s	*CB Phase Fault Delay: ##.#s*	
Dead Bus Level	Always	%	*Dead Bus Level: ##.#%*	
Pickup Acceptable Voltage Window	Always	%	*Voltage OK Pickup: ##.#%*	
Dropout Acceptable Voltage Window	Always	%	*Voltage OK Dropout: ##.#%*	
Pickup Acceptable Frequency Window	Always	Hz	*Frequency OK Pickup: ##.#Hz*	
Dropout Acceptable Frequency Window	Always	Hz	*Frequency OK Dropout: ##.#Hz*	
Stand Alone Operation	Always		*Stand Alone Mode: On/Off*	
PGen Baud Rate	Always	b/s	*PGEN Baud Rate: OFF/9600 b/s/19200 b/s/38400 b/s/ 57600 b/s/115200 b/s*	
PGen Node Id	None		*PGEN Node ID: ##*	
PGen Nodes Connected	None		*PGEN Nodes Online: ##*	
PGen Nodes Disconnected	None		*PGEN Nodes Offline: ##*	
Fail To Open Delay	Always	s	*Fail to Open Delay: ##s*	
Fail To Close Delay	Always	s	*Fail to Close Delay: ##s*	
Voltage Match Proportional Gain	Always		*Voltage Match P Gain: ##.##*	
Voltage Match Integral Gain	Always		*Voltage Match I Gain: ##.##*	
Voltage Match Derivative Gain	Always		*Voltage Match D Gain: ##.##*	
Frequency Match Proportional Gain	Always		*Freq Match P Gain: ##.##*	
Frequency Match Integral Gain	Always		*Freq Match I Gain: ##.##*	
Frequency Match Derivative Gain	Always		*Freq Match D Gain: ##.##*	
Phase Match Proportional Gain	Always		*Phase Match P Gain: ##.##*	
Phase Match Integral Gain	Always		*Phase Match I Gain: ##.##*	
Phase Match Derivative Gain	Always		*Phase Match D Gain: ##.##*	
Generator Paralleling Breaker	None			
External Bias Inputs Enabled	Always			
Synchronization Metering				
Sync Time Remaining	None	s	*Sync Time Remaining: ####s*	(Sec x 10)
Sync Dwell Time Remaining	None	s	*Dwell Time Remaining: ##.#s*	(Sec x 10)
Sync Status Generator V Hz OK	None		*Volts-Hz OK: True/False*	Bit 0: Gen_VHz_OK
Sync Status Voltage Matched	None		*Voltage Matched: True/False*	Bit 1: Synch_V_Matched
Sync Status Frequency Matched	None		*Frequency Matched: True/False*	Bit 2: Synch_Freq_Matched
Sync Status Phase Matched	None		*Phase Matched: True/False*	Bit 3: Synch_Phase_Matched
Sync Check Matched Ok	None		*In Sync: True/False*	
Real Power Load Sharing				
Real Power Baseload Setpoint	Always	%		250 = 25.0%
Real Power Disconnect Level	Always	%	*kW Disconnect Level: ##.#%*	100 = 10.0% of rated kW
Real Power Ramp Rate	Always	%/s	*kW Ramp Rate: ##.#%/s*	50 = 5.0% of rated kW/Sec
Real Power Droop Slope	Always	%@FL		20 = 2.0 % of rated speed @ 100% rated kW
Speed Bias	None		Speed Bias: *###.##*	5000 = 50.00 Note: speed bias is equal to % speed x 10 (5000 -> 50.00 -> +5% Voltage)
Load Enable	Always		*Load Enabled: On/Off*	
Base Load Mode	Always			
System Load Control	Always		*System Load Control: On/Off*	
System Sync Control	Always		*System Sync Control: On/Off*	
Trims Enabled	Always		*Trims Enabled: On/Off*	
Real Power Sharing Proportional Gain	Always		*kW Sharing P Gain: ##.##*	
Real Power Sharing Integral Gain	Always		*kW Sharing I Gain: ##.##*	
Real Power Sharing Derivative Gain	Always		*kW Sharing D Gain: ##.##*	
Torque Sharing Proportional Gain	Always			

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Torque Sharing Integral Gain	Always			
Torque Sharing Derivative Gain	Always			
Frequency Trim Proportional Gain	Always		*Freq Trim P Gain: ##.##*	
Frequency Trim Integral Gain	Always		*Freq Trim I Gain: ##.##*	
Frequency Trim Derivative Gain	Always		*Freq Trim D Gain: ##.##*	
Real Power Baseload Proportional Gain	Always			
Real Power Baseload Integral Gain	Always			
Real Power Baseload Derivative Gain	Always			
System Real Load Control Proportional Gain	Always			
System Real Load Control Integral Gain	Always			
System Real Load Control Derivative Gain	Always			
Reactive Power Load Sharing				
Reactive Power Baseload Setpoint	Always	%		600 = 60.0% Rated kVAR
Power Factor Setting	Always			80 = 0.80 PF lagging, -90 = 0.90 PF leading
Reactive Droop Slope	Always	%@FL		40 = 4.0% rated Volts @ 100% rated KVAR
Voltage Bias	None		*Voltage Bias: ###.##*	5000 = 50.00 Note voltage bias is equal to % voltage x 10 (5000 -> 50.00 -> +5% Voltage)
Var Control Mode	Always			
Reactive Power Sharing Proportional Gain	Always		*kVAR Sharing P Gain: ##.##*	
Reactive Power Sharing Integral Gain	Always		*kVAR Sharing I Gain: ##.##*	
Reactive Power Sharing Derivative Gain	Always		*kVAR Sharing D Gain: ##.##*	
Voltage Trim Proportional Gain	Always		*Volt Trim P Gain: ##.##*	
Voltage Trim Integral Gain	Always		*Volt Trim I Gain: ##.##*	
Voltage Trim Derivative Gain	Always		*Volt Trim D Gain: ##.##*	
Reactive Power Baseload Proportional Gain	Always			
Reactive Power Baseload Integral Gain	Always			
Reactive Power Baseload Derivative Gain	Always			
Power Factor Baseload Proportional Gain	Always			
Power Factor Baseload Integral Gain	Always			
Power Factor Baseload Derivative Gain	Always			
System Reactive Power Control Proportional Gain	Always			
System Reactive Power Control Integral Gain	Always			
System Reactive Power Control Derivative Gain	Always			
System Power Factor Control Proportional Gain	Always			
System Power Factor Control Integral Gain	Always			
System Power Factor Control Derivative Gain	Always			
Generator Management				
Gen Management Control Mode	Always		*Gen Management Mode: Invalid/Manual Fixed/ Run Time/Fuel Level*	
Gen Management Enabled	Always		*Gen Management: On/Off*	
Gen Management Order	Always		*Gen Management Order: #*	Only editable if in Manual Mode
Gen Management Start Percent	Always	%	*Start Capacity: ###.#%*	
Gen Management Stop Percent	Always	%	*Stop Capacity: ###.#%*	
Gen Management Start Delay	Always	s	*Start Delay: ####s*	
Gen Management Stop Delay	Always	s	*Stop Delay: ####s*	
Gen Management Start Accumulator	None		*Start Accumulator: #####*	
Gen Management Stop Accumulator	None		*Stop Accumulator: #####*	
Gen Management Start KW	None	kW	*Start kW: #####kW*	
Gen Management Stop KW	None	kW	*Stop kW: #####kW*	
Gen Management Stable Delay	Always	s	*Stable Delay: ####s*	
Gen Management Run Time Threshold	Always	h	*Run Time Threshold: ###.#hrs*	Only if in Run Time Management
Gen Management Fuel Difference Threshold	Always	%	*Fuel Level Threshold: ##.#%*	Only if in Fuel Level Management
Gen Management Min Gens Online	Always		*Minimum Gens Online: ##*	
Gen Management Min Load Shed Priority	Always		*Min Loads Added: ##*	
Gen Management Stopped By Gen Mgmt	None		*Stopped by Gen Mgmt: True/False*	

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Gen Management Total Bus Capacity	None	kW	*Total Bus Capacity: #####kW*	
Modbus				
Modbus Baud Rate	Always	b/s	*Modbus Baud Rate: OFF/9600 b/s/19200 b/s/38400 b/s/ 57600 b/s/115200 b/s*	Mpac DM: 0 = 9600; 1 = 19200; 3 = 57600
Modbus Slave Address	Always		*Modbus Address: ##*	
Engine Metering 1 (Special read only for Lloyds)				
Engine Oil Pressure				
Engine Coolant Temperature				
Programmable Analog Resistive Input 100 (See Figure 2-22)				
Analog Resistive Input Board Number	None		*I/O Board Number: X*	Indicates board number this IO point is located on
Analog Resistive Input Io Number	None			Indicates the point number, of this IO type on this board, for this configuration
Analog Resistive Input Metered Value	None		*Measurement: ###.# Ohms*	The current value of the input (scaled to the units of the function ID)
Analog Resistive Input Metered Relative Value	None			The value of the input relative to the full range of the input
Analog Resistive Input Enabled	Always		*Input Enabled: On/Off*	Indicates whether this input is enabled
Analog Resistive Input Switch Logic	Always			The type of switch that is connected to the input, where “normal” refers to the non-activated state.
Analog Resistive Input Function	Always			Indicates the functionality of this IO point
Analog Resistive Input Protectives Enabled	Always		*Low Warning: On/Off* *High Warning: On/Off* *Low Shutdown: On/Off* *High Shutdown: On/Off*	Indicates which of the protectives are active for this input
Analog Resistive Input Event	Always			The parameter ID defining the function for this input
Analog Resistive Input Sensor	Always		*Sensor Type:*	The type of sensor connected to the input
Analog Resistive Input Low Protective Inhibit Delay	Always	s	*Low Protect Inhibit: ##s*	The time, after crank disconnect, before the protectives for this input are monitored; if 0, protectives are monitored even when the engine is stopped
Analog Resistive Input High Protective Inhibit Delay	Always	s	*High Protect Inhibit: ##s*	The time, after crank disconnect, before the protectives for this input are monitored; if 0, protectives are monitored even when the engine is stopped
Analog Resistive Input Delay	Always	s		The time that the input must be active before a status change is indicated
Analog Resistive Input Inhibit Delay	Always	s		The time that the input must be active before a status change is indicated
Analog Resistive Input Normal Delay	Always	s		The time that the input must be within its normal operating range before all protectives are considered good
Analog Resistive Input Low Warning Delay	Always	s	*Low Warning Delay: ##s*	The time that the input must be within its warning operating range before a warning protective is indicated

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Analog Resistive Input Critically Low Warning Delay	Always	s		The time that the input must be within its warning operating range before a warning protective is indicated
Analog Resistive Input High Warning Delay	Always	s	*High Warning Delay: ##s*	The time that the input must be within its warning operating range before a warning protective is indicated
Analog Resistive Input Critically High Warning Delay	Always	s		The time that the input must be within its warning operating range before a warning protective is indicated
Analog Resistive Input Low Shutdown Delay	Always	s	*Low Shutdown Delay: ##s*	The time that the input must be within its shutdown operating range before a shutdown protective is indicated
Analog Resistive Input High Shutdown Delay	Always	s	*High Shutdown Delay: ##s*	The time that the input must be within its shutdown operating range before a shutdown protective is indicated
Analog Resistive Input Low Warning Limit	Always		*Low Warning Limit:*	The limit that the input must drop below to enter its low warning operating range
Analog Resistive Input Critically Low Warning Limit	Always			The limit that the input must drop below to enter its low warning operating range
Analog Resistive Input Low Shutdown Limit	Always		*Low Shutdown Limit:*	The limit that the input must drop below to enter its low shutdown operating range
Analog Resistive Input High Warning Limit	Always		*High Warning Limit:*	The limit that the input must exceed to enter its high warning operating range
Analog Resistive Input Critically High Warning Limit	Always			The limit that the input must exceed to enter its high warning operating range
Analog Resistive Input High Shutdown Limit	Always		*High Shutdown Limit:*	The limit that the input must exceed to enter its high shutdown operating range
Analog Resistive Input Deadband	Always			A percentage of the parameter value, which defines the hysteresis for the protective ranges
Analog Resistive Input Relative Upper Range Limit	Always			Indicates the limit in raw form when the input will be considered shorted high
Analog Resistive Input Relative Lower Range Limit	Always			Indicates the limit in raw form when the input will be considered shorted low
Analog Resistive Input Relative Range Limit Deadband	Always			Specifies how much the raw value needs to change by before no longer considered shorted
Analog Resistive Input Relative Range High Limit Inhibit Time	Always	s		Specifies what the inhibit time should be when the input is considered shorted high
Analog Resistive Input Relative Range Low Limit Inhibit Time	Always	s		Specifies what the inhibit time should be when the input is considered shorted low

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Analog Resistive Input Relative Range Limit Delay	Always	s		Specifies what the debounce time is on the input after the inhibit time is met
Analog Resistive Input Description	Always		*Description:*	A user-defined description of this IO
Programmable Analog Resistive Input 101 (See Figure 2-22)				
Analog Resistive Input Board Number	None		*I/O Board Number: X*	Indicates board number this IO point is located on
Analog Resistive Input Io Number	None			Indicates the point number, of this IO type on this board, for this configuration
Analog Resistive Input Metered Value	None		*Measurement: ###.# Ohms*	The current value of the input (scaled to the units of the function ID)
Analog Resistive Input Metered Relative Value	None			The value of the input relative to the full range of the input
Analog Resistive Input Enabled	Always		*Input Enabled: On/Off*	Indicates whether this input is enabled
Analog Resistive Input Switch Logic	Always			The type of switch that is connected to the input, where “normal” refers to the non-activated state.
Analog Resistive Input Function	Always			Indicates the functionality of this IO point
Analog Resistive Input Protectives Enabled	Always		*Low Warning: On/Off* *High Warning: On/Off* *Low Shutdown: On/Off* *High Shutdown: On/Off*	Indicates which of the protectives are active for this input
Analog Resistive Input Event	Always			The parameter ID defining the function for this input
Analog Resistive Input Sensor	Always		*Sensor Type:*	The type of sensor connected to the input
Analog Resistive Input Low Protective Inhibit Delay	Always	s	*Low Protect Inhibit: ##s*	The time, after crank disconnect, before the protectives for this input are monitored; if 0, protectives are monitored even when the engine is stopped
Analog Resistive Input High Protective Inhibit Delay	Always	s	*High Protect Inhibit: ##s*	The time, after crank disconnect, before the protectives for this input are monitored; if 0, protectives are monitored even when the engine is stopped
Analog Resistive Input Delay	Always	s		The time that the input must be active before a status change is indicated
Analog Resistive Input Inhibit Delay	Always	s		The time that the input must be active before a status change is indicated
Analog Resistive Input Normal Delay	Always	s		The time that the input must be within its normal operating range before all protectives are considered good
Analog Resistive Input Low Warning Delay	Always	s	*Low Warning Delay: ##s*	The time that the input must be within its warning operating range before a warning protective is indicated
Analog Resistive Input Critically Low Warning Delay	Always	s		The time that the input must be within its warning operating range before a warning protective is indicated

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Analog Resistive Input High Warning Delay	Always	s	*High Warning Delay: ##s*	The time that the input must be within its warning operating range before a warning protective is indicated
Analog Resistive Input Critically High Warning Delay	Always	s		The time that the input must be within its warning operating range before a warning protective is indicated
Analog Resistive Input Low Shutdown Delay	Always	s	*Low Shutdown Delay: ##s*	The time that the input must be within its shutdown operating range before a shutdown protective is indicated
Analog Resistive Input High Shutdown Delay	Always	s	*High Shutdown Delay: ##s*	The time that the input must be within its shutdown operating range before a shutdown protective is indicated
Analog Resistive Input Low Warning Limit	Always		*Low Warning Limit:*	The limit that the input must drop below to enter its low warning operating range
Analog Resistive Input Critically Low Warning Limit	Always			The limit that the input must drop below to enter its low warning operating range
Analog Resistive Input Low Shutdown Limit	Always		*Low Shutdown Limit:*	The limit that the input must drop below to enter its low shutdown operating range
Analog Resistive Input High Warning Limit	Always		*High Warning Limit:*	The limit that the input must exceed to enter its high warning operating range
Analog Resistive Input Critically High Warning Limit	Always			The limit that the input must exceed to enter its high warning operating range
Analog Resistive Input High Shutdown Limit	Always		*High Shutdown Limit:*	The limit that the input must exceed to enter its high shutdown operating range
Analog Resistive Input Deadband	Always			A percentage of the parameter value, which defines the hysteresis for the protective ranges
Analog Resistive Input Relative Upper Range Limit	Always			Indicates the limit in raw form when the input will be considered shorted high
Analog Resistive Input Relative Lower Range Limit	Always			Indicates the limit in raw form when the input will be considered shorted low
Analog Resistive Input Relative Range Limit Deadband	Always			Specifies how much the raw value needs to change by before no longer considered shorted
Analog Resistive Input Relative Range High Limit Inhibit Time	Always	s		Specifies what the inhibit time should be when the input is considered shorted high
Analog Resistive Input Relative Range Low Limit Inhibit Time	Always	s		Specifies what the inhibit time should be when the input is considered shorted low
Analog Resistive Input Relative Range Limit Delay	Always	s		Specifies what the debounce time is on the input after the inhibit time is met

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Analog Resistive Input Description	Always		*Description:*	A user-defined description of this IO
Programmable Analog Resistive Input 102 (See Figure 2-22)				
Analog Resistive Input Board Number	None		*I/O Board Number: X*	Indicates board number this IO point is located on
Analog Resistive Input Io Number	None			Indicates the point number, of this IO type on this board, for this configuration
Analog Resistive Input Metered Value	None		*Measurement: ###.# Ohms*	The current value of the input (scaled to the units of the function ID)
Analog Resistive Input Metered Relative Value	None			The value of the input relative to the full range of the input
Analog Resistive Input Enabled	Always		*Input Enabled: On/Off*	Indicates whether this input is enabled
Analog Resistive Input Switch Logic	Always			The type of switch that is connected to the input, where “normal” refers to the non-activated state.
Analog Resistive Input Function	Always			Indicates the functionality of this IO point
Analog Resistive Input Protectives Enabled	Always		*Low Warning: On/Off* *High Warning: On/Off* *Low Shutdown: On/Off* *High Shutdown: On/Off*	Indicates which of the protectives are active for this input
Analog Resistive Input Event	Always			The parameter ID defining the function for this input
Analog Resistive Input Sensor	Always		*Sensor Type:*	The type of sensor connected to the input
Analog Resistive Input Low Protective Inhibit Delay	Always	s	*Low Protect Inhibit: ##s*	The time, after crank disconnect, before the protectives for this input are monitored; if 0, protectives are monitored even when the engine is stopped
Analog Resistive Input High Protective Inhibit Delay	Always	s	*High Protect Inhibit: ##s*	The time, after crank disconnect, before the protectives for this input are monitored; if 0, protectives are monitored even when the engine is stopped
Analog Resistive Input Delay	Always	s		The time that the input must be active before a status change is indicated
Analog Resistive Input Inhibit Delay	Always	s		The time that the input must be active before a status change is indicated
Analog Resistive Input Normal Delay	Always	s		The time that the input must be within its normal operating range before all protectives are considered good
Analog Resistive Input Low Warning Delay	Always	s	*Low Warning Delay: ##s*	The time that the input must be within its warning operating range before a warning protective is indicated
Analog Resistive Input Critically Low Warning Delay	Always	s		The time that the input must be within its warning operating range before a warning protective is indicated
Analog Resistive Input High Warning Delay	Always	s	*High Warning Delay: ##s*	The time that the input must be within its warning operating range before a warning protective is indicated

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Analog Resistive Input Critically High Warning Delay	Always	s		The time that the input must be within its warning operating range before a warning protective is indicated
Analog Resistive Input Low Shutdown Delay	Always	s	*Low Shutdown Delay: ##s*	The time that the input must be within its shutdown operating range before a shutdown protective is indicated
Analog Resistive Input High Shutdown Delay	Always	s	*High Shutdown Delay: ##s*	The time that the input must be within its shutdown operating range before a shutdown protective is indicated
Analog Resistive Input Low Warning Limit	Always		*Low Warning Limit:*	The limit that the input must drop below to enter its low warning operating range
Analog Resistive Input Critically Low Warning Limit	Always			The limit that the input must drop below to enter its low warning operating range
Analog Resistive Input Low Shutdown Limit	Always		*Low Shutdown Limit:*	The limit that the input must drop below to enter its low shutdown operating range
Analog Resistive Input High Warning Limit	Always		*High Warning Limit:*	The limit that the input must exceed to enter its high warning operating range
Analog Resistive Input Critically High Warning Limit	Always			The limit that the input must exceed to enter its high warning operating range
Analog Resistive Input High Shutdown Limit	Always		*High Shutdown Limit:*	The limit that the input must exceed to enter its high shutdown operating range
Analog Resistive Input Deadband	Always			A percentage of the parameter value, which defines the hysteresis for the protective ranges
Analog Resistive Input Relative Upper Range Limit	Always			Indicates the limit in raw form when the input will be considered shorted high
Analog Resistive Input Relative Lower Range Limit	Always			Indicates the limit in raw form when the input will be considered shorted low
Analog Resistive Input Relative Range Limit Deadband	Always			Specifies how much the raw value needs to change by before no longer considered shorted
Analog Resistive Input Relative Range High Limit Inhibit Time	Always	s		Specifies what the inhibit time should be when the input is considered shorted high
Analog Resistive Input Relative Range Low Limit Inhibit Time	Always	s		Specifies what the inhibit time should be when the input is considered shorted low
Analog Resistive Input Relative Range Limit Delay	Always	s		Specifies what the debounce time is on the input after the inhibit time is met
Analog Resistive Input Description	Always		*Description:*	A user-defined description of this IO
Programmable Analog Resistive Input 103 (See Figure 2-22)				
Analog Resistive Input Board Number	None		*I/O Board Number: X*	Indicates board number this IO point is located on

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Analog Resistive Input Io Number	None			Indicates the point number, of this IO type on this board, for this configuration
Analog Resistive Input Metered Value	None		*Measurement: ###.# Ohms*	The current value of the input (scaled to the units of the function ID)
Analog Resistive Input Metered Relative Value	None			The value of the input relative to the full range of the input
Analog Resistive Input Enabled	Always		*Input Enabled: On/Off*	Indicates whether this input is enabled
Analog Resistive Input Switch Logic	Always			The type of switch that is connected to the input, where "normal" refers to the non-activated state.
Analog Resistive Input Function	Always			Indicates the functionality of this IO point
Analog Resistive Input Protectives Enabled	Always		*Low Warning: On/Off* *High Warning: On/Off* *Low Shutdown: On/Off* *High Shutdown: On/Off*	Indicates which of the protectives are active for this input
Analog Resistive Input Event	Always			The parameter ID defining the function for this input
Analog Resistive Input Sensor	Always		*Sensor Type:*	The type of sensor connected to the input
Analog Resistive Input Low Protective Inhibit Delay	Always	s	*Low Protect Inhibit: ##s*	The time, after crank disconnect, before the protectives for this input are monitored; if 0, protectives are monitored even when the engine is stopped
Analog Resistive Input High Protective Inhibit Delay	Always	s	*High Protect Inhibit: ##s*	The time, after crank disconnect, before the protectives for this input are monitored; if 0, protectives are monitored even when the engine is stopped
Analog Resistive Input Delay	Always	s		The time that the input must be active before a status change is indicated
Analog Resistive Input Inhibit Delay	Always	s		The time that the input must be active before a status change is indicated
Analog Resistive Input Normal Delay	Always	s		The time that the input must be within its normal operating range before all protectives are considered good
Analog Resistive Input Low Warning Delay	Always	s	*Low Warning Delay: ##s*	The time that the input must be within its warning operating range before a warning protective is indicated
Analog Resistive Input Critically Low Warning Delay	Always	s		The time that the input must be within its warning operating range before a warning protective is indicated
Analog Resistive Input High Warning Delay	Always	s	*High Warning Delay: ##s*	The time that the input must be within its warning operating range before a warning protective is indicated
Analog Resistive Input Critically High Warning Delay	Always	s		The time that the input must be within its warning operating range before a warning protective is indicated

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Analog Resistive Input Low Shutdown Delay	Always	s	*Low Shutdown Delay: ##s*	The time that the input must be within its shutdown operating range before a shutdown protective is indicated
Analog Resistive Input High Shutdown Delay	Always	s	*High Shutdown Delay: ##s*	The time that the input must be within its shutdown operating range before a shutdown protective is indicated
Analog Resistive Input Low Warning Limit	Always		*Low Warning Limit:*	The limit that the input must drop below to enter its low warning operating range
Analog Resistive Input Critically Low Warning Limit	Always			The limit that the input must drop below to enter its low warning operating range
Analog Resistive Input Low Shutdown Limit	Always		*Low Shutdown Limit:*	The limit that the input must drop below to enter its low shutdown operating range
Analog Resistive Input High Warning Limit	Always		*High Warning Limit:*	The limit that the input must exceed to enter its high warning operating range
Analog Resistive Input Critically High Warning Limit	Always			The limit that the input must exceed to enter its high warning operating range
Analog Resistive Input High Shutdown Limit	Always		*High Shutdown Limit:*	The limit that the input must exceed to enter its high shutdown operating range
Analog Resistive Input Deadband	Always			A percentage of the parameter value, which defines the hysteresis for the protective ranges
Analog Resistive Input Relative Upper Range Limit	Always			Indicates the limit in raw form when the input will be considered shorted high
Analog Resistive Input Relative Lower Range Limit	Always			Indicates the limit in raw form when the input will be considered shorted low
Analog Resistive Input Relative Range Limit Deadband	Always			Specifies how much the raw value needs to change by before no longer considered shorted
Analog Resistive Input Relative Range High Limit Inhibit Time	Always	s		Specifies what the inhibit time should be when the input is considered shorted high
Analog Resistive Input Relative Range Low Limit Inhibit Time	Always	s		Specifies what the inhibit time should be when the input is considered shorted low
Analog Resistive Input Relative Range Limit Delay	Always	s		Specifies what the debounce time is on the input after the inhibit time is met
Analog Resistive Input Description	Always		*Description:*	A user-defined description of this IO
Programmable Analog Resistive Input 104 (See Figure 2-22)				
Analog Resistive Input Board Number	None		*I/O Board Number: X*	Indicates board number this IO point is located on
Analog Resistive Input Io Number	None			Indicates the point number, of this IO type on this board, for this configuration

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Analog Resistive Input Metered Value	None		*Measurement: ###.# Ohms*	The current value of the input (scaled to the units of the function ID)
Analog Resistive Input Metered Relative Value	None			The value of the input relative to the full range of the input
Analog Resistive Input Enabled	Always		*Input Enabled: On/Off*	Indicates whether this input is enabled
Analog Resistive Input Switch Logic	Always			The type of switch that is connected to the input, where "normal" refers to the non-activated state.
Analog Resistive Input Function	Always			Indicates the functionality of this IO point
Analog Resistive Input Protectives Enabled	Always		*Low Warning: On/Off* *High Warning: On/Off* *Low Shutdown: On/Off* *High Shutdown: On/Off*	Indicates which of the protectives are active for this input
Analog Resistive Input Event	Always			The parameter ID defining the function for this input
Analog Resistive Input Sensor	Always		*Sensor Type:*	The type of sensor connected to the input
Analog Resistive Input Low Protective Inhibit Delay	Always	s	*Low Protect Inhibit: ##s*	The time, after crank disconnect, before the protectives for this input are monitored; if 0, protectives are monitored even when the engine is stopped
Analog Resistive Input High Protective Inhibit Delay	Always	s	*High Protect Inhibit: ##s*	The time, after crank disconnect, before the protectives for this input are monitored; if 0, protectives are monitored even when the engine is stopped
Analog Resistive Input Delay	Always	s		The time that the input must be active before a status change is indicated
Analog Resistive Input Inhibit Delay	Always	s		The time that the input must be active before a status change is indicated
Analog Resistive Input Normal Delay	Always	s		The time that the input must be within its normal operating range before all protectives are considered good
Analog Resistive Input Low Warning Delay	Always	s	*Low Warning Delay: ##s*	The time that the input must be within its warning operating range before a warning protective is indicated
Analog Resistive Input Critically Low Warning Delay	Always	s		The time that the input must be within its warning operating range before a warning protective is indicated
Analog Resistive Input High Warning Delay	Always	s	*High Warning Delay: ##s*	The time that the input must be within its warning operating range before a warning protective is indicated
Analog Resistive Input Critically High Warning Delay	Always	s		The time that the input must be within its warning operating range before a warning protective is indicated

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Analog Resistive Input Low Shutdown Delay	Always	s	*Low Shutdown Delay: ##s*	The time that the input must be within its shutdown operating range before a shutdown protective is indicated
Analog Resistive Input High Shutdown Delay	Always	s	*High Shutdown Delay: ##s*	The time that the input must be within its shutdown operating range before a shutdown protective is indicated
Analog Resistive Input Low Warning Limit	Always		*Low Warning Limit:*	The limit that the input must drop below to enter its low warning operating range
Analog Resistive Input Critically Low Warning Limit	Always			The limit that the input must drop below to enter its low warning operating range
Analog Resistive Input Low Shutdown Limit	Always		*Low Shutdown Limit:*	The limit that the input must drop below to enter its low shutdown operating range
Analog Resistive Input High Warning Limit	Always		*High Warning Limit:*	The limit that the input must exceed to enter its high warning operating range
Analog Resistive Input Critically High Warning Limit	Always			The limit that the input must exceed to enter its high warning operating range
Analog Resistive Input High Shutdown Limit	Always		*High Shutdown Limit:*	The limit that the input must exceed to enter its high shutdown operating range
Analog Resistive Input Deadband	Always			A percentage of the parameter value, which defines the hysteresis for the protective ranges
Analog Resistive Input Relative Upper Range Limit	Always			Indicates the limit in raw form when the input will be considered shorted high
Analog Resistive Input Relative Lower Range Limit	Always			Indicates the limit in raw form when the input will be considered shorted low
Analog Resistive Input Relative Range Limit Deadband	Always			Specifies how much the raw value needs to change by before no longer considered shorted
Analog Resistive Input Relative Range High Limit Inhibit Time	Always	s		Specifies what the inhibit time should be when the input is considered shorted high
Analog Resistive Input Relative Range Low Limit Inhibit Time	Always	s		Specifies what the inhibit time should be when the input is considered shorted low
Analog Resistive Input Relative Range Limit Delay	Always	s		Specifies what the debounce time is on the input after the inhibit time is met
Analog Resistive Input Description	Always		*Description:*	A user-defined description of this IO
Programmable Analog Resistive Input 105 (See Figure 2-22)				
Analog Resistive Input Board Number	None		*I/O Board Number: X*	Indicates board number this IO point is located on
Analog Resistive Input Io Number	None			Indicates the point number, of this IO type on this board, for this configuration

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Analog Resistive Input Metered Value	None		*Measurement: ###.# Ohms*	The current value of the input (scaled to the units of the function ID)
Analog Resistive Input Metered Relative Value	None			The value of the input relative to the full range of the input
Analog Resistive Input Enabled	Always		*Input Enabled: On/Off*	Indicates whether this input is enabled
Analog Resistive Input Switch Logic	Always			The type of switch that is connected to the input, where "normal" refers to the non-activated state.
Analog Resistive Input Function	Always			Indicates the functionality of this IO point
Analog Resistive Input Protectives Enabled	Always		*Low Warning: On/Off* *High Warning: On/Off* *Low Shutdown: On/Off* *High Shutdown: On/Off*	Indicates which of the protectives are active for this input
Analog Resistive Input Event	Always			The parameter ID defining the function for this input
Analog Resistive Input Sensor	Always		*Sensor Type:*	The type of sensor connected to the input
Analog Resistive Input Low Protective Inhibit Delay	Always	s	*Low Protect Inhibit: ##s*	The time, after crank disconnect, before the protectives for this input are monitored; if 0, protectives are monitored even when the engine is stopped
Analog Resistive Input High Protective Inhibit Delay	Always	s	*High Protect Inhibit: ##s*	The time, after crank disconnect, before the protectives for this input are monitored; if 0, protectives are monitored even when the engine is stopped
Analog Resistive Input Delay	Always	s		The time that the input must be active before a status change is indicated
Analog Resistive Input Inhibit Delay	Always	s		The time that the input must be active before a status change is indicated
Analog Resistive Input Normal Delay	Always	s		The time that the input must be within its normal operating range before all protectives are considered good
Analog Resistive Input Low Warning Delay	Always	s	*Low Warning Delay: ##s*	The time that the input must be within its warning operating range before a warning protective is indicated
Analog Resistive Input Critically Low Warning Delay	Always	s		The time that the input must be within its warning operating range before a warning protective is indicated
Analog Resistive Input High Warning Delay	Always	s	*High Warning Delay: ##s*	The time that the input must be within its warning operating range before a warning protective is indicated
Analog Resistive Input Critically High Warning Delay	Always	s		The time that the input must be within its warning operating range before a warning protective is indicated

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Analog Resistive Input Low Shutdown Delay	Always	s	*Low Shutdown Delay: ##s*	The time that the input must be within its shutdown operating range before a shutdown protective is indicated
Analog Resistive Input High Shutdown Delay	Always	s	*High Shutdown Delay: ##s*	The time that the input must be within its shutdown operating range before a shutdown protective is indicated
Analog Resistive Input Low Warning Limit	Always		*Low Warning Limit:*	The limit that the input must drop below to enter its low warning operating range
Analog Resistive Input Critically Low Warning Limit	Always			The limit that the input must drop below to enter its low warning operating range
Analog Resistive Input Low Shutdown Limit	Always		*Low Shutdown Limit:*	The limit that the input must drop below to enter its low shutdown operating range
Analog Resistive Input High Warning Limit	Always		*High Warning Limit:*	The limit that the input must exceed to enter its high warning operating range
Analog Resistive Input Critically High Warning Limit	Always			The limit that the input must exceed to enter its high warning operating range
Analog Resistive Input High Shutdown Limit	Always		*High Shutdown Limit:*	The limit that the input must exceed to enter its high shutdown operating range
Analog Resistive Input Deadband	Always			A percentage of the parameter value, which defines the hysteresis for the protective ranges
Analog Resistive Input Relative Upper Range Limit	Always			Indicates the limit in raw form when the input will be considered shorted high
Analog Resistive Input Relative Lower Range Limit	Always			Indicates the limit in raw form when the input will be considered shorted low
Analog Resistive Input Relative Range Limit Deadband	Always			Specifies how much the raw value needs to change by before no longer considered shorted
Analog Resistive Input Relative Range High Limit Inhibit Time	Always	s		Specifies what the inhibit time should be when the input is considered shorted high
Analog Resistive Input Relative Range Low Limit Inhibit Time	Always	s		Specifies what the inhibit time should be when the input is considered shorted low
Analog Resistive Input Relative Range Limit Delay	Always	s		Specifies what the debounce time is on the input after the inhibit time is met
Analog Resistive Input Description	Always		*Description:*	A user-defined description of this IO

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Programmable Analog Voltage Input 106 (See Figure 2-22)				
Analog Voltage Input Board Number	Not supported for these models.			
Analog Voltage Input Io Number				
Analog Voltage Input Metered Value	None		*Measurement: ###.# Ohms*	The current value of the input (scaled to the units of the function ID)
Analog Voltage Input Metered Relative Value	None			The value of the input relative to the full range of the input
Analog Voltage Input Enabled	Not supported for these models.			
Analog Voltage Input Switch Logic				
Analog Voltage Input Function				
Analog Voltage Input Protectives Enabled				
Analog Voltage Input Event				
Analog Voltage Input Sensor				
Analog Voltage Input Low Protective Inhibit Delay				
Analog Voltage Input High Protective Inhibit Delay				
Analog Voltage Input Delay				
Analog Voltage Input Inhibit Delay				
Analog Voltage Input Normal Delay				
Analog Voltage Input Low Warning Delay				
Analog Voltage Input Critically Low Warning Delay				
Analog Voltage Input High Warning Delay				
Analog Voltage Input Critically High Warning Delay				
Analog Voltage Input Low Shutdown Delay				
Analog Voltage Input High Shutdown Delay				
Analog Voltage Input Low Warning Limit				
Analog Voltage Input Critically Low Warning Limit				
Analog Voltage Input Low Shutdown Limit				
Analog Voltage Input High Warning Limit				
Analog Voltage Input Critically High Warning Limit				
Analog Voltage Input High Shutdown Limit				
Analog Voltage Input Deadband				
Analog Voltage Input Relative Upper Range Limit				
Analog Voltage Input Relative Lower Range Limit				
Analog Voltage Input Relative Range Limit Deadband				
Analog Voltage Input Relative Range High Limit Inhibit Time				
Analog Voltage Input Relative Range Low Limit Inhibit Time				
Analog Voltage Input Relative Range Limit Delay				
Analog Voltage Input Description				
Programmable Analog Voltage Input 107 (See Figure 2-22)				
Analog Voltage Input Board Number	Not supported for these models.			
Analog Voltage Input Io Number				
Analog Voltage Input Metered Value	None		*Measurement: ###.# Ohms*	The current value of the input (scaled to the units of the function ID)
Analog Voltage Input Metered Relative Value	None			The value of the input relative to the full range of the input
Analog Voltage Input Enabled	Not supported for these models.			
Analog Voltage Input Switch Logic				
Analog Voltage Input Function				
Analog Voltage Input Protectives Enabled				
Analog Voltage Input Event				
Analog Voltage Input Sensor				
Analog Voltage Input Low Protective Inhibit Delay				
Analog Voltage Input High Protective Inhibit Delay				
Analog Voltage Input Delay				
Analog Voltage Input Inhibit Delay				
Analog Voltage Input Normal Delay				
Analog Voltage Input Low Warning Delay				
Analog Voltage Input Critically Low Warning Delay				
Analog Voltage Input High Warning Delay				
Analog Voltage Input Critically High Warning Delay				

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Analog Voltage Input Low Shutdown Delay	Not supported for these models			
Analog Voltage Input High Shutdown Delay				
Analog Voltage Input Low Warning Limit				
Analog Voltage Input Critically Low Warning Limit				
Analog Voltage Input Low Shutdown Limit				
Analog Voltage Input High Warning Limit				
Analog Voltage Input Critically High Warning Limit				
Analog Voltage Input High Shutdown Limit				
Analog Voltage Input Deadband				
Analog Voltage Input Relative Upper Range Limit				
Analog Voltage Input Relative Lower Range Limit				
Analog Voltage Input Relative Range Limit Deadband				
Analog Voltage Input Relative Range High Limit Inhibit Time				
Analog Voltage Input Relative Range Low Limit Inhibit Time				
Analog Voltage Input Relative Range Limit Delay				
Analog Voltage Input Description				
Programmable Analog Voltage Input 108 (See Figure 2-22)				
Analog Voltage Input Board Number	Not supported for these models.			
Analog Voltage Input Io Number				
Analog Voltage Input Metered Value	None		*Measurement: ###.# Ohms*	The current value of the input (scaled to the units of the function ID)
Analog Voltage Input Metered Relative Value	None			The value of the input relative to the full range of the input
Analog Voltage Input Enabled	Not supported for these models.			
Analog Voltage Input Switch Logic				
Analog Voltage Input Function				
Analog Voltage Input Protectives Enabled				
Analog Voltage Input Event				
Analog Voltage Input Sensor				
Analog Voltage Input Low Protective Inhibit Delay				
Analog Voltage Input High Protective Inhibit Delay				
Analog Voltage Input Delay				
Analog Voltage Input Inhibit Delay				
Analog Voltage Input Normal Delay				
Analog Voltage Input Low Warning Delay				
Analog Voltage Input Critically Low Warning Delay				
Analog Voltage Input High Warning Delay				
Analog Voltage Input Critically High Warning Delay				
Analog Voltage Input Low Shutdown Delay				
Analog Voltage Input High Shutdown Delay				
Analog Voltage Input Low Warning Limit				
Analog Voltage Input Critically Low Warning Limit				
Analog Voltage Input Low Shutdown Limit				
Analog Voltage Input High Warning Limit				
Analog Voltage Input Critically High Warning Limit				
Analog Voltage Input High Shutdown Limit				
Analog Voltage Input Deadband				
Analog Voltage Input Relative Upper Range Limit				
Analog Voltage Input Relative Lower Range Limit				
Analog Voltage Input Relative Range Limit Deadband				
Analog Voltage Input Relative Range High Limit Inhibit Time				
Analog Voltage Input Relative Range Low Limit Inhibit Time				
Analog Voltage Input Relative Range Limit Delay				
Analog Voltage Input Description				

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Programmable Digital Input 109 (See Figure 2-22)				
Digital Input Board Number	None		*I/O Board Number: X*	Indicates board number this IO point is located on
Digital Input Io Number	None			Indicates the point number, of this IO type on this board, for this configuration
Digital Input Status	None			The current value of the input (scaled to the units of the function ID)
Digital Input Enabled	Always		*Enabled: On/Off*	Indicates whether this input is enabled
Digital Input Logic	Always			The type of switch that is connected to the input, where “normal” refers to the non-activated state
Digital Input Function	Always		*Function:*	Indicates the functionality of this IO point
Digital Input Event	Always		*Event:*	The parameter ID defining the function for this input
Digital Input Delay	Always	s	*Delay Time: ##s*	The time that the input must be active before a status change is indicated
Digital Input Inhibit Delay	Always	s	*Inhibit Time: ##s*	The time that the input must be active before a status change is indicated
Digital Input Description	Always		*Description:*	A user-defined description of this IO point
Programmable Digital Input 110 (See Figure 2-22)				
Digital Input Board Number	None		*I/O Board Number: X*	Indicates board number this IO point is located on
Digital Input Io Number	None			Indicates the point number, of this IO type on this board, for this configuration
Digital Input Status	None			The current value of the input (scaled to the units of the function ID)
Digital Input Enabled	Always		*Enabled: On/Off*	Indicates whether this input is enabled
Digital Input Logic	Always			The type of switch that is connected to the input, where “normal” refers to the non-activated state
Digital Input Function	Always		*Function:*	Indicates the functionality of this IO point
Digital Input Event	Always		*Event:*	The parameter ID defining the function for this input
Digital Input Delay	Always	s	*Delay Time: ##s*	The time that the input must be active before a status change is indicated
Digital Input Inhibit Delay	Always	s	*Inhibit Time: ##s*	The time that the input must be active before a status change is indicated
Digital Input Description	Always		*Description:*	A user-defined description of this IO point
Programmable Digital Input 111 (See Figure 2-22)				
Digital Input Board Number	None		*I/O Board Number: X*	Indicates board number this IO point is located on
Digital Input Io Number	None			Indicates the point number, of this IO type on this board, for this configuration

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Digital Input Status	None			The current value of the input (scaled to the units of the function ID)
Digital Input Enabled	Always		*Enabled: On/Off*	Indicates whether this input is enabled
Digital Input Logic	Always			The type of switch that is connected to the input, where “normal” refers to the non-activated state
Digital Input Function	Always		*Function:*	Indicates the functionality of this IO point
Digital Input Event	Always		*Event:*	The parameter ID defining the function for this input
Digital Input Delay	Always	s	*Delay Time: ##s*	The time that the input must be active before a status change is indicated
Digital Input Inhibit Delay	Always	s	*Inhibit Time: ##s*	The time that the input must be active before a status change is indicated
Digital Input Description	Always		*Description:*	A user-defined description of this IO point
Programmable Digital Input 112 (See Figure 2-22)				
Digital Input Board Number	None		*I/O Board Number: X*	Indicates board number this IO point is located on
Digital Input Io Number	None			Indicates the point number, of this IO type on this board, for this configuration
Digital Input Status	None			The current value of the input (scaled to the units of the function ID)
Digital Input Enabled	Always		*Enabled: On/Off*	Indicates whether this input is enabled
Digital Input Logic	Always			The type of switch that is connected to the input, where “normal” refers to the non-activated state
Digital Input Function	Always		*Function:*	Indicates the functionality of this IO point
Digital Input Event	Always		*Event:*	The parameter ID defining the function for this input
Digital Input Delay	Always	s	*Delay Time: ##s*	The time that the input must be active before a status change is indicated
Digital Input Inhibit Delay	Always	s	*Inhibit Time: ##s*	The time that the input must be active before a status change is indicated
Digital Input Description	Always		*Description:*	A user-defined description of this IO point
Programmable Digital Input 113 (See Figure 2-22)				
Digital Input Board Number	None		*I/O Board Number: X*	Indicates board number this IO point is located on
Digital Input Io Number	None			Indicates the point number, of this IO type on this board, for this configuration
Digital Input Status	None			The current value of the input (scaled to the units of the function ID)
Digital Input Enabled	Always		*Enabled: On/Off*	Indicates whether this input is enabled

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Digital Input Logic	Always			The type of switch that is connected to the input, where “normal” refers to the non-activated state
Digital Input Function	Always		*Function:*	Indicates the functionality of this IO point
Digital Input Event	Always		*Event:*	The parameter ID defining the function for this input
Digital Input Delay	Always	s	*Delay Time: ##s*	The time that the input must be active before a status change is indicated
Digital Input Inhibit Delay	Always	s	*Inhibit Time: ##s*	The time that the input must be active before a status change is indicated
Digital Input Description	Always		*Description:*	A user-defined description of this IO point
Programmable Digital Input 114 (See Figure 2-22)				
Digital Input Board Number	None		*I/O Board Number: X*	Indicates board number this IO point is located on
Digital Input Io Number	None			Indicates the point number, of this IO type on this board, for this configuration
Digital Input Status	None			The current value of the input (scaled to the units of the function ID)
Digital Input Enabled	Always		*Enabled: On/Off*	Indicates whether this input is enabled
Digital Input Logic	Always			The type of switch that is connected to the input, where “normal” refers to the non-activated state
Digital Input Function	Always		*Function:*	Indicates the functionality of this IO point
Digital Input Event	Always		*Event:*	The parameter ID defining the function for this input
Digital Input Delay	Always	s	*Delay Time: ##s*	The time that the input must be active before a status change is indicated
Digital Input Inhibit Delay	Always	s	*Inhibit Time: ##s*	The time that the input must be active before a status change is indicated
Digital Input Description	Always		*Description:*	A user-defined description of this IO point
Programmable Digital Output 115 NOTE: Tied to the CBO output (See Figure 2-22)				
Digital Output Board Number	None		*I/O Board Number: X*	Indicates board number this IO point is located on
Digital Output Io Number	None			Indicates the point number, of this IO type on this board, for this configuration
Digital Output Status	None			The value of the input relative to the full range of the input
Digital Output Enabled	Always		*Enabled: On/Off*	Indicates whether this input is enabled
Digital Output Logic	Always		*Logic: Active On/Active Off*	Indicates whether shutdown is active for this input
Digital Output Function	Always		*Function:*	Indicates the functionality of this IO point
Digital Output Event	Always		*Event:*	The parameter ID defining the function for this input

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Digital Output Description	Always		*Description:*	A user-defined description of this IO point.
Programmable Digital Output 116 NOTE: Tied to the CBC output (See Figure 2-22)				
Digital Output Board Number	None		*I/O Board Number: X*	Indicates board number this IO point is located on
Digital Output Io Number	None			Indicates the point number, of this IO type on this board, for this configuration
Digital Output Status	None			The value of the input relative to the full range of the input
Digital Output Enabled	Always		*Enabled: On/Off*	Indicates whether this input is enabled
Digital Output Logic	Always		*Logic: Active On/Active Off*	Indicates whether shutdown is active for this input
Digital Output Function	Always		*Function:*	Indicates the functionality of this IO point
Digital Output Event	Always		*Event:*	The parameter ID defining the function for this input
Digital Output Description	Always		*Description:*	A user-defined description of this IO point.
Programmable Digital Output 117 NOTE: Tied to the RD4 output (TB13 pin 13) (See Figure 2-22)				
Digital Output Board Number	None		*I/O Board Number: X*	Indicates board number this IO point is located on
Digital Output Io Number	None			Indicates the point number, of this IO type on this board, for this configuration
Digital Output Status	None			The value of the input relative to the full range of the input
Digital Output Enabled	Always		*Enabled: On/Off*	Indicates whether this input is enabled
Digital Output Logic	Always		*Logic: Active On/Active Off*	Indicates whether shutdown is active for this input
Digital Output Function	Always		*Function:*	Indicates the functionality of this IO point
Digital Output Event	Always		*Event:*	The parameter ID defining the function for this input
Digital Output Description	Always		*Description:*	A user-defined description of this IO point.
Programmable Digital Output 118 NOTE: Tied to the RD3 output (TB13 pin 12) (See Figure 2-22)				
Digital Output Board Number	None		*I/O Board Number: X*	Indicates board number this IO point is located on
Digital Output Io Number	None			Indicates the point number, of this IO type on this board, for this configuration
Digital Output Status	None			The value of the input relative to the full range of the input
Digital Output Enabled	Always		*Enabled: On/Off*	Indicates whether this input is enabled
Digital Output Logic	Always		*Logic: Active On/Active Off*	Indicates whether shutdown is active for this input
Digital Output Function	Always		*Function:*	Indicates the functionality of this IO point
Digital Output Event	Always		*Event:*	The parameter ID defining the function for this input
Digital Output Description	Always		*Description:*	A user-defined description of this IO point.

SiteTech™ Parameter	Write Access	Units	*Decision-Maker® 3500 User Interface*	Notes
Special Parameters				
Profile				
Saved Date				
File Version				
Address				
Password				

* Some functions require optional input sensors or are engine ECM dependent on some generator set models.

† ECM inputs are engine manufacturer dependent.

2.9.1 Programmable Inputs/Outputs

SiteTech™ Parameter	Decision-Maker® 3500 Parameter	Description
Programmable Analog Resistive Inputs (See Figure 2-23 when Programmable Analog Resistive Inputs are used as Digital Inputs)		
100	1	This input measures the resistance applied between P1 pin 18 and P1 pin 31 on the controller.
101	2	This input measures the resistance applied between P1 pin 30 and P1 pin 31 on the controller.
102	3	This input measures the resistance applied between P1 pin 19 and P1 pin 31 on the controller.
103	4	This input measures the resistance applied between P2 pin 12 and P1 pin 31 on the controller.
104	5	This input measures the resistance applied between P2 pin 11 and P1 pin 31 on the controller.
105	6	This input measures the resistance applied between P2 pin 10 and P1 pin 31 on the controller.
Programmable Analog Voltage Inputs		
106	1	This input measures the voltage applied between P2 pin 2 (+) and P2 pin 6 (-) on the controller. This input is commonly used for circuit breaker status.
107	2	This input measures the voltage applied between P2 pin 3 (+) and P2 pin 7 (-) on the controller. This input is commonly used for voltage bias.
108	3	This input measures the voltage applied between P2 pin 4 (+) and P2 pin 8 (-) on the controller. This input is commonly used for speed bias.
Programmable Digital Inputs		
109	1	This input is considered Closed when there is continuity between P1 pin 34 and P1 pin 31. If the **Digital Input Logic** is set to: ACTIVE CLOSE, the input becomes active when there is continuity between P1 pin 34 and P1 pin 31. ACTIVE OPEN, the input becomes active when there is no continuity between P1 pin 34 and P1 pin 31.
110	2	This input is considered Closed when there is continuity between P1 pin 22 and P1 pin 31. If the **Digital Input Logic** is set to: ACTIVE CLOSE, the input becomes active when there is continuity between P1 pin 22 and P1 pin 31. ACTIVE OPEN, the input becomes active when there is no continuity between P1 pin 22 and P1 pin 31.
111	3	This input is considered Closed when there is continuity between P1 pin 33 and P1 pin 31. If the **Digital Input Logic** is set to: ACTIVE CLOSE, the input becomes active when there is continuity between P1 pin 33 and P1 pin 31. ACTIVE OPEN, the input becomes active when there is no continuity between P1 pin 33 and P1 pin 31.
112	4	This input is considered Closed when there is continuity between P1 pin 21 and P1 pin 31. If the **Digital Input Logic** is set to: ACTIVE CLOSE, the input becomes active when there is continuity between P1 pin 21 and P1 pin 31. ACTIVE OPEN, the input becomes active when there is no continuity between P1 pin 21 and P1 pin 31.
113	5	This input is considered Closed when there is continuity between P1 pin 32 and P1 pin 31. If the **Digital Input Logic** is set to: ACTIVE CLOSE, the input becomes active when there is continuity between P1 pin 32 and P1 pin 31. ACTIVE OPEN, the input becomes active when there is no continuity between P1 pin 32 and P1 pin 31.
114	6	This input is considered Closed when there is continuity between P2 pin 1 and P1 pin 31. If the **Digital Input Logic** is set to: ACTIVE CLOSE, the input becomes active when there is continuity between P2 pin 1 and P1 pin 31. ACTIVE OPEN, the input becomes active when there is no continuity between P2 pin 1 and P1 pin 31.
Program-mable Digital Outputs	***Programmable Relay Driver Outputs***	
115	1	This output is configured to a function by selecting the corresponding Event and setting Enable to ON. Setting the **Digital Output Logic** to: ACTIVE ON makes P2 pin 5 energize (pull to battery negative) when the Event is true. ACTIVE OFF makes P2 pin 5 energize (pull to battery negative) when the Event is false.
116	2	This output is configured to a function by selecting the corresponding Event and setting Enable to ON. Setting the **Digital Output Logic** to: ACTIVE ON makes P2 pin 9 energize (pull to battery negative) when the Event is true. ACTIVE OFF makes P2 pin 9 energize (pull to battery negative) when the Event is false.
117	3	This output is configured to a function by selecting the corresponding Event and setting Enable to ON. Setting the **Digital Output Logic** to: ACTIVE ON makes P2 pin 14 energize (pull to battery negative) when the Event is true. ACTIVE OFF makes P2 pin 14 energize (pull to battery negative) when the Event is false.
118	4	This output is configured to a function by selecting the corresponding Event and setting Enable to ON. Setting the **Digital Output Logic** to: ACTIVE ON makes P2 pin 13 energize (pull to battery negative) when the Event is true. ACTIVE OFF makes P2 pin 13 energize (pull to battery negative) when the Event is false.

Figure 2-22 Programmable Inputs/Outputs on the Decision-Maker® 3500 Controller

Programmable Analog Resistive Input #1, used as Digital:

Programmable Digital Input 100	
Digital Input Board Number	1
Digital Input Io Number	1
Digital Input Status	
Digital Input Enabled	On
Digital Input Logic	Active Close
Digital Input Function	Use As A System Event
Digital Input Event	None
Digital Input Delay	0 s
Digital Input Inhibit Delay	0 s
Digital Input Description	N/A
Programmable Analog Resistive Input 100	
Analog Resistive Input Board Number	1
Analog Resistive Input Io Number	1
Analog Resistive Input Metered Value	-39.0
Analog Resistive Input Metered Relative Value	100000.0
Analog Resistive Input Enabled	On
Analog Resistive Input Switch Logic	Active Low
Analog Resistive Input Function	Use As Digital Input

Programmable Resistive Input #1 can be used as a Digital Input.

When configured as a Digital Input, it can be configured under Programmable Digital Input 100.

NOTE: This input is not recommended for connection to devices further than 30 m (98 ft.) from the generator set to avoid the potential damage to the sensitive resistive input measurement circuitry.

This input is considered "Closed" when there is less than 50 Ohms of resistance between P1 pin 18 and P1 pin 31.

If Digital Input Logic is set to "Active Close", the input becomes active when the resistance between P1 pin 18 and P1 pin 31 (as indicated in Analog Resistive Input Metered Relative Value) is below 50 Ohms.

If Digital Input Logic is set to "Active Open", the input becomes active when the resistance between P1 pin 18 and P1 pin 31 is greater than 50 Ohms.

Programmable Analog Resistive Input #2, used as Digital:

Programmable Digital Input 101	
Digital Input Board Number	1
Digital Input Io Number	2
Digital Input Status	
Digital Input Enabled	On
Digital Input Logic	Active Close
Digital Input Function	Use As A System Event
Digital Input Event	None
Digital Input Delay	0 s
Digital Input Inhibit Delay	0 s
Digital Input Description	N/A
Programmable Analog Resistive Input 101	
Analog Resistive Input Board Number	1
Analog Resistive Input Io Number	2
Analog Resistive Input Metered Value	100000.0
Analog Resistive Input Metered Relative Value	100000.0
Analog Resistive Input Enabled	On
Analog Resistive Input Switch Logic	Active Low
Analog Resistive Input Function	Use As Digital Input

Programmable Resistive Input #2 can be used as a Digital Input.

When configured as a Digital Input, it can be configured under Programmable Digital Input 101.

NOTE: This input is not recommended for connection to devices further than 30 m (98 ft.) from the generator set to avoid the potential damage to the sensitive resistive input measurement circuitry.

This input is considered "Closed" when there is less than 50 Ohms of resistance between P1 pin 30 and P1 pin 31.

If Digital Input Logic is set to "Active Close", the input becomes active when the resistance between P1 pin 30 and P1 pin 31 (as indicated in Analog Resistive Input Metered Relative Value) is below 50 Ohms.

If Digital Input Logic is set to "Active Open", the input becomes active when the resistance between P1 pin 30 and P1 pin 31 is greater than 50 Ohms.

Programmable Analog Resistive Input #3, used as Digital:

Programmable Digital Input 102	
Digital Input Board Number	1
Digital Input Io Number	3
Digital Input Status	
Digital Input Enabled	On
Digital Input Logic	Active Close
Digital Input Function	Use As A System Event
Digital Input Event	None
Digital Input Delay	0 s
Digital Input Inhibit Delay	0 s
Digital Input Description	N/A
Programmable Analog Resistive Input 102	
Analog Resistive Input Board Number	1
Analog Resistive Input Io Number	3
Analog Resistive Input Metered Value	100000.0
Analog Resistive Input Metered Relative Value	100000.0
Analog Resistive Input Enabled	On
Analog Resistive Input Switch Logic	Active Low
Analog Resistive Input Function	Use As Digital Input

Programmable Resistive Input #3 can be used as a Digital Input.

When configured as a Digital Input, it can be configured under Programmable Digital Input 102.

NOTE: This input is not recommended for connection to devices further than 30 m (98 ft.) from the generator set to avoid the potential damage to the sensitive resistive input measurement circuitry.

This input is considered "Closed" when there is less than 50 Ohms of resistance between P1 pin 19 and P1 pin 31.

If Digital Input Logic is set to "Active Close", the input becomes active when the resistance between P1 pin 19 and P1 pin 31 (as indicated in Analog Resistive Input Metered Relative Value) is below 50 Ohms.

If Digital Input Logic is set to "Active Open", the input becomes active when the resistance between P1 pin 19 and P1 pin 31 is greater than 50 Ohms.

Programmable Analog Resistive Input #4, used as Digital:

Programmable Digital Input 103	
Digital Input Board Number	1
Digital Input Io Number	4
Digital Input Status	
Digital Input Enabled	On
Digital Input Logic	Active Close
Digital Input Function	Use As A System Event
Digital Input Event	None
Digital Input Delay	0 s
Digital Input Inhibit Delay	0 s
Digital Input Description	N/A

Programmable Analog Resistive Input 103	
Analog Resistive Input Board Number	1
Analog Resistive Input Io Number	4
Analog Resistive Input Metered Value	100000.0
Analog Resistive Input Metered Relative Value	100000.0
Analog Resistive Input Enabled	On
Analog Resistive Input Switch Logic	Active Low
Analog Resistive Input Function	**Use As Digital Input**

Programmable Resistive Input #4 can be used as a Digital Input.

When configured as a Digital Input, it can be configured under Programmable Digital Input 103.

NOTE: This input is not recommended for connection to devices further than 30 m (98 ft.) from the generator set to avoid the potential damage to the sensitive resistive input measurement circuitry.

This input is considered “Closed” when there is less than 50 Ohms of resistance between P2 pin 12 and P1 pin 31.

If Digital Input Logic is set to “Active Close”, the input becomes active when the resistance between P2 pin 12 and P1 pin 31 (as indicated in Analog Resistive Input Metered Relative Value) is below 50 Ohms.

If Digital Input Logic is set to “Active Open”, the input becomes active when the resistance between P2 pin 12 and P1 pin 31 is greater than 50 Ohms.

Programmable Analog Resistive Input #5, used as Digital:

Programmable Digital Input 104	
Digital Input Board Number	1
Digital Input Io Number	5
Digital Input Status	
Digital Input Enabled	On
Digital Input Logic	Active Close
Digital Input Function	Use As A System Event
Digital Input Event	None
Digital Input Delay	0 s
Digital Input Inhibit Delay	0 s
Digital Input Description	N/A

Programmable Analog Resistive Input 104	
Analog Resistive Input Board Number	1
Analog Resistive Input Io Number	5
Analog Resistive Input Metered Value	100000.0
Analog Resistive Input Metered Relative Value	100000.0
Analog Resistive Input Enabled	On
Analog Resistive Input Switch Logic	Active Low
Analog Resistive Input Function	**Use As Digital Input**

Programmable Resistive Input #5 can be used as a Digital Input.

When configured as a Digital Input, it can be configured under Programmable Digital Input 104.

NOTE: This input is not recommended for connection to devices further than 30 m (98 ft.) from the generator set to avoid the potential damage to the sensitive resistive input measurement circuitry.

This input is considered “Closed” when there is less than 50 Ohms of resistance between P2 pin 11 and P1 pin 31.

If Digital Input Logic is set to “Active Close”, the input becomes active when the resistance between P2 pin 11 and P1 pin 31 (as indicated in Analog Resistive Input Metered Relative Value) is below 50 Ohms.

If Digital Input Logic is set to “Active Open”, the input becomes active when the resistance between P2 pin 11 and P1 pin 31 is greater than 50 Ohms.

Programmable Analog Resistive Input #6, used as Digital:

Programmable Digital Input 105	
Digital Input Board Number	1
Digital Input Io Number	6
Digital Input Status	
Digital Input Enabled	On
Digital Input Logic	Active Close
Digital Input Function	Use As A System Event
Digital Input Event	None
Digital Input Delay	0 s
Digital Input Inhibit Delay	0 s
Digital Input Description	N/A

Programmable Analog Resistive Input 105	
Analog Resistive Input Board Number	1
Analog Resistive Input Io Number	6
Analog Resistive Input Metered Value	100000.0
Analog Resistive Input Metered Relative Value	100000.0
Analog Resistive Input Enabled	On
Analog Resistive Input Switch Logic	Active Low
Analog Resistive Input Function	**Use As Digital Input**

Programmable Resistive Input #6 can be used as a Digital Input.

When configured as a Digital Input, it can be configured under Programmable Digital Input 105.

NOTE: This input is not recommended for connection to devices further than 30 m (98 ft.) from the generator set to avoid the potential damage to the sensitive resistive input measurement circuitry.

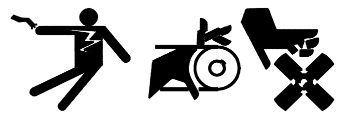
This input is considered “Closed” when there is less than 50 Ohms of resistance between P2 pin 10 and P1 pin 31.

If Digital Input Logic is set to “Active Close”, the input becomes active when the resistance between P2 pin 10 and P1 pin 31 (as indicated in Analog Resistive Input Metered Relative Value) is below 50 Ohms.

If Digital Input Logic is set to “Active Open”, the input becomes active when the resistance between P2 pin 10 and P1 pin 31 is greater than 50 Ohms.

Figure 2-23 Programmable Analog Resistive Inputs, Used as Digital Inputs

WARNING

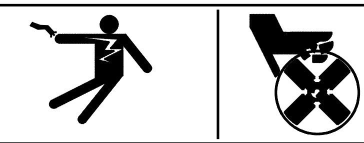


Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

WARNING



Hazardous voltage. Moving parts.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

3.1 General

Schedule routine maintenance using the service schedule located in the generator set operation manual and the runtime hours shown on the controller. If the generator set will be subject to extreme operating conditions, service the unit accordingly.

Note: See the generator set operation manual for the service schedule and other service requirements not included in this manual.

Note: High-mineral content seawater (salt water) can cause rapid destruction of metals. Wipe up all salt water spillage on and around the generator set and keep metal surfaces free from accumulated salt deposits.

Under normal operating conditions, the generator set's alternator requires no routine service. Consult Section 2.1, Prestart Checklist, for a list of routine checks.

3.2 Alternator Service

When operating the generator set under dusty or dirty conditions, use dry compressed air to blow dust out of the alternator while the generator set is running. Direct the stream of air through openings in the generator set end bracket.

3.3 Engine Service

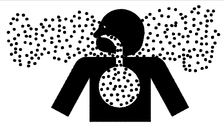
Perform engine service at the intervals specified in the engine manufacturer's service literature. Contact an authorized service distributor/dealer to obtain service literature.

Note: Have maintenance work, including battery service, performed by appropriately skilled and suitably trained maintenance personnel familiar with generator set operation and service.

Notes

4.1 Exhaust System Inspection

WARNING

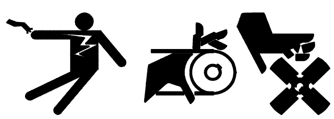


Carbon monoxide.
Can cause severe nausea, fainting, or death.

The exhaust system must be leakproof and routinely inspected.

Inspecting the exhaust system. Carbon monoxide can cause severe nausea, fainting, or death. For the safety of the craft's occupants, install a carbon monoxide detector. Never operate the generator set without a functioning carbon monoxide detector. Inspect the detector before each generator set use.

WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

1. Press the generator set OFF/RESET button to shut down the generator set.

2. Disconnect the power to the battery charger, if equipped.

3. Disconnect the generator set engine starting battery, negative (-) lead first.

At the interval specified in the service schedule, inspect the exhaust system components (exhaust manifold, mixing elbow, exhaust hose, hose clamps, silencer, and outlet flapper) for cracks, leaks, and corrosion.

Ensure that the carbon monoxide detector(s) is (1) in the craft, (2) functional, and (3) energized whenever the generator set operates.

For your safety: Never operate the generator set without a functioning carbon monoxide detector(s) for your safety and the safety of others on your vessel.

Exhaust System Inspection Points

Check for exhaust leaks and blockages. Check the silencer and piping condition and check for tight exhaust system connections.

- Check the hoses for softness, cracks, leaks, or dents. Replace the hoses as needed.
- Check for corroded or broken metal parts and replace them as needed.
- Check for loose, corroded, or missing clamps. Tighten or replace the hose clamps and/or hangers as needed.
- Check that the exhaust outlet is unobstructed.
- Visually inspect the exhaust system for exhaust leaks *(blowby)*. Check for carbon or soot residue on exhaust components. Carbon and soot residue indicates an exhaust leak. Seal leaks as needed.

4. Check that the generator set is OFF.

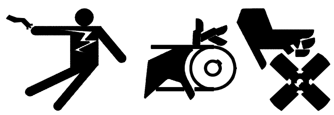
5. Reconnect the generator set engine starting battery, negative (-) lead last.

6. Reconnect the power to the battery charger, if equipped.

4.2 Servicing Mixing Elbow

The mixing elbow combines high-temperature exhaust with cooling seawater. See the operation manual for mixing elbow scheduled maintenance.

WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

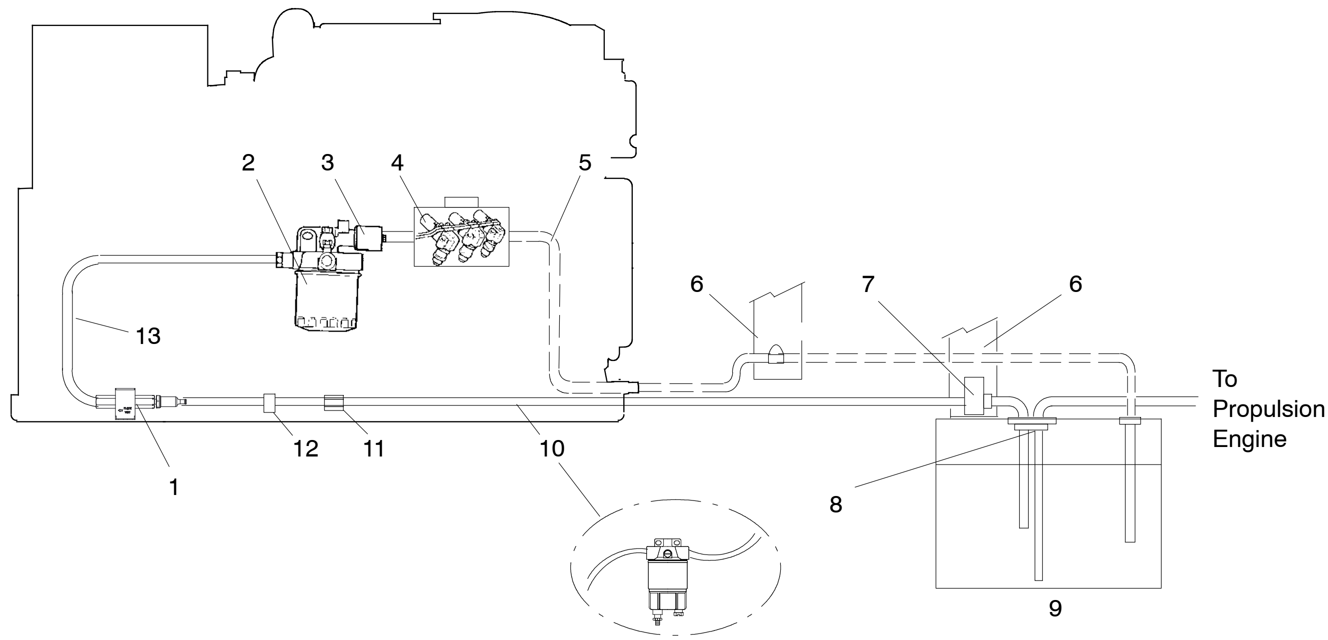
1. Check the mixing elbow for carbon buildup and corrosion inside the pipe.

2. Clean or replace the mixing elbow as necessary.

3. Inspect the exhaust manifold mounting threads for cracking and corrosion.

5.1 General

In most installations, both the generator set and the propulsion engine operate from a common fuel tank with a dual dip tube arrangement. The generator set's dip tube is shorter than the propulsion engine's dip tube. With this arrangement, fuel may not be available to the generator set when the fuel supply is low. See Figure 5-1 for a fuel system schematic.



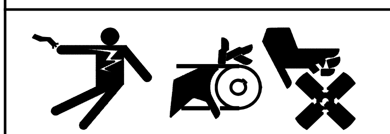
1. Fuel lift pump
2. Secondary filter
3. Fuel solenoid
4. Injection pump (non-service side)
5. Fuel return line
6. Permanent supports for fuel system components
7. Electric fuel or mechanical check valve (customer provided)
8. Dip tube (customer provided)
9. Fuel tank
10. **14-24EKOZD/12-20.5EFKOZD Models:** Primary filter, if equipped (customer provided). **32-40EKOZD/28-35EFKOZD Models:** Shipped loose with unit for customer to install.
11. Support clamp
12. Clamp
13. Fuel supply line

Figure 5-1 Fuel System, Typical

5.1.1 Fuel Filter

The quality and condition of the fuel largely determine the filter's useful life. Replace the fuel filter element as listed in the service schedule. Section 1 shows the typical location of a fuel filter. Use the applicable procedure below to replace the fuel filter.

WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

Fuel Filter Cleaning/Replacement Procedure (14-24EKOZD/12-20.5EFKOZD Models and Primary Filter on 32-40EKOZD/28-35EFKOZD Models)

1. Press the generator set OFF/RESET button to shut down the generator set.
2. Disconnect the power to the battery charger, if equipped.
3. Disconnect the generator set engine starting battery, negative (-) lead first.
4. Close the fuel supply valve.
5. Loosen the fuel filter by turning it counterclockwise. Remove the fuel filter and use rags to clean up spilled fuel oil.

   Note: Dispose of all waste materials (engine oil, fuel, filter, etc.) in an environmentally safe manner and in accordance with all applicable laws.

6. Clean the contact surface of the fuel oil filter adapter.
7. Lightly lubricate the gasket surface of the new fuel filter with fresh fuel oil. Thread the filter on the adapter until the gasket makes contact; hand-tighten the filter an additional one-half turn. Wash hands after any contact with fuel oil.
8. Open the fuel supply valve.
9. Bleed the system. See Step 12 in the following procedure (secondary filter on 32-40EKOZD/28-35EFKOZD models) or Section 5.1.2, Fuel System Bleed.

Fuel Filter Cleaning/Replacement/Bleed Procedure (Secondary Filter on 32-40EKOZD/28-35EFKOZD Models)

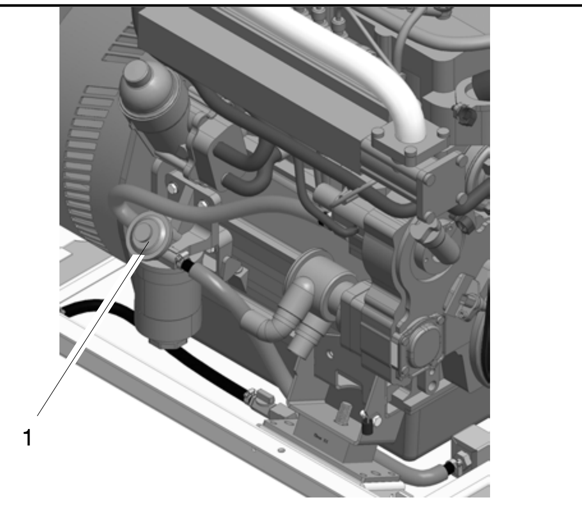
1. Press the generator set OFF/RESET button to shut down the generator set.
2. Disconnect the power to the battery charger, if equipped.
3. Disconnect the generator set engine starting battery, negative (-) lead first.
4. Close the fuel supply valve.

   Note: Place rags underneath the fuel filter during replacement procedure.

5. Disconnect the cable from the water sensor (located underneath the fuel filter cartridge).
6. Remove the water sensor from the fuel filter cartridge.
7. Loosen and remove the cartridge from the fuel filter support.
8. Lightly lubricate the gasket surface of a new fuel filter cartridge with fresh fuel oil.

   Note: Do not fill the new cartridge with fuel.

9. Tighten the new fuel filter cartridge onto the fuel filter support and torque to 17 Nm.
10. Tighten the water sensor onto the new fuel filter cartridge and torque to 5 Nm.
11. Reconnect the cable to the water sensor.
12. **Bleed Procedure.** Push repeatedly the button on the fuel filter support to fill and bleed the fuel system. See Figure 5-2.
13. Check that the generator set is OFF.
14. Reconnect the generator set engine starting battery, negative (-) lead last.
15. Reconnect the power to the battery charger, if equipped.



1. Fuel filter's button location

Figure 5-2 Fuel Filter's Button

5.1.2 Fuel System Bleed

Bleed air from the fuel system in order to reduce rough running or vapor lock. Trapped air in the fuel system can cause difficult starting and erratic engine operation.

Prime the fuel system under the following conditions:

- Before starting the engine for the first time.
- After running out of fuel and adding fuel to the tank.
- After fuel system maintenance such as changing the fuel filter, draining the fuel/water separator, or replacing a fuel system component.

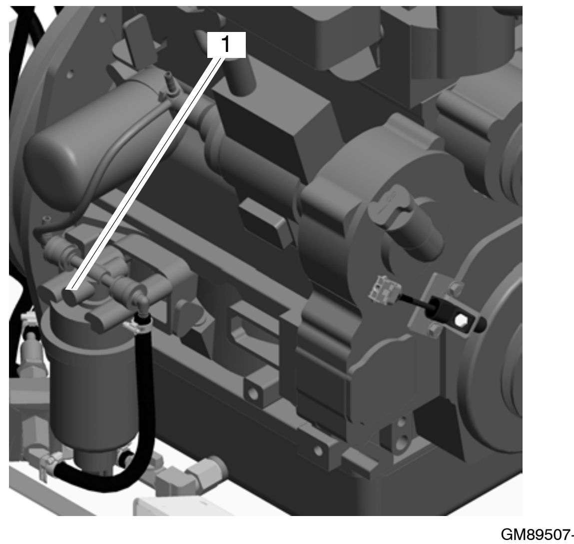
Note: Connect the battery during the priming procedure to allow engine cranking.

Note: Have a rag handy during this procedure. Wipe up any spilled diesel fuel. Wash hands after any contact with fuel.

Note: Dispose of all waste materials (engine oil, fuel, filter, etc.) in an environmentally safe manner and in accordance with all applicable laws.

Fuel System Bleed Procedure (14-24EKOZD/12-20.5EFKOZD Models)

1. Loosen the fuel filter's air vent screw. See Figure 5-3. Place a suitable container underneath to collect the fuel.
2. Initiate the auto/start sequence until fuel, free of air bubbles, flows from the vent screw at the fuel filter.
3. Tighten the fuel filter's air vent screw.



1. Fuel filter's air vent screw location

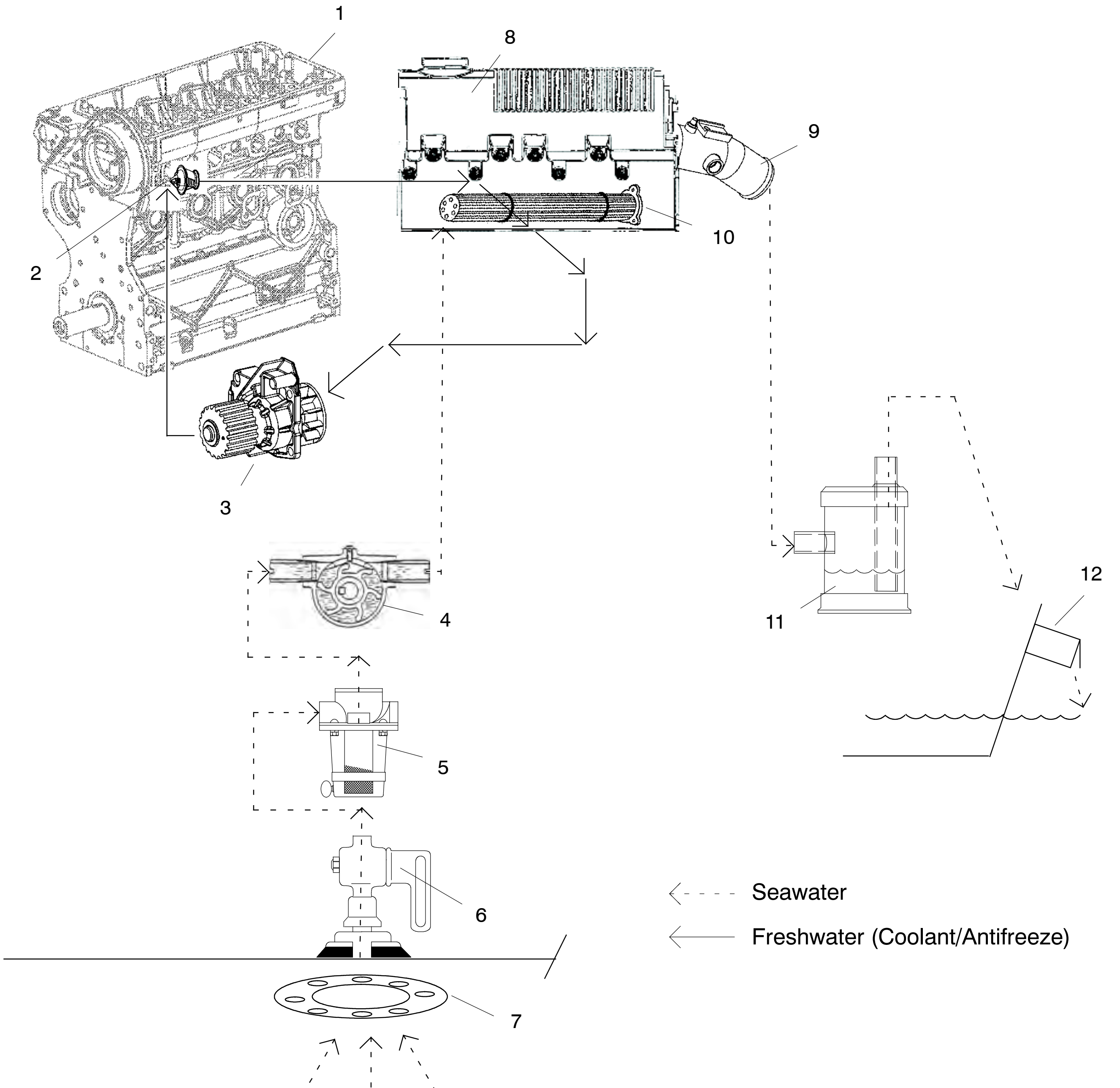
Figure 5-3 Fuel Filter's Air Vent Screw

4. Check that the generator set is OFF.
5. Reconnect the generator set engine starting battery, negative (-) lead last.
6. Reconnect the power to the battery charger, if equipped.

Notes

6.1 General

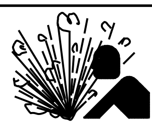
Heat exchanger cooling consists of a heat exchanger with coolant recovery tank, thermostat, rubber impeller seawater pump, centrifugal-type engine circulating pump, water-cooled exhaust manifold, and an exhaust mixer. See Figure 6-1 for cooling system components.



1. Engine block
2. Thermostat (inside thermostat assembly)
3. Engine-driven water pump
4. Engine-driven seawater pump
5. Seawater strainer (customer-supplied)
6. Seacock (customer-supplied)
7. Intake strainer (customer-supplied)
8. Water-cooled manifold
9. Exhaust mixer elbow
10. Heat exchanger (located inside manifold)
11. Silencer (customer-supplied)
12. Exhaust outlet (customer-supplied)

Figure 6-1 Cooling System Components, Typical

⚠ WARNING



Hot coolant and steam.
Can cause severe injury or death.

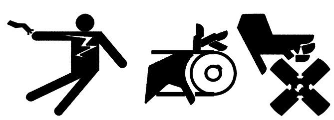
Before removing the pressure cap, stop the generator set and allow it to cool. Then loosen the pressure cap to relieve pressure.

Allow the engine to cool. Release pressure from the cooling system before removing the pressure cap. To release pressure, cover the pressure cap with a thick cloth and then slowly turn the cap counterclockwise to the first stop. Remove the cap after pressure has been completely released and the engine has cooled. Check the coolant level at the tank if the generator set has a coolant recovery tank.

NOTICE

Saltwater damage. Saltwater quickly deteriorates metals. Wipe up saltwater on and around the generator set and remove salt deposits from metal surfaces.

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

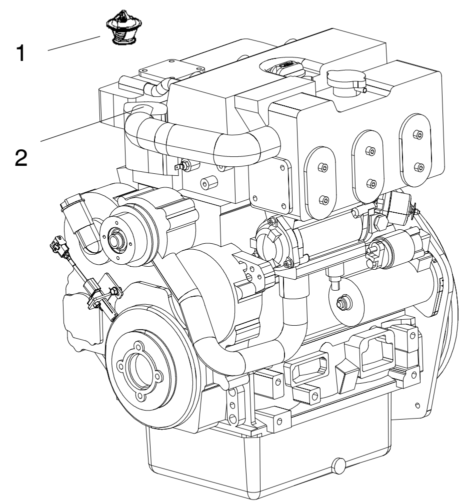
Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

6.2 Water-Cooled Exhaust Manifold

Each marine generator set has a water-cooled exhaust manifold. The coolant solution circulates through the manifold, reducing the amount of heat radiated from the exhaust into the surrounding area.

The engine thermostat is located at the location shown in Figure 6-2. Always replace the thermostat gasket every time it is disassembled.

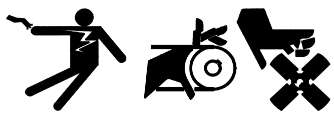


1. Thermostat (located inside thermostat housing)
2. Thermostat housing

Figure 6-2 Thermostat Location, Typical

6.3 Coolant Replacement Including Heat Exchanger Service

⚠ WARNING



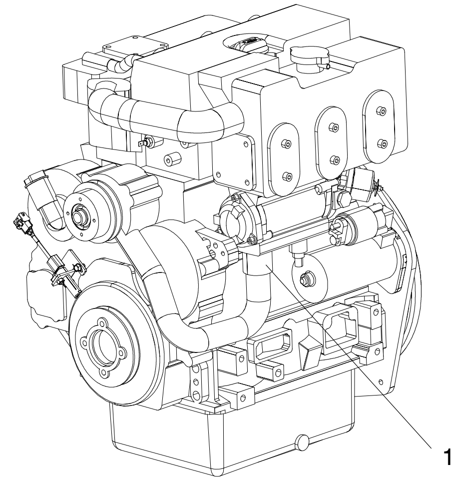
Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

At the interval specified in the Service Schedule, clean the heat exchanger tube. In a closed cooling system, seawater circulates through separate chambers within the heat exchanger to cool the engine coolant. The seawater then mixes with engine exhaust and ejects out of the exhaust mixer's outlet. See Section 1 for coolant capacity, thermostat, and pressure cap ratings.

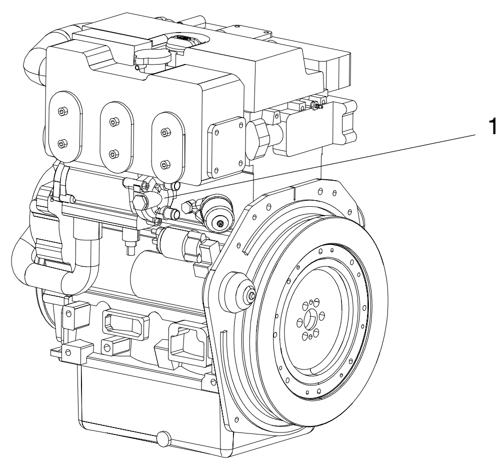
1. Press the generator set OFF/RESET button to shut down the generator set.
2. Disconnect the power to the battery charger, if equipped.
3. Disconnect the generator set engine starting battery, negative (-) lead first.
4. Disconnect the hose from the heat exchanger at the location shown in Figure 6-3. Drain the coolant.



1. Hose

Figure 6-3 Hose Location, Typical

5. Replace the hose and hose clamp.
6. Loosen the front cover screws of the heat exchanger. See Figure 6-4 and Figure 6-5.



1. Heat exchanger's front cover

Figure 6-4 Heat Exchanger Front Cover Location

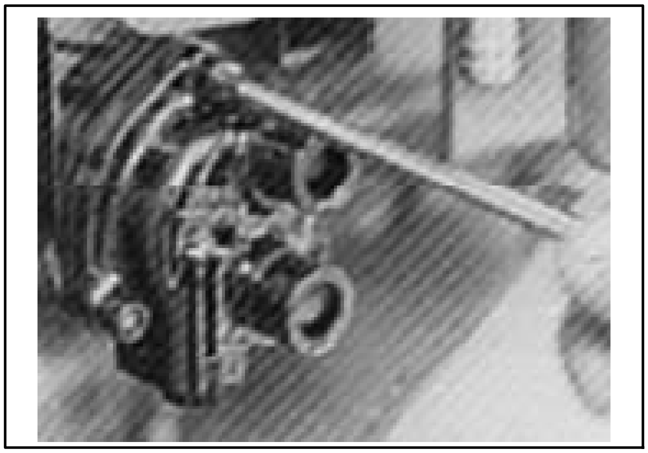


Figure 6-5 Front Cover of Heat Exchanger

7. Remove the front cover and O-ring.

8. Loosen the rear cover screws of the heat exchanger. See Figure 6-6 and Figure 6-7.

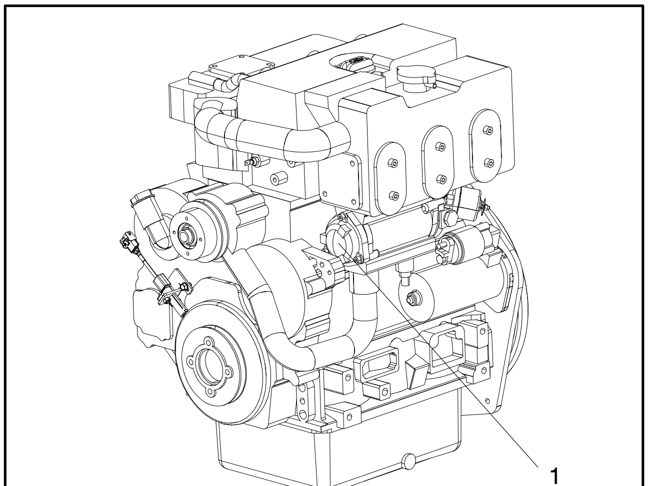


Figure 6-6 Heat Exchanger Rear Cover Location

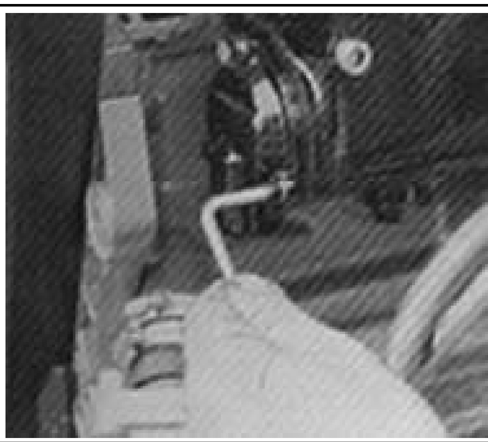


Figure 6-7 Rear Cover of Heat Exchanger

9. Remove the rear cover and O-ring.

10. Remove the heat exchanger tube. See Figure 6-8.

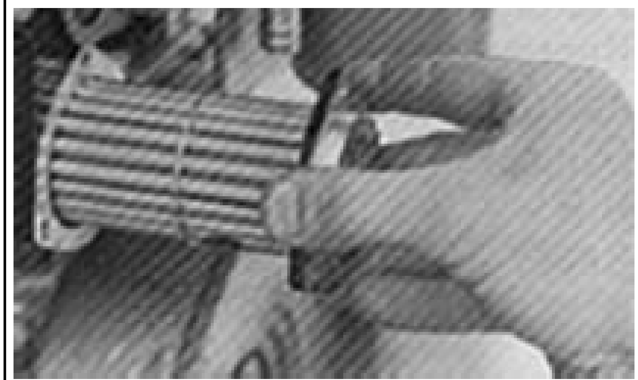


Figure 6-8 Heat Exchanger Tube

11. Dip the heat exchanger tube into a solution of 90% water and 10% hydrochloric acid. Use gloves and goggles.

12. Rinse the heat exchanger tube in clean water. See Figure 6-9.

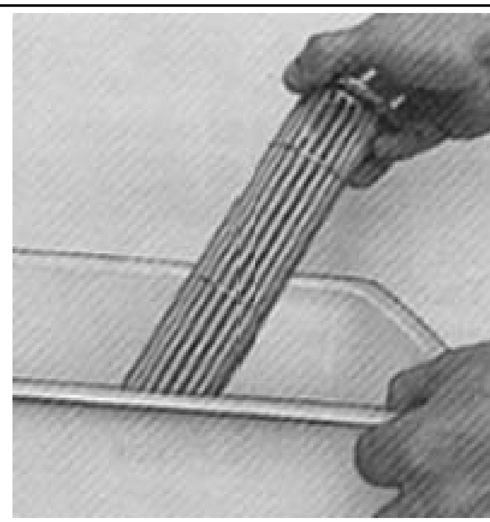


Figure 6-9 Rinse Heat Exchanger Tube

Note: Replace any damaged O-rings, seals and/or thermostat valve seals.

13. Reinstall the heat exchanger tube and O-rings. See Figure 6-10.

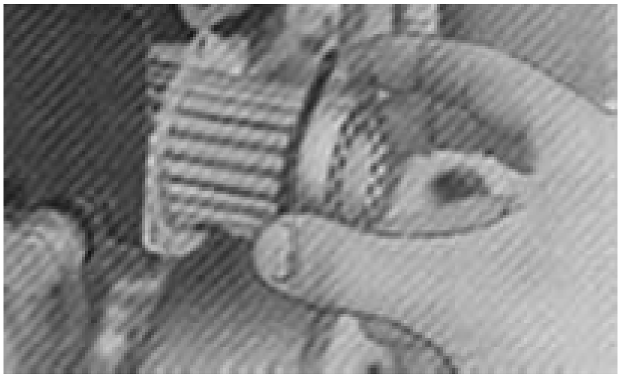


Figure 6-10 Reinstall Heat Exchanger

14. Reassemble the O-ring and front cover and tighten the screws. See Figure 6-11 and Figure 6-12.

Figure 6-11 Reinstall the O-ring and Front Cover

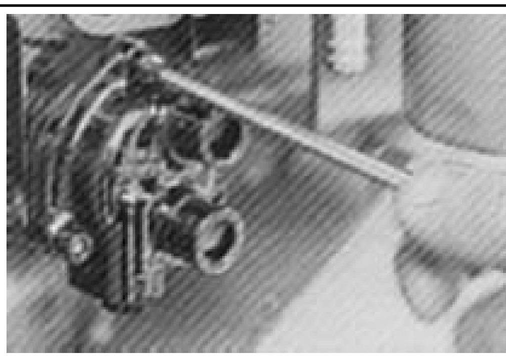


Figure 6-12 Tighten the Front Cover Screws

15. Fit the circlip and flange back into position. See Figure 6-13.

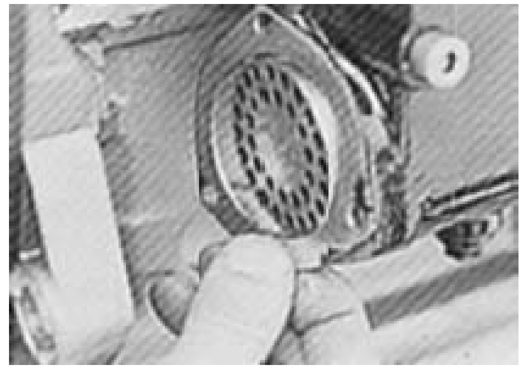
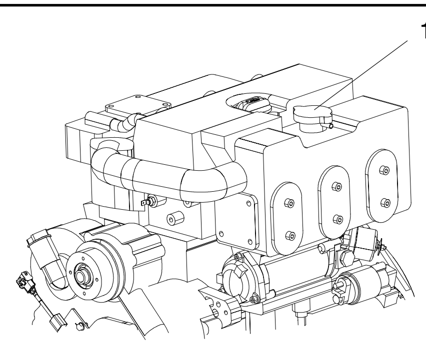


Figure 6-13 Heat Exchanger's Circlip

16. Reassemble the O-ring and rear cover and tighten the screws. See Figure 6-14.

Figure 6-14 Rear Cover of Heat Exchanger

17. Remove the pressure cap and refill the coolant. See Section 6.4 for details on coolant check and fill instructions. The level should be approx. 2 cm (0.75 in.) below the filling hole.



1. Pressure cap

Figure 6-15 Pressure Cap Location

18. Replace the pressure cap.

19. Check that the generator set is OFF.

20. Reconnect the generator set engine starting battery, negative (-) lead last.

21. Reconnect the power to the battery charger, if equipped.

6.4 Check and Fill Coolant

Note: Do not add coolant to a hot engine. Adding coolant to a hot engine can cause the cylinder block or cylinder head to crack. Wait until the engine has cooled.

Maintain the coolant level in the coolant recovery tank at approximately 1/4 full. Before filling the cooling system, close all petcocks and tighten all hose clamps. Use a solution of 50% ethylene glycol and 50% clean, softened water to inhibit rust/corrosion and prevent freezing. Add coolant, as necessary, to the coolant recovery tank. Periodically check the coolant level on closed systems by removing the pressure cap. Do not rely solely on the level in the coolant recovery tank. Add fresh coolant until level is just below the overflow tube opening.

Note: Coolant solution. A coolant solution of 50% ethylene glycol provides freezing protection to -37°C (-34°F) and overheating protection to 129°C (265°F). A coolant solution with less than 50% ethylene glycol may not provide adequate freezing and overheating protection. A coolant solution with more than 50% ethylene glycol can cause engine or component damage. Do **not** use alcohol or methanol antifreeze or mix them with the specified coolant. Consult the engine manufacturer's operation manual for engine coolant specifications.

Note: Pay special attention to the coolant level. After the coolant drains, allow time when refilling the coolant for a complete refill of the engine water jacket. Check the coolant level as prescribed in the Prestart Checklist.

NOTICE

Saltwater damage. Saltwater quickly deteriorates metals. Wipe up saltwater on and around the generator set and remove salt deposits from metal surfaces.

Bleed Procedure (14-24EKOZD & 12-20.5EFKOZD Models)

1. Remove the coolant fill cap. See Figure 1-2 for location.

Note: For 20/23EKOZD and 21/24EKOZD 60 Hz models, proceed to Step 2. For all other models, proceed to Step 6.

2. Slowly fill the coolant system until observing coolant at the first bleed point (lowest port) with the plug removed. See Figure 6-16.

3. After seeing coolant, use a funnel to fill the coolant at this port until full. Cap this port.

4. Slowly fill the coolant system until observing coolant at the second bleed point with the plug removed. See Figure 6-16.

5. After seeing coolant, use a funnel to fill the coolant at this port until full. Cap this port.

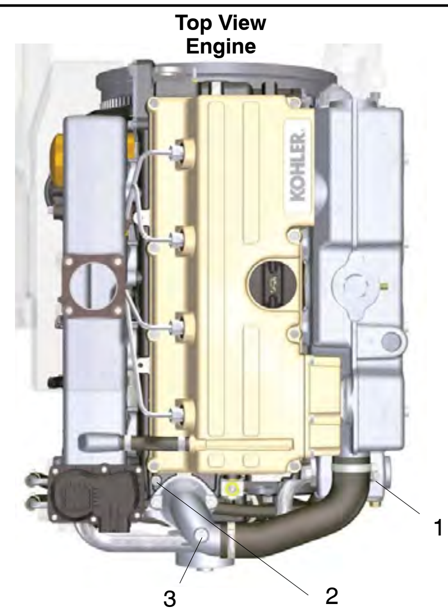
6. Slowly fill the coolant system until observing coolant at the third bleed point (highest port) with the plug removed. See Figure 6-16.

7. After seeing coolant, use a funnel to fill the coolant at this port until full. Cap this port.

8. Fill the coolant system at the filler neck to just below the overflow tube opening.

9. Lightly squeeze the end coolant hose to ensure that any loose air pockets are bled from the system.

10. Replace the coolant fill cap.



1. 1st bleed point (only available on 20/23EKOZD and 21/24EKOZD 60 Hz models)
2. 2nd bleed point (only available on 20/23EKOZD and 21/24EKOZD 60 Hz models)
3. 3rd bleed point

Figure 6-16 Bleed Point Locations

Bleed Procedure (32/40EKOZD & 28/35EFKOZD Models)

1. Remove the coolant fill cap. See Figure 1-2 for location.
2. Slowly fill the coolant system.

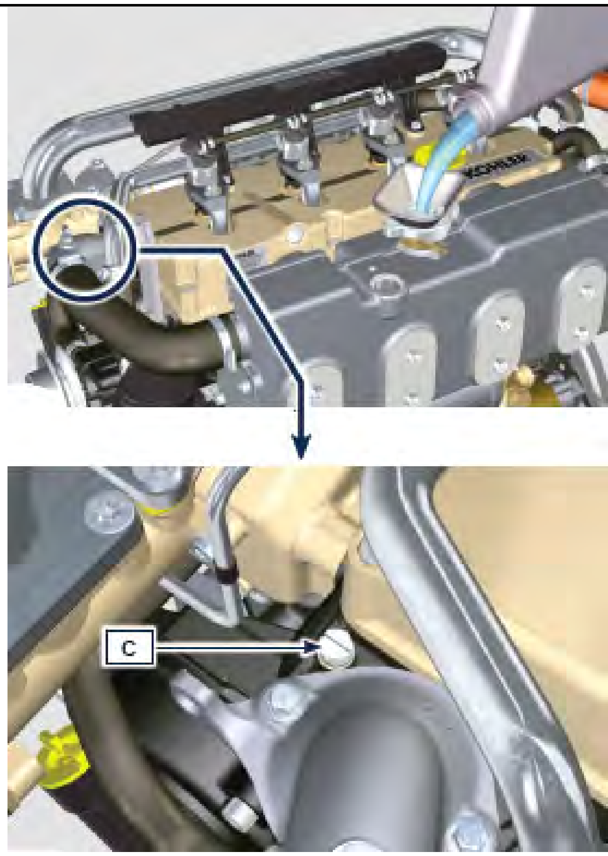


Figure 6-17 Bleed Point Location

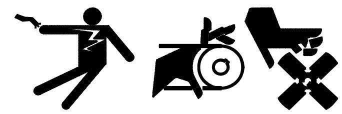
3. Loosen the capscrew C (shown in Figure 6-17) to release any air and tighten the capscrew C. Torque capscrew to 8 Nm.

Note: The max. filling level for the exhaust manifold is in correspondence of capscrew C. Complete the coolant refilling procedure as soon as the coolant starts leaking out of capscrew C.

4. Retighten capscrew C (if not already done) and the coolant fill cap.
5. After a few minutes of operation, stop the engine and allow the liquid to cool and recheck the coolant level.

6.5 Flush and Clean Cooling System

WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

For optimum protection, drain, flush, and refill the cooling system at the interval listed in the service schedule.

Pay special attention to the coolant level. When refilling the cooling system, allow time for complete refill of the engine water jacket. Check the coolant level as described in Section 6.4.

Flush and Clean Procedure:

1. Press the generator set OFF/RESET button to shut down the generator set.
2. Disconnect the power to the battery charger, if equipped.
3. Disconnect the generator set engine starting battery, negative (-) lead first.
4. Remove the water drain pipe plug located at the heat exchanger and completely drain the system.
5. Remove the pressure cap to make draining easier.
6. Drain, clean, and flush the cooling system and the coolant recovery tank with clean water.

Note: Dispose of all waste materials (engine oil, fuel, filter, etc.) in an environmentally safe manner and in accordance with all applicable laws.

7. Replace the water drain pipe plug.

8. Fill the cooling system with recommended coolant.

9. Replace the pressure cap.

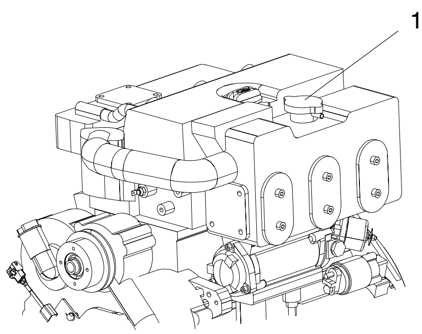
10. Check that the generator set is OFF.

11. Reconnect the generator set engine starting battery, negative (-) lead last.

12. Reconnect the power to the battery charger, if equipped.

6.6 Pressure Cap

Closed heat exchanger systems utilize a pressure cap to raise the boiling point of the coolant, enabling proper operating temperatures. If the cap leaks, replace it with a cap of the same rating. See Section 1, Specifications. The pressure cap typically has the pressure rating stamped on the cap body.

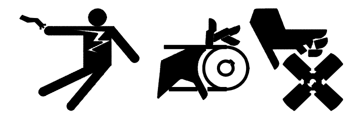


1. Pressure cap

Figure 6-18 Pressure Cap Location

6.7 Impeller Inspection and Replacement

WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

The belt-driven seawater pump is located on the service side of the generator set. Check and change the seawater pump impeller at the interval specified in the service schedule. Follow the instructions included with the impeller kit. If the instructions are not included with the kit, use the following procedure.

Impeller Inspection and Replacement Procedure:

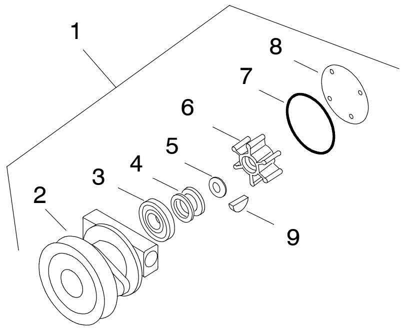
1. Press the generator set OFF/RESET button to shut down the generator set.

2. Disconnect the power to the battery charger, if equipped.

3. Disconnect the generator set engine starting battery, negative (-) lead first.

4. Close the seacock.

5. Remove the seawater pump coverplate. See Figure 6-19.

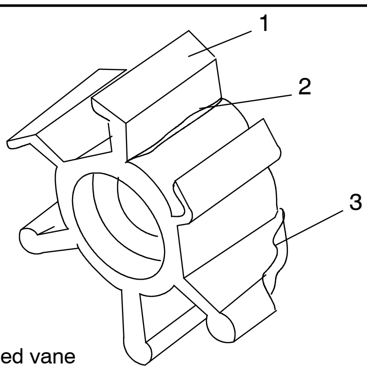


1. Seawater pump
2. Pulley
3. Ball bearing
4. Seal
5. Ceramic seat
6. Impeller
7. Gasket
8. Cover plate
9. Key

Figure 6-19 Seawater Pump, Typical

6. Remove the impeller.

7. Inspect the impeller for damage, including cracks, broken or flattened vanes. See Figure 6-20. The impeller vanes should be straight and flexible.



1. Flattened vane
2. Crack
3. Broken vane

Figure 6-20 Worn Impeller

8. Lubricate the impeller with soapy water before installation.

9. While installing the impeller, always rotate the drive shaft and the impeller together in the same direction as the engine rotation.

10. Inspect the coverplate and gasket for corrosion and/or damage. Replace components as necessary.

11. Lubricate the gasket with silicon grease and attach the gasket and coverplate to the seawater pump housing.

12. Open the seacock.

13. Check that the generator set is OFF.

14. Reconnect the generator set engine starting battery, negative (-) lead last.

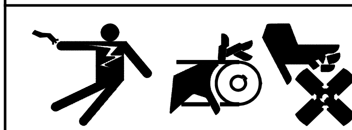
15. Reconnect the power to the battery charger, if equipped.

16. Start the generator set and check for leaks.

17. Stop the generator set and repair leaks or replace components as necessary.

6.8 Belt Tension

WARNING

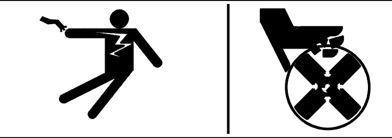


Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

WARNING



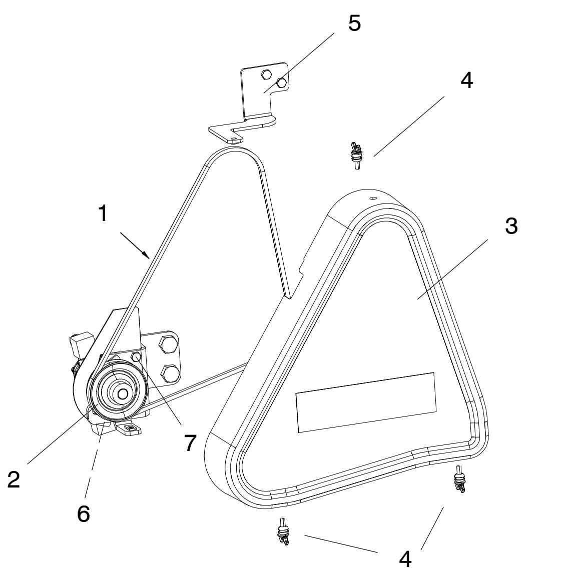
Hazardous voltage. Moving parts. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

Check the belt tension at the interval specified in the service schedule. If tension is not within the specification, adjust as necessary using the following procedure.

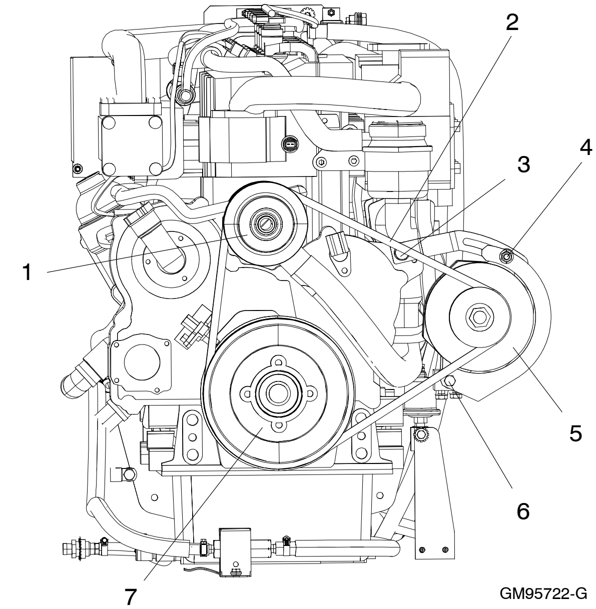
6.8.1 Belt Tensioning Procedure



1. Check the seawater pump belt deflection (tension) here
2. Seawater pump pulley
3. Belt guard
4. Wing screw and belt guard mounting hardware (qty. 3)
5. Engine mounting brackets (qty. 3)
6. Pivot screw (underneath pulley in slotted hole)
7. Seawater pump adjusting screw

Figure 6-21 Seawater Belt Tension (14- 24EKOZD/12- 20.5EFKOZD Model Shown)

Note: Unit shown with belt guard removed.



1. Engine-driven water pump pulley
2. Check the alternator belt deflection (tension) here
3. Adjusting arm pivot screw
4. Alternator adjusting screw
5. Battery charging alternator pulley
6. Alternator pivot screw
7. Crankshaft pulley

Figure 6-22 Alternator Belt Tension (32- 40EKOZD/28- 35EFKOZD Model Shown)

1. Press the generator set OFF/RESET button to shut down the generator set.

2. Disconnect the power to the battery charger, if equipped.

3. Disconnect the generator set engine starting battery, negative (-) lead first.

4. Remove the belt guard. See Figure 6-21.

5. Check the belt tension at the midpoint of the longest span of the belt by pressing with your finger approx. 10 kg (22 lbs.) of force. See Figure 6-23 for belt deflection. Recheck a new belt tension after 10 minutes of operation.

Deflection mm (in.)
10 (0.4)

Figure 6-23 Belt Specification

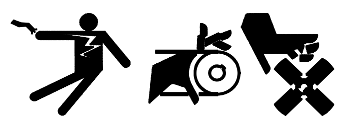
Note: If the belt tension is not within specification, go to step 3. If the belt tension is within specifications, go to step 7.

6. Loosen the pivot and adjusting screws.

7. While prying the seawater pump outward, tighten the adjusting screw.
8. Tighten the pivot screw.
9. Recheck and adjust as necessary.
10. Replace the belt guard.
11. Check that the generator set is OFF.
12. Reconnect the generator set engine starting battery, negative (-) lead last.
13. Reconnect the power to the battery charger, if equipped.

6.9 Anticorrosion Zinc Anode

WARNING

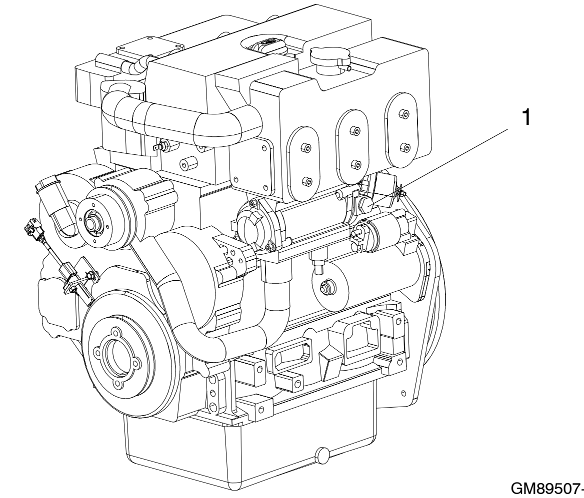


Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

The heat exchanger contains an anticorrosion zinc anode (plug) to prevent electrolytic corrosion by seawater. See Figure 6-24.



1. Zinc

Figure 6-24 Anticorrosion Zinc Anode Location

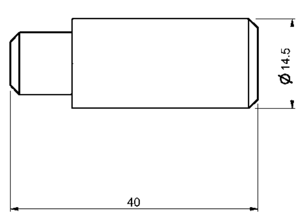
Check and replace the anticorrosion zinc anode at intervals recommended in the service schedule. Depending upon operating conditions and seawater properties, the anticorrosion zinc anode may require more frequent replacement. See Figure 6-24 for the location and use the following procedure.

Anticorrosion Zinc Anode Replacement

1. Press the generator set OFF/RESET button to shut down the generator set.
2. Disconnect the power to the battery charger, if equipped.
3. Disconnect the generator set engine starting battery, negative (-) lead first.
4. With the generator set cooled, close the seacock, open the petcock on the engine, and drain the coolant into a suitable container.
5. Remove the anticorrosion zinc anode (plug) from the heat exchanger.
6. Use a wire brush to remove the loose corrosion on the anticorrosion zinc anode. Replace the anode according to Figure 6-25 and Figure 6-26.

Anticorrosion Zinc Anode Replacement		
Models	New Anode Dimensions mm (in.)	Replace When Percent of Zinc Remaining Is:
13EKOZD/ 11EFKOZD 14EKOZD/ 12EFKOZD 15EKOZD/ 13EFKOZD 16EKOZD/ 13.5EFKOZD 20EKOZD/ 17.5EFKOZD/ 16.5EFKOZD 21EKOZD/ 18EFKOZD 17EFKOZD 23EKOZD/ 20EFKOZD/ 19.5EFKOZD 24EKOZD/ 20.5EFKOZD 32EKOZD/ 28EFKOZD 40EKOZD/ 35EFKOZD	14.5 (0.57) x 40 (1.57)	<50% of length/diameter

Figure 6-25 Anticorrosion Zinc Anode (Plug) Measurements



1. Diameter: 14.5 mm (0.57 in.)
2. Length: 40 mm (1.57 in.)

Figure 6-26 Anticorrosion Zinc Anode (Plug)

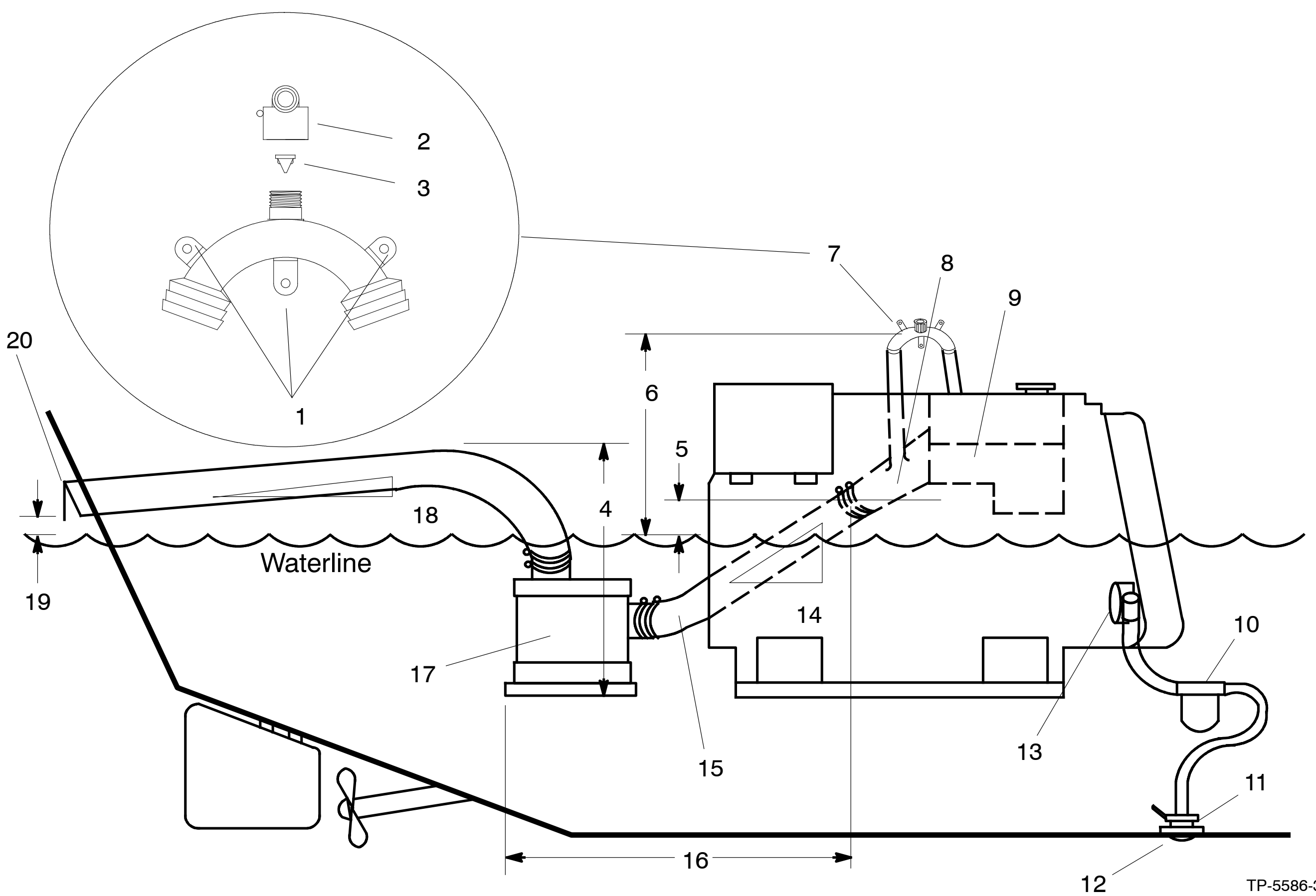
7. Clean the threaded hole of the heat exchanger and coat the threads of the anticorrosion zinc anode (plug) with pipe sealant suitable for marine applications. Cut the anticorrosion zinc to the correct length. Install the anticorrosion zinc anode into the heat exchanger.
8. Close the petcock on the engine and open the seacock. Refill the cooling system.
9. Check that the generator set is OFF.
10. Reconnect the generator set engine starting battery, negative (-) lead last.
11. Reconnect the power to the battery charger, if equipped.
12. Start the generator set and check for leaks at the anticorrosion zinc anode location. The pump is operating if the cooling water flows from the exhaust outlet. If water is not discharging at the exhaust outlet, see the Operation Manual, Prestart Checklist—Seawater Pump Priming.

6.10 Siphon Break

A siphon break prevents seawater entry into the engine when the engine exhaust manifold outlet is less than 23 cm (9 in.) above the waterline of a fully-loaded, shut-down craft. Use the following procedure to inspect the siphon break.

Siphon Break Inspection Procedure:

1. Stop the generator set.
2. Remove the retaining cap and lift out the reed valve assembly for inspection. See Figure 6-27.
3. Use a light detergent to clean the reed valve to remove residue and oxidation.
4. Check that the reed valve opening is clear.
5. Replace the siphon break if it is cracked or if the reed valve material has hardened or deteriorated.
6. Install the reed valve into the mounting base with the valve downward.
7. Install the retaining cap and finger-tighten only. Do not overtighten.



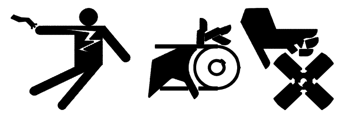
1. Mounting base
2. Retaining cap
3. Reed valve assembly
4. Silencer vertical lift 1.2 m (4 ft.) max.
5. Exhaust mixer elbow distance above waterline; if less than 23 cm (9 in.), siphon break is required
6. Siphon break distance above waterline 30.5 cm (1 ft.) min.
7. Siphon break
8. Exhaust mixer elbow
9. Heat exchanger (locations vary by model)
10. Seawater strainer
11. Seacock
12. Intake strainer
13. Engine-driven seawater pump
14. Exhaust hose pitch 1.3 cm per 30.5 cm (0.5 in./ft.) min.
15. Water lock (optional)
16. Silencer distance from exhaust mixer elbow 3 m (10 ft.) max.
17. Silencer (customer-supplied)
18. Exhaust hose pitch 1.3 cm per 30.5 cm (0.5 in./ft.) min.
19. Exhaust outlet distance above waterline 10 cm (4 in.) min.
20. Seawater outlet

NOTE: Consult the installation manual for complete explanation of dimensions and other installation considerations.

Figure 6-27 Siphon Break (Plastic "U" Type)

Notes

⚠ WARNING

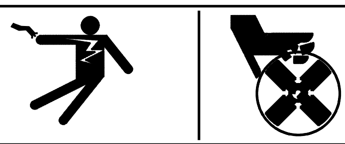


Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

⚠ WARNING



Hazardous voltage. Moving parts.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

7.1 Introduction

This section contains generator set troubleshooting, diagnostic, and repair information.

Corrective action and testing often require knowledge of electrical and electronic circuits. To avoid additional problems caused by incorrect repairs, have an authorized service distributor/dealer perform service.

Maintain a record of repairs and adjustments performed on the equipment. If the procedures in this manual do not explain how to correct the problem, contact an authorized distributor/dealer. Use the record to help describe the problem and repairs or adjustments made to the equipment.

Refer to the Engine Service Manual (TP-6939 or TP-6916) for engine service information.

The first step in troubleshooting the generator set controls is to verify that the controller is correctly configured for the generator set. The Generator Set Operation Manual explains how to check and change the controller configuration.

If the troubleshooting procedures in this section identify a bad part, refer to the parts catalog for replacement part numbers.

7.2 Initial Checks

When troubleshooting, always check for simple problems first. Check for the following common problems before replacing parts:

- **Loose connections or damaged wiring.**
- **Discharged or dead battery.** Check for a non-functioning battery charging alternator or battery charger.
- **Fault shutdown.** Check for a fault on the controller. Section 2.6.5 describes the warning faults and Section 2.6.6 describes the shutdown faults.
- **Open circuit breakers.** Reset the circuit breaker. If the circuit breaker blows again, check the circuit wiring and components for a cause.
- **Incorrect controller settings.** *Always* check the controller configuration settings before replacing the controller.
- **Controller firmware.** Some problems may be solved by updating the controller's application program. Check Tech Tools on the Kohler Power Resource Center for more information. A personal computer (laptop) and Kohler® SiteTech™ software are required to update the firmware. See the SiteTech™ operation manual for instructions.

7.3 Troubleshooting Chart

Use the following charts to diagnose and correct common problems. First check for simple causes such as a dead engine starting battery or an open circuit breaker. The table groups generator set faults and suggests likely causes and remedies. The table also refers you to more detailed information including sections of this manual, the generator set operation manual (O/M), the generator set installation manual (I/M), and the engine service manual (Engine S/M) to correct the indicated problem.

7.4 General Troubleshooting Chart

Trouble Symptoms														
Does not crank	Cranks but does not start	Starts hard	No or low output voltage	Stops suddenly	Lacks power	Overheats	Low oil pressure	High fuel consumption	Excessive or abnormal noise	Displays error message/locks up	Exercise run time and/or event records inoperative	Probable Causes	Recommended Actions	Section or Publication Reference*
Controller														
x	x											Controller circuit board(s) inoperative.	Replace the controller.	Gen. S/M
x	x											Controller circuit board(s) wiring fault.	Check the wiring.	W/D
				x								Controller fault.	Troubleshoot the controller.†	Gen. S/M
x												Controller master control button in the OFF/RESET mode.	Press the controller master control RUN or AUTO button.	Section 2
x												Engine start circuit open.	Press the controller master control RUN button to test the generator set. Troubleshoot the auto start circuit and the time delays.	Section 2, W/D, Gen. S/M
x				x								Emergency stop switch activated, if equipped.	Reset the emergency stop switch.	Section 2
										x		Controller firmware error.	Review the controller display troubleshooting chart.	
Alternator														
			x									AC output circuit breaker open.	Reset the breaker and check for AC voltage at the generator set side of the circuit breaker.	—
x												Transfer switch test switch in the OFF position.	Move the transfer switch test switch to the AUTO position.	—
			x									Wiring, terminals, or pin in the exciter field open.	Check for continuity.	Gen. S/M or W/D
			x									Main field (rotor) inoperative (open or grounded).	Test and/or replace the rotor.†	Gen. S/M
			x									Stator inoperative (open or grounded).	Test and/or replace the stator.†	Gen. S/M
									x			Vibration excessive.	Tighten loose components.†	—

* Sec./Section—numbered section of this manual; ATS—Automatic Transfer Switch; Eng.—Engine; Gen.—Generator Set; I/M—Installation Manual; O/M—Operation Manual; S/M—Service Manual; S/S—Spec Sheet; W/D—Wiring Diagram

† Have an authorized service distributor/dealer perform this service.

Trouble Symptoms														
Does not crank	Cranks but does not start	Starts hard	No or low output voltage	Stops suddenly	Lacks power	Overheats	Low oil pressure	High fuel consumption	Excessive or abnormal noise	Displays error message/locks up	Exercise run time and/or event records inoperative	Probable Causes	Recommended Actions	Section or Publication Reference*
Electrical System (DC circuits)														
x	x											Battery connections loose, corroded, or incorrect.	Verify that the battery connections are correct, clean, and tight.	—
x	x											Battery weak or dead.	Recharge or replace the battery. The spec sheet provides recommended battery CCA rating.	Eng. O/M, S/S
x	x											Starter/starter solenoid inoperative.	Replace the starter or starter solenoid.	Eng. S/M
x				x								Engine harness connector(s) not locked tight.	Disconnect the engine harness connector(s) then reconnect it to the controller.	W/D
				x								Fault shutdown.	Reset the fault switches and troubleshoot the controller.	Section 2
				x								High exhaust temperature switch inoperative.	Replace the inoperative switch.	Gen. S/M or W/D
Engine														
	x	x			x			x				Air cleaner/backfire flame arrestor clogged, if equipped.	Clean or replace the filter element.	Eng. O/M
	x	x				x		x	x			Compression weak.	Check the compression.†	Eng. S/M
			x		x	x		x	x			Engine overload.	Reduce the electrical load. See the generator set installation manual for wattage specifications.	I/M
									x			Exhaust system leak.	Inspect the exhaust system. Replace the inoperative exhaust system components.†	Section 3, I/M
									x			Exhaust system not securely installed.	Inspect the exhaust system. Tighten the loose exhaust system components.†	Section 3, I/M
		x	x		x			x				Governor, if equipped, inoperative.	Adjust the governor.†	Gen. S/M
					x				x			Valve clearance incorrect.	Adjust the valves.†	Eng. S/M
									x			Vibration excessive.	Tighten all loose hardware.	—
x	x			x						x	x	Engine ECM and/or sensors.	Troubleshoot the engine ECM and/or sensors.	Eng. O/M, Eng. S/M
				x		x						Engine overheated.	Check air intake, fuel, oil level and air inlet/outlet.	O/M, I/M
				x	x							Engine overloaded.	Reduce electrical load.	I/M

* Sec./Section—numbered section of this manual; ATS—Automatic Transfer Switch; Eng.—Engine; Gen.—Generator Set; I/M—Installation Manual; O/M—Operation Manual; S/M—Service Manual; S/S—Spec Sheet; W/D—Wiring Diagram

† Have an authorized service distributor/dealer perform this service.

Trouble Symptoms														
Does not crank	Cranks but does not start	Starts hard	No or low output voltage	Stops suddenly	Lacks power	Overheats	Low oil pressure	High fuel consumption	Excessive or abnormal noise	Displays error message/locks up	Exercise run time and/or event records inoperative	Probable Causes	Recommended Actions	Section or Publication Reference*
Cooling System														
						x		x				Air openings clogged.	Clean the air openings.	—
						x						Impeller inoperative.	Replace the impeller.	Section 3
						x		x				Seawater strainer clogged or restricted.	Clean the strainer.	Section 3
				x								High temperature shutdown.	Allow the engine to cool down. Then troubleshoot the cooling system.	Eng. O/M
				x								Low coolant level shutdown, if equipped.	Restore the coolant to normal operating level.	Eng. O/M
						x						Coolant level low.	Restore the coolant to normal operating level.	Eng. O/M
						x						Cooling water pump inoperative.	Tighten or replace the belt. Replace the water pump.	Eng. O/M or Eng. S/M
						x						Thermostat inoperative.	Replace the thermostat.	Eng. S/M
Fuel System														
	x			x								Fuel tank empty or fuel valve shut off.	Add fuel and move the fuel valve to the ON position.	—
	x	x			x							Air in fuel system (diesel only).	Bleed the diesel fuel system.	Eng. O/M
	x	x			x							Fuel or fuel injectors dirty or faulty (diesel only).	Clean, test, and/or replace the inoperative fuel injector.†	Eng. S/M
	x	x			x			x				Fuel injection timing out of adjustment (diesel only).	Adjust the fuel injection timing.†	Eng. S/M
	x				x			x				Fuel feed or injection pump inoperative (diesel only).	Rebuild or replace the injection pump.†	Eng. S/M
	x	x		x	x							Fuel filter restriction.	Clean or replace the fuel filter.†	Eng. O/M
	x											Fuel solenoid inoperative, if equipped.	Troubleshoot the fuel solenoid.†	Eng. S/M
Engine Lubrication System														
						x	x		x			Oil level low.	Restore the oil level. Inspect the generator set for oil leaks.	Eng. O/M
				x								Low oil pressure shutdown.	Check the oil level.	Eng. O/M
	x	x					x		x			Crankcase oil type incorrect for ambient temperature.	Change the oil. Use oil with a viscosity suitable for the operating climate.	Eng. O/M

* Sec./Section—numbered section of this manual; ATS—Automatic Transfer Switch; Eng.—Engine; Gen.—Generator Set; I/M—Installation Manual; O/M—Operation Manual; S/M—Service Manual; S/S—Spec Sheet; W/D—Wiring Diagram

† Have an authorized service distributor/dealer perform this service.

7.5 Controller Display Troubleshooting Chart

Trouble Symptoms	Probable Causes	Recommended Actions	Section or Publication Reference*
Controller Display and Voltage Regulator			
Display is black.	No/low battery charge.	Recharge/replace battery.	—
Display shows single segment.	Low battery voltage.	Recharge battery.	—
Display shows an error message.	Controller firmware or pushbutton/ rotary selector dial entry error.	Review the Error Message section.	—
Display locks up.	No/low battery charge.	Recharge/replace battery.	—
Output voltage ramps.	Defective exciter winding	Troubleshoot alternator components.†	Gen. S/M
Output voltage unstable.	Voltage regulation calibration incorrect	Readjust voltage regulation.†	SiteTech O/M
Unable to change voltage and current calibrations.	Calibration not enabled.	Enable calibration in Generator Metering section.	Gen. O/M

* Sec./Section—numbered section of this manual; ATS—Automatic Transfer Switch; Eng.—Engine; Gen.—Generator Set; I/M—Installation Manual; O/M—Operation Manual; S/M—Service Manual; S/S—Spec Sheet; W/D—Wiring Diagram Manual

† Have an authorized service distributor/dealer perform this service.

7.6 Paralleling Troubleshooting—When Breaker Does Not Close to Bus

7.6.1 Faults Not Shown

Step	Potential Cause	Explanation	Troubleshooting
1	PGEN communication not operational	The controller must have seen PGEN communication with at least one other node at some time since the last power cycle event before it will close the breaker.	In *Controller Config -> Communication Setup*, verify the PGEN Nodes Online is at least 2. If so, continue troubleshooting at Step 8 otherwise, continue on to Step 2.
2	Single generator application	There is only one generator on site, but the controller is expecting to see PGEN communication. The controller supports this scenario if the controller is configured in Standalone mode. Standalone mode can be set using the standalone input to the controller or in Kohler SiteTech™.	Configure a digital input to Standalone mode and assert it, or set Standalone mode in Kohler SiteTech™. Note, Standalone mode should only be asserted if there is only one generator set at the site.
3	PGEN wiring not connected correctly	PGEN communicates over an RS-485 connection. RS-485 requires that the network be connected in a daisy-chain configuration, terminated at 120 Ohms at either end of the network and that positive (B) and negative (A) polarity be maintained.	Verify wiring, all PGEN + connections should be connected with daisy-chain wire (Belden #9841 or equivalent). Verify terminations are at the end of the network. Verify that there are no unintentional or loose connections.
4	Baud rate misconfigured	One of the controllers on the network is attempting to communicate at a different baud rate than the other controllers. This results in collisions on the communication bus and incorrect interpretation of the data.	In *Controller Config -> Communication Setup*, verify that the baud rate of all generators on the network matches. Default is 57,600 baud.
5	Interference	The PGEN network is seeing noise which makes it difficult for the generator controllers to communicate.	Verify that PGEN network uses Belden #9841 or equivalent. Verify that the shield drain for the cable is grounded at only one end.
6	Short circuit in communication wiring	The RS-485 communication wires are short-circuited together.	In *Controller Config -> Communication Setup*, verify the PGEN Node ID is less than 16. If not, check the PGEN wiring for short circuits. Otherwise, continue troubleshooting to Step 7.
7	Intermittent connection in PGEN wiring	Although the generator controllers can occasionally communicate, the connection is unreliable. This can be caused by a short or open circuit.	It is not uncommon for small communications wire to not connect directly to a terminal block well. Verify there are no loose wiring connections or “whiskers” at the PGEN terminal blocks. “Fork”, “ring”, or “crow’s feet” connectors are preferred for terminal block connections.
8	Unable to establish first-on lock	The generator is trying to close to a dead bus but it is not receiving permission from one of the other nodes to allow it to do so. This can occur if one of the other nodes has seen a node removed from the network.	Cycle power on all generators.

7.6.2 Faults Shown

Step	Potential Cause	Explanation	Troubleshooting
Fault: System Voltage Mismatch Between Generators			
1	System voltage is not equivalent	One of the controllers on the network is configured differently than the other controllers. This will inhibit any of the generators from closing to the bus.	Verify the system voltage of all the generators match the requirements of the site.
Fault: System Frequency Mismatch Between Generators			
1	System frequency is not equivalent	One of the controllers on the network is configured differently than the other controllers. This will inhibit any of the generators from closing to the bus.	Verify the system frequency of all the generators match the requirements of the site.
Fault: Phase Connection Mismatch Between Generators			
1	Phase connection is not equivalent	One of the controllers on the network is configured differently than the other controllers. This will inhibit any of the generators from closing to the bus.	Verify the phase connection of all the generators match the requirements of the site.
Fault: Live Bus Sensed When Dead Bus Expected			
1	Bus is considered to be live	The controller is measuring voltage on the paralleling bus. This will inhibit the breaker from closing.	Check bus for residual voltage (sometimes induced by large transformers or motors). Possibly, adjust the Dead Bus Threshold to accommodate the residual voltage.
2	Bus sensing is not connected	The controller may see voltage on the paralleling bus when the generator is operating and the bus sensing is disconnected.	Verify the bus sensing wiring is connected to the load side of the motor-operated breaker for this generator.
Fault: Close Attempt **Fault: Fail to Close**			
1	Breaker is unable to close	The controller is attempting to close the circuit breaker but the breaker is not closing.	Watch the ready flag on the motor operator of the circuit breaker, if equipped. If it indicates not ready when the engine is stopped and toggles to the ready state when the generator is trying to close the breaker, the trip coil is acting correctly. Continue at Step 5 otherwise, continue on to Step 2.
2	Trip is not removed from the circuit breaker	The controller is attempting to close the circuit breaker but the breaker is not closing because the trip coil is still energized.	If the ready flag of the motor operator indicates ready when the engine is stopped, continue at Step 3 otherwise, continue on to Step 4.
3	CB trip relay is wired as normally open	The controller is expecting that the trip on the circuit breaker is a normally-closed contact. This is intentional as it holds a trip on the breaker if the controller is removed.	Verify the CB trip relay is wired to hold a trip on the breaker when the relay is not energized.
4	Incorrect wiring between the CB trip relay and the trip coil on the breaker	The CB trip relay is operating correctly but the trip coil on the breaker is remaining energized. This could be due to incorrect wiring between the generator controller and the circuit breaker.	Verify the wiring to the circuit breaker.
5	Close is not applied to the circuit breaker	The breaker trip is removed but the controller is not able to close the breaker.	Verify the wiring between the generator controller and the circuit breaker close coil. Check the close coil to ensure that it is not defective.
6	Breaker is not charged	The breaker is receiving the signal to close but the energizing spring is not charged.	Verify the motor operator is receiving voltage at the appropriate contacts to allow it to wind the spring.
7	Breaker is not powered	The 24V electronics on the circuit breaker require an external 24V source on a 12V generator.	Verify the 24V input which exists on paralleling generators is receiving 24VDC in the correct polarity.
8	Wiring to power is not complete	There is no voltage to the CB close relay on this circuit breaker.	Connect the supply to the CB close relay to either 24V from wire #70 or an external 24VDC supply (with battery storage).
9	Breaker status feedback is not valid, no bus sensing	The breaker closes but the controller does not see a change in status. The controller cannot see the bus is energized as the bus sensing is not connected correctly on any generators on the network.	Verify the wiring on the circuit breaker to ensure that it is connected correctly. Verify bus wiring for all nodes. Verify the generator output is connected to the line side of the generator breaker.
10	Standalone mode enabled (with no circuit breaker equipped)	The generator set expects to have a circuit breaker, even without PGEN communications, if the standalone mode is enabled.	

Step	Potential Cause	Explanation	Troubleshooting
Fault: CB Status **Warning: Bus Sensing Not Connected**			
1	Breaker status feedback is not valid, no bus sensing	The breaker closes but the controller does not see a change in status. The controller cannot see the bus is energized as the bus sensing is not connected correctly on this generator, but another generator is connected.	Verify the wiring on the circuit breaker to ensure that it is connected correctly. Verify bus wiring for this generator.
Fault: CB Status or Continuous Breaker Cycling			
1	Breaker status feedback is not valid	The breaker closes but the controller does not see a change in status. The controller sees the bus is now live.	Verify the wiring on the circuit breaker to ensure that it is connected correctly.

7.7 Paralleling Troubleshooting—When Breaker Does Close to Bus

7.7.1 Faults Shown

Step	Potential Cause	Explanation	Troubleshooting
Fault: Close Attempt **Fault: Fail to Close**			
1	Breaker status feedback is not valid, no bus sensing	The breaker closes but the controller does not see a change in status. The controller cannot see the bus is energized as the bus sensing is not connected correctly on any generators on the network.	Verify the wiring on the circuit breaker to ensure that it is connected correctly. Verify bus wiring for all nodes. Verify the generator output is connected to the line side of the generator breaker.
Fault: CB Status			
1	Breaker status feedback is not connected	The breaker closes but the controller does not see a change in status. The controller sees the bus is now live.	Verify the wiring on the circuit breaker to ensure that it is connected correctly.
2	Breaker status is short circuited	The controller sees the breaker is closed even when it is not trying to open it.	Verify connection of the breaker status wiring at the circuit breaker.
3	Breaker status feedback is connected to the wrong contacts	The controller sees open status for the breaker after telling it to close, closed status after telling it to open.	The controller is expecting the breaker status to be an “A” contact. Verify the circuit breaker auxiliary contacts are either: 11 and 14 21 and 24 31 and 34 or 41 and 44. If the breaker status contacts are removable, make sure that they are inserted in one of the OF slots and that the wires go to 1 and 4.
4	Breaker status feedback is connected to a latching contact	The breaker status indicated that it closed when it was triggered to close but it did not indicate that it was open when the breaker opened. This fault will only occur if the bus sensing is connected correctly (the controller sees the voltage go to 0 when the breaker is triggered to open).	Verify the breaker status input to the controller is connected directly to an auxiliary contact on the circuit breaker.
Fault: Bus Phase Rotation Mismatch			
1	All of the bus sensing wires are incorrectly connected	The bus sensing wires must be connected to phase A, phase B, and phase C of the bus. If any two connections are reversed, the controller can detect the reversed connections. This fault will only occur if all three wires are incorrectly connected.	Verify the bus metering connections.
2	The phase connections on the paralleling breaker are inconsistent with the generator	The power leads from the generator to the paralleling circuit breaker must be connected consistently. Phase A from the generator must go to phase A of the line side of the paralleling (motor operated) breaker, phase B from the generator to phase B of the breaker and phase C of the generator to phase C of the breaker.	Verify the output cable connections.

Step	Potential Cause	Explanation	Troubleshooting
Fault: Bus Phase Rotation Mismatch (Continued)			
3	Generator sensing is connected incorrectly	The controller measurement leads are not connected to the appropriate output phases or the phases are incorrectly labeled.	Verify the sensing leads from the controller are connected to the appropriate output leads from the generator. L1 should connect to phase A, L2 to phase B, L3 to phase C, L0 to neutral.
4	Breaker to bus wiring is inconsistent	In applications where the bus sensing is taken from a location other than the load side of the paralleling breaker, it is possible to connect the wiring incorrectly between the load side of the output breaker and the paralleling bus.	Verify the cable connections from the paralleling breaker to the paralleling bus.
Fault: Bus Voltage Amplitude Mismatch- Phase A			
1	The phase A voltage of the bus does not match the generator	The voltage measured on the bus sensing for phase A does not match the voltage measured on phase A of the generator.	Verify the bus sensing wire for phase A is connected to phase A of the load side of the paralleling breaker and there are no breaks in the wire.
Fault: Bus Voltage Amplitude Mismatch- Phase B			
1	The phase B voltage of the bus does not match the generator	The voltage measured on the bus sensing for phase B does not match the voltage measured on phase B of the generator.	Verify the bus sensing wire for phase B is connected to phase B of the load side of the paralleling breaker and there are no breaks in the wire.
Fault: Bus Voltage Amplitude Mismatch- Phase C			
1	The phase C voltage of the bus does not match the generator	The voltage measured on the bus sensing for phase C does not match the voltage measured on phase C of the generator.	Verify the bus sensing wire for phase C is connected to phase C of the load side of the paralleling breaker and there are no breaks in the wire.
Fault: Bus Voltage Amplitude Mismatch			
1	The bus metering is not connected correctly	The bus metering is not connected to the appropriate lugs of the load side of the paralleling breaker (but there is some voltage present).	Verify the bus sensing wire for all three phases is connected to the appropriate lugs on the load side of the paralleling breaker and there are no breaks in any of the wires.
2	The generator metering is not connected correctly	The generator metering is not connected to the output of the generator.	Verify the generator metering is sensed at the output of the generators. A common mistake is to connect the metering to the center tap voltages V7, V8, V9.
Fault: Phase Angle Mismatch			
1	All of the bus sensing wires are incorrectly connected	The bus sensing wires must be connected to phase A, phase B and phase C of the bus. If any two connections are reversed, the controller can detect the reversed connections. This fault will only occur if all three wires are incorrectly connected.	Verify the bus metering connections.
2	The phase connections on the paralleling breaker are inconsistent with the generator	The power leads from the generator to the paralleling circuit breaker must be connected consistently. Phase A from the generator must go to phase A of the line side of the paralleling (motor operated) breaker, phase B from the generator to phase B of the breaker, and phase C of the generator to phase C of the breaker.	Verify the output cable connections.
3	Generator sensing is connected incorrectly	The controller measurement leads are not connected to the appropriate output phases or the phases are incorrectly labeled.	Verify sensing leads from the controller are connected to the appropriate output leads from the generator. L1 should connect to phase A, L2 to phase B, L3 to phase C, L0 to neutral.
4	Breaker to bus wiring is inconsistent	In applications where the bus sensing is taken from a location other than the load side of the paralleling breaker, it is possible to connect the wiring incorrectly between the load side of the output breaker and the paralleling bus.	Verify cable connections from the paralleling breaker to the paralleling bus.
Fault: Bus Frequency Mismatch			
1	Abnormal condition	Bus frequency is not similar to generator frequency with breaker closed.	Verify bus metering is connected correctly. Reset the controller.

Step	Potential Cause	Explanation	Troubleshooting
Fault: Bus Sensing Phases A and B are Reversed			
1	The bus sensing for phase A is connected to phase B of the paralleling bus and vice versa	Phase angle from generator to bus is about 180° and bus rotation is backwards.	Verify wiring between bus sensing inputs and load side of paralleling breaker.
2	The wiring between the generator and the paralleling breaker is incorrect	Phase angle from generator to bus is about 180° and bus rotation is backwards.	Verify wiring between generator and paralleling breaker.
3	The generator metering is not connected correctly	Phase angle from generator to bus is about 180° and bus rotation is backwards.	Verify metering connections on the generator. L1 should connect to the phase A output lead. L2 to phase B, L3 to phase C, L0 to neutral.
Fault: Bus Sensing Phases B and C are Reversed			
1	The bus sensing for phase B is connected to phase C of the paralleling bus and vice versa	Phase angle from generator to bus is about - 120° and bus rotation is backwards.	Verify wiring between bus sensing inputs and load side of paralleling breaker.
2	The wiring between the generator and the paralleling breaker is incorrect	Phase angle from generator to bus is about - 120° and bus rotation is backwards.	Verify wiring between generator and paralleling breaker.
3	The generator metering is not connected correctly	Phase angle from generator to bus is about - 120° and bus rotation is backwards.	Verify metering connections on the generator. L1 should connect to the phase A output lead. L2 to phase B, L3 to phase C, L0 to neutral.
Fault: Bus Sensing Phases C and A are Reversed			
1	The bus sensing for phase A is connected to phase C of the paralleling bus and vice versa	Phase angle from generator to bus is about 120° and bus rotation is backwards.	Verify wiring between bus sensing inputs and load side of paralleling breaker.
2	The wiring between the generator and the paralleling breaker is incorrect	Phase angle from generator to bus is about 120° and bus rotation is backwards.	Verify wiring between generator and paralleling breaker.
3	The generator metering is not connected correctly	Phase angle from generator to bus is about 120° and bus rotation is backwards.	Verify metering connections on the generator. L1 should connect to the phase A output lead. L2 to phase B, L3 to phase C, L0 to neutral.
Fault: Bus Sensing Not Connected			
1	No wires connect the bus sensing on the generator to the load side of the paralleling breaker	Wiring not connected between load side of the paralleling breaker and the bus metering.	Verify that the bus sensing is connected.
2	No leads connect the generator output to the line side of the paralleling breaker	The leads connecting the output of the generator to the paralleling breaker are not connected.	Verify that the leads connecting the generator to the paralleling breaker are connected.

Step	Potential Cause	Explanation	Troubleshooting
Fault: Bus Sensing Not Connected (Continued)			
3	The line circuit breaker is open	The line circuit breaker (at the generator) is open, disconnecting the output from the generator from the line side of the paralleling breaker.	Verify that the line circuit breaker is closed.
Fault: Bus Sensing Connected to Generator Side of Breaker			
1	Bus metering is connected to the wrong side of the paralleling breaker	The controller sees the bus voltage always matches the generator voltage, even when the breaker contacts indicate that the breaker is open.	Verify the bus metering is connected on the load side of the paralleling breaker.
2	Breaker is closed and status feedback is not connected	The controller sees that the bus voltage always matches the generator voltage, even when the breaker contacts indicate that the breaker is open.	Verify the paralleling breaker control wiring is connected correctly and the status feedback is connected to an “A” contact.
Fault: Failure to Open			
1	Wiring between CB trip relay and trip coil is not connected	The CB trip relay is releasing, but the coil in the breaker is not energizing, hence the breaker is not opening.	Verify wiring to the trip coil (A4) is connected correctly.
2	CB trip relay is not receiving 24V power	The CB trip relay is releasing, but there is no voltage to apply to the trip coil. This is most likely to occur when the generator has a 12V battery and there is an external battery bank to operate the circuit breaker.	Verify the CB trip relay has a 24VDC supply which is common to the CB close relay and charge motor.

7.8 Paralleling Troubleshooting—When Running in AUTO

7.8.1 Faults Shown

Step	Potential Cause	Explanation	Troubleshooting
Fault: Generator Phase Rotation Mismatch			
1	This generator is wired with the opposite phase rotation of all the other generators on the paralleling bus	The controller has validated that the bus metering is accurate relative to this generator, if the bus phase rotation is backwards to the generator, the phase rotation must really be different.	Verify wiring between this generator and the paralleling breaker. It may be necessary to reverse two phases between the generator and the paralleling breaker and then to reverse the sensing at the bus to match. This generator should be started and closed to a dead bus again to validate the changes.
2	The wiring between the paralleling breaker and the paralleling bus is incorrectly connected (two phases are reversed)	Voltage from other generators comes into this generator as incorrect phase rotation because the wiring connections to the paralleling bus are reversed, even though the rotation of the other generators is identical to the rotation of this generator.	Verify wiring between the paralleling breaker and the paralleling bus. It may be necessary to reverse the connection of two of the leads. This generator should be started and closed to a dead bus again to validate the changes.
3	The generator which is connected to the paralleling bus has the opposite phase rotation of this generator and all others	Voltage from the other generator comes into this generator as incorrect phase rotation because the wiring connections from the other generator to the paralleling bus are reversed, even though the rotation of the other generators is identical to the rotation of this generator.	Verify wiring between the paralleling breaker and the paralleling bus of the other generator. It may be necessary to reverse two phases between the paralleling breaker and the paralleling bus on the other generator. The other generator should be started and closed to a dead bus again to validate the changes.

Step	Potential Cause	Explanation	Troubleshooting
Fault: Dead Bus Sensed When Live Bus Expected			
1	The wiring was not connected between the load side of the paralleling breaker for this generator and the paralleling bus	This generator controller observed accurate bus voltage when it closed the breaker, the other generator controller did the same, but the bus of this generator is not connected to the bus of the other generator. The other generator is energizing the load, this generator cannot energize the load as there is a disconnected wiring between this generator and the paralleling bus.	Verify wiring between the paralleling breaker and the paralleling bus of this generator.
2	The wiring was not connected between the load side of the paralleling breaker for the other generator and the paralleling bus	This generator controller observed accurate bus voltage when it closed the breaker, the other generator controller did the same, but the bus of this generator is not connected to the bus of the other generator. The other generator is not energizing the load because it is not connected to it—this generator may be able to energize the load, but there is no simple way of telling this without connecting the output of the other generator.	Verify wiring between the paralleling breaker and the paralleling bus of the other generator.
Fault: Bus Voltage Out of Spec			
1	The generators which are connected to the paralleling bus are overloaded	When the generators which are supplying a load are overloaded, their engine speed will decrease, resulting in a decrease in output voltage. Sometimes this decrease in output voltage is sufficient to allow the generators to recover.	Verify the load requirements are met by a single generator. If not, it may be necessary to connect several low priority loads to load shed outputs from the paralleling generators to avoid overloading a single generator.
2	Excessive cable lengths from generators to paralleling bus	Although a single generator can handle the load, the cables which connect the generator to the paralleling bus are too long or too small of gauge, resulting in insufficient bus voltage.	Increase wire size on the generator connection leads.
Fault: Bus Voltage Out of Spec			
1	The generators which are connected to the paralleling bus are overloaded	When the generators which are supplying a load are overloaded, their engine speed will decrease, resulting in a decrease in output voltage. Sometimes this decrease in output voltage is sufficient to allow the generators to recover.	Verify the load requirements are met by a single generator. If not, it may be necessary to connect several low priority loads to load shed outputs from the paralleling generators to avoid overloading a single generator.
2	Excessive cable lengths from generators to paralleling bus	Although a single generator can handle the load, the cables which connect the generator to the paralleling bus are too long or too small of gauge, resulting in insufficient bus voltage.	Increase wire size on the generator connection leads.
Fault: Bus Frequency Out of Spec			
1	The generators which are connected to the paralleling bus are overloaded	When the generators which are supplying a load are overloaded, their engine speed will decrease, resulting in a decrease in output voltage. Sometimes this decrease in output voltage is sufficient to allow the generators to recover.	Verify the load requirements are met by a single generator. If not, it may be necessary to connect several low priority loads to load shed outputs from the paralleling generators to avoid overloading a single generator.
Fault: Failure to Synchronize			
1	Varying load requirements drive generator frequency unstable	Heavy variations in the load on a generator will cause the speed of the generator to vary significantly. It can be difficult to synchronize with a generator with continuously changing frequency.	Adjustment of synchronizing dwell time or synchronizing gains may improve ability to synchronize.
2	Fuel variations or other environmental factors cause the generator frequency regulation to suffer	When the frequency regulation is impeded by atmospheric conditions or fuel quality, the ability to synchronize may be affected. Not only is the bus varying more than normal, but it is more difficult for the generator to control speed while synching.	It may be necessary to adjust the synchronizing gains.
3	Different sized units or units of different fuel types	The factory synchronizing gains were calibrated for equal-sized units. The response of a large unit to a small one is slightly different than two small units. A diesel generator has significantly better frequency regulation than a natural gas generator.	It may be necessary to adjust the synchronizing gains.

Step	Potential Cause	Explanation	Troubleshooting
Fault: Generator Voltage Average Line to Line: High Warning			
1	Metering calibration issue	All the generators on the paralleling bus attempt to control to the same voltage. If one has incorrect calibration, it may see this voltage as a much higher level than the other generators, resulting in a protective relay trip.	Verify the controller is measuring voltage accurately. If not, re-calibrate it.
2	Voltage drop on generator connection leads	If the generator is sourcing high current through too small of output leads, the voltage drop in these cables may require the generator to run at an increased voltage to supply the necessary current to the paralleling bus.	Install oversized connecting leads for the generator to minimize voltage drop between the generator and the paralleling bus.
3	Attempting to operate a generator in base-load mode while it is connected to a variable load	The speed bias and voltage bias control real and reactive load in base-load mode against a source with a nearly constant frequency and voltage (such as a utility source). If the generator is disconnected from the utility source, the speed and voltage will deviate to either extreme of the bias range, depending on the target load and the actual load.	Install contacts in series with the base-load mode input to the controller which are disconnected when the utility source is disconnected from the paralleling bus.
Fault: Generator Voltage Average Line to Line: Low Warning			
1	Metering calibration issue	All the generators on the paralleling bus attempt to control to the same voltage. If one has incorrect calibration, it may see this voltage as a much lower level than the other generators, resulting in a protective relay trip.	Verify the controller is measuring voltage accurately. If not, re-calibrate it.
2	Attempting to operate a generator in base-load mode while it is connected to a variable load	The speed bias and voltage bias control real and reactive load in base-load mode against a source with a nearly constant frequency and voltage (such as a utility source). If the generator is disconnected from the utility source, the speed and voltage will deviate to either extreme of the bias range, depending on the target load and the actual load.	Install contacts in series with the base-load mode input to the controller which are disconnected when the utility source is disconnected from the paralleling bus.
Fault: AC Frequency: High Warning			
1	Attempting to operate a generator in base-load mode while it is connected to a variable load	The speed bias and voltage bias control real and reactive load in base-load mode against a source with a nearly constant frequency and voltage (such as a utility source). If the generator is disconnected from the utility source, the speed and voltage will deviate to either extreme of the bias range, depending on the target load and the actual load.	Install contacts in series with the base-load mode input to the controller which are disconnected when the utility source is disconnected from the paralleling bus.
Fault: AC Frequency: Low Warning			
1	Attempting to operate a generator in base-load mode while it is connected to a variable load	The speed bias and voltage bias control real and reactive load in base-load mode against a source with a nearly constant frequency and voltage (such as a utility source). If the generator is disconnected from the utility source, the speed and voltage will deviate to either extreme of the bias range, depending on the target load and the actual load.	Install contacts in series with the base-load mode input to the controller which are disconnected when the utility source is disconnected from the paralleling bus.
Fault: Generator Total Real Power: High Warning			
1	Continuous overload	The generator breaker will trip to protect the generator from damage due to excessive loads.	Ensure that the load is low enough for a single generator to support it.
Fault: Generator Total Real Power: Low Warning			
1	Loss of fuel pressure	The generator breaker will trip to prevent generator operation. Otherwise, power could be absorbed from other generators causing potential damage to the fuel system by operating without lubrication.	Ensure that the generator has sufficient fuel to support load. Connect a fuel level sensor and place Generator Management in Fuel Level Equalization mode.
2	Quick ramp rate settings	The real power may overshoot when in a real power control situation such as base load or system control.	It may be necessary to adjust the load control gains.
3	Different sized units or units of different fuel types.	The real power may overshoot when in a real power control situation such as a load ramp or a quickly changing customer load.	It may be necessary to adjust the kW load sharing gains.
4	Different engine speed adjust settings	Setting the Engine Speed Adjust parameter high on a generator will result in that generator providing more real power than the other generators. It is possible to drive the other generators offline in light loading conditions.	Set the engine speed adjustment similarly on all generators.

Step	Potential Cause	Explanation	Troubleshooting
Fault: Generator Current Average: High Warning			
1	Excessive reactive load	The generator breaker will trip to prevent the generator from damage due to excessive stator current. Note, the controller also has a heat-model-based alternator protection algorithm (which will shut the generator down).	Ensure that the load is low enough for a single generator to support it.
Fault: Generator Total Reactive Power: Low Warning			
1	Different sized units	The reactive power may overshoot when in a power control situation such as a load ramp or a quickly changing customer load.	It may be necessary to adjust the kVAR load sharing gains.
2	Different automatic voltage regulator settings	Setting the Engine Speed Adjust parameter high on a generator will result in that generator providing more real power than the other generators. It is possible to drive the other generators offline in light loading conditions.	Set the voltage regulator average voltage adjustment to the same value on all connected generators.
3	Different voltage calibrations	Because each generator will attempt to match the target output voltage, generators with incorrect calibration may be targeting a different output voltage, thus generating or absorbing VARs.	Verify the controller is measuring voltage accurately, If not, re-calibrate.
4	Failure in voltage regulator or activator board	The generator breaker will trip to prevent the generator from absorbing VARs from the other generators. Providing power while absorbing VARs may cause that alternator to slip a pole—potentially damaging the rotor or crankshaft.	Verify the voltage regulator and activator are ok. Perform load tests to verify.
Fault: Generator Management Enabled: Erroneous Data Received Warning			
1	Two generators that are communicating on the network have different Order Selection modes	Generator management will not operate if any generators on the PGEN network have different Order Selection modes.	Adjust the Order Selection mode on any generator on the network to set the Order Selection mode in all controllers.
2	Two generators that are communicating on the network have different Stability delays	Generator management will not operate if any generators on the PGEN network have different Stability delays.	Adjust the Order Selection mode on any generator on the network to set the Stability delay in all controllers.
3	Two generators that are communicating on the network have different Redundancy Requirements	Generator management will not operate if any generators on the PGEN network have different Redundancy Requirements.	Adjust the Order Selection mode on any generator on the network to set the Redundancy Requirements in all controllers.
4	Two generators that are communicating on the network have different Maximum Run Time Hour Difference Thresholds	Generator management will not operate if any generators on the PGEN network have different Maximum Run Time Hour Difference Thresholds.	Adjust the Order Selection mode on any generator on the network to set the Maximum Run Time Hour Difference Threshold in all controllers.
5	Two generators that are communicating on the network have different Maximum Fuel Level Difference Thresholds	Generator management will not operate if any generators on the PGEN network have different Maximum Fuel Level Difference Thresholds.	Adjust the Order Selection mode on any generator on the network to set the Maximum Fuel Level Difference Threshold in all controllers.

7.9 Troubleshooting—Protective Relays

Protective Relay	Intended Function	Potential Causes	Troubleshooting
Reverse Power (on the Decision-Maker® 3500 controller: Generator Total Real Power: Low Warning)	To trip the paralleling breaker if a generator is not producing absorbing real power. A generator should always produce power while running. If the generator is not producing power, the protective relay will trip the paralleling breaker, removing the generator from the paralleling bus, as it is not contributing to the power output.	Incorrect Real Load Sharing configuration.	The engine should be able to provide power individually. If so, the Real Load Sharing configuration is probably incorrect.
		A paralleled unit in a fixed power mode (Baseload), set to a value higher than required for actual load.	Check modes on other controllers. Baseload mode on one generator may result in reverse power on the other generators. Check Baseload setting is less than actual load.
		Incorrect wiring to the CTs on one or more units on the paralleling bus (not necessarily the unit that tripped on reverse power).	Load bank each generator individually. Power should read positive and accurately. Make sure that the generator controller reads a unity power factor into a resistive load bank. If a load bank is unavailable, make sure that phase powers are all positive and that phase power factors make sense.
		Incorrect current meter calibration for one or more generators in the system.	Check current meter calibration according to the manual
		Loss of fuel (run out of fuel, a failed suction line, or failed fuel supply component such as injectors, carburetor, throttle control, etc.).	The failed generator should be easily detected as it will shut down for underspeed or underfrequency after the breaker trips. There will be no fuel pressure. Check the fuel reservoir, fuel supply lines, and fuel supply components on the engine. Check for related diagnostic messages (DTCs) from the ECU.
		Electrical failure in the engine ECU.	The generator will shut down for underspeed or underfrequency after the breaker trips. Fuel pressure will be normal. Check for related diagnostic messages (DTCs) from the ECU.
		Mechanical problem in the engine.	The generator will shut down for underspeed or underfrequency after the breaker trips. The crankshaft may be very difficult to turn. Check for related diagnostic messages (DTCs) from the ECU.
		Incorrect protective relay setting.	Ensure that protective relay settings are determined by a comprehensive coordination study using recent and accurate system data.
		No speed control through, replacement ECU not configured correctly to accept CAN speed commands, engine derates active.	Check ECU calibration file.
Over Power (on the Decision-Maker® 3500 controller: Generator Total Real Power: High Warning)	To protect the generator from overload conditions that may result in damage to the generator.	Incorrect Load Management setup.	Verify critical load is less than a single generator capacity. Load Management should be able to remove enough load to allow a single generator to support it. Verify correct wiring between load shed outputs and switching components. Verify distributed loads and ratings are consistent with Load Management configuration/settings.
		Failure of another generator.	Check Load Management settings to ensure that all loads are shed quickly enough in the event of a generator failure. Check Generator Management settings to ensure the desired minimum number of generators is selected.
		Load growth in application.	Verify that Load Management can shed enough load for a single generator to support it.
		Incorrect protective relay setting.	Ensure that protective relay settings are determined by a comprehensive coordination study using recent and accurate system data with consideration for Load Management configuration.

Protective Relay	Intended Function	Potential Causes	Troubleshooting
Reverse VARs (on the Decision-Maker® 3500 controller: Generator Total Reactive Power: Low Warning)	Protect the generator from slipping a pole due to a low excitation condition in the alternator.	Incorrect Reactive Load Sharing configuration.	Check that the engine is able to supply load and maintain normal voltage when running alone. If so, the Reactive Load Sharing configuration is probably incorrect.
		A paralleled unit in a fixed power mode (Baseload or System Load Control) or KVAR setting is higher than the actual load.	Check modes on other controllers. Baseload mode on one generator may result in reverse VARs on the other generators. Verify KVAR setting is less than the actual load requires, consider PF sharing.
		Incorrect wiring to the CTs on one or more units on the paralleling bus (not necessarily the unit that tripped on reverse power).	Load bank each generator individually. Power should read positive and accurately. Make sure that the generator controller reads a unity power factor into a resistive load bank. If a load bank is unavailable, make sure that phase powers are all positive and that phase power factors make sense.
		Incorrect current meter calibration for one or more generators in the system.	Check the current meter calibration according to the manual.
		Loose or broken wiring between controller and LED board or wound field activator.	The failed generator should be easily detected as it will shut down on undervoltage after the protective relay trips the breaker. Voltage may be unusually unstable. Check wires and connectors for any failures, intermittent or open connections.
		Activator board failure on alternator.	If alternator produces no voltage, look for bad wires or connections. If no bad connections are found, continue with Alternator troubleshooting in Section 10 or 11. Visually inspect the activator board for damage or failure.
		Broken wire or failed winding in alternator.	If alternator produces no voltage, look for bad wires or connections. If no bad connections are found, continue with Alternator troubleshooting in Section 10 or 11.
		Capacitive load.	Verify that the load on the vessel is not capacitive. If a single generator (with the CTs connected properly) is reading a leading power factor, the load is capacitive. If multiple generators are supplying the load, check for the total system load under bus metering to determine if the reactive power is leading (-).
		Incorrect Protective Relay setting.	Ensure that protective relay settings are determined by a comprehensive coordination study using recent and accurate system data. **Note:** Setting the Reverse VARs protective relay above 20% is **not** recommended as it may result in slipping a pole under high real loads.
		Loss of sensing on a voltage phase.	The controller uses three-phase sensing to regulate voltage (in a three-phase application). The loss of a single phase may cause either an overvoltage or undervoltage event. Start the generator to ensure that all three line voltages are metered accurately.

Protective Relay	Intended Function	Potential Causes	Troubleshooting
Over Current (on the Decision-Maker® 3500 controller: Generator Current Average: High Warning)	To protect the alternator from excessive heating due to stator current.	Undersized generator for application.	Ensure that the load demand is not greater than a single generator can support. This may require ensuring more than one generator is online before attempting to start a motor load. Verify Generator Management and Load Management are appropriately configured and system wiring is correct for operation as determined by a comprehensive coordination study.
		Incorrect Soft Start configuration for motor.	Some Soft Starters transfer the motor to line voltage before it has time to reach rated speed. This will cause a large current spike on the alternator. Monitor current into the motor with a current clamp and multimeter to trace the root cause. Verify appropriate soft starter configuration for generator supplied application.
		Simultaneous starting of switching motor loads.	If multiple motors exist in the application, try ensuring that they all start simultaneously to repeat the condition. If the condition repeats, it may be necessary to inhibit some motors from starting until others are up to speed. Verify Generator Management and Load Management are appropriately configured and system wiring is correct for operation as determined by a comprehensive coordination study.
		Incorrect Protective Relay setting.	Ensure that protective relay settings are determined by a comprehensive coordination study using recent and accurate system data.
Under Voltage (on the Decision-Maker® 3500 controller: Voltage Average: Low Warning)	To protect the customer loads from poor quality power.	System Control mode.	System Control mode will force all generators in the system to control reactive power to a target set by the voltage bias. If the actual reactive power is lower than the target, the voltage will increase. If the actual reactive power is higher than the target, the voltage will decrease. Make sure that no controllers are receiving a system load control input. Make sure that no controllers are configured for System Control mode in software.
		System Sync mode.	System Sync mode will force all generators in the system to match voltage to a bias level set by the voltage bias (which could be from 90% to 110% of rated voltage). Make sure that no controllers are receiving a system sync control input. Make sure that no controllers are configured for System Control mode in software.
		Baseload.	Baseload mode on a controller may decrease the voltage of the paralleling bus if attempting to unload reactive power when the other generators as configured are not able to support the load. Check for other nodes configured in Baseload mode. Check if this node is configured for Baseload.
		Excessive motor load.	Very heavy motor loads may cause the voltage to remain low for long enough to trip the undervoltage relay. Make sure that the voltage on the generator recovers to rated voltage within 1/2 of the time specified for the undervoltage protective relay when all motors are started together with a reasonable preload. If not, it may be necessary to reconsider the coordination study for the system.
		Loose wiring between controller and LED board or wound field activator.	Failure of any alternator in the paralleling system can cause an undervoltage condition (although it should be detected by a reverse VAR condition, that time delay is often longer). The failed generator should be easily detected as it will shut down on undervoltage after the protective relay trips the breaker.
		Activator board failure on alternator.	Failure of any alternator in the paralleling system can cause an undervoltage condition (although it should be detected by a reverse VAR condition, that time delay is often longer).
		Broken wire or failed winding in alternator.	Failure of any alternator in the paralleling system can cause an undervoltage condition (although it should be detected by a reverse VAR condition, that time delay is often longer).
		Voltage Trim disabled.	The Voltage Trim corrects the generator output voltage to a nominal level under normal operation. If it is disabled, the generator voltage could fall anywhere between 90% and 110% of nominal. Make sure that Trims are enabled on at least 1 of the paralleling generators.
		Loss of sensing on a voltage phase.	The controller uses three-phase sensing to regulate voltage (in a three-phase application). The loss of a single phase may cause either an overvoltage or undervoltage event. Start the generator to ensure that all three line voltages are metered accurately.
		Incorrect Protective Relay setting.	Ensure that protective relay settings are determined by a comprehensive coordination study using recent and accurate system data.

Protective Relay	Intended Function	Potential Causes	Troubleshooting
Over Voltage (on the Decision-Maker® 3500 controller: Generator Voltage Average: High Warning)	To protect the customer loads from potential damage from high voltage conditions.	System Control mode.	System Control mode will force all generators in the system to control reactive power to a target set by the voltage bias. If the actual reactive power is lower than the target, the voltage will increase. If the actual reactive power is higher than the target, the voltage will decrease. Make sure that no controllers are receiving a system load control input. Make sure that no controllers are configured for System Control mode in software.
		System Sync mode.	System Sync mode will force all generators in the system to match voltage to a bias level set by the voltage bias (which could be from 90% to 110% of rated voltage). Make sure that no controllers are receiving a system sync control input. Make sure that no controllers are configured for System Control mode in software.
		Baseload.	Baseload mode on a controller may decrease the voltage of the paralleling bus if attempting to unload reactive power when the other generators as configured are not able to support the load. Check for other nodes configured in Baseload mode. Check if this node is configured for Baseload.
		Excessive motor load.	If a large motor load is removed from the generator, the voltage will spike momentarily. The voltage should recover to the nominal value very quickly, but could trip the protective relay if the time delay is sufficiently short.
		Activator board failure on alternator.	Failure of any alternator in the paralleling system can cause an overvoltage condition (although it may also show up as reverse VARs on properly-functioning generators).
		Voltage Trim disabled.	The Voltage Trim corrects the generator output voltage to a nominal level under normal operation. If it is disabled, the generator voltage could fall anywhere between 90% and 110% of nominal. Make sure that Trims are enabled on at least 1 of the paralleling generators.
		Loss of sensing on a voltage phase.	The controller uses three-phase sensing to regulate voltage (in a three-phase application). The loss of a single phase may cause either an overvoltage or undervoltage event. Start the generator to ensure that all three line voltages are metered accurately.
		Incorrect Protective Relay setting.	Ensure that protective relay settings are determined by a comprehensive coordination study using recent and accurate system data.
Under Frequency (on the Decision-Maker® 3500 controller: AC Frequency: Low Warning)	To protect the customer loads from poor quality power.	Failure of another generator.	Check Load Management settings to ensure that all loads are shed quickly enough in the event of a generator failure.
		Load growth in application.	Verify that Load Management can shed enough load for a single generator to support it.
		Dirty air cleaner.	Check air cleaner element.
		Poor fuel supply.	Verify fuel line size and installation. Verify fuel pressure at unit under full load.
		System Control mode.	System Control mode will force all generators in the system to control real power to a target set by the speed bias. If the actual power is lower than the target, the speed will increase. If the actual power is higher than the target, the speed will decrease. Make sure that no controllers are receiving a system load control input. Make sure that no controllers are configured for System Control Mode in software.
		System Sync mode.	System Sync mode will force all generators in the system to match frequency to a bias level set by the speed bias (which could be from 95% to 105% of rated speed). Make sure that no controllers are receiving a system sync control input. Make sure that no controllers are configured for System Control Mode in software.
		Baseload.	Baseload mode on a controller may decrease the frequency of the paralleling bus if attempting to unload real power when the other generators are not able to support the load. Check for other nodes configured in Baseload mode. Check if this node is configured for Baseload.
		Frequency Trim disabled.	The Frequency Trim corrects the generator output frequency to a nominal level under normal operation. If it is disabled, the generator frequency could fall anywhere between 95% and 105% of nominal. Make sure that Trims are enabled on at least 1 of the paralleling generators.
		Incorrect Protective Relay setting.	Ensure that protective relay settings are determined by a comprehensive coordination study using recent and accurate system data.

Protective Relay	Intended Function	Potential Causes	Troubleshooting
Over Frequency (on the Decision-Maker® 3500 controller: AC Frequency: High Warning)	To protect the customer loads from poor quality power.	System Control mode.	System Control mode will force all generators in the system to control real power to a target set by the speed bias. If the actual power is lower than the target, the speed will increase. If the actual power is higher than the target, the speed will decrease. Make sure that no controllers are receiving a system load control input. Make sure that no controllers are configured for System Control mode in software.
		System Sync mode.	System Sync mode will force all generators in the system to match frequency to a bias level set by the speed bias (which could be from 95% to 105% of rated speed). Make sure that no controllers are receiving a system sync control input. Make sure that no controllers are configured for System Control Mode in software.
		Baseload.	Baseload mode on a controller may decrease the frequency of the paralleling bus if attempting to unload real power when the other generators are not able to support the load. Check for other nodes configured in Baseload mode. Check if this node is configured for Baseload.
		Excessive restriction on return line.	On certain units, excessive restriction on the return line will cause seals to fail in the injector pump which may supply unwanted fuel to the engine causing it to ’run away’ (accelerate without being commanded to do so by the ECM or governor). Verify backpressure at the return line. Ensure that no valves exist in the return line that can be accidentally closed (without knowledge of the implications).
		Frequency Trim disabled.	The Frequency Trim corrects the generator output frequency to a nominal level under normal operation. If it is disabled, the generator frequency could fall anywhere between 95% and 105% of nominal. Make sure that Trims are enabled on at least 1 of the paralleling generators.
		Incorrect Protective Relay setting.	Ensure that protective relay settings are determined by a comprehensive coordination study using recent and accurate system data.

7.10 Troubleshooting—Voltage Regulator

Symptom	Potential Causes	Troubleshooting
No voltage	Breaker status is indicating closed.	Ensure that Connected to Bus under Parallel Metering is set to False. (**Note:** This condition will have similar results in a paralleling or standalone application). If shown as True, verify that BSN and BSP wires are not connected.
	Loose wiring between controller and LED board or wound field activator.	Check wiring between controller and LED board. Perform Flashlight test. If alternator produces no voltage, look for bad wires or connections. If no bad connections are found, continue with alternator troubleshooting.
	Activator board failure on alternator.	If alternator produces no voltage, look for bad wires or connections. If no bad connections are found, continue with alternator troubleshooting in Section 10 or 11.
	Broken wire or failed winding in alternator.	If alternator produces no voltage, look for bad wires or connections in the alternator. If no bad connections are found, continue with alternator troubleshooting in Section 10 or 11.
	Speed sensor.	Verify that the controller is seeing speed above the crank disconnect level. The voltage regulator is not enabled until the engine speed exceeds the crank disconnect level.
	No ECM communications.	If the engine speed is received from the engine ECM, the voltage regulator requires a CAN message listing the speed as above the crank disconnect speed before the voltage regulator is enabled.
	Open circuit breaker.	A tripped circuit breaker on the generator will result in no voltage to the load without a failure on the generator. If the generator controller is measuring voltage, the breaker is probably tripped.
	Reversed wiring to the activator board.	Note a 0.7- 1.0 V output to the board (3B to 5B) instead of a 1.2- 1.5 V output.
Irregular voltage output	Loose wiring between controller and LED board or wound field activator.	Check the wiring between the controller and the LED board. Perform Flashlight test. If alternator produces no voltage, look for bad wires or connections. If no bad connections are found, continue with alternator troubleshooting.
	Broken wire or failed winding in alternator.	If alternator produces no voltage, look for bad wires or connections in the alternator. If no bad connections are found, continue with alternator troubleshooting in Section 10 or 11.
	Loose voltage sensing wiring to controller.	Verify wiring to voltage sensing of controller.
	Incorrect Personality Profile in controller.	Check Alternator Manufacturer setting: FRII or FRX alternators should use Alternator Manufacturer = Kohler, 4D Alternators should use Alternator Manufacturer = Kohler Wound Field
	Incorrect voltage regulation gains.	Verify voltage regulator gains: Normal Gain = 128, Stability = 128
	Incorrect Volts/Hz settings.	Verify that Volts/Hz Cut-In (knee) frequency is at least 0.5Hz below full-load operating frequency.
	Engine hunting problem.	Verify that engine is operating stably. Verify fuel supply, pressure regulator (if equipped) fuel filters (if equipped), water in fuel indicator (if equipped).
Voltage decreases as load increases and does not recover	Reactive droop is set too high.	Reactive droop should be set between 0.0% and 1.0% in single-generator applications. Reactive Droop should be set between 1.0% and 4.0% in paralleling applications.
	Voltage regulator gain is set too low.	Voltage regulator gain should be set to at least 16.
	Missing wiring between alternator and activator board.	The activator on FRX and 4D alternators requires 3-phase input (all three wires should be connected).
Voltage dips when load is applied, but recovers relatively quickly	Normal operation.	Sudden increases in reactive load on the generator will cause the voltage to dip momentarily. Large increases in load on the engine (real load) will cause the frequency to dip, resulting in voltage dip from underfrequency unload in voltage regulator.
	Excessive motor loading.	Large motor loads will cause the voltage on the generator to dip significantly. To determine the motor lock-rotor kVA that a generator will support at a given voltage dip, consult the data sheet for the alternator.
	Large transformers, lighting ballasts, UPS battery chargers, or VFDs powering up.	Many non-linear devices will demand very large inrush currents until an internal power bus is charged.

Symptom	Potential Causes	Troubleshooting
Voltage overshoots when load is removed	Normal operation.	Sudden decrease in reactive load on a generator will result in short-duration voltage spikes on the alternator. The spike duration and magnitude is minimized by the fast response alternator.
	Large motor tripping off while attempting to start.	Ensure that the motor is within the capability of the generator. Compare the motor locked-rotor kVA with the appropriate voltage dip on the alternator data sheet. It is not recommended to attempt to start a motor with a locked-rotor kVA that is greater than what would cause a 35% voltage dip.
	Large transformers or lighting ballasts disconnecting from the generator.	Lighting controllers and other 'smart' devices can cause strange loading scenarios on generators. It may be necessary to reconfigure the devices in order to get the system to operate as intended.
Excessive voltage	Incorrect connection of voltage sensing leads.	Voltage sensing leads on the DEC3500 should be connected to L1, L2 and L3 of the generator. Center Taps V7, V8 and V9 are not to be used with this controller.
	Missing/disconnected voltage sensing lead.	The controller regulates the average of the three line voltages to the target. If a single phase is lost, the controller will attempt to bring the average back to match the target.
	Incorrect controller configuration.	If the alternator is wired for single-phase and the controller is configured for three-phase, the generator will output excessive voltage.
		If the controller is configured for too high of voltage, the generator will output excessive voltage.
	Damaged activator board.	If the activator board fails to a full-on condition, the alternator will probably produce excessive voltage.
	Damaged controller.	If the controller fails to request a full-on condition from the activator board, the alternator will probably produce excessive voltage.
	Damaged alternator.	If the alternator develops an internal short circuit on one of the windings, the other windings may generate excessive voltage.
Unstable Voltage (Single Generator)	Unstable only at no load.	Check lead connections to studs for activator board.
		Ensure good connection for 3B and 5B wiring to LED board and in controller connector.
	Unstable under load.	Decrease reactive droop.
		Check engine speed stability.
		Check for rapidly varying load.
Unstable Voltage (Parallel Operation)	Unstable only in parallel, external voltage controls: 1. External control gains too high.	Verify instability of voltage bias.
	2. Internal droop setting too low.	Verify droop requirements of external controls.
	3. External controls not providing voltage control.	May require calibration, target, and/or droop adjustment in the controller.
	Unstable in parallel, PGEN paralleling.	Adjust voltage regulator gain down to 32 and stability down to 64.
		Adjust kVAR sharing gains (decrease I gain, increase D gain, decrease P gain). NOTE: These changes will slow the response of kVAR control. Verify that the system still corrects kVAR quickly enough on breaker closure.

7.11 Troubleshooting—Genset Controller

Symptom	Potential Causes	Troubleshooting
Engine does not crank	A fault is active.	Verify that E-Stop, auxiliary fault, and other latching faults are inactive before attempting to start the generator.
	Low battery condition.	The generator controller may reset when a crank sequence is initiated. If not, monitor the battery voltage while cranking to ensure that it remains above 10V.
	Missing, damaged, incorrect wiring to the starter.	Verify that the starter is receiving battery voltage to the large post on the solenoid. Verify that the 71 wire to the starter solenoid is activating when the engine is signaled to start.
	Start relay is damaged or inoperative.	Most applications drive the starter solenoid with a pilot relay. Verify that the pilot relay is supplied with battery voltage and that it is activating when the 71 wire output from the controller turns on. **Note:** The 71 wire will appear to be supplying battery voltage if all that is connected to it is a multimeter. The multimeter must be connected across the coil of the relay while the relay is plugged in.
	Starter is damaged or inoperative.	If the starter is receiving the appropriate signals, but the engine is not rotating, the starter or solenoid may be inoperative.
	Engine is unable to turn.	In some cases, the engine may be experiencing mechanical interference or damage that will not let it turn. Verify that the engine will turn with a breaker bar or ratchet on the bolt in the front pulley.
Engine cranks but does not start	Controller fault.	The generator controller is stopping the engine due to a fault before the engine is able to start. Additional troubleshooting will vary based on the fault that occurs.
	Loss of fuel prime.	If the engine progresses through a full crank cycle without starting, it is entirely possible that it is not receiving fuel. Manual priming may be required to get the engine to start.
	Air in fuel.	A pinhole in a fuel line or a trapped air pocket from assembly can inhibit an engine from starting. Manual priming and bleeding the system may be required to clear the air pocket and start the engine.
	Missing, damaged, incorrect wiring to the fuel solenoid or ECM.	If the ECM or fuel solenoid is not powered up while cranking, the engine will not be able to start. The fuel solenoid power can be verified with a multimeter and it should click when the engine is signaled to start. The ECM is powered if the controller is able to sense engine speed while cranking.
	ECM fault code.	If the ECM has a fault, it may not permit the engine to start. Further troubleshooting will depend on the fault that is present.
	Damaged or inoperative component in fuel system.	A fuel pump failure, pressure regulator failure, fuel solenoid failure, or electrical problem in a control system may prevent the engine from starting. Refer to the engine service manual for expected fuel pressures and component checkout procedures.
	Damaged or inoperative run relay.	If the ECM or fuel solenoid is not receiving power, the run relay may not be activating or making contact.
Run relay overload	Damaged or inoperative run relay.	Run Relay Overload means that the current on the Run Relay has exceeded 10A for 10ms. If the coil on the run relay is shorted, it will draw more than 10A.
	Faulty component fed by 70 wire.	If additional components (other than the run relay) are fed by the 70 wire from the controller, any of them could have developed an internal short-circuit that will draw more than 10A.
	Short circuit in wiring of 70 wire from controller.	The 70 wire may be short-circuited to ground. A multimeter between the 70 wire in P1 to the controller and ground should indicate if a short circuit is present.
	Too many devices on 70 wire.	Field-installed devices that are activated by the 70 wire from the controller may cause the current draw to exceed 10A. These devices should be powered through a pilot relay in this case.

Symptom	Potential Causes	Troubleshooting
Start Relay Overload	Damaged or inoperative crank relay.	Start Relay Overload means that the current on the Start Relay has exceeded 10A for 10ms. In systems where the 71 output from the controller drives a pilot relay to operate the starter solenoid, the coil on the relay may be short-circuited, causing the current draw on the 71 wire to exceed 10A.
	Damaged or inoperative starter solenoid.	In systems where the 71 wire from the controller directly drives the starter solenoid, an inoperative solenoid may draw more than 10A. It may be sufficient to add a pilot relay to drive the starter solenoid.
	Mag pickup wiring damaged.	The controller requires a speed signal from a mag pickup in non-ECM applications. Without a signal from the mag pickup, the controller does not know that the engine is turning. The wiring from the mag pickup may have been damaged to interrupt the signal.
	Mag pickup damaged or mal-adjusted.	If the mag pickup is damaged, misaligned or mal-adjusted, the controller will not be able to detect engine rotation and will fault for a locked rotor condition.
	Low battery charge, weak battery, or corroded battery terminals.	If the crank relay is dropping out as soon as the starter engages, the engine will not turn, but the controller may remain powered up throughout the event. The start relay and solenoid will make a chattering noise in this condition.
	Missing, damaged, incorrect wiring to the starter.	If the engine is not turning, Verify that the starter is receiving battery voltage to the large post on the solenoid. Verify that the 71 wire to the starter solenoid is activating when the engine is signaled to start.
	Start Relay is damaged or inoperative.	Most applications drive the starter solenoid with a pilot relay. Verify that the pilot relay is supplied with battery voltage and that it is activating when the 71 output from the controller turns on. **Note:** The 71 wire will appear to be supplying battery voltage if all that is connected to it is a multimeter. The multimeter must be connected across the coil of the relay while the relay is plugged in.
	Starter is damaged or inoperative.	If the starter is receiving the appropriate signals, but the engine is not rotating, the starter or solenoid may be inoperative.
	Engine is unable to turn.	In some cases, the engine may be experiencing mechanical interference or damage that will not let it turn. Verify that the engine will turn with a breaker bar or ratchet on the bolt in the front pulley.
Over Crank	Loss of fuel prime.	If the engine progresses through a full crank cycle without starting, it is entirely possible that it is not receiving fuel. Manual priming may be required to get the engine to start.
	Air in fuel.	A pinhole in a fuel line or a trapped air pocket from assembly can inhibit an engine from starting. Manual priming and bleeding the system may be required to clear the air pocket and start the engine.
	Missing, damaged, incorrect wiring to the fuel solenoid or ECM.	If the ECM or fuel solenoid is not powered up while cranking, the engine will not be able to start. The fuel solenoid power can be verified with a multimeter and it should click when the engine is signaled to start. The ECM is powered if the controller is able to sense engine speed while cranking.
	ECM fault code.	If the ECM has a fault, it may not permit the engine to start. Further troubleshooting will depend on the fault that is present.
	Damaged or inoperative component in the fuel system.	A fuel pump failure, pressure regulator failure, fuel solenoid failure, or electrical problem in a control system may prevent the engine from starting. Refer to the engine service manual for expected fuel pressures and component checkout procedures.
	Weak or damaged battery.	A weak battery or battery with a shorted cell may result in a crank speed too slow for the engine to start.
	Starter is damaged or inoperative.	The engine may not be able to start if it turns too slowly. A weak starter may result in slow rotating speed.
ECM Communication Loss	Damaged or inoperative Run Relay.	The fault requires that the ECM establishes communications and then loses it. It is possible that the Run Relay is dropping out or has an intermittent connection. Verify that the ECM is retaining power until the shutdown occurs.
	Intermittent CAN wiring connection.	Loose wiring will often vibrate on startup and cause an intermittent connection. Check connections on CAN wiring to ensure that they are tight and all crimps are well formed and making good electrical connections.
	Missing, damaged or incorrect wiring to supply power to ECM.	The ECM communication may drop out if the power supply to the ECM is intermittent. Verify wiring through all connectors to the ECM.
	Connection of additional devices to engine CAN.	Additional devices include CAN analysis tools, 3rd-party data logging solutions, ECM diagnostic software, etc. Any of these devices may cause additional traffic on the CAN lines that may cause the controller to lose communication with the ECM.
Speed Sensor Fault	Engine stalled unintentionally.	The engine stopped rotating without the controller telling it to stop. This could be caused by a loss of fuel, an external stop signal, or an unannounced ECM fault.
	Mag pickup wiring intermittent.	On non-ECM engines, this fault may indicate that the signal from the mag pickup was lost unexpectedly (which could be caused by bad wiring to the mag pickup). Review the wiring to the mag pickup, checking for loose connections on terminals and crimp joints.
	Mag pickup mal-adjusted.	A mal-adjusted mag pickup can work intermittently, it may also provide a temperature-related signal (as parts expand). Verify that the mag pickup is adjusted per the factory specifications.

Symptom	Potential Causes	Troubleshooting
ECM Mismatch Error	Incorrect configuration.	This error indicates that the ECM reported a different model type than the generator controller was expecting. The controller may have an incorrect personality profile loaded in it.
	Incorrect part replacement.	If the ECM was recently replaced, verify that it is the correct part and that it has the correct calibration in it. If it is a newer revision, check for an updated personality or firmware for the generator controller.

7.12 Troubleshooting—Paralleling

Symptom	Potential Causes	Troubleshooting
System voltage high	A generator in the system is configured to an incorrect, lower voltage setting.	Verify that all generators in the system are configured so that their system voltage matches the site requirements.
	This generator is configured to an incorrect, higher voltage setting.	Verify that all generators in the system are configured so that their system voltage matches the site requirements.
System voltage low	A generator in the system is configured to an incorrect, higher voltage setting.	Verify that all generators in the system are configured so that their system voltage matches the site requirements.
	This generator is configured to an incorrect, lower voltage setting.	Verify that all generators in the system are configured so that their system voltage matches the site requirements.
System frequency high	A generator in the system is configured to 50 Hz in a 60 Hz application.	Verify that all generators in the system are configured so that their system frequency matches the site requirements. It is possible that one of the generators will have to be reconfigured to operate at a different speed.
	This generator is configured to 60 Hz in a 50 Hz application.	Verify that all generators in the system are configured so that their system frequency matches the site requirements. It is possible that one of the generators will have to be reconfigured to operate at a different speed.
System frequency low	A generator in the system is configured to 60 Hz in a 50 Hz application.	Verify that all generators in the system are configured so that their system frequency matches the site requirements. It is possible that one of the generators will have to be reconfigured to operate at a different speed.
	This generator is configured to 50 Hz in a 60 Hz application.	Verify that all generators in the system are configured so that their system frequency matches the site requirements. It is possible that one of the generators will have to be reconfigured to operate at a different speed.
System phase connection mismatch	A generator in the system is configured to an incorrect phase connection (single-phase, delta, or wye).	Ensure that all generators in the system have an identical phase connection and that the connection matches the site requirements. **Note:** Single-phase dog-leg should not be used as a phase connection type.
	This generator is configured to an incorrect phase connection (single-phase, delta, or wye).	Ensure that all generators in the system have an identical phase connection and that the connection matches the site requirements. **Note:** Single-phase dog-leg should not be used as a phase connection type.
Generator Management mismatch (on the Decision-Maker® 3500 controller: Generator Management Enabled: Erroneous Data Received)	The Generator Management Stable Delay is different on at least one of the nodes in the system.	Either change the Generator Management Stable Delay on one generator in the paralleling system (which will update all of them) or check each generator to determine the one that doesn’t match.
	The Generator Management Min Gens Online parameter is different on at least one of the nodes in the system.	Either change the Generator Management Min Gens Online parameter on one generator in the paralleling system (which will update all of them) or check each generator to determine the one that doesn’t match.
	The Generator Management Minimum Load Shed Priority parameter is different on at least one of the nodes in the system.	Either change the Generator Management Minimum Load Shed Priority parameter on one generator in the paralleling system (which will update all of them) or check each generator to determine the one that doesn’t match.
	The Generator Management Runtime Threshold is different on at least one of the nodes in the system.	Either change the Generator Management Runtime Threshold on one generator in the paralleling system (which will update all of them) or check each generator to determine the one that doesn’t match.
	The Generator Management Fuel Difference Threshold is different on at least one of the nodes in the system	Either change the Generator Management Fuel Difference Threshold on one generator in the paralleling system (which will update all of them) or check each generator to determine the one that doesn’t match.

Symptom	Potential Causes	Troubleshooting
Phase angle fault	The bus wiring is not connected correctly on the load side of the generator paralleling breaker.	Verify bus measurement wiring.
	The paralleling breaker is indicating closed when it is actually open.	Verify breaker status accuracy by watching the status on the screen and manually operating the breaker while no generators in the paralleling system are running.
Breaker current fault	The generator has loads that are attached on the generator side of the paralleling breaker.	All loads fed by the generator should be connected downstream of the paralleling breaker. If a fire pump breaker is required, the current fault should be adjusted to accommodate the fire pump current.
	The generator breaker is closed, but is indicating open.	Verify breaker status accuracy by watching the status on the screen and manually operating the breaker while no generators in the paralleling system are running.
Failure to synchronize	The load is changing too frequently to synchronize.	Observe the frequency and voltage of the paralleling bus to ensure that they are are not changing too quickly. If so, try to find which load are causing the problem and inhibit them from receiving power until more generators are online (if possible).
	The synchronizing gains are not calibrated correctly.	Some application may require adjustment of the paralleling gains.
Close attempt fault (Fail to Close Delay: Device Out of Order) but no Failure to Close	First-On close delay or Dwell Time is too short.	Ensure that the trip relay is energizing enough before the close relay energized to remove any inhibiting mechanism tied to the trip coil.
	External protection inhibiting breaker closure.	If 3rd-party protective relays are used for permissive functions, ensure that the window on the protective relays is wider than the window on the controller. If the protective relay is not changeable, adjust the controller to be tighter than the protective relay.
	Intermittent wiring to circuit breaker.	Check wiring to circuit breaker to ensure that all connections are tight.
Failure to Close (Max Close Attempts: High)	Remove Breaker Trip not configured to Digital Output 115 or Digital Output 115 not enabled.	Verify configuration in SiteTech for Digital output 115.
	Close Breaker not configured to Digital Output 116 or Digital Output 116 not enabled.	Verify configuration in SiteTech for Digital output 116.
	No power supply to circuit breaker.	Verify that charge motor operates on motor-operated breaker.
	Incorrect wiring between terminal block and breaker relays.	Make sure that trip and close relays operate properly. Changing the event for digital output 115 and 116 to not in auto will allow for simpler troubleshooting, as pressing the off button will signal the breaker to close and pressing the auto button will signal the breaker to trip. **Note:** Make sure that Digital outputs 115 and 116 are set back to remove breaker trip and close breaker with troubleshooting is complete.
	Incorrect wiring between terminal block and circuit breaker.	Verify the wiring between the circuit breaker and the breaker close relay.
	No status feedback from circuit breaker and no bus sensing connected.	Verify that bus sensing is connected to load side of the circuit breaker. Verify the breaker status wiring is connected correctly.
	SDE contact not installed correctly.	Some circuit breakers require a contact in the SDE position of the circuit breaker in order for the motor operator to operate correctly. Verify that the SDE contact is installed per the wiring diagram for the breaker.
Failure To Open (Fail to Open Delay: Device Out of Order)	Trip wiring not installed or connected incorrectly.	Verify the wiring between the circuit breaker and the breaker trip relay.
	Breaker status wired to incorrect terminals.	The breaker status feedback (BSP and BSN) should be connected to terminals 1 and 4 (11 and 14) of the circuit breaker.
Continued breaker cycling	No breaker status feedback with bus sensing connected.	Verify the breaker status wiring is connected correctly.
	Remove breaker trip is not wired to the normally closed contact on the relay.	Verify that breaker trip relay is wired per the wiring diagram.

Symptom	Potential Causes	Troubleshooting
Breaker will not close to a live bus (but no fault is issued)	Synch Mode is set to check or off.	Verify that Synch Mode in Run is set to Active if operating the generator using the run button on the front panel. Verify that Synch Mode in Auto is set to Active if operating the generator using the remote start signal.
	Synch disabled is on.	Verify that the Disable Synchronization is not active.
	Bus phase rotation does not match generator.	Verify that Bus phase rotation and generator phase rotation match (using SiteTech or the controller UI). If they don't, close the generator breaker to a dead bus to ensure that the generator bus sensing is connected correctly. Phase rotation should match and phase angle should read between - 5° and 5° when the generator is running and the breaker is closed.
	Bus load is varying too quickly.	Observe the frequency and voltage of the paralleling bus to ensure that they are are not changing too quickly. If so, try to find which load are causing the problem and inhibit them from receiving power until more generators are online (if possible).
	Synchronizing gains are incorrectly calibrated.	Some application may require adjustment of the paralleling gains.
	Bus voltage and/or frequency is out of the normal operating range.	Make sure that enough load is connected to load management outputs that the system can reduce the load to a level that a single generator can handle.
Breaker will not close to a dead bus (but no fault is issued)	Synch Mode is set to off.	Verify that Synch Mode in Run is set to Check or Active if operating the generator using the run button on the front panel. Verify that Synch Mode in Auto is set to Check or Active if operating the generator using the remote start signal.
	Synch Disabled is on.	Verify that the Disable Synchronization is not active.
	No communications with other generator.	Check if the number of PGEN nodes is >1 (found under Controller Config -> Communication Setup on UI, or under Synchronization Control in SiteTech).
	Generator perceives bus as not being dead.	Check bus metering. Must be below the dead bus level as a percentage of system voltage. Check for loose connections and stray voltage on bus. Verify that bus is truly dead. If bus has stray voltage on it, it may be necessary to adjust the dead bus percentage up to accommodate the stray voltage.
	Another generator is indicating that it is closed to the bus.	Make sure that all other generators in the paralleling system are disconnected from the paralleling bus and are reporting breaker position correctly.

8.1 General Repair Information

This section contains Decision-Maker® 3500 controller repair information. Service part replacement of the controller is limited to the items shown with an asterisk (*) in Figure 8-1. Refer to the parts catalog for service part numbers. No other replacement service parts are available.

Before replacing the controller, remove all external accessories and other electrical connections to verify that these items are not the cause of the controller problems. Verify that the accessories and connections are functioning correctly before reconnecting them to the new controller.

Electrical noise can affect the controller operation, refer to Appendix F, Electrical Noise and Wiring Practices.

The controller receives input signals from several senders/sensors that provide fault warnings and shutdowns that can be tested for proper function. Simulating these conditions may be helpful in troubleshooting the generator set. Refer to Section 9.9, Fault Warning and Shutdown Testing.

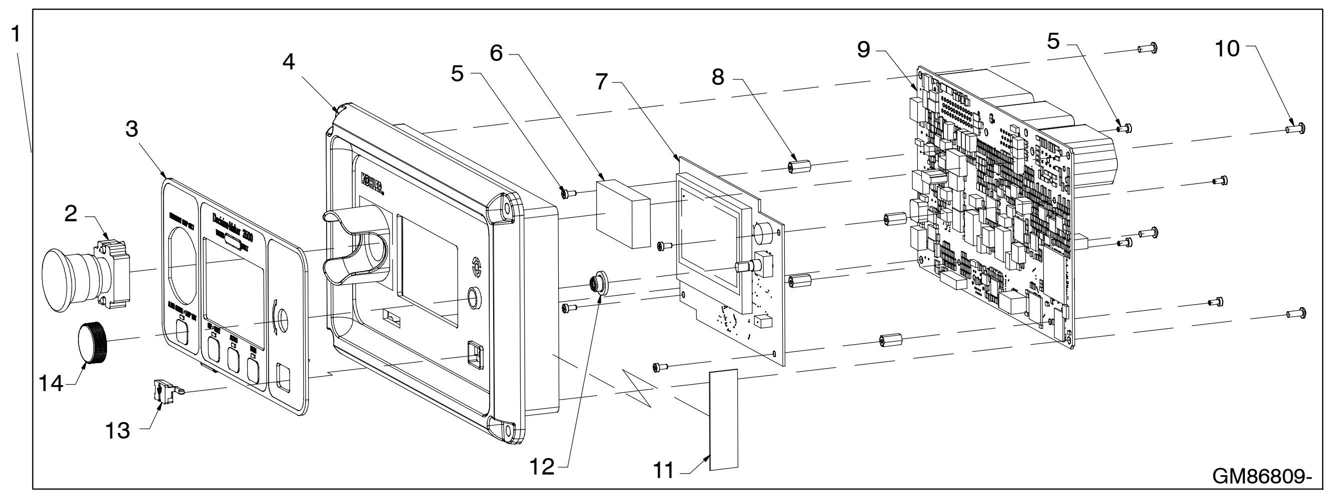
Go to the Overview Menu and verify that the Software (SW) Version is correct for the generator set model and alternator voltage. Use the operation manual for details regarding accessing the Overview Menu.

Use SiteTech™ software for updating the controller application code.

8.2 SiteTech™ Software

The following items are necessary PC requirements for using the SiteTech™ software.

- **SiteTech™ Software Version 4.1 or higher** by accessing TechTools to download on your PC hard drive or disk if not already installed on your PC.
- **TP-6701 SiteTech™ Software Operation Manual** available by accessing TechTools.
- **USB Cable** with male USB-A and mini-B connectors. See TP-6701.



1. Controller service kit (*)
2. Switch, emergency stop pushbutton (*)
3. Overlay/display, controller
4. Bezel, controller
5. Screw, machine (#4-40)
6. Gasket
7. LCD display
8. Spacer
9. Circuit board, main logic
10. Screw, plastic tapping
11. Label
12. Boot, protective controller
13. Plug, USB (*)
14. Knob, adjustment (*)

Figure 8-1 Decision-Maker® 3500 Controller, Service Replacement Parts Indicated with an asterisk (*)

8.3 Request and Status Messages

Request and Status Messages

Display messages require the user to enter additional data, confirm the previous entry or require time to process as described below.

Entry Accepted appears for several seconds after pressing the Enter key during the programming mode. The display then shows the new data.

Reset Complete indicates the user has successfully:

- Reset the maintenance records,
- Restored the AC analog inputs to the default settings, or
- Restored voltage regulator settings to the defaults.

Right Arrow → directs the user to the next menu. The menus loop; press the right arrow key to move to the next menu.

8.4 Factory Reserved Inputs

Available user inputs are dependent on factory-reserved inputs for specific engine types, engine controls, and paralleling applications. See Figure 8-2 and Figure 8-3 for analog and digital inputs that are not user-selectable.

8.5 Controller Functional Test

The controller operation includes several types of starting and stopping functions as detailed in the operation manual. The controller master control switch buttons, lamps, and alarm horn functions are summarized in Figure 2-3.

Analog Resistive Input	
A1	Oil Pressure (Resistive Sensor 1)
A2	Coolant Temperature (Resistive Sensor 2)
A3	Lloyd's Oil Pressure 2 (Resistive Sensor 3)
A4	High Exhaust Temperature (Resistive Sensor 4)
A5	Unused (Resistive Sensor 5)
A6	Unused (Resistive Sensor 6)
Analog Differential Input	
V1P	Circuit Breaker Status P (Diff. Volt Input 1P) *
V1N	Circuit Breaker Status N (Diff. Volt Input 1N)
V2P	Voltage Bias P (Diff. Volt Input 2P) *
V2N	Voltage Bias N (Diff. Volt Input 2N)
V3P	Speed Bias P (Diff. Volt Input 3P) *
V3N	Speed Bias N (Diff. Volt Input 3N)
Digital Input	
D1	Optional Low Coolant Level (Digital Input 1)
D2	Optional Low Oil Level (Digital Input 2)
D3	Optional Fuel Leak (Digital Input 3)
D4	Lloyd's High Oil Temperature (Digital Input 4)
D5	Low Seawater Pressure (Digital Input 5)
D6	Lloyd's Low Coolant Pressure (Digital Input 6)
Relay Driver Output	
RDO1	Circuit Breaker Open (RDO1) *
RDO2	Circuit Breaker Close (RDO2) *
RDO3	RDO3 Cold Start
RDO4	RDO4 Relay Output

* Used for Paralleling

Figure 8-2 User Inputs/Factory-Reserved Inputs

Pin No.		Analog	Digital
P1 Main Connector (35-Pin)			
18	Oil Pressure (Resistive Sensor 1) (wire 7)	A1	
30	Coolant Temp (Resistive Sensor 2) (wire 5)	A2	
7	Speed Pickup (+) (BLU)		
8	Speed Pickup (-) (GRN)		
15	Remote Start/Stop (wire 3)		
14	E-Stop (wire 1)		
26	E-Stop (wire 1A)		
34	Digital Input 1 (wire 31)		D1
25	Unused		
22	Digital Input 2 (wire 25)		D2
29	Current Sense CT_I1_P		
17	CT_I2_P		
28	CT_I3_P		
16	CT_IR_N CT Return		
27	Aux Shutdown / EOV (Marathon alternator)		
33	Digital Input 3 (wire 64)		D3
2	Unused		
24	Controller Power (wire P1) (Battery +)		
(Continued) P1 Main Connector (35-Pin)			
3	Controller Ground (wire N4) (Battery -)		
21	Digital Input 4 (Lloyd's High Oil Temp) (wire 69)		D4
31	Return (Analog) Isolated Ground (wire BGA)		
20	Unused		
11	COM (-) Isolated RS485		
12	COM (+) Isolated RS485		
23	PGEN (-)		
35	PGEN (+)		
9	Isolated CAN (+) (CAN 2) (yellow)		
10	Isolated CAN (-) (CAN 2) (green)		
5	Non Isolated CAN (+) (CAN 1) (yellow)		
6	Non Isolated CAN (-)(CAN 1) (green)		
13	Run (Battery +) (wire 70)		
32	Digital Input 5 (Low Seawater Pressure)		D5
19	Resistive Sensor 3 (Lloyd's Oil Pressure 2)	A3	
4	Alternator Excitation Output (wire 38)		
1	Crank Output (line 71)		
P2 Options Connector (14-Pin)			
12	Resistive Sensor 4 (High Exhaust Temperature)	A4	
11	Unused	A5	
10	Unused	A6	
1	Digital Input 6 (Lloyd's Low Coolant Pressure)		D6
2	Diff Volt Input 1P (CB Status*) BSP	V1P	
6	Diff Volt Input 1N (CB Status*) BSN	V1N	
3	Diff Volt Input 2P (Voltage Bias*) VBP	V2P	
7	Diff Volt Input 2N (Voltage Bias*) VBN	V2N	
4	Diff Volt Input 3P (Speed Bias*) SBP	V3P	
8	Diff Volt Input 3N (Speed Bias*) SBN	V3N	
5	RDO1 (CB Open*) CBO		RDO1
14	RDO3 (Cold Start) N7		RDO3
9	RDO2 (CB Close*) CBC		RDO2
13	RDO4 (Relay Output) RD3		RDO4
P3 AC Sensing Connector (7-Pin)			
7	Bus Voltage Sensing* - L1		
8	Bus Voltage Sensing* - L2		
4	Bus Voltage Sensing* - L3		
5	Gen Voltage Sensing - L3 (C)		
2	Gen Voltage Sensing - L2 (B)		
1	Gen Voltage Sensing - L1 (A)		
6	Gen Voltage Sensing - L0 (NEU)		
3	Unused		

* Used for Paralleling

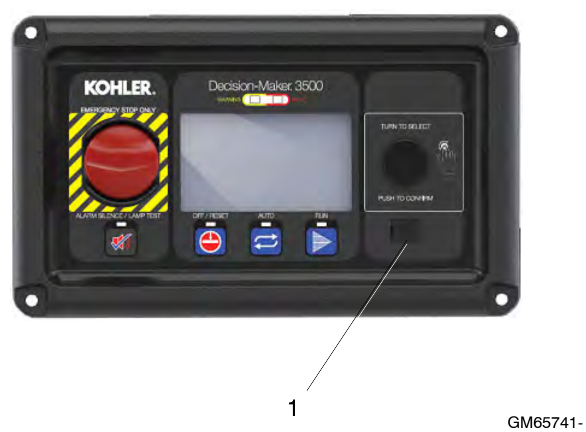
Figure 8-3 Connector (P1, P2, & P3) Designations

8.6 Controller Service Replacement Kit GM92086

Adapted from Installation Instruction TT-1638.

8.6.1 Introduction

The controller service replacement kit is available to replace a non-functional controller. Use the following procedure to install the replacement controller. See Figure 8-4 for controller identification. For features and operation of the controller, see the operation manual.



1. Mini USB connection

Figure 8-4 Decision-Maker® 3500 Controller

Note: Do not use this controller replacement installation instruction for upgrading software.

When replacing the controller, the following data must be resident for the controller to function. Controller service replacement kits do not include the three files installed at the factory. The service technician *must* install the three files into the replacement controller.

- **Application program** contains the software that controls system operation. The application file was preprogrammed in the *original* controller at the factory.

- **Personality profile** is specific to the engine and alternator and was preprogrammed in the *original* controller at the factory.

  A backup disk of the personality profile and application program is supplied with the literature packet shipped with the generator set. Typically, the Kohler authorized distributor/dealer passes this disk onto the owner. The owner should store this disk for possible future use such as controller replacement or other circumstances requiring a backup.

  Note: If the personality disk is NOT available, request a replacement from the manufacturer using the generator set serial number or order number.

- **User parameters** unique to an installation include timer values, setpoints, generator set data such as voltage and input/output selections. These parameters are typically set up for or by the installer at the time of installation. User parameters are typically recorded on the personality profile disk, a separate backup disk/drive, or written on a paper form.

Note: If the user parameters are included on the personality disk, the disk label should indicate Site Program—Yes.

Read the entire installation procedure. Perform the steps in the order shown.

Always observe applicable local and national electrical codes.

Note: The following service kit procedure changes only the controller. If the generator set requires voltage reconnection and/or frequency adjustment, see the installation manual.

8.6.2 Installation Requirements

The following items are necessary PC requirements for installing the controller service replacement kits.

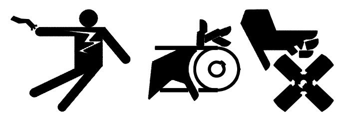
- **SiteTech™ Software Version 4.1 or higher** from the Kohler Power Resource Center website using the TechTools button to download on your PC hard drive or disk if not already installed on your PC.

- **TP-6701 SiteTech™ Software Operation Manual** available from the Kohler Power Resource Center website using the TechTools button.

- **USB Cable** with male USB-A and mini-B connectors. See TP-6701.

8.6.3 Installation Procedure

WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

1. Acquire the user parameters.
   a. Choose one of the following methods to retrieve the user parameters:

- Backup disk. If a backup disk was previously made, obtain the parameters from this disk. If a disk was not previously made, create a backup if possible using the SiteTech™ software. The existing controller must function in order to create the file.
- Paper form. Parameters may have been previously recorded on a User-Defined Settings form or other similar form.
- Controller menu. Manually review the controller menu displays if possible and enter the parameter information in the Decision-Maker® 3500 Operation Manual.

   b. Save the user parameter data for step 6c.

2. Remove the generator set from service.
   a. Press the generator set master control OFF/RESET button.
   b. Disconnect the power to the battery charger, if equipped.
   c. Disconnect the generator set engine starting battery(ies), negative (-) lead first.

3. Remove the existing controller and disconnect the electrical connections.
   a. Remove the junction box panels as needed to access the wiring.
   b. Remove the four controller panel screws.

   Note: Clearly mark all disconnected leads/connectors from the controller with tape to simplify reconnection.

   c. Disconnect the controller harness connectors:

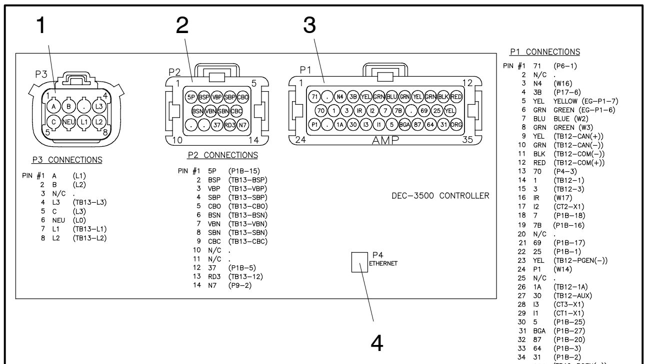
   P1 (35-Pin) Connector for engine/generator wiring harness.

   P2 (14-Pin) Connector for sensor input connections and relay driver output connections.

   P3 (8-Pin) Connector for generator set output voltage sensing and paralleling bus voltage sensing connections.

   P4 (Ethernet) Connector connects to a network communication line**.**

   Note: These connections are typical and may not apply to all applications. See the corresponding wiring diagram found in the respective wiring diagrams manual.



1. P3 (8-pin) connector
2. P2 (14-pin) connector
3. P1 (35-pin) connector
4. P4 Ethernet connector

GM92288A-A

Figure 8-5 Main Circuit Board Connectors

4. Reconnect the electrical connections and install the replacement controller.
   a. Reconnect all of the electrical connections disconnected in step 3.c.
   b. Align the controller panel with the mounting holes and install four screws.
   c. Replace the junction box panels if previously removed.

5. Restore power to the generator set.

   a. Reconnect the generator set engine starting battery, negative (-) lead last.

   b. Reconnect power to the battery charger, if equipped.

6. Set the device profile.

   a. Connect the PC to the Decision-Maker® 3500 controller using a USB cable. See Figure 8-4 for the location of the USB connection port.

   b. Start the SiteTech™ application. Insert the personality profile backup disk/drive and load the data. Refer to the Tech Tools—Software and the SiteTech™ Software Operation Manual for details.

   c. Choose one of the following methods to load the user parameters.

- Backup disk/drive. Use a PC with SiteTech™ software to load the data from the user parameter backup disk/drive.

- Paper form. Use a PC to enter the user parameter data from a filled-out form.

   d. Create a new user parameter data backup disk/drive if any changes are made using SiteTech™ software. Refer to the SiteTech™ Software Operation Manual for details.

   e. Disconnect the USB cable.

   f. Power down the unit by using the battery disconnect switch (if equipped) or by disconnecting the battery negative (-) terminal.

   g. Wait at least 15 seconds and then power up the unit by using the battery disconnect switch (if equipped) or by reconnecting the battery negative (-) terminal.

   h. Refer to the Decision-Maker® 3500 Operation Manual TP-6861. Calibrate the generator set as instructed in the Calibration submenu.

   i. Press the RUN button to start the generator set.

   j. Test the functionality of the controller by reviewing the menus and observing the system status lamps. Use the Operation Manual as needed.

   k. Press the OFF button to stop the generator set after completing the test.

   l. Reconnect the generator set to load by closing the line circuit breaker.

   m. Press the generator set master control AUTO button for startup by remote transfer switch or remote start/stop switch.

8.7 Synchronizing Test

Synchronizing is the action of matching the RMS voltage amplitude, cycle frequency and phase of the generator with the paralleling bus. The paralleling logic contains a synchronizer which controls the engine speed and voltage regulator RMS target to actively match the frequency, voltage and phase of the generator to the bus. The decision to close the paralleling breaker is determined by a synchronism check function (ANSI relay 25C). The synchronization check function also includes a dwell timer. If the frequency, voltage and phase of the generator do not match the frequency, voltage and phase of the paralleling bus, closing the generator breaker may cause damage to the generator due to large circulating fault currents and mechanical stress generated by the power angle between the two generators. Follow the Synchronizing Test below.

Synchronizing Test Sequence

1. Navigate to the **Synchronizing Setup Menu** (under the Paralleling Operation Menu).
2. Place the Sync Mode in Auto to OFF.
3. Place the Sync Mode in Run to CHECK.
4. Scroll down until the Phase Difference, Phase Match P (Proportional) Gain, Phase Match I (Integral) Gain, Phase Match D (Derivative) Gain, and Speed Bias are highlighted.
5. Provide the generator set with a start signal (AUTO-RUN).
6. Allow another generator set to start and close to bus.
7. Press the AUTO button to start, watch the screen until the phase difference is at 30 degrees, press the RUN button to observe sync behavior. Make any necessary adjustments.
8. Press the AUTO button again, watch the screen until the phase difference is at 60 degrees, press the RUN button to observe sync behavior. Make any necessary adjustments.
9. Repeat steps 7 and 8 above for 30, 60, 90, 120, 150, 180, -150, -120, -90, -60, -30, and 0 degrees. Verify minimal overshoot in all cases,.
10. If overshoot is observed, try increasing the P (Proportional) Gain first.
11. If overshoot does not improve, set the P (Proportional) Gain to 1.00 and try decreasing the I (Integral) Gain. If the phase difference does not stay within the window, it may be necessary to decrease to P (Proportional) Gain slightly.

Notes

This section provides testing and troubleshooting information on select controller and generator set accessories.

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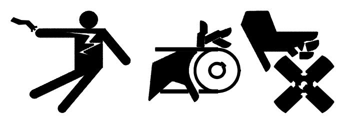
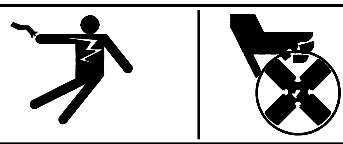


Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

WARNING



Hazardous voltage. Moving parts.
Can cause severe injury or death.

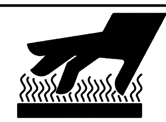
Operate the generator set only when all guards and electrical enclosures are in place.

Disconnecting the electrical load. Hazardous voltage can cause severe injury or death. Disconnect the generator set from the load by turning off the line circuit breaker or by disconnecting the generator set output leads from the transfer switch and heavily taping the ends of the leads. High voltage transferred to the load during testing may cause personal injury and equipment damage. Do not use the safeguard circuit breaker in place of the line circuit breaker. The safeguard circuit breaker does not disconnect the generator set from the load.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

WARNING

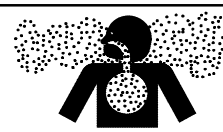


Hot engine and exhaust system.
Can cause severe injury or death.

Do not work on the generator set until it cools.

Servicing the exhaust system. Hot parts can cause severe injury or death. Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

WARNING



Carbon monoxide.
Can cause severe nausea, fainting, or death.

The exhaust system must be leakproof and routinely inspected.

Carbon monoxide symptoms. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is a poisonous gas present in exhaust gases. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Carbon monoxide poisoning symptoms include but are not limited to the following:

- Light-headedness, dizziness
- Physical fatigue, weakness in joints and muscles
- Sleepiness, mental fatigue, inability to concentrate or speak clearly, blurred vision
- Stomachache, vomiting, nausea

If experiencing any of these symptoms and carbon monoxide poisoning is possible, seek fresh air immediately and remain active. Do not sit, lie down, or fall asleep. Alert others to the possibility of carbon monoxide poisoning. Seek medical attention if the condition of affected persons does not improve within minutes of breathing fresh air.

Inspecting the exhaust system. Carbon monoxide can cause severe nausea, fainting, or death. For the safety of the craft's occupants, install a carbon monoxide detector. Never operate the generator set without a functioning carbon monoxide detector. Inspect the detector before each generator set use.

Operating the generator set. Carbon monoxide can cause severe nausea, fainting, or death. Be especially careful if operating the generator set when moored or anchored under calm conditions because gases may accumulate. If operating the generator set dockside, moor the craft so that the exhaust discharges on the lee side (the side sheltered from the wind). Always be aware of others, making sure your exhaust is directed away from other boats and buildings.

NOTICE

Electrostatic discharge damage. Electrostatic discharge (ESD) damages electronic circuit boards. Prevent electrostatic discharge damage by wearing an approved grounding wrist strap when handling electronic circuit boards or integrated circuits. An approved grounding wrist strap provides a high resistance (about 1 megohm), *not a direct short*, to ground.

9.1 Controller Handling

The controller contains an electronic printed circuit board (PCB) that is sensitive to a variety of elements and can be damaged during removal, installation, transportation, or storage. Observe the following when working with the controller.

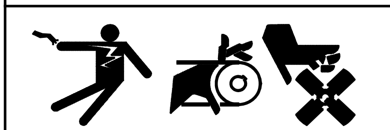
9.1.1 Handling

- Don't bend or drop the controller or any of its components.
- Don't strike the controller or any of its components with a hard object.
- Clean a dusty or dirty controller only with a vacuum cleaner, dry brush, and/or aerosol spray cans specifically for electronic equipment and components. Aerosol spray cans are typically found with computer supplies.
- Never attempt component-level circuit repairs as this may void third party certification.
- Never remove or install a controller with the power connected.
- Label wiring when disconnecting it for reconnection later.
- Remove wiring harnesses with plug connectors by pressing the locking tab(s) and pulling on the plug straight out to remove the wiring harness plug from the controller socket.
- Use caution when removing a controller in a paralleling system. If another generator set is running, the controller's harness pins may be energized.
- If the start signal to a paralleling system is only provided to one controller, consider using the emergency stop instead of cycling power on the controller otherwise the entire system may stop. Pressing the AUTO-RUN on another generator set before cycling power avoids this situation.

9.2 Other Service Parts

The removal and installation of service parts is covered by the following generic procedure. Service parts include plug-in relays, switches, lamps, meters, gauges, brackets, and other hardware.

WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

9.2.1 Removal

1. Disconnect wiring from the part(s), noting the locations from which wiring was removed for later reconnection. Tape and label the wires as needed.

2. Note the position of the part(s) and loosen or remove hardware that holds the part(s) in place. If the removal is complex or will span several days, make sketches or use a video recorder or digital camera to help capture the detail.

   Note the location, type, and condition of the hardware removed and compare it with the parts list. Replace damaged or missing hardware.

3. Carefully remove the part(s) from the unit. Gently rock plug-in parts, such as relays, from side to side while pulling straight out to remove them without bending the circuit boards.

9.2.2 Installation

1. Position the part(s) in place in the same manner that the old part was installed. Support the back of the socket when installing plug-in parts, such as relays and wiring harness plugs.

2. Tighten or reinstall hardware that holds the part(s) in place to the general torque specifications in Appendix C, General Torque Specifications, unless otherwise noted.

   If the torque specifications do not cover the application or do not seem appropriate let common sense prevail. Avoid overtorquing hardware in sheet metal and non-metallic composites.

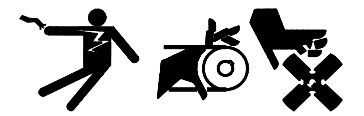
3. Reconnect wiring to the same location from which it was removed, torquing terminals to the specifications given in Section 1, Specifications.

9.3 General Information

Use the respective parts catalog to determine the appropriate replacement part. Sometimes service kits replace a given part where additional components in the kit are necessary to provide the functional component equivalent. The parts catalog illustrations may serve as a guide for replacement but be aware that multiple models are generally illustrated in a single view and details may not represent the specific application.

9.4 Leads/Wires/Connectors/ Wiring Harnesses

WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

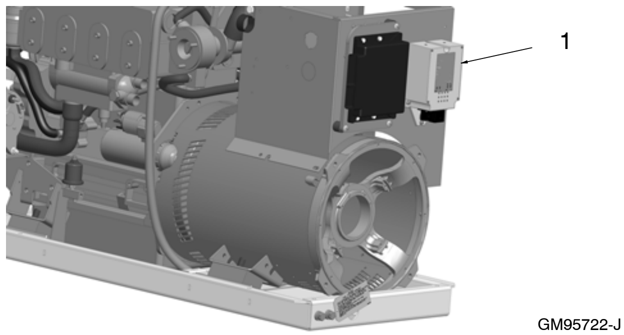
Repair/replace wiring when there is any doubt about its condition. Tape minor control circuit wire insulation cuts or abrasions less than 1 mm (0.04 in.) across by wrapping the section tightly with three layers of electrical tape.

Repair moderately damaged leads, where conductors are cut or insulation is damaged over sections shorter than about 100 mm (4 in.) or less than about 25% of the length of the wire by cutting out the damaged section and splicing in wire of the same type.

Replace extensively damaged or deteriorated leads completely. If the leads are part of a wiring harness, replace entire wiring harness. Fabricate replacement leads using the same type of wire as the old leads. Add terminals and lead markers at each end of the new load.

9.4.1 24- to 12-Volt Converter (32/40EKOZD and 28/35EFKOZD 24-Volt Models Only)

If replacing the converter, carefully disconnect the two connectors as follows.

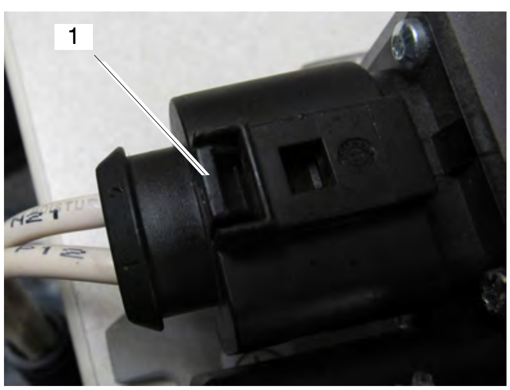


1. Converter (24-Volt Models)

Figure 9-1 Converter Location (24-Volt Models)

Small Connector (with Black Tab)

1. Pull the black tab down on the connector until it clicks. See Figure 9-2.
2. Gently slide the connector off of the converter. See Figure 9-3.



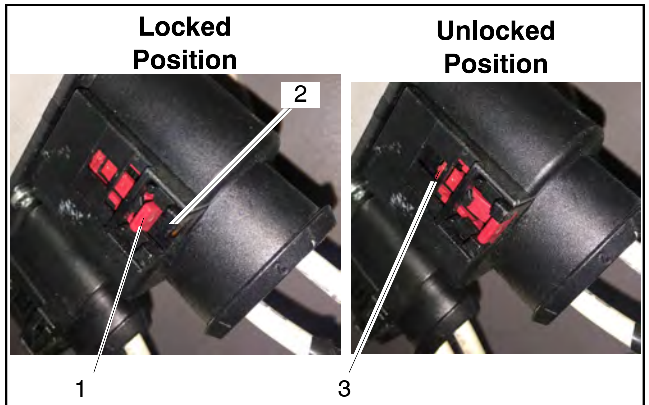
1. Black tab

Figure 9-2 Release the Small Connector (with Black Tab)

Figure 9-3 Remove the Small Connector

Large Connector (with Red Tab)

1. Pull the locking red tab down.
2. Press the red and black tab downward and inward to raise the area of the connector shown in Figure 9-4.
3. Gently slide the connector off of the converter. See Figure 9-5.



1. Red tab
2. Black tab
3. Red tab with the end raised

Figure 9-4 Locked/Unlocked Position

Figure 9-5 Remove the Large Connector

9.5 Crank Relay

The test procedure for the following crank relay (Figure 9-6) applies to other applications of the same type relay including:

- Crank relay
- Run relay
- Cold start relay
- Flash relay

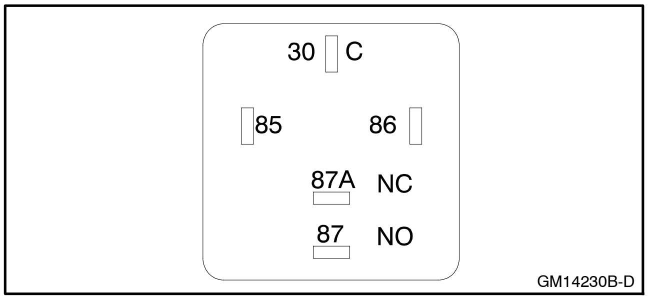


Figure 9-6 Crank Relay Contacts

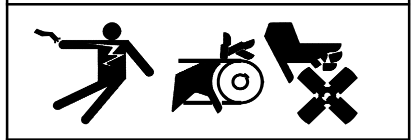
The relay is a single-pole, double-throw relay. Contacts 85 and 86 are the relay coil. See Figure 9-7 for specifications by relay part number. If replacement is necessary, do not substitute part numbers.

Relay Part Number	Coil Voltage VDC	Coil Resistance, ohms	NO/NC Contacts Rating, Amp
GM49746*	12	90 ±10	50/30
GM49747*	24	360 ±10	20/15
* These relays contain an integrated diode that may affect ohmmeter values when checking coil resistance. Be sure to check coil resistance with the ohmmeter leads connected both ways to help verify relay functionality and prevent unnecessary replacement.			

Figure 9-7 Relay Specifications

9.6 Current Transformers

WARNING

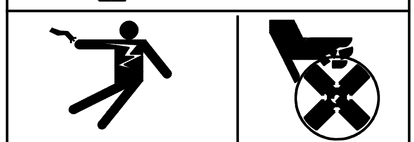


Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

WARNING



Hazardous voltage. Moving parts.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

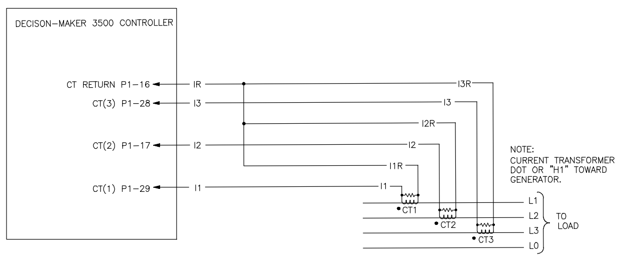
Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

9.6.1 Function and Application

The current transformers provide generator set function including signal/drive for controller sensing of alternator AC current.

See Figure 9-8. The generator set junction box contains the stator leads and the current transformers.

When replacing the current transformer or stator assembly, install the current transformer according to the generator reconnection decal on the generator set, or see the wiring diagrams. Observe the correct current transformer position when installing the stator leads. The current transformer dot or HI mark position and the stator lead direction are essential for correct component function. The dot or HI mark should face toward the stator.



See the full wiring diagram in Section 17.

ADV8672-

Figure 9-8 Current Transformers

Two styles of current transformers are used. Round (doughnut) styles have black/white leads with no mounting provisions. The square styles have two #8-32 studs/nuts for connecting the leads and four notches in the base for mounting.

A current transformer contains a coil of wire that induces a secondary voltage/current from the primary or stator lead passing through the center. The number of coil turns inside the current transformer determines the ratio. Replacement current transformers must have the same ratio as the original.

9.6.2 Testing

Use an ohmmeter to check the current transformer. Perform this test with the current transformer disconnected from the generator set. A resistance reading of infinity or 0 ohms suggests an open or shorted current transformer that needs replacement. Consider any other resistance reading acceptable.

9.7 Engine Pressure and Temperature Sensors

9.7.1 General

Use this section to test engine sensors (switches or senders) installed by the generator set manufacturer on the engine. Refer to the respective engine service manual for testing sensors installed by the engine manufacturer.

Use the following tests to determine if the engine sensor installed by the generator set manufacturer is functional. All sensors should have part numbers stamped on the metal housing. In cases where the number is illegible or missing, refer to the respective generator set parts catalog for the corresponding part number. The user must determine the sensor part number in order to determine the sensor specifications which are found in Section 1, Specifications.

The sensors can be installed on the generator set provided the leads are disconnected and a temperature or pressure gauge is available to determine the engine values. Otherwise, remove the sensor after draining the respective engine fluid (oil or coolant) and test using a separate pressure or temperature source.

The resistance of the oil pressure and water temperature sender output signals varies as the respective pressure and temperature change. Use the resistance change for verification of sender function. Disconnect all leads from the sender before checking resistance. If the sender functions and the gauge does not function, check the engine wiring harness, leads, and connectors before replacing the display board.

Some generator sets may have senders/switches incorporated with the engine ECM (electronic control module). Identify engine ECM senders/switches by lead designations listed in the following testing information. Refer to the wiring diagrams for additional lead identification information. Use the engine service manual for troubleshooting ECM senders/switches.

9.7.2 Sensor Types

The sensors referenced in this section typically provide the following controller inputs:

- High engine temperature shutdown switch
- High engine temperature warning (prealarm) switch
- Low oil pressure shutdown switch
- Low oil pressure warning (prealarm) switch
- Low water temperature warning switch
- Oil pressure gauge sender (see Section 9.7.5)
- Coolant temperature gauge sender (see Section 9.7.6)

9.7.3 Switch Testing

Before testing switch, disconnect the switch lead(s).

Pressure Switch

Some pressure switches make contact on falling pressure and some on rising pressure; refer to the respective drawing for contact style. Connect an ohmmeter to the switch terminals. Switches with one terminal require connection to ground on the switch metal body. Apply the pressure value shown in Section 1 and observe the ohmmeter before and after values to determine if the switch contacts open and close per specifications.

Temperature Switch

High water temperature switches make contact on rising temperature. Low water temperature switches make contact on falling temperature. Refer to the respective drawing for contact style. Connect an ohmmeter to the switch terminals. Switches with one terminal require connection to ground on the switch metal body. Apply the temperature value shown in Section 1 and observe the ohmmeter before and after values to determine if the switch contacts open and close per specifications.

9.7.4 Sender Testing

Before testing sender, disconnect the sender lead(s).

Pressure Sender

Pressure senders change resistance values as pressure changes. Connect an ohmmeter to the sender terminals. Senders with one terminal require connection to ground on the switch metal body. Apply pressure values shown in Section 1 and observe the ohmmeter values to determine if the sender changes resistance per specifications.

Temperature Sender

Temperature senders change resistance values as temperature changes. Connect an ohmmeter to the sender terminals. Senders with one terminal require connection to ground on the switch metal body. Apply temperature values shown in Section 1 and observe the ohmmeter values to determine if the sender changes resistance per specifications.

9.7.5 Oil Pressure Sender (OPS) Testing

Disconnect the oil pressure sender lead 7. See Figure 9-9. Check the sender resistance with an ohmmeter. Compare the resistance values when the generator set is shut down and when it is running at operating temperature to the values shown in Section 1, Specifications.

Use a mechanical oil pressure gauge to further verify correct readings.

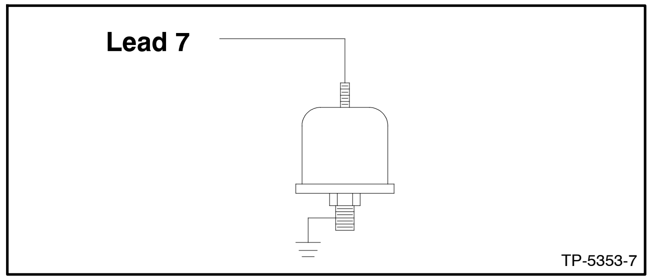


Figure 9-9 Oil Pressure Sender, Typical

9.7.6 Coolant Temperature Sender (CTS) Testing

Note: For 32/40EKOZD and 28/35EFKOZD models, consult the Engine Service Manual for CTS testing. See the List of Related Literature found at the beginning of this manual for the publication number.

The coolant temperature sender has three configurations: (1) a single function, single-terminal type, (2) a single function, two-terminal type, and (3) a dual function, two -terminal type with temperature sender and low coolant temperature switch. See Figure 9-10.

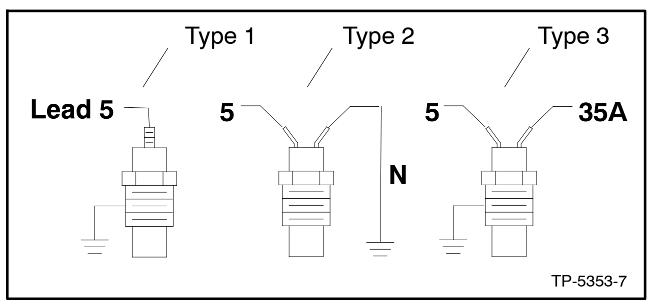


Figure 9-10 Coolant Temperature Sender, Typical

Sender type 3 has lead 5 connected to coolant temperature sender terminal with a 6-32 screw and lead 35A connected to the low water coolant temperature switch terminal with an 8-32 screw.

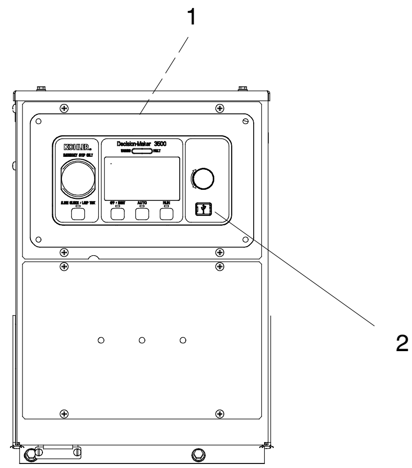
Disconnect the coolant temperature sender lead 5 (and lead N with type 2 configurations). Check the sender resistances with an ohmmeter. Compare the resistance values when the generator set is shut down and when it is running at operating temperature to the values listed in Section 1, Specifications.

9.8 Powering Up the ECU without Cranking the Engine

If connecting to Kohler's Diagnostic Tool for troubleshooting in the field or reprogramming the engine ECU, follow this procedure for 28- 40 kW marine units equipped with a Decision-Maker® 3500 controller:

1. Connect a USB cable from a Laptop (equipped with SiteTech™) to the Decision-Maker® 3500 controller. See Figure 9-11 for the USB connection at the Decision-Maker® 3500 controller.

2. Connect the Kohler Diagnostic Tool from a Laptop to the ECU Diagnostic port on the generator. See Figure 9-11 for the port location.



1. ECU diagnostic port (port included in harness located inside junction box, behind controller)
2. USB connector

Figure 9-11 ECU Diagnostic Port and USB Connector Locations

3. Open SiteTech™ after connection to the Decision-Maker® 3500 controller is established.

   Under the GENSET SYSTEM CONFIGURATION parameter, change ECM Powered Mode from "OFF" to "ON". See Figure 9-12

Genset System Configuration	
Genset System Voltage	400.0 V
Genset System Frequency	50.0 Hz
Genset Voltage Phase Connection	Three Phase Wye
Genset Power Rating	53.0 kW
Genset Apparent Power Rating	7.5 kVA
Genset Rated Current	95.6 A
Genset System Battery Voltage	24 V
Prime Power Application	Prime
Current Transformer Ratio	400
Local Start Mode	Off
Measurement System	English
Alarm Silence Always Allowed	Always
NFPA 110 Enabled	Off
Cool Down Temperature Override	Off
Oil Sensor Type	Switch
Public CAN Protocol	J1939
Display Contrast	50
Using Voltage Selector Switch	False
Genset System Language	English
Genset Maximum Percent Capacity	70.0 %
Generator Overloaded Percent	85.0 %
Under Frequency Shed Level	0.50 Hz
Base Load Add Time	60.0 s
Base Over Load Shed Time	30.0 s
Base Under Frequency Shed Time	5.0 s
Genset Fuel Type	Diesel
Battle Mode	Off
ECM Powered Mode	Off
Genset Application	Marine

Figure 9-12 Genset System Configuration Parameter (in SiteTech™)

4. When opening the Kohler Diagnostic Tool Program on the laptop, it should now power the LEDs on the EDL and attempt to establish connection with the ECU.

Note: If the RUN button is pressed or the controller is powered down, the parameter will change back to "OFF" automatically.

9.9 Fault Warning and Shutdown Testing

Adapted from Service Bulletin SB-616 6/14o, a cumulative collection of generator set models.

Some generator set models with electronic control modules (ECM) may limit or prohibit adjusting the engine speed or testing the warning and shutdown faults. This type of testing is typically required by the NFPA 110 standard for emergency power supply systems or by other governing agencies and is also useful in troubleshooting the generator set engine and controller. Figure 9-15 shows if the fault warning or fault shutdown tests are feasible.

The engine ECM or other generator set controls may impact the following shutdowns and warnings. The letter (A or B) in parentheses identifies the fault category in Figure 9-15.

- Overspeed (governor control) shutdown *
- Overcrank shutdown †
- High coolant temperature shutdown (A)
- High coolant temperature warning (A)
- Low coolant temperature warning (A)
- Low oil pressure shutdown (A)
- Low oil pressure warning (A)
- Battery charger fault warning (B)
- Low battery voltage warning (B)
- Low fuel (level or pressure) warning (B)

* Manually overspeed the engine if it is not ECM controlled.

† To test overcrank (and cyclic engine cranking) on gas fueled models, temporarily disconnect the ignition system. On diesel-fueled models, temporarily disconnect the fuel injection pump wire harness.

Use the information in Figure 9-17 to test the engine sensor/switch faults during troubleshooting of the generator set.

Test Method 1

Remove the sensor lead and ground the lead to the engine block ground or connect a jumper wire from the sensor terminal to the engine block ground.

Test Method 2

Test faults using a 5 kOhm, 10-turn, 3-watt potentiometer (part no. X-6136-36) and the illustration shown in Figure 9-13. Before starting the generator set, turn the potentiometer fully counterclockwise. While the generator set is running, turn the potentiometer clockwise until the unit shuts down.

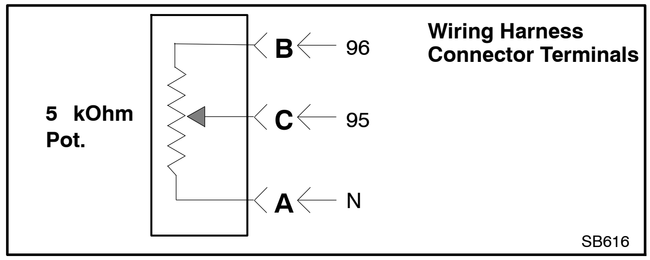


Figure 9-13 Coolant Temp. and Oil Pressure Test

Test Method 3

Test coolant temperature faults using a 500 ohm, 10-turn, 3-watt potentiometer (part no. X-6136-37) and the illustration shown in Figure 9-14. Turn potentiometer fully counterclockwise before starting the generator set. While the generator set is running, turn the potentiometer clockwise until the unit shuts down. The mating connector to the engine wiring harness connector is a Packard Electrical Division part no. 12066016.

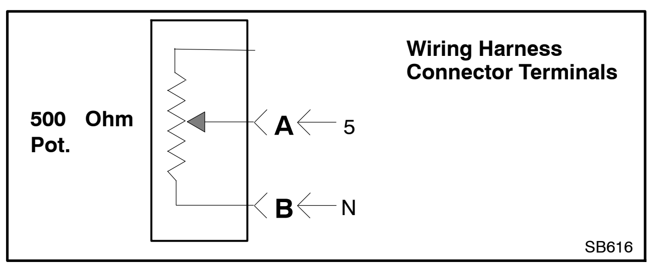


Figure 9-14 Coolant Temperature Test

Model	Engine	Governor Type	Fault Warning and Shutdown Tests			
			Overspeed	Overcrank	Engine Sensors (A)	External Sensors (B)
13EKOZD/11EFKOZD	Kohler KDI	Mechanical	Yes	Yes	Yes	Yes
14EKOZD/12EFKOZD						
15EKOZD/13EFKOZD						
16EKOZD/13.5EFKOZD						
20EKOZD/16.5EFKOZD						
20EKOZD/17.5EFKOZD						
21EKOZD/18EFKOZD						
21EKOZD/17EFKOZD						
23EKOZD/19.5EFKOZD						
23EKOZD/20EFKOZD						
24EKOZD/20.5EFKOZD						
32EKOZD/28EFKOZD		Electronic				
40EKOZD/35EFKOZD						

Figure 9-15 Feasibility of Fault Warning and Shutdown Tests

Model	Engine	Freq.	High Coolant Temperature Shutdown, °C (°F)	High Coolant Temperature Warning, °C (°F)	Low Oil Pressure Shutdown, kPa (psi)	Low Oil Pressure Warning, kPa (psi)
13EKOZD/11EFKOZD	Kohler KDI	50/60	110 (230)	107 (225)	83 (12)	138 (20)
14EKOZD/12EFKOZD						
15EKOZD/13EFKOZD						
16EKOZD/13.5EFKOZD						
20EKOZD/16.5EFKOZD						
20EKOZD/17.5EFKOZD						
21EKOZD/18EFKOZD						
21EKOZD/17EFKOZD						
23EKOZD/19.5EFKOZD						
23EKOZD/20EFKOZD						
24EKOZD/20.5EFKOZD						
32EKOZD/28EFKOZD				105 (221)		
40EKOZD/35EFKOZD						

Figure 9-16 Factory Shutdown and Warning Setpoints

Model	Engine	High Coolant Temp. Fault		Low Coolant Temp. Fault		Low Oil Pressure Fault	
		Test	Connections	Test	Connections	Test	Connections
13EKOZD/11EFKOZD	Kohler KDI	1	Lead 5	1	Lead 5	1	Lead 7
14EKOZD/12EFKOZD							
15EKOZD/13EFKOZD		3	A- Lead 5 B- Lead N	3	A- Lead 5 B- Lead N		
16EKOZD/13.5EFKOZD							
20EKOZD/16.5EFKOZD							
20EKOZD/17.5EFKOZD							
21EKOZD/18EFKOZD							
21EKOZD/17EFKOZD							
23EKOZD/19.5EFKOZD							
23EKOZD/20EFKOZD							
24EKOZD/20.5EFKOZD							
32EKOZD/28EFKOZD		Consult the Engine Service Manual					
40EKOZD/35EFKOZD							

Figure 9-17 Fault Warning and Shutdown Test Method for Decision-Maker® 3500 Controller

9.10 Motor-Operated Circuit Breakers (if equipped)

The Decision-Maker® 3500 controller provides automatic operation of a motor-operated circuit breaker including opening and closing of the breaker and synchronization of the generator output to the paralleling bus.

Note: The motor operator breaker requires a constant supply voltage of 24-30VDC. Supply voltages below 24VDC will result in failure of the motor operator breaker.

9.10.1 Automatic Closing of the Breaker

Note: The Decision-Maker® 3500 controller will only close the breaker if it receives a signal to run.

Note: In paralleling applications (two or more generator sets), PGEN connection is required to close the breaker. See PGEN connection information in the Installation Manual (TP-6952 or TP-7045) if required.

Note: In a single generator application with no PGEN connection, set the Stand Alone Operation parameter to ON in the Synchronization Control Menu in order to close the breaker.

Dead Bus Closure:

The Decision-Maker® 3500 controller monitors the following to determine if it is safe to close the paralleling breaker to a dead bus:

- **Voltage on the paralleling bus sensing connections to the controller.** The paralleling bus voltage must be below the dead bus threshold.
- **The status of the paralleling breakers of the other generators on the paralleling bus.** All the other generators in the system must have open breakers if the bus is perceived to be dead for the following reasons:
  - It is potentially harmful to provide voltage to the stator of a stopped generator.
  - If the other generator is running but the bus sensing does not indicate bus voltage, the bus sensing for the controller may not be connected and it may close out of phase to a live paralleling bus.
- **The voltage and frequency of the generator.** There is no benefit to closing the paralleling breaker to a dead bus if the generator is not producing rated voltage and frequency. The breaker will not close until the generator output is within spec to avoid providing power that is out of certain specifications.
- **Permission from other generators.** Only one generator is permitted to close to the paralleling bus when it is dead. This generator will be selected from among the running generators based on the following:
  - The first generator to start.
  - The generator controller with the lowest serial number (if they are both running at the same time).

  No controller will signal the motor-operated breaker to close until all the other generators have conceded that it will be the first to close.
- **System configuration parameters:**
  - Synch Mode in Auto

    If the generator is operating in Auto Mode (the LED above the Auto button is illuminated), this parameter must be set to one of the following for the controller to signal the breaker to close to a dead bus:
    - Check
    - Passive
    - Active
  - Synch Mode in Run

    If the generator is operating in Run Mode (the LED above the Run button is illuminated), this parameter must be set to one of the following for the controller to signal the breaker to close to a dead bus:
    - Check
    - Passive
    - Active

Note: The Check Sync Mode will only close the paralleling breaker to a dead bus, not a live one.

Live Bus Closure:

The Decision-Maker® 3500 controller monitors the following to determine if it is safe to close the paralleling breaker to a live bus:

- **Voltage and frequency of the paralleling bus as measured by the paralleling bus sensing connections to the controller.** The paralleling bus voltage must be within the validity window (same as the generator).
- **The difference between the RMS voltage of the parallelling bus and the RMS voltage of the generator.** The controller will not signal the breaker to close while the generator differs from the bus voltage by more than the Voltage Match Window threshold.
- **The difference between the frequency of the paralleling bus and the frequency of the generator.** The controller will not signal the breaker to close unless the generator frequency is within the Frequency Match Window of the frequency of the paralleling bus.
- **The Phase Difference between the generator and the paralleling bus.** The controller will not signal the breaker to close unless the phase angle between the generator output and the bus output is within the Phase Match Window (positive or negative).
- **The Phase Rotation of the generator and the paralleling bus.** The phase rotation (ABC or CBA) of the generator must match the phase rotation of the paralleling bus in order for the controller to initiate active synchronization or to signal the paralleling breaker to close.

- **System configuration parameters:**
  - Synch Mode in Auto

    If the generator is operating in Auto Mode (the LED above the Auto button is illuminated), this parameter must be set to one of the following for the controller to signal the breaker to close:
    - Passive

      The controller is not changing the speed or voltage bias for the generator but will signal the breaker to close if the voltage, frequency, phase, and phase rotation all match the paralleling bus.
    - Active

      The controller controls the speed and voltage of the generator to match phase, voltage and frequency with the parallelling bus, the breaker is signaled to close if the voltage, frequency, phase, and phase rotation all match the parallelling bus.
  - Synch Mode in Run

    If the generator is operating in the Run Mode (the LED above the Run button is illuminated), this parameter must be set to one of the following for the controller to signal the breaker to close:
    - Passive

      The controller is not changing the speed or voltage bias for the generator but will signal the breaker to close if the voltage, frequency, phase, and phase rotation all match the paralleling bus.
    - Active

      The controller controls the speed and voltage of the generator to match phase, voltage and frequency with the paralleling bus, the breaker is signaled to close if the voltage, frequency, phase, and phase rotation all match the paralleling bus.

9.10.2 Automatic Opening of the Breaker

The Decision-Maker® 3500 controller opens the paralleling breaker for any of the following conditions:

- Generator set fault
- Emergency stop
- Start signal removed
- Generator Management signals the generator to stop and the generator is unloaded
- OFF button pressed. Load enable input is removed and the generator is unloaded
- Output voltage too high
- Output voltage too low
- Output frequency too high
- Output frequency too low
- Output power too high
- Generator set absorbing power
- Output current too high
- Generator set absorbing reactive power (excitation is lost)

9.10.3 Synchronization of the Generator Output to the Paralleling Bus

The synchronizing features of the controller require a three-phase bus metering connection to ensure that the line voltage on all three phases can be monitored (to avoid high reactive power flow due to phase imbalance immediately prior to breaker closure and to ensure identical phase rotation).

The synchronizing function operates under the following conditions:

- Accurate bus sensing connection (to load side of motor-operated breaker).
- Synchronization Mode set to Active or Check. If the Sync Mode is set to passive, synchronization is monitored by not controlled.
- Generator set voltage within tolerance of rated quantities (all phases).
- Bus voltage within tolerance of rated quantities (all phases).
- Generator set phase rotation matches that of paralleling bus (ignored for single phase) alternator connections.

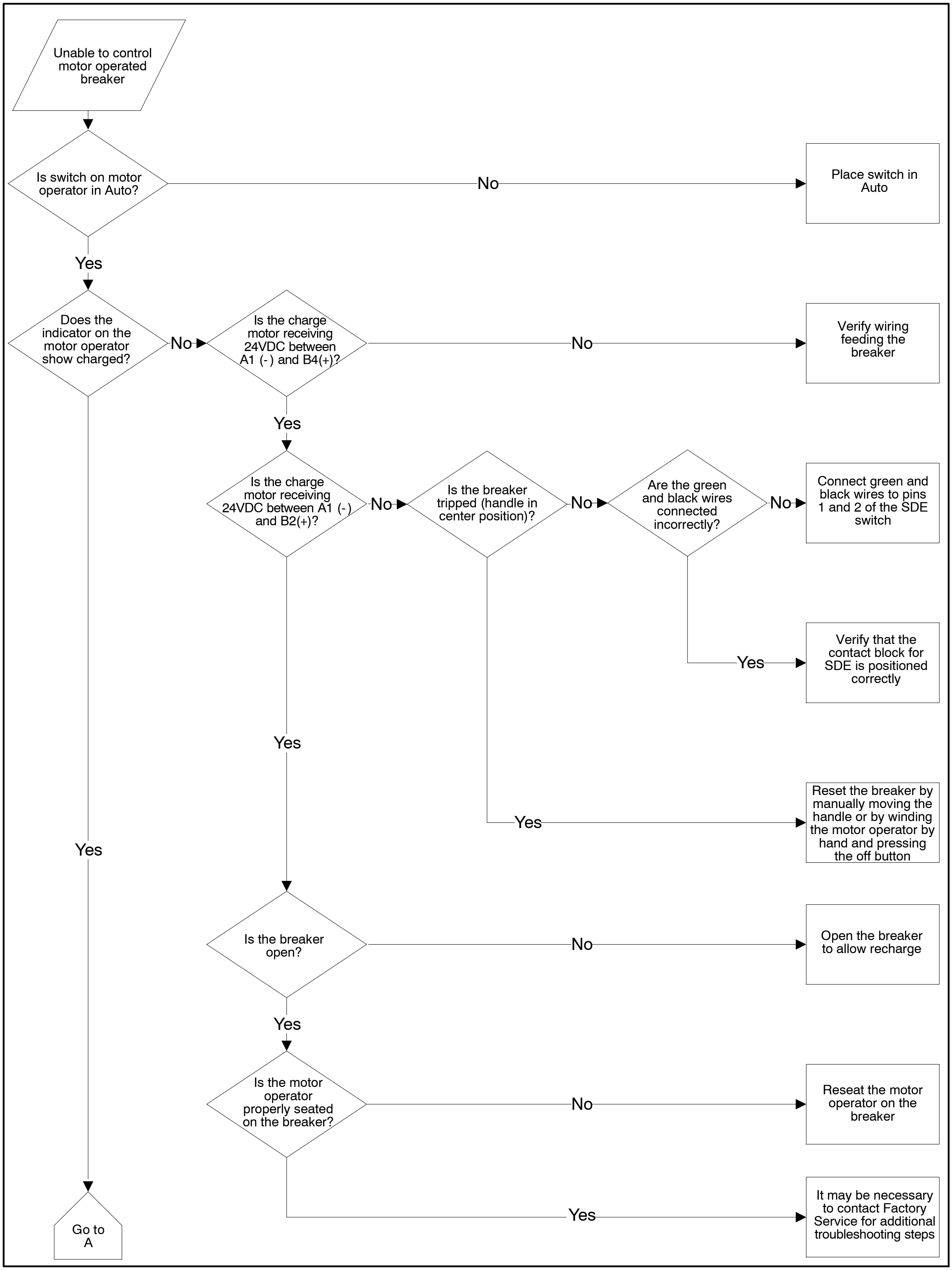
The Decision-Maker® 3500 controller controls the speed and voltage as follows:

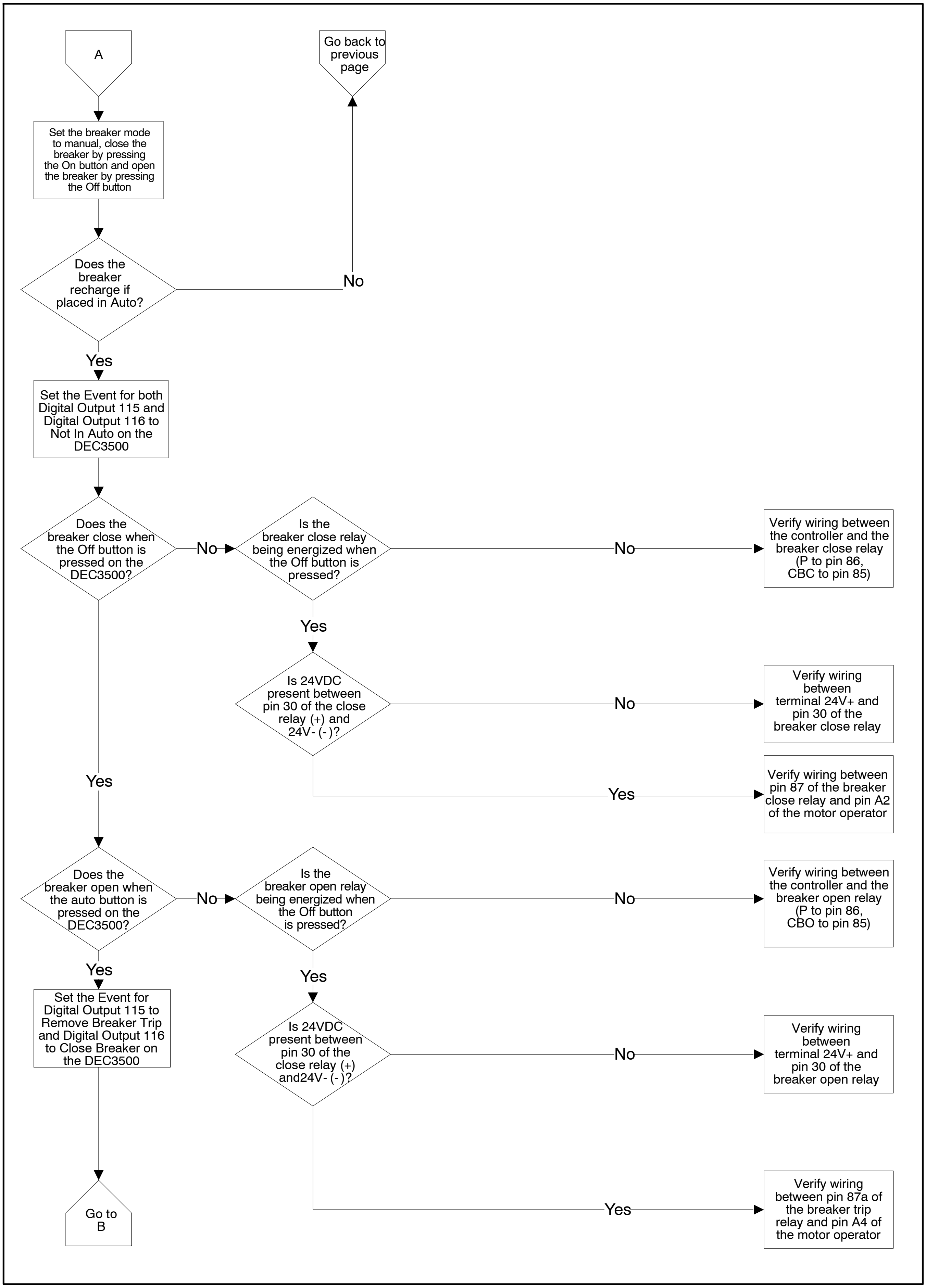
- The average single- or three-phase RMS amplitude of the generator set voltage is controlled to match the average single- or three-phase RMS amplitude of the paralleling bus.
- The cycle frequency of the generator set is controlled to match the cycle frequency of the paralleling bus.
- The phase angle between the output waveform of the generator set and the measured waveform from the paralleling bus is controlled to 0 electrical degrees.

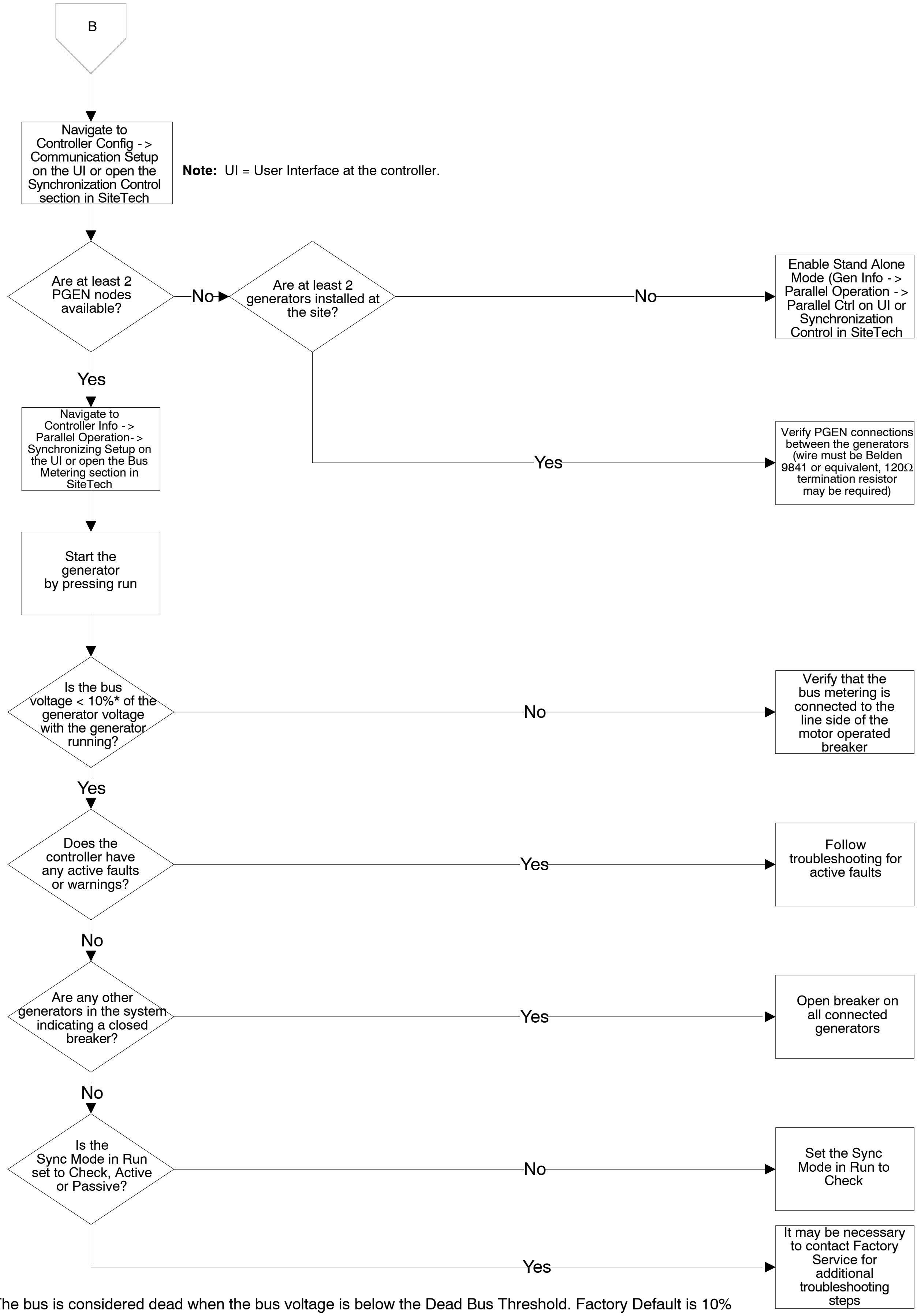
The generator set is considered to be in 0 electrical degree synchronism when all of these quantities are within the allowable threshold (window).

The breaker is signaled to close (in auto mode) after the generator set has maintained synchronism with the paralleling bus for the Dwell Time.

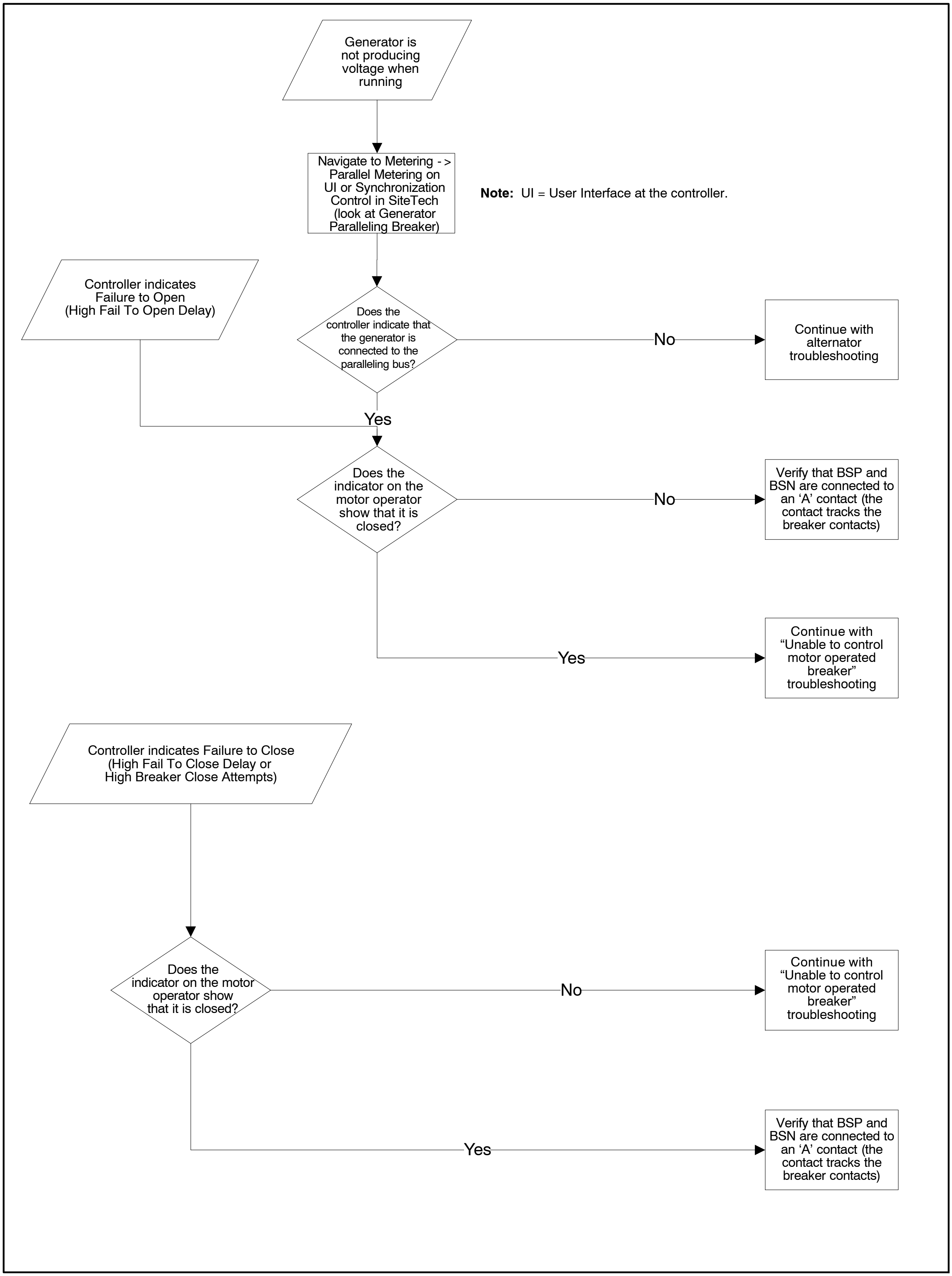
9.10.4 Troubleshooting Non-Operating Breaker




A
Go back to previous page
Set the breaker mode to manual, close the breaker by pressing the On button and open the breaker by pressing the Off button
Does the breaker recharge if placed in Auto?
No
Yes
Set the Event for both Digital Output 115 and Digital Output 116 to Not In Auto on the DEC3500
Does the breaker close when the Off button is pressed on the DEC3500?
No
Is the breaker close relay being energized when the Off button is pressed?
No
Verify wiring between the controller and the breaker close relay (P to pin 86, CBC to pin 85)
Yes
Is 24VDC present between pin 30 of the close relay (+) and 24V- (-)?
No
Verify wiring between terminal 24V+ and pin 30 of the breaker close relay
Yes
Verify wiring between pin 87 of the breaker close relay and pin A2 of the motor operator
Yes
Does the breaker open when the auto button is pressed on the DEC3500?
No
Is the breaker open relay being energized when the Off button is pressed?
No
Verify wiring between the controller and the breaker open relay (P to pin 86, CBO to pin 85)
Yes
Set the Event for Digital Output 115 to Remove Breaker Trip and Digital Output 116 to Close Breaker on the DEC3500
Yes
Is 24VDC present between pin 30 of the close relay (+) and24V- (-)?
No
Verify wiring between terminal 24V+ and pin 30 of the breaker open relay
Yes
Verify wiring between pin 87a of the breaker trip relay and pin A4 of the motor operator
Go to B



* The bus is considered dead when the bus voltage is below the Dead Bus Threshold. Factory Default is 10%


Generator is not producing voltage when running
Navigate to Metering - > Parallel Metering on UI or Synchronization Control in SiteTech (look at Generator Paralleling Breaker)
Note: UI = User Interface at the controller.
Controller indicates Failure to Open (High Fail To Open Delay)
Does the controller indicate that the generator is connected to the paralleling bus?
No
Continue with alternator troubleshooting
Yes
Does the indicator on the motor operator show that it is closed?
No
Verify that BSP and BSN are connected to an ‘A’ contact (the contact tracks the breaker contacts)
Yes
Continue with “Unable to control motor operated breaker” troubleshooting
Controller indicates Failure to Close (High Fail To Close Delay or High Breaker Close Attempts)
Does the indicator on the motor operator show that it is closed?
No
Continue with “Unable to control motor operated breaker” troubleshooting
Yes
Verify that BSP and BSN are connected to an ‘A’ contact (the contact tracks the breaker contacts)

9.11 Battery Charging Module, 13-24EKOZD/12-20.5EFKOZD Original (12/24 Volt: GM77373)

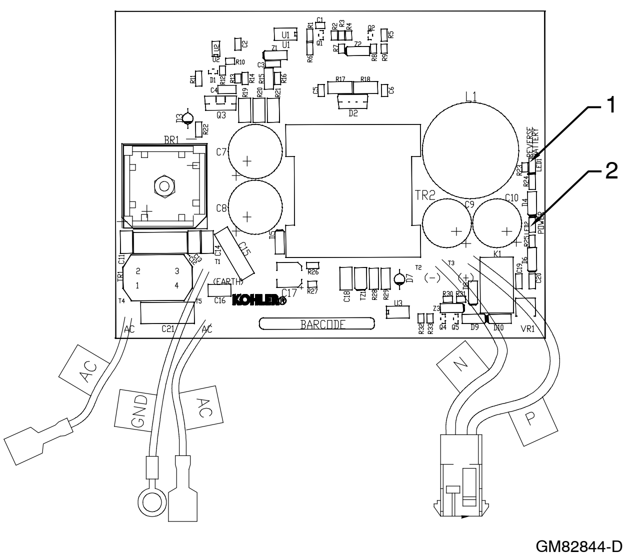
Note: For generator set variation numbers with serial numbers before:

GM102825-MA1:	336KGMGG0006
GM102825-MA2:	337PGMGG0015
GM102825-MA3:	337XGMGG0018
GM102825-MA4:	337XGMGG0009

The junction box contains a battery charging module to maintain the engine starting battery. The battery charging module monitors the battery voltage and provides 8 amps to charge the battery and capable of charging a 12 or 24 volt battery.

Note: The battery charging module is reverse-polarity protected.

Before testing the battery charging module, ensure that no other DC loads are on the generator set. At startup, after approx. 1 min., check for a change in voltage. If voltage increases, the battery charging module is functioning. If voltage decreases, the battery charging module is inoperative.



1. LED1 (red), reverse battery
2. LED2 (green), power

Figure 9-18 Battery Charging Module (GM77373)

9.12 Battery Charging Module, 13-24EKOZD/12-20.5EFKOZD Revised (12 Volt: GM105398 and 24 Volt: GM105399)

Note: For generator set variation numbers with serial numbers shown below and later:

GM102825-MA1:	336KGMGG0006
GM102825-MA2:	337PGMGG0015
GM102825-MA3:	337XGMGG0018
GM102825-MA4:	337XGMGG0009

Figure 9-19 Battery Charging Module (GM105398 and GM105399), Typical

The junction box contains a battery charging module to maintain the engine starting battery. The battery charging module monitors the battery voltage and provides 8 amps to charge the battery.

9.12.1 Three Stage Charge Cycle

The battery charger uses a three stage charge routine that most lead-acid battery manufacturers recommend to return full capacity efficiently and to extend battery life. See Figure 9-20. The charger is capable of charging a battery from zero volts.

Note: A battery left in the zero volt condition for an extended period of time will sulphate and lose capacity.

Stage 1: Fast Mode (Bulk)
Assuming that the battery is starting in a discharged state, the charger is operating in constant current mode. The charger current is maintained at a constant value and the battery voltage is allowed to rise as it is being recharged. Approximately 80% of battery capacity is returned in the constant current region.

Stage 2: Top-Off Mode (Absorption)
When the battery voltage reaches approximately 2.4 volts per cell, or 14.4 volts for a 12 volt battery and 28.8 volts for a 24 volt battery, the charger voltage is held constant at this level and the battery current is allowed to reduce. This voltage is maintained until the charging current reduces substantially indicating a full charge. At this point, the battery is fully charged.

Stage 3: Float Mode

Float mode is the final stage of the charging routine. During float mode, the voltage on the battery is held constant and maintained at approximately 13.5 volts for a 12 volt battery. This voltage will maintain the full charge condition and protect the battery from overcharging.

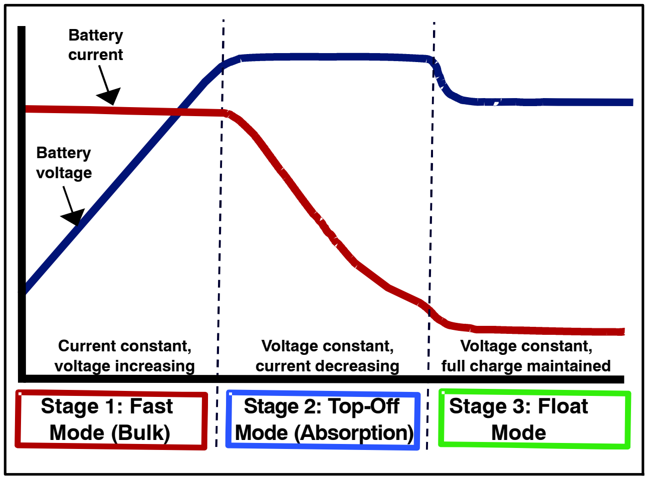


Figure 9-20 Three Stage Charging Curve

9.12.2 Protection Modes

Note: See Figure 9-21 for battery charger LED indicator information.

Over Temperature: The charger enters a fault state indicated by the:

Charger State LED OFF,
Volts LED Flashing, and
Amps LED Flashing.

The charger shuts down until it cools off and then restarts automatically. In very high ambient temperatures, it is possible for the non-auto reset thermal protection to activate.

Over Voltage/Current: The charger enters a fault state indicated by the:

Charger State LED OFF,
Volts LED Flashing, and
Amps LED Flashing.

The fault activates in the event of a regulation malfunction and inhibits the charger. If the over voltage/current condition persists, contact the factory.

Note: Never operate a charger that has been damaged in any way or try to disassemble it.

LED Indicators					
Parameter	**Red (Solid)**	**Red/Green (Alternating)**	**Green (Solid)**	**On/Off (Flashing)**	**Off (Solid)**
Charger State	Stage 1: Fast	Stage 2: Top-Off	Stage 3: Float	Checking State	Fault
Volts (Battery Voltage)	$< 75\%$ of V_{FSTRAN}	75- 85% of V_{FSTRAN}	85- 95% of V_{FSTRAN}	$> 95\%$ of V_{FSTRAN}	-
Amps (Battery Current)	30- 90% of I_{max}	10- 30% of I_{max}	$< 10\%$ of I_{max}	$> 90\%$ of I_{max}	-

Figure 9-21 Battery Charger LED Indicators

9.12.3 Charger Operation

The LED indicator lights informs the user of the progress of the charging cycle and confirms proper connections. The critical operational parameters are shown in Figure 9-22:

Parameter	Description/Condition	GM105398 (12 volt)	GM105399 (24 volt)	Tolerance	Units
V_{FSTRAN}	Fast charge transition voltage, 25C	14.4	28.8	± 0.5	VDC
V_{FLOAT}	Float voltage, $I_{OUT} < 1.0$ A, 25C	13.5	27.2	± 0.5	VDC
I_{FS}	Max current: $V_{BATT} = 12$ V @ 100 VAC, 25C	8	8	± 1.0	Amps
I_{ABTRAN}	Absorption mode transition current	1.8	1.5	± 0.5	Amps
I_{SBY}	Standby current, AC off	-	-	< 2.5	mA
V_{AC}	RMS AC voltage range	-	-	85- 140	VAC
I_{AC}	RMS AC current/15 V @ 15 amps	-	-	2- 4	RMS

Figure 9-22 Battery Charger Operational Parameters

9.12.4 Charger Troubleshooting

1. **No charger LEDs illuminate:**
   - Confirm AC/DC connections are tight and correct.
   - Inspect AC/DC cable connectors for wear and tear.
   - Verify AC power is present.
2. **Charger LEDs are blinking:**
   - Confirm AC/DC connections are tight and correct.
   - Inspect AC/DC cable connectors for wear and tear.
   - Confirm battery voltage is greater than 5 VDC (for a 12 volt battery) or 10 VDC (for a 24 volt battery).
   - If battery voltage is less than 5 VDC (for a 12 volt battery) or 10 VDC (for a 24 volt battery) and increasing, leave charger connected, this is normal operation.
   - Correct operation should occur when battery voltage is greater than 5 VDC (for a 12 volt battery) or 10 VDC (for a 24 volt battery).
   - Confirm that an overvoltage condition does not exist.
3. **Charger LEDs are correct, but the battery does not charge properly or not at all:**
   - Perform items listed under 1 above.
   - If possible, measure the battery current and confirm it is within specification.
   - If the battery current is correct, confirm there is no unintended loading.
   - If it is not possible to measure battery current, disconnect all cables and consult the factory.
4. **Charger LEDs indicate an overtemp condition:**
   - Confirm adequate ventilation in the charger vicinity.
   - Provide cooling and/or allow time for the charger to cool.
   - Normal operation will resume automatically when the thermal shutdown has terminated.
5. **Battery has an odor, is hot, or is sizzling:**

   Note: The battery may no longer be suitable for use.

   - Stay clear of the battery until the odor has subsided and obtain eye protection.
   - Immediately turn off AC power and remove all loads.
   - Ventilate the area, do not generate any spark or flame.

Note: If the charger is still not operational after performing the above checks, disconnect all cables and contact an authorized distributor/dealer for service.

Section 10 Alternator Component Testing and Adjustment (11-32 kW Generator Sets Equipped with 4D/4E Alternators)

Note: See Section 11 for 35-40 kW generator sets equipped with 4PX/4QX alternators.

10.1 Introduction

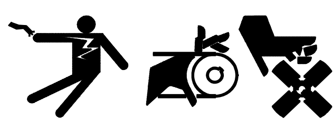
This section provides information on troubleshooting the alternator and testing components of the generator set. Contact an authorized service distributor/dealer for the appropriate technical manuals for the controller and integrated voltage regulator.

To troubleshoot the alternator assembly components, the following equipment is needed for many of the tests:

- Multimeter, qty. 2
- DC Ammeter (0-10 Amps) (required if multimeter doesn't have 10 amp current measuring capability)
- Megohmmeter
- 12-Volt battery
- 10-Amp fuse and wiring

Follow all safety precautions listed in the front of this manual and the additional precautions within the text.

WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

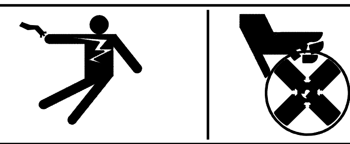
Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

WARNING



Hazardous voltage. Moving parts.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

Disconnecting the electrical load. Hazardous voltage can cause severe injury or death. Disconnect the generator set from the load by turning off the line circuit breaker or by disconnecting the generator set output leads from the transfer switch and heavily taping the ends of the leads. High voltage transferred to the load during testing may cause personal injury and equipment damage.

High voltage test. Hazardous voltage can cause severe injury or death. Follow the instructions of the test equipment manufacturer when performing high-voltage tests on the rotor or stator. An improper test procedure can damage equipment or lead to generator set failure.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

10.2 Separate Excitation

To determine the cause of no- or low-AC output, refer to the troubleshooting flowchart in Figure 10-1. Before beginning the test procedures, read all of the safety precautions at the beginning of this manual. Many of the test procedures include additional safety precautions.

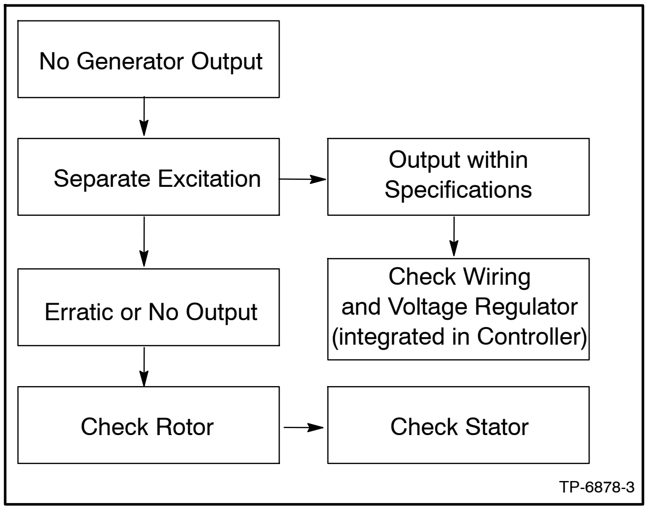


Figure 10-1 General Troubleshooting

Use the following procedure to separately excite the generator using an external voltage source (a 12-volt battery).

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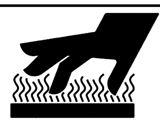


Hot engine and exhaust system. Can cause severe injury or death.

Do not work on the generator set until it cools.

Servicing the alternator. Hot parts can cause severe injury or death. Avoid touching the alternator field or exciter armature. When shorted, the alternator field and exciter armature become hot enough to cause severe burns.

Separately exciting the alternator can determine the presence of a faulty voltage regulator or determine if a running fault exists in the rotor and/or stator. An alternator component that appears good while static (stationary) may exhibit a running open or short circuit while dynamic (moving). Short circuits can be caused by centrifugal forces acting on the windings during rotation or insulation breakdown as temperatures increase.

1. Stop the generator set. Refer to the operation manual as needed.

2. Disconnect the FP/FN connector.

3. Connect an ohmmeter to the exciter field winding and measure the resistance. Note and record the ohmmeter reading.

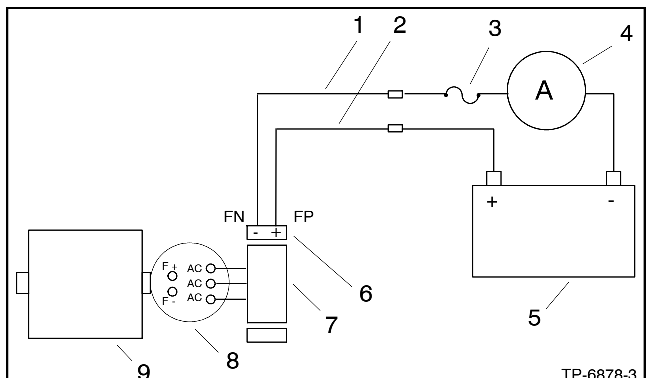
4. Disconnect the ohmmeter after measuring the resistance.

5. Connect a DC ammeter, 10-amp fuse, and a 12-volt battery to the positive (FP) and negative (FN) exciter leads as shown in Figure 10-2. Note and record the ammeter reading.

   The approximate ammeter reading should be battery voltage divided by the specified exciter field winding resistances (cold). See Section 1, Specifications, for the values.

   Example:

$$\frac{\text{12 Volts (Battery Voltage)}}{\text{5.8 Ohms Exciter Field Winding Resistance}} = \text{2.1 amps Exciter Field Winding Current}$$



1. FN lead (disconnected in step 2
2. FP lead (disconnected in step 2
3. 10-amp fuse
4. DC ammeter
5. 12-volt battery
6. Exciter field winding
7. Exciter armature
8. Rectifier module
9. Main field (rotor)

Figure 10-2 Separate Excitation Connections

6. Start the generator set. Refer to the operation manual as needed.

7. Check the ammeter values.

   Unstable ammeter reading. An increasing meter reading indicates a shorted exciter field. A decreasing meter reading to zero, or unstable reading, suggests a running open in the exciter.

   Stable ammeter reading. If the ammeter is stable, continue with the next step.

8. Use a voltmeter and check for AC output across the stator main windings and compare it to the values in Section 1, Specifications. If the stator main windings output varies considerably from those listed, a faulty stator, rotor, rectifier module, or exciter armature is likely.

9. Stop the generator set. Refer to the operation manual as needed.

If there is no alternator AC output during normal operation, but AC output is available when the generator set is separately excited, the voltage regulator is probably defective.

Note: See Section 1, Specifications, for the stator output voltages (with separately excited alternator). These specifications are based on a battery voltage of 12. Should the battery voltage vary (11- 14 volts), the resulting stator output values will also vary.

10.3 Exciter Field

Direct current from the battery magnetizes the exciter field. When the exciter armature rotates within the magnetized exciter field windings, an electrical current develops within the exciter armature. Test the exciter field according to the following procedure.

Exciter Field Test Procedure

1. Stop the generator set. Refer to the operation manual as needed.

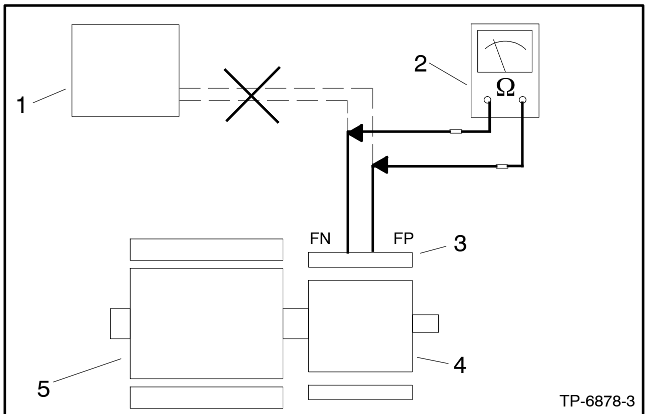
2. Disconnect the generator set engine starting battery, negative (-) lead first.

3. Disconnect the FP/FN connector between the controller/activator board and the exciter field.

4. Check the exciter field resistance by connecting an ohmmeter across exciter field FN and FP leads. See Figure 10-3. See Section 1, Specifications, for the resistance value of a cold exciter field.

   A low reading indicates an internal short and a high reading indicates an open winding. Repair or replace the exciter field if the ohmmeter readings indicate an inoperative exciter field (refer to Section 15, Generator Disassembly/Reassembly, for removal).

   If the resistance test is inconclusive, perform a megohmmeter test on the exciter field as described in the next step.

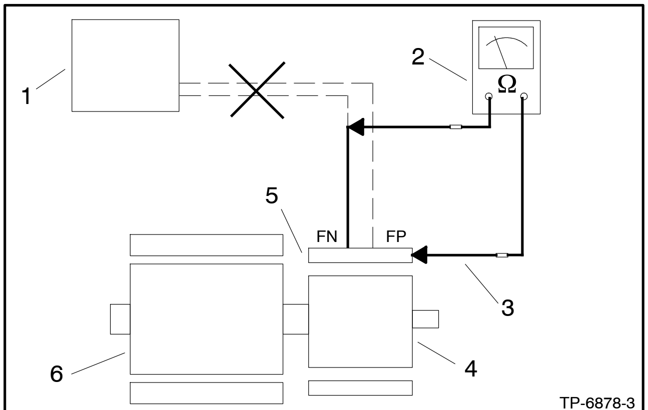


1. Generator set controller/ activator board
2. Ohmmeter
3. Exciter field
4. Exciter armature
5. Main field (rotor)

Figure 10-3 Exciter Field Resistance Test

5. Check the exciter field for a short-to-ground condition. Use a megohmmeter to apply 500 volts DC to the FN or FP lead and the exciter field frame. See Figure 10-4. Follow the megohmmeter manufacturer's instructions for megohmmeter use.

   A reading of approximately 1.5 MOhms and higher indicates the field winding is functional. A reading of less than approximately 1.5 MOhms indicates deterioration of the winding insulation and possible current flow to ground; if so, replace the exciter field.

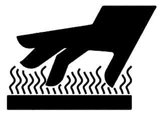


1. Generator set controller/ activator board
2. Megohmmeter
3. Frame connection
4. Exciter armature
5. Exciter field
6. Main field (rotor)

Figure 10-4 Megohmmeter Connections on the Exciter Field

10.3.1 Exciter Armature

WARNING

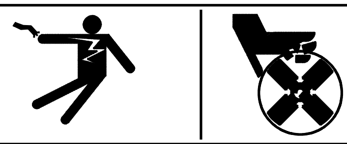


Hot engine and exhaust system. Can cause severe injury or death.

Do not work on the generator set until it cools.

Servicing the alternator. Hot parts can cause severe injury or death. Avoid touching the alternator field or exciter armature. When shorted, the alternator field and exciter armature become hot enough to cause severe burns.

WARNING



Hazardous voltage. Moving parts. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

High voltage test. Hazardous voltage can cause severe injury or death. Follow the instructions of the test equipment manufacturer when performing high-voltage tests on the rotor or stator. An improper test procedure can damage equipment or lead to generator set failure.

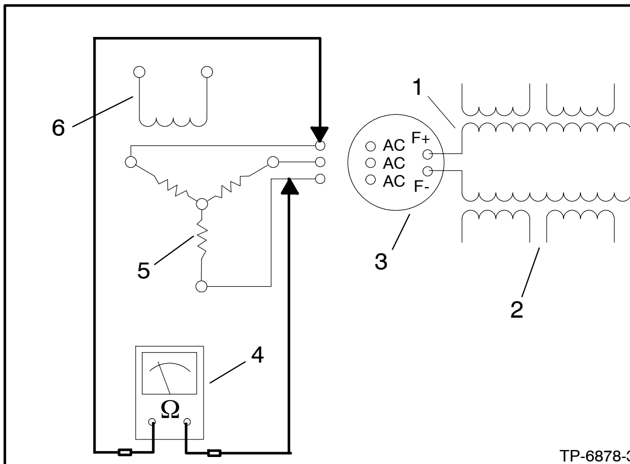
The exciter armature supplies excitation current to the generator main field through the rectifier module. Test the exciter armature as described in the following steps.

Exciter Armature Test Procedure

1. Disassemble the alternator. Refer to Section 15, Generator Disassembly/Reassembly.

2. With the alternator disassembled, disconnect the exciter armature leads from the rectifier module AC terminals

3. With an ohmmeter on the R x 1 scale, check the resistance across the exciter armature leads. See Figure 10-5. See Section 1, Specifications, for the exciter armature resistance.



1. Main field (rotor)
2. Stator windings
3. Rectifier module
4. Ohmmeter
5. Exciter armature
6. Exciter field winding

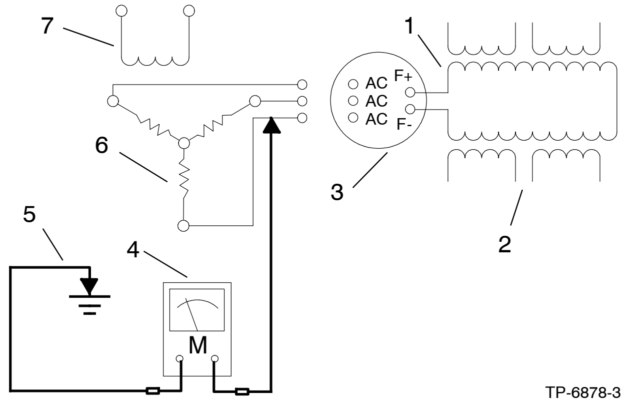
Figure 10-5 Exciter Armature Ohmmeter Test

No continuity indicates an open exciter armature winding. If the resistance test is inconclusive, perform a megohmmeter test on the exciter armature as described in the next step.

Note: Most ohmmeters will not accurately measure less than one ohm. Consider the exciter armature functional if the resistance reading (continuity) is low and there is no evidence of a shorted winding (heat discoloration).

4. Check the exciter armature winding for a short-to-ground condition. Use a megohmmeter to apply 500 volts DC to either armature lead and the exciter armature frame. Follow the megohmmeter manufacturer's instructions for using the megohmmeter. See Figure 10-6.

   A reading of approximately 1.5 MOhms and higher indicates the exciter armature is functional. A reading of less than approximately 1.5 MOhms indicates deterioration of the winding insulation and possible current flow to ground; if so, replace the exciter armature.



1. Main field (rotor)
2. Stator windings
3. Rectifier module
4. Megohmmeter
5. Exciter armature frame (shaft connection)
6. Exciter armature
7. Exciter field winding

Figure 10-6 Megohmmeter Connections on Exciter Armature

10.3.2 Rectifier Module

The rectifier module located between the exciter armature and the main field (rotor) converts AC from the exciter armature to DC, which magnetizes the generator main field (rotor). Test the rectifier module as described in the following steps.

Rectifier Module Test Procedure

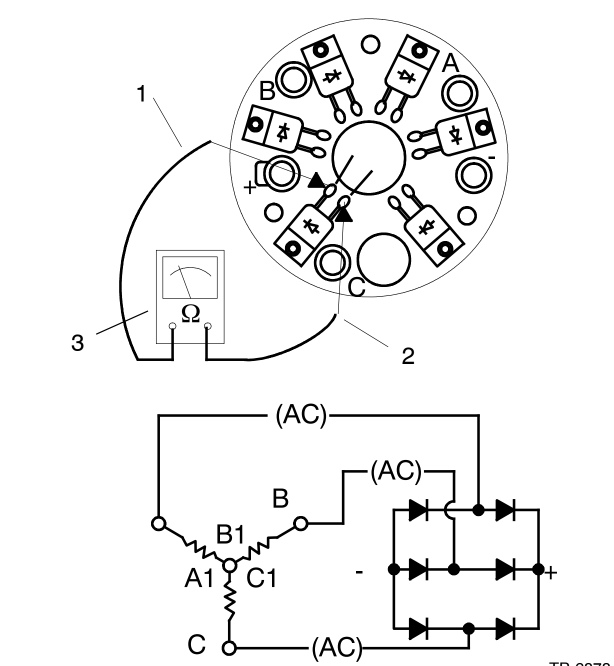
1. Disconnect the exciter armature and the main field leads from the rectifier module.

2. Perform a diode check of all six of the rectifier board diodes. Replace the rectifier module if any of the diodes tests differently than described.

   a. Test each individual diode using the multimeter diode check feature if so equipped. Refer to the multimeter instructions for procedure.

   or

   b. Use an ohmmeter on the R x 100 scale to check the resistance of the rectifier diodes as shown in Figure 10-7. The ohmmeter should show a low resistance in one direction and, upon reversing the ohmmeter leads, a high resistance in the other direction.

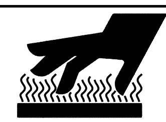


1. Diode terminal
2. Diode terminal
3. Ohmmeter

Figure 10-7 Rectifier Module Test

10.4 Rotor (Main Field)

WARNING

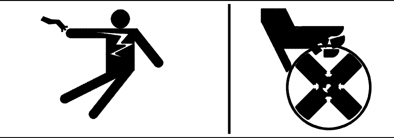


Hot engine and exhaust system. Can cause severe injury or death.

Do not work on the generator set until it cools.

Servicing the alternator. Hot parts can cause severe injury or death. Avoid touching the alternator field or exciter armature. When shorted, the alternator field and exciter armature become hot enough to cause severe burns.

WARNING



Hazardous voltage. Moving parts. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

High voltage test. Hazardous voltage can cause severe injury or death. Follow the instructions of the test equipment manufacturer when performing high-voltage tests on the rotor or stator. An improper test procedure can damage equipment or lead to generator set failure.

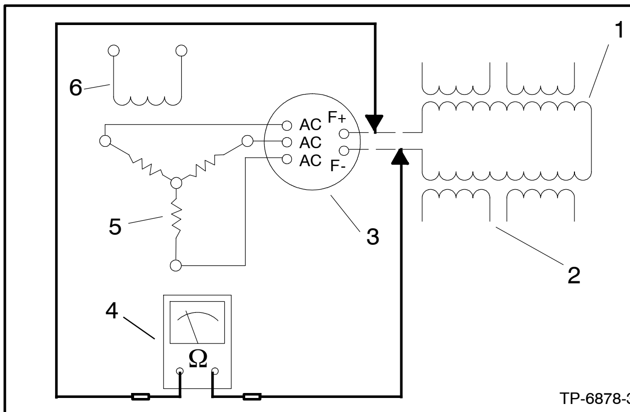
The generator rotor (magnetized by DC from the rectifier module) rotating within the stator windings induces AC in the stator windings. Test the generator rotor (main field) as described in the following steps. Disassemble the generator prior to performing this test. See Section 15, Generator Disassembly/Reassembly.

Generator Main Field (Rotor) Test Procedure

1. With the generator disassembled, disconnect the generator main field (rotor) windings at the rectifier module terminals F+ and F- .

2. Check the main field (rotor) resistance by connecting an ohmmeter across the main field (rotor) F+ and F- leads. See Figure 10-8. See Section 1, Specifications, for the resistance value.

   A low reading indicates an internal short and a high reading indicates an open winding. Repair or replace the main field (rotor) if the ohmmeter readings indicate the main field (rotor) is inoperative. If the resistance test is inconclusive, perform a megohmmeter test on the main field (rotor) as described in the next step.

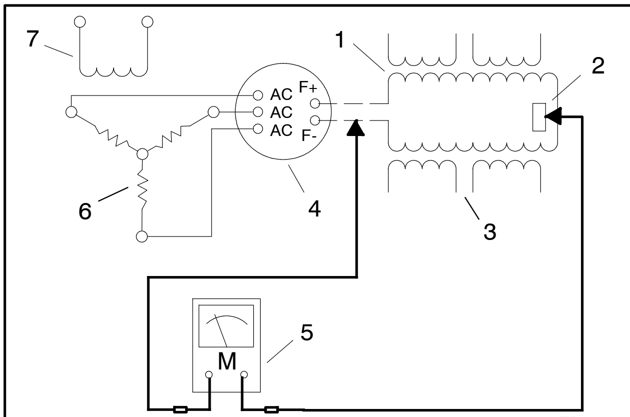


1. Main field (rotor)
2. Stator windings
3. Rectifier module
4. Ohmmeter
5. Exciter armature
6. Exciter field winding

Figure 10-8 Ohmmeter Connections on Main Field

3. Check the main field (rotor) for a short-to-ground condition by using a megohmmeter. Apply 500 volts DC to either field lead (rotor) and the main field (rotor) frame. Follow the megohmmeter manufacturer's instructions for using the megohmmeter. See Figure 10-9.

   A reading of 1.5 MOhms and higher indicates the main field (rotor) is functional. A reading of less than 1.5 MOhms indicates deterioration of the winding insulation and possible current flow to ground; if so, replace the main field (rotor).

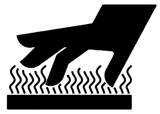


1. Main field (rotor)
2. Main field (rotor) frame (shaft connection)
3. Stator windings
4. Rectifier module
5. Megohmmeter
6. Exciter armature
7. Exciter field winding

Figure 10-9 Megohmmeter Connections on Main Field

10.5 Stator

WARNING

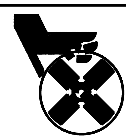


Hot engine and exhaust system. Can cause severe injury or death.

Do not work on the generator set until it cools.

Servicing the alternator. Hot parts can cause severe injury or death. Avoid touching the alternator field or exciter armature. When shorted, the alternator field and exciter armature become hot enough to cause severe burns.

WARNING



Hazardous voltage. Moving parts. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

High voltage test. Hazardous voltage can cause severe injury or death. Follow the instructions of the test equipment manufacturer when performing high-voltage tests on the rotor or stator. An improper test procedure can damage equipment or lead to generator set failure.

The stator consists of a series of coils of wire laid in a laminated steel frame. The stator leads supply voltage to the AC load and exciter regulator.

Before testing the stator, inspect it for heat discoloration and visible damage to the housing lead wires and exposed and varnished areas of the frame laminations. Be sure the stator is securely fastened in the stator housing.

The stator produces electrical output (AC) as the magnetized main field rotates within the stator windings. Test the condition of the stator according to the following procedure.

Leads 1, 2, 3, and 4 are the generator output leads on single-phase models. Leads 1 through 12 are the output leads on three-phase models. Leads 60, 61, and 62 are the auxiliary power winding leads. Refer to the schematic in Figure 10-10 or Figure 10-11 when performing the following tests.

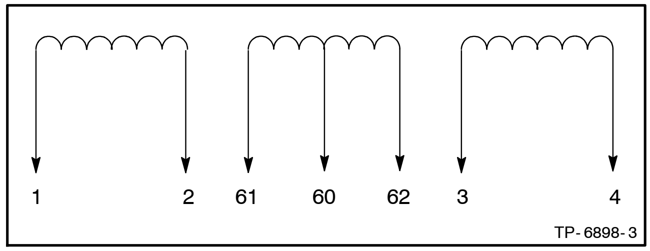


Figure 10-10 Alternator Stator Leads (Single Phase)

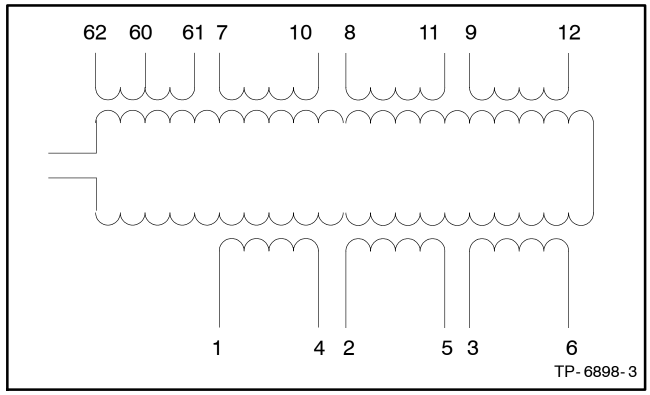


Figure 10-11 Alternator Stator Leads (Three Phase)

Stator Test Procedure

1. Press the OFF button on the generator set controller.

2. Disconnect the generator set engine starting battery, negative (-) lead first.

3. Check the generator output lead connections. See wiring diagram ADV-5875 in the Appendix to determine the voltage connection of the unit. Make note of the voltage connection for reassembly later.

4. Disconnect all the stator leads to isolate the windings. To check the stator continuity, set the ohmmeter on the R x 1 scale. Check the stator continuity by connecting the meter leads to the stator leads as shown in Figure 10-10 for single phase or Figure 10-11 for three phase. See Figure 10-12 for single-phase or Figure 10-13 for three-phase continuity test results. Perform the stator tests on all the stator windings.

Leads			Continuity
1 and 2	3 and 4	—	Yes
60 and 61	61 and 62	60 and 62	
1 and 3	1 and 4	—	No
2 and 3	2 and 4	—	
1 and 60	1 and 61	1 and 62	
2 and 60	2 and 61	2 and 62	
3 and 60	3 and 61	3 and 62	
4 and 60	4 and 61	4 and 62	
Any stator lead and ground on stator housing or frame laminations			No

Figure 10-12 Stator Continuity Test Results on a Good Stator (Single Phase)

Leads			Continuity
1 and 4	2 and 5	3 and 6	Yes
7 and 10	8 and 11	9 and 12	
60 and 61	61 and 62	60 and 62	
1 and 2	1 and 3	1 and 7	No
1 and 8	1 and 9	2 and 3	
2 and 7	2 and 8	2 and 9	
3 and 7	3 and 8	3 and 9	
7 and 8	7 and 9	8 and 9	
1 and 60	1 and 61	1 and 62	No
2 and 60	2 and 61	2 and 62	
3 and 60	3 and 61	3 and 62	
7 and 60	7 and 61	7 and 62	
8 and 60	8 and 61	8 and 62	
9 and 60	9 and 61	9 and 62	
Any stator lead and ground on stator housing or frame laminations			No

Figure 10-13 Stator Continuity Test Results on a Good Stator (Three Phase)

5. Check the cold resistance of the stator windings by connecting the meter leads to the stator leads as shown in Figure 10-12 or Figure 10-13. See Section 1, Specifications, for the stator resistance values. If the stator resistance test is inconclusive, perform a megohmmeter test on the stator as described in the next step.

   Note: Consider the stator functional if the resistance reading (continuity) is low and there is no evidence of shorted windings (heat discoloration).

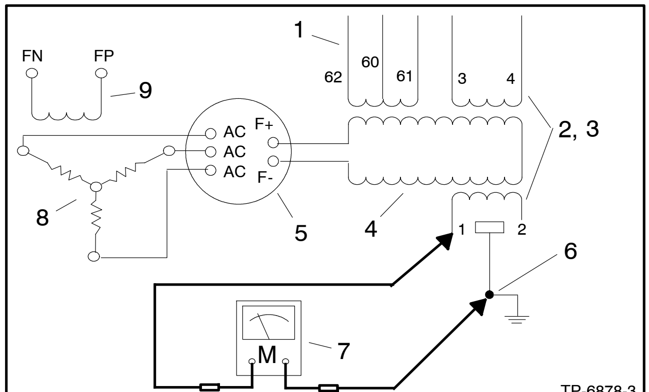
   Note: When taking an ohmmeter reading using leads 60, 61, or 62, make the connection before the fuse if used.

   Note: The stator resistance can vary directly with increased temperature.

   If any of the stator readings vary during the previous checks, replace the stator.

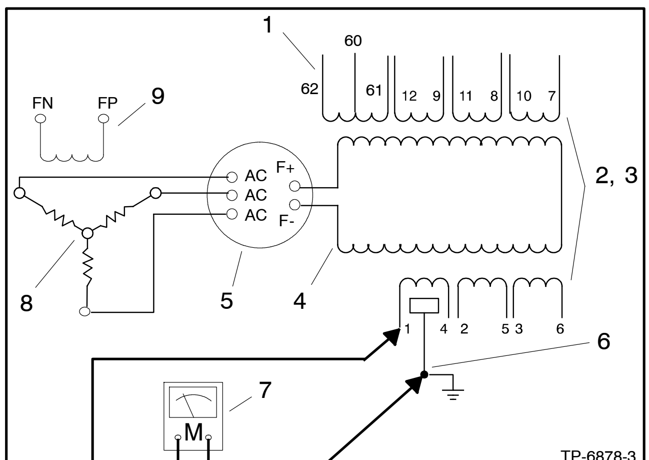
6. Check the stator for a short-to-ground condition using a megohmmeter. See Figure 10-14 for a single-phase megohmmeter connections and Figure 10-15 for three-phase megohmmeter connections.

   Apply 500 volts DC to any stator lead from each winding and the stator frame. Follow the megohmmeter manufacturer's instructions for using the megohmmeter. Repeat the test on the other leads until all of the stator windings have been tested. A reading of 1.5 MOhms and higher indicates the stator is functional. A reading of less than 1.5 MOhms indicates deterioration of the winding insulation and possible current flow to ground; if so, repair or replace the stator.



1. Auxiliary power for exciter field and voltage regulator
2. Voltage sensing (A, B, and NEU) leads (208-240 volts nominal)
3. Stator windings
4. Main field (rotor)
5. Rectifier module
6. Frame connection
7. Megohmmeter
8. Exciter armature
9. Exciter field winding

Figure 10-14 Megohmmeter Connections on Stator (Single Phase)



1. Auxiliary power for exciter field and voltage regulator
2. Voltage sensing (A, B, C, and NEU) leads (208-240 volts nominal)
3. Stator windings
4. Main field (rotor)
5. Rectifier module
6. Frame connection
7. Megohmmeter
8. Exciter armature
9. Exciter field winding

Figure 10-15 Megohmmeter Connections on Stator (Three Phase)

10.6 Voltage Regulator

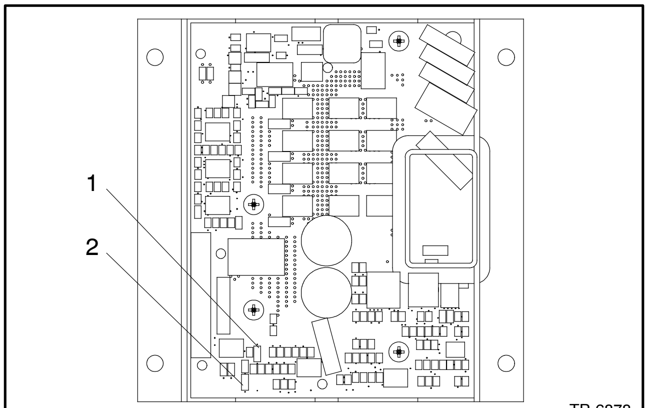
These generator sets have a controller (Decision-Maker® 3500) that has an integrated voltage regulator.

Voltage regulation is performed by the generator set controller. The activator board only interprets the pulse width modulator (PWM) signal as a target current for the alternator field and controls the current to match the target.

10.7 Activator Board GM88453

10.7.1 General

The activator board (Figure 10-16) is a current-controlling device. The output current of the activator is controlled to a given target based on the duty cycle of the pulse width modulated (PWM) signal from the LED output of the controller. The activator board switches DC voltage to the field to increase the field current when the target current increases and turns the field voltage off until the field current decays to the new level when the target current decreases.



1. DC Bus LED 1
2. Power LED 2

Figure 10-16 Activator Board GM88453

The activator board receives power from one of two sources when used with wound field alternators:

- An auxiliary winding on the alternator. This winding is located on the stator where it requires field current to produce voltage. The activator requires an additional power source to supply initial current to the field causing the auxiliary winding to produce voltage.

  Note: If the generator set has been running recently, the alternator field will typically have enough residual magnetism to power the activator board and provide power to the field.

- The cranking battery provides input voltage without a second power source to the activator board only when it is not receiving power from the auxiliary windings. The activator board energizes a relay that disconnects the DC input to the activator board when the AC input reaches about 25 VAC.

The activator board contains two LEDs for troubleshooting purposes. Power to the activator board is supplied by the alternator; therefore, the LEDs will only illuminate while the generator set is running.

- **DC Bus.** Indicates that the DC bus that provides power to the field has voltage present. The LED starts to illuminate at 8 VDC on the bus and is fully illuminated by about 14 VDC.
- **Power.** Indicates that activator board is receiving power and is able to control the output to the field. This LED must be fully illuminated (max. brightness) before any power is supplied to the field.

10.7.2 Theory of Operation

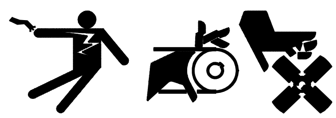
The activator board receives power as soon as the run relay is energized (the flash relay is not energized). After receiving power, the board begins controlling the field current to the target sent by the controller.

After the controller requests field current, the activator applies voltage to the field to increase the field current to the target. The flash relay is energized when the auxiliary winding voltage reaches about 25 VAC, which is usually occurs between 800 and 1200 rpm as the engine accelerates. The field current is limited by the battery voltage until enough current is flowing on the rotor field to energize the auxiliary windings.

The activator board controls current to the exciter field which controls the voltage on the exciter armature that is rectified by the rotating diode board and provides a DC voltage to the rotor field. In constant load and speed operation, the rotor field current is related to the exciter current.

In transient conditions (changing load or speed) operation, the two currents may not be related, as the rotor field has a long time constant (it takes time to change the rotor field current). The field current in the main field increases when voltage is applied to it and decreases when voltage is not applied to it. The voltage is proportional to the exciter field current. The voltage applied to the main field is proportional to the exciter field current.

WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

10.7.3 Activator Board Function and Connections

Activator board GM88453 provides the connection between the controller with integrated voltage regulator and the alternator assembly with wiring for the rotor exciter field leads (FN and FP) and auxiliary power windings (60, 61, and 62). See Figure 10-17 and Figure 10-18.

10.7.4 Activator Board Troubleshooting

Use the flowcharts on the following pages to troubleshoot the alternator assembly and activator board. The following equipment is required:

- Multimeter, qty. 2
- DC Ammeter (0-10 Amps) (required if multimeter doesn't have 10 amp current measuring capability)

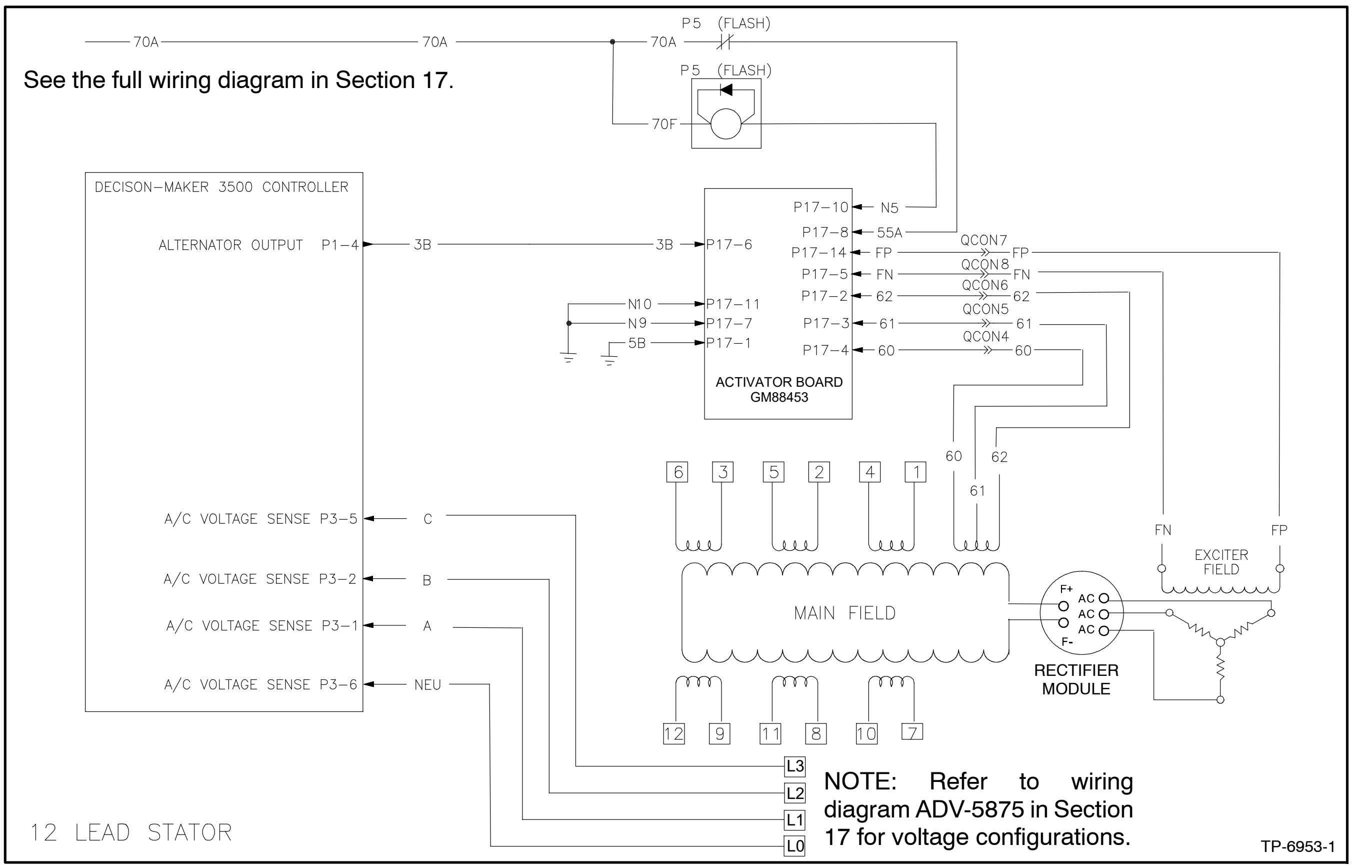
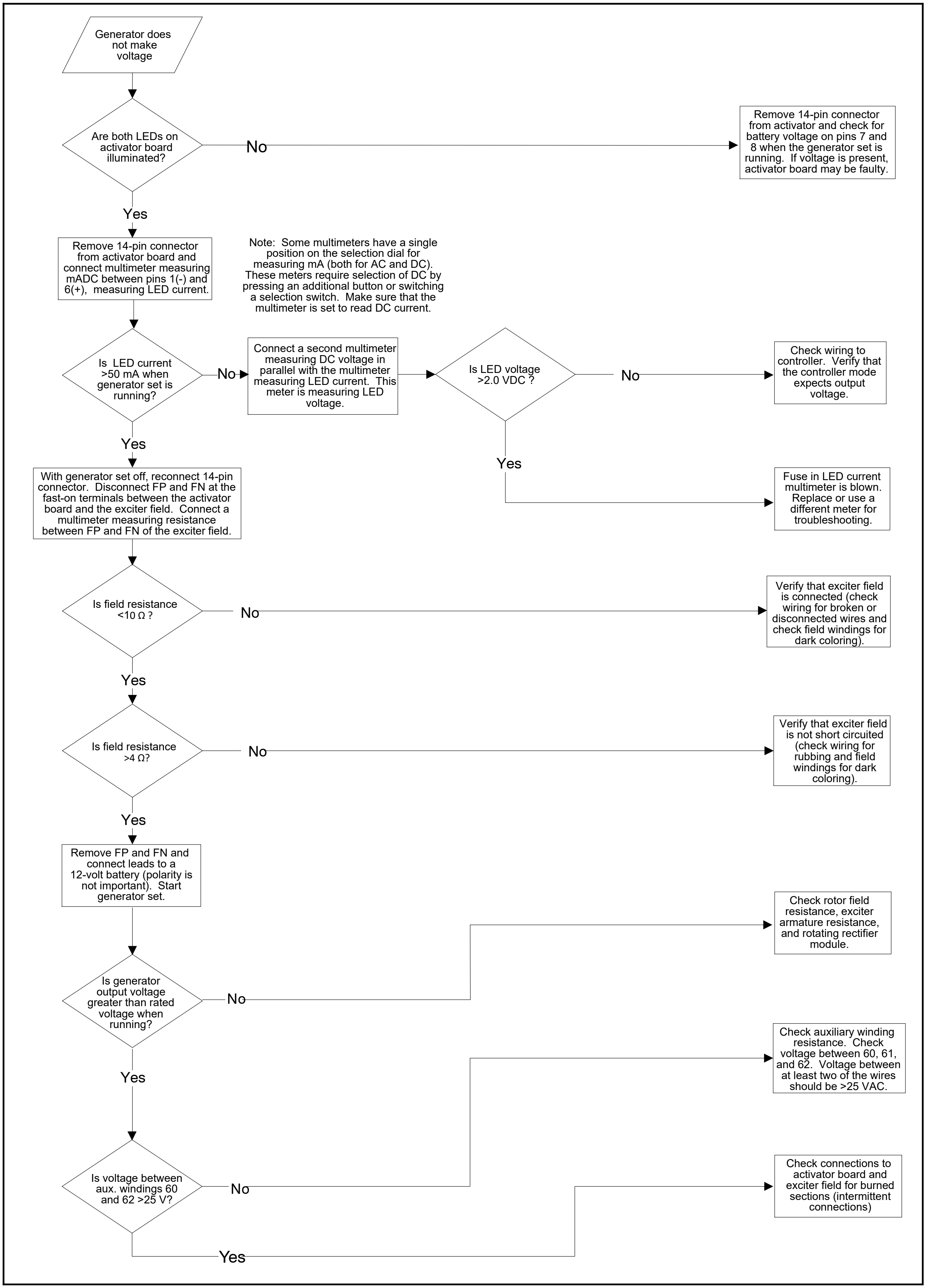
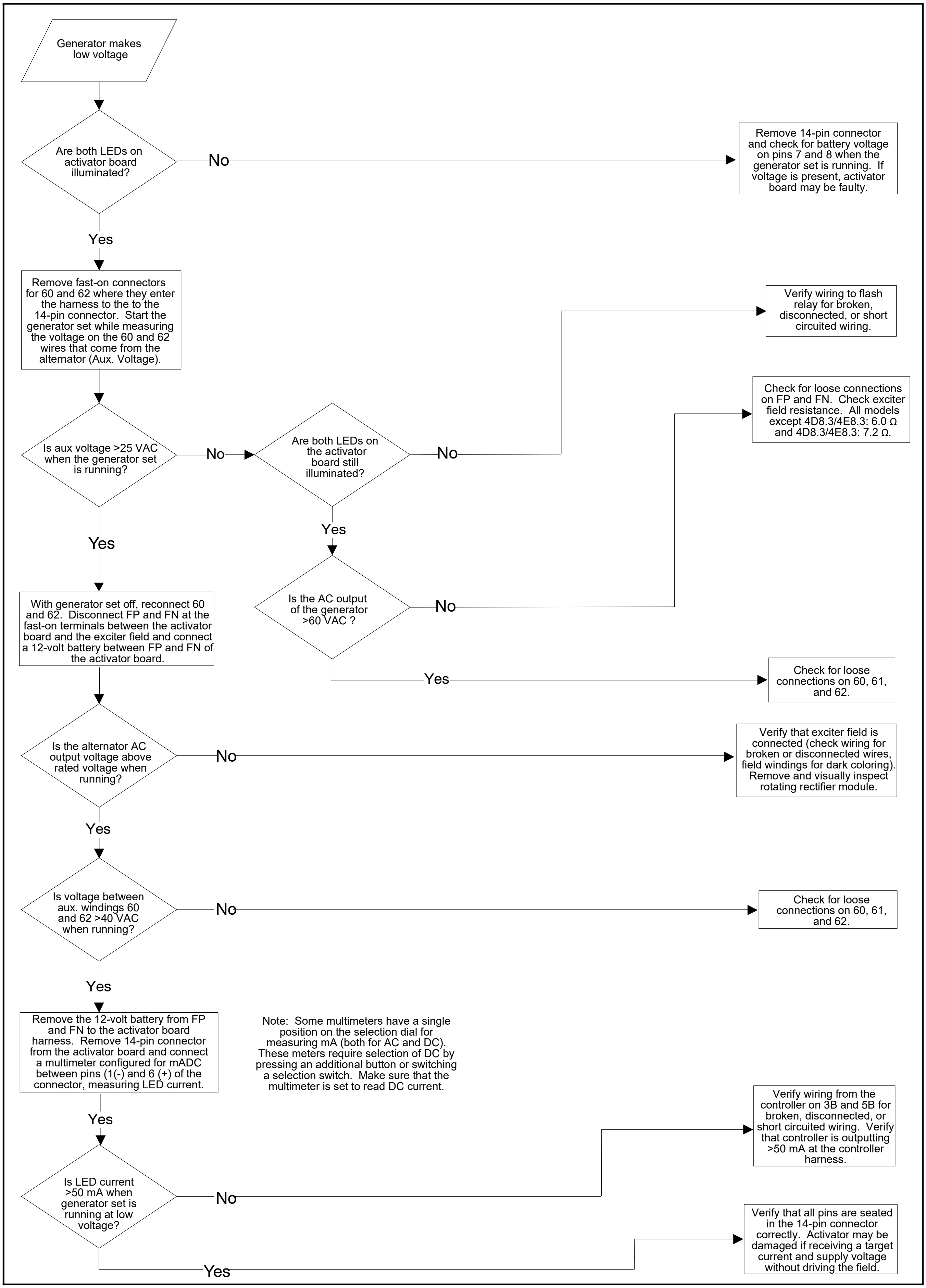


Figure 10-17 Activator Board GM88453 Connections (shown with Decision-Maker® 3500 controller)

Activator Board	Description	Comments
P17-1	PWM target current signal, 5B, LED(-)	LED is 1.2 VDC max. Can be connected to a 12-volt battery negative terminal as an activator troubleshooting test. Add a 120 ohm resistor when using a 12 VDC (battery).
P17-2	Normal power input	25-250 VAC @ 30-400 Hz (3 amps.).
P17-3	Normal power input	
P17-4	Normal power input	
P17-5	Field current output (-)	Rated at 5.0 amps. continuous, 7.8 amps peak for 1 minute.
P17-6	PWM target current signal, 3B, LED(+)	LED is 1.2 VDC max. Can be connected to a 12-volt battery positive terminal as an activator troubleshooting test. Add a 120 ohm resistor when using a 12 VDC (battery).
P17-7	Alternator power input (-)	12-200 VDC or 120 VAC (for powering the board during testing).
P17-8	Alternator power input (+)	
P17-9	Not used	
P17-10	DC bus voltage (+)	Rated at up to 30 VDC, 250 mA, relay driver output. Turns on when the DC bus that provides current to the field reaches 35 VDC. This occurs when the alternator is producing at least 25 VAC on the auxiliary windings. This output is typically used to disconnect the field flash relay.
P17-11	DC bus voltage (-)	
P17-12	Field overvoltage (+)	Rated at up to 30 VDC, 250 mA, relay driver output. Turns on when the DC voltage of the field (between FP and FN) exceeds 80 VDC indicating an over excitation condition.
P17-13	Field overvoltage (-)	
P17-14	Field current output (+)	Rated at 5.0 amps. continuous, 7.8 amps peak for 1 minute.

Figure 10-18 Activator Board P1 Connections


Generator does not make voltage
Are both LEDs on activator board illuminated?
No
Remove 14-pin connector from activator and check for battery voltage on pins 7 and 8 when the generator set is running. If voltage is present, activator board may be faulty.
Yes
Remove 14-pin connector from activator board and connect multimeter measuring mADC between pins 1(-) and 6(+), measuring LED current.
Note: Some multimeters have a single position on the selection dial for measuring mA (both for AC and DC). These meters require selection of DC by pressing an additional button or switching a selection switch. Make sure that the multimeter is set to read DC current.
Is LED current >50 mA when generator set is running?
No
Connect a second multimeter measuring DC voltage in parallel with the multimeter measuring LED current. This meter is measuring LED voltage.
Is LED voltage >2.0 VDC ?
No
Check wiring to controller. Verify that the controller mode expects output voltage.
Yes
Fuse in LED current multimeter is blown. Replace or use a different meter for troubleshooting.
Yes
With generator set off, reconnect 14-pin connector. Disconnect FP and FN at the fast-on terminals between the activator board and the exciter field. Connect a multimeter measuring resistance between FP and FN of the exciter field.
Is field resistance <10 Ω ?
No
Verify that exciter field is connected (check wiring for broken or disconnected wires and check field windings for dark coloring).
Yes
Is field resistance >4 Ω?
No
Verify that exciter field is not short circuited (check wiring for rubbing and field windings for dark coloring).
Yes
Remove FP and FN and connect leads to a 12-volt battery (polarity is not important). Start generator set.
Is generator output voltage greater than rated voltage when running?
No
Check rotor field resistance, exciter armature resistance, and rotating rectifier module.
Yes
Is voltage between aux. windings 60 and 62 >25 V?
No
Check auxiliary winding resistance. Check voltage between 60, 61, and 62. Voltage between at least two of the wires should be >25 VAC.
Yes
Check connections to activator board and exciter field for burned sections (intermittent connections)


Generator makes low voltage
Are both LEDs on activator board illuminated?
No
Remove 14-pin connector and check for battery voltage on pins 7 and 8 when the generator set is running. If voltage is present, activator board may be faulty.
Yes
Remove fast-on connectors for 60 and 62 where they enter the harness to the to the 14-pin connector. Start the generator set while measuring the voltage on the 60 and 62 wires that come from the alternator (Aux. Voltage).
Is aux voltage >25 VAC when the generator set is running?
No
Are both LEDs on the activator board still illuminated?
No
Verify wiring to flash relay for broken, disconnected, or short circuited wiring.
Yes
Is the AC output of the generator >60 VAC ?
No
Check for loose connections on FP and FN. Check exciter field resistance. All models except 4D8.3/4E8.3: 6.0 Ω and 4D8.3/4E8.3: 7.2 Ω.
Yes
Check for loose connections on 60, 61, and 62.
Yes
With generator set off, reconnect 60 and 62. Disconnect FP and FN at the fast-on terminals between the activator board and the exciter field and connect a 12-volt battery between FP and FN of the activator board.
Is the alternator AC output voltage above rated voltage when running?
No
Verify that exciter field is connected (check wiring for broken or disconnected wires, field windings for dark coloring). Remove and visually inspect rotating rectifier module.
Yes
Is voltage between aux. windings 60 and 62 >40 VAC when running?
No
Check for loose connections on 60, 61, and 62.
Yes
Remove the 12-volt battery from FP and FN to the activator board harness. Remove 14-pin connector from the activator board and connect a multimeter configured for mADC between pins (1(-) and 6 (+) of the connector, measuring LED current.
Note: Some multimeters have a single position on the selection dial for measuring mA (both for AC and DC). These meters require selection of DC by pressing an additional button or switching a selection switch. Make sure that the multimeter is set to read DC current.
Yes
Is LED current >50 mA when generator set is running at low voltage?
No
Verify wiring from the controller on 3B and 5B for broken, disconnected, or short circuited wiring. Verify that controller is outputting >50 mA at the controller harness.
Yes
Verify that all pins are seated in the 14-pin connector correctly. Activator may be damaged if receiving a target current and supply voltage without driving the field.

Notes

Section 11 Alternator Component Testing and Adjustment (35-40 kW Generator Sets Equipped with 4PX/4QX Alternators)

Note: See Section 10 for 11-32 kW generator sets equipped with 4D/4E alternators.

11.1 Introduction

This section provides information on troubleshooting the alternator and testing components of the generator set.

To troubleshoot the alternator assembly components, the following equipment is needed for many of the tests:

- Multimeter (Voltmeter/Ohmmeter)
- Megohmmeter

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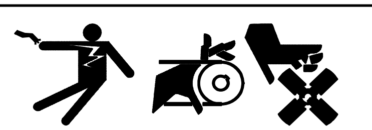

Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

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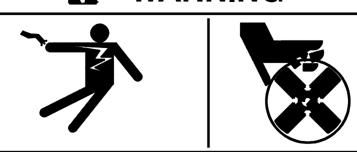


Hazardous voltage. Moving parts.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Disconnecting the electrical load. Hazardous voltage can cause severe injury or death. Disconnect the generator set from the load by turning off the line circuit breaker or by disconnecting the generator set output leads from the transfer switch and heavily taping the ends of the leads. High voltage transferred to the load during testing may cause personal injury and equipment damage.

High voltage test. Hazardous voltage can cause severe injury or death. Follow the instructions of the test equipment manufacturer when performing high-voltage tests on the rotor or stator. An improper test procedure can damage equipment or lead to generator set failure.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Testing live electrical circuits. Hazardous voltage or current can cause severe injury or death. Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment manufacturer when performing voltage tests. Observe the following precautions when performing voltage tests: (1) Remove all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Do not touch the enclosure or components inside the enclosure. (4) Be prepared for the system to operate automatically.
(600 volts and under)

11.2 Alternator Troubleshooting

Follow all safety precautions listed in the front of this manual and the additional precautions within the text. Refer to Figure 11-1, AC Voltage Control, for assistance in troubleshooting. Figure 11-2 lists various alternator output conditions and component tests.

Use the following flowcharts to troubleshoot the generator set when voltage problems are detected. The remaining parts of this section give additional and more detailed information about the individual checks/tests mentioned in the flowcharts. Use the flowcharts to initially isolate the possible problem.

This section covers alternator testing for the following conditions:

- No voltage output on any phase (Section 11.2.1)
- Overvoltage (Section 11.2.2)
- Fluctuating voltage (Section 11.2.3)

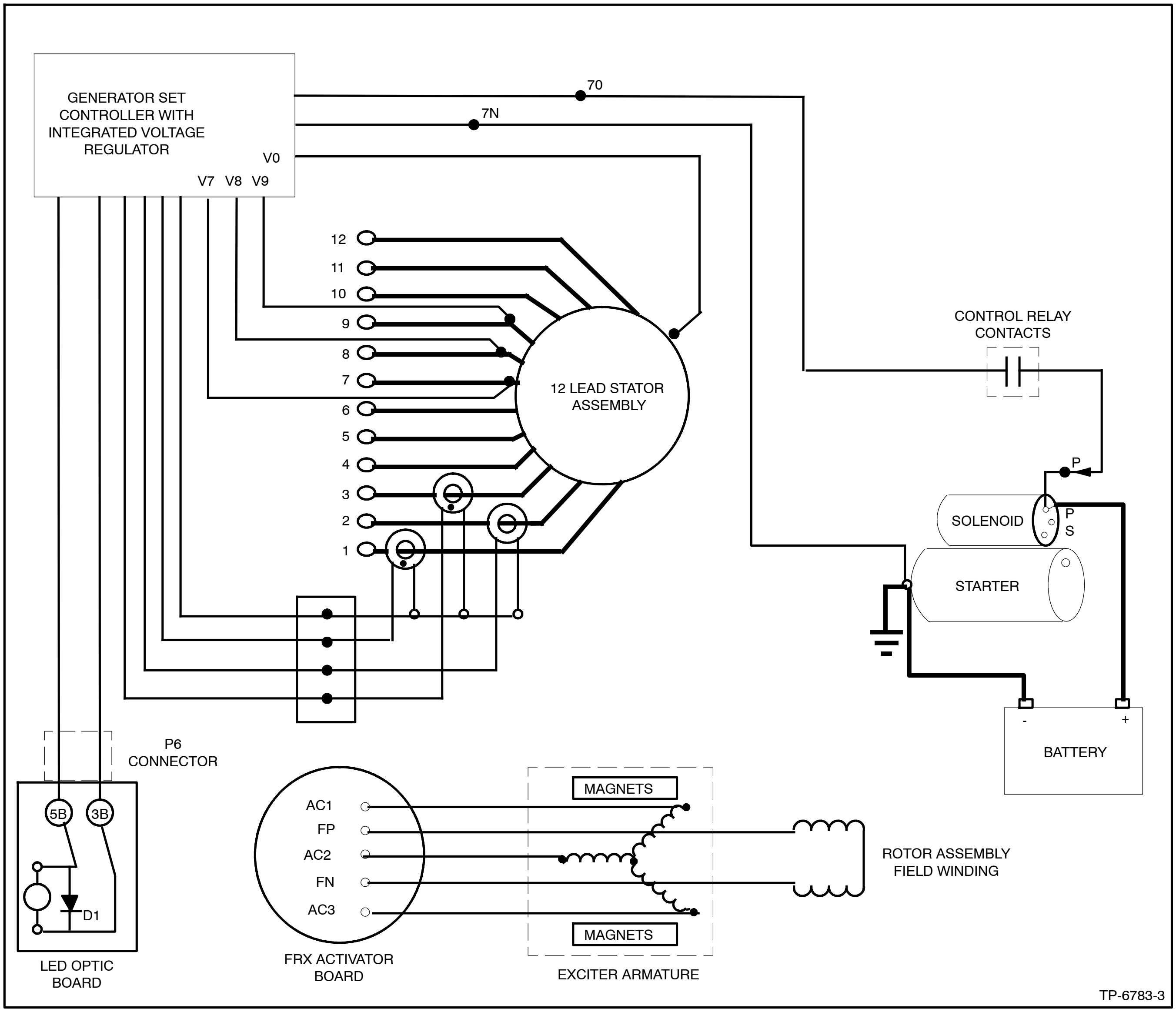


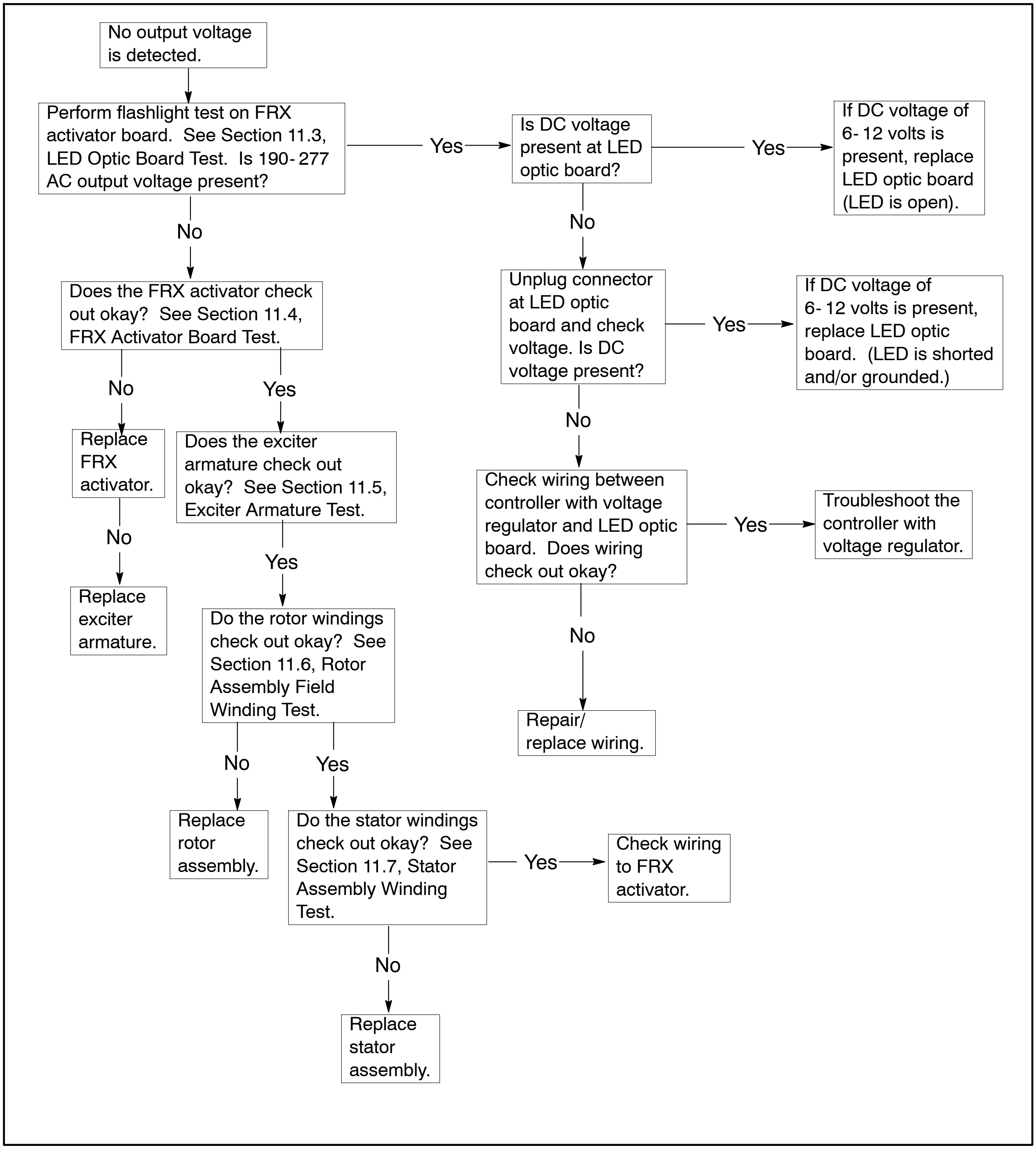
Figure 11-1 AC Voltage Control Components

Components and Circuits to Test Under Certain Alternator Output Conditions						
Alternator Output Condition	Controller with Voltage Regulator †	LED Optic Board	FRX Activator Board	Exciter Armature	Rotor Assembly Field Winding	Stator Assembly Windings
No Output	●	●	●	●	●	●
Overvoltage	●		● *			
Fluctuating Voltage	●	●	●	●	●	●

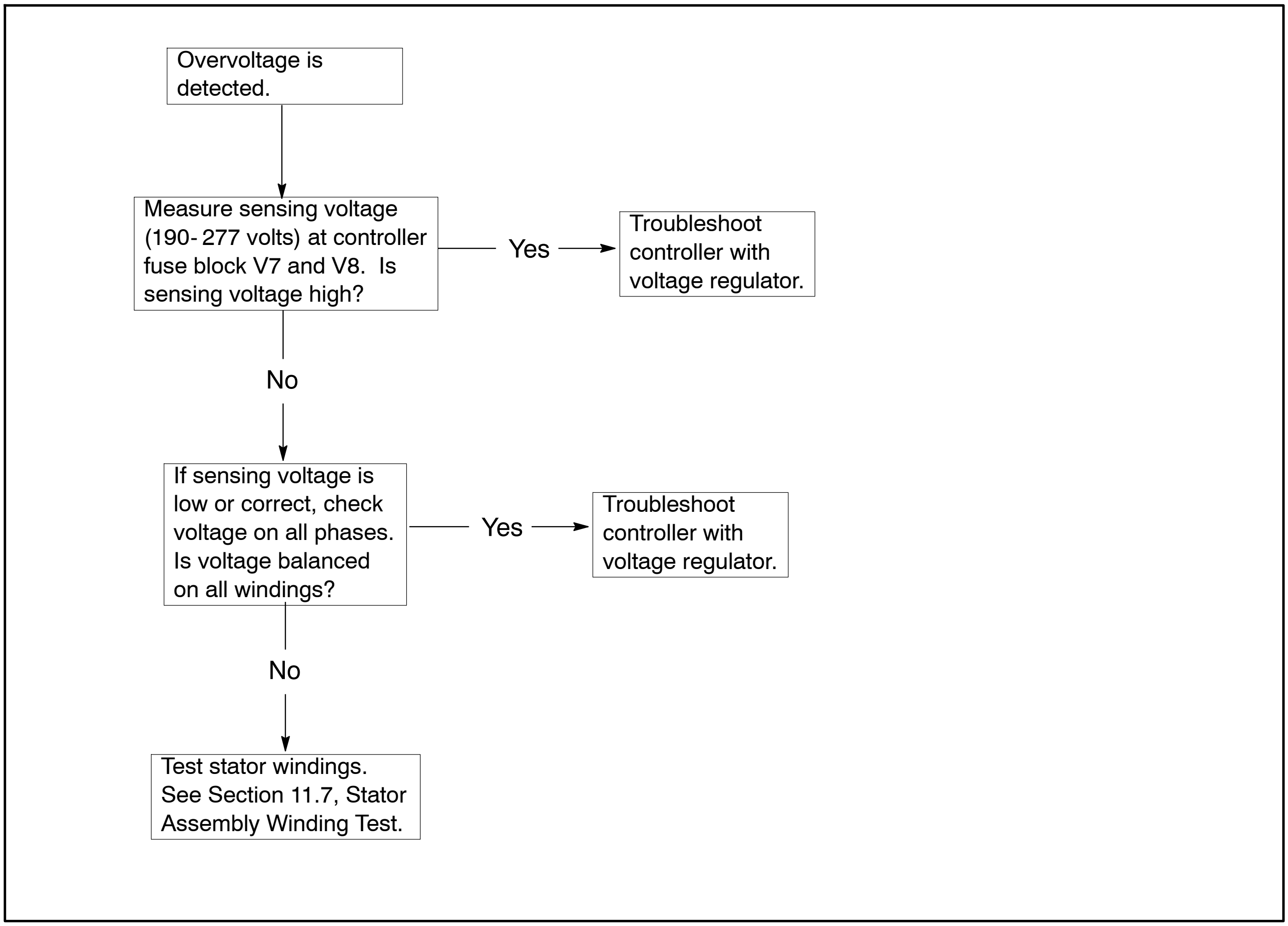
* Overvoltage will occur if an outside light source is present when the LED board is removed.
† See the operation or service manual for operation, setup, and/or troubleshooting.

Figure 11-2 Alternator Assembly Troubleshooting Guide

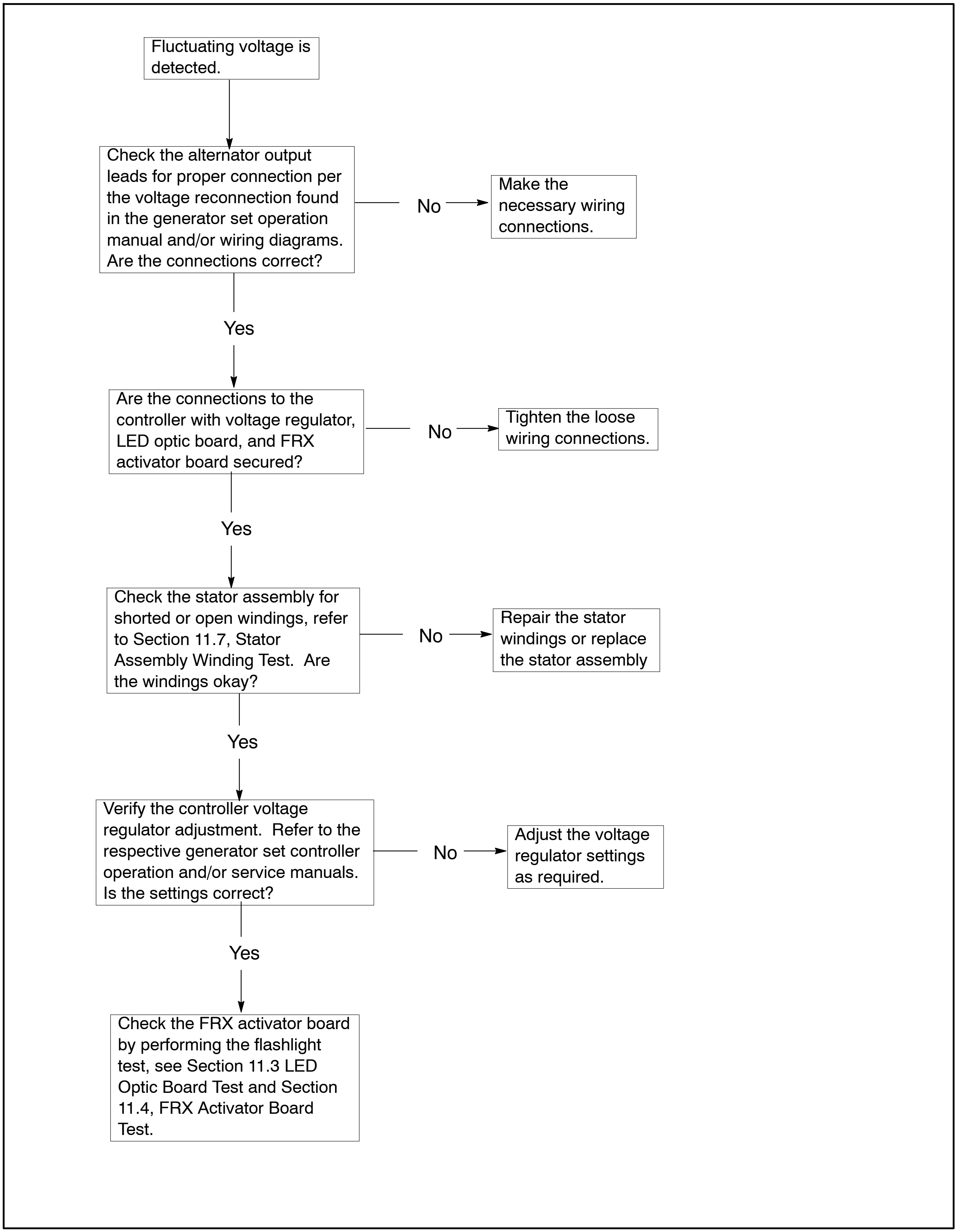
11.2.1 Troubleshooting Alternator, No Output Voltage



11.2.2 Troubleshooting Alternator, Overvoltage



11.2.3 Troubleshooting Alternator, Fluctuating Voltage

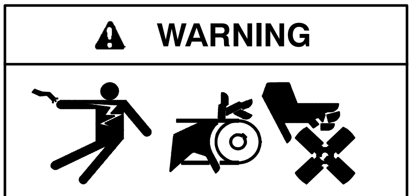


11.3 LED Optic Board Test

The following procedure provides information on testing the LED optic board. Certain steps require that the generator set be running. When the generator set is not running, disable the generator set. See the safety precautions listed below. Disconnect all load from the generator set during this test.

To test the LED optic board, the following item is needed:

- Flashlight



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

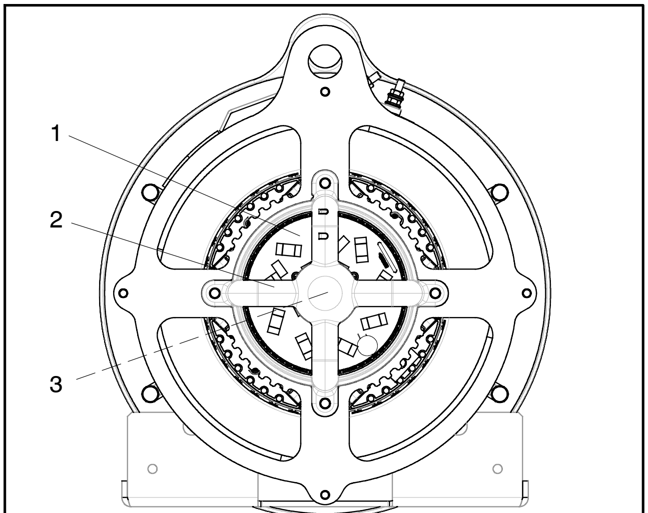
Hazardous voltage. Moving parts.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Disconnecting the electrical load. Hazardous voltage can cause severe injury or death. Disconnect the generator set from the load by turning off the line circuit breaker or by disconnecting the generator set output leads from the transfer switch and heavily taping the ends of the leads. High voltage transferred to the load during testing may cause personal injury and equipment damage.

Testing the photo transistor circuit board. Hazardous voltage can cause severe injury or death. When the end cover is removed, do not expose the photo transistor circuit board mounted on the generator set end bracket to any external light source, as exposure to light causes high voltage. Keep foreign sources of light away from the photo transistor circuit board during testing. Place black electrical tape over the LED on the circuit board before starting the generator set.

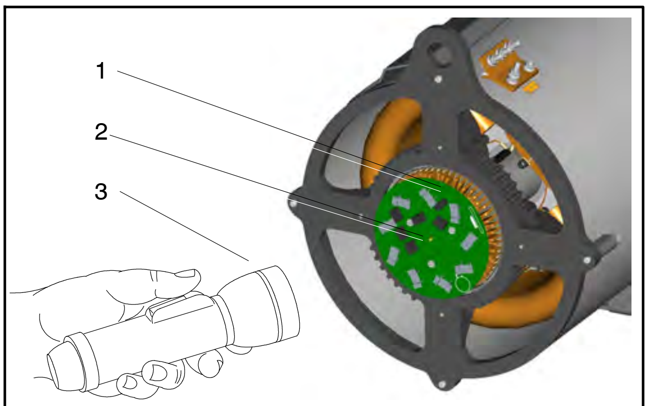
1. Remove the junction box panels from the generator end of unit and remove the LED optic board holder/LED optic board. See Figure 11-3.



1. FRX activator board
2. LED optic board holder
3. LED optic board

Figure 11-3 FRX Activator Board with LED Optic Board Installed.

2. Refer to the generator set operation manual for starting/stopping procedures. With the generator set running at no load, shine a flashlight at the exposed photo transistor on the FRX activator board. See Figure 11-4.



1. FRX activator board
2. Photo transistor
3. Flashlight

Figure 11-4 Flashlight Test on FRX Activator Board

3. Observe the AC output voltage controller display or connect a voltmeter to the output leads. High AC output voltage indicates the FRX activator board is functioning properly. The fault is likely in the wiring, controller with voltage regulator, or LED optic board as the output voltage should drop to low level when the flashlight is removed. If no output is observed, check the FRX activator board.

4. If high output voltage exists with the flashlight off, stop the generator set and place a small piece of black electrical tape over the photo transistor. Restart the unit.

   If the output voltage is reduced, there is a source of external light contamination. STOP the generator set. Find the external light source and eliminate it or block it from reaching the photo transistor.

   If the output voltage remains high, there is a failure in the FRX activator board.

5. With the generator set running at no load, approximately 1-2 volts DC should be observed at 3B (+) and 5B (-) at the LED optic board. See Figure 11-5.

6. Shine the flashlight on the photo transistor. The DC voltage reading should drop, showing that the controller with voltage regulator is functioning.

   If voltages are not observed, see Section 7.10 for voltage regulator troubleshooting.

7. STOP the generator set.

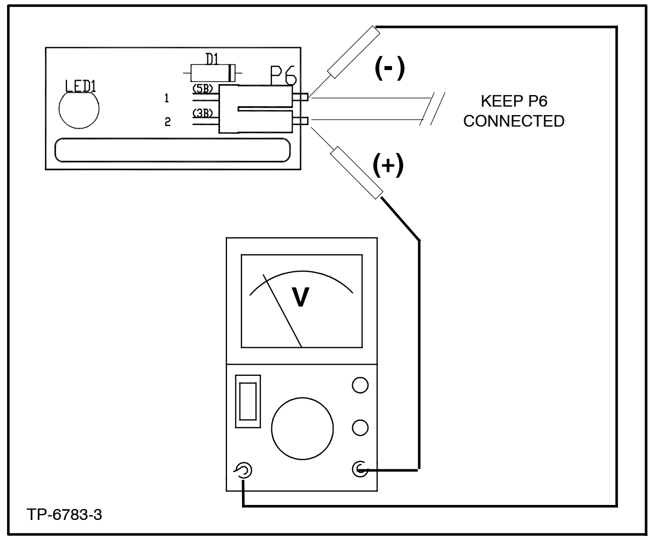


Figure 11-5 Checking LED Optic Board Voltage

11.4 FRX Activator Board Test

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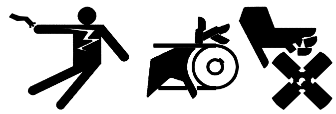
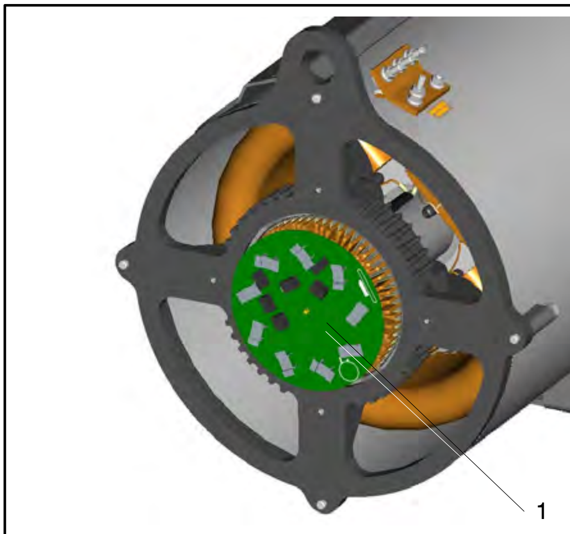


Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

The FRX activator board is mounted on the exciter armature and controls current flow to the alternator field. See Figure 11-6.



1. FRX activator board

Figure 11-6 FRX Activator Board

The following test determines if the FRX activator board is non-functional.

See Section 11.2, Alternator Troubleshooting. Examine the photo transistor board for visible signs of damage (open foil patterns and heat discoloration) before testing.

To test the FRX activator board, the following components are needed:

- One 120-volt/110-watt light bulb with socket
- Switch, DPST (double-pole/single-throw) 120 volt 10 amp minimum)
- Fuse, 1 amp (in holder)
- 120 volt AC plug with cord
- Five 6 mm screws and terminal nuts
- Flashlight

This test simulates the normal operation of the components when the alternator is running.

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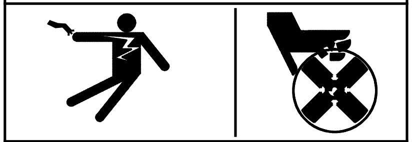


Hazardous voltage. Moving parts. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

1. Connect components as illustrated in Figure 11-7, Test A.

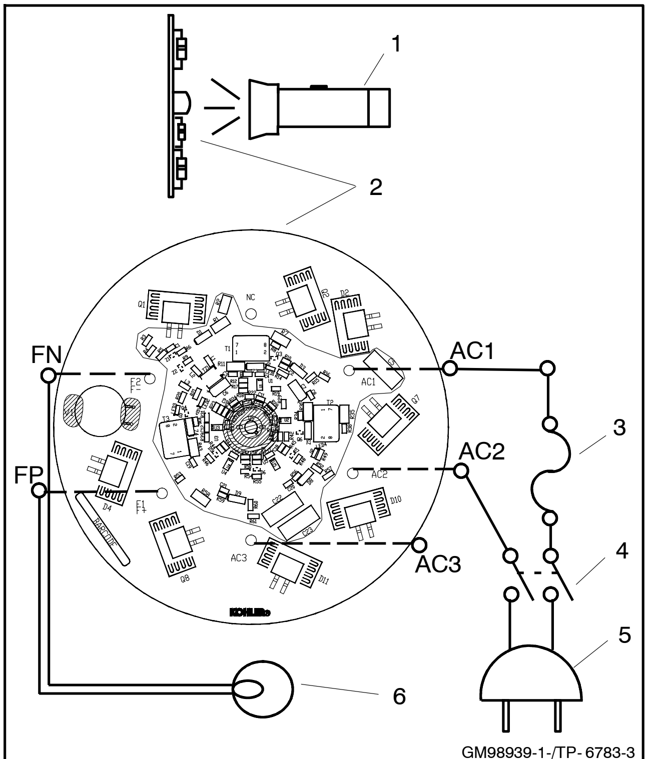
   Note: Connect 120 VAC power source to AC1 and <u>AC2</u>.

   Temporarily, install the five 6 mm screws into the AC1, AC2, AC3, F+, and F- holes on the activator board.

   Connections to the FRX activator board are made to the threaded screws located on the underside of the board. Secure all connections with terminal nuts to ensure good electrical contact with threaded screws during testing. Do not exceed 1.3 Nm (12 in. lb.) when tightening the terminal nuts. Place FRX activator board on a non-conductive surface when performing the test.

2. With the cord switch in the OFF position, plug in the electrical cord.

3. Turn the cord switch to the ON position.



1. Flashlight
2. FRX activator board
3. Fuse (1 amp)
4. Switch DPST
5. 120 volts AC plug
6. 120 volt/100 watt lamp

Figure 11-7 FRX Activator Board Test A

4. Apply light source directly to the photo transistor located in the center of the FRX activator board. Shield the photo transistor from all other sources of light during this test.

   If the FRX activator board is *functional,* the test fixture light bulb will light when the external light source is applied to the photo transistor. Remove the light source; the fixture light bulb should go out.

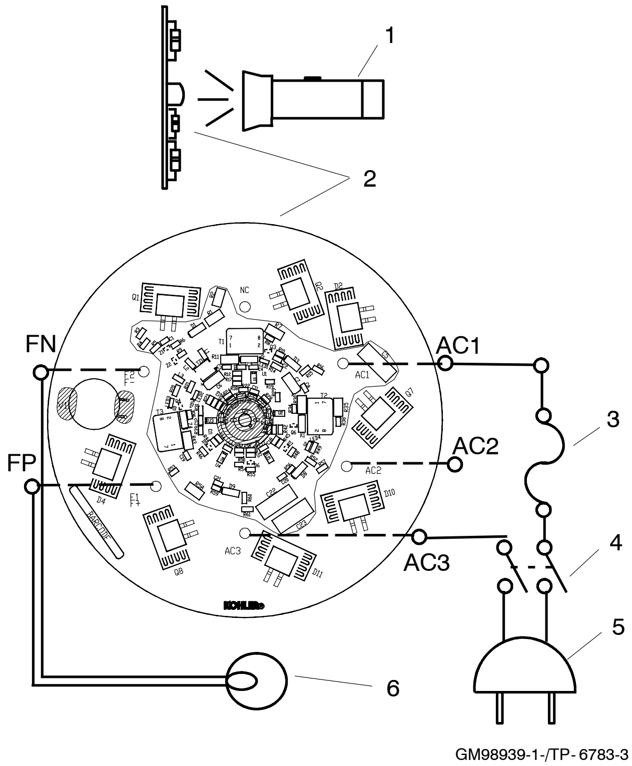
   If the test fixture light bulb does not light or is lit prior to receiving external light source, the FRX activator board is non-functional.

5. Turn the cord switch to the OFF position and unplug the electrical cord.

6. Connect components as illustrated in Figure 11-8, Test B.

   Note: Connect 120 VAC power source to AC1 and <u>AC3</u>.

7. Repeat steps 2-5. Replace the FRX activator board if it fails either test.



1. Flashlight
2. FRX activator board
3. Fuse (1 amp)
4. Switch DPST
5. 120 volts AC plug
6. 120 volt/100 watt lamp

Figure 11-8 FRX Activator Board Test B

11.5 Exciter Armature Test

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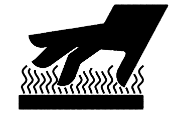

Hot engine and exhaust system.
Can cause severe injury or death.

Do not work on the generator set until it cools.

Servicing the alternator. Hot parts can cause severe injury or death. Avoid touching the alternator field or exciter armature. When shorted, the alternator field and exciter armature become hot enough to cause severe burns.

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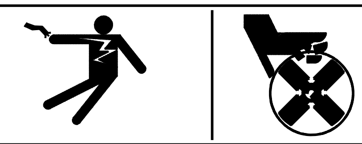

Hazardous voltage. Moving parts.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

High voltage test. Hazardous voltage can cause severe injury or death. Follow the instructions of the test equipment manufacturer when performing high-voltage tests on the rotor or stator. An improper test procedure can damage equipment or lead to generator set failure.

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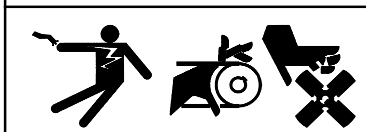
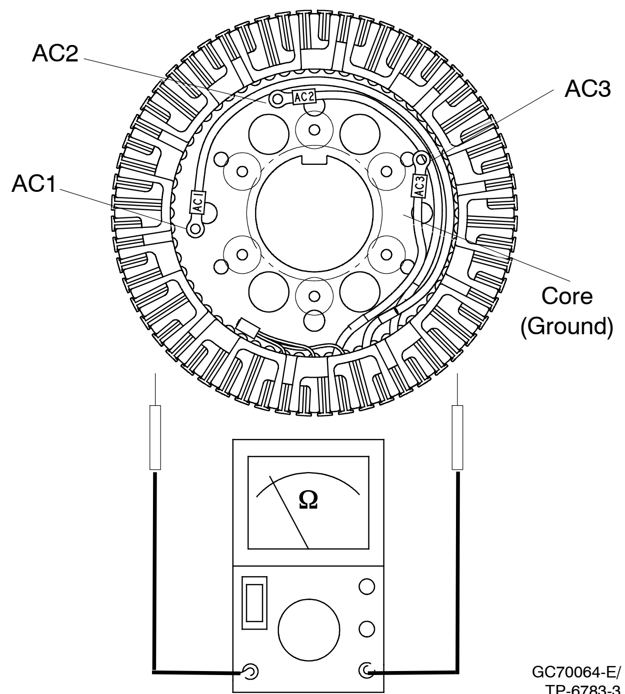


Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

1. Disconnect the battery (negative lead first).
2. Disconnect leads AC1, AC2, and AC3 from the FRX activator board or remove the activator board from the spacer.
3. Visually check the exciter armature for shorted or open winding(s)
4. With an ohmmeter, check for continuity across the AC1/AC2, AC2/AC3, and AC1/AC3. Check for continuity across AC1/core (ground), AC2/core (ground), and AC3/core (ground). See Figure 11-9. See Section 1.8, Specifications, Electrical Values for exciter armature resistance values.



Make ohmmeter connections across:

1. AC1 and AC2 leads
2. AC2 and AC3 leads
3. AC1 and AC3 leads
4. AC1 lead and core (ground)
5. AC2 lead and core (ground)
6. AC3 lead and core (ground)

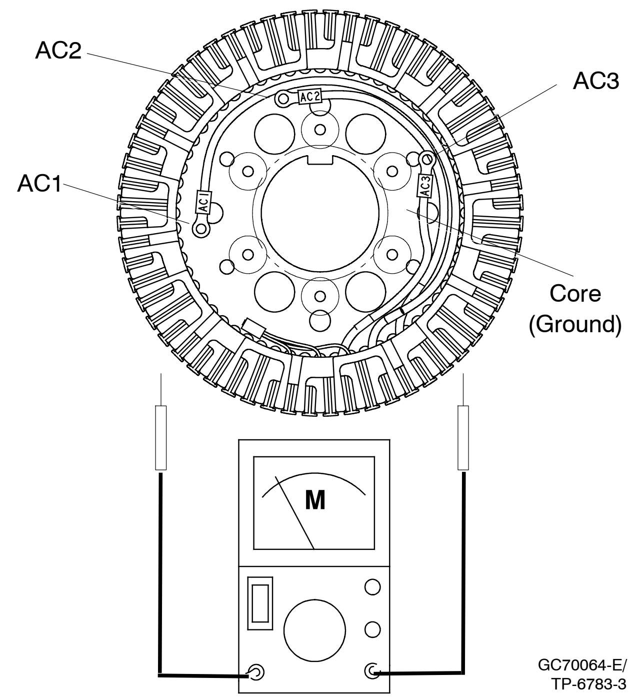
Figure 11-9 Exciter Armature Continuity Check

Out of specification readings indicate a non-functional exciter armature requiring replacement. Low resistance readings indicate a shorted winding. High resistance readings indicate an open winding. No continuity should exist between any lead and ground.

5. Repair the leads if damaged or open. Solder and insulate the splices. Use new sleeving as needed when tying leads to the core.
6. Using a megohmmeter, apply 500 volts DC to the exciter armature core and each lead. See Figure 11-10. Place the exciter armature on a non-conductive surface when performing the test. Follow the instructions of the megohmmeter manufacturer when performing this test.

   A reading of approximately 500 kOhms (1/2 megohm) and higher indicates the winding is good.

   A reading of less than 500 kOhms (approximately) indicates deterioration of winding insulation and possible current flow to ground.
7. Repair or replace exciter armature if the test shows a winding is shorted to ground. Repair the leads if damaged or open. Solder and insulate the splices. Use new sleeving as needed when tying leads to the core.



Make megohmmeter connections across:

1. AC1 lead and core (ground)
2. AC2 lead and core (ground)
3. AC3 lead and core (ground)

Figure 11-10 Exciter Armature High Voltage Test

11.6 Rotor Assembly Field Winding Test

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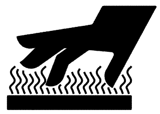

Hot engine and exhaust system.
Can cause severe injury or death.

Do not work on the generator set until it cools.

Servicing the alternator. Hot parts can cause severe injury or death. Avoid touching the alternator field or exciter armature. When shorted, the alternator field and exciter armature become hot enough to cause severe burns.

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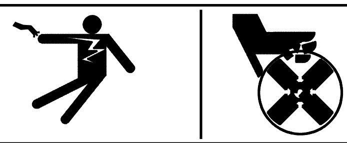

Hazardous voltage. Moving parts.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

High voltage test. Hazardous voltage can cause severe injury or death. Follow the instructions of the test equipment manufacturer when performing high-voltage tests on the rotor or stator. An improper test procedure can damage equipment or lead to generator set failure.

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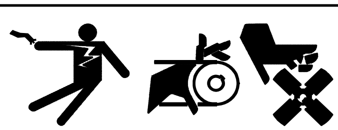


Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

1. Disconnect the battery (negative lead first).

2. Disconnect leads FP and FN from the FRX activator board or remove the activator board from the spacer.

3. Visually check the rotor assembly field for shorted or open winding(s)

4. With an ohmmeter, check for continuity across the FN/FP leads. Check for continuity across FN/rotor shaft and FP/rotor shaft. See Figure 11-11. See Section 1.8, Specifications, Electrical Values for rotor assembly field resistance values.

   Out-of-specification readings indicate a non-functional rotor assembly requiring replacement. Low resistance readings indicate a shorted winding. High resistance readings indicate an open winding. No continuity should exist between any lead and rotor shaft (ground).

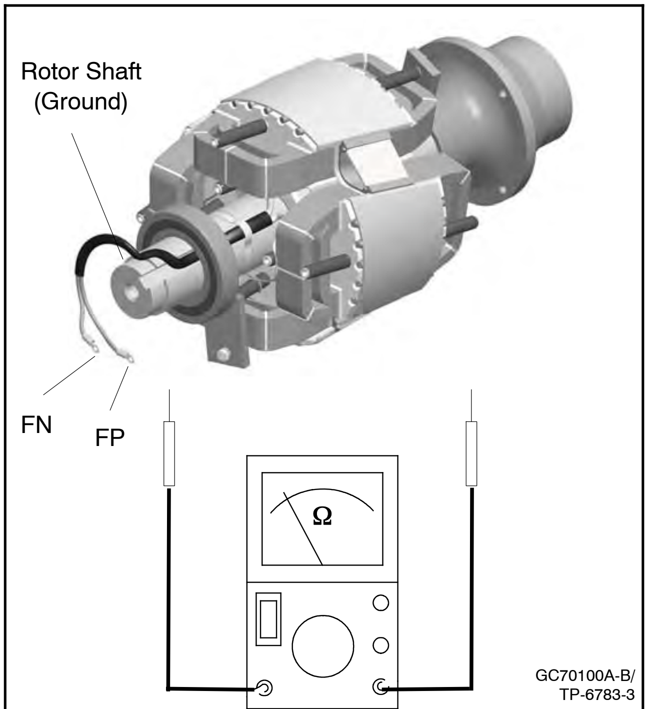
5. Repair the leads if damaged or open. Solder and insulate the splices. Use new sleeving as needed when tying leads to the core.

6. Using a megohmmeter, apply 500 volts DC to the two leads and then the rotor shaft and each lead. See Figure 11-12. Place the rotor assembly on a non-conductive surface when performing the test. Follow the instructions of the megohmmeter manufacturer when performing this test.

   A reading of approximately 500 kOhms (1/2 megohm) and higher indicates the winding is good.

   A reading of less than 500 kOhms (approximately) indicates deterioration of winding insulation and possible current flow to ground.

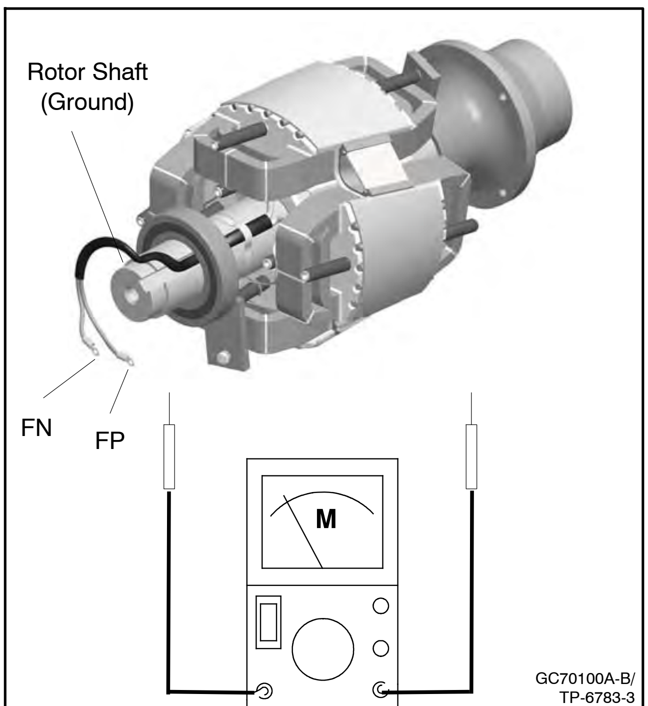
7. Repair or replace the rotor assembly if the test shows a winding is shorted to ground. Repair the leads if damaged or open. Solder and insulate the splices. Use new sleeving as needed when tying leads to the core.



Make ohmmeter connections across:

1. FP and FN leads
2. FP lead and rotor shaft (ground)
3. FN lead and rotor shaft (ground)

Figure 11-11 Rotor Field Continuity Check



Make megohmmeter connections across:

1. FP and FN leads
2. FP lead and rotor shaft (ground)
3. FN lead and rotor shaft (ground)

Figure 11-12 Rotor Field High Voltage Test

11.7 Stator Assembly Winding Test

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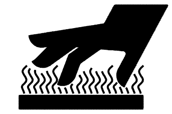

Hot engine and exhaust system. Can cause severe injury or death.

Do not work on the generator set until it cools.

Servicing the alternator. Hot parts can cause severe injury or death. Avoid touching the alternator field or exciter armature. When shorted, the alternator field and exciter armature become hot enough to cause severe burns.

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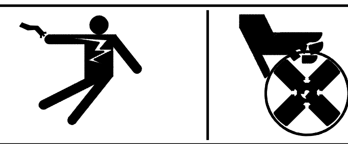

Hazardous voltage. Moving parts. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

High voltage test. Hazardous voltage can cause severe injury or death. Follow the instructions of the test equipment manufacturer when performing high-voltage tests on the rotor or stator. An improper test procedure can damage equipment or lead to generator set failure.

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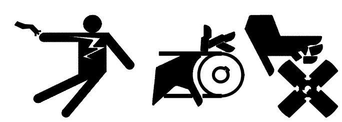
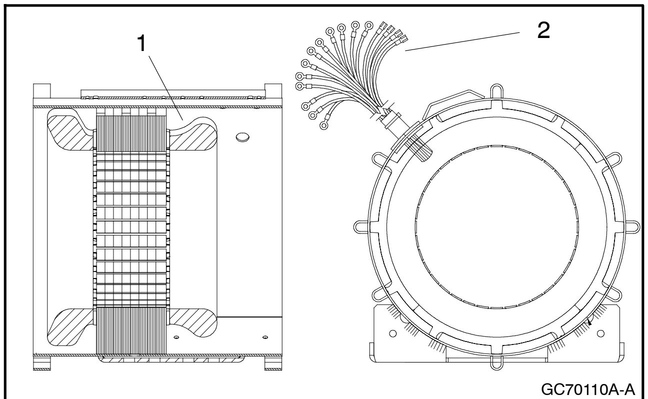


Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

1. Disconnect the battery (negative lead first).
2. Disconnect V7, V8, V9, V0 stator leads at generator set controller terminal block before doing test. Tape to insulate the terminals.
3. Disconnect the 12 leads (three-phase alternator), 6 leads (600 volt), or 4 leads (single-phase alternator). Keep each lead isolated from each other and ground.
4. Visually check the stator assembly for shorted or open winding(s). See Figure 11-13.

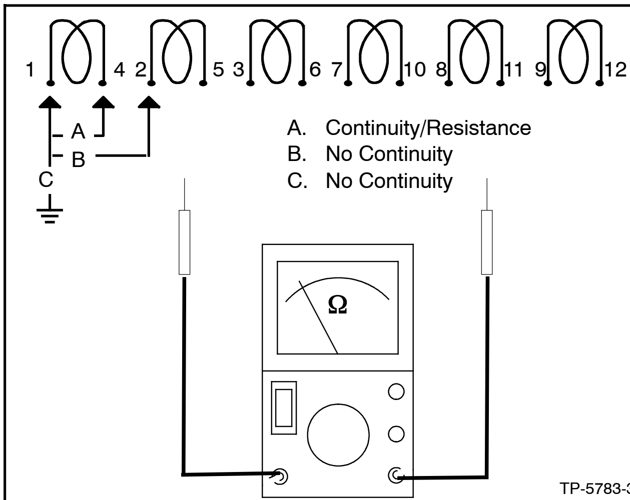


1. Windings
2. Leads

Figure 11-13 Stator Assembly

5. With ohmmeter, check **each pair** of leads for low resistance readings (continuity). High resistance across A or low resistance (continuity) across B and the stator core (ground) indicates a faulty stator; replace stator. See Figure 11-14 and Figure 11-15. See Section 1.8, Specifications, Electrical Values for stator assembly resistance values.

   Out of specification readings indicate a non-functional stator assembly requiring replacement. Low resistance readings indicate a shorted winding. High resistance readings indicate an open winding. No continuity should exist between any lead and ground.



Make ohmmeter connections across:

1. 1 and 4 leads
2. 2 and 5 leads
3. 3 and 6 leads
4. 7 and 10 leads
5. 8 and 11 leads
6. 9 and 12 leads
7. 1 and 2 leads
8. 1 and 3 leads
9. 1 and 7 leads
10. 1 and 8 leads
11. 1 and 9 leads
12. 2 and 3 leads
13. 2 and 7 leads
14. 2 and 8 leads
15. 2 and 9 leads
16. 3 and 7 leads
17. 3 and 8 leads
18. 3 and 9 leads
19. 7 and 8 leads
20. 7 and 9 leads
21. 8 and 9 leads
22. 1 lead and core (ground)
23. 2 lead and core (ground)
24. 3 lead and core (ground)
25. 7 lead and core (ground)
26. 8 lead and core (ground)
27. 9 lead and core (ground)

Figure 11-14 Stator Winding Continuity Test

<table>
<tr><th colspan="3">Ohmmeter Connections, Leads:</th><th>Continuity</th></tr>
<tr><td>1-4</td><td>2-5</td><td>3-6</td><td rowspan="2">Yes</td></tr>
<tr><td>7-10</td><td>8-11</td><td>9-12</td></tr>
<tr><td>1-2</td><td>1-3</td><td>1-7</td><td rowspan="5">No</td></tr>
<tr><td>1-8</td><td>1-9</td><td>2-3</td></tr>
<tr><td>2-7</td><td>2-8</td><td>2-9</td></tr>
<tr><td>3-7</td><td>3-8</td><td>3-9</td></tr>
<tr><td>7-8</td><td>7-9</td><td>8-9</td></tr>
<tr><td colspan="3">1 and core (ground)</td><td rowspan="6">No</td></tr>
<tr><td colspan="3">2 and core (ground)</td></tr>
<tr><td colspan="3">3 and core (ground)</td></tr>
<tr><td colspan="3">7 and core (ground)</td></tr>
<tr><td colspan="3">8 and core (ground)</td></tr>
<tr><td colspan="3">9 and core (ground)</td></tr>
</table>

Figure 11-15 Test Connections and Continuity Results for a Functional Stator Assembly

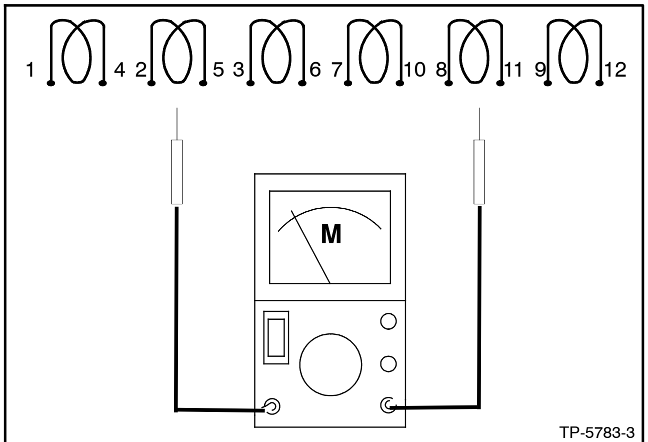
6. Repair the leads if damaged or open. Solder and insulate the splices. Use new sleeving as needed when tying leads to the core.

7. Using a megohmmeter, apply 500 volts DC to each set of windings and then to each winding and the stator core (ground). See Figure 11-16. Place the stator assembly on a non-conductive surface when performing the test. Follow the instructions of the megohmmeter manufacturer when performing this test.

   A reading of approximately 500 kOhms (1/2 megohm) and higher indicates the winding is good.

   A reading of less than 500 kOhms (approximately) indicates deterioration of winding insulation and possible current flow to ground.

8. Repair or replace the stator assembly if the test shows a winding is shorted to ground. Repair the leads if damaged or open. Solder and insulate the splices. Use new sleeving as needed when tying leads to the core.



Make megohmmeter connections across:

1. 1 and 4 leads
2. 2 and 5 leads
3. 3 and 6 leads
4. 7 and 10 leads
5. 8 and 11 leads
6. 9 and 12 leads
7. 1 lead and core (ground)
8. 2 lead and core (ground)
9. 3 lead and core (ground)
10. 7 lead and core (ground)
11. 8 lead and core (ground)
12. 9 lead and core (ground)

Figure 11-16 Stator Winding High Voltage Test

11.8 FRX Alternator Winding Maintenance

Be aware that dirt covering the stator or rotor windings is very conductive, especially when moisture is present. It is important to keep the rotor, stator, exciter, and rotating electronics clean and dry. It is highly recommended to install generator heaters, placed inside the stator frame, to reduce condensation from forming on the alternator windings.

The condition of the alternator windings can be monitored by regularly using a Megger. A Megger is a high voltage ohmmeter that can be used to measure insulation to ground resistance. The usual setting is 500 VDC so it is important to disconnect electronics from the rotor, stator, or exciter. A new, clean, and dry winding can be expected to be 10 megohms or more. The Megger reading may drop over time as the winding accumulates dust, dirt, or moisture. **If the reading drops to 500 kOhms or 0.5 megohms, consider cleaning, drying, or rewinding the alternator.**

It is best to call a motor rewind shop for assistance. Cleaning is normally done with solvents, compressed air, or is steam cleaned on a disassembled alternator.

Notes

12.1 Controller Functionality

The Decision-Maker® 3500 controller is intended for single-generator applications, applications where the generator speed and voltage is controlled by external gear to parallel the generators (External Paralleling), and applications where the controller performs the synchronization, load sharing, and generator management (Internal Paralleling).

12.1.1 Single-Generator Operation

No configuration is necessary for the Decision-Maker® 3500 controller to support single-generator operation, the personality profile that is loaded at the factory will support this mode.

The Decision-Maker® 3500 controller sets the engine speed to the target speed, which is determined by the engine run speed from the personality profile and the engine speed adjustment (which will adjust the speed down 50 rpm and up 49 rpm).

On a non-ECM engine, the Decision-Maker® 3500 controller does not control the target speed, it is set at the governor (unless the engine is fitted with an electronic governor).

The output voltage of the generator is controlled to the voltage regulator target voltage (which can be adjusted on the user interface).

12.1.2 External Paralleling

External paralleling requires the external speed and voltage bias inputs to be enabled (External Bias Inputs Enabled under Synchronization Control in SiteTech™).

The speed and voltage bias inputs are configured to revert to nominal speed and voltage when the signal goes out of range. The Speed Bias and Voltage Bias inputs are pulled down to - 3.3V when inactive, providing wire breakage detection. In the case of wire breakage, the signal will go out of range and the controller will revert to nominal speed or voltage.

With the external bias enabled, the engine speed is set based on the voltage between SBP and SBN:

- Voltage < 0.5V: Engine Run Speed (Out of Range condition).
- Voltage = 0.5V: 95% of Engine Run Speed.
- Voltage = 2.5V: Engine Run Speed.
- Voltage = 4.5V: 105% of Engine Run Speed.
- Voltage > 4.5V: Engine Run Speed (Out of Range condition).

With the external bias enabled, the output voltage is set based on the voltage between VBP and VBN:

- Voltage < 0.5V: Voltage Regulator Average Voltage Adjustment (Out of Range condition).
- Voltage = 0.5V: 90% of Voltage Regulator Average Voltage Adjustment.
- Voltage = 2.5V: Voltage Regulator Average Voltage Adjustment.
- Voltage = 4.5V: 110% of Voltage Regulator Average Voltage Adjustment.
- Voltage > 4.5V: Voltage Regulator Average Voltage Adjustment (Out of Range condition).

The Decision-Maker® 3500 controller reads the voltage on the speed and voltage bias inputs every 50 ms (20 times per second) and passes the new target to the voltage regulator and the ECM.

Reactive droop should be enabled on the Decision-Maker® 3500 controller when paralleling with another generator set (either in external or internal paralleling). The slope should be identical on all generators in the paralleling system (the default is 1.0%). Reactive Droop is configured under Reactive Power Load Sharing in SiteTech™ and in the Generator Info -> Voltage Regulation Menu and the Generator Info -> Paralleling Operation -> Sharing Setup Menu on the controller user interface.

Note: Non-ECM engines will require an electronic governor and an appropriate Kohler governor calibration in order to permit speed adjustment.

12.1.3 Internal Paralleling

The speed and voltage bias are ignored after the breaker is closed in internal paralleling operation mode except in System Sync mode and System Load Control mode (described separately). The bias inputs are accepted in passive synchronization mode or when synchronization is disabled (set to off or sync disabled input is on). Enabling these inputs will have no effect on the operation of the generator in normal operating modes.

The generator controller will enter internal paralleling mode automatically if the PGEN communication wires are connected to another Decision-Maker® 3500 controller (if External Paralleling is desired, do not connect the communication wires between two Decision-Maker® 3500 controllers).

To force a controller to Internal Paralleling mode without PGEN communication, set the Stand Alone Operation parameter to true (Under Synchronization Control in SiteTech™, in Generator Info -> Paralleling Operation -> Paralleling Setup Menu on the controller). This will make the controller behave like a paralleling controller even if it doesn't see another generator on the communication lines. This is intended for an application where the Decision-Maker® 3500 controller is controlling a motor-operated breaker on the output of the generator, but there are no other generators on the paralleling bus.

In Internal Paralleling mode, all the Decision-Maker® 3500 controllers that are communicating over PGEN will behave as a system—they are aware of the status of the other generators in the system. A start signal to any generator in the system will start all generators in the system.

Breaker Control

In Internal Paralleling mode, the Decision-Maker® 3500 controller sends signals to a motor-operated breaker to open and close. These signals are provided as Relay Drivers, and must be connected to pilot relays to operate the circuit breaker.

Bus Sensing

The Decision-Maker® 3500 controller measures three-phase, line-to-line voltage on the paralleling bus, allowing for loss of phase detection, phase rotation verification, and accurate voltage matching with imbalanced load.

The bus sensing must be connected on the opposite side of the motor-operated circuit breaker from the generator connections to allow the generator to measure and control the phase relationship across the circuit breaker.

First-On Logic

The Decision-Maker® 3500 controller uses dynamic first-on logic. The first generator to reach rated speed and voltage will be given permission to close the paralleling breaker. If two units reach rated speed and voltage at the same time, the one that was powered up first or that has the lower controller serial number will be permitted to close first. First-On negotiation is performed over the PGEN communication lines.

Synchronization

The Decision-Maker® 3500 controller can actively synchronize the generator to the paralleling bus. The personality profile for the generator will have default synchronizing settings that will permit successful synchronization under normal conditions.

Synchronization is achieved by controlling the speed bias to the ECM and the voltage bias to the Voltage Regulator. These biases are internally derived and are not related to the speed and voltage bias inputs.

Passive synch mode does allow external control of the speed and voltage bias, but closes the breaker only when the generator is in synchronism with the paralleling bus.

Load Sharing

The Decision-Maker® 3500 controller will attempt to equalize the percent loading of each of the generators that is connected to the bus in the paralleling system. This is the normal mode of operation in parallel.

Other paralleling modes should only be used in applications with additional controls that operate in parallel with the utility, but are listed below for reference:

- **Baseload Mode.** The controller adjusts speed and voltage in an effort to maintain the power output to an adjustable parameter. This mode can be used for testing, but increases risk of reverse power or reverse VARs when used in a paralleling system.
- **System Sync Mode.** All generators in the paralleling system will respond to the speed and voltage bias input of the generator with this mode enabled. This is intended to allow external gear to bring the entire generator bus into synchronism with the utility.
- **System Load Control Mode.** All generators in the paralleling system adjust speed and voltage in an effort to maintain the power output to a target set by the speed and voltage bias from an external system load control device.

Generator Management

The Decision-Maker® 3500 controller contains integral Generator Management. This functionality is disabled by default, but can be enabled to manage fuel consumption, wear and tear, and sound levels.

All generator controllers in the system need to have the same settings for the following parameters before Generator Management will be active:

- Gen Management Control Mode.
- Gen Management Run Time Threshold.
- Gen Management Fuel Difference Threshold.
- Gen Management Stable Delay.
- Gen Management Min Gens Online.
- Gen Management Min Load Shed Priority.

A warning is displayed when Generator Management is disabled because of a parameter mismatch.

Load Management

Paralleling is not required for load management (add/shed) to function, but in Internal Paralleling applications, the load shed priorities can be distributed between controllers, as a generator does not have to be running to operate load shed priorities based on the bus load and frequency.

12.2 Choosing an Application

Because the Decision-Maker® 3500 controller supports different operational modes, it is important that the mode is matched to the application where the generator will be used.

12.2.1 Single Generator

Single generator applications require no setup and are by far the simplest. This mode is for applications where a single generator is connected to loads though a manually-operated circuit breaker, where there will be no chance of paralleling with the utility and there is no external gear provided for generator control.

This application can be used even when multiple generators are included in a given power network, as long as the two generators feed different distribution busses. This application is not recommended with paralleling-capable generators, as a failure on either generator will put a portion of the load out of power (regardless of the load on the other generator) and there is no simple way to prioritize loads.

12.2.2 External Paralleling

Many applications require paralleling with existing generators. Because the Decision-Maker® 3500 controller is intended to parallel only with generators which are also running Decision-Maker® 3500 controllers, external gear is required to coordinate operation with another generator.

Certain applications require unique Generator Management scenarios or paralleling requirements (such as dead-field paralleling). These applications will require external gear to provide support for the unique features.

12.2.3 Internal Paralleling

Any multi-generator application where the generators are all operated by Decision-Maker® 3500 controllers and the standard controller functionality is sufficient for the application. This includes most standby and prime power applications where the standard Generator Management and load management are sufficient to support the customer requirements.

12.3 Paralleling Configuration Considerations

The Decision-Maker® 3500 controller requires that all units connected to a communications network for paralleling (PGEN) need to match in the following key areas:

- System Voltage
- System Frequency
- Voltage Phase Connection

If any controller on the network is different, none of the attached generators will close their circuit breakers (the system is unsure which of the generators are configured correctly).

Most Decision-Maker® 3500 controlled generators will ship with 12-lead, reconfigurable alternators. The connection of the output of the alternator will change the effective voltage range, neutral connection, and relationship between the phases.

12.3.1 Low Wye

The Decision-Maker® 3500 controller supports paralleling in a low wye configuration. This connection is the simplest and the least likely to cause confusion. In low wye configuration, the sensing leads (L1, L2, L3) are connected to the same points as the previous sensing leads (V7, V8, V9) from legacy product. The output leads from the alternator pass through the CTs only once, which is also identical to legacy product.

12.3.2 High Wye

The Decision-Maker® 3500 controller is a direct sensing controller—high wye voltage is measured at L1, L2, L3 and Neutral. Legacy product measured ~ of the output voltage using the V7, V8 and V9 taps but the taps are not used for the Decision-Maker® 3500 controller (which may cause confusion for those that are accustomed to using the center taps for voltage metering). The generator current that the Decision-Maker® 3500 controller measures is intended to be the actual generator current (each phase makes a single wrap through the CT) where legacy product wrapped the output leads through the CTs twice in the high-wye configuration. The bus sensing is also intended to be connected directly to L1, L2, and L3 of the paralleling bus (opposite side of the motor-operated paralleling breaker), where legacy product typically used a transformer or contactor.

12.3.3 Delta

The Decision-Maker® 3500 controller supports paralleling in a delta configuration, but it is important to note that the neutral of each generator needs to be bonded to the same phase (or a point between the same two phases). The controller does not verify line-neutral voltage between the generator and the paralleling bus (neutral of the bus is not measured) so it is possible to close the paralleling breaker into a short circuit. Floating delta connections are also supported.

Sensing should be connected to the L1, L2, and L3 outputs of the generator, no sensing taps or transformers are needed or desirable. Output leads should pass through the CTs only once, just as they do in wye configurations. 240 and 440 delta configurations are accepted.

12.3.4 Single Phase

The Decision-Maker® 3500 controller supports paralleling in a single-phase configuration, but it is important that the metering inputs are connected appropriately for accurate power metering. L1 current should be connected to the I1 input to the controller, L2 current should be connected to the I2 input to the controller, L1, L2, and L0 should also be connected to the appropriate inputs to the controller. Bus metering should also be connected to L1 and L2. Bus L3, Gen L3, and I3 are unused in a single-phase configuration.

Although the synchronizing logic will synchronize and allow the generator breakers to close, single-phase connection type should never be used for an alternator that is wired for three-phase, as there is no phase rotation check in single-phase mode.

12.4 Functional Operation Description

12.4.1 PGEN Communication

PGEN is a proprietary scheduled broadcast communications protocol. Each node (controller) on the network has a time slice to broadcast a packet containing pertinent generator information, other time is spent listening for packets from the other nodes. All nodes on the PGEN network will send out at least one packet every 50 ms.

12.4.2 Generator Startup

Crank Disconnect: When the engine speed exceeds the crank disconnect speed, the engine is considered to be started. The paralleling logic is only solved while the engine is running.

Voltage Ramp: After the engine is running, the voltage regulator begins ramping the target voltage up at the rate specified by the Normal Voltage Ramp Rate parameter. The voltage ramp will follow the Volts/Hz curve if the engine speed takes longer to reach the target than the voltage does.

Voltage and Frequency OK: The Voltage and Frequency OK timer starts timing as soon as the frequency and voltage of the generator are within the range specified by the Acceptable Voltage Pickup and the Acceptable Frequency Pickup parameters. The voltage and frequency for the generator are considered to be acceptable after the Voltage and Frequency OK delay has expired.

12.4.3 First-On Logic

The First-On Logic is responsible to ensure that only one generator closes its paralleling breaker to the dead bus. If two controllers close simultaneously, their voltage waveforms may be out of sync with each other, potentially resulting in damage to the equipment. After one generator closes to the paralleling bus, the others are able to ensure synchronism with it before closing their breakers.

Permission Request: When a generator voltage and frequency are considered acceptable, the controller will broadcast a message to the PGEN network requesting permission to close. Each of the other nodes must grant permission to a generator controller before it will initiate closing the circuit breaker to a dead bus.

Arbitration: If another node with higher priority (lower node ID, determined by serial number and power-up order) also requests permission in the same bus scan (50 ms) the first node must concede the right to close to the higher-priority node. Each node grants permission only to a single node, which will be the lowest node ID that it has seen a request from. All units must grant permission to the same node for it to be permitted to close.

Permission Receipt: If all connected PGEN nodes have granted permission to close through a full PGEN bus scan, a generator is permitted to close to the dead bus and removes the trip command from the circuit breaker (as it is safe for the breaker to close).

First-On Close Delay: The First-On Close Delay is intended to give the trip coil on the breaker time to retract, permitting the next close command to be successful on breakers that have a close inhibit in place when the trip is active.

Breaker Close Signal: After the First-On Close Delay has elapsed, the breaker will be signaled to close. The close signal is held until the breaker status indicates that it is closed or until the fail to close time delay expires.

Fault Handling: If the breaker has a close attempt fault (is unable to close within the Fail To Close Time Delay) the controller will renounce its claim to first-on status. This allows another controller to request permission to close to the dead bus. A generator is available to close again until the close attempts fault has expired, but will fall in the priority order according to the node ID and will be delayed by the reclose delay until it is available to close again (which will allow several other nodes to try to close to the dead bus).

After the generator controller has attempted to close the circuit breaker for the number of close attempts, the controller will issue a close attempts fault, indicate that it is unavailable to the other nodes, and start the breaker trip to shutdown time delay (default of 5 minutes). If the time delay expires without the fault being cleared, the controller will shutdown the generator (as it is not capable of providing power to the customer with the breaker open, so there is no reason to remain running). The circuit breaker fault can be reset by sending a remote reset command through Modbus or SiteTech™, by stopping the controller and pressing OFF a second time, or by pressing the AUTO button while the controller is already in 'Auto' mode.

12.4.4 Synchronizing

Synchronizing is the process by which the output of a generator is matched to the output of a paralleling bus. See Figure 12-1.

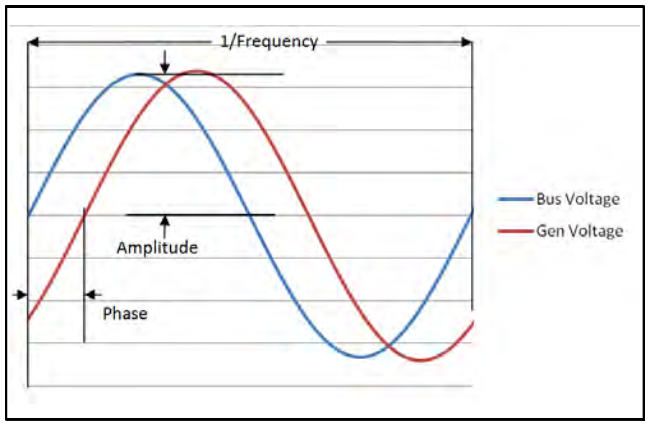


Figure 12-1 Synchronizing Amplitude, Frequency, and Phase

Because the generator voltage and the paralleling bus voltage are AC signals, they have to match in three quantities in order to be identical, amplitude, frequency, and phase. The controller adjusts the voltage regulator target and engine speed to match the generator and bus voltage in all three quantities.

Frequency Match: The synchronizer matches frequency before attempting to match voltage or phase. The phase angle varies at a rate that is related to the difference in frequency, hence it is difficult to control phase if the frequency is dramatically different.

In addition, the controller possesses underfrequency unload (Volts/Hz) so the bus voltage may be significantly lower than rated voltage if the load on the bus exceeds the generating capacity of the online generators and the bus frequency has drooped (which is a very important time for an additional generator to be able to synchronize and connect to the bus), hence matching frequency with the bus will cause the synchronizing generator to follow the same volts/Hz curve, resulting in a much closer initial voltage match.

The Frequency Match Control is only initiated if the generator frequency differs by more than the Frequency Window from the bus frequency (typically only occurs on startup and when the bus is overloaded). The Frequency Match Control adjusts the speed bias to control generator frequency to within 10% of the frequency window of the bus frequency before Frequency Match Control is disabled and Phase and Voltage Control are enabled. Phase Match Control and Frequency Match Control are not active simultaneously.

Note: The Speed Bias has an effective range of ±5% of nominal speed. The controller can't synchronize a generator to the paralleling bus if the frequency is below 95% of nominal (57 Hz on a 60 Hz system, 47.5 Hz on a 50 Hz system).

Voltage Match: The Voltage Match Control adjusts the target voltage of the voltage regulator on the generator to match the measured RMS voltage of the bus using the voltage bias. The Voltage Matching Control is not typically active in a standby system unless the bus is heavily loaded or one or more of the generators in the system has a different voltage regulator target, does not have the trims enabled, or is not calibrated correctly.

Voltage matching is more common when synchronizing to a utility source that may have up to 10% variation in the voltage amplitude depending on load on the system.

Phase Match: The Phase Match Control adjusts the target speed of the engine in the engine speed governor using the speed bias. The engine speed is increased if the generator voltage lags the bus voltage, decreased if the generator voltage leads the bus voltage. This technique is call bi-directional synchronization.

The Phase Match Control is active nearly every time that a generator synchronizes to the paralleling bus, so it is very important that it works correctly. In addition, the generator may stabilize speed with the phase difference between the output of the generator and the paralleling bus within the entire possible range of phase angles (-180° to 180°), so the phase matching sequence may be different with each start of the generator.

In Synchronism: After the voltage amplitude, frequency, and phase of the generator matches that of the bus, the controller considers the generator to be 'In Synchronism' with the paralleling bus.

When in Synchronism, the controller considers it to be safe to close the paralleling breaker. The Trip signal to the generator circuit breaker is removed when the breaker is ok to close, this allows the trip coil time to clear so that the breaker will be ready to close when it is signaled to do so.

Dwell Timer: The Dwell Timer becomes active as soon as the generator is in synchronism with the paralleling bus. It elapses time until it expires unless the generator falls out of synchronism with the paralleling bus, when it is reset.

Breaker Close Signal: When the Dwell Timer expires, the controller will signal the paralleling circuit breaker to close. The Contactor output from the controller is also energized at the time that the controller signals the breaker to close (some applications may use the contactor output for breaker status annunciation).

The Breaker Close Signal is maintained until the breaker status indicates closed, the close command is removed, or the failure to close time delay expires.

Fault Handling: If the breaker status does not indicate closed within the Failure to Close time delay, the controller will issue a close attempt fault. After the Close Retry Delay expires, the controller will try to close the breaker again until the maximum number of close attempts is reached, than the controller will issue the Failure to Close Fault and start the CB Trip to Shutdown delay.

The generator will continue to run until the CB trip to Shutdown time delay expires, at which time it will stop. The circuit breaker fault can be reset by sending a remote reset command through Modbus or SiteTech™, by stopping the controller and pressing OFF a second time, or by pressing the AUTO button while the controller is already in 'Auto' mode.

12.4.5 System Synchronization

Enabling System Synchronization mode in any controller on a paralleling bus will make all the generators on that paralleling bus respond to the speed and voltage bias that is provided to that generator.

Note: External bias must be enabled.

The Speed and Voltage Bias both respond with identical range to their action on a single generator.

This mode allows external controls to synchronize a generator bus to another source (such as an older generator or a utility) while retaining individual generator control within each generator controller.

Generator Management, kW and kVAR Sharing, and Load Management are still active in system synchronization mode. System Control Mode can be used while the generators on the paralleling bus are in a variety of operating states, including synchronizing to the paralleling bus or soft-unloading.

12.4.6 Real Power Control

The real power output of a generator is related to how much mechanical power the engine is making. When a generator is operating as a single unit, there is no good way to control the power output of the generator without controlling the power requirements of the load. In a parallel system, there is more than one source that can supply the load—hence the power can be shared between the sources, allowing it to be controlled.

Because the output of the generators is tied together, the speed of the generators will remain essentially identical, regardless of the mechanical torque that a single engine provides (providing that the load requires enough mechanical power that the single engine isn't overpowering the other engines on the bus and forcing them to accelerate and that it doesn't require more than the other generators can handle).

If the speed bias is increased, the engine governor will try to increase the air/fuel flow to the engine to cause it to accelerate. If the engine speed is unable to change, the engine torque will steadily increase as long as the target speed remains higher than the actual speed. This allows the Power Control logic to increase the load on a paralleled generator.

If the speed bias is decreased, the engine governor will try to decrease the air/fuel flow to the engine to cause it to decelerate. If the engine speed is unable to change, the engine torque will steadily decrease as long as the target speed remains lower than the actual speed. This allows the Power Control logic to decrease the load on a paralleled generator.

kW Sharing

While the controller is operating as part of a standby power system or a prime power system that is not in parallel with another source, the primary (and default) real power control mode is kW sharing. In this mode, each generator tries to control output power to the percentage of the bus capacity (the ratio between the total load on the bus and the total capacity of all online generators).

Generators that are making too much power will adjust their speed bias down, while generators that are not making enough power will adjust their speed bias up. The result is that there is no net change in the bus frequency.

If the bus frequency does drift away from nominal (due to soft loading, soft unloading, or possible fuel supply issues) there is a frequency trim feature in the controller that constantly drives the frequency toward the nominal frequency to correct for such errors. Trims must be enabled to allow the frequency trim to adjust the speed bias to maintain constant frequency. Trim should only be disabled on an islanded (not connected to the utility grid) system if the system is having trouble sharing load, and then only as a troubleshooting step.

Frequency Trim is unnecessary in synchronism with the utility grid.

Note: Frequency and Voltage Trim are enabled and disabled with a common parameter (Enable Trims). To disable one individually, the P, I, and D gains must be set to 0.

The Real Power Controller uses the Real Power Sharing gains for operation in kW Sharing mode.

Baseload

Real Power Baseload mode operates similarly to kW sharing mode except that the target power level is a stored controller parameter instead of an average bus load. Baseload mode is intended for use when in parallel with a distant or uncontrolled source (such as the utility grid).

Real Power Baseload mode is not responsive to changes in the load requirement on the paralleling bus, so placing a generator in Baseload mode on an islanded system may very well cause the other generators in the system to experience a reverse power condition if the load decreases. Baseload mode can be used as a testing mode under supervision, but should not be used long-term in an islanded application.

Frequency Trim is not active in Baseload mode.

The Real Power Controller uses the Real Power Baseload gains for operation in Baseload mode.

System Control

System Control mode controls the power level of all generators on a paralleling bus to a target level that is determined by the speed bias input. The bias input only needs to be supplied to a single generator on the communication bus in order to control all the generators on that bus. The generator that is receiving the signal does not have to be running or paralleled to the other generators, but it does need to have the system control mode and external bias enabled. If the signal is sent to multiple generators in the system, only one of them will control the bus (the others will be ignored). The preference order of the generator controllers is based on the controller serial number.

System Control mode provides an interface that allows the generators to be controlled by an external controller for soft-unloading/loading and peak shaving against a distant or uncontrolled source (such as the utility grid). The power output increases with increasing speed bias, as described in the following table:

Speed Bias < 0.5V = 50% of rated power

Speed Bias = 0.5V = 0% of rated power

Speed Bias = 2.5V = 50% of rated power

Speed Bias = 4.5V = 100% of rated power

Speed Bias > 4.5V = 50% of rated power

Frequency Trim is not active in System Control mode.

The Real Power Controller uses the System Real Load Control gains for operation in System Control mode.

Soft Load/Unload

The Real Power Control references a ramping target (according to the Real Power Ramp Rate) from 0 kW to the mode-related target for the Real Power Control when soft-loading. The target ramps from the target to 0 according to the same ramp rate in soft-unload mode.

A generator will soft-load any time that it synchronizes to a live paralleling bus. Soft-unloading is triggered by the removal of the load enable signal to the controller or by Generator Management. In both cases, the breaker will be signaled to trip when the real power drops below the disconnect level.

12.4.7 Reactive Power Control

The reactive power output of a generator is related to the magnetization energy in the alternator. When a generator is operating as a single unit, there is no good way to control the magnetization energy in the alternator without changing the output voltage of the generator. In a parallel system, there is more than one source than can supply reactive power to the load—hence the reactive power can be shared between the sources, allowing it to be controlled.

Because the output of the generators is tied together, the voltage amplitude of the generators will remain essentially identical, regardless of the magnetization energy that a single alternator provides (providing that the load requires enough magnetization energy that the single alternator isn't overpowering the other alternators on the bus and forcing them to increase output voltage and that it doesn't require more than the other alternators can handle).

If the voltage bias is increased, the voltage regulator will try to increase the field current to the alternator rotor to cause the magnetic energy in the alternator to increase, increasing the voltage output of the alternator. If the alternator voltage output is unable to change, the field current will steadily increase as long as the target voltage remains higher than the actual voltage. This allows the Power Control logic to increase the reactive load on a paralleled generator.

If the voltage bias is decreased, the voltage regulator will try to decrease the field current to the alternator to decrease the magnetization energy in the alternator and to cause the output voltage to decrease. If the alternator voltage output is unable to change, the field current will steadily decrease as long as the target voltage remains lower than the actual voltage. This allows the Power Control logic to decrease the reactive load on a paralleled generator.

kVAR Control

The reactive power controller measures and controls reactive power (kVAR). Some modes allow direct control of the kVAR to a target that is independent of the real power supplied by the generator or generator system.

The VAR Control mode parameter allows selection between the kVAR and Power Factor control modes. VAR control is always used when in load sharing mode.

These modes are listed below.

- **kVAR sharing**

  While the controller is operating as part of a standby power system or a prime power system that is not in parallel with another source, the primary (and default) reactive power control mode is kVAR sharing. In this mode, each generator tries to control output reactive power to the percentage of the bus capacity (the ratio between the total reactive load on the bus and the total reactive power capacity of all online generators).

  Generators that are making too much reactive power will adjust their voltage bias down, while generators that are not making enough power will adjust their voltage bias up. The result is that there is no net change in the bus voltage.

  If the bus voltage does drift away from nominal (due to soft loading, soft unloading, or reactive droop) there is a voltage trim feature in the controller that constantly drives the voltage toward the nominal voltage to correct for such errors. Trims must be enabled to allow the voltage trim to adjust the voltage bias to maintain constant output voltage. Trim should only be disabled on an islanded (not connected to the utility grid) system if the system is having trouble sharing load, and then only as a troubleshooting step.

  Voltage Trim is unnecessary in synchronism with the utility grid.

  Note: Voltage and Frequency Trim are enabled and disabled with a common parameter (Enable Trims). To disable one individually, the P, I, and D gains must be set to 0.

- **Baseload**

  Reactive Power Baseload mode operates similarly to kVAR sharing mode except that the target reactive power level is a stored controller parameter instead of an average bus load. Baseload mode is intended for use when in parallel with a distant or uncontrolled source (such as the utility grid).

  Reactive Power Baseload is enabled when Real Power Baseload is enabled (if the VAR control mode is set to VAR control). Baseload mode is not responsive to changes in the reactive load requirement on the paralleling bus, so placing a generator in baseload mode on an islanded system may very well cause the other generators in the system to experience an apparent loss of field condition if the reactive load decreases. Baseload mode can be used as a testing mode under supervision, but should not be used long-term in an islanded application.

  Voltage Trim is not active in Baseload mode.

  The Reactive Power Controller uses the Reactive Power Baseload gains for operation in Reactive Power Baseload mode.

- **System Control**

  System Control mode controls the reactive power level of all generators on a paralleling bus to a target level that is determined by the voltage bias input. The bias input only needs to be supplied to a single generator on the communication bus in order to control all the generators on that bus. The generator that is receiving the signal does not have to be running or paralleled to the other generators, but it does need to have the system control mode and external bias enabled. If the signal is sent to multiple generators in the system, only one of them will control the bus (the others will be ignored). The preference order of the generator controllers is based on the controller serial number.

  System Control mode provides an interface that allows the generators to be controlled by an external controller for soft-unloading/loading and peak shaving against a distant or uncontrolled source (such as the utility grid). The power output increases with increasing voltage bias, as described in the following:

  Voltage Bias < 0.5V = 50% of rated reactive power

  Voltage Bias = 0.5V = 0% of rated reactive power

  Voltage Bias = 2.5V = 50% of rated reactive power

  Voltage Bias = 4.5V = 100% of rated reactive power

  Voltage Bias > 4.5V = 50% of rated reactive power

  Voltage Trim is not active in System Control mode.

  The Reactive Power Controller uses the System Reactive Load Control gains for operation in System Control mode.

Power Factor Control

The reactive power controller measures and controls reactive power (kVAR). Power factor is the ratio of the generator real power to the generator apparent power (which is the geometric sum of the real and reactive power). To control power factor, the reactive power target must vary with changing real power.

The VAR Control mode parameter allows selection between the kVAR and Power Factor control modes. VAR control is always used when in load sharing mode.

Note: It is possible to control power factor directly, but the effect of reactive power variations on the resultant power factor is very non-linear, making it difficult to provide consistent power factor regulation over a broad range of power factor targets with a single set of gains. The power factor control modes are listed below.

- **Baseload**

  Power Factor Baseload mode operates very similarly to baseload kVAR mode except that the target reactive power is related to the real load on the generator by a ratio that is determined from the Power Factor Baseload Setpoint.

  Power Factor Baseload mode is probably the simplest way of controlling reactive power when a generator is operating at a fixed real power.

  Power Factor Baseload is enabled when Real Power Baseload is enabled (if the VAR control mode is set to power factor control). Baseload mode can be used as a testing mode under supervision, but should not be used long-term in an islanded application.

  Voltage Trim is not active in Baseload mode.

  The Reactive Power Controller uses the Power Factor Baseload gains for operation in Power Factor Baseload mode.

- **System Control**

  System Power Factor Control mode controls the power factor level of all generators on a paralleling bus to a target level that is determined by the voltage bias input. The individual generators calculate their individual reactive power requirement to meet the power factor target and control the reactive power to that requirement.

  The bias input only needs to be supplied to a single generator on the communication bus in order to control all the generators on that bus. The generator that is receiving the signal does not have to be running or paralleled to the other generators, but it does need to have the system control mode and external bias enabled. If the signal is sent to multiple generators in the system, only one of them will control the bus (the others will be ignored). The preference order of the generator controllers is based on the controller serial number.

  System Power Factor Control mode provides an interface that allows the generators to be controlled by an external controller for soft-unloading/loading and peak shaving against a distant or uncontrolled source (such as the utility grid). The target Power Factor decreases with increasing voltage bias, as described in the following:

  Voltage Bias < 0.5V = 0.75 power factor

  Voltage Bias = 0.5V = 1.00 power factor

  Voltage Bias = 2.5V = 0.75 power factor

  Voltage Bias = 4.5V = 0.50 power factor

  Voltage Bias > 4.5V = 0.75 power factor

  Voltage Trim is not active in System Power Factor Control mode.

  The Reactive Power Controller uses the System Power Factor Control gains for operation in System Control mode.

Soft Load/Unload

The Reactive Power Control runs in power factor mode any time that the system is soft unloading or loading. The power factor is set to the final target when soft loading and to the initial power factor when unloading.

12.4.8 Faults

The Decision-Maker® 3500 controller supports a variety of faults and warnings to make troubleshooting and diagnostics more transparent and streamlined. Some of the faults have an effect on the operation of the system, some indicate a malfunction in the operation of the system, others are provided only to provide the operator with status information.

Auto-Validation

Auto-Validation is a function that verifies the bus metering connections, breaker control functions, and breaker status feedback once per power cycle of the generator controller. The function is intended to detect problems in the wiring and to alert the operator with easily-understood faults that allow easy troubleshooting and repair of the fault, while protecting the generator controller from damage due to incorrect connections.

Auto-Validation supports the following messages:

- Bus Sensing Connected to Wrong Side of Paralleling Breaker (bus is live anytime gen is running and turns off with generator).
- Live Bus Sensed when Dead Bus Expected (inhibited in Baseload or System Control Mode).
- CB Status Fault (shutdown—intended to prevent the system from running with incorrect breaker status, as it could be a dangerous condition).
- Gen to Bus Phase Angle Mismatch (the generator and bus should have 0° phase angle when the breaker is closed. If all three wires are connected to incorrect phases, the measurement will show 120° out of phase with the breaker closed.).
- Bus Sensing Phases A and B are Reversed (phase C is connected correctly).
- Bus Sensing Phases B and C are Reversed (phase A is connected correctly).
- Bus Sensing Phases C and A are Reversed (phase B is connected correctly).
- Bus Sensing Phase A Connection Error (the measured voltage indicates that Phase A is not connected).
- Bus Sensing Phase B Connection Error (the measured voltage indicates that Phase B is not connected).
- Bus Sensing Phase C Connection Error (the measured voltage indicates that Phase C is not connected).
- Bus Sensing Connection Error (the Bus sensing is reading incorrectly, but none of the phases are reading as expected—probably more than one wire is disconnected).
- Bus Sensing Not Connected (none of the bus sensing wires are connected).
- Breaker Outputs Not Configured (the Breaker outputs are driven by programmable I/O. They will not work unless they have been configured).
- Breaker Status Input Not Configured (the breaker status is a programmable input in later firmware versions, if it is not configured, the system will get no status indication from the circuit breaker).

Note: Not all Auto-Validation warnings are supported in all applications and in all firmware versions.

Failure to Synchronize

A Failure to Synchronize indicates that the generator controller has been attempting to match frequency, phase, and voltage with the paralleling bus for longer than the Fail to Sync Delay without being able to maintain synchronism for the duration of the dwell timer to allow the breaker to close.

Note: Failure to Synchronize does not stop the controller from continuing to synchronize. The Failure to Synchronize Warning is reset when synchronizing stops because the breaker closes, or the synchronization is canceled.

Fail to Open

A failure to open indicates that the controller attempted to open the breaker, but that the breaker status didn't indicate open within the Fail to Open Delay. This typically indicates a wiring issue, but non-standard breakers may take longer than the default 1.0 second Fail to Open Delay to respond to a trip signal. If the breaker opens shortly after the warning occurs, it may be possible to extend the time delay to make it work, but only after considering that a delay in breaker tripping may decrease the effectiveness of the generator protective relays.

Close Attempt Fault

A Close Attempt Fault indicates that the breaker attempted to close and that the breaker did not close within the Fail to Close Delay. The controller will remove the close signal after the Fail to Close Delay has expired, so the breaker will probably not close.

A failure to close can be caused by external protective relays inhibiting closure, wiring errors, incorrect voltage for the motor operator, discharged charge spring in the breaker, etc.

Fail to Close

A Fail to Close fault indicates that the controller has tried to close the breaker for the Number of Close Attempts without a successful closure. The failure to close fault will start the Circuit Breaker Trip to Shutdown time delay, which will cause the generator to stop after it times out.

Configuration Mismatch

The paralleling system will not permit any generator to connect to the paralleling bus if the system voltage, system frequency, and phase connection are different on any of the connected generators. The generators can't safely parallel with each other if these parameters are different and the paralleling system does not know which of the generators is correct and which is not.

Protective Relays

The controller will trip the circuit breaker and issue a warning if any of the following conditions persist beyond the associated time delay:

- **Over Voltage.** This protective function is intended to protect the alternator from over excitation, but primarily is used to protect the customer loads from a potentially damaging condition.

- **Under Voltage.** This protective function is intended to protect electric motors and sensitive electronics from damage due to undervoltage. The low voltage condition may also indicate a failure in the alternator or in the sensing to the controller.

- **Over Frequency.** This protective function is intended to protect any motors that are fed by the generator from overspeeding and potentially damaging the equipment that they drive.

- **Under Frequency**. This protective function is intended to protect any motors or transformers that are fed by the generator from potential overheating and winding damage.

- **Over Power.** This protective function can be used to protect the generator. The generator controller also has an overpower shutdown, which is set to 102% for standby applications and 112% for prime power applications. A practical solution to the use of this protective relay is to connect the load management connections.

- **Reverse Power.** This protective function is intended to protect the generator system from motoring generators and to protect the fuel system of the generator from operation in a dry state. This condition is most commonly caused by a loss of fuel prime or damage to a fuel line. A reverse power condition does not otherwise damage the generator.

- **Over Current.** This protective function can be used to protect the alternator of the generator from overload conditions. The controller also contains internal alternator protection that prevents thermal damage to the alternator by stopping the engine.

- **Reverse VARs (Loss of Field).** This protective function is required to avoid potential damage to the generator caused by the alternator slipping a pole. Pole slipping can occur when the generator is providing real power (Watts) and is absorbing reactive power (VARs). Slipping a pole can cause damage to the engine crankshaft or the alternator and typically causes voltage spikes on the generator output—the condition should be avoided.

Note: The alternator can absorb VARs without damage if the real power output of the generator is very low, but the protective relay does not take the real power into account, so it needs to be set to a low enough threshold to protect against pole slipping. The default of 20% protects the alternator in most conditions, but the stability curve of the alternator should be considered when adjusting the parameters to a higher value than 20%.

12.4.9 Start Modes

The generator controller supports a system start (Auto-Run, remote start contacts, CAN gauge start signal, SiteTech™ start signal) and local start (pressing the run button). The paralleling system behaves differently depending on which start command is received.

A system start command to any generator in the system will start all generators that are in auto. If a generator is placed in auto after the start signal is applied to any generator, that generator will start. A generator does not have to be in auto to accept a start signal, but it does have to be in auto to start. The synchronizer uses the Sync Mode in Auto parameter to determine the synchronizing settings during a system start event. Generator Management and load management are only active during a system start.

A local start command to a generator will result in only that generator starting. The synchronizer uses the Sync Mode in Run parameter to determine the synchronizing settings during a local start event. Generator Management will not consider a generator that is operating in local start mode as available, even if it is running.

12.4.10 Control Inputs

The Paralleling logic accepts the following Control Inputs, configurable for a digital input:

- **Disable Synchronization.** This function will prevent the controller from synchronizing or closing the breaker to a dead bus, but will not cause the breaker to trip if it is closed. This input is commonly used to coordinate Decision-Maker® 3500 controller generators with the first-on logic of older, existing generators.

- **Load Enable.** This function allows the generator to take load. If disabled, the generator speed will drop if load is present on the paralleling bus and no other nodes are connected to support the load. If other nodes exist, the generator will control its output power to no load.

- **Baseload Mode.** This function puts the generator into baseload mode. If a start signal is received in baseload mode, the controller will start, synchronize, connect to the paralleling bus, and ramp the power control target to the baseload setpoint.

Note: The baseload input takes priority over the System control and System Sync input. Baseload mode will not ramp to the target if load enable is off. Baseload can be used to exercise generators against the utility with a fixed load, it should not be used in an islanded paralleling system except for troubleshooting purposes.

- **System Control Mode.** This function puts the generator in a power control mode where the power level for all generators on the paralleling bus is controlled by an external device using the speed and voltage bias (speed bias controls real power, voltage bias controls reactive power or power factor, depending on the VAR control mode). This mode takes priority over the System Sync Mode and requires load enable to be active in order to ramp output power to the system control target. Once the load ramp reaches the target, the generator will try to match the power target with the output power. This mode is not to be used in an islanded system, but will allow external switchgear to control the entire generator bus to soft load and unload against the utility. The speed and voltage bias can be applied to any number of generators in the system, as only one will have control of the bus. System Control Mode must be enabled on generators receiving the speed and voltage bias.

- **System Sync Mode.** This function causes all the running generators in a paralleling system to adjust their target speed and voltage to match the speed and voltage bias applied to the external bias inputs on the controller set to system sync mode. This bias can be applied to multiple units, but only one will have control of the paralleling bus. System sync mode is intended to allow external switchgear to synchronize the generator paralleling bus to the utility.

12.4.11 Generator Management

See Section 13.

12.4.12 Load Management

See Section 14.

12.4.13 Communication Failure

When a PGEN node fails to reply for 30 consecutive frames (about one second) the other nodes will detect a loss of communication with it and will default to droop sharing and time slice based first-on logic. Not all applications are configured or able to use this functionality.

12.5 Calibration and Commissioning

12.5.1 Voltage Calibration

The Decision-Maker® 3500 controller is a factory-calibrated direct-sensing paralleling controller. It is capable of reading up to 800VAC (RMS) accurately, allowing it to directly sense the output voltage in most low-voltage applications.

The voltage sensing is calibrated in the factory—no calibration is required unless a personality profile from a different controller is loaded over the factory calibration values.

If a personality profile is updated, the calibration factors for all 9 voltages (L1-L2, L2-L3, L3-L1, L1-L0, L2-L0, L3-L0, Bus L1-L2, Bus L2-L3, Bus L3-L1) should be recorded from the new controller so that they can be restored after the personality is loaded.

Calibration is possible in-application, but should only be necessary if the factory defaults are lost or overwritten.

12.5.2 Current Calibration

The current metering is calibrated at the factory for a given generator. It is performed at full load at the factory. There is a small variation in the output ratio of a CT over its supported measurement range, so this reading may vary slightly at lower loads.

If a controller is replaced, the current metering will have to be calibrated in order to guarantee power metering accuracy.

12.5.3 Gains and Settings for Paralleling

The Decision-Maker® 3500 controller is preset with factory defaults for each generator model number in the personality profile. These gains should perform adequately for most applications, but it may be necessary to perform adjustment of advanced settings.

12.6 Parameter Descriptions

Individual descriptions of the functionality of each parameter within the paralleling logic.

12.6.1 PGEN

PGEN is an auto-discovering, scheduled protocol that provides the infrastructure for time-critical inter-controller communication. PGEN stands for Paralleled Generator.

PGEN Baud Rate. The PGEN Baud rate is set at the factory to 57,600. It should only be changed under instruction from a factory representative. All nodes must have an identical baud rate for the network to communicate effectively.

Range: 9600/19200/38400/57600/115200
Default: 57600

PGEN Node ID. The Node ID is an address (allocated timeslice) that has been assigned to this node. The node ID is typically indicative of power up sequence, but not always. All node IDs behave identically on the network, the address only determines the order of communication.

Range: 1–8 or 255 (indicates short circuit on PGEN Wires)
Default: **STATUS**

PGEN Nodes Connected. The number of PGEN nodes that this node has seen communicating on the network in the last second.

Range: 1–8
Default: **STATUS**

PGEN Nodes Disconnected. The number of PGEN nodes that have stopped replying at the appropriate time. If a node with the same controller serial number as a disconnected one begins communicating again after being counted as disconnected, the disconnected node count will decrease again.

Note: Removing battery power from a controller is not the same as losing communication with that controller—the disconnected node count does not increase in the case of removal of the battery from one controller on the network.

Range: 0–7
Default: **STATUS**

12.6.2 First-On

The First-On logic ensures that two generators won't close to the paralleling bus simultaneously. Because the synchronizing is performed relative to the paralleling bus, it is impossible to verify synchronism between generators until one of them is connected to the paralleling bus. If two generators close simultaneously, they may be coupled together out-of phase (which is potentially damaging to the alternator or engine crankshaft).

First-On Parameters are found under the Synchronization Control heading in SiteTech™ and under the Generator Info -> Paralleling Operation -> Paralleling Setup menu on the user interface of the controller.

First-On Close Delay. The time between acknowledgement of victory in the first-on race and breaker closure. This time delay is intended to ensure that the trip signal has time to be removed from the circuit breaker before the close signal is applied. Setting this delay higher will only delay the system's ability to provide power in a timely fashion and should only be set to a longer delay if the breaker is failing to close.

Range: 0.1 – 10.0 sec
Default: 0.5 sec

Volts Hertz Okay Time Delay. The time after the voltage and frequency falls within the acceptable window that the controller waits before the generator is considered to be within an acceptable operating range. Extending this delay may be necessary if a generator has significant voltage or speed overshoot (although resolving the source of the overshoot would be preferred, such as decreasing the voltage ramp rate). This delay can also be used to delay first-on availability for a generator that should not close to the bus first (such as a smaller generator).

Range: 0.1 – 10.0 sec
Default: 0.5 sec

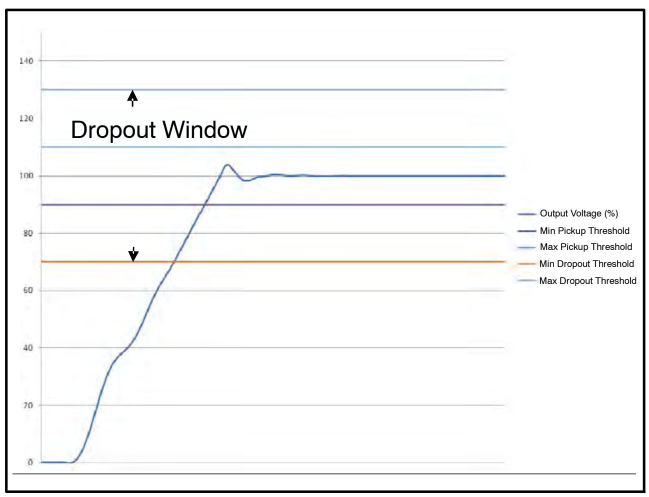
Pickup Acceptable Voltage Window. The Voltage must remain within this percentage of the system voltage for the duration of the Volts Hertz Okay Time Delay in order for the voltage to be considered acceptable to supply a customer's load. See Figure 12-2.

Note: The Volts Hertz Timer does not run unless both voltage and frequency are within the window.

Range: 1.00 – 50.00%
Default: 10.00%

Figure 12-2 Pickup Acceptable Voltage Window

Dropout Acceptable Voltage Window. Once the voltage and frequency are considered to be acceptable, the voltage has to be outside the Dropout window before it is considered to be unacceptable again. See Figure 12-3.

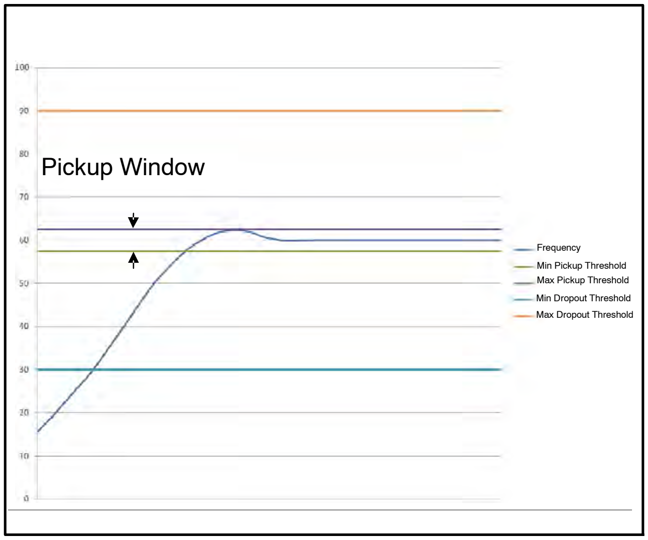


Range: 1.00 – 50.00%
Default: 30.00%

Figure 12-3 Dropout Acceptable Voltage Window

Pickup Acceptable Frequency Window. The generator frequency must remain within this window for the duration of the Volts Hertz Okay Time Delay before it is considered to be acceptable. See Figure 12-4.

Note: The Volts Hertz Timer does not run unless both voltage and frequency are within the window.

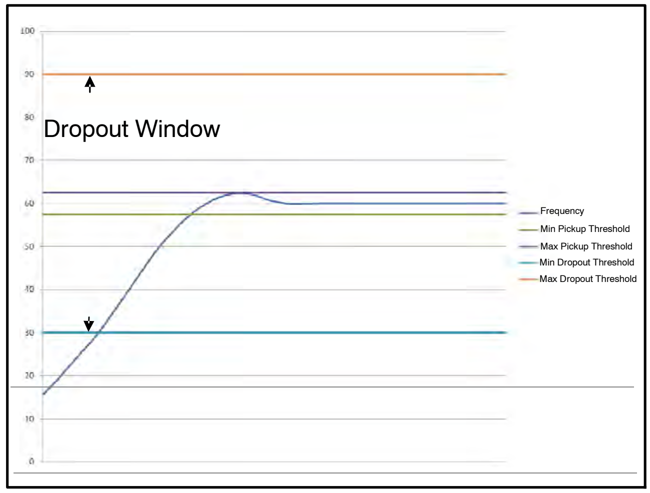


Range: 1.00 – 50.00Hz
Default: 2.50Hz

Figure 12-4 Pickup Acceptable Frequency Window

Dropout Acceptable Frequency Window. Once the Voltage and Frequency are considered to be acceptable, the frequency has to be outside the Dropout window before it is considered to be unacceptable again. See Figure 12-5.

Note: Transient Loading may cause the bus frequency to dip significantly—the paralleling breaker may trip if the voltage or frequency is perceived to be outside the dropout window for very long. The dropout frequency should be set to a large number to avoid unintended operation of the system.



Range: 1.00 – 50.00%
Default: 30.00Hz

Figure 12-5 Dropout Acceptable Frequency Window

Dead Bus Level. The threshold (in percent of rated voltage) below which the bus is considered to be dead (allowing closure without synchronization). If the bus voltage is measured to be above this threshold, but it is not within the pickup acceptable voltage window of the rated bus voltage, the generator will not synchronize or connect to the bus.

Range: 1.00 – 25.00%
Default: 10.00%

12.6.3 Synchronization

Synchronizing parameters are found under the Synchronization Control heading in SiteTech™ and under the Generator Info -> Paralleling Operation -> Synchronizing Setup menu on the user interface of the controller. The Synchronizing Status parameters can be found under the Synchronization Metering heading in SiteTech™.

Sync Mode in Auto

The Sync Mode in Auto is the mode that the paralleling logic uses for synchronization control when the generator is operating in Auto. The Decision-Maker® 3500 controller supports the following Sync Modes:

- **Off**

  Synchronizing is disabled—the breaker will not close, even to a dead bus.

- **Passive**

  The Decision-Maker® 3500 controller will not attempt to control the speed and voltage of the generator (although that can be controlled remotely), but will close the breaker if the voltage, frequency, and phase are all matched for the Dwell Time. After breaker closure, the controller will assume control of the speed and voltage bias to share load. The breaker will close to a dead bus in Passive mode.

- **Check**

  The Decision-Maker® 3500 controller activates the auto-synchronizer, but does not close the breaker to a live bus (even if the voltage, frequency, and phase are all matched for the dwell time). The breaker will close to a dead bus in check mode.

- **Active**

  The Decision-Maker® 3500 controller activates the auto-synchronizer, and will close the breaker to a live bus if the voltage, frequency, and phase are all matched for the dwell time.

- **Dead Field**

  The Synch mode cannot be set to this value in standard applications.

  Setting Dead Field Synch mode will cause this unit to start, close the breaker at a given engine RPM, and soft-ramp the voltage to the final target. All generators that start with this synch mode configuration will reach rated voltage and frequency in parallel.

  Note: Dead Field Paralleling is not supported in standard applications, the DFP voltage ramp rate, DFP breaker close RPM, and DFP fail RPM are not available as user-adjustable parameters.

Note: Synchronization will not occur if the bus is live and has different phase rotation than the generator.

Range: 1 – 4 (Off – Active)
Default: 4 (Active)

Sync Mode in Run

The Sync Mode in Run is the mode that the paralleling logic uses for synchronization control when the generator is operating in Run. Available modes are the same as the Sync Mode in Auto.

Range: 1 – 4 (Off – Active)
Default: 3 (Check)

Voltage Match Window

The voltage match window defines the maximum difference between the average line-line voltage of the generator and the average line-line voltage of the paralleling bus which will allow the generator voltage to be considered as matching the bus voltage. The generator voltage can be above or below the bus voltage, but must be within the Voltage Match Window of the bus to be considered to be matched.

This parameter is intended to avoid excessive current due to reactive power transfer. A large voltage difference may cause reactive power to transfer between generators when the paralleling breaker is closed.

Range: 1 – 10%
Default: 1%

Sync Frequency Window

The Frequency Window is the maximum difference in output frequency between the bus and the generator at which the frequency is considered to be matched. The generator frequency can be above or below the bus frequency, but must be within the Sync Frequency Window of the bus to be considered as matched.

There is a slight delay in the activation of the paralleling breaker (typically between 50 and 100ms). If the frequency difference is too high, the breaker may close out of phase, even though it was in phase when the close signal was activated.

Note: The frequency matching controller is active until the generator frequency is within 1/10 of the frequency window of the bus frequency. Once within this window, the frequency matching controller is de-activated and the phase matching controller is activated. The phase matching controller is de-activated and the frequency matching controller is activated if the frequency of the generator differs by more than the Frequency Match Window from the bus frequency.

Setting the frequency window too wide may make it difficult for the phase matching controller to work correctly.

Range: 0.1 – 5.0Hz
Default: 2.0Hz

Phase Match Window

The Phase Angle Window defines the threshold that the phase angle between the L1-L2 generator voltage and the L1-L2 paralleling bus voltage must remain below for the phase of the generator to be considered to be matched with the paralleling bus. The generator voltage may either lead or lag the bus voltage, but must be within the Phase Match Window to be considered to be matched.

Large phase angle differences between the generator and the paralleling bus when the paralleling breaker closes will result in large current spikes as the alternator field is forced to align between the generators. Phase Match Windows above 15° are not recommended.

Range: 1.0° – 20.0°
Default: 5.0°

Dwell Time

The Dwell Time is the time duration that the synchronizer requires the voltage, frequency, rotation and phase of the generator to match that of the paralleling bus before it will signal the paralleling breaker to close.

Setting the dwell time too short may cause the breaker to close when the generator frequency does not match the bus frequency very closely (resulting in a small real power discrepancy when the breaker first closes). Short dwell times are occasionally required in applications where the engine frequency regulation is loose (such as spark-ignited engines).

Setting the dwell time too long will only delay breaker closure and will not improve the real power discrepancy when the breaker closes. Dwell times longer than 2 seconds are only required in very special applications.

Range: 0.1 – 30.0 sec
Default: 0.3 sec

Voltage Match Proportional Gain

The Voltage Match Proportional Gain adjusts the Voltage Bias by an amount that is directly related to the difference between the average generator line voltage and the average bus line voltage. The voltage bias is adjusted in the direction that should decrease the difference between the generator and the paralleling bus.

Range: 0.01 – 100.00
Default: 1.00

Voltage Match Integral Gain

The Voltage Match Integral Gain adjusts the Voltage Bias at a rate that is related to the difference between the average generator line voltage and the average bus line voltage. The voltage bias is adjusted in the direction that should decrease the difference between the generator and the paralleling bus.

Range: 0.01 – 100.00
Default: 1.00

Voltage Match Derivative Gain

The Voltage Match Derivative Gain adjusts the Voltage Bias by an amount that is related to the rate of change of the difference between the average generator line voltage and the average bus line voltage. The voltage bias is adjusted in the direction that should decrease the rate of change of the difference between the generator and the paralleling bus.

Note: This gain is set very low from the factory, but may be needed to track the bus voltage if the load on the bus is changing often.

Range: 0.01 – 100.00
Default: 1.00

Frequency Match Proportional Gain

The Frequency Match Proportional Gain adjusts the Speed Bias by an amount that is directly related to the difference between the generator frequency and the bus frequency. The speed bias is adjusted in the direction that should decrease the difference between the generator and the paralleling bus.

Range: 0.01 – 100.00
Default: 1.00

Frequency Match Integral Gain

The Frequency Match Integral Gain adjusts the Speed Bias at a rate that is related to the difference between the generator frequency and the bus frequency. The speed bias is adjusted in the direction that should decrease the difference between the generator and the paralleling bus.

Range: 0.01 – 100.00
Default: 1.00

Frequency Match Derivative Gain

The Frequency Match Derivative Gain adjusts the Speed Bias by an amount that is related to the rate of change of the difference between the generator frequency and the bus frequency. The speed bias is adjusted in the direction that should decrease the rate of change of the difference between the generator and the paralleling bus.

Note: This gain is set very low from the factory, but may be needed to track the bus if the load on the bus is changing often.

Range: 0.01 – 100.00
Default: 1.00

Phase Match Proportional Gain

The Phase Match Proportional Gain adjusts the Speed Bias by an amount that is directly related to the phase difference between the generator L1-L2 voltage and the bus L1-L2 voltage. The speed bias is adjusted in the direction that should decrease phase angle between the generator and the paralleling bus.

Range: 0.01 – 100.00
Default: 1.00

Phase Match Integral Gain

The Phase Match Integral Gain adjusts the Speed Bias at a rate that is related to the phase difference between the generator L1-L2 voltage and the bus L1-L2 voltage. The speed bias is adjusted in the direction that should decrease the phase angle between the generator and the paralleling bus.

Range: 0.01 – 100.00
Default: 1.00

Phase Match Derivative Gain

The Phase Match Derivative Gain adjusts the Speed Bias by an amount that is related to the rate of change of the phase difference between the generator L1-L2 voltage and the bus L1-L2 voltage. The speed bias is adjusted in the direction that should decrease the rate of change of the phase difference between the generator and the paralleling bus.

Range: 0.01 – 100.00
Default: 1.00

Fail to Sync Delay

The Failure to Synchronize merely indicates that a generator was not able to synchronize within the expected synchronizing time. This warning on a generator in Generator Management will cause another generator to start if it is available, but will not cause the first generator to stop synchronizing.

Range: 10 – 600 sec
Default: 300 sec

Dwell Time Remaining

This parameter displays the remaining time for the dwell timer in seconds. The generator is considered to be in Sync when the dwell timer expires. If this value is resetting to the Dwell Time (directly above it in SiteTech™), the generator is not holding synchronism. This value is only updated when the controller is synchronizing (Synch Mode = Active, Passive or Check, breaker is open, generator is running).

Note: Early firmware versions for the Decision-Maker® 3500 controller do not support this parameter (there is no value populated for it).

Sync Time Remaining

The remaining time before the controller issues a fail to sync warning. The fail to sync warning will cause the Generator Management to consider this generator unreliable and to start another generator (if available). If the system commissioning has been performed properly, this warning should only occur if the system is overloaded or if there is a malfunction on this generator. This value is only populated when the generator is actively synchronizing (Sync Mode = Active, breaker is open, generator is running).

Note: Early firmware versions for the Decision-Maker® 3500 controller do not support this parameter (there is no value populated for it).

Sync Status Generator V Hz OK

This parameter indicates that the voltage and frequency of this generator are considered to be acceptable. This must be true before the generator will attempt to synchronize to the paralleling bus.

This parameter is updated every 50ms, regardless of the state of the paralleling controls.

Range: False-True
Default: False

Sync Status Voltage Matched

This parameter indicates that the average line voltage of this generator is within the Voltage Match window of the average line voltage of paralleling bus. This must be true before the generator will attempt to connect to the paralleling bus.

This parameter is only updated if the generator is synchronizing (in either active or check mode).

Range: False-True
Default: False

Sync Status Frequency Matched

This parameter indicates that the frequency of this generator is within the Frequency Match Window of the bus frequency. This must be true before the generator will attempt to connect to the paralleling bus.

This parameter is only updated if the generator is synchronizing (in either active or check mode).

Range: False-True
Default: False

Sync Status Phase Matched

This parameter indicates that the phase angle between this generator and the paralleling bus is within the Phase Match Window. This must be true before the generator will attempt to connect to the paralleling bus.

This parameter is only updated if the generator is synchronizing (in either active or check mode).

Range: False-True
Default: False

Sync Check Matched OK

This parameter indicates that the voltage, frequency, and phase of the generator are all within their respective windows of the paralleling bus. This must be true before the dwell timer will start timing. If this parameter goes false while the dwell timer is timing, the dwell timer will be reset.

This parameter is only updated if the generator is synchronizing (in either active or check mode).

Range: False-True
Default: False

12.6.4 Load Sharing

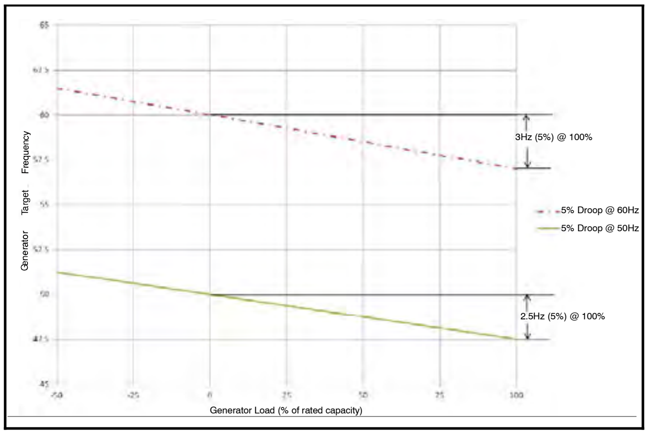
Load Sharing Parameters are found under the Real Power Load Sharing heading in SiteTech™ and under the Generator Info -> Paralleling Operation -> Sharing Setup menu on the user interface of the controller.

Real Load Sharing

- **Real Power Droop Slope**

  This controls the rate at which the target speed of the engine decreases with increasing load. Real Power Droop is intended to permit generators to share load in paralleled applications when there is no communication between the generator controllers. See Figure 12-6.

  If the load on a given generator increases, the target speed will decrease, resulting in a decrease in throttle, causing a decrease in load. The remaining load will be supplied by other generators in the paralleling system, which will cause their target speed to decrease slightly. The generator system will share load relatively evenly if they operate in droop mode, but the system frequency will vary with load.



  Range: 0.0% – 10.0%
  Default: 1.0%

Figure 12-6 Real Power Droop Slope

- **Real Power Sharing Proportional Gain**

  The Real Power Sharing Proportional Gain determines the contribution of the real power sharing proportional term to the speed bias. The proportional term is directly related to the difference between the average percent electrical loading of all gens on the bus and the percent electrical loading of this individual generator. The proportional term increases the speed bias when the average bus load is greater than the generator load.

  Range: 0.01 – 100.00
  Default: 1.00

- **Real Power Sharing Integral Gain**

  The Real Power Sharing Integral Gain determines the contribution of the real power sharing integral term to the speed bias. The integral term ramps at a rate directly related to the difference between the average percent electrical loading of all gens on the bus and the percent electrical loading of this individual generator. The integral term ramps the speed bias up when the average bus load is greater than the generator load.

  Range: 0.01 – 100.00
  Default: 1.00

- **Real Power Sharing Derivative Gain**

  The Real Power Sharing Derivative Gain determines the contribution of the real power sharing derivative term to the speed bias. The derivative term is directly related to the rate of change in the difference between the average percent electrical loading of all gens on the bus and the percent electrical loading of this individual generator. The derivative term increases the speed bias when the difference between the average bus load and the average generator load increases.

  Range: 0.01 – 100.00
  Default: 1.00

- **Torque Sharing Proportional Gain**

  The Torque Sharing Proportional Gain determines the contribution of the torque sharing proportional term to the speed bias. The proportional term is directly related to the difference between the average percent mechanical loading of all gens on the bus and the percent mechanical loading of this individual generator. The proportional term increases the speed bias when the average bus load is greater than the generator load.

  Range: 0.01 – 100.00
  Default: 1.00

- **Torque Sharing Integral Gain**

  The Torque Sharing Integral Gain determines the contribution of the torque sharing integral term to the speed bias. The integral term ramps at a rate directly related to the difference between the average percent mechanical loading of all gens on the bus and the percent mechanical loading of this individual generator. The integral term ramps the speed bias up when the average bus load is greater than the generator load.

  Range: 0.01 – 100.00
  Default: 1.00

- **Torque Sharing Derivative Gain**

  The Torque Sharing Derivative Gain determines the contribution of the torque sharing derivative term to the speed bias. The derivative term is directly related to the rate of change in the difference between the average percent mechanical loading of all gens on the bus and the percent mechanical loading of this individual generator. The derivative term increases the speed bias when the difference between the average bus load and the average generator load increases.

  Range: 0.01 – 100.00
  Default: 1.00

- **Frequency Trim Proportional Gain**

  The Frequency Trim Proportional Gain determines the contribution of the frequency trim proportional term to the speed bias. The proportional term is directly related to the difference between the target speed bias (typically 0) and the actual speed bias. The proportional term increases the speed bias when the speed bias is negative.

  Range: 0.01 – 100.00
  Default: 1.00

- **Frequency Trim Integral Gain**

  The Frequency Trim Integral Gain determines the contribution of the frequency trim integral term to the speed bias. The integral term ramps at a rate directly related to the difference between the target speed bias (typically 0) and the actual speed bias. The integral term increases the speed bias when the speed bias is negative.

  Range: 0.01 – 100.00
  Default: 1.00

- **Frequency Trim Derivative Gain**

  The Frequency Trim Derivative Gain determines the contribution of the frequency trim derivative term to the speed bias. The derivative term is related to the rate of change of the difference between the target speed bias (typically 0) and the actual speed bias. The derivative term increases the speed bias when the speed bias decreases.

  Range: 0.01 – 100.00
  Default: 1.00

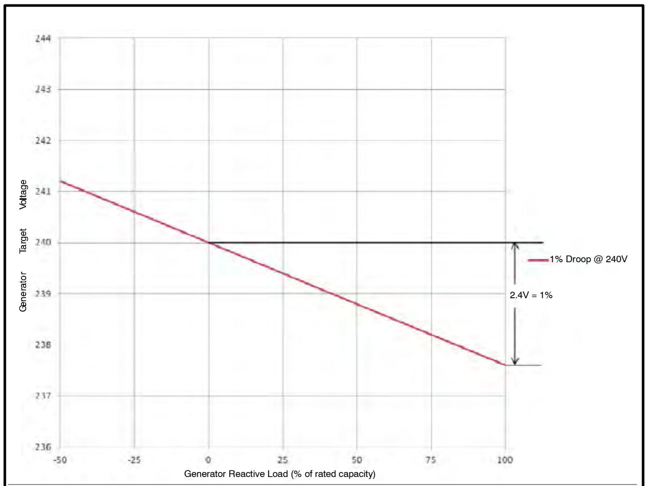
Reactive Load Sharing

- **Reactive Droop Slope**

  This controls the rate at which the target voltage of the voltage regulator decreases with increasing reactive load. Reactive Droop is intended to permit alternators to share reactive load in paralleled applications when there is no communication between the generator controllers. See Figure 12-7.

  If the reactive load on a given generator decreases, the target voltage will increase, resulting in a decrease in field current, causing a decrease in reactive power output. The remaining reactive load will be supplied by other generators in the paralleling system, which will cause their target voltage to decrease slightly. The generator system will share reactive load relatively evenly if they operate in droop mode, but the system voltage will vary with reactive load.

  Note: Paralleling systems typically require reactive droop to remain stable, as the voltage reacts much more quickly than the engine speed. The Voltage Trim is equipped to compensate for the reactive droop over time.



  Range: 0.0% – 20.0%
  Default: 1.0%

Figure 12-7 Reactive Droop Slope

- **Reactive Power Sharing Proportional Gain**

  The Reactive Power Sharing Proportional Gain determines the contribution of the reactive power sharing proportional term to the voltage bias. The proportional term is directly related to the difference between the average percent reactive loading of all gens on the bus and the percent reactive loading of this individual generator. The proportional term increases the voltage bias when the average bus reactive load is greater than the generator reactive load.

  Range: 0.01 – 100.00
  Default: 1.00

- **Reactive Power Sharing Integral Gain**

  The Reactive Power Sharing Integral Gain determines the contribution of the reactive power sharing proportional term to the voltage bias. The integral term ramps at a rate related to the difference between the average percent reactive loading of all gens on the bus and the percent reactive loading of this individual generator. The integral term increases the voltage bias when the average bus reactive load is greater than the generator reactive load.

  Range: 0.01 – 100.00
  Default: 1.00

- **Reactive Power Sharing Derivative Gain**

  The Reactive Power Sharing Derivative Gain determines the contribution of the reactive power sharing derivative term to the voltage bias. The derivative term is related to the rate of change of the difference between the average percent reactive loading of all gens on the bus and the percent reactive loading of this individual generator. The derivative term increases the voltage bias when the generator reactive load decreases relative to the bus reactive load.

  Range: 0.01 – 100.00
  Default: 1.00

- **Voltage Trim Proportional Gain**

  The Voltage Trim Proportional Gain determines the contribution of the voltage trim proportional term to the voltage bias. The proportional term is directly related to the difference between the target voltage bias (which offsets the reactive droop) and the actual voltage bias. The proportional term increases the voltage bias when the voltage bias is lower than the target.

  Range: 0.01 – 100.00
  Default: 1.00

- **Voltage Trim Integral Gain**

  The Voltage Trim Integral Gain determines the contribution of the voltage trim integral term to the voltage bias. The integral term ramps at a rate related to the difference between the target voltage bias (which offsets the reactive droop) and the actual voltage bias. The integral term increases the voltage bias when the voltage bias is lower than the target.

  Range: 0.01 – 100.00
  Default: 1.00

- **Voltage Trim Derivative Gain**

  The Voltage Trim Derivative Gain determines the contribution of the voltage trim derivative term to the voltage bias. The derivative term is directly related to the rate of change of the difference between the target voltage bias (which offsets the reactive droop) and the actual voltage bias. The derivative term increases the voltage bias when the voltage bias decreases.

  Range: 0.01 – 100.00
  Default: 1.00

12.6.5 Power Control

Real Power Disconnect Level

The Real Power Disconnect Level is the real power threshold below which the generator circuit breaker will be signaled to trip when the generator is signaled to unload (the load enable signal is removed or the parameter is set to off).

Range: 0.0% – 25.0%
Default: 5.0%

Real Power Ramp Rate

The Real Power Ramp Rate determines the rate that the generator will attempt to take and remove load. The ramp rate is used in soft-loading (when a generator closes to a live bus) and soft-unloading (when a generator is signaled to stop by Generator Management or the load enable signal is removed.

Range: 0.1%/sec – 25.0%/sec
Default: 10.0%/sec

Real Power Baseload Setpoint

The Real Power Baseload Setpoint is the final target for the load ramp when entering baseload mode and is the target for the real power controller as long as baseload is active. The setpoint could be adjusted remotely via communications, but the system is intended to operate in system control mode when paralleling with the utility using external switchgear controls.

Range: 0.0% – 100.0%
Default: 50.0%

Real Power Baseload Proportional Gain

The Real Power Baseload Proportional Gain determines the contribution of the real power control proportional term to the speed bias. The proportional term is directly related to the difference between the baseload setpoint and the percent electrical loading of this individual generator. The proportional term increases the speed bias when the baseload setpoint is greater than the generator load.

Range: 0.01 – 100.00
Default: 1.00

Real Power Baseload Integral Gain

The Real Power Baseload Integral Gain determines the contribution of the real power control integral term to the speed bias. The integral term ramps at a rate directly related to the difference between the baseload setpoint and the percent electrical loading of this individual generator. The integral term ramps the speed bias up when the baseload setpoint is greater than the generator load.

Range: 0.01 – 100.00
Default: 1.00

Real Power Baseload Derivative Gain

The Real Power Baseload Derivative Gain determines the contribution of the real power control derivative term to the speed bias. The derivative term is directly related to the rate of change in the difference between the baseload setpoint and the percent electrical loading of this individual generator. The derivative term increases the speed bias when the difference between the baseload setpoint and the generator load increases.

Range: 0.01 – 100.00
Default: 1.00

System Real Load Control Proportional Gain

The System Real Load Control Proportional Gain determines the contribution of the real power control proportional term to the speed bias. The proportional term is directly related to the difference between the system control target set by the speed bias and the percent electrical loading of this individual generator. The proportional term increases the speed bias when the system control target is greater than the generator load.

Range: 0.01 – 100.00
Default: 1.00

System Real Load Control Integral Gain

The System Real Load Control Integral Gain determines the contribution of the real power control integral term to the speed bias. The integral term ramps at a rate directly related to the difference between the system control target set by the speed bias and the percent electrical loading of this individual generator. The integral term ramps the speed bias up when the system control target is greater than the generator load.

Range: 0.01 – 100.00
Default: 1.00

System Real Load Control Derivative Gain

The System Real Load Control Derivative Gain determines the contribution of the real power control derivative term to the speed bias. The derivative term is directly related to the rate of change in the difference between the system control target set by the speed bias and the percent electrical loading of this individual generator. The derivative term increases the speed bias when the difference between the system control target and the generator load increases.

Range: 0.01 – 100.00
Default: 1.00

Reactive Power Baseload Setpoint

The Reactive Power Baseload Setpoint is the final target for the load ramp when entering baseload mode and is the target for the reactive power controller as long as baseload is active. The setpoint could be adjusted remotely via communications, but the system is intended to operate in system control mode when paralleling with the utility using external switchgear controls.

Range: 0.0% – 100.0%
Default: 50.0%

Reactive Power Baseload Proportional Gain

The Reactive Power Baseload Proportional Gain determines the contribution of the reactive power control proportional term to the voltage bias. The proportional term is directly related to the difference between the baseload setpoint and the percent reactive loading of this individual generator. The proportional term increases the voltage bias when the baseload setpoint is greater than the generator reactive load.

Range: 0.01 – 100.00
Default: 1.00

Reactive Power Baseload Integral Gain

The Reactive Power Baseload Integral Gain determines the contribution of the reactive power control integral term to the speed bias. The integral term ramps at a rate directly related to the difference between the baseload setpoint and the percent reactive loading of this individual generator. The integral term ramps the voltage bias up when the baseload setpoint is greater than the generator reactive load.

Range: 0.01 – 100.00
Default: 1.00

Reactive Power Baseload Derivative Gain

The Reactive Power Baseload Derivative Gain determines the contribution of the reactive power control derivative term to the speed bias. The derivative term is directly related to the rate of change in the difference between the baseload setpoint and the percent reactive loading of this individual generator. The derivative term increases the speed bias when the difference between the baseload setpoint and the generator reactive load increases.

Range: 0.01 – 100.00
Default: 1.00

Power Factor Baseload Setpoint

The Power Factor Baseload Setpoint is the final target for the load ramp when entering baseload mode and allows computation of the target for the reactive power controller as long as baseload is active. The setpoint could be adjusted remotely via communications, but the system is intended to operate in system control mode when paralleling with the utility using external switchgear controls.

Range: 0.50% – 1.00%
Default: 0.80%

Power Factor Baseload Proportional Gain

The Power Factor Baseload Proportional Gain determines the contribution of the reactive power control proportional term to the voltage bias. The proportional term is directly related to the difference between the reactive power target calculated from the real power and the power factor baseload setpoint and the percent reactive loading of this individual generator. The proportional term increases the voltage bias when the reactive power target is greater than the generator load.

Range: 0.01 – 100.00
Default: 1.00

Power Factor Baseload Integral Gain

The Power Factor Baseload Integral Gain determines the contribution of the reactive power control integral term to the voltage bias. The integral term ramps at a rate directly related to the difference between the reactive power target calculated from the real power and the power factor baseload setpoint and the percent electrical loading of this individual generator. The integral term ramps the speed bias up when the baseload setpoint is greater than the generator load.

Range: 0.01 – 100.00
Default: 1.00

Power Factor Baseload Derivative Gain

The Power Factor Baseload Derivative Gain determines the contribution of the reactive power control derivative term to the voltage bias. The derivative term is directly related to the rate of change in the difference between the reactive power target calculated from the real power and the power factor baseload setpoint and the percent reactive loading of this individual generator. The derivative term increases the voltage bias when the difference between the baseload setpoint and the generator load increases.

Range: 0.01 – 100.00
Default: 1.00

System Reactive Load Control Proportional Gain

The System Reactive Load Control Proportional Gain determines the contribution of the reactive power control proportional term to the voltage bias. The proportional term is directly related to the difference between the system control target set by the external voltage bias and the percent reactive loading of this individual generator. The proportional term increases the voltage bias when the system control target is greater than the generator reactive load.

Range: 0.01 – 100.00
Default: 1.00

System Reactive Load Control Integral Gain

The System Reactive Load Control Integral Gain determines the contribution of the reactive power control integral term to the voltage bias. The integral term ramps at a rate directly related to the difference between the system control target set by the external voltage bias and the percent reactive loading of this individual generator. The integral term ramps the voltage bias up when the system control target is greater than the generator reactive load.

Range: 0.01 – 100.00
Default: 1.00

System Reactive Load Control Derivative Gain

The System Reactive Load Control Derivative Gain determines the contribution of the reactive power control derivative term to the voltage bias. The derivative term is directly related to the rate of change in the difference between the system control target set by the external voltage bias and the percent reactive loading of this individual generator. The derivative term increases the voltage bias when the difference between the system control target and the generator reactive load increases.

Range: 0.01 – 100.00
Default: 1.00

System Power Factor Baseload Proportional Gain

The System Power Factor Baseload Proportional Gain determines the contribution of the reactive power control proportional term to the voltage bias. The proportional term is directly related to the difference between the reactive power target calculated from the real power and the power factor target set by the external voltage bias and the percent reactive loading of this individual generator. The proportional term increases the voltage bias when the reactive power target is greater than the generator reactive load.

Range: 0.01 – 100.00
Default: 1.00

System Power Factor Baseload Integral Gain

The System Power Factor Baseload Integral Gain determines the contribution of the reactive power control integral term to the voltage bias. The integral term ramps at a rate directly related to the difference between the reactive power target calculated from the real power and the power factor target set by the external voltage bias and the percent reactive loading of this individual generator. The integral term ramps the voltage bias up when the reactive power target is greater than the generator reactive load.

Range: 0.01 – 100.00
Default: 1.00

System Power Factor Baseload Derivative Gain

The System Power Factor Baseload Derivative Gain determines the contribution of the reactive power control derivative term to the voltage bias. The derivative term is directly related to the rate of change in the difference between the reactive power target calculated from the real power and the power factor target set by the external voltage bias and the percent reactive loading of this individual generator. The derivative term increases the voltage bias when the difference between the baseload setpoint and the generator reactive load increases.

Range: 0.01 – 100.00
Default: 1.00

12.6.6 Generator Management

Generator Management provides logic to determine how many generators are required to support the load on the generator system and which generators are the most desirable to run. If Generator Management is disabled, all available generators will run as long as a start signal is received.

Control Mode

The Control Mode parameter controls the Order Selection Method for Generator Management. The available Methods are:

- **Manual/Fixed**

  The Generator Start/Stop Order is manually selected. In this mode, the user sets the order of each generator at the controller and Generator Management retains the order (there is no automatic re-sort during operation).

  Note: All generators must have different orders. If two or more generators have the same order, Generator Management is disabled (all available generators will run, but no fault will be displayed on the controller). The system will attempt to resolve order conflicts, but this may require manual intervention, especially if more than one order is changed simultaneously (using SiteTech™). If generators are added to or subtracted from the paralleling system, the system may see an order conflict—resulting in a reassignment of the orders in the system (the order for any generator could change from the previous setting).

  Manual mode can be used in a scenario where certain generators are preferred to run more frequently for any reason (such as position, sound level, fuel efficiency, fuel type, etc.)

  The need for manual mode should decrease as additional automatic modes are added.

- **Runtime**

  The Generator Start/Stop Order is selected automatically by the controller based on the runtime hours on each generator. In this mode, the generator with the lowest runtime hours will be assigned the lowest order (starting first, stopping last), with each sequential order number being assigned to generators of increasing runtime hours. The intent is to equalize runtime hours between the units.

  If the generator system is supplying the load, Generator Management implements a Runtime Threshold to avoid starting and stopping generators every 0.1 hours. The Runtime Threshold is added to the runtime hours of generators that are not running (for the purpose of comparison), preventing excessively frequent starting and stopping of generators.

  If all the generators are running, the Order re-sorts automatically any time the runtime hours of a higher order generator drop below the hours on a lower order generator. This will not typically occur while all generators are running, as they will all be acquiring runtime hours at the same rate.

  If a generator starts because the load increases, the Order may re-sort as soon as it connects to the paralleling bus, hence the runtime hours will be equalized before the difference reaches the threshold.

  Runtime control mode is intended for application where the generators require wear-leveling, such as a prime-power application.

- **Fuel Level**

  The Generator Start/Stop Order is selected automatically by the controller based on the fuel level measured by each generator. In this mode, the generator with the highest fuel level (as measured in percentage) will be assigned the lowest order (starting first, stopping last), with each sequential order number being assigned to generators of decreasing fuel level. The intent is to equalize fuel level between the units.

  If the generator system is supplying the load, Generator Management implements a Fuel Level Threshold to avoid starting and stopping generators every time the fuel level changes (which could happen frequently if the fuel is moving). The Fuel Level Threshold is added to the fuel level of generators that are running (for the purpose of comparison), preventing excessively frequent starting and stopping of generators.

  If all the generators are running, the Order re-sorts automatically any time the fuel level of a lower order generator drops below the fuel level on a higher order generator. This will not typically occur while all generators are running, as they will all be using fuel at the same relative rate (if the tanks are sized appropriately for each generator).

  If a generator starts because the load increases, the Order may re-sort as soon as it connects to the paralleling bus, hence the fuel level will be equalized before the difference reaches the threshold.

  Fuel Level Control mode is intended to equalize fuel level in a system of generators where each generator has a separate fuel tank—it is intended to prevent the case where one generator runs out of fuel while the others have plenty.

  Range: Invalid = 0, Manual Fixed = 1, Runtime = 2, Fuel Level = 3
  Default: Runtime

Enabled

This permits disabling all Generator Management features. When Generator Management is disabled, a generator will not alert the user of a Generator Management configuration mismatch. Any generators in the paralleling system with Generator Management disabled will run if they are in auto and are receiving a start signal (they will not stop if they are not needed).

Nodes with Generator Management enabled may still see a configuration mismatch if a disabled node is configured differently.

Range: False-True
Default: False

Order

The Order that a generator will start and stop in the Generator Management sequence—Higher orders start last and stop first. This parameter is only adjustable in Manual Mode.

The Order of each of the generators in the paralleling system must be different for Generator Management to function. Generator Management will attempt to correct an order conflict, but can only do so to a limited extent.

If a generator controller is powered down or disconnected from the communications network, the remaining controllers will attempt to re-sort the order so that each generator has a unique and sequential Order—the re-sort is not always successful in manual mode.

It is important to verify the Start/Stop Order of each generator if power is cycled to one or more generators in a paralleling system where Generator Management is used in manual mode.

Range: 1-8
Default: *Depends on Power-up sequence and Ser #

Start Percentage

The Percentage of Rated Capacity on the paralleling system (the generators that are running and are active in Generator Management) above which a generator is considered for starting.

Only a generator which is available, not running and is enabled for Generator Management can be started by Generator Management.

Generator Management uses the start percentage to calculate the Start kW for this generator.

The Start Percentage should be set so that the generator system starts enough generators that any transient loading can be supported by the running generators, or to keep an additional generator running for redundancy. The default (80%) works for most applications, but applications with large switching loads may require a lower setting for the Start Percentage.

The Start Percentage should always be at least 10% higher than the stop percentage.

Range: 0.00% - 100.00%
Default: 80.00%

Stop Percentage

The Percentage of Rated Capacity on the other generators in the paralleling system (the other generators that are running and are active in Generator Management) below which a generator is considered for stopping.

Only a generator which is running (in auto) and is enabled for Generator Management can be stopped by Generator Management. Generators running in RUN (pressing the run button on the front panel) are not considered for Generator Management (their capacity is not counted toward supplying the load and they are not stopped when not needed).

Generator Management uses the stop percentage to calculate the Stop kW for this generator.

Note: The calculation is based on the capacity of the other generators on the paralleling bus, as this generator will not be providing power after it stops.

The Stop Percentage should be set so that the generator system keeps enough generators online to supply any transient loading that the application may demand (such as large chillers, air conditioners, pumps, or bow thrusters), while allowing unneeded generators to stop.

The Stop Percentage should always be at least 10% lower than the start percentage.

Range: 0.00% - 100.00%
Default: 60.00%

Start Delay

A time factor that represents the time that Generator Management will wait to start this generator if the load on the running generators exceeds the Start Percentage of this generator by 10% and all available lower-order generators are running.

The Start Delay should be configured to ensure that reasonable load spikes are handled without starting an additional generator, while allowing a generator to start if the increased load persists.

Range: 1 sec - 600 sec
Default: 30 sec

Stop Delay

A time factor that represents the time that Generator Management will wait to stop a generator if the load on the lower-order running generators drops below the Stop Percentage of this generator by 10% and all higher-order generators are already stopped.

The Stop Delay should be configured to allow generators to stop quickly if they will not be needed, but to prevent generators from stopping during a short-duration light load on the paralleling system.

Range: 0 sec - 7200 sec
Default: 300 sec

Stable Delay

The Stable Delay is the delay between the system reaching a typical loading scenario and Generator Management becoming active. This delay is intended to allow any loads connected to the system to reach a typical load level before Generator Management stops any generators.

The Stable delay should be configured to allow the Generator Management to become active when the system load has reached a nominal level (all abnormal load conditions due to a loss of power have been removed).

Range: 0 sec - 3600 sec
Default: 300sec

Runtime Threshold

The Runtime Threshold is the maximum Runtime Hour difference that Generator Management will allow before starting the lower-hour generator and stopping the higher-hour generator. This parameter is only considered with the order selection mode (control mode) set to Runtime Hours. The Threshold should be set based on the intended start/stop frequency of the generators (understanding that changing load may cause additional start/stop cycles).

Range: 0.1 h - 2400.0 h
Default: 24.0 h

Fuel Level Threshold

The Fuel Level Threshold is the maximum Fuel Level difference that Generator Management will allow before starting the generator with more fuel and stopping the generator with less fuel. This parameter is only considered with the order selection mode (control mode) set to Fuel Level. The Threshold should be set based on the intended start/stop frequency of the generators (understanding that changing load may cause additional start/stop cycles).

Range: 0.5% - 50.0%
Default: 10.0%

Min Gens Online

This parameter indicates how many generators the system will run with no load on the system. It can be used to keep an additional generator online, but is not intended to convert a system to N+1 Redundancy. N+1 Redundancy can be accomplished by setting the start and stop percentages considerably lower.

Range: 1 - 2
Default: 1

Min Load Shed Priority

Generator Management will be disabled any time the load control sheds a priority below this level. Setting the Min Load Shed Priority to 0 will disable the link between Load Control and Generator Management. Minimum Load Shed Priority should only be set to 0 if no Load Control priorities are connected to interrupt a load.

If loads are shed below this threshold, Generator Management will be disabled (resulting in all available generators starting).

Any connected Load Control priorities should disable Generator Management when they are shed, to avoid Generator Management stopping generators while loads are still adding, to allow Generator Management to start additional generators to support shed loads, and to allow extended underfrequency events to start additional generators.

Range: 0 - 6
Default: 0

12.6.7 Load Management

Load Management allows the temporary removal of loads from a paralleling generator system during startup (as a single generator will close to the dead paralleling bus and must be able to maintain rated voltage and frequency so that the other node can synchronize to it). It also removes loads in the event of a generator overload in order to maintain power to more important loads.

All load priorities are shed on receipt of a system start command, but no loads are shed during a local start.

Load Management has 6 priorities that add in sequence. Priority 1 adds first and priority 6 adds last. The priorities shed in reverse order, priority 6 sheds first and priority 1 sheds last.

The timing for a priority to add is related to the available capacity of the generator system (more capacity will result in quicker load adding).

The timing for a priority to shed is related to the degree of system overload (except for initial shed, which is instant). More overload results in quicker load shedding.

Genset Maximum Percent Capacity

The Genset Maximum Percent Capacity is the maximum level that the load management system will automatically place on the generator. Each priority is expected to provide 15% load on the generator system, so load management will ensure that the generator load is below 15% less than the Genset Maximum Percent Capacity before permitting another load to add.

Range: 0.0% - 120.0%
Default: 70.0%

Generator Overloaded Percent

The Generator Overloaded Percent is the output power threshold above which the load management system considers a generator or generator system to be overloaded. Loads will start shedding in their priority order if the generator system output power exceeds this level for long enough. Loads will continue to shed in decreasing intervals until the output power of the generator system drops below this level.

Range: 0.0% - 120.0%
Default: 85.0%

Under Frequency Shed Level

The Under Frequency Shed Level is the degree of frequency droop (operation below the nominal value) that is permitted on the generator system before the load management system considers a generator or generator system to be overloaded. Loads will start shedding in their priority order if the generator system frequency droop exceeds this level for long enough. Loads will continue to shed in decreasing intervals until the frequency of the generator system recovers to the point where the droop drops below this level.

Range: 0.00Hz - 5.00Hz
Default: 0.50Hz

Base Load Add Time

The Base Load Add Time is the time required to add a load with 25% available capacity (generator system power output is 40% below the Genset Maximum Percent Capacity). The load will add more quickly with lower load and take longer as the load increases, but the time is relative to the base load add time.

Range: 10.0 sec - 2400.0 sec
Default: 60.0 sec

Base Overload Shed Time

The Base Overload Shed Time is the time required to shed a load with 10% overload on the generator system (generator system power output is 10% above the Generator Overloaded Percent). The load will shed more quickly with higher load and take longer as the load decreases, but the time is relative to the base overload shed time.

Range: 2.0 sec - 30.0 sec
Default: 30.0 sec

Base Under Frequency Shed Time

The Base Under Frequency Shed Time is the time required to shed a load with 1Hz of frequency droop (frequency is 1Hz below the Under Frequency Shed Level less than the rated frequency of the generator). The load will shed more quickly with lower frequency and take longer as the frequency increases, but the time is relative to the Base Under Frequency Shed Time.

Range: 1.0 sec - 20.0 sec
Default: 5.0 sec

12.6.8 Miscellaneous

Fail to Open Delay

The Fail to Open Delay is the time that the controller will wait after applying a trip signal to the circuit breaker to see the breaker status indicate open. If the breaker status does not indicate open within this time, the controller will issue a Failure to Open warning. The controller continues to apply the trip signal to the circuit breaker and if the breaker opens at a later time, the warning will be cleared automatically (but still stored in the event log). If this warning recurs frequently in the event log of a generator, it may indicate that the Fail to Open Delay is set for too short of a time and that the breaker is not able to respond quickly enough to match the Fail to Open Delay. In this case, the Fail to Open delay can be lengthened, but consideration of the protective relay functionality and timing should be considered when lengthening the timing, as it may be preferred to troubleshoot the breaker for slow operation first.

Range: 0.1 sec - 30.0 sec
Default: 1.0 sec

Fail to Close Delay

The Fail to Close Delay determines the time that the controller will hold the close signal on during a close attempt. If the breaker status does not indicate that it is closed within the time allocated by the Fail to Close Delay, the controller will remove the close signal and issue a Breaker Close Attempt Fault. After the controller has seen a number of close attempt faults equal to the breaker close attempts, the controller will issue a Failure to Close. Failures to Close may be caused because the breaker requires an abnormally long time to close, but they are typically caused by wiring errors, external protective relay settings, or incorrect motor operator specifications/operating voltage.

Range: 0.1 sec - 30.0 sec
Default: 0.3 sec

Breaker Reclose Time

The Breaker Reclose Time controls the time delay between close attempts on the breaker. This is intended to allow the breaker to reset to a normal state and to operate properly on the subsequent reclose attempt.

Range: 0.5 sec - 30.0 sec
Default: 2.0 sec

Breaker Close Attempts

The Breaker Close Attempts indicates how many failed attempts to close the breaker the controller will accept before issuing a Fail to Close fault and requiring a fault reset to re-attempt breaker closure.

Range: 1 - 100
Default: 3.0 sec

Generator Paralleling Breaker

The Generator Paralleling Breaker is a Status parameter that indicates the internal measured position of the paralleling breaker. The parameter is displayed under Metering -> Paralleling Metering and under Generator Info -> Parallel Operation -> Synchronization Setup as Connected to Bus.

Range: False - True
Default: **STATUS**

Speed Bias

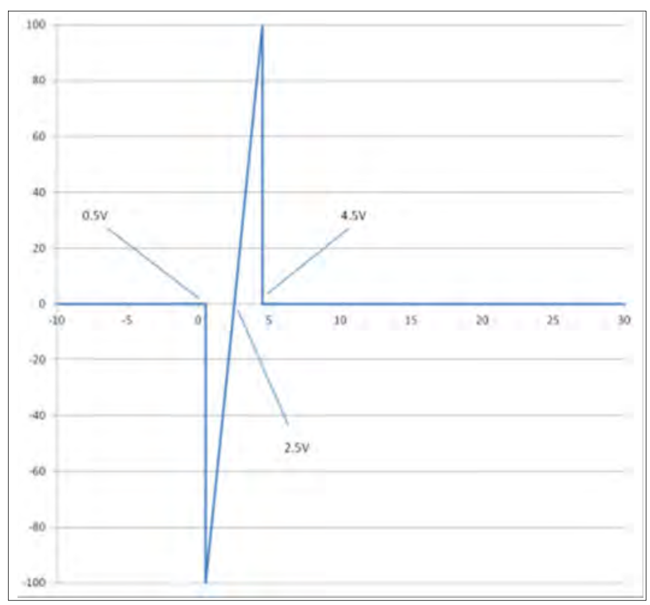
The amount that the controller is attempting to adjust the output frequency of the generator (100% bias = +5% on the engine speed, -100% = -5% on the engine speed). The controller adjusts the Speed bias to match frequency and phase with the paralleling bus.

Note: The Speed Bias can also be controlled by an external device if the External Bias Inputs Enabled parameter is true, the Stand Alone Operation parameter is false, no other generators are visible on the PGEN communications channel, and the voltage applied to the speed bias input is between 0.5V and 4.5V.

The External Speed Bias Input (SBP and SBN) is a voltage measuring channel capable of reading from -10V to 30V DC. The input is normally pulled down to -3.3V, but can be overridden by applying a voltage to the input.

The voltage that the controller sees on the voltage measuring channels is visible in the Analog Voltage Input Metered Relative Value under the Programmable Analog Voltage Input I08 heading. The input is polarity sensitive.

The Speed Bias is interpreted by the controller as illustrated in Figure 12-8.



Range: -100.00% – 100.00%
Default: 0.00% **Not Writable**

Figure 12-8 Speed Bias

Voltage Bias

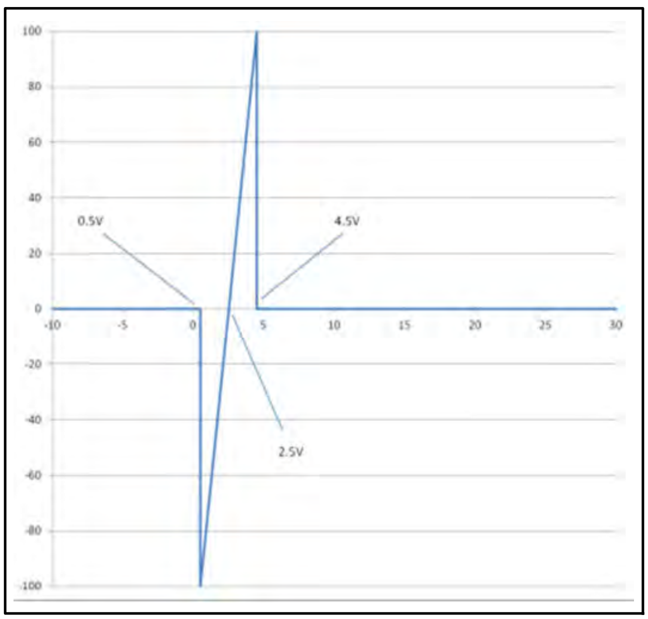
The amount that the controller is attempting to adjust the output voltage (100% bias = +10% on the output voltage, -100% = -10% on the output voltage). The controller adjusts the voltage bias to match the generator voltage to the bus voltage.

Note: The Voltage Bias can also be controlled by an external device if the External Bias Inputs Enabled parameter is true, the Stand Alone Operation parameter is false, no generators are visible on the PGEN communications channel, and the voltage applied to the voltage bias input is between 0.5V and 4.5V.

The External Voltage Bias Input (VBP and VBN) is a voltage measuring channel capable of reading from -10V to 30V DC. The input is normally pulled down to -3.3V, but can be overridden by applying a voltage to the input.

The voltage that the controller sees on the voltage measuring channels is visible in the Analog Voltage Input Metered Relative Value under the Programmable Analog Voltage Input I07 heading. The input is polarity sensitive.

The Voltage Bias is interpreted by the controller as illustrated in Figure 12-9.



Range: - 100.00% – 100.00%
Default: 0.00% **Not Writable**

Figure 12-9 Voltage Bias

Stand Alone Operation

This Parameter forces the controller to solve paralleling logic, even when it is not seeing PGEN communications with another generator. This is intended for applications where the generator is equipped with a motor operator that is controlled by the generator controller, but that the generator is equipped with a motor-operated breaker (either for disconnection means, baseload capability, or to allow for the installation of additional units in the future). Standalone mode is not necessary and should not be enabled in applications where multiple generators are in communication over PGEN or in applications where the generator is controlled by external gear that also controls the circuit breaker.

Standalone Operation can be configured as a digital input, allowing the ability to turn paralleling functionality on remotely.

Range: False - True
Default: False

Load Enable

Load Enable allows the generator controller to ramp to a target load in any of the power control modes. A controller will attempt to control load to 0% load when load enable is false, resulting in decreasing bus frequency when a single generator is supplying the load and severe load disparities when in parallel with other generators.

If Load Enable is removed after having been applied, the generator will soft-unload and trip its circuit breaker when the output power reaches the kW Disconnect Level.

Load Enable should remain on except when being used for testing, as it can cause loss of functionality that can be rather difficult to troubleshoot.

Load Enable can be configured to be a digital input to the controller, allowing external gear to signal the generator to unload and trip its breaker.

Range: False - True
Default: True

Disable Synchronization

The Disable Synchronization parameter allows blocking the controller from closing the paralleling breaker, but does not trip the breaker if asserted while the breaker is closed. This input can be used by external gear to inhibit the generator from closing to a bus. This allows integration with existing first-on systems and allows the generator to be unloaded and tripped without immediate re-synchronization and breaker closure.

This parameter can be configured to a digital input to allow it to be controlled by external gear.

Range: False - True
Default: False

Baseload Mode

Baseload Mode is intended for use in parallel with a utility source. Setting this input to true will place the controller in baseload mode, which will attempt to control the output real and reactive power to a setpoint parameter. Only the controller receiving the baseload mode signal will operate in baseload, other modes will continue to operate normally. Baseload mode takes priority over System Control mode and System Sync mode.

Baseload mode should only be used in parallel with the utility except as a troubleshooting tool. Baseload Mode is configurable as a digital input.

Range: False - True
Default: False

System Load Control

System Load Control mode is intended for use in parallel with a utility source. Setting this input to true will place all the controllers in the paralleling system in system control mode (unless baseload mode is also asserted on the controllers). System control mode controls the real and reactive power of each generator to targets set by the external speed and voltage bias, which is 50% (2.5V equivalent) when the external bias inputs are disabled. System Load Control mode can be configurable as a digital input.

Range: False - True
Default: False

System Sync Control

System Sync Control mode is intended for use in applications where it is necessary to synchronize a paralleling bus containing multiple generators to a utility source. System Sync mode causes all generators in a paralleling system to accept a speed and voltage bias from the external inputs of a single generator (as long as external bias is enabled). This allows external gear to synchronize an entire bus of generators as if it were a single generator. System Sync Control mode can be configurable as a digital input.

Range: False - True
Default: False

Enable Trims

Enable Trims allows activating/de-activating of the frequency and voltage trim functions that are available while in load sharing mode. There are few applications where the trims should be disabled, but it provides a good interface for troubleshooting.

Range: False - True
Default: True

kW Control Mode

Determines the method of controlling generator real power between the following modes:

- **Electrical Power Control Mode.** The generator controller controls power based on the electrical power that is produced by the alternator. This is the normal mode of operation.

- **Engine Torque Control Mode.** The generator controller controls power based on the mechanical torque as measured or calculated by the engine ECM. This mode is typically used if one of the generators in a paralleling system has a mechanical load which is also coupled to the engine.

Note: Not all applications support this parameter.

Range: Invalid = 0, kWe mode = 1, kWm mode = 2
Default: kWe mode

VAR Control Mode

The VAR Control mode parameters set the means that the controller uses to control reactive power in baseload and system control mode. This parameter has no effect when the generators are islanded and are merely sharing the power supplied to the load between them. The modes are:

- **PF Control Mode = 0.** Power Factor Control mode indicates that the reactive power target is related to the real power output level.
- **VAR Control Mode = 1.** VAR Control mode indicates that the reactive power target is not related to the real power output.

Range: PF Control Mode = 0, VAR Control Mode = 1
Default: PF Control Mode

External Bias Inputs Enabled

The external speed and voltage bias are set to 0 internally unless they are enabled. When enabled, they are controlled by the voltage applied to the external bias inputs. If there are no wires connected to the inputs, the biases will still read 0, as the inputs are pulled down to -3.3V, which is outside the normal range (0.5 to 4.5V). If a wire feeding the speed or voltage bias loses connection, the input should also revert to -3.3V (0 bias).

Range: False - True
Default: False

Notes

13.1 Generator Management Purpose

Generator Management is intended to decrease fuel consumption, environmental emissions, and sound emissions while improving generator life and serviceability.

13.2 Generator Management Basic Function

Generator Management supplies a stop signal to a generator. If Generator Management fails or is turned off, the stop signal is removed, resulting in the generator starting. Most faults relating to Generator Management will cause it to be disabled, causing the generator to start.

Generator Management is disabled when the start signal to the system is removed, and must go through a stability delay before it will stop generators.

13.2.1 Sequence of Operation

This sequence follows the operation of a normal paralleling system which uses Generator Management.

When a start signal is applied to any of the generators in the paralleling system, all the generators that are in auto and have no shutdown faults will start.

Figure 13-1 illustrates the system after the first generator has reached rated voltage and frequency and has closed to the paralleling bus (any of the generators can be the first to close, depending on which generator reaches rated voltage and frequency first). The Total System Capacity is that of a single generator and the load is low enough to be supported by a single generator because non-critical loads have been shed by a Load Management (also called Load Add/Shed or Load Control) system (not shown).

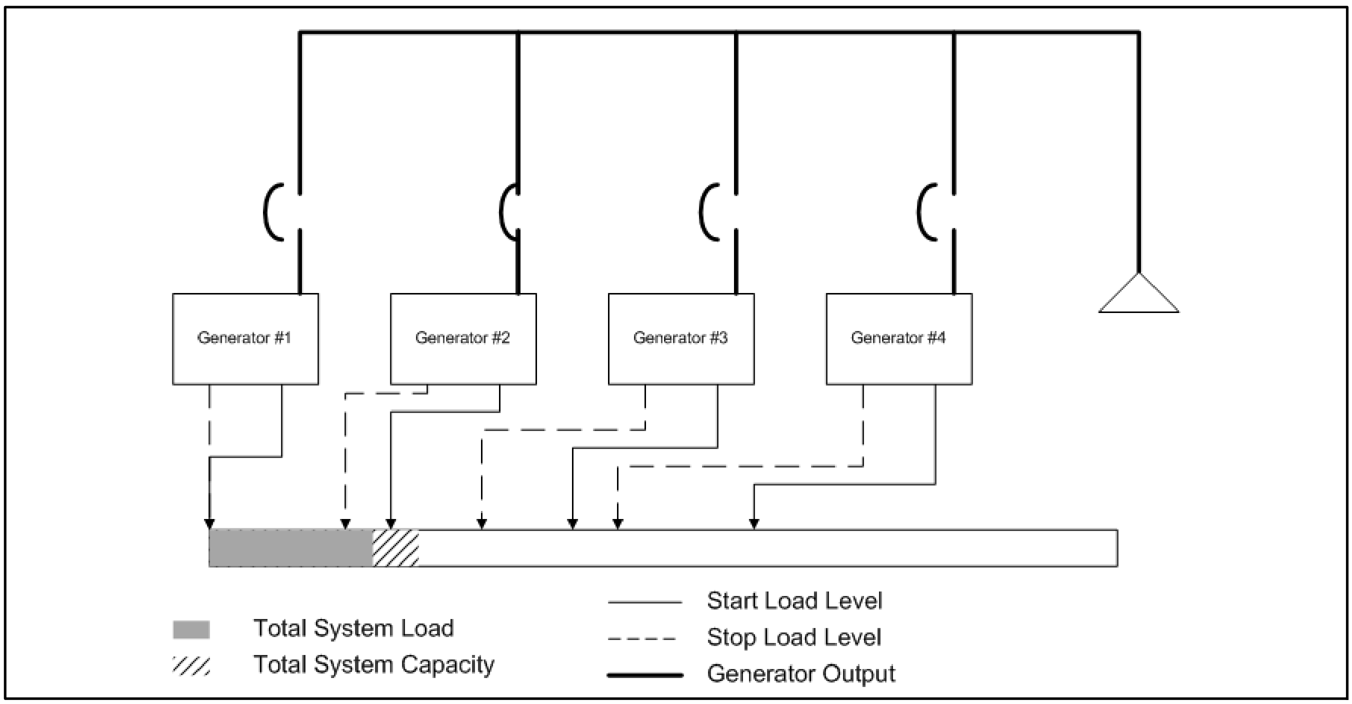


Figure 13-1 A Generator Energizes the Bus

As the other generators were synchronizing and connecting to the paralleling bus, the Load Add/Shed system added a load priority, increasing the load on the system beyond what a single generator can handle. In Figure 13-2, the system capacity is at a maximum for all generators in the paralleling system, as the generators are all connected to and supplying the load.

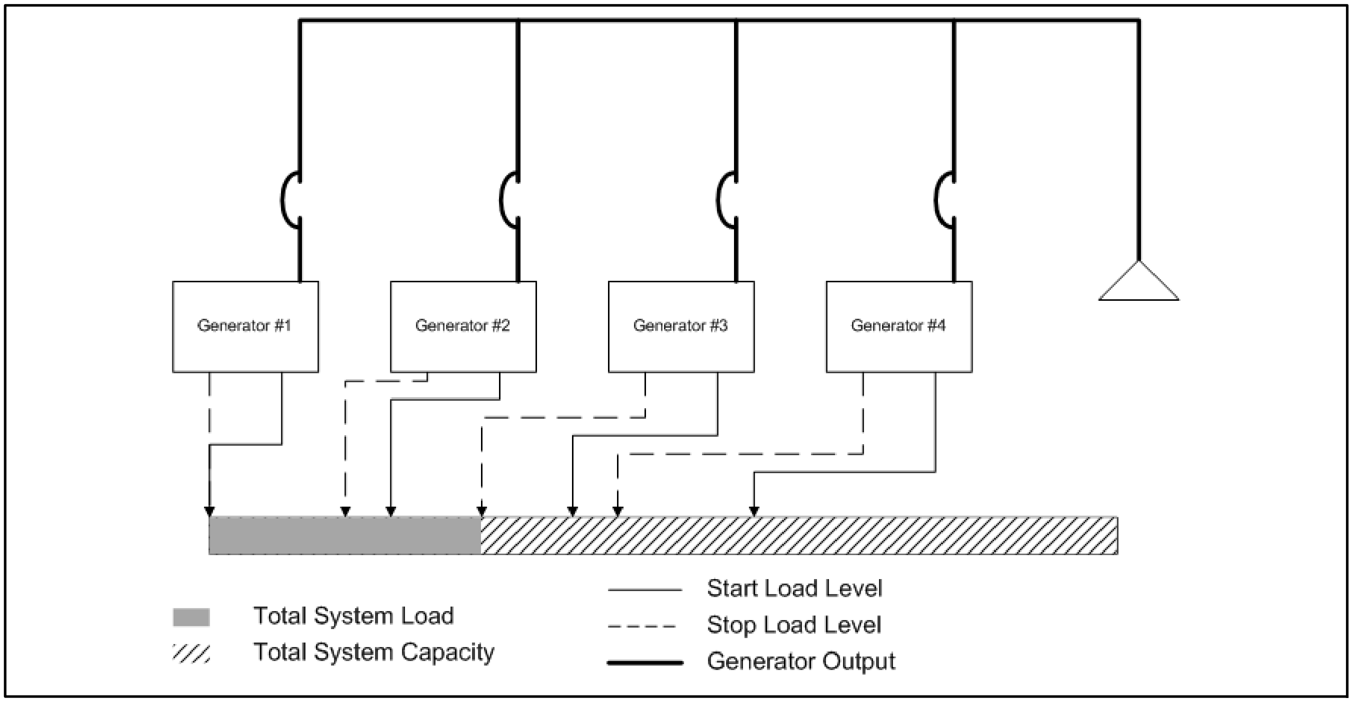


Figure 13-2 All Generators are Connected to the Paralleling Bus

Figure 13-3 is representative of the system after all load priorities have been added. With no load intentionally de-activated, Generator Management is able to assess the load on the system accurately to determine if any generators can be stopped. The load must stabilize before such determination will be accurate, so the stability delay begins.

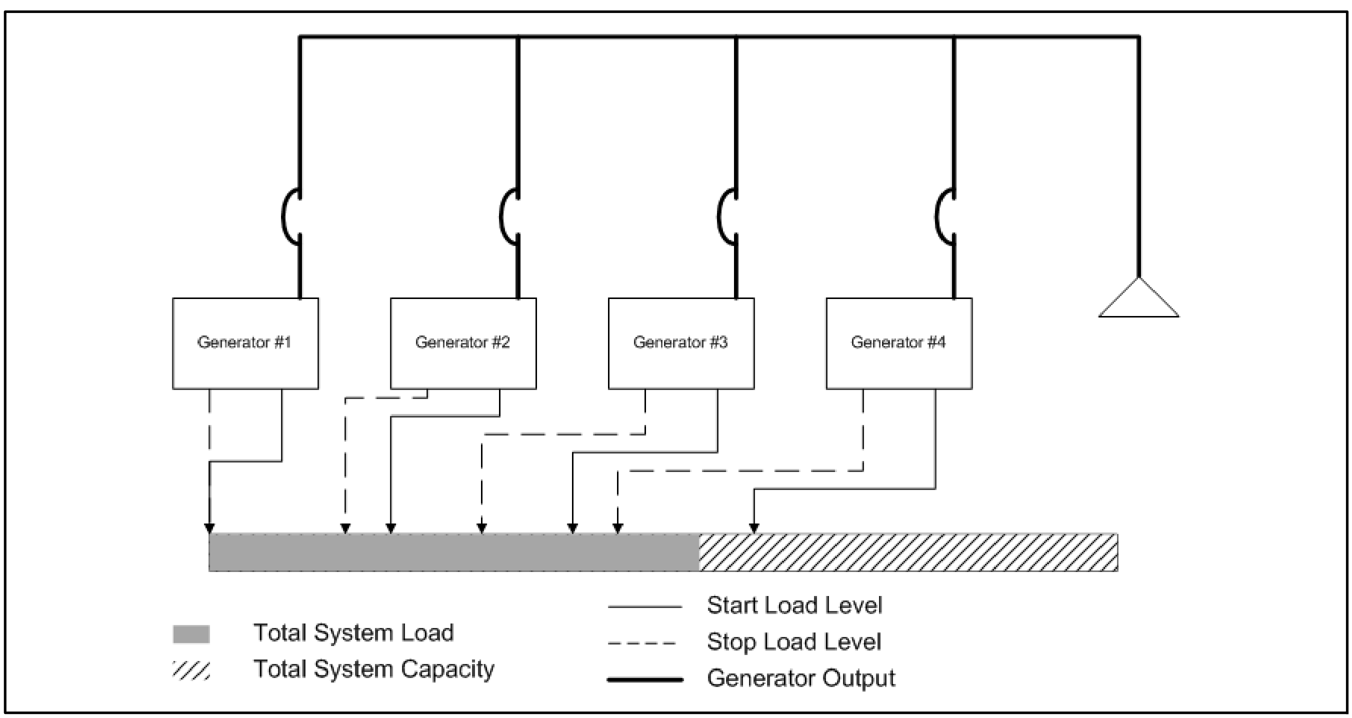


Figure 13-3 All Loads Have Been Added

By the time the Generator Management Stability Delay has expired (see Figure 13-4), the load has settled down to a steady-state level. Generator Management can start timing to stop Generator 4 because the system load is below the stop kW of Generator 4.

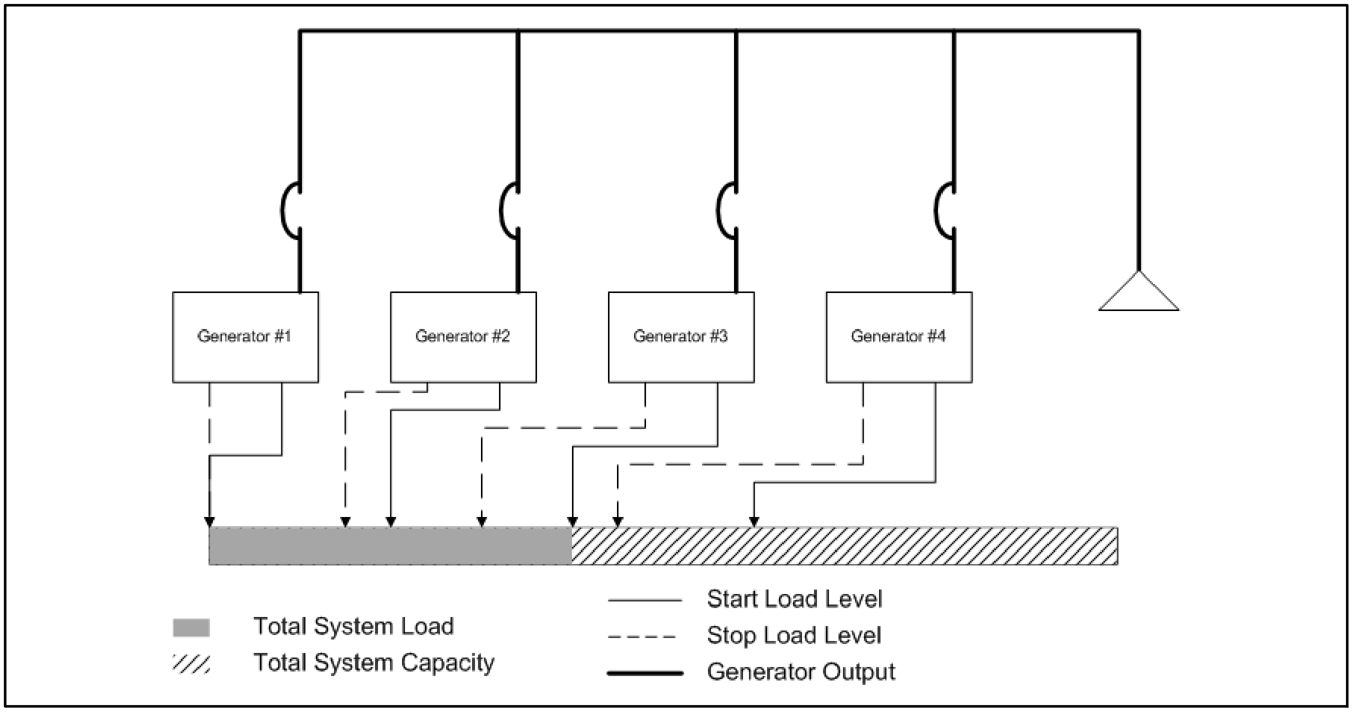


Figure 13-4 The Stability Timer has Expired

When its Stop Delay is complete, Generator 4 will soft-unload (gently transfer load to the other generators) and disconnect from the paralleling bus, either stopping or going into engine cooldown after disconnecting. After Generator 4 has stopped, the system continues to feed the load with generators 1, 2 and 3 as illustrated in Figure 13-5. The load has decreased further from the peak loading which occurred right after startup.

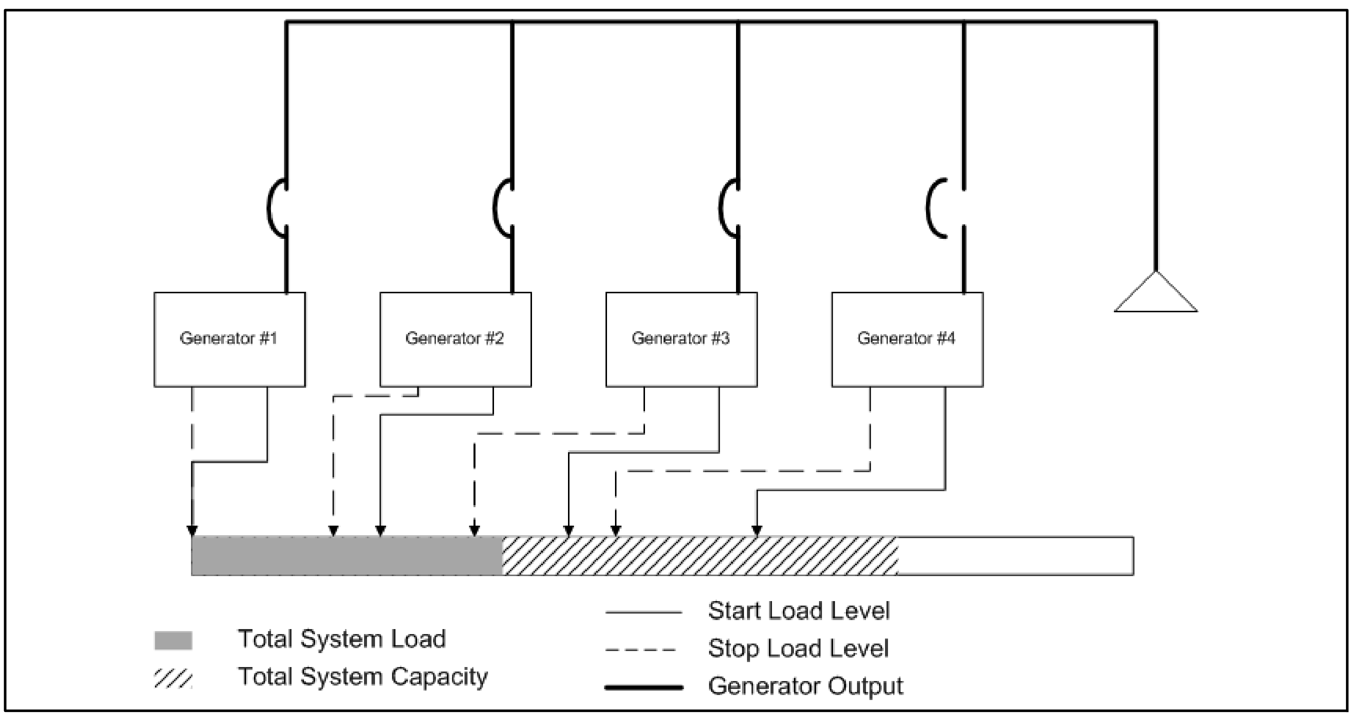


Figure 13-5 Generator 4 is Stopped by Generator Management

When the load decreases below the Stop Load Level for Generator 3, Generator Management will begin the stop delay. When the stop delay expires, Generator 3 will soft unload and disconnect from the paralleling bus, leaving only Generators 1 and 2 to supply the load (see Figure 13-6).

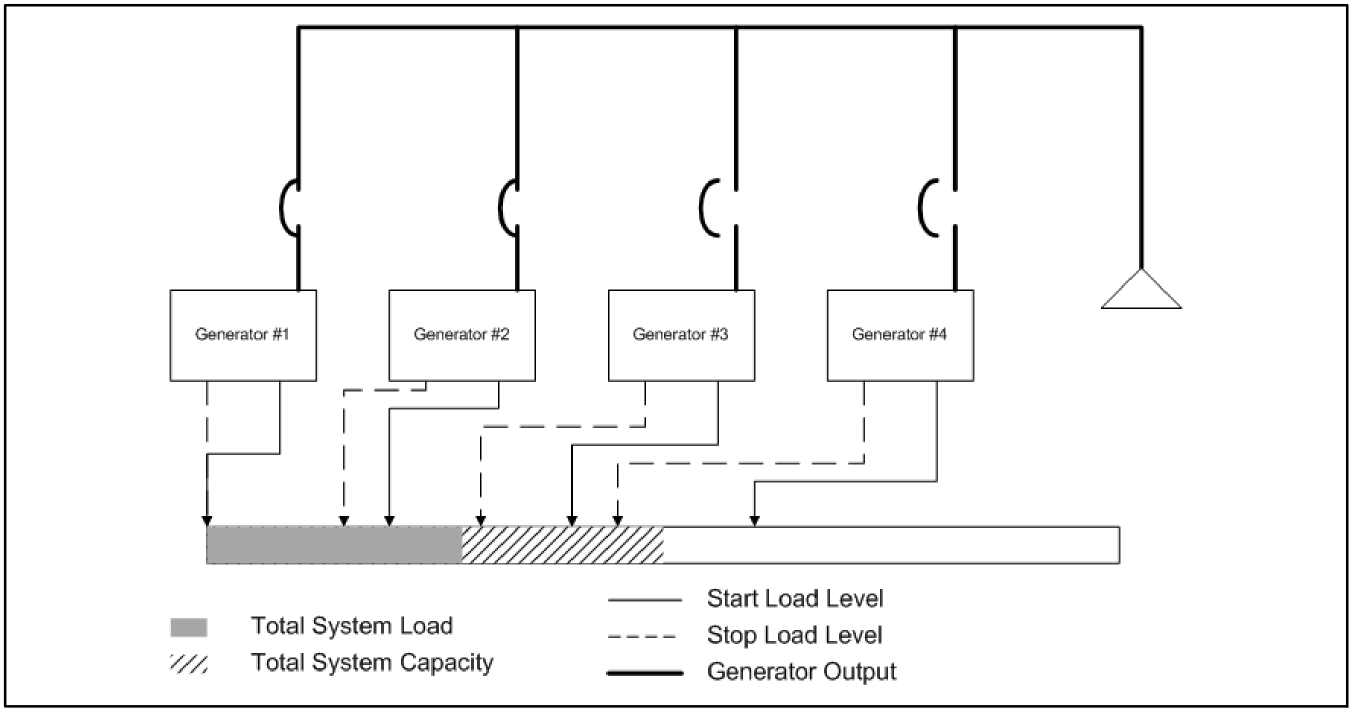


Figure 13-6 Generators 3 and 4 are Stopped by Generator Management

The load increases to a level above the Stop Load Level for Generator 3, but the system will not respond to the load increase until the load exceeds the Start Load Level of Generator 3 (see Figure 13-7).

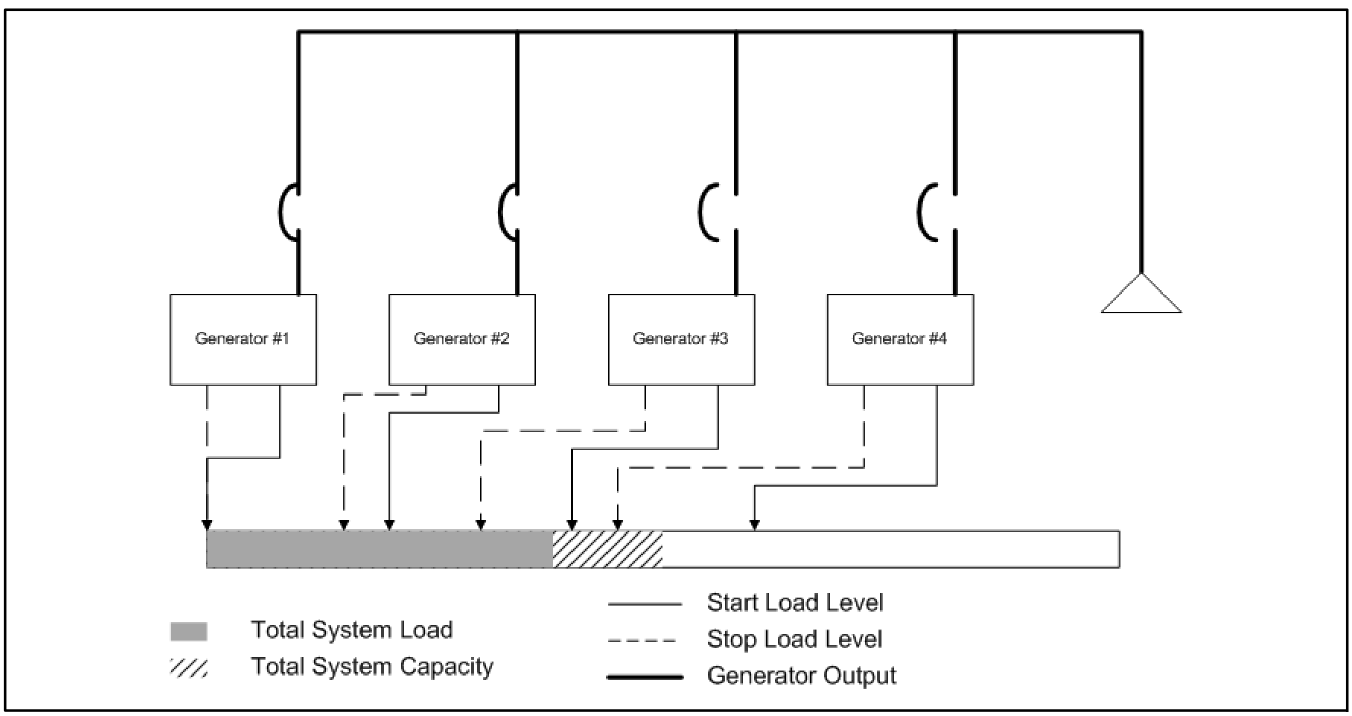


Figure 13-7 Load Increases After Generator 3 Stops

In Figure 13-8, the load increases well past the start kW for Generator 3, causing the generator to start, synchronize, and connect to the bus.

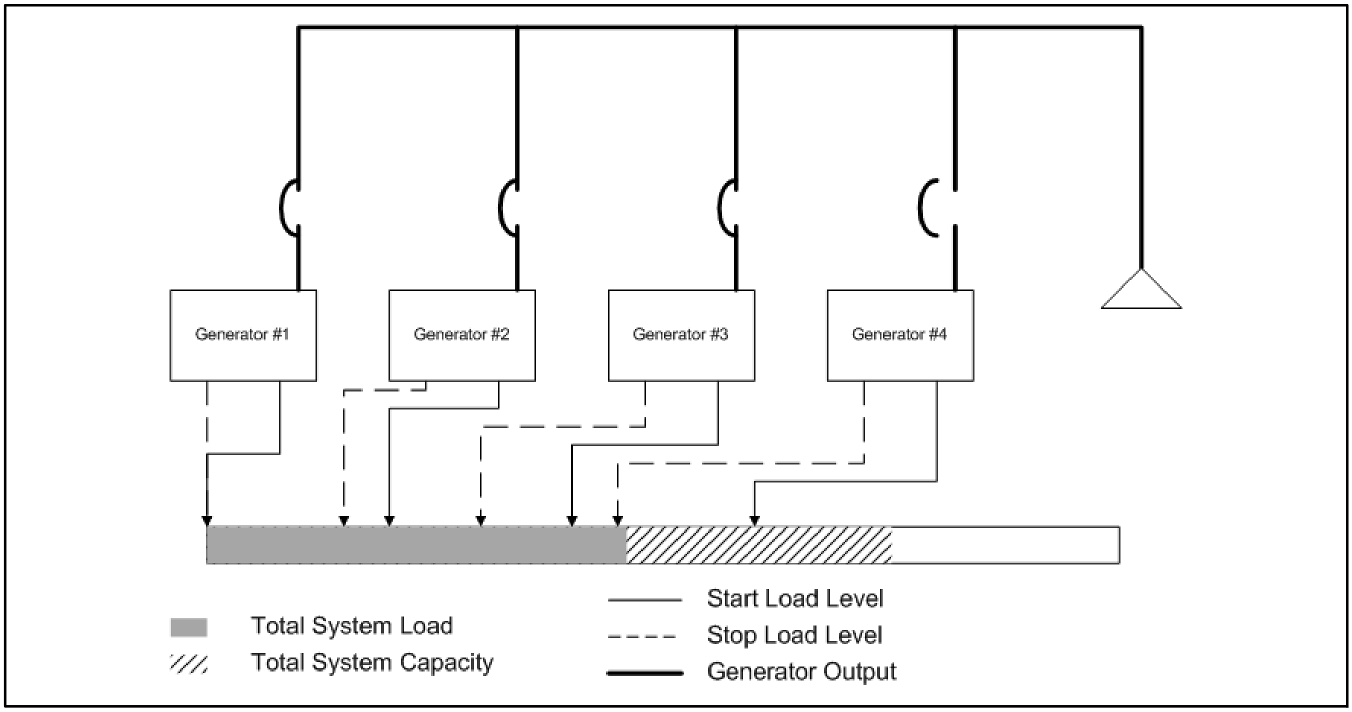


Figure 13-8 Generator 3 Restarts Due to Increase in Load

When the Start signal goes away, all generators disconnect from the paralleling bus and stop (see Figure 13-9).

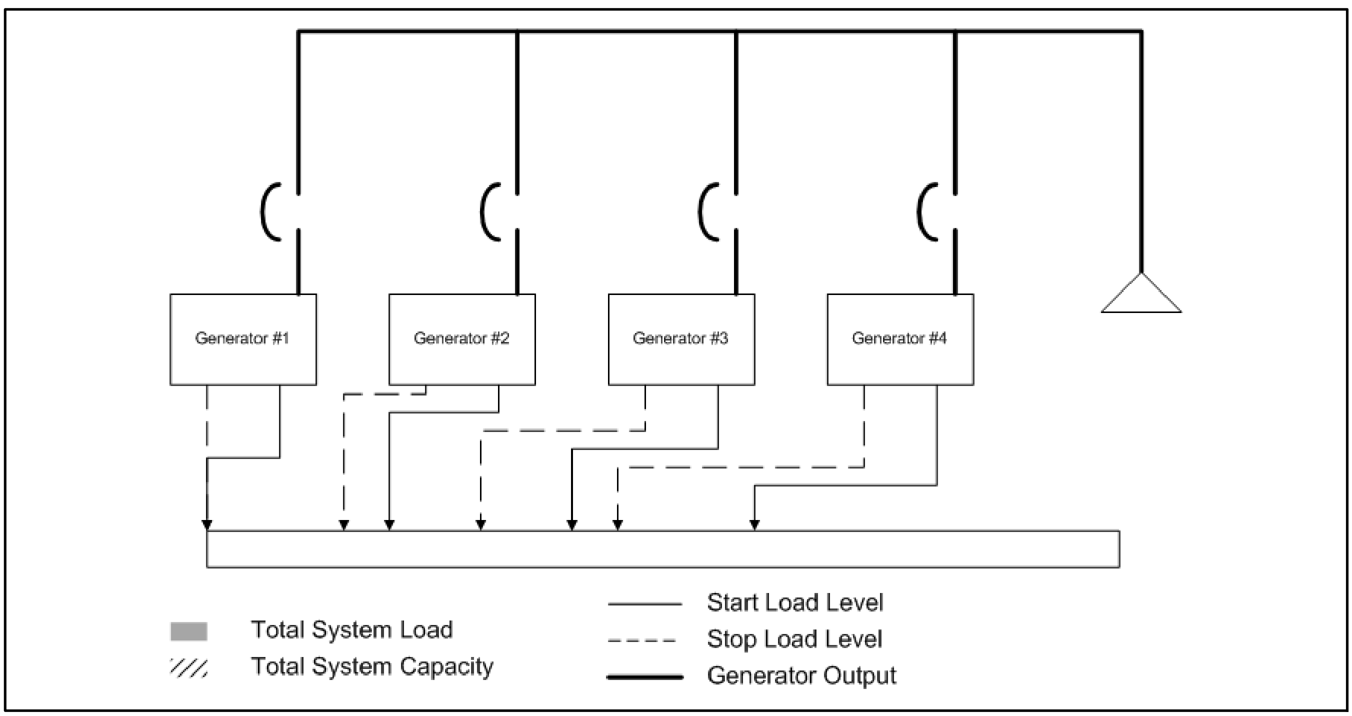


Figure 13-9 Paralleling Generator System has Returned to Standby State

Note: The generator order in the examples above matches the generator numbers for simplicity, but it is not required or even customary for the Start/Stop order of managed generators to match their generator numbers.

13.2.2 Control Approach

The Decision-Maker® 3500 controller uses Individual Generator Management. This means that each generator controller manages only the generator that it controls. Individual Generator Management allows for improved scalability, more seamless redundancy, and more comprehensive fault handling than centralized Generator Management.

Individual Generator Management controls each generator without need for additional signal routing—the communication between the generators is required for load sharing and first-on logic. Centralized Generator Management requires connection of Start and Unload signals to the generator controllers, interruption of the external start signal, and an additional module.

Figure 13-10 outlines the differences between these two types of Generator Management.

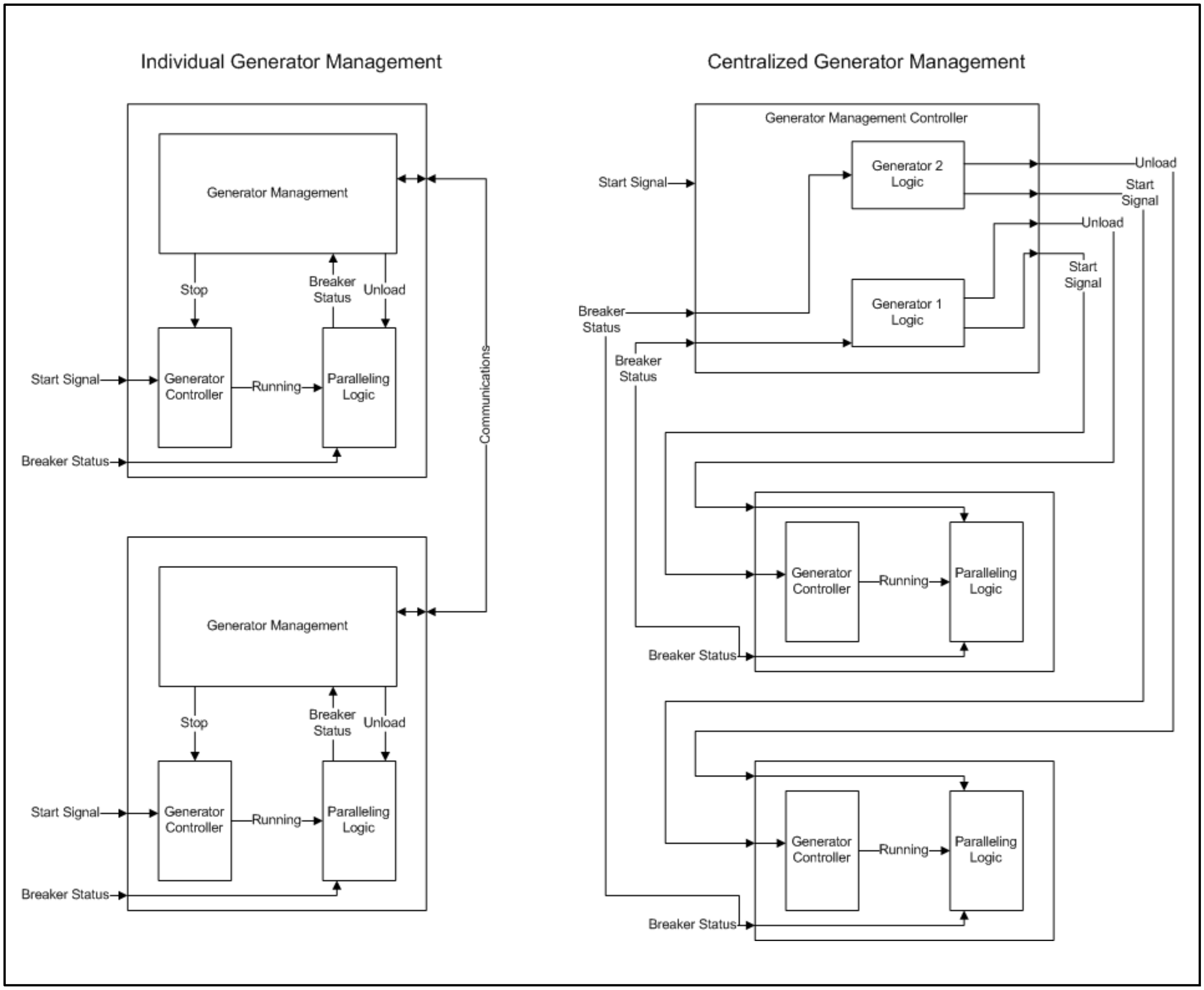


Figure 13-10 Comparison of Generator Management Topologies

The two systems operate very similarly, but the individual approach has no single point of failure for the system. The centralized system relies on the Generator Management Controller to issue the start signal to each generator—hence, a failure in the Generator Management Controller could prevent the system from responding to a start signal. The individual approach will only lose one generator if a controller fails.

13.2.3 Timing Approach

The Generator Management in the Decision-Maker® 3500 controller uses Overload-Based Start Timing and Capacity-Based Stop Timing. This means that the time to start or stop a generator depends on the loading on the system.

Start Timing

The Start Timing is inversely related to the system load—increasing system load will decrease the time to start a generator. This allows the Generator Management system to start additional generators when needed while providing ride-through capability for transient loads.

The Start Delay and Start Percentage are adjustable, but the curve shape is hard-coded for the Decision-Maker® 3500 controller.

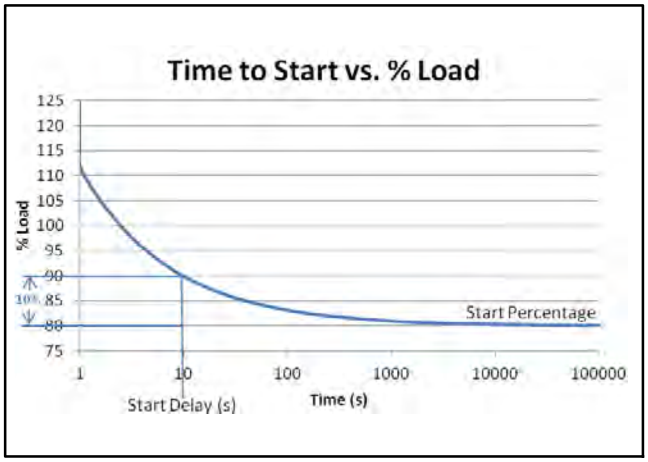


Figure 13-11 Overload-Based Start Timing
Start Percentage = 80%,
Start Delay = 10s

Figure 13-11 illustrates that the system load would have to remain at 85% of running capacity for about 40 seconds before an additional generator would start, but the generator will start within 2.5 seconds if the system load reaches 100% of running capacity. The curve shape is intended to approximate the capability of the generators.

Stop Timing

The Stop Timing is directly related to the system load—increasing system load will increase the time to stop a generator. This allows the Generator Management system to stop unneeded generators while maintaining enough capacity online to support transient loading.

The Stop Percentage and the Stop Delay are adjustable, but the shape of the curve is hard-coded in the Decision-Maker® 3500 controller.

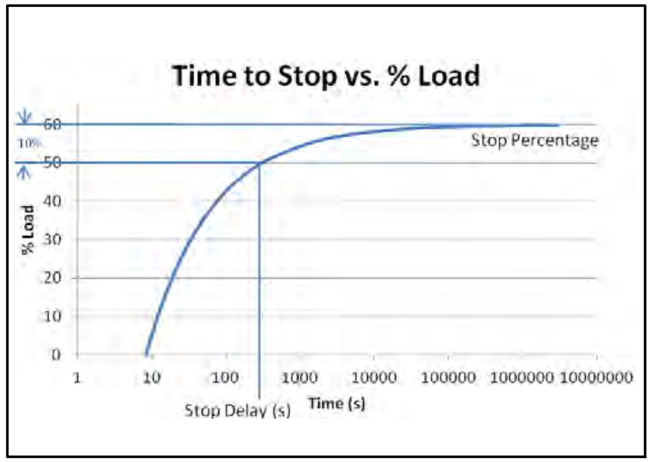


Figure 13-12 Capacity-Based Stop Timing
Stop Percentage = 60%,
Stop Delay = 300s

Figure 13-12 illustrates that Generator Management would require only 9 seconds to stop a generator if the generator system were completely unloaded, but that the generator would take 1200 seconds (20 minutes) to stop a generator if the load on the other generators would be 55% after that generator stopped. This technique helps to ensure that the system can handle the load without a particular generator before stopping that generator.

13.3 Generator Management Considerations

Generator Management is disabled by default on the Decision-Maker® 3500 controller. It is important to consider the following before enabling Generator Management:

- **Application of the Generator System.** In applications where the generators run for extended durations and for extended time intervals, Generator Management will provide a significant improvement in the life and fuel efficiency of the generators. Standby applications that run only occasionally are less dependent on Generator Management.
- **Load Types.** In applications where the load varies quickly and significantly, it is more difficult to manage the generators, as a large increase in load may overload the generator system before Generator Management can start another generator. Although Generator Management can be used in these applications, the system needs to be configured to keep enough generators online to support the transient load.
- **Generator Sizing.** If the generators are sized such that any of them can support the entirety of the load, Generator Management provides the function of stopping unneeded generators while permitting them to be available in case of a failure.
- **Criticality of the Application.** Highly critical applications typically require one or more generators in spinning reserve. Although, it is possible to configure Generator Management to keep an additional generator running, this might not meet the needs of the application.
- **Complexity of Operation.** Many facilities prefer simple, understandable system operation (all generators running when the utility is not available) which allows for easier troubleshooting (if a generator is not running, something is wrong).

13.4 Generator Management Setup

Generator Management requires consideration of several factors as each parameter is configured. The default settings will only work in certain scenarios.

13.4.1 Control Mode

The Control Mode Parameter controls the Order Selection Method for Generator Management. The available Methods are:

- **Manual/Fixed:** The Generator Start/Stop Order is manually selected. In this mode, the user sets the order of each generator at the controller and Generator Management retains the order (there is no automatic re-sort during operation).

Note: All generators must have different orders. If two or more generators have the same order, Generator Management is disabled (all available generators will run, but no fault will be displayed on the controller). The system will attempt to resolve order conflicts, but this may require manual intervention, especially if more than one order is changed simultaneously (using SiteTech™). If generators are added to or subtracted from the paralleling system, the system may see an order conflict – resulting in a reassignment of the orders in the system (the order for any generator could change from the previous setting).

Manual mode can be used in a scenario where certain generators are preferred to run more frequently for any reason (such as position, sound level, fuel efficiency, fuel type, etc.).

The need for manual mode should decrease as additional automatic modes are added.

- **Runtime:** The Generator Start/Stop Order is selected automatically by the controller based on the runtime hours on each generator. In this mode, the generator with the lowest runtime hours will be assigned the lowest order (starting first, stopping last), with each sequential order number being assigned to generators of increasing runtime hours. The intent is to equalize runtime hours between the units.

  If the generator system is supplying the load, Generator Management implements a Runtime Threshold to avoid starting and stopping generators every 0.1 hours. The Runtime Threshold is added to the runtime hours of generators that are not running (for the purpose of comparison), preventing excessively frequent starting and stopping of generators.

If all the generators are running, the order re-sorts automatically any time the runtime hours of a higher order generator drop below the hours on a lower order generator. This will not typically occur while all generators are running, as they will all be acquiring runtime hours at the same rate.

If a generator starts because the load increases, the order may re-sort as soon as it connects to the paralleling bus, hence the runtime hours will be equalized before the difference reaches the threshold.

Runtime control mode is intended for applications where the generators require wear-leveling, such as a prime-power application.

- **Fuel Level:** The Generator Start/Stop Order is selected automatically by the controller based on the fuel level measured by each generator. In this mode, the generator with the highest fuel level (as measured in percentage) will be assigned the lowest order (starting first, stopping last), with each sequential order number being assigned to generators of decreasing fuel level. The intent is to equalize fuel level between the units.

  If the generator system is supplying the load, Generator Management implements a Fuel Level Threshold to avoid starting and stopping generators every time the fuel level changes (which could happen frequently if the fuel is moving). The Fuel Level Threshold is added to the fuel level of generators that are running (for the purpose of comparison), preventing excessively frequent starting and stopping of generators.

  If all the generators are running, the order re-sorts automatically any time the fuel level of a lower order generator drops below the fuel level on a higher order generator. This will not typically occur while all generators are running, as they will all be using fuel at the same relative rate (if the tanks are sized appropriately for each generator).

  If a generator starts because the load increases, the order may re-sort as soon as it connects to the paralleling bus, hence the fuel level will be equalized before the difference reaches the threshold.

  Fuel Level Control mode is intended to equalize fuel level in a system of generators where each generator has a separate fuel tank—it is intended to prevent the case where one generator runs out of fuel while the others have plenty.

13.4.2 Enabled

This permits disabling all Generator Management features. When Generator Management is disabled, a generator will not alert the user of a Generator Management configuration mismatch. Any generators in the paralleling system with Generator Management disabled will run if they are in auto and are receiving a start signal (they will not stop if they are not needed).

Nodes with Generator Management enabled may still see a configuration mismatch if a disabled node is configured differently.

13.4.3 Order

The order that a generator will start and stop in the Generator Management sequence—higher orders start last and stop first. This parameter is only adjustable in Manual Mode. The order of each of the generators in the paralleling system must be different for Generator Management to function. Generator Management will attempt to correct an order conflict, but can only do so to a limited extent.

If a generator controller is powered down or disconnected from the communications network, the remaining controllers will attempt to re-sort the order so that each generator has a unique and sequential order—the re-sort is not always successful in manual mode.

It is important to verify the Start/Stop Order of each generator if power is cycled to one or more generators in a paralleling system where Generator Management is used in manual mode.

13.4.4 Start Percentage

The Percentage of Rated Capacity on the paralleling system (the generators that are running and are active in Generator Management) above which a generator is considered for starting.

Only a generator which is available, not running, and is enabled for Generator Management can be started by Generator Management.

Generator Management uses the start percentage to calculate the Start kW for this generator.

The Start Percentage should be set so that the generator system starts enough generators that any transient loading can be supported by the running generators, or to keep an additional generator running for redundancy. The default (80%) works for most applications, but applications with large switching loads may require a lower setting for the Start Percentage.

The Start Percentage should always be at least 10% higher than the stop percentage.

13.4.5 Stop Percentage

The Percentage of Rated Capacity on the other generators in the paralleling system (the other generators that are running and are active in Generator Management) below which a generator is considered for stopping.

Only a generator which is running (in auto) and is enabled for Generator Management can be stopped by Generator Management. Generators running in RUN (pressing the run button on the front panel) are not considered for Generator Management (their capacity is not counted toward supplying the load and they are not stopped when not needed).

Generator Management uses the stop percentage to calculate the Stop kW for this generator.

Note: The calculation is based on the capacity of the other generators on the paralleling bus, as this generator will not be providing power after it stops.

The Stop Percentage should be set so that the generator system keeps enough generators online to supply any transient loading that the application may demand (such as large chillers, air conditioners, pumps, or bow thrusters), while allowing unneeded generators to stop.

The Stop Percentage should always be at least 10% lower than the start percentage.

13.4.6 Start Delay

A time factor that represents the time that Generator Management will wait to start this generator if the load on the running generators exceeds the Start Percentage of this generator by 10% and all available lower-order generators are running.

The Start Delay should be configured to ensure that reasonable load spikes are handled without starting an additional generator, while allowing a generator to start if the increased load persists.

13.4.7 Stop Delay

A time factor that represents the time that Generator Management will wait to stop a generator if the load on the lower-order running generators drops below the Stop Percentage of this generator by 10% and all higher-order generators are already stopped.

The Stop Delay should be configured to allow generators to stop quickly if they will not be needed, but to prevent generators from stopping during a short-duration light load on the paralleling system.

13.4.8 Stable Delay

The Stable Delay is the delay between the system reaching a typical loading scenario and Generator Management becoming active. This delay is intended to allow any loads connected to the system to reach a typical load level before Generator Management stops any generators.

The Stable Delay should be configured to allow the Generator Management to become active when the system load has reached a nominal level (all abnormal load conditions due to a loss of power have been removed).

13.4.9 Runtime Threshold

The Runtime Threshold is the maximum Runtime Hour difference that Generator Management will allow before starting the lower-hour generator and stopping the higher-hour generator. This parameter is only considered with the order selection mode (control mode) set to Runtime Hours. The Threshold should be set based on the intended start/stop frequency of the generators (understanding that changing load may cause additional start/stop cycles).

13.4.10 Fuel Level Threshold

The Fuel Level Threshold is the maximum Fuel Level difference that Generator Management will allow before starting the generator with more fuel and stopping the generator with less fuel. This parameter is only considered with the order selection mode (control mode) set to Fuel Level. The Threshold should be set based on the intended start/stop frequency of the generators (understanding that changing load may cause additional start/stop cycles).

13.4.11 Min Gens Online

This parameter indicates how many generators the system will run with no load on the system. It can be used to keep an additional generator online, but is not intended to convert a system to N+1 redundancy. N+1 Redundancy can be accomplished by setting the start and stop percentages considerably lower.

13.4.12 Min Load Shed Priority

Generator Management will be disabled any time the load control sheds a priority below this level. Setting the Min Load Shed Priority to 0 will disable the link between Load Control and Generator Management. Minimum Load Shed Priority should only be set to 0 if no Load Control priorities are connected to interrupt a load.

If loads are shed below this threshold, Generator Management will be disabled (resulting in all available generators starting).

Any connected Load Control priorities should disable Generator Management when they are shed, to avoid Generator Management stopping generators while loads are still adding, to allow Generator Management to start additional generators to support shed loads, and to allow extended underfrequency events to start additional generators.

13.5 Generator Management Detailed Functional Description

13.5.1 Stability Timer

The Stability Timer must timeout before Generator Management becomes functional. The Stability Delay is adjustable as a parameter, but is a fixed amount of time (does not depend on any variables). If the timer restarts, the delay will be measured from the time of restart.

Requirements to run stability timer (all must be true):

- Start Signal is being received on at least one generator in the paralleling system (the generator that is receiving the start signal does not need to be in auto, as long as some generators in the system are available, they will start).
- At least 2 generators are connected to the paralleling bus.
- Load Priorities have added past the Minimum Load Shed Priority.
- Generator Order is Valid (unique and sequential).
- Configuration of Generator Management matches on all nodes.
- Generator Management is Enabled.

Conditions to cause a restart of the stability timer:

- Start Signal is removed from all generators in the paralleling system.
- No generators are connected to the paralleling bus.
- The Load Priority specified by Minimum Load Shed Priority is shed.
- Generator Order remains invalid for 10 seconds.
- Configuration of Generator Management is changed on a node or a node is added to the system with a different configuration.
- Generator Management is Disabled.
- A generator disconnects from the paralleling bus when it has not been told to do so by Generator Management (a user forces the generator to stop by pressing off, the circuit breaker trips due to a fault, the generator has a shutdown, etc.).

13.5.2 Stop Signal

Generator Management is supplemental to a paralleling generator system. The paralleling functionality of the system is not effected by or dependent on Generator Management. While Generator Management must coordinate with Load Add/Shed, Load Add/Shed is not dependant on Generator Management to function.

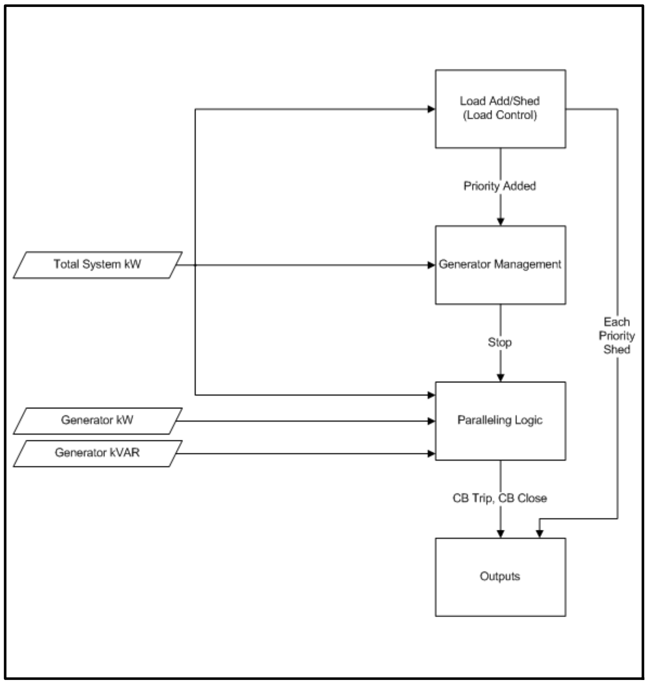


Figure 13-13 Generator Management Interaction

In effect, the function of Generator Management is limited to a single signal to the paralleling logic, telling the generator that it is no longer needed. If Generator Management is disabled, that signal is not sent, and the generator will run as long as it has a start signal, fuel, and no faults. Generator Management does not directly control any system outputs (a programmable IO can be set to track the internal Stopped by Generator Management signal, allowing annunciation of this condition).

Generator Management requires status from the Load Add/Shed in order to coordinate with it.

Setting the Min Priority Added Parameter to 0 for Generator Management effectively disables any influence that the Load Add/Shed can have over Generator Management (both functions are still considering the same parameters, so they can still be coordinated without a direct tie).

13.5.3 Stop Behavior

Because the paralleling system is not dependent on Generator Management, the Paralleling Logic behavior is also independent from Generator Management. Generator Management only controls the internal signals to the logic to override the normal inputs.

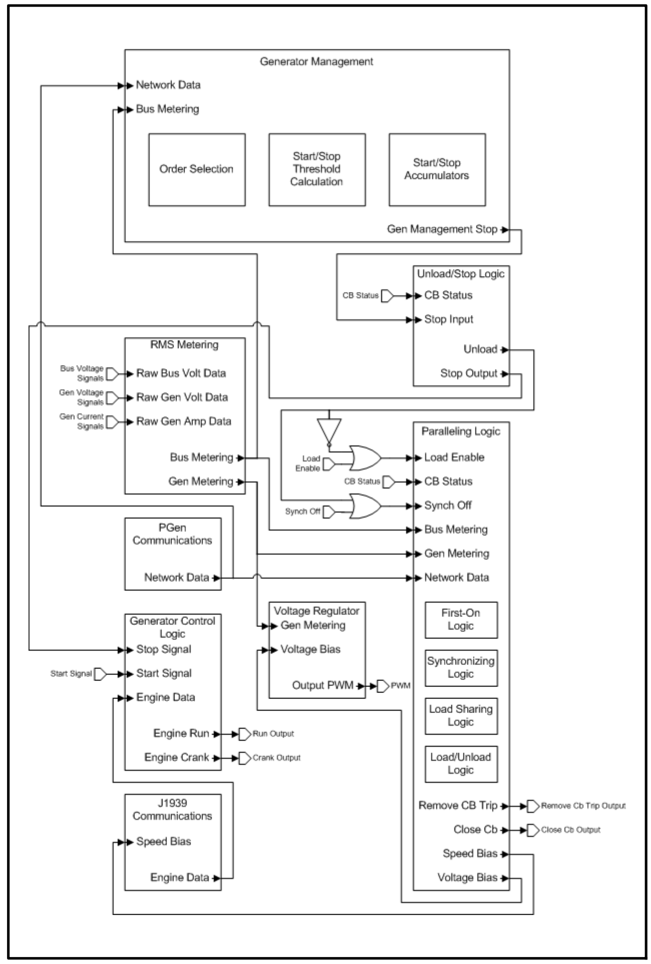


Figure 13-14 Detailed Generator Management Interaction

Figure 13-14 illustrates a more complete diagram of the interactions within the paralleling controller. To stop a generator, Generator Management provides a signal to the Unload/Stop Logic, which sends either an unload signal, or a stop signal, based on the generator connection status to the paralleling bus.

Unload Signal

The unload signal sets the Load Enable input to the paralleling logic to false and turns the synchronizer off. The paralleling logic will go into power control mode, unload a generator according to the load/unload ramp rate, and disconnect from the paralleling bus any time that load enable is removed. If the synchronizer is enabled, the paralleling logic will immediately start synchronizing to the paralleling bus and will connect again to the bus when synchronized.

To avoid unintended reclosing, the synchronizer is disabled during the unloading process, once the stop signal is sent to the Generator Control Logic, the unload signal is removed, re-enabling the Synchronizer and reverting Load Enable to the previously commanded state.

Note: If Load Enable is set to false externally (by digital input, SiteTech™, or the user interface), Generator Management is disabled for this generator. Unloading and disconnecting will only occur when load enable is removed (it changes from true to false).

Stop Signal

The Stop signal is sent to the Generator Control Logic. If this input is set, the controller will ignore any start signal that it is receiving. The stop signal is sent if the generator is disconnected from the paralleling bus and receiving a Generator Management stop signal.

Note: The Stop signal requires Generator Management to be active, if Generator Management is disabled (by user selection, configuration mismatch, order mismatch, preemptive warning, shutdown, or incorrect setting (like synchronizer set to off, load enable set to off, Baseload mode, etc.), the stop signal will be removed.

Network Data

The following information is read from the PGEN communications network for Order Selection:

- Order of all generators.
- Runtime Hours of all generators(for Runtime mode).
- Fuel Level of all generators (for Fuel Level mode).

The following information is read from the PGEN communication network for Start/Stop Threshold Calculation:

- Availability of all generators (able to start if requested).
- Connection Status with paralleling bus.
- Order of all generators.

Activation Logic:

- Runtime Threshold of all generators.
- Fuel Level Threshold of all generators.
- Order Selection Method of all generators.
- Minimum Gens Online for all generators.
- Min Load Shed Priority for all generators.
- Stable Delay for all generators.
- Order of all generators.

Bus Metering

Bus Total Real Power (sum of the power supplied by all generators which are connected to the paralleling bus).

13.5.4 Parameters

The following parameters are used for Order Selection:

- Generator Management Control Mode.
- Runtime Hour Difference (for Runtime Mode).
- Runtime Hours (for Runtime Mode).
- Fuel Level Difference (for Fuel Level Mode).
- Fuel Level Percentage (for Fuel Level Mode).
- Generator Management Order (for Manual Mode).

The following parameters are used for Start/Stop Threshold Calculation:

- Generator Management Start Percentage.
- Generator Management Stop Percentage.
- Generator Management Order.
- Generator Management Total Bus Capacity.

13.5.5 Order Selection

The Start/Stop Order only changes when the need for a change is detected. The detection of a need to change is dependent on the order selection mode.

Manual Mode: The order is only automatically re-sorted if the Generator Management orders of all generators on the PGEN network are not unique and sequential.

Runtime Mode: The order is only automatically re-sorted if the runtime hours of a higher-order generator are less than the runtime hours of this generator (including the Runtime Hour Difference if only one of the generators is stopped) or if the runtime hours of a lower-order generator are greater than the runtime hours of this generator (including the Runtime Hour Difference if only one of the generators is stopped).

Fuel Level Mode: The order is only automatically re-sorted if the fuel level of a higher-order generator is greater than the fuel level of this generator (including the

Fuel Level Difference if only one of the generators is stopped) or if the fuel level of a lower-order generator is less than the fuel level of this generator (including the Fuel Level Difference if only one of the generators is stopped).

All Modes: More than one generator has the same order.

When the need for a change is detected, the order will attempt to re-sort such that all generators have a unique and sequential order and that the order matches the order selection mode criteria (depending on mode). If there is no valid configuration to be found after 10 seconds of trying, Generator Management will be disabled until the order conflict can be resolved (this may happen automatically by fuel level or runtime changing, or may require user intervention).

Note: It is very unlikely that an order conflict will not be resolved in runtime or fuel level mode. Manual mode presents additional challenges in re-sorting that may cause an un-negotiable conflict in order numbers.

13.5.6 Start/Stop Threshold Calculation

The determination to start or stop a generator involves the comparison of the actual load on the paralleling bus with the Start Threshold (called the Start kW) and the Stop Threshold (called the Stop kW) for the generator. These thresholds are computed based on the order of the generator, the kW rating of any lower-order generators, and the availability of any lower-order generators.

The Start kW is computed as:

$$\text{Start kW} = \text{Capacity of lower order generators} \times \text{Start Percentage}$$

The Capacity of lower order generators is simply the sum of all available generators with a lower Generator Management Order than this generator.

If the Minimum Gens Online is set to 2, the lowest 2 available generators will have a start kW of 0.

The Stop kW is computed as:

$$\text{Stop kW} = \text{Capacity of lower order generators} \times \text{Stop Percentage}$$

The Capacity of lower order generators is simply the sum of all available generators with a lower Generator Management Order than this generator.

If the Minimum Gens Online is set to 2, the lowest 2 available generators will have a stop kW of 0.

13.5.7 Start/Stop Accumulators

The Start/Stop Accumulators fill at a rate which is related to the load on the system. The accumulators are full when they reach 100%. When the start accumulator for a generator is full (100%) the generator will start, synchronize, and connect to the paralleling bus (supplying the load). When the Stop Accumulator is full (100%) the generator will soft-unload, disconnect from the paralleling bus, and stop (a cooldown cycle is optional).

Start Accumulator

The Start Accumulator fills at the following rate:

$$\text{Start Accumulator Fill Rate (\%/s)} = \frac{\text{Percent Difference}^2}{\text{Start Delay} * 100}$$

The Percent Difference is computed as:

$$\text{Percent Difference} = \frac{\text{(System Load - Start kW)}}{\text{Total Capacity of Paralleling Bus}}$$ if the system load is greater than the start kW.

0 if the system load is less than or equal to the start kW.

(The *Total Capacity of Paralleling Bus* is the sum of the kW ratings of all the generators that are connected to the paralleling bus).

The Time before a generator starts is the time required to reach 100% at the given fill rate, or:

$$\text{Time To Start} = \frac{100}{\text{Start Accumulator Fill Rate}}$$

Stop Accumulator

The Stop Accumulator Fills at the following rate:

$$\text{Stop Accumulator Fill Rate (\%/s)} = \frac{\text{Percent Difference}^2}{\text{Stop Delay} * 100}$$

The Percent Difference is computed as:

$$\text{Percent Difference} = \frac{\text{(Stop kW - System Load)}}{\text{(Total Capacity of Paralleling Bus - Capacity of This Gen.)}}$$ if the system load is less than the stop kW.

0 if the system load is greater than or equal to the stop kW.

(The *Total Capacity of Paralleling Bus* is the sum of the kW ratings of all the generators that are connected to the paralleling bus).

The Time before a generator stops is the time required to reach 100% at the given fill rate, or:

$$\text{Time To Stop} = \frac{100}{\text{Stop Accumulator Fill Rate}}$$

13.5.8 Availability

An available generator needs to be able to supply power to the load if Generator Management requires additional capacity.

A generator is considered available if:

- It does not have a preemptive warning or shutdown.
- The Engine Control Switch is in Auto.
- The Synch Mode in Auto is either Passive, Active, or Dead Field.
- The breaker can close (no faults or protective relays active).
- The Generator is sharing load (not in System Control or Baseload mode, Load Enable is True).
- Generator Management is Enabled.

13.5.9 Preemptive Warning

A preemptive warning is a warning that indicates the potential of an impending failure before it actually happens. The intent of preemptive warnings is to avoid unintended overload conditions caused by a generator tripping offline. Generator Management no longer considers a generator available if it has a preemptive warning (causing an additional generator to start if it is available and necessary).

The following warnings are considered to be preemptive:

- Low Engine Oil Pressure Warning (This indicates that the engine oil pressure is lower than normal. Possible causes: bearing failure, bearing wear, oil pump wear, oil temperature too high). Low Oil Pressure Shutdown may occur shortly after this warning.

Note: If the low oil pressure warning is caused by over temperature of the oil, starting an additional engine may decrease the load on this generator enough to lower the oil temperature to a reasonable level.

- Low Engine Fuel Pressure Warning (This indicates that the engine is not receiving enough fuel. Possible causes: day tank transfer pump failure, dip-tube failure, lift pump failure, high pressure pump failure). The engine may run out of fuel and disconnect on the reverse power protective relay if this condition continues.

- High Engine Coolant Temperature (This indicates that the engine is not able to cool properly. Possible causes: low coolant level, water pump failure, thermostat failure, radiator fin corrosion, high temperature exchange fluid, exchange fluid path obstruction, etc.). High Coolant Temperature Shutdown may occur if the condition continues.

Note: If an additional generator starts, the load on this generator may decrease enough for the warning condition to go away.

- Failure to Synchronize Warning (This indicates that a generator is trying to connect to the paralleling bus, but is unable to hold synchronism long enough to connect. Possible causes: erratic load on bus, engine malfunction, incorrect synchronizing settings, etc.). This generator may not be able to supply load, so automatically start another one. If this one comes on later, the other one can stop.

- Water in Fuel Warning (This indicates that the fuel supply has enough water in it to potentially cause improper operation of the engine. Possible causes: filters in need of replacement, contaminated fuel received, water leaked into fuel supply due to improperly installed fill caps, etc.). This generator may stall if the water gets past the separator.

Note: Starting another generator may cause water to infiltrate the fuel system of all generators, but the water stored in the fuel/water separator will be distributed across more engines, possibly avoiding the stalling of all generators supplying the load.

- Fuel Tank Leak Warning (There is liquid in some interstitial space between two bulkheads of the fuel supply tank. Possible causes: rain infiltration, snow melt, fuel spill, etc.). This generator may be stopping due to a fuel tank leak shutdown, so automatically start another generator to compensate for this one.

- Loss of Fuel Warning (This generator has had a significant loss of fuel over a short period of time. Possible causes: sticking fuel float, vibration of fuel tank, actual leak, etc.). This generator may shut down due to the Loss of Fuel Shutdown, so automatically start another generator to compensate.

13.6 Generator Management Detailed Functional Sequence

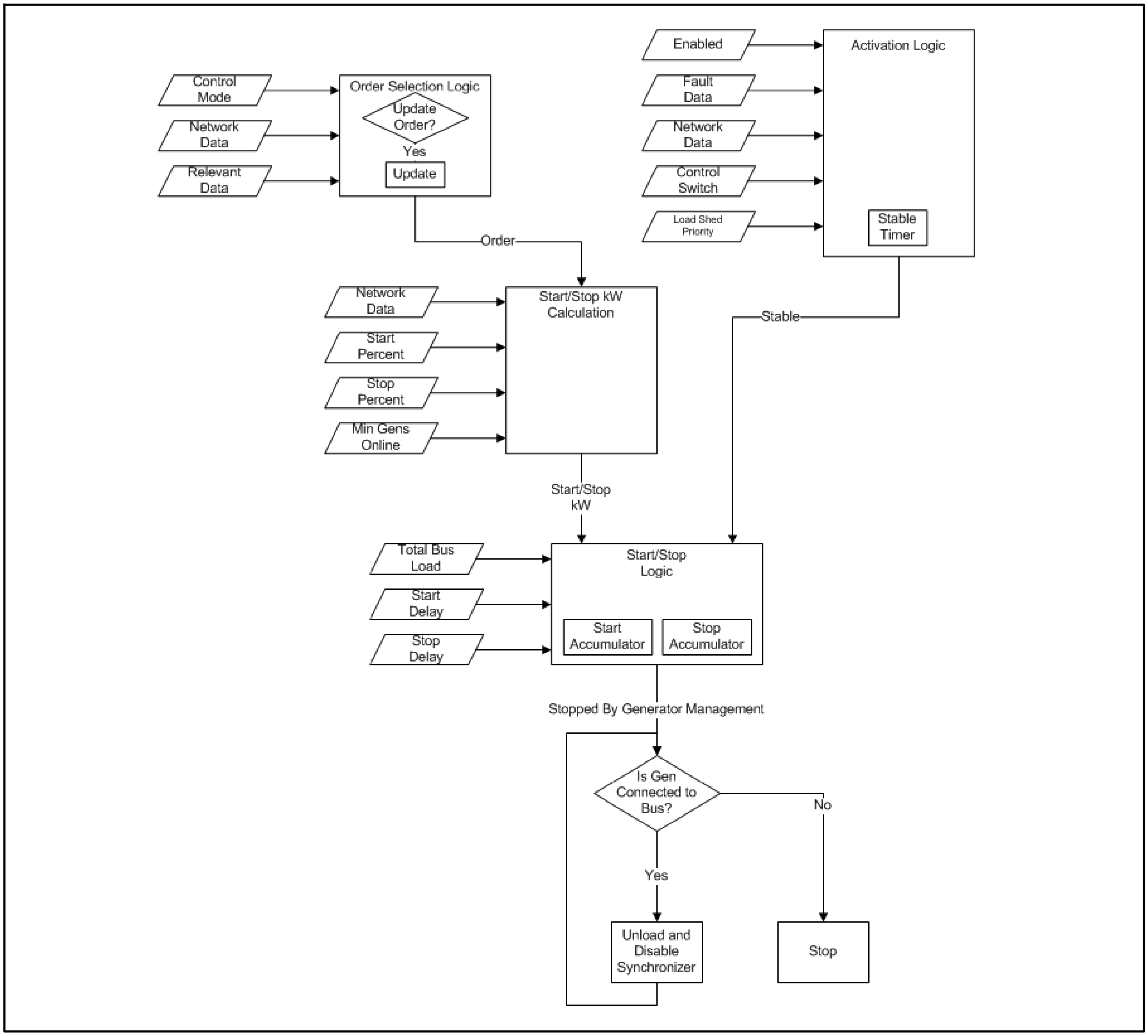


Figure 13-15 Generator Management Functional Sequence

Generator Management has four basic functional modules which fit the architecture illustrated in Figure 13-15. Each module has minimal interaction with other modules, to allow simplified interaction scenarios and functional descriptions.

13.6.1 Order Selection Logic

The order is only changed if a change is required. The criterion to determine if a change is required depends on the order selection method of the Generator Management system.

Manual Mode Order Update Required Logic

The order will attempt to re-negotiate if any of the following conditions come true:

- The order is not valid (unique and sequential). This can be caused by changing the number of generators connected to the PGEN network, or by changing settings in a single controller while it was not connected to the PGEN network.
- A user has manually adjusted the order.

Manual Mode Order Update Logic

Generator Management looks for two orders that are the same, if they are, it finds the first available sequential order and adjusts all generators with orders between the conflicting order and the available order except any units with a lock. A lock has the following requirements:

- Has a conflict with another node and
- was manually written, or
- has the lowest controller serial number of the conflicting controllers.

If the available position is higher than the conflicting order, all generator controllers with orders between the conflicting and available order are incremented, otherwise the orders are decremented on the other generator controllers.

Runtime Mode Order Update Required Logic

To determine if the order needs to re-sort, the order selection logic will compute a minimum valid order and a maximum valid order for this generator. If the existing order is between the minimum and maximum, there is no re-sort required. Otherwise, a re-sort is initiated.

Runtime Mode Order Update Logic

The order is computed by adding the runtime threshold to all units that are not connected to the paralleling bus to get effective runtime (including the runtime hour threshold). Each controller determines where it should fall in the sequence and sets the order to that value.

Conflicts in order are resolved the same way as they are in manual mode.

Fuel Level Mode Order Update Required Logic

To determine if the order needs to re-sort, the order selection logic will compute a minimum valid order and a maximum valid order for this generator. If the existing order is between the minimum and maximum, there is no re-sort required. Otherwise, a re-sort is initiated.

Fuel Level Mode Order Update Logic

The order is computed by adding the fuel level threshold to all units that are connected to the paralleling bus to get effective fuel level (including the fuel level threshold). Each controller determines where it should fall in the sequence and sets the order to that value.

Conflicts in order are resolved the same way as they are in manual and runtime mode.

13.6.2 Start/Stop kW Calculation

The Start kW for a generator is determined by summing the total capacity of all available generators with a lower order number than this one and multiplying it by the Start Percentage.

The Stop kW for a generator is determined by summing the total capacity of all available generators with a lower order number than this one and multiplying it by the Stop Percentage.

Note: The Start and Stop kW for Order 1 are always set to 0kW (never stop, always start). Order 2 is set to 0kW if the Minimum Gens Online is set to 2.

13.6.3 Activation Logic

The Stable Timer is latched to run if all of the start conditions are true, the timer will continue to run even if some of the start conditions become false, as long as none of the reset conditions are true.

13.6.4 Start/Stop Logic

The Generator Management Stop Logic is very simple, a Generator Management stop is sent if **all** of the following conditions are true:

- The Stop Accumulator is full.
- The Start Accumulator is empty.
- Generator Management is stable (the stable timer has expired).
- All lower order generators are either connected to the paralleling bus or not available.

Notes

14.1 Purpose

Load Management is intended to disconnect low-importance loads from the generator system in order to allow the generator system to continue to supply important loads. Load Management will permit low-importance loads to receive power as long as the generator system has adequate capacity to supply them, only removing them if the system is operating in a state of reduced or insufficient power to supply all the loads.

14.2 Basic Function

Load Management is available in all Decision-Maker® 3500 controllers, but is only active when the controllers are receiving a remote start signal.

Load Management controls six priority shed outputs. The priorities add and shed in a fixed order. Priority 6 sheds first and re-adds last. Priority 1 sheds last and re-adds first. The outputs are controlled with notices in the controller, but they have to be assigned to digital outputs or Relay Driver Outputs (RDOs) on the controller in order to be available to connect to low-importance loads.

Note: Load Management uses the load on a single generator and the frequency of that generator to determine load priority status if there is only a single generator in the paralleling system. Load Management uses the total generator system load and the frequency of the paralleling bus to determine load priority status if there are multiple generators in the paralleling system (hence all generators in the system add and shed priorities simultaneously (as long as the settings are identical).

14.2.1 Sequence of Operation—Single Generator System

1. **Startup Shed.** When a remote start signal is applied to the generator, the generator will start and all the load priorities will shed to ensure that the generator has enough capacity to handle the inrush load.

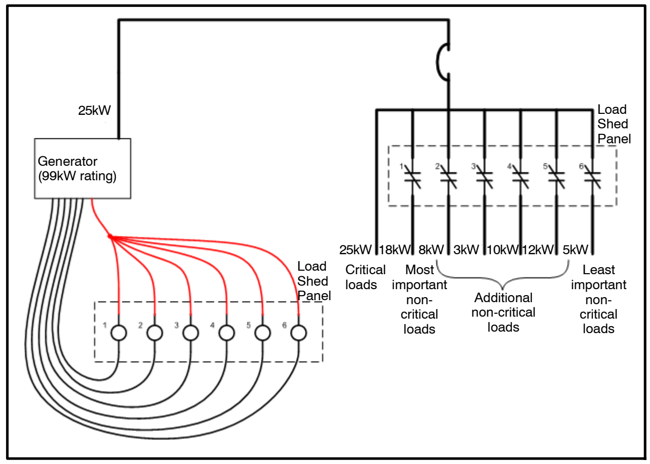


Figure 14-1 A Single Generator System Using Load Management

2. **Load Add.** After the generator starts and reaches rated voltage and frequency, Load Management will become active. If the load on the generator is more than 15% (the expected load demand per priority) below the Genset Maximum Percent Capacity, Load Management will begin timing to add the first load.

   The time required to add the first load is dependent on the Genset Maximum Percent Capacity, the Base Load Add Time, and the actual real power output of the generator.

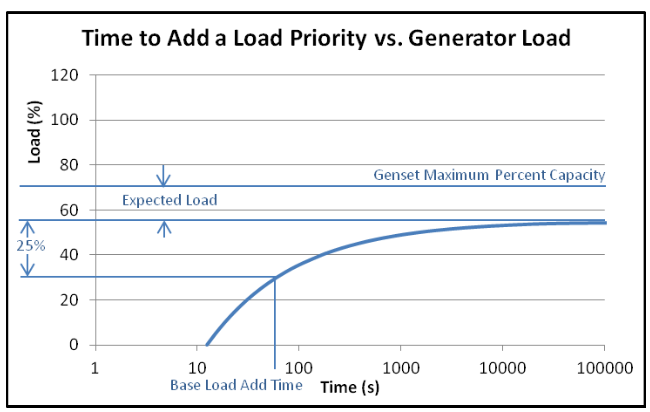


Figure 14-2 Load Add Timing Based on Generator Output Power
(Genset Max. Percent Capacity = 70%, Base Load Add Time = 60 seconds)

Each priority will add after a time delay as specified in the curve above.

In the example system illustrated in Figure 14-1, the 99 kW generator is loaded to 25% of capacity when it is supplying the critical load. Referencing Figure 14-2, the time required to add priority 1 will be approximately 42 seconds.

After the first priority adds, the generator power output may increase, resulting in an increase in the delay for subsequent loads to add.

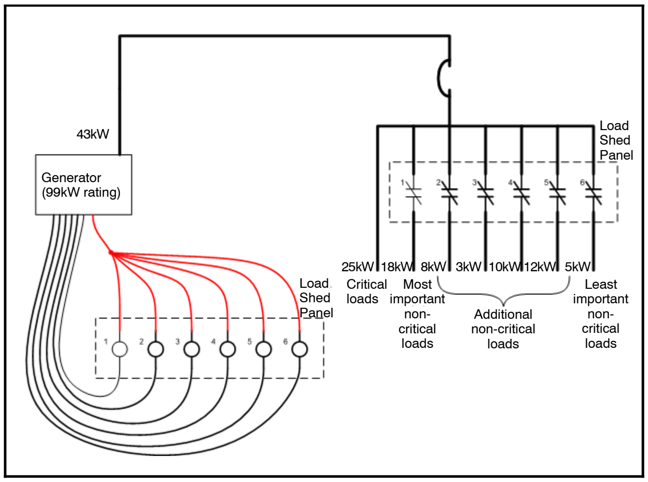


Figure 14-3 Example System After Priority 1 Has Been Added

In the example system illustrated in Figure 14-3, the 99 kW generator is loaded to 43% of capacity when it is supplying both the critical load and the load that is interrupted by load shed priority 1. Figure 14-2 indicates that load shed priority 2 will add in about 240 seconds (4 minutes) after load priority 1 is added.

The 51 kW that will be supplied by the generator with priorities 1 and 2 added will extend the time to add priority 3 to about 2400 seconds (40 minutes), although the time delay may be shortened if the load on the generator decreases and may extend if the load increases.

The time to add priority 4 will be greatly extended by the generator output power being so close to the threshold to add load without exceeding the Genset Maximum Percent Capacity that it will take 37,500 seconds (10 hours and 25 minutes) to add.

Note: In a real-world application, the requirements of the load vary enough that priority 4 would never add, as all that is required to reset the timer is to exceed the 55 kW (Genset Maximum Percent Capacity -15%) threshold for a moment.

If the power requirement of the critical and priority 1 load dropped to 12 and 7 kW, respectively, the total load on the generator would be 30 kW, which would result in priority 4 adding in 60 seconds. After priority 4 is added, the generator will be providing 40 kW, which will increase the time delay for priority 5 to about 170 seconds (nearly 3 minutes). The generator will be providing 52 kW of load after priority 5 is added, extending the delay for priority 6 to add to about 4200 seconds (1 hour and 10 minutes). Once priority 6 is added, the generator will be supplying 57 kW.

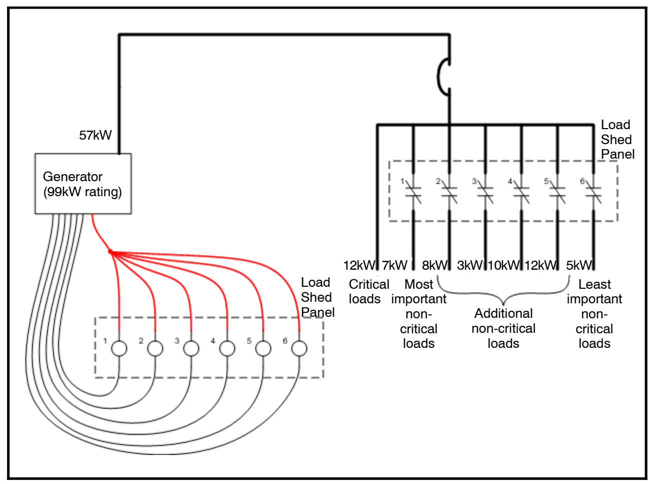


Figure 14-4 Example System After All Priorities Have Been Added

3. **Overload Shed.** When the load on the generator is too high to allow the generator to support sudden increases in load without undesirable voltage and/or frequency dips, the Load Management system will remove unimportant loads so that the critical loads continue to receive high quality power.

   In the Example system illustrated in Figure 14-1, Figure 14-3, and Figure 14-4, the generator can become overloaded if the power requirements of the critical load and the priority 1 load increase.

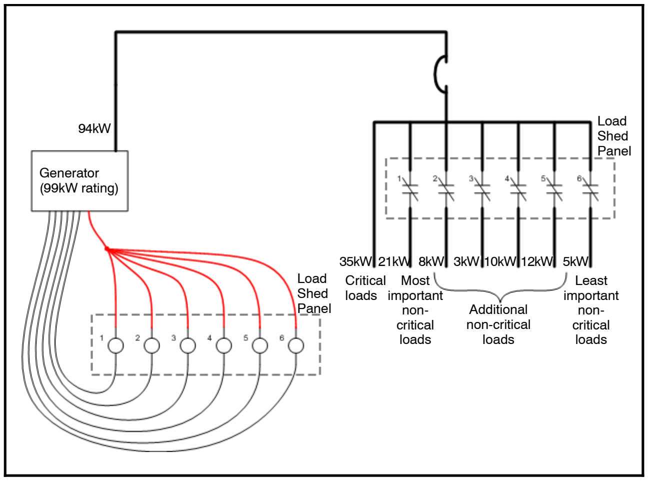


Figure 14-5 Example System With Increased Critical Load and Increase Priority 1 Load

Although the 99 kW generator is only producing 94 kW, this lies dangerously close to the maximum capacity of the generator. Any sudden increases in load may result in the generator being overloaded, potentially causing the critical load to receive voltage and frequency that are outside of normal operating parameters.

The Generator Overloaded Percent for the example system is set to the default (85%) while the generator is actually producing 95% of its rated capacity. At this difference, Load Management will begin counting to shed priority 6.

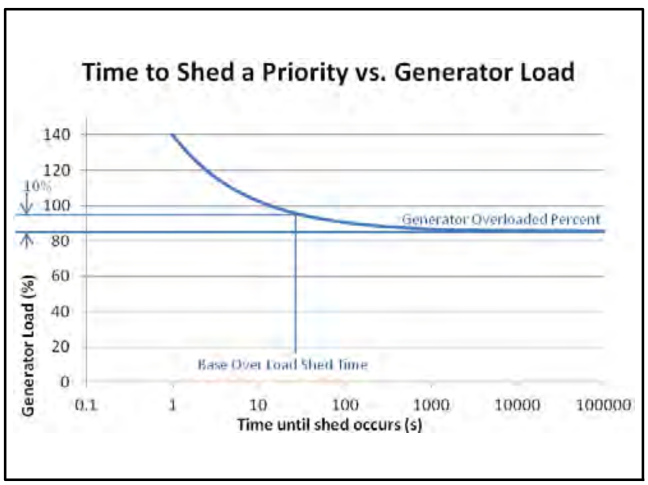


Figure 14-6 Load Shed Timing Based on Generator Output Power
(Generator Overload Percent = 85%,
Base Over Load Shed Time = 30 seconds)

Figure 14-6 indicates that at 95% of rated capacity, Load Management will wait for 30 seconds before shedding a priority. Because priority 6 is the first priority to shed from a stable state, the shed timing is identical to what is indicated by Figure 14-6.

Shedding priority 6 decreases the load on the generator by 5 kW, but it is still at 90% of rated capacity. Figure 14-6 provides a time reference for 90% load at 120 seconds (2 minutes), but Load Management will accelerate the shed timing as the overload condition was already present and was not cleared by priority 6 shedding. The acceleration factor for overload shed is 0.4, hence priority 5 will shed in 120 – (120* 0.40) = 72 seconds.

The generator output power will drop to 78 kW (79% capacity) when priority 5 sheds, allowing sufficient margin above the working load of the generator that small increases/fluctuations in the requirements of the load should be easily handled by the generator.

Priorities 5 and 6 will not add again until the generator output power drops below 55 kW for long enough for the loads to add.

4. **Underfrequency Shed.** In order to maintain acceptable power quality, loads must be shed if the frequency of the generator dips, even if the generator is not producing enough power to indicate that it is overloaded and cause an overload shed. This can occur if the engine has a dirty fuel filter or air filter, the intake air temperature is significantly warmer than the generator operating temperature, the generator is located at a high elevation, the fuel system has a restriction or improperly sized lines, or the engine is damaged or near end of life.

   Even without a failure on the engine, the Underfrequency Shed logic is active any time the generator frequency is less than the Underfrequency Shed Level below the generator nominal operating frequency. Depending on the configuration of the engine, the Underfrequency Shed timing may cause a priority to shed before the Overload Shed timing.

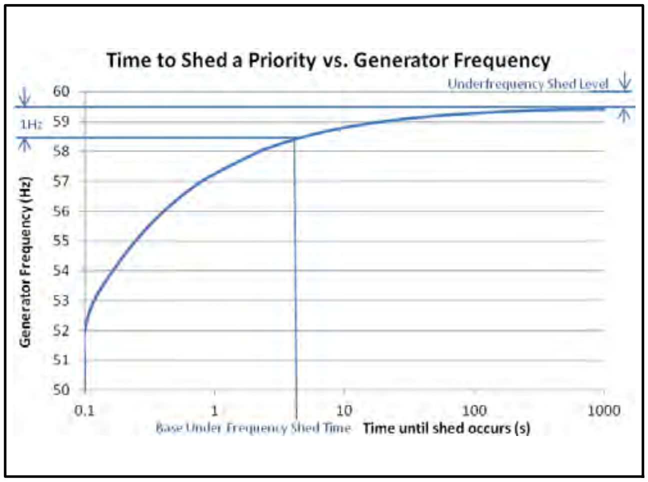


Figure 14-7 Load Shed Timing Based on Generator Frequency
(Underfrequency Shed Level = 0.50 Hz, Base Underfrequency Shed Time = 5 sec.)

If the generator was overloaded to 110% of capacity and this caused the generator frequency to dip to 58 Hz, Underfrequency Shed would cause priority 6 to shed in 2 seconds (Overload Shed would also be active, but would require 5 seconds to shed, so it would only be 40% shed).

When removing priority 6 decreases the load to 105% and causes the frequency to recover to 58.5 Hz, the curve in Figure 14-7 would indicate that priority 5 would shed in 5 seconds, but Underfrequency Shed has acceleration of 0.56, meaning that each priority sheds in half as much time as the previous priority if the condition is not cleared, hence priority 5 would actually shed in 2.5 seconds (Overload Shed would have a total time of 7.5 seconds, meaning that another 33% would be added to the 40% shed condition, making priority 4 73% shed due to overload).

When removing priority 5 decreases the load to 93% and allows the frequency to recover to 59.2 Hz in the next two seconds, the curve in Figure 14-7 would indicate that the time to shed would be about 60 seconds, but the acceleration drops it to 0.25* 60 = 15 seconds. Even at that load, the generator is allowed to recover to rated frequency by the underfrequency shed logic, but the overload shed logic will still cause the priority 4 to shed in another 15 seconds (45 sec time to shed at 93% load, and shed already 67% complete).

14.2.2 Sequence of Operation— Paralleling System

This sequence follows the operation of a normal paralleling system which uses Load Management. The Load Management logic uses the paralleling bus frequency and the paralleling bus percentage of rated capacity to determine a need to add or shed load. A generator does not have to be running to support Load Management.

When a start signal is applied to any of the generators in the paralleling system, all the generators that are in auto and have no shutdown faults will start and all the load priorities will shed. This shed is intended to remove excess load from the system so that a single generator can support it.

Figure 14-8 illustrates the system after the first generator has reached rated voltage and frequency and has closed to the paralleling bus (any of the generators can be the first to close, depending on which generator reaches rated voltage and frequency first).

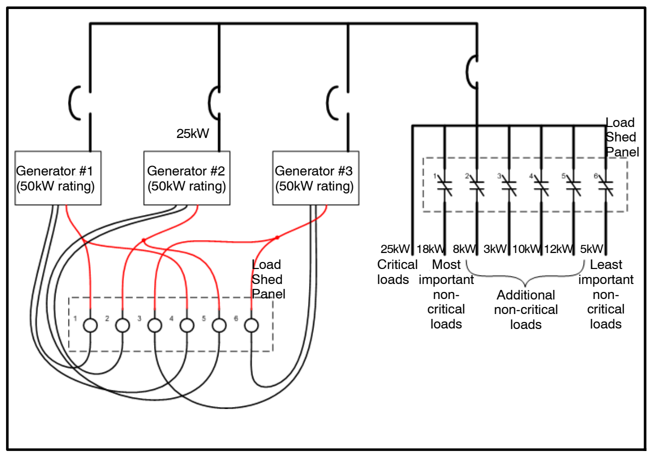


Figure 14-8 One Generator Energizes the Paralleling Bus

The load on the first generator to connect to the paralleling bus is merely that of the critical loads.

The time to Add Priority 1 can be determined from Figure 14-9 based on a 50% generator load. The curve indicates approximately 1500 seconds (25 minutes) before priority 1 will add.

After synchronizing to the paralleling bus, generators #1 and #3 will close their paralleling breakers, providing a total of 150 kW of capacity to the paralleling bus. The 25 kW load is only 17% of the capacity of the bus with all three generators supplying it, hence the time to add a priority drops to 26 seconds.

When priority 1 adds, the output from generator #1 that drives the load shed priority will de-energize.

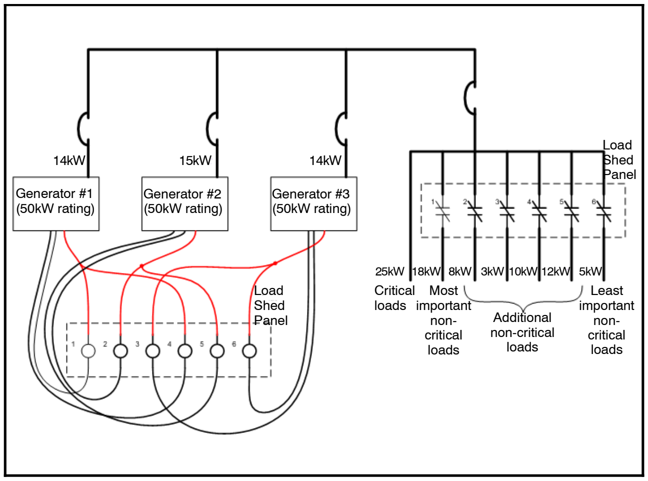


Figure 14-9 All Generators Supplying the Paralleling Bus, Priority 1 Added

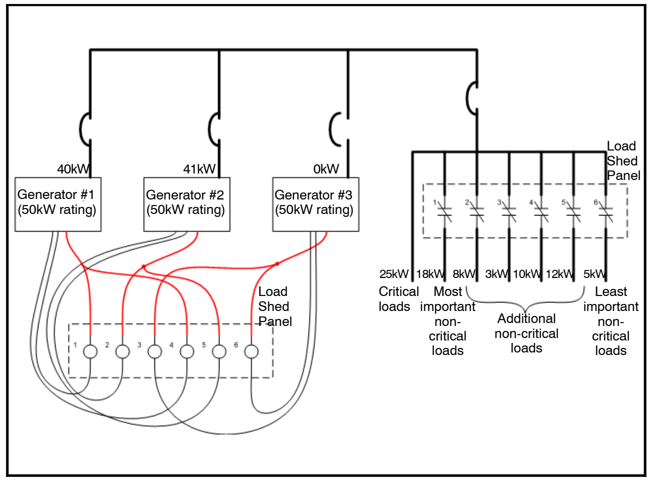


Figure 14-10 Generator #3 Stopped, All Priorities Added

With load priority 1 added, the total system load is 43 kW, shared between the three generators. This amounts to 29% of the rated capacity of the system, increasing the time delay to add priority 2 to 55 seconds.

With priority 2 online, the system load is 34%, requiring 85 seconds to add priority 3.

With priority 3 online, the system load is 36%, requiring 104 seconds to add priority 4.

With priority 4 online, the system load is 43%, requiring 260 seconds (just over 4 minutes) to add priority 5.

With priority 5 online, the system load is 51%, requiring 2400 seconds (40 minutes) to add priority 6.

After all load priorities are added, Generator Management may elect to stop a generator, but only if the stop percentage is above 81% (the load on two generators). If a generator is stopped, no loads will shed, as the percent of system capacity is below the Generator Overloaded Percent (85%).

Note: Priorities 3 and 6 will remain added unless the system is overloaded, even though they are controlled by the generator #3 controller, as the Load Management logic in the generator #3 controller looks at bus frequency and bus loading to make Load Management determinations.

Note: The case above is unlikely, as Generator Management will not typically be configured to stop a generator above 80%, as this does not leave very much available capacity for changing loads.

If the Stop Percentage for Generator Management is changed, it should not be configured to be above the Generator Overloaded Percent, as Generator Management may force a priority to shed when a generator is stopped, nor should the Start Percentage for Generator Management be above the Generator Overloaded Percent, as this may result in loads being shed while an available generator does not start to supply the loads.

If the Minimum Load Priority Online for Generator Management is set to 6, the third generator will start as soon as Load Management sheds priority 6. This would result in priority 6 re-adding and the generator stopping again, establishing a repeating cycle.

Overload Shed and Underfrequency Shed use identical timing and thresholds to the single generator case, but use the bus % kW and the bus frequency to make Load Management determinations.

14.3 Considerations

Load Management is not required or desired in all applications. Although it is active any time that the generator is receiving a system start signal, it must be configured and connected to be used. It is important to consider the following when using Load Management:

14.3.1 Total Load on the System

If the power requirements of the load will never exceed the capacity of the generator, there is no need or reason to connect and configure Load Management for the application. If the load is high enough to overload a single generator or one of the generators in a paralleling system, it should be prioritized and connected to Load Management controls.

14.3.2 Load Types

Applications where the loads are occasional will allow for generator capacity below the sum of all connected loads, but the generator can be overloaded if all the occasional loads were to demand power simultaneously.

14.3.3 Ease of Interrupting Loads

Many loads are easily controlled with a simple relay (such as HVAC systems, VFDs and Soft Starters), such loads can be tied to Load Management outputs with very little difficulty and will allow temporary power interruptions without serious loss of function.

14.3.4 Criticality of the Loads

The generator must be sized to support at least the critical loads in the application. A generator that is able to support the critical loads may be significantly smaller than the entire load requires.

Some applications have loads that can be easily categorized and prioritized. In this case, Load Management would be helpful to prevent loss of power to critical loads. If all loads are of similar importance, Load Management will be difficult to apply.

14.3.5 Number of Generators in the System

Multi-generator systems should typically utilize Load Management unless they have multiple generators simply for redundancy (any generator can handle the entire load).

14.3.6 Use of Generator Management

If Generator Management is used, the Load Management outputs should be connected to some loads to allow an additional generator time to start if the load increases suddenly past the level that the running generators can support.

14.3.7 Emissions Requirements

Some facilities require minimum load while operating. The Load Management can also be used to control loads on a load bank, maintaining the generator at or above a given load level. Other application require the generator to undergo a de-rate for a DPF regeneration cycle.

14.4 Setup

Load Management requires consideration of several factors as each parameter is configured. The default settings will work in most scenarios, but many applications will require additional configuration.

14.4.1 Genset Maximum Percent Capacity

The Genset Maximum Percent Capacity is the threshold above which the Load Management logic will not intentionally load the generator. Each load priority is expected to add 15% load to the generator system, so load priorities will not add if the load on the system is more than 15% below the Genset Maximum Percent Capacity.

Range: 0.0% – 120.0%
Default: 70.0%

14.4.2 Generator Overloaded Percent

The Generator Overloaded Percent is the threshold above which Load Management considers the generator system to be overloaded. When the generator output is above the generator overloaded percent, Load Management will start filling the accumulator to shed the highest added priority.

Range: 0.0% – 120.0%
Default: 85.0%

14.4.3 Under Frequency Shed Level

The amount of frequency dip from the nominal frequency below which the underfrequency shed starts timing. This level should be configured to avoid underfrequency shutdown or protective relay trips due to underfrequency. Because the controller has an extended underfrequency shutdown (1 minute at 1 Hz below rated speed) it is not recommended to adjust the underfrequency shed level below 59 Hz (as the generator will shut down before shedding load).

Range: 0.00 Hz – 5.00 Hz
Default: 0.50 Hz

14.4.4 Base Load Add Time

The Base Load Add Time defines the time to add a load if the generator has 25% available capacity. Available capacity is the difference between the power output level of the generator and 15% below the Genset Maximum Percent Capacity level. The timing of the load add curve is adjusted by changing the Base Load Add Time. The entire curve is shifted by a factor related to the new Base Load Add Time. A priority will take 1500 seconds to add with 50% load and a 70% Genset Maximum Percent Capacity with the default Base Load Add Time of 60 seconds, but will only take 250 seconds with a Base Load Add Time of 10 seconds.

Range: 10.0 sec – 2400.0 sec
Default: 60.0 sec

14.4.5 Base Over Load Shed Time

The Base Over Load Shed Time defines the time to shed a load if the generator has a 10% overload condition. The overload condition is the difference between the measured power output percentage of the generator and the Generator Overloaded Percent. The timing of the over load shed curve is adjusted by changing the Base Over Load Shed Time. The entire curve is shifted by a factor related to the new Base Over Load Shed Time. A priority will take 120 seconds to shed with 90% load and a 85% Generator Overloaded Percent with the default Base Over Load Shed Time of 30 seconds, but will only take 12 seconds with a Base Over Load Shed Time of 3 seconds.

Range: Range: 2.0 sec – 30.0 sec
Default: 30.0 sec

14.4.6 Base Under Frequency Shed Time

The Base Under Frequency Shed Time defines the time to shed a load if the generator has a 1 Hz underfrequency condition. The underfrequency condition is the difference between the measured frequency of the generator and the Under Frequency Shed Level less than the nominal (rated) frequency. The timing of the under frequency shed curve is adjusted by changing the Base Under Frequency Shed Time. The entire curve is shifted by a factor related to the new Base Under Frequency Shed Time. A priority will take 20 seconds to shed with the frequency drooped to 59 Hz with a 0.50 Hz Under Frequency Shed Level, a nominal frequency of 60 Hz with the default Base Under Frequency Shed Time of 5 seconds, but will only take 4 seconds with a Base Under Frequency Shed Time of 1 second.

Range: 1.0 sec – 20.0 sec
Default: 5.0 sec

14.5 Detailed Functional Description

14.5.1 Activation/Deactivation Logic

Load Management is only active when the generator system is receiving a system start signal. A generator does not have to be in AUTO in order to activate Load Management (but it does to start). The system start signal can be provided in a variety of ways:

- Manual System Start (press AUTO+Run on any controller)
- Remote Start Signal (3, 4 contacts)
- Remote Start via SiteTech™
- Remote Start via Modbus®
- Remote Start via CAN

Starting a generator in RUN does not cause Load Management to become active, although it will remain active with the generator in RUN if receiving a system start signal. Load Management is not activated when one or more of the generators in the generator system are receiving a local start and none are receiving a remote start.

The generator will receive a local start signal under the following condition:

- Manual Start (pressing RUN on a generator controller to start that generator)

Note: Load Management is deactivated when the system start signal is removed (even if the generator continues running because the individual generator is in RUN mode).

14.5.2 Output Configuration

Although Load Shed notices can be seen in SiteTech™ and on the display of the controller, the load shed notices only drive external relays (using RDOs or the CAN option board) if they are configured to do so.

Note: Although each generator has a separate Load Management system, all Load Management logic in a paralleling system uses the same power metering and frequency (bus frequency) to make Load Management decisions, hence the priorities are universal between controllers using identical firmware and Load Management configuration. If multiple generator controllers exist in the paralleling system, the Load Management priorities should be spread between the controllers and not connected to a single controller — this provides a limited measure of redundancy.

14.5.3 Startup Shed

Startup Shed occurs when Load Management is activated. The startup shed level for the Decision-Maker® 3500 controller is fixed at 0, meaning that all load priorities are shed when the Load Management system is activated.

All loads are added when the Load Management system is deactivated.

14.5.4 Generator Capacity Load Add

Generator Capacity Load Add uses the percent loading of the generator system and the Genset Maximum Percent Capacity to compute an Available Capacity. The percent loading of the generator system is taking from the generator metering in a single-generator application and from the total bus percent loading in a paralleling application.

Available Capacity is computed according to the following formula:

Available Capacity = (Genset Maximum Percent Capacity – Generator System % load)

The expected kW for the next load is hard-coded at 15%, so the reserve capacity is calculated as follows:

Reserve Capacity = (Available Capacity – 15)

The Add Accumulator fills at a rate that is dependent on the Reserve Capacity and the Base Load Add Time such that the time to add a priority is defined as:

$$t(s) = 625 * \frac{Base\ Load\ Add\ Time(s)}{Reserve\ Capacity(\%)^2}$$

The Base Load Add Time sets the add time at 25% reserve capacity, while the timing increases with additional reserve capacity (lower generator load).

Note: The add function is performed by an accumulator and the timing is determined by the rate that the accumulator fills, hence a varying load will fill the accumulator at varying rates, causing the load to add at a time that can't be calculated directly with the equation above, but can be estimated by it.

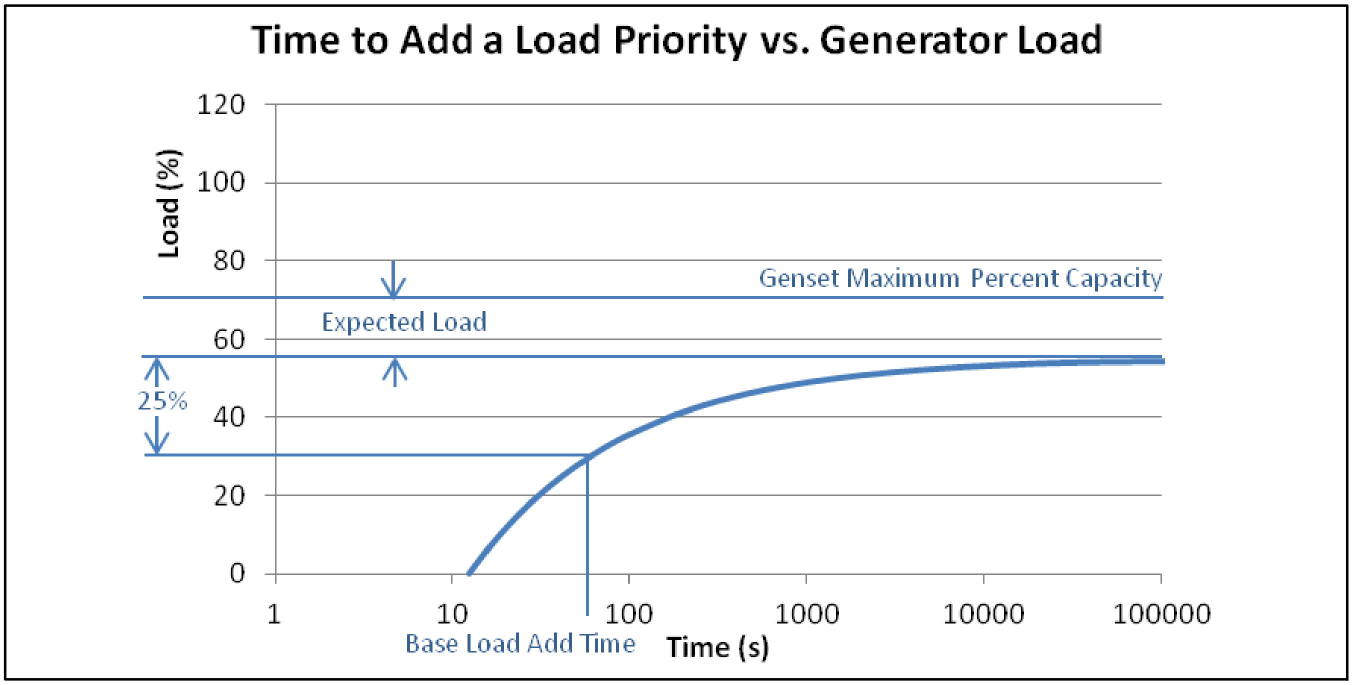


Figure 14-11 Generator Capacity Load Add Timing With Default Configuration

14.5.5 Overload Shed

Overload Shed uses the percent loading of the generator system and the Generator Overloaded Percent to compute a Degree of Overload. The percent loading of the generator system is taking from the generator metering in a single-generator application and from the total bus percent loading in a paralleling application.

Degree of Overload is computed according to the following formula:

Degree of Overload = (Generator Overloaded Percent – Generator System % load)

The kW Shed Accumulator fills at a rate that is dependent on the Degree of Overload and the Base Over Load Shed Time such that the time to shed the first priority after the overload condition occurred is defined as:

$$t(s) = 100 * \frac{Base\ Over\ Load\ Shed\ Time(s)}{Degree\ of\ Overload(\%)^2}$$

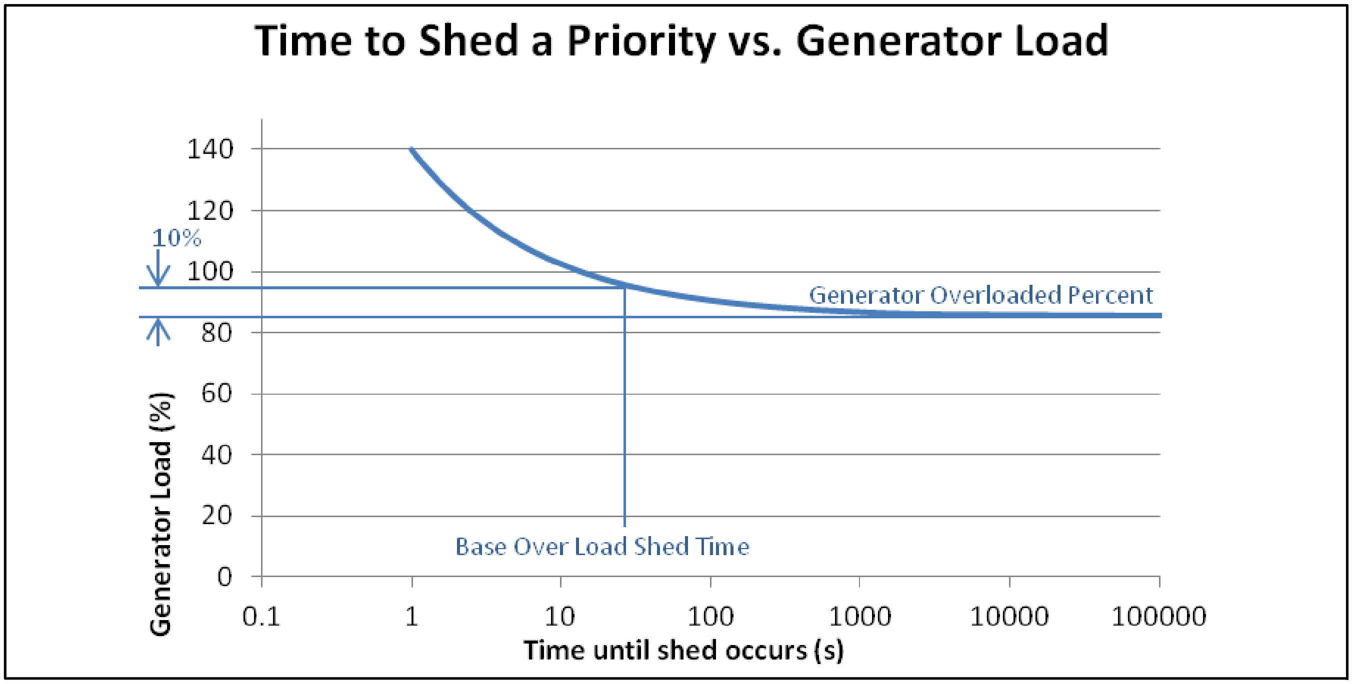


Figure 14-12 Generator Overload Shed Timing With Default Configuration

The Base Over Load Shed Time sets the shed time at a 10% degree of overload, while the time decreases with additional generator load.

The time to shed subsequent priorities decreases by a fixed 0.4 acceleration factor for each priority shed, hence if the first priority shed in 10 seconds, the second priority will shed in 6 seconds, while the third priority will shed in 3.6 seconds and the fourth priority in 2.2 seconds with the same load on the generator system.

Note: The shed function is performed by an accumulator and the timing is determined by the rate that the accumulator fills, hence a varying load will fill the accumulator at varying rates, causing the load to shed at a time that can't be calculated directly with the equation above, but can be estimated by it.

14.5.6 Under Frequency Shed Logic

Under Frequency Shed uses the output frequency of the generator system and the under Frequency Shed Level to compute a Frequency Droop. The output frequency of the generator system is taking from the generator metering in a single-generator application and from the bus metering in a paralleling application.

Frequency Droop is computed according to the following formula:

Frequency Droop = (Generator Rated Frequency – (Generator System Frequency + Under Frequency Shed Level))

The under Frequency Shed Accumulator fills at a rate that is dependent on the Frequency Droop and the Base Under Frequency Shed Time such that the time to shed the first priority after the overload condition occurred is defined as:

$$t(s) = 1 * \frac{Base\ Under\ Frequency\ Shed\ Time(s)}{Frequency\ Droop(Hz)^2}$$

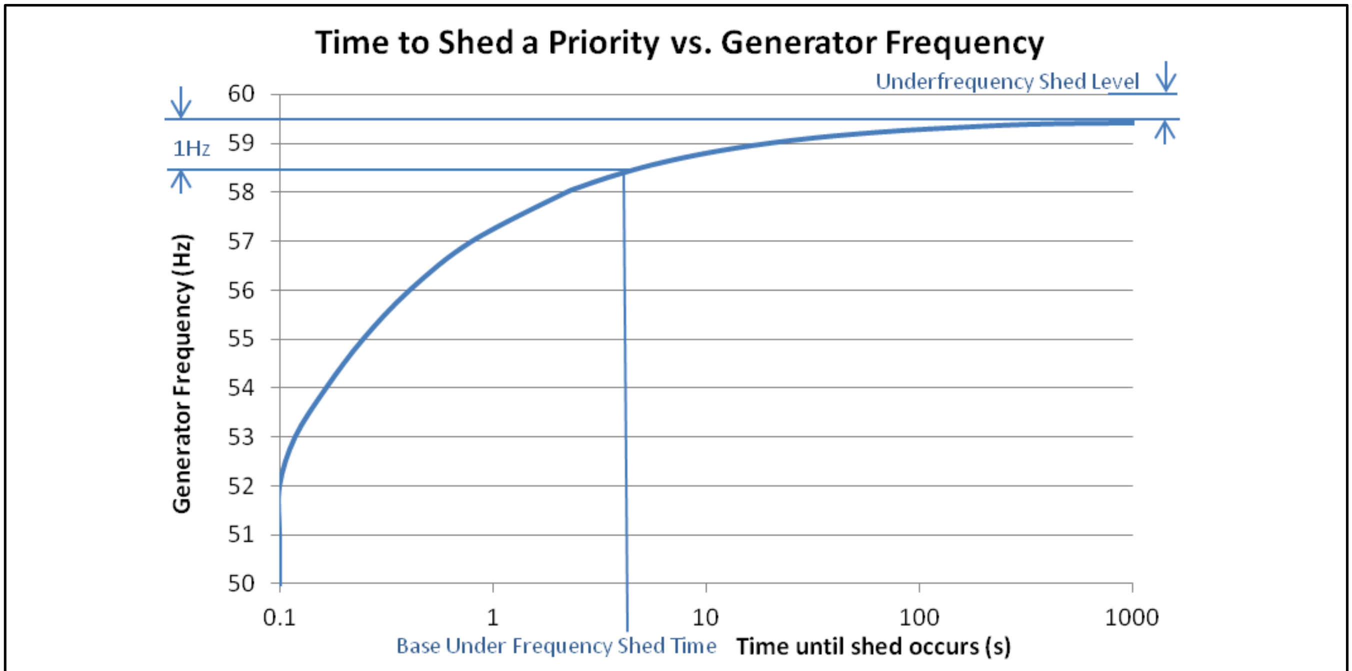


Figure 14-13 Generator Under Frequency Shed Timing With Default Configuration

The Base Under Frequency Shed Time sets the shed time at a 1 Hz frequency droop, while the time decreases as the frequency decreases (indicating additional generator load).

The time to shed subsequent priorities decreases by a fixed 0.5 acceleration factor for each priority shed, hence if the first priority shed in 10 seconds, the second priority will shed in 5 seconds, while the third priority will shed in 2.5 seconds and the fourth priority in 1.3 seconds with the same maintained frequency.

Note: The shed function is performed by an accumulator and the timing is determined by the rate that the accumulator fills, hence a varying load will fill the accumulator at varying rates, causing the load to shed at a time that can't be calculated directly with the equation above, but can be estimated by it.

Notes

Section 15 Alternator Disassembly/Reassembly

Note: Refer to Section 16 for unique differences on 35- 40 kW generator sets equipped with 4PX/4QX alternators.

15.1 Introduction

Before beginning the alternator disassembly procedure, carefully read all safety precautions at the beginning of this manual. Please observe these precautions and those included in the text during the disassembly/reassembly procedure.

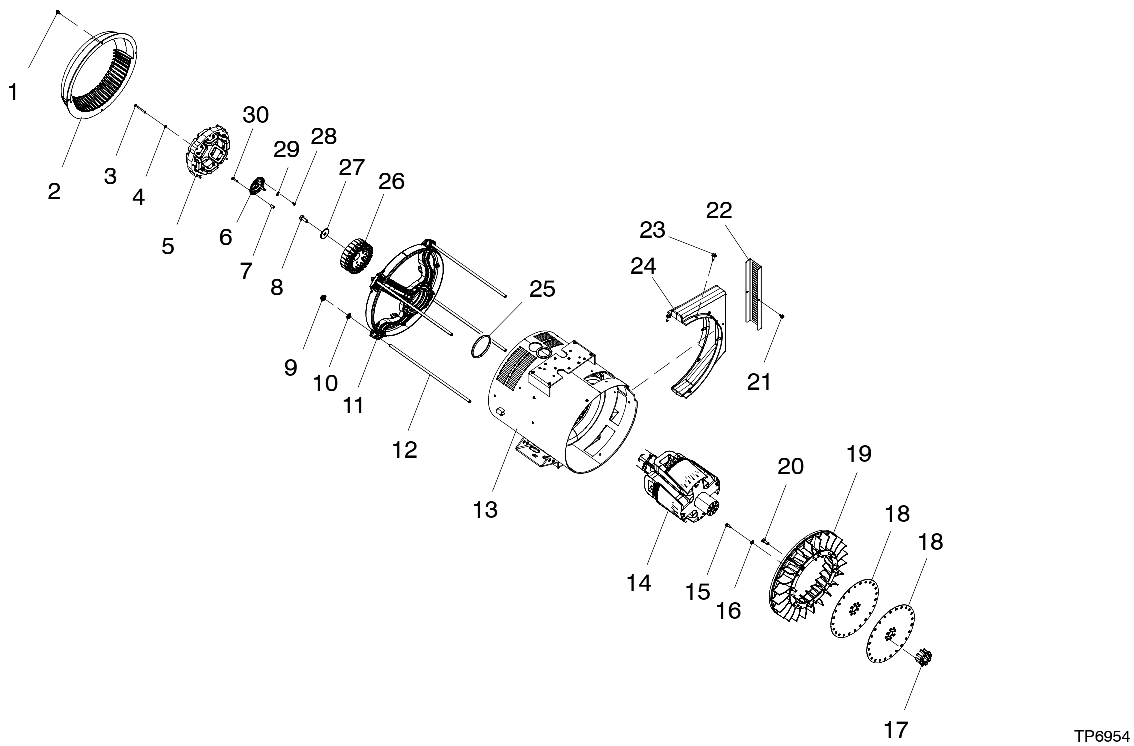
For enclosed units, remove the enclosure door, roof, and side and end panels as required to access the generator set.

Mark leads as they are disconnected. Refer to the respective wiring diagram during reassembly. See the list of related materials in the Introduction Section of this manual for literature part numbers.

Any cranes, hoists, or other lifting devices used in the disassembly or reassembly procedure must be rated for one-half ton or greater.

The following procedures cover many models and some steps may not apply to a particular engine. Use Figure 15-1 and Figure 15-2 to help understand component descriptions and general configuration of the alternator and associated components of the junction box and control box.

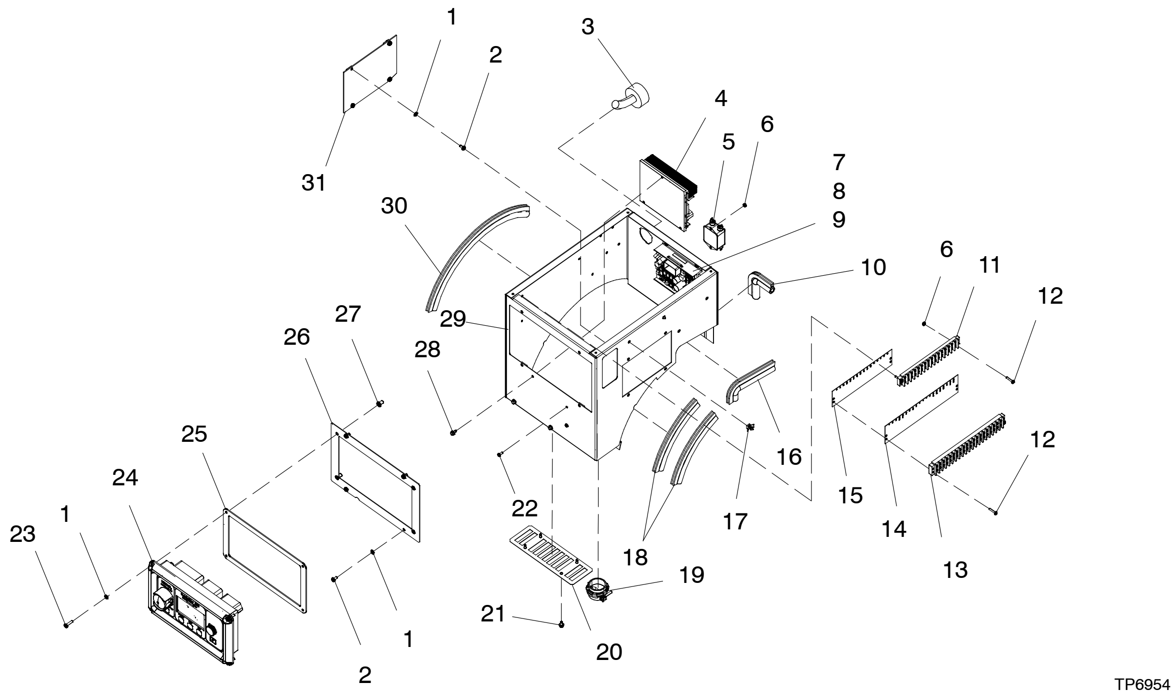
Use disassembly procedure as a step-by-step means to help disassemble the alternator. The disassembly procedure provides important information to minimize disassembly time and indicates where special configurations exist that may require taking notes. The reassembly procedure includes important alignment steps and provides critical torque specs.



1. Screws (qty. 4)
2. 4D/4E end bracket cover
3. Screws (qty. 4)
4. Plain washers (qty. 4)
5. Exciter field assembly
6. Printed circuit board assembly
7. Spacers (qty. 3)
8. Hex. cap screw
9. Hex. nuts (qty. 4)
10. Plain washers (qty. 4)
11. 4D/4E end bracket
12. Studs (qty. 4)
13. Stator assembly
14. Rotor assembly
15. Socket head screws (qty. 8)
16. Plain washers (qty. 8)
17. Hex. cap screws (qty. 8)
18. Drive disc
19. 4D/4E alternator fan
20. Socket head screws (qty. 8)
21. Screws (qty. 2)
22. End bracket air exhaust guard
23. Drill screws (qty. 5)
24. Alternator air exhaust duct
25. O-ring
26. Exciter armature
27. Plain washer
28. Machine screws (qty. 5)
29. Ring terminal (qty. 3)
30. Screws (qty. 3)

Figure 15-1 4D/4E Alternator Components, Typical (Parts Shown May Vary Slightly Between Models)

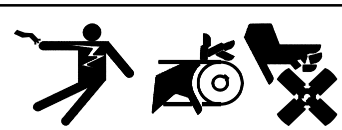
Note: See Figure 16-1 for 4PX/4QX Alternator Components.



1. Plain washers
2. Pan head screws
3. Junction box harness
4. Battery charger assembly
5. RFI power line filter
6. Hex nuts
7. Activator board assembly
8. Pan head screws
9. Hex nuts
10. Push-on trim seal
11. Terminal strip
12. Pan head screws
13. Terminal block
14. Strip marker
15. Strip marker
16. Push-on trim seal
17. Tie wrap snap-in base
18. Push-on trim seal
19. Cable connector
20. Air inlet guard
21. Crimptite screws
22. Pan head screws
23. Pan head screws
24. Controller assembly
25. Controller cover gasket
26. Controller panel
27. Threaded inserts
28. Thread forming screws
29. Junction box
30. Push-on trim seal
31. Circuit breaker cover

Figure 15-2 Junction Box and Controller Components, Typical (Parts Shown May Vary Slightly Between Models)

WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

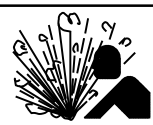
⚠ WARNING

Risk of fire.
Can cause severe injury or death.

Do not smoke or permit flames or sparks near fuels or the fuel system.

Servicing the fuel system. A flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the fuel injection system, fuel line, fuel filter, fuel pump, or other potential sources of spilled fuels or fuel vapors. Catch fuels in an approved container when removing the fuel line or fuel system.

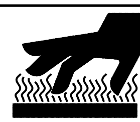
⚠ WARNING



Hot coolant and steam.
Can cause severe injury or death.

Before removing the pressure cap, stop the generator set and allow it to cool. Then loosen the pressure cap to relieve pressure.

⚠ WARNING

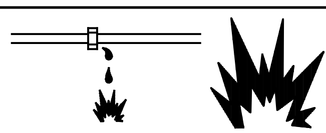


Hot engine and exhaust system.
Can cause severe injury or death.

Do not work on the generator set until it cools.

Servicing the exhaust system. Hot parts can cause severe injury or death. Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

⚠ WARNING



Explosive fuel vapors.
Can cause severe injury or death.

Use extreme care when handling, storing, and using fuels.

The fuel system. Explosive fuel vapors can cause severe injury or death. Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

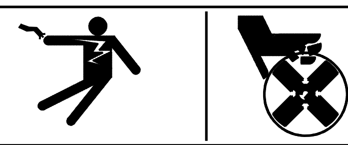
Draining the fuel system. Explosive fuel vapors can cause severe injury or death. Spilled fuel can cause an explosion. Use a container to catch fuel when draining the fuel system. Wipe up spilled fuel after draining the system.

⚠ DANGER

Hazardous voltage.
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

⚠ WARNING



Hazardous voltage. Moving parts.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Perform the following steps prior to disassembling the generator set.

1. Disconnect (negative lead first) and remove starting batteries from work area to prevent fire hazard. Disconnect AC-powered accessories, such as battery charger, block heater, battery heater, and fuel transfer pump (if equipped).

2. Shut off fuel supply. Drain fuel system as necessary by emptying fuel into proper containers. Remove fuel containers from work area to prevent fire hazard. Ventilate the work area to clear fumes.

3. Disconnect fuel, cooling, and exhaust systems as necessary to tilt generator set. Disconnect output leads or load circuit cables at generator set.

4. Any cranes, hoists, or other lifting devices used in the disassembly or reassembly procedure must be rated for the weight of the generator set. Check generator set nameplate or spec sheet for weight.

15.2 Disassembly Procedure

Note: For 35-40 kW generator sets equipped with 4PX/4QX alternators, refer to Section 16 for procedure to disassemble LED optic board, activator board, and exciter.

1. Remove the junction box and/or control box panels to access the internal components.

2. Disconnect all controller-to-engine and engine-to-alternator harnesses and wiring in the junction box. Be sure to mark the wiring as needed for reconnection during reassembly.

3. Remove the remaining junction box and/or control box components.

4. Remove the nuts and alternator guard from the studs.

5. Remove the exciter field.

   a. Remove the four bolts to remove the exciter field. See Figure 15-3.

   b. Remove the three bolts and spacers from the rectifier module.

   c. Disconnect the main field rotor leads from the rectifier module positive/negative terminals. Remove the exciter armature retaining bolt and washer. See Figure 15-4.

   d. Remove the exciter armature from the shaft, guiding the rotor leads through the open spaces in the exciter armature windings. See Figure 15-4.

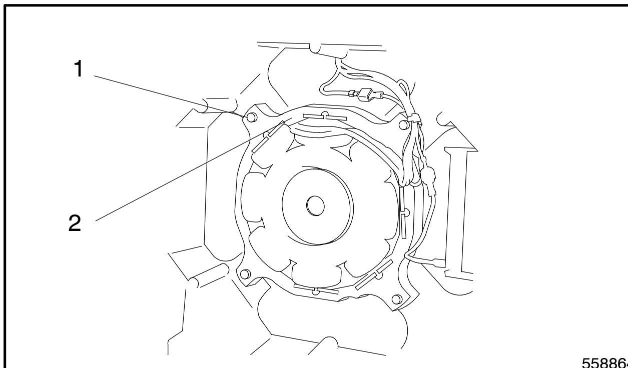
6. Attach a hoist hook to the engine lifting eye. See Figure 15-5.

   Note: The hoist capacity rating should be 500 kg (one-half ton) or greater.

7. Remove the vibromount locknut, small washer, bolt, and large washer from each vibromount. See Figure 15-5.

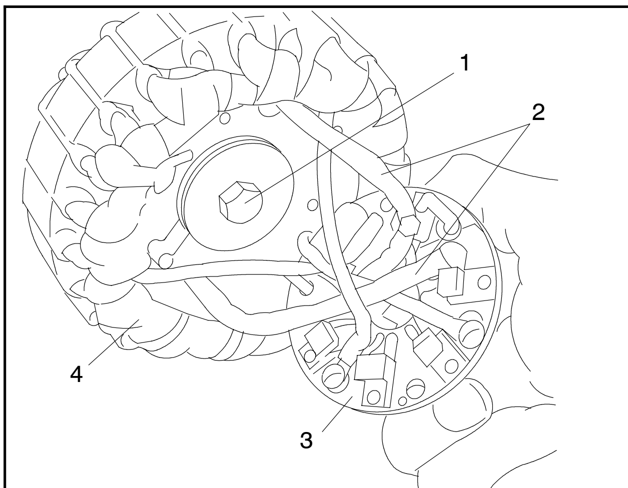
8. Raise the alternator end and place a wood block under the backplate. Lower the alternator until the wood block supports the backplate. See Figure 15-5.

9. Locate and remove the four long studs and nuts from the end bracket.



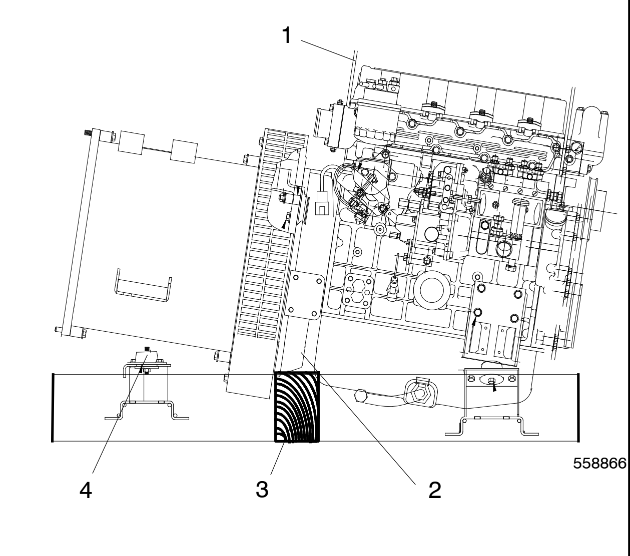
1. Bolts (4)
2. Exciter field

Figure 15-3 Exciter Field Removal



1. Exciter armature retaining bolt/washer
2. Rotor leads
3. Rectifier module
4. Exciter armature

Figure 15-4 Armature Removal



1. Lifting eye
2. Backplate
3. Wood block
4. Vibromounts

Figure 15-5 Supporting the Generator, Typical

10. Use a permanent marker (or scribe) and make an alignment mark on the stator and engine adapter for reference during reassembly. See Figure 15-6.

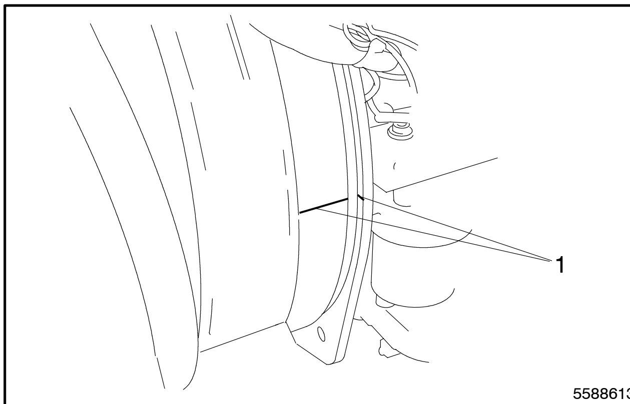
11. Install a sling capable of handling the weight of the stator housing on the stator housing. See Figure 15-7.

12. Use a two-jaw puller to pull the end bracket/stator assembly from the bearing on the rotor shaft. See Figure 15-7.

13. Remove the stator assembly from the rotor. Remove or rotate the fan guard, if necessary, to clear the vibromounts.

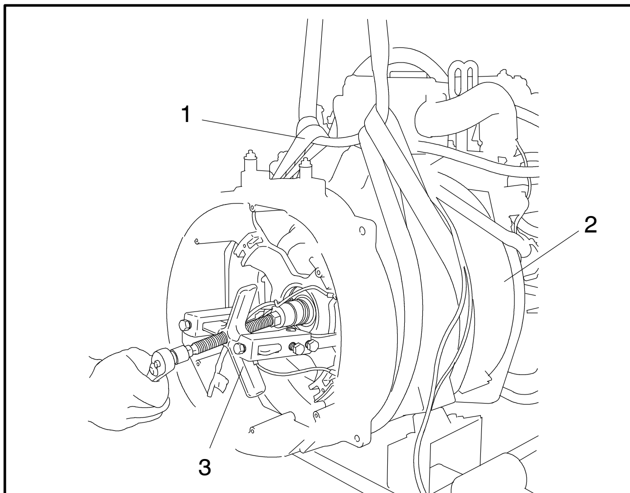
14. Use a permanent marker (or scribe) and make an alignment mark to show the fan's position on the rotor/drive disc assembly for reference during reassembly.

15. Remove the eight screws and washer attaching the alternator fan to the rotor. See Figure 15-8.



1. Alignment marks

Figure 15-6 Alignment Marks on Stator and Engine Adapter



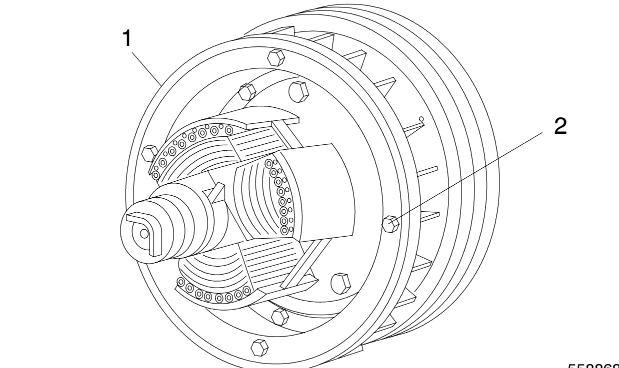
1. Sling
2. Fan guard
3. Two-jaw puller

Figure 15-7 Stator Assembly Removal

16. Remove the alternator fan. See Figure 15-8.

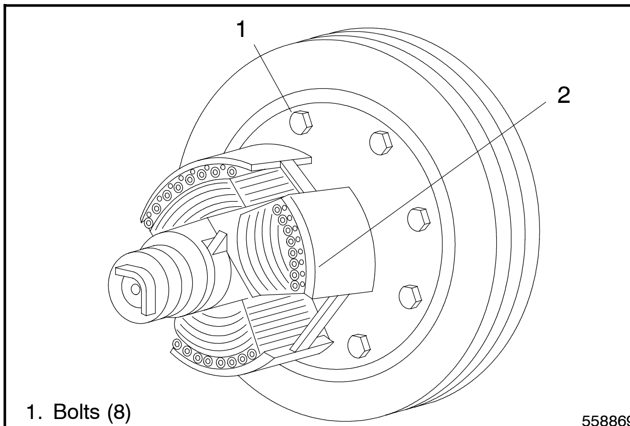
17. Remove the eight bolts and remove the drive disc/rotor assembly from the engine flywheel. See Figure 15-9.

18. Clamp the rotor in a soft-jaw vise. Remove the eight bolts and remove the drive disc assembly from the rotor. See Figure 15-10.



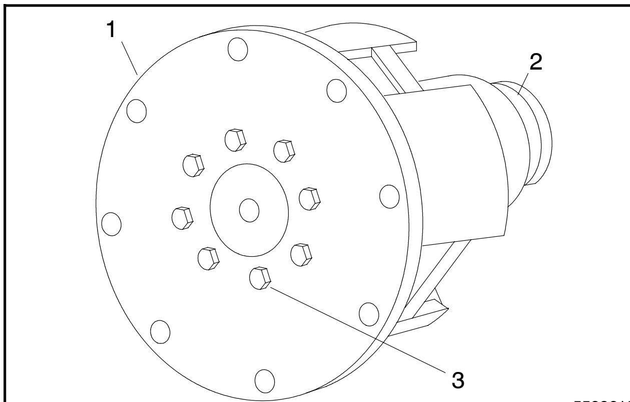
1. Fan
2. Screws with washers (8)

Figure 15-8 Fan Removal



1. Bolts (8)
2. Rotor assembly

Figure 15-9 Disc/Rotor Assembly



1. Drive disc(s) 2. Rotor 3. Bolt

Figure 15-10 Drive Disc(s)

15.3 Reassembly

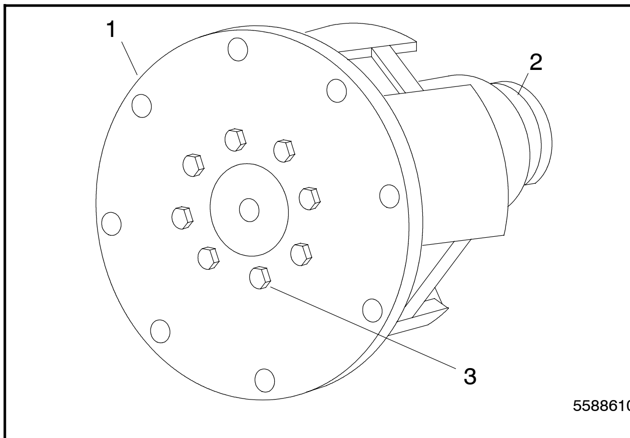
Refer to Section 1, Specifications for Torque Values and Assembly Specifications and Appendix C, General Torque Specifications during reassembly.

Note: For 35-40 kW generator sets equipped with 4PX/4QX alternators, refer to Section 16 for procedure to reassemble exciter, activator board, and LED optic board.

Note: Some hardware assembly requires the use of Loctite® 242 Blue or equivalent to the bolt threads.

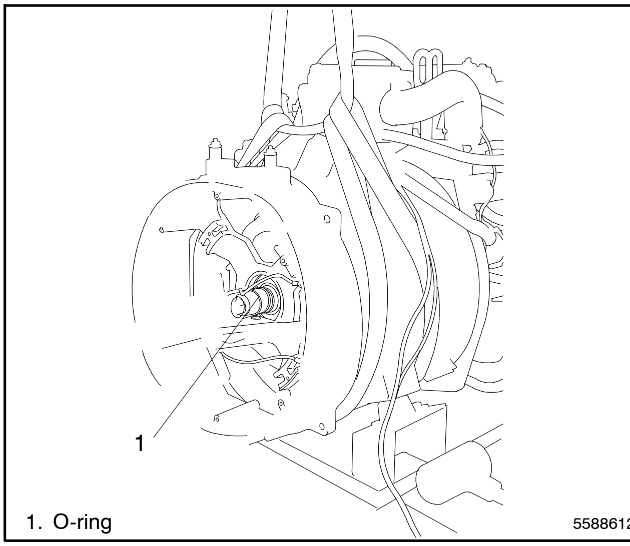
1. Use solvent to clean any threaded component holes and hardware that contain used thread sealant if they will be reused. Allow the components and hardware to dry.
2. Clamp the rotor in a soft-jaw vise. Apply thread sealant to the bolt threads. Install the drive disc(s) on the rotor and torque the eight bolts to specifications. See Figure 15-11.
3. Apply thread sealant to the bolt threads. Place the rotor/drive disc assembly on the engine flywheel and torque the eight washers and bolts to specifications.
4. Apply thread sealant to the bolt threads. Align the fan to the rotor/drive disc assembly using the marks created in the disassembly procedure. Install the fan to the drive disc using eight screws and washers and torque to specifications.

   Note: Install the fan with the flange side facing away from the flywheel.
5. Apply multi-purpose grease to the O-ring and install in the end bracket bearing bore. See Figure 15-12. Use a sling to support the stator assembly while installing the stator over the rotor. Be careful not to damage the rotor.
6. Check that the alignment marks on the stator housing and engine adapter match. See Figure 15-13.
7. Install the four long studs thru the stator assembly holes and thread into the engine adapter.
8. Align the end bracket holes over the studs and position the end bracket over the rotor bearing
9. Install the nuts on the studs and torque the studs/nuts to specifications.
10. Use the hoist to raise the alternator end. Remove the wood block from under the backplate. Lower the generator set and install a bolt, a large washer, a small washer, and a locknut on each vibromount. Remove the hoist/sling equipment.



1. Drive disc(s) 2. Rotor 3. Bolt

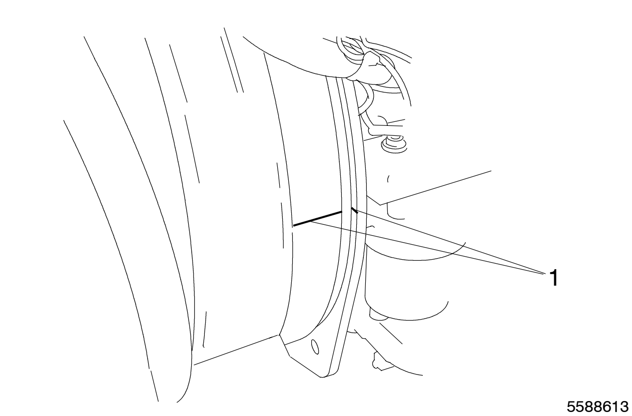
Figure 15-11 Drive Disc(s) Installation



1. O-ring

Figure 15-12 Stator Installation

Loctite® is a registered trademark of the Henkel Corporation.



1. Alignment marks

Figure 15-13 Alignment Marks

11. Apply antiseize compound to the keyed end of the rotor shaft.

12. Bring the rotor leads F1 and F2 through the open spaces in the exciter armature windings while installing the exciter armature on the shaft. Check the keyway of the shaft and key of the exciter armature for damage. Install the exciter armature retaining bolt and washer and torque to specifications. See Figure 15-14.

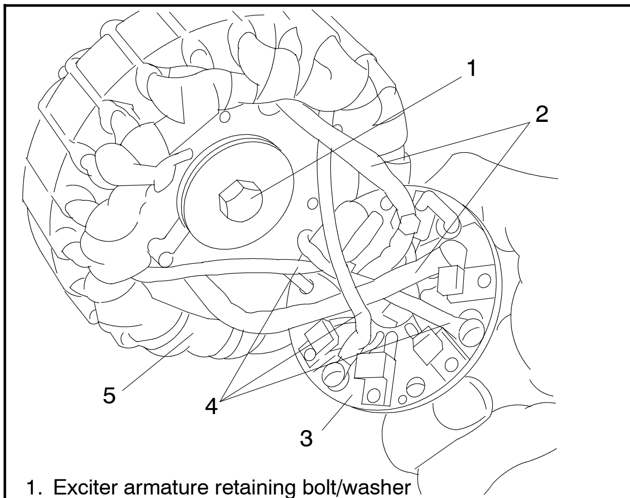
13. Use screws and lock washers to install the rotor leads F1 and F2 to the rectifier module at the positive (+) and negative (-) terminals and torque to specifications. See Figure 15-15.

    Note: Position the lock washers against the rectifier module.

14. If the exciter armature is new, locate the exciter armature lead mounting locations on the rectifier module (see Figure 15-15) and cut the exciter armature leads to eliminate slack and crimp-on terminals.

15. Use screws and lock washers to install the exciter armature leads AC (qty. 3) to the rectifier module at the A, B, and C terminals and torque to specifications.

    Note: Position the lock washers against the rectifier module.



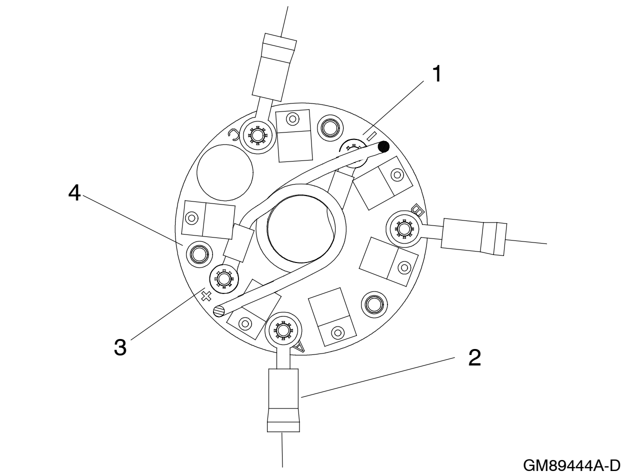
1. Exciter armature retaining bolt/washer
2. Rotor leads F1 and F2
3. Rectifier module
4. Exciter armature leads
5. Exciter armature

Figure 15-14 Exciter Armature and Rectifier Module

16. Align the holes of the rectifier module to the threaded holes in the exciter armature. Install the three screws in the rectifier module, place the three spacers on the screws, and attach the rectifier module to the exciter armature and torque to specifications.

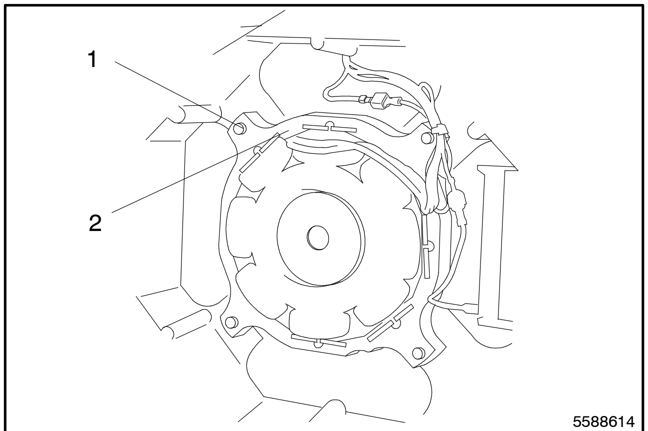
    Note: Position the spacers between the rectifier module and exciter armature.

17. Position the exciter field leads at the top. Install the exciter field using four bolts and washers and torque to specifications. See Figure 15-16.



1. Rotor F2 lead to negative (-) terminal
2. Exciter armature leads (3) AC to A, B, And C terminals
3. Rotor F1 lead to positive (+) terminal
4. Rectifier module screws, qty. 3

Figure 15-15 Rectifier Module Connections



1. Exciter field bolts (4)
2. Exciter field

Figure 15-16 Installing Exciter Field

18. Use tie wraps to secure the wires as necessary.
19. Install the alternator guard and hardware.
20. Reinstall the junction box and/or control box components and related wiring. Do not install the panels at this time.
21. Reconnect the leads to the circuit breaker and neutral stud (LO) as marked during disassembly.

    Note: For voltage reconnection diagrams, refer to the wiring diagrams in Section 17.

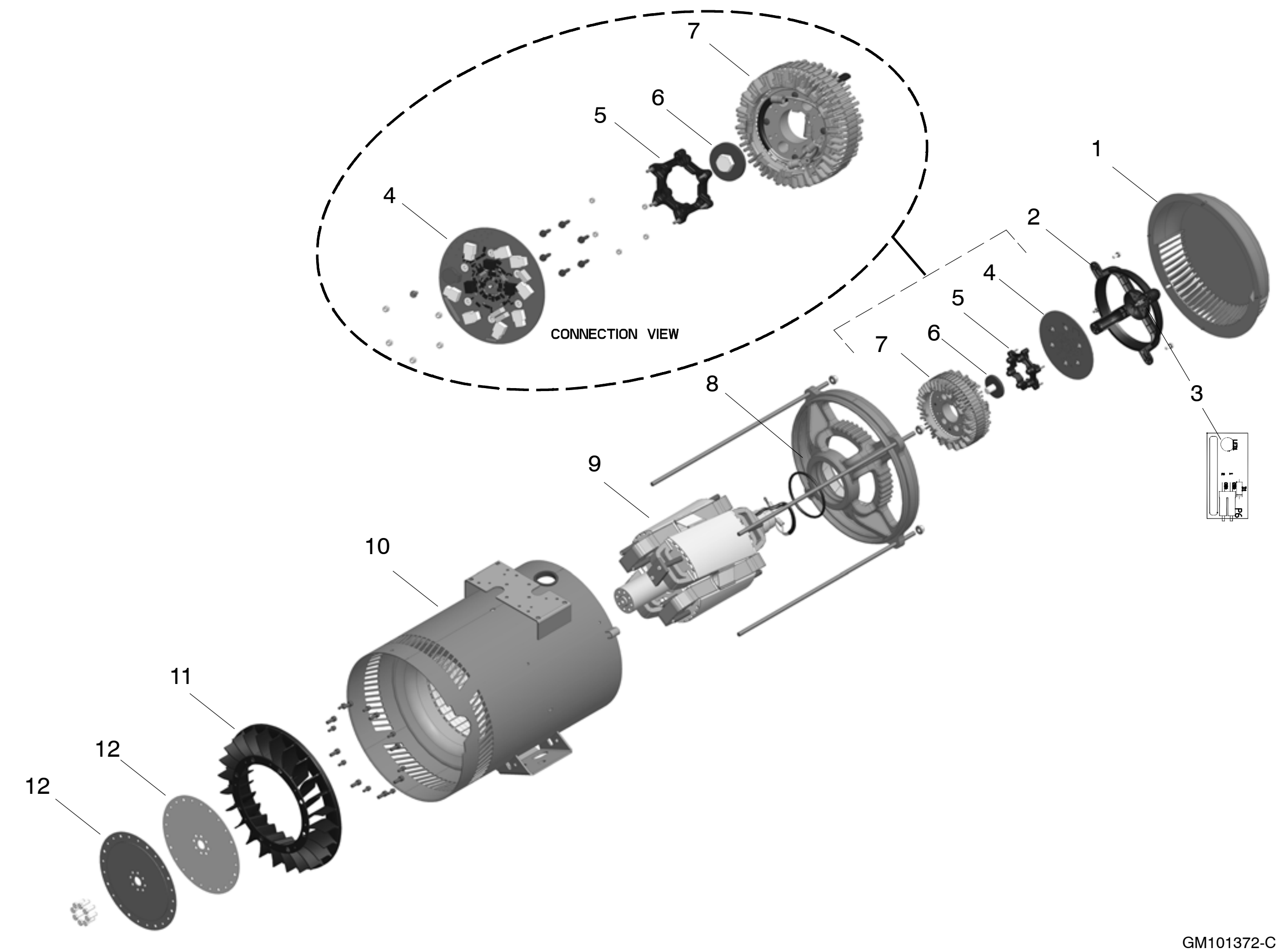
    Note: Check the generator set nameplate to verify the original voltage configuration on the unit.
22. Reconnect all controller-to-engine and engine-to-alternator harnesses and wiring in the junction box.
23. Reinstall the junction box panels.
24. Reconnect all of the external connections—the exhaust line, the fuel line to the fuel pump filter inlet, the remote interface connector, the AC output leads, and the battery cables to the battery (negative (-) lead last).
25. Reconnect the engine starting battery, negative (-) lead last.
26. Reconnect power to the battery charger and other AC accessories, if equipped.

Section 16 Additional 4PX/4QX Alternator Information

Note: See Section 15 for basic rotor/stator disassembly and reassembly procedures. Unique differences for the 35- 40 kW generator sets equipped with 4PX/4QX alternators are mentioned in this section.

Carefully read all safety precautions at the beginning of this manual.

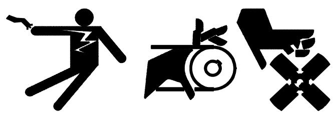
The following procedures cover many models and some steps may not apply to a particular engine. Use Figure 16-1 to help understand component descriptions and general configuration of the alternator.



1. End bracket cover
2. LED optic board holder
3. LED optic board
4. FRX activator board
5. Spacer, FRX activator
6. Bolt and bow washer, FRX activator
7. Exciter armature
8. End bracket
9. Rotor assembly
10. Stator assembly
11. Alternator fan
12. Drive discs

Figure 16-1 4PX/4QX Alternator Components, Typical

WARNING

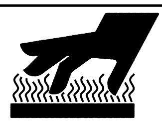


Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

WARNING



Hot engine and exhaust system.
Can cause severe injury or death.

Do not work on the generator set until it cools.

Servicing the exhaust system. Hot parts can cause severe injury or death. Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

WARNING

Explosive fuel vapors.
Can cause severe injury or death.

Use extreme care when handling, storing, and using fuels.

The fuel system. Explosive fuel vapors can cause severe injury or death. Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

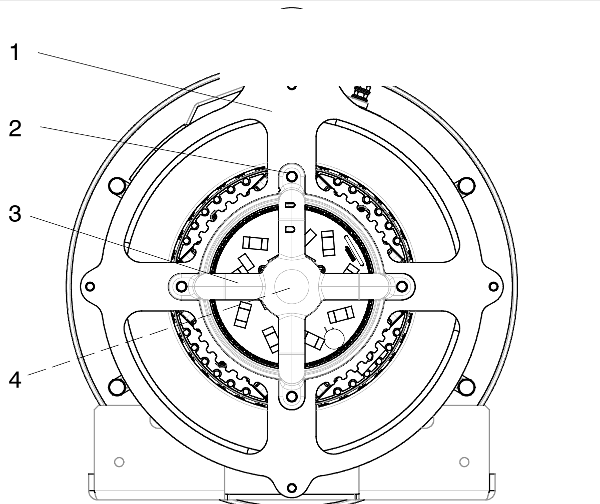
Draining the fuel system. Explosive fuel vapors can cause severe injury or death. Spilled fuel can cause an explosion. Use a container to catch fuel when draining the fuel system. Wipe up spilled fuel after draining the system.

Remember to perform the following steps prior to disassembling the generator set.

1. Disconnect (negative lead first) and remove starting batteries from work area to prevent fire hazard. Disconnect AC-powered accessories, such as battery charger, block heater, battery heater, and fuel transfer pump (if equipped).
2. Shut off fuel supply. Drain fuel system as necessary by emptying fuel into proper containers. Remove fuel containers from work area to prevent fire hazard. Ventilate the work area to clear fumes.
3. Disconnect fuel, cooling, and exhaust systems as necessary to tilt generator set. Disconnect output leads or load circuit cables at generator set.
4. Any cranes, hoists, or other lifting devices used in the disassembly or reassembly procedure must be rated for the weight of the generator set. Check generator set nameplate or spec sheet for weight.

16.1 Disassembly

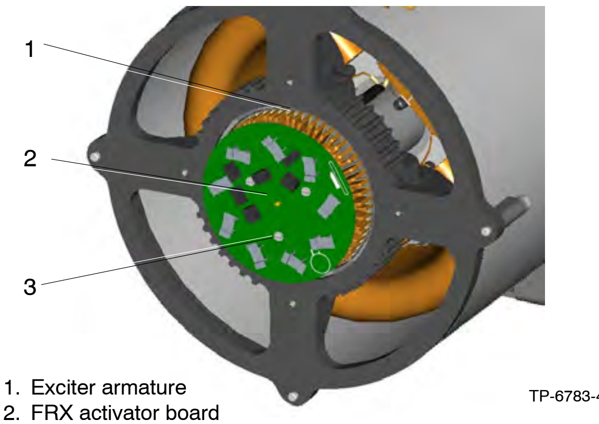
1. Remove the junction box panels. Disconnect all controller-to-engine and engine-to-alternator harnesses and wiring. Remove the junction box and controller as a unit.
2. Remove the fan guard from the alternator adapter.
3. Disconnect the two-lead P6 connector at the LED optic board.
4. Remove the LED optic board holder from the end bracket (four screws). See Figure 16-2.



1. End bracket
2. LED optic board holder mounting screws (qty. 4)
3. LED optic board holder
4. LED optic board

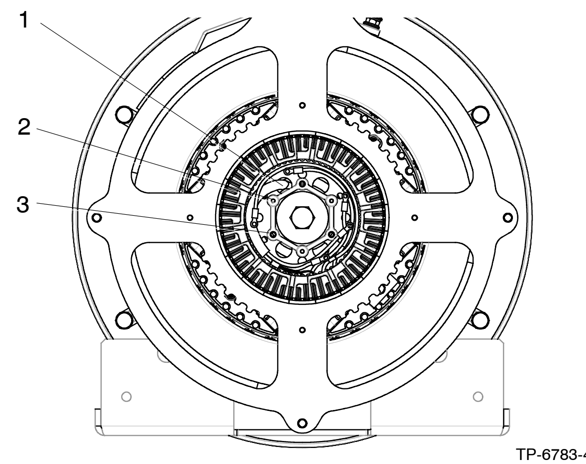
Figure 16-2 Removing LED Optic Board Holder

5. Remove the LED optic board from the LED optic board holder (one screw).
6. Remove the FRX activator board from the exciter armature assembly.
7. Remove the FRX activator spacer from the exciter armature. See Figure 16-4. Disconnect the exciter armature and rotor leads (AC1, AC2, AC3, F1, and F2) from the spacer.



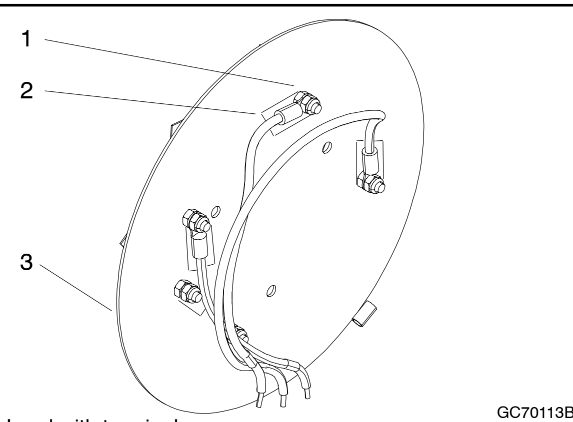
1. Exciter armature
2. FRX activator board
3. FRX activator mounting screws (qty. 3)

Figure 16-3 Removing FRX Activator Board



1. FRX activator spacer
2. Spacer mounting screws (qty. 3)
3. FRX activator mounting screw locations

Figure 16-4 Removing FRX Activator Spacer



1. Lead with terminal
2. Silkscreen positioning box
3. FRX activator board

Figure 16-5 FRX Activator Board Silkscreen Boxes

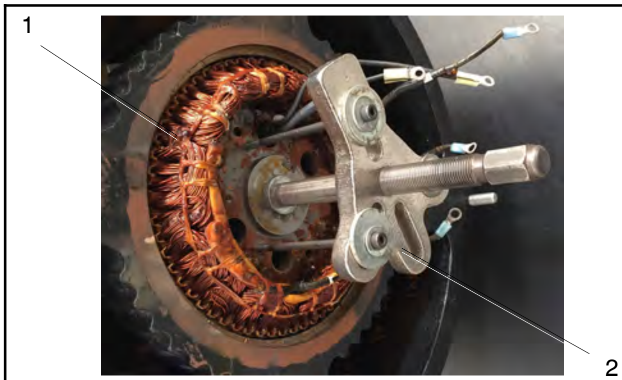
8. Remove the bolt and bow washer from the rotor assembly shaft.

9. Note the location of the rotor assembly leads (FN and FP) going through the hole in the exciter armature for assembly later.

10. Obtain the following:

- Automotive harmonic balancer puller
- Washers qty. 2 (0.266 in. ID x 1.0 in. OD)
- Thread-forming screws qty. 2 (5 mm x 35 mm long). *Kohler part number M7500D-05035-85*

Engage the exciter armature using the harmonic balancer tool and 5 mm self-tapping screws. Slowly pull the exciter armature out of the cast iron end bracket being careful to not damage the exciter magnets in the end bracket. See Figure 16-6.



1. Exciter armature
2. Automotive harmonic balancer puller

Figure 16-6 Removing Exciter Armature

Note: See Section 15 for basic rotor/stator disassembly procedures.

16.2 Reassembly

Refer to Section 1, Specifications for torque specifications and Appendix C, General Torque Specifications during reassembly.

Note: See Section 15 for basic rotor/stator reassembly procedures.

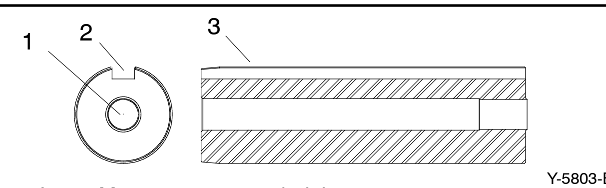
1. Hoist the alternator and engine slightly to remove the wood block(s) from under the flywheel housing. Align the alternator assembly and skid. Lower the alternator and tighten the vibromount mounting bolts.

2. Remove the slings used for suspending the alternator. Final tighten the drive discs to the flywheel. Torque hardware to specifications.

3. Apply anti-seize compound to rotor shaft.

4. Install tool Y-5803 or equivalent on the rotor shaft and attach using an M16-2.0 x 200 mm bolt. Align tool with rotor shaft keyway. See Figure 16-7.

   Note: Procure service tool Y-5803. Requires (qty. 1) M16-2.0 x 200 mm bolt.



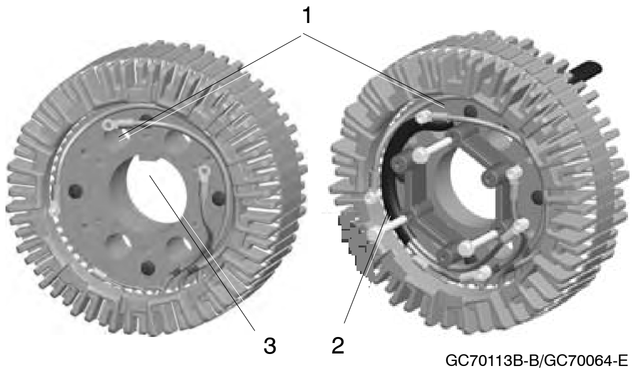
1. Insert M16-2.0 x 200 mm bolt here
2. Align key to rotor shaft
3. Tool Y-5803

Figure 16-7 Installing Tool Y-5803

5. Install exciter armature with leads to the outside over service tool Y-5803. Route the rotor leads through the hole to the left of the keyway in the exciter armature core. See Figure 16-8.

   Slide the exciter armature slowly onto stub shaft towards the end bracket magnets while pulling the rotor leads snug to remove slack and prevent pinching the rotor leads. When the exciter armature gets close to the magnets, the magnets will pull the exciter armature along the rotor shaft and the exciter armature will snap into the end bracket magnets.

6. Remove the M16-2.0 x 200 bolt and tool Y-5803.



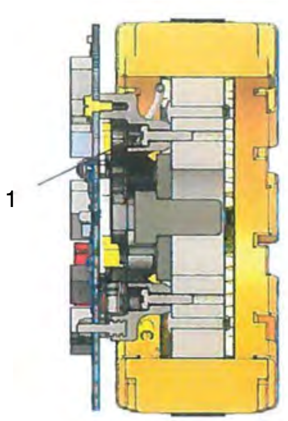
1. Route rotor assembly leads through the hole to the left of the keyway
2. Rotor assembly leads
3. Exciter armature core keyway

Figure 16-8 Exciter Armature/Rotor Leads

7. Mount the spacer to the exciter armature using six thread-forming Torx head screws. See Figure 16-9 and Figure 16-13.

Note: Orient the non-electrical connection mounting hole to the mounting hole above the keyway.

Side View



1. Thread-forming Torx head screws

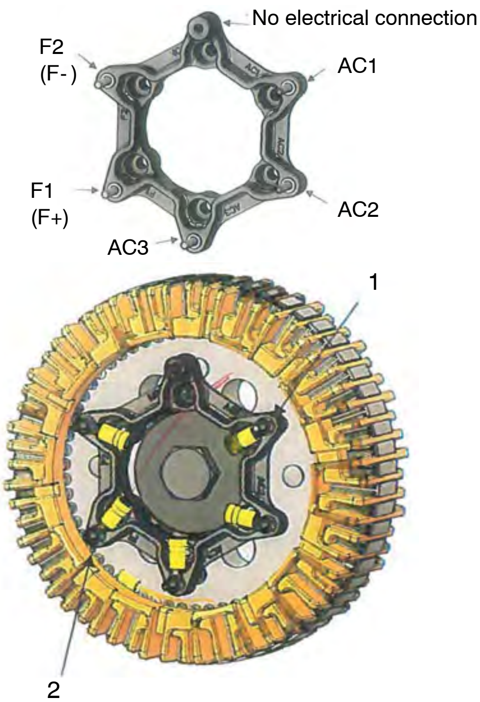
Figure 16-9 Spacer Installation

8. Route the exciter armature and rotor leads (AC1, AC2, AC3, F1, and F2) around the outer diameter of the spacer to the inside to eliminate slack. See Figure 16-10.

Note: Lead connections are identified on the spacer and in Figure 16-10.

Note: Secure excess lead length before attaching terminals.

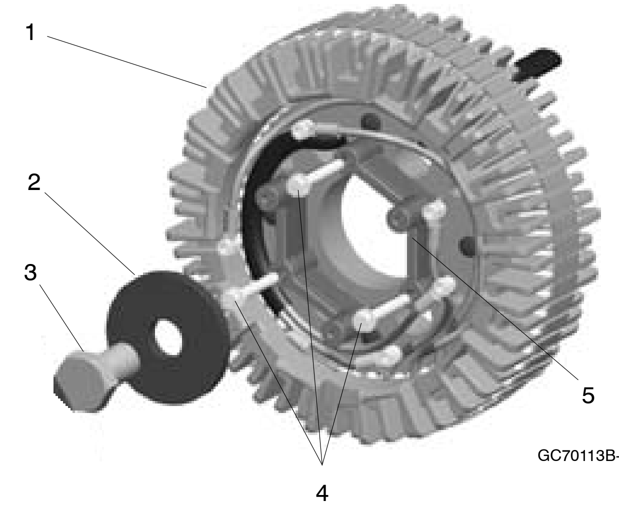
9. Use 5 terminals and **5 stainless steel hex nuts** to connect leads AC1, AC2, AC3, F1 and F2 to the spacer studs. Torque to 1.3 Nm (12 in. lbs.). Locate the terminal barrels down inside the spacer pockets. See Figure 16-10 and Figure 16-13.



1. Route leads around spacer OD to inside to eliminate slack (leads not shown).
2. Terminals and stainless steel hex nuts. Terminal barrels located down into spacer pockets.

Figure 16-10 Spacer Connections

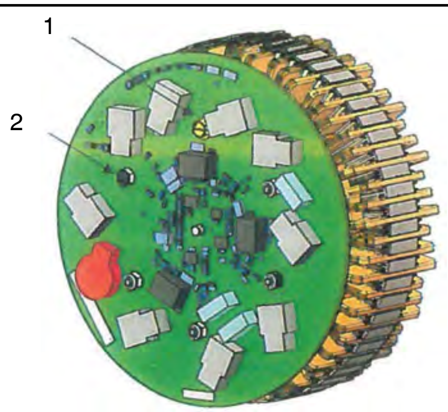
10. If the armature was changed, secure the new exciter armature by reusing the existing bolt and bow washer. See Figure 16-11. Torque to 194 Nm (143 ft. lbs.).



NOTE: Remove items 2 and 3 only when changing the armature.
1. Exciter armature
2. Bow washer (position washer with convex side outward)
3. Bolt
4. Three screws
5. Spacer

Figure 16-11 Exciter Armature

11. Secure the activator board to the studs on the spacer by using 5 stainless steel elastic stop hex nuts and a thread-forming screw. Torque to 1.3 Nm (12 in. lbs.). See Figure 16-12 and Figure 16-13.

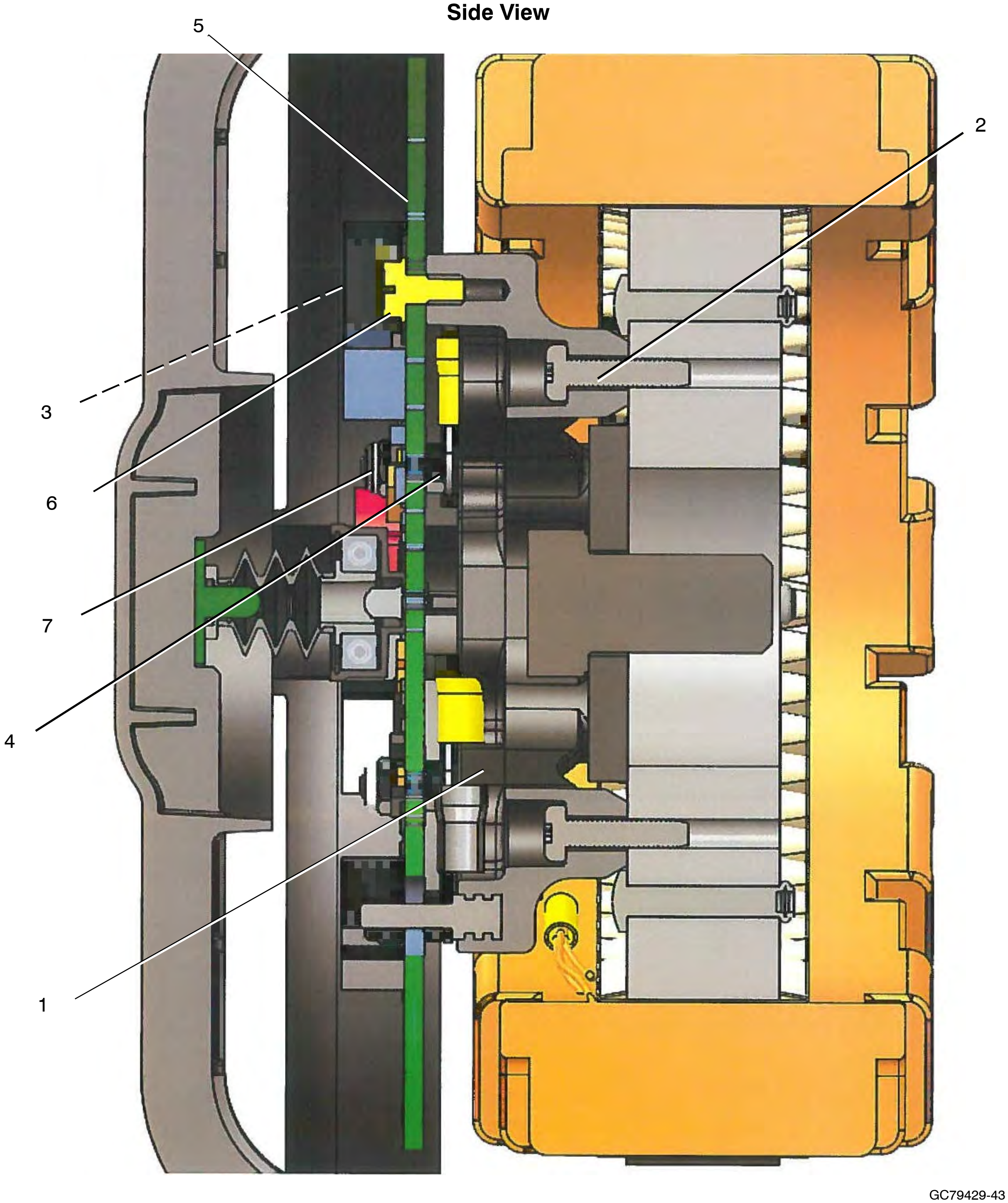


1. Thread-forming screw
2. Stainless steel nuts

Figure 16-12 Activator Board

12. Mount the LED optic board to the LED optic board holder using one screw.
13. Attach the LED optic board holder to the end bracket using four screws and torque to 6.2 Nm (4.6 ft. lbs.).
14. Reconnect the two-lead P6 connector at the LED optic board.
15. Install the fan guard to the alternator adapter.
16. Reinstall the junction box and controller.
17. Reconnect all controller-to-engine and engine-to-alternator harnesses and wiring. Refer to the wiring diagrams as required.
18. Reconnect the fuel, cooling, and exhaust systems disconnected during disassembly. Reconnect the output leads or load circuit cables at the alternator. Open the fuel supply valve.
19. Replace the junction box panels.
20. Reconnect the starting batteries, negative lead last. Connect any AC-powered accessories such as the battery charger, block heater, fuel transfer pump, etc.

Side View



Listed in order of assembly:

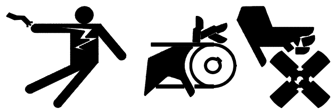
1. Spacer (GM98936)
2. Thread- forming Torx head screw (M7500CE-05020-85 qty. 6)
3. Terminal (X-283-58 qty. 5), not shown
4. Stainless steel hex nut (M934-04-SS qty. 5)
5. Activator board (GM98939-1)
6. Thread-forming screw (X-6071-8)
7. Stainless steel nylock nut (M985-04-SS qty. 5)

Figure 16-13 Components Shown in Order of Assembly (Shown with Dust Cover)

Notes

Section 17 Wiring Diagrams

WARNING

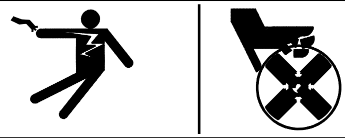


Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

WARNING



Hazardous voltage. Moving parts.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Disconnecting the electrical load. Hazardous voltage can cause severe injury or death. Disconnect the generator set from the load by turning off the line circuit breaker or by disconnecting the generator set output leads from the transfer switch and heavily taping the ends of the leads. High voltage transferred to the load during testing may cause personal injury and equipment damage. Do not use the safeguard circuit breaker in place of the line circuit breaker. The safeguard circuit breaker does not disconnect the generator set from the load.

17.1 Wiring Diagram Reference

Model	Point-to-Point	Figure	Schematic	Figure	Accessory	Figure	System Remote Display	Figure
13EKOZD/11EFKOZD 15EKOZD/13EFKOZD 17.5/16.5EFKOZD 20/19.5EFKOZD 14EKOZD/12EFKOZD 16EKOZD/13.5EFKOZD 18/17EFKOZD 20.5EFKOZD	GM92288-H	Figure 17-1 Figure 17-2	ADV-8672-G	Figure 17-3 Figure 17-4	GM88254-C	Figure 17-53 Figure 17-54	GM92060-A	Figure 17-55
20EKOZD (12 volt) 23EKOZD (12 volt) 21EKOZD (12 volt) 24EKOZD (12 volt)	GM96796-G	Figure 17-5 Figure 17-6	ADV-8780-F	Figure 17-7 Figure 17-8				
20EKOZD (24 volt) 23EKOZD (24 volt) 21EKOZD (24 volt) 24EKOZD (24 volt)	GM99447-D	Figure 17-9 Figure 17-10	ADV-8835-D	Figure 17-11 Figure 17-12				
32EKOZD/28EFKOZD (12 volt, standard ground)	GM101901-C	Figure 17-13 Figure 17-14 Figure 17-15	ADV-8939-C	Figure 17-16 Figure 17-17				
32EKOZD/28EFKOZD (24 volt, standard ground)	GM101903-D	Figure 17-18 Figure 17-19 Figure 17-20	ADV-8941-B	Figure 17-21 Figure 17-22				
32EKOZD/28EFKOZD (12 volt, isolated ground)	GM101902-C	Figure 17-23 Figure 17-24 Figure 17-25	ADV-8940-C	Figure 17-26 Figure 17-27				
32EKOZD/28EFKOZD (24 volt, isolated ground)	GM101904-D	Figure 17-28 Figure 17-29 Figure 17-30	ADV-8942-B	Figure 17-31 Figure 17-32				
40EKOZD/35EFKOZD (12 volt, standard ground)	GM102540-C	Figure 17-33 Figure 17-34 Figure 17-35	ADV-8960-C	Figure 17-36 Figure 17-37				
40EKOZD/35EFKOZD (24 volt, standard ground)	GM102542-D	Figure 17-38 Figure 17-39 Figure 17-40	ADV-8962-B	Figure 17-41 Figure 17-42				
40EKOZD/35EFKOZD (12 volt, isolated ground)	GM102541-C	Figure 17-43 Figure 17-44 Figure 17-45	ADV-8961-C	Figure 17-46 Figure 17-47				
40EKOZD/35EFKOZD (24 volt, isolated ground)	GM102543-D	Figure 17-48 Figure 17-49 Figure 17-50	ADV-8963-B	Figure 17-51 Figure 17-52				

Model	Reconnection	Figure
All	ADV-5875-Y	Figure 17-56 Figure 17-57

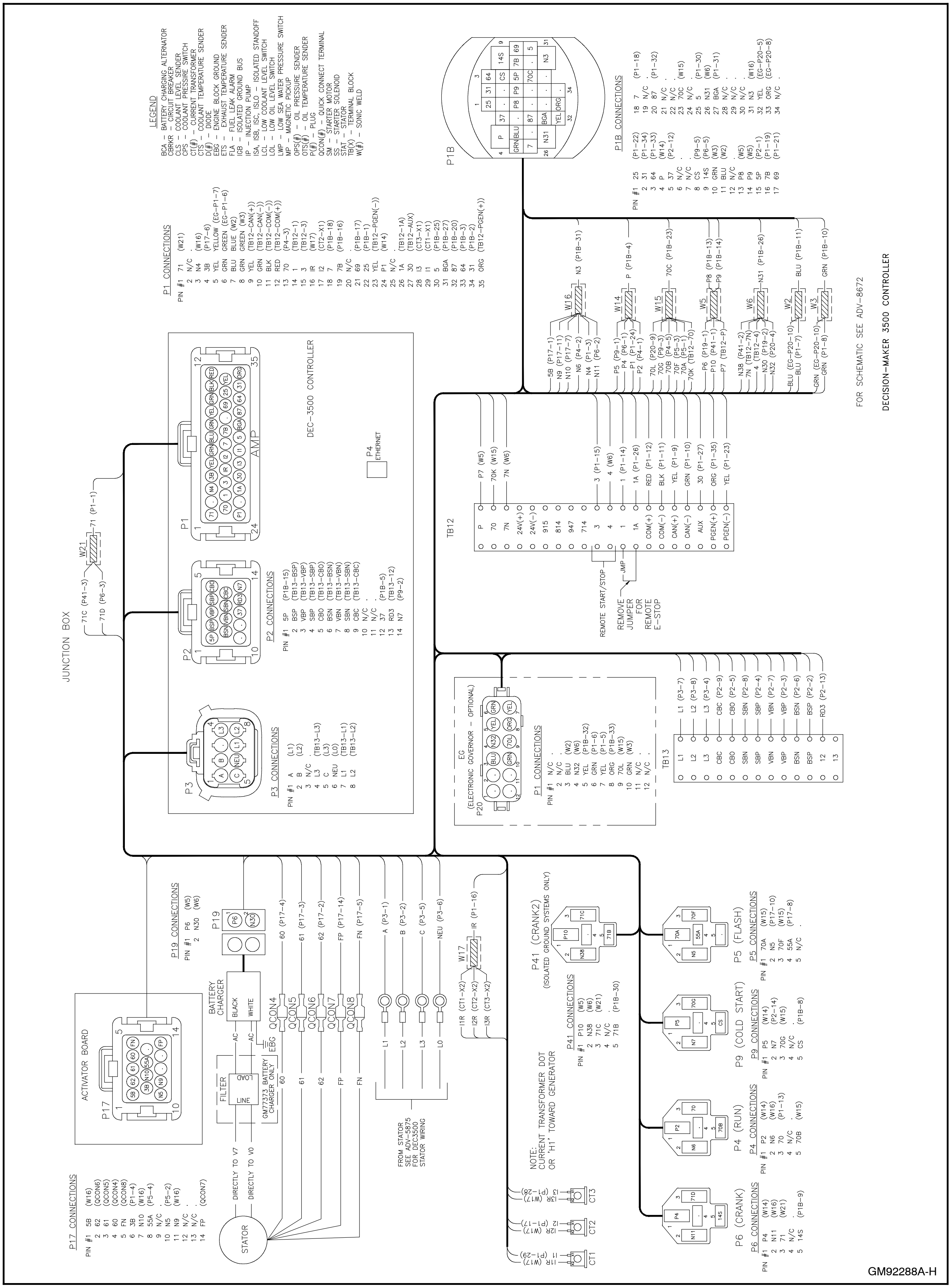


Figure 17-1 Wiring Diagram, Point-to-Point (Sheet 1 of 2) for 13-16EKOZD & 11-20.5EFKOZD Models

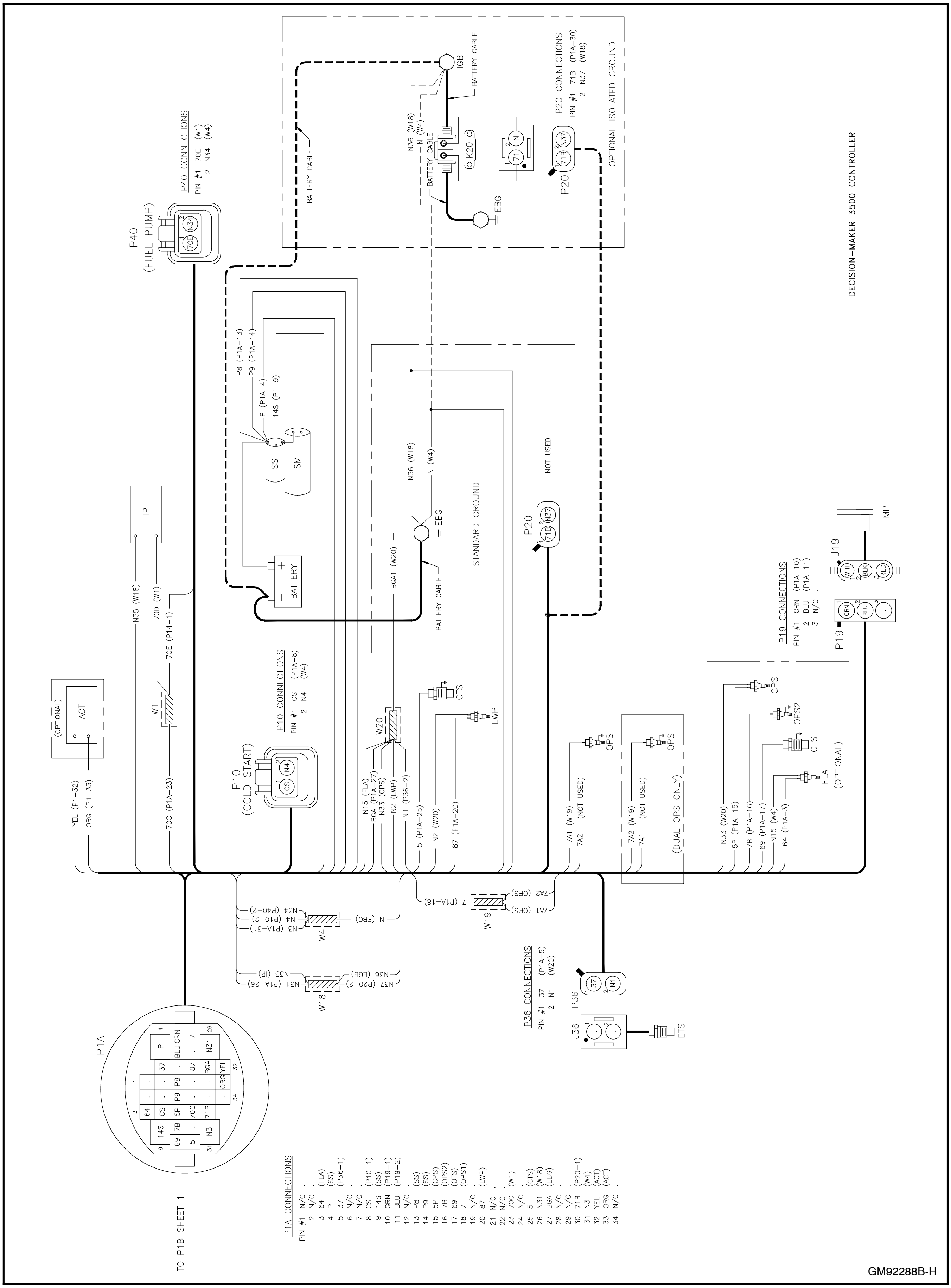


Figure 17-2 Wiring Diagram, Point-to-Point (Sheet 2 of 2) for 13- 16EKOZD & 11- 20.5EFKOZD Models

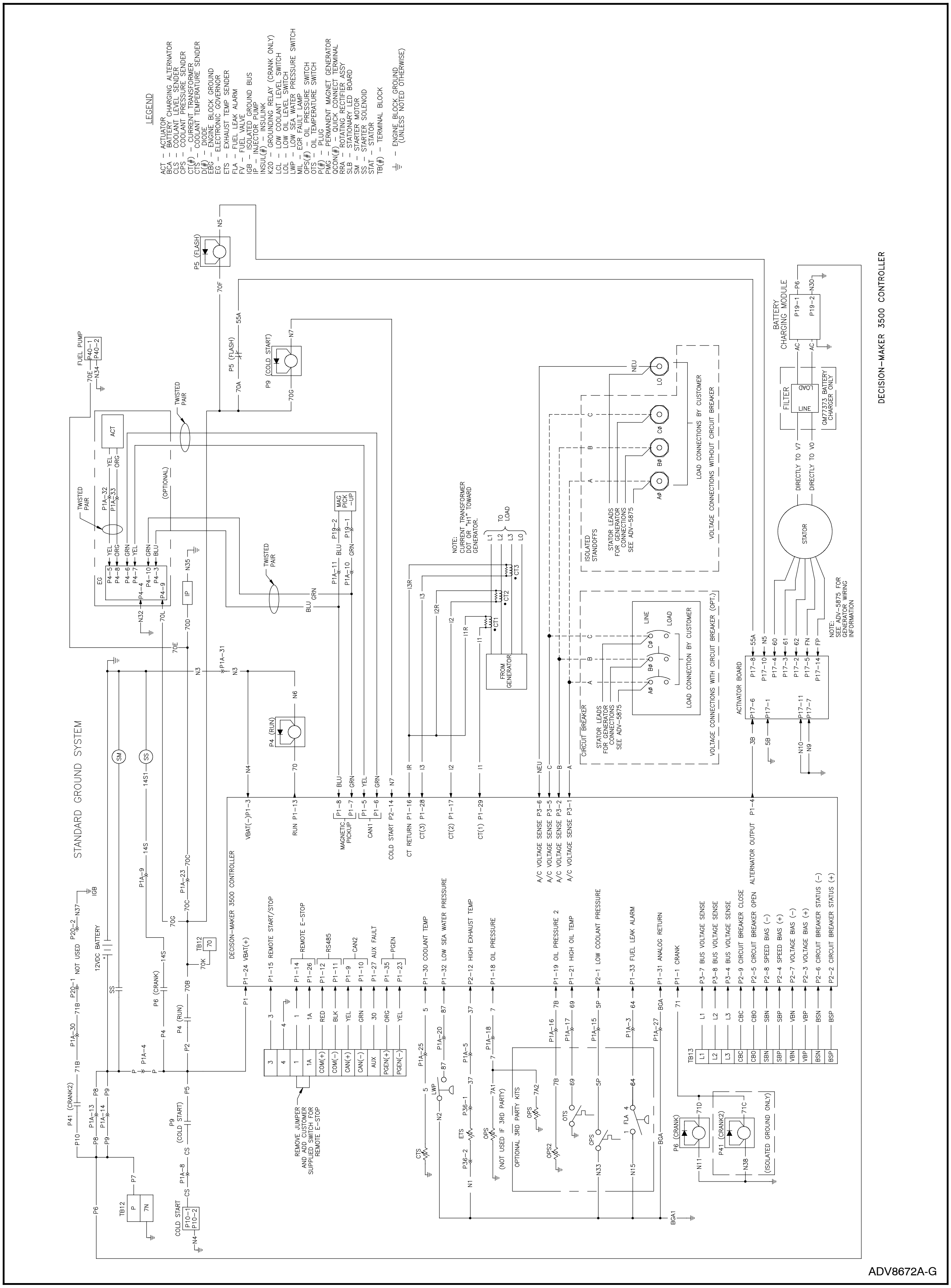


Figure 17-3 Wiring Diagram, Schematic (Sheet 1 of 2) for 13-16EKOZD & 11-20.5EFKOZD Models

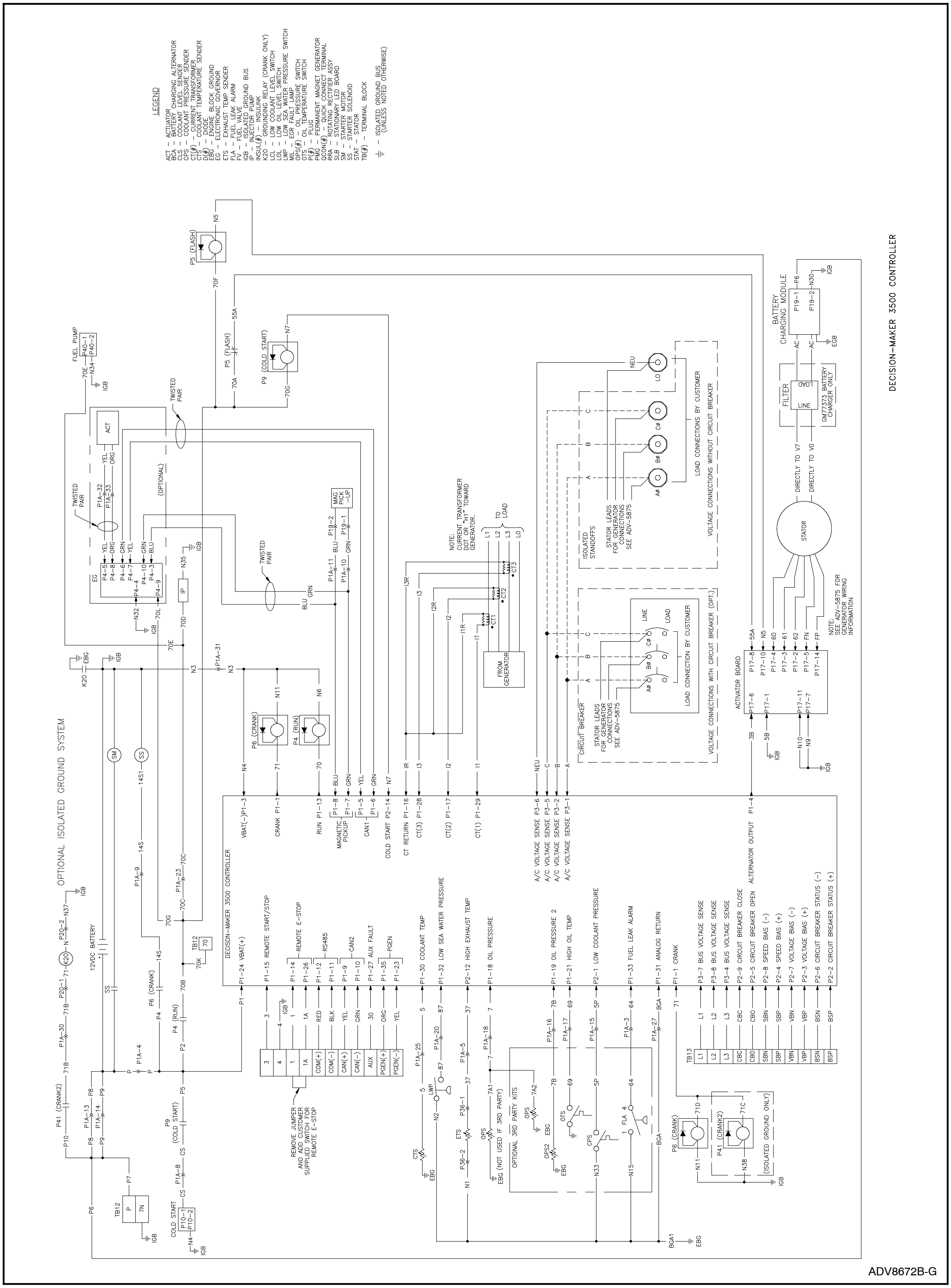


Figure 17-4 Wiring Diagram, Schematic (Sheet 2 of 2) for 13- 16EKOZD & 11- 20.5EFKOZD Models

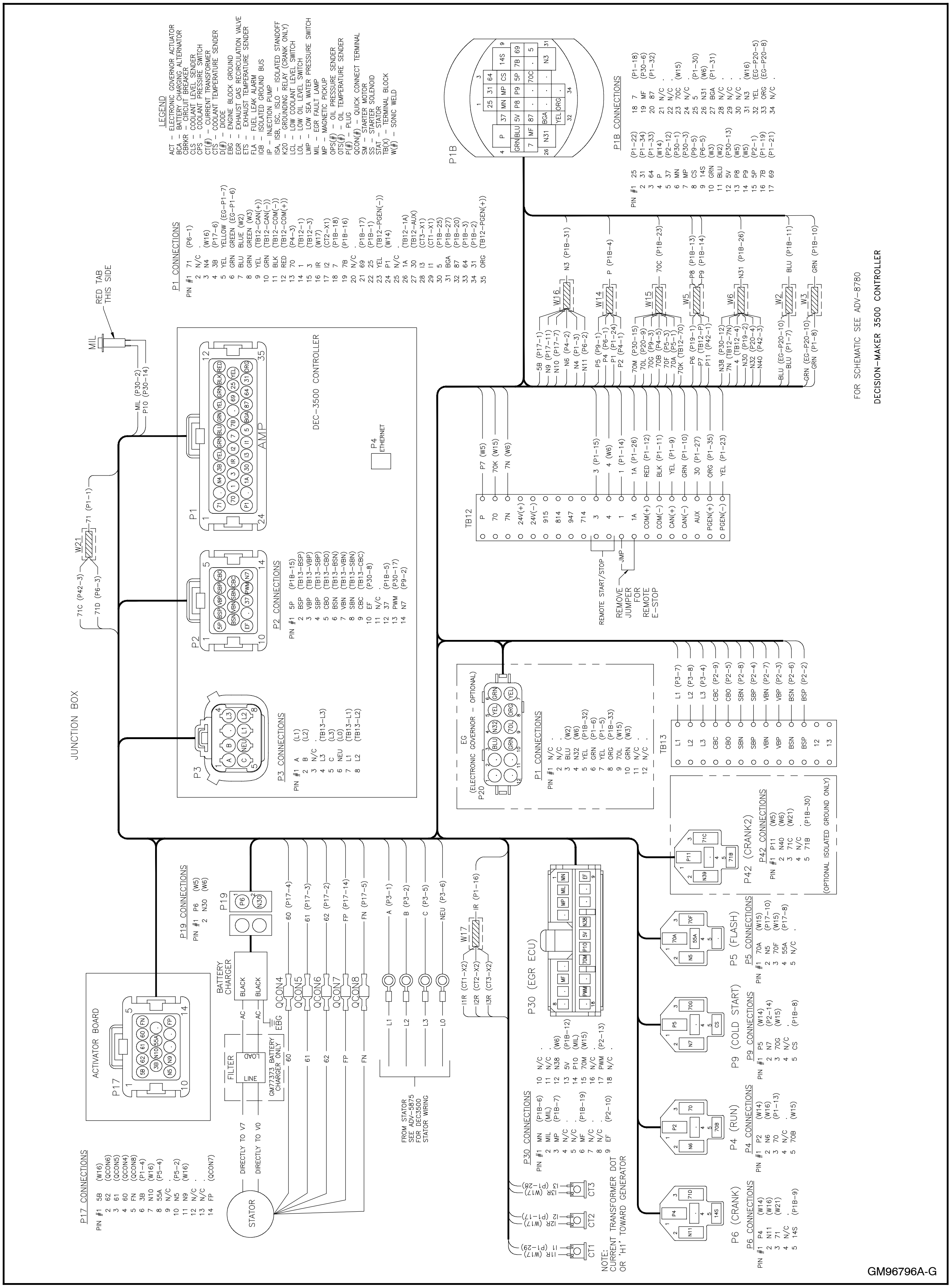


Figure 17-5 Wiring Diagram, Point-to-Point (Sheet 1 of 2) for 20- 24EKOZD 12-Volt Models

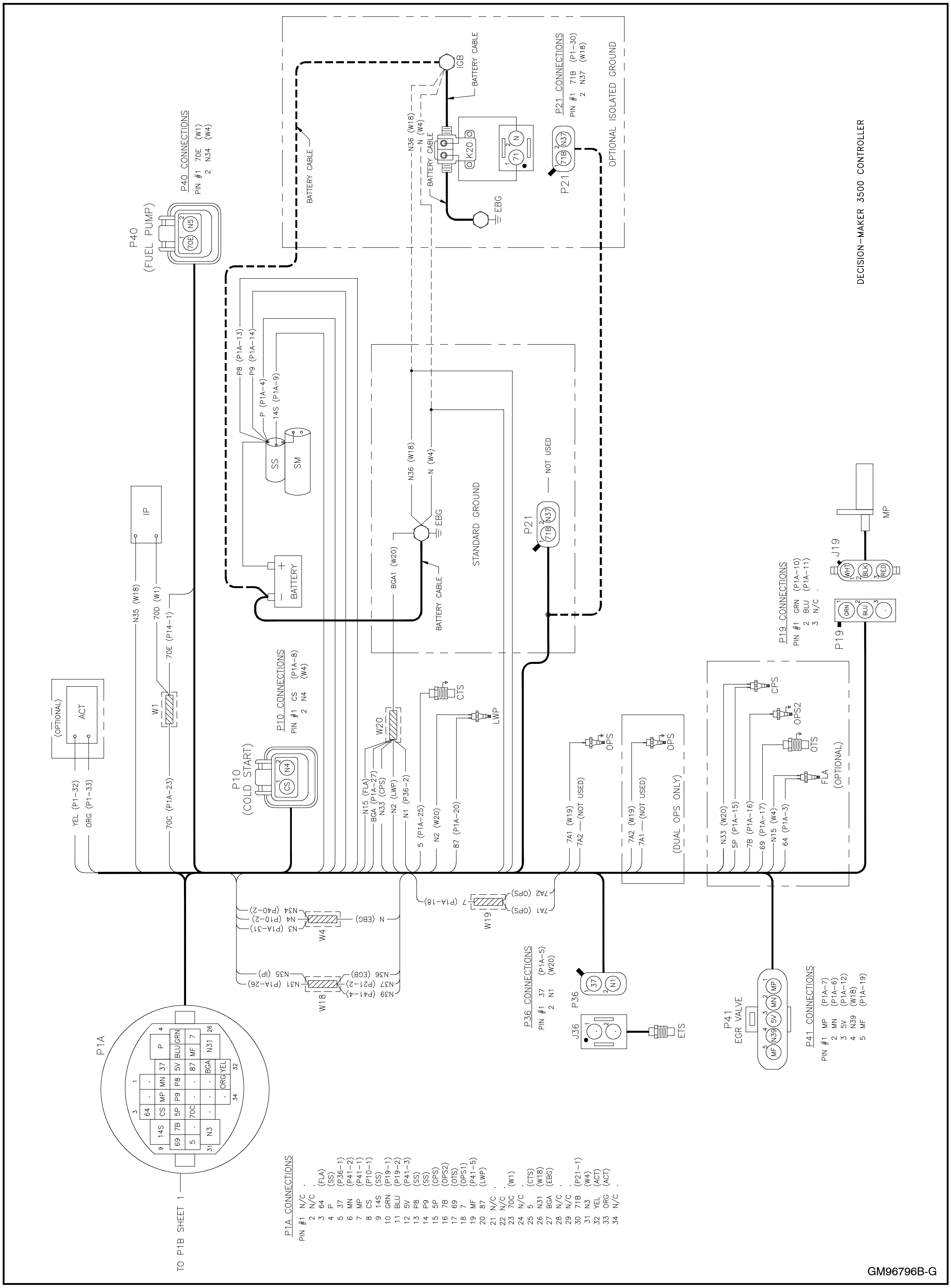


Figure 17-6 Wiring Diagram, Point-to-Point (Sheet 2 of 2) for 20- 24EKOZD 12-Volt Models

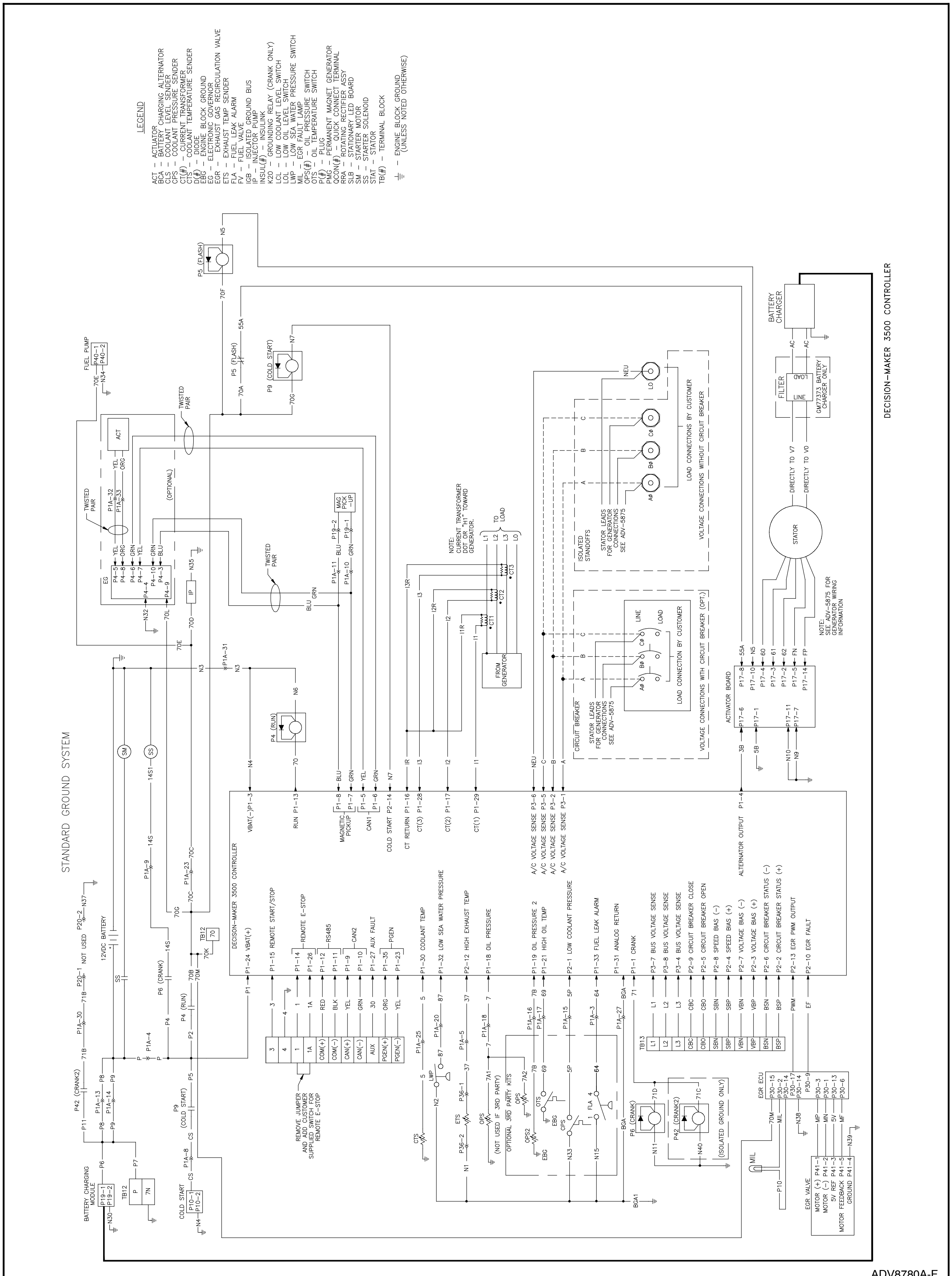


Figure 17-7 Wiring Diagram, Schematic (Sheet 1 of 2) for 20- 24EKOZD 12-Volt Models

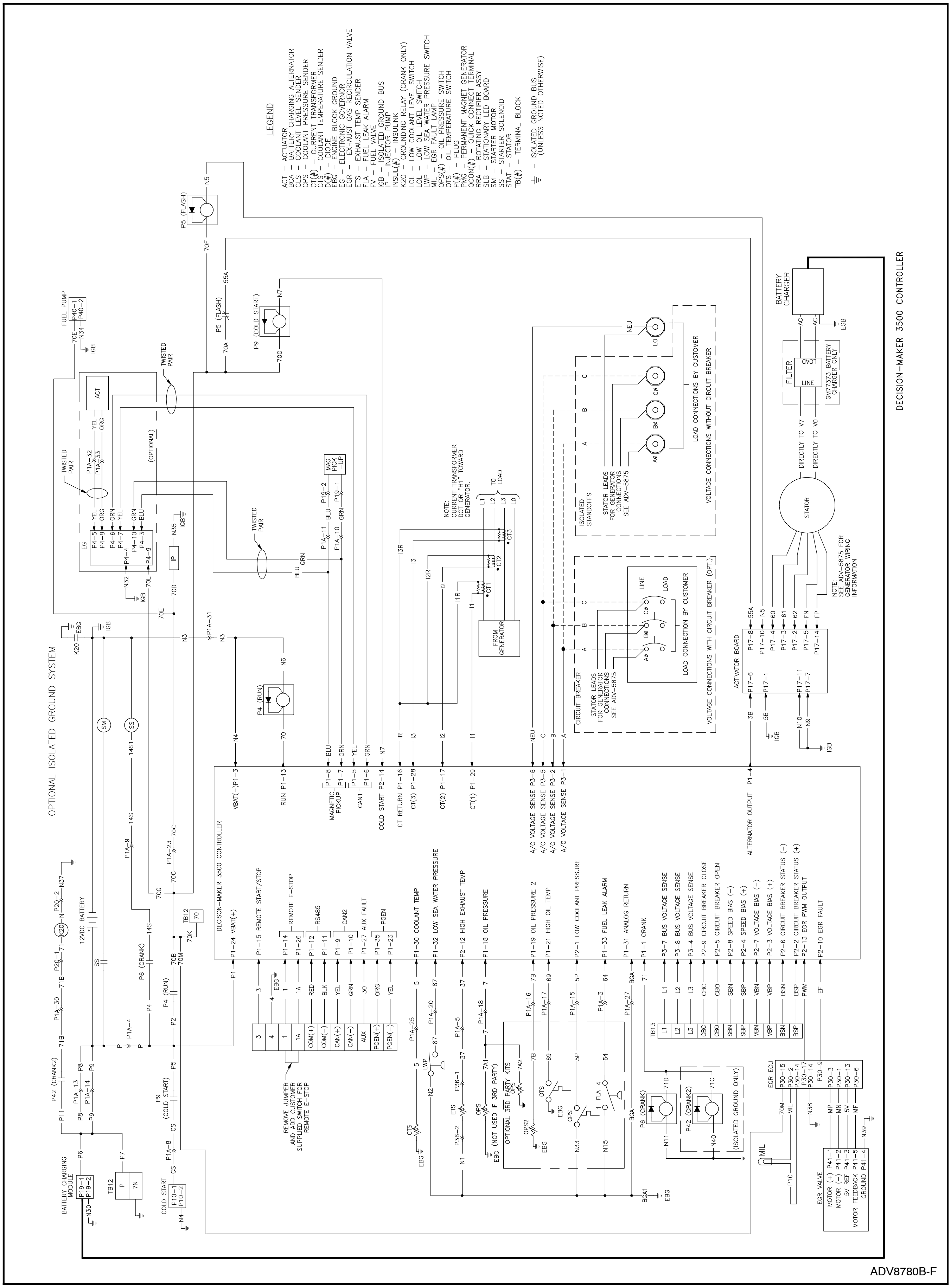


Figure 17-8 Wiring Diagram, Schematic (Sheet 2 of 2) for 20-24EKOZD 12-Volt Models

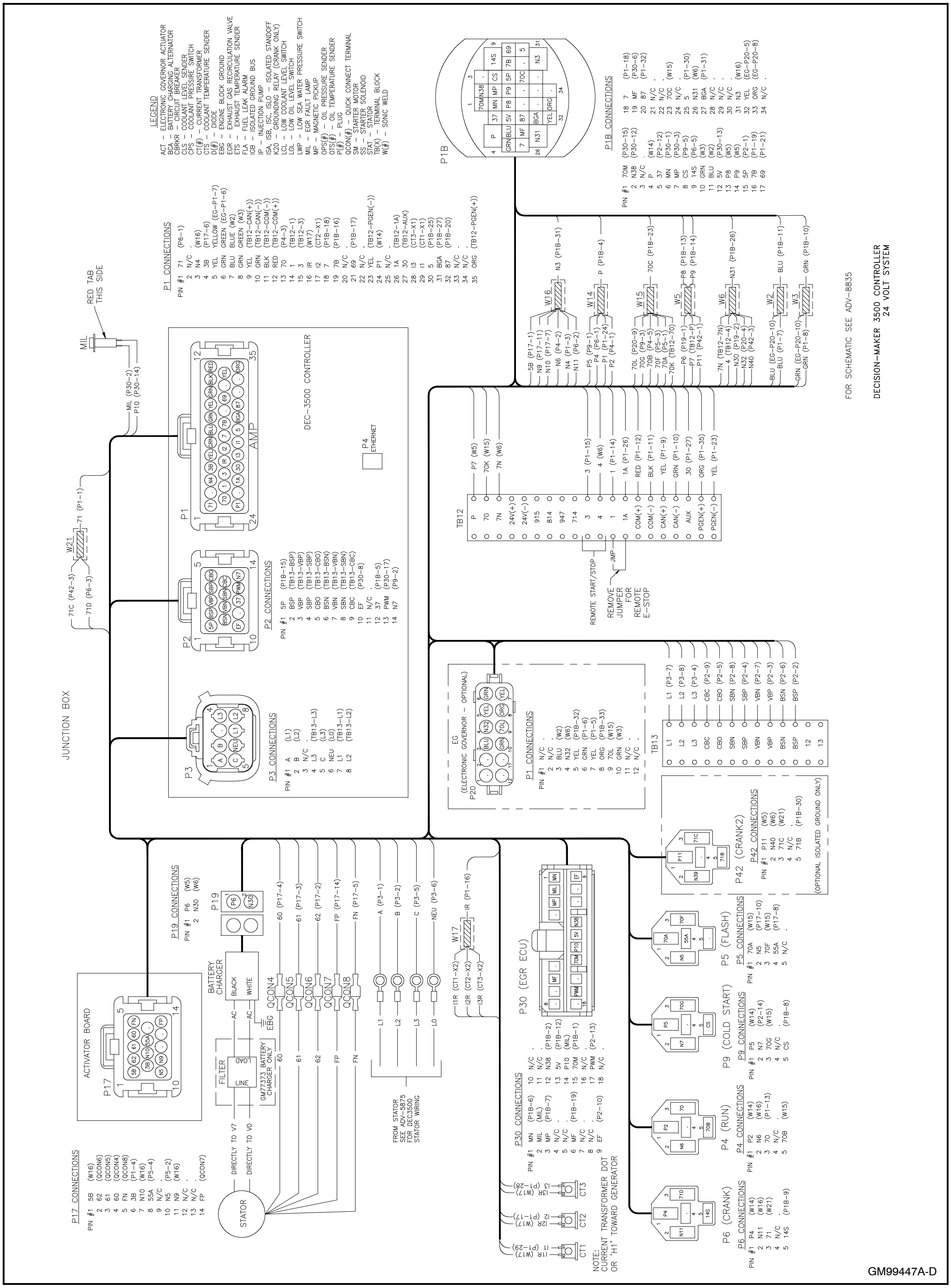


Figure 17-9 Wiring Diagram, Point-to-Point (Sheet 1 of 2) for 20- 24EKOZD 24-Volt Models

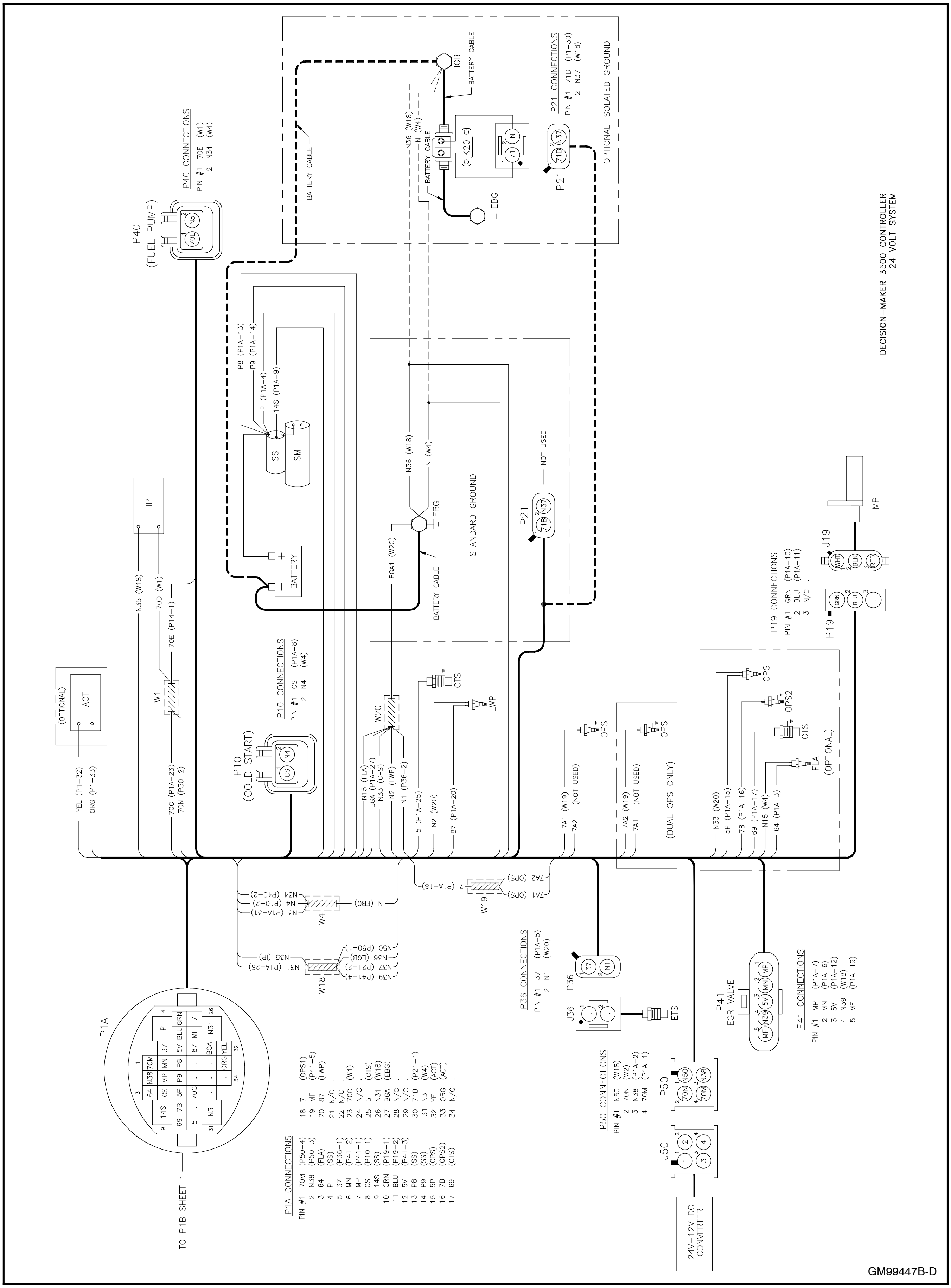


Figure 17-10 Wiring Diagram, Point-to-Point (Sheet 2 of 2) for 20- 24EKOZD 24-Volt Models

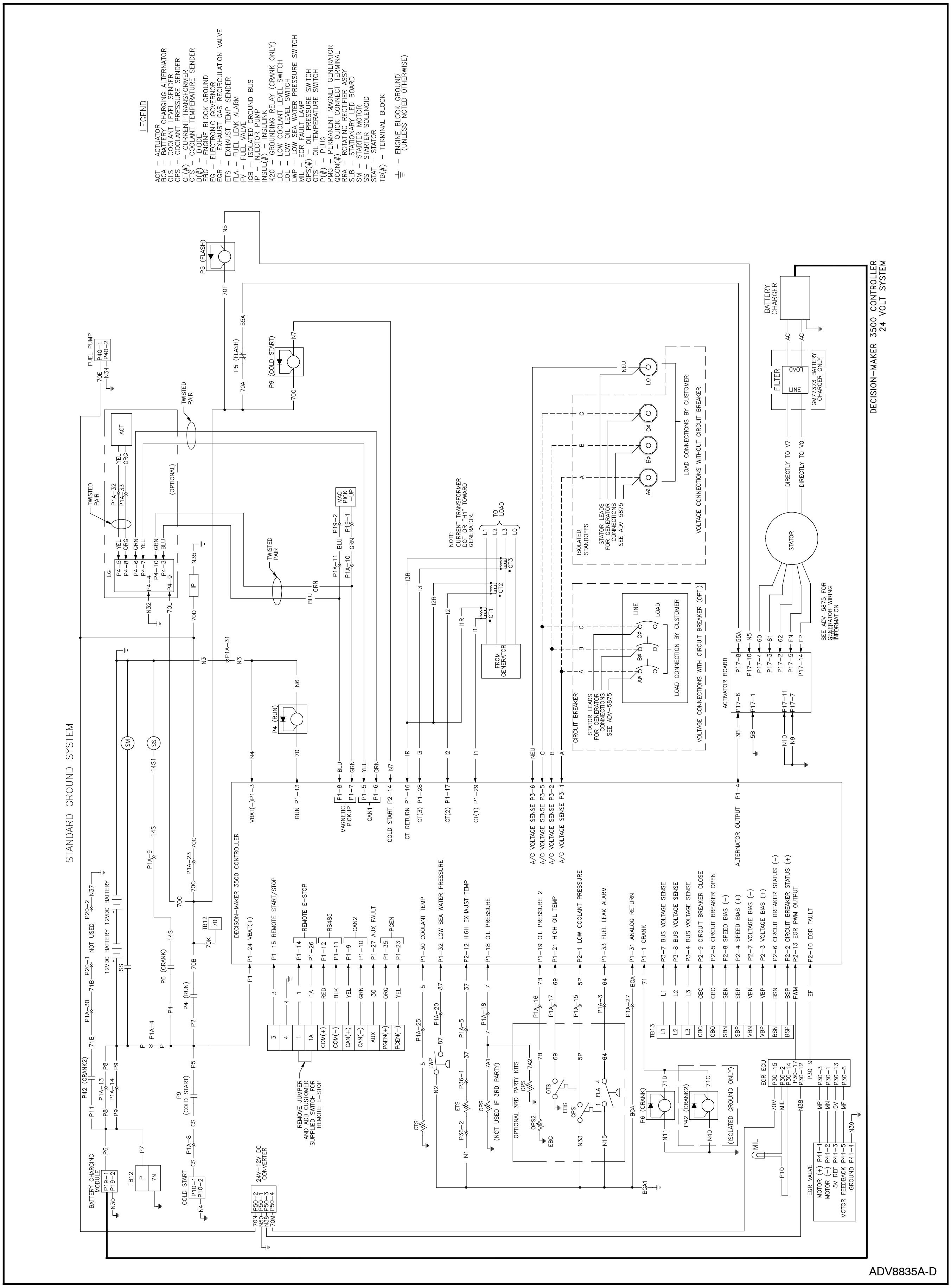


Figure 17-11 Wiring Diagram, Schematic (Sheet 1 of 2) for 20- 24EKOZD 24-Volt Models

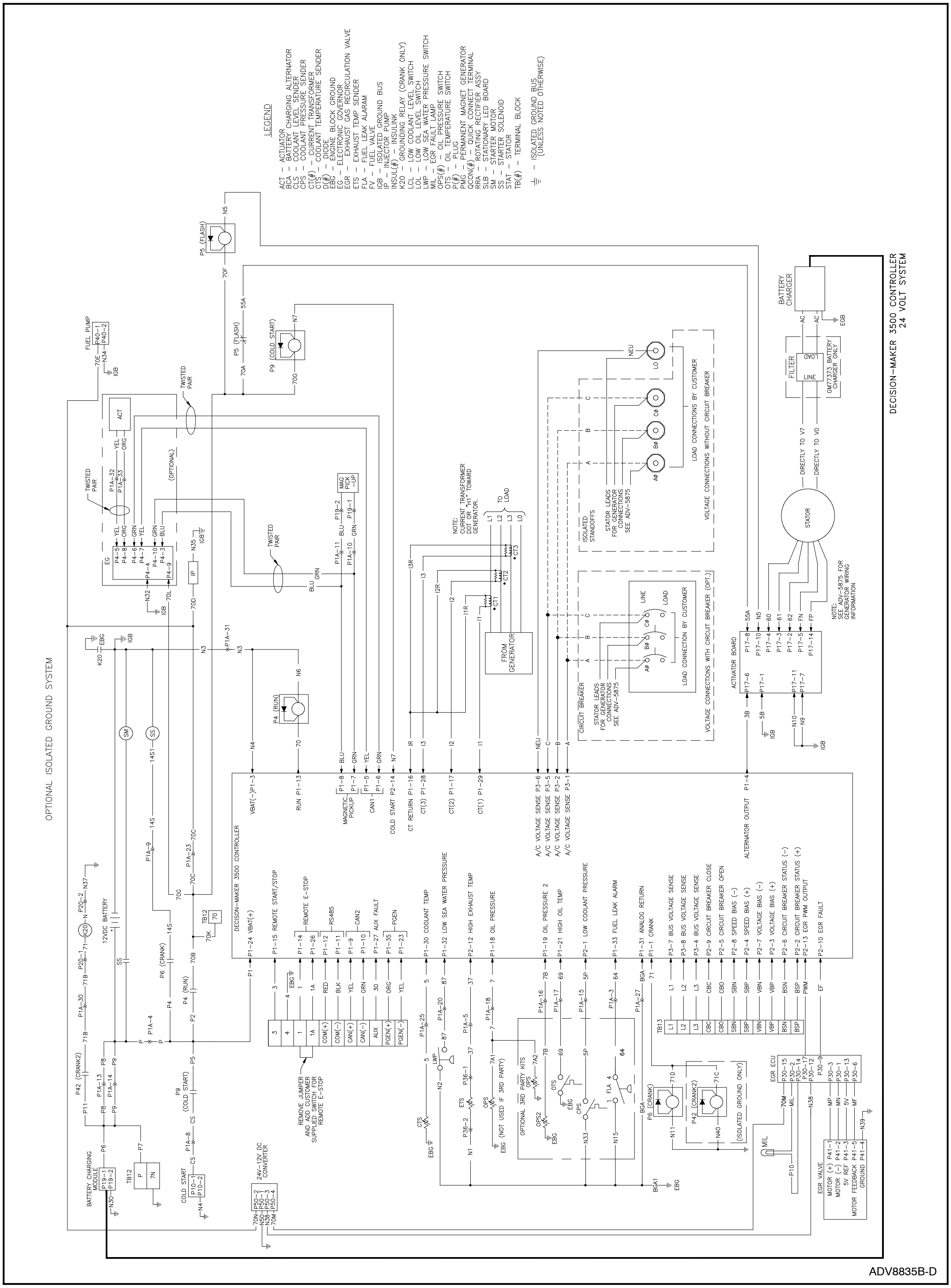


Figure 17-12 Wiring Diagram, Schematic (Sheet 2 of 2) for 20- 24EKOZD 24-Volt Models

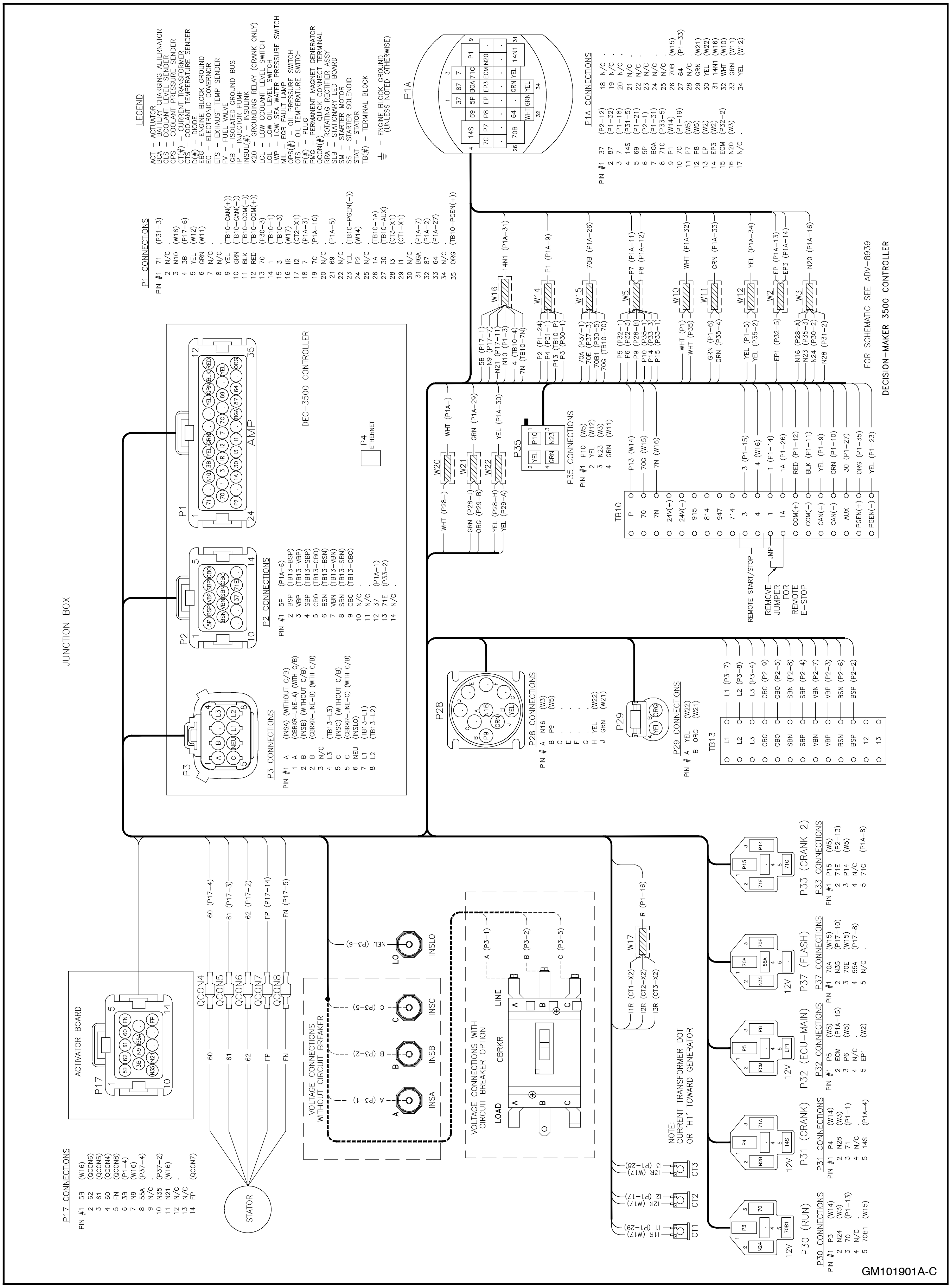


Figure 17-13 Wiring Diagram, Point-to-Point (Sheet 1 of 3) for 32EKOZD/28EFKOZD 12-Volt, Standard Ground Models

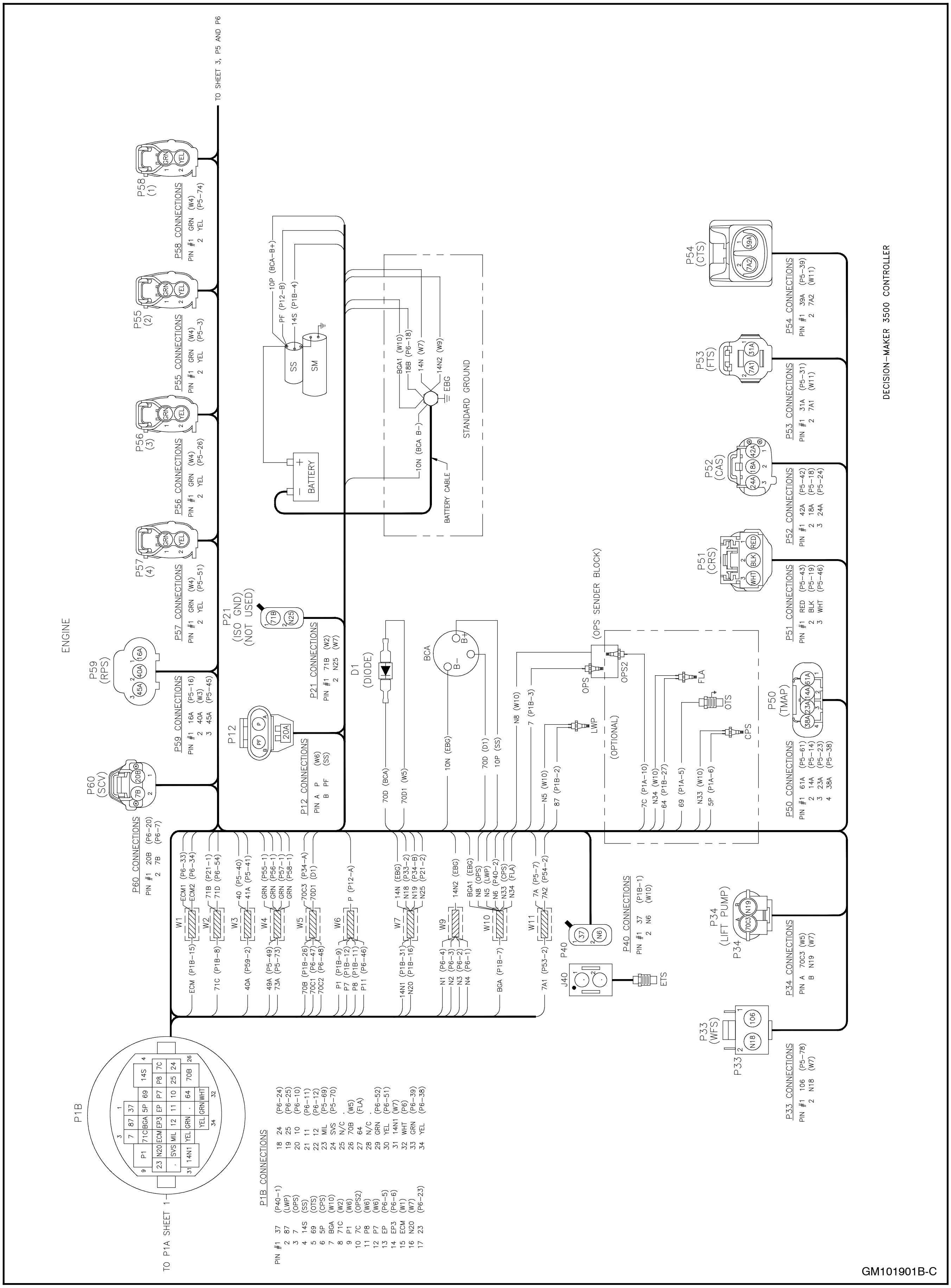


Figure 17-14 Wiring Diagram, Point-to-Point (Sheet 2 of 3) for 32EKOZD/28EFKOZD 12-Volt, Standard Ground Models

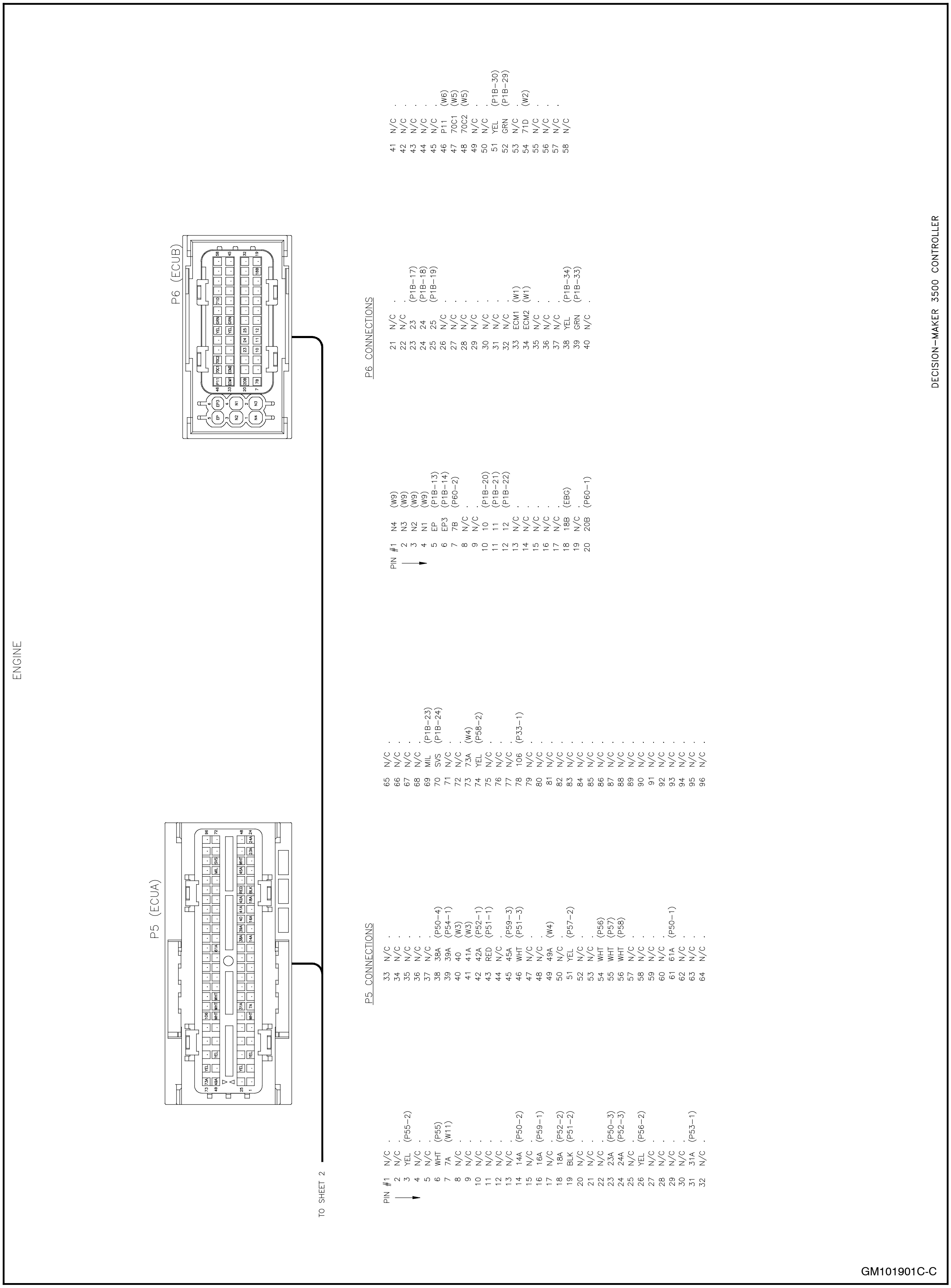


Figure 17-15 Wiring Diagram, Point-to-Point (Sheet 3 of 3) for 32EKOZD/28EFKOZD 12-Volt, Standard Ground Models

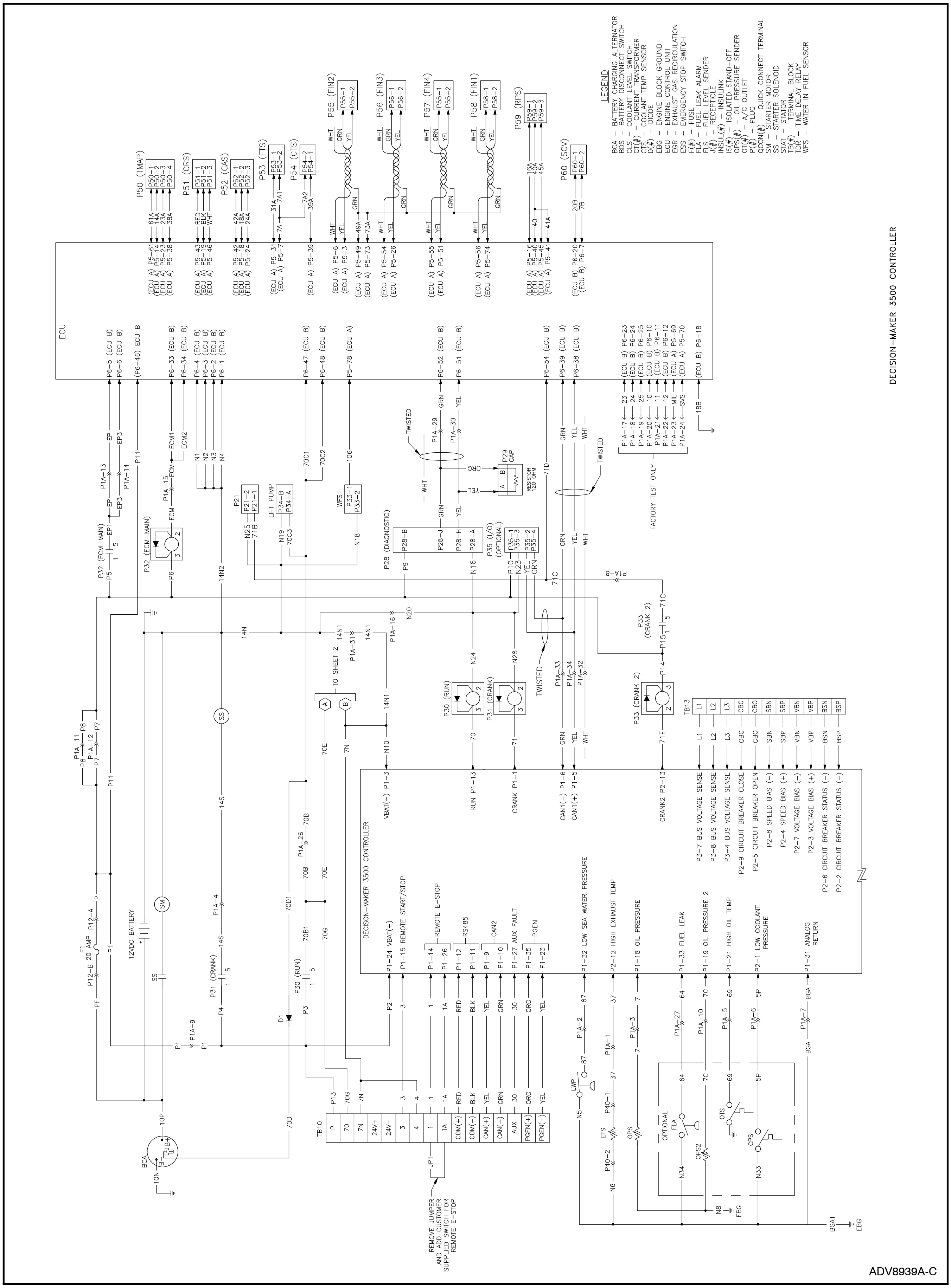


Figure 17-16 Wiring Diagram, Schematic (Sheet 1 of 2) for 32EKOZD/28EFKOZD 12-Volt, Standard Ground Models

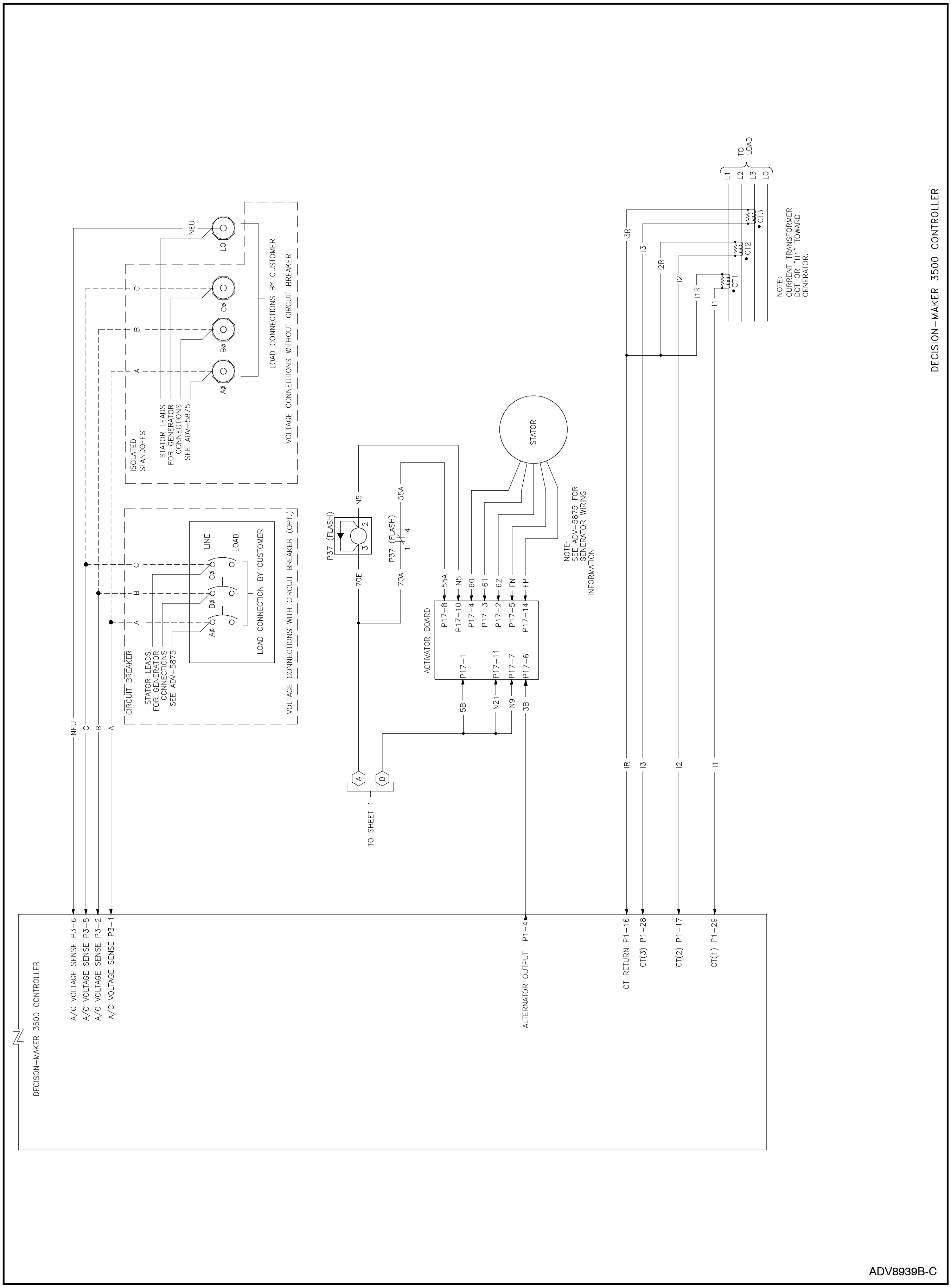


Figure 17-17 Wiring Diagram, Schematic (Sheet 2 of 2) for 32EKOZD/28EFKOZD 12-Volt, Standard Ground Models

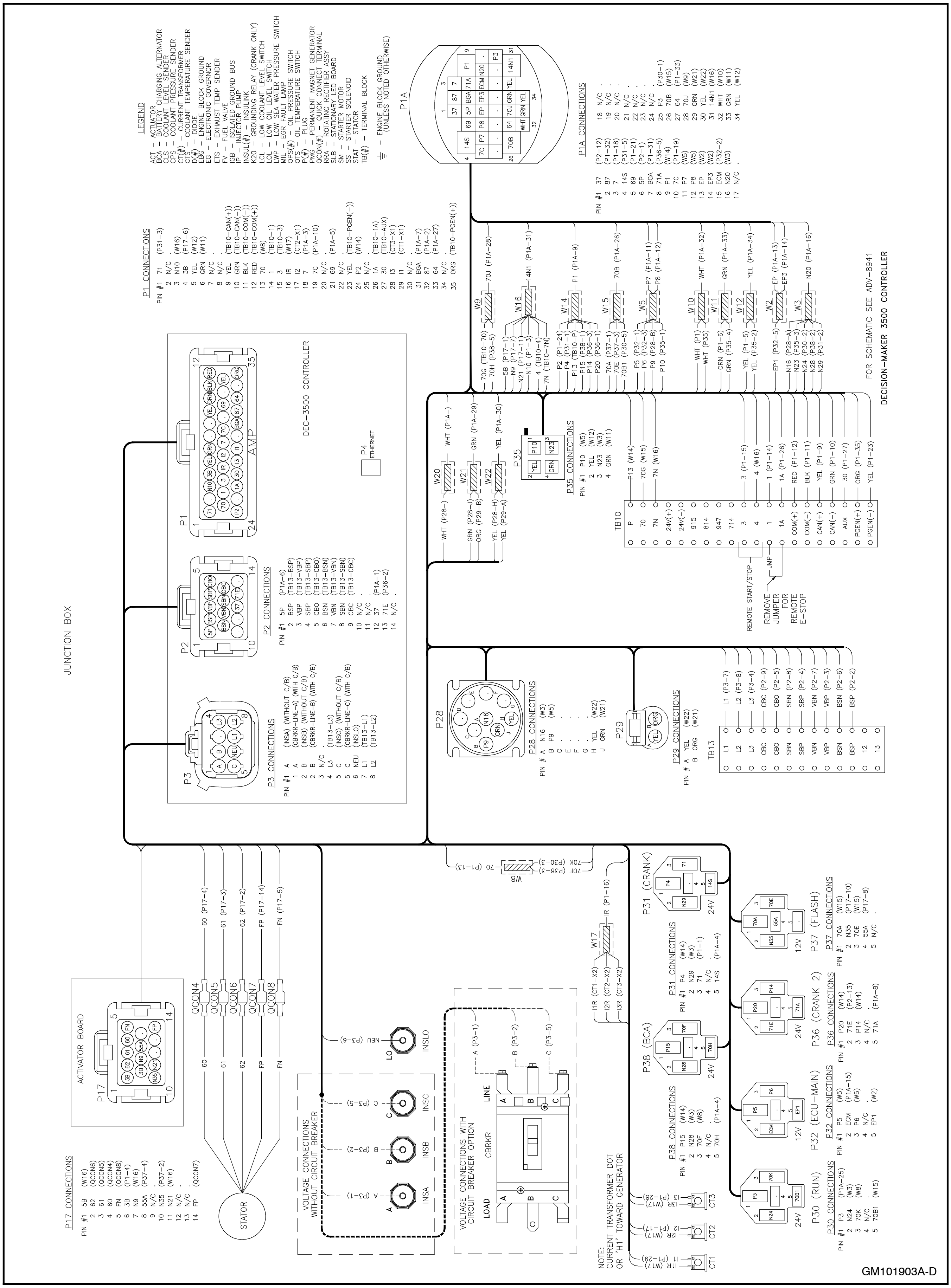


Figure 17-18 Wiring Diagram, Point-to-Point (Sheet 1 of 3) for 32EKOZD/28EFKOZD 24-Volt, Standard Ground Models

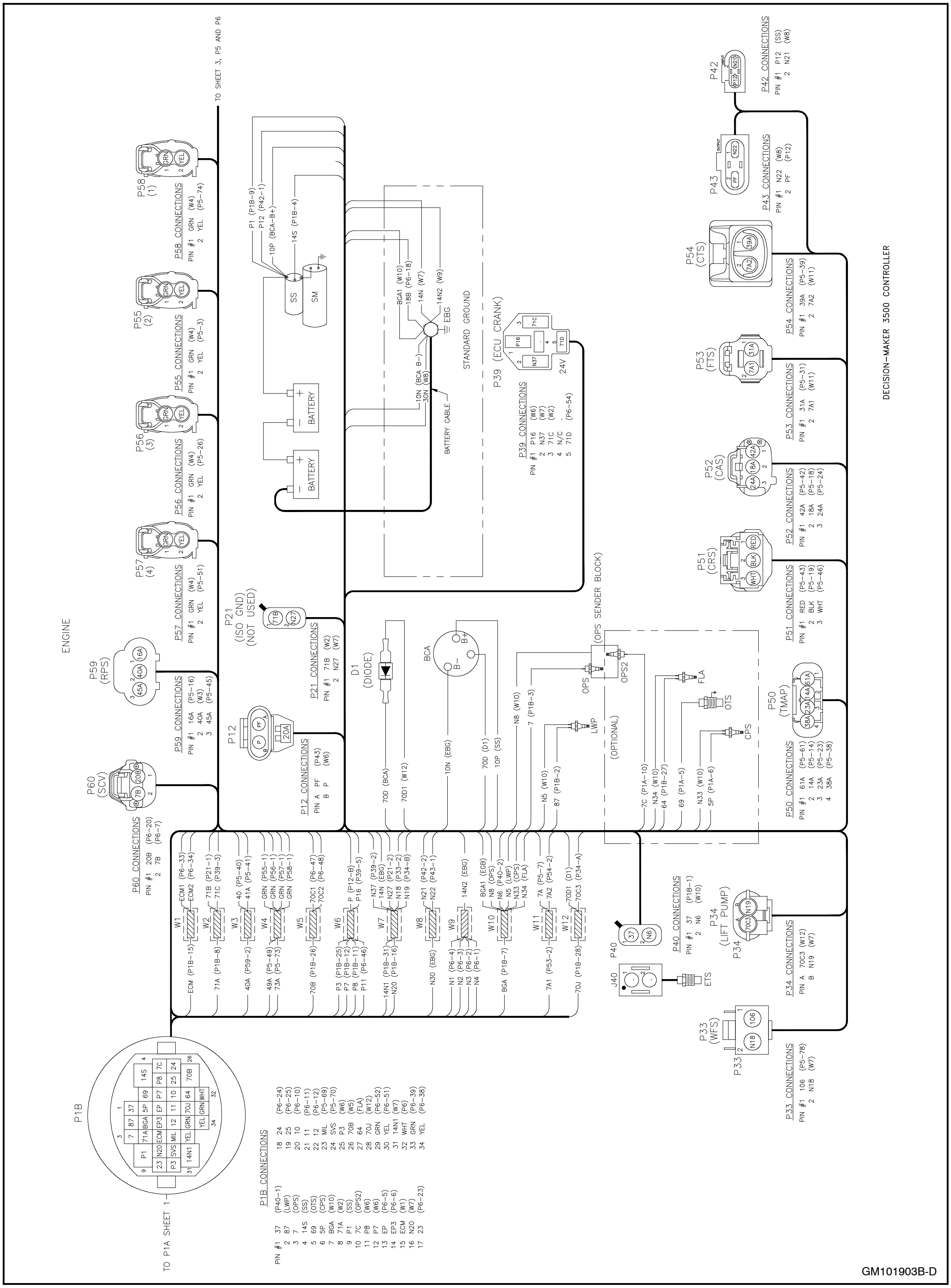


Figure 17-19 Wiring Diagram, Point-to-Point (Sheet 2 of 3) for 32EKOZD/28EFKOZD 24-Volt, Standard Ground Models

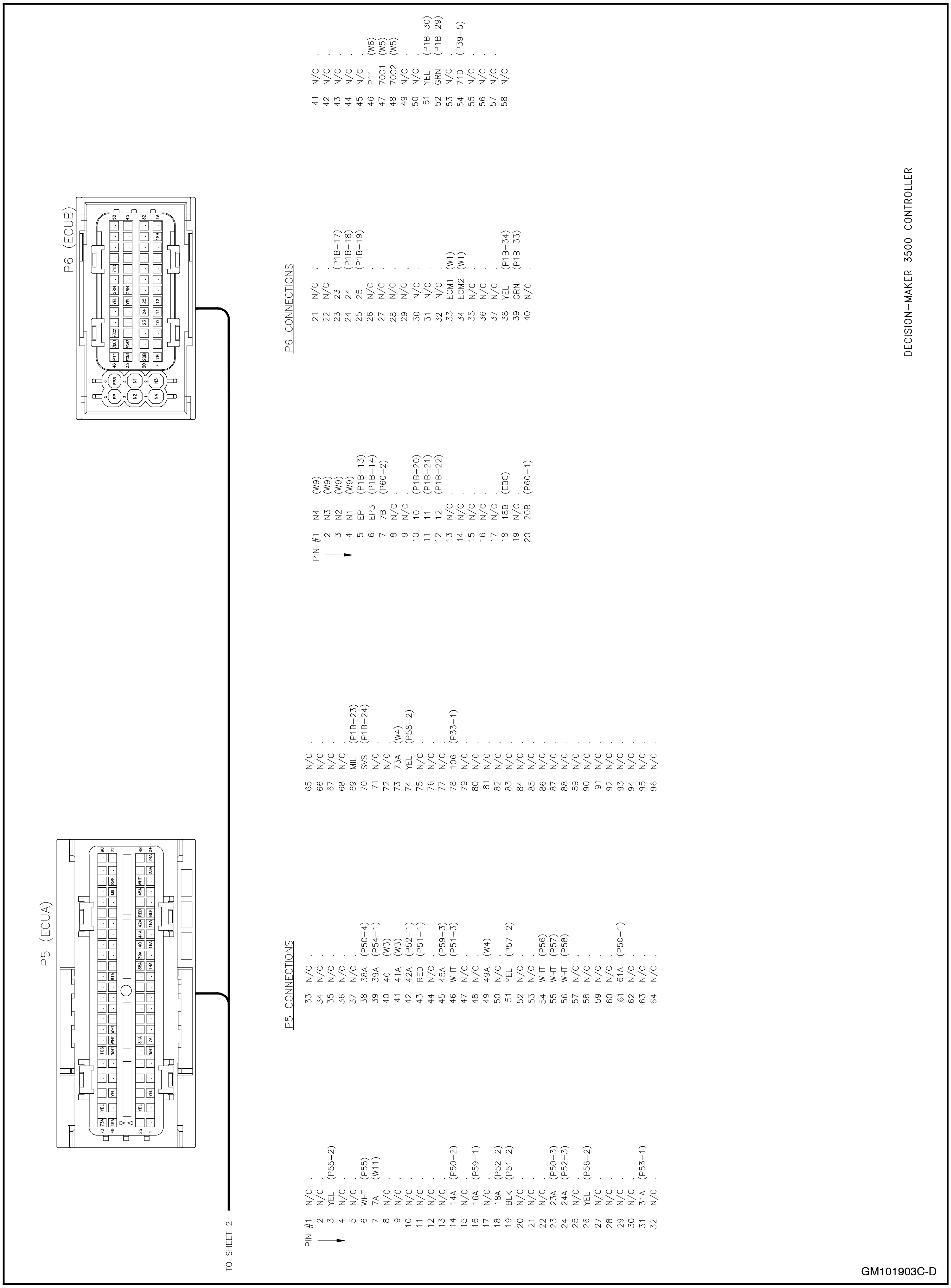


Figure 17-20 Wiring Diagram, Point-to-Point (Sheet 3 of 3) for 32EKOZD/28EFKOZD 24-Volt, Standard Ground Models

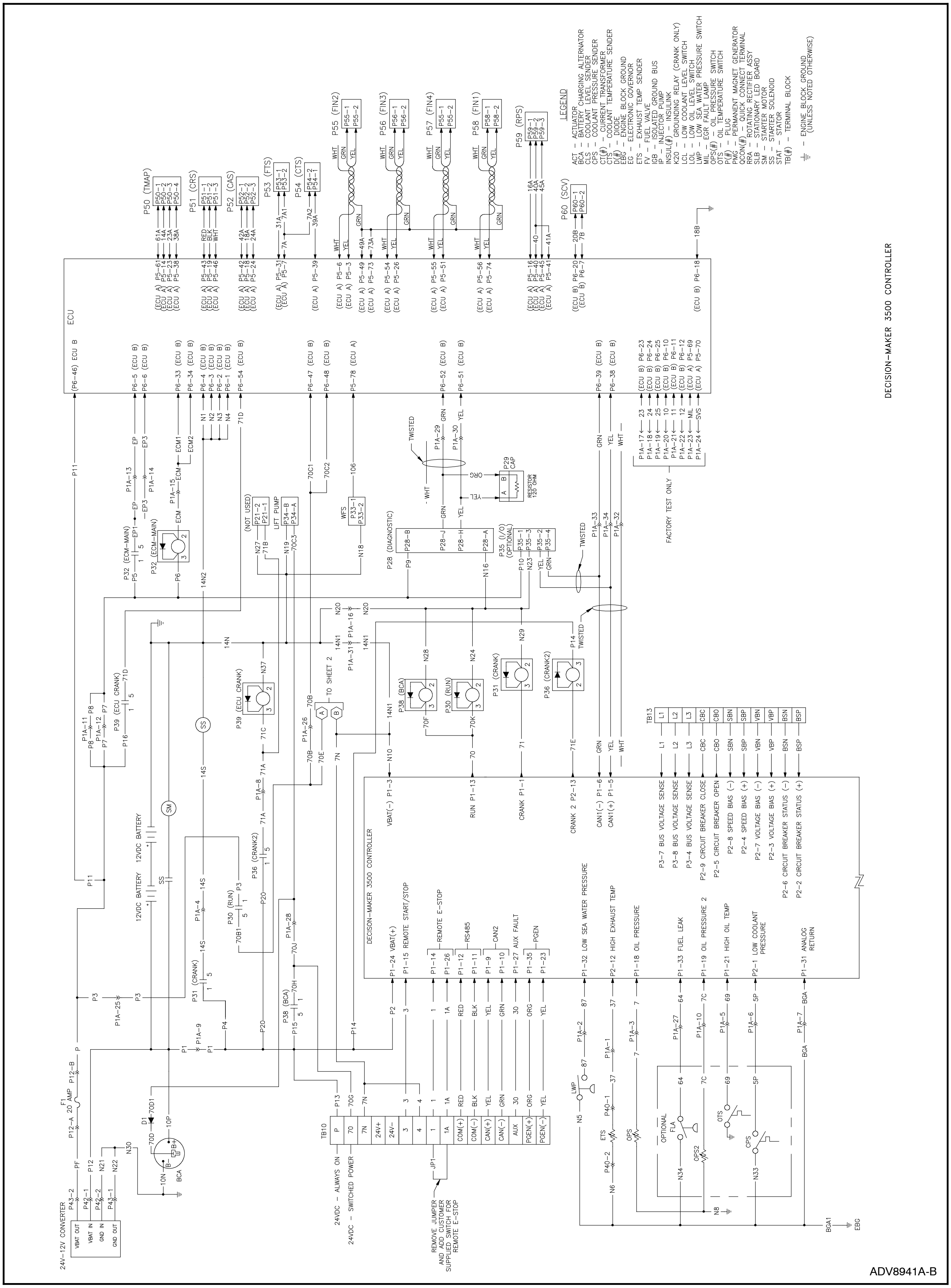
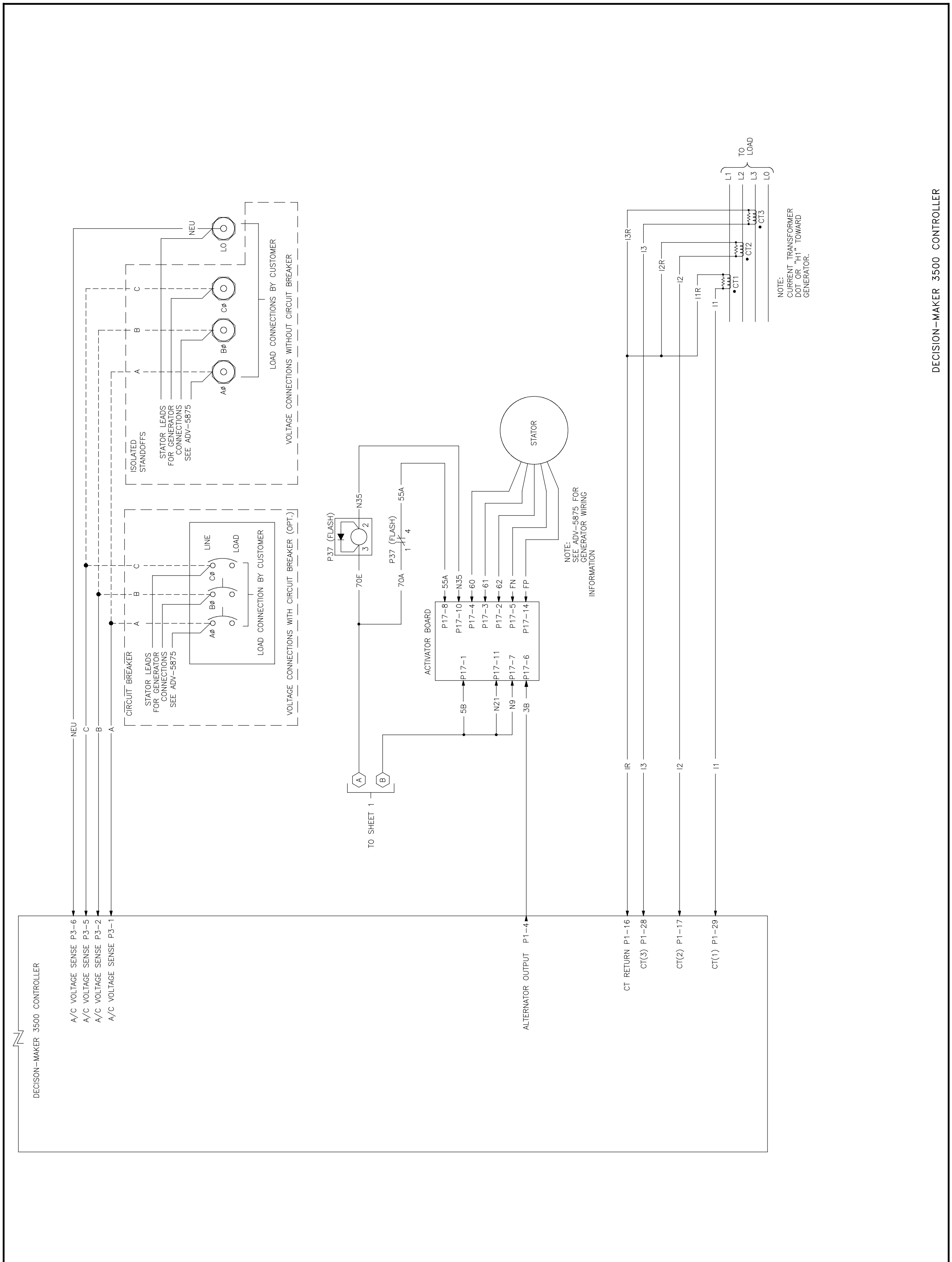


Figure 17-21 Wiring Diagram, Schematic (Sheet 1 of 2) for 32EKOZD/28EFKOZD 24-Volt, Standard Ground Models



ADV8941B-B

Figure 17-22 Wiring Diagram, Schematic (Sheet 2 of 2) for 32EKOZD/28EFKOZD 24-Volt, Standard Ground Models

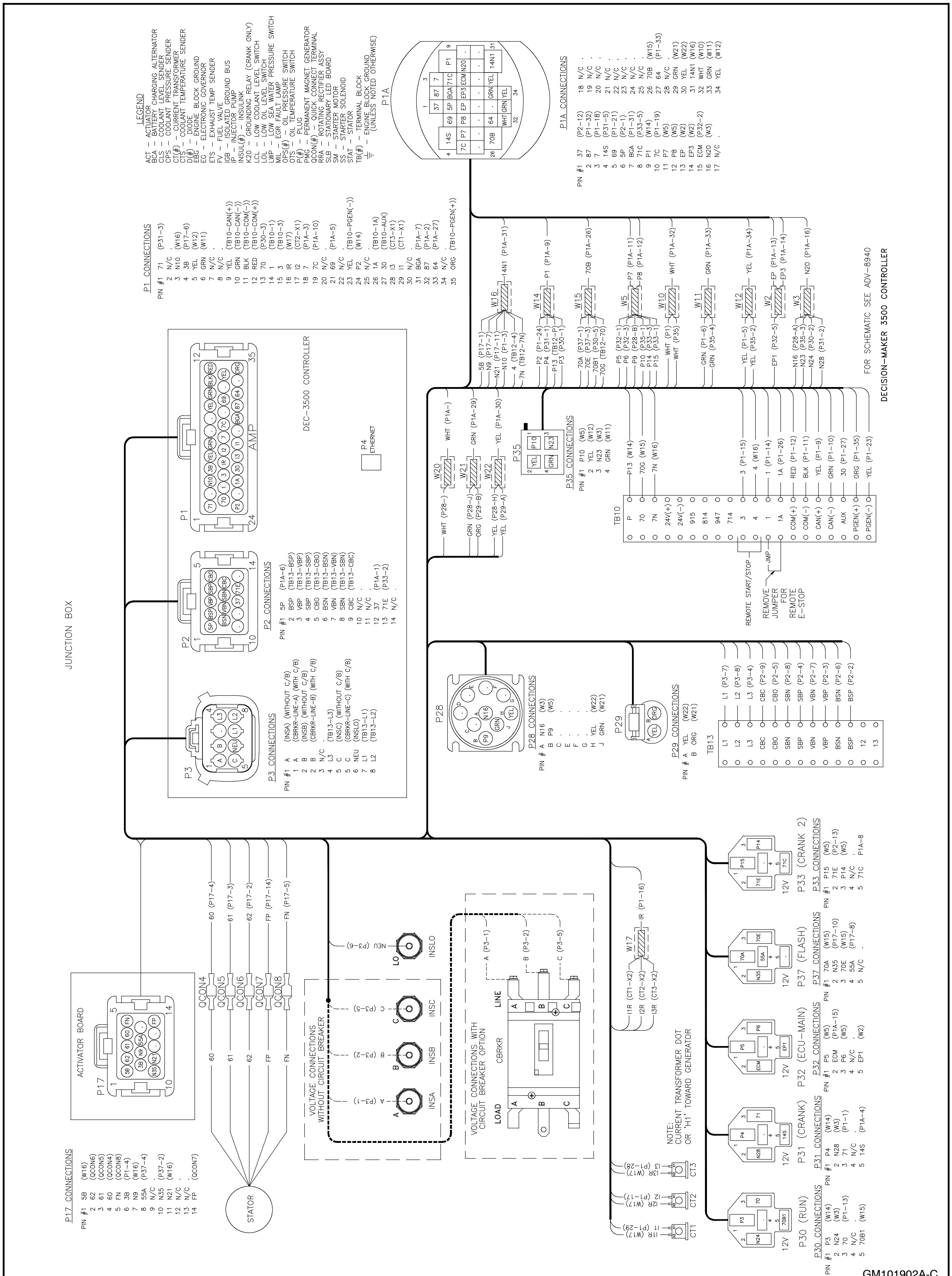


Figure 17-23 Wiring Diagram, Point-to-Point (Sheet 1 of 3) for 32EKOZD/28EFKOZD 12-Volt, Isolated Ground Models

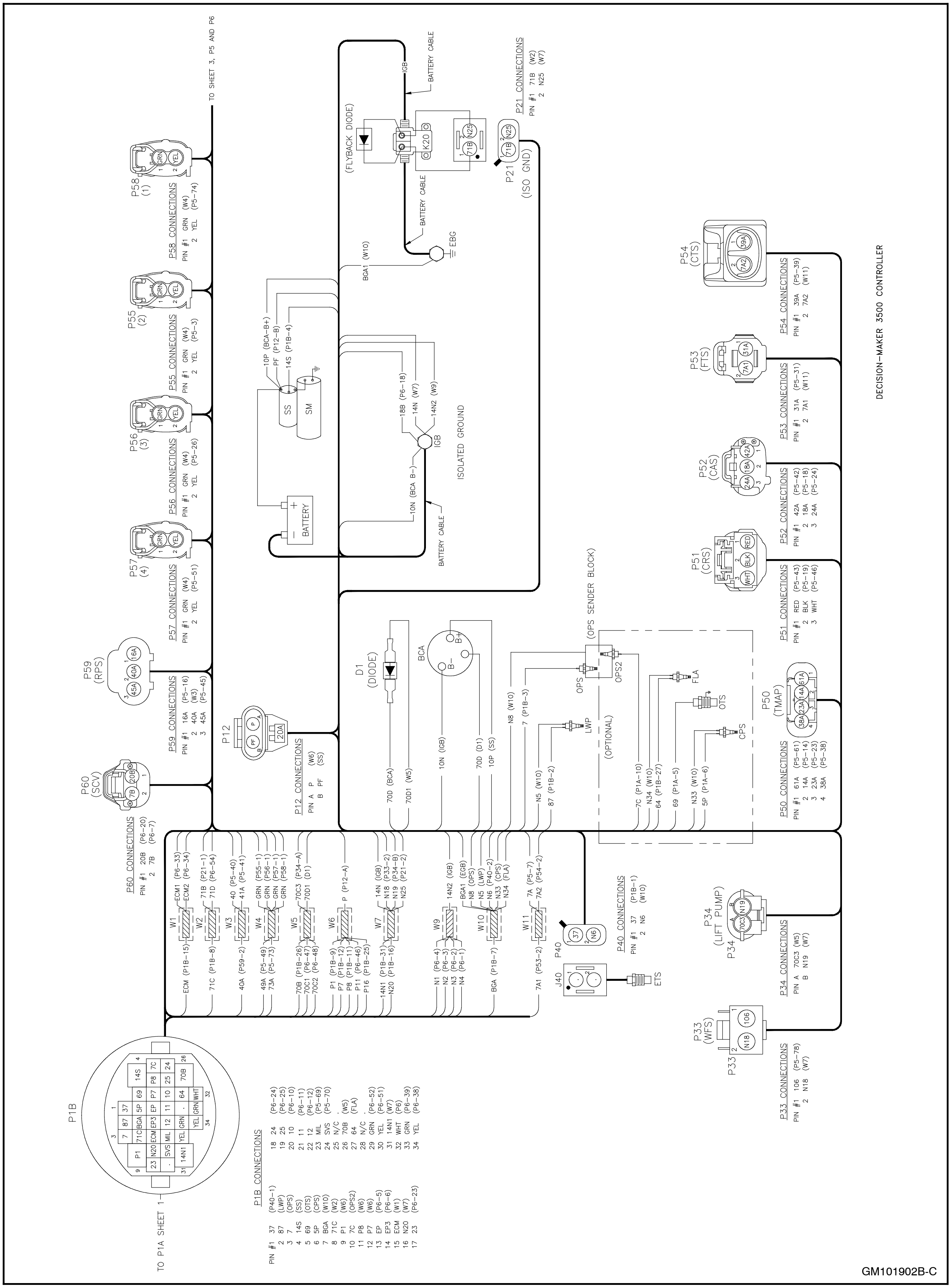


Figure 17-24 Wiring Diagram, Point-to-Point (Sheet 2 of 3) for 32EKOZD/28EFKOZD 12-Volt, Isolated Ground Models

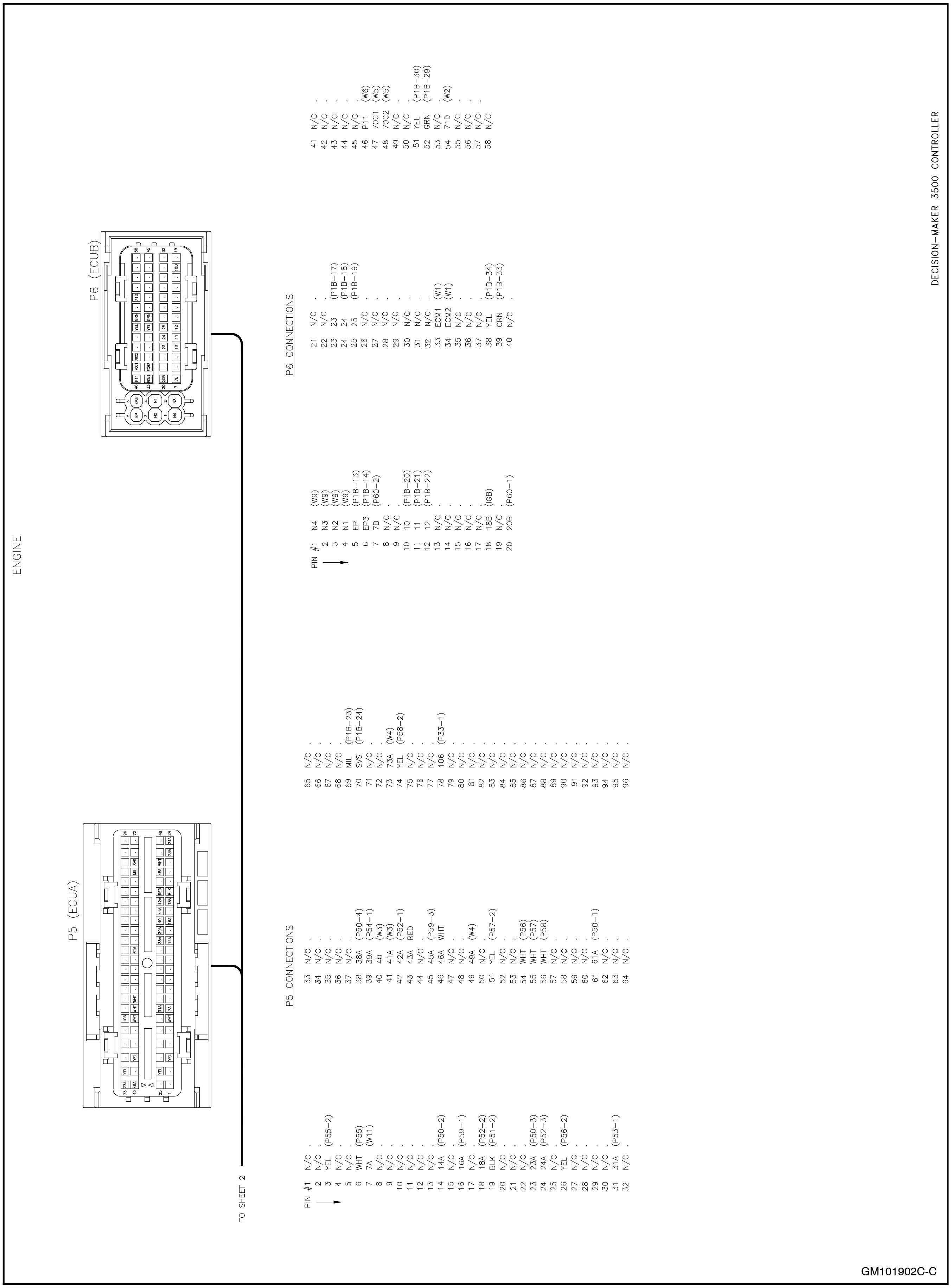


Figure 17-25 Wiring Diagram, Point-to-Point (Sheet 3 of 3) for 32EKOZD/28EFKOZD 12-Volt, Isolated Ground Models

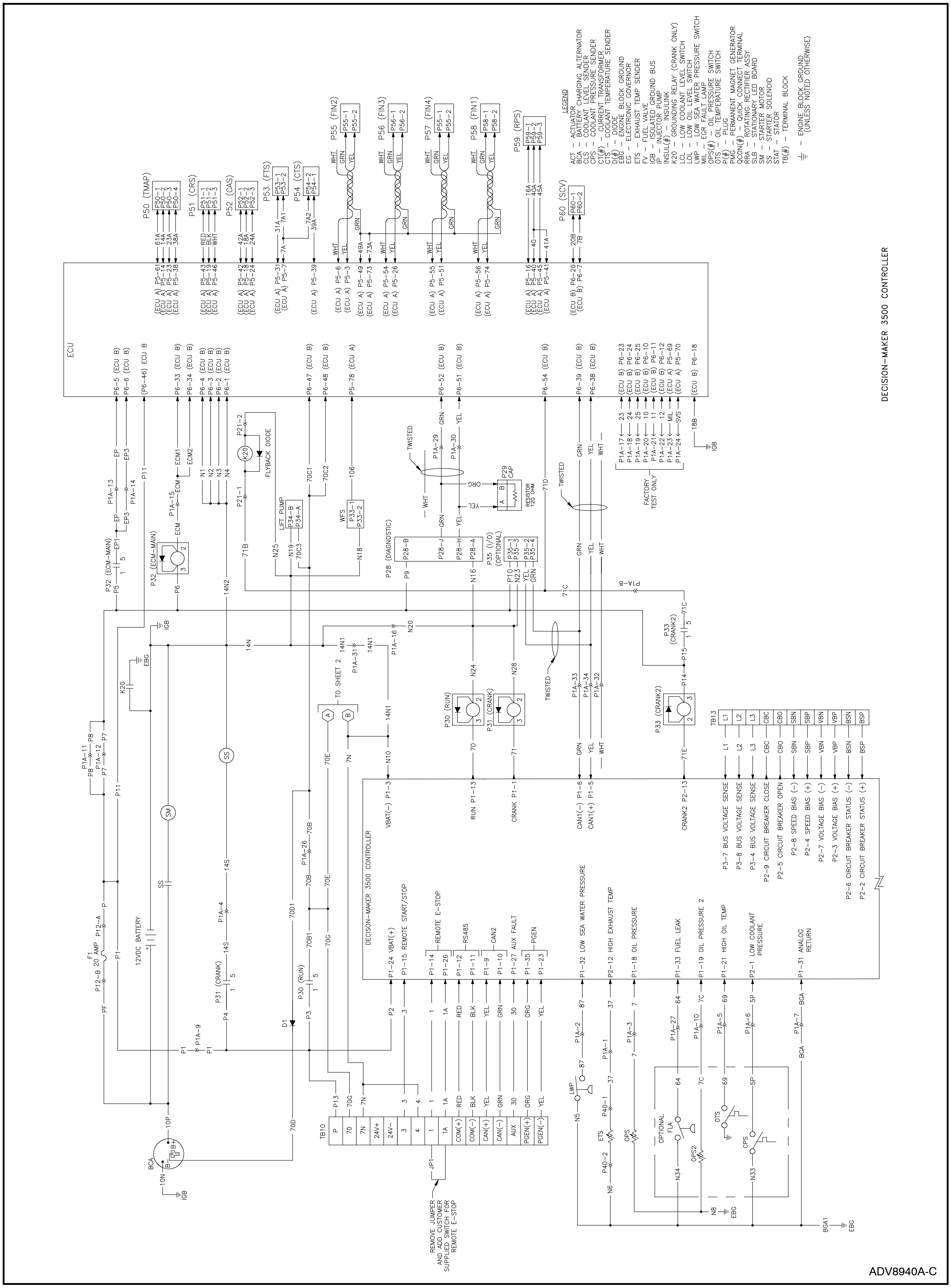


Figure 17-26 Wiring Diagram, Schematic (Sheet 1 of 2) for 32EKOZD/28EFKOZD 12-Volt, Isolated Ground Models

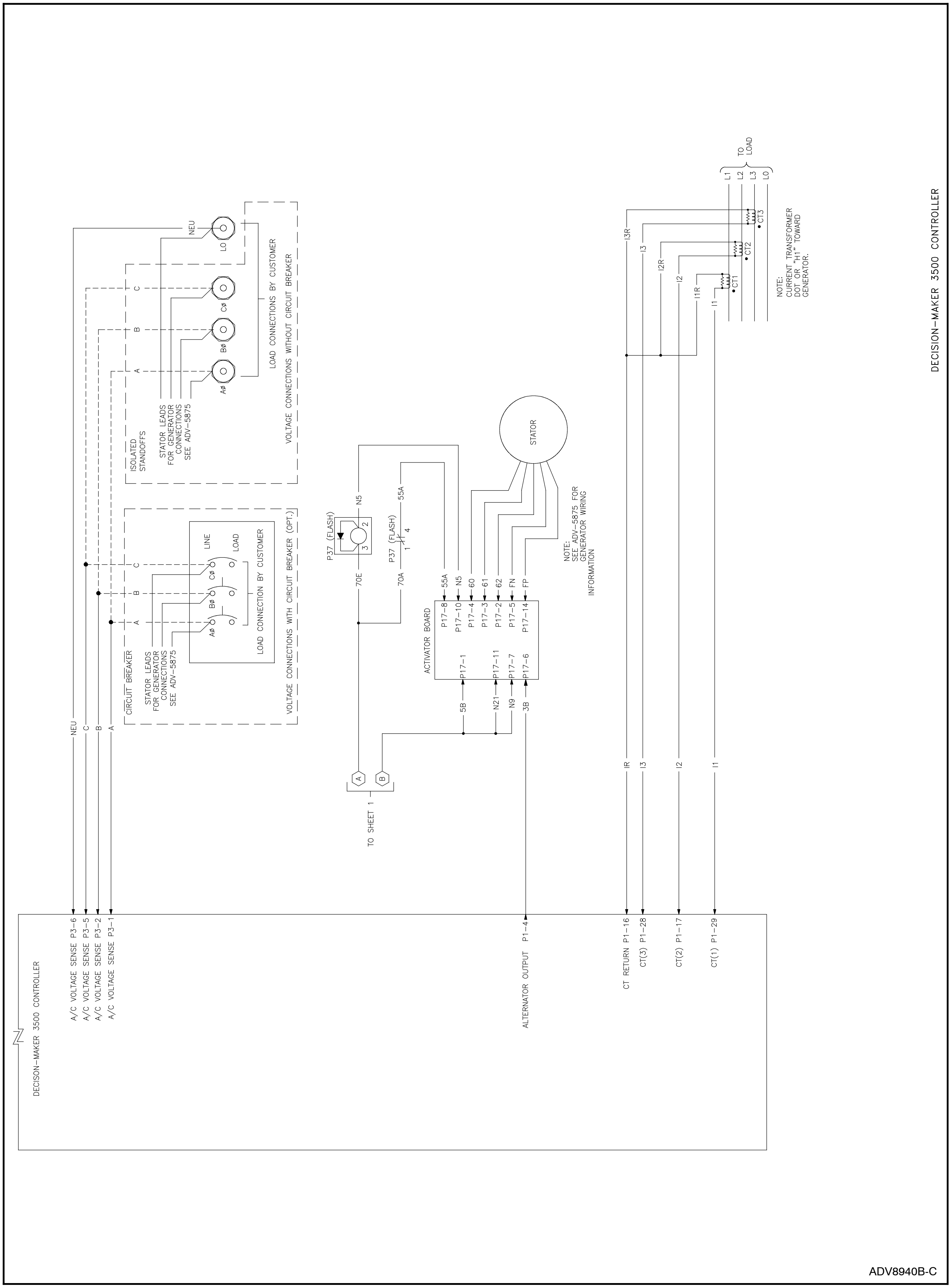


Figure 17-27 Wiring Diagram, Schematic (Sheet 2 of 2) for 32EKOZD/28EFKOZD 12-Volt, Isolated Ground Models

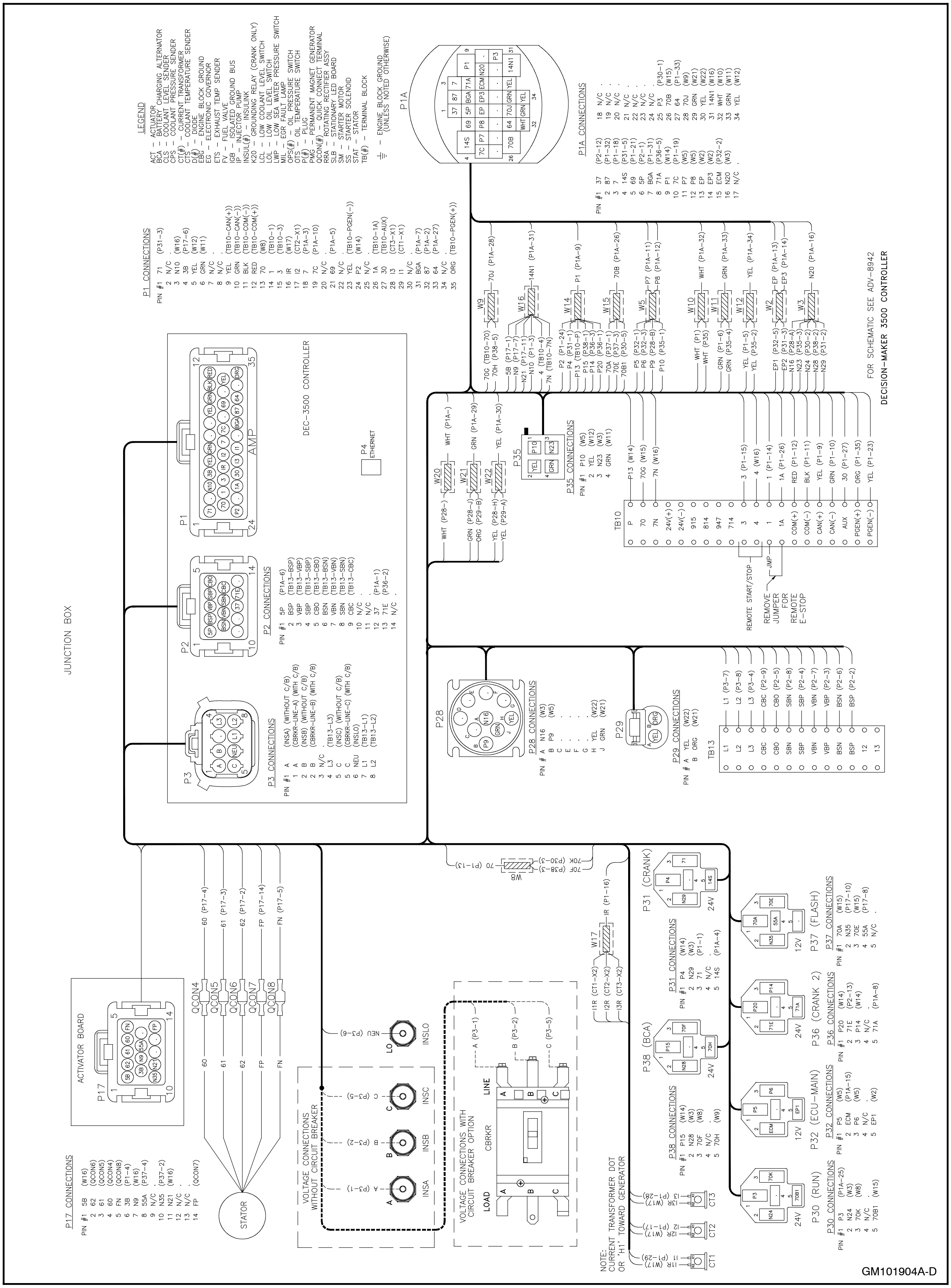


Figure 17-28 Wiring Diagram, Point-to-Point (Sheet 1 of 3) for 32EKOZD/28EFKOZD 24-Volt, Isolated Ground Models

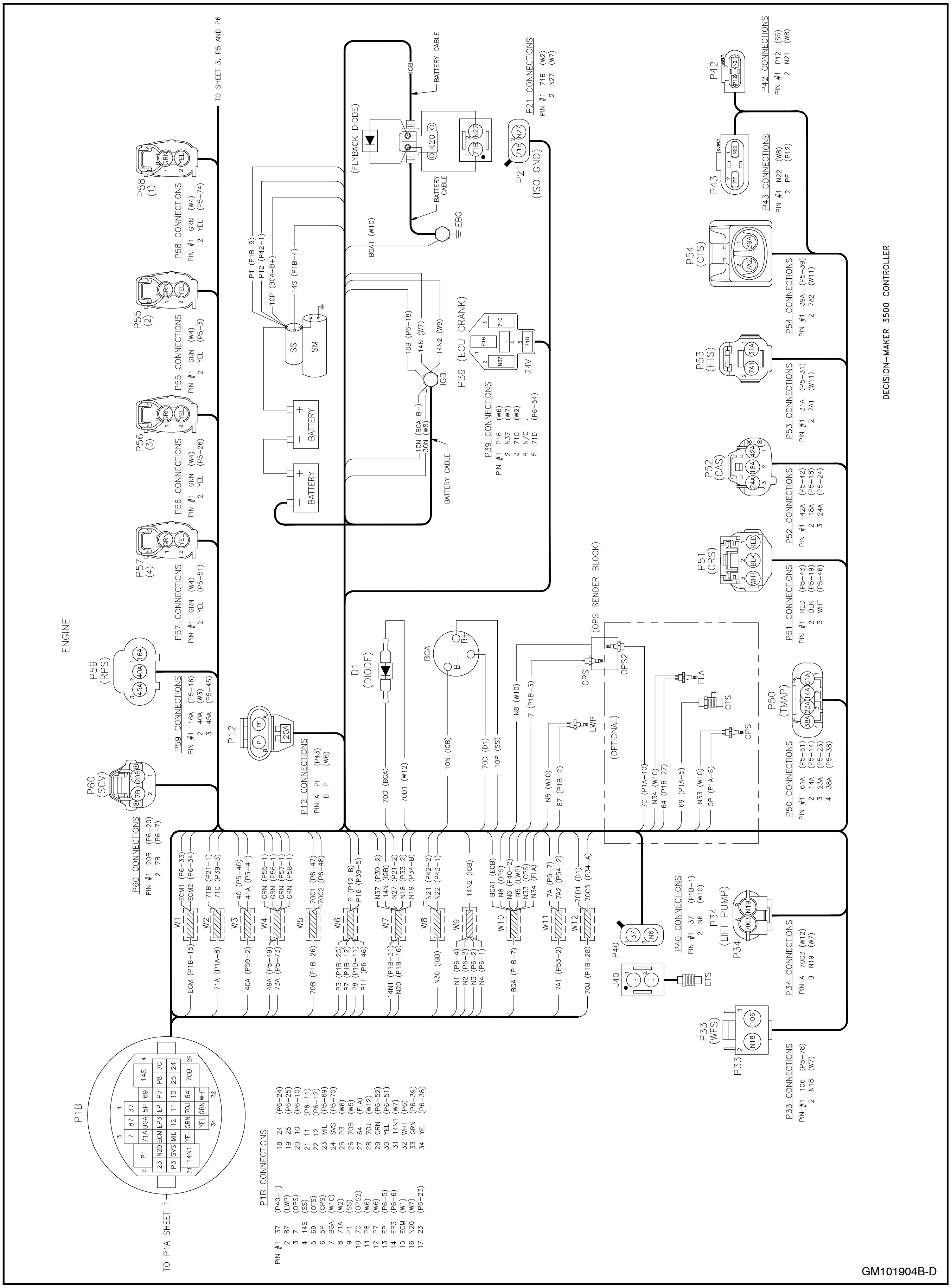


Figure 17-29 Wiring Diagram, Point-to-Point (Sheet 2 of 3) for 32EKOZD/28EFKOZD 24-Volt, Isolated Ground Models

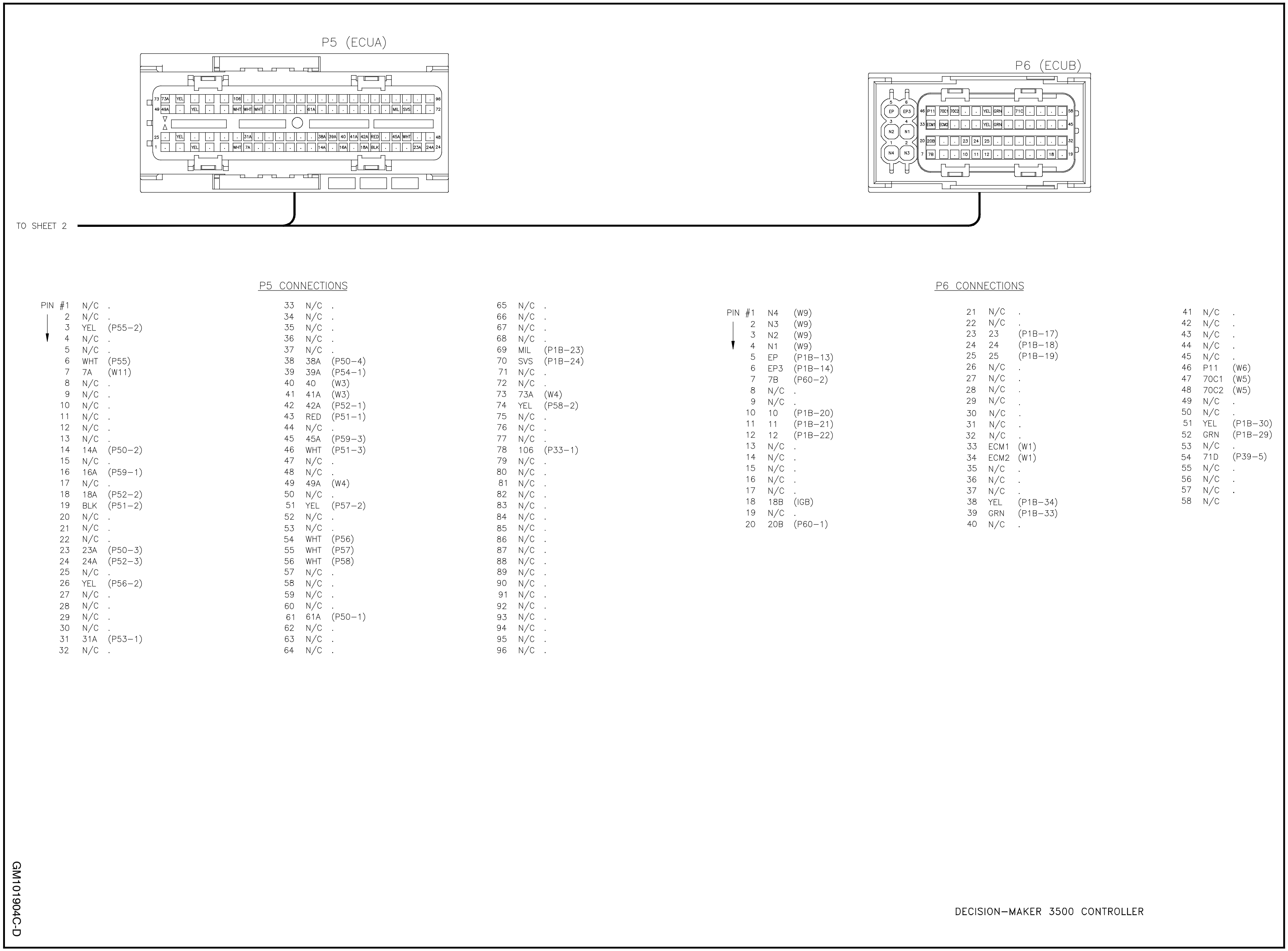


Figure 17-30 Wiring Diagram, Point-to-Point (Sheet 3 of 3) for 32EKOZD/28EFKOZD 24-Volt, Isolated Ground Models

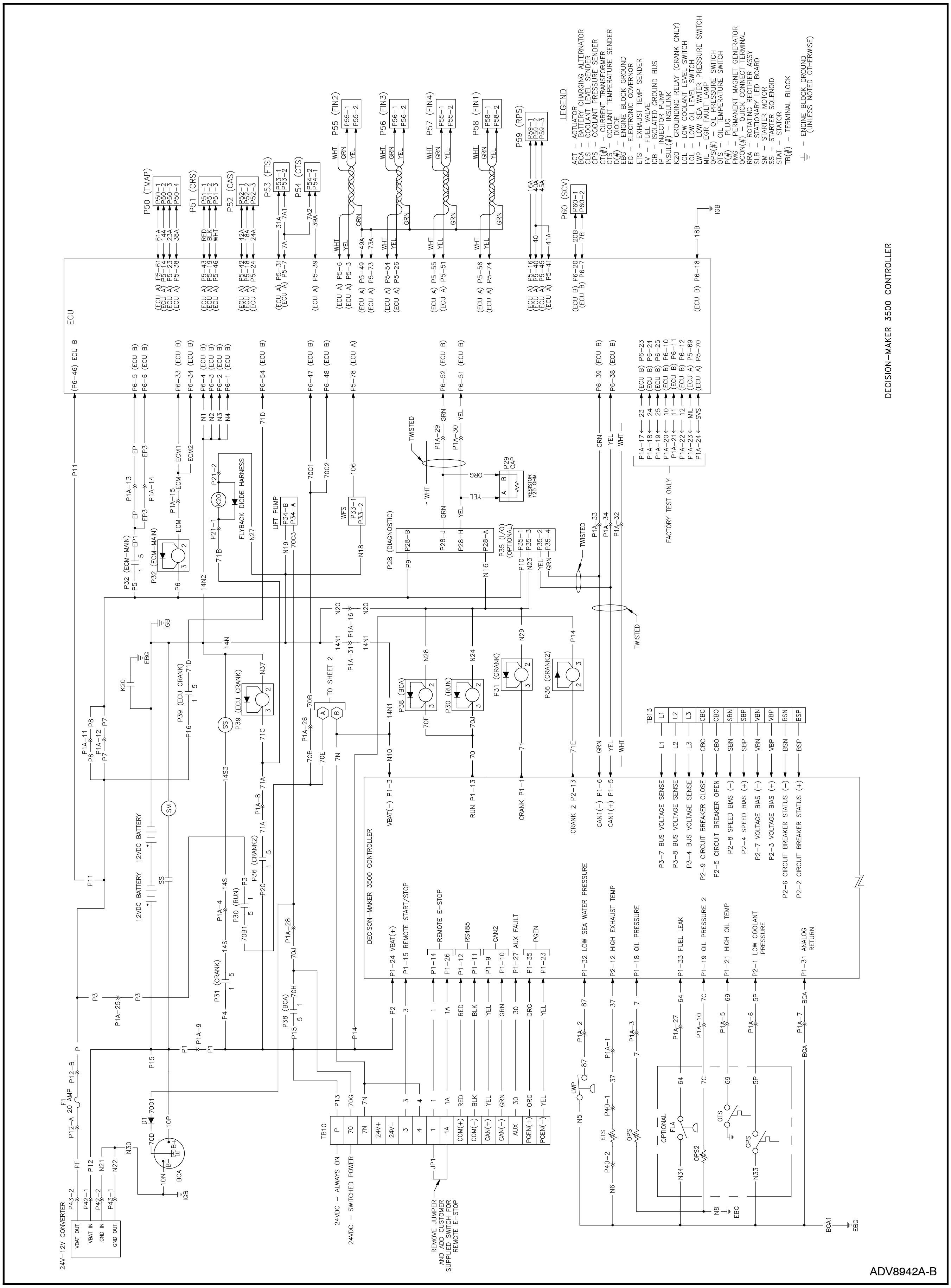


Figure 17-31 Wiring Diagram, Schematic (Sheet 1 of 2) for 32EKOZD/28EFKOZD 24-Volt, Isolated Ground Models

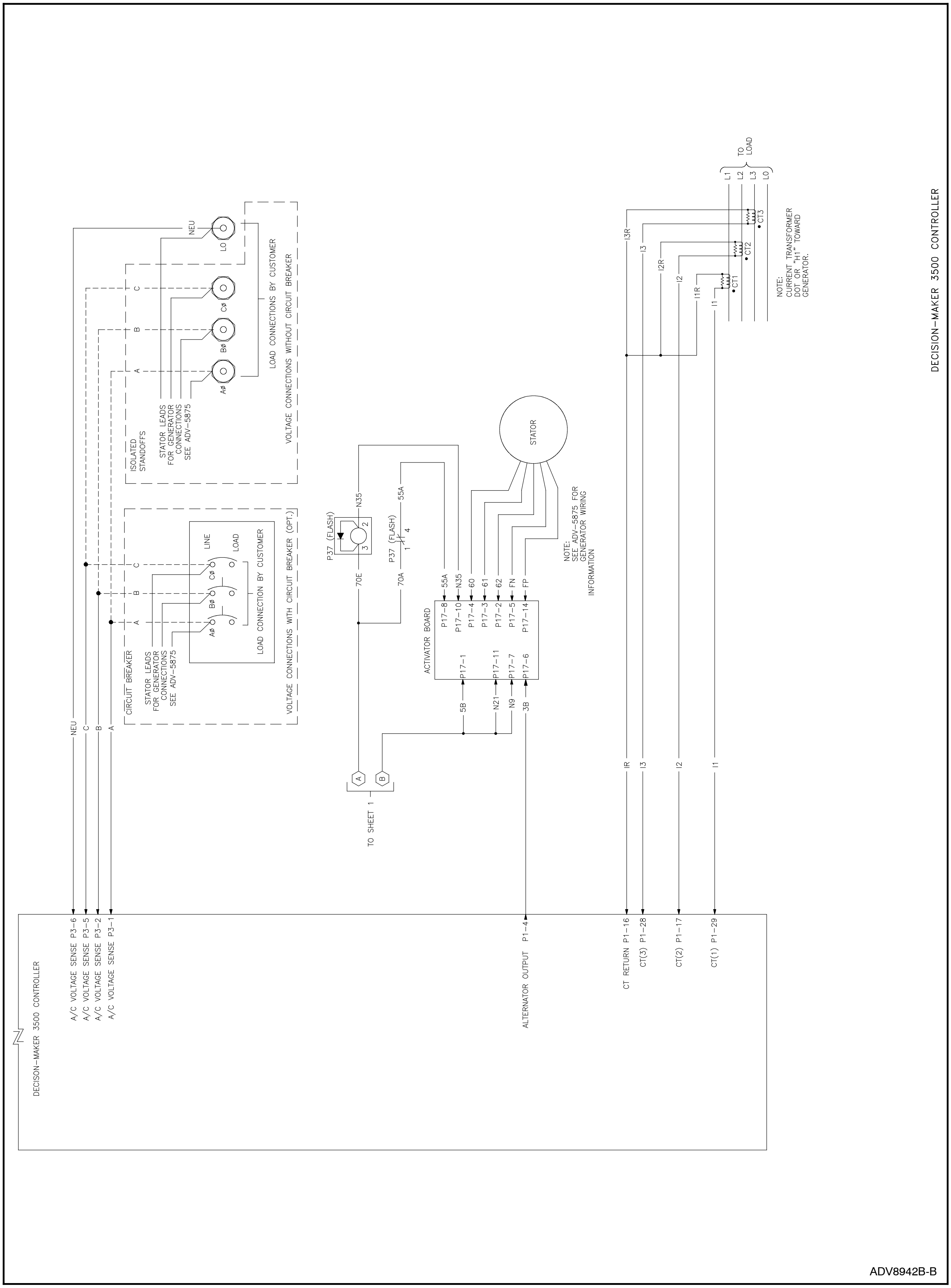


Figure 17-32 Wiring Diagram, Schematic (Sheet 2 of 2) for 32EKOZD/28EFKOZD 24-Volt, Isolated Ground Models

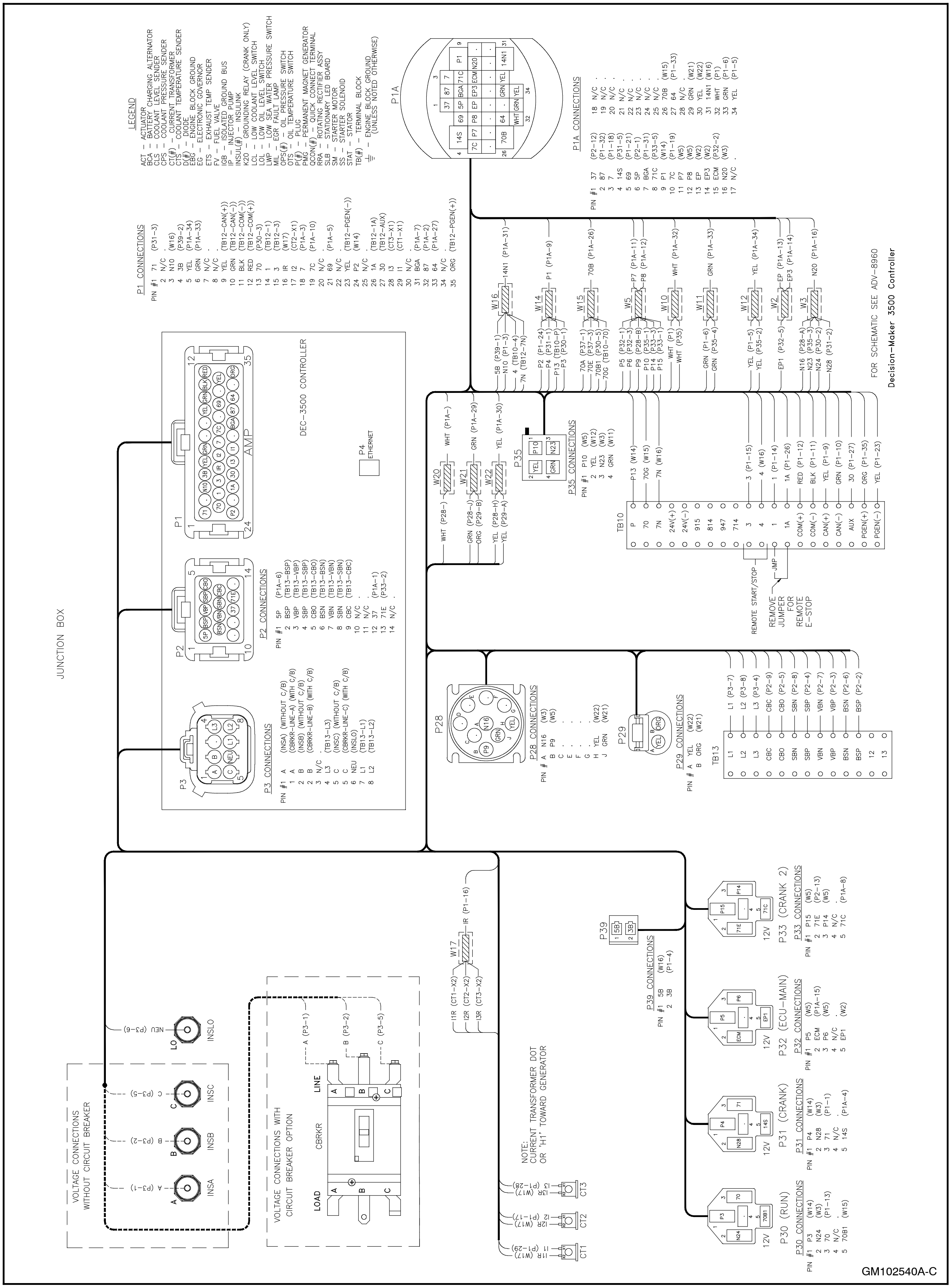


Figure 17-33 Wiring Diagram, Point-to-Point (Sheet 1 of 3) for 40EKOZD/35EFKOZD 12-Volt, Standard Ground Models

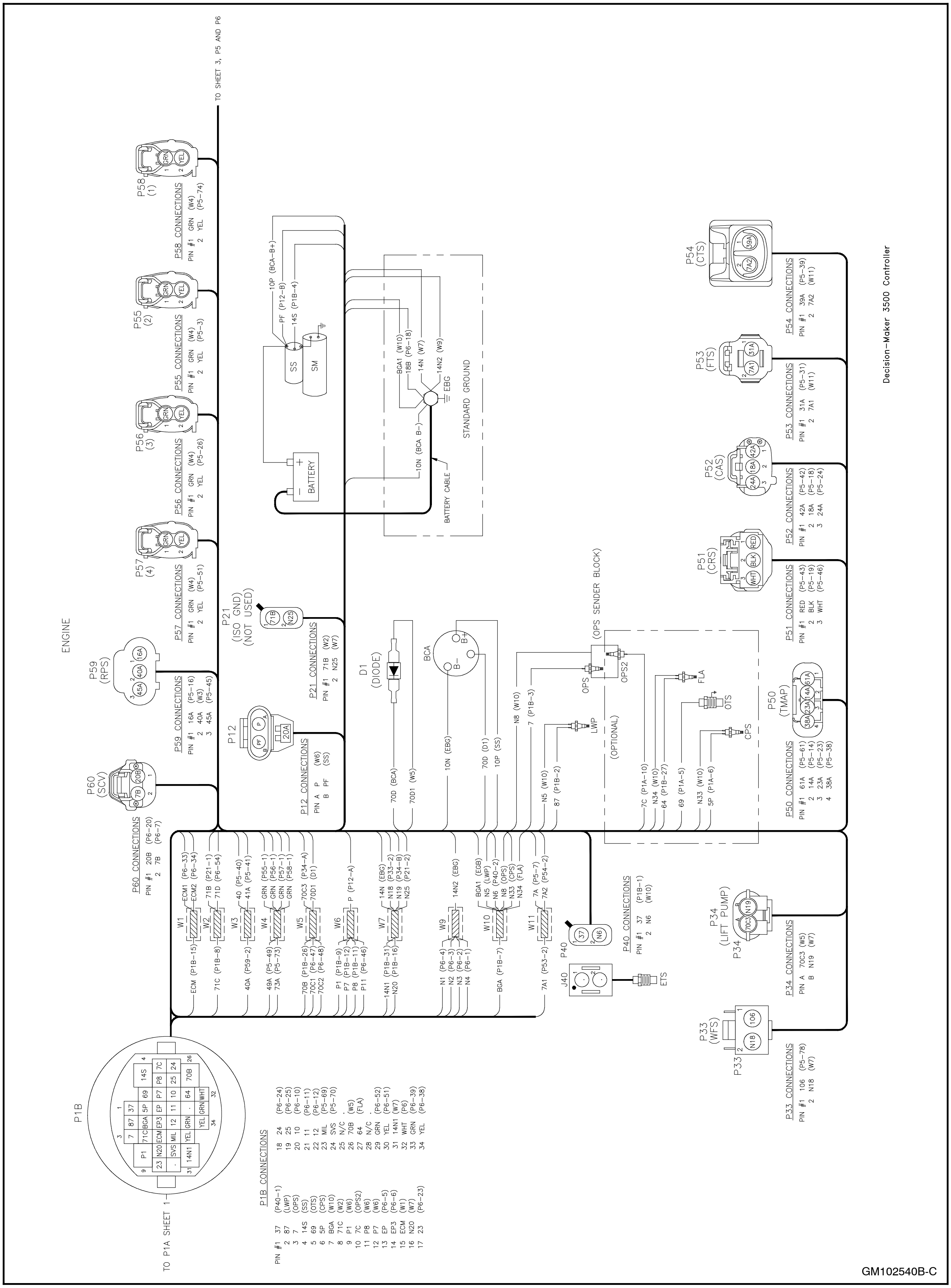


Figure 17-34 Wiring Diagram, Point-to-Point (Sheet 2 of 3) for 40EKOZD/35EFKOZD 12-Volt, Standard Ground Models

ENGINE

P5 (ECUA)

P6 (ECUB)

P5 CONNECTIONS

PIN		
#1	N/C	.
2	N/C	.
3	YEL	(P55–2)
4	N/C	.
5	N/C	.
6	WHT	(P55)
7	7A	(W11)
8	N/C	.
9	N/C	.
10	N/C	.
11	N/C	.
12	N/C	.
13	N/C	.
14	14A	(P50–2)
15	N/C	.
16	16A	(P59–1)
17	N/C	.
18	18A	(P52–2)
19	BLK	(P51–2)
20	N/C	.
21	N/C	.
22	N/C	.
23	23A	(P50–3)
24	24A	(P52–3)
25	N/C	.
26	YEL	(P56–2)
27	N/C	.
28	N/C	.
29	N/C	.
30	N/C	.
31	31A	(P53–1)
32	N/C	.
33	N/C	.
34	N/C	.
35	N/C	.
36	N/C	.
37	N/C	.
38	38A	(P50–4)
39	39A	(P54–1)
40	40	(W3)
41	41A	(W3)
42	42A	(P52–1)
43	RED	(P51–1)
44	N/C	.
45	45A	(P59–3)
46	WHT	(P51–3)
47	N/C	.
48	N/C	.
49	49A	(W4)
50	N/C	.
51	YEL	(P57–2)
52	N/C	.
53	N/C	.
54	WHT	(P56)
55	WHT	(P57)
56	WHT	(P58)
57	N/C	.
58	N/C	.
59	N/C	.
60	N/C	.
61	61A	(P50–1)
62	N/C	.
63	N/C	.
64	N/C	.
65	N/C	.
66	N/C	.
67	N/C	.
68	N/C	.
69	MIL	(P1B–23)
70	SVS	(P1B–24)
71	N/C	.
72	N/C	.
73	73A	(W4)
74	YEL	(P58–2)
75	N/C	.
76	N/C	.
77	N/C	.
78	106	(P33–1)
79	N/C	.
80	N/C	.
81	N/C	.
82	N/C	.
83	N/C	.
84	N/C	.
85	N/C	.
86	N/C	.
87	N/C	.
88	N/C	.
89	N/C	.
90	N/C	.
91	N/C	.
92	N/C	.
93	N/C	.
94	N/C	.
95	N/C	.
96	N/C	.

P6 CONNECTIONS

PIN		
#1	N4	(W9)
2	N3	(W9)
3	N2	(W9)
4	N1	(W9)
5	EP	(P1B–13)
6	EP3	(P1B–14)
7	7B	(P60–2)
8	N/C	.
9	N/C	.
10	10	(P1B–20)
11	11	(P1B–21)
12	12	(P1B–22)
13	N/C	.
14	N/C	.
15	N/C	.
16	N/C	.
17	N/C	.
18	18B	(EBG)
19	N/C	.
20	20B	(P60–1)
21	N/C	.
22	N/C	.
23	23	(P1B–17)
24	24	(P1B–18)
25	25	(P1B–19)
26	N/C	.
27	N/C	.
28	N/C	.
29	N/C	.
30	N/C	.
31	N/C	.
32	N/C	.
33	ECM1	(W1)
34	ECM2	(W1)
35	N/C	.
36	N/C	.
37	N/C	.
38	YEL	(P1B–34)
39	GRN	(P1B–33)
40	N/C	.
41	N/C	.
42	N/C	.
43	N/C	.
44	N/C	.
45	N/C	.
46	P11	(W6)
47	70C1	(W5)
48	70C2	(W5)
49	N/C	.
50	N/C	.
51	YEL	(P1B–30)
52	GRN	(P1B–29)
53	N/C	.
54	71D	(W2)
55	N/C	.
56	N/C	.
57	N/C	.
58	N/C	

Decision–Maker 3500 Controller

GM102540C-C

Figure 17-35 Wiring Diagram, Point-to-Point (Sheet 3 of 3) for 40EKOZD/35EFKOZD 12-Volt, Standard Ground Models

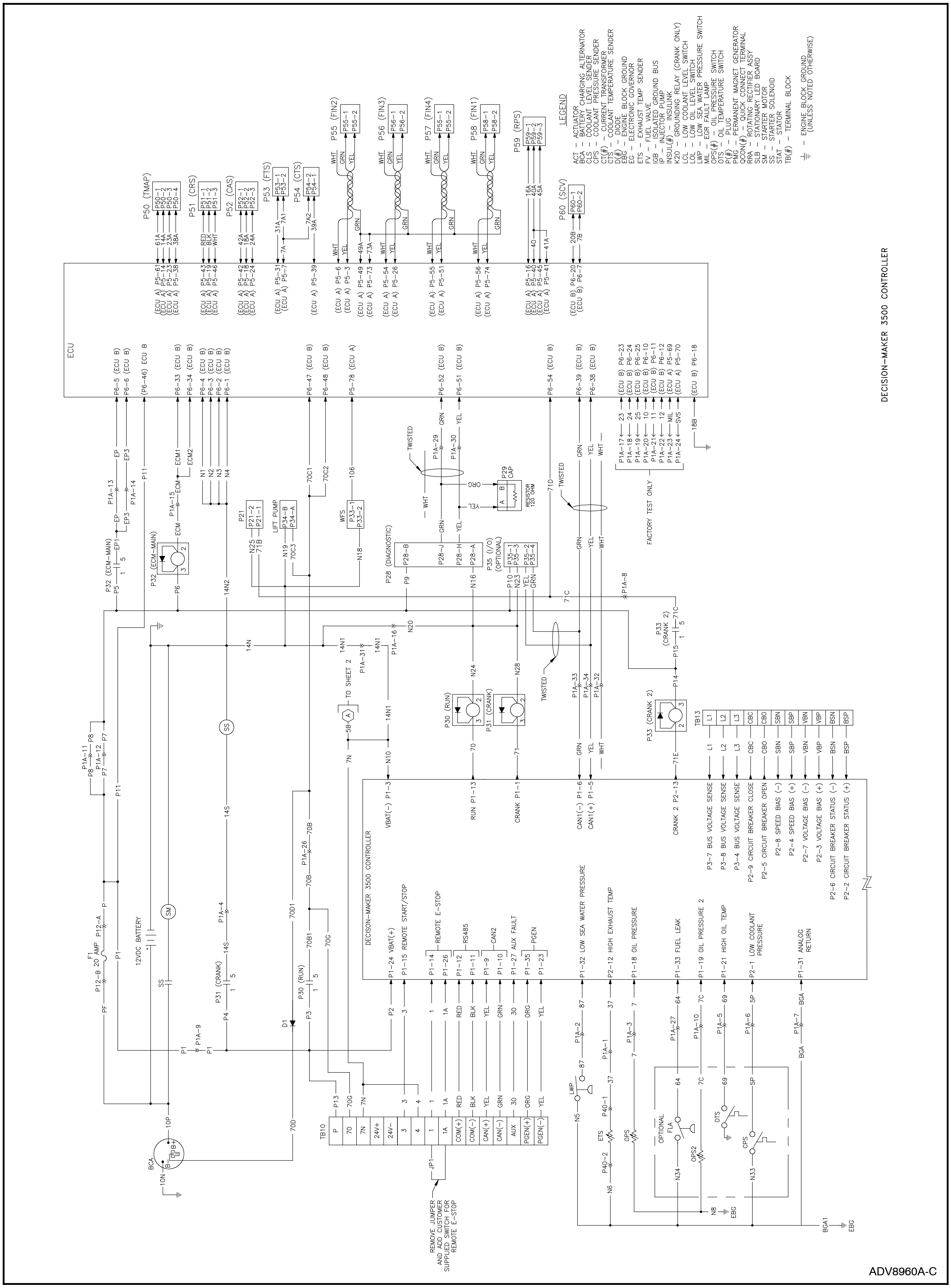


Figure 17-36 Wiring Diagram, Schematic (Sheet 1 of 2) for 40EKOZD/35EFKOZD 12-Volt, Standard Ground Models

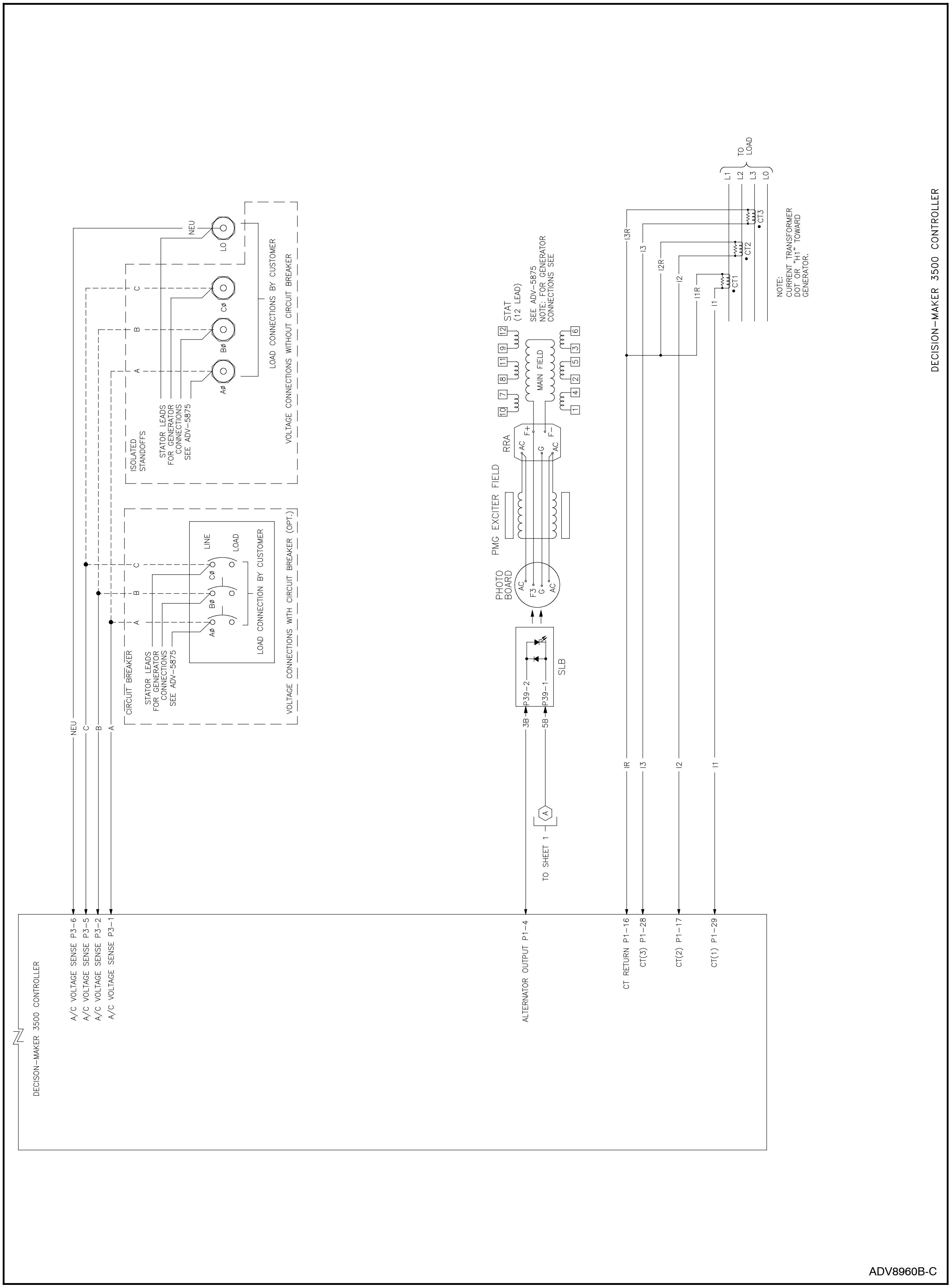


Figure 17-37 Wiring Diagram, Schematic (Sheet 2 of 2) for 40EKOZD/35EFKOZD 12-Volt, Standard Ground Models

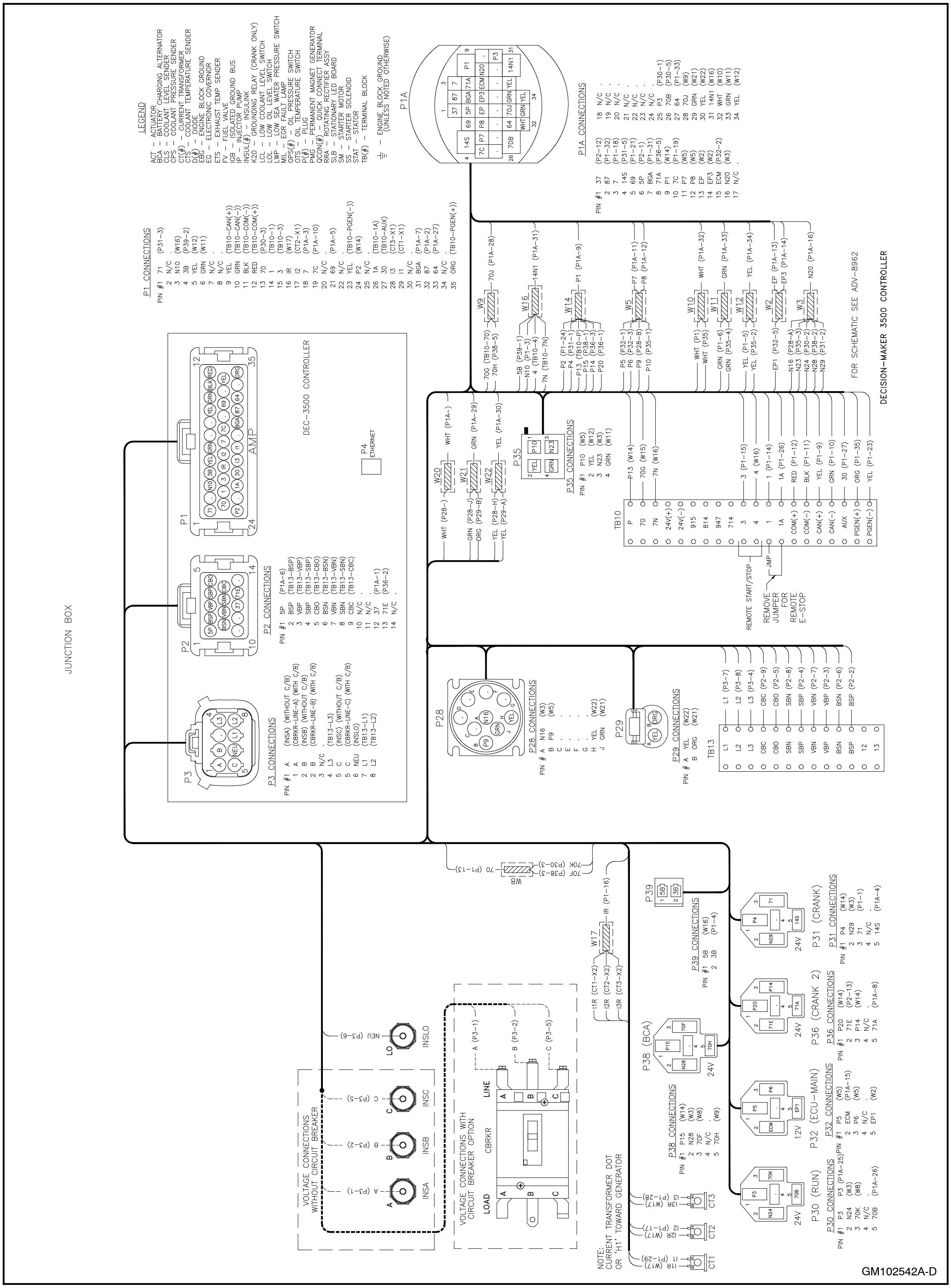


Figure 17-38 Wiring Diagram, Point-to-Point (Sheet 1 of 3) for 40EKOZD/35EFKOZD 24-Volt, Standard Ground Models

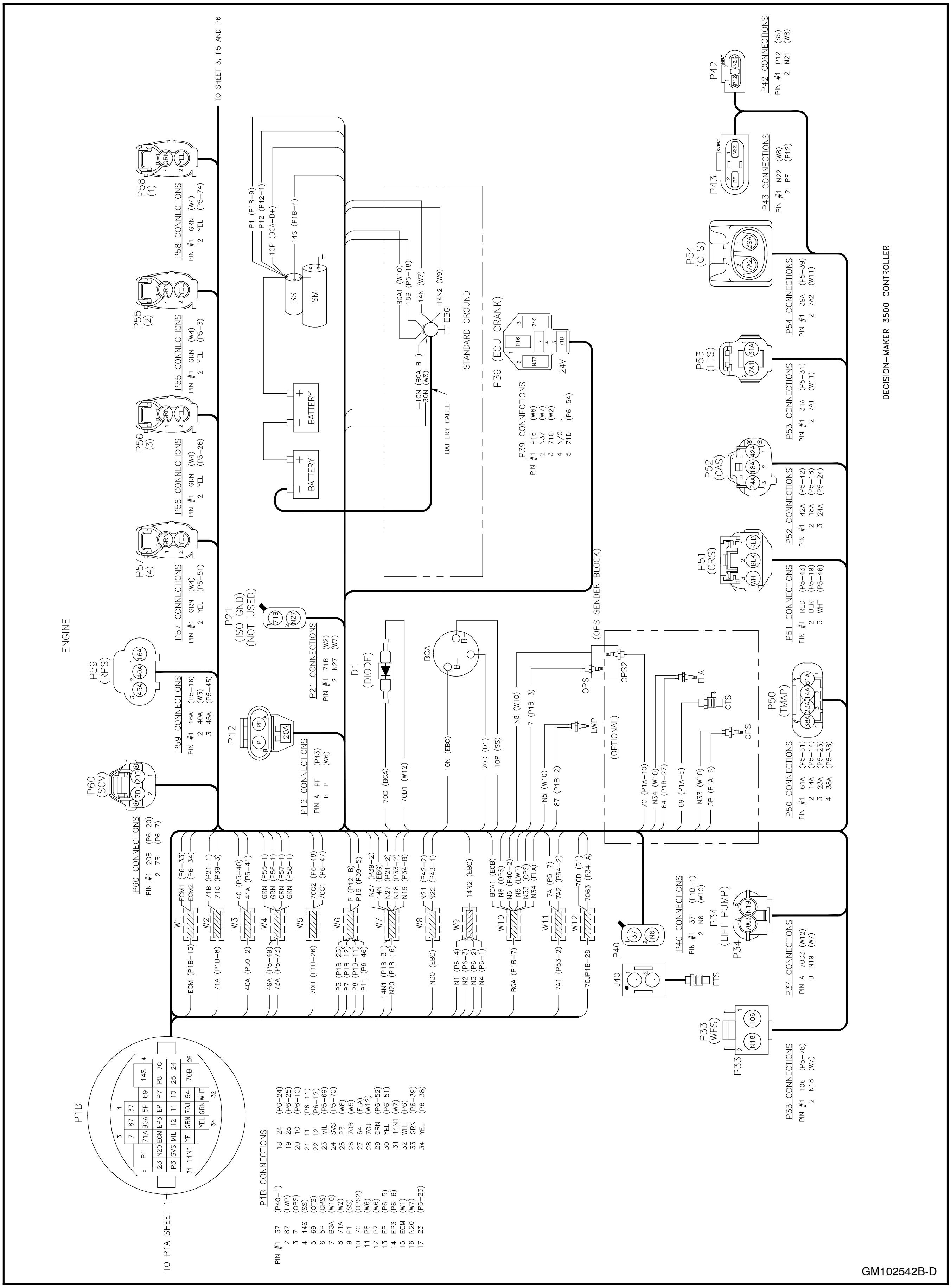


Figure 17-39 Wiring Diagram, Point-to-Point (Sheet 2 of 3) for 40EKOZD/35EFKOZD 24-Volt, Standard Ground Models

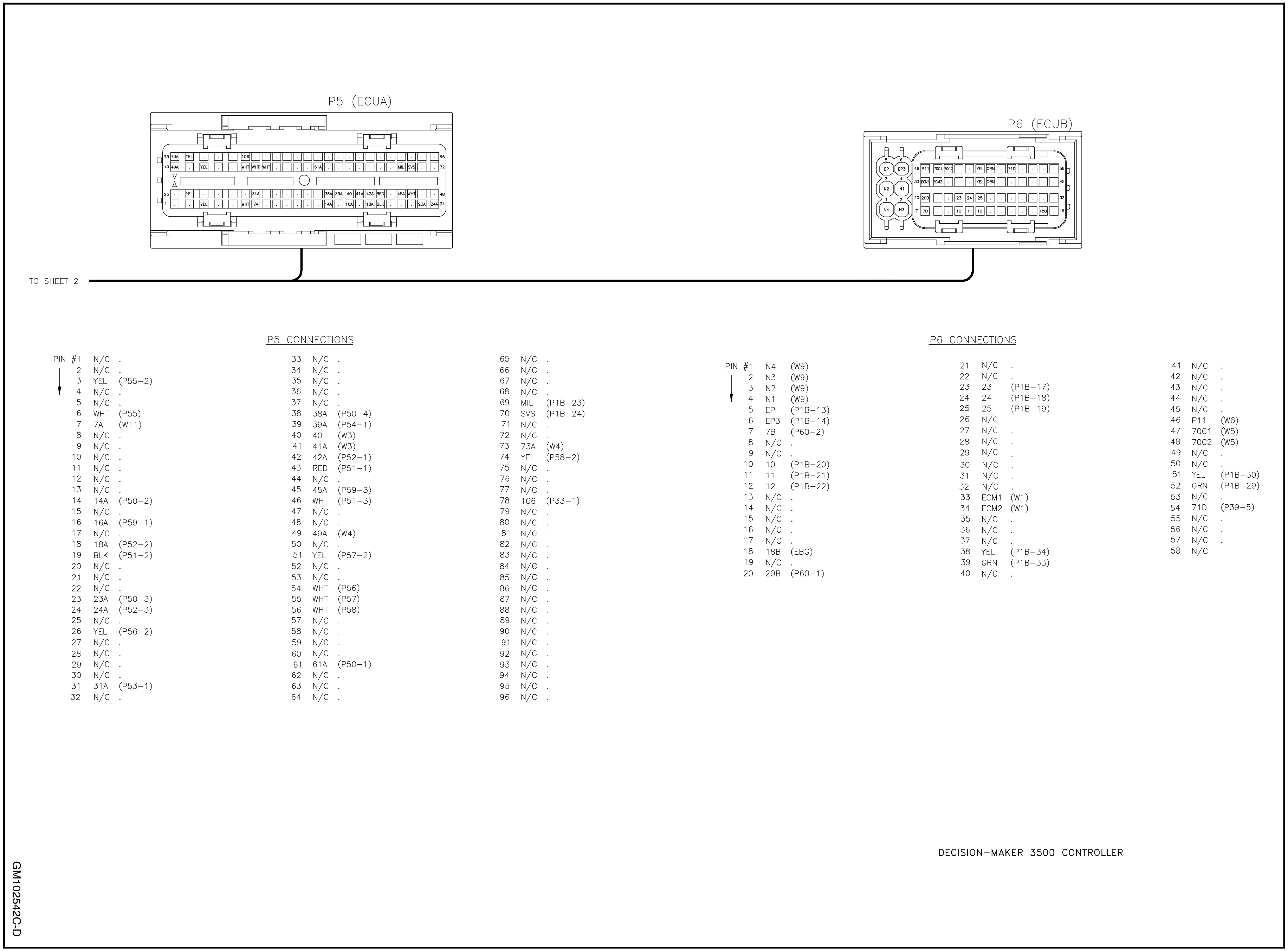


Figure 17-40 Wiring Diagram, Point-to-Point (Sheet 3 of 3) for 40EKOZD/35EFKOZD 24-Volt, Standard Ground Models

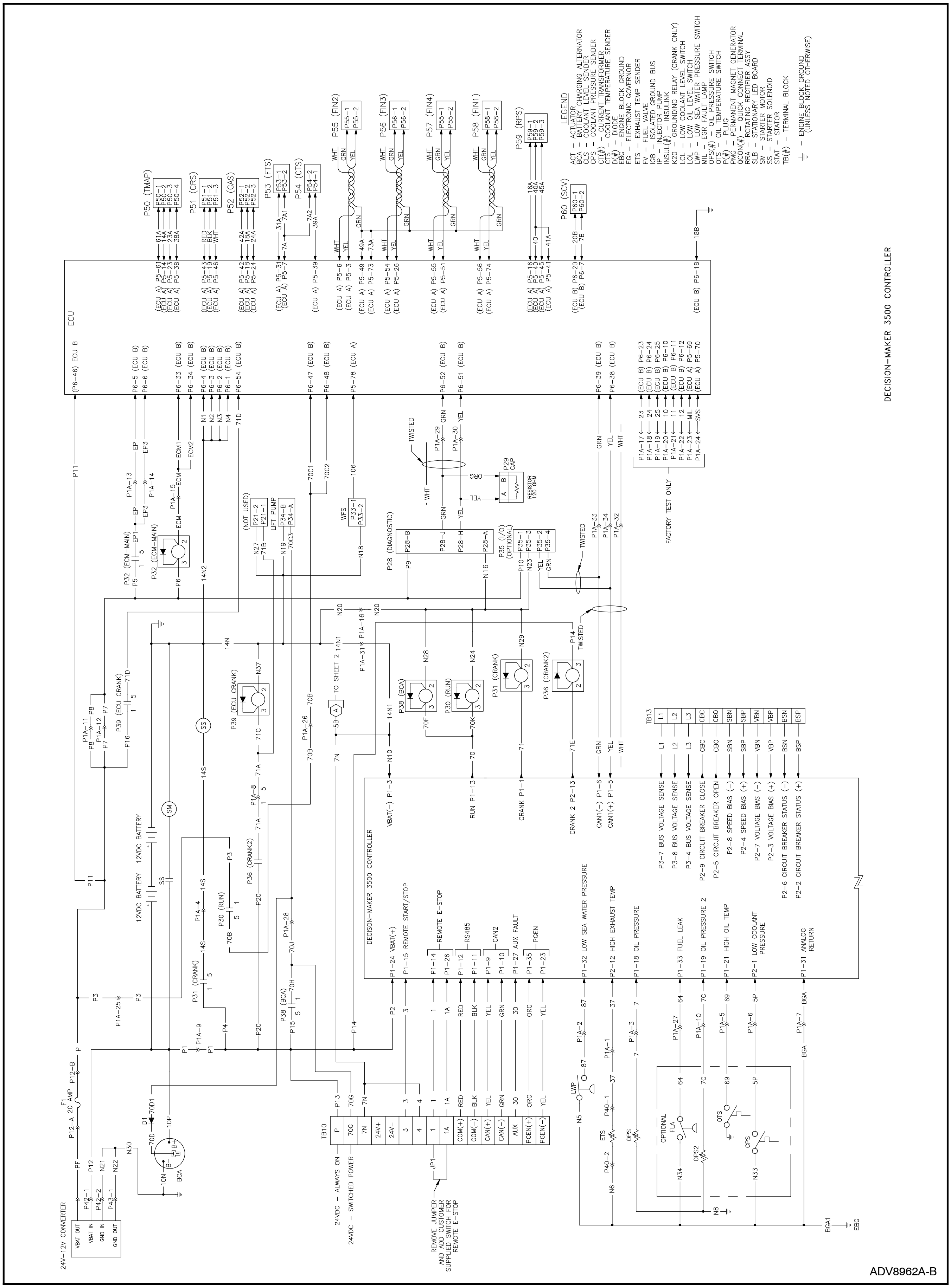


Figure 17-41 Wiring Diagram, Schematic (Sheet 1 of 2) for 40EKOZD/35EFKOZD 24-Volt, Standard Ground Models

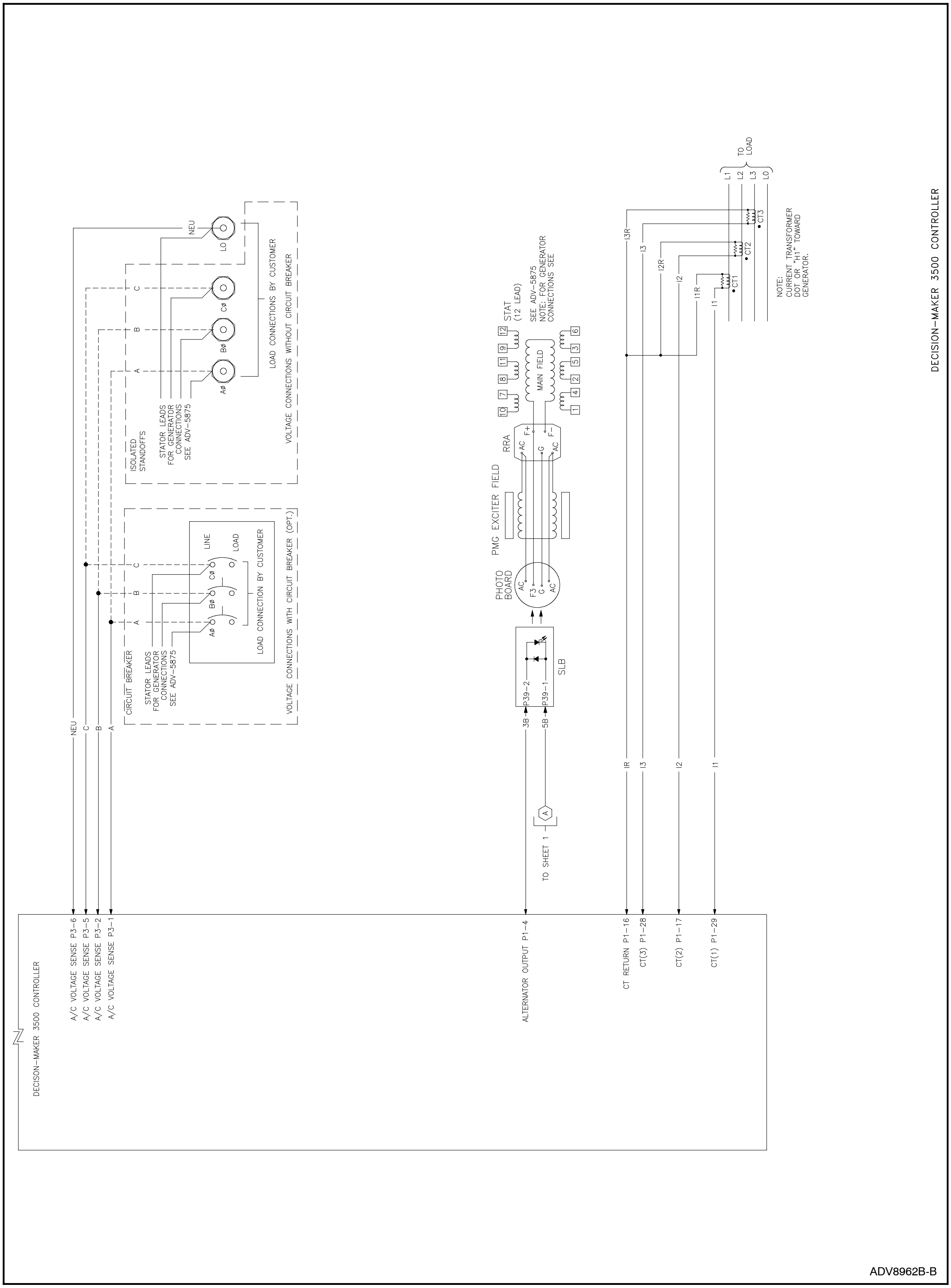


Figure 17-42 Wiring Diagram, Schematic (Sheet 2 of 2) for 40EKOZD/35EFKOZD 24-Volt, Standard Ground Models

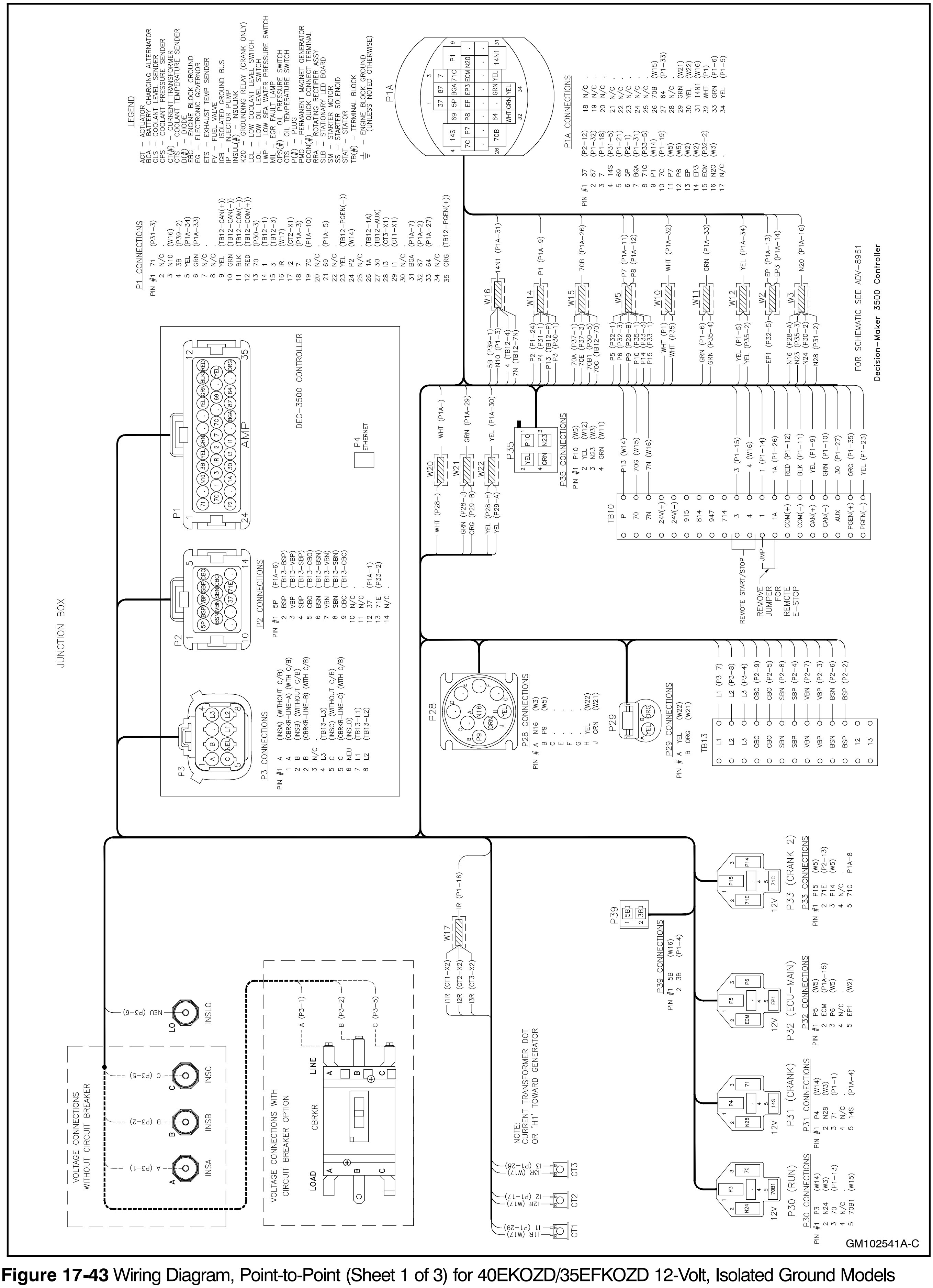


Figure 17-43 Wiring Diagram, Point-to-Point (Sheet 1 of 3) for 40EKOZD/35EFKOZD 12-Volt, Isolated Ground Models

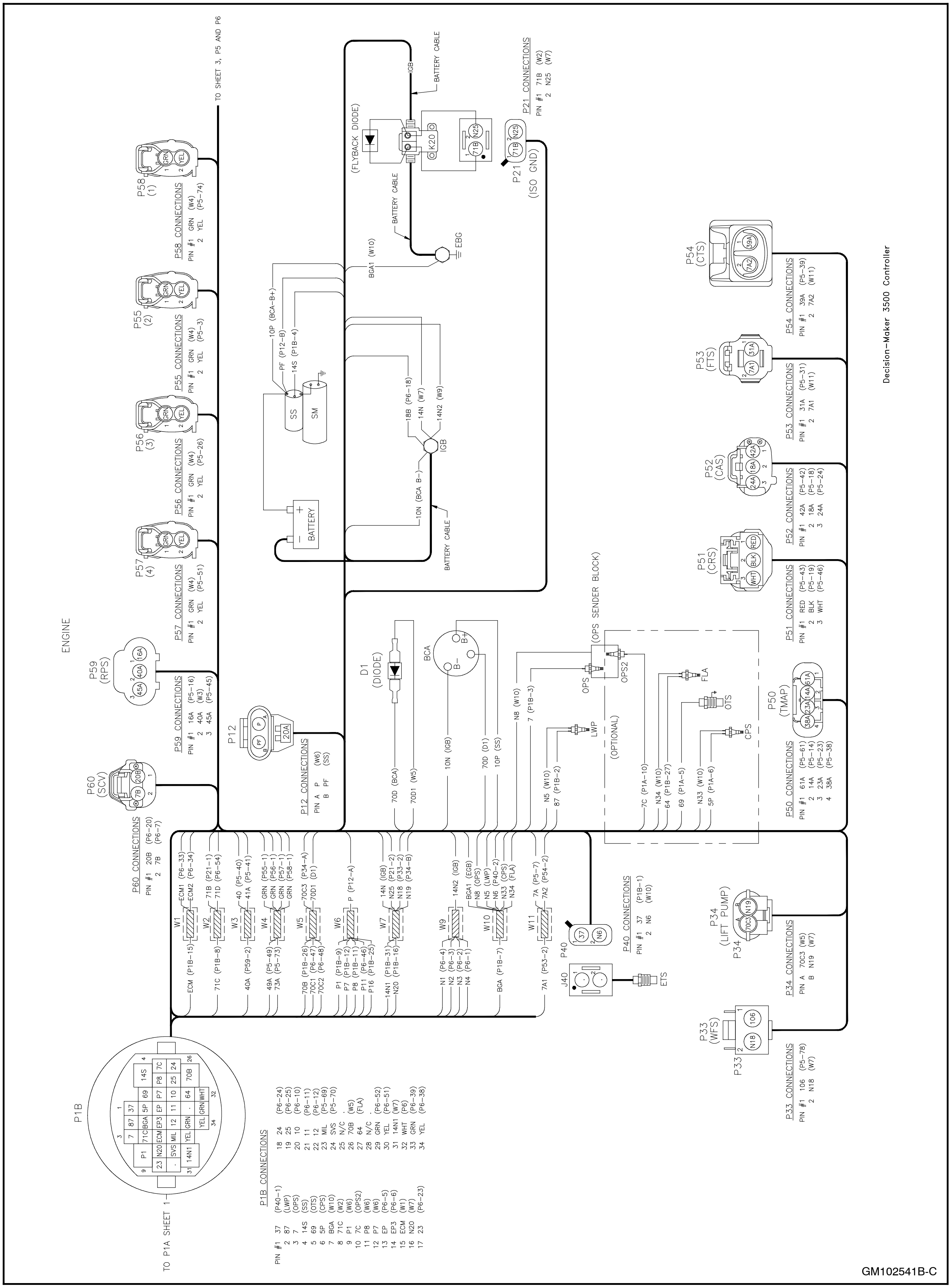


Figure 17-44 Wiring Diagram, Point-to-Point (Sheet 2 of 3) for 40EKOZD/35EFKOZD 12-Volt, Isolated Ground Models

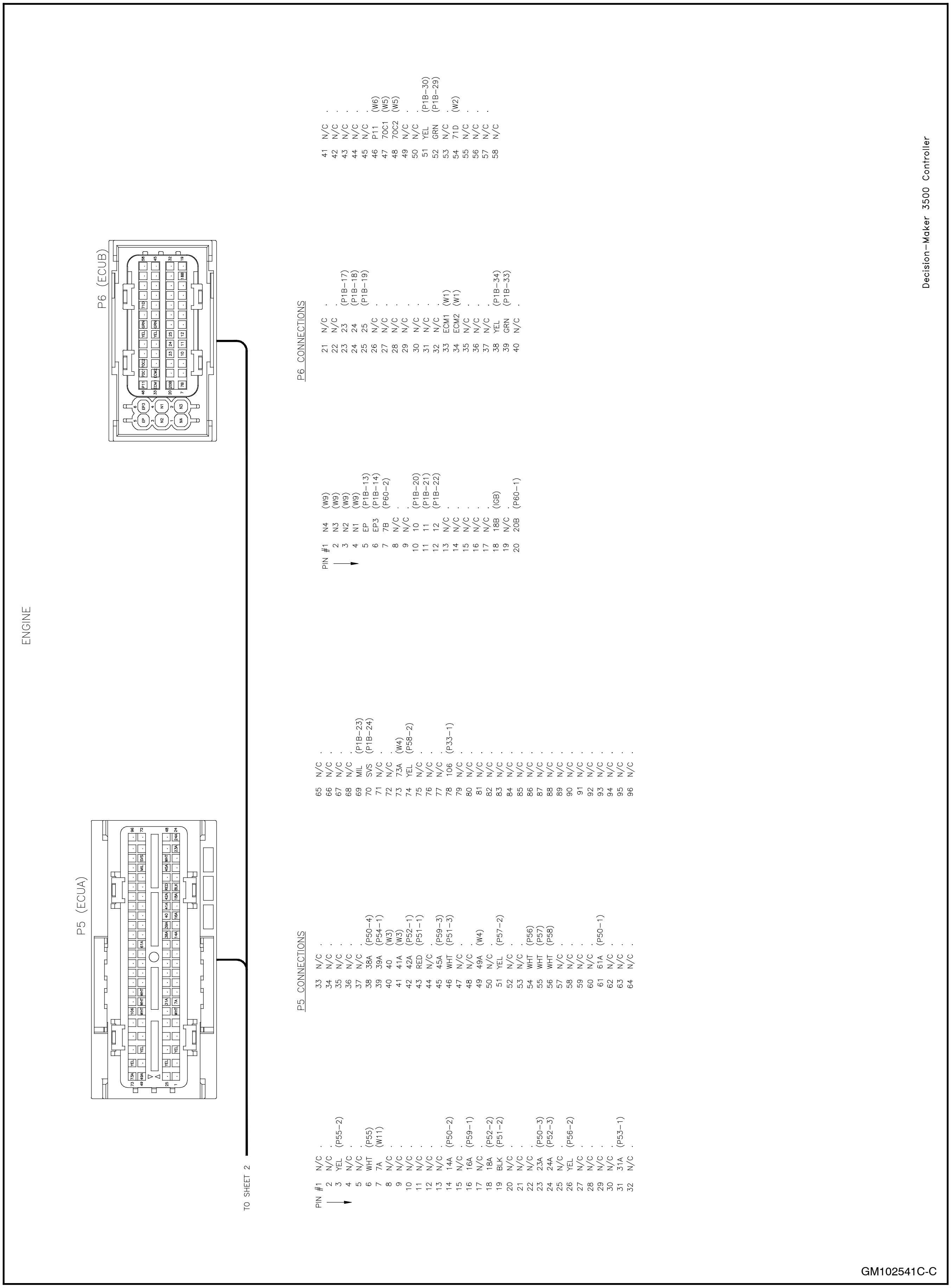


Figure 17-45 Wiring Diagram, Point-to-Point (Sheet 3 of 3) for 40EKOZD/35EFKOZD 12-Volt, Isolated Ground Models

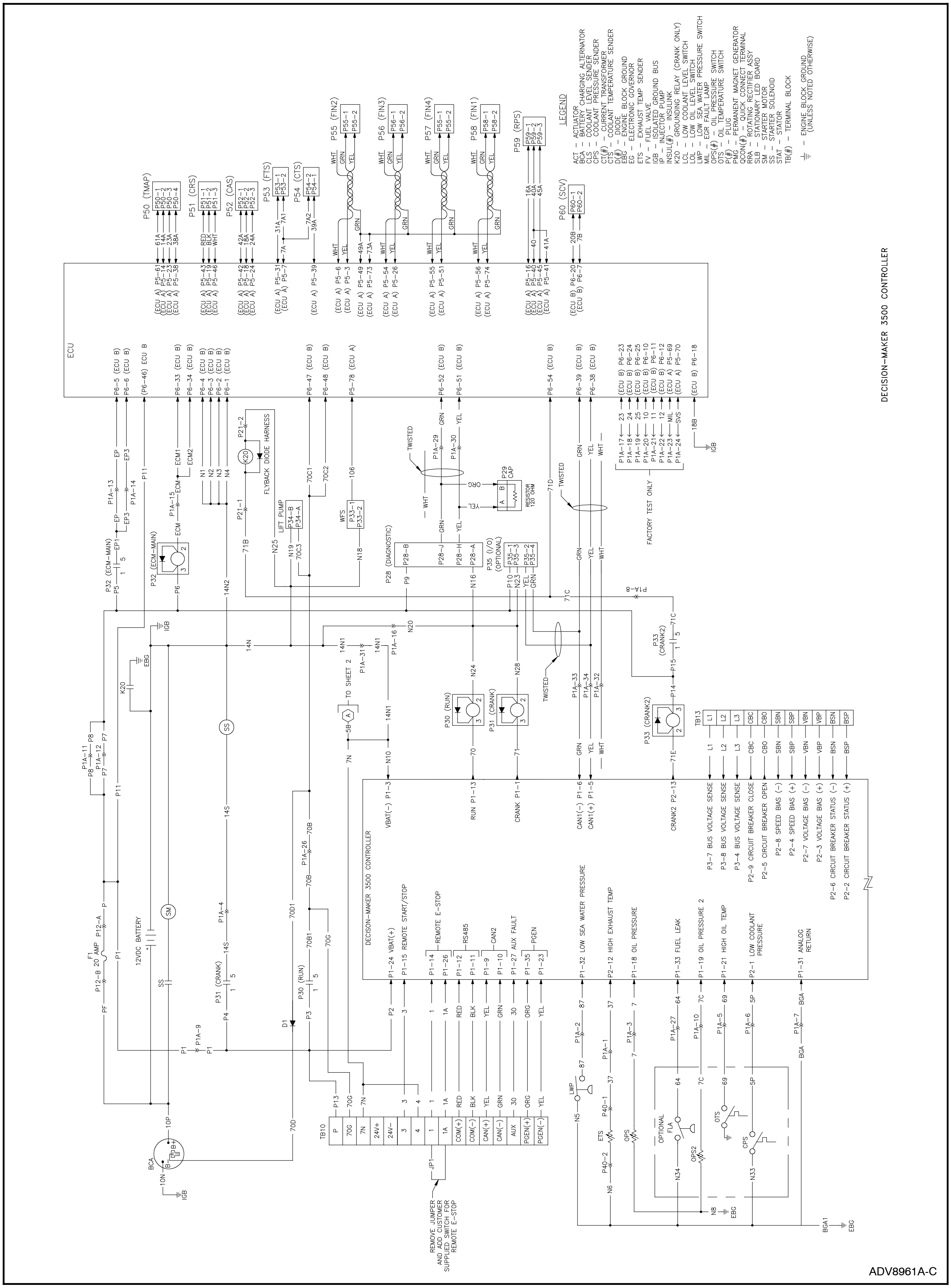


Figure 17-46 Wiring Diagram, Schematic (Sheet 1 of 2) for 40EKOZD/35EFKOZD 12-Volt, Isolated Ground Models

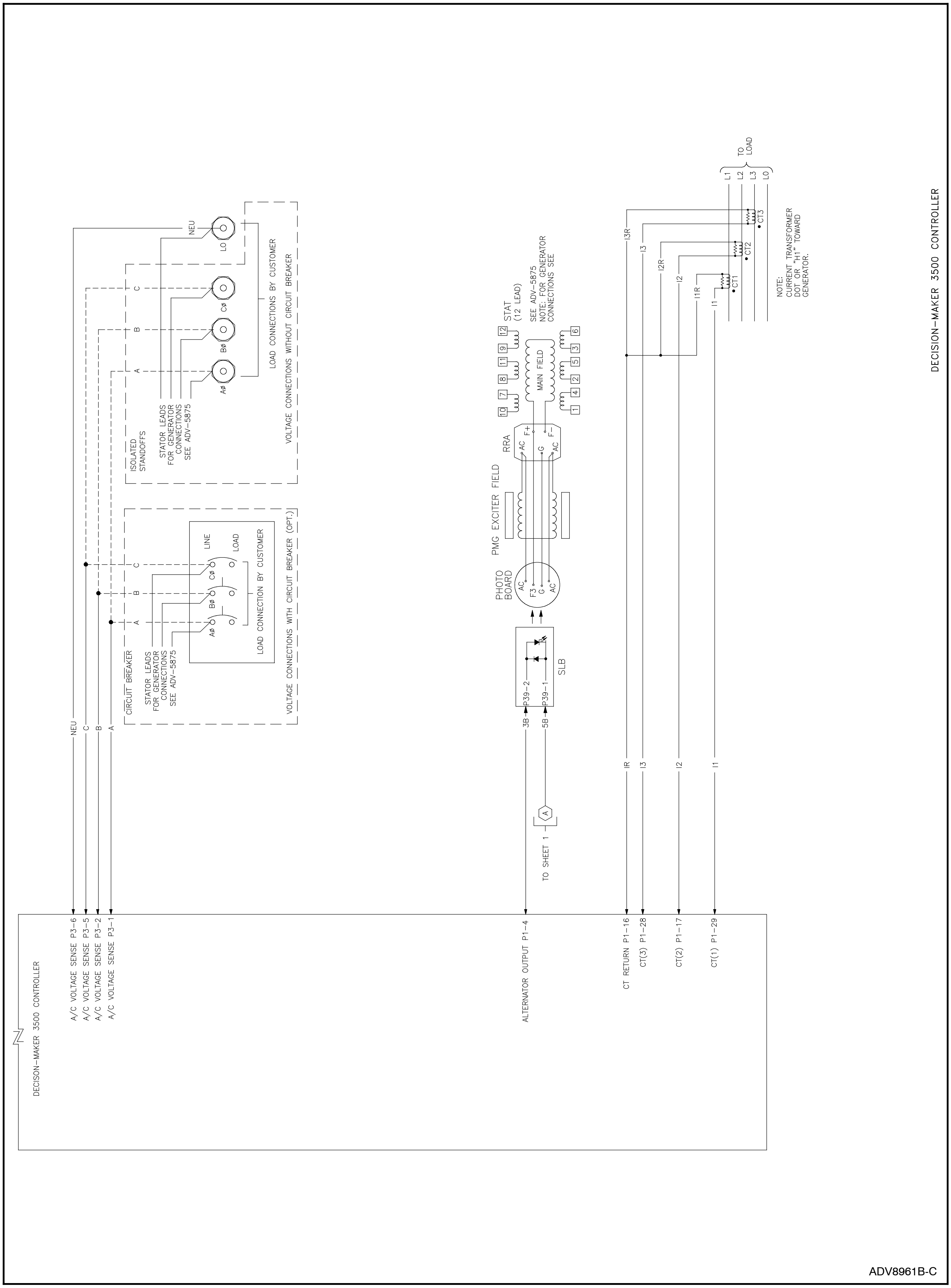


Figure 17-47 Wiring Diagram, Schematic (Sheet 2 of 2) for 40EKOZD/35EFKOZD 12-Volt, Isolated Ground Models

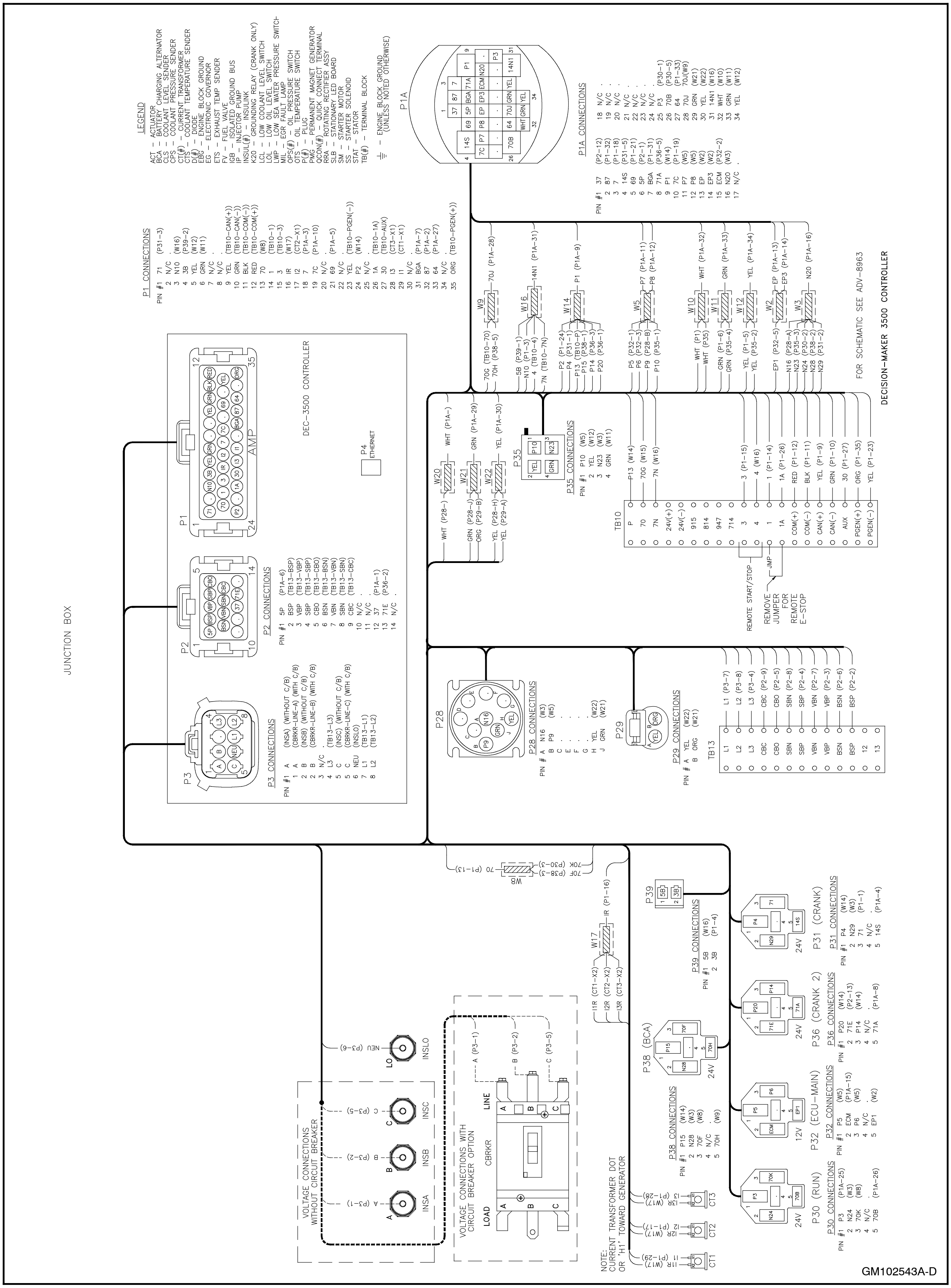


Figure 17-48 Wiring Diagram, Point-to-Point (Sheet 1 of 3) for 40EKOZD/35EFKOZD 24-Volt, Isolated Ground Models

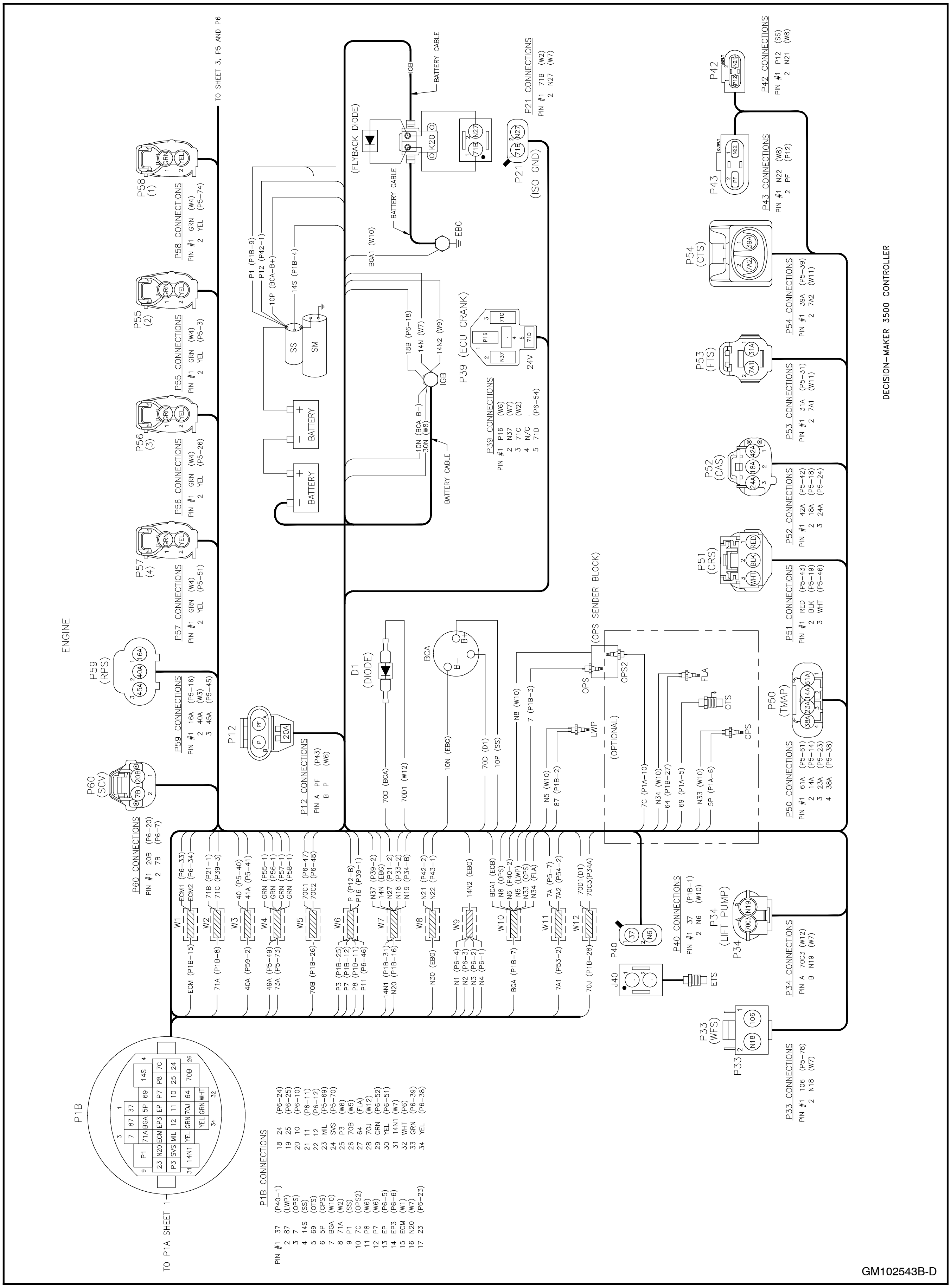


Figure 17-49 Wiring Diagram, Point-to-Point (Sheet 2 of 3) for 40EKOZD/35EFKOZD 24-Volt, Isolated Ground Models

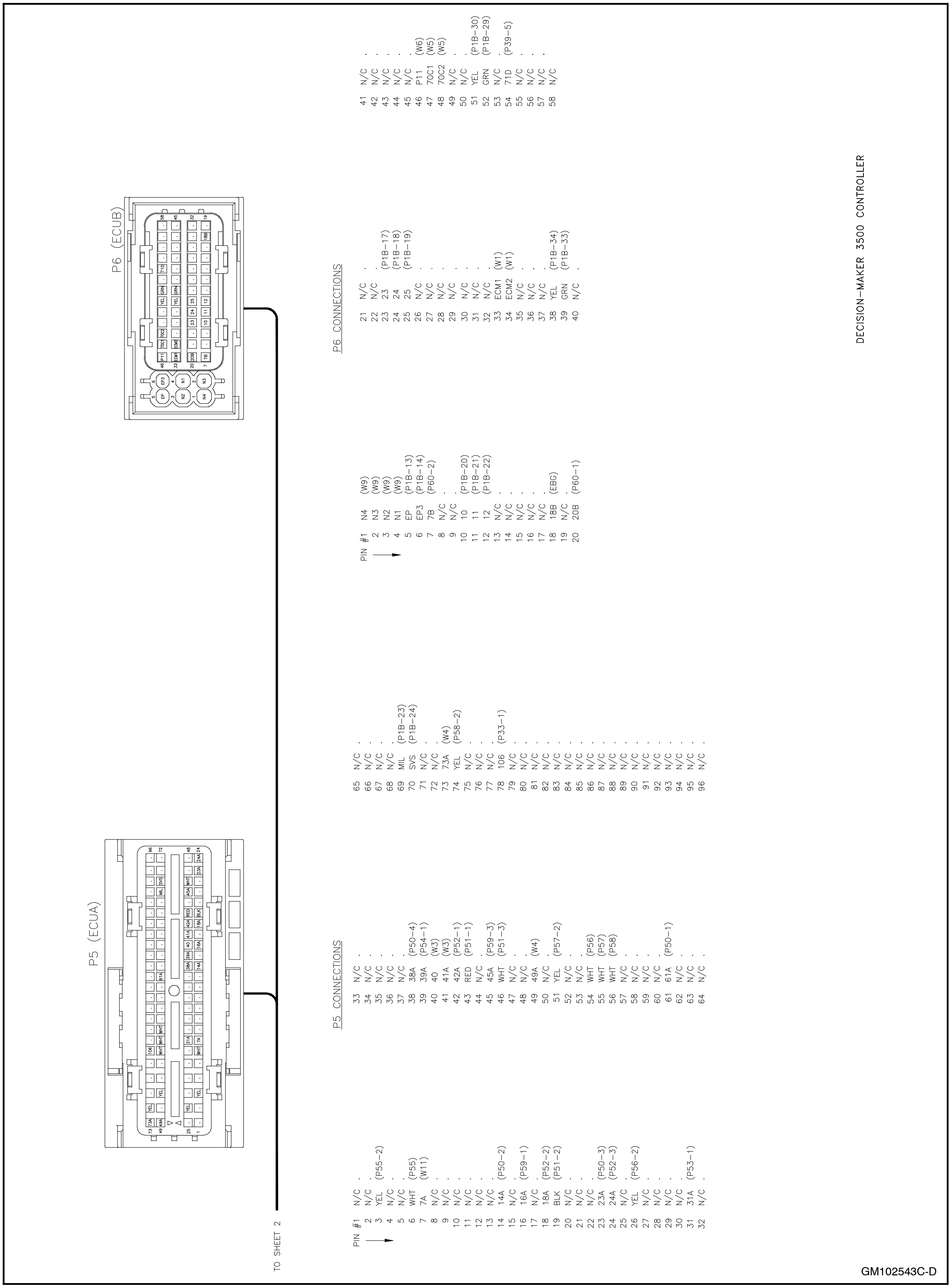


Figure 17-50 Wiring Diagram, Point-to-Point (Sheet 3 of 3) for 40EKOZD/35EFKOZD 24-Volt, Isolated Ground Models

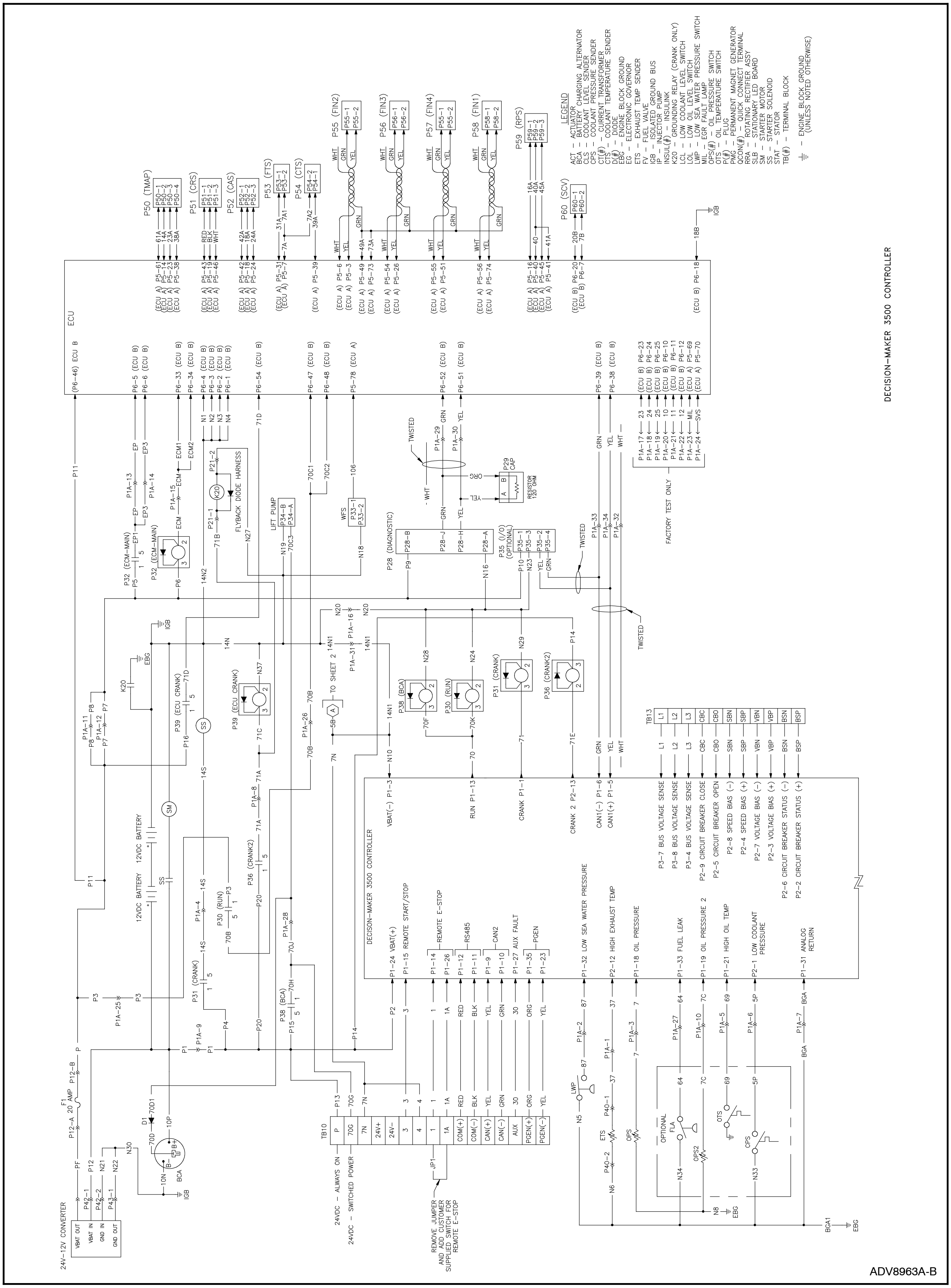
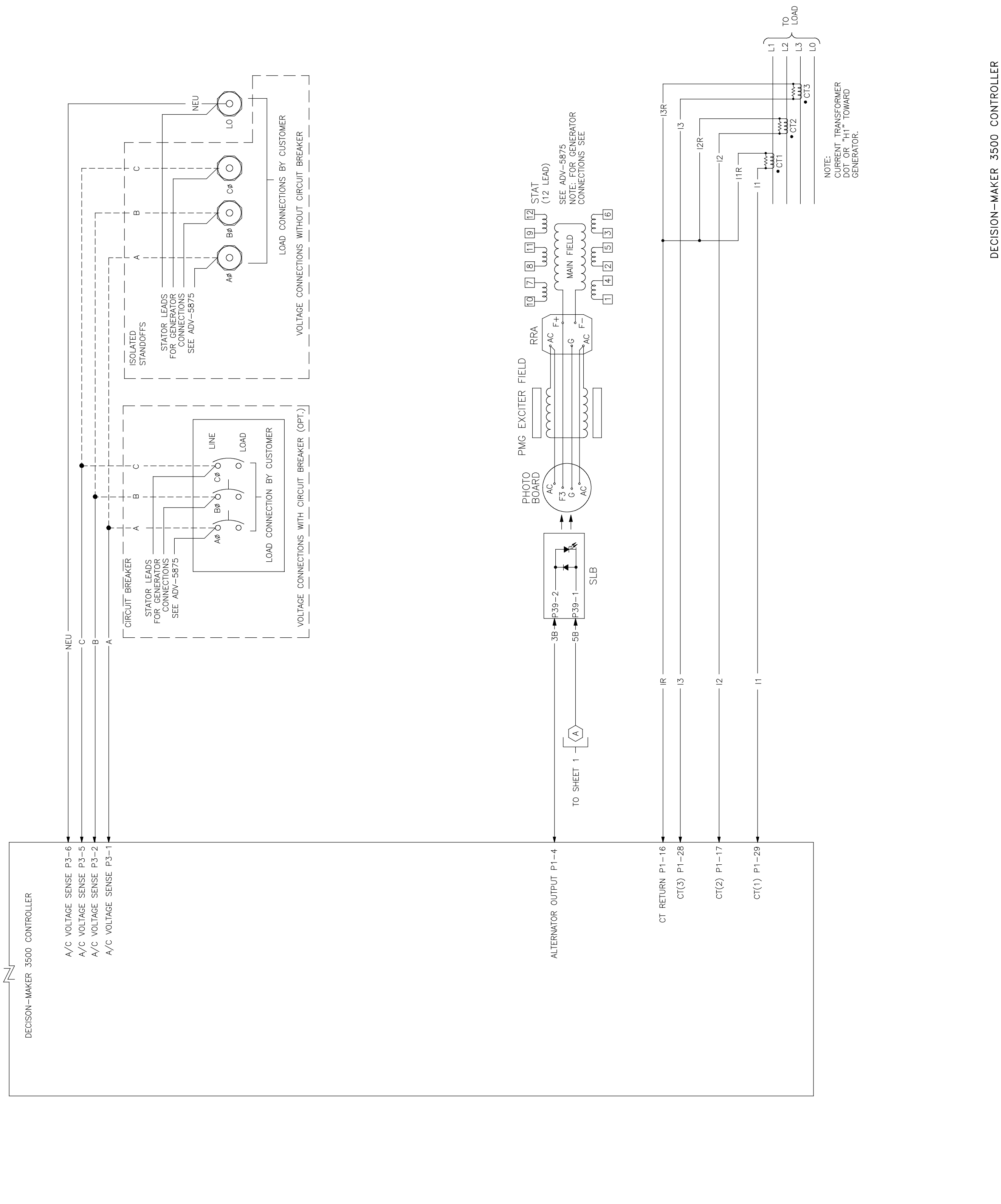


Figure 17-51 Wiring Diagram, Schematic (Sheet 1 of 2) for 40EKOZD/35EFKOZD 24-Volt, Isolated Ground Models



ADV8963B-B

Figure 17-52 Wiring Diagram, Schematic (Sheet 2 of 2) for 40EKOZD/35EFKOZD 24-Volt, Isolated Ground Models

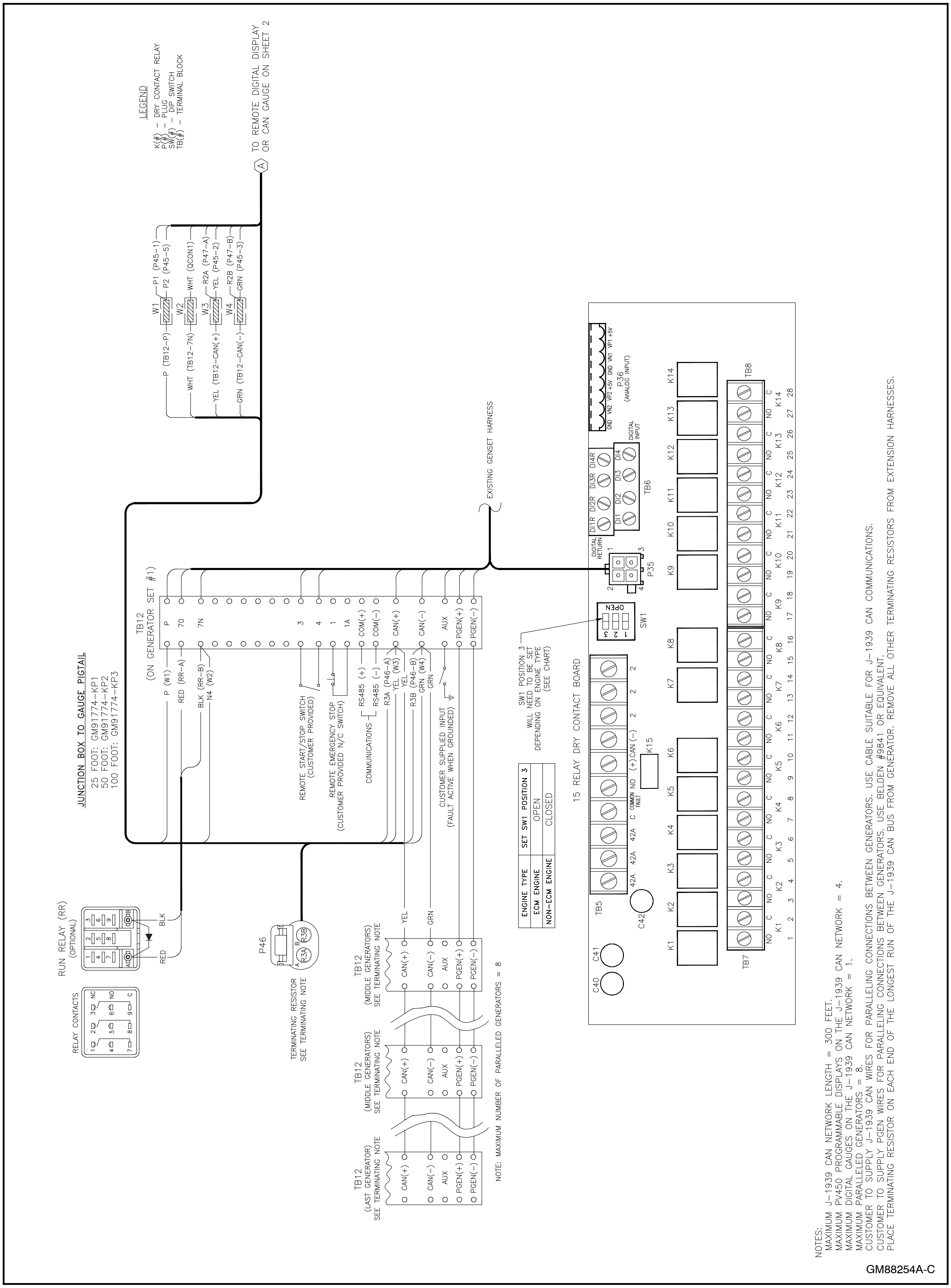


Figure 17-53 Accessory Interconnection Drawing (Sheet 1 of 2)

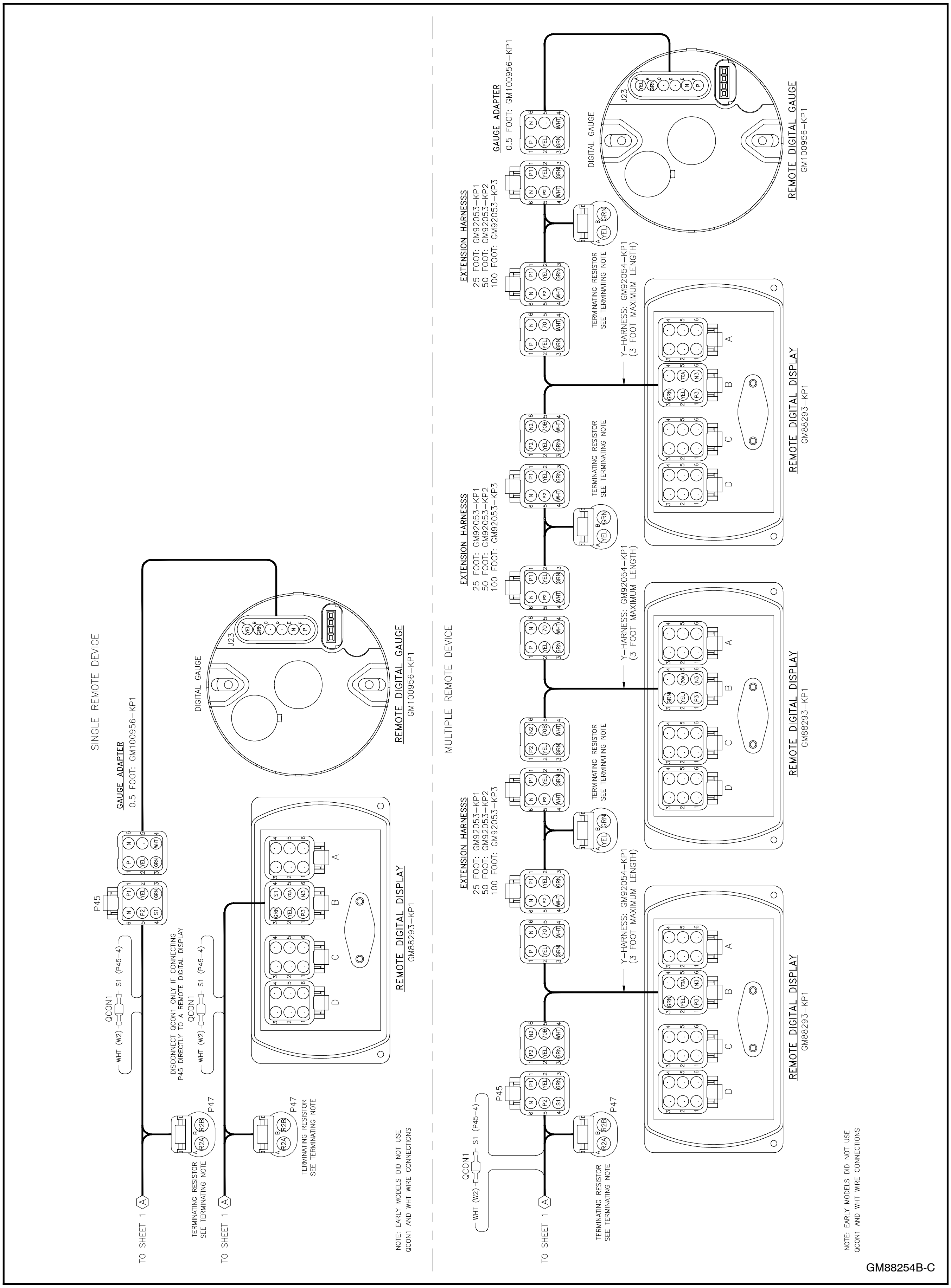


Figure 17-54 Accessory Interconnection Drawing (Sheet 2 of 2)

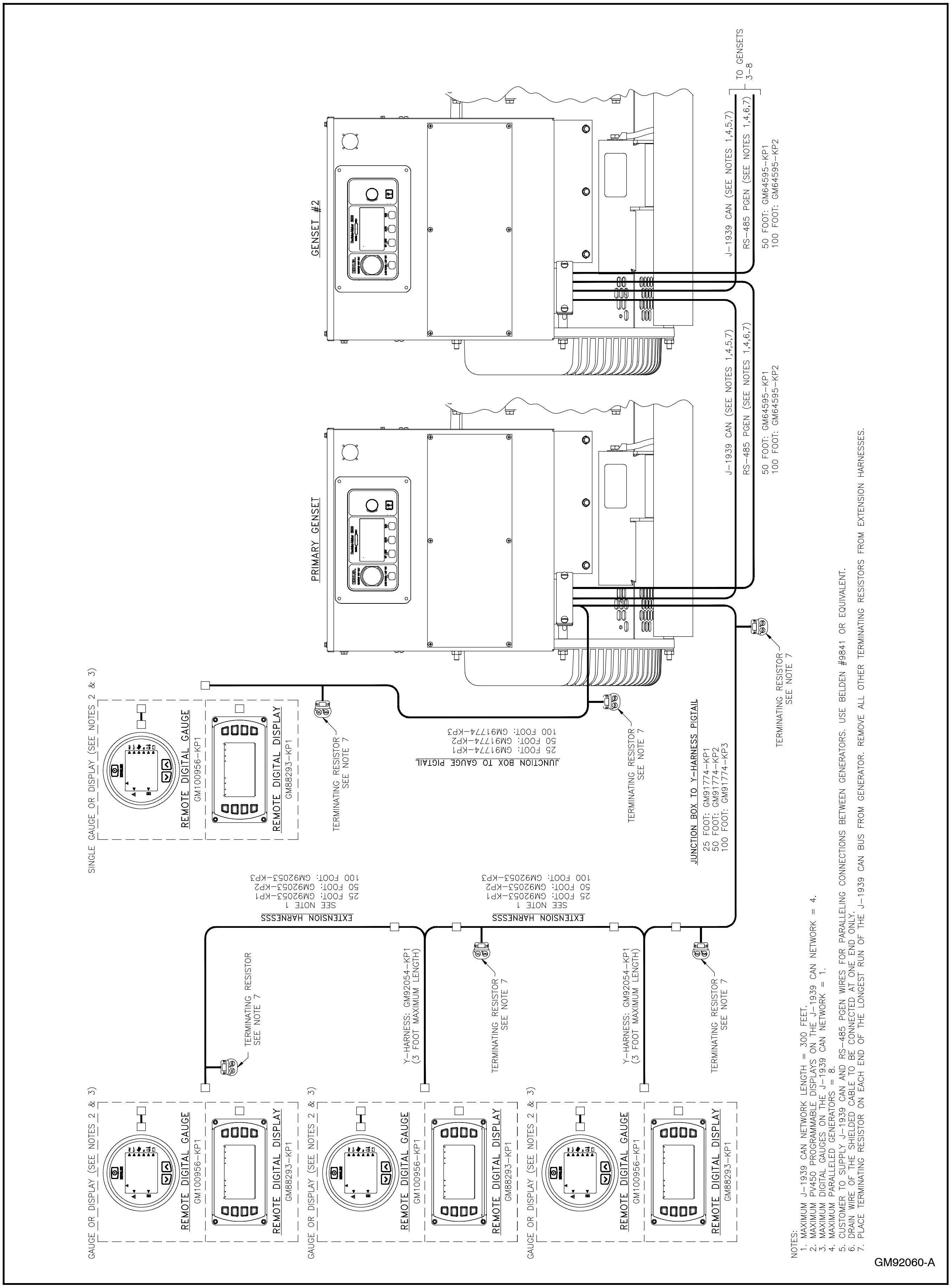


Figure 17-55 System Remote Display

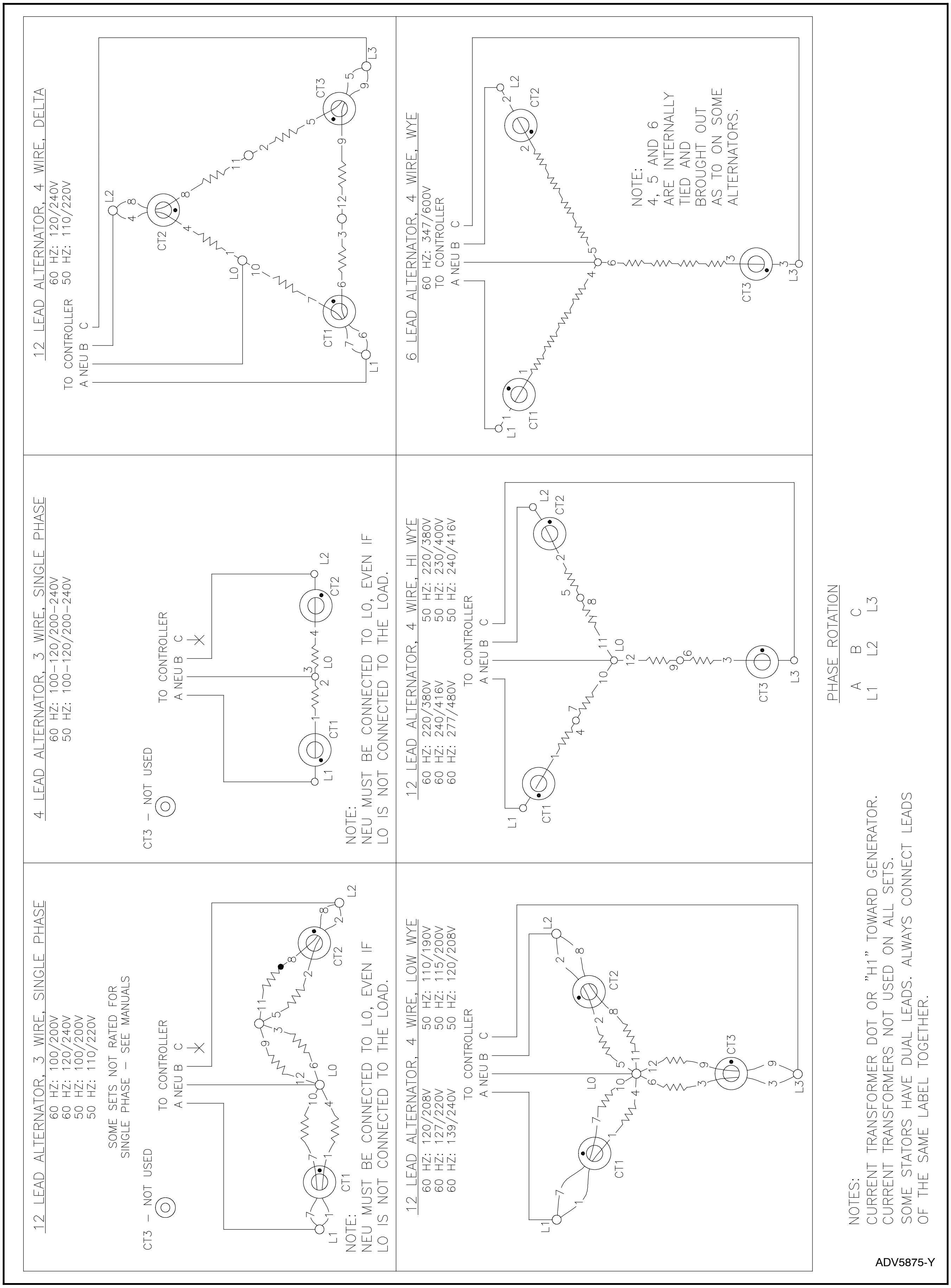


Figure 17-56 Reconnection Diagram, ADV-5875 (Sheet 1 of 2)

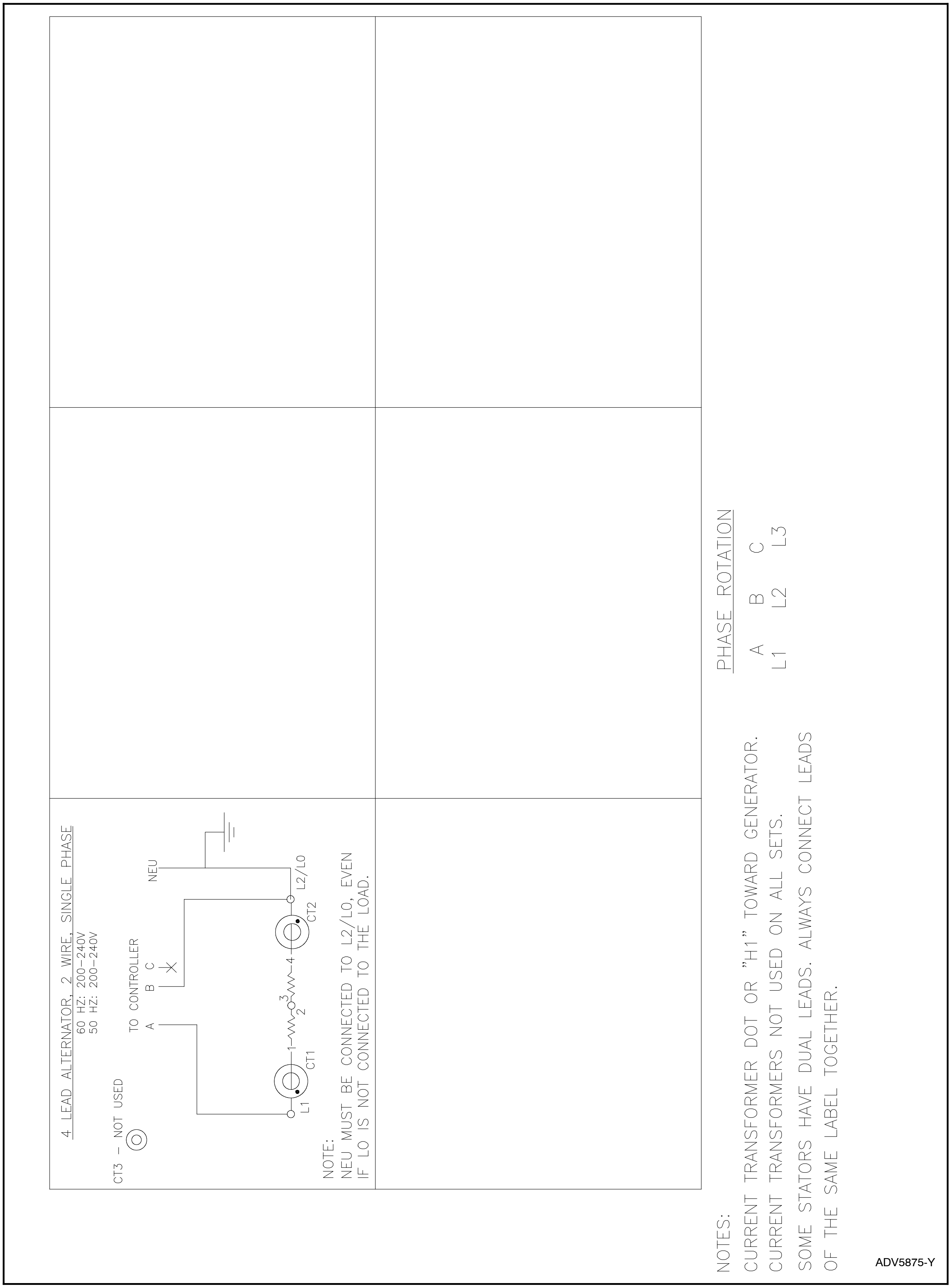


Figure 17-57 Reconnection Diagram, ADV-5875 (Sheet 2 of 2)

Notes

Appendix A Abbreviations

The following list contains abbreviations that may appear in this publication.

A, amp	ampere
ABDC	after bottom dead center
AC	alternating current
A/D	analog to digital
ADC	advanced digital control; analog to digital converter
adj.	adjust, adjustment
ADV	advertising dimensional drawing
Ah	amp-hour
AHWT	anticipatory high water temperature
AISI	American Iron and Steel Institute
ALOP	anticipatory low oil pressure
alt.	alternator
Al	aluminum
ANSI	American National Standards Institute (formerly American Standards Association, ASA)
AO	anticipatory only
APDC	Air Pollution Control District
API	American Petroleum Institute
approx.	approximate, approximately
AQMD	Air Quality Management District
AR	as required, as requested
AS	as supplied, as stated, as suggested
ASE	American Society of Engineers
ASME	American Society of Mechanical Engineers
assy.	assembly
ASTM	American Society for Testing Materials
ATDC	after top dead center
ATS	automatic transfer switch
auto.	automatic
aux.	auxiliary
avg.	average
AVR	automatic voltage regulator
AWG	American Wire Gauge
AWM	appliance wiring material
bat.	battery
BBDC	before bottom dead center
BC	battery charger, battery charging
BCA	battery charging alternator
BCI	Battery Council International
BDC	before dead center
BHP	brake horsepower
blk.	black (paint color), block (engine)
blk. htr.	block heater
BMEP	brake mean effective pressure
bps	bits per second
br.	brass
BTDC	before top dead center
Btu	British thermal unit
Btu/min.	British thermal units per minute
C	Celsius, centigrade
cal.	calorie
CAN	controller area network
CARB	California Air Resources Board
CB	circuit breaker
cc	cubic centimeter
CCA	cold cranking amps
ccw.	counterclockwise
CEC	Canadian Electrical Code
cert.	certificate, certification, certified
cfh	cubic feet per hour
cfm	cubic feet per minute
CG	center of gravity
CID	cubic inch displacement
CL	centerline
cm	centimeter
CMOS	complementary metal oxide substrate (semiconductor)
cogen.	cogeneration
com	communications (port)
coml	commercial
Coml/Rec	Commercial/Recreational
conn.	connection
cont.	continued
CPVC	chlorinated polyvinyl chloride
crit.	critical
CRT	cathode ray tube
CSA	Canadian Standards Association
CT	current transformer
Cu	copper
cUL	Canadian Underwriter's Laboratories
CUL	Canadian Underwriter's Laboratories
cu. in.	cubic inch
cw.	clockwise
CWC	city water-cooled
cyl.	cylinder
D/A	digital to analog
DAC	digital to analog converter
dB	decibel
dB(A)	decibel (A weighted)
DC	direct current
DCR	direct current resistance
deg., °	degree
dept.	department
DFMEA	Design Failure Mode and Effects Analysis
dia.	diameter
DI/EO	dual inlet/end outlet
DIN	Deutsches Institut fur Normung e. V. (also Deutsche Industrie Normenausschuss)
DIP	dual inline package
DPDT	double-pole, double-throw
DPST	double-pole, single-throw
DS	disconnect switch
DVR	digital voltage regulator
E, emer.	emergency (power source)
ECM	electronic control module, engine control module
EDI	electronic data interchange
EFR	emergency frequency relay
e.g.	for example (*exempli gratia)*
EG	electronic governor
EGSA	Electrical Generating Systems Association
EIA	Electronic Industries Association
EI/EO	end inlet/end outlet
EMI	electromagnetic interference
emiss.	emission
eng.	engine
EPA	Environmental Protection Agency
EPS	emergency power system
ER	emergency relay
ES	engineering special, engineered special
ESD	electrostatic discharge
est.	estimated
E-Stop	emergency stop
etc.	et cetera (and so forth)
exh.	exhaust
ext.	external
F	Fahrenheit, female
fglass.	fiberglass
FHM	flat head machine (screw)
fl. oz.	fluid ounce
flex.	flexible
freq.	frequency
FS	full scale
ft.	foot, feet
ft. lb.	foot pounds (torque)
ft./min.	feet per minute
ftp	file transfer protocol
g	gram
ga.	gauge (meters, wire size)
gal.	gallon
gen.	generator
genset	generator set
GFI	ground fault interrupter
GND, ⏚	ground
gov.	governor
gph	gallons per hour
gpm	gallons per minute
gr.	grade, gross
GRD	equipment ground
gr. wt.	gross weight
H x W x D	height by width by depth
HC	hex cap
HCHT	high cylinder head temperature
HD	heavy duty
HET	high exhaust temp., high engine temp.
hex	hexagon
Hg	mercury (element)
HH	hex head
HHC	hex head cap
HP	horsepower
hr.	hour
HS	heat shrink
hsg.	housing
HVAC	heating, ventilation, and air conditioning
HWT	high water temperature
Hz	hertz (cycles per second)
IC	integrated circuit
ID	inside diameter, identification
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMS	improved motor starting
in.	inch
in. H_2O	inches of water
in. Hg	inches of mercury
in. lb.	inch pounds
Inc.	incorporated
ind.	industrial
int.	internal
int./ext.	internal/external
I/O	input/output
IP	iron pipe
ISO	International Organization for Standardization
J	joule
JIS	Japanese Industry Standard

k	kilo (1000)
K	kelvin
kA	kiloampere
KB	kilobyte (2^{10} bytes)
KBus	Kohler communication protocol
kg	kilogram
kg/cm^2	kilograms per square centimeter
kgm	kilogram-meter
kg/m^3	kilograms per cubic meter
kHz	kilohertz
kJ	kilojoule
km	kilometer
kOhm, kΩ	kilo-ohm
kPa	kilopascal
kph	kilometers per hour
kV	kilovolt
kVA	kilovolt ampere
kVAR	kilovolt ampere reactive
kW	kilowatt
kWh	kilowatt-hour
kWm	kilowatt mechanical
kWth	kilowatt-thermal
L	liter
LAN	local area network
L x W x H	length by width by height
lb.	pound, pounds
lbm/ft^3	pounds mass per cubic feet
LCB	line circuit breaker
LCD	liquid crystal display
ld. shd.	load shed
LED	light emitting diode
Lph	liters per hour
Lpm	liters per minute
LOP	low oil pressure
LP	liquefied petroleum
LPG	liquefied petroleum gas
LS	left side
L_{wa}	sound power level, A weighted
LWL	low water level
LWT	low water temperature
m	meter, milli (1/1000)
M	mega (10^6 when used with SI units), male
m^3	cubic meter
m^3/hr.	cubic meters per hour
m^3/min.	cubic meters per minute
mA	milliampere
man.	manual
max.	maximum
MB	megabyte (2^{20} bytes)
MCCB	molded-case circuit breaker
MCM	one thousand circular mils
meggar	megohmmeter
MHz	megahertz
mi.	mile
mil	one one-thousandth of an inch
min.	minimum, minute
misc.	miscellaneous
MJ	megajoule
mJ	millijoule
mm	millimeter
mOhm, mΩ	milliohm
MOhm, MΩ	megohm
MOV	metal oxide varistor
MPa	megapascal
mpg	miles per gallon
mph	miles per hour
MS	military standard
ms	millisecond
m/sec.	meters per second
MTBF	mean time between failure
MTBO	mean time between overhauls
mtg.	mounting
MTU	Motoren-und Turbinen-Union
MW	megawatt
mW	milliwatt
µF	microfarad
N, norm.	normal (power source)
NA	not available, not applicable
nat. gas	natural gas
NBS	National Bureau of Standards
NC	normally closed
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
Nm	newton meter
NO	normally open
no., nos.	number, numbers
NPS	National Pipe, Straight
NPSC	National Pipe, Straight-coupling
NPT	National Standard taper pipe thread per general use
NPTF	National Pipe, Taper-Fine
NR	not required, normal relay
ns	nanosecond
OC	overcrank
OD	outside diameter
OEM	original equipment manufacturer
OF	overfrequency
opt.	option, optional
OS	oversize, overspeed
OSHA	Occupational Safety and Health Administration
OV	overvoltage
oz.	ounce
p., pp.	page, pages
PC	personal computer
PCB	printed circuit board
pF	picofarad
PF	power factor
ph., ∅	phase
PHC	Phillips® head Crimptite® (screw)
PHH	Phillips® hex head (screw)
PHM	pan head machine (screw)
PLC	programmable logic control
PMG	permanent magnet generator
pot	potentiometer, potential
ppm	parts per million
PROM	programmable read-only memory
psi	pounds per square inch
psig	pounds per square inch gauge
pt.	pint
PTC	positive temperature coefficient
PTO	power takeoff
PVC	polyvinyl chloride
qt.	quart, quarts
qty.	quantity
R	replacement (emergency) power source
rad.	radiator, radius
RAM	random access memory
RDO	relay driver output
ref.	reference
rem.	remote
Res/Coml	Residential/Commercial
RFI	radio frequency interference
RH	round head
RHM	round head machine (screw)
rly.	relay
rms	root mean square
rnd.	round
ROM	read only memory
rot.	rotate, rotating
rpm	revolutions per minute
RS	right side
RTU	remote terminal unit
RTV	room temperature vulcanization
RW	read/write
SAE	Society of Automotive Engineers
scfm	standard cubic feet per minute
SCR	silicon controlled rectifier
s, sec.	second
SI	*Systeme international d'unites,* International System of Units
SI/EO	side in/end out
sil.	silencer
SN	serial number
SNMP	simple network management protocol
SPDT	single-pole, double-throw
SPST	single-pole, single-throw
spec	specification
specs	specification(s)
sq.	square
sq. cm	square centimeter
sq. in.	square inch
SS	stainless steel
std.	standard
stl.	steel
tach.	tachometer
TD	time delay
TDC	top dead center
TDEC	time delay engine cooldown
TDEN	time delay emergency to normal
TDES	time delay engine start
TDNE	time delay normal to emergency
TDOE	time delay off to emergency
TDON	time delay off to normal
temp.	temperature
term.	terminal
THD	total harmonic distortion
TIF	telephone influence factor
TIR	total indicator reading
tol.	tolerance
turbo.	turbocharger
typ.	typical (same in multiple locations)
UF	underfrequency
UHF	ultrahigh frequency
UL	Underwriter's Laboratories, Inc.
UNC	unified coarse thread (was NC)
UNF	unified fine thread (was NF)
univ.	universal
US	undersize, underspeed
UV	ultraviolet, undervoltage
V	volt
VAC	volts alternating current
VAR	voltampere reactive
VDC	volts direct current
VFD	vacuum fluorescent display
VGA	video graphics adapter
VHF	very high frequency
W	watt
WCR	withstand and closing rating
w/	with
w/o	without
wt.	weight
xfmr	transformer

Appendix B Common Hardware Application Guidelines

Use the information below and on the following pages to identify proper fastening techniques when no specific reference for reassembly is made.

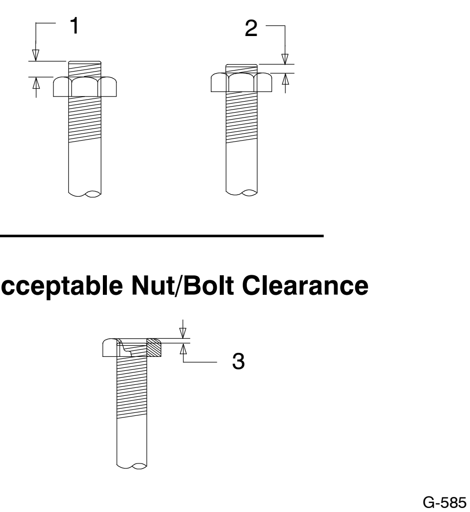
Bolt/Screw Length: When bolt/screw length is not given, use Figure 1 as a guide. As a general rule, a minimum length of one thread beyond the nut and a maximum length of 1/2 the bolt/screw diameter beyond the nut is the preferred method.

Washers and Nuts: Use split lock washers as a bolt locking device where specified. Use SAE flat washers with whiz nuts, spiralock nuts, or standard nuts and preloading (torque) of the bolt in all other applications.

See Appendix C, General Torque Specifications, and other torque specifications in the service literature.

Preferred Nut/Bolt Clearance

Unacceptable Nut/Bolt Clearance



1. 1/2 of bolt diameter
2. Min. 1 full thread beyond top of nut
3. Below top of nut

Figure 1 Acceptable Bolt Lengths

Steps for common hardware application:

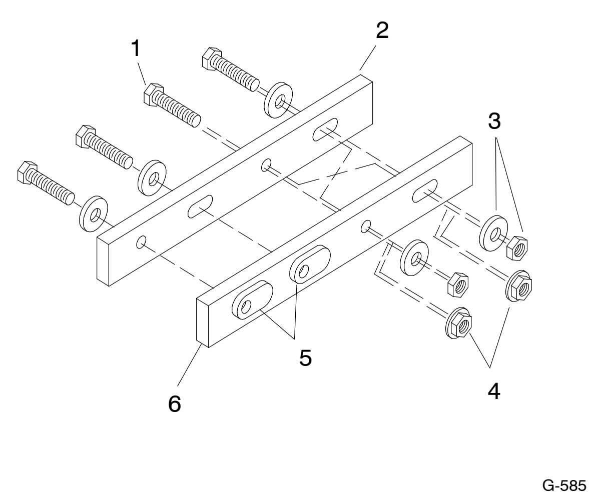
1. Determine entry hole type: round or slotted.
2. Determine exit hole type: fixed female thread (weld nut), round, or slotted.

   For round and slotted exit holes, determine if hardware is greater than 1/2 inch in diameter, or 1/2 inch in diameter or less. Hardware that is *greater than 1/2 inch* in diameter takes a standard nut and SAE washer. Hardware *1/2 inch or less* in diameter can take a properly torqued whiz nut or spiralock nut. See Figure 2.
3. Follow these SAE washer rules after determining exit hole type:

   a. Always use a washer between hardware and a slot.

   b. Always use a washer under a nut (see 2 above for exception).

   c. Use a washer under a bolt when the female thread is fixed (weld nut).
4. Refer to Figure 2, which depicts the preceding hardware configuration possibilities.



1. Cap screw
2. Entry hole types
3. Standard nut and SAE washer
4. Whiz nut or spiralock: up to 1/2 in. dia. hardware
5. Weld nuts: above 1/2 in. dia. hardware
6. Exit hole types

Figure 2 Acceptable Hardware Combinations

Appendix C General Torque Specifications

American Standard Fasteners Torque Specifications					
Size	Torque Measurement	Assembled into Cast Iron or Steel — Grade 2	Grade 5	Grade 8	Assembled into Aluminum Grade 2 or 5
8-32	Nm (in. lb.)	1.8 (16)	2.3 (20)	—	See Note 3
10-24	Nm (in. lb.)	2.9 (26)	3.6 (32)	—	
10-32	Nm (in. lb.)	2.9 (26)	3.6 (32)	—	
1/4-20	Nm (in. lb.)	6.8 (60)	10.8 (96)	14.9 (132)	
1/4-28	Nm (in. lb.)	8.1 (72)	12.2 (108)	16.3 (144)	
5/16-18	Nm (in. lb.)	13.6 (120)	21.7 (192)	29.8 (264)	
5/16-24	Nm (in. lb.)	14.9 (132)	23.1 (204)	32.5 (288)	
3/8-16	Nm (ft. lb.)	24.0 (18)	38.0 (28)	53.0 (39)	
3/8-24	Nm (ft. lb.)	27.0 (20)	42.0 (31)	60.0 (44)	
7/16-14	Nm (ft. lb.)	39.0 (29)	60.0 (44)	85.0 (63)	
7/16-20	Nm (ft. lb.)	43.0 (32)	68.0 (50)	95.0 (70)	
1/2-13	Nm (ft. lb.)	60.0 (44)	92.0 (68)	130.0 (96)	
1/2-20	Nm (ft. lb.)	66.0 (49)	103.0 (76)	146.0 (108)	
9/16-12	Nm (ft. lb.)	81.0 (60)	133.0 (98)	187.0 (138)	
9/16-18	Nm (ft. lb.)	91.0 (67)	148.0 (109)	209.0 (154)	
5/8-11	Nm (ft. lb.)	113.0 (83)	183.0 (135)	259.0 (191)	
5/8-18	Nm (ft. lb.)	128.0 (94)	208.0 (153)	293.0 (216)	
3/4-10	Nm (ft. lb.)	199.0 (147)	325.0 (240)	458.0 (338)	
3/4-16	Nm (ft. lb.)	222.0 (164)	363.0 (268)	513.0 (378)	
1-8	Nm (ft. lb.)	259.0 (191)	721.0 (532)	1109.0 (818)	
1-12	Nm (ft. lb.)	283.0 (209)	789.0 (582)	1214.0 (895)	

Metric Fasteners Torque Specifications, Measured in Nm (ft. lb.)				
Size (mm)	Assembled into Cast Iron or Steel — Grade 5.8	Grade 8.8	Grade 10.9	Assembled into Aluminum Grade 5.8 or 8.8
M6 x 1.00	6.2 (4.6)	9.5 (7)	13.6 (10)	See Note 3
M8 x 1.25	15.0 (11)	23.0 (17)	33.0 (24)	
M8 x 1.00	16.0 (11)	24.0 (18)	34.0 (25)	
M10 x 1.50	30.0 (22)	45.0 (34)	65.0 (48)	
M10 x 1.25	31.0 (23)	47.0 (35)	68.0 (50)	
M12 x 1.75	53.0 (39)	80.0 (59)	115.0 (85)	
M12 x 1.50	56.0 (41)	85.0 (63)	122.0 (90)	
M14 x 2.00	83.0 (61)	126.0 (93)	180.0 (133)	
M14 x 1.50	87.0 (64)	133.0 (98)	190.0 (140)	
M16 x 2.00	127.0 (94)	194.0 (143)	278.0 (205)	
M16 x 1.50	132.0 (97)	201.0 (148)	287.0 (212)	
M18 x 2.50	179.0 (132)	273.0 (201)	390.0 (288)	
M18 x 1.50	189.0 (140)	289.0 (213)	413.0 (305)	

Notes:
1. The torque values above are general guidelines. Always use the torque values specified in the service manuals and/or assembly drawings when they differ from the above torque values.
2. The torque values above are based on new plated threads. Increase torque values by 15% if non-plated threads are used.
3. Hardware threaded into aluminum must have either two diameters of thread engagement or a 30% or more reduction in the torque to prevent stripped threads.
4. Torque values are calculated as equivalent stress loading on American hardware with an approximate preload of 90% of the yield strength and a friction coefficient of 0.125.

Screw/Bolts/Studs	
Head Styles	
Hex Head or Machine Head	
Hex Head or Machine Head with Washer	
Flat Head (FHM)	
Round Head (RHM)	
Pan Head	
Hex Socket Head Cap or Allen™ Head Cap	
Hex Socket Head or Allen™ Head Shoulder Bolt	
Sheet Metal Screw	
Stud	
Drive Styles	
Hex	
Hex and Slotted	
Phillips®	
Slotted	
Hex Socket	

Nuts	
Nut Styles	
Hex Head	
Lock or Elastic	
Square	
Cap or Acorn	
Wing	

Washers	
Washer Styles	
Plain	
Split Lock or Spring	
Spring or Wave	
External Tooth Lock	
Internal Tooth Lock	
Internal-External Tooth Lock	

Hardness Grades	
American Standard	
Grade 2	
Grade 5	
Grade 8	
Grade 8/9 (Hex Socket Head)	
Metric	
Number stamped on hardware; 5.8 shown	5.8

Hose Clamp Covers	
Black, EPDM rubber used on worm gear clamps	

Allen™ head screw is a trademark of Holo-Krome Co.

Phillips® screw is a registered trademark of Phillips Screw Company.

Sample Dimensions

American Standard (Screws, Bolts, Studs, and Nuts)

1/4-20 x 1

- 1 — Length In Inches (Screws and Bolts)
- 20 — Threads Per Inch
- 1/4 — Major Thread Diameter In Fractional Inches Or Screw Number Size

Metric (Screws, Bolts, Studs, and Nuts)

M8-1.25 x 20

- 20 — Length In Millimeters (Screws and Bolts)
- 1.25 — Distance Between Threads In Millimeters
- M8 — Major Thread Diameter In Millimeters

Plain Washers

9/32 x 5/8 x 1/16

- 1/16 — Thickness
- 5/8 — External Dimension
- 9/32 — Internal Dimension

Lock Washers

5/8

- 5/8 — Internal Dimension

Appendix E Common Hardware List

The Common Hardware List lists part numbers and dimensions for common hardware items.

American Standard

Hex Head Bolts (Grade 5)

Part No.	Dimensions
X-465-17	1/4-20 x .38
X-465-6	1/4-20 x .50
X-465-2	1/4-20 x .62
X-465-16	1/4-20 x .75
X-465-18	1/4-20 x .88
X-465-7	1/4-20 x 1.00
X-465-8	1/4-20 x 1.25
X-465-9	1/4-20 x 1.50
X-465-10	1/4-20 x 1.75
X-465-11	1/4-20 x 2.00
X-465-12	1/4-20 x 2.25
X-465-14	1/4-20 x 2.75
X-465-21	1/4-20 x 5.00
X-465-25	1/4-28 x .38
X-465-20	1/4-28 x 1.00
X-125-33	5/16-18 x .50
X-125-23	5/16-18 x .62
X-125-3	5/16-18 x .75
X-125-31	5/16-18 x .88
X-125-5	5/16-18 x 1.00
X-125-24	5/16-18 x 1.25
X-125-34	5/16-18 x 1.50
X-125-25	5/16-18 x 1.75
X-125-26	5/16-18 x 2.00
230578	5/16-18 x 2.25
X-125-29	5/16-18 x 2.50
X-125-27	5/16-18 x 2.75
X-125-28	5/16-18 x 3.00
X-125-22	5/16-18 x 4.50
X-125-32	5/16-18 x 5.00
X-125-35	5/16-18 x 5.50
X-125-36	5/16-18 x 6.00
X-125-40	5/16-18 x 6.50
X-125-43	5/16-24 x 1.75
X-125-44	5/16-24 x 2.50
X-125-30	5/16-24 x .75
X-125-39	5/16-24 x 2.00
X-125-38	5/16-24 x 2.75
X-6238-2	3/8-16 x .62
X-6238-10	3/8-16 x .75
X-6238-3	3/8-16 x .88
X-6238-11	3/8-16 x 1.00
X-6238-4	3/8-16 x 1.25
X-6238-5	3/8-16 x 1.50
X-6238-1	3/8-16 x 1.75
X-6238-6	3/8-16 x 2.00
X-6238-17	3/8-16 x 2.25
X-6238-7	3/8-16 x 2.50
X-6238-8	3/8-16 x 2.75
X-6238-9	3/8-16 x 3.00
X-6238-19	3/8-16 x 3.25
X-6238-12	3/8-16 x 3.50
X-6238-20	3/8-16 x 3.75
X-6238-13	3/8-16 x 4.50
X-6238-18	3/8-16 x 5.50
X-6238-25	3/8-16 x 6.50

Hex Head Bolts, cont.

Part No.	Dimensions
X-6238-14	3/8-24 x .75
X-6238-16	3/8-24 x 1.25
X-6238-21	3/8-24 x 4.00
X-6238-22	3/8-24 x 4.50
X-6024-5	7/16-14 x .75
X-6024-2	7/16-14 x 1.00
X-6024-8	7/16-14 x 1.25
X-6024-3	7/16-14 x 1.50
X-6024-4	7/16-14 x 2.00
X-6024-11	7/16-14 x 2.75
X-6024-12	7/16-14 x 6.50
X-129-15	1/2-13 x .75
X-129-17	1/2-13 x 1.00
X-129-18	1/2-13 x 1.25
X-129-19	1/2-13 x 1.50
X-129-20	1/2-13 x 1.75
X-129-21	1/2-13 x 2.00
X-129-22	1/2-13 x 2.25
X-129-23	1/2-13 x 2.50
X-129-24	1/2-13 x 2.75
X-129-25	1/2-13 x 3.00
X-129-27	1/2-13 x 3.50
X-129-29	1/2-13 x 4.00
X-129-30	1/2-13 x 4.50
X-463-9	1/2-13 x 5.50
X-129-44	1/2-13 x 6.00
X-129-51	1/2-20 x .75
X-129-45	1/2-20 x 1.25
X-129-52	1/2-20 x 1.50
X-6021-3	5/8-11 x 1.00
X-6021-4	5/8-11 x 1.25
X-6021-2	5/8-11 x 1.50
X-6021-1	5/8-11 x 1.75
273049	5/8-11 x 2.00
X-6021-5	5/8-11 x 2.25
X-6021-6	5/8-11 x 2.50
X-6021-7	5/8-11 x 2.75
X-6021-12	5/8-11 x 3.75
X-6021-11	5/8-11 x 4.50
X-6021-10	5/8-11 x 6.00
X-6021-9	5/8-18 x 2.50
X-6239-1	3/4-10 x 1.00
X-6239-8	3/4-10 x 1.25
X-6239-2	3/4-10 x 1.50
X-6239-3	3/4-10 x 2.00
X-6239-4	3/4-10 x 2.50
X-6239-5	3/4-10 x 3.00
X-6239-6	3/4-10 x 3.50
X-792-1	1-8 x 2.25
X-792-5	1-8 x 3.00
X-792-8	1-8 x 5.00

Hex Nuts

Part No.	Dimensions	Type
X-6009-1	1-8	Standard
X-6210-3	6-32	Whiz
X-6210-4	8-32	Whiz
X-6210-5	10-24	Whiz
X-6210-1	10-32	Whiz
X-6210-2	1/4-20	Spiralock
X-6210-6	1/4-28	Spiralock
X-6210-7	5/16-18	Spiralock
X-6210-8	5/16-24	Spiralock
X-6210-9	3/8-16	Spiralock
X-6210-10	3/8-24	Spiralock
X-6210-11	7/16-14	Spiralock
X-6210-12	1/2-13	Spiralock
X-6210-15	7/16-20	Spiralock
X-6210-14	1/2-20	Spiralock
X-85-3	5/8-11	Standard
X-88-12	3/4-10	Standard
X-89-2	1/2-20	Standard

Washers

Part No.	ID	OD	Thick.	Bolt/ Screw
X-25-46	.125	.250	.022	#4
X-25-9	.156	.375	.049	#6
X-25-48	.188	.438	.049	#8
X-25-36	.219	.500	.049	#10
X-25-40	.281	.625	.065	1/4
X-25-85	.344	.687	.065	5/16
X-25-37	.406	.812	.065	3/8
X-25-34	.469	.922	.065	7/16
X-25-26	.531	1.062	.095	1/2
X-25-15	.656	1.312	.095	5/8
X-25-29	.812	1.469	.134	3/4
X-25-127	1.062	2.000	.134	1

Hose Clamp Covers

Part No.	Clamp Size
GM102674-1	13 mm (1/2 in.)
GM102674-2	8 mm (5/16 in.)

Metric

Hex head bolts are hardness grade 8.8 unless noted.

Hex Head Bolts (Partial Thread)

Part No.	Dimensions
M931-05055-60	M5-0.80 x 55
M931-06040-60	M6-1.00 x 40
M931-06055-60	M6-1.00 x 55
M931-06060-60	M6-1.00 x 60
M931-06060-SS	M6-1.00 x 60
M931-06070-60	M6-1.00 x 70
M931-06070-SS	M6-1.00 x 70
M931-06075-60	M6-1.00 x 75
M931-06090-60	M6-1.00 x 90
M931-06145-60	M6-1.00 x 145
M931-06150-60	M6-1.00 x 150
M931-08035-60	M8-1.25 x 35
M931-08040-60	M8-1.25 x 40
M931-08045-60	M8-1.25 x 45
M931-08050-60	M8-1.25 x 50
M931-08055-60	M8-1.25 x 55
M931-08055-82	M8-1.25 x 55*
M931-08060-60	M8-1.25 x 60
M931-08070-60	M8-1.25 x 70
M931-08070-82	M8-1.25 x 70*
M931-08075-60	M8-1.25 x 75
M931-08080-60	M8-1.25 x 80
M931-08090-60	M8-1.25 x 90
M931-08095-60	M8-1.25 x 95
M931-08100-60	M8-1.25 x 100
M931-08110-60	M8-1.25 x 110
M931-08120-60	M8-1.25 x 120
M931-08130-60	M8-1.25 x 130
M931-08140-60	M8-1.25 x 140
M931-08150-60	M8-1.25 x 150
M931-08200-60	M8-1.25 x 200
M931-10040-82	M10-1.25 x 40*
M931-10040-60	M10-1.50 x 40
M931-10045-60	M10-1.50 x 45
M931-10050-60	M10-1.50 x 50
M931-10050-82	M10-1.25 x 50*
M931-10055-60	M10-1.50 x 55
M931-10060-60	M10-1.50 x 60
M931-10065-60	M10-1.50 x 65
M931-10070-60	M10-1.50 x 70
M931-10080-60	M10-1.50 x 80
M931-10080-82	M10-1.25 x 80*
M931-10090-60	M10-1.50 x 90
M931-10090-82	M10-1.50 x 90*
M931-10100-60	M10-1.50 x 100
M931-10110-60	M10-1.50 x 110
M931-10120-60	M10-1.50 x 120
M931-10130-60	M10-1.50 x 130
M931-10140-60	M10-1.50 x 140
M931-10180-60	M10-1.50 x 180
M931-10235-60	M10-1.50 x 235
M931-10260-60	M10-1.50 x 260
M960-10330-60	M10-1.25 x 330
M931-12045-60	M12-1.75 x 45
M960-12050-60	M12-1.25 x 50
M960-12050-82	M12-1.25 x 50*
M931-12050-60	M12-1.75 x 50
M931-12050-82	M12-1.75 x 50*
M931-12055-60	M12-1.75 x 55
M931-12060-60	M12-1.75 x 60
M931-12060-82	M12-1.75 x 60*
M931-12065-60	M12-1.75 x 65
M931-12075-60	M12-1.75 x 75
M931-12080-60	M12-1.75 x 80
M931-12090-60	M12-1.75 x 90
M931-12100-60	M12-1.75 x 100
M931-12110-60	M12-1.75 x 110

Hex Head Bolts (Partial Thread), continued

Part No.	Dimensions
M960-16090-60	M16-1.50 x 90
M931-16090-60	M16-2.00 x 90
M931-16100-60	M16-2.00 x 100
M931-16100-82	M16-2.00 x 100*
M931-16120-60	M16-2.00 x 120
M931-16150-60	M16-2.00 x 150
M931-20065-60	M20-2.50 x 65
M931-20090-60	M20-2.50 x 90
M931-20100-60	M20-2.50 x 100
M931-20120-60	M20-2.50 x 120
M931-20140-60	M20-2.50 x 140
M931-20160-60	M20-2.50 x 160
M931-22090-60	M22-2.50 x 90
M931-22120-60	M22-2.50 x 120
M931-22160-60	M22-2.50 x 160
M931-24090-60	M24-3.00 x 90
M931-24120-60	M24-3.00 x 120
M931-24160-60	M24-3.00 x 160
M931-24200-60	M24-3.00 x 200

Hex Head Bolts (Full Thread)

Part No.	Dimensions
M933-04006-60	M4-0.70 x 6
M933-05030-60	M5-0.80 x 30
M933-05035-60	M5-0.80 x 35
M933-05050-60	M5-0.80 x 50
M933-06010-60	M6-1.00 x 10
M933-06012-60	M6-1.00 x 12
M933-06014-60	M6-1.00 x 14
M933-06016-60	M6-1.00 x 16
M933-06020-60	M6-1.00 x 20
M933-06025-60	M6-1.00 x 25
M933-06030-60	M6-1.00 x 30
M933-06040-60	M6-1.00 x 40
M933-06050-60	M6-1.00 x 50
M933-07025-60	M7-1.00 x 25
M933-08010-60	M8-1.25 x 10
M933-08012-60	M8-1.25 x 12
M933-08016-60	M8-1.25 x 16
M933-08020-60	M8-1.25 x 20
M933-08025-60	M8-1.25 x 25
M933-08030-60	M8-1.25 x 30
M933-08030-82	M8-1.25 x 30*
M933-10012-60	M10-1.50 x 12
M961-10020-60	M10-1.25 x 20
M933-10020-60	M10-1.50 x 20
M933-10025-60	M10-1.50 x 25
M961-10025-60	M10-1.25 x 25
M933-10025-82	M10-1.50 x 25*
M961-10030-60	M10-1.25 x 30
M933-10030-60	M10-1.50 x 30
M933-10030-82	M10-1.50 x 30*
M961-10035-60	M10-1.25 x 35
M933-10035-60	M10-1.50 x 35
M933-10035-82	M10-1.50 x 35*
M961-10040-60	M10-1.25 x 40

Hex Head Bolts (Full Thread), continued

Part No.	Dimensions
M933-12016-60	M12-1.75 x 16
M933-12020-60	M12-1.75 x 20
M961-12020-60F	M12-1.50 x 20
M933-12025-60	M12-1.75 x 25
M933-12025-82	M12-1.75 x 25*
M961-12030-60	M12-1.25 x 30
M933-12030-82	M12-1.75 x 30*
M961-12030-82F	M12-1.50 x 30*
M933-12030-60	M12-1.75 x 30
M933-12035-60	M12-1.75 x 35
M961-12040-82	M12-1.25 x 40*
M933-12040-60	M12-1.75 x 40
M933-12040-82	M12-1.75 x 40*
M961-14025-60	M14-1.50 x 25
M933-14025-60	M14-2.00 x 25
M961-14050-82	M14-1.50 x 50*
M961-16025-60	M16-1.50 x 25
M933-16025-60	M16-2.00 x 25
M961-16030-82	M16-1.50 x 30*
M933-16030-82	M16-2.00 x 30*
M933-16035-60	M16-2.00 x 35
M961-16040-60	M16-1.50 x 40
M933-16040-60	M16-2.00 x 40
M961-16045-82	M16-1.50 x 45*
M933-16045-82	M16-2.00 x 45*
M933-16050-60	M16-2.00 x 50
M933-16050-82	M16-2.00 x 50*
M933-16060-60	M16-2.00 x 60
M933-16070-60	M16-2.00 x 70
M933-18035-60	M18-2.50 x 35
M933-18050-60	M18-2.50 x 50
M933-18060-60	M18-2.50 x 60
M933-20050-60	M20-2.50 x 50
M933-20055-60	M20-2.50 x 55
M933-24060-60	M24-3.00 x 60
M933-24065-60	M24-3.00 x 65
M933-24070-60	M24-3.00 x 70

Pan Head Machine Screws

Part No.	Dimensions
M7985A-03010-20	M3-0.50 x 10
M7985A-03012-20	M3-0.50 x 12
M7985A-04010-20	M4-0.70 x 10
M7985A-04016-20	M4-0.70 x 16
M7985A-04020-20	M4-0.70 x 20
M7985A-04050-20	M4-0.70 x 50
M7985A-04100-20	M4-0.70 x 100
M7985A-05010-20	M5-0.80 x 10
M7985A-05012-20	M5-0.80 x 12
M7985A-05016-20	M5-0.80 x 16
M7985A-05020-20	M5-0.80 x 20
M7985A-05025-20	M5-0.80 x 25
M7985A-05030-20	M5-0.80 x 30
M7985A-05080-20	M5-0.80 x 80
M7985A-05100-20	M5-0.80 x 100
M7985A-06100-20	M6-1.00 x 100

Flat Head Machine Screws

Part No.	Dimensions
M965A-04012-SS	M4-0.70 x 12
M965A-05012-SS	M5-0.80 x 12
M965A-05016-20	M5-0.80 x 16
M965A-06012-20	M6-1.00 x 12

* This metric hex bolt’s hardness is grade 10.9.

Metric, continued

Part No.	Dimensions	Type
Hex Nuts		
M934-03-50	M3-0.50	Standard
M934-04-50	M4-0.70	Standard
M934-04-B	M4-0.70	Brass
M934-05-50	M5-0.80	Standard
M934-06-60	M6-1.00	Standard
M934-06-64	M6-1.00	Std. (green)
M6923-06-80	M6-1.00	Spiralock
M982-06-80	M6-1.00	Elastic Stop
M934-08-60	M8-1.25	Standard
M6923-08-80	M8-1.25	Spiralock
M982-08-80	M8-1.25	Elastic Stop
M934-10-60	M10-1.50	Standard
M934-10-60F	M10-1.25	Standard
M6923-10-80	M10-1.50	Spiralock
M6923-10-62	M10-1.50	Spiralock†
M982-10-80	M10-1.50	Elastic Stop
M934-12-60	M12-1.75	Standard
M934-12-60F	M12-1.25	Standard
M6923-12-80	M12-1.75	Spiralock
M982-12-80	M12-1.75	Elastic Stop
M982-14-60	M14-2.00	Elastic Stop
M6923-16-80	M16-2.00	Spiralock
M982-16-80	M16-2.00	Elastic Stop
M934-18-80	M18-2.5	Standard
M982-18-60	M18-2.50	Elastic Stop
M934-20-80	M20-2.50	Standard
M982-20-80	M20-2.50	Elastic Stop
M934-22-60	M22-2.50	Standard
M934-24-80	M24-3.00	Standard
M982-24-60	M24-3.00	Elastic Stop
M934-30-80	M30-3.50	Standard

Washers

Part No.	ID	OD	Thick.	Bolt/ Screw
M125A-03-80	3.2	7.0	0.5	M3
M125A-04-80	4.3	9.0	0.8	M4
M125A-05-80	5.3	10.0	1.0	M5
M125A-06-80	6.4	12.0	1.6	M6
M125A-08-80	8.4	16.0	1.6	M8
M125A-10-80	10.5	20.0	2.0	M10
M125A-12-80	13.0	24.0	2.5	M12
M125A-14-80	15.0	28.0	2.5	M14
M125A-16-80	17.0	30.0	3.0	M16
M125A-18-80	19.0	34.0	3.0	M18
M125A-20-80	21.0	37.0	3.0	M20
M125A-24-80	25.0	44.0	4.0	M24

† This metric hex nut's hardness is grade 8.

Appendix F Electrical Noise and Wiring Practices

Adapted from Service Bulletin SB-640 4/04.

Electrical noise is an unwanted electrical signal that can cause errors in measurement, loss of control, malfunctions in microprocessor-based control systems, errors in data transfer between systems over communication links, or reductions in system performance.

Good system design and wiring practices can minimize noise levels and the effects of noise.

Noise, because of its random nature, is typically characterized by frequency distribution. Many noise sources are broad-spectrum, that is, they produce many frequencies distributed over a wide range. Broad-spectrum noise is particularly troublesome because it cannot be removed easily by filtering and because it can affect a variety of systems in unpredictable ways. One common source of broad-spectrum noise is a switch, which can produce voltage and current changes when an electrical circuit is connected and disconnected.

Coupling is the transfer of signals between separate circuits. Signals from one circuit become noise in another. The amount of coupling is cumulative and is a function of the proximity of the circuits, their orientation, exposed area, and length of run. Minimize coupling by the following:

- Isolating circuits from each other by using separate raceways or conduit for AC and DC circuits
- Separating circuits from each other by locating them as far apart as possible
- Enclosing circuits with a grounded metallic shield such as an enclosure, metallic conduit, or cable shield
- Running conductors perpendicular, rather than parallel, to each other
- Running wires loosely and randomly rather than bundling them tightly together
- Twisting a circuit's wires together in pairs

In an industrial environment, there are typically five types of circuits with different noise emission and rejection capabilities. The five types of circuits are as follows:

- **High-Power Distribution.** Circuits to high-power loads such as large electric motors and heaters can emit transient high levels of broad-spectrum noise. Loads on high-power distribution circuits are nearly immune to noise.
- **General Purpose Power Distribution.** Circuits to medium-power loads such as lighting, offices, light-duty equipment, and small motors such as fans and pumps can emit transient, medium levels of broad-spectrum noise. Some electronic equipment, such as computers, emits constant levels of broad-spectrum noise in addition to transient broad-spectrum noise. Loads on general-purpose circuits, except for sensitive electronic equipment, are nearly immune to noise.
- **Control.** Control circuits include DC circuits and 120 VAC maximum AC circuits that operate at a low power level (less than 1 W). Typical circuits include circuits to switches, actuators, and dry-contact relays, including the generator engine-start circuit. Control circuits emit transient low levels of broad-spectrum noise and are fairly immune to noise.
- **Analog.** Analog circuits are low-voltage DC circuits that convey measurement information as relatively small changes in current or voltage. Typical circuits include those connected to the controller's analog inputs. Analog circuits create the lowest noise levels and are the most sensitive to noise.
- **Communication and Signaling.** Communication and signaling circuits are low-voltage circuits that convey information. Typical circuits include RS-232 and RS-485 serial communication lines, telephone lines, and computer network lines. These circuits create noise with frequencies related to the communication signaling rate. These circuits have some level of built-in noise immunity. Typical systems will detect or correct errors caused by noise below certain levels, but with a corresponding reduction in the data transfer rate.

When planning an installation, separate all of these types of circuits as much as possible to minimize the hazards of insulation failure, accidental miswiring, and noise coupling. For best results, install control circuits, analog circuits, and communication and signaling circuits separately. Combining circuit types is unavoidable in the controller's enclosure and some other areas.

Note: It is very important to isolate high- and medium-power circuits in raceways or conduit separate from the other types of circuits.

Notes

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Original Instructions (English)

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