



CITY AND COUNTY OF SAN FRANCISCO San Francisco Municipal Transportation Agency Request for Proposals THE PROCUREMENT OF 30-Foot, 40-FOOT AND 60-FOOT LOW FLOOR DIESEL HYBRID COACHES

Proposal Section	Title	Bid Submission Requirements
3-1	Electrical	 Describe in detail the low voltage wiring system including wire type, terminations, terminal boards, multiple pin connectors, shielding for RFI/EMI, wire numbering methods, overload protection, and insulation color codes. Describe in detail the high voltage wiring system (with inclusions such as in item 1, above) with special emphasis on safety features. Specifically detail any operational or maintenance activity that could pose a higher than normal safety risk. Describe the operation of the propulsion and regenerative braking system. Describe in detail the energy storage system has been designed to be modular, reliable, easily maintainable, and safe to operate. Describe in detail the function of the multiplex wiring system. Explain how electrical and electronic noise has been
		minimized. 8) Describe any components that will not meet the illustrated parts manual requirements in Section 9.2.3 of the Technical Specifications-Volume 2.
		9) Explain how the bus electric, electrical, and control systems are diagnosed and explain any self-diagnostic capability.

Please refer to the attached low voltage and high voltage information as requested in Section 3-I.





Electrical System

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1. SAFETY

1.1. Safety Procedures

When performing different types of repair to this vehicle special precautions must be taken. Failure to follow these recommendations and procedures could result in injury or severe damage to vehicle and its components.

Cordon off, mark or use a clearly defined area to work on the vehicle. The purpose of this is to warn personnel that the vehicle is being worked on and it can start at anytime. Do not start the vehicle with the PC link without first checking that the area is clear of personnel.

1.2. Welding Procedures



Before welding anywhere on vehicle, open the Battery Disconnect switch and disconnect all electronic control modules (Multiplexing, engine, transmission, ABS, and so forth). Refer to Section 11 of this manual for additional precautionary information.



2. MULTIPLEXING SYSTEM

2.1. Description

MOTE:

Refer to the Multiplexing System Layout when reviewing this information.

The Vehicle Multiplexing Module (VMM) system uses a series of remotely-mounted, Controller Area Network (CAN)

connected modules to transmit information and operate components throughout the vehicle. The system consists of several VMM 1615 solid state modules located throughout the vehicle. See "Fig. 9-1: Rear Panel" on page 2. See "Fig. 9-2: Exit Door Module Installation" on page 3. See "Fig. 9-3: Side Console Module Installation" on page 3. The modules are interconnected by a shielded CAN communication cable which is part of the wiring harness.

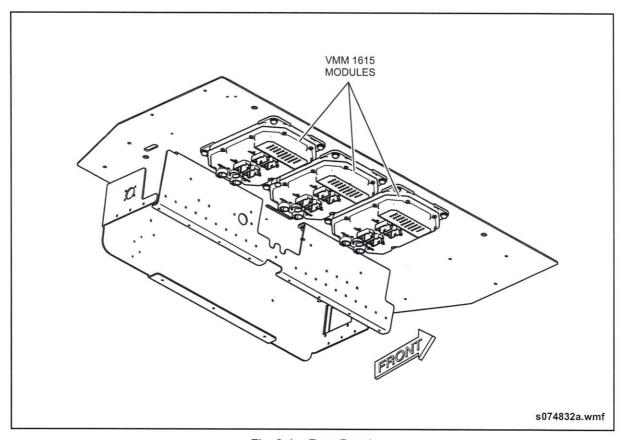


Fig. 9-1: Rear Panel

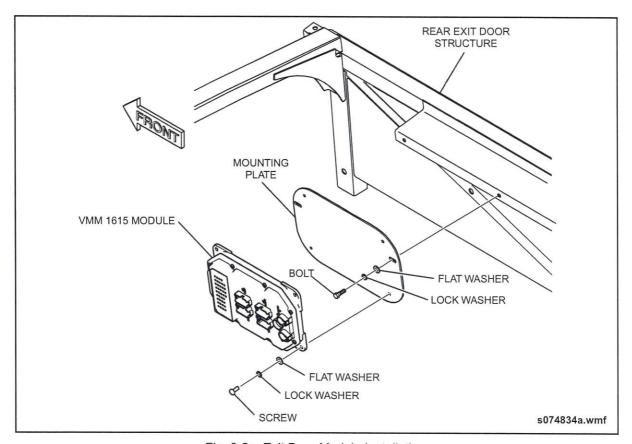


Fig. 9-2: Exit Door Module Installation

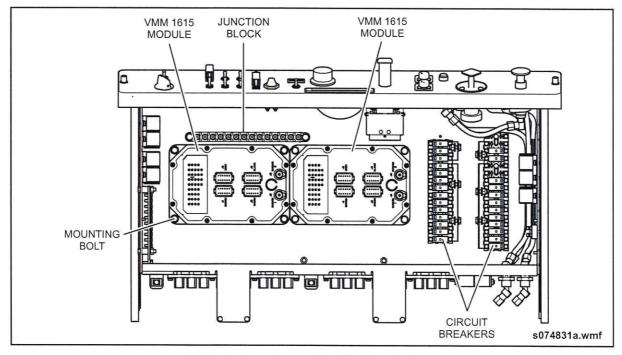


Fig. 9-3: Side Console Module Installation



2.2. VMM 1615

2.2.1. Description

The VMM1615 is a general purpose electronic controller. It has 16 inputs and 15 outputs as well as two CAN/J1939 communication ports.

The VMM1615 has seven digital inputs; five of the inputs are used for reading active high/low signals, one input is used for reading active high signals, and one input is used for active high power control. In addition, it has eight inputs capable of reading analog voltages, and one DC coupled frequency input.

The VMM1615 has 12 high-side outputs with a maximum Pulse Width Modulation (PWM) frequency of 500 Hz, four of which are capable of accurate current sensing. It also has one low-side output that is capable of current sensing with a maximum PWM frequency of 1500 Hz, and two solid state relay outputs. These outputs can

drive a variety of load types. Built to meet and exceed SAE J1455 environmental standards with enhanced diagnostics and Windows-based ladder logic programming. The modules are plug and play configurable, and have status LEDs that indicate the condition of inputs, outputs, power, and network activity.

The VMM 1615 is equipped with four colorcoded connectors and two high-current power connection points. Connectors J5 and J6 are the high-current power source for the output circuits on the module. Connector J1 (Brown) is an input, output and network connector. Connector J2 (Grey) is an input and output connector. Connector J3 (Green) is an input and output connector. And J4 (Black) contains inputs, outputs and addressing inputs for module configuration. Each module contains a set of diagnostic LEDs which can be used to monitor the inputs and outputs, input power and controller area network (CAN) activity. See "Fig. 9-4: VMM 1615 Module" on page 4.

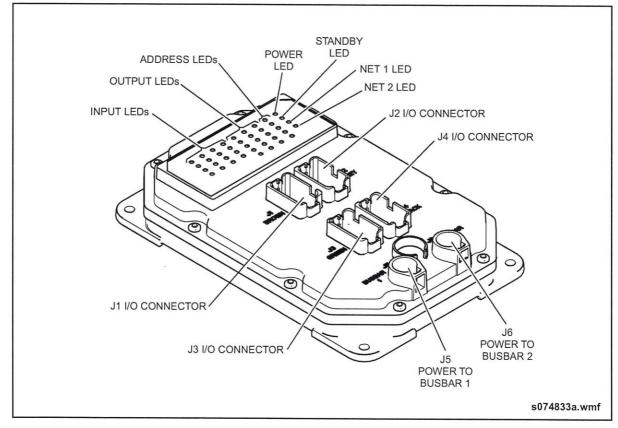


Fig. 9-4: VMM 1615 Module



2.2.2. Removal

- Open access door or remove panels as required to access module.
- Identify harness connector positions at module.
- 3. Carefully unplug harness connectors from center of module.
- Carefully unplug power connectors from the end of the module.
- Remove four screws and any other hardware retaining the module to the panel and remove the module.

2.2.3. Installation

- Position module on panel, install retaining screws and tighten.
- 2. Install any auxiliary mounting hardware.
- 3. Plug harness connectors into module.
- 4. Plug power connectors in ensuring locking tabs snap into position.
- Install removed panels and close access doors.

2.2.4. VMM 1615 Troubleshooting

The VMM 1615 module has 16 input LEDs, 15 output LEDs, a Standby LED, 2 Network Status LEDs and a power/health indicator LED. The PWR LED has three states, ON, OFF and FLASHING. When the PWR LED is on solid the unit is operating correctly. If the PWR LED is off the module is not receiving power or it is in the power save mode. If the PWR LED is flashing a fault has been detected on one of the outputs.

The NET LED flashes when there is network communication between two or more units in the system. If the NET LED is not flashing, there is a problem with the network cabling. To verify the network cable, measure the resistance between pins 8

and 9 and 10 and 11 on the Brown J1 harness connector. Ohmmeter should indicate approximately 60 ohms resistance. If the measured reading deviates from this value, check for the following:

Missing	terminating	resistor	in	the	network
cable.					

Bad	connections	at	the	network	cable	Υ
splic	es.					

☐ Broken wire in the network cable.

The input LEDs have an ON and OFF state. If an input LED is ON, the corresponding input for the LED is active. If the LED is OFF the input is inactive. Refer to "ES-I/O Assignment" in the Vehicle Systems Drawing Manual to determine the type and voltage level for each input prior to testing. If there is no change of potential when the input changes from inactive to active, the input device or wiring is defective. Digital inputs must have a ground potential to be activated. Inputs programmed as analog require 0.5 volts to activate the input. Inputs programmed as frequency require a 10 Hz or greater signal to activate.

The output LED's have three states, ON, OFF and FLASHING. If an output LED is ON, the corresponding output for the LED is active. If the LED is OFF the output is inactive. If the LED is flashing the corresponding output is faulted. Five types of faults will cause an output LED to flash:

Short circuit to power.
Short circuit to ground.
Over current.
Open load.

Refer to 15. "VENDOR SERVICE INFOR-MATION" on page 85 in this section for more diagnostic and troubleshooting information on the VMM 1615 module.



2.3. J1939 Controller Area Network (CAN) Cable

2.3.1. Description

The various ECU's and VMM modules used in the vehicle communicate information using a standard protocol called the SAE J1939 Recommended Practice for Serial Control and Communication Vehicle Network (SAE J1939 CAN). The driveline J1939 network consists of engine, transmission, and ABS ECU's and is separate from the VMM J1939 network, which consists of the VMM 1615 module. Refer to "ES-Network Topology" and "Multiplexing System Layout" for lead connections.

The J1939 network cables consist of twisted pair, shielded cables that connect the various ECU's or VMM modules located throughout the vehicle. Each end of the network cable is terminated with a 120 ohm resistor to reduce reflections of the electrical signals.

2.3.2. CAN Cable Troubleshooting

- Troubleshoot the driveline J1939 network cable as follows:
 - a. Attempt to read the engine, transmission, and ABS codes at each of the diagnostic connectors (engine compartment switchbox, and driver's area). The network cable is intact between the nine-pin diagnostic connector and the ECU if diagnostic codes can be read at each of the diagnostic connectors.
 - b. Set the Battery Disconnect switch to the OFF position.
 - Disconnect the network cable from all driveline ECU's. This is necessary as the ECU's can affect the resistive measurement.

d. Refer to Electrical Schematic "ES-Engine EN" and check continuity of the entire network cable loop between the CAN "+" and CAN "-" wires using an Ohmmeter. Loop resistance should measure 60 Ohms.

MOTE:

The diagnostic connectors located behind the driver's seat or on the engine compartment switch box are convenient places to take the reading.

- e. Check for an open or missing terminating resistor if the loop resistance measures 120 Ohms. Although each resistor is 120 Ohms, they are installed in parallel and the combined resistance value would be 60 Ohms.
- f. Check for an open circuit (break in the wiring) if the Ohmmeter reading indicates infinity or an "out of limits" value. Check for a poor electrical connection if a significant resistance value is measured.
- g. Remove the terminating resistors from either end of the network cable.
- h. Check the CAN "+" wire for continuity by connecting one lead of the Ohmmeter to the CAN "+" terminal at one end of the network cable. Run a jumper wire from the CAN "+" terminal at the opposite end of the cable and connect the other end of the jumper wire to the remaining lead on the Ohmmeter. No significant resistance should be measured.
- If significant resistance or an open condition is measured, move the jumper lead down the network cable to each connector and retest at the connector until the fault is isolated.
- j. Repeat the previous steps for the CAN "-" wire.



J1939 Controller Area Network (CAN) Cable

- Troubleshoot the VMM J1939 network cable as follows:
 - Set the Battery Disconnect switch to the OFF position.
 - Disconnect network cable connections from all VMM's, and SCU, as resistance values could be affected during cable continuity tests.
 - c. Refer to Electrical Schematic "ES-Primary Networks PN" and check continuity of the entire network cable loop between the CAN "+" and CAN "-" wires using an Ohmmeter. Loop resistance should measure 60 Ohms.

™NOTE:

The CAN "+" and CAN "-" wires can be easily accessed from any module location where the network cable has been disconnected.

d. Check for an open or missing terminating resistor if the loop resistance measures 120 Ohms. Although each resistor is 120 Ohms, they are installed in parallel and the combined resistance value would be 60 Ohms.

- e. Check for an open circuit (break in the wiring) if the Ohmmeter reading indicates infinity or an "out of limits" value. Check for a poor electrical connection if a significant resistance value is measured.
- f. Remove the terminating resistors from either end of the network cable.
- g. Check the CAN "+" wire for continuity by connecting one lead of the Ohmmeter to the CAN "+" terminal at one end of the network cable. Run a jumper wire from the CAN "+" terminal at the opposite end of the cable and connect the other end of the jumper wire to the remaining lead on the Ohmmeter. No significant resistance should be measured.
- If significant resistance or an open condition is measured, move the jumper lead down the network cable to each connector and retest at the connector until the fault is isolated.
- i. Repeat the previous steps for the CAN "-" wire.



3. ELECTRICAL SYSTEM

3.1. Description

The electrical system is a 12/24 VDC split system, negatively grounded. All components are rated at 12 or 24 Volts DC depending on the system in which they are employed. Care should be taken to ensure all replacement parts are clearly identified on their nameplates as being 12 or 24 Volts rated.

Severe damage to the alternator, regulator, battery cables, starter and so forth may result if the battery is not connected "Negative" to ground. Turn off battery disconnect switch before replacing or servicing a battery.

Ensure cables are securely tightened to battery posts and charging system components. All ground connection points should be checked periodically to ensure proper grounding is maintained.

Circuit breakers and wire gauges are sized based on the individual circuit current requirements. Replacements should be of the same rating and size.

Never replace a wire with one of a smaller size. All wires are color coded with wire markers on both ends to identify circuit function. Harness routing and tie wrapping should be periodically inspected to ensure the system is maintained.



DO NOT turn off the main disconnect switch, or disconnect the battery, or use a defective battery while the engine is running. When this occurs a substantial "load dump" could result that would damage electrical components. "Load dumps" in the electrical system are normally absorbed by the battery.

3.2. Electronic Control Modules

3.2.1. Description

This vehicle is equipped with engine, transmission, and ABS multiplexing equipment. These control modules have preprogrammed diagnostic and control capabilities. Refer to Section 4 and 5 of this manual for engine and transmission control module function and support information. Refer to Section 1 and 2 of this manual for information on the ABS control module.

The +24 VDC electrical bus bar (refer to Electrical Schematics) provides the power source for the engine Electronic Control Module (ECM), and the ABS Electronic Control Unit (ECU).

These control modules also provide direct input to instrument panel warning indicators such as Check Engine, Stop Engine, and ABS Fail.



New Flyer Industries will assume no responsibility for alterations or substitutions to the electrical system without prior authorization from our engineering department.



4. CHARGING SYSTEM

4.1. Description

The charging system is made up of the alternator and voltage regulator. The function of the charging system is to provide 24V to the electrical/multiplexing system and to recharge the battery system.

I NOTE:

Refer to 6. "BATTERY SYSTEM" on page 49 in this section for more information on this component.

4.2. Alternator

4.2.1. Description

This vehicle is equipped with a heavy-duty 450 Amp brushless alternator. The alternator is bracket-mounted on the front of the

engine and is belt-driven through the accessory drive pulley. Cooling air is provided to the rear cover of the alternator through a remote mounted air filter and connecting hose.

The alternator unit consists of a rotor, two stationary exciters (field windings), stator assembly, rectifier assembly, two aluminum frames, rear cover, and a front fan. The two aluminum frames support the rotor and bearings and also accommodate the attachment to the engine mounting cradle. The stator is installed between the front and rear frames and the three pieces are bolted together. The rear cover provides an air inlet duct and access to the power, ground, FI, and AC terminals. The front fan is mounted on the end of the rotor shaft and draws cooling air through the alternator housing. See "Fig. 9-5: Alternator Assembly" on page 10.



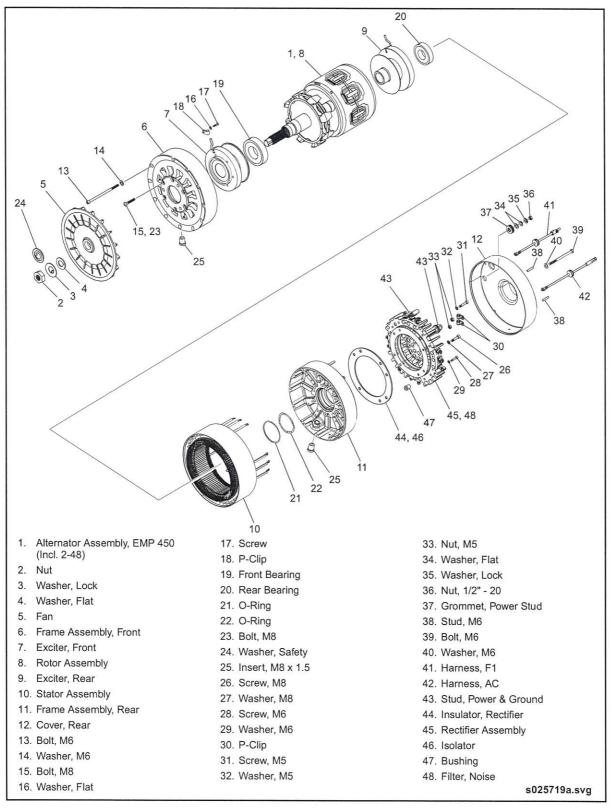


Fig. 9-5: Alternator Assembly



4.2.2. Alternator Specifications

ManufacturerEMP Advance	d Development LLC
Model	Power 450
Rated Voltage	28 VDC
Nominal Amps45	50 Amps @ 28 VDC
Maximum Continuous Sp	oeed 6500 RPM
Cooling Air-cooled, front-r	nounted integral fan
Weight	100 lbs. (45 Kg)

4.2.3. Operation

4.2.3.1. Overview

The brushless alternator operates using a rotating component, called the rotor, which is first magnetized by two stationary exciters (field windings). The magnetized rotor turns within a stationary set of conductors wound in coils called the stator. The rotor's magnetic field cuts across the stator's conductors, generating a source of electrical AC power. The alternator's rectifier converts the AC power into DC power.

4.2.3.2. Electrical Power Generation

The alternator has two field windings or exciters. The exciters are axially aligned by the bearings and the front and rear frames. The front exciter is bolted to the front frame and the rear exciter is bolted to the rear frame. The exciters are stationary field windings with each exciter being positioned in close proximity to the rotor's inner diameter. Each exciter winding has one of the wires terminated to the F1 connector and the other exciter lead is internally grounded.

When the F1 connector is supplied a modulated voltage by the voltage regulator, both exciter coils create a magnetic field which in turn is induced into the rotor. As the magnetized rotor's unique geometry turns inside of the stator, the rotors magnetic field cuts across the stator's conductors and generates electrical AC power.

The stator has four independent windings with each stator winding having three wires or conductors which allows for the generation of 3-phase AC power. The four stator windings are wound independently to allow a level of redundancy, as well as to evenly balance the electrical torque induced that is generated during transformer action. This results in smoother operation.

The process of rectifying the AC power into DC power is handled inside the alternator by the rectifier assembly. The rectifier assembly consists of two aluminum castings and four diode bank assemblies, one for each stator winding. The outer aluminum casting is the negative or ground ring and the inner casting is the positive ring. Each of the three stator wires is terminated to a set of diodes, one positive and one negative. Each diode bank has three positive diodes and three negative diodes, for a total of 24 diodes. A diode is a solid state device that allows current to flow in one direction only. The four diode banks are connected to the positive and negative cast rings in a parallel circuit. The rectifier assembly creates a relatively smooth and stable DC output without any moving parts.

There are four electrical connections on the alternator rear cover: the positive (+) output stud, the negative (-) or ground stud, the field winding connection (F1) and the AC connection. The AC harness is connected to one of the 12 stator wires and is used to indicate when the alternator is charging.



4.2.4. Alternator Troubleshooting

MOTE:

Use a digital multimeter to check all resistance values during alternator trouble-shooting.

If the alternator shaft does not rotate freely, the alternator will need to be repaired. Refer to 4.2.7. "Disassembly" on page 17 and Refer to 4.2.8. "Assembly" on page 22 in this section for procedure.

If the alternator rotates freely, but has no output, proceed as follows: See "Fig. 9-6: Alternator Electrical Schematic" on page 12.

- 1. Check AC connector and wiring integrity.
- 2. Check F1 connector and wiring integrity.
- Verify F1 is receiving 24-28 VDC signal. If not, troubleshoot the voltage regulator or vehicle charging system. Refer to 4.4. "Voltage Regulator" on page 31 in this section for more information on this component.

- 4. Check F1 Terminal resistance. Refer to 4.2.5. "Alternator Resistance Values" on page 14 in this section for specification. If the F1 resistance is not to specification, inspect the field winding coil or connections as follows:
 - Remove rear cover of alternator. Refer to 4.2.7.2. "Rear Cover" on page 18 in this section for procedure.
 - b. Verify continuity of F1 wire harness.
 Replace if damaged.
 - Verify white exciter wires are connected to ground and the red wires and the F1 harness ring terminal are securely fastened.
 - d. Remove M5 hex nut, F1 harness and both red exciter wires. Check the resistance of each red exciter wire to the white wire ring terminals. Refer to 4.2.5. "Alternator Resistance Values" on page 14 in this section for specification. If the resistance is outside of the value, the exciter may need replacing.

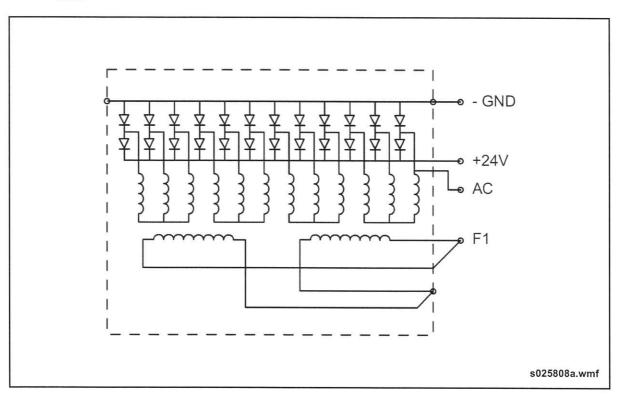


Fig. 9-6: Alternator Electrical Schematic



- Check AC Terminal resistance. Refer to 4.2.5. "Alternator Resistance Values" on page 14 in this section for specification. If the F1 resistance is not to specification, inspect the field winding coil or connections as follows:
 - Remove rear cover of alternator. Refer to 4.2.7.2. "Rear Cover" on page 18 in this section for procedure.
 - b. Verify continuity of AC wire harness.
 Replace if damaged.
 - c. Verify that the AC harness is securely connected to the stator lead. See "Fig. 9-16: Stator Winding Removal" on page 21.
 - d. Remove all (12) M5 hex nuts and stator leads from the stator terminals. Bend stator leads and ring terminals out to avoid any contact. Measure the stator lead resistance. If the resistance is not to specification, the stator assembly may need to be replaced. See "Fig. 9-7: Stator Leads" on page 13. Refer to 4.2.5. "Alternator Resistance Values" on page 14 in this section for specification.

Check the resistance between the Positive

 (+) and Negative (-) power stud. Refer to
 4.2.5. "Alternator Resistance Values" on page 14 in this section for specification.

 Replace the rectifier assembly if values are not to specification.

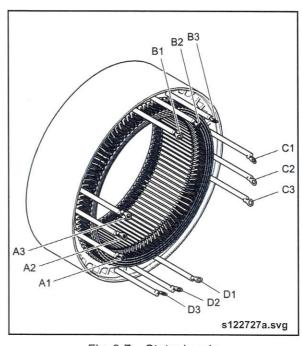


Fig. 9-7: Stator Leads



4.2.5. Alternator Resistance Values

	ALTERNATOR RESISTANCE VALUES		
LOCATION	RESISTANCE		
F1 Terminal	DMM (-) lead on Ground stud, DMM (+) lead on F1 = 4.1 ± 0.2 ohms		
	DMM (+) lead on Ground stud, DMM (-) lead on F1 = 4.1 ± 0.2 ohms		
AC Terminal	DMM (-) lead on AC, DMM (+) lead on Ground stud > 1 kilo ohm		
	DMM (+) lead on AC, DMM (-) lead on Ground stud > 1 kilo ohm		
Positive Stud to Ground Stud	DMM (-) lead on Ground stud, DMM (+) lead on Positive stud > 1 kilo ohm		
Sidding Stag	DMM (+) lead on Ground stud, DMM (-) lead on Positive stud > 1 kilo ohm		
Front Exciter 8.2 ± 0.4 ohms			
Rear Exciter	Rear Exciter 8.2 ± 0.4 ohms		
Stator Leads Stator steel frame to any stator lead ring terminal > 1 Mega ohm			
	Stator lead to stator lead on the same 3 phase winding = 0.1 - 1.0 ohms (i.e. A1 to A2, A2 to A3, A1 to A3 = 0.1 - 1.0 ohms)		
	Stator lead of one phase to another stator lead of different phase > 1 Mega ohm (i.e. A1 to B1, A1 to C2, A1 to D3 > 1 Mega ohm)		



4.2.6. Removal

- Set the Battery Disconnect switch to the OFF position.
- 2. Open the rear exterior engine access door and swing open the belt guard.
- Remove the air intake tube that crosses in front of the alternator by removing the Uclamp, and loosening the T-clamps at either end.



DO NOT cut the drive belt to remove it as the spring loaded pulley will snap back violently. This could result in personal injury or damage the pulley stop and render it unserviceable.

 Release belt tension and remove the alternator drive belt. See "Fig. 9-8: Alternator Removal & Installation" on page 16.

MOTE:

Use a 1/2" breaker bar to rotate the tensioner pulley upwards and relieve belt tension.

- 5. Enter the interior of the vehicle and raise and secure the rear passenger seat.
- Raise and secure the interior engine access door.

- Remove the two lock nuts and washers that secure the power cable bracket to the rear of the alternator.
- Loosen the T-clamp that secures the rubber elbow to the rear of the alternator and pull back the elbow.
- 9. Unplug the "F1", and "AC" wire connectors from the rear of the alternator.
- 10. Remove the 1/2" nuts and washers that secure the power and ground cables to the terminals on the rear of the alternator.
- 11. Return to the rear of the vehicle and remove the four mounting bolts and washers that attach the alternator to the engine mounting bracket.



Use appropriate lifting equipment to remove the alternator. The alternator weighs 100 lbs. (45 kg).

 Carefully lift and slide the alternator off the mounting bracket and remove unit from the vehicle.

MOTE:

The use of a forklift, with the forks drawn together, provides a cradle for the alternator and allows for easy removal from the vehicle.



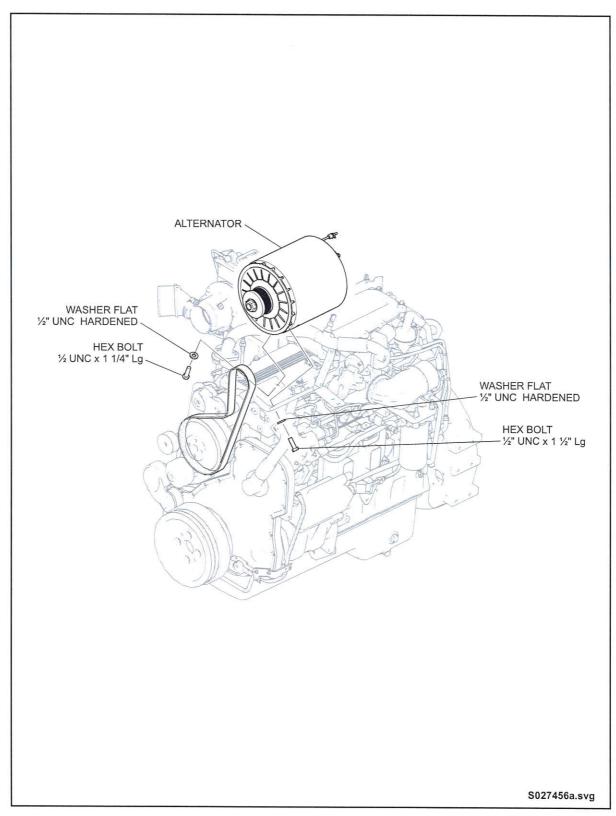


Fig. 9-8: Alternator Removal & Installation



4.2.7. Disassembly

MOTE:

Mark the alignment of the front and rear frame to the stator housing prior to disassembly. These marks will be used during reassembly to ensure correct orientation of these parts.

4.2.7.1. Pulley & Fan

- 1. Use a hammer and chisel to carefully bend back and flatten the locking tab washer.
- Loosen and remove the pulley nut, tab lock washer, and flat washer. See "Fig. 9-9: Pulley & Fan Removal" on page 17.

MOTE:

Removal of the pulley nut may require the use of an impact wrench. Wear protective gloves and grasp the fan to keep the shaft from rotating while operating the impact wrench.

Mark the front face of the pulley and use a puller (Item 7 from Alternator Special Tools List) to remove the pulley from the shaft.



DO NOT pry the fan off the shaft. The fan is cast aluminum and can be damaged easily if excessive force is used.

4. Slide the fan off the shaft.

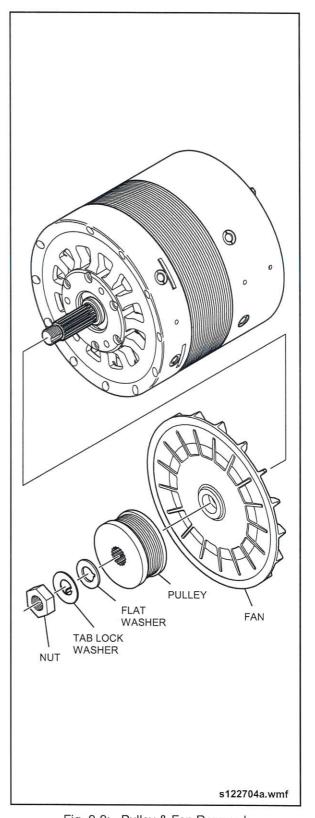


Fig. 9-9: Pulley & Fan Removal



4.2.7.2. Rear Cover

- 1. Remove the nuts and washers from the power and ground studs.
- Release the wire terminal from the connector shell on both the "F1" and "AC" connectors.

MOTE:

Use Delphi tool #12014012 (or commercial equivalent) to release terminal from connector.

- Remove the four M6 bolts from the rear cover of the alternator.
- Use a rubber mallet and carefully tap the rear cover to separate it from the rear frame.
- Push the "F1" and "AC" wire lead rubber grommets inward to remove them from the rear cover.
- Slide off the rear cover until it is completely removed. See "Fig. 9-10: Rear Cover Removal" on page 18.

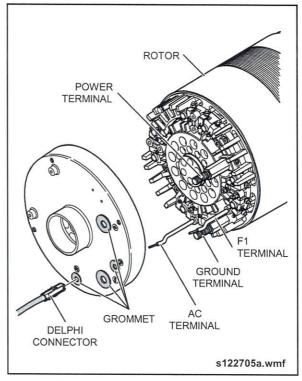


Fig. 9-10: Rear Cover Removal

4.2.7.3. Front Frame

- 1. Scribe mark the alignment of the front frame to the stator housing.
- Remove the six M8 bolts from the center of the front frame. These bolts attach the front frame to the front exciter.
- 3. Remove the eleven M6 bolts from the outer edge of the front frame. These bolts attach the front frame to the rear frame.
- Remove the front and rear exciter ring terminals from the rectifier. Make note that
 the white wires are connected to ground
 and the red wires are connected to the F1
 terminal
- 5. Straighten the ring terminal ends of the exciter wires so that the wires can pass easily through the stator housing.
- Cut away the plastic wire ties from the exciter sheathing.
- Use the front frame/exciter puller (Item 1 from Alternator Special Tools List) to remove the front frame, front bearing, and front exciter. See "Fig. 9-11: Front Frame Puller" on page 19.
- 8. Install three M8 x 60 flange head bolts into the front frame, utilizing every other bolt hole. Tighten all three bolts evenly until the puller tool is flush with the frame.
- 9. Use an impact wrench with a 3/4" socket to remove the front frame.

MOTE:

The disassembly process will damage the front bearing and a new bearing will be required during assembly.

- 10. Mark the location of the front exciter wires with respect to the slots within the stator housing as the front frame is being removed from the stator housing.
- 11.Remove the P-clip that supports the front exciter wires inside the front frame. See "Fig. 9-12: P-Clip Removal" on page 19.
- 12. Separate the front frame from the front exciter/bearing by tapping them apart. If necessary, use a large socket to press the front bearing out of the front frame. Discard the front bearing.

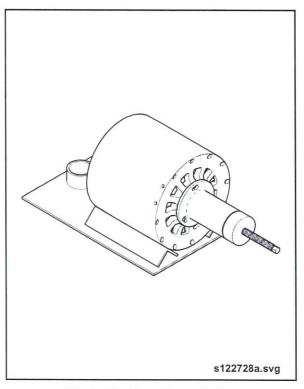


Fig. 9-11: Front Frame Puller

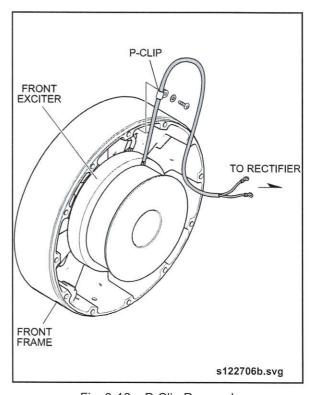


Fig. 9-12: P-Clip Removal



4.2.7.4. Rotor & Rear Exciter

- Remove the six M8 bolts that attach the rear frame to the rear exciter. See "Fig. 9-13: Rear Exciter Bolts" on page 20.
- Install the rotor removal tool (Item 2 from Alternator Special Tools List) onto the end of the alternator. See "Fig. 9-14: Rotor Removal" on page 20.

MOTE:

The rotor removal tool includes a specially modified front frame.

- Install the flat washer and nut onto the threaded end of the rotor.
- 4. Use a 3/4" socket to evenly tighten the two 1/2" puller bolts to ensure the rotor is pulled straight. Continue tightening puller bolts until the rotor contacts the front frame.
- Remove the nut and flat washer and then remove the entire rotor puller tool from the alternator.
- Carefully slide the rotor out of the stator housing, ensuring that the previously removed rear exciter wires pass easily through the rear frame. Note the location of the exciter wires with respect to the slot in the rear frame.
- 7. Remove the rear exciter from the rotor by first assembling the front bearing press/ support tool into the base fixture (Items 3 & 4 from Alternator Special Tools List), and then inserting the splined end of the rotor into the support tool.
- Use the rear bearing puller (Item 5 from Alternator Special Tools List) to remove the rear exciter and bearing from the rotor assembly. See "Fig. 9-15: Rear Exciter Removal" on page 21.
- Insert three M8 x60 flange head bolts into the rear exciter utilizing every other bolt hole. Tighten all three bolts evenly until the puller tool is flush with the rear bearing.
- 10.Use an impact wrench on the hex head of the puller screw to remove the rear exciter/ bearing from the rotor shaft.

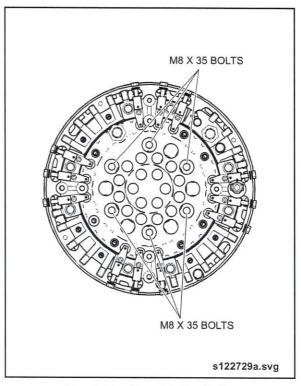


Fig. 9-13: Rear Exciter Bolts

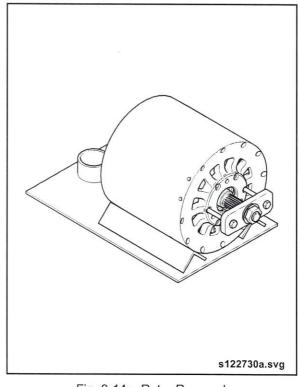


Fig. 9-14: Rotor Removal

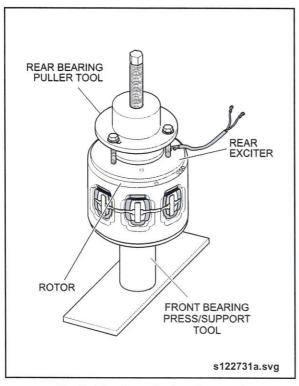


Fig. 9-15: Rear Exciter Removal

4.2.7.5. Stator Housing

- Remove all the stator winding ring terminals from the rectifier, being careful not to twist the diode terminals. Use needle-nose vise grips to keep the diode terminals from twisting while loosening the nuts. See "Fig. 9-16: Stator Winding Removal" on page 21.
- 2. Carefully remove the stator housing from the rear frame.

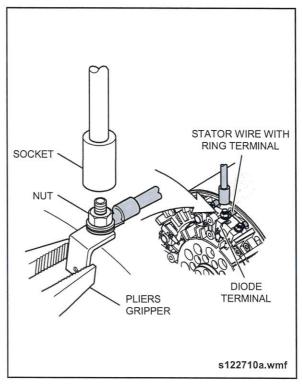


Fig. 9-16: Stator Winding Removal

4.2.7.6. Rectifier & Rear Frame

- Ensure that all stator winding and exciter ring terminals have been disconnected from the rectifier. The exciter terminals should be marked as to their location so they can be connected correctly during assembly.
- Remove the fourteen M6 bolts attaching the rectifier to the rear frame. See "Fig. 9-17: Rectifier Removal" on page 22.
- Separate the rectifier assembly from the rear frame. Discard the isolator gasket and scrape clean any silicone from the mounting surfaces See "Fig. 9-18: Rectifier Separation" on page 22.
- 4. Remove O-ring and spring washer from inside bearing seat in rear frame.



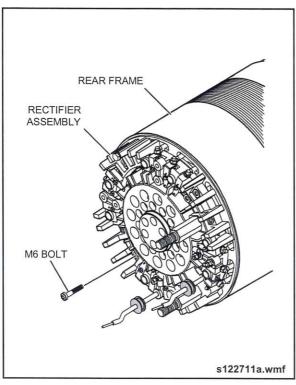


Fig. 9-17: Rectifier Removal

REAR FRAME \$122712a.wmf

Fig. 9-18: Rectifier Separation

4.2.8. Assembly

4.2.8.1. Rectifier & Rear Frame

- Assemble the rectifier onto the rear side of the rear frame using a new isolator gasket and silicone provided in the repair kit as follows:
 - Apply a thin layer of silicone to the entire surface of the isolator gasket and install the gasket onto the rectifier assembly.
 - b. Apply another thin layer of silicone to the other side of the gasket
 - Install the rectifier/gasket assembly onto the rear frame.
- Apply Loctite-242 to the fourteen M6 bolts and secure the rectifier to the rear frame. Torque bolts to 80 ± 8 in-lb. (9 ± 0.9 Nm).
- Install a new O-ring and spring washer into the bearing seat of the rear frame. See "Fig. 9-19: O-Ring & Washer Installation" on page 22.

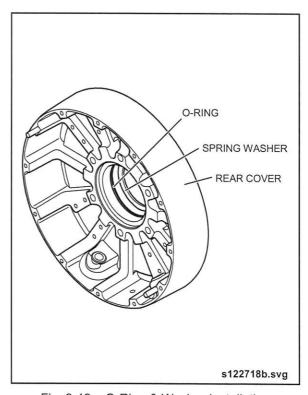


Fig. 9-19: O-Ring & Washer Installation



4.2.8.2. Stator Housing

- Align the stator housing with the rear frame using the alignment marks made during disassembly.
- 2. Apply Loctite-242 to all stator winding stud terminals
- Install ring terminals onto diode terminals and secure with washers and nuts. Torque nuts to 44 ± 4 in-lb. (5 ± 0.5 Nm). See "Fig. 9-20: Stator Terminal Installation" on page 23.

MOTE:

Use needle-nose vise grips to keep the diode terminals from twisting while tightening the nuts.

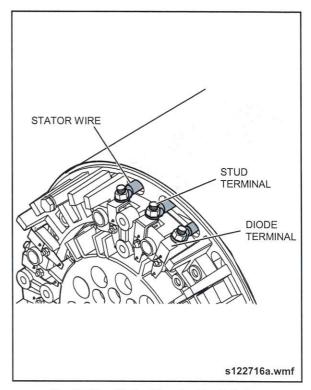


Fig. 9-20: Stator Terminal Installation



4.2.8.3. Rotor & Exciters

- Lubricate the rotor rear bearing seat with 90W oil.
- 2. Place the rear exciter and bearing assembly onto the rear side of the rotor assembly. Use the front bearing press/support tool (Item 3 from Alternator Special Tools List) to support the splined end of the rotor assembly during the pressing operation. See "Fig. 9-21: Rear Bearing Press" on page 24.

MOTE:

The rear exciter can be identified as the exciter with the shorter wire leads.

- Use the rear bearing press tool (Item 6 from Alternator Special Tools List) and press the bearing onto the rotor shaft until fully seated.
- 4. Reverse the position of the rotor so that the drive end is facing up.
- Lubricate the rotor front bearing seat with 90W oil and position the front exciter (longer wire leads) onto the rotor assembly.
- 6. Place the rotor assembly in a press, with the drive end facing up. Use the rear bearing press tool (Item 6 from Alternator Special Tools List) to support the base of the rotor. Use the front bearing press/support tool (Item 3 from Alternator Special Tools List) to press the inner race of the bearing onto the rotor until fully seated. See "Fig. 9-22: Front Bearing Press" on page 24.

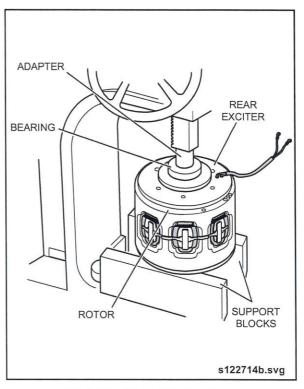


Fig. 9-21: Rear Bearing Press

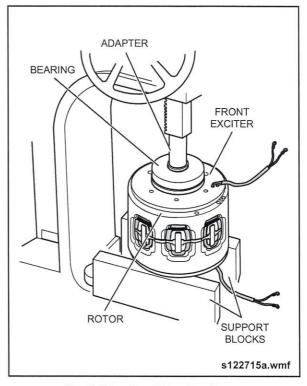


Fig. 9-22: Front Bearing Press



4.2.8.4. Front Frame

- Use the rear bearing support tool (Item 6 from Alternator Special Tools List) to support the rotor assembly.
- Place the front frame onto the drive end of the rotor assembly while aligning the P-clip mounting hole with the front exciter lead.
- Apply Loctite 242 to the threads of the six M8 bolts and install bolts through the center bolt holes of the front frame and into the threaded holes of the front exciter. Torque bolts to 12 ± 1 ft-lb. (16 ± 1.6 Nm) using a cross pattern. See "Fig. 9-23: Front Cover Installation" on page 26.
- Position the rotor and front frame onto the front bearing press/support tool and base fixture (Items 3 and 4 from Alternator Special Tools List).
- Fasten the front exciter wire to the inside of the front frame using a P-clip. Apply Loctite-242 to the threads of the fastener.
- Use the stator rear frame assembly tool (Item 8 from Alternator Special Tools LIst) and support the stator/rear frame assembly from a hoist and position directly above the front frame and rotor assembly.
- 7. Use a small gauge wire to pull the front exciter wires through the previously marked slot in the stator housing and rear frame. At the same time, use another small gauge wire to pull the rear exciter wires through the same slot on the rear frame. See "Fig. 9-24: Exciter Wire Assembly" on page 26.
- 8. Carefully lower the stator/rear frame assembly over the rotor assembly while

- guiding the exciter wires through the stator/rear frame assembly during this process. Continue to lower the stator/rear frame assembly until the stator housing is within close proximity, but not yet resting on the front frame.
- 9. Use a 6" long #2 Phillips screwdriver, or similar tool, to align the threaded holes in the rear exciter with the bolt holes in the rear frame. Also align the markings on the front frame with the markings on stator housing as the stator housing is being lowered.
- 10. Continue to lower the stator housing/rear frame/rectifier assembly over the rotor until the rear bearing is seated in the rear frame. Ensure marks made on the front frame and stator housing during disassembly are aligned.
- 11. Apply Loctite-242 to the six M8 bolts and install bolts through the bolt holes of the rear frame and into the threaded holes of the rear exciter. Torque bolts to 17 ± 2 ft-lb. (23 ± 2.3 Nm) using a cross pattern. See "Fig. 9-25: Rear Frame Bolts" on page 26.
- 12.Apply Loctite-242 to the eleven M6 bolts and install bolts into the outer row of bolt holes on the front frame. Torque bolts to 80 \pm 8 in-lb. (9 \pm 0.9 Nm).
- 13. Apply Loctite-242 to the exciter wire terminal studs on the rectifier.
- 14. Connect the two red exciter wires and the two white exciter wires to rectifier assembly as marked during disassembly. Torque nuts to 44 ± 4 in-lb.(5 ± 0.5 Nm). See "Fig. 9-26: Stator Connections" on page 26.

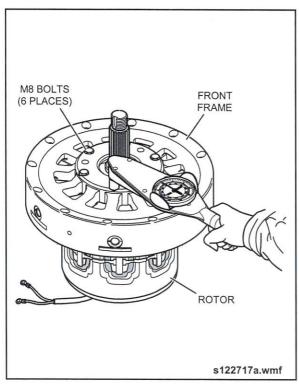


Fig. 9-23: Front Cover Installation

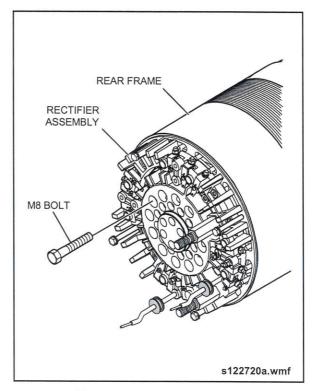


Fig. 9-25: Rear Frame Bolts

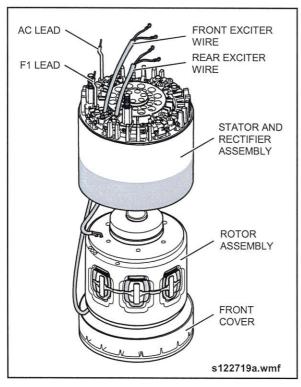


Fig. 9-24: Exciter Wire Assembly

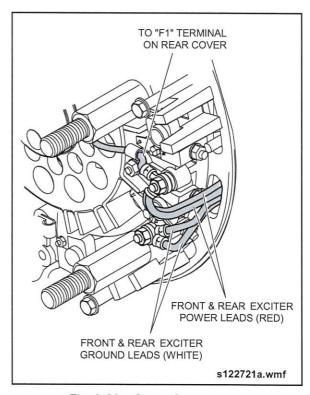


Fig. 9-26: Stator Connections



4.2.8.5. Rear Cover

- Position the rear cover above the exciter assembly and align the power and ground studs and mounting holes.
- Slide the rear cover toward the rectifier assembly while guiding the "F1" and "AC" wire leads through the cover.
- Press the "F1" and "AC" wire lead grommets into the holes in the rear cover from the inside
- Press the rear cover onto the rectifier assembly until seated and carefully pull the "F1" and "AC" wire leads through the grommets.
- 5. Apply Loctite-242 to the four M6 bolts and install bolts through the cover and into the rectifier assembly. Torque bolts to 80 ± 8 in-lb. (9 ± 0.9 Nm).
- Install the nuts and washers on the power and ground studs.
- Reinsert the wire terminals into the Delphi connectors.

RNOTE:

Spread the latching ears on the Delphi terminals so that they will lock into place on the connector housing.

4.2.8.6. Pulley & Fan

- Slide the fan onto the alternator shaft with the fan blades facing inward towards the alternator.
- Slide the pulley onto the alternator shaft with marked side facing outward from the alternator.

- Install new flat washer, tab lock washer, and nut.
- Torque pulley nut to 180 to 215 ft-lb. (245 to 290 Nm).
- Bend one side of the tab lock washer up against the flat of the pulley nut. See "Fig. 9-27: Tab Lock Washer Installation" on page 27.

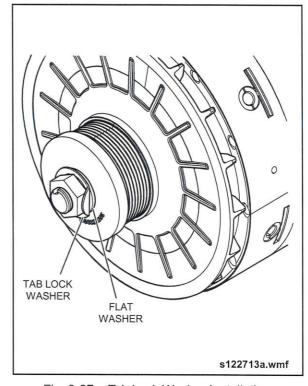


Fig. 9-27: Tab Lock Washer Installation



4.2.9. Installation



Use appropriate lifting equipment to install the alternator. The alternator weighs 100 lbs. (45 kg).

- Use appropriate lifting equipment, such as a forklift, and position the alternator on the engine mounting bracket.
- 2. Align the four holes in the bracket with the threaded holes in the alternator.
- Install four 1/2" mounting bolts and washers. Ensure transmission dipstick mounting bracket is secured by one of the mounting bolts. Torque the four mounting bolts to 65 to 74 ft-lb. (88 to 100 Nm).
- 4. Use a 1/2" breaker bar to rotate the belt tensioner pulley upwards and then carefully install the alternator drive belt over the accessory drive, idler, and alternator pulleys. Ensure the ribs of the belt are aligned with the pulley grooves then release belt tensioner.
- 5. Install the air intake tube and tighten the T-bolt clamps at either end. Torque T-bolt clamps to 60 to 75 in-lbs.

6. Secure the air intake tube to the mounting bracket using a U-clamp.

MOTE:

Ensure the U-clamp cushion is properly installed between the air intake tube and mounting bracket. Tighten the U-clamp nuts evenly.

- 7. Close and latch the belt guard.
- Move to the interior of the vehicle and connect the positive and negative cables to the alternator terminals and torque nuts to 30 to 35 ft-lbs. (40 to 48 Nm).
- 9. Connect the "F1" and "AC" wire connectors to the vehicle wiring harness.
- 10. Attach the air intake rubber elbow to the rear cover and torque T-bolt clamp nut to 60 to 75 in-lbs.
- 11.Install the power cable bracket on the rear cover of the alternator and secure with lock nuts and washers.
- 12. Close the interior engine access door and lower the rear seat.
- 13. Set Battery Disconnect switch to ON posi-
- 14. Start engine and check charging output using a voltmeter and ammeter.



4.3. Alternator Special Tools

4.3.1. Alternator Special Tools Chart

Refer to your New Flyer Parts Manual for tool part numbers. See "Fig. 9-28: Alternator Special Tools" on page 30.

SPECIAL TOOLS	DESCRIPTION
1	Puller, Front Frame/Exciter
2	Puller, Rotor
3	Press/Support Tool, Front Bearing
4	Base Fixture
5	Puller, Rear Exciter/Rear Bearing
6	Press/Support Tool, Rear Bearing
7	Puller, Pulley
8	Lifting Tool, Stator/Rear Frame Assembly



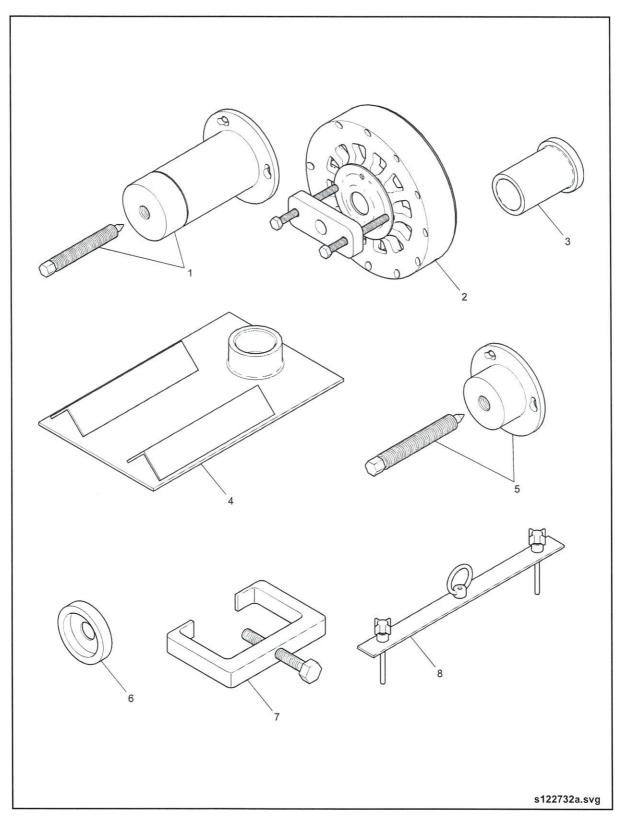


Fig. 9-28: Alternator Special Tools



4.4. Voltage Regulator



Over-charging a lead acid battery can produce explosive and hazardous gas. Any change in battery configuration from the equipment originally supplied on your New Flyer vehicle may require modification to the charging system voltage levels and battery service procedures to prevent overcharging and equipment damage.

4.4.1. Description

The voltage regulator is installed in the rear equipment box. It limits the alternator voltage to a preset value by controlling the alternator field current. The regulator is a sealed unit with an adjustment screw accessible on its face and an integral connector containing Ground, Field, Battery, Ignition and Sense terminals. The Ground terminal is connected to the rear equipment box ground bar. The Field terminal is connected to the alternator Field terminal. The Battery terminal is connected to the vehicle's 24 volt battery bus bar. The Ignition terminal is connected to the vehicle's multiplexing system, and receives current once the vehicle has been running for three seconds. The Sense terminal is not used in this application. It is only required when the vehicle batteries are located remotely from the regulator. See "Fig. 9-29: Regulator" on page 31.

Alternator operating voltage is determined by the regulator voltage adjustment. Once adjusted, the alternator voltage remains constant, and is unaffected by length of service, changes in temperature, or changes in alternator output and speed.

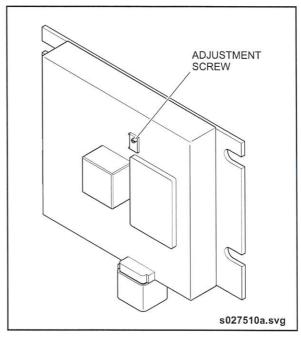


Fig. 9-29: Regulator



4.4.2. Voltage Regulator Troubleshooting

Trouble in the electrical charging system is usually indicated by one of two conditions an undercharged battery or an overcharged battery. Either condition can result from an improper voltage regulator setting. The ideal voltage setting is the one which will maintain the batteries in a fully charged condition with a minimum use of water.

A record of water usage and battery specific gravity checks over a service period of reasonable length will establish the ideal voltage setting for the vehicle involved. Where maintenance-free batteries are used, the absence of gassing indicates the voltage setting is satisfactory.

Undercharged Battery

If the batteries are undercharged and the alternator is producing the correct output, raise the regulator setting by 0.3 volts and check for an improved battery condition over a period of 48 hours. If the voltage cannot be adjusted, replace the regulator.

Overcharged Battery

If the batteries are overcharged and the alternator is producing the correct output, lower the regulator setting by 0.3 volts and check for an improved battery condition over a period of 48 hours. If the voltage cannot be adjusted, replace the regulator.

4.4.3. Adjustment

To check the voltage setting, connect a voltmeter across the Battery and Ground terminals on the regulator, and clamp an ammeter around the DC cable at the alternator. See "Fig. 9-30: Regulator Adjustment" on page 32.

Operate the engine at approximately 1000 RPM with an electrical load to produce a 30 amp output. The voltage reading should be 28 ± 0.3 VDC.

The voltage should be steady. Adjust the setting by turning the adjusting screw clockwise to increase the voltage and counter-clockwise to decrease the voltage.

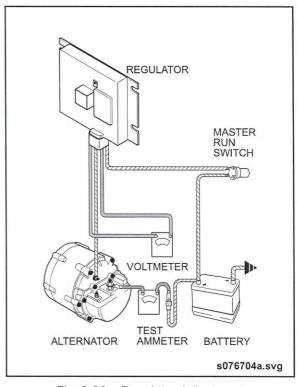


Fig. 9-30: Regulator Adjustment



4.4.4. Replacement

III NOTE:

Besides the adjustment procedure previously described, the unit is non-serviceable and should be replaced if defective. Proceed as follows:

- 1. Gain access to the regulator in the engine compartment box. See "Fig. 9-31: Regulator Removal & Installation" on page 33.
- 2. Set the Battery Disconnect switch to the OFF position.

- 3. Disconnect the harness from the regulator.
- Remove the four lock nuts and washers which secure the unit.
- 5. Remove the unit and install replacement with same mounting hardware.
- Connect vehicle wiring harness to regulator.
- Set the Battery Disconnect switch to ON position.
- 8. Check voltage setting of replacement unit. Refer to 4.4.3. "Adjustment" on page 32 in this section for procedure.

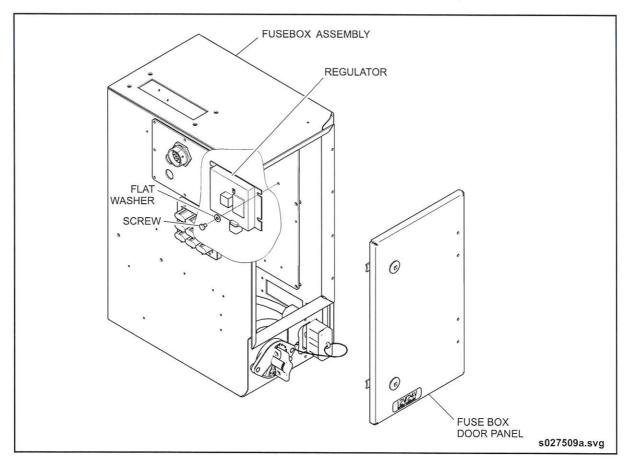


Fig. 9-31: Regulator Removal & Installation



5. ELECTRICAL STARTING SYSTEM

5.1. Description

The starter is a heavy-duty unit, solenoid operated through an enclosed shift lever and equipped with a sprag-type over-running clutch. A removable plug in the shift lever housing permits adjustment of pinion clearance. The nose housing can be rotated to obtain a number of different solenoid positions with respect to the mounting flange.

Armature shaft is supported in bronze bushings at three points: in commutator end frame, in shift lever housing and in nose housing. Positive lubrication is provided at each bushing and contacts the armature shaft. A waste-filled oil reservoir for each wick provides a large oil supply.

O-ring seals are used between commutator end frame and field frame and between shift lever housing and field frame. A solenoid linkage seal and lip-type armature shaft seal (at shift lever housing) prevent entry of oil into solenoid case and starter main case.

Four brush holders mounted on the brush holder plate carry the one-piece brushes. As shown on internal wiring diagram, two sets of brushes are connected to the ground terminal stud on commutator end frame; these connections are made through the brush holder mounting plate. The other two sets of brushes are insulated from mounting plate and connect to field coil leads.

5.2. Operation

MOTE:

The multiplexing system limits continuous starter operation to 14 seconds. The starter circuit is then disconnected for 60 seconds to allow the starter to cool down.

The solenoid windings are energized when the ignition start button is pushed. The resulting plunger and shift lever movement causes the pinion to engage the engine flywheel ring gear and the solenoid main contacts to close and cranking takes place. In case of butt engagement, the motor is not energized to prevent damage to the pinion and gear teeth.

When the engine starts, pinion overrun protects the armature from excessive speed until the switch is opened, at which time the return spring causes the pinion to disengage. When the engine starts, the "start" circuit is automatically broken by a starter control circuit (which is sensitive to alternator output). This prevents excessive overrun and damage to the drive and armature windings.

5.3. Removal

™NOTE:

Before removing starter, make preliminary checks.

- 1. Turn battery disconnect switch off.
- 2. Remove wires and cable from starter and solenoid. Tag all wiring for identification purposes when reinstalling starter.
- Secure a suitable strap around the starter, then remove the three bolts and lock washers attaching starter to engine. Carefully remove starter. See "Fig. 9-32: Starter Motor Installation" on page 35.

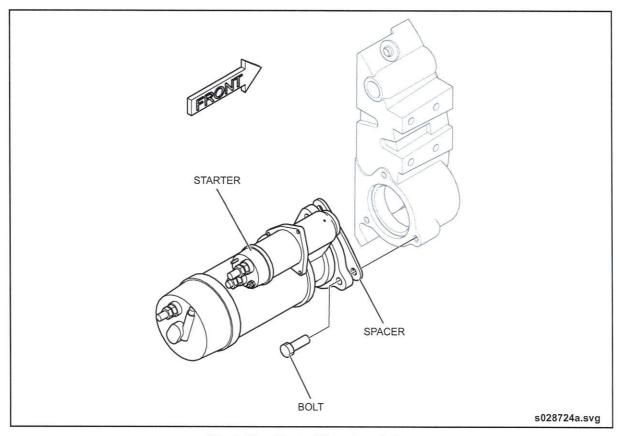


Fig. 9-32: Starter Motor Installation

5.4. Maintenance

5.4.1. Lubrication

All wicks and oil reservoirs should be saturated with SAE 10 oil and splines underneath the clutch should be lubricated with a light coat of SAE 10 oil, periodically, or at time of engine overhaul.

All connections should be kept clean and tight and brushes inspected for wear. See "Fig. 9-33: Typical Starter Motor Circuit" on page 35.

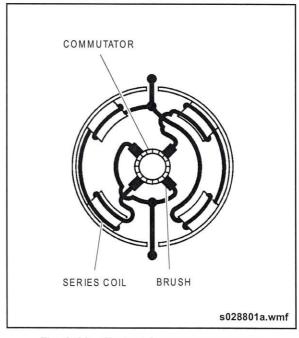


Fig. 9-33: Typical Starter Motor Circuit



5.4.2. Brush Inspection

- Remove the attaching bolts (6) and separate the commutator end cap from field frame. Inspect brushes for wear.
 - When brushes are worn down to less than one-half their original length, they must be replaced (orig. length is 3/4"/19.05 mm).
- Ensure that brush holders are clean and brushes are not binding in holders. The full brush surface should ride on the commutator to give proper performance.
- Check by hand to ensure that the brush springs are giving firm contact between the brushes and commutator. If springs are distorted or discolored, they should be replaced.
- Be sure all leads are secure in brushes and that terminal clips are properly soldered to leads.

5.4.3. Brush Removal

- 1. Remove starter motor from engine.
- Remove commutator end cap from field frame.
- Remove screws and washers attaching the field coil and brush leads to brush holders.

 Remove remaining screws securing brush leads. Using screwdriver, lift brush holder spring back and remove brush from holder.

5.4.4. Brush Installation

- Using a suitable screwdriver, lift up brush holder spring and with groove in brush aligned with ridge in holder, insert brushes into holders.
- Check by hand to ensure that the brush springs are giving firm contact between the brushes and commutator. If springs are distorted or discolored, they should be replaced.
- Be sure all leads are secure in brushes and that terminal clips are properly soldered to leads.
- Position brush leads and field coil leads to brush holders and attach with screws and washers. Tighten screws firmly.
- Make sure brush holders are clean and brushes are not binding in the holders. The full brush surface should ride on the commutator to give proper performance.
- 6. Perform "no-load" test. Install starter motor on engine.

5.5. Electrical Starting System Troubleshooting

5.5.1. Starter Circuit Inspection

- Before removing any unit in the cranking circuit for repair, the following preliminary checks should be made:
 - To ensure battery is fully charged, perform battery tests.
 - Wiring: Inspect wiring for damage. Inspect all connections for corrosion or looseness. Clean and tighten all cable connections as required.
 - c. Magnetic switch, solenoid and control switches: Inspect all switches to determine their condition. Connect a jumper lead around any switch suspected of being defective. If the system functions properly using this method, check and/ or replace the by-passed switch. See "Fig. 9-34: Solenoid Winding Check" on page 37. See "Fig. 9-35: Testing Solenoid Winding" on page 37.
 - d. Motor: If the battery, wiring and switches are in satisfactory condition and the engine is known to be functioning properly, remove the starter motor. With starter motor removed from the engine, check to see that armature is not "frozen" in position by prying on the pinion with a screwdriver. Tight bearings, a bent armature shaft or a loose pole shoe screw will prevent the armature from turning freely. If the armature is frozen or does not turn freely, the motor should be disassembled and the problem corrected. However, if the armature rotates freely, the motor should be given the following no-load test before disassembly.

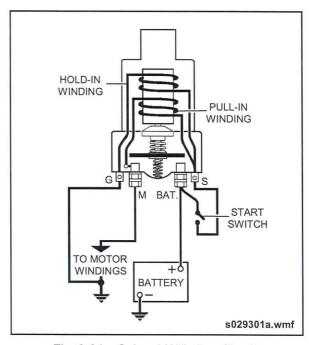


Fig. 9-34: Solenoid Winding Check

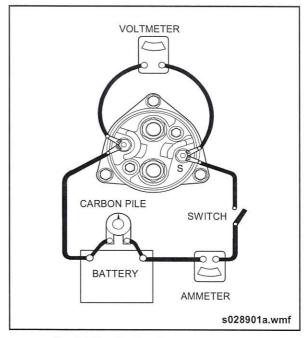


Fig. 9-35: Testing Solenoid Winding

Electrical Starting System Troubleshooting

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5.5.2. Starter No-Load Test

To perform test, make test connections as follows:

- Connect an ammeter in series with the positive (+) cable from the two 12-volt batteries and the BAT terminal of the starter solenoid. See "Fig. 9-36: No-Load Test" on page 38.
- Connect a switch in the open position from the starter solenoid BAT terminal to the solenoid switch (S) terminal.
- Connect a lead from the starter commutator end terminal to battery negative (-) terminal
- Connect a voltmeter from the solenoid motor (M) terminal to commutator end terminal on the starter motor.
- Install RPM indicator (tachometer) to end of armature shaft to determine armature RPM.
- 6. Close the switch and note the RPM, current and voltage reading. It is not necessary to obtain the exact voltage specified.

Reading should be:

Volts - 20 Min. Amps - 50 Max. Amps - 90 Min. RPM - 6300 Max. RPM - 8400

 If exact voltage reading is desired, connect a carbon pile across one of the two 12-volt batteries to reduce voltage to specified value.

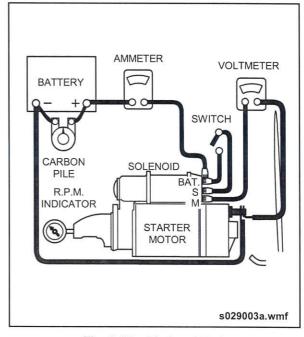


Fig. 9-36: No-Load Test



Electrical Starting System Troubleshooting

5.5.3. No-Load Test Result

- Rated current draw and no-load speed indicates normal condition of the starter motor.
- Low free-speed and high current draw indicates:
 - Excessive friction: tight, dirty, or worn bearings, bent armature shaft or loose pole shoes allowing armature to drag.
 - Shorted armature: this can be further checked on a growler after disassembly.
 - c. Grounded armature of fields: check further after disassembly.
- Failure of starter to operate with high current draw indicates:
 - a. A direct ground in the terminal or fields.
 - b. "Frozen" bearings. This should have been determined by turning the armature by hand.

- Failure to operate with no current draw indicates:
 - Open circuit: this can be checked after disassembly by inspecting internal connections and tracing circuit with a test lamp.
 - Open armature coils: inspect the commutator for badly burned bars after disassembly.
 - c. Broken brush springs, worn brushes, high insulation between the commutator bars or other causes which would prevent good contact between the brushes and commutator.
- Low no-load speed and low current draw indicates high internal resistance due to poor connections, defective leads, or commutator "varnish" and causes listed under step 4 preceding.
- High free-speed and high current draw indicates shorted fields. If shorted fields are suspected, replace the field coil assembly and check for improved performance.



5.5.4. Starter Solenoid Switch Troubleshooting

The basic solenoid circuit with dual windings is shown. See "Fig. 9-37: Testing Solenoid Pull-In Winding" on page 41. The hold-in winding is connected from the (S) terminal to the (M) terminal.

- When the start switch is closed: both windings are energized and the magnetism produced by each acts together to strongly attract the plunger into the core. The pull-in winding current returns to the battery through the motor windings.
- With the motor cranking: the hold-in winding magnetism is sufficient to hold the plunger in and the contact disc shorts out the pull-in winding, thereby avoiding excessive heat.
- 3. When the switch is opened: battery current flows through the contact disc to the (M) terminal and through the pull-in winding in the reverse direction and the hold-in winding in the normal direction. The two magnetic fields oppose and essentially cancel out each other. The return springs cause the solenoid to return to its original position thus completing the cranking cycle.
- 4. The solenoid can be checked electrically by connecting a battery of the specified voltage, a switch and an ammeter to the two solenoid windings. With all leads disconnected from the solenoid, make test connections as shown.

Connect switch and ammeter to the (S) and (M) terminals.

To reduce the voltage to the specified value, if needed, connect the carbon pile between the battery and (M) terminal as shown by dashed line instead of across the battery.

If a carbon pile is not needed, connect a jumper directly from the battery to the (M) terminal as shown in dashed lines.



To prevent overheating, DO NOT leave the pull-in winding energized more than 15 seconds. The current draw will decrease as the winding temperature increases.

An operational method is as follows:

- a. Connect battery to (S) terminal and to (G) terminal.
- A plunger inserted inside solenoid should be magnetically attracted. If not, hold-in winding is open.
- c. Connect battery to (S) terminal and to (M) terminal. A plunger inserted inside solenoid should be magnetically attracted. If not, pull-in winding is open.
- d. Connect battery to (M) terminal and to (G) terminal. A plunger inserted inside solenoid should not be magnetically attracted. If it is, windings are shorted.
- e. Connect battery from (G) terminal to solenoid case or metal ground. A plunger inserted inside solenoid should not be magnetically attracted. If it is, windings are grounded.
- Solenoid requires no periodic maintenance other than keeping the terminals clean and tight.
- Always check action of solenoid if it has been removed. If unit fails to function, first check wiring before condemning the solenoid. Solenoid windings can be checked for current draw, open circuit, or shorts. Adjust carbon pile for specified voltage reading, then record amperage reading.
- 7. A burned solenoid coil, excessively carbonized terminal contacts or contact disc should be replaced (contact disc can be reversed). Also check resistance between solenoid motor terminal stud and "hold-in" winding terminal lug, since oxidation sometimes insulates the terminal lug from the terminal stud (resistance should be no more than 0.2 ohms). Whenever solenoid is removed from the starter motor, pinion clearance must be checked and properly adjusted.

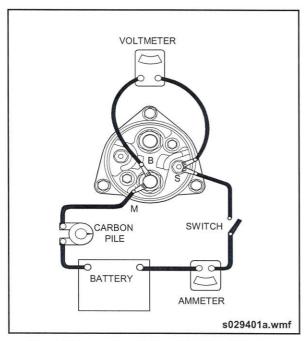


Fig. 9-37: Testing Solenoid Pull-In Winding

5.6. Disassembly

Normally the starter motor should be disassembled only as far as necessary to repair or replace defective parts.



As a precaution, safety glasses should be worn when disassembling the starter motor.

- Note the relative position of the solenoid, lever housing, and nose housing for later reassembly. See "Fig. 9-38: Starter Motor Assembly" on page 42.
- Disconnect field coil connector from solenoid motor terminal and ground return lead from solenoid.
- 3. Remove attaching bolts and separate the commutator end cap from the field frame.
- 4. Remove attaching screws to separate brush plate assembly from field frame.
- Separate nose housing and field frame from lever housing by removing attaching bolts.
- 6. Remove pinion stop.
- 7. Remove armature and clutch assembly from lever housing.
- 8. Separate solenoid from lever housing by pulling apart.
- It is not necessary to further disassemble starter unless parts require replacement. Refer to 5.6.1. "Inspection, Tests & Repair of Starter" on page 43 in this section for procedure.



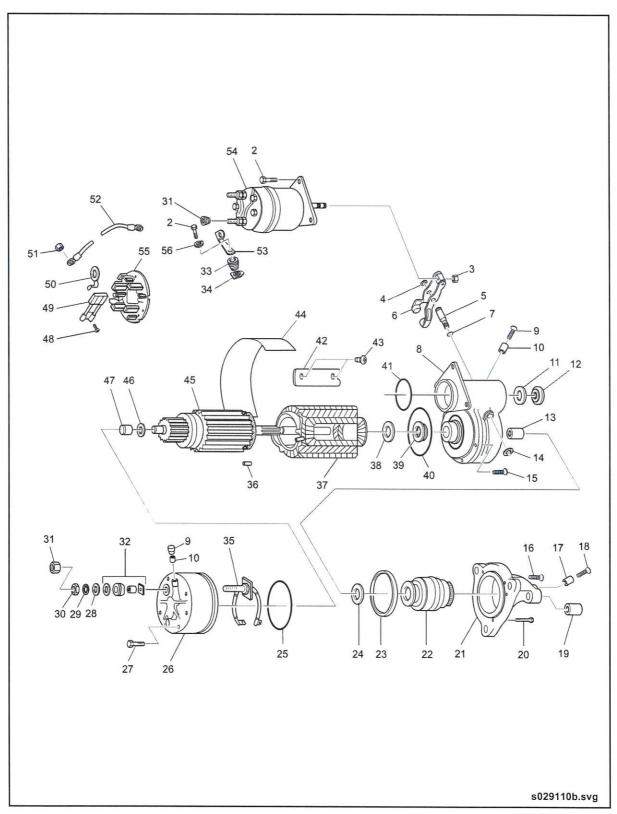


Fig. 9-38: Starter Motor Assembly



- Starter Motor Assembly, 24V (Incl. 2...60)
- 2. Screw
- 3. Nut, Plunger Rod Guide Adjusting
- 4. O-Ring, Shift Lever Shaft 1/2" O.D.
- 5. Shaft, Shift Lever
- 6. Lever, Shift
- 7. O-Ring, Shift Lever Shaft 3/8" O.D.
- 8. Lever, Housing
- 9. Cup
- 10. Wick, Oil Reservoir Lever Housing
- Gasket, Inspection Plug Lever Housing
- 12. Plug, Inspection Lever Housing
- 13. Bushing, Lever Housing
- 14. Snap Ring
- 15. Screw, Lever Housing Attachment
- 16. Plug, Drive Housing Mounting Holes
- 17. Wick, Oil Reservoir D.E.
- 18. Cup, Oil Reservoir D.E.
- 19. Bushing, Drive Housing

- 20. Screw, Drive Housing Attachment
- 21. Housing Drive
- 22. Drive Assembly
- 23. O-Ring, between Dr. Housing & Lever Housing
- 24. Washer, Brake
- 25. O-Ring, On Motor Frame C.E. End
- 26. Frame, C.E.
- 27. Screw & Washer Assembly, C.E. Frame Attachment
- 28. Washer
- 29. Washer, Lock Internal Tooth 1/2"
- 30. Nut, Terminal C.E. Frame
- 31. Nut & Washer Assembly, C.E. Frame
- 32. Insulation, C.E. Terminal\
- Insulator, Field Terminal (Outside Frame)
- Insulator, Field Terminal (Inside Frame)
- 35. Lead, C.E. Terminal
- 36. Pin, Spring

- 37. Coil, Field
- 38. Washer, Space D.E.
- 39. Seal, Oil Lever Housing
- 40. O-Ring
- 41. O-Ring, Switch & Lever Housing
- 42. Pole, Shoe
- 43. Screw, Pole Shoe
- 44. Insulator, Field Coil C.E.
- 45. Armature
- 46. Washer, Thrust C.E.
- 47. Bushing, C.E. Frame
- 48. Screw
- 49. Brush
- 50. Spring, Brush
- 51. Nut
- 52. Lead
- 53. Connector, Field Terminal to Switch
- 54. Switch
- 55. Brush Plate, Assembly
- 56. Washer, Plain Field Terminal

Starter Motor Assembly (parts list)

5.6.1. Inspection, Tests & Repair of Starter



The drive assembly, armature and field frame and coils assembly should not be cleaned in any degreasing tank or with grease dissolving solution, Since these would dissolve the lubricant in the drive mechanism and damage the insulation in the armature and field coils.

All parts except the drive should be cleaned with mineral spirits and a brush. The drive should be wiped with a clean cloth.

NEVER use emery cloth to clean commutator.

5.6.2. Brushes & Holders

Inspect the brushes for wear. If they are worn excessively when compared with a new brush, they should be replaced. Make certain the brush holders are clean and the brushes are not binding in the holders.

The full brush surface should ride on the commutator to give proper performance. Check by hand to insure that the brush springs are giving firm contact between the brushes and the commutator. If the springs are distorted or discolored, they should be replaced.



5.6.3. Armature

If the armature commutator is worn, dirty, out-of-round, or has high insulation, the armature should be put in a lathe and the commutator turned down.

The insulation should then be undercut 1/32" (0.794)mm) wide and 1/32" deep and the slots cleaned out to remove any trace of dirt or copper dust. As a final step in this procedure, the commutator should be sanded lightly with No. 00 sandpaper to remove any burrs left as a result of the undercutting procedure. Do not cut deeper than necessary to remove rough spots or out-of-round condition.

Check the armature for open and/or short circuits and grounds as follows:

1. Open circuit test

Open circuits are usually caused by excessively long cranking periods. The most likely place for an open circuit to occur is at the commutator riser bars. Inspect the points where the conductors are joined to the commutator bars for loose connections. Poor connections cause arcing and burning of commutator bars as the cranking motor is used. If the bars are not too badly burned, repair can often be done by soldering (or welding) the leads in the riser bars (using Rosin Flux) and turning down the commutator in a lathe to remove the burnt material. The insulation should then be undercut as noted previously.

2. Short circuit test

Short circuits in the armature are located by the use of a growler. When armature is rotated in the growler with a steel strip such as a hacksaw blade held above it, the blade will vibrate above the area of the armature core in which the short circuit is located. Shorts between bars are sometimes produced by brush dust or copper between the bars. These shorts can be eliminated by cleaning out the slots. See "Fig. 9-39: Checking Armature (shorts)" on page 44.

3. Ground test

Grounds in the armature can be detected with a 110-volt test lamp and test probes. If the lamp lights with one test probe placed on commutator and the other on the core or shaft, the armature is grounded. Grounds occur as a result of insulation failure, which is often brought about by overheating due to excessively long cranking periods, or by accumulation of brush dust between the commutator bars and the steel commutator ring.

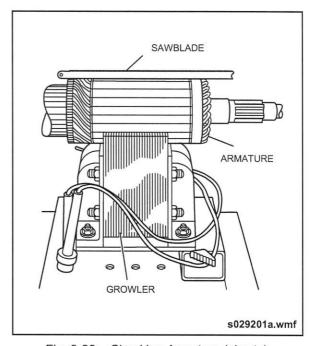


Fig. 9-39: Checking Armature (shorts)



5.6.4. Field Coils

Internal wiring circuit is shown. The field coils can be checked for grounds and opens using a test lamp as follows:

1. Grounds

The field coil ground connection must be disconnected during this test. Connect one lead of the 110-volt test lamp to the field frame and the other lead to the field connector terminal stud on the field frame. If the lamp lights, at least one of the field coils is grounded and must be repaired or replaced.

II NOTE:

This check cannot be made unless the ground connection is disconnected.

2. Opens

Connect one test lamp lead to the terminal stud on field frame and the other in turn to each of the field coil leads which connect to the brush holders; the lamp should light. If lamp fails to light, the field coils are open.

3. Replacement

Field coils can be removed from the field frame by using a pole shoe screwdriver.

A pole shoe spreader should also be used to prevent shorting or grounding the field coils as the pole shoes are tightened into place. Each pole shoe has a long lip on one side and short lip on the other. They should be installed with the long lip pointing in the direction of armature rotation so it becomes the trailing (not leading) edge of the pole shoe.

5.6.5. Commutator End Frame

Remove brushes. Place one test lamp lead on end frame and the other, in turn, on each of the brush holders and on terminal stud. If lamp lights, it is an indication of defective brush holder insulation or terminal insulators. Replace defective insulators under brush holder mounting plates or at terminal stud.

Check brush spring tension. Examine brush holders and hinge pins for bent or damaged condition. Any condition which might prohibit free brush action must be

corrected. If brushes are worn down to less than one-half their original length, they must be replaced. Original length is 3/4" (19.05 mm). Be sure leads are secure in brushes and that terminal clips are properly soldered to leads.

Examine bushing in end frame for excessive wear or out-of-round condition. Replace bushing, if necessary, as follows:

- Remove expansion plug from armature shaft bore.
- Remove expansion plug from oil reservoir and remove pipe plug from oil wick passage. Remove packing and oil wick from reservoir.
- 3. Press old bushing from end frame and press new bushing into place.
- Using a drill same size as oil wick passage, run drill through passage to cut through edge of bushing. Remove burrs from bushing caused by drilling operation.
- Install new oil wick and fill oil reservoir with fine wool packing material. Saturate reservoir packing and oil wick with SAE-10 oil, then install new expansion plug with gasket in oil reservoir opening.
- 6. Install new expansion plug with gasket in armature shaft bore in end frame.

5.6.6. Shift Lever Housing

Inspect oil seal and bushing in shift lever housing for evidence of damage or excessive wear.

Replace bushing, if necessary. New oil seal lip must point inward.

If shift lever appears excessively loose on lever shaft, worn parts can be replaced by removing retaining ring from exposed small end of lever shaft, then driving shaft out of housing. When installing lever and shaft, use new O-rings in grooves in shaft.

5.6.7. Drive Housing

Inspect bushing in nose housing for wear, referring to specifications for original bushing diameter. Replace bushing, if necessary.



5.6.8. Drive Assembly

Drive pinion must rotate freely in overrunning direction and must not slip in cranking direction. The drive assembly can be serviced as follows: See "Fig. 9-40: Drive Clutch Assembly" on page 46.

1. Disassembly

Using suitable tools, remove the pinion stop cup and split washer from sleeve.

MOTE:

In removing the pinion stop cup it will probably be damaged. Use new cup at assembly.

Remove pinion, spring retainer outer cup, spring and spring retainer inner cup.

2. Inspection and repair

Inspect spring and spring retainer cups. If not in good usable condition, replace with new part. Inspect pinion. If teeth are chipped or cracked, replace pinion. Inspect sleeve bushings.

If bushings do not meet specifications listed at end of this group, press old bushings out of sleeve and press new bushings into place. Ream bushings to specifications listed at end of this group.

3. Assembly

Install spring retainer inner cup, spring and spring retainer outer cup on sleeve. Install pinion and pinion stop cup on clutch sleeve. Install split-type washers in groove at end of clutch sleeve.

Position clutch sleeve assembly in a vise, then with pinion seated firmly against the pinion stop cup and using suitable tools, bend pinion stop cup lip over split washers, locking pinion stop and split washers together

MOTE:

DO NOT lubricate the stops (sprags) as they are lubricated for life.

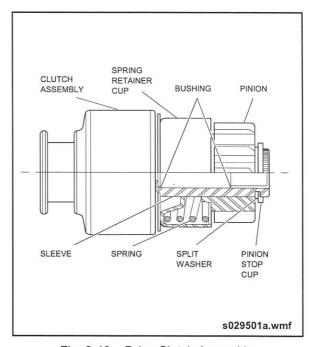


Fig. 9-40: Drive Clutch Assembly



5.7. Assembly

- Lubricate splines of armature shaft with SAE-10 oil, then insert drive end of armature shaft through shift lever housing until shaft just extends through housing. Place O-rings and collar over armature shaft and position in counter-bore in housing. Place brake washer over end of shaft.
- Position drive clutch assembly in lever housing with lugs on lever yoke engaging groove in drive clutch shift collar, then push armature shaft through housing and drive clutch.
- 3. Place gasket in counter-bore in shift lever housing, then install drive housing over armature shaft and position at lever housing, with marks made prior to disassembly aligned. Attach drive housing to lever housing with six socket head screws, tighten screws to 13 to 17 ft-lb. (18 to 23 Nm) torque.
- 4. Install new O-ring in groove in field frame side of shift lever housing. Install field frame over armature and position against shift lever housing as noted prior to disassembly. Attach lever housing to field frame with five cap screws and lock washers. Tighten cap screws.
- 5. Position solenoid with plunger rod end inserted into shift lever housing. Fasten solenoid case to shift lever housing with three cap screws and lock washers. Through the opening in opposite end of lever housing, make sure plunger rod passes through plunger rod guide in shift lever. Thread adjusting nut a few turns onto plunger rod. Install connector strap on the solenoid "motor" terminal and field frame stud
- Place thrust washer over commutator end of armature shaft. Place new O-ring in groove around commutator end frame. Pull the armature out of the field frame just far enough to permit the brush to be placed over the commutator. Connect field coil leads and brush leads to brush holders.

Align commutator end frame and armature with field frame as noted prior to disassembly. Attach end frame to field frame with cap screws and lock washers. Tighten cap screws firmly.

- 7. Connect solenoid ground lead to terminal stud on commutator end frame.
- Saturate all wicks and fill oil reservoirs with SAE-10 oil.
- 9. Adjust pinion clearance as directed below:
 - a. Connect a battery to the solenoid.
 - Momentarily, flash a jumper lead from ground return terminal to terminal MTR.
 The drive will now shift into cranking position and remain so until the battery is disconnected.
 - Push the pinion or drive back towards the commutator end to eliminate any freeplay.
 - d. Measure the distance between the drive and the housing.
 - e. Adjust the clearance by removing the plug and turning the shaft nut. The clearance should be 8.3 and 9.9 mm. See "Fig. 9-41: Starter Motor Pinion Clearance Check" on page 47.

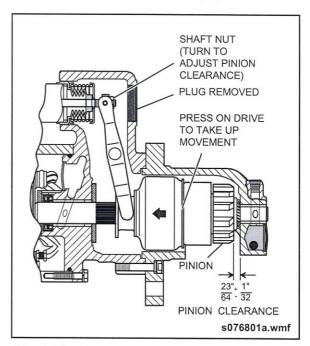


Fig. 9-41: Starter Motor Pinion Clearance Check



5.8. Installation

MOTE:

Before installing starter, perform "no-load" test.

- Use a suitable strap to raise the motor into position.
- 2. Place spacer between starter and engine flywheel housing and install starter using three M12 bolts. Torque bolts to 75 ft-lb. (102 Nm).
- Connect cables and wires to their respective terminals. Torque positive and negative terminal nut 1/2" 13 UNC to 20 to 25 ft-lb. (27 to 34 Nm). Torque solenoid "S" terminal nut #10 32 to 15 to 30 in-lb.
- Set Battery Disconnect switch to the ON position and check operation of starter motor.



6. BATTERY SYSTEM

6.1. Description

The battery system consists of the vehicle batteries and tray, the battery disconnect switch, and the vehicle fuses. The battery tray is located at the rear curbside of the vehicle behind an access door. It is a stainless steel assembly which houses the batteries and which is equipped with steel rollers and a grab handle to allow ease of access. See "Fig. 9-42: Battery Tray" on page 49. The battery disconnect switch is located on the fusebox, above the battery tray. See "Fig. 9-43: Battery Disconnect Switch & Fuses" on page 50. This switch isolates the batteries from the vehicle elec-

trical system. It must be set to the OFF position whenever electrical maintenance is performed. A cutoff switch access door is provided in the main battery access door to allow disconnection of electrical power without having to open the battery access door. The vehicle fuses are located in the fusebox adjacent to the battery tray. Refer to the PS (Power & Starting) Electrical Schematic for the battery system electrical connections.

MOTE:

ALWAYS set Battery Disconnect switches to the OFF position before disconnecting battery cables. Engine must be OFF before any disconnecting.

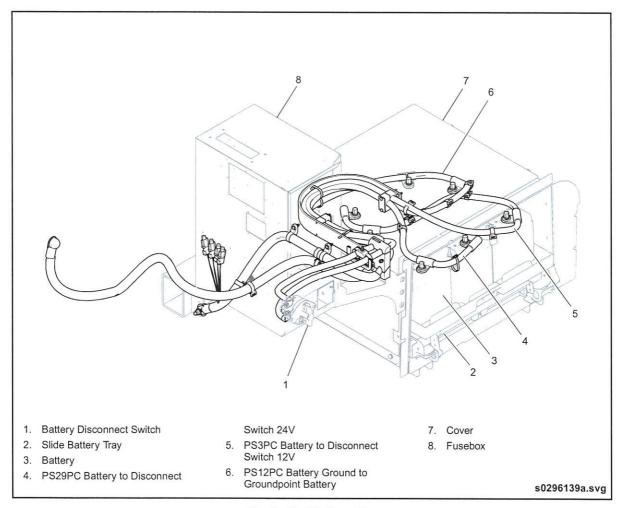


Fig. 9-42: Battery Tray



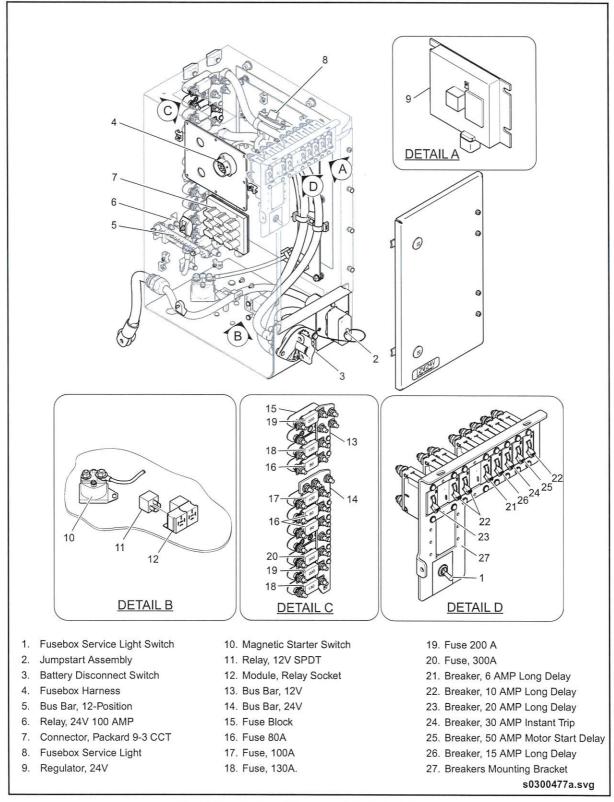


Fig. 9-43: Battery Disconnect Switch & Fuses



6.2. Battery Disconnect Switch

6.2.1. Description

The Battery Disconnect switch is located inside the battery compartment, on the face of the fusebox cover. This rotary switch serves to disconnect the batteries from the vehicle 12/24V electrical systems. It is accessible through the battery access door. To disconnect the batteries from the electrical system, rotate the battery disconnect switch to the OFF position. Always rotate this switch to the OFF position before disconnecting any battery cables.

MOTE:

Use several wrappings of electrical tape to insulate any disconnected power cable ends or battery terminals that could be accidentally grounded during maintenance activity.

6.3. Jumpstart Installation



DO NOT use conventional jumper cables when starting the vehicle. ALWAYS use an approved jumpstart adapter that is designed to be used with the vehicle jumpstart quick-connector.

6.3.1. Description

This vehicle is provided with a jumpstart installation for emergency starts. The installation consists of a quick-connect jumpstart connector which is wired directly to the vehicle 24VDC power supply and ground circuits. The connector is mounted below the battery disconnect switch on the rear equipment box.

Refer to the PS (Power and Starting) Electrical Schematic for the wiring connections for the electrical starting and the battery systems.



Before connecting an external voltage, ensure that the Battery Disconnect switch is ON.



6.4. Fusebox Assembly

6.4.1. Description

The fusebox assembly is located directly above the battery tray in the battery compartment. The main components of the fusebox assembly include the Battery Disconnect switch, voltage regulator, fuse panel, circuit breaker panel, and Compartment Light switch. Refer to 6.2. "Battery Disconnect Switch" on page 51 in this section for more information on this component.

6.4.2. Fusebox Torque Chart



ALWAYS torque electrical connections to specified torque when replacing any components. Loose connections can result in arcing, component damage, and possibly fire.

FUSEBOX TORQUE CHART					
DEVICE	FASTENER	TORQUE ft-lb. (Nm)			
Battery Disconnect Switch to Power Cables	Lock Nut	14 ft-lb. (19 Nm)			
Circuit Breakers	Lock Nut 1/4" - 20 UNC	3.5 ft-lb. (4.7 Nm)			
Fuse Limiters	Lock Nut 5/16" - 24 UNF	10 ft-lb. (13.5 Nm) see Note 1			
Grid Heater Relay to Power Cables	Lock Nut 5/16" - 24 UNF	4 ft-lb. (5.4 Nm)			
Magnetic Starter Relay Power Cables	Lock Nut 5/16" - 18 UNC	12 ft-lb. (16.3 Nm)			

Note 1: Install fuse and end directly against bus bar without washer in between. Use required number of washers on panel side to level fuse with panel.



6.5. Batteries



ALWAYS replace batteries with the same type and size identified in your New Flyer Parts Manual and charge the batteries using the recommended voltage. Over-charging a lead acid battery can produce explosive and hazardous gas. Any change in battery configuration may require modification to the charging system voltage levels and battery service procedures to prevent over-charging and equipment Consult the damage. battery manufacturer's recommendations before installing replacement components.

6.5.1. Description

This vehicle is equipped with 12 volt, heavy duty, maintenance free batteries. Electrolyte cannot be added to these batteries. Batteries are equipped with positive and negative terminal posts, and vents to allow gases to escape.

6.5.2. Batteries Specifications

	12	VO	It
	_	VO	•

- 31 group size
- □ 950 cold cranking amperes
- □ 170 minute reserve capacity
- ☐ 94 AH battery capacity

6.5.3. Removal

- Set the Battery Disconnect switch to the OFF position.
- 2. Remove the wing nut and washers and pivot the battery tray retainer bracket downward. Slide the battery tray out to the fully extended position.

- Note the positive and negative terminals on the batteries and tag the cables before removing. Refer to Battery Hookup decal on inside of fusebox door.
- 4. Disconnect the cables from the negative terminals of the battery.
- Disconnect the cables from the positive terminals of the battery, including the jumper cable.
- Remove the three nuts from the battery holdown retainer. Remove the cable hanger with cables and tie out of the way. Remove the battery holdown retainer.
- 7. Carefully lift and remove the batteries from the tray.

6.5.4. Installation

- Install the batteries into the tray with the positive and negative terminals arranged as originally removed.
- Secure the batteries in place using the holdown retainer and nuts. Position the battery cable hanger and bracket in place and secure.
- Connect the positive cables and jumper cable to their respective terminals as marked on removal. Torque to 10 - 15 ftlbs
- 4. Connect the negative cables to the battery negative terminal. Torque to 10 15 ft-lbs.
- Ensure exposed battery terminals are protected with a coating of dielectric grease.
 Ensure protective rubber boots are installed over the positive terminal connectors.
- 6. Slide the battery tray into the fully retracted position.
- 7. Pivot the battery tray retainer bracket upwards to engage the stud on the battery tray. Install flat washer, lock washer, and wing nut.
- 8. Set the Battery Disconnect switch to the ON position.



6.5.5. Battery Charging

Observe the following when charging batteries on this vehicle:

- □ Charge rates between 3 and 50 amperes are generally satisfactory as long as spewing of electrolyte does not occur or the battery does not feel excessively hot (over 125°F/52°C). If spewing occurs, or temperature exceeds 125°F, the charging rate must be reduced or temporarily halted to permit cooling. Battery temperature can be estimated by touching or feeling the battery case.
- ☐ Shake or tilt the battery at hourly intervals during charging to mix the electrolyte.
- ☐ Battery charging consists of a charge current in amperes for a period of time in hours. Thus, a 25-ampere charging rate for 2 hours would be 50 ampere-hour charge to the battery.

Charging time will vary due to:

☐ Size of battery - A completely discharged large heavy-duty battery requires more than twice the recharging as a completely discharged small passenger car battery.

- □ Temperature A longer time will be needed to charge any battery at 0°F than at 80°F. When a fast charger is connected to a cold battery, the current accepted by the battery will be very low at first, then in time the battery will accept a higher rate as the battery warms.
- □ State-of-Charge A completely discharged battery requires more than twice as much charge as a one-half charged battery. Because the electrolyte is nearly pure water and a poor conductor in a completely discharged battery, the current accepted is very low at first. Later, as the charging current causes the electrolyte acid content to increase, the charging current will likewise increase.
- ☐ Charger Capacity A charger which can supply only 5 amperes will require a much longer period of charging than a charger that can supply 30 amperes or more.



6.5.6. Functional Test

6.5.6.1. Visual Inspection

The first step in testing the battery should be a visual inspection which very often will save time and expense in determining battery condition.

- Check outside of battery for a broken or cracked casing, or broken or cracked cover. If damage is evident, the battery should be replaced.
- Check for loose terminal posts, cable connections, and for evidence of corrosion. Correct as required before proceeding with test.

6.5.6.2. Load Test

MARNING

Wear safety goggles when working with batteries. Immediately flush any areas of skin which have been in contact with battery acid. When disconnecting battery cables, ALWAYS disconnect the negative cable first.

- Set the Battery Disconnect switch to the OFF position.
- 2. Disconnect the cables from the battery.
- Assemble adapters, if available, onto battery leads. Adapters are available from battery manufacturer. Connect voltmeter and battery load tester across battery terminals. If adapters are not available, attach tester clamps to contact lead pads. Tighten hex nuts to hold clamps against lead pads.
- 4. If batteries have just been on charge, remove surface charge by applying a 300 ampere load across the battery terminals for 15 seconds, then turn off load and allow the battery 15 seconds to recover. Do not remove surface charge from batteries that have been in storage.
- Refer to 6.5.6.3. "Voltage & Electrolyte Temperature" on page 55 included with this test to determine acceptable battery voltage during test.
- Apply a 310 ampere load to the battery for 15 seconds and observe voltmeter read-

- ing. Compare last observed voltage reading to chart.
- Replace battery if voltage is below acceptable chart rating. Clean battery and return to service if voltage is acceptable.

6.5.6.3. Voltage & Electrolyte Temperature

VOLTAGE & ELECTROLYTE TEMPERATURE Min. Required **Estimated** Voltage Under 15 Electrolyte Temp. Sec. Load 70°F (21°C) & above 9.6 50°F (10°C) 9.4 30°F (-1°C) 9.1 15°F (-10°C) 88 0°F (-18°C) 8.5 below 0°F 8.0

6.5.7. Batteries Troubleshooting

Check for the following conditions if the batteries pass the functional test, yet do not perform well in service:

- ☐ Vehicle accessories left on for long periods of time.
- ☐ Faulty vehicle charging system.
- ☐ High wiring resistance.
- Vehicle loads exceeding alternator capacity.
- Shorted wires.
- Extended slow speed driving with high electrical loads.
- Loose or corroded battery connections.
- Improper battery charging.
- ☐ High resistance connections or defects in cranking system.
- ☐ Lengthy vehicle storage with batteries not disconnected. Batteries connected to stored vehicles can discharge in a six to eight week period, due to small current drains. Discharged batteries can freeze and be difficult to recharge.



6.6. Voltage Equalizer

6.6.1. Description

The battery voltage equalizer is located in the battery compartment and bracket-mounted to the side structure on the curb-side of the vehicle. The voltage equalizer is a power management system used to obtain a 12 VDC power source from a 24 VDC electrical system and to have the batteries function as if they are in series and parallel at the same time. In addition to providing regulated 12 VDC power, the

system ensures that battery voltages remain equal. See "Fig. 9-44: Battery Voltage Equalizer Installation" on page 56.

6.6.2. Voltage Equalizer Specifications

Manufacturer Vanner Power Group
Model
Input Voltage 24V 18 to 32 volts
Maximum 24V Input Amps43 amps
Output Amps 12V 0 to 80 amps

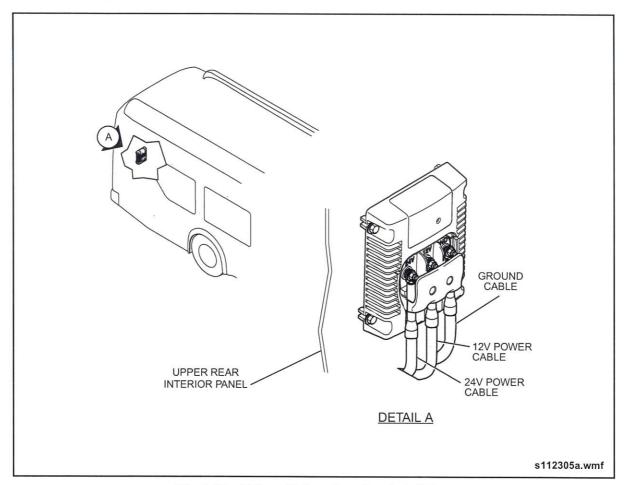


Fig. 9-44: Battery Voltage Equalizer Installation



6.6.3. Operation

The voltage equalizer is connected to the battery system at the 12 VDC, 24 VDC, and ground points. The voltage equalizer maintains voltage balance between the batteries and therefore the charge acceptance rate of each battery to within 0.05 volts at light load and 0.1 volts at full rated load.

When the voltage of the battery that is supplying the 12 VDC vehicle load is higher than or equal to the other battery, the equalizer is operating in a standby mode, for example it is not transferring power from its 24 VDC input to its 12 VDC output.

When a 12 VDC load is present and the voltage in the battery supplying the 12 VDC load is less than the voltage in the other battery, then the voltage equalizer activates and transfers sufficient current from the other battery to satisfy the load and maintain an equal voltage and charge in both batteries.

6.6.4. Voltage Equalizer Testing

 If the battery voltage is below 24V, start the vehicle or apply a 24V battery charger to the batteries. With the engine running, turn ON 12V loads up to the equalizer rated capacity. Measure DC amps on the equalizer +12V cable to verify load amperages.

MOTE:

The following readings are all taken at the equalizer.

- Measure and record the voltage between the equalizer +12V and GND terminals. This is referred to as Battery A voltage.
- 4. Measure and record the voltage between the equalizer +24V and +12V terminals. This is referred to as Battery B voltage.
- Subtract Battery A voltage from Battery B voltage and compare readings.

MOTE:

An overload condition exists when the 12 volt loads exceeds the equalizer's rated capacity. The overload condition will not damage the equalizer but may cause damage to the batteries. To correct an overload condition the 12 volt load must be reduced or the equalizer capacity must be increased.

VOLTAGE EQUALIZER TESTING					
VOLTAGE COMPARISON	EQUALIZER STATUS				
Battery A is lower than Battery B but within 0.05 volt	OFF	Stand by mode			
Battery A is lower than Battery B by 0.05 to 0.10 volts	ON	Normal operating mode			
Battery A is lower than Battery B by more than 0.10 volts	ON	Self protection mode due to an overload condition.			
Battery A is lower than Battery B by more than 0.10 volts	OFF	The equalizer is not functioning correctly			
Battery A is higher than Battery B	Abnormal condition - suspect that Battery B is defective or has a 12V load connected to it.				



6.6.5. Replacement Procedure



Ensure the wire connections to the equalizer are installed exactly as described. Incorrectly connected wires can damage the unit and possibly cause fires.

- 1. Set the Battery Disconnect switch to the OFF position.
- Obtain access to the equalizer through the curbside panel at the rear of the vehicle interior.

- 3. Remove the two screws and the protective plastic cover from the equalizer.
- 4. Tag and disconnect the three power cables from the terminal studs.
- 5. Remove the bolts and lock washers and remove the equalizer from the vehicle.
- 6. Installation is the reverse of removal.

MOTE:

Torque the nuts on the wire terminals to 120 in-lb. (13.5 Nm) during installation.



7. EXTERIOR LIGHTS

See "Fig. 9-45: Exterior Lamps" on page 60.

7.1. Headlights

7.1.1. Description

The headlight assemblies contain an LED low beam, an LED amber turn light and a high beam bulb. The LED lights have a 10,000 hour service life rating. The high beam has a replaceable bulb. Each headlight assembly is controlled by its own headlight module located behind the wiper motor access door.

7.1.2. Operation

The low beam headlights operate at full intensity when the Master Run switch is in either the DAY-RUN or NIGHT-RUN positions. The high beam headlights operate only when the Master run switch is in NIGHT-PARK and the high beam foot switch is activated. The LED headlight module will output a signal to the LCD display on the instrument panel if a headlight or turn signal fails to operate.

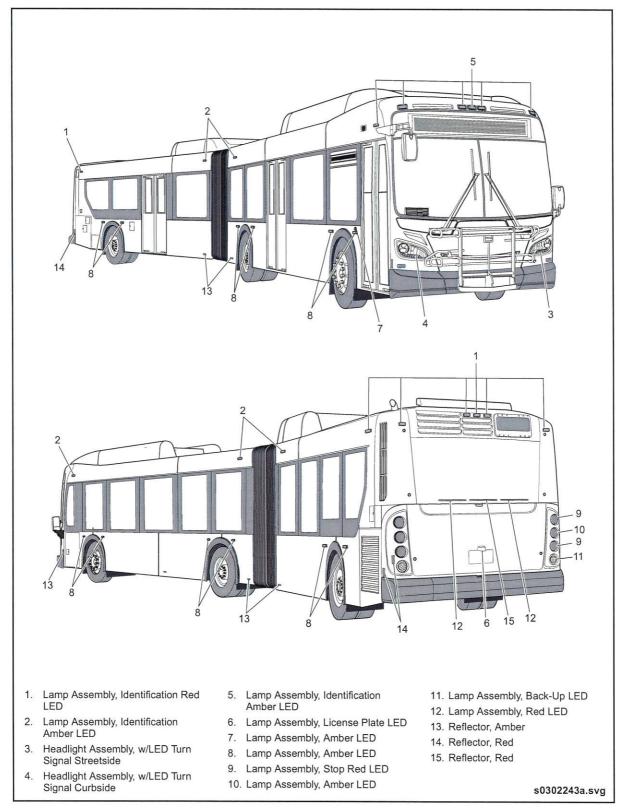


Fig. 9-45: Exterior Lamps



7.1.3. Removal

III NOTE:

Replacing a faulty low beam or turn signal light requires the replacement of the complete headlight assembly. The high beam bulb can be replaced separately and can be accessed from the interior of the vehicle without removing the complete headlight assembly.

- 1. Set the Battery Disconnect switch to the OFF position.
- 2. Gain access to the headlight assemblies by opening the exterior wiper motor access doors, interior LH lower dash panel access door, and interior RH lower dash panel access door. See "Fig. 9-46: Headlight Removal & Installation" on page 62.

- Access the headlight assembly from the interior of the vehicle and disconnect the wiring harness.
- Remove the nuts and washers that retain the headlight assembly to the front mask and remove the unit from the vehicle.
- 5. Remove the high beam bulb with a 1/4 turn CCW twisting motion.

MOTE:

Determine that the problem is in the headlight and not in the module by plugging the removed headlight into the working headlight module on the opposite side. Replace the headlight assembly if it still does not function.



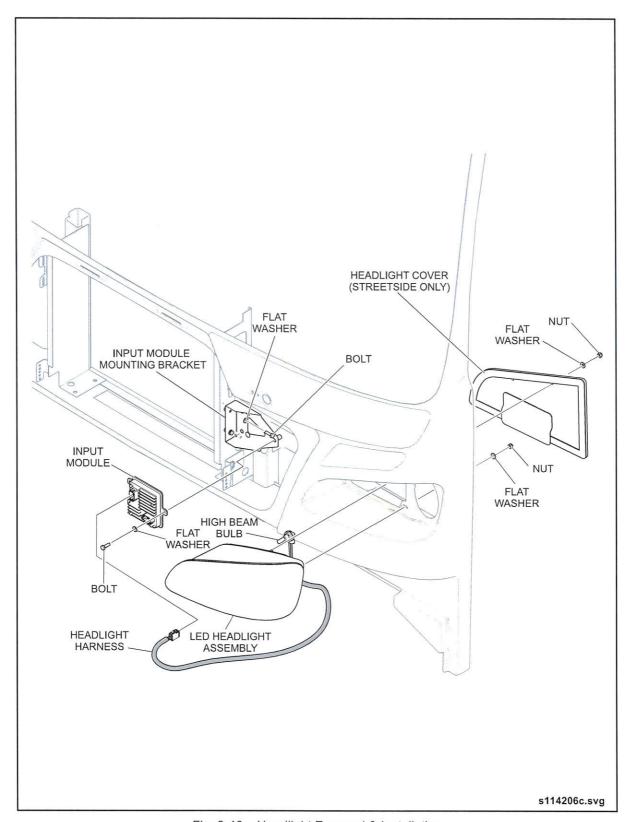


Fig. 9-46: Headlight Removal & Installation



7.1.4. Installation

- Install a new headlight assembly using the original washers and nuts.
- 2. Install a new high beam bulb with a 1/4 turn CW twisting motion, being careful not to touch the glass surface of the bulb with bare hands or any other object that could leave an oily residue on the bulb.
- Connect the wiring harness to the headlight assembly and secure the harness with cable ties.
- 4. Close and secure all access doors.
- Set the Battery Disconnect switch to the ON position and test operation of the headlight assembly.
- 6. Adjust the headlights if required. Refer to 7.1.5. "Headlight Aiming" on page 63 in this section for aiming procedure.

7.1.5. Headlight Aiming

The LED headlights should be checked at regular intervals to ensure that they are properly aimed in accordance with local vehicle regulations. The headlight assembly is a single unit containing the low beam, high beam, and turn light. A single vertical adjustment screw, accessible from the interior of the vehicle, is provided for aiming the headlight assembly. Proper high beam setting is achieved when the low beam is set correctly.

The preferred method of aiming headlights is with the use of specialized optical headlight aiming equipment and is described in the following procedure. If specialized equipment is not available, headlights can be aimed using prescribed markings on a wall and parking the vehicle a specified distance from the wall. Refer to 7.1.6. "Headlight Aiming (Alternate Procedure)" on page 66 in this section for aiming instructions.

- Move the vehicle to a level surface and set the parking brake.
- Ensure that the tires are properly inflated and that the vehicle ride height is set per specifications. Refer to Section 3 of this manual for ride height adjustment procedures.
- Open the interior LH and RH lower dash panel access doors to gain access to the headlight adjusting screw.

MOTE:

The following steps assume the use of Canbuilt commercial headlight aiming equipment. Headlight aiming equipment from other manufacturers will require different alignment procedures. Consult the equipment manufacturer's instructions for specific procedures.

- 4. Compensate for floor slope as follows:
 - a. Positioning the aimer at the front of the vehicle.
 - b. Turn on the laser by turning the knob on the laser housing.



DO NOT stare into the aimer's laser beam as damage to the eyes may result. The aimer emits class II laser radiation at a wavelength of 630 to 680 nm with a power output of less than 1 mW.

- c. Measure the center of the laser beam height from the floor at the front wheel and at the back wheels.
- d. The distance from the floor should be the same. If it is not, adjust the floor slope knob on the aimer's base until they are equal.



- Place the aimer in front of one headlamp approximately 10 to 14 in. (25 to 35 cm) from the headlamp assembly.
- 6. Rotate the aimer positioning pointer to the front of the aimer. Adjust the aimer so that the positioning pointer is at the center of the round lens of the low beam then rotate the pointer back into its stored location.
- Square the aimer to the front of the vehicle as follows:
 - a. Choose two symmetrical points on the front of the vehicle, located at the same height. The upper part of the headlight assembly or two points on the defroster/wiper access door may work.
 - Looking through the lateral alignment visor, make both chosen points lie on the visor's wire, by slightly rotating the aimer.
 - c. The aimer is now ready to test the headlights.

- Set the Master Run switch to NIGHT-RUN to operate the headlights. Ensure that the high beam is off.
- Observe the pattern displayed on the screen and determine the required direction of adjustment. See "Fig. 9-47: Headlight Aiming" on page 65.
- 10. Use the adjusting screw on the back of the headlight assembly to vertically position the headlight in the desired target area of the aiming equipment.

MOTE:

Use a 5/32" socket to turn the adjusting screw. Rotate the screw CW to raise the beam pattern and CCW to lower the beam pattern.

11. When the adjustment is completed, turn off the headlights, remove the headlight aiming equipment, and close and secure all access doors.



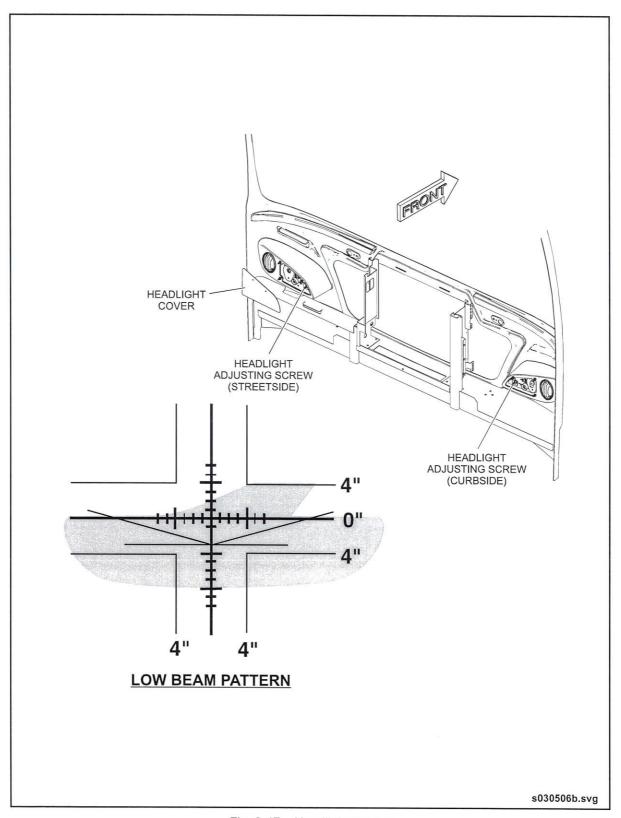


Fig. 9-47: Headlight Aiming



7.1.6. Headlight Aiming (Alternate Procedure)

MOTE:

The following procedure describes how to set up headlight aiming marks for the low beam lights. Markings can be made directly on the wall surface if practical, otherwise use a 4' x 8' sheet of plywood, or suitable equivalent, painted white.

- Draw a vertical line C-C on the aiming surface representing centerline of vehicle. Extend this centerline at a right angle along the floor so that it can be used to position the vehicle square to the aiming surface. See "Fig. 9-49: Low Beam Headlight Aiming" on page 67.
- 2. Position vehicle on level floor with low beam headlights 25' (7.62 m) from the aiming surface. Centerline of vehicle must be positioned so that it is at a right angle to the vertical surface.
- Measure height of low beam headlight centers from floor and mark this height on vertical surface. Draw a horizontal line A-A on vertical surface at this height. Extend this line to approximate the width of the vehicle.

PNOTE:

The center of the low beam is marked with a dimple molded into the headlight assembly. If the dimple is not present, measure to the center of the round lens surrounding the low beam elements. See "Fig. 9-48: Low Beam Center Location" on page 66.

- 4. Measure distance between centers of outer (low beam) lights and divide this distance equally on both sides of centerline C-C. Draw a vertical line (D-D and E-E) through each of these points.
- 5. Draw a line on an upward angle to the right from the intersection of lines A-A and D-D. Draw a similar line from the intersection of lines A-A and E-E. These angled lines, approximately 45°, represent the kink where the cutoff line bends upward.

MOTE:

The upward bend angle of the cutoff line needs to be added to the aiming marks once the first set of low beam lights have been centered and adjusted vertically. Draw a line corresponding to the illuminated upward angle.

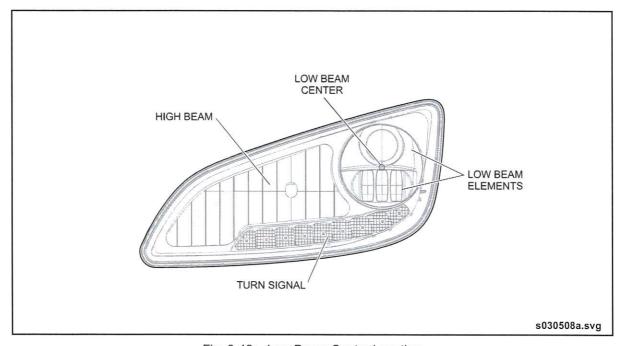


Fig. 9-48: Low Beam Center Location



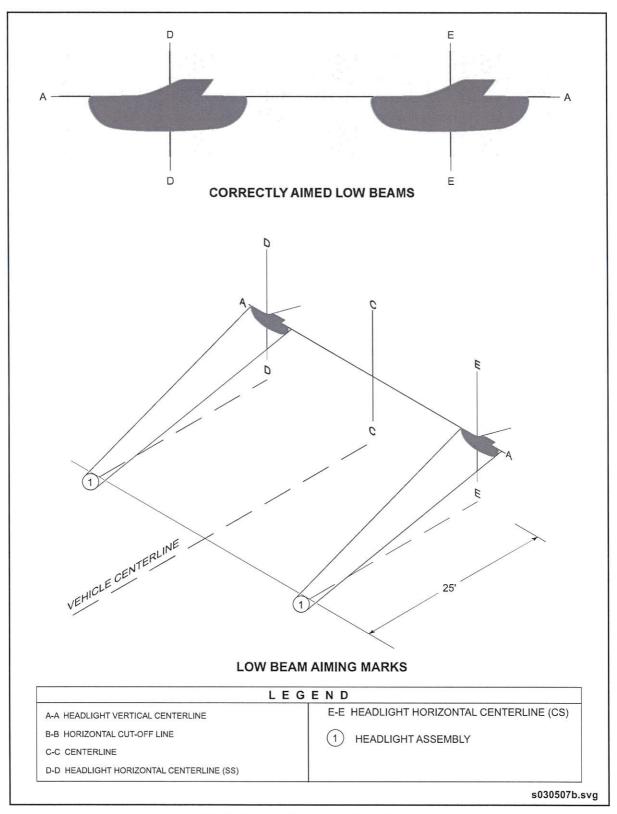


Fig. 9-49: Low Beam Headlight Aiming



8. INTERIOR LIGHTS

8.1. Aisle Lights

8.1.1. Description

The aisle light panels are located above the side windows on either side of the passenger aisle. See "Fig. 9-50: Aisle Lights Layout" on page 68.

Each lighting panel consists of one or more banks of lights, depending on the length of the panel. Each bank of lights consists of a clever board installed in series with several basic boards. The clever board provides the power entry and dimming capability for the entire bank. The power entry and dimming connector

installed on each clever board is referred to as a "finger board". See "Fig. 9-51: LED Aisle Lights Assembly" on page 69.

Each LED board contains surface-mounted LED's arranged in a single row pattern. The dimming level for the light banks is factory preset. Dimmable lighting panel banks can be adjusted using a programming fob. Refer to 8.1.5. "Dimming Adjustments" on page 72 in this section for adjustment procedure.

The LED boards are protected with a plastic translucent lens that runs the entire length of the lighting panels. The lighting panels also include speakers for the vehicle P.A. system as well as duct liners and distribution vents for the heating system.

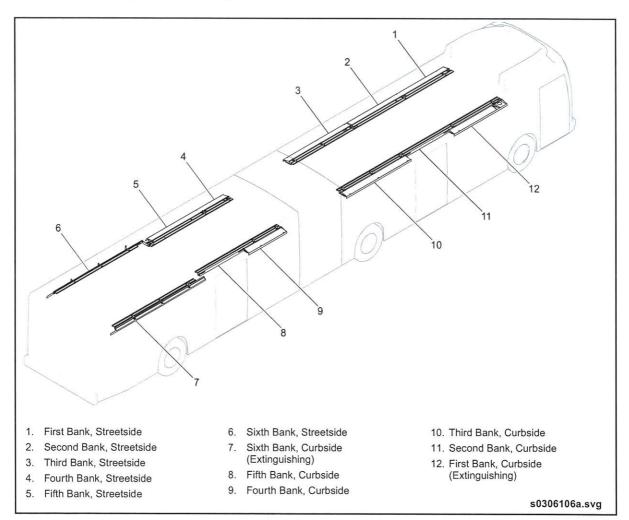


Fig. 9-50: Aisle Lights Layout



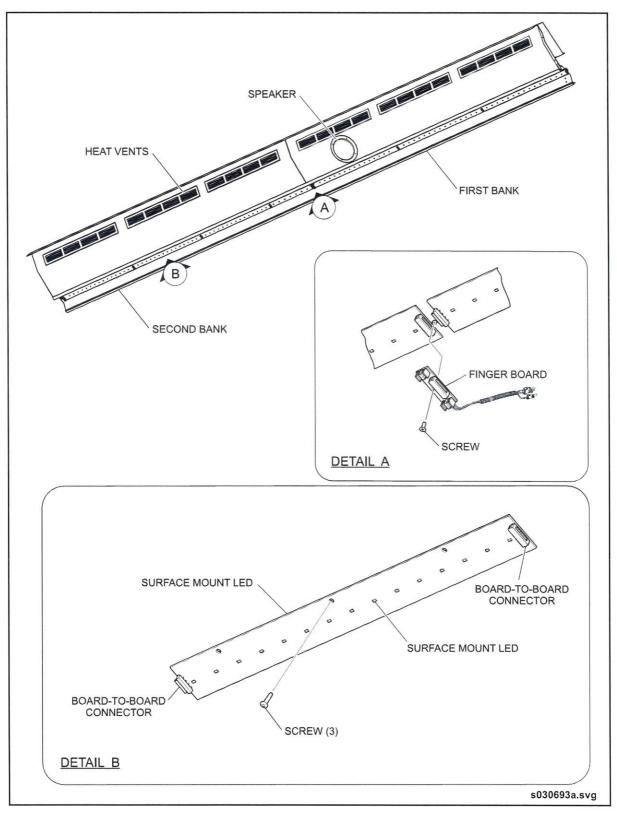


Fig. 9-51: LED Aisle Lights Assembly



8.1.2. Aisle Lights Specifications

Manufacturer	TCB Industries
Model GEN 3	with Clever Boards
Lighting Panel Aluminum, powder-c and duct liner	coated c/w speaker
Voltage	24 VDC
LED's15 per boa	rd @ 0.125 W each
Speakers	8 Ohms, 30 W

8.1.3. Operation

The Aisle Lights switch on the side console provides the operator control of the aisle lights based on the programming configuration for the ON, NORMAL and OFF settings of this switch. Refer to Section 19 of this manual for more information on the operation of the Aisle Lights switch.

8.1.4. Aisle Lights Troubleshooting

MOTE:

Refer to Electrical Systems Drawings "ES-Electrical Schematics-IL" and the Vansco PLC program when performing troubleshooting. Troubleshooting the lighting panels should always be performed in the following sequence:

- Confirm lighting program Refer to Section 19 of this manual for definition of which panels illuminate or dim and under what conditions.
- Identify the symptoms and the conditions under which the problem occurs. Example: one bank of lights fail to illuminate during NIGHT-RUN with aisle lights switch in NORMAL position and entrance door closed. Establish the conditions under which the lighting panel should illuminate.
- Confirm that the proper inputs and outputs are present at the VMM modules during the condition identified in the previous step.
- If proper inputs not received at VMM module(s), then trace vehicle wiring circuit for power at switches, connectors, and fuses.
- If proper outputs confirmed at VMM module(s), then check lighting panel connectors for voltage.
- Check finger board connector for power and dimming signals as applicable. Confirm ground circuit from lighting panel to vehicle ground.



8.1.4.1. Troubleshooting Tips

It is important to understand the operating principles of the LED lighting boards in order to properly troubleshoot problems. The following list of operating characteristics and possible problems will help isolate the condition and minimize time spent troubleshooting.

Each lighting bank consists of one clever board and several basic boards. The clever board receives the power and dimming inputs and transmits these signals through the series-connected board-to board connectors on each of the basic boards.

- If the clever board loses a power or dimming signal, then all basic boards in that bank that are connected to the clever board will lose the power or dimming signal.
- ☐ If the clever board and one or more downstream basic boards illuminate, but the remainder don't, then the likely problem is with a board-to-board connector at one of the basic boards.

Each lighting board has its own driver that is capable of powering 30 LED's. The LED's are electrically connected in groups.

- ☐ If a lighting board driver fails, then all LED's in that board will fail to illuminate. The driver is not repairable and the board must be replaced.
- ☐ If only some LED's in a lighting board fail to illuminate, then an internal connection within the board has failed and the board must be replaced.

The root cause of many electrical problems can be traced to loose or corroded electrical connectors. This is very typical of intermittent problems. Inspect the electrical connections at the following locations:

- ☐ Vehicle harness connection to lighting panel harness.
- ☐ Finger board remove IDC connector cover and check for improperly crimped wires.
- ☐ Board-to-board connectors slide cover back and inspect terminals. Ensure the three screws fastening the lighting board to the panel are secure. Sometimes loosening these screws and repositioning the lighting board will correct the faulty connection.



8.1.5. Dimming Adjustments

The dimmable lighting panels normally operate at 50% lighting intensity and increase to 100% when the entrance door is open. The factory preset dimming level can be adjusted individually on each bank of lights. The following instructions describe the adjustment procedure:

- Remove the lens. Refer to 8.1.6.1. "Lens" on page 73 in this section for procedure.
- Set the Master Run switch to NIGHT-RUN and set the Aisle Light switch to a position that will illuminate all lights. Ensure that the entrance door remains closed during the adjustment procedure.
- Identify the bank of lights that need to be adjusted and located the clever lighting board on that particular bank of lights.

MOTE:

The clever board provides the power and dimming signal for the downstream basic lighting boards in each bank of lights. The clever board receives power and dimming signals from the finger board and can be easily identified by the three-wire connector on the end of the board.

- 4. Locate the three programming pads on the clever lighting board. The programming pads are labeled "DOWN UP" and "DIM PGM". See "Fig. 9-52: Lighting Board Programming Pads" on page 72.
- 5. Place the pins of the programming fob onto the programming pads. Press the button on the DOWN side of the fob to reduce lighting intensity and press the button on the UP side of the fob to increase lighting intensity. See "Fig. 9-53: Lighting Board Dimming Adjustment" on page 72.

MOTE:

Each press of the button will change lighting intensity by 5%. The dimming level can be adjusted within the range of 0% to 100% lighting intensity.

- Test the operation of aisle lights and ensure that the dimmable lighting panels increase to 100% lighting intensity when the entrance door is opened.
- 7. Replace the lens once all adjustments have been made.

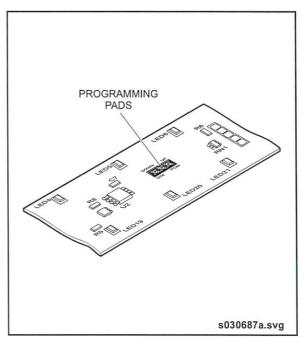


Fig. 9-52: Lighting Board Programming Pads

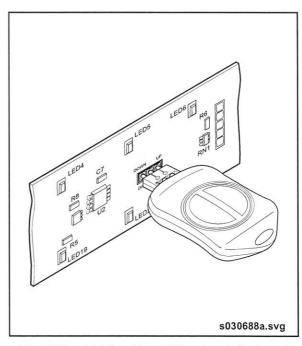


Fig. 9-53: Lighting Board Dimming Adjustment



8.1.6. Removal

8.1.6.1. Lens

MOTE:

The lens is one continuous piece and runs the entire length of the lighting panels. Servicing the LED lighting panels will require removal of the full length of the lens.

- 1. Remove the end cover.
- Starting at one end, compress the upper edge of the lens to release it from the mounting channel. See "Fig. 9-54: Lens Removal" on page 73.

INOTE:

An additional person will be required to support the lens while the other person is working along the length of the lens to release it from the mounting channel.

 Once the upper edge has been released, carefully work along the length of the lens to release the lower edge. Ensure that the lens is properly supported during removal to avoid excessive bending and possible lens damage.

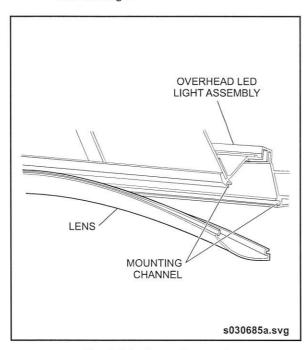


Fig. 9-54: Lens Removal

8.1.6.2. LED Lighting Board

™NOTE:

The LED boards are not repairable and must be replaced as an assembly if defective

- Remove the lens. Refer to 8.1.6.1. "Lens" on page 73 in this section for procedure.
- Slide the cover back on the board-to-board connectors on each end of the lighting board.
- Remove the three mounting screws that attach the LED lighting board to the lighting panel.
- 4. Remove the lighting board from the lighting panel.

8.1.6.3. Finger Board

- Remove the lens. Refer to 8.1.6.1. "Lens" on page 73 in this section for procedure.
- Locate the finger board which is typically installed at the beginning of a bank of lighting boards. See "Fig. 9-55: Finger Board Assembly" on page 74.
- Use a machinist's scribe or dental pick to pry off the cover on the IDC connector of the finger board.

MOTE:

Typically there will be one cover for the power (red) and ground (black) wires located at one end of the finger board and another cover at the opposite end for the dimming signal (yellow) wire.

- 4. Note the position of the wires for reassembly and then carefully pull the wires out of the Insulation Displacement Connector (IDC) and clean any residual insulation from the blades of the connector.
- Remove the single mounting screw.
- 6. Remove the finger board by sliding it outward from the lighting board.



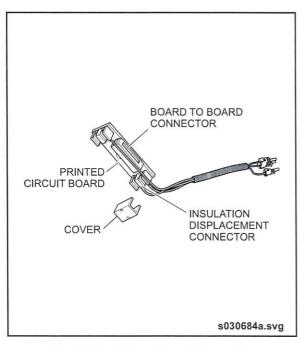


Fig. 9-55: Finger Board Assembly

8.1.7. Installation

8.1.7.1. Lens

- Position the length of lens beneath the lighting panels and support on the seat backs.
- Start at one end and insert the lower lip of the lens into the mounting channel, ensuring that the end of the lens is flush with the end of the lighting panel.

MOTE:

An additional person will be required to support the lens as it is being raised into position.

- Continue to work along the length of the panels, inserting the lower lip of the lens into the mounting channel while another person follows behind, compressing the upper lip on the lens into the mounting channel.
- Reinstall end cover.

8.1.7.2. LED Lighting Board

- Position the lighting board on the panel ensuring that the board is correctly oriented and the male/female board-to-board connectors properly align their mating counterparts.
- Install and tighten the three mounting screws.
- Slide the cover over the board-to-board connectors to ensure the connectors are locked in place.

8.1.7.3. Finger Board

- Place the finger board in position and slide it into the lighting board connector.
- 2. Secure the finger board to extrusion with a single screw.
- 3. Place the red wire into the IDC and press wire into position with the insertion tool tip (commercially available tool).
- 4. Repeat the previous step for the black and yellow wires.
- 5. Snap the IDC connector covers in place.
- 6. Reinstall lens.



DOOR MASTER SWITCH

9.1. Description

The Door Master switch is a two-position toggle switch located in the destination sign panel. The switch is labeled ON for normal operation and OFF for emergency operation.

9.2. Operation



The Door Master switch is primarily intended to be used in emergency situations to disable the brake and accelerator interlock system and allow the vehicle to be moved. Positioning the Door Master switch in the OFF position will disable the exit door function and several safety features including:

- Shift selector can be shifted without foot on brake treadle.
- Shift selector can be shifted and vehicle moved with wheelchair ramp deployed.
- Exit doors can be opened with the vehicle in motion by using the emergency release control valve. Brake interlocks will not apply in this situation.

The Door Master toggle switch controls power to the brake interlocks and exit door. When the switch is in the ON position, the entrance and exit doors are fully functional. In this mode, opening the exit door, kneeling the vehicle or operating the wheelchair ramp engages the interlocks. Engaging the interlocks applies the rear brakes and deactivates the accelerator.

Positioning the Door Master switch in the OFF position disables the brake and accelerator interlocks and inhibits operation of the exit door controller. The entrance door, however, remains fully functional. A warning buzzer sounds and the Rear Door Open indicator illuminates on the instrument panel. In this mode, the exit door only opens if the emergency release control valve is activated. The control valve is located behind the breakable window to the left of the exit door.

9.3. Functional Tests



Observe the necessary safety precautions while conducting the following test. Ensure that the wheels are chocked to prevent inadvertent vehicle movement. Advise all personnel to stand clear of the vehicle during testing.

9.3.1. Normal Operation Test

Test normal operation of the Door Master switch and interlock system as follows:

- Start the engine, apply the parking brake, and set the shift selector in neutral [N]. Ensure the Door Master switch is set to the ON (normal) position.
- Move the door controller to position #3, #4, or #5 to enable the exit door. The brake and accelerator interlocks should apply.
- 3. Test application of the brake and accelerator interlocks by releasing the parking brake and slowly applying the accelerator treadle. The engine should remain locked in the idle setting and not respond to accelerator treadle movement. The rear stoplights should remain illuminated even with the parking brake released and no application of the brake treadle.
- 4. Test normal release of the brake and accelerator interlocks by moving the door controller to position #1 to disable the exit door. Set the shift selector in drive [D] and then press on the brake treadle. The combination of having the shift selector in gear and the brake treadle applied will unlatch the interlocks. Return the shift selector to neutral [N].
- Verify that the interlocks are released by lightly applying the accelerator treadle and confirming that the engine responds to accelerator movement and that the rear stop lights are extinguished.

Door Master Switch Troubleshooting



9.3.2. Emergency Operation Test

Test emergency operation of the Door Master switch as follows:

- Apply the accelerator and brake interlocks by re-establishing the conditions defined in steps 1 & 2 of "Normal Operation Test".
- Set the Door Master switch to the OFF (emergency) position. This will release the brake and accelerator interlocks and disable exit door function.
- Verify that the interlocks have been deactivated by releasing the parking brake and lightly applying the accelerator treadle. The engine should respond to accelerator movement and the rear stop lights should extinguish.

9.4. Door Master Switch Troubleshooting

- Set the Battery Disconnect switch to the OFF position.
- Disconnect wire leads from Door Master switch and test function of switch.
 - a. Set the switch to the ON position and test for continuity between the switch terminals using an ohmmeter.

- Set the switch to the OFF position and test for an open circuit between the switch terminals using an ohmmeter.
- 3. Replace the switch if it fails to meet either of the preceding test criteria.
- 4. Connect the wire leads to the switch.
- Set the Battery Disconnect switch to the ON position.
- Set the Master Run switch to the DAY-RUN or NIGHT-RUN position and set the Door Master switch to the ON (normal/closed) position.
- 7. Use a voltmeter and connect probes between one of the switch terminals and ground. A reading of approximately 24V should be obtained. Move the positive lead of the voltmeter to the other switch terminal. A reading of approximately 24V should be obtained.
- Set the Door Master switch to the OFF (emergency/open) position. Use a voltmeter and test for 24V at both switch terminals as described in the preceding step. A reading of approximately 24V should be obtained on the input terminal only. Refer to Electrical Schematics for wire lead identification.



10. HORNS & WARNING ALARMS

10.1. Electric Horn

10.1.1. Description

- ☐ Two electric horns are mounted on the front bulkhead plate. Each horn is carefully adjusted and inspected during manufacture and should operate indefinitely without attention. If a horn does become inoperative, it must be replaced. See "Fig. 9-56: Horns Installation" on page 77.
- ☐ If a horn fails to operate, the trouble may be in the external circuit. Quick checks may be made with a jumper lead as follows, to isolate trouble:

- Open side console door for access to horn relay. Connect a jumper lead from No. 2 terminal on horn relay to ground. If horns operate, the trouble is in the horn control circuit (between horn button and horn relay). If horns do not operate, remove jumper lead and proceed to next step.
- ☐ Momentarily, connect a jumper lead between No. 1 and 3 terminals on horn relay. If horn operates, the relay is defective.

10.2. Warning Alarms

MOTE:

Refer to the General Information Section of this manual for information on warning alarms.

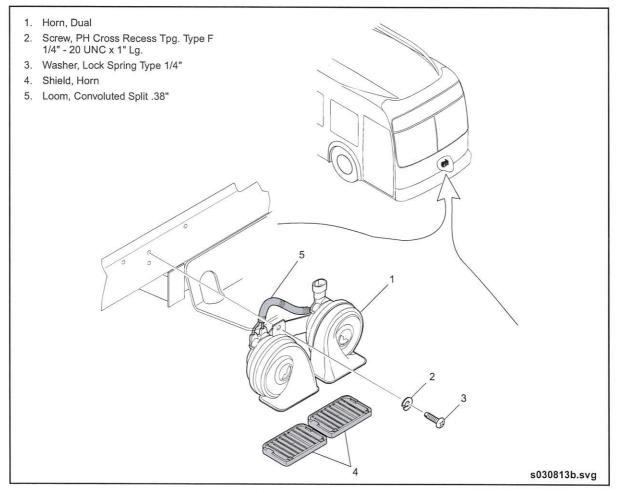


Fig. 9-56: Horns Installation



11. AUTOMATIC VOICE ANNOUNCEMENT (AVA) & AUTOMATIC VEHICLE LOCATOR (AVL) SYSTEM

11.1. Description

The AVA/AVL system includes: See "Fig. 9-57: AVA/AVL System" on page 78.

Operator's Control Unit (OCU) located on the driver's overhead panel.

- □ DR700 Vehicle Logic Unit (VLU) located inside the electronic equipment enclosure.
- ☐ J1708 port expander inside the electronic equipment enclosure.
- Two LED information signs, mounted in the HVAC covers.
- ☐ Automatic Gain Control (AGC) microphone, ceiling-mounted near the exit door.
- ☐ Roof-mounted Tri-band antennas.

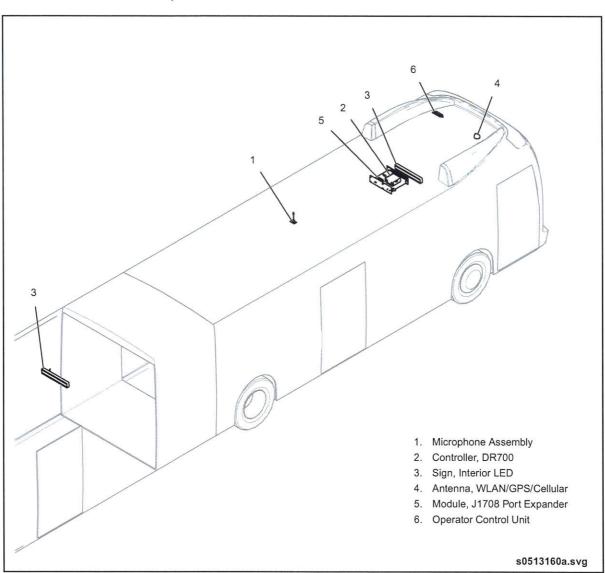


Fig. 9-57: AVA/AVL System



11.2. Operation

The DR700 is able to communicate, collect and distribute data with all of the vehicle electronics via industry standard and proprietary protocols.

In addition, the DR700 is a fully integrated automatic voice announcement and public address system, ready to communicate all of the ADA required information to vehicle passengers.

The digital portion is controlled by a 1.6 GHz COM express module running Windows 7 embedded. It supports two serial, four USB and two mini-PCI express expansion ports. Additionally it supports Solid State Flash memory via embedded mSATA interface, DVI, WLAN, optional cellular and multiple Ethernet ports. A secondary processor supports two J1939 (CAN) ports, two J1708 and two more serial ports, along with all the digital inputs and outputs required. A plug-in Global Positioning System allows the simultaneous tracking of up to twenty satellites and utilizes a solid state heading sensor to permit dead reckoning navigation.

The additional Power Audio Board holds the power conditioning circuits, audio processor, five high quality audio amplifiers, microphone, and AVC (auto volume control) inputs, full public address capabilities with push to talk and volume control.

The system also provides for radio, handset, and driver's speaker audio.

The GPS receiver and heading sensor on the DR700 is integrated into the controller.

The reception of GPS signals requires an unobstructed, line of sight view of the sky. The GPS antenna cannot be covered. The

antenna is typically toward the front center of the vehicle. It connects to the GPS receiver located in the DR700 via an antenna cable. It is critical to the proper operation of the DR700 system that the antenna cable is never pinched or sharply bent. If such a condition does occur, replace the antenna cable. Never attempt to repair the antenna cable.

The GPS receiver interprets GPS data and heading sensor information to determine the vehicles position, heading and velocity. The system date and time are also determined via the GPS satellite network.

The GPS receiver is an internal plug-in component of the DR700 and is capable of tracking up to 20 satellites, and has dead reckoning logic capable of providing position information for short periods of time while satellite reception is impeded.

The heading sensor is also located internally, and can be mounted in several orientations such that the sensor is always pointing towards (parallel with) the sky. Refer to the mounting section regarding the DR700 orientation.

The DR700 is designed to facilitate and support the integration of multi-vendor equipment, both existing and future, into one coordinated system. Additional I/O ports, software support for equipment-specific protocols and third-party equipment can be configured on the VLU.

The DR700 is SAE J1708 & SAE J1939 compliant and comes fully equipped to communicate the J1587 protocol. In addition, the standard VLU provides a number of digital and serial ports for connecting existing and future on-vehicle electronics.



12. AUTOMATIC PASSENGER COUNTER (APC) SYSTEM

12.1. Description

This vehicle is equipped with an APC system that uses overhead infrared sensors at

the entrance and exit doorways to collect ridership information. A *Dilax PCU 210* mounted in the electronic equipment enclosure is used to gather and analyze the data.



13. DRIVER/VEHICLE MONITORING SYSTEM

13.1. Description

The New Flyer Connect™Driver/Vehicle Monitoring System measures and records vehicle operating parameters and location in real time. See "Fig. 9-58: Driver/Vehicle Monitoring System" on page 81. The system consists of:

☐ A Main Board Unit (MBU) located in the electronic equipment enclosure.

☐ A GPS/Data Modem Unit mounted on the ceiling of the vehicle, above the driver.

13.2. Operation

The Driver/Vehicle Monitoring System is connected to the vehicle's J1939 and J1587 networks. Information from these networks is monitored and transmitted, in real time, to allow transit authorities to monitor driver performance and vehicle condition.

The Main Board Unit contains a 3-axis accelerometer to monitor hard acceleration and braking and fast turning.

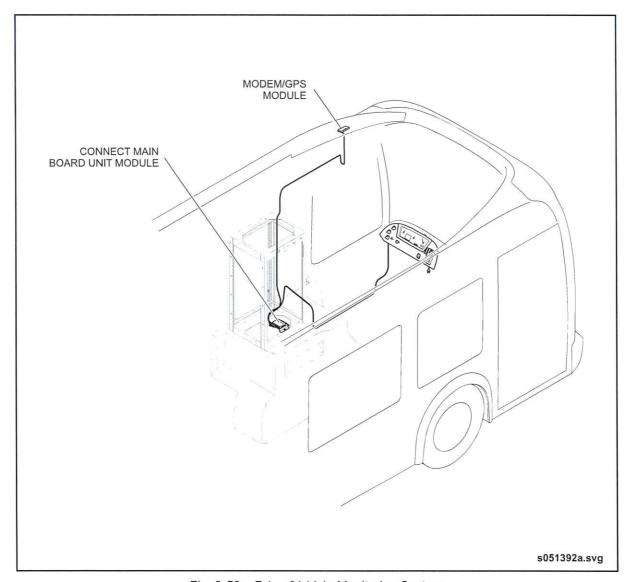


Fig. 9-58: Driver/Vehicle Monitoring System



14. ELECTRICAL SYSTEM SCHEMATICS

14.1. General

These schematics identify the various components of the electrical system, loca-

tions and specific data and are useful to troubleshoot the system. The schematics and related subject matter are disclosed in confidence and must be returned upon request. See "Fig. 9-59: VMM Schematic" on page 82.

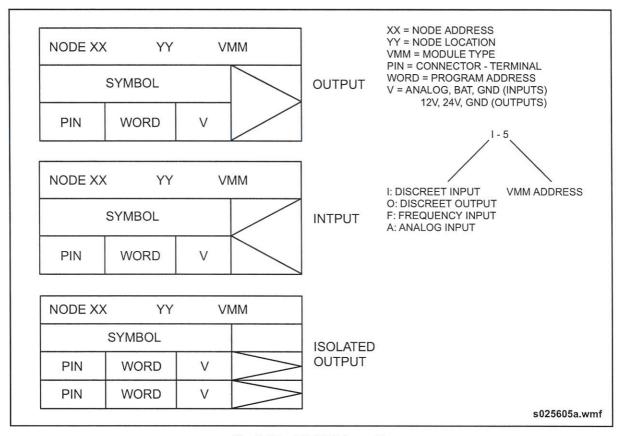


Fig. 9-59: VMM Schematic



14.2. Reading Schematics

Three codes are used for locating an I/O device; an address code (for the electronic control system), page code (to locate the device on a schematic), and a location code (the physical location on the vehicle).

Each schematic has a horizontal grid from 1 to 9, and a vertical grid from A to G. A two letter page code which is derived from the function in the vehicle that the schematic page represents is found in the title of each schematic.

A device legend explaining the I/O is included in the upper right corner of the schematic. Within each arrow of the schematic symbol is a location code to assist in finding the device. This location code gives the physical location of the I/O device on the vehicle (for example SC - the side console panel).

The schematic page titled "I/O Assignments" shows the input and output connections to each module. The inputs/outputs are shown in tables with their address code, a brief description, and page code. To locate the input/output on a schematic use the given page code to match the schematic title (for example from schematic "I/O Assignments" input, hazard switch (address code I2-4) is shown with a DS page code, then input can be located on the schematic titled DS (Driver's Signals).

Having located the device on the schematic (by matching address codes), the location code-SC can be found. Therefore the device is located in the side console panel of the vehicle.

14.3. Wire Codes

An abbreviated form of the address is stamped on the wire connected to each I/O device. By simply looking at the wire, you can determine immediately what input or output is connected to any device controlled by the electronic control system.

For example, output O17-3 could be connected to the control module via wire EL80. If this wire runs to a terminal and splits to more devices, the wire at the electronic control system would be labeled EL80A, and the other wires would be labeled EL80B, EL80C and so forth.

Wiring not connected to the electronic control system is stamped with a code derived from the position of the wire on the schematic. The wire code is built up from the schematic code, the grid location, a digit from 1 to 9, and a letter if there are several wires connected to a common terminal.

Every wire running directly from a circuit breaker to a distinct load has a unique number, not a letter suffix.

14.4. Wire Colors

The following wire colors are used throughout the vehicle:

24 VOLT POWERRED
12 VOLT POWERLIGHT BLUE
ELECTRONIC CONTROL INPUT WIRINGYELLOW
YELLOW
GROUNDSWHITE
SWITCHED POWER/GROUNDTAN

The communication network is shown as a double line.



14.5. Page Codes

Each schematic has a horizontal grid from 1 to 9, and a vertical grid from A to G. A two letter page code which is derived from the function in the vehicle that the schematic page represents is found in the title of each schematic.

Here are the page codes for electrical schematics:

PAGE CODES	
PAGE CODE	TITLE
GI	General Information
PD	Power Distribution
10	I/O Assignments
NT	Network Topology
PN	Primary Networks
PS	Power & Starting
EN	Engine
TR	Transmission
CC	Climate Control
DC	Door Controls
DS	Driver's Signal
EL	Exterior Lighting
IL	Interior Lighting
LI	Lighting
LK	Kneeling
СР	Communication Provisions
AF	Auxiliary Functions
JC	Joint Control
FS	Fire Suppression
AB	Anti-Lock Braking
IP	Instrument Panel
SP	Spare Wires

14.6. Device Nomenclature

Where a device is supplied by a third party as part of a system, and is given a code by the vendor, that same code is used on the NFI schematic. For example, connectors supplied by ZF on their harnesses will be labeled BN(X) on the NFI schematic, just as they are in the ZF documentation.

Unique devices require no code for identification purposes, and are labeled on the schematic according to function.

Multiple devices such as circuit breakers and fuses are assigned a code based on the schematic page on which they are found. Thus F4DS is found on page DS, although it may feed loads found on other pages. This is clearly marked on the schematic.





15. VENDOR SERVICE INFORMATION

The following supplier manuals contain additional reference information.

15.1. Vansco Manuals

- □ VMM 1210/1280/1615 Software User Guide
- □ VMM 1615 Hardware User Guide



Hybrid Drive System

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SAFETY

IPS NOTE:

Consult Allison Electric Drive Field Engineering before performing any work on the vehicle which involves the drive unit.

1.1. High Voltage Safety



The Allison H 40/50 EP System™ uses potentially hazardous electrical energy. All high voltage hybrid propulsion components are identified with High Voltage warning labels or symbols. DO NOT attempt to service components containing potentially hazardous electrical energy if you are not trained to do so.

Normal operating conditions:

ESS Voltage Range432 to 780 VDC DPIM DC Current Range -350 to +350 A



All persons working with potentially hazardous electrical energy should familiarize themselves with safe electrical work practices. Refer to 1.1.6. "Electrical Safe Work Practices" on page 5 in this section for procedure.

1.1.1. High Voltage Interlock Loop (HVIL)



DO NOT rely solely on the HVIL system to de-energize the electric drive system. Always perform the appropriate voltage checks and use lockout energy control techniques to ensure the system is deenergized. DO NOT attempt to bypass the HVIL system for any reason. Serious personal injury or death may result if proper safety procedures are not followed.

The Propulsion System uses a High Voltage Interlock Loop to attempt to prevent access to energized potentially hazardous electrical circuits. HVIL switches are located on the high voltage AC connectors on the drive unit and DPIM and on the high voltage DC connectors on the ESS and DPIM. Opening the covers on any of these connectors will cause the HVIL switch to open and mechanically disconnect high voltage energy from the system.

1.1.2. High Voltage Isolation Fault Detection

The Propulsion System uses Isolation Fault Detection to identify a short to the vehicle chassis on the high voltage circuit. The Check System indicator on the instrument panel will illuminate if this fault condition occurs and will automatically shutdown the vehicle.



1.1.3. General High Voltage Precautions

Always treat electrical systems as if they are powered ON. Make sure Master Run switch is in the STOP-ENGINE position. Set the Battery Disconnect switch to OFF. Always follow the High Voltage Disconnect Verification procedure before performing any work on the system.

1.1.4. High Voltage Disconnect Verification



ALWAYS wear high voltage (Class 0 isolation) protective gloves when working on high voltage equipment (Item 11, 12, or 13 from Special Tools list).

- Set Master Run switch to the STOP-ENGINE position.
- Set the Battery Disconnect switch to the OFF position. Use a lockout device to prevent unauthorized access to the Battery Disconnect switch.
- Remove connector PI120 (low voltage 24pin connector) from the DPIM. See "Fig. 51: DPIM Low Voltage Connections" on page 3.
- Remove connector PB140 (low voltage 31pin connector) from the ESS. See "Fig. 52: ESS Low Voltage Connections" on page 3.
- Remove both HVIL covers on the ESS. See "Fig. 53: ESS HVIL Cover Removal" on page 3.
- Remove the positive and negative connectors from the ESS. See "Fig. 54: ESS High Voltage Connections" on page 3. Use a lockout device to prevent unauthorized reinstallation.



Use a voltmeter, such as a Fluke 87, that is UL Listed E59794 and CSA Certified LR44340, IEC-1010-1, 1000V Category III input protection.

- Measure the following voltages using an approved voltmeter.
 - a. ESS positive to negative terminals. See "Fig. 55: ESS Voltage Check Between HV Terminals" on page 4. Voltage reading must be less than 3VDC before work can continue.
 - ESS positive terminal to chassis ground. See "Fig. 56: ESS Voltage Check Between HV Terminals & Ground" on page 4. Voltage reading must be less than 3VDC before work can continue.
 - c. ESS negative terminal to chassis ground. Voltage reading must be less than 3VDC before work can continue.
- 8. Remove the AC and DC lug access covers from the DPIM. Use an approved voltmeter to perform the following measurements:
 - a. DC positive to negative terminal. See "Fig. 57: Voltage Check Between DPIM DC HV Terminals" on page 4. Voltage reading must be less than 3VDC before work can continue.
 - DC positive terminal to chassis ground.
 See "Fig. 58: Votlage Check Between DPIM DC HV Terminals & Ground" on page 4. Voltage reading must be less than 3VDC before work can continue.
 - c. DC negative terminal to chassis ground. Voltage reading must be less than 3VDC before work can continue.
 - d. AC phase to phase; A-B, A-C, B-C. Voltage reading must be less than 3VDC before work can continue.
 - e. AC phase to chassis ground. See "Fig. 59: Voltage Check Between Each DPIM AC Phase & Ground" on page 5. Voltage reading must be less than 3VDC before work can continue.
 - f. Work can now be performed on the high voltage system.

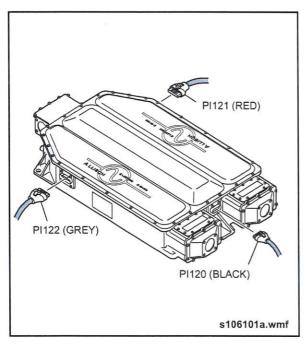


Fig. 51: DPIM Low Voltage Connections

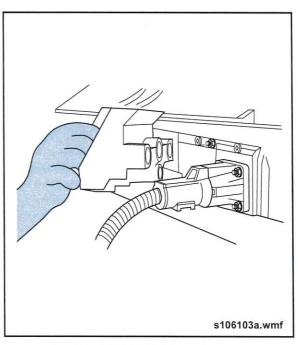


Fig. 53: ESS HVIL Cover Removal

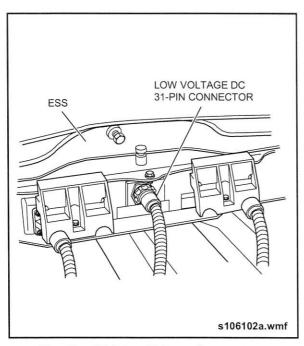


Fig. 52: ESS Low Voltage Connections

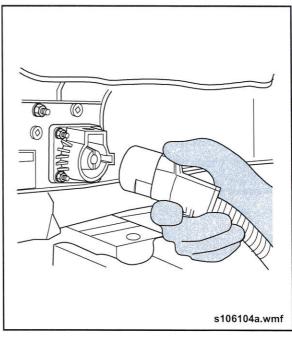


Fig. 54: ESS High Voltage Connections



Fig. 55: ESS Voltage Check Between HV
Terminals

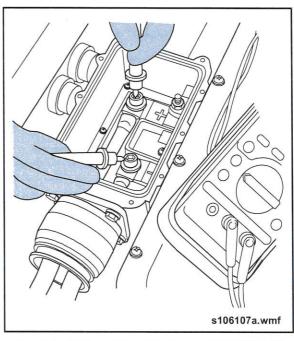


Fig. 57: Voltage Check Between DPIM DC HV Terminals



Fig. 56: ESS Voltage Check Between HV Terminals & Ground

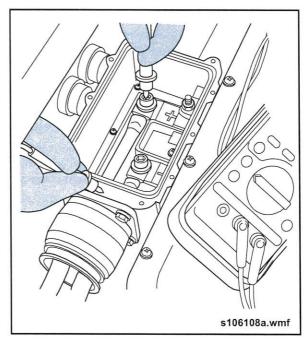


Fig. 58: Votlage Check Between DPIM DC HV Terminals & Ground

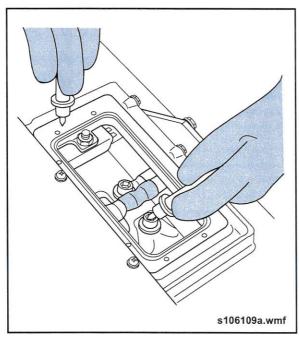


Fig. 59: Voltage Check Between Each DPIM AC Phase & Ground

1.1.5. Energy Storage Lockout

Use lockout devices to prevent installation of the ESS DC connectors during service. Refer to Allison Electric Drive System Service Manual for acceptable devices.

1.1.6. Electrical Safe Work Practices

Reference the following sources to obtain more information on establishing safe electrical work practices:

- □ www.OSHA.gov, 29CFR 1910 Subpart S
- ☐ www.NFPA.org, NFPA 70E-2004



1.2. General Safety

YOU ARE RESPONSIBLE for becoming completely familiar with the warnings and cautions described in this section regarding the drive unit. These warnings and cautions advise against the use of specific service methods that can result in personal injury, damage to the equipment, or cause the equipment to be made unsafe. Anyone who uses a service procedure or tool which is not recommended by New Flyer Industries or Allison Electric Drives must first be thoroughly satisfied that neither personal safety nor equipment safety will be jeopardized by the service methods selected.

Proper service and repair is important to the safe, reliable operation of the equipment. The service procedures recommended by Allison Electric Drives are described in this section and are effective methods for performing service operations. Some of these service operations require the use of tools specially designed for the purpose. The special tools should be used when and as recommended.

Refer to the General Information Section of this manual for information on types of hoists, hoisting procedures, jackstands and related safety information. Refer to this information and read carefully before lifting, hoisting or jacking the vehicle.

Always ensure that the vehicle is appropriately hoisted and blocked for procedures which require elevating the vehicle. Be aware of the limitations of the blocking equipment, and always ensure that the jarring and shaking created by component removal and installation procedures does not overload the blocks, or cause the vehicle to become unstable.

Certain procedures may require the vehicle be operated in an elevated position in order to accurately troubleshoot and diagnose a problem. If the vehicle must be running while elevated, become familiar with the repair area prior to starting the engine. Take special care in noting areas which will become hot, electrically energized, and areas where moving and rotating components are located. Limit the work in these areas as personal and equipment safety is at risk.

For procedures which involve air lines, ensure the line is safely depressurized prior to disconnecting. Disconnecting pressurized lines will cause solid particles deposited in the line to be uncontrollably propelled, and will also cause the hose end to whip randomly as the air escapes.

During electrical diagnosis procedures an understanding of the vehicle's electric circuits is important to anticipate the results of connecting test equipment. During component removal or installation, ensure the Battery Disconnect switch is in the OFF position.

Failure to follow this procedure may result in personal injury or component failure.

Observe the following procedures involving hydraulic line removal.

- Hydraulic fluid is corrosive and should not be exposed to skin for extensive periods of time.
- Wear eye protection at all times.
- Pressurized lines should not be disconnected until the pressure is safely and controllably released.



2. HYBRID DRIVE SYSTEM

2.1. Description

The Hybrid Drive System consists of:

- Drive Unit
- □ Dual Power Inverter Module (DPIM)
- ☐ Energy Storage System (ESS)
- ☐ Transmission and Vehicle Control Modules (TCM/VCM)
- ☐ Pushbutton Shift Selector (PBSS)

2.2. Hybrid Drive Specifications

Manufacturer Allison Transmission
Model
Control System 4th Generation Controls
Maximum Output Torque4000 ft-lb.
Maximum Regenerative Braking1400 ft-lb.
Dry Weight919 lbs (417 kg)



2.3. Operation

This vehicle is powered by a parallel hybrid system that blends both mechanical and electrical power paths to drive the vehicle. The system consists of a diesel engine, drive unit, Energy Storage System (ESS), Dual Power Inverter Module (DPIM), and electronic controls. See "Fig. 5-10: Hybrid Drive System Layout" on page 8.

The diesel engine is conventionally mounted and coupled to the drive unit. The drive unit is an arrangement of three planetary gearsets, two clutches, and two motor/generators that work together with an electronic control unit to provide two continuously variable operating ranges.

Diesel engine torque is blended with the drive unit's electric motors to propel the vehicle. The motors primarily accelerate the vehicle from a standstill to about 12 mph. At cruising speeds the vehicle is propelled primarily by the diesel engine.

The Energy Storage System (ESS) is a modular roof-mounted battery pack. It stores the AC energy provided by the motor/generators which has been converted to DC energy by the DPIM unit. The DPIM unit also converts the stored DC energy back to AC in order to drive the motor/generators when required.

The electric motors in the drive unit can be driven by the weight of the vehicle, through the driveline, during deceleration and create electrical energy generation. This process, known as "regenerative braking", also slows the vehicle by imposing a drag on the driveline.

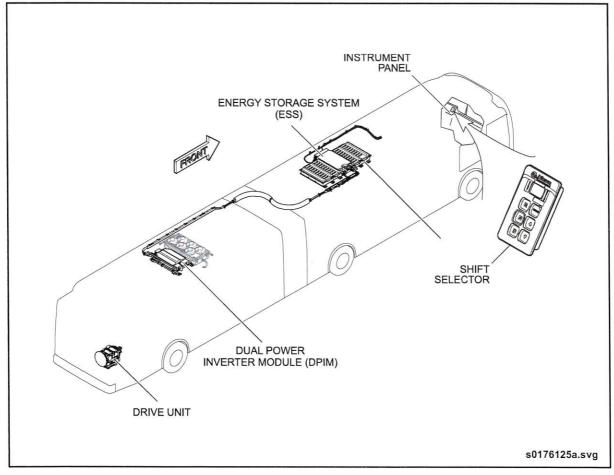


Fig. 5-10: Hybrid Drive System Layout



2.4. Drive Unit

2.4.1. Description

The drive unit is mounted to the vehicle engine and coupled to the driveline in the same manner as a transmission. The unit

contains two concentric electric motors that, in combination with planetary gearing and rotating and stationary clutches, provide infinitely variable forward and reverse speeds. See "Fig. 5-11: Drive Unit Removal & Installation" on page 9.

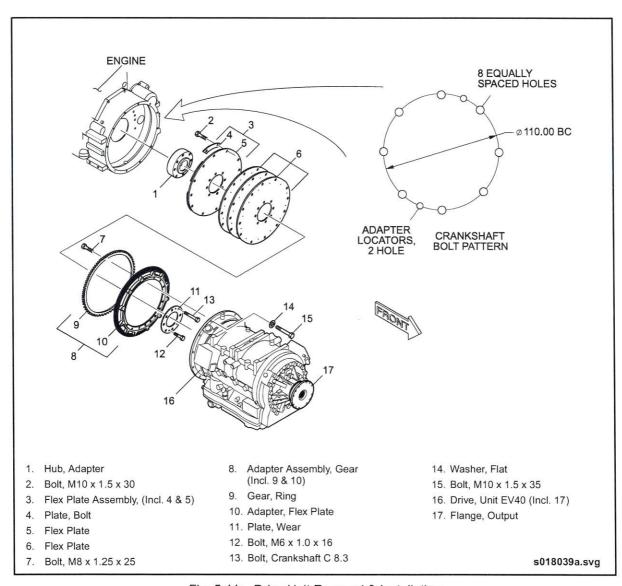


Fig. 5-11: Drive Unit Removal & Installation



2.4.2. Operation

The drive unit is used to turn the engine flywheel during vehicle starting. The engine does not require a starter motor. During vehicle operation, power from the roof-mounted Electrical Storage System is combined with engine power within the drive unit to accelerate the vehicle. This process is called torque blending.

2.4.2.1. Regenerative Braking

Regenerative braking is an energy recovery process that occurs whenever the throttle is not applied and the vehicle is moving forward. During this process a drive unit motor is electrically switched from motor operation to generator operation. The vehicle's rotating driveshaft then turns the motor/generator. The electrical energy produced is routed through the roof-mounted Dual Power Inverter Module (DPIM) to the Energy Storage System. This interaction of the magnetic fields within the motor/generator also produces drag on the vehicle driveline and slows the vehicle. Braking force increases when the service brakes are applied.

Pressing the DOWN (\$\psi\$) arrow while moving forward increases the regenerative braking effect of the drive unit. The Pushbutton Shift Selector (PBSS) displays [F] or [L] to identify the level of regenerative braking in use. Increasing regenerative braking does not limit forward speed to a particular range. The drive unit remains in the selected regenerative braking mode until the Master Run switch is set to the STOP-ENGINE or NIGHT-PARK position, the UP (\$\tau\$) or DOWN (\$\psi\$) arrows are used, or Neutral [N] is selected. Following any of these conditions, the system returns to the default regenerative braking level.

2.4.2.2. Drive Unit Fluid Level Check



Ensure the following conditions are met prior to conducting a fluid level check:

- ☐ Vehicle is brought to a complete stop on a level surface.
- ☐ Drive unit is in neutral [N].
- □ Parking brake is applied.
- Vehicle wheels are chocked.

The drive unit is equipped with an electronic Oil Level Sensor (OLS). The OLS provides a means to check the drive unit fluid level. To display fluid level, simultaneously press the UP (↑) and DOWN (↓) arrow keys on the push button shift selector (PBSS) for five seconds. The vehicle must meet the following conditions for two minutes before readings can be obtained:

- ☐ Engine at idle (750 to 850 RPM)
- □ Sump fluid at operating temperature of 68° to 176°F (20° to 80°C).
- Drive unit output shaft stopped.
- Drive unit in neutral [N].
- Oil level sensor functioning properly.

Fluid level condition will be displayed instantly if the above conditions have been met for a two-minute period prior to the request. However, if the two-minute period has not been met, a countdown display will be shown during the two-minute period. An invalid for display code will be shown if an operational condition has not been met. Refer to 2.4.2.3. "Invalid for Display Codes" on page 11 in this section for display codes and their meaning. The countdown is restarted when the condition causing the invalid for display code is corrected.



2.4.2.3. Invalid for Display Codes

DISPLAY SEQUENCE	INTERPRETATION OF DISPLAY
oL,,50	Engine RPM too low, below 750 RPM
oL,,59	Engine RPM too high, above 850 RPM
oL,,65	Neutral [N] not selected
oL,,70	Sump fluid temperature too low
oL,,79	Sump fluid temperature too high
oL,,89	Output shaft rotation
oL,,95	Sensor failure*

2.4.2.4. Shift Selector Display Codes

MOTE:

The fluid level information is displayed one character at a time. Press the neutral [N] button once to exit the Fluid Level mode.

SHIFT SELECTOR DISPLAY CODES		
DISPLAY SEQUENCE	DISPLAY MEANING	
oL, oK	Fluid level correct	
oL, Lo, 1	Fluid level is 1 quart low	
oL, HI, 1	Fluid level is 1 quart high	



2.4.3. Removal



Refer to 1.1. "High Voltage Safety" on page 1 in this section and familiarize yourself with the safety requirements before performing any maintenance or repair on the Allison E^P System™. Refer to Allison E^P Systems™ Service Manual.

MOTE:

The following procedure describes removal and installation of the drive unit without removing the engine from the vehicle. Refer to Section 4 of this manual for the removal and installation procedure of the engine and drive unit as an assembly. Further information on the drive unit can be obtained from Allison Electric Drive Field Engineering.

- Park vehicle on level surface with parking brake applied and wheels chocked.
- Set Battery Disconnect switch to OFF position.
- Perform high voltage disconnect verification. Refer to 1.1.4. "High Voltage Disconnect Verification" on page 2 in this section for procedure.
- 4. Drain fluid from drive unit.
- Remove clamp securing dipstick tube to mounting bracket. Remove dipstick tube from grommet in drive unit housing.
- Disconnect the DPIM oil lines and oil cooler lines from the drive unit.
- Disconnect all electrical connectors from drive unit including main harness, A and B motor speed sensors, output speed sensors, and HVIL switches.

Remove high voltage covers and disconnect lugs retaining HV wiring.

ROTE:

If there is insufficient clearance to access high voltage covers at this time, this procedure can be performed when the drive unit has been separated and lowered from the engine. Ensure adequate cable slack is provided. DO NOT stretch HV cables.

- Disconnect vehicle driveshaft from the drive unit output yoke. Position the disconnected driveshaft to avoid interference when removing the drive unit.
- 10. Securely support the drive unit with a hoist, jack, or other suitable removal equipment.
- 11. Remove engine flywheel access cover. Rotate the engine flywheel until a flexplate-to-ring gear bolt is centered in the opening of the viewing hole. See "Fig. 5-12: Flexplate Access Cover" on page 13.
- 12. Remove the bolt and rotate the engine until the next bolt is centered in the opening. Repeat this process until all six M10 bolts are removed.

MOTE:

In order to ease the removal/installation process it is recommended the rear mounts be loosened from the engine mounting pads.

- 13. Use a suitable jack to support the weight of the engine.
- 14. Loosen the 3/4" isolator mount bolt on each rear mount. Loosen, but do not remove, the M12 bolts that attach each rear mount to the engine. Remove the 5/8" nut, bolt, and washer from one end of the tie bar that connects the two rear mounts together.
- 15. Remove the four M14 bolts that attach each rear mount to the drive unit.



 Loosen but do not completely remove four equally spaced drive unit to flywheel housing M10 bolts.

MOTE:

These bolts will act as guides when the drive unit is initially separated from engine and help prevent misalignment damage to the torque converter.

- 17. Remove the remaining eight M10 bolts.
- 18. Carefully separate the drive unit from the engine and pull straight back until the drive unit contacts the heads of the four bolts that were previously loosened.



Ensure that the drive unit is properly aligned and supported so that it will not roll or slip when the final four bolts are removed.

- 19. Remove the final four M10 bolts and move the drive unit away from the engine.
- 20. Ensure that all items and electrical connectors have been disconnected before lowering drive unit.
- 21.Lower the drive unit and hoist to a work stand or bench. Use Stator Housing Fixture (Item 1 from Special Tools List).

IP NOTE:

If a replacement drive unit is being installed, it will be necessary to transfer the ring gear and flexplate adapter assembly to the new unit. Proceed with following step:

22. Remove ten M8 bolts that retain the ring gear and flexplate adapter assembly to the damper assembly and remove ring gear and flexplate assembly from drive unit.

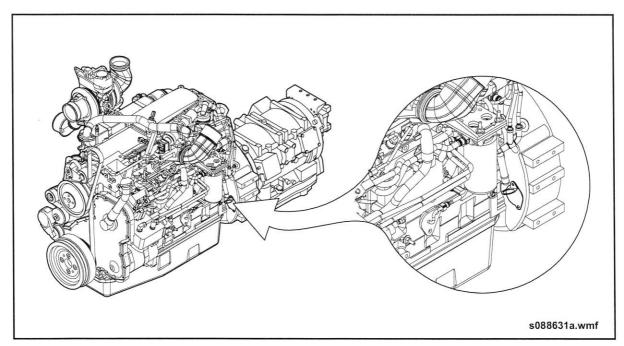


Fig. 5-12: Flexplate Access Cover



2.4.4. Installation

- Transfer the ring gear and flexplate assembly to the new drive unit, if required, and fasten in place with ten M8 bolts. Torque to 25 ft-lb. (34 Nm).
- Install headless guide pins at four equally spaced locations on the engine flywheel housing to help align drive unit during installation.
- Install a headless guide pin into one of the threaded holes in the flexplate adapter to help align flexplate with drive unit flexplate adapter during installation. Ensure that this guide pin is positioned so as to be centered within the engine access opening when the drive unit is joined to the engine.
- Apply molybdenum-disulfide (Molykote) grease on the pilot boss of the damper assembly.



Ensure that the drive unit is properly aligned and supported so that it will not roll or slip as the drive unit is being moved into position.

- Carefully push the drive unit towards the engine while guiding the pilot boss on the damper assembly into the engine flywheel hub adapter and also aligning the flexplate guide bolt into a bolt hole on the flexplate.
- Seat the drive unit squarely against the engine flywheel housing. Install eight M10 bolts and washers and finger tighten only at this time.



The drive unit must seat flush with the engine flywheel housing before mounting bolts are tightened. DO NOT use mounting bolts to draw mating flanges together. If interference is experienced, move the drive unit away from the engine and investigate the cause.

- 7. Remove the four guide bolts and install the remaining four M10 bolts and washers. First, torque these four equally spaced bolts 38 to 45 ft-lb. (51 to 61 Nm), then torque remainder of bolts using a crisscross pattern.
- 8. Remove the flexplate guide bolt from the engine flywheel access opening and replace with an M10 bolt. Hand tighten only at this time.
- Rotate the flexplate to the next hole and install another M10 bolt. Repeat this process until all bolts are installed hand tight.
- 10. Torque the M10 flexplate bolts to 50 ft-lb. (68 Nm).
- 11. Install the engine flywheel access cover.
- 12.Install the four M14 bolts that attach each rear mount to the drive unit. Torque 95 ft-lb. (129 Nm).
- Torque the four M12 bolts that attach each rear mount to the engine to 75 ft-lb. (102 Nm).
- 14. Install the 5/8" bolt, nut, and washer that attaches the tie bar to the rear mounts. Torque bolt to 70 ft-lb. (95 Nm).



- 15. Lower the engine and drive unit assembly to allow the rear mounts to take the weight of the assembly. Torque the isolator mount 3/4" bolt to 250 ft-lb. (339 Nm).
- 16. Connect driveshaft to output yoke of drive unit. Refer to Section 2 of this manual for procedure.
- 17. Connect lugs that retain high voltage wiring to drive unit. Install high voltage covers with new Electromagnetic Interference (EMI) gasket and torque cover bolts to 21 ft-lb. (28 Nm). See "Fig. 5-13: High Voltage Cable EMI Gaskets" on page 16.

NOTE:

Electromagnetic interference (EMI) gaskets are required on the high voltage cables to suppress EMI emissions and avoid possible interference with the vehicle electronic components. The EMI gaskets are not reusable and must be replaced each time the high voltage cables are reconnected.

18. Connect all electrical connectors to drive unit including main harness, (A) and (B) motor speed sensors, output speed sensors, and HVIL switches. 19. Connect the DPIM oil lines and oil cooler lines to the drive unit.

MOTE:

If drive unit was removed due to internal failure, the oil cooler, hydraulic cooler, DPIM, and interconnecting hoses will have to be cleaned and flushed.

- 20.Install dipstick tube into grommet in drive unit housing, ensuring beaded portion of tube compresses grommet against housing. Secure tube to mounting bracket using clamp.
- 21. Fill drive unit with fluid. Refer to the Preventive Maintenance Section of this manual for fluid specification.
- 22. Set the Battery Disconnect switch to the ON position.
- 23. Start engine and check for leaks. Top up fluid level if necessary. Refer to 2.4.2.2. "Drive Unit Fluid Level Check" on page 10 in this section for fluid level checking procedure.

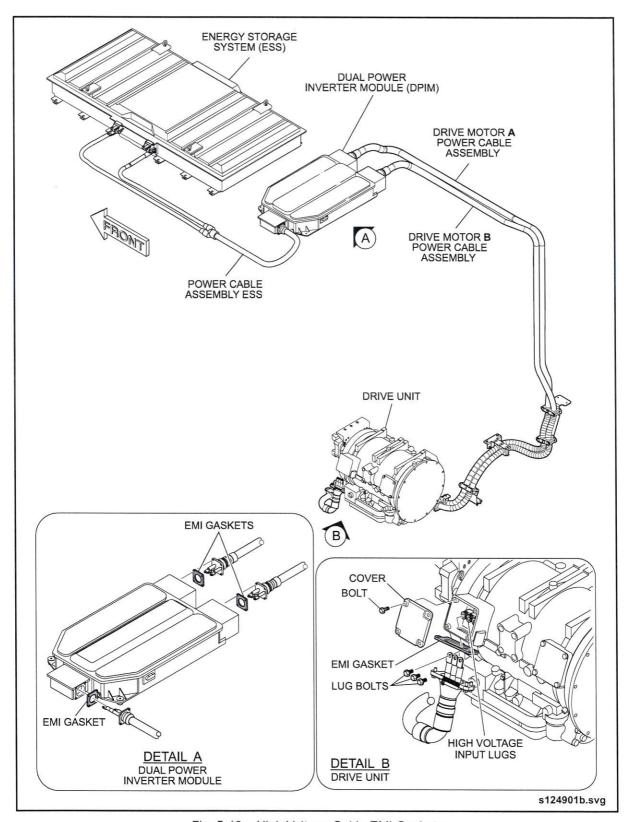


Fig. 5-13: High Voltage Cable EMI Gaskets



2.5. Dual Power Inverter Module (DPIM)

2.5.1. Description

The DPIM is located in the DPIM/Hydraulic Cooler rack enclosure on the roof of the rear section of the vehicle. The DPIM consists of two inverters that are enclosed in a common housing and are capable of producing 160 kW continuous 3-phase AC output. The DPIM is electrically-connected to the drive unit using two high voltage AC connectors located at one end of the unit. The DPIM is electrically-connected to the ESS using a high voltage DC connector located at the opposite end of the unit. Three low voltage DC multi-pin connectors are also provided. The module is oil-cooled

and is connected to the drive unit oil system using flexible hoses. See "Fig. 5-14: DPIM Installation" on page 17.

2.5.2. Operation

The DPIM converts AC electricity to DC electricity and vice-versa. During regenerative braking, AC electricity generated by the drive unit is converted to DC electricity by the DPIM and stored in the Energy Storage System (ESS). During the run mode, the DPIM utilizes the stored DC electricity and converts it to AC electricity to power the drive unit. The DPIM receives a torque command from the Transmission Control Module (TCM) and controls the magnitude and frequency of the phase currents to meet the required demand.

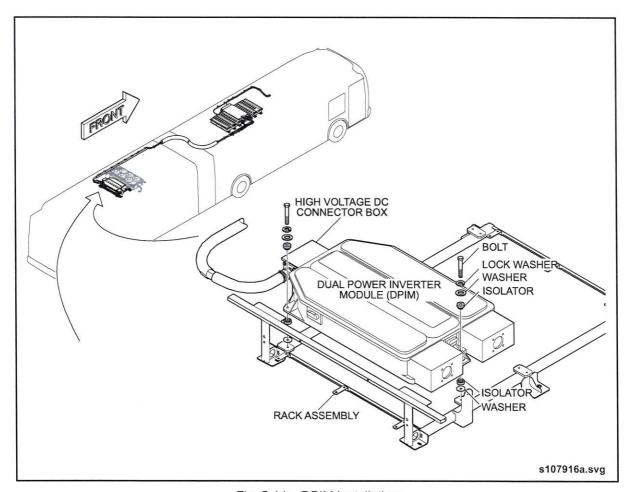


Fig. 5-14: DPIM Installation



2.5.3. Removal



Refer to 1.1. "High Voltage Safety" on page 1 in this section and familiarize yourself with the safety requirements before performing any maintenance or repair on the Allison E^P System™. Refer to Allison E^P Systems™ Service Manual.

- 1. Park vehicle on level surface with parking brake applied and wheels chocked.
- Set Battery Disconnect switch to OFF position.
- Perform high voltage disconnect verification. Refer to 1.1.4. "High Voltage Disconnect Verification" on page 2 in this section for procedure.
- 4. Drain fluid from drive unit.

- Disconnect the three low voltage DC multipin connectors (PI120, PI121, and PI122) from the DPIM.
- Remove the cover from the high voltage DC connector box and disconnect the negative and positive lugs. Ensure wires are properly identified before removing wire pass-through assembly from lug box assembly.
- Remove the cover from each high voltage AC connector box and disconnect the three phase lugs. Ensure wires are properly identified before removing wire passthrough assembly from lug box assembly.
- Remove oil cooler lines from DPIM housing. Identify and mark location of oil cooler lines.
- Remove the three bolts and vibration isolation mounts that retain the DPIM housing to the rack structure. Remove DPIM from vehicle.



2.5.4. Installation



The low voltage system control wiring must be tested before being connected to the DPIM. DO NOT make connections to DPIM if any test results exceed the test fail voltage, as damage to the DPIM may result.

- Confirm vehicle low voltage wiring integrity using the DPIM Installation Protection Device. Refer to 2.5.5. "DPIM Installation Protection Device (DIPD)" on page 20 in this section for procedure.
- Install the DPIM into vehicle rack structure and secure with three bolts and isolation mounts. Torque bolts to 30 ft-lb. (41 Nm) maximum.
- Install oil cooler lines as marked during removal
- 4. Install the AC high voltage cabling and wire pass-through assemblies with new EMI gasket. Torque pass-through connector 47 to 53 in-lb. (5 to 6 Nm).

MOTE:

Electromagnetic interference (EMI) gaskets are required on the high voltage cables to suppress EMI emissions and avoid possible interference with the vehicle electronic components. The EMI gaskets are not reusable and must be replaced each time the high voltage cables are reconnected.

 Ensure the phase connections are correctly installed as noted during removal. Install both AC cover plates and torque cover screws 11 to 13 in-lb. Install the DC high voltage cabling and wire pass-through assembly with new EMI gasket. Torque pass-through connector 47 to 53 in-lb. (5 to 6 Nm).

NOTE:

Electromagnetic interference (EMI) gaskets are required on the high voltage cables to suppress EMI emissions and avoid possible interference with the vehicle electronic components. The EMI gaskets are not reusable and must be replaced each time the high voltage cables are reconnected.

- Ensure the negative and positive lugs are correctly installed as noted during removal. Install cover plates and torque cover screws 11 to 13 in-lb.
- Install the three low voltage DC multi-pin connectors (PI120, PI121, and PI122) to the DPIM.
- Reinstall the positive and negative high voltage DC cables that were disconnected from the ESS during the High Voltage Disconnect Verification Procedure. Reinstall the protective covers over the cable connectors.
- 10. Fill the drive unit with fluid. Refer to the Preventive Maintenance Section of this manual for fluid specification.
- 11. Set the Battery Disconnect switch to the ON position.
- 12. Start engine and check for oil leaks.
- 13.Allow the drive unit fluid to come up to operating temperature and perform fluid level check. Refer to 2.4.2.2. "Drive Unit Fluid Level Check" on page 10 in this section for procedure. Top up fluid level as necessary.



2.5.5. DPIM Installation Protection Device (DIPD)

MOTE:

Use the DPID whenever the DPIM is replaced or whenever connecting wire harnesses have been replaced or repaired.

2.5.5.1. Description

The DPIM Installation Protection Device (DIPD) (Item 9 from Special Tools List) is used to test for the presence of any potentially damaging voltages prior to installation of the DPIM. The DIPD will interface to the system by way of the same low voltage connectors and harnesses the DPIM will utilize when installed. The DIPD will be temporarily connected to the low voltage control system wiring in place of the DPIM. The system low voltage supply will be energized, and the vehicle ignition will be turned on to establish the initial conditions necessary for the installation protection check.

MOTE:

This device does not prove a wiring installation is correct for proper DPIM operation. The DIPD will only provide a visual indication (illuminated LEDs) to verify that there are no potentially damaging voltages applied to the DPIM low voltage system interconnection points.

The DIPD will detect the presence of voltage levels, above the maximum allowed on any single pin, or combination of pins associated with the DPIM low voltage system interconnections. In some instances, voltages significantly lower than the maximum allowable will be considered a failure if it has been determined that voltage level is indicative of improper wiring.

The following table lists the low voltage connections available for DPIM operation and the maximum allowable voltage that may be applied to each pin without risking damage to the DPIM internal circuitry. This table provides a listing of the (nominal/maximum) voltage failure set point for each interconnection point.



2.5.5.2. Maximum Allowable Voltage

		MAX	IMUM	ALLOWA	BLE VOL	TAGE		
PI120 Pin	Maximum Allowable Voltage	Test Fail Voltage (Max)	PI121 Pin	Maximum Allowable Voltage	Test Fail Voltage (Max)	PI122 Pin	Maximum Allowable Voltage	Test Fail Voltage (Max)
1	7 Volts	5 Volts	1	7 Volts	5 Volts	1	32 Volts	18 Volts
2	7 Volts	5 Volts	2	7 Volts	5 Volts	2	32 Volts	18 Volts
3	7 Volts	5 Volts	3	7 Volts	5 Volts	3	25 Volts	18 Volts
4	7 Volts	5 Volts	4	7 Volts	5 Volts	4	25 Volts	18 Volts
5	No Connection	N/A	5	No Connection	N/A	5	32 Volts	18 Volts
6	25 Volts	5 Volts	6	25 Volts	5 Volts	6	32 Volts	18 Volts
7	14 Volts	14 Volts	7	14 Volts	14 Volts	7	32 Volts	5 Volts
8	32 Volts	3 Volts	8	32 Volts	3 Volts	8	25 Volts	5 Volts
9	25 Volts	5 Volts	9	25 Volts	5 Volts	9	25 Volts	5 Volts
10	14 Volts	14 Volts	10	14 Volts	14 Volts	10	No Connection	N/A
11	25 Volts	5 Volts	11	25 Volts	5 Volts	11	No Connection	N/A
12	14 Volts	14 Volts	12	14 Volts	14 Volts	12	32 Volts	5 Volts
13	32 Volts	5 Volts	13	32 Volts	5 Volts	13	32 Volts	3 Volts
14	No Connection	N/A	14	No Connection	N/A	14	18 Volts	18 Volts
15	10 Volts	5 Volts	15	10 Volts	5 Volts	15	18 Volts	18 Volts
16	No Connection	5 Volts	16	No Connection	5 Volts	16	32 Volts	N/A
17	32 Volts	3 Volts	17	32 Volts	3 Volts	17	32 Volts	N/A
18	32 Volts	3 Volts	18	32 Volts	3 Volts	18	32 Volts	N/A
19	7 Volts	5 Volts	19	7 Volts	5 Volts	19	32 Volts	N/A
20	7 Volts	5 Volts	20	7 Volts	5 Volts	20	32 Volts	N/A
21	32 Volts	3 Volts	21	32 Volts	3 Volts	21	32 Volts	N/A



	MAXIMUM ALLOWABLE VOLTAGE							
PI120 Pin	Maximum Allowable Voltage	Test Fail Voltage (Max)	PI121 Pin	Maximum Allowable Voltage	Test Fail Voltage (Max)	PI122 Pin	Maximum Allowable Voltage	Test Fail Voltage (Max)
22	32 Volts	8 Volts	22	32 Volts	8 Volts	22	32 Volts	3 Volts
23	14 Volts	5 Volts	23	14 Volts	5 Volts	23	18 Volts	18 Volts
24	32 Volts	3 Volts	24	32 Volts	3 Volts	24	18 Volts	18 Volts
25	32 Volts	8 Volts	25	32 Volts	8 Volts			
26	14 Volts	5 Volts	26	14 Volts	5 Volts			
27	32 Volts	8 Volts	27	32 Volts	8 Volts			
28	14 Volts	5 Volts	28	14 Volts	5 Volts			
29	32 Volts	3 Volts	29	32 Volts	3 Volts			
30	32 Volts	3 Volts	30	32 Volts	3 Volts			
31	10 Volts	5 Volts	31	10 Volts	5 Volts			
32	32 Volts	5 Volts	32	32 Volts	5 Volts			

The DIPD will simulate the 12V sensor supply voltages normally supplied by the DPIM internal circuitry and make appropriate measurements to ensure this power has not been inadvertently routed to another interconnection point on the DPIM which could be damaged by the application of 12VDC.

The following conditions will cause the DIPD LED's to illuminate:

- ☐ Proper low voltage supply and ground connections to the system.
- Supply power within proper voltage range.
- Proper system initial conditions met.

☐ No improper voltage applied to any applicable pin(s).

III NOTE:

If any of the previous test results are not satisfactory, the associated indicating lamp will turn off or blink depending upon the location and type of fault.

The DIPD will perform a short (approximately 5 second) test of all indicating lamps when power is applied to the device, (PI122 connector mated with vehicle). All five lamps (the indicating lamps and the test lamp on the DIPD) should illuminate during this time.

2.5.5.3. Operation

The DIPD connects to any system designed to utilize a DPIM by way of three low voltage connectors that are mated to the system harnessing in the same manner as a DPIM. These connectors are designated as PI120 (Red, 32-pin), PI121 (Gray, 32-pin) and PI122 (Black, 24-pin)

It is imperative that all wiring installation and any other construction efforts which could potentially damage system wiring, are completed throughout the entire vehicle prior to execution of the DIPD test procedure. This ensures meaningful results while testing with the DIPD.

The vehicle low voltage harness installation should be retested with the DIPD following any maintenance or modification that affects the DPIM low voltage interface wiring.

2.5.5.4. Functional Test

MOTE:

This test procedure assumes that a DPIM has not been connected to the low voltage harnessing system prior to testing with the DIPD. If this is not the case, the DPIM must be fully de-energized and the low voltage harnessing system connectors (PI120, PI121 and PI122) disconnected from the DPIM prior to continuing with the following steps.

1. Establish proper initial system conditions for testing as follows:

IP NOTE:

Various DIPD display combinations may exist as proper initial system conditions for testing are being established in the steps below. These displays are evaluated in subsequent operations and may be ignored until Step 1 is fully completed.

- a. Ensure all 12VDC and/or 24VDC power interrupting devices are configured for normal operation of the system to be tested. Set Battery Disconnect switch to the ON position and set the Master Run switch to STOP-ENGINE.
- b. Connect the DIPD to each of the DPIM low voltage harness connectors (PI120, PI121 and PI122) of the system to be tested. (The DIPD connectors are color coded and keyed to assist proper connection.)
- Set the Master Run switch to the DAY-RUN position.
- 2. Summary of DIPD Test Result:
 - If all four DIPD display lamps are illuminated continuously, the low voltage harness does not contain wiring errors that could potentially damage a DPIM when installed.

IP NOTE:

This testing does not verify that the vehicle wiring is correct for proper DPIM operation. It only verifies that potentially damaging voltages will not be applied to the device through the low voltage interface.

b. If any of the four DIPD display lamps are not illuminated or flashing, then the vehicle low voltage wiring interface contains errors which could potentially damage the DPIM if installed. Under this condition, the low voltage wiring harness errors must be located and corrected before attempting to install the DPIM.



- Detailed evaluation of DIPD displayed test result:
 - a. The Power Circuits OK lamp should be illuminated indicating that each of the 12V supply and ground pins are properly connected.
 - b. The Power Circuits OK lamp will not be illuminated if any of the following improper conditions exist:
 - Any one of the four 12V supply pins are not connected (or improperly connected to another electrical point within the system).
 - Any one of the four Ground pins are not connected (or improperly connected to another electrical point within the system).
 - iii. 12V supply voltage is less than 10VDC.
 - 12V supply voltage is greater than 18VDC.

INOTE:

The DIPD will function with any one 12V supply and any one Ground pin connected correctly.

- The Supply Voltage OK lamp should be illuminated indicating that the supply voltage is within acceptable voltage limits.
- d. The Supply Voltage OK lamp will not be illuminated if any of the following improper conditions exist:
 - i. 12V supply voltage is less than 10VDC.
 - ii. 12V supply voltage is greater than 18VDC.
- The Setup OK lamp should be illuminated indicating the vehicle Ignition signal is properly applied.

- f. The Setup OK lamp will not be illuminated if any of the following improper conditions exist:
 - Master Run switch not ON (DAY or NIGHT-RUN).

MOTE:

The vehicle ignition power is applied to Pins PI122-16 and PI122-17. The DIPD must detect 12V (nominal) at either pin for the Setup OK lamp to be illuminated.

- ii. No 12V supply pin is connected.
- g. The Test Result OK lamp should be illuminated (continuously) indicating that no potentially damaging voltages have been detected on any DPIM low voltage pin.

MOTE:

Two separate, repeating tests are performed alternately by the DIPD. The low voltage interface is tested with and without simulated DPIM 12V sensor supply outputs. If either test fails, the Test Result OK lamp will be extinguished during that specific test. Therefore, a flashing Test Result OK lamp indication is to be interpreted as an indication of an improper wiring condition.

- h. The Test Result OK lamp will not be illuminated (or flash) if any of the following improper conditions exist:
 - An improper (potentially damaging to the DPIM) voltage is detected at any low voltage interface pin.
 - ii. 12V supply voltage is less than 10VDC.
 - 12V supply voltage is greater than 18VDC.



2.6. Energy Storage System (ESS)

2.6.1. Description

The ESS consists of a nickel metal hydride battery pack and connecting electrical cables. The ESS battery pack is located in the Battery Rack Enclosure on the roof of the vehicle. The battery pack is connected to the DPIM with high voltage DC cables and to the vehicle system wiring with a low voltage DC multi-pin connector. Cooled air is ducted around the battery pack to cool the unit. Refer to Section 10 of this manual for information on the Battery Cooler. See "Fig. 5-15: ESS Installation" on page 25.

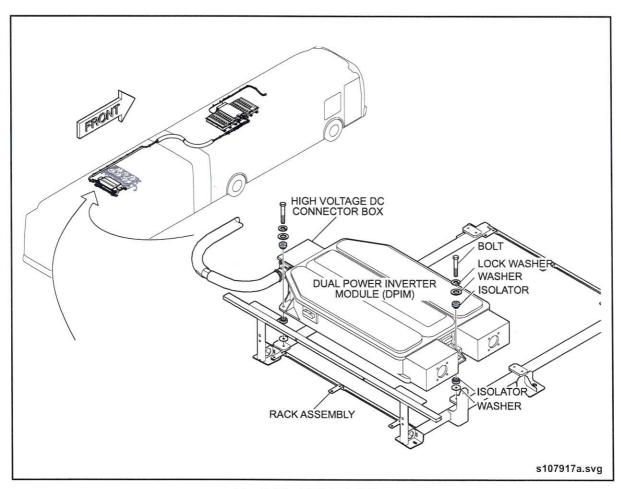


Fig. 5-15: ESS Installation



2.6.2. Operation

The ESS stores energy generated by the drive unit and captured during regenerative braking. This energy is available on demand to the drive unit. The battery pack is non-serviceable and does not require off-vehicle charging.

2.6.3. Removal



Refer to 1.1. "High Voltage Safety" on page 1 in this section and familiarize yourself with the safety requirements before performing any maintenance or repair on the Allison E^P System™. Refer to Allison E^P Systems™ Service Manual.

- 1. Park vehicle on level surface with parking brake applied and wheels chocked.
- Set Battery Disconnect switch to OFF position.
- Perform High Voltage Disconnect Verification Procedure as described in this section.
- Remove steel braided hose from hydrogen vent.
- Remove 12 mounting bolts, nuts, and washers.
- Attach lifting fixture (Item 10 from Special Tools List) to the four lifting eyes on the battery pack and lift battery pack from vehicle.

2.6.4. Installation



The low voltage system control wiring must be tested before being connected to the ESS. DO NOT make connections to ESS if any test results exceed the test fail voltage, as damage to the battery pack may result.

- Confirm vehicle low voltage wiring integrity using the Battery Pack Installation Protection Device. Refer to 2.6.5. "Battery Pack Installation Protection Device (BIPD)" on page 27 in this section for procedure.
- 2. Install the battery pack into vehicle rack structure using lifting rig. Secure with 12 bolts, nuts, and washers. Torque bolts 38 to 45 ft-lb. (51 to 61 Nm).
- 3. Attach hydrogen vent tubing.
- Reinstall the positive and negative high voltage DC cables that were disconnected from the ESS during the High Voltage Disconnect Verification Procedure. Reinstall the protective covers over the cable connectors.
- Connect low voltage DC multi-pin connector
- Set Battery Disconnect switch to the ON position.
- 7. Start engine and verify systems operation.



2.6.5. Battery Pack Installation Protection Device (BIPD)

MOTE:

Use the BIPD whenever the ESS is replaced or whenever connecting wire harnesses have been replaced or repaired.

2.6.5.1. Description

The Battery Pack Installation Protection Device (BIPD) (Item 8 from Special Tools List) is used to test for the presence of any potentially damaging voltages prior to installation of the ESS. The BIPD will interface to the system by way of the same low voltage connectors and harnesses the ESS will utilize when installed. The BIPD will be temporarily connected to the low voltage control system wiring in place of the ESS. The system low voltage supply will be energized, and the vehicle ignition will be turned on to establish the initial conditions necessary for the installation protection check.

MOTE:

This device does not prove a wiring installation is correct for proper ESS operation. The BIPD will only provide a visual indication (illuminated LEDs) to verify that there are no potentially damaging voltages applied to the ESS low voltage system interconnection points.

The BIPD will detect the presence of voltage levels, above or below those allowed on any single pin, or combination of pins associated with the ESS low voltage system interconnections. The following table provides a listing of the maximum, minimum, and failure voltages for each interconnection point.

2.6.5.2. Maximum/Minimum Allowable Voltage

MAXIMUM/MINIMUM ALLOWABLE VOLTAGE							
CONNECTOR PIN	SIGNAL NAME	MAXIMUM ALLOWABLE VOLTAGE	MINIMUM ALLOWABLE VOLTAGE	TEST FAIL VOLTAGE			
А	CAN HI	18VDC	N/A	17VDC			
В	CAN LO	18VDC	N/A	17VDC			
С	CAN Shield	0VDC	N/A	2VDC			
D	ES Relay Closed	N/A	N/A	N/A			
E	Ignition	N/A	N/A	N/A			
F	+12V Battery Supply	18VDC	9VDC	17VDC/10VDC			
G	+12V Battery Return	N/A	N/A	N/A			
Н	+12V Battery Return	N/A	N/A	N/A			
J	No Connection	N/A	N/A	N/A			
К	No Connection	N/A	N/A	N/A			
L	ES Wake-Up	N/A	N/A	N/A			



	MAXIMUM/MIN	IMUM ALLOW	ABLE VOLTAG	E
CONNECTOR PIN	SIGNAL NAME	MAXIMUM ALLOWABLE VOLTAGE	MINIMUM ALLOWABLE VOLTAGE	TEST FAIL VOLTAGE
М	No Connection	N/A	N/A	N/A
N	No Connection	N/A	N/A	N/A
Р	+12V Battery Supply	18VDC	9VDC	17VDC/10VDC
Q	No Connection	N/A	N/A	N/A
R	+12V Battery Return	N/A	N/A	N/A
S	No Connection	N/A	N/A	N/A
Т	No Connection	N/A	N/A	N/A
U	No Connection	N/A	N/A	N/A
V	No Connection	N/A	N/A	N/A
W	No Connection	N/A	N/A	N/A
Х	No Connection	N/A	N/A	N/A
Y	No Connection	N/A	N/A	N/A
Z	+24V Battery Return	N/A	N/A	N/A
а	+24V Battery Supply	N/A	18VDC	18VDC
b	+24V Battery Supply	N/A	18VDC	18VDC
С	+24V Battery Supply	N/A	18VDC	18VDC
d	No Connection	N/A	N/A	N/A
е	+24V Battery Return	N/A	N/A	N/A
f	+24V Battery Return	N/A	N/A	N/A
g	No Connection	N/A	N/A	N/A

Energy Storage System (ESS)

The BIPD provides a visual indication of the following:

- Proper low voltage supply and ground connections to the system.
- Supply power within proper voltage range.
- Proper system initial conditions met.
- □ No improper voltage applied to any applicable pin(s).

™NOTE:

If any of the test results are not satisfactory, the associated indicating lamp will turn off or blink depending upon the location and type of fault.

The BIPD will perform a short (approximately 2 second) test of all indicating lamps when power is applied to the device.

2.6.5.3. Operation

The BIPD connects to a system designed to utilize an Energy Storage System by way of the low voltage connector that is mated to the system harnessing in the same manner as a battery pack.

It is imperative that all wiring installation and any other construction efforts that could potentially damage system wiring, are completed throughout the entire vehicle prior to execution of the BIPD test procedure. This ensures a meaningful test result.

It is recommended that the vehicle low voltage harness installation be re-tested with the BIPD following any maintenance or modification that affects any Energy Storage System low voltage interface wiring.

2.6.5.4. Functional Test

ROTE:

This test procedure assumes that a battery pack has not been connected to the low voltage harnessing system prior to testing with the BIPD. If this is not the case, the low voltage harnessing system connector must be disconnected from the Energy Storage System prior to continuing with the following steps.

1. Establish proper initial system conditions for testing as follows:

MOTE:

Various BIPD display combinations may exist as proper initial system conditions for testing are being established in the steps below. These displays are evaluated in subsequent operations and may be ignored until Step 1 is fully completed.

- a. Ensure all 12VDC and/or 24VDC power interrupting devices are configured for normal operation of the system to be tested. Set Battery Disconnect switch to the ON position and set the Master Run switch to STOP-ENGINE.
- Connect the BIPD to the ESS low voltage harness connector of the system to be tested.
- Set the Master Run switch to the DAY-RUN position.
- 2. Summary of BIPD Test Result:
 - a. If all four BIPD display lamps are illuminated continuously, the low voltage harness does not contain wiring errors that could potentially damage a battery pack when installed.

POTE:

This testing does not verify that the vehicle wiring is correct for proper ESS operation. It only verifies that potentially damaging voltages will not be applied to the device through the low voltage interface.

b. If any of the four BIPD display lamps are not illuminated, then the vehicle low voltage wiring interface contains errors which could potentially damage the ESS if installed. Under this condition, the low voltage wiring harness errors must be located and corrected before attempting to install the battery pack.



- Detailed evaluation of BIPD displayed test result:
 - a. The Power Circuits OK lamp should be illuminated indicating that each of the 12V supply and ground pins are properly connected.
 - b. The Power Circuits OK lamp will not be illuminated if any of the following improper conditions exist:
 - Either of the two 12V supply pins are not connected (or improperly connected to another electrical point within the system).
 - Any one of the three 12V Ground pins are not connected (or improperly connected to another electrical point within the system).
 - iii. Any one of the three 24V supply pins are not connected (or improperly connected to another electrical point within the system).
 - iv. Any one of the three 24V return pins are not connected (or improperly connected to another electrical point within the system).
 - v. 12V supply voltage is less than 10VDC.
 - vi. 12V supply voltage is greater than 18VDC.

MOTE:

The BIPD will function with any one 12V supply and any one Ground pin connected correctly.

c. The "Supply Voltage OK" lamp should be illuminated indicating that the 12V and 24V supply voltages are within acceptable limits.

- d. The "Supply Voltage OK" lamp will not be illuminated if any of the following improper conditions exist:
 - 12V supply voltage is less than 10VDC.
 - 12V supply voltage is greater than 18VDC.
 - iii. 24V supply voltage is less than 18VDC.
 - iv. No 12V supply pin is connected.
- The "Setup OK" lamp should be illuminated indicating the vehicle ignition signal is properly applied.
- f. The "Setup OK" lamp will not be illuminated if any of the following improper conditions exist:
 - Master Run switch not ON (DAY or NIGHT-RUN).
 - No 12V or 24V return pin is connected.

I NOTE:

The vehicle Ignition power is applied to Pin E. The BIPD must detect 12V (nominal) for the Setup OK lamp to be illuminated.

- g. The Test Result OK lamp should be illuminated indicating that no potentially damaging voltages have been detected on any ESS low voltage pin.
- h. The Test Result OK lamp will not be illuminated if any of the following improper conditions exist:
 - An improper (potentially damaging to the ESS) voltage is detected at any low voltage interface pin.
 - ii. 12V supply voltage is less than 10VDC.
 - 12V supply voltage is greater than 18VDC.



Transmission & Vehicle Control Modules (TCM/VCM)

2.7. **Transmission & Vehicle Control** Modules (TCM/VCM)

2.7.1. Description

The TCM/VCM consist of two panelmounted electronic control modules. One is located behind the first streetside lighting panel near the streetside in the rear. The other one is mounted in the rear panel with the vehicle's multiplexing modules and other electronic components.

2.7.2. Operation

The TCM/VCM modules monitor and control system components, store system control calibrations, and perform diagnostic functions. Refer to your Allison E^P Systems™Service and Troubleshooting Manual for more information on these components.



2.8. Push Button Shift Selector (PBSS)

2.8.1. Description

The PBSS is located on the right side of instrument panel and is used by the operator to select the direction of operation. The shift selector panel includes a display panel and six keypads. The direction of operation is shown on the display. The shift selector directional buttons are: See "Fig. 5-16: Shift Selector" on page 32.

- ☐ D Forward, commands forward vehicle movement. [F] shown on the display.
- □ N Neutral, commands neutral, no vehicle movement. [N] shown on the display.
- R Reverse, commands rearward vehicle movement. [R] shown on display.

2.8.2. Operation

Pressing the Down (\$\pm\$) arrow button while in Forward operation commands the system to increase the regenerative braking system. The display will change from [F] to [L] to indicate that increased regenerative braking has been selected. The system will return to the default regenerative braking level whenever the Master Run switch is cycled.

Simultaneously pressing the Up (\uparrow) and Down (\downarrow) arrow buttons for five seconds, while in neutral [N], will initiate the fluid level checking process. Refer to 2.4.2.2. "Drive Unit Fluid Level Check" on page 10 in this section for procedure.

Simultaneously pressing the Up (\uparrow) and Down (\downarrow) arrow buttons again, while in neutral, will activate the diagnostic mode in which diagnostic codes can be retrieved. Codes will be displayed in traditional main code/sub code format. Press the mode button to access the next code (up to nine codes can be stored). Clear codes by holding mode button for 10 seconds. Press and hold the Up (\uparrow) and Down (\downarrow) arrow buttons to exit the diagnostic mode.

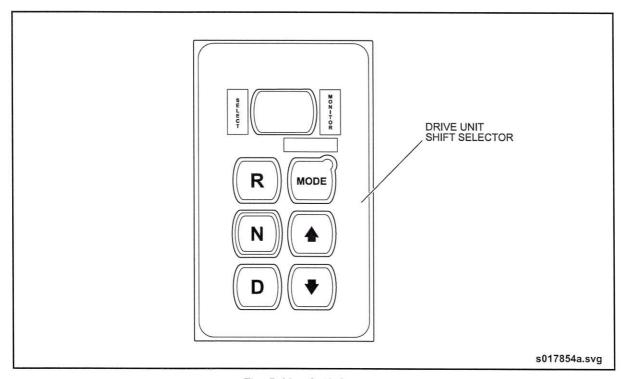


Fig. 5-16: Shift Selector



3. SPECIAL TOOLS

3.1. Special Tools Chart

Refer to your New Flyer Parts Manual for purchase part numbers. See "Fig. 5-17: Special Tools" on page 34.

SPECIAL TOOLS	DESCRIPTION
1	Stator housing fixture, lifting turnover stand
2	High Impedance Digital Multimeter set
3	Adapter to 9 pin Deutsch
4	Softing CAN card 2
5	Harness assembly, TCM/DPIM/VCM
6	Harness assembly, Drive unit/ESS
7	WTEC III universal breakout box
8	ESS installation protection device
9	DPIM installation protection device
10	Engergy Storage removal installation fixture
11	Gloves, HV large
12	Gloves, HV medium
13	Gloves, HV small



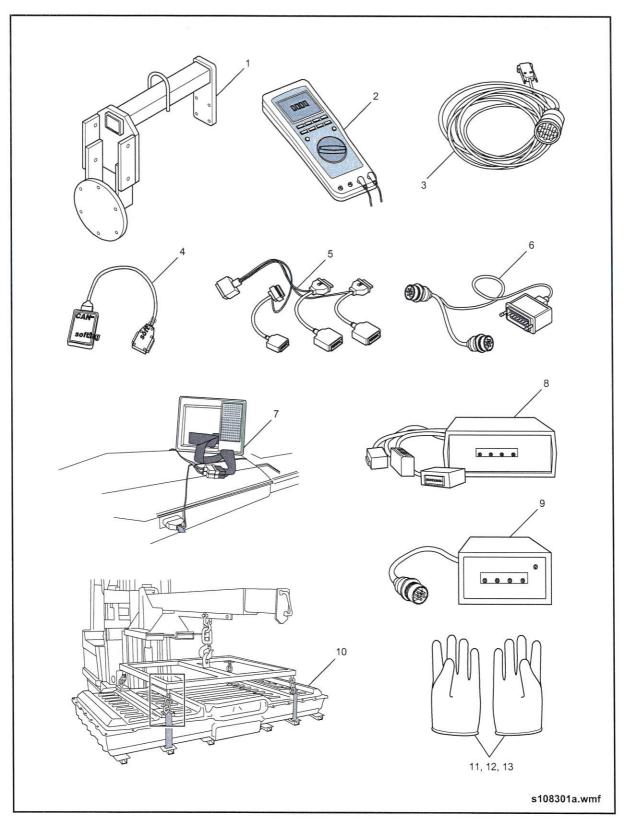
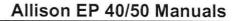


Fig. 5-17: Special Tools





4. VENDOR SERVICE INFORMATION

The following supplier manuals contain additional reference information.

4.	1	ΛII	ison	ED	10/	50	Man	unale	-
ͺ		AII	13011		40/	JU	IVIAI	ıuaı	3

Parts Manual
Service Manual
Troubleshooting Manual
Principles of Operation

Operator Manual





#284+286-001 | Model: Xcelsior | Lengths: All | Propulsions: All

Multiplexing System

New Flyer uses superior multiplexing power provided by Parker Vansco.

- Vansco has more than 25 years of experience in developing state-of-the-art electronic control systems and components; it was acquired by Parker Hannifin in 2008
- Parker Hannifin Corporation (NYSE: PH) is the world's leading diversified manufacturer of motion control technologies and systems, with annual sales exceeding \$12 billion

Product Features

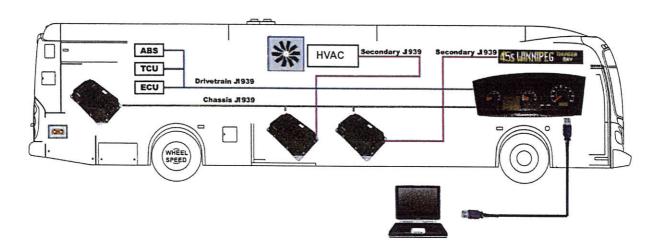
- Industry standard communications protocol and ladder logic software
- Single style auto-programming module controls all functions and reduces inventory (35' and 40' buses have six modules, a 60' bus has seven
- Easy-to-use diagnostics software runs directly on your laptop in Windows; free lifetime upgrades
- In service on more than 10,000 New Flyer buses in North America

Multiplexing Module (VMM) System, also called Programmable Logic Controller (PLC), is utilized to:

- · reduce wiring complexity
- · minimize wiring costs
- · simplify troubleshooting
- · provide unparalleled reliability

Benefits

- Multiplexing system uses industry standard CAN J1939 communications protocol
- Certified to J1455 environmental standard rating
 - Rugged Parker Vansco module meets or exceeds all test requirements for temperature, electrical transients, EMC, pressure wash, and immersion
 - All solid state construction (no internal fuses) to ensure reliable, low maintenance system
- · Industry standard ladder logic software
 - Ladder logic view for input and output relationships, real time diagnostics
 - I/O view defines all inputs, outputs
- User friendly software runs in Windows (32 bit operating systems)







· Easy-to-use diagnostics

- Ladder logic and documentation can be uploaded directly to an internet enabled PC, system supports remote diagnostics across a LAN or the Internet
- Multiplexing module can be configured to log a cycle count or a cumulative duration count for any input, output, or communication signal without adding components to the system
- Free lifetime software license and upgrades
- Basic diagnostics achieved through LEDs on module with Input/Output LEDs, Net LEDs, Power LED, Address LEDs
- · One style module to control all systems
 - Reduces required inventory
 - All modules work independently; in the event of a failed module, others will still operate
- · Auto programming (Plug & Play) feature

Upon connection to a VMM system, the Parker Vansco Multiplexing Module auto-programs itself from the other modules. No programming tools, special exchange software or PC connections are required to exchange a module; it is "Plug and Play."

· The multi-master system

Allows multiplexing modules within a system to store and execute a common ladder logic program; the multi-master system architecture facilitates distribution of critical functions and minimizes the number of different modules within a system.

· Internal gateway control

Ability to force gateway on or off through the software

- · Designed with familiar concepts to reduce training
 - Same ladder logic
 - Same LED diagnostics
 - Features, such auto-programming and the multi-master system, reduce maintenance cost

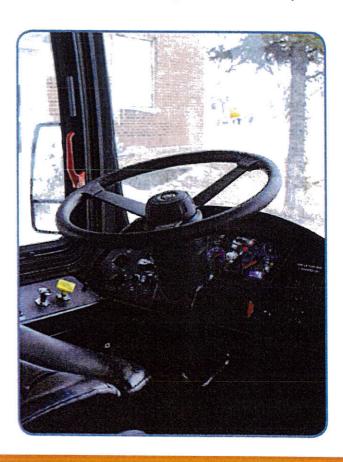
· Total system supplier

- New Flyer can supply a complete Parker Vansco system,

- comprising multiplexing modules and an instrument cluster (gauges, tell tales, and harnesses), or customers can select components that work with third party equipment
- Custom electronic components (New Flyer, working with Parker Vansco, can design and manufacture custom components)

Superb service/warranty

- Parker Vansco has been installed on more than 10,000 New Flyer buses in North America
- New Flyer's Service Organization coordinates warranty claims through iWarranty
- New Flyer maintains extensive service networks and comprehensive in-house engineering resources
- Three year/150,000 miles parts and labor warranty







Specifications

Parker	V	ansco	V	lod	u	e
--------	---	-------	---	-----	---	---

CORE	
Micro Processor	Power PC
Flash	1 Mbyte up to 2 Mbyte
RAM	64 Kbyte up to 512 Kbyte
Eeprom	32 Kbyte
Bus Speed (Clock)	80 Mhz
COMMUNICATION CHANNELS	
CAN Buses	2
Wake on CAN	CAN Bus 1
COMMUNICATION PROTOCOL	
SAE J1939	Yes (2)
CAN	Yes (2)
Gateway Functionality	Yes
Router Functionality	No
RV-C Capable	No
GMLAN	No
J1708	No
RS232	No
Built in DLA capability	No
Diagnotic Messages (DM)	Yes
CAN Messages (User Definable)	Yes

Parker Vansco Module

VISUAL DIAGNOSTICS	
Power LED	1
Network LED	2
Fault LED	
Input LED	21
Output LED	15
SYSTEM ARCHITECTURE	
Master - Master	Yes
Single Part Solution	Yes
Mix and Match Controllers	Yes
SOFTWARE	
Software License Cost	No
Programming Modules	Program with PC for the first time, then if a unit is replaced, they Plug and Play each other.
Power Shedding	Yes
OTHER	
Module Addressing	5 dedicated inputs for addressing
Power Control	1 (AH)
Total Continuous Current per Controller	80 Amps
Total User Configurable Inputs	16
Total User Configurable Outputs	15





Parker Vansco VMM1615

- Total of 16 inputs
- · Six switch (digital) inputs
 - One input with power control switched to high
 - Six programmable input switch high or low
- · Eight analog / digital inputs
- · One DC frequency input
- · Total of 15 outputs
 - 6 outputs, 10 A max
 - 4 outputs, 5 A max
- 3 outputs, 2 x 2.5 A high side, 1 x 2.5 A low side
 - 2 solid state outputs, 1 A max
 - Total Current 80 A max
 - 2 V or 24 V operation
 - Split power bus
 - 5V/8V Regulated Sensor Supply
- PWM outputs 1- 100%, 100 Hz
- · Solid state switching and circuit protection
- · Accurate current sense on selected outputs
- · Internal power protection and conditioning
- 2 CAN ports, 1 with wake on CAN, both J1939 communications protocol
- · Built-in pocket gateway functionality



Parker Vansco Xcelsior Instrument Cluster

- Contemporary dash design with the industry's first standard electronic automotive-style instrument panel
- Integrated inputs, outputs, gauges, LCDs, tell tales, and user buttons in one drop-in package
- · 2 CAN ports for built in pocket gateway functionality
- Bridges drivetrain J1939 to chassis J1939
- USB device port; uses a standard cable to communicate with a PC
- · Total of 27 inputs
 - 3 Wake Ups Active High
 - 12 Digital Active Low
 - 6 Digital Active High
 - 5 Analogs (3 Position Switch Settings)
 - 1 Frequency Input
- · Total of 3 outputs
 - 2 High Side Outputs 2 A max.
 - 1 Low Side Output 2.5 A max.
- User programmable routing table for passing or blocking of J1939 Messages
- · User programmable inputs, outputs, gauges, tell tales, and LCDs
- Uses a standard off the shelf USB A-B cable to communicate with a PC
- Uploading, downloading and diagnostics are all done from two points on the vehicle (front & rear)
 - The instrument cluster serves as built-in service tool
- · Advanced Diagnostics
 - Real time diagnostics
 - All documentation is stored in the VMMs
 - Monitor all inputs and outputs from one location
 - Monitor analog voltage
 - 'Force' inputs or outputs On or OFF
 - Upload logs and error codes



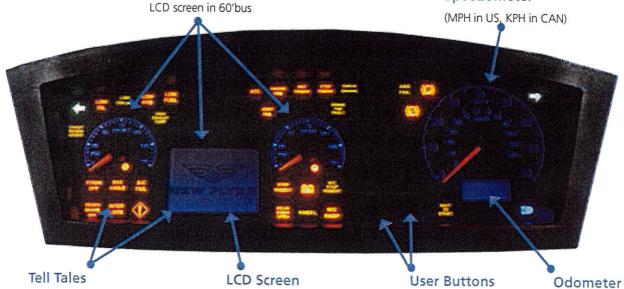


Xcelsior Electronic Instrument Cluster

Air Pressure Gauges

Two gauges in 40' bus
Third gauge positioned above

Speedometer



- Up to 31 standard tell tales illuminate on dash
- Additional selected tell tales are programmed to display on LCD screen

· Up to four LCD screens

- Each LCD screen displays between 1 to 4 gauges
- 2010 EPA regulation requires that an urea level gauge always be present and in the "1" position

Examples of LCD Screen Configurations







