DIAGNOSTIC REPAIR MANUAL

GENERAC®

Variable Speed Constant Frequency (60 Hz) Synergy™ Air-Cooled Product with G-Flex™ Technology

Models:

18 kW NG, 20kW LP - Synergy
15 kW NG & LP - EcoGen

STANDBY GENERATORS

Frequently Asked Questions

Q: Do I have to supply the generator with the 100% loaded BTU rated fuel supply and pipe size?

A: Yes, the generator needs the 100% loaded BTU fuel rating to start, run and handle loads. The fuel pipe must be sized for 100% load, regardless of the load.

Q: What distance does the gas regulator need to be from the generator?

A: Distance is best practices per the regulator manufacturer's instruction to assure proper operation of the regulator and also to meet code.

Q: Can I use a fuel shut off valve that is not "Full Flow Rated"?

A: No, it must be a Full Flow Rated valve and must also match the required fuel pipe ID dimensions.

Q: Do pipe elbows, tees, drip legs, etc. affect gas pipe size and flow?

A: Yes, they are restrictions to gas flow. You must add 2.5ft. (.76m) per each elbow, tee, etc. to the overall calculated distance from the source to the generator.

Q: Can I leave the unit on the shipping pallet and install it?

A: No, it must be installed per local jurisdiction, code and the instructions as outlined by Generac.

Q: Can the generator be mounted indoors or in a structure?

A: No, it is designed, manufactured and sold for outdoor use only!

Q: Can I run the Main AC and Control Wires in the same conduit?

A: Yes, this wiring can be run in the same conduit if the appropriate rated wire and insulation is used and it meets code.

Q: Can the Transfer Switch be mounted outdoors?

A: Only if it's a NEMA 3R rated transfer switch.

Q: Can I use the variable speed generator set with ANY transfer switch?

A: No, the only switch you can use is a Load shed type switch equipped with a "FLS" load shed module.

Q: Can I add a Transfer Switch to the EcoGen model generator?

A: No, the EcoGen is designed for Off-Grid applications and is not configurable for a transfer switch.

Quick Reference Guide (Synergy™ Controllers)

Problem	LED	Things to Check	Active Alarm	Solution
Unit running in AUTO but no power in house.	GREEN	Check MLCB.	NONE	Check MLCB. If the MLCB is in the ON position contact the servicing dealer.
Unit shuts down during operation.	RED	Check the LED's/ Screen for alarms.	HIGH TEMPERATURE	Check ventilation around the generator, intake, exhaust and rear of generator. If no obstruction contact serving dealer.
Unit shuts down during operation.	RED	Check the LED's/ Screen for alarms.	OVERLOAD REMOVE LOAD	Clear alarm and remove household loads from the generator. Put back in AUTO and restart.
Unit was running and shuts down, attempts to restart.	RED	Check the LED's/ Screen for alarms.	RPM SENSE LOSS	Clear alarm and remove household loads from the generator. Put back in AUTO and restart. It may be a fuel issue so contact the servicing dealer.
Unit will not start in AUTO with utility loss.	NONE	See if screen says unit not activated.	NOT ACTIVATED	Refer to activation section in owners manual.

Unit will not start in AUTO with utility loss.	GREEN	Check screen for start delay countdown.	None	If the start up delay is greater than expected, contact servicing dealer to adjust from 2 to 1500 seconds.
Unit will not start in AUTO with utility loss.	RED	Check the LED's/ Screen for alarms.	LOW OIL PRESSURE	Check Oil Level/Add Oil Per Owners Manual. If oil level is correct contact servicing dealer.
Unit will not start in AUTO with utility loss.	RED	Check the LED's/ Screen for alarms.	RPM SENSE LOSS	Clear alarm. Check the battery using the control panel under the MAIN menu using the BATTERY MENU option. If it states battery is GOOD contact servicing dealer. If it states CHECK BATTERY replace the battery.
Unit will not start in AUTO with utility loss.	RED	Check the LED's/ Screen for alarms.	OVERCRANK	Check fuel line shutoff valve is in the ON position. Clear alarm. Attempt to start the unit in MANUAL. If it does not start or starts and runs rough, contact servicing dealer.
Unit will not start in AUTO with utility loss.	RED	Check the LED's/ Screen for alarms.	LOW VOLTS REMOVE LOAD	Clear alarm and remove household loads from the generator. Put back in AUTO and restart.
Unit will not start in AUTO with utility loss.	RED	Check the LED's/ Screen for alarms.	FUSE PROBLEM	Check the 7.5 Amp fuse. If it is bad replace it with an ATO 7.5 Amp fuse, if not contact servicing dealer.
Unit will not start in AUTO with utility loss.	RED	Check the LED's/ Screen for alarms.	OVERSPEED	Contact servicing dealer.
Unit will not start in AUTO with utility loss.	RED	Check the LED's/ Screen for alarms.	UNDERVOLTAGE	Contact servicing dealer.
Unit will not start in AUTO with utility loss.	RED	Check the LED's/ Screen for alarms.	UNDERSPEED	Contact servicing dealer.
Unit will not start in AUTO with utility loss.	RED	Check the LED's/ Screen for alarms.	STEPPER OVERCURRENT	Contact servicing dealer.
Unit will not start in AUTO with utility loss.	RED	Check the LED's/ Screen for alarms.	MISWIRE	Contact servicing dealer.
Unit will not start in AUTO with utility loss.	RED	Check the LED's/ Screen for alarms.	OVERVOLTAGE	Contact servicing dealer.

Yellow LED illuminated in any state.	YELLOW	Check the screen for additional information.	LOW BATTERY	Clear alarm. Check the battery using the control panel under the MAIN menu using the BATTERY MENU option. If it states battery is GOOD contact servicing dealer. If it states CHECK BATTERY replace the battery.
Yellow LED illuminated in any state.	YELLOW	Check the screen for additional information.	BATTERY PROBLEM	Contact servicing dealer.
Yellow LED illuminated in any state.	YELLOW	Check the screen for additional information.	CHARGER WARNING	Contact servicing dealer
Yellow LED illuminated in any state.	YELLOW	Check the screen for additional information.	SERVICE A	Perform SERVICE A maintenance, hit ENTER to clear.
Yellow LED illuminated in any state.	YELLOW	Check the screen for additional information.	SERVICE B	Perform SERVICE B maintenance, hit ENTER to clear.
Yellow LED illuminated in any state.	YELLOW	Check the screen for additional information.	Inspect Battery	Inspect Battery, hit ENTER to clear.

Safety

Throughout this publication and on tags and decals affixed to the generator, DANGER, WARNING, and CAUTION blocks are used to alert personnel to special instructions about a particular operation that may be hazardous if performed incorrectly or carelessly. Observe them carefully. Their definitions are as follows:

DANGER

Indicates a hazardous situation which, if not avoided, will result in death or serious injury.

(000001)

WARNING

Indicates a hazardous situation which, if not avoided, could result in death or serious injury.

(000002)

CAUTION

Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

(000003)

NOTE: Notes provide additional information important to a procedure or component.

These safety alerts cannot eliminate the hazards they indicate. Observing safety precautions and strict compliance with the special instructions while performing the action or service are essential to preventing accidents.

WARNING

California Proposition 65. Engine exhaust and some of its constituents are known to the state of California to cause cancer, birth defects, and other reproductive harm.

(000004)

WARNING

California Proposition 65. This product contains or emits chemicals known to the state of California to cause cancer, birth defects, and other reproductive harm.

(000005)

Read This Manual Thoroughly

This diagnostic manual has been written and published by Generac to aid dealer technicians and company service personnel when servicing the products described herein.

It is assumed that these personnel are familiar with the servicing procedures for these products, or like or similar products manufactured and marketed by Generac, and that they have been trained in the recommended servicing procedures for these products, including the use of common hand tools and any special Generac tools or tools from other suppliers.

Generac could not possibly know of and advise the service trade of all conceivable procedures by which a service might be performed and of the possible hazards and/or results of each method. We have not undertaken any such wide evaluation. Therefore, anyone who uses a procedure or tool not recommended by Generac must first satisfy themselves that neither his nor the products safety will be endangered by the service procedure selected.

All information, illustrations and specifications in this manual are based on the latest product information available at the time of publication.

When working on these products, remember that the electrical system and engine ignition system are capable of violent and damaging short circuits or severe electrical shocks. If you intend to perform work where electrical terminals could be grounded or touched, the battery cables should be disconnected at the battery.

Any time the intake or exhaust openings of the engine are exposed during service, they should be covered to prevent accidental entry of foreign material. Entry of such materials will result in extensive damage when the engine Is started.

During any maintenance procedure, replacement fasteners must have the same measurements and strength as the fasteners that were removed. Metric bolts and nuts have numbers that indicate their strength. Customary bolts use radial lines to indicate strength while most customary nuts do not have strength markings. Mismatched or incorrect fasteners can cause damage, malfunction and possible injury.

Replacement Parts

When servicing this equipment, it is extremely important that all components be properly installed and tightened. If improperly installed and tightened, sparks could ignite fuel vapors from fuel system leaks.

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Table of Contents

Introduction

This diagnostic repair manual has been prepared especially for familiarizing service personnel with the testing, troubleshooting and repair of air-cooled product that utilizes Synergy controllers. Every effort has been expended to ensure that the information and instructions in the manual are accurate and current. However, the manufacturer reserves the right to change, alter or otherwise improve the product at any time without prior notification.

This manual is not intended to provide detailed disassembly and reassembly of the entire Residential product line. This manual is intended to:

- Provide the service technician with an understanding of how the various assemblies and systems work.
- Assist the technician in finding the cause of malfunctions.
- Effect the expeditious repair of the equipment.

Parts

Part 1 – General Information – Provides basic understanding of the generator as well as basic installation information and operating instructions.

Part 2 – AC Generators – Provides the basics of the AC alternator design and the AC troubleshooting portion of the manual.

Part 3 – Transfer Switch – Provides the troubleshooting and diagnostic testing procedure for the pre-packaged transfer switch.

Part 4 – Engine/DC Control – Provides the troubleshooting and diagnostic testing procedure for engine related problems on the Synergy™ Controller with G-Flex™ AVR.

Part 5 – Operational Tests – Provides basic operational and system function testing to ensure proper operation of the unit.

Part 6 – Disassembly – Provides step-by-step instructions for the replacement of the rotor/stator and engine.

Part 7 – Electrical Data – Illustrates all of the electrical and wiring diagrams for the various kW ranges and transfer switches.

Data Plate

The data plate that is affixed to the generator contains important information pertaining to the unit, including its model number, serial number, amperage rating, and voltage rating. The information from this data plate may be required when requesting information, ordering parts, etc.

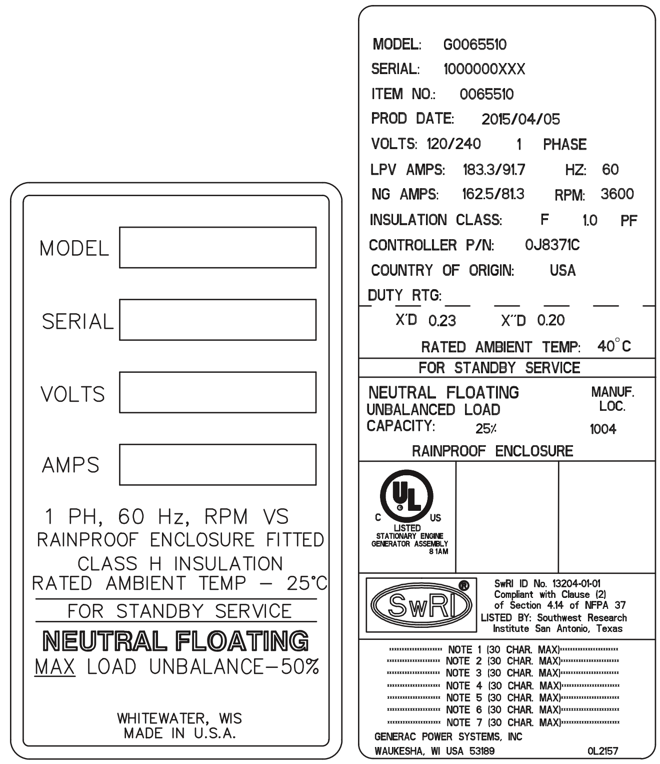

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Figure 1-1. Typical Data Plates

Serial Number

Used for specific unit identification and warranty tracking purposes.

Generator Identification

The variable speed constant frequency air-cooled product utilizes a 999cc OHVI V-twin engine.

999cc Engine

- Overhead Valve
- Twin Cylinders
- Synergy™ with G-Flex™ AVR Controllers

Specifications

Table 1-1. 60 Hz – Synergy Generator with G-Flex Technology		
Unit	15 kW EcoGen	20 kW Synergy
Rated Voltage	240	240
Rated Max. Continuous Load Current (Amps) 240 Volts (LP/NG)	62.5/62.5	83.3/75
Main Line Circuit Breaker	65 Amp	90 Amp
Model Identification Resistor	5K36	8K66
Phase	1	1
Rated AC Frequency	60 Hz	60 Hz
Battery Requirement	Group 26R, 12 Volts and 525 CCA Minimum	Group 26R, 12 Volts and 525 CCA Minimum
Unit Weight - lbs (kg)	536 (243)	513 (233)
Enclosure	Aluminum	Aluminum
Normal Operating Range	This unit is tested in accordance to UL 2200 standards with an operating temperature of 20 °F (-29 °C) to 122 °F. (50 °C). For areas where temperatures fall below 32° F (0° C), a cold weather kit is required. When operated above 77 °F (25 °C) there may be a decrease in engine power. (Please reference the engine specifications section).	

These generators are rated in accordance with UL 2200, Safety Standard for Stationary Engine Generator Assemblies and CSA-C22.2 No. 100-04 Standard for Motors and Generators.
* Natural Gas ratings will depend on specific fuel Btu/joules content. Typical derates are between 10-20% off the LP gas rating.
** Circuits to be moved must be protected by same size breaker: For example, a 15 amp circuit in the main panel must be a 15 amp circuit in the transfer switch.

Table 1-2. 60 Hz – Stator Winding Resistance Values / Rotor Resistance*		
	15 kW EcoGen	20 kW Synergy
Power Windings: Across 11 & 22	0.0396 - 0.0460	0.0396 - 0.0460
Power Windings: Across 11&44	0.0792 - 0.0920	0.0792 - 0.0920
Power Windings: Across 33 & 44	0.0396 - 0.0460	0.0396 - 0.0460
Sensing Windings: Across 11 & 44	0.0792 - 0.0920	0.0792 - 0.0920
Excitation Windings: Across 2 & 6	0.1533 - 0.1781	0.1533 - 0.1781
Rotor Resistance	0.684 - 0.795	0.684 - 0.795

* Resistance values shown are based on new windings at 20 °C. Actual readings may vary based on type of meter used and any other components or connections included in the circuit being tested.

Table 1-3. Engine with Synergy controller		
Model	15 kW EcoGen	20 kW Synergy
Type of Engine	GT-999	GT-999
Number of Cylinders	2	2
Displacement	999cc	999cc
Cylinder Block	Aluminum w/Cast Iron Sleeve	Aluminum w/Cast Iron Sleeve
Recommended Spark Plug	Refer To Owners Manual	Refer To Owners Manual
Spark Plug Gap	Refer To Owners Manual	Refer To Owners Manual
Compression Pressure	160 psi +/- 10-15%	160 psi +/- 10-15%
Starter	12 VDC	12 VDC
Oil Capacity Including Filter	Approx. 3.75 Qts/3.55 L	Approx. 1.9 Qts/1.8 L
Recommended Oil Filter	Part # 070185F	Part # 070185F
Recommended AVR Filter	Part # 0K3054	Part # 0K3054
Recommended Air Filter	Part # 0J8478	Part # 0J8478
Engine power is subject to and limited by such factors as fuel Btu/joules content, ambient temperature and altitude. Engine power decreases about 3.5 percent for each 1000 feet (304.8 meters) above sea level and will decrease about 1 percent for each 6 °C (10 °F) above 15 °C (60 °F) ambient temperature.		

IMPORTANT NOTE: All unit specifications are subject to change.

Table 1-4. Fuel Consumption With Synergy Controller				
Unit	**Natural Gas***		**LP Vapor****	
	1/2 Load	Full Load	1/2 Load	Full Load
18/20 kW Synergy	205 / 5.8	308 / 8.72	2.08 / 7.87	3.85 / 14.57
15 kW EcoGen	128 / 3.63	302 / 8.55	1.28 / 4.85	2.62 / 9.92

Values given are approximate.
* Natural gas is in cubic feet per hour./cubic meters per hour.
** LP is in gallons per hour / liters per hour.

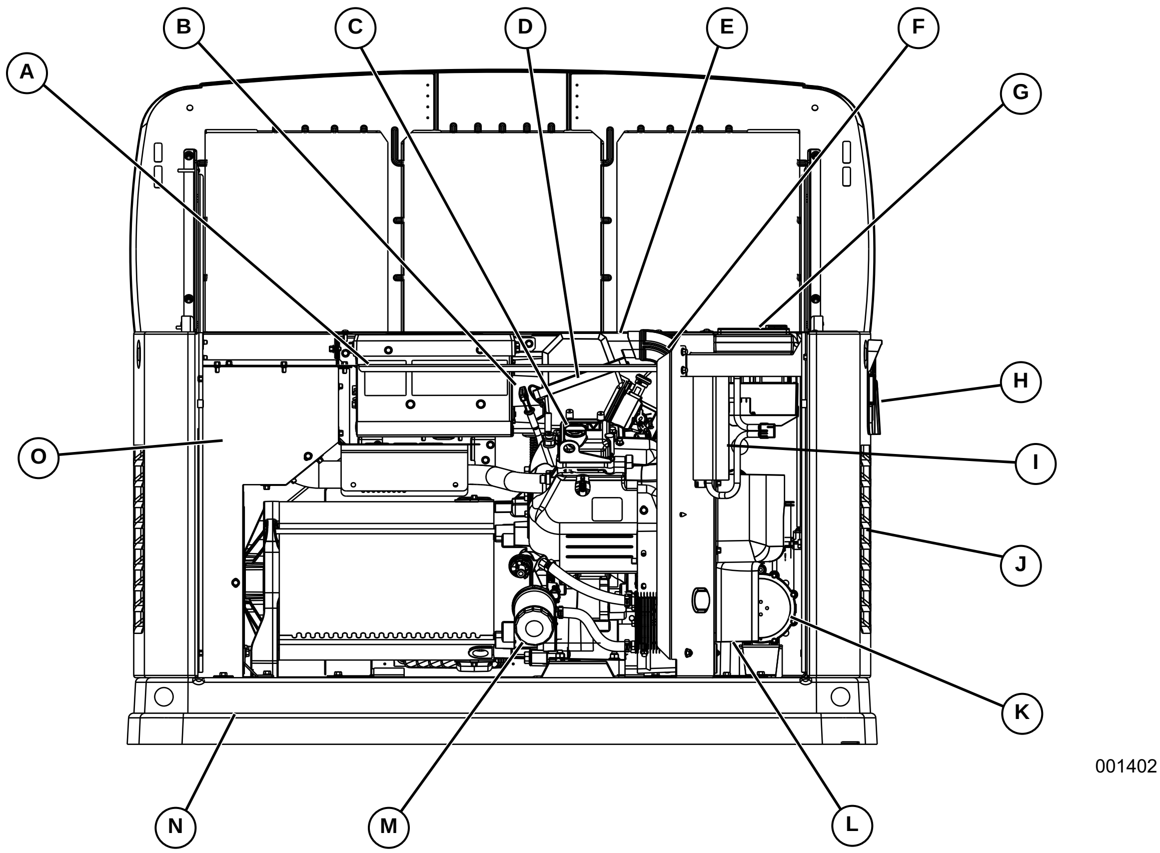


Figure 1-2. Synergy Component Locations

A. Automatic Voltage Regulator (AVR)
B. Oil Dipstick
C. Oil Fill Cap
D. Engine Air Filter
E. AVR Air Filter
F. Data Label
G. Control Pad
H. Circuit Breakers
I Large Fan Power Supply
J. Fuel Inlet (Back)
K. Fuel Regulator
L. Battery Compartment
M. Oil Filter
N. Composite Base
O. Exhaust Enclosure

IMPORTANT NOTE: All unit specifications are subject to change.

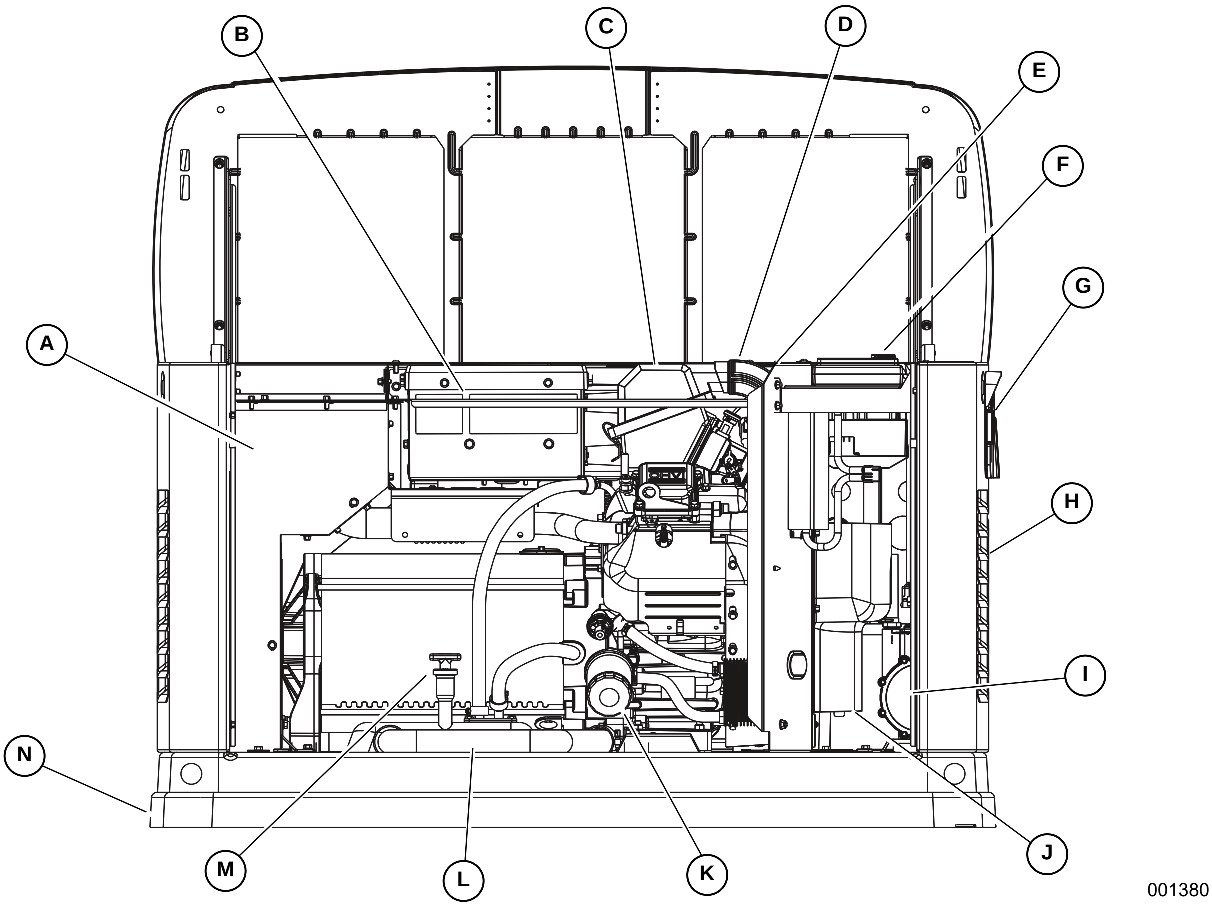


Figure 1-3. EcoGen Component Locations

A. Exhaust Enclosure
B. Automatic Voltage Regulator (AVR)
C. Engine Air Filter
D. AVR Air Filter
E. Data Label
F. Control Pad
G. Circuit Breakers
H. Fuel Inlet (Back)
I. Fuel Regulator
J. Battery Compartment
K. Oil Filter
L. Oil Tank
M. Oil Dipstick
N. Composite Base

IMPORTANT NOTE: All unit specifications are subject to change.

The Fuel Supply

The primary fuel source utilized for operating, testing and adjusting air-cooled residential units is natural gas (NG). When necessary, it is possible to convert units with air-cooled engines to use liquid propane vapor (LPV). See ***Reconfiguring the Fuel System*** for the conversion procedure.

LPV gas is usually supplied as a liquid in high-pressure tanks. Air-cooled product requires a “vapor withdrawal” type of fuel supply system when liquid propane (LP) gas is used. The “vapor withdrawal” system utilizes the gaseous fuel vapors that form at the top of the supply tank.

The pressure at which LP is delivered to the generator may vary considerably, depending on ambient temperatures. In cold weather, supply pressures may drop to “zero”. In warm weather, extremely high gas pressures may be encountered. A primary regulator is required to maintain proper gas supply pressures.

Synergy Units

Required fuel pressure for natural gas is 3.5 inches to 7 inches water column (0.12 to 0.25 psi); and for liquid propane, 10 inches to 12 inches of water column (0.36 to 0.43 psi).

NOTE: A primary regulator is required to maintain proper fuel pressure.

DANGER

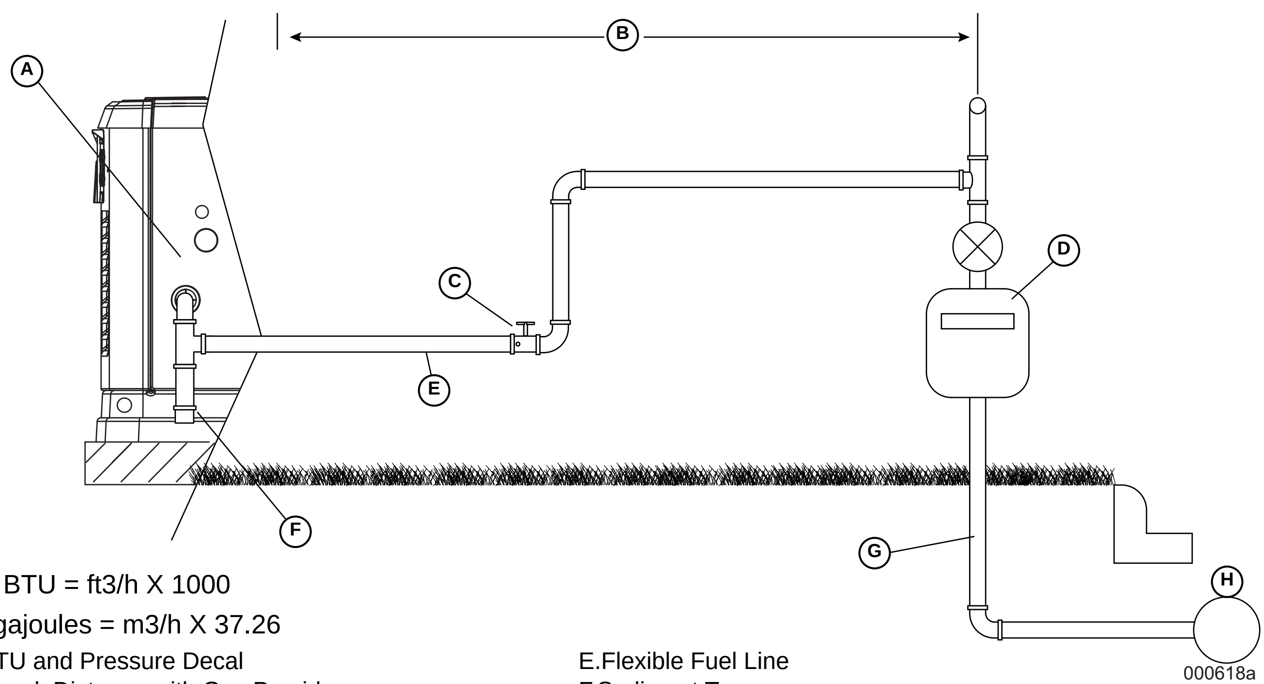
Explosion and Fire. Fuel and vapors are extremely flammable and explosive. No leakage of fuel is permitted. Keep fire and spark away. Failure to do so will result in death or serious injury. (000192)

Use of a flexible length of hose between the generator fuel connection and the rigid fuel lines is required. This will help prevent line breakage that might be caused by vibration or if the generator shifts or settles. The flexible fuel line must be approved for use with gaseous fuels.

CAUTION

Equipment damage. Do not bend flexible fuel line. Bends in fuel line restrict fuel flow and reduce ability to absorb vibration. (000205)

Flexible fuel line should be kept as straight as possible between connections. The offset for flexible fuel lines is 10 degrees. Exceeding the offset can cause the fittings to crack.

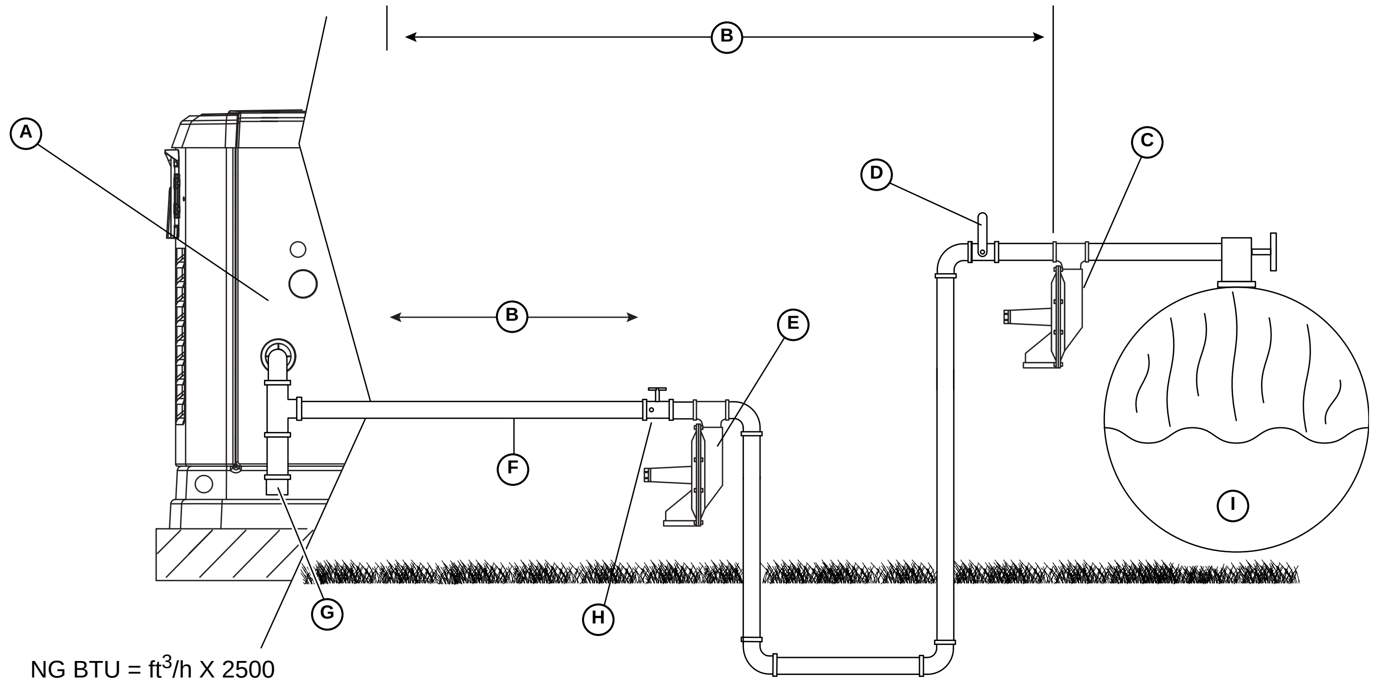


NG BTU = ft3/h X 1000

Megajoules = m3/h X 37.26

A.BTU and Pressure Decal
B.Check Distance with Gas Provider
C.Manual Shut Off Valve With Pressure Port
D.Size Gas Meter for Generator Load Plus All Appliance Loads
E.Flexible Fuel Line
F.Sediment Trap
G.For Underground Installations, Verify Piping System for Code Compliance
H.Gas Main

Figure 3-4. Typical Natural Gas Fuel Installation



NG BTU = ft^3/h X 2500

Megajoules = m^3/h X 93.15

A.BTU and Pressure Decal
B.Check Distance with Gas Provider
C.Primary Fuel Pressure Regulator Per LP Provider
D.Manual Shut Off Valve
E.Secondary Fuel Pressure Regulator
F.Flexible Fuel Line
G.Sediment Trap
H.Manual Shut Off Valve With Pressure Port
I.Size fuel tank large enough to provide required BTUs for generator and ALL connected appliance loads. Be sure to correct for weather evaporation.

Figure 3-5. Typical LP Fuel Installation

Introduction

It is the responsibility of the installer to verify that the generator installation was performed properly. A careful inspection must be performed when the installation is complete. All applicable codes, standards, and regulations pertaining to such installations must be strictly complied with. Regulations established by the Occupational Safety and Health Administration (OSHA) must be complied with as well.

Prior to initial startup of the unit, the installer must verify that the generator has been properly prepared for use. This includes the following:

- An adequate supply of the correct fuel must be available for generator operation.
- The engine must be properly serviced with the recommended oil.
- If using liquid propane (LP), use only the "vapor withdrawal" system. This type of system uses the vapors formed above the liquid fuel in the storage tank.

The engine is equipped with a fuel carburetion system that meets the specification of the 1997 California Air Resources Board for tamper-proof dual fuel systems. The unit will run on natural gas or LP, but it has been factory set and tested to run on natural gas. When the change from natural gas to LP is needed, the fuel system must be re-configured. See ***Reconfiguring the Fuel System*** for further information.

Recommended fuels should have a British Thermal Unit (BTU) content of at least 1,000 BTUs per cubic feet for natural gas; or at least 2,520 BTUs per cubic feet for LP. Ask the fuel supplier for the BTU content of the fuel.

NOTE: All pipe sizing, construction and layout must comply with NFPA 54 for natural gas applications and NFPA 58 for liquid propane applications. After installation, verify that the fuel pressure NEVER drops below the minimum requirements.

Prior to installation of the generator, the installer should consult local fuel suppliers or the fire marshal to check codes and regulations for proper installation. Local codes will mandate correct routing of gaseous fuel line piping around gardens, shrubs and other landscaping to prevent any damage.

When installing the unit where local conditions include flooding, tornadoes, hurricanes, earthquakes and unstable ground, special considerations should be given for the flexibility and strength of piping and connections.

Use an approved pipe sealant or joint compound on all threaded fittings.

Typical Fuel Pipe Sizing

NOTE: These are approximate values. Use the appropriate spec sheet and/or owner's manual for specific values.

NOTES:

- Pipe sizing is based on 0.5 in $H_2$0 pressure drop.
- Sizing includes a nominal number of elbows and tees.
- Verify adequate service and meter sizing.

Table 1-5. Natural Gas Pipe Sizing

	For 5-7 inches of water column (9-13 mm mercury)					For 3.5-5 inches of water column (7-9 mm mercury)		
	Allowable Pipe Distances (feet / meters)							
Pipe Size (in / mm)	0.75 / 19	1 / 25	1.25 / 32	1.5 / 38	2 / 51	1 / 25	1.25 / 32	1.5 / 38
20 kW Synergy	—	20 / 6.1	130 / 39.62	305 / 92.96	945 / 288.04	10 / 3.05	60 / 18.29	125 / 38.1
15 kW EcoGen	—	20 / 6	100 / 30	200 / 60		10 / 3	60 / 18	125 / 38

Table 1-6. LP Vapor Pipe Sizing

	For 10–12 inches of water column (19–22 mm mercury)		
	Allowable Pipe Distances (feet / meters)		
Pipe Size (in / mm)	0.75 / 19	1 / 25	1.25 / 32
20 kW Synergy	15 / 4.57	115 / 35.05	480 / 146.3
15 kW EcoGen	20 / 6	70 / 21	350 / 106

NOTE: A minimum of one approved manual shutoff valve must be installed in the gaseous fuel supply line as required by code. The valve must be easily accessible. Local codes determine the proper location.

Fuel Consumption

The fuel consumption rates for this unit are listed in ***Specifications*** at the front of this manual – ***Fuel Consumption With Synergy Controller***.

Reconfiguring the Fuel System

Converting from natural gas configuration to LP vapor can be accomplished with the following procedure. See ***Figure 3-6*** for fuel conversion knob location.

NOTE: The fuel selection (LP/NG) must be updated on the controller during initial power up using the Installation Wizard in the navigation menu. See ***Figure 7-2***.

NOTE: The orange fuel conversion knob (A) is located on the top of the fuel mixer on V-twin engines (B).

To select the fuel type, turn the valve towards the marked fuel source arrow until it stops. Fuel knob will rotate 180° and slide into the mixer body when converting to LP.

IMPORTANT NOTE: Synergy controlled models may start and run like normal with the improper fuel selected! Verify the proper fuel is selected!

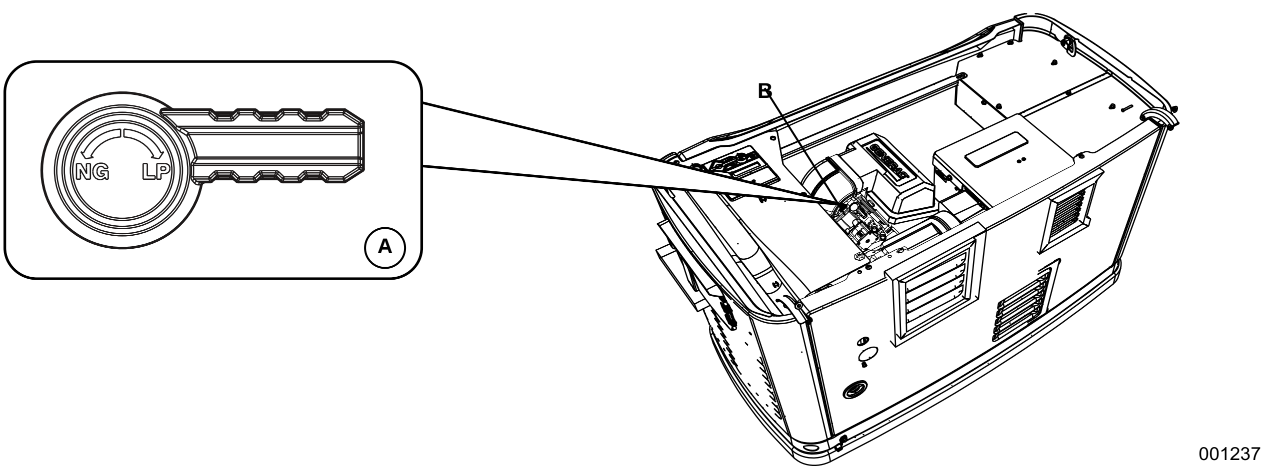


Figure 3-6. Fuel Conversion Knob Location

Digital Multimeters

Devices used to measure electrical properties are called meters. The following apply:

- To measure AC voltage, use an AC voltmeter.
- To measure DC voltage, use a DC voltmeter.
- Use a frequency meter to measure AC frequency In "Hertz" or "cycles per second".
- Use an ohmmeter to read circuit resistance, in "ohms".
- Use a diode tester for testing diode component(s)

Digital Multimeters (DM) are available to measure all of the above.

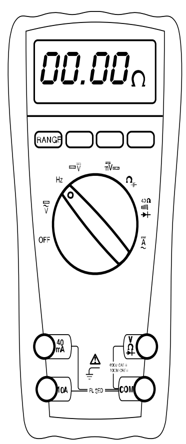


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Figure 1-7. Digital Multimeter

Measuring AC Voltage

An accurate AC voltmeter or a DM may be used to read generator AC output voltage. The following guidelines apply:

1. Always read generator AC output voltage at the rated operating speed and AC frequency of the unit.
2. The rated AC output voltage of the unit is approximately 237 to 244 VAC and is adjustable.
3. Use only an AC voltmeter to measure AC voltage. Do not use a DC voltmeter for this purpose.

⚠DANGER

Electrocution. Contact with bare wires, terminals, and connections while generator is running will result in death or serious injury.

(000144)

Measuring DC Voltage

A DC voltmeter or a DM may be used to measure DC voltages. Always observe the following rules:

1. Always observe correct DC polarity.
   a. Some DMs may be equipped with a polarity switch.
   b. On meters that do not have a polarity switch, DC polarity must be reversed by reversing the test leads.
2. Before reading DC voltage, always set the meter to a higher voltage scale than the anticipated reading. If in doubt, start at the highest scale and adjust the scale downward until correct readings are obtained.
3. The design of some meters is based on the "current flow" theory while others are based on the "electron flow" theory.
   - The "current flow" theory assumes that direct current flows from the positive (+) to the negative (-).
   - The "electron flow" theory assumes that current flows from negative (-) to positive (+).

NOTE: When testing generators, the "current flow" theory is applied. That is, current is assumed to flow from positive (+) to negative (-).

Measuring AC Frequency

In the standard synchronous alternator utilized across the Generac product line, frequency output voltage (60 Hz) is regulated by controlling engine speed. Output frequency is fixed by alternator speed, with output frequency being equal to rotor mechanical speed—60 Hz (3600 rpm).

The AVR on Synergy and EcoGen units provides power to the alternator field similar to the way existing voltage regulators provide power. The frequency produced by the unit is a combination of the actual speed of the running engine with the AVR making up the difference to provide the 60 Hz requirement.

Example:

If frequency output from the AVR is 15 Hz, minimum engine speed for this unit would be 2700 rpm (45 Hz). (60 Hz - 15 Hz = 45 Hz).

Frequency output from the AVR can range from 0.3 Hz to 15 Hz, depending on engine rpm. Engine rpm and AVR frequency output is determined by the load on the unit.

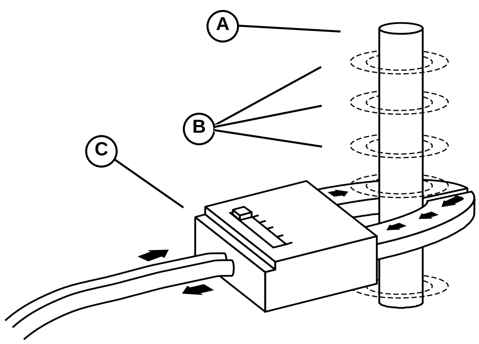
Maximum engine speed is 3600 rpm (60 Hz).

Measuring Current

Clamp-On

To read current flow in Amperes, a clamp-on ammeter may be used. This type of meter indicates current flow through a conductor by measuring the strength of the magnetic field around that conductor. The meter consists of a current transformer with a split core and a rectifier type instrument connected to the secondary. The primary of the current transformer is the conductor through which the current to be measured flows. The split core allows the instrument to be clamped around the conductor without disconnecting it.

Current flowing through a conductor may be measured safely and easily. A line-splitter can be used to measure current in a cord without separating the conductors.



A. Conductor

B. Magnetic Field

C. Clamp-On Ammeter Attachment

Figure 1-8. Clamp-On Ammeter

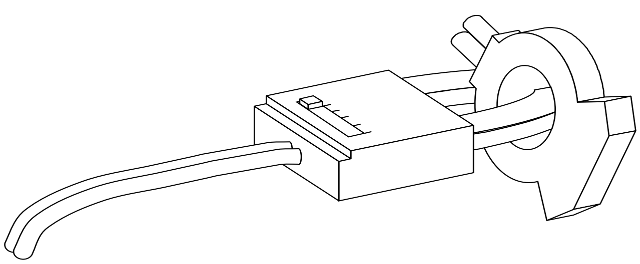


Figure 1-9. Line-Splitter

NOTE: If the physical size of the conductor or ammeter capacity does not permit all lines to be measured simultaneously, measure current flow in each line individually. Then, add the individual readings.

In-Line

An in-line ammeter may also be used to read current flow in Amperes. Most Digital Multimeters (DM) have the capability to measure amperes.

This usually requires the positive meter test lead to be connected to the appropriate amperes plug, and the meter to be set to the amperes position. Once the meter is properly set up to measure amperes the circuit being measured must be physically broken. The meter will connected in-line, or in series, with the component being measured.

In ***Figure 1-10*** the control wire to a relay has been disconnected. The meter is then used to connect and supply voltage to the relay to energize it and to measure the amperes going to it.

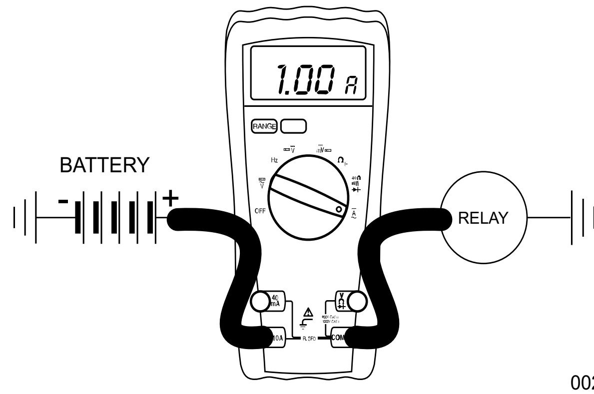


Figure 1-10. A VOM as an In-Line Meter

Measuring Resistance

A Digital Multimeter may be used to measure resistance in a circuit. Resistance values can be very valuable when testing coils or windings, such as the stator and rotor windings, or checking a wire for an open or grounded condition.

When testing stator windings, remember that the resistance of these windings is very low. Some meters are not capable of reading such a low resistance and will simply read CONTINUITY.

If proper procedures are used, the following conditions can be detected using a DM:

- A “short-to-ground” condition in any stator or rotor winding, or a short to ground on a specific control wire.
- Shorting together of any two parallel stator windings.
- Shorting together of any two isolated stator windings.
- An open condition in any stator or rotor winding, or an open in a control wire.

Component testing may require a specific resistance value or a test for INFINITY or CONTINUITY. Infinity is an OPEN condition between two electrical points, which would read as no resistance, or OL (Open Line) on a DM. Continuity is a closed condition between two electrical points, which would be indicated as very low resistance (000.000) or “ZERO” on a DM.

Electrical Units

Ampere

The rate of electron flow in a circuit is represented by the AMPERE. The ampere is the number of electrons flowing past a given point at a given time. One AMPERE is equal to just slightly more than 6.241x1018 electrons per second.

With alternating current (AC), the electrons flow first in one direction, then reverse and move in the opposite direction. They will repeat this cycle at regular intervals. A wave diagram, called a “sine wave” shows that current goes from zero to maximum positive value, then reverses and goes from zero to maximum negative value. Two reversals of current flow is called a cycle. The number of cycles per second is called frequency and is usually stated in “Hertz”.

Volt

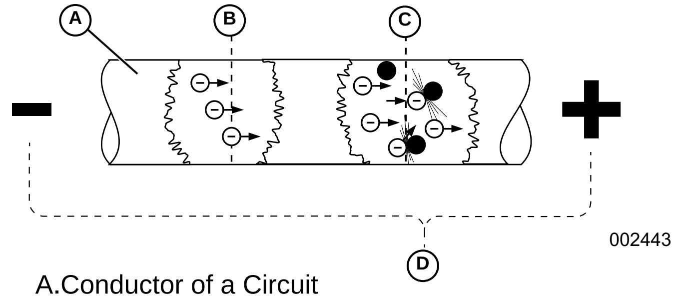
The VOLT is the unit used to measure electrical pressure, or the difference in electrical potential that causes electrons to flow. Very few electrons will flow when voltage is weak. More electrons will flow as voltage becomes stronger. Voltage may be considered to be a state of unbalance and current flow as an attempt to regain balance. One volt is the amount of Electromotive Force (EMF) that will cause a current of 1 ampere to flow through 1 ohm of resistance.

Ohm

There is a natural resistance or opposition to the flow of electrons. The OHM is the unit of resistance in every circuit. When an EMF is applied to a complete circuit, electrons are forced to flow in a single direction rather than their free or orbiting pattern. The resistance of a conductor depends on:

- Physical makeup
- Cross-sectional area
- Length
- Temperature

As the conductor’s temperature increases, its resistance increases in direct proportion. One (1) ohm of resistance will permit one (1) ampere of current to flow when one (1) volt of EMF is applied.



A.Conductor of a Circuit

B.Ohm

C.Ampere

D.Volt

Figure 1-11. Electrical Units

Ohm’s Law

A definite and exact relationship exists between VOLTS, OHMS and AMPERES. The value of one can be calculated when the value of the other two are known. Ohm’s Law states that in any circuit the current will increase when voltage increases but resistance remains the same, and current will decrease when resistance Increases and voltage remains the same.

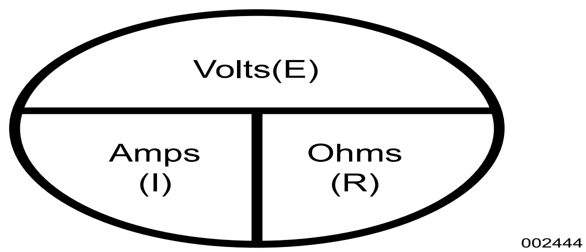


Figure 1-12. Ohm’s Law

If AMPERES is unknown while VOLTS and OHMS are known, use the following formula:

$$\text{Amperes} = \frac{\text{Volts}}{\text{Ohms}}$$

If VOLTS is unknown while AMPERES and OHMS are known, use the following formula:

Volts (E) = Amperes (I) x Ohms (R)

If OHMS is unknown but VOLTS and AMPERES are known, use the following:

$$\text{Ohms} = \frac{\text{Volts}}{\text{Amperes}}$$

Table 1-7. Electrical Formulas

To Find	Known Values	1-phase	3-phase
Kilowatts (kW)	Volts, Current, Power Factor	E x I 1000	E x I x 1.73 x PF 1000
KVA	Volts, Current	E x I 1000	E x I x 1.73 1000
Amperes	kW, Volts, Power Factor	kW x 1000 E	kW x 1000 E x 1.73 x PF
Watts	Volts, Amps, Power Factor	Volts x Amps	E x I x 1.73 x PF
No. of Rotor Poles	Frequency, RPM	2 x 60 x Frequency RPM	2 x 60 x Frequency RPM
Frequency	RPM, No. of Rotor Poles	RPM x Poles 2 x 60	RPM x Poles 2 x 60
RPM	Frequency, No. of Rotor Poles	2 x 60 x Frequency Rotor Poles	2 x 60 x Frequency Rotor Poles
kW (required for Motor)	Motor Horsepower, Efficiency	HP x 0.746 Efficiency	HP x 0.746 Efficiency
Resistance	Volts, Amperes	E I	E I
Volts	Ohm, Amperes	I x R	I x R
Amperes	Ohms, Volts	E R	E R

E = Volts   I = Amperes   R = Resistance (Ohms)   PF = Power Factor

Visual Inspection

Perform a thorough visual inspection before testing or troubleshooting an alternator. Remove the access covers and look closely for any obvious problems. Look for the following:

- Burned or broken wires, broken wire connectors, damaged mounting brackets, etc.
- Loose or frayed wiring insulation, loose or dirty connections.
- Check that all wiring is well clear of rotating parts.
- Verify that the generators voltage output matches utility voltage.
- Look for foreign objects, loose nuts, bolts and other fasteners.
- Clean the area around the generator. Clear away paper, leaves, snow, and other objects that might blow against the generator and obstruct air flow.

Insulation Resistance

The insulation resistances of stator and rotor windings are a measurement of the integrity of the insulating material that separates the electrical windings from the generator steel core. This resistance can degrade over time or due to such contaminates as dust, dirt, oil, grease and especially moisture. In most cases, failures of stator and rotor windings are due to a break down in the insulation. In many cases, a low insulation resistance is caused by moisture that collects while the generator is shut down. When problems are caused by moisture buildup on the windings, this can usually be corrected by drying the windings. Cleaning and drying the windings can usually eliminate dirt and moisture that has built up in the generator windings.

The Megohmmeter

Introduction

A Megohmmeter (often called a megger), consists of a meter calibrated in megohms and a power supply.

IMPORTANT NOTE: When testing stators and rotors, set megger to 500 volts and apply voltage for a maximum of one second. Follow the megger manufacturers instructions carefully. Do not exceed 500 volts or apply voltage longer than 1 second. Megger HIGH voltages could cause damage to other components on the generator. Take the proper precautions before testing.

Testing Stator Insulation

See ***Figure 1-13***. Isolate all stator leads and connect all the stator leads together.

Use a megger power setting of 500 volts. Connect one megger test lead to the junction of all the stator leads. Connect the other test lead to a frame ground on the stator can. Read the number of megohms on the meter.

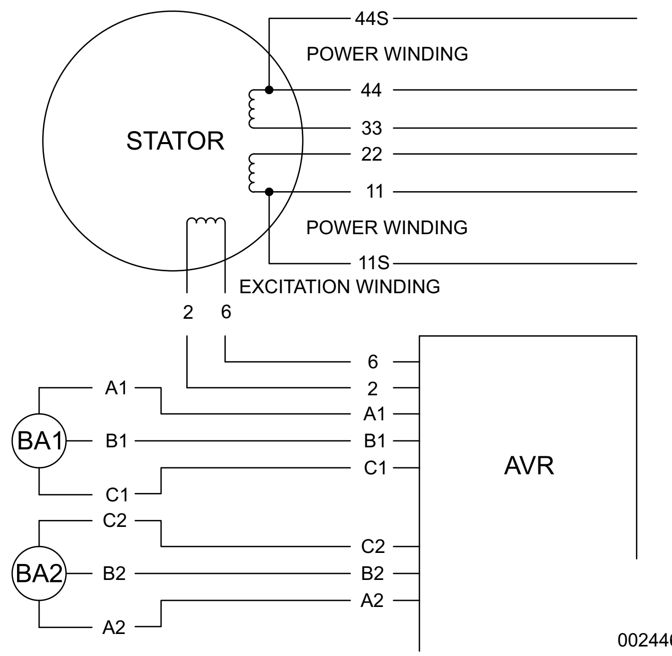


Figure 1-13. Typical VSCF Stator Output Leads

To calculate the minimum acceptable megger readings use the following formula:

$$\text{Minimum Insulation Resistance (In "Megohms")} = \frac{\text{Generator Rated Volts}}{1000} + 1$$

Example: Generator is rated at 120 VAC. Divide 120 by 1000 to obtain 0.12. Then add 1 to obtain 1.12 megohms. Minimum insulation resistance for a 120 VAC stator is 1.12 megohms.

$$\frac{120}{1000} + 1 = 1.2 \text{ megohms}$$

If the stator insulation resistance is less than the calculated minimum resistance, clean and dry the stator. Then, repeat the test. If resistance is still low, replace the stator.

Use the megger to test for shorts between isolated windings as outlined in “Stator Insulation Tests.”

Testing Rotor Insulation

Apply a voltage of 500 volts across each rotor slip ring separately, and a clean frame ground (i.e. the rotor shaft).

IMPORTANT NOTE: When testing stators and rotors, set megger to 500 volts and apply voltage for a maximum of one second. Follow the megger manufacturers instructions carefully. Do not exceed 500 volts or apply voltage longer than 1 second. Megger HIGH voltages could cause damage to other components on the generator. Take the proper precautions before testing.

Rotor Minimum Insulation Resistance:

1.5 Megohms

Cleaning the Generator

Caked or greasy dirt may be loosened with a soft brush or a damp cloth. A vacuum system may be used to clean up loosened dirt. Dust and dirt may also be removed using dry, low-pressure air (25 psi maximum).

IMPORTANT NOTE: Do not use sprayed water to clean the generator. Residual water on generator windings and terminals could cause serious problems.

Drying the Generator

The procedure for drying an alternator is as follows:

1. Open the generator main circuit breaker.

IMPORTANT NOTE: Generator should have no electrical loads applied while drying.

2. Disconnect all wires in a manner that allows the alternator to be completely disconnected.
3. Provide an external source to blow warm, dry air through the generator interior (around the rotor and stator windings.

NOTE: Do not exceed 185 ºF (85 ºC).

4. Connect stator lead.
5. Start the generator and let it run for 2 or 3 hours.
6. Shutdown the generator and repeat the insulation resistance tests.

Operating Instructions

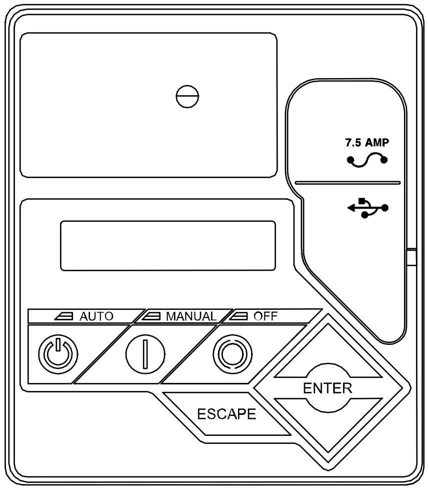


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Figure 1-14. Synergy™ Controller

⚠DANGER

Automatic start-up. Disconnect utility power and render unit inoperable before working on unit. Failure to do so will result in death or serious injury.

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AUTO-OFF-MANUAL Mode

AUTO Mode – Selecting this mode activates fully automatic system operation. It also allows the unit to automatically start and exercise the engine every seven days with the setting of the exercise timer. See Section 5.1 ***Setting the Exercise Time***.

OFF Mode – This mode shuts down the engine. This mode also prevents automatic operation.

MANUAL Mode – Set the controller to MANUAL to crank and start the engine. Transfer to standby power will not occur unless there is a Utility failure.

7.5 Amp Fuse

This fuse protects the controller and DC components against overload.

NOTE: If the fuse element has melted open due to an overload, engine cranking or running can still occur with Firmware v1.12 or higher. With Firmware older than v1.12, the unit will generate a E2400 Alarm Code.

NOTE: Use only an identical 7.5 amp fuse for replacement.

User Interface

Exercise Time

This generator is equipped with a configurable exercise timer with two settings:

1. **Day/Time of exercise** – once set, the generator will start and exercise on the day of the week and at the time of day specified. During the exercise period, the unit runs for approximately five minutes, and then shuts down.
2. **Exercise Frequency** – can be set to WEEKLY, BIWEEKLY or MONTHLY. If monthly is selected, the date of the month must be entered. Transfer of loads to the generator does not occur during the exercise cycle unless utility power is lost.

NOTE: The exerciser will only work with the AUTO-OFF-MANUAL switch in AUTO.

Activation Wizard

When battery power is applied to the generator during the installation process, the controller will light up. However, if the generator is not activated it will NOT run in the auto mode in the event of a power outage. Activating the generator is a simple one-time process that is guided by the controller screen prompts. Once the product is activated, the controller will not prompt you again, even if the battery is disconnected. See Section 5.1 ***Activation*** for the activation wizard procedure.

Installation Wizard

During the initial setup of the controller, an interconnection self-test will load on the screen.

Upon power up, this controller will go through a system self test which will check for the presence of Utility voltage on the DC circuits. If the installer mistakenly connects the AC Utility sense wires onto the DC terminal block the controller may be rendered inoperable. If the self-test failed and detected Utility voltage on the DC circuits, the controller will display a warning message and lock out the generator, preventing damage to the controller. The problem must be corrected and power to the controller must be cycled for this warning message to clear. Utility voltage on N1 and N2 must be present inside the generator control panel for the self-test to begin. Each time power to the controller is cycled the self-test will check for correct wiring.

IMPORTANT NOTE: Damage caused by improper wiring of the control wires is not covered by warranty.

Time and Date

After the successful completion of the installation wizard, the controller will prompt the user to set the minimum settings to operate. The prompts are as follows:

- Current date
- Current time
- Exercise time
- Exercise day

These settings may be changed at any time using the "EDIT" menu. See Section 1.10 ***Control Panel Menu System Navigation***.

NOTE: Maintenance interval initialization will take place when the exercise time is set.

If the fuse or the 12 volt battery is removed, the Installation Wizard will operate when power has been restored. The only prompts that will follow are the current time and date.

NOTE: To test the generator prior to installation, press the "ENTER" key to avoid setting up the exercise time. This will ensure that when the customer powers up the unit, the controller will prompt the customer to enter the exercise time.

Low Speed Exercise

When enabled, this feature allows the generator to exercise at 1950 rpm. Low speed exercise can be disabled from the "EDIT" menu. See Section 1.10 ***Control Panel Menu System Navigation***.

NOTE: if the generator is running under low speed exercise and utility fails, the generator will return to normal operating speed and transfer to standby. If the generator is running under low speed exercise and utility fails but the generator shuts down, check fuel conversion.

Display Interface Menus

The LCD display is as detailed below

- The "Home" page is the default page and will display if no keys are pressed for 30 seconds. This page normally shows the current status and the current time and date. It will also display the highest priority active Alarm and/or Warning along with the backlight flashing when one of these events occurs. In the case of multiple Alarms or Warnings, the controller will only display the first message. To clear an Alarm or Warning, see Section 4.2 ***Engine Protective Devices***.
- The display backlight is normally off. If the user presses any key, the backlight will come on automatically and remain on for 30 seconds after the last key is pressed.
- The "Main Menu" page allows the user to navigate to all other pages or sub-menus by using the UP/DOWN and Enter keys. Each press of the Escape key steps back to the previous menu until the main menu is reached. This page displays the following options:
- System
- Date/Time
- Battery
- Sub Menus
- History, Maint
- Edit
- Dealer

See Section 1.10 ***Control Panel Menu System Navigation***.

To Select Automatic Operation

The following procedure applies only to installations which utilize an air-cooled generator in conjunction with a transfer switch. Residential transfer switches do not have intelligent circuits of their own. PCB logic in the controller controls the automatic operation of the transfer switch and the generator.

To select automatic operation when a transfer switch is installed along with a home standby generator, the procedure is as follows:

1. Verify the contactor in the transfer switch is in the UTILITY position. If needed, manually actuate the switch contacts to the UTILITY position. See Section 5.1 ***Manual Transfer Switch Operation*** for specific instructions.
2. Verify that Utility voltage is available to the UTILITY terminals N1 and N2.
3. Actuate the generator main line circuit breaker (MLCB) to the "Closed" position.
4. Set the generator controller to AUTO.

Following the procedure of Steps 1 through 4, a dropout in Utility voltage below a preset level will result in automatic generator cranking and start-up. Following startup, and with no controller faults present, the transfer switch will actuate to the "Standby" position.

Manual Operation

Transfer to STANDBY and Manual Startup

To start the generator manually and to transfer electrical loads to the generator, the procedure is as follows:

1. On the generator, set the controller to OFF.
2. On the generator, set the main line circuit breaker (MLCB) to the "Open" Position.

3. Locate a means of Utility disconnect and set it to the OFF position. Manually actuate the contactor to the STANDBY position. See Section 5.1 ***Manual Transfer Switch Operation*** for specific instructions.
4. On the generator, set the controller to MANUAL.
5. Engine will crank and start.
6. Let the engine warm up and stabilize for a minute or two at no-load. Set the generators MLCB to the "Closed" position. Generator voltage is available to the transferred electrical loads.

Transfer Back to UTILITY and Manual Shutdown

To shutdown the generator and transfer electrical loads back to the UTILITY position, the procedure is as follows:

1. Set the generator's MLCB to the "Open" position.
2. Allow the generator to run at no-load for several minutes to cool.
3. Set the generator controller to OFF.
4. Locate a means of Utility disconnect and set it to OFF.
5. Manually actuate the contactor to the UTILITY position.
6. Restore Utility voltage to the transfer switch, by the means that was utilized in Step 4.
7. Set the generator controller to AUTO.

With the generator in AUTO, a dropout in utility voltage below a preset level will result in automatic generator cranking and start-up. Following startup, the transfer switch will actuate to the STANDBY position.

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Introduction

When the generator is installed in conjunction with a transfer switch, either manual or automatic operation is possible. See Section 5.1 for the manual transfer and engine startup, manual shutdown and re-transfer, and full automatic operation procedure.

Utility Failure

Initial Conditions

The generator is in AUTO, ready to run, and the contactor is in the UTILITY position.

1. When Utility fails (below 65% of nominal), a 10-second line interrupt delay time is started.*
2. If Utility is still not present when the timer expires, the engine will crank and start.
3. Once started a five (5) second engine warm-up timer* will start.
4. When the warm-up timer expires the controller will transfer load to the generator.

If Utility voltage is restored (above 75% of nominal*) at any time between the initiation of the engine start and when the generator is ready to accept load, (five second warm-up time has not elapsed), the controller will complete the start cycle and run the generator through its normal cool down cycle; however the contactor will remain in the UTILITY position.

** Adjustable*

Cranking

When the controller is in AUTO the engine will crank cyclically five (5) times as follows:

- 16 second crank,
- 7 second rest,
- 16 second crank,
- 7 second rest followed by 3 additional cycles of 7 second cranks followed by 7 second rests.

NOTE: Synergy units do not have a choke.

Failure to Start

Failure to start is defined as any of the following occurrences during cranking.

- Not reaching starter dropout within the specified crank cycle.
- Reaching starter dropout, but then not reaching 2200 rpm within 15 seconds. After which the controller will go into a rest cycle for 7 seconds, then continue the rest of the crank cycle.

NOTE: Starter dropout is defined as 4 cycles at 1,000 RPM.

NOTE: During a rest cycle the start and fuel outputs are de-energized and the magneto output is shorted to ground.

Cranking Conditions

The following notes apply during the crank cycle.

1. Starter motor will not engage within 5 seconds of the engine shutting down.
2. The fuel output will not be energized with the starter.
3. The starter and magneto outputs will be energized together.
4. Once the starter energizes, the controller will begin looking for engine rotation. If it does not sense an rpm signal within 3 seconds it will shut down and latch out on “RPM Sensor Loss.”

NOTE: Throttle will preset before starter engages.

5. Once the controller sees an rpm signal it will energize the fuel solenoid, open the throttle, and continue the crank sequence.

NOTE: The fuel solenoid does not activate earlier because if the engine does not crank, the engine and exhaust could potentially fill up with fuel. It may take up to 3 seconds to detect cranking on the engine with a magneto rpm measurement. This would result in 3 seconds of fuel being delivered, increasing the chances of a backfire.

6. The starter motor will disengage when speed reaches starter dropout.
7. If the generator does not reach 2200 rpm within 15 seconds, a re-crank cycle will occur.
8. If the engine stops turning between starter dropout and 2200 rpm the board will go into a rest cycle for 7 seconds then re-crank (if additional crank cycles remain).
9. Once started the generator will wait for a hold off period before starting to monitor oil pressure and oil temperature. See Section 4.2 ***Engine Protective Devices***.
10. During a manual crank attempt, if the controller is changed from MANUAL to OFF, the crank attempt will abort.
11. During automatic crank attempt, if Utility returns, the cranking cycle does NOT abort, but continues until complete. Once the engine starts, it will run for one minute then shut down.

Load Transfer Parameters

The transfer of load when the generator is running is dependent upon the operating mode as follows:

Manual

- No transfer to Standby when Utility is present.
- Transfer to STANDBY will occur if Utility fails (below 65% of nominal) for 10 consecutive seconds.
- Transfer back to UTILITY when Utility returns for 15 consecutive seconds. The engine will continue to run until removed from the Manual mode.

Auto (and EcoGen “On Grid”)

- Transfer to standby will occur if Utility fails (below 65% of nominal*) for five (5) consecutive seconds*.
- A five (5) second engine warm-up timer will initialize.
- Transfer back to UTILITY if Utility subsequently returns.
- Transfer to STANDBY if Utility is still not present.
- Transfer back to UTILITY once Utility returns (above 80% of nominal*) for 15 seconds.
- Transfer back to UTILITY, if present, if the generator is shut down for any reason (such as the switch turned to the OFF position or a Shutdown Alarm 0.
- After transferring back to UTILITY the engine will shut down after a one (1) minute cool-down timer expires.

* Fixed on Nexus controllers, adjustable on Evolution controllers.

Auto (EcoGen OFF GRID only)

With the unit set to OFF GRID Mode and unit in AUTO:

- 2-wire start circuit is closed.
- Unit will crank with no delay.
- A five (5) second engine warm-up timer will initialize.
- After 5 second warm-up, Transfer Wire 23 is completed to ground.
- 2-wire start circuit is opened.
- 15 second timer expires.
- Wire 23 released from ground.
- Unit shuts down.

* Unit can be programmed with or without a one minute cool-down period after shut down.

Exercise

- Exercise will not function if the generator is already running in either AUTO or MANUAL.
- During exercise, the controller will only transfer if Utility fails during exercise for 10 seconds, and will follow the steps outlined above for Auto operation.

Utility Restored

The generator is running, contactor in STANDBY, running in Utility failure. When the Utility returns (above 75% of nominal*), a 15 second Return to Utility Timer will start. If the Utility supply is still present and acceptable at the completion of this timer, the control will transfer the load back to UTILITY and run the engine through a one (1) minute cool down period and then shut down. If Utility fails for three (3) seconds during this cool down period, the control will transfer load back to the generator and continue to run while monitoring for Utility to return.

* Adjustable

Section 1.8 General Maintenance

Introduction

Performing proper maintenance on a generator will ensure proper function during operation. Once a generator has failed, it is already too late. Ensuring the proper oil changes and inspections have been completed at the specified times will help keep the generator reliable.

Maintenance Message

When a maintenance period expires, a warning alert will be displayed. Pressing the Enter key on the controller will reset the alert and will prompt the user to confirm the action. Resetting will clear the alert and reset the maintenance counters for all annunciated warnings. The history log will record the alert. Once restored, a prompt will appear for the user to set the time and date. The new date and time will adjust the maintenance counters accordingly.

NOTE: The maintenance counter will not accumulate without battery voltage.

NOTE: Since most maintenance alerts will occur at the same time (most have two year intervals), only one will appear on the control panel display at any one time. Once the first alert is cleared, the next active alert will be displayed. Refer to current owners manual for maintenance schedules.

Message Interval

See ***Table 1-8*** for typical inspection items and intervals.

Table 1-8. Message Intervals (Example)

"Inspect Battery"	1 Year
"Change Oil & Filter"	200 Hours or 2 years
"Inspect Air Filter"	200 Hours or 2 years
"Change Air Filter"	200 Hours or 2 years
"Inspect Spark Plugs"	200 Hours or 2 years
"Change spark Plugs"	400 Hours or 10 years

NOTE: Refer to unit Owner's Manual for specific messages and intervals.

Resetting Maintenance Intervals

When a complete maintenance inspection has been completed before a specific alert was generated, it is possible to reset the intervals to prevent future alerts from occurring for maintenance that was just performed.

To reset the intervals see Section 4.1 **Menu System Navigation**.

Once intervals are reset, all maintenance counters will start from the current time and date of the generator.

Engine Oil

Modern oils play vital functions in protecting the engine. Lubricating oil acts to reduce friction and wear, cool engine parts, seal combustion chambers, clean engine components, and inhibit corrosion.

Engine Oil Recommendations

All oil should meet minimum American Petroleum Institute (API) Service Class SJ, SL or better. Do not use special additives. Select the oil's viscosity grade according to the expected operating temperature.

NOTE: Refer to unit Owner's Manual for specific engine oil recommendations.

⚠CAUTION

Engine damage. Verify proper type and quantity of engine oil prior to starting engine. Failure to do so could result in engine damage.

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Air Filter

Air is necessary for successful combustion in the engine. Clean air (almost 100% pure) is critical to engine survival and vital to its performance. There are operational signs when an air filter has become completely plugged. The engine begins to lose power, and fuel consumption increases. Black smoke may blow from the exhaust. Continued operation with a plugged air filter may cause severe damage to the engine.

Spark Plugs

Good spark is essential to properly maintaining the engine. Although replacement may not be required, inspection of the plugs during routing maintenance is critical. Always verify that spark plugs are gapped according to the specifications. Improperly gaped spark plugs will effect the operation of the engine.

NOTE: Refer to unit Owner's Manual for specific spark plug gaps.

Battery

Performing proper battery maintenance at the required intervals will allow for proper starting of the generator during a power outage. Some common things to look for and check during maintenance are:

- Inspect the battery posts and cables for tightness and corrosion. Tighten and clean as necessary.
- Check the battery fluid level of unsealed batteries and, if necessary, fill with distilled water only. Do not use tap water in batteries.
- Have the state of charge and conditions checked with an automotive-type battery hydrometer.

NOTE: See ***Test 45—Check Battery and Cables*** for further testing the state of a battery.

Valve Clearance

Proper valve clearance is vital to ensuring longevity of the engine. After the first 25 hours of operation, check the engine valve clearance and adjust as necessary. Checking of the engine valve clearance thereafter periodically will increase reliability of the Generator. See ***Test 63—Check and Adjust Valves*** for specification and adjustment procedure.

Some symptoms of an engine with valves in need of adjustment are:

- Hard starting
- Smoke out of the exhaust
- Rough running
- Lack of horse power

Visual Inspection

During all service intervals, a proper visual inspection must be conducted to ensure proper function, airflow, and to prevent fire hazards.

Air inlet and outlet openings in the generator compartment must be open and unobstructed for continued proper operation. This includes such obstructions as high grass, weeds, brush, leaves, and snow.

⚠WARNING

Risk of Fire. Hot surfaces could ignite combustibles, resulting in fire. Fire could result in death or serious injury.

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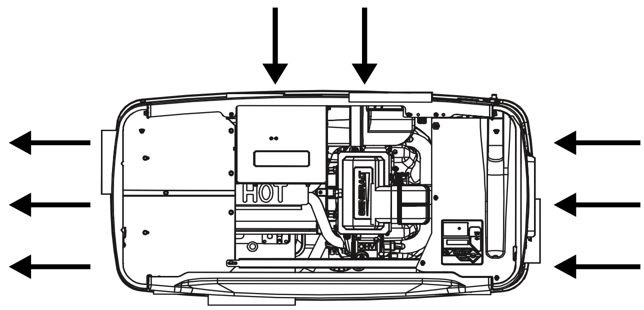

Figure 1-15. Cooling Vent Locations

Corrosion Protection

Periodically wash and wax the enclosure using automotive type products. Frequent washing is recommended in salt water/coastal areas. Spray engine linkages with a light oil such as WD-40.

Section 1.9 *Wireless Remote*

Mobile Link™

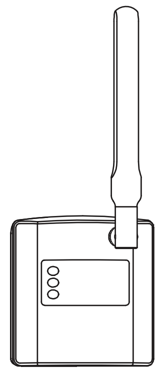

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Figure 1-16. Mobile Link Unit

Table 1-9. Mobile Link Troubleshooting.

Problem	Cause	Correction
All LEDs off	1. No power to Mobile Link unit.	1. Check the 5 Amp fuse located on the yellow harness wire. 2. Check harness is connected to battery properly. Yellow to (+) Battery/ Black to (-) Battery. 3. Reseat connector to Mobile Link. 4. Replace cable.
Top LED off	1. Unit not enrolled.	1. Enroll Mobile Link at www.StandbyStatus.com. 2. Verify Mobile Device Number is enrolled at www.StandbySta-tus.com and enrolled number matches Mobile Device Number (MDN) of the Mobile Link unit.
Middle LED flashing	1. Poor connection.	1. Reseat connector at generator controller and Mobile Link. 2. Replace cable.
Bottom LED off	1. No cellular network connection.	1. Check cellular coverage in your area. 2. Mobile Link in "Suspended" mode. Contact Customer Service for assistance at 1-888-436-3722.
Bottom LED flashing	1. Cellular connection pending. 2. Server may be down.	1. Network connection established. Awaiting server response. 2. Wait for problem to resolve itself.*

* The Mobile Link will retry several times before resting and retrying later. The full retry cycle lasts for about one (1) hour and includes several resets of the internal cellular modem. When these resets occur, the Mobile Link will indicate a loss of the cellular network connection until it is reestablished. If the end of the retry cycle has been reached without successfully completing communication with the server, the Mobile Link will rest for an hour, and then start another retry cycle. This rest period can be interrupted by switching the generator from OFF to AUTO. The Mobile Link will continue this cycle until it successfully connects to the server and receives a response.

Diagnosing Mobile Link Communication to Controller

A flashing middle LED on the Mobile Link controller indicates a loss of communication between the Mobile Link unit and the generator controller.

The problem can be the generator controller, the Mobile Link controller, or the harness between the two units.

To determine the problem, perform voltage checks according to the charts below. This will help determine whether the Mobile Link controller or the generator controller is at fault.

Three wires are used to communicate between the Mobile Link controller and the generator controller. The SHLD wire is connected to the Mobile Link controller only. There are two communication wires (Wires 387 and 388) connected between the two controllers.

First, verify that the harness is plugged in correctly and that the generator starts and runs properly. If the harness is plugged in correctly and there is still no communication, disconnect both ends of the harness. Perform a continuity test on the wires in the harness to verify that they are not shorted between one another, and there are no opens except for the shield wire, which is connected to the Mobile Link connector only.

There are four charts. Charts 1 and 2 are used with all connectors connected while back probing each wire to battery ground (-) and to battery positive (+).

Charts 3 and 4 determine the voltage output from each unit while the other end of the harness is disconnected.

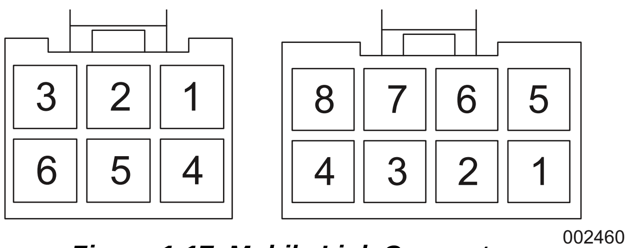

Figure 1-17. Mobile Link Connector

Chart 1 – Back Probe at Mobile Link connector
(All connectors plugged in) All voltages +/- 0.5 volts

	DM Negative lead on Battery NEG	DM Positive lead on Battery POS
Pin 1, Wire SHLD	0 VDC	Battery Voltage
Pin 2, Wire 388	- 4.2 to - 5.6 VDC Fluctuating	18.0 to 19.2 VDC Fluctuating
Pin 3, EMPTY	EMPTY	EMPTY
Pin 4, Wire 0	0 VDC	Battery Voltage
Pin 5, Wire 387	-5.8 to -6.8 VDC Fluctuating	22.33 VDC
Pin 6, Wire 13A	Battery Voltage	0 VDC

Chart 2 – Back Probe at Evolution Controller
(All connectors plugged in) All voltages +/- 0.5 volts

	DM Negative lead on Battery NEG	DM Positive lead on Battery POS
Pin 7, Wire 388	4.4 to - 5.3 VDC Fluctuating	18.3 to 19.4 VDC Fluctuating
Pin 8, Wire 387	6.0 to - 6.8 VDC Fluctuating	19.8 to 20.5 VDC Fluctuating

Chart 3 – Back Probe at Mobile Link connector
(Mobile Link connector unplugged) All voltages +/- 0.5 volts

	DM Negative lead on Battery NEG	DM Positive lead on Battery POS
Pin 1, Wire SHLD	0 VDC	0 VDC
Pin 2, Wire 388	0 VDC	Battery Voltage
Pin 3, EMPTY	EMPTY	EMPTY
Pin 4, Wire 0	0 VDC	Battery Voltage
Pin 5, Wire 387	- 8.56 VDC	22.33 VDC
Pin 6, Wire 13A	Battery Voltage	0 VDC
If no voltages are indicated based on this chart the controller is at fault.		

Chart 4 – Back Probe at Evolution Controller
(Mobile link plugged in Evolution connector unplugged) All voltages +/- 0.5 volts

	DM Negative lead on Battery NEG	DM Positive lead on Battery POS
Pin 7, Wire 388	- 5.5 VDC	19.3 VDC
Pin 8, Wire 387	0 VDC	Battery Voltage
If no voltages are indicated based on this chart the Mobile Link unit is at fault.		

If all LEDs are on and Mobile Link is communicating normally, then the power wire (13A), ground wire (0), and fuse to the Mobile Link unit are good.

If no LEDs are illuminated on the Mobile link unit, verify that the power wire (13A), ground wire (0), and fuse to the Mobile Link Unit are good.

Navigation Keys

There are four selection and navigation keys below the display.

Escape

The ESCAPE key will cause the display to move back toward the main menu.

Enter

The ENTER key is used to activate a menu or accept a value when it is changed.

Up and Down

The UP and DOWN triangle keys perform a number of functions depending on which screen of a menu is active.

- Move to the next choice (the menu to be selected will flash on and off).
- Left and right arrows to move between the various editable menus.
- Increase or decrease a value or change a choice in an editable menu (i.e. from Yes to No).

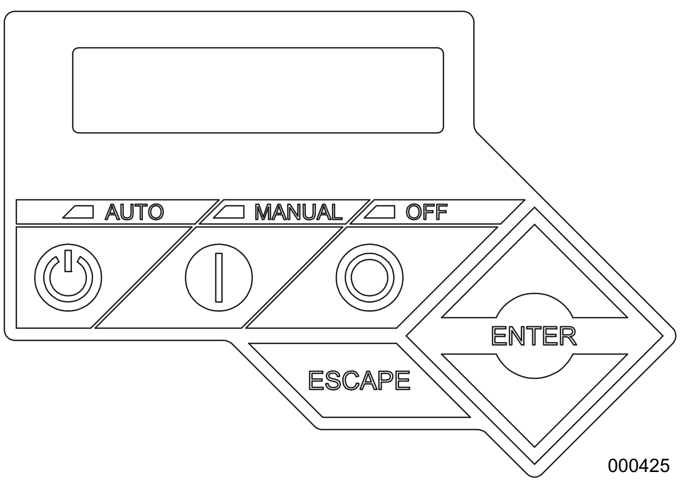

Figure 1-18. Synergy™ Display and Navigation Buttons

Main Menu

To get to the Main Menu from any other display, press the ESCAPE key one or more times. The Main Menu is shown in ***Figure 1-19***. The menu system diagram is shown in ***Figure 3-28*** and ***Figure 3-29***.

There are four selections in the Main Menu: System, Date/Time, Battery, Sub Menus.

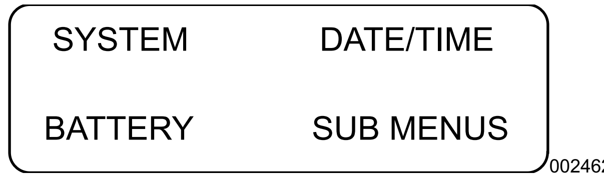

Figure 1-19. Synergy™ Display Main Menu

System

Selecting SYSTEM returns to the Main Display.

Date/Time

Selecting DATE/TIME displays current date and time.

Battery

Selecting BATTERY displays the battery condition.

Sub Menus

Selecting SUB MENUS displays the Sub Menu screen.

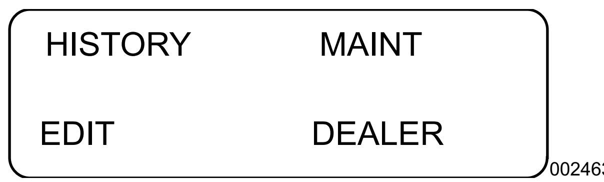

Figure 1-20. Synergy™ Sub Menu

History

The History Menu displays two history logs:

- **Alarm Log:** displays the last 50 alarm conditions. They are in date and time order, numbered from 1 to 50, with 1 being the most recent. Use the UP and DOWN triangle keys to move from alarm to alarm. Each alarm lists the date, time, and description of the alarm.
- **Run Log:** displays the last 50 Run events. It will display the date and time as well as a brief description of the event; for instance Running – Utility Lost; Stopped – Auto.

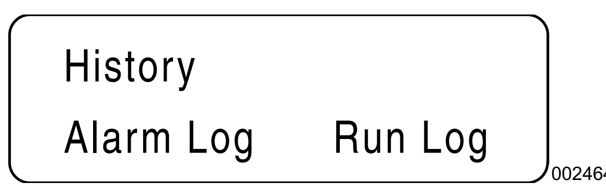

Figure 1-21. History Menu

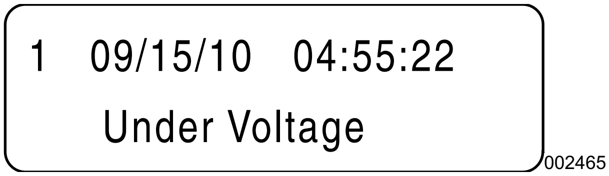

Figure 1-22. Alarm Log Display

Use the UP and DOWN triangle keys to move from the most recent Alarm (1) to the oldest (50).

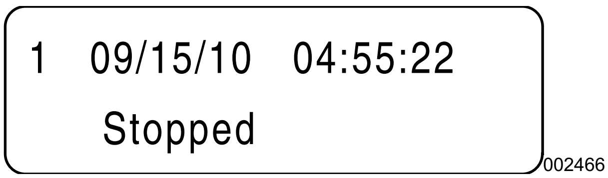

Figure 1-23. Run Log Display.

Use the UP and DOWN triangle keys to move from the most recent Run event (1) to the oldest (50).

Maint

The MAINT Menu displays three selections: Maint Log, Run Hrs, and Scheduled.

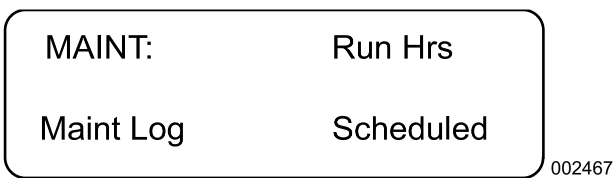

Figure 1-24. Maint Menu

Edit

Selecting the Edit Menu enables editing of the following selections:

- Language
- Fuel Selection
- Current Date/Time
- Exercise Time, and
- Firmware Update

Run Hrs

View the amount of actual run hours on the unit.

Scheduled

View when the next scheduled maintenance is due.

Maint Log

Review the history of maintenance recorded on the unit.

Synergy™ Dealer Menu

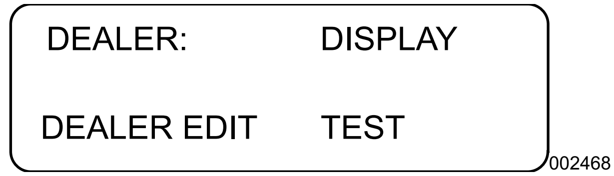

Figure 1-25. Synergy™ Dealer Menu

Dealer

The Dealer Menu displays three selections:

- Display
- Dealer Edit
- Test

Display

The Display Menu displays these selections:

- Battery Voltage
- Charging Status
- Run Hours
- Output Volts
- Output Frequency (Hz)
- Engine Speed (RPM)
- Utility Input Volts
- V Firmware Hardware
- VV Firmware
- Bootloader EEPROM
- Command
- Node Hz Volts

Use the UP and DOWN triangle keys to move between selections.

Dealer Edit

The Dealer Edit Menu displays these selections:

- Startup Delay
- Run Hours
- Util Volts Low Value
- Util Recovery Volts
- Calibrate Current 1
- Calibrate Current 2
- Calibrate Volts
- 2-Wire Start Select (Synergy)
- OFF/ON Grid (EcoGen)
- Reset Maintenance

These are editable selections within this menu selection.

NOTE: When OFF/ON Grid or 2-Wire Start are selected another selection becomes available: Cool Down – No or Yes.

Test

Provides four test tools integral to the control panel: Inputs, Outputs, Display, and QT-Test.

- **INPUTS** displays the status of the 8 input channels monitored by the control panel. See ***Table 1-10***. Each input represents an open or closed set of contacts, and will display either a “0” or “1”. A “0” represents an open contact. A “1” represents a closed contact. This screen also displays Utility Voltage.
- **OUTPUTS** displays the status of the output relays used by the control panel to initiate commands (like Crank and Run, or Transfer). See ***Table 1-10***. Each channel represents a relay with a either a “0” or “1”. A “0” represents a relay that is de-energized (OFF). A “1” represents a relay that is energized (ON). This screen will also display the Generator Output Voltage.
- **Display** provides two flashing bars that test the display LEDs. As the bars flash on and off, bad sectors will not turn on. If a sector does not turn on, those LEDs are not working. The control panel requires replacement to correct a bad display.
- QT-Test is available when enabled on the unit. It provides a way to test the Quiet Test mode of the generator. When tested the generator will run at a lower speed (rpm) during the test. For the unit to perform an actual Quiet Test Exercise, it must be enabled in the Exercise Time editing menu.

NOTE: Utility must be present and the controller must be in AUTO to unlock the Sub Test menu and perform the QT-Test.

Inputs

Inputs are numbered from left to right (1-8).

0 indicates an Input is OFF

1 indicates an Input is ON

For example, in ***Figure 1-26*** Inputs 1 and 7 are ON (Low Oil Pressure and the Auto switch). This indicates the unit is shut down and in AUTO.

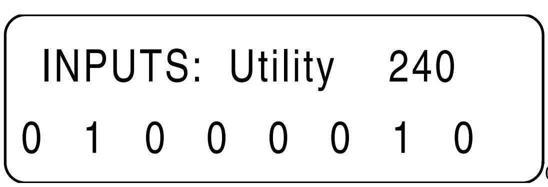

Figure 1-26. Test Inputs Display

Outputs

Outputs are numbered from left to right (1-8).

0 indicates the Output is OFF

1 indicates the Output is ON

For example, in ***Figure 1-27*** there are no Outputs ON. This indicates the unit is shut down.

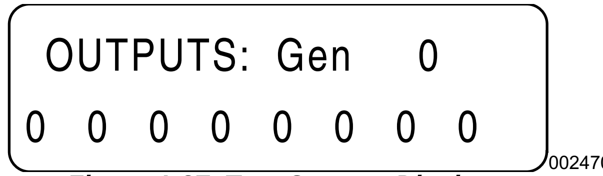

Figure 1-27. Test Outputs Display

Table 1-10. Digital Inputs and Outputs

Position	Digital Inputs	Digital Outputs
1	Not Used	Not Used
2	Low Oil Pressure	Not Used
3	High Temperature	Not Used
4	Not Used	Battery Charger Relay
5	Wiring Error Detect	Fuel
6	Not Used	Starter
7	Auto	Ignition
8	Manual	Transfer

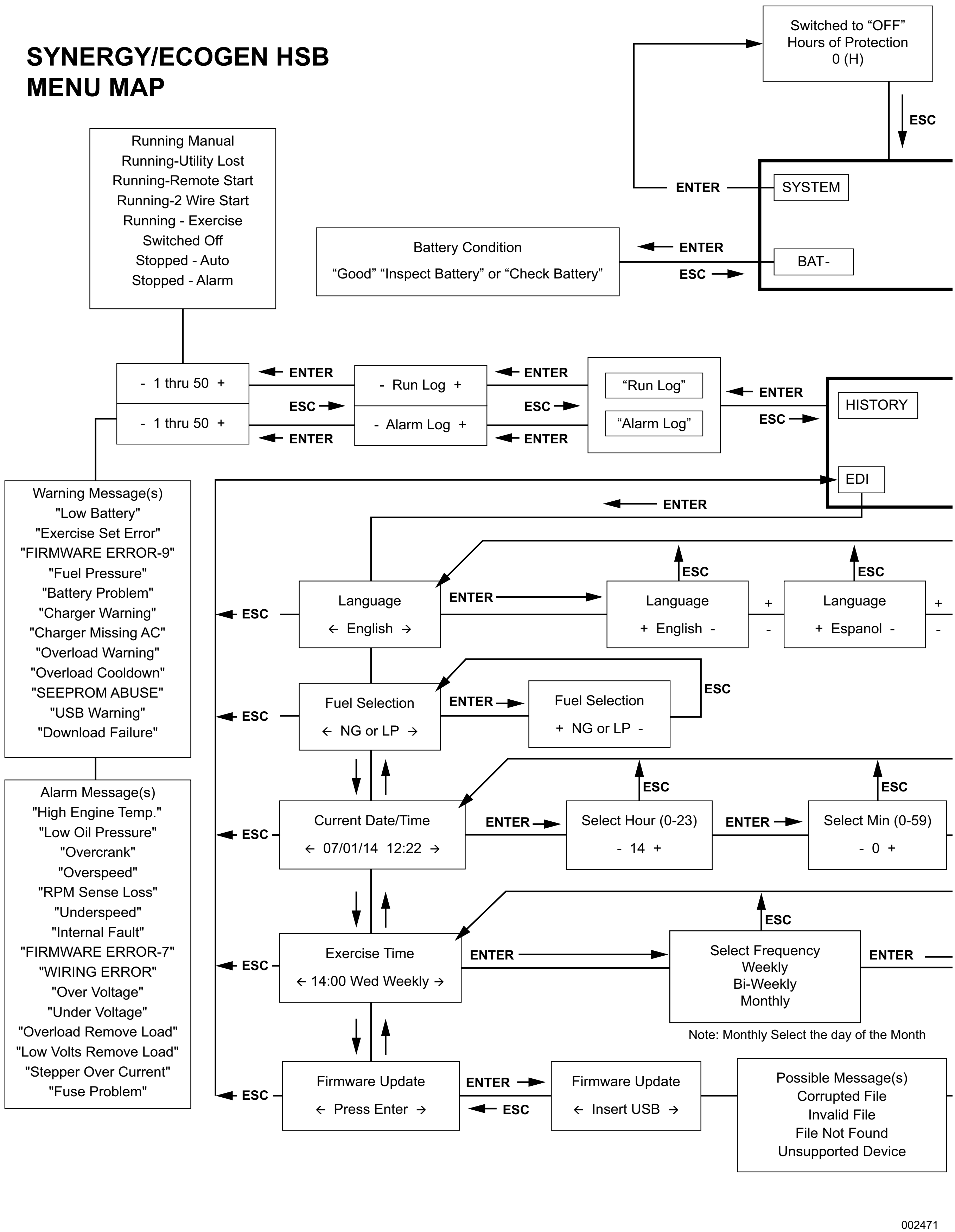

Figure 3-28. Synergy/EcoGen Main Menu Map

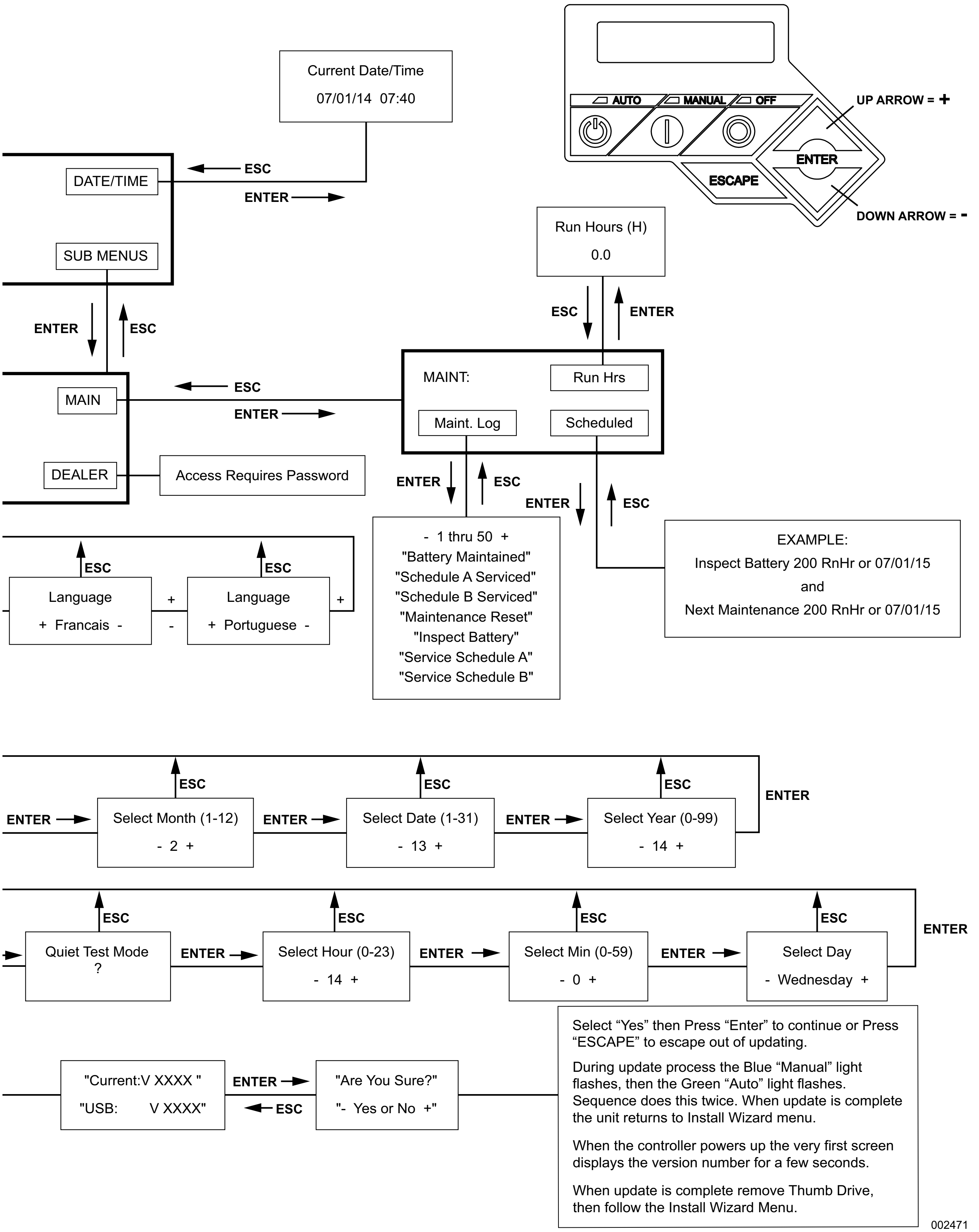

Figure 3-29. Synergy/EcoGen Main Menu Map

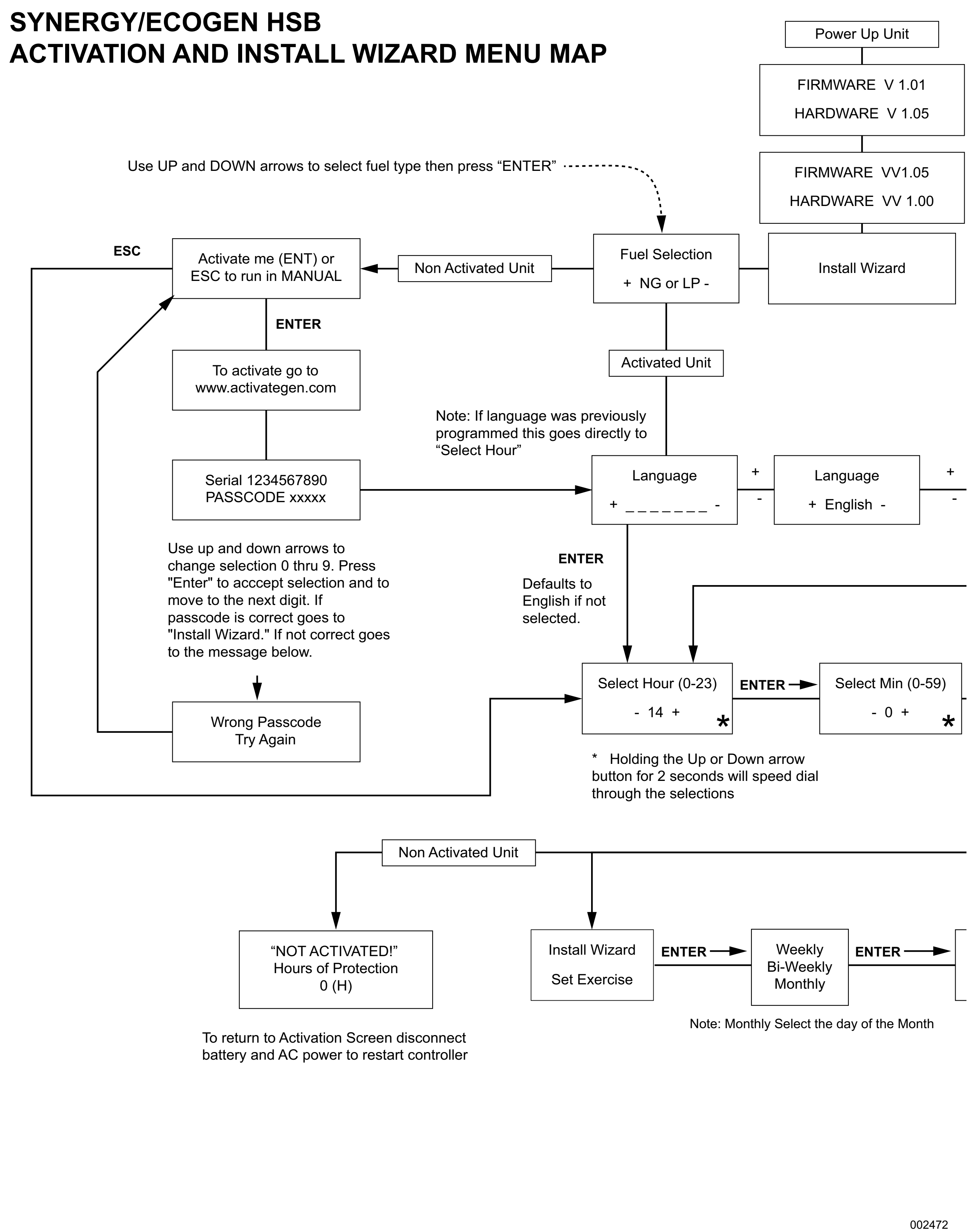

Figure 3-30. Synergy/EcoGen Activation and Install Wizard Menu Map

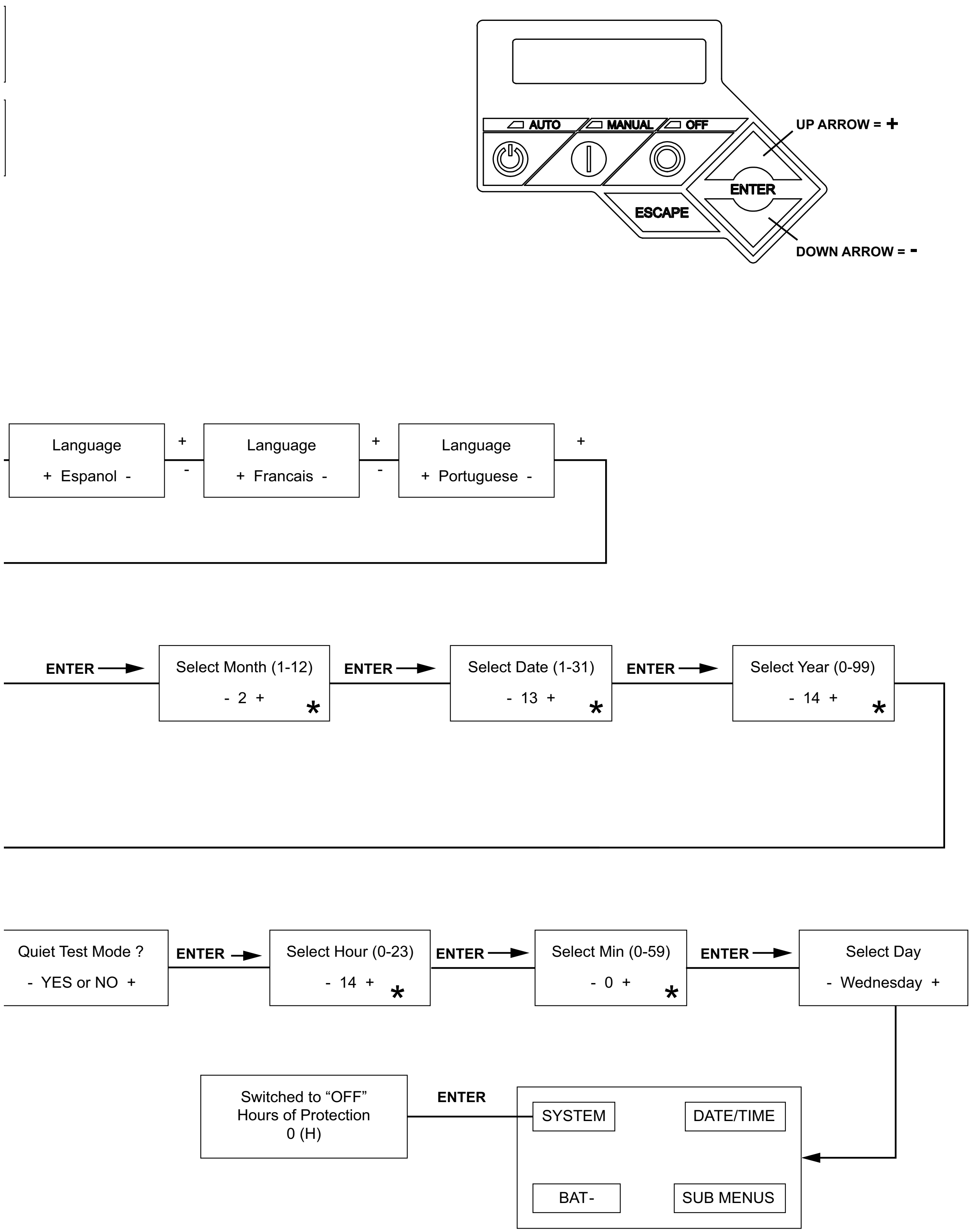

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Figure 3-31. Synergy/EcoGen Activation and Install Wizard Menu Map

SYNERGY/ECOGEN HSB FIRMWARE MENU MAP

Alternate Firmware Update Method:

Control unit at main screen and Insert Thumb drive with Firmware

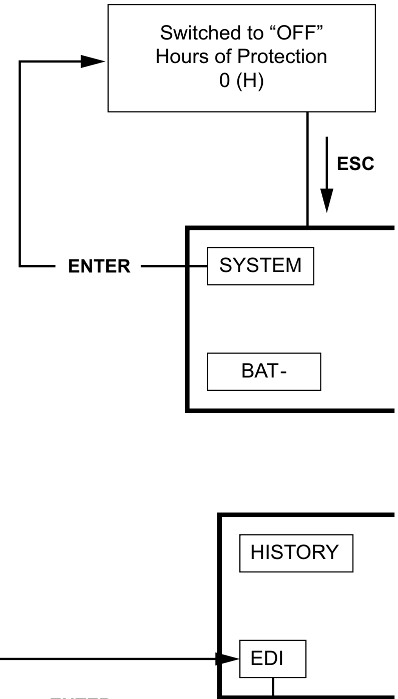
Power the unit down completely. Disconnect AC power.

Repower the controller allow unit to complete the update process.

During update process the Blue “Manual” light flashes, then the Green “Auto” light flashes. Sequence does this twice. When update is complete the unit returns to setup menu.

When the controller powers up the very first screen displays the version number for a few seconds.

When unit finishes update remove thumb drive then follow the Install Wizard menu.



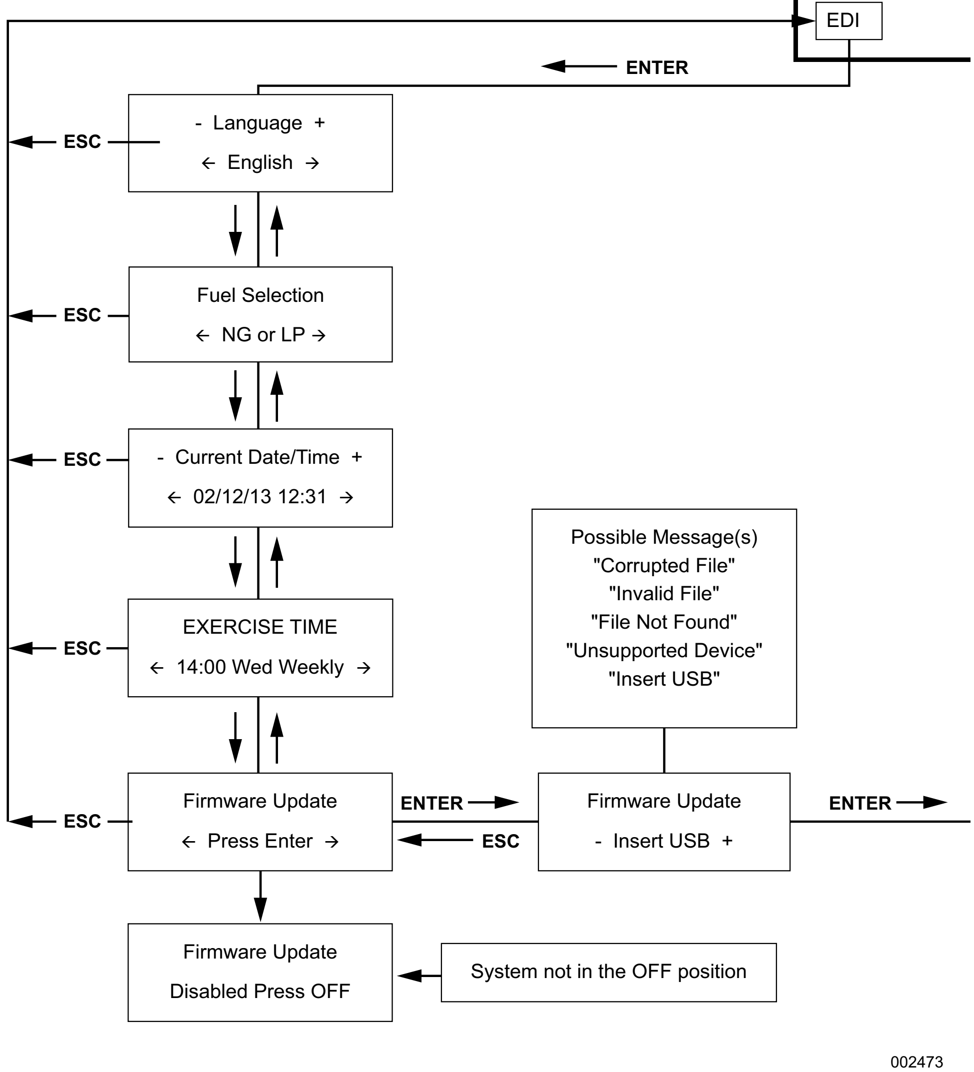


Figure 3-32. Synergy/EcoGen Firmware Menu Map

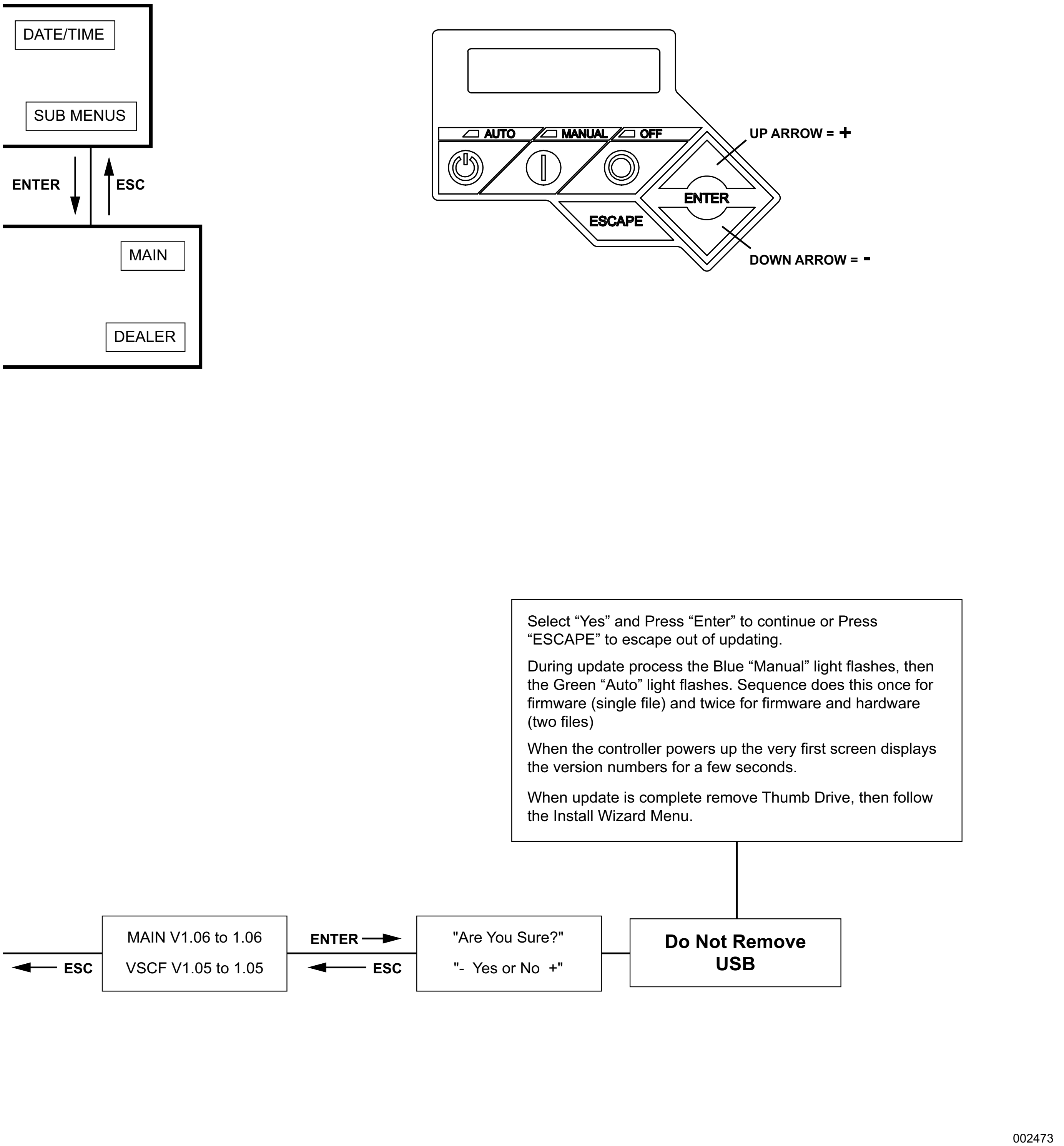


Figure 3-33. Synergy/EcoGen Firmware Menu Map

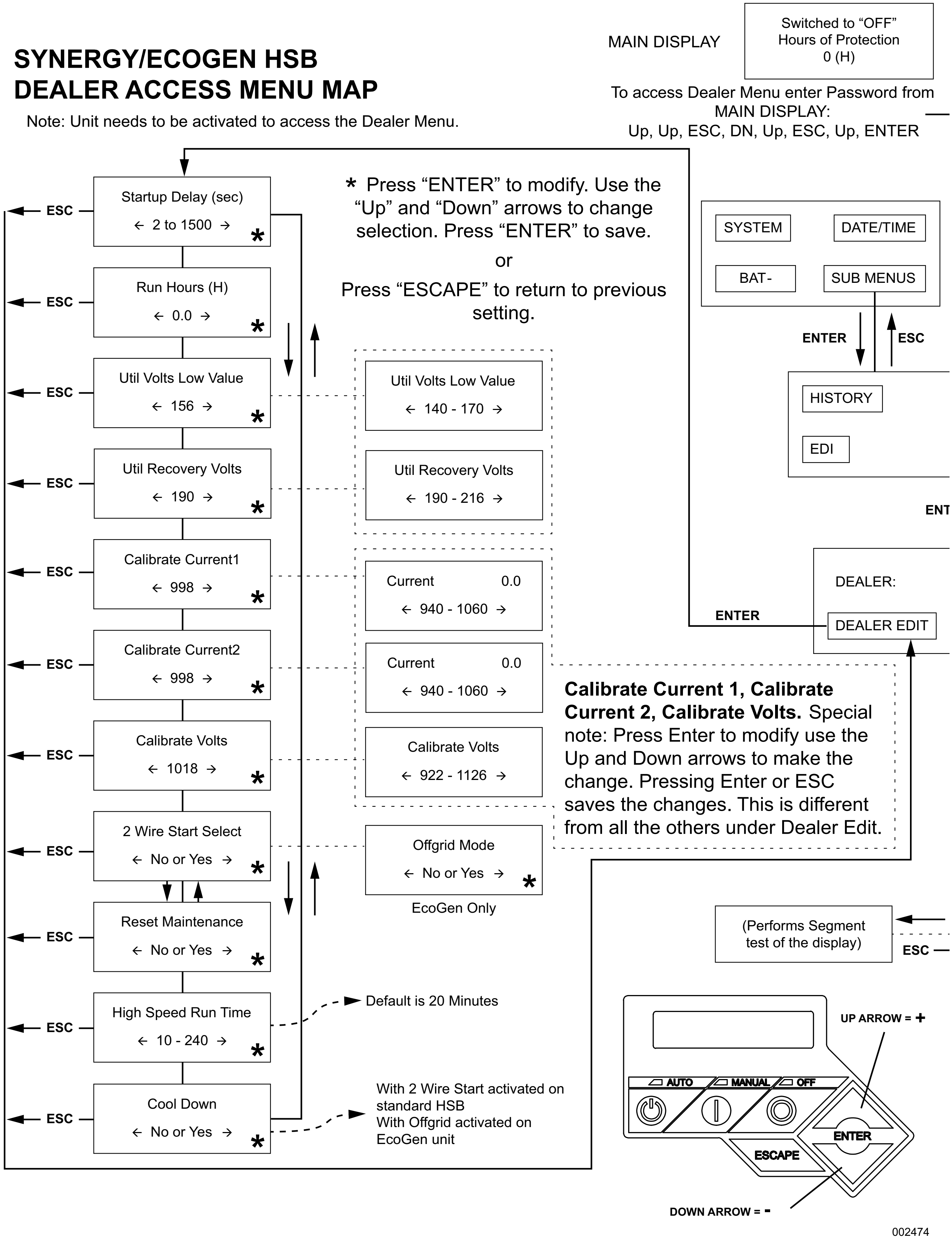


Figure 3-34. Synergy/EcoGen Dealer Menu Map

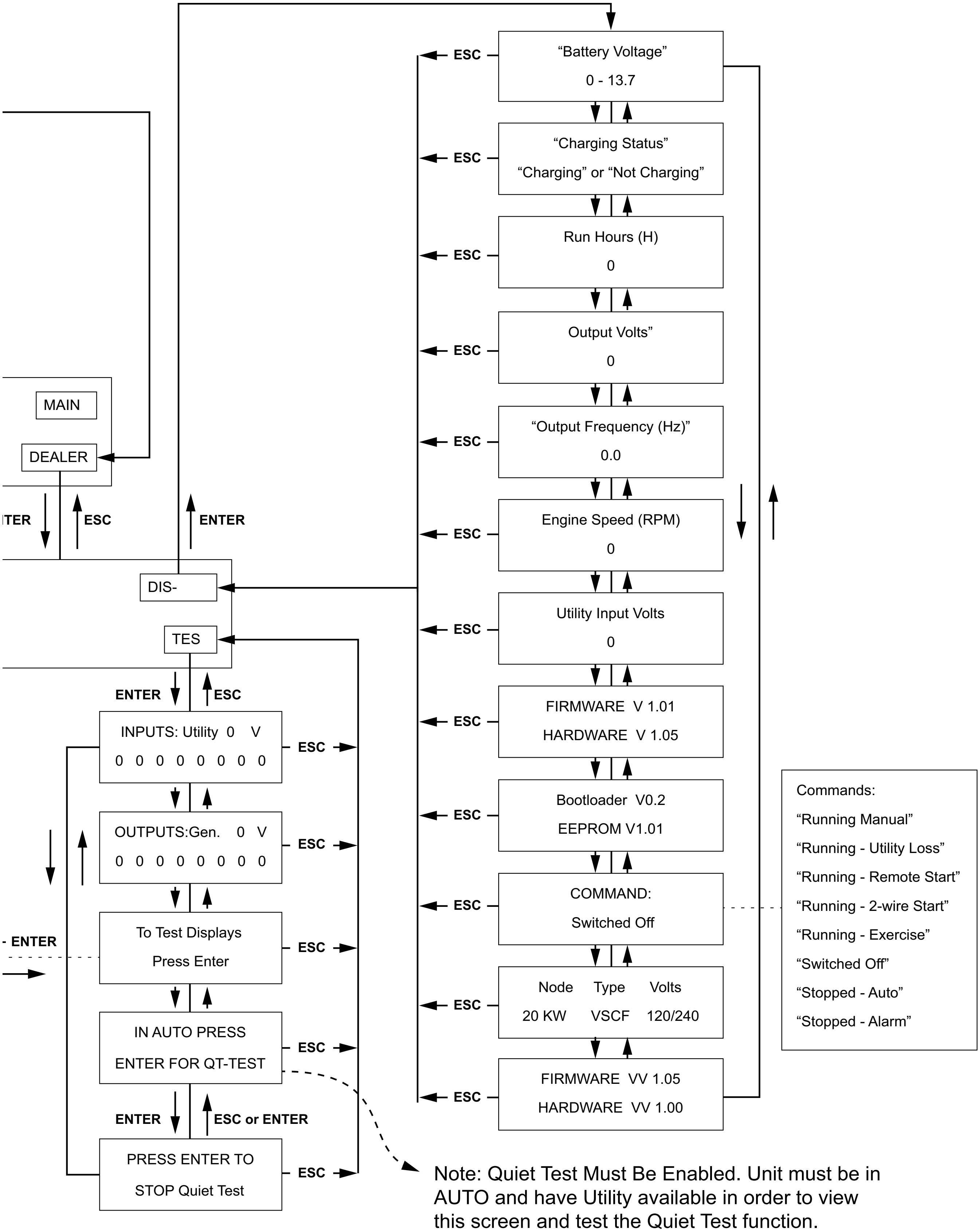


Figure 3-35. Synergy/EcoGen Dealer Menu Map

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Section 1.11 General Troubleshooting Guidelines

Introduction

This section familiarizes the service technician with recommended procedures for testing and evaluating various problems that can occur on air-cooled home standby product. Become familiar with these guidelines before attempting to troubleshoot any of the three main generator components: AC Generator, Air-Cooled Engine, Transfer Switch.

Troubleshooting flow charts provide the simplest, and quickest means of troubleshooting typical problems that might occur on air-cooled home standby product. Performing the appropriate tests as indicated by the flow charts will help identify faulty components and systems. Once identified, the components or systems can be repaired or replaced as necessary.

The test procedures in each section require a basic knowledge of electricity and electrical safety, hand tool skills, and use of multimeters.

Testing and troubleshooting methods covered in this manual are not exhaustive. No attempt has been made to discuss, evaluate and advise the home standby service trade of all conceivable ways in which service and trouble diagnosis must be performed. Any test method not recommended herein must be deemed safe for personnel and equipment.

Recommended Tools

In addition to standard hand tools, some test procedures require the use of specialized test equipment as follows:

- A Digital multimeter (DM).
- Standard meter test leads, and appropriate testing probes.

NOTE: The manufacturer carries a set of flexible pin leads (P/N 0J09460SRV) for use with AMP connector plugs. These can also be used and are recommended for back probing MOLEX (White) connectors. Optionally, but least recommended, the manufacturer also carries a set of acceptable piercing probes (P/N 0G7172). Other suppliers piercing probes may be used. Fluke also provides a high quality piercing probe (P/N AC89).

Air-cooled engine troubleshooting requirements:

- A manometer which measures low pressure in Inches of Water Column (inch WC or in$H_2$0).
- An ignition spark tester (P/N 0C5969).

A Service Tool Kit (P/N 0K71330SRV) is available and recommended for performing service work on air-cooled home standby product.

Troubleshooting Reminders and Tips

The most important step in troubleshooting is identifying the actual problem. Use the History capability of the Evolution panel to help identify what the panel is seeing. Use the Alarm Log to view the faults that caused the Warning or Alarm Shutdown. The date/time stamp provides the date and time (to the second) that the alarm event occurred. If there are several alarms that all have the same date-time stamps, go to the first in the series of alarms for that time. Some failures can cause a cascading series of faults to occur, one right after the other. Compare the Alarm Log and the Run Log to each other to see the operational sequence of events.

For example: If the unit shut down on “ALARM - Low Oil Pressure,” look to see what time the unit started. If it started at 8/20/10 14:27:30 (2:27 pm), and shut down on low oil pressure on 8/30/10 10:15:22 (10:15 am), then the most likely cause of the loss of oil pressure was low oil level. The unit ran, providing power, for 10 days straight (approximately 234 hours). This would be validated by simply checking the oil level of the unit. These are air-cooled 4-cycle engines and will use oil while running. If run for extended periods of time (several weeks for instance) they will require periodic shut-down to check oil level and do a general inspection.

The next step is to determine the applicable flow chart to use to help diagnose the problem. Use the flow chart index for the part of the generator you are working with.

- Use **Section 2 – AC Generators** for problems involving voltage.
- Use **Section 3 – Transfer Switch** for problems with the transfer switch.
- Use **Section 4 – Engine/DC Control** for engine problems.

The index for each section will help clarify the problem and which flow chart to use. For each flow chart, start at the top and use the indicated test to verify whether or not a component or control item is working properly. At the end of each test follow the “GOOD” or “BAD” arrows and perform the next test.

It is always good practice to continue to ask questions during the troubleshooting process. When evaluating a problem, these questions may help identify the problem more quickly.

- What is it doing? (low voltage; not cranking; not transferring; etc)
- What should it do? (run and start; transfer; shutdown; etc)

- Does the same thing happen each time?
- When is it happening?
- What could or would cause this?
- What type of test will either prove or disprove the cause of the fault?

Important Note Concerning Connectors

A number of the tests require the use of a multimeter and a set of test probes.

It is very easy to damage the female pins in the connectors on the control panel and STR (Molex connector) which goes to the alternator can.

DO NOT ATTEMPT TO PUSH PROBE TIPS INTO THE CONNECTOR PINS OF ANY AMP or MOLEX CONNECTORS. Doing so will damage the female pin which will create further problems. Use the appropriate probes on specific wires to check voltage. Use the flexible pin leads, available from the manufacturer (PN 0J09460SRV) to work with AMP connector plugs. Another alternative is to use approved back probes from the back side of the connector.

Introduction

The alternator contained within the generator is a revolving field (rotor) type with a stationary armature (stator). Excitation to the field is provided through brushes and slip rings (direct excitation). The generator may be used to supply electrical power for the operation of 120 and/or 240 VAC, 1-phase, 60 Hz, AC loads.

Engine-Generator Drive System

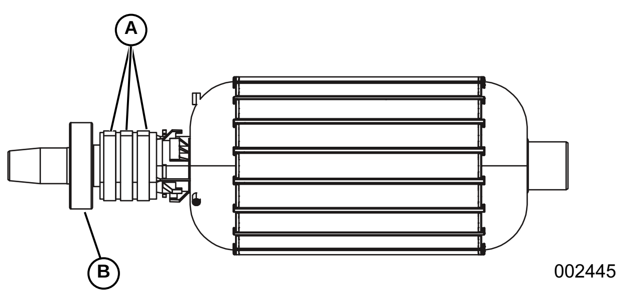
The air-cooled engine is directly coupled to the rotor internally. Both the engine and the rotor operate from 2750 to 3650 rpm to provide a 60 HZ AC output.

Alternator Assembly

The standard alternator consists of three basic components: a rotor, stator, and brush assembly. The rotor assembly provides the magnetic field which will induce a voltage into the stator assembly. The brush assembly provides the electrical connection to the rotor, which allows for excitation voltage and current to create the needed magnetic field.

Rotor

Operating the rotor from 2750 to 3600 rpm will supply a 60 HZ AC frequency. The tapered rotor shaft mounts to the tapered crankshaft of the engine and is held in place with a single through bolt. As the rotor rotates, lines of magnetic flux cut across the stator assembly windings to induce voltage into the stator windings. The rotor shaft has three (3) slip rings near the rear-bearing carrier. The bearing is pressed onto the end of the rotor shaft.



A. Slip rings
B. Bearing

Figure 2-1. Rotor

Stator

See *Figure 2-2*. The stator houses a dual power winding and an excitation winding. There are typically eight (8) stator leads coming from the stator.

The stator is supported by an adapter molded into the engine block, and by a rear-bearing carrier. Four stator bolts connect the rear bearing carrier and the stator can to the engine.

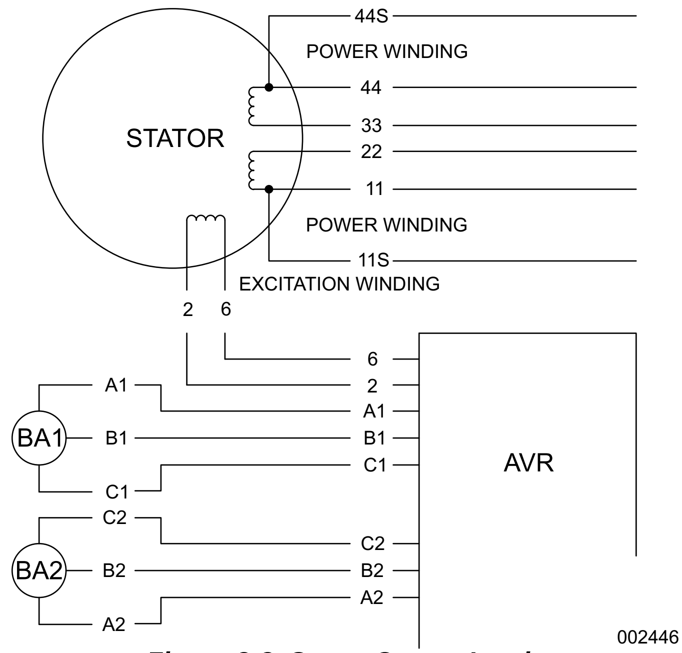
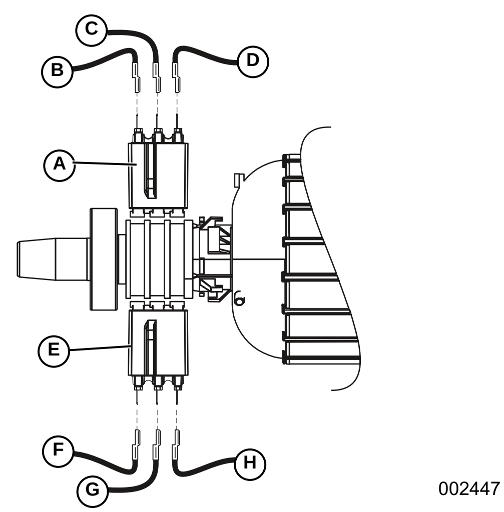


Figure 2-2. Stator Output Leads

Brush Holder and Brushes

The brush holder and brushes are attached to the rear bearing carrier. Brushes allow for electrical connection to the rotor.



A. Brush Assembly 1
B. A1
C. B1
D. C1
E. Brush Assembly 2
F. A2
G. B2
H. C2

Figure 2-3. Brush Holder and Brushes

Other AC Generator Components

Located within the generator control panel enclosure are the controller, connection points, starter contactor relay (SCR), and main line circuit breaker (MLCB).

Voltage Regulator

The Automatic Voltage Regulator (AVR) in the Synergy unit is a separate component of the display control panel. The AVR receives unregulated AC output voltage from the stator excitation winding (DPE) through Wires 2 and 6. The AVR gates the AC and regulates it based on the sensed voltage output of the stator. The output of the AVR field excitation voltage is then delivered to the rotor windings through the brushes and slip rings. The voltage regulator senses the AC output voltage of the alternator through Wires 11S and 44S.

The control panel provides user interface with the AVR and fault detection based on those items monitored by the AVR.

Example: Under Voltage/Over Voltage are communicated to the control panel over the communications line.

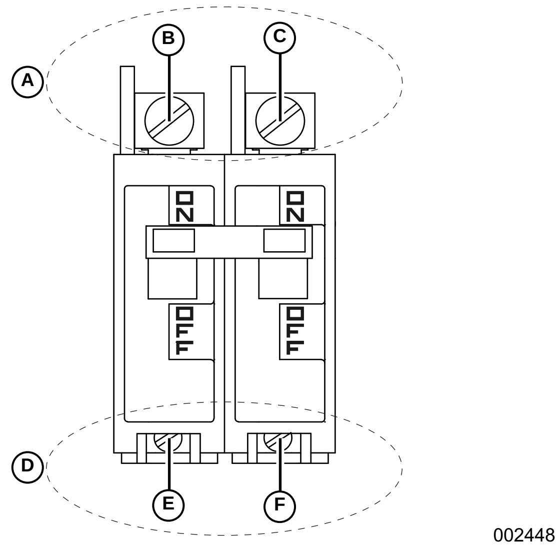
Evolution Controller (When in AUTO)

Under-voltage – If generator voltage falls below 80% of rated (192V for a 240V unit) for 5 seconds or continuously for 10 seconds, the generator will attempt to crank a total of 3 times. If proper voltage is not achieved after the 3rd attempt, the unit will shut down and an alarm will display.

Over-voltage – If generator voltage rises above 130% of rated (312V for a 240V unit) for 5 seconds or continuously for 1/5 of a second, the generator will shut down and an alarm will display.

Main Line Circuit Breaker

The main line circuit breaker protects the generator against electrical overload. See ***Specifications*** for specific amperage ratings.



A. Line Side
B. 11
C. 44
D. Load Side
E. E1
F. E2

Figure 2-4. Main Line Circuit Breaker

Variable Speed Constant Frequency Operating Diagram

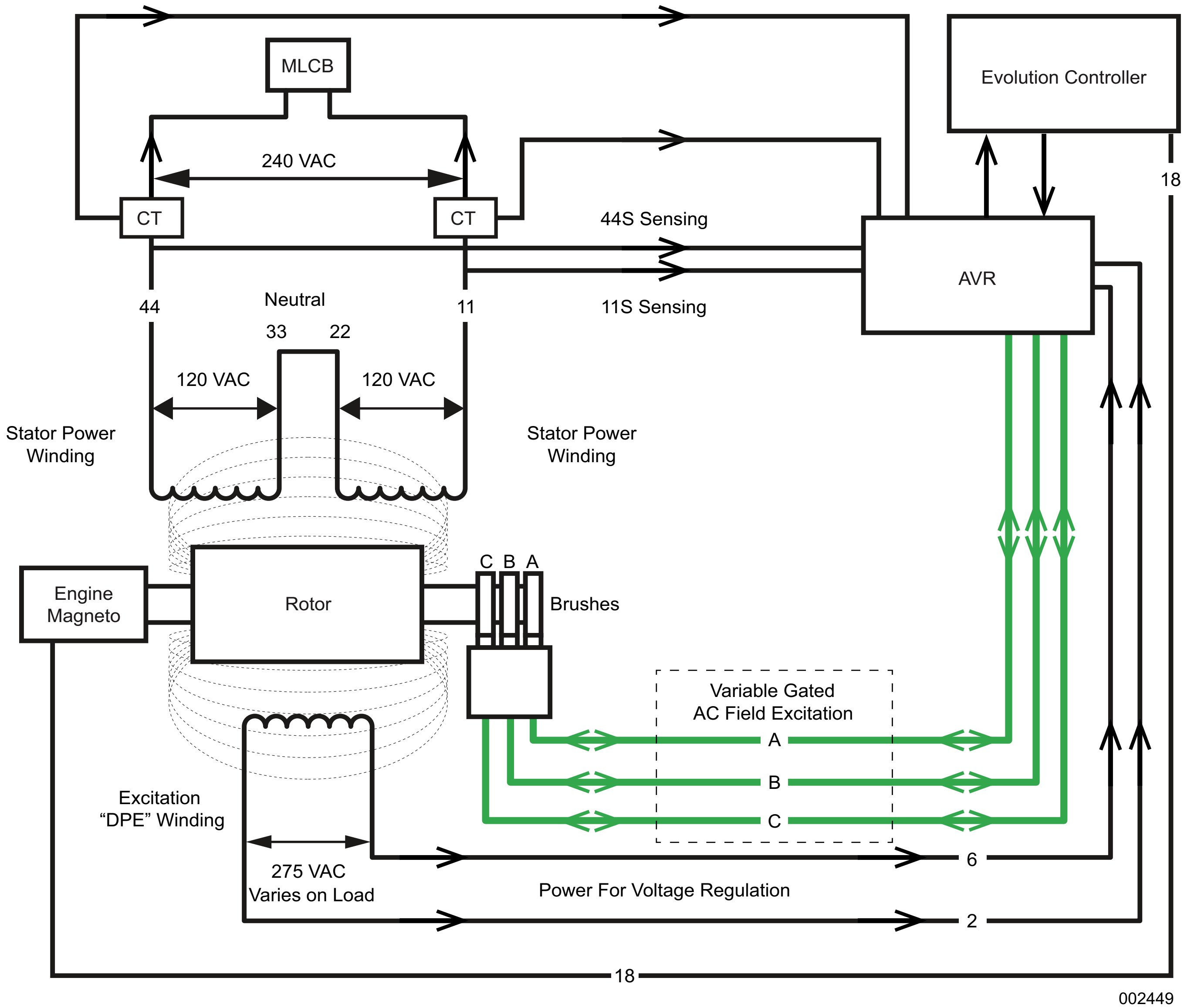


Figure 4-5. Synergy™ with G-Flex™ AVR Schematic

Table 2-1. Evolution™ Controller e-Codes

Displayed Alarm	Alarm/ Warning	e-Code Breakdown	Description	Notes
Controller Fault	ALARM		No E-code on HSB	Replace Controller
Overcrank	ALARM	1100	Condition - Engine Cranks but will not Start Unit turns over but will not start. Controller is receiving signal on Wire 18.	Problem 17
Overspeed	ALARM	1200	Prolonged Over 72 Hz for 3 seconds. Possible cause: Stepper motor/mixer body assembly issue.	Test 12
Overspeed	ALARM	1205	Instantaneous Over 75Hz for 0.1 second (100 milliseconds). Possible cause: Stepper motor/mixer body assembly issue.	Test 12
Low Oil Pressure	ALARM	1300	Occurred while running The default Extended alarm for low oil pressure. Check oil level and pressure.	Test 61
High Temperature	ALARM	1400	Condition - Air Flow Impeded / Flow Issue Check the inlet/outlet for debris.	Test 62
RPM Sensor	ALARM	1501	Twin Cylinder+Running Twin Cylinder Running faults to RPM Sensor Loss. Possible Causes: air pocket in fuel line, dirty fuel, missing ignition pulse (loss of one of the primary coils).	Test 50 and Test 64
RPM Sensor	ALARM	1505	Twin Cylinder+Cranking Twin Cylinder Cranking faults to RPM sensor loss Possible Cause: starter motor issue, missing ignition pulse (loss of one of the primary coils).	If engine cranks, Test 64. If engine does not crank, Problem 15.
Underspeed	ALARM	1600	Condition - Unit is Overloaded Unit is Overloaded slowing engine speed, fuel supply low or throttle control problem.	Problem 3, Test 50 or Test 12
Overvoltage	ALARM	1800	Prolonged Over-Voltage Voltage reported to the controller from the AVR via communication line.	Perform Test 2
Undervoltage	ALARM	1900	Prolonged Under-Voltage Undervoltage due to loss of voltage for some time (10+ seconds). Voltage reported to the controller from the AVR via communication line.	Perform Test 2
Undervoltage	ALARM	1901	Undervoltage value reported to Evolution controller. Verify Generator output voltage in the Dealer Menu display of the Evolution controller. AVR voltage information is sent to the Evolution controller via communication lines.	Check communication wires between AVR and Evolution controller. Perform Test 2
Wiring Error	ALARM	2099	Customer connection low voltage and high voltage wires are crossed.	Check customer connection in generator
Overload Remove Load	ALARM	2100	Overloaded - Default (Output Current Method) Unit is overloaded, one of the two CTs is detecting an overload condition. Check transfer switch loadshed functionality. (Change load dynamics or utilize loadshed).	Remove Load
Stepper Overcurrent	ALARM	2399	Current flow in stepper coil(s) above specification	Test 12
Fuse Problem	ALARM	2400	Missing / Damaged Fuse (not displayed on Firmware 1.12 and newer) The 7.5 amp Controller Fuse is missing or blown (open).	Test 44
Low Battery	WARNING		Condition->Battery less than 12.1 Volts for 60 seconds	Test 45
Battery Problem	WARNING		Condition->More than 16 Volts of battery voltage or 600 milliamperes or more of charge current at the end of an 18 hour charge	Test 45
Charger Warning	WARNING		Less than 12.5 volts of battery voltage at the end of a 18 hour charge	Problem 22
Charger Missing AC	WARNING		AC power is missing from the battery charger input	Problem 22
SEEPROM Abuse	WARNING		Condition->more than 1200 writes to the EEPROM in a 5 minute period.	

Table 2-2. VR VSCF-Codes

Ecode	Alarm	Description	Possible Causes	Tests
1048	VSCF Overload	Large DC link (phase) current for 100us	Rotor has shorted, or AVR phase wire short (or miswired), or brush short.	Perform Rotor Brush Test
1049	VSCF Overload	Sustained Generator output voltage of < 120V for a total of 2ms (100us sampling) after reaching operating voltage, AND very high current (>> max load)	The generator output is shorted or severely overloaded. Identify and clear the overload then restart.	Check for Overload conditions Proper Load Shedding
1050	VSCF Low Battery	Low supply voltage detected <8 VDC	The voltage supply to the AVR is low. Since the supply comes from the controller, either 1) The AVR is miswired to the controller 2) The controller is outputting the wrong voltage (faulty) 3) The AVR has internal issue	Check AVR Power and ground circuits from controller to AVR for proper voltage and ground
1051	VSCF High Battery	High supply voltage detected >16.2 VDC	The voltage supply to the AVR is High. 1) External battery charger is being used 2) AVR supply is mis-wired	Check for external charger issue Check harness for proper wiring
1052	VSCF DC Overvoltage	DC link overvoltage >400 VDC	1) The generator was temporarily overloaded 2) The output was temporarily shorted 3) Throttle is stuck (open) 4) Internal AVR issue	Check for Overload conditions Check proper Stepper operation
1053	VSCF Gate Fault	IGBT gate driver fault	Possible causes are: 1) The brushes are incorrectly wired. 2) The rotor is shorted. 3) The brushes are arcing or worn. 4) The generator was severely overloaded (shorted). 5) One of the fans is blocked or not working. Insufficient air flow. 6) Off" was pressed when the "Small Fan Failure" Warning was present (Ecode 1070)	Perform Rotor Brush Test Check for Overload conditions Check AVR Air flow for restriction Perform Small fan test Perform Large Fan Test Perform Auxiliary Power Supply test
1054	VSCF IGBT Overtemp.	Set for >85 deg. C	Probable causes are: 1) The AVR air filter needs replacing. 2) The air path is blocked, either intake or exhaust or through the unit. 3) The BIG fan is not running Perform Small Fan and Large Fan test 4) There is an air leak in the AVR enclosure. 5) The engine is running too hot. 6) Ambient temperature above 50C.	Check for Overload conditions Check AVR Air flow for restriction Perform Small fan test Perform Large Fan test Perform Auxiliary Power Supply test Check Generator air vents for restriction Insufficient air flow around unit
1055	VSCF Phase Error	If Vrms>125 & Hz < 45 while ramping	An incorrect voltage and frequency has been detected during starting. Probable causes are: 1) The stepper motor is not working or the linkage is binding. 2) The gas pressure is low and the engine is not coming up to speed. 3) The brushes are incorrectly wired. 4) The brushes are arcing or worn. 5) The brushes are not connecting to the slip-ring. 6) The rotor is shorted. 7) The generator has started into a severe load. 8) Brush harness connector is damaged.	Check for proper fuel supply and settings must be within specifications of unit Open MLCB and retest unit Check for Overload conditions Perform Rotor Brush test Check stepper operation Perform stepper motor test Check rotor resistance at slip rings

Table 2-2. VR VSCF-Codes

1056	VSCF Undervoltage	Main controller detects a low output voltage	The generator output voltage is too low. Possible causes are: 1) The load is too large 2) The stator is damaged 3) The rotor is damaged 4) The brushes are incorrectly wired 5) The brushes are arcing or worn 6) The AVR is damaged	Open MLCB and retest unit Check for Overload conditions Perform Rotor Brush test Perform Power Winding and DPE winding tests
1057	VSCF Overvoltage	Generator overvoltage >265 Vrms	Probable causes are: 1) The generator has been overloaded 2) The generator has started into a severe load.	Open MLCB and retest unit Check for overload conditions on startup
1058	VSCF DC Undervoltage	Loss of aux winding field <100 VDC	The DPE winding supplies this voltage. Possible faults are: 1) DPE is miswired/not connected. 2) DPE winding is faulty (rotor fault) 3) The brushes are arcing or worn. 4) Brushes are miswired or faulty.	Perform Power Winding and DPE tests Perform Rotor Brush test Inspect harness
1059	VSCF Field Loss	Output is < 50 Vrms. Immediately upon completion of startup voltage ramp. (1 rms sample)	The unit has detected there is no output voltage while starting up. Probable causes are: 1) The DPE winding is miswired 2) The DPE is producing no voltage into the AVR. 3) The brushes are arcing or worn. 4) Brushes are miswired or faulty. 5) The rotor is shorted. 6) The AVR is damaged.	Perform Power Winding and DPE tests Perform Rotor Brush test Check harness connections to AVR
1060	Big Fan Failure	PCB temperature has exceeded 70C ALARM	This alarm occurs when the AVR electronics temperature exceeds 70C. Possible causes are: 1) The AVR air filter needs replacing. 2) The air path is blocked, either intake or exhaust. 3) The BIG fan is not running (it only runs when the engine runs). 4) There is an air leak in the AVR enclosure. 5) The engine is running too hot. 6) The ambient temperature is above 50C.	Check for Overload conditions Check AVR Air flow for restriction Perform Large Fan test Perform Auxiliary Power Supply test Check Generator air vents for restriction Insufficient air flow around unit Perform Small Fan Test
1061	VSCF Field Loss	Output is < 20 Vrms for 16 cycles	The unit has detected the output voltage has been lost while running. Possible causes are: 1) Fuel loss. 2) The DPE is no longer generating voltage into the AVR. 3) The brushes are arcing or worn. 4) Brushes are miswired or faulty. 5) The rotor is shorted. 6) The AVR is damaged.	Check fuel supply and fuel pressure Perform Power Winding and DPE tests Perform Rotor Brush Test Check harness connections to AVR
1062	VSCF Comms Loss	Main controller detects no VSCF modbus messages have been received.	The AVR needs to communicate with the controller, as such there is a shielded cable connecting the two units. Possible faults: 1)Comm's cable / connection has become faulty. 2) Incorrectly shielded 3) The AVR has no power to it. Check the LED's on the AVR. The green one should be lit (only). 4) One of the controllers is damaged. 5) The firmware download has failed. 6) Can occur when using a DMM on these wires.	Check communication wires between controller and AVR for shorts, opens, proper routing, and check pin fit. Check shield wires are properly grounded. Check for correct firmware version Check static voltages on Communication wires with unit not running
1063	VSCF Enable Mismatch	Main controller detects the VSCF Enable state reported by VSCF does not match the state set by HSB.	Probable causes: 1)The enable wire is missing between the AVR and HSB controllers. 2) The enable wire is shorted or miswired, or connector is loose. 3) The controller is faulty. 4) The AVR is faulty.	Check AVR P1 connections Check controller connections Check Enable circuit for proper operation

Table 2-2. VR VSCF-Codes

1064	VSCF Speed PWM Loss	Main controller detects the speed PWM command from VSCF is not received	Probable causes: 1)The speed signal wire is missing between the AVR and HSB controllers. 2) The speed signal wire is shorted or miswired, or connector is loose. 3) The controller is faulty. 4) The AVR is faulty.	Check continuity on the PWM communication lines. Check connector and pin fit
1065	Overfrequenc y	Main controller detects an over frequency alarm	Engine is 25% over 60Hz for 100ms OR Engine is 20% over 60Hz for 3s	Check stepper operation sticking binding AVR internal issue
1066	VSCF Speed mismatch	Engine speed does not match commanded speed.	1) Large load not wired through loadshed module. 2) Fuel issues (run out, pressure, hose bent), Fuel pin in wrong position. 3) Large overload. 4) Cold engine, not responding. 5) Sticking throttle, throttle wiring. 6) Engine problem.	Fuel Supply not in specifications. Incorrect fuel selection Restricted fuel supply, Check fuel hoses to mixer for restriction Check proper fuel pin selection or restriction in pin orifices. Open MLCB and retest possible Overloaded condition. Perform stepper test Check wire harness proper routing and pin fit. Check magnetos for proper operation. Internal engine concerns
1070	Small fan failure	Current for fan is wrong.	The small fan current is detected as wrong. Possible causes are: 1) Fan wires are broken/miswired. 2) Fan is stalled/clogged. 3) Air path is blocked.	Check AVR Air flow for restriction Perform Small Fan Test
--	Bootloader fails	Fails to load	Probable causes: 1) The USB stick is incompatible 2) The file is not on the USB stick 3) The file is in the wrong folder 4) The file is the wrong file name	
--	Green LED not lit	The AVR has no power	Check the AVR power wiring	
--	Green LED pulsating	The fan is running in cooldown mode	Normal operation	
--	Red LED lit	The AVR has detected a fault	See the display for messages	
	Output voltage is little low or high		Controller not calibrated	Calibrate voltage with calibrated equipment
	Generator does not pull full power		Current calibration not correct Faulty wiring or improperly orientated CT(s) Fuel problem	Calibrate amperage with calibrated equipment Inspect proper installation and test CT(s) Check fuel supply and fuel pressure

Table 2-3. Synergy™ Loadshed

Symptom	Possible Causes
Generator stalls when large load is applied.* *Any load larger than 9 kW (NG) or 10kW (LP) must connected via a load shed module.	1) Check for Fast loadshed proper operation. Large load(s) not properly setup for load shedding. 2) Loadshed is incorrectly wired. 3) Check condition of transfer signal. Wire 23 should be wired to the AVR, NOT the controller. There should only be one wire. 4) Total load is too large for LP (>19 kW)* 5) Total load is too large for NG (>18 kW)*
Large loads keep getting shed and locked out (load led goes out for 30 min.	1) Total load is too big for the generator.
No lights on OPCB	1) Check for proper DC voltage on Wire 194 – approximately12 VDC. 2) Check Wire 0 for proper ground. 3) Remove all wires from OPCB except Wire 194 and 0. Press the reset button for 5 seconds then wait 5 minutes. If there are still no lights, replace the module. If lights return check disconnected wires for proper circuit operation.
OPCB won’t shed loads	1) Connect a DM to Wire 23 and ground. 2) With generator in OFF mode, approximately12 VDC should be measured 3) With generator in AUTO mode, simulate a transfer from utility to standby (loss of utility). Wire 23 should drop from approximately12 VDC to zero. If not, verify operation of Wire 23 circuit.

Field Boost

During the engine's crank cycle, the control panel provides battery voltage (12 VDC) on Wire 56 to energize the starter contactor relay (SCR).

Theory of Operation

Engine Cranking

When cranking and starting, the small fan is tested for a few seconds. Cranking is terminated at approximately 1500 rpm.

An internal relay in the HSB controller supplies 12 VDC power to the AVR during cranking via the AVR Power Wire. The green LED is lit on the AVR if it has power.

As the speed reaches 2200 rpm, the HSB controller begins communication with the AVR over the communications link (RS485 port) and activates the Enable signal to the AVR. The HSB controller checks for a speed signal that is sent back from the AVR.

The AVR controller energizes the field at 2200 rpm using 12 VDC power (from the HSB internal relay), which is inverted to a three-phase sinusoidal waveform at a very low frequency of 0.3 Hz. This frequency is normally used to make up the difference between engine speed and 60 Hz at the output of the generator, so at initial startup it will increase from 0.3 Hz to about 15 Hz when at least 125 Volts has been achieved. At a low speed of 2700 rpm*, this frequency will be at about 15 Hz (60 – (2700/60) = 15) and taper off to 0.3 Hz as it nears 3600 rpm.

This is applied to the rotor via the three-phase wire connections and causes the DPE winding to energize and build up AC voltage. The AVR then rectifies this voltage and inverts it to feed AC to the rotor. Stator output voltage begins to build at this point.

The initial internal target voltage is set at 180 VRMS and the initial target rpm is 3000 to reduce the load on the engine. At this early stage, while the engine is building rpm and voltage, there are small short term goal (STG) voltage steps taken to the target voltage. As the STG voltage approaches the targeted voltage, the AVR performs some checks to see if the brushes / slip rings / AVR and the AVR 3-phase connections are working properly. It does this by checking if the stator output voltage is greater than 125 VRMS but the frequency is less than 45 Hz. If this happens, a “VSCF Phase Error” alarm (e-Code 1055) is displayed and the unit shuts down.

Once the STG voltage has reached its target, the engine and the alternator will be creating actual output close to the target voltage (depending on adverse starting conditions such as very cold temperatures, low fuel pressure etc.). The AVR then checks the stator output voltage. If it is less than 50 VRMS, the controller will display a “VSCF field loss” alarm (E-code 1059).

Once the engine speed is above 2950 rpm, the frequency has reached at least 55 Hz and the output voltage is greater than 140 VRMS, the target voltage is set at the full 240 VRMS and the speed is slowly ramped up to the full 3600 rpm over a period of about 1.5 seconds to avoid rpm overshoot.

*Also at 2700 rpm the AVR performs a phase check on the rotor connections.

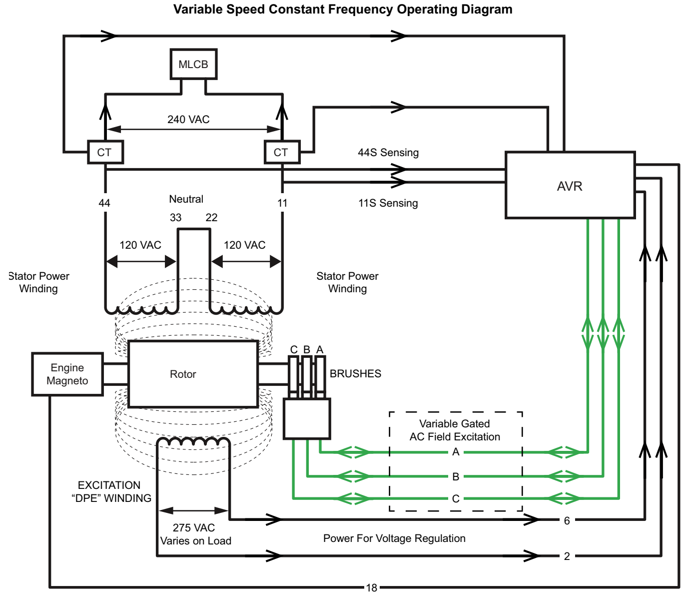


Figure 2-6. Operating Diagram

Field Excitation

AC voltage from the DPE winding provides power to the AVR. The AVR gates and converts the AC voltage to DC voltage, then back to AC which is then supplied to the rotor windings via the brushes.

The AVR senses the AC output voltage through Sensing Wires 11S and 44S which are connected to the main power leads (11 and 44) in the stator can. The AVR will continue to increase excitation voltage to the rotor until the desired AC output voltage is reached. It will continue to “regulate” excitation voltage as necessary to provide a constant AC output voltage to the load.

The regulated excitation from the regulator is delivered to the rotor windings through Wires A1-A2, B1-B2, C1-C2 through the brushes and slip rings. This results in current flowing through the desired field windings.

The greater the current flow through the windings the more concentrated the lines of flux around the rotor become. The more concentrated the lines of flux around the rotor, which cut across the stationary stator windings, the greater the voltage induced into the stator. Refer to *Figure 2-7* **and** *Figure 2-8*.

Initially, the AC power windings output voltage "sensed" by the AVR is low. The AVR reacts by increasing the excitation voltage (and hence current flow) to the rotor until AC output voltage increases to a preset level. The AVR then maintains the voltage at this level. For example, if voltage exceeds the desired level, the AVR will decrease excitation. Conversely, if voltage drops below the desired level, the AVR responds by increasing excitation.

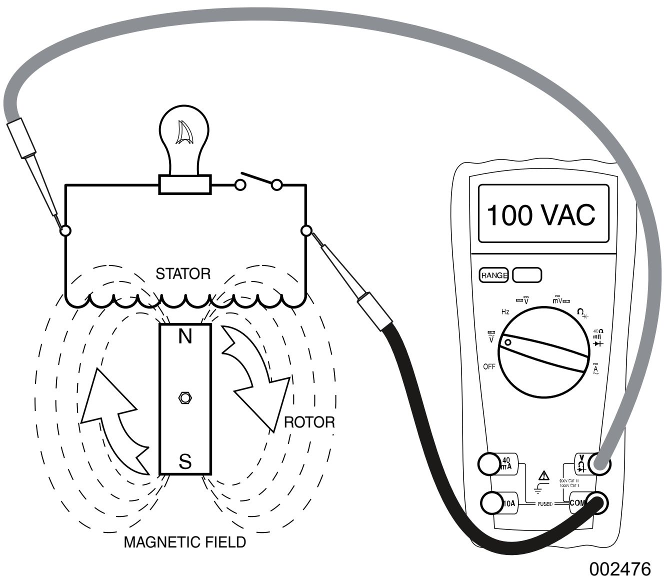


Figure 2-7. Low Field Excitation Voltage = Low Magnetic Lines of Flux = Low AC Output

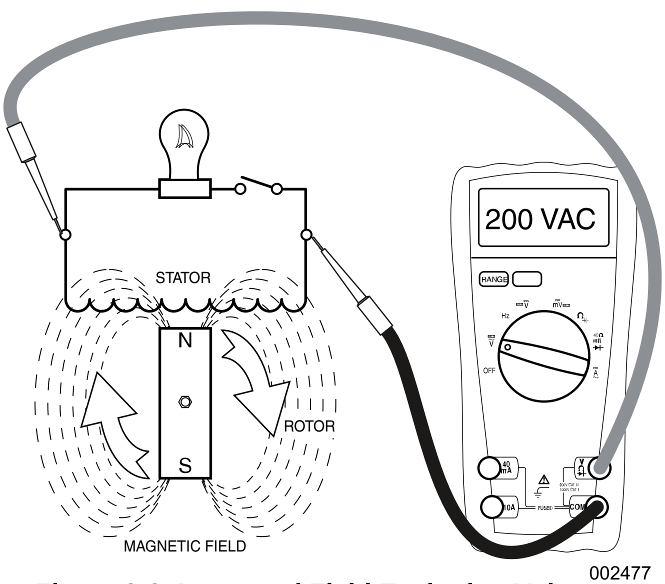


Figure 2-8. Increased Field Excitation Voltage = Increased Magnetic Lines of Flux = Increased AC Output Voltage

AC Power Winding Output

When electrical loads are connected across the AC power windings to complete the circuit, current flows through the circuit powering the loads.

As load changes this will result in a corresponding change in voltage; as load demand increases the voltage will tend to drop; as load demand decreases the voltage will tend to increase. The AVR changes excitation to provide a constant output voltage with minimal increase or decrease during load changes. Frequency is also affected during load changes. However, frequency is a function of rotor speed (engine rpm); the engine electronic governor (integral to the control panel) and the AVR will respond to any engine speed changes to maintain a stable, isochronous, frequency output based on the specifications of the unit.

The Automatic Voltage Regulator and the Electronic Governor work together to provide output voltage regulation of +/- 1% voltage regulation and +/- 0.25% steady state, isochronous, frequency (speed) regulation within the load capabilities of the unit.

Synergy RPM and Frequency

A Synergy unit utilizes variable speed technology to reduce engine rpm while maintaining proper frequency and current output. An AVR (Automatic Voltage Regulator) uses Current Transformers (CTs) to monitor the electrical load and determines the necessary rpm to maintain proper amperage. A signal is sent to the controller, which adjusts the stepper motor throttle position to achieve the necessary rpm. The AVR compensates for the frequency difference to maintain the appropriate frequency and amps for the electrical load.

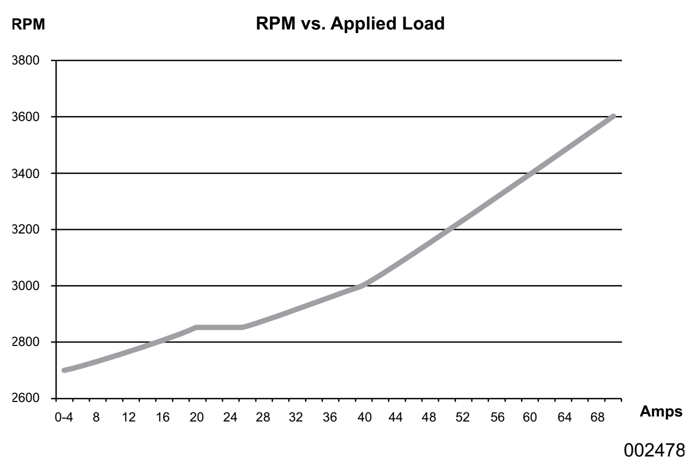


Figure 2-9. RPM vs. Applied Load

Current Transformers

The AVR monitors load (current) through two Current Transformers (CT) mounted in the AC connection box area. The CTs provide an AC output signal proportional to the current flowing in load leads 11 and 44.

CT1 and CT2 have identical functions, diagnostic procedures and calibration processes. CT1 wire circuits 398A and 399A monitor the current flow on Wire 11. CT2 wire circuits 398B and 399B monitor the current flow on Wire 44. The Evolution control panel is used to calibrate the CTs. A password is required to access the Dealer Edit menu when performing calibrations. When ever working with the CTs handle with caution and with the circuit powered down. The CTs are polarity sensitive so always make sure that the Power lead goes through the GREEN DOT side of the CTs first, then to the MLCB.

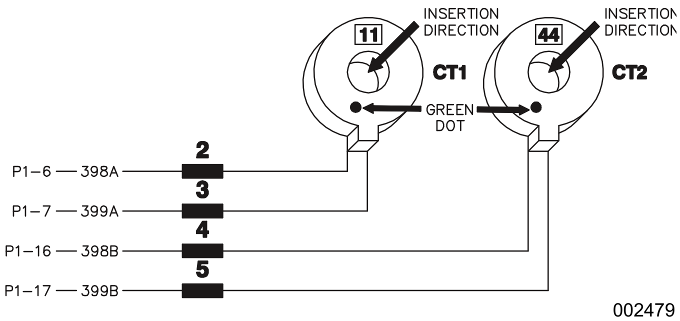


Figure 2-10. Current Transformers

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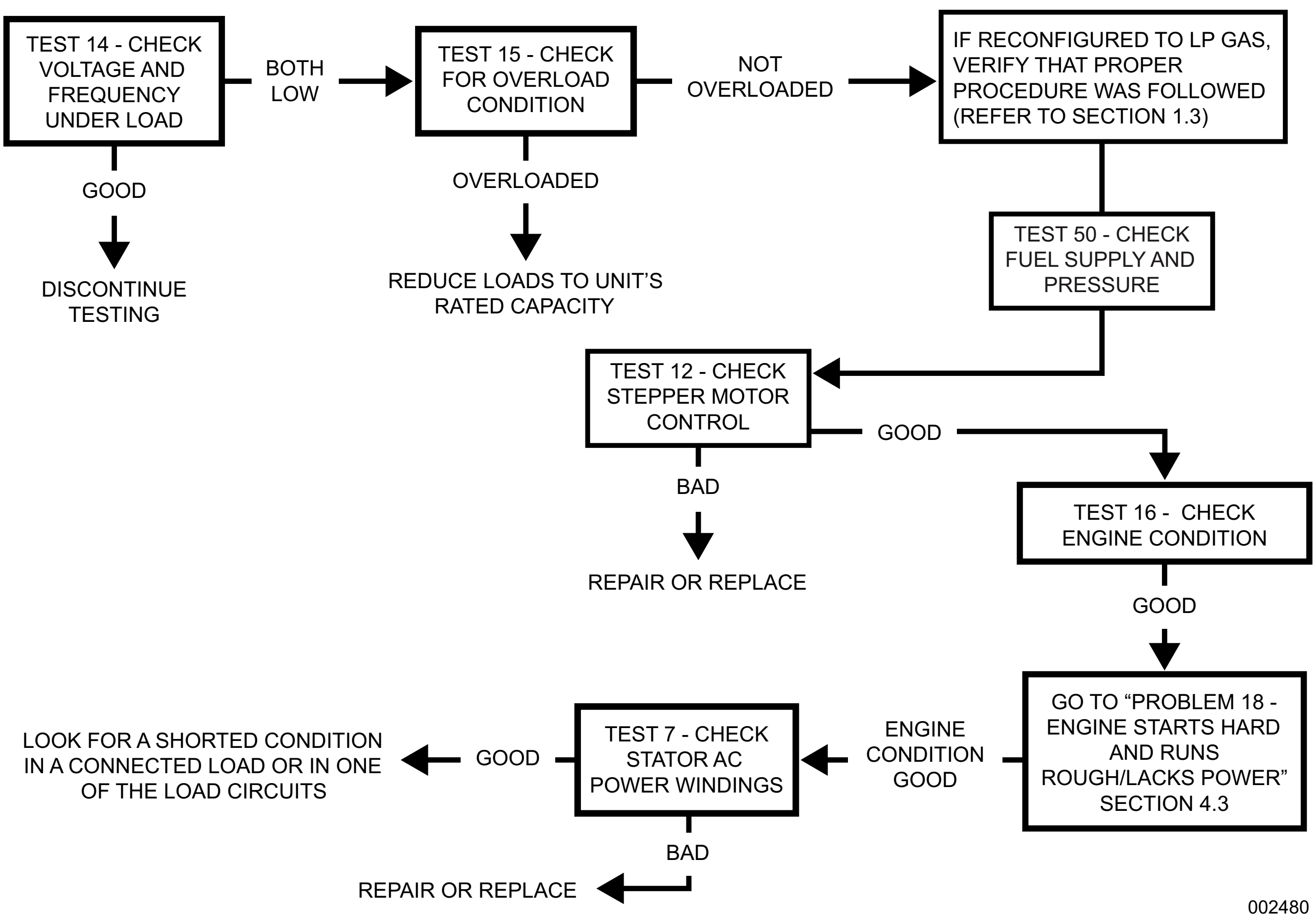
Section 2.3 Troubleshooting Flow Charts

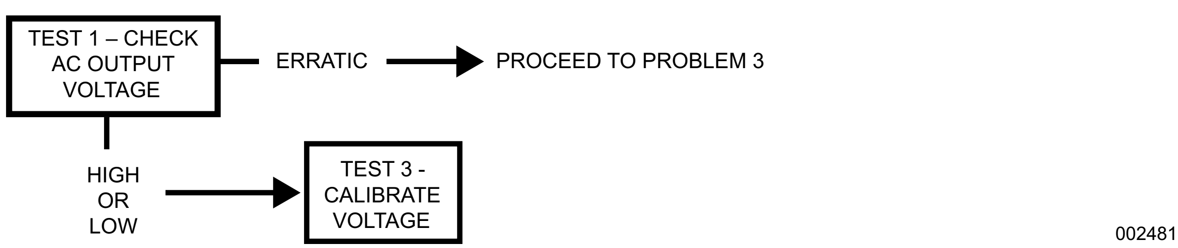
Introduction

Use the “Flow Charts” in conjunction with the detailed instructions in **Section 2.4**. Test numbers and/or verbiage used in the flow charts correspond to the numbered tests and/or verbiage in Section 2.4. The first step in using the flow charts is to identify the correct problem on the following pages. For best results, perform all tests in the exact sequence shown in the flow charts.

Problem 3 – Voltage and Frequency Drop Excessively When Loads Are Applied



Problem 4 – Unstable Voltage or Incorrect Output Which is Not Triggering a Shutdown



IMPORTANT NOTE: Clear any faults in the controller before proceeding with any running diagnostic steps!

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Introduction

This section familiarizes the service technician with acceptable procedures for the testing and evaluation of various problems that can occur on the standby generators with air-cooled engines. Use this section in conjunction with Section 2.3, **Troubleshooting Flow Charts**. The numbered tests in this section correspond with those of Section 2.3.

Some test procedures in this section may require the use of specialized test equipment, meters or tools. Most tests can be performed with a digital multimeter (DM). An AC frequency meter is required where frequency readings must be taken. To measure AC loads it is acceptable to use a clamp-on ammeter.

Testing and troubleshooting methods covered in this section are not exhaustive. No attempt has been made to discuss, evaluate and advise the home standby service trade of all conceivable ways in which service and trouble diagnosis must be performed. Accordingly, anyone who uses a test method not recommended herein must first satisfy himself that the procedure or method he has selected will jeopardize neither his nor the product's safety.

Safety

Service personnel who work on this equipment should be aware of the dangers of such equipment. Extremely high and dangerous voltages are present that can kill or cause serious injury. Gaseous fuels are highly explosive and can ignite by the slightest spark. Engine exhaust gases contain deadly carbon monoxide gas that can cause unconsciousness or even death. Contact with moving parts can cause serious injury. The list of hazards is seemingly endless.

When working on this equipment, use common sense and remain alert at all times. Never work on this equipment while you are physically or mentally fatigued. If you do not understand a component, device or system, do not work on it.

AC Troubleshooting

It is always good practice to continue to ask questions during the troubleshooting process. When evaluating the problem asking some of these questions may help identify the problem quicker.

- What is the generator supposed to do?
- What fault (Alarm) is shutting the generator down?
- Is the fault a symptom of another problem?
- Does the generator have the same fault consistently?
- When does the fault occur?
- After the fault occurred what was displayed in the LCD?
- Why would this happen?
- How would this happen?
- What type of test will either prove or disprove the cause of the fault?

Test 1—Check AC Output Voltage

General Theory

Use a DM to check the generators output voltage. Test output voltages at the unit's main circuit breaker (MLCB) terminals. Refer to the unit's data plate for rated line-to-line and line-to-neutral voltages.

⚠DANGER

Electrocution. High voltage is present at test terminals. Contact with live terminals will result in death or serious injury.

(000129)

IMPORTANT NOTE: The generator will be running. Connect meter test clamps to the high voltage terminals while the generator is shut down. Stay clear of power terminals during the test. Make sure the meter clamps are securely attached and will not shake loose.

Procedure

1. Set the DM to measure AC voltage.
2. See ***Figure 2-11***. With the engine shut down, connect the meter test leads across the load terminals of the generators MLCB. This will measure line-to-line voltage.
3. Set the MLCB to the OPEN position. Verify that all electrical loads are disconnected from the generator.
4. Set the controller to MANUAL.

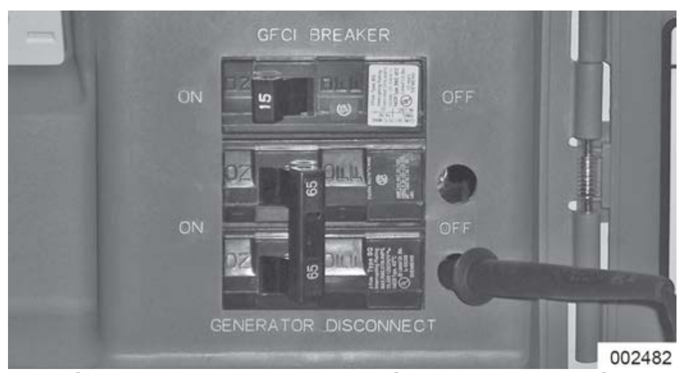


Figure 2-11. MLCB Test Points Pre 2016 Units

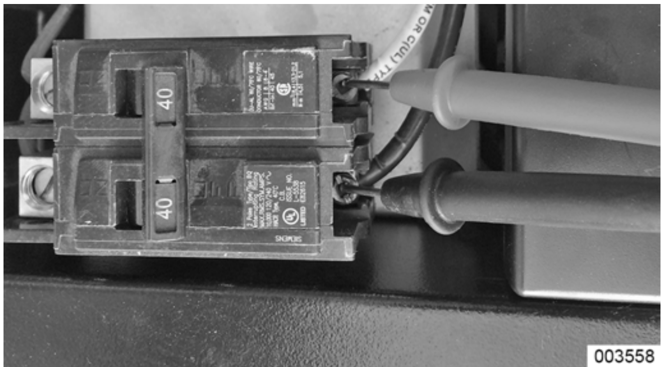


Figure 2-12. MLCB Test Points 2016 Units

NOTE: AC under and over-voltage shut downs have a 10 second delay.

5. Set the MLCB to the CLOSED position. Measure and record the voltage.
6. Set the controller to OFF.

Results

1. If the DM indicated approximately 240–244 VAC, the output voltage is good.
2. If the DM indicated any other readings the voltage is BAD. Refer to the flow chart.

NOTE: Residual voltage may be defined as the voltage produced by rotor residual magnetism alone. The amount of voltage induced into the stator AC power windings by residual voltage alone will be approximately 2–16 VAC, depending on the characteristics of the specific Generator. If a unit is supplying residual voltage only, either excitation current is not reaching the rotor or the rotor windings are open and the excitation current cannot pass. On current units with air-cooled engines, field boost current flow is available to the rotor after 2200 rpm.

Test 2—Undervoltage and Overvoltage Testing (E-Codes 1800 and 1900)

General Theory

Voltage output of the Synergy unit is controlled and monitored by the AVR via Wire 11S and Wire 44S. The voltage values are communicated to the Evolution controller via the RS 485 communication wires. Voltage output of the generator can be viewed on the Output screen of the Dealer Menu in the Evolution controller.

Procedure

1. Set DM to measure AC voltage.
2. Back probe Wires 11S and 44S at the AVR with a DM. Start and run the unit and record the values.
3. Measure and record the output voltage at the MLCB with the DM while the unit is running.
4. View and record the Gen OUTPUT Display of the controller while the unit is running.

Results

1. If the voltage measured at the AVR Wires and the MLCB is correct, but the Evolution controller display is zero, check the communication wires and communication operation between the AVR and controller for proper operation.
2. If the voltage measured at the MLCB is correct, but the voltage measured at the AVR Wires is zero or low, perform testing on the sensing wires.
3. If the measured or displayed voltage is below 80% of nominal or above the 110% (slow response) or 130% (high response), perform stator, rotor, power winding tests. If these are correct replace the AVR.

Test 3—Calibrate Voltage

General Theory

When voltage output is too high or too low, it is possible to adjust voltage output of the generator. To access this menu a password will be required to be entered into controller.

NOTE: Replacement controllers and AVRs need to be checked but typically do not require calibration unless output is not within the specifications. (Refer to the unit data decal and to the Specifications section in the front of this manual.)

Procedure

1. Set DM to measure AC voltage.
2. Open the main line circuit breaker (MLCB) on the generator.
3. Using appropriate back probes, measure output voltage at the AVR connector (wires 11S and 44S).
4. On the controller, press the ESC key until the main menu is present. (Refer to the ***Control Panel Menu System Navigation*** found in Section 1.10)
5. While at this screen proceed to enter the appropriate password:

   UP, UP, ESC, DOWN, UP, ESC, UP, ENTER
6. After the password has been entered, proceed to DEALER, then press ENTER to proceed to DEALER EDIT.
7. Press the down arrow key until the screen indicates CALIBRATE VOLTAGE and press ENTER. A value will appear on the screen.

NOTE: The default setting from the factory for calibration is 1024. The controller can be adjusted from 700–1300.

8. Set controller to MANUAL.
9. While the unit is running, use the UP or DOWN arrows to adjust the calibration setting. A higher value will create a lower voltage at the AVR connection and vice versa a lower value will create a higher voltage at the AVR connection.

Calibration factor must NOT be adjusted below 990 or above 1040. Adjusting outside of this window could result in damage to the machine. The controller can be adjusted from 700–1300.

10. Once a desired output voltage has been achieved, press ENTER to save the new setting.

NOTE: The calibration setting will reset to being a password protected option after the controller is left idle.

Verification

While the unit is running, verify that the output voltage at the AVR connection is consistent within 5 volts to what the controller displays in the TEST menu under OUTPUTS in the TEST section (Refer to Section 1.10 ***Control Panel Menu System Navigation***).

Results

1. If during the verification process, the output voltage at the AVR connector and the display match and the calibration setting was not adjusted outside of the window, stop testing.
2. When calibration process is completed:
   a. If utility is not present, open all breakers to loads in the building.
   b. If utility is present disconnect wire 23 from customer connection deck in generator, verify transfer switch is in the utility position, then close the MLCB on the generator and verify proper voltage output at the MLCB test points. See ***Figure 2-11***.
   c. If voltage is correct, connect loads and verify voltage.
   d. If voltage now out of spec check the loads in the building. Testing the unit with a load bank may be required to determine if the problem is the building or the unit.
3. Restore the system to proper operation when completed.

Test 4—Rotor Circuit Resistance Check (Circuit A1, A2; B1, B2; C1, C2)

General Theory

AC voltage is fed to the rotor through three sets of two wires (six total) and two sets of three brushes. If any one of the wires, brushes, slip rings, or a winding in the rotor itself fails, a proper field will not be created and will result in an e-code failure. Procedure A verifies the integrity of the wires, connections, brushes and slip rings, while Procedure B verifies the integrity of the rotor and its phases. The rotor will need to be rotated slightly to seat the brushes before testing. Also, removal of the AVR is required to perform this test.

Required Tools

- A Digital Multimeter (DM)

IMPORTANT NOTE: The small DC fan on the AVR is energized after shutdown and continues to run for up to one hour to prevent heat from building up in the AVR electronics. If the green LED light is flashing, power to the AVR MUST NOT be removed.

Procedure A

1. Remove the 7.5 amp fuse from the control panel (be sure the green LED on AVR is not flashing).
2. Expose the AVR lower harness connections by removing the AVR assembly. See removal instructions in the disassembly section of this manual.
3. Disconnect the harness connector containing wires A1, A2, B1, B2; C1, C2 from the AVR.
4. Remove wire 56 from the SCR.
5. Verify the brushes are seated for testing by one of two methods:
   a. Rotate alternator blower fan by hand.
   b. Momentarily (1–3 seconds) connect a fused jumper wire from battery positive to the terminal on the SCR from which wire 56 was removed.
6. Set the DM to measure resistance.
7. Using special harness adapter 0L0587, connect the meter test leads to the following harness wire connections. Measure and record the resistance of each connection.
   a. One lead to wire A1 and one lead to wire A2.
   b. One lead to wire B1 and one lead to wire B2.
   c. One lead to wire C1 and one lead to wire C2.
   d. One lead to engine ground and one lead to each wire (A1, A2, B1, B2, C1, C2).

NOTE: These measurements are taken through the harness and the brushes. They will typically be above the rotor winding resistance values.

Results

1. If the meter indicated a resistance value of OPEN or a resistance value above 10 ohms in any one of steps 7a, 7b, or 7c, check the brush harness, brush assembly, and brushes to slip rings for proper function.
2. A resistance of OPEN is normal in step 7d. If CONTINUITY is identified in step 7d, check brush harness, brush assembly, rotor for continuity to ground. Stop testing and refer to ***Stator/Rotor/Engine Removal*** in Section 6.1 ***Major Disassembly***.
3. If the meter indicated resistance values consistent with the values of 1–5 ohms in step 7a, 7b, and 7c, and OPEN in step 7d continue to Procedure B.

Procedure B

1. Verify AVR is still disconnected. Perform steps 1–7 from Procedure A, if not yet completed.
2. Connect the meter test leads to the following harness wire connections, measure and record the resistance of each connection.
   a. One lead to wire A1 and one lead to wire B1.
   b. One lead to wire B1 and one lead to wire C1.
   c. One lead to wire C1 and one lead to wire A1.
   d. One lead to engine ground and one lead to each wire (A1, A2, B1, B2, C1, C2).

NOTE: Measure directly on the slip rings to get an actual reading of the rotor windings.

Results

1. If the meter indicated a resistance value of OPEN in steps 2a, 2b, or 2c the rotor winding is OPEN.
2. A resistance of OPEN is normal in step 7d. If CONTINUITY is identified in step 7d check brush harness, brush assembly, rotor for continuity to ground. Stop testing and refer to ***Stator/Rotor/ Engine Removal*** in Section 6.1 ***Major Disassembly***. Inspect all components for damage or improper operation.
3. If the meter indicated resistance values consistent with the values of approx. 1–5 ohms in step 2a, 2b, 2c and in step 2d the value of OPEN, refer to the flow chart.

Test 6—Test Excitation Winding Circuit 2 and 6

General Theory

The voltage regulator (internal to the AVR) requires an unregulated voltage from the stator in order to supply excitation power to the regulator which provides AC field excitation current to the rotor. The alternator may be producing this voltage, but if the voltage is not being supplied to the regulator, it will fault out for under-voltage. This test will verify the integrity of the excitation (DPE) winding inside the stator and the connections to the AVR.

NOTE: The AVR receives AC from the DPE winding. AC is converted to DC, then inverted back to AC and delivered to the brushes.

Procedure

1. Remove the 7.5 amp fuse from the control panel (be sure the green LED light on AVR is not flashing).
2. Expose the AVR lower harness connections by removing the AVR assembly.
3. Disconnect the harness connectors containing wires 2 and 6 from the AVR.
4. Set the DM to measure resistance.
5. Connect one-meter test lead to the stator harness (wire 2) and the other meter test lead to the stator harness (wire 6). Measure and record the resistance.
6. With one lead connected to wire 2 or 6 connect the other DM lead to good clean ground. Measure and record resistance.

Results

1. If the meter indicated a resistance value consistent with the values found in the specifications, and not shorted to ground in step 6, stop testing and refer back to the flow chart.
2. If the meter indicated a resistance value of OPEN, or a resistance value inconsistent with the values found in the specifications, confirm wiring and/or replace the stator.

Test 7—Power Winding Resistance Test

General Theory

The voltage regulator (internal to the AVR) requires sensing leads to monitor generator output. Also, the output windings of the alternator are necessary to power the load. The alternator may be producing this voltage, but if the voltage is not being supplied to the regulator, or if the voltage to the load is incorrect, the generator will fault out for under-voltage. This test will verify the integrity of the windings in the stator and associated connections. Procedure A will confirm stator winding resistance values. Procedure B will confirm any shorts to ground. Procedure C will confirm any internal shorts other windings. Removal of the AVR is required to perform this test.

Required Tools

- A digital multimeter (DM)
- Meter test leads that are capable of measuring voltage inside a connector without damaging the socket. A set of black and red test leads (P/N 0J09460SRV) for this application are available from Generac.

IMPORTANT NOTE: The small DC fan on the AVR is energized after shutdown and continues to run for up to one hour to prevent heat from building up in the AVR electronics. If the Green LED light is flashing, power to the AVR MUST NOT be removed.

Procedure A—Test Winding Resistance Values

1. Remove the 7.5 amp fuse from the control panel (be sure the green LED light on AVR is not flashing).
2. Expose the AVR lower harness connections by removing the AVR assembly. See removal instructions in the disassembly section of this manual.

3. Disconnect Wires 11 and 44 from the main line circuit breaker (MLCB).
4. Disconnect Wires 22 and 33 from the NEUTRAL connection and separate the leads.
5. Disconnect the P1 connector from the AVR (this contains wires 11S and 44S). Do not remove these wires from the connector.
6. Disconnect the harness connector containing Wires 2 and 6 from the AVR.
7. Make sure all of the disconnected leads are isolated from each other and are not touching frame ground during the test.
8. Set the DM to measure resistance.

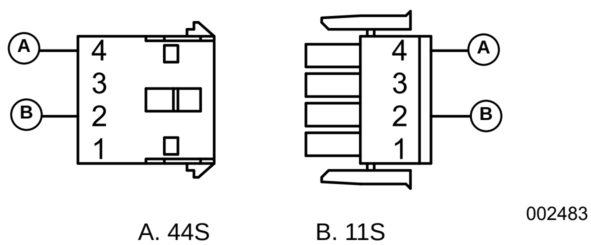


Figure 2-13. Stator Connector Pin Locations

9. Measure and record the resistance values for each set of windings between the A and B test points as shown in ***Table 2-4***. Record the results in ***Table 2-7***.

Table 2-4. Test Points - Procedure A

Test Point A	Test Point B
Stator Lead Wire 11	Stator Lead 22
Stator Lead Wire 33	Stator Lead 44
P1 Connector Wire 11S	P1 Connector Wire 44S

Procedure B—Test Windings for a Short to Ground

1. Perform steps 1–5 from Procedure A, if not yet completed.
2. Measure and record the resistance values for each set of windings between the A and B test points as shown in ***Table 2-5***. Record the results in ***Table 2-7***.

Table 2-5. Test Points - Procedure B

Test Point A	Test Point B
Stator Lead Wire 11	Good Engine Ground
Stator Lead Wire 33	Good Engine Ground
P1 Connector Wire 22S	Good Engine Ground

Procedure C—Test For A Short Circuit Between Windings

1. Perform steps 1–5 from Procedure A, if not yet completed.
2. Measure and record the resistance values for each set of windings between the A and B test points as shown in ***Table 2-6***. Record the results in ***Table 2-7***

Table 2-6. Test Points - Procedure C

Test Point A	Test Point B
Stator Lead Wire 11	Stator Lead Wire 33
Stator Lead Wire 11	Stator Lead Wire 44
Stator Lead Wire 2	Stator Lead Wire 33
Stator Lead Wire 6	Stator Lead Wire 44

Table 2-7. Test 7 – Power Windings Resistance Test Results

Test Point A	Test Point B	Results
Procedure A		
Stator Lead Wire 11	Stator Lead 22	
Stator Lead Wire 33	Stator Lead 44	
P1 Connector Wire 11S	P1 Connector Wire 44S	
Procedure B		
Stator Lead Wire 11	Good Engine Ground	
Stator Lead Wire 33	Good Engine Ground	
P1 Connector Wire 22S	Good Engine Ground	
Procedure C		
Stator Lead Wire 11	Stator Lead Wire 33	
Stator Lead Wire 11	Stator Lead Wire 44	
Stator Lead Wire 2	Stator Lead Wire 33	
Stator Lead Wire 6	Stator Lead Wire 44	

Results

1. **Procedure A:** (resistance test) If the meter indicated a resistance value of OPEN, or a resistance value inconsistent with the values found in the specifications in step, stop testing and refer back to the flow charts.
2. **Procedure B:** (grounded windings) Any resistance value other than INFINITY (OPEN) indicates a grounded winding.
3. **Procedure C:** (shorted windings) Any resistance value other than INFINITY (OPEN) indicates a shorted winding.

NOTE: Additional copies of ***Table 2-7*** can be found in Appendix C Supplemental Worksheets at the back of this manual.

Test 8—Auxiliary Power Supply Test

General Theory

The large fan (120mm x 120mm), which is external to the AVR, requires DC Voltage to operate. This voltage is provided by a power supply (located under the control panel) which is powered by the sensing leads (11S & 44S). If the voltage is not being supplied to the fan, or if voltage to the power supply is not available, the fan will not operate. An AVR over-temp e-code will display. This test will verify the integrity of the large fan power supply, the voltage input, output to the fan, and associated connections.

Required Tools

- A digital multimeter (DM)
- Meter test leads that are capable of measuring voltage inside a connector without damaging the socket. A set of Black and Red test leads (P/N 0J09460SRV) for this application are available from Generac.

IMPORTANT NOTE: The small DC fan on the AVR is energized after shutdown and continues to run for up to one hour to prevent heat from building up in the AVR electronics. If the Green LED light is flashing, power to the AVR MUST NOT be removed.

Procedure

1. Locate the 20 pin connector (P1) at the AVR. DO NOT DISCONNECT.
2. Locate and identify the Red wire (P1-19) and Black wire (P1-9) (DC fan power supply to AVR).
3. Set the DM to measure DC Voltage.
4. Connect one meter test lead with adapter probe to the Red wire (P1-19) and one meter test lead with adapter probe to the Black wire (P1-9).
5. Start the generator in manual mode, allow the unit to run for 10 seconds, record your highest reading, then shut the unit down.
   a. If the meter indicated approximately 11.8 ± 0.5 VDC, stop testing and refer back to the flow chart. Auxiliary Power Supply Good.
   b. If the meter indicated 0 VDC or less than 11.8 ± 0.5 VDC, proceed to step 6.
6. Locate the connector to the fan power supply located under the control panel. DO NOT DISCONNECT.
7. Set the DM to measure DC Voltage.
8. Connect meter test leads to the harness side of the power supply connector with the red lead to the Red wire (Pin 1) and Black test lead to the Black wire (Pin 2) on the connector. Start the generator in manual mode and allow it to run for 10 seconds. Measure and record the voltage, then shut the unit down.
   a. If meter indicated 0 VDC or less than approximately 11.8 ± 0.5 VDC, proceed to Step 14.
   b. If the meter indicated approximately 11.8 ± 0.5 VDC, but did not indicate proper voltage in step 5, shut down the generator and proceed to Step 9.
9. Locate the 20 pin connector (P1) at the AVR. DO NOT DISCONNECT.
10. Locate the connector to the fan power supply and disconnect.
11. Set the DM to measure resistance (ohms).
12. Connect one meter test lead to the Red wire (Pin 1) of the power supply connector (harness side) and one meter test lead to the Red wire (P1-19) at the AVR P1 connector. Measure and record the resistance.
13. Connect one meter test lead to the Black wire (Pin 2) at the power supply connector (harness side) and one meter test lead to the Black wire (P1-9) at the AVR P1 Connector. Measure and record the resistance.
    a. If the meter indicated an OPEN (INFINITY) on either the Red or Black wire in step 12 or step 13, repair the failed (OPEN) wire, then retest beginning at Step 1.
14. Connect the meter red test lead to the Red wire (Pin 1) of the power supply side of the power supply, and the black meter test lead to the Black wire (Pin 2) on the power supply side of the connector.
15. Start the generator in manual mode, allow the unit to run for 10 seconds, record your highest reading, then shut the unit down.
    a. If meter indicated 0 VDC, or less than approximately 11.8 ± 0.5 VDC, proceed to step 16.
    b. If meter indicated approximately 11.8 ± 0.5 VDC, but did not indicate proper voltage in step 8, repair the power supply connector.
16. Locate the connector to the fan power supply under the control panel.
17. Set the DM to measure AC voltage.
18. Connect one meter test lead to Wire 11S (pin 4) of the harness side of the power supply connector and one meter test lead to Wire 44S (pin 5) of the same connector.
19. Start the generator in manual mode allow unit to run for 10 seconds. Measure and record the voltage, then shut the unit down.
    a. If the meter indicated 240 VAC (line to line generator MLCB voltage), and did not indicate DC voltage in Step 15, replace the fan power supply.
    b. If the meter indicated less than 240 VAC, stop testing and refer back to the flow chart (power winding resistance test).

Test 9—Small Fan Power Supply Test

General Theory

The small fan (80mm x 80mm) is external to the AVR, and requires DC Voltage to operate. This voltage is provided internally by the AVR. This fan operates after shutdown for up to 80 minutes (if necessary) to cool the AVR electronics. If the voltage is not being supplied to the fan, the fan will not operate and an AVR over-temp e-Code may display. This test will verify the voltage to the small fan and associated connections.

Required Tools

- A digital multimeter (DM)
- Meter test leads that are capable of measuring voltage inside a connector without damaging the socket. A set of Black and Red test leads (P/N 0J09460SRV) for this application are available from Generac.

IMPORTANT NOTE: The small DC fan on the AVR is energized after shutdown and continues to run for up to one hour to prevent heat from building up in the AVR electronics. If the Green LED light is flashing, power to the AVR MUST NOT be removed.

NOTE: During this test procedure, verify that the Green LED light is fading on and off. This indicates that the AVR is in a cool-down state and that power should be available to the small fan. If the Green LED light is not fading on and off, start the generator, allow the unit to achieve full operating speed, then shut the unit down. If the Green LED light is still not fading on and off, stop testing and refer to the flow chart.

Procedure

⚠WARNING

Moving Parts. Keep clothing, hair, and appendages away from moving parts. Failure to do so could result in death or serious injury.

(000111)

1. Verify that the green LED light is fading on and off, which indicates that the fan should be on.
2. Remove the AVR air inlet housing and visually observe the small fan.
   a. If the fan(s) are spinning, stop testing and refer back to the flow chart.
   b. If the fan(s) are not spinning, proceed to the next step.
3. Locate the 4 pin connector (P2) at the AVR. DO NOT DISCONNECT.
4. Locate and identify the White (P2-3) and Blue (P2-4) wires (small DC fan power supply).
5. Set the DM to measure DC Voltage.
6. Connect one meter test lead to the White (P2-3) wire and one meter test lead to Blue (P2-4) wire.
7. Measure and record the voltage.
   a. If the meter indicated approximately 13.5 ± 0.5 VDC and the small fan was not spinning in Step 2, replace the fan assembly.
   b. If the meter indicated 0 VDC or less than approximately 11.5 VDC, proceed to Step 9.
8. Locate and disconnect the 4 pin connector (P2) to the fan assembly.
9. Connect meter test leads to the pins on the AVR (P-2) connector from which the White (P2-3) wire and Blue (P2-4) wires were connected.
   a. If the meter indicated approximately 13.5 ± 0.5 VDC, inspect the male and female pins in the P2 Connector. If either is damaged, replace the damaged (P2) Molex connector/pin components.
   b. If the meter indicated 0 VDC or less than approximately 11.5 VDC, proceed to step 10.
10. Locate the 20 pin connector (P1) at the AVR. DO NOT DISCONNECT.
11. Locate and identify Wire 482 (P1-5) and Wire 483 (P1-15) (AVR Power).
12. Set the DM to measure DC voltage.
13. Connect one meter test lead with adapter probe to Wire 482 (P1-5) and one meter test lead with adapter probe Wire 483 (P1-15).
14. Measure and record the voltage.
   a. If the meter indicated 12.5 VDC (AVR power), and did not indicate DC voltage in step 9, stop testing and refer to the flow chart (Replace AVR).
   b. If the meter indicated less than 11.5 VDC, stop testing and refer back to the flow chart (controller test).

Test 10 – Large Fan Test

General Theory

The large fan is external to the AVR and requires DC voltage to operate. This voltage is provided by the large fan power supply. If the voltage is not being supplied to the fan, or if the voltage to the power supply is not available, the fan will not operate. An AVR over-temp e-Code will display and AVR failure is possible. This test will verify the integrity of the large fan, the voltage output to the fan and associated connections.

Required Tools

- A digital multimeter (DM)
- Meter test leads that are capable of measuring voltage inside a connector without damaging the socket. A set of Black and Red test leads (P/N 0J09460SRV) for this application are available from Generac.

IMPORTANT NOTE: The small DC fan on the AVR is energized after shutdown and continues to run for up to one hour to prevent heat from building up in the AVR electronics. If the Green LED light is flashing, power to the AVR MUST NOT be removed.

Procedure

1. Locate the 4 pin connector (P2) at the AVR. DO NOT DISCONNECT.
2. Locate and identify the Black and Red wires (large DC fan power supply).
3. Set the DM to measure DC voltage.
4. Connect one meter test lead to the Black wire and one meter test lead to Red wire.
5. Start the generator and allow it to run for 10 seconds.
6. Measure and record the voltage, then shut the generator down.
   a. If the meter indicated approximately 11.5 VDC, replace the fan assembly.
   b. If the meter indicated 0 VDC or less than approximately 11.5 VDC, proceed to step 7.
7. Locate and disconnect the connector to the fans (P2).
8. Inspect the male and female pins in the P2 Connector.
   a. If either is damaged, replace the damaged Molex connector/pin components.
   b. If no damage exists, proceed to step 9.
9. Locate the 20 pin connector (P1) at the AVR. DO NOT DISCONNECT.
10. Locate and identify the Black (P1-9) and Red (P1-19) wires (DC fan power supply).
11. Set the DM to measure DC Voltage.
12. Connect one meter test lead with adapter probe to the Black (P1-9) wire and one meter test lead to Red (P1-19) wire with adapter probe.
13. Start the generator and allow the unit to run for 10 seconds.
14. Measure and record the voltage, then shut the unit down.
    a. If the meter indicated approximately 12.5 VDC, but did not indicate voltage in Step 6, stop testing and refer back to the flow chart. (Replace AVR)
    b. If the meter indicated 0 VDC or less than approximately 11.5 VDC, refer back to the flow chart (Auxiliary Power Supply Test).

Test 12—Check Stepper Motor Control

General Theory

1. Remove air cleaner cover to access stepper motor and/or visually see throttle plates.
2. Physically move the throttle and verify the stepper motor, linkage, and throttle do not bind in any way. If any binding is felt, repair or replace components as needed. The stepper motor will have resistance as it moves through its travel.
3. Physically and visually move the throttle to the closed position by pulling the stepper motor arm towards the idle stop. See ***Figure 2-14***, ***Figure 2-15***, ***Figure 2-16***, and ***Figure 2-17***.
4. Set the controller to MANUAL.
5. Observe and record the stepper motor's movement. It should cycle open, closed, and then go to the mid-point (small venturi starting position). See the picture sequence.
6. Set the controller to OFF.
7. Physically move the throttle to the open position by pulling the stepper motor arm away from the idle stop.
8. Set the controller to MANUAL.
9. Observe and record the stepper motor's movement.
10. Set the controller to OFF.
11. If no movement was seen in steps 5 or 9, remove the controller and verify the six pin connector on the controller is seated properly, remove the connector and then replace it and test again. If problems persist, proceed to step 12.
12. Set DM to measure resistance.

NOTE: Press down with the meter leads on the exposed connector terminals. Do not probe into the connector.

13. Connect the meter test leads across points A and B as shown in ***Table 2-8*** and compare to the specified value.

Table 2-8. Stepper Motor Testing

Test Point A	Test Point B	Resistance Value
Red wire	Orange wire	approx. 10-11Ω
Red wire	Yellow wire	approx. 10-11Ω
Red wire	Brown wire	approx. 10-11Ω
Red wire	Black wire	approx. 10-11Ω
Red wire	Ground	INFINITY

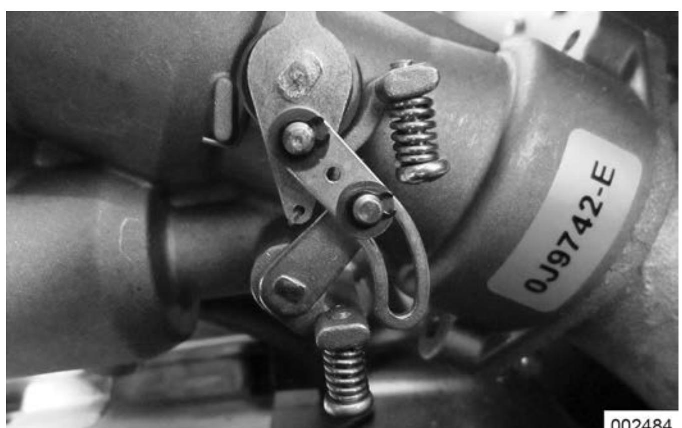


Figure 2-14. Stepper Motor Starting Position and/or Mid-point

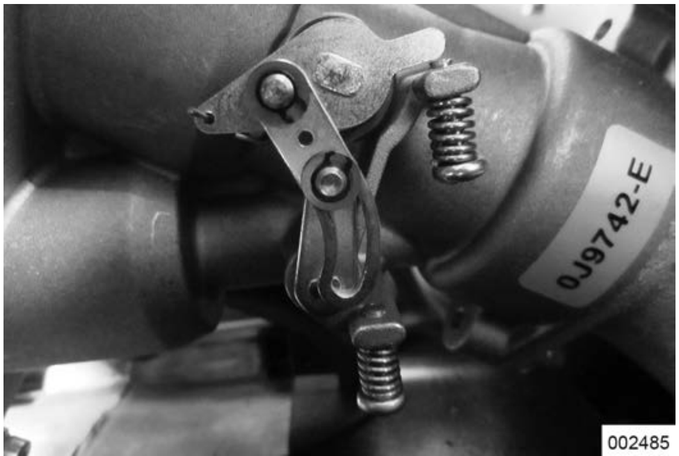


Figure 2-15. Stepper Motor Wide Open = Opens Both Venturis

Figure 2-16. Stepper Motor Closed – Closes Both Venturis

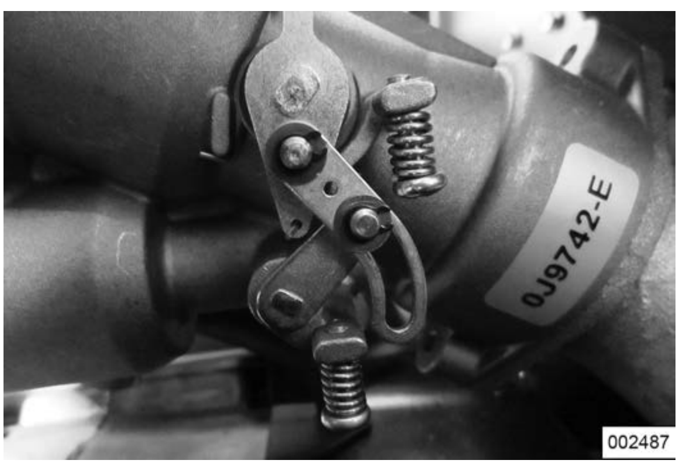


Figure 2-17. Stepper Motor Mid-point = Starting Point, Smaller Venturi Wide Open

Results

1. If the stepper motor in step 5 moved to the wide-open position, the closed position in step 9, and the DM indicated CORRECT resistance values, refer to the flow chart.
2. If the stepper motor failed to change the throttle position in steps 5 or 9, replace stepper motor.
3. If the stepper motor in step 5 moved to the wide-open position, the closed position in step 9, and the DM indicated INCORRECT resistance values, replace stepper motor.

Test 14—Check Voltage and Frequency Under Load

General Theory

It is possible for the generator AC output frequency and voltage to be good at no-load, but they may drop excessively when electrical loads are applied. This condition, in which voltage and frequency drop excessively when loads are applied can be caused by (a) overloading the generator, (b) loss of engine power or performance, or (c) a shorted condition in the stator windings or in one or more connected loads.

Procedure

1. Set DM to measure AC voltage.
2. Connect an accurate AC frequency meter and an AC voltmeter across the stator AC power winding leads.
3. Start the engine, let it stabilize and warm-up.
4. Apply electrical loads to the generator equal to the rated capacity of the unit. Measure and record the frequency and the voltage.

Results

1. If the DM indicated 60 Hz and approximately 248 VAC during full load, discontinue testing.
2. If the DM indicated a frequency and voltage that dropped while under full load, refer to the flow chart.

Test 15—Check for an Overload Condition

General Theory

An “overload” condition is one in which the generator rated wattage/amperage capacity has been exceeded. To test for an overload condition on an installed unit, the recommended method is to use an ammeter. See Section 1.4 Measuring Current.

Procedure

1. Connect the clamp-on ammeter to the generator according to the ammeter manufacturer’s specifications.

2. Transfer all normal electrical loads to the generator; measure and record the amperage.

Results

1. If the ammeter indicated amperage readings that were ABOVE the unit's specified ratings, reduce loads to the unit's rated capacity.
2. If the ammeter indicated amperage readings that were BELOW the unit's specified ratings, but rpm and frequency dropped excessively, refer to flowchart.

Test 16—Check Engine Condition

General Theory

If engine speed and frequency drop excessively under load, the engine may be underpowered. An underpowered engine can be the result of a dirty air cleaner, loss of engine compression, faulty fuel settings, or incorrect ignition timing, etc. A decrease in available horsepower will proportionally lead to a decrease in kW.

Procedure

For engine testing, troubleshooting, and repair procedures refer to Section 4.5 ***Diagnostic Tests***. For further engine repair information, refer to the appropriate engine service manual.

Test 17—Current Calibration

General Theory

The AVR monitors load (current) through two current transformers (CT) mounted in the AC connection box area. The CTs provide an AC output signal proportional to the current flowing in the load leads 11 and 44.

CT1 and CT2 have identical functions, diagnostic procedures, and calibration process. CT1 wire circuits 398A and 399A monitor the current flow on wire 11. CT2 wire circuits 398B and 399B monitor the current flow on wire 44. The Evolution control panel is used to calibrate the CTs. A password is required to access the dealer edit menu when performing calibrations. When either the Evolution Controller, Synergy AVR or the CTs are replaced, CT1 and CT2 must be calibrated.

NOTE: Verify Wires 11 and 44 are fed through the side of the CT with the Green dot.

Procedure

DANGER

Electrocution. Lethal voltage may be present at current transformers (CTs). Do not touch CTs while primary current is applied. Doing so will result in death or serious injury. (000310)

1. Connect a load bank to the output circuit of the generator. This can be done at the MLCB or at the transfer switch.

NOTE: If load bank is unavailable, use normal building load.

2. Place the amp meter over the circuit being checked. CT1 "Current Calibration1" – wire 11 and CT2 "Current Calibration2" – wire 44.
3. Start the generator and allow it to warm up for 10 seconds.
4. Place a load on the generator that matches the rated output of the generator.
5. Select the correct current calibration display menu under the Dealer Edit menu.
6. Press ENTER to view both the generator's output and the calibration value of that CT.
7. Adjust the generator display using the UP and DOWN arrows to match the amp meter's calibrated reading.
8. Once the display panel's reading matches the amp meter, press the ENTER button to save the new calibration. Repeat the process for CT2 current calibrations.
9. When both calibration adjustments are correct, remove the load from the generator and allow the generator and load bank to cool before shutting down.

Results

With loads applied, CT1 - wires 398A/399A and CT2 - wires 398B/399B deliver approximately 0.0–1.5 VAC based on percentage of amps (load). Approximate values (when back-probed at connector):

25 amps = 0.380 mVAC
50 amps = 0.755 mVAC
75 amps = 1.133 VAC
100 amps = 1.510 VAC

Introduction

The “V-Type” Contactor is available in 200 Amp rating at 250 volts maximum with a 2-pole configuration (single phase only).

Automatic transfer operation of the transfer switch is controlled by the generator.

NOTE: An EcoGen™ unit may not be connected to a transfer switch. Refer to this section if the unit is connected to this model transfer switch.

Enclosure

The transfer switch enclosure is a National Electrical Manufacturer’s Association (NEMA) Type 1. Based on NEMA Standard 250, the following standard applies:

NEMA 1 – Enclosures constructed for indoor use to provide a degree of protection against incidental contact with the enclosed equipment and to provide a degree of protection against falling dirt.

Transfer Switch Contactor

The basic 2-pole CONTACTOR consists of a pair of movable LOAD contacts, a pair of stationary UTILITY contacts, and a pair of stationary STANDBY contacts. The LOAD contacts connect to the UTILITY contacts by a utility closing coil or to the STANDBY contacts using the standby closing coil. See ***Figure 3-1*** and ***Figure 3-2***. The LOAD contacts can be moved to either the UTILITY or STANDBY position by means of a manual transfer handle. The closing coils are energized and actuated by the voltage source from the side to which the load is being transferred. For example, if the CONTACTOR is in the UTILITY position, the standby closing coil will energize utilizing Standby voltage.

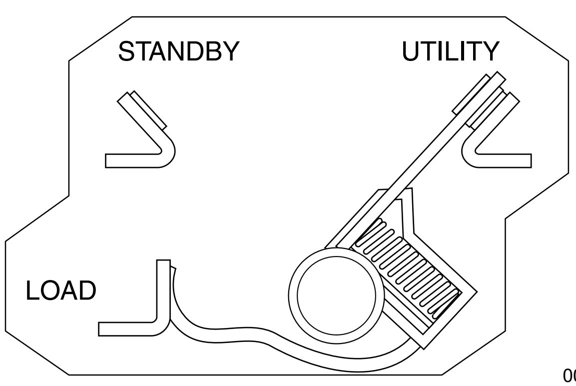


Figure 3-1. Load Connected to Utility Power Source

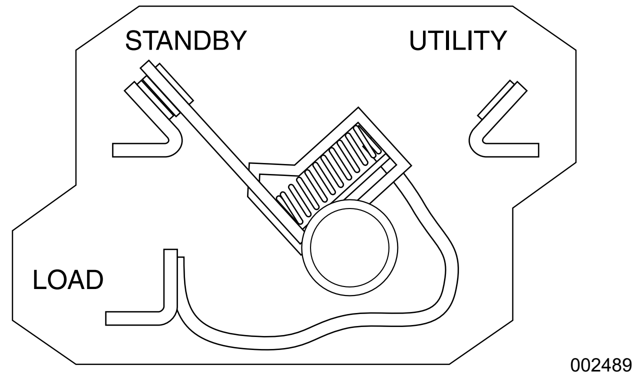
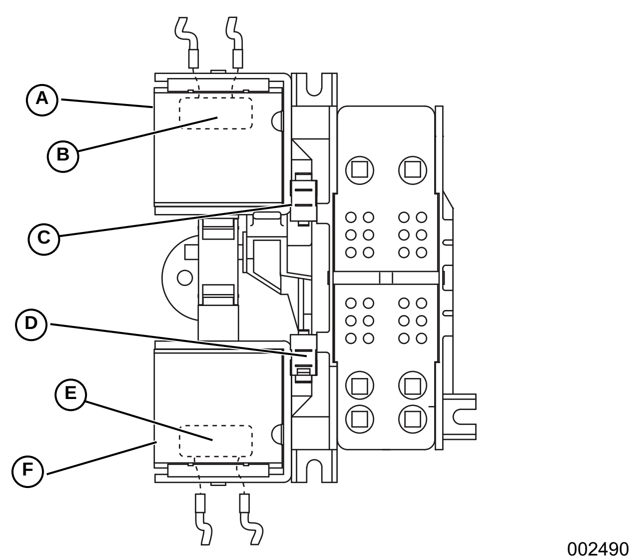


Figure 3-2. Load Connected to Standby Power Source

Utility Closing Coil C1

See ***Figure 3-3***. The utility closing coil (C1) utilizes rectified Utility source power to actuate the LOAD contacts to the UTILITY position. When energized, the coil will move the LOAD contacts to an “over center” position. The coil and the spring force will complete the transfer to UTILITY. A bridge rectifier, which changes the Utility source alternating current (AC) to direct current (DC), is sealed in the coil wrappings. If either coil or bridge rectifier replacement becomes necessary, replace the coil assembly.



A. Utility Closing Coil C1
B. Bridge Rectifier
C. Limit Switch SW2
C. Limit Switch SW3
E. Bridge Rectifier
F. Standby Closing Coil C2

Figure 3-3. The “V-Type” Transfer Mechanism

Standby Closing Coil C2

The standby closing coil (C2) utilizes rectified Standby source power to actuate the LOAD contacts to their STANDBY position. Energizing the coil moves the LOAD contacts to an “over center” position. The coil and the spring force will complete the transfer to STANDBY. If either the coil or the bridge rectifier replacement becomes necessary replace the coil assembly.

Limit Switches SW2 and SW3

The LOAD contacts mechanically actuate the limit switches. When the LOAD contacts connect to the UTILITY contacts, the limit switch (SW2) opens the Utility circuit to C1 and the limit switch (SW3) closes the Standby circuit to standby closing coil (C2). The limit switches “arm” the system for transfer back to the opposite source. An open condition in SW2 will prevent re-transfer to UTILITY. An open condition in SW3 will prevent transfer to the STANDBY.

Transfer Relay

Figure 3-4 shows the transfer relay electrical schematic. Transfer relay operation is controlled by the AVR mounted on the generator set. The transfer relay operates as follows:

1. Generator battery voltage (12 VDC) is available to the transfer relay coil from the Evolution controller, via Wire 194 to Relay Terminal 8.
   a. The 12 VDC circuit is completed through the transfer relay coil and back to the AVR via Wire 23.
   b. AVR logic holds the Wire 23 circuit open to ground (Normally Open circuit) and the relay is de-energized.
   c. When de-energized, the relay contacts are in their normal condition (one set open, N.O.; and one set closed, N.C.)
   d. The normally closed relay contacts deliver utility source power to the utility closing circuit of the transfer switch.
   e. The normally open relay contacts will deliver standby source power to the transfer switch standby closing circuit only when the transfer relay is energized by the control panel.
2. During automatic system operation, when the Generator controller senses that Utility source voltage has dropped out, the controller will initiate a ten second “Line Interrupt Delay” timer (programmable). At the end of the factory default ten second delay the controller will crank and start the engine.
3. When the circuit board senses that the engine has started (via Wire 18 from the magneto circuit), the controller will initiate a five second “Engine Warm-up Timer.”
4. When the “engine warm-up timer” has timed out, the AVR receives a message via controller logic, and closes the Wire 23 circuit to ground.
   a. The transfer relay energizes.
   b. The relay’s normally closed contacts open and the normally open contacts close.
   c. When the normally open contacts close, standby source power is delivered to the standby closing coil and transfer to STANDBY occurs.

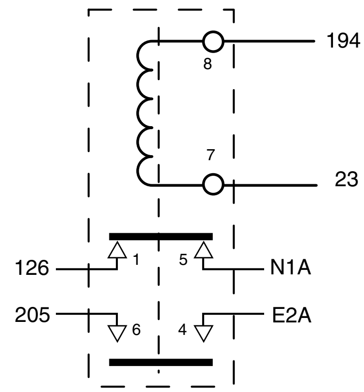


Figure 3-4. Typical Transfer Relay Schematic

5. When the controller senses that utility source voltage has been restored (nominal for 15 seconds), the AVR receives a message and opens the Wire 23 circuit from ground.
   a. The transfer relay will de-energize, the normally closed contacts will close and the normally open contacts will open.
   b. When the normally closed relay contacts close, utility source voltage is delivered to the utility closing coil to energize that coil.
   c. Transfer back to UTILITY occurs.

Neutral Lug

The Generator is equipped with an ungrounded neutral. The neutral lug in the transfer switch is isolated from the switch enclosure.

Manual Transfer Handle

The manual transfer handle is retained in the transfer switch enclosure by means of a wing nut and stud. Use the handle to manually move the contactor to the UTILITY or “STANDBY position.

Instructions on use of the manual transfer handle are located in Section 5.1 ***System Functional Tests and Setup Procedures***.

Customer Connections

See ***Figure 3-6***. During system installation, the control wires must be properly landed between the generator and transfer switch.

Utility N1 and N2

N1 and N2 provide the utility voltage-sensing signal to the controller. The controller utilizes the sensing circuit as follows:

If utility source voltage drops below the set nominal value for ten seconds, controller logic will initiate automatic cranking and startup. The AVR will transfer the switch to the STANDBY position after a five second engine warm-up timer.

Load T1

Wire T1, connected to the Load side of the contactor, provides 120 VAC for the battery charging circuit (the battery charger is an integral component of the controller). The charger maintains battery voltage anytime the load terminals have voltage available.

Control 194, 23

Wires 194 and 23 provide control of the transfer relay by the controller and AVR. Wire 194 provides continuous DC voltage to the transfer switch via the Evolution controller. Wire 23 is held open from ground by the AVR and by Evolution controller logic communicated to the AVR. Wire 23 is held open until a utility failure is sensed.

Fuse Holder

The fuse holder holds three fuses, designated as fuses F1, F2, and F3.

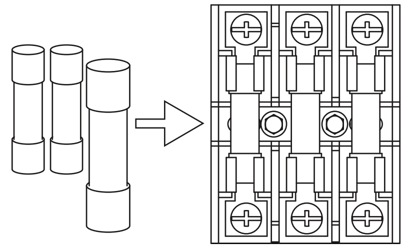


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Figure 3-5. Fuse Holder

Fuses F1, F2

These two fuses protects the N1 and N2 circuit against overload.

Fuse F3

This T1 fuse protects the battery charger against overload.

Fuse F4

This T2 fuse protects the battery charger against overload (50 Hz only).

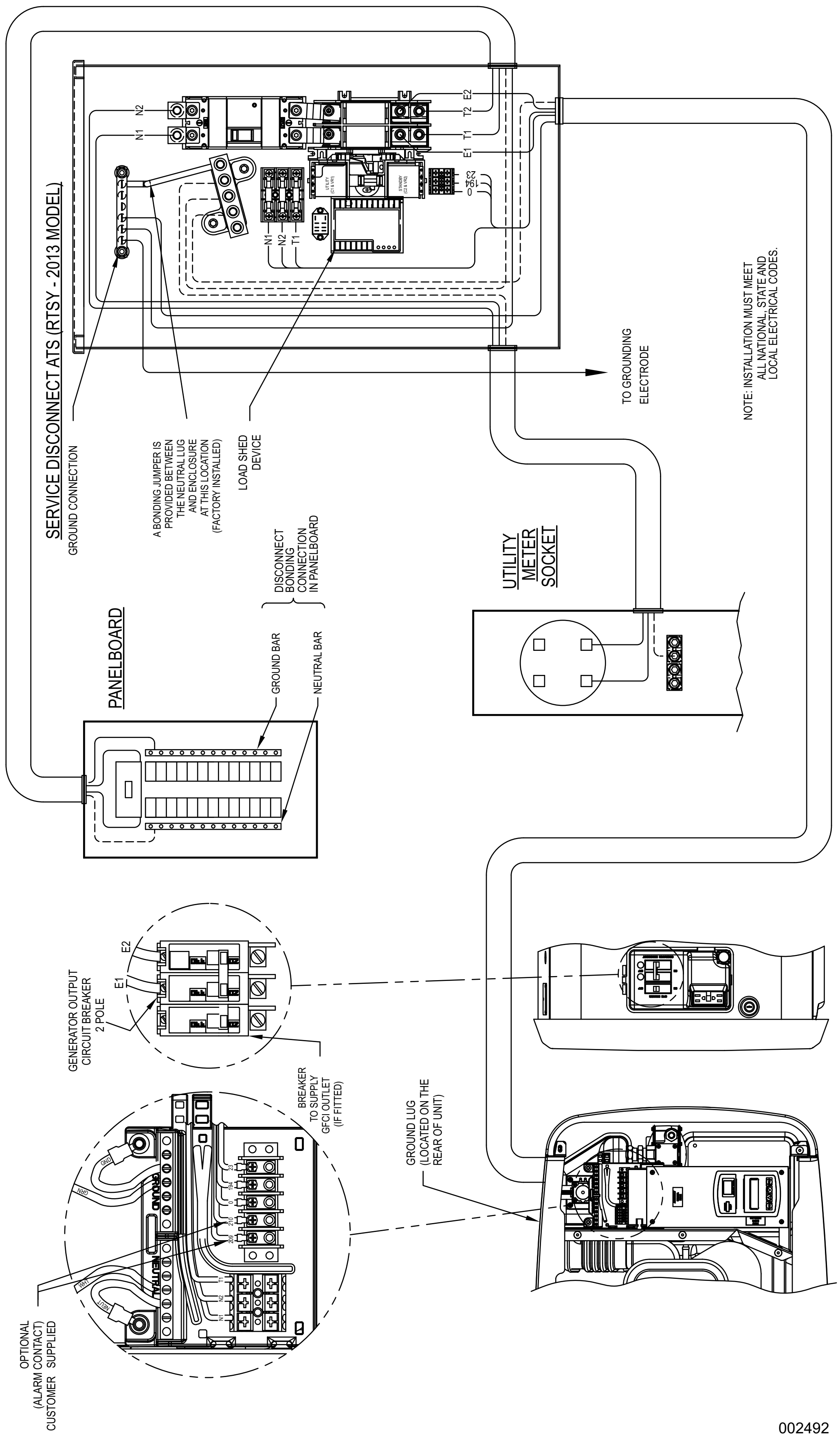


Figure 3-6. A Typical Interconnection Drawing

Load Shed Module and Operation

The Load Shed Module (OPCB Over Load Prevention Control Board) is designed to prevent an overload on the generator when it is supplying customer loads. Up to six loads can be managed by the load shed module; 2 air conditioner loads and 4 additional loads. The load shed module manages the loads by "shedding" the connected loads in the event of a drop in generator frequency (overload). Loads to be "shed" are grouped in 4 priority levels on the load shed module.

Power and ground to the logic side of the OPCB board is completed via Wire 194 (12 VDC) and Wire 0 (GND).

Priority 1 and 2 each connections for one air conditioner and one contactor. Both an air conditioner and a contactor can be used at the same time if desired. To control an air conditioner, no additional equipment is required. Internal relays interrupt the thermostat 24 VAC control signal to disable the air conditioner load.

Priority 3 and 4 have connections for one contactor only.

Four LEDs located on the load shed module will indicate when a load priority level is enabled or disabled.

Any load, including a central air conditioner, can be controlled via a contactor that must be purchased separately. Up to four contactors can be controlled by the load shed module.

When installed with the optional 24 volt transformer kit, the OPCB supplies 24 VAC to each contactor.

PCB operations include both "Normal" and "Fast" load shed programs.

Test Button

A TEST button on the bottom of the OPCB forces the unit to act as if an overload has occurred. The TEST button functions when the ATS is in either the Utility or the Generator position, and operates even when the transfer signal is inactive.

Figure 3-7. OPCB TEST Button

1. Turn on the utility supply to the ATS.
2. Press and hold the TEST button on the OPCB for five (5) seconds.
3. Verify that all of the connected loads to be "shed" become disabled. LED lights go out and the PMM modules are turned off.
4. After five (5) minutes verify AC 1 and Load 1 are energized. Status LED AC 1 and Load 1 is ON.
5. 15 seconds after Priority 1 is ON verify AC 2 and Load 2 are energized. Status LED AC 2 and Load 2 are ON
6. 15 seconds after Priority 2 is ON verify Load 3 is energized. Status LED Load 3 is ON
7. After another 15 seconds, Load 4 is energized. Status LED Load 4 is ON

Normal Load Shed Operation

With the generator running and the transfer switch in the STANDBY position, the generator is now powering the load. The OPCB module monitors Wire 23 and with this line being pulled low the module begins to monitor the T1 line for generator frequency.

The 4 green status LEDs will indicate when a load priority level is enabled or disabled.

All loads are enabled when the transfer signal is off. (ATS in Utility position).

When the transfer signal is pulled low (active) all loads will be disabled

- Priority 1 loads are enabled after 5 minutes.
- Priority 2 loads are enabled after 15 seconds.
- Priority 3 load is enabled after another 15 seconds.
- Priority 4 load is enabled after another 15 seconds.

When utility returns, the transfer signal is released High (inactive), and the transfer switch returns to UTILITY position. The module will then drop all loads. After five minutes all priorities are enabled at the same time.

Overload Detection

Generator overload condition is determined by generator frequency. Loads are shed when the frequency is <58Hz for 3 seconds or <50 Hz for ½ second.

When an overload is detected all loads are disabled. During the re-enabling process the module looks for the Priority that caused the overload condition.

Example below:

- After 5 minutes Priority 1 loads are enabled.
- After 15 seconds Priority 2 loads are enabled.
- After another 15 seconds Priority 3 load is enabled, Generator Hz drops to 50 Hz and Priority 3 is turned OFF
- After another 15 seconds Priority 4 load is enabled
- After 30 minutes Priority 3 is enabled and retested. If Hz is OK, Priority 3 stays ON.

If an overload is detected within 15 seconds of a level being enabled, that load level is then locked out. The sequence will continue till all load levels have been checked (Temporarily bypassing the faulting level). The level that caused the overload will not be enabled/tested again for 30 minutes. The module will continue testing the locked out priority every 30 minutes until the issue is corrected or utility power is restored.

A locked Priority can be unlocked by pressing the reset button. A locked Priority will also be unlocked when utility returns and Wire 23 is released from ground and goes High (inactive).

Figure 3-8 and the next 14 figures follow the sequence of operation. When an overload condition occurs on example Priority Circuit 3. After a 30 minute timer expires, Priority 3 is activated. If the frequency is still OK then all priorities will remain active.

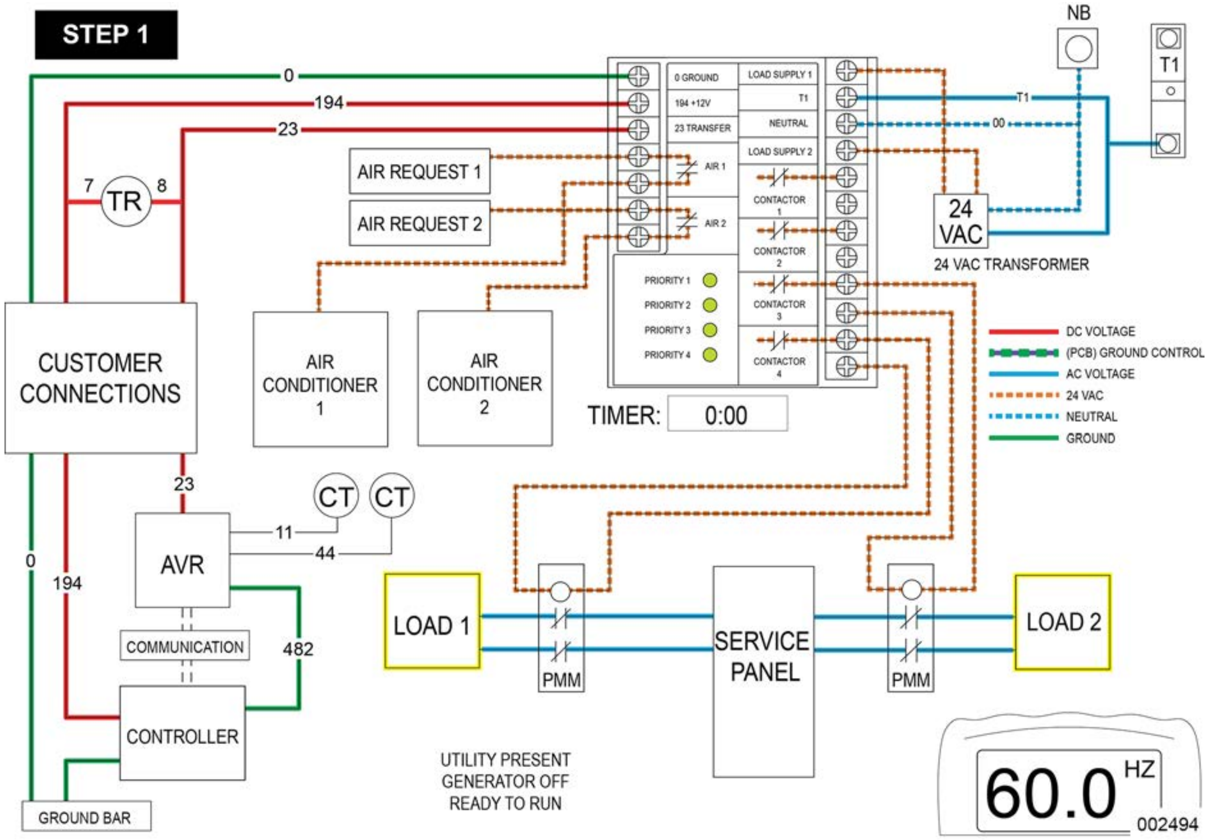


Figure 3-8.

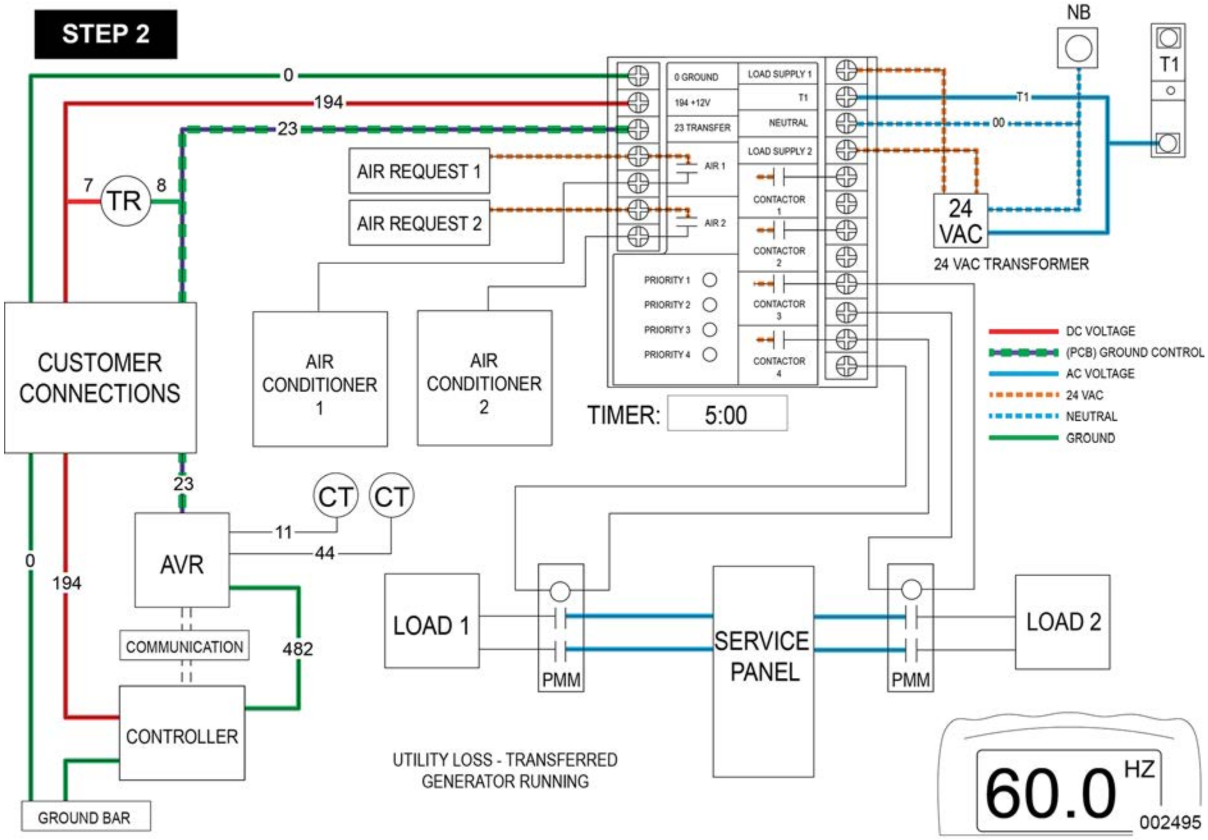


Figure 3-9.

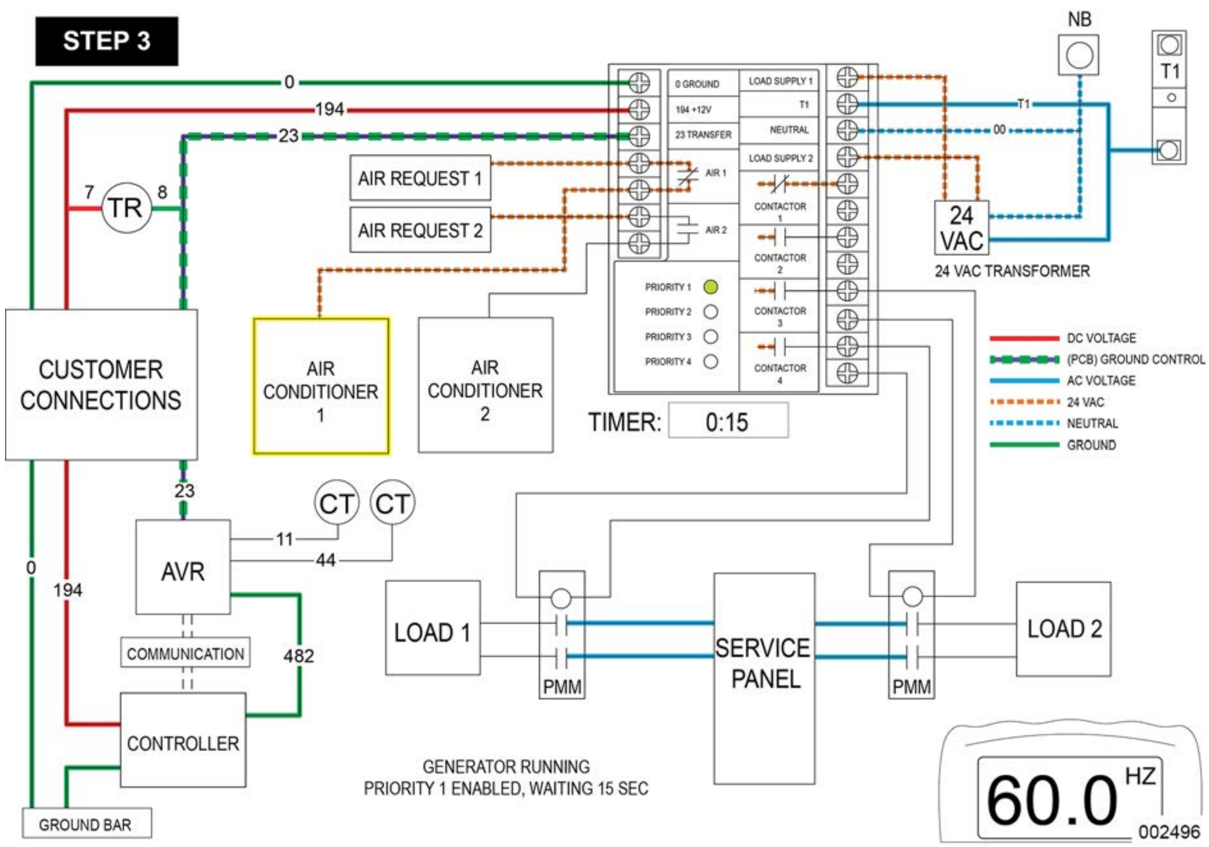


Figure 3-10.

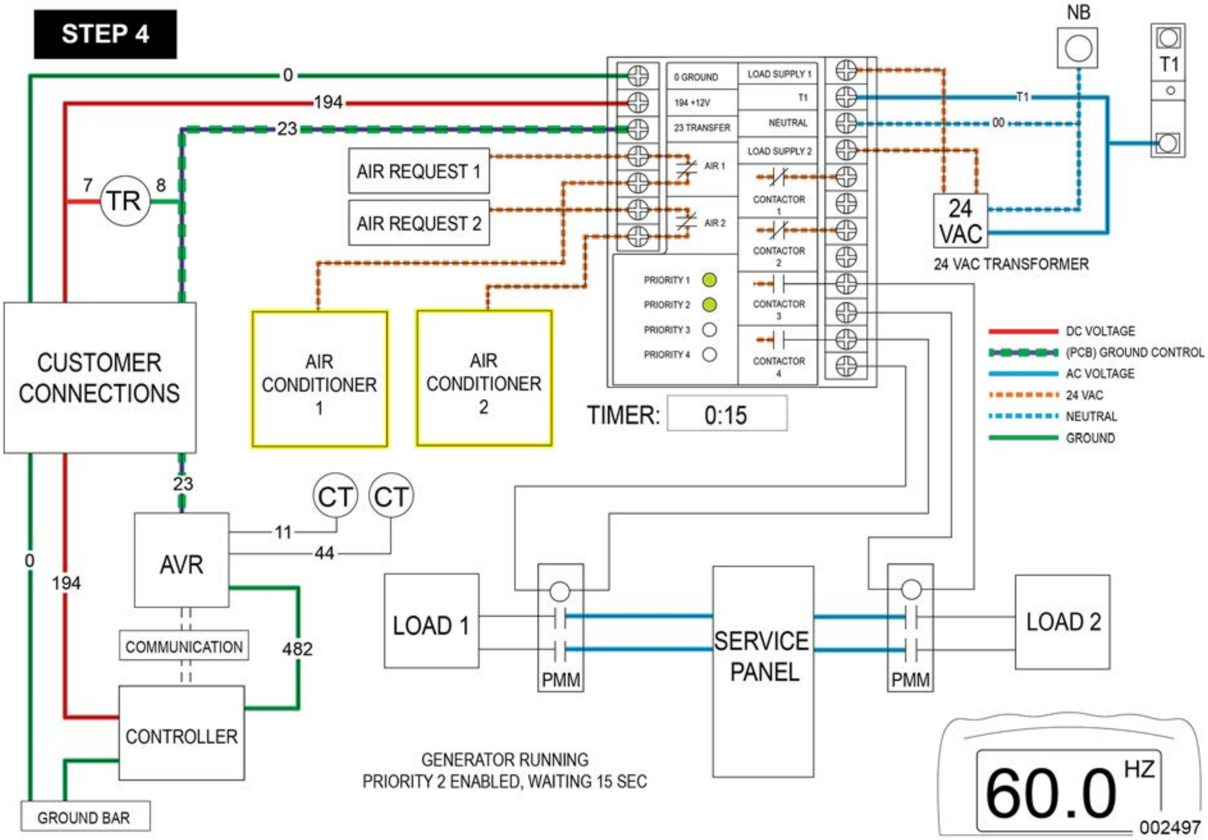


Figure 3-11.

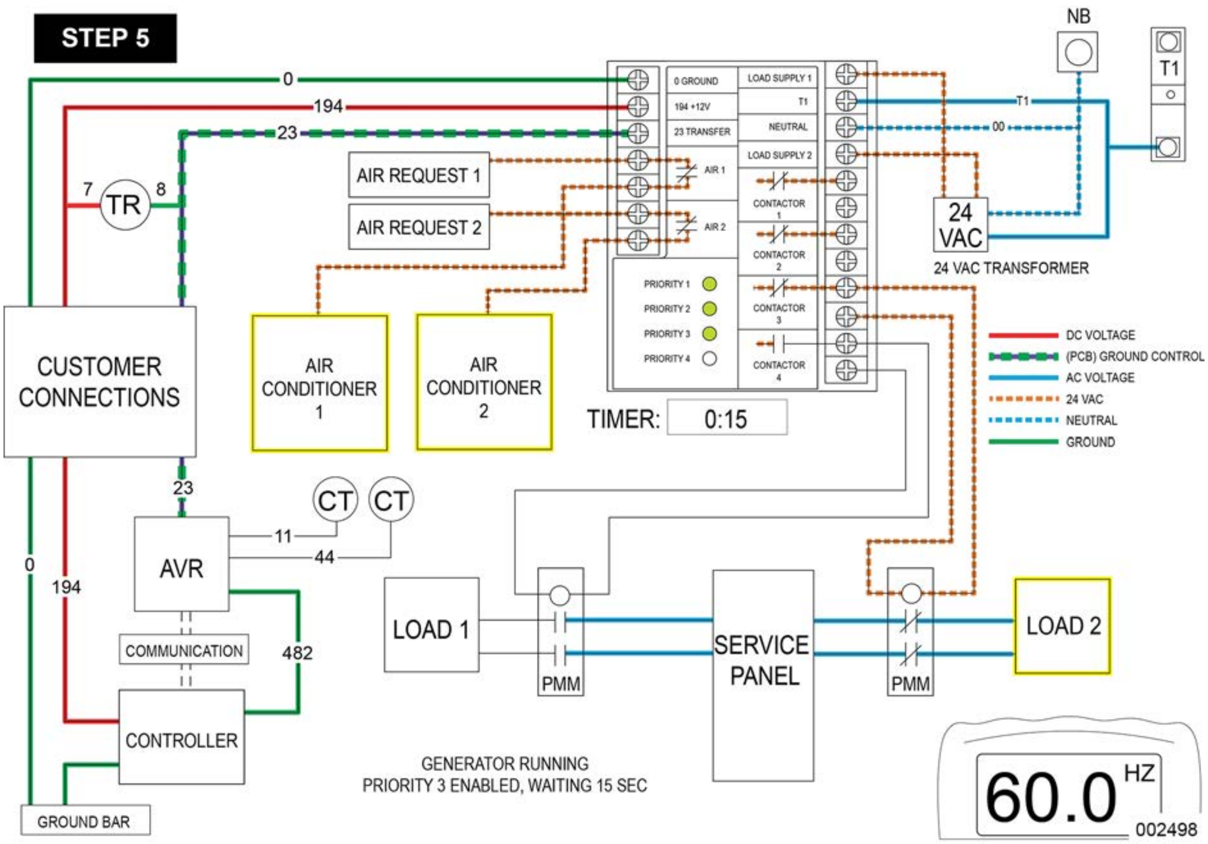


Figure 3-12.

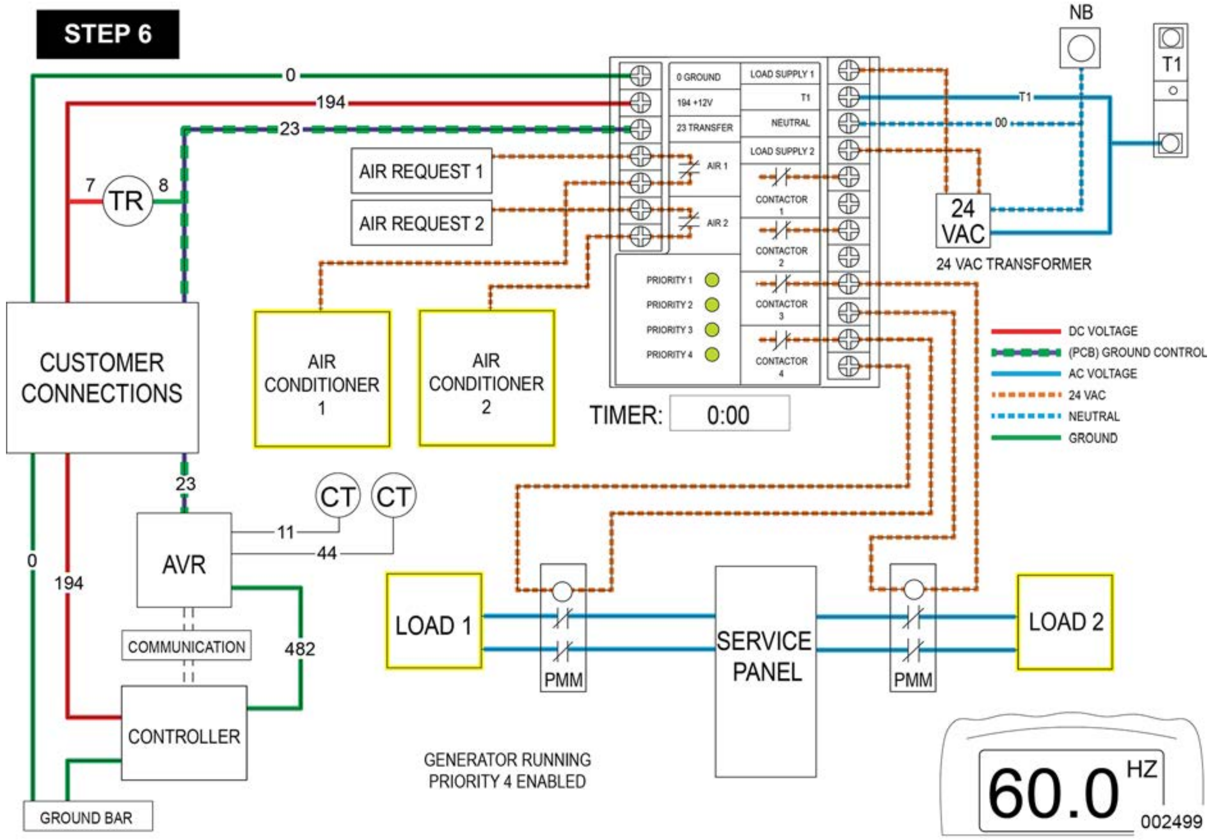


Figure 3-13.

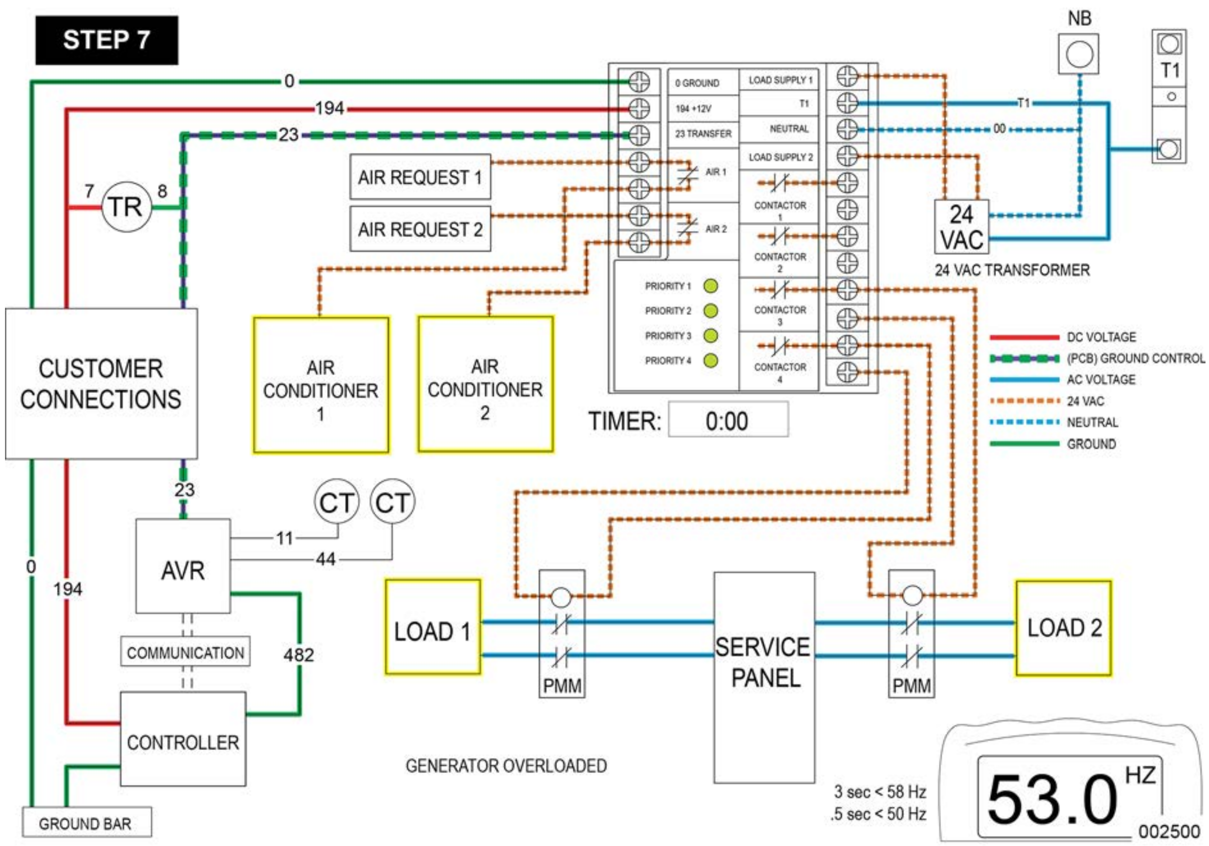


Figure 3-14.

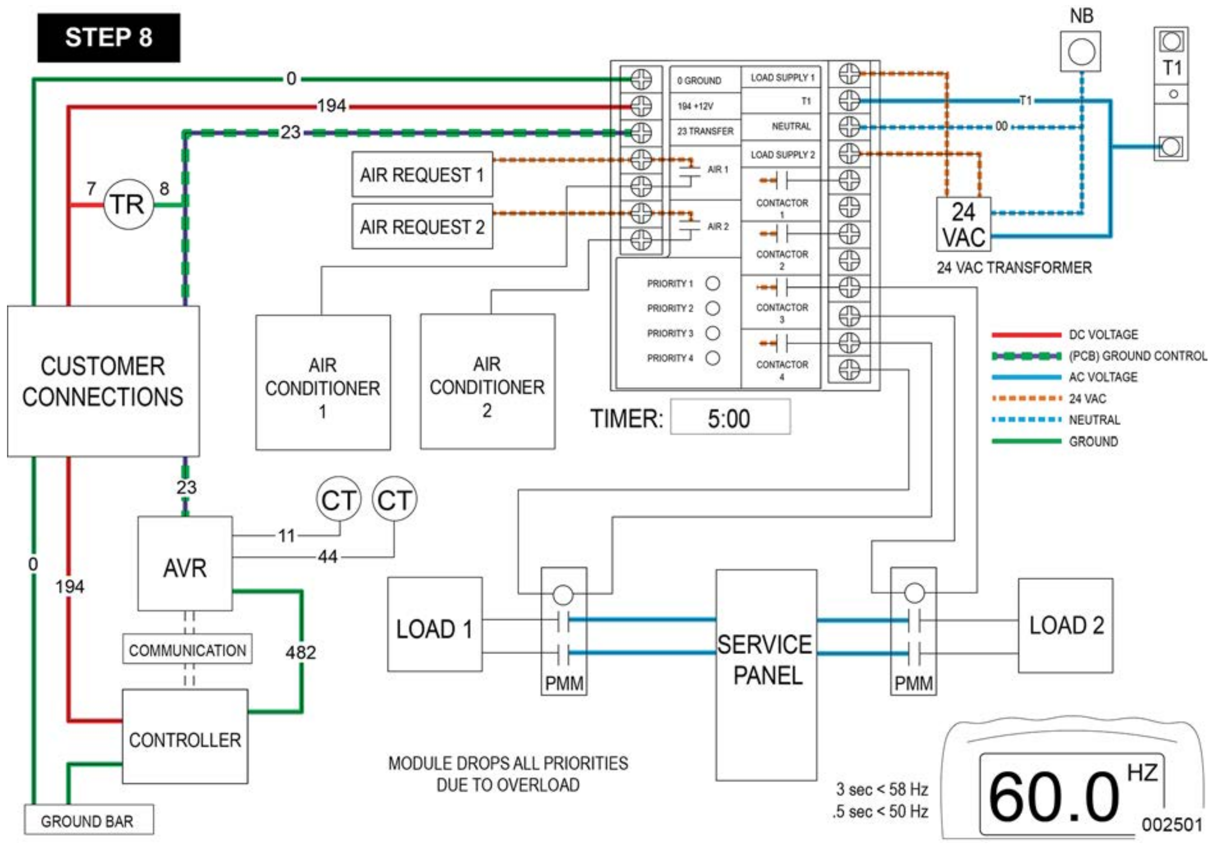


Figure 3-15.

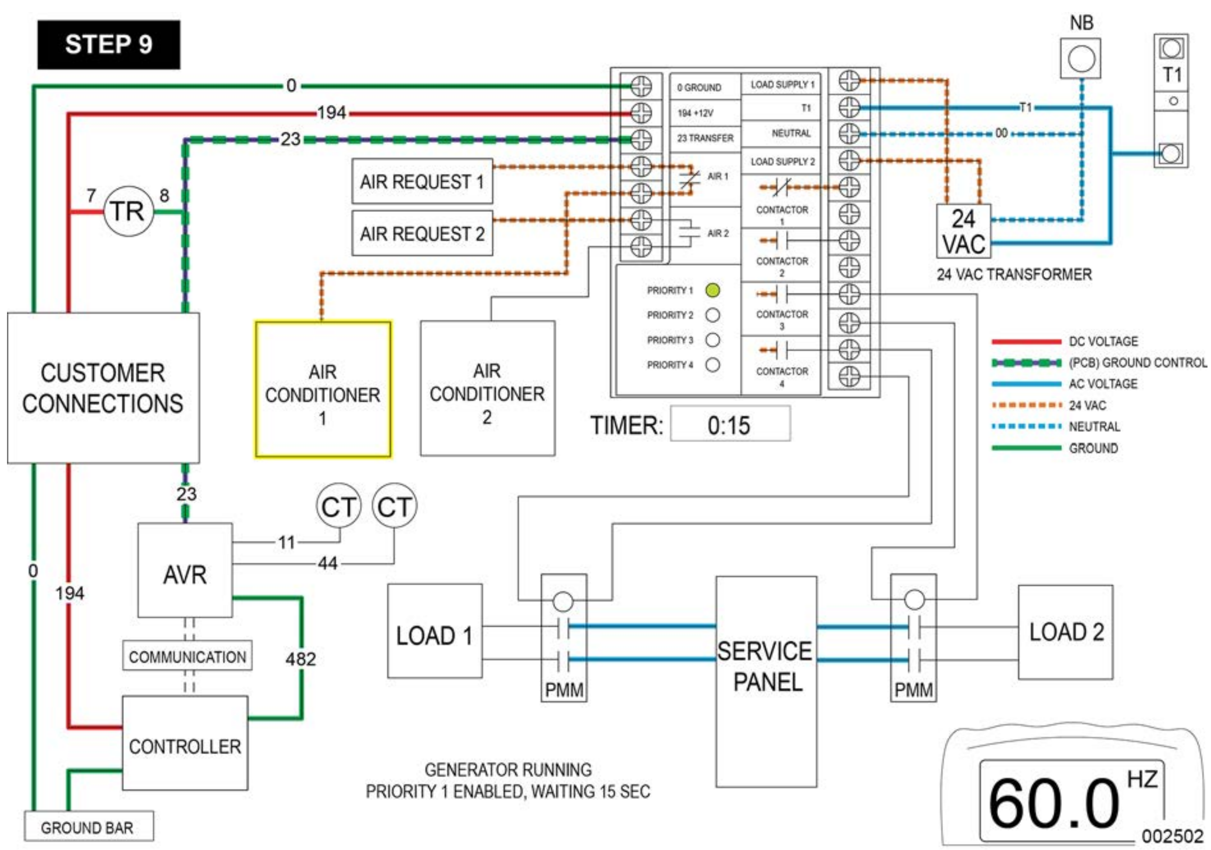


Figure 3-16.

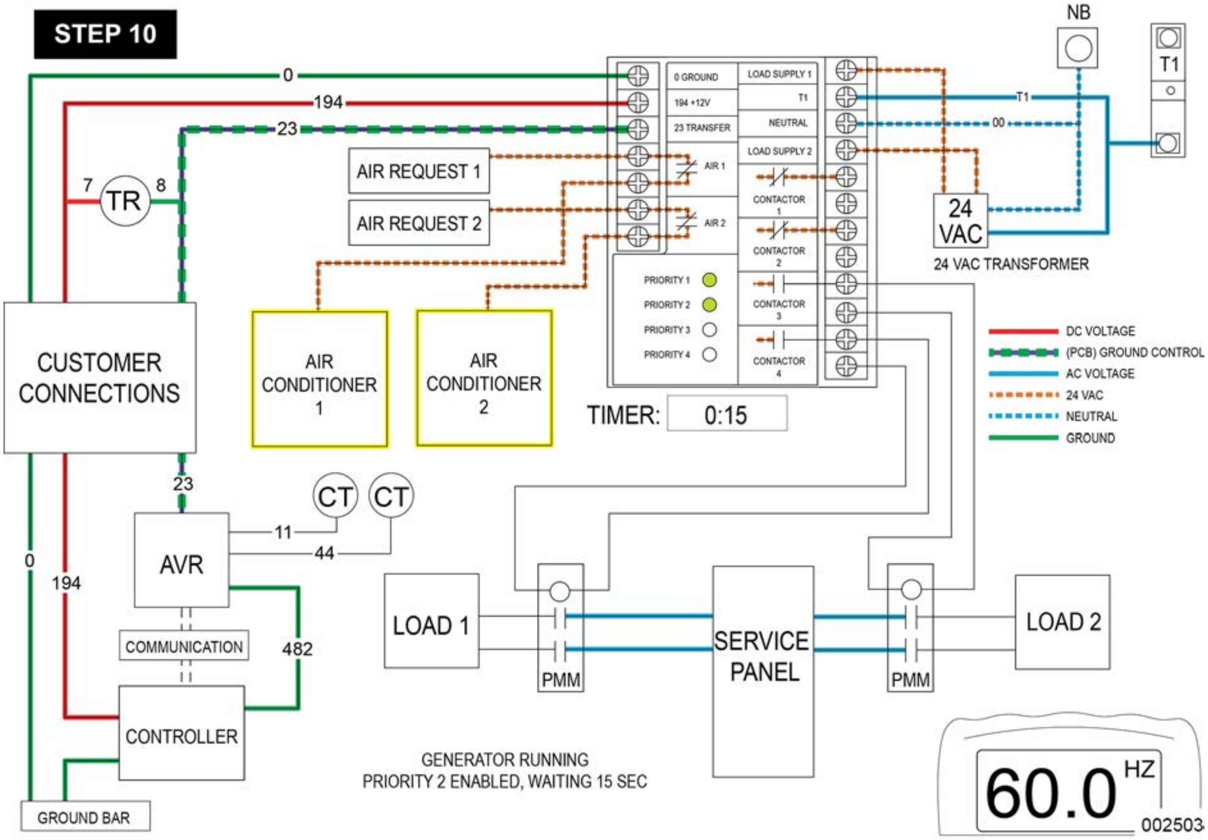


Figure 3-17.

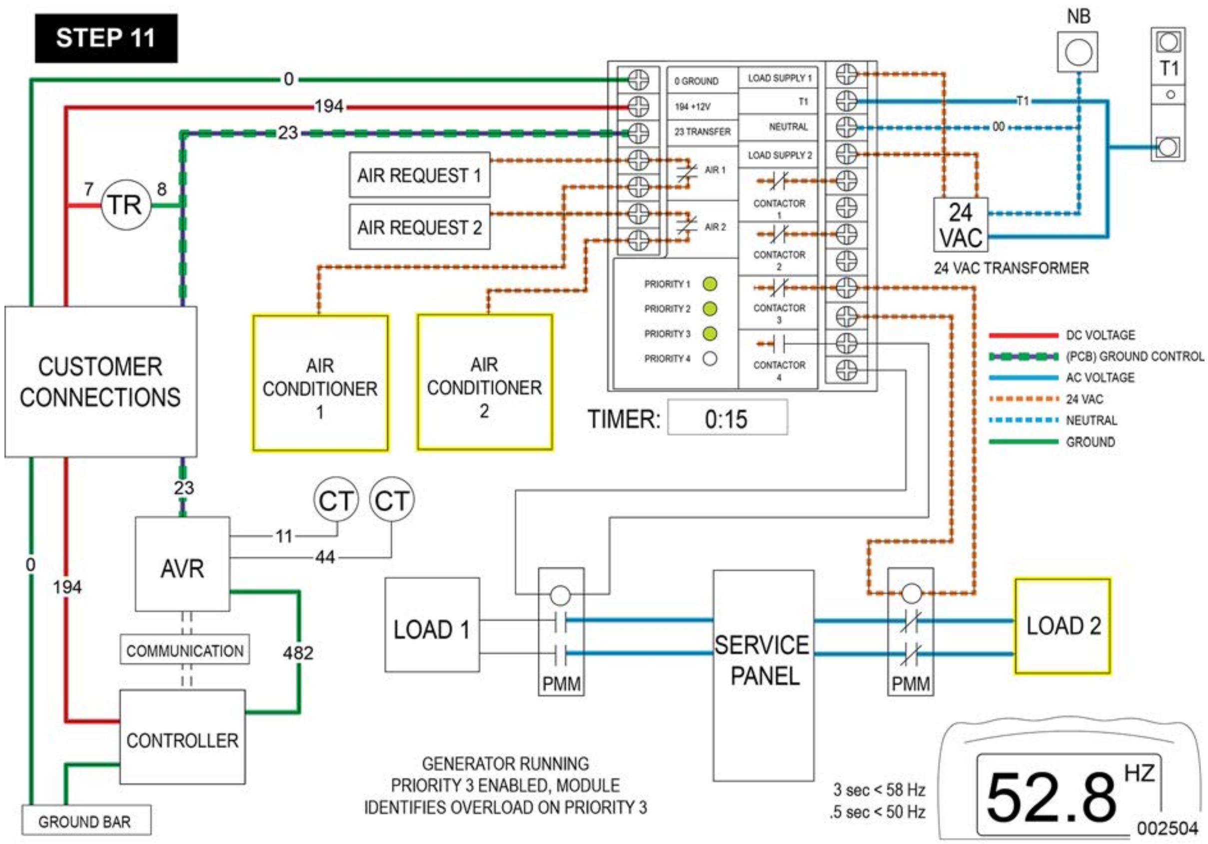


Figure 3-18.

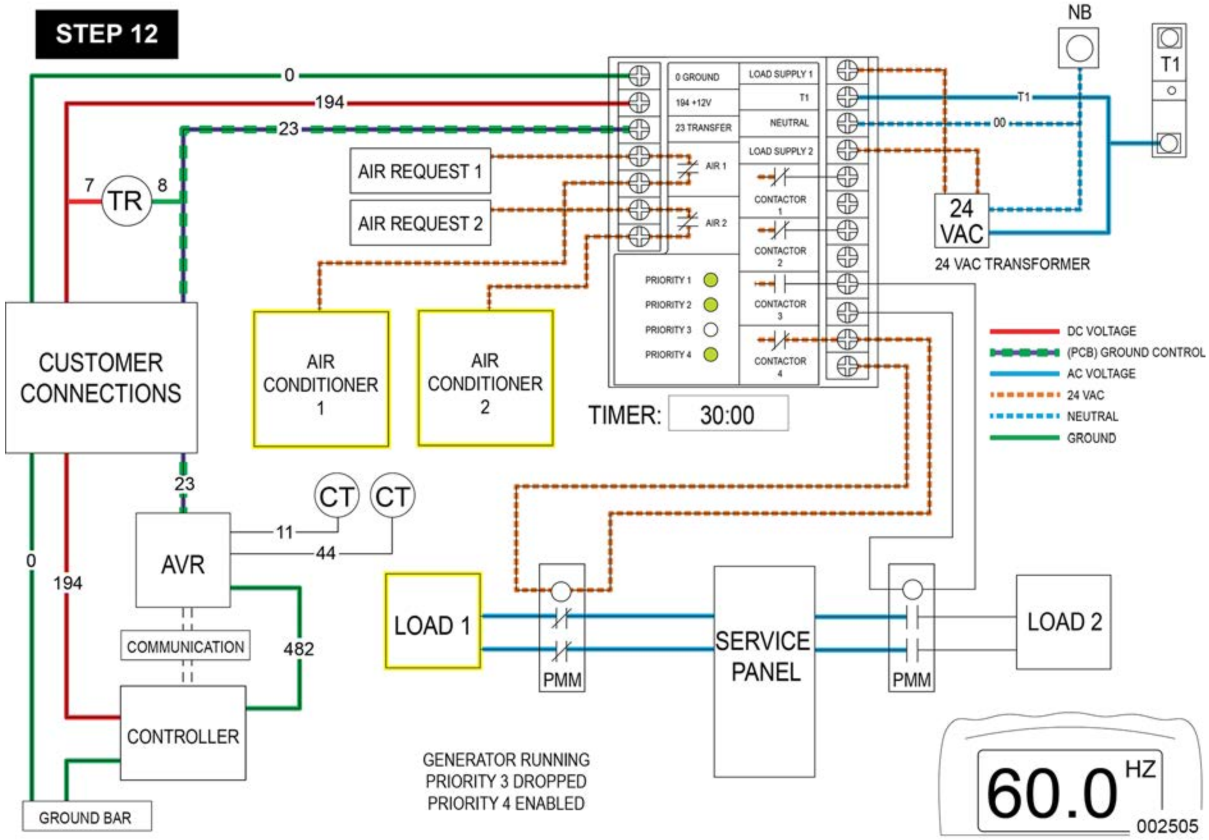


Figure 3-19.

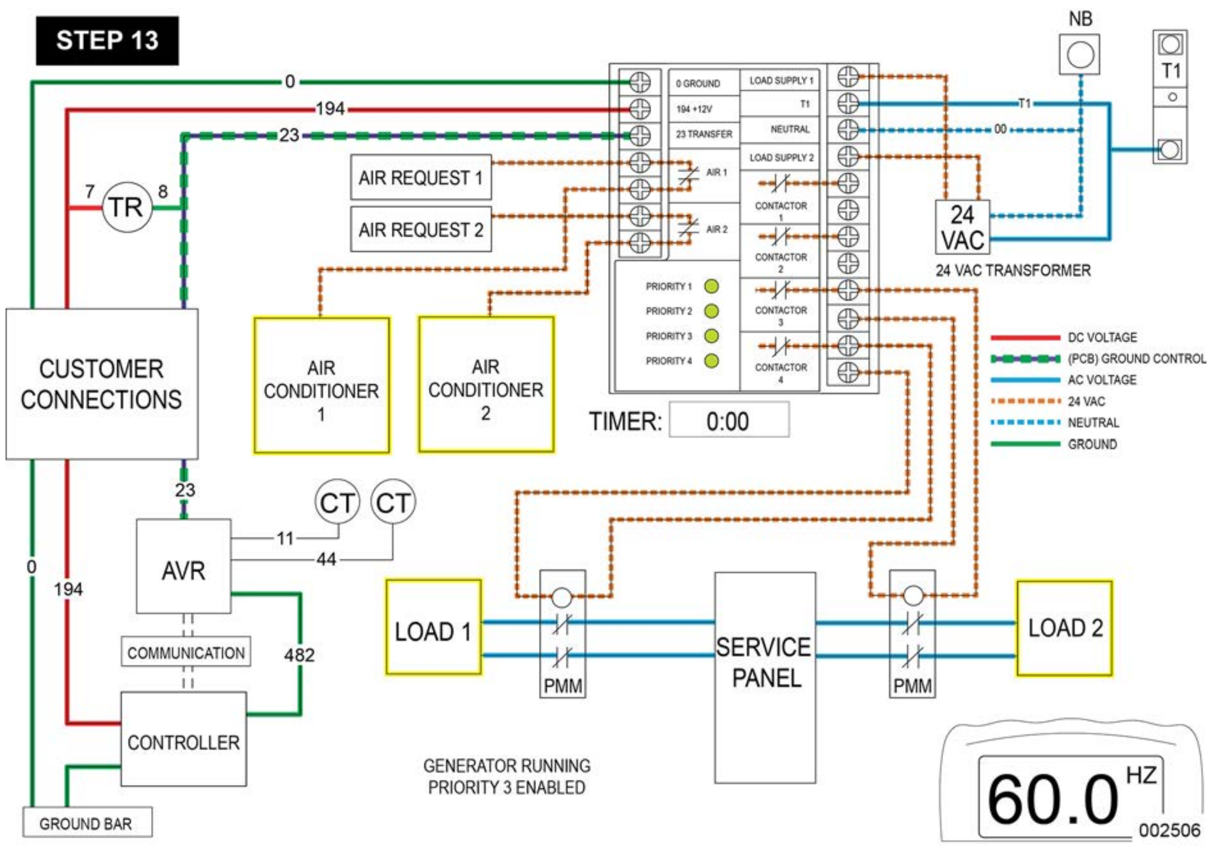


Figure 3-20.

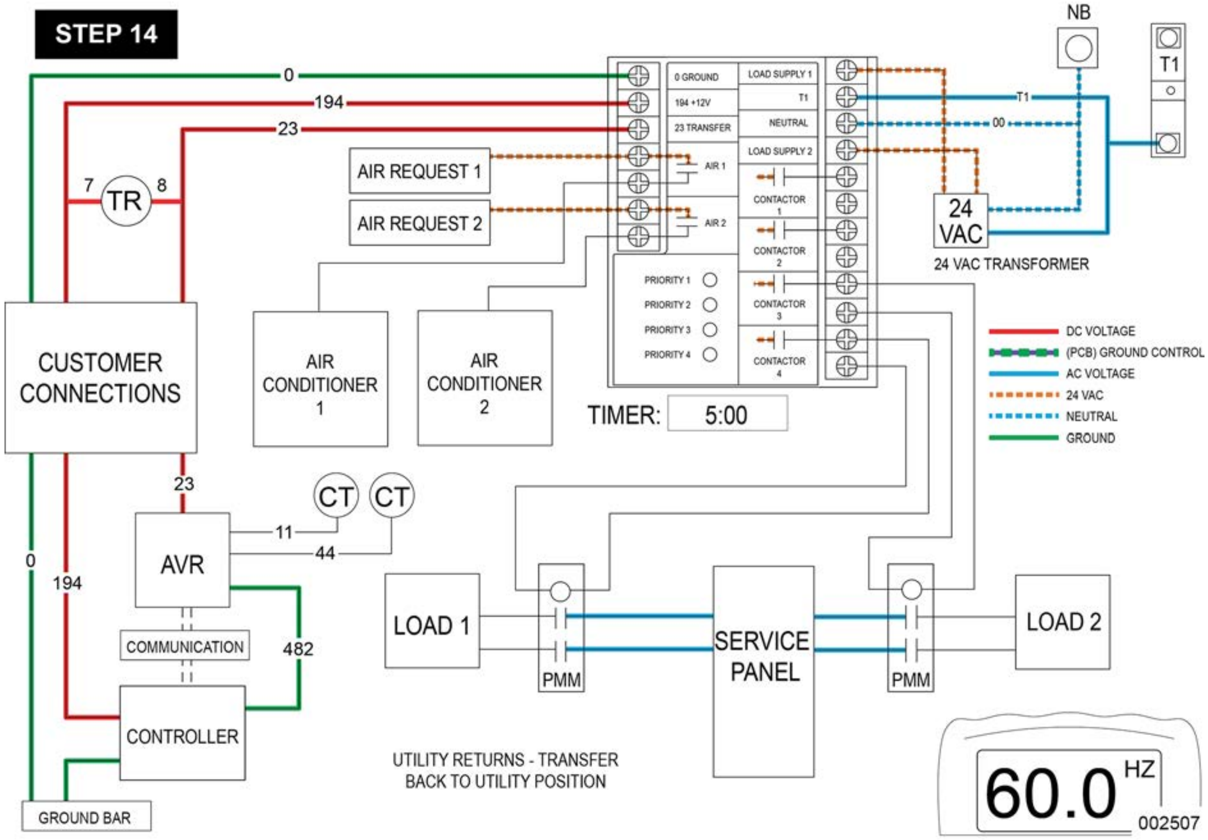


Figure 3-21.

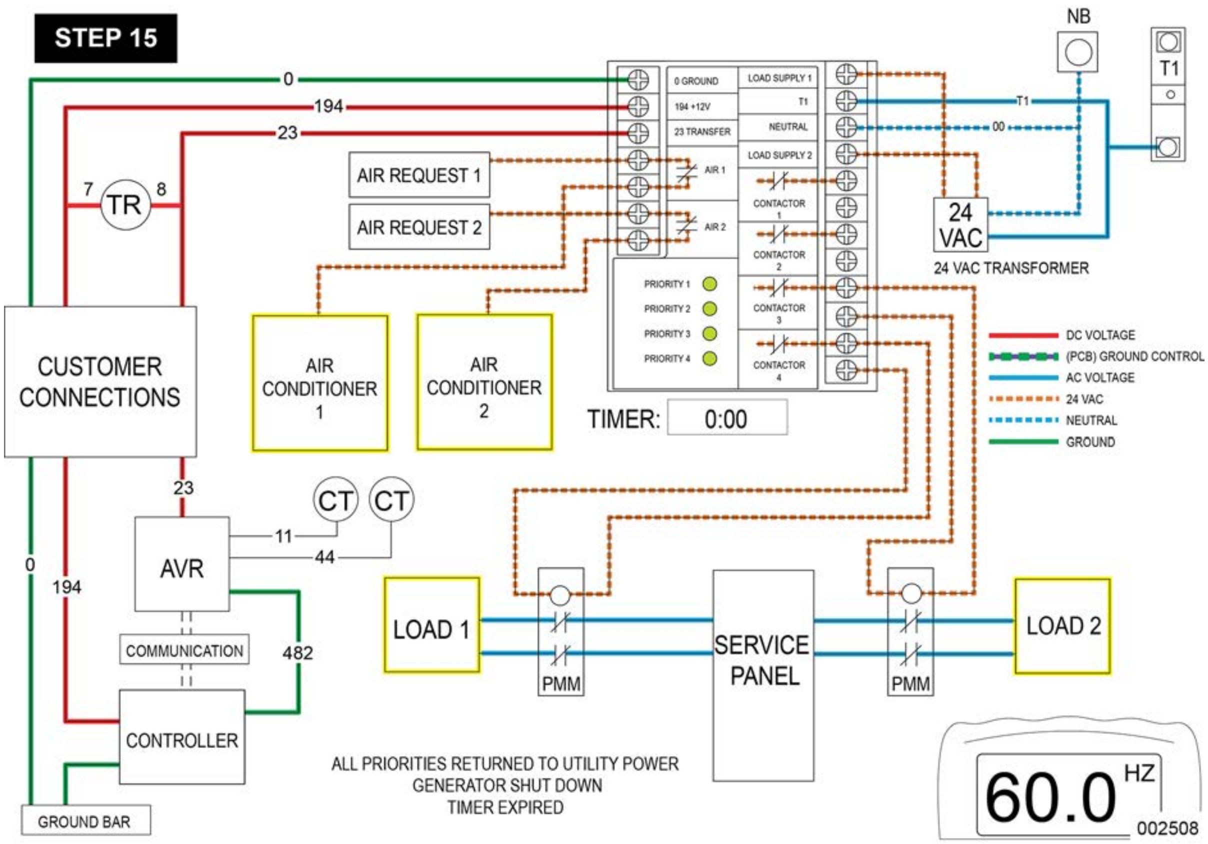


Figure 3-22.

Fast Load Shed Operation

When large loads occur during low speed operation, Synergy units utilize a “Fast Load Shed” program to manage the loads.

When the AVR senses the application of a large load* (via the CTs) while the engine is at low speed, the load is assessed momentarily. The AVR determines the load, and then sends a request signal on Wire 23 to the OPCB module to initiate the Fast Load Shed program.

**> 9 kW or 2HP (NG); > 10 kW or 2HP (LP)*

The OPCB module then drops all loads and the AVR sends a request to the Evolution controller to ramp the engine speed up to 3600 rpm. This action prevents the engine from stalling.

Loads are then individually applied when the engine is up to speed, starting with Priority 3. This initial step takes about six seconds from dropping the loads to activating Priority 3.

The sequence continues as follows:

- Priority 4 is enabled 15 seconds after Priority 3 is activated.
- Priority 1 is enabled 5 minutes after Priority 4 is activated.
- Priority 2 is enabled 15 seconds after Priority 1 is activated.

Air conditioners have designated connections on the OPCB, and are only reapplied after five minutes (to protect the air conditioner motor).

The engine remains at 3600 rpm until the load is stabilized, or for 20 minutes.† This prevents nuisance ramping due to intermittent loads, such as well pumps and sump pumps.

† default – a programmable timer in the Evolution controller

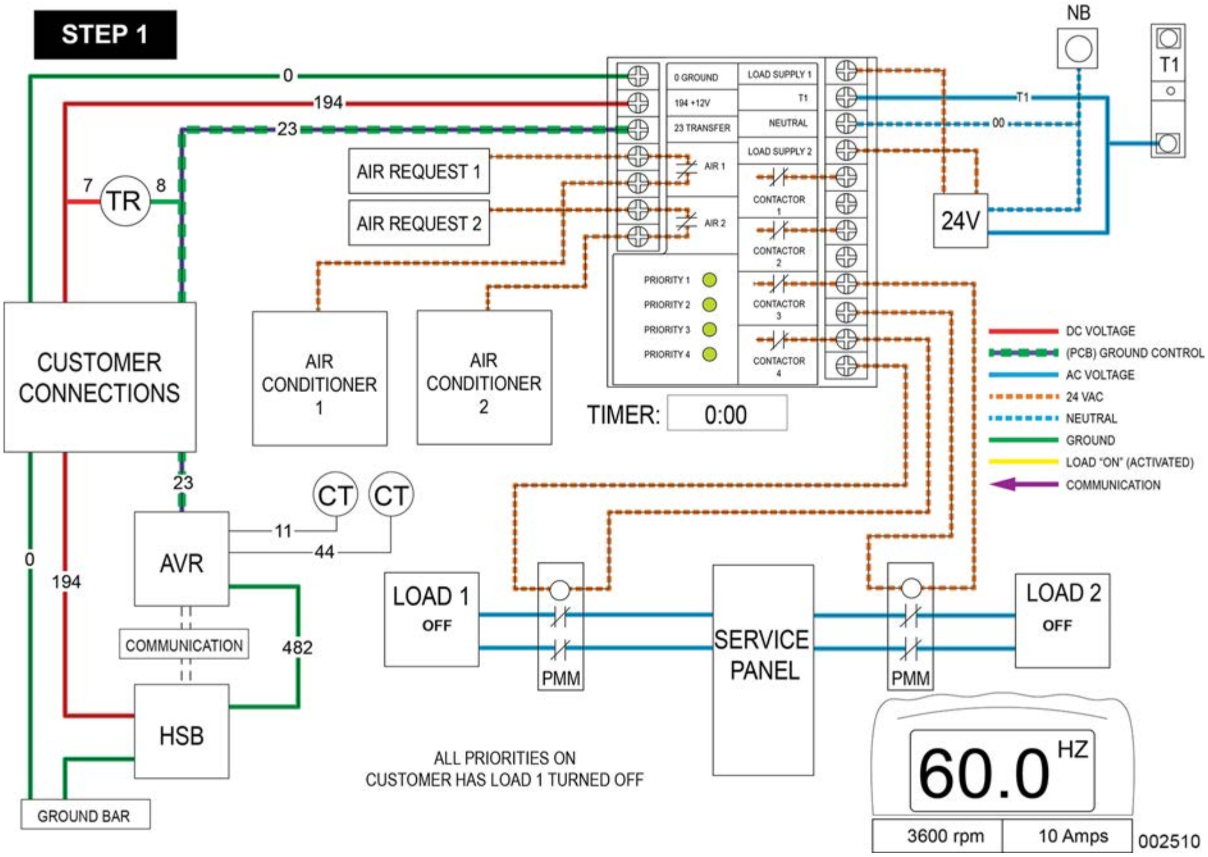


Figure 3-23.

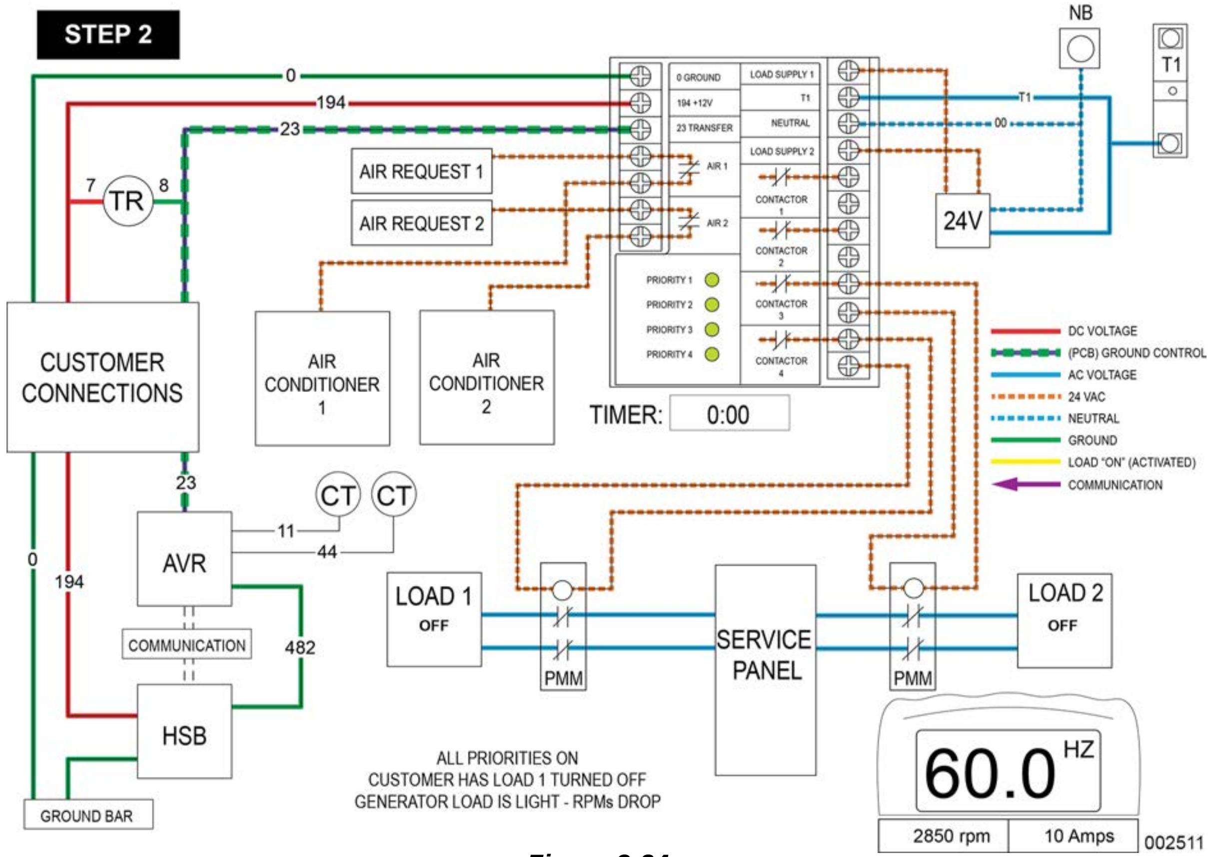


Figure 3-24.

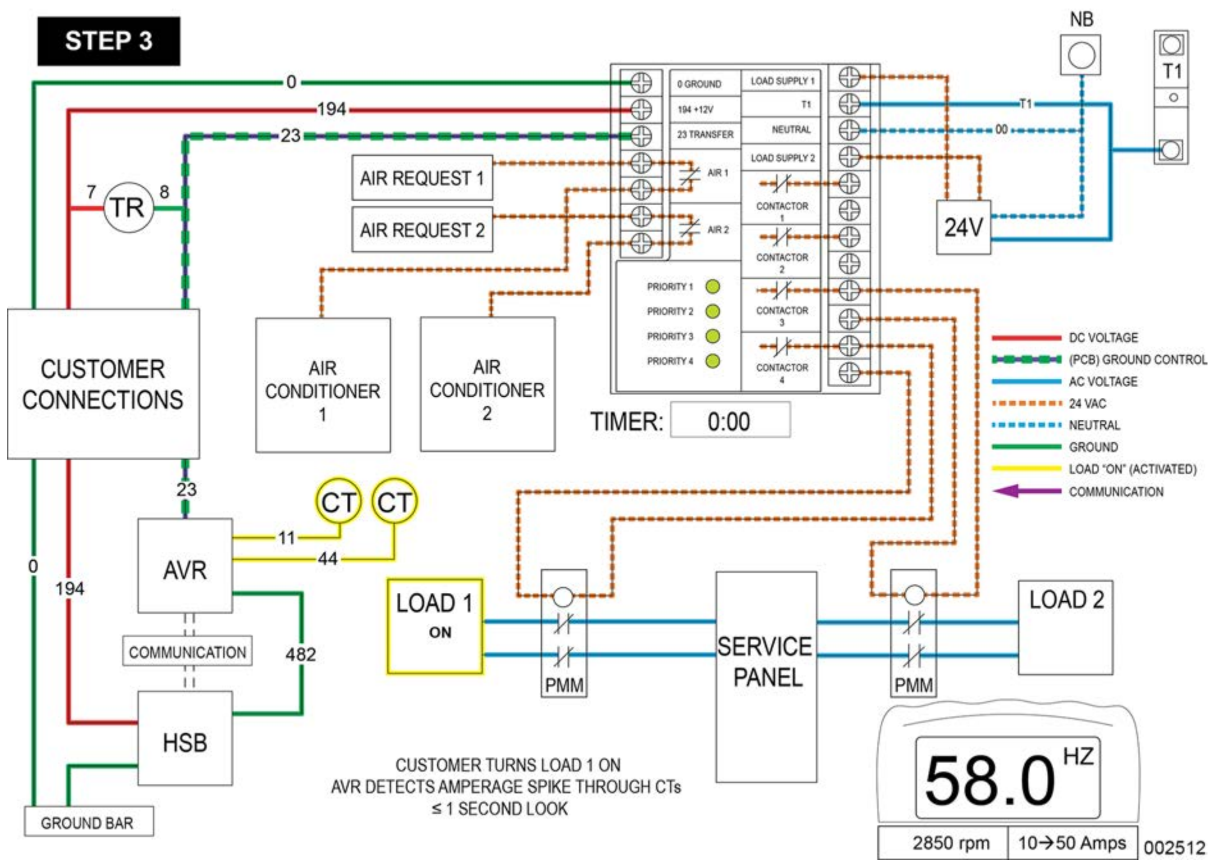


Figure 3-25.

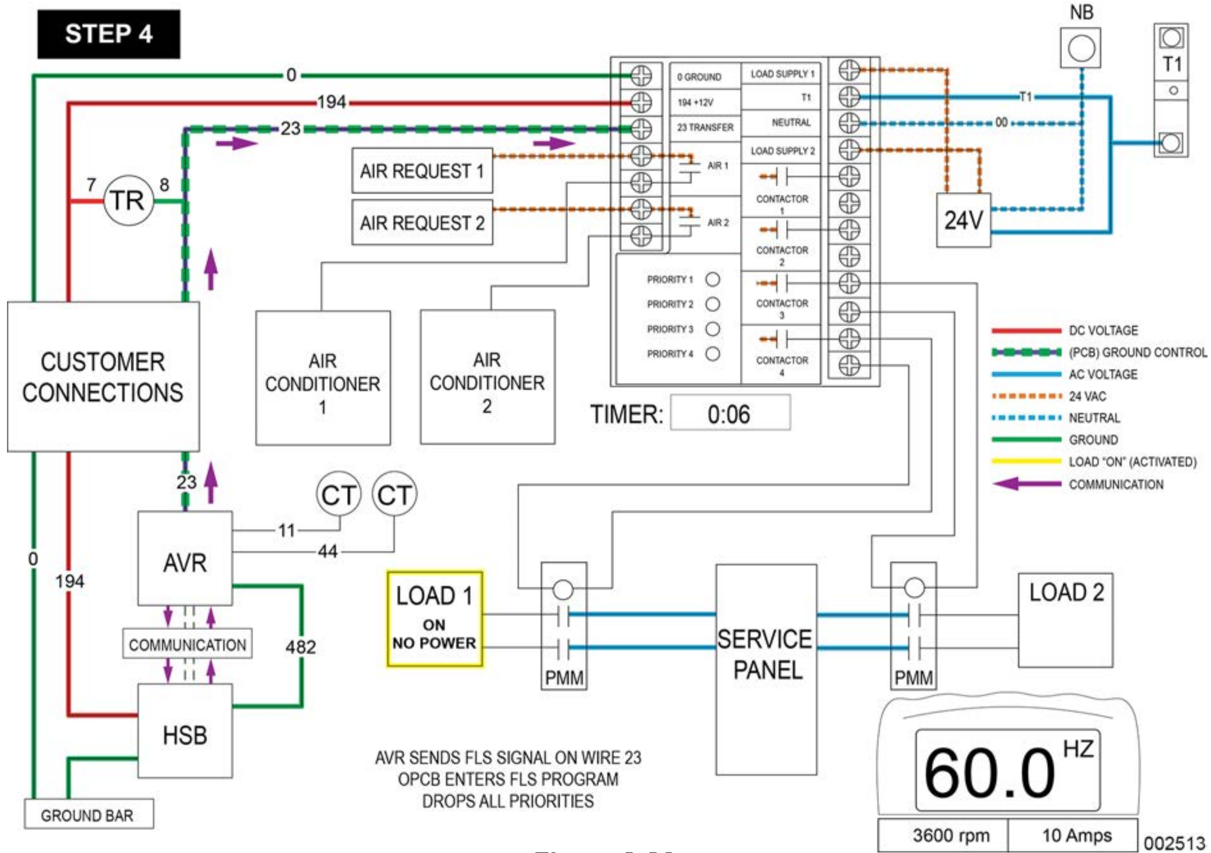


Figure 3-26.

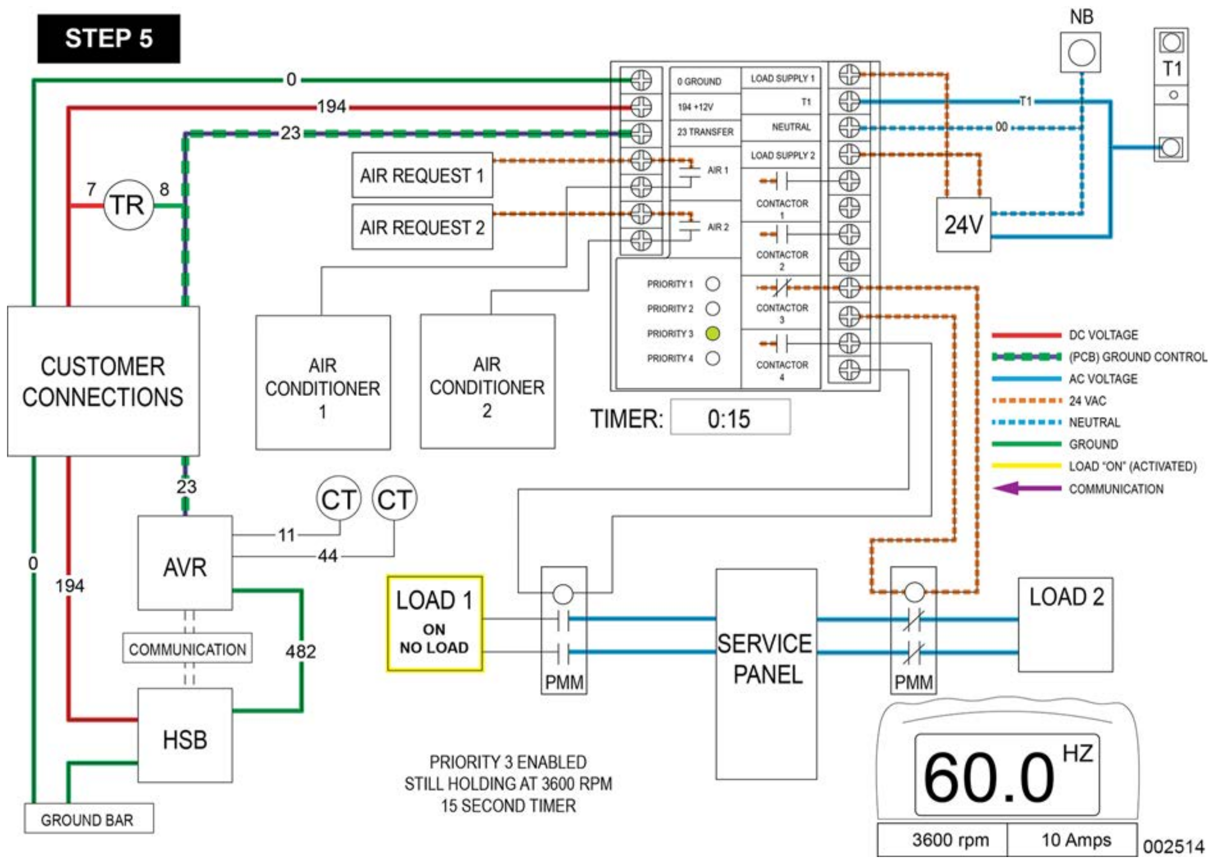


Figure 3-27.

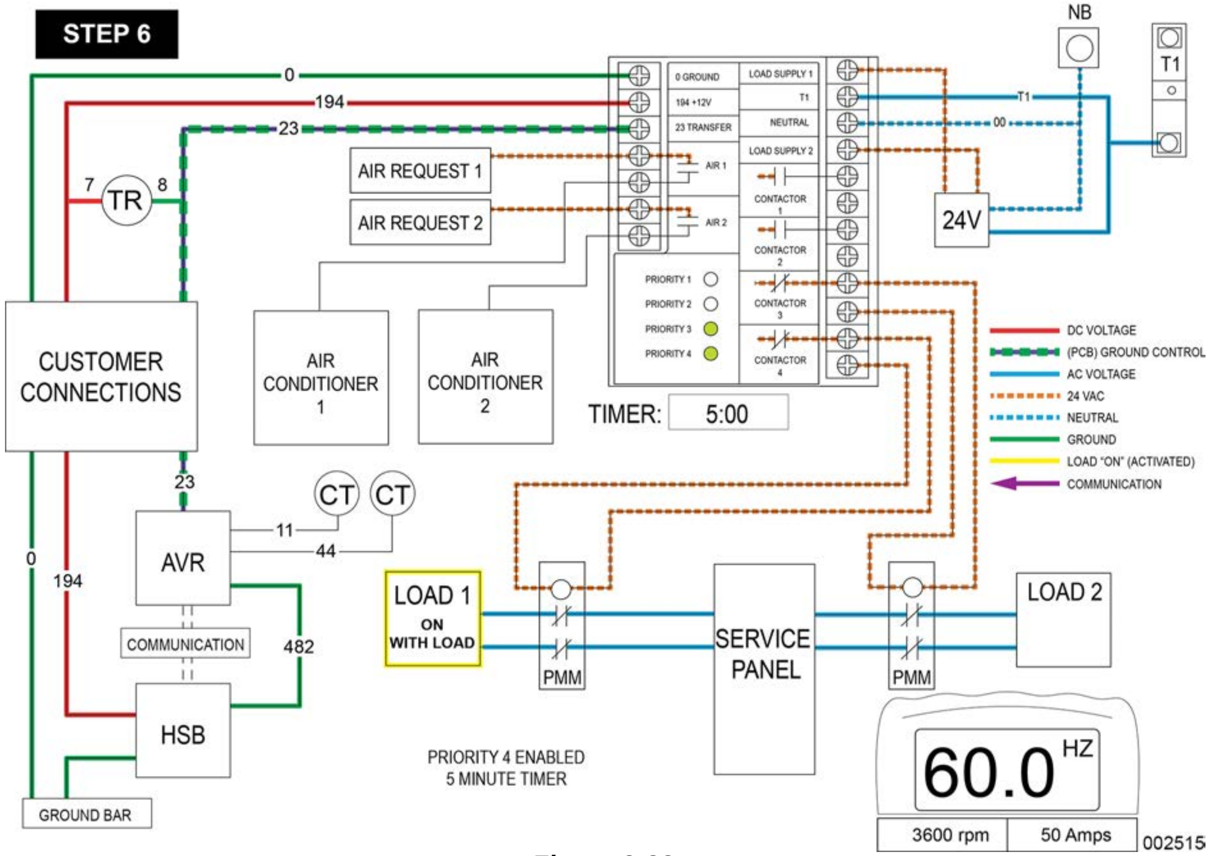


Figure 3-28.

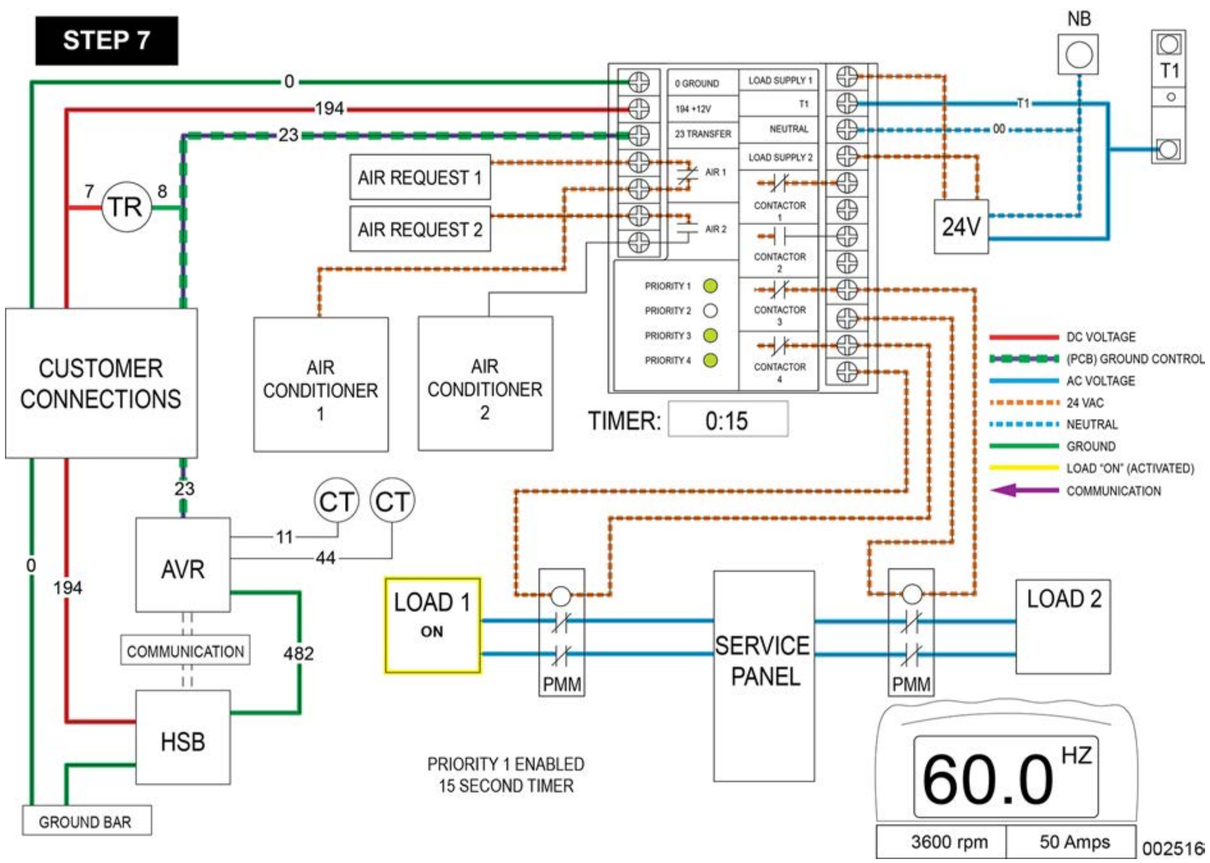


Figure 3-29.

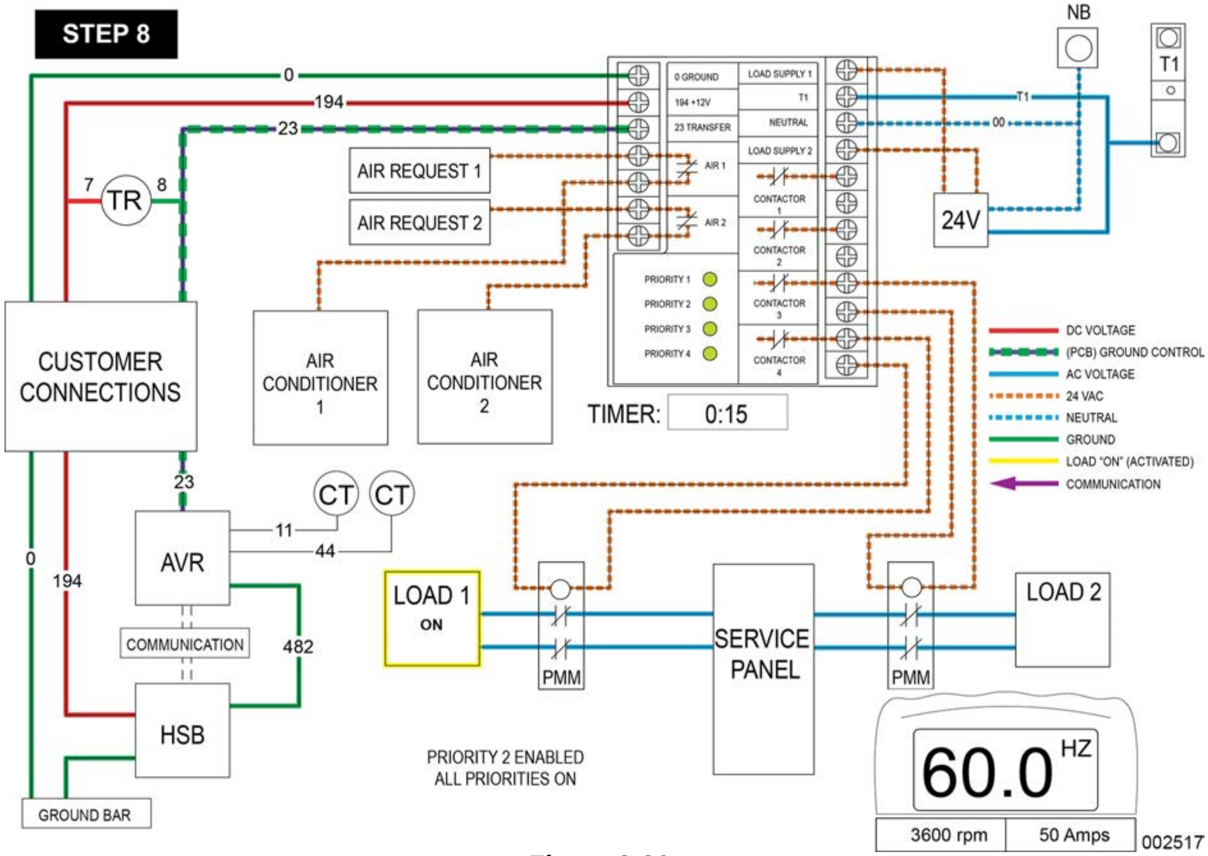

STEP 8
0
194
23
7
TR
8
AIR REQUEST 1
AIR REQUEST 2
CUSTOMER CONNECTIONS
AIR CONDITIONER 1
AIR CONDITIONER 2
0 GROUND
194 +12V
23 TRANSFER
LOAD SUPPLY 1
T1
NEUTRAL
LOAD SUPPLY 2
AIR 1
AIR 2
CONTACTOR 1
CONTACTOR 2
CONTACTOR 3
CONTACTOR 4
PRIORITY 1
PRIORITY 2
PRIORITY 3
PRIORITY 4
TIMER: 0:15
NB
T1
00
24V
DC VOLTAGE
(PCB) GROUND CONTROL
AC VOLTAGE
24 VAC
NEUTRAL
GROUND
LOAD "ON" (ACTIVATED)
COMMUNICATION
CT
CT
11
44
AVR
COMMUNICATION
482
HSB
GROUND BAR
LOAD 1
ON
PMM
SERVICE PANEL
PMM
LOAD 2
PRIORITY 2 ENABLED
ALL PRIORITIES ON
60.0 HZ
3600 rpm
50 Amps
002517

Figure 3-30.

Power Supply Connections for Contactors

The Overload Prevention Control Board (OPCB) logic side is powered via Wire 194 (12DC) and Wire 0 (GND). The frequency of the generator is monitored by the module on T1 and 00 Neutral (120 VAC) when it is active. Optional is the 24 VAC class 2 transformer that can be purchased from the manufacturer. Mounting holes are provided in the enclosure subplate for mounting of the transformer. The 24 VAC transformer supplies 24 VAC for the Load contacts on the OPCM for the optional PMM modules. The 120 VAC supply is fused at 5 amps and is factory connected to OPCB terminals labeled “T1” and “Neutral.”

24 VAC Supply

Transformer connections are made as shown in ***Figure 3-34***.

- Blue wire - OPCB “LOAD SUPPLY 1” terminal
- Black wire - OPCB “T1” terminal
- White wire - OPCB “NEUTRAL” terminal
- Yellow wire - OPCB “LOAD SUPPLY 2” terminal

Control of a Separate Contactor

A separate contactor relay module can be purchased from the manufacturer.

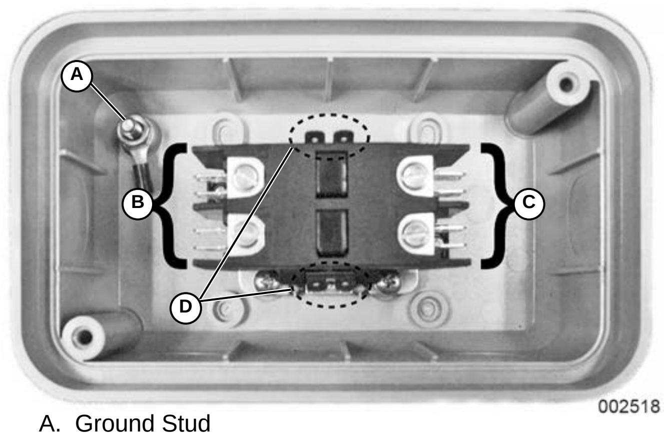
1. Mount the contactor module and connect the load to the main contacts.
2. Connect the contactor coil to the desired LSM (Contactor 1, 2, 3 or 4) terminals on the terminal strip.
3. Connect additional load shedding contactors in a similar fashion.

Power Management Module

The PMM is for use with the Overload Prevention Control Board (OPCB).

The Power Management Module (PPM) 24 VAC contactor is NOT supplied with the transfer switch. It can be purchased separately from the manufacturer.

The OPCB is mounted in the transfer switch. The OPCB provides 24 VAC to the PMM contactor operating coil via the installed 24 VAC transformer. These PMM contactor coil connections are made at the OPCB terminal strip.

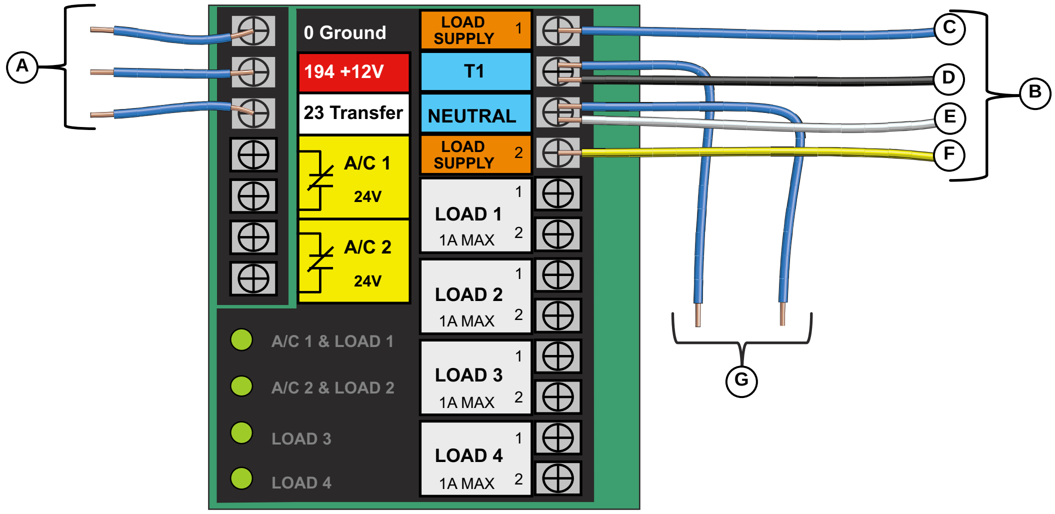


A. Ground Stud
B. Line Connections Terminals L1 & L2
C. Load Connections Terminals T1 & T2
D. Contactor Control Connections

Figure 3-31.

Figure 3-32. Power Management Module

Figure 3-33. PMM Starter Kit



A. Factory wiring
B. Transformer leads Field installed
C. Blue
D. Black
E. White
F. Yellow
G. Existing wiring

Figure 3-34. 24 VAC Supply Connections

Table 3-1. Evolution™ Controller e-Codes

Displayed Alarm	Alarm/ Warning	e-Code Breakdown	Description	Notes
Controller Fault	ALARM		No E-code on HSB	Replace Controller
Overcrank	ALARM	1100	Condition - Engine Cranks but will not Start Unit turns over but will not start. Controller is receiving signal on Wire 18.	Problem 17
Overspeed	ALARM	1200	Prolonged Over 72 Hz for 3 seconds. Possible cause: Stepper motor/mixer body assembly issue.	Test 12
Overspeed	ALARM	1205	Instantaneous Over 75Hz for 0.1 second (100 milliseconds). Possible cause: Stepper motor/mixer body assembly issue.	Test 12
Low Oil Pressure	ALARM	1300	Occurred while running The default Extended alarm for low oil pressure. Check oil level and pressure.	Test 61
High Temperature	ALARM	1400	Condition - Air Flow Impeded / Flow Issue Check the inlet/outlet for debris.	Test 62
RPM Sensor	ALARM	1501	Twin Cylinder+Running Twin Cylinder Running faults to RPM Sensor Loss. Possible Causes: air pocket in fuel line, dirty fuel, missing ignition pulse (loss of one of the primary coils).	Test 50 and Test 64
RPM Sensor	ALARM	1505	Twin Cylinder+Cranking Twin Cylinder Cranking faults to RPM sensor loss Possible Cause: starter motor issue, missing ignition pulse (loss of one of the primary coils).	If engine cranks, Test 64. If engine does not crank, Problem 15.
Underspeed	ALARM	1600	Condition - Unit is Overloaded Unit is Overloaded slowing engine speed, fuel supply low or throttle control problem.	Problem 3, Test 50 or Test 12
Overvoltage	ALARM	1800	Prolonged Over-Voltage Voltage reported to the controller from the AVR via communication line.	Perform Test 2
Undervoltage	ALARM	1900	Prolonged Under-Voltage Undervoltage due to loss of voltage for some time (10+ seconds). Voltage reported to the controller from the AVR via communication line.	Perform Test 2
Undervoltage	ALARM	1901	Undervoltage value reported to Evolution controller. Verify Generator output voltage in the Dealer Menu display of the Evolution controller. AVR voltage information is sent to the Evolution controller via communication lines.	Check communication wires between AVR and Evolution controller. Perform Test 2
Wiring Error	ALARM	2099	Customer connection low voltage and high voltage wires are crossed.	Check customer connection in generator
Overload Remove Load	ALARM	2100	Overloaded - Default (Output Current Method) Unit is overloaded, one of the two CTs is detecting an overload condition. Check transfer switch loadshed functionality. (Change load dynamics or utilize loadshed).	Remove Load
Stepper Overcurrent	ALARM	2399	Current flow in stepper coil(s) above specification	Test 12
Fuse Problem	ALARM	2400	Missing / Damaged Fuse (not displayed on Firmware 1.12 and newer) The 7.5 amp Controller Fuse is missing or blown (open).	Test 44
Low Battery	WARNING		Condition->Battery less than 12.1 Volts for 60 seconds	Test 45
Battery Problem	WARNING		Condition->More than 16 Volts of battery voltage or 600 milliamperes or more of charge current at the end of an 18 hour charge	Test 45
Charger Warning	WARNING		Less than 12.5 volts of battery voltage at the end of a 18 hour charge	Problem 22
Charger Missing AC	WARNING		AC power is missing from the battery charger input	Problem 22
SEEPROM Abuse	WARNING		Condition->more than 1200 writes to the EEPROM in a 5 minute period.	

Table 3-2. VR VSCF-Codes

Ecode	Alarm	Description	Possible Causes	Tests
1048	VSCF Overload	Large DC link (phase) current for 100us	Rotor has shorted, or AVR phase wire short (or miswired), or brush short.	Perform Rotor Brush Test
1049	VSCF Overload	Sustained Generator output voltage of < 120V for a total of 2ms (100us sampling) after reaching operating voltage, AND very high current (>> max load)	The generator output is shorted or severely overloaded. Identify and clear the overload then restart.	Check for Overload conditions Proper Load Shedding
1050	VSCF Low Battery	Low supply voltage detected <8 VDC	The voltage supply to the AVR is low. Since the supply comes from the controller, either 1) The AVR is miswired to the controller 2) The controller is outputting the wrong voltage (faulty) 3) The AVR has internal issue	Check AVR Power and ground circuits from controller to AVR for proper voltage and ground
1051	VSCF High Battery	High supply voltage detected >16.2 VDC	The voltage supply to the AVR is High. 1) External battery charger is being used 2) AVR supply is mis-wired	Check for external charger issue Check harness for proper wiring
1052	VSCF DC Overvoltage	DC link overvoltage >400 VDC	1) The generator was temporarily overloaded 2) The output was temporarily shorted 3) Throttle is stuck (open) 4) Internal AVR issue	Check for Overload conditions Check proper Stepper operation
1053	VSCF Gate Fault	IGBT gate driver fault	Possible causes are: 1) The brushes are incorrectly wired. 2) The rotor is shorted. 3) The brushes are arcing or worn. 4) The generator was severely overloaded (shorted). 5) One of the fans is blocked or not working. Insufficient air flow. 6) Off" was pressed when the "Small Fan Failure" Warning was present (Ecode 1070)	Perform Rotor Brush Test Check for Overload conditions Check AVR Air flow for restriction Perform Small fan test Perform Large Fan Test Perform Auxiliary Power Supply test
1054	VSCF IGBT Overtemp.	Set for >85 deg. C	Probable causes are: 1) The AVR air filter needs replacing. 2) The air path is blocked, either intake or exhaust or through the unit. 3) The BIG fan is not running Perform Small Fan and Large Fan test 4) There is an air leak in the AVR enclosure. 5) The engine is running too hot. 6) Ambient temperature above 50C.	Check for Overload conditions Check AVR Air flow for restriction Perform Small fan test Perform Large Fan test Perform Auxiliary Power Supply test Check Generator air vents for restriction Insufficient air flow around unit
1055	VSCF Phase Error	If Vrms>125 & Hz < 45 while ramping	An incorrect voltage and frequency has been detected during starting. Probable causes are: 1) The stepper motor is not working or the linkage is binding. 2) The gas pressure is low and the engine is not coming up to speed. 3) The brushes are incorrectly wired. 4) The brushes are arcing or worn. 5) The brushes are not connecting to the slip-ring. 6) The rotor is shorted. 7) The generator has started into a severe load. 8) Brush harness connector is damaged.	Check for proper fuel supply and settings must be within specifications of unit Open MLCB and retest unit Check for Overload conditions Perform Rotor Brush test Check stepper operation Perform stepper motor test Check rotor resistance at slip rings

Table 3-2. VR VSCF-Codes

1056	VSCF Undervoltage	Main controller detects a low output voltage	The generator output voltage is too low. Possible causes are: 1) The load is too large 2) The stator is damaged 3) The rotor is damaged 4) The brushes are incorrectly wired 5) The brushes are arcing or worn 6) The AVR is damaged	Open MLCB and retest unit Check for Overload conditions Perform Rotor Brush test Perform Power Winding and DPE winding tests
1057	VSCF Overvoltage	Generator overvoltage >265 Vrms	Probable causes are: 1) The generator has been overloaded 2) The generator has started into a severe load.	Open MLCB and retest unit Check for overload conditions on startup
1058	VSCF DC Undervoltage	Loss of aux winding field <100 VDC	The DPE winding supplies this voltage. Possible faults are: 1) DPE is miswired/not connected. 2) DPE winding is faulty (rotor fault) 3) The brushes are arcing or worn. 4) Brushes are miswired or faulty.	Perform Power Winding and DPE tests Perform Rotor Brush test Inspect harness
1059	VSCF Field Loss	Output is < 50 Vrms. Immediately upon completion of startup voltage ramp. (1 rms sample)	The unit has detected there is no output voltage while starting up. Probable causes are: 1) The DPE winding is miswired 2) The DPE is producing no voltage into the AVR. 3) The brushes are arcing or worn. 4) Brushes are miswired or faulty. 5) The rotor is shorted. 6) The AVR is damaged.	Perform Power Winding and DPE tests Perform Rotor Brush test Check harness connections to AVR
1060	Big Fan Failure	PCB temperature has exceeded 70C ALARM	This alarm occurs when the AVR electronics temperature exceeds 70C. Possible causes are: 1) The AVR air filter needs replacing. 2) The air path is blocked, either intake or exhaust. 3) The BIG fan is not running (it only runs when the engine runs). 4) There is an air leak in the AVR enclosure. 5) The engine is running too hot. 6) The ambient temperature is above 50C.	Check for Overload conditions Check AVR Air flow for restriction Perform Large Fan test Perform Auxiliary Power Supply test Check Generator air vents for restriction Insufficient air flow around unit Perform Small Fan Test
1061	VSCF Field Loss	Output is < 20 Vrms for 16 cycles	The unit has detected the output voltage has been lost while running. Possible causes are: 1) Fuel loss. 2) The DPE is no longer generating voltage into the AVR. 3) The brushes are arcing or worn. 4) Brushes are miswired or faulty. 5) The rotor is shorted. 6) The AVR is damaged.	Check fuel supply and fuel pressure Perform Power Winding and DPE tests Perform Rotor Brush Test Check harness connections to AVR
1062	VSCF Comms Loss	Main controller detects no VSCF modbus messages have been received.	The AVR needs to communicate with the controller, as such there is a shielded cable connecting the two units. Possible faults: 1)Comm's cable / connection has become faulty. 2) Incorrectly shielded 3) The AVR has no power to it. Check the LED's on the AVR. The green one should be lit (only). 4) One of the controllers is damaged. 5) The firmware download has failed. 6) Can occur when using a DMM on these wires.	Check communication wires between controller and AVR for shorts, opens, proper routing, and check pin fit. Check shield wires are properly grounded. Check for correct firmware version Check static voltages on Communication wires with unit not running
1063	VSCF Enable Mismatch	Main controller detects the VSCF Enable state reported by VSCF does not match the state set by HSB.	Probable causes: 1)The enable wire is missing between the AVR and HSB controllers. 2) The enable wire is shorted or miswired, or connector is loose. 3) The controller is faulty. 4) The AVR is faulty.	Check AVR P1 connections Check controller connections Check Enable circuit for proper operation

Table 3-2. VR VSCF-Codes

1064	VSCF Speed PWM Loss	Main controller detects the speed PWM command from VSCF is not received	Probable causes: 1)The speed signal wire is missing between the AVR and HSB controllers. 2) The speed signal wire is shorted or miswired, or connector is loose. 3) The controller is faulty. 4) The AVR is faulty.	Check continuity on the PWM communication lines. Check connector and pin fit
1065	Overfrequency	Main controller detects an over frequency alarm	Engine is 25% over 60Hz for 100ms OR Engine is 20% over 60Hz for 3s	Check stepper operation sticking binding AVR internal issue
1066	VSCF Speed mismatch	Engine speed does not match commanded speed.	1) Large load not wired through loadshed module. 2) Fuel issues (run out, pressure, hose bent), Fuel pin in wrong position. 3) Large overload. 4) Cold engine, not responding. 5) Sticking throttle, throttle wiring. 6) Engine problem.	Fuel Supply not in specifications. Incorrect fuel selection Restricted fuel supply, Check fuel hoses to mixer for restriction Check proper fuel pin selection or restriction in pin orifices. Open MLCB and retest possible Overloaded condition. Perform stepper test Check wire harness proper routing and pin fit. Check magnetos for proper operation. Internal engine concerns
1070	Small fan failure	Current for fan is wrong.	The small fan current is detected as wrong. Possible causes are: 1) Fan wires are broken/miswired. 2) Fan is stalled/clogged. 3) Air path is blocked.	Check AVR Air flow for restriction Perform Small Fan Test
--	Bootloader fails	Fails to load	Probable causes: 1) The USB stick is incompatible 2) The file is not on the USB stick 3) The file is in the wrong folder 4) The file is the wrong file name	
--	Green LED not lit	The AVR has no power	Check the AVR power wiring	
--	Green LED pulsating	The fan is running in cooldown mode	Normal operation	
--	Red LED lit	The AVR has detected a fault	See the display for messages	
	Output voltage is little low or high		Controller not calibrated	Calibrate voltage with calibrated equipment
	Generator does not pull full power		Current calibration not correct Faulty wiring or improperly orientated CT(s) Fuel problem	Calibrate amperage with calibrated equipment Inspect proper installation and test CT(s) Check fuel supply and fuel pressure

Table 3-3. Synergy™ Loadshed

Symptom	Possible Causes
Generator stalls when large load is applied.* *Any load larger than 9 kW (NG) or 10kW (LP) must connected via a load shed module.	1) Check for Fast loadshed proper operation. Large load(s) not properly setup for load shedding. 2) Loadshed is incorrectly wired. 3) Check condition of transfer signal. Wire 23 should be wired to the AVR, NOT the controller. There should only be one wire. 4) Total load is too large for LP (>19 kW)* 5) Total load is too large for NG (>18 kW)*
Large loads keep getting shed and locked out (load led goes out for 30 min.	1) Total load is too big for the generator.
No lights on OPCB	1) Check for proper DC voltage on Wire 194 – approximately12 VDC. 2) Check Wire 0 for proper ground. 3) Remove all wires from OPCB except Wire 194 and 0. Press the reset button for 5 seconds then wait 5 minutes. If there are still no lights, replace the module. If lights return check disconnected wires for proper circuit operation.
OPCB won’t shed loads	1) Connect a DM to Wire 23 and ground. 2) With generator in OFF mode, approximately12 VDC should be measured 3) With generator in AUTO mode, simulate a transfer from utility to standby (loss of utility). Wire 23 should drop from approximately12 VDC to zero. If not, verify operation of Wire 23 circuit.

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Utility Source Voltage Available

Figure 3-35 is a schematic representation of the transfer switch with utility source power available. The circuit condition is briefly described as follows:

- Utility source voltage is available to terminal lugs N1 and N2 of the contactor; the transfer switch is in the UTILITY position and Utility voltage is available to T1 and T2, customer load.
- Utility source voltage is available to the limit switch (SW2) via the normally closed transfer relay contacts (1 and 5) and Wire 126; however, SW2 is open and the circuit to the utility closing coil is open.
- Utility voltage "sensing" signals are delivered to controller on the generator, via Wire N1A, and a 5-amp fuse (F1). The second line of the utility voltage "sensing" circuit is via Wire N2A, and a 5 amp fuse (F2).

NOTE: This is an example of Transfer Switch Operational Analysis. For troubleshooting use the operational analysis with the appropriate wiring/schematic diagrams.

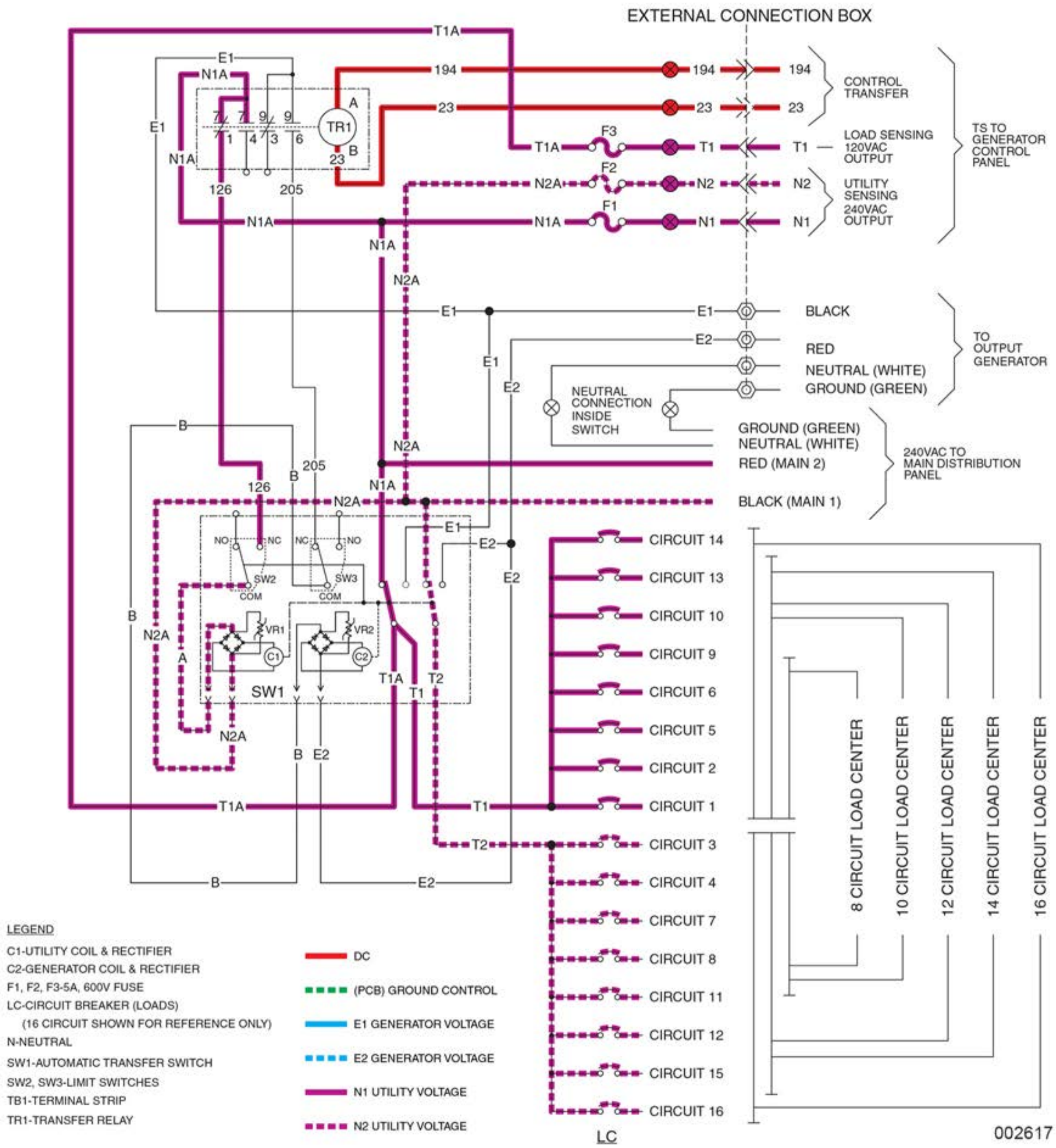


Figure 3-35. Utility Source Voltage Available

Utility Source Voltage Failure

If Utility source voltage drops below 65% of nominal voltage for ten seconds, the controller will initiate engine start. After the generator starts a five (5) second engine warm-up timer is initiated. During this warm-up the generator is running at rated frequency and voltage. ***Figure 3-36*** is a schematic representation of the transfer switch with the Generator running with voltage available to the transfer switch.

generator voltage available on contactor terminals E1 and E2.

- Controller logic is holding Wire 23 open from ground.
- Generator voltage from terminal E2 is available at the standby coil (C2). Generator voltage from Terminal E1 is available to the transfer relay at Pin 4. The transfer relay is not energized so E1 voltage will not go through the N.O. contact (4 & 6) to Wire 205.

NOTE: This is an example of Transfer Switch Operational Analysis. For troubleshooting use the operational analysis with the appropriate wiring/schematic diagrams.

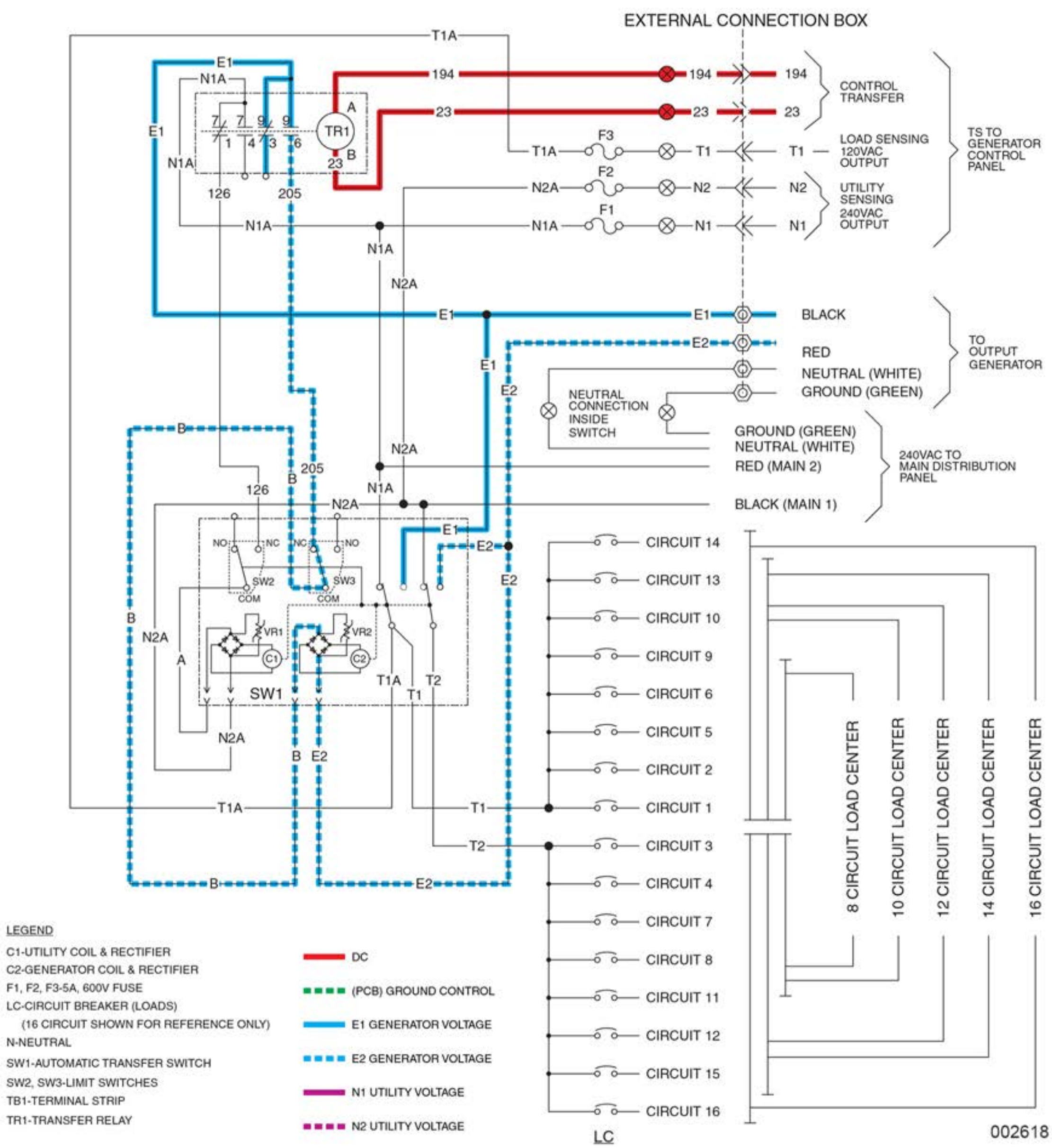


Figure 3-36. Utility Source Voltage Failure

Transferring to Standby

12 VDC is delivered to the transfer relay through Wire 194 and back to the AVR through Wire 23. When the five (5) second engine warm-up timer expires, the AVR will take Wire 23 to ground which will energize the transfer relay. The N.O. and N.C. relay contacts will change states. This will connect generator voltage from E1 at Pin 4 to Wire 205. The voltage will go through the N.C contact of SW3. Voltage from both E1 and E2 will be available at the C2 coil. This voltage will pass through the rectifier in the coil. The coil will then energize.

NOTE: This is an example of Transfer Switch Operational Analysis. For troubleshooting use the operational analysis with the appropriate wiring/schematic diagrams.

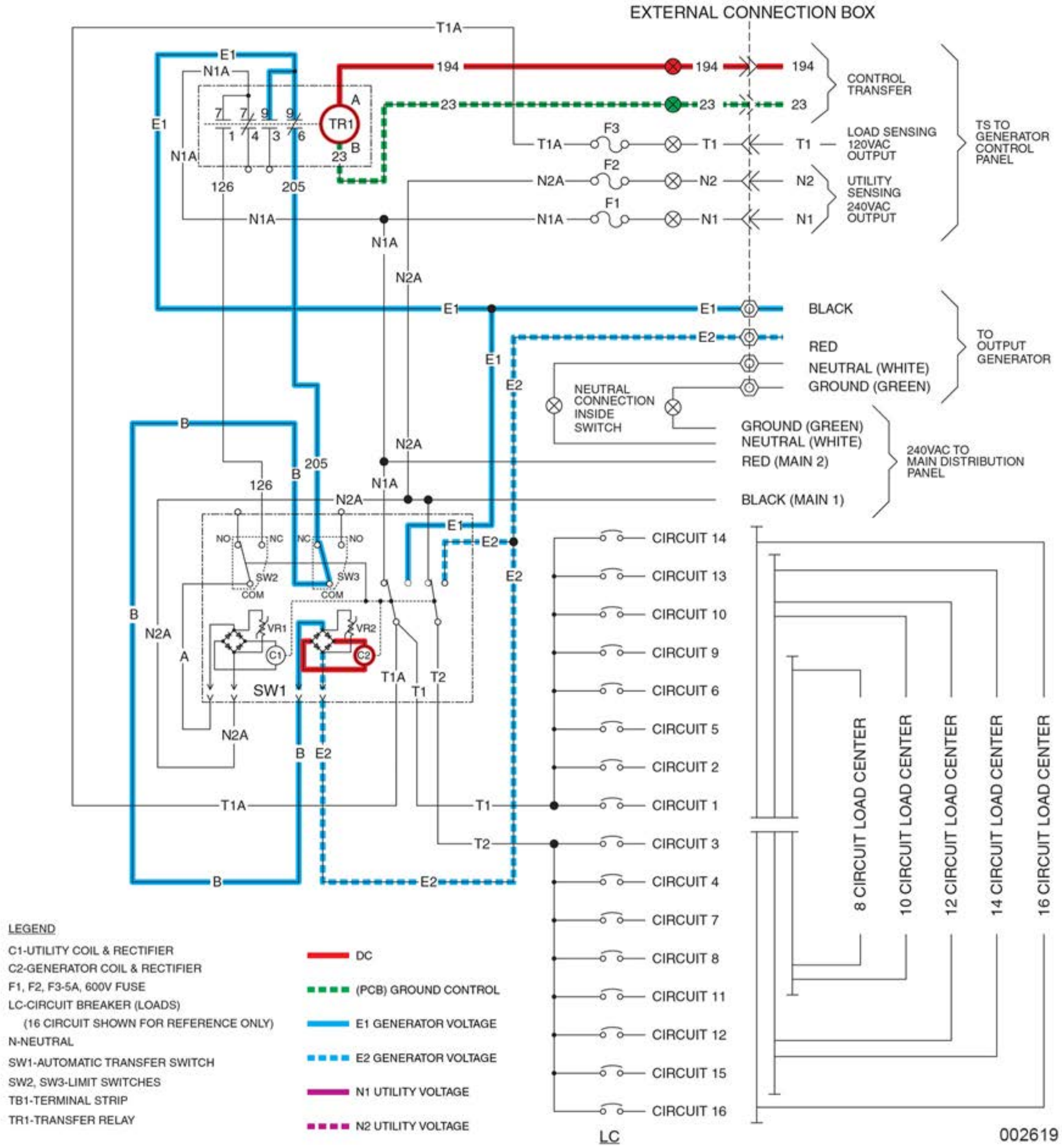


Figure 3-37. Transferring to Standby

Transferred to Standby

When the standby coil (C2) energizes it pulls the contactor to an “over center” position towards the STANDBY position, the transfer switch mechanically snaps to that position. Upon closure of the main contacts to the STANDBY position limit switches SW2 and SW3 mechanically actuate to “arm” the circuit for re-transfer to the UTILITY position. When SW3 changes it opens the circuit providing voltage to the standby closing coil (C2). Voltage from the generator, connected through T1 and T2, provides power to customer connected loads.

NOTE: This is an example of Transfer Switch Operational Analysis. For troubleshooting use the operational analysis with the appropriate wiring/schematic diagrams.

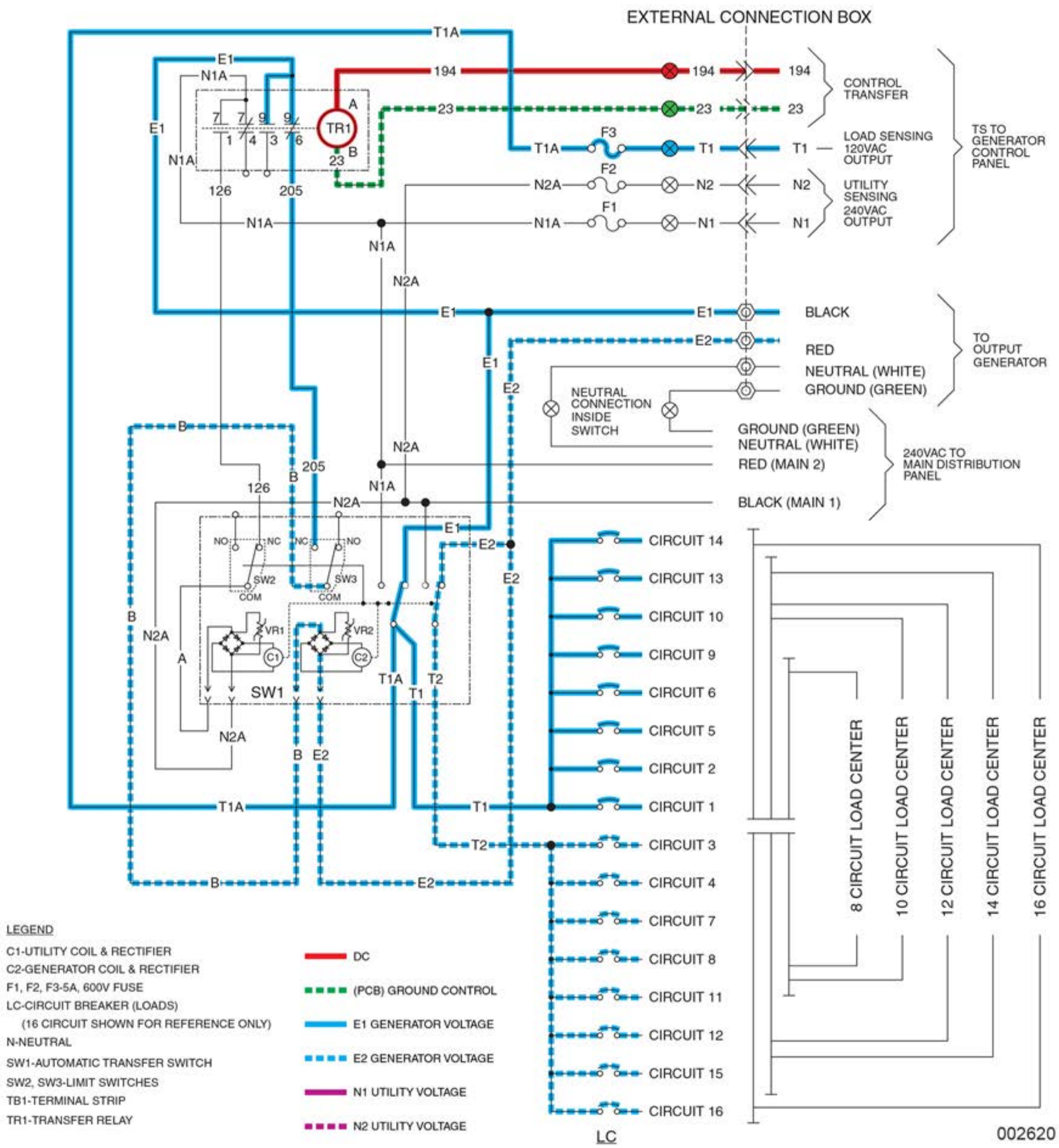


Figure 3-38. Transferred to Standby

Utility Restored

Utility voltage is restored and available to terminals N1 and N2. The Utility voltage is "sensed" by the controller and, if it is above 75% of nominal for 15 consecutive seconds, a transfer back to UTILITY will occur.

NOTE: This is an example of Transfer Switch Operational Analysis. For troubleshooting use the operational analysis with the appropriate wiring/schematic diagrams.

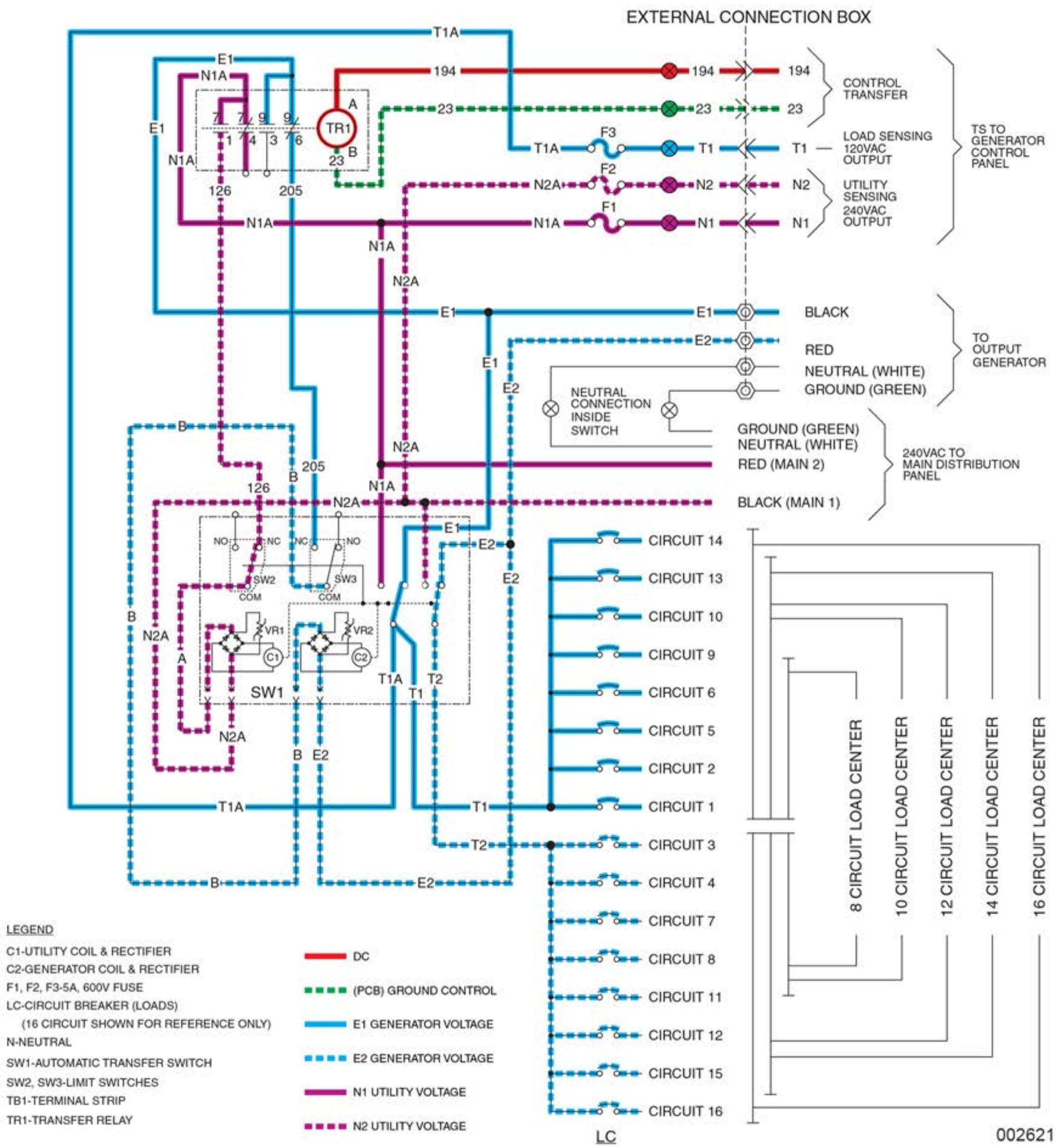


Figure 3-39. Utility Restored

Utility Restored, Transferring Back to Utility

After the 15 second return to utility delay expires, the AVR will open the Wire 23 circuit from ground. The transfer relay (TR1) de-energizes, the N.O. and N.C. contacts change state. Utility voltage is delivered to the utility closing coil (C1) through Wires N1A and N2A, the normally closed contacts (1 and 5), Wire 126, and limit switch (SW2). With utility voltage applied to both sides of the utility closing coil (C1), the rectifier in the coil causes the coil to energize.

NOTE: This is an example of Transfer Switch Operational Analysis. For troubleshooting use the operational analysis with the appropriate wiring/schematic diagrams.

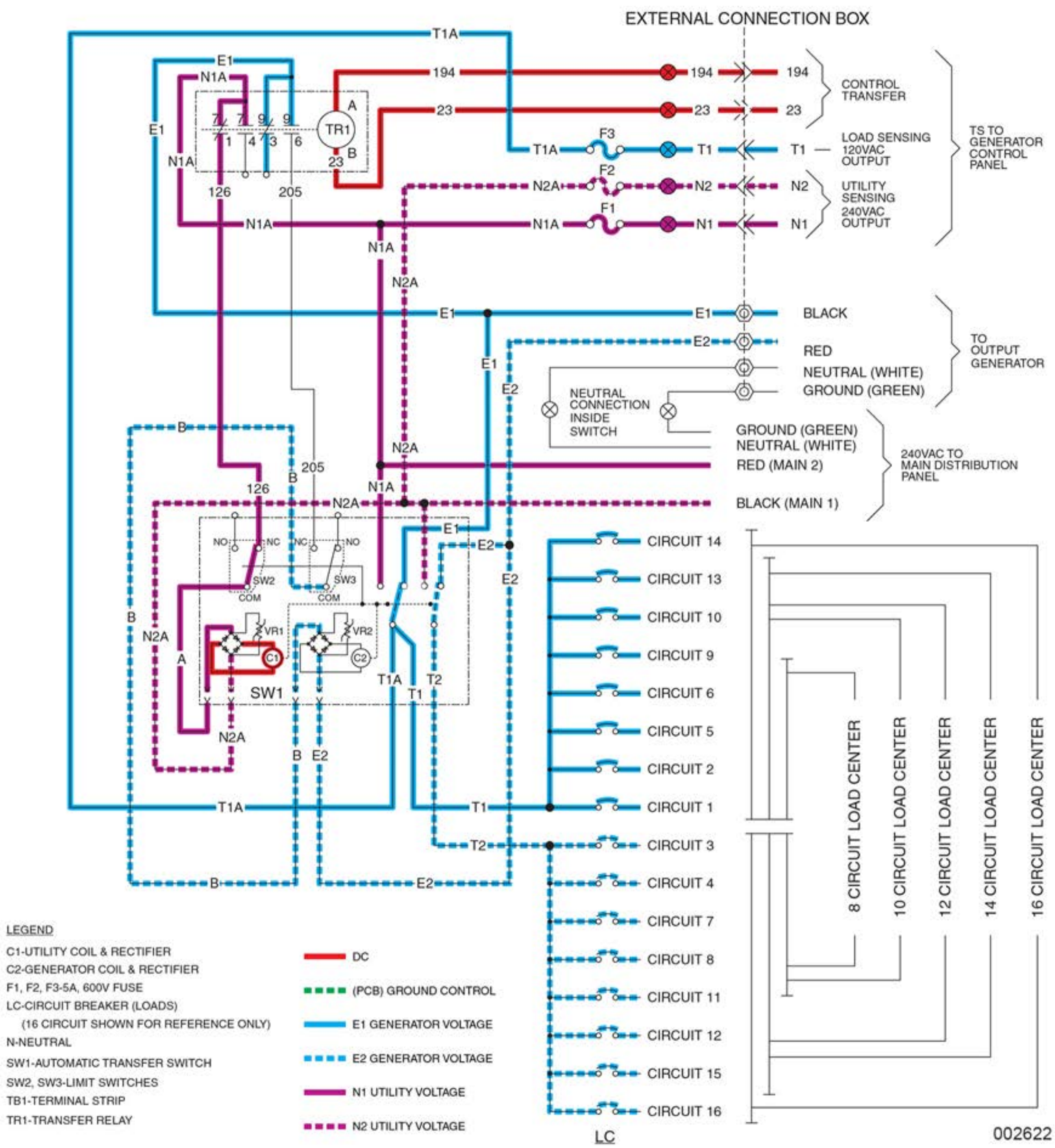


Figure 3-40. Utility Restored, Transferring Back to Utility

Utility Restored, Transferred Back to Utility

As the utility closing coil pulls the transfer switch to an “over center” position, the switch mechanically snaps to the UTILITY position. Upon closure of the contacts to UTILITY, the limit switches (SW2 and SW3) mechanically actuate to “arm” the circuit for the next transfer to STANDBY. When switch SW2 changes states, the circuit providing voltage to the utility transfer coil is opened, and the coil de-energizes.

NOTE: This is an example of Transfer Switch Operational Analysis. For troubleshooting use the operational analysis with the appropriate wiring/schematic diagrams.

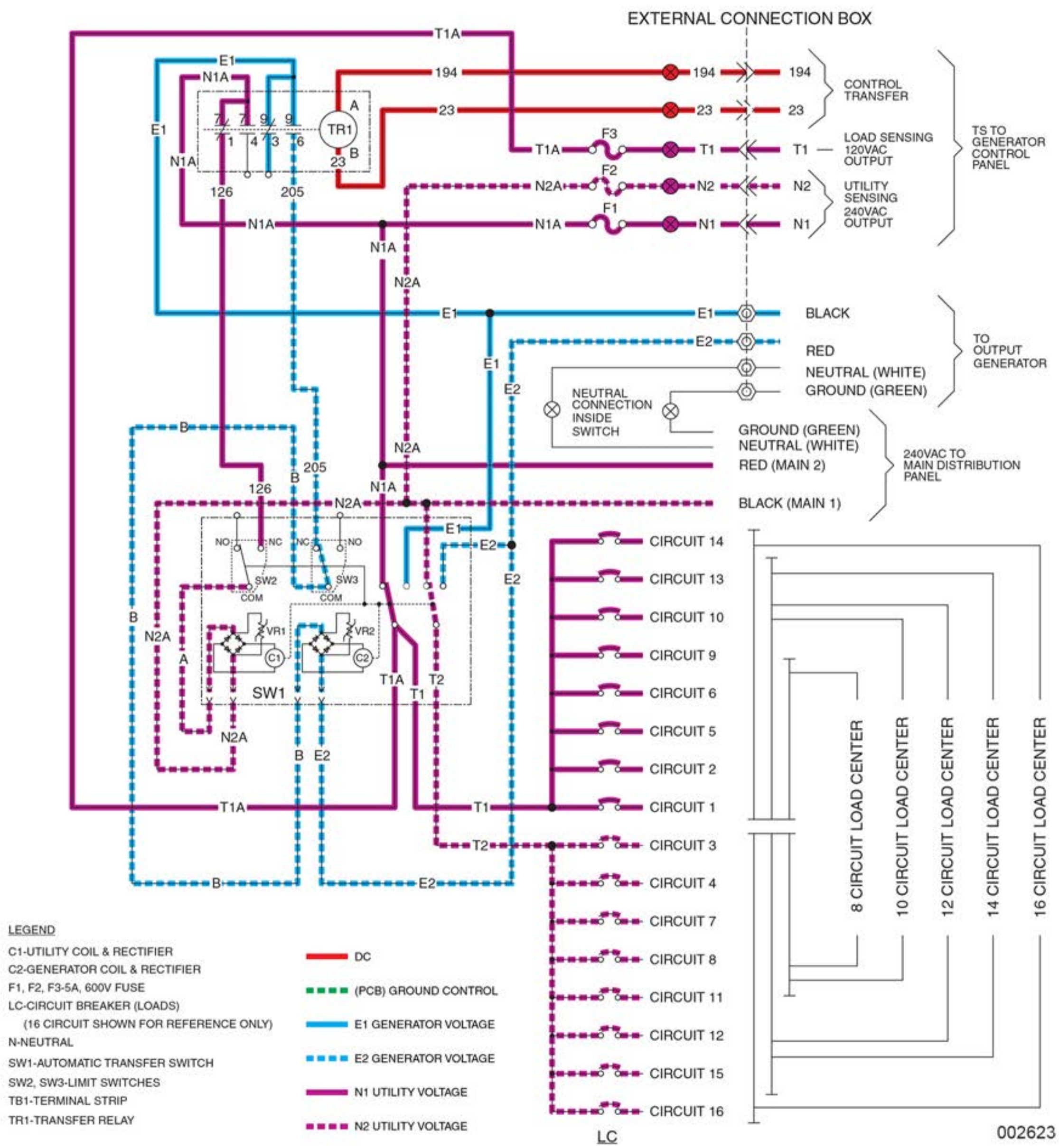


Figure 3-41. Utility Restored, Transferred Back to Utility

Transferred Back to Utility, Generator Shutdown

When the transfer switch returns to the UTILITY position the controller will shut the generator down after the one minute engine cool-down timer expires.

After generator has cooled and shut down, the AVR initiates a cool down process. When the AVR has cooled sufficiently, it also shuts down.

NOTE: This is an example of Transfer Switch Operational Analysis. For troubleshooting use the operational analysis with the appropriate wiring/schematic diagrams.

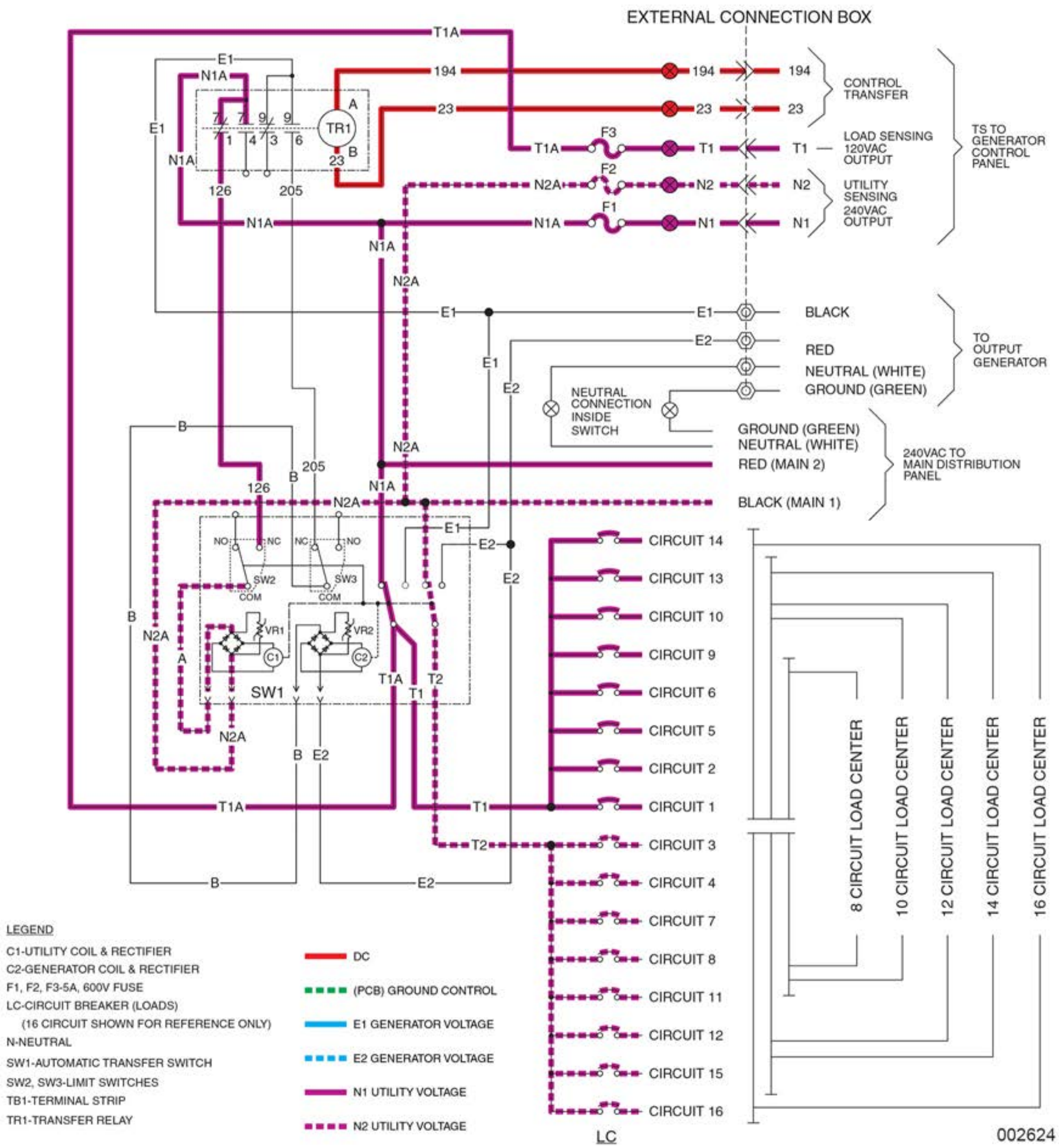
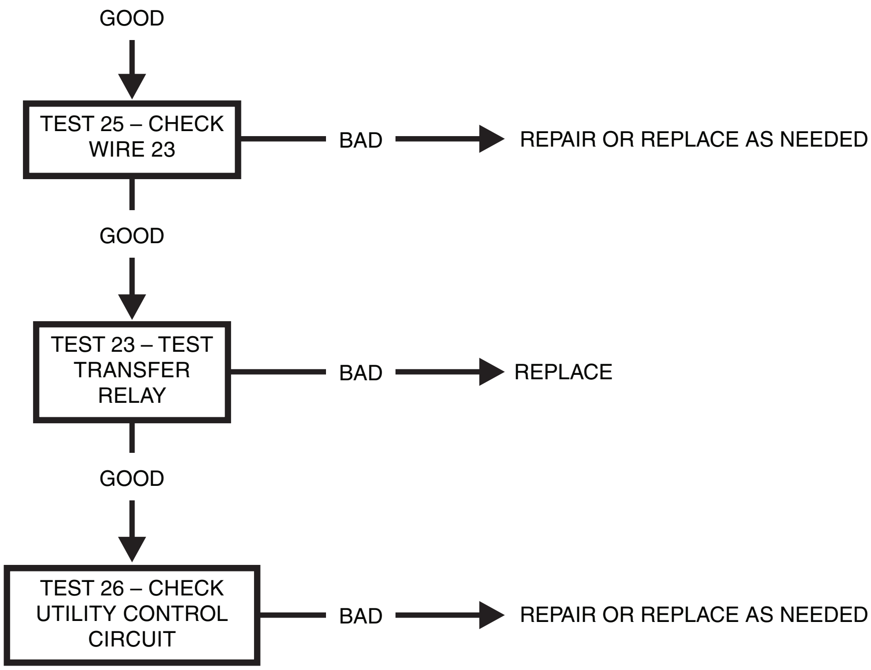


Figure 3-42. Transferred Back to Utility, Generator Shutdown

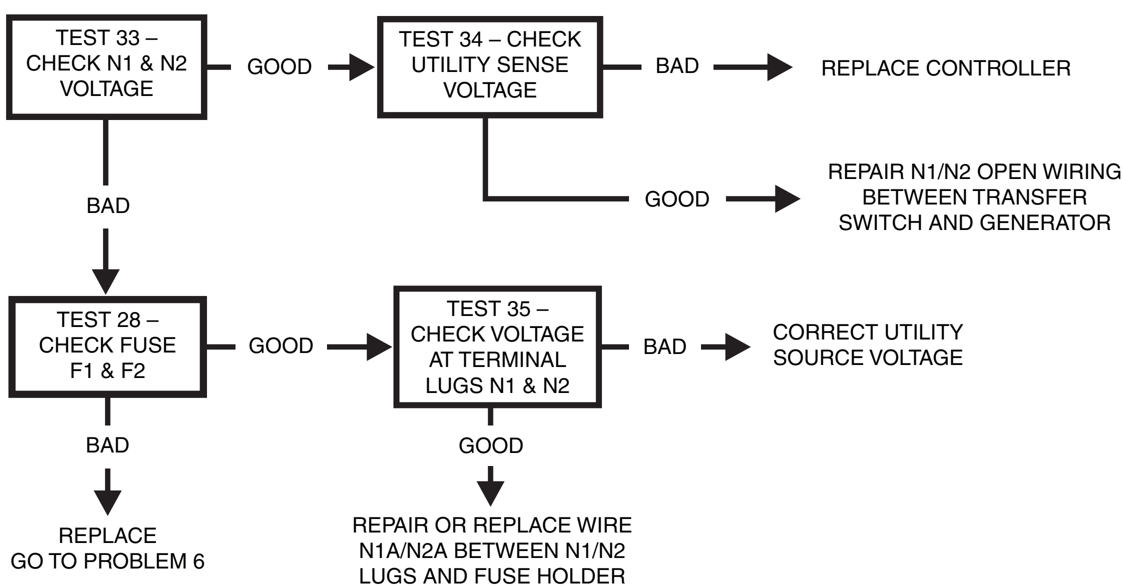
Introduction

Use the “Flow Charts” in conjunction with the detailed instructions in Section 3.4. Test numbers used in the flow charts correspond to the numbered tests in Section 3.4. The first step in using the flow charts is to identify the correct problem on the following pages. For best results, perform all tests in the exact sequence shown in the flow charts.

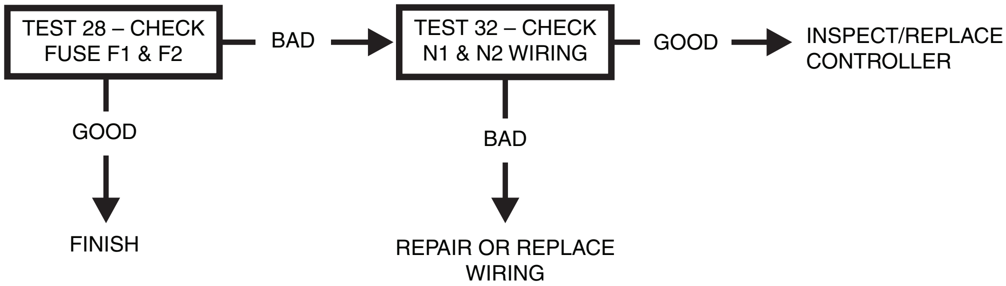
Problem 7 – In Automatic Mode, Generator Starts When Loss of Utility Occurs, Generator Shuts Down When Utility Returns But There is No Re-transfer to Utility Power
Or
Generator Transfers to Standby During Exercise or in Manual Mode



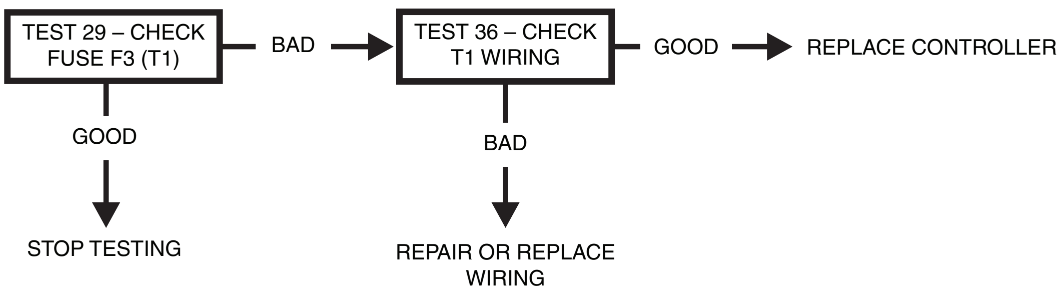
Problem 8 – Unit Starts and May or May Not Transfer When Utility Power is On



Problem 9 – Blown F1 or F2 Fuse



Problem 10 – Blown T1 Fuse



Section 3.4 Diagnostic Tests

Introduction

This section familiarizes the service technician with acceptable procedures for the testing and evaluation of various problems that can occur on pre-packaged transfer switches. The numbered tests in this section correspond with the flow charts in Section 3.3: ***Troubleshooting Flowcharts***.

Some test procedures in this section may require the use of specialized test equipment, meters or tools. Most tests can be performed with a Digital Multimeter (DM). An AC frequency meter is required, where frequency readings must be taken. To measure AC loads it is acceptable to use a clamp-on ammeter.

Testing and troubleshooting methods covered in this section are not exhaustive. No attempt has been made to discuss, evaluate and advise the home standby service trade of all conceivable ways in which service and trouble diagnosis must be performed. Accordingly, anyone who uses a test method not recommended herein must first satisfy himself that the procedure or method he has selected will jeopardize neither his nor the products safety.

Safety

Service personnel who work on this equipment should be aware of the dangers of such equipment. Extremely high and dangerous voltages are present that can kill or cause serious injury. Gaseous fuels are highly explosive and can ignite by the slightest spark. Engine exhaust gases contain deadly carbon monoxide gas that can cause unconsciousness or even death. Contact with moving parts can cause serious injury. The list of hazards is seemingly endless.

When working on this equipment, use common sense and remain alert at all times. Never work on this equipment while physically or mentally fatigued. If you do not understand a component, device or system, do not work on it.

Transfer Switch Troubleshooting

It is always good practice to continue to ask questions during the troubleshooting process. When evaluating the problem, asking some of these questions may help identify the problem quicker.

- What is the transfer switch doing?
- What was the transfer switch supposed to do?
- Does the transfer switch have the same fault consistently, and when does it occur?
- Who is controlling it?
- Exactly what is occurring?
- When is it happening?
- Why would this happen?
- How would this happen?
- What type of test will either prove or disprove the cause of the fault?

Test 20—Check Voltage at Terminal Lugs E1 and E2

General Theory

While in AUTOMATIC mode, the standby closing coil (C2) energizes utilizing generator output to transfer to the STANDBY position. Transfer to STANDBY cannot occur unless generator voltage is available to the transfer switch.

If the generator is not producing the correct voltage, it will shutdown on an under or over-voltage alarm and thus will not be running.

Two procedures have been provided for this test. The first procedure is performed in the event that the generator is already running in a utility failure. The second procedure is performed if the generator has already shutdown. It is not required to complete both procedures.

⚠DANGER

Electrocution. High voltage is present at transfer switch and terminals. Contact with live terminals will result in death or serious injury.

(000129)

Procedure 1: Generator Running in Utility Failure, Switch did not Transfer

1. Set multimeter (DM) to measure AC voltage.
2. If the generator engine has started automatically (due to a utility failure) and is running, check the position of the generator main line circuit breaker. The circuit breaker must be set to the CLOSED position. After confirming that the generator main circuit breaker is set to the CLOSED position, verify the voltage at transfer switch contactor terminal lugs E1 and E2 with an accurate AC meter. The meter should indicate generator line-to-line voltage.

Procedure 2: Generator Shutdown

1. Set the controller to OFF.
2. Set DM to measure AC voltage.
3. Disconnect utility voltage from the transfer switch.

4. Verify the contactor is in the UTILITY position.
5. Verify the generator main line circuit breaker (MLCB) is in the CLOSED position.
6. Set the controller to MANUAL.
7. If transfer to the STANDBY position does not occur, check the voltage across terminal lugs E1 and E2. The DM should indicate generator line-line voltage.

Results

1. If normal transfer to the STANDBY position occurs, discontinue testing.
2. If transfer to the STANDBY position did not occur, but the generator continued to run for longer than 10 seconds, and the DM did not indicate voltage across E1 and E2, proceed to ***Test 1—Check AC Output Voltage***.
3. If transfer to the STANDBY position did not occur and the DM indicated proper voltage across E1 and E2 this test is GOOD; refer to back to flow chart.
4. If transfer to the STANDBY position did not occur and the generator faulted on undervoltage, refer to ***Table 3-1*** and ***Table 3-2*** in Section 3.1 ***Description and Major Components*** for the undervoltage fault code displayed on the controller.

Test 21—Check Manual Transfer Switch Operation

General Theory

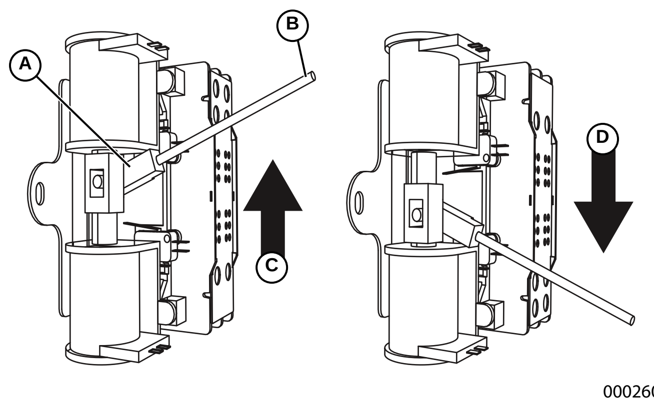
In automatic operating mode, when utility source voltage drops below a preset level, the engine should crank and start. On engine startup, an “engine warm-up timer” on the generator should start timing. After the timer has expired (about 15 seconds), the transfer relay (TR1) energizes to deliver generator source voltage to the standby closing coil terminals. If generator voltage is available to the standby closing coil terminals, but transfer to standby does not occur, the cause of the failure may be (a) a failed standby closing coil and/or bridge rectifier, or (b) a seized or sticking actuating coil or load contact. This test will help to evaluate whether any sticking or binding is present in the contactor.

Procedure

1. Set the generator main line circuit breaker (MLCB) to the OPEN position.
2. Set the controller to OFF.
3. Disconnect utility from the transfer switch.

NOTE: Do not attempt manual transfer switch operation until all voltage to the switch has been disconnected. Failure to turn off all power voltage supplies may result in extremely hazardous and possibly lethal electrical shock.

4. Locate the manual transfer handle inside the switch enclosure.
5. See ***Figure 3-43***. Insert the un-insulated end of the handle over the transfer switch-operating lever.
6. Manually actuate the contactor lever up to the UTILITY position.
7. Actuate the operating lever down to the STANDBY position.
8. Repeat step 5 several times. When the contactor lever is moved, slight force should be needed until the lever reaches its center position. As the lever moves past its “over center” position, an over-center spring should snap the movable load contacts against the stationary standby or utility contacts.
9. Actuate the contactor to the UTILITY position.



A. Transfer switch-operating lever

B. Manual transfer handle

C. Load connected to utility power source

Figure 3-43. Manual Transfer Switch Operation

Results

1. If there is no evidence of binding, sticking, or excessive force required the test is GOOD; refer to flow chart.
2. If evidence of sticking, binding, excessive force is required to move the contactor, find cause of binding or sticking and repair or replace damaged components.

Test 22—Check 23 and 194 Circuit

General Theory

NOTE: There are three variations of transfer relays (TR1) used in production. See the figures in ***Test 23—Test Transfer Relay*** for identification.

An OPEN circuit in the switch control wiring will prevent a transfer from occurring. Terminal “A” or “7” or “13” of the transfer relay (TR1) connects to wire 194. Terminal “B” or “8” or “14” connects to wire 23. Wire 194 provides 12

VDC to terminal “A” or “7” or “13”, and the AVR holds wire 23 open from ground. With wire 23 open from ground TR1 is de-energized.

NOTE: De-energized TR1 relay voltage checks:

- Wire 194 to Ground = 12 VDC
- Wire 194 to Wire 23 = 0 VDC
- Wire 23 to Ground =12 VDC

Table 3-4. TR1 Relay Terminal Connections

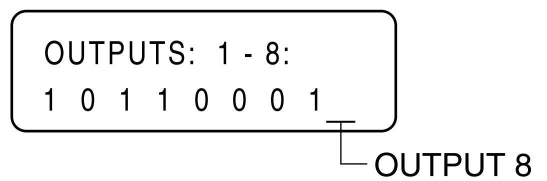
Coil Resis-tance	Wire 194	Wire 23	Wire N1A	Wire 126	Wire E1	Wire 205
160 Ohms	7	8	5	1	6	4

Procedure/Results

1. Disconnect and isolate wire 23 at the transfer switch terminal strip coming from the generator. Set the generator's controller to AUTO mode; simulate a utility failure.
2. Once the generator is running, connect a jumper wire from ground to wire 23 located at the terminal strip. Listen and visually watch for the energizing of the TR1 relay and for the transfer to standby.
   a. If the TR1 relay visually and audibly energized and the contactor transferred to the STANDBY position, stop testing, proceed to ***Test 25—Check Wire 23***.
   b. If the transfer relay did not energize, continue to step 3.
   c. If the TR1 relay visually and audibly energized and the CONTACTOR did not transfer to the STANDBY position, proceed to ***Test 23—Test Transfer Relay***.
3. Set the generator controller to OFF mode.
4. Set DM to measure DC voltage.
5. Connect the negative (-) test lead to ground in the transfer switch. Connect the positive (+) test lead to wire 194 at the terminal strip located in the transfer switch.
   a. If voltage is present, proceed to step 6.
   b. If voltage is not present, proceed to step 17.
6. Connect the positive (+) test lead to wire 23 at the terminal strip located in the transfer switch. Connect the negative (-) test lead to a ground in the transfer switch.
   a. If voltage is present, proceed to step 9.
   b. If voltage is not present, proceed to step 7.
7. Set DM to measure resistance.
8. Remove wire 23 and wire 194 going to the TR1 relay from the terminal strip. Connect the meter test leads across wire 23 and wire 194 (going to the relay).
   a. The DM should indicate TR1 coil resistance indicated in ***Table 3-4***.
   b. If coil resistance is not measured, remove wire 23 and wire 194 from the TR1 relay. Measure across the TR1 terminal connections indicated in ***Table 3-4***.
   c. If coil resistance is measured, repair or replace wire 23 or wire 194 between the terminal strip and the TR1 relay.
   d. If coil resistance is not measured, replace TR1 relay and retest.

NOTE: Re-connect wires before proceeding to step 9.

9. Connect the negative (-) test lead to the ground lug in the generator control panel. Connect the positive (+) test lead to wire 23 in the generator at the customer connection terminal strip.
   a. If voltage is present, proceed to step 10.
   b. If voltage is not present, repair wiring between transfer switch and generator control panel.
10. Simulate a power failure (open utility service breaker) with the controller in the AUTO mode. Approximately 10 seconds after starting, navigate to the controller's digital output screen.
11. See ***Figure 3-44***. Digital output 8 is the wire 23 output from the controller.



002522

Figure 3-44. The Output Screen – Output 8

12. If output 8 shows a “1”, then the control board is grounding wire 23.
   a. If output 8 did not change replace the controller.
   b. If output 8 did change, proceed to next step.
13. Locate and disconnect the appropriate harness connectors from the controller and AVR.
14. Set the DM to measure resistance.
15. Connect one meter test lead to pin for wire 23 on the connector. Connect the other meter test lead to pin for wire 194. DM should indicate coil resistance shown in ***Table 3-4***.
   a. If the DM indicated correct resistance, repair or replace the wire 23 connection.
   b. If the DM indicated INFINITY, repair or replace wire 23 between harness connector and the generator terminal strip.
   c. If resistance is not within specification, proceed to ***Test 23—Test Transfer Relay***.

16. Set DM to measure DC voltage.
17. Connect the negative (-) test lead to the ground lug in the generator control panel. Connect the positive (+) test lead to wire 194 at the terminal strip in the generator control panel.
    a. If voltage is present, repair wire 194 between the generator terminal strip and transfer switch terminal strip.
    b. If voltage is not present, proceed to step 18.
18. Locate and disconnect the proper connector from the controller.
19. Set DM to measure resistance.
20. Connect one meter test lead to wire 194 at the generators customer connection terminal strip. Connect the other meter test lead to the proper pin at the controller connector.
21. Continuity should be measured.
    a. If continuity is not measured, repair pin connection and/or wire 194 between the connector and terminal strip.
    b. If continuity is measured, proceed to step 24.
22. Remove the generator fuse.
23. Reconnect the controller connector.
24. Re-install the fuse.
25. Disconnect wire 194 from the generator's terminal strip.
26. Set DM to measure DC voltage.
27. Connect one meter test lead to wire 194. Connect the other meter test lead to a clean frame ground, 12 VDC should be measured.
    a. If 12 VDC is not measured, replace the controller.
    b. If 12 VDC is measured, a short exists on wire 194 or the TR1 relay. Repair or replace as needed.

Test 23—Test Transfer Relay

General Theory

In automatic mode, transfer to standby will not occur until the transfer relay (TR1) energizes. When TR1 relay energizes, generator source voltage is available to operate the standby closing coil. Without generator source voltage available, the closing coil will remain de-energized and transfer to the STANDBY position will not occur. This test will determine if the TR1 relay is functioning normally.

Procedure

1. See ***Figure 3-45*** for transfer relay wiring configuration. Disconnect all wires from the TR1 relay to prevent interaction.

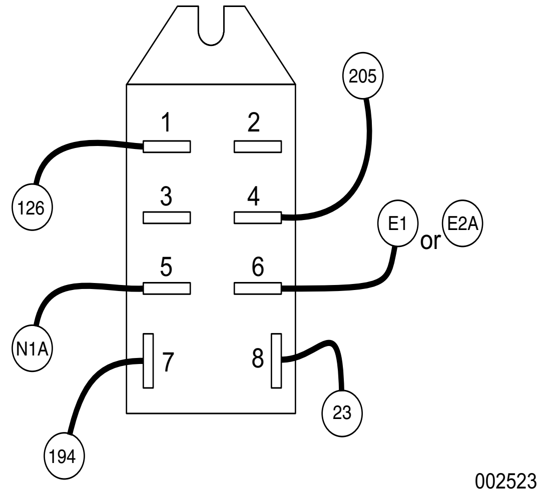


Figure 3-45. Transfer Relay Test Points

2. Set DM to measure resistance.
3. See ***Figure 3-45***. With the wires disconnected, connect the DM test leads across relay terminals where wires 194 and 23 were connected. Measure and record the resistance.
4. See ***Figure 3-45***. Using jumper wires, connect one fused jumper wire from the positive post of the battery to the relay terminal that had wire 194 and connect the other jumper wire from the negative post of the battery to the relay terminal that had wire 23.
5. Connect the DM test leads across relay terminals per ***Table 3-5***. Measure and record the resistance energized and De-energized.
    a. Energize the relay. The meter should indicate either INFINITY or CONTINUITY according to ***Table 3-5***.
    b. De-energize the relay. The DM should indicate CONTINUITY or INFINITY according to ***Table 3-5***.
6. Repeat step 5 across relay terminals 7 and 1.

Table 3-5. Horizontal Mounted “Clear” Transfer Relay OMRON®

Connect DM Test Leads Across:	Desired Meter Reading	
	Energized	De-Energized
Terminals 4 and 6	Continuity	Infinity
Terminals 1 and 5	Infinity	Continuity
Terminals 7 and 8 (Coil)		160 Ohms

Results

1. Compare the results with ***Table 3-5***. If the relay tests good, refer back to flow chart.
2. Replace relay if defective.

Test 24—Test Standby Control Circuit

General Theory

See *Figure 3-46*. The standby coil (C2) requires 240 VAC to energize. When the transfer relay energizes, 240 VAC is applied to the C2 coil. Once energized, the coil will pull the contactor down to the STANDBY position. Once in the STANDBY position, the limit switch (SW3) will open, removing AC voltage from the C2 coil.

Procedure/Results

1. Set the DM to measure AC voltage.
2. Measure between the E2 terminal and terminal 2 of the C2 coil, the DM should indicate 240 VAC.
   a. If 240 VAC was not measured, continue testing.
   b. If 240 VAC was measured, replace the C2 coil.
3. Verify the contactor is in the UTILITY position.
4. Remove wire B from the C2 coil.
5. Set the controller to AUTO. Turn off utility power supply to the transfer switch, simulating a utility failure. The generator should start and the transfer relay should energize.
6. Measure across lugs E1 and E2, the DM should indicate 240 VAC.
   a. If 240 VAC was NOT measured, go back to Test 20.
   b. If 240 VAC was measured, proceed to step 7.
7. Measure for the voltage on wire B from the lug to 1 of the C2 coil (Wire B previously removed from the coil) and B, the DM should indicate 240 VAC.
   a. If 240 VAC was NOT measured, repair or replace Wire E2.
   b. If 240 VAC was measured, proceed to step 8.
8. Measure between the E2 lug and terminal 9 on the TR1, the DM should indicate 240 VAC.
   a. If 240 VAC was NOT measured, repair or replace wire E1.
   b. If 240 VAC was measured, proceed to step 8.
9. Measure between the E2 terminal and terminal 6 of the TR1, the DM should indicate 240 VAC.
   a. If 240 VAC was NOT measured, replace transfer relay.
   b. If 240 VAC was measured, proceed to step 10.
10. Measure between the E2 terminal and the top terminal of SW3 the DM should indicate 240 VAC.
    a. If 240 VAC was NOT measured, repair or replace wire 205.
    b. If 240 VAC was measured, proceed to step 11.
11. Measure between the E2 terminal and the bottom terminal of the SW3, the DM should indicate 240 VAC.
    a. If 240 VAC was NOT measured, verify the limit switch (SW3) is wired correctly, proceed to *Test 27—Test Limit Switches*.
    b. If 240 VAC was measured, proceed to step 12.
12. Measure between the E2 terminal and terminal 2 of the C2 coil, the DM should indicate 240 VAC.
    a. If 240 VAC was NOT measured, repair or replace wire B.
    b. If 240 VAC was measured, replace the C2 coil.

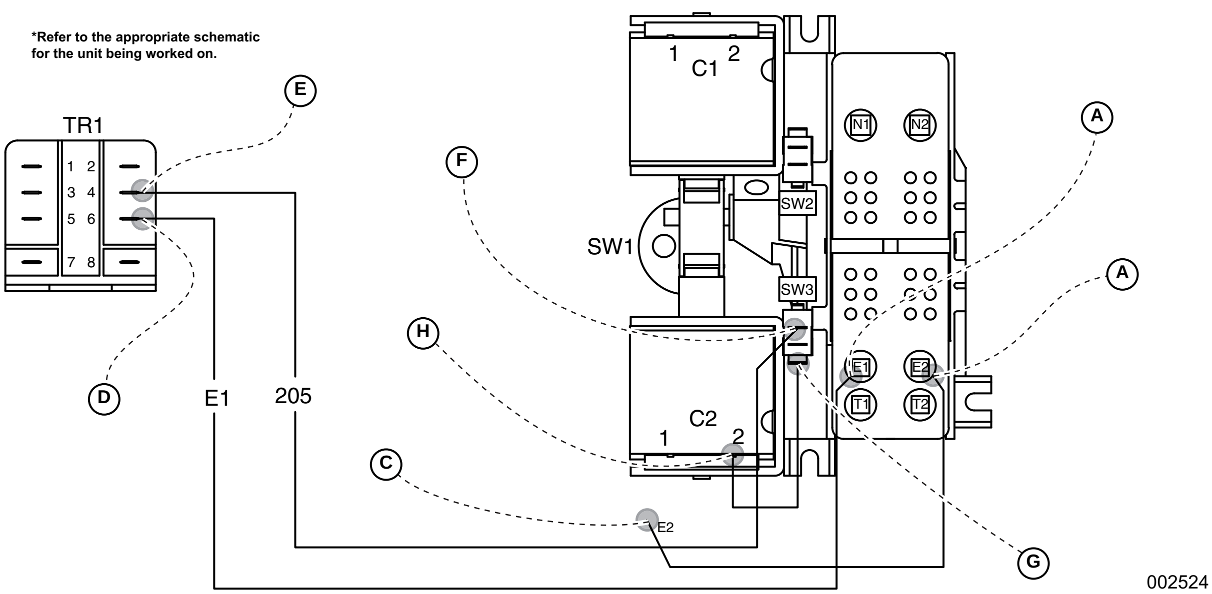


*Figure 3-46. Typical Standby Control Circuit Test Points**

Test 25—Check Wire 23

General Theory

The AVR and controller located in the generator are responsible for grounding wire 23 in order to initiate a transfer. When wire 23 closes to ground the transfer relay (TR1) energizes. To initiate a transfer to utility, the TR1 relay must de-energize. If the TR1 relay is staying energized, a grounded wire 23 could be the cause.

Procedure/Results

1. Set the DM to measure DC voltage.
2. Set the controller to OFF.
3. Connect the positive meter test lead to wire 194 and connect the negative meter test lead to wire 23 located in the customer connection in the transfer switch.
    a. If 0 VDC was measured, proceed to step 4.
    b. If 12 VDC was measured, proceed to step 13.
4. Set the controller to AUTO.
5. Connect the positive meter test lead to wire 194 and connect the negative meter test lead to wire 23 located in the transfer switch.
    a. If 12 VDC was measured, proceed to step 6.
    b. If 0 VDC was measured, the wire 23 circuit is good, refer back to flow chart.
6. Access the output screen shown below via the menu system based on the controller you are working with.
7. See ***Figure 3-47***. Digital output 8 is the wire 23 output from the controller.
8. If output 8 shows a “1”, then the control board is requesting the grounding of wire 23.
9. See ***Figure 3-48***. Locate the terminal strip in the generator control panel. Disconnect wire 23 coming in from the transfer switch (customer side).

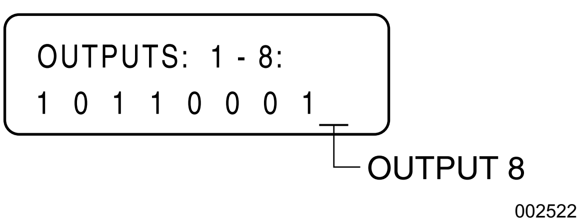
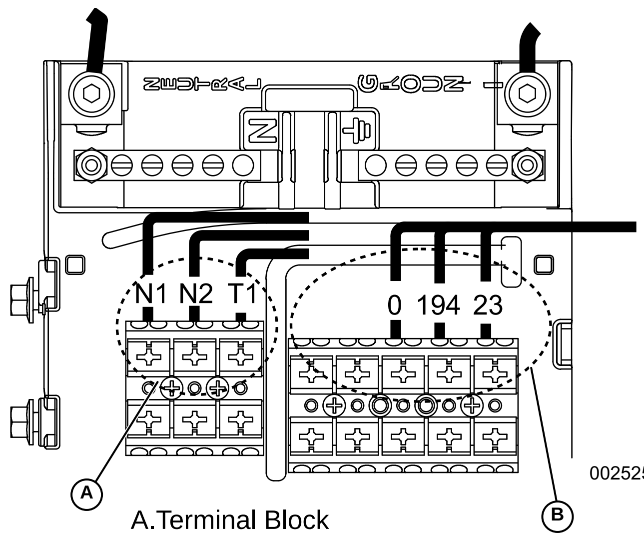


Figure 3-47. The Output Screen – Output 8

10. Connect the positive meter test lead to wire 194 at the terminal strip in the generator and connect the negative meter test lead to wire 23 just removed from the terminal strip in step 9 (customer side).
    a. If 0 VDC was measured, proceed to step 11.
    b. If 12 VDC was measured, a short to ground exists on wire 23 between the generator and transfer switch. Repair or replace wire 23 as needed between the generator control panel and transfer switch relay (TR1).
11. Continue to have wire 23 disconnected on the customer side.
12. Disconnect the appropriate connector from the AVR.
13. Set DM to measure resistance.
14. Connect one meter test lead to wire 23 connected at the terminal strip (see Figure 98) and connect the other meter test lead to a clean frame ground.
    a. If INFINITY or OPEN was measured, replace the AVR.
    b. If CONTINUITY was measured, wire 23 is shorted to ground. Repair or replace wire 23 between the AVR connector and the generator terminal strip.



A.Terminal Block

B.Terminal Strip - Customer Side

Figure 3-48. Transfer Relay Test Points

Test 26—Test Utility Control Circuit

General Theory

See **Figure 99**. The utility coil (C1) requires 240 VAC to energize. When the transfer relay (TR1) de-energizes, 240 VAC is applied to the C1 coil. Once energized, the coil will pull the CONTACTOR up to the UTILITY position. Once in the UTILITY position, the limit switch (SW2) will open, removing AC voltage from the C1 coil.

Procedure

1. Set the controller to OFF. Disconnect wire 194 from the transfer switch terminal strip.
2. Set DM to measure AC voltage.
3. Disconnect utility supply voltage from the transfer switch.
4. Verify the transfer switch is in the STANDBY position.

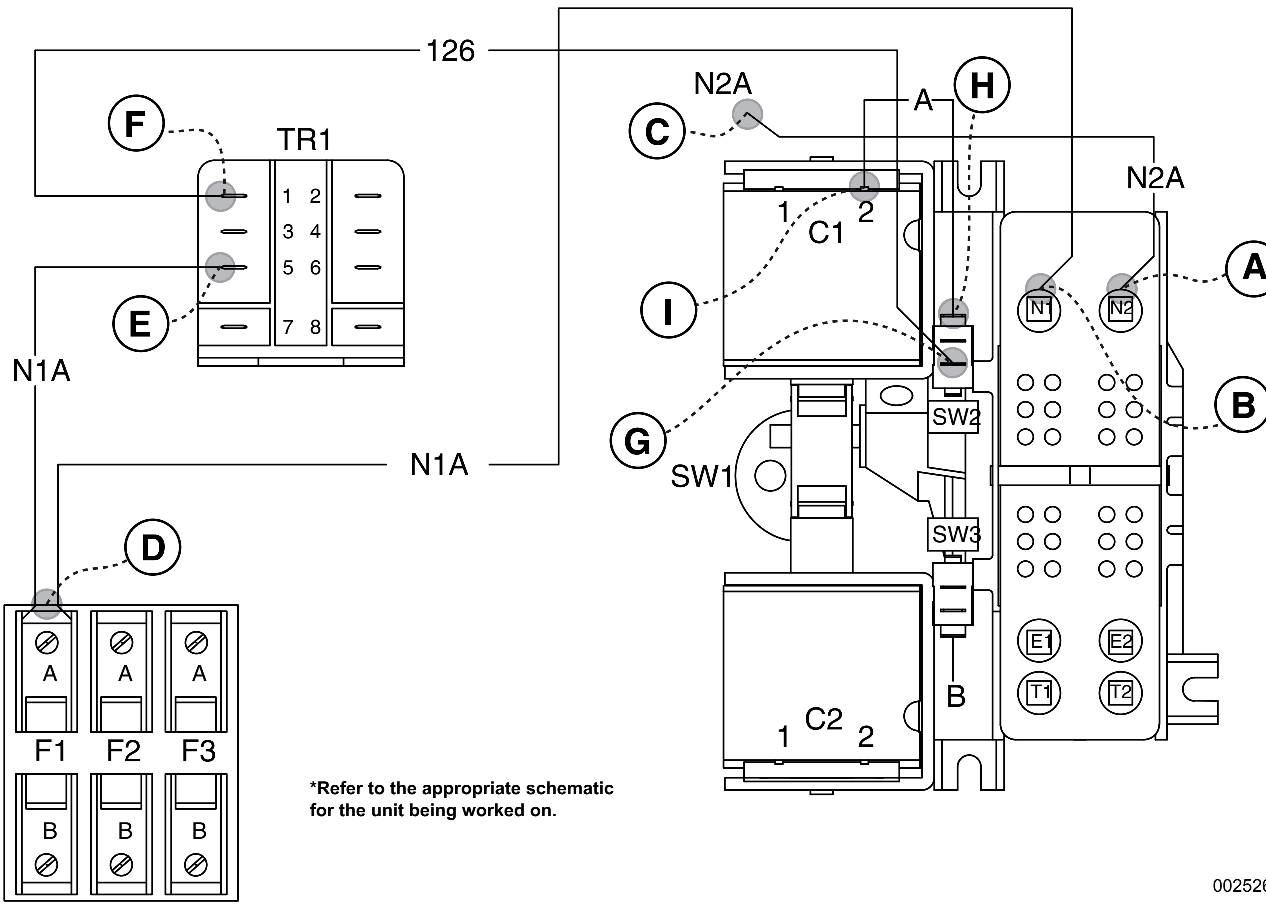


Figure 3-49. Typical Utility Control Circuit Test Points

5. Turn on utility supply voltage to the transfer switch.
   a. If transfer to utility occurs, the transfer relay (TR1) was energized preventing a re-transfer to utility. Proceed to ***Test 25—Check Wire 23***.
   b. If transfer to utility does NOT occur, proceed to step 7.
6. Remove two wires from the utility coil and check for 240 VAC.
   a. If 240 VAC is measured check utility coil for continuity.
   b. If 240 VAC is not measured proceed to step 9.
7. Checking coil continuity:
   a. If continuity is measured proceed to step 8.
   b. If there is no continuity, replace the coil.
8. Measure the voltage across point C (wire N2A previously removed) and B. The DM should indicate 240 VAC.
   a. If 240 VAC was NOT measured, repair or replace wire N2A.
   b. If 240 VAC was measured, proceed to step 9.
9. Measure for voltage between the N2 lug and the F1 terminal A. The DM should indicate 240 VAC.
   a. If 240 VAC was NOT measured, repair or replace wire N1A.
   b. If 240 VAC was measured, proceed to step 10.
10. Measure for voltage from the N2 lug and terminal 7 of the TR1, the DM should indicate 240 VAC.
    a. If 240 VAC was NOT measured, repair or replace wire N1A.
    b. If 240 VAC was measured, proceed to step 11.
11. Measure for voltage between the N2 lug and terminal 1 of the TR1, the DM should indicate 240 VAC.
    a. If 240 VAC was NOT measured, replace transfer relay.
    b. If 240 VAC was measured, proceed to step 12.
12. Measure for voltage between the N2 lug and the bottom terminal of the SW2. The DM should indicate 240 VAC.
    a. If 240 VAC was NOT measured, repair or replace wire 126.
    b. If 240 VAC was measured, proceed to step 13.
13. Measure for voltage between the N2 lug and the top terminal of the SW2. The DM should indicate 240 VAC.
    a. If 240 VAC was not measured, verify the limit switch (SW2) is wired correctly and proceed to ***Test 27—Test Limit Switches***.
    b. If 240 VAC was measured, proceed to step 14.

14. Measure for voltage between the N2 lug and terminal 2 of the C1 coil, the DM should indicate 240 VAC.
    a. If 240 VAC was not measured, repair or replace wire A.
    b. If 240 VAC was measured, replace the C1 coil.

Test 27—Test Limit Switches

General Theory

Wired to the normally closed contacts, the limit switches provide a means to interrupt the transfer circuits. When the contactor changes position, the limit switches contacts change state to become OPEN.

Procedure

With the controller set to OFF, the generator main circuit breaker OPEN, and utility voltage disconnected from the transfer switch, test limit switches SW2 and SW3 as follows.

1. To prevent interaction, disconnect wire 126 and wire A from the limit switch (SW2) terminals.
2. Set the DM to measure resistance.
3. Connect the DM meter test leads across the two outer terminals on SW2 from which the wires were disconnected.
4. Manually actuate the contactor to the STANDBY position, measure and record the resistance.
5. Manually actuate the contactor to the UTILITY position, measure and record the resistance.
6. Repeat step 4–5 several times and verify the DM reading at each switch position.
7. To prevent interaction, disconnect wire 205 and wire B from the limit switch (SW3) terminals.
8. Connect the DM meter test leads across the two outer terminals on SW3 from which the wires were disconnected.
9. Manually actuate the contactor to the STANDBY position, measure and record the resistance.
10. Manually actuate the contactor to the UTILITY position, measure and record the resistance.
11. Repeat step 4–5 several times and verify the DM reading at each switch position.

    Coil Nominal Resistance: 480–520k ohms

Results

1. If the DM indicated CONTINUITY in step 4 and 10, and INFINITY in step 5 and 9 the limit switches are good, refer to the flowchart.
2. If the DM did NOT indicate CONTINUITY in step 4 or 10, and INFINITY in step 5 or 9 the limit switch(es) are bad, repair or replace appropriate switch(es).

Test 28—Check Fuses F1 and F2

General Theory

Fuses F1 and F2 are connected in series with the N1 and N2 circuits, respectively. A blown fuse will open the applicable circuit and will result in (a) generator startup and transfer to STANDBY, or (b) failure to re-transfer back to utility source.

Procedure

1. On the generator panel, set the controller to OFF.
2. Disconnect utility from the transfer switch.
3. Remove fuse F1 and F2 from the fuse holder. (See **Figure 102**).
4. Inspect and test fuses for an OPEN condition with a DM set to measure resistance, CONTINUITY should be measured across the fuse.

Results

Replace blown fuse(s) as needed.

Test 29—Check Fuse F3

General Theory

Connected in series with load wire T1, F3 provides 120 VAC to the generator to operate the battery charger. A blown fuse will result in a possible dead battery situation.

Procedure

1. On the generator panel, set the controller to OFF.
2. Disconnect utility from the transfer switch.
3. Remove fuse F3 from the fuse holder.
4. Inspect and test fuses for an OPEN condition with a DM set to measure resistance, CONTINUITY should be measured across the fuse.

Results

Replace blown fuse as needed.

Test 30—Check Main Circuit Breaker

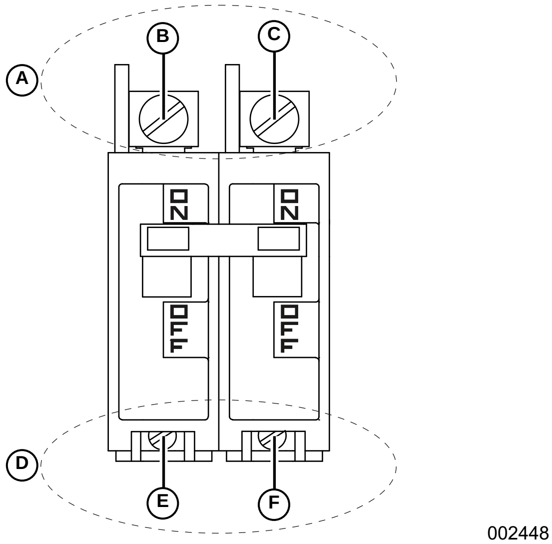
General Theory

Often the most obvious cause of a problem is overlooked. If the generator main line circuit breaker (MLCB) is set to OPEN, the electrical loads will not receive power. If the connected loads are not receiving voltage a possible cause could be, the MLCB has failed OPEN.

Procedure

The generator main line circuit breaker (MLCB) is located underneath the control panel side cover. If loads are not receiving power, make sure the breaker is set to the CLOSED position. If the beaker is suspected of failure, test it as follows.

1. Set the DM to measure resistance.
2. With the generator shutdown, disconnect all wires from the MLCB terminals, to prevent interaction.
3. See ***Figure 3-50***. Connect one meter test lead to the wire 11 terminal on the breaker and the other test lead to the E1 terminal.



A. Line Side
B. 11
C. 44
D. Load Side
E. E1
F. E2

Figure 3-50. Main Line Circuit Breaker

4. Set the breaker to its CLOSED position. The DM should indicate CONTINUITY.
5. Set the breaker to its OPEN position. The DM should indicate INFINITY.
6. Repeat step 4 and 5 with the DM meter leads connected across the wire 44 terminal and the E2 terminal.

Results

1. If the circuit breaker tests good, refer back to the flow chart.
2. If the breaker failed steps 4 or 5, replace the breaker.

Test 32—Check N1 and N2 Wiring

General Theory

A shorted wire N1 or N2 to ground can cause fuse F1 or F2 to blow.

Procedure

1. On the generator panel, set the controller to OFF.
2. Turn off the utility power supply to the transfer switch, using whatever means provided.
3. Remove fuses F1, F2, and F3 from the fuse holder.
4. Remove the generator control panel cover. Disconnect the connector that supplies the controller T1 located in the control panel.
5. Set DM to measure resistance.
6. Connect the positive meter test lead to wire N1 at the terminal block in the control panel.
   a. Connect the negative meter lead to the ground lug. INFINITY should be measured.
   b. Connect the negative meter lead to wire 23 at the terminal strip. INFINITY should be measured.
   c. Connect the negative meter lead to wire 194 at the terminal strip. INFINITY should be measured.
   d. Connect the negative meter lead to wire 0 at the terminal strip. INFINITY should be measured.
   e. Connect the negative meter lead to wire N2 at the terminal block. INFINITY should be measured.
   f. Connect the negative meter lead to the neutral connection. INFINITY should be measured.
7. Connect the positive meter test lead to wire N2 at the terminal block in the control panel.
   a. Connect the negative meter lead to the ground lug. INFINITY should be measured.
   b. Connect the negative meter lead to wire 23 at the terminal strip. INFINITY should be measured.
   c. Connect the negative meter lead to wire 194 at the terminal strip. INFINITY should be measured.
   d. Connect the negative meter lead to wire 0 at the terminal strip. INFINITY should be measured.
   e. Connect the negative meter lead to the neutral connection. INFINITY should be measured.

Results

If a short is indicated in step 6 or 7, repair wiring and repeat test.

Test 33—Check N1 and N2 Voltage

General Theory

Loss of utility source voltage to the generator will initiate a startup and transfer by the generator. Testing at the control panel terminal block will divide the system in two, thereby reducing troubleshooting time.

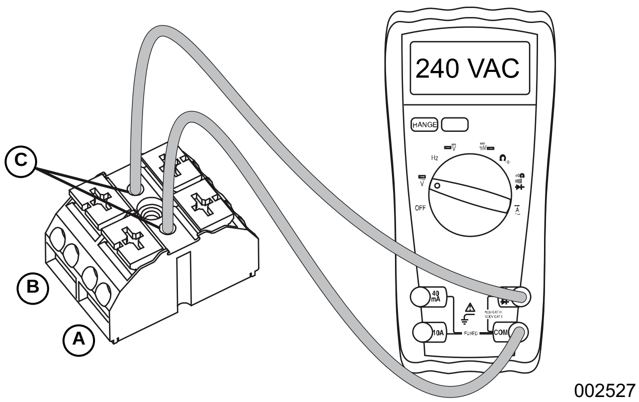
Procedure

1. Set the controller to OFF.
2. Set a DM to measure AC voltage.

3. See *Figure 3-51*. Connect one test lead to wire N1 at the terminal block in the generator control panel. Connect the other test lead to wire N2. Utility line-to-line voltage should be measured.

Results

Refer to **Flow Chart**.



A. N1
B. N2
C. Test Points

Figure 3-51. Terminal Block Test Points

Test 34—Check Utility Sensing Voltage at the Circuit Board

General Theory

If the generator starts and transfer to STANDBY occurs in the automatic mode when acceptable UTILITY source voltage is available at the terminal block, the next step is to determine if sensing voltage is reaching the controller.

NOTE: When controller is in AUTO, the green LED is illuminated. UTILITY LOSS will display with delay start timer when utility is not available.

NOTE: Verify controller is not in 2-wire start mode.

Procedure

1. Set the controller to OFF.
2. Disconnect the harness connector from the controller.
3. Set a DM to measure AC voltage.
4. Connect one meter test lead to wire N1. Connect the other meter test lead to wire N2. Approximately 240 VAC should be measured.

Results

1. If voltage was measured in step 4 and the pin connections are good, replace the circuit board.
2. If voltage was NOT measured in step 4, repair or replace wire N1/N2 between connector and terminal block.

Test 35—Check Utility Sense Voltage

The N1 and N2 terminals in the transfer switch deliver utility voltage sensing to a circuit board. If voltage at the terminals is zero or low, standby generator startup and transfer to the standby source will occur automatically as controlled by the circuit board. Zero or low voltage at these terminals will also prevent transfer back to the utility source.

Procedure

With utility source voltage available to terminal lugs N1 and N2, use a DM to test for utility source line-to-line voltage across terminal locations N1 and N2 terminals. Normal line-to-line utility source voltage should be indicated.

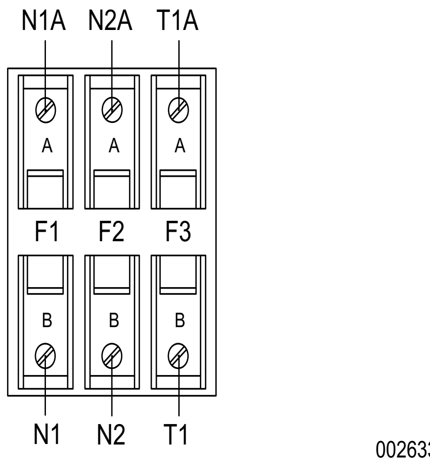


Figure 3-52. Transfer Switch Fuse Block

Results

1. If voltage reading across the N1 and N2 terminals is zero or low, refer to **Flow Chart**.
2. If voltage reading is good, refer to **Flow Chart**.

Test 36—Check T1 Wiring

General Theory

If the T1 wiring is shorted to ground can cause the F3 fuse to blow.

Procedure

1. Set the controller to OFF.
2. Remove F1, F2, and F3 from the fuse holder in the transfer switch.
3. Disconnect the proper controller harness connector that has wire T1 in it from the controller.
4. Set the DM to measure resistance.
   a. Connect one meter test lead to T1 on the customer connection in the generator and the other meter lead to ground. Measure and record the resistance.

b. Connect one meter test lead to T1 on the customer connection in the generator and the other meter test lead to wire 194. Measure and record the resistance.
c. Connect one meter test lead to T1 on the customer connection in the generator and the other meter test lead to wire 23. Measure and record the resistance.
d. Connect one meter test lead to T1 on the customer connection in the generator and the other meter test lead to wire N1. Measure and record the resistance.
e. Connect one meter test lead to T1 on the customer connection in the generator and the other meter test lead to wire N2. Measure and record the resistance.

Results

1. If the DM indicated INFINITY in steps 4a-4e, replace the controller.
2. If the DM indicated CONTINUITY, repair or replace the wiring in the appropriate circuit.

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Introduction

This section will familiarize the reader with the various components that make up the Engine and DC Control systems.

Topics covered in this section are:

- Customer Connections
- Controller
- G-Flex™ (AVR)
- LED Display
- Battery Charger
- AUTO-OFF-MANUAL
- 7.5 Amp Fuse
- Starter Contactor Relay
- Common Alarm Relay
- Connector Pin Descriptions
- AVR Power Up
- Menu System Navigation

Customer Connection

The terminals of this terminal strip connect to identically numbered terminals in the transfer switch. The terminal block provides the electrical connection for the controller.

The terminal block provides the following connection points:

- UTILITY N1 (Utility Sensing)
- UTILITY N2 (Utility Sensing)
- LOAD T1 (Internal Battery Charger) - 60 Hz Unit
- Wire 194 (Transfer Relay)
- Wire 23 (Transfer Relay)

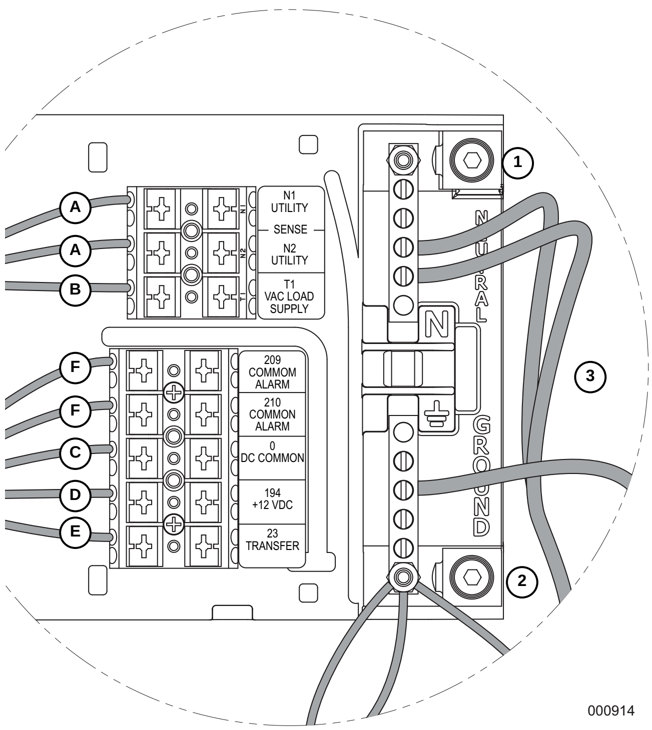


Table 4-1. Control Panel Connections		
Terminal Numbering Decal		Wire Numbers
A	YELLOW #1 & #2	N1 & N2 - 240 VAC - Sensing for Utility Dropout and Pickup
B*	BLUE #3	T1 - Fused 120 VAC for Battery Charger (*see NOTE)
C	BLACK #3	0 - DC (-) Common Ground Wire
D	RED #4	194 - DC (+) 12 VDC for Transfer Controls
E	WHITE #5	23 - Transfer Control Signal Wire
F	BLUE #1 & #2	Optional Alarm Relay Contacts (Normally Open)
Note: Must be connected to keep battery charged whether unit is running or not.		

Table 6.2: 2–Wire Start Wire Connections

Wire	Connection	Location
178	Female Faston	Hanging from controller above battery compartment
183	Female Faston	

Table 4-3. Ground and Neutral Connections	
1	Large Neutral Lug Torque Spec 2/0 TO 14 AWG 120 **in-lb** (13.56 N-m)
2	Large Ground Lug Torque Spec 2/0 TO 14 AWG 120 **in-lb** (13.56 N-m)
3	Ground and Neutral Bus Bar Torque Specs: 4-6 AWG 35 **in-lb** (3.95 N-m) 8 AWG 25 **in-lb** (2.82 N-m) 10-14 AWG 20 **in-lb** (2.26 N-m)

Figure 4-1. Synergy Control Wiring - 60 Hz (found behind control board)

Table 4-4. Control Wire Recommended Length and Size	
Maximum Wire Length	**Recommended Wire Size**
1-115 ft (1-35 m)	No. 18 AWG
116-185 ft (36-56 m)	No. 16 AWG
186-295 ft (57-89 m)	No. 14 AWG
296-460 ft (90-140 m)	No. 12 AWG

Controller

The controller is responsible for all standby electric system operations including engine startup, engine running, and engine shutdown. In addition, the controller performs the following functions:

- Automatic voltage regulation (See Section 2.1 ***Description and Major Component***).
- Starts and exercises the generator based on programmed setting.
- Automatic engine shutdown in the event of low oil pressure, high oil temperature, over speed, no rpm sense, over crank, or low battery.
- Maintains proper battery charge.

The controller and AVR harness connectors are used to interconnect the controller with the various circuits of the DC and AC systems. Connector pin locations, numbers, associated wires and circuit functions are listed in the appropriate appendix in the back of this diagnostics manual.

To control the Generator the controller utilizes digital inputs and outputs. See ***Table 4-5*** for the specific position and function. See “Menu Navigation” to view state of output or input.

NOTE: The generator engine will crank and start and run based on the programmed exercise setting. If Quiet Test is enabled will run at the low exercise speed.

Table 4-5. Digital Inputs and Outputs

Position	Digital Inputs	Digital Outputs
1	Not Used	Not Used
2	Low Oil Pressure	Not Used
3	High Temperature	Not Used
4	Not Used	Battery Charger Relay
5	Wiring Error Detect	Fuel
6	Not Used	Starter
7	Auto	Ignition
8	Manual	Transfer

G-Flex™ (AVR)

The AVR is responsible for:

- Brush/rotor excitation
- Automatic voltage regulation
- Load calculations
- Automatic transfer
- Automatic re-transfer

LED Display

Located next to the circuit breaker access panel on the generator, the LED Display provides a visual annunciation of the Generators status. The LED Display has three LED, a red, a yellow, and a green.

- **Red LED**- Illuminates during an Alarm condition or when the controller is set to OFF mode.
- **Yellow LED**- Illuminates when the controller generates a Maintenance Alert and attention is required.
- **Green LED**- Illuminates when the system is ready to respond to a Utility failure.

Battery Charger

The battery charger operates at variable voltage levels depending on ambient temperature.

- 13.5 VDC at High Temperature
- 14.1 VDC at Normal Temperature
- 14.6 VDC at Low Temperature

The battery charger is powered from a 120 VAC Load connection through a fuse (F3) in the transfer switch. This 120 VAC source must be connected to the generator in order to operate the charger.

During a utility failure, the charger will momentarily be turned off until the generator is connected to the Load. During normal operation, the battery charger supplies all the power to the controller; the generator battery is not used to supply power.

The battery charger will begin its charge cycle when battery voltage drops below approximately 12.6V. The charger provides current directly to the battery dependent on temperature, and the battery is charged at the appropriate voltage level for 18 hours. At the end of the 18 hour charge period battery charge current is measured when the generator is off. If battery charge current at the end of the 18 hour charge time is greater than a preset level, or the battery open-circuit voltage is less than approximately 12.5V, “Charger Warning” warning is raised. If the engine cranks during the 18 hour charge period, then the 18 hour charge timer is restarted.

At the end of the 18 hour charge period the charger does one of two things. If the temperature is less than approximately 40 ºF the battery is continuously charged at a voltage of 14.1V (i.e. the charge voltage is changed from 14.6V to 14.1V after 18 hours). If the temperature is above approximately 40 ºF then the charger will stop charging the battery after 18 hours.

The battery has a similar role as that found in an automobile application. It sits doing nothing until it either self-discharges below 12.6V or an engine crank occurs (i.e. such as occurs during the programmed exercise cycle). If either condition occurs the battery charge will begin its 18 hour charge cycle.

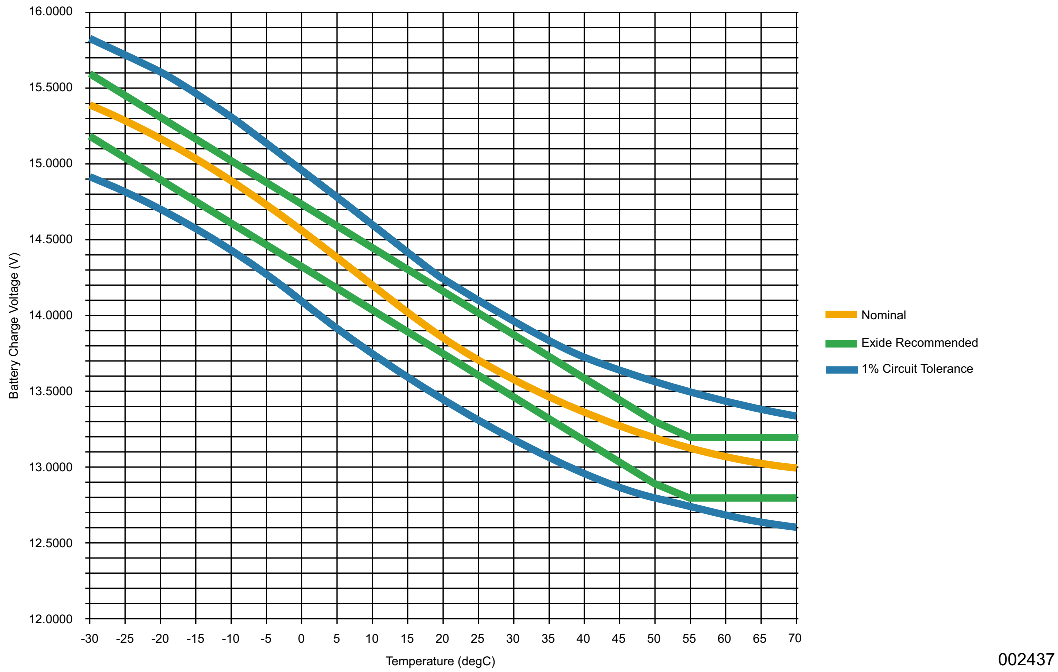


Figure 4-2. Battery Voltage Charge Affected By Battery Ambient Temperature

AUTO-OFF-MANUAL

This feature permits the operator to (a) select fully automatic operation, (b) start the Generator manually, or (c) stop the engine and prevent the automatic startup. The controller has Off-Manual-Auto Mode buttons. See *Figure 4-3* for the location of the push buttons.

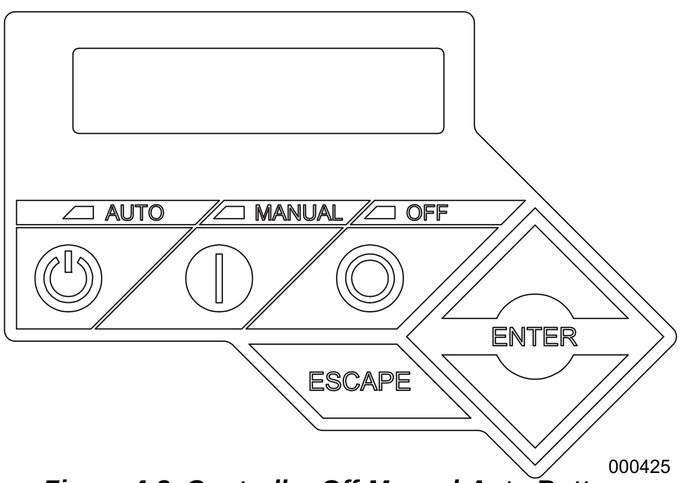


Figure 4-3. Controller Off-Manual-Auto Buttons

7.5 Amp Fuse

The fuse protects the controller against excessive current. If the fuse has blown, engine cranking and operation will not be possible for units with firmware older than 1.12. For units with firmware 1.12 or newer, engine cranking and operation will be possible. Should fuse replacement become necessary, use only an equivalent 7.5 amp replacement fuse.

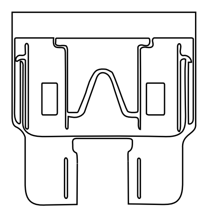


Figure 4-4. Typical 7.5 Amp Fuse

Starter Contactor Relay/Solenoid

V-Twin Models

See *Figure 4-5*. The starter contactor relay (SCR) provides a safe and controlled method of energizing the solenoid located on the starter. The controller is responsible for energizing the relay when the start command is given.

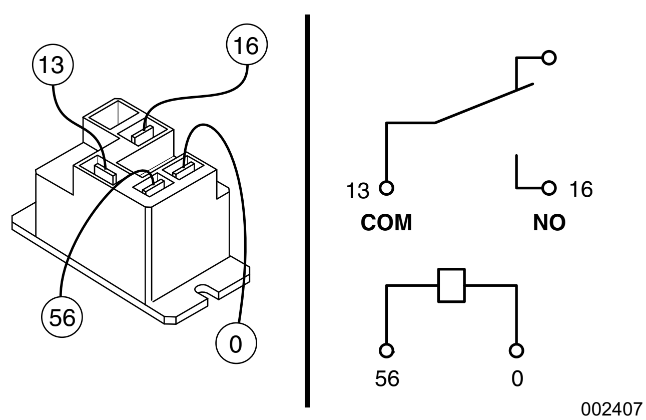


Figure 4-5. Starter Contactor Relay

Common Alarm Relay

The common alarm relay provides a set of contacts to drive a customer provided external alarm indication. When the control is powered up, if there are no Alarms, the relay contacts will be OPEN. Any ALARM (not warning) will trigger the common alarm relay to operate, closing the contacts. The connections are made to the generator customer connection terminal strip at Terminals 1 and 2 (Wires 209 and 210).

Table 4-6. Specifications

Contact Rating:	10A at 250 VAC	5A at 30 VDC

NOTE: Contact rating is for resistive load only

Circuit Pin Descriptions

Table 4-7 provides the physical Wire ID and circuit functions.

Table 4-7. Circuit Pin Descriptions

Wire ID	Circuit Function
0	Common Ground (DC) DC Field Excitation Ground
00	Neutral Connection for T1 (battery charger)
2	DPE Winding (AC Excitation power)
6	DPE Winding (AC Excitation power)
11S	240 VAC Generator Voltage Sensing
13	12 VDC un-fused for the controller
14	12 VDC output for engine run condition.
18	Ignition Shutdown: The controller grounds Wire 18 for ignition shutdown and receives a reference signal for speed control while cranking and running
23	Switched to ground (internally) to energize the Transfer Relay
44S	240 VAC Generator Voltage Sensing
56	12 VDC output to starter contactor relay/solenoid
85	High temperature shutdown: Shutdown occurs when Wire 85 is grounded by contact closure in the oil temperature switch
86	Low oil pressure shutdown: Shutdown occurs when Wire 86 is grounded by loss of oil pressure in the LOP switch
178	Two-wire Start Return
183	Two-wire Start Input
194	Provides 12 VDC to the transfer relay (TR1)
209	Common Alarm Relay Output
210	Common Alarm Relay Output
387	RS-232 Port 1 Rx
387A	RS-232 Port 2 Rx
388	RS-232 Port 1 Tx
388A	RS-232 Port 2 Tx
389	RS-232 Port 1 Gnd
389A	RS-232 Port 2 Gnd
398A	Generator Current Sense A2
398B	Generator Current Sense B2
399A	Generator Current Sense A1
399B	Generator Current Sense B1
476	PWM DC Voltage Supply (Positive)
477	PWM DC Voltage (Signal)
478	PWM DC Voltage (Ground)
479	Comms DC Voltage (Signal -)*
480	COMMS DC Voltage (Signal +)*
481	COMMS DC Voltage (Ground)
482	AVR Ground
483	AVR Power (Positive)
484	AVR ENABLE (Positive)
485	AVR ENABLE (Ground)
817	Grounded by the controller to turn on System Ready (Green) LED
818	Grounded by the controller to turn on Alarm (Red) LED
819	Grounded by the controller to turn on the Maintenance (Yellow) LED
820	Positive voltage (5VDC) for status LEDs
Black	From remote power supply for Large Fan NEG
Red	From remote power supply for Large Fan POS
SHLD	Bolted to back panel GND
N1	240 VAC Utility sensing voltage
N2	240 VAC Utility sensing voltage
R1	Model ID Resistor
R3	Model ID Resistor
T1	120 VAC for Battery Charger
Red	Stepper Power
Orange	Stepper Motor B2 coil
Yellow	Stepper Motor B1 coil
Brown	Stepper Motor A2 coil
Black	Stepper Motor A1 coil

Menu System Navigation

To get to the MENU, use the “Esc” key from any page. It may need to be pressed several times before getting to the menu page. The currently selected menu is displayed as a flashing word. Navigate to the desired menu item by using the +/- keys. When the desired menu item is flashing, press the ENTER key. Depending on the menu selected, there may be a list of choices presented. Use the same navigation method to select the desired screen (refer to the Menu System diagram, ***Figure 4-6*** through ***Figure 4-9***). Refer to Section 1.10 ***Control Panel Menu System Navigation*** for additional information.

Changing Settings (Edit Menu)

To change a setting, such as display contrast, go to the EDIT menu and use the +/- keys to navigate to the setting to change. Once this setting is displayed (e.g. Contrast), press the ENTER key to go into the edit mode. Use the +/- keys to change the setting, press the ENTER key to store the new setting.

NOTE: If the ENTER key is not pressed to save the new setting, it will only be saved temporarily. The next time the battery is disconnected, the setting will revert back to the old setting.

Synergy AVR Power Up and Communications

Unique to the Synergy unit is the G-Flex™ AVR (Automatic Voltage Regulator) controller. The AVR system is powered up in a unique way and has several communication systems that are used on this unit.

Powering up the AVR and activating the AVR works in combination with the Display Controller. With the system at rest there is no power or communication between the two controllers. With activation of the MANUAL button, or when in “AUTO” upon a utility loss, the unit will crank, start, run, and communicate in a matter of seconds to be ready to transfer and supply generator power to the facility.

Power to the AVR is supplied via the “AVR POWER” circuit (12 VDC) and is supplied to the AVR via the display controller during the cranking cycle. The Green LED located on top of the AVR will light to indicate when appropriate power is supplied to the AVR. When the rpm reaches 2200 the display controller with activate the “ENABLE” circuit. When the ENABLE line is activated the AVR begins the process producing power from the generator along with communications on the RS 485 and the PWM lines. The AVR will use the AVR POWER circuit to begin the process of generating output voltage by converting this DC voltage to AC and supplying this AC voltage to the brushes and then to the rotor. The 2 controllers will communicate back and forth through the startup cycle, verifying information during the self test cycles and through the full running cycle of the generator, and continue until the generator cooldown period is complete. As the engine is shut off the ENABLE line is then turned off and the AVR will enter it’s cool down period. When this cooldown period has elapsed, the display controller disconnects the AVR POWER circuit and communication, putting the AVR into sleep mode.

Diagnosing Power Up of the AVR

Using the chart and wiring diagrams locate the AVR POWER circuit and the ENABLE lines. The AVR Ground Circuit (Wire 482) goes to the display controller and connects to ground within the controller. Check continuity of Wire 482 from the P1 connector to battery ground. If continuity is not correct check each section of this circuit for proper continuity. AVR POWER Wire 483 supplies 12 VDC from an internal relay within the display controller during unit cranking. The Green LED on top of the AVR will not light up if no voltage is indicated at the P1 connection. Check the same circuit at the display controller. If there is voltage at the display controller and not the AVR P1 connector, check harness condition and connections. If no voltage is indicated at the display controller connection during cranking, verify power and ground to the display controller and proper controller operation. If this is OK there is an internal controller issue.

ENABLE Line Diagnostics

The ENABLE line is not activated until the engine reaches 2200 rpm. Use the wiring diagram locate the Wire 484 (POS) circuit and the Wire 485 (GND) circuits. Using a DM, back probe and verify that proper voltage and ground connections are found at P1. As the unit starts up and runs be sure the units engine is getting above the 2200 rpm. If voltage is not correct, locate the same wire connections at the display controller connector and retest. If voltage is correct check the harness continuity and connections and repair as needed. If no voltage is found at the display controller connections verify controller power and ground and operation. If all are OK, there is an internal controller issue.

Communications and Diagnosing Communication Lines

Communication Between Synergy AVR and Display Controller

RS 485 MODBUS (9600 baud) Communication. This line is for all communications and verifications between the display controller and the AVR except for rpm. All rpm information is done on the PWM line. This communication is done via three wires between the controllers. A shield wire surrounds all three wires and is connected to ground at one end only.

PWM (Pulse Width Modulation) Communication is primarily used for rpm requests and rpm information between the display controller and the AVR. This communication is done via three wires connected between the two controllers.

Diagnosing communication line RS 485 and PWM will be done with the unit NOT running. The testing process will be determined depending on the state of the AVR with the Green LED light OFF or with the Green LED light fading ON and OFF. Trying to test the communication lines while the unit is running without using special equipment will cause communication errors and create false errors which will lead to false diagnosis.

Testing on all communication wires will be done via back probing the AVR P1 connector with the proper back probe adapters and matching the readings on a DM with the information located in the appropriate chart(s). Use the wiring diagrams and the proper pin out charts to identify the wires and pin locations to perform the appropriate tests and to get accurate results. The AVR requires sufficient time to cool down before removing power from the system. With sufficient cooldown completed, remove the 7.5 amp fuse and T1. Perform a visual inspection of the harness and seating of connectors P1 and J4. If not seated properly, correct the concern and retest the unit to verify fault condition. If the fault still exists after diagnostics are complete, continue on. Disconnect connectors and perform a continuity check of all the harness communication wires between the two controller connections while disconnected. If harness and connections are OK reconnect connectors, repower the unit and verify voltage values per the Communication Voltage Chart.

Communication Between Synergy AVR and OPCB Load Control Module

PLC (Powerline Carrier) Communication: This communication is a one way communication from the AVR to OPCB Load Shed Module. For example: the AVR has Wire 23 pulled to ground and the generator is running at a low speed (2800 rpm) due to a light load conditions. A large load comes on and the AVR identifies this load based on the amperage spike through the CTs. The AVR determines the size of the load and determines that the load is too great at the present rpm level. The AVR will send a communication signal down Wire 23 to the Load Shed Module and the LCM identifies this signal to initiate the Fast Load Shed program.

Diagnosing this event between the AVR and the LCM would require the use of special equipment, so all connections, the condition of Wire 23, and proper functioning of Wire 23 must be verified before performing any other testing.

Table 4-8. AVR P1 Connector Communication Chart

Pin Location	Wire #	Description	Green Light Fading On & Off	Green Light OFF
		AVR	Back probe	Back probe
P1	476	PWM DC Voltage Supply (Positive)	4.92 VDC	4.95 VDC
P2	479	Comms DC Voltage (Signal -)*	2.4 to 2.6 VDC	1.39 VDC
P3	480	COMMS DC VOLTAGE (Signal +)*	2.3 to 2.4 VDC	4.13 VDC
P4	481	COMMS DC VOLTAGE (Ground)	0 VDC	0 VDC
P5	482	AVR Ground	0 VDC	0 VDC
P6	398A	Current Transformer	0 VDC	0 VDC
P7	399A	Current Transformer	0 VDC	0 VDC
P8	23	Transfer control wire	12 VDC	12 VDC
P9	Black	From remote power supply for Large Fan NEG	0 VDC	0 VDC
P10	11S	Generator Voltage Sense	0 Volts	0 VDC
P11	477	PWM DC VOLTAGE (Signal)	1.93 VDC	4.94 VDC
P12	478	PWM DC VOLTAGE (Ground)	0 VDC	0 VDC
P13	484	AVR ENABLE (Positive)	4.89 VDC	4.95 VDC
P14	485	AVR ENABLE (Ground)	4.0 VDC	4.05 VDC

P15	483	AVR Power (Positive)	13.65 VDC	0 VDC
P16	398B	Current Transformer	0.0 VDC	0 VDC
P17	399B	Current Transformer	0.0 VDC	0 VDC
P18	SHLD	Bolted to back panel GND	0 VDC	0 VDC
P19	Red	From remote power supply for Large Fan POS	0 VDC	0 VDC
P20	44S	Generator Voltage Sense	0 volts	VDC
Note: All voltages within 0.5 volts from battery ground				

Table 4-9. AVR Connector Operating Voltages

Pins	Signals	Units	Off, with Utility	Cranking	Running 0% Load (2700 rpm)	Running 50% Load	Low Speed Exercise	Cooldown (Running)	Cooldown (1 Hour)	AVR Shut down
P1-13, P1-14	AVR Enable	DC Volts	0	0	3.6	3.6	3.6	3.6	0	0
P1-12, P1-11	PWM DC Voltage	DC Volts	0	2	1.242	1.8	0.875	2	2	0
P1-4, P1-3	Comms DC Voltage	DC Volts	4.1	2.6	2.6	2.6	2.6	2.6	2.6	0
P1-5, P1-15	AVR Power	DC Volts	0	13.4	13.6	13.16	13.2	13.15	13.52	0
	Big Fan	DC Volts	0	0.16	11.42	11.4	11.54	11.42	0	0
	Small Fan	DC Volts	0	0	5.6*	5.4*	0.86*	6	13.3	0
	DPE Voltage	AC Volts	0	~0	252	256	144	256	1.7	0
P1-8, Ground	Transfer Signal	DC Volts	10.8 VDC	12	12 (not xfered) 0 (xfered)	0	12	0	0	12
P1-10, P1-20	Gen Sense Voltage	AC Volts	0	0.1	240	240	138	240	0	0
P1-10, P1-20	Gen Sense Frequency	Hertz	0	7-9	60	60	32.5	60	0	0
	Battery Voltage	DC Volts	13.6	11.08	13.42	13.2	13.23	13.02	12.95	12.9

NOTE: All parameters are expected to have a tolerance of up to a volt for high voltage lines and half a volt for low voltage lines.

NOTE: * Small fan is not powered at this time. The running of the large fan causes small fan to turn, inducing a voltage.

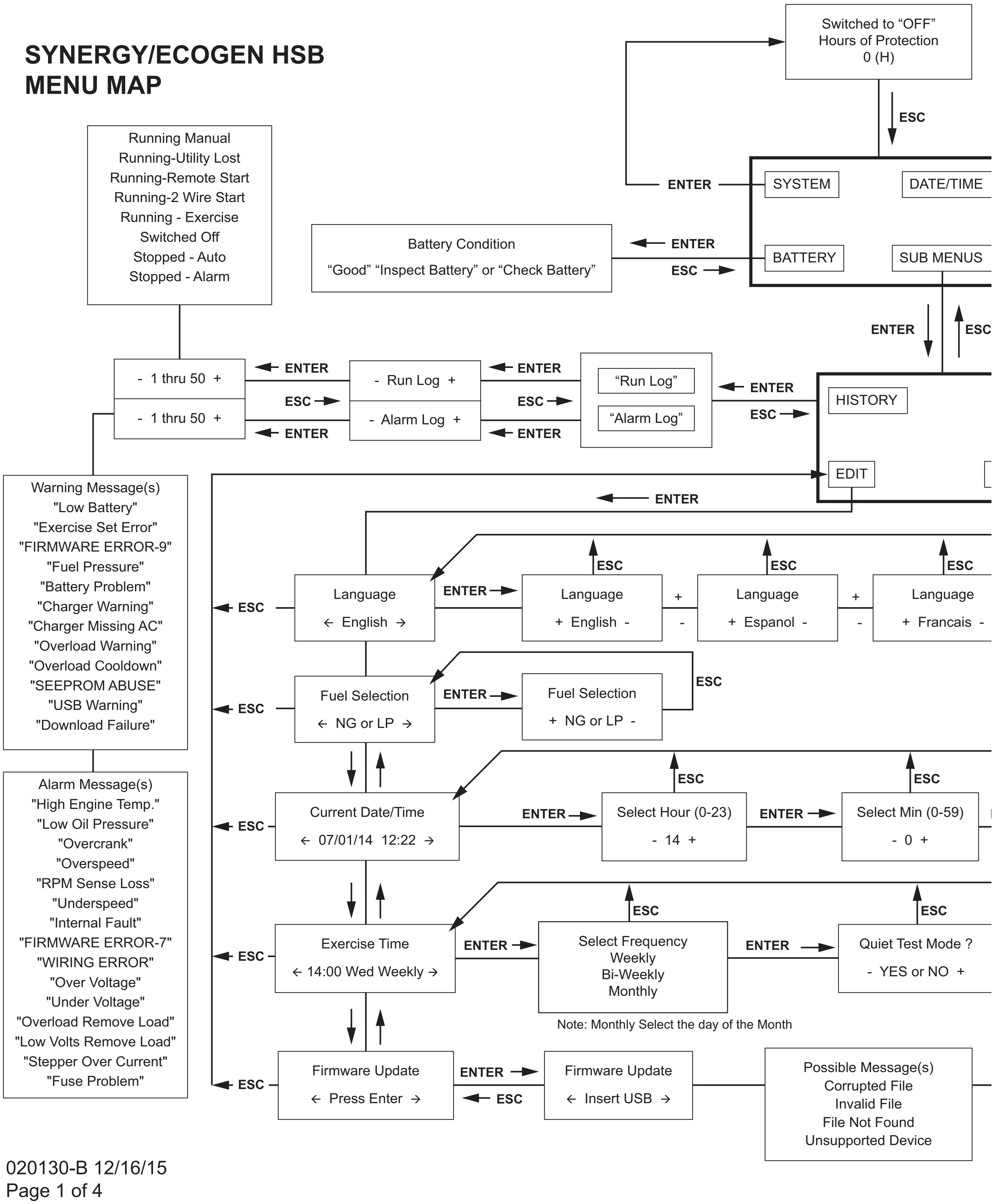


Figure 4-6. Synergy/EcoGen Main Menu Map

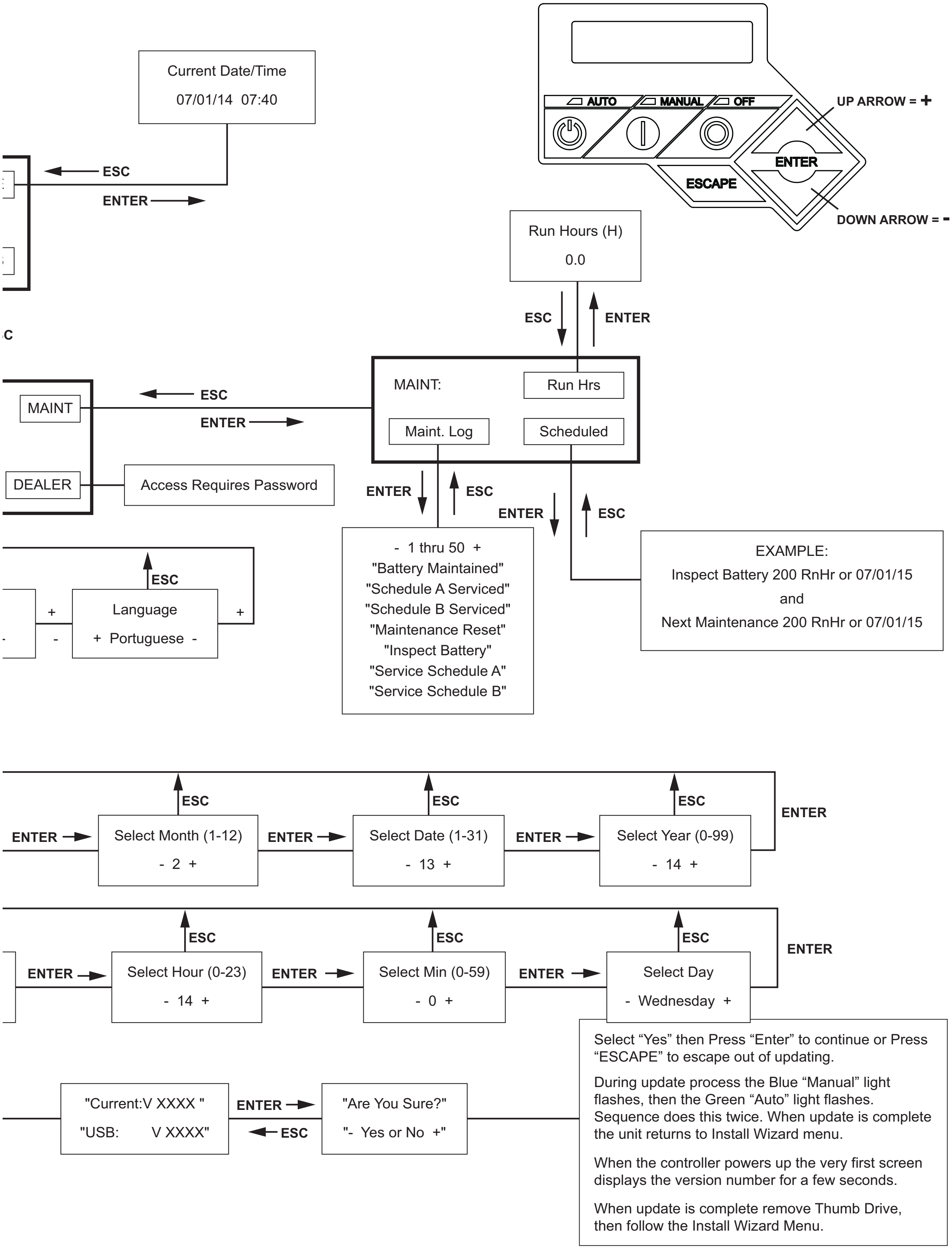


Figure 4-7. Synergy/EcoGen Main Menu Map

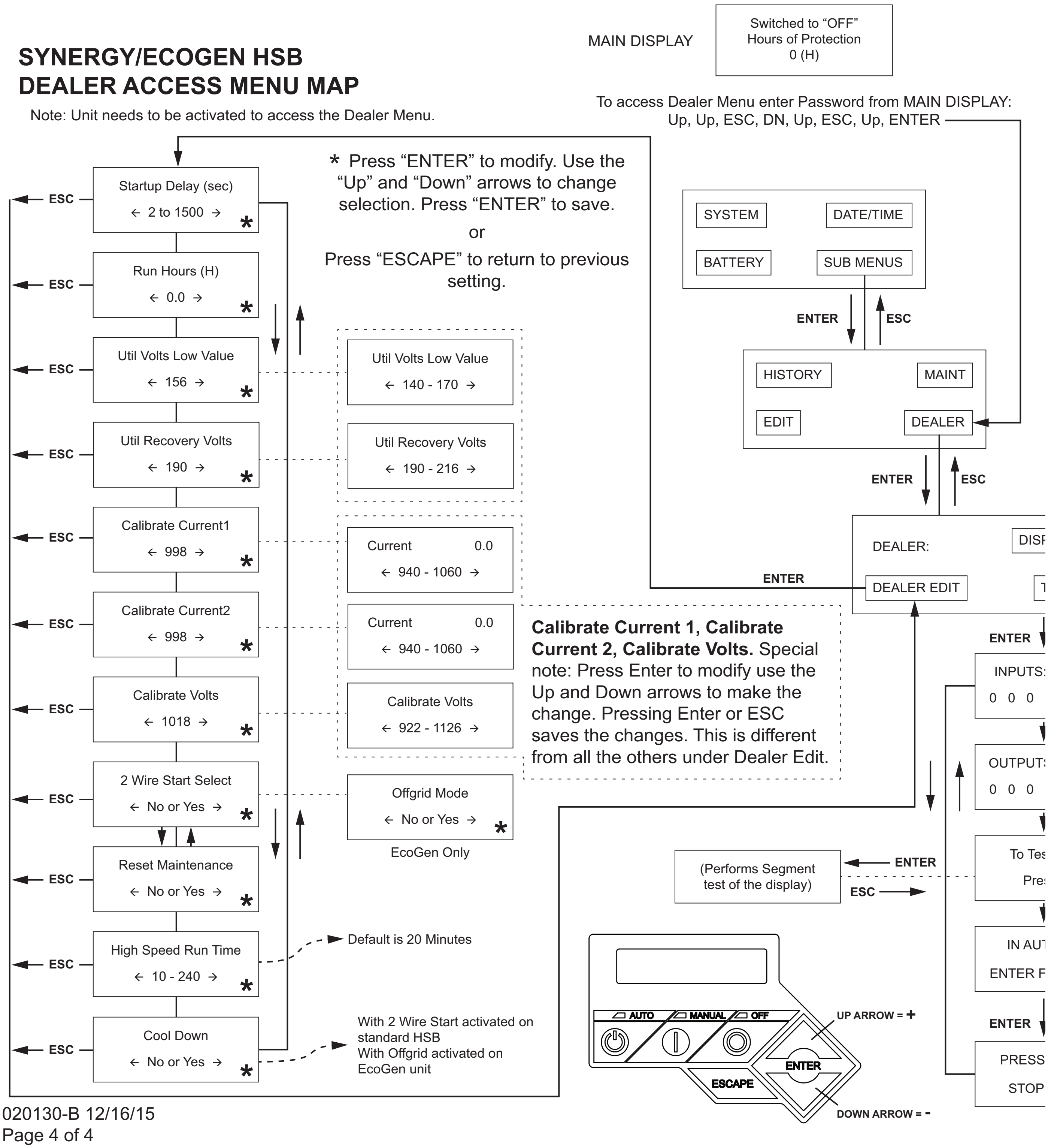


Figure 4-8. Synergy/EcoGen Dealer Access Menu Map

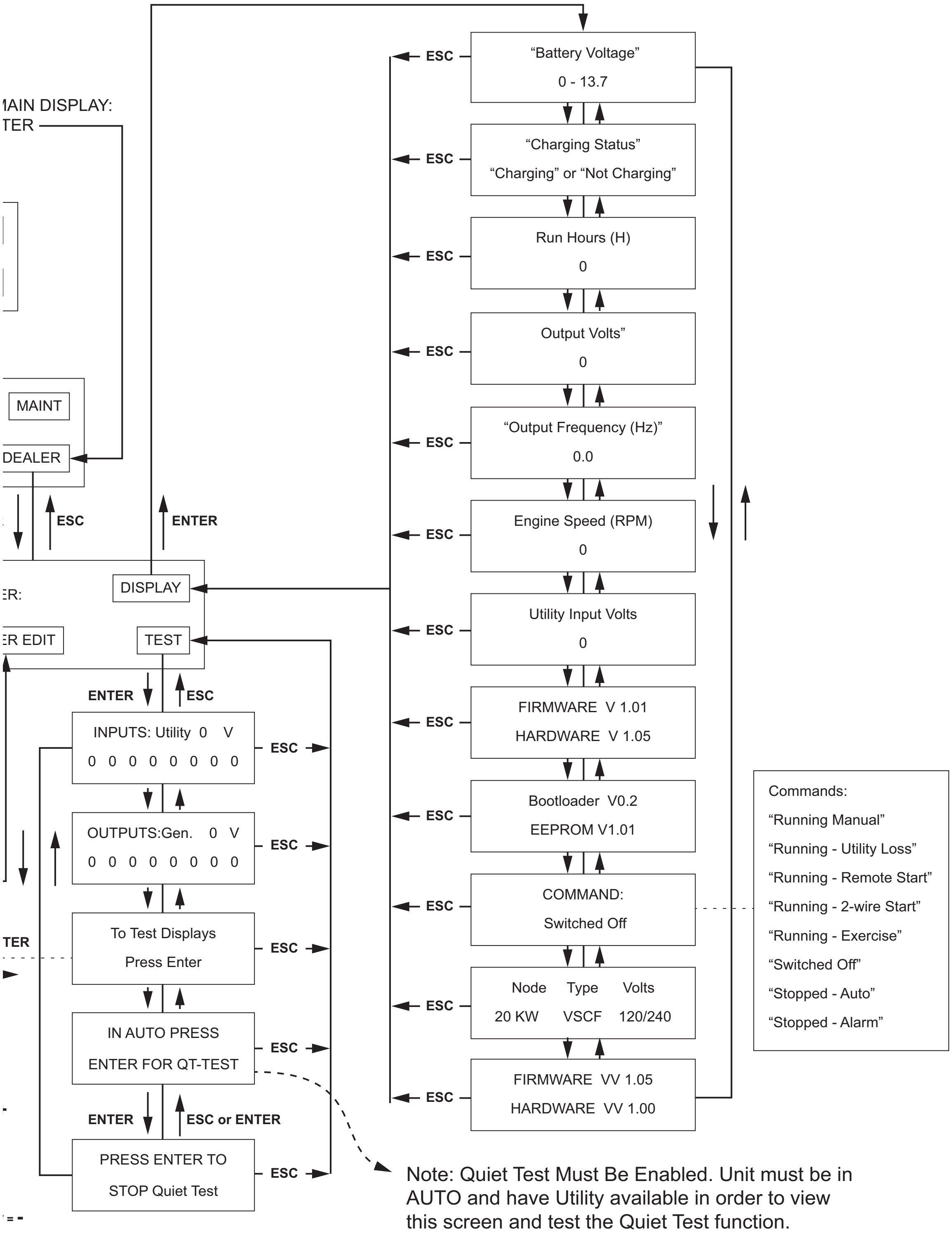


Figure 4-9. Synergy/EcoGen Dealer Access Menu Map

Table 4-10. Evolution™ Controller e-Codes

Displayed Alarm	Alarm/ Warning	e-Code Breakdown	Description	Notes
Controller Fault	ALARM		No E-code on HSB	Replace Controller
Overcrank	ALARM	1100	Condition - Engine Cranks but will not Start Unit turns over but will not start. Controller is receiving signal on Wire 18.	Problem 17
Overspeed	ALARM	1200	Prolonged Over 72 Hz for 3 seconds. Possible cause: Stepper motor/mixer body assembly issue.	Test 12
Overspeed	ALARM	1205	Instantaneous Over 75Hz for 0.1 second (100 milliseconds). Possible cause: Stepper motor/mixer body assembly issue.	Test 12
Low Oil Pressure	ALARM	1300	Occurred while running The default Extended alarm for low oil pressure. Check oil level and pressure.	Test 61
High Temperature	ALARM	1400	Condition - Air Flow Impeded / Flow Issue Check the inlet/outlet for debris.	Test 62
RPM Sensor	ALARM	1501	Twin Cylinder+Running Twin Cylinder Running faults to RPM Sensor Loss. Possible Causes: air pocket in fuel line, dirty fuel, missing ignition pulse (loss of one of the primary coils).	Test 50 and Test 64
RPM Sensor	ALARM	1505	Twin Cylinder+Cranking Twin Cylinder Cranking faults to RPM sensor loss Possible Cause: starter motor issue, missing ignition pulse (loss of one of the primary coils).	If engine cranks, Test 64. If engine does not crank, Problem 15.
Underspeed	ALARM	1600	Condition - Unit is Overloaded Unit is Overloaded slowing engine speed, fuel supply low or throttle control problem.	Problem 3, Test 50 or Test 12
Overvoltage	ALARM	1800	Prolonged Over-Voltage Voltage reported to the controller from the AVR via communication line.	Perform Test 2
Undervoltage	ALARM	1900	Prolonged Under-Voltage Undervoltage due to loss of voltage for some time (10+ seconds). Voltage reported to the controller from the AVR via communication line.	Perform Test 2
Undervoltage	ALARM	1901	Undervoltage value reported to Evolution controller. Verify Generator output voltage in the Dealer Menu display of the Evolution controller. AVR voltage information is sent to the Evolution controller via communication lines.	Check communication wires between AVR and Evolution controller. Perform Test 2
Wiring Error	ALARM	2099	Customer connection low voltage and high voltage wires are crossed.	Check customer connection in generator
Overload Remove Load	ALARM	2100	Overloaded - Default (Output Current Method) Unit is overloaded, one of the two CTs is detecting an overload condition. Check transfer switch loadshed functionality. (Change load dynamics or utilize loadshed).	Remove Load
Stepper Overcurrent	ALARM	2399	Current flow in stepper coil(s) above specification	Test 12
Fuse Problem	ALARM	2400	Missing / Damaged Fuse (not displayed on Firmware 1.12 and newer) The 7.5 amp Controller Fuse is missing or blown (open).	Test 44
Low Battery	WARNING		Condition->Battery less than 12.1 Volts for 60 seconds	Test 45
Battery Problem	WARNING		Condition->More than 16 Volts of battery voltage or 600 milliamperes or more of charge current at the end of an 18 hour charge	Test 45
Charger Warning	WARNING		Less than 12.5 volts of battery voltage at the end of a 18 hour charge	Problem 22
Charger Missing AC	WARNING		AC power is missing from the battery charger input	Problem 22
SEEPROM Abuse	WARNING		Condition->more than 1200 writes to the EEPROM in a 5 minute period.	

Table 4-11. VR VSCF-Codes

Ecode	Alarm	Description	Possible Causes	Tests
1048	VSCF Overload	Large DC link (phase) current for 100us	Rotor has shorted, or AVR phase wire short (or miswired), or brush short.	Perform Rotor Brush Test
1049	VSCF Overload	Sustained Generator output voltage of < 120V for a total of 2ms (100us sampling) after reaching operating voltage, AND very high current (>> max load)	The generator output is shorted or severely overloaded. Identify and clear the overload then restart.	Check for Overload conditions Proper Load Shedding
1050	VSCF Low Battery	Low supply voltage detected <8 VDC	The voltage supply to the AVR is low. Since the supply comes from the controller, either 1) The AVR is miswired to the controller 2) The controller is outputting the wrong voltage (faulty) 3) The AVR has internal issue	Check AVR Power and ground circuits from controller to AVR for proper voltage and ground
1051	VSCF High Battery	High supply voltage detected >16.2 VDC	The voltage supply to the AVR is High. 1) External battery charger is being used 2) AVR supply is mis-wired	Check for external charger issue Check harness for proper wiring
1052	VSCF DC Overvoltage	DC link overvoltage >400 VDC	1) The generator was temporarily overloaded 2) The output was temporarily shorted 3) Throttle is stuck (open) 4) Internal AVR issue	Check for Overload conditions Check proper Stepper operation
1053	VSCF Gate Fault	IGBT gate driver fault	Possible causes are: 1) The brushes are incorrectly wired. 2) The rotor is shorted. 3) The brushes are arcing or worn. 4) The generator was severely overloaded (shorted). 5) One of the fans is blocked or not working. Insufficient air flow. 6) Off" was pressed when the "Small Fan Failure" Warning was present (Ecode 1070)	Perform Rotor Brush Test Check for Overload conditions Check AVR Air flow for restriction Perform Small fan test Perform Large Fan Test Perform Auxiliary Power Supply test
1054	VSCF IGBT Overtemp.	Set for >85 deg. C	Probable causes are: 1) The AVR air filter needs replacing. 2) The air path is blocked, either intake or exhaust or through the unit. 3) The BIG fan is not running Perform Small Fan and Large Fan test 4) There is an air leak in the AVR enclosure. 5) The engine is running too hot. 6) Ambient temperature above 50C.	Check for Overload conditions Check AVR Air flow for restriction Perform Small fan test Perform Large Fan test Perform Auxiliary Power Supply test Check Generator air vents for restriction Insufficient air flow around unit
1055	VSCF Phase Error	If Vrms>125 & Hz < 45 while ramping	An incorrect voltage and frequency has been detected during starting. Probable causes are: 1) The stepper motor is not working or the linkage is binding. 2) The gas pressure is low and the engine is not coming up to speed. 3) The brushes are incorrectly wired. 4) The brushes are arcing or worn. 5) The brushes are not connecting to the slip-ring. 6) The rotor is shorted. 7) The generator has started into a severe load. 8) Brush harness connector is damaged.	Check for proper fuel supply and settings must be within specifications of unit Open MLCB and retest unit Check for Overload conditions Perform Rotor Brush test Check stepper operation Perform stepper motor test Check rotor resistance at slip rings

Table 4-11. VR VSCF-Codes

1056	VSCF Undervoltage	Main controller detects a low output voltage	The generator output voltage is too low. Possible causes are: 1) The load is too large 2) The stator is damaged 3) The rotor is damaged 4) The brushes are incorrectly wired 5) The brushes are arcing or worn 6) The AVR is damaged	Open MLCB and retest unit Check for Overload conditions Perform Rotor Brush test Perform Power Winding and DPE winding tests
1057	VSCF Overvoltage	Generator overvoltage >265 Vrms	Probable causes are: 1) The generator has been overloaded 2) The generator has started into a severe load.	Open MLCB and retest unit Check for overload conditions on startup
1058	VSCF DC Undervoltage	Loss of aux winding field <100 VDC	The DPE winding supplies this voltage. Possible faults are: 1) DPE is miswired/not connected. 2) DPE winding is faulty (rotor fault) 3) The brushes are arcing or worn. 4) Brushes are miswired or faulty.	Perform Power Winding and DPE tests Perform Rotor Brush test Inspect harness
1059	VSCF Field Loss	Output is < 50 Vrms. Immediately upon completion of startup voltage ramp. (1 rms sample)	The unit has detected there is no output voltage while starting up. Probable causes are: 1) The DPE winding is miswired 2) The DPE is producing no voltage into the AVR. 3) The brushes are arcing or worn. 4) Brushes are miswired or faulty. 5) The rotor is shorted. 6) The AVR is damaged.	Perform Power Winding and DPE tests Perform Rotor Brush test Check harness connections to AVR
1060	Big Fan Failure	PCB temperature has exceeded 70C ALARM	This alarm occurs when the AVR electronics temperature exceeds 70C. Possible causes are: 1) The AVR air filter needs replacing. 2) The air path is blocked, either intake or exhaust. 3) The BIG fan is not running (it only runs when the engine runs). 4) There is an air leak in the AVR enclosure. 5) The engine is running too hot. 6) The ambient temperature is above 50C.	Check for Overload conditions Check AVR Air flow for restriction Perform Large Fan test Perform Auxiliary Power Supply test Check Generator air vents for restriction Insufficient air flow around unit Perform Small Fan Test
1061	VSCF Field Loss	Output is < 20 Vrms for 16 cycles	The unit has detected the output voltage has been lost while running. Possible causes are: 1) Fuel loss. 2) The DPE is no longer generating voltage into the AVR. 3) The brushes are arcing or worn. 4) Brushes are miswired or faulty. 5) The rotor is shorted. 6) The AVR is damaged.	Check fuel supply and fuel pressure Perform Power Winding and DPE tests Perform Rotor Brush Test Check harness connections to AVR
1062	VSCF Comms Loss	Main controller detects no VSCF modbus messages have been received.	The AVR needs to communicate with the controller, as such there is a shielded cable connecting the two units. Possible faults: 1)Comm's cable / connection has become faulty. 2) Incorrectly shielded 3) The AVR has no power to it. Check the LED's on the AVR. The green one should be lit (only). 4) One of the controllers is damaged. 5) The firmware download has failed. 6) Can occur when using a DMM on these wires.	Check communication wires between controller and AVR for shorts, opens, proper routing, and check pin fit. Check shield wires are properly grounded. Check for correct firmware version Check static voltages on Communication wires with unit not running
1063	VSCF Enable Mismatch	Main controller detects the VSCF Enable state reported by VSCF does not match the state set by HSB.	Probable causes: 1)The enable wire is missing between the AVR and HSB controllers. 2) The enable wire is shorted or miswired, or connector is loose. 3) The controller is faulty. 4) The AVR is faulty.	Check AVR P1 connections Check controller connections Check Enable circuit for proper operation

Table 4-11. VR VSCF-Codes

1064	VSCF Speed PWM Loss	Main controller detects the speed PWM command from VSCF is not received	Probable causes: 1)The speed signal wire is missing between the AVR and HSB controllers. 2) The speed signal wire is shorted or miswired, or connector is loose. 3) The controller is faulty. 4) The AVR is faulty.	Check continuity on the PWM communication lines. Check connector and pin fit
1065	Overfrequency	Main controller detects an over frequency alarm	Engine is 25% over 60Hz for 100ms OR Engine is 20% over 60Hz for 3s	Check stepper operation sticking binding AVR internal issue
1066	VSCF Speed mismatch	Engine speed does not match commanded speed.	1) Large load not wired through loadshed module. 2) Fuel issues (run out, pressure, hose bent), Fuel pin in wrong position. 3) Large overload. 4) Cold engine, not responding. 5) Sticking throttle, throttle wiring. 6) Engine problem.	Fuel Supply not in specifications. Incorrect fuel selection Restricted fuel supply, Check fuel hoses to mixer for restriction Check proper fuel pin selection or restriction in pin orifices. Open MLCB and retest possible Overloaded condition. Perform stepper test Check wire harness proper routing and pin fit. Check magnetos for proper operation. Internal engine concerns
1070	Small fan failure	Current for fan is wrong.	The small fan current is detected as wrong. Possible causes are: 1) Fan wires are broken/miswired. 2) Fan is stalled/clogged. 3) Air path is blocked.	Check AVR Air flow for restriction Perform Small Fan Test
--	Bootloader fails	Fails to load	Probable causes: 1) The USB stick is incompatible 2) The file is not on the USB stick 3) The file is in the wrong folder 4) The file is the wrong file name	
--	Green LED not lit	The AVR has no power	Check the AVR power wiring	
--	Green LED pulsating	The fan is running in cooldown mode	Normal operation	
--	Red LED lit	The AVR has detected a fault	See the display for messages	
	Output voltage is little low or high		Controller not calibrated	Calibrate voltage with calibrated equipment
	Generator does not pull full power		Current calibration not correct Faulty wiring or improperly orientated CT(s) Fuel problem	Calibrate amperage with calibrated equipment Inspect proper installation and test CT(s) Check fuel supply and fuel pressure

Table 4-12. Synergy™ Loadshed

Symptom	Possible Causes
Generator stalls when large load is applied.* *Any load larger than 9 kW (NG) or 10kW (LP) must connected via a load shed module.	1) Check for Fast loadshed proper operation. Large load(s) not properly setup for load shedding. 2) Loadshed is incorrectly wired. 3) Check condition of transfer signal. Wire 23 should be wired to the AVR, NOT the controller. There should only be one wire. 4) Total load is too large for LP (>19 kW)* 5) Total load is too large for NG (>18 kW)*
Large loads keep getting shed and locked out (load led goes out for 30 min.	1) Total load is too big for the generator.
No lights on OPCB	1) Check for proper DC voltage on Wire 194 – approximately12 VDC. 2) Check Wire 0 for proper ground. 3) Remove all wires from OPCB except Wire 194 and 0. Press the reset button for 5 seconds then wait 5 minutes. If there are still no lights, replace the module. If lights return check disconnected wires for proper circuit operation.
OPCB won't shed loads	1) Connect a DM to Wire 23 and ground. 2) With generator in OFF mode, approximately12 VDC should be measured 3) With generator in AUTO mode, simulate a transfer from utility to standby (loss of utility). Wire 23 should drop from approximately12 VDC to zero. If not, verify operation of Wire 23 circuit.

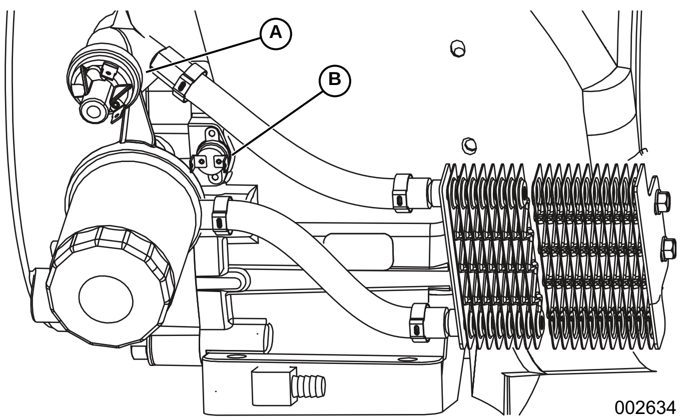
Engine Protective Devices

Standby power generators will often run unattended for long periods. Such operating parameters as (a) battery voltage, (b) engine oil pressure, (c) engine temperature, (d) engine operating speed, and (e) engine cranking and startup are not monitored by an operator during automatic operation. Because engine operation will not be monitored, the use of engine protective safety devices is required to prevent engine damage in the event of a problem. There are alarm codes programmed to display when certain conditions exist. These codes are displayed where they apply in the headings below and elsewhere in this manual.

Low Battery Warning

The controller will continually monitor the battery voltage and display a “Low Battery” message if the battery voltage falls below 12.1 VDC. After a 60 second delay, a fault code will be set. The fault will remain until repaired.

No other action is taken on a low battery condition. The warning will automatically clear if the battery voltage rises above 12.4 VDC.



A.Low Oil Switch B.High Temp Switch

Figure 4-10. Engine Protective Switches

Low Oil Pressure

(Synergy e-Code 1300)

See ***Figure 4-10***. An oil pressure switch is mounted on the oil filter adapter. This switch has normally closed contacts that are held open by engine oil pressure during cranking and startup. Should oil pressure drop below approximately 5 psi, the switch contacts will close. On closure of the switch contacts, the Wire 86 circuit from the controller will be connected to ground. The controller’s logic will then de-energize a “run relay” (internal to the controller). The run relay’s contacts will then open and the 12 VDC run circuit will be terminated. This will result in closure of the fuel shutoff solenoid and loss of engine ignition.

High Temperature Switch

(Synergy e-Code 1400)

See ***Figure 4-10***. The contacts of this switch close if the temperature exceeds approximately 293 ºF (144 ºC), initiating an engine shutdown. The generator will automatically restart and the fault on the LCD display will reset once the temperature has returned to a safe operating level.

Overspeed

During engine cranking and operation the controller receives AC voltage and frequency signals from the ignition magneto via Wire 18. Should the speed exceed approximately 72 Hz (4320 rpm), the controller’s logic will de-energize the “run relay” (internal to the controller). The relay contacts will open terminating engine ignition and closing the fuel shutoff solenoid; the engine will then shut down. This feature protects the engine and alternator against damaging over speeds. During cranking the rpm signal generated by the magnetos is used to terminate engine cranking.

RPM Sensor Failure

(Synergy e-Code 1501, 1505)

During cranking if the board does not see a valid rpm signal within three (3) seconds it will shutdown and latch out on “RPM Sensor Loss.”

If the rpm signal is lost for one full second during running, the controller will shutdown the engine, wait 15 seconds, then re-crank the engine.

If an rpm signal is not detected within the first three (3) seconds of cranking, the controller will shut down the engine down and latch out on “RPM Sensor Loss.”

If an rpm signal is detected the engine will start and run normally. If the rpm signal is subsequently lost again, the controller will try one re-crank attempt before latching out and the LCD displays “RPM Sensor Loss.”

NOTE: A common cause of RPM Sensor Loss fault is the lack of engine cranking. This could be due to a faulty crank circuit or a faulty starter.

Overcrank

(Synergy e-Code 1100)

This feature prevents the generator from damage when it continually attempts to start and another problem, such as no fuel supply, prevents it from starting. The unit will crank and rest for a preset time limit. It will then stop cranking and the LCD screen will indicate an “Overcrank” condition.

NOTE: If the fault is not repaired, the overcrank fault will continue to occur.

The system will control the cyclic cranking as follows: 16 second crank, seven (7) second rest, 16 second crank, seven (7) second rest followed by three (3) additional cycles of seven (7) second cranks followed by seven (7) second rests.

Failure to Start

This is defined as any of the following occurrences during cranking.

1. Not reaching starter dropout within the specified crank cycle. Starter dropout is defined as four (4) cycles at 1,500 rpm.
2. Reaching starter dropout, but then not reaching 2200 rpm within 15 seconds. In this case the control board will go into a rest cycle for seven (7) seconds, then continue the rest of the crank cycle.
3. During a rest cycle the start and fuel outputs are de-energized and the magneto output is shorted to ground.

Cranking Conditions

The following notes apply during the cranking cycle.

1. Starter motor will not engage within five (5) seconds of the engine shutting down.
2. The fuel output will not be energized with the starter.
3. The starter and magneto outputs will be energized together.
4. Once the starter is energized the control board will begin looking for engine rotation. If it does not see an rpm signal within three (3) seconds it will shut down and latch out on “RPM Sensor Loss.”
5. Once the control board sees an rpm signal it will energize the fuel solenoid, drive the throttle open and continue the crank sequence.
6. Starter motor will disengage when speed reaches starter dropout.
7. If the generator does not reach 2200 rpm within 15 seconds, re-crank cycle will occur.
8. If engine stops turning between starter dropout and 2200 rpm, the board will go into a rest cycle for seven (7) seconds then re-crank (if additional crank cycles exist).
9. Once started, the generator will wait for a hold-off period before starting to monitor oil pressure and oil temperature (refer to the Alarm Messages section for hold-off times).
10. During cranking, if the controller is in the OFF mode, cranking stops immediately.
11. During Auto mode cranking, if the Utility returns, the cranking cycle does NOT abort but continues until complete. Once the engine starts, it will run for one (1) minute, and then shut down.

Under-Frequency

After starting, if the generator stays under a set frequency for more than 30 seconds, it will shutdown.

Table 4-13. Synergy Under-frequency Shutdown Settings

Unit Hertz	Shutdown Frequency
60 Hz	55 Hz

Clearing an Alarm

When the generator is shut down due to a latching alarm, the controller must be set to the OFF mode and the “Enter” key pressed to unlatch any active fault and clear the corresponding fault alarm message.

1. Not reaching starter dropout within the specified crank cycle. Starter dropout is defined as four (4) cycles at 1,500 rpm.
2. Reaching starter dropout, but then not reaching 2200 rpm within 15 seconds. In this case the control board will go into a rest cycle for seven (7) seconds, then continue the rest of the crank cycle.
3. During a rest cycle the start and fuel outputs are de-energized and the magneto output is shorted to ground.

Table 4-14. Synergy Warnings and Alarm Parameters						
Description	Hold-off Time	Duration Time	Continuous or 2 looks	Upper threshold	Lower threshold	Lockout Type
Low Oil Pressure	5 seconds	8 seconds	2 looks	Digital input	Digital input	Hard Lockout
RPM Sensor Loss	3 seconds	1.1 seconds	Continuous	Timed signal loss	Timed signal loss	2 Recrank, Hard Lockout
Wiring error	0 seconds	7.5% of 100 ms	100 ms sample periods	7.50%	None	Hard Lockout
High temp.	10 seconds	1 second	2 looks	Digital input	Digital input	Auto Reset
Underspeed	5 seconds	30 seconds	Continuous	None	55 Hz/3300 rpm	Hard Lockout
Overspeed Instant	0 seconds	.1 second	Continuous	75 HZ/4500 rpm	None	Hard Lockout
Overspeed Slow	0 seconds	3 seconds	Continuous	72 HZ/4320 rpm	None	Hard Lockout
Undervoltage Fast*	10 seconds	2 seconds	Continuous	None	15 Volts or no zero crosses detected	2 Recrank, Hard Lockout
Undervoltage Slow*	5 seconds	10 seconds	Continuous	None	80% of nominal	2 Recrank, Hard Lockout
Overvoltage fast *	5 seconds	1/5 second	Continuous	130% nominal	None	Hard Lockout
Overvoltage slow *	5 seconds	3 seconds	Continuous	110% nominal	None	Hard Lockout
EEPROM Abuse Warning	0 seconds	NA	Continuous	NA	NA	Warning
Stepper Overcurrent	0 seconds	Instant	Continuous	NA	NA	Hard Lockout
Fuse Problem	0 seconds	75% of 100ms	Continuous	NA	NA	Hard Lockout
Overload Alarm	0 seconds	20 seconds	Continuous	102% rated current	NA	Hard Lockout
Overload Cooldown	0 seconds	5 minutes	NA	NA	NA	Running with no voltage
Overload Undervoltage	5 seconds	10 seconds	Continuous	NA	80% of nominal after Overload Alarm	Hard Lockout
Low Battery	60 seconds	As long as battery is <12.1 VDC	Continuous	NA	12.1 V or less	Warning
Battery Problem	0 seconds	NA	Continuous	> 16V immediate OR > 600mA for 5 sec after 18hr charge cycle		Warning
Charger Warning	0 seconds	NA	Continuous	NA	12.5 V at end of charge cycle	Warning
Charger Missing AC	15 seconds	As long as AC is missing	Continuous except cranking	NA	NA	Warning
Overcrank	0 seconds	5 attempts	NA	NA	NA	Hard Lockout

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Section 4.3 *Operational Analysis – Synergy*

Introduction

The "Operational Analysis" is intended to familiarize the service technician with the operation of the DC and AC control system. A thorough understanding of how the system works is essential to sound and logical troubleshooting.

Utility Source Voltage Available

Refer to ***Figure 4-11***. The circuit condition with the controller set to the AUTO mode and with Utility source power available can be briefly described as follows:

1. Utility source voltage is available to the transfer switch Terminal Lugs N1 and N2 and the CONTACTOR is in the "Utility" position.
2. Utility voltage is available to the controller via Wire N1 and N2.
3. Load voltage (120 VAC) is available to the controller via Wire T1 for Battery Charger.
4. The controller is shown in the AUTO mode. Battery voltage is available to the circuit board via Wire 13, the 7.5 amp fuse (F1). Wire 194 provides 12 VDC to the transfer relay in the transfer switch.
5. Wire 820 supplies 5 VDC to the Tri-Light Annunciator and Wire 817 for the Green System Ready LED is gated to ground.

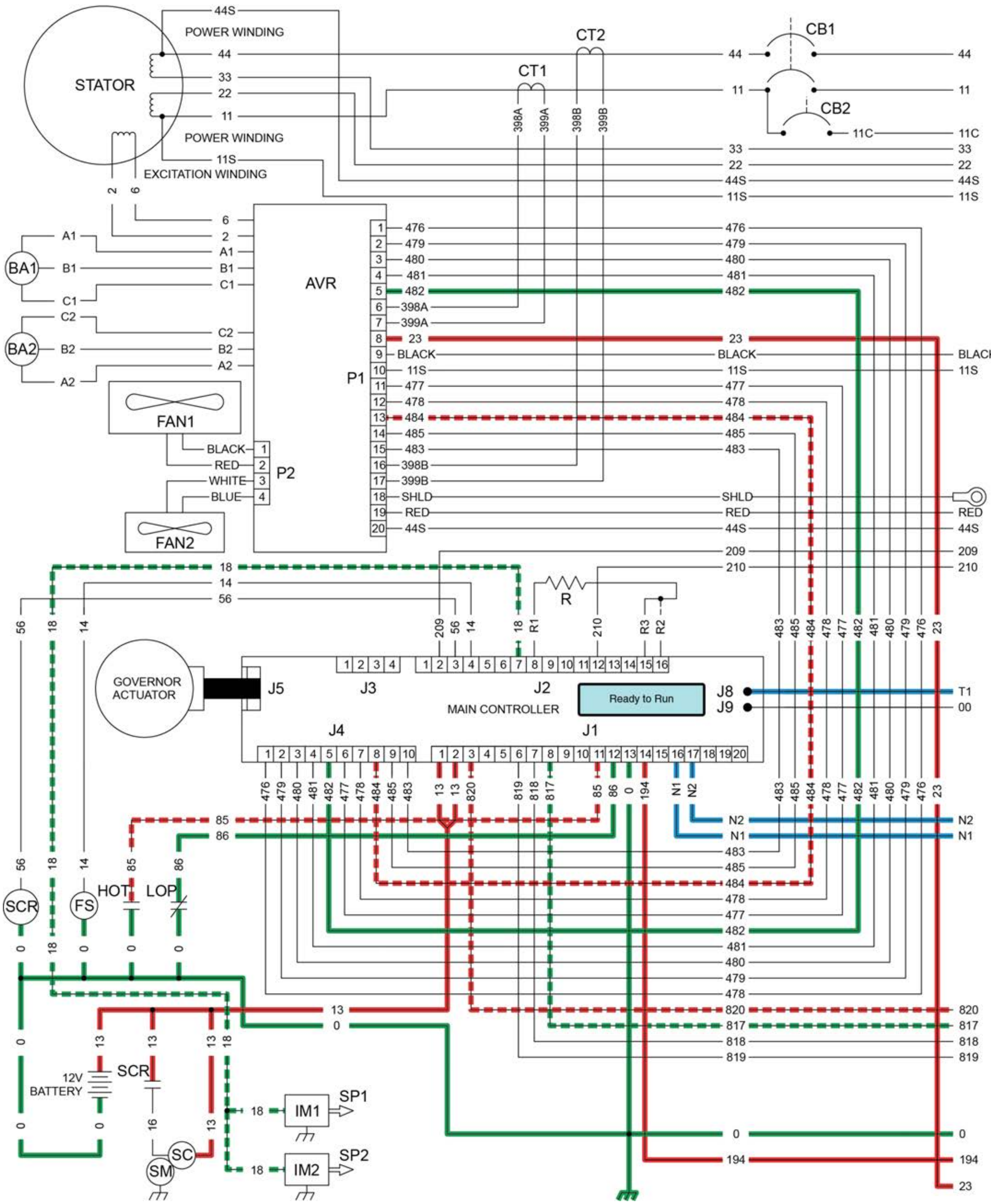
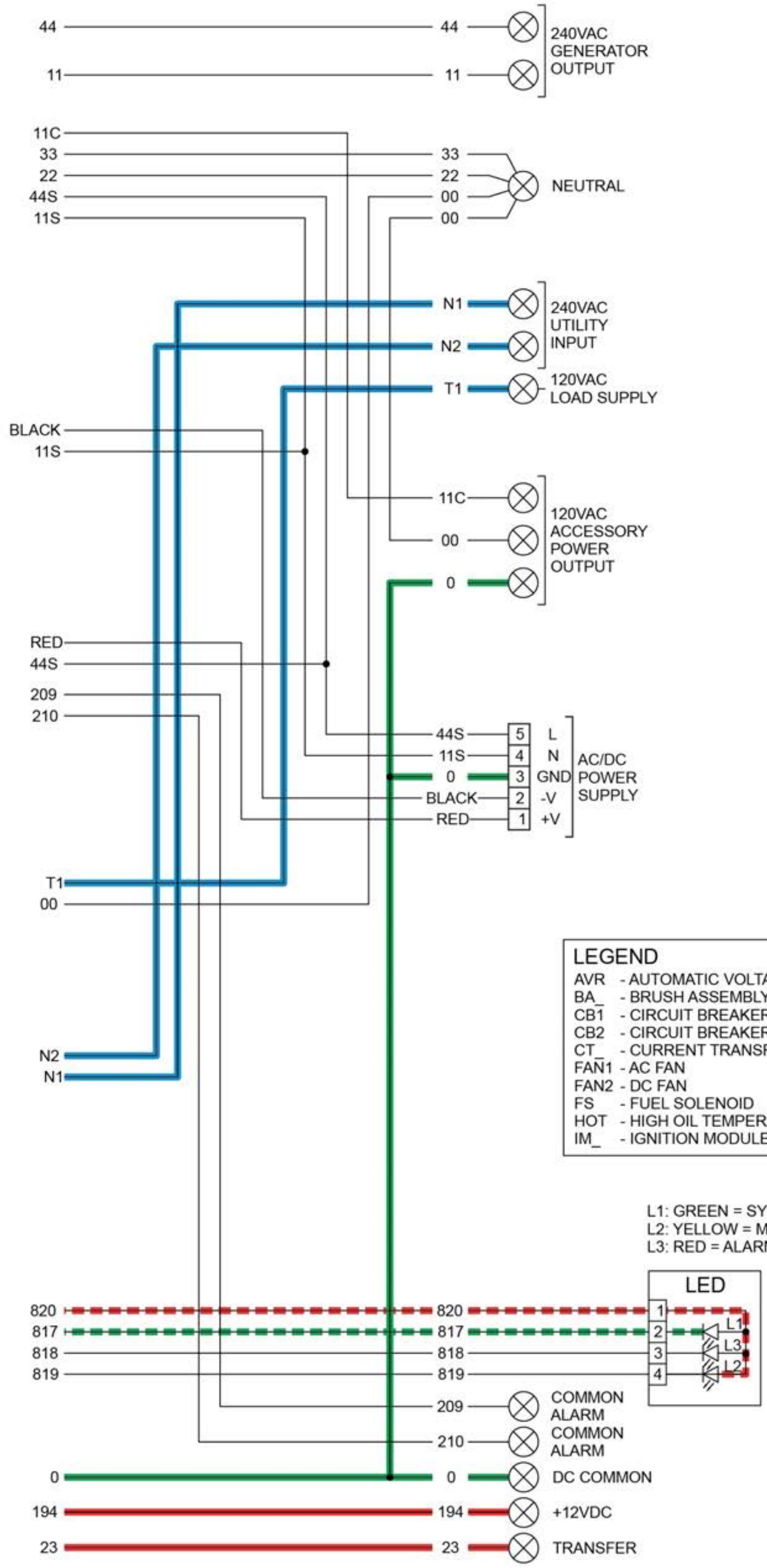

STATOR
POWER WINDING
POWER WINDING
EXCITATION WINDING
CT1
CT2
CB1
CB2
AVR
P1
P2
BA1
BA2
FAN1
FAN2
BLACK
RED
WHITE
BLUE
SHLD
R
GOVERNOR ACTUATOR
J5
J3
J2
J4
J1
J8
J9
MAIN CONTROLLER
Ready to Run
T1
00
N1
N2
SCR
FS
HOT
LOP
12V BATTERY
SC
SM
IM1
IM2
SP1
SP2

Figure 4-11.

Utility Voltage Available



- = 12 VDC ALWAYS PRESENT
- = AC VOLTAGE
- = PULSE VAC
- = GROUND
- = PCB GROUND CONTROL
- = 12 VDC DURING CRANKING ONLY
- = 12 VDC DURING ENGINE RUN CONDITION
- = HIGH VOLTAGE IGNITION SPARK
- = DC FIELD EXCITATION
- = 5 VDC TO LED
- = FAN GROUND
- = COMMUNICATION PLC

LEGEND

AVR	- AUTOMATIC VOLTAGE REGULATOR	J_	- MAIN CONTROLLER CONNECTIONS
BA_	- BRUSH ASSEMBLY	LED	- LED BOARD
CB1	- CIRCUIT BREAKER (MAIN OUTPUT)	LOP	- LOW OIL PRESSURE SWITCH
CB2	- CIRCUIT BREAKER (GFCI)	P_	- AVR CONNECTIONS
CT_	- CURRENT TRANSFORMER	R_	- RESISTOR
FAN1	- AC FAN	SC	- STARTER CONTACTOR
FAN2	- DC FAN	SCR	- STARTER CONTROL RELAY
FS	- FUEL SOLENOID	SM	- STARTER MOTOR
HOT	- HIGH OIL TEMPERATURE SWITCH	SP_	- SPARK PLUG
IM_	- IGNITION MODULE		

L1: GREEN = SYSTEM READY
L2: YELLOW = MAINTENANCE REQUIRED
L3: RED = ALARM

Notes

Initial Dropout of Utility Source Voltage

Refer to ***Figure 4-12***. Should a Utility power failure occur, circuit condition may be briefly described as follows:

1. The controller continually monitors for acceptable Utility voltage via N1 and N2. Should Utility voltage drop below approximately 65% (adjustable, see chart) of the nominal source voltage, a programmable timer on the controller will turn on.
2. In ***Figure 4-12***, the 5-second timer (factory default, adjustable from 2-1500 seconds) is still timing and engine cranking has not yet begun.

Utility Dropout	
Factory Default	**Adjustable Dropout**
60 Hz = 156VAC	60 Hz = 140-171VAC

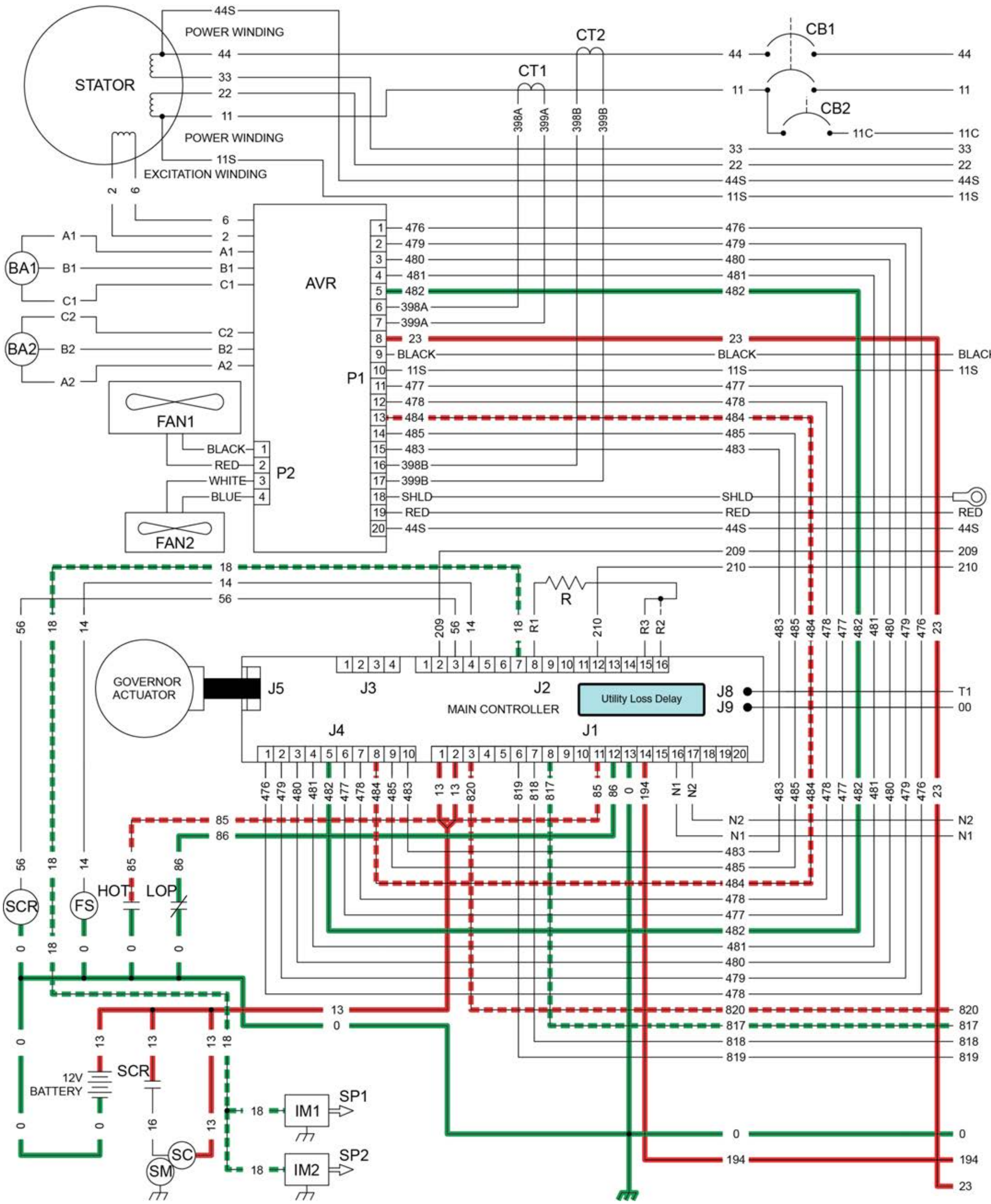
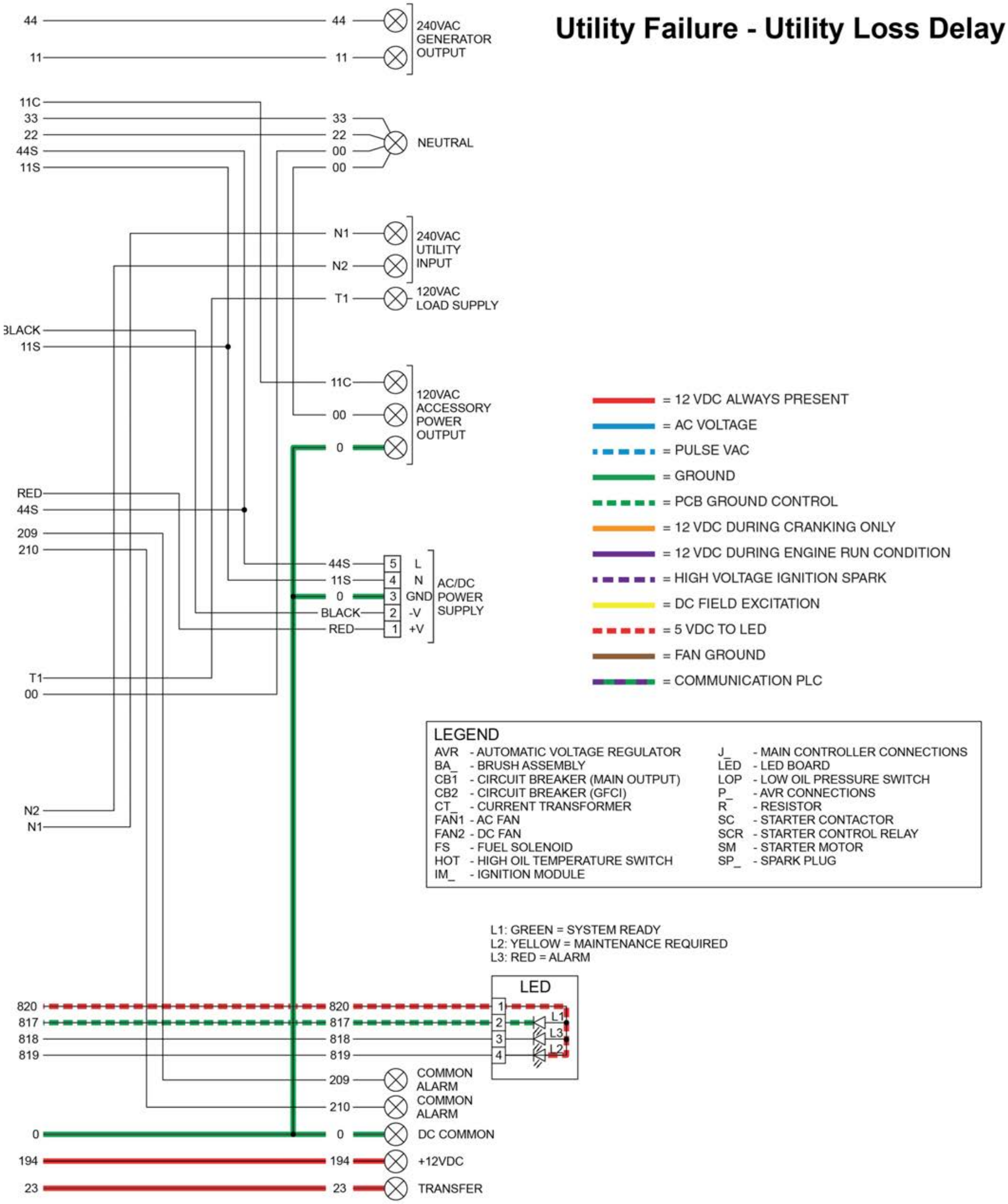

STATOR
POWER WINDING
POWER WINDING
EXCITATION WINDING
CT1
CT2
CB1
CB2
AVR
P1
P2
BA1
BA2
FAN1
FAN2
BLACK
RED
WHITE
BLUE
SHLD
R
GOVERNOR ACTUATOR
J5
J3
J2
J4
J1
J8
J9
MAIN CONTROLLER
Utility Loss Delay
SCR
FS
HOT
LOP
12V BATTERY
SC
SM
IM1
IM2
SP1
SP2
T1
00

Figure 4-12.

Utility Failure - Utility Loss Delay



Notes

Utility Voltage Failure and Engine Cranking

See ***Figure 4-13***.

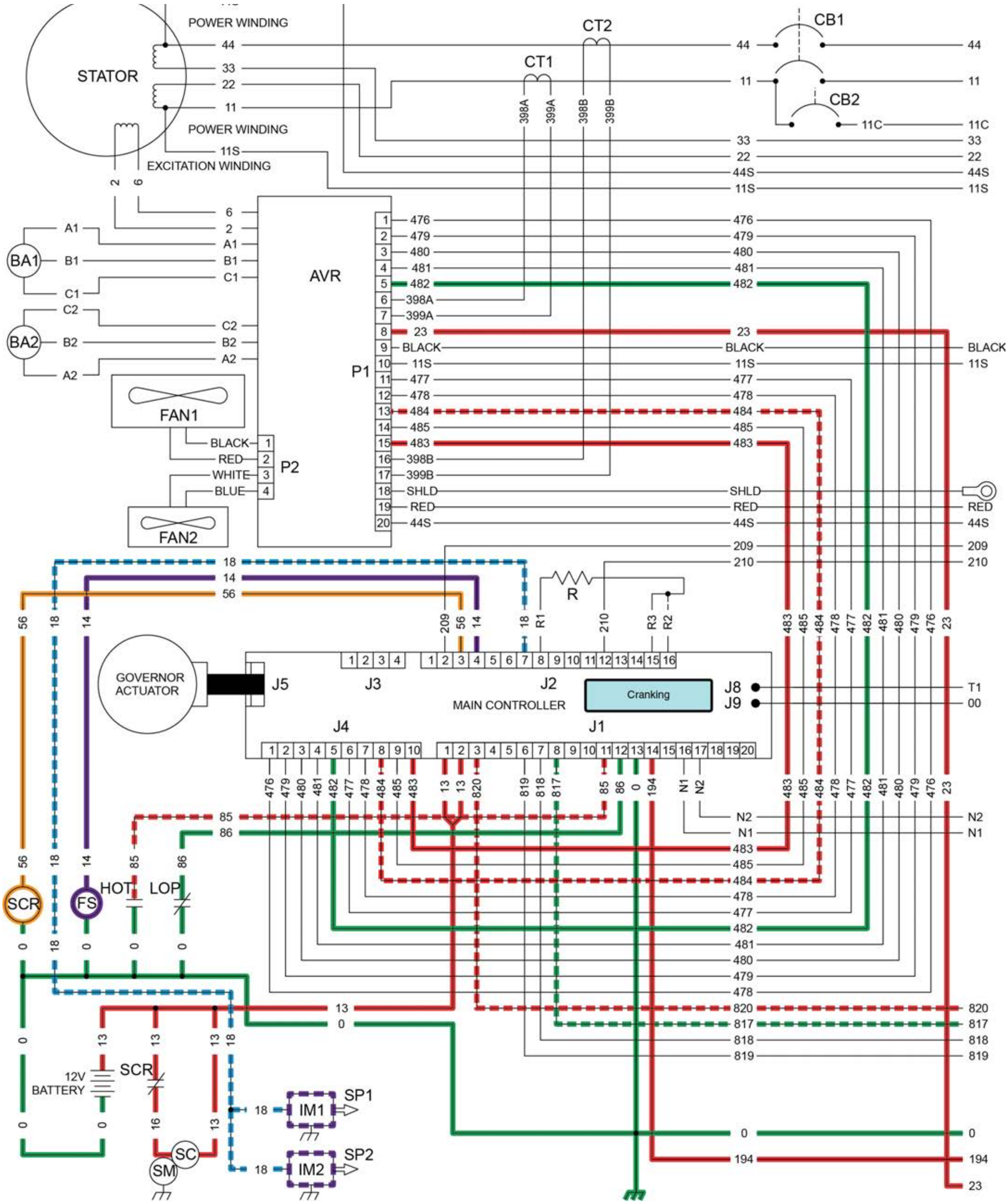
1. After the controller's adjustable programed timer has timed out, if Utility voltage is still below the programmed utility drop out level, the controller's logic will energize the internal crank relay followed by the internal run relay.
2. When the internal crank relay energizes 12 VDC is delivered to the starter contactor relay (SCR) via Wire 56. When the SCR energizes, its contacts close and battery voltage is delivered to a starter contactor (SC). When the SC energizes, its contacts close and battery voltage is delivered to the starter motor (SM); the engine is now cranking.
3. A 12 VDC power supply is delivered to the stepper motor via the Red Wire and the other wires are gated to ground by the controller to open the throttle position.

NOTE: The stepper motor will cycle the mixer to a full open throttle position (which opens both venturis), back to a closed position and then to the starting position of opening the throttle of the small venturi.

4. With the engine cranking a pulsing AC speed reference signal is generated by the magneto(s) and is delivered to the controller through Wire 18. If a valid signal is received, the controller will energize the internal run relay and deliver 12 VDC on Wire 14. The fuel solenoid energizes (opens) and fuel is available to the engine.

NOTE: If the controller does not see an rpm signal, it will not energize Wire 14/Fuel Solenoid.

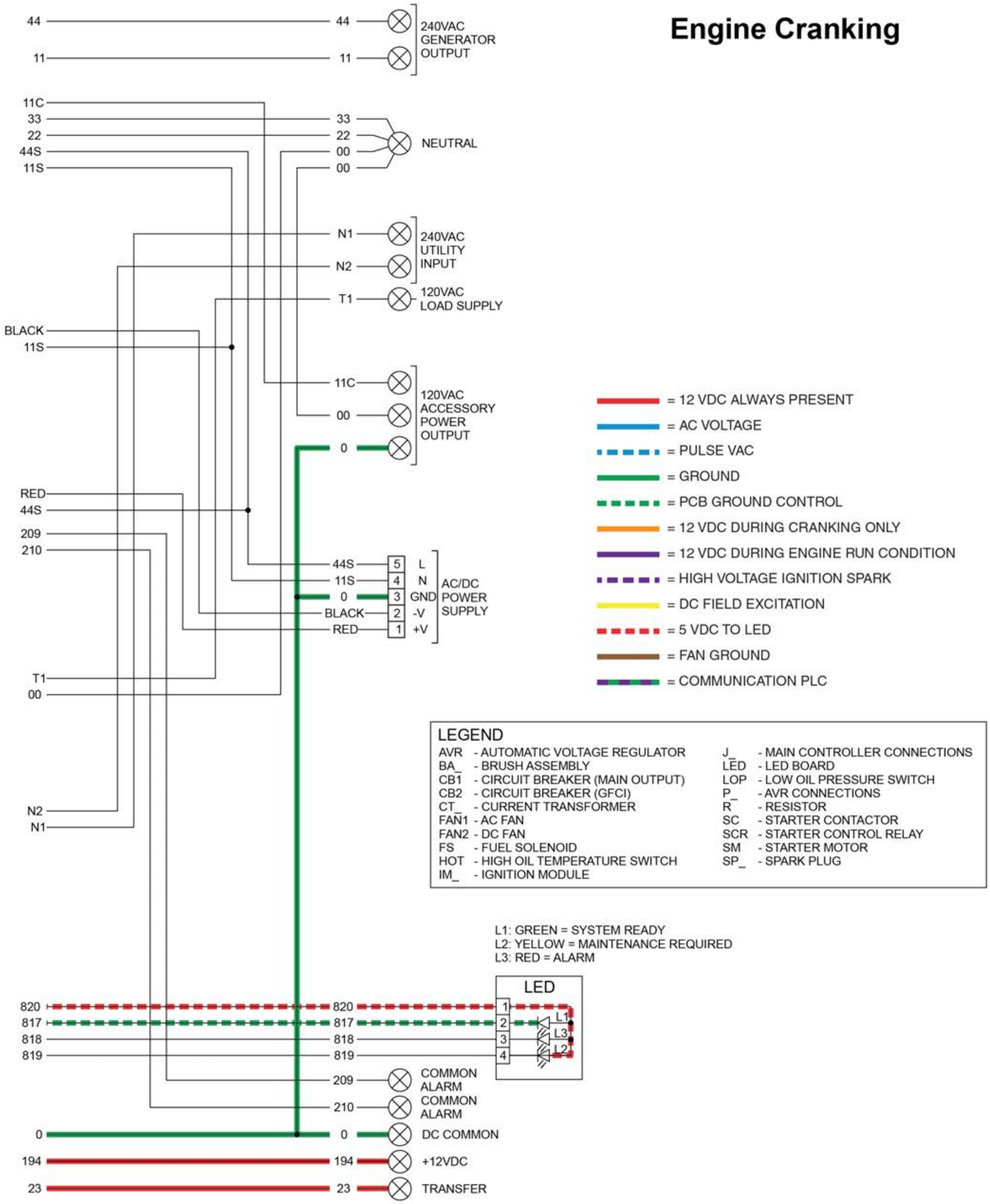
5. With ignition and fuel flow available the engine rpm will begin to increase.
6. The HSB controller now applies power to the AVR during cranking. The Green LED on the AVR will be lit if it has power.



POWER WINDING
STATOR
POWER WINDING
EXCITATION WINDING
CT1
CT2
CB1
CB2
44
33
22
11
11S
11C
44S
398A
399A
398B
399B
BA1
BA2
A1
B1
C1
C2
B2
A2
AVR
P1
P2
FAN1
FAN2
BLACK
RED
WHITE
BLUE
476
479
480
481
482
23
477
478
484
485
483
SHLD
209
210
R
R1
R3
R2
GOVERNOR ACTUATOR
J5
J3
J2
J4
J1
J8
J9
T1
00
MAIN CONTROLLER
Cranking
85
86
820
819
818
817
194
N1
N2
56
18
14
SCR
FS
HOT
LOP
12V BATTERY
SC
SM
IM1
IM2
SP1
SP2
0
13
16

Figure 4-13.

Engine Cranking



Notes

Engine Startup and Running

See ***Figure 4-14***. With the fuel solenoid open and ignition occurring, the engine starts. Engine startup and running may be described as follows:

1. Cranking terminates at approximately 1500 rpm.
2. Once the speed reaches 2200 rpm, the controller sends the enable signal to the AVR and also begins communicating with the AVR through the communications link (RS485 port). Several functions occur at this time. First, if the communications link is faulty in any way the unit will shut down with a “VSCF Comms Loss” alarm (E-code 1062).
3. The controller checks the enable signal wiring by reading its state via the communications link. If the signals do not match then the unit shuts down with a “VSCF Enable Mismatch” alarm (E-code 1063).
4. The controller checks for a speed signal that is sent back from the AVR. If the speed signal is missing, a “VSCF Speed PWM Loss” alarm is displayed (E-code 1064). The AVR will send an rpm request to the controller via the PWM communication line.
5. The AVR controller energizes the field at 2200 rpm using the 12V battery power which is inverted to a three phase sinusoidal waveform at a very low frequency of 0.3 Hz. This frequency is normally used to make up the difference between engine speed and 60 Hz at the output of the generator, so at initial startup it will increase from 0.3 Hz to about 15 Hz when at least 125 volts has been achieved. At a low speed of 2700 rpm, this frequency will be at about 15 Hz (60 – (2700/60) = 15) and taper off to 0.3 Hz as it nears 3600 rpm.
6. This is applied to the rotor via the three phase wire connections and causes the DPE winding to energize and build up AC voltage. The AVR then rectifies this voltage and inverts it to feed AC to the rotor. Stator output voltage begins to build at this point.
7. The initial internal target voltage is set at 180 VRMS and the initial target rpm is 3000 to reduce the load on the engine. At this early stage, while the engine is building rpm and voltage, there are small short term goal (STG) voltage steps taken to the target voltage. As the STG voltage is incremented to the targeted voltage, the AVR performs some checks to see if the brushes / slip rings / AVR and the AVR 3 phase connections are working properly. It does this by checking if the stator output voltage is greater than 125 VRMS but the frequency is less than 45 Hz. If this happens, a “VSCF Phase Error” alarm (E-code 1055) is displayed and the unit shuts down.
8. Once the STG voltage has reached its target, the engine and the alternator will be creating actual output close to the target voltage (depending on adverse starting conditions such as very cold temperatures, low fuel pressure, etc.). The AVR then checks the stator output voltage. If it is less than 50 VRMS, the controller will display a “VSCF Field Loss” alarm (E-code 1059).
9. Once the engine speed is above 2950 rpm, the frequency has reached at least 55 Hz and the output voltage is greater than 140 VRMS, the target voltage is set at the full 240 VRMS and the speed is slowly ramped up to the full 3600 rpm over a period of about 1.5 seconds to avoid rpm overshoot. The system is now “started”.
10. At 2200 rpm the hold off timers activate and the 5 second “warm-up timer” goes active. The “engine warm-up timer” will run for 5 seconds. When this timer finishes timing the controller’s logic will initiate a transfer to the “Standby” position. As shown in the next series, the timer is still running and transfer has not yet occurred.
11. The Generator AC output is now available to the transfer switch Terminal Lugs E1 and E2 and to the normally open contacts of the transfer relay. However, the transfer relay is de-energized and its contacts are open.

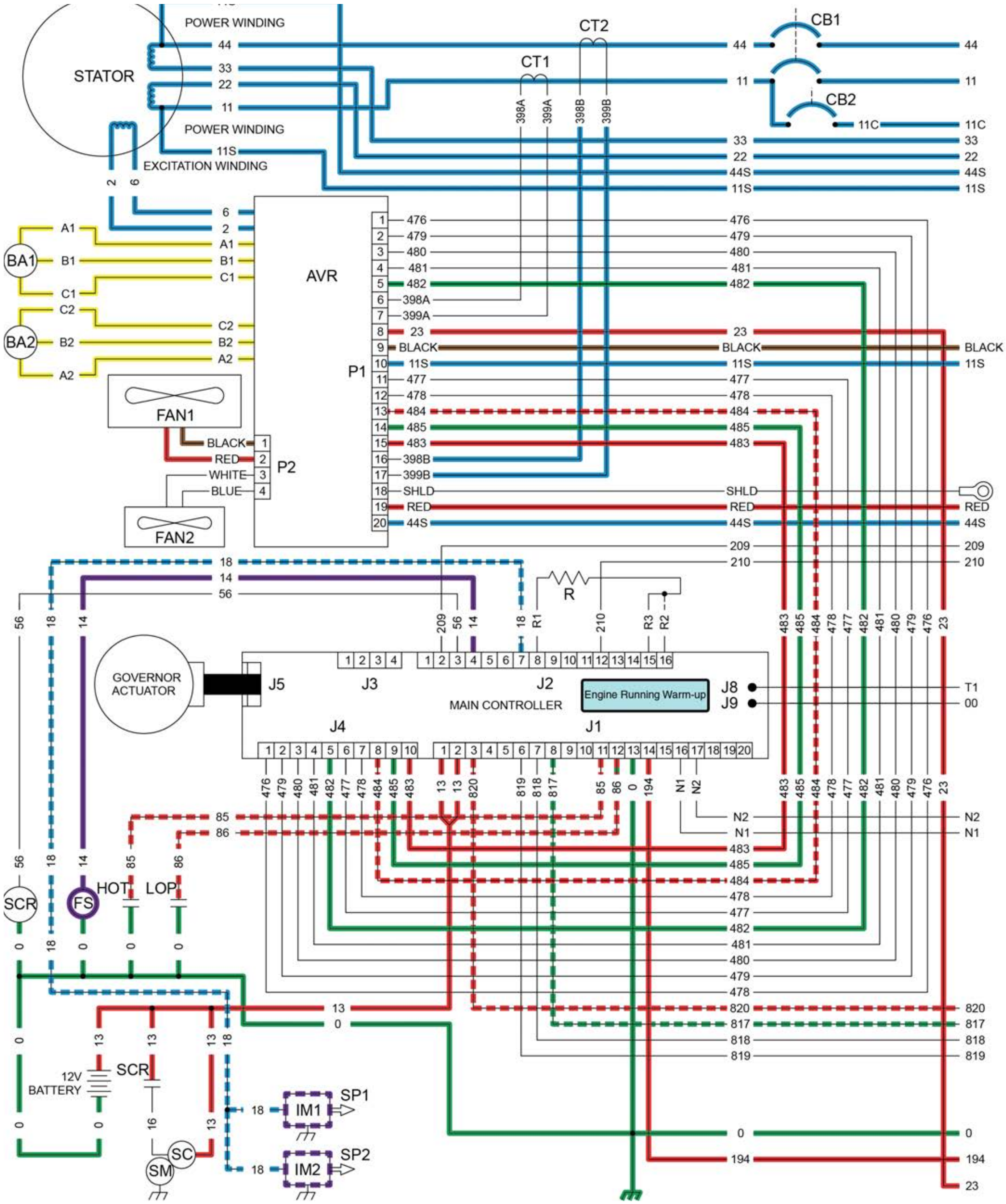
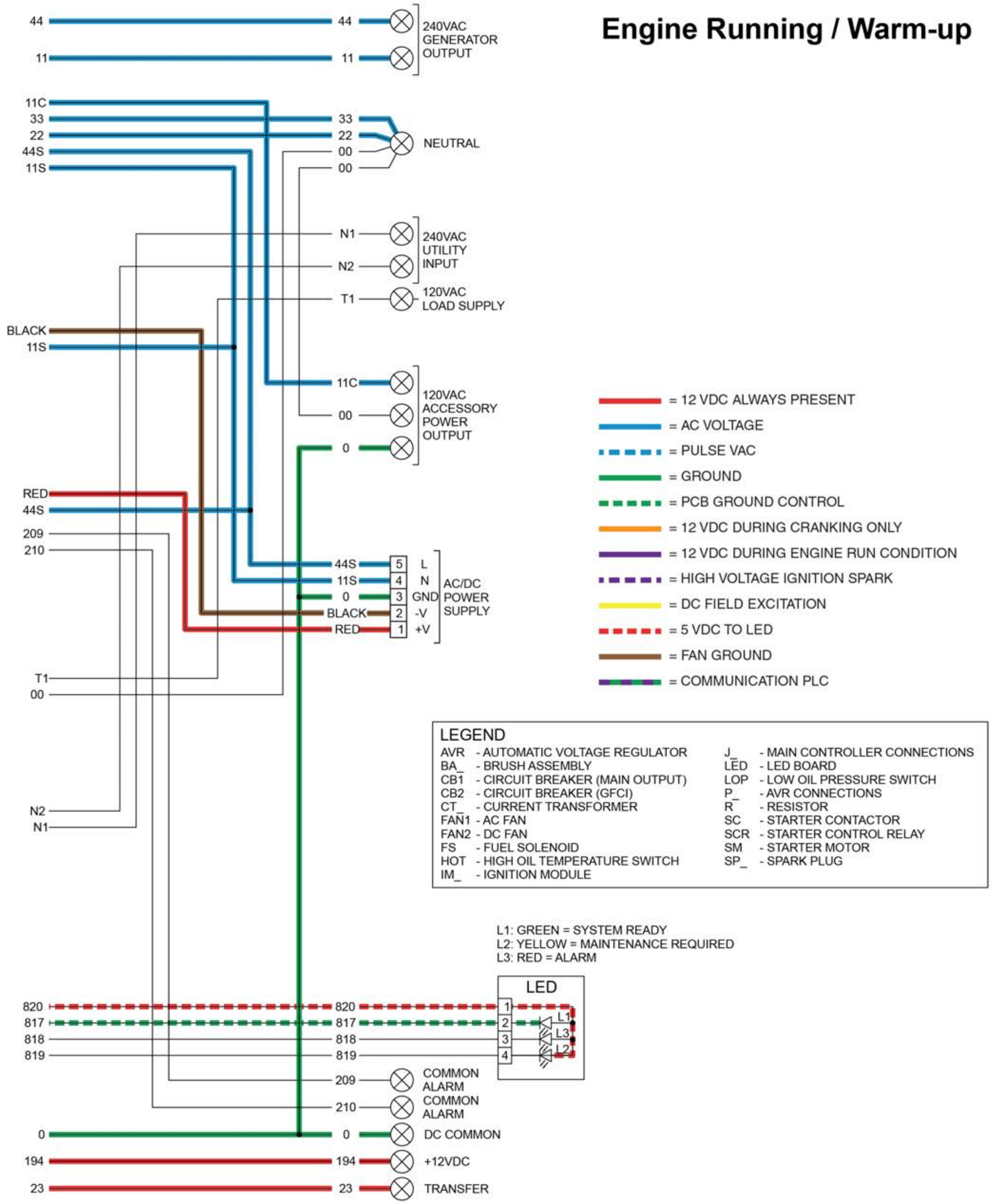

STATOR
POWER WINDING
EXCITATION WINDING
CT1
CT2
CB1
CB2
AVR
P1
P2
FAN1
FAN2
BA1
BA2
R
GOVERNOR ACTUATOR
J5
J3
J2
J8
J9
MAIN CONTROLLER
Engine Running Warm-up
J4
J1
SCR
FS
HOT
LOP
12V BATTERY
SC
SM
IM1
IM2
SP1
SP2

Figure 4-14.

Engine Running / Warm-up



Notes

Transfer to Standby

In ***Figure 4-15*** the Generator is running, the controller's "engine warm-up" timer has expired and generator AC output is available to the transfer switch Terminal Lugs E1 and E2 and to the open contacts on the transfer relay. Transfer to Standby may be briefly described as follows:

1. 12 VDC is delivered to the transfer relay coil (TR1 - Terminal A) via Wire 194. The 12 VDC circuit is completed back to the AVR via Wire 23 (TR1 - Terminal B). However, AVR logic holds Wire 23 open from ground and the TR1 relay is de-energized.
2. When the "engine warm-up timer" expires, the controller and the AVR communicate to verify conditions are correct and the AVR will take Wire 23 to ground. The TR1 relay energizes and its normally open contacts close (standby position).
3. While running, the pulsing AC speed reference from the ignition magneto(s) to the controller via Wire 18 will be used for the following functions:
   a. governor speed control to maintain requested rpm from the AVR through different loads
   b. overspeed
   c. underspeed
4. With no, or a light load, the stepper motor will control the throttle position of the smaller venturi. As the load demand increases and with the smaller venturi at wide open, it will start to open the larger venturi as needed for load/fuel demand.
5. With loads applied, CT1 - Wires 398A/399A and CT2 - Wires 398B/399B deliver approximately 0- 1.5 VAC based on percentage of Amps (load).

Approximate Values (when back-probed at connector):

- 25 = 53.87 mVAC RMS
- 50 = 107.74 mVAC RMS
- 75 = 161.61 mVAC RMS
- 100 = 215.48 mVAC RMS

⚠DANGER

Electrocution. Lethal voltage may be present at current transformers (CTs). Do not touch CTs while primary current is applied. Doing so will result in death or serious injury. (000310)

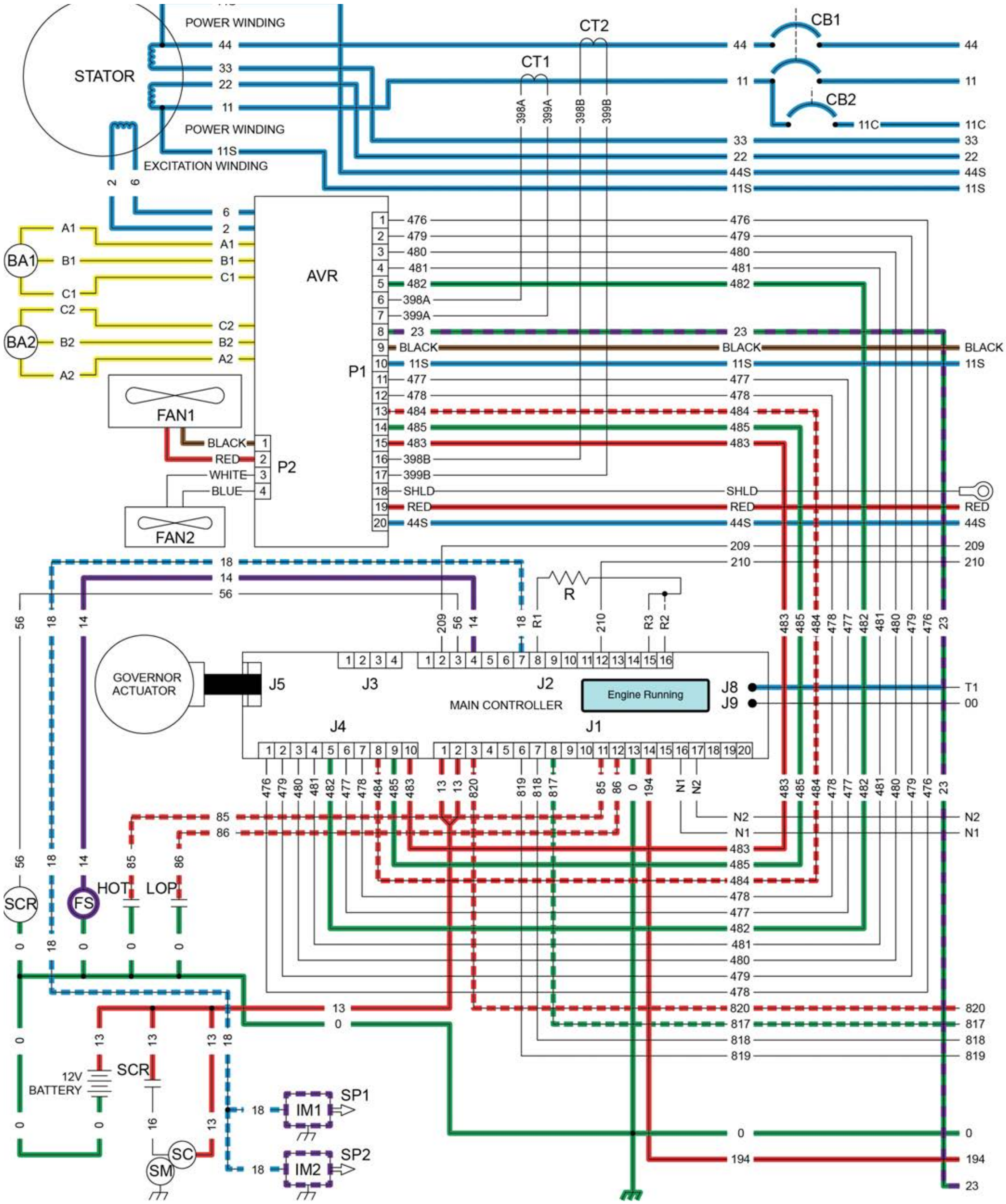
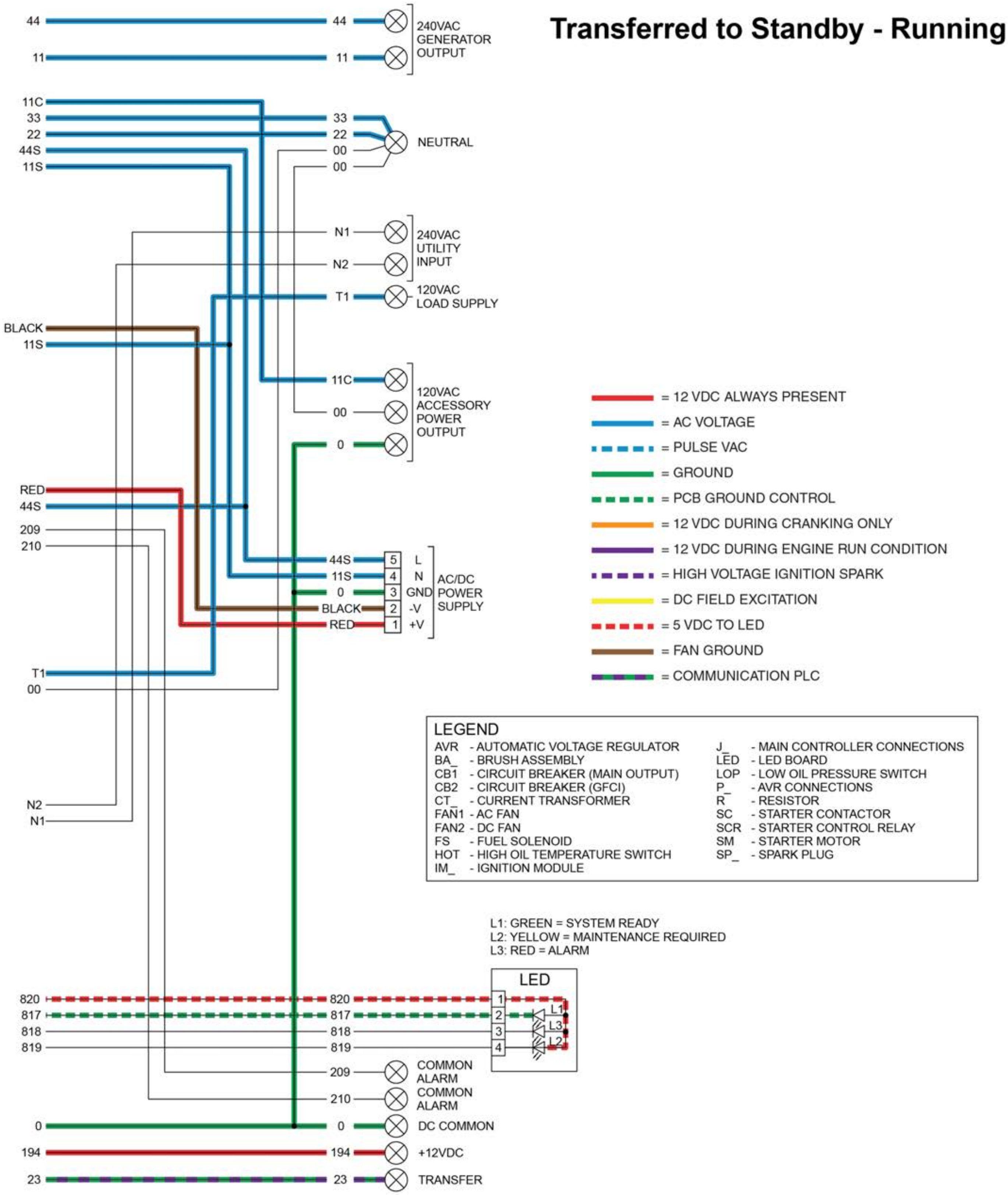

STATOR
POWER WINDING
POWER WINDING
EXCITATION WINDING
CT1
CT2
CB1
CB2
AVR
P1
P2
FAN1
FAN2
BA1
BA2
R
GOVERNOR ACTUATOR
J5
J3
J2
J4
J1
J8
J9
MAIN CONTROLLER
Engine Running
SCR
FS
HOT
LOP
12V BATTERY
SCR
SC
SM
IM1
IM2
SP1
SP2

Figure 4-15.

Transferred to Standby - Running



Notes

Utility Voltage Restored and Re-transfer to Utility

In ***Figure 4-16*** the Load is powered by Generator voltage. On restoration of Utility voltage, the following events will occur:

1. On restoration of Utility voltage above 75% (programmable, see chart for range) of the nominal rated voltage, a “re-transfer time delay” on the controller starts timing. The timer will run for 15 seconds.
2. At the end of the 15 seconds, the “re-transfer time delay” will stop timing. The controller will send a request over the RS 485 communication line to the AVR and the AVR will open the Wire 23 circuit from ground. The transfer relay (TR1) will de-energize.
3. When the TR1 relay de-energizes its utility side contacts close. Utility voltage is then delivered to the utility closing coil (C1), via Wire N1A and N2A, the closed TR1 contacts, Wire 126, limit switch (SW2), and a bridge rectifier.
4. The C1 coil energizes and moves the main contacts to their “Utility” Position; the LOAD terminals are now powered by Utility.
5. Movement of the main contacts to the “Utility” position actuates the limit switches. SW2 opens and SW3 moves to the Standby source side.

NOTE: Note: If utility fails during the cool-down timer cycle for 5 seconds, the controller will send a request over the RS 485 communication line to the AVR and the AVR will transfer back to standby.

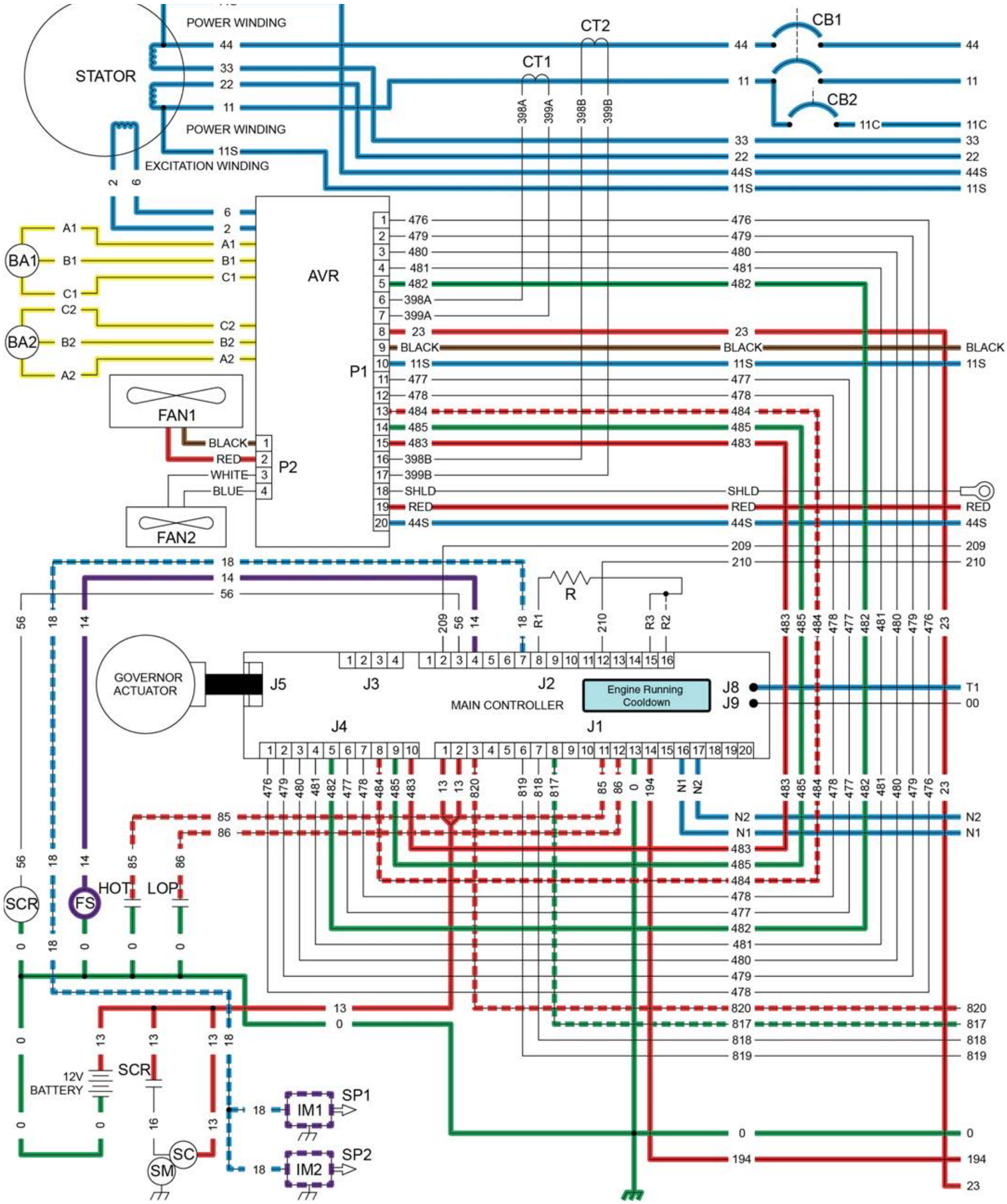
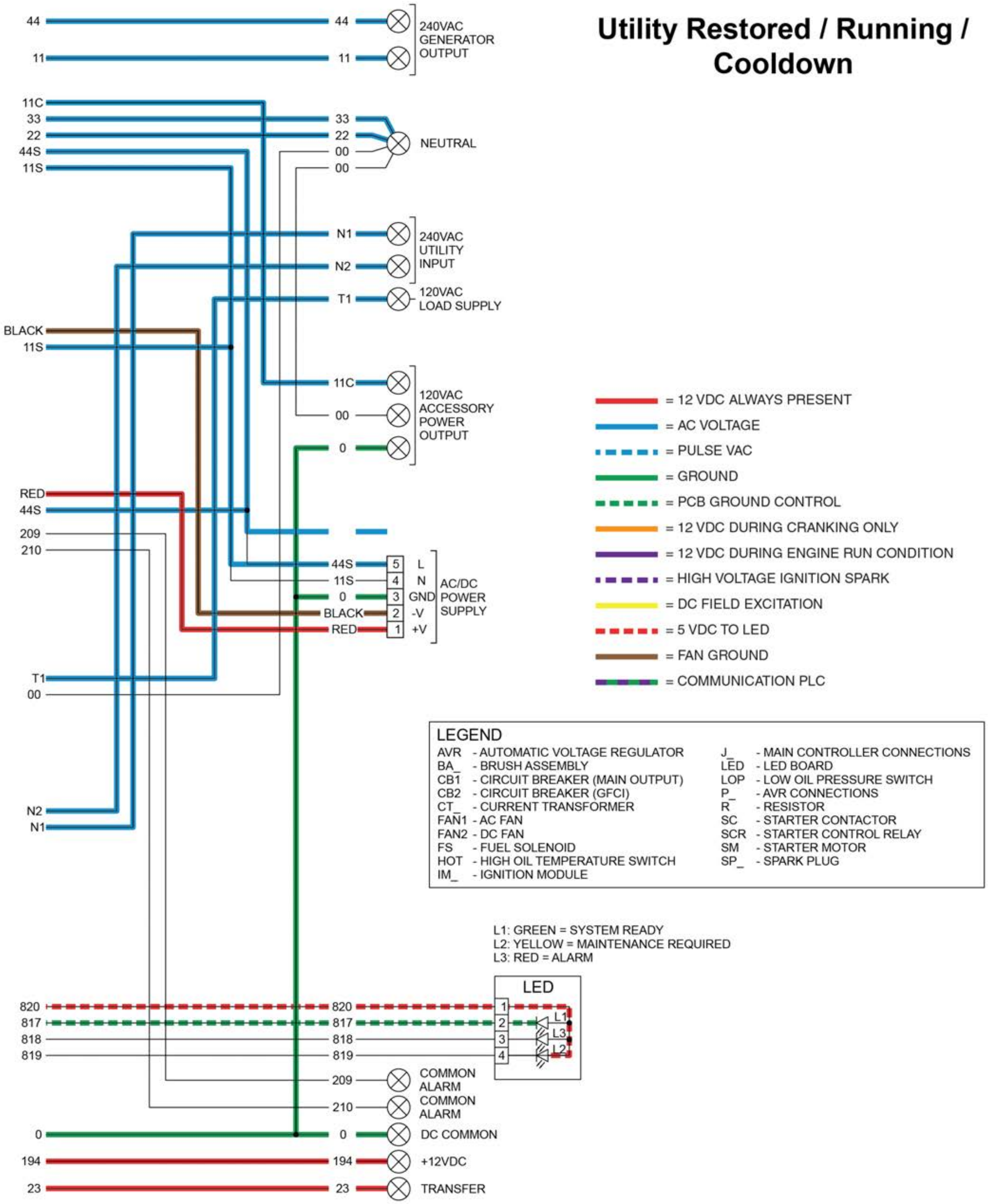

POWER WINDING
STATOR
EXCITATION WINDING
CT1
CT2
CB1
CB2
AVR
P1
P2
FAN1
FAN2
BA1
BA2
GOVERNOR ACTUATOR
J5
J3
J2
J4
J1
J8
J9
MAIN CONTROLLER
Engine Running
Cooldown
R
SCR
FS
HOT
LOP
12V BATTERY
SC
SM
IM1
IM2
SP1
SP2

Figure 4-16.

Utility Restored / Running / Cooldown



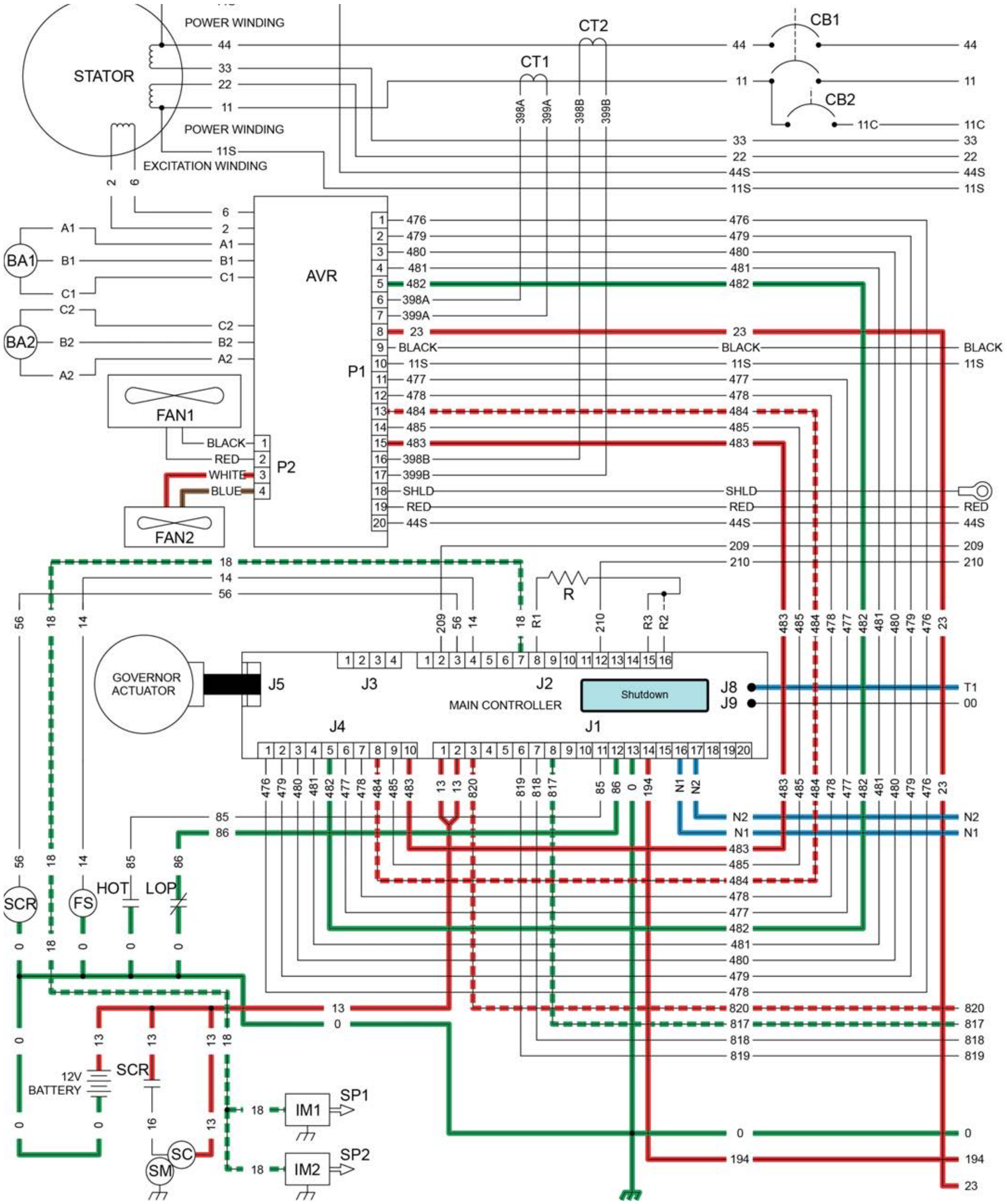
Notes

Engine Shutdown

See ***Figure 4-17***. Following re-transfer back to the Utility source an “engine cool-down timer” on the controller starts timing. When the timer has expired (approximately one minute), the controller will de-energize the internal run relay removing fuel from the engine. The following events will occur:

1. The DC circuit to Wire 14 and the fuel solenoid will open. The fuel solenoid will de-energize and close to terminate the fuel supply to the engine.
2. The controller’s logic will connect the engine’s ignition magnetos to ground via Wire 18. Ignition will terminate.
3. Without fuel flow and without ignition the engine will shut down.
4. The AVR will now be placed into cool-down mode. The controller will turn off the ENABLE line to the AVR and the AVR will begin the cool-down process. This will activate the Small Fan.
5. The Green LED located on top of the AVR will be fading ON and OFF to indicate the cooling process is activated.
6. The Small Fan runs from 50 minutes to 80 minutes depending on the temperature within the AVR and ambient temperatures. Once the this goal has been met a request from the AVR to the controller to shut down is sent via communications RS-485
7. The Controller will turn off its internal relay that supplies 12 Volts via Wire 483 “AVR Power.”
8. Shut down of RS 485 communications communication between the 2 components will also be powered down.
9. The completed cool down process will be indicated via the green LED located on top of the AVR that will now be OFF.

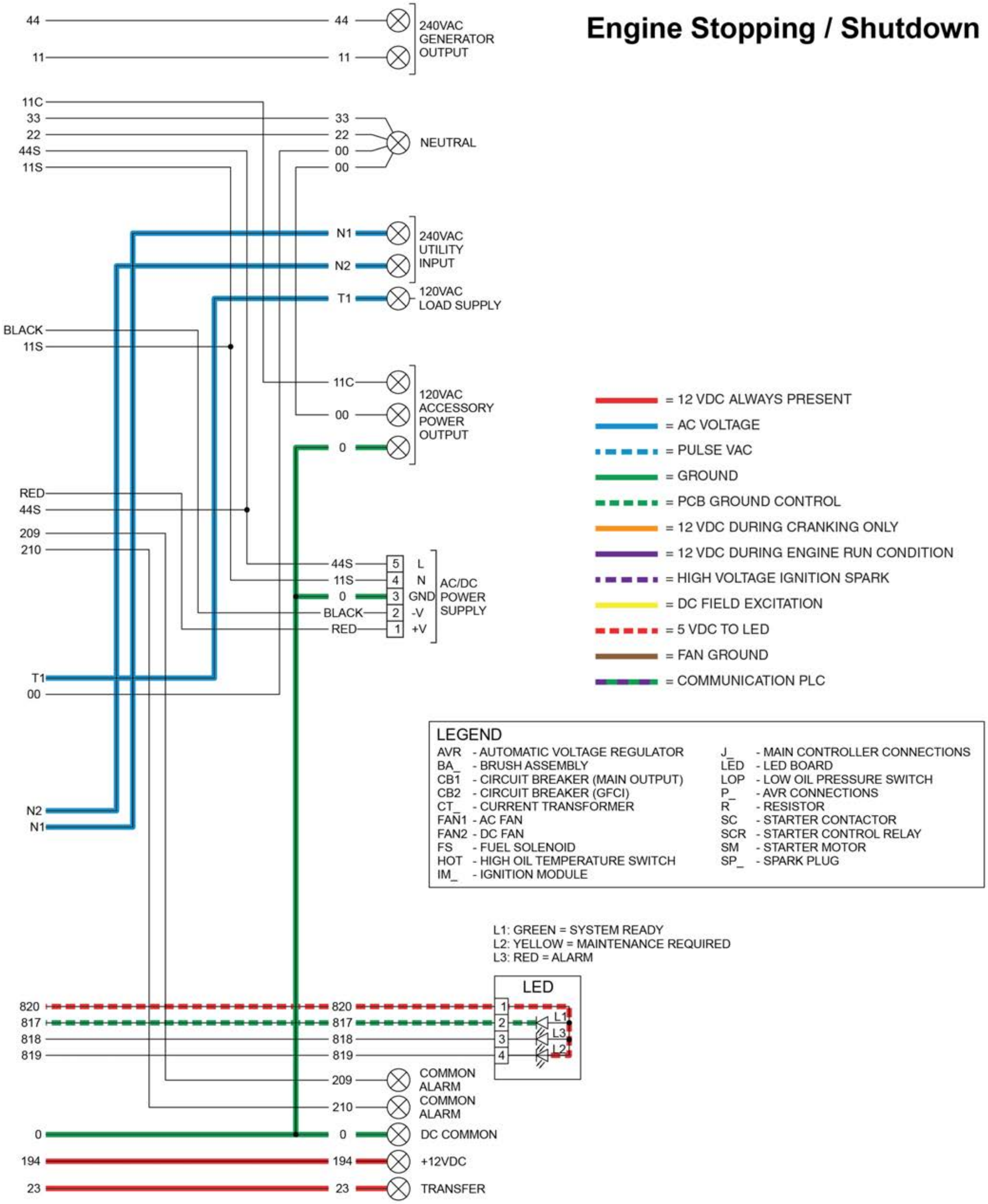
NOTE: After shutdown, the small DC fan is energized from the AVR controller (the green LED is fading ON and OFF) and will continue to run for as long as 80 minutes to prevent heat from building up in the AVR electronics. After an hour the electronics temperature is checked. If the temperature is above 140°F (60°C) a further 10 minute cooldown period is added. This is repeated up to 80 minutes total. The fan is then powered down, and the HSB controller removes power to the AVR controller to conserve battery power (the green LED is now off).



STATOR
POWER WINDING
POWER WINDING
EXCITATION WINDING
CT1
CT2
CB1
CB2
AVR
P1
P2
BA1
BA2
FAN1
FAN2
R
GOVERNOR ACTUATOR
J5
J3
J2
J8
J9
Shutdown
MAIN CONTROLLER
J4
J1
SCR
FS
HOT
LOP
12V BATTERY
SC
SM
IM1
IM2
SP1
SP2
BLACK
RED
WHITE
BLUE
SHLD
T1
00
N1
N2

Figure 4-17.

Engine Stopping / Shutdown



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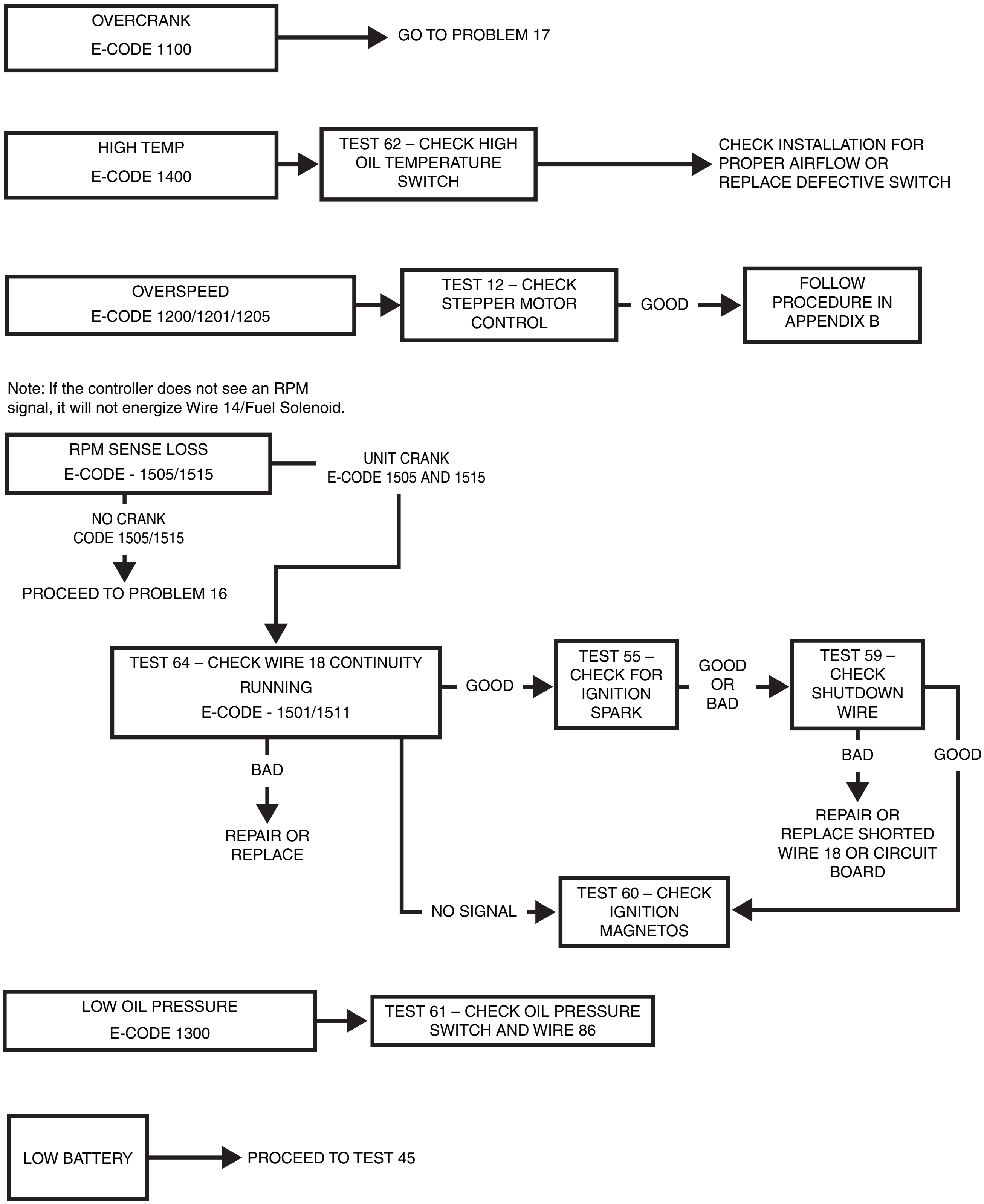
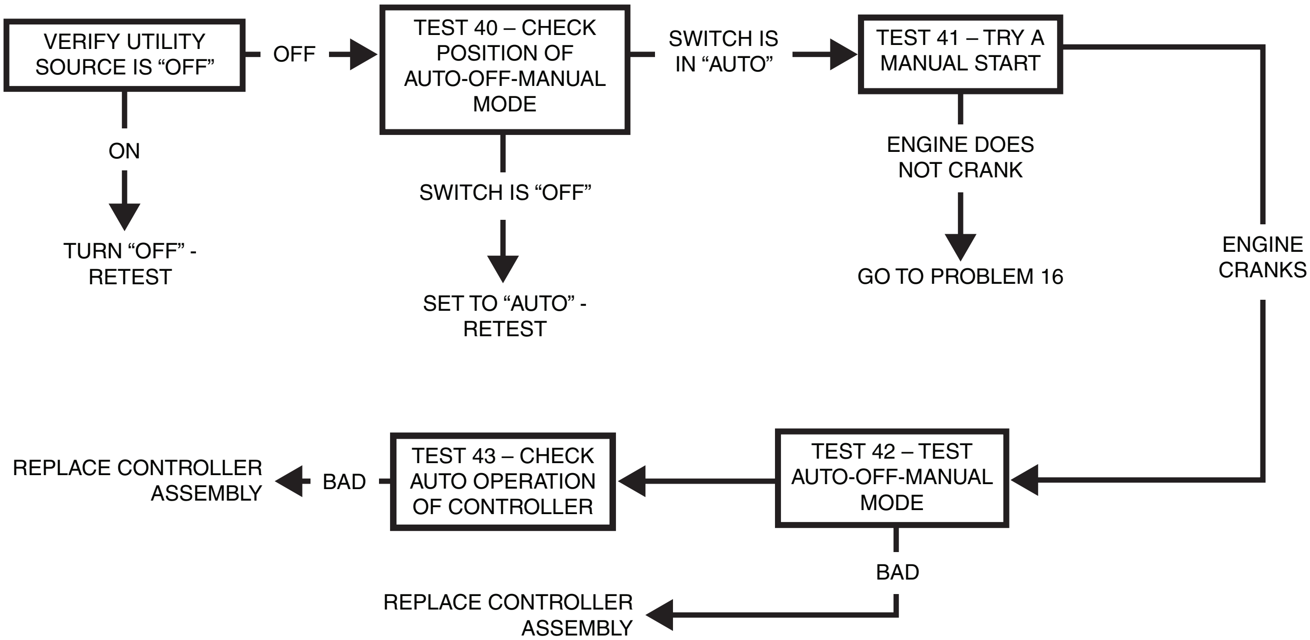
Problem 14 – Shutdown Alarm/Fault Occurred During Crank Attempt, Start or Run

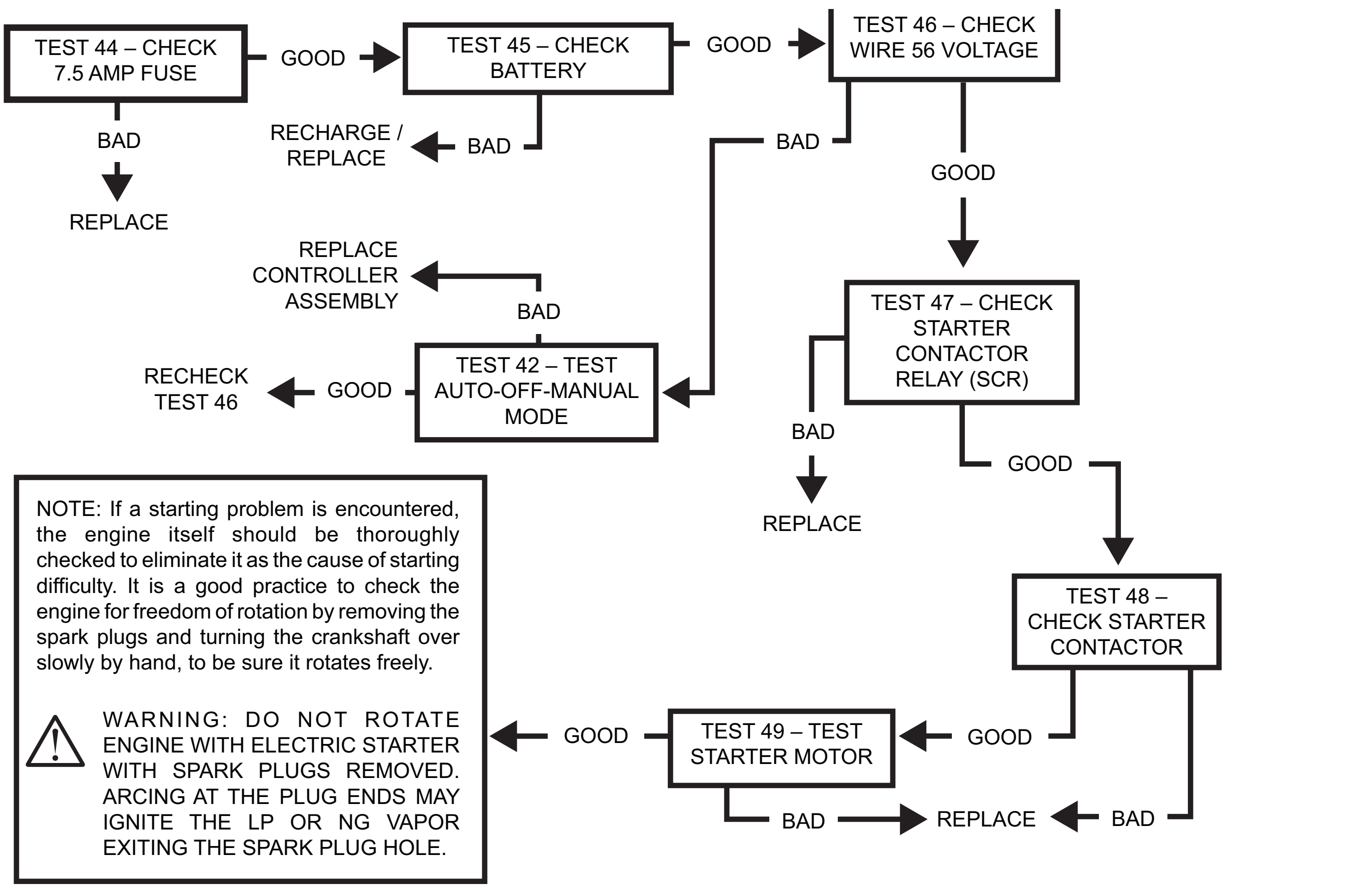


IMPORTANT NOTE: Clear any faults in the controller before proceeding with any running diagnostic steps!

Problem 15 – Engine Will Not Crank When Utility Power Source Fails

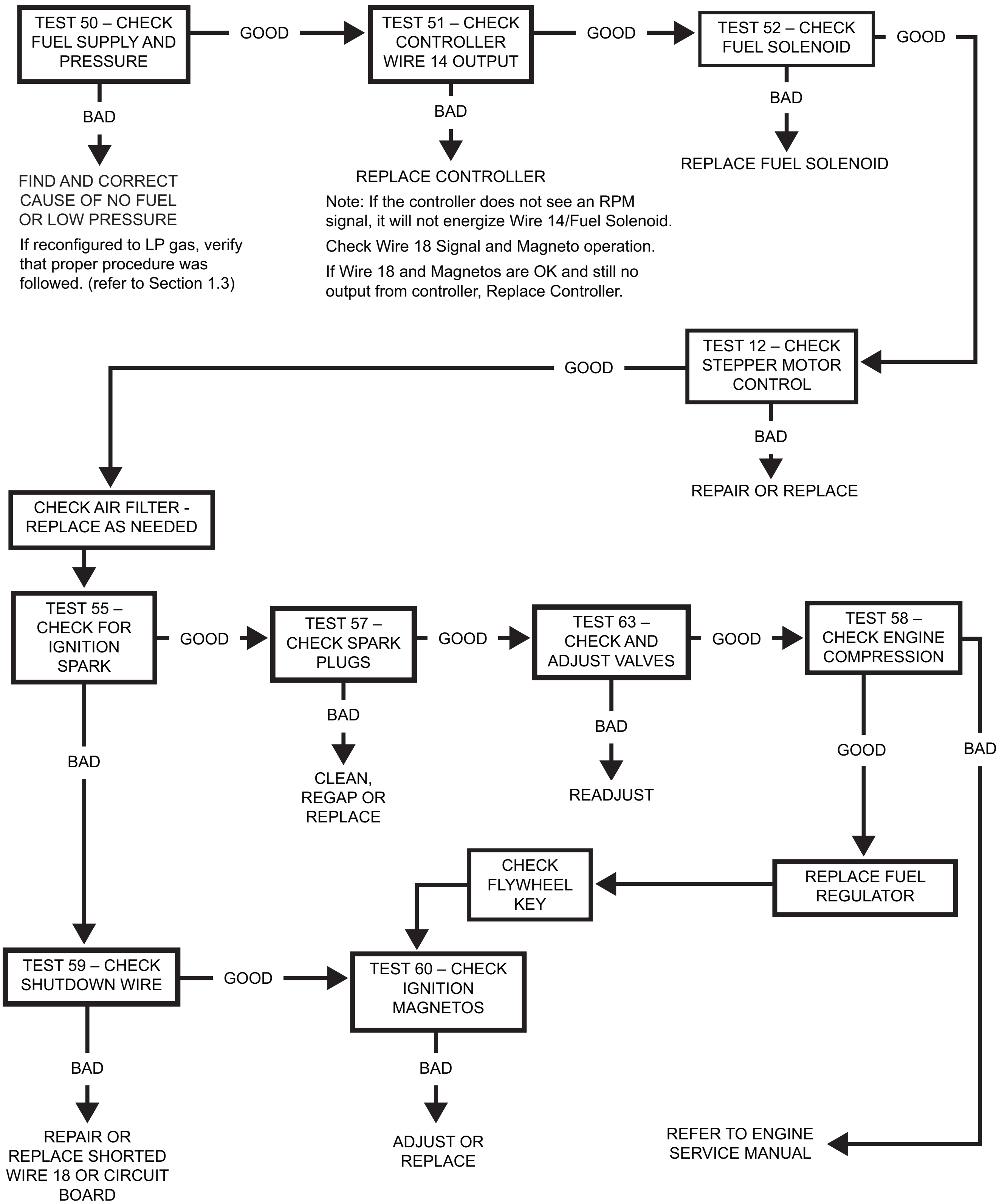


Problem 16 – Engine Will Not Crank When Controller Switch is Set to “MANUAL” Mode



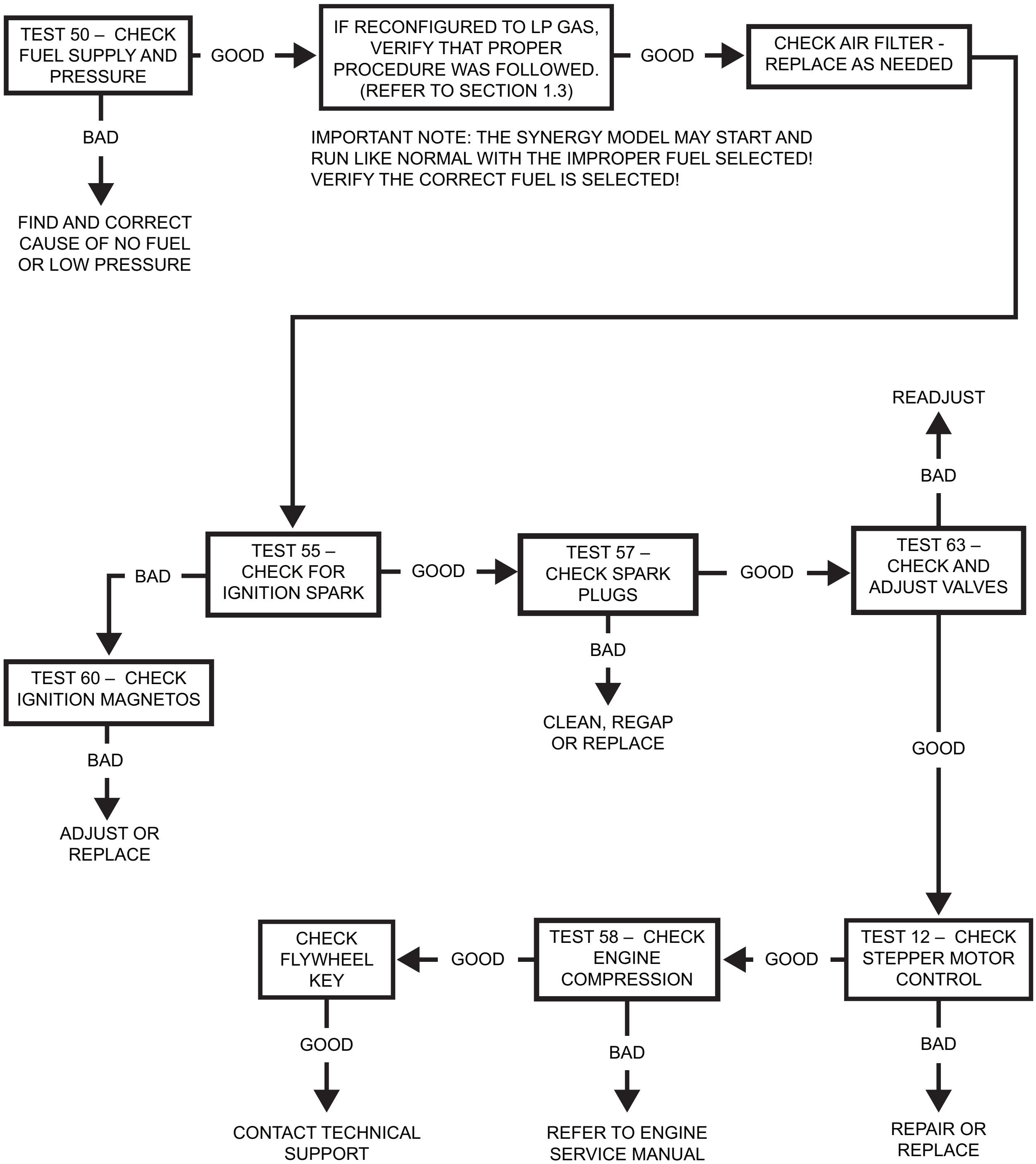
IMPORTANT NOTE: Clear any faults in the controller before proceeding with any running diagnostic steps!

Problem 17 – Engine Cranks but Will Not Start



IMPORTANT NOTE: Clear any faults in the controller before proceeding with any running diagnostic steps!

Problem 18 – Engine Starts Hard and/or Runs Rough / Lacks Power / Backfires / Hunting / Erratic Operation

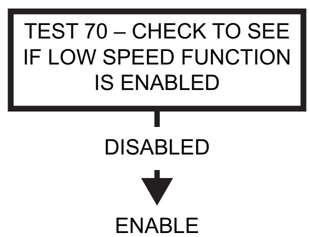


IMPORTANT NOTE: Clear any faults in the controller before proceeding with any running diagnostic steps!

Problem 19 – 7.5 Amp Fuse (F1) Blown (e-Code 2400)

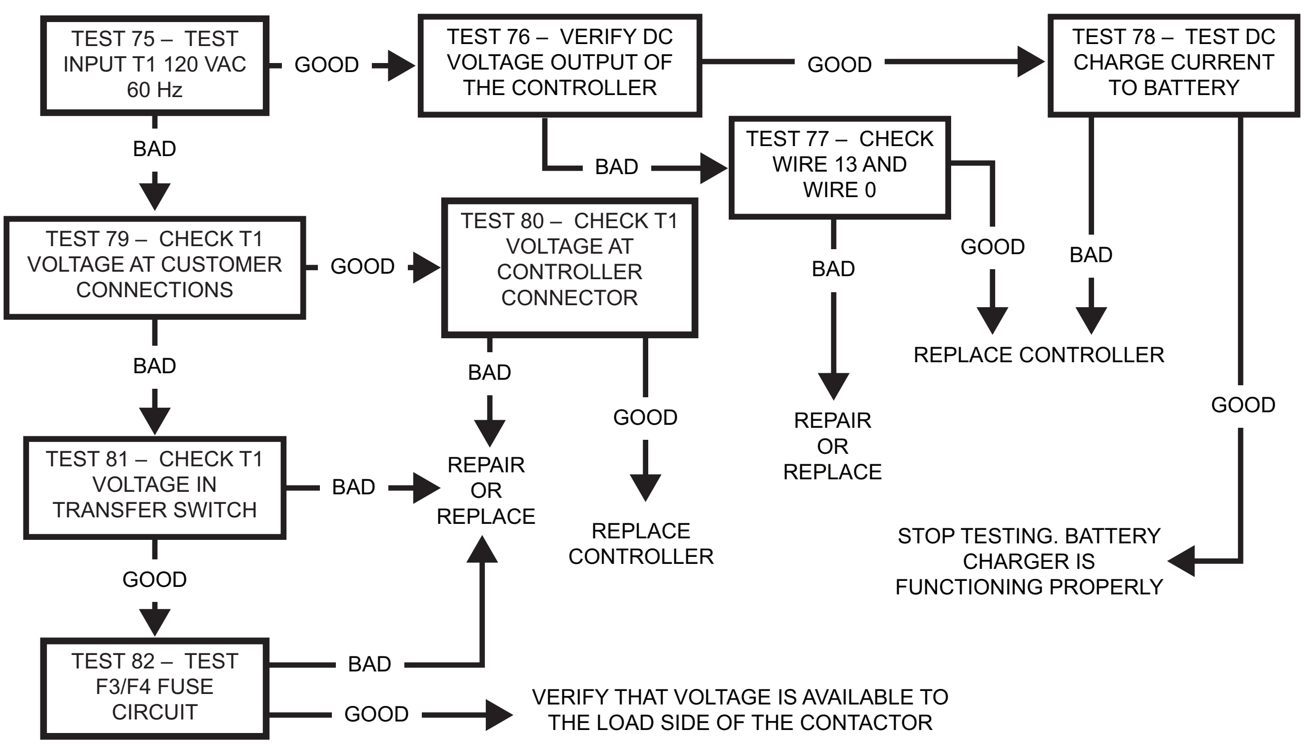
Problem 20 – Generator Will Not Exercise

Problem 21 – No Low Speed Exercise



Problem 22 – Battery is Dead

Note: T1 = 60 Hz



IMPORTANT NOTE: Clear any faults in the controller before proceeding with any running diagnostic steps!

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Introduction

This section familiarizes the service technician with acceptable procedures for the testing and evaluation of various problems that can occur on standby generators with air-cooled engines. The numbered tests in this section correspond with the flow charts in **Section 4.4, *Troubleshooting Flowcharts***.

Some test procedures in this section require the use of specialized test equipment, meters, or tools. Most tests can be performed with a digital multimeter (DM). An AC frequency meter is required where frequency readings must be taken.

Testing and troubleshooting methods covered in this section are not exhaustive. No attempt has been made to discuss, evaluate and advise the home standby service trade of all conceivable ways in which service and trouble diagnosis must be performed. Accordingly, anyone who uses a test method not recommended herein must first satisfy himself that the procedure or method he has selected will jeopardize neither his nor the products safety.

Figure 4-18 shows the DM in two different states. The left DM indicates an OPEN circuit or INFINITY. The right DM indicates a dead short or CONTINUITY. Throughout the troubleshooting, refer back to ***Figure 4-18*** as needed to understand what the meter is indicating about the particular circuit that was tested.

NOTE: CONTINUITY is equal to 0.01 ohms of resistance or a dead short.

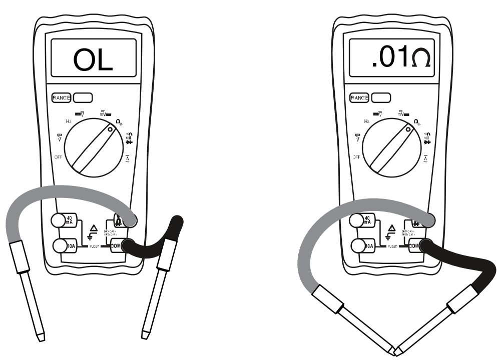

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Figure 4-18. INFINITY (Left) and CONTINUITY (Right) Meter Readings

Safety

Service personnel who work on this equipment should be aware of the dangers of such equipment. Extremely high and dangerous voltages are present that can kill or cause serious injury. Gaseous fuels are highly explosive and can ignite by the slightest spark. Engine exhaust gases contain deadly carbon monoxide gas that can cause unconsciousness or even death. Contact with moving parts can cause serious injury. The list of hazards is seemingly endless.

When working on this equipment, use common sense and remain alert at all times. Never work on this equipment while you are physically or mentally fatigued. If you do not understand a component, device or system, do not work on it.

Engine/DC Troubleshooting

It is always good practice to continue to ask questions during the troubleshooting process. When evaluating the problem asking some of these questions may help identify the problem more quickly.

- What is the generator doing?
- What is the fault that the generator is shutting down for?
- After the fault occurred, what was the LCD displaying?
- Is there another Alarm in the log just previous to the shutdown?
- Is the fault causing the shutdown a symptom of another problem?
- Does the generator have the same fault consistently, and when does it occur?
- What was the generator supposed to do?
- Who is controlling it?
- Exactly what is occurring?
- When is it happening?
- Why would this happen?
- How would this happen?
- What type of test will either prove or disprove the cause of the fault?

Test 40—Check position of AUTO-OFF-MANUAL Mode

General Theory

For the system to operate automatically, the generator's controller must be set to the AUTO mode. The generator will not crank and start on occurrence of a utility failure unless the switch is in the AUTO mode. In addition, the generator will not exercise every seven days as programmed unless the switch is in AUTO mode.

Procedure

With the controller set to the AUTO mode, test automatic operation. Testing of automatic operation can be accomplished by turning off the utility power supply to the transfer switch. When the utility power is turned off the generator should crank and start. Following startup, transfer to the STANDBY position should occur. Refer to Section 1.7 ***Automatic Operating Parameters***.

Results

1. If normal automatic operation is obtained, discontinue tests.
2. If the engine does not crank when utility power is turned off, refer to the flow chart.

Test 41—Try a Manual Start

General Theory

The first step in troubleshooting for an "Engine Won't Crank" condition is to determine if the problem is related to automatic operations only or if the engine will not crank manually either.

Procedure

1. Set the controller to OFF.
2. Set the main line circuit breaker (MLCB) to the OPEN position.
3. Set the controller set to MANUAL.
   a. The engine should crank cyclically through its "crank-rest" cycles until it starts.
   b. Let the engine stabilize and warm up for a few minutes after it starts.

Results

1. If the engine cranks manually, but does not crank automatically, refer to the flow chart.
2. If the engine does not crank manually proceed to **Problem 16**.

Test 42—Test the Function of The AUTO-OFF-MANUAL Mode

Procedure

1. See ***Figure 4-19***. Navigate to the input screen using the menu system for the controller being worked on.
2. With the inputs screen displayed, place the controller to the AUTO mode. If the controller reads the auto input from the switch, input 7 will change from "0" to "1". See ***Table 4-5*** in Section 4.1 for a description of the Inputs.
3. With the inputs screen displayed, place the controller to the MANUAL mode. If the controller reads an input from the switch, input 8 will change from "0" to "1".

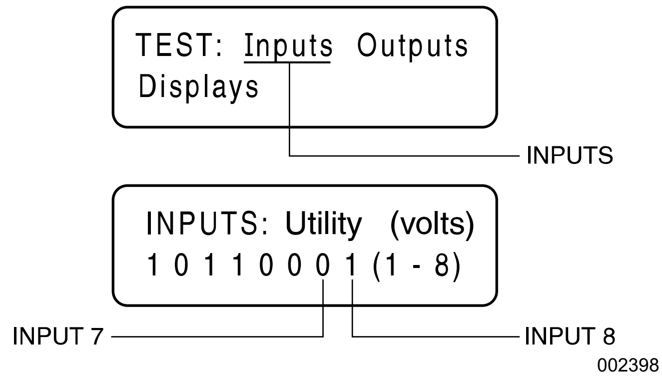

Figure 4-19. The Input Screens

4. With the controller in the OFF mode, both inputs will read zero.

Results

1. If controller failed either step 2 or 3, replace the controller assembly.
2. If the controller passed step 2 and 3, refer to flow chart.

Test 43—Test Auto Operations of Controller

General Theory

Initial Conditions: The generator is in AUTO mode, ready to run, and voltage is being supplied by utility. When utility fails (below programmed setting), a five (Default) second (programmable) line interrupt delay time is started. If the utility is still gone when the timer expires, the engine will crank and start. Once started a five second engine warm-up timer will be initiated. When the warm-up timer expires, the controller will transfer the load to the generator. If utility voltage is restored above programmed limits at any time from the initiation of the engine start until the generator is ready to accept a load (five second warm-up time has not elapsed), the controller will complete the start cycle and run the generator through its normal cool down cycle; however, the voltage will remain on the utility source.

Procedure

1. Place the generator controller in the AUTO mode.
2. Simulate a power failure by opening utility supply breaker. If the generator cranks and starts and the switch transfers, the test is good; STOP.
3. If the generator does not perform the sequence of events listed in the above discussion, check all sensing lines and proper power and ground to the controller. If all circuits are correct replace the controller.

Results

Refer to the flow chart

Test 44—Check 7.5 Amp Fuse Alarm Code 2400

NOTE: Use the alarm log in the control panel to help troubleshoot various problems. For instance, if the unit does not crank the control panel will display “Stopped-Alarm RPM Sensor Loss.” If the fuse is bad and the unit attempts to crank error code 2400 “Fuse Problem” will display.

General Theory

The 7.5 amp fuse is located on the generator control console. A blown fuse will prevent battery power from reaching the circuit board with the same result as setting the controller to OFF mode; the display and menus will remain active but the unit will not be able to crank or run.

Procedure

Remove and inspect the 7.5 amp fuse (F1). Visually inspect the fuse and fuse element. If the fuse element looks good, or if it cannot be visually inspected, test the fuse for an open with a DM or continuity tester.

Results

1. If the fuse if good, refer back to the flow chart.
2. If the fuse is bad, it should be replaced. Use only an identical 7.5 amp replacement fuse.
3. If fuse continues to blow, proceed to **Problem 19** flow chart.

Test 45—Check Battery and Cables

General Theory

Battery power is used to (a) crank the engine and (b) to power the circuit board. Low or no battery voltage can result in failure of the engine to crank, either manually or during automatic operation. The battery charger in the control panel is not designed to recharge a dead battery. As well, if there is a loose connection or corrosion associated with a wire (positive or negative), battery voltage may be present, but because of the high resistance, will not allow current to flow. Electrical voltage drop varies according to current flow. Unless the circuit is operated so current flows through it, voltage drop cannot be measured. So, to properly measure voltage drop, a crank attempt will need to be performed. This test will determine whether the battery, battery cables, or both are at fault.

Procedure A. Perform Starter Circuit Voltage Drop Test:

1. Remove the T1 fuse from the transfer switch.
2. Set a DM to measure DC voltage.
3. Connect the red meter test lead to the positive battery post and connect the black meter test lead to the negative battery post.
   a. If battery voltage is 12.1 VDC or below, proceed to Procedure C or Procedure D.
   b. If battery voltage is 12.2 VDC or above, proceed to next step. (For this test, battery voltage should be at least 12.2 VDC)
4. Turn off the fuel source and remove wire 14 from the fuel solenoid to inhibit any possible startup.
5. Refer to battery post and starter connections in ***Figure 4-20*** and perform a voltage drop test as indicated.
6. Set the controller to MANUAL. Measure and record the voltage.
7. Record readings from test points V1, V2, and V3 as depicted in ***Figure 4-20***. Although resistance-free connections, wires and cables would be ideal, most of them will contain at least some voltage drop. The maximum voltage readings you should see are as follows:
   a. 0.00–0.10 VDC across a connection
   b. 0.10–0.20 VDC on a ground connection
   c. 0.20–0.30 VDC across a wire or cable (V1, V2)
   d. 0.20–0.30 VDC across a switch or starter contactor
   e. 0.40–0.50 VDC across the entire circuit
8. If voltage drop is greater than the above, based on the circuit or component, proceed to Procedure B. If voltage drop is within the above, based on the circuit or component, proceed to Procedure C or D.

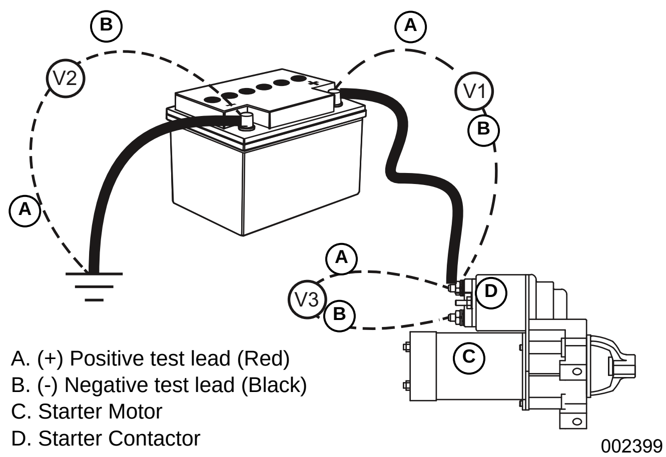

Figure 4-20. Starter Circuit Voltage Drop Test

Procedure B. Inspect Battery Cables, Terminals and Connections:

1. Inspect battery cables and battery posts.
2. If cable clamps or terminals are corroded, clean away all corrosion.
   a. If corrosion cannot be cleaned or eliminated, replace the component in question.
3. Make sure all cable clamps are tight. The red battery cable from the starter contactor (SC) must be securely attached to the positive (+) battery post; the black cable from the frame ground stud must be tightly attached to the negative (-) battery post.

Procedure C. Perform a load test on the Battery: (All Lead-Acid Type Batteries)

1. Remove 7.5 amp fuse from the controller.
2. Remove the T-1 fuse from the transfer switch.
3. Disconnect both negative and positive cables.

NOTE: Disconnect negative cable first.

4. Using a lead acid battery load tester test the load capability of the battery.
5. Follow the load tester's manufacturer's instructions carefully.
6. Connect both positive and negative cables.

NOTE: Connect positive cable first.

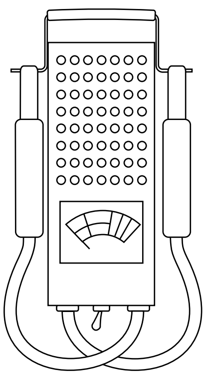

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Figure 4-21. A Typical Battery Load Tester

NOTE: Use of a quality conductance battery tester is also recommended.

Procedure D.Test Battery State of Charge: (Non-Maintenance Free Battery Only)

1. Use a temperature compensated automotive type battery hydrometer to test battery state of charge.
2. Follow the hydrometer manufacturer's instructions carefully. Read the specific gravity of the electrolyte fluid in each battery cell.
3. If cells are low, distilled water can be added to refill cell compartment.

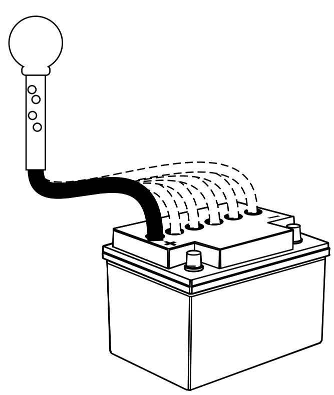

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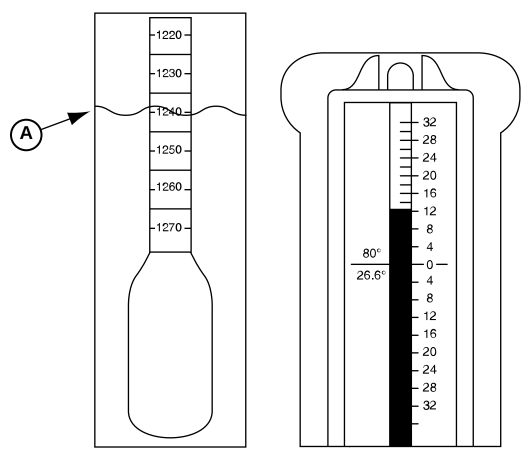
Figure 4-22. Using a Battery Hydrometer

4. If the hydrometer does not have a "percentage of charge" scale, compare the reading obtained to the following:
   a. An average reading of 1.260 indicates the battery is 100% charged.
   b. An average reading of 1.230 means the battery is 75% charged.
   c. An average reading of 1.200 means the battery is 50% charged.
   d. An average reading of 1.170 indicates the battery is 25% charged.
5. Test Battery Condition:
   a. If the difference between the highest and lowest reading cells is greater than 0.050 (50 points), battery condition has deteriorated and the battery should be replaced.
   b. If the highest reading cell has a specific gravity of less than 1.230, the test for condition is questionable. Recharge the battery to a 100% state of charge, and then repeat the test for condition.

Results from Procedure C or Procedure D

1. If the DM indicated less than 10.5 VDC in Procedure C, remove the battery and recharge with an automotive battery charger.
2. If battery fails tests in Procedure C or D, replace with a new battery.
3. If battery condition is good, refer to the flow chart.



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A. Liquid Level

Cell #	Specific Gravity
1	1.255
2	1.260
3	1.235
4	1.250
5	1.240
6	1.225

HIGH READING

⇧

35 POINTS DIFFERENCE

⇩

LOW READING

Figure 4-23. Reading a Battery Hydrometer

Test 46—Check Wire 56 Voltage

General Theory

During an automatic start or when starting manually, an internal crank relay energizes. Each time the crank relay energizes, the controller should deliver 12 VDC to a start contactor relay (SCR), or starter contactor (SC) and the engine should crank. This test will verify (a) that the crank relay on the controller is energizing, and (b) that the controller is delivering 12 VDC to the SCR relay or the SC.

NOTE: If the unit does not crank the alarm log will display, “Stopped-Alarm RPM Sense Loss.”

Procedure

1. Set the DM to measure DC voltage.
2. Locate and disconnect wire 56 from the SCR.
3. Connect one meter test lead to wire 56 and the other meter test lead to a clean frame ground.
4. Set the controller to MANUAL. Observe the meter, the DM should indicate battery voltage. If battery voltage was measured, stop testing and refer back to the flow chart. If voltage was NOT measured, proceed to step 5.

NOTE: If controller is in an alarm state, digital output will not change. Be sure to clear the fault prior to performing step 5.

5. Navigate to the digital output screen using the menu system for the controller being worked on.
   a. See ***Figure 4-24***. Digital output 6 is wire 56 output from the board.
6. Set the controller to MANUAL and observe digital output 6. If the controller is working correctly output 6 will change from a “0” to a “1”, observe and record the change in state.
   a. Hold button down to view change of state.

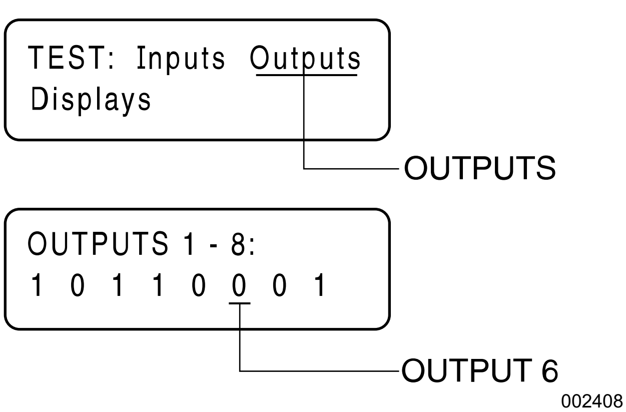


Figure 4-24. The Output Screens

7. Set a DM to measure resistance.
8. Remove 7.5 amp fuse.
9. Disconnect the harness connector from the controller.
10. Remove Wire 56 from the starter contactor relay.
11. Connect one meter test lead to disconnected wire 56 and connect the other test lead to the controller side of the harness (wire 56), measure and record the resistance.

Results

1. If the DM indicated battery voltage in step 4, refer to the flow chart.
2. If the digital output in step 5 did not change, replace the controller.
3. If the DM did NOT indicate CONTINUITY in step 11, repair or replace wire 56 between the controller side of the harness and the relay or contactor.

Test 47—Test Starter Contactor Relay

General Theory

The starter contactor relay (SCR) located in the control panel must energize for cranking to occur. Once energized the normally open contacts of the SCR will close and battery voltage will be available to wire 16 and to the starter contactor (SC).

Procedure

1. Set a DM to measure DC voltage.
2. Disconnect wire 13 from the SCR located in the control panel.
3. Connect the positive meter test lead to wire 13 and connect the negative meter test lead to a common ground. Measure and record the voltage.
4. Connect wire 13 to the SCR.
5. Disconnect wire 16 from the SCR.

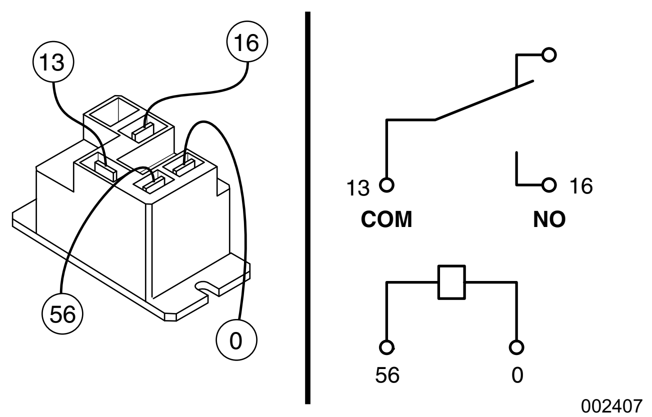


Figure 4-25. Starter Contactor Relay (V-Twin Units)

6. Connect the positive meter test lead to the SCR terminal from which wire 16 was removed and connect the negative meter test lead to a common ground.

7. Set the controller to MANUAL. Measure and record the voltage.
8. Set the DM to measure resistance.
9. Remove wire 56 and wire 0 from the SCR. Measure and record the resistance at the terminals where wire 56 and wire 0 were removed. If resistance was not measured replace the SCR. If resistance was measured go to step 10.
10. Disconnect wire 0 from the SCR.
11. Connect one meter test lead to wire 0 and connect the negative meter test lead to common ground. Measure and record the resistance.

Results

1. If battery voltage was NOT measured in step 3, repair or replace wire 13 between the SCR and the SC.
2. If battery voltage was NOT measured in step 7 and CONTINUITY was measured in step 11, replace the SCR.
3. If CONTINUITY was NOT measured in step 11, repair or replace wire 0.
4. If battery voltage was measured in step 6 and CONTINUITY was measured in step 11, refer to the flow chart.

Test 48—Test Starter Contactor

General Theory

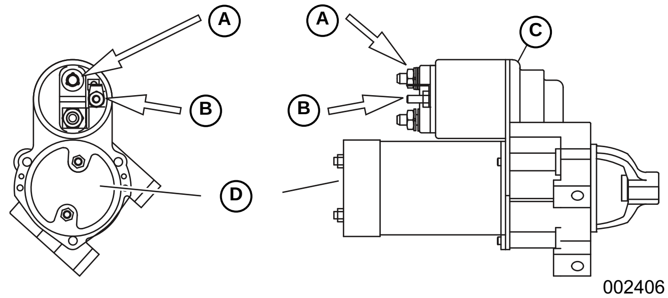
The coil in the starter contactor (SC) must energize and its normally open contacts close or the engine will not crank. This test will determine if the SC is working.

Procedure

Carefully inspect the starter motor cable that runs from the battery to the starter motor. Cable connections must be clean and tight. If connections are dirty or corroded, remove the cable and clean cable terminals and terminal studs. Replace any cable that is defective or badly corroded.

See ***Figure 4-26*** for test points.

1. Set DM to measure DC voltage.
2. Connect the positive meter test lead to the positive post of the battery and connect the negative meter test lead to the negative post of the battery. The DM should indicate battery voltage. This measure will be a reference during the testing procedure.
3. Connect the positive meter test lead to test point 1 and connect the negative meter test lead to a common ground. Measure and record the voltage.
4. Connect the positive meter test lead to test point 2 and connect the negative meter test lead to a common ground.



A. Test Point 1
B. Test Point 2
C. Starter Contactor
D. Start Motor

Figure 4-26. The Starter Contactor (V-twin Units)

5. Set the controller to MANUAL. Measure and record the voltage at test point 2 (wire 16). The contactor will energize.

Results

1. If the DM did not indicate battery voltage in step 5, measure the resistance on wire 16 at the SCR and the contactor. If no resistance is measured, repair or replace wire 16 between the SCR and the contactor.

Test 49 – Test Starter Motor

Conditions Affecting Starter Motor Performance

- A binding or seizing condition in the starter motor bearings.
- A shorted, open or grounded armature.
  - Shorted armature (wire insulation worn and wires touching one another). Indicated by low or no rpm.
  - Open armature (wire broken). Indicated by low or no rpm and excessive current draw.
  - Grounded armature (wire insulation worn and wire touching armature lamination or shaft). Indicated by excessive current draw or no rpm.
- A defective starter motor switch.
- Broken, damaged or weak magnets.
- Starter drive dirty or binding.

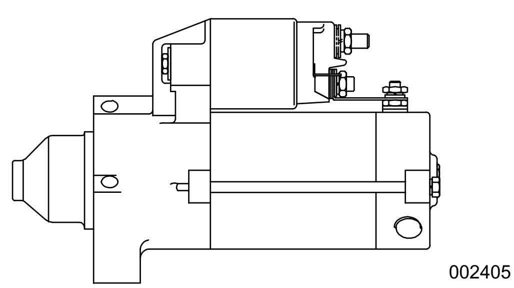


Figure 4-27. Starter Motor (V-Twin Engine)

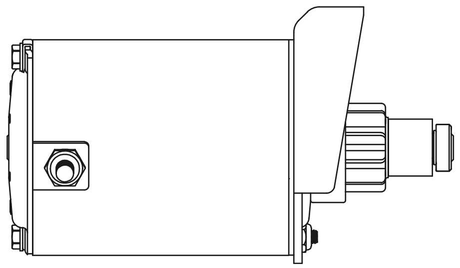


Figure 4-28. Starter Motor (410cc Single Cylinder Engine Units Only)

General Theory

Test 45 verified that the battery is fully charged and that the battery cables and connections are within the voltage drop specifications. Test 46 verified that the circuit board is delivering DC voltage to the starter contactor relay (SCR). Test 47 verified the operation of the SCR. Test 48 verified the operation of the starter contactor (SC). Another possible cause of an “Engine Won’t Crank” problem is a failure of the starter motor itself.

Procedure

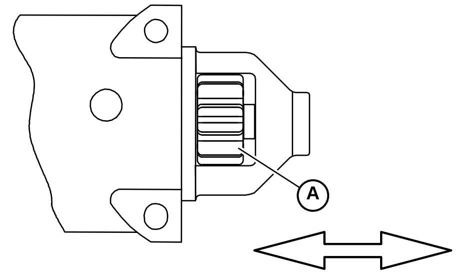
1. Set a DM to measure DC voltage (12 VDC).
2. Connect the meter positive (+) test lead to the starter contactor stud which has the small jumper wire connected to the starter.
3. Connect the common (-) test lead to the starter motor frame.
4. Set the controller to MANUAL and observe the meter. Meter should indicate battery voltage, starter motor should operate and engine should crank.

Results

1. If battery voltage is indicated on the meter but starter motor did not operate, remove and bench test the starter motor (see following test).
2. If battery voltage was indicated and the starter motor tried to engage (pinion engaged), but engine did not crank, check for mechanical binding of the engine or rotor.
3. If engine turns over slightly, go to ***Test 63—Check and Adjust Valves***. If valve clearance is too loose the valves will not fully open which could slow down cranking of the engine.

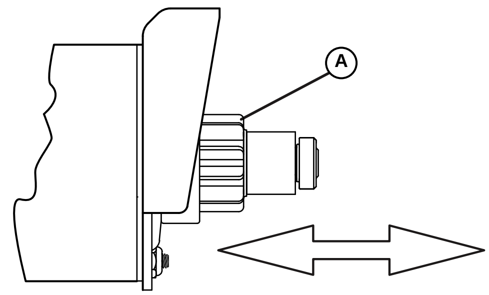
Checking The Pinion

When the starter motor is activated, the pinion gear should move and engage the flywheel ring gear. If the pinion does not move normally, inspect the pinion for binding or sticking.



A. Pinion

Figure 4-29. Check Pinion Gear Operation (V-Twin Engines)



A. Pinion

Figure 4-30. Check Pinion Gear Operation (410cc Single Cylinder Engine Units Only)

Test 50—Check Fuel Supply and Pressure

General Theory

The air-cooled generator was factory tested and adjusted using natural gas as a fuel. If desired, LP (propane) gas may be used. However, when converting to propane, some minor adjustments are required. The following conditions apply for a unit to operate correctly:

- An adequate gas supply and sufficient fuel pressure must be available or the engine will not start.
- Minimum recommended gaseous fuel pressure at the generator fuel inlet connection is 3.5 in for natural gas (NG) or 10 inches water column for LP gas.
- Maximum gaseous fuel pressure at the generator fuel inlet connection is 7 inches water column for natural gas or 12 inches water column for LP gas.
- When propane gas is used, only a “vapor withdrawal” system may be used. This type of system utilizes the gas that forms above the liquid fuel. The vapor pressure must be high enough to ensure engine operation.
- The gaseous fuel system must be properly tested for leaks following installation and periodically thereafter. No leakage is permitted. Leak test methods must comply strictly with gas codes.

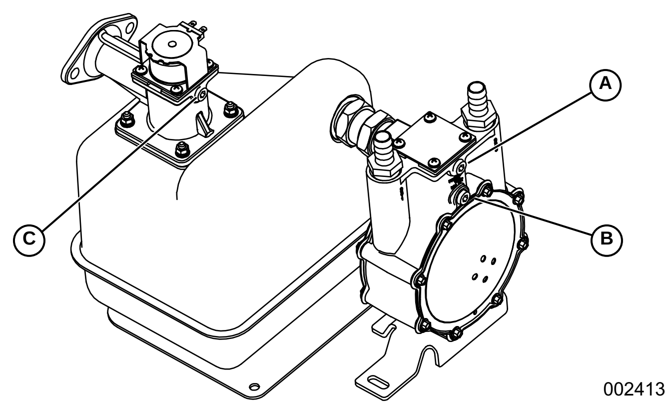
⚠DANGER

Explosion and Fire. Fuel and vapors are extremely flammable and explosive. No leakage of fuel is permitted. Keep fire and spark away. Failure to do so will result in death or serious injury. (000192)

Procedure

A water manometer or a gauge that is calibrated in “ounces per square inch” may be used to measure the fuel pressure. Fuel pressure at the inlet side of the fuel solenoid valve should be between 3.5–7.0 inches water column for natural gas (NG), or 10–12 inches water column for LP gas.

1. See ***Figure 4-31*** for the gas pressure test point on the fuel regulator. The fuel pressure can be checked at port 3.
2. With the manometer connected properly, crank the engine. Nominal fuel pressure should be measured. If pressure is not measured while cranking refer back to flow chart.



A.Test Port 1 B.Test Port 2 C.Test Port 3

Figure 4-31. Gas Pressure Test points

NOTE: Where a primary regulator is used to establish fuel inlet pressure, adjustment of that regulator is usually the responsibility of the fuel supplier or the fuel supply system installer.

12-20 kW Units Only

The test port (port 3) below the fuel solenoid may be used to take a fuel pressure reading before the fuel solenoid. Consistent pressure should be measured at this port both while the generator is running and when the generator is off.

Results

1. If fuel supply and pressure are adequate but engine will not start, refer to the flow chart.
2. If generator starts but runs rough or lacks power, repeat the above procedure with the generator running and under load. The fuel supply system must be able to maintain between 3.5–7.0 inches water column for natural gas (NG), or 10–12 inches water column for LP gas. If proper fuel supply and pressure is maintained, refer to **Problem 18** Flow Chart.

NOTE: If pressure is above specifications, correct/adjust supply regulator to generator to maintain proper fuel pressure. Recommend no more than a 1 in drop in fuel pressure from no load to full load operation while staying within specifications.

Test 51—Check Controller Wire 14 Outputs

General Theory

During any crank attempt, the controllers crank relay and run relay are both energized. When the run relay energizes, its contacts close and 12 VDC is delivered to the Wire 14 circuit and to the fuel solenoid. The solenoid energizes open to allow fuel flow to the engine. This test will determine if the controller is working properly.

Procedure

1. Set the controller to OFF.
2. Set a DM to measure DC voltage.
3. Disconnect wire 14 from the fuel solenoid (FS).
4. Connect the positive test lead to the disconnected wire 14 from step 3, and connect the negative test lead to a clean frame ground.
5. Set the controller to MANUAL. The meter should indicate battery voltage.
   a. If battery voltage is indicated, refer to the flow chart.
   b. If battery voltage is not measured, proceed to step 6.

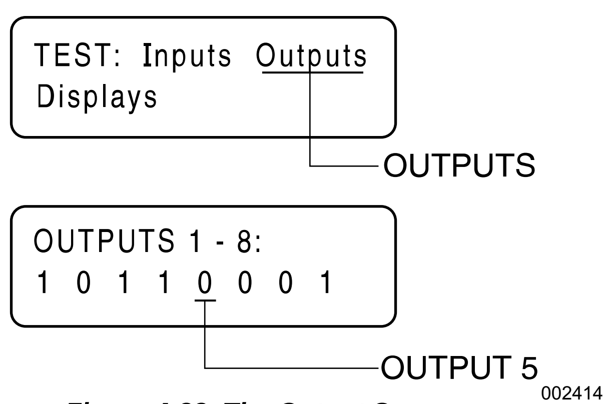


Figure 4-32. The Output Screens

6. Navigate to the digital output display using the menu system for the controller.
7. Output 5 is wire 14 out from the controller. If the controller is functioning properly, output 5 will change from a “0” to a “1” while the unit is cranking.
   a. If the DM did NOT indicate voltage in step 5 and output did not change in step 7, replace the controller.

b. If the DM did NOT indicate voltage in Step 5 and the output in step 7 changed, proceed to step 11. Disconnect the 7.5 amp fuse.

8. Disconnect the appropriate harness connector from the controller.

9. Set a DM to measure resistance.

10. Connect one meter test lead to wire 14 that was disconnected in step 3 and connect the other meter test lead to wire 14 at the controller side of the harness connector (wire 14). See “Appendix A” for proper wire and connector pin identification.

a. If the DM indicated CONTINUITY, repeat step 5 and then retest.

b. If CONTINUITY is not measured, repair or replace wire 14 between the controller harness connector and the fuel solenoid.

Results

Refer to the flow chart.

Test 52—Check Fuel Solenoid

General Theory

In Test 67, if battery voltage was delivered to wire 14, the fuel solenoid should have energized open. This test will verify whether or not the fuel solenoid is operating.

Fuel solenoid FS1 nominal resistance	15–16 ohms

Procedure

1. Install a manometer to port 2 on the fuel regulator. See ***Figure 4-31***.
2. Set the controller to MANUAL.
3. Proper gas pressure should be measured during cranking. If gas pressure is measured, the fuel solenoid is operating. If gas pressure is not measured, repair or replace the fuel solenoid.

Results

If fuel pressure was measured in any of the preceding tests it indicates that the fuel solenoid is operating properly. Refer to the flow chart for the next test.

Test 55—Check for Ignition Spark

General Theory

If the engine cranks but will not start, one cause might be that an ignition system failure has occurred. A special spark tester can be used to check for ignition spark.

See ***Figure 4-33***. When using this style spark tester, the adjustment screw must be set to the proper distance for the style of ignition system being tested. For the magneto system used on the HSB engines, set the distance of the adjustment screw tip at min 10kV. When performing the test monitor the gap for proper spark and color.

The cranking system and engine must be in proper working order to insure accurate results.

Figure 4-33. Spark Tester

Procedure

1. Turn off the fuel supply to the generator.
2. Remove spark plug leads from the spark plugs.
3. See ***Figure 4-34***. Attach the clamp of the spark tester to the engine cylinder head.
4. Attach the spark plug lead to spark tester terminal.
5. Set the controller to MANUAL.
6. While the engine is cranking, observe the spark tester. If spark jumps the tester gap, you may assume the engine ignition system is operating satisfactorily.

NOTE: The engine flywheel must rotate at 350 rpm (or higher) to obtain a good test of the solid-state ignition system.

Figure 4-34. Checking Ignition Spark

7. See ***Figure 4-35***. To determine if an engine miss is ignition related, connect the spark tester in series with the spark plug wire and spark plug. Then, crank and start the engine. A spark miss will be readily apparent. If spark jumps the spark tester gap regularly, but the engine miss continues, the problem is in the spark plug or in the fuel system.
8. Repeat step 1–7 on the second cylinder.

NOTE: A sheared flywheel key may change ignition timing but sparking will still occur across the spark tester gap.

Figure 4-35. Checking Engine Miss

Results

1. If no spark or very weak spark occurs, proceed to ***Test 59—Check Shutdown Wire***.
2. If spark is present and the engine still will not start, proceed to ***Test 57—Check Condition of Spark Plugs***.
3. When checking for engine miss, if sparking occurs at regular intervals, but an engine miss continues, proceed to ***Test 57—Check Condition of Spark Plugs***.
4. When checking for engine miss, if a spark miss is readily apparent, proceed to ***Test 60—Check and Adjust Ignition Magnetos***.

Test 57—Check Condition of Spark Plugs

General Theory

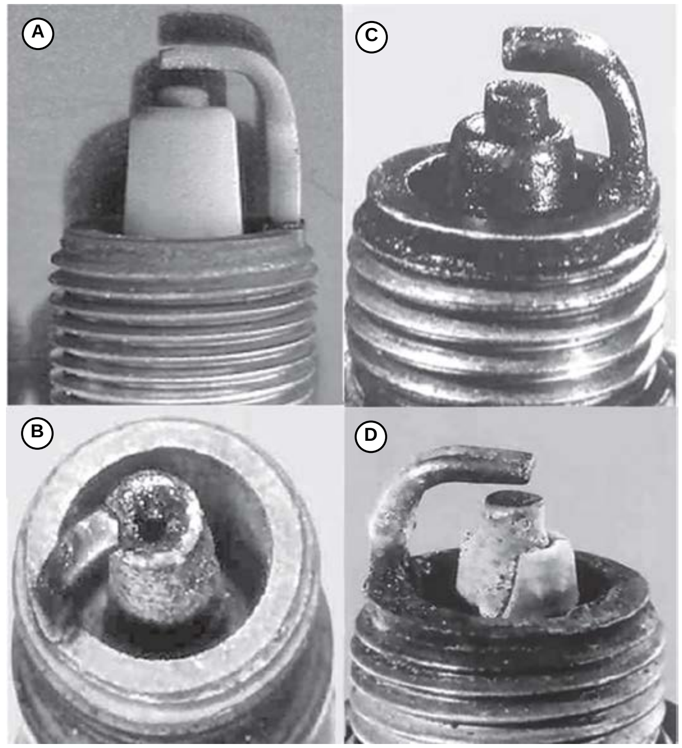
If the engine will not start and Test 55 indicated good ignition spark, some possible causes could be fouled or damaged electrodes. An engine miss may also be caused by defective spark plug(s).

Procedure

See ***Figure 4-36*** for types of engine related spark plug problems.

1. Remove spark plug(s) and inspect for any visible damage.
2. Replace any spark plug having burned electrodes or cracked porcelain.
3. See ***Figure 4-37***. Using a wire feeler gauge set the gap on new or used spark plugs as recommended in the Owner's Manual.

NOTE: Always check the specifications of the unit being serviced for correct plug and settings.



A.	Normal	C.	Misfires
B.	Pre Ignition	D.	Detonation

Figure 4-36. Spark Plug Conditions

Results

1. Clean, re-gap or replace plugs as necessary, repeat test.
2. If spark plugs are good, refer back to flow chart.

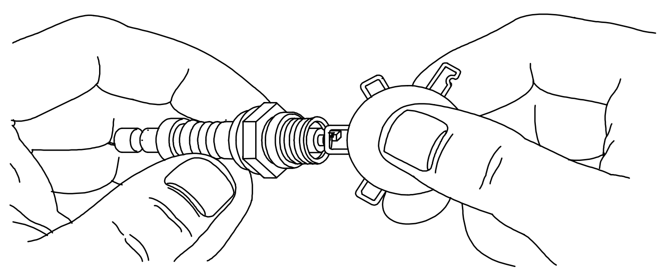


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Figure 4-37. Checking Spark Plug Gap

Test 58—Check Engine / Compression Test / Cylinder Leak Down Test

Introduction

Performing the following test procedures will accurately diagnose some of the most common problems:

- Will not start
- Lack of power
- Runs Rough
- Vibration
- Overheating
- High Oil Consumption
- Check Compression

General Theory

Lost or reduced engine compression can result in a failure of the engine to start, or a rough operation. One or more of the following will usually cause loss of compression:

- Blown or leaking cylinder head gasket.
- Improperly seated or sticking-valves.
- Worn piston rings or cylinder (This will also result in high oil consumption).

For air-cooled engines, the minimum allowable compression pressure for a cold engine is typically 150 psi. Compression values are based on accurate process and proper procedure. However, testing has proven that an accurate indication of compression in the cylinder can be obtained by using the following procedure.

NOTE: Battery and starting system must be in good condition to get accurate results.

NOTE: Valve adjustment is critical to proper compression testing. Make certain valve adjustment is correct before proceeding with test.

Procedure

1. Shut off the fuel supply to the unit.
2. Remove both spark plugs.
3. Place a jumper wire from the spark plug boot wire terminal to ground, OR ground wire 18 at the magneto lead connects to harness connection to disable spark.
4. Unplug the stepper motor connector from the controller and open the throttle to wide open.
5. Insert a compression gauge into the cylinder.
6. Crank the engine until there is no further increase in pressure.
7. Record the highest reading obtained.
8. Repeat the procedure for the remaining cylinder if applicable and record the highest reading.

NOTE: See ***Specifications*** in Section 1.1 for acceptable compression values.

Results

The difference in pressure between the two cylinders should not exceed 25%. If the difference in compression is greater that 25% loss of compression in the lowest reading cylinder is indicated.

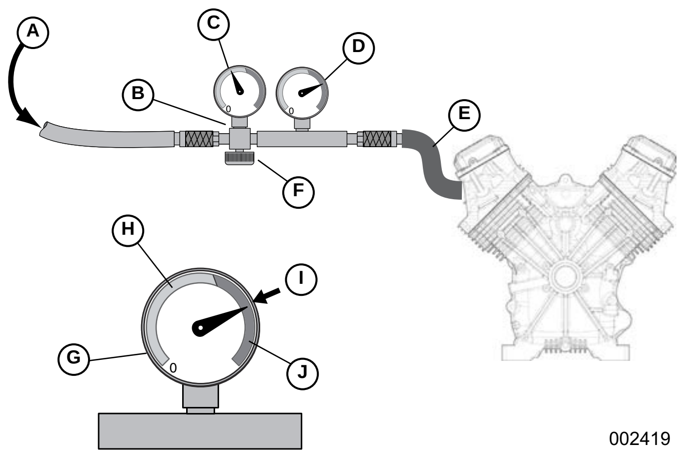
Example 1: If the pressure reading of cylinder #1 is 165 psi and of cylinder #2 is 160 psi the difference is 5 psi. Divide “5” by the highest reading (165) to obtain the percentage of 3%.

Cylinder Leak Down Test

General Theory

The cylinder leak down tester checks the sealing (compression) ability of the engine by measuring air leakage from the combustion chamber. Compression loss can present many different symptoms. This test is designed to detect the section of the engine where the fault lies before disassembling the engine. ***Figure 4-38*** represents a standard tester available on the market.

NOTE: Refer to the tool manufacturer's instructions for variations of this procedure.



A. Compressed air in
B. Air pressure regulator
C. Inlet gauge pressure set point
D. Outlet gauge pressure
E. To spark plug hole
F. Regulator adjustment knob
G. Outlet gauge
H. Red range indicates unacceptable leakage
I. Needle indicates minimal air leakage
J. Green range indicates acceptable leakage

Figure 4-38. Cylinder Leakdown Tester

Procedure

1. Shut off the fuel supply.
2. Remove the spark plug(s) from the cylinder.
3. Gain access to the flywheel or to the generator fan assembly. Remove the valve cover.
4. Rotate the engine crankshaft until the piston reaches top dead center (TDC) on the cylinder you are working on. In this position, both the intake and exhaust valves will be closed. If the engine is not properly positioned at TDC the results of the test may be inaccurate at diagnosing a problem.
5. Attach cylinder leak down tester adapter to spark plug hole.

6. Connect an air source of 90 psi to the cylinder leak down tester.

NOTE: Note check manufacture of the tool for proper setting.

7. Monitor the flywheel/generator fan for rotation from top dead center as you apply air in the next step.
8. Adjust the regulated pressure on the gauge to the manufactures setting for the tool that you are using—typically 90 psi. Be sure flywheel/fan has not rotated.
9. Read the gauge on the tester for cylinder percent of leakage. A leakage of 20% is normally acceptable. Use good judgment, and listen for air escaping at the carburetor (air intake), the exhaust, the side of the head where head and block join, and the crankcase breather. This will determine where the fault lies.
10. Repeat Steps 1–9 on remaining cylinder if applicable.

Results

- Air escapes at the carburetor (air intake)—check intake valve
- Air escapes through the exhaust—check exhaust valve
- Air escapes through the breather—check piston rings
- Air escapes between the cylinder head and block—the head gasket should be replaced and check both gasket surfaces.

Test 59—Check Shutdown Wire

General Theory

The controller uses Wire 18 for two purposes: first, to measure engine rpm; second, to shutdown the engine. The controller's logic during a shutdown will apply a ground to Wire 18. Wire 18 is connected to the ignition magneto(s). The grounded magneto will not be able to produce spark.

Procedure

1. See ***Figure 4-39***. Disconnect Wire 18 at the bullet connector.
2. Remove Wire 56 from the starter contactor relay (SCR). Utilizing a jumper wire, jump 12 VDC from the positive battery terminal to the terminal on the SCR from which Wire 56 was removed. The generator will start cranking. As it is cranking, repeat ***Test 55—Check for Ignition Spark***. Reconnect wire 56 when done.
3. With Wire 18 removed, if spark is now present, proceed to check for a short to ground (steps 4–7).
4. Disconnect the harness connector from the controller.

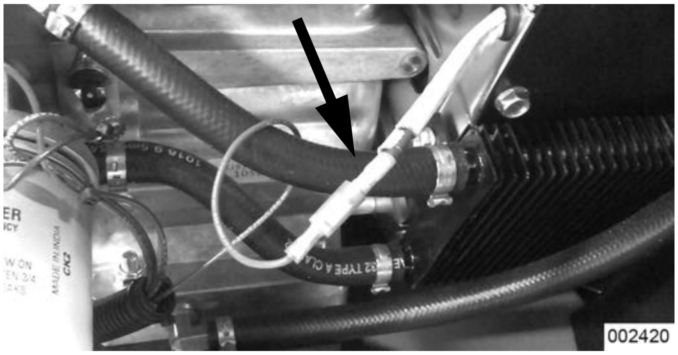


Figure 4-39. Wire 18 Connection

5. Set the DM to measure resistance.
6. Connect one meter test lead to Wire 18 (disconnected in Step 1) and connect the other meter test lead to a clean frame ground, measure and record the resistance.
7. Connect all disconnected wires and connectors.

Results

1. If the DM indicated CONTINUITY to ground in step 6, repair or replace shorted ground Wire 18 between the engine and the controller connector.
2. If the DM indicated INFINITY to ground in step 6, replace the control board and re-test for spark.
3. If ignition (spark) was not present in Step 2 with Wire 18 disconnected, proceed to ***Test 60—Check and Adjust Ignition Magnetos***.

Test 60—Check and Adjust Ignition Magnetos

General Theory

In Test 55, a spark tester was used to check for engine ignition. If sparking or weak spark occurred, one possible cause might be the ignition magneto(s). This test consists of checking values across the primary and secondary windings of the magneto and adjusting the air gap between the ignition magneto(s) and the flywheel. The flywheel and flywheel key will also be checked during this test. A diode is installed in the primary winding inside the coil. This is done to inhibit a spark occurring on both magnetos at the same time.

Procedure: Testing Magnetos

1. Disconnect Wire 18 at the bullet connector.
2. Disconnect spark plug wires from the spark plugs on cylinder one and two.
3. Set DM to measure resistance when performing resistance checks and to diode function when performing the diode test.

4. Follow the chart connections and note readings on DM to chart.

NOTE: Readings are approximate.

5. Secondary resistance check: Connect a meter lead to the spark plug wire and connect the other meter lead to battery ground. Record your readings and compare to ***Table 4-15***. Readings are approximate.
6. Primary resistance and diode check: Connect the meter lead to the bolt connector or bullet connector where wire 18 was disconnected in step 1. Connect the other meter lead to the spark plug wire or to ground following ***Table 4-15***.
7. Repeat steps 5–6 on cylinder two. If readings are not measured, replace the magnetos.

NOTE: It is recommended to replace Magnetos in pairs.

NOTE: Readings can change based on supplier changes. Check GENservice or contact Generac for updates.

Table 4-15.		
Resistance with Wire 18 disconnected		
Magneto Wire Diagnostics		**V-Twins**
POS Test Lead	**NEG Test Lead**	**Ohms**
To Magneto	To Ground	1.5-2.5 M
To Ground	To Magneto	OL
To Magneto	To Plug Wire	1.5-2.5 M
To Plug Wire	To Magneto	OL
To Plug Wire	To Ground	7-14 K
Diode Test		**V-Twins**
POS Test Lead	**NEG Test Lead**	**VDC**
To Magneto	To Ground	0.5-0.6
To Ground	To Magneto	OL
Resistance with Wire 18 connected		
AC Voltage Wire 18 Backprobed		**VAC**
Cranking		3-5
Running @ 3600 rpm		14-20
Running @ 3000 rpm		11.5-16.5
Frequency		**Hz**
Cranking		13-17

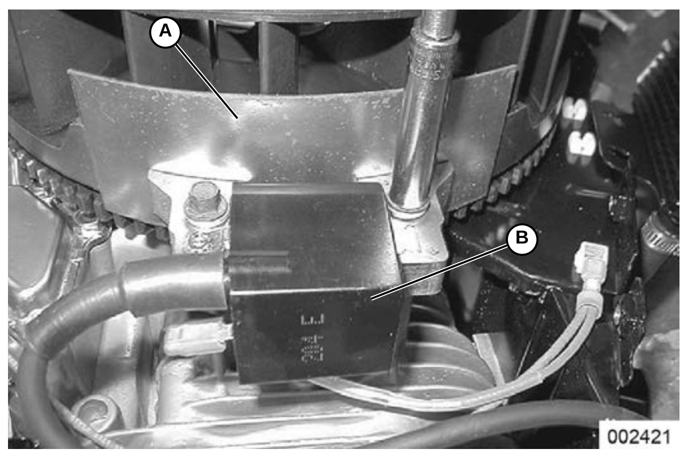
Table 4-15.		
Resistance with Wire 18 disconnected		
Magneto Wire Diagnostics		**V-Twins**
POS Test Lead	**NEG Test Lead**	**Ohms**
Running @ 3600 rpm		120
Running @ 3000 rpm		100

Procedure: Adjusting Magneto Flywheel Gap

1. See ***Figure 4-40***. Rotate the flywheel (by hand) until the magnet is under the module (armature) laminations.
2. Place a 0.008–0.012 in (0.20–0.30 mm) non metallic thickness gauge between the flywheel magnet and the module laminations.

NOTE: A typical business card is approximately 0.010 in thick.

3. Loosen the mounting screws and let the magnet pull the magneto down against the thickness gauge.
4. Tighten both mounting screws.
5. To remove the thickness gauge, rotate the flywheel (manually).



A. 0.008-0.012" Gauge
B. Magneto

Figure 4-40. Setting Ignition Magneto Air Gap

6. Repeat the above procedure for the second magneto.
7. Repeat ***Test 55—Check for Ignition Spark*** and check for spark across the spark tester gap.
   a. A spark test may be conducted with unit dissembled by following this procedure.
   b. Battery must be connected.
   c. The harness connector must be connected to the controller.
   d. Remove wire 56 from the SCR located

beneath the controller.

NOTE: Make sure all debris is cleared from the engine compartment and all body parts are clear from flywheel before proceeding.

e. Refer to ***Test 55—Check for Ignition Spark***.

f. Utilizing a jumper wire, connect a wire to the 194 terminal block. Connect the other end to where wire 56 was disconnected in step 7d. The engine should crank once the jumper from 194 is connected.

8. If spark was not indicated, replace magnetos.

NOTE: If gap is only adjusted, ensure to properly test the magnetos by cranking the engine over before reassembly occurs. Spark should be present on both cylinders before reassembly should be completed.

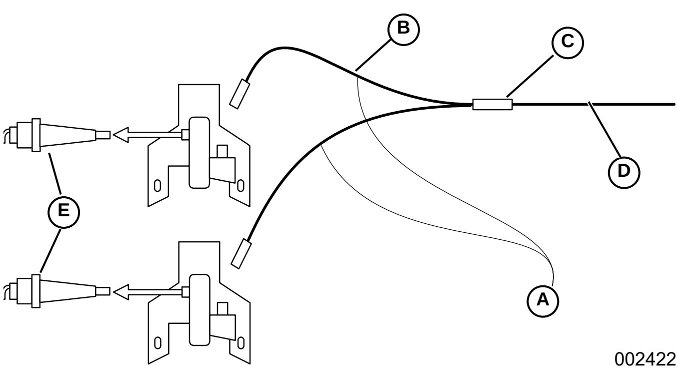
9. If air gap was not out of adjustment, test ground wires.

10. Set a DM to the measure resistance.

11. See ***Figure 4-41***. Disconnect the engine wire harness from the ignition magnetos

a. Disconnect wire 18 at the bullet connector.

12. Connect one meter test lead to one of the wires removed from the ignition magneto(s). Connect the other test lead to frame ground. INFINITY should be measured. If CONTINUITY is measured, replace the shutdown harness.



A. Remove leads
B. Engine wire harness
C. Stud connector
D. Wire 18 to circuit board
E. Spark plug

Figure 4-41. Engine Ground Harness

13. Now check the flywheel magnet by holding a screwdriver at the extreme end of its handle and with its point down. When the tip of the screwdriver is moved to within 0.75 in (19 mm) of the magnet, the blade should be pulled in against the magnet.

14. For rough running or hard starting engines check the flywheel key. The flywheel's taper is locked on the crankshaft taper by the torque of the flywheel nut. A keyway is provided for alignment only and theoretically carries no load.

NOTE: If the flywheel key becomes sheared or even partially sheared, ignition timing can change. Incorrect timing can result in hard starting or failure to start.

Results

If sparking still does not occur after adjusting the armature air gap, testing the ground wires and performing the basic flywheel test, replace the ignition magneto(s).

Procedure, Replacing Magnetos:

1. Follow all steps of the **Major Disassembly procedures that are located in Sect ion 6**.

2. Once the magnetos are visible, make note of how they are connected.

NOTE: Each magneto has its own part number. Verify the part number prior to installation.

3. See ***Figure 4-42***. Cylinder one is the back cylinder.

4. See ***Figure 4-43***. Cylinder two is the front cylinder.

5. See ***Figure 4-44***. When installing new magnetos there will be one with a short plug wire and one with a longer plug wire.

NOTE: Magneto gap to flywheel needs to be 0.010 in.

6. Short plug wire will be installed on back cylinder (cylinder one).

7. Long plug wire (B) will be installed on front cylinder (cylinder two).

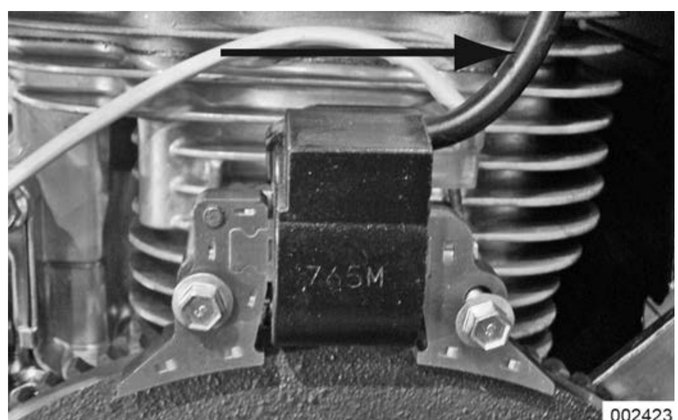


Figure 4-42. Cylinder One (Back, Short)

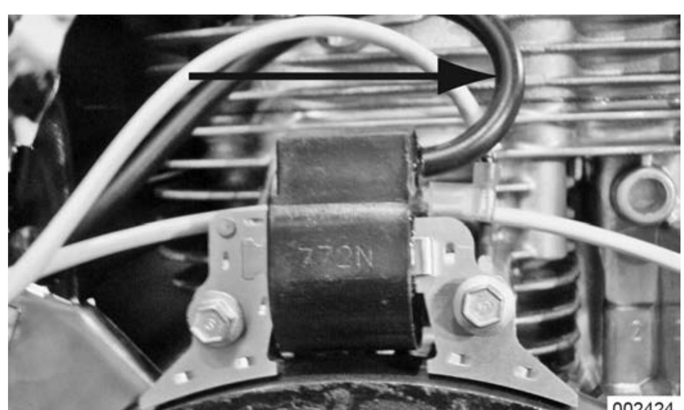
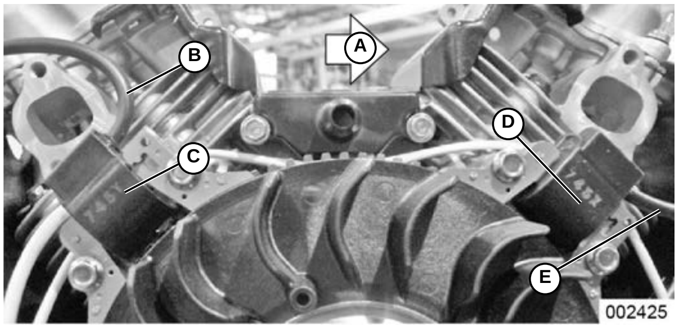


Figure 4-43. Cylinder Two (Front, Long)



A. Back Of Enclosure
B. Long Spark Plug Wire
C. Cylinder One
D. Cylinder Two
E. Short Spark Plug Wire

Figure 4-44. Magneto Positions

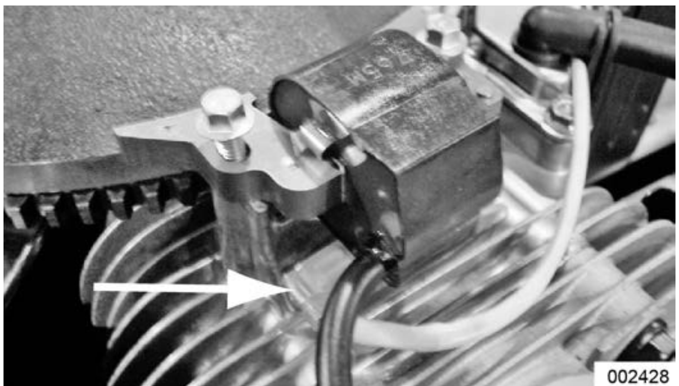


Figure 4-45. Cylinder One Shutdown Wire

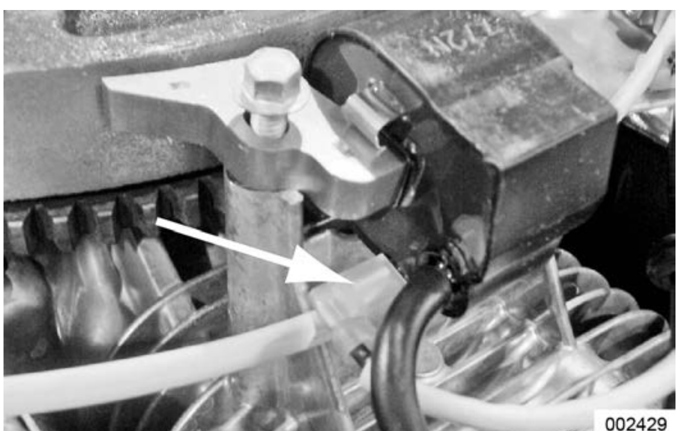


Figure 4-46. Cylinder Two Shutdown Wire

8. Verify correct installation of magnetos by ensuring both spark plug wires point to the back of the enclosure and shutdown terminals are nearest cylinder head as shown in ***Figure 4-45*** and ***Figure 4-46***.

Test 61—Check Oil Pressure Switch and Wire 86 (Evolution e-Code 1300)

General Theory

If the oil pressure switch contacts have failed in their closed position, the engine will crank and start, however shutdown will occur within about 5–10 seconds. If the engine cranks and starts, then shuts down almost immediately with a Shutdown-Alarm Low Oil Pressure, the cause may be one or more of the following:

- Low engine oil level
- Low oil pressure
- A defective oil pressure switch
- Shorted harness
- Controller issue

Procedure

1. Navigate to the digital inputs display screen of the controller being worked on.
   a. See ***Figure 4-47***. Digital input 2 is wire 86 from the low oil pressure switch to the board.
   b. Set the controller to MANUAL.
   c. Observe input 2 for a change from “1” to “0”. A change from “1” to “0” indicates that the control board sensed the LOP switch change states. If the generator still shuts down, replace controller.
   d. If the input did change states, the oil pressure switch is good. An intermittent oil pressure problem may still be present and should be checked with a mechanical gauge as in step 4.

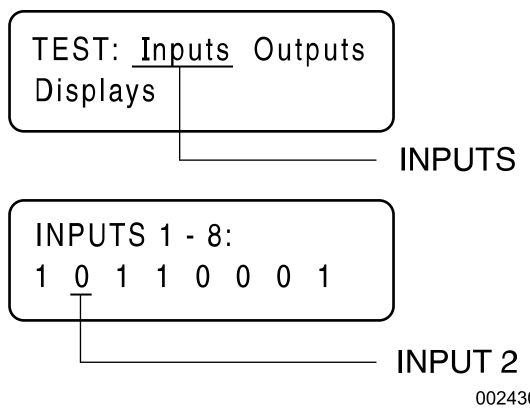


Figure 4-47. The Input Screens

2. Check engine crankcase oil level.
   a. Check engine oil level.
   b. If necessary, add the recommended oil to the dipstick FULL mark. DO NOT FILL ABOVE THE FULL MARK.
3. With oil level correct, try starting the engine.
   a. If engine still cranks and starts, but then shuts down, go to step 4.
   b. If engine cranks and runs normally, discontinue tests.

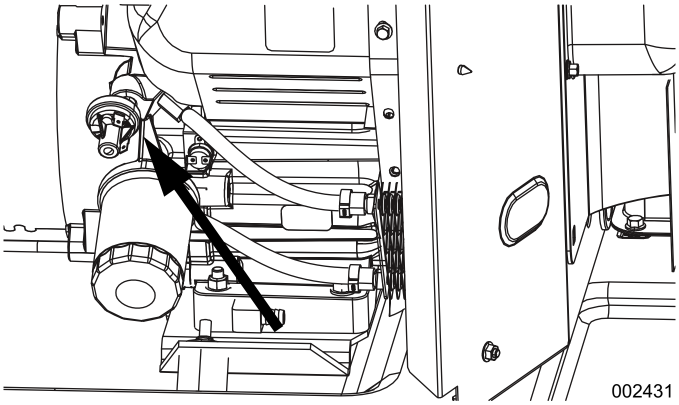


Figure 4-48. Oil Pressure Switch

4. Do the following:

a. Disconnect wire 86 and wire 0 from the oil pressure switch terminals. Remove the switch and install an oil pressure gauge in its place.

b. Start the engine while observing the oil pressure reading on the gauge.

c. Note the oil pressure.

(1) Normal oil pressure is approximately 35–40 psi with engine running. If normal oil pressure is indicated, go to step 5 of this test.

(2) If oil pressure is below about 4.5 psi, shut engine down immediately. A problem exists in the engine lubrication system.

NOTE: The oil pressure switch is rated at 10 psi for V-twin engines.

5. Remove the oil pressure gauge and reinstall the oil pressure switch. Do NOT connect wire 86 or wire 0 to the switch terminals.

a. Set a DM to measure resistance.

b. Connect the DM test lead across the low oil pressure (LOP) switch terminals. With the engine shut down, the DM should indicate CONTINUITY. If INFINITY was measured, replace the LOP switch.

c. With the DM still connected to the LOP switch, set the AUTO-OFF-MANUAL switch to MANUAL. The DM should indicate INFINITY once the engine has had a chance to build pressure.

6. Set the DM to measure DC voltage.

a. Disconnect wire 86 at the low oil pressure switch.

b. Connect the black meter test lead to a good ground, and the red meter test lead to wire 86. Approximately 5 VDC should be measured. If 5 VDC is not measured, go to Test 6 and check continuity on wire 86 from the LOP switch back to the J4 connector.

7. Keep the DM set to measure resistance.

a. Disconnect the appropriate harness connector from the controller, and disconnect wire 86 and wire 0 from the LOP switch.

b. Connect one meter test lead to the disconnected wire 86 and connect the other meter test lead to wire 86. The DM should indicate CONTINUITY. If CONTINUITY was not measured, repair or replace wire 86 between the LOP switch and the controller harness connector.

c. With wire 86 still disconnected from the LOP switch and the controller harness connector, connect one meter test lead to disconnected wire 86 and the other meter test lead to a clean frame ground. The DM should indicate INFINITY. If CONTINUITY was measured a short to ground exists on wire 86. Repair or replace as needed.

Results

1. If the switch operated properly and proper oil pressure was measured, and wires 86 and 0 tested good, and/or the input would not change on the controller, replace the controller.

Test 62—Check High Oil Temperature Switch (e-Code 1400)

General Theory

If the temperature switch contacts have failed in a closed position, the engine will fault out on OVERTEMP. If the unit is in an overheated condition, the switch contacts will close at 293 °F (145 °C). This will normally occur from inadequate airflow through the generator.

Procedure

1. Verify that the engine has cooled down (engine block is cool to the touch). This will allow the contacts in the high oil temperature switch to open.

2. Check the installation and area surrounding the generator. There should be at least 3 ft (1 m) of clear area around the entire unit. Make sure that there are no obstructions preventing cooling air from entering or exiting the enclosure.

3. Disconnect wire 85 and wire 0 from the high oil temperature switch.

4. Set a DM to measure resistance. Connect the test leads across the switch terminals. The meter should read INFINITY (0L).

5. If the switch tested good in step 4, and a true overtemperature condition has not occurred, check wire 85 for a short to ground. Remove harness connector from the controller. Set the DM to measure resistance. Connect one test lead to wire 85 (disconnected from high oil temperature switch).

Connect the other test lead to a clean frame ground. INFINITY should be measured.

Testing High Oil Temperature Switch

6. Remove the high oil temperature switch.
7. See *Figure 4-49*. Immerse the sensing tip of the switch in oil, along with a suitable thermometer.
8. Set a DM to measure resistance. Then, connect the DM test leads across the switch terminal and the switch body. The meter should read INFINITY.
9. Heat the oil in the container. When the thermometer reads approximately 283–305 °F. (139–151 °C.), the DM should indicate CONTINUITY.

Results

1. If the switch fails step 4, or steps 8–9, replace the switch.
2. If INFINITY was not measured in step 5, repair or replace wire 85 between the circuit board and the high oil temperature switch.

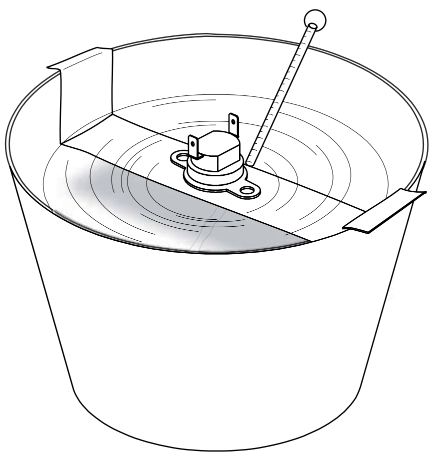


Figure 4-49. Testing the Oil Temperature Switch

Test 63—Check and Adjust Valves

General Theory

Improperly adjusted valves can cause various engine related problems including, but not limited to, hard starting, rough running, and lack of power. The valve adjustment procedure for both cylinders of the V-twin engines is the same.

Procedure: Intake and Exhaust

Verify the piston is at top dead center (TDC) of its compression stroke (both valves closed). The cold valve clearance should be 0.002–0.004 in (0.05–0.1 mm).

Proceed as follows to check and adjust the valve to rocker arm clearance:

1. Remove the four screws from the rocker cover.
2. Remove the rocker cover and rocker cover gasket.
3. See *Figure 4-50*. Loosen the rocker arm jam nut. Use a 10 mm Allen wrench to turn the pivot ball stud and check the clearance between the rocker arm and the valve stem with a flat feeler gauge.
4. When the valve clearance is correct, hold the pivot ball stud with the Allen wrench and tighten the rocker arm jam nut. Tighten the jam nut to 174 **in-lbs** (19.6 Nm). After tightening the jam nut, recheck the valve clearance to make sure it did not change.
5. Install the rocker cover gasket, rocker cover and the four screws. Tighten screws to 60 **in-lbs** (6.8 Nm).

Results

Adjust valve clearance as necessary, then retest.

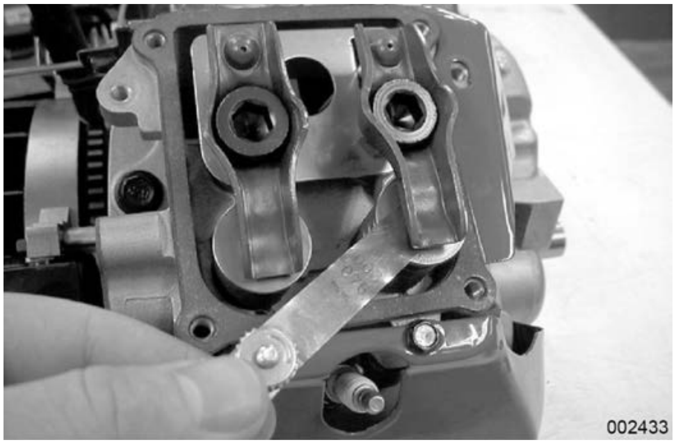


Figure 4-50. Valve Adjustment

Test 64—Check Wire 18 Continuity

General Theory

During cranking and running, the controller receives a pulse from the ignition magneto(s) via wire 18. When cranking, this signal has an AC voltage of approximately 3–6 volts on V-twin engines. If the controller does not receive this signal, the unit will shut down due to no rpm sensing.

Procedure

1. Set the DM to measure AC voltage.
2. See *Figure 4-51*. Back probe the harness connector for wire 18 with one meter lead. Connect the other meter lead to clean frame ground or preferably the battery negative post.

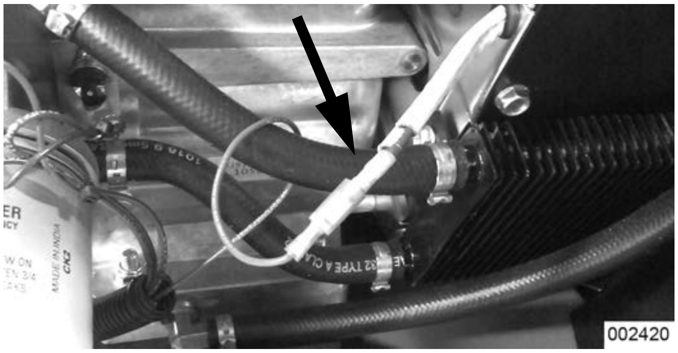


Figure 4-51. Wire 18 Connection

3. Set the controller to MANUAL.
4. While unit is cranking, measure and record the voltage.
   a. If the DM indicated approximately 3–6 VAC, proceed to step 6.
   b. If the DM did NOT indicate the appropriate voltage, go to the next step.
5. Disconnect wire 18 the from magneto sensing lead.
   a. Connect one meter test lead to a clean frame ground and connect the other meter test lead to the magneto lead terminal.
   b. Set the controller to MANUAL. While unit is cranking, measure and record the voltage.
   c. If the DM indicated approximately 3–6 VAC, proceed to step 6.
   d. If the DM did NOT indicate the appropriate voltage, go back to the flow chart (Problem 14) and follow “No Signal” (Test 60).
6. Set the DM to measure resistance.
7. Disconnect the harness connector containing wire 18 from the controller.
8. Connect one meter test lead to a clean frame ground and connect the other meter test lead to wire 18.
   a. If the DM indicated low resistance (0.01), check for a short to ground in the wire 18 circuit.
   b. If the DM indicated 0/L OPEN circuit proceed to step 9.
9. Connect one meter test lead to harness side of wire 18 that went to the magneto and connect the other meter test lead to wire 18 at the controller connector.
   a. If the DM indicated CONTINUITY, refer to the flow chart (Problem 14, RPM Sense Loss).
   b. If the DM indicated INFINITY repair or replace wire 18 between the magneto connector and the controller connector.

Test 65—Test Exercise Function

General Theory

The following parameters must be met in order for the weekly exercise to occur:

- Exercise Time set in controller.
- Controller set to AUTO mode.

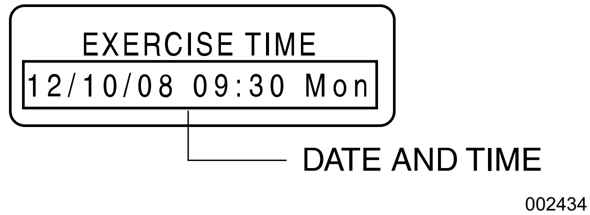


Figure 4-52. The Exercise Screen

Procedure

Utility voltage must be present and QT TEST must be enabled.

1. Set the controller to AUTO.
2. Enter the dealer password to enter the Dealer Edit Menu.
3. Select TEST.
4. Press ENTER.
5. Press arrow key until IN AUTO PRESS ENTER FOR QT-TEST is displayed.
6. Press ENTER.
7. The generator should start and run the low speed exercise.
8. Press ENTER to stop test.

Results

1. If the unit starts and runs in MANUAL, but fails to exercise without any alarms present, replace the controller.

Test 66—Test Cranking and Running Circuits

General Theory

This test will check all of the circuits that are “Hot” with battery voltage and which could cause the main fuse to blow. Refer to ***Table 4-16*** throughout the procedure for the known resistance values of components.

Figure 4-53 shows the DM in two different states. The left DM indicates an OPEN circuit or INFINITY. The right DM indicates a dead short or CONTINUITY. Throughout the troubleshooting, refer to ***Figure 4-53*** as needed to understand what the meter is indicating about the particular circuit that was tested.

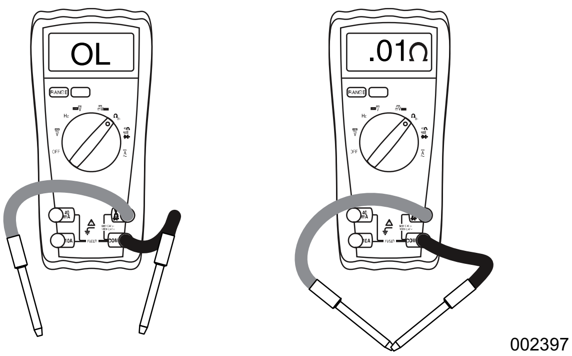


Figure 4-53. INFINITY (Left) and CONTINUITY (Right) Meter Readings

NOTE: CONTINUITY is equal to 0.01 ohms of resistance or a dead short.

Table 4-16. Component Resistance Values	
Starter Contactor Relay	155–158Ω
Main Fuel Solenoid	15–16Ω

Procedure

1. Set a DM to measure resistance.
2. Disconnect the harness from the controller.
3. Connect one meter lead to a clean frame ground and connect the other meter test lead to each of the following tests points in ***Table 4-17***, measure and record the resistance.

Table 4-18 has been provided to record the results of this test. Additional copies of this table can be found in **Appendix C - Supplemental Worksheets** at the back of this manual.

Table 4-17. Resistance Measurements

Test Point	Pin Location	Circuit	20 kW
1	*	Wire 14	16Ω
2	*	Wire 56	155Ω
3	*	Wire 194	OPEN
* Use Appendix A for pin locations			

Results

1. Compare the results of step 3 with ***Table 4-17***.
   a. If the DM indicates less than 16 ohms at Test Point 1 proceed to ***Test 67—Test Run Circuit***.
   b. If the DM indicates less than 155 ohms at Test Point 2 proceed to ***Test 68—Test Crank Circuit***.
   c. If the DM indicated CONTINUITY at Test Point 3 proceed to ***Test 69—Test Transfer Relay Circuit***.
   d. If the DM indicated proper resistance values at all test points, replace the controller.

Table 4-18. Test 66 Results

Test Point	Pin Location	Circuit	Result
1	*	Wire 14	
2	*	Wire 56	
3	*	Wire 194	
* Use Appendix A for pin locations			

Test 67—Test Run Circuit

General Theory

Wire 14 provides 12 VDC during cranking and running. If the DM indicated less than 15 ohms in the previous test, one of the possible causes could be a faulty harness or solenoid.

Procedure

1. Set a DM to measure resistance.
2. Disconnect wire 14 from the fuel solenoid (FS).
3. Connect one meter test lead to the FS terminal from which wire 14 was removed. Connect the other meter test lead to the ground terminal. Measure and record the resistance.

Results

1. If the DM indicated less than 15 ohms in step 3, replace the FS solenoid.
2. Refer to ***Table 4-17*** and if the DM indicated the correct resistance for the component, a short to ground exists on wire 14. Repair and replace wire 14 as needed.

Test 68—Test Crank Circuit

General Theory

Wire 56 provides 12 VDC during cranking only. If the DM indicated less than 155 ohms at the start contactor relay in the previous test, one of the possible causes could be a faulty relay or solenoid.

Procedure

1. Set a DM to measure resistance.
2. Disconnect wire 56 and 0 from the starter contactor relay (SCR).
3. Connect one meter test lead to the SCR terminal from which wire 56 was removed. Connect the other meter test lead to the terminal from which wire 0 was removed. Measure and record the resistance.

Results

1. If the DM indicated ohms less than the value in *Table 4-17* in Step 3, replace the SCR relay.
2. If the DM indicated the correct resistance for the component, a short to ground exists on Wire 56. Repair and replace wire 56 as needed.

Test 69—Test Transfer Relay Circuit

General Theory

Wire 194 provides 12 VDC for the transfer relay (TR1). If the DM indicated CONTINUITY in the previous test, one of the possible causes could be a faulty relay.

Procedure

1. Set a DM to measure resistance.
2. Disconnect Wire 194 and 23 from TR1 relay located inside the transfer switch.
3. Connect one meter test lead to Terminal A on the relay and connect the other meter test lead to terminal B, measure and record the resistance.

Table 4-19. TR1 Relay Terminal Connections

Relay	Clear Rectangle
Coil Resistance	160 Ohms
Wire 194	7
Wire 23	8
Wire N1A	5
Wire 126	1
Wire E1	6
Wire 205	4

Results

1. A short exists if the DM indicates less than optimal resistance in step 3. Repair or replace as needed.

Test 70—Check to See If Low Speed Function is Enabled

General Theory

The generator is equipped with a low speed exercise function. When enabled, the low speed exercise function allows the generator to exercise at 1950 rpm. If it is disabled it will exercise at 3600 rpm during exercise.

Procedure

1. From the main display enter the Edit Menu using the menu map.
2. Arrow up or down until Exercise Time is displayed.
3. Press ENTER.
4. “Quiet Test Mode? Yes or No” will be displayed. Be sure “Yes” is displayed. If not, change selection to Yes.
5. Press ENTER to save change.
6. Return to main display.

Results

Enable the exercise function if it is not already enabled. Refer to the flow chart.

Test 75—Test 120 Volt Input (T1)

General Theory

The controller requires 120 VAC supplied from the load side of the contactor in the transfer switch to function properly. When the circuit is supplied to the controller it will allow the controller to remain ON, but in a disabled mode where it will not crank or function properly.

Procedure

NOTE: Charger Missing AC alarm may appear while performing this test procedure. Ignore this alarm, it is a symptom of the test procedure.

1. Locate the 7.5 amp fuse on the controller.
2. Remove the fuse and observe the LCD screen.

Results

1. If the controller remained illuminated or continued to show its status after the fuse was removed, the 120 VAC input is good.
2. If the controller powered down when the fuse was removed, the controller is not getting the 120 VAC input. Refer to the flow chart.

Test 76—Verify DC Voltage Output of the Controller

General Theory

The battery voltage of the unit can be viewed within the Status menu of the controller. This test procedure will verify battery voltage connections to the controller.

Procedure

1. Navigate to the Battery Voltage menu in the controller.
   a. Press ESC until the main menu screen is present.
   b. Press the right arrow key until Status is flashing. Press ENTER.
   c. Press the right arrow key until Display is flashing. Press ENTER.
   d. Press the right arrow key until Battery Voltage displays. Press ENTER.

2. Record the displayed voltage.

Results

1. If the battery voltage indicated on the display is greater than 12 VDC, the connections to the controller from the battery are good. Refer to the flow chart.
2. If the battery voltage indicated on the display is 0 VDC, the connections to the controller are bad. Refer to the flow chart.
3. If the battery voltage indicated on the display is between 1–11 VDC, charge or replace the battery.

Test 77—Check Wire 13 and Wire 0

General Theory

The previous test indicated that battery voltage was not available to the controller and it was operating only off of the 120 VAC input from T1.

Procedure

1. Set DM to measure DC voltage.
2. Remove the 7.5 amp fuse from the controller.
3. Connect one meter lead to the left side of the fuse holder where the fuse was removed. Connect the other meter test lead to a clean frame ground. Measure and record the voltage.
4. Disconnect the appropriate harness connector from the controller.
5. Connect one meter test lead to harness connector pin for wire 13 and the other meter test lead to harness connector pin for wire 0. Measure and record the voltage.

Results

1. If the DM indicated battery voltage in steps 3 and 5, replace the controller.
2. If the DM indicated battery voltage in step 3, but did NOT indicate battery voltage in step 5, repair or replace wire 0 between the harness connector and the ground stud.

Test 78—Test DC Charge Current to the Battery

General Theory

Previous testing has verified the 120 VAC input connection and the battery connection. This test procedure will determine if there is a negative draw on the battery or a positive one, which will indicate successful operation of the charger.

Procedure

NOTE: A Charger Warning alert may be generated during this test procedure. It will not effect the results of the test and can be acknowledged when testing is complete.

1. Set the controller to MANUAL and crank the engine for 2–3 seconds.
2. Disconnect the negative cable battery.
3. Set the DM to measure DC amperage.

NOTE: Consult the meters owner's manual to verify proper setup of meter and that the internal fuse is good before proceeding.

4. Connect the positive (red) meter test lead to the negative battery post and connect the negative (black) meter test lead to disconnected negative battery cable. Measure and record the amperage.

Results

1. If the DM indicated positive DC amperage between 50 milliamps to 2.5 amps, stop testing. The charger is functioning properly.
2. If the DM indicated negative DC amperage, replace the controller.

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Figure 4-54. Positive DC Amps

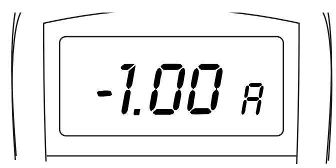

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Figure 4-55. Negative DC Amps

Test 79—Check T1 Voltage at Customer Connections

Procedure

1. Set a DM to measure AC Voltage.
2. Connect one meter test lead to the T1 terminal block at the customer connections in the generator. Connect the other meter test lead to the NEUTRAL connection. Measure and record the voltage.

Results

1. If the DM indicated 120 VAC, proceed to check voltage at the J5 connector, refer to the flow chart.
2. If the DM indicated less than 120 VAC or 0, refer to the flow chart.

TEST 80—Check T1 Voltage at Controller Connector

If 120 VAC was available on the customer connection block between T1 and neutral, the problem may be an open wire or bad connector at the controller harness connection.

Procedure

1. Disconnect the controller connector at the control panel.
2. Set the DM to measure AC voltage.
   a. Check the voltage at the controller harness connector pin between wire T1 and the neutral connection on the customer connection block. If voltage is present, proceed to step 3. If voltage is not present, check the T1 wire from the customer connection block to the controller harness connector.
3. Check the voltage between wire 00 of the controller harness connector pin and T1 at the customer connection block. If voltage is present, inspect and repair the connection pins at controller harness connector. If voltage is not available, check the 00 wire from the customer connection block to the controller harness connector.
4. If 120 VAC is present between T1 and 00 of the controller harness connector, and the pins are in good condition, then the fault lies in the controller itself. Replace the controller.

Test 81—Check T1 Voltage in Transfer Switch

General Theory

If voltage was not present in the generator, the most likely cause is a blown T1 fuse or an open wire.

Procedure

1. Set the DM to measure AC voltage.
2. Connect one meter test lead to the bottom side of the T1 fuse holder and the other meter test lead to the NEUTRAL connection. Measure and record the voltage.

Results

1. If the DM indicated proper voltage, repair or replace faulty wire between the generator and the fuse holder.
2. If the DM indicated less than proper voltage or 0, refer to the flow chart.

Test 82—Test F3 Fuse Circuit

Procedure

1. Set a DM to measure AC voltage.
2. Connect one meter test lead to the top side of the T1 fuse holder and connect the other test lead to the NEUTRAL connection. Measure and record the voltage.
   a. If the DM indicated 120 VAC, proceed to step 3.
   b. If the DM indicated less than 120 VAC or 0, verify that load voltage is available to the load side of the contactor.
3. On the generator panel, set the AUTO-OFF-MANUAL switch to OFF.
4. Disconnect utility from the transfer switch.
5. See ***Figure 4-56***. Remove fuse F3 from the fuse holder.
6. Inspect and test fuses for an OPEN condition with a DM set to measure resistance, CONTINUITY should be measured across the fuse.

Results

1. Replace blown fuse as needed and proceed to Problem 10 Blown T1 Fuse.

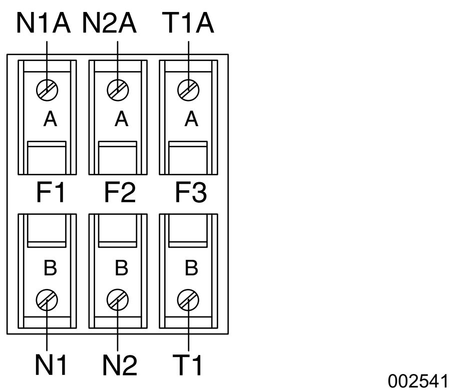


Figure 4-56. Transfer Switch Fuse Block

Section 5.1 System Functional Tests and Setup Procedures

Introduction

Following home standby electric system installation and periodically thereafter, the system should be tested. Functional tests of the system include the following:

- Manual transfer switch operation.
- System voltage tests.
- Generator Tests Under Load.
- Testing automatic operation.

Before proceeding with functional tests, read instructions and information on tags or decals affixed to the generator and transfer switch. Perform all tests in the exact order given in this section.

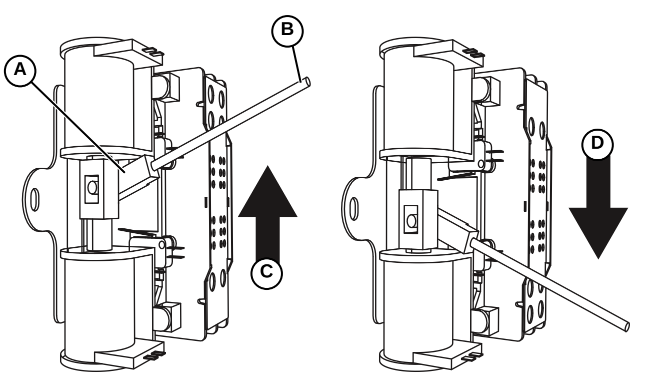
Manual Transfer Switch Operation

"W/V-Type" Transfer Switches

⚠DANGER

Electrocution. Do not manually transfer under load. Disconnect transfer switch from all power sources prior to manual transfer. Failure to do so will result in death or serious injury, and equipment damage. (000132)

1. On the generator panel, set the controller to OFF.
2. Turn OFF the utility power supply to the transfer switch using whatever means provided (such as a "Utility" main line circuit breaker).
3. Set the generator main line circuit breaker to OFF (or open).
4. Remove the manual transfer handle from the enclosure.



A. Transfer switch-operating lever
B. Manual transfer handle
C. Load connected to utility power source
D. Load connected to standby power source

Figure 5-1. Manual Transfer Switch Operation

5. Place open end of the manual transfer handle over transfer switch operating lever.
6. To connect LOAD terminal lugs to the utility power source, move, the handle upward.
7. To connect LOAD terminals to the standby power source, move the handle downward.
8. Actuate the switch to UTILITY and to MANUAL several times. Make sure no evidence of binding or interference is felt.
9. When satisfied that manual transfer switch operation is correct, actuate the main contacts to their UTILITY position (Load connected to the utility power supply).

Electrical Checks

Complete electrical checks as follows:

1. Set the generator main circuit breaker to its OFF (or open) position.
2. Set the generator AUTO-OFF-MANUAL switch to the OFF position.
3. Turn off all loads connected to the transfer switch Terminals T1 and T2.
4. Turn on the utility power supply to the transfer switch using the means provided (such as a utility main line circuit breaker).

Setting the Exercise Time

This generator is equipped with an exercise timer. Once it is set, the generator will start and exercise based on the program selected, on the day of the week and at the time of day specified. During this exercise period, the unit runs for approximately 5 minutes and then shuts down. Transfer of load to the generator output does not occur during the exercise cycle unless Utility power is lost.

After the Activation process has been completed, an installation wizard will prompt the user to set the minimum settings to operate. These settings are simple: "Current Time/Date" and "Exercise Day/Time".

The exercise settings can be changed at any time via the "EDIT" menu (See Section 4.1 ***Menu System Navigation***). If the 12 volt battery is disconnect or the fuse removed, the Installation Assistant will operate upon power restoration. The only difference being that the display will only prompt the customer for the current time and date.

If the installer tests the Generator prior to installation, press the “ENTER” key to avoid setting the exercise time. This will ensure that the customer will still be prompted to enter an exercise time when the unit is first powered up.

The exerciser will only work in AUTO and will not work unless this procedure is performed. The current date/time will need to be reset every time the 12 volt battery is disconnected and then reconnected, and/or when the fuse is removed.

Refer to appropriate Menu Map in Section 4.1 **Menu System Navigation**.

Generator Set-up

When battery power is applied to the generator during the installation process, the controller will light up. However, the generator still needs to be activated before it will automatically run in the event of a power outage.

Activation

To receive the activation code, you must have the unit serial number and go to: www.generac.com, “Service & Support” Tab and then “Activate Your Home Standby” under the “Generac Owners” list. You can also receive an activation code by calling 1-888-9ACTIVATE (1-888-922-8482).

Activating the generator is a simple, one-time process that is guided by the controller screen prompts. Once the product is activated, the controller screen will not prompt you to activate again, even if you disconnect the generator battery, fuse and battery charge circuit (T1 60 Hz / T1 & T2 50 Hz).

After obtaining your activation code, please complete the following steps at the generator’s control panel:

1. Upon first power up of the generator, the display interface will begin an installation wizard.

NOTE: If the unit has already been powered up, it will be necessary to disconnect the generator battery, fuse and battery charge circuit (T1 60 Hz / T1 & T2 50Hz).

2. The installation wizard will prompt the user to set the fuel type and after choosing fuel type and “Enter”, the display will then annunciate “Activate me (ENT) or ESC” to run in MANUAL.
3. Press Enter and use the up/down arrows and the enter keys to put the activation code in.

NOTE: If you push ESC to run in MANUAL, the unit will not function in AUTO. To enter the activation code at a later time, it will be necessary to disconnect the generator battery, fuse and battery charge circuit (T1).

If the unit is not activated, the install wizard will only allow the programming to operate the generator. These settings are: Current Date/Time and Exercise Day/Time and annunciate “NOT ACTIVATED”.

It the unit is activated, the install wizard will allow further programming parameters and Auto operation. The maintenance intervals will be initialized when the exercise time is entered. The exercise settings can be changed at any time via the EDIT menu. If the 12 volt battery is disconnected or the fuse removed, the installation wizard will operate upon power restoration. The only difference is the display will only prompt the customer for the current Time and Date.

Front Engine Access

Safety

1. Set the controller to OFF.
2. See *Figure 6-1*. Remove the 7.5 amp main fuse.
3. Remove the N1 and N2 fuse from the transfer switch.
4. Remove T1 fuse to disable battery charging.

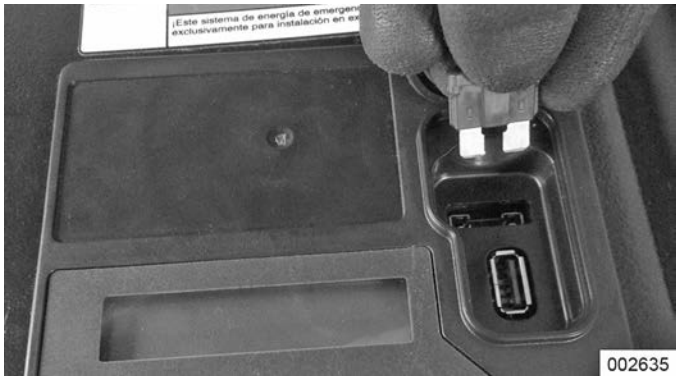


Figure 6-1. Remove 7.5 Amp Fuse

5. Turn off fuel supply to the generator.
6. Lift the hood and remove the front door.
7. Remove battery from the generator.

Front Engine Access

1. **Remove Controls Cover:** See *Figure 6-2*. Use a 5/32” Hex Allen wrench remove two bolts and ground washer from the controls cover. Remove the controls cover.

Figure 6-2.

2. Remove controller: See *Figure 6-3*. Use a 1/4” socket to remove the screw directly underneath the support bracket. Slide the controller back to line up the tabs on the controller with the openings on the divider wall.

Figure 6-3. Tabs on Controller

3. **Remove control harnesses:** Disconnect all connectors and remove the controller.
4. **Remove Stator Wires:** Remove all wires from the main circuit breaker, remove the neutral and ground wires from landing lugs.
5. **Remove Control Wires:** See *Figure 6-4*. Remove Wires N1, N2, T1, 0, 194, 23, and unit status lights from the control box.

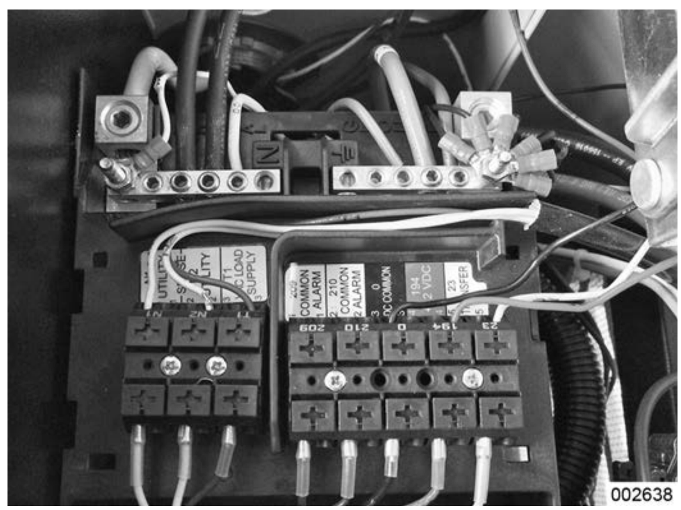


Figure 6-4.

6. **Remove controller mounting box on controller:** See *Figure 6-5*. Use an 8mm socket to remove the two screws from the rear of the controller mounting box. Use a 10mm socket to remove the two bolts from under the front of the controller mounting box.

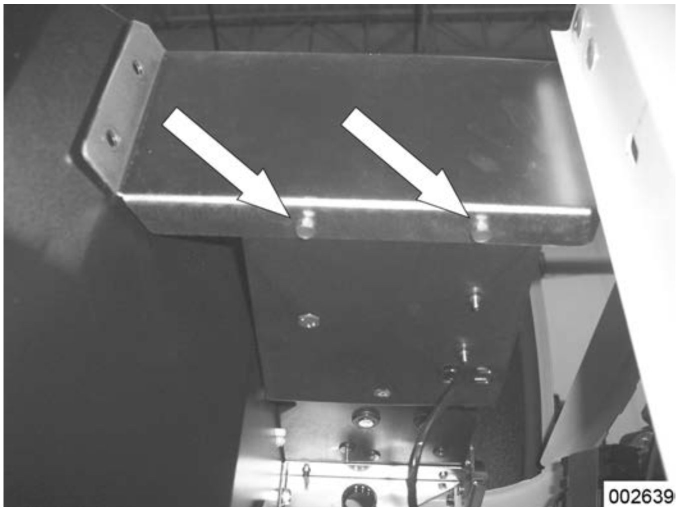


Figure 6-5.

7. **Remove engine intake baffle:** See ***Figure 6-6***. Use a 10mm socket to remove the two bolts from the engine intake baffle. There are tabs holding the backside of the baffle to the divider panel. Pull baffle forward carefully.

Figure 6-6.

8. **Loosen side panel:** See ***Figure 6-7***. Use a 10mm socket to remove the two bolts from the base of the enclosure side panel.
9. **Unbolt enclosure side panel mounting bracket:** See ***Figure 6-7***. Use a 10mm socket to remove the two bolts from the enclosure side panel mounting bracket.

Figure 6-7.

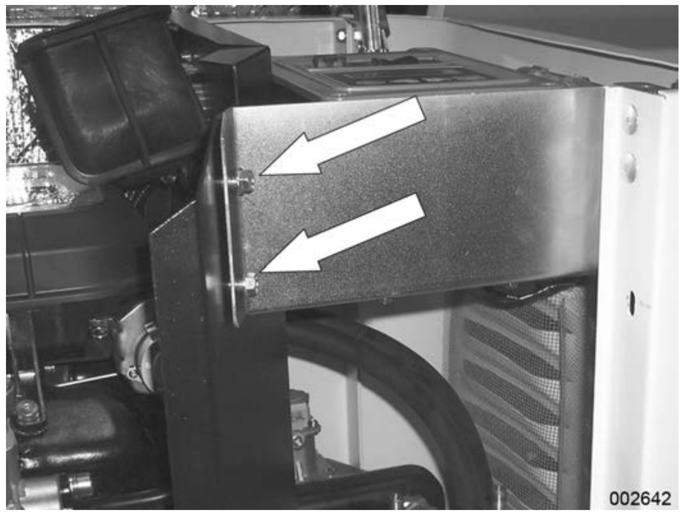


Figure 6-8.

10. **Remove fuel regulator:** See ***Figure 6-9***. Remove the two fuel hoses at the top of the regulator. Use a 10mm socket to remove one 10mm bolt from the base of the plenum and one 10mm bolt from the base of the fuel regulator. Flex the enclosure side out to allow for room to remove the regulator assembly.

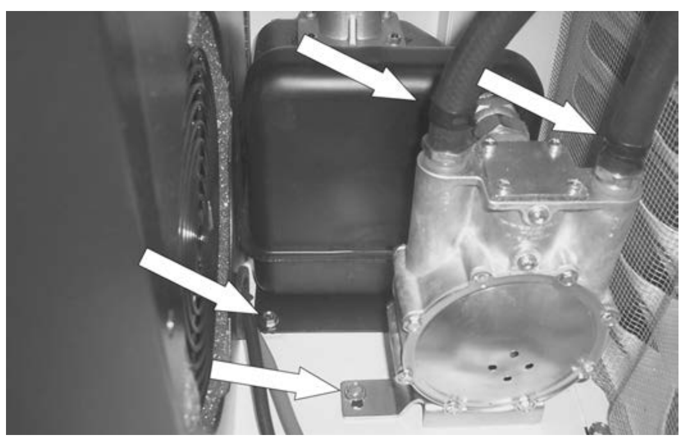


Figure 6-9.

11. **Remove engine divider panel:** See ***Figure 6-10*** Use a 10mm socket to remove the rear 10mm bolt from the base of the enclosure.

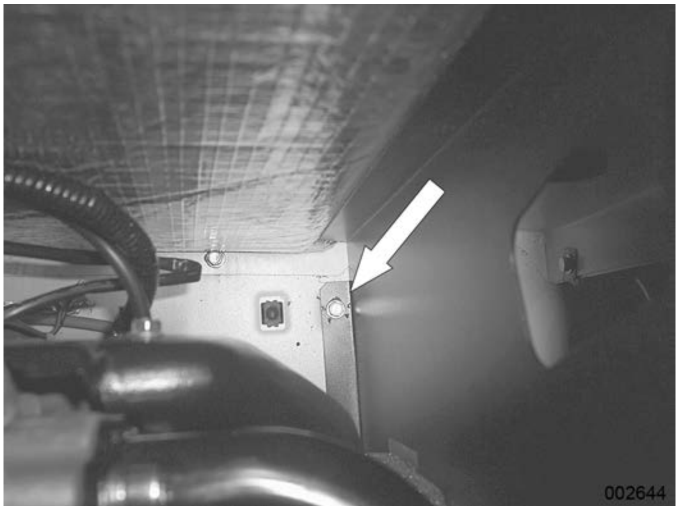


Figure 6-10.

12. See ***Figure 6-11***. Remove the front 10mm bolt from the base of the enclosure.

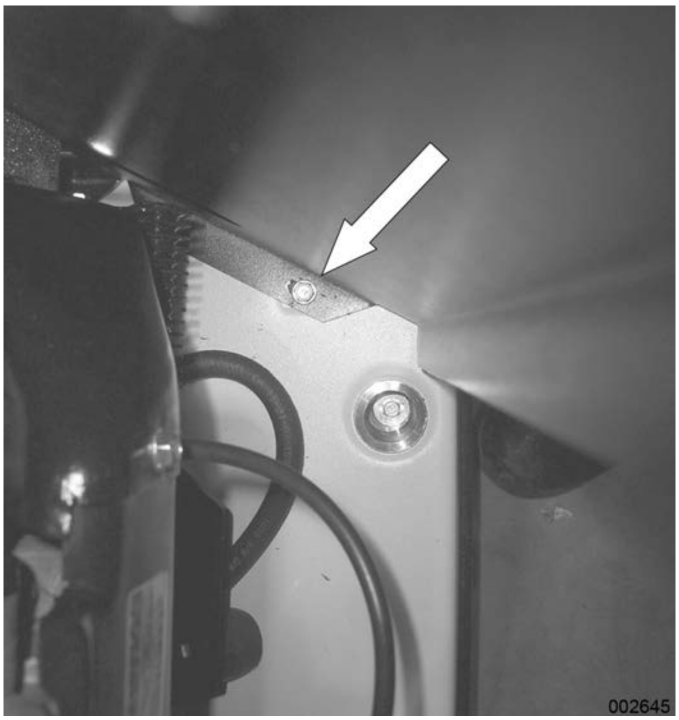


Figure 6-11.

13. **Remove Air Box:** See ***Figure 6-12***. Using a 6mm Allen wrench remove the four intake manifold socket head cap screws.

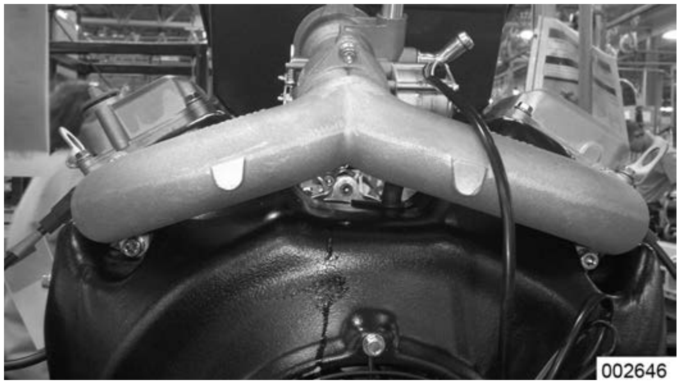


Figure 6-12. Intake Manifold

14. See ***Figure 6-13***. Use a 4mm Allen wrench to remove the four airbox Allen head shoulder bolts. While removing the airbox remove the four rubber washers.

Figure 6-13. Air Box

15. **Unbolt Oil Cooler:** See ***Figure 6-14***. Use a 10mm socket to remove the two 10mm bolts from the front of the oil cooler.

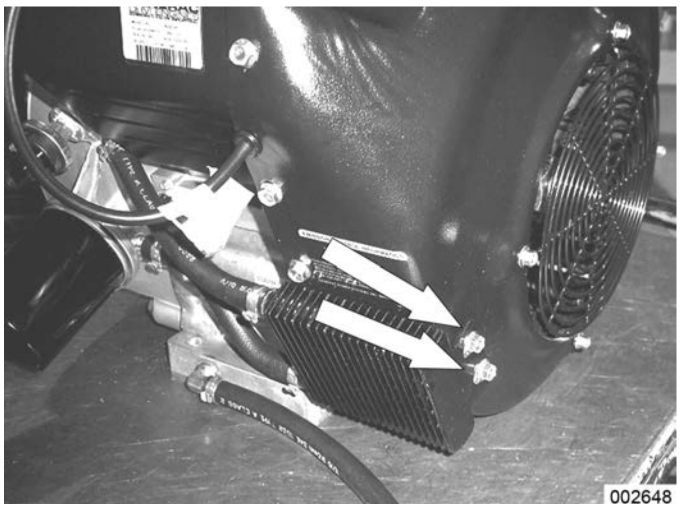


Figure 6-14.

16. See ***Figure 6-15***. Remove the two 10mm bolts from the rear of the oil cooler.

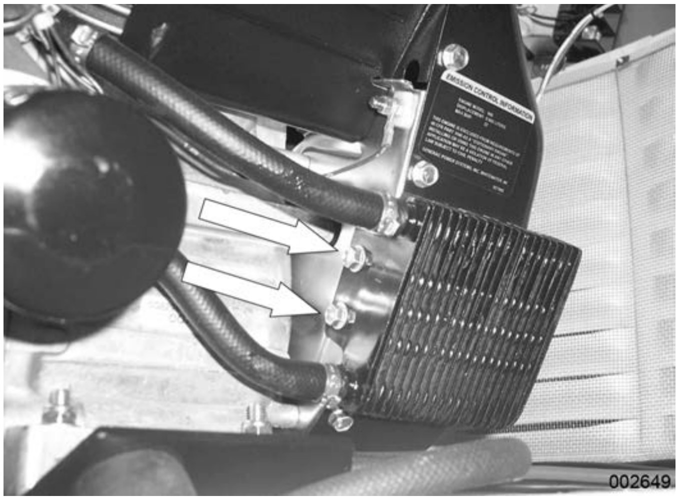


Figure 6-15.

17. **Remove Blower Housing:** See ***Figure 6-16***. Use a 4mm Allen wrench to remove one button head cap screw from top of blower housing. Use a 10mm socket to remove one 10mm bolt from the top of the blower housing.

Figure 6-16.

18. See ***Figure 6-17***. Use a 10mm socket to remove four 10mm bolts from the right-side of the blower housing.

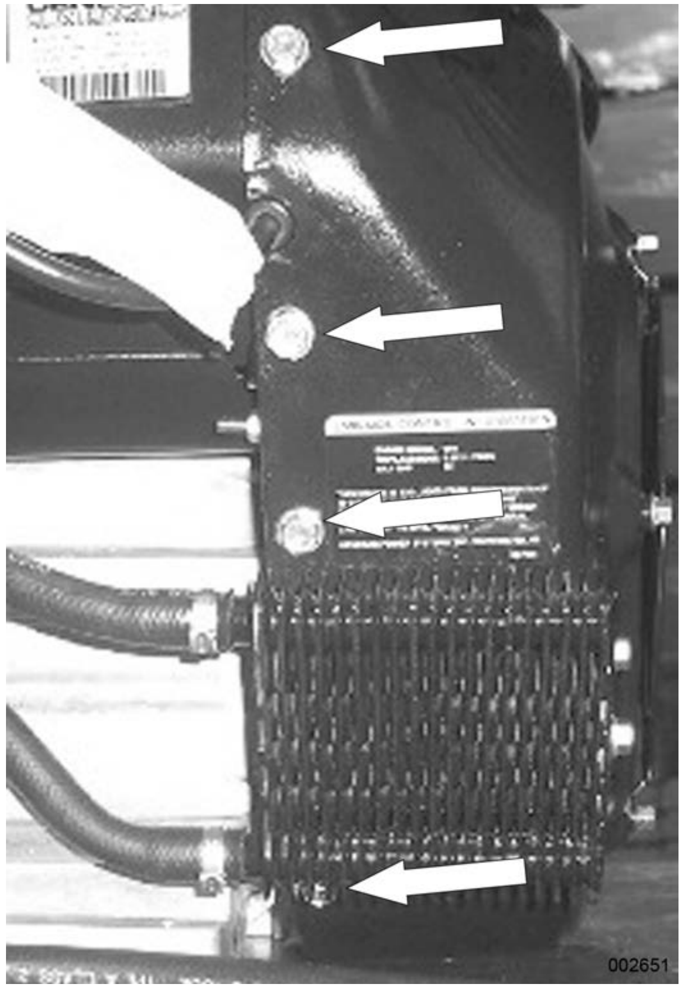


Figure 6-17.

19. See ***Figure 6-18***. Use a 10mm socket to remove four 10mm bolts from the left-side of the blower housing.
20. Remove blower housing.

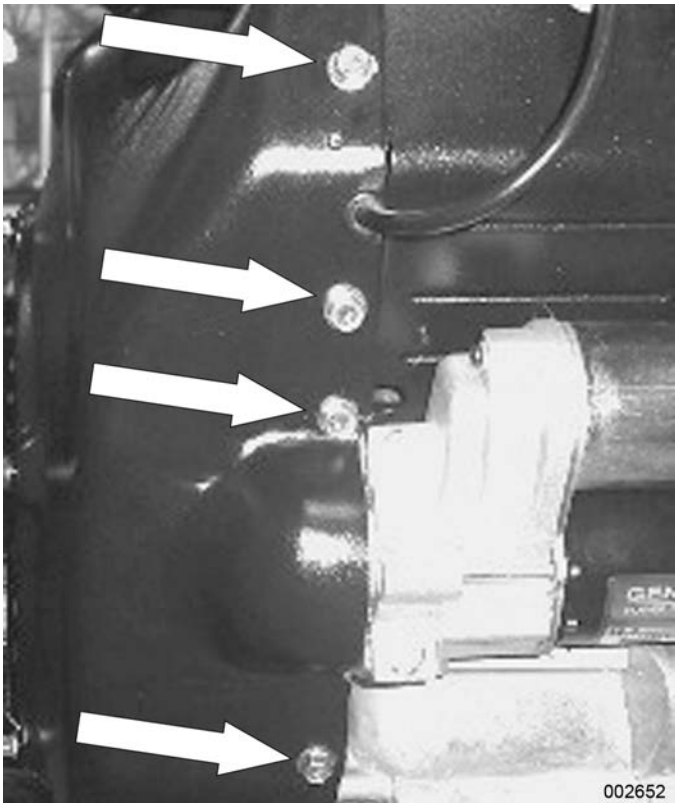


Figure 6-18.

Major Disassembly

Safety:

1. Set the controller to OFF.
2. See ***Figure 6-19***. Remove the 7.5 amp main fuse.
3. Remove the N1 and N2 fuses from the transfer switch.
4. Remove T1 Fuse to disable battery charging.

Figure 6-19. Remove 7.5 Amp Fuse

5. Turn off fuel supply to the generator.
6. Lift the hood and remove the front door.
7. Disconnect negative battery cable from the battery.

AVR Removal

Required Tools

- Standard Mechanics Tool Set

IMPORTANT NOTE: The small DC fan on the AVR is energized after shutdown and continues to run for up to one hour to prevent heat from building up in the AVR electronics. If the green LED light is flashing, power to the AVR MUST NOT be removed.

Procedure

1. **Remove Fuse:** Remove the 7.5 amp fuse from the control panel (be sure the green LED light on AVR is not flashing).
2. **Disable T1:** Remove T1 source voltage by pulling the T1 Fuse or turning off the Utility Source.
3. **Remove AVR Intake Duct:** See Figure 187. Use a 10mm socket to remove the screw holding the AVR intake duct to the back panel. Remove the intake duct and set aside.
4. **Disconnect Harness:** Disconnect the P1 connector/harness by pressing retaining clip and pulling on the connector. Do not disconnect the P2 connector at this time.
5. **Remove Hardware:** Use a 10mm socket to remove the two screws securing AVR to the back panel.
6. **Remove AVR:** Carefully remove the AVR and set it on top of the exhaust enclosure covers to expose the lower harnesses.

Figure 6-20. AVR

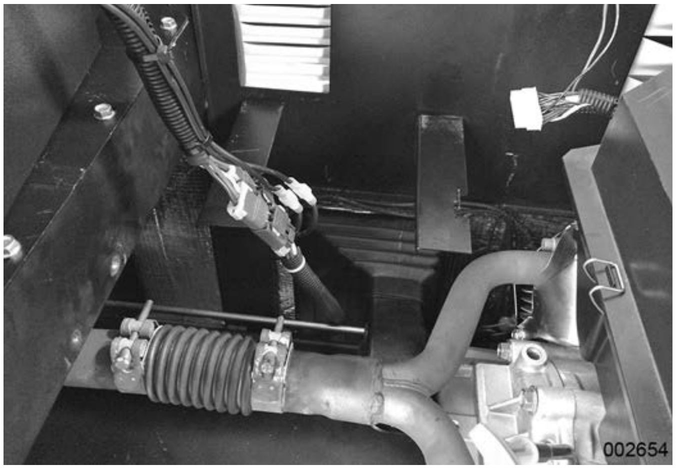


Figure 6-21. AVR Removed

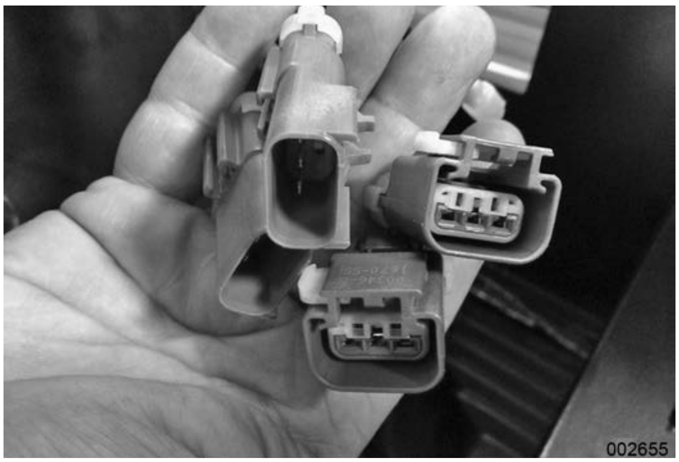


Figure 6-22. AVR Brushes Disconnected

7. **Disconnect Lower Harnesses:** Disconnect the harness connectors containing Wires A1, A2, B1, B2, C1, C2 from the AVR. Disconnect the harness connectors containing Wires 2 and 6 from the AVR.
8. **Set AVR Aside:** Set the AVR in a safe and dry area.

Stator/Rotor/Engine Removal

Required Tools

- Stator Holding Adapters (PN 0K8824)
- Rotor Protector Sheet (PN 0K8210)
- Vibration Dampener Puller
- 3” M12x1.75 Bolt
- Standard Mechanics Tool Set (Including a Rubber Mallet or Dead-Blow Hammer)
- Also needed are 3 or 4 small 2x4 blocks of wood.

1. **Remove AVR:** See AVR Removal.
2. **Remove Top Exhaust Enclosure Covers:** See ***Figure 6-23***. Use a 10mm socket to remove the nine bolts from the exhaust top covers. Remove covers.

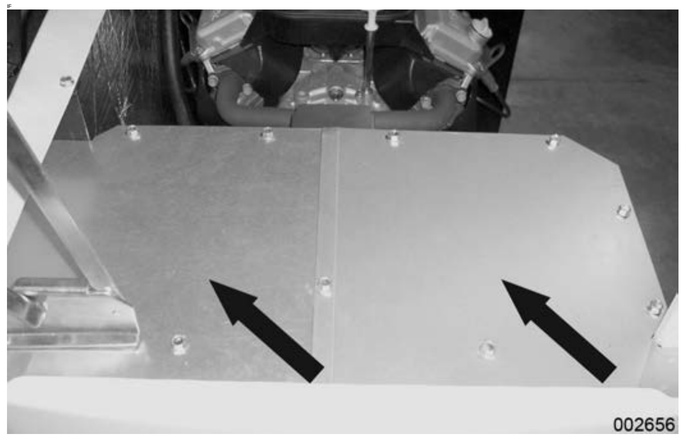


Figure 6-23.

3. **Remove Side Exhaust Enclosure Cover:** See ***Figure 6-24***. Use a 10mm socket to remove the five bolts from the exhaust side cover. Remove side covers.

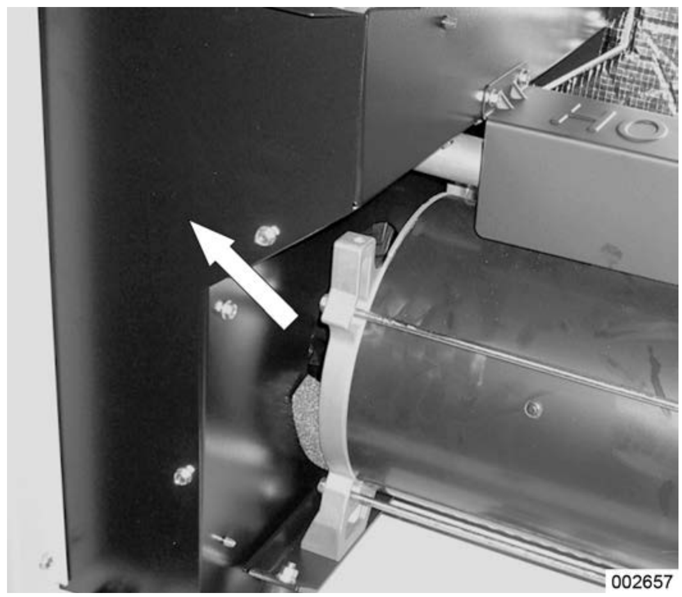


Figure 6-24.

4. Loosen Exhaust Flex Cover: See ***Figure 6-25***. Use a 10mm socket to remove the two bolts from the exhaust flex pipe cover. Remove the cover.

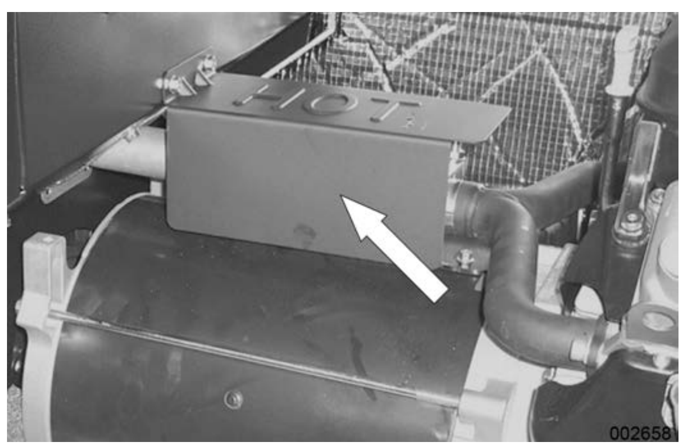


Figure 6-25.

5. **Remove Exhaust Flex Pipe:** See ***Figure 6-26*** and ***Figure 6-27***. Use a 10mm socket to loosen the right side muffler clamp. Exhaust flex will be removed with the muffler, resonator and divider panel.

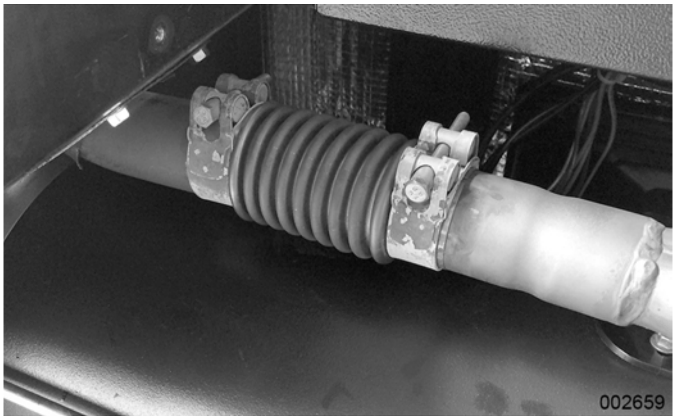


Figure 6-26.

Figure 6-27.

6. **Remove Left-side enclosure:** See ***Figure 6-28***. Use a 10mm ratchet wrench to remove the horizontal 10mm bolt that connects the side panel to the back panel. Use a 10mm socket to remove three bolts from the base of the enclosure.

NOTE: The muffler is shown removed for better view of the bolts.

7. See ***Figure 6-29***. Use a 10mm socket and wrench to remove the top hinge bolt and loosen the bottom bolt.

NOTE: The muffler is shown removed for better view of the bolts.

8. While holding the roof, remove the bottom hinge bolt.

9. Remove the side panel by sliding it forward then re-install the hinge bolt.

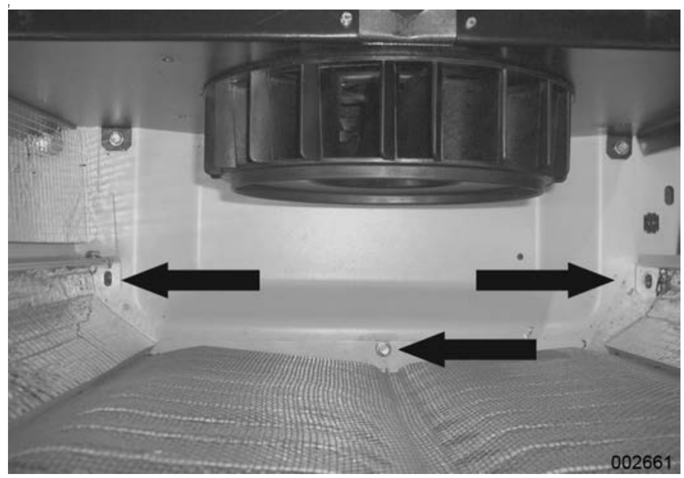


Figure 6-28.

Figure 6-29.

10. **Remove Rotor Bolt:** See ***Figure 6-30***. Use a 9/16” socket to remove the rotor bolt.

Figure 6-30.

11. Insert one M12 x 1.75 bolt into rotor end, leaving about 1/2” of thread exposed in preparation for next step.

Figure 6-31.

12. **Remove Fan:** See ***Figure 6-32***. Attach a vibration dampener or suitable puller to the fan using two M8 x 1.25 bolts. Remove the fan from the rotor.

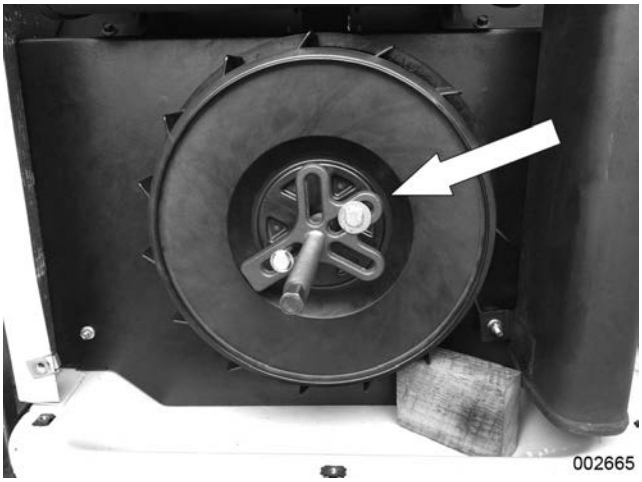


Figure 6-32.

13. **Remove Alternator Divider Panel:** See ***Figure 6-33***. Use a 10mm socket to remove two bottom base bolts. Use a 4mm Allen wrench to remove one top rear bolt. Remove the panel with muffler, resonator and flex pipe still attached.

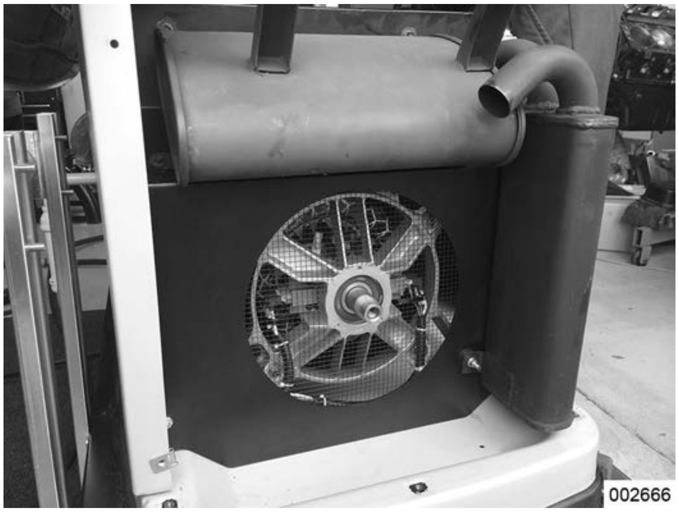


Figure 6-33.

14. **Install Rotor Bolt:** Install the rotor bolt to keep the rotor in place while the bearing support is being removed.

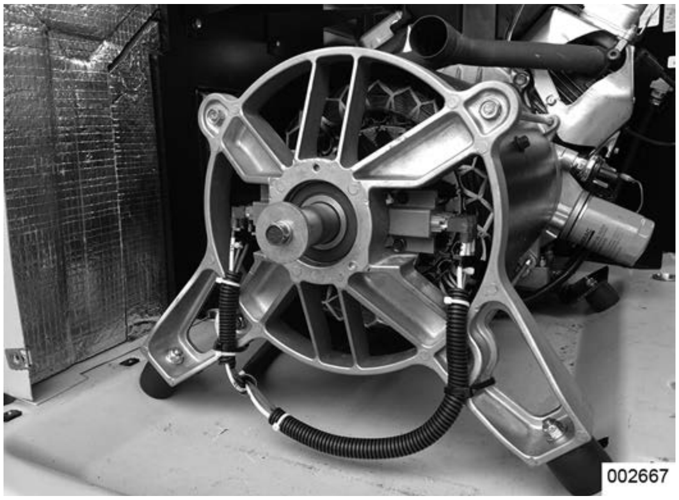


Figure 6-34.

15. **Remove Brushes:** See ***Figure 6-35***. Use a 7mm socket to remove brushes with the brush wires attached. Use side cutters to remove the tie wraps securing the brush wire harness to the outside of the stator. Set the brushes and wire harness assembly in a safe place.

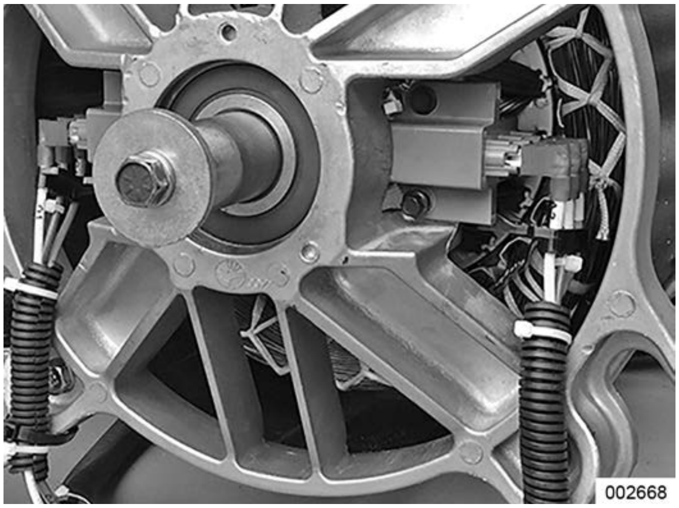


Figure 6-35.

NOTE: See ***Figure 6-36***. There is an engine mount located underneath the engine near where the alternator and engine come together. This clamping screw must be loosened before lifting the alternator up to set the wood block in place.

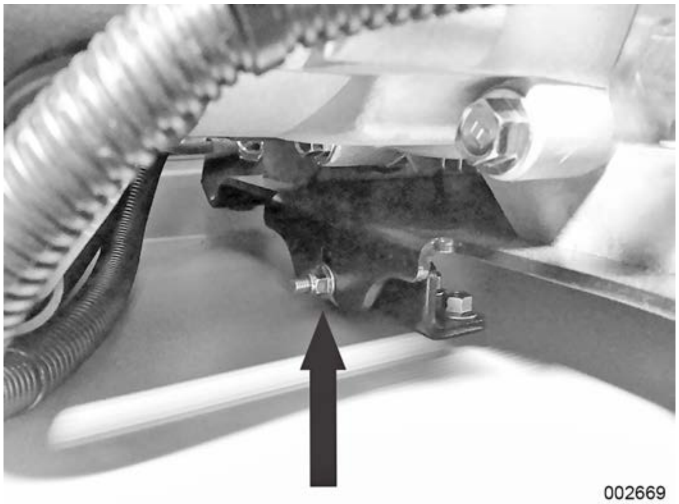


Figure 6-36.

16. **Rear Bearing Carrier Removal:** See ***Figure 6-37***. Use a 13mm socket to remove the two nuts from the alternator mounting bracket rubber mounts.

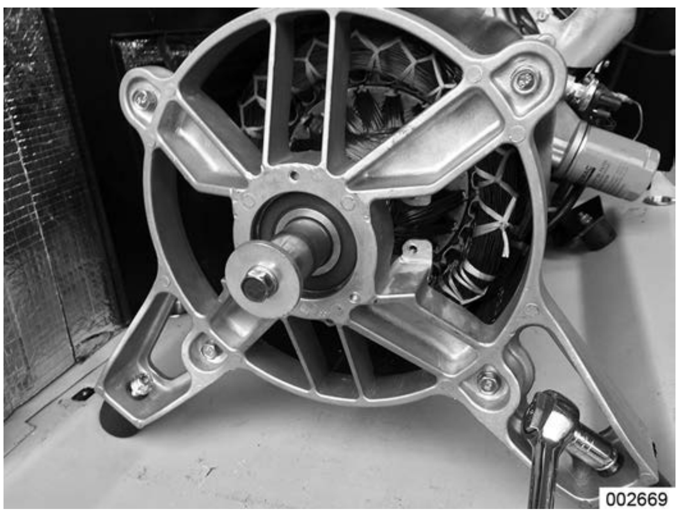


Figure 6-37.

17. Use a 13mm socket to remove the four stator hold down bolts.
18. See ***Figure 6-38***. Lift the back end of the alternator up and place a 2"x 4" piece of wood under the engine.

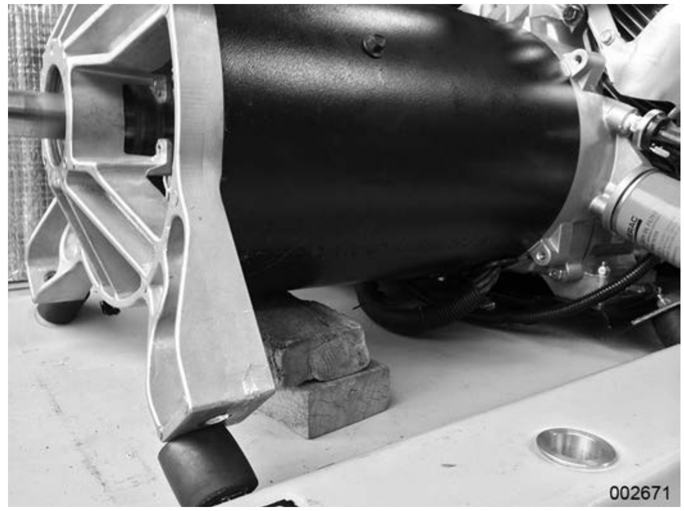


Figure 6-38.

19. See ***Figure 6-38***. Use a small rubber mallet or suitable dead-blow hammer to remove the rear bearing carrier.

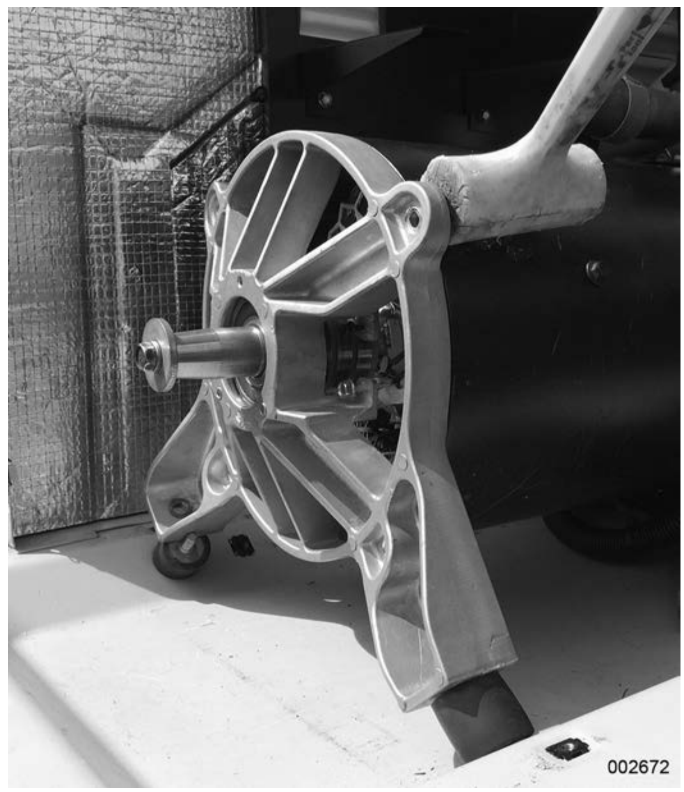


Figure 6-39.

20. **Stator Holding Tool:** See ***Figure 6-40***. Insert two previously removed stator bolts into the two stator holding adapters (0K8824) and screw the bolts into the engine at the 10 o'clock and 4 o'clock positions. Tighten only enough to hold the stator in place. DO NOT OVER TIGHTEN!

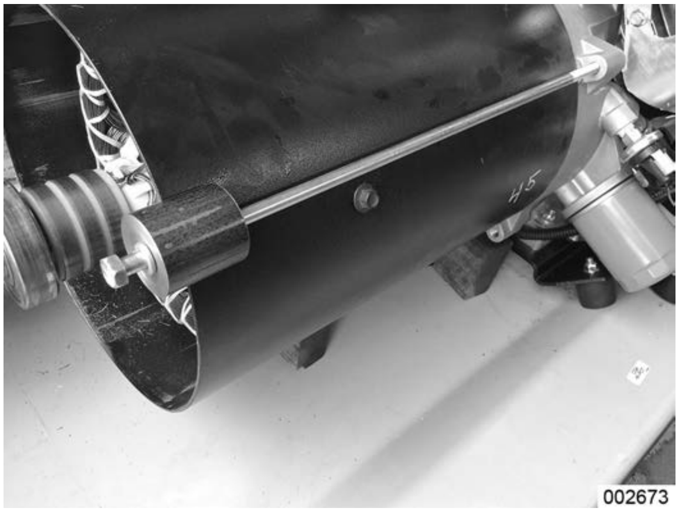


Figure 6-40.

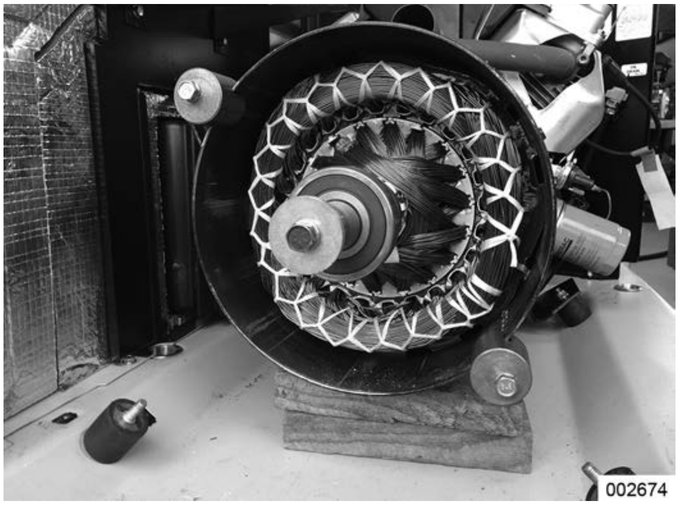


Figure 6-41.

21. **Rotor Removal Protection:** See ***Figure 6-41***. Insert the rotor protector sheet (PN 0K8210) between the rotor and stator assemblies.

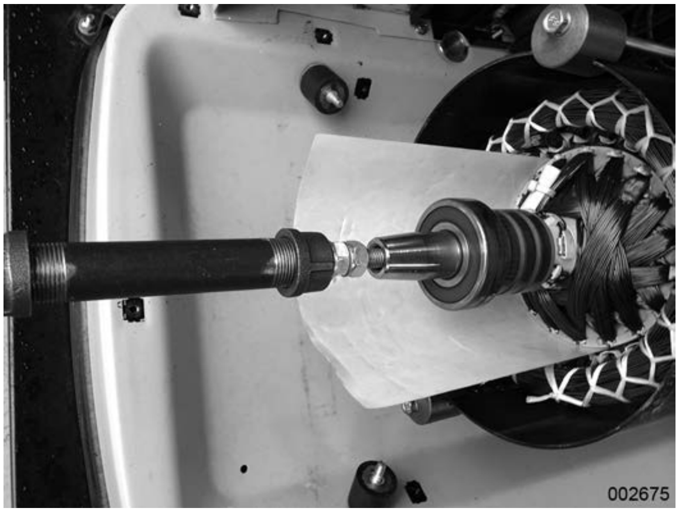


Figure 6-42.

22. **Rotor Separation:** Remove rotor bolt and cut 2 inches from the rotor bolt. Slot the end of the bolt to suit a flat blade screwdriver.

NOTE: See ***Synergy Rotor Removal Tools*** at the end of this section for construction of special tools.

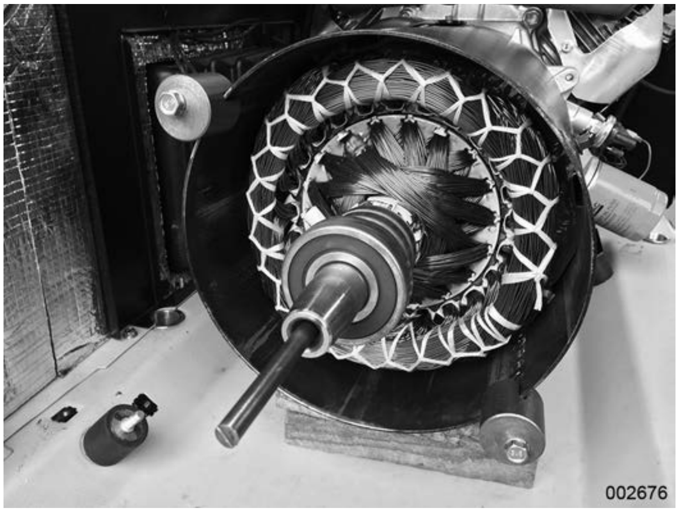


Figure 6-43.

23. See ***Figure 6-43***. Slide the rotor bolt back through the rotor and use a screwdriver to screw it into the crankshaft. Screw a 3” M12 x 1.75 bolt into rotor end. Apply torque to the 3” M12 x 1.75 bolt until rotor breaks free from the tapered crankshaft.

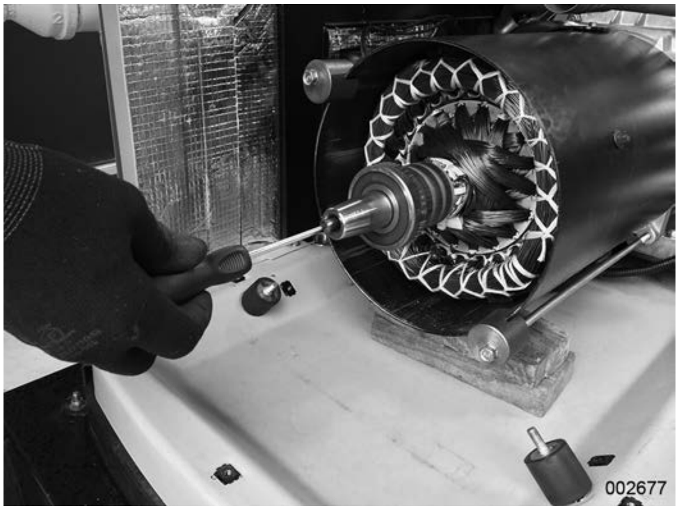


Figure 6-44.

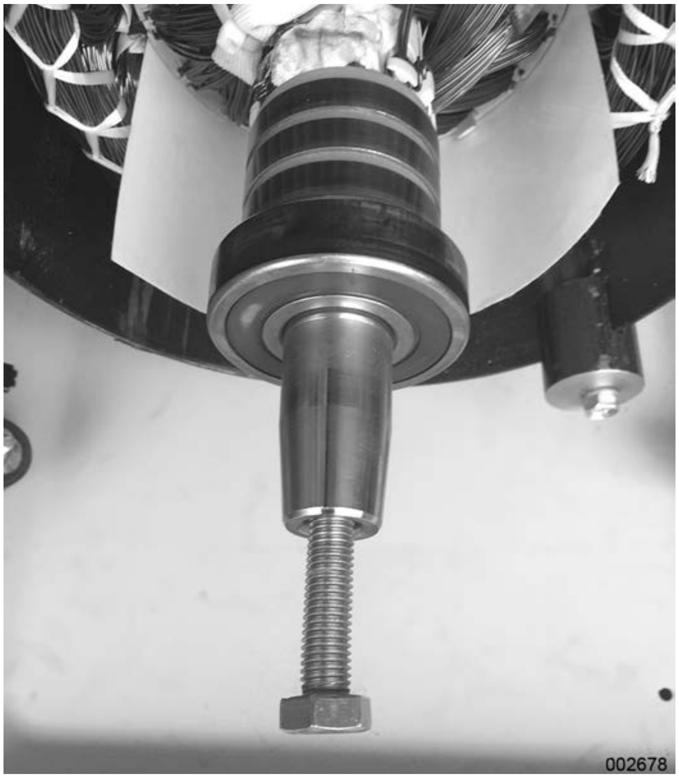


Figure 6-45.

24. **Rotor Removal:** See ***Figure 6-44***. Screw a pipe fitted with a 3” M12 x 1.75 into the rotor end. Use a loop of hose to support the rotor as it is being removed from the stator.

NOTE: See ***Synergy Rotor Removal Tools*** at the end of this section for construction of special tools.

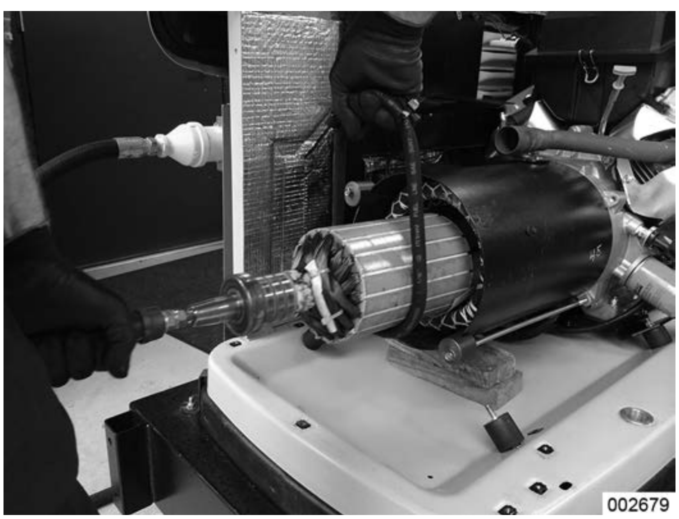


Figure 6-46.

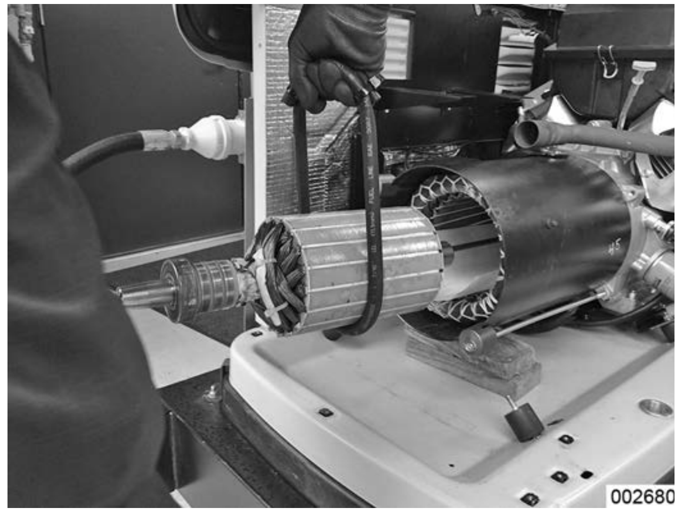


Figure 6-47.

25. **Remove Stator Wires:** Remove all connectors from the controller. Remove all wires the common neutral and ground wires from landing lugs. Remove wires from main beakers.
26. **Alternator Air Intake:** See ***Figure 6-47***. Disconnect alternator intake bellows.

Figure 6-48.

27. **Removing Stator:** Use short 2” x 4” pieces of wood to support the stator and engine. Remove the stator holding adapter tool and separate the stator from the engine.

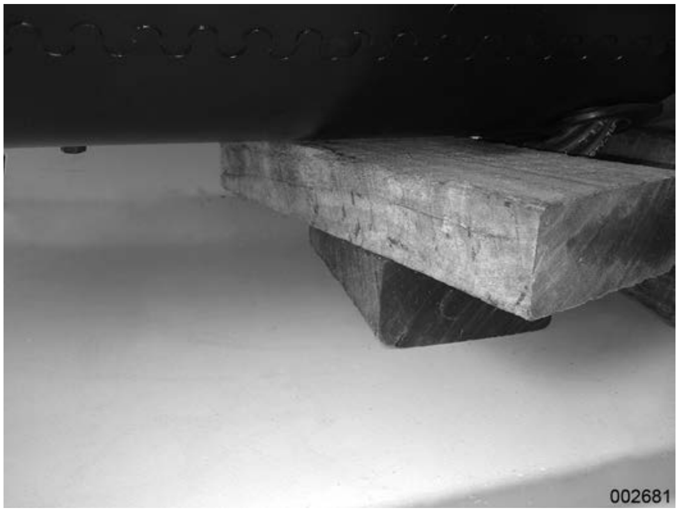


Figure 6-49.

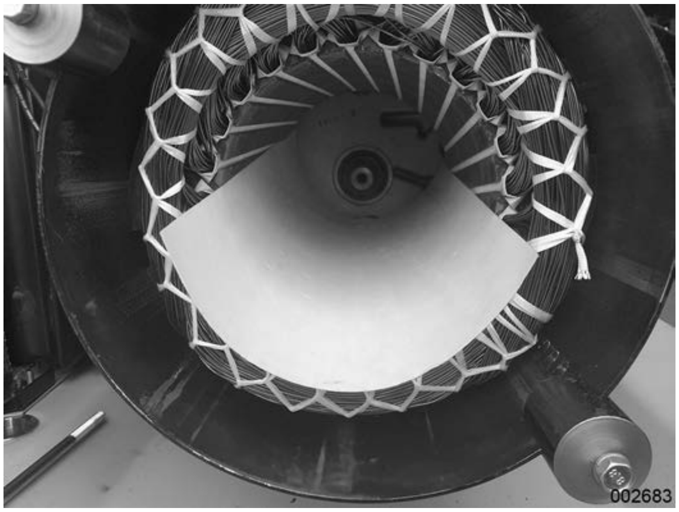


Figure 6-50.

Figure 6-51.

28. **Remove Engine:** See ***Figure 6-52***. Use a 13mm socket to remove the two engine mount nuts with ground wires.

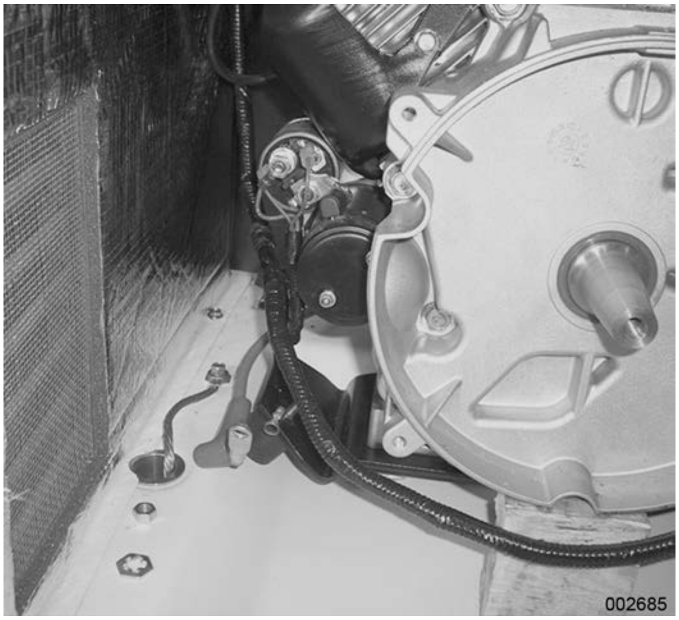


Figure 6-52.

29. **Remove Engine:** See ***Figure 6-53***. Use appropriate lifting equipment to remove the engine.

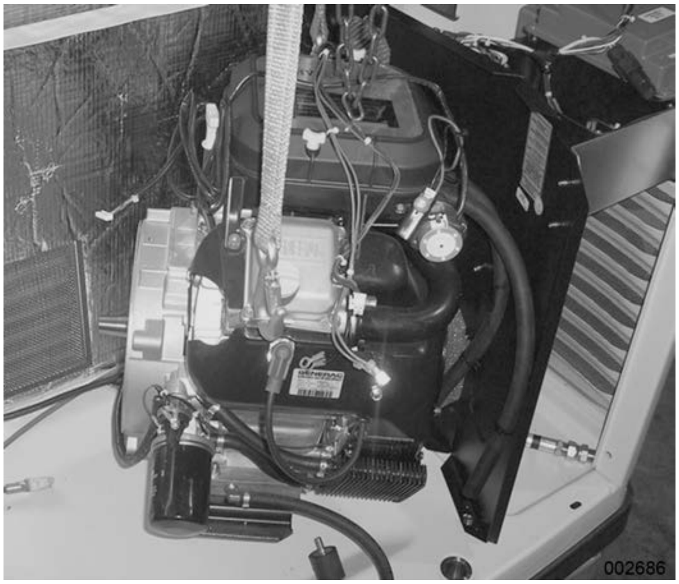


Figure 6-53.

Engine/Stator/Rotor Installation

1. **Installing Stator:** See ***Figure 6-54***. Install the stator before installing the rotor. Be sure to support the stator with proper 2” x 4” blocking.

NOTE: Install plugs before mounting the stator.

Figure 6-54.

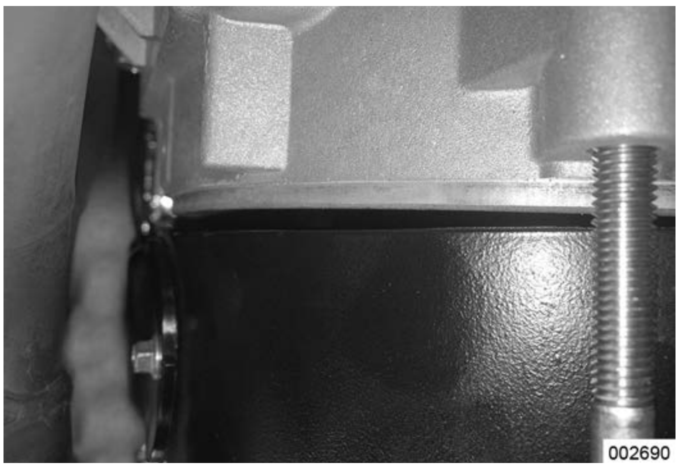


Figure 6-55.

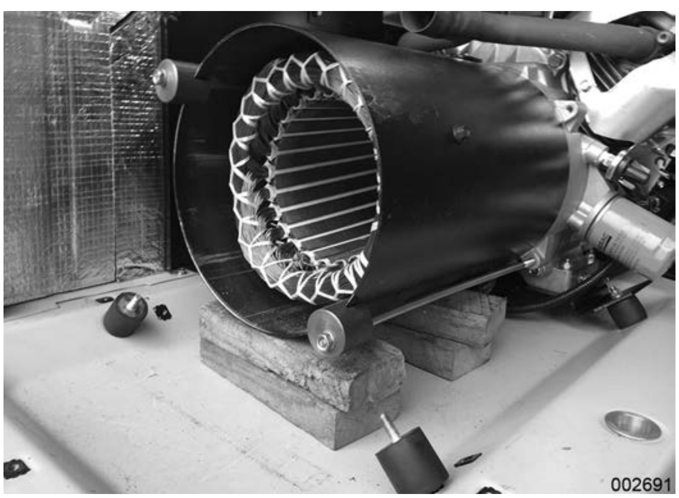


Figure 6-56.

2. **Rotor Installation:** Insert the rotor being sure to use the protector sheet (0K8210), pipe handle and support hose. Temporarily install the rotor bolt to hold the rotor in place while continuing the assembly process.

IMPORTANT NOTE: Remove the protector sheet before installing the bearing carrier.

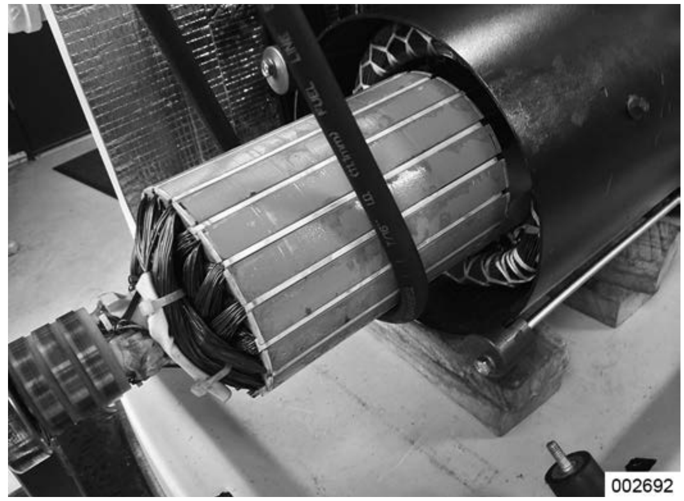


Figure 6-57.

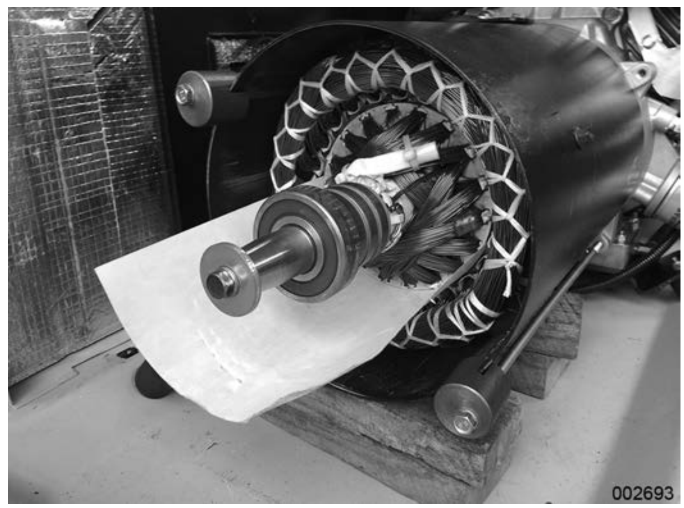


Figure 6-58.

3. **Rear Bearing Carrier:** Use a small rubber mallet or suitable dead-blow hammer to attach the rear bearing carrier.

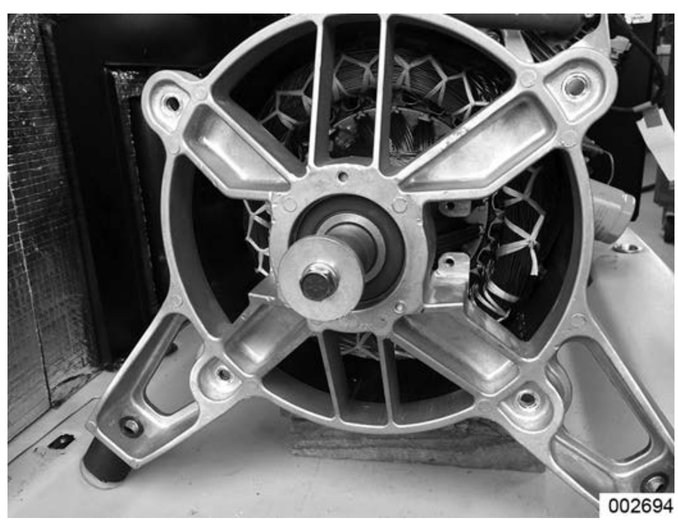


Figure 6-59.

4. **Insert Stator Bolts:** Insert the four stator holding bolts through the rear bearing carrier and secure to the engine. Use a quality torque wrench to tighten the stator bolts in an X pattern to the ***Torque Specifications*** listed in this manual.

NOTE: Do not over tighten!

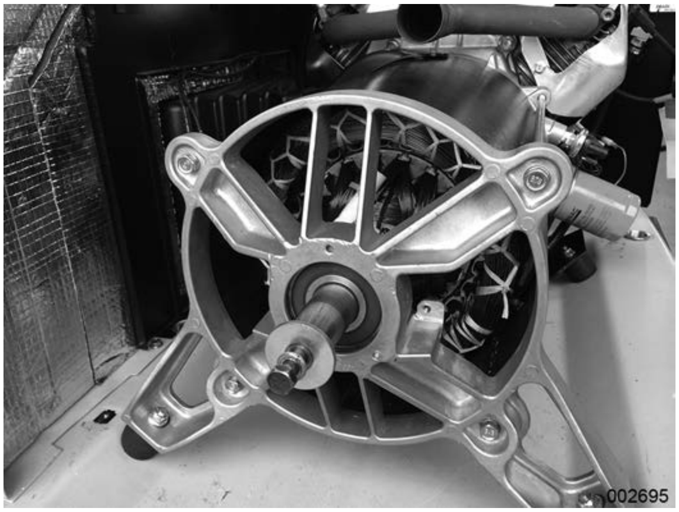


Figure 6-60.

5. **Install Brushes:** See ***Figure 6-61***. Use a 7mm socket to secure the brushes to the rear bearing carrier. Properly route the brush wire harness to the back of the stator. If the brushes were disconnected from the harness, pay close attention to the wire numbers and positions during assembly. Use tie wraps to secure the brush wires to the outside of the rear bearing carrier legs.

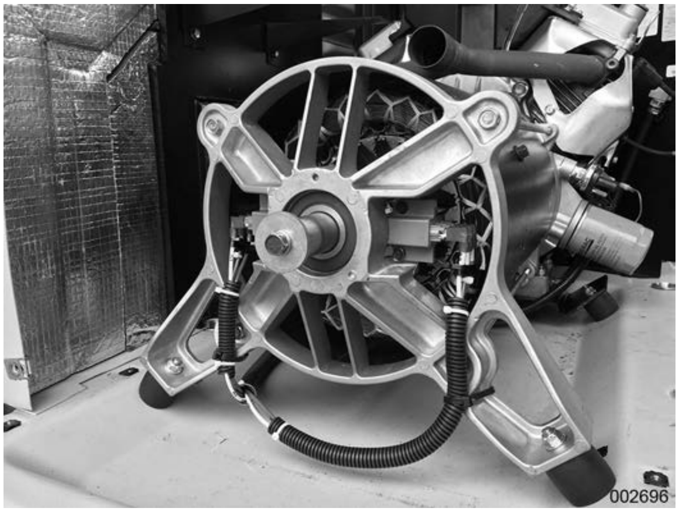


Figure 6-61.

6. **Attach Divider Panel:** Attach the alternator divider panel with two bottom base bolts and other fastening hardware. Attach the panel with muffler, resonator and flex pipe still attached. Tighten the right side clamp on the flex pipe. Tighten all fasteners to the ***Torque Specifications*** listed in this manual.

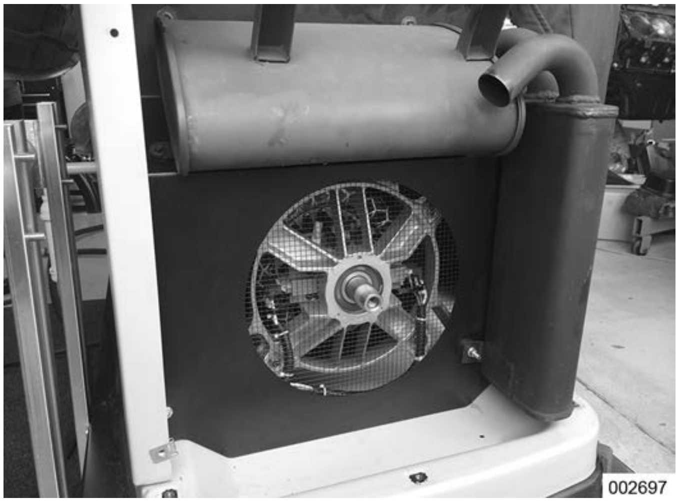


Figure 6-62.

7. **Install Fan and Rotor Bolt:** Attach the fan and insert the rotor bolt. Tighten the rotor bolt to the ***Torque Specifications*** listed in this manual.

Figure 6-63.

8. **Attach Enclosures and Covers:** Secure all panels and enclosure covers with appropriate hardware. Tighten all fasteners to the ***Torque Specifications*** listed in this manual.

Figure 6-64.

Figure 6-65.

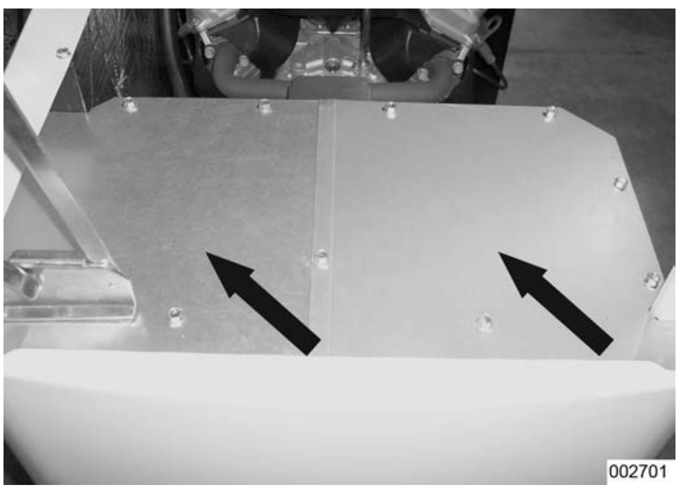


Figure 6-66.

9. **Install AVR:** Install the AVR reversing the procedure described in the AVR removal instructions.
10. **Install Stator Wires:** Connect wires to the main circuit breaker, connect the neutral and ground wires from landing lugs.

NOTE: Wires 11 and 44 must be routed correctly through the CTs. Wire 11 through CT1, and Wire 44 through CT2. Always feed the wire through the “GREEN DOT” side.

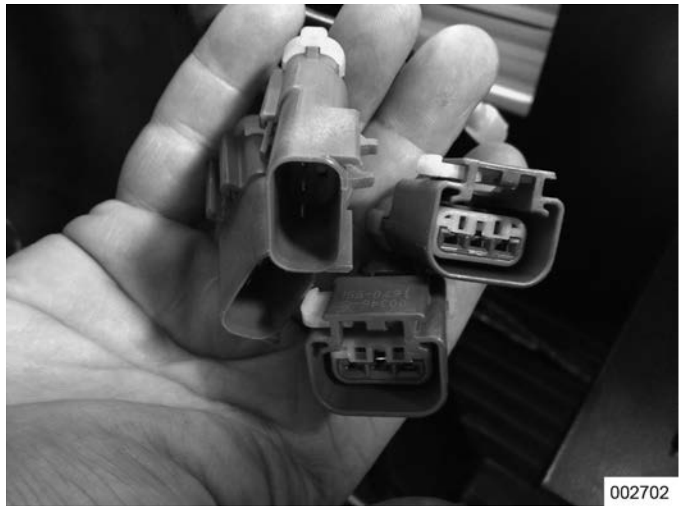


Figure 6-67. AVR Brushes Disconnected

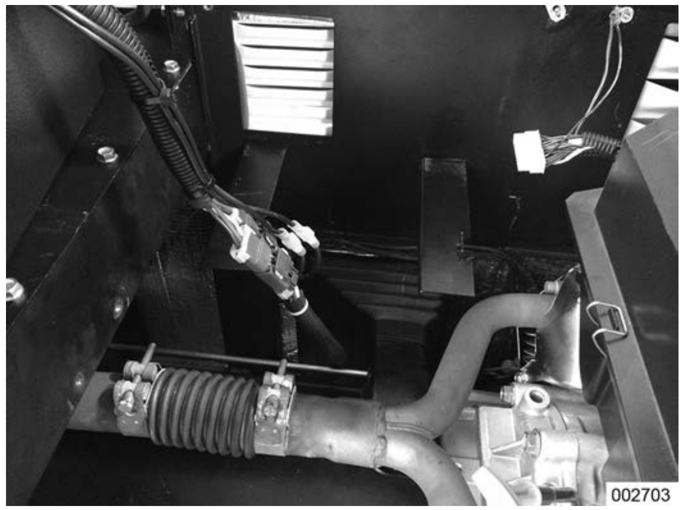


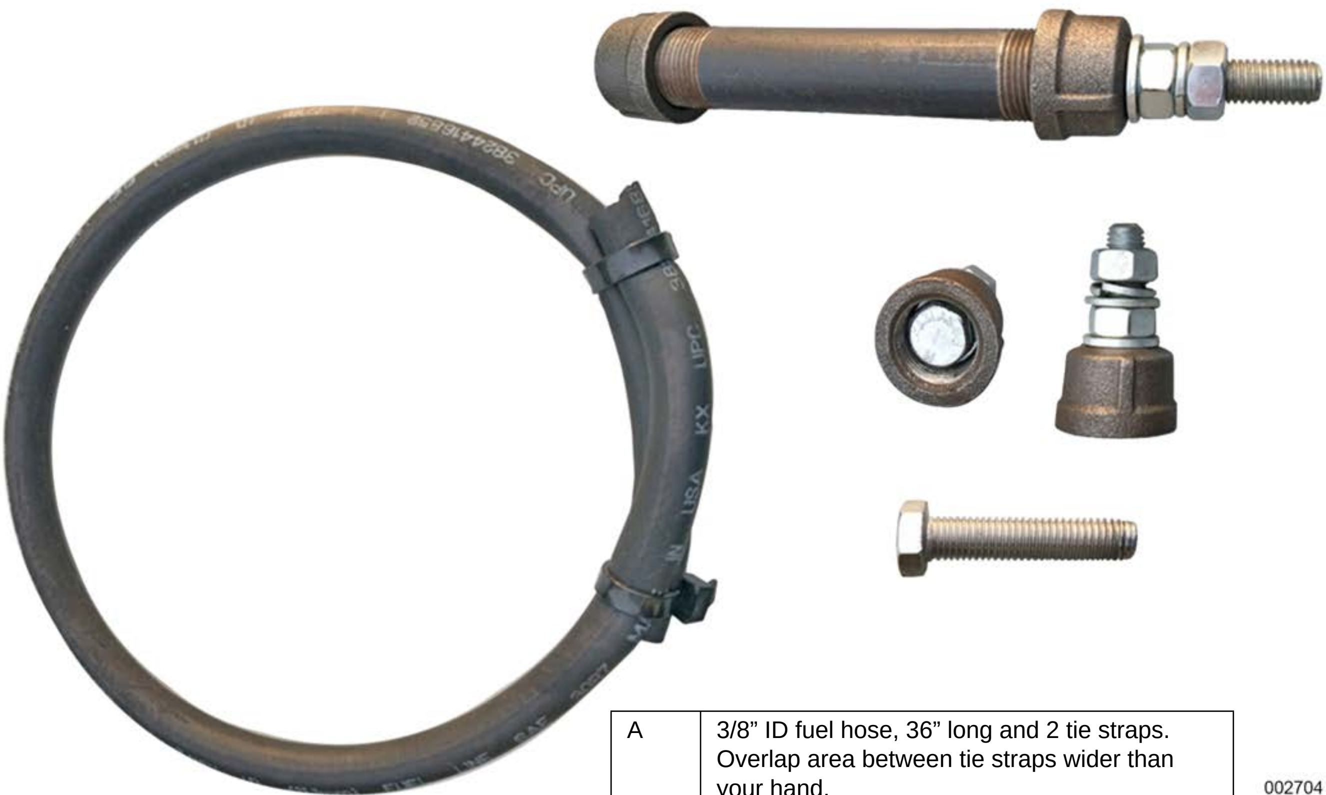
Figure 6-68. AVR Brushes Connected

Figure 6-69. AVR

Synergy Rotor Removal Tools

Discussion

See ***Figure 6-70***. These special tools can be constructed from common hardware items as shown in the figure below.



A	3/8” ID fuel hose, 36” long and 2 tie straps. Overlap area between tie straps wider than your hand.
B	¾” Pipe 6” Long and 2 End Caps
C	Bolt - 12 mm x 1.75 x 55mm
D	Inside view. Drill hole in center and tap 12mm x 1.75mm

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Figure 6-70. Synergy Rotor Removal Tools

Torque Specifications

Stator Bolts	6 ft-lbs (+1 / -0)
Rotor Bolt	30 ft-lbs
Engine Adapter	25 ft-lbs
Exhaust Manifold	18 ft-lbs
M5-0.8 Taptite Screw Into Aluminum	25-50 in-lbs
M5-0.8 Taptite Screw Into Pierced Hole	25-50 in-lbs
M6-1.0 Taptite Screw Into Aluminum	50-96 in-lbs

M6-1.0 Taptite Screw Into Pierced Hole	50-96 in-lbs
M6-1.0 Taptite Screw Into Weldnut	50-96 in-lbs
M8-1.25 Taptite Screw Into Aluminum	12-18 ft-lbs
M8-1.25 Taptite Screw Into Pierced Hole	12-18 ft-lbs
M6-1.0 Nylok Nut Onto Weld Stud	16-65 in-lbs
M6-1.0 Nylok Nut Onto Hinge Stud	30-36 in-lbs

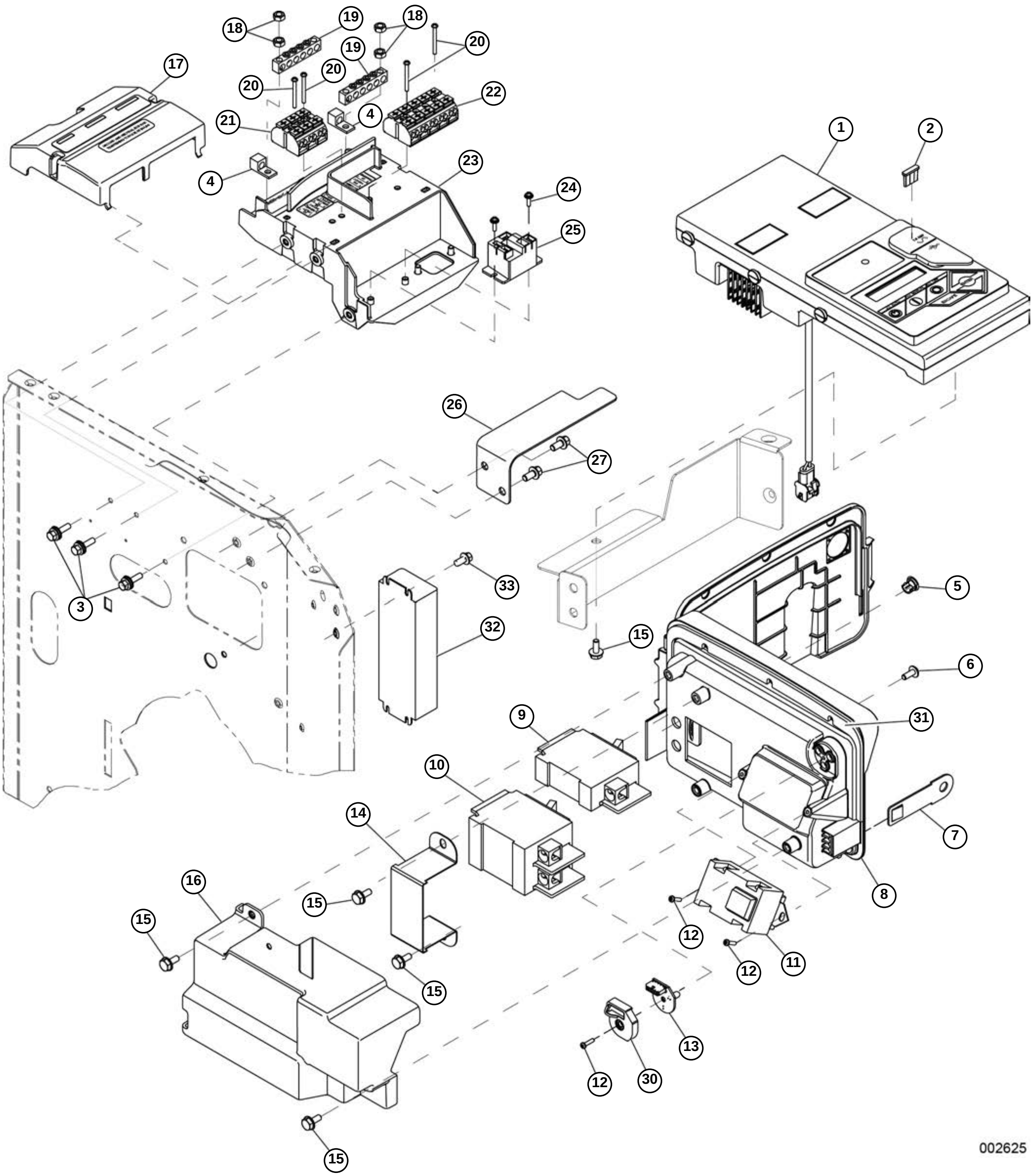
Note: torques are dynamic values with ±10% tolerance unless otherwise noted.

Section 6.2 *Exploded Views*

Introduction

The exploded views in this section are provided for general reference only. For unit specific exploded views refer to the Service and Support page at the manufacturer’s website.

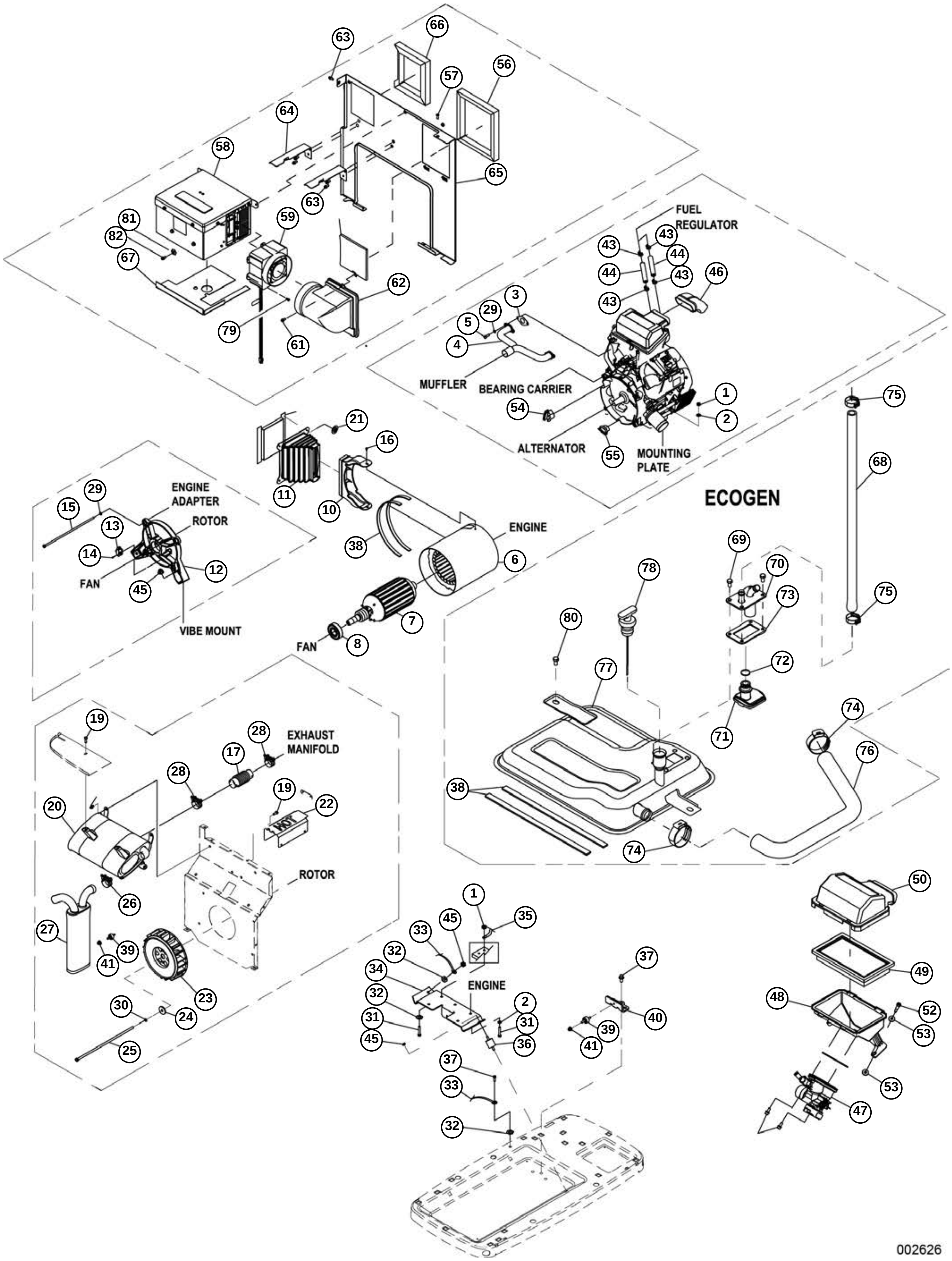
Control Panel – Pre 2016 Synergy Units



Control Panel – Pre 2016 Synergy Units

Item	Qty.	Description
1	1	Assy Controller
2	Ref	Fuse ATO Type 7.5Amp (Brown)
3	3	Screw HHFC M5-0.8X12 W/Patch
4	2	Lug Sldlss #2-#14 Al
5	2	Plug Plastic Dome 7/16” - HSB
6	3	Screw PPHTF #10-16 X 1/2 B
7	1	Eye Hasp Control Panel
8	1	Control Box Assy
9	1	CB 15A Single Pole 120V W/ GFCI
10	1	CB Double Pole 240V
11	1	Outlet, 15A GFCI Duplex White
12	1	Screw HH Hi-Lo M4x10mm
13	1	Assy PCB Tri LED Display
14	1	CB Bracket Control Box 2P Bq
15	5	Screw Reduced HH Hi-Lo M6x10mm
16	1	Shield Circuit Breaker Box
17	1	Cover Cust Connect
18	4	Nut Hex M5-0.8 G8 Clear Zinc
19	2	Ground Bar (4) 4-14 AWG Conn
20	4	Screw PPHM M3-0.5 X 30
21	1	Term Block 3P Ul 12-20AWG
22	1	Term Block 5P Ul 12-20AWG
23	1	Customer Conn Shelf
24	2	Screw PPHM M3-0.5 X 16 Sems
25	1	Relay 12V 30A SPST
26	1	Back Controller Support Bracket
27	2	Screw HHTT M6-1.0 X 12 Zinc
28	1	Harness (Not Shown)
29	1	Resistor (Not Shown)
30	1	Cover, Led
31	1	Gasket, Circuit Breaker Box
32	1	Power Supply
33	2	Screw HHT M4-0.7 X 8 Zp

Generator – Pre 2016 Synergy Units



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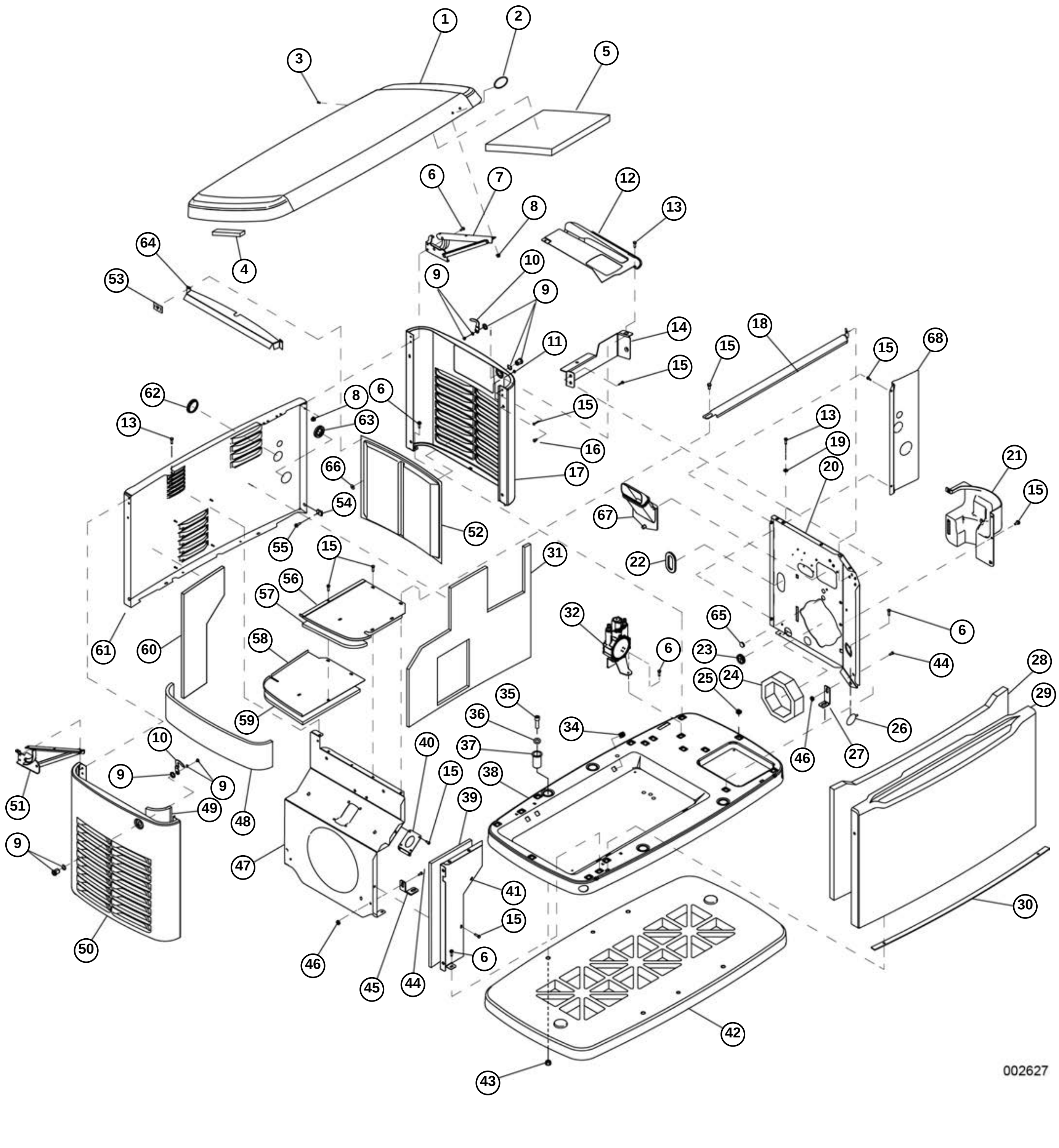
Generator – Pre 2016 Synergy Units

Item	Qty.	Description
1	4	Nut Hex Lock M8-1.25 NY Ins
2	6	Washer Flat 5/16-M8 Zinc
3	2	Gasket, Exhaust Port
4	1	Manifold
5	4	Screw SHC M8-1.25 X 20 C12.9
6	1	Stator
7	1	Rotor
8	1	Bearing 1.1811-2.8346
9	2	Screw HHTT M6-1.0 X 10 Yel Chr
10	1	Duct - Alternator Air - 10" Can - HSB
11	1	Alternator Air In Bellows
12	1	Carrier, Rear Bearing Machined
13	2	Assembly 3 Brush
14	4	Screw HHTT M5-0.8 X 16
15	4	Screw IHHC M8-1.25 X 390 G8.8
16	4	Washer Self Locking 1" Dia 12 Ga
17	1	Exh Flex 1-3/4”
18	4	Screw HHTT M8-1.2 X 12 BP
19	4	Screw HHTT M6-1.0 X 12 Zinc
20	1	Muffler
21	1	Louver Screen, Alt Air In
22	1	Flex Pipe Cover
23	1	Fan Exhaust GT999 Extended Hub
24	1	Washer Flat 0.406ID X 1.62OD
25	1	Screw IHHC 3/8-24 X 17.50
26	1	Clamp
27	1	Resonator
28	2	Clamp Band Dia 42.7-46.7 MM
29	8	Washer Lock M8-5/16
30	1	Washer Lock 3/8
31	4	Screw Hhc M8-1.25 X 50 C8.8
32	3	Washer Lock Special 5/16
33	1	Earth Strap
34	1	990 Eng Mounting Brkt
35	1	Cable Batt Blk #6 30.0" Neg
36	4	Vib Mnt
37	4	Screw HHTT M8-1.2 X 16 Yc
38	4.6 ft	Tape, Foam 1/16” X 1/2” (EcoGen)
39	1	Vib Mnt 0.50 X 1.0 X M6x1.00
40	1	Powerhead Bracket
41	1	Nut Flange M6-1.0 Nylok
42	1	Cable Batt Red #6 38.5" Pos (Not Shown)

Item	Qty.	Description
43	4	Clamp Hose Band 0.75
44	2	Hose LP NG 1/2” ID
45	4	Nut Flange 5/16-18 Nylok
46	1	Snorkel Elbow To Air Box
47		Assy Mixer HSB
48	1	Air Box Base
49	1	Filter Air Element
50	1	Airbox HSB
51	4	Screw SHC M6-1.0 X 16Lg Sems
52	2	Screw Shldr (8MM) M6-1.0 X 29
53	4	Washer, Rubber 1/4” X 1/8” Thk
54	1	Plug, Gearcover Adapter
55	1	Plug, Gearcover Adapter-Small
56	1	Foam Duct Controller
57	1	Screw SWT ¼-20 X 5/8
58	1	Assy AVR HSB
59	1	Assembly Fan Housing AVR HSB
60	1	Filter Air Synergy
61	1	Screw HHFC M6-1.0 X 12 W/M5
62	1	Bellows Inverter Encl Intake
63	6	Screw HHTT M6-1.0 X 12 Zinc
64	2	Bracket Support Synergy
65	1	Weldment Panel Back Support
66	1	Foam Duct VSCF Backbone Exhaust
67	1	Heat Shield PSA Wrap
68	1	VSCF EcoGen Vent Hose (EcoGen)
69	4	Screw Hhc M6-1.0 X 12 G8.8 (EcoGen)
70	1	Oil Reservoir Blkhd (EcoGen)
71	1	Oil Reservoir VSCF Ecogen Pickup (Eco-Gen)
72	1	O-Ring 2-015 Fluorosilicone (EcoGen)
73	1	Oil Reservoir VSCF Ecogen Blkhd Gasket (EcoGen)
74	2	Clamp, Hose Oetiker Stplss 37.6 (Eco-Gen)
75	3	Clamp, Hose Oetiker Stplss 21 (EcoGen)
76	1	Oil Reservoir Drain Hose (EcoGen)
77	1	Oil Reservoir VSCF EcoGen 5L (EcoGen)
78	1	Dipstick, EcoGen Orange (EcoGen)
79	3	Screw HHC M4-0.7 X 10 C8.8
80	2	Screw HHFC M6-1.0 X 20 G8.8 (EcoGen)
81	1	Washer Lock Special ¼”
82	1	Screw HHTT M6-1.0 X 16 Zyc

Enclosure – Pre 2016 Synergy Units

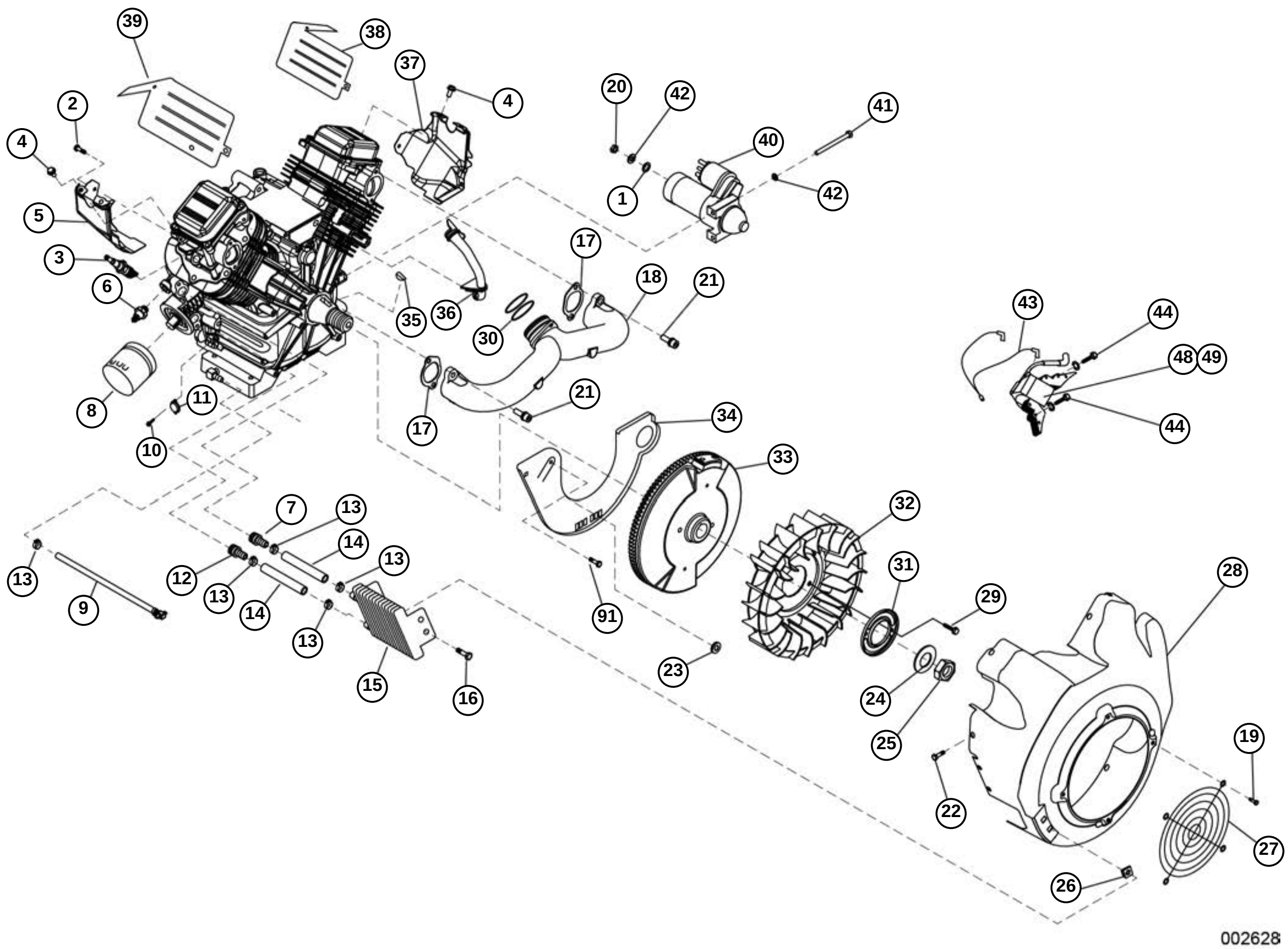


Enclosure – Pre 2016 Synergy Units

Item	Qty.	Description
1	1	Roof Assembly Aluminum Grey
2	1	Badge Holder - Oval
3	1	Plug 6.35 Black
4	10.5 ft.	Gasket, Extruded Trim
5	3	Foam, Enclosure Roof 1.00" Thk
6	18-19	Screw HHFC M6-1.0 X 20 G8.8
7	1	Hinge Assembly Intake End
8	8	Nut Flange M6-1.0 Nylok
9	2	1/4 Turn Locking Latch
10	2	1/4 Turn Latch Pawl
11	2	Nut Top Lock FL M6-1.0
12	1	Controller Fascia
13	5	Screw SWT 1/4-20 X 5/8
14	1	Bracket Ctrl Pnl Front
15	25	Screw HHTT M6-1.0 X 12 Zinc
16	2	Spacer Door
17	1	End Panel, Intake
18	1	Cross Support HSB
19	1	Washer Lock Special 1/4”
20	1	Panel Engine Divider HSB
21	1	Intake Baffle
22	2	Grommet Oval 31.75 X 50.8
23	1	Grommet, 38.1 Dia. Cross Slit
24	1	Foam Duct, Engine Divider
25	17	Panel Clip, M6-1.00 Expansion
	19	Panel Clip, M6-1.00 Expansion (EcoGen)
26	1	Pushbutton Wire Tie
27	2	Bracket L HSB Divider Pnl
28	1	Foam, Front Panel
29	1	Enclosure Front Panel
30	1	Gasket, HSB Door Seal
31	1	Foam, Back Panel
32	1	Assy Regulator
34	6	Panel Clip - 5/16-18 Expansion

Item	Qty.	Description
35	4	Screw SHC 3/8-16 X1.25 W/Patch
36	4	Washer Flat 3/8-M10 Zinc
37	4	Bushing, HSB Enclosure Base
38	1	Enclosure, Base
39	1	Foam, Front Exhst Shield
40	1	Gasket Exhaust
41	1	Front Exhaust Shield
42	1	Pad Mtg Base W/Hex Pockets
43	4	Nut Hex 3/8-16 Steel
44	4	Screw HHFC M6-1.0 X 12 G8.8
45	2	Bracket Exh Pnl
46	4	Nut Hex FL Whiz M6-1.0
47	1	Exhst Dvdr Pnl
48	1	Foam, Exhaust End Panel
49	2	Foam, Exhaust End Panel Sides
50	1	Encl End Panel, Exhaust Side
51	1	Hinge Assy Exhaust End
52	2	Screen - HSB Louvers
53	3	Washer Self Locking-.106 Stud
54	2	Clip U M6-1.0
55	2	Screw HHFC M6-1.0 X 14 G8.8
56	1	Cover, Front Exhaust Enclosure
57	1	Foam, Top Front Exhaust Cover
58	1	Cover, Back Exhaust Enclosure
59	1	Foam, Top Back Exhaust Cover
60	1	Foam, Back Panel, Muffler Comp
61	1	Encl Back Pnl HSB
62	1	Plug Steel 1.750
63	1	Grommet Fuel Line 3/4”
64	1	Deflector
65	1	Plug Plastic 0.687"
66	13	Washer Self Locking 1" Dia 12 Ga
67	1	Snorkel, Engine Air Intake
68	1	Shield, Back Panel

Engine, GN990/999 Pre 2016 Synergy Units

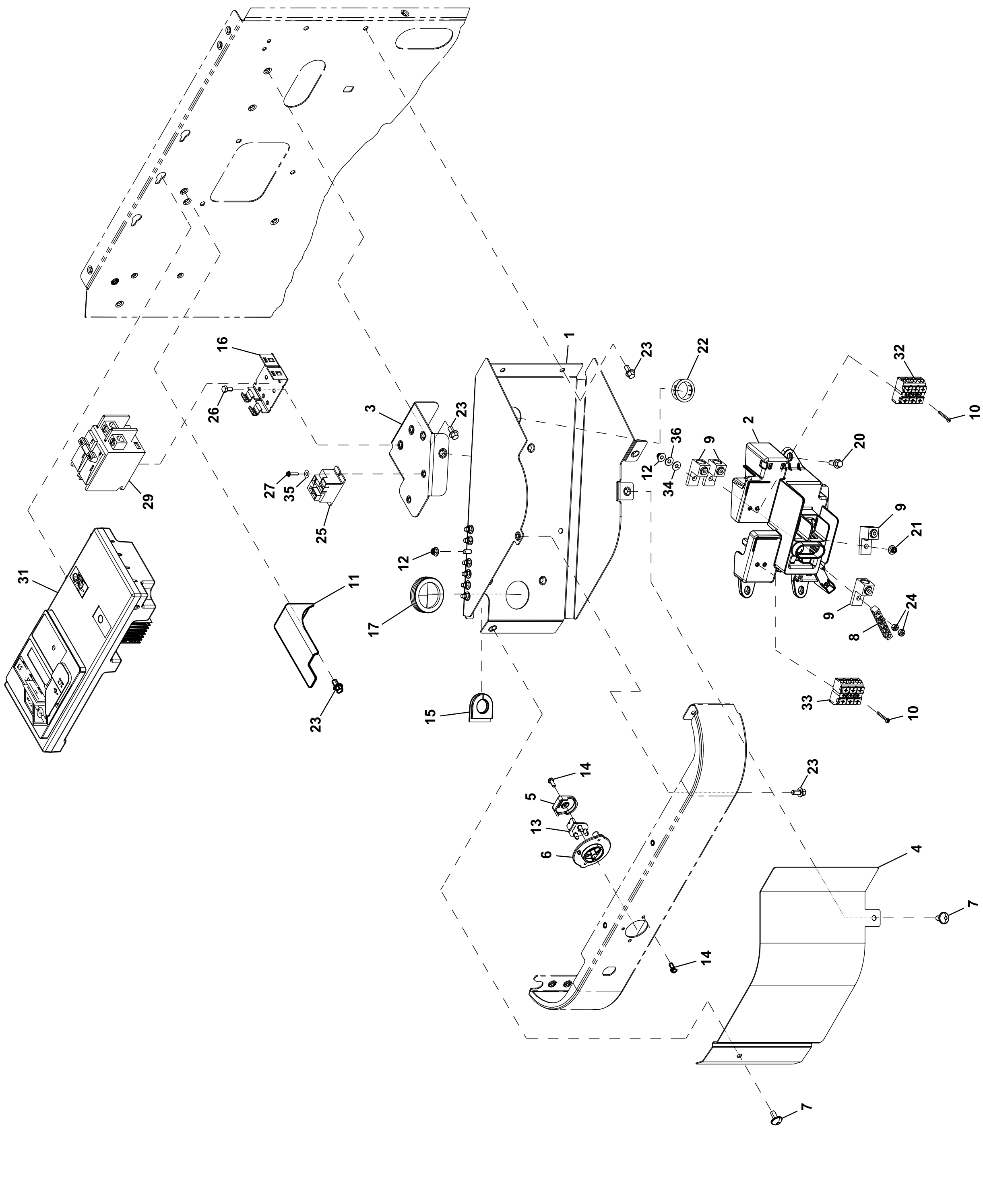


Engine, GN990/999 Pre 2016 Synergy Units

Item	Qty.	Description
1	1	Washer Flat M8 – 5/16
2	2	Screw M6-1.0 X 12
3	2	Spark plug, RCY14 0.040” Gap
4	2	Screw Taptite M5 – 0.8 X 8
5	1	Wrapper, Lower Cylinder 2 Zinc
6	1	Switch, Oil Press
7	1	Extended Barbed Str ¼ Npt X 3/8
8	1	Oil Filter, 90Mm
9	1	Assy, Oil Drain Hose Org
10	2	Screw PPHM #4-40 X 5/16 Sems
11	1	Switch, Thermal 293F
12	1	Barbed Straight 1/4 NPT X 3/8
13	5	Clamp, Hose Oetiker Stepless 18.5MM
14	2	Hose 3/8” 300psi 6" Lg Oil
15	1	Cooler, Oil
16	4	Screw Plastite 1/4-15 X 3/4
17	2	Gasket, Manifold / Port
18	1	Manifold Int Gth999 2X
19	4	Screw, HHTT M6-1 X 10 Long
20	1	Nut, Hex Lock M5-0.8 Zinc
21	4	Screw SHC M8 – 1.25 X 30 Sems
22	16	Screw Taptite M6–1X12 Clear Zinc
23	1	Grommet 3/16 X 1/16
24	1	Washer, 25MM I.D.
25	1	Nut, Hex M24

Item	Qty.	Description
25	1	Nut, Hex M24
26	4	Nut, Grommet 1/4 Plug
27	1	Guard, Fan
28	1	Housing, Blower Ng Cooler
29	2	Screw HHFCS M8 – 1.25 X 10 G8.8
30	2	O-Ring 1-3/4 X 1/16
31	1	Plate, Fan
32	1	Fan, Nylon
33	1	Assy, Flywheel
34	1	Plate, Backing With Cut Out
35	1	Key, Woodruff 4 X 19D
36	1	Hose Breather
37	1	Wrapper, Lower Cylinder 1 Zinc
38	1	Wrapper, Upper Cylinder 1 Zinc
39	1	Wrapper, Upper Cylinder 2 Zinc
40	1	Starter Motor Hear Reduced
41	2	Screw HHC M8 – 1.25 X 85 G8.8
42	3	Washer Lock M8 – 5/16
43	1	Assembly, Ground Wire
44	4	Screw Taptite M6 – 1.0 X 20 Zinc
48	1	Assy, Ign Coil W/Diode, Cylinder 1
49	1	Assy, Ign Coil W/Diode, Cylinder 2
50	2	Nut Hex Lock M5x 0.8

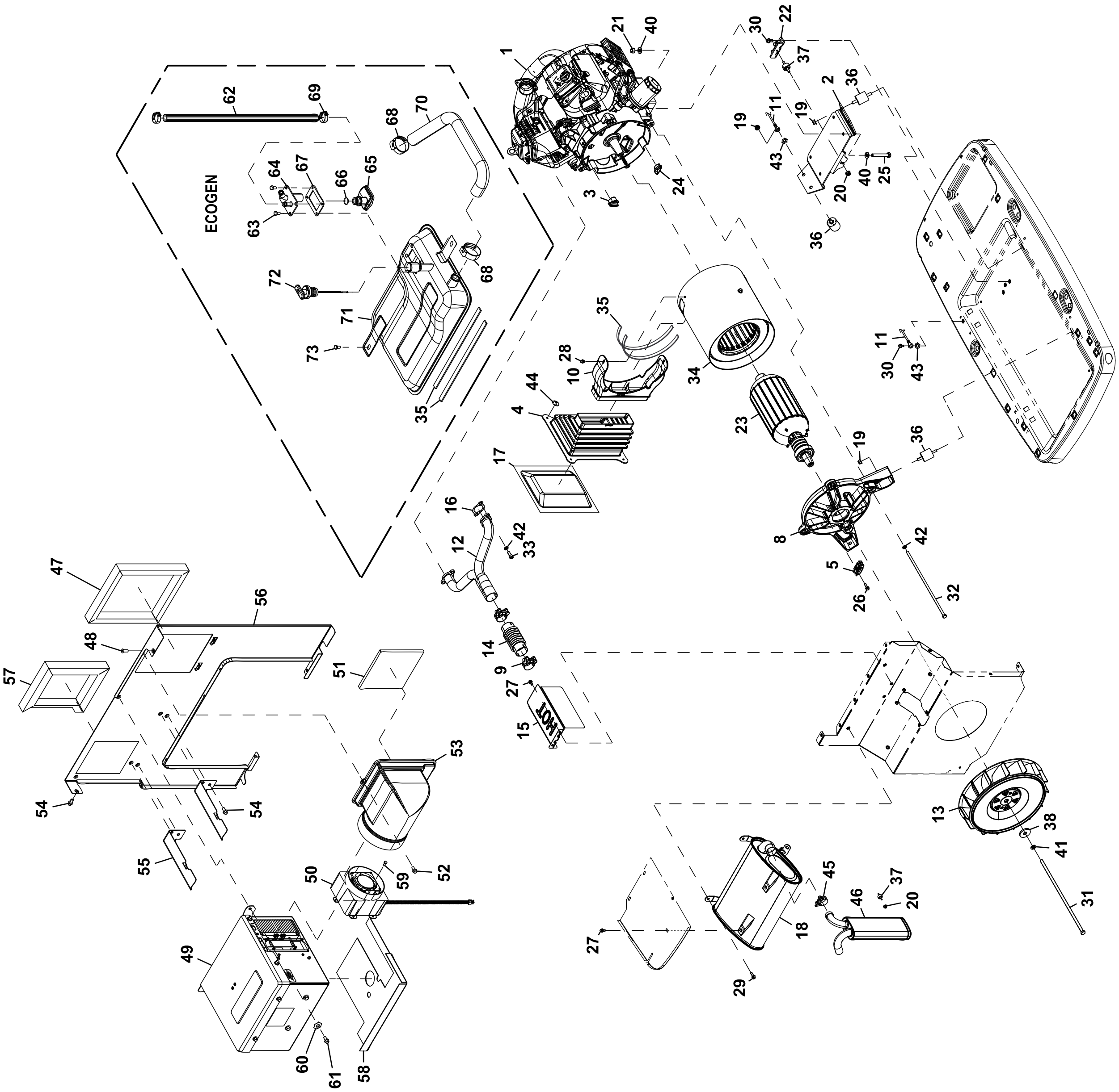
Control Panel – 2016 Synergy Units



Control Panel – 2016 Synergy Units

Item	Qty.	Description
1	1	CONN BOX W/WLD STUD AND PEMS
2	1	CUSTOMER CONNECTION PANEL
3	1	CIRCUIT BREAKER BRACKET
4	1	ACCESS PANEL
5	1	LED BACK COVER
6	1	LED PLATE
7	2	SCREW SWT M6-1.0 X 16 ZK
8	1	GROUND BAR (4) 4-14 AWG ALUM
9	4	LUG SLDLSS #2-#14 AL
10	4	SCREW BHSC M3-0.5 X 25MM
11	1	BACK CNTRLR SUPP BRKT
12	9	NUT FLANGE M5-0.8 NYLOCK
13	1	ASSY PCB TRI LED DISPLAY
14	3	SCREW HH HI-LO M4 X 10MM
15	1	GROMMET WIRE SLEEVE
16	1	BRKT CB MTG BACK
17	1	GROMMET
18	1	WIRE #3BLK L1- #10RNG 13.0LNG (NOT SHOWN)
19	1	WIRE #3RED L2- #10RNG 15.0LNG (NOT SHOWN)
20	3	SCREW HHTT M6-1.0 X 16 ZYC
21	1	NUT FLANGE M6-1.0 NYLOK
22	1	BUSHING SNAP SB-1093-937
23	8	SCREW HHTT M6-1.0 X 12 ZINC
24	2	NUT HEX M5-0.8 G8 CLEAR ZINC
25	1	RELAY 12VDC 30A SPST PILOT DUTY
26	2	SCREW HHC M5-0.8 X 10 C8.8
27	2	SCREW BHSC M3-0.5 X 10MM
28	2	TIE WRAP UL 3.9" X .10" NATL (NOT SHOWN)
29	1	CB 0100A 2P 240V S BQ2 LB
30	1	HARN AIR COOLED HSB (NOT SHOWN)
31	1	CONTROLLER AC HSB VSCF
32	1	TERM BLOCK 3P UL 12-20 AWG LBL
33	1	TERM BLOCK 3P UL 12-20 AWG LBL
34	2	WASHER FLAT M5
35	2	WASHER FLAT M3
36	2	WASHER LOCK M5

Generator – 2016 Synergy Units

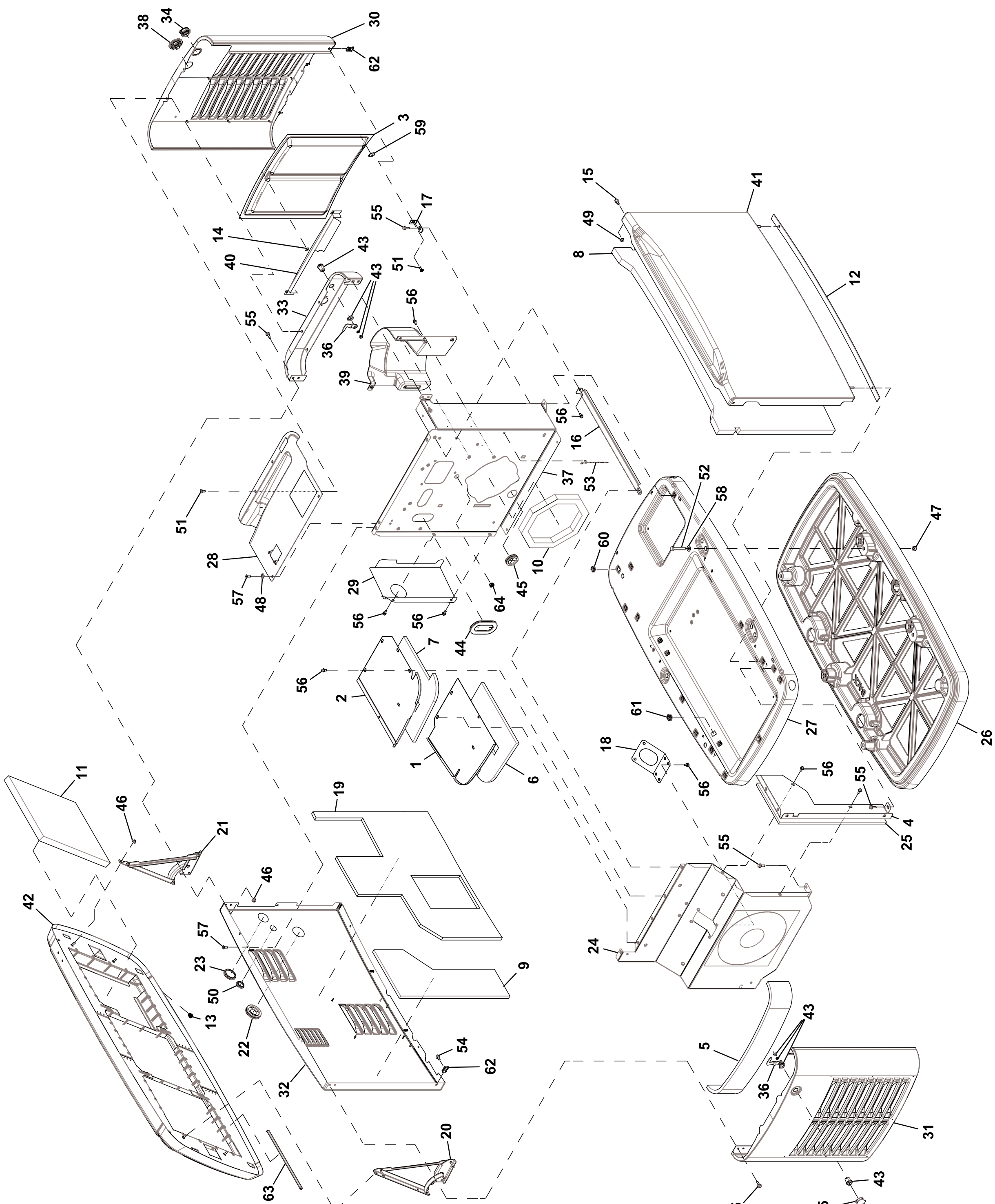


Generator – 2016 Synergy Units

Item	Qty.	Description
1	1	ENGINE GTH999 VARSP HSB
2	1	999 ENG MOUNTING BRKT
3	1	PLUG GEAR COVER ADAPTOR
4	1	ALT AIR IN BELLOWS
5	2	VSCF 3 BRUSH ASSEMBLY
6	1	CABLE BATT BLK #6 30.0” NEG (NOT SHOWN)
7	1	CABLE BATT RED #6 38.5” POS (NOT SHOWN)
8	1	CARRIER REAR BEARING MACHINED
9	2	CLAMP BAND DIA 42.7-46.7MM
10	1	DUCT – ALT AIR – 10” CAN – HSB
11	1	EARTH STRAP
12	1	EXHAUST MANIFOLD
13	1	FAN EXHAUST
14	1	FLEX PIPE
15	1	FLEX PIPE COVER
16	2	GASKET, EXHAUST
17	1	LOUVER SCREEN, ALT AIR IN
18	1	MUFFLER
19	6	NUT FLANGE 5/16-18 NYLOK
20	3	NUT FLANGE M6-1.0 NYLOK
21	4	NUT HEX LOCK M8-1.25 NY INS
22	1	POWERHEAD BRACKET
23	1	ROTOR
24	1	PLUG GEAR COVER ADAPTOR-SMALL
25	4	SCREW HHC M8-1.25 X 50 C8.8
26	4	SCREW HHTT M5 - 0.8 X 16
27	4	SCREW HHTT M6-1.0 X 12 ZINC
28	2	SCREW HHTT M6-1.0 X 8 ZYC
29	4	SCREW HHTT M8-1.2 X 12 BP
30	4	SCREW HHTT M8-1.2 X 16 YC
31	1	SCREW IHHC 3/8-24 X 17.50
32	4	SCREW IHHC M8-1.25 X 390 G8.8

Item	Qty.	Description
33	4	SCREW SCH M8-1.25 X 20 C12.9
34	1	STATOR
35	2.6 ft	TAPE, FOAM 1/8” X 1/2"
36	6	VIB MOUNT 1.5 X 1.38 X 5/16-18
37	2	VIB MOUNT .50 X 1.0 X M6X1.00
38	1	WASHER FLAT .406ID X 1.62OD
39	3 ft	CONDUIT FLEX .75” ID FR (NOT SHOWN)
40	6	WASHER FLAT 5/16/-M8 ZINC
41	1	WASHER LOCK 3/8
42	8	WASHER LOCK M8-5/16
43	3	WASHER LOCK SPECIAL 5/16
44	4	WASHER SELF LOCKING 1” DIA 12GA
45	1	CLAMP
46	1	RESONATOR
47	1	FOAM DUCT CONTROLLER
48	1	SCREW SWT ¼-20 X 5/8
49	1	ASSY AVR HSB
50	1	ASSEMBLY FAN HOUSING AVR HSB
51	1	FILTER AIR SYNERGY
52	1	SCREW HHFC M6-1.0 X 12 W/M5
53	1	BELLOWS INVERTER ENCL INTAKE
54	6	SCREW HHTT M6-1.0 X 12 ZINC
55	2	BRACKET SUPPORT SYNERGY
56	1	WELDMENT PANEL BACK SUPPORT
57	1	FOAM DUCT VSCF BACKBONE EXHAUST
58	1	HEAT SHIELD PSA WRAP
59	3	SCREW HHC M4-0.7 X 10 C8.8
60	1	WASHER LOCK SPECIAL ¼”
61	1	SCREW HHTT M6-1.0 X 16 ZYC
62	1	VSCF ECOGEN VENT HOSE (ECOGEN)
63	4	SCREW HHC M6-1.0 X 12 G8.8 (ECO-GEN)

Enclosure – 2016 Synergy Units

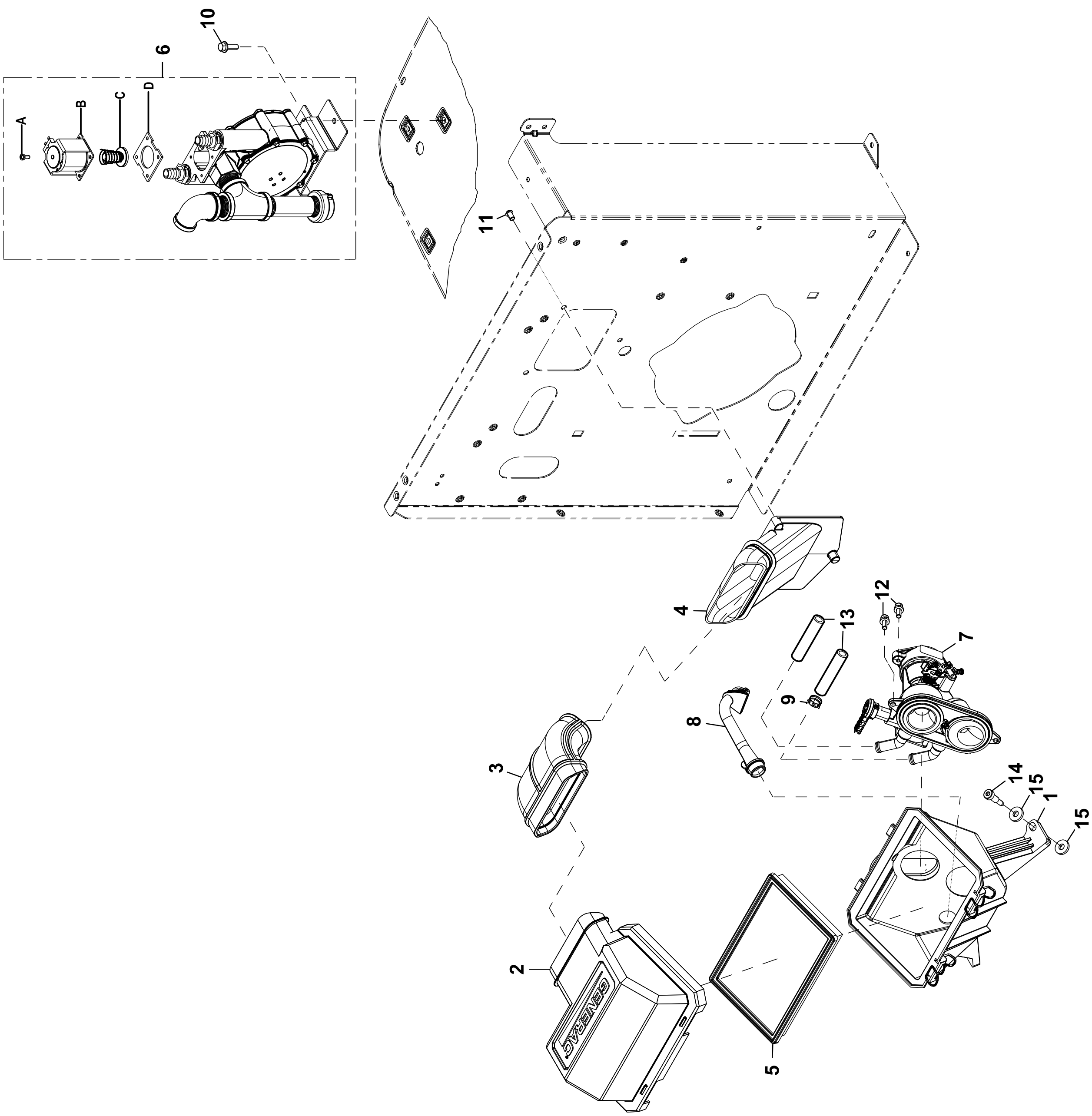


Enclosure – 2016 Synergy Units

Item	Qty.	Description
1	1	COVER, BACK EXHAUST ENCLOSURE
2	1	COVER, FRONT EXHAUST ENCLO-SURE
3	2	SCREEN - HSB LOUVERS
4	1	FRONT EXHAUST SHIELD
5	1	FOAM, EXHAUST END PANEL
6	1	FOAM, TOP BACK EXHAUST COVER
7	1	FOAM, TOP FRONT EXHAUST COVER
8	1	FOAM, FRONT PANEL
9	1	FOAM, BACK PANEL, MUFFLER COMP
10	1	FOAM DUCT ENGINE DIVIDER
11	3	FOAM, ENCLOSURE ROOF
12	1	GASKET, HSB DOOR SEAL
13	1	PLUG 6.35 BLACK
14	3	WASHER SELF LOCKING-.106 STUD
15	2	SPACER 2008 HSB DOOR
16	1	CROSS SUPPORT HSB
17	1	BRACKET L HSB
18	1	GASKET EXHAUST PANEL
19	1	FOAM, BACK PANEL
20	1	HINGE ASSY EXHAUST END
21	1	HINGE ASSY INTAKE END
22	1	GROMMET FUEL LINE 3/4"
23	1	PLUG STEEL 1.750
24	1	EXHST DVDR PNL WLDNT
25	1	FOAM EXHAUST FRONT PANEL
26	1	MOUNTING PAD
27	1	BASE
28	1	CONTROLLER FASCIA 999 HSB
29	1	SHIELD, 999 FUEL REGULATOR
30	1	WELDMNT, INTAKE END PANEL GALV
31	1	EXHAUST END PANEL, HSB
32	1	WELDMENT, HSB BACK PANEL

Item	Qty.	Description
33	1	WLDMNT BRKT HSB TOP SUPPORT
34	1	LOCK CAP INTAKE
35	1	LOCK CAP INTAKE
36	2	LOCK PAWL
37	1	PANEL ENGINE DIVIDER 999 HSB
38	1	LENS HOLDER, W/GASKET
39	1	INTAKE BAFFLE HSB
40	1	HSB INTAKE DEFLECTOR
41	1	WELDMENT FRONT PNL
42	1	ROOF ASSY HSB
43	2	1/4 TURN LOCKING LATCH
44	2	GROMMET OVAL 31.75 X 50.8
45	1	GROMMET, 38.1 DIA. CROSS SLIT
46	8	NUT FLANGE M6-1.0 NYLOK
47	4	NUT HEX 3/8-16 STEEL
48	1	WASHER LOCK SPECIAL 1/4"
49	2	NUT TOP LOCK FL M6-1.0
50	1	PLUG STEEL 1.0625
51	3	SCREW BFHSC M6-1.0 X 16 CLEAR ZP
52	4	SCREW HHC 3/8-16 X 2-1/4 G5
53	1	PUSH BUTTON WIRE TIE
54	1	SCREW HHFC M6-1.0 X 14 G8.8
55	15	SCREW HHFC M6-1.0 X 20 G8.8
56	25	SCREW HHTT M6-1.0 X 12 ZINC
57	4	SCREW SWT 1/4-20 X 5/8
58	4	WASHER FLAT M10 HEAVY DUTY
59	13	WASHER SELF LOCKING 1"DIA 12GA
60	13	PANEL CLIP, M6-1.00 EXPANSION
61	8	PANEL CLIP - 5/16-18 EXPANSION
62	2	CLIP U M6-1.0
63	10.5 ft	GASKET, EXTRUDED TRIM
64	1	PLUG PLASTIC 0.687”

Fuel System 2016 Synergy Units



Fuel System 2016 Synergy Units

Item	Qty.	Description
1	1	ASSY AIRBOX HSB2013 GTH999
2	1	CVR AIRBOX HSB 2016 GTH999
3	1	SNORKEL ELBOW TO AIRBOX
4	1	SNORKEL ENGINE AIR INTAKE
5	1	FILTER ELEMENT 236 X 139 X 37
6	1	ASSY REGULATOR 3/4” INLET
A	4	SCREW PPHM M4-0.7 X 10 SEMS
B	1	SOLENOID SHUTOFF VALVE
C	1	ASSY SOLEN PLUNGER & SPRING
D	1	GASKET SOLENOID
7	1	ASSY MIXER VSCF HSB 2016
8	1	BREATHER HOSE GTH999
9	4	CLAMP HOSE BAND .75
10	2	SCREW HHFC M6-1.0 X 20 G8.8
11	3	SCREW HH HI-LO M6.2X10MM
12	4	SCREW SHC M6-1.0 X 16 LG SEMS
13	2	HOSE LP NG 1/2" ID 24" L
14	2	SCREW SHLDR (8MM) M6-1.0 X 29
15	4	WASHER, RUBBER 1/4" X 1/8" THK

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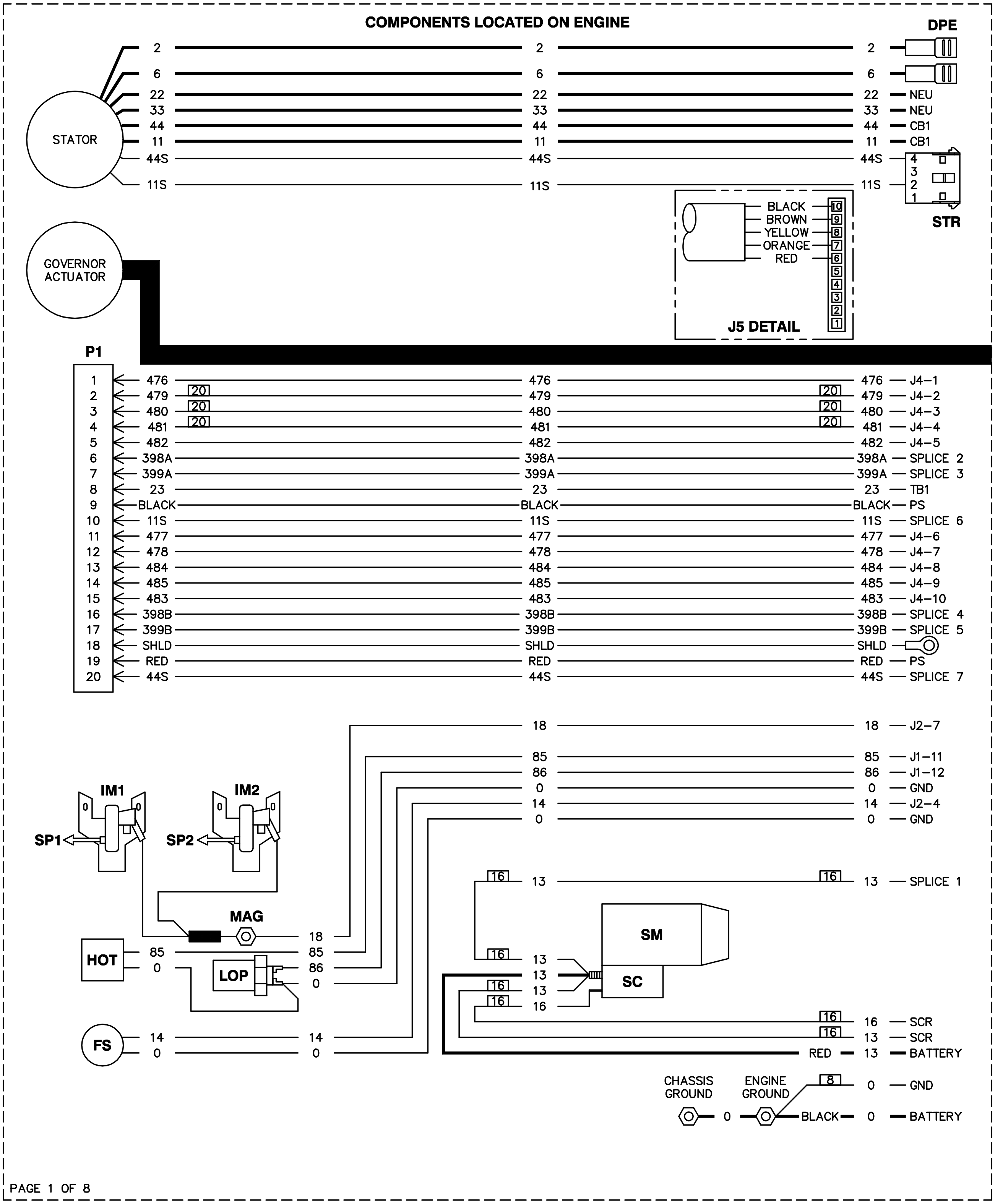
Section 7.1 *0K3218-C WD/SD Pre 2016 Synergy Air-Cooled HSB VSCF 60 Hz*

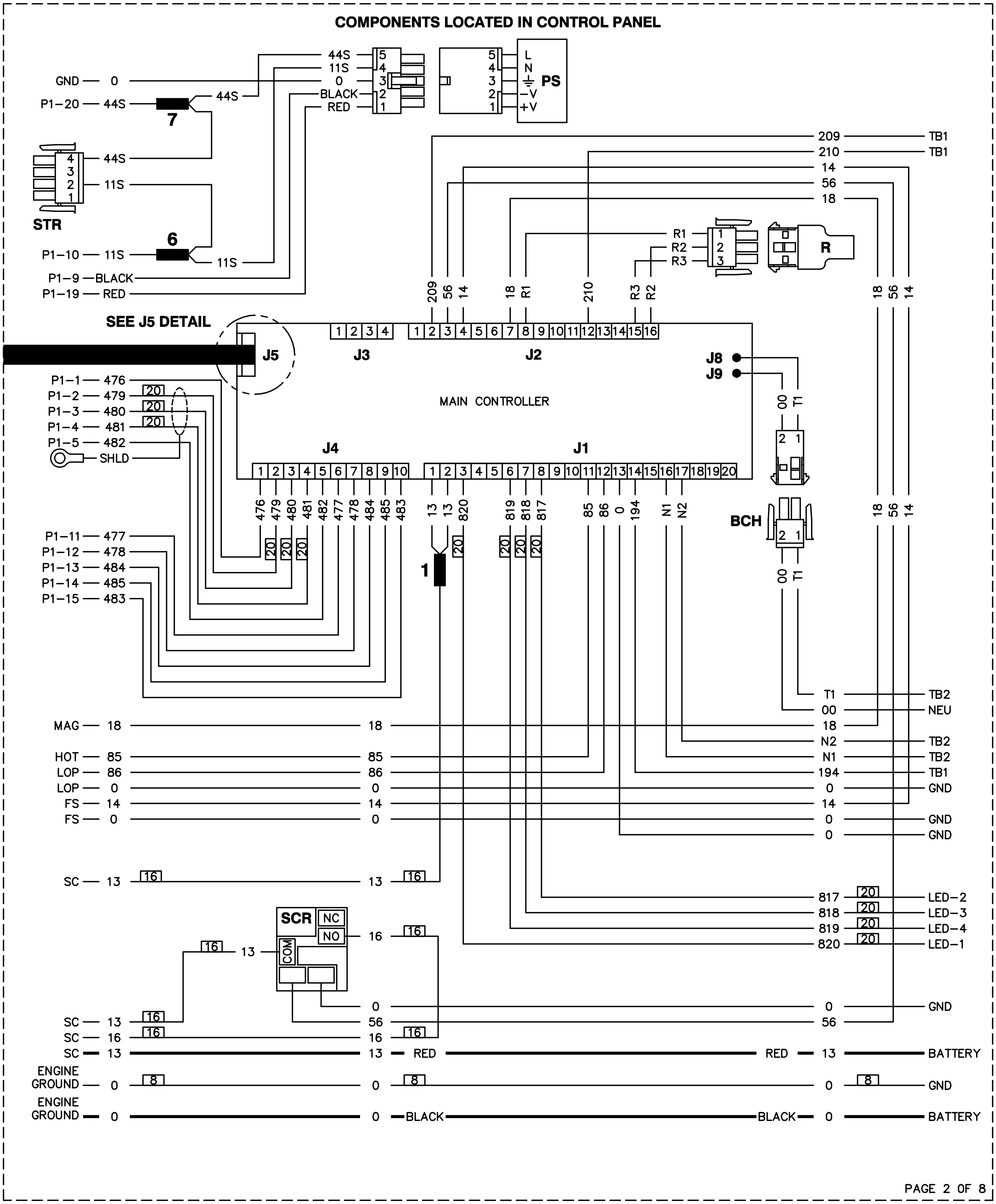
GROUP G



WIRING - DIAGRAM
2013 AIR COOLED HSB VSCF
DRAWING #: 0K3218

REVISION: J-9156-C
DATE: 8/5/14
PAGE 1 OF 8

GROUP G



WIRING - DIAGRAM

REVISION: J-9156-C

2013 AIR COOLED HSB VSCF

DATE: 8/5/14

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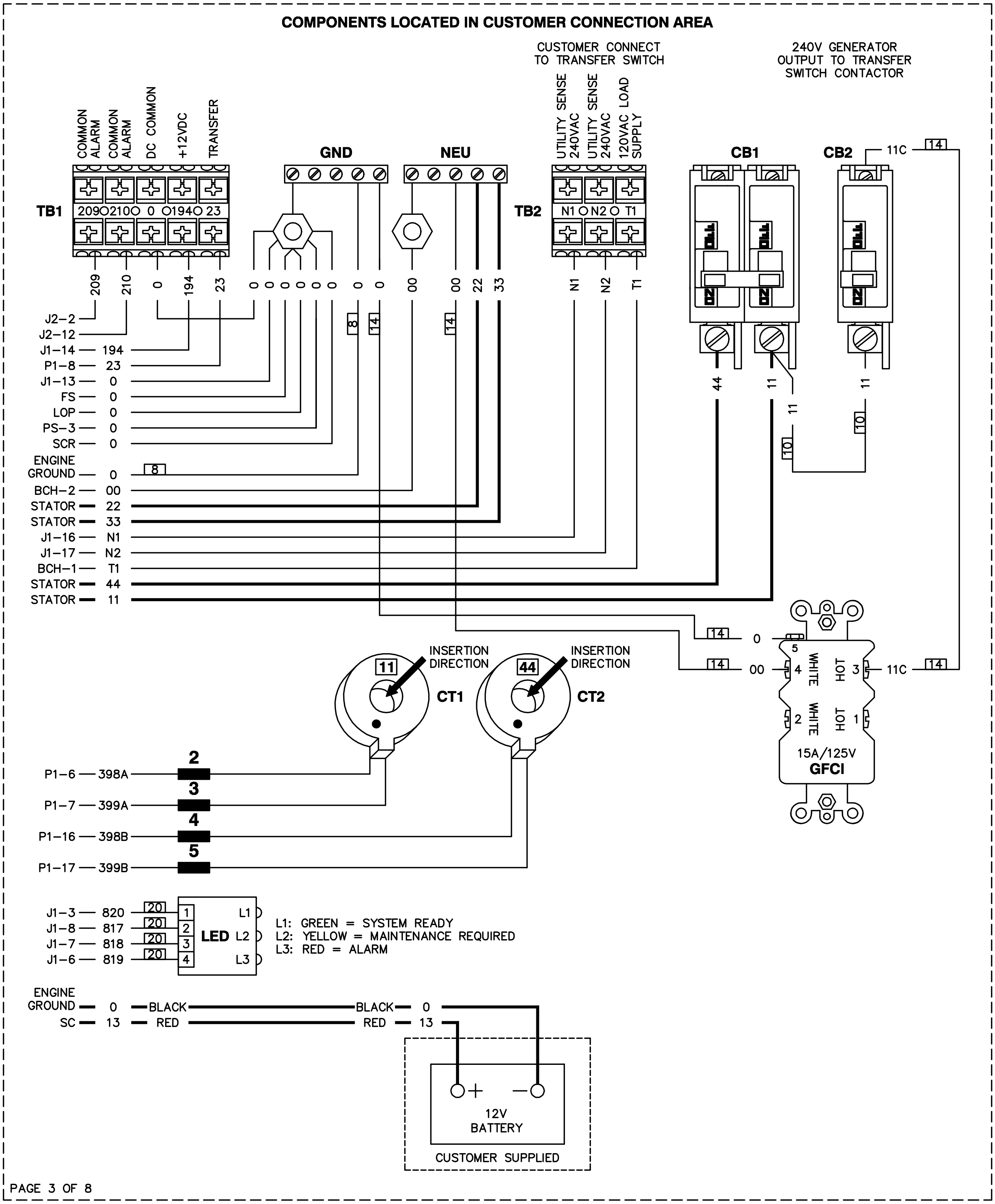
DRAWING #: 0K3218

GROUP G



WIRING - DIAGRAM

REVISION: J-9156-C

2013 AIR COOLED HSB VSCF

DATE: 8/5/14

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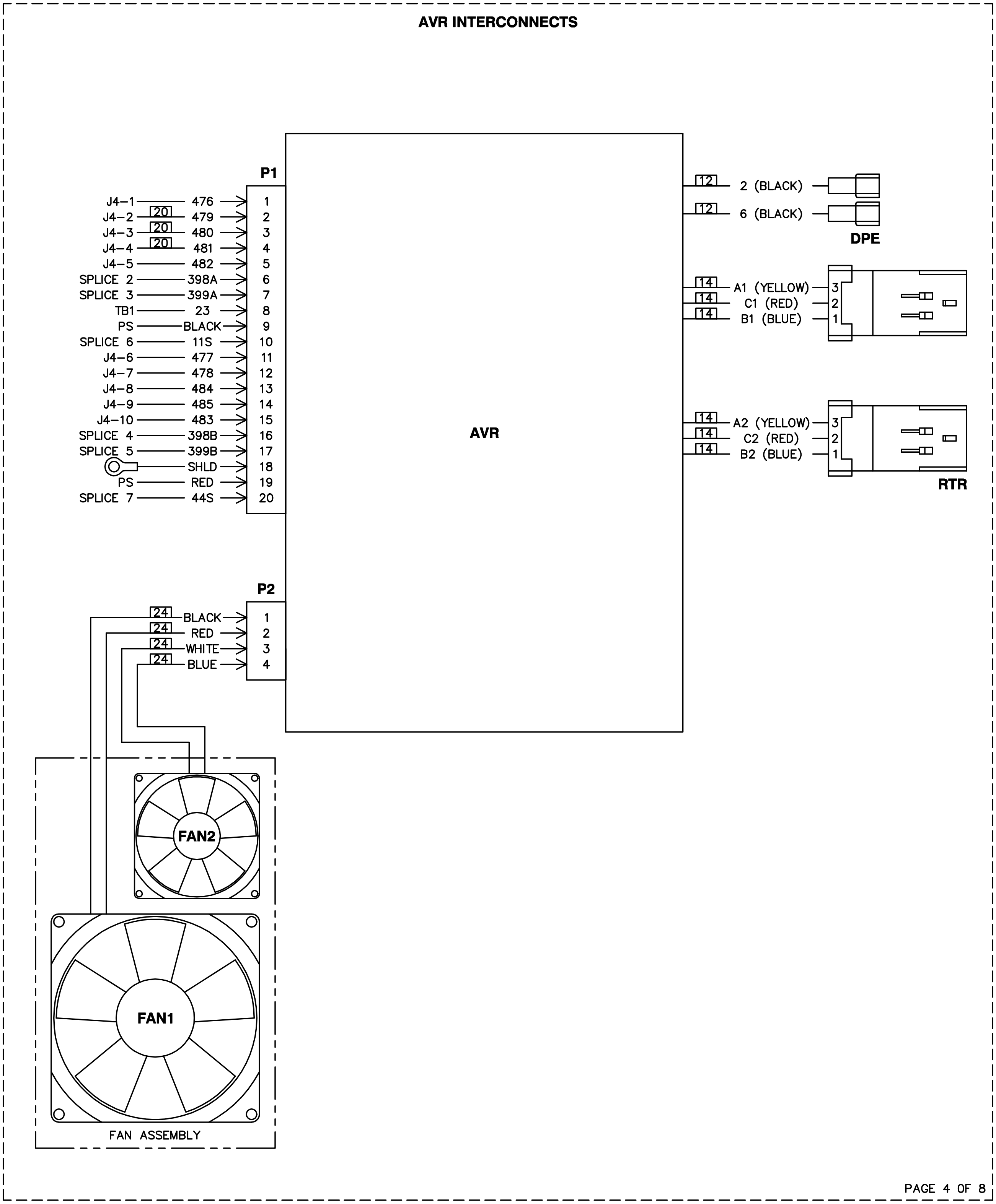
DRAWING #: 0K3218

GROUP G



WIRING - DIAGRAM

REVISION: J-9156-C

2013 AIR COOLED HSB VSCF

DATE: 8/5/14

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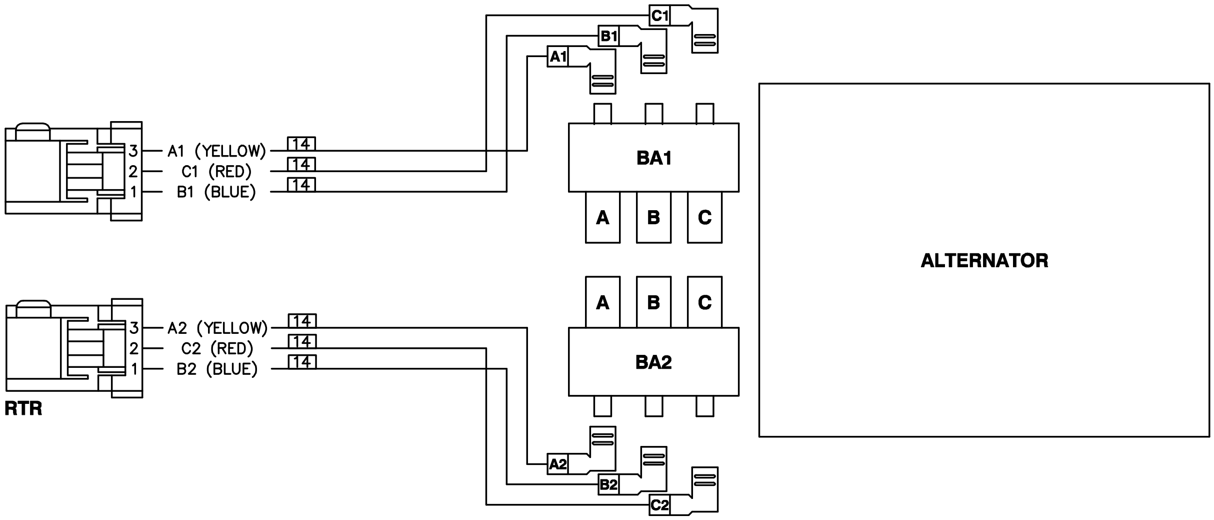
DRAWING #: 0K3218

GROUP G

AVR INTERCONNECTS



LEGEND

AVR	– AUTOMATIC VOLTAGE REGULATOR	LED	– LED BOARD
BA_	– BRUSH ASSEMBLY	LOP	– LOW OIL PRESSURE SWITCH
BCH	– BATTERY CHARGER	MAG	– MAGNETO
CB1	– CIRCUIT BREAKER (MAIN OUTPUT)	NEU	– NEUTRAL
CB2	– CIRCUIT BREAKER (GFCI)	P_	– AVR CONNECTIONS
CT_	– CURRENT TRANSFORMER	PS	– AC/DC POWER SUPPLY
DPE	– DISPLACED PHASE EXCITATION	R	– RESISTOR
FAN1	– AC FAN	RTR	– ROTOR
FAN2	– DC FAN	SC	– STARTER CONTACTOR
FS	– FUEL SOLENOID	SCR	– STARTER CONTROL RELAY
GFCI	– GROUND FAULT CIRCUIT INTERRUPT	SHLD	– SHIELD
GND	– GROUND	SM	– STARTER MOTOR
HOT	– HIGH OIL TEMPERATURE SWITCH	SP_	– SPARK PLUG
IM_	– IGNITION MODULE	STR	– STATOR
J_	– MAIN CONTROLLER CONNECTIONS	TB_	– TERMINAL BLOCK

NOTE: ALL WIRES 18 AWG 300V UL LISTED UNLESS SHOWN OTHERWISE.

12 — AWG SIZE

SPLICE NUMBER — 2

WIRE SPLICE

PAGE 5 OF 8

WIRING - DIAGRAM

REVISION: J-9156-C — 2013 AIR COOLED HSB VSCF

DATE: 8/5/14 — PAGE 5 OF 8 — DRAWING #: 0K3218

GROUP G

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WIRING - DIAGRAM

REVISION: J-9156-C

2013 AIR COOLED HSB VSCF

DATE: 8/5/14

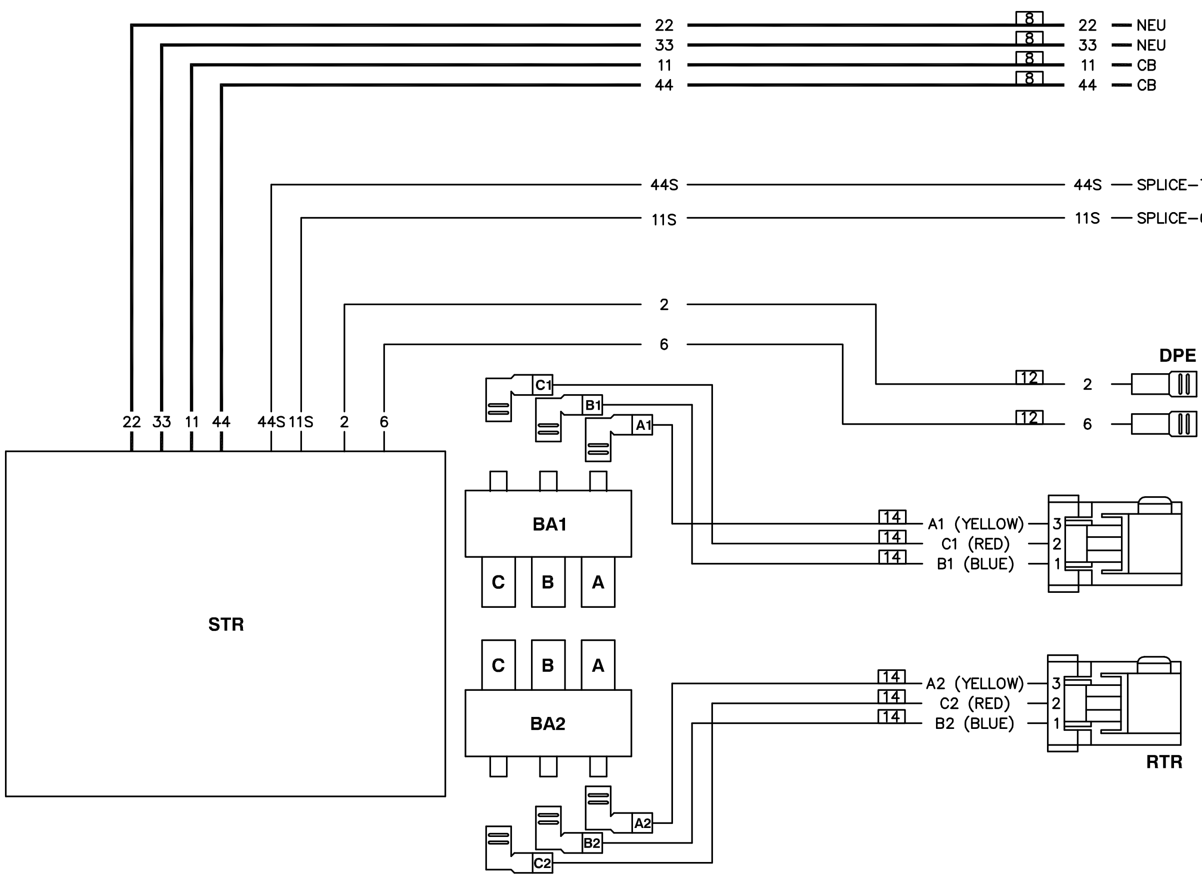
PAGE 6 OF 8

DRAWING #: 0K3218

Section 7.2 0L6825-A WD/SD 2016 Synergy Air-Cooled HSB VSCF 60 Hz

GROUP G

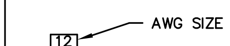
ALTERNATOR INTERCONNECTS

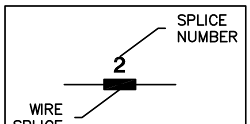


LEGEND

AVR	– AUTOMATIC VOLTAGE REGULATOR	MAG	– MAGNETO
BA_	– BRUSH ASSEMBLY	NEU	– NEUTRAL
BCH	– BATTERY CHARGER	P_	– VSCF AVR CONNECTIONS
CB	– CIRCUIT BREAKER	PS	– POWER SUPPLY
CT_	– CURRENT TRANSFORMER	R	– RESISTOR
DPE	– DISPLACED PHASE EXCITATION	RTR	– ROTOR
FAN1	– AC FAN	SC	– STARTER CONTACTOR
FAN2	– DC FAN	SCR	– STARTER CONTROL RELAY
FS	– FUEL SOLENOID	SHLD	– SHIELD
GND	– GROUND	SM	– STARTER MOTOR
HOT	– HIGH OIL TEMPERATURE SWITCH	SP_	– SPARK PLUG
IM_	– IGNITION MODULE	STR	– STATOR
J_	– MAIN CONTROLLER CONNECTIONS	TB_	– TERMINAL BLOCK
LED	– LED BOARD		
LOP	– LOW OIL PRESSURE SWITCH		

NOTE: ALL WIRES 18 AWG 300V UL LISTED UNLESS SHOWN OTHERWISE.





PAGE 1 OF 8

WIRING - DIAGRAM

REVISION: A

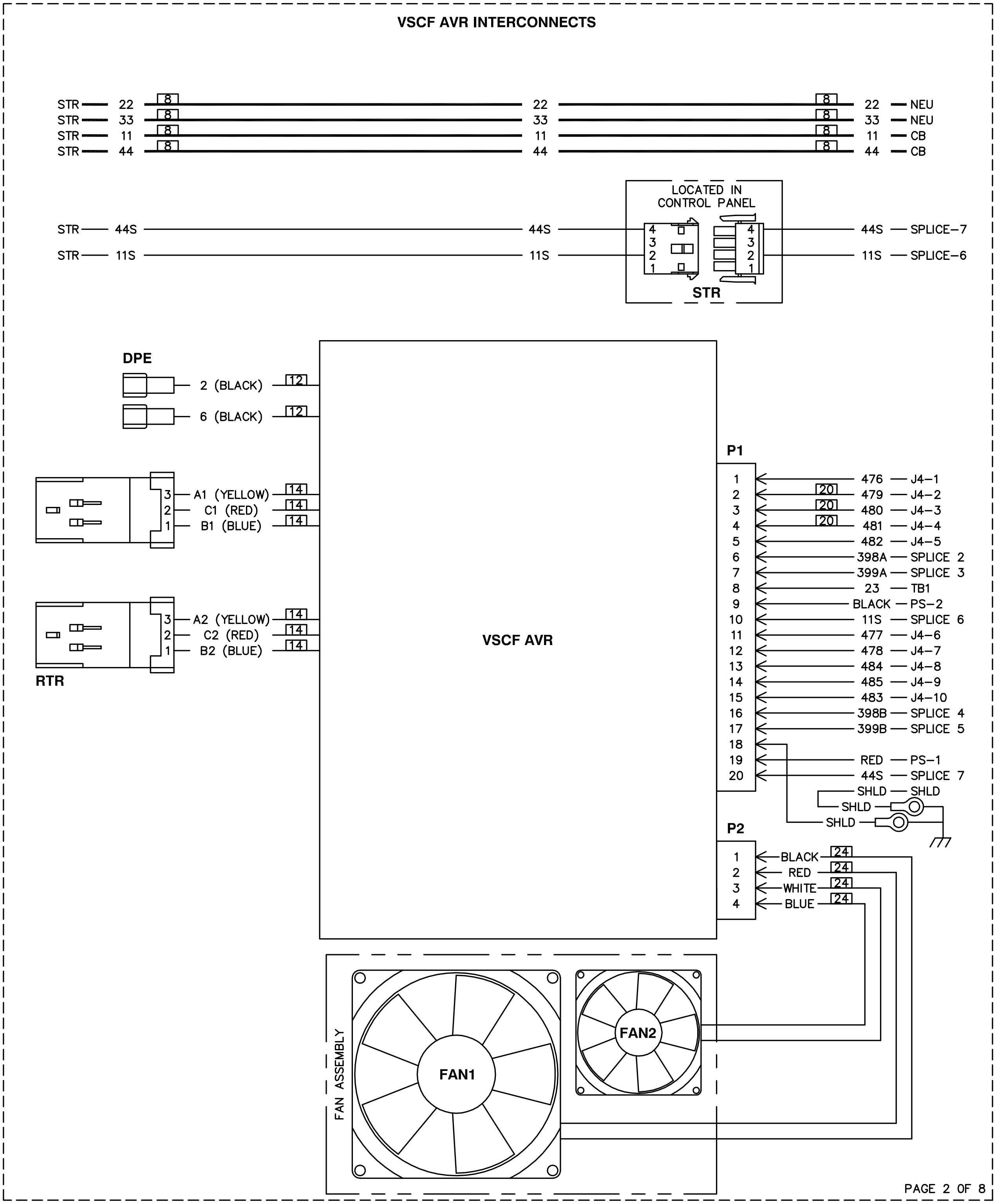
AIR COOLED HSB 20KW SYNERGY

06/03/16

PAGE 1 OF 8

0L6825

GROUP G



WIRING - DIAGRAM

REVISION: A

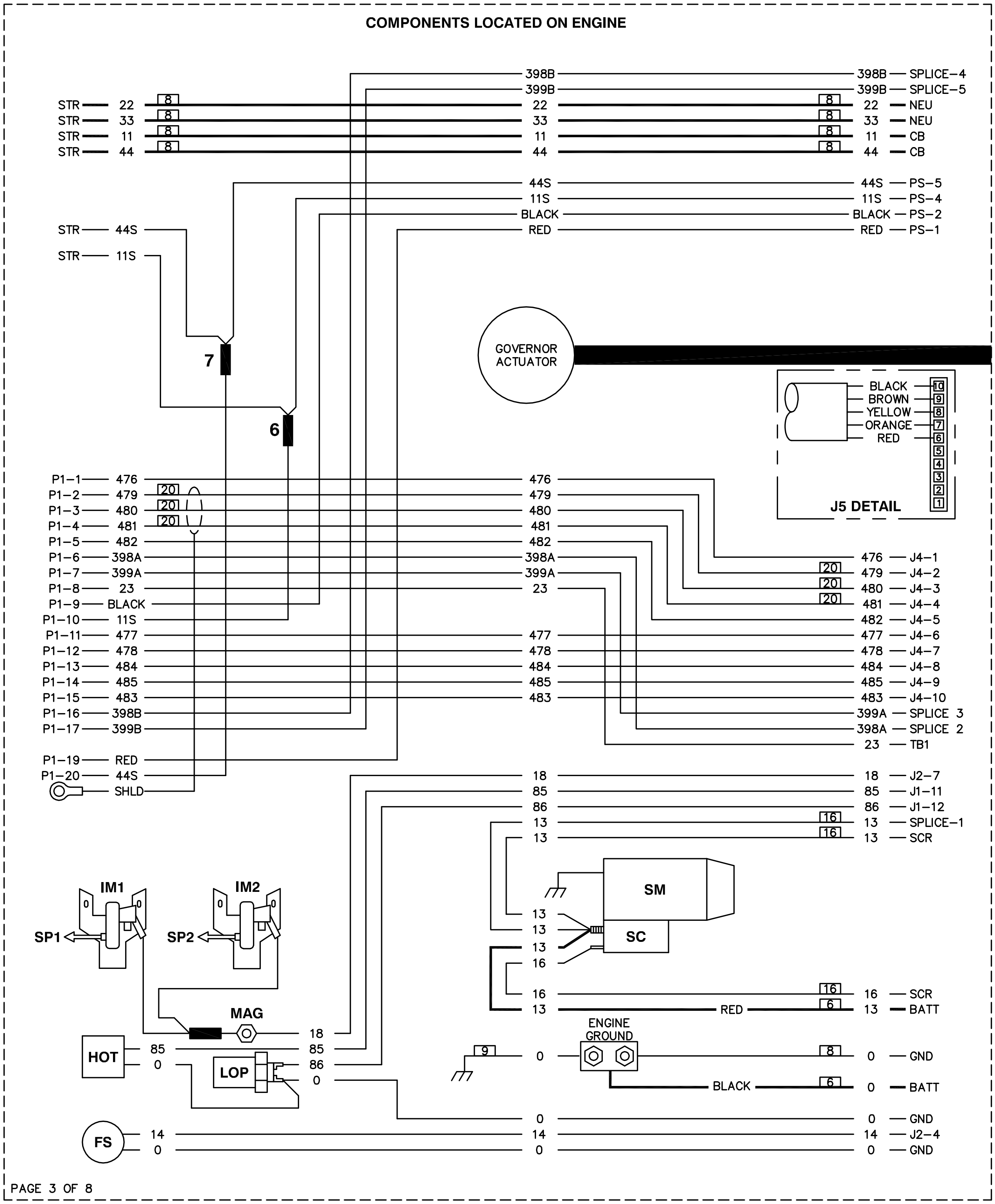
AIR COOLED HSB 20KW SYNERGY

06/03/16

PAGE 2 OF 8

0L6825

GROUP G



WIRING - DIAGRAM

REVISION: A

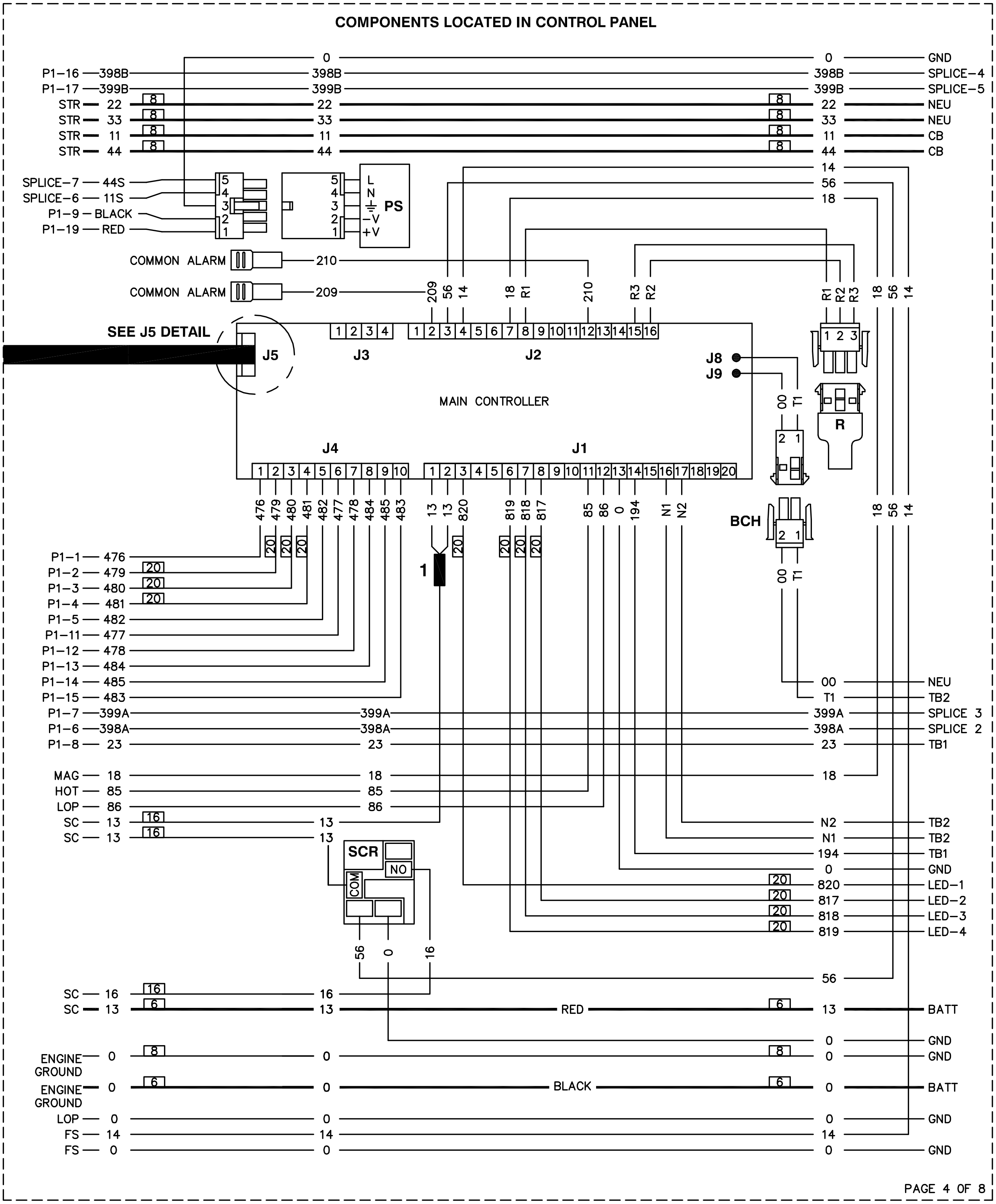
AIR COOLED HSB 20KW SYNERGY

06/03/16

PAGE 3 OF 8

0L6825

GROUP G



WIRING - DIAGRAM

REVISION: A

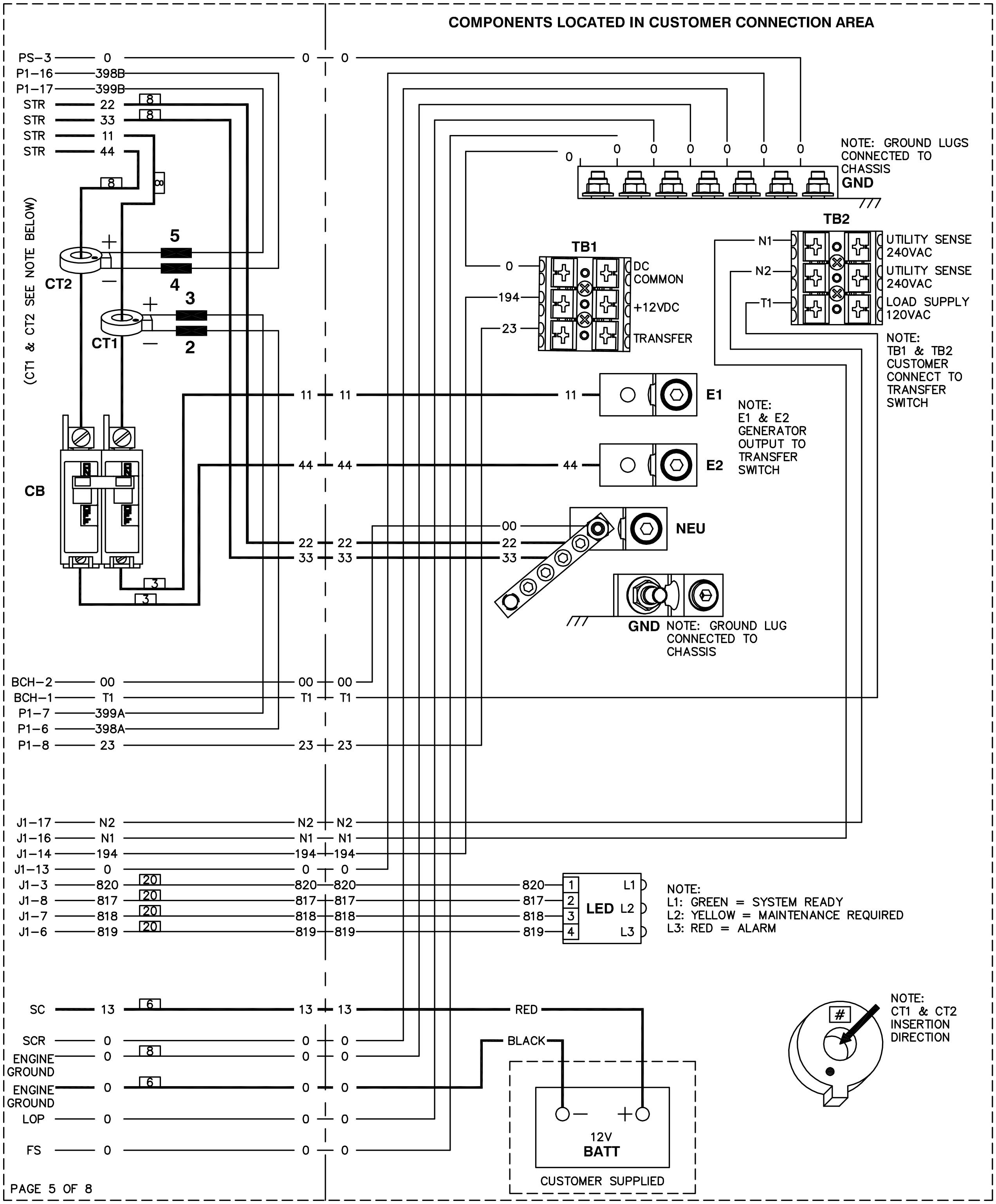
AIR COOLED HSB 20KW SYNERGY

06/03/16

PAGE 4 OF 8

0L6825

GROUP G



WIRING - DIAGRAM

REVISION: A

AIR COOLED HSB 20KW SYNERGY

06/03/16

PAGE 5 OF 8

0L6825

GROUP G

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PAGE 6 OF 8

WIRING - DIAGRAM

REVISION: A

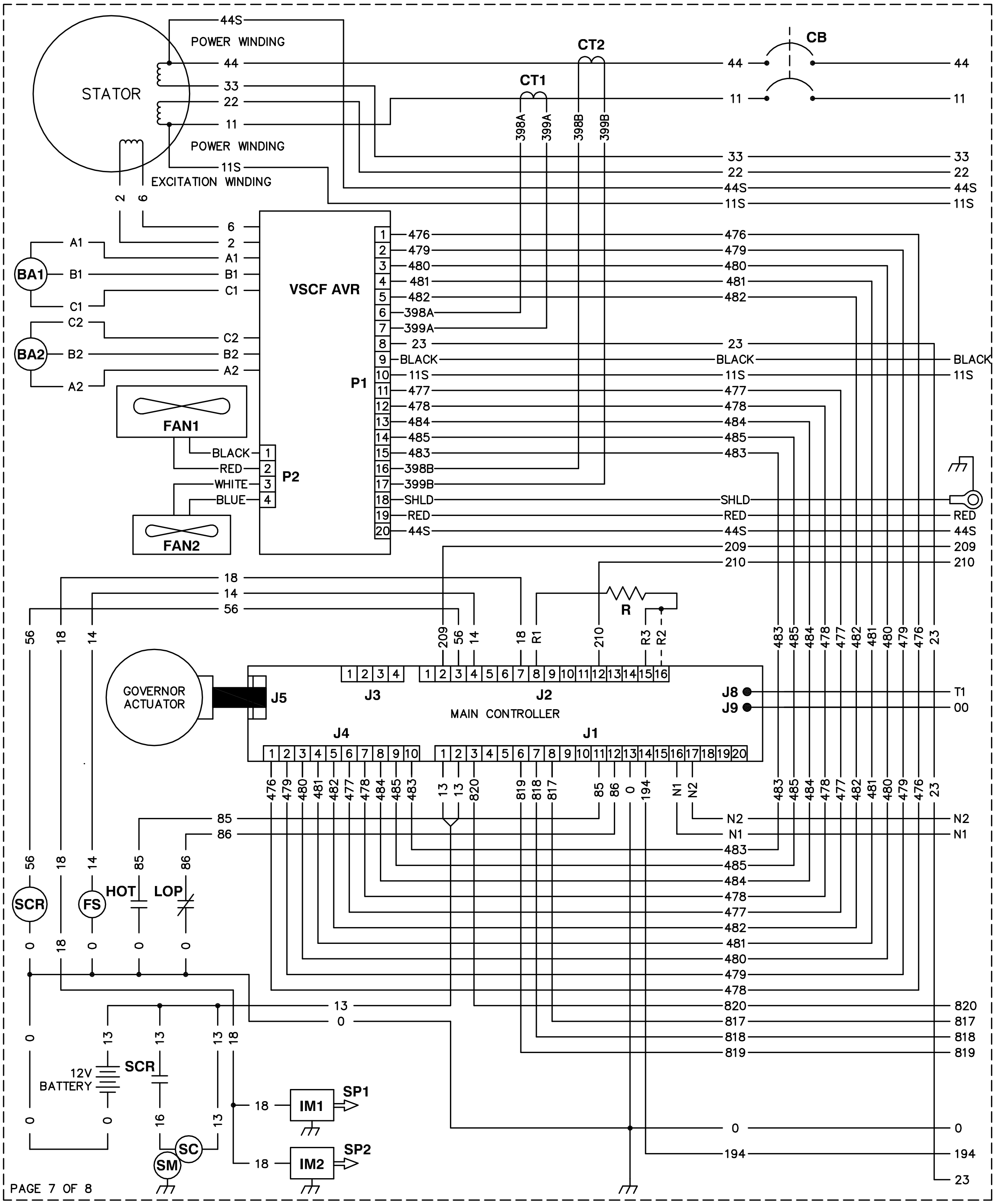
AIR COOLED HSB 20KW SYNERGY

06/03/16

PAGE 6 OF 8

0L6825

GROUP G



REVISION: A

SCHEMATIC - DIAGRAM

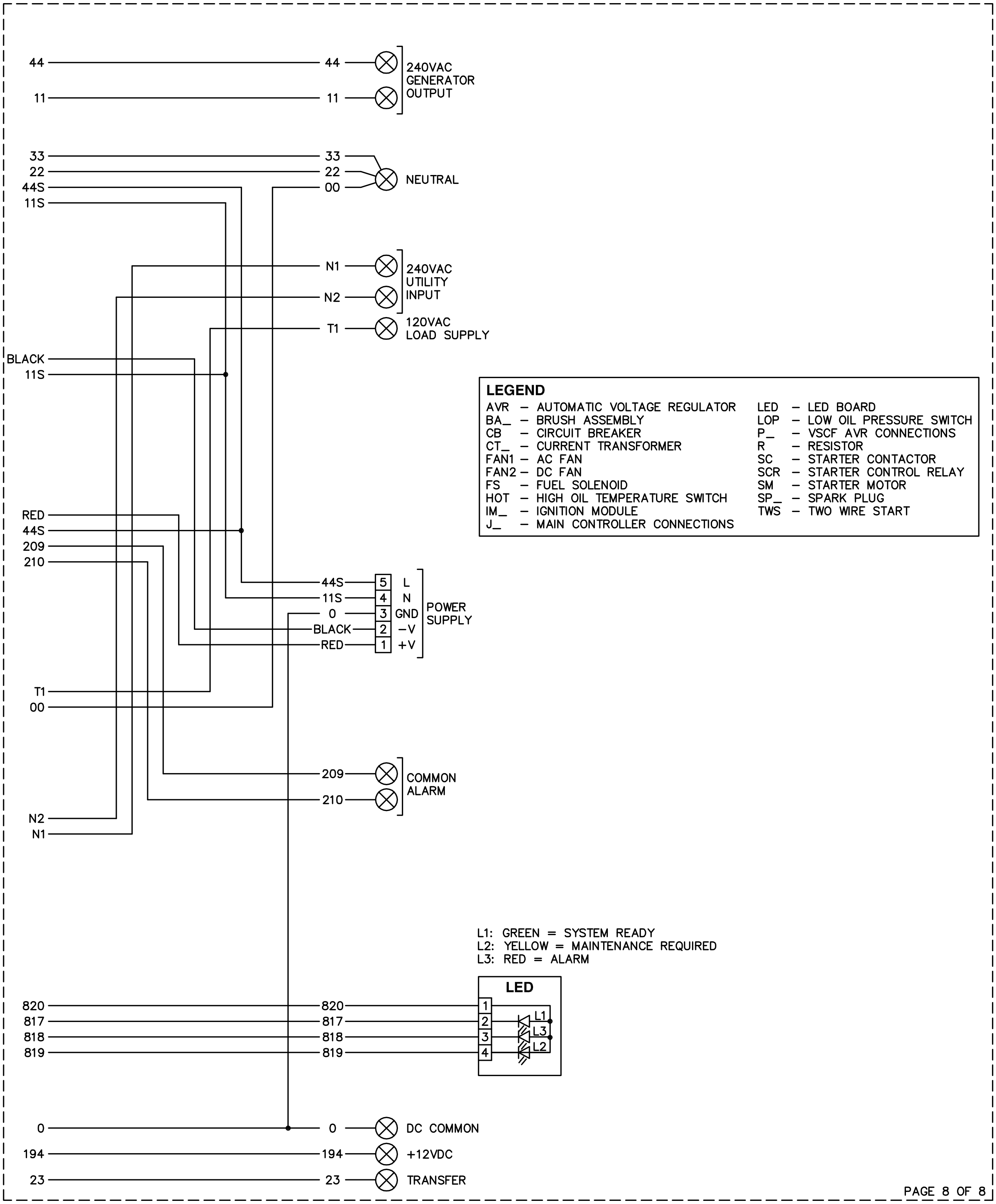
AIR COOLED HSB 20KW SYNERGY

06/03/16

PAGE 7 OF 8

0L6825

GROUP G



LEGEND

AVR – AUTOMATIC VOLTAGE REGULATOR	LED – LED BOARD
BA_ – BRUSH ASSEMBLY	LOP – LOW OIL PRESSURE SWITCH
CB – CIRCUIT BREAKER	P_ – VSCF AVR CONNECTIONS
CT_ – CURRENT TRANSFORMER	R – RESISTOR
FAN1 – AC FAN	SC – STARTER CONTACTOR
FAN2 – DC FAN	SCR – STARTER CONTROL RELAY
FS – FUEL SOLENOID	SM – STARTER MOTOR
HOT – HIGH OIL TEMPERATURE SWITCH	SP_ – SPARK PLUG
IM_ – IGNITION MODULE	TWS – TWO WIRE START
J_ – MAIN CONTROLLER CONNECTIONS	

SCHEMATIC - DIAGRAM

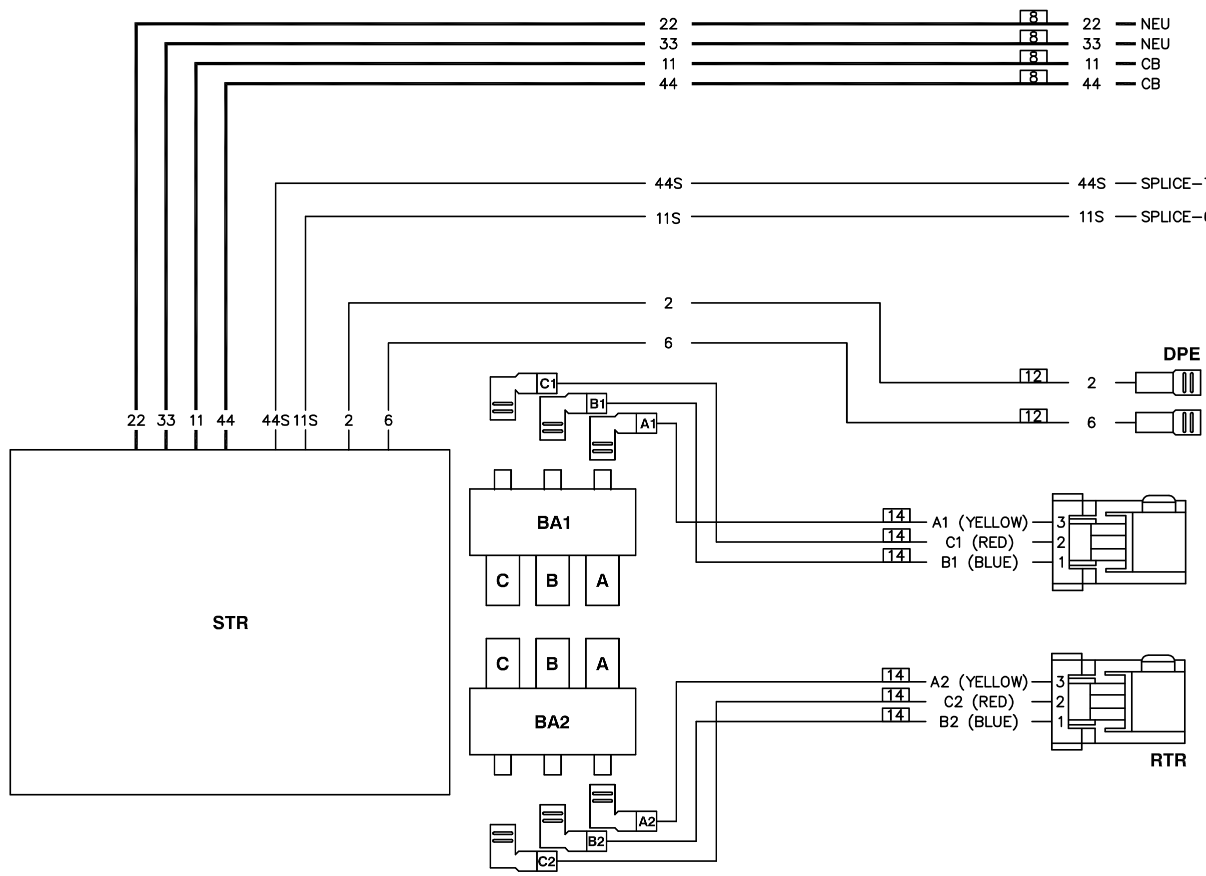
REVISION: A — AIR COOLED HSB 20KW SYNERGY

06/03/16 — PAGE 8 OF 8 — 0L6825

Section 7.3 *0L6826-A WD/SD 2016 EcoGen Air-Cooled HSB 60 Hz*

GROUP G

ALTERNATOR INTERCONNECTS



LEGEND

AVR	– AUTOMATIC VOLTAGE REGULATOR	MAG	– MAGNETO
BA_	– BRUSH ASSEMBLY	NEU	– NEUTRAL
BCH	– BATTERY CHARGER	P_	– VSCF AVR CONNECTIONS
CB	– CIRCUIT BREAKER	PS	– POWER SUPPLY
CT_	– CURRENT TRANSFORMER	R	– RESISTOR
DPE	– DISPLACED PHASE EXCITATION	RTR	– ROTOR
FAN1	– AC FAN	SC	– STARTER CONTACTOR
FAN2	– DC FAN	SCR	– STARTER CONTROL RELAY
FS	– FUEL SOLENOID	SHLD	– SHIELD
GND	– GROUND	SM	– STARTER MOTOR
HOT	– HIGH OIL TEMPERATURE SWITCH	SP_	– SPARK PLUG
IM_	– IGNITION MODULE	STR	– STATOR
J_	– MAIN CONTROLLER CONNECTIONS	TB_	– TERMINAL BLOCK
LED	– LED BOARD	TWS	– TWO WIRE START
LOP	– LOW OIL PRESSURE SWITCH		

NOTE: ALL WIRES 18 AWG 300V UL LISTED UNLESS SHOWN OTHERWISE.

12 — AWG SIZE

2 — SPLICE NUMBER

WIRE SPLICE

PAGE 1 OF 8

WIRING - DIAGRAM

REVISION: A

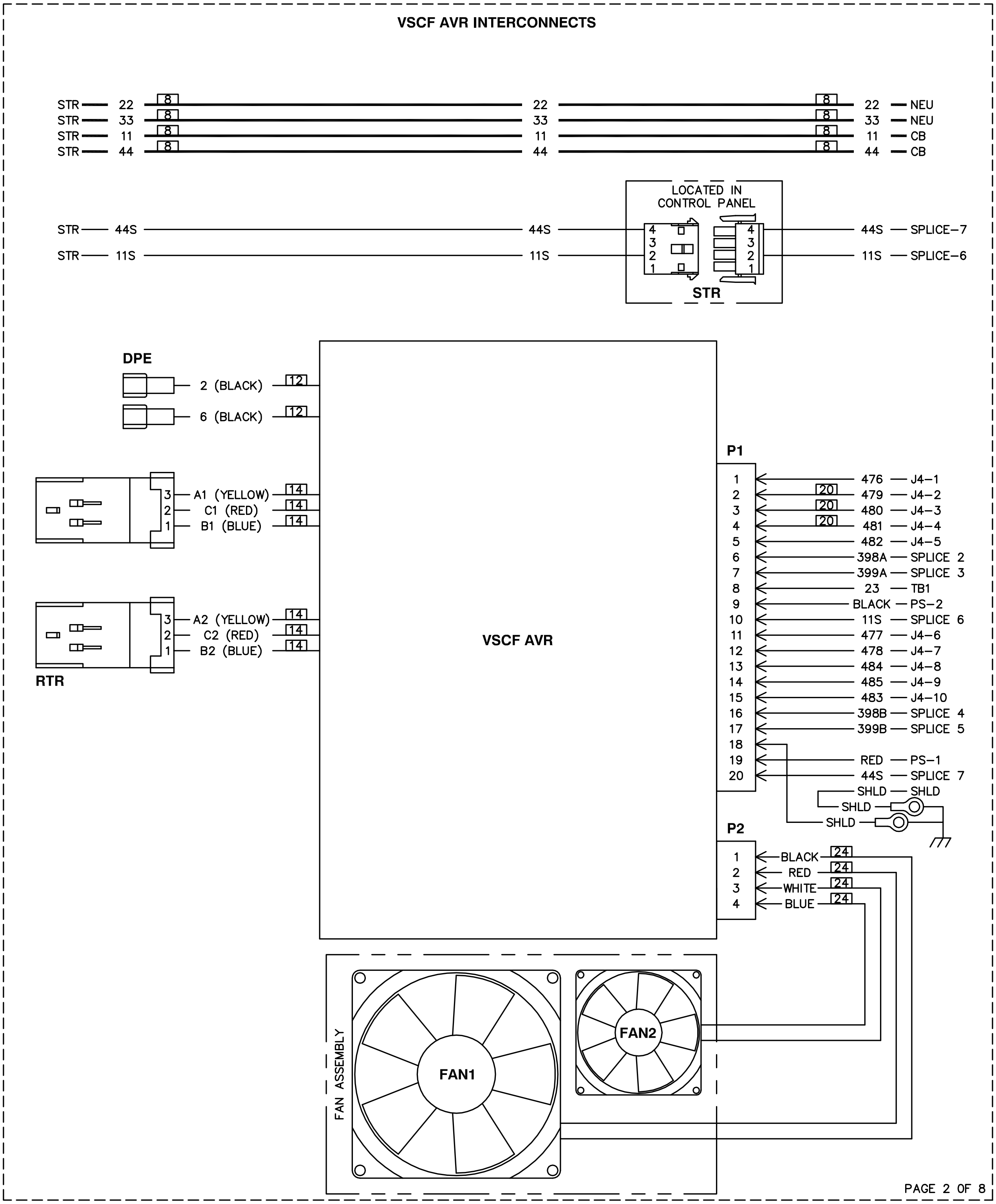
AIR COOLED HSB 15KW ECOGEN

DATE: 06/03/16

PAGE 1 OF 8

DRAWING #: 0L6826

GROUP G



WIRING - DIAGRAM

REVISION: A

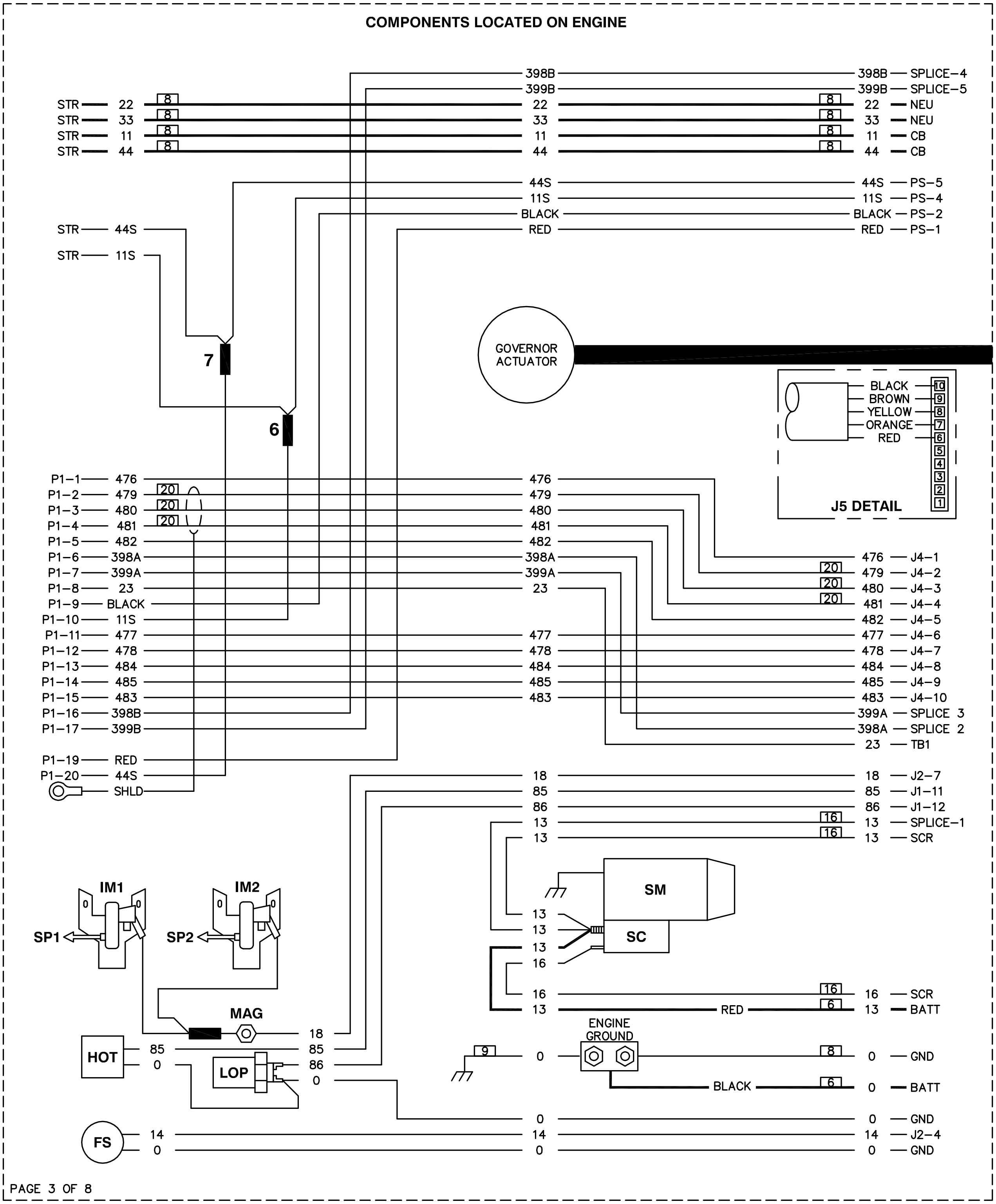
AIR COOLED HSB 15KW ECOGEN

DATE: 06/03/16

PAGE 2 OF 8

DRAWING #: 0L6826

GROUP G



WIRING - DIAGRAM

REVISION: A

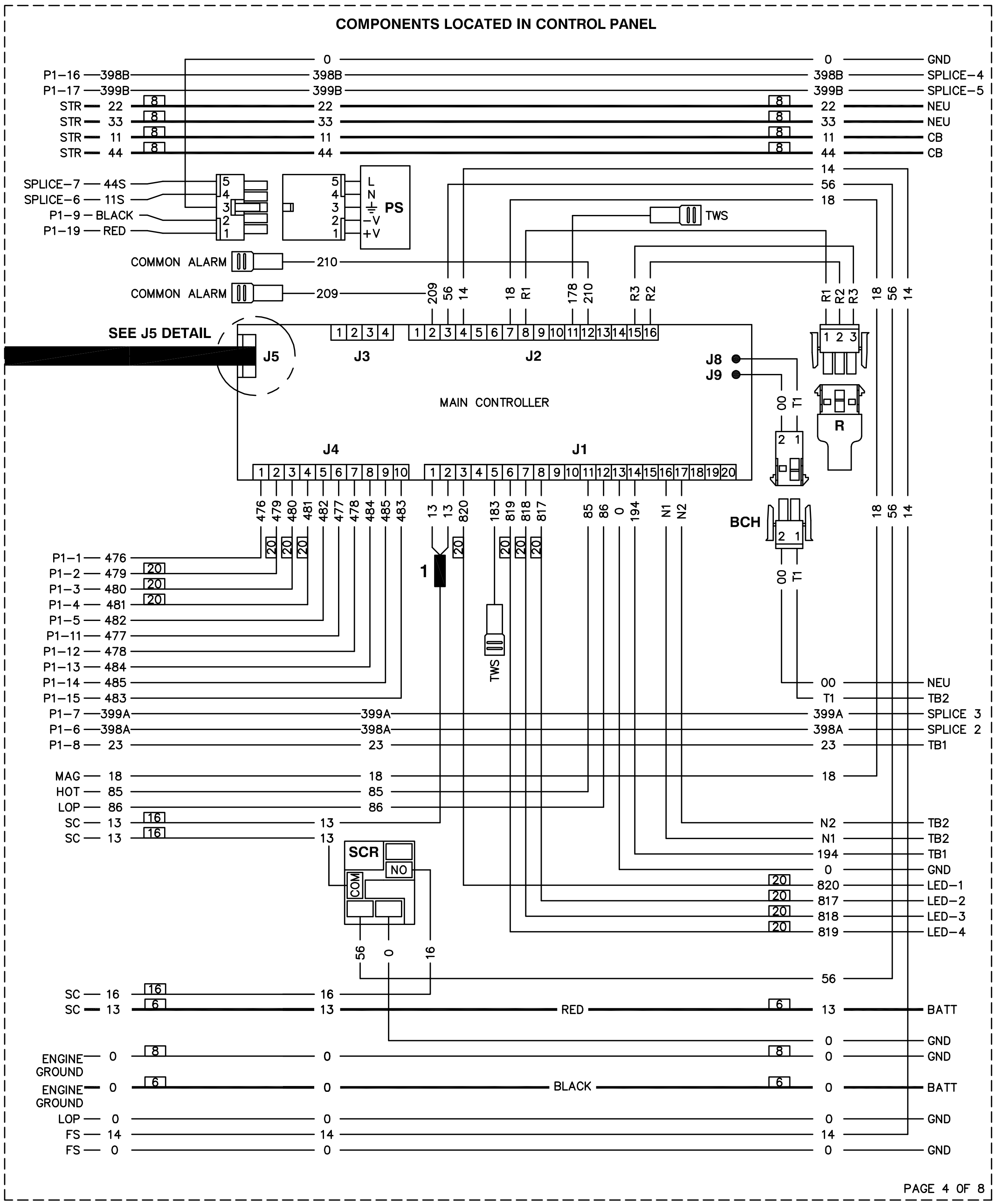
AIR COOLED HSB 15KW ECOGEN

DATE: 06/03/16

PAGE 3 OF 8

DRAWING #: 0L6826

GROUP G



WIRING - DIAGRAM

REVISION: A

AIR COOLED HSB 15KW ECOGEN

DATE: 06/03/16

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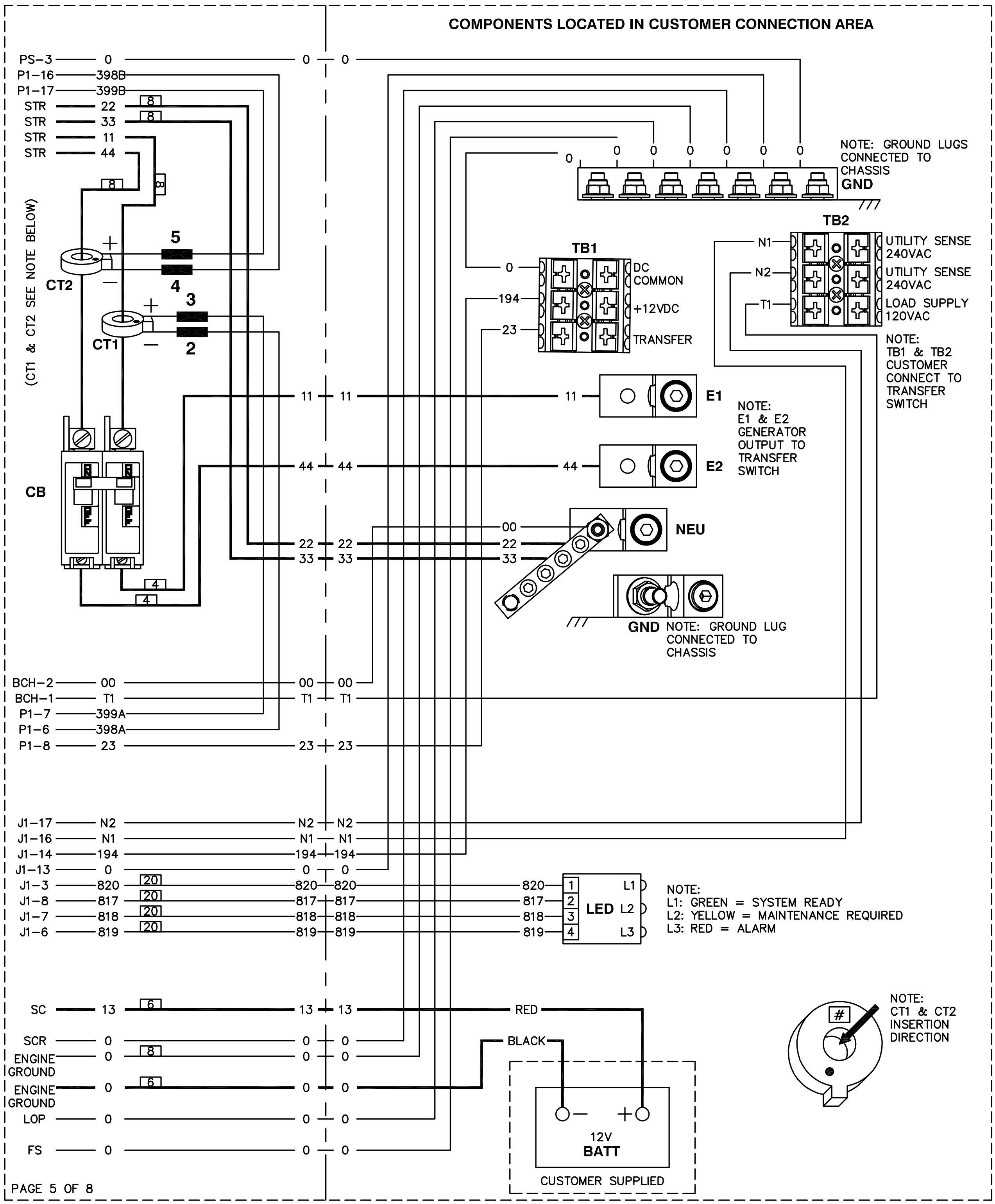
DRAWING #: 0L6826

GROUP G



WIRING - DIAGRAM

REVISION: A

AIR COOLED HSB 15KW ECOGEN

DATE: 06/03/16

PAGE 5 OF 8

DRAWING #: 0L6826

GROUP G

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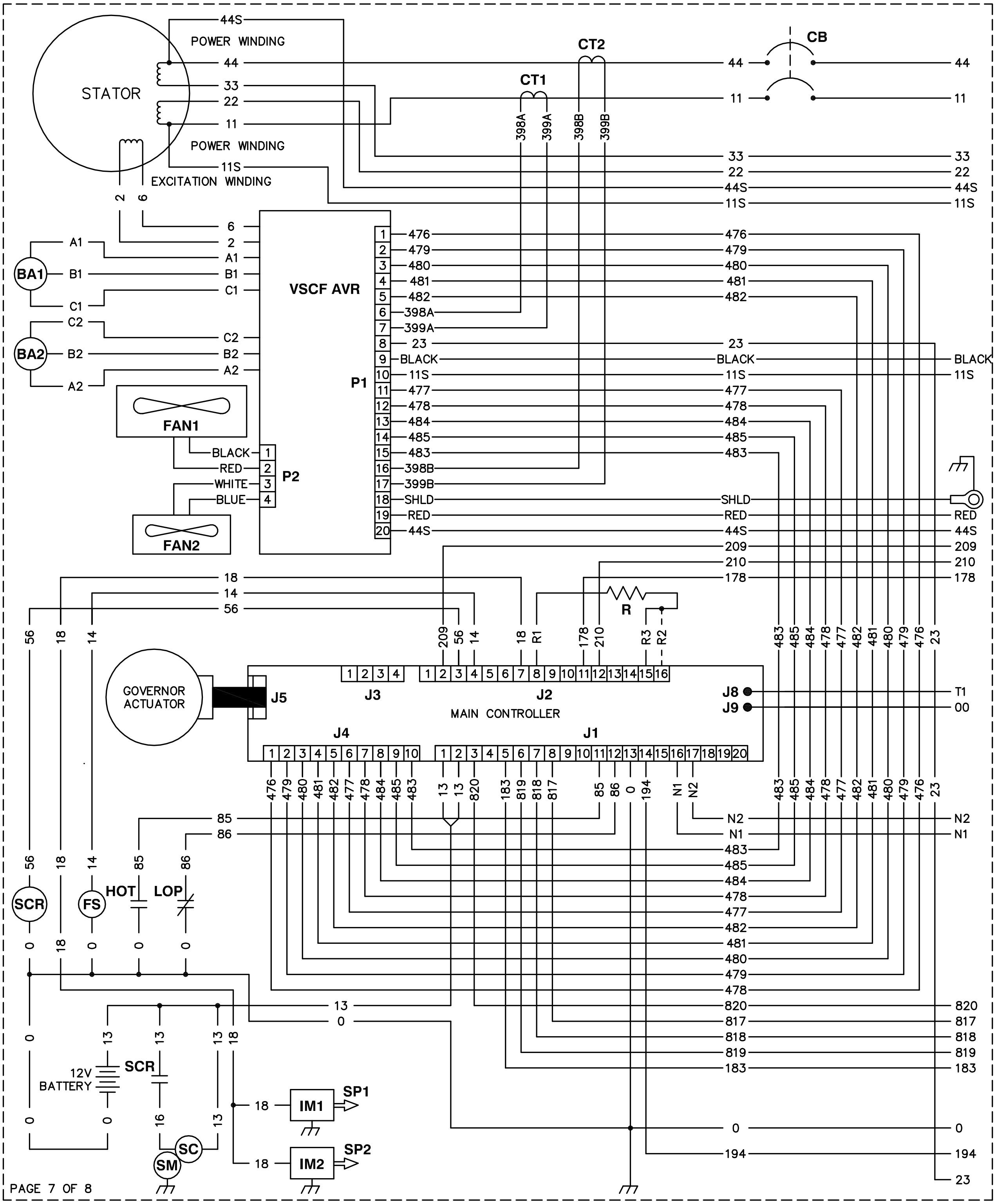
PAGE 6 OF 8

WIRING - DIAGRAM
AIR COOLED HSB 15KW ECOGEN
DRAWING #: 0L6826

REVISION: A
DATE: 06/03/16

PAGE 6 OF 8

GROUP G



SCHEMATIC - DIAGRAM

REVISION: A

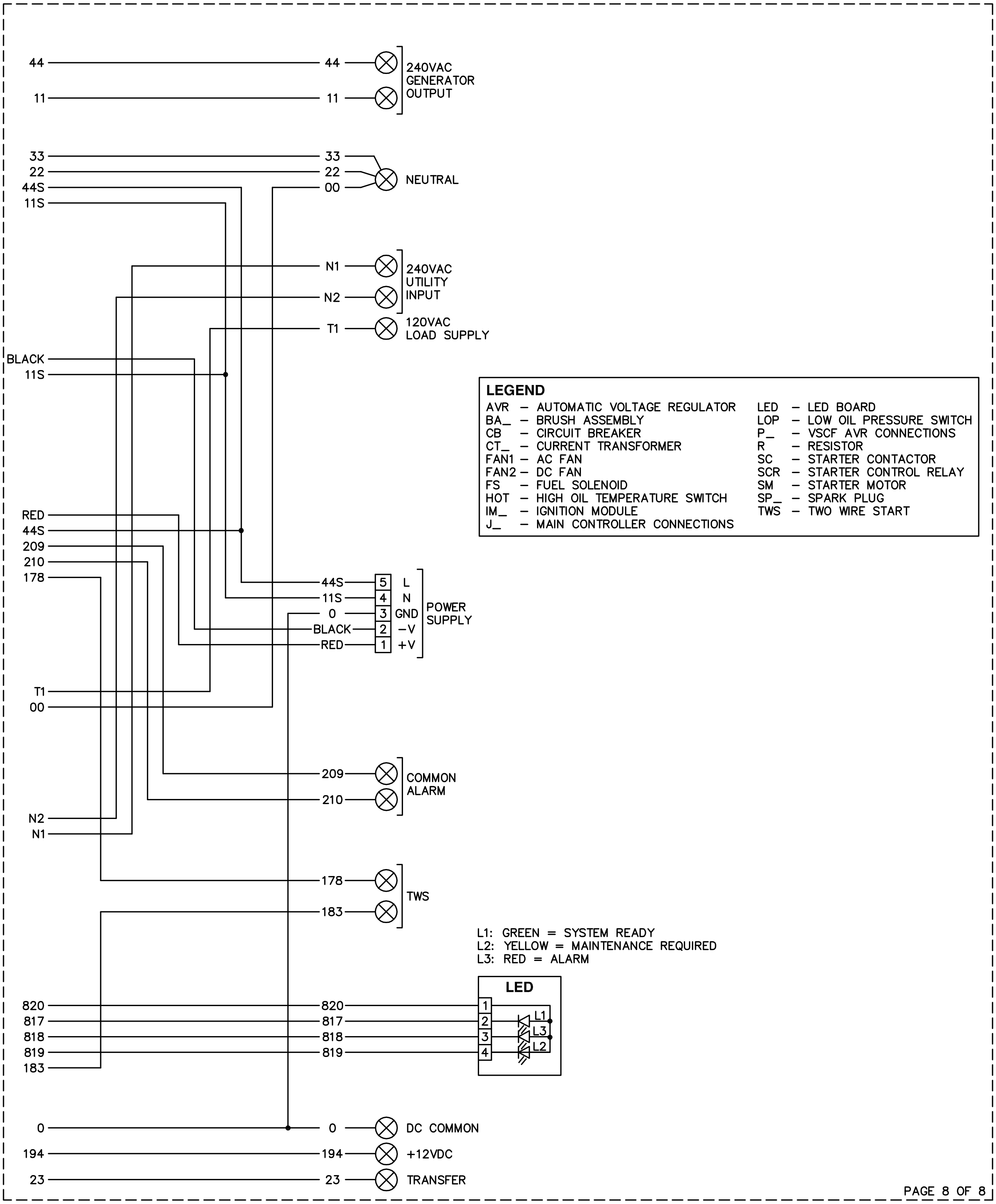
AIR COOLED HSB 15KW ECOGEN

DATE: 06/03/16

PAGE 7 OF 8

DRAWING #: 0L6826

GROUP G



SCHEMATIC - DIAGRAM

REVISION: A

AIR COOLED HSB 15KW ECOGEN

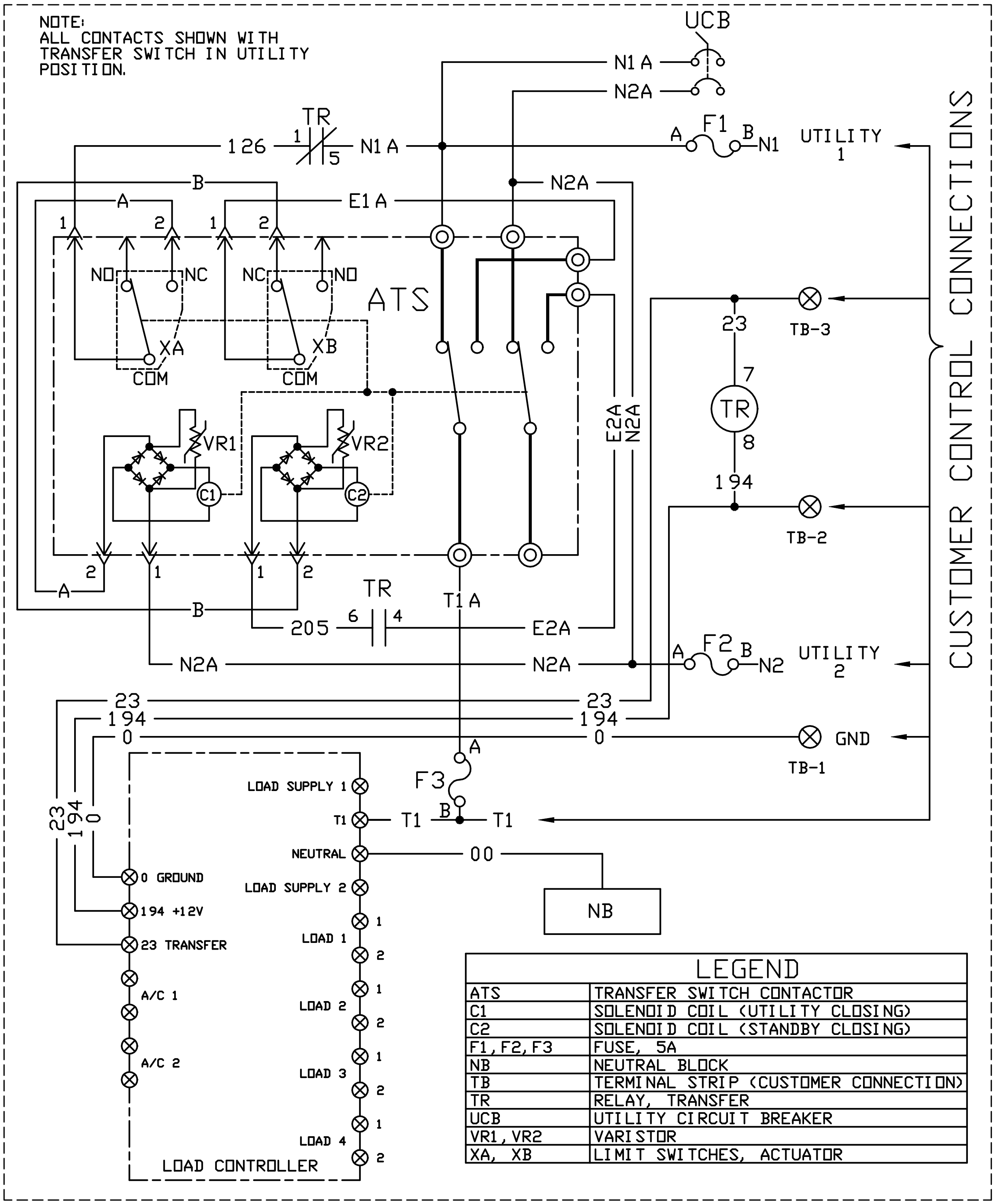
DATE: 06/03/16

PAGE 8 OF 8

DRAWING #: 0L6826

Section 7.4 *0K7642-A SD/WD HSB Transfer Switch with FLS*

GROUP G



LEGEND

ATS	TRANSFER SWITCH CONTACTOR
C1	SOLENOID COIL (UTILITY CLOSING)
C2	SOLENOID COIL (STANDBY CLOSING)
F1, F2, F3	FUSE, 5A
NB	NEUTRAL BLOCK
TB	TERMINAL STRIP (CUSTOMER CONNECTION)
TR	RELAY, TRANSFER
UCB	UTILITY CIRCUIT BREAKER
VR1, VR2	VARISTOR
XA, XB	LIMIT SWITCHES, ACTUATOR

SCHEMATIC - DIAGRAM

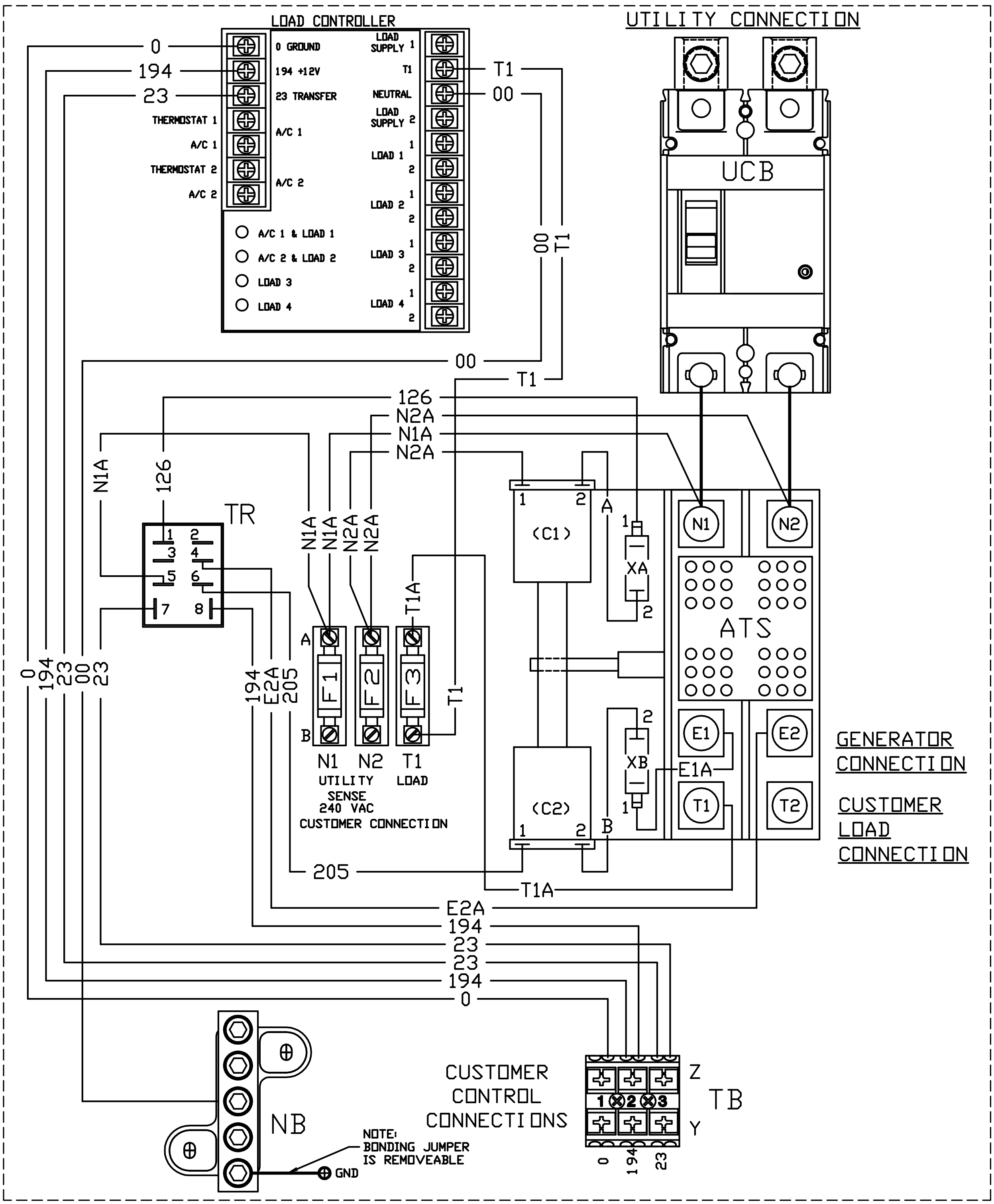
REVISION: -A-

DATE: 03/03/14

RTSB 2014

DRAWING #: 0K7642

GROUP G



WIRING - DIAGRAM

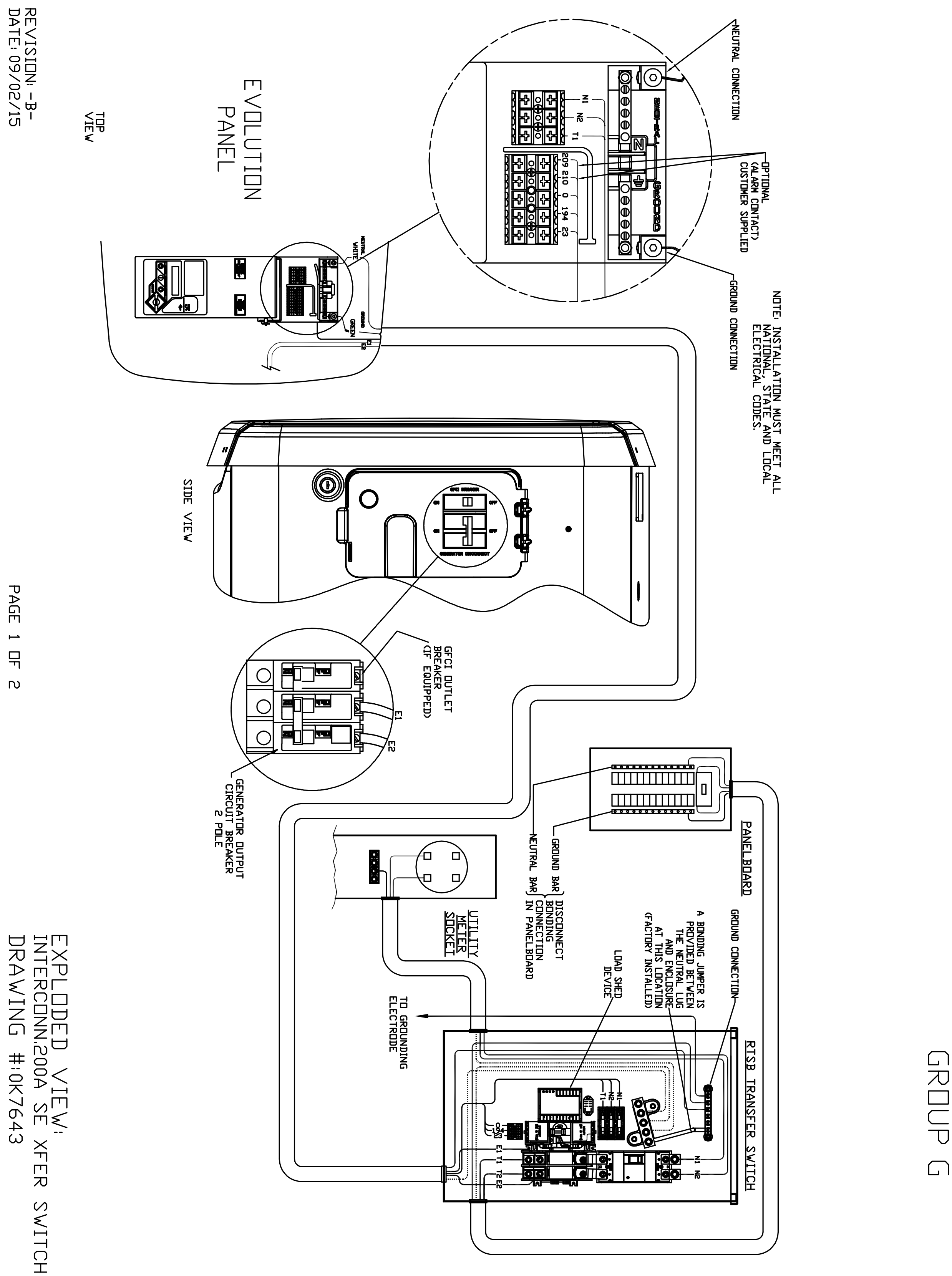
RTSB 2014

DRAWING #: 0K7642

REVISION: -A-

DATE: 03/03/14

Section 7.5 *0K7643-B – Interconnection Diagram HSB Transfer Switch with FLS*



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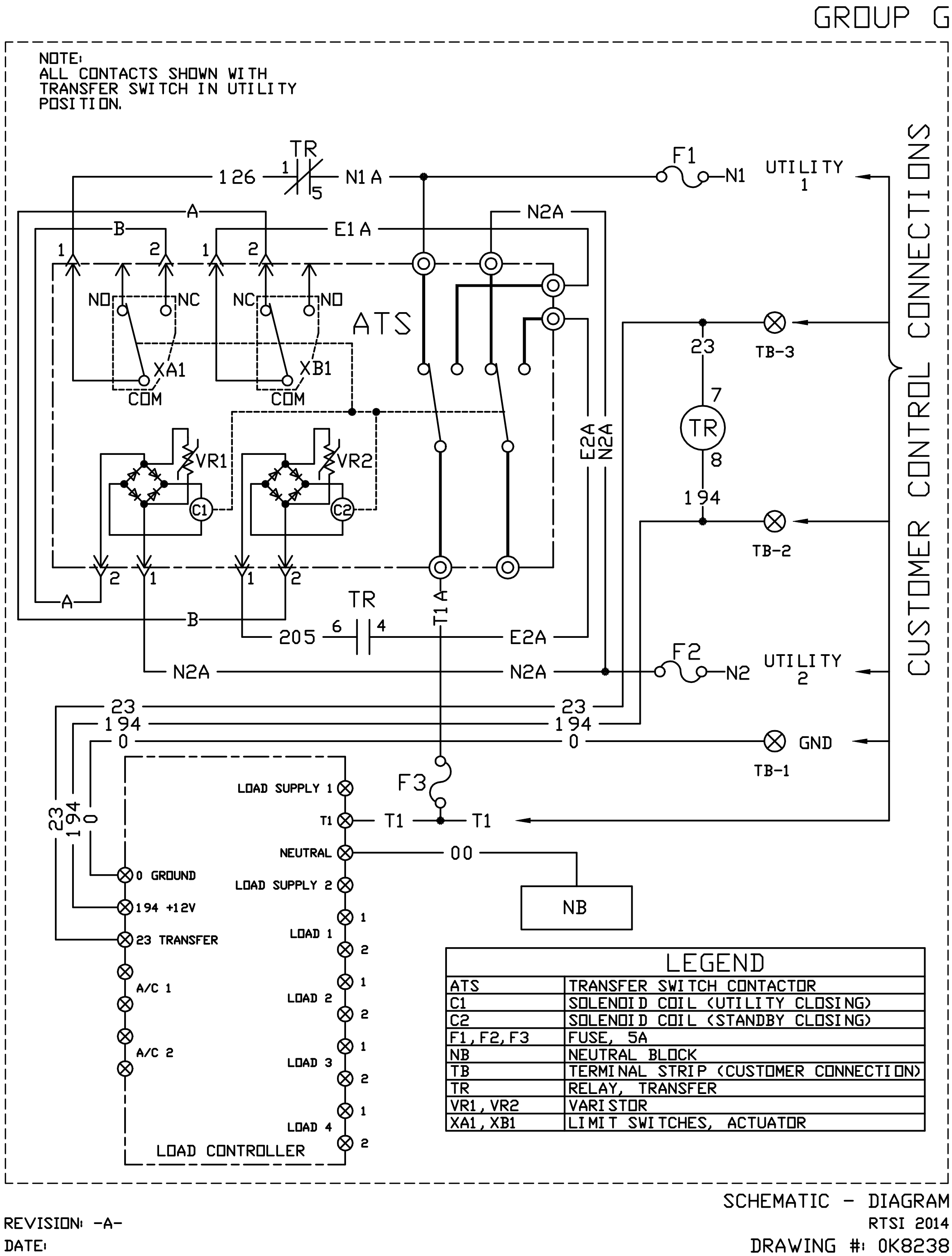
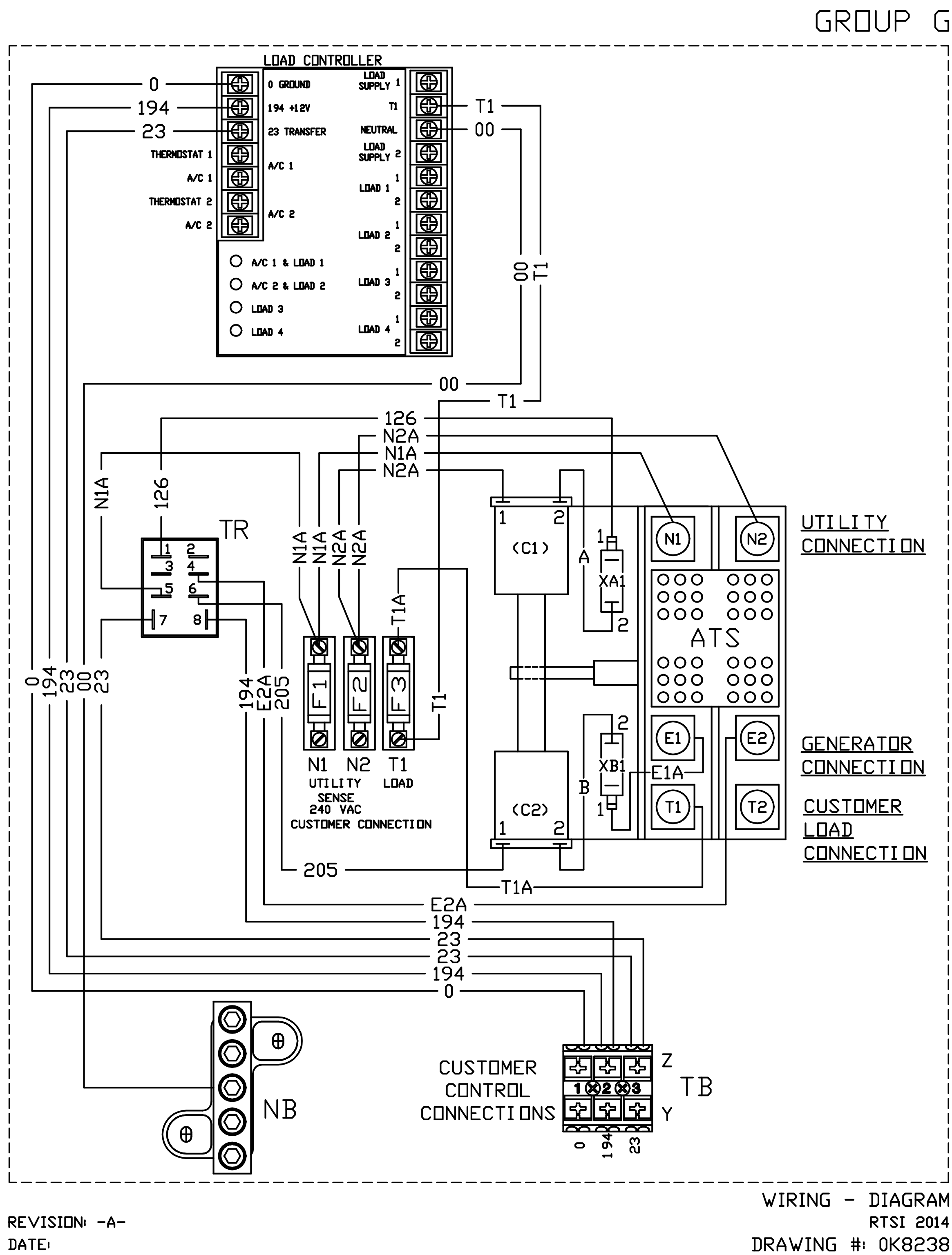
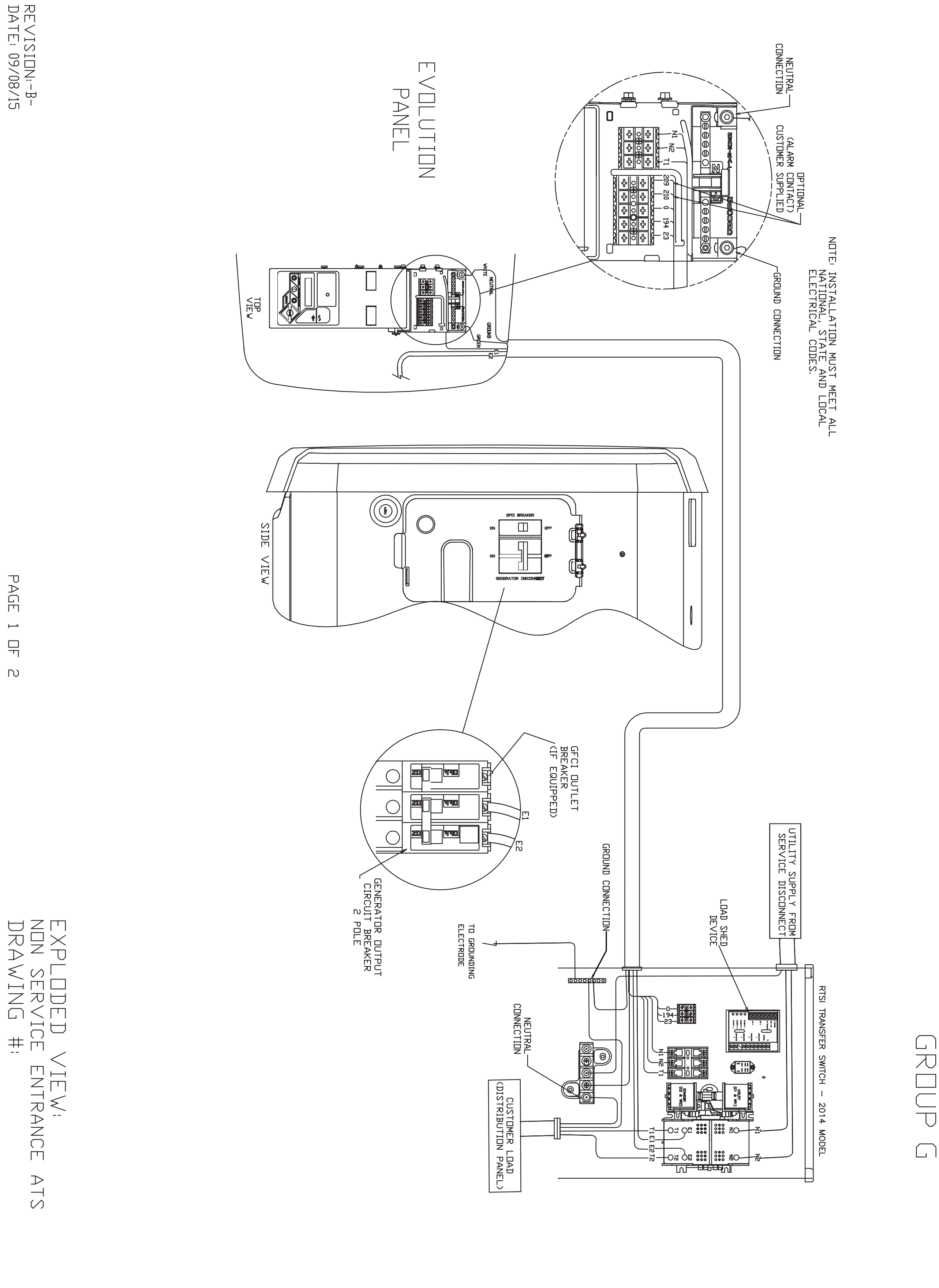
Section 7.6 0K8238-A – SD/WD HSB Transfer Switch



LEGEND	
ATS	TRANSFER SWITCH CONTACTOR
C1	SOLENOID COIL (UTILITY CLOSING)
C2	SOLENOID COIL (STANDBY CLOSING)
F1, F2, F3	FUSE, 5A
NB	NEUTRAL BLOCK
TB	TERMINAL STRIP (CUSTOMER CONNECTION)
TR	RELAY, TRANSFER
VR1, VR2	VARISTOR
XA1, XB1	LIMIT SWITCHES, ACTUATOR


GROUP G
LOAD CONTROLLER
0 GROUND
194 +12V
23 TRANSFER
THERMOSTAT 1
A/C 1
THERMOSTAT 2
A/C 2
LOAD SUPPLY 1
T1
NEUTRAL
LOAD SUPPLY 2
LOAD 1
LOAD 2
LOAD 3
LOAD 4
A/C 1 & LOAD 1
A/C 2 & LOAD 2
LOAD 3
LOAD 4
TR
F1
F2
F3
N1 N2 T1
UTILITY SENSE 240 VAC
LOAD
CUSTOMER CONNECTION
(C1)
(C2)
XA1
XB1
ATS
UTILITY CONNECTION
GENERATOR CONNECTION
CUSTOMER LOAD CONNECTION
CUSTOMER CONTROL CONNECTIONS
NB
TB
WIRING - DIAGRAM
RTSI 2014
DRAWING #: 0K8238
REVISION: -A-
DATE:

Section 7.7 *0K8239-A – Interconnection Diagram HSB Transfer Switch*



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Important Note

For *General Troubleshooting Guidelines* refer to Section 1.11.

Use wire numbers only and disregard any specific “J” Connector references. Utilize the wire numbers and controller pin out chart in this appendix per specific connector styles!

Probing and Pin Extraction

Use the special tool (P/N 0J09460SRV) to back probe the connector.

NOTE: DO NOT front probe Molex Connectors.

Diagnostic procedures in this manual do not call out the connector or pin number, only the wire number.

This section (Appendix A) is to be used as a resource to identify the correct pin location and connector on the controller being diagnosed.

NOTE: If probing and/or back-probing results in a “BAD” condition, before condemning the controller, remove the pin/plug in question and verify the pin/plug is not distorted, bent and/or not making electrical contact! Repair as needed!

003539

Figure 1-1. Special Tool (P/N 0J09460SRV) Back Probe

002450

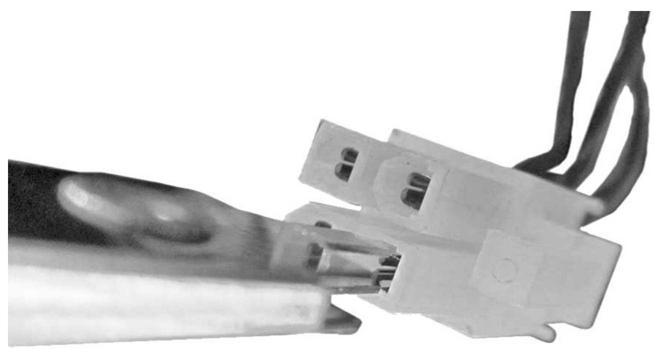
Figure 1-2. Back-Probing Molex Connector

002451

Figure 1-3. Probing AMP Connector

002452

Figure 1-4. Molex Pin Extractor Tool Part# 0K4445



002453

Figure 1-5. Using Molex Pin Extractor Tool

Synergy Controller

See Figure 239 – Synergy Air-cooled Panel has 3 Molex style connectors on the back (J1, J2, & J4), one actuator connector (J5), a battery charger connector (J8 & J9), and a connector socket for a remote annunciator (optional accessory).

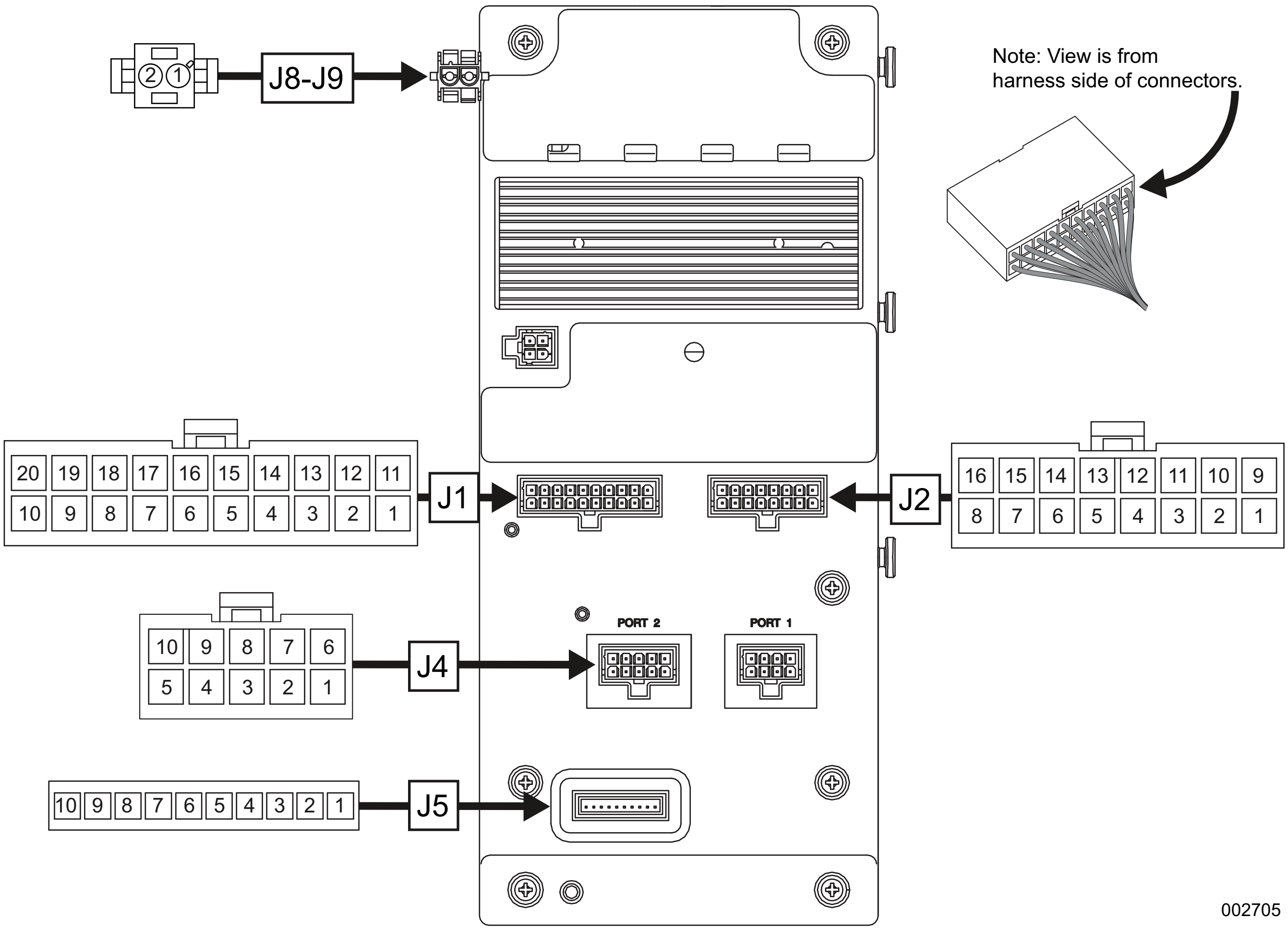


Figure 1-6. Synergy Air-cooled Panel and Connectors (Harness End)

J1 Connector		
Pin	**Wire**	**Circuit Function**
J1-1	13	12 VDC un-fused for the controller
J1-2	13	12 VDC un-fused for the controller
J1-3	820	Positive voltage (5 VDC) for status LEDs
J1-4	-	Not Used
J1-5	178	Not Used, Optional - 2-Wire Start (return)
J1-6	819	Grounded by the controller to turn on the Maintenance (Yellow) LED
J1-7	818	Grounded by the controller to turn on Alarm (Red) LED
J1-8	817	Grounded by the controller to turn on System Ready (Green) LED
J1-9	398A	Generator Current Sense A2
J1-10	399A	Generator Current Sense A1
J1-11	85	High temperature shutdown: Shutdown occurs when Wire 85 is grounded by contact closure in the oil temperature switch
J1-12	86	Low oil pressure shutdown: Shutdown occurs when Wire 86 is grounded by loss of oil pressure in the LOP switch
J1-13	0	Common Ground (DC) DC Field Excitation Ground
J1-14	194	Provides 12 VDC to the transfer relay (TR1)
J1-15	-	Not Used - UL Required Spacing
J1-16	N1	240 VAC Utility sensing voltage
J1-17	N2	240 VAC Utility sensing voltage
J1-18	-	Not Used - UL Required Spacing
J1-19	-	Not Used
J1-20	-	Not Used

J2 Connector		
Pin	**Wire**	**Circuit Function**
J2-1		
J2-2	209	Common Alarm Relay Output
J2-3	56	12 VDC output to starter contactor relay/ solenoid
J2-4	14	12 VDC output for engine run condition. Fuel solenoid supply voltage.
J2-5	-	Not Used
J2-6	-	Not Used
J2-7	18	Ignition Shutdown: The controller grounds Wire 18 for ignition shutdown and receives a reference signal for speed control while cranking and running
J2-8	R1	Model ID Resistor
J2-9	-	Not Used
J2-10	-	Not Used
J2-11	183	Not Used, Optional - 2-Wire Start
J2-12	210	Common Alarm Relay Output
J2-13	-	Not Used
J2-14	-	Not Used
J2-15	R3	Model ID Resistor
J2-16	R2	Model ID Resistor

J4 Connector		
Pin	**Wire**	**Circuit Function**
J4-1	476	PWM DC Voltage Supply (Positive)
J4-2	479	Comms DC Voltage (Signal -)*
J4-3	480	Comms DC Voltage (Signal +)*
J4-4	481	Comms DC Voltage (Ground)
J4-5	482	AVR Ground
J4-6	477	PWM DC Voltage (Signal)
J4-7	478	PWM DC Voltage (Ground)
J4-8	484	AVR Enable (Positive)
J4-9	485	AVR Enable (Ground)
J4-10	483	AVR Power (Positive)

J5 Connector		
Pin	**Wire**	**Circuit Function**
J5-1	-	Not Used
J5-2	-	Not Used
J5-3	-	Not Used
J5-4	-	Not Used
J5-5	-	Not Used
J5-6	Red	Stepper Power
J5-7	Orange	Stepper Motor B2 Coil
J5-8	Yellow	Stepper Motor B1 Coil
J5-9	Brown	Stepper Motor A2 Coil
J5-10	Black	Stepper Motor A1 Coil
J8-J9 Connector		
Pin	**Wire**	**Circuit Function**
1	T1	120 VAC Power for the Battery Charger
2	0	Neutral Connection for T1 (battery charger)

J8-J9 Connector		
Pin	**Wire**	**Circuit Function**
1	T1	120 VAC Power for the Battery Charger
2	0	Neutral Connection for T1 (battery charger)

Synergy AVR

See Figure 239 – Synergy Air-cooled AVR has 2 Molex style connectors on the back (P1 and P2).

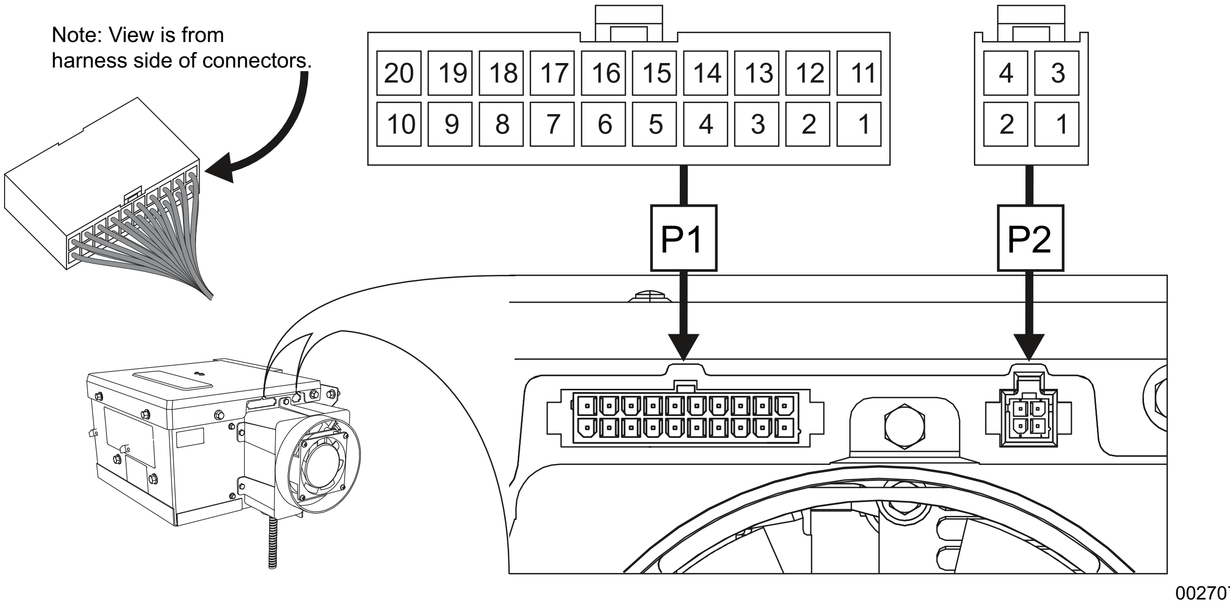


Figure 1-7. Synergy Air-cooled AVR and Connectors (Harness End)

P1 Connector		
Pin	**Wire**	**Circuit Function**
P1-1	476	PWM DC Voltage Supply (Positive)
P1-2	479	Comms DC Voltage (Signal -)*
P1-3	480	Comms DC Voltage (Signal +)*
P1-4	481	Comms DC Voltage (Ground)
P1-5	482	AVR Ground
P1-6	398A	Current Transformer
P1-7	399A	Current Transformer
P1-8	23	Transfer control wire
P1-9	BLACK	Aux Power Supply (GND)
P1-10	11S	Generator Voltage Sense
P1-11	477	PWM DC Voltage (Signal)
P1-12	478	PWM DC Voltage (Ground)
P1-13	484	AVR Enable (Positive)
P1-14	485	AVR Enable (Ground)
P1-15	483	AVR Power (Positive)
P1-16	398B	Current Transformer
P1-17	399B	Current Transformer
P1-18	SHLD	Shield GND
P1-19	RED	Aux Power Supply (Positive)
P1-20	44S	Generator Voltage Sense

P2 Connector		
Pin	**Wire**	**Circuit Function**
P2-1	BLACK	Large Fan
P2-2	RED	Large Fan
P2-3	WHITE	Small Fan
P2-4	BLUE	Small Fan

Test 7 – Power Windings Resistance Test Results		
Test Point A	Test Point B	Results
Procedure A		
Stator Lead Wire 11	Stator Lead 22	
Stator Lead Wire 33	Stator Lead 44	
P1 Connector Wire 11S	P1 Connector Wire 44S	
Procedure B		
Stator Lead Wire 11	Good Engine Ground	
Stator Lead Wire 33	Good Engine Ground	
P1 Connector Wire 22S	Good Engine Ground	
Procedure C		
Stator Lead Wire 11	Stator Lead Wire 33	
Stator Lead Wire 11	Stator Lead Wire 44	
Stator Lead Wire 2	Stator Lead Wire 33	
Stator Lead Wire 6	Stator Lead Wire 44	

Test 7 – Power Windings Resistance Test Results		
Test Point A	Test Point B	Results
Procedure A		
Stator Lead Wire 11	Stator Lead 22	
Stator Lead Wire 33	Stator Lead 44	
P1 Connector Wire 11S	P1 Connector Wire 44S	
Procedure B		
Stator Lead Wire 11	Good Engine Ground	
Stator Lead Wire 33	Good Engine Ground	
P1 Connector Wire 22S	Good Engine Ground	
Procedure C		
Stator Lead Wire 11	Stator Lead Wire 33	
Stator Lead Wire 11	Stator Lead Wire 44	
Stator Lead Wire 2	Stator Lead Wire 33	
Stator Lead Wire 6	Stator Lead Wire 44	

Test 7 – Power Windings Resistance Test Results		
Test Point A	Test Point B	Results
Procedure A		
Stator Lead Wire 11	Stator Lead 22	
Stator Lead Wire 33	Stator Lead 44	
P1 Connector Wire 11S	P1 Connector Wire 44S	
Procedure B		
Stator Lead Wire 11	Good Engine Ground	
Stator Lead Wire 33	Good Engine Ground	
P1 Connector Wire 22S	Good Engine Ground	
Procedure C		
Stator Lead Wire 11	Stator Lead Wire 33	
Stator Lead Wire 11	Stator Lead Wire 44	
Stator Lead Wire 2	Stator Lead Wire 33	
Stator Lead Wire 6	Stator Lead Wire 44	

Test 7 – Power Windings Resistance Test Results		
Test Point A	Test Point B	Results
Procedure A		
Stator Lead Wire 11	Stator Lead 22	
Stator Lead Wire 33	Stator Lead 44	
P1 Connector Wire 11S	P1 Connector Wire 44S	
Procedure B		
Stator Lead Wire 11	Good Engine Ground	
Stator Lead Wire 33	Good Engine Ground	
P1 Connector Wire 22S	Good Engine Ground	
Procedure C		
Stator Lead Wire 11	Stator Lead Wire 33	
Stator Lead Wire 11	Stator Lead Wire 44	
Stator Lead Wire 2	Stator Lead Wire 33	
Stator Lead Wire 6	Stator Lead Wire 44	

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Part No. 0K9138 Rev. B Date 07/26/16

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