DIAGNOSTIC REPAIR MANUAL

GENERAC®

50 Hz and 60 Hz Air-Cooled Product with Evolution™ and Evolution 2.0™ Control

STANDBY GENERATORS

⚠WARNING

CANCER AND REPRODUCTIVE HARM
www.P65Warnings.ca.gov.

(000393a)

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.

Read This Manual Thoroughly

This diagnostic manual has been written and published by Generac to aid qualified Generac 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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Section 1.1 Generator Basics

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 the Evolution 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 has been divided into SECTIONS and each section consists of SUBSECTIONS.

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.

Sections

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

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

Section 3 – Engine/DC Control – Provides the troubleshooting and diagnostic testing procedure for engine related problems on the Evolution™ Controllers.

Section 4 – Disassembly – Provides detailed step-by-step instructions for the replacement of the rotor/stator and engine.

Section 5 – Electrical Data – Illustrates all of the electrical and wiring diagrams for the various kW ranges and transfer switches.

Specifications

For rated power capacity, rated voltages, maximum load, harmonic distortion, main line circuit breaker sizes, number of phases, number of rotor poles, rated frequency, power factor, battery requirement, unit weight, dimensions, sound output, exercise duration, engine type, number of cylinders, displacement, cylinder block design, valve arrangement, ignition system, governor system, compression ratio, starter system, oil capacity, operating rpm, and fuel consumption, please refer to the specific unit's spec sheet located at www.generac.com.

IMPORTANT NOTE: All unit specifications are subject to change.

Table 1-1. Stator Winding Resistance Values / Rotor Resistance*

	Power Windings Across 11 & 22	Power Windings Across 11&44	Power Windings Across 33 & 44	Sensing Windings Across 11s & 44s	Excitation Windings Across 2 & 6	Rotor Resistance
8 kW	0.16 - 0.18	0.32 - 0.37	0.16 - 0.18	0.35 - 0.41	0.55 - 0.64	4.96 - 5.76
9 kW	0.16 - 0.18	0.32 - 0.37	0.16 - 0.18	0.37 - 0.43	1 - 1.16	6.30 - 7.32
10 kW (2019)	0.13 - 0.16	0.26 - 0.32	0.13 - 0.16	0.31 - 0.38	0.9 - 1.05	6.82 - 7.93
11 kW	0.16 - 0.18	0.32 - 0.37	0.16 - 0.18	0.35 - 0.41	0.55 - 0.64	4.97 - 5.76
13 kW (2019)	0.13 - 0.15	0.26 - 0.31	0.13 - 0.15	0.3 - 0.35	0.84 - 0.98	7.09 - 8.23
13/14 kW	0.12 - 0.14	0.25 - 0.29	0.12 - 0.14	0.28 - 0.33	0.85 - 0.99	7.22 - 8.39
15 kW	0.08 - 0.09	0.11 - 0.12	0.08 - 0.09	0.11 - 0.12	0.71 - 0.82	8.39 - 9.72
16 kW (2019)	0.07 - 0.08	0.14 - 0.17	0.07 - 0.08	0.2 - 0.23	0.71 - 0.82	8.37 - 9.72
16/17 kW	0.07 - 0.08	0.14 - 0.17	0.07 - 0.08	0.2 - 0.23	0.71 - 0.82	8.37 - 9.72
20 kW	0.04 - 0.05	0.08 - 0.1	0.04 - 0.05	0.14 - 0.16	0.61 - 0.71	9.54 - 11.10
22 kW	0.04 - 0.04	0.07 - 0.08	0.04 - 0.04	0.15 - 0.18	0.64 - 0.74	10.25 - 11.92
24 kW	0.04 - 0.04	0.09 - 0.11	0.05 - 0.05	0.09 - 0.11	0.71 - 0.82	9.99 - 11.61
8 kVA (50 Hz)	0.18 - 0.2	0.35 - 0.41	0.18 - 0.2	0.35 - 0.41	0.69 - 0.81	6.82 - 7.93
10 kVA (50 Hz)	0.08 - 0.1	0.16 - 0.19	0.08 - 0.1	0.16 - 0.19	0.74 - 0.86	8.28 - 9.62
13 kVA (50 Hz)	0.06 - 0.07	0.12 - 0.14	0.06 - 0.07	0.12 - 0.14	0.69 - 0.81	9.54 - 11.1

* Resistance values shown are based on new windings at 68 °F (20 °C) with neutrals connected. Actual readings may vary based on type of meter used and any other components or connections included in the circuit being tested.

Table 1-2. Fuel Consumption with Evolution and Evolution 2.0 Controller				
Unit	**Natural Gas***		**LP Vapor****	
	1/2 Load	**Full Load**	**1/2 Load**	**Full Load**
7/8 kW	78/2.21	121/3.43	0.87/3.29	1.42/5.37
9 kW (2017 and newer)	90/2.55	120/3.40	0.87/3.29	1.37/5.20
10/11 kW	124/3.51	195/5.52	1.18/4.45	1.92/7.28
10 kW (2019)	101/2.86	127/3.60	0.97/3.66	1.48/5.62
11 kW (2017 and newer)	107/3.03	159/4.50	1.22/4.62	1.97/7.45
13/13 kW	157/4.45	255/7.22	1.64/6.2	2.95/11.15
13 kW (2019)	154/4.36	225/6.37	1.54/5.83	2.45/9.28
14/14 kW	177/5.01	279/7.9	1.85/6.99	3.07/11.61
15/15 kW	185/5.24	296/8.38	1.83/6.91	3.19/10.82
16/16 kW	193/5.47	296/8.38	1.9/7.2	3.19/12.07
16/16 kW (2017 and newer)	218/6.17	309/8.75	2.03/7.70	2.94/11.11
16 kW (2019)	182/5.15	245/6.94	1.70/6.45	2.99/11.32
16/17 kW	193/5.47	312/8.83	1.99/7.53	3.57/13.53
17 kW (2017 and newer)	193/5.47	312/8.83	2.0/7.57	3.57/13.53
18/20 kW	205/5.8	308/8.72	2.08/7.87	3.85/14.57
20 kW (2017 and newer)	204/5.78	301/8.52	2.37/8.99	3.56/13.48
22 kW	184/5.21	281/7.96	2.16/8.16	3.68/13.94
22 kW (2017 and newer)	228/6.46	327/9.26	2.53/9.57	3.90/14.77

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

IMPORTANT NOTE: All unit specifications are subject to change.

Table 1-3. Engine with Evolution and Evolution 2.0 Controller							
Displacement	**Model**	**No. of Cylinders**	**Oil Capacity (w/Filter)**	**Recommended Spark Plug**	**Spark Plug Gap**	**Valve Clearance**	**Compression Pressure**
410cc	8 kW	1	Approx. 1.5 Qt/ 1.4L	RC12YC Generac P/N 0G0767A	0.508 mm (0.020 inch)	0.05-0.1mm (0.002-0.004 in)	190 psi +/- 10-15%
426cc	9 kW	1	Approx. 1.1 Qt/ 1.0L	RC12YC Generac P/N 0G0767A	0.508 mm (0.020 inch)	0.05-0.1mm (0.002-0.004 in)	80–120 psi *
460cc	10 kW	1	Approx. 1.1 Qt/ 1.0L	RC12YC Generac P/N 0G0767A	0.508 mm (0.020 inch)	0.05-0.1mm (0.002-0.004 in)	80–120 psi *
530cc	11 kW	2	Approx. 1.7 Qt/ 1.6L	BPR6HS/RL87YC Generac P/N 0E9368	0.76 mm (0.030 inch)	0.05-0.1mm (0.002-0.004 in)	170 psi +/- 10-15%
816cc	13/16 kW (2019) 14/18 kW (2020)	2	Approx. 2.2 Qt/ 2.1L	RC12YC Generac P/N 0G0767A	0.508 mm (0.020 inch)	Hydraulic lifters—Not adjustable	180–220 psi
992cc	13/14/15/16/17 kW	2	Approx. 1.9 Qt/ 1.8L	RC14YC Generac P/N 0E7585	1.02 mm (0.040 inch)	0.05-0.1mm (0.002-0.004 in)	185 psi +/- 10-15%
999cc	16/17kW (2017) 20/22/24 kW	2	Approx. 1.9 Qt/ 1.8L	RC12YC Generac P/N 0G0767A	1.02 mm (0.040 inch)	0.05-0.1mm (0.002-0.004 in)	185 psi +/- 10-15%

* The 426 cc and the 460 cc engine have an Automatic Compression Release (ACR) system that will not allow full compression while cranking. Full compression resumes at 650 RPM when ACR disengages.

Component Locator

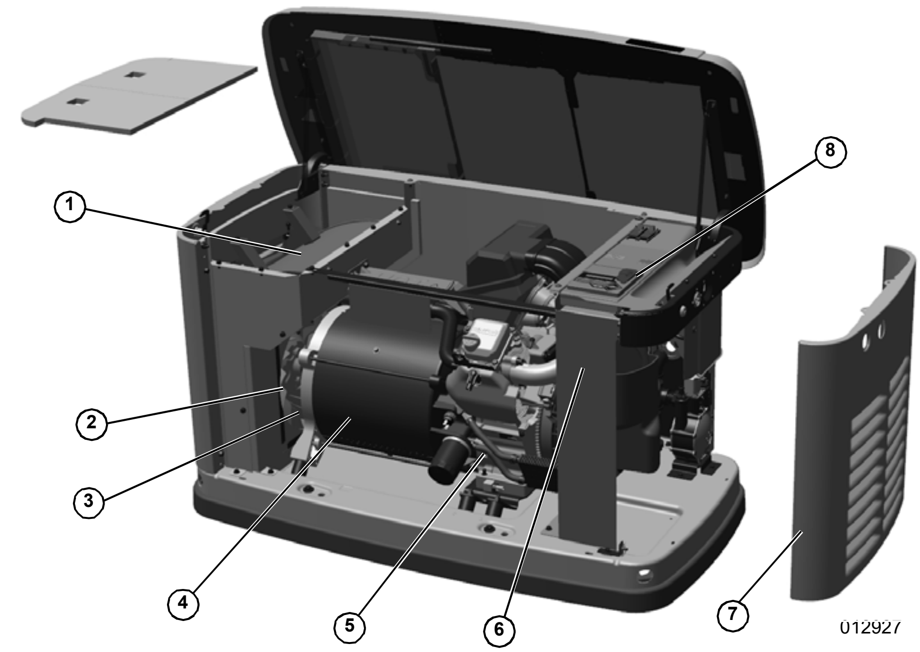

Figure 1-1.

1. Exhaust
2. Generator Fan
3. Brush Assembly (mounted to bearing carrier)
4. Alternator
5. Engine
6. Data Plate
7. Access Panel
8. Evolution Controller

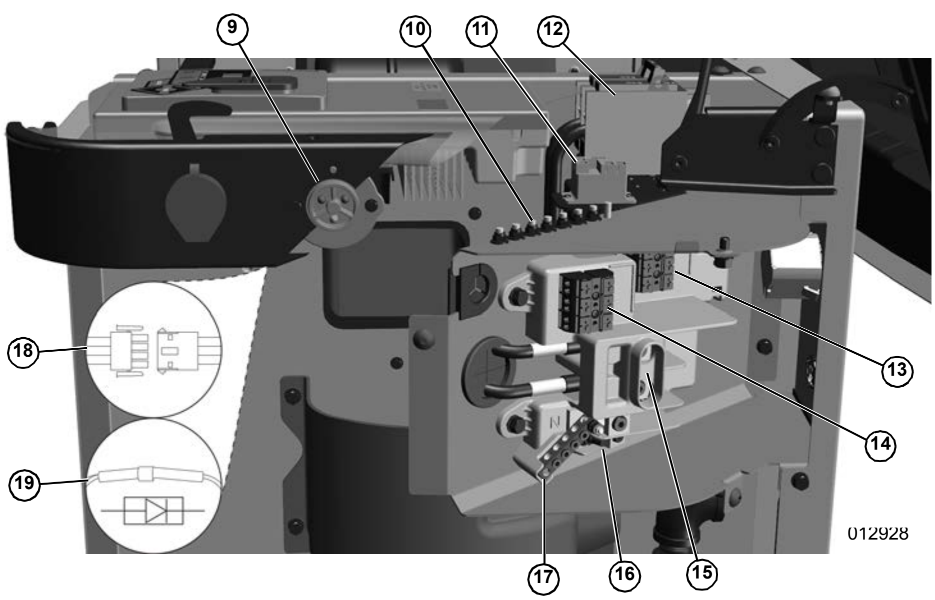

Figure 1-2.

9. LED Status
10. Chassis ground lugs
11. Starter Contactor Relay (SCR)
12. Main Line Circuit Breaker (MLCB)
13. AC Wago Block
14. DC Wago Block
15. E1 and E2 Lugs
16. Ground Lug
17. Neutral Lug
18. Stator Connector (STR) (in harness)
19. Field Boost Diode (in harness)

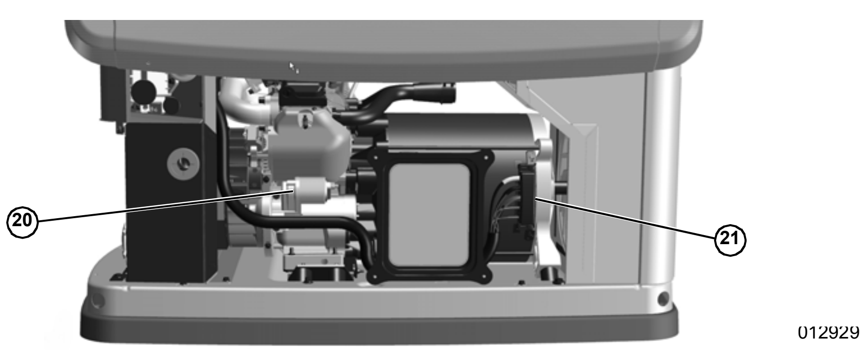

Figure 1-3.

20. Starter Contactor (SC)
21. Stator Terminal Block (STB) (if equipped)

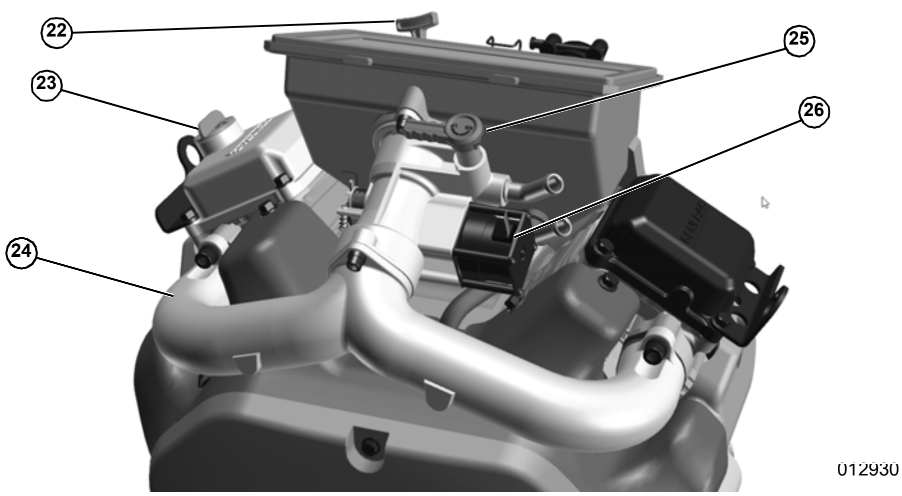

Figure 1-4.

22. Oil Dipstick
23. Oil Fill
24. Intake Manifold
25. Fuel Select
26. Stepper Motor

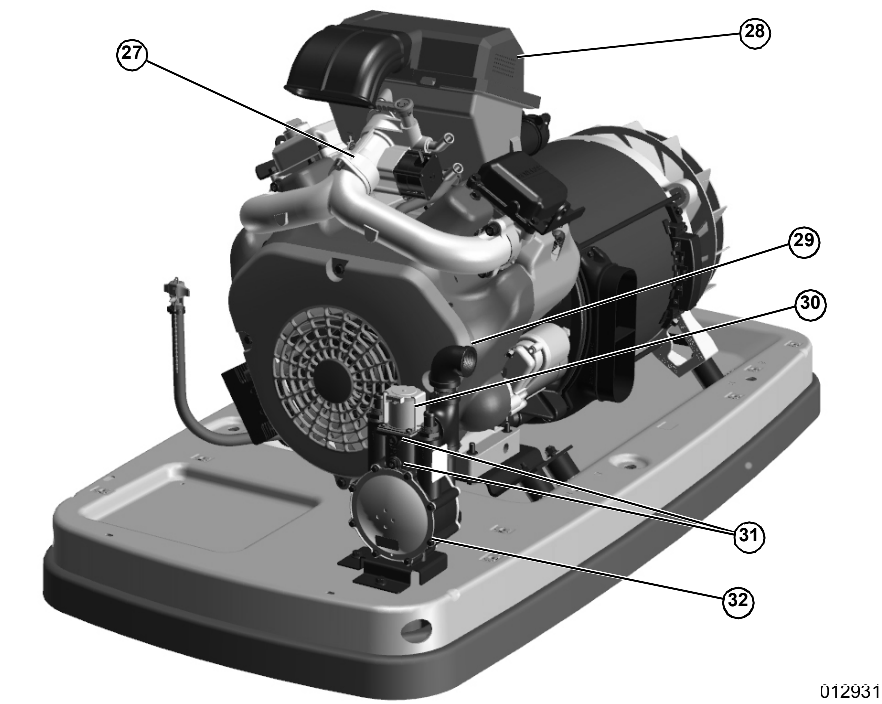

Figure 1-5.

27. Venturi Mixer
28. Air Filter
29. Fuel Supply
30. Fuel Solenoid
31. Test Ports
32. Demand Regulator

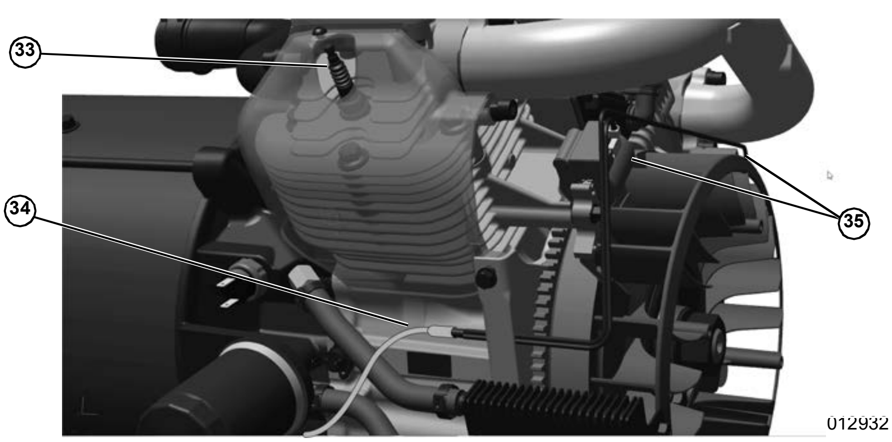

Figure 1-6.

33. Spark Plug
34. Wire 18
35. Ignition Magnetos

Table 1-4. Symptom Related Diagnostic Guide

Problem - Symptom	Go To…
Aux Shutdown - E2800	Check harness/switches
Battery is Dead	Section 4.5, Problem 22
Charger Missing AC	Problem 22
Charger Warning	Problem 22
Controller displays “Model Ident Problem Fix Harness Resistor”	Section 4.5, Problem 23
Controller Fuse (7.5 Amp - F1) Blown (open)	Section 4.5, Problem 19
Controller Goes Dark and Reboots when Starting	Section 4.5, Problem 16
Controller Displays “Warming Up” longer than 5 seconds	Preliminary Output Voltage Test (POVT)
Engine Backfires and/or Hunts or Erratic Operation	Section 4.5, Problem 18
Engine Cranks but Will Not Start	Section 4.5, Problem 17
Engine Starts Hard and/or Runs Rough or Lacks Power	Section 4.5, Problem 18
Engine Will Not Crank When Controller Set to AUTO or MANUAL	Section 4.5, Problem 16
Engine Will Not Crank When Utility Power Source Fails	Section 4.5, Problem 15
Generator Produces High Voltage	Section 2.2, P.O.V.T.
Generator Shuts Down for Under Voltage	Section 2.2, P.O.V.T.
Generator Will Not Exercise	Section 4.5, Problem 20
High Temperature - E1400	Test 62
Incorrect Voltage Output, but does not Trigger a Shutdown	Section 2.2, Problem 4
Low Battery	Test 45
Low Oil Pressure - E1300	Test 61
Model Ident Problem - Fix Harness Resistor	Problem 23
No Low-Speed Exercise	Section 4.5, Problem 21
Over Crank - E1100	Section 4.5, Problem 17
Overload Remove Load - E2100	Test 15
Overspeed - E1200, E1205	Test 53 (was Test 12)
Overspeed - E1207	Test 64 and Test 60
Overvoltage - E1800	Section 2.2, Problem 2
RPM Sense Failure - E1501, E1511	Test 50 and Test 64
RPM Sense Failure (Engine Cranks) - E1505, E1515	Test 64
RPM Sense Failure (Engine Does Not Crank) - E1505, E1515	Problem 15
Shutdown Fault Occurred During Crank Attempt, Start or Run	Section 4.5, Problem 14
Under Speed - E1600, E1603	Problem 3, Test 50, Test 53
Undervoltage - E1900, E1901, E1902, E1906	Section 2.2, P.O.V.T.
Undervoltage Overload - E2299	Test 15
Unstable Voltage, but does not Trigger a Shutdown	Section 2.2, Problem 4
Voltage and Frequency Drop Excessively When Loads Are Applied	Section 2.2, Problem 3
Wiring Error - E2099	Check Wiring Interconnection

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, including loose or dirty connections.
- All wiring is well clear of rotating and hot parts.
- Generator output voltage rating matches utility voltage.
- Foreign objects, loose nuts, bolts and other fasteners.
- Area around the generator is clean and clear of 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 Megohmmeter to 500 volts and apply voltage for a maximum of one second. Follow the Megohmmeter manufacturers instructions carefully. Do not exceed 500 volts or apply voltage longer than 1 second. Megohmmeter HIGH voltages could cause damage to other components on the generator. Take the proper precautions before testing.

Testing Stator Insulation

See ***Figure 1-7***. Isolate all stator leads and connect all the stator leads together.

Use a Megohmmeter power setting of 500 volts. Connect one Megohmmeter 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.

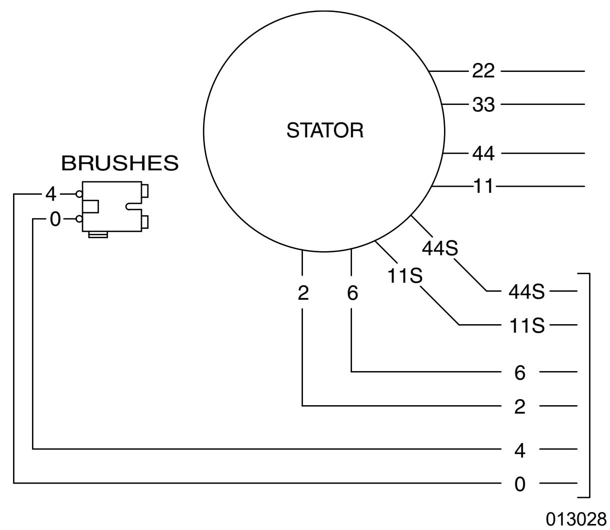

Figure 1-7. Typical Stator Output Leads

To calculate the minimum acceptable Megohmmeter 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 Megohmmeter to test for shorts between isolated windings as outlined in “Stator Insulation Tests.”

Testing Rotor Insulation

Apply a voltage of 500 volts across the rotor positive slip ring (nearest the rotor bearing), and a ground (i.e. the rotor shaft).

IMPORTANT NOTE: When testing stators and rotors, set Megohmmeter to 500 volts and apply voltage for a maximum of one second. Follow the Megohmmeter manufacturers instructions carefully. Do not exceed 500 volts or apply voltage longer than 1 second. Megohmmeter 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.

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.

Navigation Keys

See ***Figure 1-8***. There are four selection and navigation keys below the display.

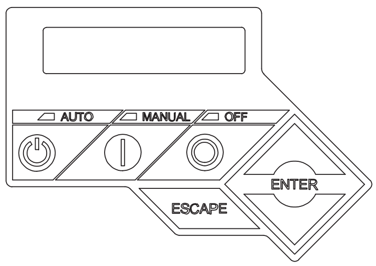

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Figure 1-8. Evolution Display and Navigation Buttons

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).
- Move left and right between various editable menus.
- Increase or decrease a value or change a choice in an editable menu (i.e. from Yes to No).

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 1-9*** and ***Figure 1-10***. The menu system diagram is shown in ***Figure 1-20*** and ***Figure 1-28***.

There are four selections in the Main Menu: System, Date/Time, Battery (Evolution 1.0), WIFI or Setup WIFI* (Evolution 2.0), Sub Menus.

SYSTEM	DATE/TIME
BATTERY	SUB MENUS

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Figure 1-9. Evolution 1.0 Display Main Menu

SYSTEM	DATE/TIME
WIFI*	SUB MENUS

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Figure 1-10. Evolution 2.0 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.

HISTORY	MAINT
EDIT	DEALER

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Figure 1-11. Evolution 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.

History
Alarm Log Run Log

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Figure 1-12. History Menu

1 09/15/10 04:55:22
Under Voltage

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Figure 1-13. Alarm Log Display

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

1 09/15/10 04:55:22
Stopped

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Figure 1-14. Run Log Display.

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

Maint (Evolution 1.0)

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

MAINT:	Run Hrs
Maint Log	Scheduled

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Figure 1-15. Maint Menu (Evolution 1.0)

Battery (Evolution 2.0)

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

Battery	Run Hrs
Maint Log	Scheduled

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Figure 1-16. Battery Menu (Evolution 2.0)

Edit

Selecting the Edit Menu enables editing of the following selections:

- Language
- Fuel Selection
- Cold Smart Start (firmware 1.14 and above)
- Current Date/Time
- Exercise Time
- Exercise Frequency
- Firmware Update

Table 1-5. Cold Smart Start Parameters

Node	8 - 20 kW	22 - 24 kW
Cold Smart Start (2015-02) and Ambient Temp display screen	X	X
Temperature Threshold	50 ºF	20 ºF
Default Setting	Yes	Yes
Transfer Time Delay	30 sec	30 sec

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.

Evolution Dealer Menu

Dealer

The Dealer Menu displays three selections:

- Display
- Dealer Edit
- Test

DEALER:	DISPLAY
DEALER EDIT	TEST

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Figure 1-17. Evolution Dealer Menu

Display

The Display Menu displays these selections:

- Battery Voltage
- Charging Status
- Run Hours
- Output Volts
- Output Frequency (Hz)
- Engine Speed (RPM)
- Utility Input Volts
- Ambient Temperature (ºF)
- V Firmware Hardware
- 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
- Set Output Voltage (Evolution 2.0)
- Calibrate Current 1
- Calibrate Current 2
- Calibrate Volts
- 2-Wire Start Select
- Wi-Fi Options (Evolution 2.0)
- Go To Wizard (Evolution 2.0)
- Reset Maintenance
- Factory Reset (Evolution 2.0)

These are editable selections within this menu selection.

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 1-6***. 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 1-6***. 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.

NOTE: This will also flash the 3 LED's on the left side of the unit.

- 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 1-18*** Inputs 2 and 7 are ON (Low Oil Pressure and the Auto switch). This indicates the unit is shut down and in AUTO.

NOTE: On an Evolution controller, the 1 (ON) in Input 7 is only visible while the AUTO mode is depressed. When the AUTO mode is released Utility 7 reverts to a 0 on the display.

INPUTS: Utility 240
0 1 0 0 0 0 1 0

002469

Figure 1-18. 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 1-19*** there are no Outputs ON. This indicates the unit is shut down.

OUTPUTS: Gen 0
0 0 0 0 0 0 0 0

002470

Figure 1-19. Test Outputs Display

Table 1-6. Digital Inputs and Outputs

Position	Digital Inputs	Digital Outputs
1	Auxiliary Shutdown	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	2-Wire Start	Starter
7	Auto	Ignition
8	Manual	Transfer

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.

Evolution 2.0/Sync 3.0 HSB Menu Map—EDIT

Note: Menu functions and features may vary depending on unit model and firmware revision.

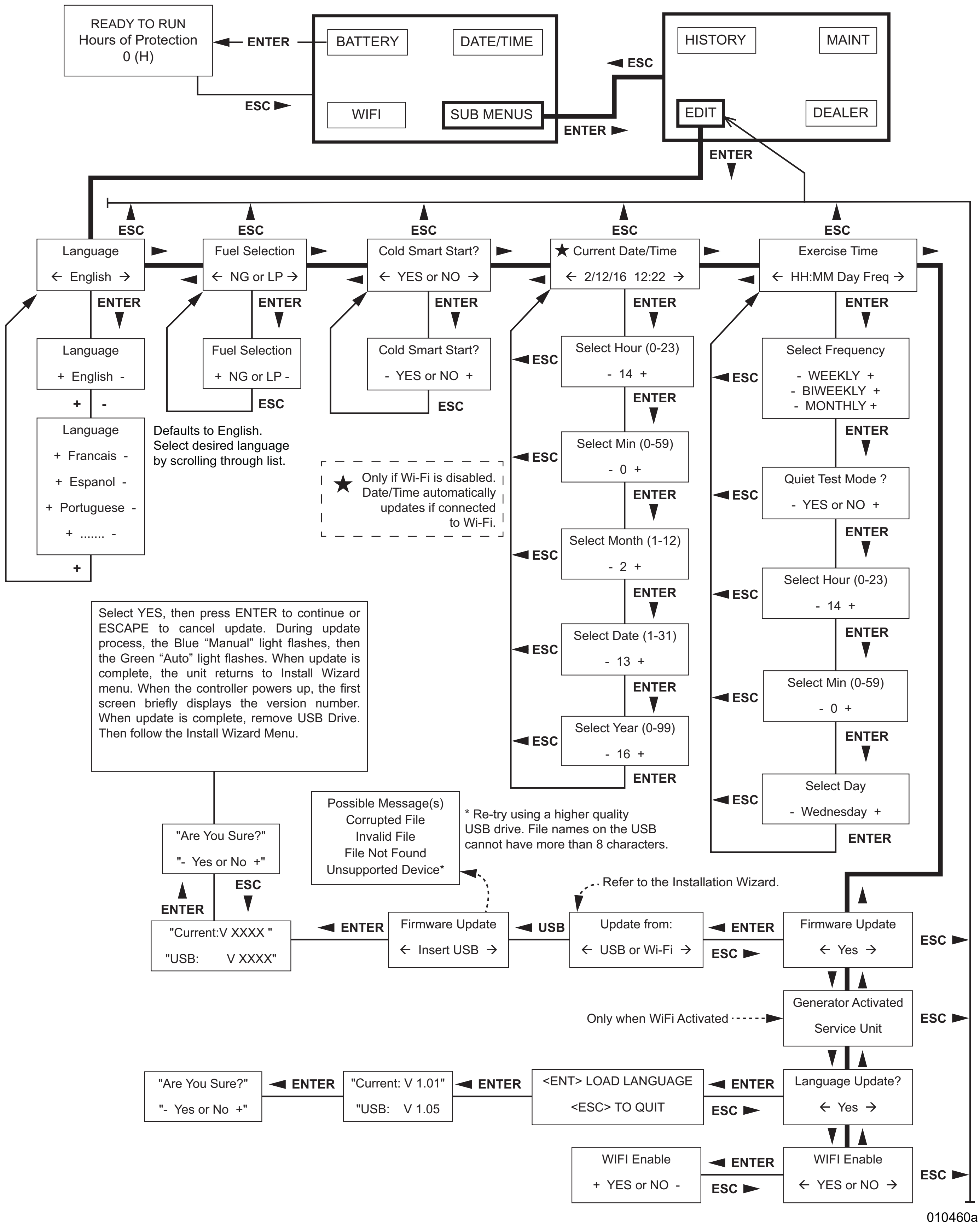


Figure 1-20. Evolution 2.0/Sync 3.0 HSB Menu Map—EDIT

Evolution 2.0/Sync 3.0 HSB Menu Map—HISTORY, MAINT

Note: Menu functions and features may vary depending on unit model and firmware revision.

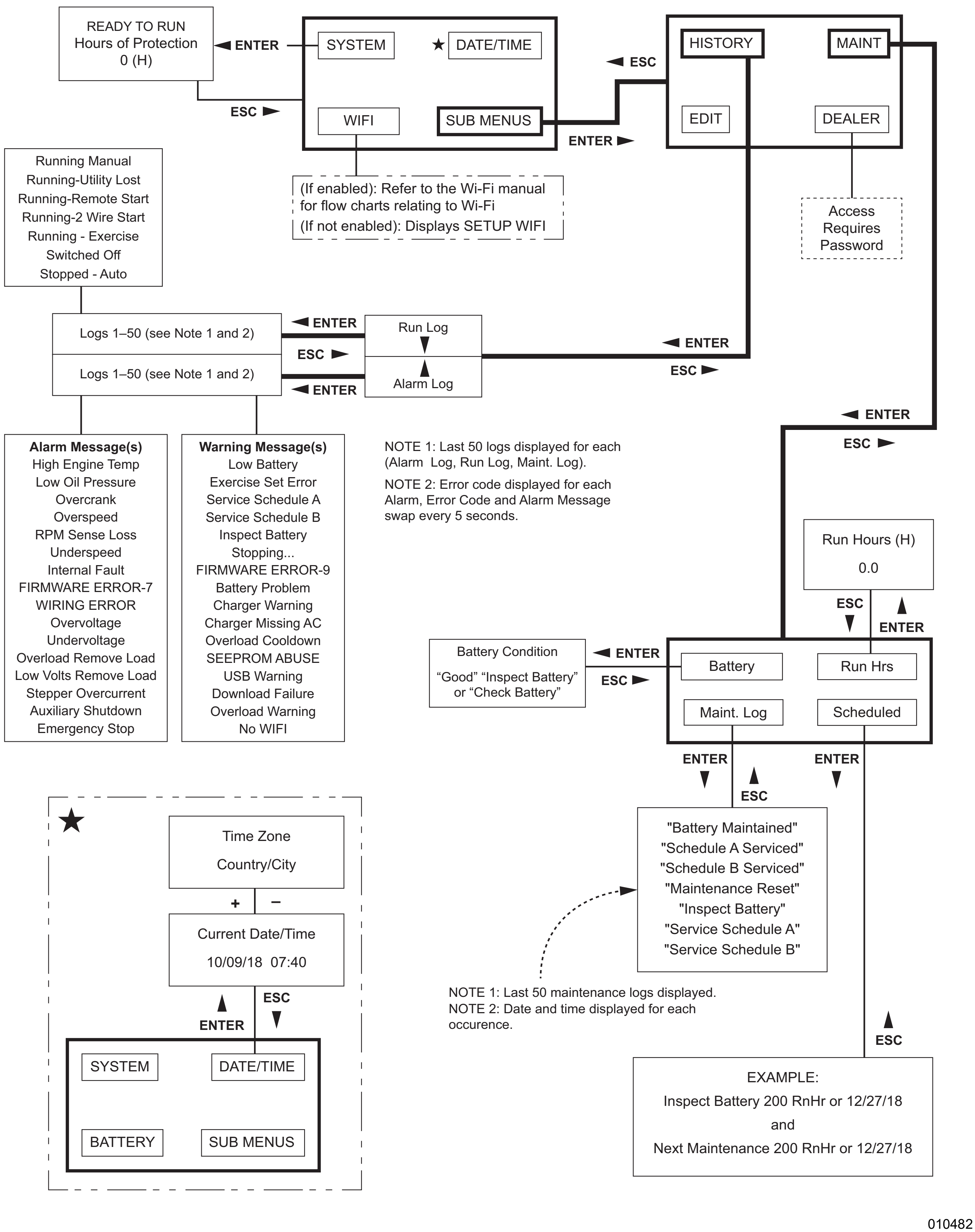


Figure 1-21. Evolution 2.0/Sync 3.0 HSB Menu Map—HISTORY, MAINT

Evolution 2.0/Sync 3.0 HSB Menu Map—SYSTEM

Note: Menu functions and features may vary depending on unit model and firmware revision.

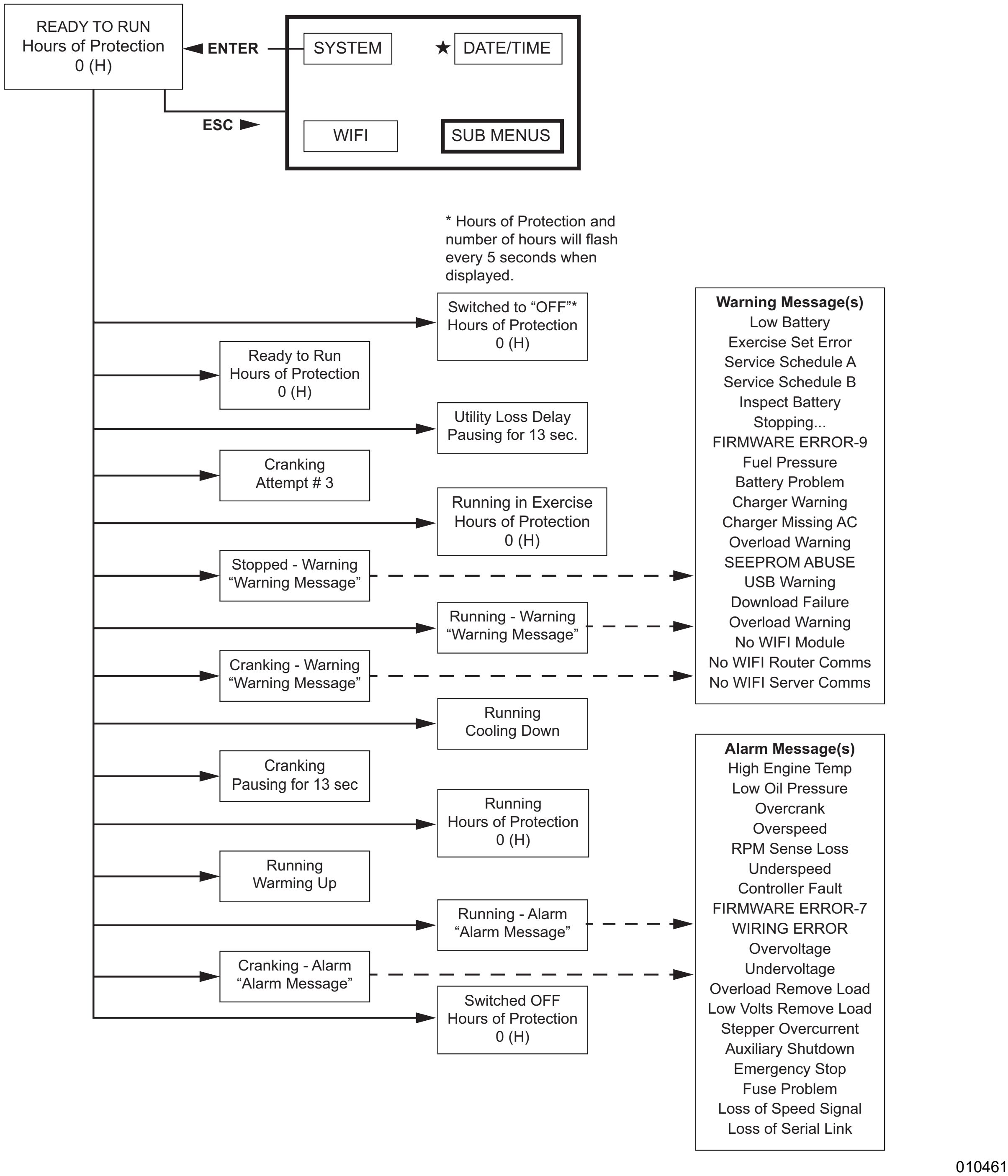


Figure 1-22. Evolution 2.0/Sync 3.0 HSB Menu Map—SYSTEM

Evolution 2.0/Sync 3.0 HSB Menu Map—ACTIVATION

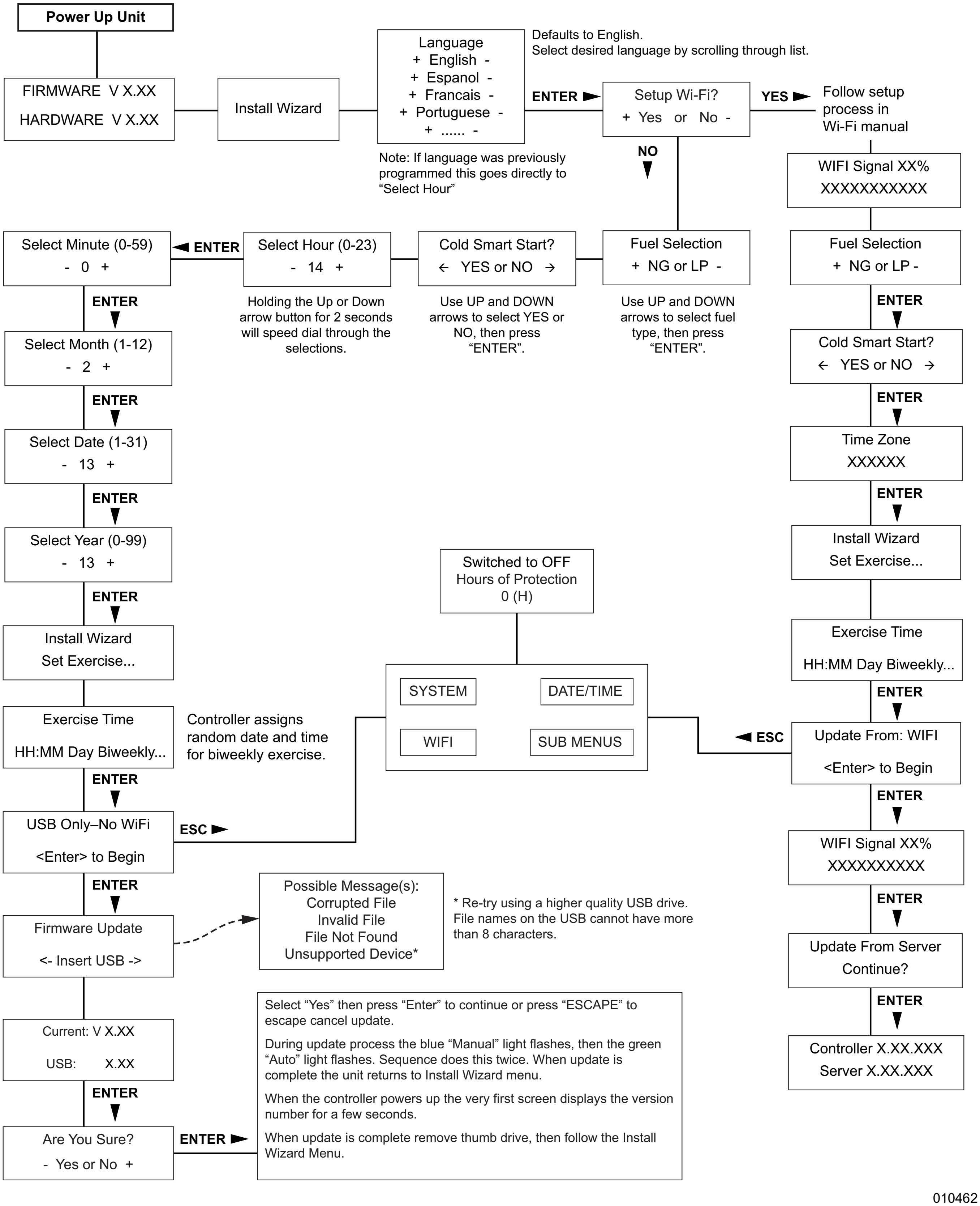


Figure 1-23. Evolution 2.0/Sync 3.0 HSB Menu Map—ACTIVATION

Evolution 2.0/Sync 3.0 HSB Menu Map—FIRMWARE

Note: Menu functions and features may vary depending on unit model and firmware revision.

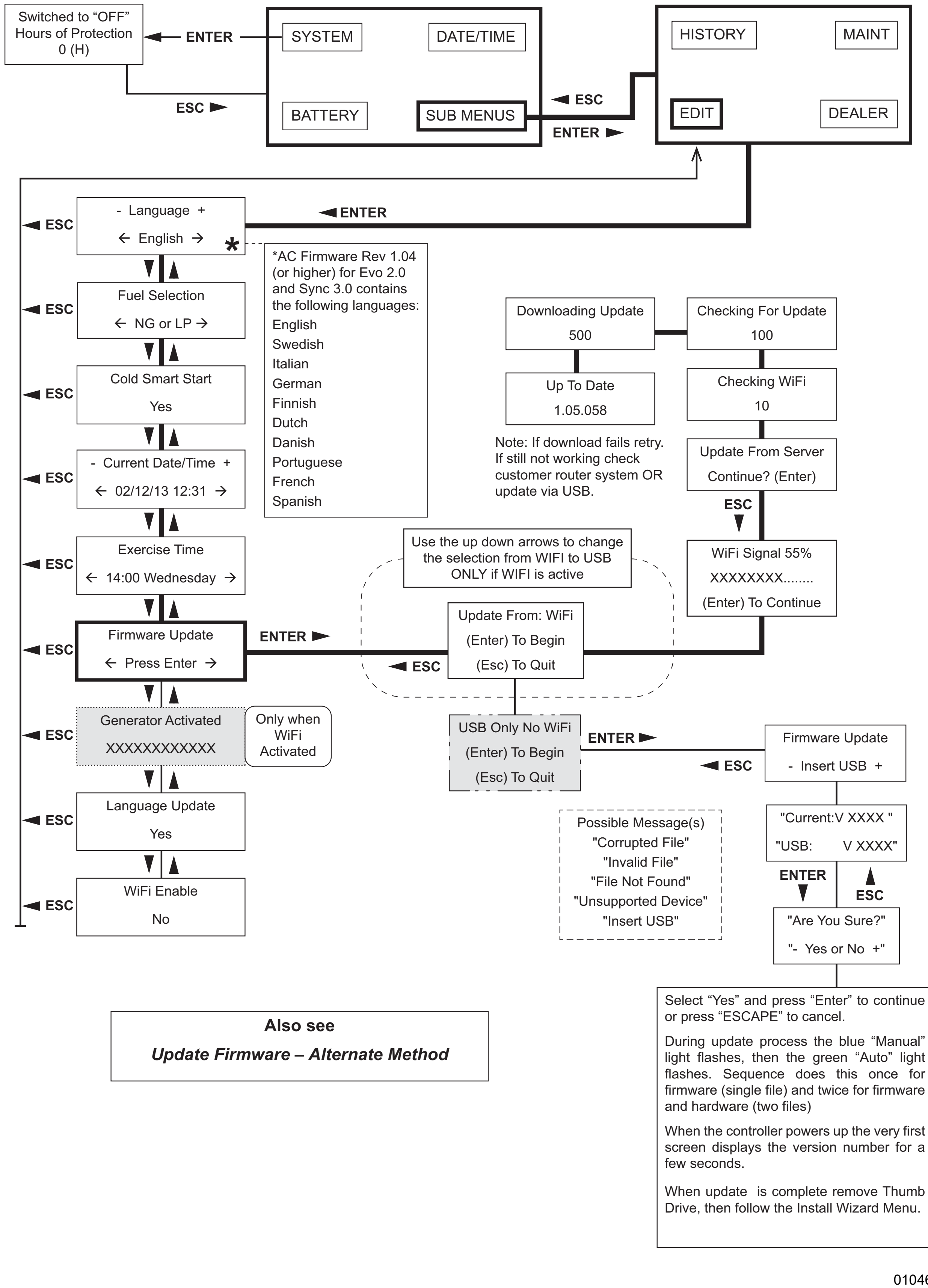


Figure 1-24. Evolution 2.0/Sync 3.0 HSB Menu Map—FIRMWARE

Evolution 2.0/Sync 3.0 HSB Menu Map—DEALER EDIT

To access Dealer Menu enter Password from MAIN DISPLAY:

UP, UP, ESC, DN, UP, ESC, UP, ENTER

Note:Unit needs to be activated to access the Dealer Menu.

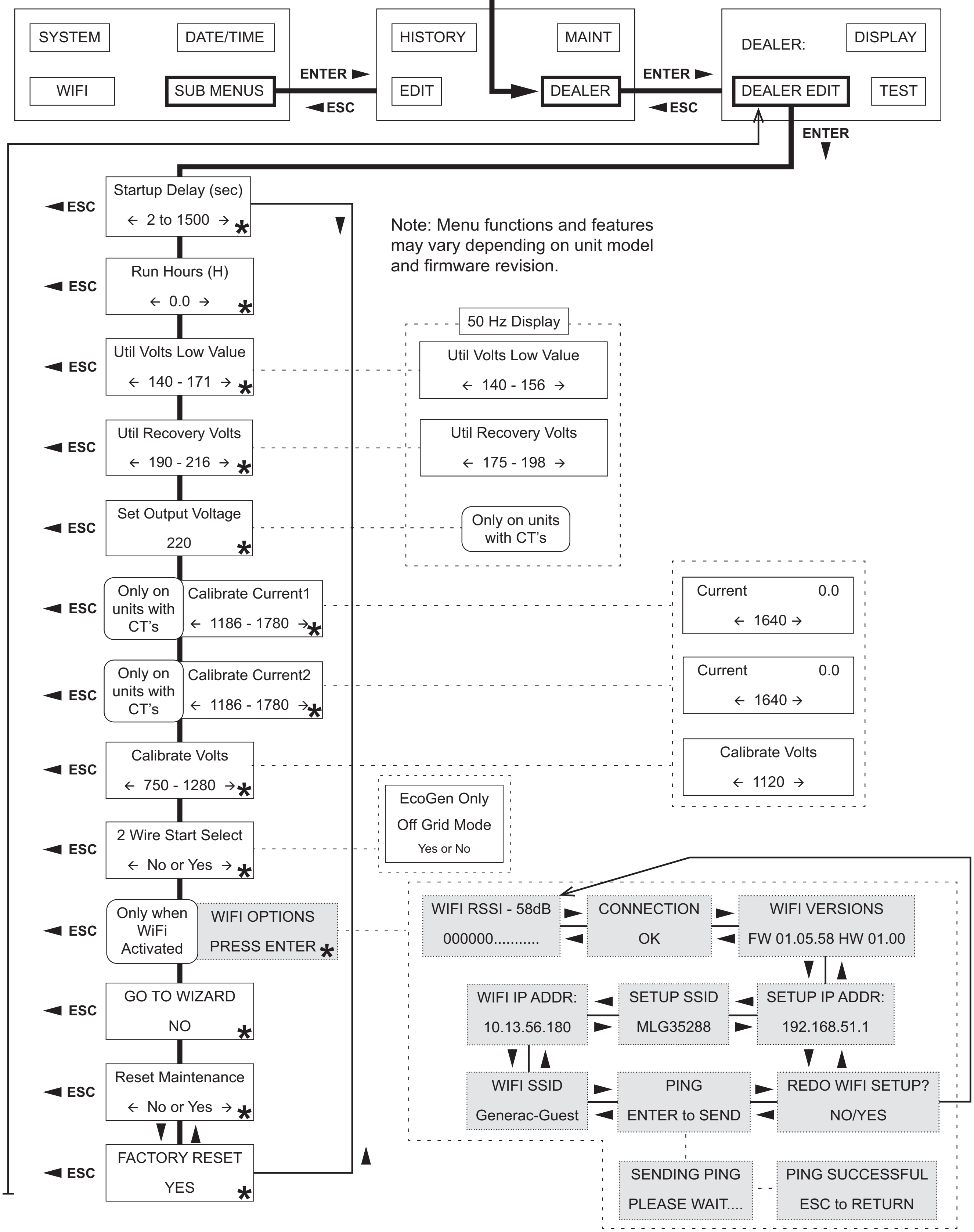


Figure 1-25. Evolution 2.0/Sync 3.0 HSB Menu Map—DEALER EDIT

Evolution 2.0/Sync 3.0 HSB Menu Map—DEALER TEST

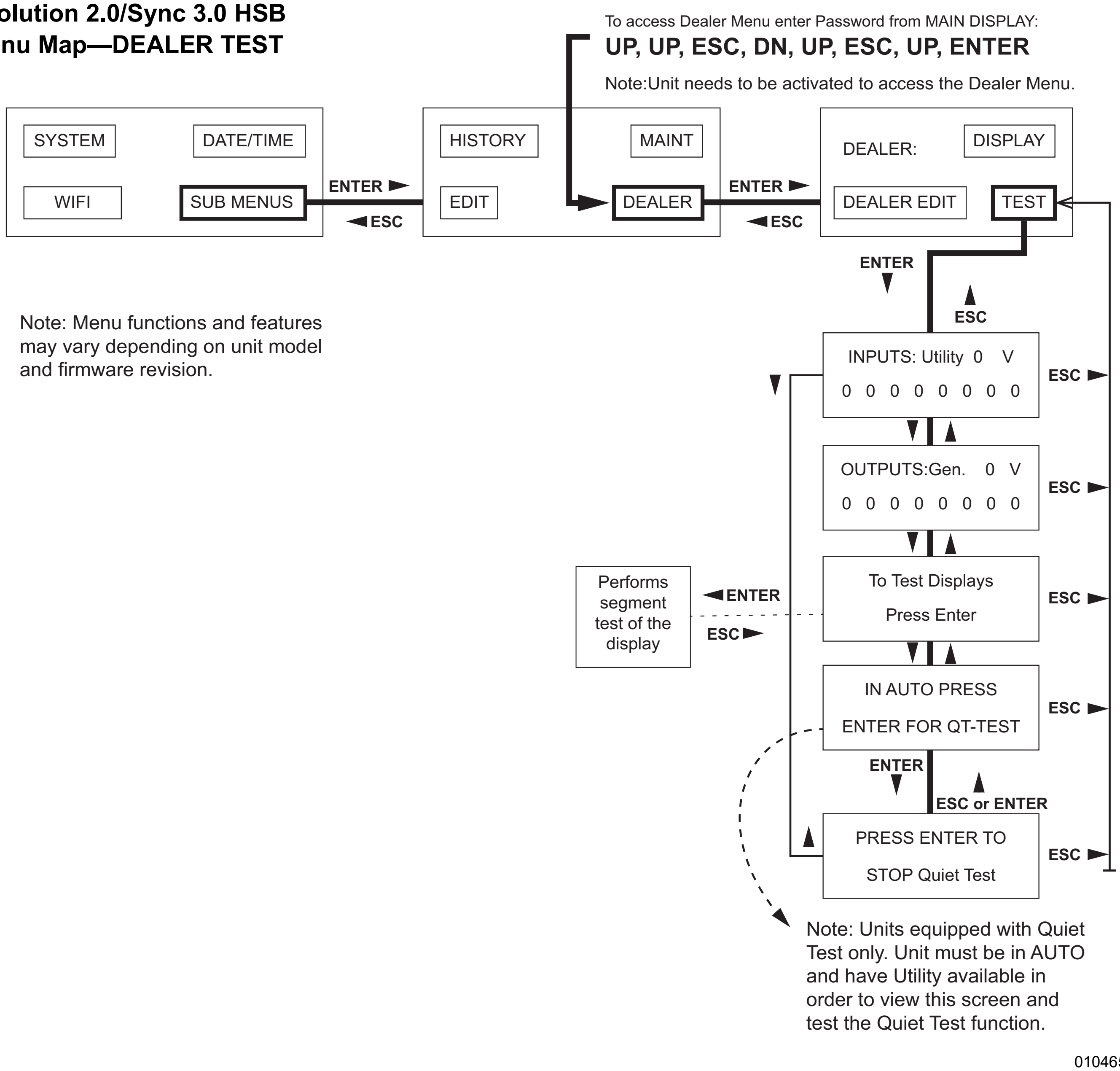


Figure 1-26. Evolution 2.0/Sync 3.0 HSB Menu Map—DEALER TEST

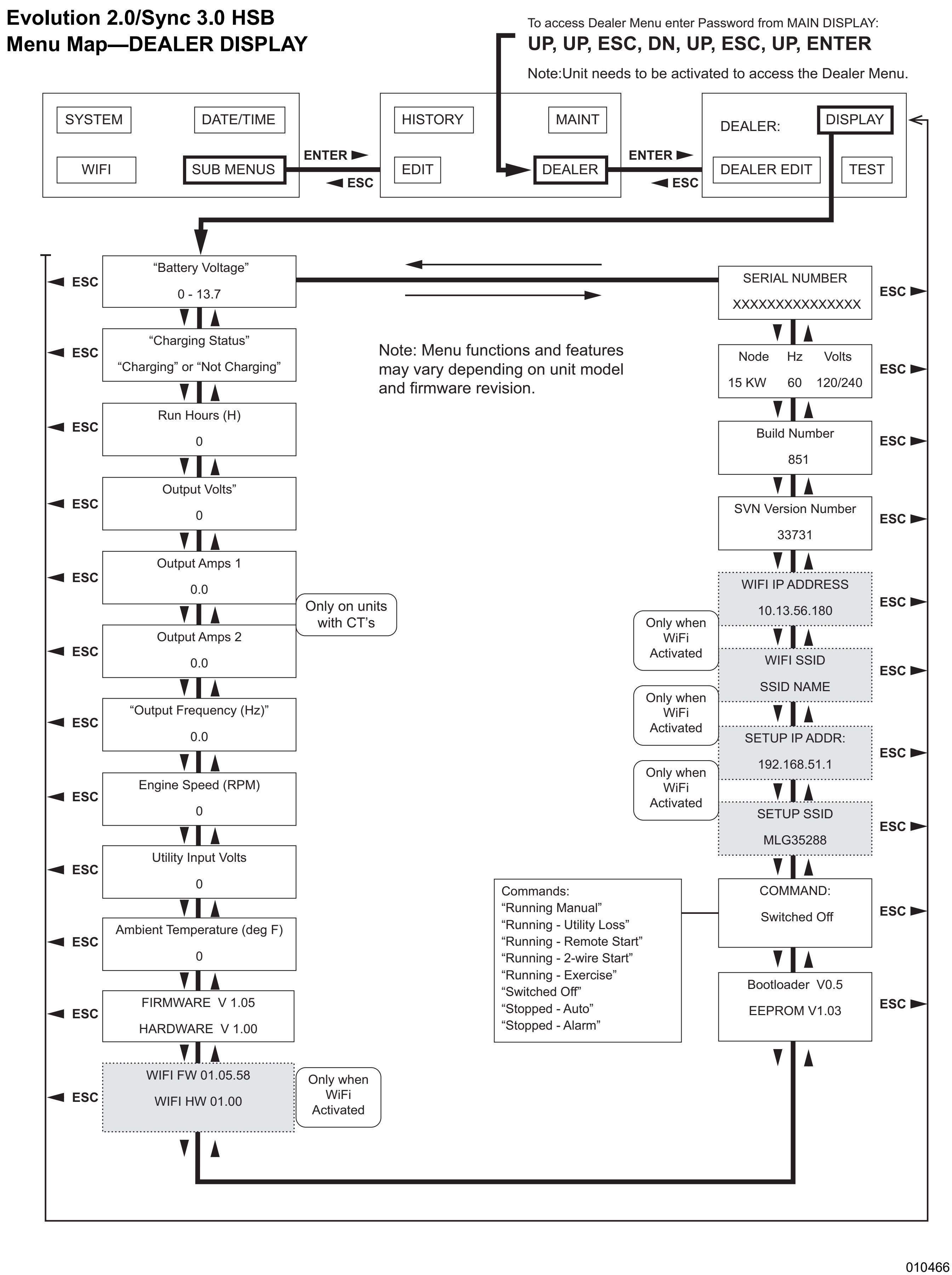


Figure 1-27. Evolution 2.0/Sync 3.0 HSB Menu Map—DEALER DISPLAY

Evolution 1.0/Sync 2.0 HSB Menu Map—EDIT

Note: Menu functions and features may vary depending on unit model and firmware revision.

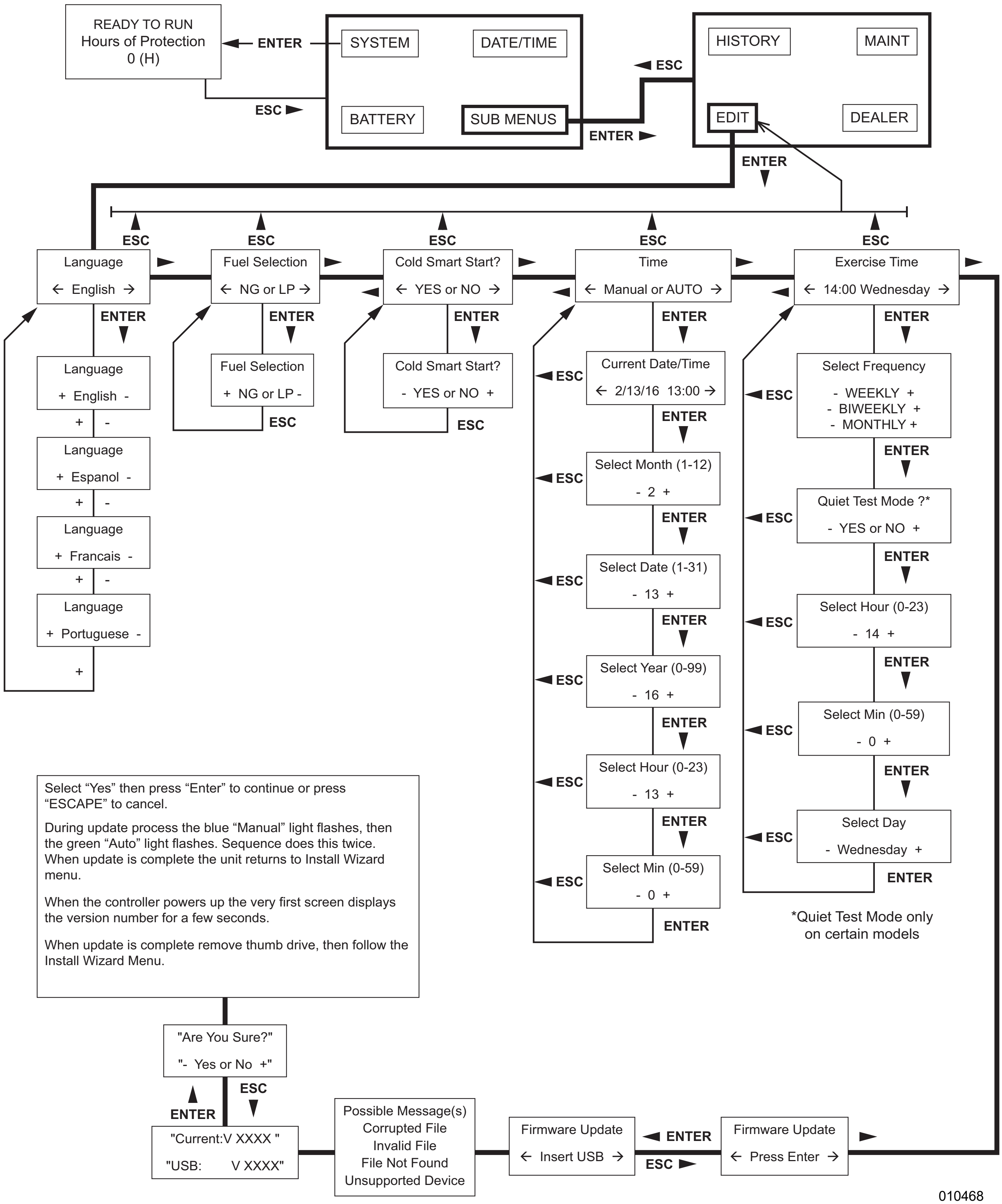


Figure 1-28. Evolution 1.0/Sync 2.0 HSB Menu Map—EDIT

Evolution 1.0/Sync 2.0 HSB Menu Map—HISTORY, MAINT

Note: Menu functions and features may vary depending on unit model and firmware revision.

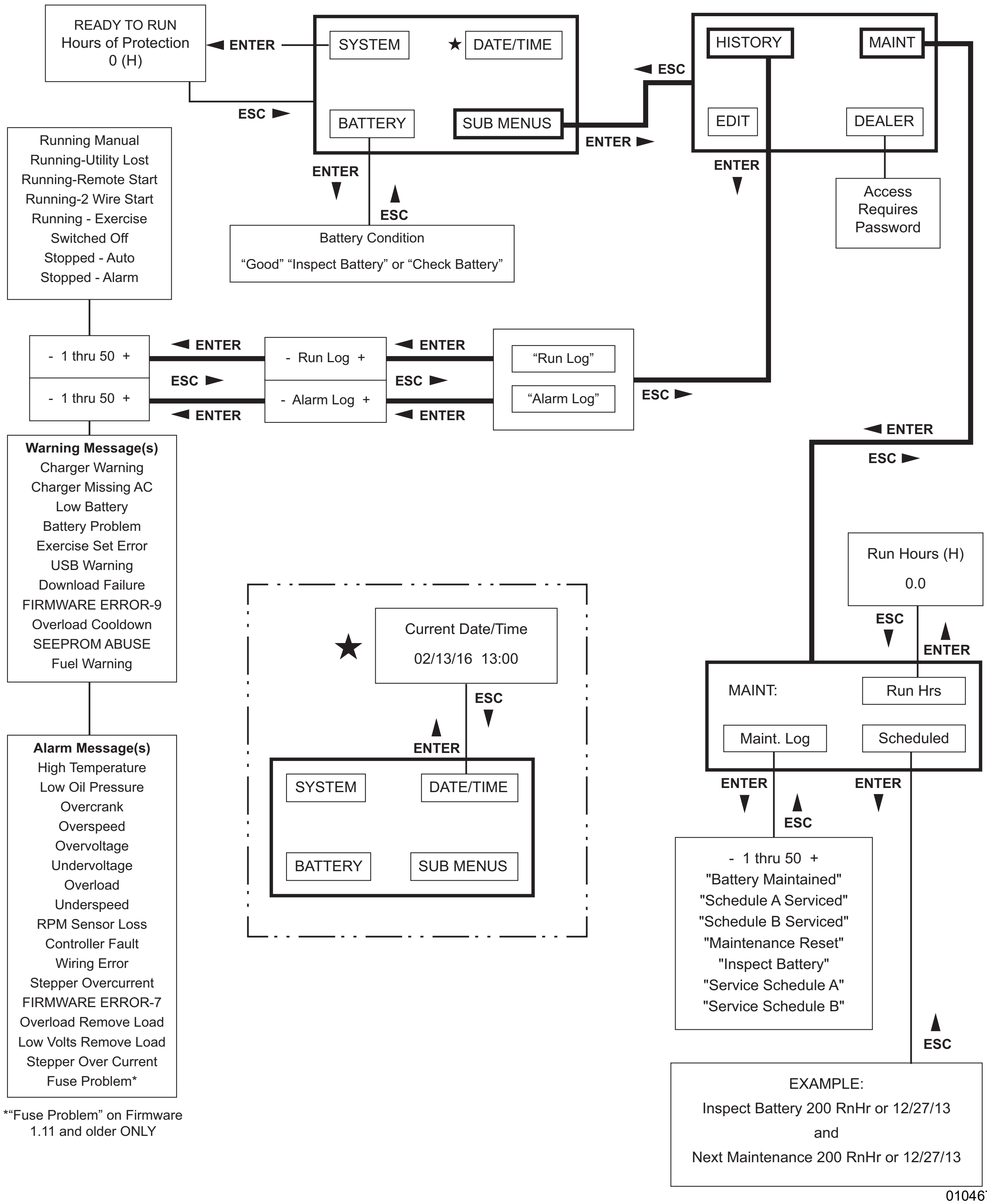


Figure 1-29. Evolution 1.0/Sync 2.0 HSB Menu Map—HISTORY, MAINT

Evolution 1.0/Sync 2.0 HSB Menu Map—ACTIVATION

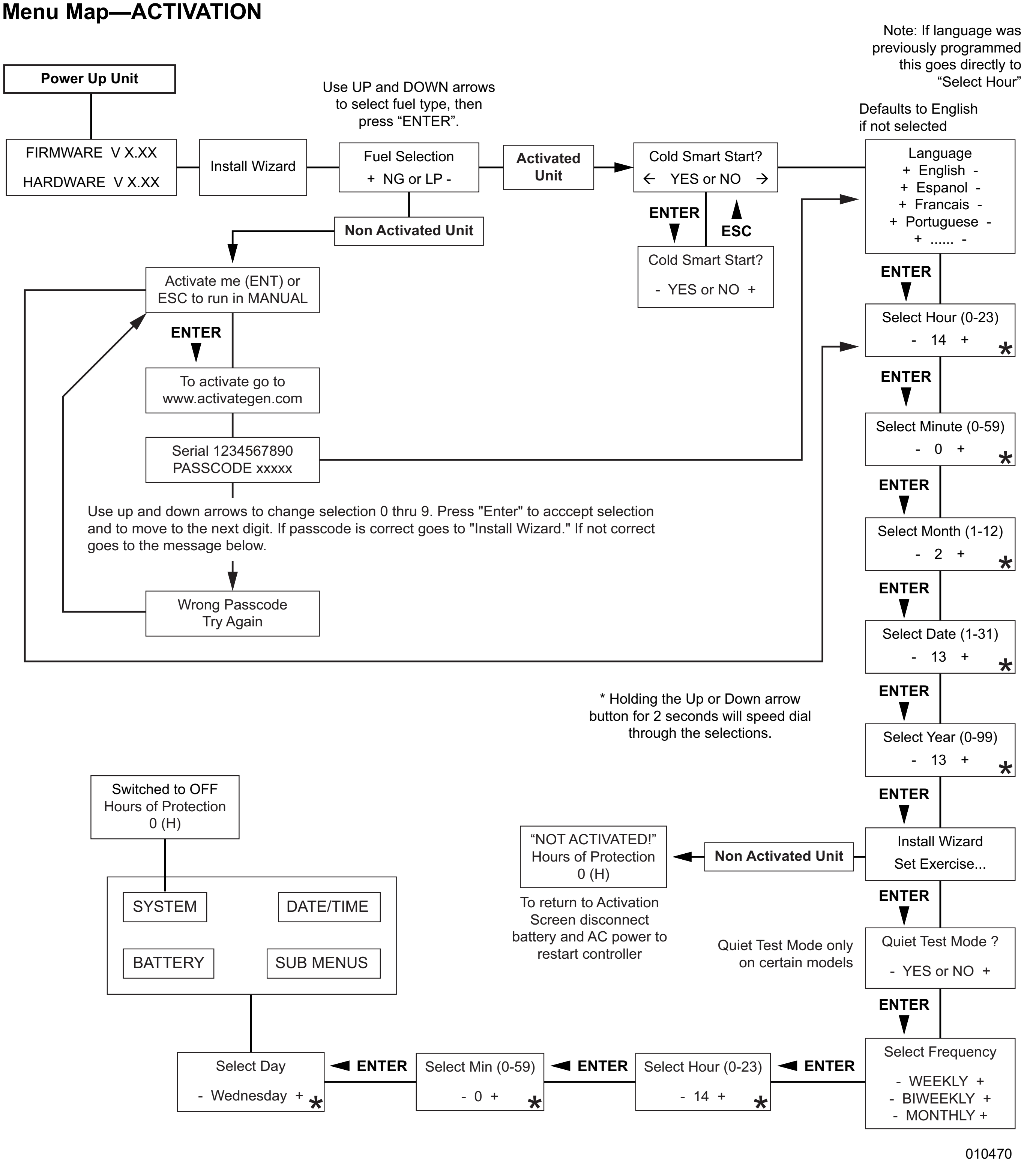
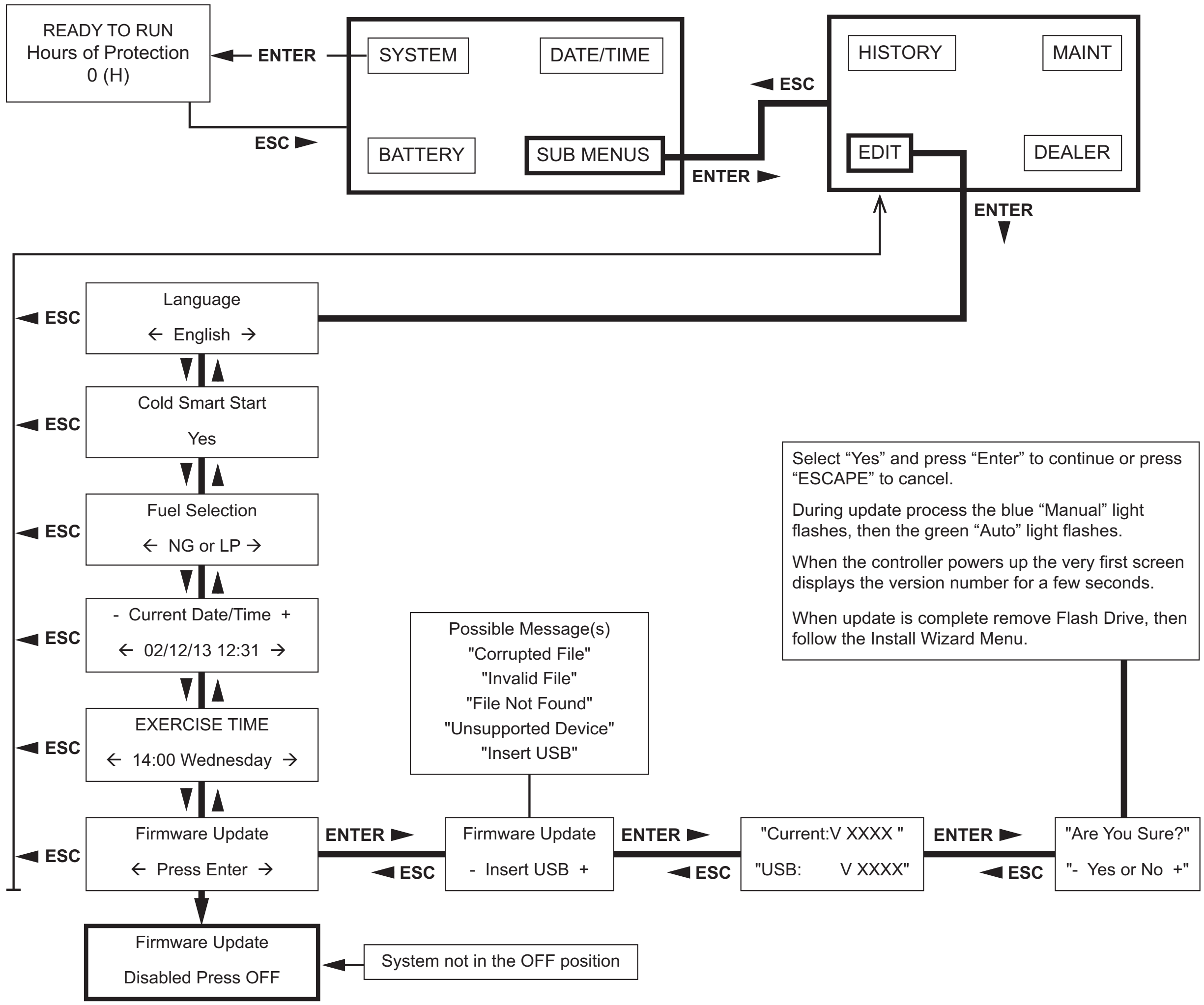


Figure 1-30. Evolution 1.0/Sync 2.0 HSB Menu Map—ACTIVATION

Evolution 1.0/Sync 2.0 HSB Menu Map—FIRMWARE

Note: Menu functions and features may vary depending on unit model and firmware revision.



Also see

Update Firmware – Alternate Method

010471a

Figure 1-31. Evolution 1.0/Sync 2.0 HSB Menu Map—FIRMWARE

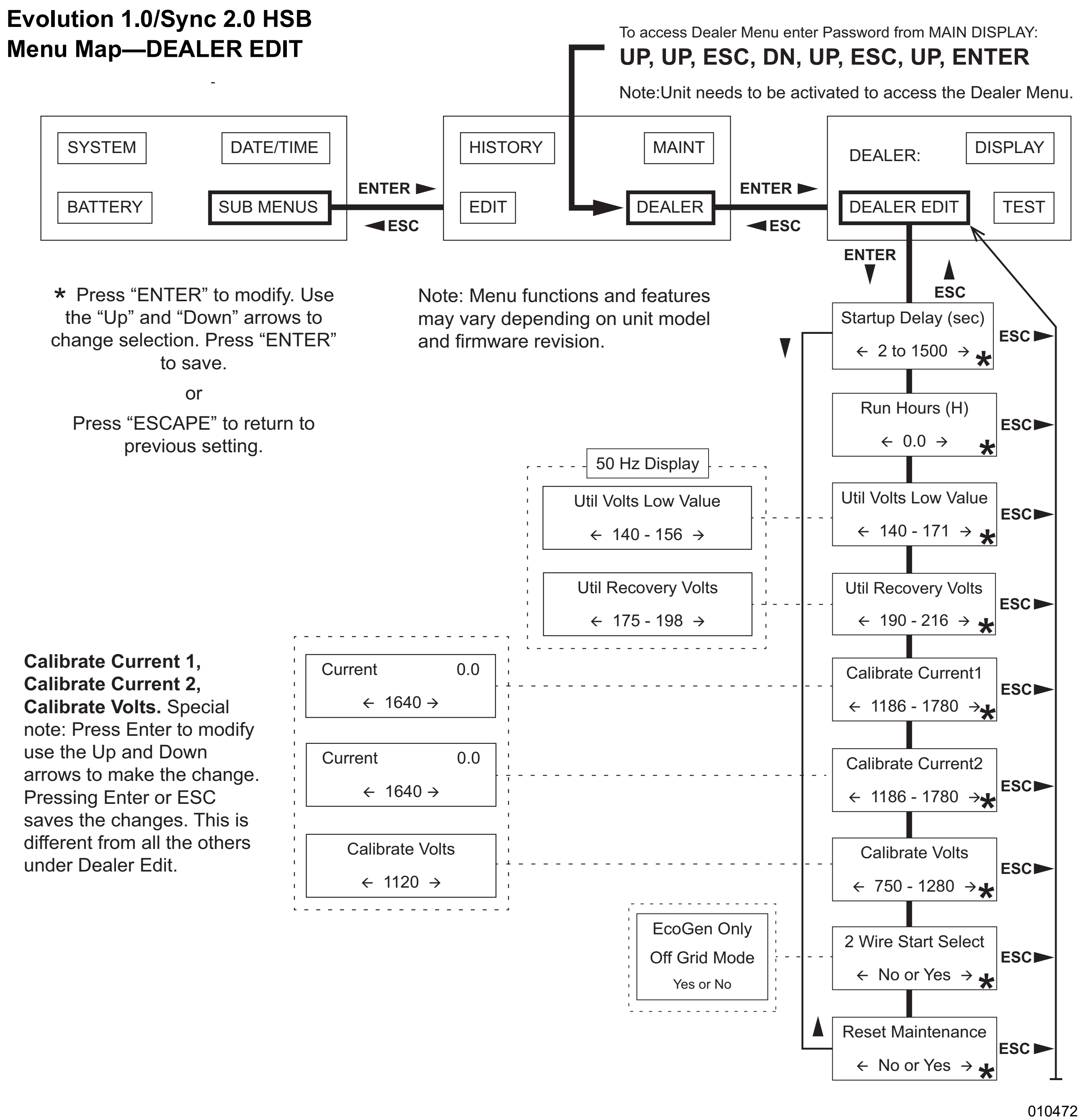


Figure 1-32. Evolution 1.0/Sync 2.0 HSB Menu Map—DEALER EDIT

Evolution 1.0/Sync 2.0 HSB Menu Map—DEALER TEST

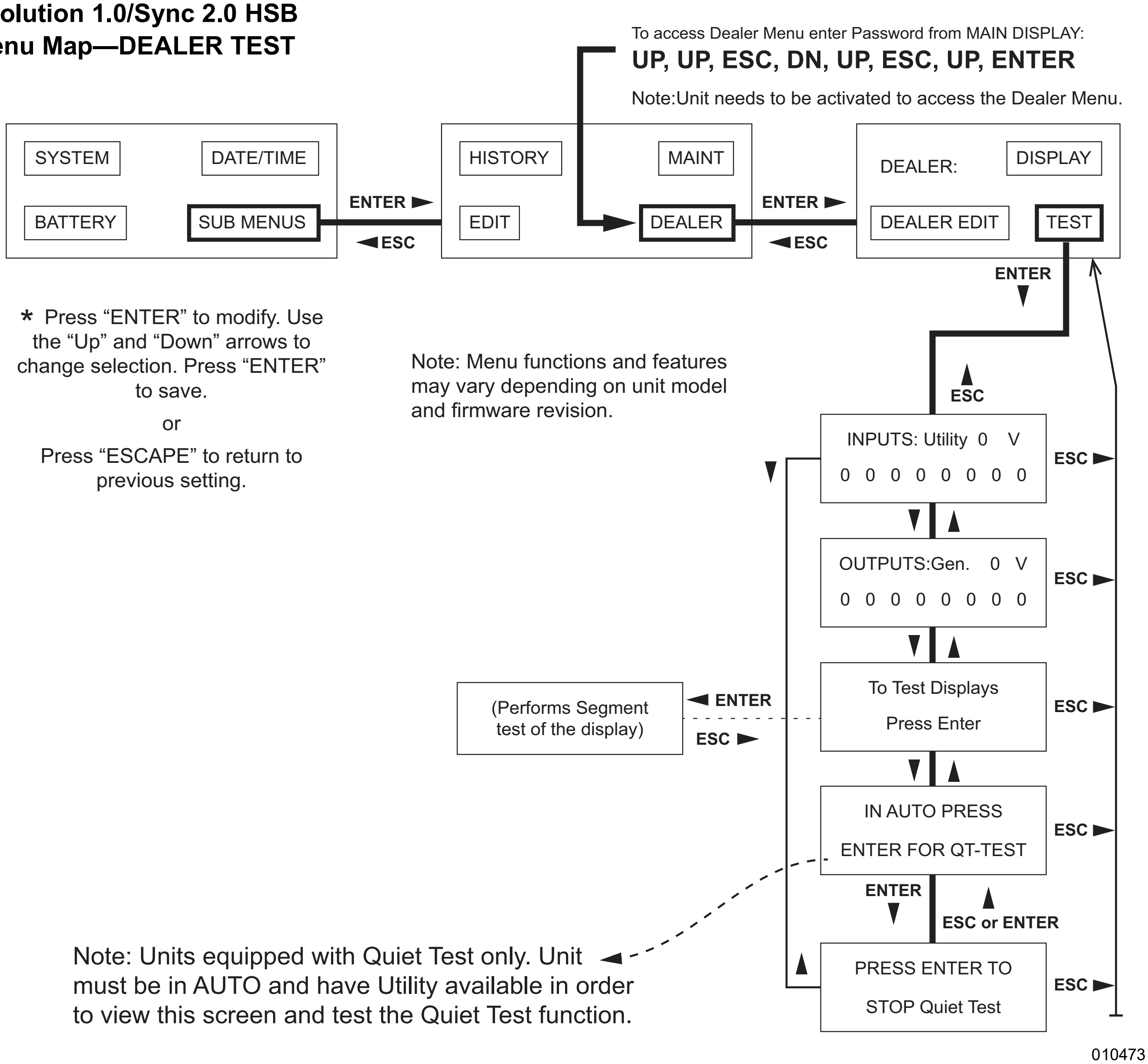
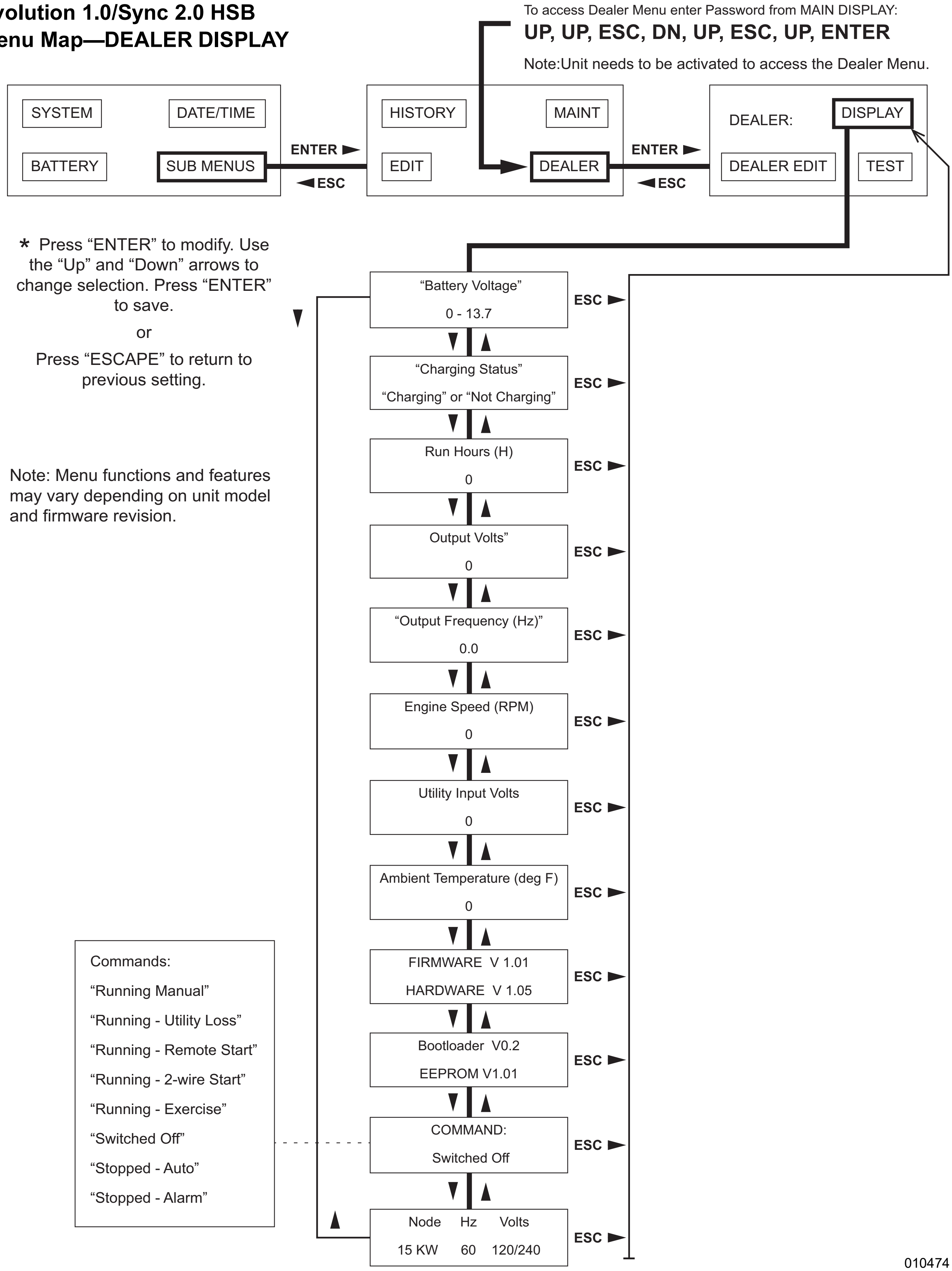


Figure 1-33. Evolution 1.0/Sync 2.0 HSB Menu Map—DEALER TEST

Evolution 1.0/Sync 2.0 HSB Menu Map—DEALER DISPLAY



Evolution 1.0/Sync 2.0 HSB Menu Map—DEALER DISPLAY

Update Firmware – Alternate Method

With the unit controller at MAIN screen, insert the flash drive with the latest firmware.

Power the unit down completely by performing the following:

1. Remove the 7.5 Amp fuse.
2. See ***Figure 1-34***. Disconnect AC power at the T1 connection (A).

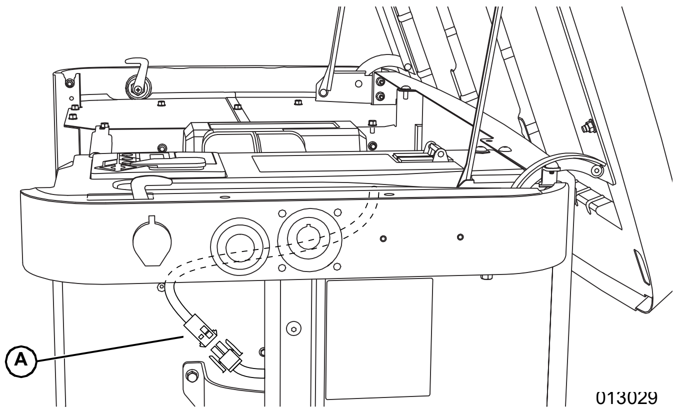


Figure 1-34. T1 Connection

Re-power the controller by performing the following:

1. Insert the 7.5 Amp fuse.
2. See ***Figure 1-34***. Connect AC power at the T1 connection.

Allow controller to boot up and complete the update process.

During the update process the blue “Manual” light flashes, then the green “Auto” light flashes. When the controller powers up, the first screen briefly displays the version number and when complete, returns to the “INSTALL WIZARD” screen.

When unit finishes its update, remove Flash Drive then follow the Install Wizard menu.

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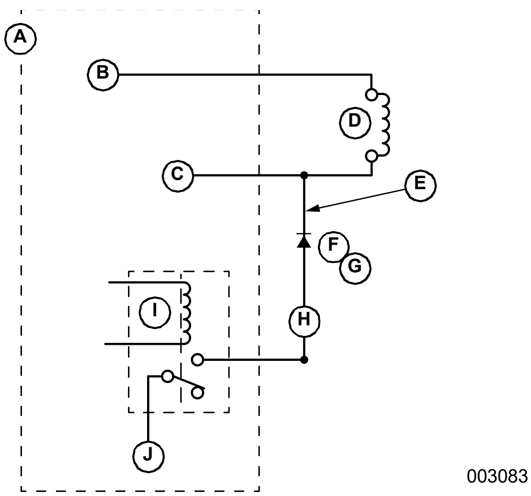
Field Boost

See *Figure 2-1*. The Evolution controller has a dedicated field flash output on Wire 4A which flows through the field boost diode to Wire 4.



A. Evolution Controller
B. Field Excitation Ground Wire 0
C. +VDC Gated Variable Wire 4
D. Rotor
E. Wire 4
F. Field Boost Diode
G. 12 VDC
H. Wire 4A
I. Field Boost Relay
J. 12 VDC

Figure 2-1. Evolution Field Boost Circuit

The dedicated field flash relay with logic is separate from and does not involve the start circuit. Depending on the firmware version, the field flash will turn on and off depending on engine speed and system voltage.

Evolution 1.0 Firmware versions up to 1.11 – Field boost turns on at 2200 rpm. Field boost shuts off after 10 seconds, or when voltage is 88 VAC, whichever comes first.

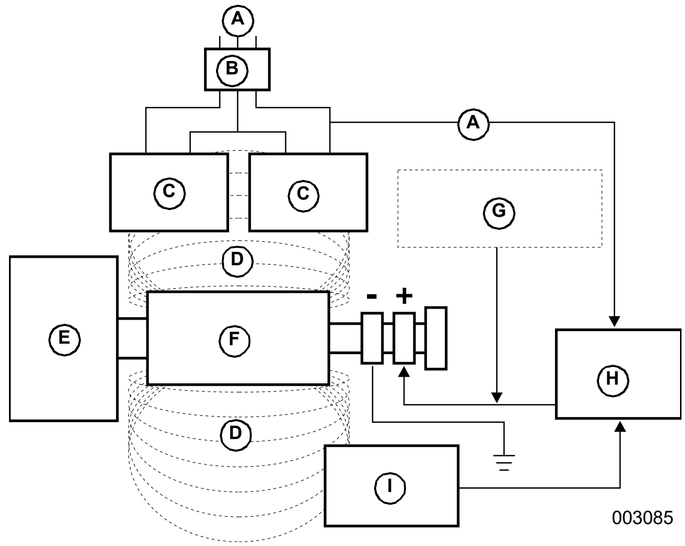
Evolution 1.0 Firmware (v1.12 and above) and Evolution 2.0 (all firmware) – Field boost turns on at 2200 rpm. Field boost shuts off when system voltage reaches 80% of nominal (192 VAC on a 240V generator). This firmware version allows the generator to run up to four additional minutes before shutting down on undervoltage. This will allow sufficient time for the unit to make a positive connection between the brushes and slip rings and build proper system voltage. The firmware also allows for two to four* additional attempts of 15 seconds each following an unsuccessful four minute cycle.

* Number of additional attempts depends on the unit.

Operation

Engine Cranking

See *Figure 2-2*. Once the engine is running at 2200 rpm, field boost voltage causes the rotor to magnetize. The rotor magnetic field induces a voltage into the stator AC power windings, and the stator excitation (DPE) windings. During cranking, field boost magnetism is capable of creating approximately one-half the unit's rated voltage.



A. To Load
B. Main Line Circuit Breaker
C. Stator Power Winding
D. Magnetic Field
E. Engine - Direct drive
F. Rotor
G. Field Boost Circuit
H. Voltage Regulator
I. Stator Excitation Winding

Figure 2-2. Operating Diagram

Field Excitation

AC voltage from the DPE winding provides power to the AVR. The AVR gates and converts AC voltage to DC voltage, and provides regulated variable DC voltage to the rotor through Wires 4 and 0. When the field flash relay disengages (above 80% of nominal output voltage), the AVR then provides excitation voltage to the rotor.

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 windings. 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.

Regulated excitation from the regulator is delivered to the rotor windings through Wire 4 and the positive brush and slip ring. This results in current flowing through the field windings to the negative slip ring and brush, and then to ground.

See ***Figure 2-3* and *Figure 2-4***. 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.

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.

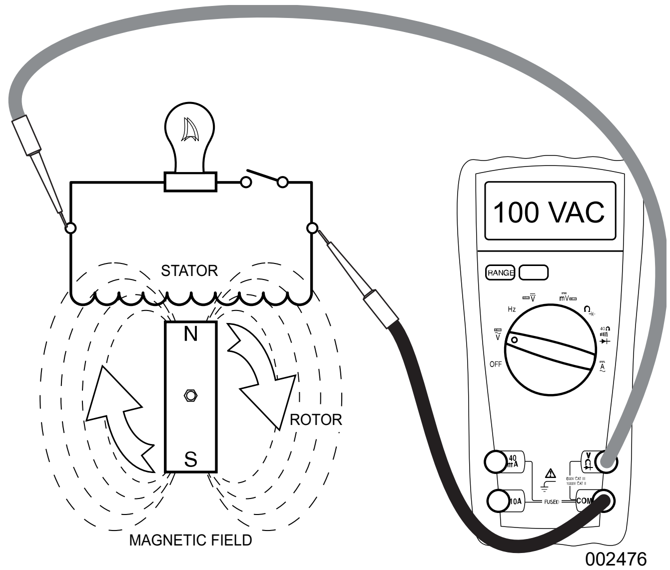


Figure 2-3. Low Field Excitation Voltage = Low Magnetic Lines of Flux = Low AC Output

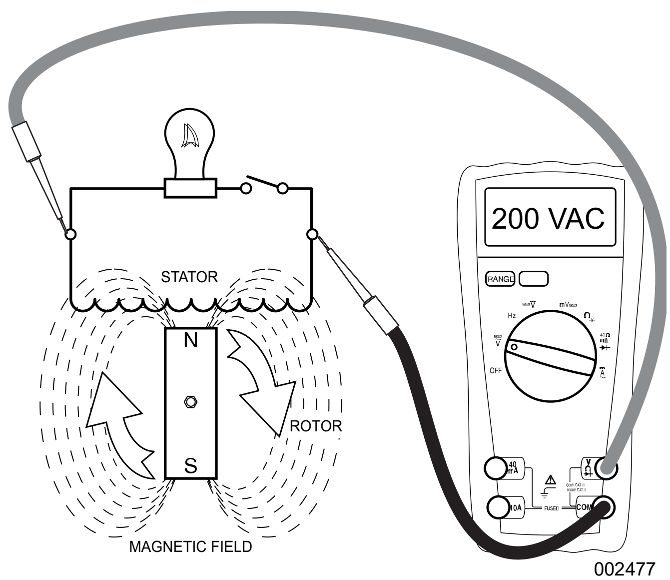


Figure 2-4. Increased Field Excitation Voltage = Increased Magnetic Lines of Flux = Increased AC Output Voltage

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.

Load changes will result in a corresponding change in voltage. As load demand increases the voltage will decrease. As load demand decreases the voltage will 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.

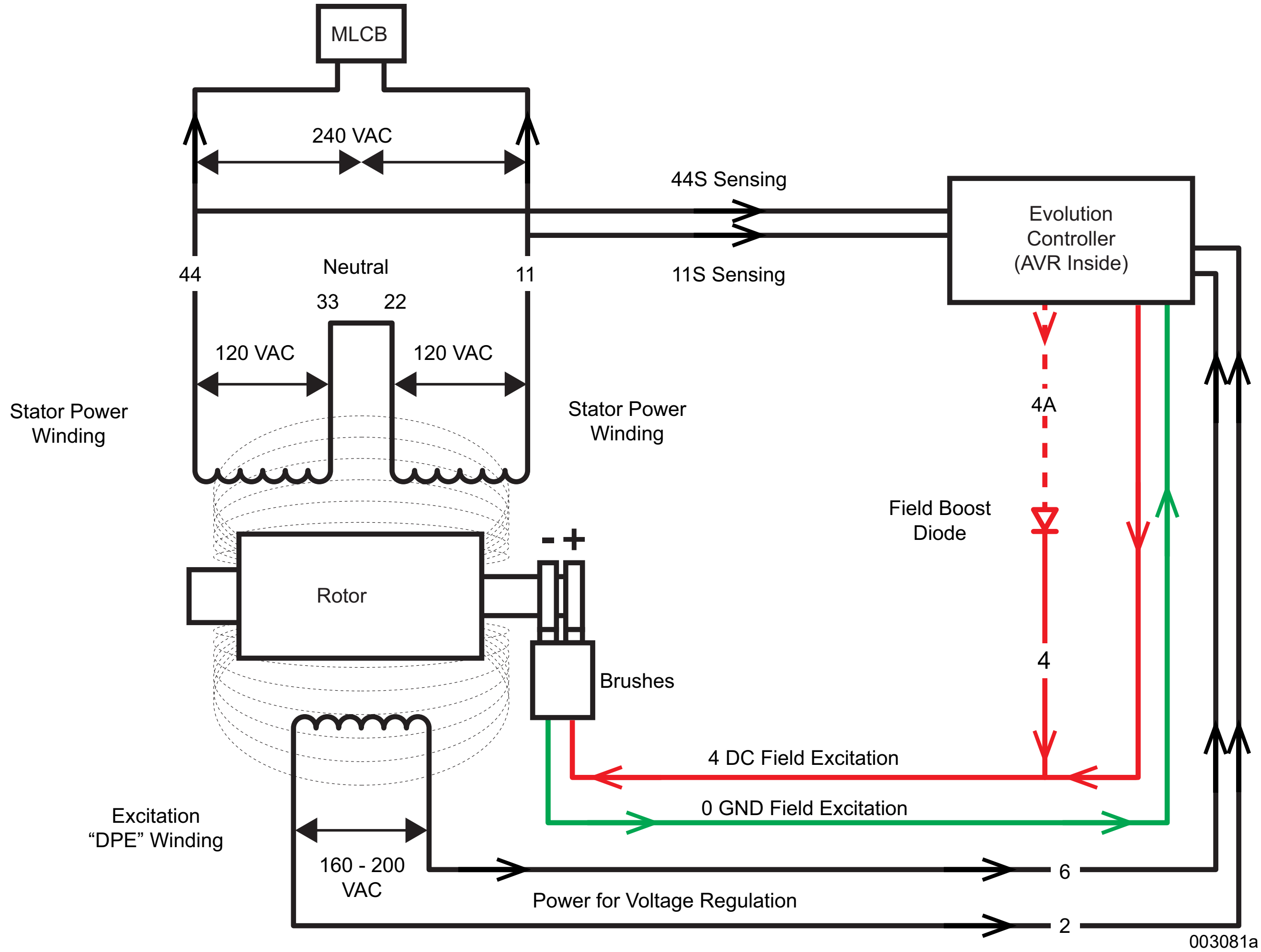


Figure 2-5. Evolution (All) Voltage Regulator Schematic

AVR = Automatic Voltage Regulator
DPE = Displaced Phase Excitation
MLCB = Main Line Circuit Breaker
VAC = Volts Alternating Current

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Evolution™ Controller E-Codes

NOTE: For any Displayed Alarm on the controller, use the Action Step as a starting point.

Displayed Alarm	Alarm/ Warning	E-Code Breakdown	Description	Action Step
Controller Fault	ALARM		**No E-code on HSB**	Replace Controller
Overcrank	ALARM	1100	**Condition - Engine Cranks but will not Start (5 crank attempts)** Unit turns over but will not start. Controller is receiving signal on Wire 18.	Problem 17
Overspeed	ALARM	1200	**Prolonged (60 Hz on a 50 Hz unit, 72Hz on 60Hz unit)** Over specified Hz for 3 seconds. Possible cause: Stepper motor/mixer body assembly issue.	Test 54
Overspeed	ALARM	1205	**Instantaneous (62 Hz on a 50 Hz unit, 75Hz on 60Hz unit)** Over specified Hz for 0.1 second (100 milliseconds). Possible cause: Stepper motor/mixer body assembly issue.	Test 54
Overspeed	ALARM	1207	Monitors zero cross timing of the AVR to determine the alternator frequency which is a speed indicator. Set for 150 milliseconds of 4500 rpm or higher. Used if the normal ignition pulse sequence(s) are not being seen by the controller.	Test 64 and Test 60
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. Check temperature sensor and wiring.	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.
RPM Sensor	ALARM	1511	**Single Cylinder+Running** Single Cylinder Running RPM sensor loss Possible Causes: air pocket in fuel line, dirty fuel. Loss of ignition pulse.	Test 50 and Test 64
RPM Sensor	ALARM	1515	**Single Cylinder+Cranking** Single Cylinder Cranking faults to RPM sensor loss Possible Cause: starter motor and/or engine issue. Loss of ignition pulse.	If engine cranks, Test 64. If engine does not crank, Problem 15.
Underspeed	ALARM	1600	**Condition - Unit is Overloaded (55 Hz for 60 Hz for 30 sec, 40 Hz for 50 Hz unit** Unit is Overloaded slowing engine speed, fuel supply low or throttle control problem.	Problem 3, or Test 50, or Test 54
Underspeed	ALARM	1603	**Underspeed** The engine never comes up to 3600 RPM.	Check fuel selection and fuel supply
Overvoltage	ALARM	1800	**Prolonged Over-Voltage**	Problem 2
Undervoltage	ALARM	1900	**Prolonged Under-Voltage** Undervoltage due to loss of voltage. Below 80% for 10+ seconds) Controller will display "WARMING UP" for 4 minutes. Refer to **Section 2.2**.	Perform Preliminary Output Voltage Test Note: Verify controller has latest firmware.
Undervoltage	ALARM	1901	**Instantaneous** **Undervoltage due to sudden loss of voltage.** (Voltage less than 15 sec 2 sec+) Controller will display "WARMING UP" for 4 minutes. Refer to **Section 2.2**.	Perform Preliminary Output Voltage Test Note: Verify controller has latest firmware.
Undervoltage	ALARM	1902	**Both Zero Crosses missing** Undervoltage due to faulty excitation winding, or zero cross circuit, or circuit in general. Possible cause: loose wiring, field boost hardware failure. (Both zero cross missing greater than 1.5 sec) Controller will display "WARMING UP" for 4 minutes. Refer to **Section 2.2**.	Perform Preliminary Output Voltage Test Note: Verify controller has latest firmware.
Undervoltage	ALARM	1906	**Single Zero Cross missing** Undervoltage due to faulty excitation winding, zero cross circuit, or circuit in general. Possible cause: field boost hardware failure. (One zero cross missing greater than 1.5 sec) Controller will display "WARMING UP" for 4 minutes. Refer to **Section 2.2**.	Perform Preliminary Output Voltage Test Note: Verify controller has latest firmware.

Evolution™ Controller E-Codes

NOTE: For any Displayed Alarm on the controller, use the Action Step as a starting point.

Displayed Alarm	Alarm/ Warning	E-Code Breakdown	Description	Action Step
Wiring Error	ALARM	2098	**Mis-wired Customer connection** Insufficient DC voltage on transfer power output.	Check for shorted 194 to ground. Refer to RTS Diagnostic Manual A0001176044.
Wiring Error	ALARM	2099	**Mis-wired** Customer connection low voltage and high voltage wires are crossed.	Check for AC voltage on Wire 194 at customer connection in generator.
Overload Remove Load	ALARM	2100	**Overloaded - Default (Output Current Method)** Unit is overloaded. One or both CT(s) detecting an overload condition. Check transfer switch load shed functionality. (Change load dynamics or utilize load shed).	Remove Load
Undervoltage Overload	ALARM	2299	Unit was overloaded and attempted to start with a large load connected. The unit can not ramp up the generator voltage to its normal target voltage value if it starts with a large load connected	Remove Load
Stepper Overcurrent	ALARM	2399	Current flow in stepper coil(s) above specification.	Test 54 Note: Verify controller has latest firmware.
Fuse Problem	ALARM	2400*	**Missing / Damaged Fuse** The 7.5 amp Controller Fuse is missing or blown (open). *Firmware version 1.11 and older only	Test 44 Note: Verify controller has latest firmware.
Aux Shutdown	ALARM	2800	External shut down circuit is open.	Check the continuity of the harness and operation of the switch(es). Repair/ replace as needed.
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
Model Ident Problem - Fix Harness Resistor			Controller was powered up before the resistor plug was connected.	Problem 23 - Controller displays “Model Ident Problem Fix Harness Resistor” fault
	Service Schedule		Service Schedule A 200hours 2 years Service Schedule B 400 Hours 4 years	Perform Maintenance

Additional Codes For 8 and 9 kW Units (Evolution 1.0 Controller Only)

Displayed Alarm	Alarm/ Warning	E-Code Breakdown	Description	Action Step
Overcrank	ALARM	1101	**Engine/Starter Problem** Limiting number of cranking cycles to protect the starter motor.	If the engine has tried to crank for 10 times unsuccessfully, this will trigger.
Overload Remove Load	ALARM	2102	**Overloaded** Unit re-cranks 5 times when load is applied, engine dies (0 RPM) and has low voltage (< 180V)	Check for Overloaded condition on unit. Inspect stepper motor operation.
Overload Remove Load	ALARM	2103	**Overloaded** Unit has run and attempted to accept load 10 times, could not accept due to overload condition	Check for Overloaded condition on unit

Introduction

Begin troubleshooting by performing the ***Preliminary Output Voltage Test*** . Then use the “Flow Charts” in conjunction with the detailed instructions in Section 2.3, ***Diagnostic Tests*** . Test numbers and/or verbiage used in the flow charts correspond to the numbered tests and/or verbiage in Section 2.3.

For best results, perform all tests in the exact sequence shown in the flow charts.

Preliminary Output Voltage Test

NOTE: This test is for Evolution 1.0 firmware (v1.12 and above) and Evolution 2.0 (all firmware) and does not apply to VSCF Synergy.

General Theory

When an Alarm of the 1900 group (Undervoltage) is displayed on the controller, certain tests need to be performed to determine the actual fault. With the latest firmware, up to four minutes (in Manual Mode) is available to measure output voltage before shutting down on “Under Voltage”. Measuring output voltage as described in this test will help determine the next step in troubleshooting. Refer to ***Table 2-1***.

When measuring output voltage, it is important to look at the output voltage displayed on the control panel as well as measuring actual output voltage of the generator.

NOTE: If the unit enters a shutdown during this procedure, acknowledge the alarm by pressing the OFF button and then ENTER. Restart unit if necessary to complete the test.

Procedure

1. Gain access to the main line circuit breaker (MLCB) on the generator.
   a. On Evolution 1.0 (2016 and prior), access is obtained from back side of breaker.
   b. On Evolution 1.0 (2017 and later) and all 2.0, access is obtained by removing the controller fascia.
2. Set the MLCB to the OPEN (OFF) position to avoid any possible output voltage to the home.
3. Navigate to Dealer>Display>Voltage using the dealer password for the controller.
4. Set a digital multimeter (DMM) to measure AC voltage.
5. Connect one meter test lead to Wire 11 and the other meter test lead to Wire 44 at the alternator side of the MLCB.
6. Set the controller to MANUAL. Allow generator to start and stabilize.
7. Measure and record the voltage indicated on the DMM.
8. Visually monitor the output volts displayed on the controller.
9. Record the value indicated.

   Voltage Indicated on the Controller: _________

   Measured Voltage Output at MLCB: __________

10. Shut the unit down by pressing the OFF button on the controller.
11. Use ***Table 2-1*** to determine which test to perform.

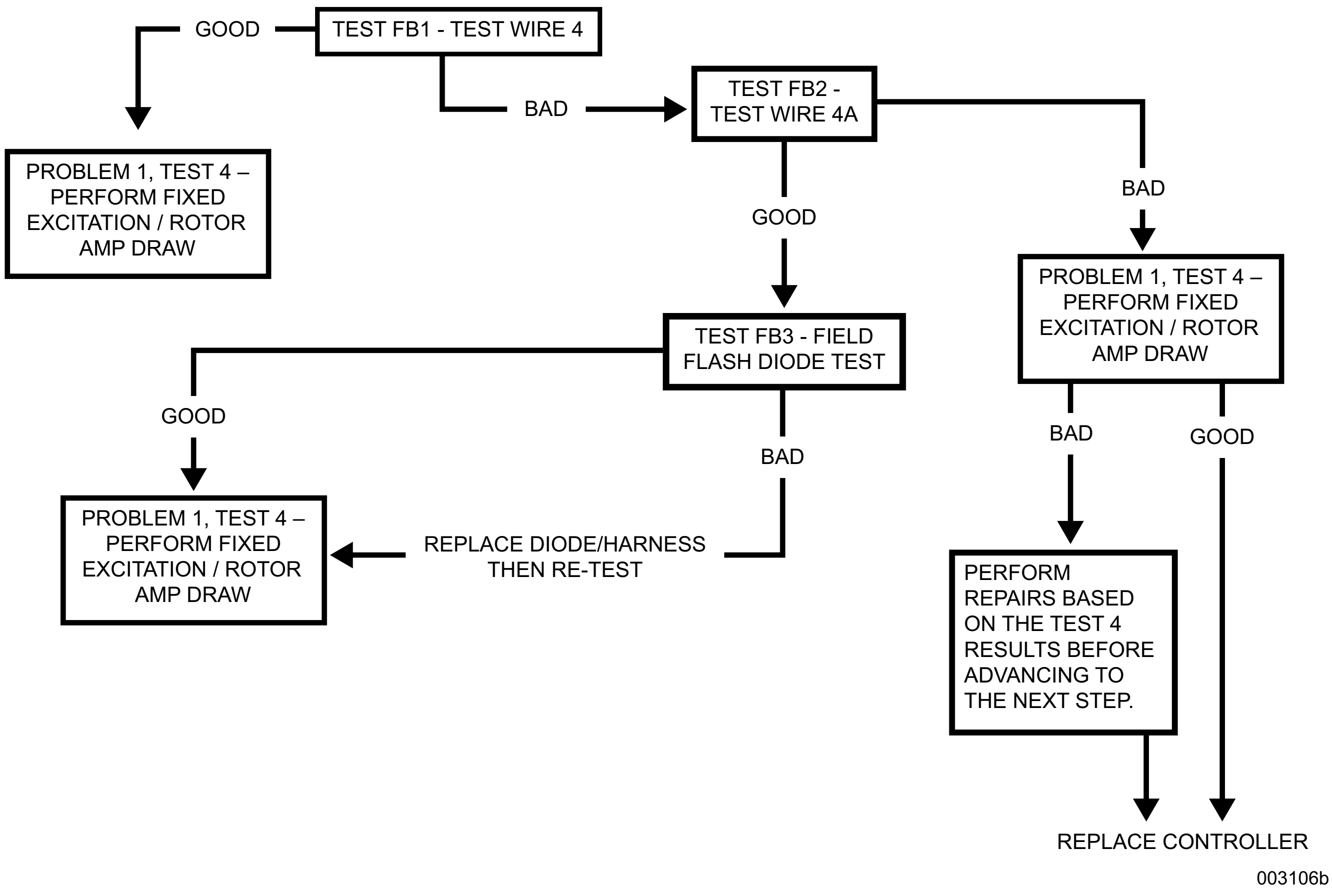
Table 2-1. Preliminary Output Voltage Test Results

Controller Voltage	MLCB Voltage	Perform Test(s):	Flow Chart Path Begin:
0 (+10%)	140–180 (+ or – 10%)	***Test 6 – Test Excitation Winding***	Test 4, Path C
140–185 (+ or – 10%)	140–185 (+ or – 10%)	***Test FB1 – Wire 4 Test***	FBCT
0 (Residual voltage may be present)	0 (Residual voltage may be present)	***Test FB2 – Wire 4A Test*** if necessary, perform tests as defined in the ***Field Boost Circuit Test (FBCT)*** flowchart.	FBCT
~50% of measured voltage	≥300	***Test 5 – Test Sensing Circuit Wires 11S and 44S***	Test 4, Path B
240 (approximately)	240 (approximately)	***Test 14 – Check Voltage and Frequency Under Load*** and/or ***Test 16 – Check Engine Condition***	Problem 18

Table 2-2. Output Voltage Test Results

Voltage		Voltage		Voltage	
Indicated Controller		Indicated Controller		Indicated Controller	
Measured Output		Measured Output		Measured Output	

Field Boost Circuit Test (FBCT)

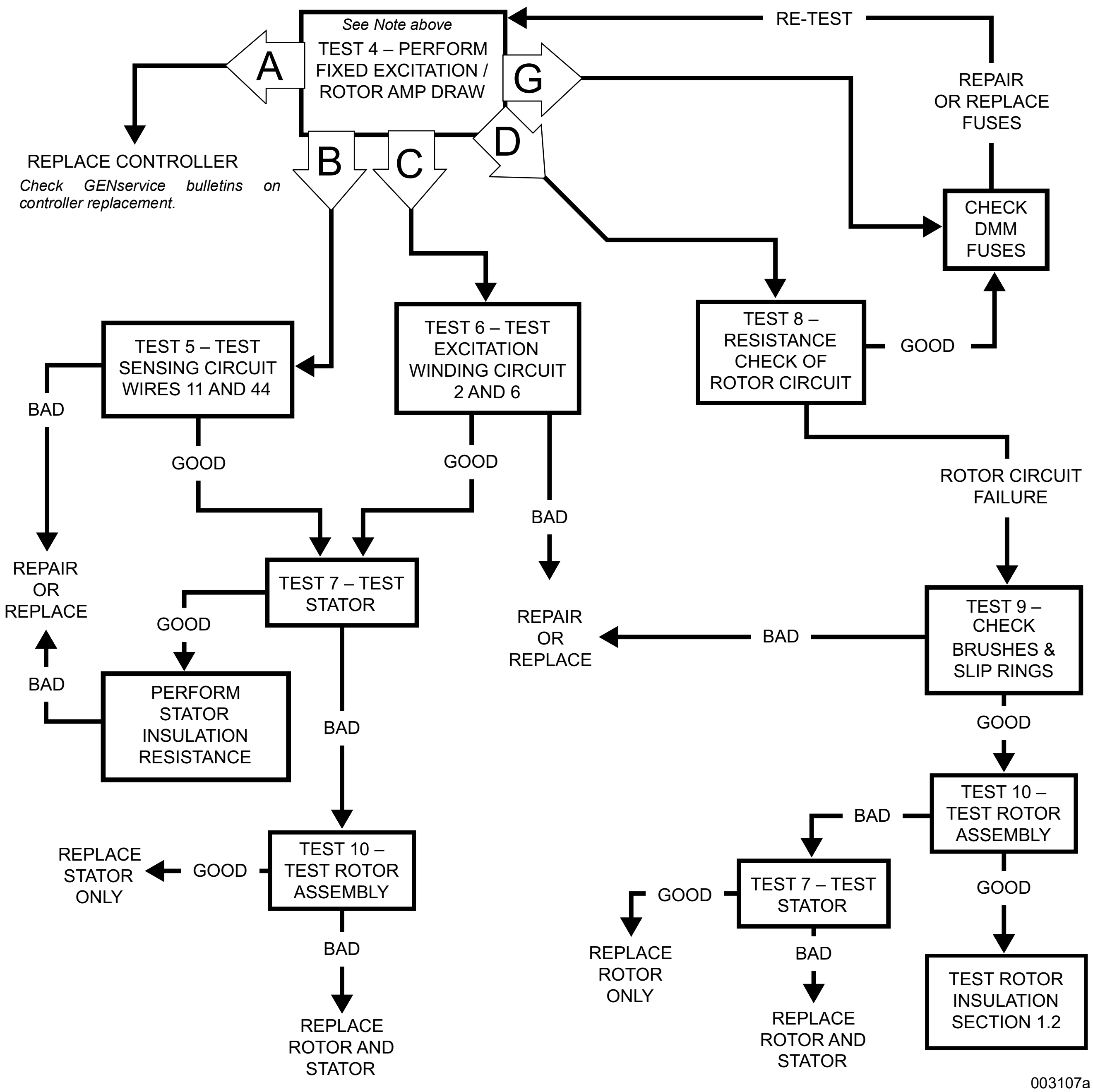


IMPORTANT NOTE: Clear any faults in the controller before proceeding with any running diagnostic steps!

NOTE: Perform FBCT "Field Boost Circuit Test" PRIOR to performing Test 4. After performing "Field Boost Circuit Test" in it's entirety, compare the results with the "Test 4 Results Table" to determine letter code result A through H on this page and the next.

Problem 1 – Generator Shuts Down for Under Voltage

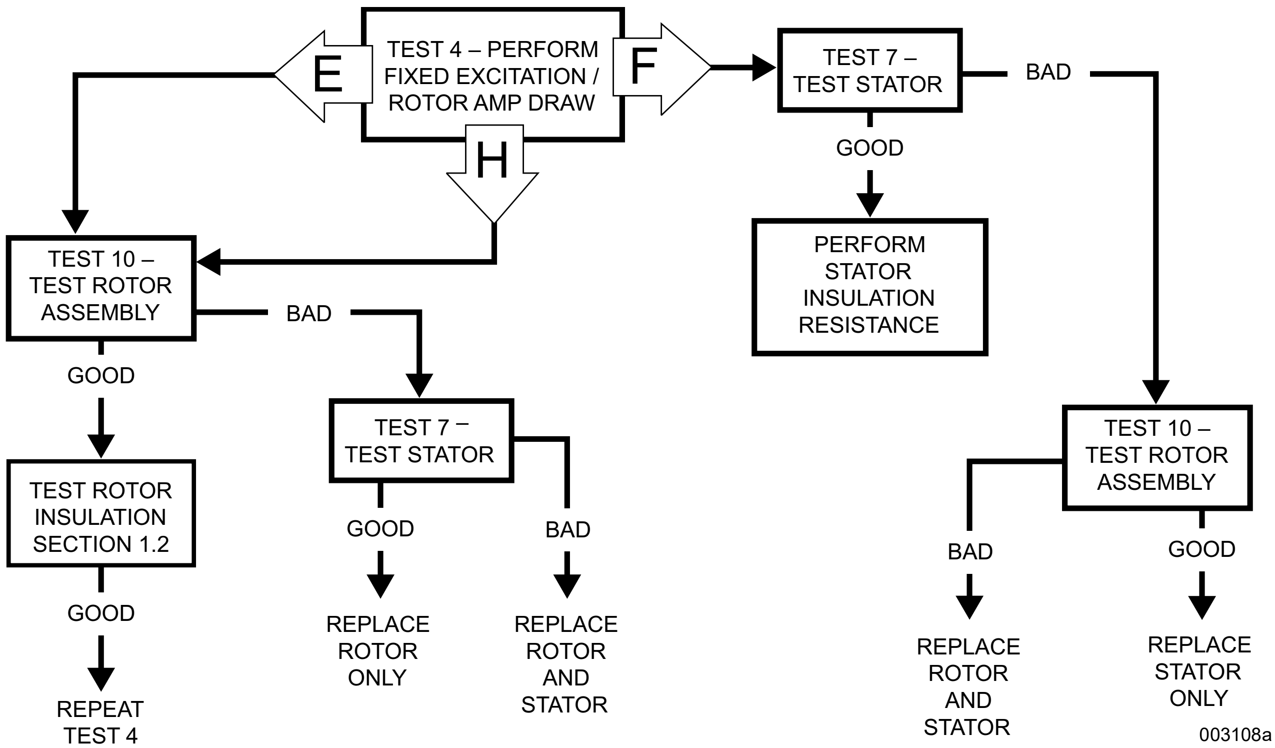
NOTE: Evolution 1.0 (non-Synergy) Firmware (v1.12 and above) and Evolution 2.0 (all firmware), perform the Preliminary Output Voltage Test.



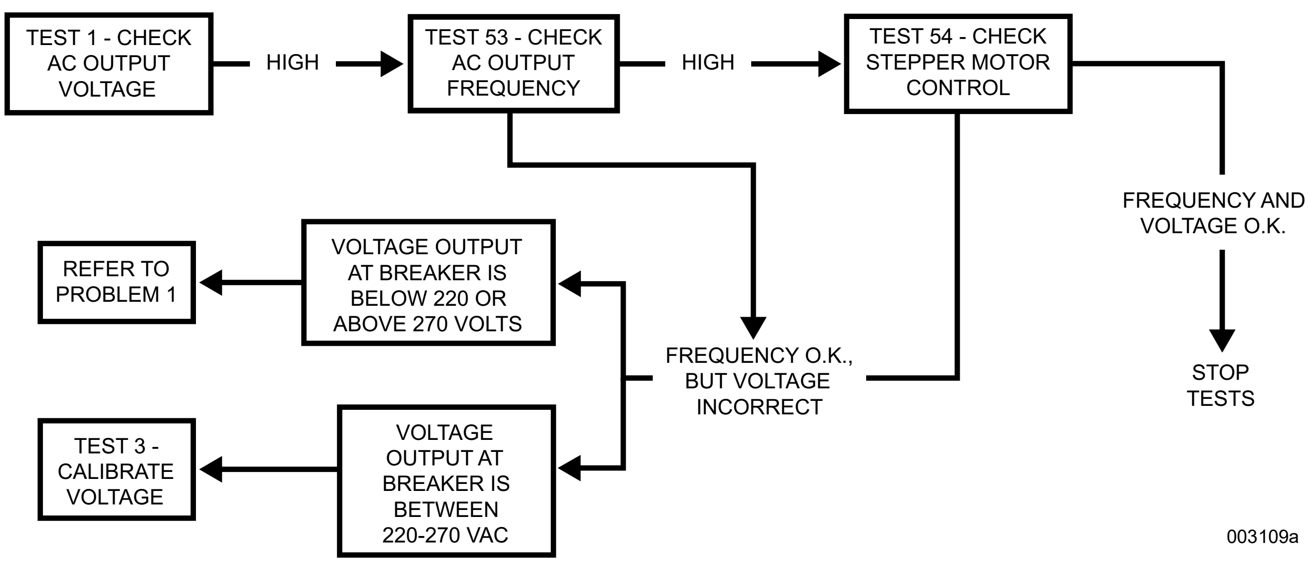
IMPORTANT NOTE: Clear any faults in the controller before proceeding with any running diagnostic steps!

Problem 1 – Generator Shuts Down for Under Voltage (Continued)

NOTE: Evolution 1.0 (non-Synergy) Firmware (v1.12 and above) and Evolution 2.0 (all firmware), perform the Preliminary Output Voltage Test.

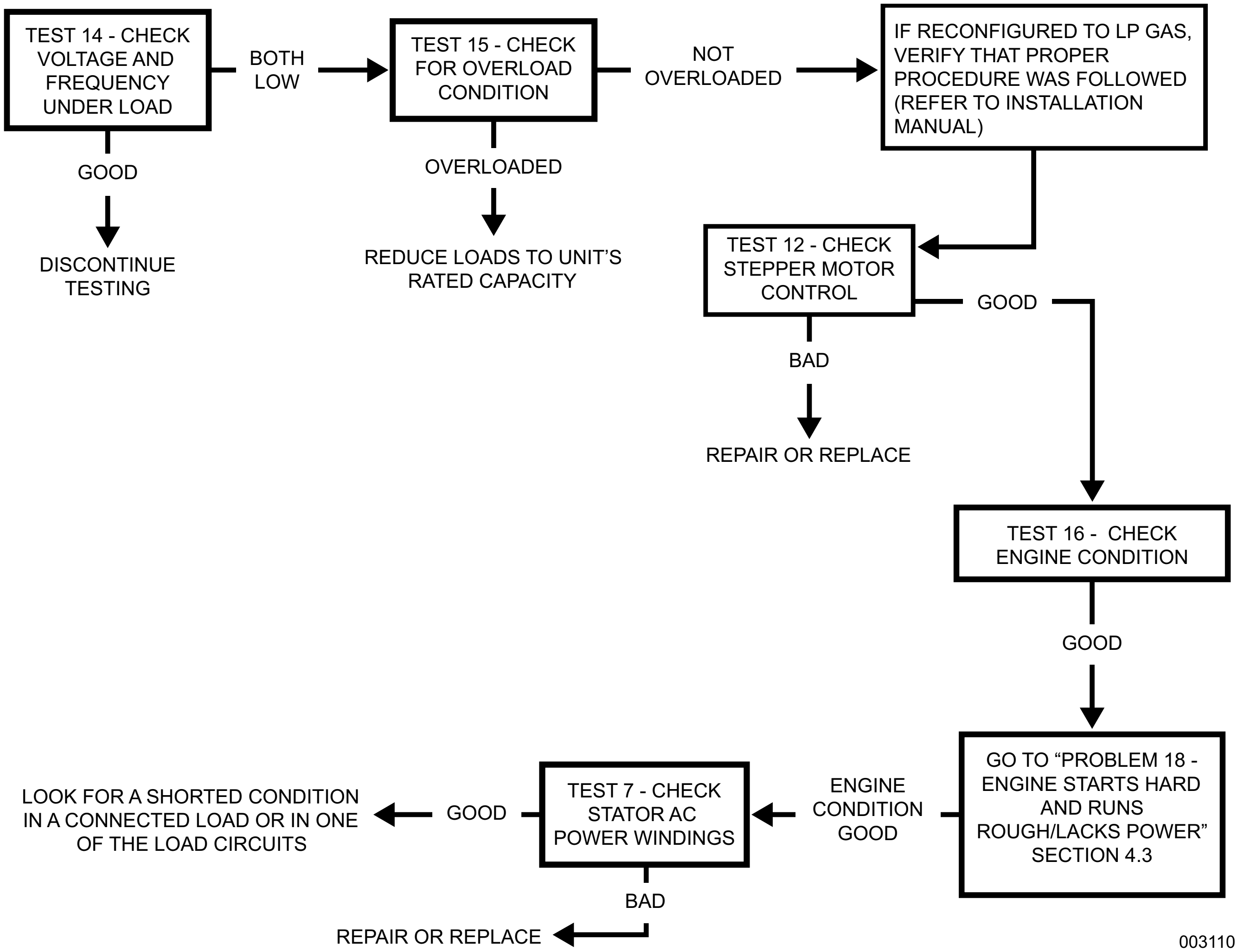


Problem 2 – Generator Produces High Voltage

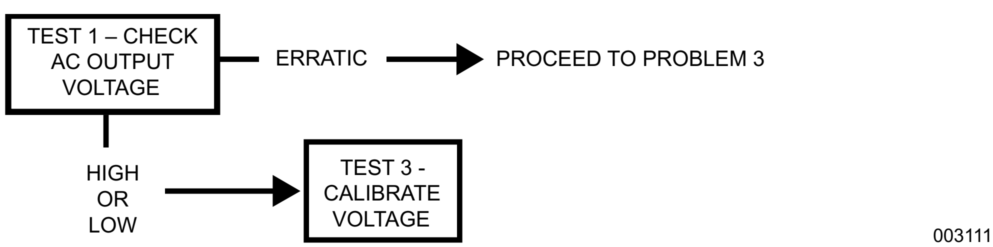


IMPORTANT NOTE: Clear any faults in the controller before proceeding with any running diagnostic steps!

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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Section 2.3 Diagnostic Tests

Introduction

This section provides acceptable procedures for the testing and evaluation of various problems that can occur on standby generators with air-cooled engines. Use this section in conjunction with Section 2.2,*Troubleshooting Flow Charts*. The numbered tests in this section correspond with those of Section 2.2.

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 (DMM). 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 physically or mentally fatigued. If you do not understand a component, device or system, do not work on it.

AC Troubleshooting

Continue to ask questions during the troubleshooting process. Asking some of these questions may help identify the problem more quickly.

- 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 same fault happen consistently?
- When does the fault occur?
- After the fault occurred what was displayed on 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 DMM 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.

(000311)

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. Verify the meter clamps are securely attached and will not shake loose.

Procedure

1. Set the DMM to measure AC voltage.
2. See *Figure 2-6*. With the engine shut down, connect the meter test leads across the load terminals of the generator MLCB. This will measure line-to-line voltage.

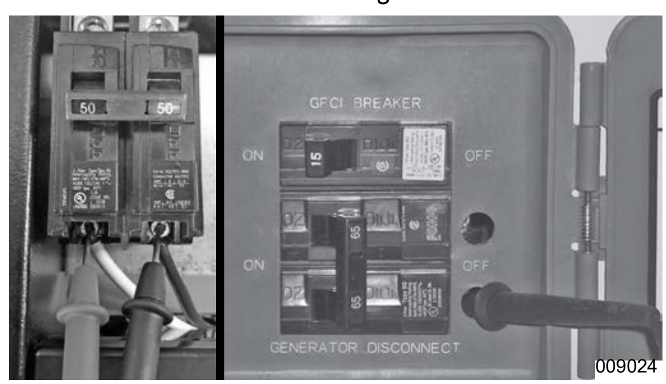


Figure 2-6. MLCB Test Points 2017 and Newer (Left) Pre 2017 (Right)

3. Set the MLCB to the "Open" position. Verify that all electrical loads are disconnected from the generator.
4. Set the controller to MANUAL.

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 DMM indicated approximately 240-244 VAC, the output voltage is good.
2. If the DMM indicated any other readings the voltage is bad. Refer back 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 to 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 the engine reaches 2200 rpm.

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 must 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 DMM to measure AC voltage.
2. Open the Main Line Circuit Breaker (MLCB) on the generator.
3. On the controller, press the ESC key until the main menu is present. (See ***Evolution Menu System Navigation***)
4. From the main menu enter the dealer password and proceed to DEALER > DEALER EDIT > CALIBRATE VOLTAGE then press ENTER.
5. After pressing enter, a value will appear on the screen.
6. Using appropriate back probes, measure output voltage at the AVR connector (Wires 11S and 44S).

NOTE: The default setting from the factory for calibration is 1024. The Evolution controller is adjustable from 750-1280.

7. Set controller to MANUAL and allow engine to start.
8. While the unit is running, use the UP or DOWN arrows to adjust the calibration setting. A higher value will create a lower voltage. A lower value will create a higher voltage.
9. 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 breaker is consistent within 5 volts of the value displayed in the controller TEST menu (See ***Evolution Menu System Navigation***).

Results

1. If during the verification process the output voltage at the breaker and the display match and the calibration setting was not adjusted outside of the window, stop testing.
2. If a correct voltage output was not achieved using the window specified, perform the Field Boost Test (FBT) and then refer to “Problem 1 – Test 4 Fixed Excitation / Rotor Amp Draw Test.”

Field Boost Circuit Tests

Test FB1 – Wire 4 Test

General Theory

This test is to verify that Wire 4 is receiving field flash voltage from wire 4A during startup of the generator.

NOTE: See ***Field Boost*** in Section 2.1 for analysis of field boost parameters.

Procedure (using J3 Breakout Harness)

1. Set DMM to measure DC voltage.
2. Disconnect the generator harness J3 connector from the controller.
3. Connect the female end of the J3 breakout harness to the unit harness.

IMPORTANT NOTE: DO NOT CONNECT the male end of the J3 breakout harness to the controller.

4. Insert meter test leads into the DC excitation test points of the breakout harness (4 and 0).
5. Clear all faults and place generator in MANUAL mode and start engine.
6. Observe the meter for DC Field Flash Voltage.

Procedure (without using J3 Breakout Harness)

1. Set DMM to measure DC voltage.
2. Locate Wire 4 on back of control panel. Disconnect the wire harness connector from the control panel.
3. Insert the Red meter lead adapter into the back of the wire harness on Wire 4.
4. Place Black lead on a good common ground or negative post on the engine battery.
5. Clear all faults and place generator in the manual mode and start engine.
6. Measure and record field flash voltage.

NOTE: See ***Field Boost*** in Section 2.1 for analysis of field boost parameters.

Results

1. If approximately 12 VDC was measured field flash is passing through the field boost diode. Test is good. Go back to flow chart for next test.
2. If 0 volts was measured, test is bad, proceed back to the field boost circuit test flow chart.

Test FB2 – Wire 4A Test

General Theory

To verify that the field flash is working properly.

Procedure

1. Set DMM to measure DC voltage.
2. Locate Wire 4A on back of control panel. Leave harness connector connected to control panel.
3. Insert Red back probe into connector that contains Wire 4A.
4. Touch Black probe lead to the battery negative post.
5. Clear all faults on the control panel and place into manual mode.
6. Measure and record field flash voltage

NOTE: See ***Field Boost*** in Section 2.1 for analysis of field boost parameters.

7. Record measurements.

Results

1. If approximately 12 VDC (engine battery voltage) was measured during field flash, the control board is good. Refer back to the flow chart.
2. If 0 VDC was measured during field flash, refer back to the flow chart.

Test FB3 – Field Flash Diode Test

General Theory

When testing a diode using the Diode function on the meter, DC voltage will be displayed on the meter. The meter is applying a small amount of voltage (from the meter's battery) across the circuit and is measuring how much voltage (pressure) it takes to open the diode. Approximately 0.5 volts DC is typical. A diode that measures 0.5 VDC in one direction and "0L" in the other is a good working diode. This test is to verify that the field flash diode is working properly.

Procedure (using J3 Breakout Harness)

1. Remove 7.5 amp fuse from control panel.
2. Set DMM to diode check function (preferred). If the DMM does not have a diode check selection, use the resistance or "Ohms" selection.
3. Locate and disconnect Wire 4A wire harness connector from control panel.
4. Locate and disconnect the generator harness J3 connector from the controller.
5. Connect the female end of the J3 breakout harness to the unit harness.

IMPORTANT NOTE: DO NOT CONNECT the male end of the J3 breakout harness to the controller.

NOTE: J2 harness connector remains unplugged and the J3 breakout harness remains connected to the harness for the remaining steps.

6. With appropriate test probe adapter, insert the black meter lead into the back of the wire harness on Wire 4A.
7. Insert the red meter test lead into the J3 Breakout Harness Wire 4 test point.
8. Record reading on the meter.
9. With appropriate test probe adapter, insert the red meter lead into the back of the wire harness on Wire 4A.
10. Insert the black meter test lead into the Wire 4 test point on the J3 breakout harness.
11. Record reading on the meter.

Procedure (without using J3 Breakout Harness)

1. Remove 7.5 amp fuse from control panel.
2. Set the DMM to the diode check function (preferred). If the DMM does not have a diode check selection, use the resistance or "Ohms" selection.
3. Locate Wire 4A wire harness connector and disconnect from control panel.
4. With test probe, insert the Black lead into the back of the wire harness on Wire 4A.
5. Locate Wire 4 wire harness connector and disconnect from control panel.
6. With test probe, insert the Red lead into the back of the wire harness on Wire 4.
7. Record reading.

Table 2-3. Test Results

Test Point	Results	
Ohms Test		Ohms
Diode Test		VDC

NOTE: Leave wire harness/harnesses unplugged.

8. Locate Wire 4A.
9. With test probe, insert the Red lead into the BACK of the wire harness on Wire 4A.
10. Locate Wire 4.
11. With test probe, insert the Black lead into the BACK of the wire harness on Wire 4.
12. Record reading.

Table 2-4. Test Results

Test Point	Results	
Ohms Test		Ohms
Diode Test		VDC

Results

1. If a reading of OL for Diode or OHMS test was recorded in Step 7 and approximately 0.5 Volts (Diode setting) or approximately 2.07M OHMS (Ohms setting) was recorded in Step 12, the diode is good. Replace 7.5 amp fuse and wire harness/harnesses into proper receptacles. Refer back to flow chart.
2. If readings of INFINITY (OL) on Step 7 and INFINITY on Step 12, Diode or wire is bad (open), wire harness/diode needs to be repaired/replaced.
3. If readings of approximately 0.5 Volts (in Diode setting) or CONTINUITY (Resistance in “Ohms” setting) in Step 7 and Step 12, Diode is bad (shorted), diode needs to be repaired/replaced.

Test 4 – Fixed Excitation Test/Rotor Amp Draw Test

General Theory

A fixed DC current supplied to the rotor will induce a magnetic field in the rotor. With the generator running, this should create a proportional voltage output from the stator windings. Using the MIN/MAX feature of a digital multimeter (DMM), it is possible to capture the maximum output of a particular winding before faulting out on under-voltage.

Use *Table 2-5* to record the results of the following procedure. These results may be required when requesting factory support.

Table 2-5. Test 4 Results

Test Point	Results	
Wires 2 and 6 Voltage		VAC
Wires 11s and 44s Voltage		VAC
Static Rotor Amp Draw		Amps
Running Rotor Amp Draw		Amps
Column Identified		

Required Tools

- A Digital Multimeter (DMM) equipped with a MIN/ MAX feature
- Meter test leads capable of measuring voltage inside a connector without damaging the socket. A set of black and red test leads for this application are available from the manufacturer. Contact your nearest servicing dealer for more information.

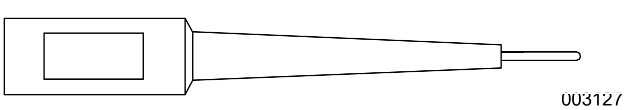


Figure 2-7. Narrow Test Probe

NOTE: It is not recommended to use any testing device other than the manufacturer's approved test lead adapters (P/N 0J09460SRV).

NOTE: These adapters are to be used on Evolution controllers with white Molex connectors (back-probe only).

Optional Tools

- ***J3 Breakout Harness Test Procedures*** Part Number A0000659764

Procedure: Fixed Excitation Test

IMPORTANT NOTE: DO NOT proceed to Step 1 until the Preliminary Output Voltage Test has been performed.

1. Remove the 7.5 amp fuse from the controller.
2. Locate and disconnect the appropriate harness connector with Wires 2 and 6 from the controller.

IMPORTANT NOTE: During this procedure, DO NOT reconnect this connector to the controller!

3. Set DMM to measure AC voltage.
4. Using the scale feature of the DMM, set to the first available scale greater than 100 (i.e. “600”).

NOTE: Refer to the manufacturer’s owners manual for specific information on using manual scaling.

5. Set meter to MIN/MAX.

NOTE: Refer to the manufacturer’s owners manual for specific information on using the MIN/MAX feature.

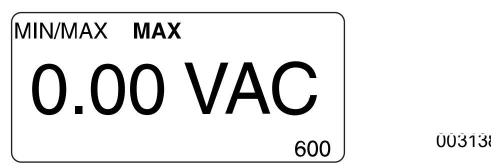


Figure 2-8.

6. Using approved meter test probes, connect one meter test lead to the appropriate harness pin for Wire 6 and the other meter test lead to the appropriate harness pin for Wire 2.
7. Install the 7.5 amp fuse.
8. Set the controller to MANUAL.
9. Measure and record the voltage indicated between Wires 2 and 6 as indicated by the DMM.
10. Acknowledge and reset the under-voltage alarm present on the controller.
11. Set the controller to OFF.
12. Re-locate meter test probes to the appropriate harness pin for Wire 11S and the appropriate harness pin for Wire 44S.
13. Set the controller to MANUAL.
14. Measure and record the voltage indicated between Wire 11S and 44S as indicated by the DMM.
15. Acknowledge and reset the under-voltage alarm present on the controller.
16. Set the controller to OFF.

Procedure: Rotor Amp Draw

1. Disengage the MIN/MAX feature and manual scale on the DMM.
2. Set DMM to measure DC amperage.
3. Verify the connector (previously disconnected in the Fixed Excitation Test) is disconnected.

NOTE: Consult the meters documentation for proper setup procedure.

4. Connect the Black (negative) meter test lead to the appropriate harness pin for Wire 4 and the Red (positive) test lead to the positive battery terminal.
5. Measure and record the static rotor amp draw.
6. Set the controller to MANUAL.
7. Measure and record the running rotor amp draw.
8. Acknowledge and reset the under-voltage alarm present on the controller.
9. Set the controller to OFF.

Results

1. Using the values recorded in the above procedure, compare the results to ***Table 2-7***. Determine the appropriate lettered column to use and refer back to the flow chart. The rotor amp draws are a calculated amp draw and actual amperage readings may vary depending on the resistance of the rotor.

   12.9 VDC/12.3 Ohms = 1.05 DC Amps

Table 2-6. Example

Model	17 kW
Wires 2 and 6 Voltage	53 VAC
Wires 11 and 44 Voltage	31 VAC
Static Rotor Amp Draw	1.09 Amp
Running Rotor Amp Draw	1.10 Amp

These results match Column B in the chart. Refer back to Problem 1 and follow letter "B".

Table 2-7. TEST 4 Results – Fixed Excitation Test/Rotor Amp Draw Test (8–24 kW)

Results:	Size	A	B	C	D	E	F	G	H
Voltage Results Wire 2 & 6	ALL	Above 50 VAC	Above 50 VAC	Below 50 VAC	Zero or Residual Volts	Below 50 VAC	Below 50 VAC	Above 50 VAC	Below 50 VAC
Voltage Results Wire 11 & 44	ALL	Above 50 VAC	Below 50 VAC	Above 50 VAC	Zero or Residual Volts	Below 50 VAC	Below 50 VAC	Above 50 VAC	Below 50 VAC
Static Rotor Amp Draw	8 kW ↕ 24 kW	2.0A ↕ 1.0A	2.0A ↕ 1.0A	2.0A ↕ 1.0A	Zero Current Draw	Above 2.5A	2.0A ↕ 1.0A	Zero Current Draw	2.0A ↕ 1.0A
Running Rotor Amp Draw	8 kW ↕ 24 kW	2.0A ↕ 1.0A	2.0A ↕ 1.0A	2.0A ↕ 1.0A	Zero Current Draw	Above 2.5A	2.0A ↕ 1.0A	Zero Current Draw	Above 2.5A

Note: Lower kW units typically have a higher current draw and higher kW units typically have a lower current draw. Actual values measured may vary by as much as 0.5 amps; depending on the type and quality of meter used, the condition of the unit, and how good the connection is between the test leads and test points.

🡐 *MATCH RESULTS WITH LETTER AND REFER TO FLOW CHART IN SECTION 2.2 "Problem 1"* 🡒

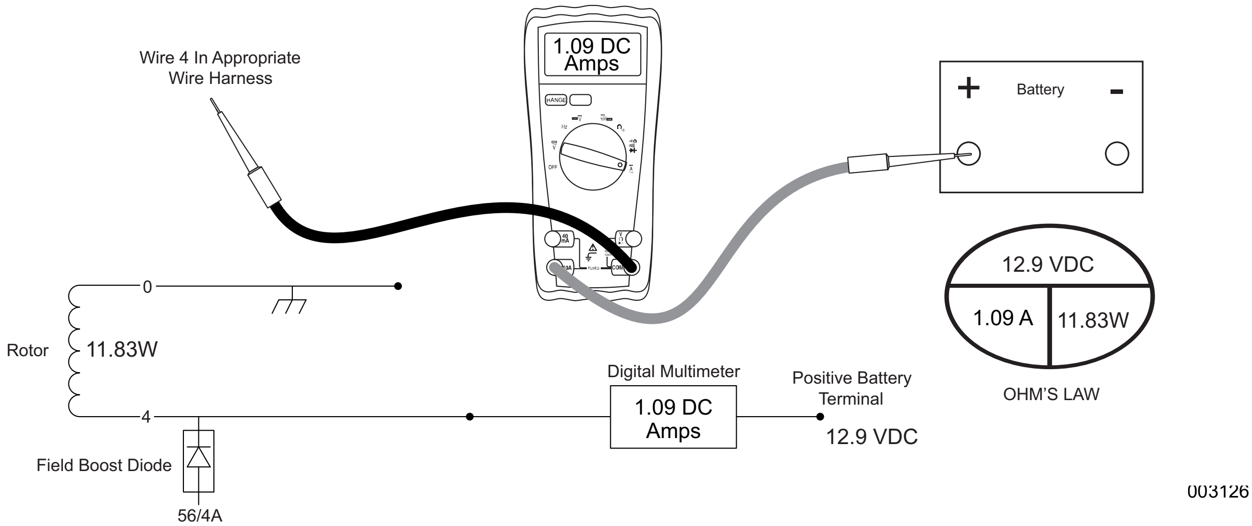


Figure 2-9. Rotor Amp Draw Test

NOTE: To calculate rotor amp draw take the battery voltage applied, divided by the actual resistance reading of the rotor. Rotor resistance can be measured between Wires 4 and 0 in the appropriate harness.

Test 5 – Test Sensing Circuit Wires 11S and 44S

General Theory

The voltage regulator (internal to the controller) requires a reference voltage to regulate at a specific voltage and to recognize if the alternator is producing voltage. The alternator may be producing voltage, but if the voltage regulator cannot sense the voltage, it will full field the rotor, produce in excess of 300 VAC and fault out for under-voltage. This test will verify the integrity of the sensing circuit.

Required Tools

- Meter test leads 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. See ***Figure 2-7***.

NOTE: It is not recommended to use any testing device other than the manufacturer's approved test lead adapters.

NOTE: Stator winding resistance values are very low. Some meters will not read such a low resistance, and will simply indicate different ranges of resistance. The manufacturer recommends a high quality digital type meter capable of reading a very low resistance.

Procedure A

1. Remove the 7.5 amp fuse from the control panel.
2. Gain access to and expose the lower harness connections under the controller.
3. Disconnect harness connector J1 from the controller which contains Wires 11S and 44S.
4. Set the DMM to measure resistance.
5. Connect one meter test lead to the appropriate harness pin for Wire 11S. Connect the other meter test lead to the appropriate harness pin for Wire 44S. Measure and record the resistance.
   a. If the meter indicated a resistance value consistent with the values found in Section 1.1 ***Specifications***, stop testing and refer back to flow chart (Good).
   b. If the meter indicated OPEN, proceed to Procedure B or Procedure C.

Procedure B – Units with STR Connector Only

1. Set DMM to measure resistance.
2. See ***Figure 2-10***. Locate and disconnect STR connector in wire harness.

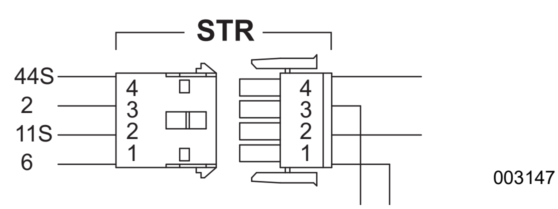


Figure 2-10. Stator Connector (STR) Pin Locations

3. Connect meter test leads the appropriate harness pins containing Wire 11S and Wire 44S in the STR connector leading to the Stator. Measure and record the resistance.
   a. If the meter indicated a resistance value consistent with the values found in Section 1.1 ***Specifications***, repair or replace Wire 11S and/or Wire 44S between the STR Connector and the J1 Connector.
   b. If the meter indicated an OPEN or a value inconsistent with the values found in Section 1.1 ***Specifications***, go to Test 7.

Procedure C – Units with STR Connector and STB Stator Terminal Block

1. Set DMM to measure resistance.
2. See ***Figure 2-10***. Locate and disconnect STR connector in wire harness.
3. Connect meter test leads to the appropriate harness pins containing Wire 11S and Wire 44S in the STR connector leading to the stator. Measure and record the resistance.
   a. If the meter indicated a resistance value consistent with the values found in Section 1.1 ***Specifications***, stop testing and refer back to the flow chart (Good).
   b. If the meter indicated OPEN, proceed to Step 4.
4. See ***Figure 2-11*** and ***Figure 2-12***. Remove the stator terminal block cover and identify the studs containing Wires 11S and 44S.

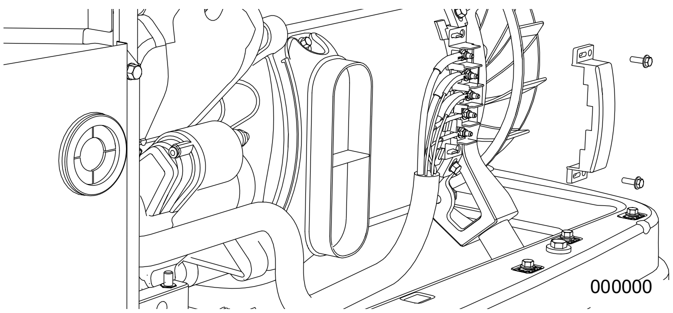


Figure 2-11. Stator Terminal Block Cover

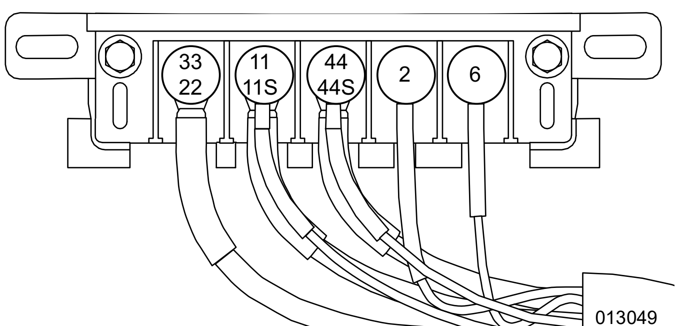


Figure 2-12. Stator Terminal Block Wires

5. Verify harness connections to the stator terminal block are tight and secure.
6. Observe the meter for resistance of the sensing circuit (11S and 44S) on the Terminal studs.
   a. If the meter indicated a resistance value of less than 0.3 ohms in Step 6, but was OPEN in Step 3, repair or replace Wire 11S and/or Wire 44S between the STR Connector and the STB Terminal Block. Refer back to flow chart (Good).
   b. If the meter indicated an OPEN or a value inconsistent with the values found in Section 1.1 ***Specifications***, go to Test 7.

Test 6 – Test Excitation Winding

General Theory

The controller's internal voltage regulator requires unregulated voltage from the stator to supply excitation power to the regulator. The regulator supplies DC 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 connections to the voltage regulator.

Required Tools

- **MINIMUM:** Meter test leads 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. See ***Figure 2-13***.

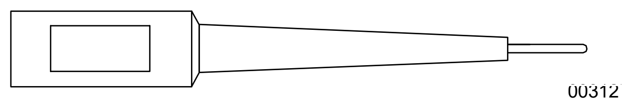


Figure 2-13. Narrow Test Probe

- **SUGGESTED:** A J3 Breakout Harness, P/N A0000659764 allows ease of meter lead connectivity. The J3 Breakout Harness with instructions is available as a kit P/N A0001273377. See ***Figure 2-14***.

Figure 2-14. J3 Breakout Harness

NOTE: It is not recommended to use any testing device other than the manufacturer's approved test lead adapters.

NOTE: Zero the meter leads or subtract meter lead resistance from actual reading to ensure accurate results.

Procedure A – using J3 Breakout Harness, P/N A0000659764

1. Disconnect the generator harness J3 connector.
2. Connect the female end of the J3 breakout harness to the unit harness.
3. DO NOT CONNECT the male end of the J3 breakout harness to the controller.
4. Insert meter test leads into the AC excitation test points of the breakout harness (6 and 2).
5. Observe the meter for resistance on the excitation winding (6 and 2).

a. If meter indicated a resistance value consistent with the values found in Section 1.1 ***Specifications***, stop testing and refer back to Problem 1 flow chart, Path C. (Good).

b. If meter indicated an OPEN, proceed to Procedure B.

Procedure A – not using J3 Breakout Harness

1. Remove the 7.5 amp fuse from the control panel.
2. Gain access to and expose the lower harness connections under the controller.
3. Disconnect the J3 harness connector containing Wires 2 and 6 from the controller.
4. Set DMM to measure resistance.
5. Connect one meter test lead to the harness pin for Wire 2 and the other meter test lead to the harness pin for Wire 6. Observe the meter for resistance on the Excitation winding (6 and 2).
   a. If meter indicated a resistance value consistent with the values found in Section 1.1 Specifications, stop testing and refer back to Problem 1 flow chart, Path C. (Good).
   b. If meter indicated an OPEN, proceed to Procedure B or C.

Procedure B – Units with STR Connector Only

1. See ***Figure 2-15***. Disconnect the STR connector located in the wire harness.

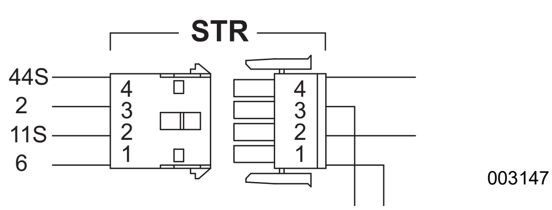


Figure 2-15. Stator Connector (STR) Pin Locations

2. Set DMM to measure resistance.
3. On the STR connector that leads to the stator, connect one meter test lead to Wire 2 and the other meter test lead to Wire 6. Observe the meter for resistance on the excitation winding (6 and 2) at the STR connector.
   a. If the meter indicated a resistance value consistent with the values found in Section 1.1 ***Specifications***, repair or replace Wire 2, Wire 6, or both wires between the controller and the STR (stator) connector. Measure Ohms between Wire 2 and 2 or Wire 6 and 6 to confirm which wire is open.
   b. If the meter indicated an OPEN or a value inconsistent with the values found in Section 1.1 ***Specifications***, go to Test 7.

Procedure C – Units with STR Connector and STB Stator Terminal Block

1. See ***Figure 2-15***. Disconnect the STR connector located in the wire harness.
2. Set DMM to measure resistance.
3. On the STR connector that leads to the stator, connect one meter test lead to Wire 2 and the other meter test lead to Wire 6. Observe the meter for resistance on the excitation winding (6 and 2) at the STR connector.
   a. If the meter indicated a resistance value consistent with the values found in Section 1.1 ***Specifications***, repair or replace Wire 2, Wire 6, or both wires between the controller and the STR (stator) connector. Measure Ohms between Wire 2 and 2 or Wire 6 and 6 to confirm which wire is open.
   b. If the meter indicated an OPEN or a value inconsistent with the values found in Section 1.1 ***Specifications***, go to Step 4.
4. See ***Figure 2-16*** and ***Figure 2-17***. Remove the stator terminal block cover (A) and identify the studs containing Wires 2 and 6.

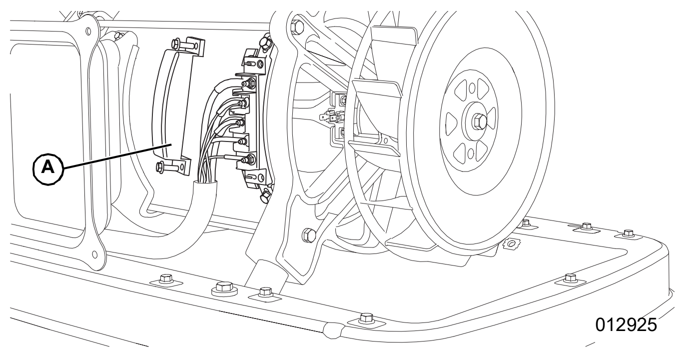


Figure 2-16. Stator Terminal Block (STB)

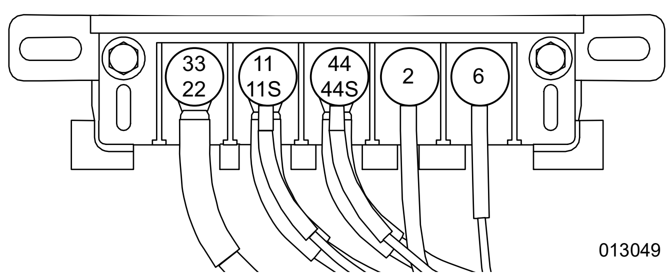


Figure 2-17. Stator Terminal Block Wires

5. Check to see that harness connections to the stator terminal block (P/N A0000029777) are tight and secure.
6. Set DMM to measure resistance.
7. Observe the meter for resistance of the excitation winding (6 and 2) on the terminal studs.
   a. If the meter indicated a resistance value consistent with the values found in Section 1.1 ***Specifications***, repair or replace Wire 2, Wire

6, or both wires between the STR (stator) connector and the STB (stator terminal block). Measure Ohms between Wire 2 and 2 or Wire 6 and 6 to confirm which wire is open.

b. If the meter indicated an OPEN or a value inconsistent with the values found in Section 1.1 ***Specifications***, go to Test 7.

Results

1. See ***Figure 2-16***. If the meter indicated a resistance value of OPEN in Procedure A, but a resistance value consistent with the values found in ***Specifications*** in Procedure B or Procedure C, repair or replace Wire 2 and/or 6 between the referenced connection points. Measure continuity on Wire 2 or Wire 6 between the referenced connection points to confirm which (or both) wire(s) is/are open.
2. If the meter indicated a resistance value consistent with the values found in ***Specifications*** in Procedure A, Procedure B or Procedure C, stop testing and refer back to the flow chart (GOOD).
3. If the meter indicated a resistance value of OPEN or a resistance value inconsistent with the values found in ***Specifications*** in Procedure B or Procedure C, go to Test 7.

Test 7 – Test the Stator with a DMM

General Theory

This test will use a digital multimeter (DMM) to test the stator windings for the following faults:

- An OPEN circuit condition
- A “short-to-ground” condition
- A short circuit between windings

Table 2-8 has been provided to record the results of the following procedure. These results may be required when requesting factory support.

IMPORTANT NOTE: It is the recommendation of the factory to perform this test procedure using piercing probes on the wire side of the connector. Testing inside the connector itself can cause unnecessary damage to the unit resulting in poor or loose connections.

Required Tools

- Meter test leads 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. See ***Figure 2-18***.

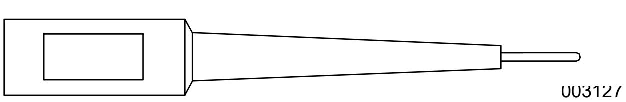


Figure 2-18. Narrow Test Probe

NOTE: It is not recommended to use any testing device other than the manufacturer's approved test lead adapters.

Resistance Test with Neutrals Disconnected (with STR Connector only)

1. Disconnect Wires 11 and 44 from the main line circuit breaker (MLCB).
2. Disconnect Wires 22 and 33 from the NEUTRAL connection and separate the leads.
3. See ***Figure 2-15***. Disconnect the STR (stator) connector on the harness.
4. Isolate all disconnected leads from each other and keep from touching the frame during test.
5. Set the DMM to measure resistance.
6. Measure and record the resistance values for each set of windings between the A and B test points as shown in ***Table 2-8***.

Table 2-8. Stator Results (w/STR connector)

Test Point A	Test Point B	Results
Resistance Test with Neutrals Disconnected		
Stator Lead Wire 11	Stator Lead 22	
Stator Lead Wire 33	Stator Lead 44	
STR Pin 2 Wire 11S	Stator Lead 22	
STR Pin 4 Wire 44S	Stator Lead 33	
STR Pin 1 Wire 6	STR Pin 3 Wire 2	
Test Windings for a Short to Ground		
Stator Lead Wire 11	Ground	
Stator Lead Wire 44	Ground	
STR Pin 4 Wire 44S	Ground	
STR Pin 2 Wire 11S	Ground	
STR Pin 3 Wire 2	Ground	
Test For A Short Circuit Between Windings		
STR Pin 3 Wire 2	STR Pin 2 Wire 11S	
STR Pin 3 Wire 2	STR Pin 4 Wire 44S	
STR Pin 3 Wire 2	Stator Lead Wire 11	
STR Pin 3 Wire 2	Stator Lead Wire 44	
Stator Lead Wire 11	STR Pin 4 Wire 44S	
Stator Lead Wire 11	Stator Lead Wire 44	

Resistance Test with Neutrals Connected (with STB Stator Terminal Block only)

1. See ***Figure 2-19***. Remove the stator terminal block cover (A) to expose all wires/studs (33/22, 11, 44, 2, and 6).

2. Verify harness connections to the stator terminal block are tight and secure.

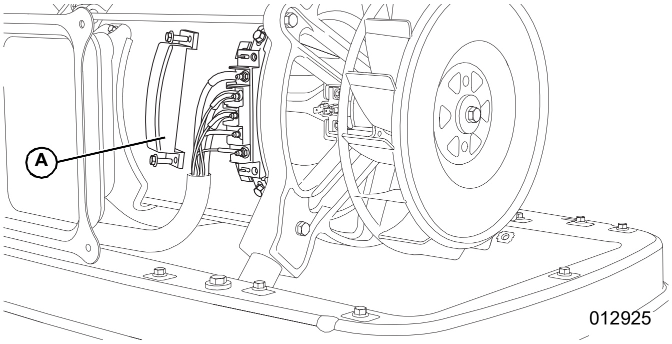


Figure 2-19. Stator Terminal Block (STB)

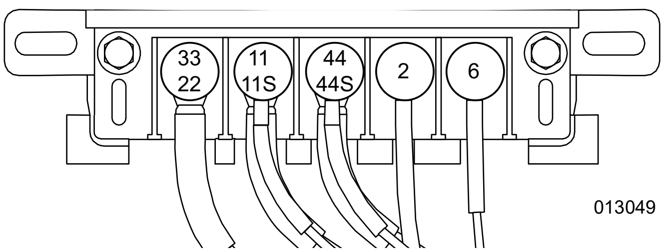


Figure 2-20. Stator Terminal Block Wires

3. Set DMM to measure resistance.
4. Measure and record the resistance values for each set of windings between the A and B test points as shown in ***Table 2-9***.

Table 2-9. Stator Results (w/STB terminal block)

Test Point A	Test Point B	Results
Resistance Test with Neutrals Disconnected		
Stator Stud Wire 11	Stator Stud Wire 44	
Stator Stud Wire 2	Stator Stud Wire 6	
Test Windings for a Short to Ground		
Stator Stud Wire 11 or 44	Ground	
Stator Stud Wire 2		
Test For A Short Circuit Between Windings		
Stator Stud Wire 2 or 6	Stator Stud Wire 11	
	Stator Stud Wire 22/33	
	Stator Lead Wire 44	

Test 8 – Resistance Check of Rotor Circuit

General Theory

During the rotor amp draw test in Test 4, if the amp draw was zero, then an OPEN circuit should be present on Wires 4 and 0. This test will verify if the readings were accurate and verify the field boost circuit.

Procedure

1. Remove the 7.5 amp fuse from the control panel.
2. Remove the cover and controller to expose the lower harness connections.
3. Disconnect the J3 harness connector containing Wires 4 and 0 from the controller.
4. Set the DMM to measure resistance.
5. Connect one meter test lead to the appropriate harness pin for Wire 4 and connect the other meter test lead to the appropriate harness pin for Wire 0. Measure and record the resistance.
6. Connect one meter test lead to the appropriate harness pin for Wire 4 and connect the other meter test lead to a ground connection. Measure and record the resistance.

Results

Refer to the front of this manual for correct Rotor resistance values.

1. If the DMM indicated the correct resistance values in Steps 5 and 6, refer back to flowchart (Good).
2. If the DMM indicated INFINITY in Steps 5 and 6, refer back to flowchart (Rotor Circuit Failure).

Test 9 – Check Brushes and Slip Rings

General Theory

The brushes and slip rings function to provide an electrical connection for excitation current from the stationary components to the rotating rotor. Made of a special long lasting material, brushes seldom wear out or fail. However, slip rings can develop a tarnish or film that can inhibit or offer resistance to the flow of current. Such a non-conducting film usually develops during non-operating periods. Broken or disconnected wiring can also cause loss of field excitation current to the rotor.

Procedure

1. Disassemble the generator until the brushes and slip rings are exposed. Refer to Section 5.1 ***Major Disassembly***.
2. Inspect the brush wires and verify they are secured and properly connected.
3. Inspect the brush assembly for excessive wear, or damage.
4. Inspect the rotor slip rings. If their appearance is dull or tarnished, polish with a fine grade abrasive material.

IMPORTANT NOTE: Do not use metallic grit (such as emery cloth) to polish slip rings. This may cause irreversible damage to the rotor.

5. Disconnect the J3 harness connector from the controller containing Wires 4 and 0.
6. Set the DMM to measure resistance.
7. Wire 0, located on the negative brush terminal, provides an electrical connection to ground for the rotor and the voltage regulator in the controller. To test this wire for an OPEN condition, remove Wire 0 from the brush assembly. Measure resistance between the negative brush and the controller connector Wire 0.
   - If the DMM indicated INFINITY, repair or replace Wire 0 at the point of failure.
   - If the DMM indicated CONTINUITY, continue to Step 8.
8. Wire 4, located on the positive brush terminal, provides an electrical connection for excitation current to flow between the rotor and the voltage regulator in the controller. To test this wire for an OPEN condition, remove Wire 4 from the brush assembly. Measure resistance between the negative brush and the controller connector Wire 4.
   - If the DMM indicated INFINITY, repair or replace Wire 4 at the point of failure.
   - If the DMM indicated CONTINUITY, continue to Step 9.
9. With Wire 4 still disconnected at the brush assembly, connect one meter test lead to Wire 4 at the brush and connect the other meter test lead to frame ground.
   - If the DMM indicated CONTINUITY, repair or replace Wire 4 at the point of failure.
   - If the DMM indicated INFINITY, refer back to the flow chart.

Results

1. Repair, replace, or reconnect wires as necessary.
2. Replace any damaged slip rings or brush holder.
3. Clean and polish slip rings as required.

Test 10 – Test Rotor Assembly

General Theory

A rotor having open windings will cause loss of excitation current flow and as a result generator AC output voltage will drop to “residual” voltage. A “shorted” rotor winding can result in a low voltage condition.

Procedure

1. Remove the brush assembly from the slip rings to prevent interaction.
2. Set a DMM to measure resistance.
3. Connect one meter test lead to the positive slip ring (nearest the rotor bearing) and the common test lead to the negative slip ring, measure and record the resistance.
4. Connect one meter test lead to the positive slip ring and connect the other meter test lead to a ground connection. Measure and record the resistance.

Results

1. Compare the resistance measured in Step 3 with Section 1.1 ***Specifications***. Replace rotor as required.
2. If the DMM indicated CONTINUITY in Step 4, replace the rotor assembly.

Test 14 – Check Voltage and Frequency Under Load

General Theory

It is possible for 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 a DMM 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 DMM indicated 60 Hz and approximately 240 VAC during full load, discontinue testing.
2. If the DMM indicated a frequency and voltage that dropped while under full load, refer back to flow chart.

Test 15 – Check for an Overload Condition

General Theory

An “overload” condition exists when 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.

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 rated capacity of the unit.
2. If the ammeter indicated amperage readings that were below the unit's specified ratings, but rpm and frequency dropped excessively refer back 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 3.5** ***Troubleshooting Flowcharts*** and **Section 3.6** ***Diagnostic Tests***. For further engine repair information, refer to the appropriate engine service manual.

Test 17 – Current Calibration (8–20 KW Units)

General Theory

An Evolution unit 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 CTs are calibrated using the Evolution control panel. A password is required to access the Dealer Edit menu when performing calibrations.

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

Procedure

1. Connect a load bank to the output circuit of the generator. This should be done at the generator's MLCB.
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 generator output and the calibration value of that CT.
7. Adjust up or down the generator display to match the Amp meter's calibrated reading. (Use the controllers UP and DOWN arrows to make adjustments)
8. Once the display panel 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 to 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

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)

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
- Menu System Navigation
- LED Display
- Battery Charger
- AUTO-OFF-MANUAL
- 7.5 Amp Fuse
- Starter Contactor Relay
- Common Alarm Relay
- Connector Pin Descriptions

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 at the following connection points:

- UTILITY N1 (Utility Sensing)
- UTILITY N2 (Utility Sensing)
- LOAD T1 (Internal Battery Charger) - 60 Hz Unit
- LOAD T2 (Internal Battery Charger) - 50 Hz Unit
- Wire 194 (Transfer Relay)
- Wire 23 (Transfer Relay)

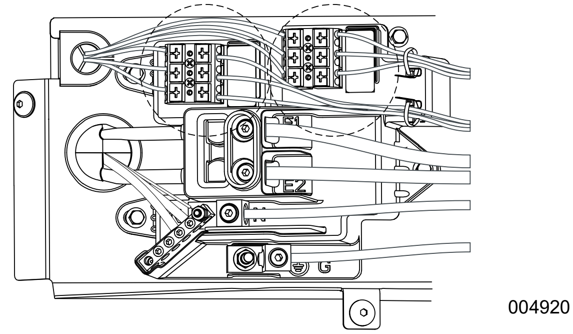


Figure 3-1. 2017 Evolution Customer Connections

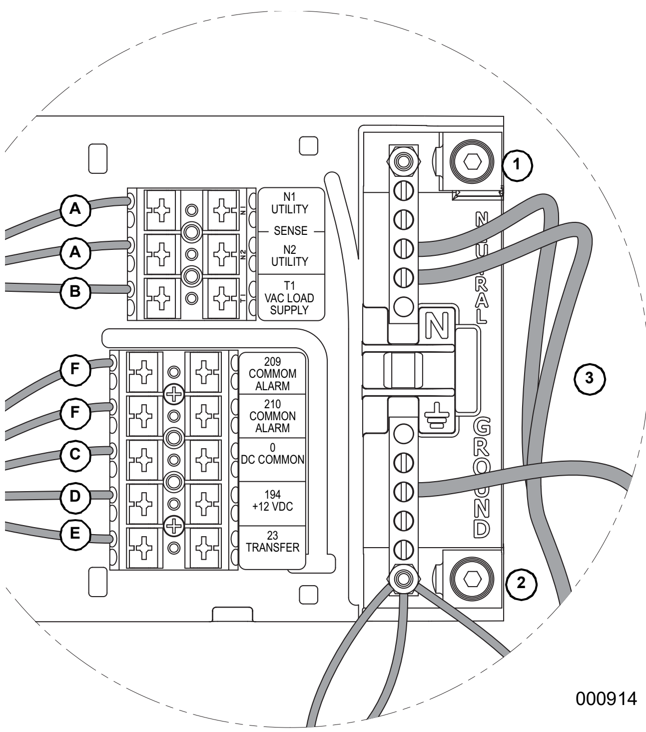


Table 3-1. Control Panel Connections		
Terminal Numbering Decal		Wire Numbers
A	YELLOW #1 & #2	N1 & N2 - 240 VAC - Sensing for Utility Dropout and Pickup
B*	BLUE #3	T1 - Fused 120 VAC for Battery Charger (*see NOTE)
C	BLACK #3	0 - DC (-) Common Ground Wire
D	RED #4	194 - DC (+) 12 VDC for Transfer Controls
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 3-2. 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)
Note: A 25 in-lb (2.82 Nm) torque should be applied to the ground wire and neutral wire connection to the ground/neutral bar.	

Figure 3-2. Evolution (2016 and older) Control Wiring - 60 Hz (found behind control board)

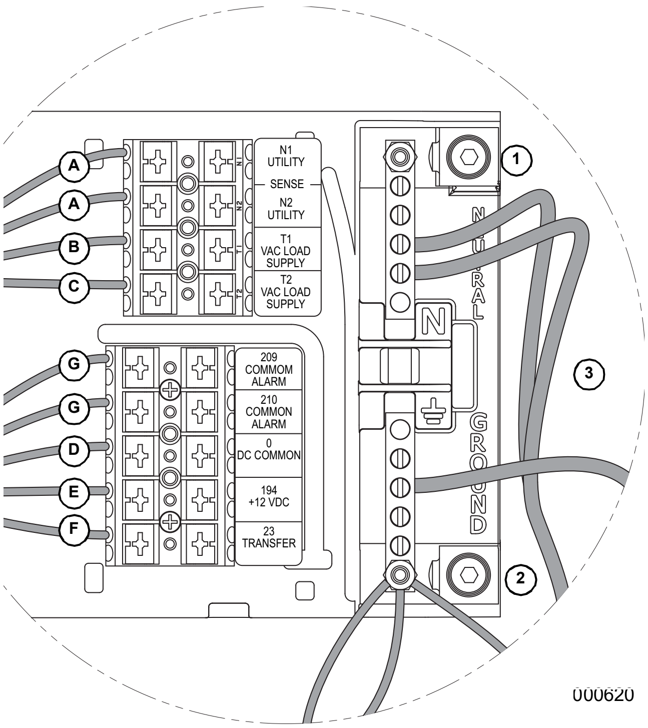


Table 3-3. Control Panel Connections

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*	WHITE #4	T2 - Fused 120 VAC for Battery Charger (*see NOTE)
D	BLACK #3	0 - DC (-) Common Ground Wire
E	RED #4	194 - DC (+) 12 VDC for Transfer Controls
F	WHITE #5	23 - Transfer Control Signal Wire
G	BLUE #1 & #2	Optional Alarm Relay Contacts (Normally Open)
Note: Must be connected to keep battery charged whether unit is running or not.		

Table 3-4. 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 3-3. Evolution (2016 and older) Control Wiring - 50 Hz (found behind control board)

Controller

The controller is responsible for all standby electric system operations including (a) engine startup, (b) engine running, (c) automatic transfer, (d) automatic re-transfer, and (e) engine shutdown. In addition, the controller performs the following functions:

- Automatic voltage regulation.
- Starts and exercises the generator once every seven days.
- 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 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 3-5*** for the specific position and function. See ***Menu System Navigation*** to view state of output or input.

Table 3-5. Digital Inputs and Outputs

Position	Digital Inputs	Digital Outputs
1	Not Used/Aux Shutdown*	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	2-Wire Start	Starter
7	Auto	Ignition
8	Manual	Transfer
* Evolution1.0 (firmware v1.18 and higher) and Evolution 2.0 (all firmware) units.		

IMPORTANT NOTE: The generator engine will crank and start when the 7-day exerciser is set. The unit will also crank and start every 7 days thereafter, on the programmed day and time.

IMPORTANT NOTE: If the controller was OFF during its scheduled exercise time it will immediately attempt to exercise when the unit is set to AUTO.

LED Display

Located next to the right side lock cylinder on the generator, the LED Display provides a visual indication the generators status. The LED Display has three LEDs:

- 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.

NOTE: On 2017 Evolution 1.0 (firmware v1.17 and higher) and Evolution 2.0 (all firmware) the Green LED will flash when unit has transferred to standby and is carrying load.

Battery Charger

The charger operates at one of three battery charging 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.

NOTE: 50 Hz units use fuses F3 and F4 and a 220 VAC supply to the battery 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 pre-set level, or the battery open-circuit voltage is less than approximately 12.5V, a "Charger 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 weekly exercise cycle). If either condition occurs the battery charge will begin its 18 hour charge cycle.

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 Evolution controller has OFF-MANUAL-AUTO Mode membrane push buttons. See ***Figure 3-4*** for the location of the push buttons.

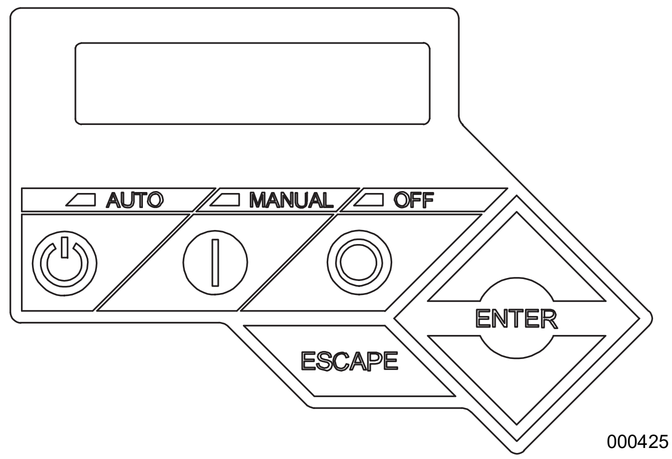


Figure 3-4. Evolution controller Off-Manual-Auto Buttons

Fuse

The fuse protects the controller against excessive current. If the fuse has blown, engine cranking and operation will not be possible. Should fuse replacement become necessary, use only an equivalent 7.5 amp replacement fuse.

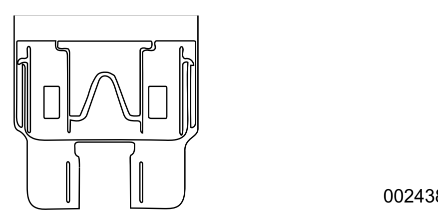


Figure 3-5. Typical 7.5 Amp Fuse

Starter Contactor Relay/Solenoid

(V-Twins and units with 426cc Engine)

See ***Figure 3-6***. 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.

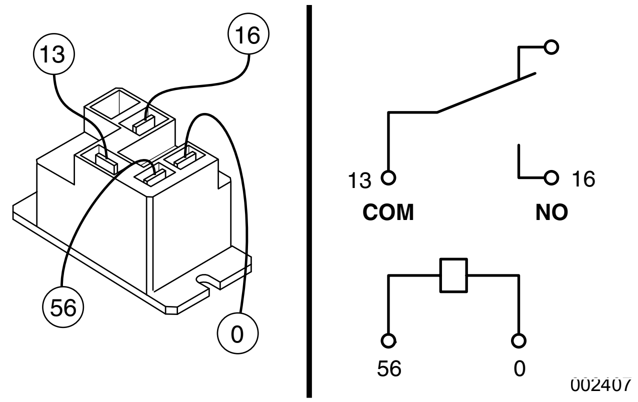


Figure 3-6. Starter Contactor Relay (V-twin Units)

(410cc Single Cylinder Engine Units Only)

See ***Figure 3-7***. The Starter Contactor (SC) is located in the engine compartment and is mounted against the firewall. The SC provides the electrical connection to safely engage the starter.

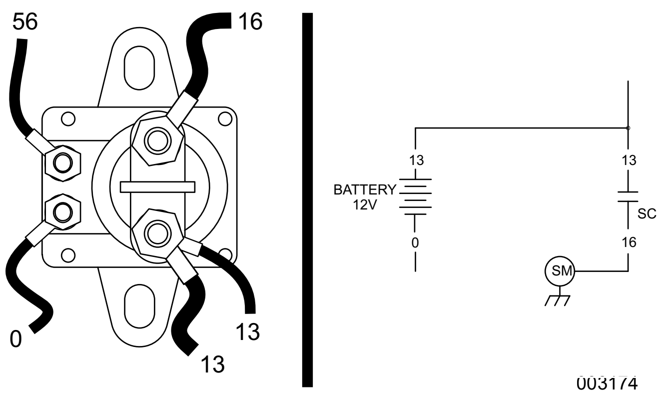


Figure 3-7. The Starter Contactor (Single Cylinder Units)

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.

On Evolution units (2016 and older), the connections are made to the generator customer connection terminal strip (or WAGO block) at Terminals 1 and 2 (Wires 209 and 210).

On Evolution units (2017 and newer) the connections are made to the controller via Wires 209 and 210 by connecting to the dedicated wire connections.

Table 3-6. Specifications	
Contact Rating:	200 mA at 12 VDC

NOTE: Contact rating is for resistive load only

Circuit Pin Descriptions

Appendix A ***Controller Identification*** provides the physical wire identification and circuit functions.

Menu System Navigation

To get to the menu page, press the ESCAPE 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 up and down arrow keys. When the desired menu item is flashing, press ENTER. Depending on the menu selected, a list of choices may be presented. Use the same navigation method to select the desired screen. Refer to Section 1.3 ***Evolution 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 up and down arrow 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 up and down arrow 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.

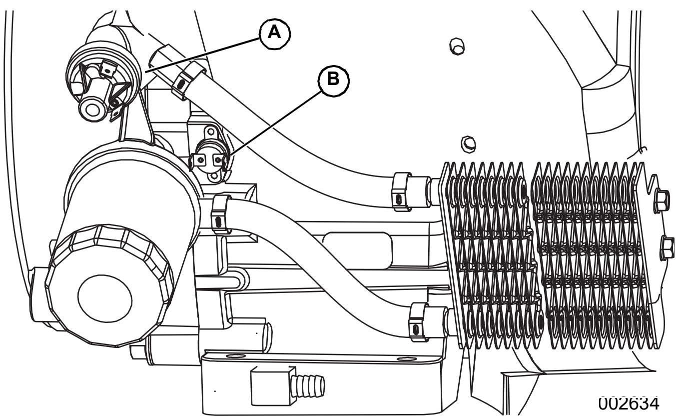
Engine Protective Devices

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 warning 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 3-8. Engine Protective Switches

Low Oil Pressure
(E-Code 1300)

All Evolution 2017 and Prior Models

See ***Figure 3-8***. An oil pressure switch is mounted near the oil filter. 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, followed by the grounding of the ignition circuit. This will result in closure of the fuel shutoff solenoid and subsequent loss of engine ignition.

All Evolution 2.0 and Newer Models: This switch has normally open contacts that are held closed by engine oil pressure during cranking and startup. Should oil pressure drop below approximately 10 psi, the switch contacts will open. Upon opening of the switch contacts, Wire 86 circuit from the controller will be disconnected from ground. The controller’s logic responds in the same way as Evolution 1.0, shutting the unit down.

High Temperature Switch
(E-Code 1400)

All Evolution 2017 and Prior Models

See ***Figure 3-8***. The contacts of this switch are normally open and will 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.

All Evolution 2.0 and Newer Models: The contacts of this switch are normally closed and will open if the temperature exceeds approximately 310 ºF (154 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
(E-Code 1200 and 1205)

During engine cranking and operation the controller receives AC voltage and frequency signals from the ignition magneto via Wire 18. If engine speed exceeds approximately 72 Hz (4320 rpm), controller 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 protects the engine and alternator against damaging over speeds. During cranking, the rpm signal generated by the magnetos is used to terminate engine cranking.

Evolution 2.0 Overspeed
(E-Code 1207)

The controller monitors the zero cross timing of the AVR to determine alternator frequency. Alternator frequency is an indicator of speed. Set for 150 milliseconds of 4500 rpm or higher. Used if the normal ignition pulse sequence(s) are not being seen by the controller.

RPM Sensor Failure
(E-Code 1501, 1505, 1511, 1515)

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 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, a faulty starter, or a weak battery.

Overcrank
(Evolution 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.

Cyclic cranking is controlled 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 speed within the specified crank cycle. Starter dropout speed is defined as four (4) engine cycles at 1,500 rpm (1,800 rpm for 8 kW units).
2. Reaching starter dropout speed, 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 via the magnetos and Wire 18 into the control panel. 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, a rest and 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 3-7. Evolution Under-frequency Shutdown Settings

Unit Hertz	Shutdown Frequency
50 Hz	40 Hz
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.

Table 3-8. Evolution 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 4 sec (8 kW only)	1.1 seconds	Continuous	Timed signal loss	Timed signal loss	2 Re crank, 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 60 Hz	5 seconds	30 seconds	Continuous	None	55 Hz/3300 RPM	Hard Lockout
Underspeed 50 Hz	5 seconds	30 seconds	Continuous	None	40 Hz/2400 RPM	Hard Lockout
Overspeed Instant 50 Hz	0 seconds	.1 second	Continuous	62.5 Hz/3750 RPM	None	Hard Lockout
Overspeed Slow 50 Hz	0 seconds	3 seconds	Continuous	60Hz/3600 RPM	None	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 Re crank, Hard Lockout
Undervoltage Slow*	5 seconds	10 seconds	Continuous	None	80% of nominal	2 Re crank, 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
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 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 (Evolution 1.0)	15 seconds	As long as AC is missing	Continuous except cranking	NA	NA	Warning
Charger Missing AC (Evolution 2.0)	3 Minutes	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 3.3 Operational Analysis – Evolution 2.0

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

The circuit condition with the controller set to AUTO and with Utility source power available can be briefly described as follows:

- Utility source voltage is available to the transfer switch Terminal Lugs N1 and N2 and the CONTACTOR is in the "Utility" position.
- Utility voltage is available to the controller via Wire N1 and N2.
- Load voltage (120 VAC) is available to the controller via Wire T1 for Battery Charger. (220-240 VAC on T1 and T2 50 Hz only)
- 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.
- Wire 820 supplies 5 VDC to the Tri-Light Annunciator and Wire 817 for the Green System Ready LED is gated to ground.

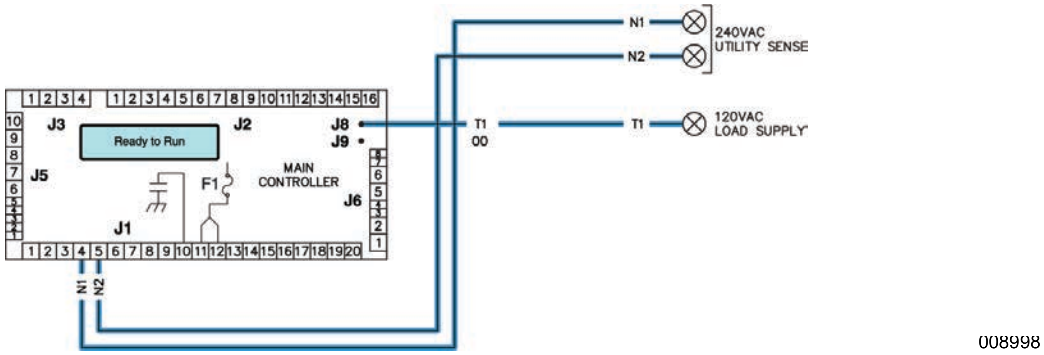

Figure 3-9.

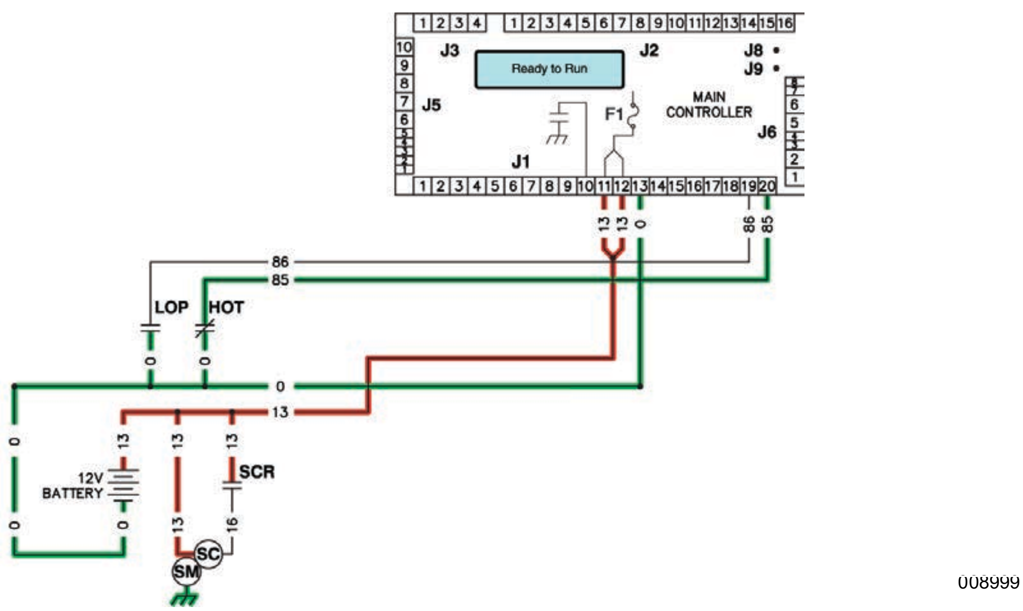

Figure 3-10.

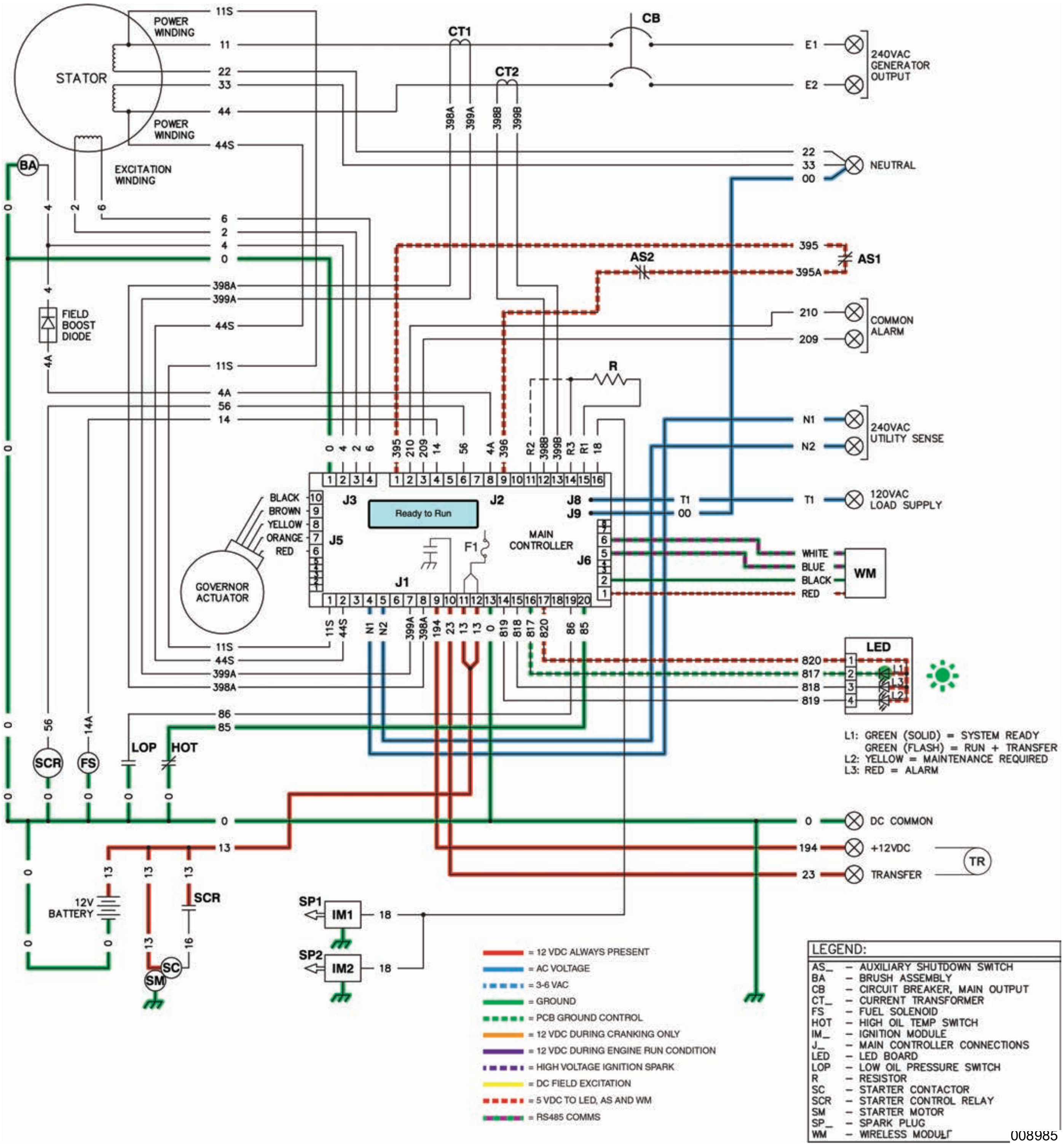

Figure 3-11. Utility Source Voltage Available

Initial Dropout of Utility Source Voltage

See ***Figure 3-13***. Should a Utility power failure occur, circuit condition may be briefly described as follows:

- 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.
- The 5-second timer (factory default, but adjustable from 2-1500 seconds) is still timing and engine cranking has not yet begun.

Utility Dropout	
Factory Default	**Adjustable Dropout Voltage**
60 Hz = 156 VAC	60 Hz = 140-171 VAC
50 Hz = 142 VAC	50 Hz = 140-156 VAC

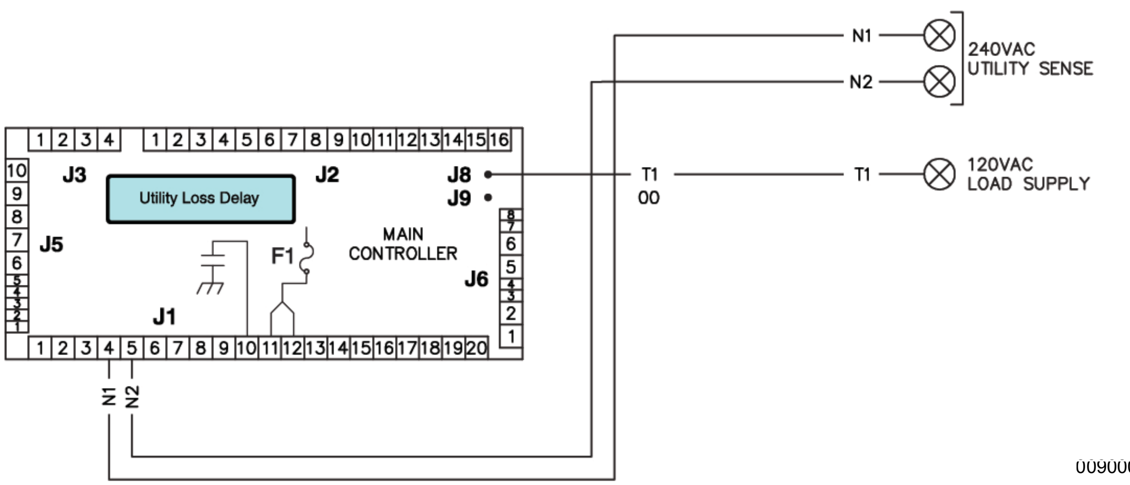

Figure 3-12.

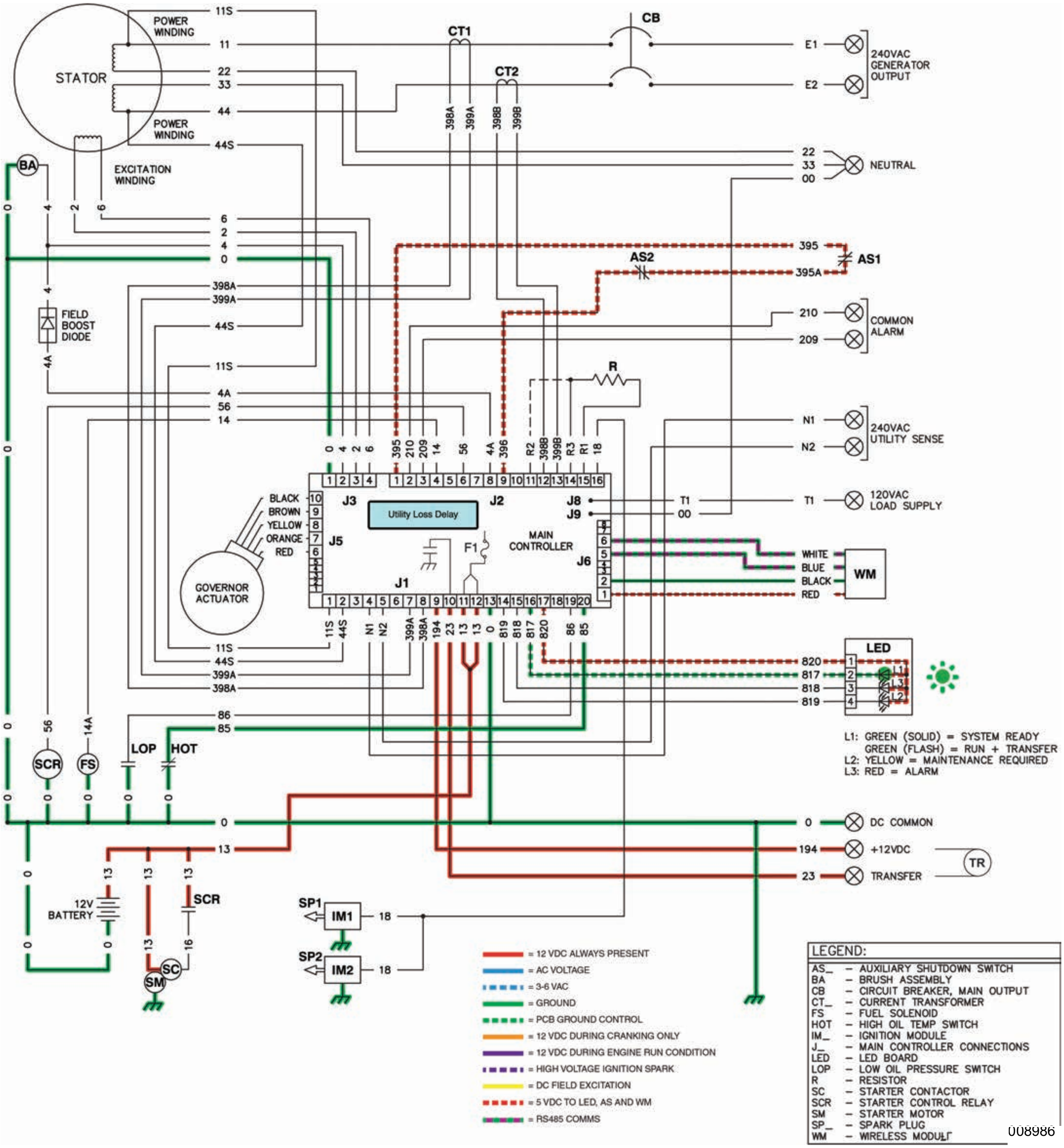

Figure 3-13. Initial Dropout of Utility Source Voltage

Utility Voltage Failure and Engine Cranking

- After the controller's adjustable programmed 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.
- 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.
- 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, which partially opens the small venturi.

- 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 (mechanically opens) and fuel is available to the engine.

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

- With ignition and fuel flow available the engine RPM will begin to increase.

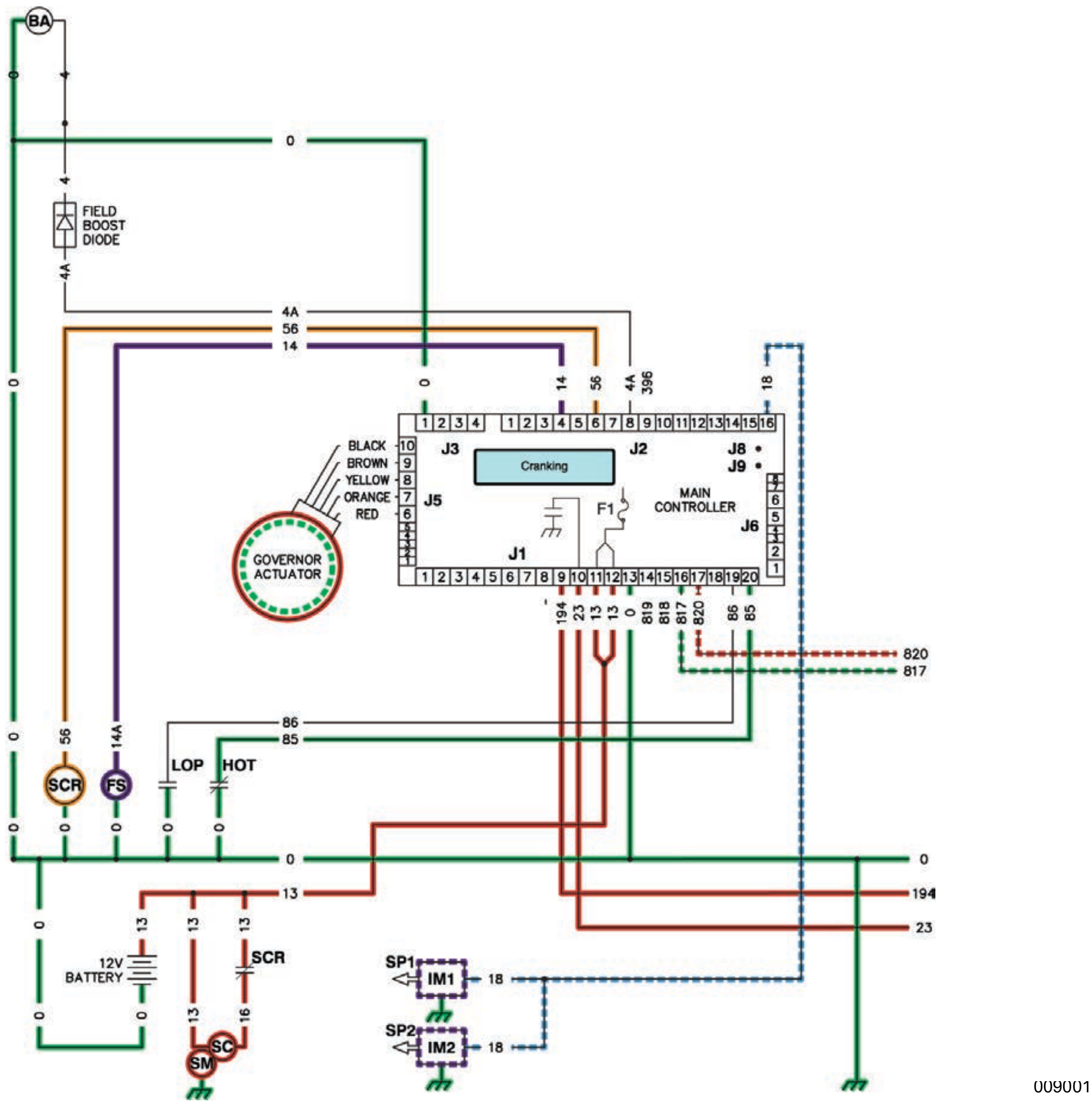

Figure 3-14.

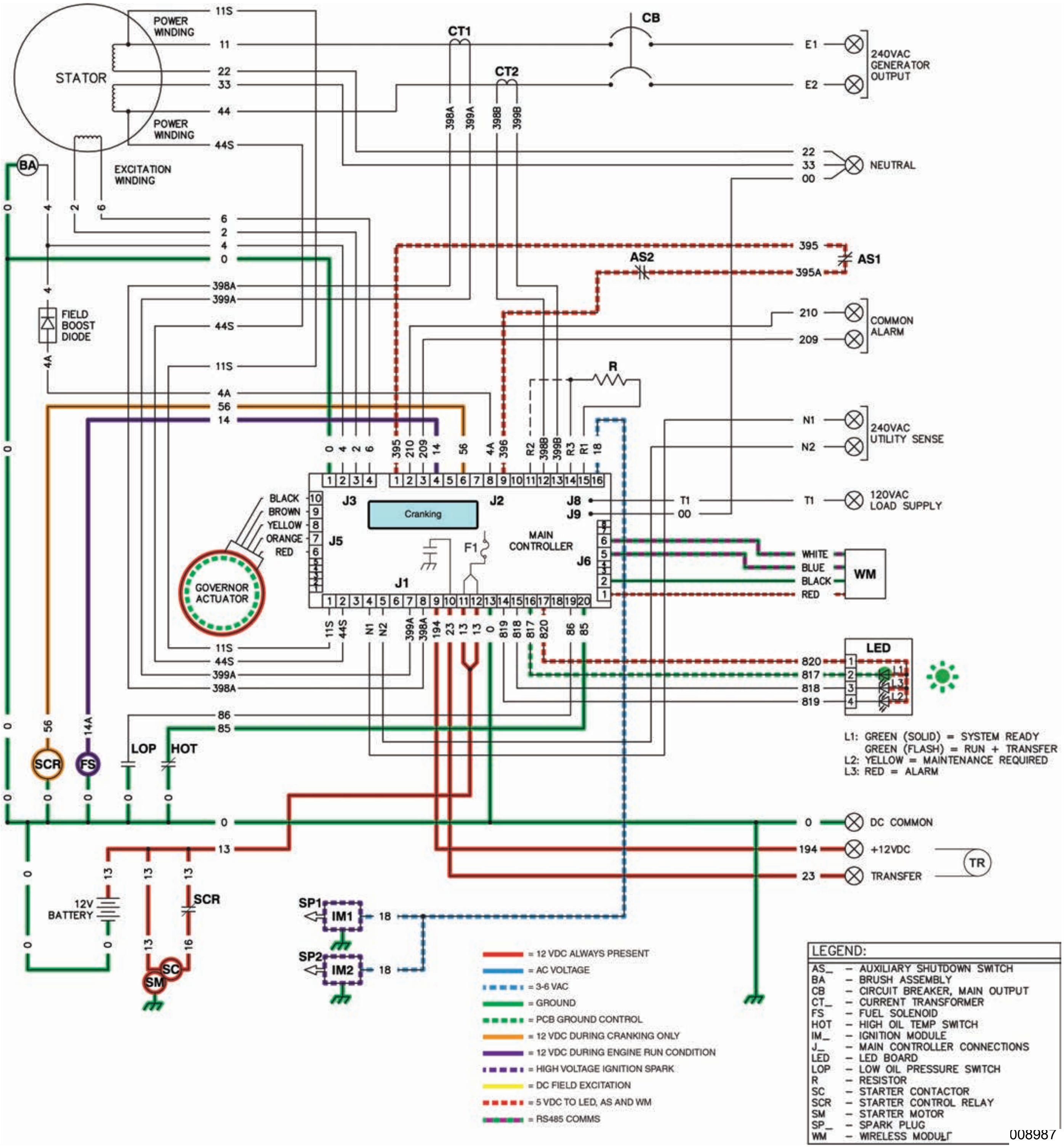

Figure 3-15. Utility Voltage Failure and Engine Cranking

Engine Startup and Running

With the fuel solenoid open and ignition occurring, the engine starts. Engine startup and running may be briefly described as follows:

- The ignition magneto(s) deliver a speed reference signal to the controller via Wire 18. Once the controller determines that the engine is running, the controller:
  a. terminates cranking by de-energizing Wire 56 at approximately 1500 RPM (V-twin) and 1800 RPM (single cylinder).
  b. energizes a field flash relay in the controller at 2200 RPM which delivers 12 VDC on Wire 4A through a field boost diode and to the rotor via Wire 4. The field boost will continue for a pre-determined time, or until field boost parameters are achieved, whichever occurs first.

NOTE: See "Field Boost" in Section 2.2 for analysis of Evolution field boost parameters.

  c. also 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.
- Generator AC output is 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.

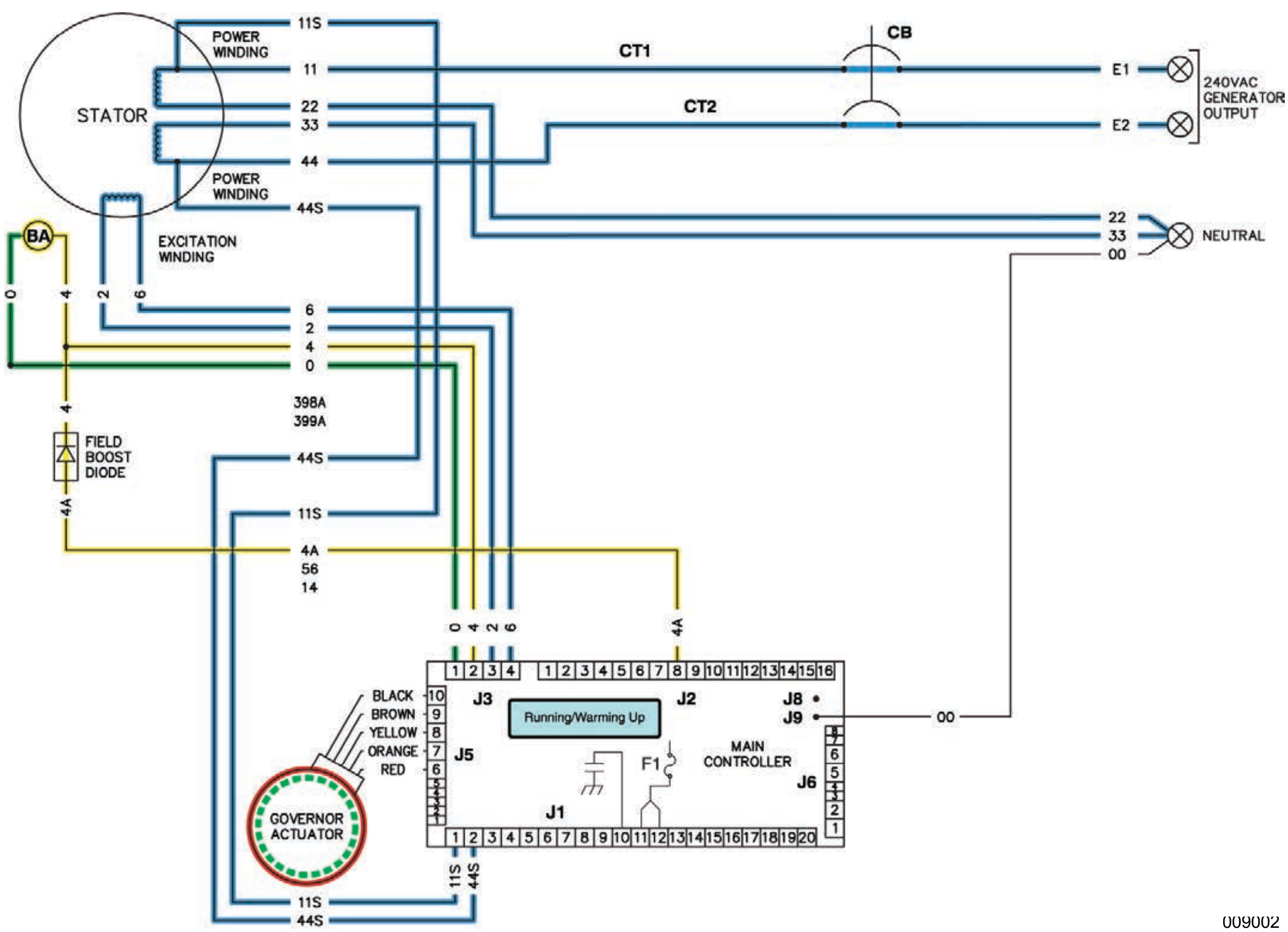

Figure 3-16.

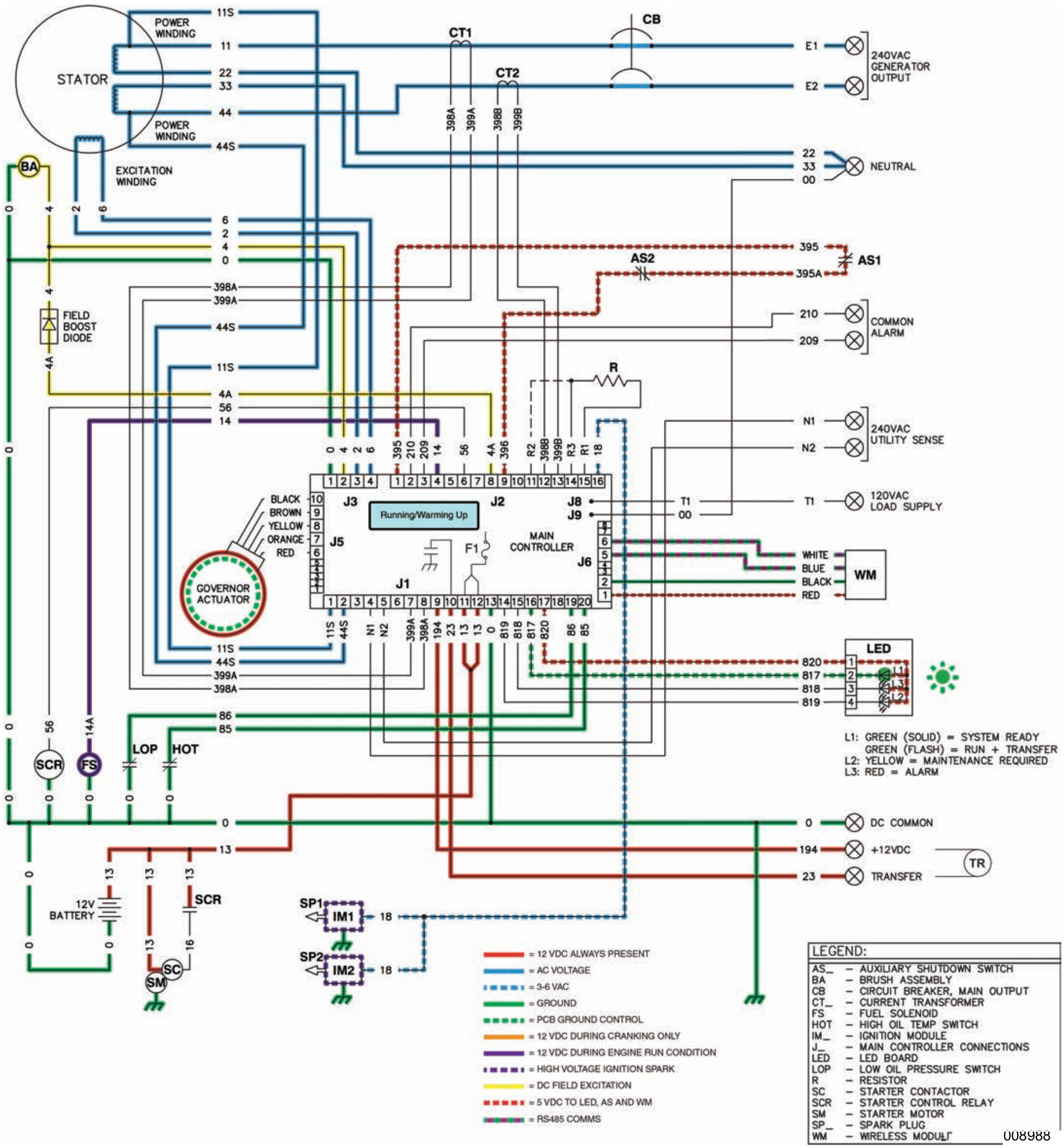

Figure 3-17. Engine Startup and Running

Transfer to Standby

In ***Figure 3-19*** 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:

- 12 VDC is delivered to the transfer relay coil via Wire 194. The 12 VDC circuit is completed back to the controller via Wire 23. However, the controller's logic holds Wire 23 open from ground and the transfer relay is de-energized.
- When the "engine warm-up timer" expires, the controller will take Wire 23 to ground. The transfer relay energizes and its normally open contacts close (standby position).
- 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 frequency through different loads
  b. overspeed
  c. underspeed
- 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 nearly wide open, it will start to open the larger venturi as needed for load/fuel demand.
- 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 Amps = 0.380 mVAC

50 Amps = 0.755 mVAC

75 Amps = 1.133 VAC

100 Amps = 1.510 VAC

⚠ 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)

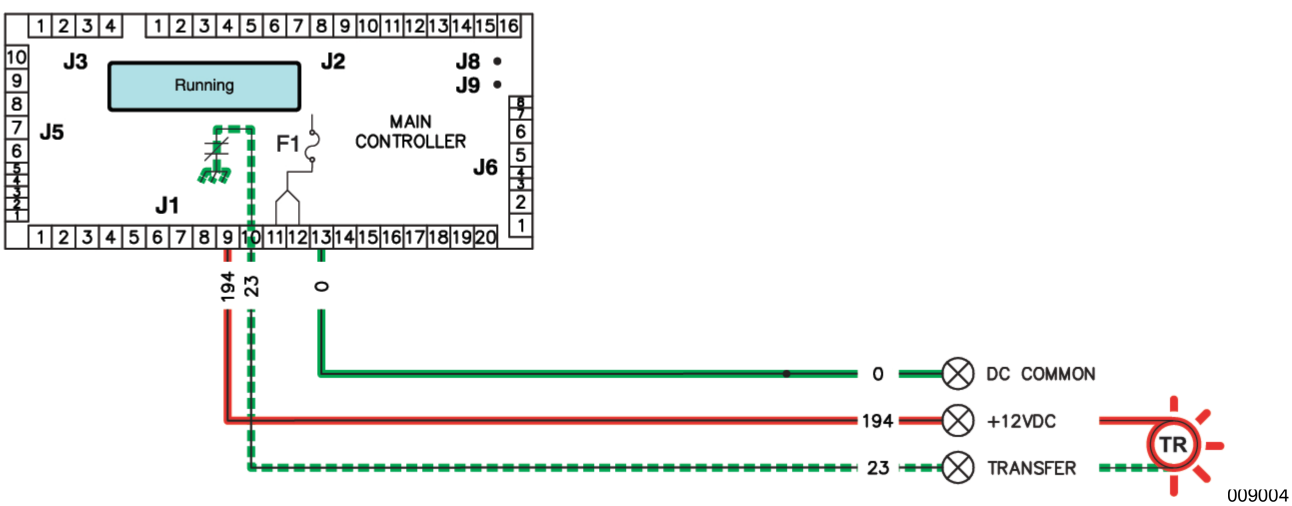

Figure 3-18.

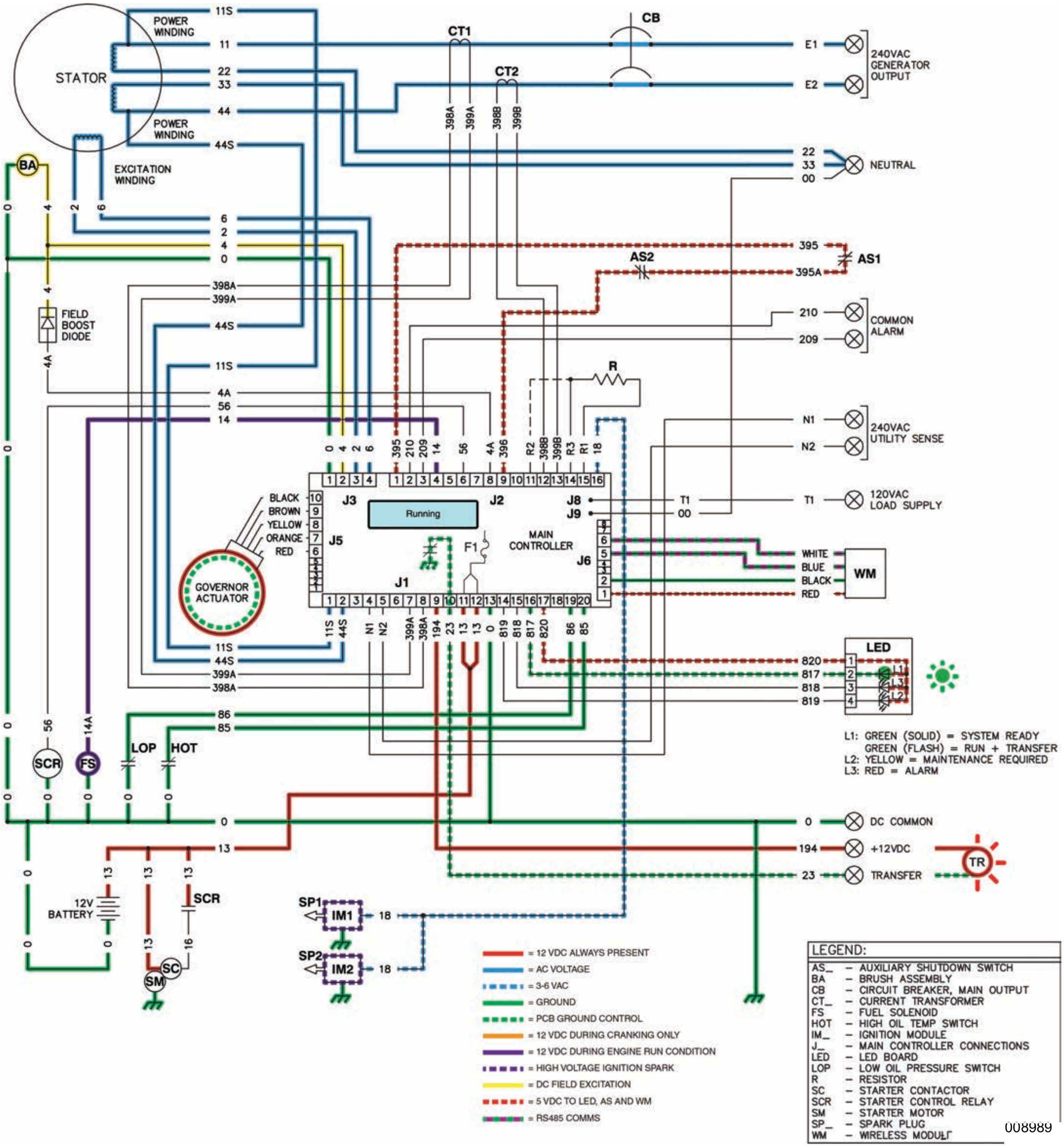

Figure 3-19. Transfer to Standby

Utility Voltage Restored and Re-transfer to Utility

The Load is powered by Generator voltage. On restoration of Utility voltage, the following events will occur:

- 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.
- At the end of the 15 seconds, the "re-transfer time delay" will stop timing. The controller will open the Wire 23 circuit from ground and the transfer relay will de-energize.
- The generator continues to run in its cooling down mode.

NOTE: If utility fails during the cool-down timer cycle for 5 seconds, the controller will transfer back to standby.

Utility Pickup	
Factory Default	**Adjustable Pickup Voltage**
60 Hz = 190 VAC	60 Hz = 190-216 VAC
50 Hz = 175 VAC	50 Hz = 175-198 VAC

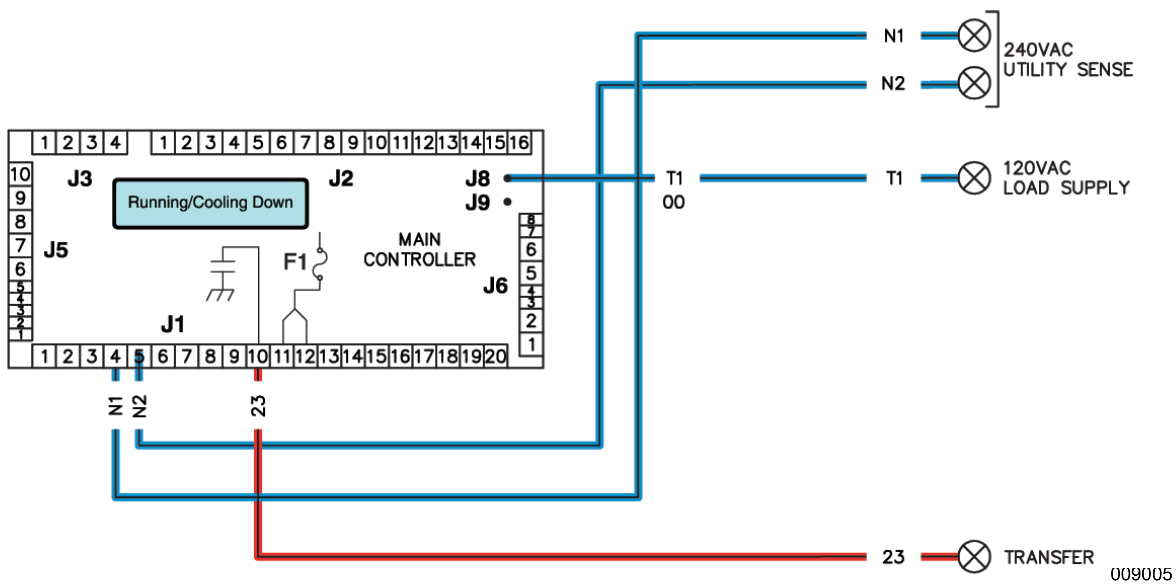

Figure 3-20.

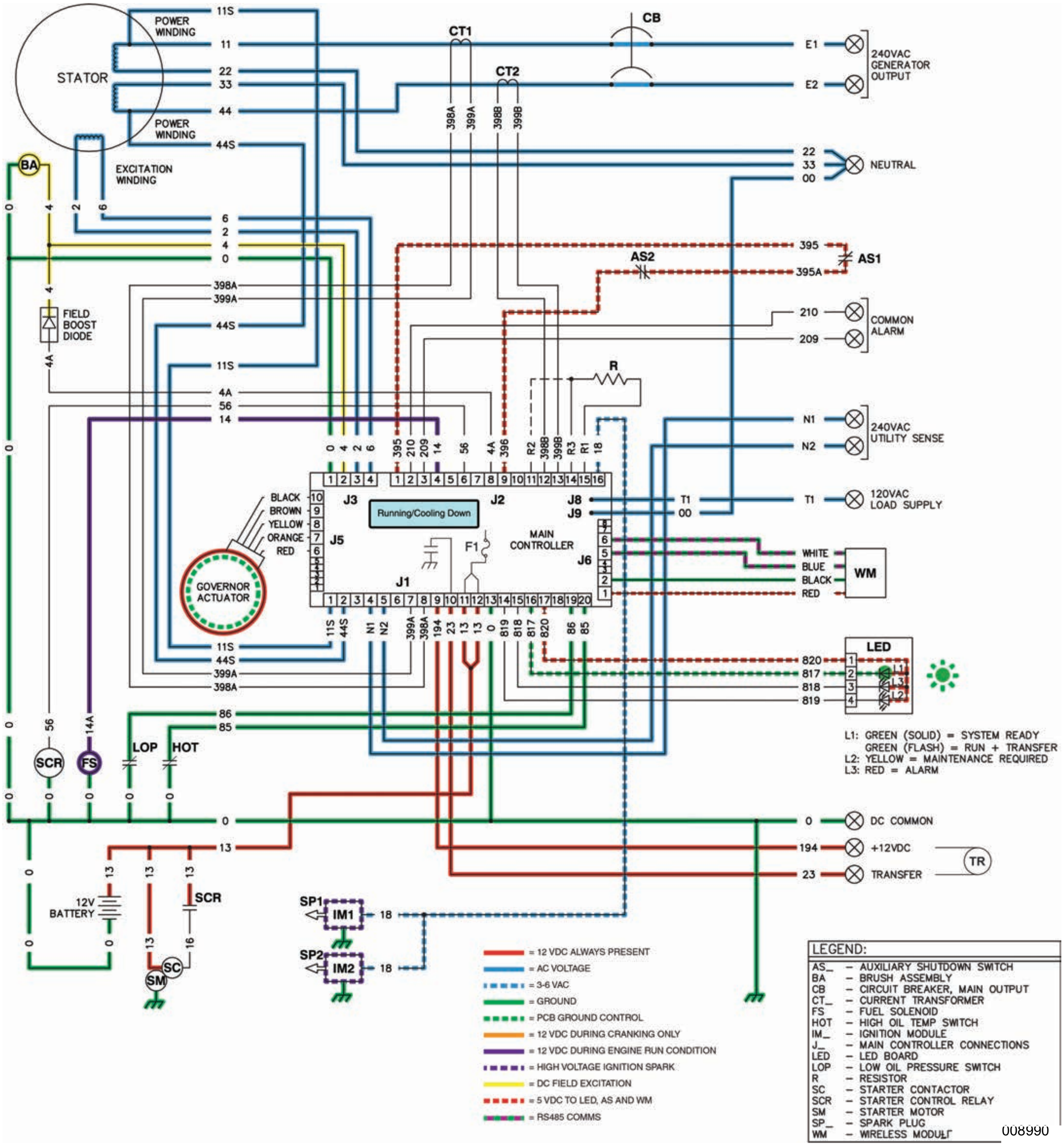

Figure 3-21. Utility Voltage Restored and Re-transfer to Utility

Engine Shutdown

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:

- Wire 14 (run circuit) will de-energize and the fuel solenoid will close to terminate the fuel supply to the engine.
- After a short fuel burn off, the controller’s logic will connect the engine’s ignition magnetos to ground via Wire 18. Ignition will terminate.
- Without fuel flow and without ignition the engine will shut down.

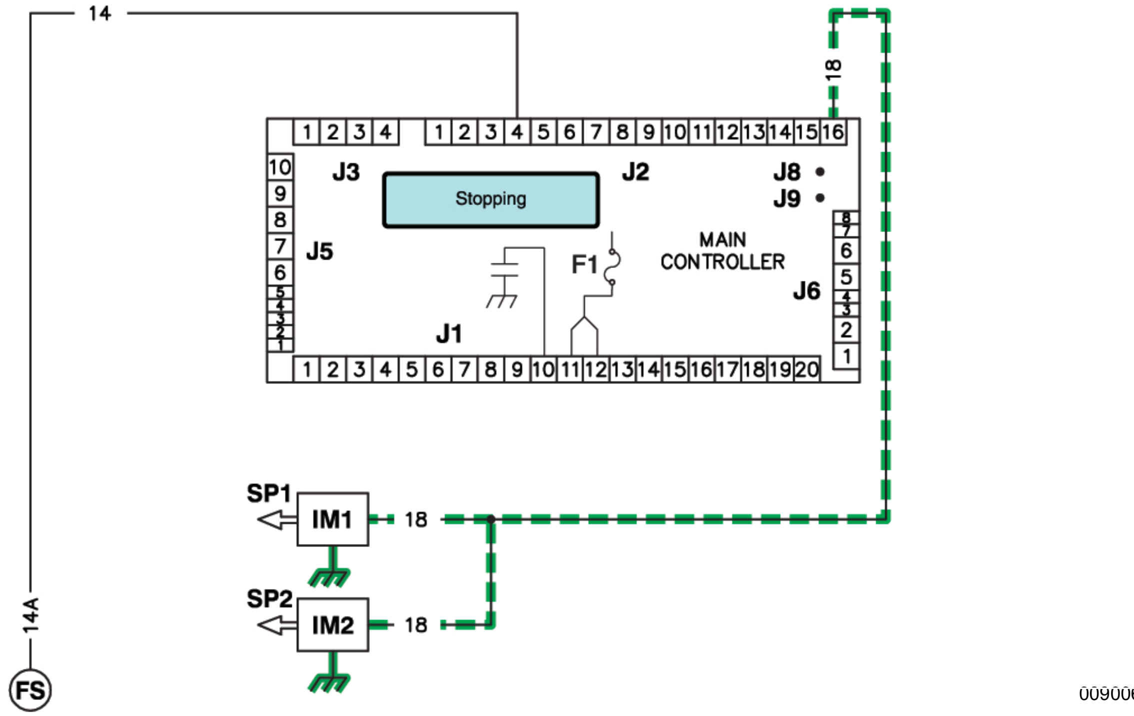

Figure 3-22.

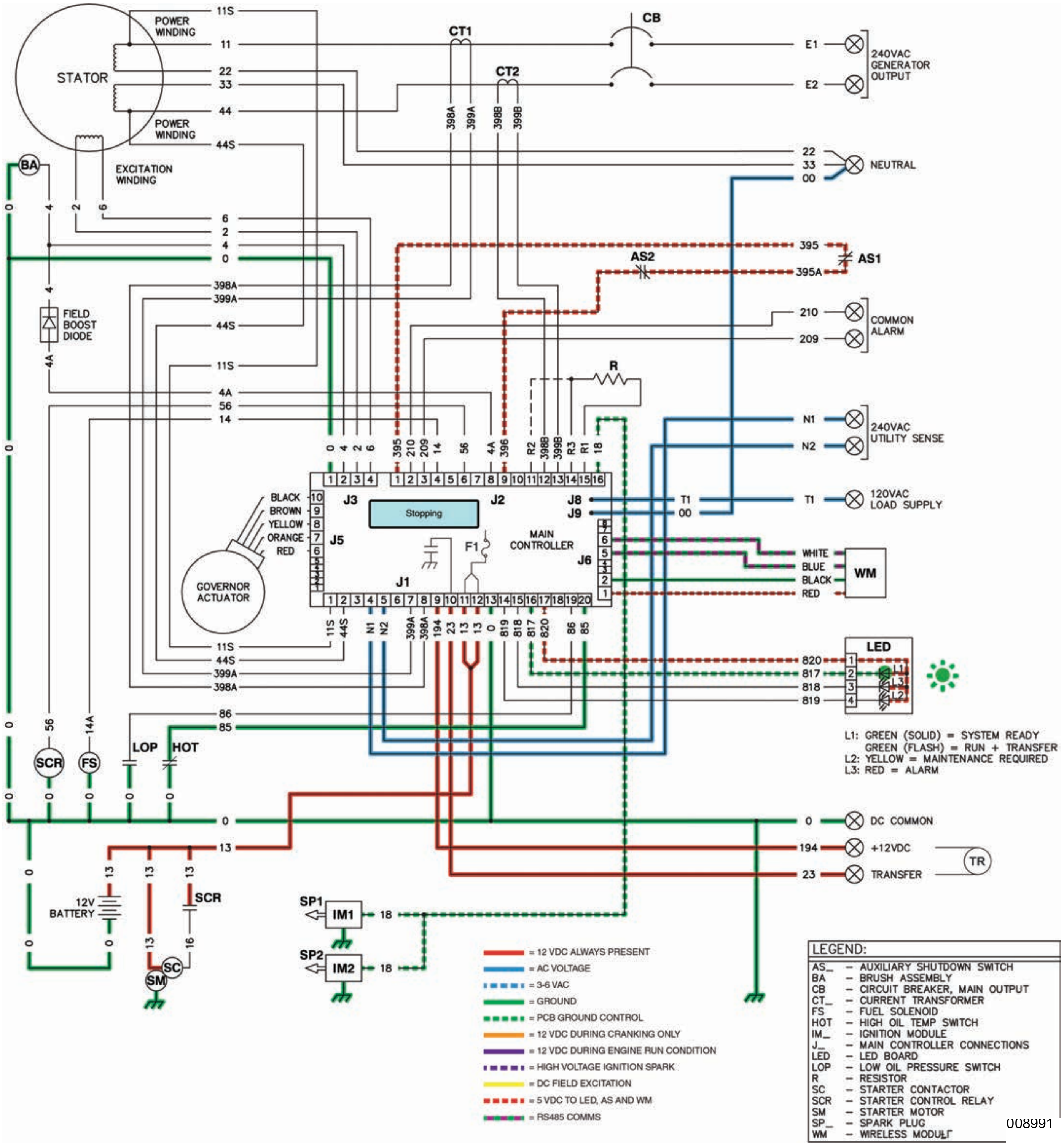

Figure 3-23. Engine Shutdown

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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

The circuit condition with the controller set to AUTO and with Utility source power available can be briefly described as follows:

- Utility source voltage is available to the transfer switch Terminal Lugs N1 and N2 and the CONTACTOR is in the “Utility” position.
- Utility voltage is available to the controller via Wire N1 and N2.
- Load voltage (120 VAC) is available to the controller via Wire T1 for Battery Charger. (220 VAC on T1 and T2 50 Hz only)
- 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.
- Wire 820 supplies 5 VDC to the Tri-Light Annunciator and Wire 817 for the Green System Ready LED is gated to ground.

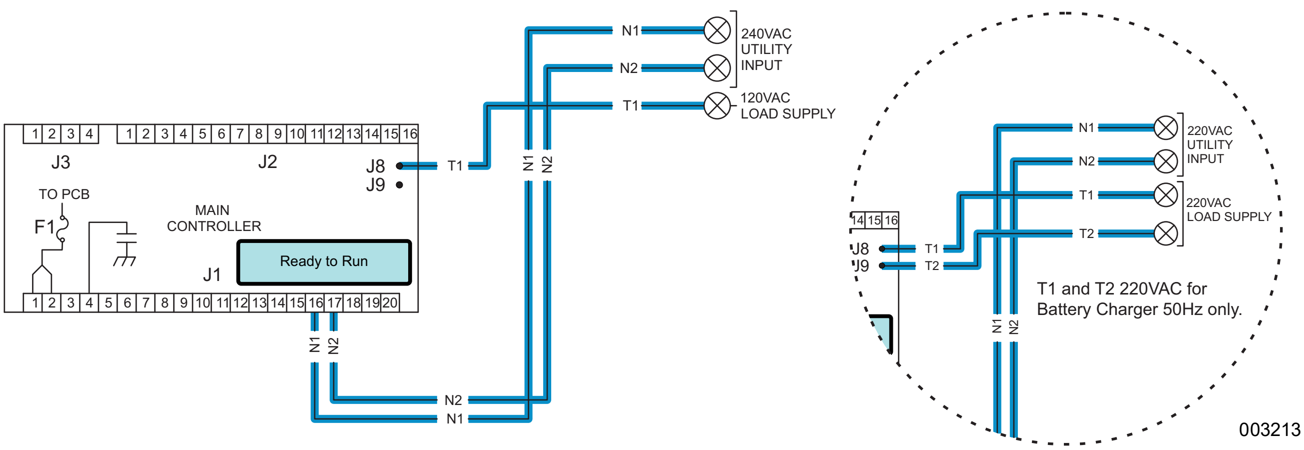


Figure 3-24.

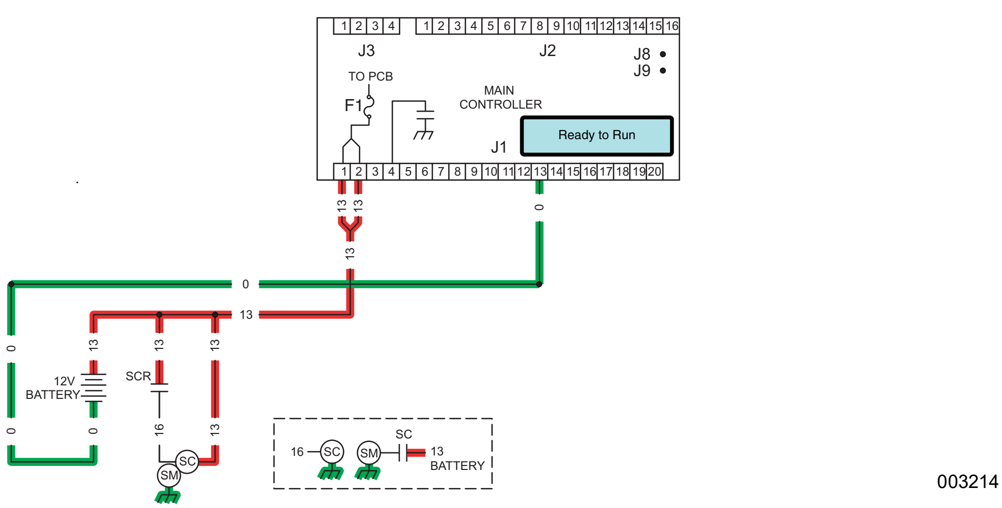


Figure 3-25.

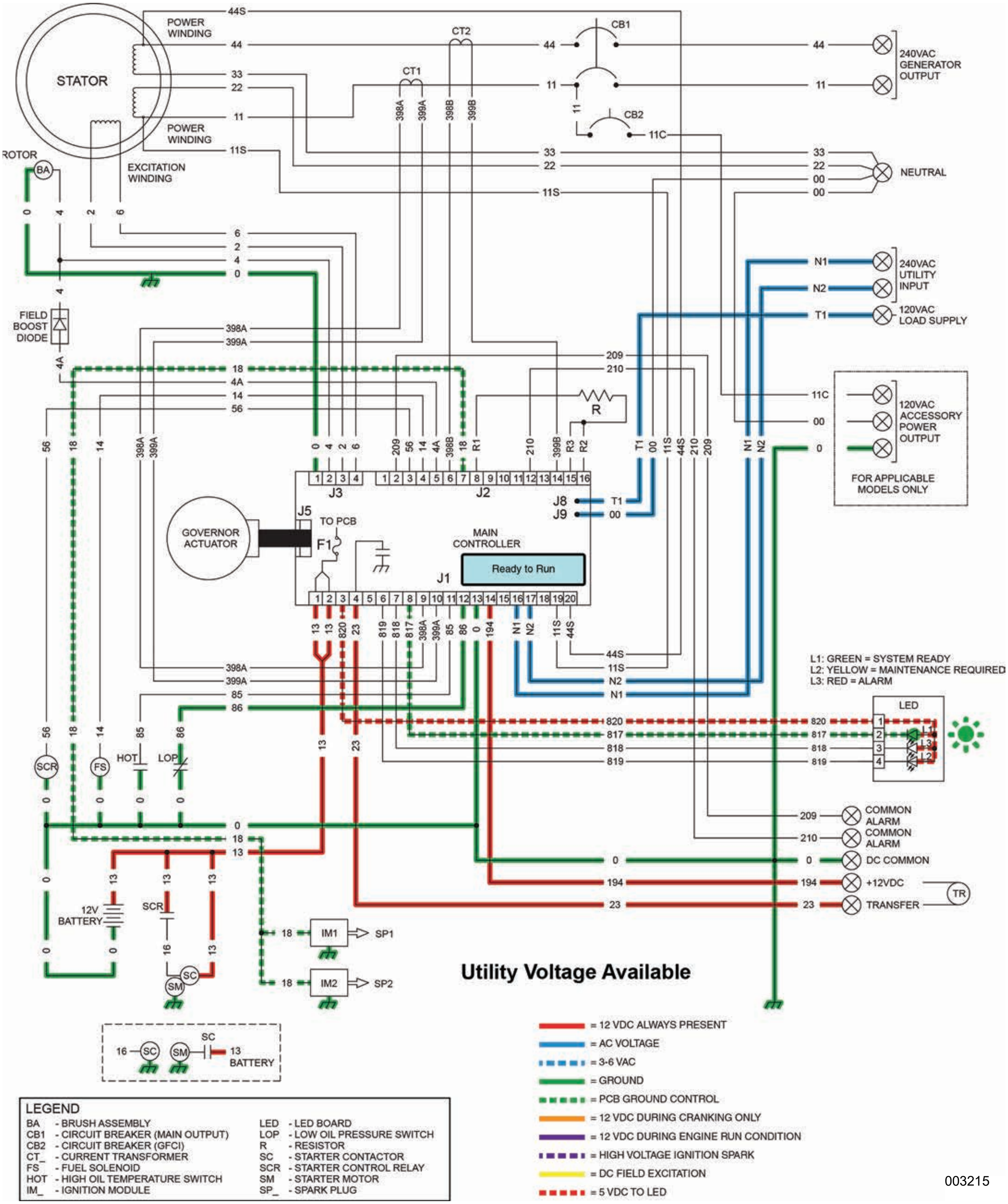


Figure 3-26. Utility Source Voltage Available

Initial Dropout of Utility Source Voltage

See *Figure 3-28*. Should a Utility power failure occur, circuit condition may be briefly described as follows:

- 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.
- The 5-second timer (factory default, but adjustable from 2-1500 seconds) is still timing and engine cranking has not yet begun.

Utility Dropout	
Factory Default	**Adjustable Dropout Voltage**
60 Hz = 156 VAC	60 Hz = 140-171 VAC
50 Hz = 142 VAC	50 Hz = 140-156 VAC

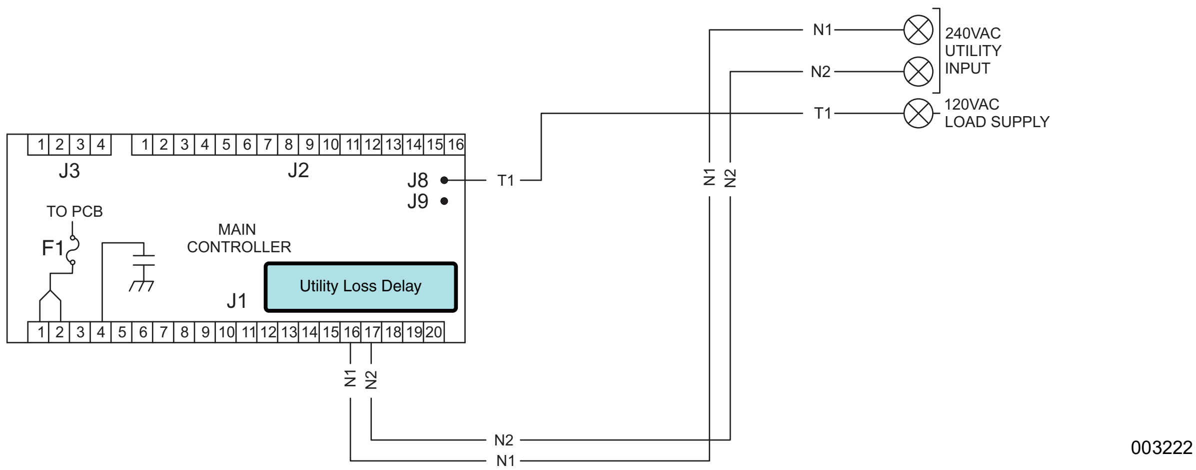
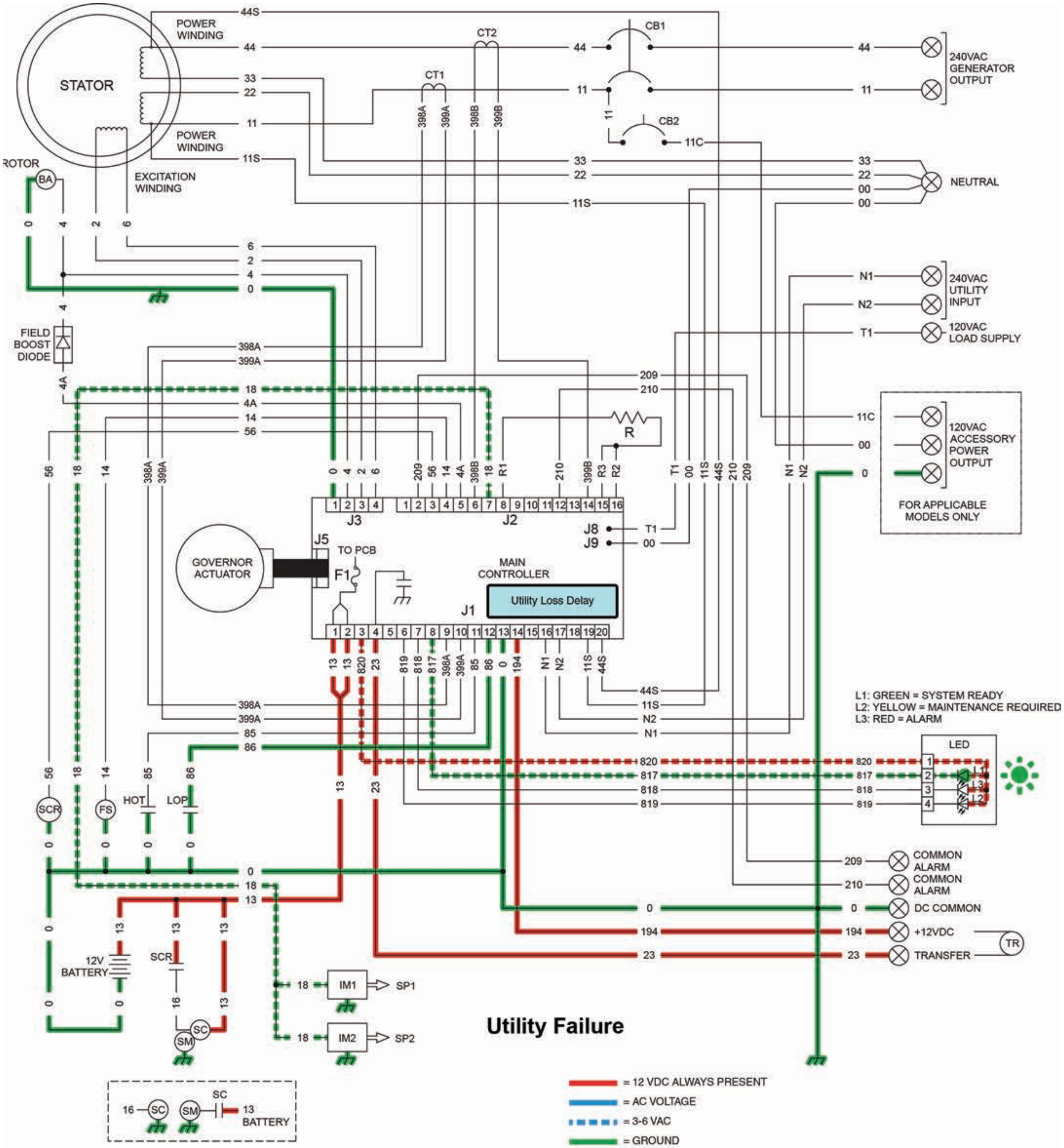


Figure 3-27.



LEGEND

BA	- BRUSH ASSEMBLY	LED	- LED BOARD
CB1	- CIRCUIT BREAKER (MAIN OUTPUT)	LOP	- LOW OIL PRESSURE SWITCH
CB2	- CIRCUIT BREAKER (GFCI)	R	- RESISTOR
CT_	- CURRENT TRANSFORMER	SC	- STARTER CONTACTOR
FS	- FUEL SOLENOID	SCR	- STARTER CONTROL RELAY
HOT	- HIGH OIL TEMPERATURE SWITCH	SM	- STARTER MOTOR
IM_	- IGNITION MODULE	SP_	- SPARK PLUG

Figure 3-28. Initial Dropout of Utility Source Voltage

Utility Voltage Failure and Engine Cranking

- After the controller's adjustable programmed 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.
- 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.
- 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, which partially opens the small venturi.

- 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 (mechanically opens) and fuel is available to the engine.

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

- With ignition and fuel flow available the engine RPM will begin to increase.

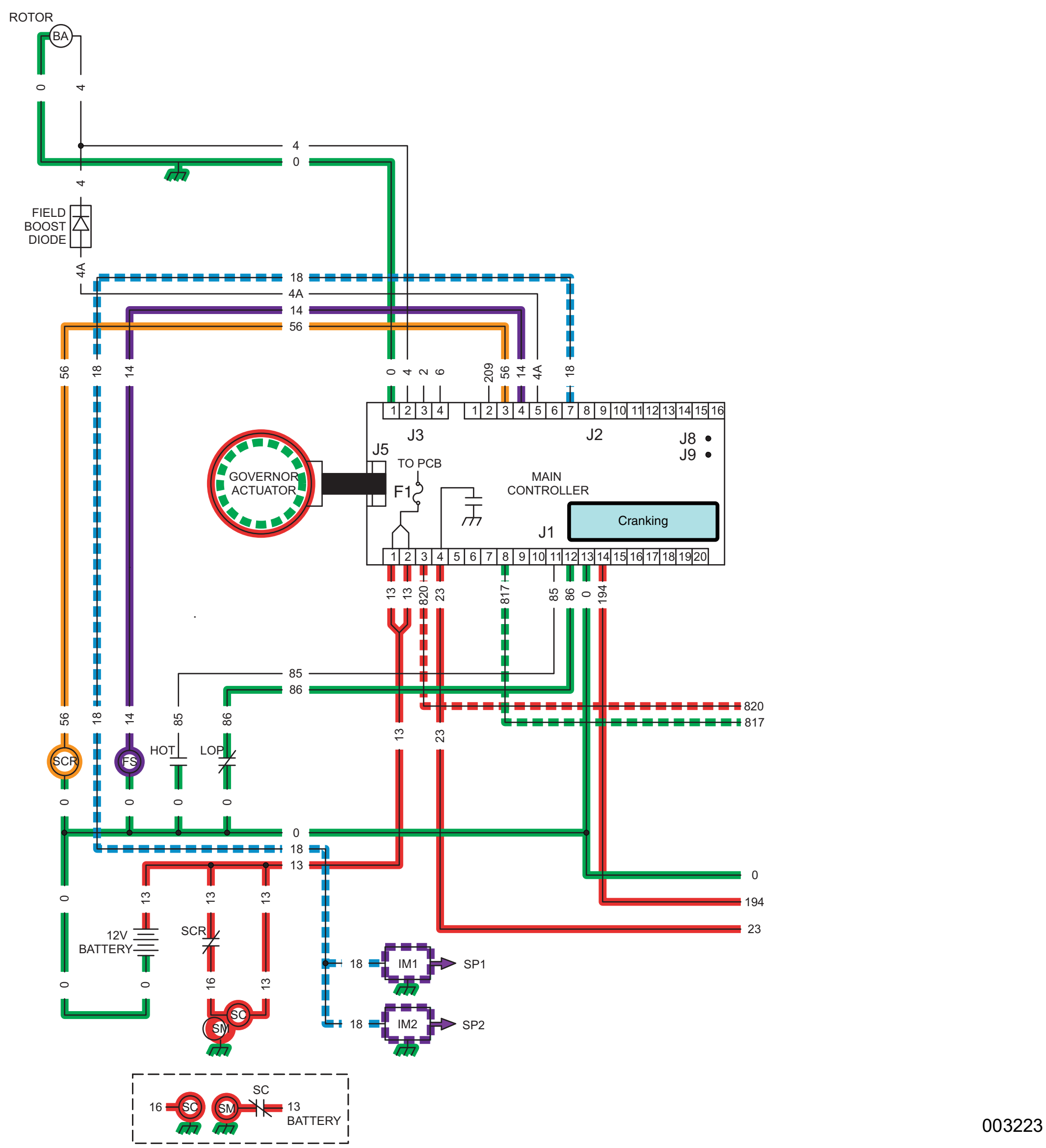


Figure 3-29.

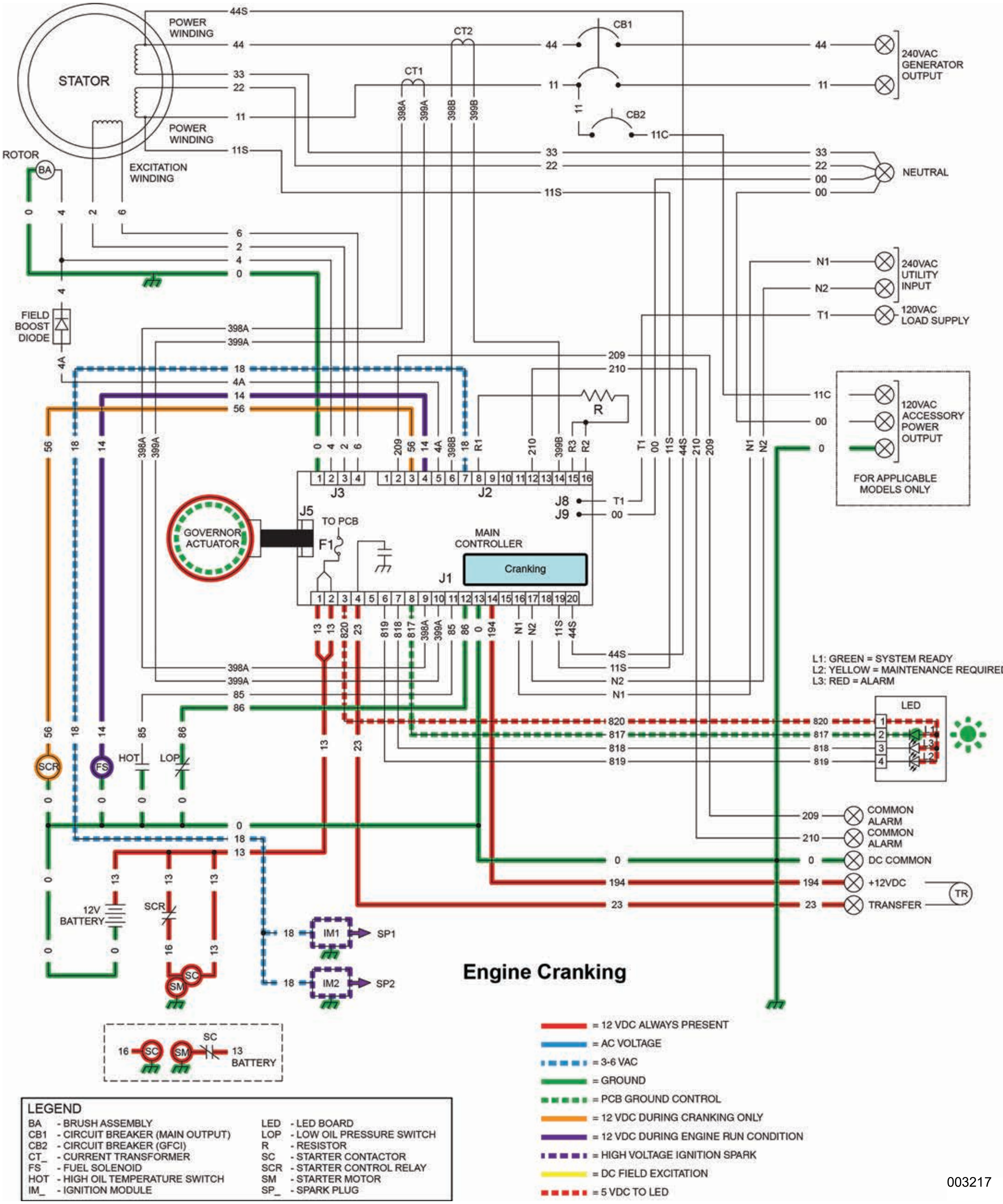


Figure 3-30. Utility Voltage Failure and Engine Cranking

Engine Startup and Running

With the fuel solenoid open and ignition occurring, the engine starts. Engine startup and running may be briefly described as follows:

- The ignition magneto(s) deliver a speed reference signal to the controller via Wire 18. Once the controller determines that the engine is running, the controller:
    a. terminates cranking by de-energizing Wire 56 at approximately 1500 RPM (V-twin) and 1800 RPM (single cylinder).
    b. energizes a field flash relay in the controller at 2200 RPM which delivers 12 VDC on Wire 4A through a field boost diode and to the rotor via Wire 4. The field boost will continue for a pre-determined time, or until field boost parameters are achieved, whichever occurs first.

NOTE: See "Field Boost" in Section 2.2 for analysis of Evolution field boost parameters.

    c. also 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.
- Generator AC output is 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.

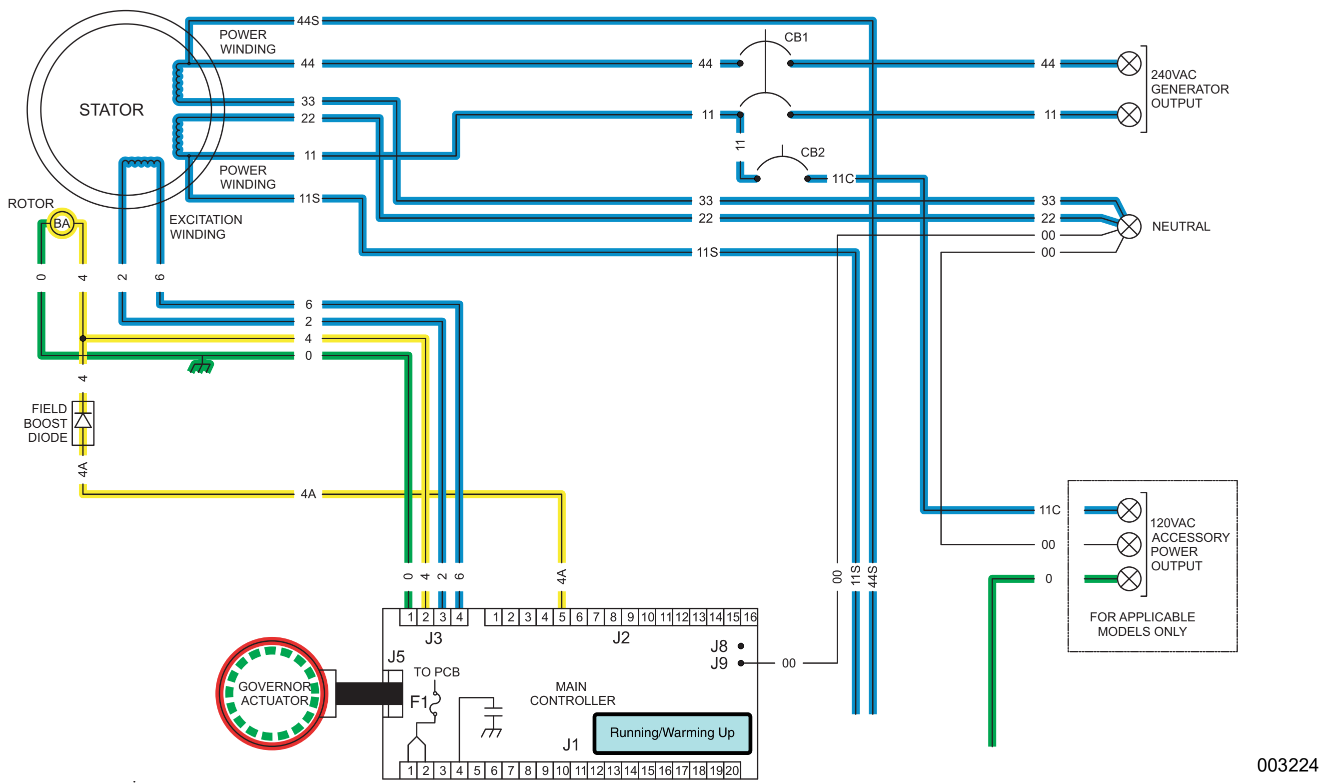


Figure 3-31.

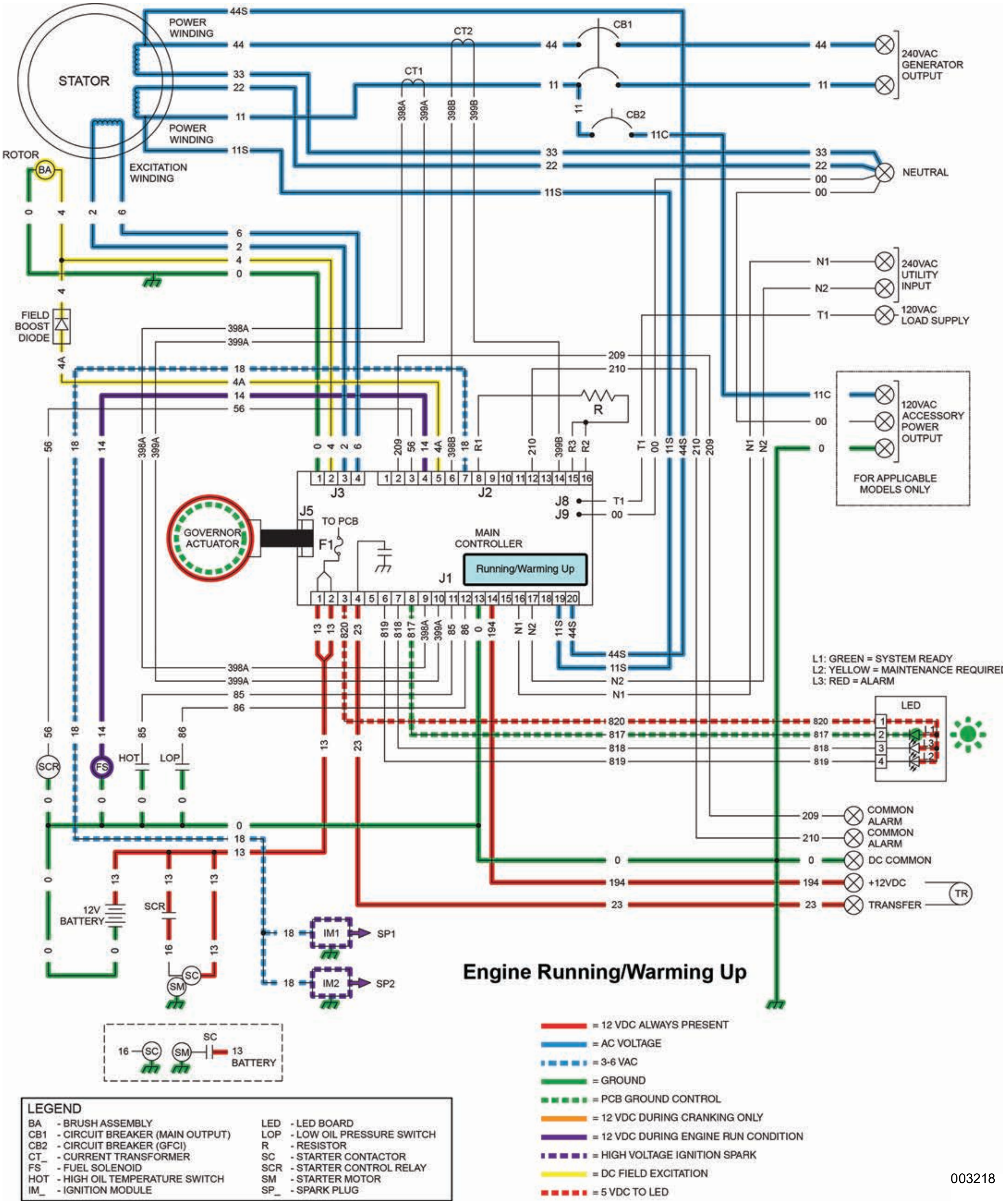


Figure 3-32. Engine Startup and Running

Transfer to Standby

In ***Figure 3-34*** 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:

- 12 VDC is delivered to the transfer relay coil via Wire 194. The 12 VDC circuit is completed back to the controller via Wire 23. However, the controller's logic holds Wire 23 open from ground and the transfer relay is de-energized.
- When the "engine warm-up timer" expires, the controller will take Wire 23 to ground. The transfer relay energizes and its normally open contacts close (standby position).
- 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 frequency through different loads
  - b. overspeed
  - c. underspeed
- 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 nearly wide open, it will start to open the larger venturi as needed for load/fuel demand.
- 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 Amps = 0.380 mVAC

50 Amps = 0.755 mVAC

75 Amps = 1.133 VAC

100 Amps = 1.510 VAC

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)

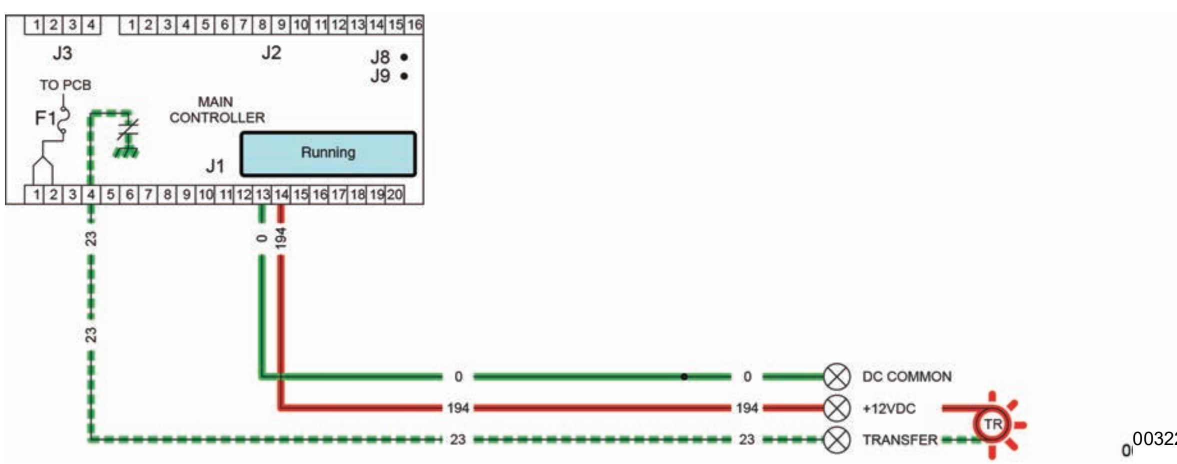


Figure 3-33.

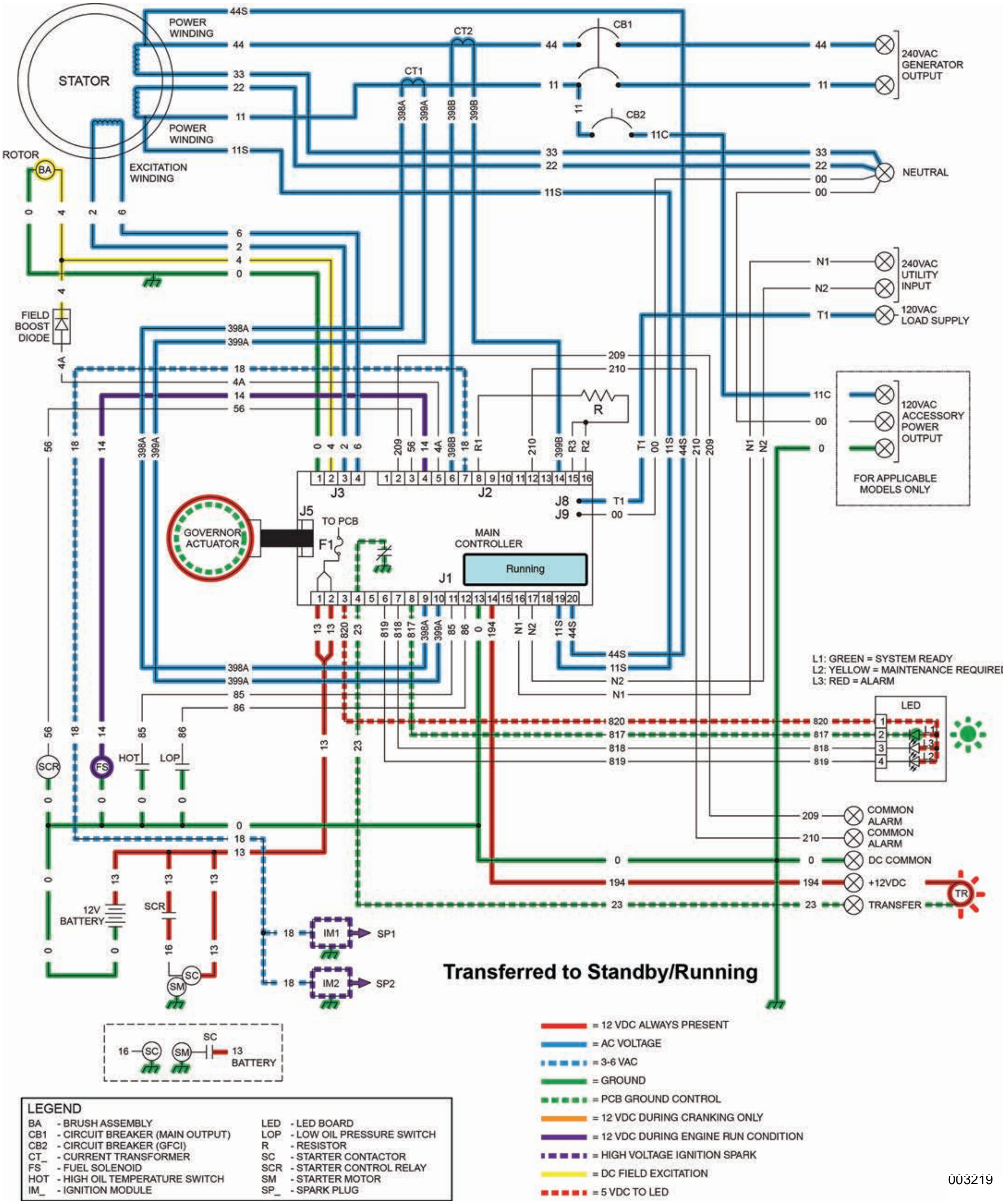


Figure 3-34. Transfer to Standby

Utility Voltage Restored and Re-transfer to Utility

The Load is powered by Generator voltage. On restoration of Utility voltage, the following events will occur:

- 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.
- At the end of the 15 seconds, the "re-transfer time delay" will stop timing. The controller will open the Wire 23 circuit from ground and the transfer relay will de-energize.
- The generator continues to run in its cooling down mode.

NOTE: If utility fails during the cool-down timer cycle for 5 seconds, the controller will transfer back to standby.

Utility Pickup	
Factory Default	**Adjustable Pickup Voltage**
60 Hz = 190 VAC	60 Hz = 190-216 VAC
50 Hz = 175 VAC	50 Hz = 175-198 VAC

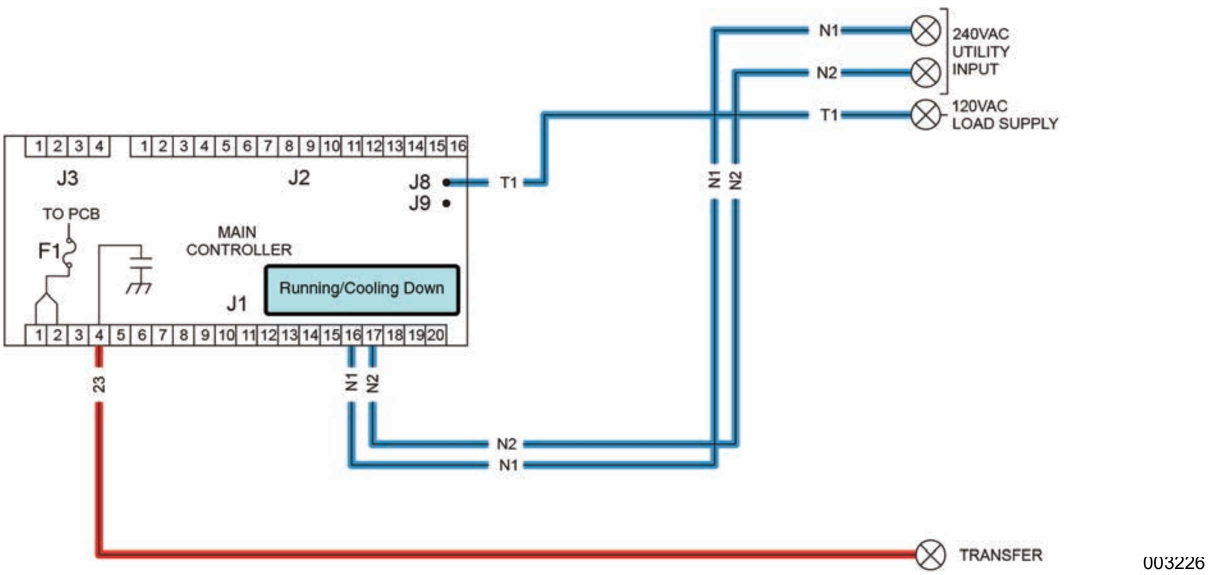


Figure 3-35.

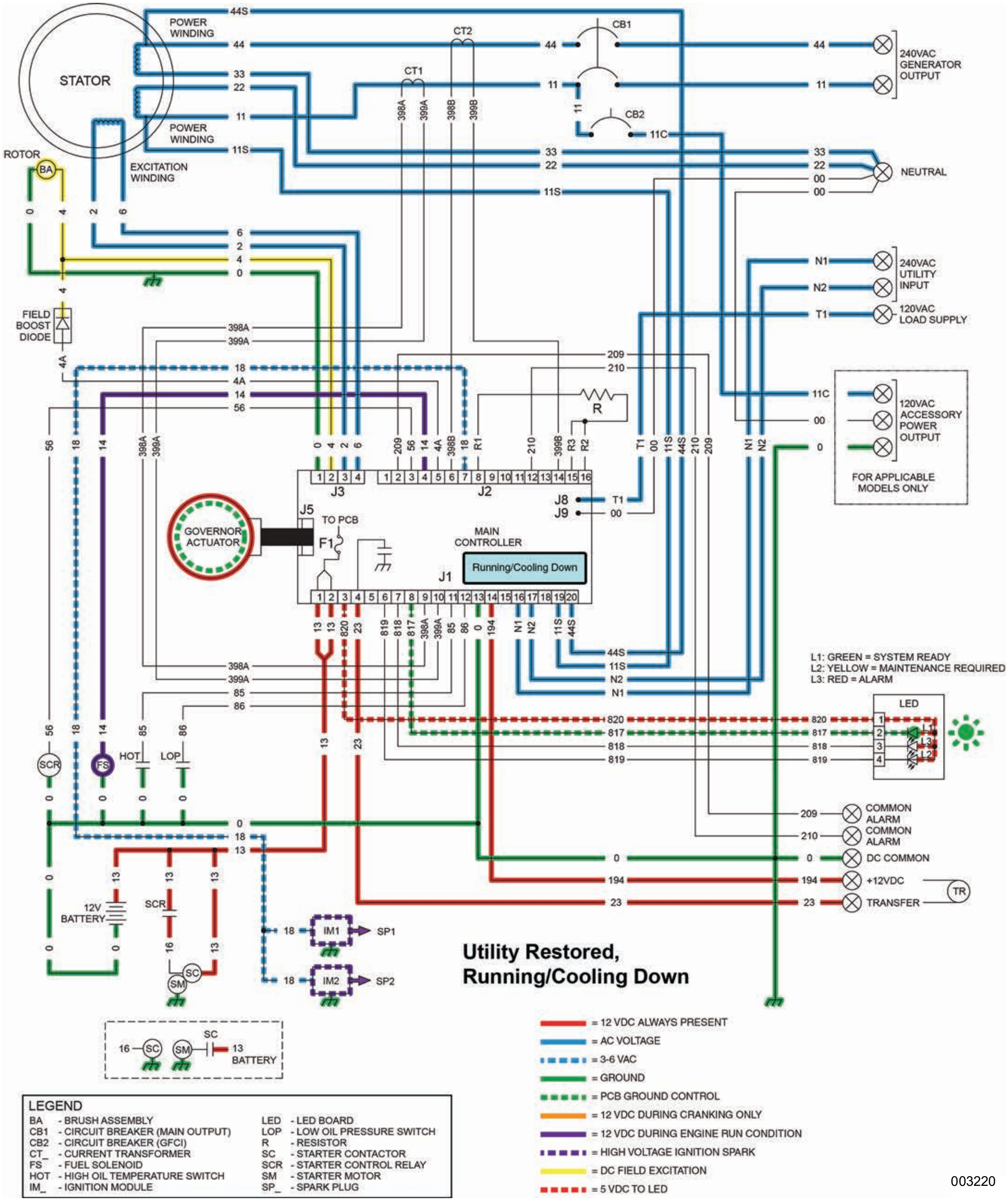


Figure 3-36. Utility Voltage Restored and Re-transfer to Utility

Engine Shutdown

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:

- Wire 14 (run circuit) will de-energize and the fuel solenoid will close to terminate the fuel supply to the engine.
- The controller's logic will connect the engine's ignition magnetos to ground via Wire 18. Ignition will terminate.
- Without fuel flow and without ignition the engine will shut down.

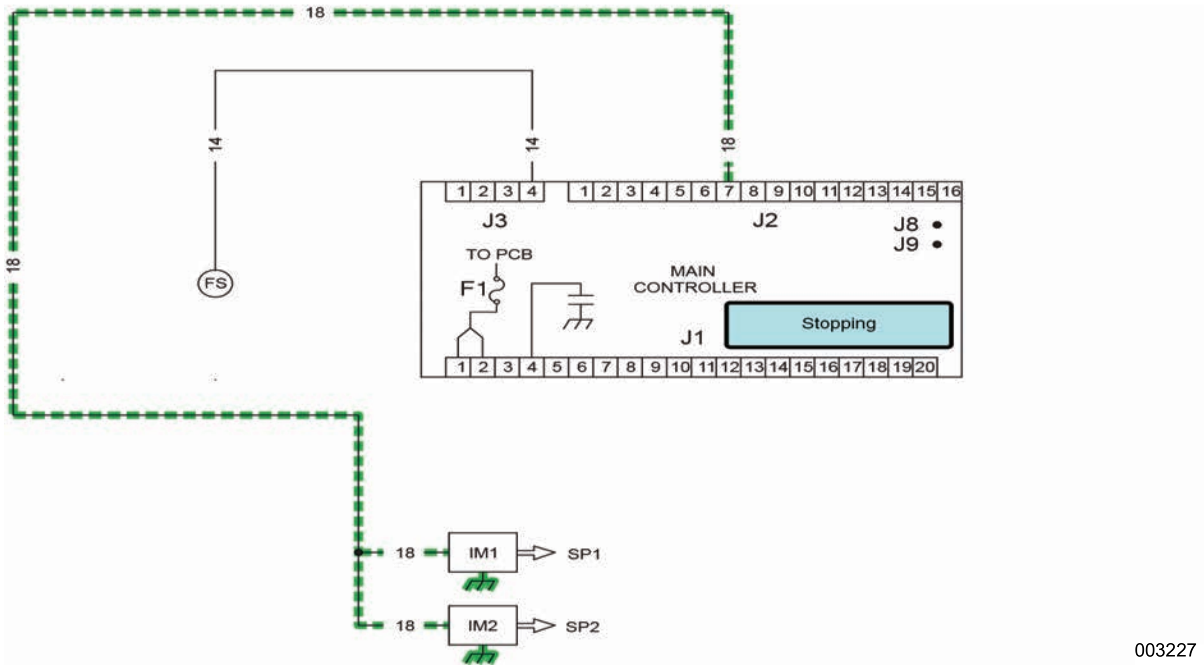


Figure 3-37.

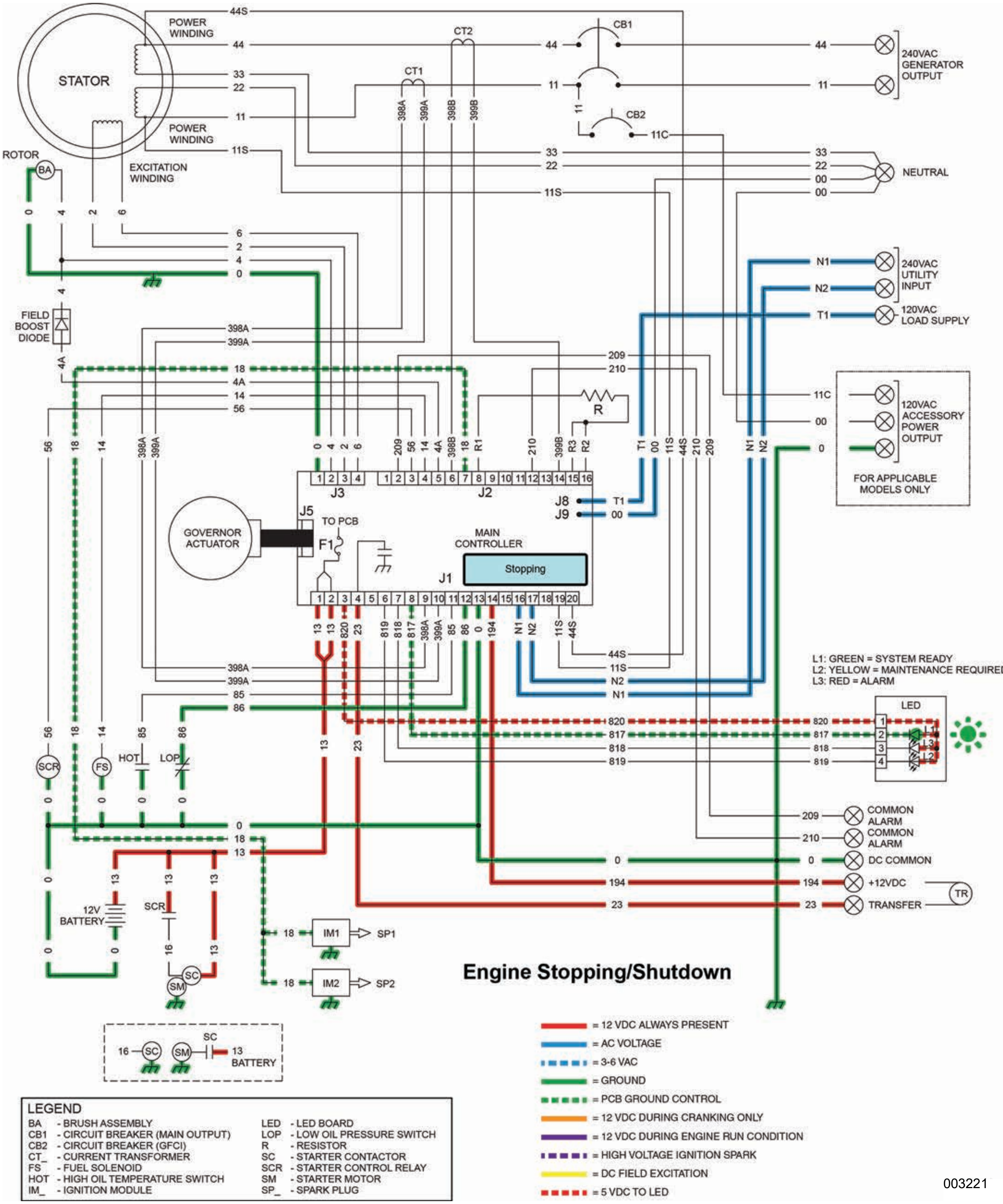


Figure 3-38. Engine Shutdown

Evolution™ Controller E-Codes

NOTE: For any Displayed Alarm on the controller, use the Action Step as a starting point.

Displayed Alarm	Alarm/ Warning	E-Code Breakdown	Description	Action Step
Controller Fault	ALARM		**No E-code on HSB**	Replace Controller
Overcrank	ALARM	1100	**Condition - Engine Cranks but will not Start (5 crank attempts)** Unit turns over but will not start. Controller is receiving signal on Wire 18.	Problem 17
Overspeed	ALARM	1200	**Prolonged (60 Hz on a 50 Hz unit, 72Hz on 60Hz unit)** Over specified Hz for 3 seconds. Possible cause: Stepper motor/mixer body assembly issue.	Test 54
Overspeed	ALARM	1205	**Instantaneous (62 Hz on a 50 Hz unit, 75Hz on 60Hz unit)** Over specified Hz for 0.1 second (100 milliseconds). Possible cause: Stepper motor/mixer body assembly issue.	Test 54
Overspeed	ALARM	1207	Monitors zero cross timing of the AVR to determine the alternator frequency which is a speed indicator. Set for 150 milliseconds of 4500 rpm or higher. Used if the normal ignition pulse sequence(s) are not being seen by the controller.	Test 64 and Test 60
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. Check temperature sensor and wiring.	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.
RPM Sensor	ALARM	1511	**Single Cylinder+Running** Single Cylinder Running RPM sensor loss Possible Causes: air pocket in fuel line, dirty fuel. Loss of ignition pulse.	Test 50 and Test 64
RPM Sensor	ALARM	1515	**Single Cylinder+Cranking** Single Cylinder Cranking faults to RPM sensor loss Possible Cause: starter motor and/or engine issue. Loss of ignition pulse.	If engine cranks, Test 64. If engine does not crank, Problem 15.
Underspeed	ALARM	1600	**Condition - Unit is Overloaded (55 Hz for 60 Hz for 30 sec, 40 Hz for 50 Hz unit** Unit is Overloaded slowing engine speed, fuel supply low or throttle control problem.	Problem 3, or Test 50, or Test 54
Underspeed	ALARM	1603	**Underspeed** The engine never comes up to 3600 RPM.	Check fuel selection and fuel supply
Overvoltage	ALARM	1800	**Prolonged Over-Voltage**	Problem 2
Undervoltage	ALARM	1900	**Prolonged Under-Voltage** Undervoltage due to loss of voltage. Below 80% for 10+ seconds) Controller will display “WARMING UP” for 4 minutes. Refer to **Section 2.2**.	Perform Preliminary Output Voltage Test Note: Verify controller has latest firmware.
Undervoltage	ALARM	1901	**Instantaneous** **Undervoltage due to sudden loss of voltage.** (Voltage less than 15 sec 2 sec+) Controller will display “WARMING UP” for 4 minutes. Refer to **Section 2.2**.	Perform Preliminary Output Voltage Test Note: Verify controller has latest firmware.
Undervoltage	ALARM	1902	**Both Zero Crosses missing** Undervoltage due to faulty excitation winding, or zero cross circuit, or circuit in general. Possible cause: loose wiring, field boost hardware failure. (Both zero cross missing greater than 1.5 sec) Controller will display “WARMING UP” for 4 minutes. Refer to **Section 2.2**.	Perform Preliminary Output Voltage Test Note: Verify controller has latest firmware.
Undervoltage	ALARM	1906	**Single Zero Cross missing** Undervoltage due to faulty excitation winding, zero cross circuit, or circuit in general. Possible cause: field boost hardware failure. (One zero cross missing greater than 1.5 sec) Controller will display “WARMING UP” for 4 minutes. Refer to **Section 2.2**.	Perform Preliminary Output Voltage Test Note: Verify controller has latest firmware.

Evolution™ Controller E-Codes

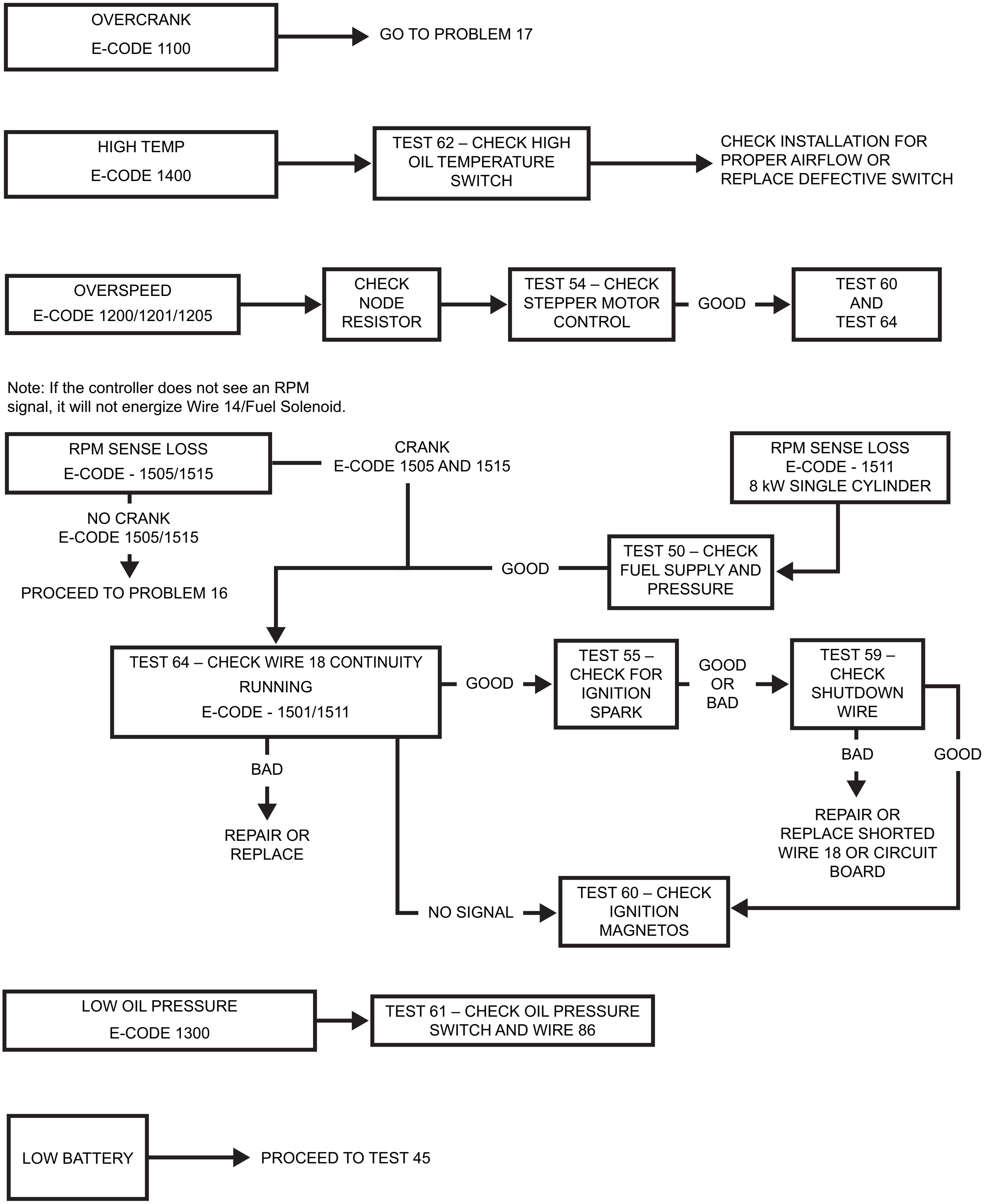
NOTE: For any Displayed Alarm on the controller, use the Action Step as a starting point.

Displayed Alarm	Alarm/ Warning	E-Code Breakdown	Description	Action Step
Wiring Error	ALARM	2098	**Mis-wired Customer connection** Insufficient DC voltage on transfer power output.	Check for shorted 194 to ground. Refer to RTS Diagnostic Manual A0001176044.
Wiring Error	ALARM	2099	**Mis-wired** Customer connection low voltage and high voltage wires are crossed.	Check for AC voltage on Wire 194 at customer connection in generator.
Overload Remove Load	ALARM	2100	**Overloaded - Default (Output Current Method)** Unit is overloaded. One or both CT(s) detecting an overload condition. Check transfer switch load shed functionality. (Change load dynamics or utilize load shed).	Remove Load
Undervoltage Overload	ALARM	2299	Unit was overloaded and attempted to start with a large load connected. The unit can not ramp up the generator voltage to its normal target voltage value if it starts with a large load connected	Remove Load
Stepper Overcurrent	ALARM	2399	Current flow in stepper coil(s) above specification.	Test 54 Note: Verify controller has latest firmware.
Fuse Problem	ALARM	2400*	**Missing / Damaged Fuse** The 7.5 amp Controller Fuse is missing or blown (open). *Firmware version 1.11 and older only	Test 44 Note: Verify controller has latest firmware.
Aux Shutdown	ALARM	2800	External shut down circuit is open.	Check the continuity of the harness and operation of the switch(es). Repair/ replace as needed.
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
Model Ident Problem - Fix Harness Resistor			Controller was powered up before the resistor plug was connected.	Problem 23 - Controller displays "Model Ident Problem Fix Harness Resistor" fault
	Service Schedule		Service Schedule A 200hours 2 years Service Schedule B 400 Hours 4 years	Perform Maintenance

Additional Codes For 8 and 9 kW Units (Evolution 1.0 Controller Only)

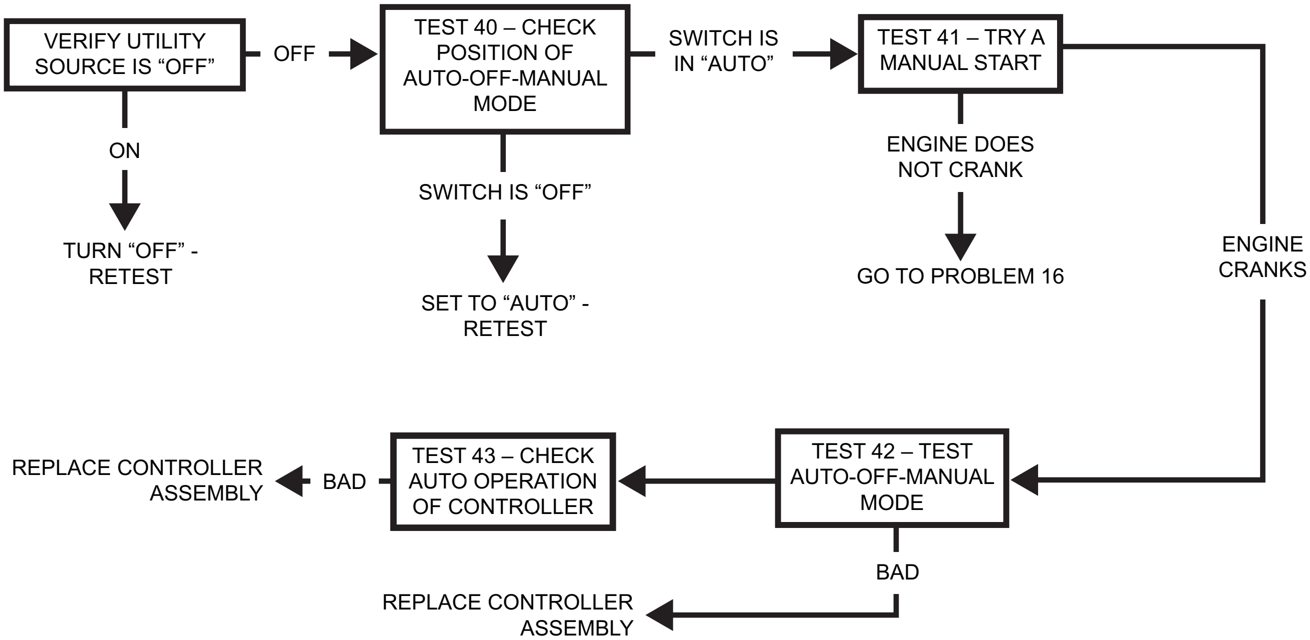
Displayed Alarm	Alarm/ Warning	E-Code Breakdown	Description	Action Step
Overcrank	ALARM	1101	**Engine/Starter Problem** Limiting number of cranking cycles to protect the starter motor.	If the engine has tried to crank for 10 times unsuccessfully, this will trigger.
Overload Remove Load	ALARM	2102	**Overloaded** Unit re-cranks 5 times when load is applied, engine dies (0 RPM) and has low voltage (< 180V)	Check for Overloaded condition on unit. Inspect stepper motor operation.
Overload Remove Load	ALARM	2103	**Overloaded** Unit has run and attempted to accept load 10 times, could not accept due to overload condition	Check for Overloaded condition on unit

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

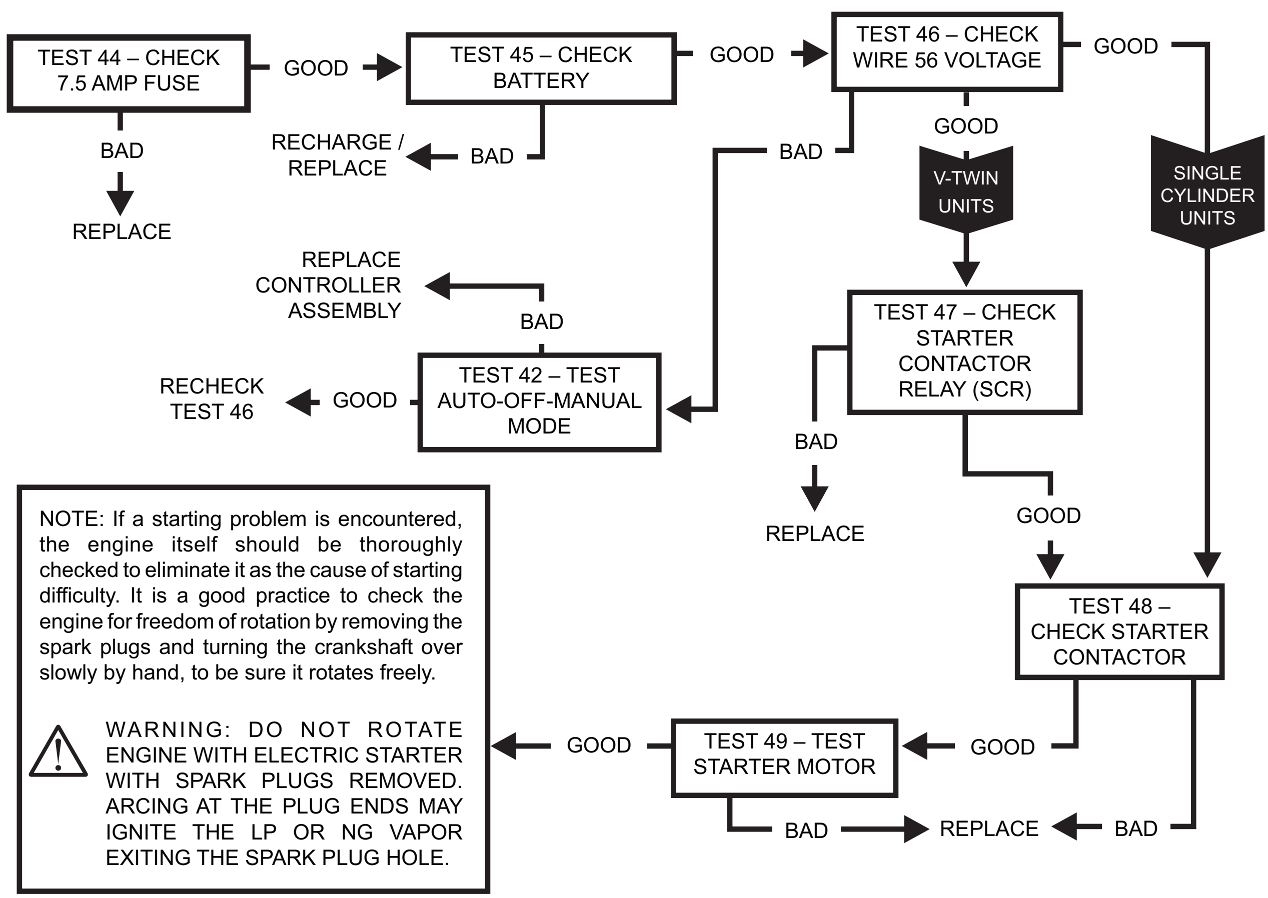


IMPORTANT NOTE: Clear any faults in the controller before proceeding with any running diagnostic steps!

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



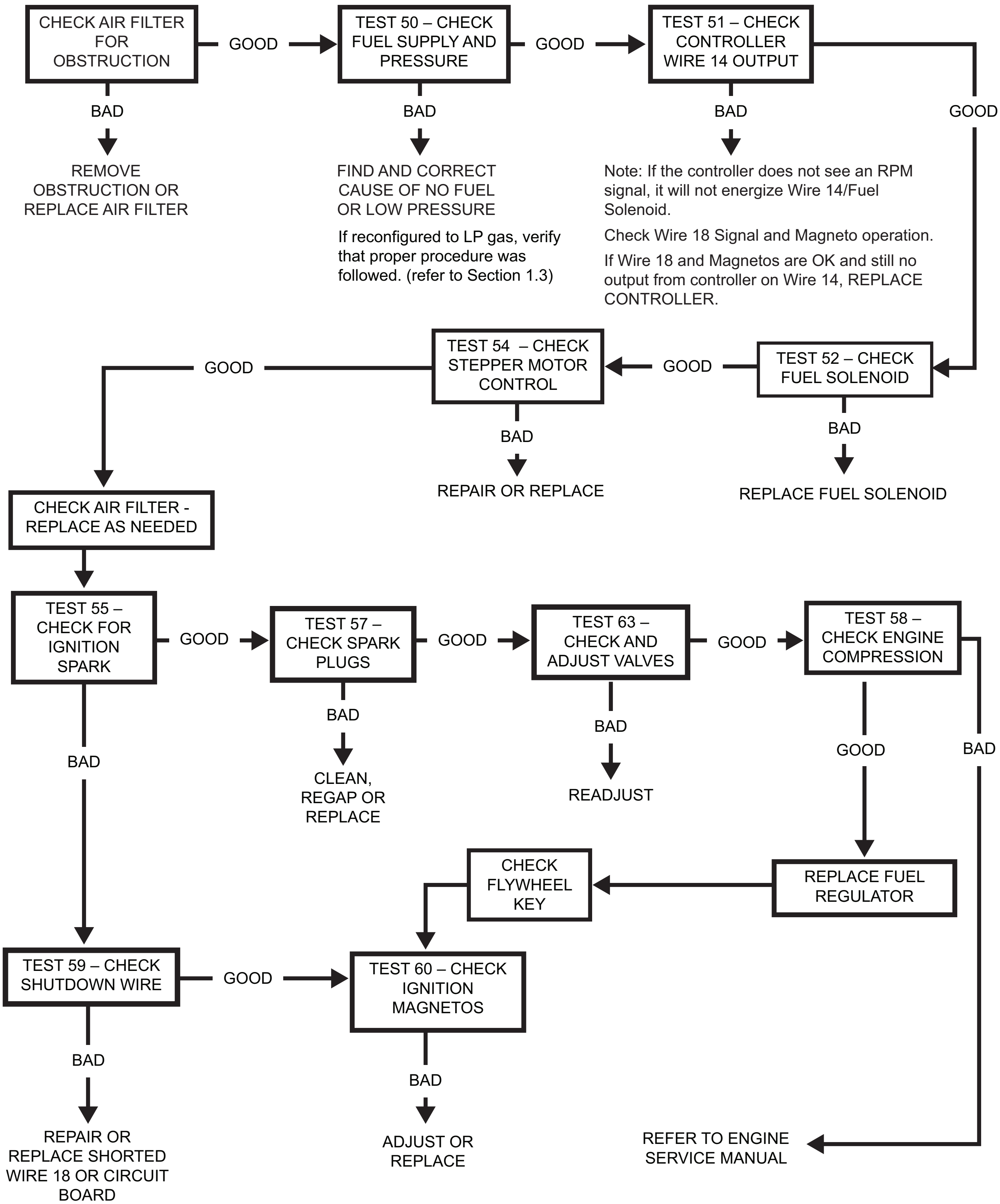
Problem 16 – Engine Will Not Crank When Controller is Set to MANUAL or Controller Goes Dark and Reboots



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

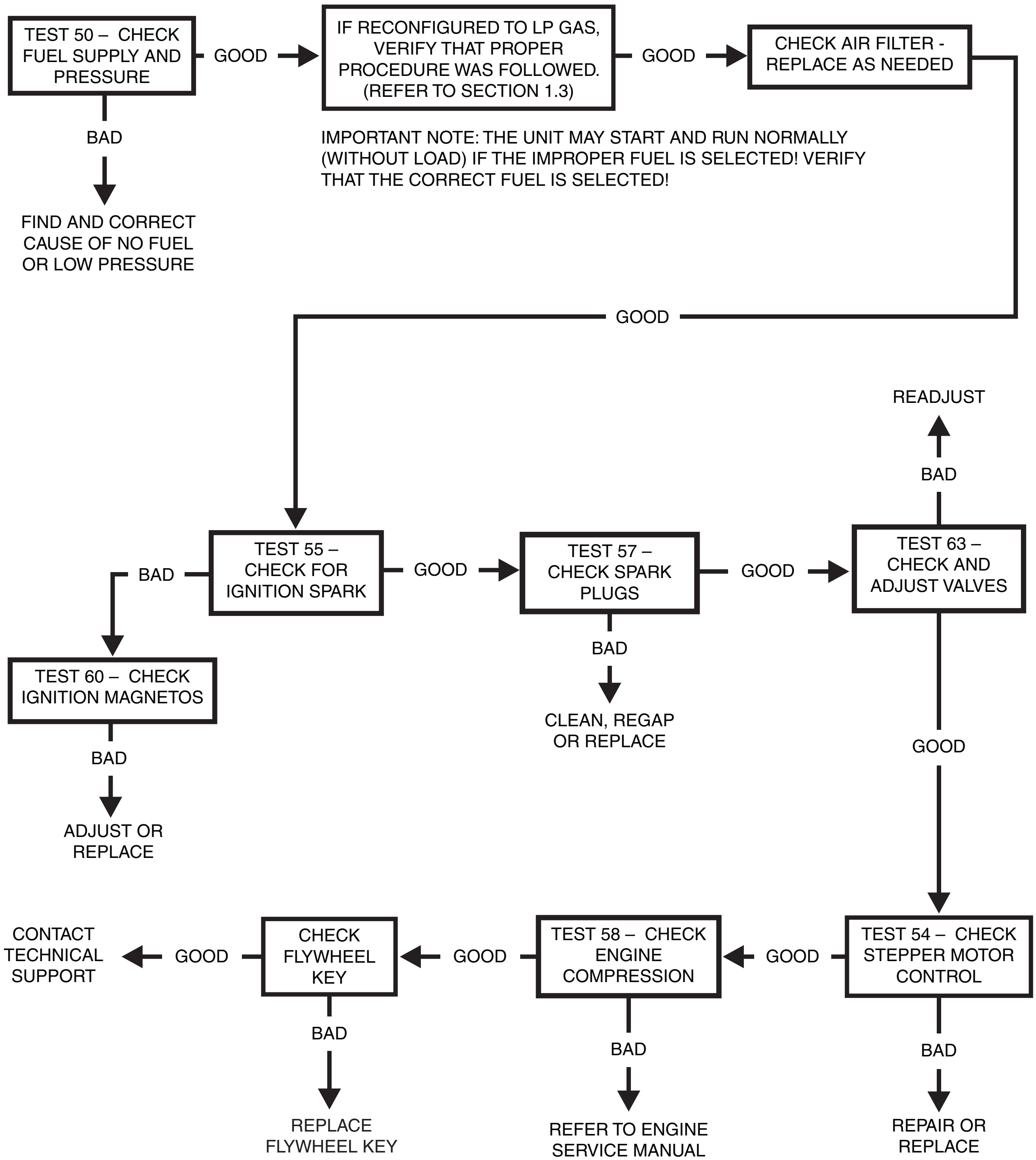
Problem 17 – Engine Cranks but Will Not Start

IMPORTANT NOTE: Verify that the fuel selector is correct for the supplied fuel type.



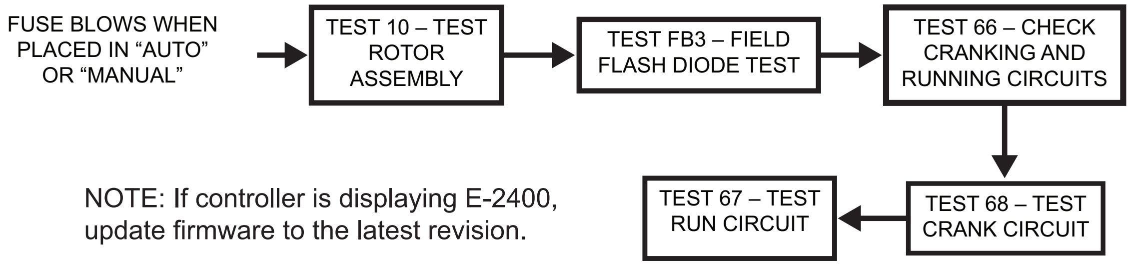
IMPORTANT NOTE: Clear any faults in the controller before proceeding with any running diagnostic steps!

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



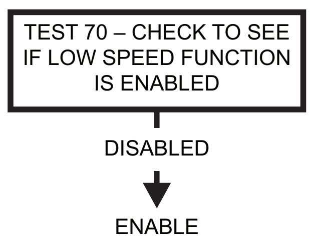
IMPORTANT NOTE: Clear any faults in the controller before proceeding with any running diagnostic steps!

Problem 19 – 7.5 Amp Fuse (F1 in Controller) Blown



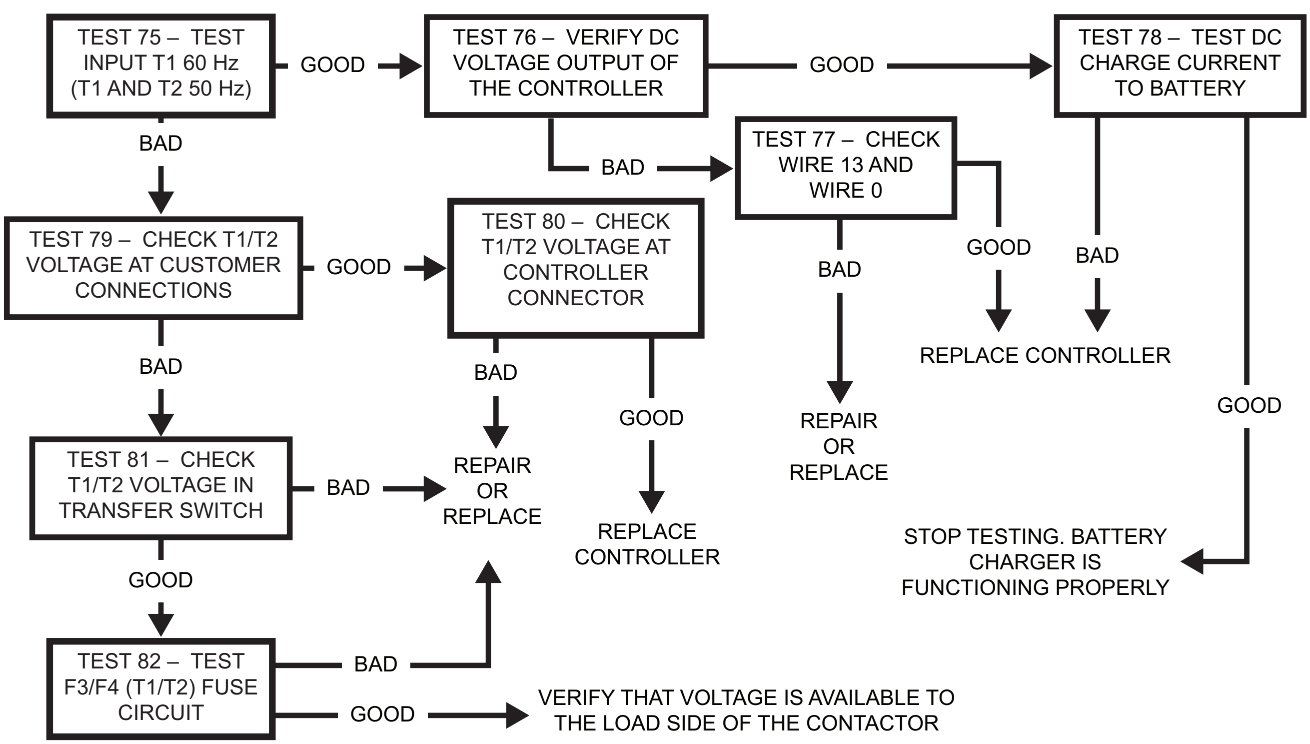
Problem 20 – Generator Will Not Exercise

Problem 21 – No Low Speed Exercise



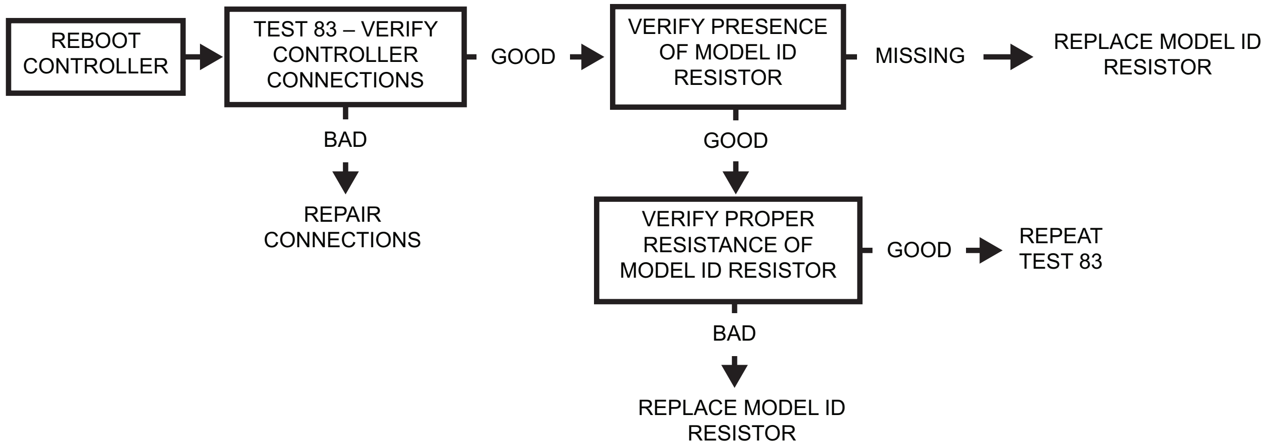
Problem 22 – Battery is Dead

Note: T1 = 60 Hz, T1 & T2 = 50 Hz



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

Problem 23 - Controller displays "Model Ident Problem Fix Harness Resistor" fault



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

Section 3.6 Diagnostic Tests

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 4.5, *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 (DMM). 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 3-39 shows the DMM in two different states. The left DMM indicates an OPEN circuit or INFINITY. The right DMM indicates a dead short or CONTINUITY. Throughout the troubleshooting, refer back to ***Figure 3-39*** 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.

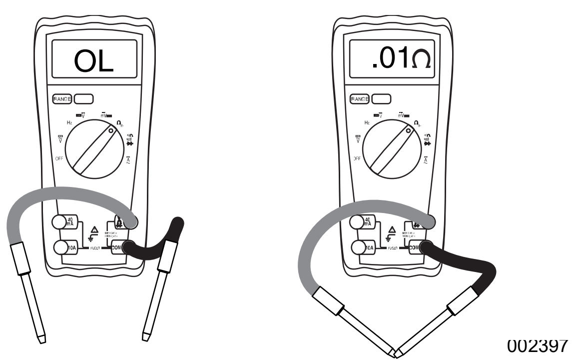


Figure 3-39. INFINITY (Left) and CONTINUITY (Right) Meter Readings

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 good practice to continue asking questions during the troubleshooting process. Asking some of these questions during evaluation may help identify a 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

If the system is to operate automatically, the generator's controller must be set to AUTO. The generator will not crank and start on occurrence of a Utility failure unless the switch is in AUTO. In addition, the generator will not exercise every seven (7) days as programmed unless the switch is in AUTO.

Procedure

With the controller set to AUTO, 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.

Results

1. If normal automatic operation is obtained, discontinue tests.
2. If the engine does not crank when Utility power is turned off refer back 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 back to 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 3-40***. Navigate to the Input Screen using the menu system for the controller being worked on.

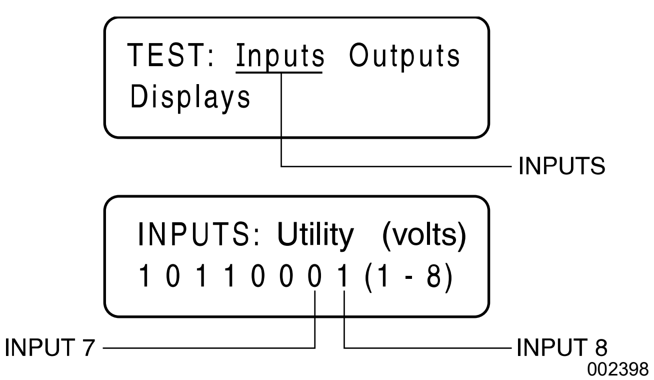


Figure 3-40. The Input Screens

2. With the Inputs Screen displayed, set the controller to AUTO. If the controller reads the auto input from the switch, Input 7 will change from "0" to "1". See ***Table 3-5*** in Section 4.1 for a description of the inputs.
3. With the Inputs Screen displayed place the controller to MANUAL. If the controller reads an input from the Switch, Input 8 will change from "0" to "1".
4. With the controller set to OFF, both inputs will read zero.

Results

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

Test 43 – Test Auto Operations of the Controller

General Theory

Initial Conditions: The generator is in AUTO, ready to run, and voltage is being supplied by Utility. When Utility fails (below 65% of nominal), a 10 second (optionally 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 10 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 (75% of nominal) at any time from the initiation of the engine start until the generator is ready to accept a load (5 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. Set the generator controller to AUTO.
2. Simulate a power failure by opening the Utility supply breaker. If the generator cranks and starts and the switch transfers, close the Utility supply breaker to return utility power. Within 15 seconds the unit should transfer back to the Utility position and enter into a cool down mode for one minute, then shut down. If the generator performs this sequence of events the test is good; STOP.
3. If the generator does not perform the sequence of events listed in the above discussion, diagnose based on the symptom or Alarms displayed.

Results

Refer back to the flow chart.

Test 44 – Check 7.5 Amp Fuse

(Alarm Code 2400 Firmware 1.11 and Older)

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 the alarm log will display "Inspect Battery" first, and then "Stopped-Alarm RPM Sense Loss."

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. 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 DMM 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 and the controller to blank out and restart in either MANUAL or AUTO modes of operation. 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. 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.

NOTE: The battery charger in the control panel is not designed to recharge a dead battery.

Procedure A. 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.

NOTE: If corrosion cannot be cleaned or eliminated, replace the component in question.

3. Verify 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.
4. If the above inspection points have been verified satisfactory, proceed to Procedure B.

Procedure B. Perform a Battery Open Circuit Voltage Test

1. See *Figure 3-41*. Remove the T1 fuse from the transfer switch or disconnect the J8-J9 connector for T1 (A) to disable the battery charger.

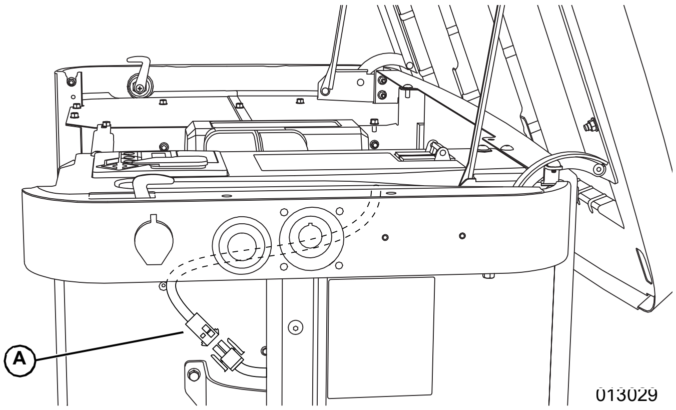


Figure 3-41. T1 Connection

2. Set a DMM 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.
4. Measure and record the OCV (Open Circuit Voltage)
   a. If battery voltage is 12.1 VDC, but greater than 9.0 VDC, or if engine does not crank (turn over), proceed to Procedure C.
   b. If battery voltage is 12.2 VDC or above and the engine does or does not crank, proceed to Procedure D.

Procedure C. Perform a Conductance Test with a Conductance Type Battery Tester

IMPORTANT NOTE: To properly load test a battery when using a resistance type load tester, the battery must be completely full of electrolyte, fully charged and the load applied must be 1/2 of the battery's CCA Rating. (e.g. 540/2=270A) For this reason, a resistance type load tester is not recommended.

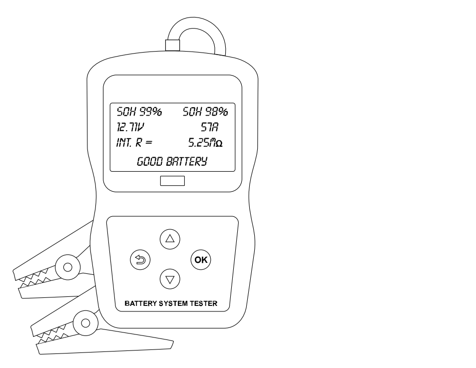


Figure 3-42. Conductance Type Battery Tester

1. Remove 7.5 amp fuse from the controller.

2. Remove the T1 fuse from the transfer switch or disconnect the J8-J9 connector for T1 (see image) to disable the battery charger.
3. Connect the test leads to the positive and negative posts of the battery being tested and follow the conductance battery tester manufacturer's instructions. Test results should not indicate anything lower than 60% of the battery's rated CCA. If battery CCA is 60% or less, replace battery with new.
4. If the above test results have been verified as satisfactory, proceed to Procedure D.

Procedure D. Perform Starter Circuit Voltage Drop Test

1. Turn off the fuel source and remove Wire 14 from the fuel solenoid to inhibit any possible startup.
2. Refer to battery post and starter connections in Figure 4-41 and Figure 4-42 and perform a voltage drop tests as indicated.

NOTE: Some older single cylinder units have a bulkhead mounted starter solenoid.

3. Set the controller to MANUAL. Measure and record the voltage.
4. Record readings from test points V1 (A), V2 (B), V3 (C), V4 (D) as depicted in Figure 4-41 and Figure 4-42.

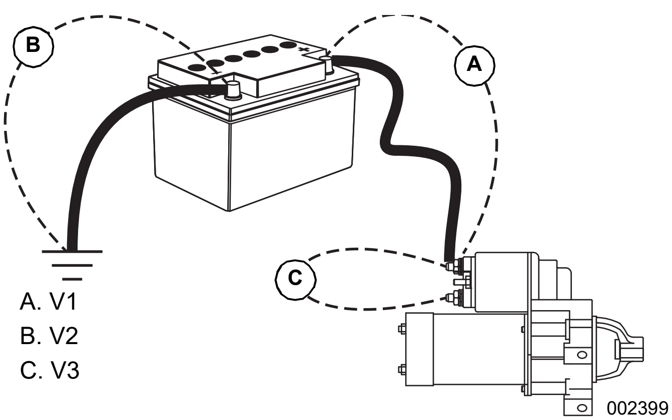


Figure 3-43.

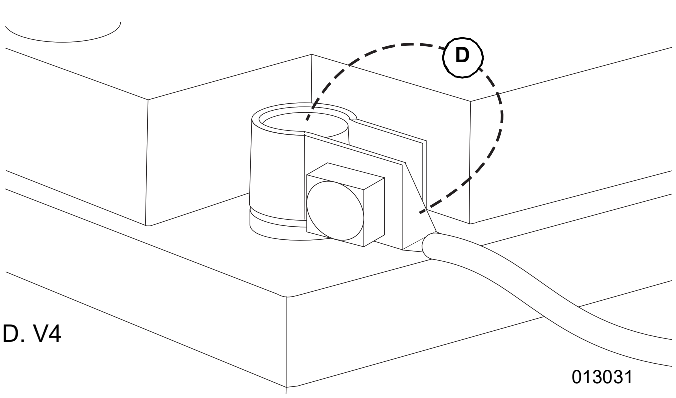


Figure 3-44.

5. Although resistance-free connections, wires and cables would be ideal, most of them will contain at least some voltage drop. Maximum voltage readings are shown in ***Table 3-9***:
6. If any of the voltages are greater than indication in ***Table 3-9***, repair or replace the component as needed.
7. After repairs are made, perform Procedure C (Conductance Test) and record the value for future record keeping.

Table 3-9. Maximum Voltage Readings

DC Volts	Connection	Test
0.00-0.10	Battery Post to Battery Terminal	(V4)
0.10-0.20	Any Ground	Ground
0.20-0.30	Across a wire or cable	(Vl & V2)
0.20-0.30	Across a switch or starter contactor	(V3)
0.40-0.50	Across an entire circuit	(Pos or Neg)

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 starter 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 DMM to measure DC voltage.
2. Locate and disconnect Wire 56 from the SCR on V-Twin units and the SC on single cylinder units.
3. Connect one meter test lead to Wire 56 and the other meter test lead to the battery negative terminal.
4. Set the controller to MANUAL. Observe the meter. The DMM 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. Clear the fault prior to performing Step 5.

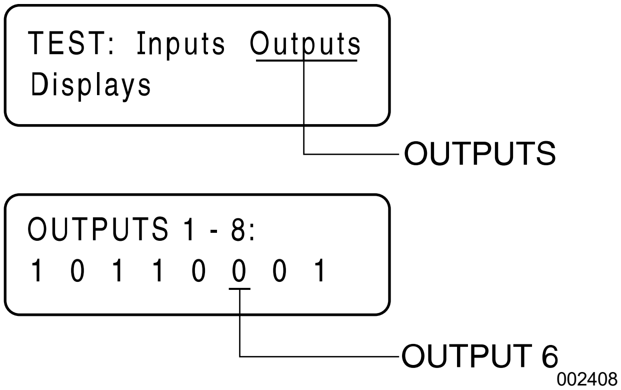


Figure 3-45. The Output Screens

5. Navigate to the Digital Output Screen using the menu system for the controller being worked on.
   a. See *Figure 3-45*. Digital Output 6 is Wire 56 output from the board.
6. Set the controller to MANUAL and observe digital output Number 6. If the controller is working correctly output Number 6 will change from a “0” to a “1”. Observe and record the change in state.
   a. Press MANUAL button to view change of state.
   b. If the controller indicated a “1” then proceed to the next step.
7. Set a DMM to measure DC volts. Use one meter lead to back probe Wire 56 at the controller connector, leaving the connector connected to the controller. Connect the other meter lead to ground. Set the controller to MANUAL and measure the voltage.
   a. If battery voltage is measured go step 8.
   b. If no voltage is measured replace the controller.
8. Set a DMM to measure resistance.
9. Remove 7.5 amp fuse.
10. Disconnect the harness connector from the controller.
11. Remove Wire 56 from the starter contactor relay (V-twin units) or from the starter contactor (single cylinder units).
12. Connect one meter test lead to disconnected Wire 56 and connect the other meter test lead to the controller side of the harness (Wire 56), measure and record the resistance.

Results

1. If the DMM indicated battery voltage in Step 4, refer back to the flow chart.
2. If the Digital Output in Step 5 did not change, replace the controller.
3. If the DMM did NOT indicate CONTINUITY in Step 12, repair or replace Wire 56 between the controller side of the harness and the relay or contactor.
4. If wire did have continuity and the controller indicated “1” in step 6 then replace controller.

Test 47 – Test Starter Contactor Relay
(V-Twin Engine)

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).

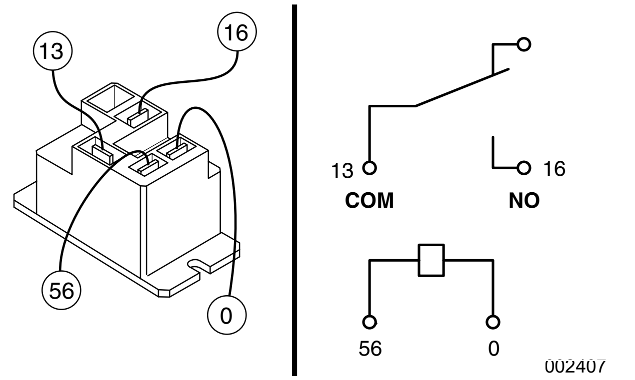


Figure 3-46. Starter Contactor Relay (V-Twin Engine)

Procedure

1. Set a DMM 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.
6. Connect the positive meter test lead to the **terminal** on the SCR from which Wire 16 was removed and connect the negative meter test lead to a common ground.

IMPORTANT NOTE: Do not test wire.

7. Set the controller to MANUAL. Measure and record the voltage.
   a. If voltage is measured, stop testing and go to the results of this test procedure.
   b. If voltage is not measured, continue to the next step.
8. Set the DMM 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. Connect the positive 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 10, replace the SCR.
3. If CONTINUITY was NOT measured in Step 10, repair or replace Wire 0.
4. If battery voltage was measured in Step 7, refer back to flow chart.

Test 48 – Test Starter Contactor

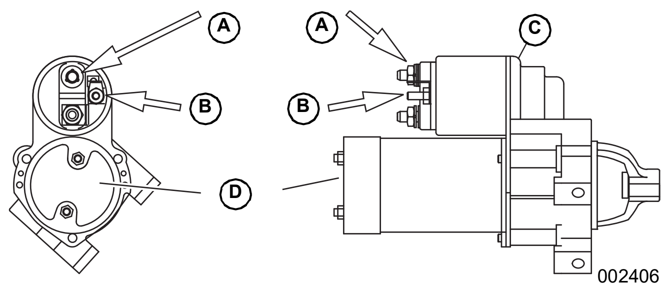
General Theory

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

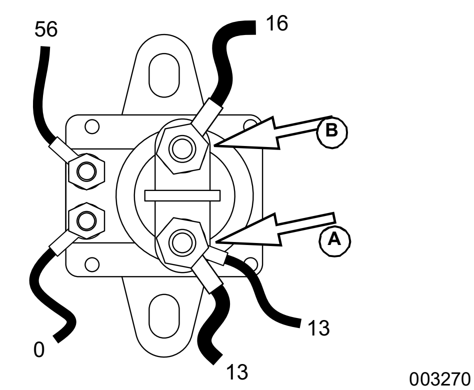
Carefully inspect the starter motor cable that runs from the battery to the starter motor. Cable connections must be clean and tight. If connections are dirty or corroded, remove the cable and clean cable terminals and terminal studs. Replace any cable that is defective or badly corroded.

See ***Figure 3-47*** and ***Figure 3-48*** for Test Points.



A. Test Point A
B. Test Point B
C. Starter Contactor
D. Starter Motor

Figure 3-47. Starter Contactor (V-Twins and units with 426cc Engine)



A. Test Point A
B. Test Point B

Figure 3-48. Starter Contactor (410cc Single Cylinder Engine Units Only)

1. Set DMM 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 DMM should indicate battery voltage. This measurement will be a reference during the testing procedure.
3. Connect the positive meter test lead to Test Point A and connect the negative meter test lead to an engine ground. Measure and record the voltage.
4. Connect the positive meter test lead to Test Point B and connect the negative meter test lead to an engine ground.
5. Set the controller to MANUAL. Measure and record the voltage at Test Point B. The contactor should energize.

Results: V-Twin Engine

1. If the DMM did not indicate battery voltage in Step 5, measure the resistance on Wire 16 between the SCR and the contactor. If OL was measured on the meter, repair or replace Wire 16 between the SCR and the contactor.

Results: 410cc Single Cylinder Engine Units Only

1. If battery voltage was indicated in Steps 3 and 5, measure the resistance between Test Point B and starter motor. If no resistance is measured, repair or replace Wire 16. If resistance is measured, refer back to the flow chart.
2. If battery voltage was indicated in Step 3, but not in Step 5, replace the starter contactor.

Results: 426cc or 460cc Single Cylinder Engine Units Only

1. If battery voltage was indicated in Steps 3 and 5, stop testing and refer back to the flowchart.
2. If battery voltage was indicated in Step 3, but not in Step 5, measure the resistance between Test Point B and Controller connection point for Wire 56 (Use Appendix A for pin locations). If OL was measured on the meter, repair or replace Wire 56. If resistance was measured, refer back to the flow chart.

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.

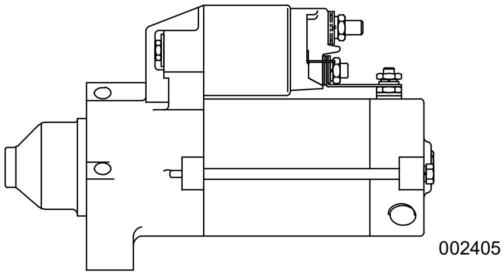


Figure 3-49. Starter Motor (V-Twins and units with 426cc and 460cc engines)

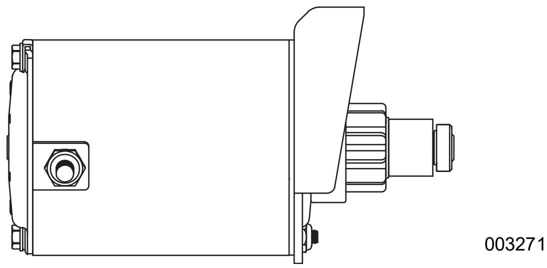


Figure 3-50. Starter Motor (410cc Single Cylinder Engine Units Only)

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 DMM to measure DC voltage (12 VDC).
2. Connect the meter positive (+) test lead to the starter contactor stud which has the small jumper wire or plate connected to the starter motor.
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.
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.

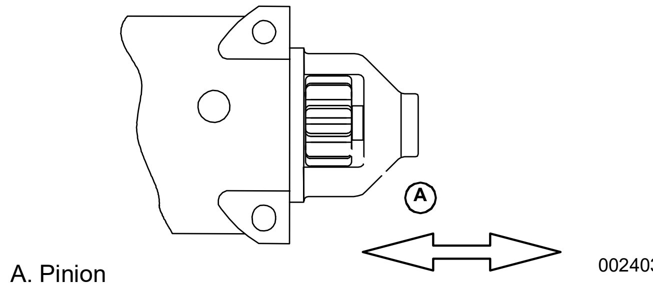


Figure 3-51. Check Pinion Gear Operation (V-Twins and units with 426cc Engine)

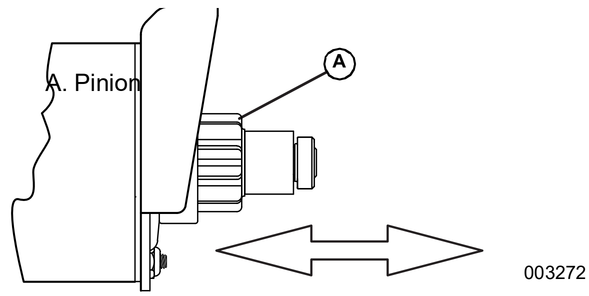


Figure 3-52. Check Pinion Gear Operation (410cc Single Cylinder Engine Units Only)

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 5 inches water column 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.

IMPORTANT NOTE: In localities where only low pressure NG is available, 3.5 inches water column is an acceptable minimum when oversized piping is incorporated.

- 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.

IMPORTANT NOTE: Visually inspect the fuel regulator and plenum tank for signs of leaks or damage.

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)

IMPORTANT NOTE: Verify that the fuel selector is properly set for the supplied fuel type.

IMPORTANT NOTE: Refer to installation manual to confirm correct pipe sizing before testing unit. If pipe sizing is inadequate, correct pipe sizing before continuing with diagnostics.

Procedure

A water manometer or a gauge that is calibrated in "inches of water column" should be used to measure the fuel pressure. Fuel pressure at the inlet side of the fuel solenoid valve should be between 3.5–7 inches water column for natural gas (NG), or 10-12 inches water column for LP gas.

1. See ***Figure 3-53*** and ***Figure 3-54*** for the gas pressure test point on the fuel demand regulator. Static fuel pressure can be checked at Port 1 (A) on all fuel regulators. Running fuel pressure can be checked at Port(s) 2 and/or 3 (B) on all fuel regulators.
2. With the manometer connected properly to Port 1 (A), check the static pressure. Nominal fuel pressure should be measured. If pressure is not measured refer back to flow chart. If pressure is measured, go to Step 3.
3. With the manometer properly connected to Port 2 or Port 3 (B), set the controller to MANUAL mode and check the cranking and/or running pressure. Nominal fuel pressure should be measured while cranking or running. If pressure is not measured refer back to the flow chart.

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.

NOTE: The static pressure port (A) (before solenoid) is ALWAYS closest to the solenoid, regardless of the demand regulator/plenum tank configuration.

Units with a Plenum Tank Only

The Port 3 (B) 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 pressures are adequate in Step 2 and Step 3, but engine will not start refer back 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 5-7 inches water column, or 10-12 inches water column for LP gas. If proper fuel supply and pressure is maintained, refer to ***Problem 18 – Engine Starts Hard and/or Runs Rough / Lacks Power / Backfires / Hunting / Erratic Operation***.

NOTE: If the manometer shows excessive pressure drop or unstable readings, this could be due to undersized fuel pipe or the regulator being too close to the generator.

NOTE: If pressure is above specifications correct/adjust supply regulator to generator to maintain proper fuel pressure.

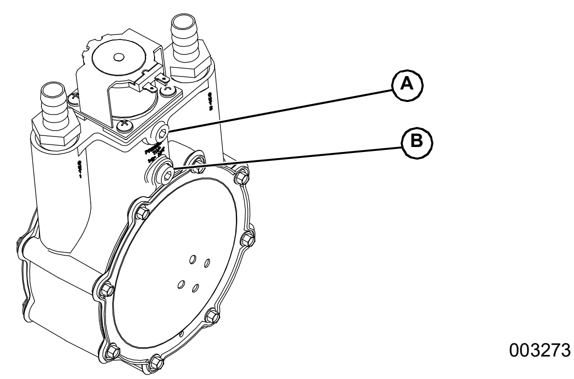


Figure 3-53. Gas Pressure Test points (8-24 kW without Plenum)

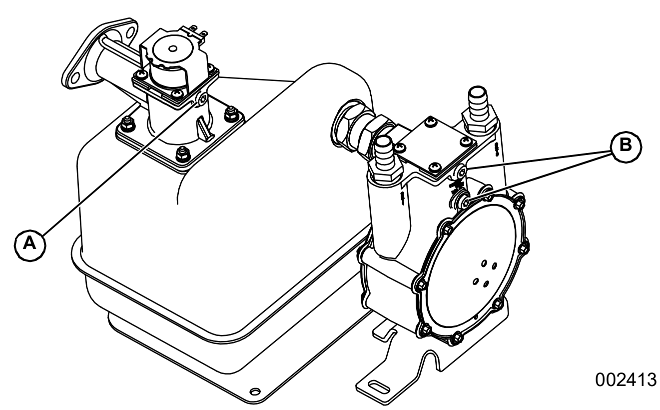


Figure 3-54. Gas Pressure Test points (12-20 kW with Plenum)

Test 51 – Check Controller Wire 14 Outputs

General Theory

During any crank attempt, the controllers crank relay and run relays both are 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 DMM to measure DC voltage.
3. Disconnect Wire 14 from the fuel solenoid (FS).
4. Connect the positive test lead to the disconnected Wire14 from Step 3 and connect the negative test lead to the negative battery post or an engine ground.
5. Set the controller to MANUAL. The meter should indicate battery voltage once the engine rotates. If the engine doesn't crank, refer to appropriate flow chart.
   a. If battery voltage is indicated, refer back to flow chart.
   b. If battery voltage is not measured, proceed to Step 6.
6. Navigate to the Digital Output display using the menu system for the controller.

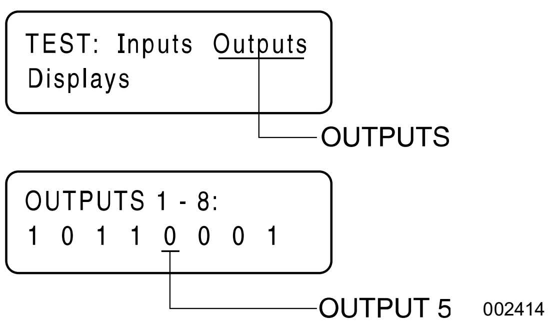


Figure 3-55. The Output Screens

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 DMM did NOT indicate voltage in Step 5 and output did not change in Step 7, replace the controller.
   b. If the DMM did NOT indicate voltage in Step 5 and the output in Step 7 changed, proceed to Step 11.
8. Disconnect the 7.5 amp Fuse.
9. Disconnect the appropriate harness connector from the controller.
10. Set a DMM to measure resistance.
11. Connect one meter test lead to Wire 14 (disconnected in Step 3). 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 DMM 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 back to flow chart.

Test 52 – Check Fuel Solenoid

General Theory

In Test 51, if battery voltage was delivered to Wire 14, the fuel solenoid should have energized and opened to allow fuel through the demand regulator. This test will verify whether the fuel solenoid is operating or not.

Procedure: 8–24 kW Units

1. If fuel supply and pressures were adequate in Test 50, but engine will not start, refer back to the flow chart.
2. See ***Figure 3-53*** or ***Figure 3-54***. Install a manometer to Port 2 or Port 3 (B) on the fuel regulator.
3. Set the controller to MANUAL mode.
   a. Proper gas pressure should be measured during cranking. If gas pressure is measured, the fuel solenoid is operating. Refer back to the flow chart.
   b. If gas pressure is not measured, proceed to next step.
4. Set DMM to measure resistance.
5. Disconnect Wire 14 and Wire 0 on the fuel solenoid. Connect meter leads across the two spade terminals of the solenoid. Measure and record the resistance. Compare the resistance measured to the values in ***Table 3-10***.
   a. If the resistance measured was within specification, refer back to the flow chart.
   b. If the resistance measured was NOT within specification, replace the solenoid.

Table 3-10.

Fuel Solenoid	Resistance Specification (approximate)
Short Solenoid Nominal Resistance	15 ohms
Tall Solenoid Nominal Resistance	30 ohms
Fuel Solenoid FS1 Nominal Resistance	15 ohms
Fuel Solenoid FS2 Nominal Resistance (if equipped)	30 ohms

Test 53 – Check AC Output Frequency

General Theory

Generator AC frequency is proportional to the operating speed of the rotor. The 2-Pole rotor will produce a 50 Hertz AC frequency at 3000 rpm and a 60 Hertz AC frequency at 3600 rpm.

NOTE: Engine Speed is in direct correlation to frequency (Hertz). The controller monitors Wire 18 to maintain proper frequency.

Tools Required

- A meter capable of measuring AC frequency.

Procedure

1. See ***Figure 3-56***. Connect an accurate AC frequency meter across the Wires 11 and 44 Terminals of the generator main line circuit breaker (MLCB).

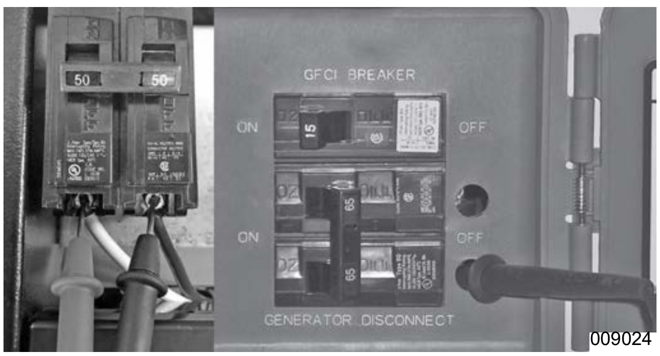


Figure 3-56. MLCB Test Points 2017 and Newer (Left) Pre 2017 (Right)

2. Set the controller to MANUAL.
3. Let engine stabilize. Measure and record the frequency.

Results

1. If the meter indicated 59-61 Hertz, refer back to flow chart.
2. If the meter indicated a value outside the accepted range, refer back to flow chart.

Test 54 – Check Stepper Motor Control

Procedure: V-Twin and Single Cylinder

1. Gain visual access to the carburetor/mixer throttle linkage.
2. Set the controller to MANUAL.
3. Observe and record the stepper motor movement.
   a. The stepper motor should sweep the mixer linkage (and throttle plates) to a full open position (opening both venturis), back to a closed position and then to the starting position (a slight opening of the throttle in the small venturi). See ***Figure 3-57***, ***Figure 3-58***, ***Figure 3-59***, and ***Figure 3-60***.

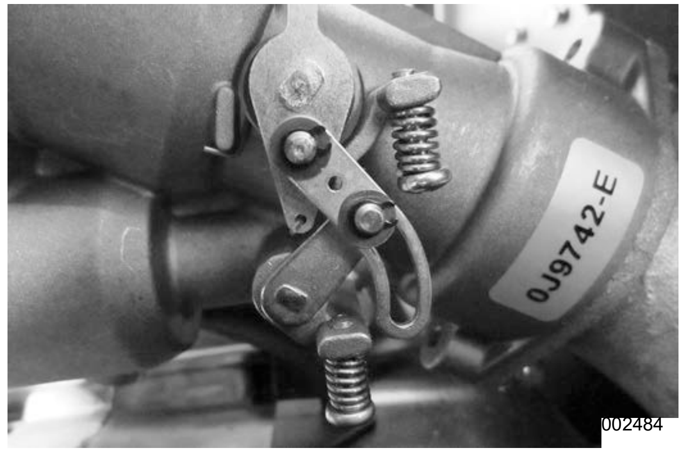


Figure 3-57. Stepper Motor Starting Position and/or Mid-point

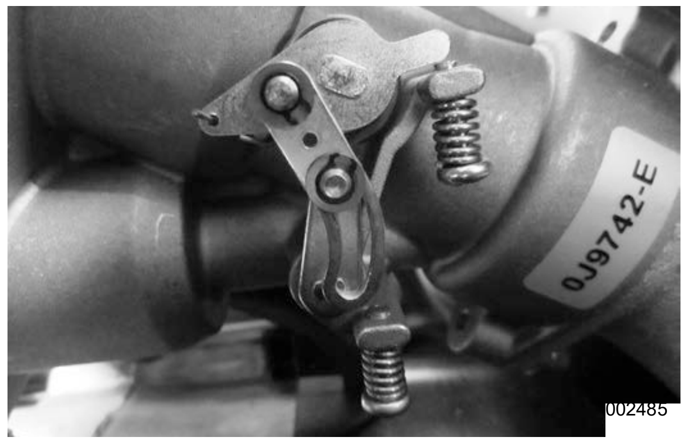


Figure 3-58. Stepper Motor Wide Open = Opens Both Venturis

Figure 3-59. Stepper Motor Closed – Closes Both Venturis

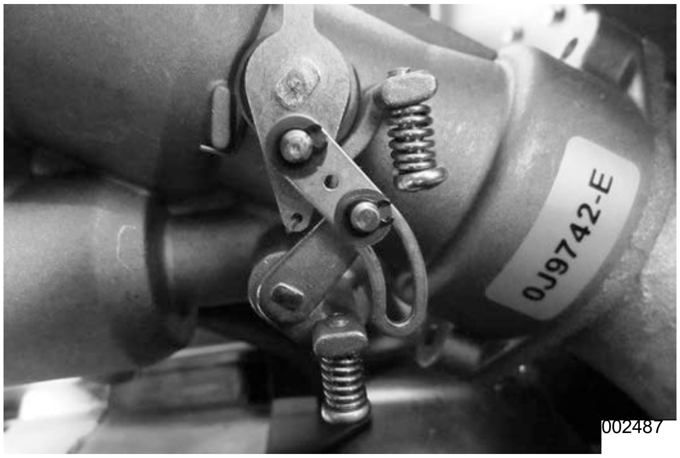


Figure 3-60. Stepper Motor Mid-point = Starting Point, Smaller Venturi Partially Open

4. Set the controller to OFF.
5. If movement WAS NOT seen in Step 3, gain access to the underside of the controller and verify the 10-pin (6-wire) connector on the controller is seated properly. Remove the connector and then reconnect it. Repeat Steps 2, 3 and 4.
   a. If the problem was a no-start condition, attempt to start the generator.
   b. If the generator does not start, refer back to the flowchart.
   c. If movement WAS seen and other problems persist, continue to next step.
6. Remove air cleaner cover to visually access the carburetor/mixer throttle plates.
7. Physically move the throttle from closed position to wide-open position and verify the stepper motor, linkage and throttle plates do not bind in any way. If any binding is seen or felt, replace the carburetor/ mixer assembly.

NOTE: The stepper motor will have minimal resistance as it is moved manually through its travel.

8. If the throttle movement was without difficulty, but problems persist, continue to next step.
9. Set the DMM to measure resistance.

NOTE: Press meter leads firmly onto the exposed terminals of the connector. Do not probe into the connector or wires.

10. Connect the meter test leads across points A and B as shown in ***Table 3-11*** and compare to the specified value.

Table 3-11. 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

11. If the stepper motor indicated appropriate resistance values, refer back to flow chart.
12. If the stepper motor indicated inappropriate resistance values, replace the carburetor/mixer assembly.

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 3-61***. When using this style spark tester the adjustment screw must be set to the proper distance for the type of ignition system being tested.

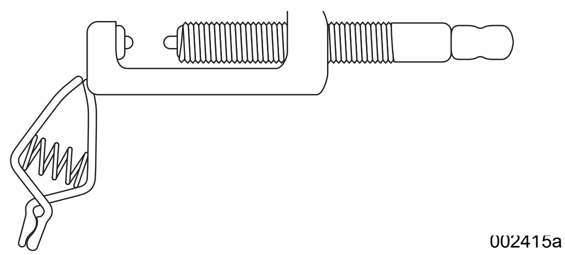


Figure 3-61. Spark Tester

NOTE: For the magneto system used on the HSB engines, set the distance of the adjustment screw tip at the 10kV mark. 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.

Procedure

1. Turn off the fuel supply to the generator.
2. Remove spark plug leads from the spark plugs.
3. See ***Figure 3-62***. Attach the clamp of the spark tester to the engine cylinder head.

Figure 3-62. Checking Ignition Spark

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, 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.

7. See ***Figure 3-63***. 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.

V-Twin Only

8. Repeat Step 1 through 7 on the second cylinder.

NOTE: A sheared flywheel key may change ignition timing but sparking will still occur across the spark tester gap.

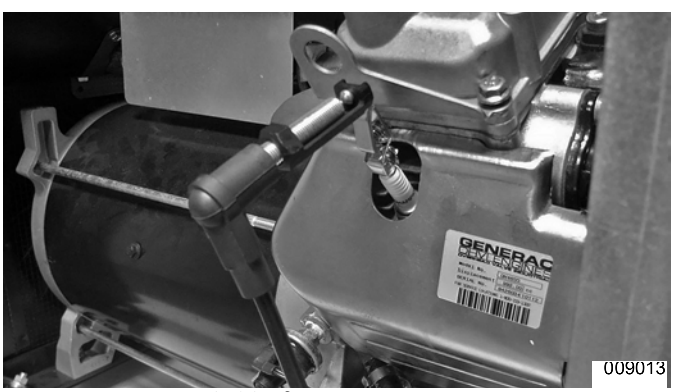


Figure 3-63. Checking Engine Miss

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

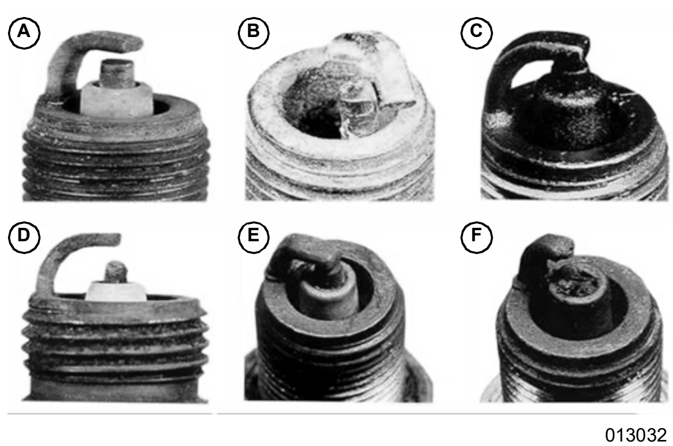
General Theory

If the engine will not start and Test 55 indicated good ignition spark, a possible cause could be fouled or damaged electrodes. Spark plugs used in gaseous powered engines have a much higher ignition temperature compared to gasoline engines. The spark plug(s) are under much higher cylinder pressures due to higher compression ratios.

Because gaseous fuels are more difficult to ignite, the gap between the electrodes of the spark plug must be properly sized for the spark to ionize the gap. If the spark plug gap is incorrect it will affect the energy needed to spark, which can cause misfires or poor ignition of the fuel mixture.

Procedure

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 3-65***. Use a wire feeler gauge to set the gap on new or existing spark plugs as per ***Table 3-12***.



A.	Normal	D.	Overheated
B.	Mechanical Damage	E.	Insulator Glazing
C.	Oil Fouled	F.	Pre-Ignition

Figure 3-64. 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.

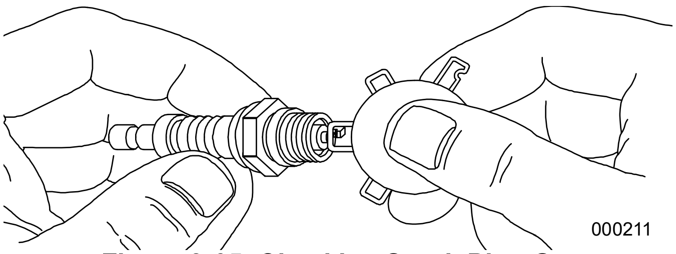


Figure 3-65. Checking Spark Plug Gap

Table 3-12. Spark Plug Gap				
Engine Size	kW Rating	Plug Gap	Recommended Plug	Manufacturer
410 cc	8	0.030 inch	RC12YC	Champion
426 cc	9	0.020 inch	RC12YC	Champion
460 cc	9/10	0.020 inch	RC12YC	Champion
530 cc	10/11	0.030 inch	BPR6HS	NGK
816 cc	13/16, 14/18	0.020 inch	RC12YC	Champion
992 cc	12-18	0.040 inch	RC14YC	Champion
999 cc	20-24	0.040 inch	RC12YC	Champion

NOTE: Always check the specifications of the unit you are working on for correct plug and settings. See Section 1.1 ***Specifications***.

NOTE: Tighten spark plug(s) to 18.4 ft-lbs (25 Nm).

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
- Inability to carry full load

Check Compression

General Theory

Lost or reduced engine compression can result in a failure of the engine to start, or 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.

IMPORTANT NOTE: Valve adjustment is critical to proper compression testing. Verify 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 percent. If the difference in compression is greater that 25 percent, loss of compression in the lowest reading cylinder is indicated.

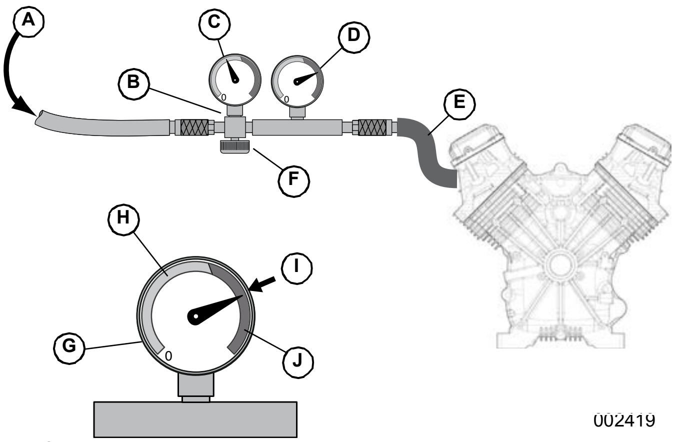
Example 1: If the pressure reading of Cylinder #1 is 165 PSI and of Cylinder #2 is 160 PSI the difference is 5 PSI. Divide “5” by the highest reading (165) to obtain the percentage of 3.0 percent.

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 3-66*** 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 3-66. 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) of the compression stroke on the cylinder being tested. 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.
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: Refer to the tool manufacturer's instructions 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. Verify flywheel/fan has not rotated.
9. Read the gauge on the tester for cylinder percent of leakage. A leakage of 20 percent 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 help determine where the fault lies.
10. Repeat Steps 1 through 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 – replace head gasket and check both gasket surfaces.

Test 59 – Check Shutdown Wire

General Theory

The controller uses Wire 18 for two purposes:

- to measure engine rpm.
- to shutdown the engine. During a shutdown, controller logic 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 3-67*** and ***Figure 3-68***. Disconnect Wire 18.

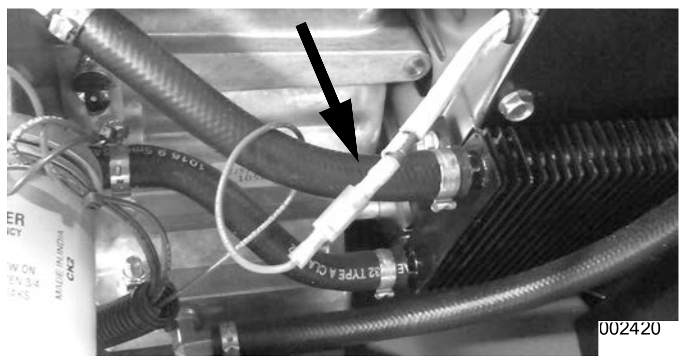


Figure 3-67. Wire 18 Connection – V-Twin Units

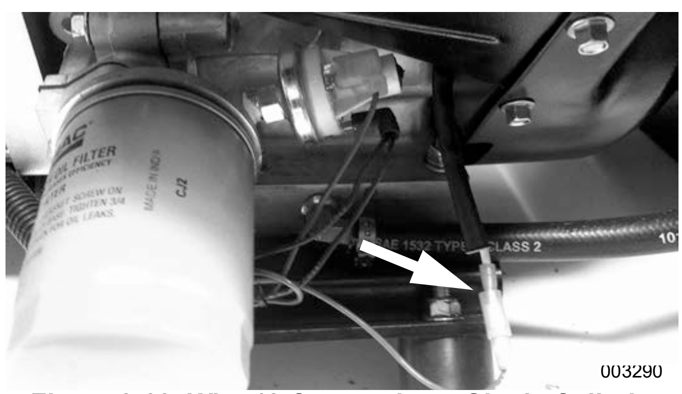


Figure 3-68. Wire 18 Connection – Single Cylinder Units

2. Depending on engine type, do the following:
   a. On V-twin units, 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.

b. On single cylinder units, connect a jumper wire from the stud to which Wire 56 is connected on the starter contactor (SC) and 12 VDC from the positive battery terminal. The generator will start cranking. As it is cranking, repeat ***Test 55 – Check for Ignition Spark***. Reconnect Wire 56 when done.

3. If spark is now present with Wire 18 removed, proceed to check for a short to ground (Steps 4 through 7).
4. Disconnect the harness connector from the controller.
5. Set the DMM to measure resistance.
6. Connect one meter test lead to Wire 18 (disconnected in Step 1) and connect the other meter test lead to an engine ground. Measure and record the resistance.
7. Connect all disconnected wires and connectors.

Results

1. If the DMM indicated CONTINUITY to ground in Step 6, repair or replace shorted ground Wire 18 between the engine and the controller connector.
2. If the DMM 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.

NOTE: On V-Twin units 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.

NOTE: On V-Twin units both ignition coils must be installed in the correct orientation with the with the white dot marking facing away from the engine.

Procedure: Testing Magnetos

1. See ***Figure 3-67*** and ***Figure 3-68***. Disconnect Wire 18 at the bullet connector.
2. Depending on engine type, disconnect spark plug wires from the spark plugs on one or both cylinders.
3. Set DMM to measure resistance when performing resistance checks and to Diode function when performing the Diode Test.
4. Follow the chart connections and record readings on DMM 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 the readings and compare to ***Table 3-13***. Readings are approximate.
6. **Primary Resistance Check:** Connect the meter lead indicated in ***Table 3-13*** 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. Perform all tests as indicated in ***Table 3-13***.
7. **Diode Check:** Connect the meter lead indicated in ***Table 3-14*** to the bolt connector or bullet connector where Wire 18 was disconnected in Step 1. Connect the other meter lead to ground. Perform all tests as indicated in ***Table 3-14***.
8. On V-twin generators, repeat Steps 5 and 6 on Cylinder Two. If readings are not measured, replace the magnetos.

NOTE: On V-twin generators it is recommended to replace magnetos in pairs.

NOTE: Readings can change based on supplier changes. Check GENservice or contact Generac for updates.

NOTE: Resistance values can vary depending on the type and quality of meter being used.

Table 3-13.

Measurements with Wire 18 disconnected

Magneto Wire Diagnostics		V-Twins	Single Cyl
POS Test Lead	**NEG Test Lead**	**Ohms**	**Ohms**
To Magneto Wire	To Ground	250k–2.5 M	.5-1.0
To Ground	To Magneto Wire	OL	3.0
To Magneto Wire	To Plug Wire	250k–2.5 M	10-11 K

Table 3-13.			
Measurements with Wire 18 disconnected			
Magneto Wire Diagnostics		**V-Twins**	**Single Cyl**
POS Test Lead	**NEG Test Lead**	**Ohms**	**Ohms**
To Plug Wire	To Magneto Wire	OL	10-11 K
To Plug Wire	To Ground	7-14 K	9-16 K
Measurements with Wire 18 connected			
AC Voltage Wire 18 Backprobed		**V-Twins**	**Single Cyl**
Cranking		3-5 VAC	1.5-2 VAC
Running @ 3600 rpm		14-20 VAC	7-8.5 VAC
Running @ 3000 rpm		11.5-16.5 VAC	5.8-7 VAC
Frequency		**V-Twins**	**Single Cyl**
Cranking		35-45 Hz	13-17 Hz
Running @ 3600 rpm		120 Hz	60 Hz
Running @ 3000 rpm		100 Hz	50 Hz

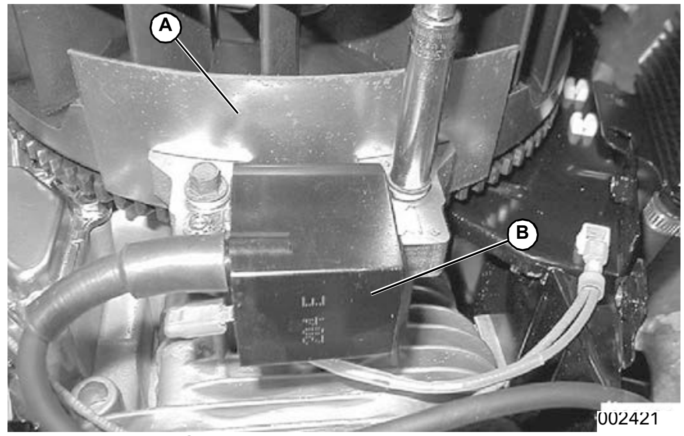
Table 3-14.			
Diode Test		**V-Twins**	**Single Cyl**
POS Test Lead	**NEG Test Lead**	**VDC**	**VDC**
To Magneto Wire	To Ground	0.5-0.6	N/A
To Ground	To Magneto Wire	OL	N/A

Procedure: Adjusting Magneto Flywheel Gap

The air gap between the ignition magneto and the flywheel on single cylinder engines is not adjustable. Proceed directly to Step 10 for single cylinder engines.

For V-twin engines, proceed as follows:

1. See ***Figure 3-69***. Rotate the flywheel (by hand) until the magnet is under the module (armature) laminations.



A. 0.008-0.012” Gauge
B. Magneto

Figure 3-69. Setting Ignition Magneto Air Gap

2. Place a 0.008-0.012 inch (0.20-0.30mm) non metallic thickness gauge between the flywheel magnet and the module laminations.

NOTE: A typical business card is approximately 0.010 inch thick.

3. Loosen the mounting screws and let the magnet pull the magneto down against the thickness gauge.
4. Tighten mounting bolts to 5.6–7.4 ft-lbs (7.6–10 Nm).
5. To remove the thickness gauge, rotate the flywheel (manually).
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 disassembled 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.

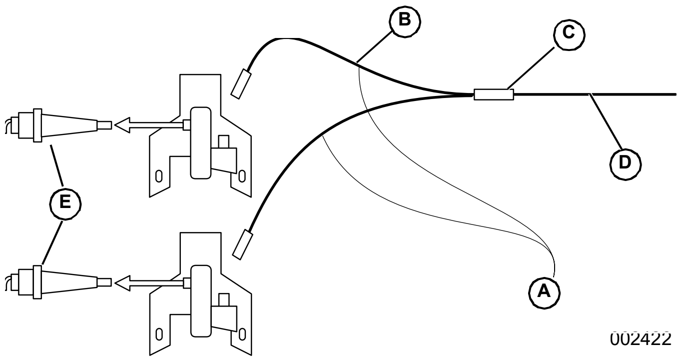
NOTE: Verify all debris is cleared from the engine compartment and all body parts are clear from flywheel before proceeding.

   e. Refer to ***Test 55 – Check for Ignition Spark***.
   f. Connect a jumper 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, properly test the magnetos by cranking the engine before reassembly. Spark should be present on both cylinders.

9. If air gap was not out of adjustment, test ground wires.

10. Set a DMM to the measure resistance.
11. See ***Figure 3-70***. Disconnect the engine wire harness from the ignition magnetos.
    - See ***Figure 3-67*** and ***Figure 3-68***. Disconnect Wire 18 at the bullet connector.



A. Remove leads
B. Engine wire harness
C. Bullet connector
D. Wire 18 to circuit board
E. Spark plug

Figure 3-70. Engine Ground Harness

12. Connect one meter test lead to one of the wires removed from the ignition magneto(s). Connect the other test lead to an engine ground. INFINITY should be measured. If CONTINUITY is measured, replace the shutdown harness.
13. 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 3/4 inch (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.

NOTE: As stated earlier, the armature air gap is fixed for single cylinder engine models and is not adjustable. Visually inspect the armature air gap and hold down bolts.

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 ***Major Disassembly***.
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 3-71***. Cylinder one is the back cylinder.
4. See ***Figure 3-72***. Cylinder two is the front cylinder.
5. See ***Figure 3-73***. 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 inch.

NOTE: On V-Twin units both ignition coils must be installed in the correct orientation with the with the white dot marking facing away from the engine.

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).
8. Verify installation of magnetos correctly by ensuring both spark plug wires point to the back of the enclosure and shutdown terminals are nearest cylinder head as shown in ***Figure 3-74*** and ***Figure 3-75***.
9. Tighten mounting bolts to 5.6–7.4 ft-lbs (7.6–10 Nm).

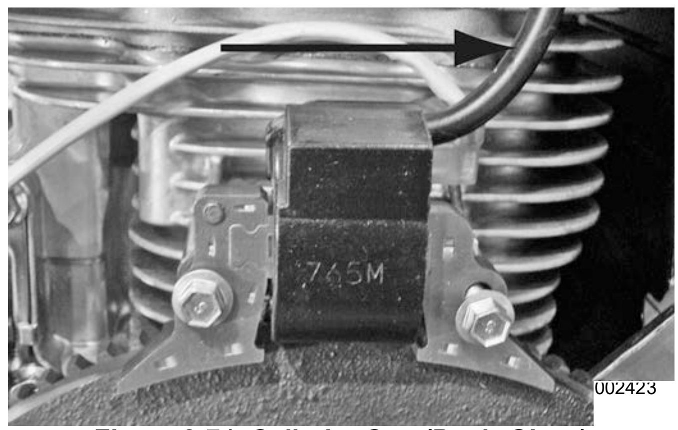


Figure 3-71. Cylinder One (Back, Short)

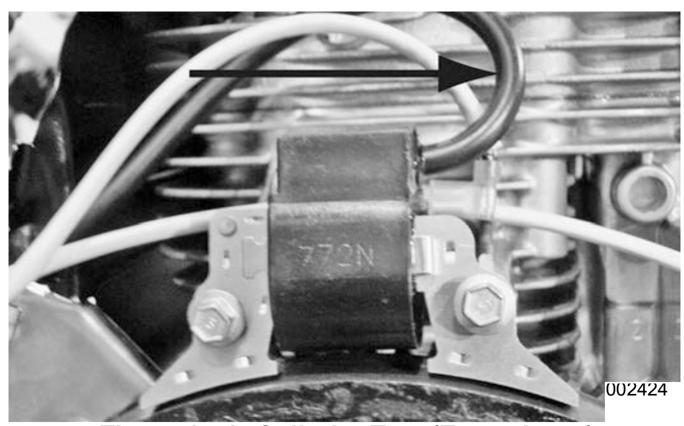
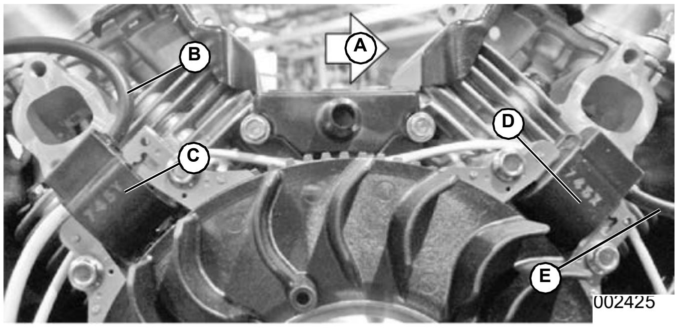


Figure 3-72. Cylinder Two (Front, Long)



A. Back Of Enclosure
B. Long Spark Plug Wire
C. Cylinder Two
D. Cylinder One
E. Short Spark Plug Wire

Figure 3-73. Magneto Positions

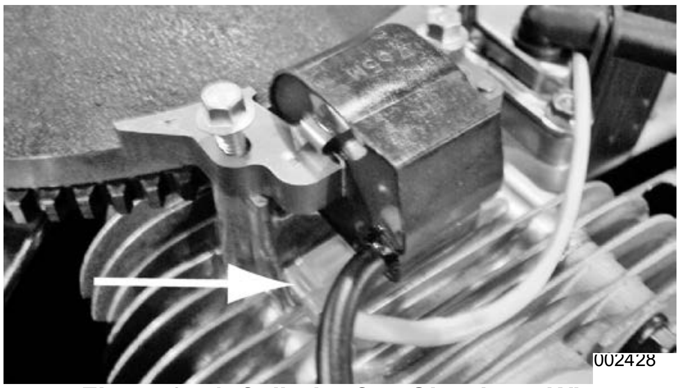


Figure 3-74. Cylinder One Shutdown Wire

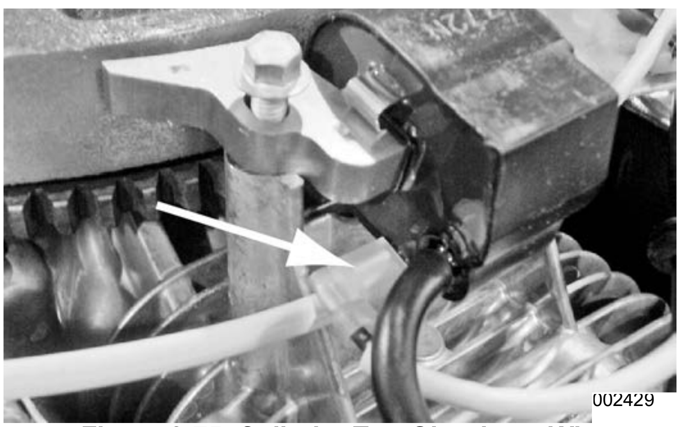


Figure 3-75. Cylinder Two Shutdown Wire

Test 61 – Check Oil Pressure Switch (LOP) and Wire 86 (E-Code 1300)

General Theory

If the engine cranks and starts, then shuts down within about 5 (five) to 10 (ten) seconds 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 (LOP).

NOTE: Evolution 1.0 oil pressure switch is Normally Closed (N.C.) with no oil pressure. Evolution 2.0 oil pressure switch is Normally Open (N.O.) with no oil pressure.

Procedure

1. See ***Figure 3-76***. Navigate to the Digital inputs display screen of the controller being worked on.

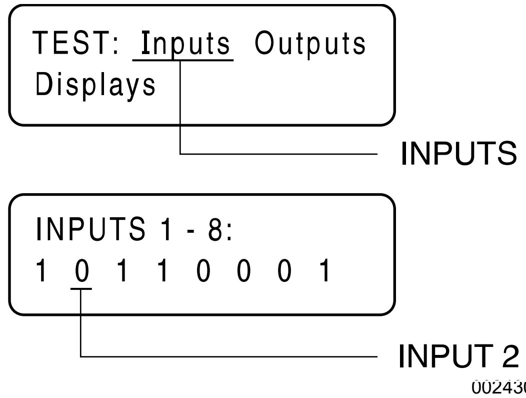


Figure 3-76. The Input Screens

   a. Digital Input 2 is Wire 86 from the LOP switch to the board.
   b. Set the controller to MANUAL.
   c. Observe Input 2 for a change from “1” to “0” (Evolution 1.0), or from “0” to “1” (Evolution 2.0).
   d. A visible change on Input 2 indicates that the control board sensed the LOP switch changed states. If the generator still shuts down, replace controller.
   e. If the input did change states, the LOP switch is good. An intermittent oil pressure problem may still be present and should be checked with a mechanical gauge as in Step 4.
2. Check engine crankcase oil level. If necessary, add the recommended oil to the dipstick FULL mark. DO NOT OVERFILL 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.
4. Do the following:
   a. Disconnect Wire 86 and Wire 0 from the LOP 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, and 5 psi for single cylinder engines.

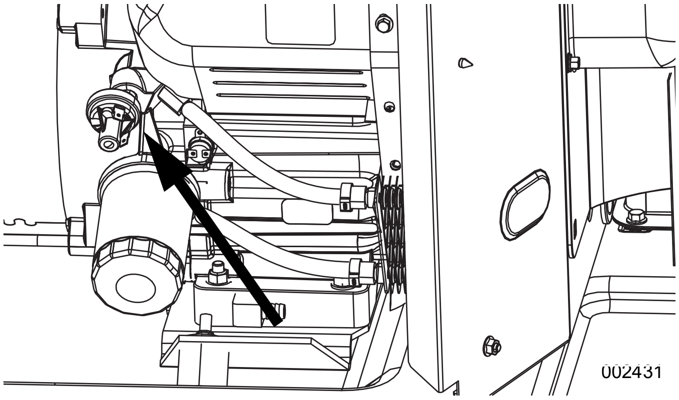


Figure 3-77. Oil Pressure Switch

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 DMM to measure resistance.
   b. Connect the DMM test leads across the LOP switch terminals. With the engine shut down, the DMM should indicate:
      - Evolution 1.0—CONTINUITY. If INFINITY was measured, replace the LOP switch.
      - Evolution 2.0—INFINITY. If CONTINUITY was measured, replace the LOP switch.
   c. With the DMM still connected to the LOP switch, set the AUTO-OFF-MANUAL switch MANUAL. The DMM should indicate:
      - Evolution 1.0—INFINITY after the engine has had a chance to build pressure.
      - Evolution 2.0—CONTINUITY after the engine has had a chance to build pressure.
6. Set the DMM 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 3.3 VDC should be measured. If 3.3 VDC is not measured, go to Step 7and check continuity on Wire 86 from the LOP switch back to the J4 connector.
7. Keep the DMM 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 DMM 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 an engine ground. The DMM 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 310 °F (154 °C) This is normally caused by inadequate airflow through the generator.

NOTE: Evolution 1.0 high oil temperature switch is Normally Open (N.O.) with no high oil temperature condition. Evolution 2.0 is Normally Closed (N.C.) with no high oil temperature condition.

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 three feet 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 DMM 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, proceed to step 6.
6. Remove harness connector from the controller.
7. Set the DMM to measure resistance.
8. Connect one test lead to Wire 85 (disconnected from High Oil Temperature Switch). Connect the other test lead to an engine ground. INFINITY should be measured.

Testing High Oil Temperature Switch

9. Remove the High Oil Temperature Switch.
10. See *Figure 3-78*. Immerse the sensing tip of the switch in oil, along with a suitable thermometer.

11. Set a DMM to measure resistance. Then, connect the DMM test leads across the switch terminal and the switch body. The meter should read INFINITY.
12. Heat the oil in the container. When the thermometer reads approximately 299-321 °F (148-160 °C), the DMM should indicate CONTINUITY.

Results

1. If the switch fails Step 4, or Steps 11-12, replace the switch.
2. If INFINITY was not measured in Step 8, repair or replace Wire 85 between the Circuit Board and the High Oil Temperature Switch.

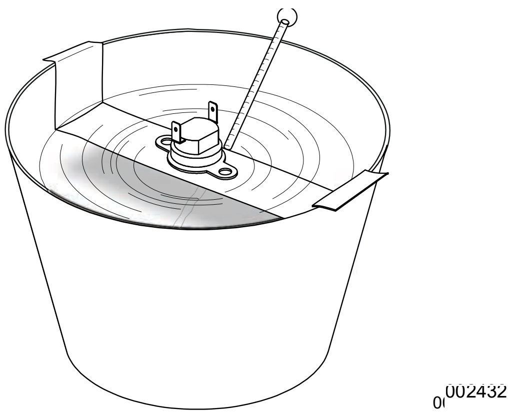


Figure 3-78. Testing the Oil Temperature Switch

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 procedures for single cylinder and V-twin engines are different and vary according to engine displacement.

NOTE: 2019 and newer units with 816cc engines have hydraulic valve lifters which do not require adjustment.

Check Valve Clearance

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.

(000191)

NOTE: The engine should be cool before checking the valve clearance. Adjustment is not needed if valve clearance is within the dimensions provided in Section 1.1 ***Specifications***.

Verify the piston is at Top Dead Center (TDC) of its compression stroke (both valves closed).

NOTE: A small non-metallic object, such as a plastic straw, can be inserted through the spark plug opening and rested on the piston. Piston movement will cause the object to move up and down, giving a visual indication of TDC.

Adjust Valve Clearance

See ***Figure 3-79*** or ***Figure 3-80***. Check and adjust the valve to rocker arm clearance as follows:

1. Remove the four screws attaching the valve cover and remove valve cover.
2. Discard valve cover gasket.
3. Loosen the rocker jam nut (C) using a 10 mm wrench (9-11 kW units) or 13 mm wrench (16-24 kW units.)
4. Turn the pivot ball stud (D) using a 14 mm wrench (9 kW units), 8 mm wrench (11 kW units), or 10 mm Allen wrench (16-24 kW units) while checking clearance between the rocker arm (E) and the valve stem (F) with a feeler gauge. Adjust clearance as per Section 1.1 ***Specifications***.

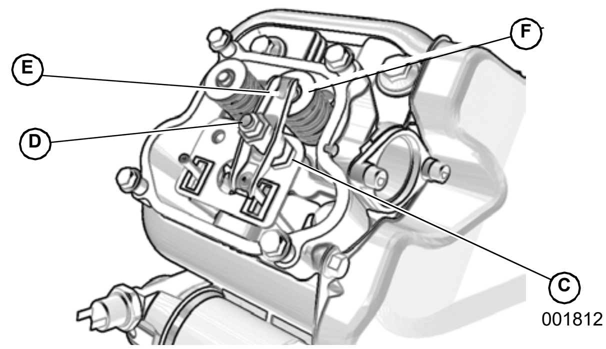


Figure 3-79. Valve Clearance Adjustment (9 kW - 426cc / 10 kW - 460cc engine)

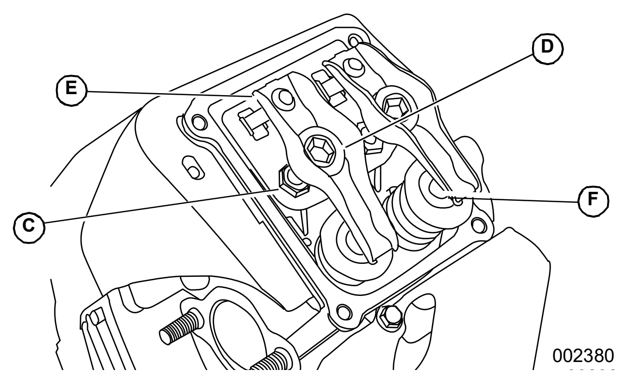


Figure 3-80. Valve Clearance Adjustment (8 kW, 11-24 kW - 530cc through 999cc)

NOTE: Hold the rocker arm jam nut in place as the pivot ball stud is turned.

5. When valve clearance is correct, hold the pivot ball stud (D) in place with a wrench and tighten the rocker arm jam nut. Tighten the jam nut according to the following torque specifications:

8 kW	174 **in-lbs** (19.68 Nm)
9 kW	53 **in-lbs** (6.0 Nm)
11 kW	72 **in-lbs** (8.2 Nm)
16–24kW	174 **in-lbs** (19.68 Nm)

6. After tightening the jam nut, check valve clearance again to verify it did not change.
7. Install new valve cover gasket.
8. Install the valve cover. Tighten fasteners in a cross pattern to:

8 kW	48 **in-lbs** (5.4 Nm)
9 kW	80 **in-lbs** (9.0 Nm)
11–24kW	60 **in-lbs** (6.8 Nm)

9. Repeat the process for the other cylinder if unit is a V-Twin.

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. During cranking, this signal has an AC voltage of approximately 3-6 Volts on V-twin engines, and approximately 2-3 Volts on single cylinder engines. If the controller does not receive this signal, the unit will shut down due to no rpm sensing.

Procedure

1. Set the DMM to measure AC voltage.
2. Disconnect Wire 14 to inhibit any possible startup.
3. See *Figure 3-81*. Back probe Wire 18 harness connector. Do not disconnect this wire.

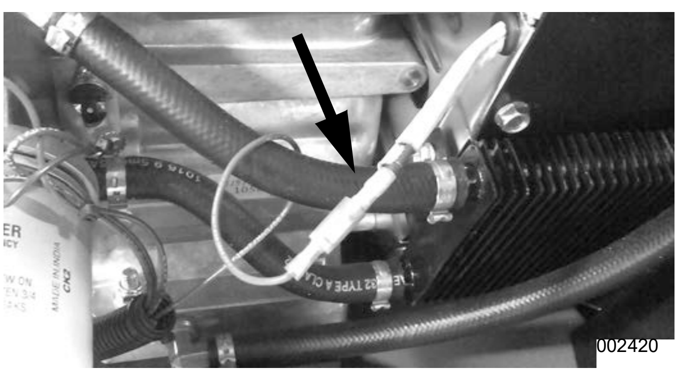


Figure 3-81. Wire 18 Connection

4. Set the controller to MANUAL.
5. While unit is cranking measure and record the voltage.
   a. If the DMM indicated approximately 3-6 VAC for V-twin or 2-3 VAC for single cylinder, proceed to Step 7.
   b. If the DMM did NOT indicate the appropriate voltage, go to the Step 6.
6. Disconnect Wire 18 from magneto sensing lead.
   a. Connect one meter test lead to an engine ground and connect the other meter test lead to the magneto lead terminal.
   b. Set the controller to MANUAL and while unit is cranking measure and record the voltage.
   c. If the DMM indicated approximately 3-6 VAC for V-Twin and 2-3 VAC for single cylinder, proceed to Step 6.
   d. If the DMM did NOT indicate the appropriate voltage, go back to the flow chart (Problem 14) and follow “No Signal” (**Test 60**).
7. Set the DMM to measure resistance.
8. Disconnect the harness connector containing Wire 18 from the controller.
9. Connect one meter test lead to an engine ground and connect the other meter test lead to Wire 18.
   a. If the DMM indicated low resistance (.01), check for a short to ground in the Wire 18 circuit.
   b. If the DMM indicated O/L OPEN circuit proceed to Step 9.
10. 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 DMM indicated CONTINUITY, refer back to the flow chart (Problem 14, RPM Sense Loss).
    b. If the DMM 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.

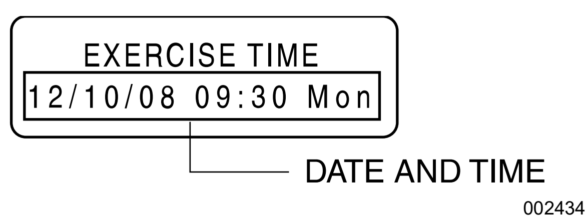


Figure 3-82. The Exercise Screen

Procedure: 8–14 kW (EVO 1.0 Controller)

NOTE: Utility voltage must be present.

Make a record of the date and time the generator is set to exercise.

1. Record the current date and time of the unit.

2. Navigate to the Exercise settings screen of the controller being worked on.
3. Press “Enter”.
4. Adjust exercise time to 5 minutes ahead of the date and time noted in Step 1.
5. Return to the Main Display where “READY TO RUN” is displayed. The controller must be in AUTO mode with utility present for the unit to exercise.
6. Watch the generator display and note the time. When the date and time reaches the time that was programmed for exercise the unit should crank and run. “Running in Exercise” will display if the exercise feature is working properly.

Procedure: 15-24 kW (EVO 1.0 Controller) 11-24 kW (Honeywell™) 9-24 kW (EVO 2.0 Controller)

NOTE: Utility voltage must be present for exercise to occur.

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. To stop test press ENTER.

Results

1. In all models, if the unit starts 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 3-15*** throughout the procedure for the known resistance values of components.

Figure 3-83 shows the DMM in two different states. The left DMM indicates an OPEN circuit or INFINITY. The right DMM indicates a dead short or CONTINUITY. Throughout the troubleshooting, refer to ***Figure 3-83*** as needed to understand what the meter is indicating about the circuit being tested.

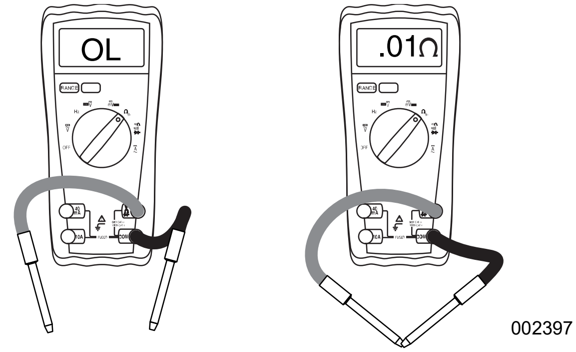


Figure 3-83. INFINITY (Left) and CONTINUITY (Right) Meter Readings

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

Table 3-15. Component Resistance Values	
Starter Contactor	8Ω
Starter Contactor Relay	155 - 158Ω
Fuel Solenoid(s)	15 - 16Ω

Procedure

1. Set a DMM to measure resistance.
2. Disconnect the harness from the controller.
3. Connect one meter lead to battery negative (ground) and connect the other meter test lead to each of the tests points in ***Table 3-16***. Measure and record the resistance.

Table 3-16. Resistance Measurements

Test Point	Pin Location	Circuit	20 kW
1	*	Wire 14	16Ω
2	*	Wire 56	155Ω

* Use Appendix A for pin locations

Results

1. Compare the results of Step 3 with ***Table 3-16***.
   a. If the DMM indicates less than the value in ***Table 3-16*** at Test Point 1 proceed to ***Test 67 – Test Run Circuit***.
   b. If the DMM indicates less than the value in table 4-16 at Test Point 2 proceed to ***Test 68 – Test Crank Circuit***.
   c. If the DMM indicated proper resistance values at all Test Points, refer to FB3 Diode Test.

Test 67 – Test Run Circuit

General Theory

Wire 14 provides 12 VDC during cranking and running. If the DMM indicated less than 15 Ohms in the previous test, one possible cause could be a faulty harness or solenoid.

Procedure: 8 kW

1. Set a DMM 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 DMM indicated less than 15 ohms in Step 3, replace the FS solenoid.
2. Refer to ***Table 3-16*** and if the DMM 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 DMM indicated less than 8 ohms (8 kW) at the starter contactor or less than 155 ohms (10-20 kW) at the starter contactor relay in the previous test, one possible cause could be a faulty relay or solenoid.

Procedure: 8–10 kW

1. Set a DMM to measure resistance.
2. Disconnect Wire 56 from the starter contactor (SC).
3. Connect one meter test lead to the SC terminal from which Wire 56 was removed. Connect the other meter test lead to the ground terminal. Measure and record the resistance.

Results

1. If the DMM indicated less than 8 ohms of resistance in Step 3, a short exists. Repair or replace as needed.
2. If the DMM indicated less than 3 ohms in step 4 replace the CS solenoid.

Procedure: 13–24 kW

1. Set a DMM 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 DMM indicated less than 155 ohms in Step 3, replace the SCR relay.
2. If the DMM indicated less than 3 ohms in step 4 replace the CS solenoid.
3. Refer to ***Table 3-15*** and if the DMM indicated the correct resistance for the component, a short to ground exists on Wire 56. Repair and replace Wire 56 as needed.

Test 70 – Check For Low Speed Function Enable

(Available only on certain models)

General Theory

Some generators are equipped with a low speed exercise function. When enabled, the low speed exercise function allows the generator to exercise at a lower rpm. When low speed exercise is disabled the generator will exercise at 3600 rpm.

Procedure (If equipped)

1. From the main display enter the Edit Menu using the menu map.
2. Press UP or DOWN Arrow key until “Exercise Time” is displayed.
3. Press ENTER.
4. “Quiet Test Mode? Yes or No” will be displayed. Press UP or DOWN Arrow key until “Yes” is displayed.
5. Press ENTER to save change.
6. Return to Main Display.

Results

Enable the exercise function if it is not already enabled. Refer back to flow chart.

Test 75 – Test 120 Volt Input (T1) 60 Hz 240 Volt Input (T1 - T2) 50 Hz

General Theory

The controller requires 120 VAC (60 HZ Unit) or 240 VAC (50 HZ Unit) 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: “Inspect Battery” 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 (60 Hz) or 240 VAC (50 Hz) input is good.
2. If the controller powered down when the fuse was removed, the controller is not getting the 120 VAC (60 Hz) or 240 VAC (50 HZ) input. Return to the flow chart (Test 79).

Test 76 – Verify DC Voltage Output of the Controller

General Theory

The battery voltage of the unit can be viewed within the "Display" menu of the controller. This test procedure will verify battery voltage to the controller.

Procedure

1. Use the Navigation Menu Map for the controller being serviced.

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 back to flow chart.
2. If the battery voltage indicated on the display is 0 VDC, the connections to the controller are bad. Refer back to flow chart.
3. If the battery voltage indicated on the display is between 1 VDC to 11 VDC, check cables and connections, or 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 DMM 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 previously connected. Connect the other meter test lead to battery negative (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 DMM indicated battery voltage in Steps 3 and 5, replace the controller.
2. If the DMM 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 "Low Battery" or "Inspect Battery" 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. Set the controller to OFF.
3. Disconnect the negative cable battery.
4. Set the DMM to measure DC amperage.

NOTE: Consult the meters owner's manual to ensure proper setup of meter and that the internal fuse is good before proceeding.

5. 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 DMM indicated positive DC amperage between 50 milliamps to 2.5 amps, stop testing. The charger is functioning properly.
2. If the DMM indicated negative DC amperage, replace the controller.

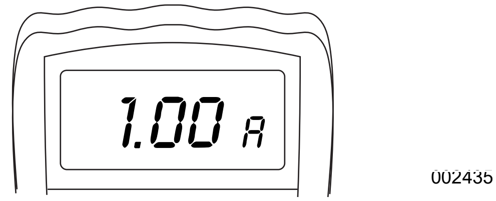


Figure 3-84. Positive DC Amps

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Figure 3-85. Negative DC Amps

Test 79 – Check T1 Voltage at Customer Connections

Procedure

1. Set a DMM 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 DMM indicated 120 VAC, proceed to check voltage at the J5 connector, refer back to flow chart.
2. If the DMM indicated less than 120 VAC or 0, refer back to flow chart.

Test 80 – Check T1 Voltage at Controller Connector

General Theory

If 120 VAC was available on the customer connection block between T1 and neutral for 60 Hz units, or 240 VAC between T1 and T2 for 50 Hz units, 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 DMM to measure AC voltage.
   a. For 60 Hz units 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.
   b. For 50 Hz units check the voltage at the controller harness connector pins between T1 and the neutral connection, then between T2 and the neutral connection on the customer connection block. If voltage is not present check the T1/T2 wires from the customer connection block to the controller harness connector. If Voltage is present, replace the controller.
3. For 60 Hz units only, 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 is in the controller. Replace the controller.

Test 81 – Check T1/T2 Voltage in Transfer Switch

General Theory

If voltage was not present in the generator, the most likely cause is a blown T1/T2 fuse or an open wire.

Procedure

1. Set the DMM to measure AC voltage.
2. Connect one meter test lead to the bottom side of the T1 fuse holder (T1/T2 for 50 Hz units) and the other meter test lead to the NEUTRAL connection. Measure and record the voltage.

Results

1. If the DMM indicated proper voltage, repair or replace faulty wire between the generator and the fuse holder.
2. If the DMM indicated less than proper voltage or 0, refer back to the flow chart.

Test 82 – Test F3 (T1) Fuse Circuit

Procedure

1. Set a DMM to measure AC voltage.
2. Connect one meter test lead to the top side of the F3 (T1) fuse holder and connect the other test lead to the NEUTRAL connection. Measure and record the voltage.
   a. If the DMM indicated 120 VAC, proceed to Step 3.
   b. If the DMM indicated less than 120 VAC or 0, verify that Load voltage is available to the LOAD side of the CONTACTOR.
3. Set the controller to OFF.
4. Disconnect Utility from the transfer switch.
5. See ***Figure 3-86***. Remove fuse F3 (T1) from the fuse holder.
6. Inspect and test fuses for an OPEN condition with a DMM 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."

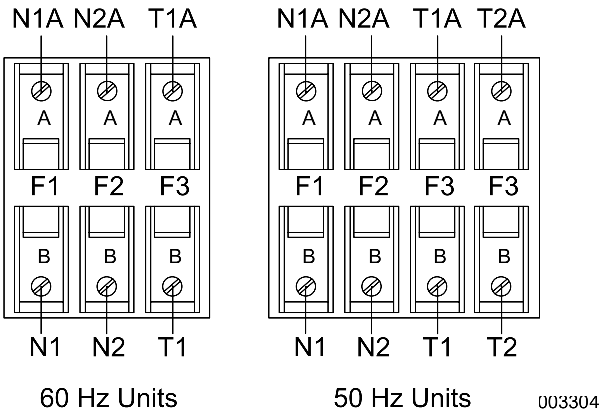

Figure 3-86. Transfer Switch Fuse Block

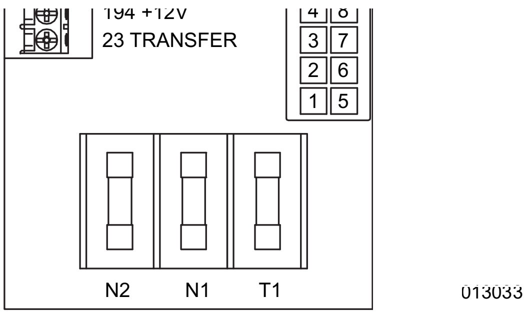

Figure 3-87. iSACM Fuse Block

Test 83 – Verify Model ID Resistor Connections

General Theory

Table 4-17 identifies Model ID resistors for specific air-cooled generator models. The Model ID Resistor allows the controller to identify the size/model of the generator and is specific to each model. When replacing (or removing and reinstalling) an Evolution 1.0 (Sync 2.0) or Evolution 2.0 (Sync 3.0) controller, if the controller is not powered up in the proper sequence, it will result in a "Model Ident Problem Fix Harness Resistor" fault. This fault does not have an associated E-Code.

Procedure

1. Disconnect battery charger supply voltage (T1) to the controller (J8-J9 connector).
2. Remove 7.5 Amp fuse in the controller. This will power down the controller.
3. Disconnect harness connectors J1 and J2.
4. Inspect the following pins for any looseness or poor connections. Refer to Appendix A.
   a. Evolution 2.0 (Sync 3.0) - J2-11, J2-14 and J2-15.
   b. Evolution 1.0 (Sync 2.0) - J2-8, J2-15 and J2-16.

NOTE: Certain models may not use all 3 wire/pins.

5. Reconnect harness connectors J2 and then J1 (specifically in this order).
6. Install 7.5 Amp fuse in the controller. This will power up the controller.
7. Reconnect battery charger supply voltage (T1) to the controller (J8-J9 connector).
8. When the controller has powered up, it will display the Install Wizard. Make any necessary adjustments to the controller settings and verify correct operations of generator and transfer switch.

Result

If the "Model Ident Problem Fix Harness Resistor" does not reappear, discontinue testing.

If the "Model Ident Problem Fix Harness Resistor" fault returns, or is intermittently persistent, test the Model ID resistor for proper resistance. Replace the Model ID harness resistor if resistance reading is outside of specification and restarting the controller did not correct the fault.

NOTE: Refer to Service Information Bulletin SIB14-11-ALL for further information.

Table 4-17. Model ID Resistor Data

Part Number	Generator Node	Resistance Pin 1 to Pin 3	Resistance Pin 1 to Pin 2
0K0258A	8 kW / 10 kW	2.4k	OL
0K0258B	9 kW	365	OL
10000003605	EVO2.0 Ecogen	3.2k	OL
0K0258D	13 kW	4.1k	OL
0K0258E	14 kW / 22 kW	787	OL
0K0258F	15 kW / 22 kW	5.3k	OL
0K0258G	16 kW	6.8k	OL
0K0258H	17 kW	1.2k	OL
0H0258J	20 kW	1.8k	OL
0K0258K	20 kW Synergy / 208 3 -Phase	8.6k	OL
0K0258L	EVO1.0 Ecogen / 308 3-Phase	11.3k	OL
0K0258M	8 kVA 50 Hz	15k	OL
0K0258N	10 kVA 50 Hz	21k	OL
0K0258P	13 kVA 50 Hz	31.6k	OL
0K0258Q	EVO 1.0 11 kW	56.2k	OL
0K0258AA	EVO 2.0 11 kW	2.4k	Continuity
0K0258BB	22 kW	365	Continuity
10000033399	16 kW with 816cc	3.2k	Continuity
A0000923647	14 kW with 816cc	4.1k	Continuity
A0000923648	18 kW with 816cc	787	Continuity

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Front Engine Access (2016 and prior models)

Safety

1. Set the controller to OFF.
2. See ***Figure 4-1***. Remove the 7.5 amp main fuse.
3. Remove the N1 and N2 fuses from the transfer switch.

Figure 4-1. Remove 7.5 Amp Fuse

4. Turn off fuel supply to the generator and remove the flex-line from the fuel regulator.
5. Remove Utility power from the generator.
6. Remove the front door.
7. Remove battery from the generator.

Front Engine Access

1. **Remove Controls Cover:** See ***Figure 4-2***. Depending on unit, use a Torx T-27 socket or 5/32" (4 mm) Hex Allen socket to remove screws and ground washer from the controls cover. Remove the controls cover.

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Figure 4-2.

2. **Remove Controller:** See ***Figure 4-3***. Use a 1/4" socket to remove the screw that is directly underneath the support bracket and then slide the controller back to line up the tabs on the controller with the openings on the divider wall.

Figure 4-3. Tabs on Controller

3. **Remove Control Harnesses:** See ***Figure 4-4***. Disconnect all connectors and remove the controller.

Figure 4-4. Controller Connections

4. **Remove Stator Wires:** See *Figure 4-5*. Remove all wires from the main circuit breaker, remove the neutral and ground wires from landing lugs.

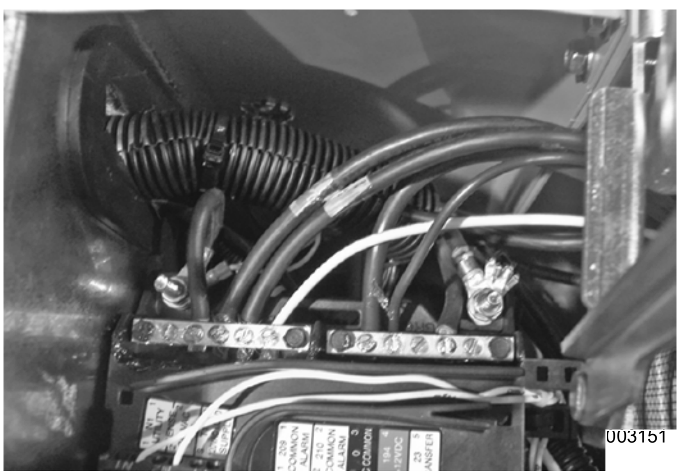

Figure 4-5.

5. **Remove Control Wires:** See *Figure 4-6*. Remove Wires N1, N2, T1, 0, 194, 23, GFCI Outlet, and unit status lights from the control box.

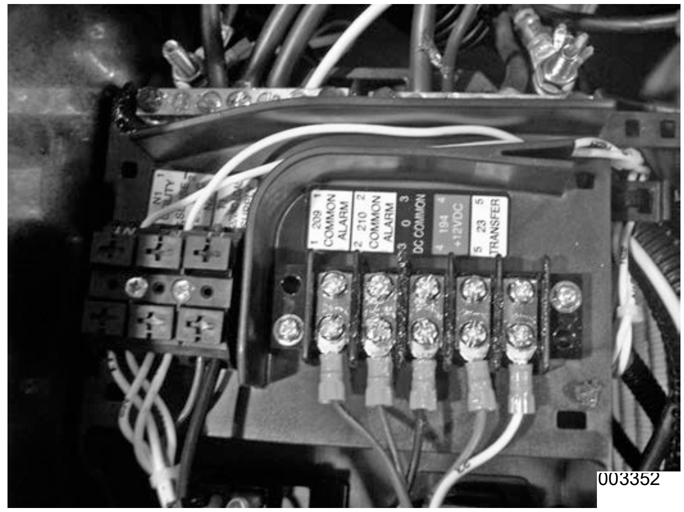

Figure 4-6.

6. **Remove Engine Intake Baffle:** See *Figure 4-7*. Use a 10 mm socket to remove the two bolts from the engine intake baffle. Pull baffle out carefully, there are tabs holding the backside of the baffle to the divider panel.

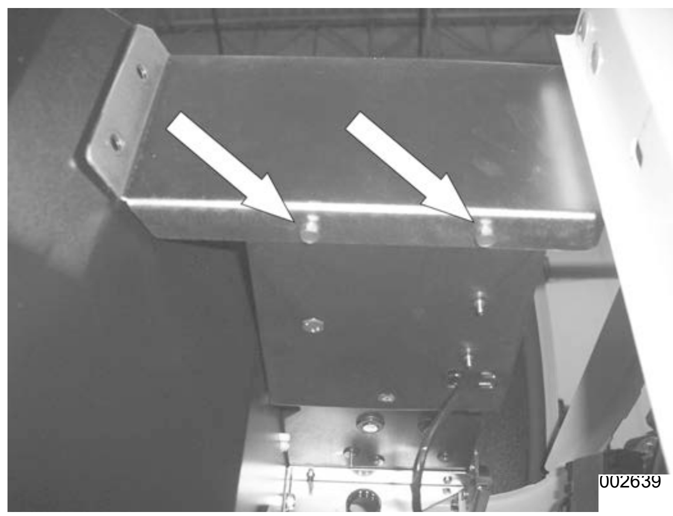

Figure 4-7.

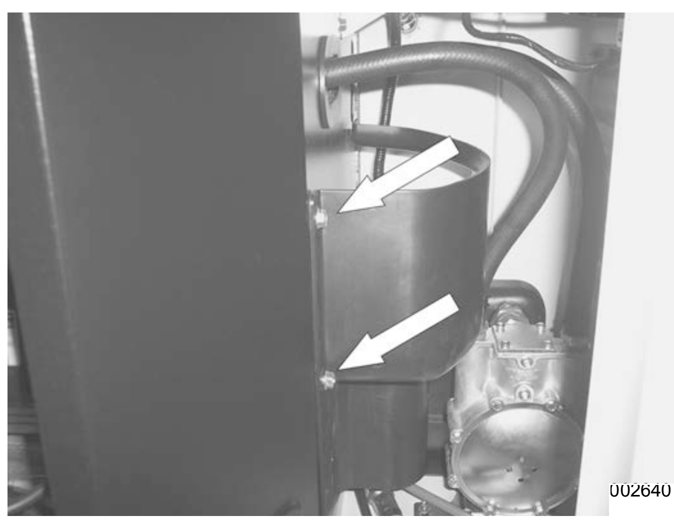

Figure 4-8.

7. **Loosen Side Panel:** See ***Figure 4-7***. Using a 10 mm socket remove the two bolts from the base of the enclosure side panel.
8. **Unbolt Enclosure Side Panel Mounting Bracket:** See ***Figure 4-7***. Using a 10 mm socket remove the two bolts from the enclosure side panel mounting bracket.

Figure 4-9.

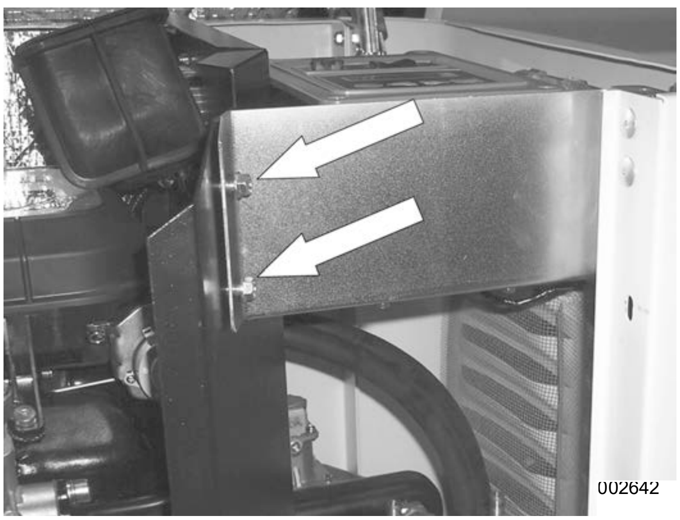

Figure 4-10.

9. **Remove Fuel Regulator:** See ***Figure 4-11***. Remove the two fuel hoses at the top of the regulator. Use a 10 mm socket to remove one 10 mm bolt from the base of the plenum and one 10 mm bolt from the base of the fuel regulator. Flex the enclosure side out to allow for room to remove the regulator assembly.

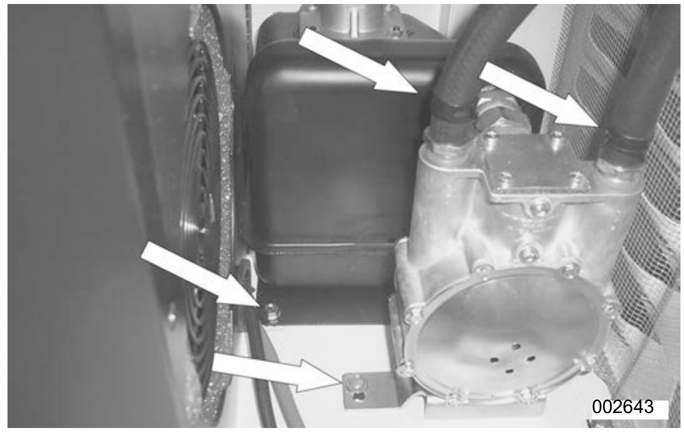

Figure 4-11.

10. **Remove Engine Divider Panel:** See ***Figure 4-12***. Use a 10 mm socket to remove the rear 10 mm bolt from the base of the enclosure. See ***Figure 4-13***. Remove the front 10 mm bolt from the base of the enclosure.

Figure 4-12.

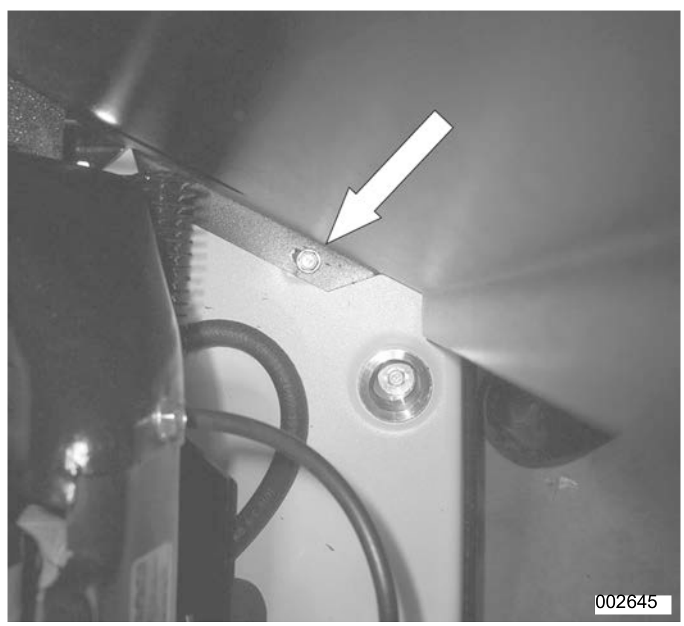

Figure 4-13.

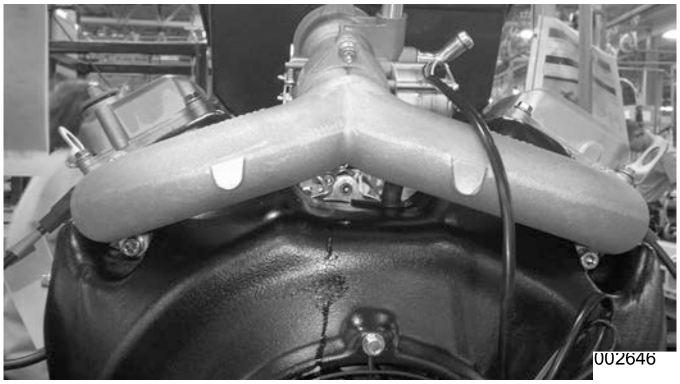

Figure 4-14. Intake Manifold

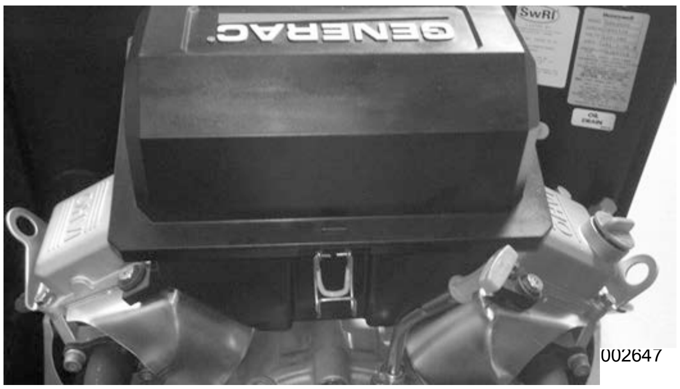

Figure 4-15. Air Box

11. **Unbolt Oil Cooler:** See ***Figure 4-16***. Use a 10 mm socket to remove the two 10 mm bolts from the front of the oil cooler. See ***Figure 4-17***. Remove the two 10 mm bolts from the rear of the oil cooler.

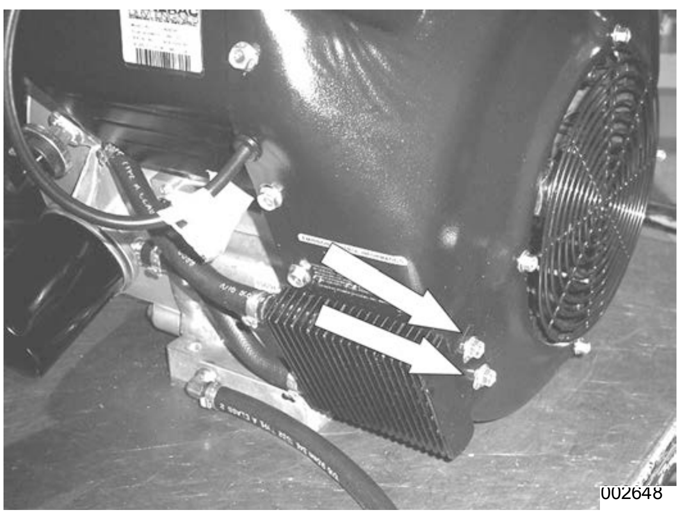

Figure 4-16.

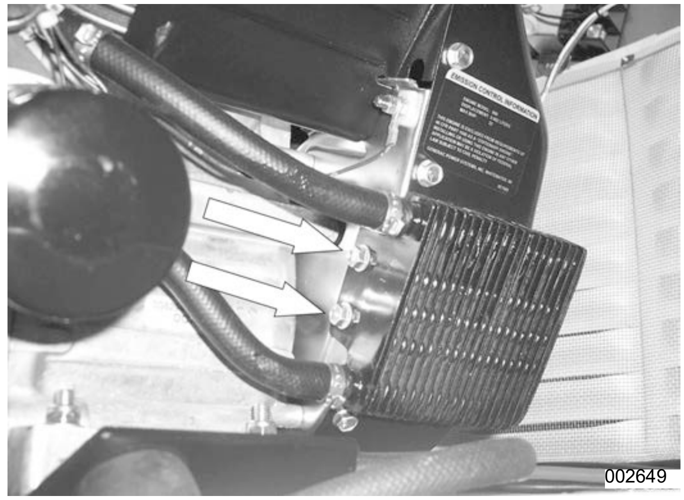

Figure 4-17.

12. **Remove Blower Housing:** See ***Figure 4-18***. Use a 4 mm Allen wrench to remove one button head cap screw from top of blower housing. Use a 10 mm socket to remove one 10 mm bolt from the top of the blower housing.

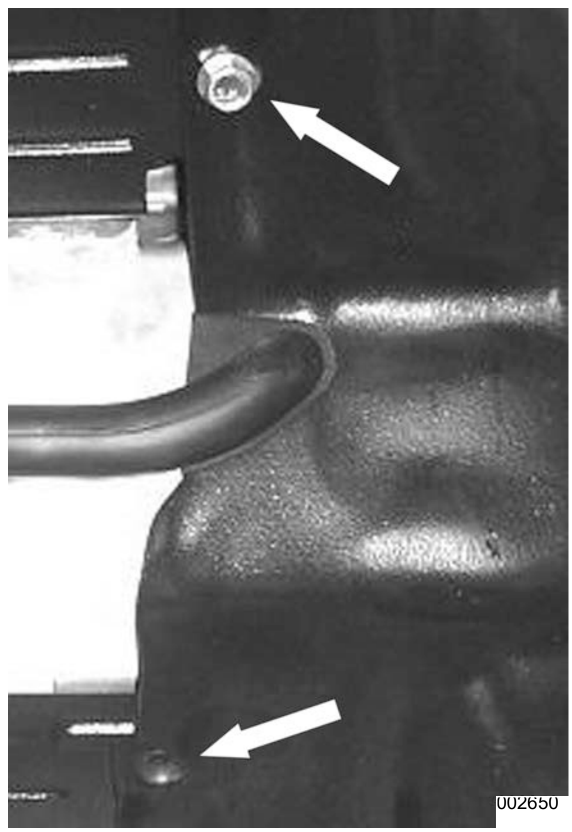

Figure 4-18.

13. See ***Figure 4-19*** and ***Figure 4-20***. Use a 10 mm socket to remove four 10 mm bolts from the right-side of the blower housing, and four 10 mm bolts from the left-side of the blower housing.
14. Remove blower housing.

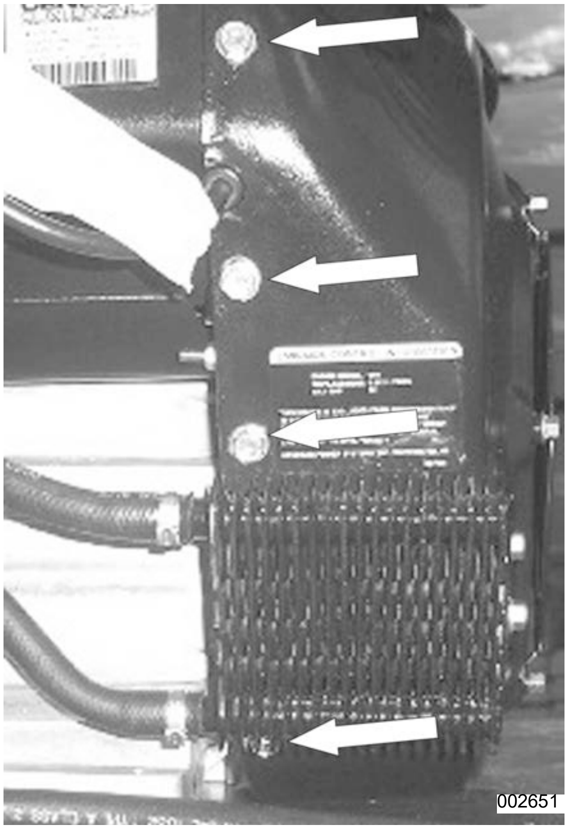

Figure 4-19.

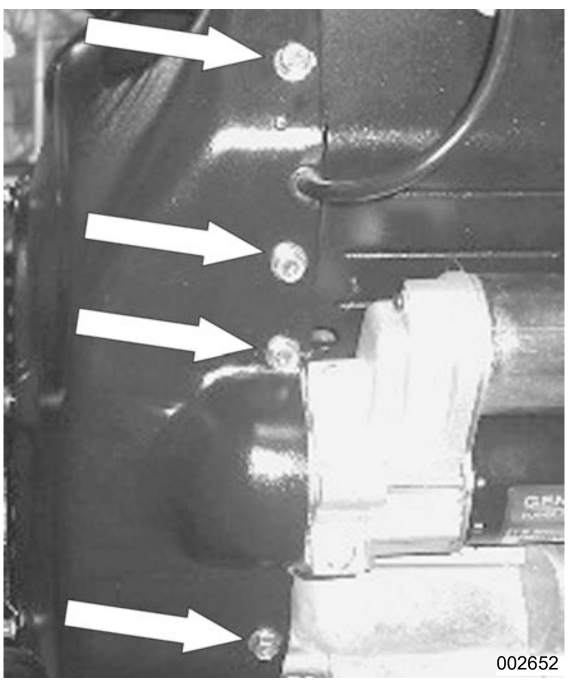

Figure 4-20.

2017 and Newer HSB Front Access

1. Set the controller to OFF.
2. Remove the 7.5 amp main fuse.

Figure 4-21.

3. Remove the N1 and N2 fuses from the transfer switch.
4. Turn off fuel supply to the generator.
5. Remove the front door and the right side access panel
6. Remove battery.

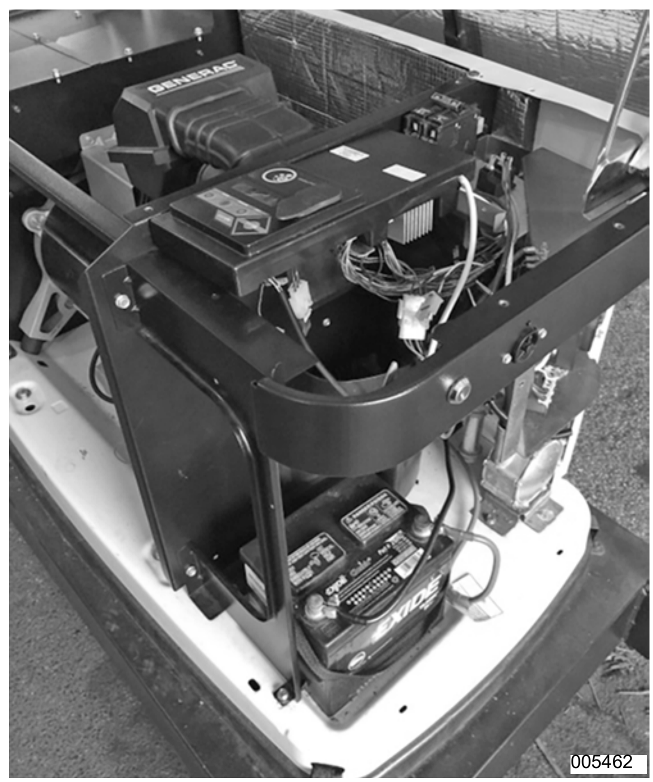

Figure 4-22.

7. **Remove Controls Cover:** Use a 4mm Hex Allen socket to remove the bolts and ground washer from the controls cover.
8. Remove the controls cover.
9. Remove the controller.

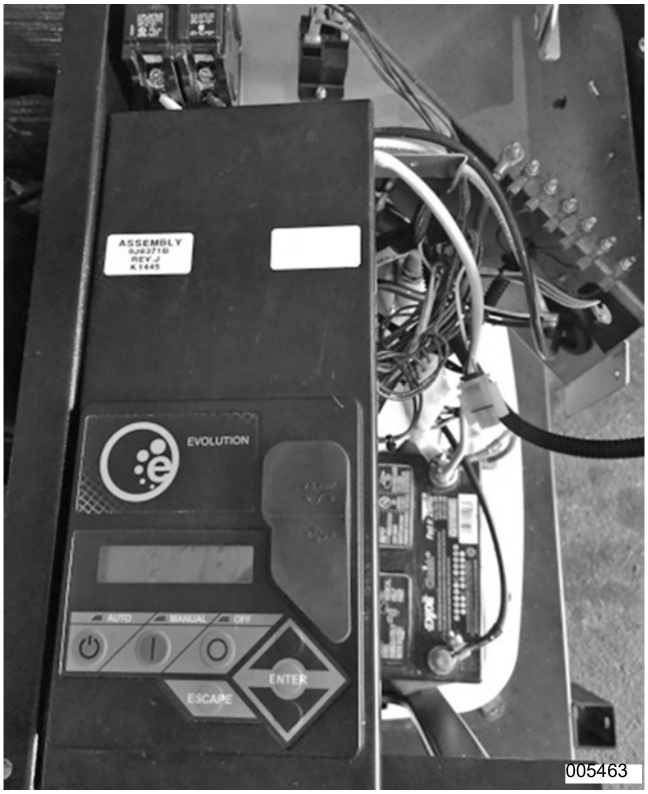

Figure 4-23.

10. Remove control harnesses.
11. Disconnect all connectors and remove the controller.

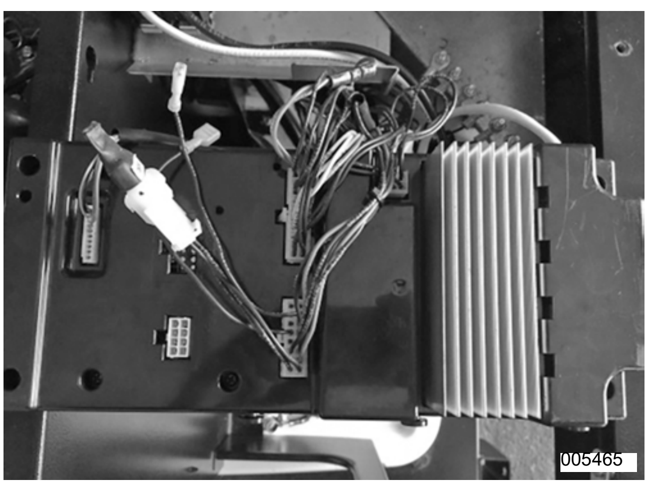

Figure 4-24.

12. Remove right side support panel from divider panel.

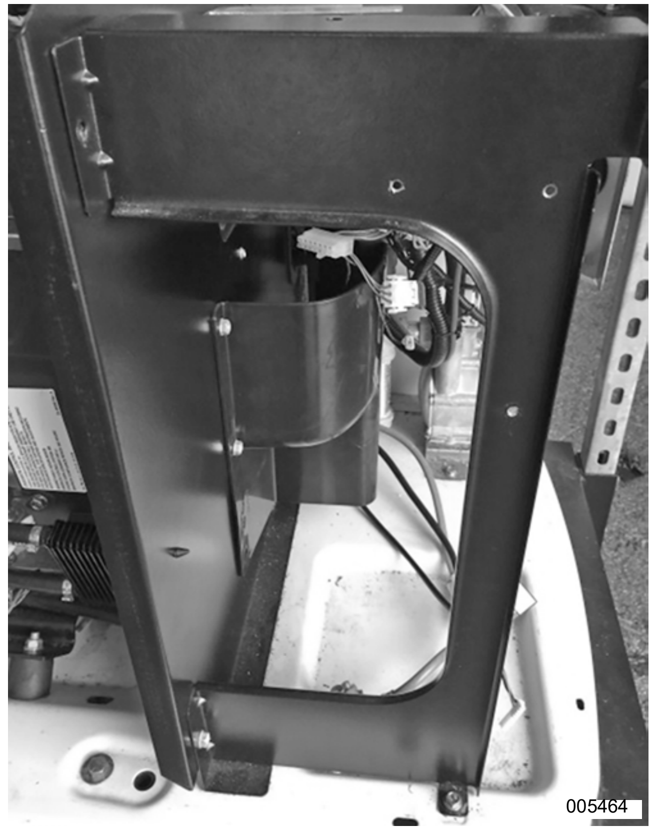

Figure 4-25.

13. Remove engine intake baffle.
14. Use a 10 mm socket to remove the two bolts from the engine intake baffle. Pull baffle out carefully. There are tabs holding the back of the baffle to the divider panel.

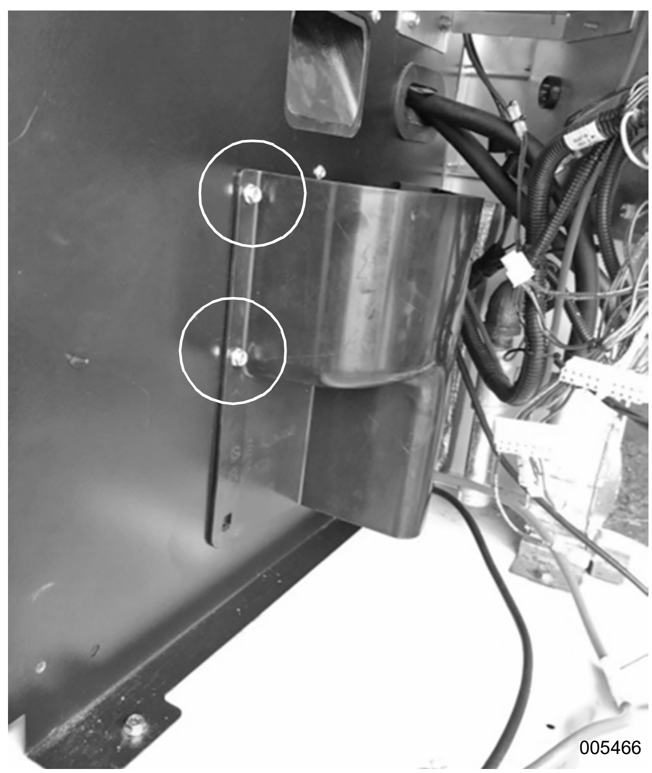

Figure 4-26.

Figure 4-27.

15. Remove circuit breaker mounting plate.

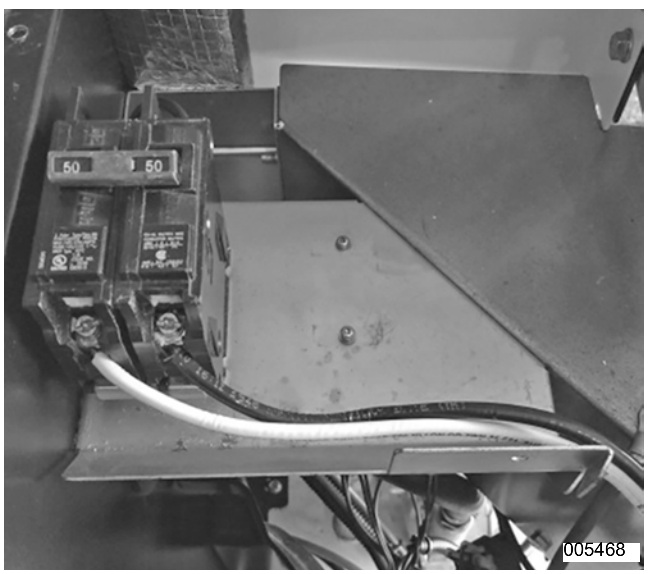

Figure 4-28.

16. Remove cap screw located above the electrical connection pad in the customer connection area.

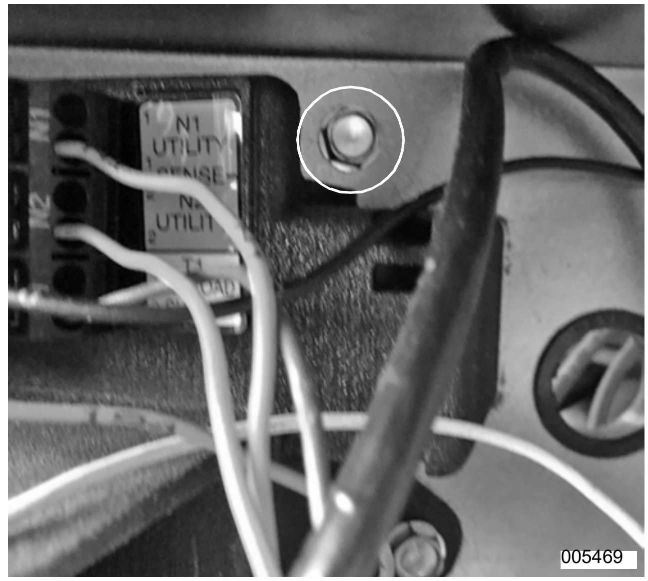

Figure 4-29.

17. Remove the 2 inside cap screws under the breaker tray connecting to the divider panel.

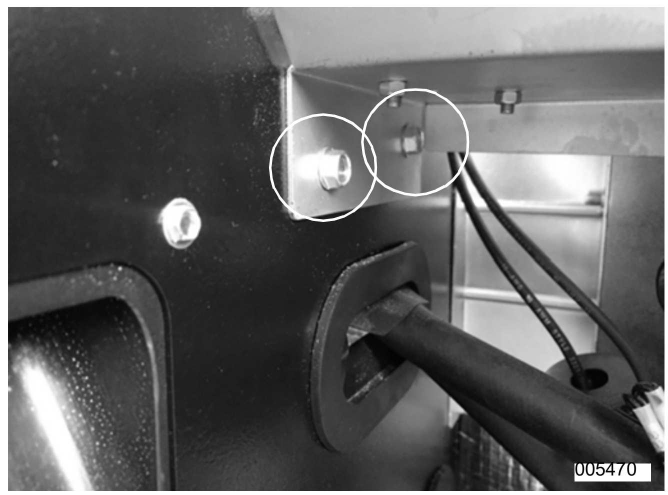

Figure 4-30.

18. Disconnect wires from breaker.

Figure 4-31.

19. Swing breaker with tray out of the way leaving the wires on the outlet side of breaker connected.
20. Remove air cleaner cover and rubber inlet duct.

Figure 4-32.

21. Remove the 2 brass colored mounting screws from the divider panel to the base.

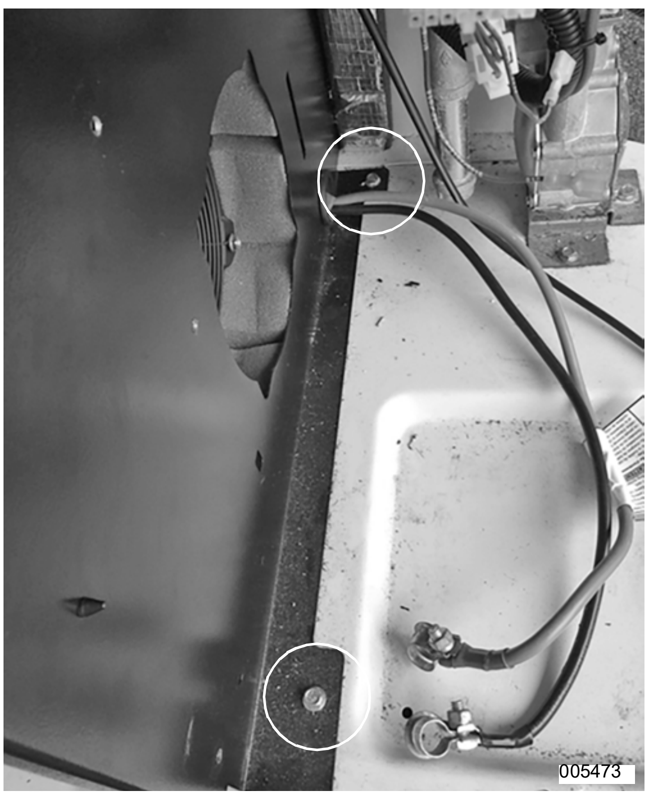

Figure 4-33.

22. Remove two cap screws from the back of the divider panel (located on the engine side).

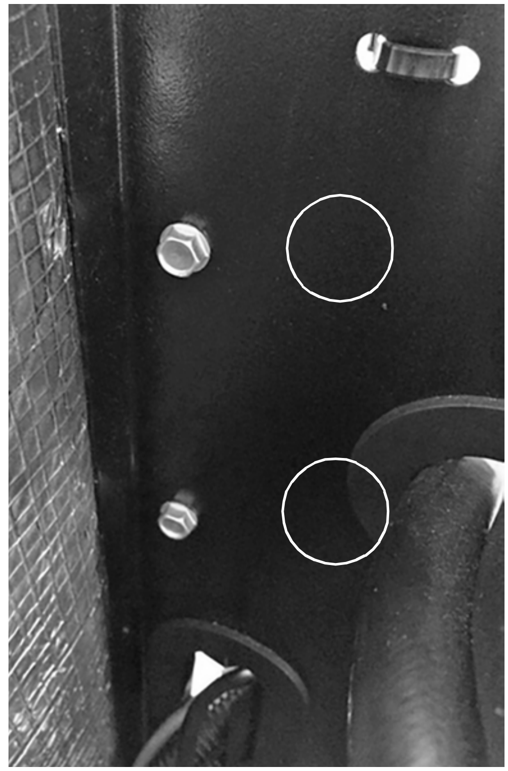

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Figure 4-34.

23. Remove Allen screw back side of divider panel to back panel of generator.

Figure 4-35.

24. Pivot panel out for access to front of engine.

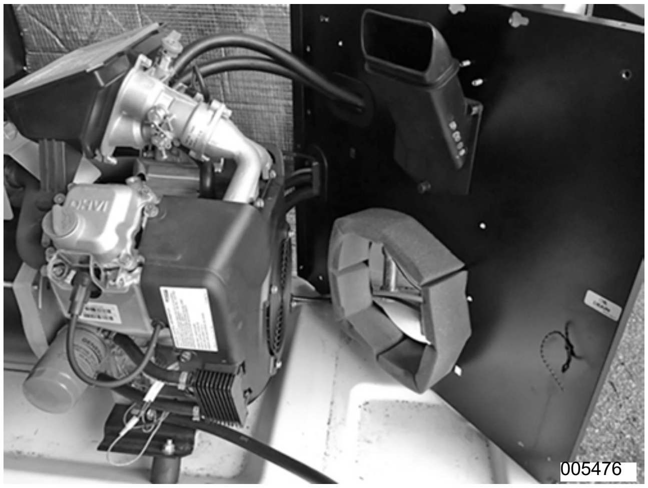

Figure 4-36.

25. Remove the blower housing (front engine cover) per Engine Service manual procedures.

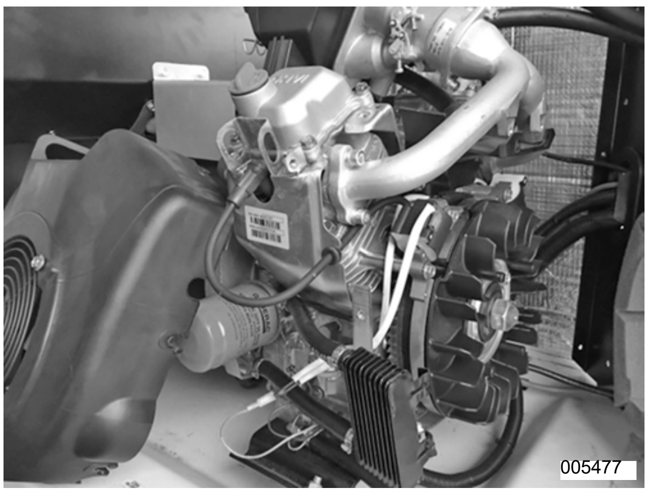

Figure 4-37.

26. Reassemble in reverse order.

Major Disassembly (2016 and prior models)

Safety

1. Set the controller to OFF.
2. See ***Figure 4-38***. Remove the 7.5 amp main fuse.
3. Remove the N1 and N2 fuses from the transfer switch.

Figure 4-38. Remove 7.5 Amp Fuse

4. Turn off fuel supply to the generator and remove the flex-line from the fuel regulator.
5. Remove Utility power from the generator.
6. Remove the front door.
7. Remove battery from the generator.

Stator/Rotor/Engine Removal

1. **Remove Top Exhaust Enclosure Covers:** See ***Figure 4-39***. Use a 10 mm socket to remove the nine bolts from the exhaust top covers. Remove covers.

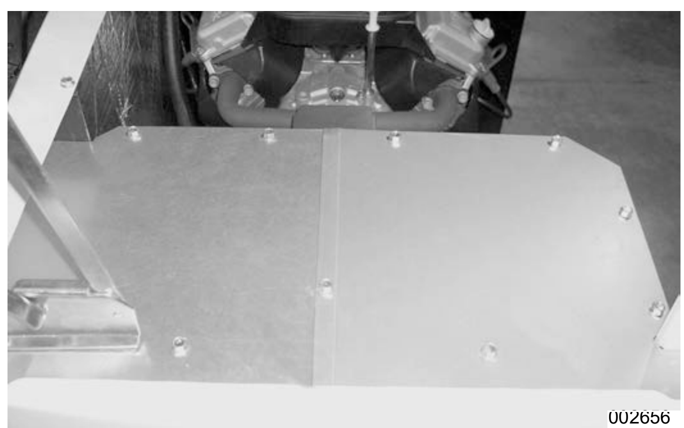

Figure 4-39.

2. **Remove Side Exhaust Enclosure Cover:** See ***Figure 4-40***. Use a 10 mm socket to remove the five bolts from the exhaust side cover. Remove side covers.

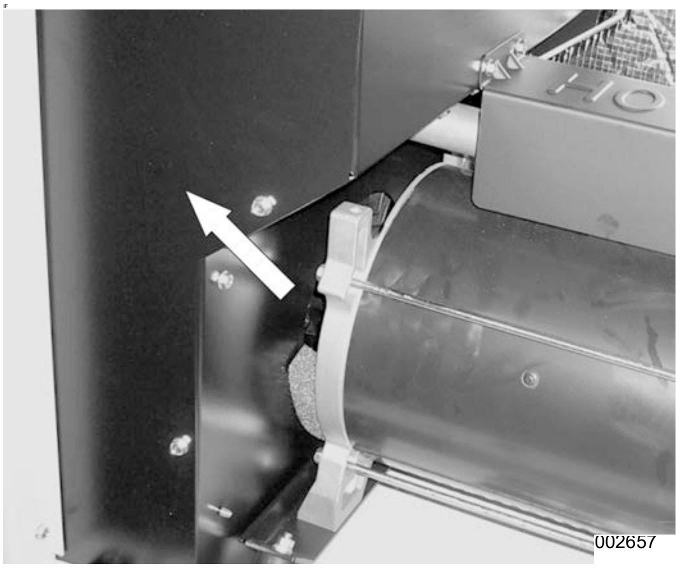

Figure 4-40.

3. **Remove Exhaust Flex Cover:** See ***Figure 4-41***. Use a 10 mm socket to remove the two bolts from the exhaust flex pipe cover. Remove the cover.

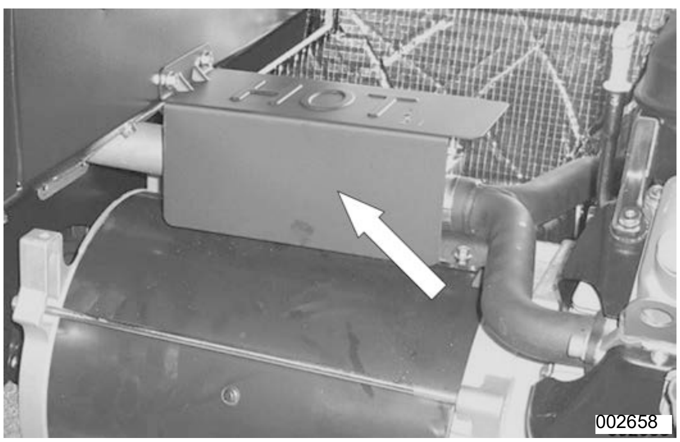

Figure 4-41.

4. **Remove Exhaust Flex Pipe:** See ***Figure 4-42***. Use a ½" socket to remove the front and rear muffler clamp. Slide exhaust flex toward engine to completely expose the muffler flange.

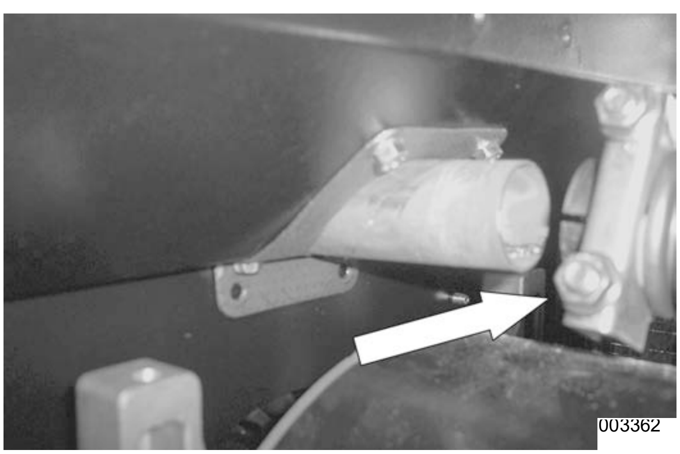

Figure 4-42.

5. **Muffler Assembly:** See ***Figure 4-43***. Depending on the clamp, use a ½" or 10 mm socket to remove the muffler clamp and flex pipe. Leave muffler attached to the divider panel.

Figure 4-43.

6. **Remove Left-side Enclosure:** See ***Figure 4-44***. Use a 10 mm ratchet wrench to remove the horizontal 10 mm bolt that connects the side panel to the back panel.
7. Use a 10 mm socket to remove three bolts from the base of the enclosure.

NOTE: The muffler is shown removed for better view of the bolts.

8. See ***Figure 4-45***. Use a 10 mm socket and wrench to remove the top hinge bolt and loosen the bottom bolt.
9. While holding the roof, remove the bottom hinge bolt.
10. Remove the side panel by sliding it forward then re-install the hinge bolt.

NOTE: The muffler has been removed for better view of the bolts.

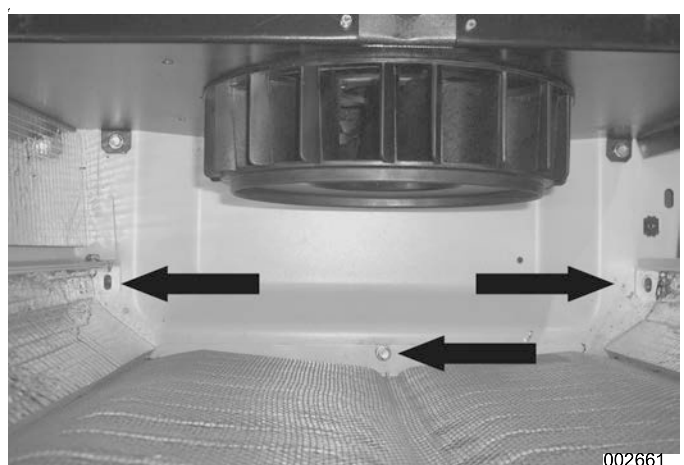

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Figure 4-44.

Figure 4-45.

11. **Remove Fan Housing Cover:** See ***Figure*** . Use a 10 mm socket to remove four bolts from the fan housing cover (if equipped).
12. Remove the fan housing cover.

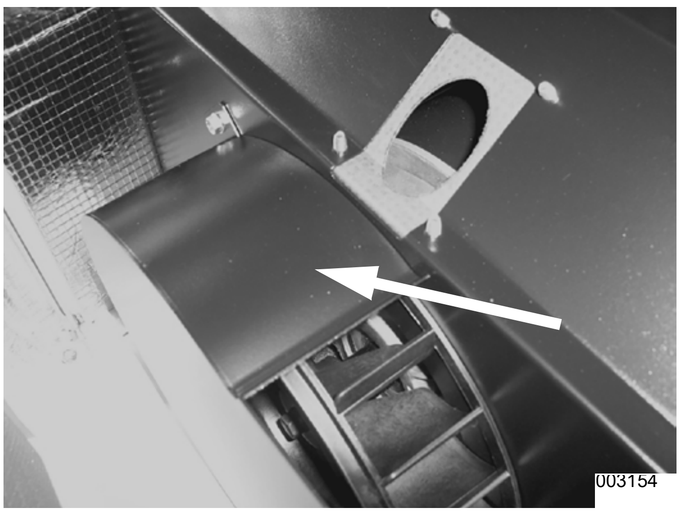

Figure 4-46.

13. **Remove Rotor Bolt:** See ***Figure 4-47***. Use a 9/16" socket to remove rotor bolt.

Figure 4-47.

NOTE: See ***Figure 4-48***. After removing the rotor bolt, install a 12 mm x 1.75 mm cap screw in the end of the rotor shaft. This will be used in conjunction with the puller in the following step.

Figure 4-48.

14. **Remove Rotor Fan:** See ***Figure 4-49***. Attach a vibration dampener or suitable puller to the fan using two M8 x 1.25 bolts.
15. Remove the fan from the rotor.

Figure 4-49.

16. **Remove Alternator Divider Panel:** See ***Figure 4-50***. Depending on the unit, use a 10 mm socket or 4 mm Allen wrench to remove two bottom base bolts.

NOTE: Muffler assembly remains attached to the alternator divider panel during removal.

17. Use a T27 torx driver to remove one top rear bolt.
18. Remove the panel.

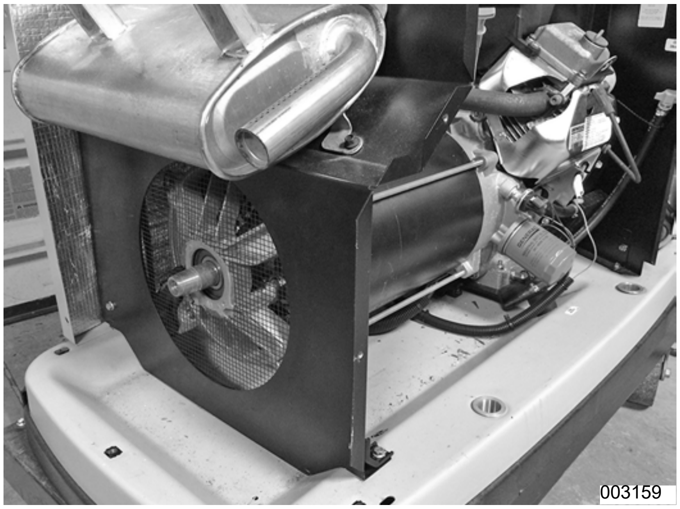

Figure 4-50.

19. **Remove Brushes:** See ***Figure 4-51***. Use a 7 mm socket to remove brushes.

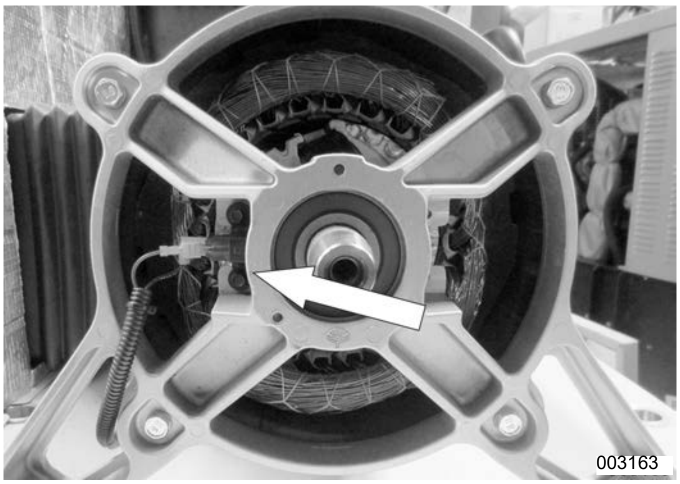

Figure 4-51. Brushes Location

20. **Remove Brush Wires:** See ***Figure 4-52***. Use a side cutters to remove the tie wraps securing the brush wires to the outside of stator.

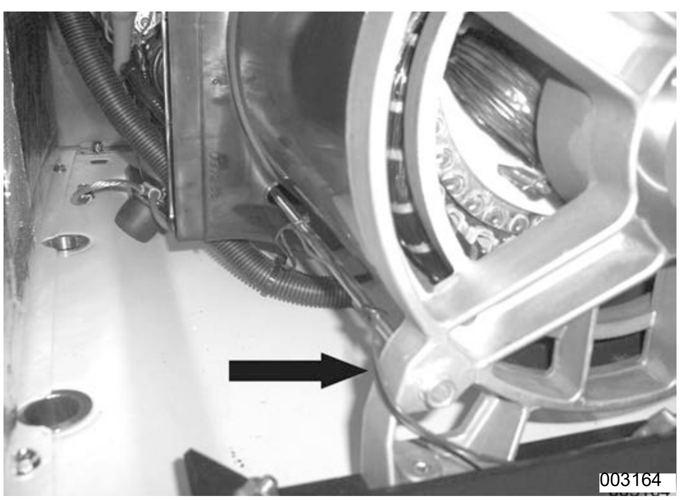

Figure 4-52.

21. **Remove Controls Cover:** See ***Figure 4-53***. Use a Torx T-27 socket or 5/32" Hex Allen socket to remove two bolts and ground washer from the controls cover. Remove the controls cover.
22. **Remove Stator Wires:** See ***Figure 4-53***. Remove all connectors from the controller, remove all wires the common neutral and ground wires from landing lugs, and remove wires from main beakers.

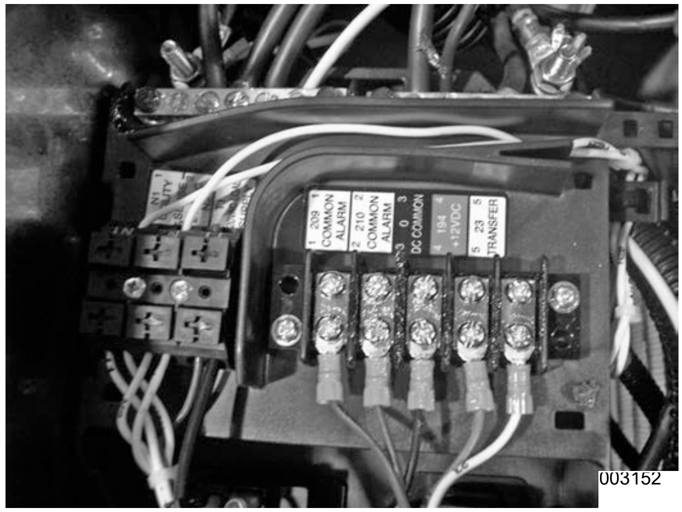

Figure 4-53.

23. **Alternator Air Intake Bellows Removal:** See ***Figure 4-54***. Remove alternator intake bellows.

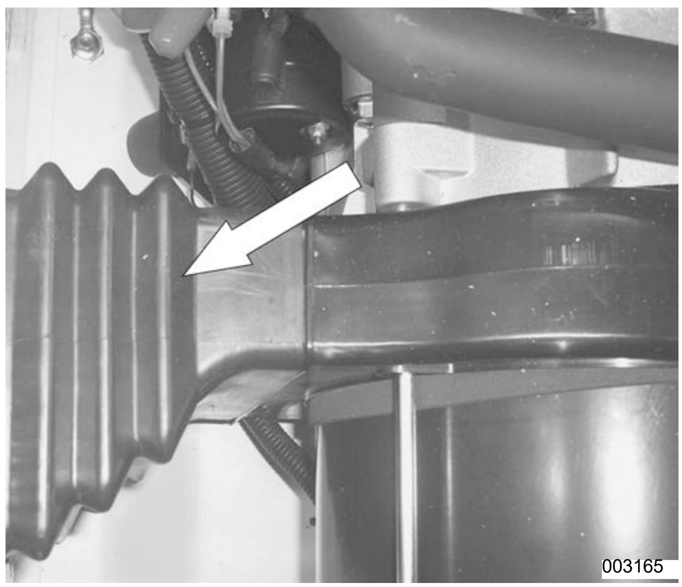

Figure 4-54.

24. **Rear Bearing Carrier Removal:** See ***Figure 4-55***. Use a 13 mm socket to remove the two nuts from the alternator mounting bracket rubber mounts.

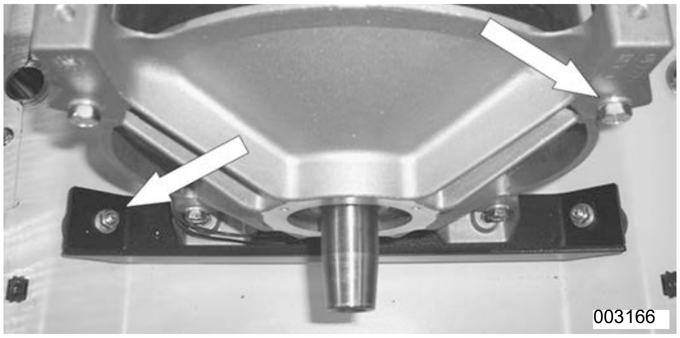

Figure 4-55.

25. See ***Figure 4-57***. Lift the back end of the alternator up and place a 2”x 4” piece of wood under the engine*.

NOTE: *See ***Figure 4-56***. On Evolution product there is a center engine mount and clamping screw. This clamping screw must be loosened before lifting the alternator up to set the wood block in place.

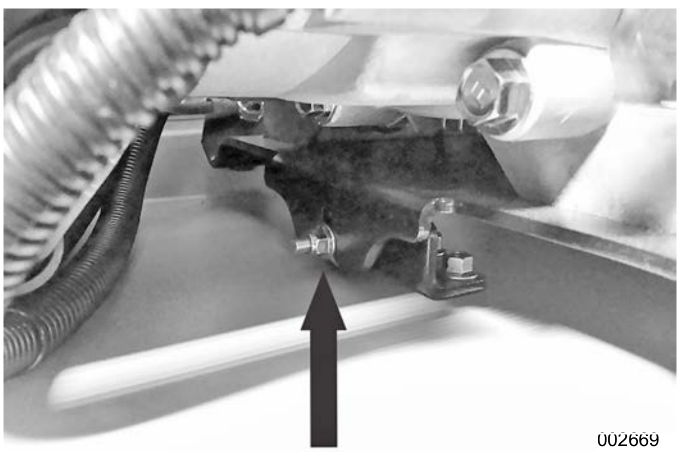

Figure 4-56.

26. Use a 13 mm socket to remove the four stator hold down bolts.
27. Use a small rubber mallet to remove the rear bearing carrier.

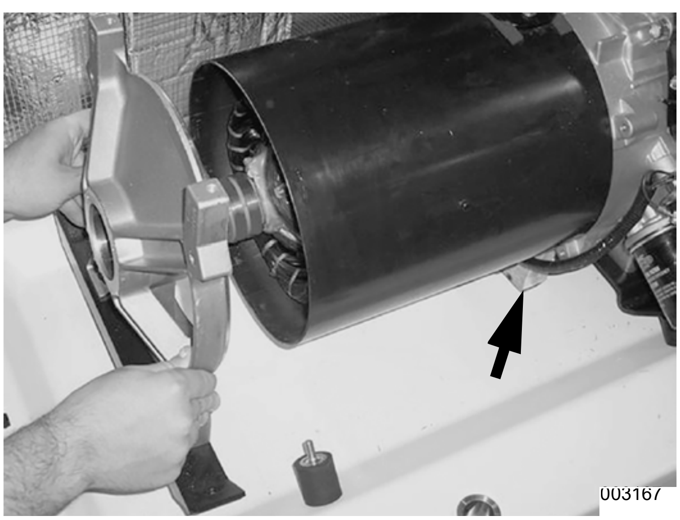

Figure 4-57.

28. See ***Figure 4-58***. Remove stator.

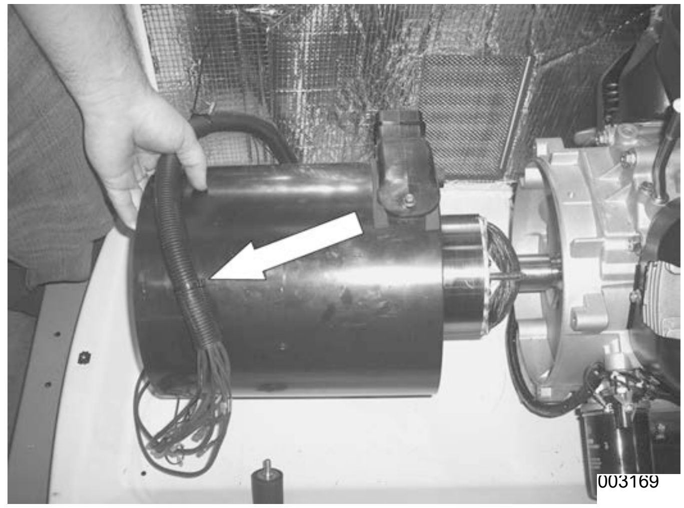

Figure 4-58.

29. **Rotor Removal:**

NOTE: Each model uses a specific rotor bolt. Verify the correct bolt is being used for the rotor being serviced.

a. Cut 0.5 inches from the rotor bolt. Slot the end of the bolt to suit a flat blade screwdriver.
b. Slide the rotor bolt back through the rotor and use a screwdriver to screw it into the crankshaft. Be sure to thread in a minimum of 3/8” to ensure enough threads for puller cap screw.
c. Screw a 3” M12x1.75 cap screw into rotor.
d. Apply torque to the 3” M12x1.75 cap screw until taper breaks free from crankshaft.

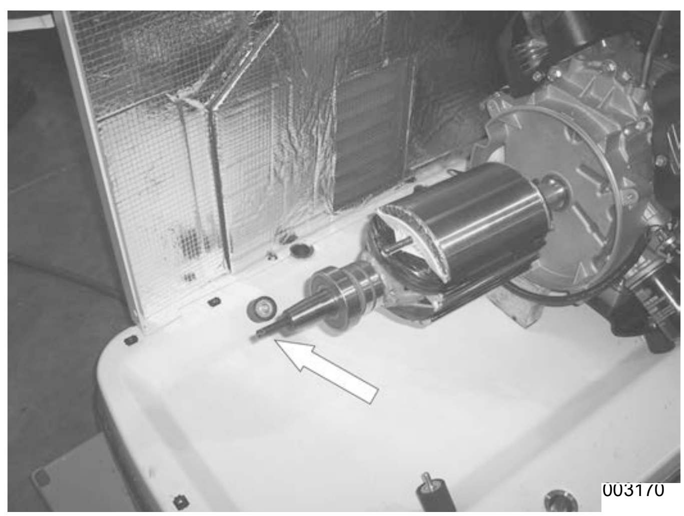

Figure 4-59.

30. **Remove Engine:** See ***Figure*** . Using a 13 mm socket, remove the two engine mount nuts with ground wires.

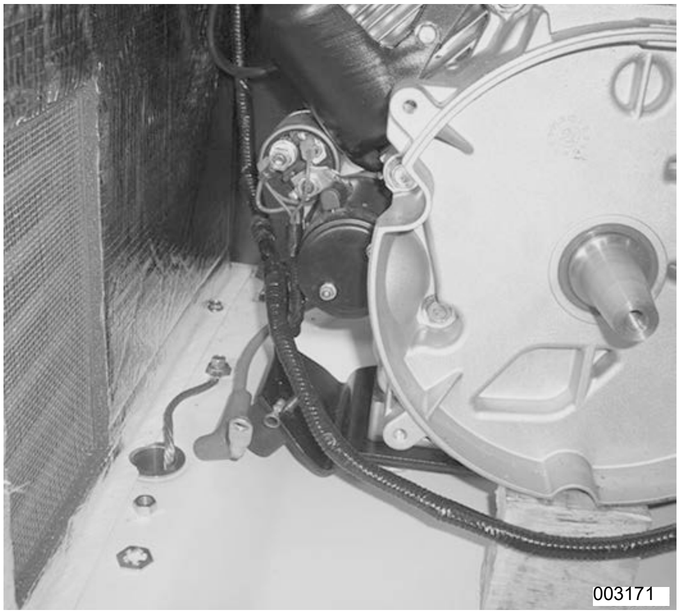

Figure 4-60.

31. See ***Figure 4-61***. Using proper lifting equipment remove the engine.

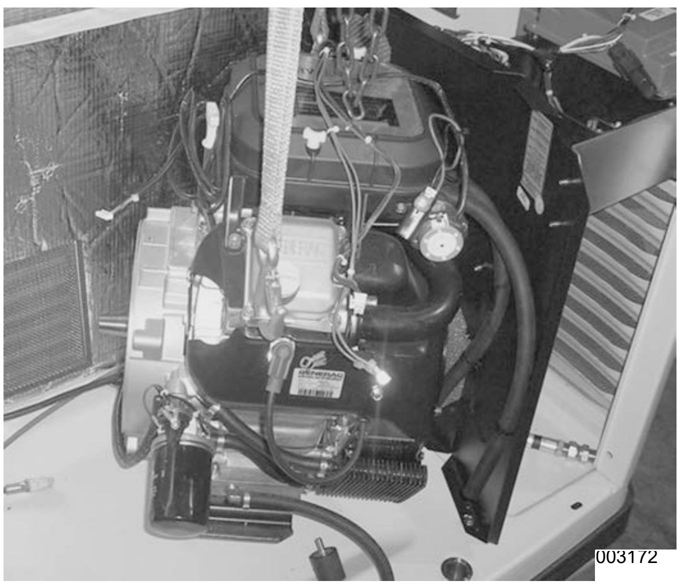

Figure 4-61.

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 values are dynamic, with ±10% tolerance unless otherwise noted.

Major Disassembly(2017 and newer models)

Safety

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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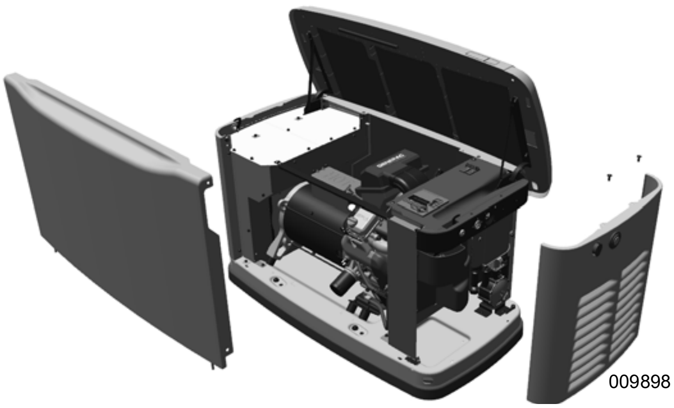


Figure 4-62.

1. Lift the hood.
2. Remove front door.
3. Remove right side panel.

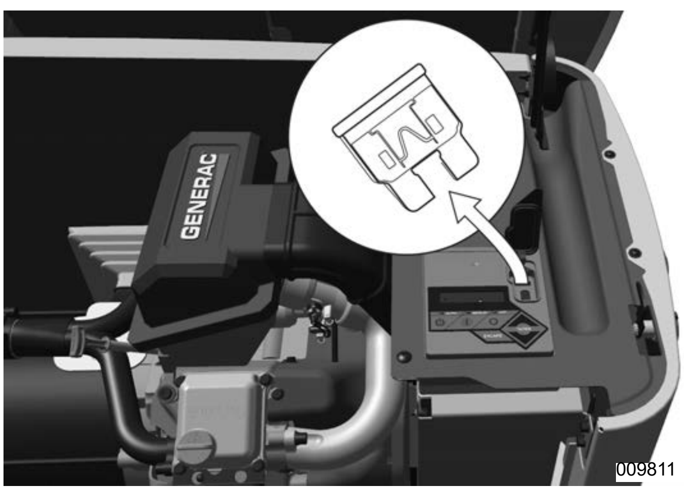


Figure 4-63.

4. Set the controller to OFF.
5. Remove 7.5 amp main fuse.
6. Remove N1 and N2 fuses from the transfer switch.
7. Remove T1/T2 fuse(s) to disable battery charging.
8. Turn off fuel supply to generator.
9. Disconnect negative battery cable from battery.

Stator and Rotor Removal

Required Tools

- Stator holding adapters (PN 0K8824)
- Rotor protector sheet (PN 0K8210)
- Vibration dampener puller
- 3 inch M12x1.75 Bolt
- Standard mechanics tool set
- Rubber mallet or dead-blow hammer
- Torque wrenches (Inch lbs and Foot lbs)
- 3 or 4 small 2”x4” blocks of wood.

Removing Center Support

Figure 4-64.

10. Use a 10 mm socket to remove two (2) bolts from the center support.

Removing Top Exhaust Enclosure Covers

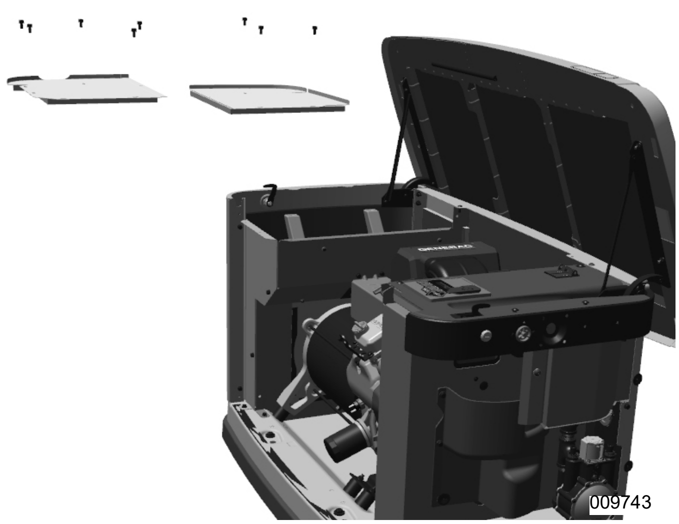


Figure 4-65.

1. Use a 10 mm socket to remove nine (9) bolts from the exhaust top covers.
2. Remove covers.

Removing Side Exhaust Enclosure Cover

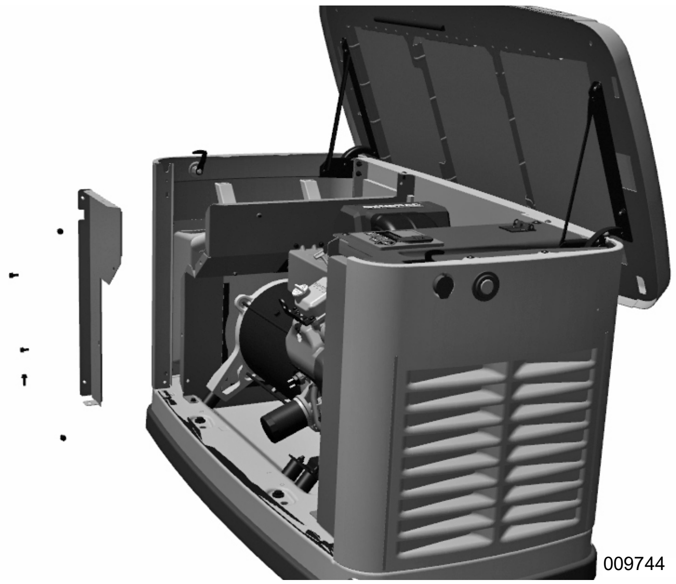


Figure 4-66.

1. Use a 10 mm socket to remove five (5) bolts from the exhaust side cover.
2. Remove exhaust side cover.

Removing Exhaust Flex Cover

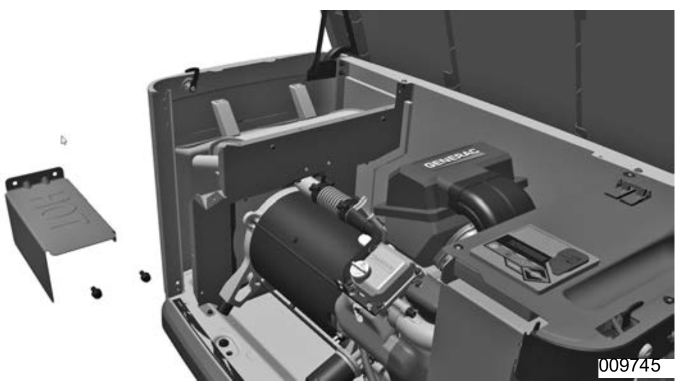


Figure 4-67.

1. Use a 10 mm socket to remove two bolts from the exhaust flex pipe cover.
2. Remove the cover.

Loosening Exhaust Flex Pipe

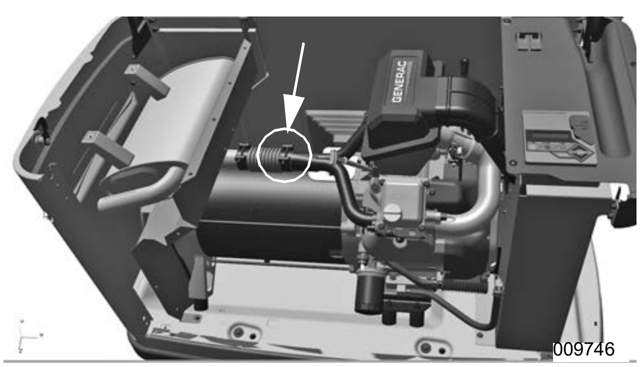


Figure 4-68.

1. Use a 10mm socket to loosen the right side muffler clamp.

NOTE: Exhaust flex will be removed with the muffler, resonator and divider panel as a complete assembly.

Removing Left-side Enclosure

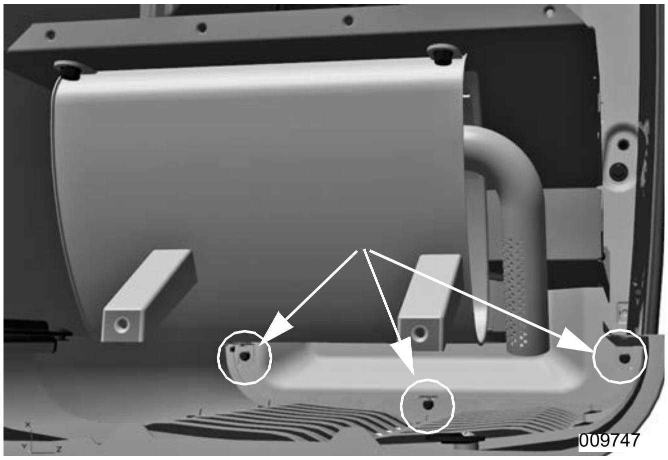


Figure 4-69. Three bolts at base of enclosure

1. Locate three (3) bolts at the base of left side enclosure.

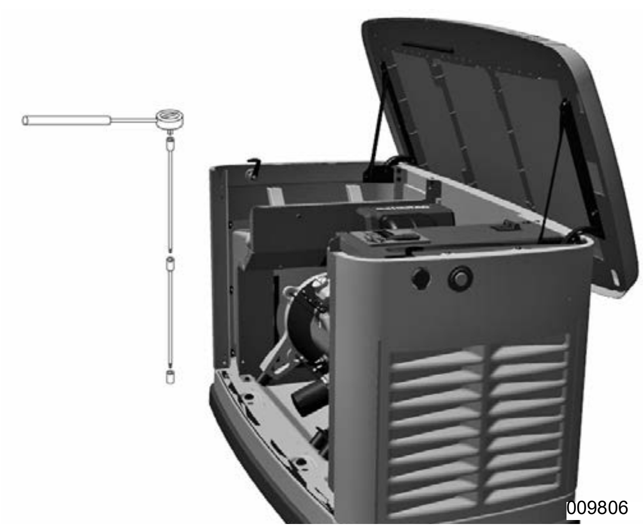


Figure 4-70.

2. Use a 10mm socket with a long extension to remove three bolts from the base of the enclosure.

NOTE: Procedure may require more than one socket extender.

Figure 4-71.

3. Use a 10 mm socket and wrench to remove the top hinge bolt and loosen the bottom bolt.
4. While supporting the roof, remove the bottom hinge bolt.
5. Remove the side panel by tipping it out.

NOTE: Continue supporting roof.

Figure 4-72.

6. Insert one of the hinge bolts through the hinge and through the back cover to support the roof in place.

Removing Rotor Bolt

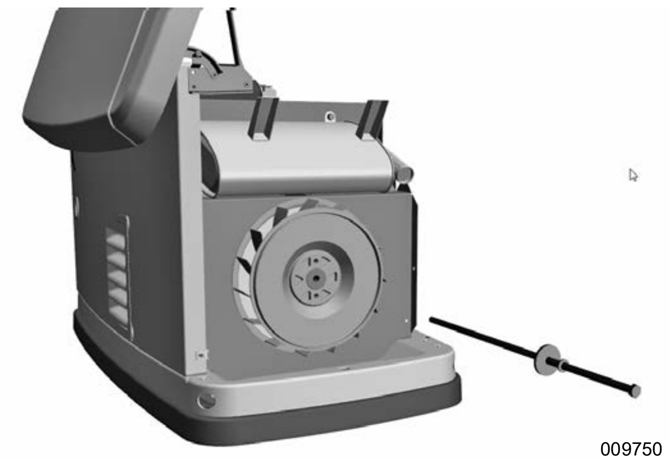


Figure 4-73.

1. Use a 9/16” socket to remove rotor bolt.

Removing Fan

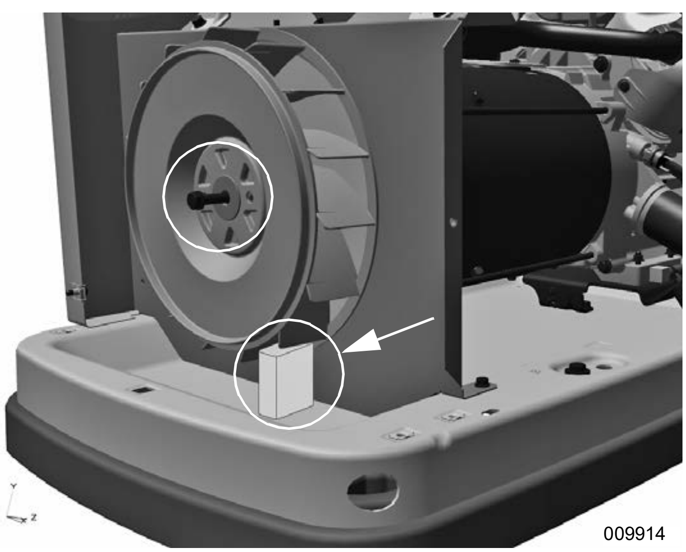


Figure 4-74.

1. Thread a 3 inch M12 x 1.75 bolt into rotor end, leaving about 1/2” of thread exposed in preparation for next step.

NOTE: Wedge a 2”x4” block of wood between base and fan blade to hold fan stationary.

Figure 4-75.

2. Attach a vibration dampener puller or suitable alternative puller to the fan using two M8 x 1.25 bolts.

NOTE: Thread the puller bolts at least ½” into the fan.

3. Tighten the central puller shaft with a wrench to loosen the fan from the rotor shaft.

Figure 4-76.

4. Remove the fan from the rotor.

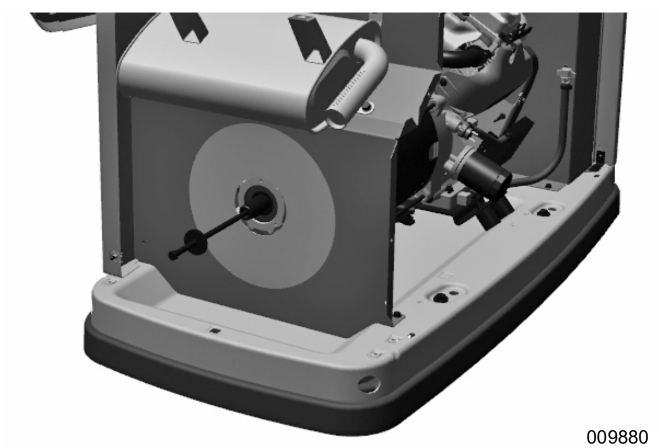


Figure 4-77.

5. Re-install the long rotor bolt with washer and tighten finger tight.

Removing Alternator Divider Panel

Figure 4-78.

1. Use a 10 mm socket wrench to remove two bottom base bolts.
2. Use a 4mm Allen wrench to remove one top rear bolt.
3. Remove the panel with muffler and flex pipe still attached.

NOTE: Muffler and flex pipe remain attached to alternator divider panel during removal.

Removing Brushes

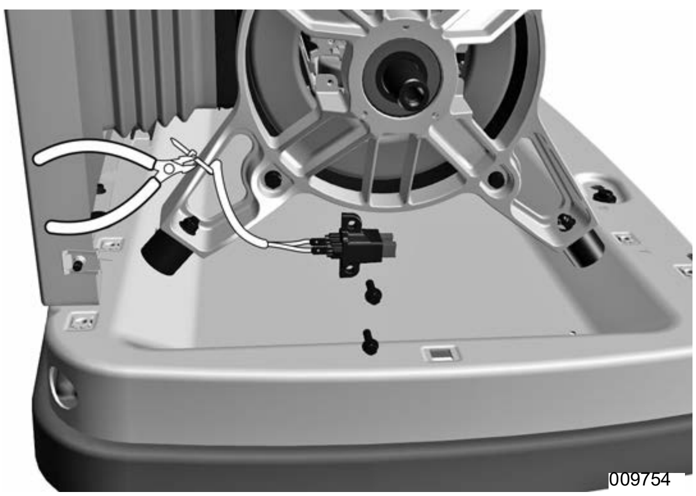


Figure 4-79.

1. Use a 7mm socket to remove brush assembly with brush wires attached.
2. Use wire cutters to remove any tie wraps securing brush wire harness to the outside of the stator.
3. Set brushes and wire harness assembly aside to a safe place.

Loosening Engine Mount

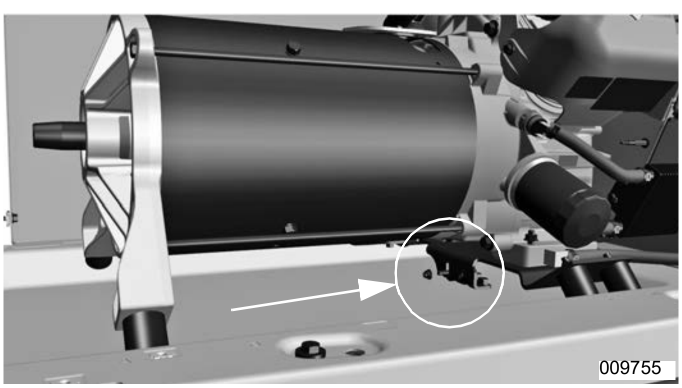


Figure 4-80.

1. Loosen the engine mount located underneath the engine near where the alternator and engine are joined.

NOTE: The engine mount must be loosened before lifting the alternator.

Removing Rear Bearing Carrier

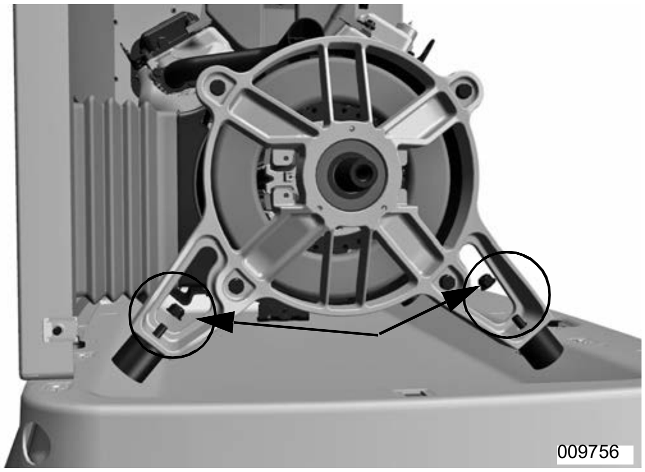


Figure 4-81.

1. Use a 13mm socket to remove the nuts from the two bearing carrier lower mounting bracket rubber mounts.

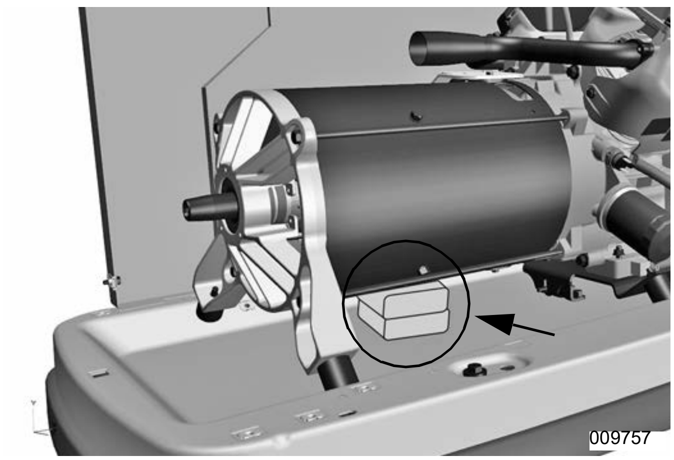


Figure 4-82.

2. Lift the back end of the alternator up and place a 2" x 4" piece of wood under the stator. Use additional blocks of wood if needed.

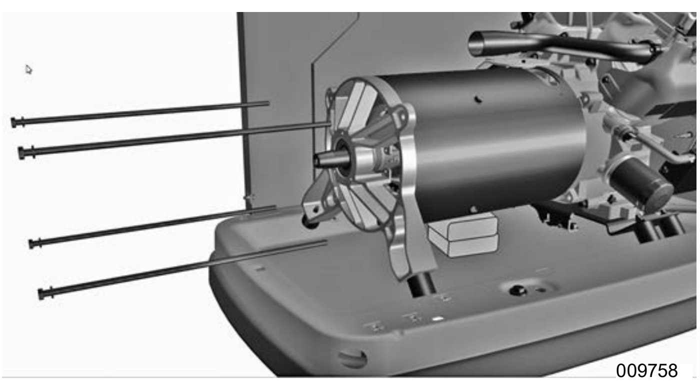


Figure 4-83.

3. Use a 13 mm socket to remove the four (4) stator bolts.

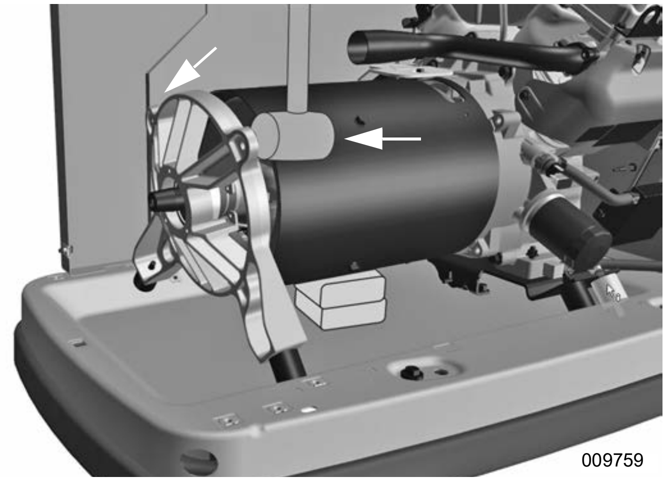


Figure 4-84.

4. Use a small rubber mallet or suitable dead-blow hammer to remove the rear bearing carrier.

NOTE: Use short deliberate blows and alternate tapping between the upper lobes of the bearing carrier until it is free from the alternator can and rotor shaft bearing.

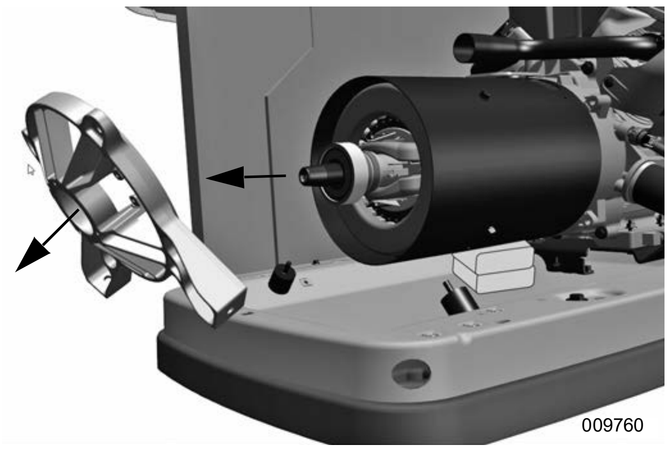


Figure 4-85.

Installing Stator Holding Tool

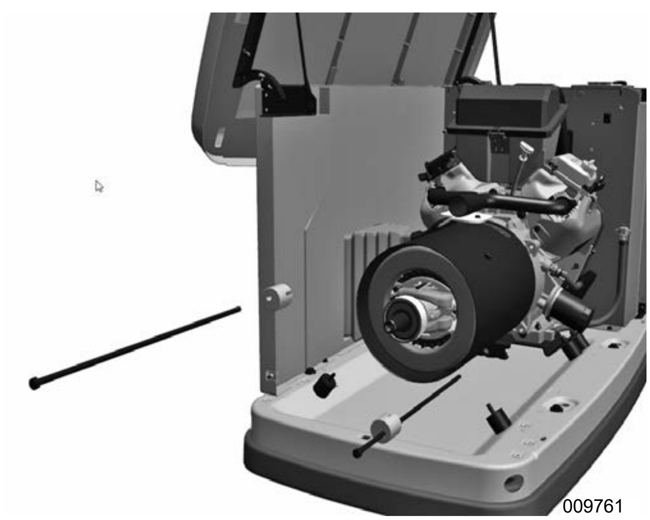


Figure 4-86.

5. Insert two previously removed stator bolts into the two stator holding adapters (P/N 0K8824).

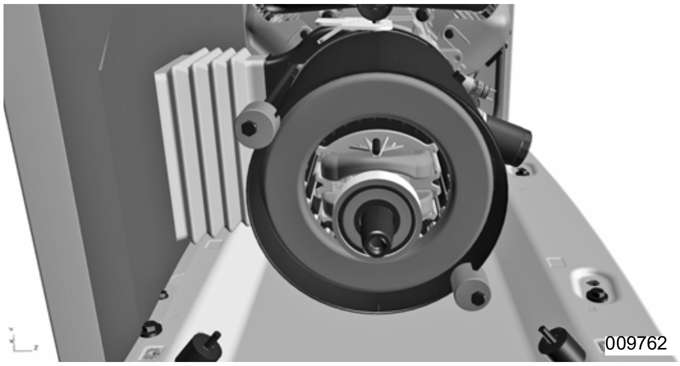


Figure 4-87.

6. 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.

NOTE: DO NOT OVER TIGHTEN.

Separating Rotor

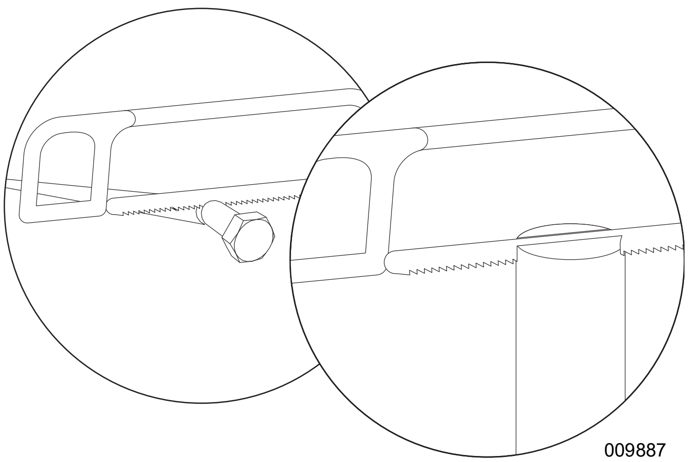


Figure 4-88.

1. Remove rotor bolt and cut 1.25 in (38.1 mm) from head of bolt, leaving bolt 16.25 in (41.28 cm) length.
2. Use a hacksaw or suitable cutting wheel to cut a slot in the cut end of the rotor bolt.

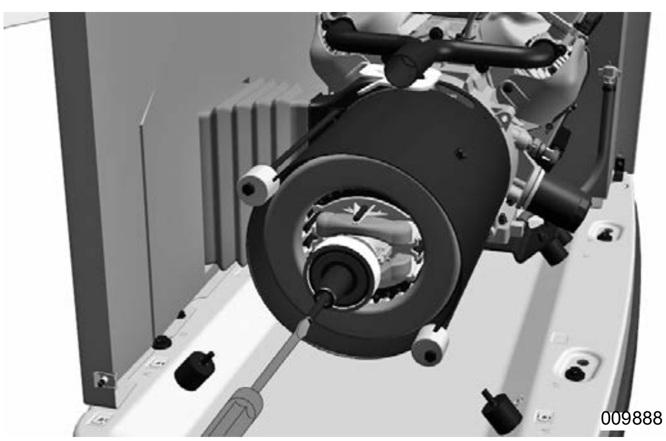


Figure 4-89.

3. Thread the cut rotor bolt into the crankshaft, allowing about an inch of threads exposed for the following steps.

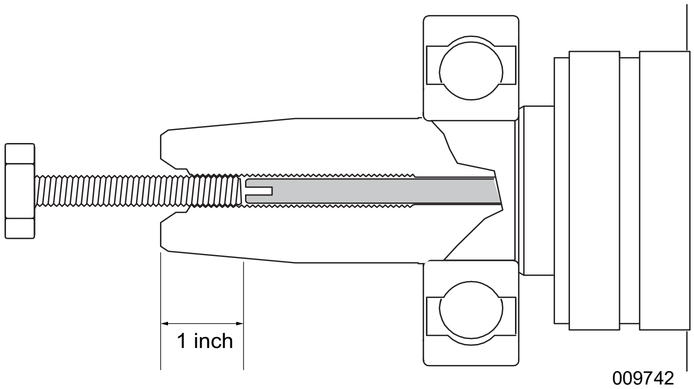


Figure 4-90.

4. Screw a 3" M12 x 1.75 bolt (PN 0H48930203) into rotor end.

Rotor Removal Protection

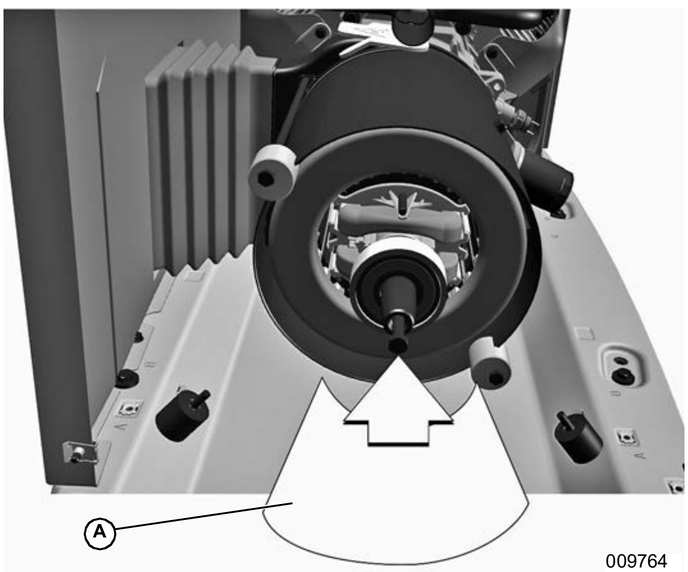


Figure 4-91.

5. Insert the rotor protector sheet (A) (PN 0K8210) between the rotor and stator assembly.

Removing Rotor

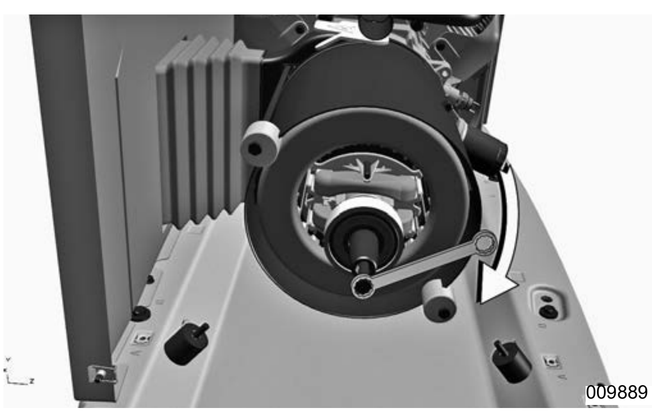


Figure 4-92.

1. Apply torque to the 3" M12 x 1.75 bolt until rotor breaks free from the tapered engine crankshaft.

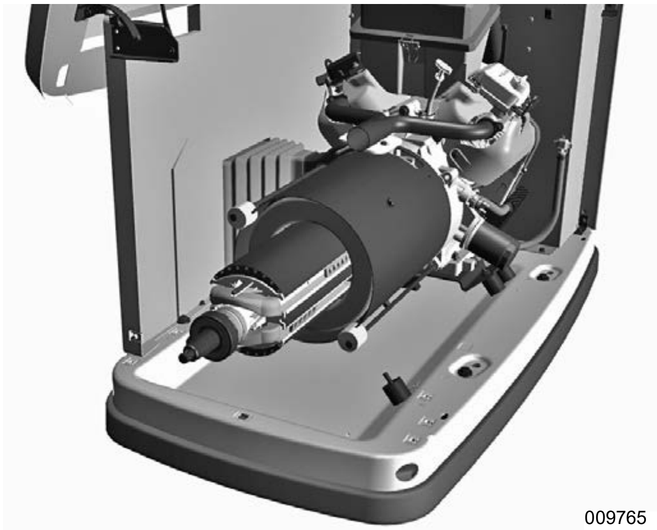


Figure 4-93.

2. Carefully slide rotor (on protective sheet) out of the stator can. Place the rotor in a safe area to prevent any damage.
3. Remove the modified rotor bolt from the crankshaft.

Removing Stator Wires (Units without STB Terminal Block)

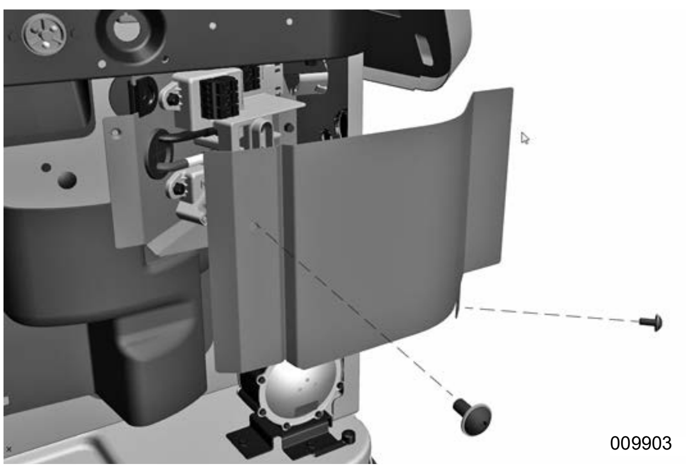


Figure 4-94.

1. Loosen two (2) screws and remove customer connection access panel.

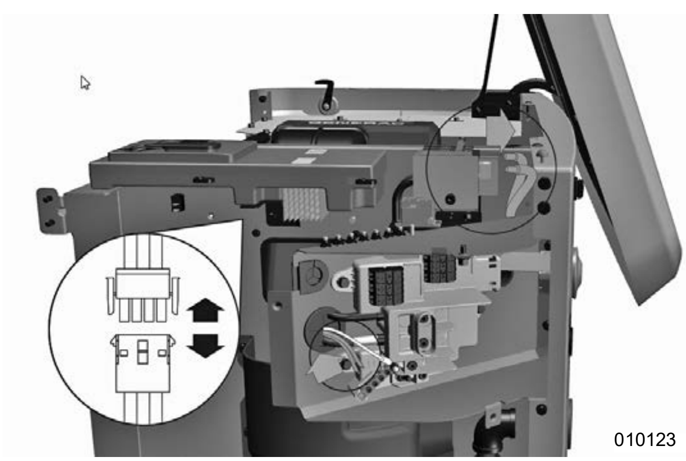


Figure 4-95.

2. Remove Wire 11 and Wire 44 from MLCB (A).
3. Remove Wire 22 and Wire 33 (B) from the terminal strip.
4. Disconnect STR connector (C).

Removing Stator Wires (Units with STB Terminal Block)

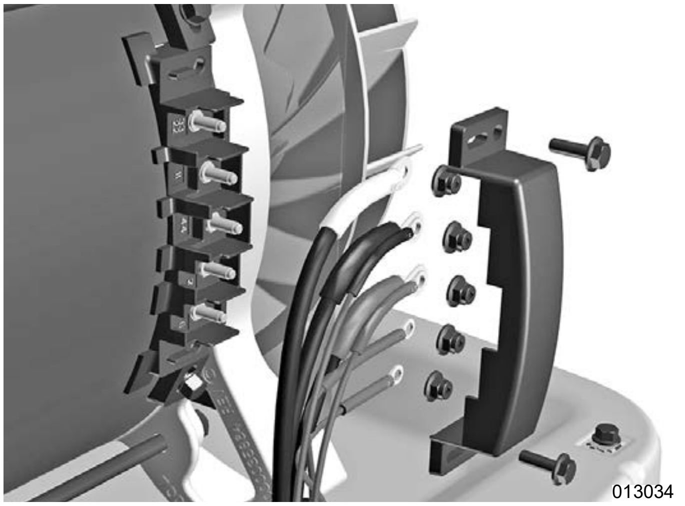


Figure 4-96.

1. Remove all wires from STB terminal Block

Alternator Air Intake

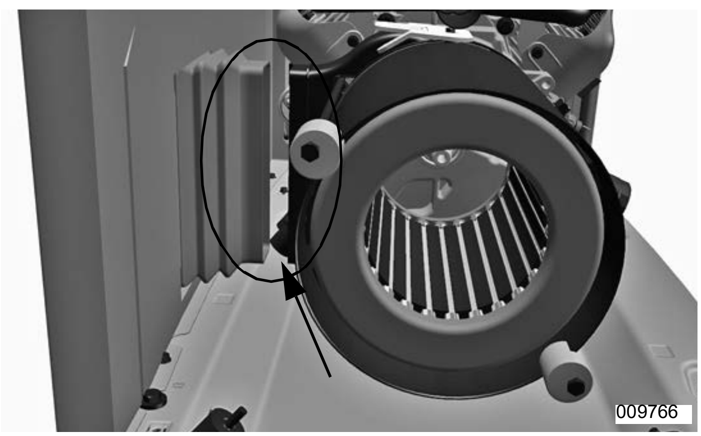


Figure 4-97.

1. Disconnect alternator intake bellows.

NOTE: Leave the molded duct attached to the stator can in place.

Removing Stator

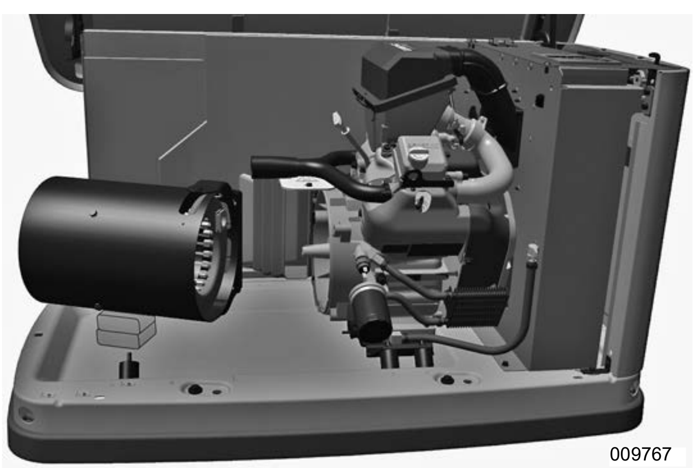


Figure 4-98.

1. Use short 2" x 4" pieces of wood to support the stator.
2. Remove the two stator bolts and holding adapters.
3. Separate the stator from the engine.

Engine Removal

Removing Air Filter And Air Box Cover

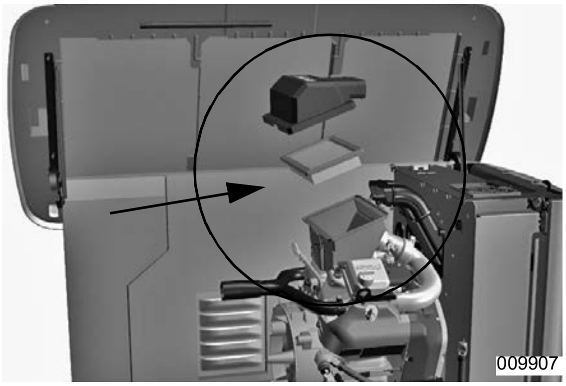


Figure 4-99.

1. Remove air box cover and air filter.

Disconnecting All Wires, Harnesses, and Hoses From Engine

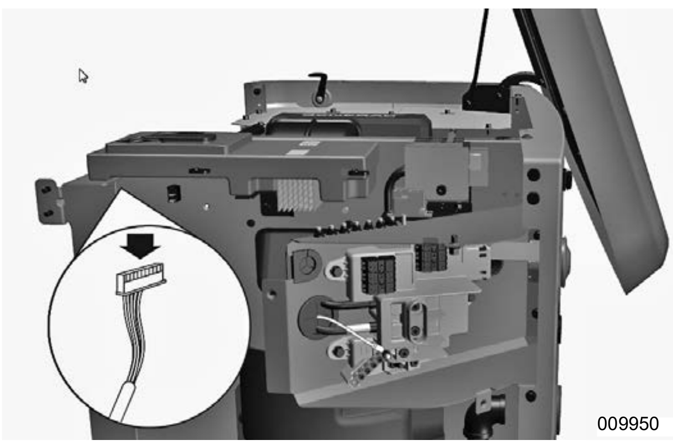


Figure 4-100.

1. Disconnect J5 stepper motor harness connector from controller.

Figure 4-101.

2. Disconnect positive battery cable (Wire 13) from starter
3. Disconnect Wire 16 (v-twin) or Wire 56 (single cylinder) from starter solenoid.

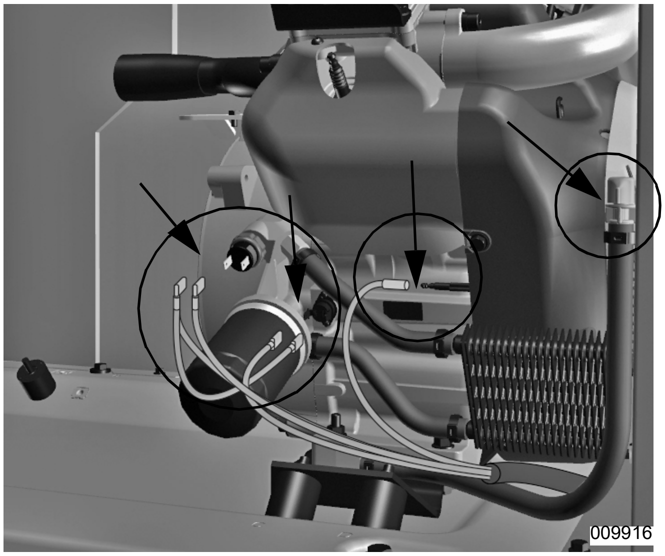


Figure 4-102.

4. Disconnect Wire 85 and Wire 0 from the high oil temperature switch (HOT).
5. Disconnect Wire 86 and Wire 0 from the low oil pressure switch (LOP).
6. Disconnect Wire 18 bullet connector.
7. Release the plug end of the oil drain hose from the stowage retainer.

Figure 4-103.

8. Disconnect fuel hoses from mixer assembly.

Removing Engine

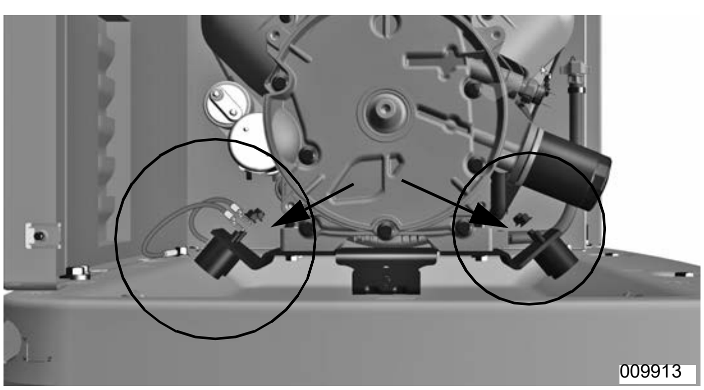


Figure 4-104.

1. Remove four (4) nuts from engine mount studs.
2. Disconnect ground wire from engine mount stud.

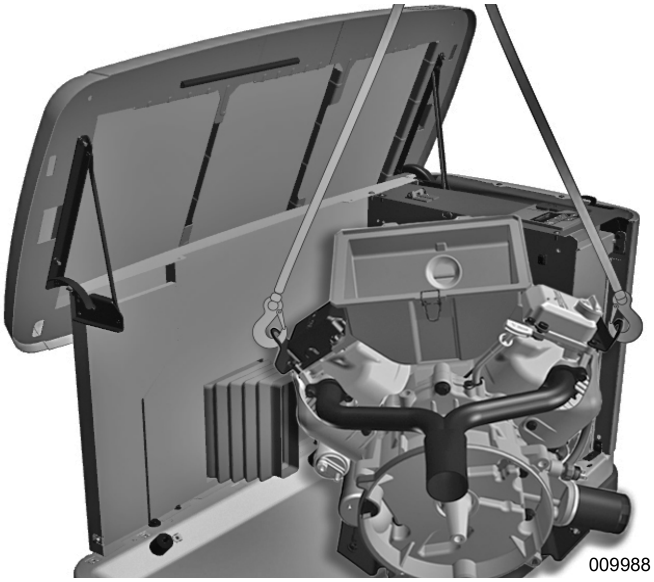

009988

Figure 4-105.

3. Use proper lifting equipment to lift and remove the engine.

NOTE: Secure the loose ends of the oil drain hose and the stepper motor harness to the engine to avoid damage when lifting.

Engine Installation

Required Tools

- Hoist or winch for lifting engine
- Standard mechanics tool set

Installing Engine


009988

Figure 4-106.

1. Use proper lifting equipment to lift the engine into place.

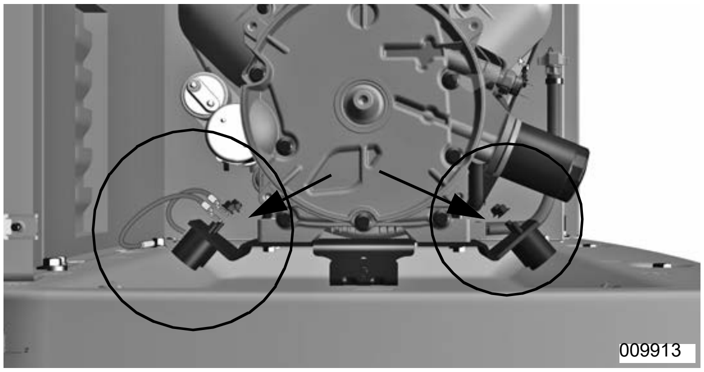


Figure 4-107.

2. Install four (4) nuts to engine isolator studs.
3. Connect ground wire to engine isolator stud.
4. Install and tighten nuts.

NOTE: See ***Specifications*** for proper torque values.

Connecting All Wires, Harnesses, and Hoses To Engine

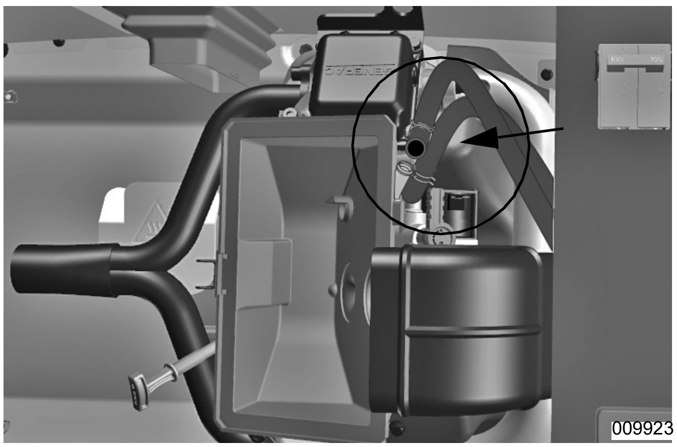


Figure 4-108.

1. Connect fuel hoses to mixer assembly and properly position clamps.

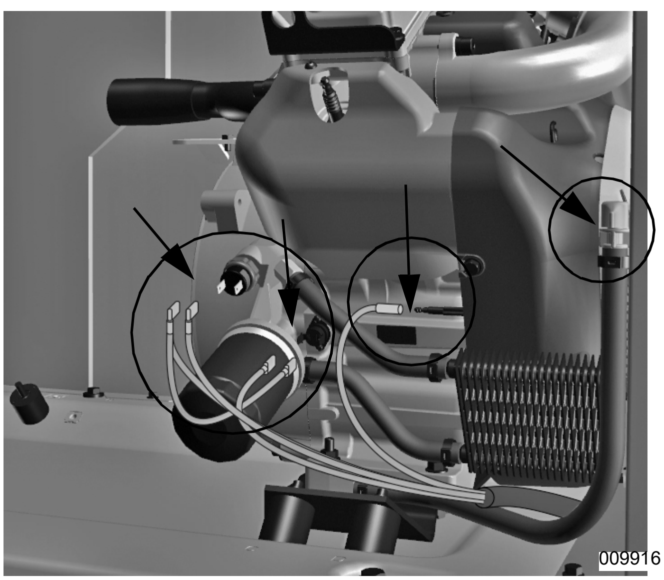


Figure 4-109.

2. Connect Wire 85 and Wire 0 to the high oil temperature switch (HOT).
3. Connect Wire 86 and Wire 0 to the low oil pressure switch (LOP).
4. Connect Wire 18 bullet connector.
5. Attach the plug end of the oil drain hose to the stowage retainer.

Figure 4-110.

6. Connect positive battery cable (Wire 13) to starter
7. Connect Wire 16 (v-twin) or Wire 56 (single cylinder) to starter solenoid.

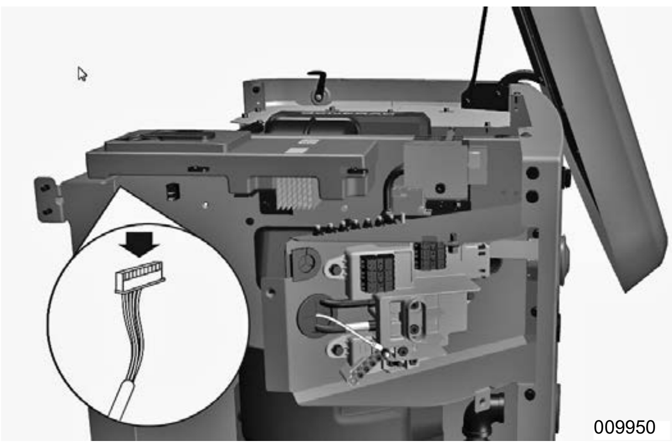


Figure 4-111.

8. Connect J5 stepper motor harness connector to controller.

NOTE: Properly route stepper motor harness in the reverse order of removal.

Installing Air Filter And Air Box Cover

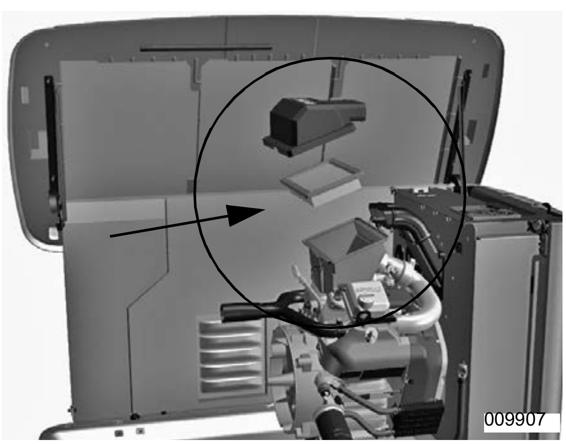


Figure 4-112.

1. Install air filter and air box cover.

Stator and Rotor Installation

Required Tools

- Stator holding adapters (PN 0K8824)
- Rotor protector sheet (PN 0K8210)
- Vibration dampener puller
- 3 inch M12x1.75 Bolt
- Standard mechanics tool set
- Rubber mallet or dead-blow hammer
- Torque wrenches (Inch lbs and Foot lbs)
- 3 or 4 small 2”x4” blocks of wood.

Installing Stator

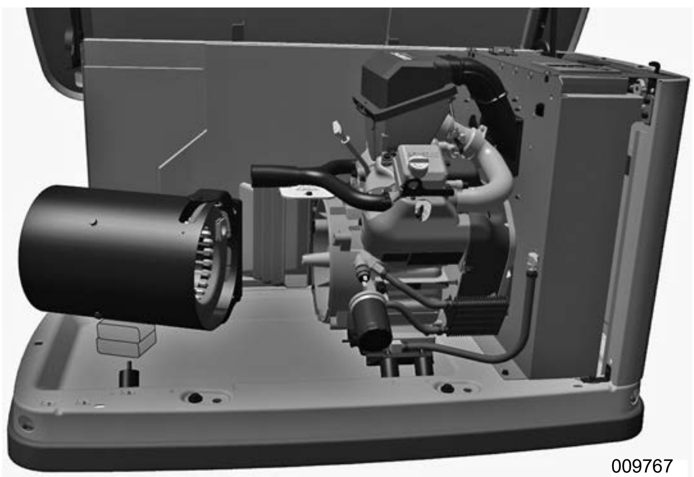


Figure 4-113.

1. Use short 2" x 4" pieces of wood to support the stator.

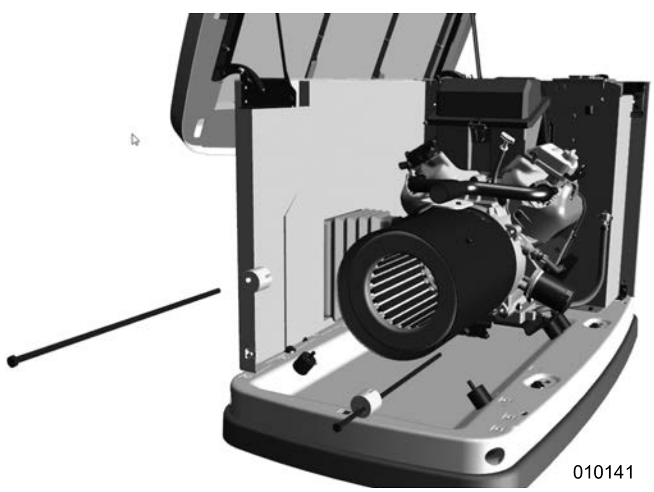


Figure 4-114.

2. Insert two stator bolts into the two stator holding adapters (0K8824).
3. 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.

NOTE: Do not over tighten.

Alternator Air Intake

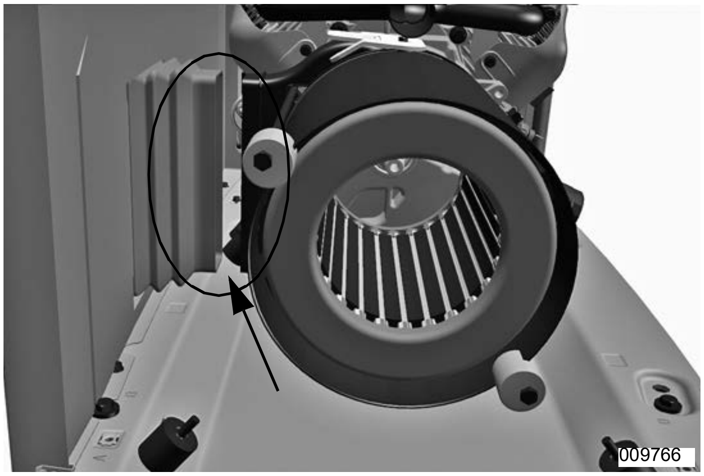


Figure 4-115.

1. Connect alternator intake bellows to the molded duct attached to the stator can.

Connecting Stator Wires

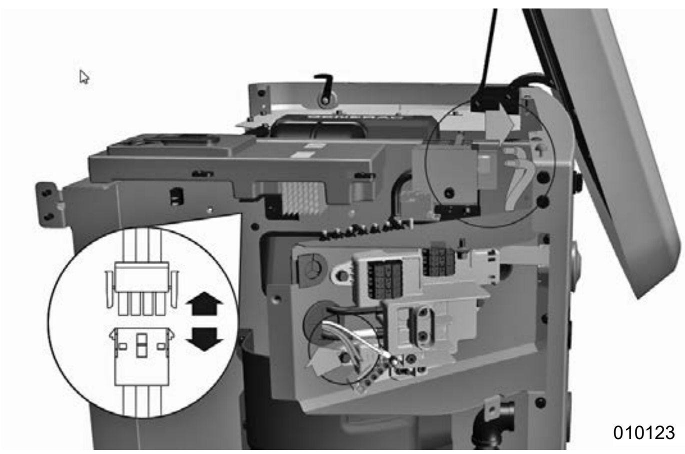


Figure 4-116.

1. Connect Wire 11 and Wire 44 to MLCB (A).
2. Connect Wire 22 and Wire 33 (B) to the terminal strip.
3. Connect STR connector (C).

NOTE: Properly route all stator wires in the reverse order of removal.

Installing Customer Connection Access Panel

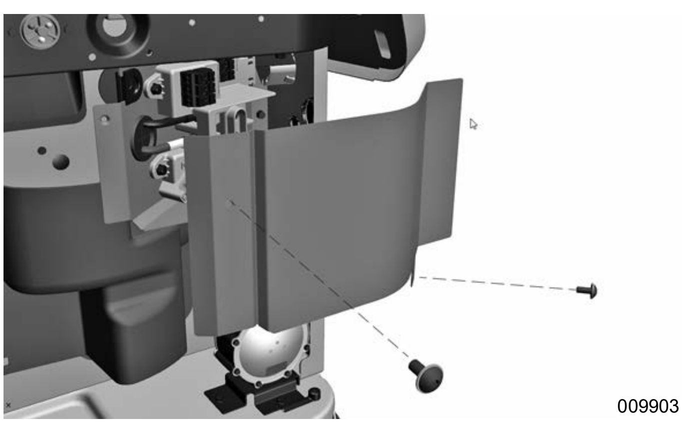


Figure 4-117.

1. Install customer connection access panel and tighten two (2) screws.

Installing Rotor and Rear Bearing Carrier

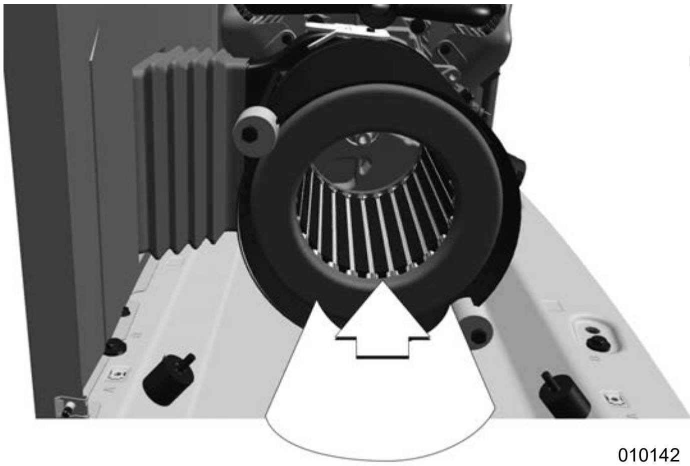


Figure 4-118.

1. Insert the rotor protector sheet (A) (PN 0K8210) into stator assembly.

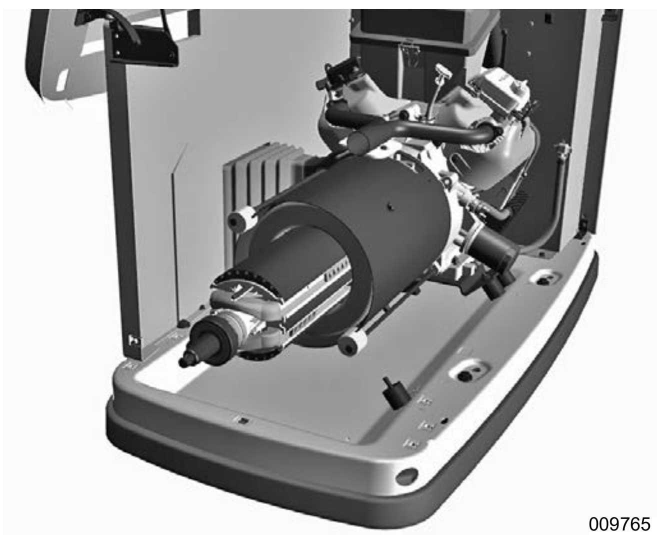


Figure 4-119.

2. Carefully slide rotor (on protective sheet) into the stator can.

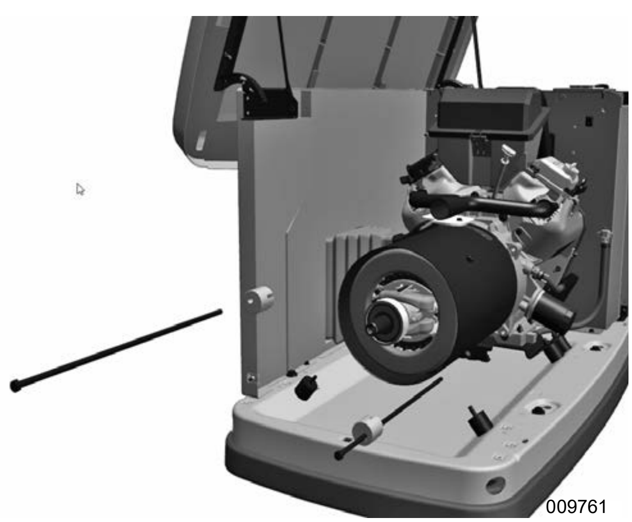


Figure 4-120.

3. Remove the two stator holding adapters (0K8824) and stator bolts.

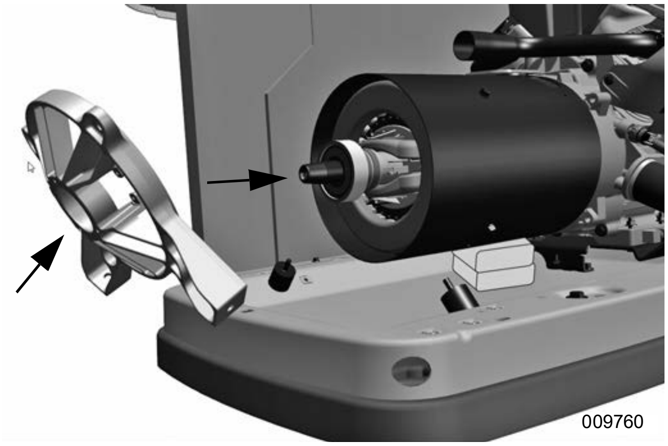


Figure 4-121.

4. Set the rear bearing carrier in place on the mounting isolators.

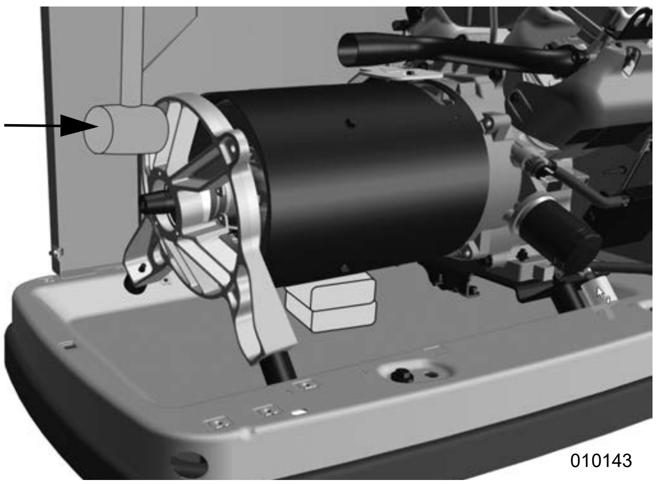


Figure 4-122.

5. Use a small rubber mallet or suitable dead-blow hammer to set the rear bearing carrier in place.

NOTE: Use short deliberate blows to tap the bearing carrier until firmly seated on stator.

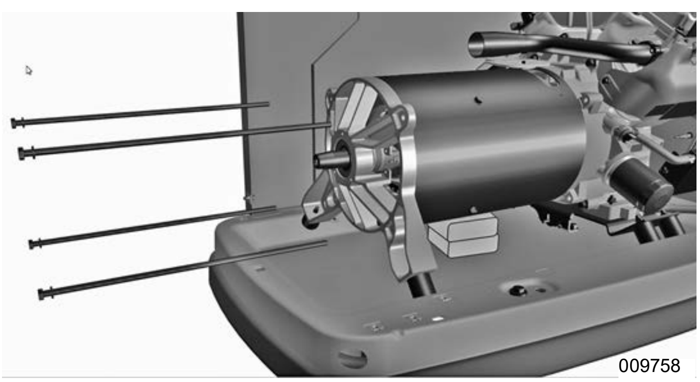


Figure 4-123.

6. install the four (4) stator bolts and lock washers.
7. Use a 13 mm socket to tighten stator bolts.

IMPORTANT NOTE: Stator bolts must be tightened to the correct specification. See ***Torque Specifications*** for proper values.

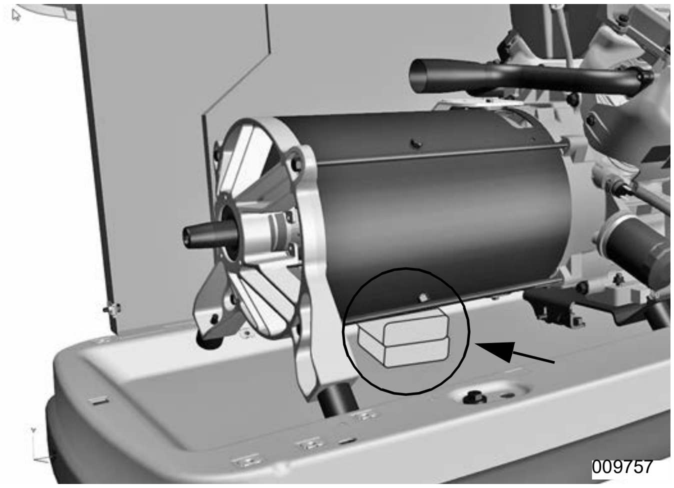


Figure 4-124.

8. Remove blocks of wood from under stator.

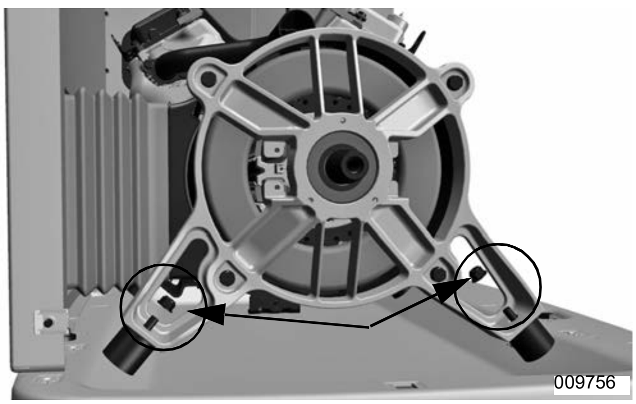


Figure 4-125.

9. Use a 13mm socket to install and tighten the nuts onto the two bearing carrier isolators.

NOTE: See ***Specifications*** for proper torque values.

Tightening Engine Mount

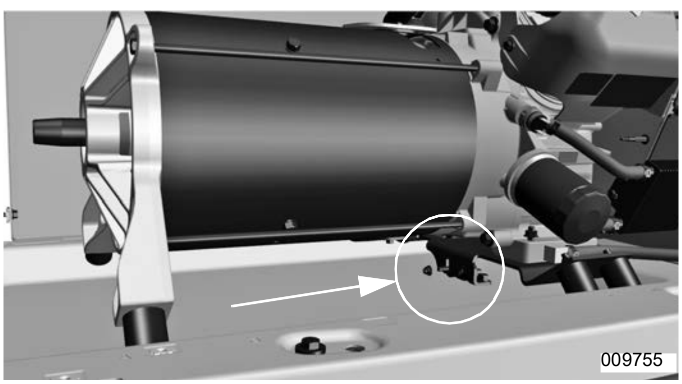


Figure 4-126.

1. Install and tighten the engine mount nut.

NOTE: See ***Specifications*** for proper torque values.

Installing Brushes

Figure 4-127.

1. Install brush assembly and tighten screws with a 7mm socket.
2. Use tie wraps to secure brush wire harness to the outside of the stator.

NOTE: See ***Specifications*** for proper torque values.

Installing Alternator Divider Panel

Figure 4-128.

1. Set the divider panel and muffler assembly in place.

NOTE: Be sure to guide exhaust flex onto the exhaust pipe while setting divider in place.

2. Use a 10 mm socket wrench to tighten two bottom base bolts.
3. Use a 4mm Allen wrench to tighten one top rear bolt.

NOTE: See ***Torque Specifications*** for proper values.

NOTE: The rear lower mounting tab on the divider panel may be facing in or out.

Installing Fan and Rotor Bolt

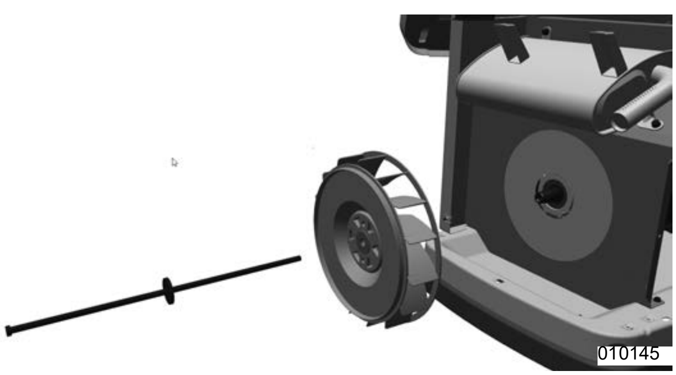


Figure 4-129.

1. Install the fan on the rotor shaft.
2. Insert the rotor bolt and washer into the rotor shaft.
3. Use a 9/16” socket to tighten rotor bolt.

NOTE: See ***Specifications*** for proper torque values.

Installing Left-side Enclosure

1. Set the side panel in place.

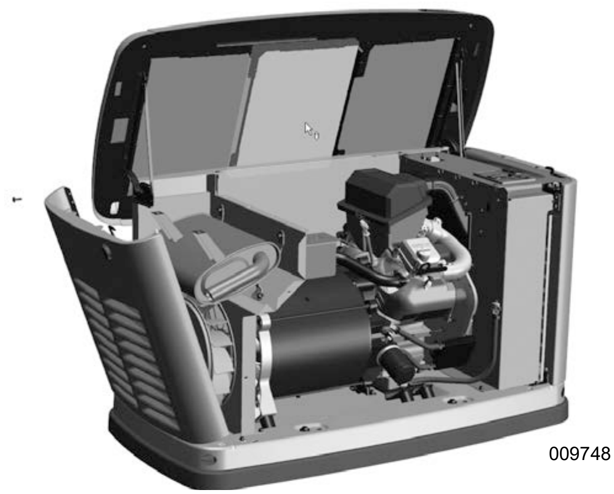


Figure 4-130.

2. Install three (3) bolts at the base of left side enclosure.

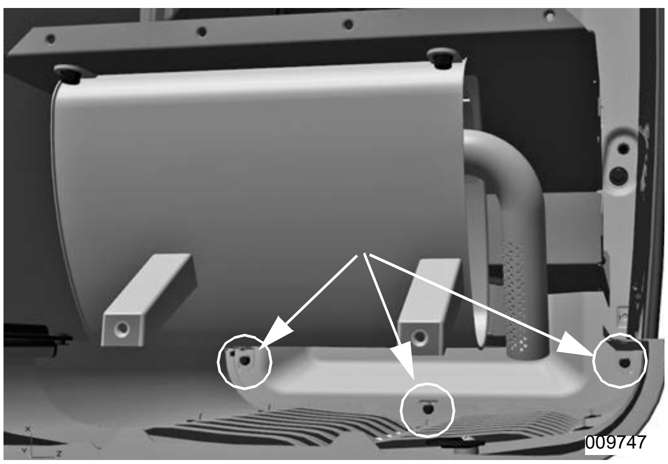


Figure 4-131. Three bolts at base of enclosure

3. Use a 10mm socket with a long extension to tighten the bolts.

NOTE: See ***Specifications*** for proper torque values.

NOTE: Procedure may require more than one socket extension.

Figure 4-132.

Figure 4-133.

4. While supporting hood, unsecure hinge from back panel and place hinge bolts through side panel and back panel holes.
5. Tighten bolts.

See ***Specifications*** for proper torque values.

Tightening Exhaust Flex Pipe

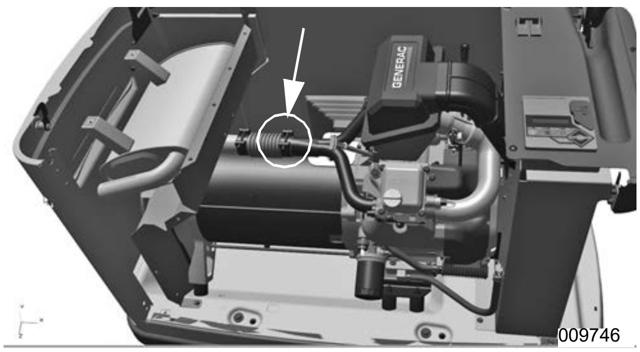


Figure 4-134.

1. Use a 10mm socket to tighten the right side muffler clamp.

Installing Exhaust Flex Cover

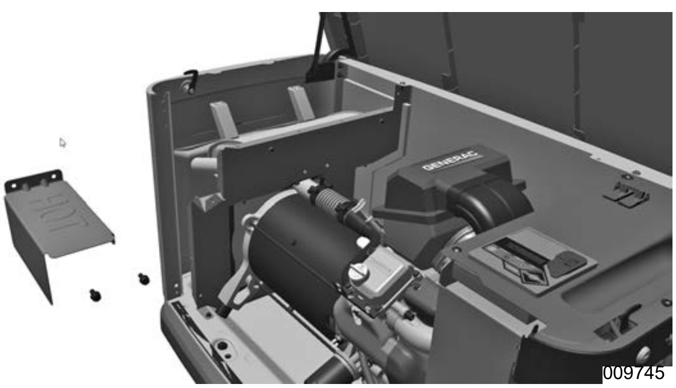


Figure 4-135.

1. Install the exhaust flex pipe cover.
2. Use a 10 mm socket to tighten two bolts.

NOTE: See ***Specifications*** for proper torque values.

Installing Side Exhaust Enclosure Cover

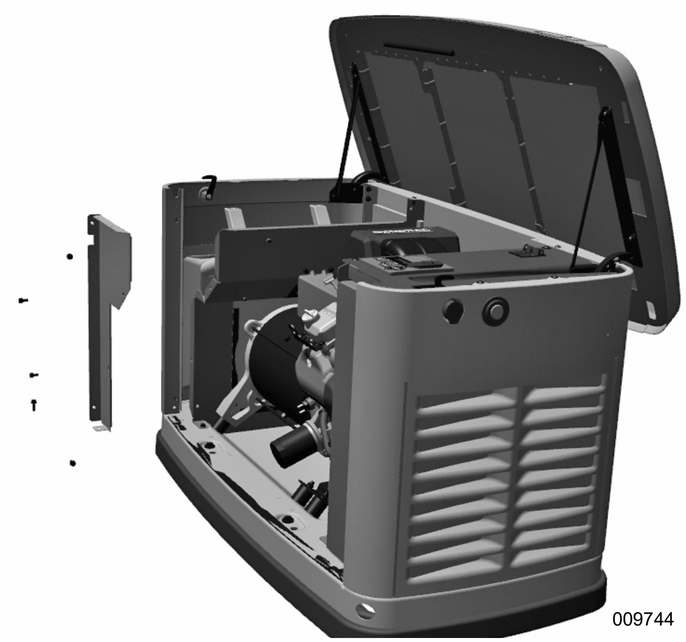


Figure 4-136.

1. Install exhaust side cover.
2. Use a 10 mm socket to tighten five (5) bolts on the exhaust side cover.

NOTE: See ***Specifications*** for proper torque values.

Installing Top Exhaust Enclosure Covers

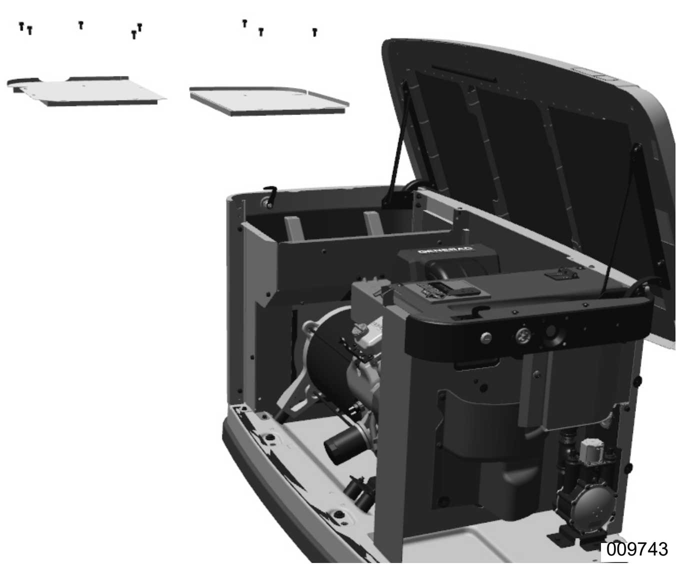


Figure 4-137.

1. Install exhaust top covers.
2. Use a 10 mm socket to tighten nine (9) bolts on the exhaust top covers.

NOTE: See ***Specifications*** for proper torque values.

Installing Center Support

Figure 4-138.

1. Install the center support.
2. Use a 10 mm socket to tighten two (2) bolts.

NOTE: See ***Specifications*** for proper torque values.

Torque Specifications

Stator Bolts	6 ft-lbs (+1 / -0)	0.5 Nm
Rotor Bolt	30 ft-lbs	2.5 Nm
Engine Adapter	25 ft-lbs	2.08 Nm
Exhaust Manifold	18 ft-lbs	1.5 Nm
M5-0.8 Taptite Screw Into Aluminum	25–50 **in-lbs**	2.82–5.64 Nm
M5-0.8 Taptite Screw Into Pierced Hole	25–50 **in-lbs**	2.82–5.64 Nm
M6-1.0 Taptite Screw Into Aluminum	50–96 **in-lbs**	5.64–10.84 Nm
M6-1.0 Taptite Screw Into Pierced Hole	50–96 **in-lbs**	5.64–10.84 Nm
M6-1.0 Taptite Screw Into Weldnut	50–96 **in-lbs**	5.64–10.84 Nm
M8-1.25 Taptite Screw Into Aluminum	12–18 ft-lbs	1.0–1.5 Nm
M8-1.25 Taptite Screw Into Pierced Hole	12–18 ft-lbs	1.0–1.5 Nm
M6-1.0 Nylok Nut Onto Weld Stud	16–65 **in-lbs**	1.8–7.34 Nm
M6-1.0 Nylok Nut Onto Hinge Stud	30–36 **in-lbs**	3.39–4.0 Nm
Stator Terminal Block Mounting/Cover Fasteners	15 **in-lbs**	1.69 Nm
Stator Terminal Lead Stud Fasteners	35 **in-lbs**	3.95 Nm

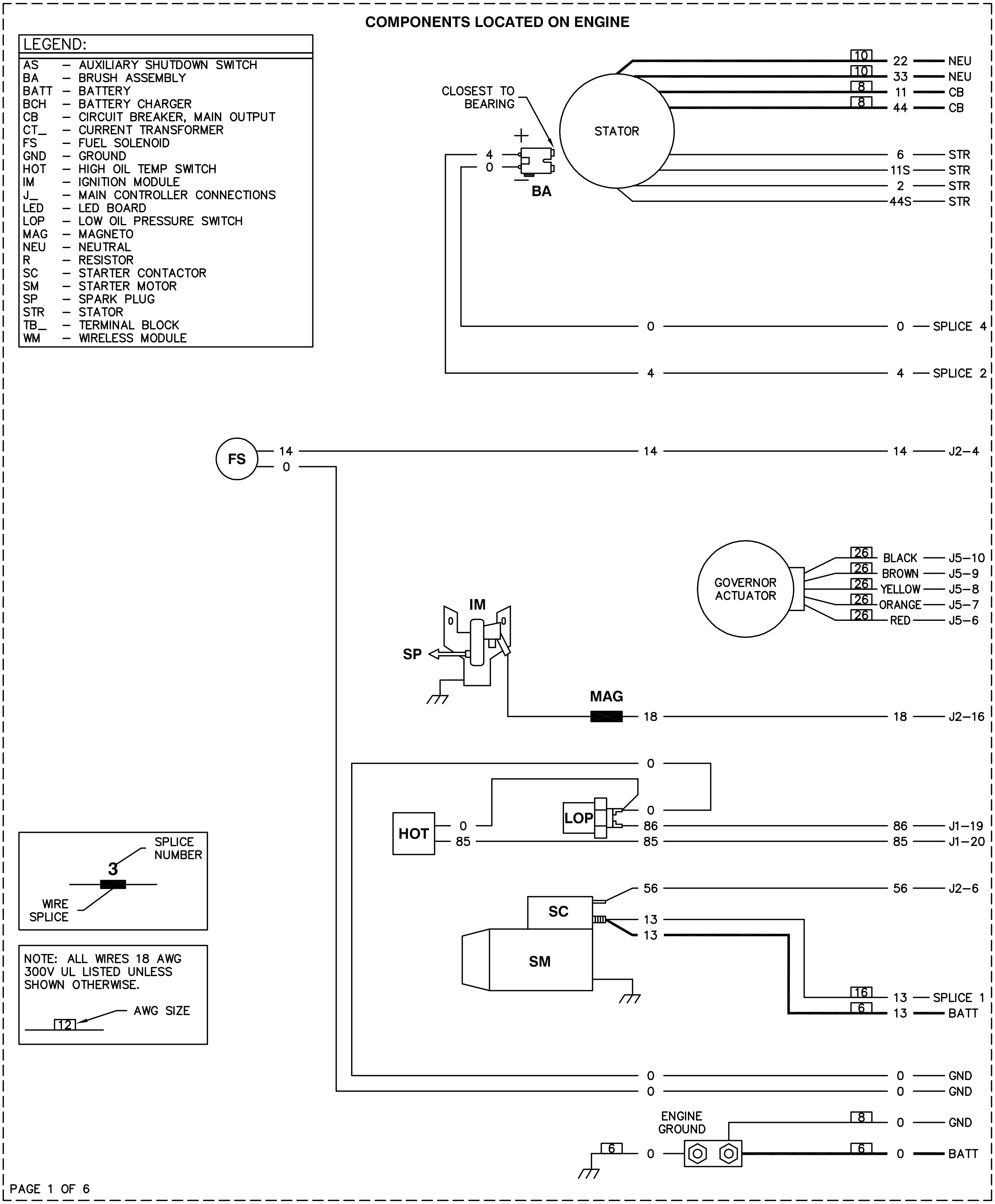
NOTE: Torques values are dynamic, with ±10% tolerance unless otherwise noted.

Section 5.1 *10000006453-E WD/SD Air-cooled HSB Evolution 2.0 w/426-460cc Engine 60 Hz*

Introduction

The diagrams in this section are provided for general reference only. For unit specific diagrams refer to the Service and Support page at the manufacturer's website.

GROUP WD



WIRING - DIAGRAM

AC HSB EVO2 60HZ 426

REVISION: E

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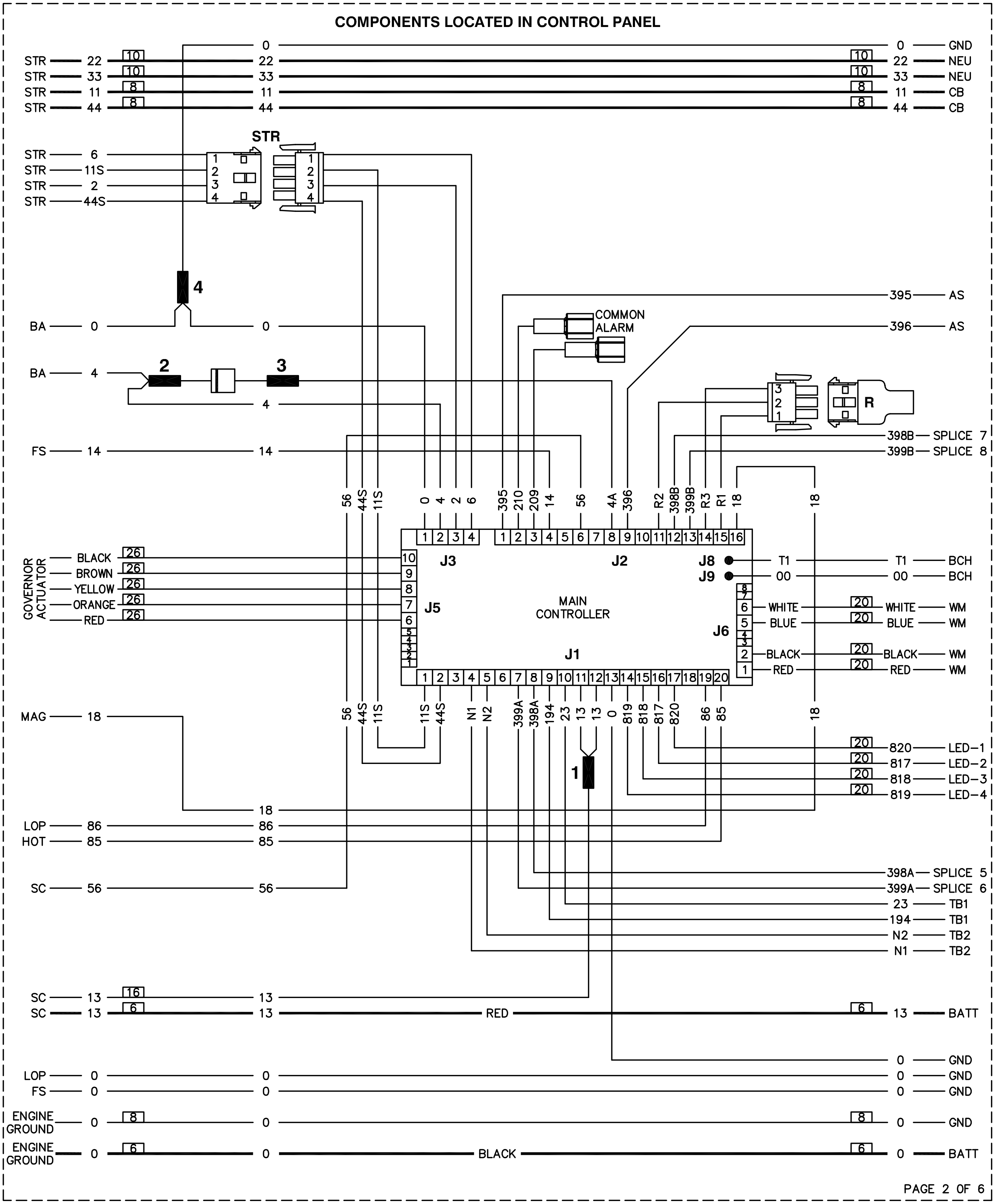
GROUP WD



WIRING - DIAGRAM

REVISION: E

AC HSB EVO2 60HZ 426

DATE: 08/10/17

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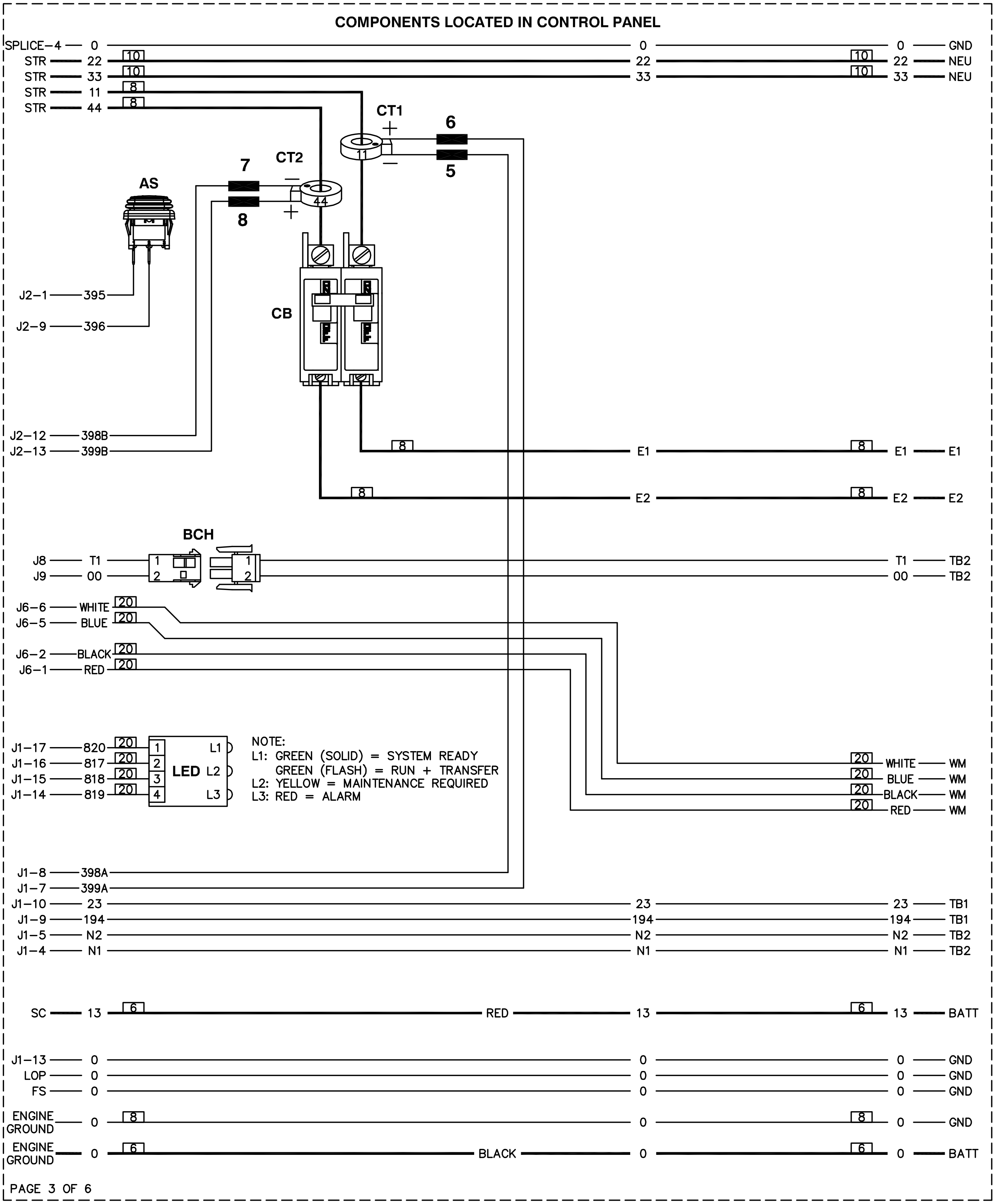
DRAWING #: 10000006453

GROUP WD



WIRING - DIAGRAM

REVISION: E

AC HSB EVO2 60HZ 426

DATE: 08/10/17

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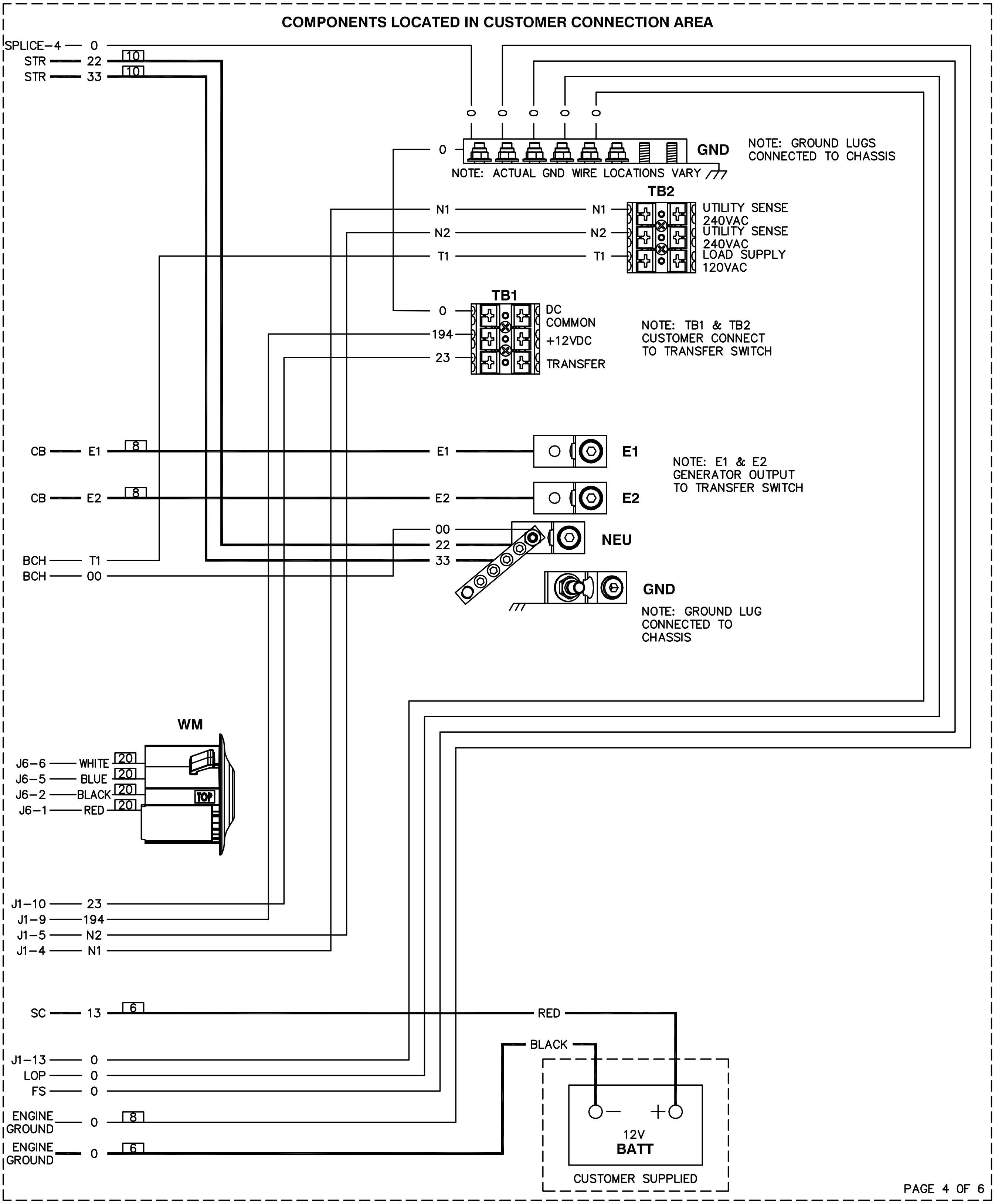
DRAWING #: 10000006453

GROUP WD



WIRING - DIAGRAM

REVISION: E

AC HSB EVO2 60HZ 426

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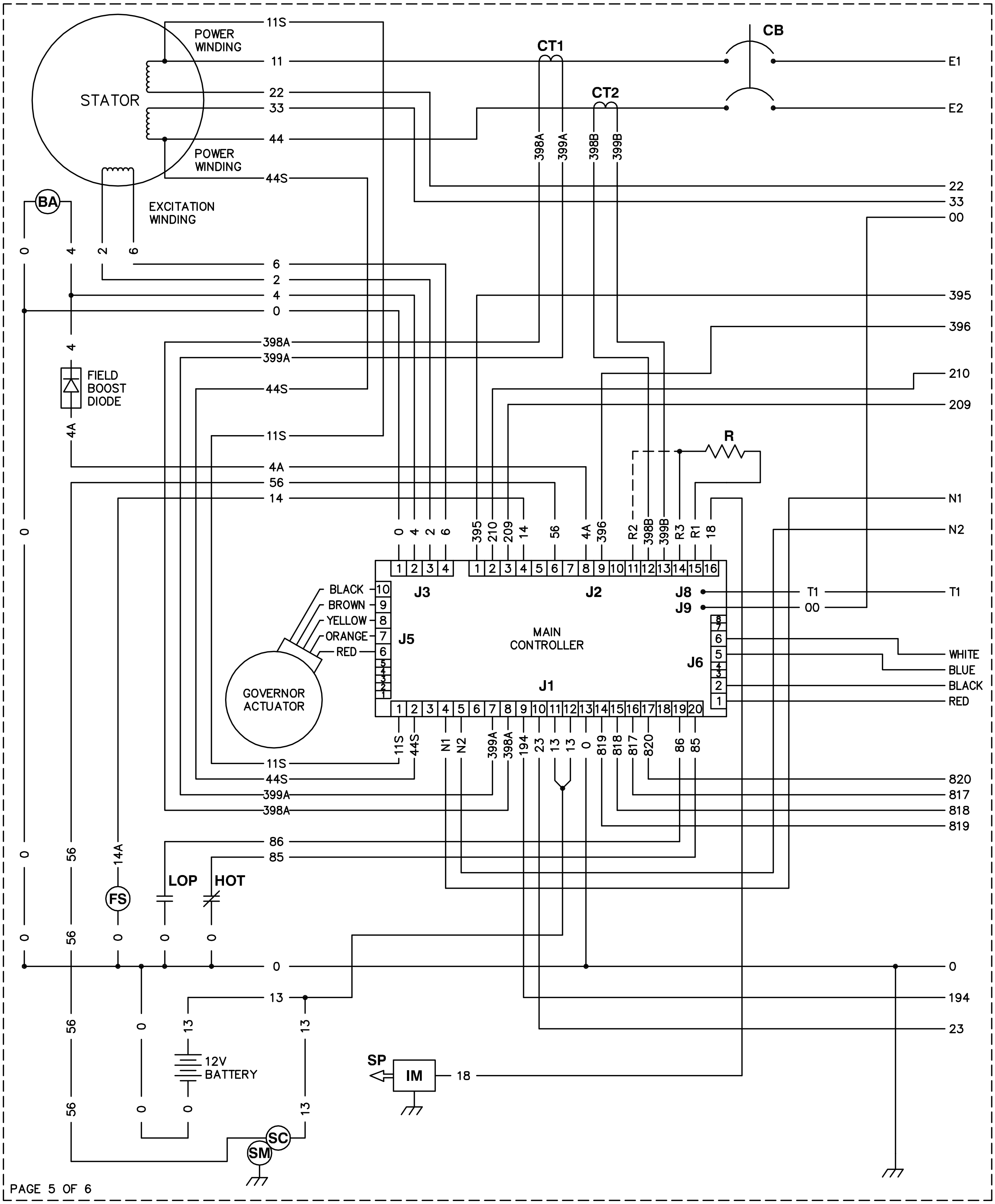
DRAWING #: 10000006453

GROUP WD



SCHEMATIC - DIAGRAM

REVISION: E

AC HSB EVO2 60HZ 426

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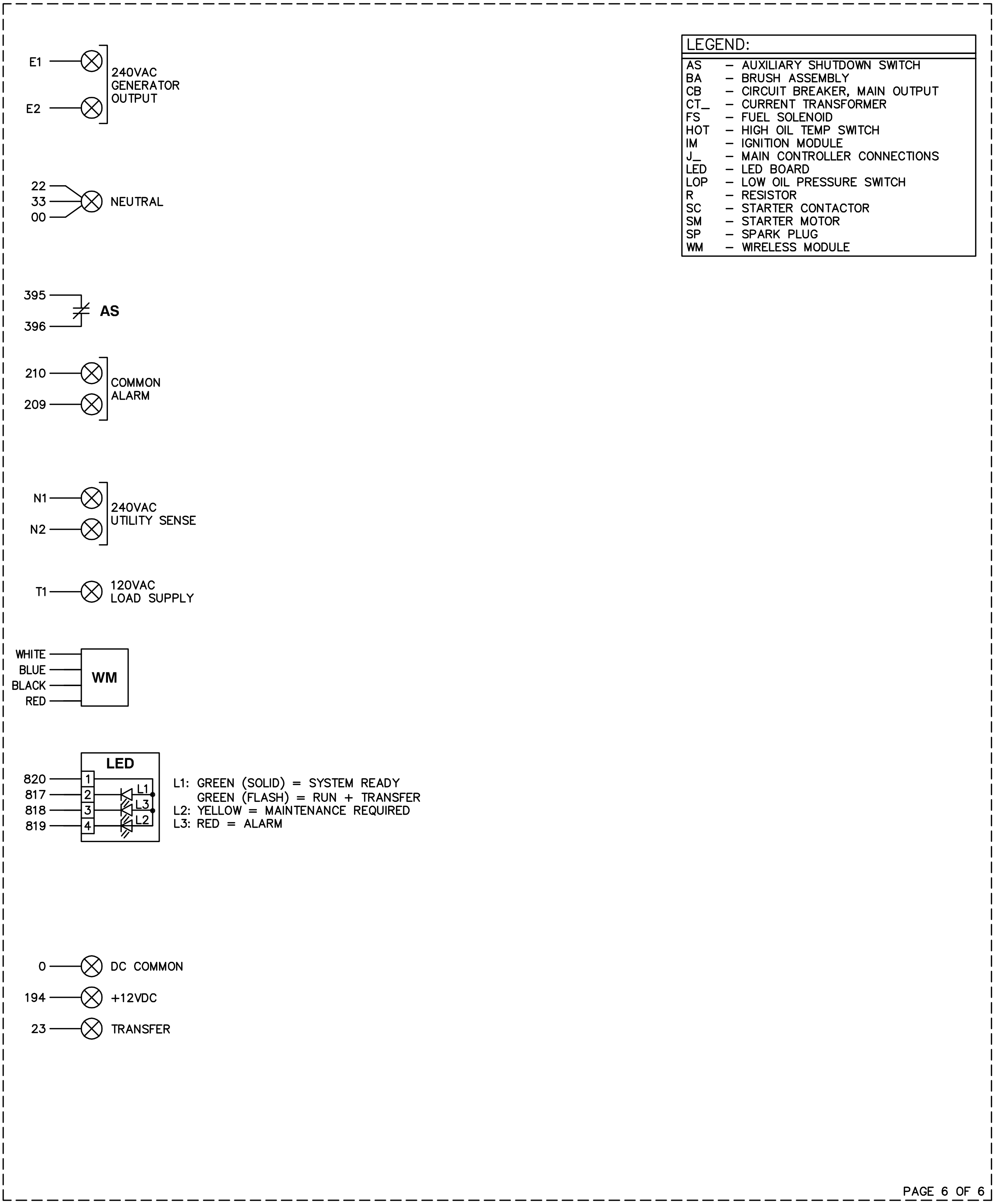
DRAWING #: 10000006453

GROUP WD



SCHEMATIC - DIAGRAM
AC HSB EVO2 60HZ 426

REVISION: E
DATE: 08/10/17

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DRAWING #: 10000006453

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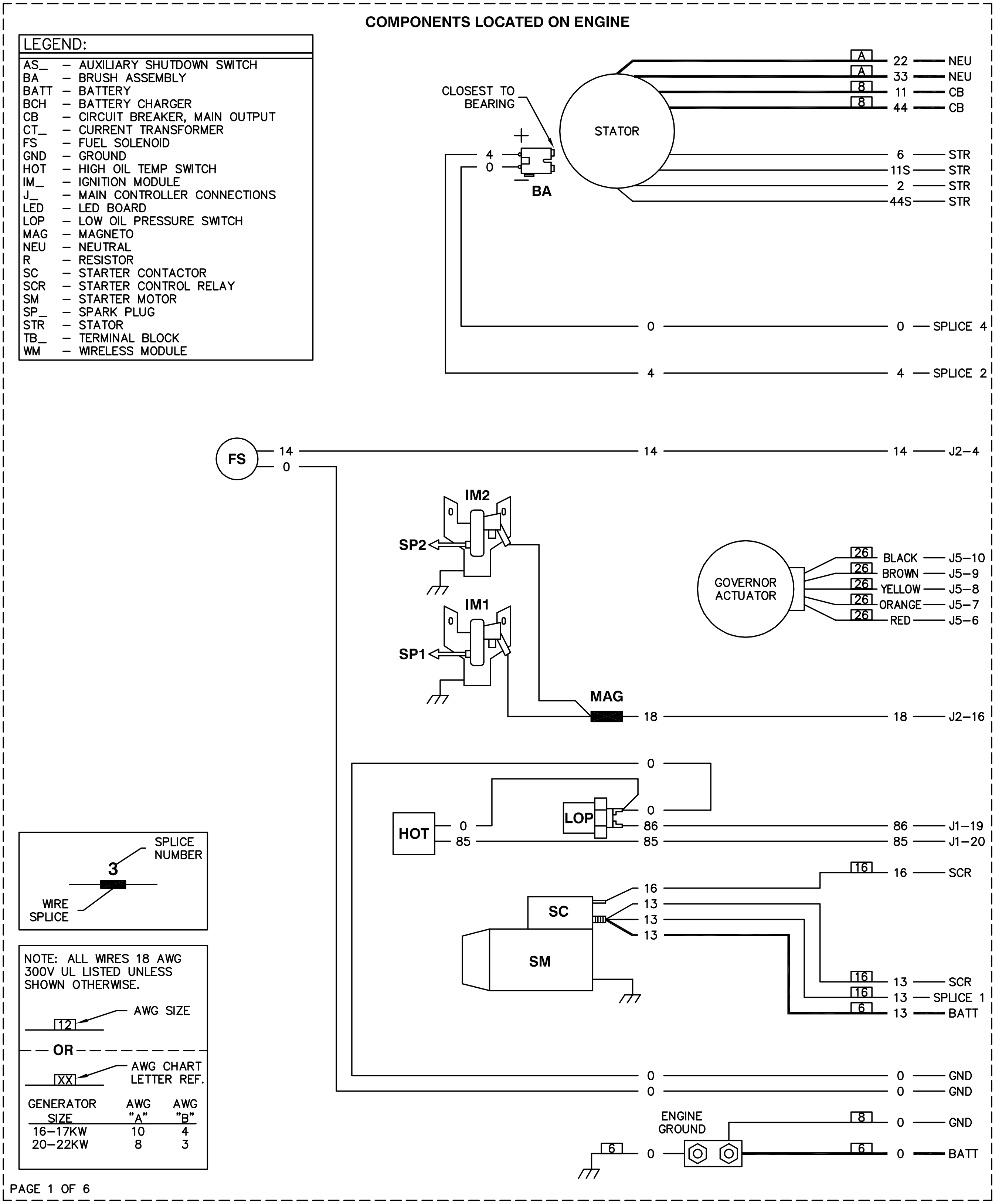
Section 5.2 *10000017243-A WD/SD Air-cooled HSB Evolution 2.0 w/816-999cc Engine 60 Hz*

Introduction

The diagrams in this section are provided for general reference only. For unit specific diagrams refer to the Service and Support page at the manufacturer’s website.

GROUP WD



WIRING - DIAGRAM

AC HSB EVO2 60HZ 999

REVISION: A

DATE: 08/10/17

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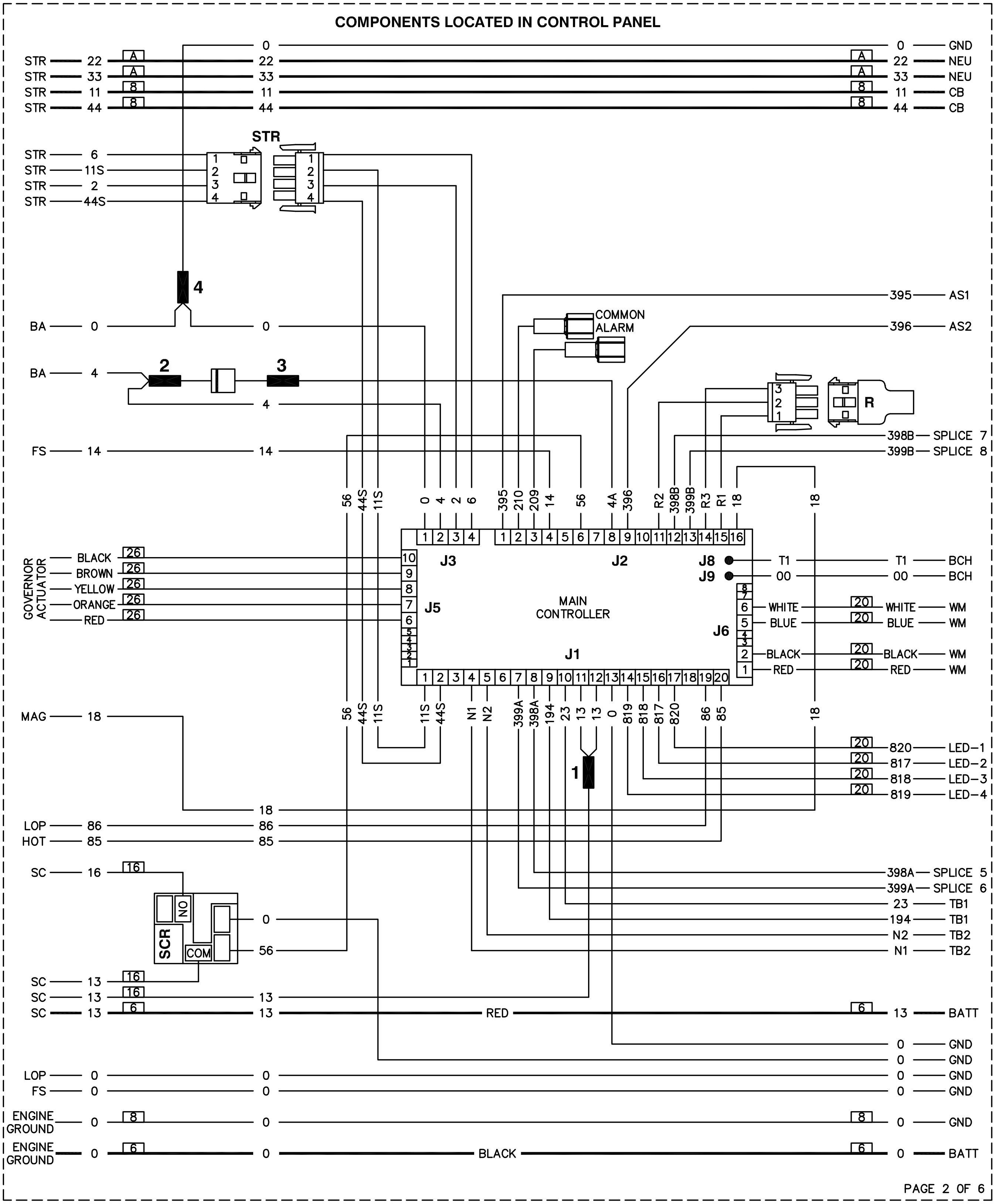
DRAWING #: 10000017243

GROUP WD



WIRING - DIAGRAM

AC HSB EVO2 60HZ 999

REVISION: A

DATE: 08/10/17

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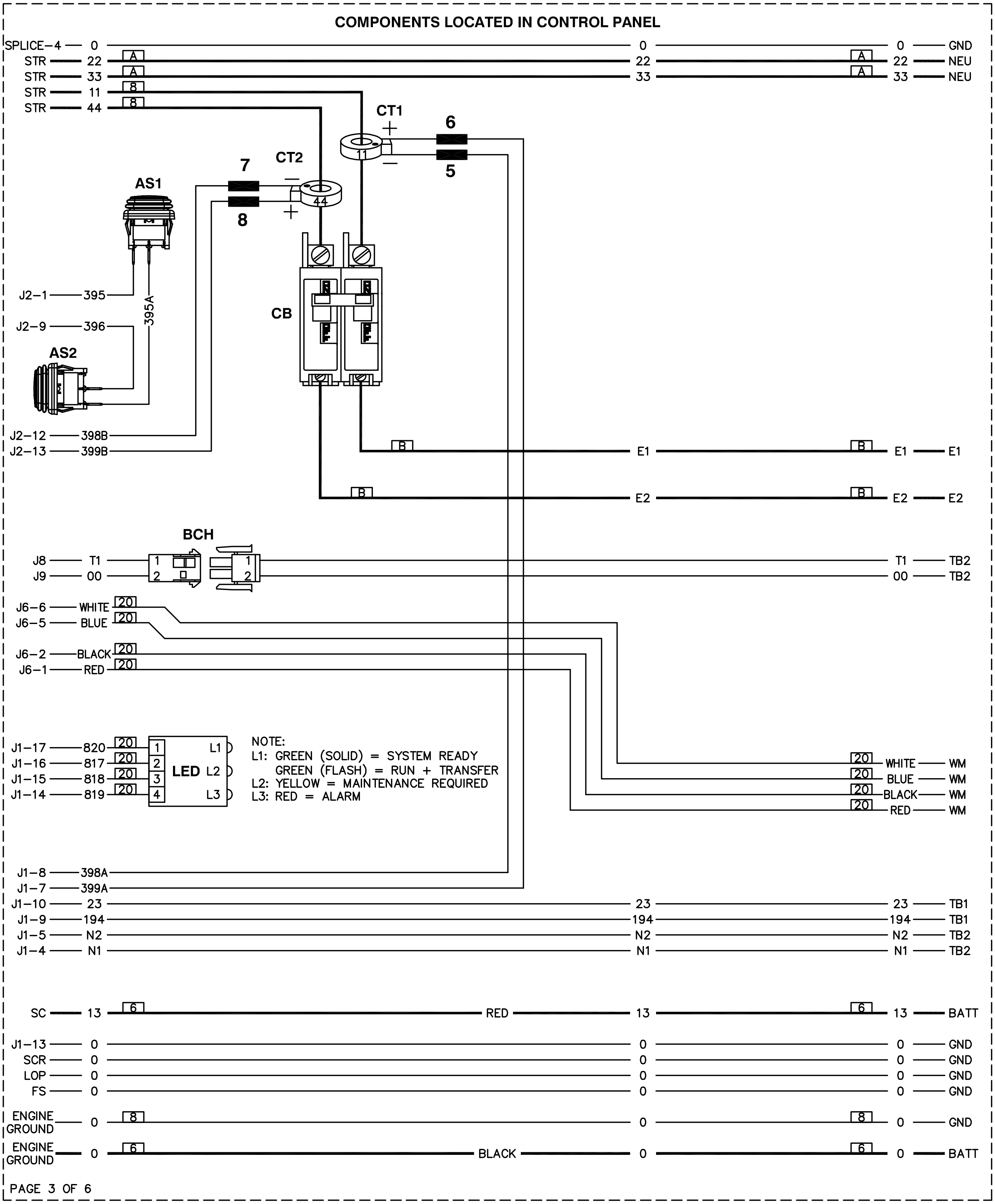
DRAWING #: 10000017243

GROUP WD



WIRING - DIAGRAM

REVISION: A

AC HSB EVO2 60HZ 999

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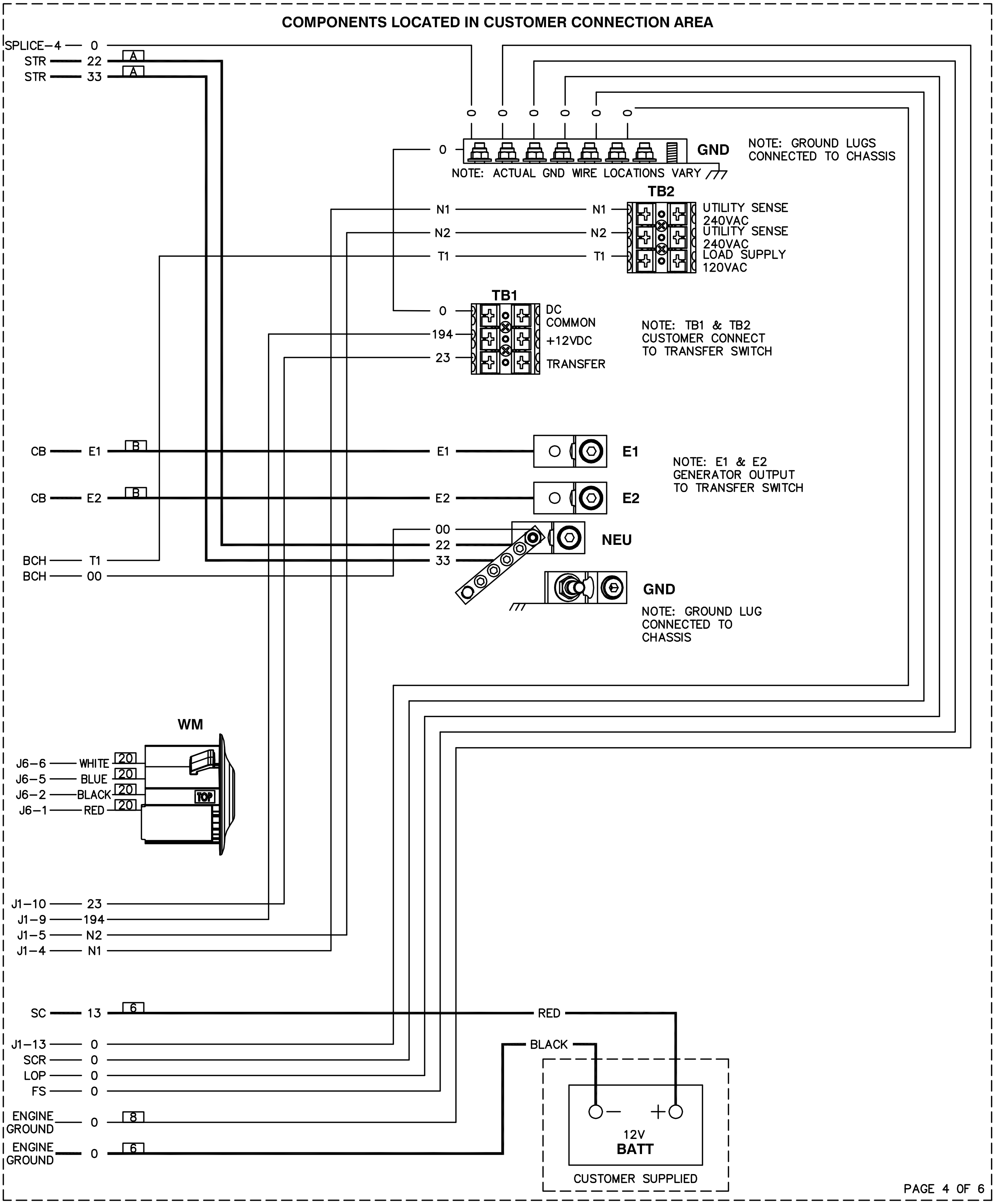
DRAWING #: 10000017243

GROUP WD



WIRING - DIAGRAM
AC HSB EVO2 60HZ 999
REVISION: A
DATE: 08/10/17
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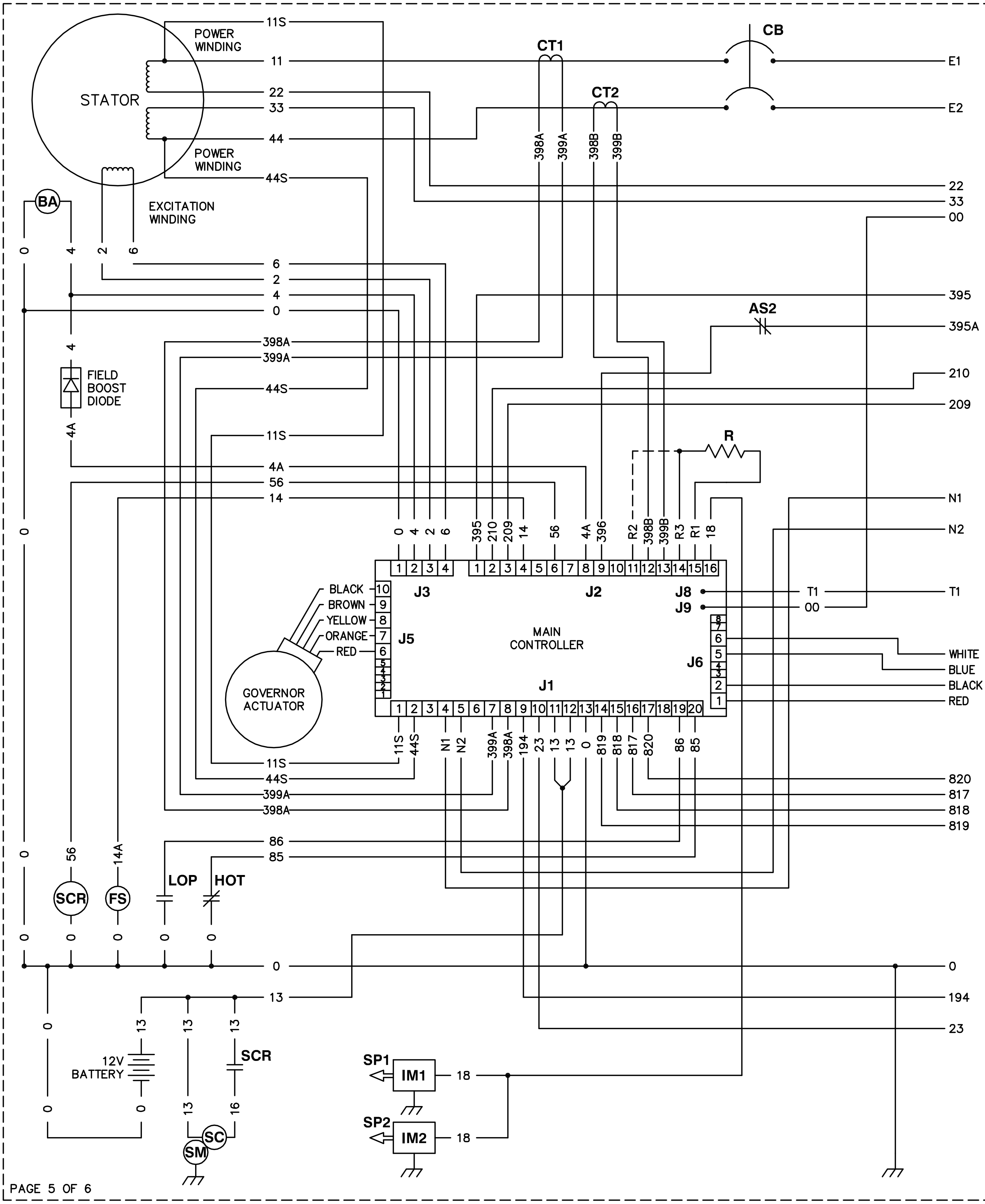
DRAWING #: 10000017243

GROUP WD



SCHEMATIC - DIAGRAM

AC HSB EVO2 60HZ 999

REVISION: A

DATE: 08/10/17

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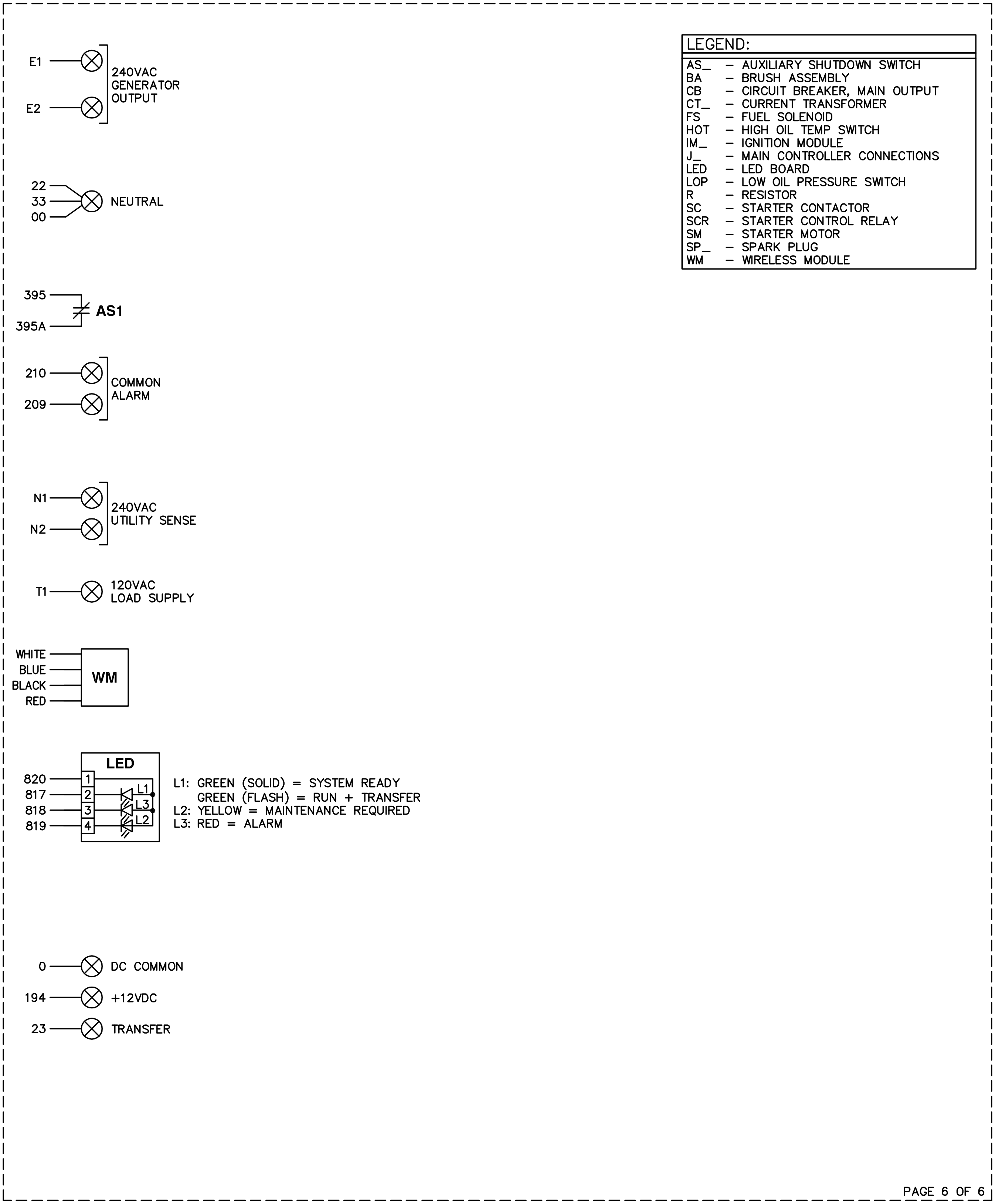
DRAWING #: 10000017243

GROUP WD



SCHEMATIC - DIAGRAM

REVISION: A

AC HSB EVO2 60HZ 999

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DRAWING #: 10000017243

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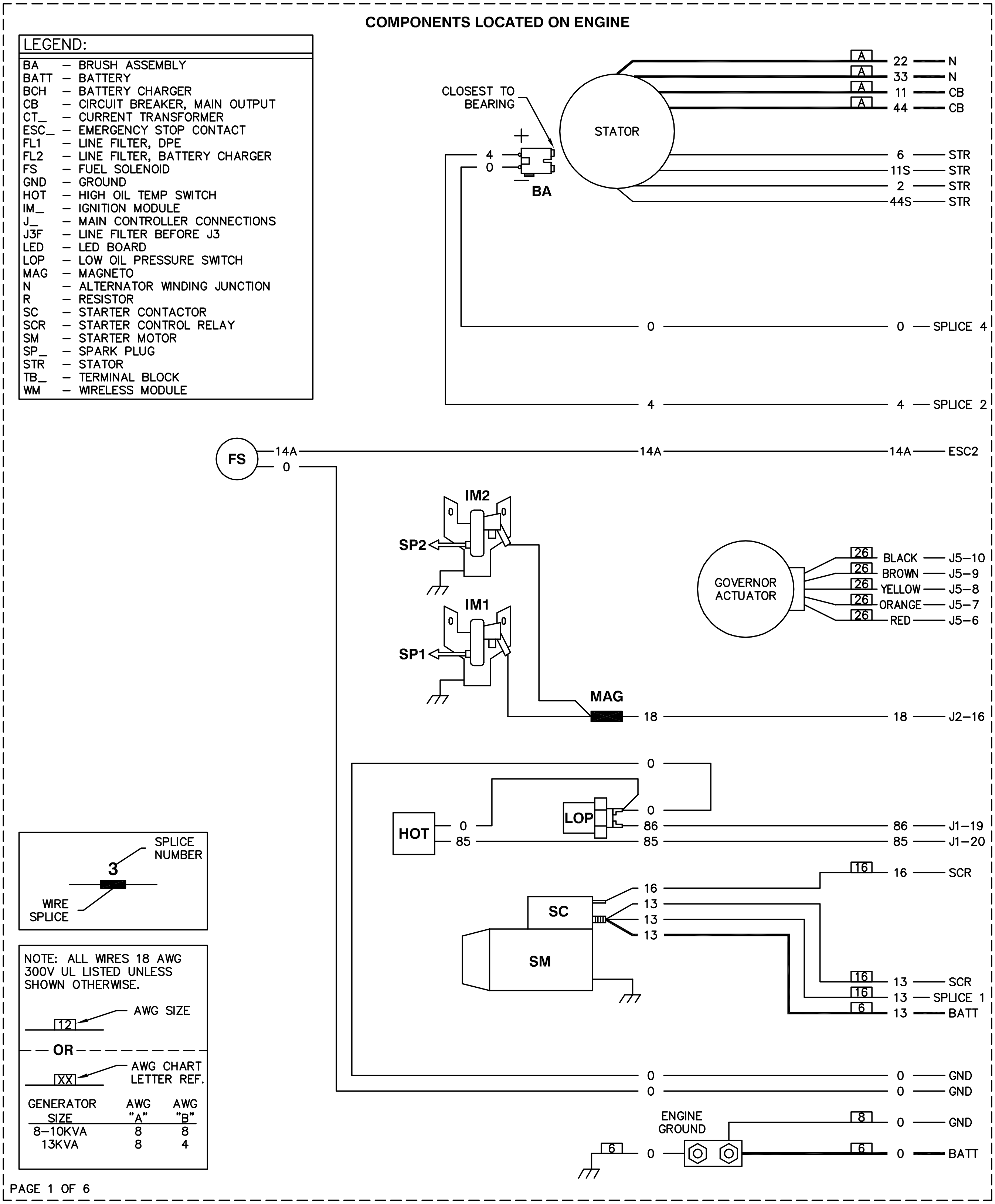
Section 5.3 *10000007481-G WD/SD Air-cooled HSB Evolution 2.0 50 Hz 1-phase CE*

Introduction

The diagrams in this section are provided for general reference only. For unit specific diagrams refer to the Service and Support page at the manufacturer’s website.

GROUP WD



WIRING - DIAGRAM

REVISION: G

AC HSB EVO2 50HZ 1PH CE

DATE: 06/28/18

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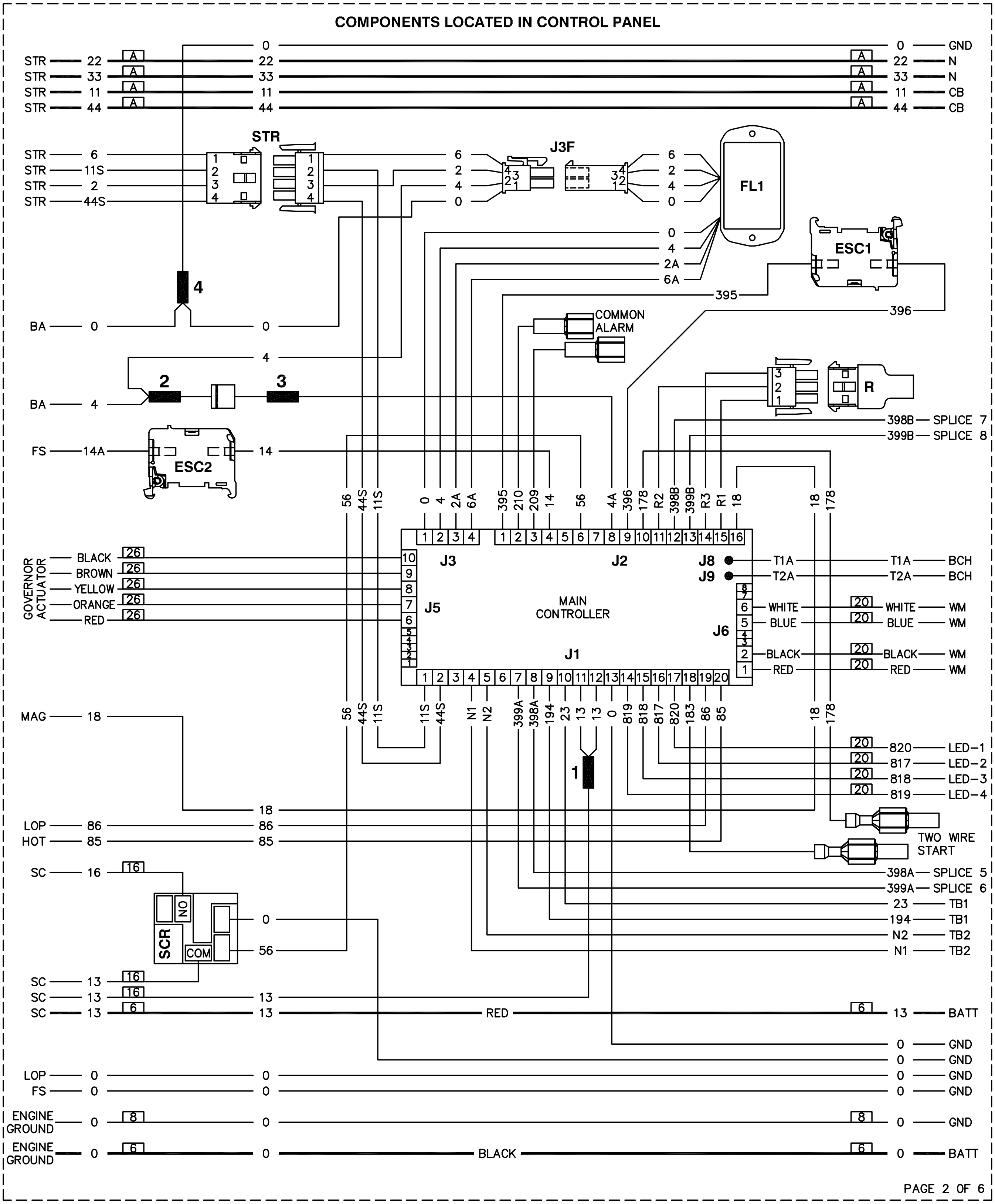
DRAWING #: 10000007481

GROUP WD



WIRING - DIAGRAM

REVISION: G

AC HSB EVO2 50HZ 1PH CE

DATE: 06/28/18

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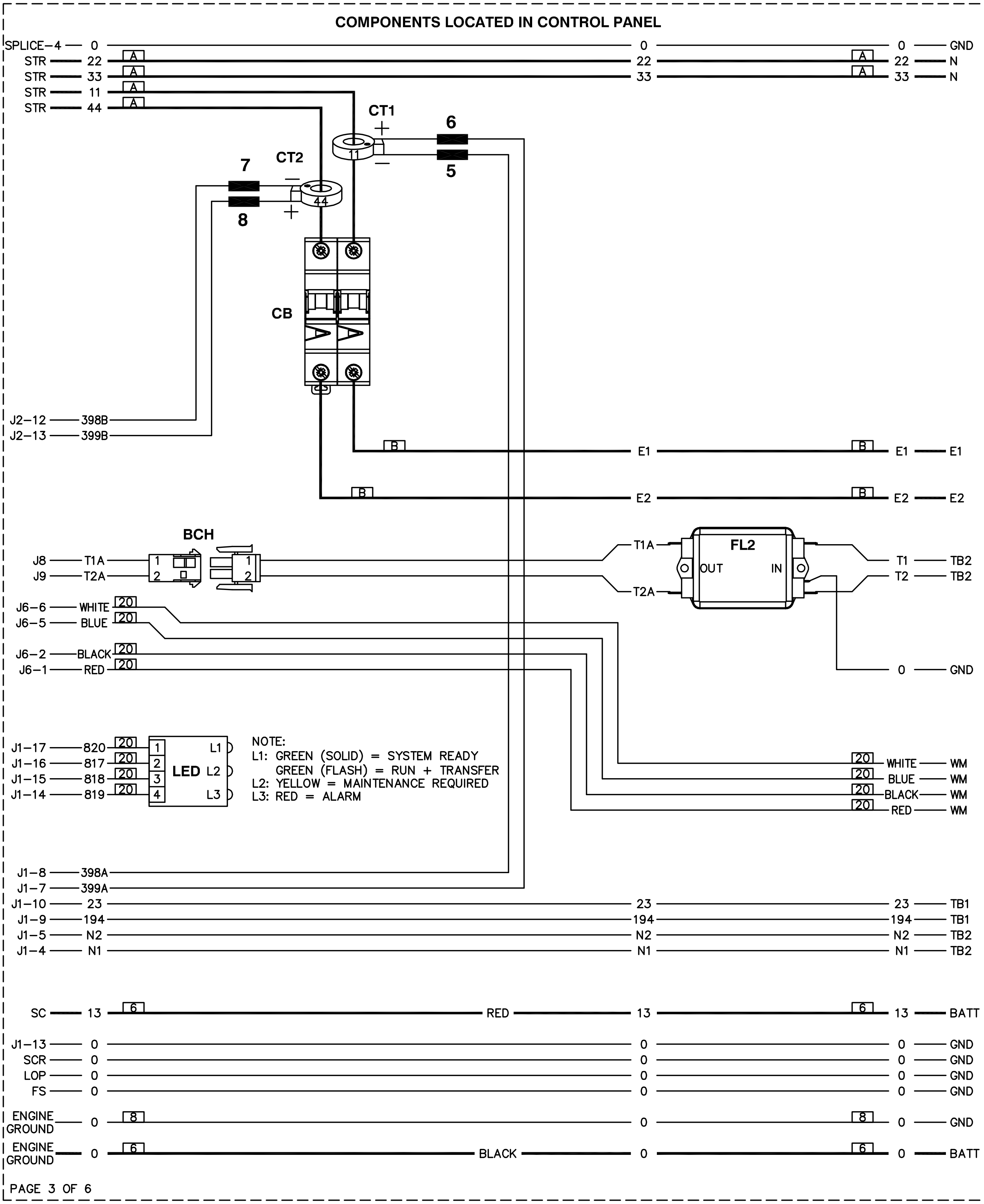
DRAWING #: 10000007481

GROUP WD



WIRING - DIAGRAM

REVISION: G

AC HSB EVO2 50HZ 1PH CE

DATE: 06/28/18

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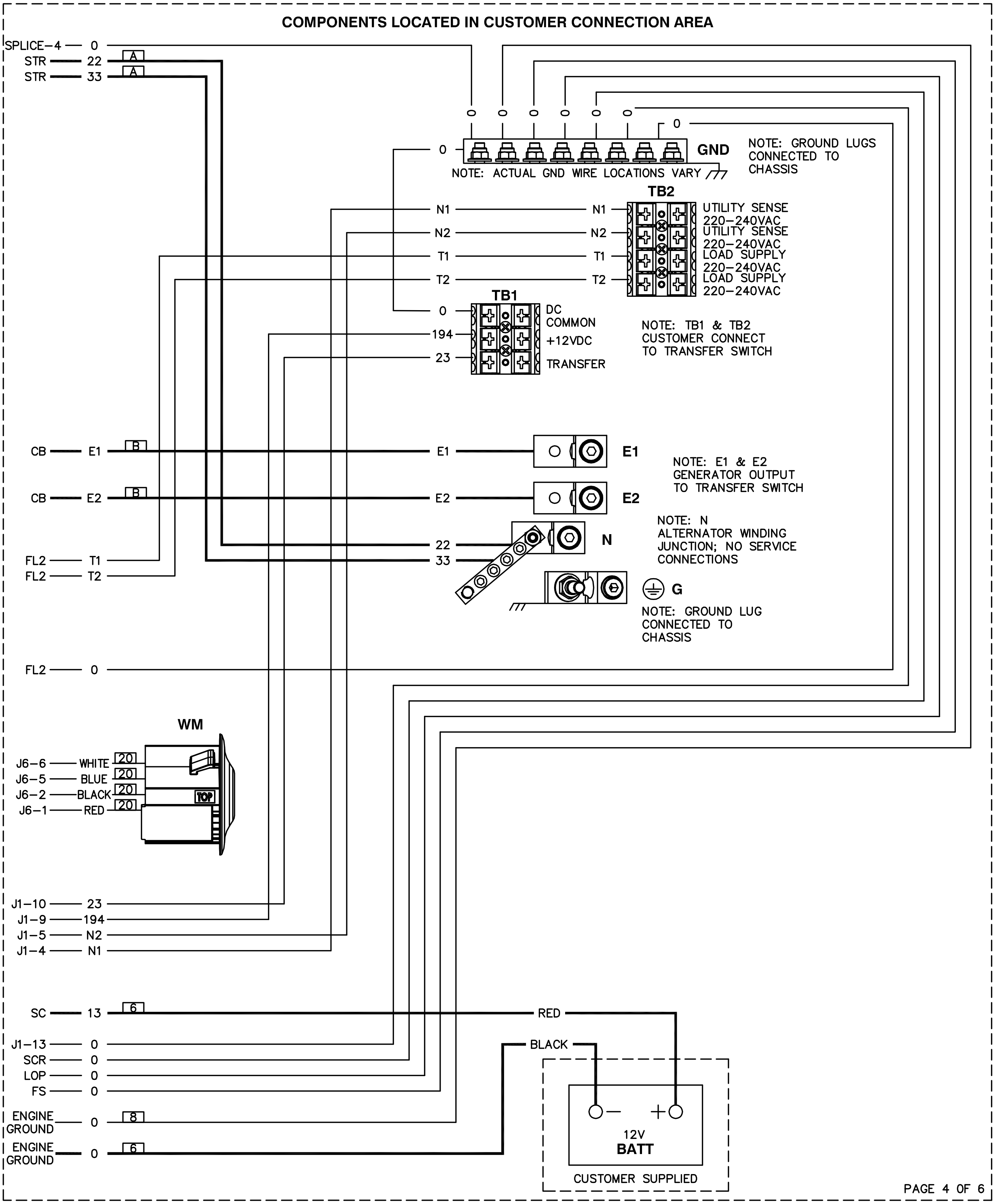
DRAWING #: 10000007481

GROUP WD



WIRING - DIAGRAM

AC HSB EVO2 50HZ 1PH CE

REVISION: G

DATE: 06/28/18

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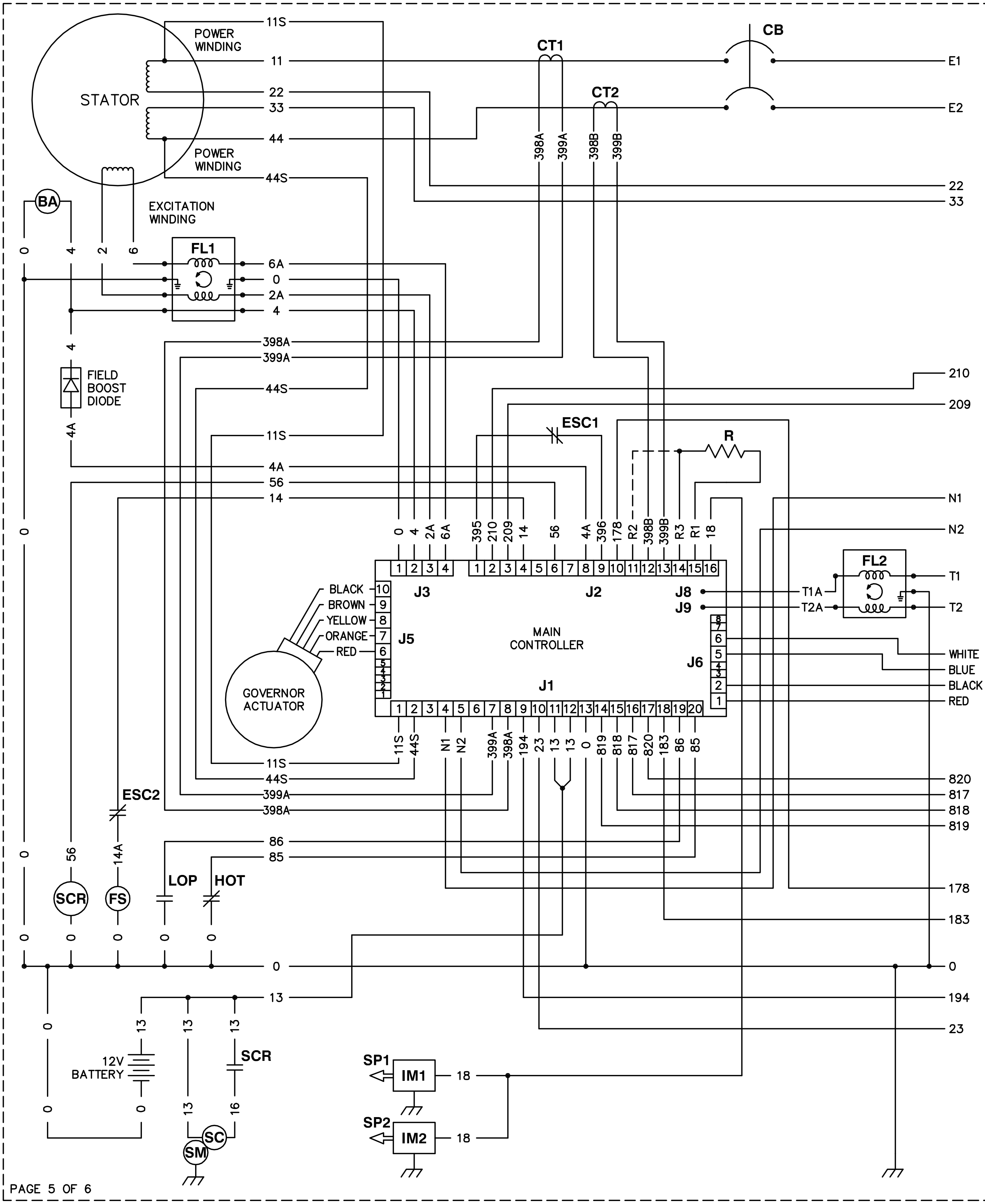
GROUP WD



SCHEMATIC - DIAGRAM

REVISION: G

AC HSB EVO2 50HZ 1PH CE

DATE: 06/28/18

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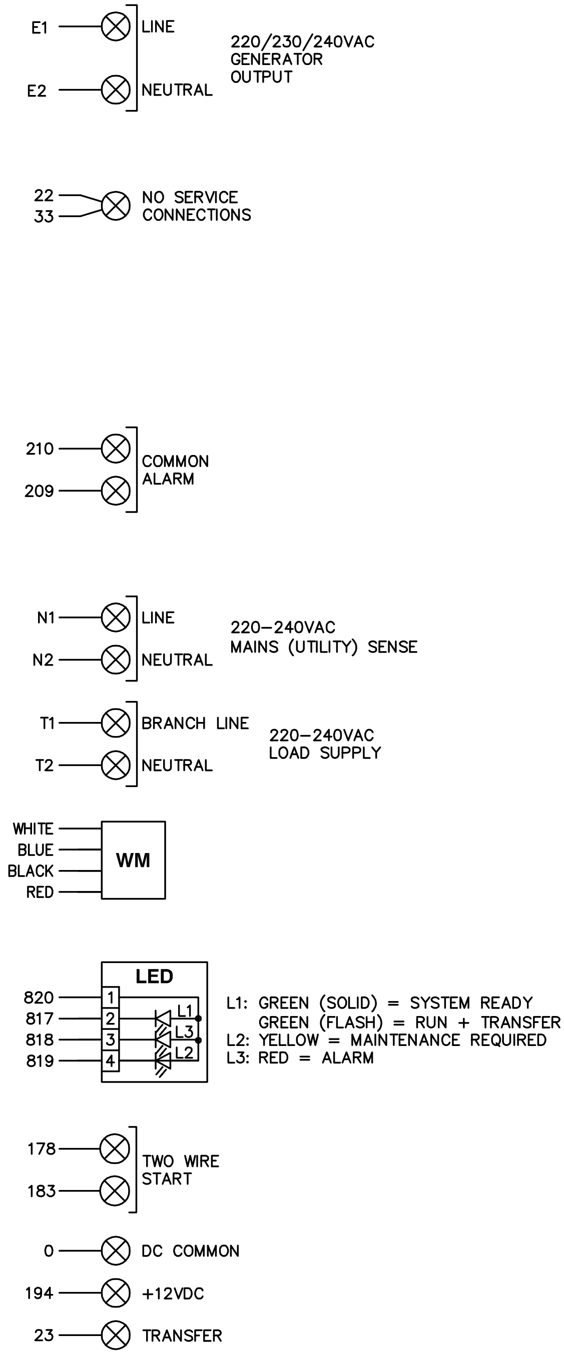
DRAWING #: 10000007481

GROUP WD

LEGEND:	
BA	– BRUSH ASSEMBLY
CB	– CIRCUIT BREAKER, MAIN OUTPUT
CT_	– CURRENT TRANSFORMER
ESC_	– EMERGENCY STOP CONTACT
FL1	– LINE FILTER, DPE
FL2	– LINE FILTER, BATTERY CHARGER
FS	– FUEL SOLENOID
HOT	– HIGH OIL TEMP SWITCH
IM_	– IGNITION MODULE
J_	– MAIN CONTROLLER CONNECTIONS
LED	– LED BOARD
LOP	– LOW OIL PRESSURE SWITCH
R	– RESISTOR
SC	– STARTER CONTACTOR
SCR	– STARTER CONTROL RELAY
SM	– STARTER MOTOR
SP_	– SPARK PLUG
WM	– WIRELESS MODULE



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SCHEMATIC - DIAGRAM

REVISION: G

AC HSB EVO2 50HZ 1PH CE

DATE: 06/28/18

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DRAWING #: 10000007481

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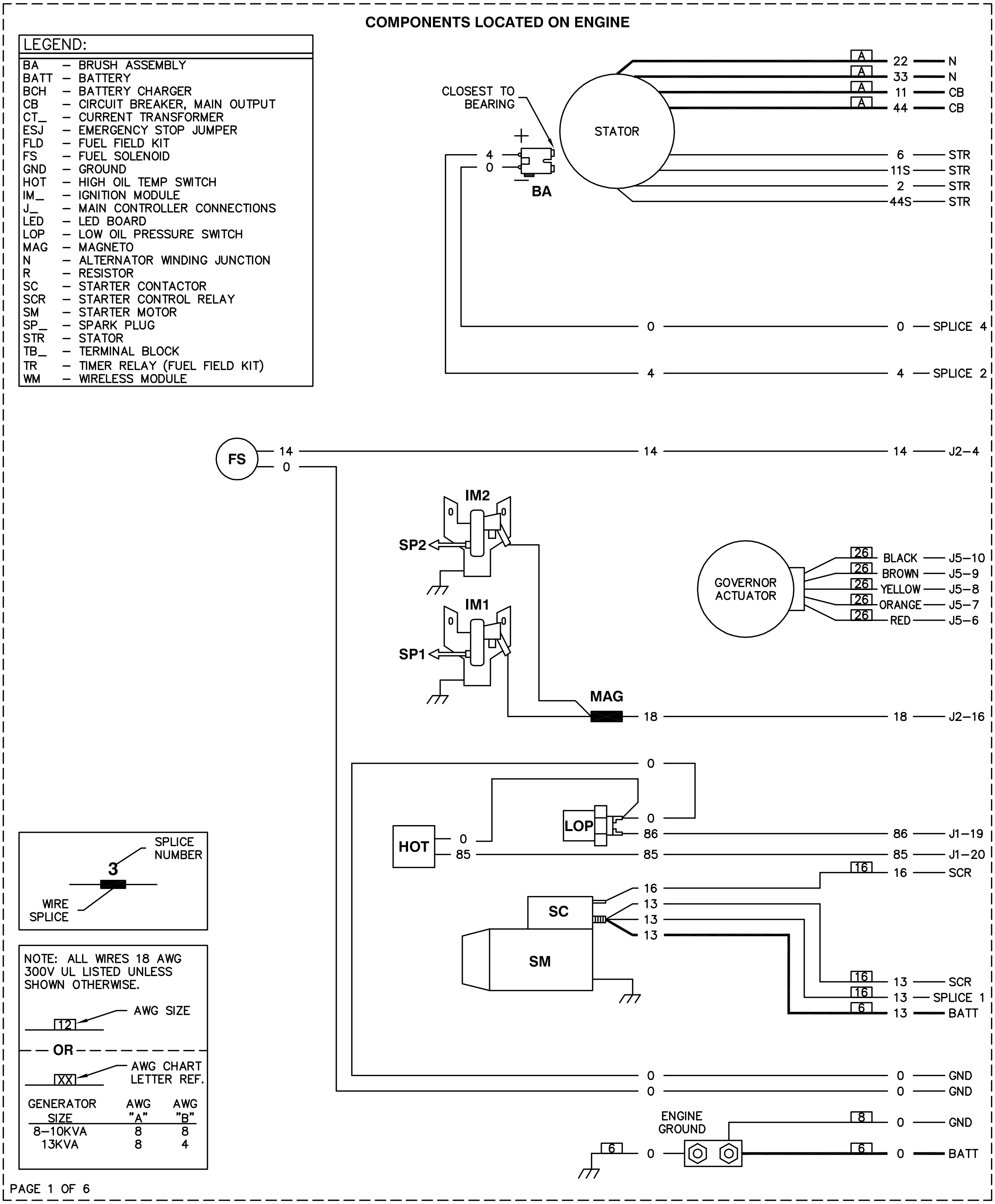
Section 5.4 10000008280-G WD/SD Air-cooled HSB Evolution 2.0 50 Hz Australia

Introduction

The diagrams in this section are provided for general reference only. For unit specific diagrams refer to the Service and Support page at the manufacturer's website.

GROUP WD



WIRING - DIAGRAM

REVISION: G

AC HSB EVO2 50HZ AUS

DATE: 06/28/18

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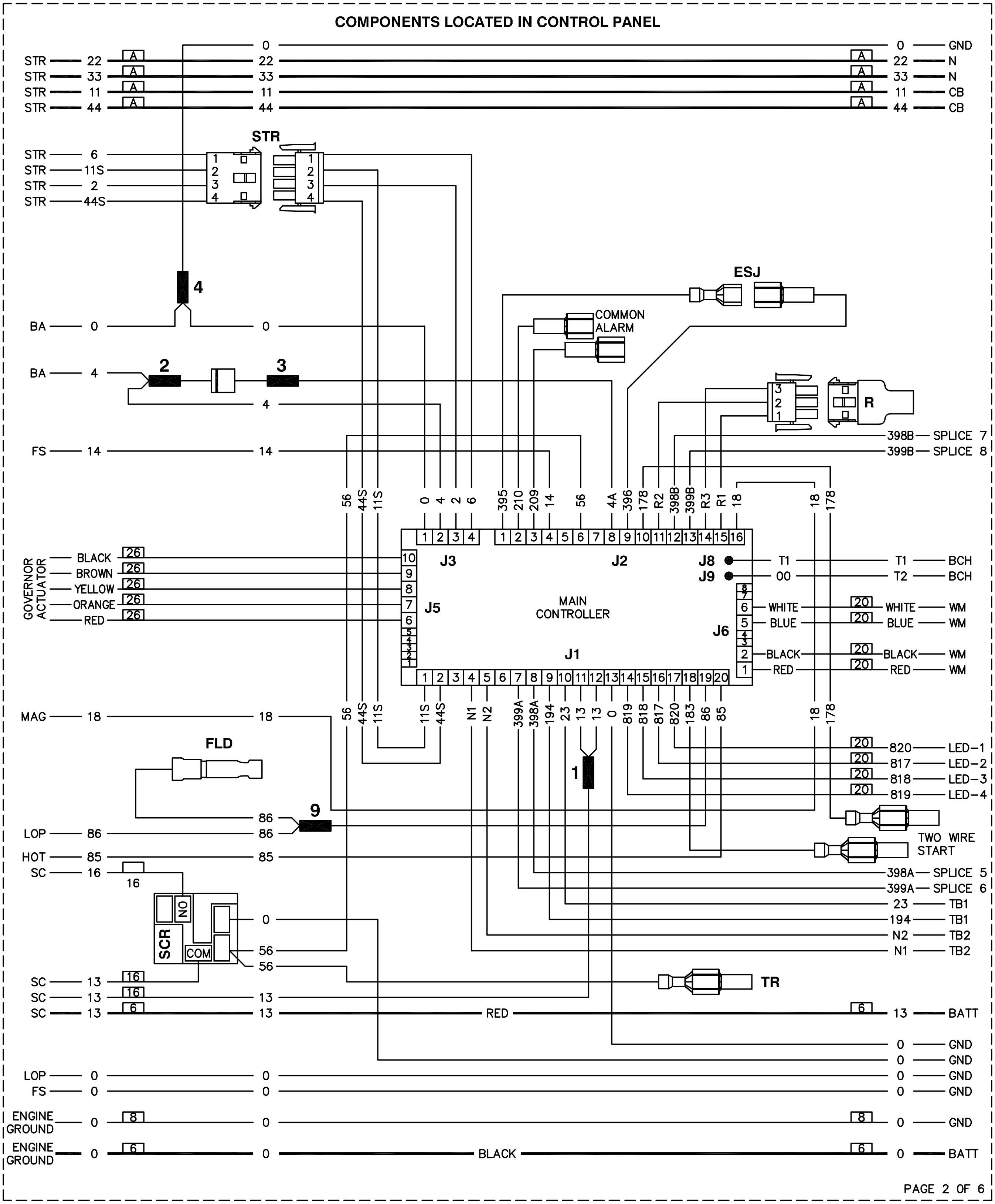
DRAWING #: 10000008280

GROUP WD



WIRING - DIAGRAM

AC HSB EVO2 50HZ AUS

REVISION: G

DATE: 06/28/18

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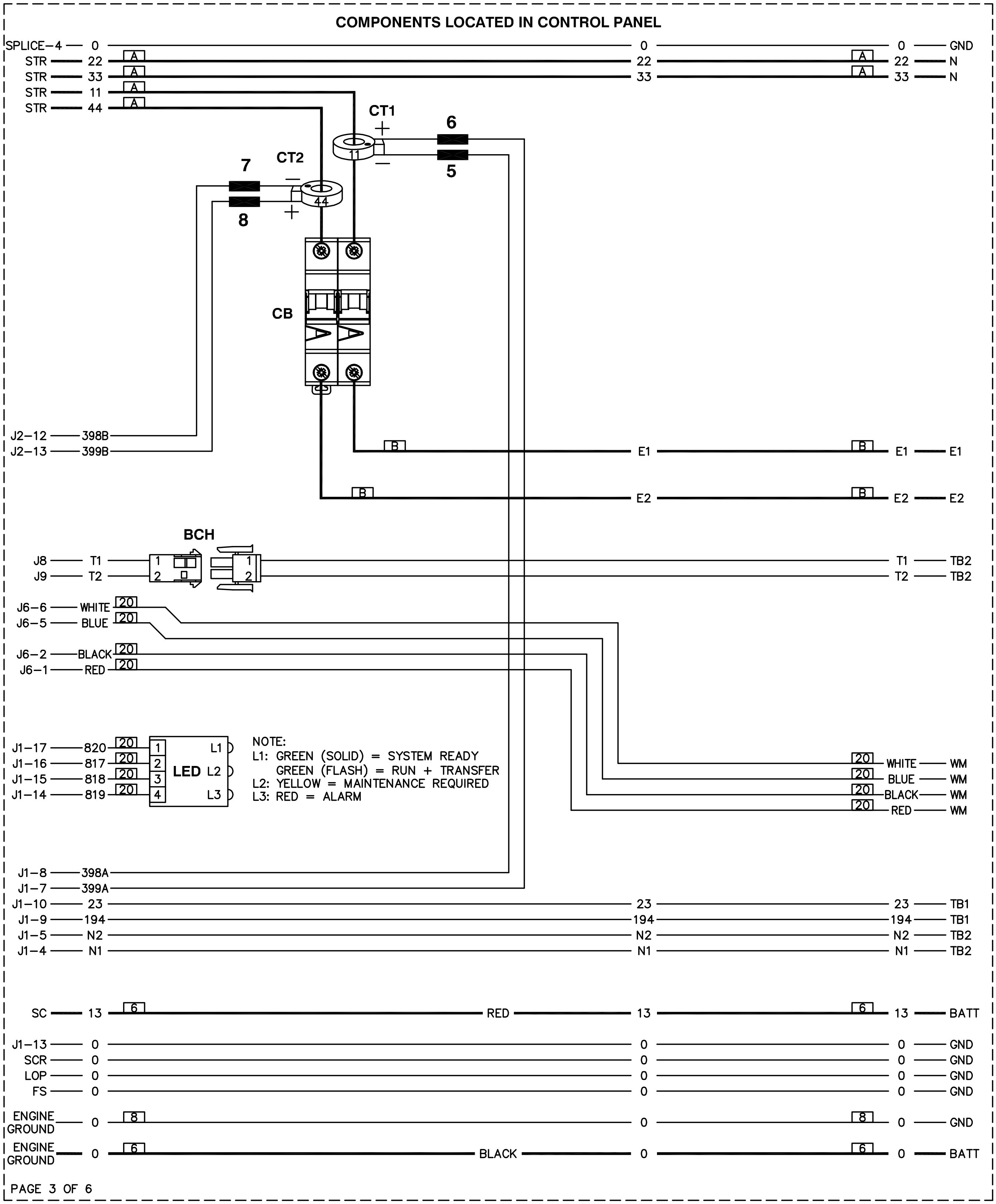
DRAWING #: 10000008280

GROUP WD



WIRING - DIAGRAM

REVISION: G

AC HSB EVO2 50HZ AUS

DATE: 06/28/18

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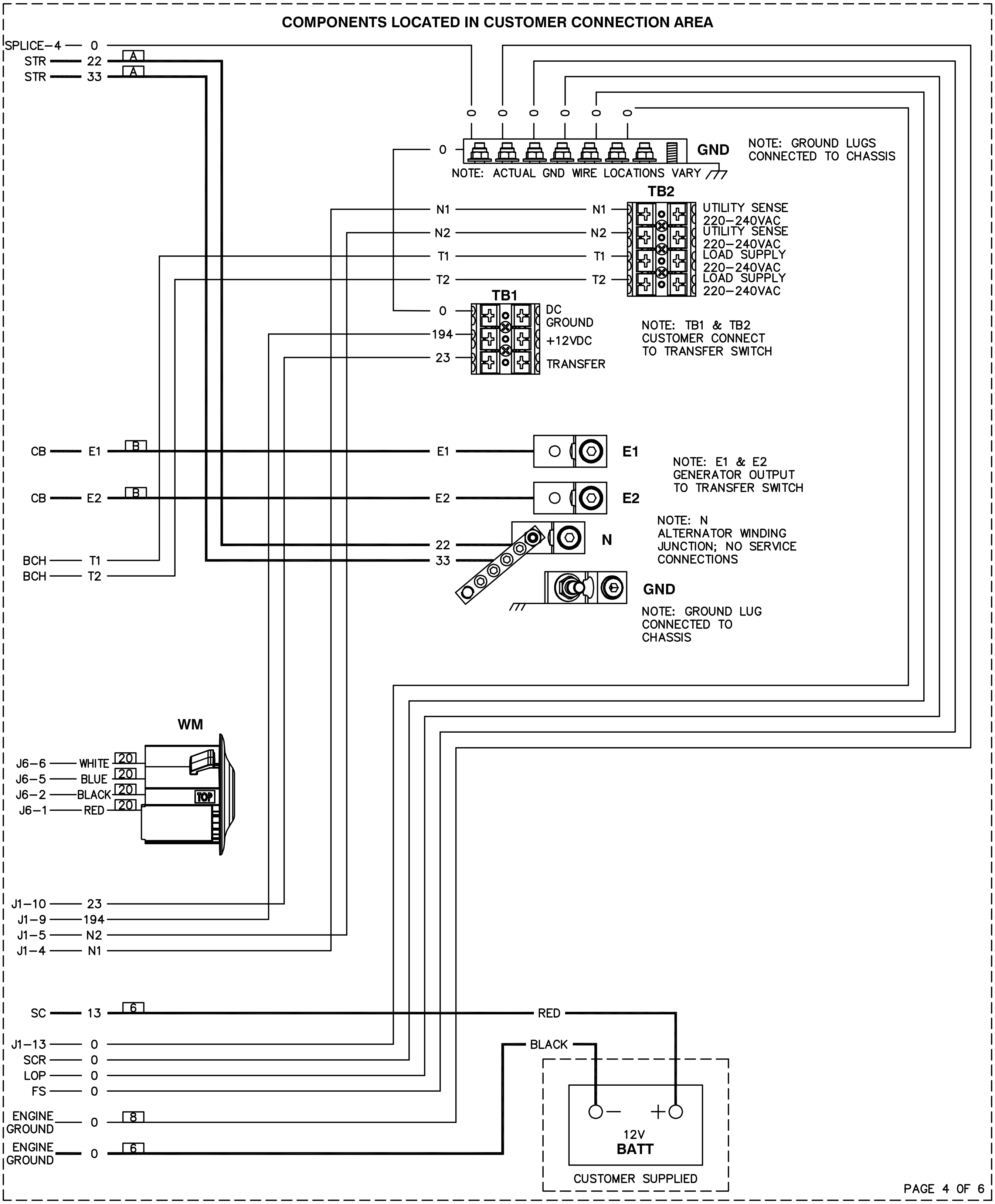
DRAWING #: 10000008280

GROUP WD



WIRING - DIAGRAM

REVISION: G

AC HSB EVO2 50HZ AUS

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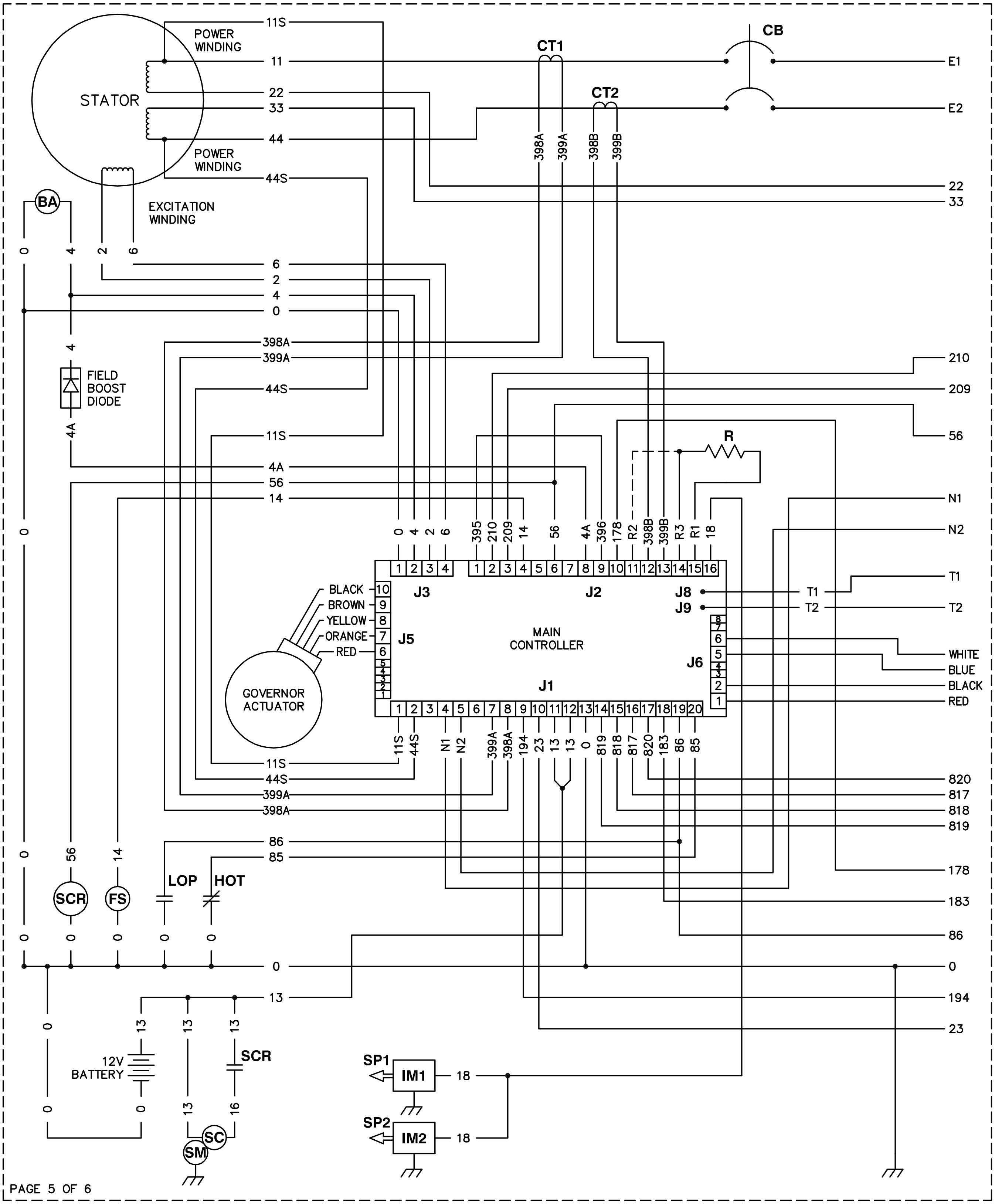
DRAWING #: 10000008280

GROUP WD



SCHEMATIC - DIAGRAM

AC HSB EVO2 50HZ AUS

REVISION: G

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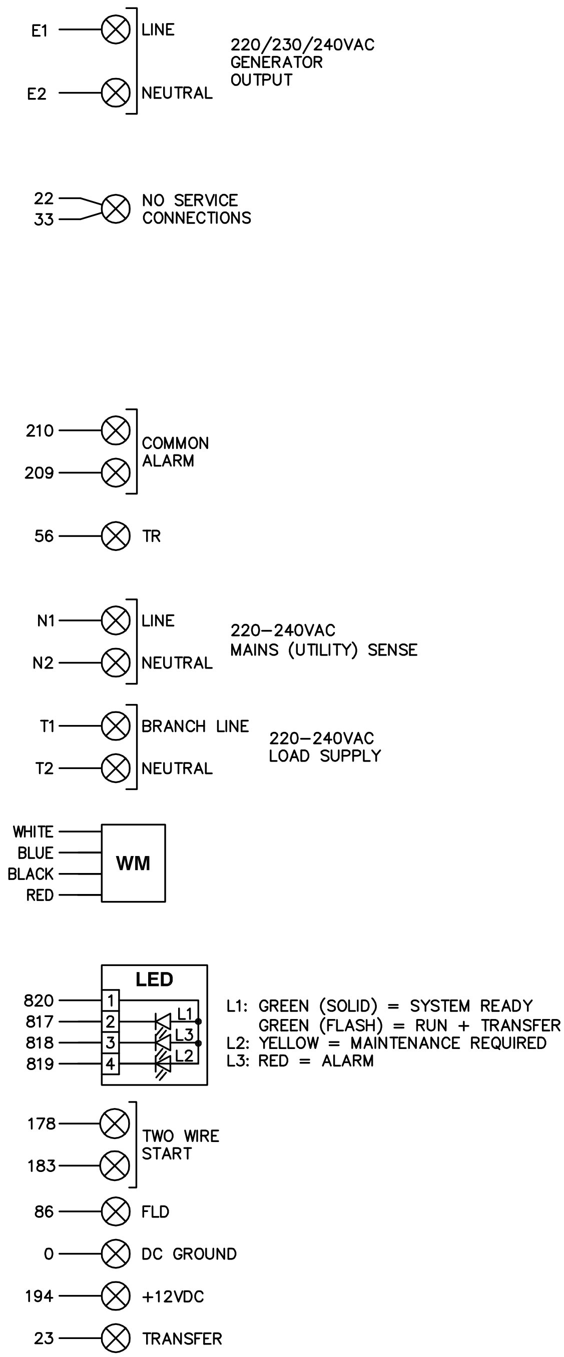
DRAWING #: 10000008280

GROUP WD



LEGEND:

BA	– BRUSH ASSEMBLY
CB	– CIRCUIT BREAKER, MAIN OUTPUT
CT_	– CURRENT TRANSFORMER
FLD	– FUEL FIELD KIT
FS	– FUEL SOLENOID
HOT	– HIGH OIL TEMP SWITCH
IM_	– IGNITION MODULE
J_	– MAIN CONTROLLER CONNECTIONS
LED	– LED BOARD
LOP	– LOW OIL PRESSURE SWITCH
R	– RESISTOR
SC	– STARTER CONTACTOR
SCR	– STARTER CONTROL RELAY
SM	– STARTER MOTOR
SP_	– SPARK PLUG
TR	– TIMER RELAY (FUEL FIELD KIT)
WM	– WIRELESS MODULE

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SCHEMATIC - DIAGRAM

AC HSB EVO2 50HZ AUS

REVISION: G

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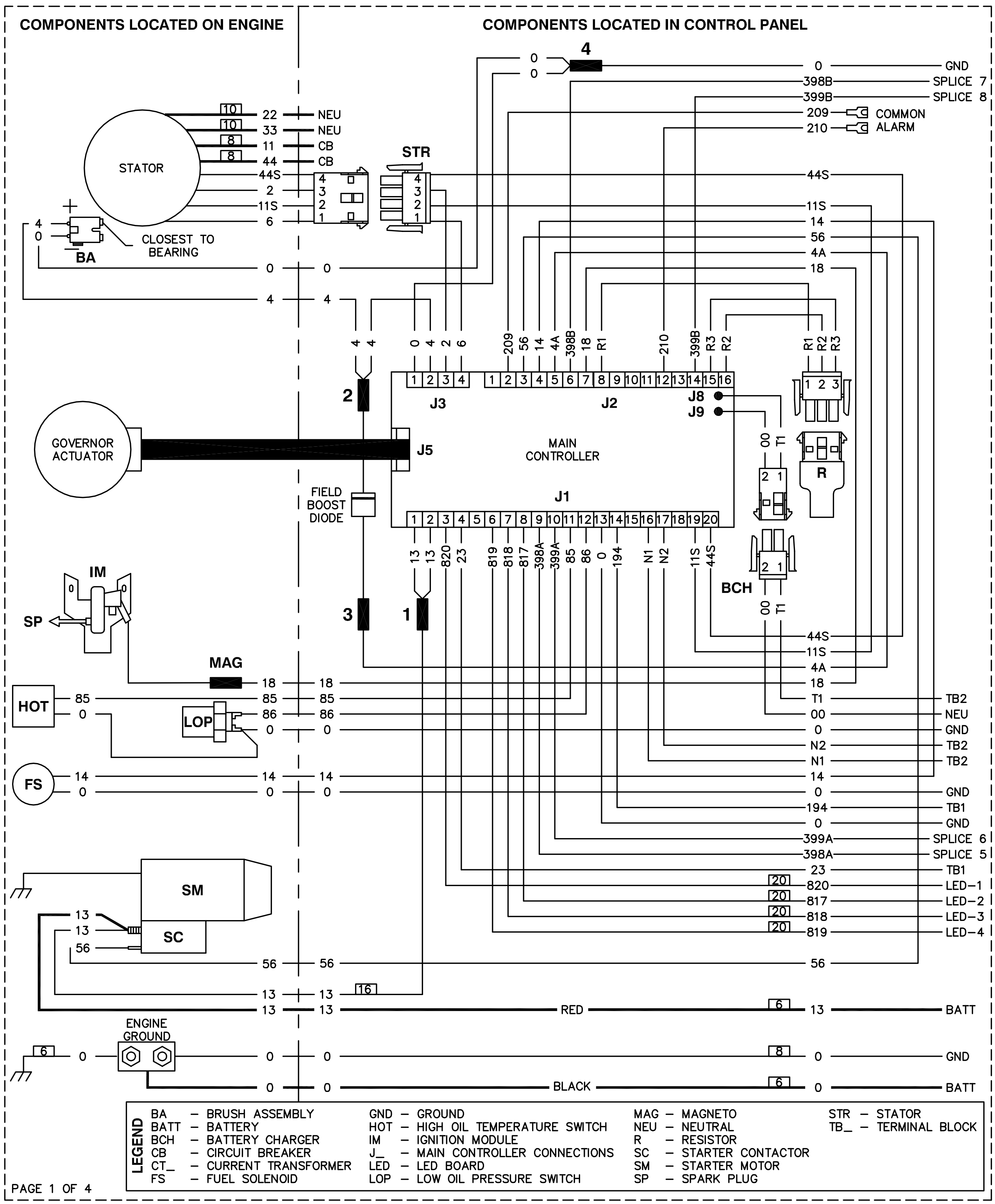
Section 5.5 *0L6822-B WD/SD Air-cooled 2017 Evolution 1.0 and newer (not Evolution 2.0) 9 kW 60 Hz*

Introduction

The diagrams in this section are provided for general reference only. For unit specific diagrams refer to the Service and Support page at the manufacturer's website.

GROUP WD



WIRING - DIAGRAM

REVISION: B

AIR COOLED HSB 9KW

DATE: 03/08/17

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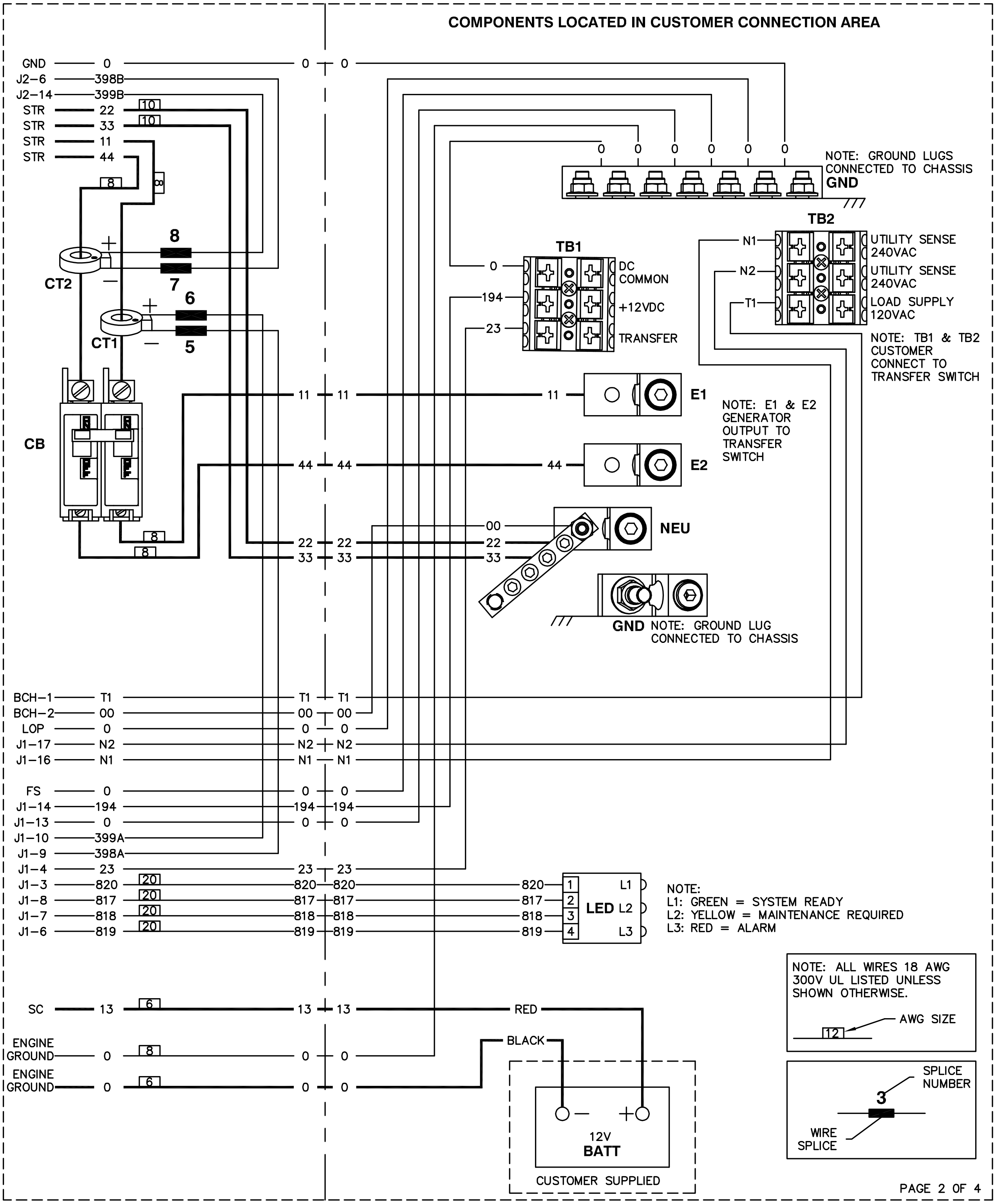
GROUP WD



WIRING - DIAGRAM

REVISION: B — AIR COOLED HSB 9KW

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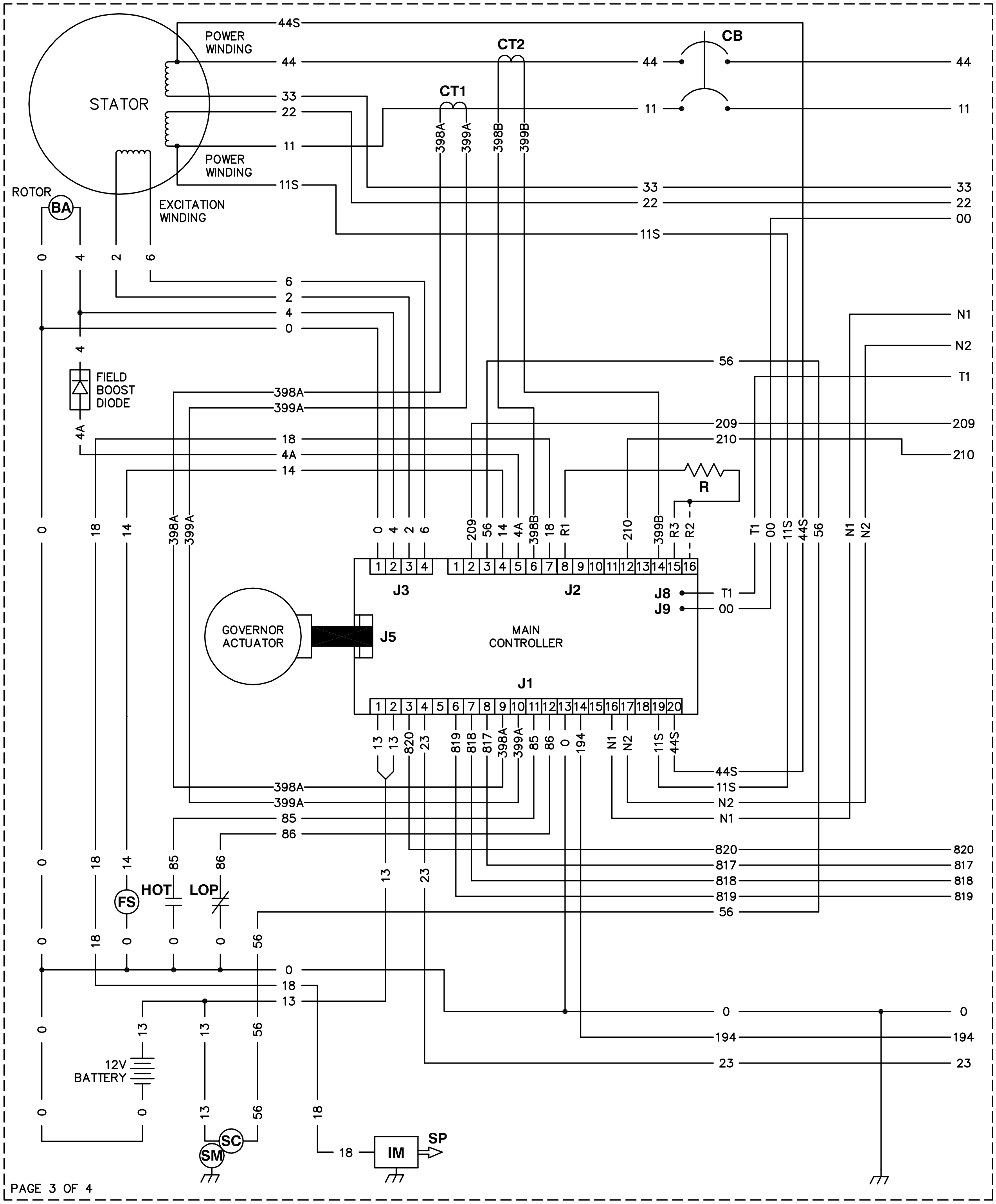
GROUP WD



SCHEMATIC - DIAGRAM

REVISION: B

AIR COOLED HSB 9KW

DATE: 03/08/17

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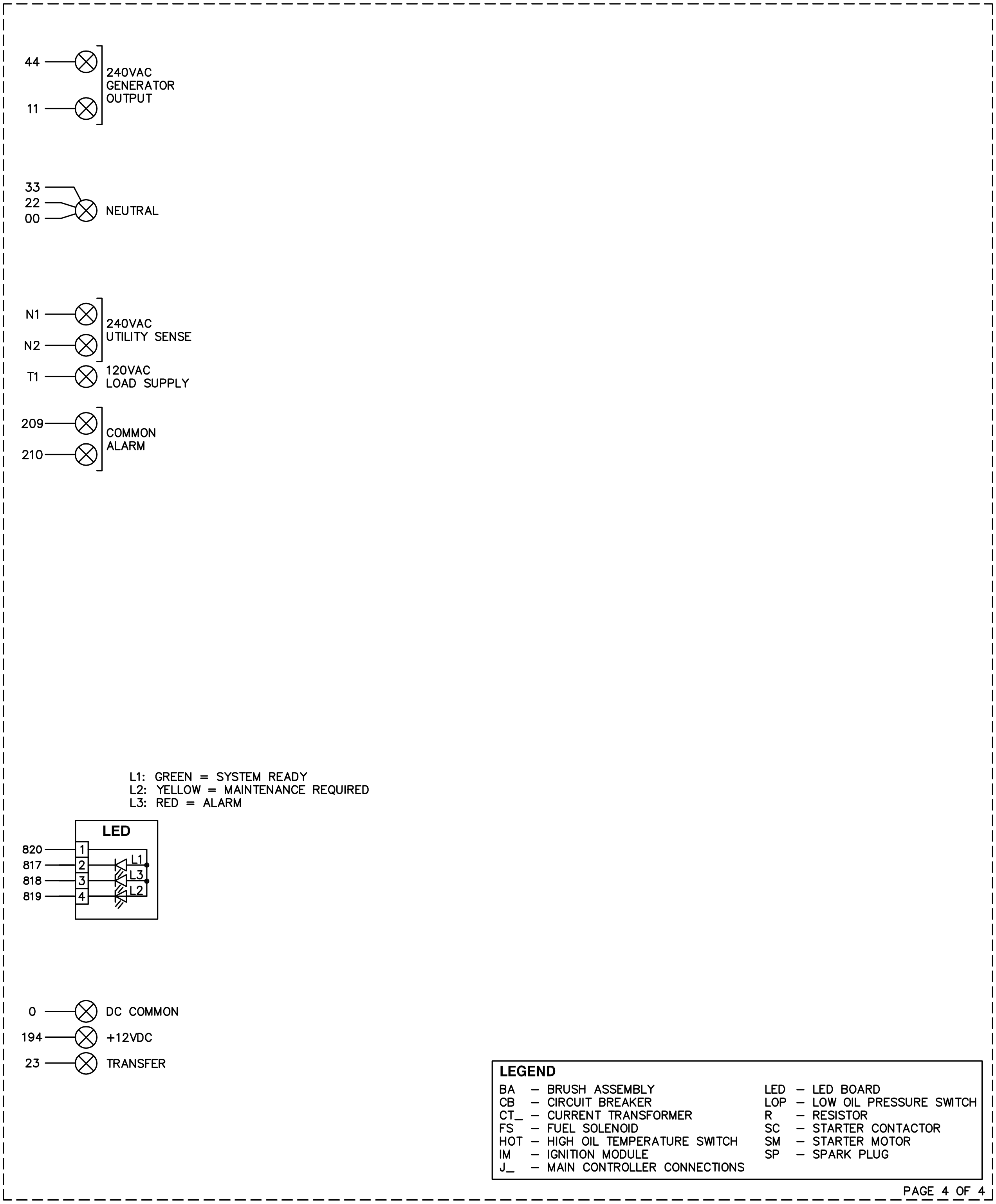
GROUP WD



SCHEMATIC - DIAGRAM

REVISION: B

AIR COOLED HSB 9KW

DATE: 03/08/17

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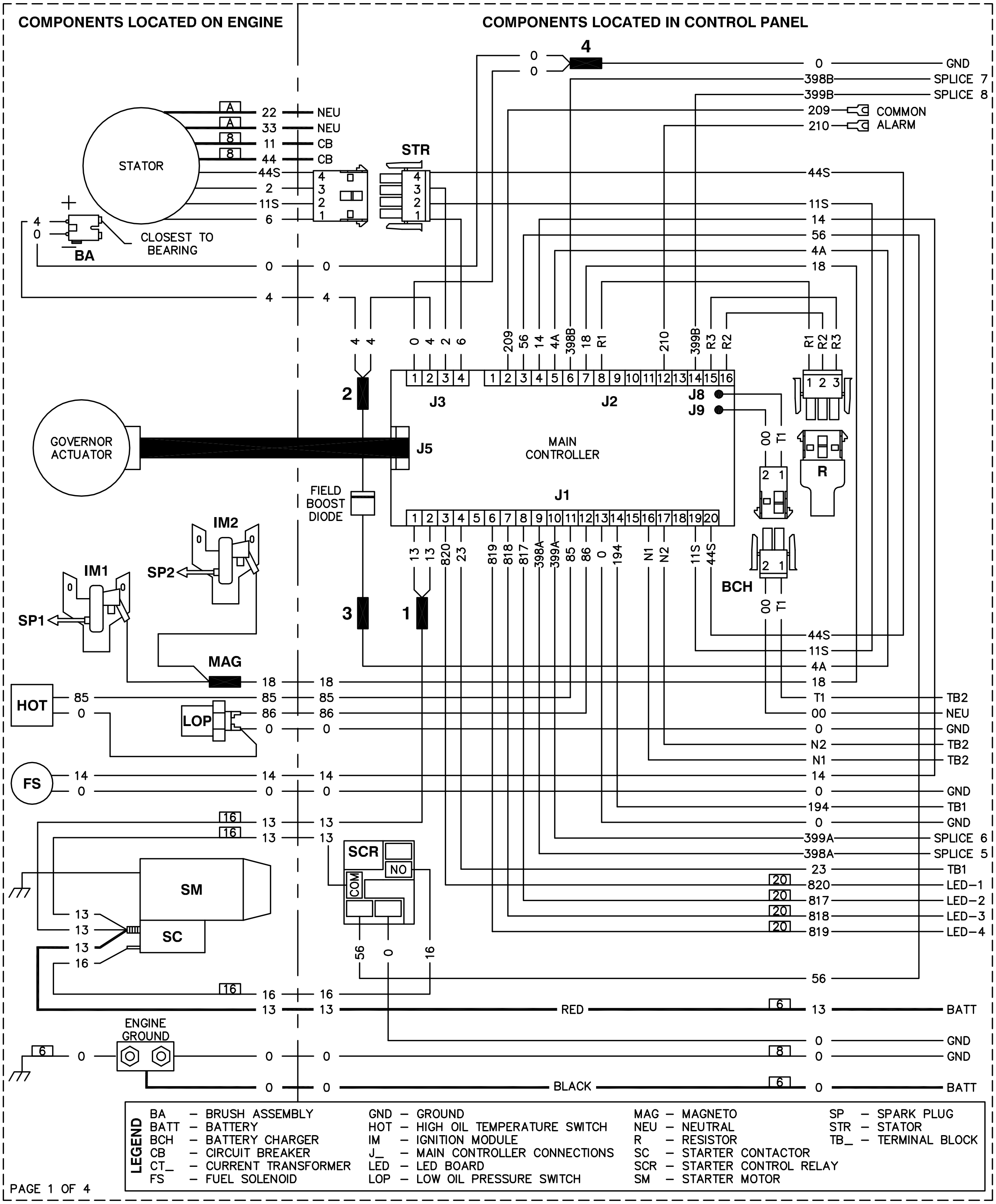
Section 5.6 *0L6823-B WD/SD Air-cooled 2017 Evolution 1.0 and newer (not Evolution 2.0) 60 Hz*

Introduction

The diagrams in this section are provided for general reference only. For unit specific diagrams refer to the Service and Support page at the manufacturer’s website.

GROUP WD



WIRING - DIAGRAM

AIR COOLED HSB 60HZ

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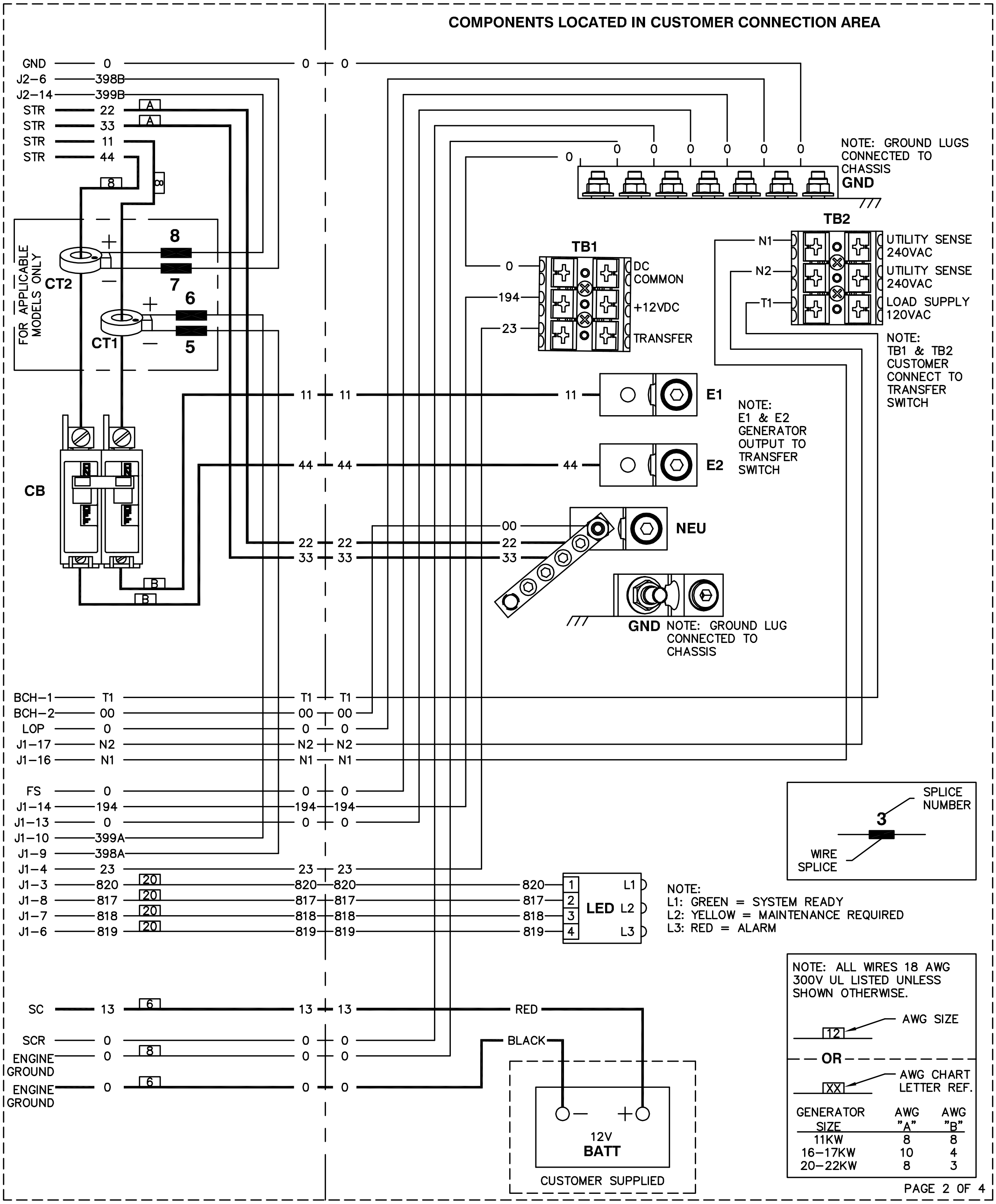
GROUP WD



WIRING - DIAGRAM

REVISION: B

AIR COOLED HSB 60HZ

DATE: 03/15/17

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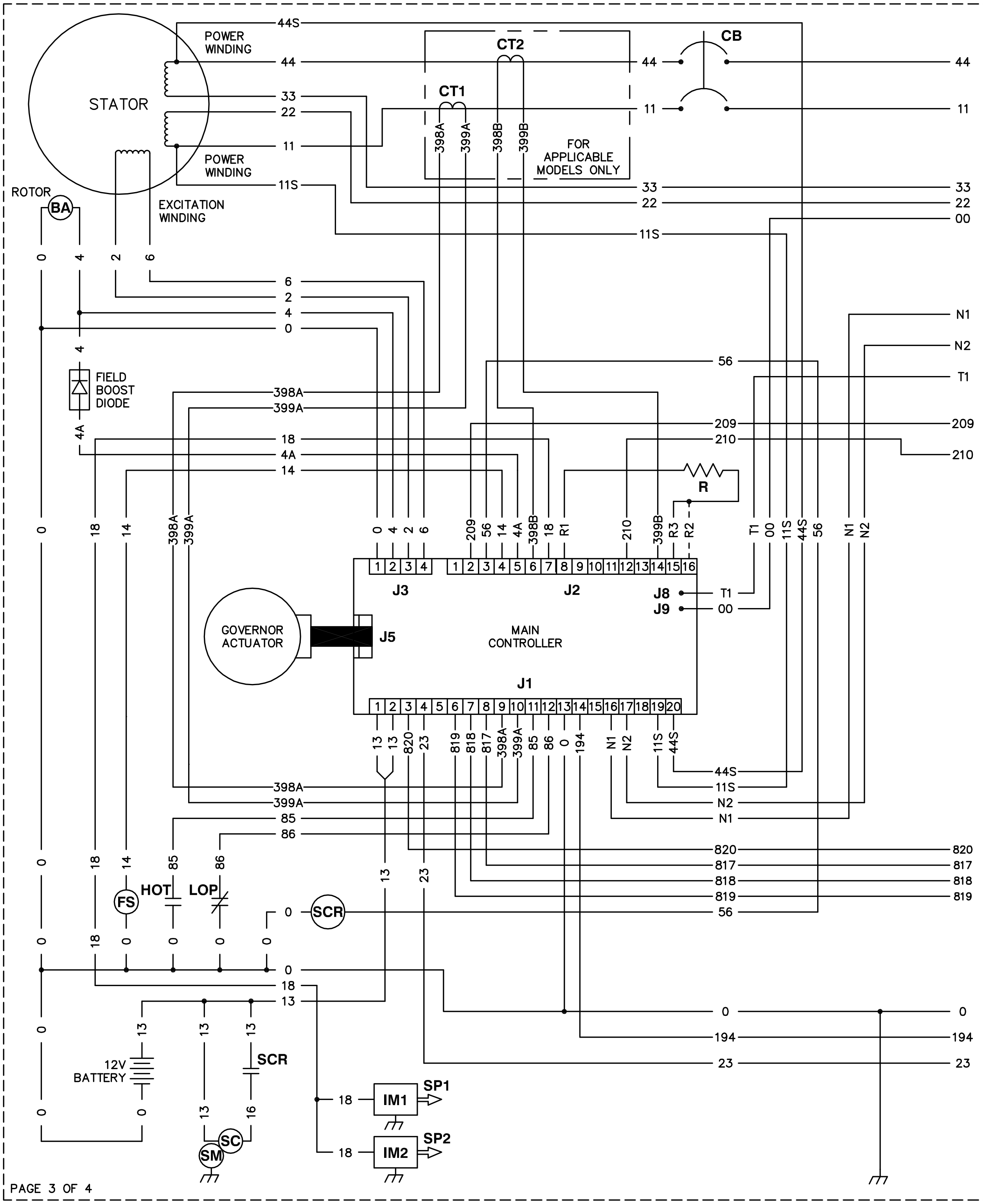
DRAWING #: 0L6823

GROUP WD



SCHEMATIC - DIAGRAM

REVISION: B
AIR COOLED HSB 60HZ

DATE: 03/15/17
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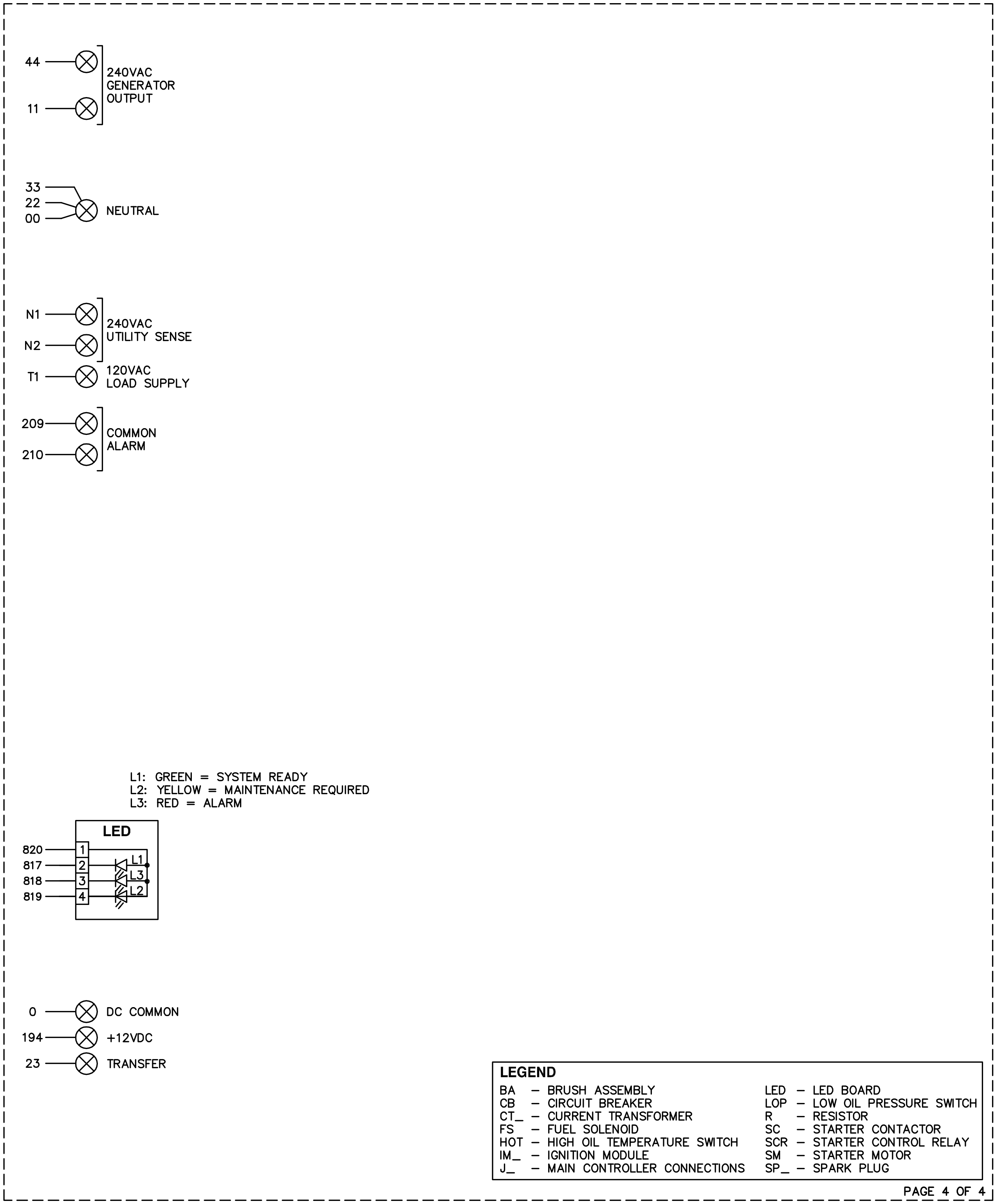
DRAWING #: 0L6823

GROUP WD



SCHEMATIC - DIAGRAM

REVISION: B

AIR COOLED HSB 60HZ

DATE: 03/15/17

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DRAWING #: 0L6823

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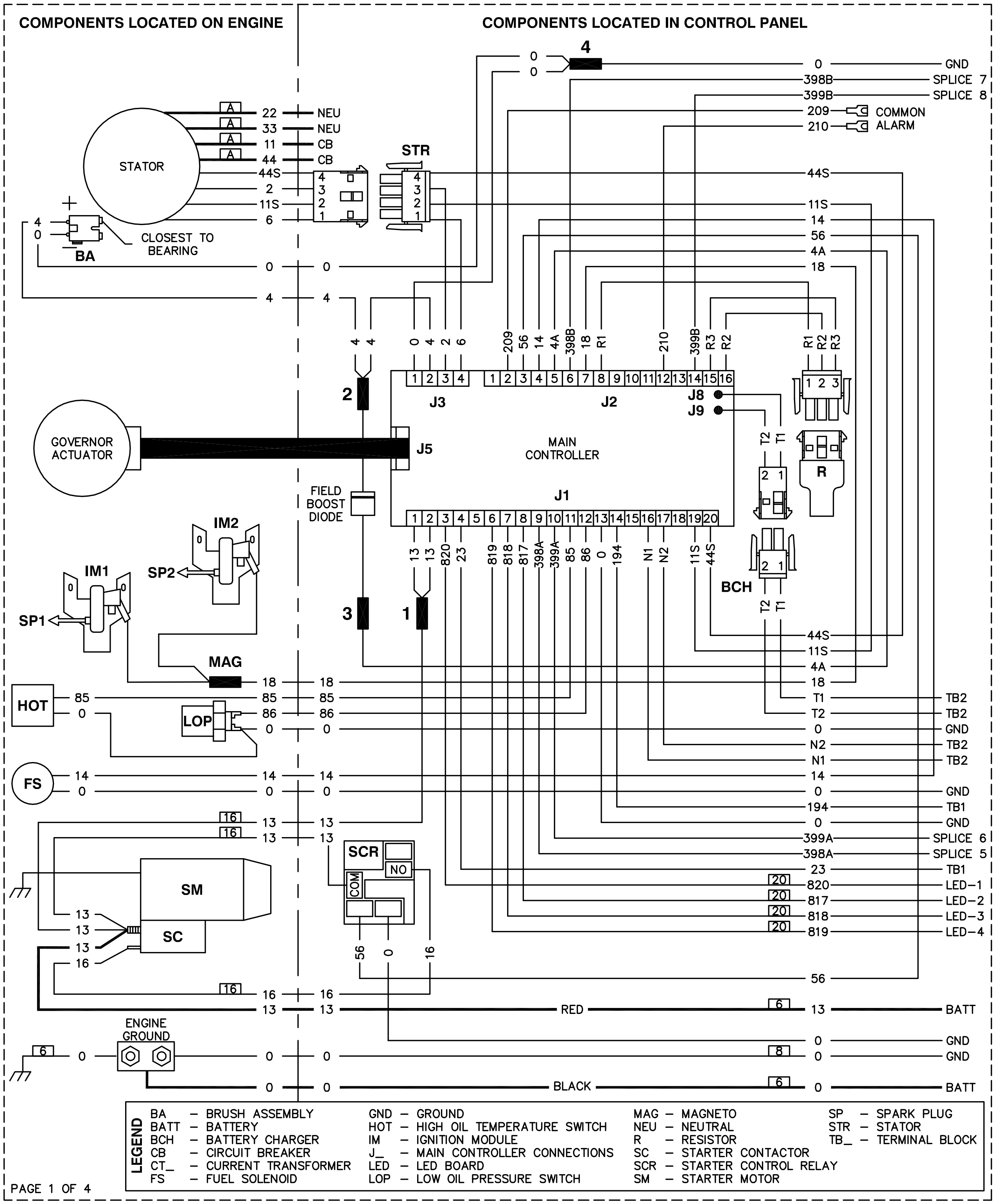
Section 5.7 *0L6824-B WD/SD Air-cooled 2017 Evolution 1.0 and newer (not Evolution 2.0) 50 Hz*

Introduction

The diagrams in this section are provided for general reference only. For unit specific diagrams refer to the Service and Support page at the manufacturer’s website.

GROUP WD



WIRING - DIAGRAM

AIR COOLED HSB 50HZ

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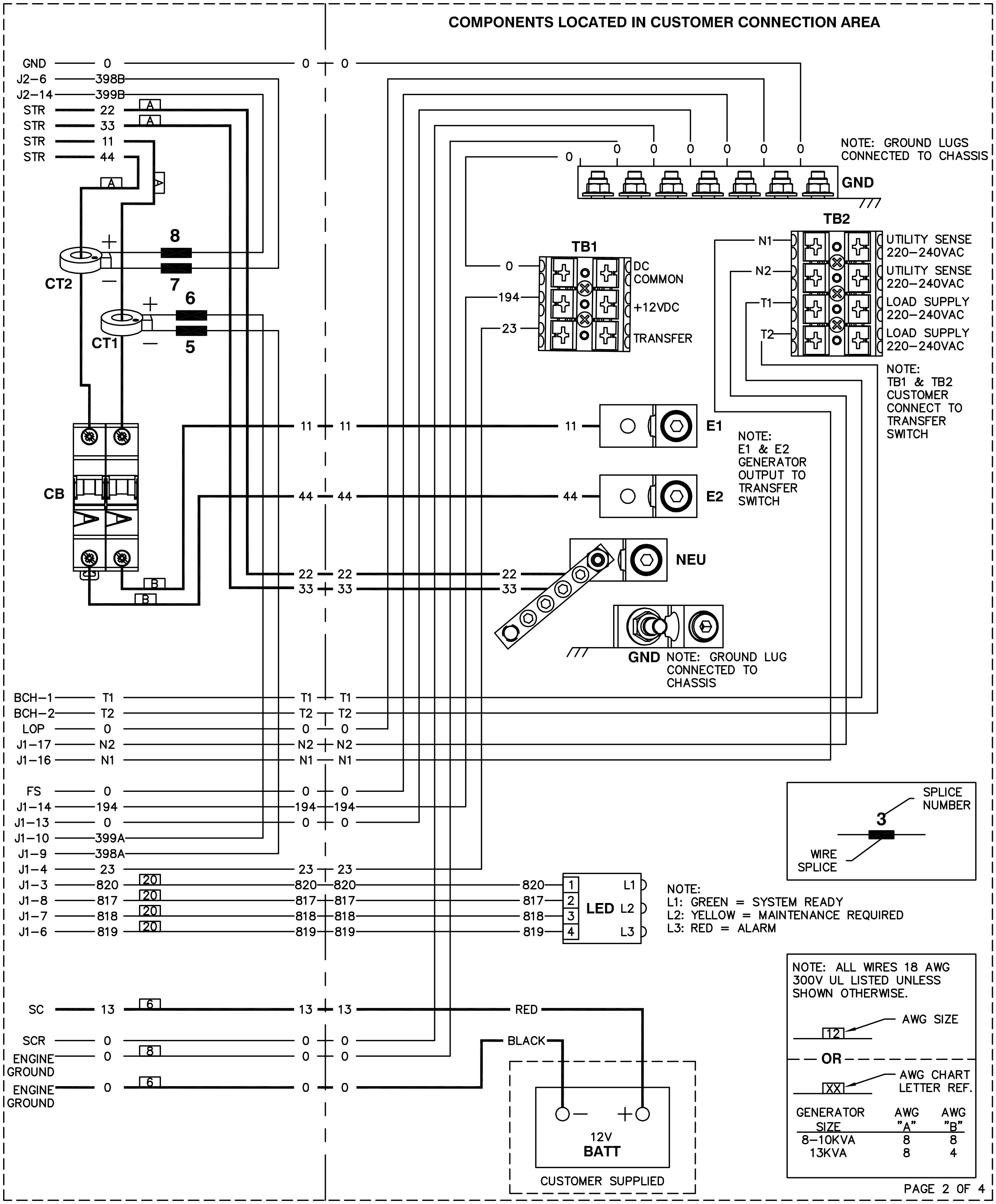
DRAWING #: 0L6824

GROUP WD



WIRING - DIAGRAM

REVISION: B

AIR COOLED HSB 50HZ

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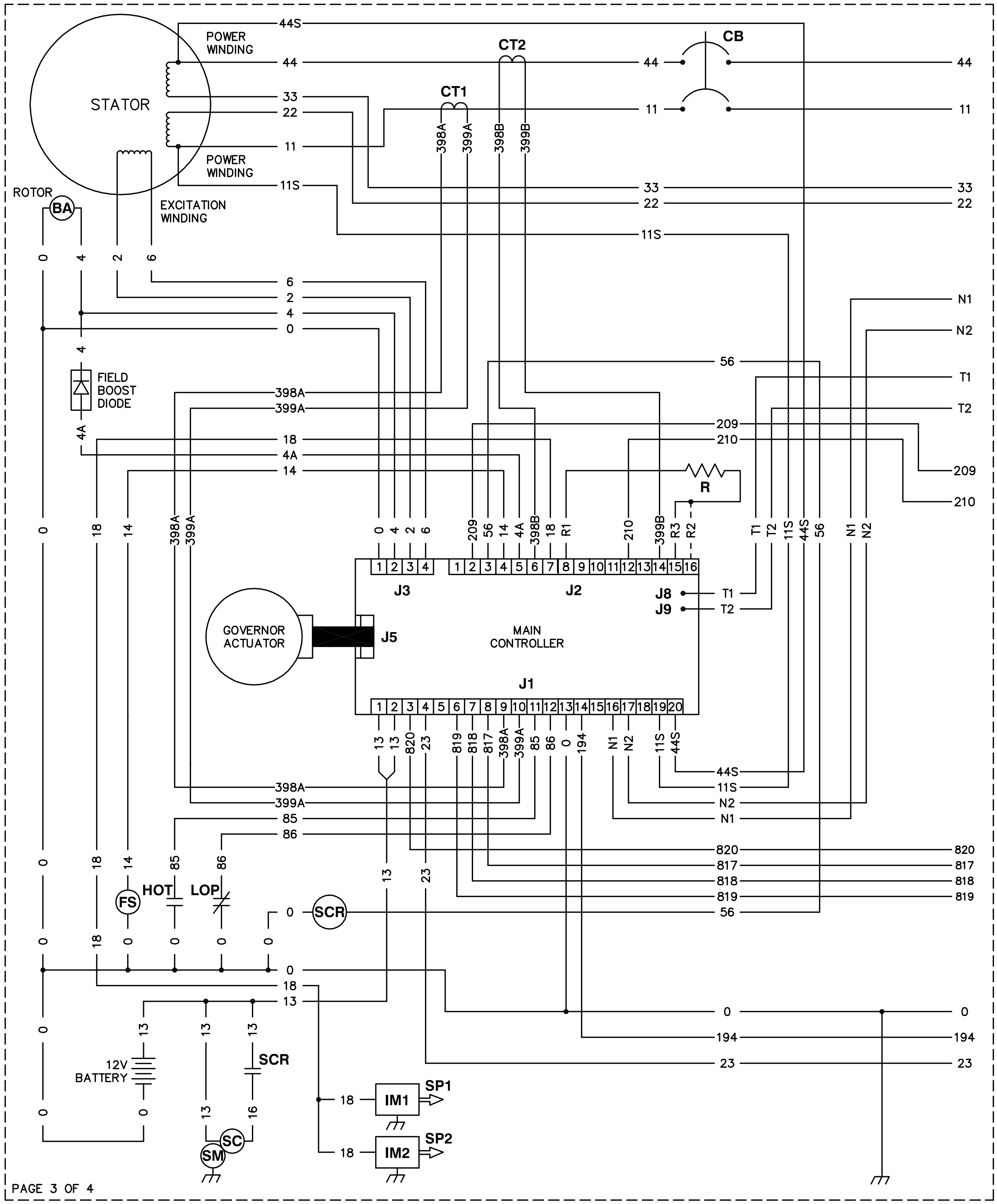
DRAWING #: 0L6824

GROUP WD



SCHEMATIC - DIAGRAM

REVISION: B

AIR COOLED HSB 50HZ

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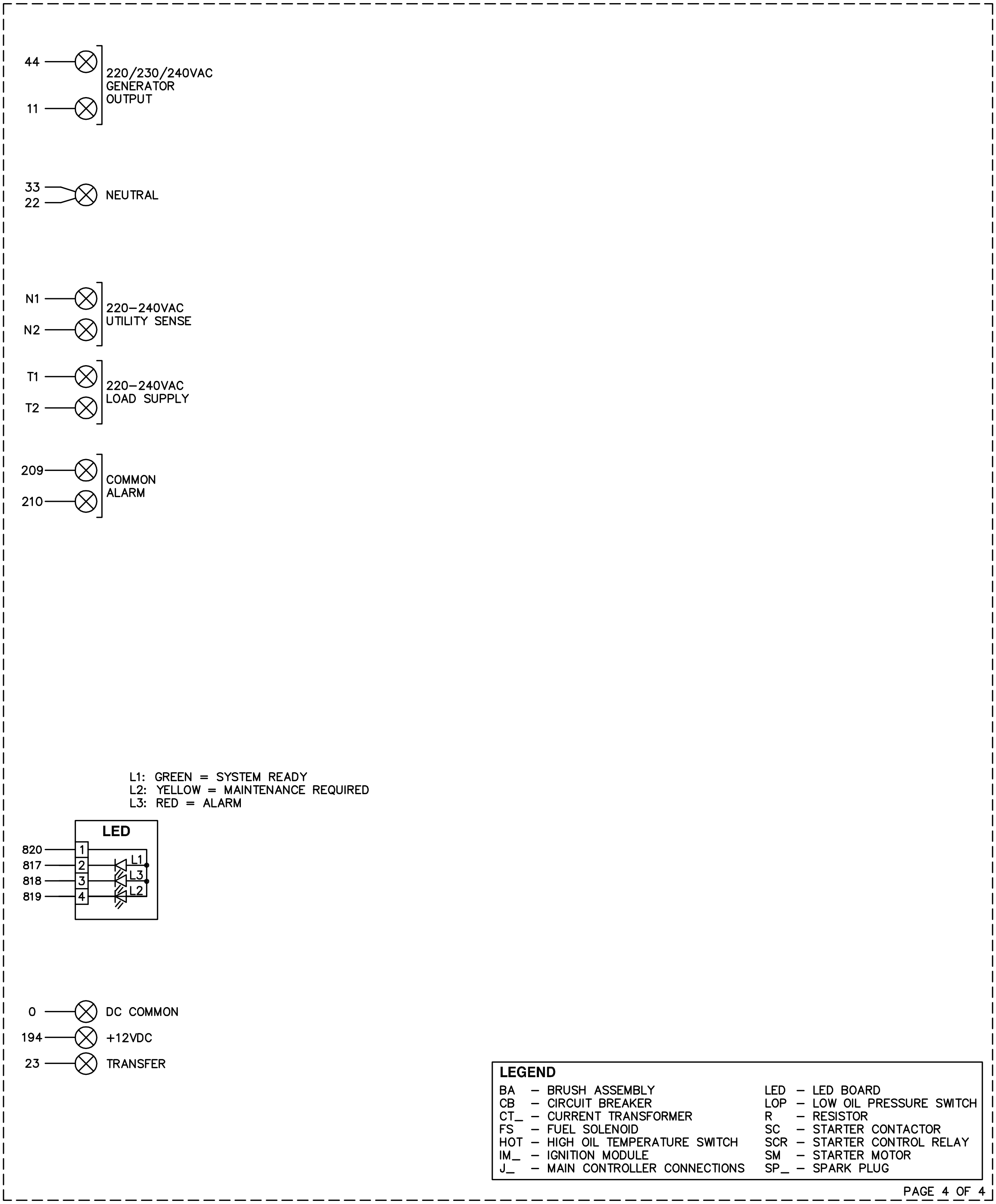
DRAWING #: 0L6824

GROUP WD



SCHEMATIC - DIAGRAM

REVISION: B

AIR COOLED HSB 50HZ

DATE: 03/08/17

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DRAWING #: 0L6824

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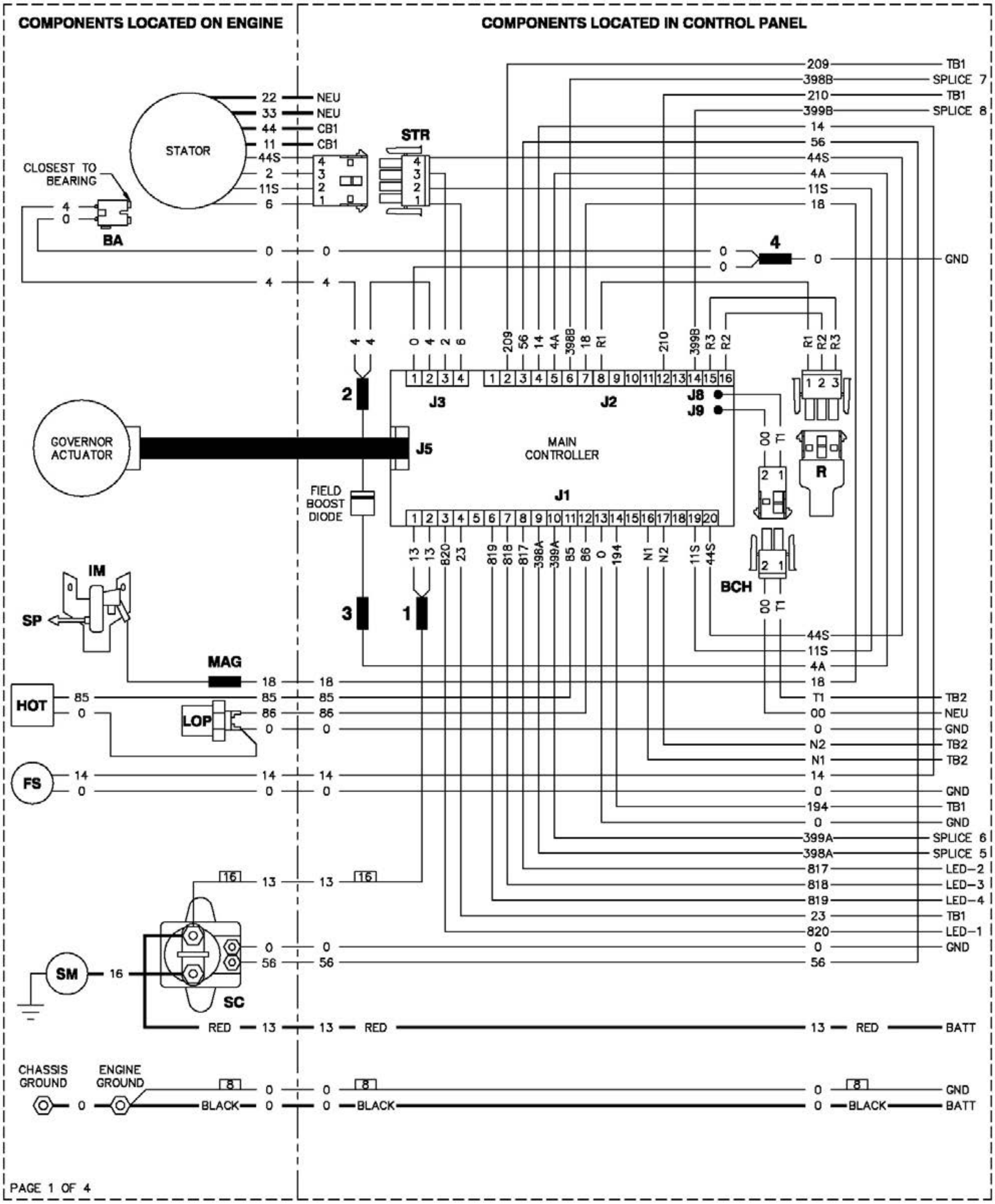
Section 5.8 *0K2945-E WD/SD Air-cooled 2017 Evolution 1.0 and newer (not Evolution 2.0) 8 kW 60 Hz*

Introduction

The diagrams in this section are provided for general reference only. For unit specific diagrams refer to the Service and Support page at the manufacturer's website.

GROUP G



WIRING - DIAGRAM

8KW 2013 AIR COOLED HSB

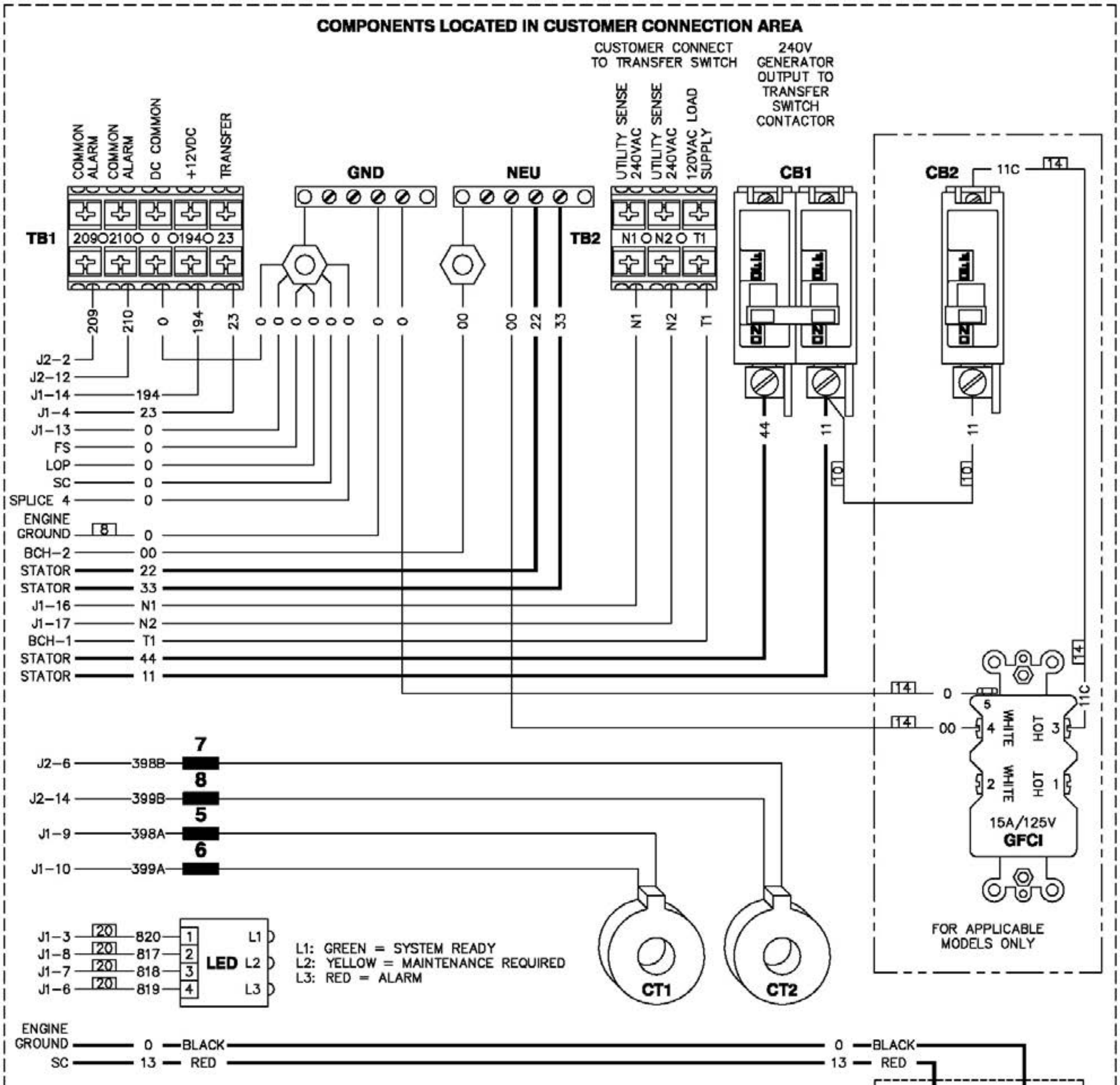
REVISION: J-7579-E

DATE: 1/21/14

PAGE 1 OF 4

DRAWING #: 0K2945

GROUP G



LEGEND

BA	BRUSH ASSEMBLY	NEU	NEUTRAL
BATT	BATTERY	R	RESISTOR
BCH	BATTERY CHARGER	SC	STARTER CONTACTOR
CB1	CIRCUIT BREAKER (MAIN OUTPUT)	SM	STARTER MOTOR
CB2	CIRCUIT BREAKER (GFCI)	SP	SPARK PLUG
CT_	CURRENT TRANSFORMER	STR	STATOR
FS	FUEL SOLENOID	TB_	TERMINAL BLOCKS
GFCI	GROUND FAULT CIRCUIT INTERRUPT		
GND	GROUND		
HOT	HIGH OIL TEMPERATURE SWITCH		
IM	IGNITION MODULE		
LED	LED BOARD		
LOP	LOW OIL PRESSURE SWITCH		
MAG	MAGNETO		

NOTE: ALL WIRES 18 AWG 300V UL LISTED UNLESS SHOWN OTHERWISE.

12 — AWG SIZE

3 — SPLICE NUMBER

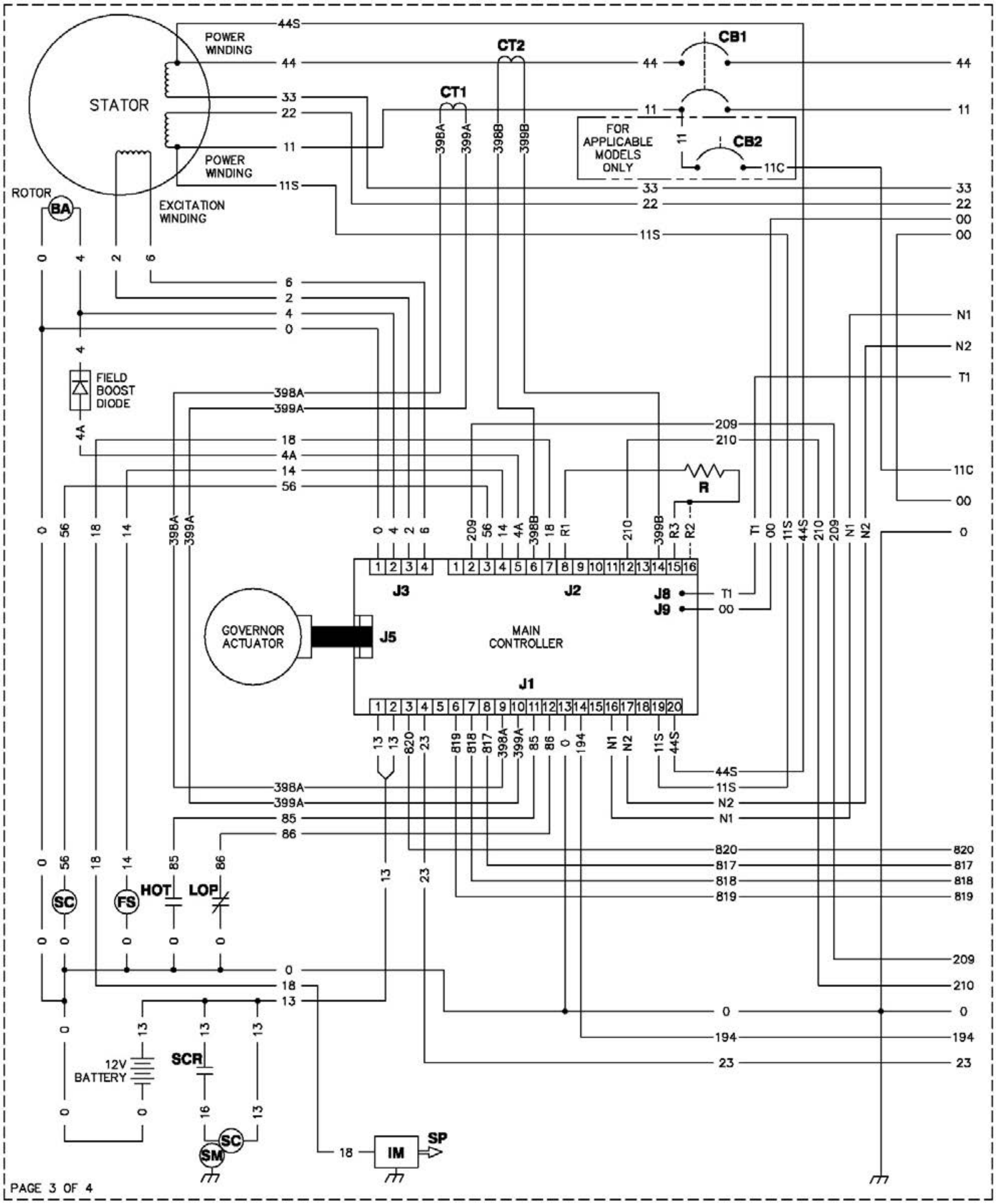
WIRE SPLICE

PAGE 2 OF 4

WIRING - DIAGRAM
8KW 2013 AIR COOLED HSB
DRAWING #: 0K2945

REVISION: J-7579-E
DATE: 1/21/14
PAGE 2 OF 4

GROUP G



SCHEMATIC - DIAGRAM

8KW 2013 AIR COOLED HSB

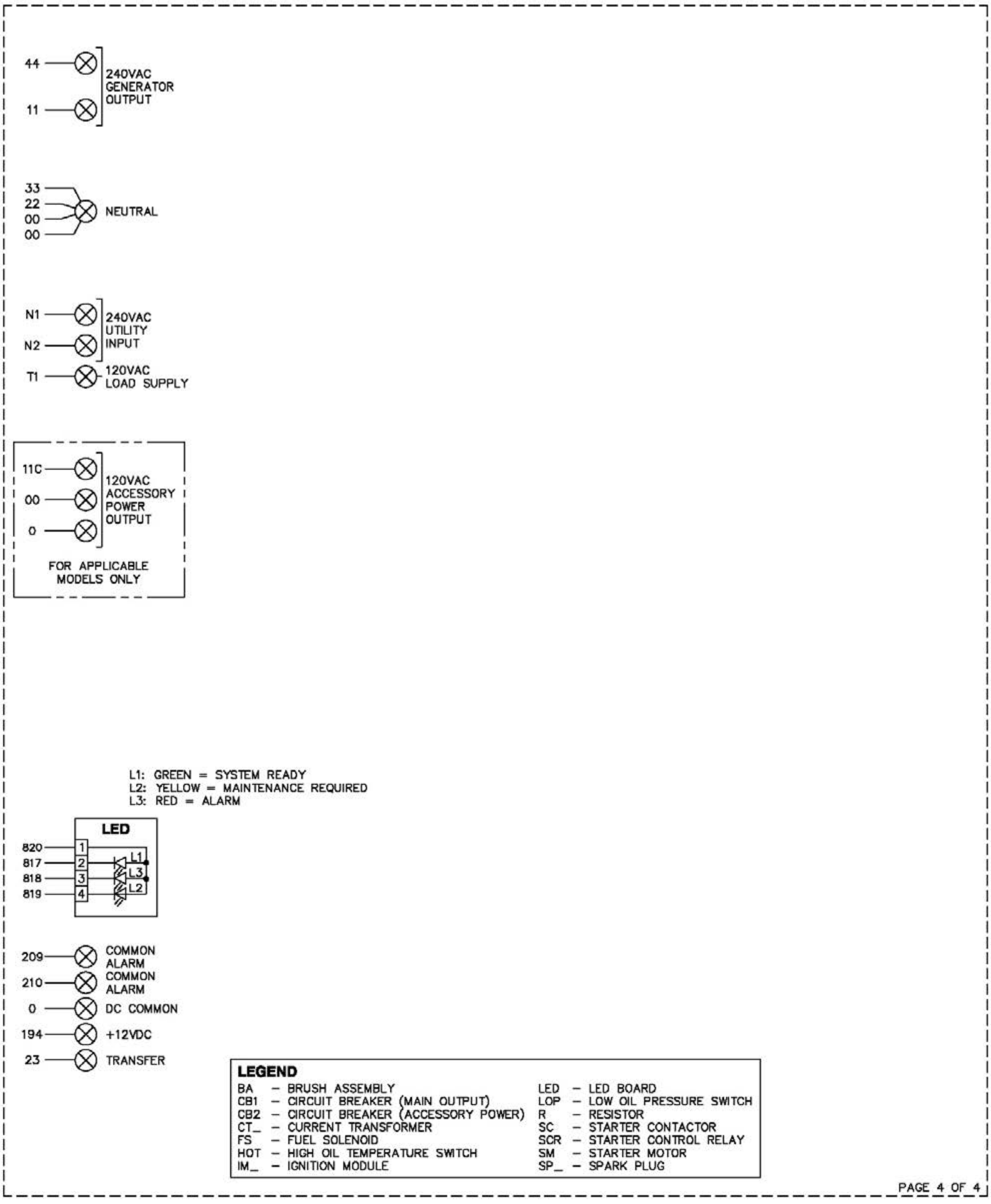
REVISION: J-7579-E

DATE: 1/21/14

PAGE 3 OF 4

DRAWING #: 0K2945

GROUP G



SCHEMATIC - DIAGRAM

8KW 2013 AIR COOLED HSB

REVISION: J-7579-E

DATE: 1/21/14

PAGE 4 OF 4

DRAWING #: 0K2945

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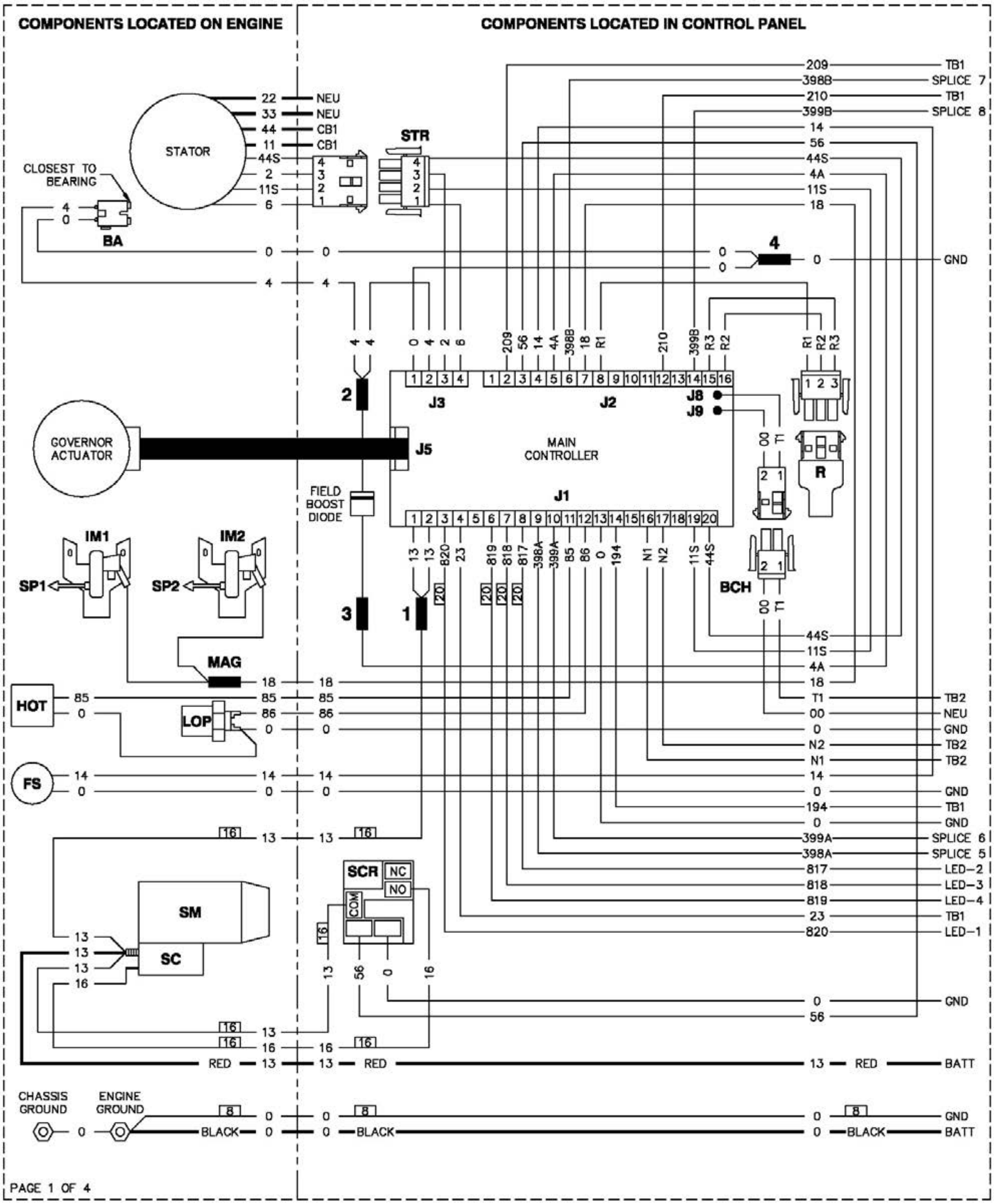
Section 5.9 *0J9961-D WD/SD Air-cooled Pre 2016 Evolution 1.0 (not Evolution 2.0) 11-24 kW 60 Hz*

Introduction

The diagrams in this section are provided for general reference only. For unit specific diagrams refer to the Service and Support page at the manufacturer's website.

GROUP G

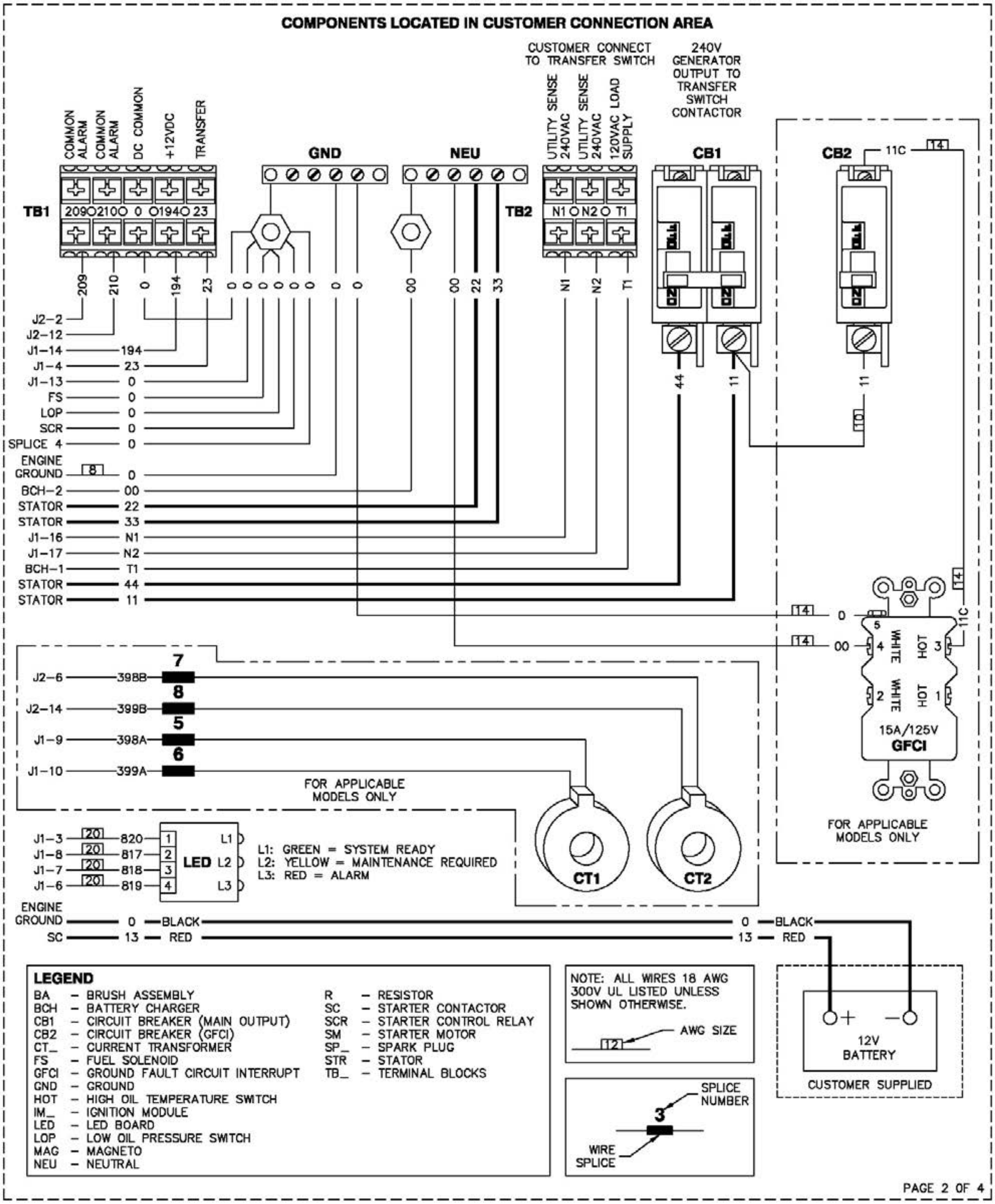


WIRING - DIAGRAM
2013 AIR COOLED HSB 60HZ
DRAWING #: 0J9961

REVISION: J-5714-D
DATE: 6/19/13

PAGE 1 OF 4

GROUP G

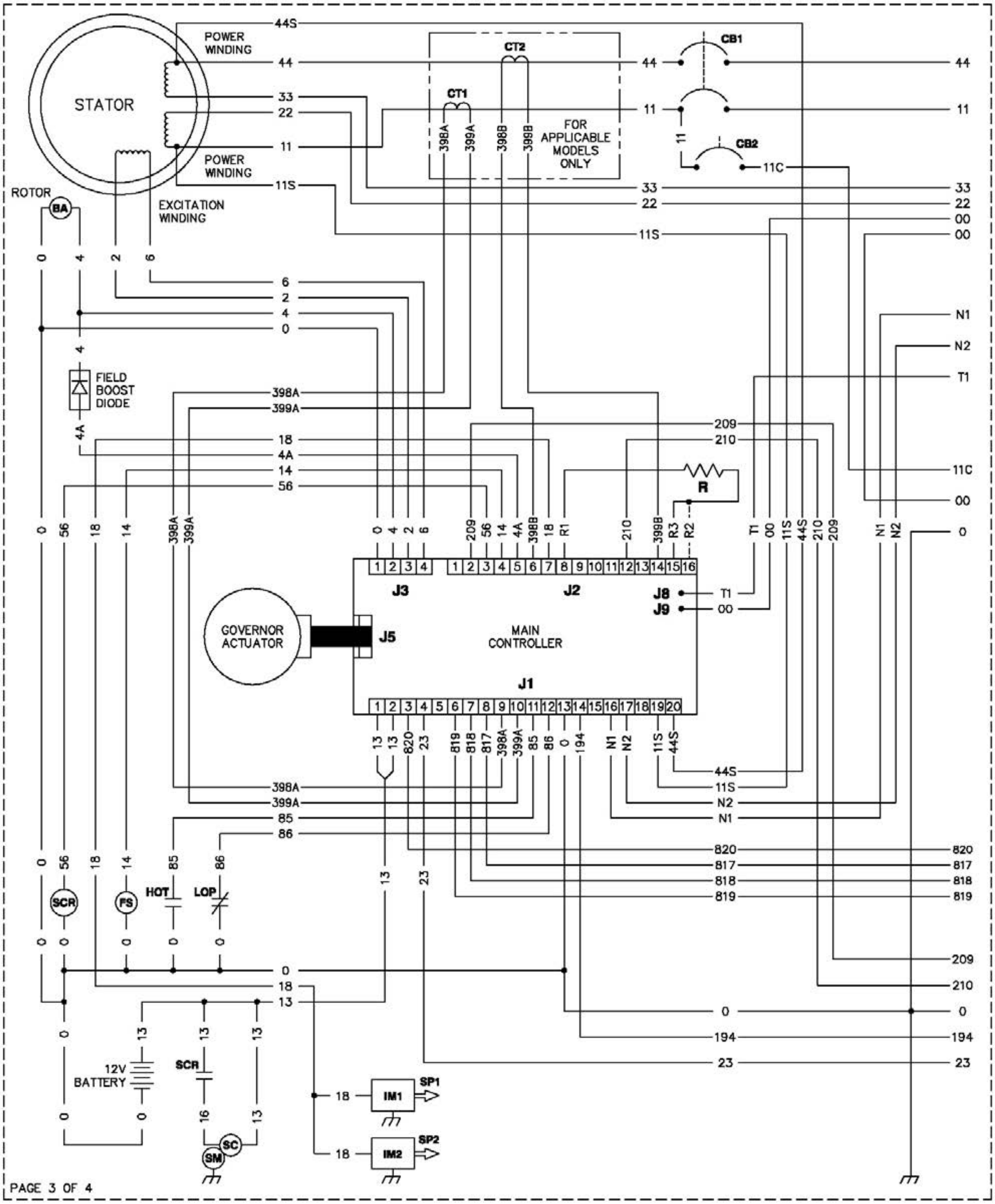


WIRING - DIAGRAM
2013 AIR COOLED HSB 60HZ
DRAWING #: 0J9961

REVISION: J-5714-D
DATE: 6/19/13

PAGE 2 OF 4

GROUP G



SCHEMATIC - DIAGRAM

2013 AIR COOLED HSB 60HZ

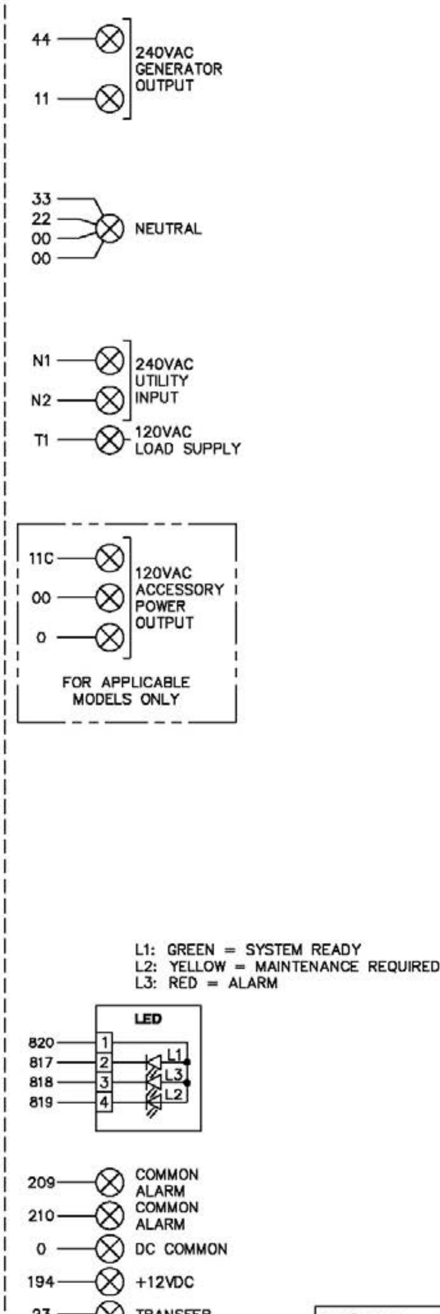
DRAWING #: 0J9961

REVISION: J-5714-D

DATE: 6/19/13

PAGE 3 OF 4

GROUP G



LEGEND

BA	– BRUSH ASSEMBLY	LED	– LED BOARD
CB1	– CIRCUIT BREAKER (MAIN OUTPUT)	LOP	– LOW OIL PRESSURE SWITCH
CB2	– CIRCUIT BREAKER (GFCI)	R	– RESISTOR
CT_	– CURRENT TRANSFORMER	SC	– STARTER CONTACTOR
FS	– FUEL SOLENOID	SCR	– STARTER CONTROL RELAY
HOT	– HIGH OIL TEMPERATURE SWITCH	SM	– STARTER MOTOR
IM_	– IGNITION MODULE	SP_	– SPARK PLUG

PAGE 4 OF 4

SCHEMATIC - DIAGRAM

2013 AIR COOLED HSB 60HZ

REVISION: J-5714-D

DATE: 6/19/13

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DRAWING #: 0J9961

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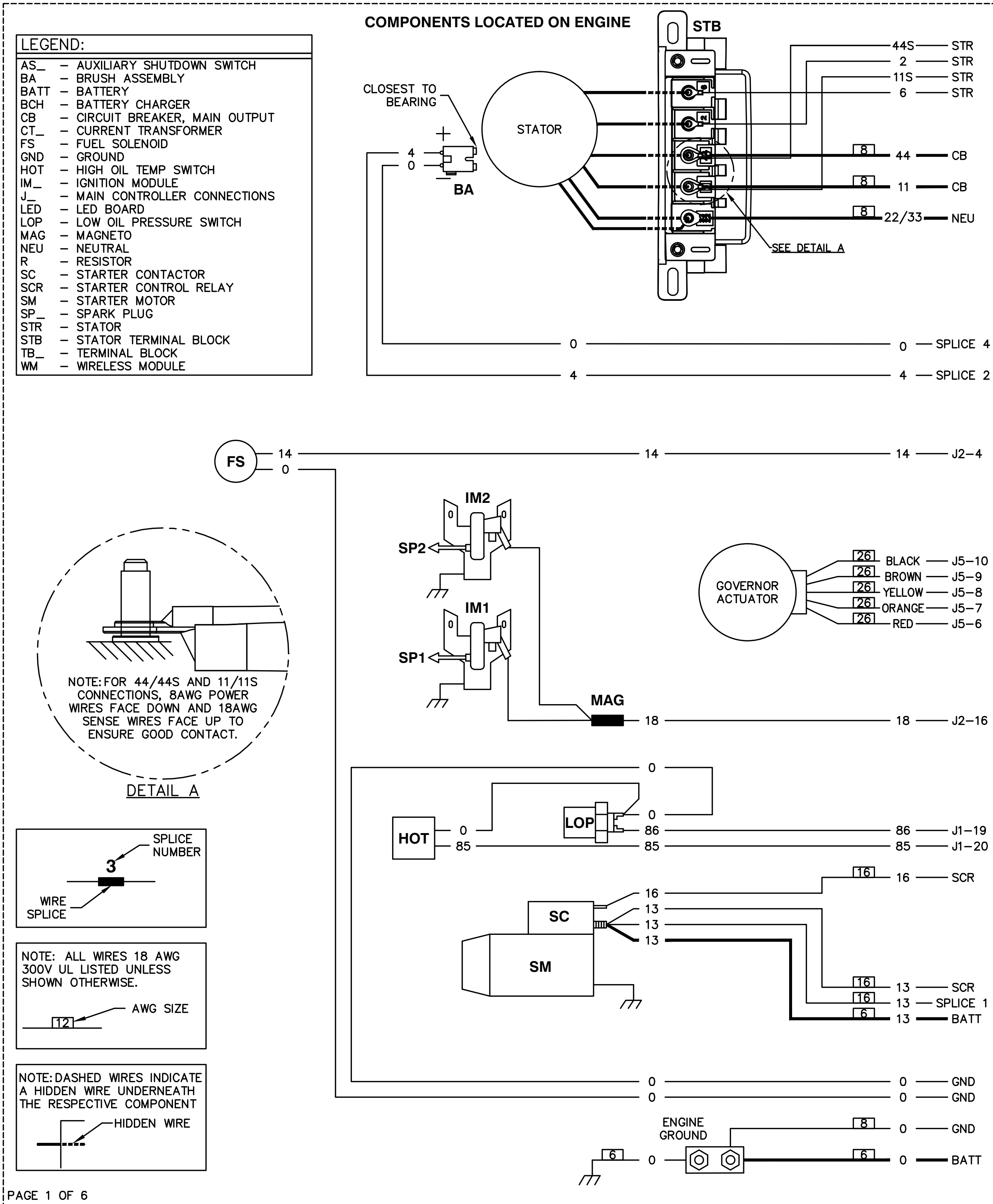
Section 5.10 *A0000189156-A WD/SD Air-cooled Evolution 2.0 w816-999cc Engine kW 60 Hz*

Introduction

The diagrams in this section are provided for general reference only. For unit specific diagrams refer to the Service and Support page at the manufacturer’s website.

GROUP WD



WIRING - DIAGRAM

AC HSB EVO2 60HZ 1PH W/ STB

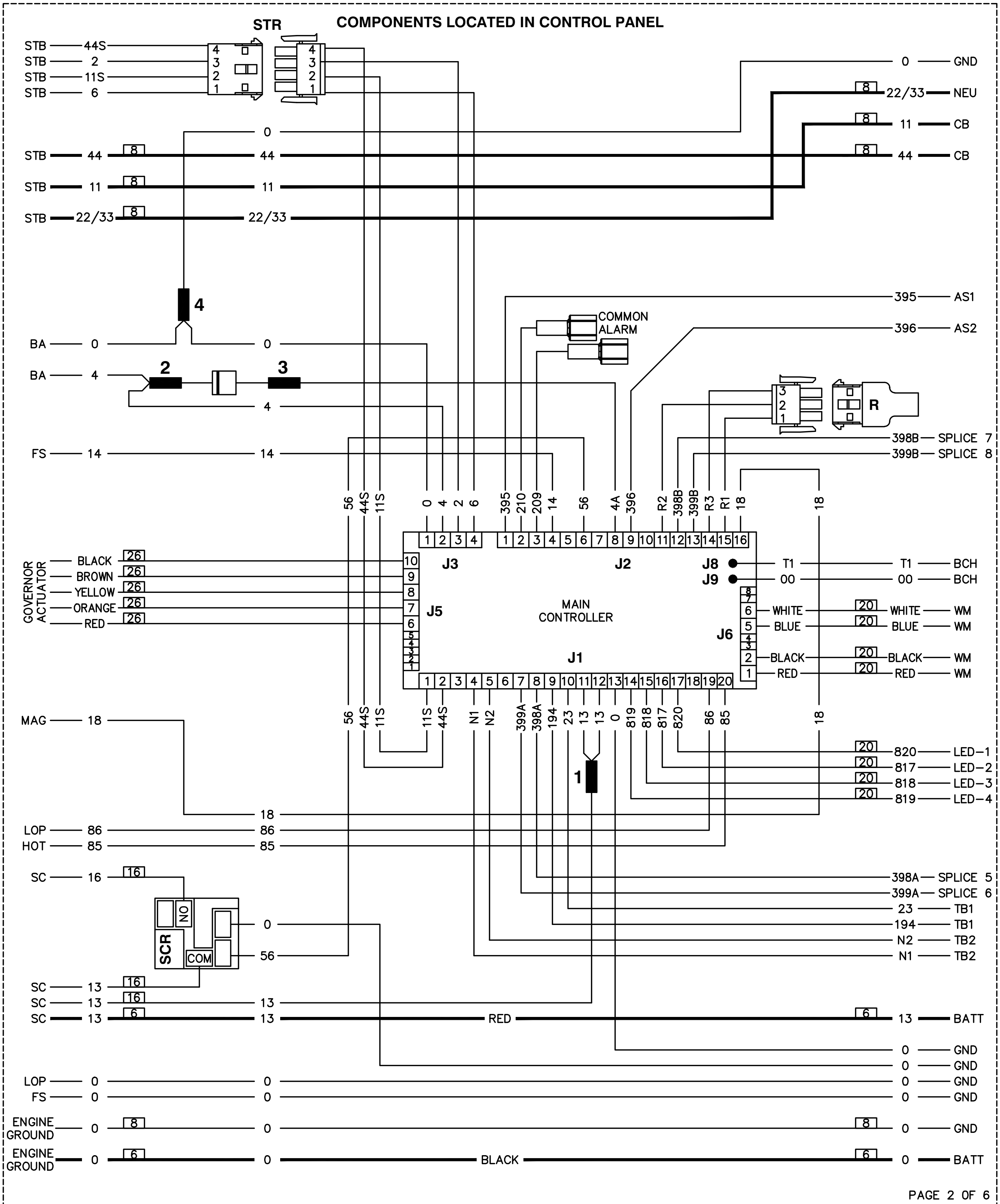
REVISION: A

DATE: 10/17/19

PAGE 1 OF 6

DRAWING #: A0000189156

GROUP WD

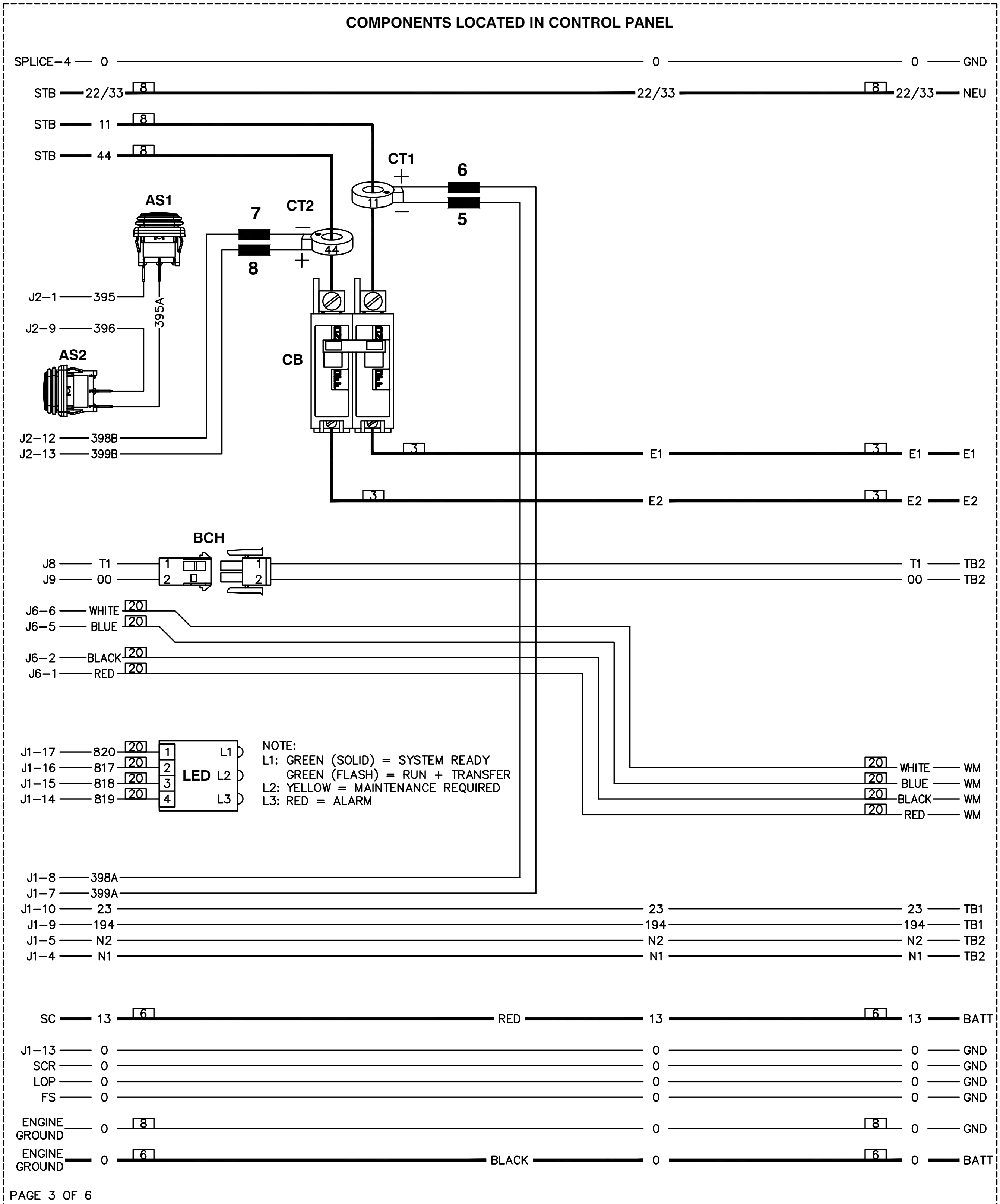


WIRING - DIAGRAM

REVISION: A

AC HSB EVO2 60HZ 1PH W/ STB

GROUP WD



WIRING - DIAGRAM

REVISION: A

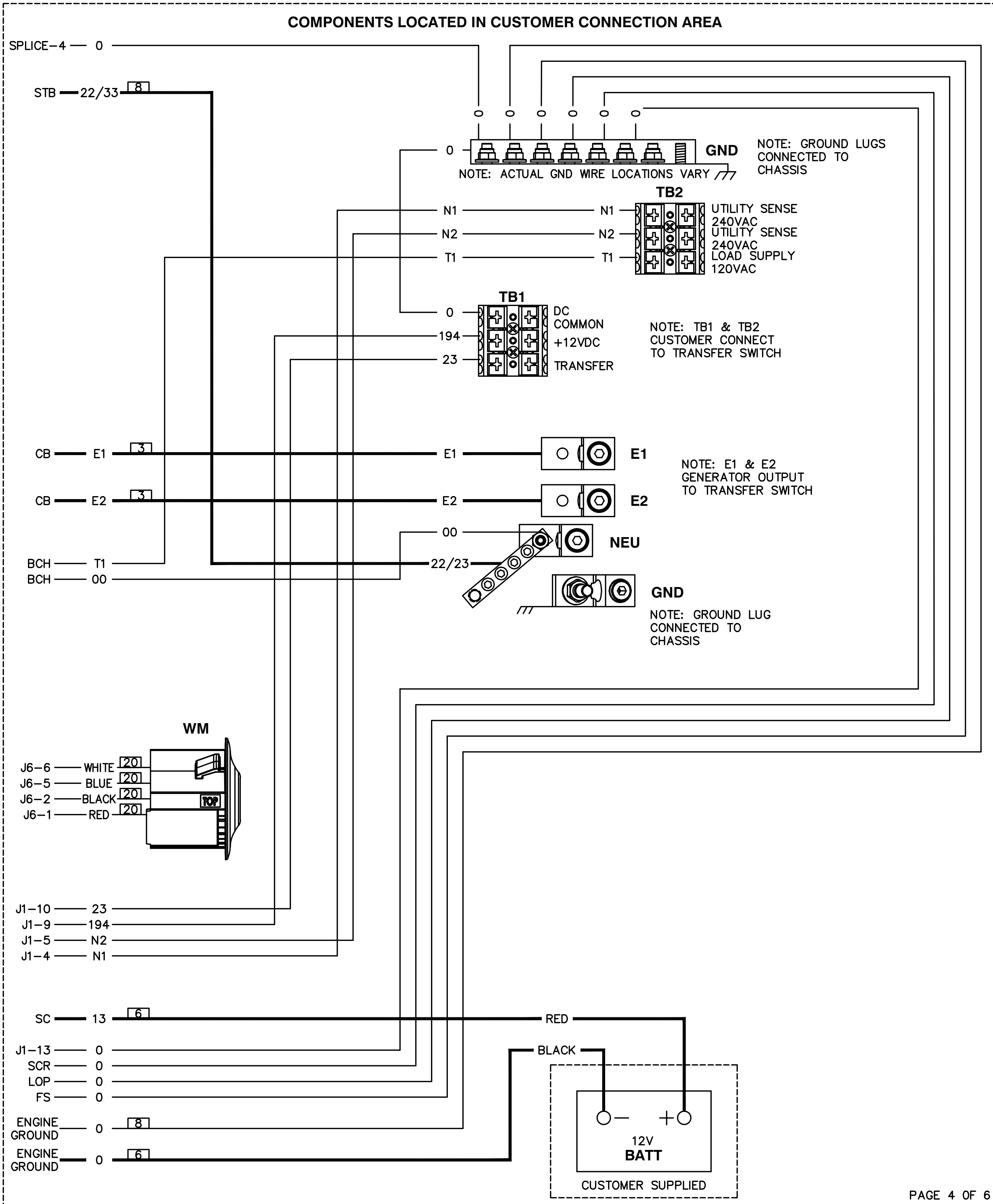
AC HSB EVO2 60HZ 1PH W/ STB

DATE: 10/17/19

PAGE 3 OF 6

DRAWING #: A0000189156

GROUP WD



WIRING - DIAGRAM

REVISION: A

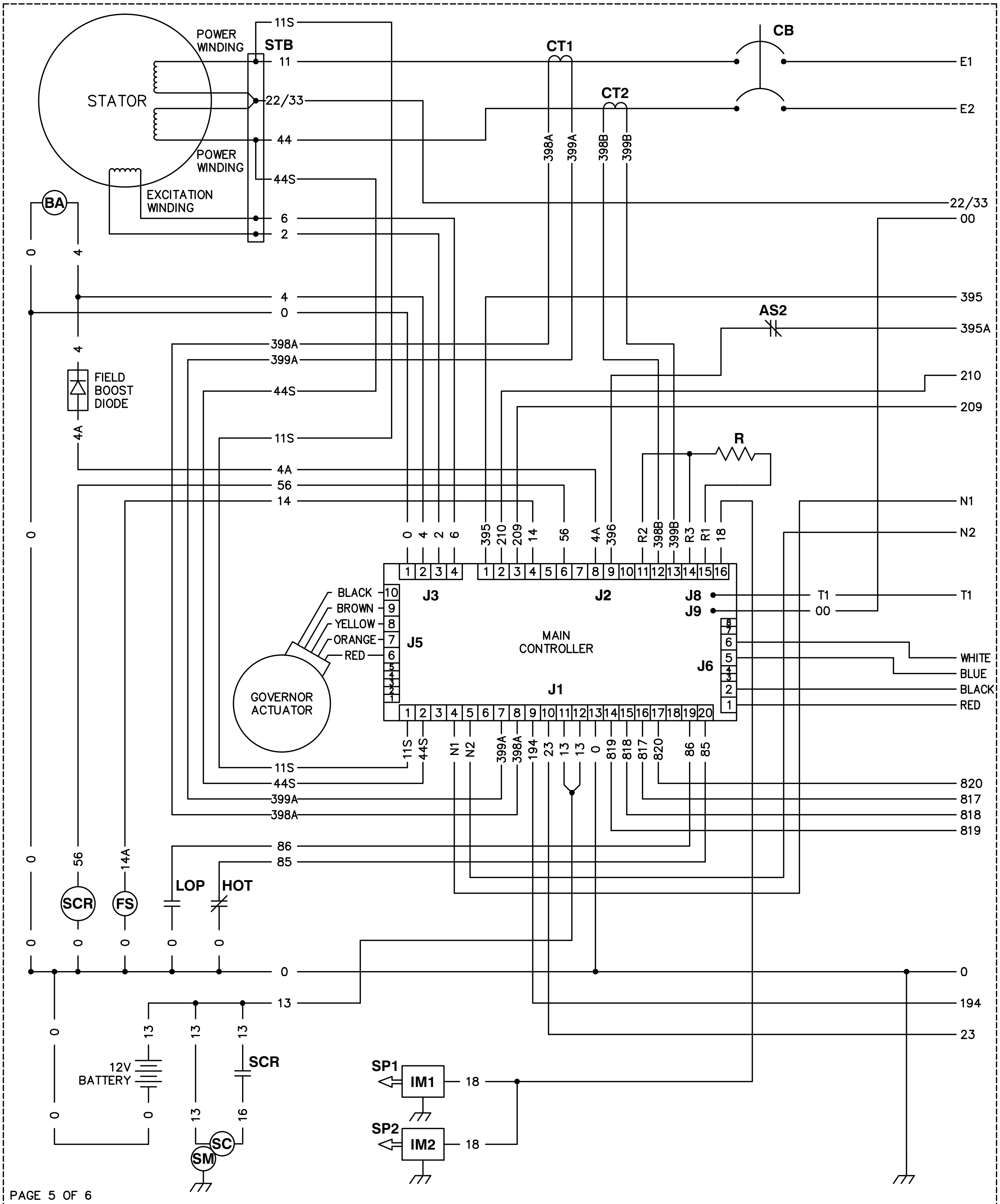
AC HSB EVO2 60HZ 1PH W/ STB

DATE: 10/17/19

PAGE 4 OF 6

DRAWING #: A0000189156

GROUP WD



SCHEMATIC - DIAGRAM

AC HSB EVO2 60HZ 1PH W/ STB

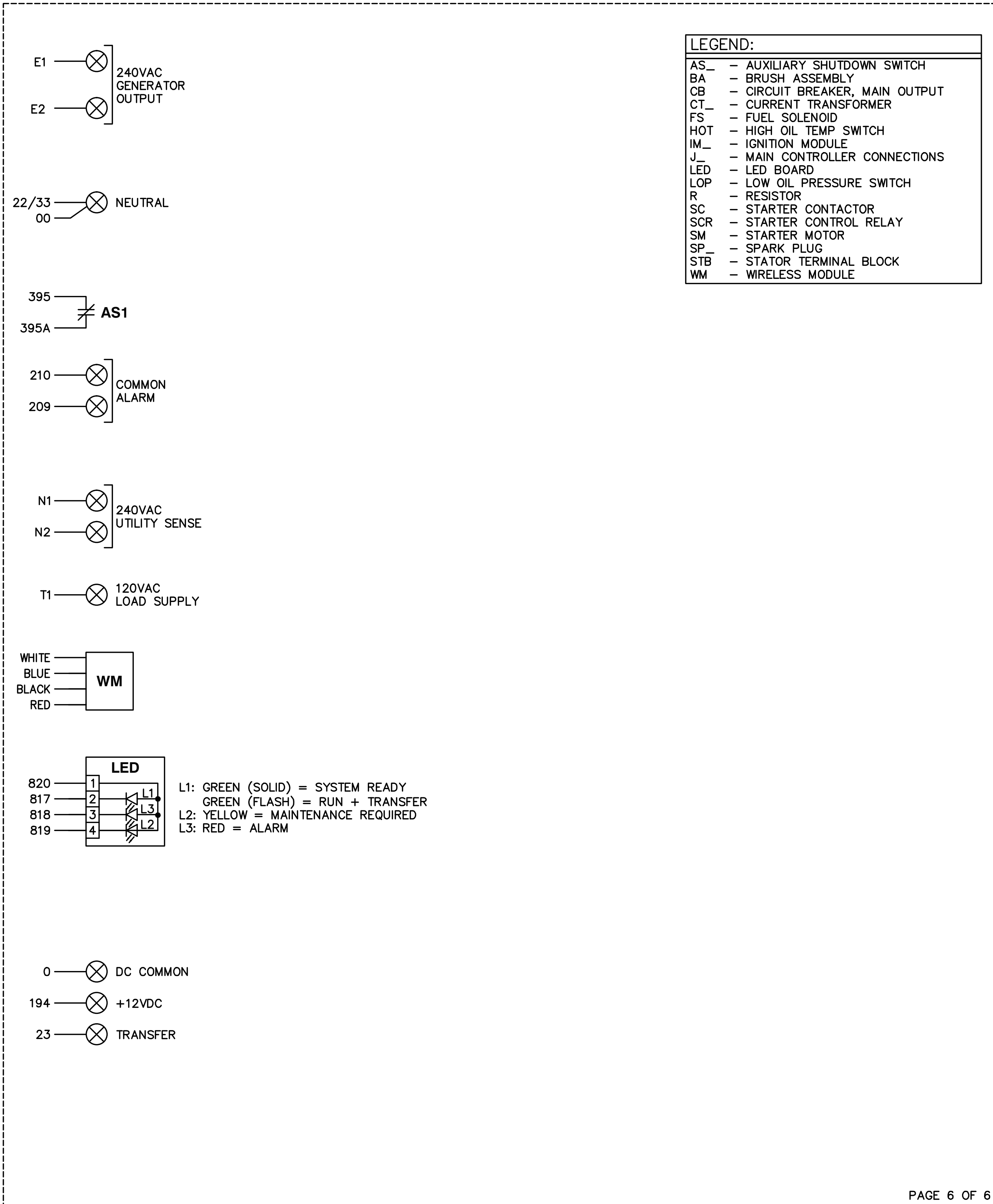
DRAWING #: A0000189156

REVISION: A

DATE: 10/17/19

PAGE 5 OF 6

GROUP WD



SCHEMATIC - DIAGRAM

REVISION: A

AC HSB EVO2 60HZ 1PH W/ STB

DATE: 10/17/19

PAGE 6 OF 6

DRAWING #: A0000189156

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Important Note

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

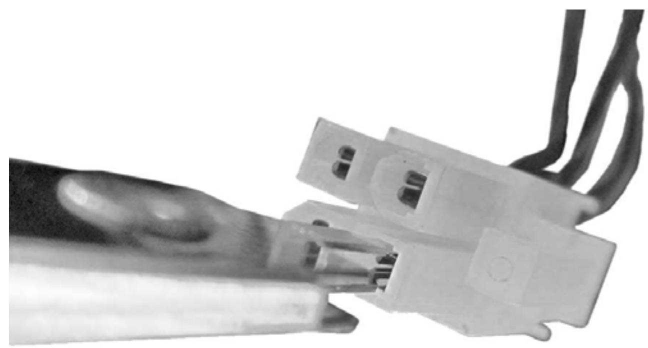
Figure A-1. Special Tool (P/N 0J09460SRV) Back Probe

002450

Figure A-2. Back-Probing Molex Connector

002452

Figure A-3. Molex Pin Extractor Tool Part# 0K4445



002453

Figure A-4. Using Molex Pin Extractor Tool

J3 Breakout Harness Test Procedures

Part Number A0000659764

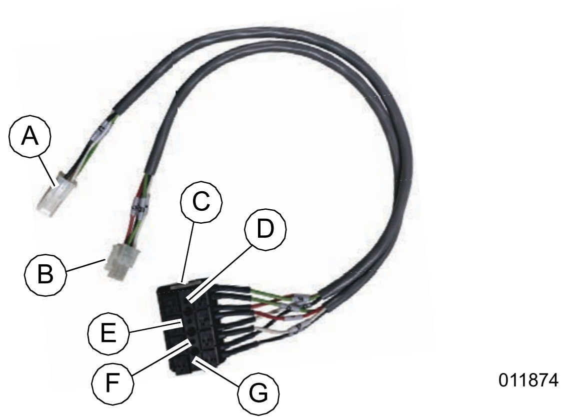


Figure 2. J3 Breakout Harness

A	Female end J3	E	Wire 2
B	Male end J3	F	Wire 4
C	WAGO block	G	Wire 0
D	Wire 6	—	—

Testing Voltage

Checking DC Voltage on Wires 4 and 0

Proceed as follows to check DC voltage on Wires 4 and 0 using a DMM:

1. Verify generator is in OFF mode.
2. Disconnect generator harness J3 connector.
3. See *Figure 2*. Connect male end (B) of J3 breakout harness to controller.
4. Connect female end (A) of J3 breakout harness to generator harness.
5. Set digital multimeter (DMM) to measure DC volts.
6. Insert DMM test leads to DC Excitation (Wires 4 [F] and 0 [G]) test points of the J3 breakout harness.
7. Set generator to MANUAL and observe DMM for DC volts.

See air cooled diagnostic manual 10000041488 (rev B or higher) for further information.

Checking AC Voltage on Wires 2 and 6

Proceeds as follows to check AC voltage on Wires 2 and 6 using a DMM:

1. Verify generator is in OFF mode.
2. Disconnect generator harness J3 connector.
3. Connect male end of J3 breakout harness to controller.
4. Connect female end of J3 breakout harness to generator harness.
5. Set DMM to measure AC volts.
6. Insert DMM test leads to AC Excitation (Wire 2 [E] and 6 [D]) test points of the J3 breakout harness.
7. Set generator to MANUAL and observe DMM for AC volts.

See air cooled diagnostic manual 10000041488 (rev B or higher) for further information.

Testing Resistance

Checking Rotor Winding Resistance on Wires 4 and 0

Proceed as follows to check rotor winding resistance on Wires 4 and 0 using a DMM:

1. Verify generator is in OFF mode.
2. Disconnect generator harness J3 connector.
3. Connect female end of J3 breakout harness to generator harness.

NOTE: Do not connect male end of J3 breakout harness to controller.

4. Set DMM to measure resistance.
5. Insert DMM test leads into DC Excitation (Wire 4 and 0) test points of J3 breakout harness.
6. Observe DMM for resistance on DC Excitation windings (4 and 0).

See air cooled diagnostic manual 10000041488 (rev B or higher) for further information.

Checking AC Excitation Winding Resistance on Wires 2 and 6

Proceed as follows to check AC Excitation winding resistance on Wires 2 and 6 using a DMM:

1. Verify generator is in OFF mode.
2. Disconnect generator harness J3 connector.
3. Connect female end of J3 breakout harness to generator harness.

NOTE: Do not connect male end of J3 breakout harness to controller.

4. Set DMM to measure resistance.
5. Insert DMM test leads into AC Excitation (Wire 2 and 6) test points of J3 breakout harness.
6. Observe DMM for resistance on AC Excitation windings (2 and 6).

See air cooled diagnostic manual 10000041488 (rev B or higher) for further information.

Testing Fixed Excitation

Checking Rotor Winding Current Draw Using Wires 4 and 0 (Static and Running)

Proceed as follows to check rotor winding current draw using Wires 4 and 0 using a DMM:

1. Verify generator is in OFF mode.
2. Disconnect generator harness J3 connector.
3. Connect female end of J3 breakout harness to generator harness.

NOTE: Do not connect male end of J3 breakout harness to controller.

4. Set DMM to measure current (10A). See DMM manufacturer's specific instructions to configure for amp draw testing.
5. See ***Figure 3***. Apply DC power to Wire 4 (F) and Wire 0 (G) test points of the WAGO end (C) of the J3 breakout harness using a 12 VDC power supply (generator battery) (J) with the DMM (H) in series.

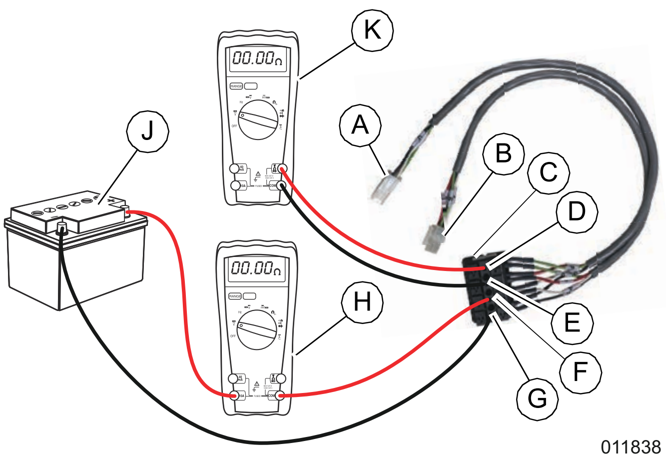


Figure 3. J3 Breakout Harness Testing Setup

6. Observe DMM for current draw on rotor winding circuit (4 and 0).
7. Set generator to MANUAL and observe DMM for current (amps).

See air cooled diagnostic manual 10000041488 (rev B or higher) for further information.

Checking Fixed (Steady) AC Excitation on Wires 2 and 6 While Running

Proceed as follows to check fixed AC excitation on Wires 2 and 6 while running:

IMPORTANT NOTE: A second meter is required to complete this test.

1. Verify generator is in OFF mode.
2. Disconnect generator harness J3 connector.
3. See ***Figure 3***. Connect female end (B) of J3 breakout harness to generator harness.

NOTE: Do not connect male end (A) of J3 breakout harness to controller.

4. Set first DMM (H) to measure current (10A). See DMM manufacturer's specific instructions to configure for amp draw testing.
5. Set second DMM (K) to measure AC volts. Insert DMM test leads into AC Excitation (Wire 2 and 6) test points.
6. See ***Figure 3***. Apply DC power to Wire 4 and Wire 0 test points of the WAGO end of the J3 breakout harness using a 12 VDC power supply (generator battery) with the DMM in series.
7. Observe second DMM for AC volts on the AC Excitation circuit (Wire 2 and 6).

See air cooled diagnostic manual 10000041488 (rev B or higher) for further information.

Evolution 2.0 Controller

See ***Figure A-2*** – Evolution Air-cooled Controller has 3 Molex style connectors on the back (J1, J2, & J3), one actuator connector (J5), a battery charger connector (J8 & J9), and a connector socket for a remote annunciator (optional accessory).

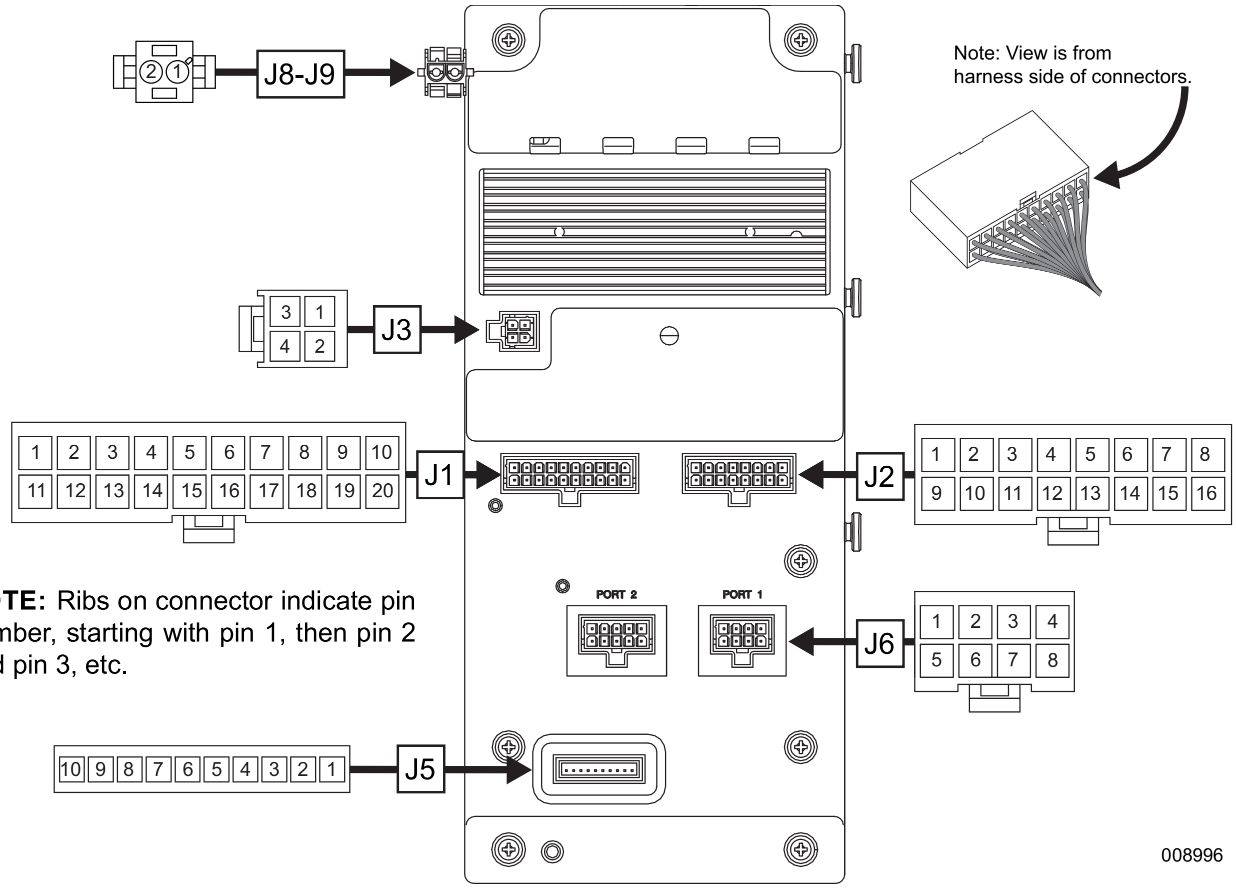


Figure 1-1. Evolution 2.0 Air-cooled Panel and Connectors (Harness End)

J1 Connector		
Pin	**Wire**	**Circuit Function**
J1-1	11S	208/240 VAC Generator Voltage Sensing
J1-2	44S	208/240 VAC Generator Voltage Sensing
J1-3	–	Not Used - UL Required Spacing
J1-4	N1	240 VAC (60hz) 190 - 208 VAC (50Hz) Utility sensing voltage
J1-5	N2	240 VAC (60hz) 190 - 208 VAC (50Hz) Utility sensing voltage
J1-6	–	Not Used - UL Required Spacing
J1-7	398A	Generator Current Sense A (+)
J1-8	399A	Generator Current Sense A (Gnd)
J1-9	194	Provides 12 VDC to the transfer relay
J1-10	23	Switched to ground (internally) to energize the Transfer Relay
J1-11	13	12 VDC un-fused for the controller
J1-12	13	12 VDC un-fused for the controller
J1-13	0	Common Ground (DC) DC Field Excitation Ground
J1-14	819	Grounded by the controller to turn on the Maintenance (Yellow) LED
J1-15	818	Grounded by the controller to turn on Alarm (Red) LED
J1-16	817	Grounded by the controller to turn on System Ready (Green) LED
J1-17	820	Positive voltage (5VDC) for status LEDs
J1-18	178	Not Used, Optional - 2-Wire Start (return)
J1-19	86	Low oil pressure shutdown: Shutdown occurs when Wire 86 is ungrounded by loss of oil pressure in the LOP switch
J1-20	85	High temperature shutdown: Shutdown occurs when Wire 85 is ungrounded by contact opening in the oil temperature switch

J2 Connector		
Pin	**Wire**	**Circuit Function**
J2-1	395	Auxiliary Shutdown Ground
J2-2	210	Common Alarm Relay Output
J2-3	209	Common Alarm Relay Input
J2-4	14	12 VDC output for engine run condition. Fuel solenoid supply voltage.
J2-5	–	Not Used
J2-6	56	12 VDC output to starter contactor relay/ solenoid
J2-7	–	Not Used
J2-8	4A	DC (+) Field Excitation (Before Field Boost Diode)
J2-9	396	Auxiliary Shutdown: When wire 396 is grounded
J2-10	183	Not Used, Optional - 2-Wire Start (+5 VDC)
J2-11	R2	Model ID Resistor
J2-12	399B	Generator Current Sense B1
J2-13	398B	Generator Current Sense B2
J2-14	R3	Model ID Resistor (+)
J2-15	R1	Model ID Resistor (-)
J2-16	18	1. Reference signal - Controller receives speed sensing during start and run. 2. Ignition Shutdown - Controller grounded for shutdown.

J3 Connector		
Pin	**Wire**	**Circuit Function**
J3-1	0	Common Ground (DC) DC Field Excitation Ground
J3-2	4	DC (+) Field Excitation
J3-3	2	DPE Winding (AC Excitation power)
J3-4	6	DPE Winding (AC Excitation power)

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	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

J6 Connector		
Pin	**Wire**	**Circuit Function**
J6-1	–	Accessory (5V)
J6-2	–	Accessory (Gnd)
J6-3	–	Accessory (+12V)
J6-4	–	PORT 2 (Gnd)
J6-5	–	RS485 Data (-)
J6-6	–	RS485 Data (+)
J6-7	–	PORT 2 Receive
J6-8	–	PORT 2 Transmit

J8-J9 Connector		
Pin	**Wire**	**Circuit Function**
1	T1	120 - 240 VAC Power for the Battery Charger
2	00 - 60 Hz T2 - 50 Hz	60 Hz - Neutral Connection for T1 50 Hz - Line 2 for Battery Charger

Evolution 1.0 Controller

See ***Figure A-2*** – Evolution 1.0 Air-cooled Controller has 3 Molex style connectors on the back (J1, J2, & J3), one actuator connector (J5), a battery charger connector (J8 & J9), and a connector socket for a remote annunciator (optional accessory).

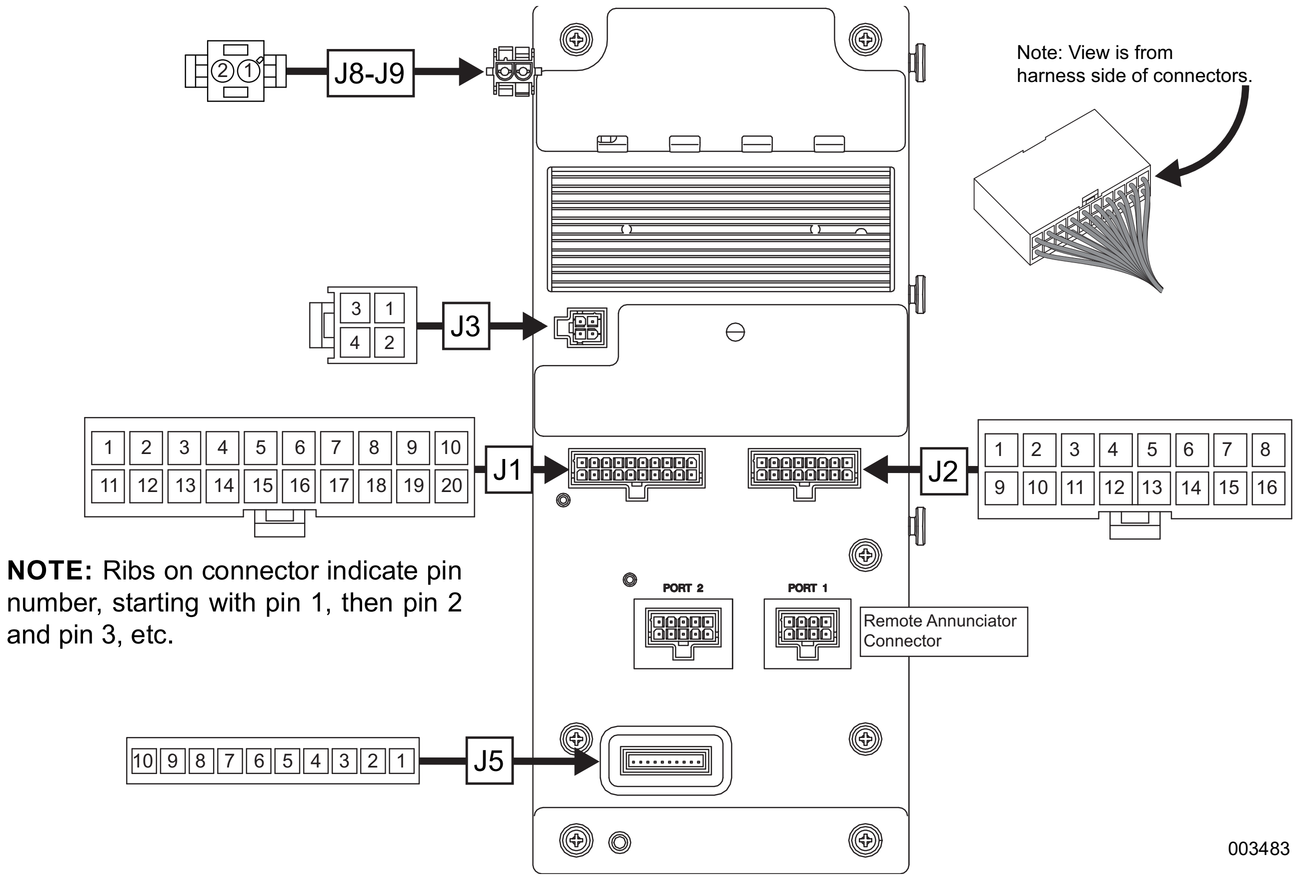


Figure A-2. Evolution 1.0 Air-cooled Panel and Connectors (Harness End)

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 (5VDC) for status LEDs
J1-4	23	Switched to ground (internally) to energize the Transfer Relay
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 Connector		
Pin	**Wire**	**Circuit Function**
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
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	11S	240 VAC Generator Voltage Sensing
J1-20	44S	240 VAC Generator Voltage Sensing

J2 Connector		
Pin	**Wire**	**Circuit Function**
J2-1	-	Not Used
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	4A	DC (+) Field Excitation (Before Field Boost Diode)
J2-6	398A	Generator Current Sense B2
J2-7	18	1. Reference signal - Controller receives speed sensing during start and run. 2. Ignition Shutdown - Controller grounded for shutdown.
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	399B	Generator Current Sense B1
J2-15	R3	Model ID Resistor
J2-16	R2	Model ID Resistor

J3 Connector		
Pin	**Wire**	**Circuit Function**
J3-1	0	Common Ground (DC) DC Field Excitation Ground
J3-2	4	DC (+) Field Excitation
J3-3	2	DPE Winding (AC Excitation power)
J3-4	6	DPE Winding (AC Excitation power)

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	00 - 60 Hz T2 - 50 Hz	60 Hz - Neutral Connection for T1 50 Hz - Line 2 for Battery Charger

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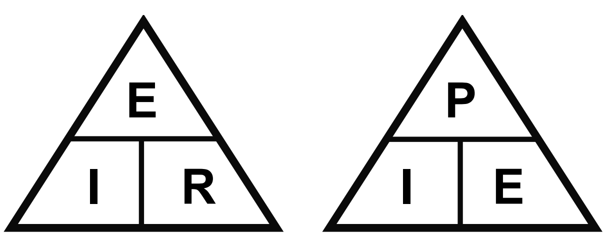
Electrical Formulas

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

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

Term	Symbol	Measurement
Current	I	Amps
Wattage	P	Watts
Voltage	E	Volts
Resistance	R	Ohms



003003

Constant	Shift		Result	
Voltage E	Resistance Increase	⇧	Current Decrease	⇩
Voltage E	Resistance Decrease	⇩	Current Increase	⇧
Resistance R	Voltage Decrease	⇩	Current Decrease	⇩
Resistance R	Voltage Increase	⇧	Current Increase	⇧
Current I	Resistance Decrease	⇩	Voltage Decrease	⇩
Current I	Resistance Increase	⇧	Voltage Increase	⇧
Power P	Voltage Increase	⇧	Power Increase	⇧
Power P	Voltage Decrease	⇩	Power Decrease	⇩
Power P	Current Increase	⇧	Power Increase	⇧
Power P	Current Decrease	⇩	Power Decrease	⇩

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