



# 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
connectors, shielding for RFI/EMI, wire numbering methods, overload protection, and insulation color code 2) Describe in detail the high voltage wiring system (wit inclusions such as in item 1, above) with special empha on safety features. Specifically detail any operational or maintenance activity that could pose a higher than norm safety risk.  3) Describe the operation of the propulsion and regenerative braking system.  4) Describe in detail the energy storage system.  5) Describe how the overall electrical system has been designed to be modular, reliable, easily maintainable, a safe to operate.  6) Describe in detail the function of the multiplex wiring system.  7) 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 Technical Specifications-Volume 2.  9) Explain how the bus electric, electrical, and control	3-I	Electrical	methods, overload protection, and insulation color codes.  2) 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.  3) Describe the operation of the propulsion and regenerative braking system.  4) Describe in detail the energy storage system.  5) Describe how the overall electrical system has been designed to be modular, reliable, easily maintainable, and safe to operate.  6) Describe in detail the function of the multiplex wiring system.  7) 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

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



# **Electrical System**

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# SAFETY

# 1.1. High Voltage Safety



The BAE System uses potentially hazardous electrical energy. There is a risk of electric shock. Only trained service personnel should access components of the hybrid drive system. Failure to observe all high voltage electrical safety precautions may result in personal injury and/or death.

While servicing the vehicle, remove jewelry, wear safety glasses and safety shoes. Wear linesman's high voltage gloves (rated at 1000 VDC minimum) when working in or around the traction motor, generator or battery enclosures/energy storage systems.

Refer to Section 5 of this manual for further information on the vehicle's high voltage system.

#### 1.2. 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.

# 1.3. Welding Procedures



Before welding anywhere on vehicle, open the Battery Disconnect switch and disconnect all electronic control modules (Multiplexing, engine, transmission/drive unit, 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.

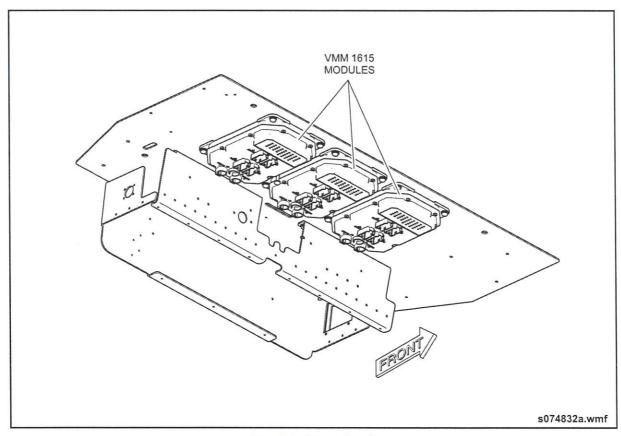


Fig. 9-1: Rear Panel

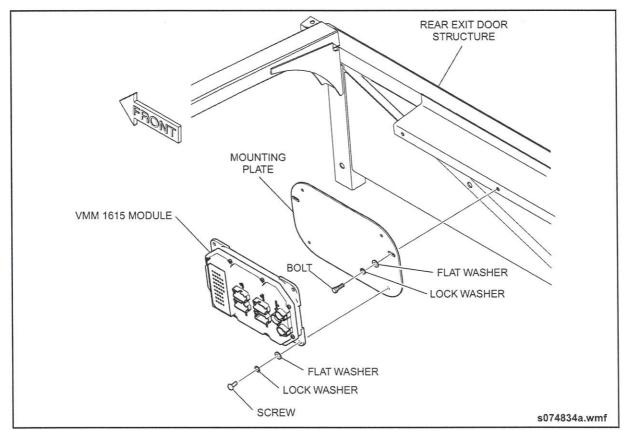


Fig. 9-2: Exit Door Module Installation

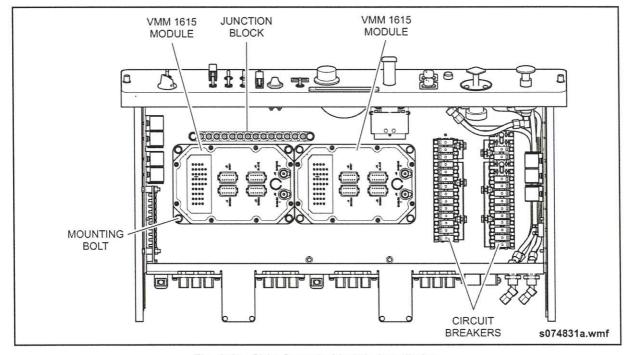


Fig. 9-3: Side Console Module Installation



#### 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.

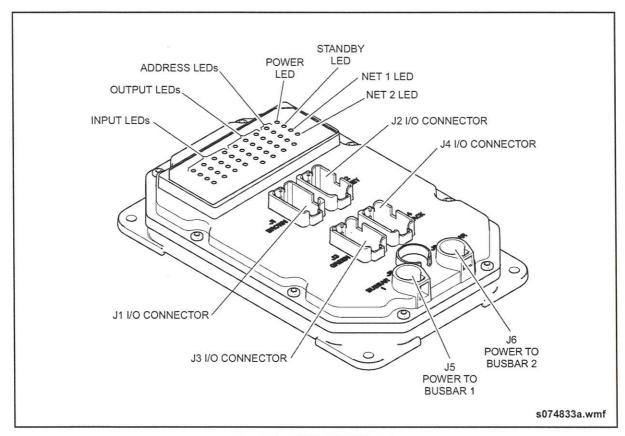


Fig. 9-4: VMM 1615 Module



#### 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 Y splices.
- 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 19. "VENDOR SERVICE INFOR-MATION" on page 63 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/drive unit, 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/drive unit, 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:
  - a. 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.

# MOTE:

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.
- 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.
- h. 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, propulsion system, 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 propulsion system 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 Stop System, Check System, System Overtemp, 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

# MOTE:

The Charging system on this vehicle consists of a roof-mounted Auxiliary Power

Supply (APS). The APS is part of the hybrid propulsion system. Refer to Section 5 of this manual for information on the Hybrid Propulsion System including the Auxiliary Power Supply.



#### BATTERY SYSTEM

# 5.1. 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. 9-5: Battery Tray" on page 10. The battery disconnect switch is located on the fusebox, above the battery tray. See "Fig. 9-6: Battery Disconnect Switch & Fuses" on page 11. 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 above 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.

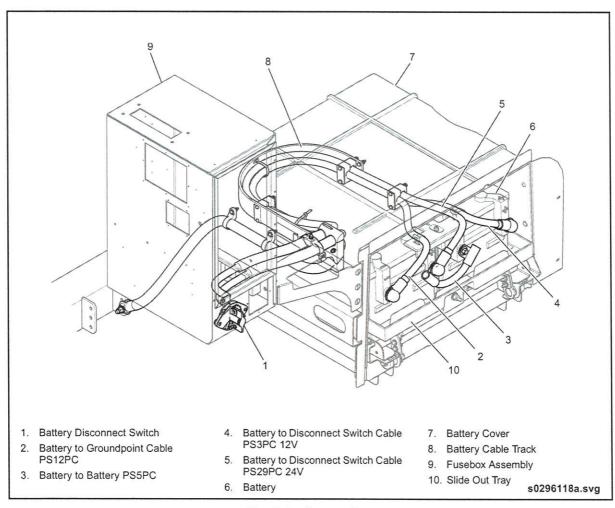


Fig. 9-5: Battery Tray

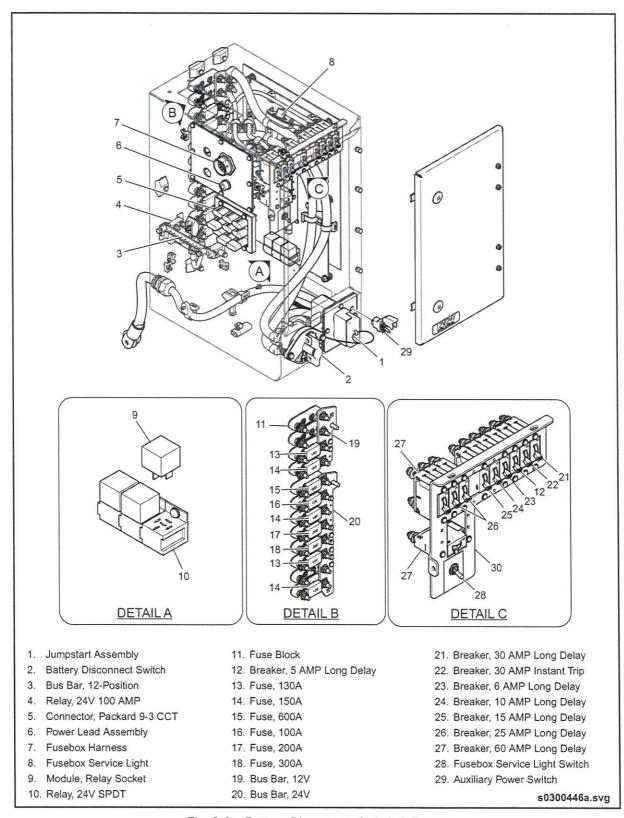


Fig. 9-6: Battery Disconnect Switch & Fuses



# 5.2. Battery Disconnect Switch

#### 5.2.1. 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.

#### 5.3. 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.

# 5.3.1. 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.



# 5.4. Fusebox Assembly

#### 5.4.1. 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. See "5.2. Battery Disconnect Switch" on page 12. in this section for more information on this component.

#### 5.4.2. 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)	

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.



#### 5.5. 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 overcharging and equipment damage. Consult the battery manufacturer's recommendations before installing replacement components.

#### 5.5.1. Description

This vehicle is equipped with 12 volt deep cycle heavy duty maintenance free Absorbed Glass Mat (AGM) batteries. The batteries have sealed pressure valves to allow gases to escape and should never be opened. Electrolyte is absorbed in the glass mat and cannot be added to these batteries. Batteries are equipped with threaded positive and negative terminals.

#### MOTE:

Opening the vent caps will void the battery warranty.

#### 5.5.2. Batteries Specifications

12	Vo	It

☐ 8D group size

☐ 1450 cold cranking amperes

480 minute reserve capacity

245 Ah battery capacity

#### 5.5.3. Removal

- Set the Battery Disconnect switches to the OFF position.
- 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 the inside of the 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.
- Carefully lift and remove the batteries from the tray.

#### 5.5.4. 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.
- Connect the negative cables to the battery negative terminal.
- 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.
- 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.



#### 5.5.5. Battery Charging

BATTERY CHARGING State of Charge to Open Circuit Voltage Comparison			
100%	12.8 Volts or Higher		
75%	12.6 Volts		
50%	12.3 Volts		
25%	12 Volts		
0%	11.8 Volts		

#### MOTE:

The true open circuit voltage of a battery can only be determined after the battery has been removed from the load (charge or discharge) for 24 hours.

Observe the following when charging the batteries:

- An adapter kit should be used in charging threaded-terminal batteries when they are out of the vehicle.
- □ When the threaded-terminal battery is in the vehicle, connect the charger's leads to the studs or nuts at the battery's terminals.

- □ A temperature compensated, voltage regulated charger must be used and the charging voltage must be limited to 14.4 to 14.6 volts at 68°F. Refer to "AGM Battery Temperature & Charging Voltage" chart.
- ☐ Allow for adequate air circulation around the batteries.
- ☐ Approximately 60% of the total charging time will be required to bring the battery to 90% state of charge. The remaining 40% of the charging time will be required to bring the battery to full charge.



#### 5.5.6. AGM Battery Temperature & Charging Voltage

AGM BATTERY TEMPERATURE & CHARGING VOLTAGE			
Temperature (°F)	Optimum Charge Voltage	Maximum Charge Voltage	
Above 120	13.60	13.90	
110 - 120	13.80	14.10	
100 - 110	13.90	14.20	
90 - 100	14.00	14.30	
70 - 80	14.30	14.60	
60 - 70	14.45	14.75	
50 - 60	14.60	14.90	
40 - 50	14.80	15.10	
Under 40	14.10	15.40	

#### 5.5.7. Functional Test

#### 5.5.7.1. Visual Inspection

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

#### 5.5.7.2. Load Test



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.
- 4. Connect voltmeter and battery load tester across battery terminals.
- 5. If adapters are not available, attach tester clamps to contact lead pads. Tighten hex nuts to hold clamps against lead pads.
- Recharge battery if open circuit voltage is below 75%. Refer to "Battery Charging" in this section.
- 7. Apply a load equal to 1/2 the cold cranking amps for 15 seconds.
- 8. Voltage should stabilize above 9.6 volts while under load.
- 9. If voltage is below 9.6 volts recharge battery and repeat test.
- 10. Replace battery if voltage is below specifications. Clean battery and return to service if voltage is acceptable.



#### 5.5.8. 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.
- 2. Faulty vehicle charging system.
- 3. High wiring resistance.
- Vehicle loads exceeding alternator capacity.
- 5. Shorted wiring.

- Extended slow speed driving with high electrical loads.
- 7. Loose or corroded battery connections.
- 8. Improper battery charging.
- High resistance connections or defects in cranking system.
- 10.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.
- 11. Discharged batteries can freeze and be difficult to recharge.



# 5.6. Voltage Equalizer

#### 5.6.1. 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. 9-7: Battery Voltage Equalizer Installation" on page 18.

#### 5.6.2. Voltage Equalizer Specifications

Manufacturer	Vanner Power Group
Model	70 - 80
Input Voltage 24V	18 to 32 volts
Maximum 24V Input A	mps43 amps
Output Amps 12V	0 to 80 amps

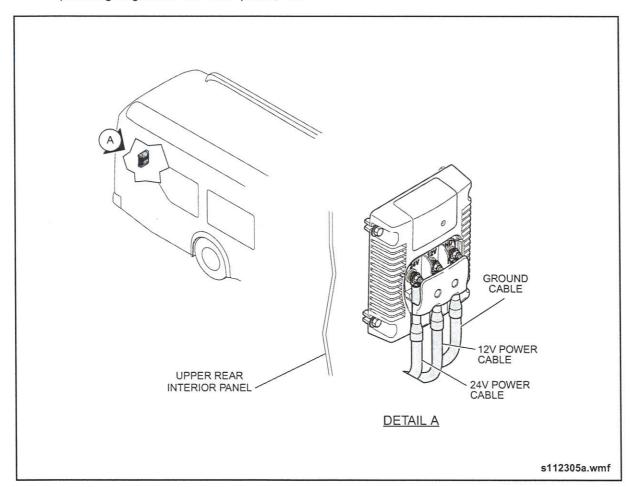


Fig. 9-7: Battery Voltage Equalizer Installation



#### 5.6.3. 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.

#### 5.6.4. 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.		



#### 5.6.5. 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.

- 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.
- 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.
- Installation is the reverse of removal.

#### MOTE:

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



#### EXTERIOR LIGHTS

See "Fig. 9-8: Exterior Lamps" on page 22.

# 6.1. Headlights

#### 6.1.1. 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.

### 6.1.2. 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.

#### 6.1.3. Removal

## MOTE:

Replacing a faulty low beam or turn signal light requires the replacement of the com-

plete 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.

- Set the Battery Disconnect switch to the OFF position.
- 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. 9-9: Headlight Removal & Installation" on page 23.
- 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.



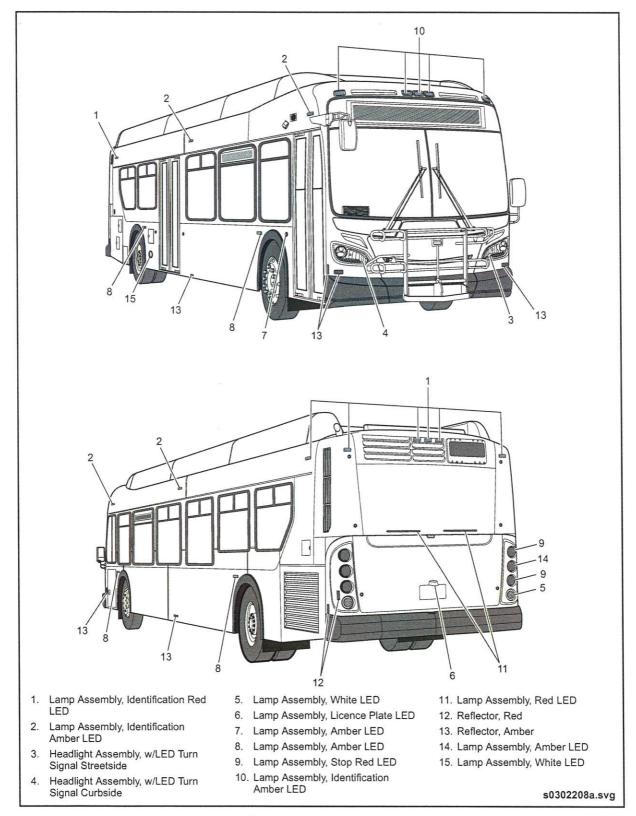


Fig. 9-8: Exterior Lamps



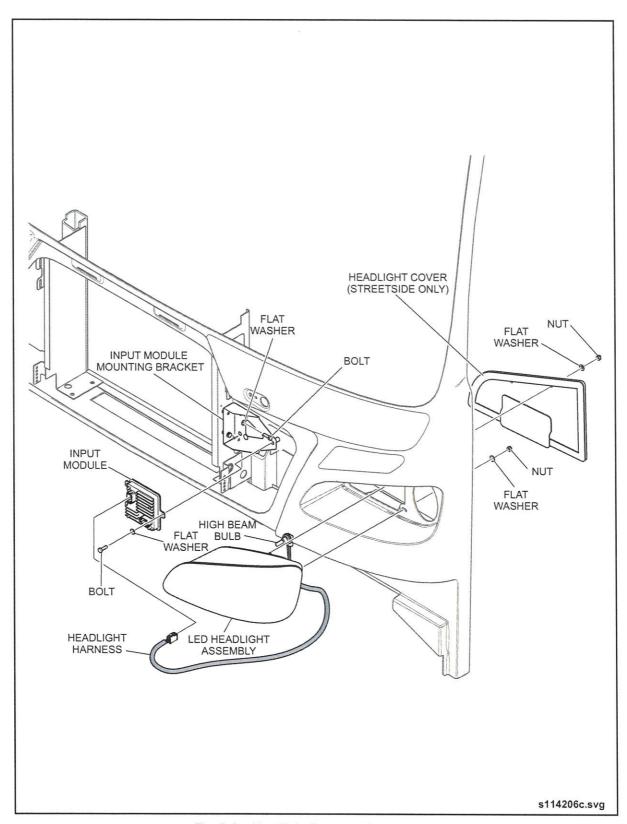


Fig. 9-9: Headlight Removal & Installation



#### 6.1.4. Installation

- Install a new headlight assembly using the original washers and nuts.
- 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.
- Adjust the headlights if required. Refer to 6.1.5. "Headlight Aiming" on page 24 in this section for aiming procedure.

#### 6.1.5. 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 6.1.6. "Headlight Aiming (Alternate Procedure)" on page 27 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.
- 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.
- 7. 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. 9-10: Headlight Aiming" on page 26.
- 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.



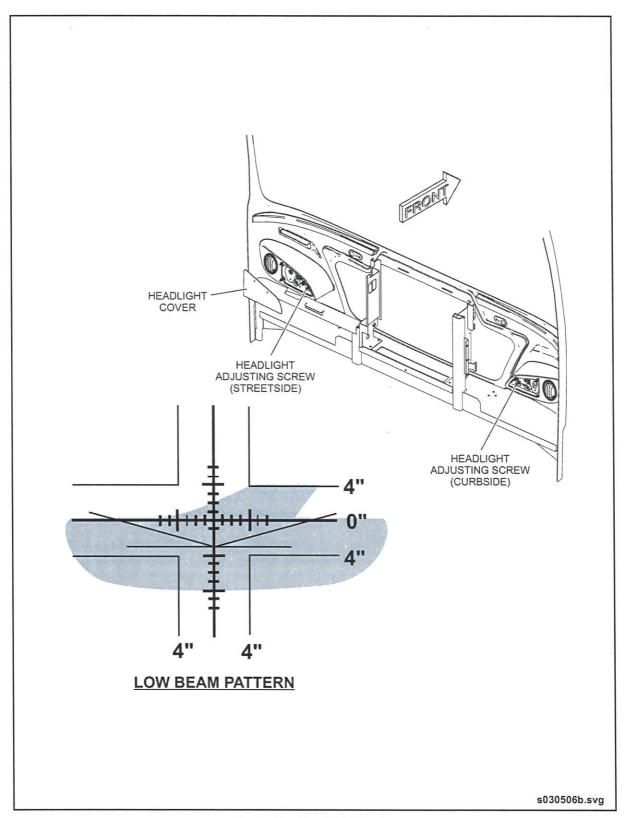


Fig. 9-10: Headlight Aiming



# 6.1.6. 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. 9-12: Low Beam Headlight Aiming" on page 28.
- 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. 9-11: Low Beam Center Location" on page 27.

- 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.

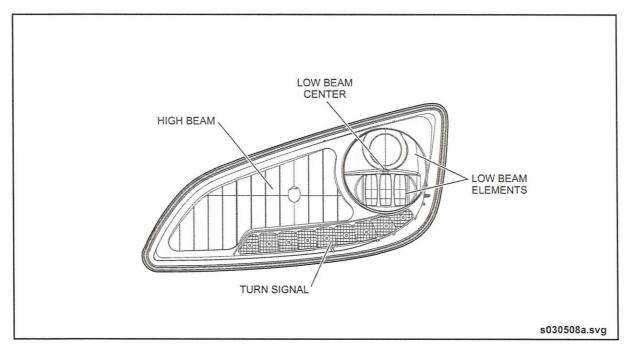


Fig. 9-11: Low Beam Center Location



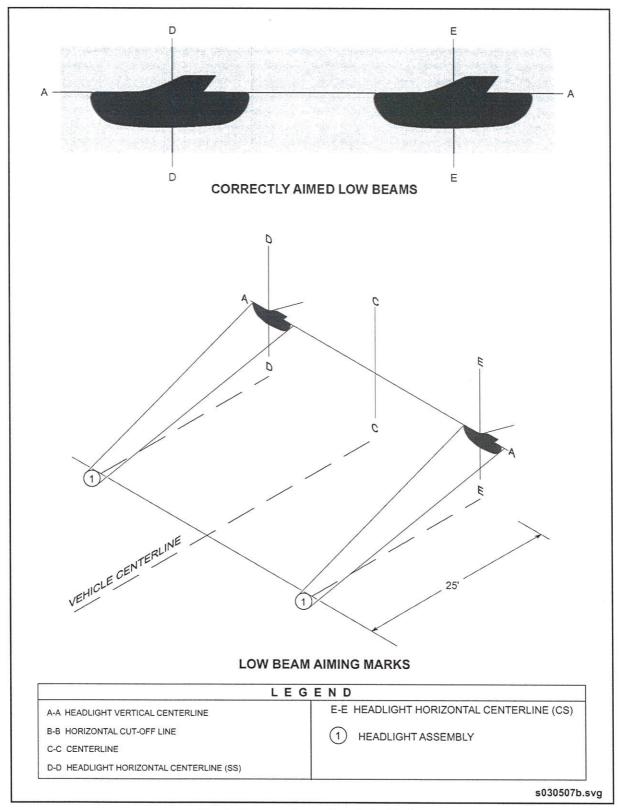


Fig. 9-12: Low Beam Headlight Aiming



#### INTERIOR LIGHTS

# 7.1. Aisle Lights

#### 7.1.1. Description

The aisle light panels are located above the side windows on either side of the passenger aisle. See "Fig. 9-13: Aisle Lights Layout" on page 29.

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. 9-14: LED Aisle Lights Assembly" on page 30.

Each LED board contains surfacemounted LED's arranged in a single row pattern. The dimming level for the first bank is factory preset to extinguish and the second banks are preset to 100%. Dimmable lighting panel banks can be adjusted using a programming fob. Refer to 7.1.5. "Dimming Adjustments" on page 33 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.

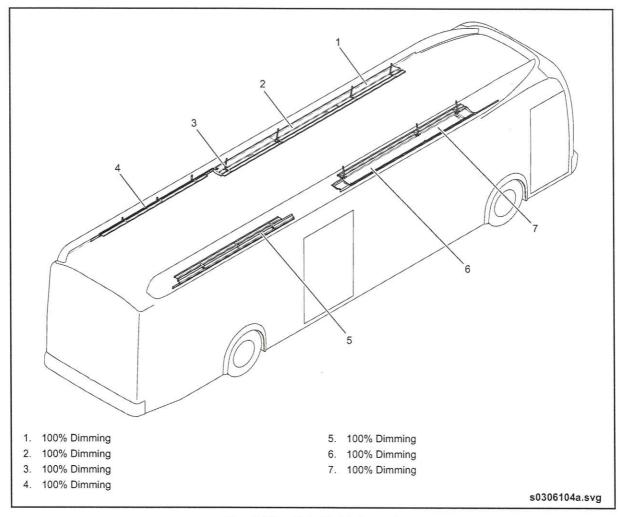


Fig. 9-13: Aisle Lights Layout



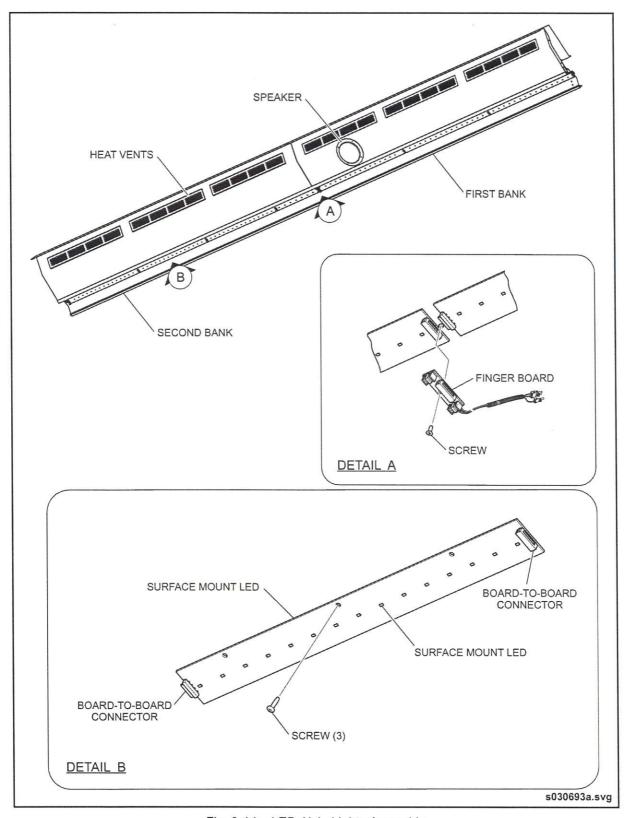


Fig. 9-14: LED Aisle Lights Assembly



#### 7.1.2. Aisle Lights Specifications

Manufacturer	TCB Industries
Model GEN 3 w	ith Clever Boards
Lighting Panel Aluminum, powder-coa and duct liner	ated c/w speake
Voltage	24 VDC
LED's15 per board	@ 0.125 W each
Speakers	8 Ohms, 30 W

#### 7.1.3. 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.

The first bank on the streetside and curbside are dimmable and factory set to extinguish. The second bank on the streetside and curbside are dimmable and factory set to 100% lighting intensity. The front bank on streetside and curbside will illuminate to full intensity when the entrance door is open.

#### 7.1.4. 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.



#### 7.1.4.1. 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.



### 7.1.5. 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 7.1.6.1. "Lens" on page 34 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.
- 3. 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.

- Locate the three programming pads on the clever lighting board. The programming pads are labeled "DOWN UP" and "DIM PGM". See "Fig. 9-15: Lighting Board Programming Pads" on page 33.
- 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. 9-16: Lighting Board Dimming Adjustment" on page 33.

#### IGNOTE:

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.

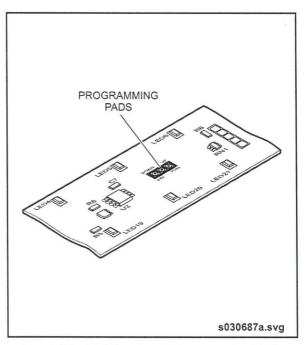


Fig. 9-15: Lighting Board Programming Pads

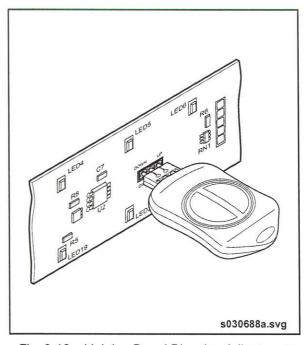


Fig. 9-16: Lighting Board Dimming Adjustment



#### 7.1.6. Removal

#### 7.1.6.1. 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. 9-17: Lens Removal" on page 34.

#### MOTE:

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.

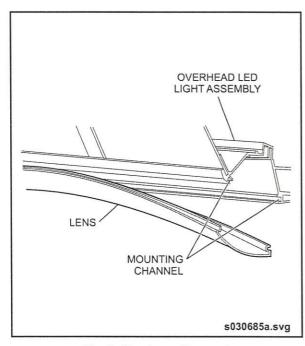


Fig. 9-17: Lens Removal

#### 7.1.6.2. LED Lighting Board

### MOTE:

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

- Remove the lens. Refer to 7.1.6.1. "Lens" on page 34 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.
- Remove the lighting board from the lighting panel.

#### 7.1.6.3. Finger Board

- 1. Remove the lens. Refer to 7.1.6.1. "Lens" on page 34 in this section for procedure.
- Locate the finger board which is typically installed at the beginning of a bank of lighting boards. See "Fig. 9-18: Finger Board Assembly" on page 35.
- 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.

- 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.
- 5. Remove the single mounting screw.
- 6. Remove the finger board by sliding it outward from the lighting board.

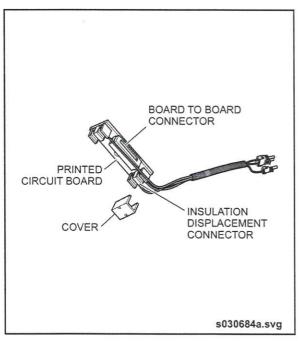


Fig. 9-18: Finger Board Assembly

#### 7.1.7. Installation

#### 7.1.7.1. 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.
- 4. Reinstall end cover.

#### 7.1.7.2. 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.

#### 7.1.7.3. 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).
- Repeat the previous step for the black and yellow wires.
- 5. Snap the IDC connector covers in place.
- 6. Reinstall lens.



### DOOR MASTER SWITCH

# 8.1. Description

The Door Master switch is a two-position toggle switch located in the driver's overhead panel. The switch is labeled ON for normal operation and OFF for emergency operation.

# 8.2. 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:

- Vehicle can be shifted without foot on brake treadle.
- Vehicle 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.

### 8.3. 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.

#### 8.3.1. 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 vehicle 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 vehicle in drive [D] and then press on the brake treadle. The combination of having the vehicle in gear and the brake treadle applied will unlatch the interlocks. Return the vehicle 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**

#### 8.3.2. Emergency Operation Test

Test emergency operation of the Door Master switch as follows:

- 1. 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.

# 8.4. 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.
  - 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.
- 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.



# HORNS & WARNING ALARMS

#### 9.1. Electric Horn

# 9.1.1. 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. 9-19: Horns Installation" on page 38.
- ☐ 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.

# 9.2. Warning Alarms

# MOTE:

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

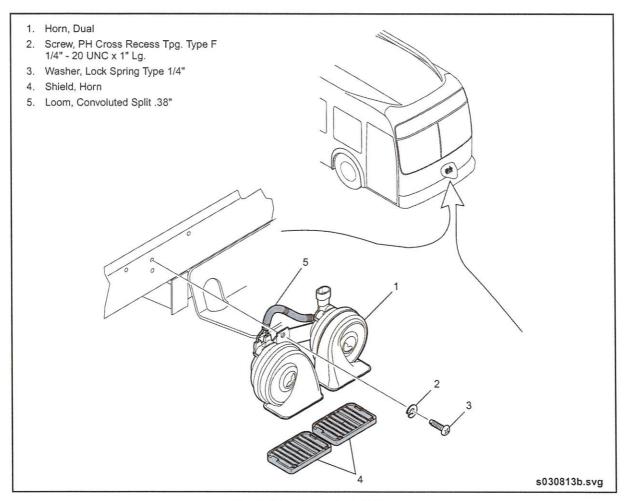


Fig. 9-19: Horns Installation



# 10. DRIVER/VEHICLE MONITORING SYSTEM

# 10.1. Description

The New Flyer Connect™ Driver/Vehicle Monitoring System measures and records vehicle operating parameters and location in real time. See "Fig. 9-20: Driver/Vehicle Monitoring System" on page 39. 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.
- ☐ A Driver Maneuver Awareness System (DMAS) display mounted on the instrument panel.

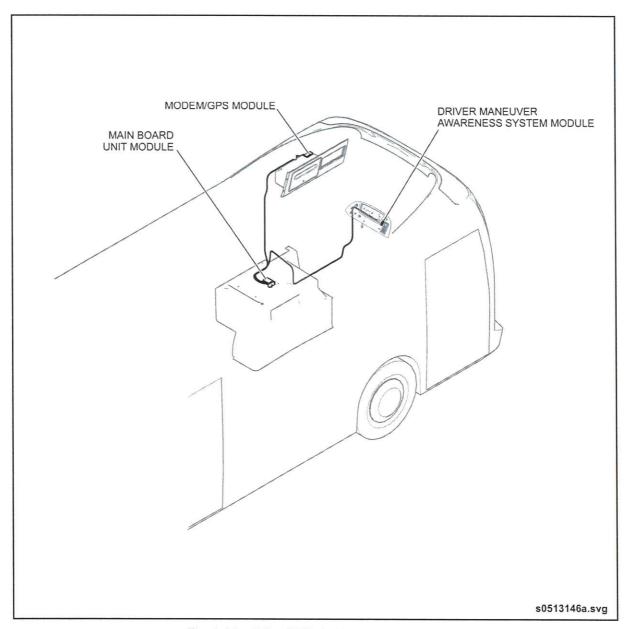


Fig. 9-20: Driver/Vehicle Monitoring System



# 10.2. 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. The Driver Maneuver Awareness System (DMAS) is an LED bar graph display that provides the driver with feedback on these parameters and warns when accepted values are being exceeded. See "Fig. 9-21: DMAS Display" on page 40.

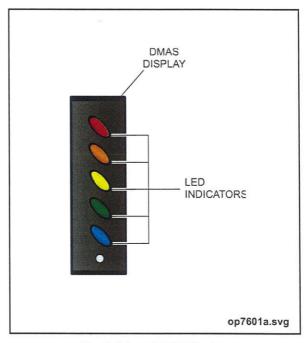


Fig. 9-21: DMAS Display



# 11. FLEET MANAGEMENT SYSTEM

# 11.1. Description

This vehicle is equipped with a Fleetwatch data logger and transceiver used to capture and report vehicle performance and fault codes from the existing J1939 network. The data logger and transceiver modules are located inside the electronic equipment enclosure on the streetside wheel housing.

# 11.2. Operation

Data can be collected and reported on demand to a wireless Fleetwatch receiver station located in a service lane. Vehicle number, total mileage and engine hours are reported each reading. The user can select a set of items such as engine and transmission/drive unit fault codes. These are recorded with the date and time of the beginning and ending of the last occurrence observed. The data logger can be integrated with the Fleetwatch fluid management system to report engine oil pressure and coolant temperature etc. for the previous 24 hours including minimum and maximum values observed.

# 11.3. Fleet Management System Troubleshooting

- Ensure the correct vehicle number is programmed into the data logger by reading it with the receiver station MR55.
- Check power is being supplied to the onboard modules. Power should be in the 9-32 VDC range.
- Open the logger module by removing the lid. Check all wires and connectors. Make sure wires are stripped correctly and secured in the right positions in the connectors according to the diagrams in the lid of the module.
- 4. Ensure all connectors are plugged into the correct positions. Ensure orange/yellow indicator light is on.

#### 11.4. Removal

- Open the electronic equipment enclosure and locate the data logger assembly.
- 2. Disconnect the vehicle interface harness from the from the data logger.
- 3. Remove the mounting hardware securing the data logger plate.
- 4. Remove the data logger assembly from the vehicle.



### 11.5. Installation

- 1. Install the data logger and transceiver using adhesive strips onto the mounting plate. See "Fig. 9-22: Fleet Management System Installation" on page 42.
- 2. Place the data logger assembly into the vehicle and fasten it with the hardware.

# MOTE:

The transceiver must be facing the window in order to work properly. Check that there is no metal between the transceiver and the outside of the vehicle.

- 3. Connect the wire harnesses.
- 4. Close the electronic equipment enclosure.

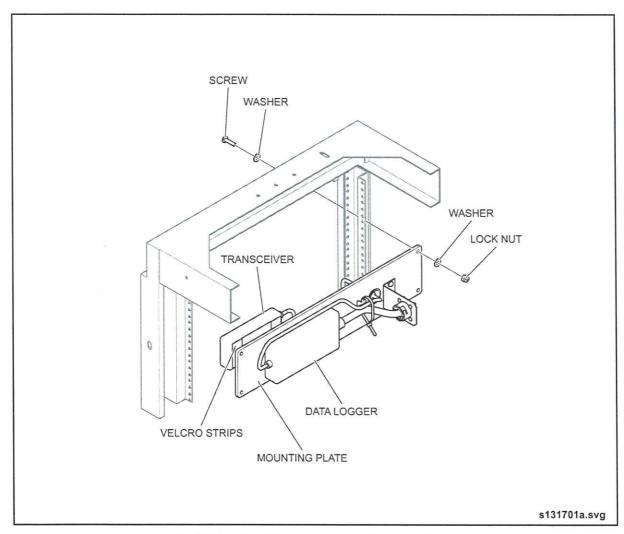


Fig. 9-22: Fleet Management System Installation



# 12. VIDEO SURVEILLANCE SYSTEM

# 12.1. Description

A video surveillance system records events as they occur on the vehicle. The system consists of:

- ☐ A DTI MDR-5L digital video recorder.
- Uninterruptable Power Supply (UPS) module located in the electronic equipment enclosure.
- ☐ Firetide wireless module located in the electronic equipment enclosure.

- ☐ Eight interior cameras (5 Analog, 4 Internet Protocol, 1 wireless).
- ☐ Two exterior cameras.
- ☐ A microphone located in the destination sign access door.
- ☐ A microphone located near the exit door.
- An event marker switch/status light located on the side console.

The cameras are located throughout the vehicle to ensure full coverage of the vehicle's interior and partial coverage of the exterior. See "Fig. 9-23: Video Surveillance System" on page 43.

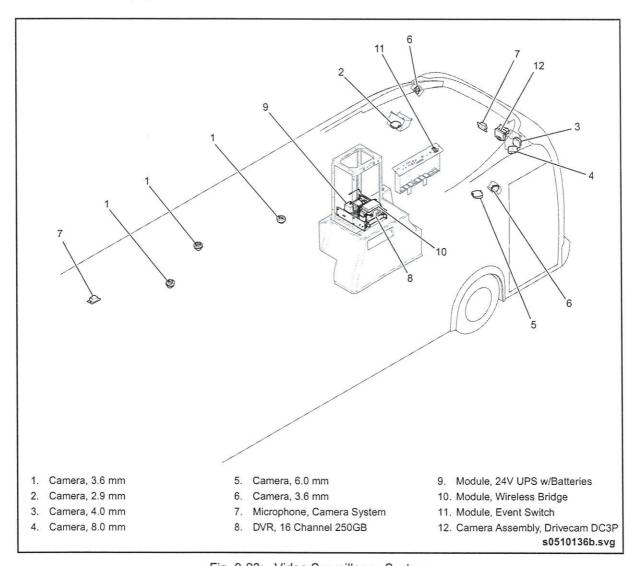


Fig. 9-23: Video Surveillance System



# 12.2. Operation

DVR power is activated when the Master Run switch is set to either the DAY-RUN, NIGHT-RUN or NIGHT-PARK position. Camera's record activity on the vehicle and the microphones record the audio.

The event marker switch/status light is mounted on the side console. Pressing the switch marks and saves incidents for storage and retrieval on the DVR hard drive. During normal operation the green LED will be on solid. System problems are indicated by the green LED switching off or the red LED switching on. In either case, further troubleshooting may be required to resolve the problem.

In the event of power failure the UPS module provides temporary battery back-up so the video surveillance can continue recording or be properly shut down.

# 12.3. Video Surveillance System Troubleshooting

Refer to the EMP Service Manual for troubleshooting, diagnostic, and repair procedures. Refer to 19. "VENDOR SERVICE INFORMATION" on page 63 in this section for further information.

# 12.4. Maintenance

Refer to the Preventive Maintenance Section of this manual for scheduled maintenance intervals and requirements.



# 13. ELECTRONIC STROKE ALERT (e-STROKE)

# 13.1. Description

The e-STROKE System provides real-time monitoring of the push rod stroke in each brake chamber. The system consists of:

- ☐ Electronic sensor-equipped brake chambers at each wheel.
- A 50 psi brake pressure transducer located on the pressure switch bracket below the side console panel.

- □ A Chassis Communication Module (CCM) located on the forward face of the streetside wheelhousing. See "Fig. 9-24: E-Stroke Chassis Communication Module" on page 45.
- A Brake Alert indicator on the instrument panel.
- Brake Lining Wear indicators in the brake lining at each wheel.
- Interconnecting wiring harness.

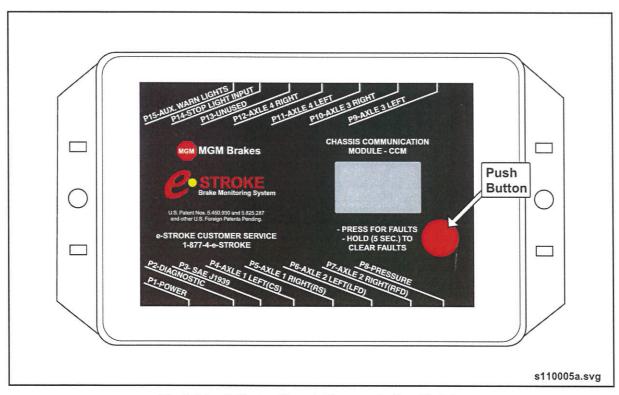


Fig. 9-24: E-Stroke Chassis Communication Module



# 13.2. Operation

The e-Stroke system continuously monitors the vehicle braking system while in operation and will illuminate the Brake Alert indicator on the instrument panel if any active fault conditions are present. The indicator will extinguish when the fault is no longer active or has been repaired. Inactive faults are stored in memory and can be retrieved by using blink codes and the system warning indicator.

#### MOTE:

Blink codes will be displayed for active blink codes only if an active fault is occurring at the time. The active fault will need to be repaired and the Brake Alert indicator extinguished before any stored inactive faults can be displayed.

Blink codes can be displayed using the following sequence:

- To retrieve the active or in-active stored fault codes, press the red push button on the front of the e-Stroke module for one second and release. This will start the blink code sequence.
- Observe the Brake Alert indicator on the instrument panel and count the blink codes. Refer to 13.2.2. "Blink Code Definitions" on page 47 in this section for blink code definitions.
- The blink codes will be displayed in a loop until the Master Run switch is shut off or the fault codes are cleared.
- To clear the fault codes press and hold the red push button on the front of the module for a minimum of five seconds and release.
- The warning light will blink 10 times acknowledging that the stored fault codes have been cleared.

#### 13.2.1. Blink Code Timing

BLINK CODE TIMING		
CONDITION	DURATION	
Indicator ON	0.5 seconds	
Indicator OFF	0.1 seconds	
Pause between digits	1.5 seconds	
Pause between faults	4 seconds	

#### MOTE:

Pressing the push button for five seconds will clear stored fault codes but will not correct the cause of the original fault.



### 13.2.2. Blink Code Definitions

BLINK CODE DEFINITIONS			
FIRST DIGIT	TYPE OF FAULT	SECOND DIGIT	LOCATION OF FAULT
1	No fault	1	No fault (only if first digit = 1)
2	Non-functioning brake	1	Front axle - left
		2	Front axle - right
		3	Rear axle - left
		4	Rear axle - right
3	Over-stroked brake	1	Front axle - left
		2	Front axle - right
		3	Rear axle - left
		4	Rear axle - right
4	Dragging brake	1	Front axle - left
		2	Front axle - right
		3	Rear axle - left
		4	Rear axle - right
5	e-Stroke sensor fault	1	Front axle - left
		2	Front axle - right
		3	Rear axle - left
		4	Rear axle - right
6	Lining wear warning	1	Front axle - left
		2	Front axle - right
		3	Rear axle - left
		4	Rear axle - right
7	e-Stroke system fault	1	Pressure Transducer
		2	SAE J1708/J1939 Communication
10	e-Stroke fault codes cleared		



### 13.2.3. Diagnostic Program

The e-Stroke RS-232 diagnostic program may be used to acquire the following information from the brake monitoring system:

- Current wheel-specific brake and lining status
- Stored fault history
- System status

Module information: software version, configuration, serial number

The diagnostic program kit includes diagnostic program software CD, RS-232 diagnostic/programming harness, and USB high-speed serial adapter harness. Refer to MGM Brakes User Guide for information on using the program.

# 13.3. E-Stroke Troubleshooting

E-STROKE TROUBLESHOOTING			
PROBLEM	POSSIBLE CAUSE	ACTION	
System warning light does not illuminate.	Loss of 12V power supply	Make sure Master Run switch is set to DAY-RUN or NIGHT-RUN.	
		Test circuit breaker in the CCM power supply cable for an open circuit. Refer to "ES-Anti-Lock Braking System" schematic.	
		Check CCM power cable for electrical shorts or cut wires. Replace any damaged cable with MGM brake cables.	
		Test vehicle system voltage. It must be 10 - 30 volts.	
		Check electrical connectors for corrosion and ensure connector body tabs are locked.	
		Check for faulty or burned-out warning light.	
		Replace Chassis Communication Module.	
CCM indicates a dragging brake.	Mechanical damage, linkage binding, incorrect push-rod length, or brake chamber pressure not exhausting completely.	Actuator push rod must be perpendicular to the bottom of the non-pressure housing within ±3°. If greater than 3°, check for loose mounting hardware or distorted axle mounting bracket.	
		Inspect brake actuator for improperly cut push rod (too short). Pull the yoke pin. The shaft should not retract.	



E-STROKE TROUBLESHOOTING			
PROBLEM	POSSIBLE CAUSE	ACTION	
		Ensure service brake chamber is not pressurized. If pressurized, check for a faulty quick release valve. Also check for possible air leakage past the push rod seal on the parking brake chamber (for wheels with tandem parking brakes only).	
		Ensure parking brake air pressure is at least 95 psi.	
		Check for rusted or worn foundation brake components.	
		Check for damage to sleeve on push rod which would cause the calibration to change.	
		Chock wheels and release air pressure from spring brake and service brake chambers. Inspect plastic sleeve on push rod. If the push rod angle is too great, the plastic sleeve may hang up on the plastic stone guard inside the unit. This can prevent the push rod from fully retracting back to zero stroke.	
		Chock wheels and release air pressure from spring brake and service brake chambers and check that push-rod fully retracts to zero stroke. Adjust or replace slack adjuster if necessary.	
9		Check for failed connection between the CCM and the J1708 or J1939 networks.	
CCM indicates non-functioning brake.	ake. pressure transducer, faulty brake	Ensure brake actuator sensor is properly installed.	
	actuator sensor, faulty diaphragm.	Replace brake application air pressure transducer.	
		Inspect brake actuator for movement when service brake is applied and troubleshoot brake chamber diaphragm or air system to brake chamber.	



E-STROKE TROUBLESHOOTING			
PROBLEM	POSSIBLE CAUSE	ACTION	
CCM indicates over-stroke condition.	Valid over-stroke condition, faulty brake actuator sensor, mechanical damage, linkage	Measure stroke to verify over- stroke condition.	
	binding.	Unplug sensor assembly at wheel and plug in a new sensor assembly. If Orange LED indicator no longer blinks, install the new sensor assembly.	
		Check for damage to sleeve on push rod which would cause the calibration to change.	
		Chock wheels and release air pressure from spring brake and service brake chambers and check that push-rod fully retracts to zero stroke. Adjust or replace slack adjuster if necessary.	
CCM indicates faulty wheel sensor/cable.	Faulty brake actuator or wheel sensor. Damaged or disconnected harness.	Ensure brake actuator sensor is properly installed.	
		Inspect brake actuator sensor and cable for damage and replace if necessary.	
		Unplug connector and measure resistance between the sensor red (positive) and black (negative) wires, using a digital meter. Resistance should be 12k-16k ohms.	
		Unplug sensor assembly at wheel and plug in a new sensor assembly. If Orange LED indicator no longer blinks, install the new sensor assembly.	
		Unplug sensor harness and connect a new sensor harness. If Orange LED indicator no longer blinks, install the new sensor harness.	
		Check red and black wires to wheel sensor for open circuit condition.	
CCM indicates a dragging. brake with no brake application or over stroke fault with brake application.	Faulty wheel sensor cable.	Check green and black wires to wheel sensor for open or short circuit condition, corrosion or damage.	



E-STROKE TROUBLESHOOTING				
PROBLEM POSSIBLE CAUSE ACTION				
CCM indicates non functioning brakes	Faulty brake application pressure transducer.	Replace brake application air pressure transducer.		
		Inspect brake actuator for movement when service brake is applied and troubleshoot brake chamber diaphragm or air system to brake chamber.		
CCM indicates lining wear warning with brake lining ok.	Short circuit in lining wear sensor.	Check for grounded lining wear sensor or damaged lining wear cable.		
CCM indicates lining wear failure with brake lining ok.	Open circuit in lining wear sensor.	Check for open circuit in lining wear sensor or lining wear cable.		
CCM indicates a communication problem or e-Stroke warning light illuminates for no apparent reason	Faulty J1708 or J1939 network bus connection.	Check J1708 and J1939 network busses for proper connection, corrosion or damage.		



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

# 14.1. Description

The AVA/AVL System is an automatic vehicle information system that controls the vehicle's sign and public address systems. See "Fig. 9-25: AVA/AVL System" on page 53. It also uses GPS-based Automatic Message Triggering (AMT) which automatically determines adherence to the vehicle route and provides completely automatic triggering of next stop messages. The AVA/AVL system includes:

- DR600 Vehicle Logic Unit (VLU) located in the electronic equipment enclosure.
   Heading Sensor.
- ☐ Wireless Module.
- ☐ Power Control Module.

	Power	Filter.	
The same of			

- □ J1708 Port Expander.
- ☐ LED information sign, ceiling-mounted in the forward area of the vehicle.
- ☐ Roof-mounted GPS, WLAN and radio antennas.
- ☐ Automatic Gain Control (AGC) microphone, ceiling-mounted in rear of vehicle.
- ☐ Six interior speakers.
- ☐ Exterior speaker.

The AVA/AVL system also incorporates public address system components which include:

- A foot operated P.A Switch located on the driver's platform.
- Stealthmic microphone module located on the steering column.
- ☐ Stealthmic processor module located in the electronic equipment enclosure.



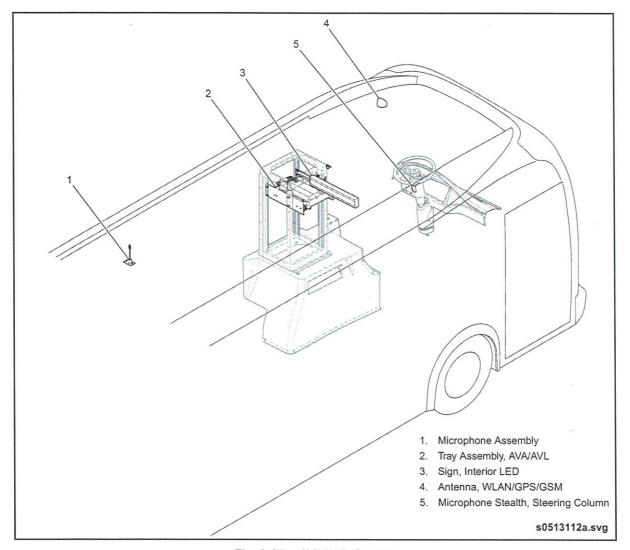


Fig. 9-25: AVA/AVL System

# 14.2. Operation

The DR600 is an advanced vehicle logic unit (VLU) that is able to communicate, collect and distribute data with all of the vehicle electronics via industry standard and proprietary protocols.

The DR600 is a fully integrated automatic voice announcement and public address system, ready to communicate all of the ADA required information to vehicle passengers. The DR600 features a new backlit two-line by 16 character LCD display and five LED indicators, located on the front panel, to provide detailed system status and feedback during maintenance. A Data Port (USB 2.0) is also located on the

front panel and is used for updating the system database via a USB data key. All data is safely stored in non-volatile flash memory so there are no moving parts to break or wear out.

On power-up, the system automatically runs a set of self-diagnostics tests and verbally alerts the user over the vehicle speakers of any irregular or fault conditions. This allows the operator and maintenance staff to quickly resolve any issues. The system's current status can always be viewed from the front panel display. The user can also initiate a more comprehensive set of diagnostics in troubleshooting system issues.



#### 14.2.1. DR600 Front Panel

The DR600 has five (5) LED indicators and one 2 line x 16 character backlit Liquid Crystal Display (LCD) on the front panel. These features are used to monitor the system status and to be used in problem solving.

- □ POWER (Green) This LED will illuminate when +9 to 18VDC is present on the J1pin 16 and the ignition sense has +9 to 28VDC present.
- STATUS (Yellow) This LED will illuminate as events occur.
- ☐ AUDIO (Yellow) This LED will illuminate audio is played on the internal speakers.
- CLIP (Red) This LED will illuminate if the audio amplifiers are being overdriven.
- ☐ FAULT (Red) This LED will illuminate if the speaker lines are shorted or the audio amplifiers are shut down.

# 14.3. Stealthmic System

The Stealthmic System is a handsfree digital microphone system that allows the operator to make internal public address announcements without removing his/her hands from the steering wheel. The microphone module is located on the steering column and the processor module is located in the electronic equipment enclosure.

#### 14.3.1. Operation

Record and play an announcement as follows:

- Press the PA footswitch and speak into the microphone module to record an announcement.
- ☐ Release the P.A. footswitch once the announcement is complete.
- Momentarily press and release the P.A. footswitch to play the announcement. The announcement will be played over the vehicle interior speakers.
- Momentarily press and release the PA switch a second time to stop playback of the announcement. Alternatively, press and hold the PA footswitch to stop playback and record another announcement.
- The Stealthmic System will override prerecorded stop announcements from the vehicle AVA/AVL System.

### MOTE:

If an auxiliary microphone is connected, simply depress the PTT (push-to-talk) switch on the microphone and speak normally. The auxiliary microphone is not delayed.

#### 14.3.2. Stealthmic System Troubleshooting

The processor module contains 4 LED's which can be used for troubleshooting. There is no calibration or setup required for the Stealthmic System (other than setting gain or volume of the PA amplifier).

STEALTHMIC SYSTEM TROUBLESHOOTING		
LED DESCRIPTION/INDICATON		
Power	Processor Module is receiving power from vehicle supply	
DSP	Illuminates during playback of PA announcement	
Recording	Illuminates during recording of the PA announcement	
Aux Mic	Illuminates when PTT active on auxiliary microphone	



# 15. AUTOMATIC PASSENGER COUNTER (APC) SYSTEM

# 15.1. Description

The APC system monitors the movement of passengers entering or exiting the vehicle. See "Fig. 9-26: APC System" on page 55. The major components of the APC system include:

- ☐ Smart Sensor and WIFI Module located in the electronic equipment enclosure.
- ☐ APC transmitter located on wheelchair ramp access door.
- ☐ APC reflectors located on the curbside luggage rack.
- ☐ APC Sensors two sensors located in the exit door, modesty panels.
- ☐ A roof mounted multiband antenna.

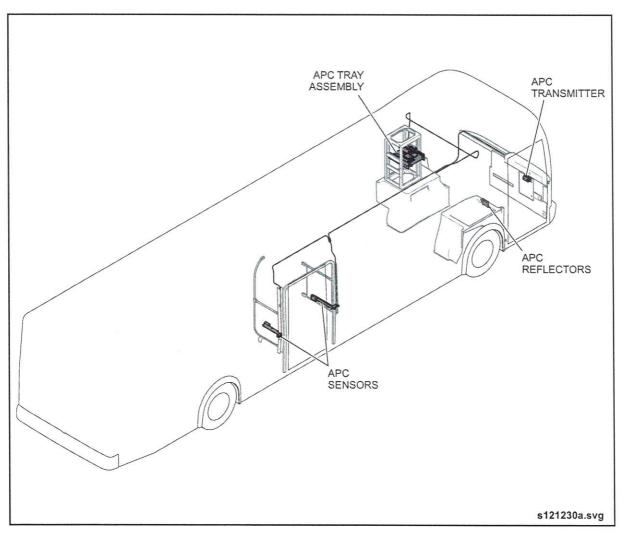


Fig. 9-26: APC System



# 16. AUTOMATIC VEHICLE LOCATION (AVL) SYSTEM

# 16.1. Description

The AVL System consists of the following components. See "Fig. 9-27: AVL System" on page 56.

- ☐ Rabbit Tracker Module located in the electronic equipment enclosure.
- ☐ GPS/Radio Antenna located on the roof.
- ☐ Charge Guard module.
- ☐ Interconnecting cables and harnesses.

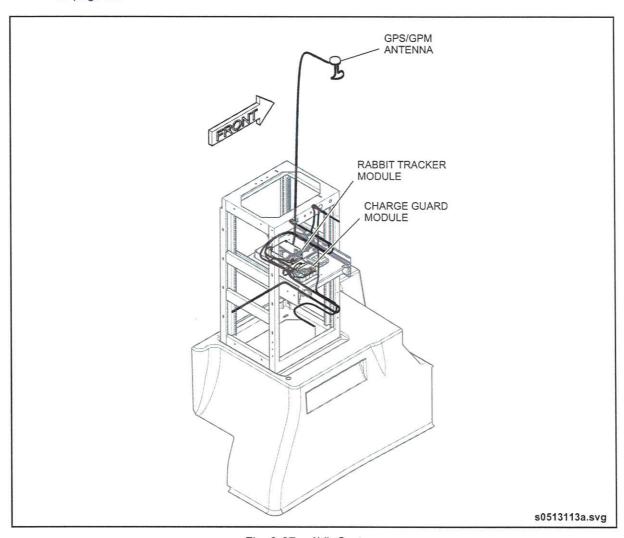


Fig. 9-27: AVL System



# 16.2. Operation

The Rabbit Tracker Module sends the location of the vehicle back to a central server which then uses the information to provide real-time updates of vehicle locations and scheduling to passengers that they can access on their wireless device. GPS data for the AVL system is provided by the AVA/AVL System through a serial communication cable. Refer to 14. "AUTOMATIC VOICE ANNOUNCEMENT (AVA) & AUTOMATIC VEHICLE LOCATOR (AVL) SYSTEM" on page 52 in this section for more information on the AVA/AVL System.

The Rabbit Tracker device has three LED indicators:

- ☐ Radio (Green) On when Radio Lock.
- ☐ GPS (Green) Flashing when GPS Lock.
- ☐ PWR (Red) On when 12 VDC applied.

The Charge Guard module will allow the Rabbit Tracker unit to stay powered up to 60 minutes after the Master Run switch has been switched to STOP-ENGINE. When the Charge Guard system is on, the Tracker combination will draw approximately 0.60 amp and when the Charge Guard switches off, the idle circuit of the Charge Guard will draw approximately 0.02 amp.

#### 16.3. Functional Test

The following test verifies the following functionality:

- 1. Power
- 2. GPS NMEA Data Stream
- Radio Lock cellular network modem logging

For each of the following steps please refer to LED Indicators on Nextbus Rabbit Tracker.

#### 1. Power:

The Power LED indicator will be SOLID RED if power is working properly. If the Power LED indicator is not SOLID RED check Nextbus Rabbit Tracker power connection.

#### GPS NMEA Data Stream:

The GPS LED indicator will be FLASHING GREEN ONCE EVERY SECOND if DR600 is functioning properly. If GPS LED indicator is not FLASHING GREEN ONCE EVERY SECOND check connection between Nextbus Rabbit Tracker (serial port) and DR600 (port 1A/1C) and ensure DR600 is functioning properly.

Radio Lock cellular network modem logging:

The Radio LED indicator will be SOLID GREEN if the Radio Lock cellular network modem logging is working properly. If the Radio LED indicator is not SOLID GREEN check Nextbus Rabbit Tracker antenna connections.



# 17. TRAFFIC SIGNAL PRIORITY SYSTEM

# 17.1. Description

The traffic signal priority system consists of the following components:

☐ Traffic Signal Emitter

- ☐ Opticom Priority Control System
- ☐ Radio/GPS Antenna

The Traffic Signal Emitter is mounted on the exterior front of the vehicle and the Opticom Priority Control System is mounted in the electronic equipment enclosure. The Radio/GPS Antenna is located on the roof of the vehicle. See "Fig. 9-28: Traffic Signal Priority System" on page 58.

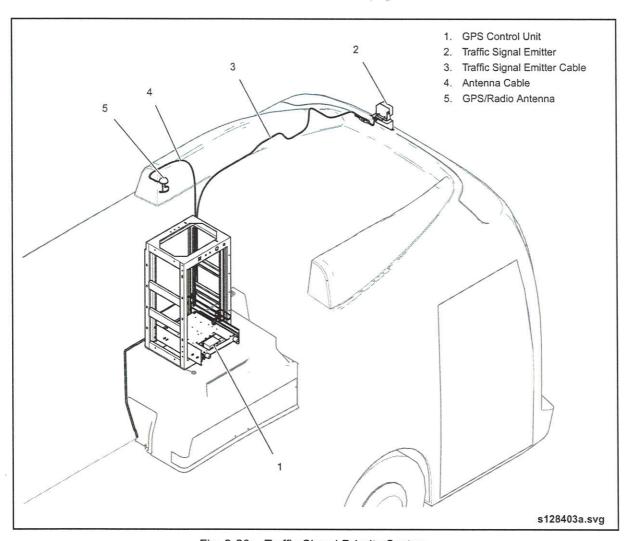


Fig. 9-28: Traffic Signal Priority System



# 17.2. Traffic Signal Emitter

#### 17.2.1. Description

The Traffic Signal Emitter is a compact, lightweight, weather-resistant encoded signal device intended for use on priority vehicles. The emitter consists of an LED array with an integral power supply and the required cables.

### 17.2.2. Operation

The encoded signal pattern (composed of the individual vehicle class code and vehicle identification number) generated by the emitter is determined through the use of interface software or remote coding unit.

The model emitter separates precisely timed pulses of infrared light at the base flash rate of approximately 10 or 14 Hz. It also interleaves programmed encoded pulses that carry the vehicle class and ID number information. These infrared pulses are sensed and processed by other Infrared system components to cause activation of the system.

# 17.3. Opticom Priority Control System

#### 17.3.1. Description

The Opticom GPS System is an electronic control module that controls the Traffic Sig-

nal Emitter. It assists authorized priority vehicles through signalized intersections by providing temporary right-of-way through the use of common traffic controller functions.

### 17.3.2. Operation

The GPS receiver obtains information from the constellation of global positioning satellites. This information is used to compute the location, speed and heading of the vehicle. This information, along with a priority request and the state of the vehicle's turn signal, is broadcast using the 2.4 GHz spread spectrum transceiver.

Opticom GPS System intersection equipment receives the radio transmission from the vehicle equipment. The intersection equipment then compares the information being received from the vehicle with the parameters stored in the intersection equipment's memory. If the vehicle is heading toward the intersection in a predefined approach corridor, is requesting pre-emption or priority and has met all other programmed parameters, the corresponding phase selector output is activated. This output is connected to the traffic controller. When activated, the controller cycles to grant a green light to the requesting vehicle or holds the green, allowing the vehicle to pass through the intersection.



# 18. ELECTRICAL SYSTEM SCHEMATICS

#### 18.1. 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. 9-29: VMM Schematic" on page 60.

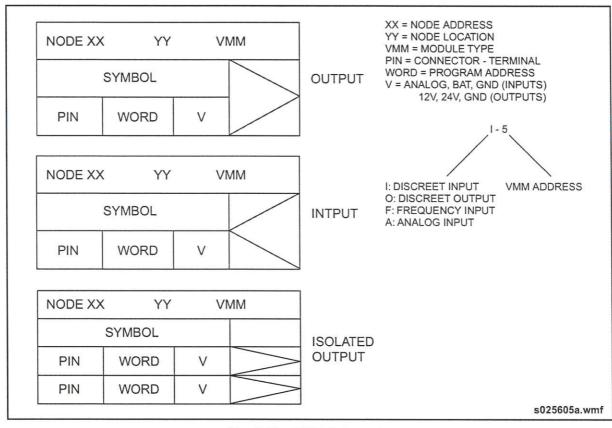


Fig. 9-29: VMM Schematic



# 18.2. 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.

#### 18.3. 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.

#### 18.4. Wire Colors

The following wire colors are used throughout the vehicle:

24 VOLT POWERRED
12 VOLT POWERLIGHT BLUE
ELECTRONIC CONTROL INPUT WIRINGYELLOW
GROUNDSWHITE
SWITCHED POWER/GROUND TAN

The communication network is shown as a double line.



### 18.5. 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	
HP	Hybrid Propulsion	
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	
AB	Anti-Lock Braking	
IP	Instrument Panel	
SP	Spare Wires	

#### 18.6. 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.



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# SAFETY

# 1.1. High Voltage Safety

#### 1.1.1. High Voltage Safety Dangers

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



The BAE System uses potentially hazardous electrical energy. There is a risk of electric shock. Only trained service personnel should access components of the hybrid drive system. Failure to observe all high voltage electrical safety precautions may result in personal injury and/or death.



ALWAYS wear safety glasses and safety shoes, and remove jewelry while servic-

ing the vehicle. Wear linesman's high voltage gloves (rated at 1000 VDC minimum) when working in or around the traction motor, generator, propulsion control and energy storage systems.



NEVER perform diagnostic tests using the IDS "Test Mode" while the vehicle is raised on jack stands or a hoist. Failure to comply can result in personal injury or death and cause severe damage to the vehicle.



A severe shock hazard still exists, even after disconnecting and locking out electrical power. The Energy Storage System (ESS) modules are still energized when the Battery Disconnect switch is set in the OFF position. ALWAYS use extreme caution when working in the area of ESS enclosures.



#### 1.1.2. Hybrid Drive System Warnings

WARNING indicates an operating procedure or practice, which if not strictly observed, could result in damage to or destruction of equipment.



ALWAYS perform lock-out or tag-out procedures during hybrid drive system maintenance. If the vehicle was running just prior to conducting maintenance, allow four minutes for component electrical discharge before proceeding.



ALWAYS perform lock-out or tag-out procedures while maintenance is performed on and hybrid drive system component. Lock-out will prevent any inadvertent reapplication of power while maintenance personnel may be touching high voltage electrical connections.

ALWAYS use a digital multi-meter (DMM) to verify whether an electrical circuit is de-energized before touching any electrical conductor during hybrid drive system maintenance.



ALWAYS ensure that all personnel and equipment are away from the vehicle when conducting post-installation tests. Incorrect ACTM phase wiring connections could result in unanticipated directional movement of the vehicle.

# **⚠ WARNING**

ALWAYS wear protective safety gloves when handling hybrid drive components that were recently in operation. Surface temperature of hybrid drive components may exceed 104°F (40°C).

### 1.1.3. Hybrid Drive System Cautions

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



The hybrid drive system incorporates an electronic protection system which is activated whenever a fault condition exists. The protection system will remain active until the fault has been cleared or the Master Run switch has been cycled to STOP ENGINE and back to DAY-RUN positions.



DO NOT attempt to operate the vehicle for extended periods using the System Override toggle switch located on the driver's side console. Failure of or damage to hybrid drive components may result from improper use of this switch. Use of this switch is limited to 10 seconds continuous or 30 seconds overall operation.



# 1.2. General Safety Procedures

YOU ARE RESPONSIBLE for becoming completely familiar with the warnings and cautions described in this section regarding the hybrid drive system. 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 BAE 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 BAE Systems 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, jack stands 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 major components of the BAE Hybrid Drive System include:

- ☐ Alternating Current Traction Motor (ACTM) coupled to the rear axle via a driveshaft
- ☐ Integrated Starter Generator (ISG) directly driven by the diesel engine
- Propulsion Control System (PCS) located on the rooftop and consists of an inverter, electronic controller, and high voltage contactor.

- Auxiliary Power Supply (APS) located on the rooftop next to the Propulsion Control System
- ☐ Energy Storage System (ESS) battery pack located on the rooftop
- System Control Unit (SCU) located behind a lighting panel on the streetside of the vehicle.
- Push Button Shift Selector located on the instrument panel
- Electronic Cooling Package (ECP) Refer to Section 6 of this manual for information on the ECP system.

See "Fig. 5-1: Hybrid Drive System Layout" on page 5.



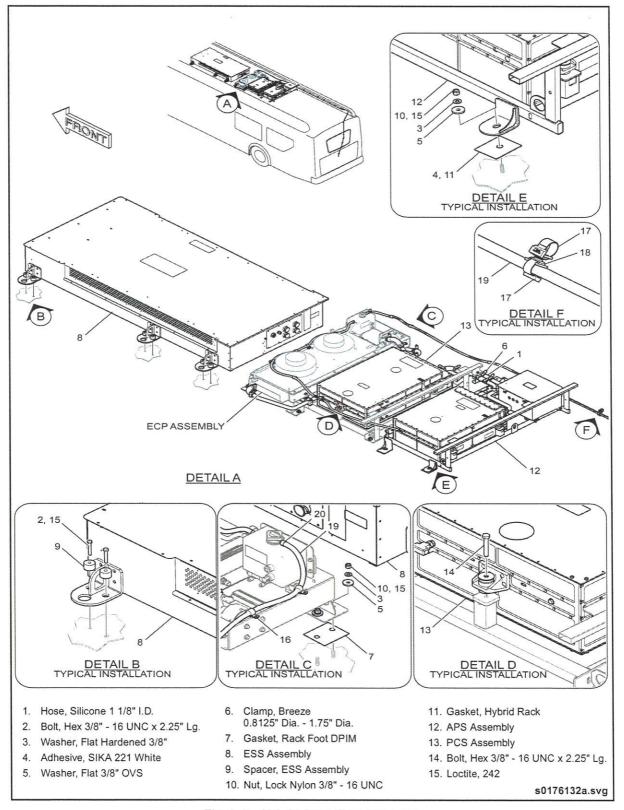


Fig. 5-1: Hybrid Drive System Layout



## 2.2. Operation

The series hybrid drive system utilizes a conventionally mounted diesel engine coupled to an Integrated Starter Generator (ISG) to produce electrical energy. The generator is also used as a starting motor for the diesel engine.

The AC current produced by the generator is converted to DC current by the rooftop Propulsion Control System (PCS) and stored in the rooftop Energy Storage System (ESS).

The PCS controls and delivers AC power to the Alternating Current Traction Motor (ACTM). A Planetary Speed Reducer (PSR) is mounted on the end of the ACTM and provides mechanical speed reduction through a planetary gear set to drive the rear axle.

### 2.2.1. Regenerative Braking

Regenerative Braking comes into effect when the accelerator is released and the traction motor is being driven by the decelerating vehicle through the axle driveline and rear wheels. The System Control Unit (SCU) will then signal the Propulsion Control System (PCS) to extract power from the motor which, in effect, switches the function of the traction motor to a generator. The electrical output of the traction motor "generator" is stored by the Energy Storage System (ESS). This process of capturing the vehicle's kinetic energy and causing decelerations is known as regenerative braking.

### 2.2.2. Automatic Protection

The BAE propulsion system incorporates several built-in checks which automatically protect the propulsion system from various fault conditions such as component overspeed, under-voltage, over-voltage, over-charging, under-charging, over-temperature, and under-temperature.

# Alternating Current Traction Motor (ACTM)

# 2.3. Alternating Current Traction Motor (ACTM)

## 2.3.1. Description

The traction motor is a high-power AC induction motor that incorporates an electronically controlled oil pump and a planetary speed reducer. The traction motor is bolted to the end face of the Integrated Starter Generator (ISG), but there is no drive connection between the two components.

The drive end of the traction motor is coupled to the driveline and rear axle via a planetary speed reducer, which is part of the traction motor. The planetary speed reducer shares the same lubricating oil as the traction motor.

The traction motor assembly is cooled by a combination of externally supplied coolant and self-contained lubricating/cooling oil internally. The lubricating oil passes through a heat exchanger, mounted on the side of the unit, and transfers heat to the surrounding coolant that is passing through the heat exchanger.

### 2.3.2. ACTM Specifications

Model	TB200
Power	265 HP (200 KW)
@ 300 fpm to 2300	rpm (unveline)

Torque 3760 ft-lb. (5100 Nm) peak @ 200 rpm (driveline)
Speed 0 to 2485 rpm (driveline)
Operating Temperature
Planetary Speed ReducerReducer 4.024:1
DC Bus Operating Voltage 630 Nominal
Weight750 lb. (340 kg)

### 2.3.3. Operation

The traction motor provides the vehicle with motive power and is controlled by the Propulsion Control System (PCS). When the accelerator treadle is depressed the traction motor acts as a motor to drive the vehicle. When the accelerator is released, the traction motor acts as a generator to absorb the vehicle's kinetic energy and slow the vehicle.

### 2.3.4. Maintenance

Refer the Preventive Maintenance Section of this manual for scheduled maintenance activities and intervals. Refer to 4. "VENDOR SERVICE INFORMATION" on page 26 in this section for comprehensive troubleshooting, servicing, and testing information.



#### 2.3.5. 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 system. Refer to 4. "VENDOR SERVICE INFORMATION" on page 26 in this section for BAE High Voltage safety requirements.



DO NOT perform maintenance unless you have been properly trained on high voltage safety and are familiar with the safety requirements and procedures detailed in the BAE VPMS System Manual. Adhere to the procedures described in the vendor manual.

### MOTE:

The following procedure describes removal and installation of the traction motor without removing the engine or starter generator from the vehicle. Refer to Section 4 of this manual for the removal and installation procedure of the engine and traction motor/starter generator as an assembly

## MOTE:

There is no internal mechanical connection between the traction motor and the starter generator. The traction motor is bolted to the starter generator for installation convenience only.

- 1. Park vehicle on level surface with parking brake applied and wheels chocked.
- Set Battery Disconnect switch to the OFF position and lock-out or tag-out the switch.
- 3. Drain the Radiator.
- 4. Disconnect the supply and return coolant hoses from the top of the traction motor.

### MOTE:

Use the coolant drain plug on the side of the starter generator to drain coolant from the traction motor. Use 20 psi regulated air pressure at the coolant passageway on the traction motor to aid complete coolant drain.

- Mount engine support brackets. See "Fig. 5-2: Engine Support Bracket Installation" on page 9. Refer to 3.1. "Special Tools Chart" on page 24 in this section for support brackets.
- Disconnect compressor discharge line from muffler tank.
- 7. Disconnect discharge line from governor.
- Remove cover plate from generator and disconnect high voltage lines. Refer to 4. "VENDOR SERVICE INFORMATION" on page 26 in this section for high voltage disconnect procedure.
- Disconnect cables and remove bracket from Planetary Speed Reducer.
- 10. Disconnect driveshaft and remove from vehicle.

### MOTE:

Due to clearance concerns, it may be necessary to dismantle the drive shaft and remove half of it.

- 11. Use a lift table or similar equipment to support the weight of the traction motor.
- 12.Remove the 3/4" lock nut and bolt that attach the side mounts to the vehicle structure. Note the location of the washers for reassembly.

### MOTE:

It may be necessary to access the streetside mount from the vehicle interior access panel.

- 13. Remove the four M16 bolts that attach the side mount plates to the traction motor. Remove the mount assembly from the vehicle.
- 14. Disconnect remaining high voltage cable from starter generator at the phase connection plate

# **Alternating Current Traction Motor (ACTM)**

15. Unbolt traction motor from starter generator.

# **△** CAUTION

Ensure that the traction motor is properly supported and aligned with the lift table when separating from the starter generator in the following step.

16. Carefully separate the traction motor from the starter generator and pull straight back.

### MOTE:

Remove the two O-rings at top of traction motor-to-generator mating flange.

- 17. Move the traction motor away from the starter generator.
- 18.Ensure that all items and electrical connectors have been disconnected before lowering traction motor.
- 19. Lower the traction motor and use a hoist to move the unit to a work stand or bench.

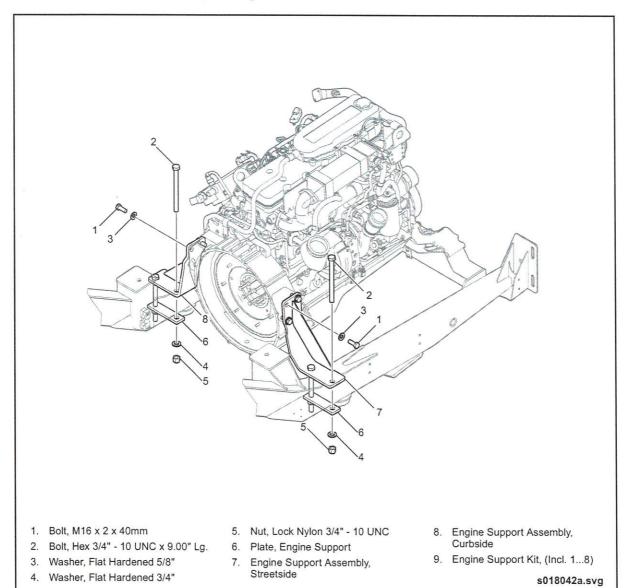


Fig. 5-2: Engine Support Bracket Installation



### 2.3.6. Installation

 Ensure that the traction motor is properly aligned and supported by the lift table. See "Fig. 5-3: ACTM/ISG Installation" on page 12.

### MOTE:

There are guide pins built into the generator housing to help align traction motor during installation.

- 2. Place traction motor rubber vibration mounts in place on chassis mounts.
- Apply Parker "Super O-Lube" or equivalent silicone based O-ring lubricant on the two O-rings and place them on the coolant transfer passage tubes at the top of the traction motor-to-generator mating flange.
- Install high voltage cables at phase connection cover location while the traction motor is being raised.
- Carefully push the traction motor towards the starter generator until it engages the alignment pins.



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

Install the ten M10 bolts and the two M12 bolts that attach the traction motor to the starter generator.

### MOTE:

The two M12 bolts are located in the bottom-most positions and face the opposite direction of the other ten mounting bolts.

- Torque the ten M10 bolts to 61 ± 6 ft-lbs. (83 ± 8 Nm) and torque the two M12 bolts to 107 ± 11 ft-lbs. (145 ± 15 Nm). Use an alternating criss-cross pattern to torque the bolts and apply torque witness marks to the bolt heads.
- Perform a pressure test at this time to ensure that the O-rings in the cooling passageways are properly installed and that there are no internal leaks.



DO NOT use unregulated shop air to pressure test the system, otherwise internal components could be damaged. Under no circumstances exceed 40 psi air pressure.

- a. Locally fabricate a plate with pressure testing adapters to supply air to one coolant passageway while blanking off the other passageway.
- b. Install a pressure regulator and shutoff valve in the air supply line.
- c. Set pressure regulator to 25 psi and close air supply shutoff valve. Observe pressure reading for five minutes to ensure no leakage exists.

## **Alternating Current Traction Motor (ACTM)**

 Position the side mounts in place and use four M16 bolts to attach the bracket to the traction motor and use the 3/4" bolt and lock nut to attach the rubber mount to the vehicle structure. Ensure the washers are installed in the same position as noted during removal.

### MOTE:

It may be necessary to adjust the position of the lift table in order to simultaneously align the side mount fasteners with the traction motor and vehicle structure.

10. Torque the four M16 bolts in the side mount bracket to 186 ft-lbs. (252 Nm).

### MOTE:

It may be necessary to use a crowfoot or similar torque wrench extension tool to access the bolt heads. Apply the appropriate torque correction factor to suit the length of the adapter.

- 11. Torque the 3/4" lock nut on the rubber mount to 250 ft-lbs. (339 Nm).
- 12. Install the phase connection cover plate and secure the high voltage cables from the opposite side through the HVIL access location. Torque to 57 ft-lbs (77Nm).
- 13. Connect driveshaft to output yoke of traction motor. Refer to Section 2 of this manual for procedure.
- Connect cable brackets and HVIL connectors.
- Connect air lines at governor and muffler tank.
- 16. Connect coolant hoses
- 17.Fill the hybrid drive coolant system. See Section 6 of this manual for the fill procedure.
- 18.Set the Battery Disconnect switch to the ON position.
- 19. Start engine and check for leaks. Top up coolant level if necessary.



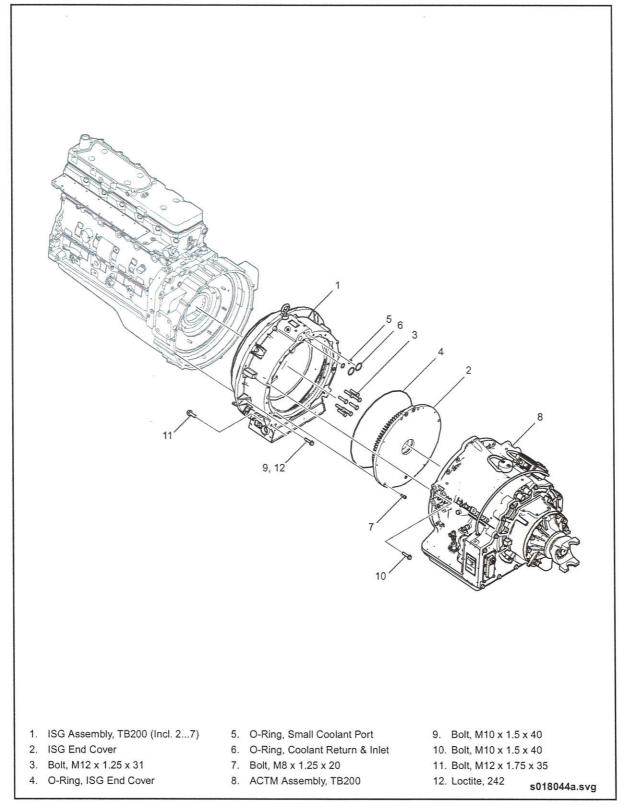


Fig. 5-3: ACTM/ISG Installation

## Integrated Starter Generator (ISG)

# 2.4. Integrated Starter Generator (ISG)

## 2.4.1. Description

The ISG is a liquid-cooled, high-efficiency, brushless, permanent magnet starter/generator that is used primarily to generate electrical energy for the hybrid propulsion system, but can also be used as a starter to start the diesel engine. The ISG is mounted to the engine bellhousing and directly coupled to the engine crankshaft.

005 - (000 1014) - - 1

### 2.4.2. ISG Specifications

@ 2300rpm	55 hp (200 KW) continuous
Speed	0-3000 rpm
Operating Tempe Max inlet cool	eratureant 85°C (185°F)
Weight 285	lb (130 kg) 305 lb (138 kg)
	Liquid cooled

### 2.4.3. Operation

The ISG converts the diesel engine's mechanical energy into electrical energy for use by the propulsion system. The ISG speed and output power are managed by the System Control Unit (SCU) and the Propulsion Control System (PCS) in conjunction with the diesel engine and vehicle duty cycle to achieve optimized overall system performance.

### 2.4.4. Maintenance

Refer the Preventive Maintenance Section of this manual for scheduled maintenance activities and intervals. Refer to 4. "VENDOR SERVICE INFORMATION" on page 26 in this section for comprehensive troubleshooting, servicing, and testing information.



#### 2.4.5. 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 system. Refer to 4. "VENDOR SERVICE INFORMATION" on page 26 in this section for BAE High Voltage safety requirements.



DO NOT perform maintenance unless you have been properly trained on high voltage safety and are familiar with the safety requirements and procedures detailed in the BAE VPMS System Manual. Adhere to the procedures described in the vendor manual.

### MOTE:

The following procedure describes removal and installation of the Integrated Starter Generator (ISG) without removing the engine from the vehicle. Refer to Section 4 of this manual for the removal and installation procedure of the engine and traction motor/starter generator as an assembly.

### MOTE

There is no internal mechanical connection between the traction motor and the starter generator. The traction motor is bolted to the starter generator for installation convenience only.

- Park vehicle on level surface with parking brake applied and wheels chocked.
- 2. Set Battery Disconnect switch to the OFF position and lock-out or tag-out the switch.
- Remove Traction Motor. Refer to 2.3. "Alternating Current Traction Motor (ACTM)" on page 7 in this section for detailed removal instructions.

### MOTE:

The following instructions assume that the vehicle is raised, the Traction Motor has been removed, and the engine flywheel

housing is properly supported with the special engine mount adapter brackets. Refer to 3. "SPECIAL TOOLS" on page 24 in this section for information on the engine mount adapter brackets.

- Disconnect JI, J3, J4, and RTD temperature sensor electrical connectors from the ISG.
- Disconnect the high-voltage three-phase cables from the ISG.
- 6. Disconnect the two coolant bleed lines from the top of the ISG stator housing.
- Remove the coolant drain plugs from the bottom of the end cover and from the side of the stator housing. Drain coolant into a suitable container.

## MOTE:

The coolant drain procedure may have already been done during the removal of the Traction Motor, If not, then it is recommended to use 20 psi regulated air pressure at the coolant passageway above the end cover to aid in complete coolant drain.

- 8. Remove the six M8 bolts from the ISG end cover. See "Fig. 5-4: ISG Installation" on page 15.
- Use three of the removed M8 bolts as jacking screws and install at the three threaded jacking screw locations on the end cover.
   Apply pressure equally to the three jacking screws and remove end cover. Discard large O-ring.
- 10.Remove and discard two smaller O-rings located in the coolant passages at the top of the stator housing.

### MOTE:

The following shimming procedure is necessary to maintain relative alignment between the rotor and stator housing during the removal process. The rotor and stator must be removed as a unit due to the strong magnetic force that prevents the rotor from being removed separately.

11.Insert a large sheet of plastic shim stock between the rotor and stator to take up the clearance and prevent the rotor from dropping on the stator housing during removal.





The approximate 300 lb. weight of the ISG must be supported using lifting equipment designed for this purpose.

- 12. Position a lift table or similar equipment beneath the ISG and raise the table to take the weight of the ISG.
- 13. Remove the ten M10 bolts that secure the ISG to the engine flywheel housing. Do not attempt to separate the ISG from the engine flywheel housing at this time.
- 14. Remove the eight M12 bolts that attach the rotor to the engine crankshaft flange.

### MOTE:

The following step involves the use of jackscrews to separate the stator housing and

- rotor assembly from the engine flywheel housing and engine crankshaft flange respectively. The jackscrew procedure must be performed equally on both components to ensure that no relative axial displacement between the stator housing and rotor occur during the removal process.
- 15. Use two of the removed M12 bolts as jacking screws and install at the two threaded jacking screw locations on the rotor. Use two of the removed M10 bolts as jacking screws and install at the two threaded jacking screw locations on the stator housing mounting flange. Apply pressure equally to all the jacking screws and carefully separate the stator housing and rotor from the engine.
- 16.Lower the lift table and remove the ISG assembly from the vehicle.

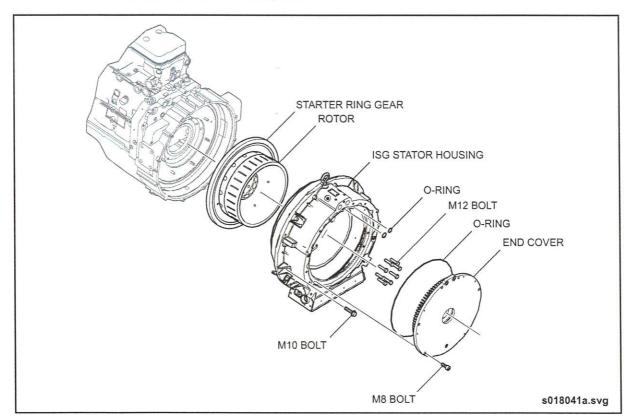


Fig. 5-4: ISG Installation



### 2.4.6. Installation

- Use a lift table or other suitable lifting equipment to support the ISG and position the lift table so that the mounting holes in the rotor align with the threaded holes in the crankshaft flange.
- Fasten the rotor to the engine crankshaft flange using eight M12 bolts and handtighten only at this time.
- Align the stator housing mounting holes with the threaded holes in the engine flywheel housing. Apply Loctite 242 to the bolt threads and install the ten M10 bolts. Hand-tighten only at this time.
- 4. Torque the rotor mounting bolts in two stages. Use an alternating criss-cross pattern and torque bolts 22 ± 2 ft-lbs. (30 ± 3 Nm). Final tighten the bolts an additional 60 degrees rotation, using an alternating criss-cross pattern. Apply torque witness marks to the bolt heads.
- Torque the stator housing mounting bolts to 53 ± 5 ft-lbs. (72 ± 7 Nm), using an alternating criss-cross pattern. Apply torque witness marks to the bolt heads.
- Remove the plastic shim stock from the rotor.
- Apply Parker "Super-O-Lube" or equivalent silicone-based O-ring lubricant and install three new O-rings Two smaller O-rings locate in the machined grooves in the stator housing and a single large O-ring locates on the O.D. of the end cover.
- 8. Use the two alignment pins to properly position the end cover on the stator housing. Install six M8 bolts and torque to 23 ± 2 ft-lbs. (31 ± 3 Nm) using an alternating criss-cross pattern. Apply torque witness marks to the bolt heads.
- Install the two coolant drain plugs and torque to 10 ft-lbs. (13.6 Nm).

10. Perform a pressure test at this time to ensure that the O-rings in the cooling passageways and end cover are properly installed and that there are no internal leaks.



DO NOT use unregulated shop air to pressure test the system, otherwise internal components could be damaged. Under no circumstances exceed 40 psi air pressure.

- a. Locally fabricate a plate with pressure testing adapters to supply air to one coolant passageway while blanking off the other coolant passageway. See "Fig. 55: ISG Pressure Test" on page 17.
- Temporarily plug the two coolant vent ports at the top of the ISG stator housing.
- c. Install a pressure regulator and shutoff valve in the air supply line.
- d. Set pressure regulator tot 25 psi and close air supply shutoff valve. Observe pressure reading for five minutes to ensure no leakage exists.
- 11. Remove pressure testing equipment.
- 12. Connect the coolant bleed lines to the top of the ISG stator housing.
- Connect the high-voltage cables, RTD temperature sensor, and electrical harnesses to the ISG.
- 14. Install the Traction Motor, top up coolant, and perform functional test. Refer to 2.3. "Alternating Current Traction Motor (ACTM)" on page 7 in this section for detailed installation instructions.

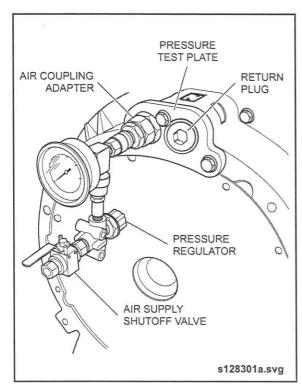


Fig. 55: ISG Pressure Test

## 2.5. Energy Storage System (ESS)

### 2.5.1. Description

The roof-mounted ESS consists of 16 battery modules, each containing 96 individual lithium-ion cells. The roof-mounted enclosure uses two fans to draw cooling air through the battery modules.

## 2.5.2. ESS Specifications

Nominal Voltage	.630 VDC
Power Capability	
±200 KW peak, ±50 KW co	ontinuous

Reserve	11.2 KW/hr
Operating Temperate	ure52°C (125°F)
Height	11.7 inches (297 mm
Width	41 inches (1041 mm)
Length	84 inches (2135 mm)
Weight800 lb (	365 kg) 740 lb ( 336 kg)
	Forced ambient air to 125°F (52°C)

### 2.5.3. Operation

The ESS provides energy during vehicle acceleration and peak power demands and recaptures energy during deceleration. The charge and discharge power are controlled by the Propulsion Control System (PCS) which communicates with other components in the hybrid drive system via the J1939 Data Link. The ESS uses one positive and one negative contactor to disconnect from the hybrid drive propulsion system when either the engine is shut down or when a Stop System fault is detected.

The ESS utilizes a self-contained Battery Management System (BMS) which monitors each battery module individually, provides continuous cell voltage equalization, and monitors ESS temperature.

### 2.5.4. Maintenance

Refer the Preventive Maintenance Section of this manual for scheduled maintenance activities and intervals. Refer to 4. "VENDOR SERVICE INFORMATION" on page 26 in this section for comprehensive troubleshooting, servicing, and testing information.



### 2.5.5. 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 system. Refer to 4. "VENDOR SERVICE INFORMATION" on page 26 in this section for BAE High Voltage safety requirements.

- Park vehicle on level surface with parking brake applied and wheels chocked.
- Set Battery Disconnect switch to the OFF position and lock-out or tag-out the switch.



DO NOT perform maintenance unless you have been properly trained on high voltage safety and are familiar with the safety requirements and procedures detailed in the BAE VPMS System Manual. Adhere to the procedures described in the vendor manual.



Use work platforms or scaffolding whenever working on roof-mounted components. Ensure maintenance personnel use an approved safety harness.

- Disconnect the ESS electrical cables. Refer to 4. "VENDOR SERVICE INFOR-MATION" on page 26 in this section for electrical disconnect procedures.
- Remove 12 mounting bolts, washers, and spacers that secure the ESS to the vehicle roof structure.
- Attach lifting equipment to the ESS, ensuring that all six lifting brackets are utilized and the load is evenly distributed and balanced.
- 6. Remove ESS from the vehicle.

#### 2.5.6. Installation

- Use appropriate lifting equipment and position the ESS on the vehicle rooftop rack.
- 2. Secure the ESS to the rack structure using 12 bolts, washers, and spacers. Torque bolts to 38 to 45 ft-lb. (51 to 61 Nm).
- Connect the ESS electrical cables. Refer to 4. "VENDOR SERVICE INFORMATION" on page 26 in this section for electrical connection procedures.
- Set Battery Disconnect switch to the ON position.
- 5. Start engine and verify system operation.



## 2.6. System Control Unit (SCU)

### 2.6.1. Description

The SCU, in conjunction with the Propulsion Control System, directs the energy flow in the hybrid-electric system using data from the driver interfaces and system components. The SCU is mounted behind a lighting panel on the interior streetside of the vehicle.

### 2.6.2. SCU Specifications

Operating Temperature External am	e nbient: -40° C to 75° C
Height	3.9 in (99 mm)
Width	8.7 in (221 mm)
Length	15 in (385 mm)
Weight	10 lb (4.5 kg)
Free convection ai surfaces	ir cooled on all exterior

### 2.6.3. Operation

The SCU and the Propulsion Control System (PCS) control the diesel engine speed,

generator power, and traction motor torque. The SCU accepts commands from the primary driver interfaces (accelerator, brake, gear selection, Master Run switch etc.), Energy Storage System (ESS), Propulsion Control System (PCS), and other vehicle systems. It uses this information to control the engine load and RPM, provide optimal power, torque, and speed commands to the PCS and manage the ESS state of charge. The SCU is also used to monitor the overall hybrid drive system and provide diagnostic information.

### 2.6.4. Removal & Installation

- Set the Battery Disconnect switch to the OFF position.
- Remove the streetside lighting panel located above the third and fourth windows
- 3. Unplug electrical connectors.
- Disconnect dedicated ground wire.
- 5. Remove fasteners that attach SCU module to mounting plate.
- 6. Installation is the reverse of removal.



# 2.7. Propulsion Control System (PCS)

### 2.7.1. Description

The PCS is the power processing and power management center for the hybrid drive system and is mounted on the rooftop aft of the Electronic Cooling Package (ECP). The primary components of the PCS are the controller electronics, inverter, and a high voltage contactor. The PCS is liquid cooled using a dedicated cooling module (ECP). Refer to Section 6 of this manual for information on the ECP.

### 2.7.2. PCS Specifications

Net Power Handling ....... 360/400 KW continuous/intermittent

Operating Temperature Coolant temperature -20°C to 45°C nominal (65°C max)

External ambient -40° C to 75° C

Weight 175 lb (79 kg)

## 2.7.3. Operation

The PCS accepts torque, speed, and directional commands from the System Control Unit (SCU) as well as discrete sensor inputs from the traction motor and generator. The PCS uses this information to provide optimal power to and from the traction motor and generator. It also regulates the high voltage DC-Link and maintains the Energy Storage System (ESS) state of charge. The PCS also has the capability to monitor the system and provide diagnostic information.

### 2.7.4. Maintenance

Refer the Preventive Maintenance Section of this manual for scheduled maintenance activities and intervals. Refer to 4. "VENDOR SERVICE INFORMATION" on page 26 in this section for comprehensive troubleshooting, servicing, and testing information.

## **Propulsion Control System (PCS)**

### 2.7.5. 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 system. Refer to 4. "VENDOR SERVICE INFORMATION" on page 26 in this section for BAE High Voltage safety requirements.

- Park vehicle on level surface with parking brake applied and wheels chocked.
- Set Battery Disconnect switch to the OFF position and lock-out or tag-out switch.



DO NOT perform maintenance unless you have been properly trained on high voltage safety and are familiar with the safety requirements and procedures detailed in the BAE VPMS System Manual. Adhere to the procedures described in the vendor manual.



Use work platforms or scaffolding whenever working on roof-mounted components. Ensure maintenance personnel use an approved safety harness.

- Disconnect the PCS electrical cables. Refer to 4. "VENDOR SERVICE INFOR-MATION" on page 26 in this section for electrical disconnect procedures.
- Drain coolant into suitable container and disconnect coolant hoses and vent lines from PCS.
- Remove the four sets of mounting bolts, washers, and rubber isolators that secure the ESS to the vehicle roof structure.
- Attach suitable lifting equipment to the PCS, ensuring that the load is evenly distributed and balanced.
- 7. Remove PCS from the vehicle.

#### 2.7.6. Installation

- Use appropriate lifting equipment and position the PCS on the vehicle rooftop rack.
- Secure the PCS to the rack structure using bolts, washers, and rubber isolators. Torque bolts to 25 to 30 ft-lb. (34 to 41 Nm).
- Fill Electronic Cooling Package (ECP) reservoir. Refer to Section 6 of this manual for ECP fill and deaeration procedures.
- Connect the PCS electrical cables. Refer to 4. "VENDOR SERVICE INFORMATION" on page 26 in this section for electrical connection procedures.
- Set Battery Disconnect switch to the ON position.
- 6. Start engine and run a diagnostic test to verify system operation.



## 2.8. Auxiliary Power Supply (APS)

### 2.8.1. Description

The Auxiliary Power Supply (APS) is roof mounted on the rack next to the Propulsion control System and the Electronics cooling package. It is connected to the Energy Supply System (ESS), the Electronics Cooling Package (ECP) and supplies power to the vehicle's auxiliary components via a high voltage junction box. Refer to Section 9 of this manual for more information on the junction box.

### 2.8.2. Auxiliary Power Supply Specifications

### 2.8.3. Operation

The APS is a dual level voltage converter. It converts the nominal 633 VDC input power from the Energy Supply System (ESS) battery pack to 28 VDC for the vehicle's battery system and electrical accessories. The APS also receives 600 VAC power from the Integrated Starter Generator (ISG) and converts to 230 VAC power for the accessories drive motor and HVAC compressor drive motor.

### 2.8.4. 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 system. Refer to 4. "VENDOR SERVICE INFORMATION" on page 26 in this section for BAE High Voltage safety requirements.

- Park vehicle on level surface with parking brake applied and wheels chocked.
- Set Battery Disconnect switch to the OFF position and lock-out or tag-out the switch.



DO NOT perform maintenance unless you have been properly trained on high voltage safety and are familiar with the safety requirements and procedures detailed in the BAE VPMS System Manual. Adhere to the procedures described in the vendor manual.



Use work platforms or scaffolding whenever working on roof-mounted components. Ensure maintenance personnel use an approved safety harness.



The surface of the APS may be hot.

- Disconnect the APS electrical cables. Refer to 4. "VENDOR SERVICE INFOR-MATION" on page 26 in this section for electrical disconnect procedures.
- Drain coolant into suitable container and disconnect coolant hoses from APS.
- Remove the three sets of mounting bolts, washers, and rubber isolators that secure the APS to the vehicle roof structure.
- Attach suitable lifting equipment to the APS, ensuring that the load is evenly distributed and balanced.
- 7. Remove APS from the vehicle.



#### 2.8.5. Installation

- Use appropriate lifting equipment and position the APS on the vehicle rooftop rack.
- 2. Secure the APS to the rack structure using bolts, washers, and rubber isolators.
- 3. Connect Electronic Cooling Package (ECP) hoses to APS.
- Fill Electronic Cooling Package reservoir. Refer to Section 6 of this manual for ECP fill and deaeration procedures.
- Connect the APS electrical cables. Refer to 4. "VENDOR SERVICE INFORMATION" on page 26 in this section for electrical connection procedures.
- 6. Set Battery Disconnect switch to the ON position.
- Start engine and run a diagnostic test to verify system operation.
- Check for leaks in the coolant system connections.

### 2.9. Shift Selector

### 2.9.1. Description

The hybrid drive shift selector is located on the right side of instrument panel and is used by the operator to select the vehicle direction of operation. The shift selector has three shift buttons arranged vertically.

- D Forward, commands forward vehicle movement.
- N Neutral, commands neutral, no vehicle movement.
- R Reverse, commands reverse vehicle movement.

### 2.9.2. Operation

- 1. Before starting the vehicle:
  - Set the shift selector to the neutral [N] position.

- b. Apply the parking brake.
- c. Apply the brake treadle.
- 2. Push the Start button on the side console.
- With the vehicle running, apply firm pressure on the brake treadle and select [D] or [R] on the shift selector.
- Release parking brake and the brake treadle to proceed.
- To change direction, bring the vehicle to a full stop, apply firm pressure on the brake treadle and select the desired direction.

### MOTE:

To switch from one direction to the other, e.g., from forward to reverse, first shift into Neutral [N] before selecting [R]. A solid light indicates proper shift engagement. If the light is blinking, repeat shift instructions. While switching from one direction to the other, if you do not first shift into Neutral [N], the drive system will not accept your request and you will have to select Neutral [N] before selecting either direction again. Take care that one of the shift buttons is always selected and that two shift buttons are never selected at the same time.

## MOTE:

A back-up alarm activates when reverse IRI is selected.

When parking or shutting down the vehicle, come to a full stop, apply the parking brake, select neutral [N] and release the brake treadle.



NEVER leave the driver's seat while the shift selector is in an operating position [R] or [D].





#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**

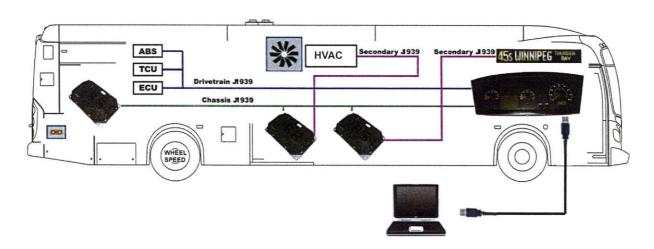
- Industry standard communications protocol and ladder logic software
- Single style auto-programming module controls all functions and reduces inventory (35' and 40' buses have six modules, a 60' bus has seven
- Easy-to-use diagnostics software runs directly on your laptop in Windows; free lifetime 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	Vansco N	/lodu	e
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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	
R5232	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	The same of the sa
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



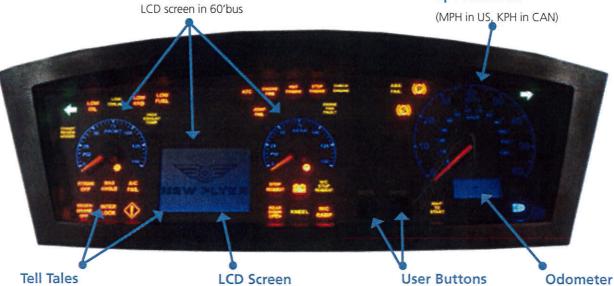


## **Xcelsior Electronic Instrument Cluster**

### Air Pressure Gauges

- Two gauges in 40' bus · Third gauge positioned above
- LCD screen in 60'bus

## 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**









