VOLUME 2

Cooling
Intake & Exhaust
Fuel System
Instrumentation
Multiplex System
Body Electrical
Chassis Electrical
Steering
Body Structure
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This manual is Revision B of the 2011 BBCV Service Manual. It is the latest BBCV Service Manual available at the time of publication of this 2012 TechRef DVD, Edition A.
You may purchase from your nearest Blue Bird Parts Dealer additional copies and/or later versions of the TechRef DVD as they become available.

BLUE BIRD **VISION**

BBCV

SERVICE MANUAL

2011

BLUE BIRD

VISION

10013327

Revision B

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The Blue Bird Vision complies with all applicable federal and state regulations. These include, but are not be limited to, Federal ADA as well as state accessibility, safety and security requirements.

The Blue Bird Vision meets all applicable Federal Motor Vehicle Safety Standards (FMVSS) rules and regulations.

In the event of any conflict between the requirements of this publication and any applicable legal requirement, the legal requirement prevails. Technical requirements that exceed the legal requirements are not considered to conflict.

Many of the components of Blue Bird buses are obtained from outside suppliers. Where maintenance and/or service information conflicts with the component manufacturer's documentation, the manufacturer's documentation prevails.

Blue Bird Corporation continually endeavors to improve its products and reserves the right to change without notice. Text, illustrations, and specifications in this manual are based on information available at the time of printing.

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Overview

The cooling system on the Blue Bird Vision is designed to maintain the temperature of the engine within the optimum operating range, throughout the conditions for which the vehicle is intended to function.

The down-flow radiator and transmission fluid cooler are fabricated together. The engine coolant and transmission fluid radiator is assembled to the Charge Air cooler prior to installation in the chassis. The radiator is mounted at the front of the vehicle, behind the first cross-member and between the frame rails.

A 9-blade, 24 inch diameter nylon fan assists by pulling ambient air over the radiator. The operation of the fan is controlled by signals from the engine Electronic Control Module (ECM). Control of the fan is limited to "Fully-On" or "Fully-Off" by an electromagnetic clutch arrangement.

Power to drive the fan is supplied by a polly vee fan belt, driven directly by the engine. An automatic belt tensioner helps to keep the drive belt at the proper tension for maximum drive function and service life.

The water pump provides coolant flow within the cooling system, at a level sufficient to maintain pressure of less than 10 psi. Circulation of the coolant liquid is critical to maintaining proper operating temperature. Coolant absorbs heat generated by the combustion action of the engine and by friction generated by the moving parts. The heated coolant circulates through a system of pipes and hoses to the radiator, where heat is transferred to the atmosphere by the ambient air flowing over fins in the radiator.

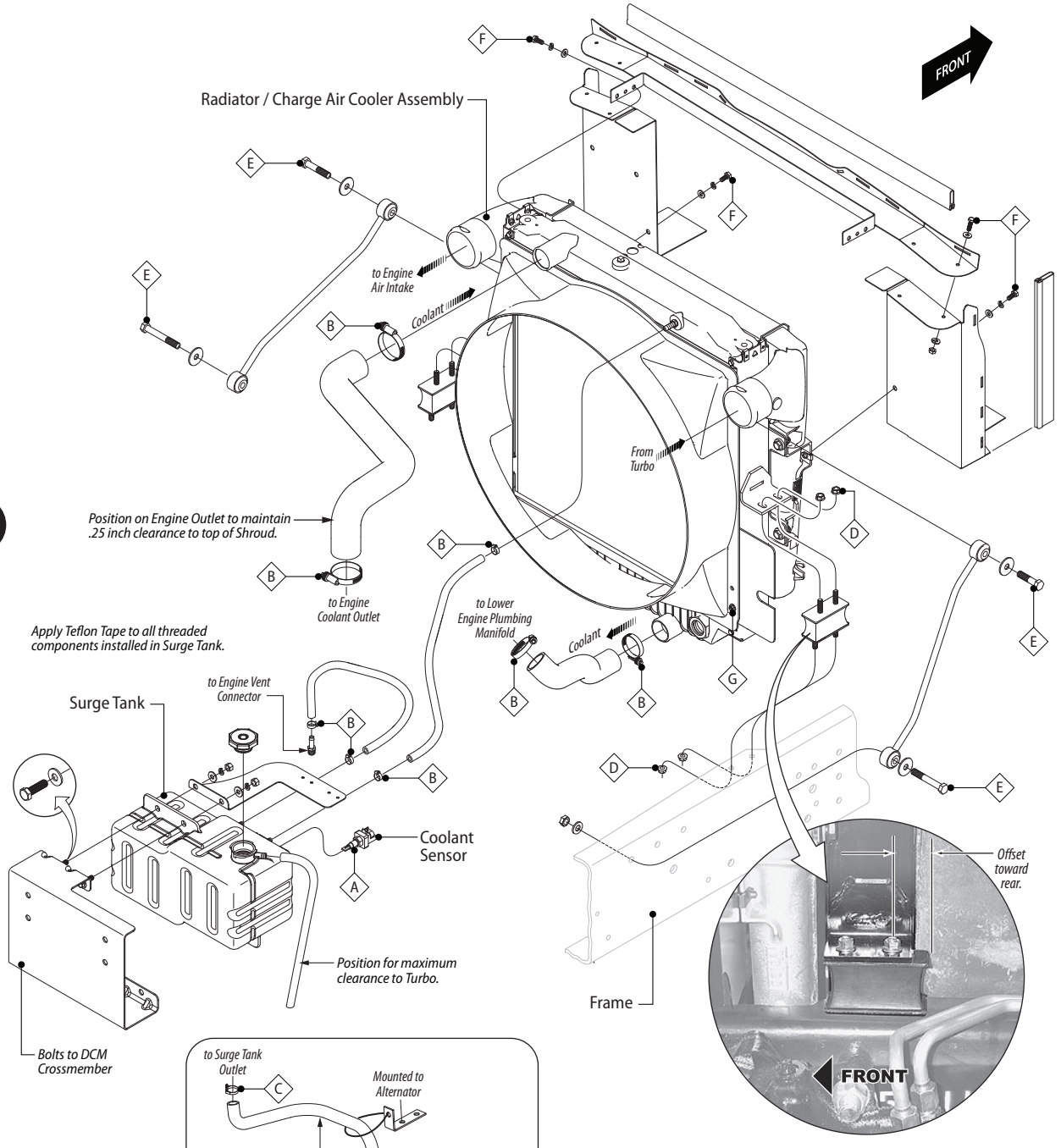
When excessively high operating temperature is observed, first check for proper fluid level in the coolant reservoir or "surge tank". If the fluid level is low and cannot be maintained without constant refill, inspect for leaks at pipe and hose connections. Also look for damaged hoses due to heat or chaffing from incorrect routing. During cold weather, the coach heater system may also be an area of leaks.

Debris accumulation in the radiator fins or bent fins restricting airflowmay also cause overheating.

The three main symptoms of trouble in the cooling system are overheating, overcooling, and loss of coolant. A cooling system should first be diagnosed by a thorough visual inspection. If this reveals no useful information, tools and test equipment will be needed to proceed.

In the case of overheating, the next step is to verify the proper operation of the thermostats. Refer to the appropriate Cummins publication for instructions regarding the removal and testing of the thermostats.

WARNING ***The engine, coolant, and transmission fluid may be very hot (possibly above the boiling point at atmospheric pressure). Use caution when working with these components. Allow the system to cool to the point where you can comfortably lay your hand on the engine block and radiator before working on it. Refer to the Introduction section of this manual for advice on the environmental considerations required when working with these materials.***



Torque Specifications			
Flag	Item	Qty.	Torque
A	Sensor	1	4.5-6.0 ft.lbs.
B	Clamps	8	7.5-8.3 ft.lbs.
C	Clamps	2	3.75-4.5 ft.lbs.
D	Nuts	8	29-33 ft.lbs.
E	Capscrews	4	56 ft.lbs.
F	Capscrews	10	7-10 ft.lbs.
G	Nuts	4	3-5 ft.lbs.

Cooling System *Major Components*

About Coolant

As emission and performance regulations become more stringent, the normal operation temerature range for turbocharged diesel engines increases. One of the consequences is that careful maintenance of the cooling system becomes increasingly critical in prolonging the life of the engine. At higher temperatures, relatively minor imbalances or impurities in the coolant can dramatially increase the potential for corrosion. Establish a disciplined and consistent regimine for monitoring and testing the coolant in your Blue Bird school buses. Keep accurate records, use only coolants recommended by the engine manufacturer. Change coolant within its specification lifetime and never mix different types of coolant.

Periodic testing and maintenance of the coolant should be performed in accordance to the engine manufacturer's specifications. Testing and maintenance procecures differ between standard-life and extended-life coolants. Locally available test strips may be used to test standard-life coolants. However, such test strips are not appropriate for long-life coolants; therefore long-life or extended-life coolants must be sample tested at qualified cooant laboratories. Because specification, recommendation, and terminologies differ among engine manufacturers, Blue Bird advises stictly adhering to the coolant maintenance specifications of the engine manufacturer. Carefully following the engine manufacturer's recommendations is the surest way to maintain compliance with engine warranties.

Beginning in January of 2007, Blue Bird implemented a program to simplify the coolant types installed at the factory.

Standard Equipment Coolant

Cummins Fleetguard ES Compleat 50/50 premix (blue in color) is installed as standard equipment with Cummins.

This coolant meets all specifications and requirements for extended-life coolant and is to be considered standard-life coolant when installed in Cummins engines.

Note: *If you wish to convert from standard life coolant to Fleetguard ES Optimax extended life coolant, follow the guidelines set forth in the Fleetguard Maintenance Bulletin, MB1/04-1 at www.cumminsfiltration.com/pdfs/product_lit/americas_brochures/MB1-04-1.pdf.*

Optional Extended Life Coolant

Cummins Fleetguard ES Optimax 60/40 premix (red in color) is installed in bus products equipped with Cummins engines when purchased with an option for extended-life coolant.

Coolant Decals

On all models, Blue Bird installs a decal stating:

- The type of coolant installed at the factory.
- The coolant manufacturer's part number for one gallon quantity, suitable for regular top-off and refill.
- The coolant manufacturer's part number for one gallon quantity of the concentrate version of the installed coolant, suitable for formulating stronger glycol mixture ratio.

Blue Bird also installs a second decal containing radiator warnings. Both decals are mounted near the coolant fill neck.

Coolant Maintenance

Blue Bird advises strictly abiding by the following policy for all coolant maintenance for the life of the vehicle.

Never Mix Coolant Types

Routine coolant addition (top-off) must match the installed coolant type and brand. Do not mix coolants of different colors, types, or brands in the same engine.

Strictly Follow The Engine Manufacturer's Specifications

Each engine manufacturer publishes its own specific requirements for testing and maintaining coolant in their respective engines. Blue Bird recommends strictly abiding by the engine manufacturer's testing and maintenance schedules and draining, flushing, refilling procedures to maintain compliance with the engine warranty requirements. Blue Bird recommends that you maintain accurate vehicle-specific service records of all coolant system maintenance procedures performed.

Note: *For more information on coolant testing tools see: www.cumminsfiltration.com/pdfs/product_lit/americas_brochures/LT15068.pdf.*

For Cummins engines using Fleetguard ES coolants, send coolant samples to Fleetguard for Monitor C testing, as specified in the Cummins Operator's Manual. Label sample as Extended-Life coolant.

Always Mix Concentrate With Premix Coolant, Not Water

If concentrated coolant is added in order to raise the glycol ratio, use only the concentrate version of the same premix coolant type and brand as installed. Do not mix the concentrate with water. Instead, mix the concentrate with the premix version of the same coolant.

Only Add Tap Water In Emergency Situations

A regularly-scheduled bus inspection and maintenance program should be followed to prevent coolant losses due to damaged or worn hoses, loose clamps, etc.

If coolant is lost while the bus is in use, and roadside emergency measures are called for, replenish the coolant with the same premix type and brand if possible. If the proper coolant is not available, and water must be used, use only de-ionized water if possible. Ordinary tap water should only be used if proper coolant or de-ionized water are not available.

Whenever tap water alone has been added, the bus should be taken to a service facility and the entire cooling system should be completely drained, flushed, and refilled with premix coolant.

FACTORY INSTALLED COOLANTS

Cummins, Fleetguard ES Compleat

Blue in color. Standard equipment coolant in all D3FE, D3RE, BBCV.

Considered standard-life coolant in Cummins engines.

Concentrate version may be mixed with the pre-mix version to lower freezing point.

AVAILABILITY

50/50 Premix

1 Gallon Container

2 1/2 Gallon Container

55 Gallon Drum

330 Gallon Tote

Concentrate

1 Gallon Container

Cummins, Fleetguard ES Optimax

Red in color. Optional coolant in D3FE, D3RE, BBCV, with Cummins engines.

Qualifies as extended-life coolant in Cummins engines.

Blue Bird installs 60/40 premix, which is not available in one gallon containers, but is available in larger containers (listed).

The 50/50 premix may be mixed with the concentrate version per Fleetguard's instructions to achieve 60/40 ratio.

Concentrate version may be mixed with the pre-mix version to lower freezing point.

AVAILABILITY

50/50 Premix

1 Gallon Container

60/40 Premix

55 Gallon Drum

275 Gallon Tote

Concentrate

1 Gallon Container

Coolant Fill Procedure

CAUTION ***Engine cooling system including body hearters must be completely filled.***

1. **Engine should be OFF.**

CAUTION ***Never run the engine when there is no coolant in the system. Otherwise severe engine damage could result.***

2. **If heating system is empty:** Open cab-heater supply valve (at top-rear of engine), but close cab-heater return valve (at transmission oil cooler on FE's or at water inlet housing on CV's). Otherwise keep both valves closed.

3. **If heating system is empty:** Open cab-heater bleeder valve, located on the cab-heater return valve housing. Place a clean bucket under the bleed valve opening to catch coolant. (Instead of bucket, could attach a small-diameter hose to bleed valve outlet and place free end of hose into coolant tank fill opening.)

4. Fill system to the Cold-Full line on the coolant tank. Keep pressure cap removed from the coolant tank after filling.

5. Allow system to settle for 5 minutes, then refill to Cold-Full line on coolant tank if necessary. Repeat until coolant level remains at the Cold-Full line.

6. **If heating system is empty:** Turn-on "ignition" key (but do not start engine), set defroster temperature control to full-hot, and turn on booster pump, if so equipped.

7. Start engine and idle for 1-2 minutes, keeping a close watch of the coolant level in the tank. **If the tank empties, shut off engine immediately.**

8. Refill the coolant tank to the Cold-Full line.

9. Restart the engine, idle for 1 minute, keeping a close eye on the coolant level. Run engine up to its governed speed, still keeping eye on the coolant level in the tank at all times. **If the tank empties, shut off engine immediately;** return to step 8.

10. **If filling heater system:** When a steady stream of coolant is emitted from the heater bleeder valve, close the bleeder valve and open the cab heater return valve. If emitted coolant in bucket s clean, save to add to the system later.

11. Run the engine at its governed speed for at least 5 minutes, or until the engine thermostat opens a couple times (at 190°F-195°F, which is slightly past the gauge mid-point (180°F) towards "H" (260°F)). This should take no more than 15 minutes.

12. Reduce engine speed to low-idle and check coolant level in tank. If below the Cold-Full line, add coolant until the level is back at the Cold-Full line.

13. Increase engine speed to governed and run for 10 minutes, then reduce engine speed to about 1,600 rpm and run for another 10 minutes.

14. Return engine to idle and check coolant level in tank; add coolant as necessary.

15. Install pressure cap. Cooling system is now fully operational.

Heater Cut Off Valves

The Blue Bird Vision is equipped with two cutoff valves which can be used to isolate the heaters portion of the coolant circuit from the engine portion. These valves may be used to minimize spillage when performing maintenance tasks between coolant changes, such as replacing a damaged coolant hose. Both valves must be open when bleeding air from the heater circuit.

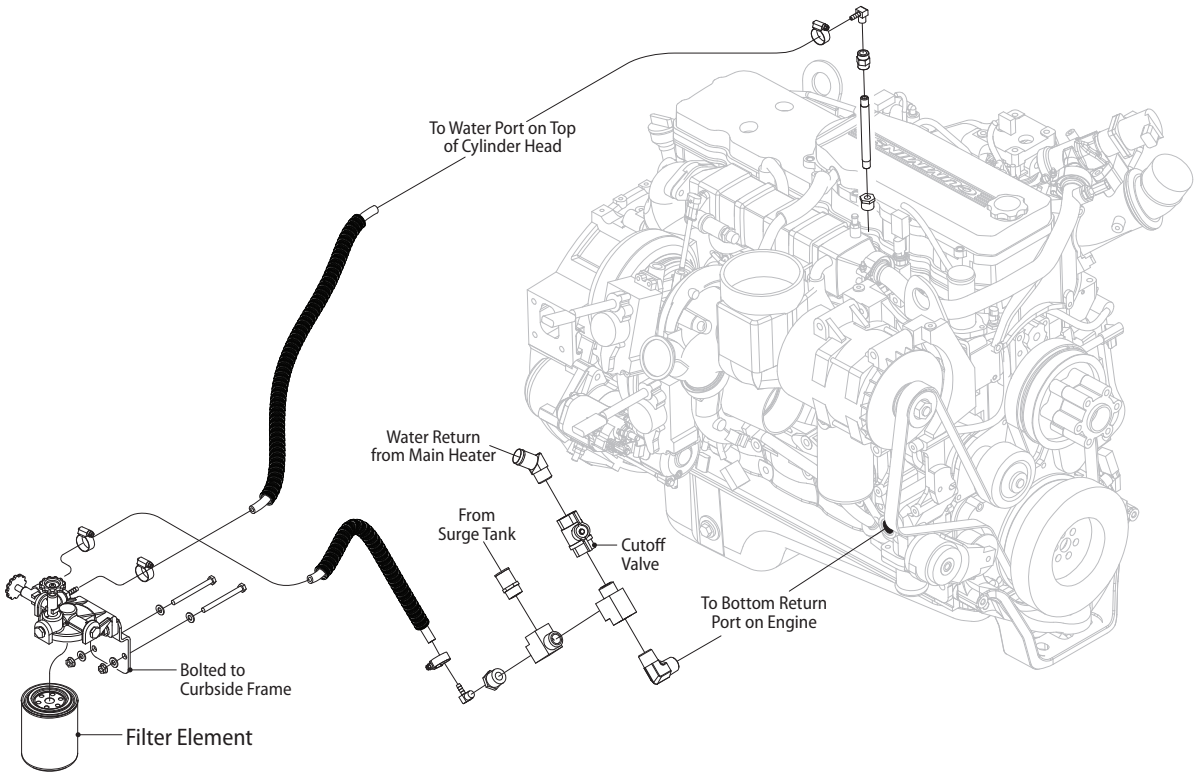
Heater Cut Offs

Top right side of engine

Lower right side of engine

Coolant Filter

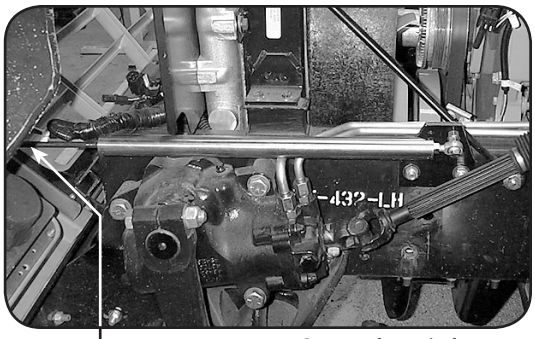
If the unit under repair is equipped with a water filter, the paper cartridge must be replaced at 1,000 hour/6 month intervals. Use Blue Bird p/n 00064641. Do not use filter cartridges with Supplemental Cooling Additives (SCAs).



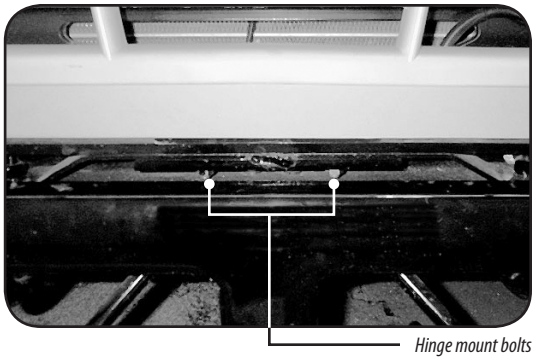
Perry Water Filter *Optional*

Radiator

Removal



Disconnect front ends of gas springs.


Hinge mount bolts

1. Disconnect the headlight wiring harnesses.
2. Remove the gas springs from each side of the hood.
3. Remove 2 bolts at the center of the hood, just above the bumper. (Remove the holding bracket, hinges and hood as an assembly.)
4. Remove the drain plug from the transmission to drain the fluid into a suitable container.
5. Remove the transmission cooler hoses at the transmission to drain the fluid into a suitable container, observing all applicable local, state and federal laws concerning disposal of hazardous fluids. If the adapter fittings are removed from the bottom of the radiator, mark the orientation to aid at assembly.
6. Remove the transmission cooler hoses from the radiator.
7. Using the petcock at the lower left-hand (driver's) side of the radiator, drain the engine and radiator of coolant into a suitable container.
8. Remove the 4 nuts and bolts from the engine air intake grille.
9. Remove the air intake piping completely or ensure that it is secured out of the way.

CAUTION ***Cover all openings in the engine, transmission, and radiator as they are opened. Plug all removed tubing, hoses and piping to prevent contamination.***

10. After removing all the hoses and piping, remove 2 capscrews from each corner of the fan shroud assembly.
11. Pull the shroud as far rearward (over the fan) as possible. Allow the shroud to hang over the fan blades. If the vehicle is equipped with shutters, see the instructions for their removal below.
12. Remove the capscrew from each side of the radiator.

13. Remove and discard the locknut at each support assembly, where it attaches to the frame rail. Store the support out of the way.

14. Remove and discard 2 locknuts from the isolator at each side of the radiator.

15. Carefully lift the radiator clear of the frame rails. Ensure the fins on the radiator and charge air are protected.

Reintallation

Both baffles must be in position and their respective seals in place for the cooling system to perform correctly.

When installing the radiator isolators, exercise care to orient the 20 mm edge distance toward the front of the bus. If the 35 mm edge is installed toward the front, there will not be space for the fan shroud and shutters.

When installing the fan, use 4 new split-ring lock washers. Torque the capscrews to 33–58 ft. lbs. (44.74–78.64 Nm). Ensure the fan blades are oriented to produce airflow through the radiator and toward the engine when rotated counter clockwise.

1. Position the fan shroud over the fan as far as possible.

2. Centering the assembly, carefully position the radiator onto the isolators at each frame rail. Torque new locknuts to 29–33 ft lb (39.32–44.74 Nm), at 4 places.

3. Position and install the radiator braces (14). Torque all 4 fasteners to 70–80 ft lb (94.91–108.47 Nm). Use new Grade 8 locknuts at the frame rail.

4. Position and install the transmission fluid cooler hoses to the bottom of the radiator. Ensure the hoses are in the proper position. The left (driver's) side transmission hose connects to the driver's side of the radiator. Ensure that the protective loom is installed on the transmission lines. The threads in the bottom of the radiator are National Pipe Threads (NPT). These threads require the application of Loctite 557™ pipe sealant with Teflon™. Follow the directions and warnings on the package. Start the fitting 1 thread into the proper location, and then apply the sealant. Torque to 70–77 ft lb (94.91–104.40 Nm).

5. Install the transmission drain plug. Torque to 22–30 ft lb (30–40 Nm).

6. If so equipped, position the shutter assembly onto the radiator.

7. Position the shroud onto the radiator and shutter assembly.

8. Loosely install 2 capscrews at each corner.

9. Turn the fan blades by hand. Ensure that the blades are centered in the shroud and do not touch at any point.

10. When the fan blades are centered in the shroud, torque the 8 fasteners to 30–38 ft lb (40.67–51.52 Nm).

11. Install the bottom coolant hose. Torque clamps to 5 ft lb (6.8 Nm).

12. Install the upper coolant hose; torque the clamp to 5 ft lb (6.78 Nm). Ensure the protective loom is installed on the top radiator hose.

13. Route the intake charge air tube over the radiator hose and install to charge air cooler. Torque clamp to 5 ft lb (6.78 Nm).

14. Install the charge air tube from the turbo outlet to the curb side charge air cooler fitting. Torque the clamps to 5 ft lb (6.8 Nm).

15. It is important that the baffles and their seals are properly positioned. Torque fasteners to 5–6 ft lb (6.78–8.13 Nm).

16. Install the hood in the reverse order of its removal. Torque the hinge fasteners to 25–37 ft lb (33.90–50.17 Nm).

17. Torque the gas assist spring fasteners to 16–18 ft. lbs. (21.69–24.40 Nm).

Fan Clutch

The Blue Bird Vision fan clutch is a Horton direct sense viscous fan clutch which combines a traditional viscous fan drive with an on/off fan clutch controlled by the engine ECM.

The same engine drive belt that spins the water pump and alternator also spins a Horton fan drive assembly which is bolted to the front of the engine block. The shaft of the fan clutch is bolted to the hub of the fan drive assembly and a 25" cooling fan is bolted to the hub of the fan clutch. During engine operation, the drive belt spins the drive hub which spins the shaft of the fan clutch. At low engine temperatures, the internal resistance of the viscous fan clutch causes the fan clutch hub and fan to rotate at approximately 40% of the input rpm. Upon detecting the designed engine operating temperature of approximately 195° F, the engine ECM signals the fan relay, which signals the fan clutch to engage the fan. This engagement of the fan clutch results in the fan turning at the same rpm as the engine; thus providing maximum air flow through the radiator core. The fan clutch and control wiring are designed to allow for the fan to remain engaged or "on" in the event of power loss to the fan circuit; the fan relay must supply power to the fan clutch control coil to disengage the fan.

A single two circuit - power and ground - wiring connector is used to make connections with the engine wiring harness (see schematic, wiring, engine). The fan clutch wiring harness routes along the anti-turn bracket from the engine to the control collar of the fan clutch assembly.

Removal

The fan clutch is assembled to a mounting bracket which bolts to the front of the engine. The fan clutch can usually be removed with the fan still attached, by removal of the Charged Air Intake tube on the left side of the engine compartment and unbolting the fan clutch from the drive hub.

1. Loosen the clamps at each end of the Charge Air Intake Tube and remove the Charge Air Intake Tube. Cover the open ends to prevent contamination.

2. Disconnect the electrical connector from the engine wiring harness and remove the fasteners connecting the anti-turn brace to the engine mounted anti-turn bracket.

3. Remove the four bolts which mount the fan clutch to the drive hub.

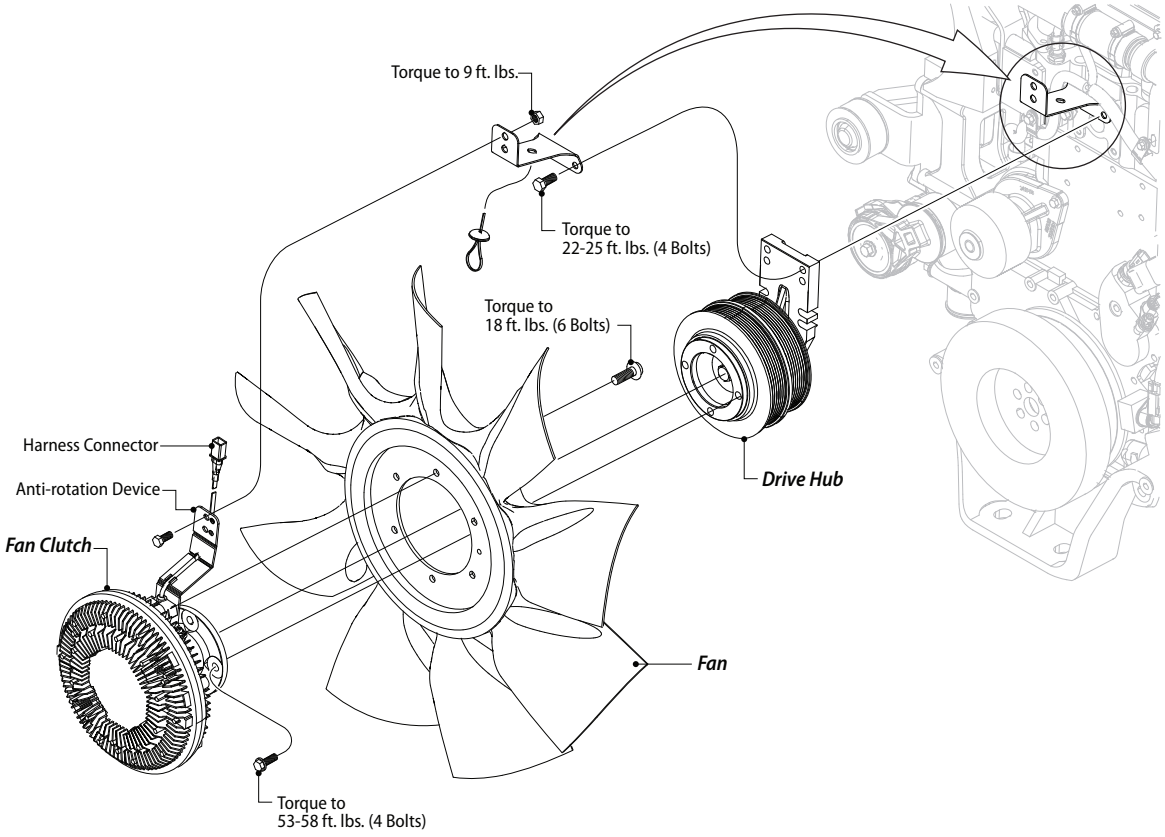
4. Carefully maneuver the fan, with clutch and bracket attached, out toward the driver's side of the engine compartment.

5. To remove the fan from the clutch assembly, acquire assistance in holding the fan at several places while removing the six bolts which fasten it to the fan clutch assembly.

Reinstallation

Reinstall in reverse order of the removal procedure, using these torque values when reassembling:

Fan clutch to drive hub:	53-58 ft. lbs. (71.8-78.6 Nm.)
Anti-rotation device to bracket:	9 ft. lbs. (12.2 Nm.)
Fan to fan clutch:	18 ft. lbs. (24.4 Nm.)
Drive hub to engine:	22-25 ft. lbs. (29.8-33.9 Nm.)



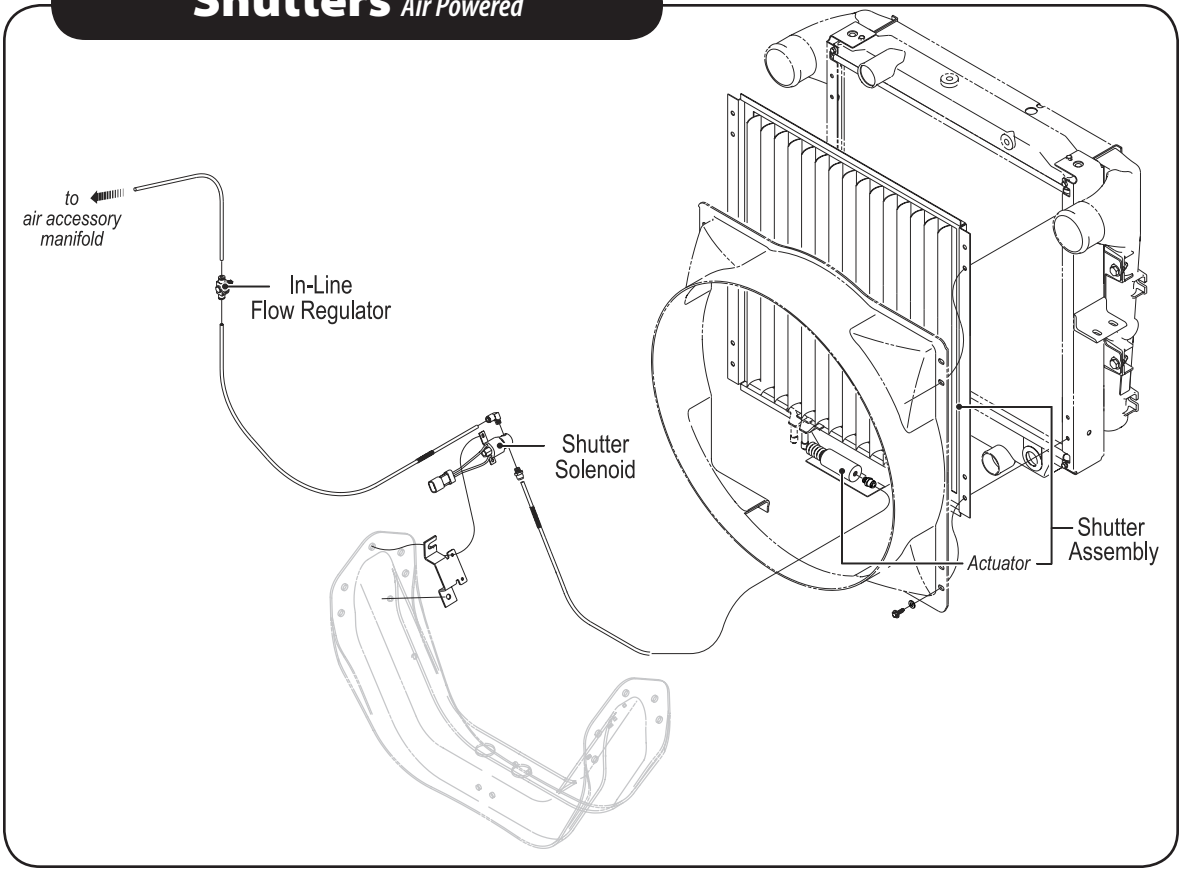
Shutters

Your Blue Bird Vision may be equipped with a shutter system to help with temperature control in colder climates. The shutters are spring-loaded and are normally open. When the operating temperature of the engine falls below the recommended range, the shutters close to prevent air flow through the fins of the radiator. Shutters may be hydraulically operated or pneumatically operated.

The shutter system requires little maintenance, but should be lubricated and checked routinely for smooth operation. If debris or corrosion is allowed to collect in the mechanism, it can bind or jam the shutters, preventing them from opening, and leading to engine overheating.

The shutter assembly is installed between the radiator and the shroud and the 8 bolts that attach the shroud fasten it. The actuator assembly is located at the bottom center of the shutter assembly and is controlled by a valve located on the frame rail inside the front deep–U cross member. This valve is controlled by 185° Alarmstat controls located in the Charge Air (CA) pipe, between the CA cooler and the engine intake, and in the thermostat housing on the engine. There is no practical method to check the operation of the Alarmstats. If they are suspected of malfunctioning, substitution is the method of testing.

Shutters *Air Powered*

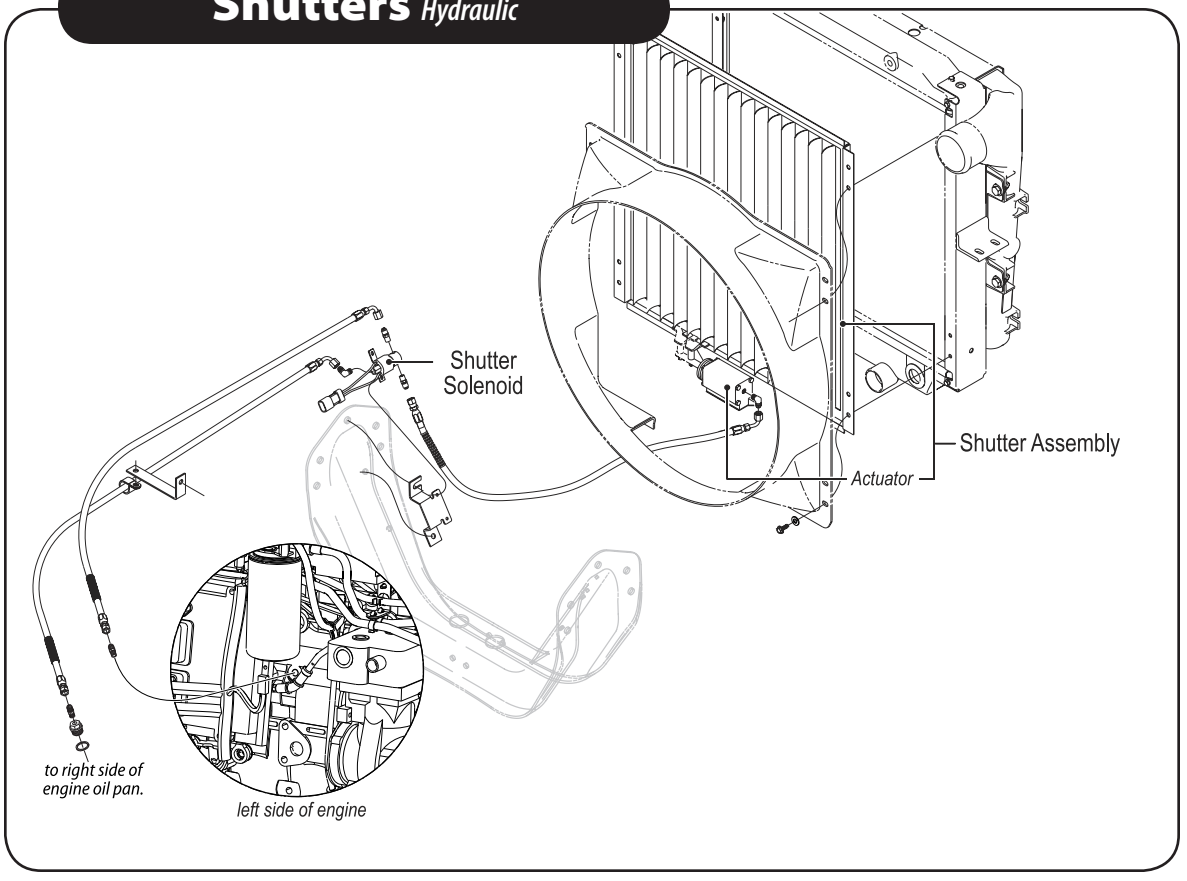


Removal

1. Remove the actuator supply tube from the shutter actuator.
2. If necessary, remove the top radiator hose.
3. Remove the 2 capscrews from each corner of the shroud/shutters assembly.
4. Carefully lift the shutters assembly from the unit.

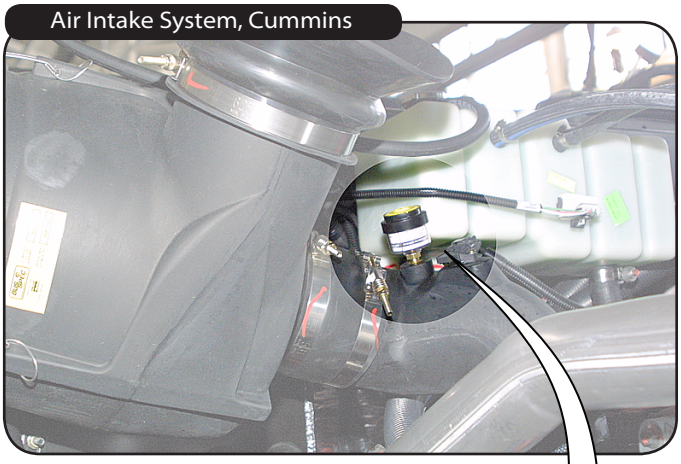
Shutter installation is accomplished in the reverse order of the removal instructions.

Shutters *Hydraulic*



Intake System

Air Intake System, Cummins

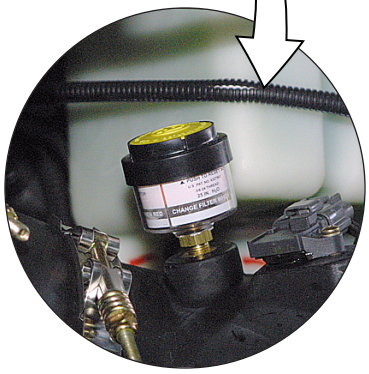


Clean air is necessary for efficient fuel combustion and for normal engine life on any engine, and even more so for turbocharged engines like the Cummins ISB. Because intake air is forced into the intake manifold under pressure, both the volume and velocity of air flow is greater than in a naturally aspirated engine. Any opportunity for airborne contaminants to enter the intake flow represents a potential for serious damage to engine life. Therefore, careful inspection of the entire intake tract should be a part of regularly scheduled maintenance, and any signs of dust or debris entrace must be repaired immediately.

Fresh air enters the intake duct through vents built into the engine hood. The air enters a canister-type air filter mounted on top of the engine's right side, immediately above the engine's turbocharger. The filter element is of dry pleated fiber type and is easily accessible for replacement without tools, and without removal of any other chassis components or brackets. The element must be replaced when dirty, not cleaned and re-used.

After passing through the filter element, fresh air enters the turbocharger though a short plastic duct on the left side of the filter cansiter. A pressure-sensing restriction indicator mounted on this duct provides a visual alert in the case of restriction of the air flow entering the turbocharger.

The turbocharger compresses and forces the air through a metal pipe with rubber seal joints at each end into the Charge AIr Cooler mounted to the front of the engine's radiator. The air leaves the Charge Air Cooler through a similar piping arrangement on the left side of the engine, which directs it into the intake manifold.



Air Restriction Indicator (Cummins shown)

Normal reading. Some fluctuation while the engine is running is acceptable.

At a vaccuum of 25 inches H_2O, the red piston locks, indicating that the air intake tract is too restricted.

Air Restriction Indicator

The Air Restriction Indicator is visible from the right side of the bus when the engine compartment hood is raised. During engine operation, the indicator monitors vaccuum pressure inside the air filter elbow. As vaccuum increases, the indicator's red piston becomes visible through the clear portion of the housing indicating that air flow is being restricted by a clogged filter, debris, or other obstruction. The Air Restriction Indicator is variable until the monitored vaccuum increases to a measure of 25 inches H_2O. At that measure, the red piston fills the clear portion, and locks in its position. The indicator must then be manually reset by pressing the reset button after the restrictive condition has been corrected.

CAUTION ***The Air Restriction Indicator activates only when an air flow restriction has occured. A normal reading (no red showing) must not be misunderstood as an indication that the air filter is clean, and does not preclude the need for other inspection and maintenance. For example, a leak in the intake will allow damaging debris to enter, but will not be indicated by the Air Restriction Indicator.***

Filter restriction and proper operation of the indicator may be verified by pressing the reset button on the top of the indicator. If restriction is occurring, the red indictor will move when the engine is under load. The indicator will lock in position if the monitored vaccuum increases to 25 inches H_2O.

It is important to understand that the Air Restriction Indicator does not detect leaks, and will not properly indicate restrictions in a leaking intake system. Check for leaks in all inlet hoses, tubes and connections. If a leak is found, correct it immediately, using original replacement parts and torqing all clamps.

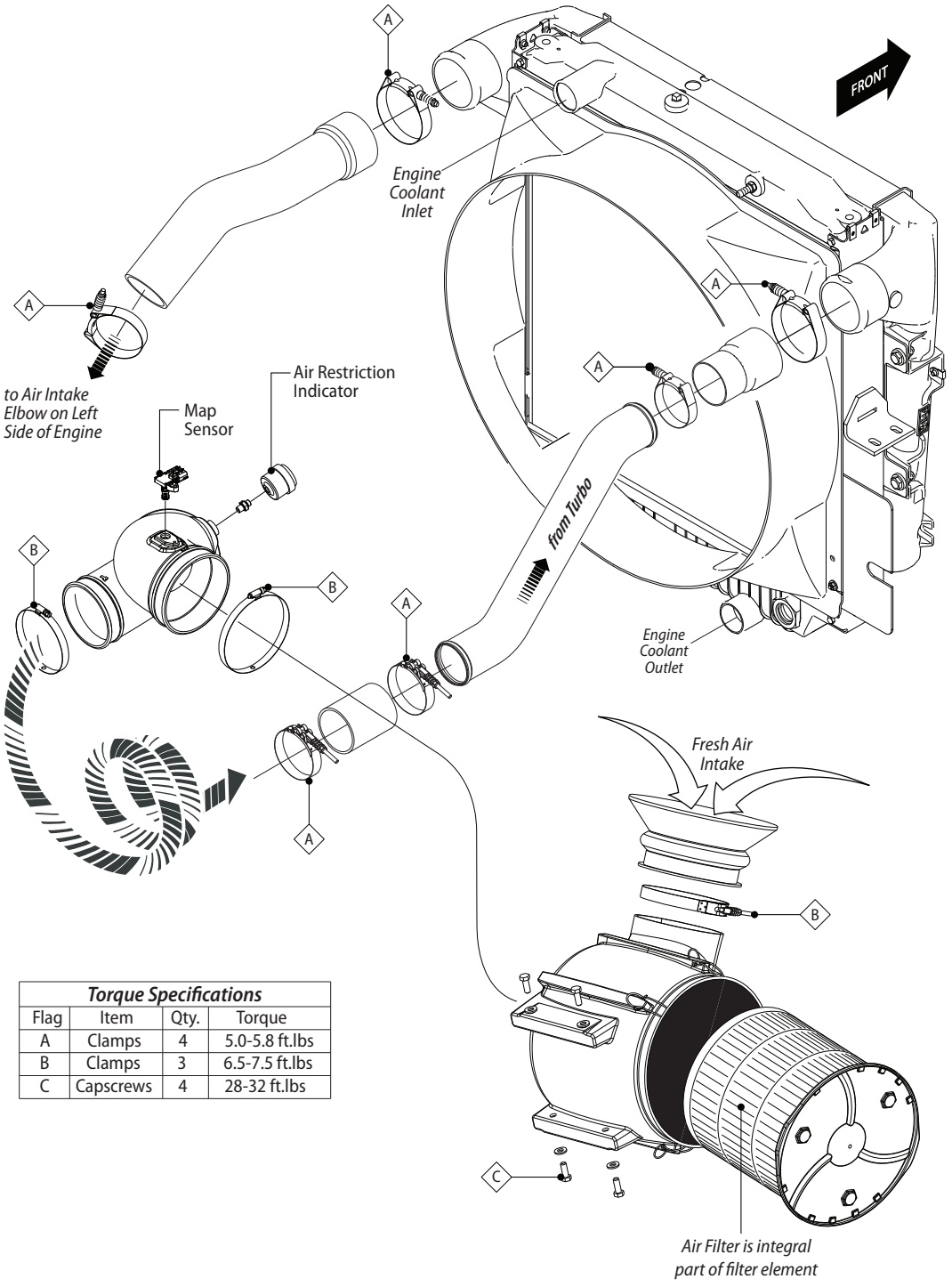
The Air Restriction Indicator can also be tested using a calibrated vacuum gauge and vacuum pump. Check the full range of the indicator, and verify that the red indicator locks into position at 25 inches H_2O. The Air Restriction Indicator is not repairable, and should be replaced if found to be operating incorrectly.

Charge Air System

The turbocharger of the engine uses the heat energy in the exhaust gases to compress the intake tract's filtered air on its way to the intake manifold, thereby delivering a denser charge of air into the combustion chambers, improving combustion and increasing horsepower.

Immediately after leaving the exhaust manifold, and before continuing on to the exhaust system, exhaust gases pass through the turbine chamber of a turbocharger unit mounted on the right side of the engine. The spinning turbine shaft passes through a seal into the impeller chamber, where it drives the impeller vanes. The turbine and impeller sides of the turbocharger are sealed, preventing exhaust gasses from mixing with fresh intake air. The impeller draws fresh air which has passed through the air filter, and compresses it. The compressed air leaves the impeller chamber and is routed through sealed tubing to the Charge Air Cooler, mounted immediately in front of the engine radiator. The Charge Air Cooler is a separate radiator which allows the heat of the compressed air to dissipate to the atmosphere. The compressed and now cooled air proceeds from the Charge Air Cooler through tubing to the left side of the engine where it enters the intake manifold.

Air Intake System



Torque Specifications			
Flag	Item	Qty.	Torque
A	Clamps	4	5.0-5.8 ft.lbs
B	Clamps	3	6.5-7.5 ft.lbs
C	Capscrews	4	28-32 ft.lbs

Intake System Maintenance

Although it is a simple system, dilligent maintenance and inspection of the air intake tract is critical to not only proper performance, but also to engine life and warranty compliance. Any leak along the various tubings and clamped joints of the intake tract, including the charge air track, is an opportunity for the engine to ingest abrasive dirt or contamination into the valves and combustion chambers under pressure. Never run the engine with the air cleaner or its filter element removed. Use only original replacement parts to avoid poor fit and consequent air leakage. Visually inspect the intake tract whenever working in the engine compartment. and follow the scheduled maintenance guidelines in the Specs & Maintenance chapter of this manual as a minimum.

CAUTION ***The intake system inspection and maintenance intervals indicated below are guidelines which assume normal operating conditions. Appropriate service intervals vary according to operating conditions. In dusty or high humidity environments, more frequent service may be required.***

General Inspection

Under normal operating conditions, inspect the Air Restriction Indicator daily (more frequently in dusty high humidity conditions). Inspect the air intake system every 3 months or 5000 miles. Inspect the system for:

- Air Restriction Indicator. If red indicator is visible, replace the air cleaner element, and check the system for debris and other restrictions.
- Clamps. Tighten loose clamps and check for proper fit and seal. Replace if corroded, broken or otherwise damaged.
- Ducts and piping. Inspect for wear, damage, or abrasion.
- Air cleaner element. Replace if soiled, wet, torn, or otherwise damaged. Ensure proper installation and seal.
- Mounting brackets. Check for loose or damaged mounts.
- Charged air system piping. Tighten loose clamps. Check for wear spots and holes in the piping.
- Air compressor inlet lines. Tighten. Check for wear or other damage.

Clamps should be tightened to the following specifications:

Spring-loaded clamps. ***Tighten to near full spring compression.***

T-Bolt clamps. ***Tighten to 50 in. lbs. (5.6 Nm).***

Worm gear clamps. ***Tighten to 38–42 in. lbs. (4.2–4.7 Nm).***

Hose clamps already in service. ***Tighten to 10 in. lbs. (1.1 Nm).***

Air Cleaner Element

Unlatch the four clips and lift out the filter element. The lid is an integral part of the element.

Air Filter Element Replacement

Replace the air filter element at least once a year, and whenever the Air Restriction Indicator has been activated (shows red). Other indicators of a dirty air cleaner element include loss of power or excessive exhaust smoke. To replace the air cleaner element:

1. Unlatch the four quick release latch clamps holding the lid to the top of the air filter housing.

2. Remove the lid to expose the air cleaner element.

3. Pull the air cleaner element straight out of the filter housing. A rotating or rocking motion may help unseat the element.

4. Before replacing the element, inspect all clamps, hoses, piping and seals.

   - Inspect inside the intake elbow for signs of dust or debris finding its way into the system through leaks. Replace any damaged components allowing the leak, and clean the debris inside the elbow and ducts before installing a new element.

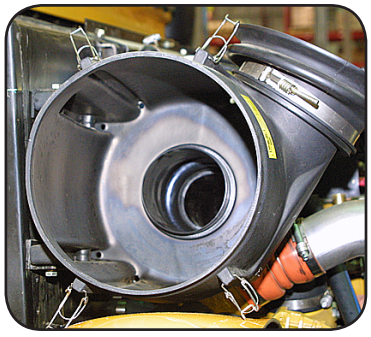
   - If evidence of leaks is found, check the tube between the charged air cooler and the engine intake for contamination. If contamination is found, the charged air cooler should be replaced.

5. Install a new air cleaner element, fully seating its bottom seal.

6. Assemble removed parts in reverse order of disassembly.

7. Replace the filter housing top. Ensure it is properly seated, and secure with the four quick release clamps. If necessary, a clamp's tension may be tightened by using pliers to carefully shorten its curve.

8. Reset the Air Restriction Indicator by pushing the reset button. This will allow the indicator to monitor the newly installed components.



The element fits snuggly around its bottom seal. A gentle rocking or rotating motion will help unseat it.

With the element removed, check the inside of the elbow for any sign of contamination due to leaks before replacing the element..

About 2010 Exhaust Emissions

In 2010, emissions requirements changed for all on-road vehicles equipped with a diesel engine. Both Nitrogen Oxide (NOx) and particulate matter are reduced by 90% from 2004 levels. Specifically, NOx was reduced to 0.2-g/hp-hr while the particulate standard was reduced to 0.01-g/hp-hr. The Environmental Protection Agency (EPA) allowed for NOx phase-in from 2007 through 2009. During this time 50% of the engines produced met the 0.2-g/hp-hr NOx standard, while 50% continued to meet the 2.5-g/hp-hr NOx+NMHC standard. Most engine manufacturers used the NOx phase-in provisions along with averaging to certify engines to a NOx value roughly halfway between 2.5-g/hp-hr NOx+NMHC and the 0.2-g/hp-hr NOx levels through 2009. This calculates to approximately 1.2-g/hp-hr NOx. Beginning in the 2010 emission compliant engines, 100% of the 0.2-g/hp-hr standard for NOx must be met.

The PM level was not phased in, and thus all engine produced were required to be at 0.01-g particulate matter beginning January 2007. In addition to the lower NOx and particulate matter levels, crankcase gases are also included in the emissions measurements. This requirement has driven closed crankcase systems in 2007 or ultra-low emissions from open systems. In open systems crankcase gases are vented into the atmosphere through a breather/filter tube arrangement. Closed systems reroute crankcase ventilation gases from the breather tube back into the engine intake airflow to be used for combustion.

On-Board Diagnostics (OBD)

Beginning in 2010, the California Air Resources Board (CARB) requires engine manufacturers to phase in On-Board Diagnostics (OBD) on their highest-volume heavy-duty engines. By 2013 all engines including the ISB and ISC produced will have to be OBD-compliant per CARB requirements. It is expected that the EPA will have the same OBD requirements as CARB beginning in 2013. The CARB is also requiring engine manufacturers to comply with a new Service Information Regulation (SIR). In essence, the SIR requires that engine manufacturers provide the necessary troubleshooting, maintenance and service information to third-party service centers as well as to their own service channel. This approach should allow customers to have access to proper diagnosis and repair of their engine to ensure that the engine remains in emissions compliance for the life of the engine.

The OBD system detects emissions-related malfunctions, alerts the operator of the bus to the detected malfunction, stores diagnostic records of the malfunction and supports off-board communications to a diagnostic service tool (e.g., scan tool) to allow the efficient service and maintenance of your bus. The Service Information Report makes it possible for the aftermarket service centers as well as the engine manufacturer's support centers to service and maintain the emissions control systems to their proper performance levels.

Fuel and Lubricating Oil Requirements

The EPA has lowered the limit for sulfur in diesel fuel from 500 parts per million (ppm) to 15 ppm. This fuel standard was phased in beginning October 1, 2006 (80% participation) through September 1, 2010 (100% participation). In 2010, all indications show that 15-ppm Ultra-Low Sulfur Diesel (ULSD) fuel is widely available. Use of ULSD fuel is critical for proper performance of exhaust aftertreatment systems. Beginning in 2007, all heavy-duty, mid-range and light-duty diesel engines are required to operate using ULSD fuel.

Biodiesel is growing in popularity which is why Cummins Engines are capable to operate on B20 biodiesel. Refer to the Cummins service literature or service center for more information.

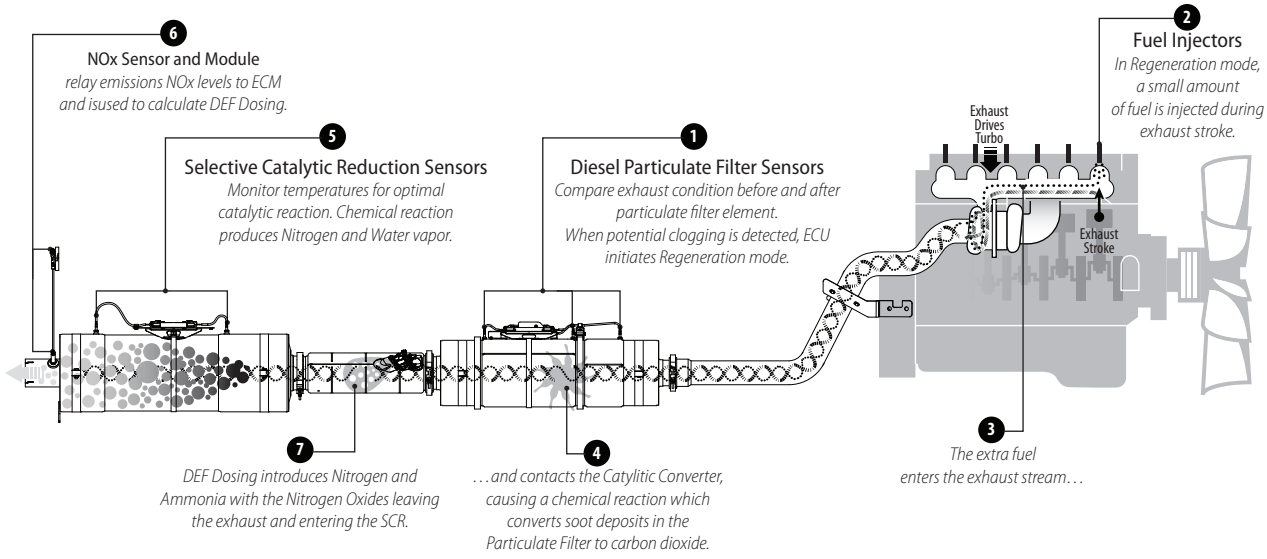
New specifications have been released for lubrication oil compatible with low-emissions engines for 2007-2010. The primary focus has been to make the oils compatible with exhaust aftertreatment devices (e.g., diesel particulate filter). In 2007 the requirement had been to reduce ash in the oil in order to enable extended maintenance intervals on the diesel particulate filter while maintaining the important lubricity capability of the lubricant. The low-ash oil classification (CJ-4) that was released for 2007 on-highway emission compliant engines must also be used in the 2010 emission compliant engines. A new oil classification is not required for 2010.

Integrated Cooled EGR

Cooled Exhaust Gas Recirculation (EGR) technology, introduced in 2002 to meet the 2.5-g/hp-hr NOx+NMHC standards, created the foundation for the EPA 2007 and EPA 2010 products. Cooled EGR is very effective at reducing NOx levels. The EGR system takes a measured quantity of exhaust gas, passes it through a cooler before mixing it with the incoming air charge to the cylinder. The EGR adds heat capacity and reduces oxygen concentration in the combustion chamber by diluting the incoming ambient air with cool exhaust gases. During combustion, EGR has the effect of reducing flame temperatures which, in turn, reduces NOx production since NOx is proportional to temperature. This allows the engine to be tuned for the best fuel economy and performance at lower NOx levels. EGR was used to attain the NOx levels introduced in 2007 and in current 2010 engines. In order to control both NOx and particulate emissions accurately, the amount of recirculated exhaust gas and air has to be precisely metered into the engine under all operating conditions.

This has driven the use of advanced Variable Geometry Turbochargers (VGT) that continuously vary the quantity of air delivered to the engine. The VGT features a one-piece sliding nozzle which moves continuously to vary the power of the turbine and the amount of air delivered to the engine. It is used in concert with an EGR control valve to accurately meter the EGR into the intake system

Cummins Exhaust



Exhaust System

New federally mandated emission standards affect all buses equipped with 2010 emission standard engines. The exhaust systems for Cummins engines in Blue Bird buses are aftertreatment systems which incorporate a Diesel Particulate Filters (DPF), a Decomposition Reactor and a Selective Catalytic Reduction (SCR) system instead of ordinary mufflers. This sophisticated exhaust system reduces emissions by trapping particulate matter (soot) and reducing the level of NOx (nitrogen oxides) in the exhaust stream.

As the exhaust leaves the turbo on the engine it is first channeled through the DPF. The DPF contains a filter which traps the particulate matter in the exhaust stream. The rate at which the soot accumulates is dependent upon multiple conditions including the quality of the diesel fuel, type of engine oil, ambient temperature, engine load, and other factors. Over time, the trapped particulate matter accumulates in the DPF filter and must be removed through a process referred to as regeneration. Regeneration uses heat to convert most of the trapped particulate matter in the filter into carbon dioxide, and leaves behind a small amount of ash. Regeneration is conceptually similar to the cleaning mode of a self-cleaning oven in that heat removes the accumulated soot.

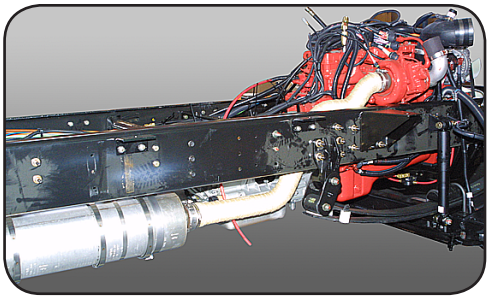
CAUTION ***In 2010 diesel engines, use only diesel fuel labeled Ultra Low Sulfer, per the engine manufacturer's specifications.***
Use oils meeting API CJ-4/SL and Cummins Engine Standard CES-20081. See Cummins Owners Manual ISB 6.7L CM2150 for details.

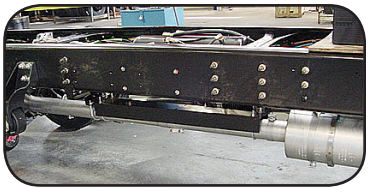
As the exhaust leaves the DPF it enters a decomposition reactor where a fine mist of Diesel Exhaust Fluid (DEF) is sprayed into the exhaust stream. The DEF vaporizes in the decomposition reactor converting it into Nitrogen and Ammonia. This exhaust mixture then leaves the decomposition reactor and enters the SCR catalyst which prompts a chemical reaction. The harmful NOx in the exhaust combines with the ammonia (NH_3) to form harmless nitrogen (N_2) and Water Vapor (H_2O). Because of the higher operating temperatures involved, the exhaust system components are insulated from other chassis components.

Engine-Specific Technologies

Although the purpose and general principles of aftertreatment exhaust systems are similar among engine manufacturers, both the terminology and the mechanisms to perform "active" regeneration differ. Cummins has developed unique technologies for accomplishing and controlling the active regeneration process. The engine-specific ECMs which control the process are also different. Engine manufacturers differ in the construction of the DPF units, the exhaust flow paths, and other related components. It is for these reasons that the service technician must now regard that portion of the exhaust system from the engine to the outlet port of the SCR system as part of the engine package itself.

This chapter provides conceptual explanations of the Cummins systems. However, the service technician must refer to the engine manufacturer's operators' manual and service literature regarding service and maintenance of the 2010 exhaust system.





The exhaust systems of 2007 and newer engines incorporate engine-specific Diesel Particulate Filters, which operate at higher temperatures during their Regeneration cycles. The front exhaust pipes are insulated, and heat shields are installed at locations along the exhaust tubing.

Exhaust Aftertreatment

2010 emissions standards-compliant Cummins engines incorporate an Aftertreatment System. The first part of the aftertreatment system is to trap particulate matter (soot) in the DPF filter. As the soot accumulates on the filter it must be cleaned to prevent backpressure. Cleaning is accomplished with heat created through regeneration. Regeneration occurs in three ways:

- Some regeneration occurs "naturally" whenever operating conditions (speed, engine load, etc.) result in exhaust system temperatures high enough to oxidize accumulated soot. Terminology differs between engine manufacturers, but this unassisted regeneration mode can generically be referred to as "passive" regeneration.
- Regeneration can be caused by raising the temperature of the exhaust system. A set of sensors mounted on the DPF assembly enable the Electronic Control Module (ECM) to monitor the buildup. The ECM then automatically activates and de-activates a system designed to increase exhaust temperature when the ECM senses that regeneration is needed, and when certain requirements, including a minimum travel speed, are met. This automatic "heat assisted" mode can be generically referred to as "active" regeneration.
- Regeneration can be manually activated by means of a switch. This procedure is generically referred to as "stationary" or "manual" regeneration, and should only be performed by or under the direction of a qualified service technician, and in a controlled environment to avoid the potential for human injury or fire hazards.

The ECM communicates the need for regeneration to the driver by a set of visual and audible signals in the instrument cluster. An additional alert, the High Exhaust System Temperature (HEST) indicator, notifies the driver whenever exhaust system temperature is high due to recent regeneration. Periodically, the normal ash accumulation which results from the regeneration process must be removed from the DPF using equipment designed for that purpose at qualified engine service facilities. Refer to the engine manufacturer's documentation for these service intervals.

Cummins Passive Regeneration

When driving at high speeds or with heavy loads, the exhaust system is hot enough to turn soot accumulation inside the DPF into carbon dioxide. Temperatures generated in this mode are comparable to those of pre-2007-standards engines.

At moderate and continuous speeds or engine load conditions, normal exhaust temperatures may be maintained at a high enough level for normal operation to prevent additional accumulation. At moderate-to-heavy operating conditions, normal exhaust heat may be high enough to reduce accumulated soot levels.

Cummins Active Regeneration

Accumulation occurs most at low speeds and relatively low temperatures. Frequent stop-and-go and continual low-speed operation typical of some school bus routes may not always generate sufficient heat to keep the particulate filter clear.

Sensors monitor the pressure differential before and after the DPF, and also monitor temperature. The pressure and temperature data is communicated to the ECM. When the pressure / temperature readings indicate that the particulate filter is beginning to become restricted, the ECM may signal the system to enter an Active Regeneration mode.

During Active Regeneration, a small amount of fuel is injected into the exhaust stream by the engine's fuel injector during the engine's exhaust stroke. This fuel reacts with the diesel oxidation catalyst in the DPF, raising the temperature of the exhaust flow sufficiently to remove the accumulation. This process activates and deactivates automatically as-needed during normal operation.

Active Regeneration begins only if DPF accumulation has reached a certain level and if the bus is moving above a preset speed threshold (approximately 40 mph). If the bus is operated above the speed threshold long enough, the soot accumulation on the filter clears and Active Regeneration mode stops automatically.

If the bus is slowed to below a certain speed threshold while in Active Regeneration mode, the Active Regeneration stops, even if the cleaning process has not completed. If the bus slows or stops while the exhaust system temperature is still high due to recent Active Regeneration, the High Exhaust System Temperature (HEST) indicator appears on the driver's instrument panel to notify the driver that the exhaust system temperature is elevated.

Cummins Stationary Regeneration

Active Regeneration removes the accumulation at an increased rate. However, each time the bus slows to below the speed threshold, and each time exhaust temperature drops to levels insufficient for soot to be cleared, accumulation may increase.

Depending upon the operating conditions, there may not be sufficient opportunity or duration for either Passive Regeneration (normal running) or Active Regeneration (ECM initiated) to keep the filter clear therefore a Stationary Regeneration must eventually be performed. Stationary Regeneration is initiated with the use of a manually activated switch

During Stationary Regeneration, temperatures inside the exhaust can exceed 1300°F. Stationary Regeneration must be performed in a controlled environment where precautions are taken to avoid any hazard that might result from the elevated temperatures. Blue Bird strongly recommends that Stationary Regeneration be performed only by, or under the supervision of a qualified service technician. Read carefully the section titled **Stationary Regeneration Precautions**.

Stationary Regeneration is initiated by means of a momentary toggle switch. Operating the switch starts a Stationary Regeneration only if certain conditions are met: The ECM must have indicated that Regeneration is needed (as indicated by the appearance of the DPF indicator). The bus must be stopped with the parking brake on, the engine must be running and the transmission must be in Neutral. During a Stationary Regeneration procedure, the process is monitored and controlled by the engine ECM. Depending on the severity of the restriction, the engine may raise its idle speed. The Regeneration process continues until the filter is clean, and then the process stops automatically. The bus may then be returned to normal service. (For more information, see **DPF Regeneration**.)

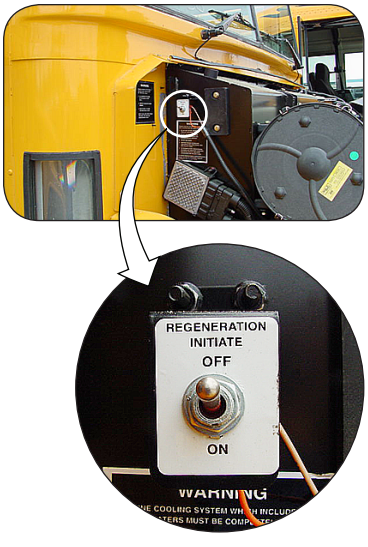
Cummins Exhaust Gas Recirculation

In the Cummins ISB engine, a portion of the exhaust is returned to the engine intake which adds an inert gas and reduces emissions. A device on the engine exhaust routes a small amount of the exhaust through a cooler, mixes it with fresh air, and re-introduces it into the intake stream. This helps lower the temperature during combustion, which reduces the formation of Nitrogen Oxides (NOx).

WARNING ***The aftertreatment regeneration process can cause extremely high exhaust gas temperatures hot enough to ignite or melt common materials, and to burn people.***

Carefully read, understand, and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual (and other related engine manufacturer's literature) regarding safe operation when the HEST indicator is on.

Carefully read, understand, and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual (and other engine manufacturer's literature) regarding safety conditions when performing Stationary regeneration.



Regeneration switch for use by Service Technicians performing Stationary Regeneration only in a controlled, fire-hazard-free environment.

DPF Regeneration

As with most new mechanical processes, the introduction of more sophisticated exhaust systems in 2007 and 2010 emission standard-compliant engines, a higher degree of understanding is required to troubleshoot these systems. Engine manufacturers have designed their own methods to meet the EPA standards, and therefore describe the process in somewhat differing terms. The Cummins equipped Blue Bird bus system is not complicated, but both Drivers and service technicians should be familiar with the regeneration process.

As soot builds up in the DPF filter, the driver is notified in several stages by visual and audible alerts. As the need for regeneration becomes more severe, the alerts become increasingly imperative to act upon; and the penalty for postponing the needed regeneration also increases.

When the earliest alerts occur, there is ample time to complete a route and then have a Stationary Regeneration procedure performed at a proper facility. If early alerts are ignored, and the condition is allowed to worsen, the engine will eventually de-rate automatically, and performance will reduce noticeably. If the condition is allowed to become severe, a Stationary Regeneration may not be possible, and the DPF may require removal and cleaning with specialized equipment. Therefore, to minimize disruption of your bus operation, the regeneration-related alerts should be heeded and responded to at their early stages as a matter of routine.

Aftertreatment Terms

The following summarizes some of the terms associated with the exhaust systems of Blue Bird buses equipped with 2010 emission standards compliant engines. Both the driver and technician should become familiar with the following terms:

Aftertreatment. The process of filtering engine exhaust in order to reduce emissions, and purging the exhaust system of accumulated exhaust residue.

DPF (Diesel Particulate Filter). A component in the exhaust system which takes the place of a traditional muffler. A DPF contains a special dissimilar metals filter which traps particulate matter (soot), which is then converted to carbon dioxide by the aftertreatment process. The Cummins DPF also contains a DOC also known as a catalytic converter.

Regeneration. The process of cleaning accumulated soot from the filtering components inside the DPF. Regeneration occurs at high exhaust system temperatures to turn the soot into carbon dioxide gas. Regeneration can be thought of as conceptually similar to the clean cycle of a self-cleaning oven.

***WARNING** Postponing regeneration beyond the early indications may result in the engine being automatically de-rated, reducing power while driving.*

***WARNING** The aftertreatment regeneration process can cause extremely high exhaust gas temperatures hot enough to ignite or melt common materials, and to burn people.*

Carefully read, understand, and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual (and other related engine manufacturer's literature) regarding safe operation when the HEST indicator is on.

Carefully read, understand, and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual (and other engine manufacturer's literature) regarding safety conditions when performing Stationary regeneration.

HEST Indicator (High Exhaust System Temperature). An instrument panel indicator which appears when the exhaust temperature is unusually high due to recent regeneration. This is a normal behavior of the aftertreatment system, intended to notify the driver and technician that the exhaust system temperature is high and that caution should be observed around the exhaust system.

DPF Indicator. An instrument panel indicator which displays when particulate accumulation has reached a preset level in the DPF, and regeneration is needed. The bus should either be operated with a more demanding duty cycle until the indicator goes off, or it should be scheduled for a Stationary Regeneration at a service facility.

DPF Regeneration Levels of Notification

Regeneration—the process which clears soot accumulation in the DPF—occurs automatically as the bus is operated, as long as certain operating conditions (such as minimum speed thresholds) are met. When bus operating conditions do not provide adequate opportunity for the regeneration system to keep the DPF clear, soot begins to accumulate. A system of driver alerts keeps the driver informed of when the exhaust system is in need of regeneration, and of high exhaust temperature associated with regeneration. Several levels of regeneration alerts occur in sequence, each indicating a more imperative warning.

High Exhaust Temperature Notification

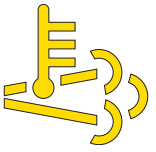
The High Exhaust System Temperature (HEST) indicator appears to alert the driver when exhaust temperature is unusually high and that prudent judgement should be applied regarding the proximity of people or combustibles to the exhaust system. For example, the bus should not be parked on a surface of grass or weeds.

The HEST indicator appears whenever the exhaust temperature is high (752°F or above), regardless of moving speed.

The driver should be familiar with and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual regarding safe operation when the HEST indicator is on.

- The HEST alert appears in the instrument panel's warning bank.
- The audible alarm sounds one beep.

HEST Notification



The HEST alert appears in the instrument panel's warning bank.

The audible alert sounds one beep.

Level 1 Regeneration Notification: DPF Indicator Appears

In low-demand operating conditions, it is possible that the regeneration system does not have sufficient opportunity to prevent particulate build-up in the DPF. The ECM senses that accumulation is occurring and that regeneration is needed. When notified, Regeneration should be done as soon as possible. The driver is notified as follows:

- The DPF Regeneration alert activates.
- The audible alert sounds one beep.

The regeneration can be accomplished in either of two ways: If practical, the bus could simply be operated for a while at a speed above the automatic regeneration threshold; or the bus could be taken to a suitable location to have a Stationary Regeneration procedure performed.

If the bus is operated at a minimum highway driving speed (40 mph Cummins), the automatic regeneration system will activate. If minimum speed is maintained long enough (usually 20-30 minutes), the automatic regeneration mode can likely reduce the soot sufficiently to cause the DPF Icon to go off.

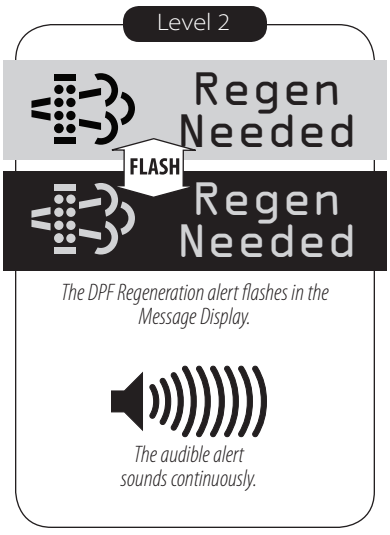
Therefore, the first appearance of the DPF icon should be perceived by the driver as a normal notification of action that needs to be taken, but not as an emergency situation. Typically, even if the bus route does not afford immediate opportunity for higher-speed operation, there is sufficient time to finish the bus route and return to the bus maintenance shop before a higher level of notification occurs. Exactly how much time after the first appearance of the DPF indicator represents is dependant upon specific operating conditions. However, current data from Cummins suggest that, at this level of notification, the DPF needs to undergo regeneration within two to six hours of bus operation. If regeneration does not begin, the next level of notification will activate.

Level 2 Notification: DPF Indicator Blinks

If the bus continues to be operated without taking the measures indicated by a Level 1 Notification (described above), particulate accumulation continues, and a Level 2 notification occurs:

- The DPF Regeneration alert begins to flash.
- The audible alarm sounds continuously.
- The engine may be automatically de-rated.

The above indications should be viewed with a higher degree of urgency and that the exhaust system is in need of regeneration soon. As soon as practical, the bus should be operated at or above the minimum speed needed to allow automatic regeneration to activate, or a Stationary Regeneration must be performed. Current data from Cummins suggest that at this level of notification, regeneration needs to be performed within the next one to two hours of bus operation. Otherwise, the third level of notification will occur.



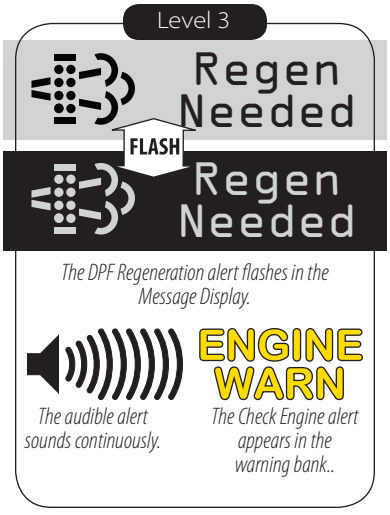
Level 3 Notification: Check Engine Indicator Appears

If the bus continues to be operated without taking the measures indicated by a Level 2 Notification, particulate accumulation will continue. These indicators are activated:

- The DPF Regeneration alert continues to flash.
- The audible alert sounds continuously.
- The engine is automatically de-rated.
- The Check Engine alert appears.

The above indicates that a Manual Regeneration must be performed as soon as possible. Because the engine is automatically de-rated it may not be possible to drive at sufficient speed to cause active regeneration to occur.

Depending upon the severity of the accumulation, the regeneration switch may not be allowed to initiate a regeneration without use of Cummins's PC-based diagnostic software, Insite.



Level 4 Notification: Stop Engine Indicator Appears

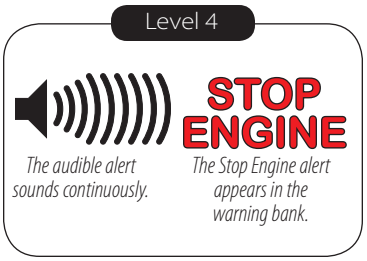
If the bus continues to be operated without taking the measures indicated by a Level 3 Notification, particulate accumulation reaches a critical level. Engine power is automatically de-rated *further* by the ECM. These indicators are activated:

- The DPF Regeneration alert deactivates.
- The audible alert sounds continuously.
- The engine is further de-rated.
- The Check Engine alert deactivates.
- The red Stop Engine alert appears.

The above indicates that accumulation has progressed to critical levels and the bus should be stopped with the engine off as soon as it is safe to do so. The bus should remain shut down until the aftertreatment system has been serviced.

The regeneration switch will not be allowed to initiate a regeneration without use of Cummins's PC-based diagnostic software, Insite.

Removal and cleaning of the DPF using specialized equipment may be required.



Stationary Regeneration Precautions

During active regeneration, the exhaust system can reach extremely high temperatures. Automatic active regeneration, which occurs while driving the bus, is programmed to occur only when the bus is moving at a minimum speed, and it stops when the vehicle slows or stops.

The HEST indicator appears whenever high temperature condition exists.

When performing a Stationary Regeneration, the entire process occurs for an extended period while the bus is stopped. It is therefore critical that prudent human safety and fire hazard precautions are followed. Those precautions include:

- Read, understand, and abide by all the precautions pertaining to regeneration procedures in the engine manufacturer's Operator's Manual.

- If at all possible, the Stationary Regeneration procedure should be conducted at a service facility by trained technicians.

- The Driver's first priority is the safety of the passengers. If a Stationary Regeneration must unavoidably be done by the Driver under a qualified technician's direction, alternate transportation should be arranged first, or passengers should be removed under proper supervision to a location away from the bus.

- Select an appropriate location to park the vehicle.

    - Choose a surface that will not burn or melt under high temperature, such as clean concrete or gravel, *not grass or asphalt*.

    - Ensure that nothing that can burn, melt, or explode (gasoline, wood, paper, plastics, fabric, compressed gas containers, hydraulic lines) is near the exhaust outlet. Abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual regarding safe operation when performing a Stationary Regeneration.

- Park the bus securely.

    - Set the parking brake. Put the transmission in Neutral. Chock the wheels.

- Secure the exhaust area.

- If bystanders might enter the area, set up barriers to keep people safely away from the exhaust outlet.
- If the procedure is performed indoors at a service facility, attach an exhaust discharge pipe rated for at least 1500°F.
- Keep a fire extinguisher nearby.

- Check exhaust system surfaces to confirm that no tools, rags, grease, debris or any other objects are on or near the exhaust system.
- Start the engine.
- Operate the Regeneration Switch to begin the regeneration process.
- Monitor the process. If any unsafe condition occurs, shut off the engine immediately. During the regeneration process, the engine may change speed, and the turbocharger may whistle. When the process is complete, the engine will return to normal idle speed. Exhaust gas and exhaust surface temperatures will remain elevated until they have had time to cool to normal levels.

SCR Treatment

The Selective Catalytic Reduction (SCR) system uses diesel exhaust fluid (DEF) as a chemical reactant. The DEF converts to ammonia in the exhaust stream. The SCR catalyst is mounted in the exhaust stream and is similar in outward appearance to a muffler. It contains chemical compounds which, in the presence of ammonia, help transform nitrogen oxides into harmless nitrogen and water.

In an SCR system, the rate at which DEF is sprayed must be tightly controlled. If the rate is too high, not all of the ammonia will react with the NOx and some ammonia will "slip" through the catalyst. If the rate is too low, the desired NOx reduction will not be achieved. Both situations are undesirable and must be avoided.

The SCR system consumes DEF at a rate of approximately 2% of the amount of fuel used, depending on bus operation. Therefore a 15 gal tank of DEF will treat approximately 750 gallons of diesel fuel.

The DEF tank level indicator can be found in quadrant 3 of the message display center located in the instrument cluster. This display provides a constant reading indicating the percent of fluid in the tank. If a problem is identified with the amount of fluid or the quality of the fluid a priority message will appear in quadrant 1 of the message display center indicating the fault.

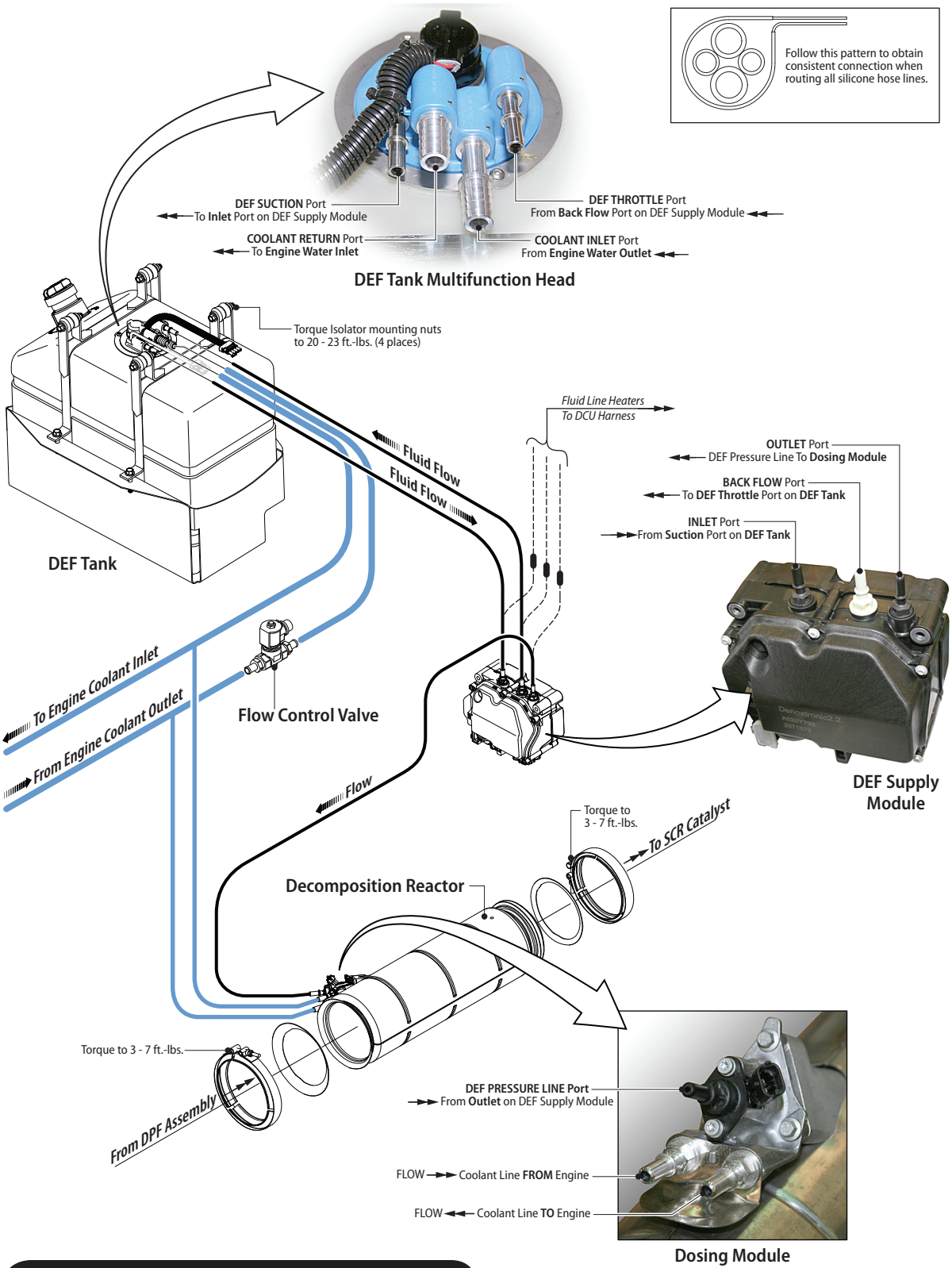
Keeping adequate levels of DEF in the tank is crucial to the operation of the SCR system. When low levels are indicated, refill the tank using only approved DEF solution. The DEF has its own tank and fill port with a blue cap. You will notice the fill port is smaller than the diesel fuel port. This is to prevent putting diesel fuel into the DEF tank. Conversely, care should be given not to put DEF in the diesel fuel tank. Read all decals carefully before refilling.

CAUTION ***DO NOT put diesel fuel in the DEF tank. DO NOT put DEF in the fuel tank of the bus.***

DEF Fill Door

DEF Fill located to the left of the entrance door.

Diesel Fill



SCR System Plumbing

Selective Catalytic Reduction Components

Dosing Control Unit (DCU). The DCU is a computer, designed as the central control for the diesel exhaust fluid dosing system. This module handles the dosing activity by energizing and de-energizing the Dosing Module. It also monitors and adjusts the diesel exhaust fluid tank temperature by adjusting the engine coolant control valve. In cold temperatures it will also energize electrical line heaters on the diesel exhaust fluid lines to thaw and prevent freezing during operation. The diesel exhaust fluid tank level sensor information is also monitored by the DCU. The dosing control unit is in constant communication with the engine ECM through a data communications line. Before servicing this unit, the DCU must be disconnected from the battery before installing or removing the electrical connectors. The DCU is mounted on a bracket attached to the inside of the right frame rail near the diesel exhaust fluid tank.

Dosing Control Unit

CAUTION ***Disconnect battery before removing or installing electrical connectors. DO NOT use battery disconnect switch.***

Diesel Exhaust Fluid (DEF) Tank. The DEF Tank is a 15 gallon medium-high density polyethylene tank. This tank is designed to hold 15 usable gallons of DEF. The usable amount of fluid in the tank is displayed in the instrument panel's driver information panel as a percent of DEF in the tank. The tank fill neck has a 19 mm diameter restrictor to prevent inserting a diesel fuel fill nozzle. The tank is also designed to prevent overfilling. When the tank is full there will be approximately 10% empty space at the top of the tank for fluid expansion due to temperature. If the fluid level in the tank drops to 10% the driver will be notified with a priority message in the instrument panel accompanied by a warning light (see *DEF Levels of Notification*). The feed line in the tank has a serviceable 100 micron filter. This filter is back-flushed each time the bus is turned off due to a purge cycle (see *Purge Cycle*). The tank also has a heater which uses engine coolant to regulate the temperature of the DEF. When the outside temperature is below 11°F the tank heater will maintain a minimum temperature of 21°F during operation. Above this temperature the DEF will be maintained at ambient temperature. The tank also houses a fluid temperature sensor and a fluid level sensor. A multifunction head provides access to the DEF feed line, return line, and coolant lines as well as electrical connections to the two sensors. The tank is supported by a metal housing which is attached to the frame rail out rigging with four isolators. The tank and fill port are located on the right side of the bus near the entrance door.

DEF Fill Door

DEF Fill located to the left of the entrance door.

Diesel Fill

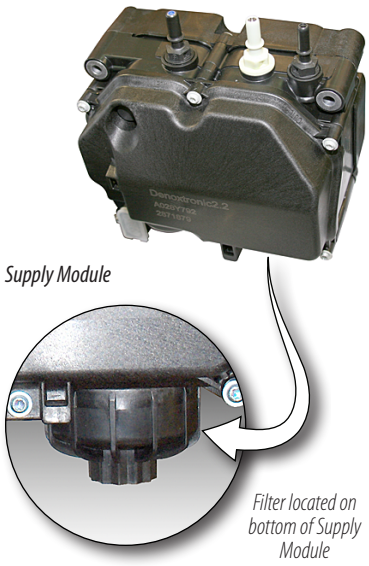
Diesel Exhaust Fluid (DEF). Diesel Exhaust Fluid (DEF) is a nontoxic, nonpolluting, non-hazardous and nonflammable solution. It is stable, colorless, and meets accepted international standards for purity and composition. DEF is safe to handle and store and poses no serious risk to humans, animals, equipment or the environment when handled properly. Refer to MSDS sheets currently available. DEF is a solution of 32.5% high purity urea and 67.5% de-ionized water. This ratio is critical due to the fact that both the urea and water will freeze together at 11°F. At this temperature both the urea and water will not only freeze, but thaw at the same rate, ensuring that as it thaws the fluid does not become diluted or over concentrated. This ratio is the ideal solution as it provides the lowest freeze point for both the urea and water, preventing degradation of the solution. Also, the SCR system is calibrated to the 32.5% ratio for optimum NOx reduction during operation. The DEF you purchase should state and display the certification of the American Petroleum Institute, German Institute for Standardization DIN70700, the International Organization for Standardization ISO 22241-1 and meet AUS – 32 specifications. This will ensure the proper purity and concentration. For more information on these specifications, visit *www.iso.org*. DEF packages will also have a date code located somewhere on the product. The first digit of the date code represents the fluid batch number and the next six digits reflect the date that the batch was filled.

During bus operation, the SCR system is designed to provide heat for the tank and supply lines. If the DEF freezes during shut down, starting and normal operation of the bus will not be inhibited. The system is designed to quickly return the DEF to a liquid state and the operation of the bus will not be impacted.

CAUTION ***Anti-gelling or freeze point improvers or additives of any type are not approved for DEF. Any further blending or adjusting of the DEF mixture will impede its ability to perform correctly and may cause damage to the SCR components.***

DEF should be stored in a cool, dry, well-ventilated area, out of direct sun light. The shelf life is a function of ambient storage temperatures. DEF will degrade over time depending on temperature and exposure to sunlight. The optimum storage temperature is up to 77° F (25° C) where shelf life will be greater than two years. DEF stored between 10° and 90° F will have a shelf life greater than one year. DEF can be tested using a refractometer designed for this purpose.

Supply Module. The Supply Module is part of a high accuracy system for injecting diesel exhaust fluid into the exhaust aftertreatment system. It has a 12V electronically operated pump and metering system, controlled by the DCU, which delivers diesel exhaust fluid to the Dosing Module mounted in the exhaust system downstream of the diesel particulate filter. The Supply Module has two filters, a 100 micron inlet filter and a 10 micron main filter which is serviceable. The Supply Module and Dosing Module system is designed to deliver a precise amount of DEF solution by weight into the exhaust system according to capacity, which is calculated by an external algorithm. The Supply Module also houses a heater and temperature sensors to thaw and keep the DEF in a liquid state during cold temperatures, a pressure sensor to regulate the output pressure to 130 psi and a reverting valve that clears the fluid lines during shut down (see *Purge Cycle*). The Supply Module is attached to a bracket on the inside of the frame rail near the DEF tank.



Supply Module

CAUTION ***When handling or storing the Supply Module, suitable precautions should be made to protect it from damage. If this component is dropped it should not be used.***

Dosing Module. The Dosing Module is mounted to the decomposition reactor and is used to add diesel exhaust fluid to the exhaust stream. DEF is supplied to the Dosing Module from the Supply Module through a pressure line with an operating pressure of 130 psi. When needed, the DCM will activate the Dosing Module which will introduce a fine mist of DEF to the exhaust stream. The DEF is supplied to the Dosing Module at an operating temperature between 23°F and 158°F. Because this is part of the exhaust system, temperatures can become extremely hot which would cause the DEF to vaporize. To prevent this from happening, engine coolant is continuously circulated through the module while in operation. Coolant supply and return lines (3/8" SAE J2044 quick connect fittings) are provided and supply a minimum of 0.17 GPM at idle to a maximum of 2.0 GPM during bus operation. Care should be taken not to break or damage the plastic DEF pressure line fitting (5/16" SAE J2044 quick disconnect).

Dosing Module

CAUTION ***Never use the Dosing Module as a carry handle when servicing the Decomposition Reactor. Suitable precautions should be used to protect the Dosing Module from damage when storing and handling. The protective caps provided with the module should not be removed until final installation of the fluid lines. If this component is dropped it should not be used.***

Decomposition Reactor. The Decomposition Reactor is located downstream to the DPF between the DPF and SCR unit. It measures 19 inches long and has a diameter of five inches with a half inch of insulation making the outside diameter six inches. The Decomposition Reactor has an integrated diesel exhaust fluid diffuser inside the housing designed so that the ammonia contained in the injected DEF can decompose and be adequately mixed with the exhaust stream before it reaches the SCR Catalyst. The Decomposition Reactor is supplied with a Dosing Module already mounted on the reactor flange. The decomposition reactor assembly must be clamped and properly torqued to the DPF and SCR units using gaskets and full Marmon joints with "vee" band clamps to minimize leakage and heat loss, which is critical to the process. Never use the Dosing Module as a handle when picking up the decomposition reactor assembly.

Selective Catalytic Reduction (SCR) Device. The SCR device is comprised of a canister which contains a selective catalytic reduction catalyst and two temperature sensors. The temperature sensors are used to determine when the SCR unit has reached the required temperature to support the chemical reactions and allow diesel exhaust fluid dosing. An oxygen sensor is also mounted to the outlet section of the canister. The SCR catalyst uses Ammonia (NH3), contained in the injected diesel exhaust fluid and formed in the decomposition reactor, to react with the NOx in the exhaust stream. The catalyst prompts a chemical reaction combining the ammonia and the nitrogen oxides ($4NH3 + 4NOx + O2 = 4N2 + 6H2O$) to form harmless Nitrogen (N2) and Water (H2O). This reaction is temperature dependent therefore it is important that all insulation is intact and all connections are leak free. On the bottom of the canister is a moisture drain hole in the outlet section. Hot exhaust gas will escape the drain hole with temperatures reaching 300° F three inches radially outward from the holes exit during normal active regeneration. Be careful not to plug this hole or cover it with the mounting straps. Caution should be observed while working in this area with the engine running. To avoid damage to the SCR device only ultra low sulfur diesel fuel with a maximum sulfur content of 15 ppm.

Nitrogen Oxide (NOx) Sensor/Module. The NOx sensor is part of an assembly which includes the NOx sensor probe and NOx sensor control module. A 12v sensor cable attaches these components to form an assembly. There are two cable lengths available, 24.2 inch (615mm) and 36 inch (915mm) to accommodate variations in the configuration of the system. The cable should be anchored to insure cable temperature does not exceed 392 deg F (200 deg C). The NOx sensor probe is located on the outlet tube of the SCR device and is connected to an electronic control module mounted to the frame rail. The NOx sensor communicates with the engine ECU on the J1939 data link and continually monitors the NOx level leaving the SCR device ensuring that the emissions are compliant with the EPA 2010 standard by meeting or exceeding NOx removal at 0.2-g/HP-HR.

Diesel Exhaust Fluid (DEF) Lines. The diesel exhaust fluid lines carry DEF from the supply tank to the supply module which pumps the fluid to the dosing module. There are three DEF lines involved in supplying the pump a steady flow of fluid and supplying it to the dosing module. The Supply line from the tank to the Supply Module is called the Inlet or Suction line and is a 3/8" line with SAE J2044 quick connect fittings. This line is designed sufficiently rigid to prevent collapse due to a vacuum of up to 8.9 in. Hg (300 mbar) created during the suction event. The second line is the Throttle line which is the backflow line from the supply module. This line is also a 3/8" line used to return unused DEF to the tank. The third line is a 5/16" Pressure line which connects the Supply Module to the Dosing Module with SAE J2044 quick disconnect fittings. The Supply Module provides a pressure head of 130psi to the pressure line providing DEF to the dosing module for injection into the exhaust stream. This is a flexible line made of polytetrafluoroethylene (PTFE) allowing movement between the Supply Module and the Dosing Module. The line also has high thermal resistance withstanding temperatures up to 248° F (120C). All three lines offer excellent chemical resistance and are heated electrically with a series resistant heating circuit wrapped around the lines with a protective thermoplastic jacket.

Purge Cycle

The parts of this system vulnerable to freezing in the winter are the external lines and fittings between the supply module and the dosing module. Exposed lines and fittings will freeze and prevent diesel exhaust fluid from flowing. The purge cycle is necessary to protect the dosing system from expansion of the DEF during a hard freeze which would damage the dosing system components. During a purge cycle the supply module pumps the diesel exhaust fluid inside the supply, pressure, and throttle lines back into the DEF tank. This is done through a reverting valve located inside the supply module. Purging begins when the ignition is switched to the "Key Off" position and is completed in 60 seconds. This allows adequate time for the DEF lines to empty, protecting the dosing system components from damage due to thermal expansion of the DEF as a result of deep freeze conditions. Battery power must remain on during this process until the purge process is complete.

CAUTION ***Power to the Supply Module must remain on for 60 seconds after ignition is switched off to complete the purge cycle.***

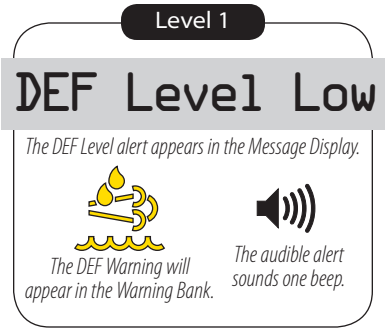
DEF Levels of Notification

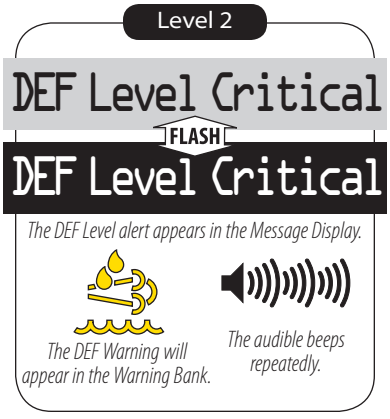
A system of driver alerts keeps the driver informed of when the DEF is in need of service. When fluid is low or contaminated, several levels of alerts occur in sequence, each indicating a more imperative warning. When priority warnings occur, they will appear in Quad 1 of the Message Display in lieu of the odometer reading while Quad 3 indicates fluid level in the DEF tank at all times. The notifications are as shown below.

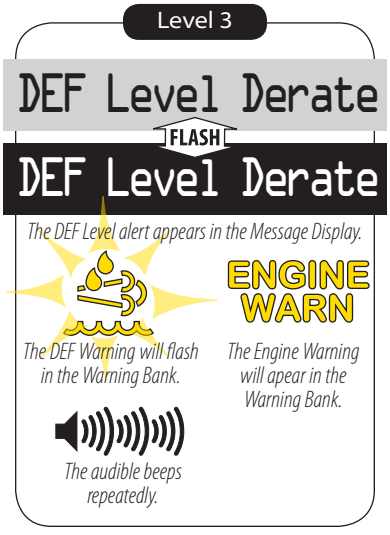
DEF Level 1. When the DEF level reaches 10% in the tank, a **DEF LEVEL LOW** warning will appear in Quad 1 of the Message Display at which point the amber DEF warning icon will appear in the lower left warning bank. This warning is accompanied with a single beep.

DEF Level 2. When the DEF level reaches 5% in the tank, a **DEF LEVEL CRITICAL** warning will appear in Quad 1 of the Message Display, this DEF LEVEL CRITICAL warning display will flash from positive to negative and the amber DEF Warning icon will remain in the lower left warning bank. This warning is accompanied with repeating beeps.

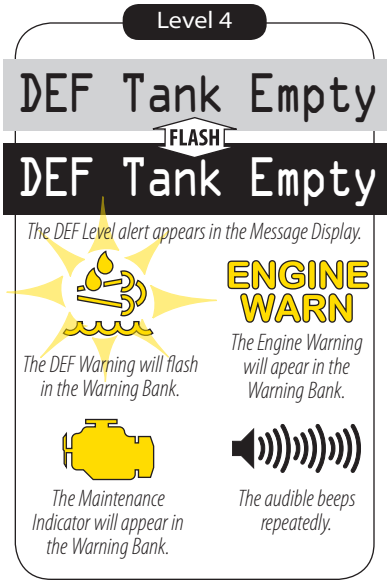
DEF Level 3. When the DEF level reaches 2.5% in the tank, a **DEF LEVEL DERATE** warning will appear in Quad 1 of the Message Display, this DEF LEVEL DERATE warning display will flash from positive to negative**.** The amber DEF Warning icon will commence flashing in the lower left warning bank and an addtional amber Engine Warning light will appear. At this point a 25% engine torque derating will occur.



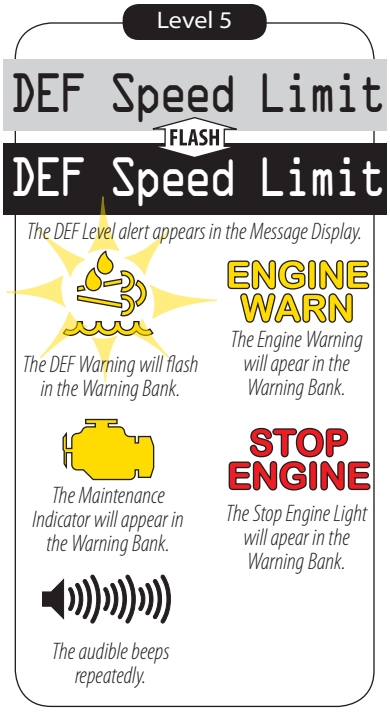




DEF Level 4. When the DEF level reaches 0% in the tank, a **DEF TANK EMPTY** warning will appear in Quad 1 of the Message Display, this DEF TANK EMPTY warning display will flash from positive to negative**.** The amber DEF Warning icon will continue flashing in the lower left warning bank and an addtional amber Engine Warning light and an amber Maintenance Indicator icon will appear. Continued 25% engine torque derating.



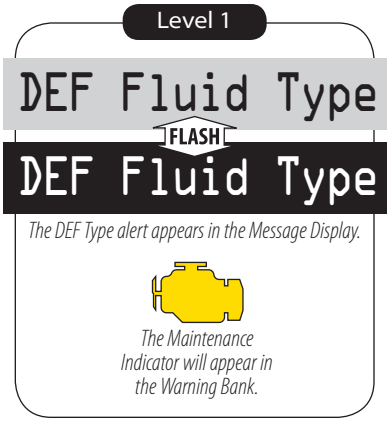
DEF Level 5. When DEF sytem can no longer maintain pressure, a **DEF SPEED LIMIT** warning will appear in Quad 1 of the Message Display, this DEF SPEED LIMIT warning display will flash from positive to negative**.** The amber DEF Warning icon will continue flashing in the lower left warning bank. The amber Engine Warning light and the amber Maintenance Indicator icon will remain illuminated and a red Stop Engine light will appear. At this point a 5 MPH speed limit will be introduced with the 25% engine torque derating.

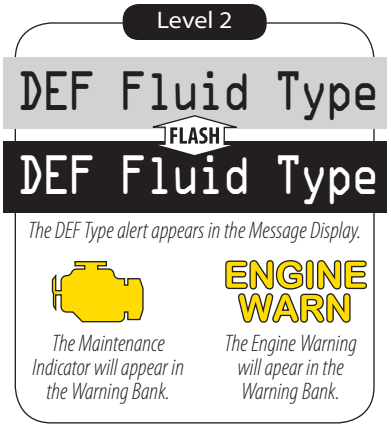


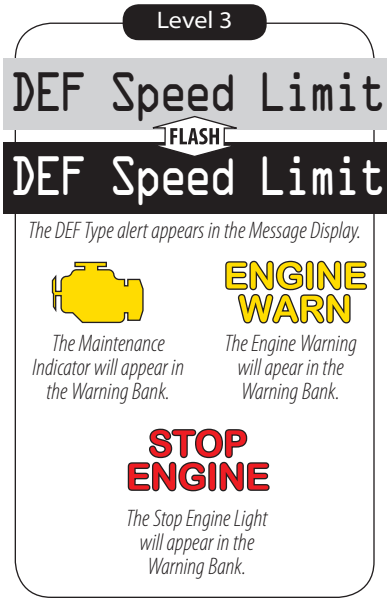
DEF Type Level 1. When incorrect fluid or mixture is introduced into the tank, a **DEF FLUID TYPE** warning will appear in Quad 1 of the Message Display, this DEF FLUID TYPE warning display will flash from positive to negative**.** The amber Maintenance Indicator icon will appear in the lower left warning bank. The integrity of the DEF solution needs to be checked using a refractometer. DEF system service should be attained within 10 hours or subsequent levels of derating will occur.

DEF Type Level 2. The **DEF FLUID TYPE** warning in Quad 1 of the Message Display continues to flash from positive to negative**.** The amber Maintenance Indicator icon and an additional amber Engine Warning light will appear in the lower left warning bank. At this point a 25% engine torque derating will occur. DEF system service should be attained within 10 hours or subsequent levels of derating will occur.

DEF Type Level 3. After 10 Hours at level 2, a **DEF SPEED LIMIT** warning will appear in Quad 1 of the Message Display, this DEF SPEED LIMIT warning display will flash from positive to negative**.** The amber Maintenance Indicator icon and the amber Engine Warning light will remain illuminated and and a red Stop Engine light will appear. At this point a 5 MPH speed limit will be introduced with the 25% engine torque derating.





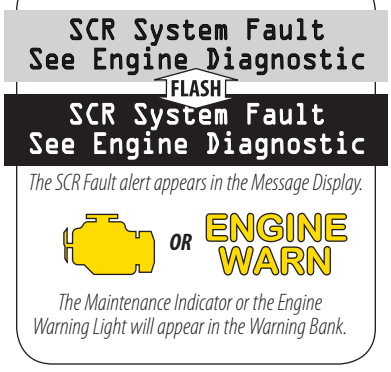


SCR Fault Level 1. When an SCR System Fault is detected, a **SCR SYSTEM FAULT SEE ENGINE DIAGNOSTIC** warning will appear in Quad 1 of the Message Display, this SCR SYSTEM FAULT SEE ENGINE DIAGNOSTIC will flash from positive to negative. The amber Maintenance Indicator icon *OR* the amber Engine Warning light will appear in the lower left warning bank. Engine diagnostic codes should be recorded and appropriate repairs should be made. DEF system service should be attained within 10 hours or subsequent levels of derating will occur.

SCR Fault Level 2. After 10 Hours at level 1, both the amber Maintenance Indicator icon and the amber Engine Warning light *WILL* be illuminated and a 25% engine torque derating will occur. DEF system service should be attained within 30 hours or subsequent levels of derating will occur.

SCR Fault Level 3. After 30 Hours at level 2, the amber Maintenance Indicator icon, the amber Engine Warning light and the Stop Engine light WILL be illuminated. At this point a 5 MPH speed limit will be introduced with a 25% engine torque derating.

Level 1



The SCR Fault alert appears in the Message Display.

OR

The Maintenance Indicator or the Engine Warning Light will appear in the Warning Bank.

Level 2

The SCR Fault alert appears in the Message Display.

The Maintenance Indicator will appear in the Warning Bank.

The Engine Warning will apear in the Warning Bank.

Level 3

The SCR Fault alert appears in the Message Display.

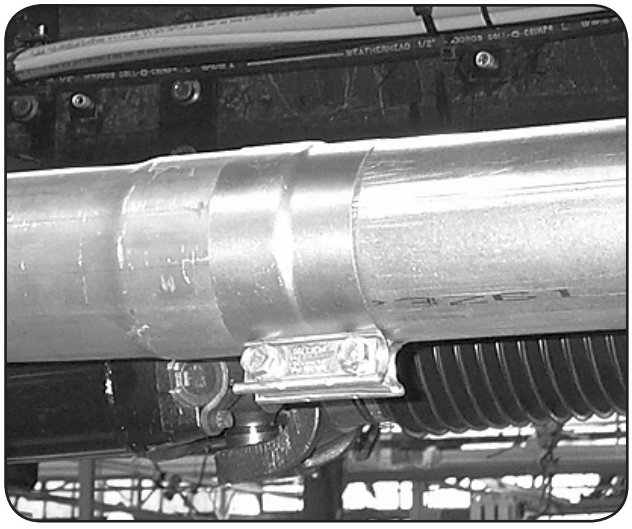
The Maintenance Indicator will appear in the Warning Bank.

The Engine Warning will apear in the Warning Bank.

The Stop Engine Light will appear in the Warning Bank.

Exhaust Piping

The exhaust system is designed to move hot exhaust gases from the engine, underneath and toward the rear of the bus, while preventing contamination of the passenger area. All pipes and connections must be inspected for leaks at least monthly to provide continued safe transport of passengers.



Typical Exhaust Clamp

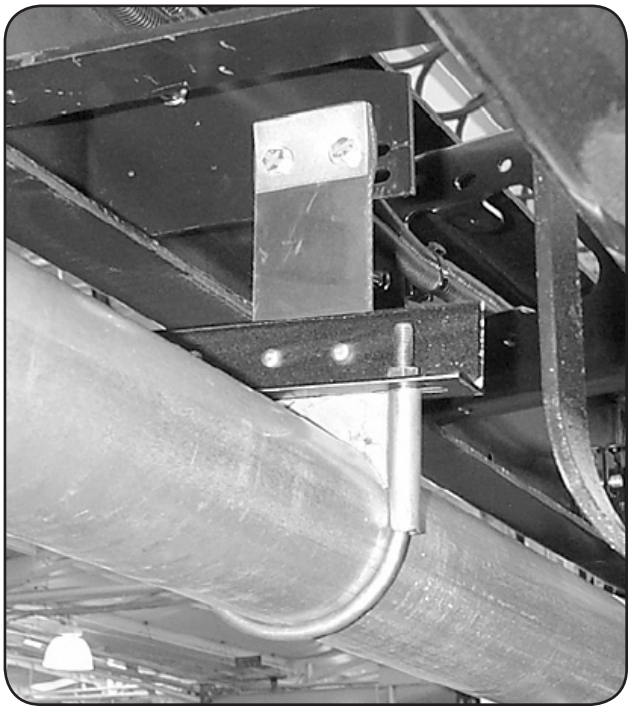
CAUTION ***Never work under a bus with the engine running. Never work under a bus until the wheels are chocked, to prevent movement in either direction.***

Although the exact configuration of exhaust pipe and tailpipe sections is dependent upon the wheelbase and body length of the particular bus, the pipe sections, joint clamps and suspension hangers are similar. As a general rule, to remove the exhaust system, or any part of it, start at the rear most hanger and work forward.

Typical Exhaust Hanger

SCR/DPF Assembly Removal

This general procedure applies to all wheelbases. See Exhaust illustrations at rear of this chapter.



1. Start at the rear bumper and loosen all the sections forward until you reach the SCR.
2. Remove the clamp securing the tailpipe onto the SCR.
3. With the slack produced by loosening the section clamps rearward, remove the tailpipe section nearest the SCR.
4. Disconnect all electrical harnesses from the SCR, Decomposition Reactor, and DPF. See *Exhaust, SCR Aftertreatment Harness*, next page.
4. Loosen the nuts at the straps securing the SCR.
5. Loosen the Vee-Band clamp which secures the SCR to the Decomposition Reactor.
6. Support the SCR and remove the strap from the hanger.

If it is necessary to continue removing exhaust system sections, proceed from the SCR toward the engine as far as necessary. Proceed to remove DPF in same manner as SCR.

DPF/SCR Assembly Reinstallation

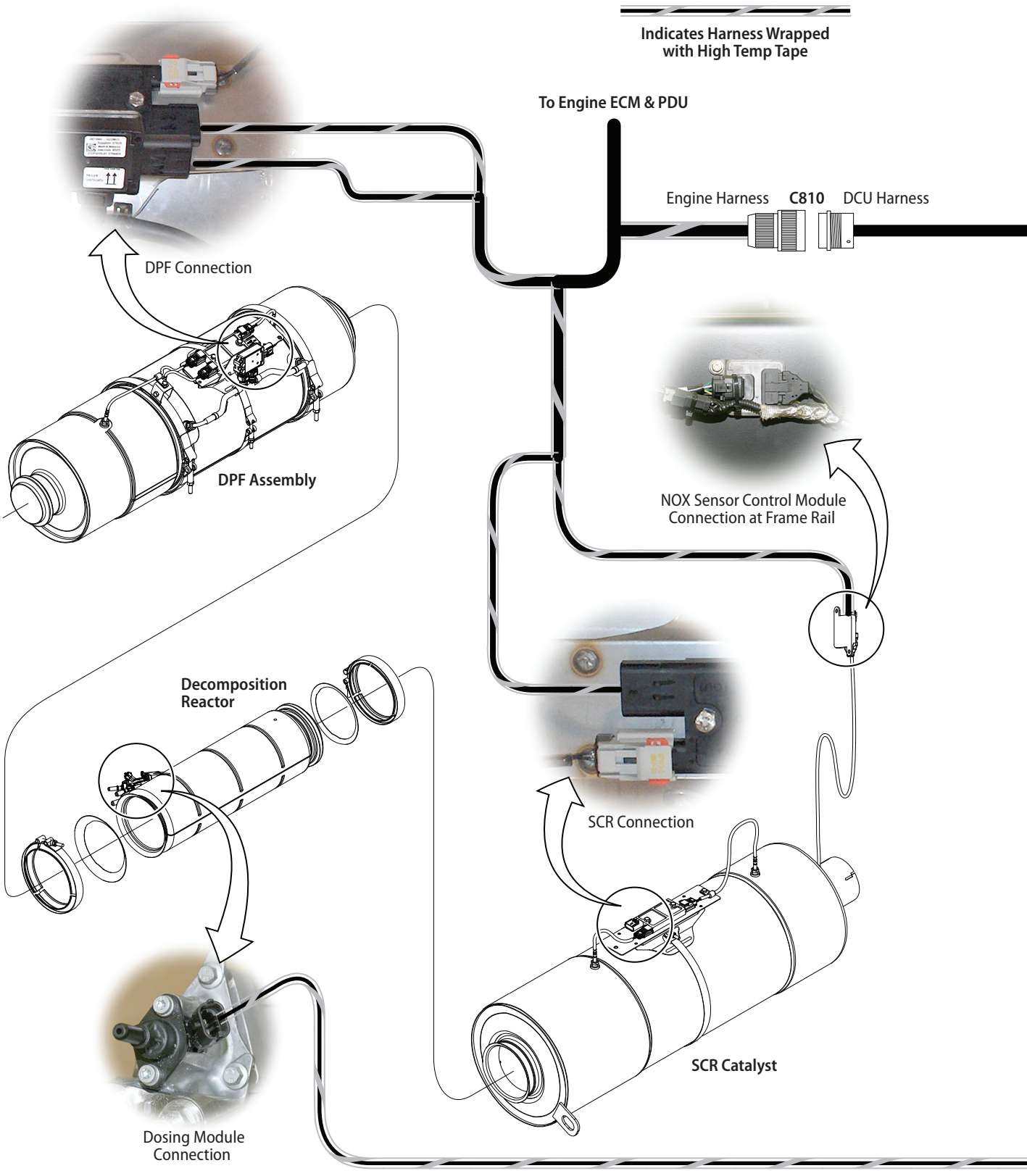
When assembling the exhaust system, start at the forward most section and work toward the rear of the bus. Always use new clamps and hardware.

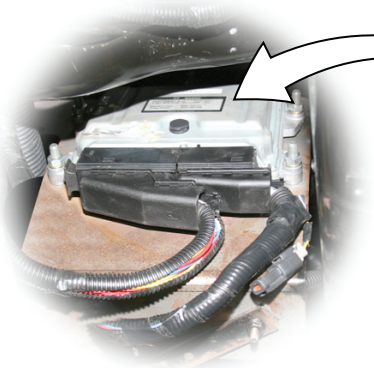
1. Assemble the exhaust pipe to the DPF. Leave all connectors loose for final adjustment.

2 Use new wideband clamps and hardware.

3. Tighten the strap holding the DPF.

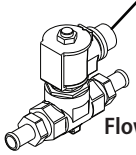
4. Continue working toward the rear of the vehicle. Leave all joints loose until the entire tailpipe assembly is in the correct position, and then tighten all the clamps.


Indicates Harness Wrapped with High Temp Tape
To Engine ECM & PDU
Engine Harness
C810
DCU Harness
DPF Connection
DPF Assembly
NOX Sensor Control Module Connection at Frame Rail
Decomposition Reactor
SCR Connection
SCR Catalyst
Dosing Module Connection

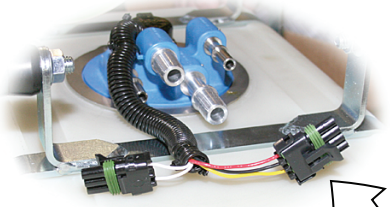


DCU Module Connection
viewed from under bus

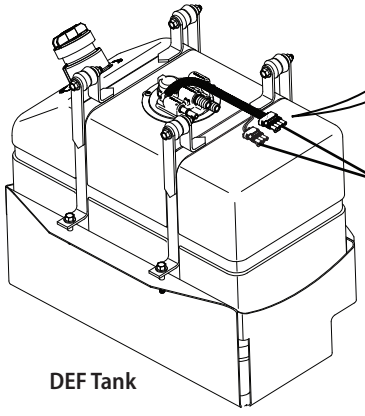
DCU Module



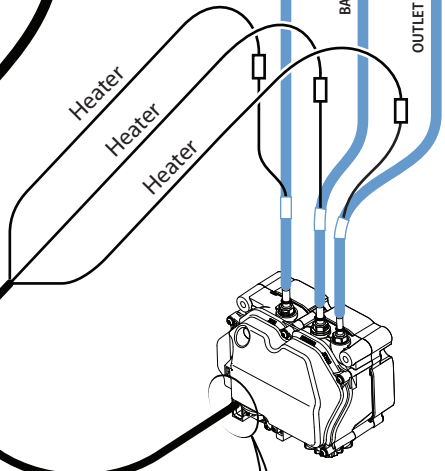
Flow Control Valve



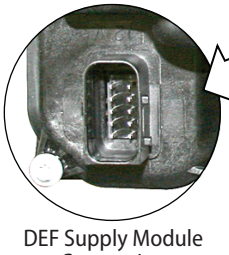
DEF Tank Harness Connection



DEF Tank



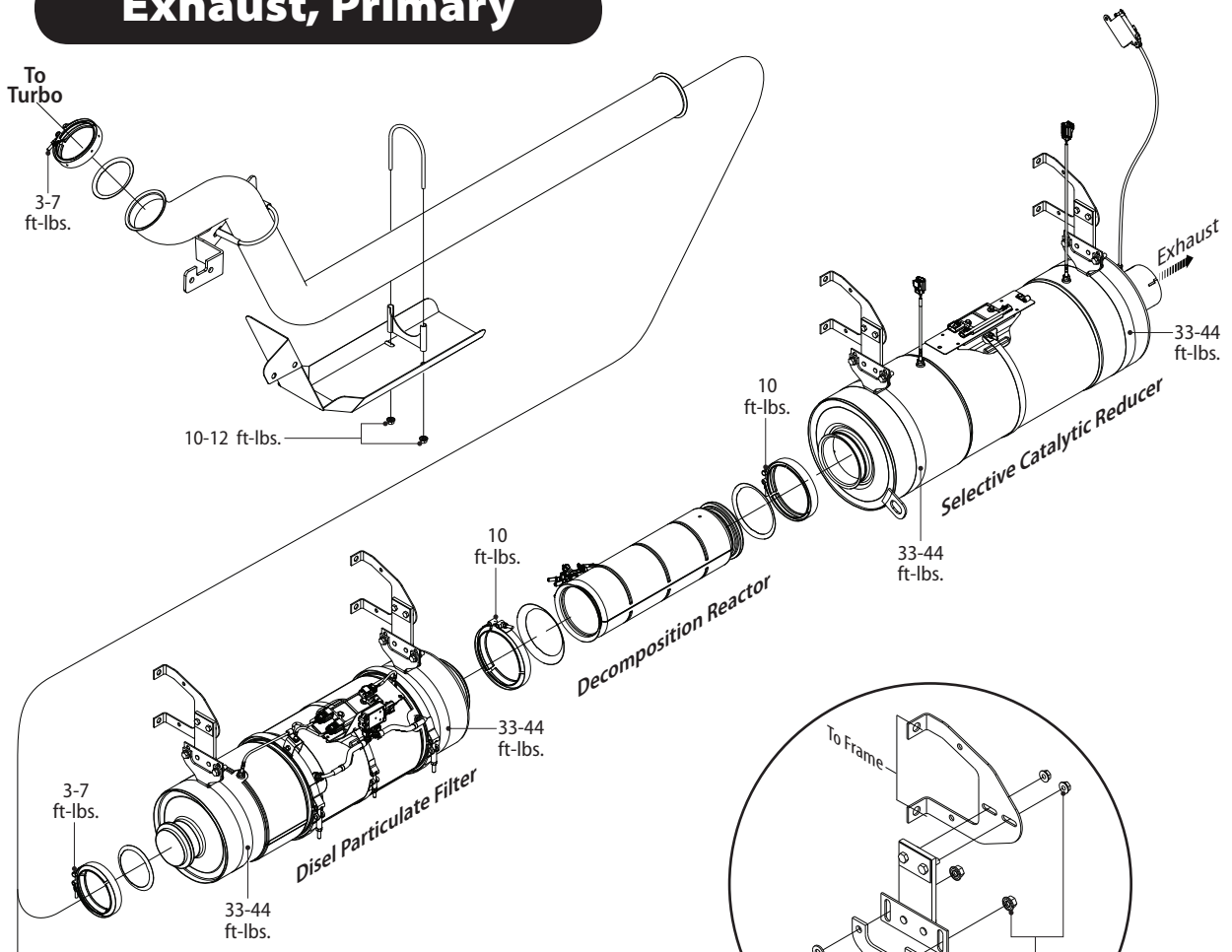
DEF Supply
Module



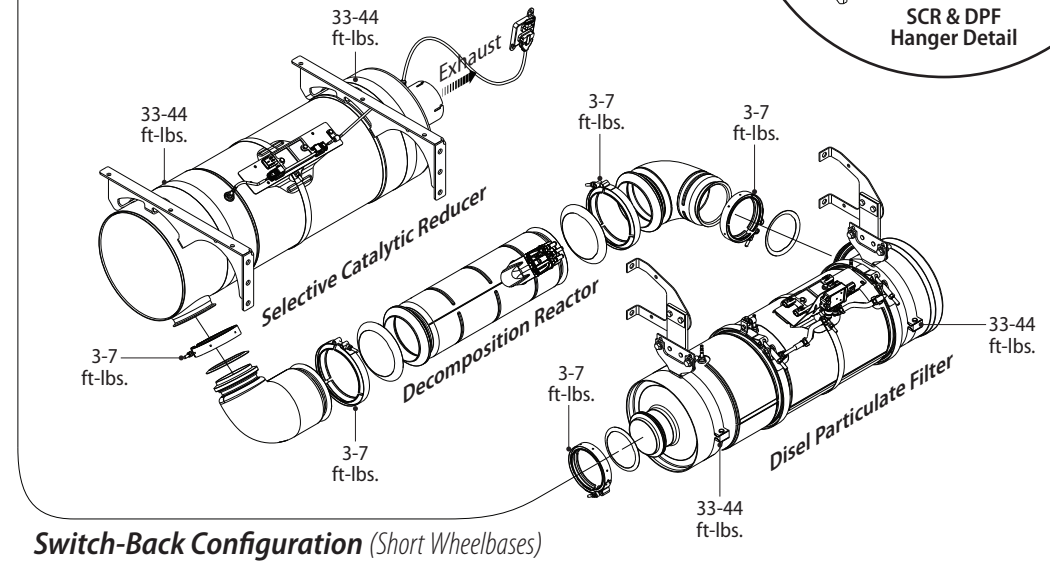
DEF Supply Module
Connection

Exhaust, SCR Aftertreatment Harness

Exhaust, Primary



In-Line Configuration *(Long Wheelbases)*

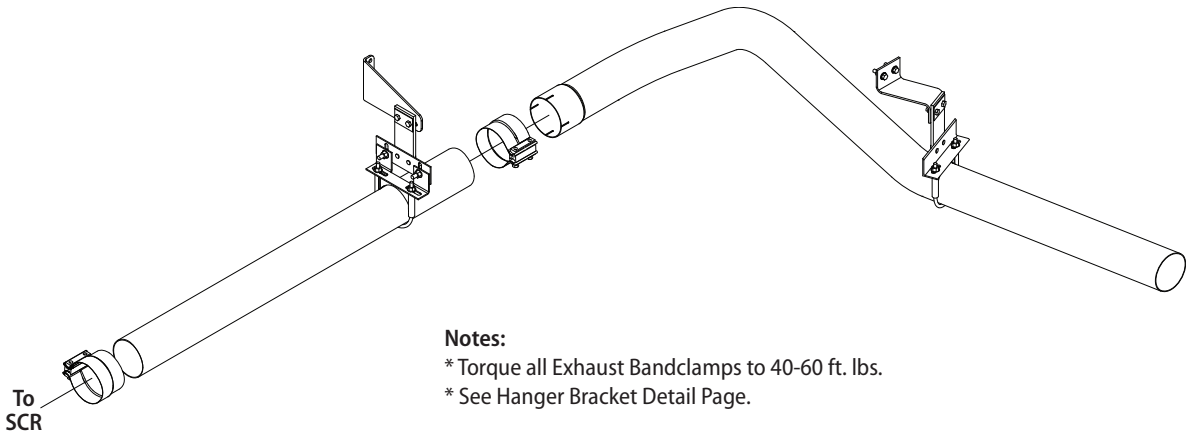


Switch-Back Configuration *(Short Wheelbases)*

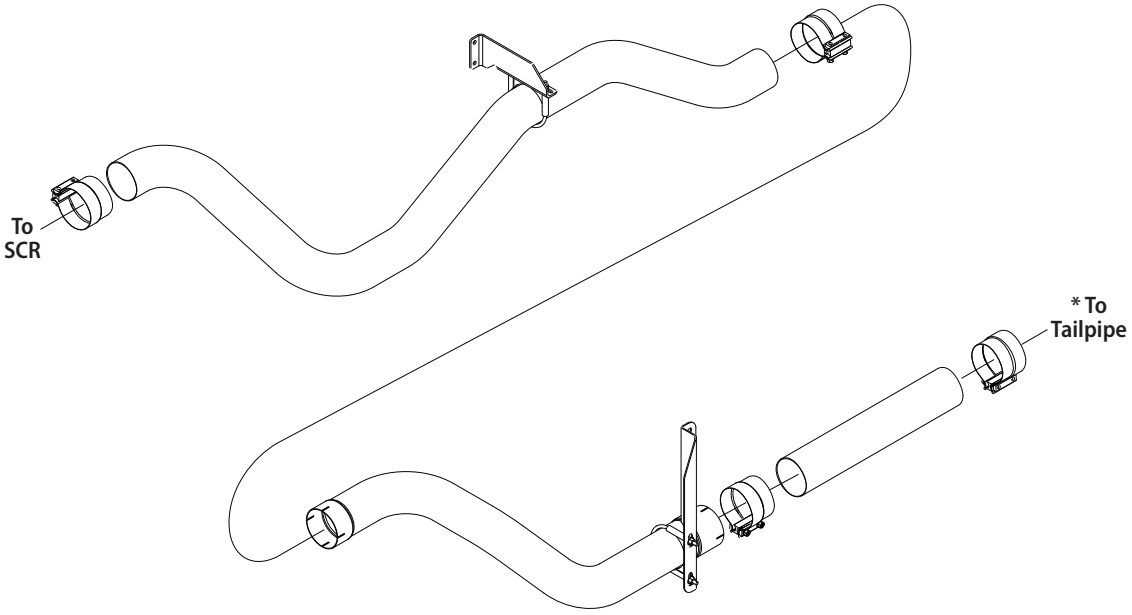
D0004140A & D0004141A

Exhaust, Secondary *(out the side)*

D0004160A



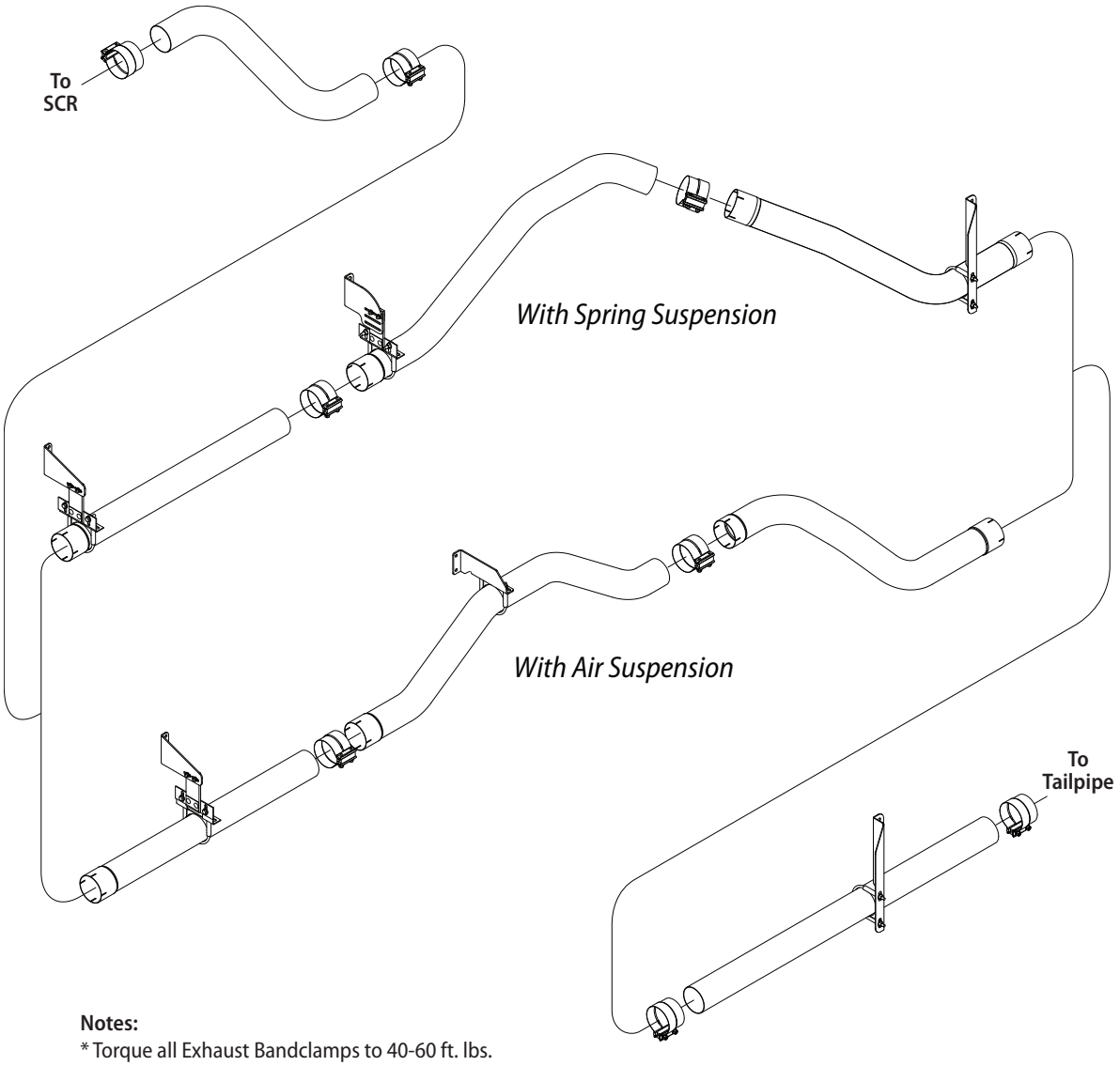
Notes:
* Torque all Exhaust Bandclamps to 40-60 ft. lbs.
* See Hanger Bracket Detail Page.



D0004144A

Notes:
* Torque all Exhaust Bandclamps to 40-60 ft. lbs.
* See Hanger Bracket Detail Page.
* See Tailpipe Option Page.

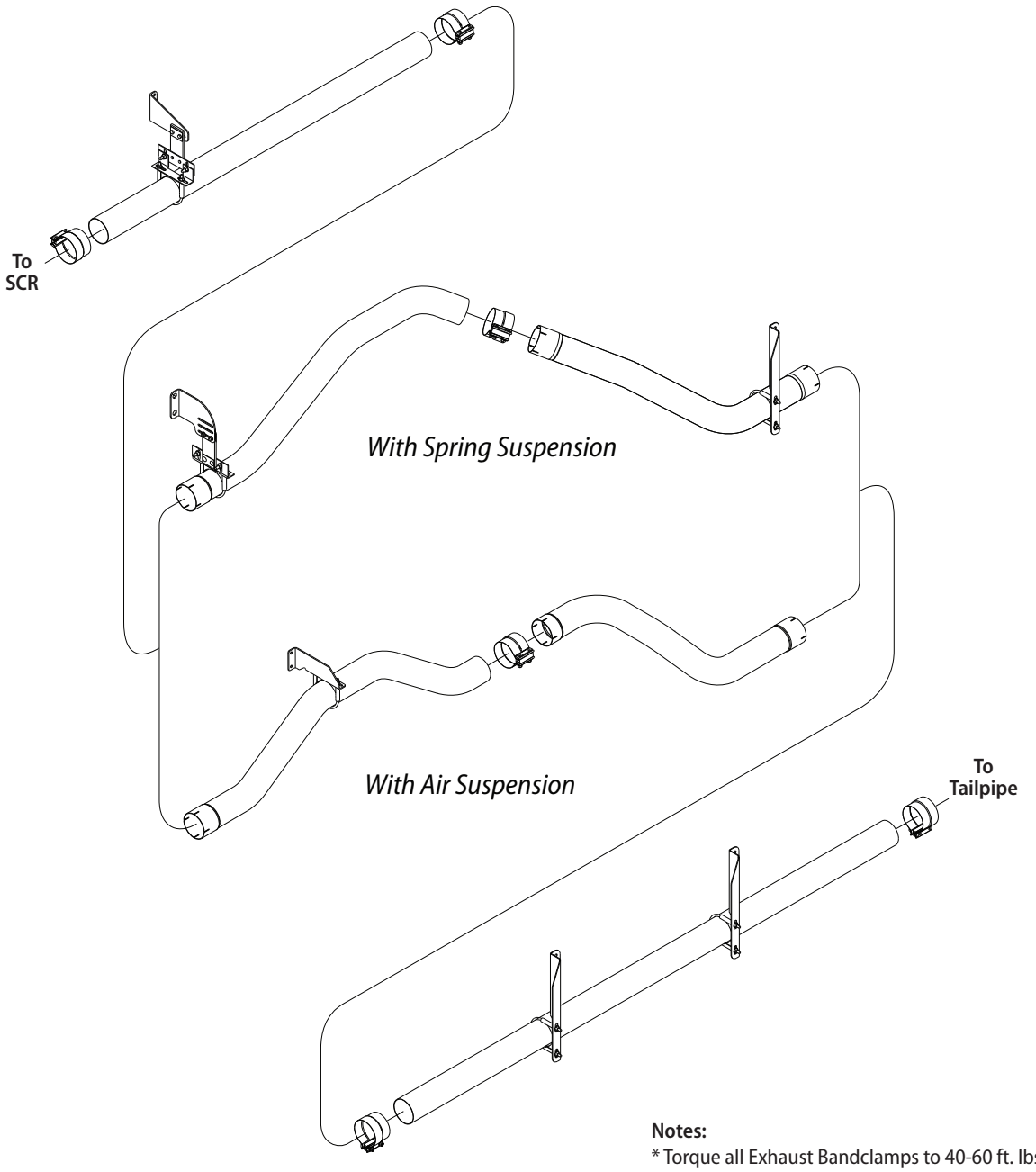
Exhaust, Secondary *(169 wb)*



Notes:
* Torque all Exhaust Bandclamps to 40-60 ft. lbs.
* See Hanger Bracket Detail Page.
* See Tailpipe Option Page.

D00041145A

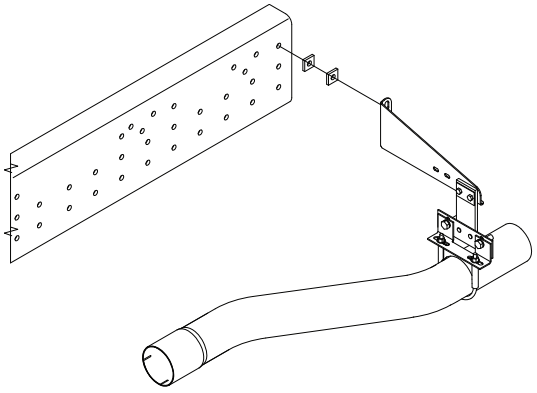
Exhaust, Secondary *(189-217 wb)*



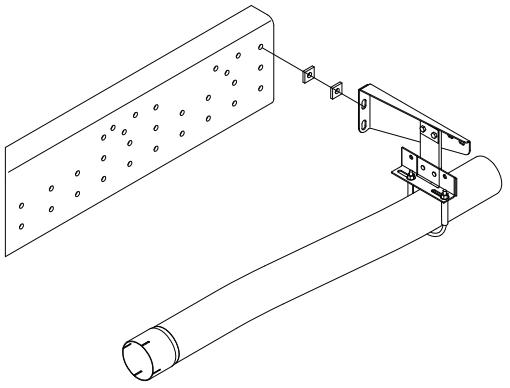
Notes:
* Torque all Exhaust Bandclamps to 40-60 ft. lbs.
* See Hanger Bracket Detail Page.
* See Tailpipe Option Page.

D0004146A

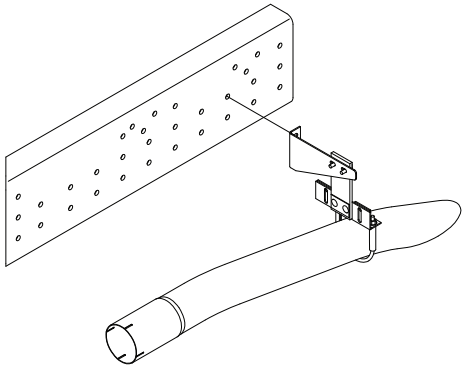
Exhaust, Secondary *(238-280 wb)*



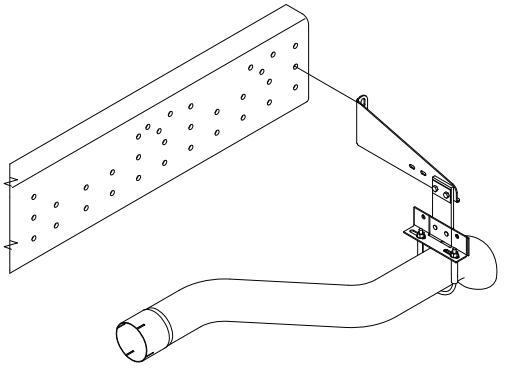
Tailpipe Under Bumper Option



Tailpipe Thru Bumper Option



Tailpipe Turn Down Option

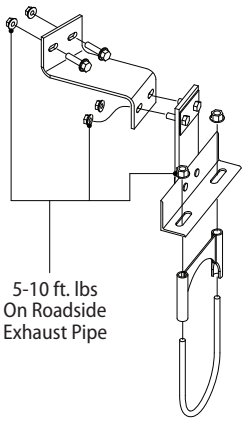


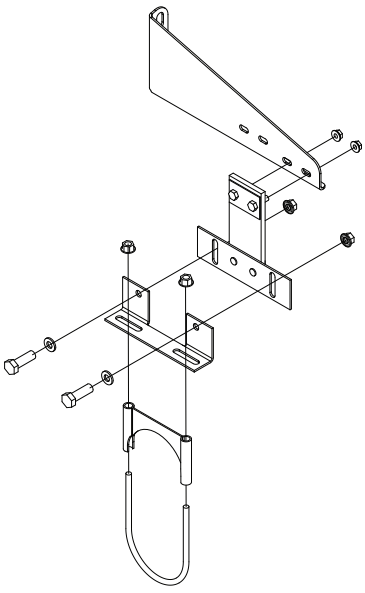
Tailpipe 90° Turn Down Option

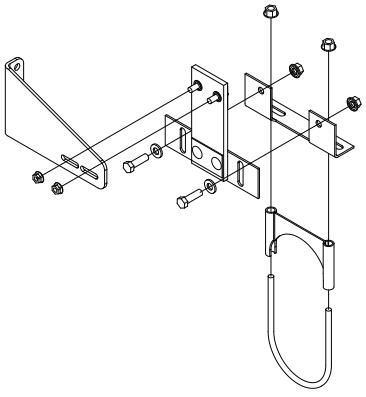
Notes:
* Torque all Exhaust Bandclamps to 40-60 ft. lbs.
* See Hanger Bracket Detail Page.

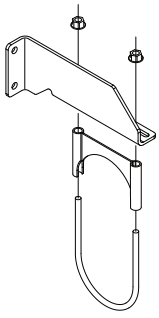
D0004146A

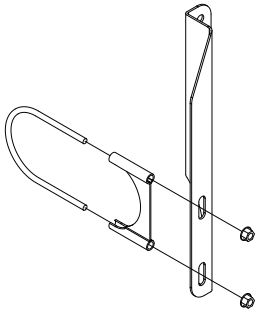
Exhaust, Tailpipe Options

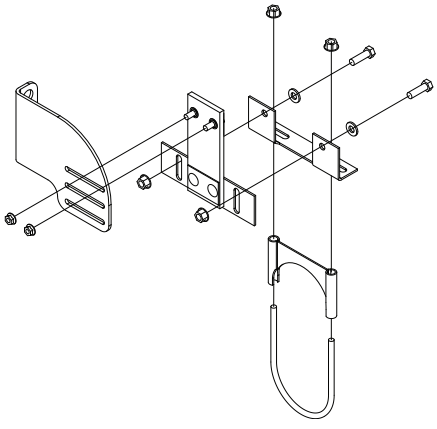












Notes:
* Torque all Hanger Bracket Nuts to 13-15 ft. lbs. except where noted.

Exhaust, Hanger Bracket Details

Fuel System

The Vision's fuel tank is mounted in the rear overhang between the frame rails and is made of 12-gauge (HRLCCQ–T125) aluminized steel. The fuel system meets the requirements of Federal Motor Vehicle Safety Standard (FMVSS) 301, Fuel Systems Integrity For School Buses.

Observe all safety and environmental warnings and precautions in the Introduction chapter of this manual before performing any of the tests and maintenance procedures in the section.

WARNING ***Blue Bird does not approve or disapprove additions to or modifications of Blue Bird fuel systems. Blue Bird fuel systems are designed and installed to meet federal standards and engine manufacturer's guidelines. The upfitter or modifier assumes all responsibility for vehicle engine and fuel system if the fuel system is changed or modified.***

All fuel system components must be a minimum of 7" from any exhaust system component unless properly shielded..

CAUTION ***In 2010 diesel engines, use only diesel fuel labeled Ultra Low Sulfer, per the engine manufacturer's specifications. In Caterpillar, use oils meeting API CJ-4 or Caterpillar ECF-3 compliant. See Caterpillar Operation and Maintenance Manual SEBU8083-08 for details. In Cummins, use oils meeting API CJ-4/SL and Cummins Engine Standard CES-20081. See Cummins Owners Manual ISB 6.7L CM2150 for details.***

The system includes a flush-mounted inspection plate over the sending unit, mounted in the bus floor and covered with floor covering material. This inspection plate is located near the centerline of the bus and approximately inline with the filler tube neck at the fuel door.

The system is designed with either 60- or 100-gallons fuel capacity depending upon wheelbase. The fuel tank is equipped with a ½-inch NPT plug in the bottom. This plug must be removed periodically to allow collected water and sediment to drain. When the discharge is clean fuel, replace the plug.

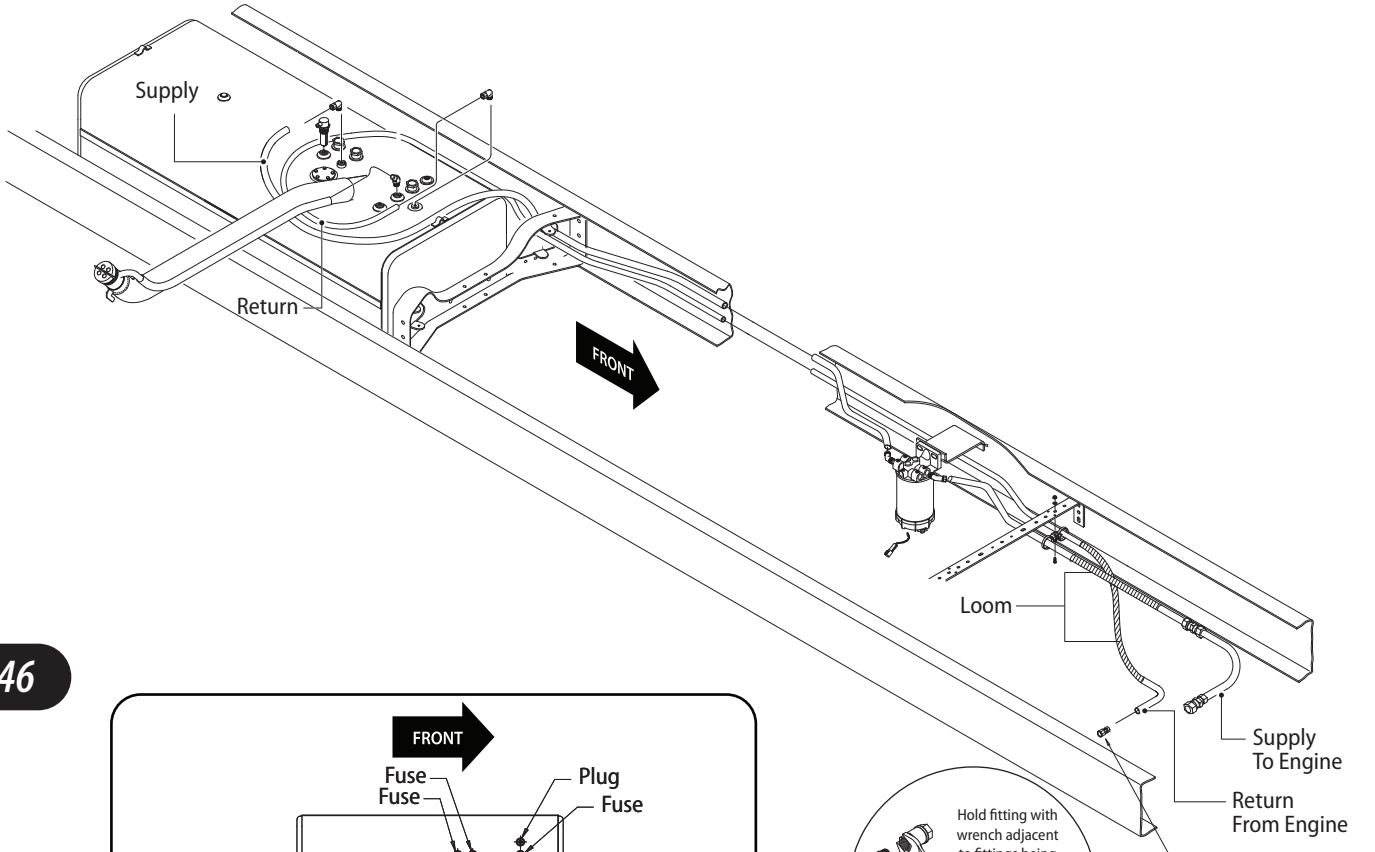
Wheel Base	Gallons / Liters
189 inches	60 / 227.12
217 inches	60 / 227.12
238 inches	60 / 227.12
252 inches	100 / 378.54
273 inches	100 / 378.54

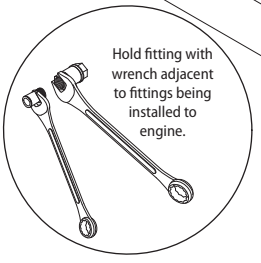
All fuel system lines and components must be secured a minimum of 7 inches (178 mm) from any exhaust component.

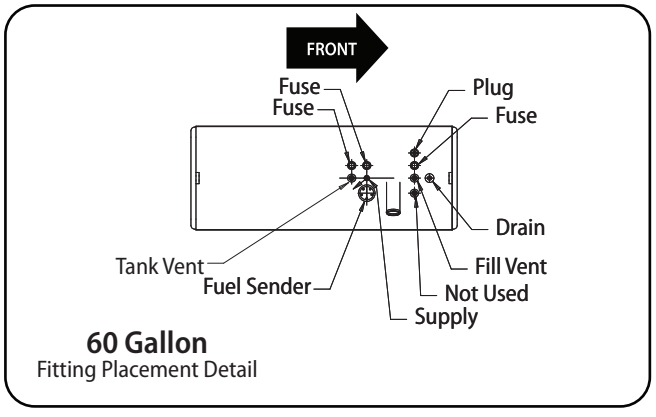
Do not repair a damaged fuel line; replace it. The number of clamps required to secure the fuel lines is dependent upon the wheelbase of the bus. When removing a clamp, ensure it is replaced in the proper position. Check with your Blue Bird Distributor for replacement fuel lines.

Wheelbase	Number of Clamps
189	6
217	7
238	8
252	8
273	9

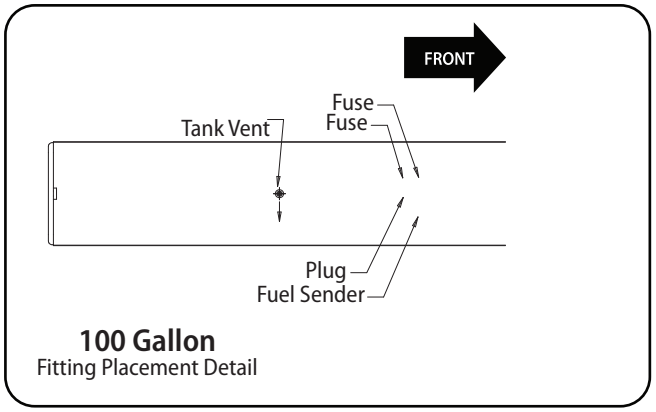
Fuel System







60 Gallon
Fitting Placement Detail



100 Gallon
Fitting Placement Detail

0087409

Assembling Fittings

1. Cut tubing squarely. Maximum of 15° angle allowable. (Use of Parker tube cutter PTC-001 is recommended.)
2. Check that port or mating part is clean and free of debris.
3. Insert tubing into fitting until it bottoms on seat.
4. Tighten nut with wrench until one thread remains visible on the fitting body. (This will allow for a number of remakes.) Or, turn down the nut until finger tight; then tighten as indicated below:

TUBE SIZE	TURNS BEYOND HAND-TIGHT
¼	3
⅜ & ½	4
⅝ & ¾	3 ½

When installing item #10, Tighten one turn beyond finger tight. Then Continue turning to orient barb.

Fuel Filters

The fuel/water separator and primary fuel filter is located just forward of the rear axle, on the inside of the left hand frame rail on the driver's side. This separator must be drained daily to ensure the fuel is clean and free of water, as it enters the secondary fuel filter.

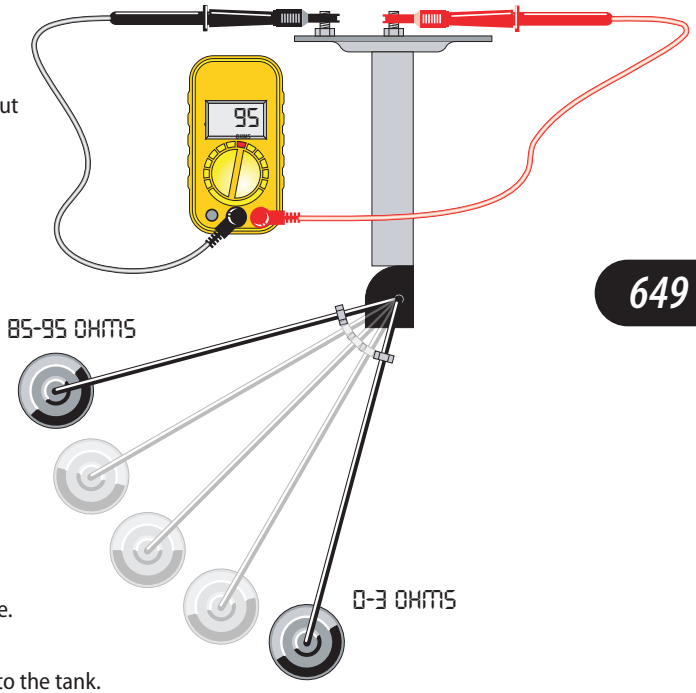
The fuel/water separator and primary filter cartridge (Part Number R90-BB-02) must be changed, at a minimum, at prescribed intervals provided in the Preventative Maintenance Schedule. This interval is 11,000 miles (17,700km) or 1,100 gallons (4150 L) of fuel consumption, or 250 hours of engine operation or 6 months; whichever is the first to occur. The spin on filter cartridge replacement is R90-BB-02. This is a 30-micron PRIMARY filter; therefore, secondary/final filtration is required before the fuel reaches the engine. The filter cartridge must be replaced immediately to avoid contamination of the fuel system. Contaminated fuel may make it necessary to change this filter cartridge at any time, not only at scheduled intervals.

The secondary fuel filter is located on the left-hand (driver's) side of the engine, on a mounting bracket just behind the air compressor. This filter must be changed according to the Preventative Maintenance Schedule as well. Just one tank of contaminated fuel can cause this filter to need change without regard to the schedule.

Fuel Level Sending Unit

The Fuel Level Sending Unit is mounted in the top of the fuel tank. An access plate located in the floor center aisle provides access to the sending unit for testing and replacement.

An electrical terminal in the top center of the sending unit receives signal voltage from the instrument cluster. A ground terminal near the outer edge of the sender connects to ground via the chassis harness. The signal current passes through a mechanical variable resistor, which is actuated by the sender's float arm. As the float rises and falls with the level of fuel in the tank, it varies the resistance of the unit from 0~3 ohms when the float arm is at its lowest (empty tank) to 85~90 when the arm is fully raised (full tank). This resistance is monitored by the control module of the instrument cluster, which registers it as a percentage and passes it to the fuel gauge.



Testing the Fuel Level Sending Unit

A multimeter may be used to check the resistance of the sending unit. If the actual fuel level is known, the sender may be tested witout removing it from the fuel tank:

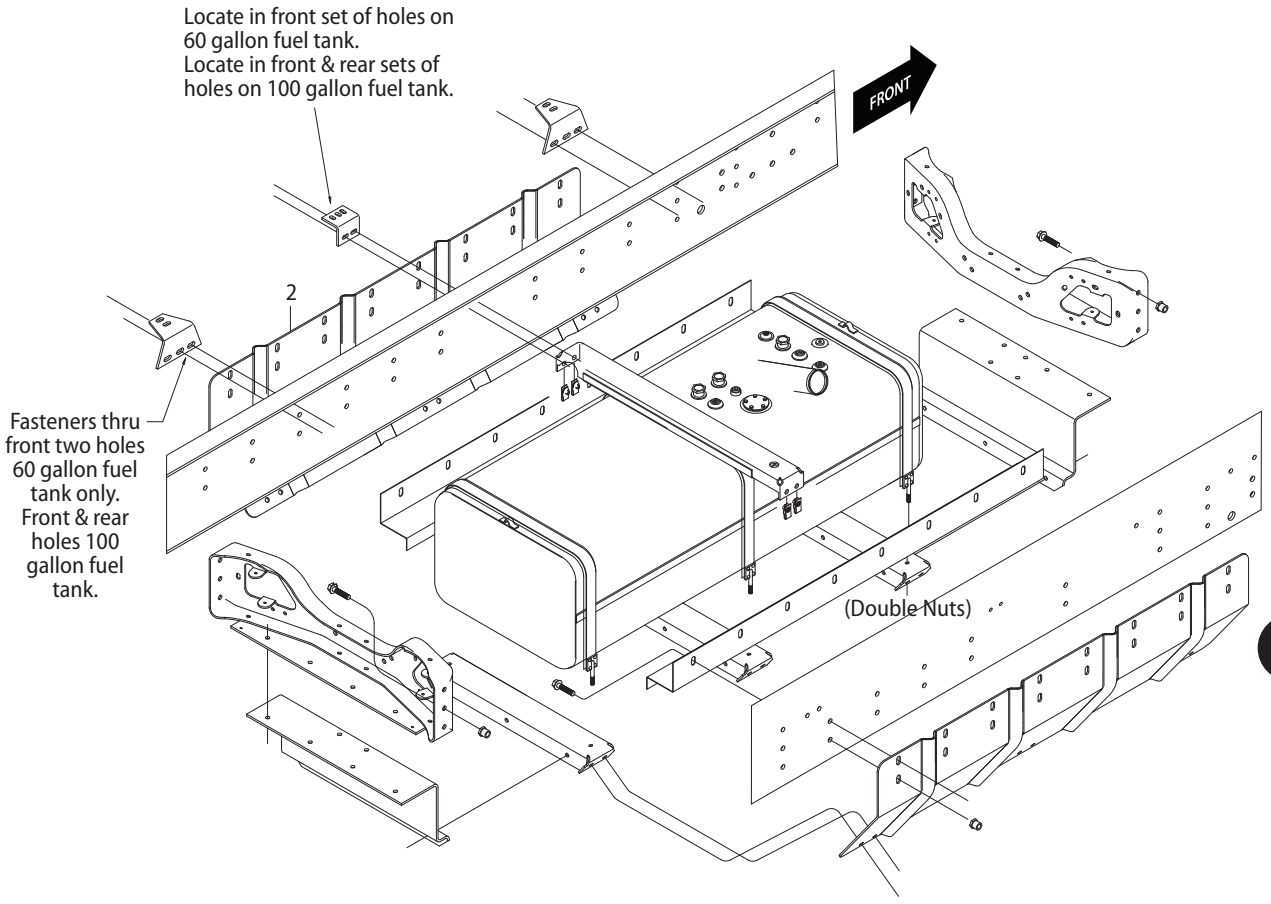
1. Inside the bus, remove the screws securing the access plate. Remove the plate.
2. Disconnect all wires from the sending unit.
3. Set the multimeter to measure ohms. Connect the positive test lead to the terminal in the center of the sending unit. Connect the negative lead to the outer terminal.
4. Turn on the multimeter and note the resistance. If the tank is full, the resistance should be approximately 85~90 ohms.

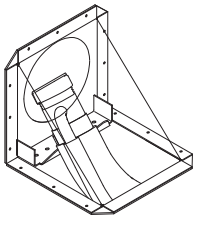
To further test the sending unit with it removed from the tank:

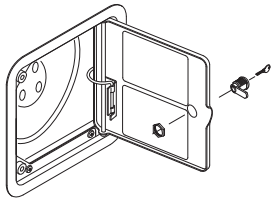
1. Remove the screws securing the access plate. Remove the plate.
2. Disconnect all wires from the sending unit.
3. Remove the five hex held bolts which secure the sending unit to the tank. Remove the sending unit, being careful to avoid damaging the gasket.
4. Set the multimeter to read ohms. Connect the positive test lead to the terminal in the center of the sending unit. Connect the negative lead to the outer terminal.
5. Hold the sending unit with its mounting plate parallel to the floor, and the float arm hanging free in the empty position. Turn on the multimeter and note the resistance. With the arm in the lowered (empty) position, the resistance should be approximately 0~3 Ohms.
6. Slowly raise the float arm. The resistance should increase proportionally to the movement of the arm until it reaches 85~90 Ohms at the fully raised (full) position. If the reading is out of range, intermittent or sporadic, replace the sending unit.

650

Fuel Tank & Barrier







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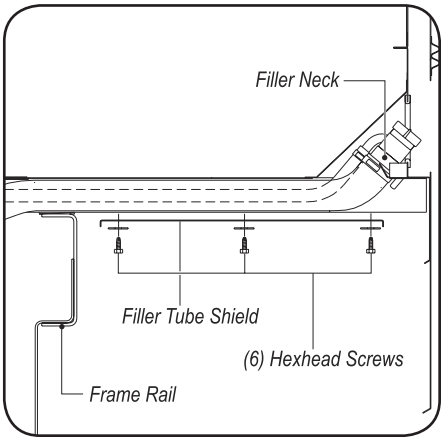
Fuel Tank

Draining the Fuel Tank

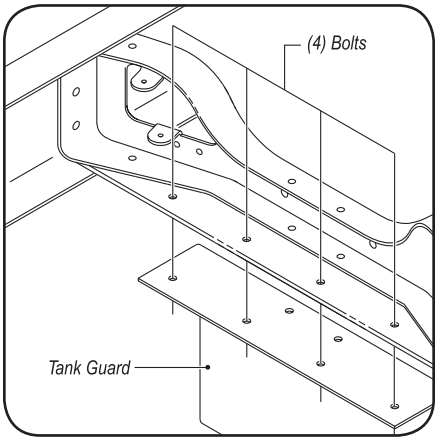
Caterpillar scheduled Level 1 Maintenance also requires that the fuel tank be drained of accumulated sediment and water. To drain the fuel tank:

1. Observe all safety warnings and environmental cautions. See the Introduction chapter of this service manual.
2. Remove the drain plug from the bottom of the fuel tank.
3. When only clean fuel is being discharged from the tank, replace the drain plug. Install finger tight. Wipe the exposed threads and apply Loctite 557 with Teflon™ to the exposed threads. Continue to tighten the plug 1½ turns.
4. Wipe clean and ensure there is no leak.



Fuel Tank Removal

1. Using the drain plug in the bottom of the tank, drain the fuel into suitable containers. Loosely install the plug to prevent entry of debris.
2. Place a suitable support device under the tank.
3. Remove 6 hexhead screws from the filler tube cover.
4. Remove 4 bolts from the front tank guard.
5. Remove 4 bolts from rear tank guard.
6. Remove 2 bolts from each end of each tank support. Lower the tank carefully until it is possible to remove the fuel lines and wiring from the top of the tank. There is a loop of approximately 18 inches (457 mm) slack at the top of the tank for this purpose.
7. Remove all fuel lines and the filler tube. Carefully cover each opening as it is opened, to prevent con-tamination.
8. Remove the sender wiring.

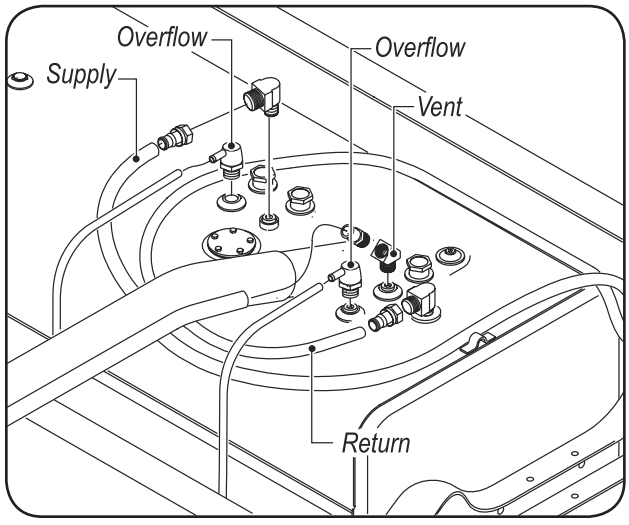


Assembly of New Fuel Tank

1. Position the new fuel tank on the support rails.
2. Install the tie-down straps.

WARNING ***Ensure there is protective webbing between the straps and the fuel tank, and between the fuel tank and the support members. There must be no metal-to-metal contact.***

3. Install overflow fitting in 2 places. Tighten the fittings finger tight; then apply a bead of Perma-Lok™ LH-150 (or equivalent) thread sealant around the ex-posed threads. Then tighten 2 turns further, using an appropriate, open-end wrench. Do not use an adjustable wrench. Ensure the barbs of the fittings are directed at the nearest edge of the fuel tank and in the direction of the filler tube.
4. Install an 18–20 inch (458–508 mm) length of tubing to direct fuel overflow past the frame rail.
5. Install the return line 90° fitting finger tight at the appropriate opening. Tighten the fitting finger tight, and then apply a bead of Perma-Lok™ LH-150 (or equivalent) thread sealant around the exposed threads. Then, tighten 2 turns further using an appro-priate, open-end wrench. Orient the flange thread toward the outboard edge of the fuel tank and in the direction the filler tube runs.
6. Install the supply line 90° fitting at the appropriate fuel tank opening. Tighten the fitting finger tight. Then apply a bead of Perma-Lok™ LH-150 (or equivalent) thread sealant around the exposed threads, and tighten 2 turns further using an appropri-ate, open-end wrench. Orient the flange thread toward the outboard edge of the fuel tank and in the direction the filler tube runs.
7. Install the 45° elbow vent fitting finger tight into the appropriate opening in the fuel tank. Apply a bead of Perma-Lok™ LH-150 (or equivalent) thread sealant around the exposed threads. Tighten 2 turns further using an appropriate, open-end wrench. Orient the flange thread toward the outboard edge of the fuel tank and in the direction the filler tube runs.
8. Install the tubing adapter into the 45° elbow vent fitting. Tighten finger tight. Apply a bead of thread sealant Perma-Lok™ LH 150 and tighten 1 ½ flats further.



Fuel Tank Installation

Installation of the fuel tank is accomplished in the reverse order of the removal instructions above.

1. Position the fuel tank on the tank supports.

WARNING ***Ensure there is protective webbing between the straps and the fuel tank, and between the fuel tank and the support members. There must be no metal-to-metal contact.***

2. Loosely attach one end of the tank tie down straps.
3. Wrap the tie down straps over the fuel tank and loosely install the other side.
4. Ensure the tank is properly oriented. The front is the end of the tank with the hose fittings.
5. Position the front tank guard and install it to the front tank support. Torque 3 bolts (200) to 36–52 Ft lb (48.81–70.50 Nm). Use new lock nuts.
6. Position the rear tank guard and install it to the rear tank support. Torque to 36–52 Ft lb (48.81–70.50 Nm). Use new lock nuts.
7. Position the fuel tank beneath the chassis.
8. Raise the tank to a level where it is possible to install the fuel lines and wiring. Clean sender wiring termi-nals prior to assembly. Protect the sender terminals with heavy grease.
9. Torque hose clamps to 45 In lb (5.08 Nm). Worm gears and drive hex or slot should be oriented toward the top for accessibility.
10. Lift the fuel tank into position.
11. Install the 4 bolts in the front tank guard. Use a flat washer on each side of the installation. Use a new locknut. Torque to 36–52 Ft lb (48.81–70.50 Nm).
12. Install the 4 bolts in the rear tank guard. Use a flat washer on each side of the installation. Use a new locknut. Torque to 36–52 Ft lb (48.81–70.50 Nm).
13. Install the 2 bolts at each end of each tank support. Use a flat washer at each side of the installation. Use new locknuts. Torque to 40–58 Ft lb (54.25–78.64 Nm).
14. Ensure the fuel tank is centered, front to rear and side-to-side.
15. Tighten the first nut on each tank strap to 40 Ft lb (54.23 Nm). Then, while holding the first nut, torque the jam nut to 40 Ft lb (54.23 Nm).
16. Install the drain plug in the bottom of the fuel tank finger tight. Then, apply a bead of Loctite ™ 557 with Teflon™, or equivalent, to the exposed threads. Continue to tighten 2 full turns. Wipe clean.

Accelerator Control, Electronic

The Vision's throttle control regulates engine speed not by direct mechanical linkage, but by electronically communicating the position of the pedal to the engine's Electronic Control Module (ECM). The ECM in turn controls the engine's fuel system to adjust engine speed.

When the pedal is pressed, its lever arm rotates a spring-loaded mechanism inside the throttle assembly's upper housing. Attached to the side of the housing is an electronic position sensor which varies a signal it sends to the engine ECM. The signal modulates according to the position of the rotating part of the pedal assembly.

Being electronic, the accelerator is mounted entirely inside the bus, with no part of it extending through the firewall. The assembly is not rebuildable; therefore, it must be replaced as a unit if damaged or faulty. The pedal position sensor requires no adjustment, and is not rebuildable. However it is replaceable as a separate unit from the pedal assembly (Blue Bird kit # 0064032).

Testing And Troubleshooting (Cummins)

The Cummins accelerator pedal incorporates two Throttle Position Sensors to provide the required input to the engine ECM. These components are non serviceable and should not be removed from the accelerator assembly or you could risk voiding the warranty. Each component has three wires going through a weather-pak connector and can be tested individually for proper operation.

Throttle Position Sensor Coil Resistance

The Throttle Position Sensor provides the engine an analog signal instructing it to increase or decrease RPM based on the position of the accelerator. This is done with a three wire potentiometer. The sensor is provided a continuous 5V DC (pin B27) and a ground (pin B28) by the engine ECU. As the accelerator pedal is depressed, the throttle position sensor will relay its position to the engine (pin B35). The throttle position sensor can be tested by the following:

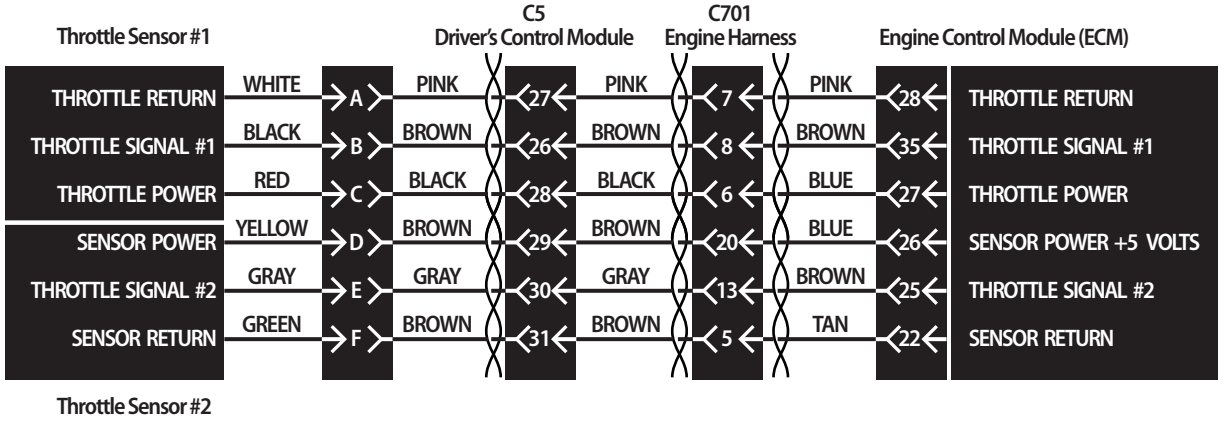
Disconnect sensor plug and meassure resistance on accelerator side of connector between:

- Pins C and A. (Supply and Return) Value should be between 2000 and 3000 ohms.
- Pins C and B. (Supply and Return) Released pedal value should be between 1500 and 3000 ohms.
- Pins C and B. (Supply and Return) Depressed pedal value should be between 200 and 1500 ohms.

Resistance should decrease proportionally as pedal is depressed. Released pedal resistance minus depressed pedal resistancemust be greater than 1000 ohms.

CAUTION ***Do not attempt to adjust or repair throttle position sensor or idle validation sensor. Warranty will be voided.***

Should the accelerator fail to meet specifications the entire pedal must be replaced.



Overview

The Blue Bird Vision instrument cluster uses all electronic analog gauges with stepper motor technology coupled to a microcontroller that provides the necessary electrical control. In addition to gauges, this ACTIA® manufactured instrument cluster includes an LCD display panel known as a Message Display Center and gauge warning indicators which provide illuminated visual alerts to the Driver.

The instrument cluster receives both analog inputs from such components as the fuel tank sender and instrument panel dimmer switch; binary inputs from brake and directional signal switches; and digital signals from components such as the engine and transmission control modules, via the J1939 and J1587 data buses.

The instrument cluster comes with several modes of operation. The system is in Sleep Mode when the battery power is applied to the cluster with no other activity. In this mode the microprocessor deactivates the power maintain output resulting in low power draws of less than 3mA to support the clock. When the instrument cluster sences a change to an input signal such as turning the iginition key on or turning on the headlights, the cluster wakes up and then decides which mode to enter depending on which input is active. Limited Mode is a stand by mode entered when there is battery power available and the iginition is turned off, but other input signals are requiring the system to operate such as hazard warning lights or brake interlock request. Another mode of operation is the Start-Up Mode. This mode is entered when the iginition is turned on. When the start-up mode is initiated the cluster will go through a functional diagnostic test, if the self-test option is enabled (default). During this test you will see the gauge pointers drive to zero position (pause) then move to half scale (pause) and then move to full scale (pause) before returning to the zero position, and finaly going to the commanded position. During this time all warning lights will perform a lamp check by turning on for 5 seconds, and the three different audible tones will be checked by turning on for 1 second. During this start-up mode, the microprocessor also monitors all the inputs. If a problem is detected an error message will be displayed and the gauges will wag to flag the communication failure. The Ignition Mode is the normal operational mode of the system and is active as long as the ignition switch is on. When the ignition is turned off the microprocessor will zero all gauges, except the fuel gauge which will remain at its last command position. The Self-Diagnostic Mode is entered through a menu selection. The self-diagnostic tests include the gauges, LCD, warning lights, binary inputs, analog inputs and binary outputs. Detailed specifications can be found in the Message Display Center section of the appendix.

The backlighting on this instrument cluster is adjustable through an internal dimmer. This is done using the two buttons on the face of the cluster. The backlight color can also be changed through the setting and diagnostics menu accessed using the same two buttons on the face of the cluster. Backlight colors are blue, light blue, white, red and green. The white LCD and amber pointer backlights are not adjustable.

The cluster also uses its microprocessor to compute logic required for certain units to function. When the logic is satisfyied, an output is generated and sent to these units to satisfy their operational needs. Units requiring logic outputs include Speed Detect used in the brake interlock system, Seat Belt Logic used for alarms and Lift Authorization used to supply power to deploy the handicap wheelchair lift.

The instrument cluster is a sealed unit with no serviceable parts including gauges, lights and buzzers. If your cluster is found to be defective, it is replaced in whole as a unit.

Appendixes In This Chapter

Appendix 1. Blue Bird Corporate Cluster Functional Specification. This ACTIA publication was created especially for Blue Bird and details the operation of the instrument system including a detailed explanation of the Message Display Center's menus and diagnostic capabilities.

Instrument Cluster

The VISION'S instrument cluster is a single unit of all-electronic guages and warning lights, which receive both analog inputs from such components as the fuel tank sender, oil pressure sensor; and digital signals from components such as the engine and transmission control modules. A centrally-located Message Display Center displays the odometer reading, error alerts, and service technician diagnostic information. If the VISION is equipped with hydraulic brakes, the instrument cluster contains 5 gauges. Buses equipped with air brakes have two additional gauges indicating primary (front) and secondary (rear) air pressure.

1. **Speedometer.** Indicates vehicle speed in miles/hour or kilometers/hour.

2. **Tachometer.** Indicates engine speed in revolutions per minute times 1000.

3. **Message Display Center.** Displays additional information to the vehicle operator. See Message Display Center.

4. **Fuel Gauge.** Indicates fuel level in tank. Fuel gauge bank includes illuminated Low Fuel Indicator and Low Fuel Pressure Indicator.

5. **Coolant Temperature Gauge.** Indicates engine coolant temperature and includes an engine coolant temperature warning indicator.

6. **Oil Pressure Gauge.** Indicates engine oil pressure and includes an oil pressure warning indicator.

7. **Front Air Gauge.** Indicates air pressure in front brake reservoir and includes a low air warning indicator.

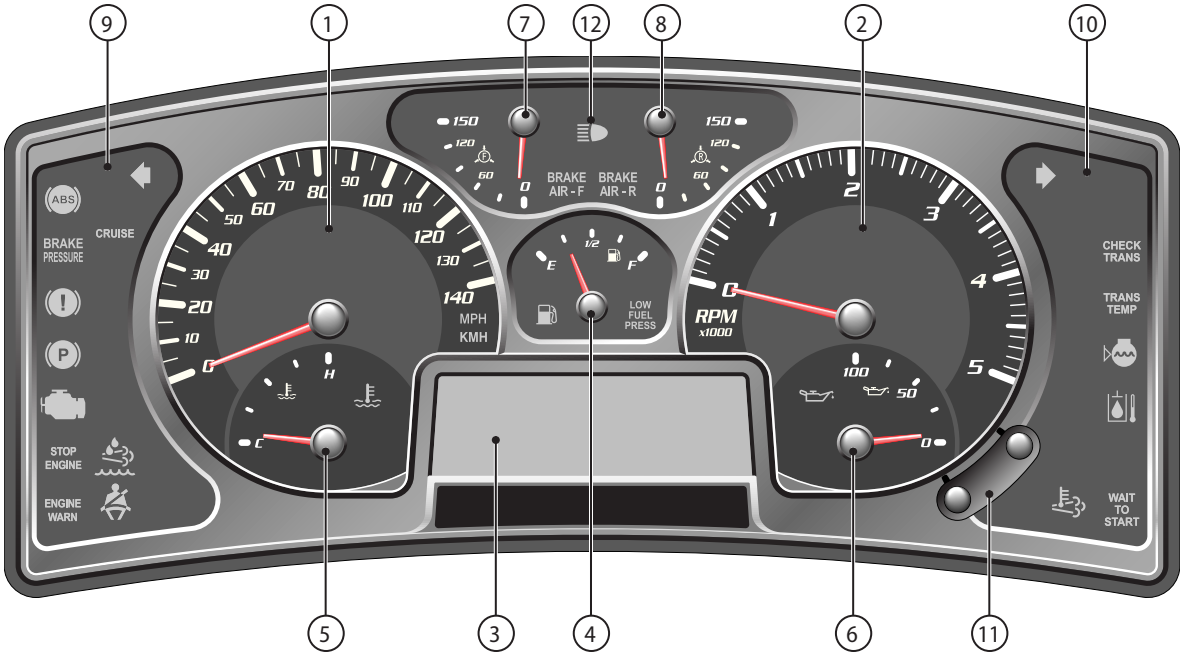
8. **Rear Air Gauge.** Indicates air pressure in rear brake reservoir and includes a low air warning indicator.

9. **Left Warning Bank.** Cluster of indicator lamps. See Warning Bank Indicators.

10. **Right Warning Bank.** Cluster of indicator lamps. See Warning Bank Indicators.

11. **Message Display Center Control Panel.** Two buttons which activate and toggle the menus of the Message Display Center. These buttons also serve as an Instrument Panel Dimmer, see *Dimmer Adjustment*.

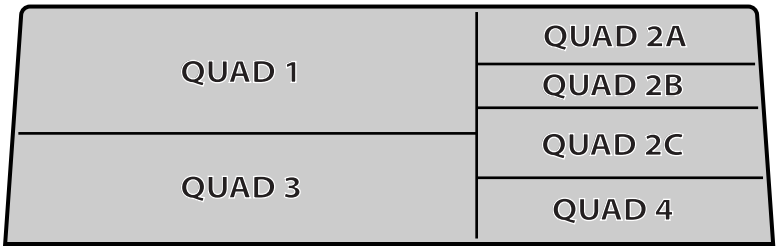
12. **Headlight Highbeam Indicator.**



Message Display Center

The message display center provides additional information to the vehicle operator. It is located at the bottom center of the instrument panel and is divided into six zones. Each zone displays data relayed to the vehicle operator from vehicle systems. The message display center can also be used for diagnostic purposes by trained service technicians. The zones of the display are selected and toggled by the two buttons on the message display control panel on the lower right side of the tachometer. Other function of the message display control panel include, setting the clock, dimmer adjustment, contrast adjustment, and backlight color adjustment. See pages 662 - 663.

Message Display Control Panel



Quad 1. Displays the Odometer, Trip 1 Odometer and Trip 2 Odometer. The odometer registers the mileage on the vehicle and the trip odometers may be set to register mileage from destination to destination. On the message display control panel press and release the bottom button to toggle between odometer and trip odometer settings. Press the top button to reset trip odometer. This quad also displays all general priority messages when triggered. The priority messages can be removed by pressing the bottom button or cycling the ignition.

Quad 2A. Displays Gear Selection. **N** - Neutral, **R** - Reverse, and **D** - Drive.

Quad 2B. Displays alternator output voltage (in Volts) and can display the amount of current being drawn by the vehicle electrical system (in Amps).

Quad 2C. Displays the service brake applied pressure on buses equipped with air brakes. This shows how much air pressure in psi (pounds per square inch) is being applied to the front and rear brakes when the brake pedal is pressed. This feature will only display when programmed. This quadrant can also be programmed to to display suspension air pressure in buses equipped with hydraulic brakes.

Quad 3. Displays the diesel exhaust fluid (DEF) gauge. This is the normal run display for busses equipped with 2010 emission standard diesel engines. The DEF gauge is displayed at all times.

Quad 4. Displays a clock. On the message display control panel press bottom button to activate the zone then press and release both buttons simultaneously. Use the top button to select 12 or 24 hour clock setting.

Priority Messages

No Engine Communication
No Transmission Communication
No ABS Communication
Data Link Warning
Vehicle Speed Error
Engine Door Open
Brake Interlock Set
Brake Interlock Fail
Brake Interlock Requested
Retarder Applied
DEF Level Low
DEF Level Critical
DEF Level Derate
DEF Level Empty
DEF Speed Limit
DEF Fluid Type
* Stop Engine
* Engine Warning
* Hi Trans Temp
* Low Oil Pressure
* High Engine Temp
* Low Coolant Level
* Turn Signal On
* Voltage Error
* Water In Fuel
* Lift Not Stowed
* Regen Needed
* High Exhaust Temp
* Alternator Fail
* Headlights On
* ATC Active
* Range Inhibit
* Transmission Oil Life
* Trans Oil Filter
* Transmission Oil Service

** (Messages Shown with Icon)*

Warning Bank Indicators

Two arrangements of LED-illuminated warning lights provide feedback to the Driver about various systems. These are located to the right and left sides of the instrument panel, indicator definitions are shown on the following page.

An audible sound speaker is incorporated into the back of the instrument cluster, and sounds to accompany the indicator light warnings. The audible alarm also serves to indicate turn signal blink and turn signal reminder.

Left Turn. Flashes with left turn signal.

ABS. Indicates fault in the anti-lock brakes system. Complete route then service as soon as possible.

Brake Pressure. Indicates brake failure. Stop vehicle and call for assistance.

Service Brakes. Indicates service brakes have been applied.

Park. Indicates parking brake is applied.

Maintenance Indicator Lamp. Indicates maintenance required.

Stop Engine. The engine ECU has detected a problem which can lead to engine damage. Stop the engine and call for assistance.

Engine Warn. The engine needs service.

Diesel Exhaust Fluid. DEF low level warning light.

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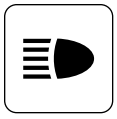


High Beam. Headlights are in high beam.

Cruise. Cruise control has been activated.

Brake Air Front. Indicates front brake air pressure outside of normal operating range.

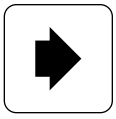
Brake Air Rear. Indicates rear brake air pressure outside of normal operating range.

Low Fuel. Indicates fuel level at 12 percent of maximum capacity.

Low Fuel Pressure. Indicates low fuel pressure on compressed natural gas vehicles.

High Coolant Temp. Indicates coolant temperature out of normal operating range.

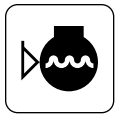
Seat Belt. Indicates driver seatbelt not engaged.



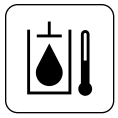
Right Turn. Flashes with right turn signal.

Check Trans. The transmission needs service.

Trans Temp. The transmission temperature is beyond normal operating range.



Coolant Level. Indicates low coolant level.



Hydraulic Fluid Temperature. The hydraulic fluid temperature is beyond normal operating range.

Wait to Start. Indicates engine preheating. Wait until indicator goes off before starting engine.

HEST. High Exhaust System Temperature. Indicates elevated exhaust temperature

Oil Pressure. Indicates low oil pressure.

Set the Clock

To set the clock, be sure the park brake is set then press and hold the bottom button on the face of the instrument cluster for approximately 5 seconds. This will display the Settings and Diagnostics screen. Press either the top or bottom button to move to the highlighted bar to menu item 6 – Set Clock. Press both buttons simultaneously to select "hours" then use the upper and lower buttons to increase or decrease the setting. Press both buttons simultaneously to set the hours. Repeat the process for the "minutes" setting. A lapse of ten seconds or more of inactivity will return the display to the previous screen automatically.

Message Display Control Panel

Dimmer Adjustment

Dimming or brightening the backlight in the instrument cluster can be accomplished two ways. The first is when the bus is stationary with park brake set. The second is in Drive Mode when the park brake is released and the headlight switch is in the "ON" position. In either case the new setting will be stored in memory.

When the bus is stationary and the park brake is set, dimming the instrument cluster is achieved through a menu in the drivers display in the cluster. Set the park brake then press and hold the bottom button on the face of the instrument cluster for approximately 5 seconds. This will display the Settings and Diagnostics screen. Press either the top or bottom button to move the highlighted bar to menu item 4 – Dimmer. Press both buttons simultaneously to select "dimmer" then use the upper and lower buttons to increase or decrease the backlight intensity. Press both buttons simultaneously to set the dimmer and exit the menu. A lapse of ten seconds or more of inactivity will return the display to the previous screen automatically.

If the bus is in drive mode by having the park brake released, the dimmer can be adjusted by pressing either the top or bottom buttons to brighten or dim the instrument cluster. The headlight switch must be in the "ON" position for this function to operate.

Contrast Adjustment

Set the park brake then press and hold the bottom button on the face of the instrument cluster for approximately 5 seconds. This will display the Settings and Diagnostics screen. Press either the top or bottom button to move the highlighted bar to menu item 3 – Contrast. Press both buttons simultaneously to select "contrast" then use the upper and lower buttons to increase or decrease the contrast. Press both buttons simultaneously to set. A lapse of ten seconds or more of inactivity while in this mode will return the display to the previous screen automatically.

Backlight Color Adjustment

The backlight color can be adjusted to illuminate in any of five different colors (Red, Green, Blue, Lt Blue, White). To change the backlight color set the park brake then press and hold the bottom button on the face of the instrument cluster for approximately 5 seconds. This will display the Settings and Diagnostics screen. Press either the top or bottom button to move the highlighted bar to menu item 5 – BL Color. Press both buttons simultaneously to select "BL Color" then use the upper or lower buttons to toggle between a list of preset colors. Press both buttons simultaneously to set the color and exit the menu. A lapse of ten seconds or more of inactivity while in this mode will return the display to the previous screen automatically.

Instrument Cluster Removal

The instrument cluster is designed for easy removal from its housing by means of screws around the perimeter of its face. The instrument cluster itself is not designed for disassembly and is removed as a unit.

1. Turn the iginition switch to the off position and remove the key. Lower the steering wheel to the bottom of its travel.

2. Remove the four screws from the corners of the instrument panel which houses the instrument cluster. This will allow access to the back of the instrument cluster for removal and installation.

3. Remove the seven machine screws from around the instrument cluster's perimeter. This will detach the cluster from the instrument panel.

4. Carefully rotate the instrument cluster and pull it away from the dash housing. Tilt the cluster face down to gain access to the back.

5. Disconnect the electrical connectors from the back of the instrument cluster and remove unit.

Instrument Cluster Installation

The installation of the instrument cluster is done in the reverse order of the removal. After it has been installed the Cluster must be configured or programmed to operate accurately for the bus it was installed. Failure to do this may result in inaccurate instrument readings.

1. Connect the electrical connectors to the back of the instrument cluster.

2. Carefully rotate the cluster and center it in the panel for attachment. Position the cluster so the mounting holes align. You will need to reach behind the panel to hold the cluster in position while securing the seven mounting screws.

3. Secure the panel by installing the four mounting screws located in each corner.

4. Enter the Configuration Menu to set-up specific features for your instrument cluster. To do this first be sure the ignition is in the off position. Press and hold the top and bottom buttons on the face of the cluster. While holding these buttons presses in, turn on the ignition. Release the buttons when a menu appears in the drivers information display. This display will allow you to set-up items in the configuration menu.

5. You can use the top and bottom buttons on the face of the cluster to scroll up or down. Press both buttons simultaneously to enter the configuration value. After entering the value the highlight bar will automatically move to the next item to be set –up. If the cluster has logged less than 25 miles all menu items can be changed. After 25 miles you will not be able to change some items, only user configurable items. See appendix 1 for more details. This menu will auto exit after 10 seconds with no activity.

52765 Bridger Court
Elkhart, IN 46514
USA

Phone:
Fax:
www.actia.com

Bluebird Corporate Cluster Functional Specification

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1. PURPOSE

This document is the design specifications for the development of a corporate cluster for Bluebird Bus Corporation. Initially to be used on the D3 and CV bus lines.
The instrumentation is based on gauges with stepper motor technology, married to a microcontroller that provides the necessary electrical control. Circuit provisions are included to assure compliance with SAE J1455 "in cab" standards and Bluebird electrical SP13 environmental specification.
All gauges and indicator or warning lamps as well as displays are to comply with FMVSS/CMVSS 101 standards unless deviation is approved by the customer in writing.

2. SCOPE

This document covers the operational specifications of the instrument panel and gauge system for use in Bluebird school buses. Engine, transmission, ABS and other Mux systems used in this application are listed in the table below:

Engines	Transmissions	ABS Systems	BCM/CCM/Diag
Cummins ISB07 (Diesel) / ISC07 (Diesel) / ISB10 (Diesel) / ISC10 (Diesel) / ISLG (J1939)	Allison 2000/2500 / 3000 (1939)	Wabco Hydraulic Systems (J1939)	BBA3 Rear Run Box 0079080
GM 8.1L (Gas) ECM (J1850* & GMLAN)		Bendix EC30 Air Systems (J1939)	
CAT C7 (Diesel) (J1939)		Bendix EC60 Air Systems (J1939)	

*Note: J1850 communications facilitated through Actia J1850 to J1939 converter module (Actia # 106622)

3. RELATED DOCUMENTS

For more detail on functional or visual details of this instrument system, the following documents must be consulted:

- 110763 Dial face with Air Gauges-If spec change effects graphics, updated art must be supplied to the Customer for approval and documentation on their end.
- 110764 Dial face without Air Gauges- If spec change effects graphics, updated art must be supplied to the Customer for approval and documentation on their end.

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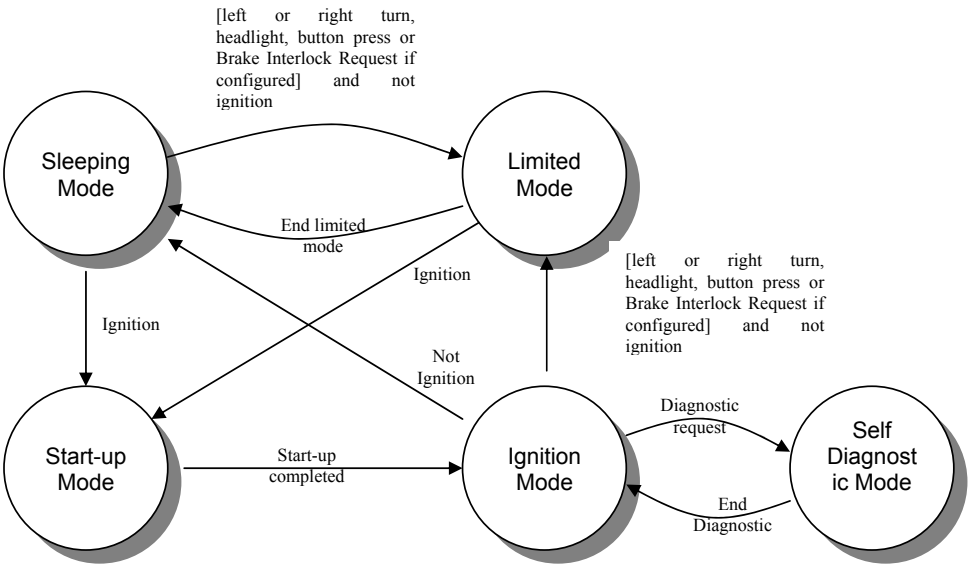
4. MODES OF OPERATION



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4.1. Sleep Mode

If battery power is applied to the system with no other activity, it will be in sleep mode. When the system is in Sleep Mode the microprocessor is stopped.

4.1.1. POWER SUPPLY

The system exits Sleep Mode when one of the wake-up inputs becomes active. When the cluster wakes up, it first begins to control the power supply by activating the power supply maintain output. It then decides, depending on which wake up input is active, what mode must be entered. When the system goes back to sleep after the deactivation of the wakeup input, it simply deactivates the power supply maintain output.

4.1.2. LIN DEVICES

All LIN devices will remain awake for 10s after loss of wakeup. The master will stay awake for 4 seconds after loss of IGN and 10 seconds after loss of any other wakeup.

4.1.3. CLOCK

The clock will remain awake in the background as long as battery power is applied. It will only display on LCD when in Limited or Ignition mode.

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4.2. Limited Mode

The system runs in limited mode when battery power is available, the ignition input is not active but other input signals are requiring the system to operate. The system exits limited mode when the ignition becomes active or the input signals that caused the system to wake-up become inactive.

4.2.1. DISPLAY ODOMETER & CLOCK IN LCD

The odometer and Clock is readable with the ignition off when the Headlight input is Active or Mode or Trip button is pressed. The cluster will go back to sleep mode if the Headlight input is not active or 15 sec after the mode or trip was pressed.

4.2.2. HAZARD WARNING LIGHTS

The right and left turn icons are operational with the ignition off when the hazard lights are turned on (right and/or left turn binary inputs high).

4.2.3. BRAKE INTERLOCK REQUEST

When this input is Active the cluster power supply will wake up only to check the Battery control lift config and depending on the setting will either carry out the logic for the outputs as described in section 7 of this document or go back to sleep.

4.3. Start-Up Mode

The ignition binary input is used to sense if the key switch is on or off. The cluster enters start-up mode when the ignition is on. If the start-up self-test option is enabled, the system will go through the functional diagnostic tests described in the start-up self-test option section.

If the self-test option is disabled the gauges should drive to zero, with the exception of fuel which remains at its last commanded position, then default to actual values received by data buss messages/senders at startup.

All warning lights will perform a lamp check by turning on for 5 seconds and then go out. After lamp check, active warning lights will turn.

The cluster will determine which data buses are connected and which devices are present. Error messages will display if a data bus is missing or a device that had been previously found is now missing. If the data bus should fail, a communications error should be displayed on the LCD, and the gauges will wag to flag the communication failure.

4.3.1. START-UP UP SELF-TEST OPTION

The start up self-test is an option enabled through the setup menu. The factory setting for this option is enabled.

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4.3.1.1. Gauges

Gauge pointers will drive to zero position. The pointers will then drive up scale, pausing at ½ scale, before completing the sweep to full scale. The pointers will then return to zero position before moving to the commanded position.

4.3.1.2. LCD

During the up scale sweep of the pointers, the LCD will turn all its segments on for one second, off for one second and then display the opening message. The opening message is the Bluebird logo followed by the software ID, complete with revision level.

4.3.1.3. Warning Lights

Starting at the up scale pointer sweep, all warning lights will turn on for 5 seconds and then go out. Active warning lights will turn on when the gauges go to their commanded position.

4.3.1.4. Audible Alarm

The audible alarm will sound three different tones for one second each during the up scale swing of the pointers.

4.4. Ignition Mode

The ignition mode is active as long as the ignition switch is on.
The ignition is the normal operational mode of the system.

If the ignition line goes low the micro will zero all gauges, except the fuel gauge which will remain at its last commanded position, and store any data to the EEPROM before turning the supply off.

After storing the data, the system goes to sleep mode after a delay of approximately 4 seconds.

4.5. Sleep Mode

When the system is in sleep mode the clusters microprocessor goes into low power mode and draws less than 3 mA to support the clock function.

The system exits sleep mode when one of the wake-up inputs become active. When the cluster wakes up, it first begins to control the power supply by activating the power supply maintain output. It then decides, depending on which wake up input is active, what mode must be entered.

When the system goes back to sleep, it simply deactivates the power supply maintain output.

4.6. Self-Diagnostic Mode

The self-diagnostic mode is entered through a menu selection using the LCD. Diagnostics is only available when the Park Brake is set.

The self-diagnostic includes the following tests:

- Gauges
- LCD

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- Warning Lights
- Binary Inputs
- Analog Inputs
- Binary Outputs

Detail specifications are found in the Message Display Center section.

4.7. Test Panel Mode

The test cluster mode can only be activated through Actia provided software. When selected, the software is configured as a production chassis test fixture. The functions below describe the difference in operation for this mode:

1) An active Binary Input on WB PIN 6 will configure the cluster for Chassis with System Air (If it is not active it will be configured for a Hydraulic system)
2) An active Binary Input on WB PIN 7 will configure the cluster for Chassis with Applied Air (front and rear applied air).

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5. IGNITION MODE

5.1. Gauge Display

5.1.1. SPEEDOMETER

Data Source	Stepper	Range	Movement	Scale	Indicator Light
J1939 - PGN65265 GMLAN -TBD	M404	187°	CW	Linear 0° = 0 187° = 140	MPH – D426 K/mh – D427

Note: Scale units (MPH -Km/h) scale will be noted though dead front indications on the speedometer.

5.1.2. TACHOMETER

Data Source	Stepper	Range	Movement	Scale	Warning Light	WL Trigger	WL Alarm	Alarm Acknowledge
J1939 - PGN61444 GMLAN - TBD	M401	187 °	CW	Linear 0° = 0 RPM 187 ° = 5000 RPM	None	None	None	N/A

5.1.3. FUEL GAUGE

Data Source	Stepper	Range	Movement	Scale	Warning Light	WL Trigger	WL Alarm	Alarm Acknowledge
Diesel - CL_Pin_34 Gas - CL_Pin_34	M403	90°	CW	Piecewise Linear 0° = Empty 90° = Full 93° = Max(no tick)	Amber – FMVSS 571-101 Table 2 Fuel Level (D428) Fuel Pressure (D429)	On if fuel ≤ 12.5% Then off if fuel ≥ 18% (Gas / Diesel)	Beep 1	Yes/5 min. Reoccur
CNG - CL_Pin_10					Amber – Text "Low Fuel Pressure" (D429)	On if fuel ≤ 1.6Vdc Then off if fuel ≥ 1.7Vdc(CNG)		

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5.1.4. OIL PRESSURE GAUGE

Data Source	Stepper	Range	Movement	Scale	Warning Light	WL Trigger	WL Alarm	Alarm Acknowledge
J1939 - PGN65263 GMLAN - TBD	M402	90°	CCW	Linear 0° = 0 PSI 90 ° = 100 PSI	Red – FMVSS 571-101 Table 2 (D430)	J1939 - DM1SPN100 GMLAN - TBD	Continuous 1	Yes/5 min. Reoccur

5.1.5. COOLANT TEMPERATURE GAUGE

Data Source	Stepper	Range	Movement	Scale	Warning Light	WL Trigger	WL Alarm	Alarm Acknowledge
J1939 - PGN65262 GMLAN - TBD	M405	90°	CW	Linear 0° (C) = 100°F 90° (H) = 260°F	Red – FMVSS 571-101 Table 2 (D425)	J1939 - PGN65262 GMLAN - TBD	Continuous 1	Yes/5 min. Reoccur

5.1.6. FRONT AIR GAUGE

Data Source	Stepper	Range	Movement	Scale	Warning Light	WL Trigger	WL Alarm	Alarm Acknowledge
CL_Pin_11	M407	90°	CW	Linear 0° = 0 PSI 90° = 150 PSI	Red – text "BRAKE AIR-F" (D431)	On when front air ≤ 65 PSI Then off when ≥ 72 PSI	Continuous 1	No

5.1.7. REAR AIR GAUGE

Data Source	Stepper	Range	Movement	Scale	Warning Light	WL Trigger	WL Alarm	Alarm Acknowledge
CL_Pin_12	M406	90°	CCW	Linear 0° = 0 PSI 90° = 150 PSI	Red – text "BRAKE AIR-R" (D432)	On when Rear air ≤ 65 PSI Then off when ≥ 72 PSI	Continuous 1	No

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5.2. Backlighting

The gauge backlighting will be turned on when the backlight (CL_Pin_19) input is active.

Dimming of the backlight is done using an "internal dimmer" which is controlled using the buttons on the cluster. If the park brake is set the dimmer can be accessed through the diagnostic menu.

If the park brake is not set, and the Headlight input is active then the up and down buttons will automatically become the dimmer adjustment. To adjust the backlight intensity in this state, the buttons can be pressed and held to adjust progressively. In this state, if Trip or Odometer access or access to any other quadrant is needed, both buttons must be pressed and they will temporarily return to menue navigation mode.

If any PIM's are active the buttons will be used to acknowledge those faults before they can be used as dimmer controls or for display naivigation.

Once adjusted the setting is stored in the EEPROM.

5.2.1. GAUGES

The gauge backlight can be selected by the end user. The selected color is controlled through the setting and diagnostics menu using the buttons on the cluster. Once adjusted the setting is stored in the EEPROM.

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Colors	R %	G %	B %
Blue	0	0	100
Light Blue	0	47	100
White	62	100	91
Red	100	0	0
Green	0	100	0

5.2.2. LCD

The LCD backlight is not selectable by the end user.

Color
White

5.2.3. POINTER

The pointer backlight is not selectable by the end user.

Color
Amber

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5.3. Warning Bank Indicators

5.3.1. LAMP GENERAL DETAIL

The lamps detailed below are either indicator lights activated to show the engagement of some chassis function or warning lights to show a fault in a particular chassis function.

Some warning lights have an alarm associated with them. This alarm will be one of several preset speaker profiles. See alarm section for profile details. Alarm and duration are referenced for each lamp. If no duration is listed the alarm will continue until the fault is gone.

Some warnings have an associated LCD Warning message that will be displayed along with the warning light. See the message display section for specifics on those messages.

All warnings with associated alarms/display messages can be "acknowledged". If the user acknowledges the warning by pressing the ***top button***, the display will go back to the previous screen and the alarm will stop, but the indicator lamp will remain active. The alarm/display will reocure if fault still exists at text ignition of in a predetermined time frame if noted.

5.3.2. MISC INDICATOR/WARNING LAMPS

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D401	LEFT TURN	GRN 527nm	SAE J1362 # 14.9	CL_Pin_21	ON Active High	Click 1

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D413	RIGHT TURN	GRN 527nm	SAE J1362 # 14.9	CL_Pin_23	ON Active High	Click 1

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D403	CRUISE	GRN 527nm	Text "Cruise"	J1939 - CruiseActive GMLAN – TBD	ON = Anything except 000 or 111	None

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D433	HIGH BEAM	BLU 469nm	SAE J1362 # 14.1	CL_Pin_20	ON Active High	None

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D411	SEAT BELT	RED 610nm	Modified SAE J1362 No. 8.14	CL_Pin_32	see seat belt logic section below	Beep 3

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5.3.3. BRAKE SYSTEM WARNINGS

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D402	ABS	YEL 590nm	SAE J1362 No. 12.11	J1939 - PGN61441ABS	ON = 01	Beep 1/for 5 sec

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D404	BRAKE FAILURE (Engllish)	RED 610nm	Text "BRAKE PRESSURE"	CL_Pin_17	ON Active Low (only if configured for English units)	Continuous

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D405	BRAKE FAILURE	RED 590 nm	Symbol ISO2575 B.01	CL_Pin_17	ON Active Low (only if configured for Metric units)	Continuous

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D406	PARK BRAKE	RED 610nm	SAE J1362 No. 12.6	CL_Pin_22 BIN_AL	On steady if Active and IGN is ON	NONE
					Flash at 1Hz for 2 min then Off if not active & Ignition Off Flash at 1Hz if Active & Ignition on & ≥ 3 MPH	Beep 2 when Lamp is on or flashing
	BRAKE FAILURE (Metric)			CL_Pin_17_AL	On steady if Active	Continuous

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D420	HIGH HYDRAULIC OIL TEMP	RED 610nm	SAE J1362 No. 11.6	Not required	Not required	Not required

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5.3.4. ENGINE WARNING LAMPS

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D412	ENGINE WARNING	YEL 590nm	Text "Engine Warn"	J1939 - DM1AmberWarnLamp GMLAN – TBD	ON for SPN ANY_FMI ANY	Continuous /until acknowledged
				when the idle shutdown (PGN65252Shutdown.) becomes active.	indicator is illuminated and will flash on and off at a 3Hz Idle shutdown will have priority on J1939 over engine warning.	
				(gateway) SPN 59645	FMI 18	
				(SCR) DMI_Lamp Any_SPN1569 Or DM1_Lamp Any_SPN5246	FMI 31	
				PGN64892	Value 011 lamp will flash in sequence with DPF display Flash	See DPF PIM

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D410	STOP ENGINE	RED 610nm	Text "Stop Engine"	J1939 - DM1RedStopLamp GMLAN – TBD	ON for SPN ANY_FMI ANY	Continuous 1
				(SCR) DM1_Lamp Any_SPN5246	FMI 31	
				PGN64892	Value 100 lamp is on steady	See DPF PIM

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D418	LOW COOLANT LEVEL	YEL 590nm	SAE J1362 No. 9.9	J1939 - DM1LowCoolantLamp GMLAN – TBD	Flashing at 1Hz for SPN111_ FMI 1, 11, 18 and AMBER Lamp	Continuous /until acknowledged

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D424	WAIT TO START	GRN 527nm	Text "Wait To Start"	J1939 - PGN65252 Or CL Pin 36	ON = 01 ON=BIN AL	NONE

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5.3.5. TRANSMISSION WARNING LAMPS

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D416	CHECK TRANS	RED 610nm	Text "Check Trans"	J1939 - DM1CheckTransLamp GMLAN – TBD	ON for SPN 2003_ FMI 31 and AMBER Lamp	None

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D417	HIGH TRANS TEMP	YEL 590nm	Text "Trans Temp"	J1939 - DM1HighTransTempLamp GMLAN – TBD	ON for SPN 177_ FMI 15	Continuous /until acknowledged

5.3.6. EMISSION SYSTEM WARNING LAMPS

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D408	MIL	YEL 590nm	Symbol ISO2575 F.01	J1939 - DM1 MIL Lamp GMLAN – TBD	ON for SPN ANY_FMI ANY	Continuous /until acknowledged
				(SCR) DMI_Lamp Any_SPN1569 Or DM1_Lamp Any_SPN5246	FMI 31	

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D409	DEF	YEL 590nm	Symbol per Cummins AEB 21.81	PGN 65110_SPN 5245	001 = On Solid	Beep 1/ Single beep
					100 = Flashing	Beep 1/ Repeating

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D423	HIGH EXHAUST TEMP	YEL 590nm	Engine Manufacturer Defined	J1939 - PGN64892_SPN3698	Same as Display Message	Same as Display Message

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5.3.7. SPARE LAMPS

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D407	SPARE	RED 610nm	TBD	TBD	TBD	TBD

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D414	SPARE	RED 610nm	TBD	TBD	TBD	TBD

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D415	SPARE	RED 610nm	TBD	TBD	TBD	TBD

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D419	SPARE	YEL 590nm	TBD	TBD	TBD	TBD

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D421	SPARE	YEL 590nm	TBD	TBD	TBD	TBD

Pos	Function	Color	Graphic	Data Source	Trigger Logic	Alarm/Duration
D422	SPARE	RED 610nm	TBD	TBD	TBD	TBD

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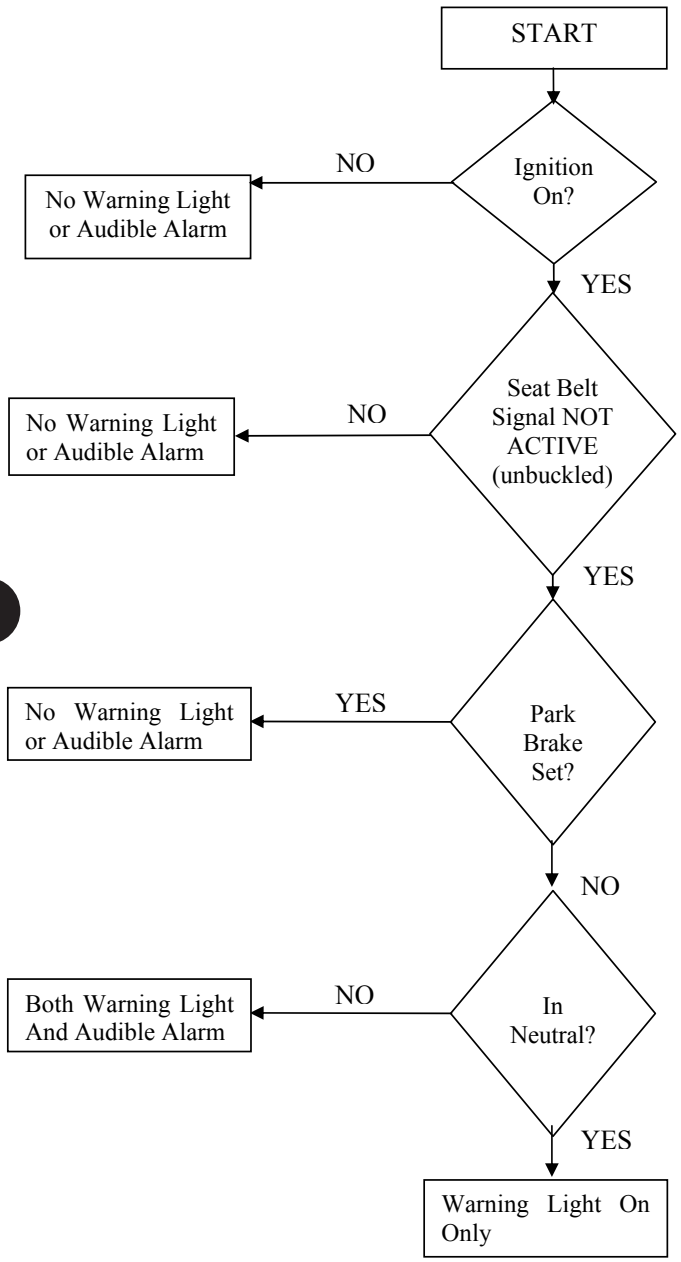
5.3.8. SEAT BELT LOGIC

This warning light & audible alarm are active when the requirements are met, shown in the flow chart below:



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6. AUDIBLE ALARM

6.1. Tone Definition

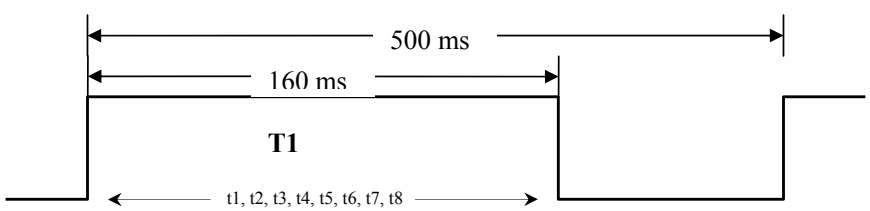
The following table details the available alarms mentioned throughout this document. These will be referred to by their Audible Alarm name throughout this document to define audible alarms for specific functions. The Frequency of the alarm is detailed below. The Period is shown as the "ON" time repeated tones and then the Repetition describes how often the tone is repeated.

Continuous and Click alarms cannot be acknowledged unless otherwise stated. All Beep Alarms will have a 5 min reoccurrence when acknowledged unless otherwise stated.

Audible Alarm	Freq.	Period	Repetition
Continuous 1 (Buzzer)	2.8KHz	N/A	Continuous (see section 11.1 for timeout config detail)
Beep 1 (Alarm)	2.0KHz	160 ms	2 Hz
Beep 2 (Chime)	2.8KHz	160 ms	2 Hz
Beep 3 (Seat Belt)	2.0KHz	160 ms	Continuous
Click 1 (Relay)	See below	See below	See Below

6.1.1. TURN SIGNAL CLICK

Turn signal Click				
T1	**On** Click (Hz)	Duration (ms)	**Off** Click (Hz)	Duration (ms)
t1	10,000	160	10,000	160
t2	6,200	80	2,800	80
t3	2,400	10	2,400	10
t4	10,000	160	10,000	160
t5	6,200	150	6,200	80
t6	3,600	80	2,800	40
t7	920	40	10,000	160
t8	6,200	150 830	6,200	80 770



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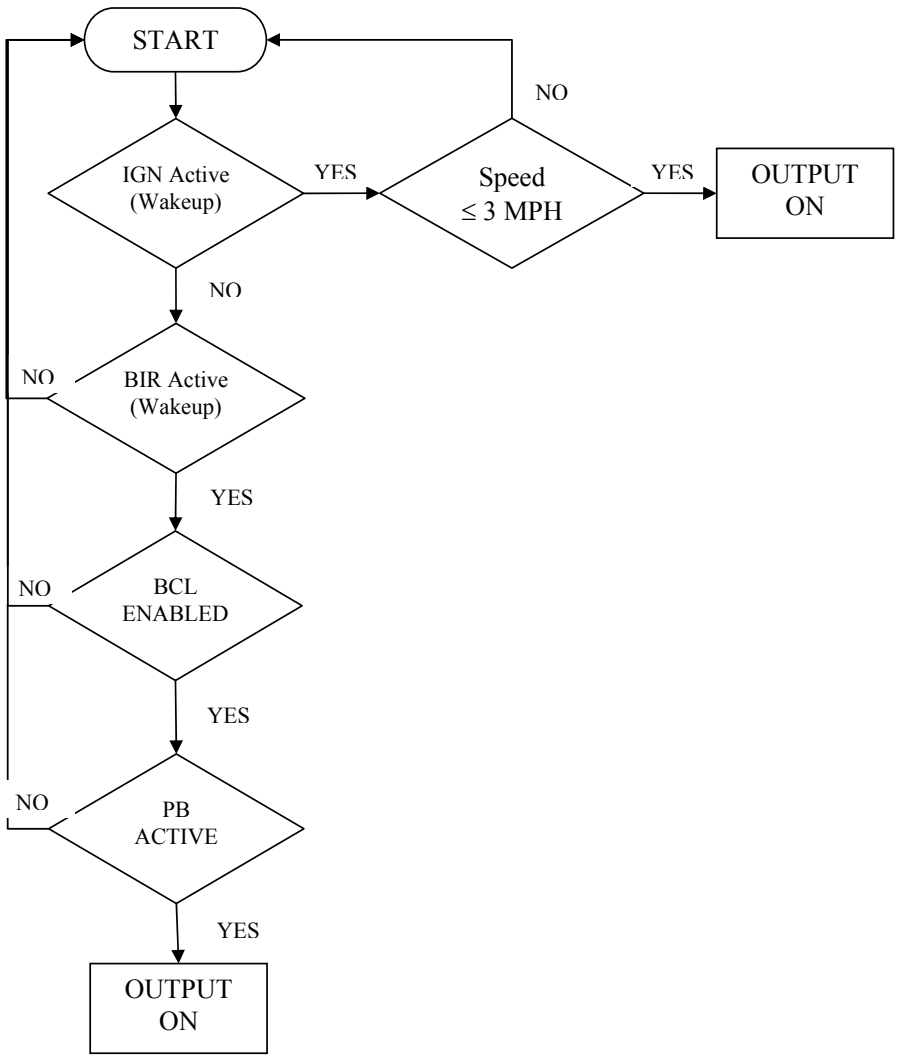
7. BINARY OUTPUTS

7.1. Speed Detect

Speed Detect output will be active according to the logic below. While active when ignition is off. The display will be on with ODO and Clock and will not display a PIM in Quad 1. Limited mode shown below will appear a sleep with no lamps, alarms, or displays. The cluster will simply be waiting for up to 10 min to see if BIR is active.



Note: BIR=Brake Interrupt Request; BCL= Battery Control Lift Config; PB=Park Brake, IGN=Ignition

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7.2. Shutter Solenoid

This binary output is a low side drive output and is normally active. For the logic listed below this output will become inactive.

Cummins Engines:
Inactive output when PGN 65262 Byte 1 has a value of ≥ 180°F and PGN 65270 Byte 3 has a value ≥ 100°F or engine is not running.

CAT Engines:
Inactive output when PGN 65262 Byte 1 has a value of ≥ 180°F and PGN 65270 Byte 3 has a value ≥ 140°F or engine is not running.

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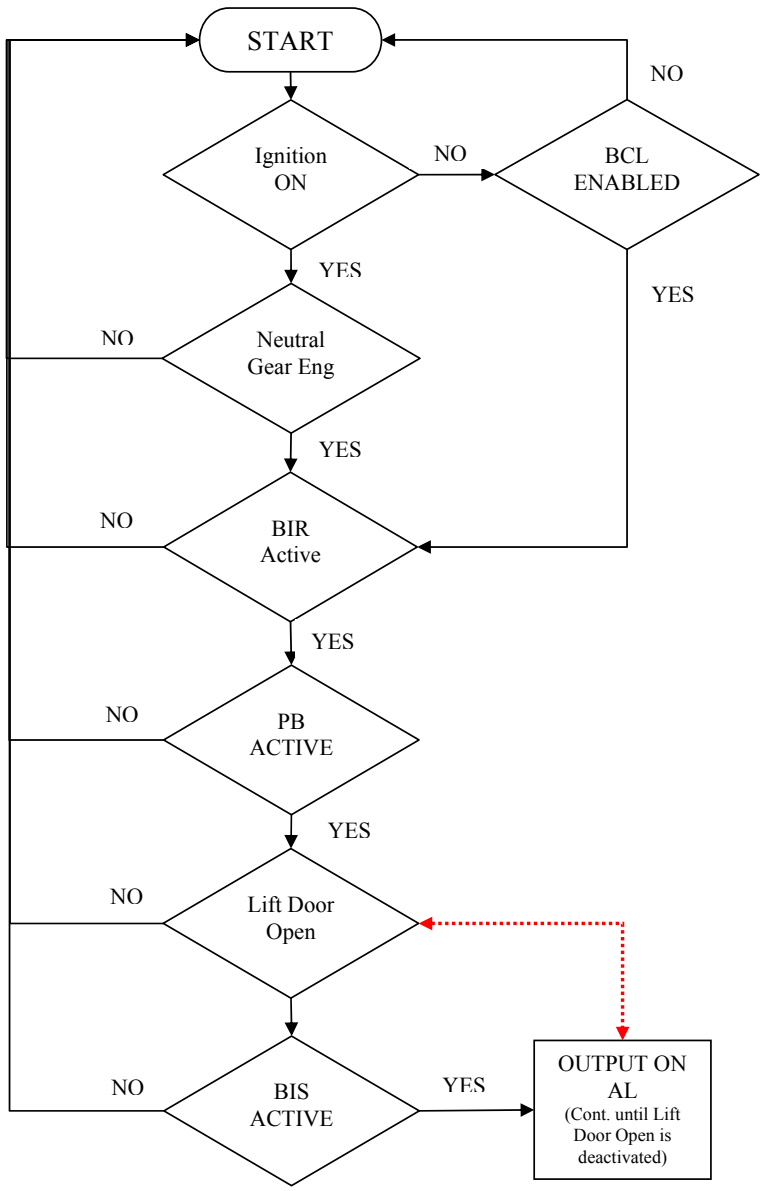
7.3. Lift Authorization

Lift Authorization output will be active according to the logic below. The display will be on with ODO and Clock and display the message "LIFT AUTHORIZATION ON" while active when ignition is off.



Note: BIR=Brake Interrupt Request; BCL= Battery Control Lift Config; BIS=Brake Interlock Set; PB=Park Brake

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8. COMMUNICATION

There are two communication channels for data transfer between the vehicle and the speedometer. One channel for CAN 2.0B/GMLAN (Controller Area Network) and a second channel for CAN 2.0B/SAE J1939 (Controller Area Network).

All frames transmitted by the speedometer on J1939 are continuously sent at the standard broadcast rate for the frame using source address (SA) 23dec (17h).

The cluster communicates via the LIN bus to slave devices. The slave gauges are updated every 80mSec.

8.1. J1939 Auto Detect Function

The cluster will monitor the J1939 at start up and will look for Engine (SA00h), Transmission (SA03h) and ABS (SA0Bh) systems. To allow the cluster to be configured to multiple engines, Transmission or ABS combinations the cluster will request component ID's first by sending a global request for PGN65259 SPN 586 and 587 (BAM). If a module does not answer a request will be made specifically to that SA.

8.1.1. ENGINE ID

The engine responses expected will be as follows.

	Engine Cummins				
ID Byte (ASCII)	Cummins ISB07	Cummins ISC07	Cummins ISL G	Cummins ISB10	Cummins ISC10
1	C	C	C	C	C
2	M	M	M	M	M
3	M	M	M	M	M
4	N	N	N	N	N
5	S	S	S	S	S
6	*	*	*	*	*
7	6	6	6	**6**	**6**
8	B	C	L	**B**	**C**
9					
10	u	u	U	**u**	**u**
11	0	0	0	**1**	**1**
12	7	7	7	**0**	**0**
13	D	D	G	**D**	**D**
14	0	0	0	**0**	**0**
15	6	8	8	**6**	**8**
16	7	3	9	**7**	**3**
17	*	*	*	*	*
18	*	*	*	*	*
19	*	*	*	*	*

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	Engine Caterpillar		
ID Byte (ASCII)	CAT C7	CAT C9	
1	C	C	
2	T	T	
3	R	R	
4	P	P	
5	L	L	
6	*	*	
7	C	C	
8	-	-	
9	7	9	
10	*	*	
11	*	*	
12	*	*	
13			
14			
15 16 17 18 19			

	Engine GM 8.1L (1850)		
ID Byte (ASCII)	GM		
1	G		
2	Y		
3	*		
4	X (last digit 1)		
5	X (last digit 1)		
6	*		
7	*		
8	*		

GM 8.1L LTG propane engine will communicate on 1850 and for this application the Gateway module will be used so if the Gateway is present on the 1939 data bus, the cluster will assume the GM propane engine is used. See 111702 specification for general Gateway message support details.

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8.1.2. TRANS ID

The transmission responses expected will be as follows.

	Transmission		
ID Byte (ASCII)	Allison 2000	Allison 2500	Allison 3000
1	A	A	A
2	L	L	L
3	L	L	L
4	S	S	S
5	N	N	N
6	*	*	*
7	M	M	M
8	D	D	D
9	2	2	3
10	0	5	0
11	0	0	0
12	0	0	0
13	*	*	*
14	*	*	*
15	*	*	*

8.1.3. ABS ID

The ABS module responses expected will be as follows.

	ABS Bendix (Air)		
ID Byte (ASCII)	EC60-sta	EC60-pre	
1	B	B	
2	N	N	
3	D	D	
4	W	W	
5	S	S	
6	*	*	
7	E	E	
8	C	C	
9	6	6	
10	0	0	
11	-	-	
12	S	P	
13	T	R	
14	A	E	
15	*	*	
16	*	*	
17	*	*	

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8.2. Plug and Play Function

The cluster keeps historical list of slave (LIN) devices attached and continuously verifies that all devices are present while in Ignition mode. When a new device is found it is added to the list. If a device is found missing, a Data Link Warning message will be sent to the LCD but is NOT removed from the list. Devices can only be removed from the list through the diagnostic menu.

8.3. J1939 Communication Errors

If a parameter is not received by J1939 for 5 seconds it will be flagged as missing. Missing LCD information will display a "-" and missing gauge information will be signaled by wagging the pointer from dial end to dial end. A missing J1939 data bus will be announced in the LCD.
If a LIN parameter is missing for 5 seconds the gauge will wag the pointer from dial end to dial end and flash the warning LED.

8.4. GMLAN Communication Errors

If a parameter is not received by GMLAN for ?? seconds it will be flagged as missing. Missing LCD information will display a "-" and missing gauge information will be signaled by wagging the pointer from dial end to dial end. A missing GMLAN data bus will be announced in the LCD.
If a LIN parameter is missing for 5 seconds the gauge will wag the pointer from dial end to dial end and flash the warning LED.

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8.5. Messages Sent

8.5.1. SERVICE BRAKE

Input Data Source	Message Trigger	Message Sent
CL_Pin_24	BIN AH	J1939 - PGN65265_SPN 597 = 01 GMLAN – TBD
See Lift Authorize Logic	If trigger above is NOT active or lift authorize conditions are met	J1939 - PGN65265_SPN 597 = 00 GMLAN – TBD

8.5.2. THROTTLE INTERLOCK (A3/D3 ONLY)

Input Data Source	Message Trigger	Message Sent
Throttle Interlock Logic flow charts	The throttle interlock message is sent to the engine when the Throttle Interlock conditions (Flow Chart Below) are met.	J1939 (CAT)- PGN65264_SPN 980 = 01 J1939 (Cummins)- PGN61441_SPN 972 = 01 GMLAN - TBD

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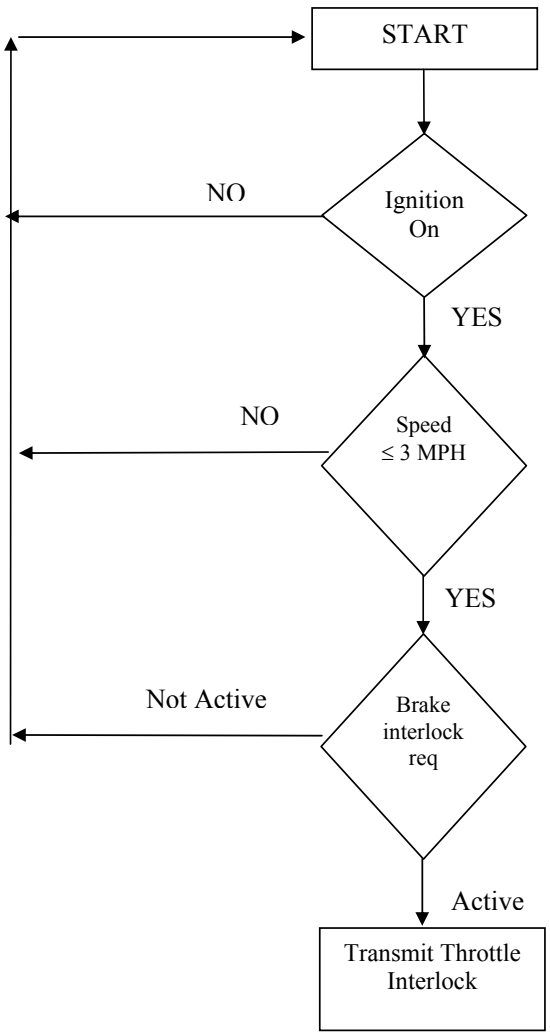
8.5.2.1. Throttle Interlock

The function of the throttle interlock message is shown in the flow chart below:



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8.5.3. PARK BRAKE

Input Data Source	Message Trigger	Message Sent
CL_Pin_22	BIN AL	J1939 - PGN65265_SPN 70 = 01 GMLAN - TBD

8.5.4. FAST IDLE

Input Data Source	Message Trigger	Message Sent
CL_Pin_25	If this input is active AND Park Brake is set AND in Neutral Gear AND Service Brake (CL 24) is NOT active	J1939 (CAT) - PGN65264_SPN 980 = 01 J1939 (CAT) - PGN65264_SPN 979 = 01 J1939 (CMNS) - PGN65264_SPN 979 = 01 GMLAN - TBD

8.5.5. REAR RUN BOX SUPPORT

This message is a proprietary message that will be sent continuously with a transmission rate of 100ms on EF2B. The details of the message contents are in the table below.

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8.5.5.1. Byte 1

Input Data Source	Bit Address	Value
Cluster Transmission Type Config Setting (currently no manual transmission feature supported in the cluster)	Bit 1	0=Automatic Transmission Config 1=Manual Transmission Config
Cluster Engine Type Config Setting (Had to combine these to use 2 bits for support of all 8 of the current cluster supported engines)	Bit 2 Bit 3	00 = Cummins Diesel/Cummins CNG/GM 01 = CAT Diesel
Cluster Units Confg Setting	Bit 4	0=English 1=Metric
Cluster Wait to Start Input Status	Bit 5	0=Inactive 1=Active
Cluster Head Light Input Status (Currently RRB does not actually use this)	Bit 6	0=Inactive 1=Active
Cluster Engine Oil Pressure Logic	Bit 7	0=Valid Range 1=Over Range
Cluster Engine Oil Pressure Logic	Bit 8	0=Valid Range 1=Under Range

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8.5.5.1. Byte 2

Input Data Source	Bit Address	Value
Cluster Fuel Level Logic	Bit 1	0=Valid Range 1=Over Range
Cluster Fuel Level Logic	Bit 2-8	Fuel level = 0-100%

8.5.5.2. Byte 3&4

Input Data Source	Bit Address	Value
Cluster Engine Oil Pressure Logic	Byte 3 & 4	Oil Pressure 0-1000 kPa

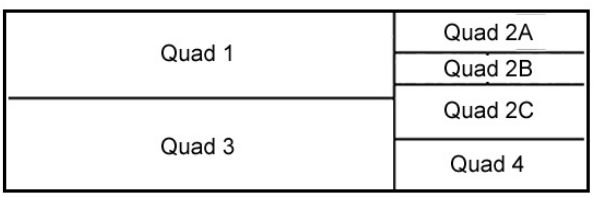
8.5.5.3. Byte 5&6

Input Data Source	Bit Address	Value
Cluster Ammeter Logic	Byte 5 & 6	Ammeter (-)200A to +200A

9. MESSAGE DISPLAY CENTER

9.1. Drive Mode Screen

During normal operation the LCD displays in 4 quadrants. The user can activate and navigate between quadrant 3 & 4 by pressing and release the ***lower*** button to highlight quadrant 3 and then press and release both buttons to select quadrant 4. Quadrant 1 is controlled only by the4 upper button and quadrant 2 has no user configuration so it cannot be selected. To toggle though the available selections for the active quadrant press the ***upper*** or ***lower*** button to toggle up or down respectively.



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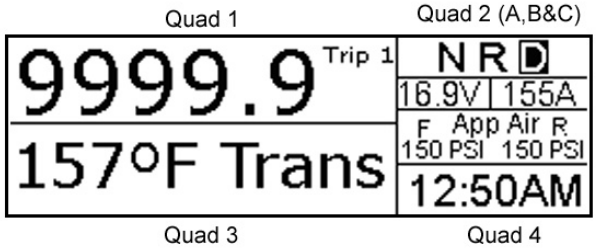
9.2. Standard Drive Mode Configuration



If the cluster is configured for engine model years older than 2010 engine (i.e. ISB/ISC10) the display will be configured as shown above.

Specifics of this organization are below broken down by display quadrant. All requirements below assume the cluster buttons are in normal mode. If they are in Dimmer mode due to backlight on and PB NOT set, both buttons will be required to be pressed to temporarily enter this normal mode (Section 5.2).

9.2.1. Standard Quadrant 1

Quadrant 1 is dedicated to the odometer or the trip odometers. This quadrant is always 169 pixels wide by 37 pixels tall. The user can toggle between the odometer, trip 1 and trip 2 by simply pressing and releasing the top button. Two trip odometers are available and will be designated T1 & T2 when displayed. To reset T1 or T2 simply press and hold the top button while that trip distance is displayed.

Function	**Data Source**	**Text Format**	**Display Example**	**Trigger Logic**	Display Notes	**Alarm/ Duration**
Odometer	J1939 – PGN62265_SPN 84	XXXXXX X.X	9999999.9 / 157°F Trans			
Trip1	J1939 – PGN62265_SPN 84	XXXX.X	9999.9 Trip 1 / 157°F Trans			
Trip2	J1939 – PGN62265_SPN 84	XXXX.X	9999.9 Trip 2 / 157°F Trans			

9.2.1.1. Odometer Logic

All odometers have a resolution of 0.1 mi/km. Leading zeros are only displayed in the 1's position. The vehicle distance is calculated every 80 msec. and stored within the cluster in kilometers. It can be displayed in miles or kilometers. The odometer reading will be displayed when the ignition switch is off by activating the headlights or pressing either button on the cluster.

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9.2.1.2. Odometer Accuracy

Accuracy of the odometer value is dependant on two (2) main variables. 1) The algorithm in the speedometer for calculating distance, and 2) the speed value transmitted by the ECM. The algorithm has been designed and written to calculate the distance with the accuracy and resolution necessary to exceed SAE recommendations. The distance is calculated every 80 msec. to reduce error during any rapid speed change the vehicle might make. The speed data is dependant on the calibration parameters for tire size and axle ratio being properly entered into the ECM. These are the same parameters necessary to have the ECM properly calculate the vehicle speed and distance value. Testing has indicated that the algorithm will calculate mileage within ±0.07% of actual based on the speed received. This far exceeds the SAE recommended ±0.3% found in SAE J1226.

9.2.1.3. Normal Shutdown

The odometer value is stored to the EEPROM at each 1-kilometer increment (0.62 mi) and when the ignition switch is turned off. The value is stored to 1/100 of a kilometer resolution (33 ft) using a 4-byte memory location within an array. Each store is made sequentially to one (1) of eight (8) locations in the array so at any point in time the last eight (8) values are maintained. Each value stored is verified at the time it is saved. Multiple store attempts to a location will be made if necessary, and if not successful, the memory location will be tagged as bad. The "precount" that is used to increment the odometer every 1/100th km is also saved. The "precount value is 115200. Therefore, our internal resolution is 1/11520000th of a km or 0.003385827 inches. This value is stored on power down and recovered on power up.

9.2.1.4. Abnormal shutdown

If there is battery power loss at the speedometer prior to turning the ignition off, an abnormal shut down will occur. The odometer value, when power is restored, will return to the last kilometer increment value saved; i.e. the last XXX.0 kilometer rollover. Therefore, the **maximum** distance lost by an abnormal shutdown will be 0.9 km (0.56 mi). Battery loss that occurs >4 seconds after turning the ignition off will NOT result in an abnormal shutdown. The occurrence of an abnormal shutdown during the life of a vehicle should be rare.

9.2.1.5. Durability

The EEPROM store routine will allow for a minimum of 4 million store cycles. The design will accommodate 200 key-offs per day, 260 days per year, for 20 years plus 1.609344 million kilometers (1,000,000 mi) which could be seen if the vehicle is used on a delivery route, with a 50% safety factor (200*260*20+1,609,334) = 2,649,334+51% = 4,000,494 store cycles. An error recovery scheme is implemented that will allow the odometer value to be recovered should a hardware failure in one of the EEPROM memory cells occur.

9.2.1.6. Error Recovery

The error recovery algorithm will check each stored value to determine if the values are in sequence (low to high) and 1 km or less apart. If this condition is found no errors are present and no further action is required. If a value is found to be out of order or greater than 1 km from the others, the software will identify the largest value in the group with the proper sequence and use that value.

In the unlikely event the speedometer fails in such a way that the odometer value cannot be displayed, the factory, in most instances, will be able to recover the stored value.

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9.2.1.7. Maximum Reading

The odometer will stop incrementing when the maximum display count is reached. Therefore, the value will not rollover to zero and continue incrementing but will freeze at 9,999,999.9.

9.2.1.8. Service Programming

If replacement of the cluster becomes necessary, the actual vehicle mileage may be programmed into the odometer using Actia proprietary software. The mileage may be incremented, but not decremented, using this software.

9.2.1.9. Service Gauges

Replacement clusters will be shipped in a mode that allows the installer to preset actual vehicle distance, thus eliminating the need to "tag" the vehicle. Documentation on how this mode works can be found in Actia document # 104426.

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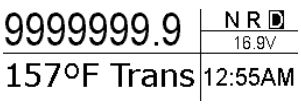
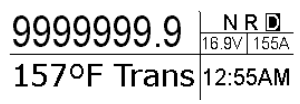
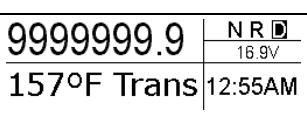
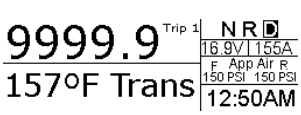
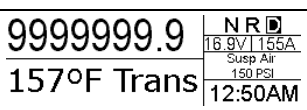
9.2.2. STANDARD QUADRANT 2

Quadrant 2A/2B/2C is configured based on active chassis features. Quad 2 is 80 pixels wide independent of the configuration. Quad 2A is dedicated to the PRNDL and will always be 20 pixels high. Quad 2B is dedicated to Voltmeter, and Ammeter (if configured active). Depending on the presence of air configurations, 2B will be 17 pixels high (no air) or 15 pixels high (with air). Quadrant 2C will display only if Applied Air or Suspension Air feature is configured active and will be 20 pixels high if present.

Function	Data Source	Text Format	Display Example	Trigger Logic	Display Notes	Alarm/ Duration
Voltmeter	J1939 - PGN65271_SPN 168 or PGN65271_SPN 158 If both are available SPN 168 will be used GMLAN – TBD	XX.XV				
Ammeter	CL_Pin_15 GMLAN – TBD	XX.XA			undA or ovrA displayed if the input is under or over our valid voltage range.	
Current Gear	J1939 - PGN61445_SPN 523 GMLAN - TBD	N R D				
Front Applied Air	CL_Pin_13	XXX PSI				
Rear Applied Air	CL_Pin_14	XXX PSI				
Suspension Air (Hyd bus only)	CL_Pin_11	XXX PSI				

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9.2.3. STANDARD QUADRANT 3

Quadrant 3 is dedicated to the parameters screen and the priority messages. This quadrant is 169 pixels wide by 39 pixels tall.

9.2.3.1. Parameters

Quad 3 can be configured by the user to display any one of these parameters. The user must press and release the bottom button which will highlight the quadrant in reverse video. Then to toggle the selection you must either press the bottom button or top button to scroll through the possible parameters to display. This Quad will default back to Trans Temp at each ignition cycle.

Function	**Data Source**	**Text Format**	**Display Example**	**Trigger Logic**	Display Notes	**Alarm/ Duration**
Trans Temp	J1939 - PGN65272_SPN 177 GMLAN – TBD	XXX°X Trans	9999999.9 N R D 16.9V 157°F Trans 12:55AM			
Intake Manifold Temp	J1939 - PGN65270_SPN 105 GMLAN – TBD	XXX°X IMT	9999999.9 N R D 16.9V 155A 150°F IMT 12:55AM		Not available for GM 1850	
Engine Hourmeter	J1939 - PGN65253_SPN 247 GMLAN – TBD	XX.X Hrs	9999999.9 N R D 16.9V 155A 8977.4 Hrs 12:55AM			
Boost Pressure	J1939 - PGN65270_SPN102 GMLAN – TBD	XXXX XXX Boost	9999999.9 N R D 16.9V 155A 5PSI Boost 12:55AM		Not available for GM 1850	
Instantaneous Fuel Econ	J1939 - PGN65266_SPN 184 GMLAN – TBD	XXXX XXX Inst	9999999.9 N R D 16.9V 155A 12.5MPG Inst 12:55AM		Not available for GM 1850	
Average Fuel Econ	See section 9.4.1.1 GMLAN – TBD	XXXX XXX Avg	9999999.9 N R D 16.9V 155A 12.5MPG Avg 12:55AM		Not available for GM 1850	

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9.2.3.2. Average Fuel Consumption Detail

Total Distance (TD)

This is an independent trip odometer dedicated to Average Fuel Consumption calculations and will not be displayed. This distance is calculated using the wheel based vehicle speed (CCVS) in Kmh multiplied by the time traveled. For the trip distance it simply logs this distance from the time of Average Fuel Consumption reset to the current time giving you Total Distance traveled (TD). This data would be stored in the EEPROM.

TD = CCVS * T

Total Fuel Consumed (TFC)

This is the total fuel used value calculated by using the Total Fuel Used (PGN65257_SPN250 SA00) given in L.

This calculation is based on total fuel captured at the last Average fuel reset (TFr) and every 1s after that (TFn). TFC is calculated by subtracting the reset value (TFr) from the current value (TFn). This data would be stored in the EEPROM.

$TFC = TF_{(n)} - TF_{(r)}$

Average Trip (AT)

This calculation is based on TD recorded since the last AT reset. This data would be stored in the EEPROM.

The AT can be reset if the Average Fuel consumption display is selected for Quad 3. The user will be given a choice to reset or not using the Top button. If the AT is reset the current TFC value will be stored as $TF_{(r)}$. and AFC displayed is set equal to Instantaneous Fuel Economy received from the engine (SPN 184)

AFCr = IFE

Average Calc

At every 1s after the AT reset the following formula will be used to calculate Average Fuel Consumption:

AFC = TFC / TD

This process will continue every 1s until the AVG is reset.

Note : Both Instantaneous and Average Fuel Economy values are stored in EEPROM. After power up both previously calculated values are kept until a next valid calculation occurs. If no message for the fuel is broadcasted than those values will not change. At manufacturing the Fuel Economy values are reset to 0. This can of course be displayed in mpg for English units when converted.

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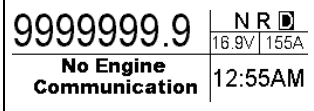
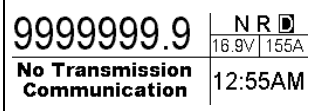
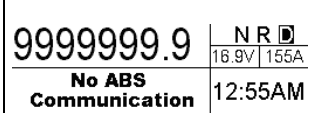
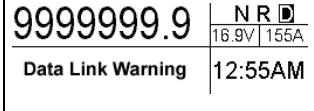
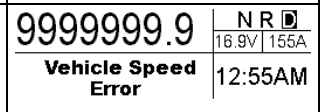
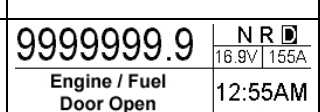
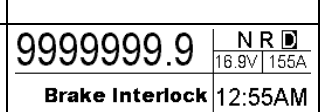
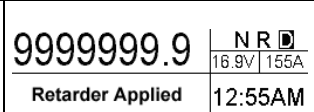
9.2.3.3. Priority Messages

Quad 3 content will be replaced by these messages in the event of their trigger logic being satisfied. Some of these messages can be acknowledged by pressing the bottom button which will return Quad 3 to previous display until the recurrence time, next ignition or the trigger logic is not satisfied. Any lamps associated with the acknowledged PIM will remain on until the fault is gone or Ignition is turned off. If multiple triggers are present, the associated priority messages will cycle every 2 seconds.

Function	**Data Source**	**Text Format**	**Display Example**	**Trigger Logic**	Display Notes	**Alarm/ Duration**
Engine Comm Fail	J1939 – SA00 GMLAN – TBD	As Shown		Not Available >1s	Message Flashing forward to reverse video at 500msec intervals	None
Trans Comm Fail	J1939 – SA03 GMLAN – TBD	As Shown		Not Available >1s	Message Flashing forward to reverse video at 500msec intervals	None
ABS Comm Fail	J1939 – SA0B GMLAN – TBD	As Shown		Not Available >1s	Message Flashing forward to reverse video at 500msec intervals	None
Data Link Warning	Historical List of connected devices	As Shown		Missing device that was present	Message Flashing forward to reverse video at 500msec intervals	None
Vehicle Speed Error	J1939 – PGN65265_SPN 84 GMLAN – TBD	As Shown		J1939 data is either N/A or in the error data range	Message Flashing forward to reverse video at 500msec intervals	Beep 1
Engine Door Open/Fuel Door Open	CL_Pin_28	As Shown		Active Low	Message Flashing forward to reverse video at 500msec intervals	Continuous/ Until Fault is gone
Brake Interlock	See Section 9.4.2.1 below	See Section 9.2.3.4 below		See Section 9.4.2.1 below	See Section 9.4.2.1 below	See Section 9.4.2.1 below
Retarder Applied	J1939 – PGN61440_SPN 1667 GMLAN – TBD	As Shown		Value = 01	Message Flashing forward to reverse video at 500msec intervals	None

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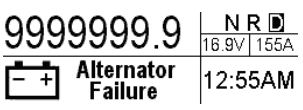
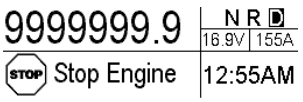
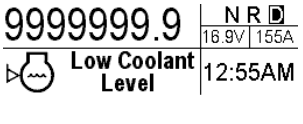
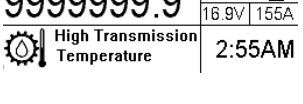
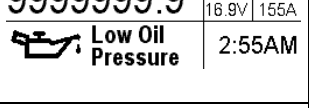
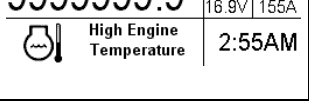
Function	**Data Source**	**Text Format**	**Display Example**	**Trigger Logic**	Display Notes	**Alarm/ Duration**
Alternator Fail	Internal Logic	As Shown		RPM > 400 and VBAT < 12V for > 180 sec.	Symbol flashing forward to reverse video at 500msec intervals	Continuous/ Until Acknowledged
Stop Engine	1939- DM1 SA 00 GMLAN – TBD	As Shown		Red Stop Lamp	Symbol flashing forward to reverse video at 500msec intervals	Continuous/ Until Fault is gone
Low Coolant Level	1939- DM1 SA 00 GMLAN – TBD	As Shown		SPN 111_FMI 1, 11 or 18	Symbol flashing forward to reverse video at 500msec intervals	Continuous/ Until Acknowledged
Hi Trans Temp	1939- DM1 SA 03 GMLAN – TBD	As Shown		SPN 177_FMI 15	Symbol flashing forward to reverse video at 500msec intervals	Continuous/ Until Acknowledged
Low Oil Pressure	1939- DM1 SA 00 GMLAN – TBD	As Shown		SPN 100_FMI 1, 11 or 18	Symbol flashing forward to reverse video at 500msec intervals	Continuous/ Until Acknowledged
Hi Engine Temp	1939- DM1 SA 00 GMLAN – TBD	As Shown		SPN 110_FMI 0, 11 or 16	Symbol flashing forward to reverse video at 500msec intervals	Continuous/ Until Acknowledged

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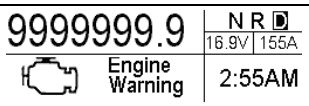
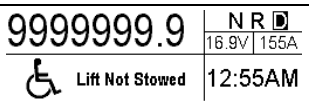
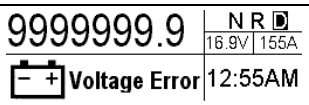
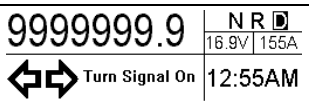
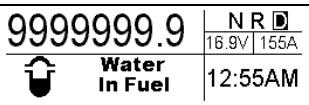
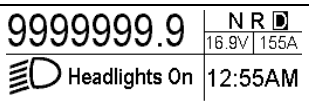
Function	**Data Source**	**Text Format**	**Display Example**	**Trigger Logic**	Display Notes	**Alarm/ Duration**
Engine Warning	1939- DM1 SA 00 GMLAN – TBD	As Shown		Amber Warning Lamp	Symbol flashing forward to reverse video at 500msec intervals	Continuous/ Until Acknowledged
Lift Not Stowed	CL_Pin_33	As Shown		Active Low	Symbol flashing forward to reverse video at 500msec intervals	Beep 1/ Until Acknowledged
Battery Voltage Error	J1939 – PGN65271_SPN 168 GMLAN – TBD	As Shown		On ≤ 11.0V for > 30 sec (then off at 12.1V) On ≥ 15.5V (then off at 15.3V)	Symbol flashing forward to reverse video at 500msec intervals	Beep 1/for 5 sec
Turn Signal Warning	CL_Pin_21 or CL_Pin_23	As Shown		When vehicle travels 1 mile with either turn signal on but not both	Symbol flashing forward to reverse video at 500msec intervals	Beep 1
Water in Fuel	J1939 – PGN65279_SPN 97	As Shown		Value = 01	Symbol flashing forward to reverse video at 500msec intervals	Beep 1/Until Acknowledged
Headlight Alert	CL_Pin_19	As Shown		Ignition is OFF and Headlights input is Active	Symbol flashing forward to reverse video at 500msec intervals	Beep 1/for 2 min.

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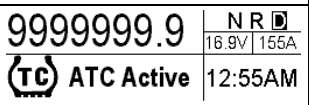
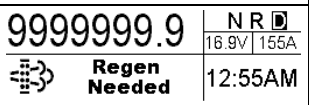
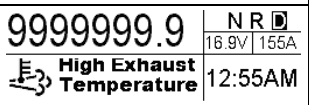
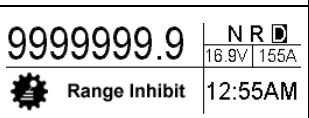
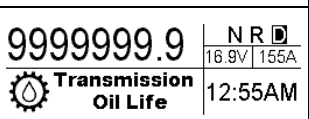
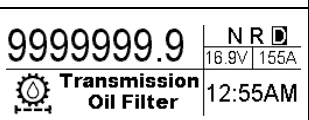
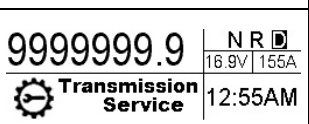
Function	Data Source	Text Format	Display Example	Trigger Logic	Display Notes	Alarm/ Duration
ATC	J1939 – PGN61441_SPN 1793 GMLAN – TBD	As Shown		Value = 01	Symbol flashing forward to reverse video at 500msec intervals	Beep 1/for 5 sec
DPF	J1939 – PGN64892_SPN3697	As Shown		000 = OFF 001 = ON 100 = Fast blink	Symbol flashing forward to reverse video at 500msec intervals	Beep 1/for 5 sec
Hi Exhaust Temp	J1939 – PGN64892_SPN3698	As Shown		000 = OFF 001 = ON 100 = Fast blink	Symbol flashing forward to reverse video at 500msec intervals	Beep 1/for 5 sec
Range Inhibit	J1939 – PGN65098_SPN 1851 GMLAN – TBD	As Shown		Value = 01	Symbol flashing forward to reverse video at 500msec intervals	None
Trans Oil Life	J1939 – DM1 SA 03 GMLAN – TBD	As Shown		SPN 4177_FMI 17	Symbol flashing forward to reverse video at 500msec intervals	None
Trans Oil Filter	J1939 – DM1 SA 03 GMLAN – TBD	As Shown		SPN 3359_FMI 31	Symbol flashing forward to reverse video at 500msec intervals	None
Trans Oil Service	J1939 – DM1 SA 03	As Shown		SPN 4178_FMI 31	Symbol flashing forward to reverse video at 500msec intervals	None

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9.2.3.4. Brake Interlock Display Message Detail

The brake interlock Priority Interrupt Display message will function per logic below. This message is NOT acknowledgeable. If BIR is active the cluster must stay awake until it is deactivated.

Air Brakes Systems w/ Brake interlock (40051-02)

Scenario	Vehicle Speed	Brake Interlock Alarm Input (CL PIN 27)	Brake Interlock Request Input (CL PIN 26)	Brake Interlock Set Input (CL PIN 35)	Cluster Behavior
1	≤ 3 MPH	N/A	ACTIVE	ACTIVE	PIM = BRAKE INTERLOCK SET ALARM = NONE
2	≤ 3 MPH	N/A	ACTIVE	INACTIVE	PIM = BRAKE INTERLOCK FAIL (flashing forward to reverse video at 500msec intervals) ALARM = Continuous 1 until fault is gone
3	> 3 MPH	N/A	ACTIVE	N/A	PIM = BRAKE INTERLOCK REQUESTED (flashing forward to reverse video at 500msec intervals) ALARM = Beep 2 on for 5 sec/off for 15 sec until fault is gone

Hydraulic Brakes Systems w/ Brake interlock (40051-01)

Scenario	Vehicle Speed	Brake Interlock Alarm Input (CL PIN 27)	Brake Interlock Request Input (CL PIN 26)	Brake Interlock Set Input (CL PIN 35)	Cluster Behavior
1	≤ 3 MPH	INACTIVE	ACTIVE	INACTIVE	PIM = BRAKE INTERLOCK SETTING (flashing forward to reverse video at 500msec intervals) ALARM = Beep 1 until fault is gone
2	≤ 3 MPH	INACTIVE	ACTIVE	ACTIVE	PIM = BRAKE INTERLOCK SET ALARM = Beep 2 for 2 sec
3	≤ 3 MPH	ACTIVE	ACTIVE	INACTIVE	PIM = BRAKE INTERLOCK FAIL (flashing forward to reverse video at 500msec intervals) ALARM = Continuous 1 until fault is gone
4	> 3 MPH	N/A	ACTIVE	N/A	PIM = BRAKE INTERLOCK REQUESTED (flashing forward to reverse video at 500msec intervals) ALARM = Beep 2 on for 5 sec/off for 15 sec until fault is gone

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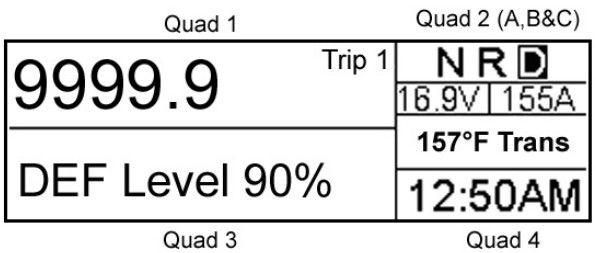
9.2.4. STANDARD QUADRANT 4

Quadrant 4 is dedicated to the clock. If Applied Air or Suspension Air feature is active, Quad 4 is 80x15. If no air features are active then the Quad 4 is 80x23. Quad 4 can be toggled between 12 and 24 hour mode settings. To do this you must first press and release the bottom button to activate quad 3, and then press and release both buttons simultaneously which will highlight quad 4 in reverse video and allow you to toggle between the 2 modes by pressing and releasing the top or button.

Function	**Data Source**	**Text Format**	**Display Example**	**Trigger Logic**	Display Notes	**Alarm/ Duration**
Clock	Internal clock crystal	XX:XX AM	9999999.9 N R D 16.9V 155A 157°F Trans 12:55AM 9999999.9 N R D 16.9V 155A 157°F Trans F App Air R 150 PSI 150 PSI 12:50AM		When clock is highlighted pressing & holding the ***m & t*** buttons changes from 12 to 24 hour mode	

9.3. DEF Drive Mode Configuration



If the cluster is configured for a model year 2010 engine (i.e. ISB/ISC10) the display will be configured to allow the DEF gauge to be displayed in Quad 3 at all times.

Specifics of this reorganization are below broken down by display quadrant. All requirements below assume the cluster buttons are in normal mode. If they are in Dimmer mode due to backlight on and PB NOT set, both buttons will be required to be pressed to temporarily enter this normal mode (Section 5.2).

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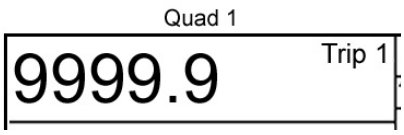
9.3.1. DEF QUAD 1



9.3.1.1. Odometers & Parameters

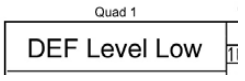
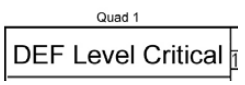
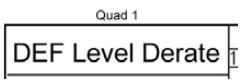
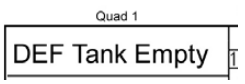
In addition to the Odometer, Trip 1 and Trip 2 that are already available in Quad 1, the list of parameters available for display in DEF Quad 1 are the same items described in the Standard Quad 3 section above that would normally be available in Standard Quad 3 config. In this configuration, these parameters can be toggled in the same manor that the Odo, Trip 1 and Trip 2 are toggled in the standard configuration.

9.3.1.2. General PIM's

All of the general PIM's that are currently displayed in Standard Quad 3 must be displayed in DEF Quad 1 when their related fault is active. Their acknowledgability and reoccurrence must work the same and look the same as they do in the standard configuration.

9.3.1.3. SCR Warning specific PIM's

The following table of SCR specific PIM's must be displayed in DEF Quad 1 when their related warning trigger logic is active. If the trigger logic for a specific PIM requires SPN/FMI's that would trigger a lower priority SCR PIM, the higher severity PIM will take precedence and will NOT cycle with lower priority PIM's. The acknowledgability and reoccurrence must work as described in the table.

Function	**Data Source**	**Display Example**	Display Notes	**Trigger Logic**	**Alarm/ Duration**	**Acknowledge Reoccurrence**
DEF Low	J1939 – SA00		On solid	SPN1761 FMI 17	Beep 1/ Single beep	Next Ignition
DEF Level Critical	J1939 – SA00		Message Flashing forward to reverse video at 500msec intervals	SPN1761 FMI 18	Beep 1/ Repeating	Next Ignition
DEF Level De-rate	J1939 – SA00		Message Flashing forward to reverse video at 500msec intervals	SPN1761 FMI 1 SPN1569 FMI 31	Same as ENGINE WARN lamp (Amber Lamp)	5 min.
DEF Level Empty	J1939 – SA00		Message Flashing forward to reverse video at 500msec intervals	SPN1761 FMI 1 SPN1569 FMI 31 SPN5392 FMI 31 SPN4096 FMI 31	Same as ENGINE WARN lamp (Amber Lamp)	N/A

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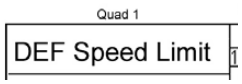
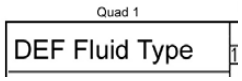
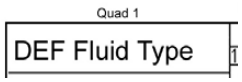
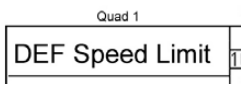
Function	**Data Source**	**Display Example**	Display Notes	**Trigger Logic**	**Alarm/ Duration**	**Acknowledge Reoccurrence**
DEF Level Shut Down	J1939 – SA00		Message Flashing forward to reverse video at 500msec intervals	SPN1761 FMI 1 SPN1569 FMI 31 SPN5392 FMI 31 SPN4096 FMI 31 SPN5246 FMI 31	Same as ENGINE STOP lamp (Red Lamp)	N/A
Incorrect Reducing Agent	J1939 – SA00		Message Flashing forward to reverse video at 500msec intervals	SPN 4094 FMI 31	Same as ENGINE WARN lamp (Amber Lamp)	N/A
Incorrect Reducing Agent +10hr	J1939 – SA00		Message Flashing forward to reverse video at 500msec intervals	SPN 4094 FMI 31 SPN 1569 FMI 31	Same as ENGINE WARN lamp (Amber Lamp)	N/A
Incorrect Reducing Agent Shutdown	J1939 – SA00		Message Flashing forward to reverse video at 500msec intervals	SPN 4094 FMI 31 SPN 1569 FMI 31 SPN 5246 FMI 31	Same as ENGINE STOP lamp (Red Lamp)	N/A

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9.3.1.4. SCR Fault Specific PIM's

The following table of SCR Fault Specific PIM's must be displayed in DEF Quad 1 when their related fault is active. Their acknowledgability and reoccurrence must work as described in the table. The table below is based on the Cummins AEB 21.81 dated 11-30-09.

Any associated lamps must NOT turn off if acknowledged, only alarm and display are effected.

Function	**Data Source**	**Display Example**	Display Notes	**Trigger Logic**		**Alarm/ Duration**	**Acknowledge Reoccurrence**
See AEB 21.81 Table 8	J1939 – SA00	Quad 1 SCR SYSTEM FAULT SEE ENG DIAGNOSTIC	Message Flashing forward to reverse video at 500msec intervals	SPN	FM1	Same as ENGINE WARN lamp (Amber Lamp) or STOP ENGINE lamp (Red Lamp) depending on which DM1 lamp is received from the engine. Red Lamp takes precedence if both are received.	N/A
				1761	3		
				3031	3		
				3216	4 and 9		
				3226	2, 4 and 9		
				3360	9		
				3361	2, 5 and 12		
				3362	7 and 31		
				3363	5		
				4094	31		
				4096	31		
				4334	2, 3, 4, 16 and 18		
				4340	5		
				4342	5		
				4344	5		
				4346	5		
				4360	3		
				4363	3		
				4376	5		
				5394	4 and 5		
				5491	5		

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9.3.2. DEF QUAD 2A

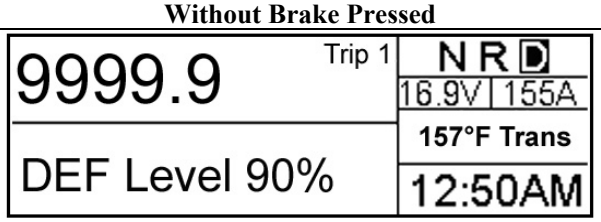
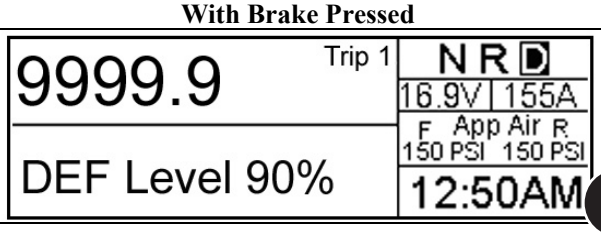
This quadrant will work and look the same as it does in the standard configuration displaying the PRNDL.

9.3.3. DEF QUAD 2B

This quadrant will work and look the same as it does in the standard configuration displaying the system voltage and ammeter when available.

9.3.4. DEF QUAD 2C

Under normal operation Transmission Temperature must be displayed in this DEF Quad 2C. It will look and work the same as it does in the standard config (reference section 9.4.1). When brake pressure is applied, Trans Temp must be temporarily replaced by Front and Rear Applied Air Pressure. This display will look and work the same as it does in the standard configuration (reference section 9.3). When the pressure is not applied it will return to Trans Temp.

Without Brake Pressed	With Brake Pressed
	

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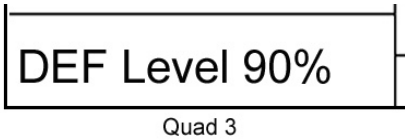
9.3.5. DEF QUAD 3



The DEF Fluid level must be displayed as a percent of full tank in DEF Quad 3 at all times as shown above. Data source for this will be found in PGN 65110 SPN 1761 from SA 00 (reference Cummins AEB 15.93).

9.3.6. DEF QUAD 4

This quadrant will work and look the same as it does in standard configuration displaying the clock.

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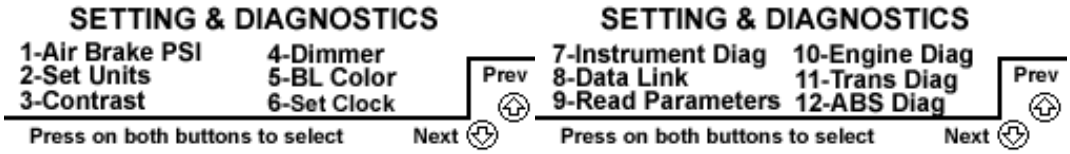
10. SETTINGS AND DIAGNOSTIC



This menu allows the user to change certain features from their default settings and to use diagnostics to trouble shoot the instrumentation. Access this menu by setting the park brake and then from the Drive Mode Screen press the ***lower*** button for >5 seconds.

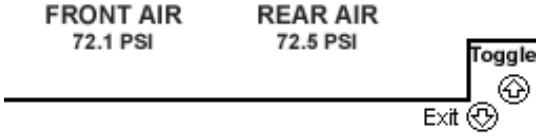
The item highlighted in **reverse video** will be selected when both of the buttons are pressed together. Pressing either button separately will move the highlight through the list, as indicated by the arrow, so other items can be selected. This menu will auto exit to the drive screen after 10 sec timeout with no activity.

If the PB is set and Diagnostic mode is entered by holding down the bottom button, this mode must exit to the drive mode screen any time a DEF System warning (see Table in section 9.6) becomes active. Once the active warning is gone Diagnostic mode can be entered again if PB is set and the bottom button is held.

Diagnostic Mode must not be entered if a DEF System warning is currently active Unless RPM is <400.

10.1. Air Brake PSI

Selecting menu item 1 brings up the following screen that is used to perform Pre-trip Brake Inspections. It will show Front and Rear brake system PSI. Pressing the down button will exit to the previous screen.



10.2. Set Units

Selecting menu item 2 brings up the following screen that is used to select if values are to be displayed in Metric units or English units. This will change the Speedo reading and units lamp, display/menu items except Air which will always be displayed as PSI, and change which brake system fail lamp is used. Pressing the down button will exit to the previous screen.

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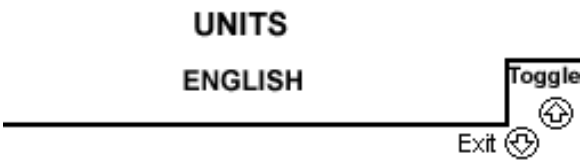
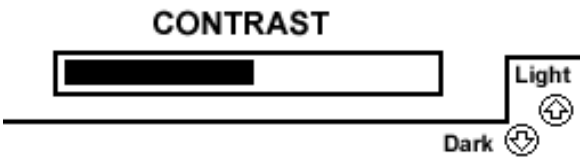


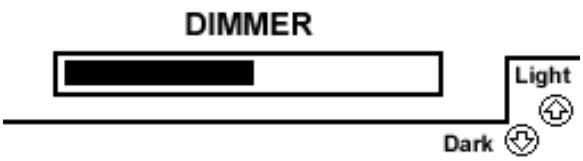
10.3. Contrast

Selecting menu item 3 displays a screen to allow setting the LCD contrast. Pressing the ***lower*** button will increase contrast while pressing the ***upper*** button will decrease contrast. This menu will auto exit to the previous screen after 10 sec timeout with no activity.



10.4. Dimmer

Selecting menu item 4 displays a screen to allow setting the cluster backlighting brightness. Pressing the ***lower*** button will decrease brightness while pressing the ***upper*** button will increase it. The buttons can be held for progressive dimming. This menu will auto exit to the previous screen after 10 sec timeout with no activity.



10.5. Backlight color

Selecting menu item 5 displays a screen to allow setting the cluster backlighting color. Pressing the buttons will toggle between a list of preset colors.

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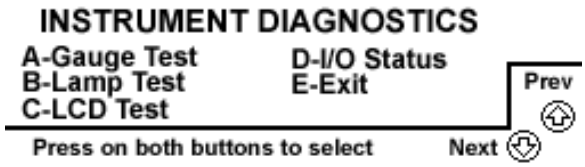
10.6. Set Clock

Selecting menu item 6 allows the user to set the clock. Pressing both buttons will first select the "hours" selection and it will be highlighted. Pressing both buttons again will select minutes. Once a selection is highlighted, then the ***lower*** buttons will decrease the setting and the ***upper*** button will increment the setting. If a selection is not made this menu will timeout to the previous menu after 15 seconds.

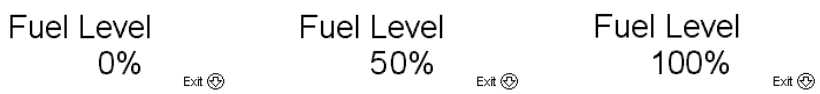
10.7. Instrument Diagnostics

Selecting menu item 7 in the Settings and Diagnostic Menu will display the instrument diagnostic menu.



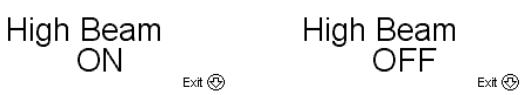
10.7.1. Gauge Test

Item A - The selected gauge will be driven through three positions pausing at each position as shown in the LCD as a percentage of scale. This test will proceed through all gauges and return to the menu. Pressing the ***lower*** button (Exit) will end the test and return to the previous menu.



10.7.2. Lamp Test

Item B - Turns each IP warning lamp (not the vehicle load) on then off displaying the lamp name and status in the LCD. This test goes through all warning lamps and then returns to the menu. Pressing the ***lower*** button (Exit) will end the test and return to the previous menu. (High beam test shown as an example)



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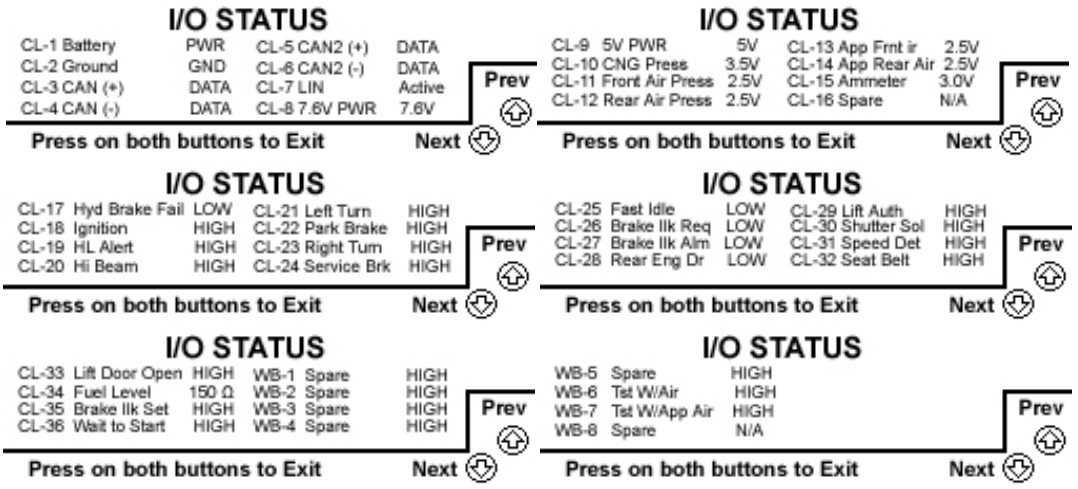
10.7.3. LCD TEST

Item C – Displays the Bluebird logo in normal and reverse video three times and then return to the previous menu. Pressing the ***lower*** button will end the test and return to the previous menu.

10.7.4. I/O STATUS

Item D – Displays the module-pin number, and the status as received by the vehicle's electrical system. Scroll through all the status screen by screen using the up and down arrows. Press both buttons to exit to the previous screen. (screens shown for reference only, actual inputs may differ)



Note: The value "high" and "low" refers to the voltage level at the connector pin for binary inputs. Warning bank information will only be shown if warning bank is detected on the LIN data bus. This information will be continuously updated to assist in troubleshooting

10.7.5. I/O STATUS

Item E – Exits from this menu to the previous screen.

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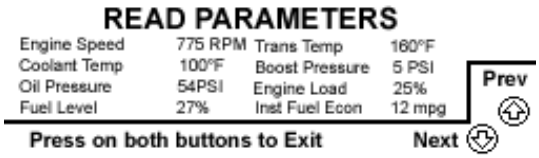
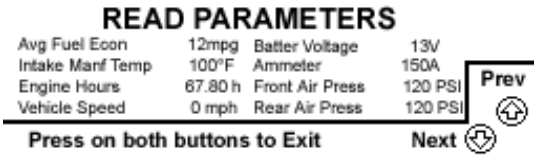
10.8. Data Link

Item 8– The LIN will be checked and each device found on that data bus would be displayed. If the device is saved automatically in this list and is disconnected from the system a warning will be displayed. You can delete the device from this list to avoid this warning by scrolling to the device in the list and pressing both buttons. Once removed, the cluster will not display a warning unless the device is reconnected and auto saved back to the list. Press the Exit button to exit to the previous screen.

10.9. Read Parameters

Item 9 – Displays all of the converted values for the applications parameters in a table form for vehicle troubleshooting. You can scroll though to view them and press both buttons to exit to the previous screen.





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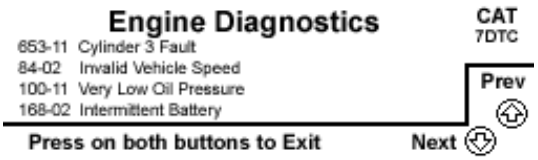
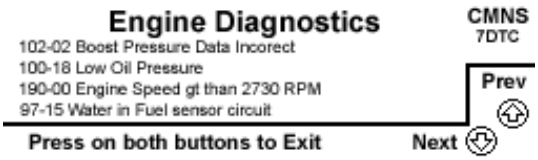
10.10. Engine Diagnostic

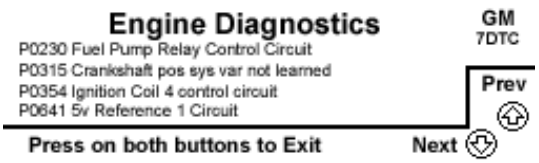
Item 10- Displays engine DTC's in a format dependant on engine type. Engine type and number of active DTC's is located in upper right corner. Press both buttons to exit to previous screen.

CAT/Cummins
This screen displays the Suspect Parameter Number (SPN) and Failure mode Identifier (FMI) as received from the engine for active faults via J1939 (Active faults shown below as examples)





GM
This screen displays the J2012 DTC Display as received from the engine for active faults via 1939 (Converted from 1850)/GMLAN (Active faults shown below as examples)



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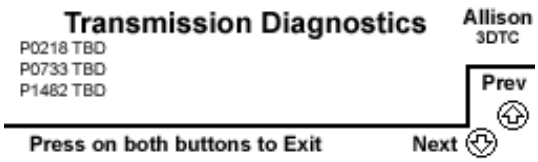
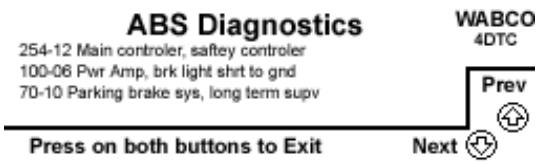
10.11. Trans Diagnostic

Item 11- This screen displays J2012 DTC Display as received from the transmission for active faults via J1939 (Active faults shown below as examples). Transmission type and number of active DTC's is located in upper right corner. Press both buttons to exit to previous screen.



10.12. ABS Diagnostic

Item 12-ABS Diagnostics – This screen displays the Suspect Parameter Number (SPN) and Failure mode Identifier (FMI) as received from the ABS for active faults via J1939. (Two active faults shown below as an example). Brake system type and number of active DTC's is located in upper right corner. Press both buttons to exit to previous screen.



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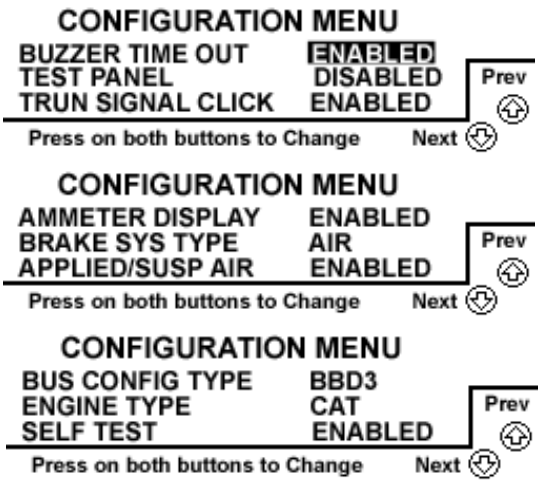
11. CONFIGURATION MENU

Holding both buttons pressed while turning the ignition on enters the Configuration Menu. In this menu configurable features can be enabled and disabled. If the cluster has logged less than 25 mi, all menu selections can be changed using the buttons. After 25 mi some items will only be able to be modified using a Diagnostic tool via PC or other diagnostic interface that can communicate with the cluster on the diagnostic layer, or by entering the password for the UNLOCK feature (see section 11.12).

To change a feature configuration with the buttons scroll up or down to it and then press both buttons to change the config. After 25 mi, you will be able to see all menu items but only change the items that are USER CONFIGURABLE (see the feature config tables for this info). The rest will require the diagnostic tool after 25 mi. This menu will auto exit and the cluster will re-initialize its startup routine after 10 sec timeout with no activity.



The default value of these settings is defined on the assembly line print and set on the line per part number.

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11.1. Buzzer Time out Enable

When this configuration is ENABLED the continuous 1 audible alarm (Buzzer) would be allowed to timeout in 15 sec if the engine speed is < 400 RPM. When this configuration is DISABLED the continuous audible alarm will not time out.

11.2. Test Panel

When this configuration is ENABLED the cluster is set as a manufacturing tool for the chassis test fixture and the software will ignore the internal configuration for BRAKE SYS TYPE and APPLIED/SUSP AIR. It will instead receive this configuration information from the optional input module binary inputs (See section 12.8). When this configuration is DISABLED the cluster is set as a normal production part and will use the internal configuration to determine BRAKE SYS TYPE and the presence of APPLIED or SUSPENSION AIR. This feature is displayed in this menu but can only be changed using a VCI and ACTIA provided software.

11.3. Turn Signal Click

When this configuration is ENABLED the turn signal will use the simulated relay click audible sound. When this configuration is DISABLED there will be no sound for turn signal.

11.4. Ammeter Display

When this configuration is ENABLED the Ammeter value is shown in the display beside the Voltmeter (See section 7.1). When this configuration is DISABLED only the Voltmeter is shown.

11.5. Brake System Type

When this configuration is set to AIR, the software is configured to use the Front and Rear Air inputs to display the front and rear air pressure on the appropriate gauges. When configured as HYD the software will not drive these gauges and will use the Front Air input to determine Suspension Air Pressure. This setting will also effect how the Brake Interlock PIM logic works (section 9.4.2.1)

11.6. Applied/Suspension Air

When this configuration is ENABLED the software is configured to display Applied Front and Rear Air Pressure (for Air Brake System) or Suspension Air (for Hydraulic Brake System) depending on Brake System Type Configuration. When DISABLEED Applied air/Suspension air are NOT displayed (See section 7.1).

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11.7. Bus Configuration Type

The cluster can be configured to be used on one of two product lines, BBD3 or BBCV. This setting will effect the binary logic for Park Brake and Fast Idle inputs. They will be as follows:

Input	BBD3	BBCV
Park Brake	AL	AH
Fast Idle	AH	AL

11.8. Engine Configuration Type

This configuration is set by internal logic based on Engine ID's broadcast on the data bus. This will effect what messages are sent for Throttle Interlock and Fast Idle functions (section 8.6). It may also effect what Parameters are available to display in Quad 3 on the LCD (section 9.4.1). And if 2010 engine's are present it will effect the entire layout of the LCD (reference section 9.6)

11.9. Self Test

When this configuration is ENABLED the cluster will perform a startup self test at Ignition (See section 4.2.1) When the configuration is the cluster will not perform a startup self test.

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11.10. Battery Controlled Lift

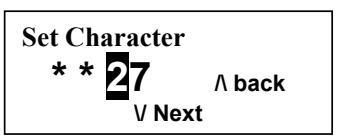
When this configuration enabled it affects the logic of several of the outputs. See section 7 for details.

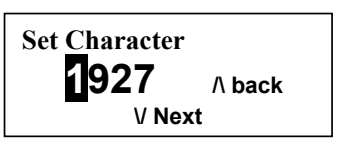
11.11. Seatbelt Logic

When this configuration is ENABLED the Seatbelt Logic for the alarm and lamp detailed in section 5.4.1 will apply. If it is DISABLED this logic will not apply. No alarm or lamp will be triggered if this is the case. When disabled, if the seatbelt input is pulled low, this will automatically enable the configuration.

11.12. Unlock

Selecting this option will allow the user to enter a password using the buttons on the cluster in order to unlock the configurations above that lock out after 25 mi (see section 12 for lockout detail) to make ALL configurations accessible temporarily. The astric will highlight and characters will be incremented by pressing the up button. Pressing the down button will advance to the next character. Pressing both buttons when the last character is selected will make all configs will be accessable. If no configuration item is selected before the menu timeout in 20 sec the cluster will reset and the password must be reentered to unlock the configuration items again.





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12. FEATURE PROGRAMMING

The following table shows the bit address for the configurable features. These will be set by Manf. depending on the configuration that is built. Some of these can be configured through the diag menu as shown above. The default value for manf. to set will be defined on the family print 111027 per part number.

12.1. Byte 0

Feature	Bit Address	Value	User Configurable after 25 mi.
Buzzer Timeout Enable	Bit 0	0=OFF 1=ON	YES
Test Panel Enable	Bit 1	0=OFF 1=ON	NO
Turn signal click Enable	Bit 2	0=OFF 1=ON	YES
Ammeter Enable	Bit 3	0=OFF 1=ON	YES
Brake System Type	Bit 4	0=Air (Bendix) 1=Hydraulic (WABCO)	NO
Applied Air/Suspension Air Enable (If bit 4 is set to Air this option effects Applied Air/If it is set to Hydraulic it effects the Suspension air feature)	Bit 5	0=Disabled (OFF) 1=Enabled (ON)	YES
Buss Type	Bit 6	0=BBD3 1=BBCV	NO
Clock Mode	Bit 7	0= 12 hrs mode 1= 24 hrs mode	YES

12.2. Byte 1

Feature	Bit Address	Value	User Configurable after 25 mi.
Engine Type	Bit 0 Bit 1 Bit 2 Bit 3	0001 = Cummins ISB07 (1939) 0010 = Cummins ISC07 (1939) 0011 = Cummins ISLG07 (1939) 0100 = CAT Diesel C7 (1939) 0101 = GM Gas(1850) 0110 = GM Gas (GMLAN) 0111 = Cummins ISB10 (1939) 1000 = Cummins ISC10 (1939)	NO
Battery Controlled Lift Option	Bit 4	0=Disabled (OFF) 1=Enabled (ON)	NO
ABS Type	Bit 5	0= WABCO 1=Bendix	NO
Trans Type	Bit 6	0=Allison 1=Other	NO
Seat Belt Logic	Bit 7	0=Disabled 1=Enabled	NO

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12.3. Diagnostic Commands

The following table shows the possible feature values for diagnostic commanded features set by manf. by specific command or by enabling defaults set in the application code. The default value for manf. to set will be defined on the family print 111027 per part number.

Feature	Command Configured Value	Application Default Setting	User Configurable after 25 mi.
Service Gauge	YES/NO	N/A—Manf Set per print	NO
Self Test	ON/OFF	N/A—Manf Set per print	YES
Display Units (Metric/US)	METRIC/US	N/A—Manf Set per print	YES
Dimmer	0-100%	100%	YES
Contrast	0-100%	50%	YES
Engine Hrs	XXXX Hrs	0 hrs	NO
Trip 1	XXXXXXX.X mi	0 mi	YES
Trip 2	XXXXXXX.X mi	0 mi	YES
Odometer Reference		0	NO
Active LIN device		0	YES
Data link warning		0	YES
Backlight Color	Blue, Lt Blue, White, Red, Green	Green	YES
Device ID			NO
Wakeup			NO

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13. RELATED STANDARDS

SAE J1455 *Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design (Heavy-Duty Trucks)*
SAE J1211 *Recommended Environmental Practices for Electronic Equipment Design*
*SAE J1113/** *Electromagnetic Compatibility Measurement Procedures and Limits for Vehicle Components*
SAE J1812 *Function Performance Status Classification for EMC Immunity Testing*
SAE J2217 *Photometric Guidelines for Instrument Panel Displays that Accommodate Older Drivers*
SAE J1939 *Recommended Practice for Truck and Bus Control and Communications Network*
SAE J1708 *Serial Data Communications Between Microcomputer Systems*
SAE J1587 *Joint SAE/TMC Electronic Data Interchange Between Microcomputer Systems in Heavy-Duty Vehicle Applications*
SAE J1226 *Electric Speedometer Specification – On Road*
SAE J1399 *Electric Tachometer Specification*
SAE J1810 *Electrical Indicating System Specification*
SAE J1048 *Symbols for Motor Vehicles Controls, Indicators and Tell-Tales*
SAE J1362 *Graphical Symbols for Operator Controls and Displays on Off-Road Self-Propelled Work Machines*
FMVSS 302 *Flammability of interior materials*
LIN Specification Package Revision 1.2
ELECSP13 *Bluebird Engineering Standard - Electrical environmental specification*
FMVSS/CMVSS 101
FMVSS/CMVSS 105
FMVSS/CMVSS 135
GMW3097
GMW3172

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14. GLOSSARY/ABBREVIATIONS

TBD – To be determined
EEPROM – Electrically Erasable Programmable Read Only Memory
SAE – Society of Automotive Engineers
PGN – Parameter Group Number (J1939)
SPN – Suspect Parameter Number (J1939)
FMI – Failure Mode Identifier (J1939)

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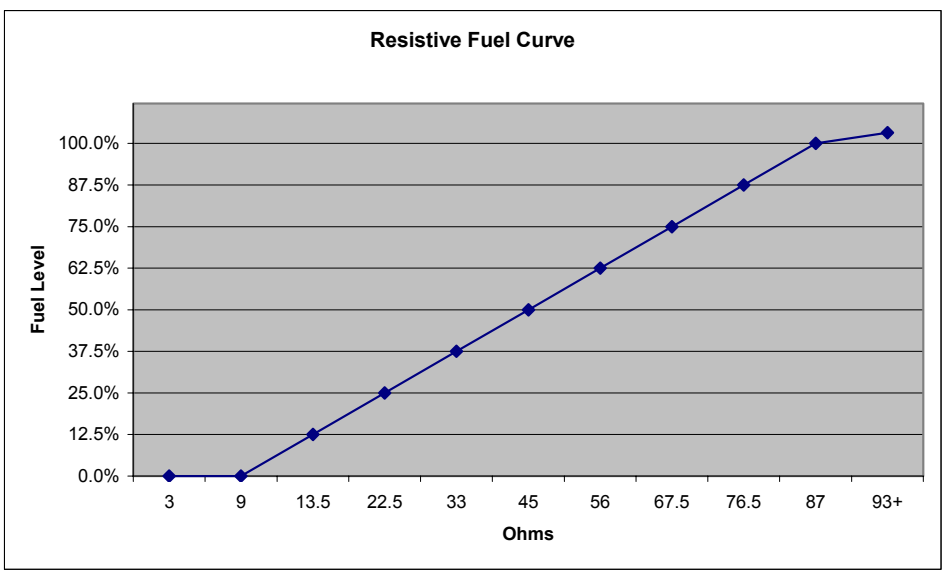
14.1. Resistive Fuel Sender

Type:	Resistive Sender
Mfr:	??
Mfr P/N:	??

Fuel Level	Indication	Ohms
0.0%	E	3
0.0%	E	9
12.5%	1/8	13.5
25.0%	1/4	22.5
37.5%	3/8	33
50.0%	1/2	45
62.5%	5/8	56
75.0%	3/4	67.5
87.5%	7/8	76.5
100.0%	F	87
103.2%	F+3deg	93+



Note:
If the sender is over 180 ohms the system will assume that it is a **"out of tolerance"** sender and the fuel level gauge will display a fault by wagging.

Indication is realative to the initial calibration position.

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14.2. Voltage Fuel Sender

Voutput = (PSI*(4/3600))+1

Type: Pressure Transducer
Manufacturer: Energy Kinetic
Mfg part# EK-110-1S-36C
0-3600PSI = 1 – 5 V

Energy Kinetic Pressure Sender				**Voltage**							
Pressure(PSI)	Voltage(V)	Expected V	Error	Pressure(PSI)	Voltage(V)	Expected V	Error	Pressure(PSI)	Voltage(V)	Expected V	Error
100	1.154	1.111	3.860%	1100	2.223	2.222	0.035%	2600	3.925	3.889	0.929%
125	1.186	1.139	4.137%	1200	2.336	2.333	0.114%	2700	4.042	4.000	1.050%
150	1.218	1.167	4.400%	1300	2.485	2.444	1.659%	2800	4.170	4.111	1.432%
175	1.247	1.194	4.400%	1400	2.610	2.556	2.130%	2900	4.200	4.222	0.526%
200	1.278	1.222	4.564%	1500	2.663	2.667	0.138%	3000	4.370	4.333	0.846%
225	1.304	1.250	4.320%	1600	2.829	2.778	1.844%	3100	4.490	4.444	1.025%
250	1.335	1.278	4.478%	1700	2.945	2.889	1.942%	3200	4.600	4.556	0.976%
300	1.394	1.333	4.550%	1800	3.055	3.000	1.833%	3300	4.710	4.667	0.929%
400	1.498	1.444	3.708%	1900	3.171	3.111	1.925%	3400	4.810	4.778	0.674%
500	1.600	1.556	2.857%	2000	3.265	3.222	1.328%	3500	4.900	4.889	0.227%
600	1.711	1.667	2.660%	2100	3.393	3.333	1.790%	3600	5.000	5.000	0.000%
700	1.769	1.778	0.494%	2200	3.481	3.444	1.061%				
800	1.896	1.889	0.376%	2300	3.605	3.556	1.391%				
900	2.056	2.000	2.800%	2400	3.725	3.667	1.591%				
1000	2.159	2.111	2.268%	2500	3.815	3.778	0.985%				

4.5% error = 162 psi for a 3600 psi transducer

Indication	Nominal PSI
Empty	260
1/8	665
1/4	1070
3/8	1475
1/2	1880
5/8	2285
3/4	2690
7/8	3095
Full	3500

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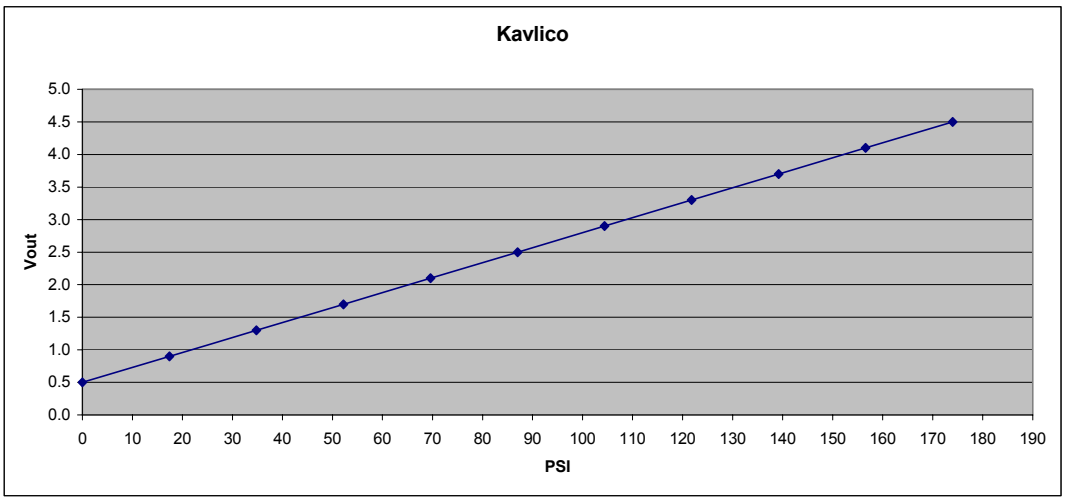
14.3. Air Pressure Sensors

174 PSI

Kavlico P2000-5192	
Psi	voltage
0	0.50
17.4	0.90
34.8	1.30
52.2	1.70
69.6	2.10
87	2.50
104.4	2.90
121.8	3.30
139.2	3.70
156.6	4.10
174	4.50



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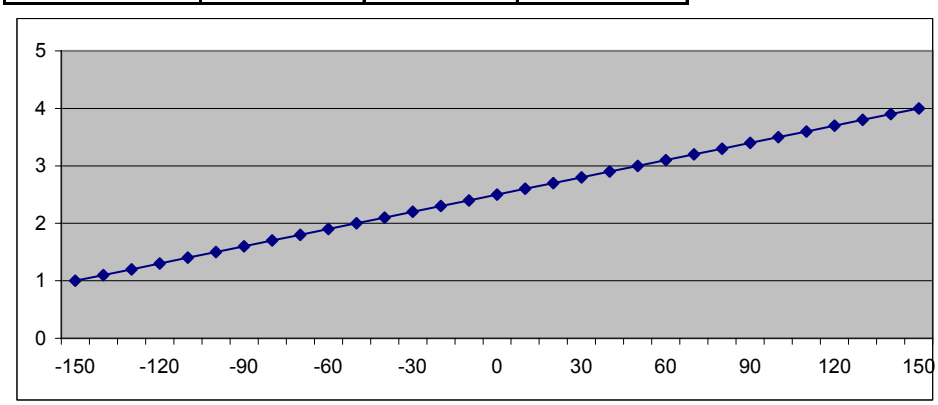
14.4. Ammeter

Type **Ammeter Hall Effect Sensor**
Manufacturer **Sure Power**
Mftr part# DCCS45S-200

Indication (Amps)	Minimum (V)	Nominal (V)	Maximum (V)
-150	0.9900	1	1.0100
-140	1.0890	1.1	1.1110
-130	1.1880	1.2	1.2120
-120	1.2870	1.3	1.3130
-110	1.3860	1.4	1.4140
-100	1.4850	1.5	1.5150
-90	1.5840	1.6	1.6160
-80	1.6830	1.7	1.7170
-70	1.7820	1.8	1.8180
-60	1.8810	1.9	1.9190
-50	1.9800	2	2.0200
-40	2.0790	2.1	2.1210
-30	2.1780	2.2	2.2220
-20	2.2770	2.3	2.3230
-10	2.3760	2.4	2.4240
0	2.4750	2.5	2.5250
10	2.5740	2.6	2.6260
20	2.6730	2.7	2.7270
30	2.7720	2.8	2.8280
40	2.8710	2.9	2.9290
50	2.9700	3	3.0300
60	3.0690	3.1	3.1310
70	3.1680	3.2	3.2320
80	3.2670	3.3	3.3330
90	3.3660	3.4	3.4340
100	3.4650	3.5	3.5350
110	3.5640	3.6	3.6360
120	3.6630	3.7	3.7370
130	3.7620	3.8	3.8380
140	3.8610	3.9	3.9390
150	3.9600	4	4.0400



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14.5. J1939 Table of Messages

Frame	PGN	Name	Byte	TX/RX	English / Metric Units	Source Address
Engine Hours	65,253 (00FEE5)	Total engine hours	1,2,3,4	RQ	H	0
Component ID	65,259 (00FEEB)	Component ID	Multipacket	RQ		0
Cruise Control/Vehicle Speed	65,265 (00FEF1)	Wheel-based vehicle speed	2,3	RX	MPH/ km/h	0
Cruise Control/Vehicle Speed	65,265 (00FEF1)	Service Brake	4 b 6&5	TX		17
Cruise Control/Vehicle Speed	65,265 (00FEF1)	Park Brake	1 b 4&3	TX		17
PTO	65,264 (00FEF0)	Throttle Interlock (CAT)	6 b 2&1	TX		17
PTO	65,264 (00FEF0)	Engine PTO Governor enable switch	6 b 2&1	TX		17
PTO	65,264 (00FEF0)	Engine Remote PTO Governor Programmed Speed Control Switch	6 b 4&3	TX		17
EBC1	61,441 (00F001)	Throttle Interlock (Cummins)	4 b 2&1	TX		17
EBC1	61,441 (00F001)	ABS	6 b 6&5	RX		0B
EBC1	61,441 (00F001)	ATC	6 b 8&7	RX		0B
Shutdown	65,252 (00FEE4)	Wait to Start	4 b 2&1	RX		0
DM1	65,226 (00FECA)	Active DTC	3-6	RX		0
DM1	65,226 (00FECA)	Protect lamp	1 b 2&1	RX		0
DM1	65,226 (00FECA)	Amber warning lamp	1 b 4&3	RX		0
DM1	65,226 (00FECA)	Red Stop lamp	1 b 6&5	RX		0
DM1	65,226 (00FECA)	MIL Lamp	1 b 8&7	RX		0
Shutdown	65,252 (00FEE4)	Idle Shutdown Active (SPN 594)	1 b 4&3	RX		0
EEC1	61,444 (00F004)	Engine speed	4,5	RX	RPM	0
EEC2	61,443 (00F003)	Percent load	3	RX	%	0
Engine Fluid Level/Pressure	65,263 (00FEEF)	Engine oil pressure	4	RX	PSI/ KPa	0
Engine Temperature	65,262 (00FEEE)	Engine coolant temp.	1	RX	°F / °C	0
ERC1	61,440 (00F000)	Retarder	4 b 4&3	RX		0F or 10 or 29
ETC1	61,442 (00F002)	Electronic Trans. Controller	N/A	RX		3
ETC7	65,098 (00FE4A)	Shift inhibit	2 b 8&7	RX		3
Fuel Economy	65,266 (00FEF2)	Instantaneous fuel econ	3,4	RX	MPG/ L/100Km	0
Fuel Economy	65,266 (00FEF2)	Average fuel economy	5,6	RX	MPG/ L/100Km	0
Inlet/Exhaust Conditions	65,270 (00FEF6)	Boost pressure	2	RX	PSI/ KPa	0
Inlet/Exhaust Conditions	65,270 (00FEF6)	Intake manifold temperature	3	RX	°F / °C	0
Transmission Fluids	65,272 (00FEF8)	Transmission oil temp.	5,6	RX	°F / °C	3
ETC2	61,445 (00F005)	Transmission Current Gear 7Dh = neutral; ≤7Ch = reverse, 7Eh though 84h = drive	4	RX		3
Vehicle Electrical Power	65,271 (00FEF7)	Electrical potential (volts)	5,6	RX	V	0
Vehicle Electrical Power	65,271 (00FEF7)	Battery potential (volts) Switched	7,8	RX	V	0
Dash Display	65,276 (00FEFC)	Fuel Level	2	RX	%	0
WFI	65,279 (00FEFF)	Water in fuel	1 b 2&1	RX		0
PTC1	64,892 (00FD7C)	Particulate Trap Lamp Command	1 b 1-3	RX		0
PTC1	64,892 (00FD7C)	Exhaust System High Temp	7 b 3-5	RX		0
Cruise Control/Vehicle Speed	65,265 (00FEF1)/SPN 527	Cruise Control State	7B, 8, 7, 6	RX		0
AT1T1	65110 (00FE56)/5245	Aftertreatment 1 DEF tank Low Level Indicator	5B, 8, 7, 6	RX	Status	0
AT1T1	65110 (00FE56)/1761	Aftertreatment 1 SCR Catalyst tank level	1B	RX	%	0
ACTIA Proprietary	61227 (00EF2B)	Ammeter—for RRB	B5-6	TX	Measured	17
ACTIA Proprietary	61227 (00EF2B)	Engine Oil—for RRB	B3-4	TX	Measured	17
ACTIA Proprietary	61227 (00EF2B)	Fuel—for RRB	B2	TX	Measured	17
ACTIA Proprietary	61227 (00EF2B)	Cluster Status—for RRB	B1	TX	Measured	17
Defined Faults	**PGN**	**Name**	**Lamp**	**SPN**	**FMI**	**Source**

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						Address
DM1	65,226 (00FECA)	High Coolant Temp	ANY	110	0, 11 and 16	0
DM1	65,226 (00FECA)	Low Oil Pressure	ANY	100	1, 11 and 18	0
DM1	65,226 (00FECA)	Amber warning light/Check Transmission	AMBER	2003	31	3
DM1	65,226 (00FECA)	High Trans Temperature	AMBER	177	15	3
DM1	65,226 (00FECA)	Low Coolant Level	ANY	111	1, 11 and 18	0
DM1	65,226 (00FECA)	Trans Fluid Filter	N/A	3359	31	3
DM1	65,226 (00FECA)	Trans Fluid Life	N/A	4177	17	3
DM1	65,226 (00FECA)	Trans Service	N/A	4178	31	3
DM1	65,226 (00FECA)	Aftertreatment 1 SCR Catalyst tank level	N/A	1761	17	0
DM1	65,226 (00FECA)	Aftertreatment 1 SCR Catalyst tank level	N/A	1761	18	0
DM1	65,226 (00FECA)	Aftertreatment 1 SCR Catalyst tank level	N/A	1761	1	0
DM1	65,226 (00FECA)	Engine protection tourque derate	N/A	1569	31	0
DM1	65,226 (00FECA)	Aftertreatment Diesel Exhaust Fluid Dosing Unit Loss of Prime	N/A	5392	31	0
DM1	65,226 (00FECA)	NOx limits exceeded due to Empty Reagent Tank	N/A	4096	31	0
DM1	65,226 (00FECA)	Aftertreatment SCR Operator Inducement Severity	N/A	5246	31	0
DM1	65,226 (00FECA)	NOx limits exceeded due to Insufficient Reagent Quality	N/A	4094	31	0

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14.6. GM LAN Tabel

TBD

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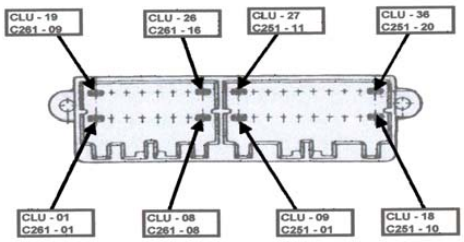
14.7. Cluster Connector



Term (CLU)	Term (C261/251)	Designation	Wakeup Hardware/ Software	Description
1	C261 01	Battery		Unswitched positive (+) 14V
2	C261 02	Ground		Chassis ground
3	C261 03	CAN+	S	SAE J1939 Databus
4	C261 04	CAN-	S	SAE J1939 Databus
5	C261 05	CAN+	S	SAE GMLAN Databus
6	C261 06	CAN-	S	SAE GMLAN Databus
7	C261 07	LIN		LIN Databus
8	C261 08	+7.6V Power		Slave device power output [800ma max current draw]
9	C251 01	+5 Vdc		Regulated +5Vdc Sensor Power [50ma max current draw]
10	C251 02	CNG Fuel Pressure Sender	S	VAI 1-5V [*Software Configurable VAI 0-7V*]
11	C251 03	Front Air Pressure Sender/Suspension Air	S	VAI 0.5-4.5V [*Software Configurable VAI 0-7V*]
12	C251 04	Rear Air Pressure Sender	S	VAI 0.5-4.5V [*Software Configurable VAI 0-7V*]
13	C251 05	Applied Front Air Pressure Sender	S	VAI 0.5-4.5V [*Software Configurable VAI 0-7V*]
14	C251 06	Applied Rear Air Pressure Sender	S	VAI 0.5-4.5V [*Software Configurable VAI 0-7V*]
15	C251 07	Ammeter	S	VAI 1-4V [*Software Configurable VAI 0-7V*]
16	C251 08	Spare		VAI 0-18V [*Software Configurable VAI 0-18V*]
17	C251 09	Hydraulic Brake Failure	S	BIN AL [*Software Configurable RAI*]
18	C251 10	Ignition	S	Binary Input - Active High
19	C261 09	Headlight Alert/Backlight On	S	BIN AH [*Software Configurable BIN AL/AH/RAI*]
20	C261 10	Hi Beam	S	BIN AH [*Software Configurable BIN AL/AH/RAI*]
21	C261 11	Left Turn	S	BIN AH [*Software Configurable BIN AL/AH/RAI*]
22	C261 12	Park Brake	S	See Buss Type Config [*Software Configurable BIN AL/AH/RAI*]
23	C261 13	Right Turn	S	BIN AH [*Software Configurable BIN AL/AH/RAI*]
24	C261 14	Service Brake Status	S	BIN AH [*Software Configurable BIN AL/AH/RAI*]
25	C261 15	Fast Idle	S	See Buss Type Config [*Software Configurable BIN AL/AH/RAI*]
26	C251 16	Brake Interlock Request	S	BIN AL [*Software Configurable RAI*]
27	C251 11	Brake Interlock Alarm	S	BIN AL [*Software Configurable RAI*]
28	C251 12	Rear Engine Door	S	BIN AL [*Software Configurable RAI*]
29	C251 13	Lift Authorize		BINOUT 1 - Active Low (1A max current draw – Sink)
30	C251 14	Shutter Solenoid		BINOUT 2 - Active Low (1A max current draw – Sink)
31	C251 15	Speed Detect Out		BINOUT 3 - Active Low (1A max current draw - Sink)
32	C251 16	Seat Belt	S	BIN AL [*Software Configurable RAI/FREQ*]
33	C251 17	Lift Door Open/Not stowed	S	BIN AL [*Software Configurable RAI/FREQ*]
34	C251 18	Fuel Level Sender		Binary Input - Active Low/RAI 0-400 Ohms (See Chart)
35	C251 19	Brake Interlock Set (AIR)/Lock (Hyd)		Binary Input - Active Low/RAI 0-400 Ohms
36	C251 20	Wait to Start		Binary Input - Active Low/RAI 0-400 Ohms

Signal low = Chassis Ground (0.0V – 1.5V) Signal high = 4.0V up to Ignition Voltage

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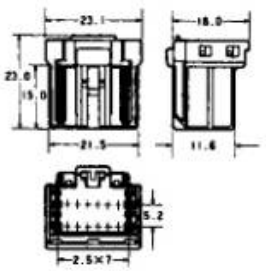
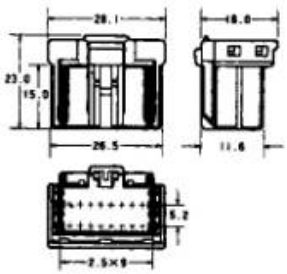
14.8. Cluster Mating Connectors

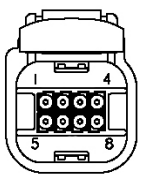
16 positions (2 X 8) (Actia P/N 102130)
Tyco US Part Number: 175966-2



20 positions (2 X 10) (Actia P/N 102131)
Tyco US Part Number: 175967-2



14.9. Warning Module Binary Input connector



8 positions (2 X 4) (Actia P/N 100950)
Tyco US Part Number: 1411001-1
LIN ID=0x92
ACTIA Assembly Module P/N: 103936

Terminal	Designation	Description
1	Spare	Binary Input - Active low
2	Spare	Binary Input - Active low
3	Spare	Binary Input - Active low
4	Spare	Binary Input - Active low
5	Spare	Binary Input - Active low
6	Test Panel w/Air System	Binary Input - Active low
7	Test Panel w/Applied Air	Binary Input - Active low
8	Spare	Binary Input - Active low

Signal low = Chassis Ground (0.0V – 1.5V)
Signal high = 4.0V up to Ignition Voltage

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14.10. 1850 Gateway Module

Tyco GET64 series sealed connector.
8 positions (2 X 4) (Actia P/N 100950)
Tyco US Part Number: 1411001-1

.

Terminal	Designation	Description
1	Battery	**Unswitched positive (+)**
2	Ground	Chassis ground (-)
3	CAN+	SAE J1939 Data bus
4	CAN-	SAE J1939 Data bus
5	Switched Battery	Ignition input (wakeup)
6	Input 2	Multi Functional Input
7	Input 1	Multi Functional Input
8	J1850	SAE J1850 Data bus

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15. APPENDIX B

15.1. Service Set Odometer Feature --

Warning – U.S. Federal Law requires that the odometer accurately display the vehicle's actual mileage. It is the responsibility of the person installing the Cluster to make sure the mileage programmed into the odometer correctly matches the vehicle's actual mileage.

The Service Set feature allows the season odometer and buss type to be set by the service technician installing a new cluster into a vehicle. The odometer value and bus type is programmed using the front panel buttons and no other tools are necessary.

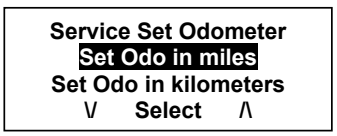
When the Cluster is powered up the LCD will display the fact that this is a Service Set Gauge and the odometer must be set. The Cluster will function in a limited mode until the Odometer and bus type has been set. Access to the set feature is controlled in the EEPROM and is secured using a four-byte code that prevents accidental access to this feature.

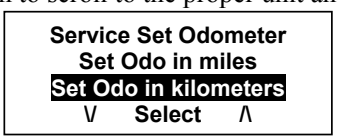
15.2. Limited Function

All gauge pointers will sit at zero position and not operate prior to setting the odometer while the LCD will only show the Service Set messages. All other parts of the system will operate. Warning icons located in the warning modules and in gauges will function normally and buzzer tones associated with the warnings will be allowed. Once odometer and bus type are set, the Service Set Gauge screen will not be seen again and the odometer value cannot be changed.

15.3. Setting the Units

Prior to setting the odometer value the technician must indicate to the gauge whether English (miles) or metric (kilometers) units are being set. The gauge will default to the unit that was set when the gauge left the factory. To change, press the ***m*** or ***t*** button to scroll to the proper unit and press both buttons to select.





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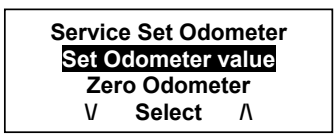
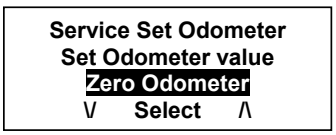
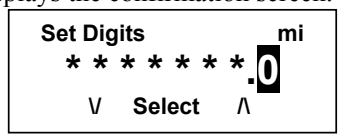
15.4. Setting the Odometer Value

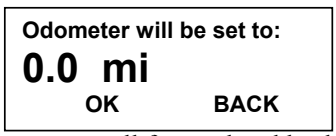
By using the ***m*** or ***t*** button to scroll you can highlight either Set Odometer Value or Zero Odometer.



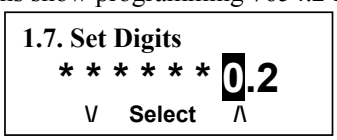


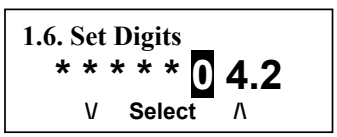
Selecting Set Odometer Value displays the Set Digits screen, while selecting Zero Odometer displays the confirmation screen.

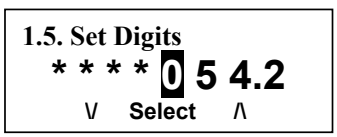


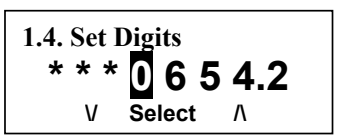


Each digit is set by using the ***m*** and ***t*** buttons to scroll forward and backward through the digits 0 – 9. Pressing ***m*** and ***t*** together stores the digit and displays the next digit to be set. The following screens show programming 7654.2 into the odometer.









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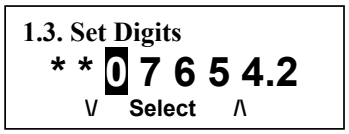
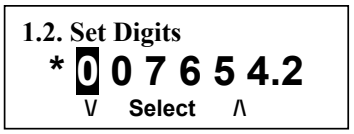
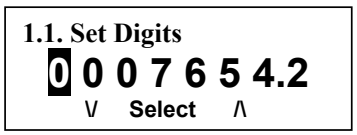
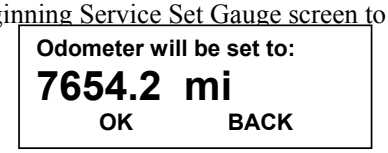
All digits must be set, but since pressing the ***m*** and ***t*** buttons together for select brings up the next digit as zero, you can quickly set the remaining digits to zero.







Once all digits have been set the confirmation screen will be displayed. Pressing ***m*** will accept the mileage and display the service bus type option while pressing ***t*** will take you back to the beginning Service Set Gauge screen to start over.



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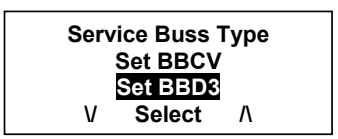
15.5. Setting the Service Bus Type

By using the ***m*** or ***t*** button to scroll you can highlight either BBCV or BBD3. This is important as the Park Brake logic different for both.



Once bus type has been set the confirmation screen will be displayed. Pressing ***m*** will accept the the value and restart the cluster in normal ignition mode with these settings while pressing ***t*** will take you back to the Service Bus Type setting to reset the bus type.

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Overview

Many of the Blue Bird Vision's electrical circuits communicate and interact with each other through an advanced Multiplex control system. This solid-state system provides significant advantages over traditional wiring:

- Multiplex simplifies the system by replacing multiple mechanical relays and switches with reliable solid-state components.

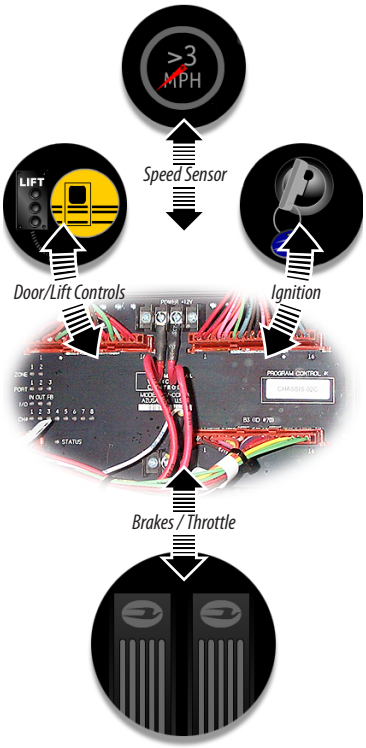
- Multiplex provides intelligent programmed (rather than mechanical) interaction between components. Multiple component signals are transmitted simultaneously along a common data bus, and are monitored and controlled by a digital microprocessor.

- The Multiplex module also serves as a centralized troubleshooting tool which simplifies the process of isolating causes of electrical malfunctions, without requiring special diagnostic hardware/software interfaces.

The Multiplex system may be thought of as similar in purpose and function to already-familiar electronic control devices such as the engine ECU, or the Weldon warning light control module. The main differences are that the programmable module(s) of a multiplex system are programmed for specific vehicles, and provides information to the technician by means of a series of visible LED indicators rather than by means of special diagnostic interface ports.

The Multiplex systems installed on the Blue BIrd Vision is relatively simple. It primarily controls chassis-related on/off state devices. Most body circuits are wired conventionally. (Some chassis circuits receive Inputs from body components such as vandal locks and door signal switches and some body circuits are controlled by outputs from the MPX system such as turn signals.) Although the modular nature of Multiplex components allows it to be configured for complex systems using multiple modules located in several control "zones", the Vision's Multiplex system consists of one zone with a single control module.

The central component of the Multiplex system is the MPX Module, the microprocessor which handles communication between various circuits. The role of the MPX Module is similar to that of a telephone switchboard which makes and breaks connections for multiple individual "calls" (between two components) and/or "conference calls" (between several components), simultaneously. Input signals from various circuits arrive at the MPX Module. Inside the Module, the Inputs trigger Output signals which activate/deactivate other components or circuits. The programming of the MPX Module determines which Input (or combination of Inputs) results in any particular Output. Specific programming of each module is identified by a program control number on the front of the module. The Module also internally generates a Feedback signal for each load circuit, and continually monitors the Feedback signals to verify the integrity of the circuits, much as a technician would use an Ohm meter to test continuity.

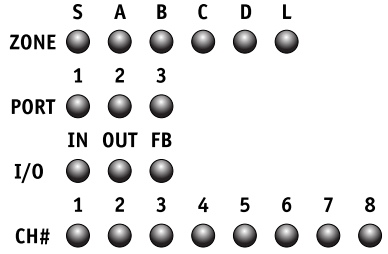


Multiplex System

The Brake & Throttle Interlock system is an example of how multiplexing handles simultaneous communications between seemingly unrelated components.

An array of Light Emitting Diodes (LEDs) on the MPX Module provides the means by which a technician can visually monitor the status of individual Inputs, Outputs, and Feedbacks. The technician uses a dash-mounted Diagnostic Switch to select which circuits the LEDs display, and whether they indicate Inputs, Outputs, or Feedback. To interpret the LEDs, the technician refers primarily to two printed references presented later in this chapter: the Input/Output charts and the Ladder Logic diagrams.

As with any new technology, troubleshooting and servicing a Multiplex system requires an initial familiarization, a firm conceptual understanding, and the acquisition of new skills (such as reading Ladder Logic diagrams). However, Multiplexing does not supersede or invalidate what a qualified electrical technician already knows about troubleshooting and diagnosis. Rather, it provides a new and valuable tool to assist the qualified technician in narrowing down the source of a problem, thereby minimizing downtime and reducing operating costs.



MPX Module

The CV-CCM-C Main Bus Controller (MPX Module) is mounted in the Power Distribution Unit to the right of the driver's area. The Module electronics are powered by "clean" 12 volt power from the battery bus bar, which isolates it from the normal current fluctuation or "line noise" of power circuits affected by the alternator. Five connectors on the module labeled A, B, C, D, and E, receive Inputs from sensors and switches, and convey Outputs to actuators, lamp loads, and other devices.

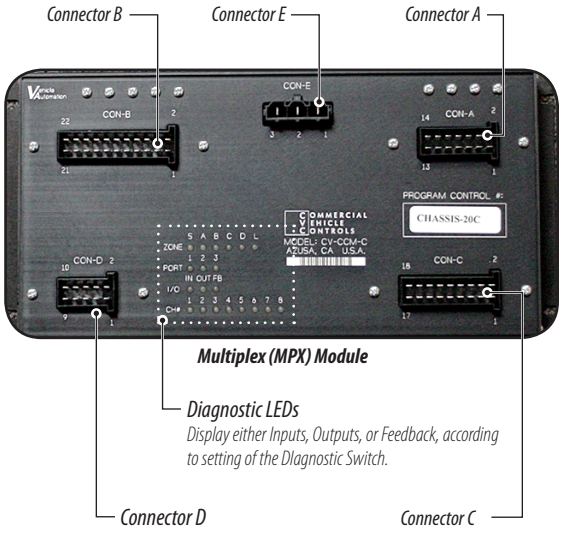
Four rows of LEDs indicate the status of the controlled circuits:

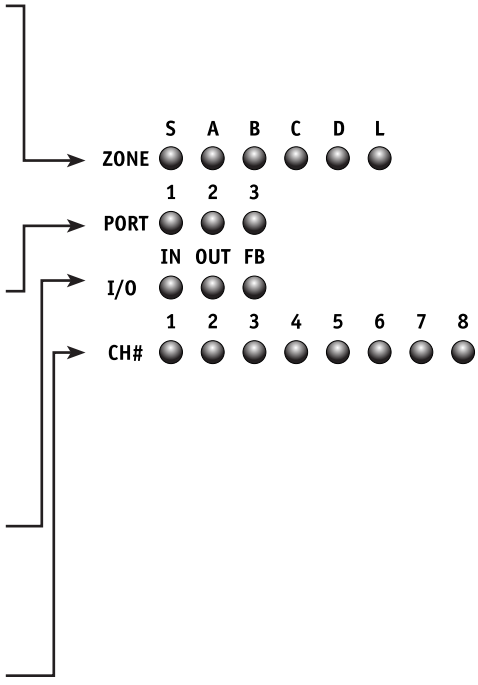
Zone: The top row consists of six LEDs, labeled S, A, B, C, D, and L. The Blue Bird Vision's single-zone Multiplex System is contained within Zone A. (Note that all of the addresses shown in the Input and Output charts begin with "A".) The Zone L LED goes off when the Multiplex System enters Sleep Mode. S and A are the only functionally active LEDs, B, C, D, and L are not active at this time. When power is first applied to the system, all the LEDs come on momentarily, and then go off. The Zone A LED then blinks a number of times, corresponding to the revision version of the software installed. Finally, the Zone A LED goes off and the system is in its normal operating mode.

Port: The three LEDs in this row correspond to the three input/output connector Ports. When the MPX Module has been put in diagnostic mode by pressing the Diagnostic Switch, these LEDs indicate which Port the rows of I/O and CH# LEDs are presently indicating.

I/O: When in diagnostic mode, the three LEDs in this row, labeled IN, OUT, and FB, indicate whether the row of CH# LEDs immediately below are presently monitoring Inputs, Outputs, or Feedback.

CH#: When in diagnostic mode, the bottom row of eight LEDs indicate the current state (active on or inactive of) of each of the Inputs, Outputs, or Feedback being monitored (depending upon which I/O LED is on) of the Port presently indicated by the Port LEDs.



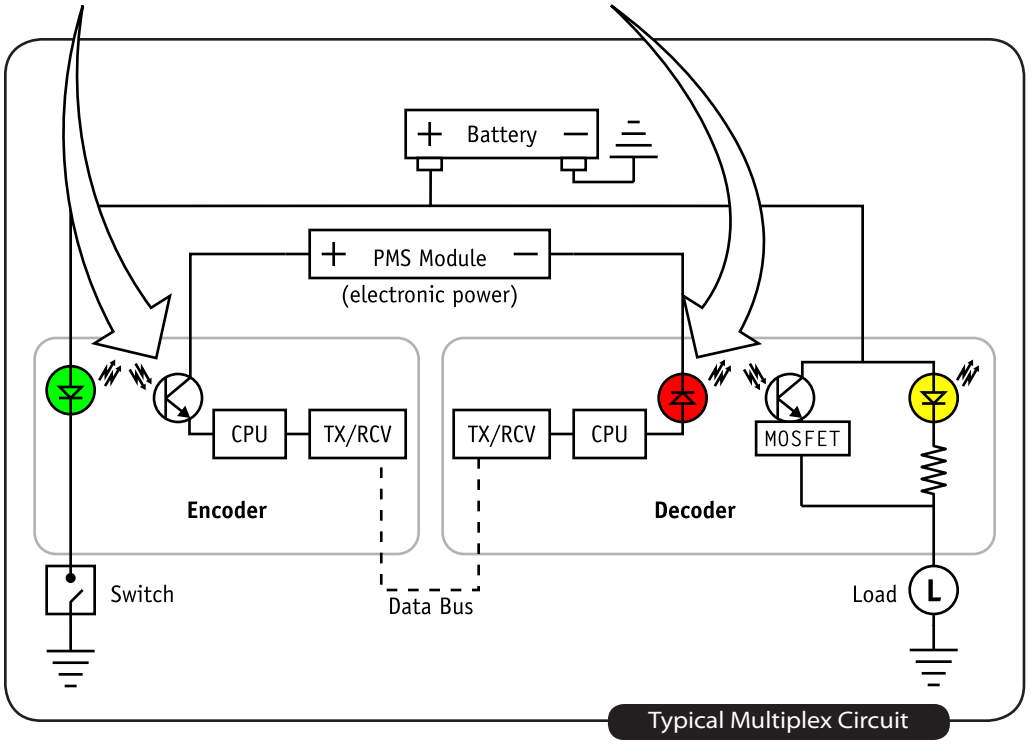


The LEDs serve as visual indicators. However, they also represent the type of mechanism by which Output circuits are "notified" of the presence of particular Inputs. Inside the MPX Module, an LED in a given Input circuit turns on when the circuit is Active. Nearby, a solid state photo sensor in the Output circuit detects the internal light source and either closes or opens an Output Circuit according to the programming of the Module. In turn, the status of the Output Circuit is similarly sensed by a photo sensor in the load circuit. In this sense, the LEDs can be thought of as actually performing the function of electrical relays.

Rather than having fuses, the MBC provides solid state circuit protection. If an Output is turned on and is drawing too much current (as in the case of a short circuit), the Module turns the Output off before there can be any damage to the Output transistor and circuit.

LEDs As Circuit Relays. . .

The CPU "watches" Input LEDs with photosensors. . . . . . and activates the appropriate Output(s).



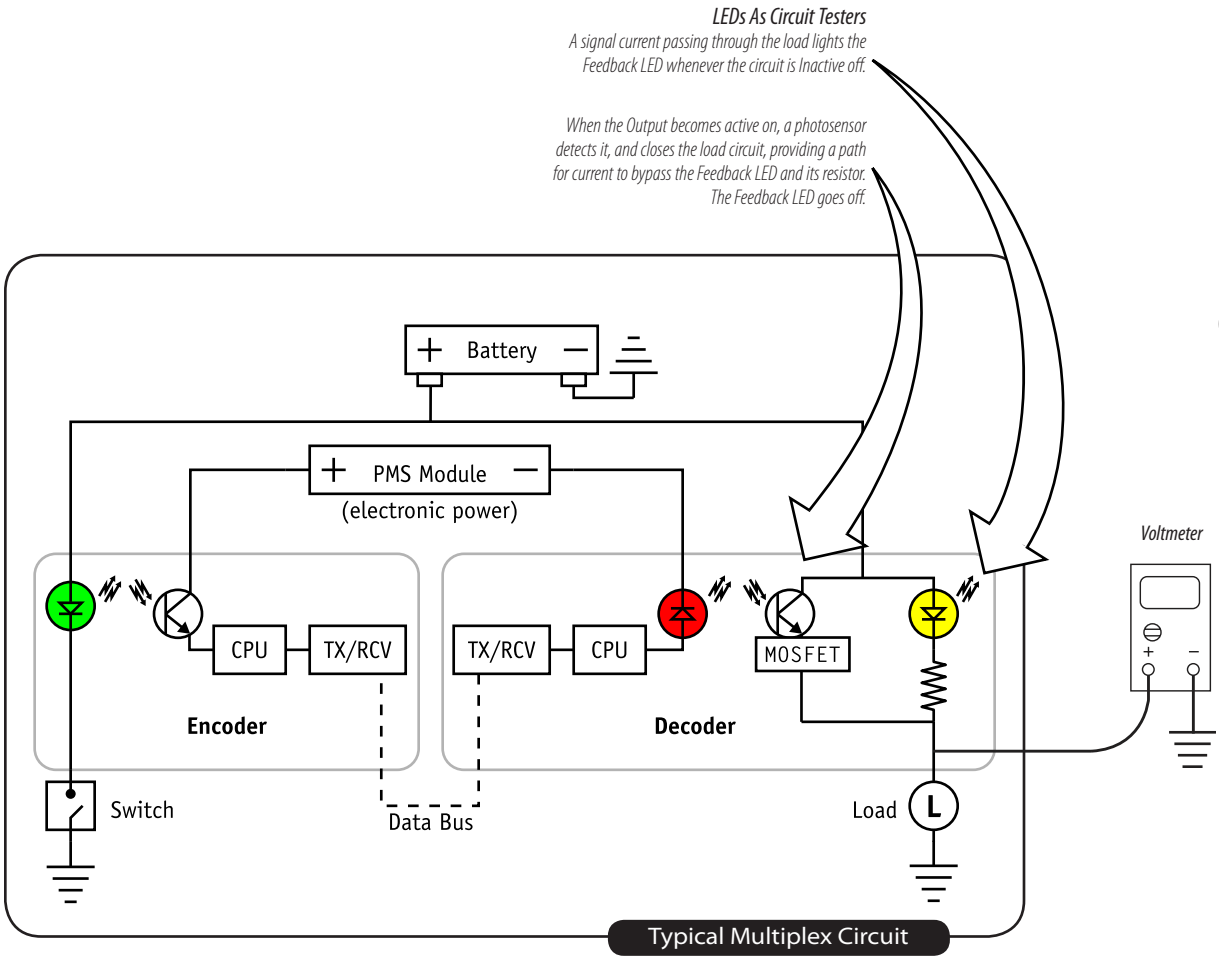
Typical Multiplex Circuit

Feedback Circuits

Internal Feedback circuits in the MPX Module are connected in parallel to the load side of Output circuits. A Feedback circuit conducts a faint current through the load, a resistor, and the Feedback LED. Thus, when the module is set to display Feedbacks, each of the bottom row LEDs acts much like a conventional ohm meter, indicating the integrity (continuity) of the load side of the circuit it monitors.

When the load circuit is switched on, full working current is able to bypass the Feedback LED circuit. This removes the voltage differential across the LED and resistor, and the LED goes off.

Thus, in a properly performing load circuit, the Feedback LED should be on (indicating that the circuit is ready) when the circuit is Inactive; and should be off when the circuit is Active. If the Feedback LED is on while the circuit is Active, this is an indication of a short in the load side of the circuit.



Sleep Mode

The normal monitoring functions of the MPX Module draw a small current from the vehicle batteries. To minimize battery drain while the bus is parked, the Multiplex system automatically goes into a low current-draw Sleep Mode one hour after ignition is turned off. The Module awakens from Sleep Mode when either the ignition switch is turned on or one of a number of other circuits is used (headlights, stoplights, directional lights, horn, accessory switch). There is a slight delay while the system is awakening from Sleep Mode when the system is turned on.

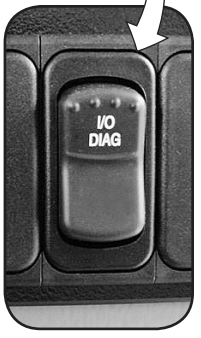
The Sleep Mode delay may differ on some units, in accordance with specific state requirements. For example, in a state which requires the lift to be operable only with the ignition switch removed, a longer delay time may be programmed to allow time for the lift to be used.

Diagnostic Mode

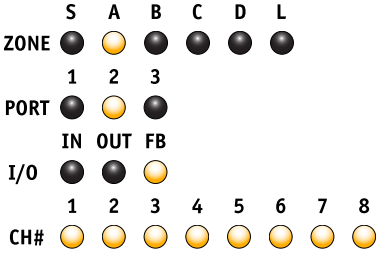
Except for the Zone S LED (which indicates Sleep Mode), the other LEDs only light when the MPX Module has been put into Diagnostic mode by pressing the Diagnostic switch. Each subsequent press of the switch cycles through the Ports and I/O options in the following order:

1st press: Puts the Module in Diagnostic Mode, displaying Port 1 Inputs.
2nd press: Port 1 Outputs.
3rd press: Port 1 Feedbacks.
4th press: Port 2 Inputs.
5th press: Port 2 Outputs.
6th press: Port 2 Feedbacks.
7th press: Port 3 Inputs.
8th press: Port 3 Outputs.
9th press: Port 3 Feedbacks.
10th press: Ends Diagnostic Mode. Only the Zone 2 LED remains on.

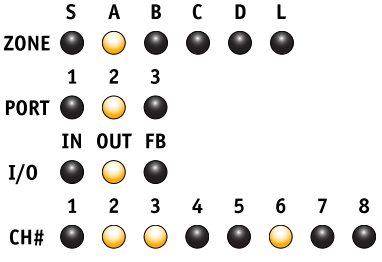
ABS Diagnostic Switch



Diagnostic Mode Switch
Cycles the MBC's display through Ports, Inputs, Outputs, and Feedbacks. (3-position momentary)



In this example, the LEDs are indicating the A2 Feedbacks. . .



. . . and here, the A2 Outputs.

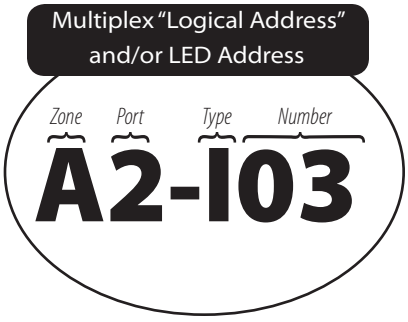
○ LED on
● LED off

Multiplex References

Two printed references are provided to assist the technician in interpreting the Main Bus Controller's LEDs:

Input and Output Tables

Generally speaking, the first step in troubleshooting an electrical problem is to determine whether the affected or suspected circuit is part of the Multiplex system. The Input and Output Tables included in this chapter list the circuits with which the Multiplex system interacts.



Multiplex Inputs Table. The Inputs Table lists the circuits from which the Main Bus Controller receives Input signals.

The second column (Zone/Port-Input#) shows the Multiplex "logical address" and/or "LED address" of each Input circuit. These addresses are not circuit/pin locations, but relate directly to the Ladder Logic diagrams. For example, the Accessory Switch address is A2-I03 (Zone A, Port 2-Input number 03).

The third column (connector port) shows the physical pin location of the circuits; which Pin of which Port Connector on the MPX Module to which the Input circuits are wired. For example, the Input wire leading from the Accessory Switch is connected to the Module at AC-03 (Port C, Pin 03).

The third and fourth columns list the wire color and whether the Input is a ground or a 12 volt connection.

Outputs Table. The Outputs table lists the circuits for which the Main Bus Controller issues Outputs. This table is organized similarly to the Inputs table:

The second column (Zone/Port-Input#) shows the Multiplex "address" and/or "LED address" of each Output circuit. These addresses are not circuit/pin locations, but relate directly to the Ladder Logic diagrams. For example, the Accessory Hot Output's address is A3-O08 (Zone A, Port 3-Output number 08).

The third column (connector port) shows the physical pin location of the circuits; which Pin of which Port Connector on the MPX Module to which the Output circuits are wired. For example, the Accessory Hot Output signal wire is connected to the Module at AB-116 (Port B, Pin 116).

The third and fourth columns list the wire color and whether the Output is a ground or a 12 volt connection.

The Outputs Table has a sixth column labeled Ladder Chart Line. This is the line of the Ladder Logic which describes the requirements for the specific Output. For example, to troubleshoot the Accessory Hot Output, you would refer to the Ladder Logic line 32, which describes the requirements for an Accessory Hot Output. (Note that the Zone/Port-Output# address of the Accessory Hot Output is the item at the right end of the Logic Line 32.)

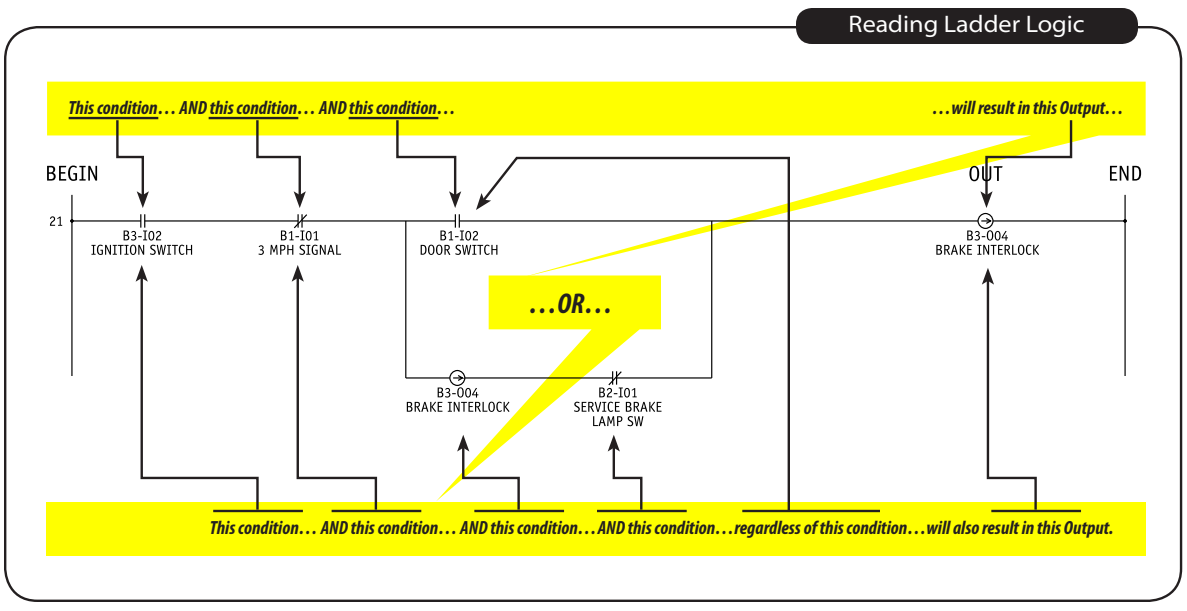
Ladder Logic Diagrams

The Ladder Logic Charts are not wiring schematics. They are diagrams of the "logic," or rules which the Multiplex program follows to determine which set of Inputs and/or other conditions results in each particular Output. Each horizontal "rung" of the diagrams graphically describes a set of requirements for the Output indicated at the right end of the line. Most of the requirements are either Inputs or other Outputs. (There are occasional requirements for signals which are generated internally by the MPX Module's internal circuitry or programming, rather than by a physical component on the bus.)

Each symbol on a logic line represents one particular requirement for the Output indicated at the right end of the line. Reading a line from left to right, *all* of the requirements encountered along the path must be satisfied in order for the Output at the right end of the line to occur. Thus, the horizontal lines between requirement symbols may be thought of as logical "and" statements. (An important basic principle of Ladder Logic is that a symbol can denote a requirement for either the presence on *or absence* off of a condition or signal.)

Some Logic diagrams provide alternate paths by which to reach the Output at the right end. These alternate paths may be thought of as logical "or" statements. If a requirement on the uppermost path is not met, the Output may still be achieved if all of the requirements of an alternate path are met.

Thus, troubleshooting a circuit which interacts with the Multiplex system involves finding the Ladder Logic diagram for the desired Output; and then systematically verifying each of its requirements by comparing the chart to what is actually happening according to the LEDs on the MPX Module. When a discrepancy is found, it is an indication that the problem exists "upstream" from that point in the Logic. This will become clearer as you continue through this chapter.



Ladder Logic Symbols

Following is a description of the symbols which appear on the Ladder Logic charts:

Inputs. A Logic Ladder diagram may require a particular Input to be either Active or Inactive. Active Inputs are symbolized by two vertical lines. Inactive Inputs are indicated by the same symbol, but with a diagonal slash.

Active Input LED On

Inactive Input LED Off

Outputs. Outputs do not only occur at the right end of Logic diagrams. A particular Output (or its absence) can also be a requirement for another Output. There is only one true functional output per logic line located on the far right. All other outputs are required conditions. Therefore, symbols exist for both Active and Inactive Outputs. An Active Output is symbolized by a right-pointing arrow inside a circle. The same symbol with a diagonal slash indicates an Inactive Output.

Active Output On

Inactive Output Off

Timers. A Timer is an internal signal generated by the Multiplex program. Timers are represented as rectangles containing abbreviated labels, such as the Turn Signal Flasher at address B1-I01, labeled FLS.

Active Timer (Flasher Shown)

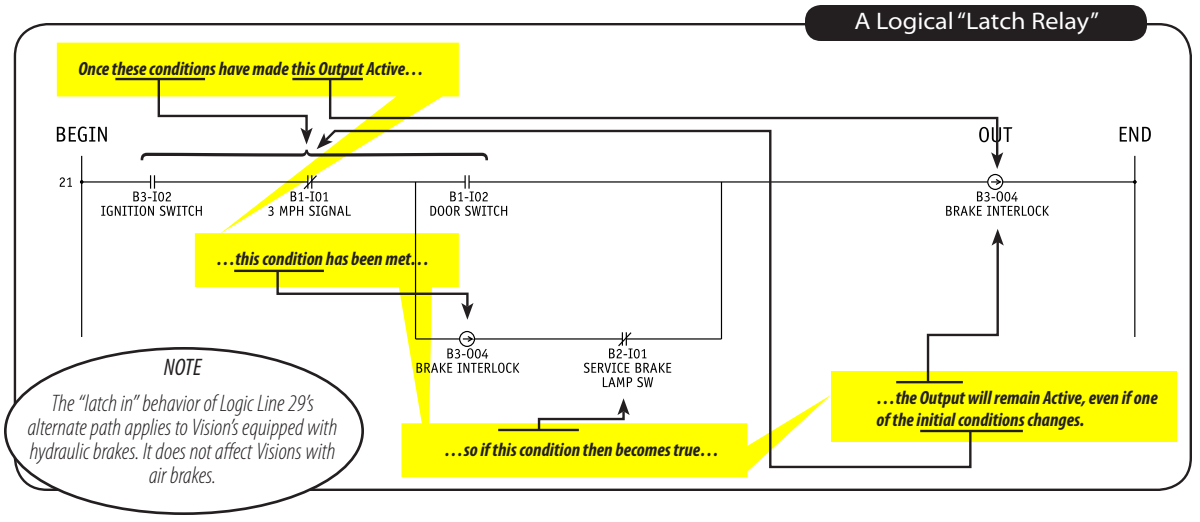
Flags. A Flag symbol is identical to an Output symbol (right-pointing arrow inside a circle), but with a letter F next to it. A Flag may be thought of as similar to a function in programming; a "shorthand" way to refer to another "mini-program", or set of commands. Thus, a Flags is a kind of Output, and has its own Ladder Logic diagram. Each flag has its own logic line but does not have an output pin, connector and circuit associated wiht it. When a Flag is encountered somewhere along a Logic Line, its own Logic diagram must be examined in turn to fully investigate the circuit.

Active Flag On

Inactive Flag Off

Logical "Latch Relays"

Occasionally, a particular Output may appear to be a requirement for itself. In such situations, it is helpful to realize that the Multiplex program performs the horizontal "rungs" of a Ladder in sequence, not all at once. If an initial set of conditions has made an Output true, that Output may then become one of a second set of conditions which will *keep* the Output true—even if one or all of the initial conditions changes. The Brake Interlock circuit is an example of this kind of Logic Line.

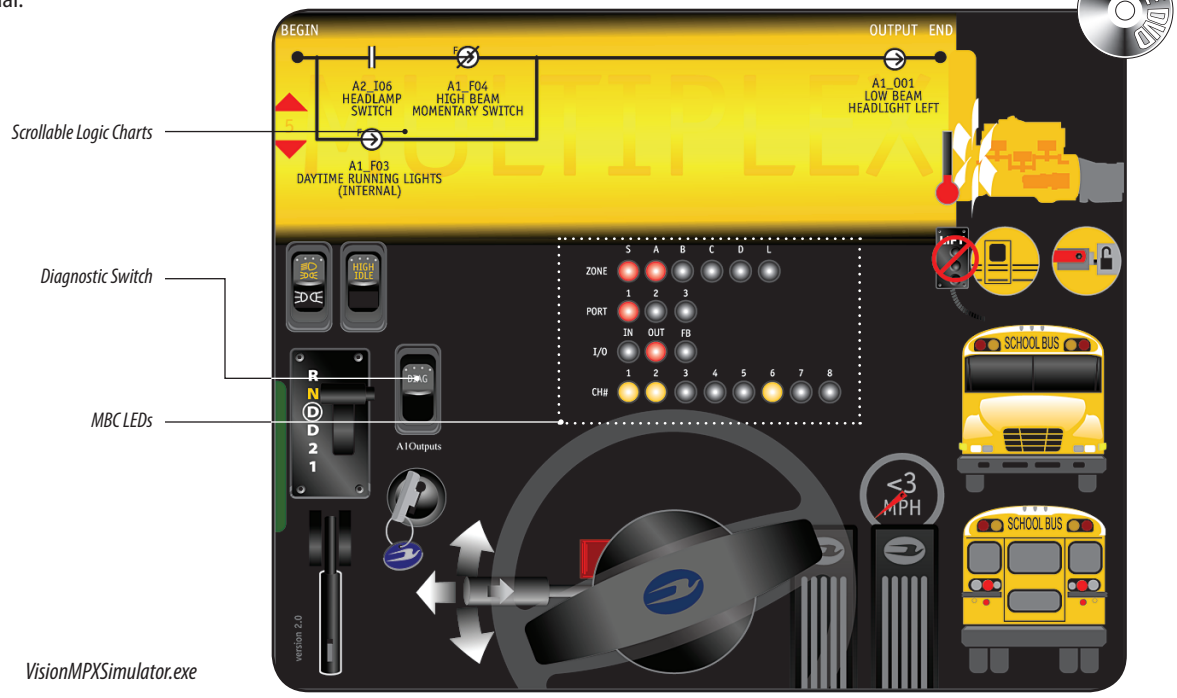


Vision MPX Simulator

Blue Bird has provided another reference tool to help technicians become more quickly acquainted with the Vision's Multiplex system. On the DVD provided with the bus at the time of delivery is a file named **VisionMPXSimulator.exe.** This is a small self-running Macromedia® Flash®-based application, suitable for use on most current Windows® computers.

CAUTION ***The Vision Multiplex Simulator is provided as a reference tool to help service technicians become more quickly familiar with the Blue Bird Vision's Multiplex system. It is intended for training/learning purposes only (not for actual troubleshooting). The software is only a SIMULATION of the Blue Bird Vision's Multiplex system. Although it imitates the behavior of the Vision's Multiplex Module, it does not contain the actual multiplex program. Because the actual program installed on buses is subject to change at the factory, the behavior of the Vision MPX Simulator may not exactly match that of your particular Vision unit(s).***

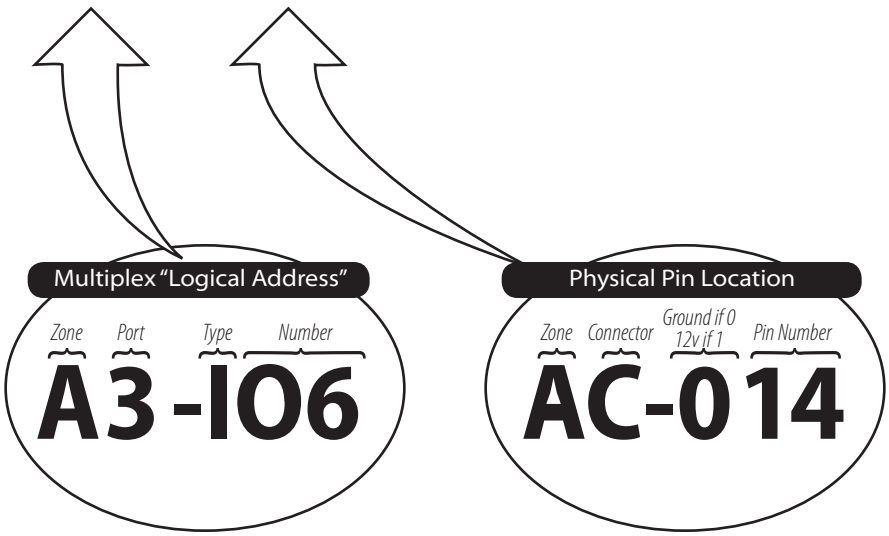
The Vision MPX Simulator operates upon a script which imitates the logic of the Ladder Logic diagrams of a 2008 Vision. Interactive on-screen controls represent the driver controls which generate Multiplex Inputs. Other animated graphic elements indicate the results of most Multiplex Outputs, as they are generated in response to the Inputs. An on-screen Diagnostic Switch allows the user to cycle the bank of "LEDs" to display Inputs, Outputs, or Feedbacks, simulating the behavior of the actual MPX Module. For reference while observing the behaviors of the LEDs, at the top of the screen is a scrolling list of the same set of Ladder Logic charts printed in this manual.



Input Tables

Multiplex Inputs Table

	Circuit Description	Input LED	Connector / Port-Pin	Wire Color	Intput
1	Accessory Switch	A2-I03	AC-003	YL	Ground
2	Brake Light Switch	A1-I05	AB-111	RD	12 Volts
3	Diagnostic Switch	A3-I07	AC-015	GN	Ground
4	Door Signal	A3-I03	AC-011	BL	Ground
5					
6	Headlight Switch	A2-I06	AC-006	OR	Ground
7	High Beam Switch	A2-I07	AC-007	OR	Ground
8	High/Fast Idle	A2-I01	AC-001	GN	Ground
9	Horn Signal	A3-I02	AC-010	GY	Ground
10	Ignition Switch	A2-I04	AC-004	PK	Ground
11	Interlock Feedback	A3-I05	AC-013	OR	Ground
12	Neutral Signal	A1-I03	AB-107	RD	12 Volts
13	Park/Tail Light Switch	A1-I07	AA-004	BN	Ground
14	Park Brake Switch	A1-I06	AB-012	PK	Ground
15	Reverse Signal	A1-I02	AB-004	BL	Ground
16	Speed Signal	A1-I01	AB-003	RD	Ground
17	Starter Lockout Signal	A2-I02	AC-102	RD	12 Volts
18	Starter Switch	A2-I05	AC-005	PU	Ground
19	Turn Signal, Left	A2-I08	AC-008	YL	Ground
20	Turn Signal, Right	A3-I01	AC-009	GN	Ground
21	Vandal Lock	A3-I08	AC-016	TN	Ground
22	Washer Pump Switch	A1-I04	AB-108	PK	12 Volts
23	Intermittent Wiper Switch	A3-I04	AC-112	BK	12 Volts
24	SCC Alarm	A3-I06	AC-014	GN	Ground



Output Tables

Multiplex Outputs Table

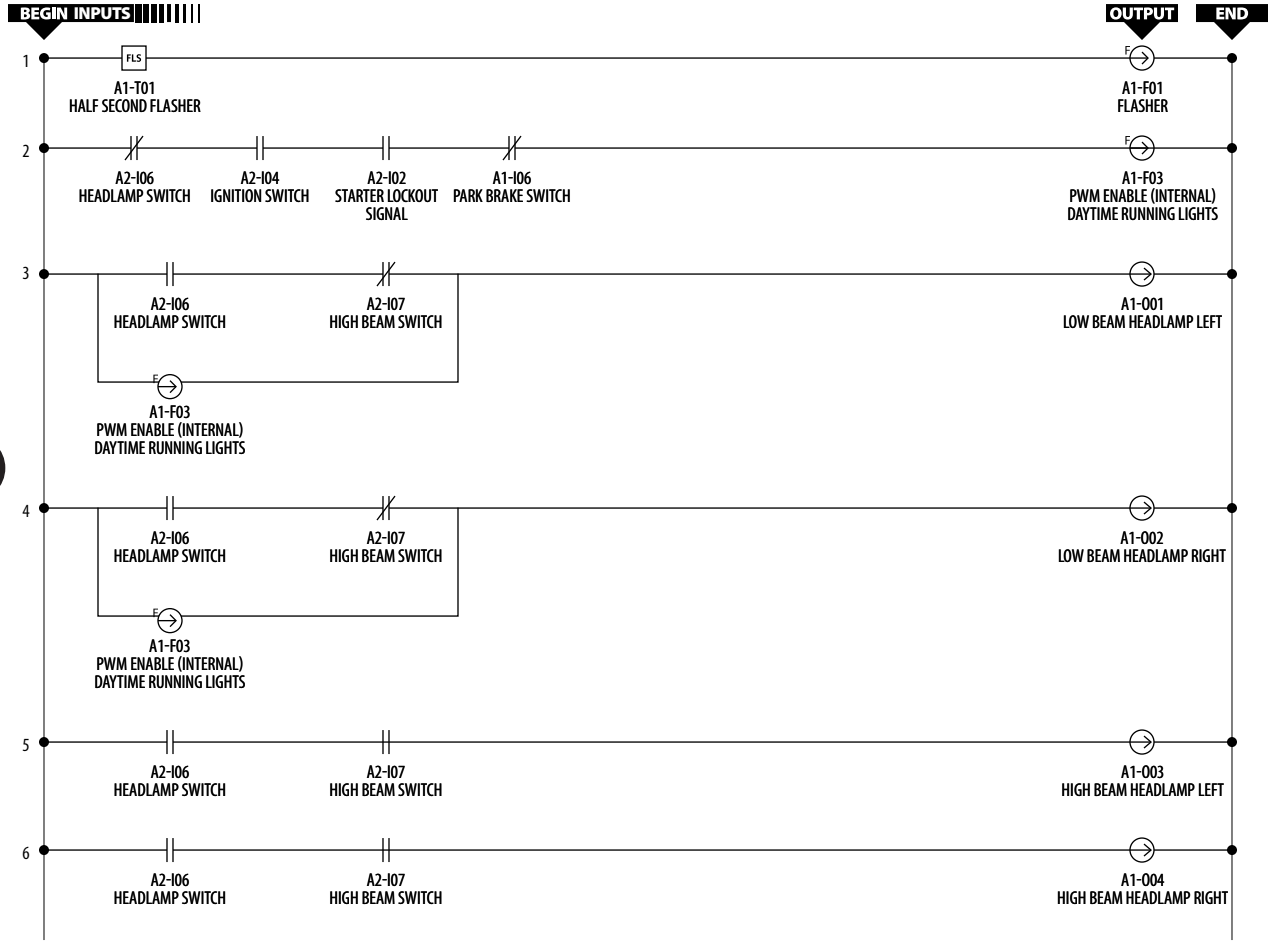
	Circuit Description	Output LED	Connector / Port-Pin	Wire Color	Output	Ladder Chart Line
1	Accessory Hot	A3-008	AB-116	GN	12 Volts	32
2	Back up Lights	A2-004	AA-107	BL	12 Volts	14
3	Brake Interlock	A3-005	AB-015	WH	Ground	29
4						
5	High/Fast Idle	A3-001	AB-001	OR	Ground	25
6	Headlight, High Left	A1-003	AA-110	RD	12 Volts	5
7	Headlight, High Right	A1-004	AA-112	PU	12 Volts	6
8	Headlight, Low Left	A1-001	AA-102	BN	12 Volts	3
9	Headlight, Low Right	A1-002	AA-106	OR	12 Volts	4
10	Horn	A1-008	AB-114X	BK	12 Volts	10
11	Ignition	A2-006	AA-111	OR	12 Volts	16
12	Ignition Dropout	A2-007	AA-113	PK	12 Volts	17
13	Park Brake	A2-003	AA-105	PK	12 Volts	13
14	Park Lights	A1-006	AB-106	BN	12 Volts	8
15	Shift Inhibit Signal	A3-002	AB-005	GN	Ground	26
16	Lift Enable	A3-006	AB-021	RD	Ground	30
17	Ex. Brake Stop Light	A3-004	AA-09	RD	12 Volts	28
18	Starter Relay	A2-008	AA-114	RD	12 Volts	18
19	Stop Lights Relay	A2-005	AA-109	RD	12 Volts	15
20	Throttle Interlock	A3-003	AB-009	BN	Ground	27
21	Turn Signal, Left	A1-005	AB-102X	YL	12 Volts	7
22	Turn Signal, Right	A1-007	AB-110X	GN	12 Volts	9
23	Wiper Washer Pump	A3-007	AB-122	TN	12 Volts	31
24	Intermittent Wiper Motor	A2-001	AA-101	BN	12 Volts	11
25	Shutters	A2-002	AA-103	OR	12 Volts	12

(STANDARD) LADDER LOGIC DIAGRAMS

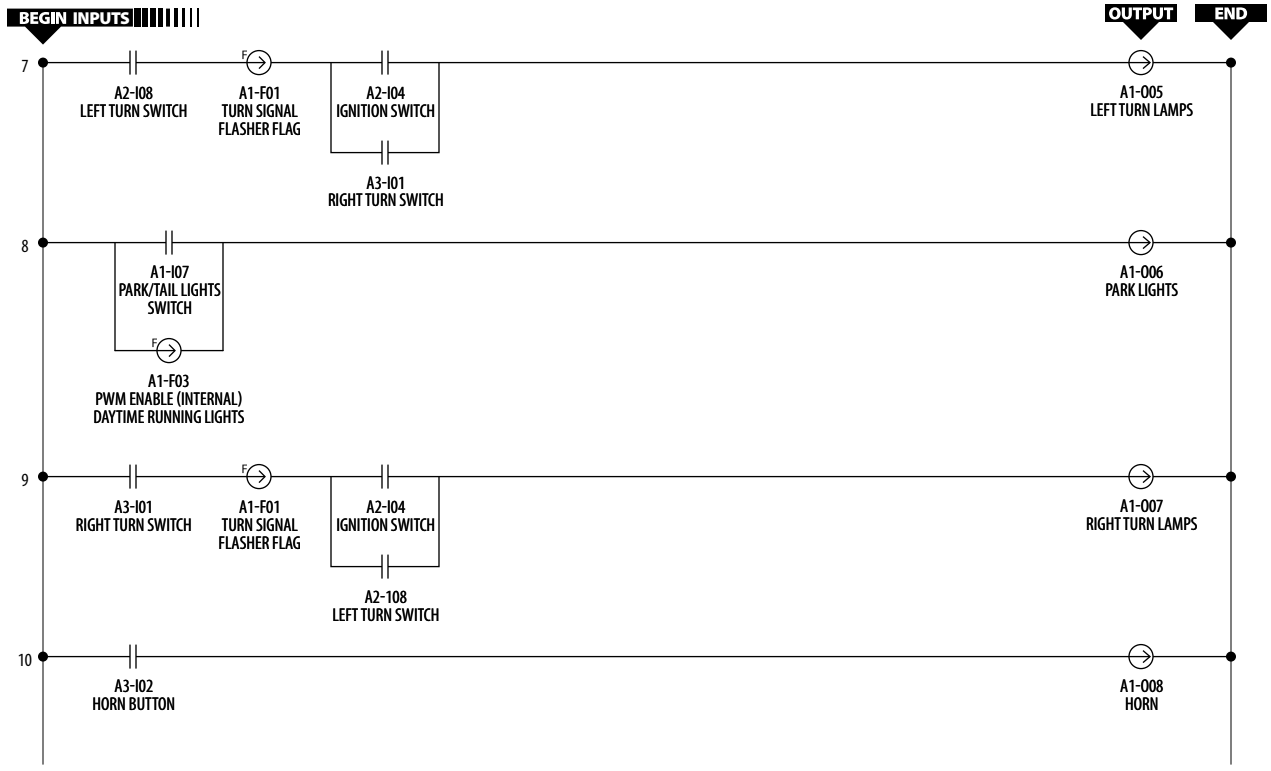
Symbols Key

Active Input (LED ON) | *Inactive Input (LED OFF)* | *Active Output (LED ON)* | *Inactive Output (LED OFF)* | *Active Timer (Flasher Shown)* | *Active Flag* | *Inactive Flag*

(STANDARD) PORT 1 FLAGS



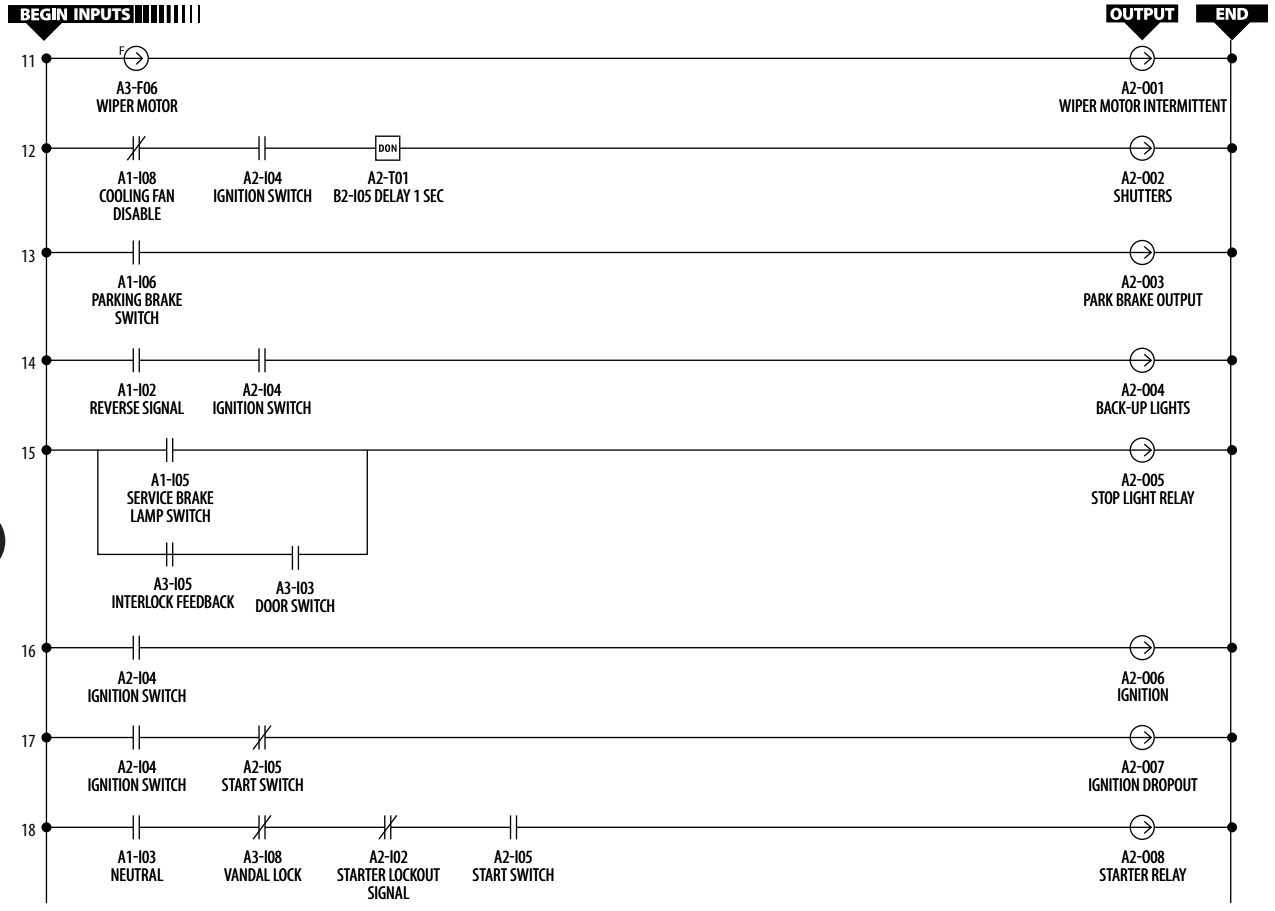
(STANDARD) PORT 1 OUTPUTS



Symbols Key

Active Input (LED ON) | *Inactive Input (LED OFF)* | *Active Output (LED ON)* | *Inactive Output (LED OFF)* | *Active Timer (Flasher Shown)* | *Active Flag* | *Inactive Flag*

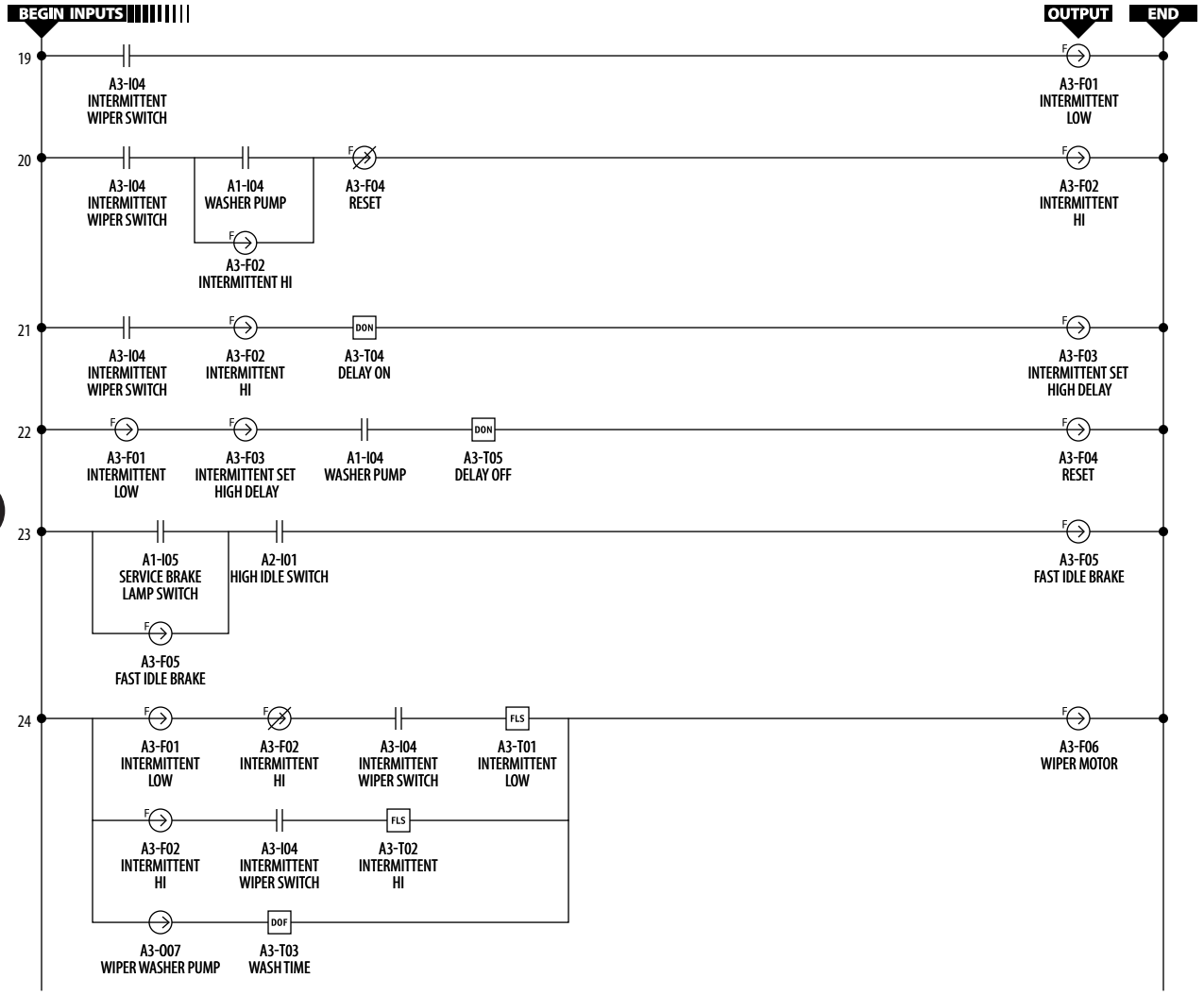
(STANDARD) PORT 2 OUTPUTS



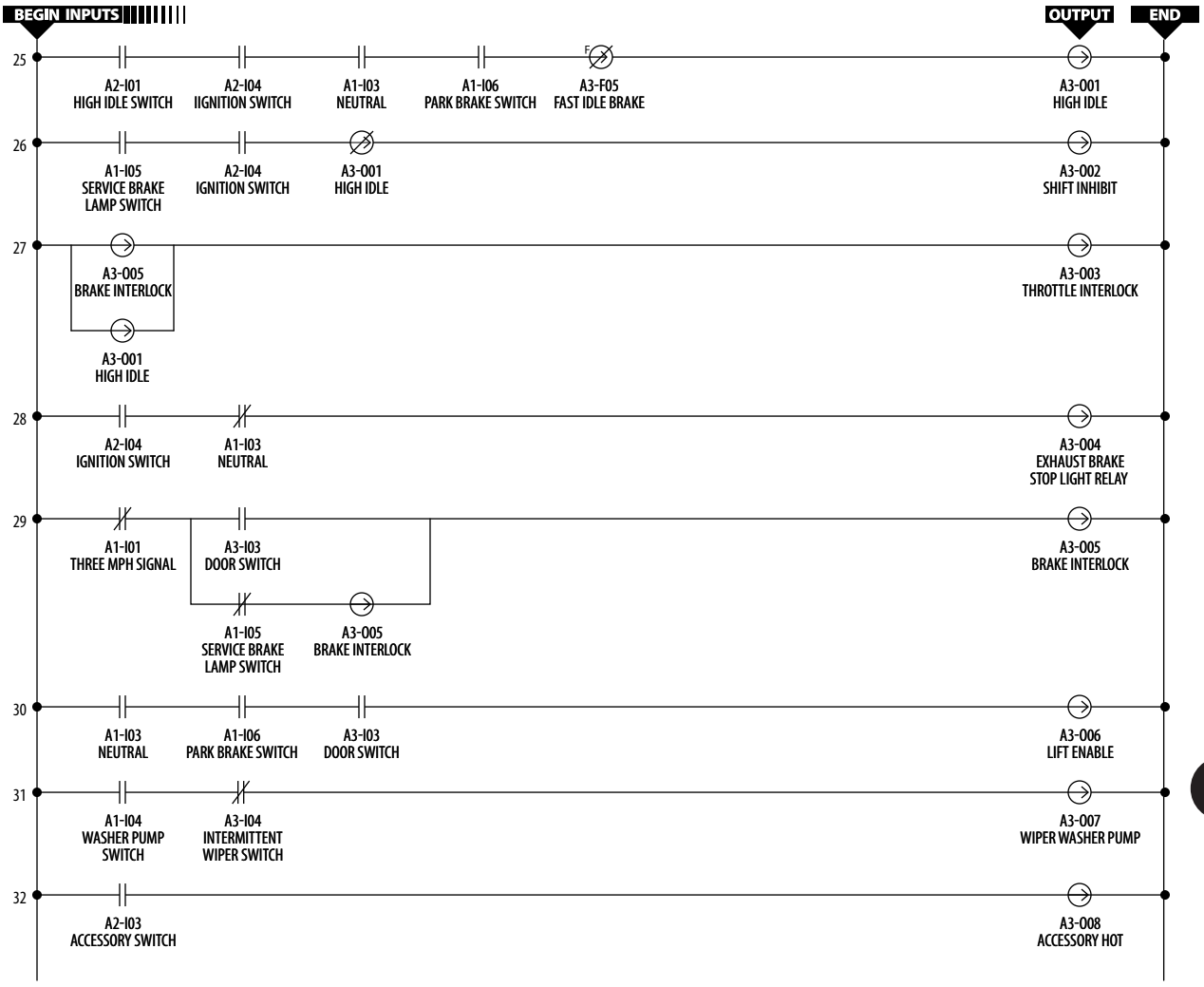
Symbols Key

Active Input (LED ON) | *Inactive Input (LED OFF)* | *Active Output (LED ON)* | *Inactive Output (LED OFF)* | *Active Timer (Flasher Shown)* | *Active Flag* | *Inactive Flag*

(STANDARD) PORT 3 FLAGS



(STANDARD) PORT 3 OUTPUTS

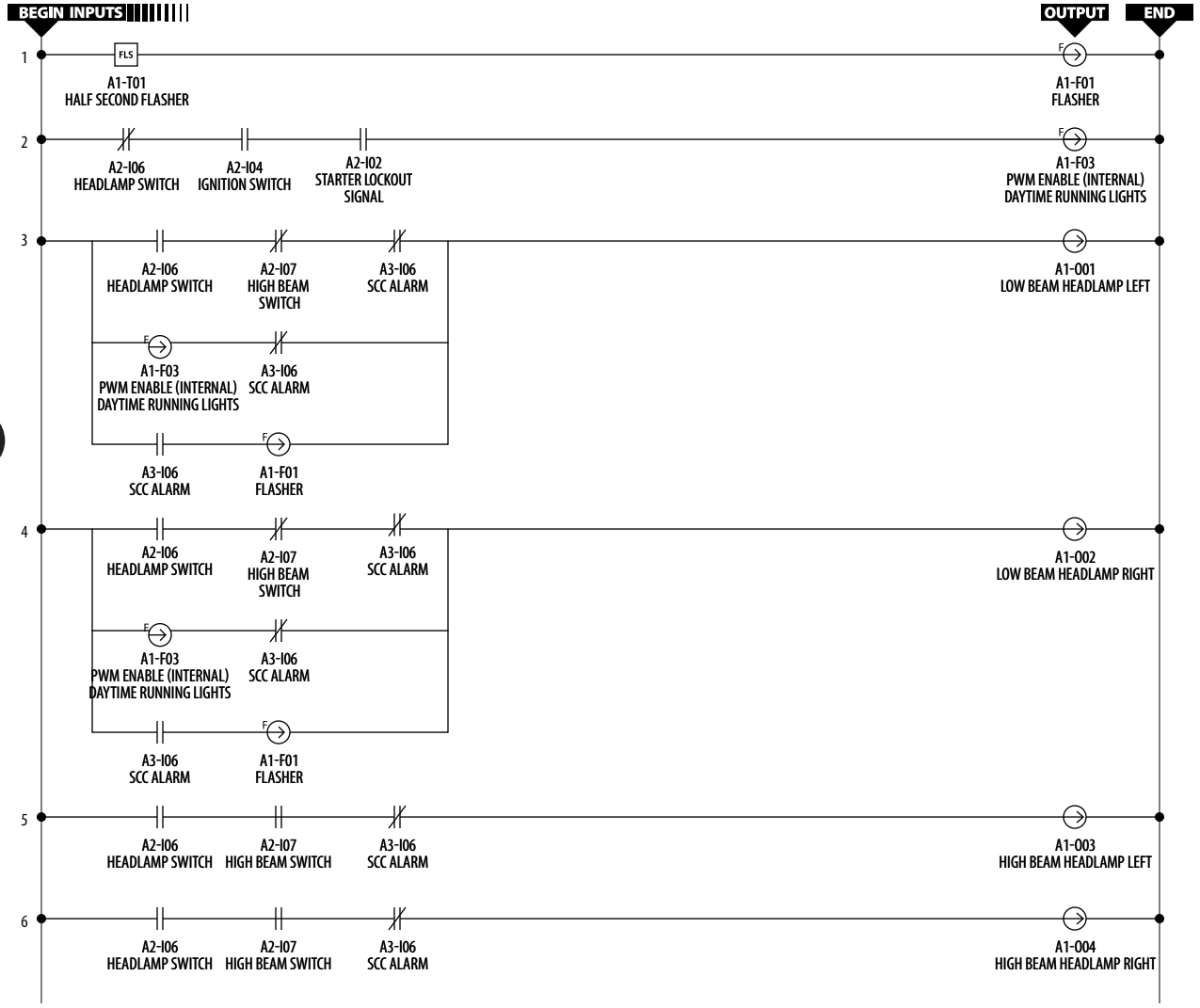


(FLORIDA) LADDER LOGIC DIAGRAMS

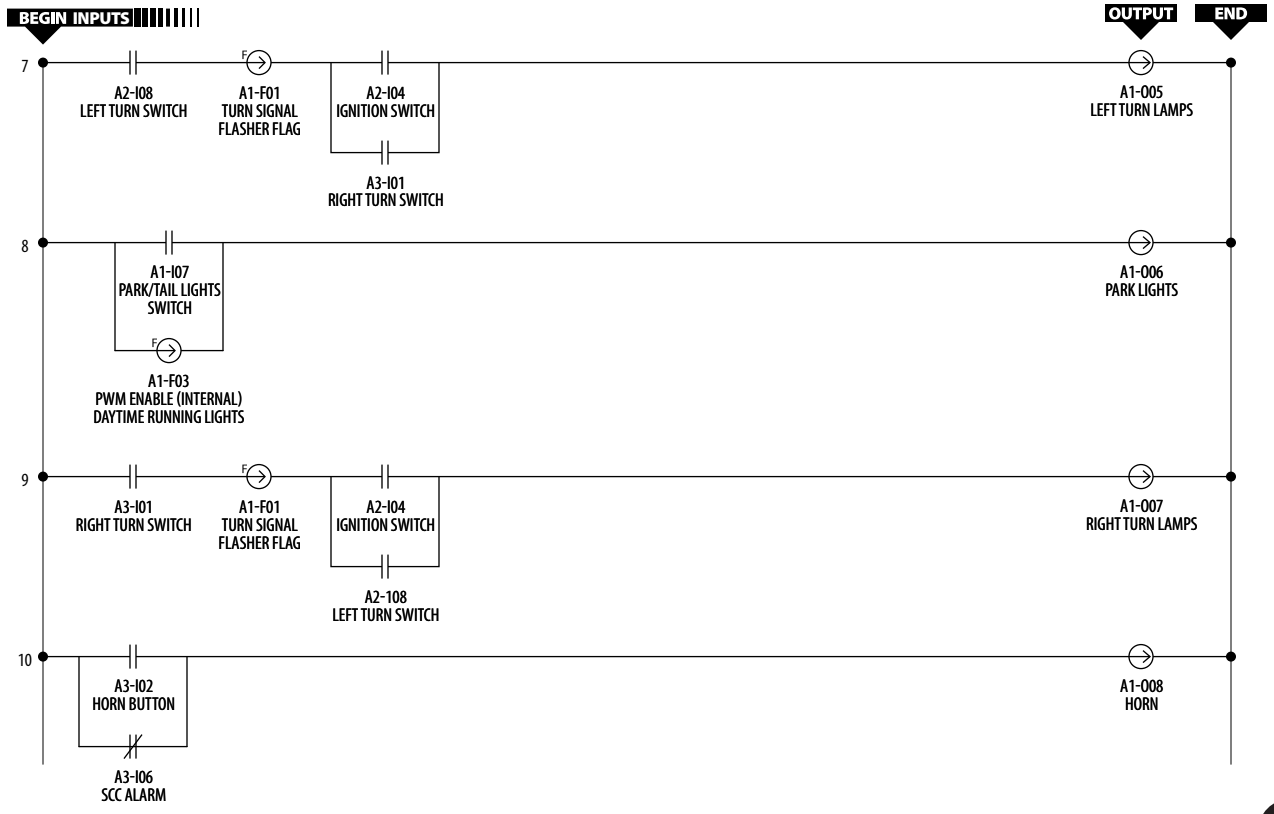
Symbols Key

Active Input (LED ON) | *Inactive Input (LED OFF)* | *Active Output (LED ON)* | *Inactive Output (LED OFF)* | *Active Timer (Flasher Shown)* | *Active Flag* | *Inactive Flag*

(FLORIDA) PORT 1 FLAGS



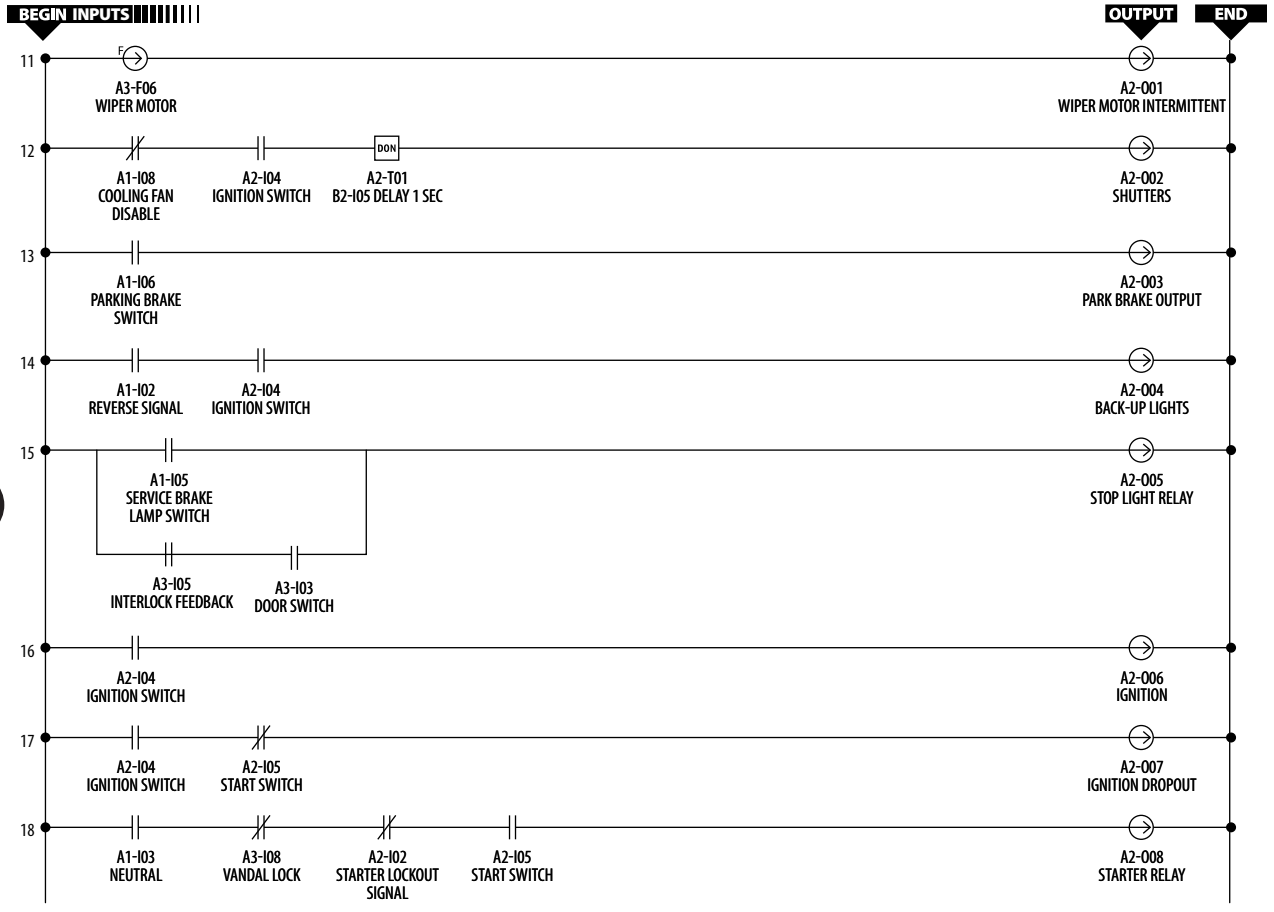
(FLORIDA) PORT 1 OUTPUTS



Symbols Key

Active Input (LED ON) | *Inactive Input (LED OFF)* | *Active Output (LED ON)* | *Inactive Output (LED OFF)* | *Active Timer (Flasher Shown)* | *Active Flag* | *Inactive Flag*

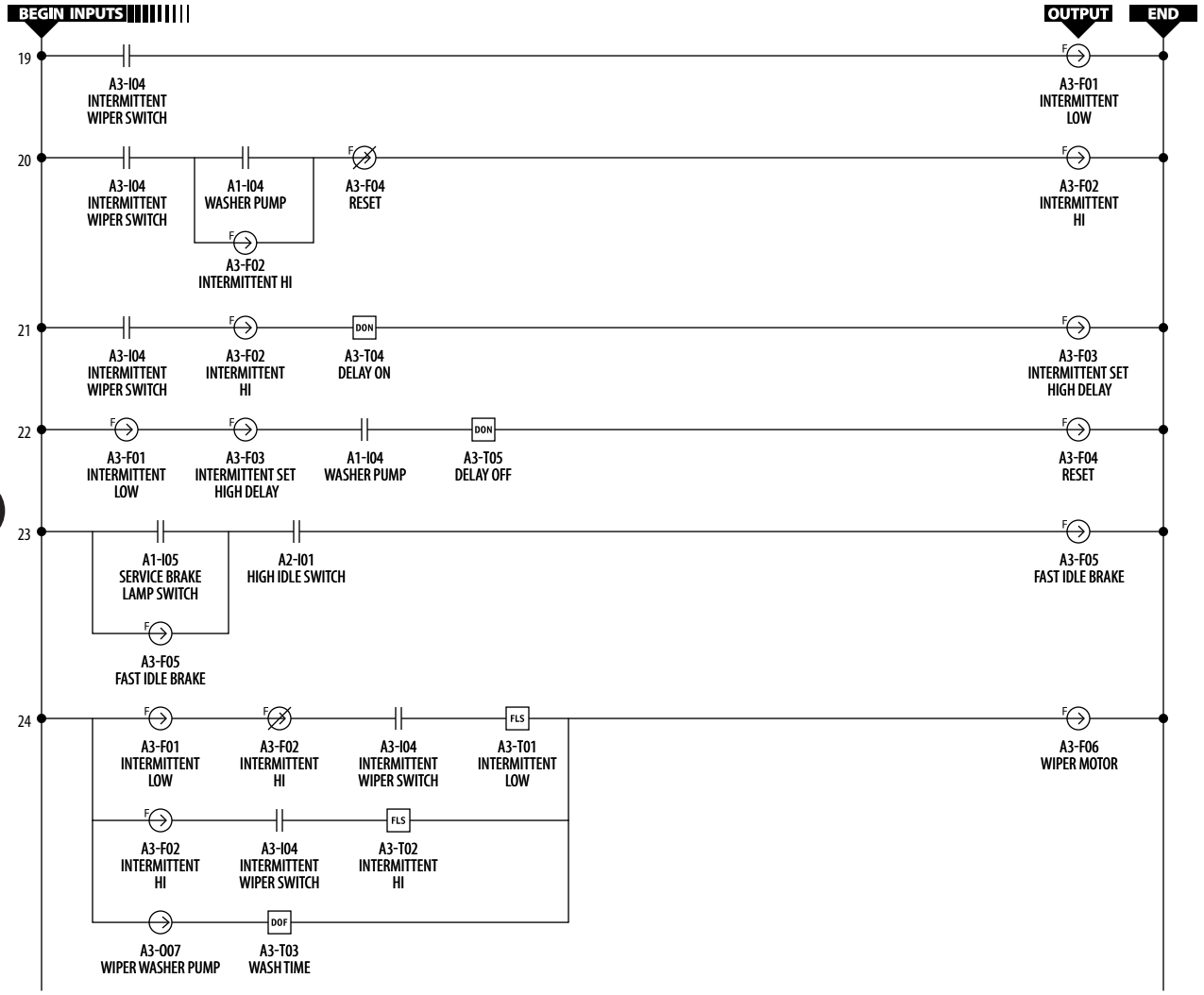
(FLORIDA) PORT 2 OUTPUTS



Symbols Key

Active Input (LED ON) | *Inactive Input (LED OFF)* | *Active Output (LED ON)* | *Inactive Output (LED OFF)* | *Active Timer (Flasher Shown)* | *Active Flag* | *Inactive Flag*

(FLORIDA) PORT 3 FLAGS



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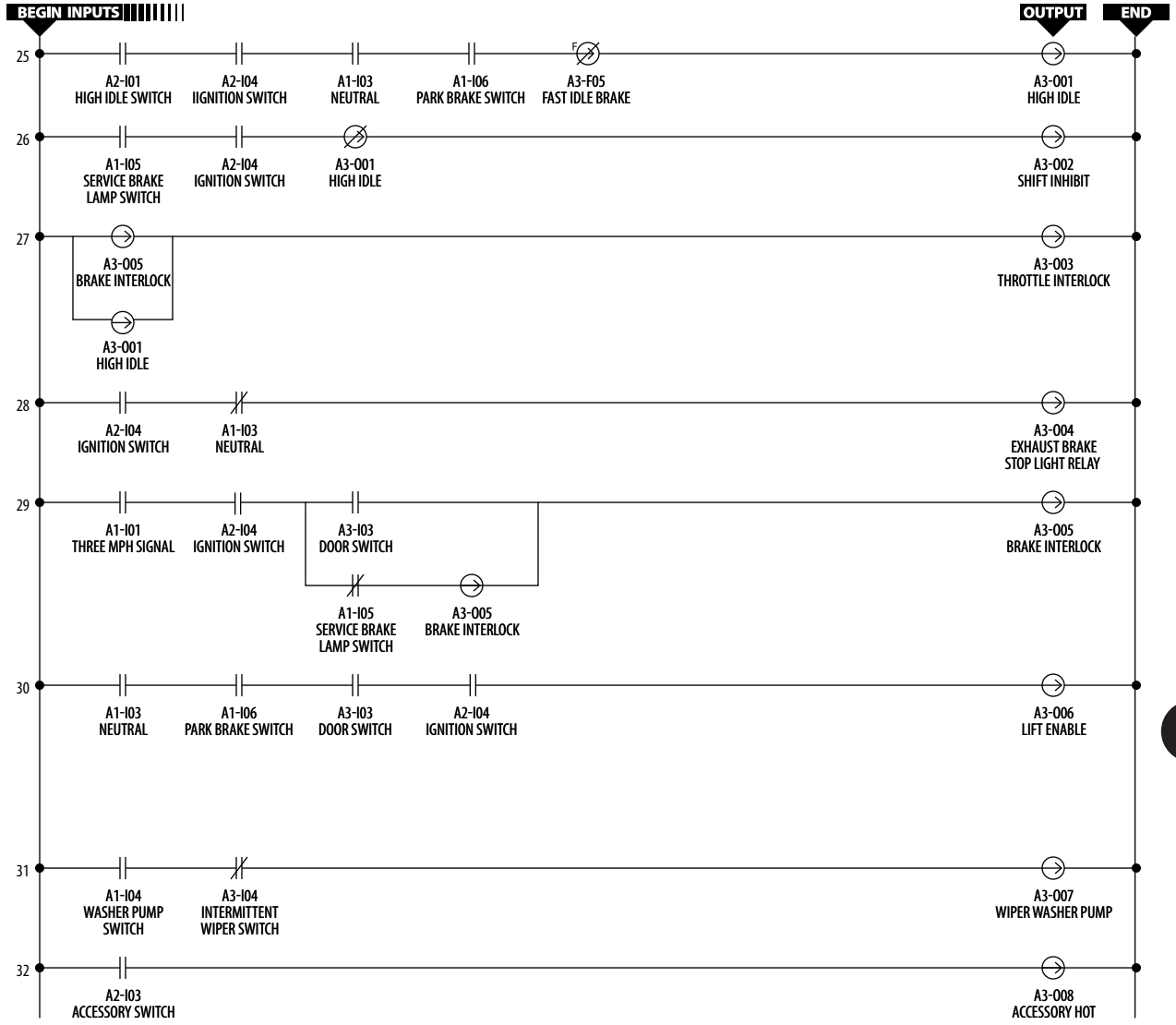
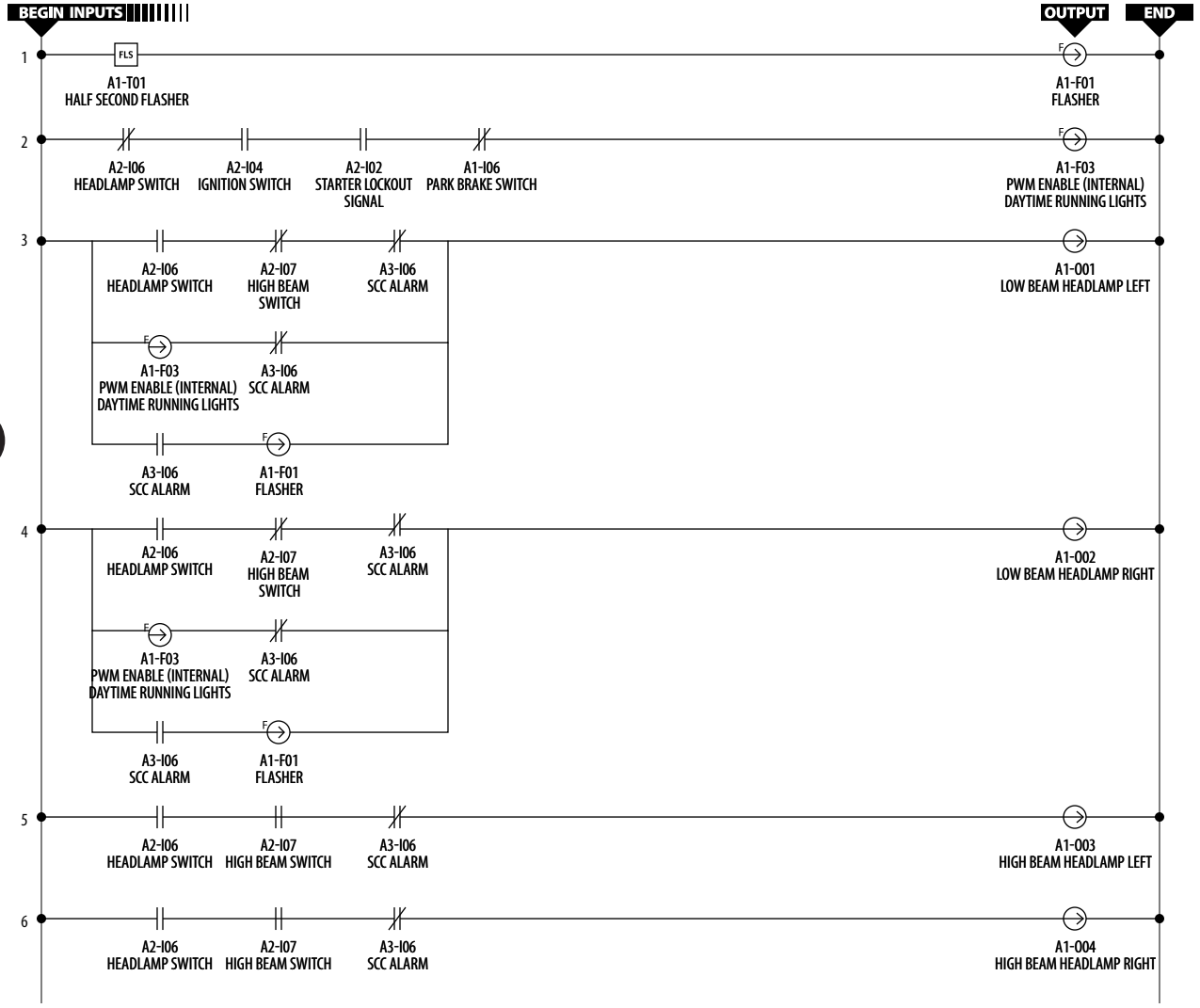


(WYOMING) LADDER LOGIC DIAGRAMS

Symbols Key

Active Input (LED ON) | *Inactive Input (LED OFF)* | *Active Output (LED ON)* | *Inactive Output (LED OFF)* | *Active Timer (Flasher Shown)* | *Active Flag* | *Inactive Flag*

(WYOMING) PORT 1 FLAGS



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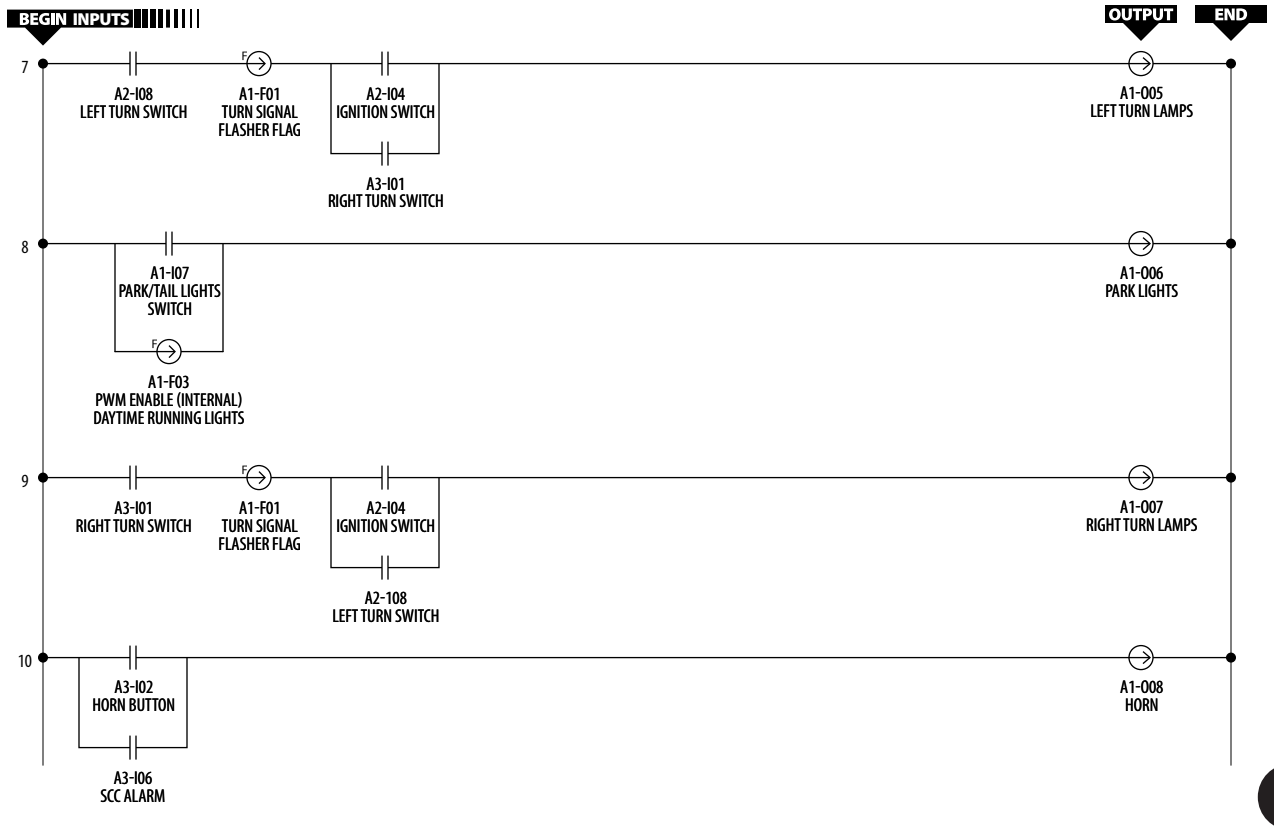
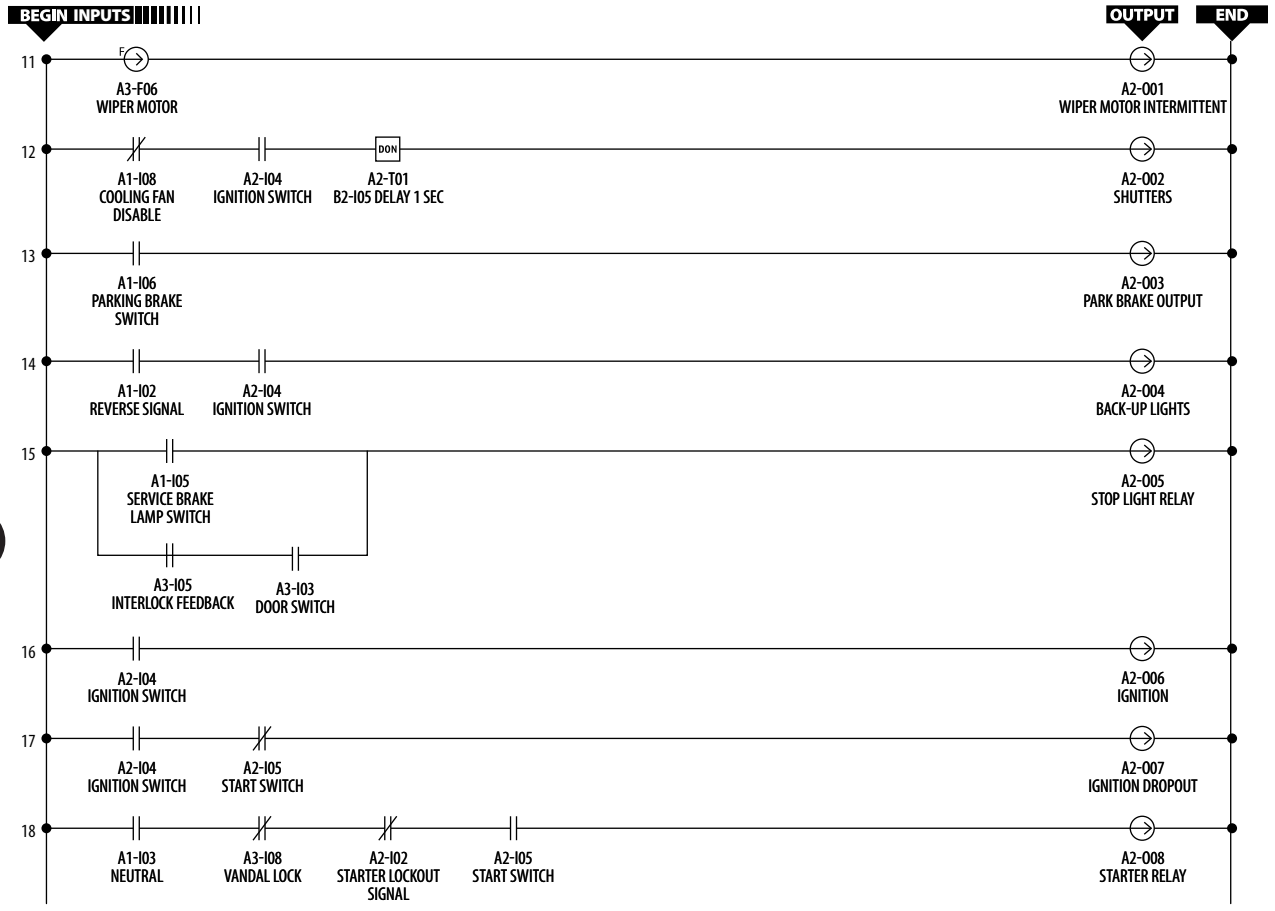


Symbols Key

Active Input (LED ON) | *Inactive Input (LED OFF)* | *Active Output (LED ON)* | *Inactive Output (LED OFF)* | *Active Timer (Flasher Shown)* | *Active Flag* | *Inactive Flag*

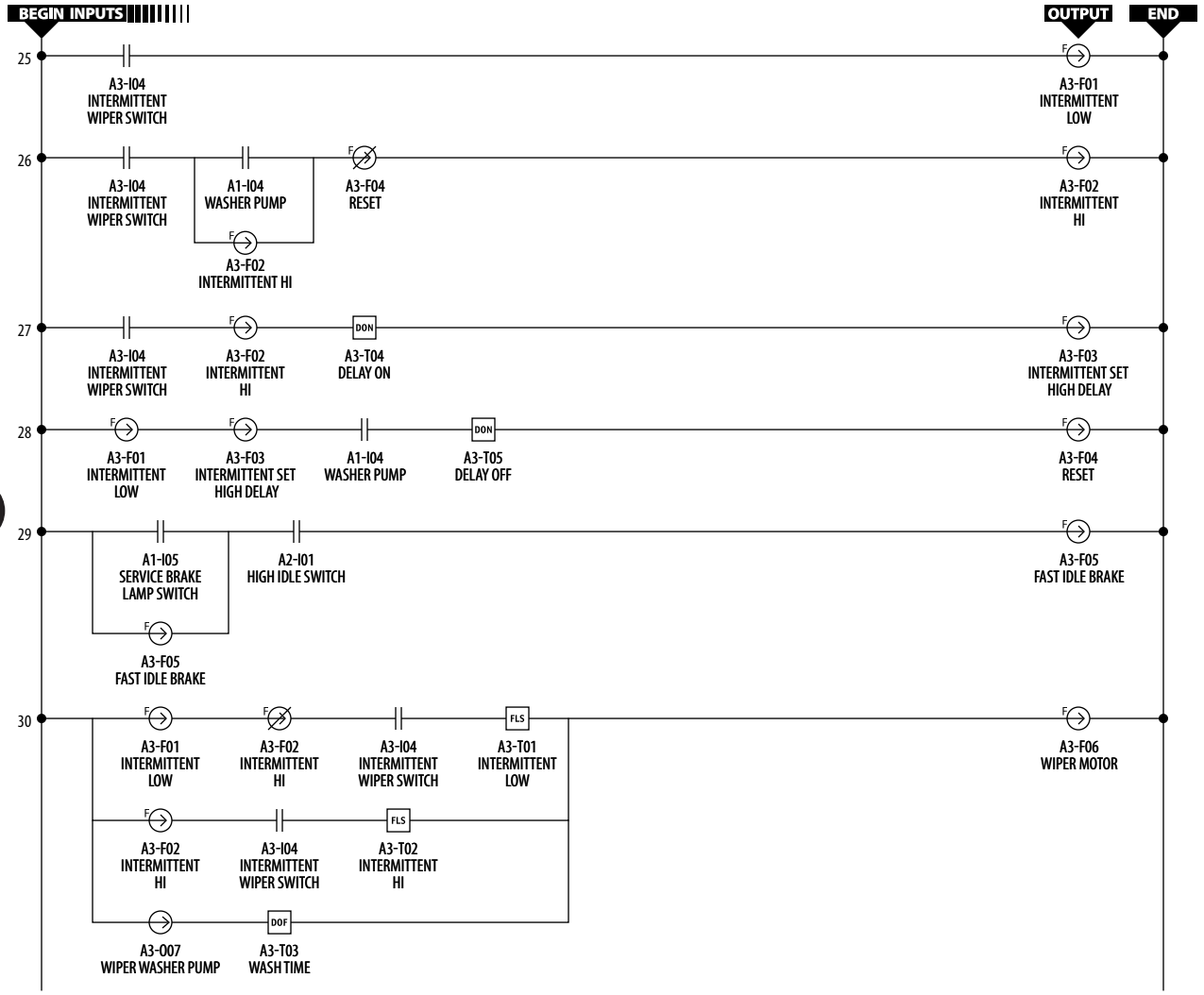
(WYOMING) PORT 2 OUTPUTS



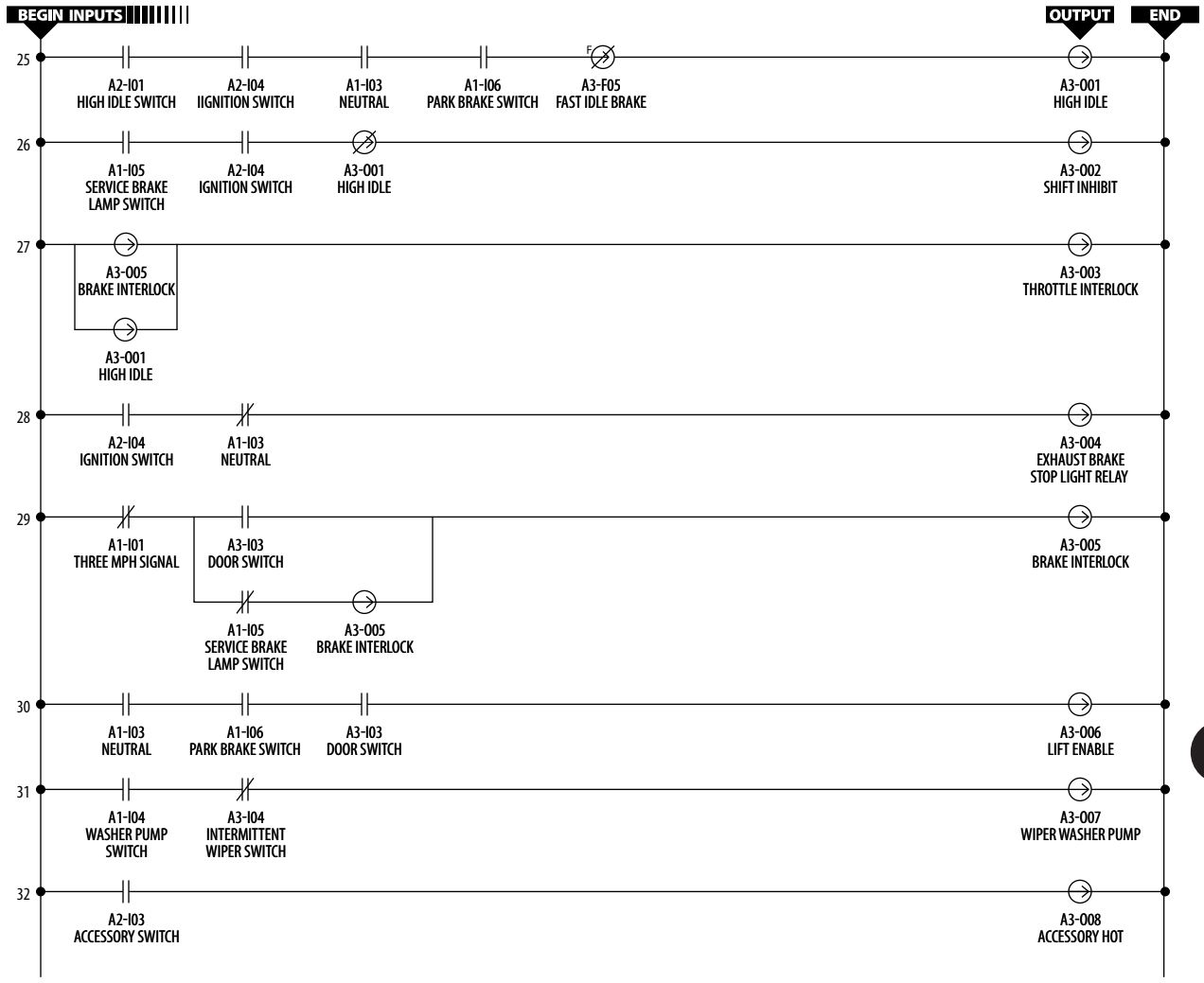
Symbols Key

Active Input (LED ON) | *Inactive Input (LED OFF)* | *Active Output (LED ON)* | *Inactive Output (LED OFF)* | *Active Timer (Flasher Shown)* | *Active Flag* | *Inactive Flag*

(WYOMING) PORT 3 FLAGS



(WYOMING) PORT 3 OUTPUTS

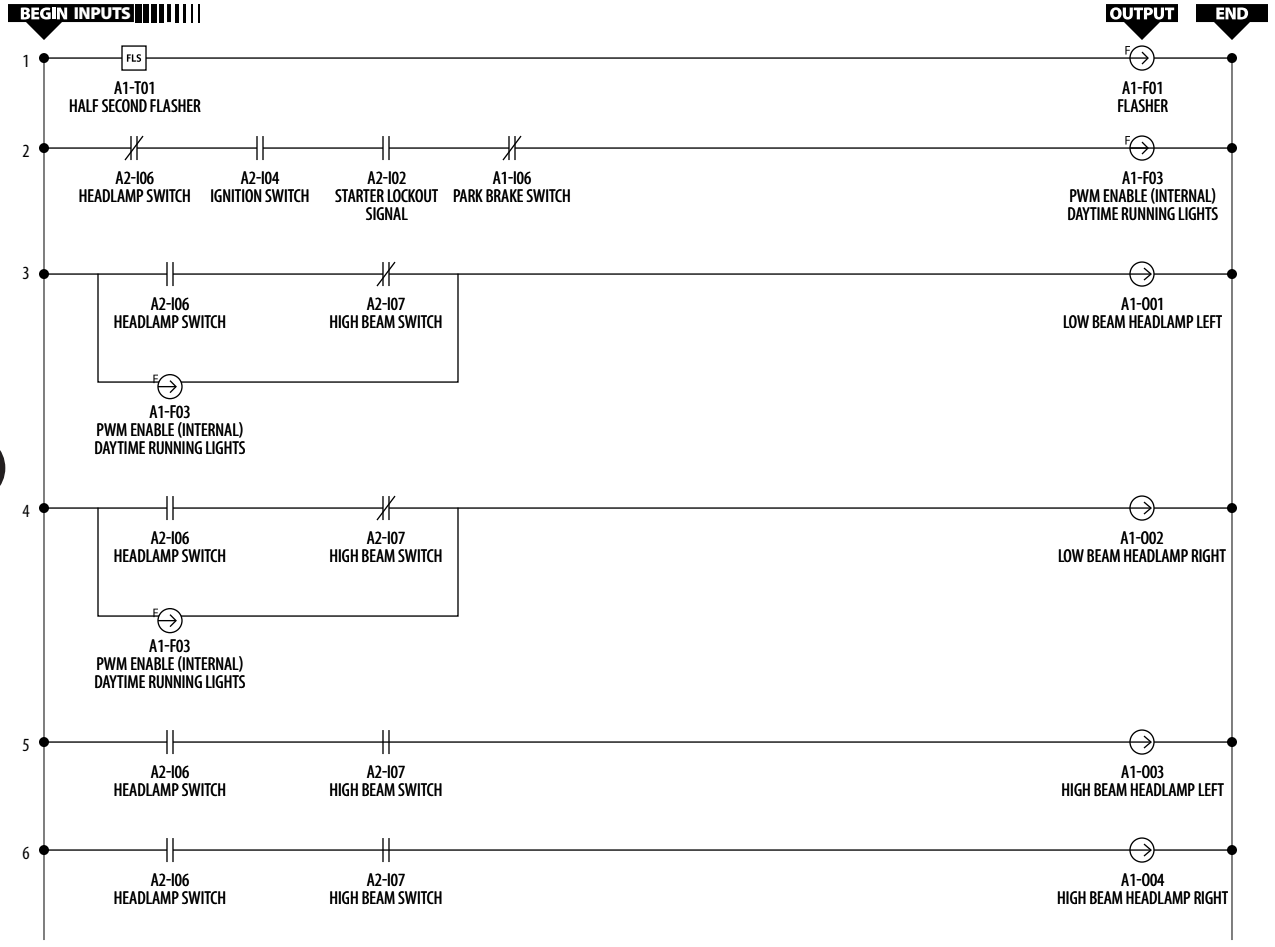


(CALIFORNIA) LADDER LOGIC DIAGRAMS

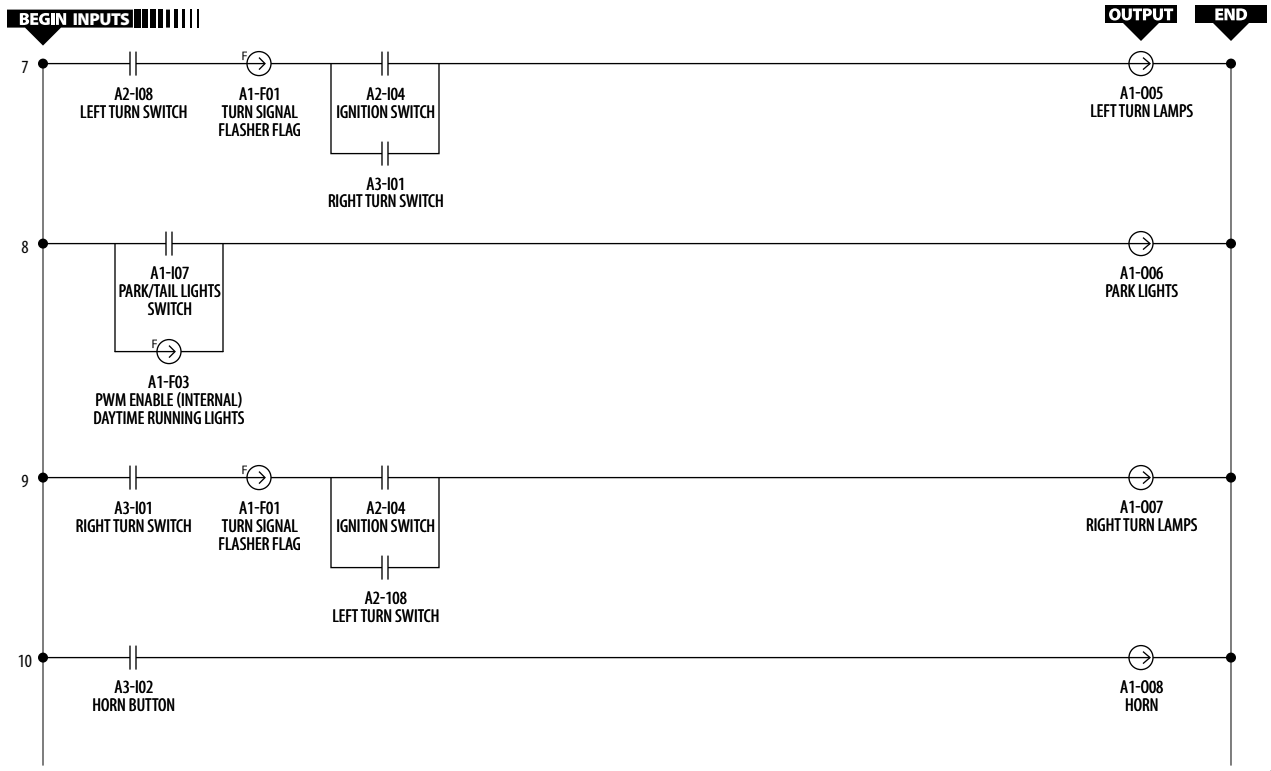
Symbols Key

Active Input (LED ON) | *Inactive Input (LED OFF)* | *Active Output (LED ON)* | *Inactive Output (LED OFF)* | *Active Timer (Flasher Shown)* | *Active Flag* | *Inactive Flag*

(CALIFORNIA) PORT 1 FLAGS



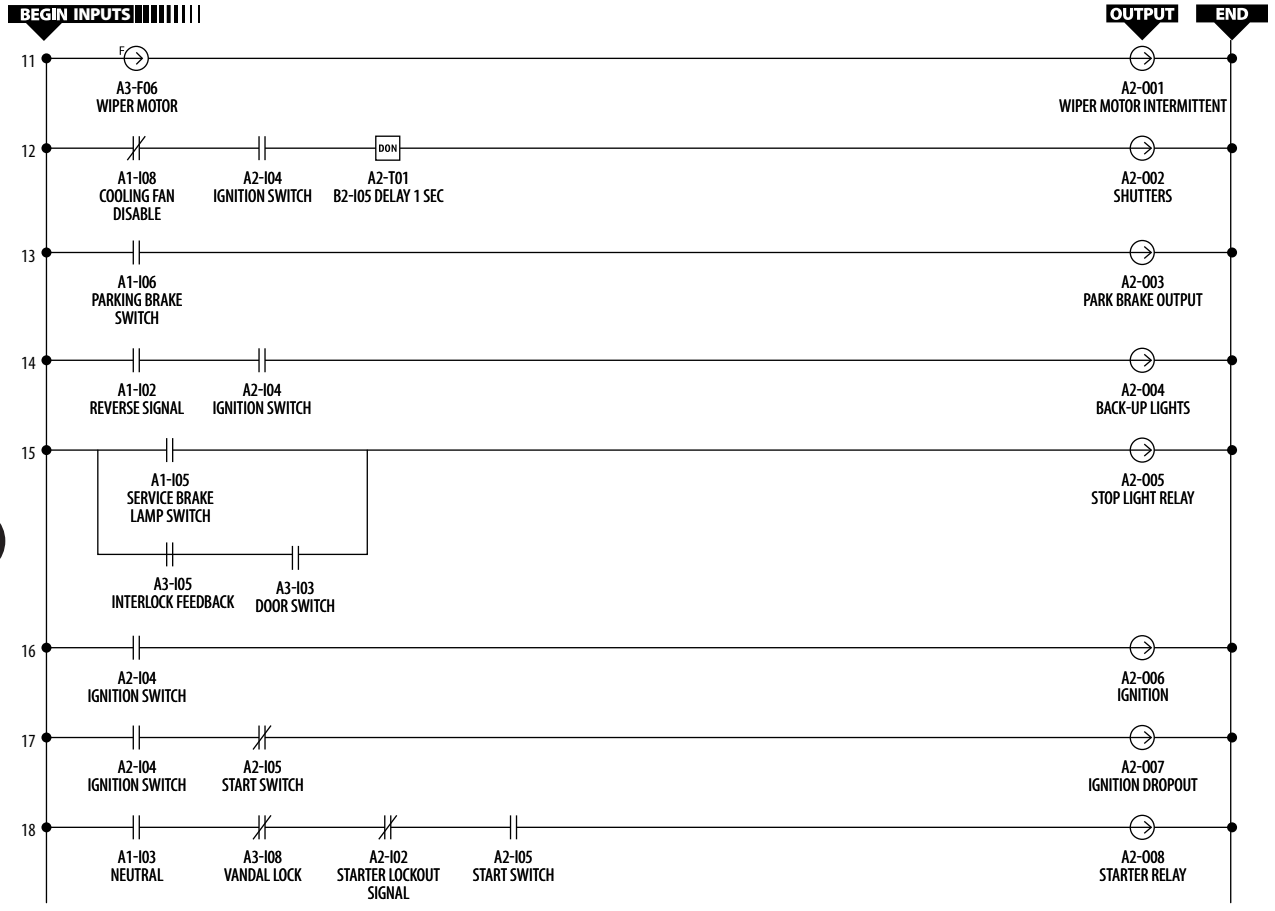
(CALIFORNIA) PORT 1 OUTPUTS



Symbols Key

Active Input (LED ON) | *Inactive Input (LED OFF)* | *Active Output (LED ON)* | *Inactive Output (LED OFF)* | *Active Timer (Flasher Shown)* | *Active Flag* | *Inactive Flag*

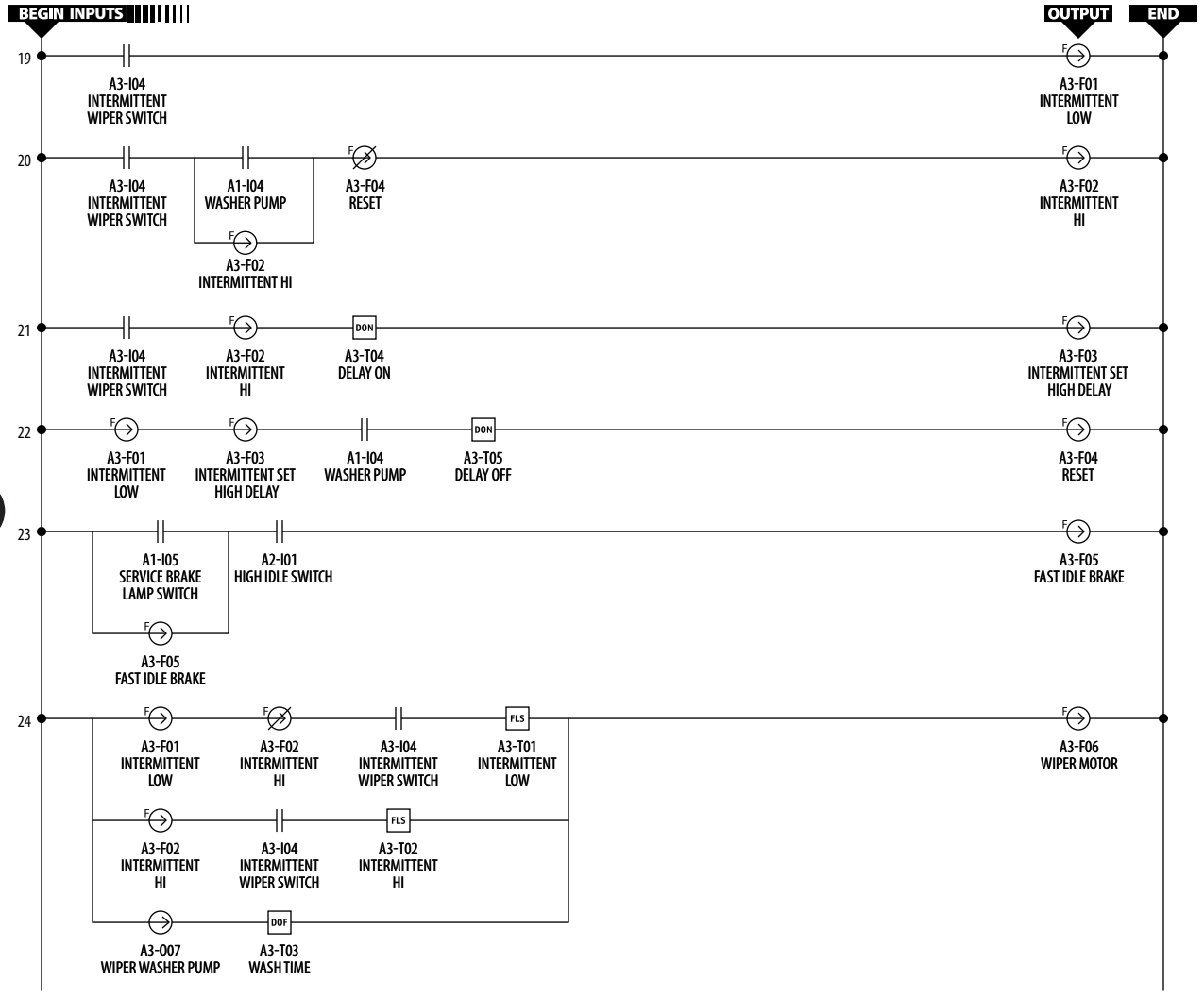
(CALIFORNIA) PORT 2 OUTPUTS



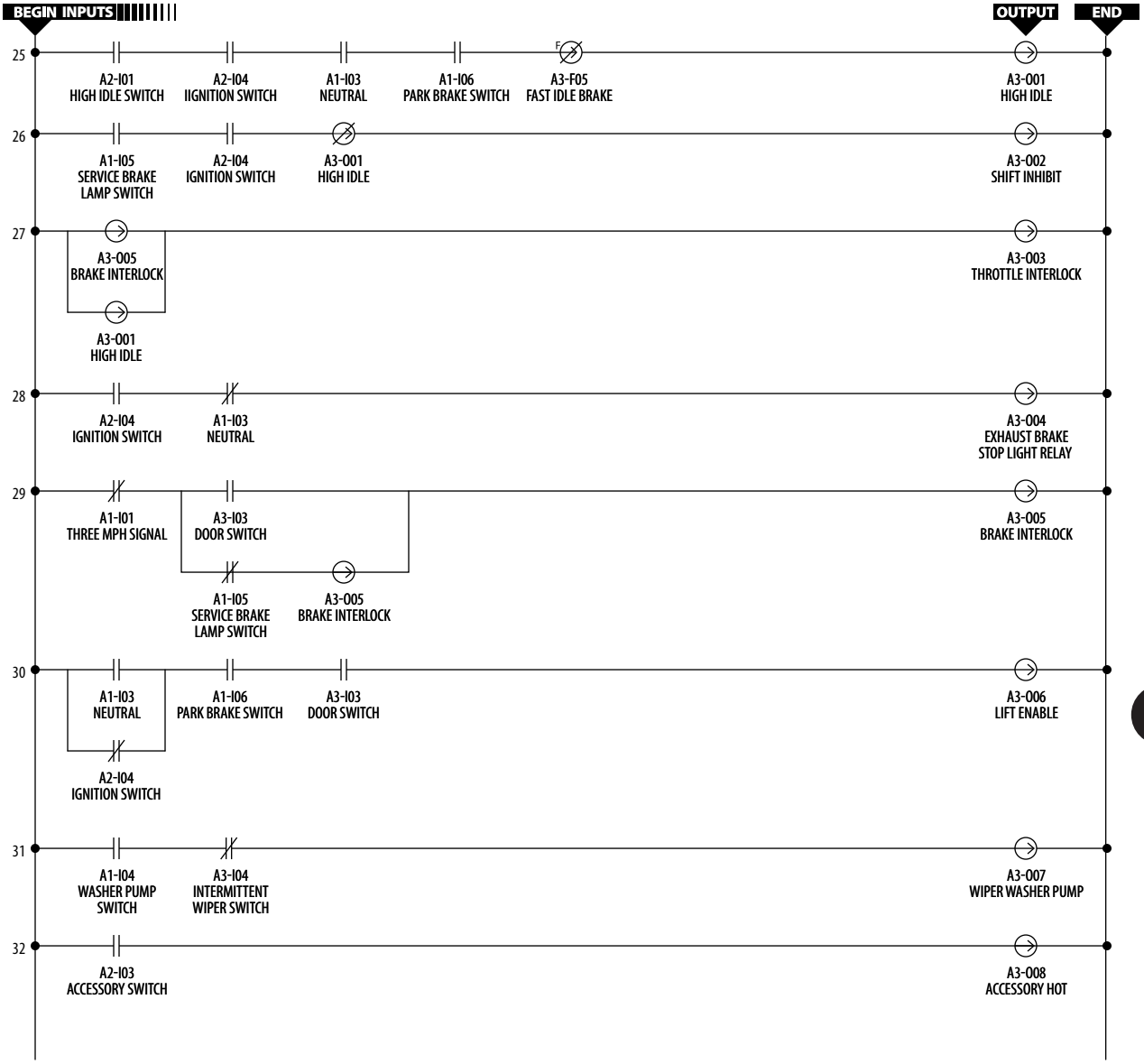
Symbols Key

Active Input (LED ON) | *Inactive Input (LED OFF)* | *Active Output (LED ON)* | *Inactive Output (LED OFF)* | *Active Timer (Flasher Shown)* | *Active Flag* | *Inactive Flag*

(CALIFORNIA) PORT 3 FLAGS



(CALIFORNIA) PORT 3 OUTPUTS



Troubleshooting In Diagnostic Mode

General Approach

A systematic approach to electrical troubleshooting of the Blue Bird Vision follows these general steps:

1. **Check the Inputs and Outputs Tables.** First determine if the affected circuit is one which interacts with or is controlled by the Multiplex system. Note the circuit's logical address (Zone-Port-Input/Output #) and its physical location (Connector / Port Pin). (If the issue is not a Multiplex circuit, refer to the Electrical System chapter and appropriate wiring schematics to troubleshoot conventionally.)

2. **Check the Output.** Operate the appropriate bus controls or switches to set the conditions which are required for the circuit's Output to be Active. (Refer to the Ladder Logic Diagrams to determine the required conditions.) If the MPX Module is generating an Active Output signal, but the circuit is not operational, at least part of the problem exists "downstream" of the Multiplex logic; probably in the Output's own load circuit. That is, since the Output signal is present, there is no reason at this point to suspect the "upstream" circuits of Inputs or other Outputs which are requirements of the desired Output. Troubleshooting efforts should be focussed upon the circuit beginning from the Output's Connector / Port Pin, through the load, and to ground.

3. **Check the Feedback.** To further verify that the problem exists in the load circuit, and to possibly gain additional information about its nature, create conditions (turn off switches, etc.) which should cause the Output to be Inactive. Then verify that the circuit's Feedback LED is on. If the Feedback LED is off when the Output is Inactive, an open is indicated in the load circuit, because the Feedback signal is not being conducted through the load. If the Feedback LED of a malfunctioning load circuit is on when the Output is Inactive (as it is in a correctly functioning circuit), the Feedback signal is being conducted, and you at least have an indication of continuity. If the Feedback LED is on while the Output is Active, a short in the load circuit is indicated.

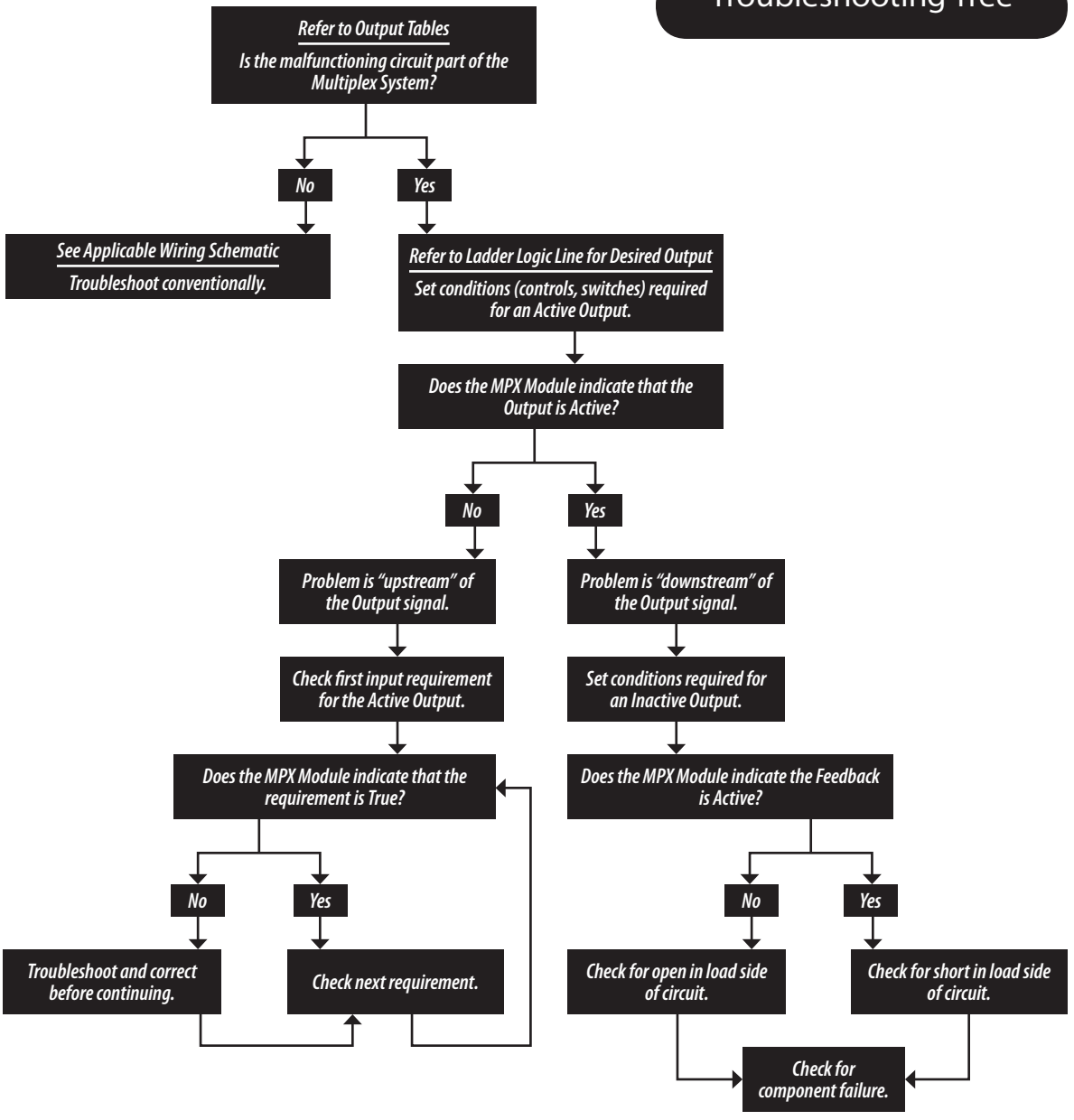
4. **Check Each Requirement.** If the desired Output is shown by the MPX Module to be Inactive when it should be Active, the problem should be assumed to be "upstream" of the Output signal; at least one of the conditions (Inputs) required for an Active Output signal is absent. Referring to the Ladder Logic Diagrams, begin checking each requirement's LED to verify it is correctly Active (on) or Inactive (off). If a discrepancy is found, a malfunction is indicated "upstream" of that point in the logic (for example, a failed Input). Thus, comparing the states of the MPX Module's LEDs against the requirements of the Ladder Logic Diagrams enables the technician to quickly "narrow down" the source of the problem.

As you proceed, remember that:

- The Logic Line for a particular Active Output may require that certain Inputs are Active (LED on) while other Inputs are *In*active (LED off). It is helpful, therefore, to think of each item encountered on the Logic Line as a "statement" which is either *true* or *false* (This Input active=true; This Input inactive=true; This Input inactive=false). You seek to find and correct the false "statements."

- The set of requirements for an Active Output may include requirements that other Outputs—which have their own Logic Lines—are either Active or Inactive. In such cases, the required Output states must also be investigated according to their own Logic Lines.

Troubleshooting Tree



Multiplex Terms:

Multiplex: A way of transmitting multiple lines of communications (signals) simultaneously on one data line. This is similar in principle to the J1939 wiring harness which connects the engine, transmission, and ABS electronic modules together, providing an multiple communications between their respective electronic control modules. The Vision's Multiplex system uses a module containing microcomputer technology and electronic switching devices to provide a modern method of power distribution, circuit control, and circuit protection using.

MPX: Blue Bird's abreviation for Multiplex.

Hard-wiring: A conventional method of routing current from an electrical source to a load and back to the source using copper wire, switches, relays, circuit breakers, fuseable links, fuses and other non-electronic components.

MPX Input: Typically a ground or 12 volt signal supplied to the MPX module, necessary for the MPX Module to produce an Output. An examle of an Input is the hard wired ground signal the turn signal switch provides to the MPX module when the turn signal is switched on. The programming of the MPX Module can require that a particular Input be either active (on) or inactive (off) in order to generate a particular Output.

Active Input: An Input which is in an "ON" state when received by the MPX Module. When troubleshooting, a active input symbol in the Logic Diagram indicates the LED in question should be ON to satisfy the requirement of the Output.

Inactive Input: An Input whic is in an "OFF" state when received by the MPX Module. When troubleshooting, an inactive input symbol in the Logic Diagram indicates the LED in question should be OFF to satisfy the requirement of the Output.

Output: A 12 volt or ground signal available at a physical output pin on the MPX Module. The Output is the end result of the functionality of the MPX module after *all* the requirements have been satisfied.

Active Output: An Output that is "ON" or "True". An Active Output is providing voltage or ground for a downstream load. When troubleshooting, an active output symbol at the right end of the Logic Diagram indicates the LED in question should be ON when all the requirements of the Logic Diagram are satisfied.

Inactive Output: An Output that is "OFF" or "False." An inactive Output is not providing voltage or ground for a down streamload. When troubleshooting, an inactive output symbol at the right end of the Logic Diagram indicates the LED in question should be OFF when all the requirements of the Logic Diagram are satisfied.

Flag: F An Output that is internally generated by the MPX Module, but which is not directly indicated on the troubleshooting LEDs. A Flag may be thought of as a programmatic function of the MPX Module logic. See Troubleshooting Principles, below, for more information.

Logic Diagram: A diagram describing which requirements are necessary for the MPX module to provide particular Outputs.

Logic Line: One horizontal path of the Logic Diagram. Each Logic Line leads to a single true Output located on the far right of the line. Along the path are icons indicating the requirement for that Output to be true. Depending on the programmed circuit logic for that particular function, a Logic Line may have only one requirement (Input) or several. Each requirement and Output on the Logic Line is identified by a description and an LED address.

LED Addresses: An alpha-numerical code which denotes which arrangement of LEDs on the MPX Module is associated with a particular Input or Output.

Connector/Pin Addresses: An alpha-numerical code which denotes which physical connector pin on the MPX Module is associated with a particular Input or Output.

Troubleshooting Principles:

About Flags

A Flag is an Output that is internally generated by the MPX Module. Just as with any other Output, a Flag is generated when a set of requirements (Inputs) are true. Being an internal signal, however, a Flag has neither a physical Output pin nor a voltage or ground signal associated with it that can be directly checked by the technician. A Flag therefore, can be thought of as an internal function, which may in turn be used as a requirement on other Logic Lines.

The troubleshooting LEDs only indicate the active or inactive state of Outputs and Inputs. They do not display the state of Flags. Therefore, Flags are verified by a process of elimination. When troubleshooting a logic diagram that results in a Flag, the technician uses the troubleshooting LEDs to verify the required state of Inputs and Outputs required for the Flag to be active. When all of the Flag's requirements have been verified, the technician must assume that the Flag has been generated and that it is active.

If the Flag occurs as one of the requirements for a physical Output that can be verified by an LED, the troubleshooting LEDs can be used to confirm that all requirements *except* the Flag are satisfied. If all the verifiable Inputs are true, yet the desired Output does not occur, then the technician could logically assume the Flag is suspect. The technician would then look for a Logic Line that ends in the suspect Flag. If there is one, he would proceed to verify the requirements for that Flag to be active, and so on. If all the verifiable conditions check out correctly, and yet the desired output is not achieved, then the functioning of the MPX module would be suspect. Blue BIrd recommends contacting your Blue Bird service source to confirm your troubleshooting before replacing a Multiples module.

One of the circuits on a 2008 and later model Visions has a more complex MPX logic then on previous models, and serve as examples of the troubleshooting of circuits involving Flags: The intermittent wiper logic. The circuit incorporates multiple logic lines which generate flags that are in turn used as requirements (Inputs) on other Logic Lines. Only when all the Logic Lines involved have been satisfied, will a voltage be provided by the MPX module to energize the circuit.

Flag Example: Wiper motor intermittent A2-O01 (Logic Line 11)

This Logic Line is an example of one which involves Flags, and therefore may require a process of elimination when troubleshooting. Logic diagrams 11, 19, 20, 21, 22, 24, and 31 all have a role in providing an intermittent wiper with two intervals. A similar troubleshooting methodology would be used.

Troubleshooting Example

The following example steps through a typical examination of a Ladder Logic diagram, using the Vision MPX Simulator for illustrative purposes. DoubleClick the VisionMPXSimulator.exe icon to launch it.

The Problem. This example assumes a problem with starting the bus. It will walk through an investigation of the Multiplex logic which affects starting.

1. **Refer to Input/Output Tables.** The tables reveal that the Multiplex system does indeed contains logic affecting several circuits having to do with starting the bus. The MPX Module receives Inputs named Ignition Switch, Neutral, Vandal Lock, Starter Lockout Signal, and Starter Switch. Outputs are generated by the MPX Module named Ignition, Ignition Dropout, and Starter Relay. Often, by merely considering these listings we can gain "hints" regarding how the Multiplex system comes into play: For example, it is easy to "guess" that the Starter Lockout Signal must be Inactive in order to start the bus.

   In this scenario, we'll assume the starter is not turning, and therefore begin our investigation with the Starter Signal Output. We note that the physical pin location for this Output is AA-114 (Connector A, pin number 14). The Outputs Table lists the logical address of the Starter Relay Output as A2-O08 (Port 2, Ouput number 8), and also shows that that Output is on line #18 of the Ladder Logic diagrams.

Input Tables

Multiplex Inputs Table

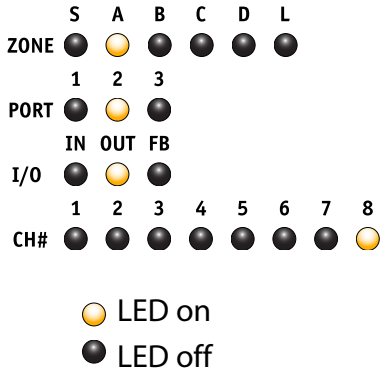
	Circuit Description	Input LED	Connector / Port-Pin
1	Accessory Switch	A2-I03	AC-003
2	Brake Light Switch	A1-I05	AB-111
3	Diagnostic Switch	A3-I07	AC-015
4	Door Signal	A3-I03	AC-011
5	Fan, Cooling Disable (Cat only)	A1-I08	AA-108
6	Headlight Switch	A2-I06	AC-006
7	High Beam Switch	A2-I07	AC-007
8	High/Fast Idle	A2-I01	AC-001
9	Horn Signal	A3-I02	AC-010
10	Ignition Switch	A2-I04	AC-004
11	Interlock Feedback	A3-I05	AC-013
12	**Neutral Signal**	**A1-I03**	**AB-107**
13	Park/Tail Light Switch	A1-I07	AA-004
14	Park Brake Switch	A1-I06	AB-012
15	Reverse Signal	A1-I02	AB-004
16	Speed Signal	A1-I01	AB-003
17	**Starter Lockout Signal**	**A2-I02**	**AC-102**
18	**Starter Switch**	**A2-I05**	**AC-005**
19	Turn Signal, Left	A2-I08	AC-008
20	Turn Signal, Right	A3-I01	AC-009
21	**Vandal Lock**	**A3-I08**	**AC-016**
22	Washer Pump Switch	A1-I04	AB-108
23	Intermittent Wiper Switch	A3-I04	AC-112
24	SCC Alarm	A3-I06	AC-014

Output Tables

Multiplex Outputs Table

	Circuit Description	Output LED	Connector / Port-Pin
1	Accessory Hot	A3-O08	AB-116
2	Back up Lights	A2-O04	AA-107
3	Brake Interlock	A3-O05	AB-015
4	Fan Control Power (Cat Only)	A2-O02	AA-103
5	High/Fast Idle	A3-O01	AB-001
6	Headlight, High Left	A1-O03	AA-110
7	Headlight, High Right	A1-O04	AA-112
8	Headlight, Low Left	A1-O01	AA-102
9	Headlight, Low Right	A1-O02	AA-106
10	Horn	A1-O08	AB-114X
11	Ignition	A2-O06	AA-111
12	Ignition Dropout	A2-O07	AA-113
13	Park Brake	A2-O03	AA-105
14	Park Lights	A1-O06	AB-106
15	Shift Inhibit Signal	A3-O02	AB-005
16	Lift Enable	A3-O06	AB-021
17	Ex. Brake Stop Light (Cat only)	A3-O04	AA-09
18	**Starter Relay**	**A2-O08**	**AA-114**
19	Stop Lights Relay	A2-O05	AA-109
20	Throttle Interlock	A3-O03	AB-009
21	Turn Signal, Left	A1-O05	AB-102X
22	Turn Signal, Right	A1-O07	AB-110X
23	Wiper Washer Pump	A3-O07	AB-122
24	Intermittent Wiper Motor	A2-O01	AA-101
25	Shutters	A2-O02	AA-103

2. **Check the Output.** To check the status of a desired Output, we must first put the MPX Module in Diagnostic Mode and cycle it to display Outputs for the appropriate Port. Press the Diagnostic Switch repeatedly until the Port 2 LED (in the PORT row) is on, and then until the Output LED (in the I/O row) is on. Turn the ignition switch to the start position and note whether the #8 LED (in the CH# row) comes on when attempting to start the engine. By verifying an active output first, you are in fact, verifying all input requirements are correct. If any one requirement does not match the logic line the MPX module will not activate the output.



3. **Check the Feedback.** If the A2-O08 LED lights when trying to start the engine, we know that the MPX Module is generating an Active Starter Relay Output. If the starter failed to operate despite the Output being Active, the cause would most likely be "downstream" of the multiplex system, in the load circuit itself (i.e.; Starter Relay, Solenoid, etc.) That is, there would be no reason at this point to suspect the various circuits which are required for an Active Starter Relay Output, because the Output is Active. Even in such a case, though, further insight into the nature of a problem may be gained by checking the Feedback LED.

   Press the Diagnostic Switch once more to cycle the MPX Module to monitor the A2-O08 Feedback LEDs. (Note the Output and Feedback use the same LED address.) In our scenario, if the Starter Relay's Feedback LED were on while its Output is Active, it would, therefore, be reasonable to suspect a short to ground in the Output load circuit or a failed MPX Module.

   The most likely cause for an Output LED's being on while the Feedback LED is on is that a short to ground has been detected by the MPX Module. In that case, a MOSFET (the electronic switching device and circuit protector inside the Module) will trip (open the circuit) and deactivate the Output, thus protecting the circuit from damage. The Output circuit connector should be removed and a conventional short to ground test with a voltmeter should be conducted.

If a short to ground is not indicated by the above condition (an Output LED's being on while the Feedback is on), the MPX Module is suspect. A physical test at the output pin could be conducted. It is important to bear in mind that the MOSFET will not reset simply because the short has been removed or the connector containing the circuit in question has been removed from the MPX Module. If a short to ground has occurred, the Output will continue to be deactivated by the MOSFET in its tripped (open) state. It can be reset by turning the ignition switch off, or by causing one of the required Inputs for that circuit to be inactive. One could misdiagnose a correctly functioning MPX Module or even damage the Module by checking for voltage on an Output that has been shorted to ground without first performing these steps:

1. turn the ignition switch off.
2. Isolate the short.
3. turn the ignition switch on.
4. verify that all requirements for an active Output are correct (true).
5. Refer to the output chart to see if the Output should be 12 volts or ground.
6. Measure the Output at the correct terminal for the correct condition with a voltmeter.

If the physical output is not found to be correct by conducting the above test, the MPX Module is suspect. Confirm proper voltage and grounds at connectors D and E with a voltmeter. Consider consulting with a Blue Bird service source to confirm your diagnosis before replacing the MPX Module.

If, as is normal, the Feedback LED is off while the Output is Active, then the circuit should be operative. If not, there is an open on the Output circuit. Thus, in cases where the desired Output is Active, but the circuit is still inoperative, the Feedback LED can help indicate whether the probable cause is an open or a short.

But what if a desired Output is Inactive? Even then it is still good practice to check the Feedback LED before proceeding to verify the presence of each requirement for an Active Output. In our example, we know that if the Starter Relay Output is Inactive, we should see its Feedback LED on, indicating that continuity exists in the Starter circuit, and that it should become operative when the Output becomes Active. But if the Feedback LED were off while the Output is Inactive, then we would already have an indication of an open in the Starter circuit, and that the Starter will not work even when the requirements for an Active Starter Signal Ouput are met.

4. **Check Each Requirement.** At this point in our example, we assume that the Starter Relay Output is Inactive, and that the Feedback LED is on, as it should be. It is now safe to assume that any starting problem must be "upstream" of the load circuit itself. We must begin to systematically ensure that each of the requirements for the Starter Relay Output to be active is met. It is now time to refer to the Logic Diagram.

   As indicated in the Output Table, Logic Line # 18 is the one which leads to an Active Starter Signal Output. Click the yellow tab at the upper left of the Vision MPX Simulator to reveal a scrolling list of the Logic Diagrams. Click the red down arrow to scroll down to line 18.

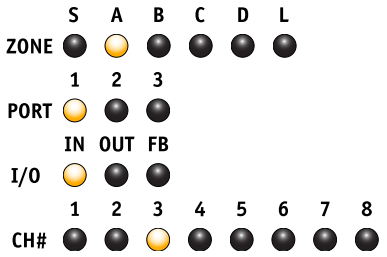
   Reading from left to right, we see that the requirements for an Active Starter Signal are:

   - The Neutral Signal Input at logical address A1-I03 must be Active.
   - The Vandal Lock Input at A3-I08 must be Inactive.
   - The Starter Lockout Signal Input at A2-I02 must be Inactive.
   - The Front Start Switch Input at A2-I05 must be Active.

   Our procedure, then, is to systematically set the controls which operate each of these requirements and verify their Active or Inactive status:

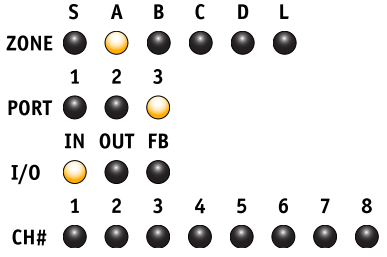
Logic Line 18 of the Logic Diagrams

4.1. Verify that the transmission is in Neutral. Press the Diagnostic Switch enough times to cycle the MPX Module LEDs to display Zone A Port 1 Inputs. If the #3 Input LED were not on, at least part of the problem would have already been isolated. In this case, you would then refer to the wiring schematic for the Neutral signal switch and troubleshoot that circuit. Locating a wiring schematic for a specific failure can be simplified by referring to the Input Tables. Locate the Input that has failed (in this case, the Neutral Signal, Line 12). The third column shows AB-107, indicating the Neutral Signal circuit connects to the MPX Module through the B connector pin number 7. Connectors A, B, and C of the MPX Module have dedicated wiring schematics. Referring to the wiring schematic index page, find that the AB Multiplex Module (Zone A Connector B) is located on sheet 11 (for Cummins ISB07). The circuit in question is located at pin 7 of the AB connector. Since the A1-I03 LED is on, the Input is Active as it should be, and we proceed to step 4.2.



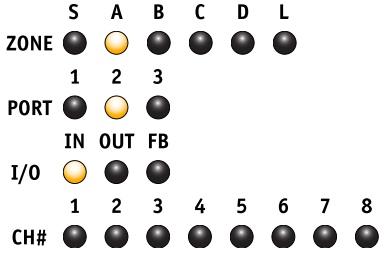
The MPX Module is displaying A1 Inputs. Input #3 (Neutral Signal) is Active.

4.2 Make sure the Vandal Lock is not on. This is an A3 Input, so the MPX Module needs to be cycled to indicate addresses for A3 Inputs. However, now we are looking for an *In*active Input, not an Active one. Verify that the #8 Input LED is off. If the A3-I08 Input LED were to stay on while the Vandal Lock was unlocked, it might be suggestive of a stuck or shorted Vandal Lock signal switch. Again, you would refer to the appropriate wiring schematic and troubleshoot that circuit.



The MPX Module is displaying A3 Inputs. LED #8 (Vandal Lock Signal) is off—satisfying a requirement for an Inactive Input.

4.3 The fourth requirement is also for an Inactive Input; the Starter Lockout Signal. The Starter Lockout Signal is generated by the engine ECU to prevent the starter from engaging if the engine is already running. Therefore, it is not an Input over which the Driver has direct control. He controls it indirectly by starting the bus. Put the MPX Module in its display mode for A2 Inputs and verify that the #2 Input LED is off. If it were on when the engine is not running, a diagnostic check of the engine ECU would be in order.

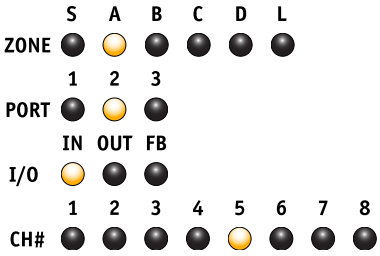


The MPX Module is displaying A2 Inputs. LED #2 is off, so the Starter Lockout Signal is Inactive.

4.4 Finally, the A2-I05 Start Switch Input must be Active. This is a signal from the ignition switch when it is turned to the Start position. The MPX Module is already displaying A2 Inputs, and the #5 Input LED is off. Press and hold the ignition switch and you will see that the #5 LED comes on while the switch is in the Start Position. If this did not occur, the ignition switch or its wiring would be suspect.

Notice also that as soon as the engine starts, the #2 LED (Starter Lockout Signal, described above in Step 4.3) comes on and remains on until you click the ignition switch again to turn off the engine.

As the #2 Starter Lock Out Signal becomes Active, it no longer provides a correct requirement for the MPX Module to provide a Starter Relay Output. Therefore, when the engines starts, the MPX Module will deactivate the Starter Relay Output and the starter will disengage even if the driver keeps the ignition switch in the Start position.



Still displaying A2 Inputs, LED #5 is on only when the ignition switch is in its momentary Start position. As soon as the engine starts, LED #2 (Starter Lockout Signal) comes on and remains on until the engine is switched off.

At this point, you have verified the presence of a full set of conditions (Inputs) required for an Active Starter Signal Output, and the starting circuit should be functional. If you experiment with the MPX Simulator by changing any of the required conditions, you will see that when any of the requirements are not met, the A2-O08 Output will not be Active, and the engine will not start. This example has shown that the Multiplex Diagnostic Mode can be used to quickly isolate the location of an electrical system malfunction in a circuit with which the MPX Module interacts. (For example, consider how much time might be spent in determining that the cause of a starting problem is a damaged parking brake switch, without the benefit of multiplex.) Note that the use of Multiplex does not negate or invalidate traditional means of tracing and troubleshooting circuits, but serves to eliminate much of the preliminary guesswork in determining which circuit(s) to investigate.

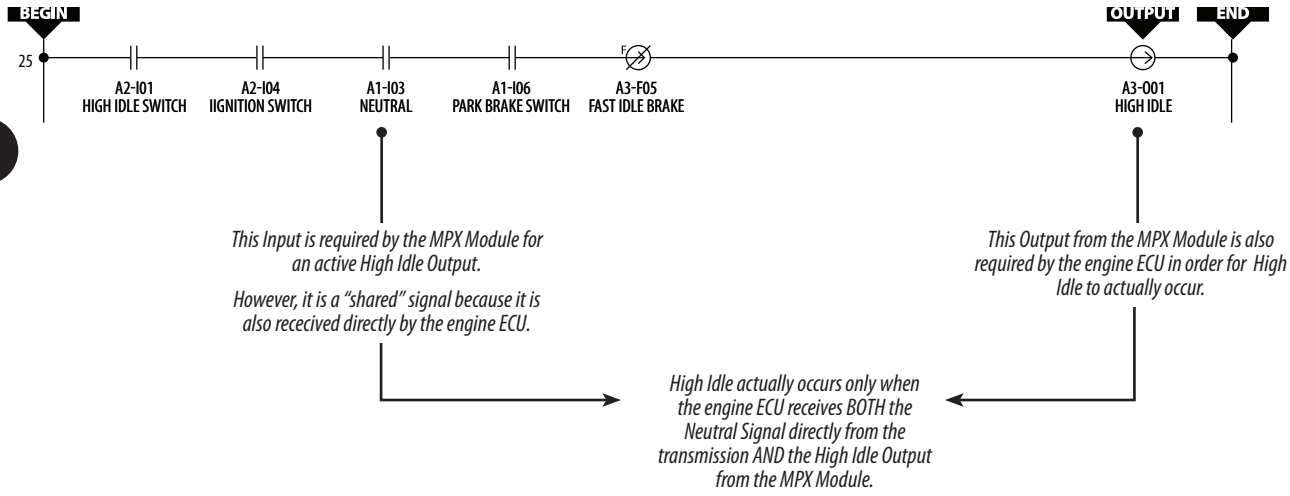
In a real-case scenario, only after verifying all the required conditions, yet still finding the Output to be Inactive and/or the circuit inoperative, should there be reason to suspect a failure of the MPX Module itself. Remember that all Input and Outputs can be verified using a multimeter at the associated Connector/ Port-Pin locations. In the unlikely case that you have thorougly investigated the Multiplex Logic and have come to suspect a defective MPX Module, you may wish to contact your Blue Bird Distributor's service technicians for a second opinion verification of your troubleshooting.

Shared Logic

To avoid confusion when reading Ladder Logic and trobleshooting, remember that the requirements shown on a Ladder Logic line are only requirements for the MPX Module to make the Output indicated at the end of the line Active. It is possible for other conditions to be required beyond the scope of the Multiplex system. In the present implementation of Multiplex one such "special case" is the Fast Idle logic, shown on line 25 of the Ladder Logic charts for the Blue Bird Vision with a Caterpillar engine.

The Active Fast Idle Output from the MPX Module is one of two signals required by the Caterpillar ECM before it engages Fast Idle. The other is a signal required by the engine ECU logic. The Caterpillar ECU, much like the MPX Module, also requires Two Active Inputs: An Active Neutral Input, and an Active High Idle Input from the MPX Module.

In other words, Logic Line 25 is correct for the MPX Module to generate an Active Fast Idle Output; but Neutral is also required by the engine ECM for it to cause High Idle to actually occur. In this sense, even though the MPX Module and engine ECM are separate processors which do not share programming, they work together to "share" the logical requirements for a particular function. The Active Fast Idle Output from the MPX Module alone does not cause the actual occurance of High Idle; it serves as but one of the ECM's requirements.



Overview

Electrical systems on the Blue Bird Vision falls into two categories: standard electrical circuits and optional or "feature driven" electrical circuits. Standard circuits consist of typical electrical systems found on every Blue Bird Vision, i.e, turn signal circuit, wiper circuit, etc. The optional circuits or feature driven circuits consist of electrical systems that are not standard on a Blue Bird Vision i.e, vandal lock circuit, heated mirrors etc. There are many options requiring electrical circuits available on the Blue Bird Vision. The number of options on any given bus depends on how the bus was ordered and manufactured. When determining if a circuit is optional, the bus application must be considered. In most cases the Blue Bird Vision will be used in a school bus application, therefore the optional eight light warning circuit would be considered a standard circuit for that application. Consideration should also be given to federal and state school bus requirements in determining if specific electrical systems are standard or optional for the bus to be operated in your area.

The body electrical circuits can be divided into two groups: Conventional electrical circuits and circuits designed with electronics. With the introduction of the 2011 model Blue Bird Vision, the body electrical system has been upgraded and simplified by the introduction of a Body Control Module (BCM). This is an electronic module designed to control a portion of the body electrical system by serving as a central switching station, receiving inputs from various sources and providing outputs depending on how the circuit was designed to function. The module represents a modern means of power distribution using electronic switching devices, circuit control, and circuit protection. It manages the body electrical system according to pre-programed logic. The BCM serves a similar function for a portion of the body electrical system as an ECU serves an engine, transmission or ABS system.

Technical Terms:

A review of the following terms and their definition will provide a better overall understanding of the body electrical systems covered in this chapter.

Body Control Module (BCM): An electronic device that manages a portion of the body electrical circuits. The BCM monitors inputs, computes circuit function and activates outputs to electrical loads.

MOSFET: An electronic switching device inside the BCM with circuit protection capability.

BCM Circuit Logic: The designed function of a circuit that dictates what conditions are necessary to activate a specific electrical circuit as indicated by a line of ladder logic.

Ladder Logic Line: A means of communicating circuit logic or function, it identifies the input status (active/on or inactive/off) necessary to activate a specific output. Logic lines are identified by their output description and referenced by a number located to the left of each ladder logic line.

Active Input: || An active input has a 12 volt or ground potential that is measurable by a multi-meter at a specific input terminal on the BCM.

Inactive Input: An input which is in an "OFF" state, the absence of voltage or ground potential on a specific input terminal on the BCM.

Active Output: An active output has a 12 volt potential measurable by a volt meter at a specific output terminal on the BCM.

Inactive Output: An inactive output has an absence of voltage potential on a specific output terminal on the BCM.

Flag: An output generated and used inside the BCM. Flags do not have external output circuits but they do have ladder logic lines.

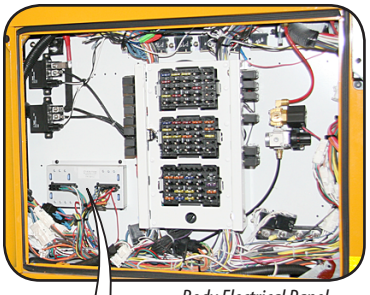
Hard Wired: A conventional method of routing current from an electrical source to a load and back to the source using wire, switches, relays, circuit breakers, fuses, fuseable links, and other non-electronic components.

Electronic Control Unit (ECU): An electronic device that manages electrical circuits according to a pre-programed logic typically used to control engines, transmissions, ABS systems, etc.

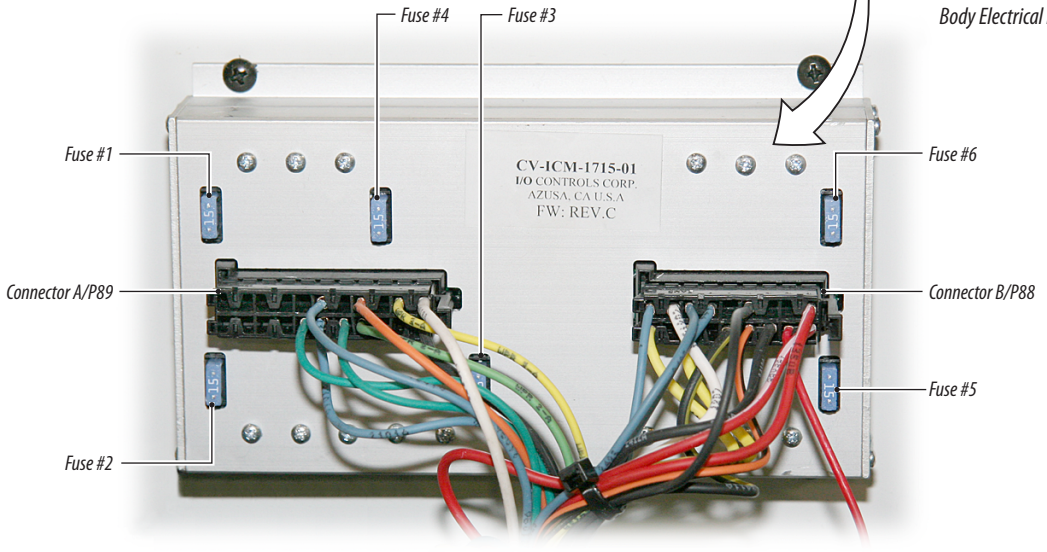
Body Control Module (BCM)

There are four specific body control modules available for the Blue Bird Vision. The particular module installed on a bus depends on the bus application (school bus or non-school bus) and specific options the bus is manufactured with. The four modules are identified by the last two digits of the model number.

BCM Model	Description/Application
CV-ICM-1715-01	Standard School bus application
CV-ICM-1715-02	School bus, warning light pilot (incandescent)
CV-ICM-1715-03	School bus, warning light pilot (LED)
CV-ICM-1715-04	Non-school bus application



Body Electrical Panel



Body Control Module (BCM)

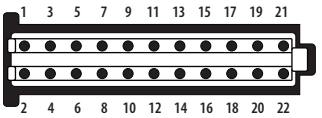
For a more detailed explanation of the modules operating characteristics we will reference a standard school bus BCM, unless stated otherwise.

All body control modules programmed and designated for standard school bus application will function identically and can be installed on any Blue Bird Vision manufactured with a standard electrical system. There are no variations between modules with the same model number. The BCM will never need reprogramming. If a module fails it would be replaced with a new module having the same programming and designation.

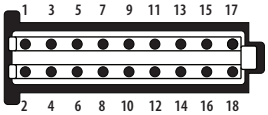
The Body Control Module is located in the body electrical panel. The module is equipped with a 22 pin AMP connector (connector A / P89) and an 18 pin AMP connector (connector B / P88) for interfacing with the bus electrical system. A decal can be found in the body electrical panel access door. Each connector provides connections for inputs and outputs.

The module receives power from the bus electrical system through four power inputs, each with its own circuit protection, and two ground circuits. The remaining pins in connector A & B provide an interface for input signals and output signals (reference the input and output table). Each output represents a specific task or function that the BCM manages/controls.

BCM Connector Pin Locations



A/P89 Connector



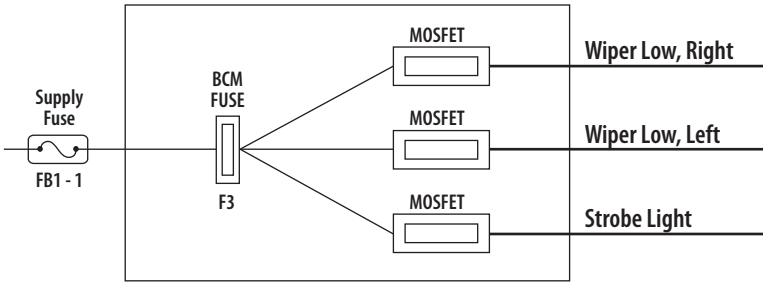
B/P88 Connector

BCM Circuit Protection

Six automotive style fuses are located on the front of the module. Each fuse provides a function similar to a master fuse. They protect a designated group of output circuits but their main function is to protect internal components of the control module. If an electrical fault occurs, creating a spike (a very quick high current draw) within the circuit or if the total load of a specific group of circuits exceeds the rated amps, the fuse will blow protecting the circuits and the internal components of the module. The decal in the body electrical panel access door will identify each fuse, its rating, its location and the circuits each fuse protects. The BCM Output Table also references the fuse location on the front of the BCM.

When circuit logic has been satisfied, the BCM will activate an output to the load or to a relay that will carry the load. The specific pin and connector number for each output can be identified by referencing the BCM output table. Each output circuit is activated and protected by an electronic device located inside the module, called a MOSFET. A MOSFET is a metal oxide semiconductor field effect transistor or in simpler terms an electronic switching device with circuit protection capabilities. The MOSFET receives a signal from the BCM microprocessor when input circuit logic has been satisfied. The MOSFET will activate (turn on) and supply 12 volts to meet circuit requirements as indicated by a ladder logic line. When the microprocessor deactivates the signal to the MOSFET, the MOSFET opens deactivating (turns off) the output circuit. In this function the MOSFET works similar to a regular transistor, switching a circuit on or off electronically according to a signal from the microprocessor. In the event a fault occurs on the circuit, if the circuit is overloaded (draws more current than it was designed to provide) or if a short to ground occurs, the MOSFET reacts similar to an automatic circuit breaker. The MOSFET deactivates the output and protects the circuit. The MOSFET will continue to hold in the open mode as long as the electrical

fault is active. When the fault is removed or corrected the MOSFET will revert back to its transistor mode activating and inactivating the output depending on the signal from the microprocessor. The MOSFET may have to be cycled (deactivate one or more inputs specific to the MOSFETs output circuit then re-activate the circuit) before it will reset and revert back to its transistor mode. The MOSFET is the primary device protecting the individual output circuits.



Typical Body Control Module Current Flow

As indicated in the Body ControlModule Current Flow illustration, electrical current will flow through three circuit protection devices for all circuits controlled by the BCM; A **Supply Fuse** located in one of the three fuse blocks located in the body electrical panel; A **BCM Fuse** located on the front of the BCM; A **MOSFET** located inside the BCM.

Another characteristic of the BCM is its power down mode. When the ignition switch is turned off the module will systematically go into a sleep mode. The module will draw very low current (less than 1ma) and will not operate unless certain inputs become active. Input circuits not having wake up status will not function if the ignition switch is off. Input circuits having wake up status will function with the ignition switch off but when the input is deactivated the module will return to its sleep mode. Reference the BCM input table to identify the specific inputs that will cause the control module to wake up in a fully functional mode.

The BCM is designed to monitor full on or full off body circuit inputs and deliver an output according to circuit logic. The BCM is programed to recognize when inputs are active (on) and or inactive (off), the module compares each input or a group of inputs with it's pre-programed logic and activates outputs accordingly. The body control module does not manage all body circuits. To determine which circuits are managed by the BCM see the BCM input and output tables.

BCM Input and Output Table

One of the first steps in understanding body electrical systems on the Blue Bird Vision is to determine which circuits are controlled by the BCM. The BCM Input and Output Table can be used as a quick reference to identify which circuits are managed by the body control module.

The input table provides a description of each input circuit the BCM manages. It identifies the pin number and connector for each input circuit connected to the module, the circuit number, circuit color, whether the input is 12V or Ground and whether or not the input, if activated, would cause the module to wake up.

The output table provides information for each output the BCM manages plus other information that is specific to outputs. The table also indicates which input source feeds current to a specific output, which BCM fuse protects a specific output or group of outputs, and the specific ladder logic line to use when troubleshooting a circuit by referencing each output to its specific logic line. Therefore the output table can be used as a quick reference to locate a specific ladder logic line.

BCM Input Table

	Circuit Description	Pin Number	Connector	Circuit Number	Circuit Color	Input	Wake-Up
1	Power 2	22	A / P89	1124HH	BK	12 Volts	
2	Power 3	17	A / P89	1148D	BK	12 Volts	
3	Ground	21	A / P89	1216FF	WH	Ground	
4	Wiper Switch 1	15	A / P89	WRP1-A	OR	12 Volts	
5	Wiper Switch 2	16	A / P89	WRP2-A	LT/GN	12 Volts	
6	Wiper Switch 3	19	A / P89	WRP3-A	YL	12 Volts	
7	Wiper Park Right	12	A / P89	2101A	PK	Ground	
8	Wiper Park Left	11	A / P89	2109A	BL	Ground	
9	Mirror Heat Switch	20	A / P89	2105L	PU	Ground	
10	Ignition	11	B / P88	1182A	B/Y	12 Volts	Yes
11	Power 4	18	B / P88	1350RR	RD/WH	12 Volts	
12	Power 5	17	B / P88	1350B	RD/WH	12 Volts	
13	Ground	3	B / P88	1207	WH	Ground	
14	12v Wake Up	16	B / P88	1350SS	RD/WH	12 Volts	Yes
15	Warning Light Start Switch	12	B / P88	2410	OR/BK	12 Volts	
16	W/L Flash Only After Amber	1	B / P88	1221SS	LT/BL	Ground	
17	W/L Flash Red When Door is Open	7	B / P88	1221TT	LT/BL	Ground	
18	Cross Arm Cancel	8	B / P88	2425BB	LT/BL	12 Volts	

BCM Output Table

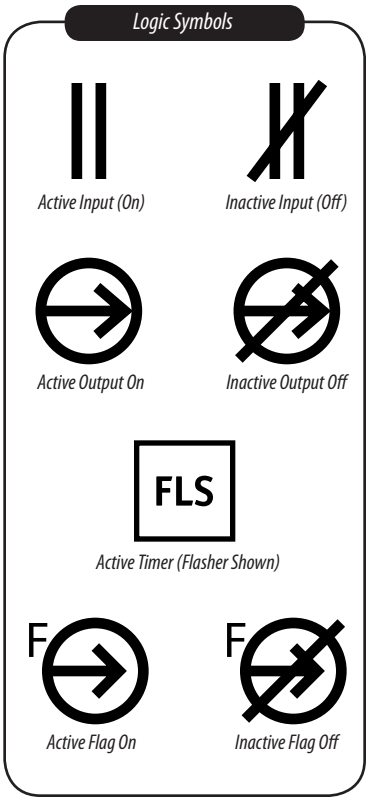
	Circuit Description	Pin Number	Connector	Input Source Pin	Fuse	Circuit Number	Circuit Color	Output	Ladder Logic Line
1	Wiper Low, Right	14	A / P89	2	3	2111A	DK/GN	12 Volts	9
2	Wiper Low, Left	10	A / P89	2	3	2110A	DK/GN	12 Volts	8
3	Strobe Light with Warning Light	18	A / P89	2	3	2430E	R	12 Volts	10
4	Mirror Heat	13	A / P89	3	4	2105H	PU	12 Volts	12
5	Amber Warning Light, Right	2	B / P88	4	5	2413A	YL/BK	12 Volts	22
6	Amber Warning Light, Left	10	B / P88	4	5	2411A	BK/YL	12 Volts	23
7	Red Warning Light, Right	6	B / P88	4	5	2414A	YL	12 Volts	25
8	Red Warning Light, Left	14	B / P88	4	5	2412A	BK	12 Volts	26
9	Stop Arm	5	B / P88	5	6	2425	LT/BL	12 Volts	28
10	Cross Arm	9	B / P88	5	6	2426	LT/BL	12 Volts	30
11	W/L Pilot Lights	13	B / P88	5	6	2417	PU	12 Volts	--

Ladder Logic Lines

As defined in the technical terms, a ladder logic line or logic diagram provides a means of communicating circuit logic or circuit function. To understand an electrical circuit a technician needs to know the circuit function and what conditions are necessary for the BCM to activate the circuit. All outputs managed by the BCM will have their own logic line. Each logic line is identified by it's output description and referenced with a number to the left of the logic line. The logic line relating to a specific output can be located by referencing the last column in the output table or simply reviewing the output description (located on the far right of the logic line) of each logic line until you locate the logic line in question.

Each logic line consists of a horizontal line with a description of all inputs and input status necessary to make the circuit function on the left and the output being activated on the far right. Each logic line will have one or more inputs but will only have one output. The description of each input and output is placed just below the horizontal line. A logic symbol is placed above each input and output description. This symbol indicates the status of each input or output, if they should be active (on) or inactive (off). Circuit logic may require some inputs on a logic line to be active while requiring other inputs on the same logic line to be inactive before the microprocessor in the BCM will activate a specific output. When all of the inputs on the logic line are set according to the logic symbols (active/on or inactive/off), input logic will be satisfied and the microprocessor in the BCM will signal for the output to be activated.

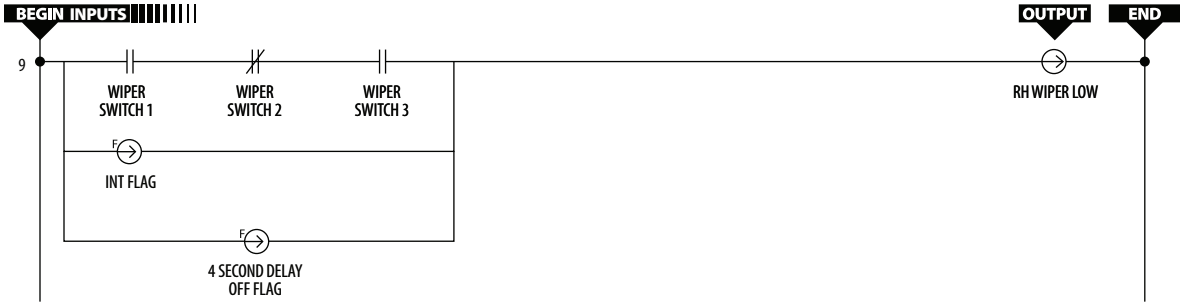
The following example, logic line number 9 is the Right Hand (RH) Wiper, Low logic and further explains how a logic line communicates circuit logic and function. To simplify the example further we will assume the RH wiper low logic line only has one horizontal input line as indicated below.



Reading and understanding a logic line is similar to reading a sentence from left to right. Reading the RH wiper, low logic line indicates the BCM will activate (turn on) an output to the RH wiper motor when three conditions exist: (1) the BCM receives an active input from wiper switch 1; (2) the BCM senses an inactive input from wiper switch 2; (3) the BCM receives an active input from wiper switch 3. To meet or satisfy circuit logic the BCM's microprocessor is programed to activate a RH wiper low output on pin number 14, connector A (reference output table) when all three of these conditions exist. It does not matter in what order each input and input status has been satisfied, the BCM must see all three conditions. Although all three inputs in this example originate from the same switch, the wiper switch, they represent individual inputs to the BCM and should be considered as such.

Reading the logic line from left to right provides all the necessary inputs, input status (active/on or inactive/off) and the specific output that will be activated when all the requirements are satisfied. If you think of a ladder logic line as a formula, it could be written as: inputs + input status = output.

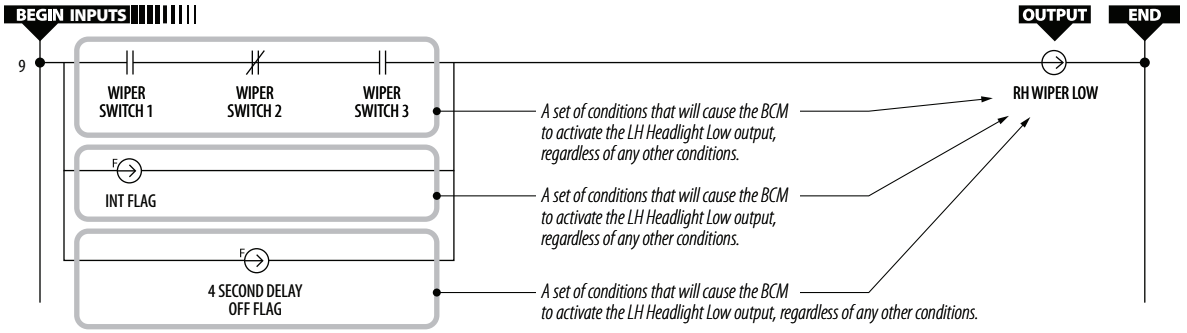
If there were only one horizontal input line on the RH wiper, low logic line, meeting the three conditions discussed in example one would be the only way to activate the RH wiper motor on low speed. However, there are three horizontal input lines for the RH wiper, low output.



Each of the three horizontal input lines represents a separate logic path or set of conditions, if satisfied, would result in the BCM activating an output to the RH wiper motor. The first set of conditions, the top line of inputs, has already been discussed in example 1; if the BCM receives an active input from wiper switch 1 and senses an inactive input from wiper switch 2 and receives an active input from wiper switch 3, regardless of any other conditions, the BCM will activate a RH wiper motor low output. The second set of conditions, the middle line of inputs, will activate the RH wiper motor output when the "Int Flag" becomes active regardless of any other conditions. The third set of conditions, the bottom line of inputs, will activate the RH wiper motor output when the "4 Second Delay Off Flag" becomes active regardless of any other conditions. The term "flag" mentioned in this example will be explained later. The point to understand is: each individual set of inputs (top, middle, bottom), regardless of any other condition, represents a logic path that, if satisfied, would activate the RH wiper motor, low output.

Logic lines having multiple input lines come in various configurations. Each horizontal input line represents a potential logic path. The vertical lines connecting the horizontal input lines also create a potential logic path. A logic line having multiple input lines provides multiple conditions or sets of conditions to activate the same output. Simply trace the multiple logic paths from begin (far left) to end (far right) one at a time in your mind, moving left to right, up and down without backing up. You will always start at the beginning on the top line and end up on the top line with the output. If there are three input lines, as in logic line number 9, you should be able to trace three input logic paths from beginning to end. The inputs and input status encountered on each individual path would represent a unique set of conditions necessary to activate the output regardless of any other condition. During the tracing process some overlap of horizontal and vertical lines may occur, therefore, the same input or set of inputs may be encountered on multiple logic paths.

If the RH wiper, low circuit were designed with the same logic but without using electronic controls it would consist of an interacting series of relays and integrated hard wired circuits. Or a more complex circuit. By managing some of the body electrical circuits the BCM eliminates part of the dated electrical systems and simplifies body electrical logic and function.

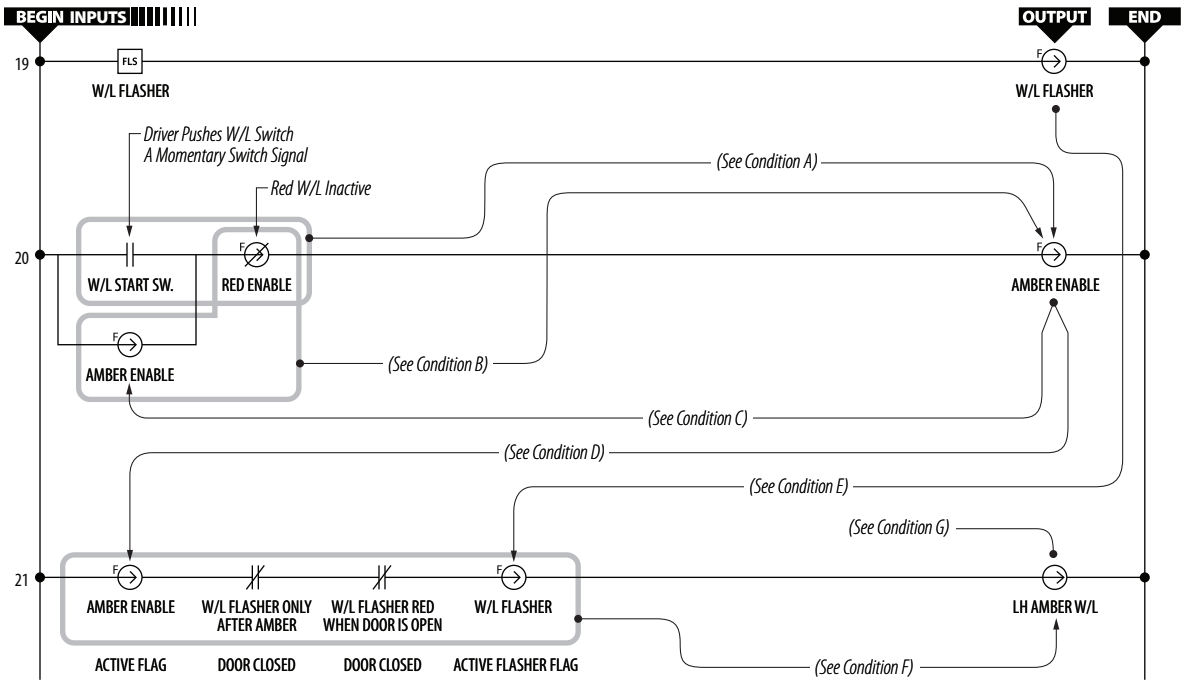


As indicated in logic line number 9, some of the inputs required to generate a RH wiper low output are called Flags. The technical terms describes a flag as an output generated and used inside the BCM. Flags do not have external outputs and are not listed in the output table. They are generated in much the same way as a regular output (an external output from the BCM) is generated. Each flag requires specific inputs and correct input status to activate its output. All Flags have their own logic line to convey it's logic and function. A flag has a similar symbol as a regular output but with an "F" placed just outside of the circle (see Logic Symbols).

The symbol representing a flag can be encountered on both sides of a logic line. A flag symbol will be located on the far right of its own logic line indicating it is an output. When a Flag symbol is encountered on the left side of a logic line it is being used as an input, and represents a condition that must be satisfied to generate a specific output. To understand the logic or function of a flag when it is encountered as an input you would need to locate the logic line for that flag. Review the output description of each logic line until you locate the flag in question. The inputs and input status required to activate the flag would be located on the left. Read the logic line from left to right as you would a logic line having a regular output.

To further explain the function of a flag reference logic line number 19, W/L (Warning Light) Flasher Flag. The only input required to generate a W/L Flasher Flag is an active W/L Flasher. The W/L Flasher input represents an electronic timer circuit generated inside the BCM. When activated, this input will provide an alternating switch/on switch/off function. By itself, the W/L Flasher is non-function outside of the BCM. Flags do not have external output circuits. Only when the W/L Flasher Flag is placed on the input side of a logic line, that has an external output, will it become externally functional by cycling that output on and off. When the W/L Flasher Flag is placed on the LH Amber W/L logic line it becomes externally functional by cycling the LH Amber W/L output circuit on and off.

The following example will explain the inter action of multiple logic lines to produce one functional output.



Ladder Logic Example

Condition A: A set of Inputs and input status (conditions), if satisfied, will cause the BCM to activate the Amber Enable Output Flag, regardless of any other conditions.

Condition B: A set of Inputs and input status (conditions), if satisfied, will cause the BCM to activate the Amber Enable Output Flag, regardless of any other conditions.

Condition C: Once activated the Amber Enable flag can be used as an input on its own logic line to keep itself activated until the red W/Ls are activated.

Condition D: Flags are outputs generated and used inside the BCM, they do not have external outputs and do not show up on the output table. For the Amber Enable flag to be functional external of the BCM, it must be used as an input on a logic line.

The Amber Enable flag indicates the driver is requesting the Amber W/L to activate as long as the Red W/Ls are inactive.

Condition E: Flags are outputs generated and used inside the BCM, , they do not have external outputs and do not show up on the output table. For the W/L Flasher Flag to be functional external of the BCM it must be used as an input on a logic line.

The W/L Flasher Flag indicates the W/L Flasher internal of the BCM has been activated and it will alternately activate and inactivate the output of the logic line it is placed on.

Condition F: A set of Inputs and input status (conditions), if satisfied, will cause the BCM to activate the Right Hand Amber W/L Output.

Condition G: The Left Hand Amber W/L Output symbol represents a signal to the LH Amber WL MOSFET to activate and supply a 12 volt output to the LH Amber WL output circuit.

Troubleshooting Body Electrical Circuits

CAUTION ***Failure to follow specific troubleshooting guidelines could result in damage to Body Control Module or other electrical systems .***

Use a high impedance multi-meter for circuit testing.

1. Determine if the failed circuit is managed by the Body Control Module.
   a. Review the circuit description column in the BCM Output Table.
   b. If the circuit is not in the list, it is not managed by the BCM.
      - Locate the circuit wiring diagram and use conventional electrical circuit troubleshooting to resolve the issue.
   c. If the circuit is in the list, it is managed by the BCM, go to step 2.

2. Check the BCM for required output.
   a. Refer to the BCM output table for the connector and pin number of the failed circuit.
   b. Set all the conditions necessary for the specific output circuit to be active (on).
      - Locate the circuit in question on the BCM output table, refer to the last column for the applicable logic line (each logic line is referenced with a number to the left of the line), reference inputs and input status, set inputs accordingly.
   c. Using a volt meter, probe the output circuit at the BCM for a full 12 volts.
      - If the voltage is correct, the test indicates the BCM and all inputs and circuit status are functioning properly and the failure is downstream of the BCM. The failure could be in the output circuit, other downstream control devices, or the load itself may have failed. Refer to the output circuit electrical diagram and use conventional electrical circuit troubleshooting to identify the fault.
      - If full voltage is not detected on the output circuit, the test indicates one of the following conditions: (1) One of the BCM electrical supply fuses has failed.(2) One of the BCM output circuit fuses has failed. (3) One or more of the power or grounds circuits supplying the BCM has failed. (4) One or more of the inputs for that specific circuit has failed. or (5) the BCM has failed.

3. Check power supply for the BCM.
   a. Check power supply fuses. There are four power supply circuits each protected with a fuse located inside the body electrical panel (not the fuses located on the BCM, see decal on access door).
   b. Check the six BCM output circuit fuses located on the BCM.
   c. Refer to the BCM input table and identify the connector and pin numbers for all the electrical supply and ground circuits.
      - Use a multi-meter to confirm all power and ground circuits are good.
      - Use conventional electrical troubleshooting to determine failure of power or ground circuits.

4. Check BCM Inputs.
   a. Locate the circuit in question on the BCM output table, refer to the last column for the applicable logic line. Each logic line is reference with a number to the left of the line.
   b. Systematically check input circuits as indicated on the logic line.
   c. Set conditions (active or inactive depending on each input logic or status symbol) for all inputs required to generate an active output for the circuit in question.
   d. Refer to the input table for the connector and pin number of each input.
   e. Probe each input (keep in mind some of the inputs may be active and others inactive to satisfy circuit logic, refer to the logic symbol above each input,

inputs are designated 12V or ground, refer to the input table).

f. Locate the electrical diagram for the failed input and use conventional electrical troubleshooting to resolve the issue.
g. If all of the inputs test good a failure may have occurred inside the BCM.

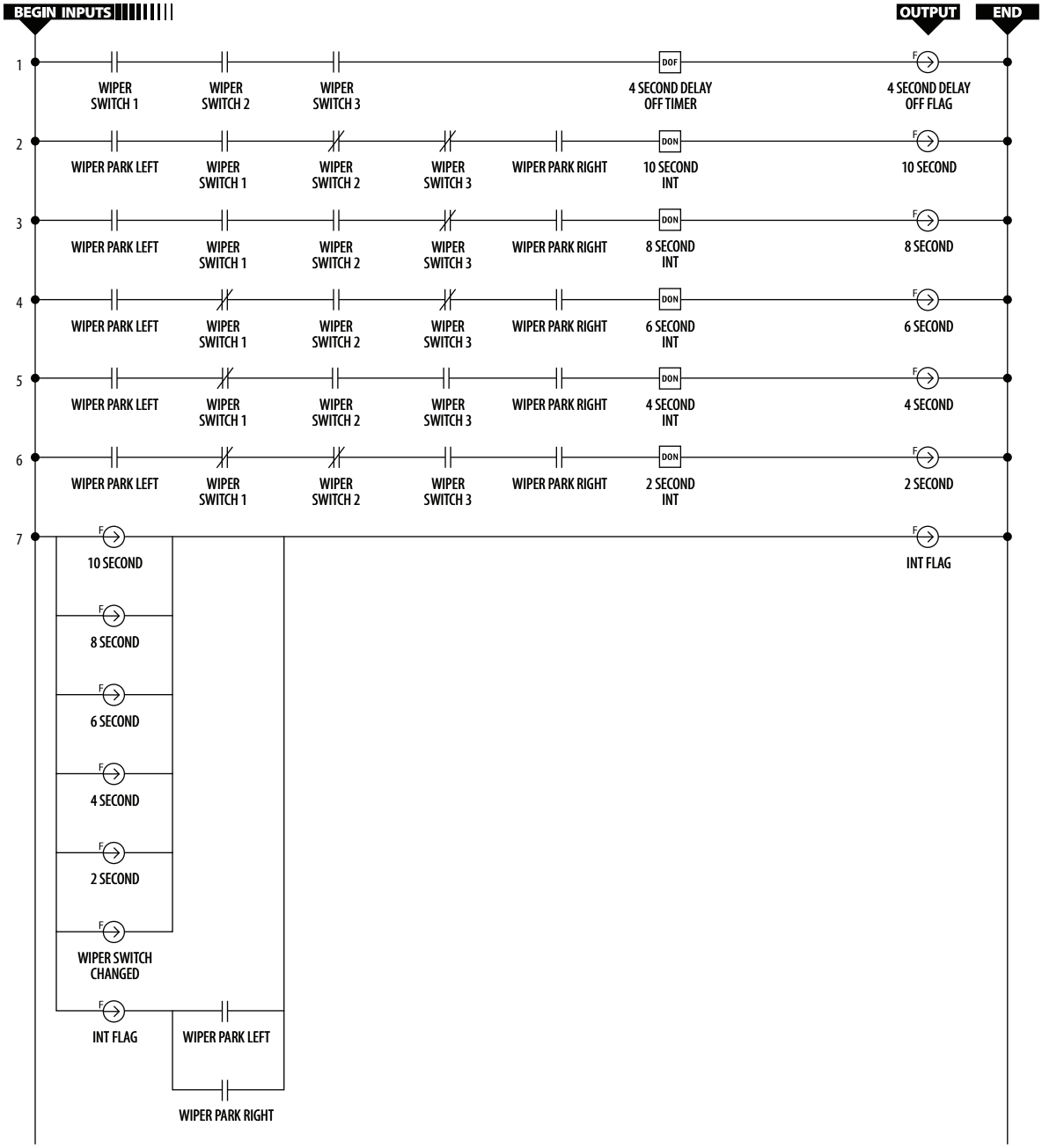
5. Confirm the Body Control Module has failed.
   a. Refer to the BCM output table and check specific BCM output.
   b. Refer to the BCM input tables and check for 12V on all power inputs.
   c. Check all supply fuses and BCM output fuses located on the BCM.
   d. Refer to the input table and check all ground inputs (less than 10 ohm).
   e. Refer to the specific ladder logic line and check each input.
   f. Review all the troubleshooting steps (steps 1 – 5) that apply to the failed circuit. If the cause of the failure has not been discovered by repeating the troubleshooting steps a second time, a failure may have occurred in the BCM.

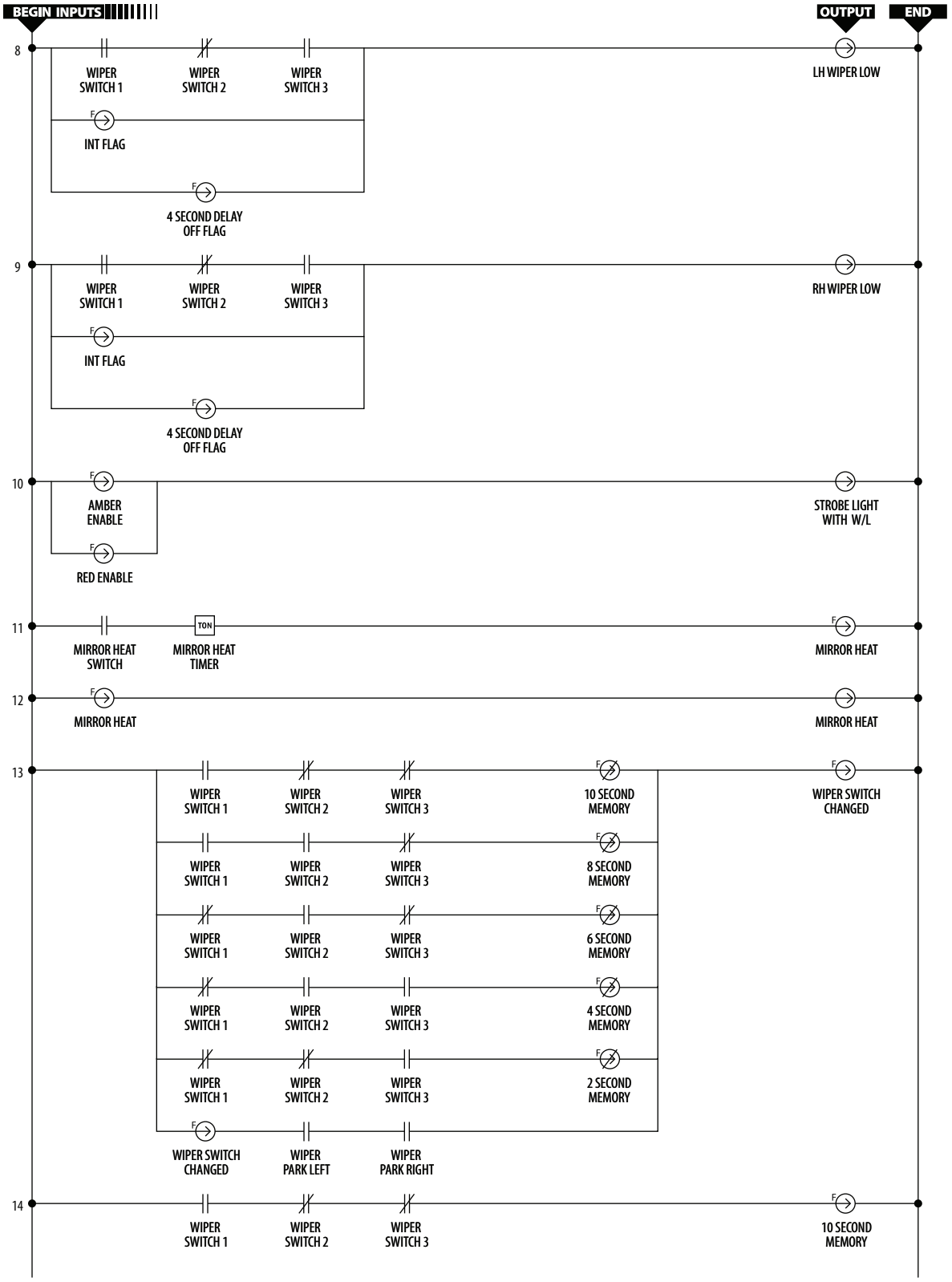
The Body Control Module has been designed specifically for the Blue Bird school bus application and manufactured to provide long service life. The BCM was designed with dual protection that supports the integrity of the output circuits and internal components of the module. The BCMs are assembled using premium grade quality components designed for the loads and environments of school bus operations. Carefully review all troubleshooting procedures and call your Blue Bird Service Provider prior to replacing the BCM.

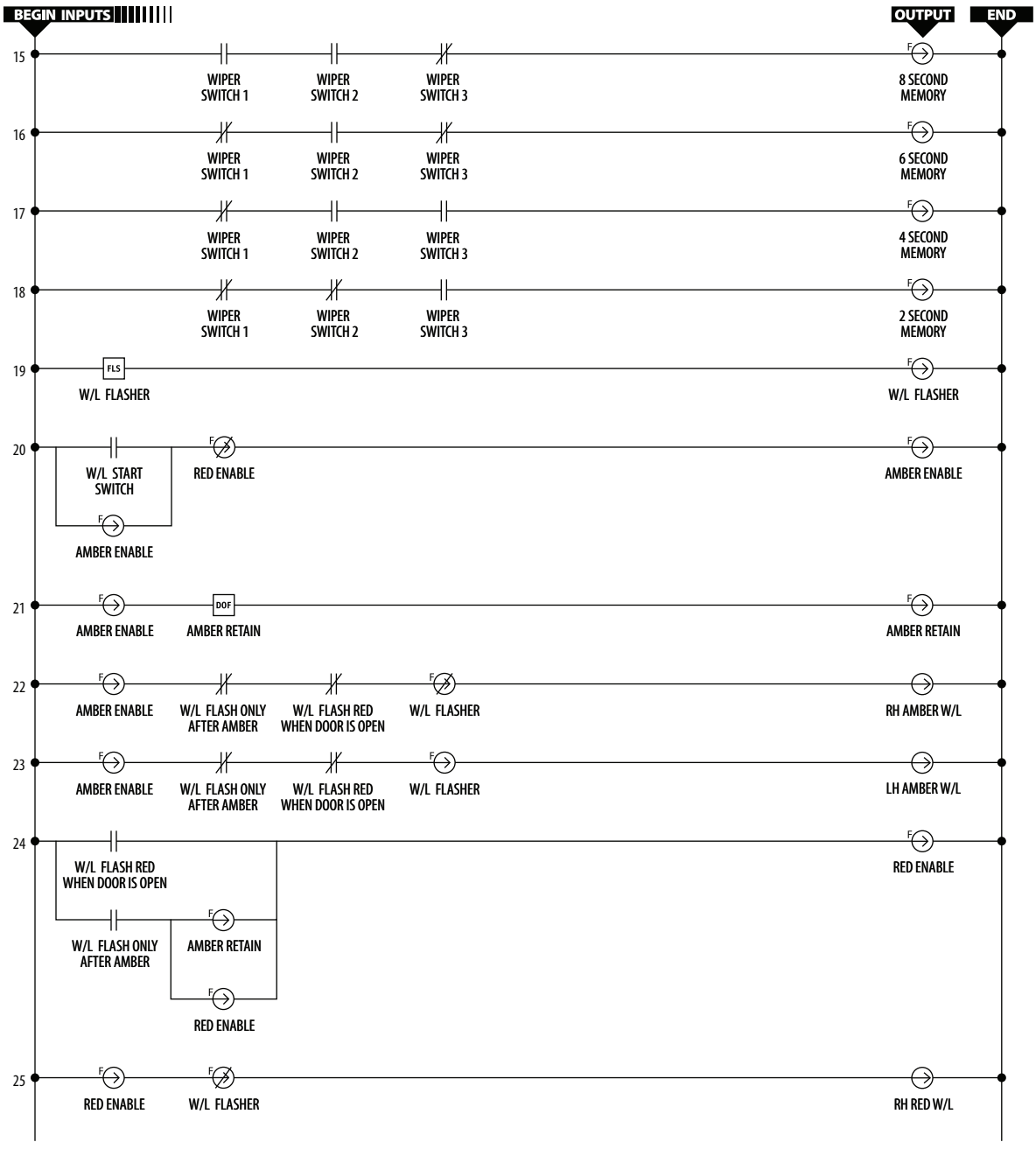
BCM Ladder Logic Diagrams

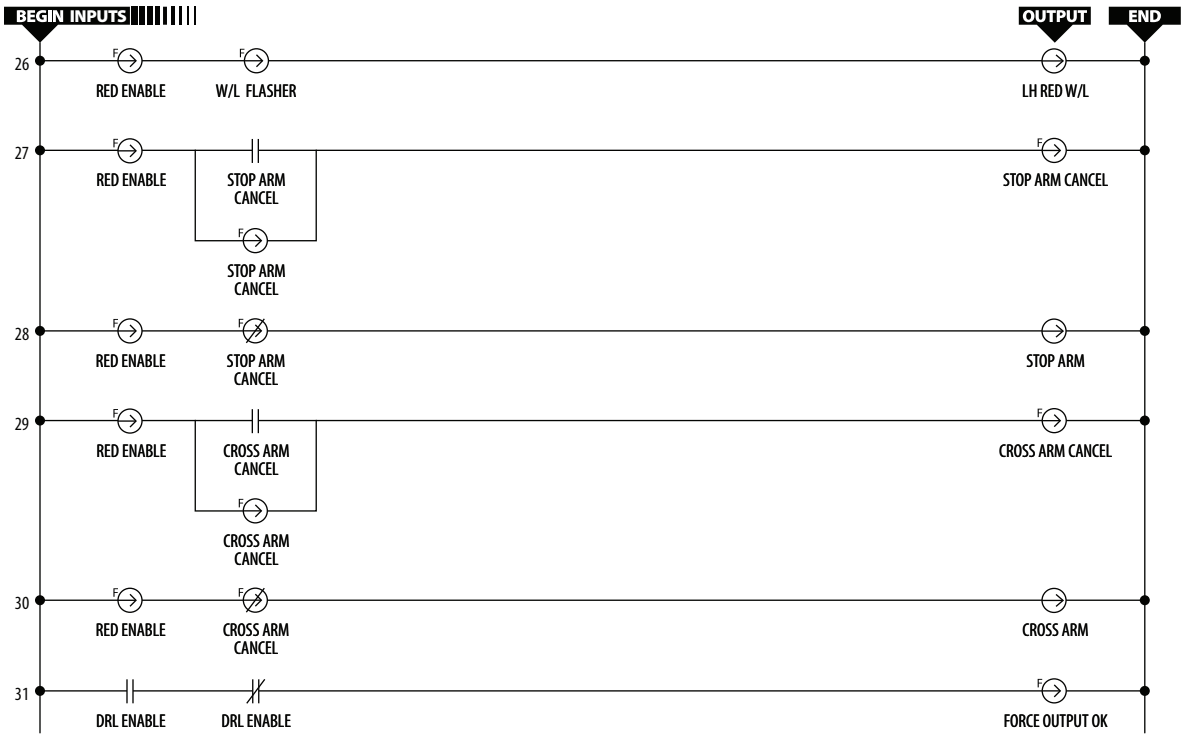
Logic Symbols Key

Active Input *Inactive Input* *Active Output* *Inactive Output* *Active Timer (Flasher Shown)* *Active Flag* *Inactive Flag*




BEGIN INPUTS
OUTPUT
END
8
WIPER SWITCH 1
WIPER SWITCH 2
WIPER SWITCH 3
INT FLAG
4 SECOND DELAY OFF FLAG
LH WIPER LOW
9
WIPER SWITCH 1
WIPER SWITCH 2
WIPER SWITCH 3
INT FLAG
4 SECOND DELAY OFF FLAG
RH WIPER LOW
10
AMBER ENABLE
RED ENABLE
STROBE LIGHT WITH W/L
11
MIRROR HEAT SWITCH
TON
MIRROR HEAT TIMER
MIRROR HEAT
12
MIRROR HEAT
MIRROR HEAT
13
WIPER SWITCH 1
WIPER SWITCH 2
WIPER SWITCH 3
10 SECOND MEMORY
8 SECOND MEMORY
6 SECOND MEMORY
4 SECOND MEMORY
2 SECOND MEMORY
WIPER SWITCH CHANGED
WIPER PARK LEFT
WIPER PARK RIGHT
WIPER SWITCH CHANGED
14
10 SECOND MEMORY


BEGIN INPUTS
OUTPUT
END
15
WIPER SWITCH 1
WIPER SWITCH 2
WIPER SWITCH 3
8 SECOND MEMORY
16
WIPER SWITCH 1
WIPER SWITCH 2
WIPER SWITCH 3
6 SECOND MEMORY
17
WIPER SWITCH 1
WIPER SWITCH 2
WIPER SWITCH 3
4 SECOND MEMORY
18
WIPER SWITCH 1
WIPER SWITCH 2
WIPER SWITCH 3
2 SECOND MEMORY
19
FLS
W/L FLASHER
W/L FLASHER
20
W/L START SWITCH
AMBER ENABLE
RED ENABLE
AMBER ENABLE
21
AMBER ENABLE
DOF
AMBER RETAIN
AMBER RETAIN
22
AMBER ENABLE
W/L FLASH ONLY AFTER AMBER
W/L FLASH RED WHEN DOOR IS OPEN
W/L FLASHER
RH AMBER W/L
23
AMBER ENABLE
W/L FLASH ONLY AFTER AMBER
W/L FLASH RED WHEN DOOR IS OPEN
W/L FLASHER
LH AMBER W/L
24
W/L FLASH RED WHEN DOOR IS OPEN
W/L FLASH ONLY AFTER AMBER
AMBER RETAIN
RED ENABLE
RED ENABLE
25
RED ENABLE
W/L FLASHER
RH RED W/L


BEGIN INPUTS
OUTPUT
END
26
RED ENABLE
W/L FLASHER
LH RED W/L
27
RED ENABLE
STOP ARM CANCEL
STOP ARM CANCEL
STOP ARM CANCEL
28
RED ENABLE
STOP ARM CANCEL
STOP ARM
29
RED ENABLE
CROSS ARM CANCEL
CROSS ARM CANCEL
CROSS ARM CANCEL
30
RED ENABLE
CROSS ARM CANCEL
CROSS ARM
31
DRL ENABLE
DRL ENABLE
FORCE OUTPUT OK

Doran Warning Light Monitor

The Doran Monitor™ is a current sensing device. If current is flowing through one of the bus lamp circuits, the monitor senses it and illuminates the corresponding monitor light emitting diode (LED). When a lamp burns out, current flow through the circuit stops and the corresponding LED on the monitor does not illuminate, indicating the outside lamp is not functioning. The Doran™ Monitor is located in the bulkhead over the windshield and slightly to the left of the driver.

Warning lights are such an essential safety feature, it is important to know when they are not working properly. This is the function of the Doran monitor. Its display is a schematic of the lights as they appear outside the bus. It continuously monitors the current in each lamp. If current is flowing through a particular bus lamp circuit (i.e., the light is on), the monitor senses this and lights the corresponding monitor bulb. If the bus lamp burns out, current ceases and the corresponding monitor bulb goes out, indicating a fault. Once the defective lamp is replaced, and the warning lights are working normally again, this also should be shown by the monitor.

The Doran monitor is a reliable, long-life device, but as with most electrical instruments, it can be overheated and damaged if an overload occurs in a bus light. Such overloads can exist if a bus light circuit becomes shorted, forcing current through a coil in the monitor that exceeds the coil's rated capacity. Short circuits can occur if improper connections are made during installations, bus repairs, etc. If the monitor has an optional thermistor overload protection, the tail light circuits are overload-protected. (Thermistors are located on the bottom of the component side of the printed circuit board.)

Doran Troubleshooting

CAUTION ***Do not attempt to check a light emitting diode (LED) with an ohmmeter. Some digital voltmeters (DVM) have a diode checking position, which is acceptable for testing LEDs. Any repair of the Doran Warning Light Monitor™ should be referred to a qualified technician.***

If the Doran Warning Light Monitor™ does not display any indicator LEDs:

- An overload situation may have created an open circuit: Check the system fuses.
- An overload (due to addition of extra lights or other loads to the circuit) or physical damage may have burned or broken a conductor on the printed circuit board: Remove the extra load and replace the damaged printed circuit board.
- Excessive vibration or abuse has resulted in a damaged monitor. Replace the printed circuit board.

If a particular LED on the Doran Warning Light Monitor™ does not display, but the bus running lights are operating properly:

- The coil is burned due to an overload. Replace the coil kit.

- A solder joint has weakened (a cold solder joint). Flow new solder on the connection.
- The reed switch has failed, the reed has broken, or the contacts have failed. Replace the reed switch kit.
- The printed circuit board is broken or burned. Replace the printed circuit board.
- There is an open in the LED circuit. Replace the LED.

If a monitor LED indicator is on, but the bus running light indicated is not operating, or the bus running light switch is in the off position and the monitor indicates the running lights are operating:

- Replace the coil and reed switch kit.

If neither the bus running lights nor the Doran Warning Light Monitor™ operates properly:

- The running light bulb may be burned out. Replace the light bulb.
- The overload thermistor has protected the circuit from overload. Remove the overload condition (a short; incorrect light bulb(s); Extra lights, etc.) (i.e., trailer lights, etc.)

Calibration

To self calibrate the monitor, ALL monitored lights must be in working order. For faster calibration, the operator may turn on as many exterior lights as possible at the start of the procedure. The operator will be required to activate these lights during the calibration procedure. Operator may begin with the tail/head lights on, hazard lights (for the turn signals), and the amber warning lights flashing (door closed).

1. Turn on ignition and start engine – Engine is running to assure proper voltage for operation and calibration. The GREEN LED voltage indicator at the bottom center of the monitor MUST BE ILLUMINATED indicating the voltage is within limits for proper operation. Before beginning calibration, allow time for the voltage to stabilize to its normal running voltage. After cranking the engine the battery voltage may be lower than normal. Allow time for the battery to recharge.

2. When the ignition is turned on, all LED's on monitor will be enabled for a few seconds to verify that all LED's are working.

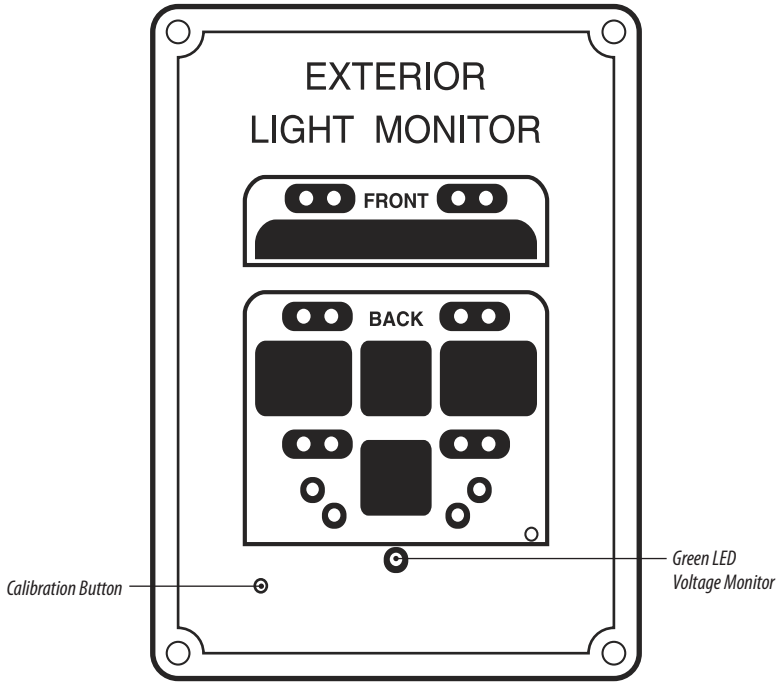
3. To enter the calibration mode, press and hold the calibrate button through the face plate hole for longer than two (2) seconds. This button/hole may be found located at the bottom left corner of the bus image on the monitor face plate. The first light to calibrate will begin flashing when the unit enters calibration mode. You may use an object such as an allen wrench or paper clip to activate the switch.

4. The unit will begin calibrating each light in a sequence. Each light tested must be active at the time of the calibration. As each light is calibrated, the matching monitor LED will flash. Operator shall activate (if not active) the bus light corresponding to the flashing LED. The sequence is as follows:

    a. Left turn signal – switch on
    b. Right turn signal – switch on
    c. Stop lights (left, then right side 7" will flash) – press brake pedal
    d. Tail light (left, then right side 4" will flash) – switch on (brakes off)
    e. Backup lights – press brake/clutch and engage reverse
    f. Each Amber warning light – switch on with door closed
    g. Each Red warning light – open door

5. Calibrated lights are indicated by the corresponding LED staying illuminated on the monitor. The unit continues to loop through the sequence flashing the un-calibrated lights until all lights are calibrated.

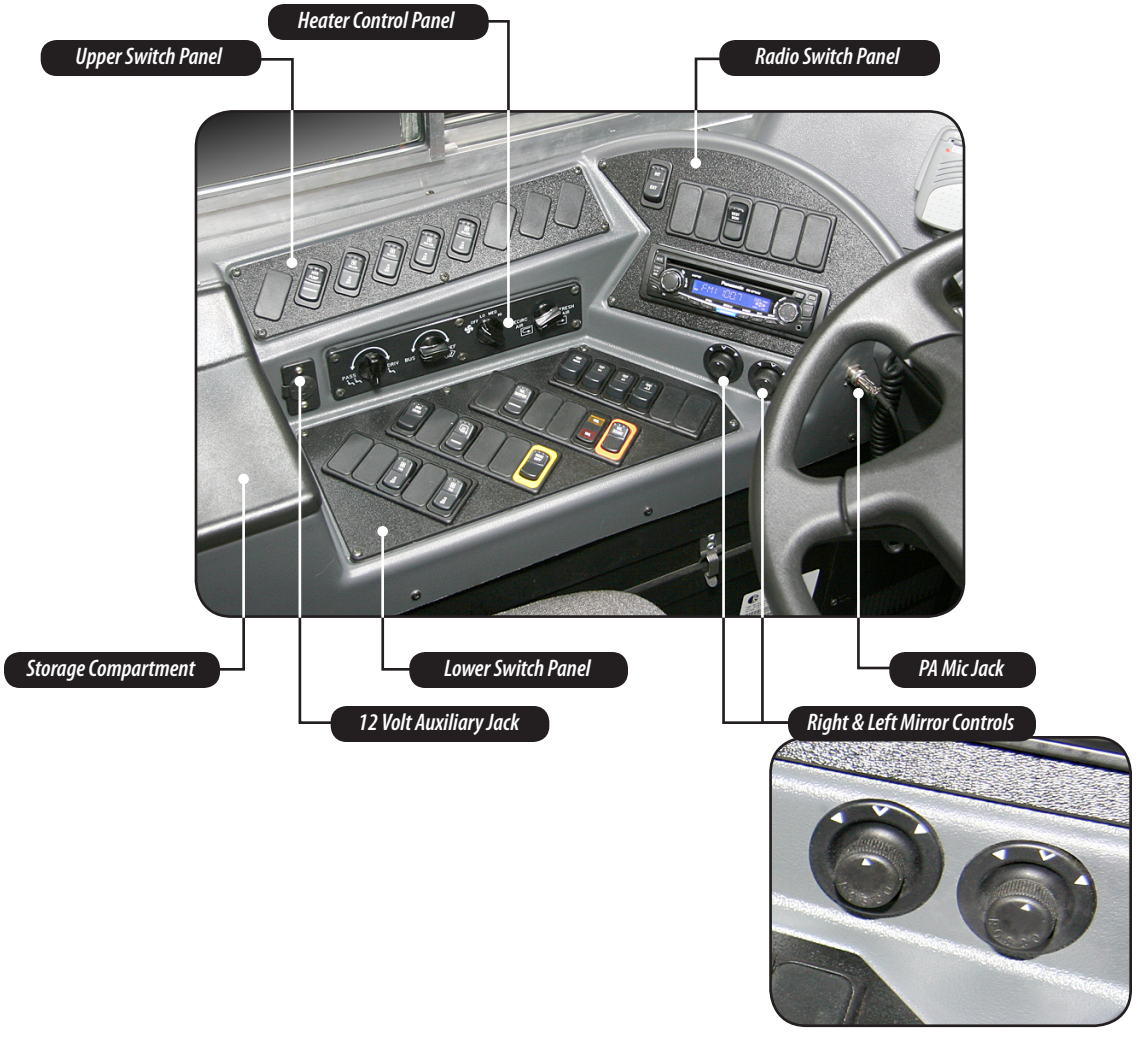
6. When all LED's are illuminated, turn off ignition to complete the calibration.



Left Switch Console

The left switch console under the driver's side window shown here consist of, the Radio Switch Panel, the Heater Control Panel, Right and left rearview mirror controls, upper and lower switch banks, a storage compartment, the optional PA mic jack and a 12 volt auxiliary jack as well.

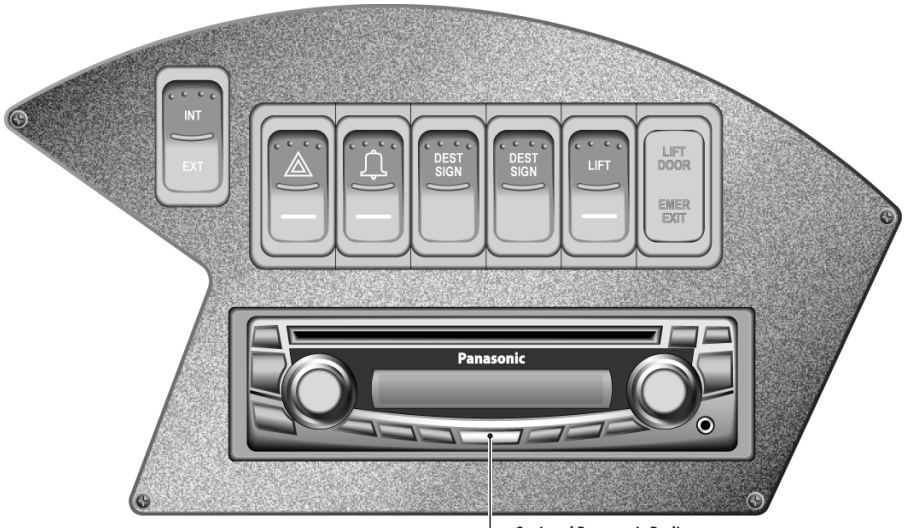
The left switch console contains three switch panel banks. The exact arrangement of switches in all switch panels is somewhat dependent upon specific state specifications. (For example, some states require additional switches for red and amber Warning Light pilots.) Shown are the standard and most common configurations. If your bus differs from the diagarms shown, check with your local specifications and familiarize yourself with each switch function.



Radio Switch Panel

The radio console switch panel located to the left of the driver and shown below includes a Panasonic AM/FM stereo cassette or CD player with PA system, depending on option ordered. The panel contains switches for standard and optional equipment and will be equipped only with switches for options that are included on your bus and therefore may differ from the panel shown here. The following is a list of switches and indicators found in this panel and their descriptive icons.

PA Mic



Optional Panasonic Radio
With CD or Cassette and optional PA Mic.

INT — **Public Address.** Interior and exterior speakers.

EXT

Hazard Lights. This switch turns on / off the front and rear turn signals as blinking hazard flashers.

Chimes. Provides power for passenger compartment chime system.

DEST SIGN — **Destination Sign.**

LIFT — **Lift.** Provides power for lift operation.

LIFT DOOR — **Indicator Lights.** Lift door open and /or Emergency door open.

EMER EXIT

Upper Left Switch Panel

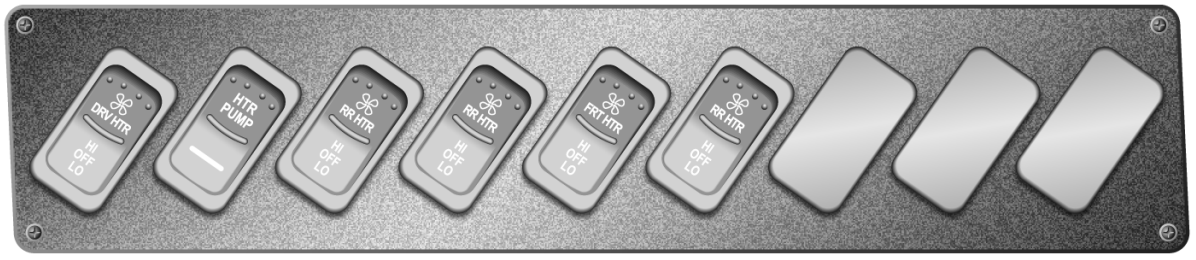
The upper left switch panel located directly below the driver's window and shown below includes switches that control the heater systems installed on your bus. The panel contains switches for standard and optional equipment heaters including front and rear heaters, the driver's heater, underseat heaters, and auxiliary heater pump. The panel will be equipped only with switches for options that are included on your bus and therefore may differ from the panel shown here. The following is a list of switches and their descriptive icons found in this panel.

Driver's Heater Fan. High, off and low positions.

Heater pump. Provides power to auxiliary heater pump, supplying heat to the passenger compartment.

Underseat Heater Fan Switches. 3-position (High, Off, Low) . Additional 3-position heater switches may be located in the left console lower panel if the bus is equipped with optional passenger area heaters. These switches control the fan speed of underseat heaters.

Perimeter Convection Heater Switch. 2-position (On / Off). If the bus is equipped with optional perimeter convection heaters in the passenger area, a switch is provided to toggle these heaters on and off. This switch operates an electric valve which controls the flow of engine-heated water.



Heater Control Panel

The Heater Control panel of the Side Console contains controls for the front heater unit which is housed immedately below the Side Console left of the Driver seat. Ducts from this unit also provide windshield defrosting.

Fresh / Recirculate. This knob controls the type air, which is circulated by the heater system and fan. By turning clockwise, air is circulated from the interior of the vehicle. This is desirable when trying to heat passenger compartment rapidly. By turning the control knob counterclockwise air from outside the bus is used in the system. This is helpful when trying to cool the vehicle.

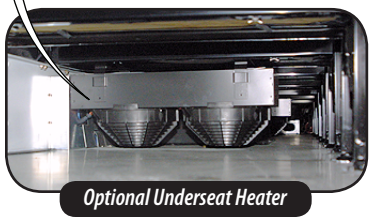
Heater Fan. This knob adjusts the speed of the fan, which circulates the air in the system. In the counter clockwise position, the blower is off. By turning clockwise, 3 speeds can be achieved — low, medium and high..

Defrost / Bus. This knob adjusts the air flow balance between the vehicle passenger compartment and the windshield. By turning knob clockwise, a damper is moved and air is diverted toward the windshield for defrosting.

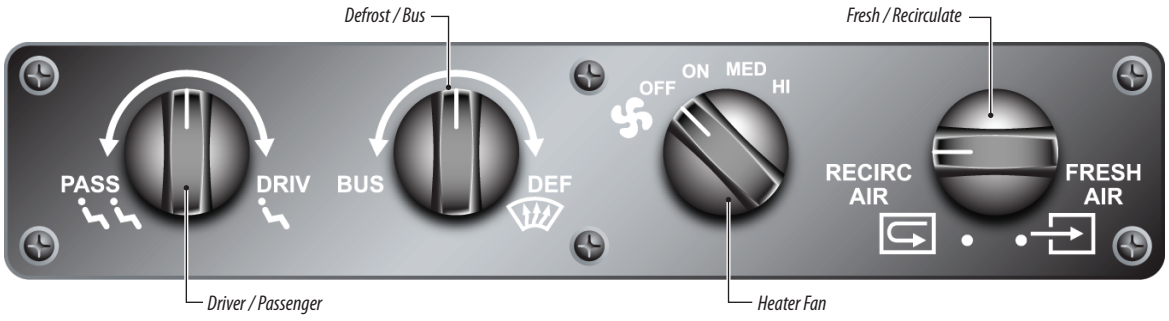
Driver / Passenger. This knob Adjusts air flow balance in two directions. By turning knob clockwise, a damper is moved and air is diverted toward the driver. By turning counterclockwise, the air is diverted toward passengers. The amount of air diverted is proportional to amount the knob is turned.

Front Entry Heater

Underseat Heater Switches



Optional Underseat Heater



Lower Left Switch Panel

The lower left switch panel located directly beside the driver consist of switches for standard and optional equipment. The panel will be equipped only with switches for options that are included on your bus and therefore may differ from the panel shown here. The following is a list of switches and indicators found in this panel and their descriptive icons.

Rear Dome Lghts. Turns on / off the overhead lights in the passenger area. Some Vision buses have two of these switches, one each for the dome lights in the front half and rear half or the right side and left side the bus.

Left Side Dome Lights.

Right Side Dome Lights.

Driver's Dome Light. Turns on / off the overhead light in the Driver area.

Door Switch. Press and hold the top of this momentary rocker switch to open the entrance door. The door stops automatically when it reaches the end of its travel. Press and hold the bottom of the switch to close the door.

Warning Light Start. Switch with orange bezel. A momentary switch which initiates the Warning Light sequence. Press this switch upon approach to each school bus stop. In most Warning Light System configurations, this activates the amber warning light flashers. When the door is then opened, the red warning lights are activated and the stop arm and crossing arm extend. This also activates the Sleeping Child check system, as indicated on the Driver Information Display.

Warning Light Indicators. Red and yellow.

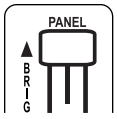
Warning Light Emergency. This momentary switch activates the red warning lights for use in the case of emergency, such as a roadside hazard.

Warning Light Master. Enables entire warning light system. This switch must be on whenever the Warning Light System system is required. Specific requirements vary according to state specifications. Generally, the use of the Warning Light System is required whenever picking up and discharging students. The Master switch enables you to disable the Warning Light System when stopping for other purposes such as fueling stops.

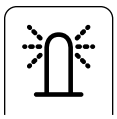
CAUTION ***Be sure to turn the Warning Light Master Switch off when the bus is parked overnight. Whenever the Warning Light Master switch is on, the Vision's Multiplex System will not enter its sleep mode, even if the key is removed. This will lead to battery discharge.***

Stop Arm/Crossing Arm Cancel. Interupts stop arm and/or crossing arm sequence. Pressing this momentary switch retracts the Stop Arm and Crossing Arm if they are extended. Pressing it again extends them.

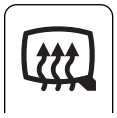
Noise Suppression. Includes yellow bezel. Momentary or on/off. When pressed and held, certain noisy devices such as auxilliary fans, heater blowers and radio are momentarily turned off to enable the Driver to better hear ambient sounds, such as railroad signals and gate intercoms or personnel, etc.



Console Panel Dimmer. Dims or brightens Console Panel switches.



Strobe Light. Controls the roof-mounted strobe light.

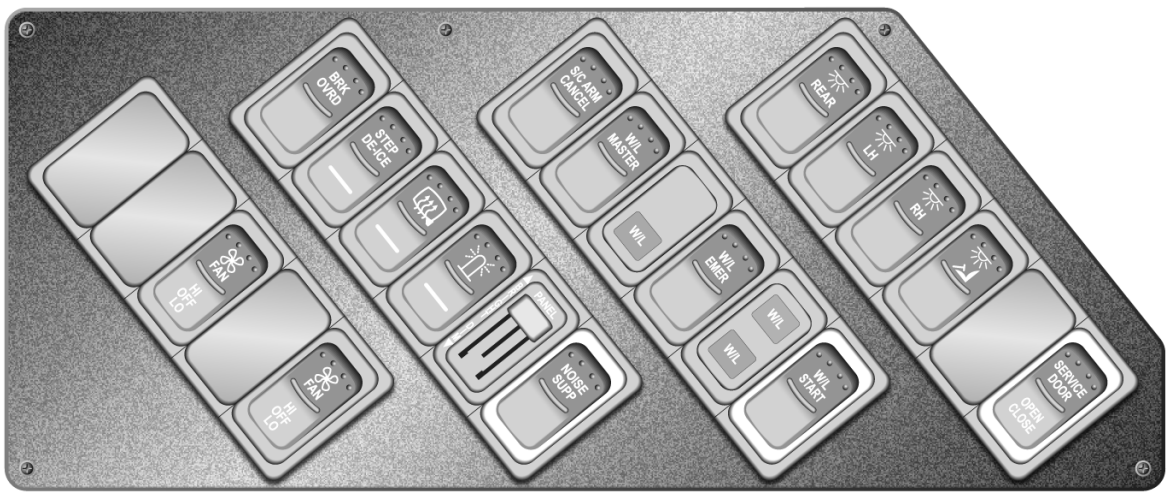


Mirror Defrost. Activates defrosting system for exterior rearview mirrors.

Step De-Ice. Activates de-icing system for entrance door steps.

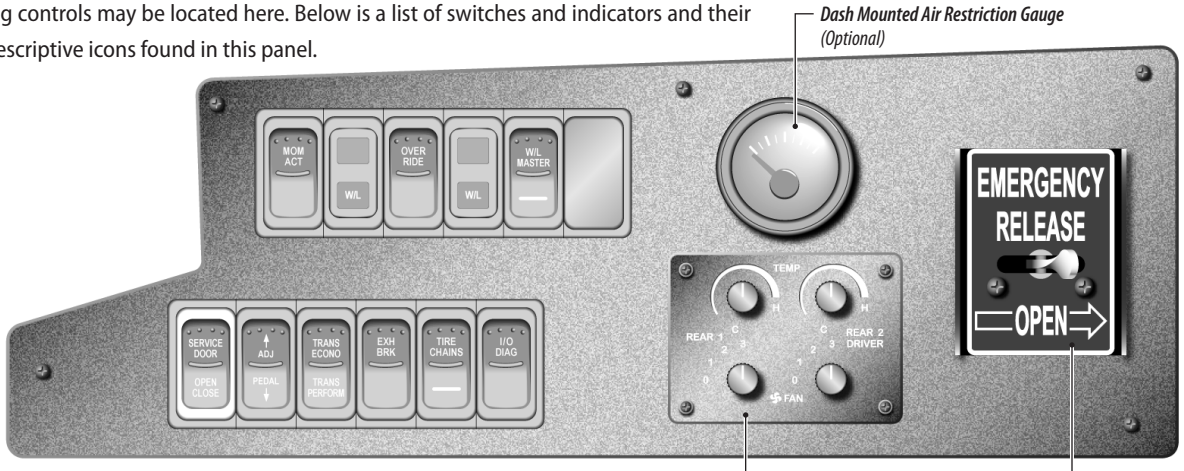
Brake Interlock Overide. Momentary switch overides Brake Interlock system.

Fans. Left, center and right auxiliary fans. High, low, and off positions. Fans are provided for general air circulation, Driver comfort, and/or to help accellerate windshield de-fogging under certain conditions.



Right Console Switch Panel

The right switch panel located toward the center of the bus consist of switches for standard and optional equipment. The panel will be equipped only with switches for options that are included on your bus and therefore may differ from the panel shown here. Other options such as a dash mounted air restriction gauge, a relocated air door emergency release and a location for the standard or electronic air conditioning controls may be located here. Below is a list of switches and indicators and their descriptive icons found in this panel.



MOM ACT — **Warning Light Momentary.** Activates the warning light system.

OVER RIDE — **Override.** Switch enables an override of the sequencial locks. (Fearure Specific).

W/L MASTER — **Warning Light Master.** Enables entire warning light system. This switch must be on whenever the Warning Light System system is required. Specific requirements vary according to state specifications. Generally, the use of the Warning Light System is required whenever picking up and discharging students. The Master switch enables you to disable the Warning Light System when stopping for other purposes such as fueling stops.

W/L — **Warning Light Indicators.** Red and yellow.

SERVICE DOOR / OPEN CLOSE — **Electctric Entrance Door.** Switch with blue bezel. Press and hold the top of this momentary rocker switch to open the entrance door. The door stops automatically when it reaches the end of its travel. Press and hold the bottom of the switch to close the door.

ADJ / PEDAL — **Pedal Adjustment.** Allows forward and rearward movement of the accelerator and brake pedal. Provides a 3 inch range of movement.

TRANS ECONO — **Transmission Economy.** Puts transmission into an economy shift pattern. Can be used for long trips.

TRANS PERFORM — **Transmission Perform** puts transmission into a performance shift mode. This is the default mode for the tramsmission and can be used for short stop and go trips.

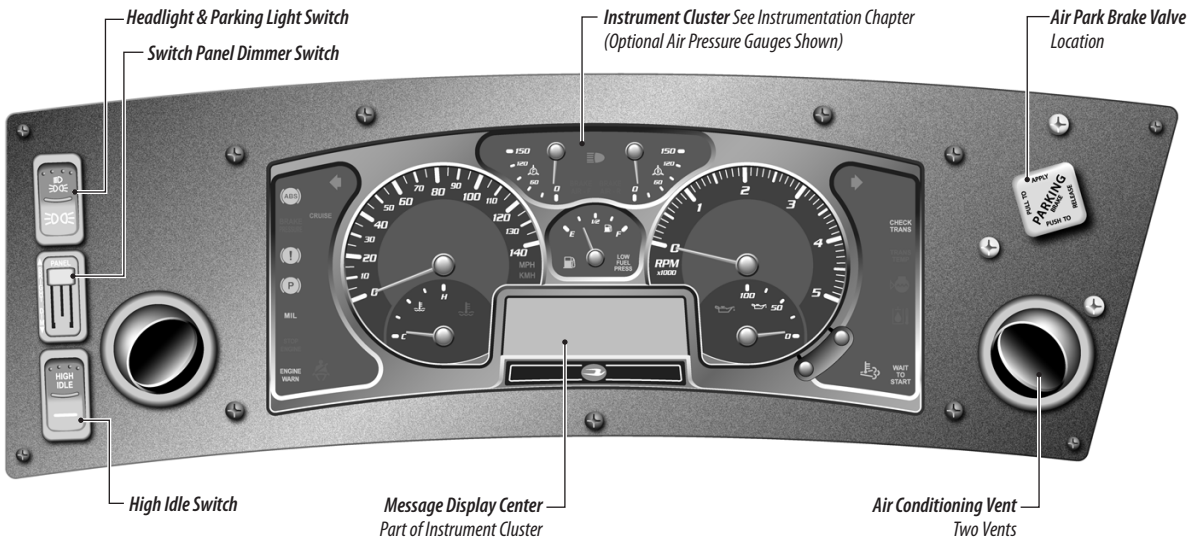
EXH BRK — **Exhaust Brake.** Activates the exhaust brake to help slow engine speed during deceleration.

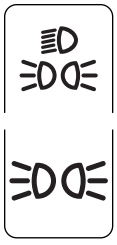
TIRE CHAINS — **Tire Chains.** Drops tire chains into position for icy conditions.

I/O DIAG — **Diagnostic Switch.** Provides diagnostic functions for the IO Control Multiplex system and the ABS system. For use by qualified personnel for diagnostic purposes only.

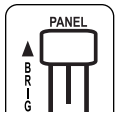
Driver's Instrument Panel

The driver's instrument panel behind the steering wheel and shown here consist of the instrument panel cluster, headlight switch, panel dimmer switch, high idle switch and air conditioning vents. If your bus is equipped with air brakes the parking brake valve is also located in this panel.





Headlights & Parking Lights. This switch turns headlights on and off, or turns on Parking Lights. Because daytime running lights are required, the headlights shine at a lower amperage during normal bus operation after the engine is running, even when this switch is in the bottom position.



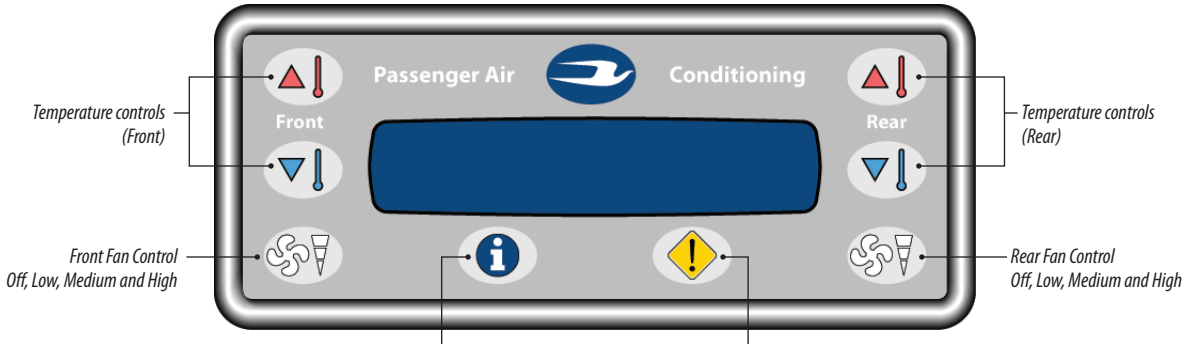
Switch Panel Dimmer. This slider switch is continuous, but has three detents. It adjusts the brightness of the switch panels backlighted switches. For brightening and dimming of the Instrument Cluster, see *Instrument Cluster/ Message Display Center* in the *Instrumentation* chapter of this manual.

High Idle. This switch raises the engine idle RPM when in the on position. This may be used during engine / heater warmup and to increase alternator output in driving conditions which cause a high battery drain, such as very frequent stop / go while multiple accessories are on. This function is also useful when the bus is parked and left running for long periods of time or when electrical system demands are high such as running the AC or operating a wheelchair lift. Place the transmission in Neutral and set the Parking Brake before switching the engine to High Idle.

Heat and Air Controls

The optional heat and air control panels are defined below. For further explanation of heater switches and controls, see Upper Left Switch Panel and Heater Control Panel, under Left Console Switch Panel found in ths manual. For additional information on optional air conditioning, see your Comfort Aire publication supplied with your air conditioned bus.

Comfort Aire Manual Controls



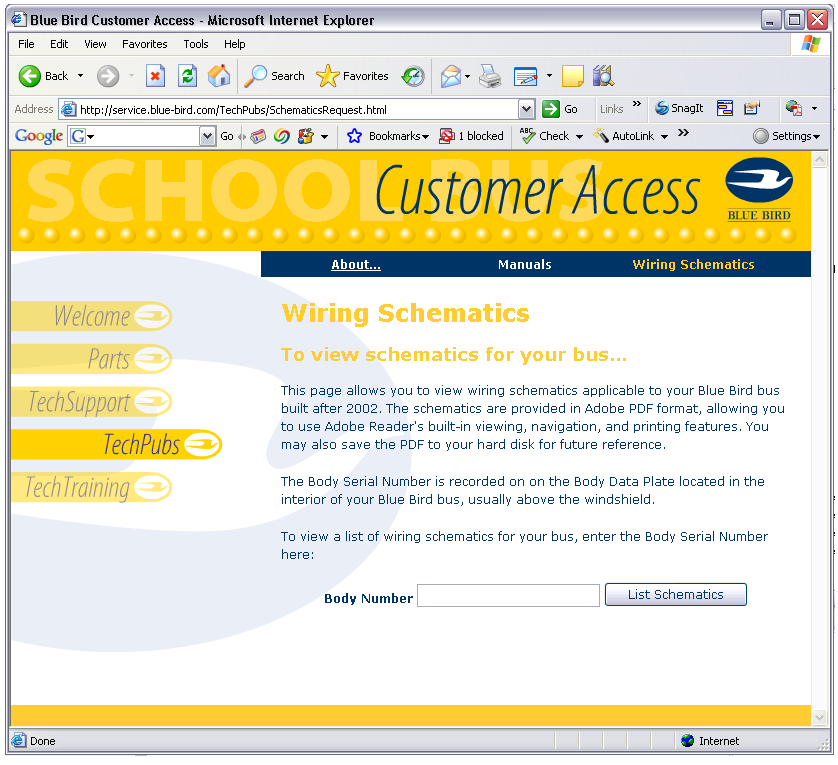
Comfort Aire Electronic Controls

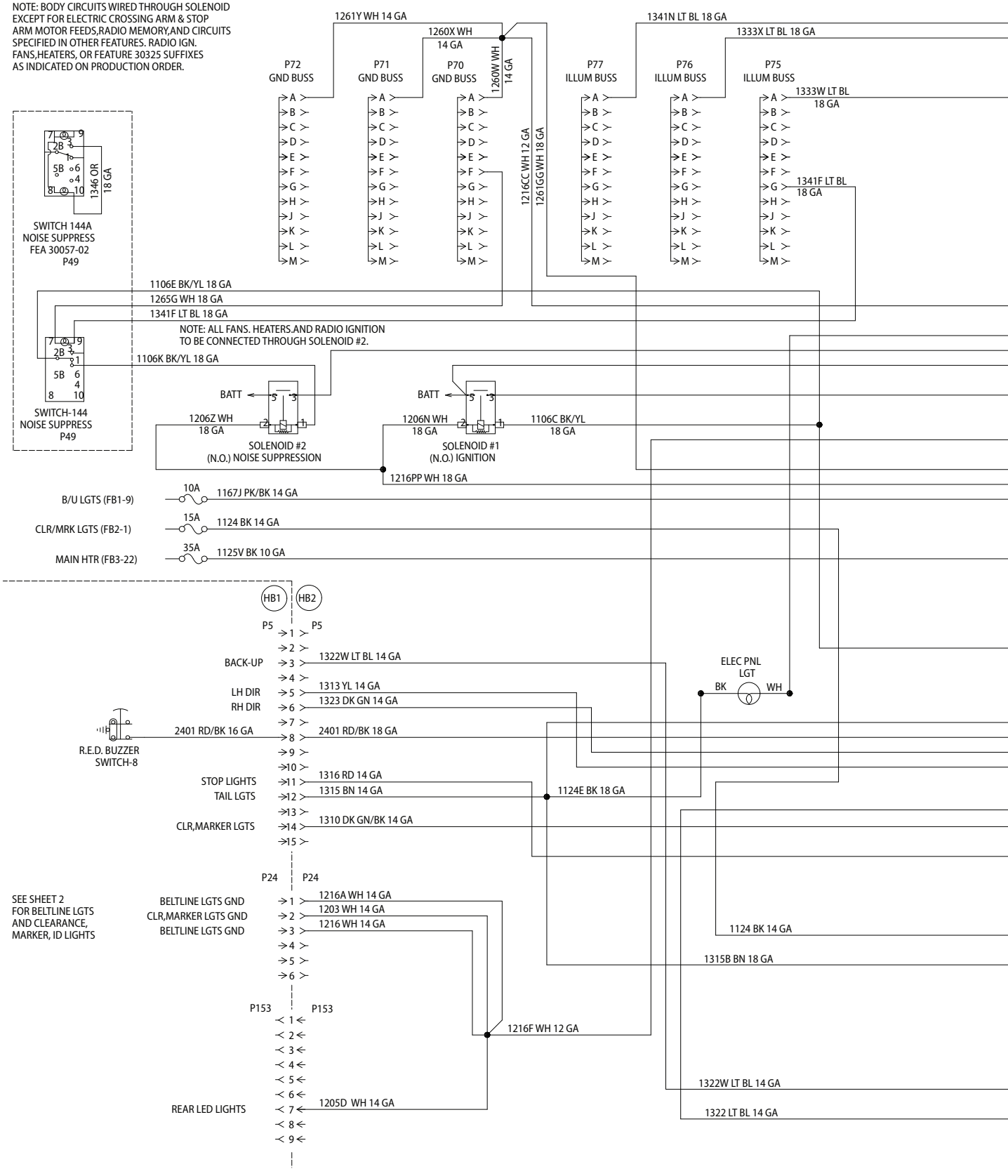
Body Wiring Schematics

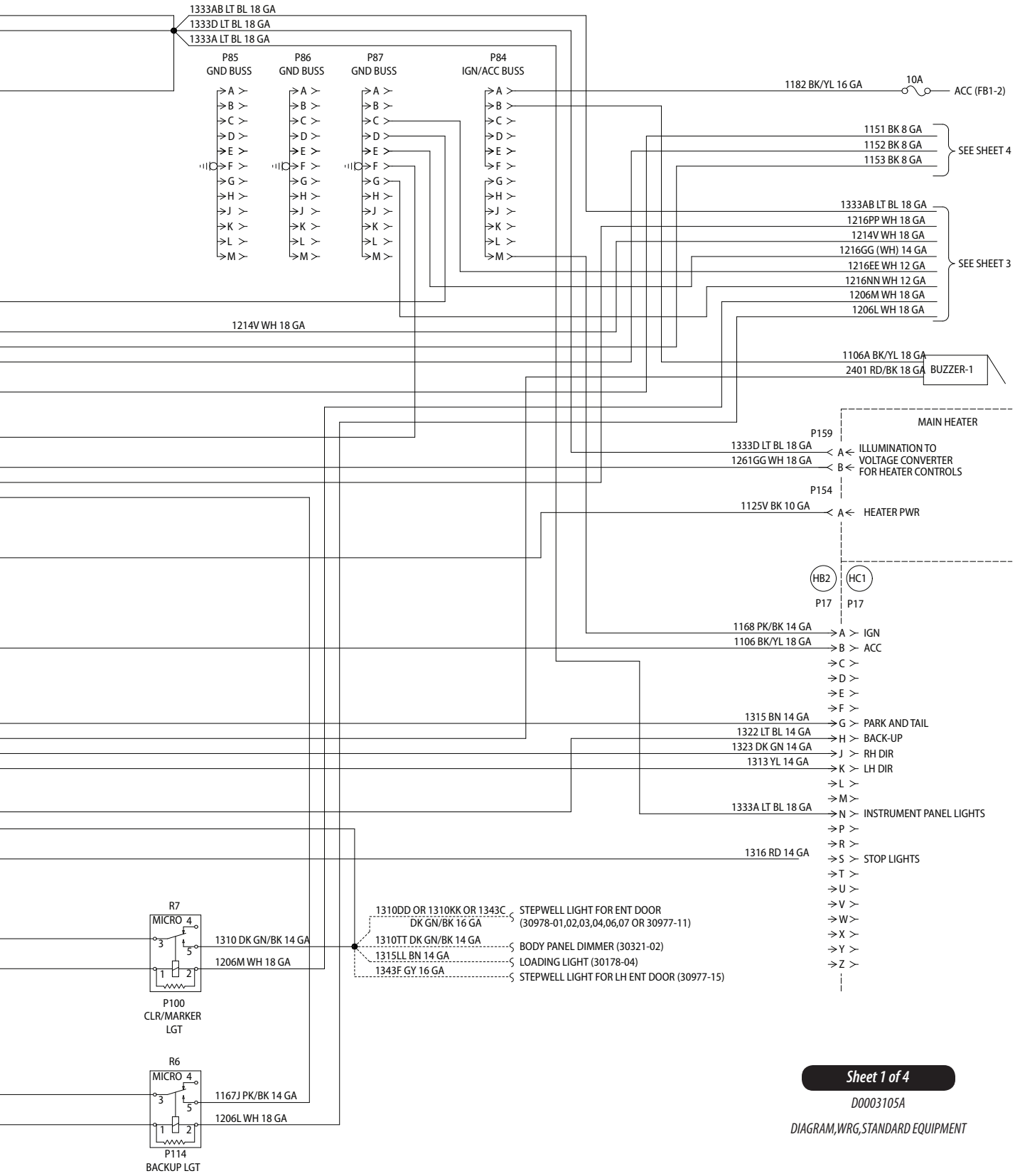
Many customers select options which affect the wiring on a Blue Bird Vision. The drawings on the DVD are in resolution-independent vector format. This allows you to zoom them at will, without the images becomming jagged which occur with bit-map formats. This also means that you may print the drawing to your own office or desktop printer while maintaining legibility even at significant reductions.

For more information see; **About the TechReference DVD; Electrical Schematics** located in the **Introduction** section of **Volume 1**. Also see additional wiring schematics for your bus at the Customer Access web site:

http://service.blue-bird.com/wiringschematics



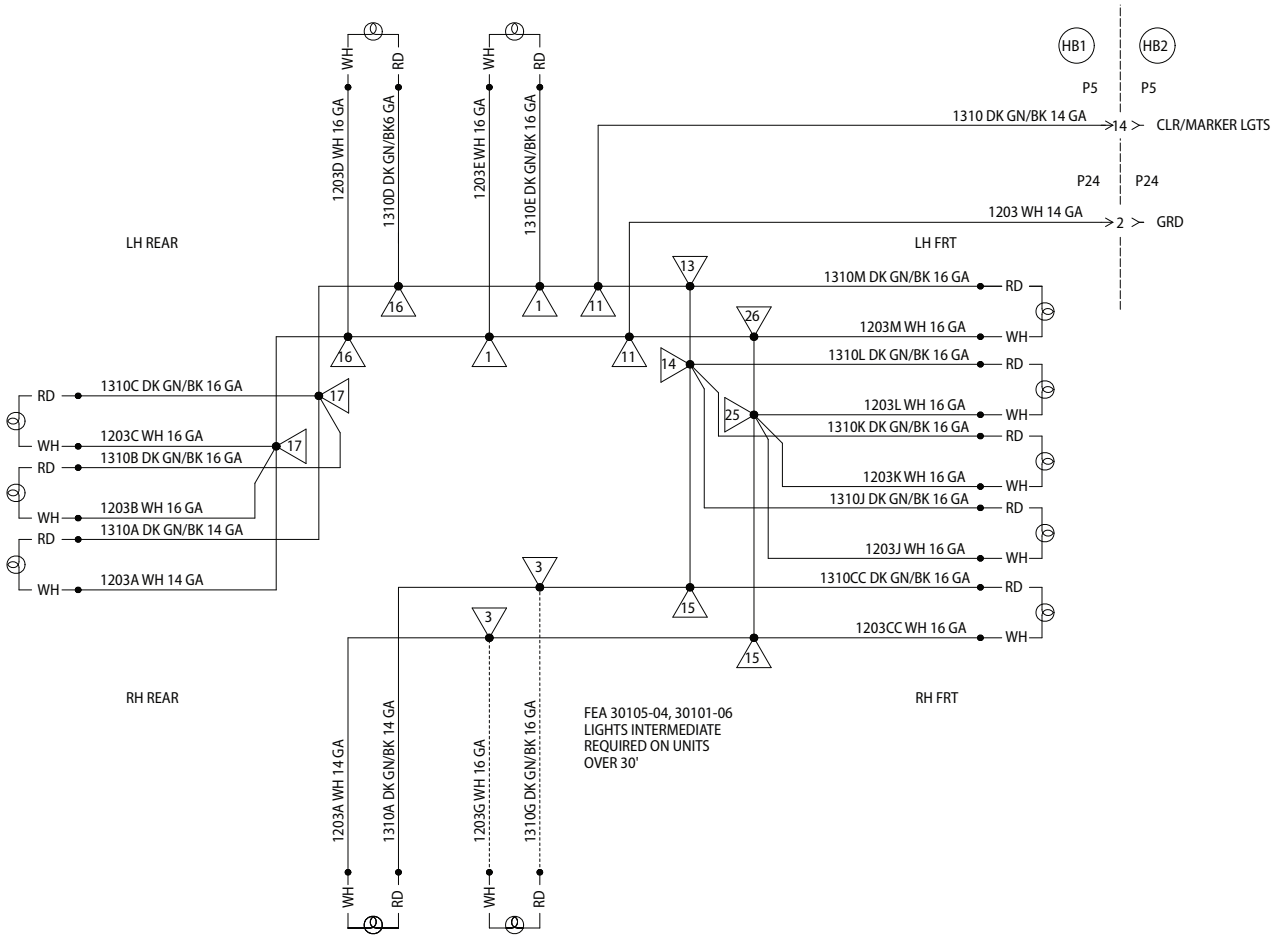

NOTE: BODY CIRCUITS WIRED THROUGH SOLENOID EXCEPT FOR ELECTRIC CROSSING ARM & STOP ARM MOTOR FEEDS,RADIO MEMORY,AND CIRCUITS SPECIFIED IN OTHER FEATURES. RADIO IGN. FANS,HEATERS, OR FEATURE 30325 SUFFIXES AS INDICATED ON PRODUCTION ORDER.
1261Y WH 14 GA
1260X WH 14 GA
1260W WH 14 GA
1341N LT BL 18 GA
1333X LT BL 18 GA
P72 GND BUSS
P71 GND BUSS
P70 GND BUSS
P77 ILLUM BUSS
P76 ILLUM BUSS
P75 ILLUM BUSS
1333W LT BL 18 GA
1341F LT BL 18 GA
1216CC WH 12 GA
1261GG WH 18 GA
1346 OR 18 GA
SWITCH 144A NOISE SUPPRESS FEA 30057-02 P49
1106E BK/YL 18 GA
1265G WH 18 GA
1341F LT BL 18 GA
NOTE: ALL FANS. HEATERS.AND RADIO IGNITION TO BE CONNECTED THROUGH SOLENOID #2.
1106K BK/YL 18 GA
SWITCH-144 NOISE SUPPRESS P49
BATT
1206Z WH 18 GA
SOLENOID #2 (N.O.) NOISE SUPPRESSION
1206N WH 18 GA
SOLENOID #1 (N.O.) IGNITION
1106C BK/YL 18 GA
1216PP WH 18 GA
B/U LGTS (FB1-9)
10A
1167J PK/BK 14 GA
CLR/MRK LGTS (FB2-1)
15A
1124 BK 14 GA
MAIN HTR (FB3-22)
35A
1125V BK 10 GA
HB1
HB2
P5
P5
BACK-UP
1322W LT BL 14 GA
LH DIR
1313 YL 14 GA
RH DIR
1323 DK GN 14 GA
2401 RD/BK 16 GA
2401 RD/BK 18 GA
R.E.D. BUZZER SWITCH-8
STOP LIGHTS
1316 RD 14 GA
TAIL LGTS
1315 BN 14 GA
1124E BK 18 GA
CLR,MARKER LGTS
1310 DK GN/BK 14 GA
ELEC PNL LGT
BK
WH
P24
P24
SEE SHEET 2 FOR BELTLINE LGTS AND CLEARANCE, MARKER, ID LIGHTS
BELTLINE LGTS GND
1216A WH 14 GA
CLR,MARKER LGTS GND
1203 WH 14 GA
BELTLINE LGTS GND
1216 WH 14 GA
1124 BK 14 GA
1315B BN 18 GA
P153
P153
1216F WH 12 GA
1322W LT BL 14 GA
REAR LED LIGHTS
1205D WH 14 GA
1322 LT BL 14 GA



Sheet 1 of 4

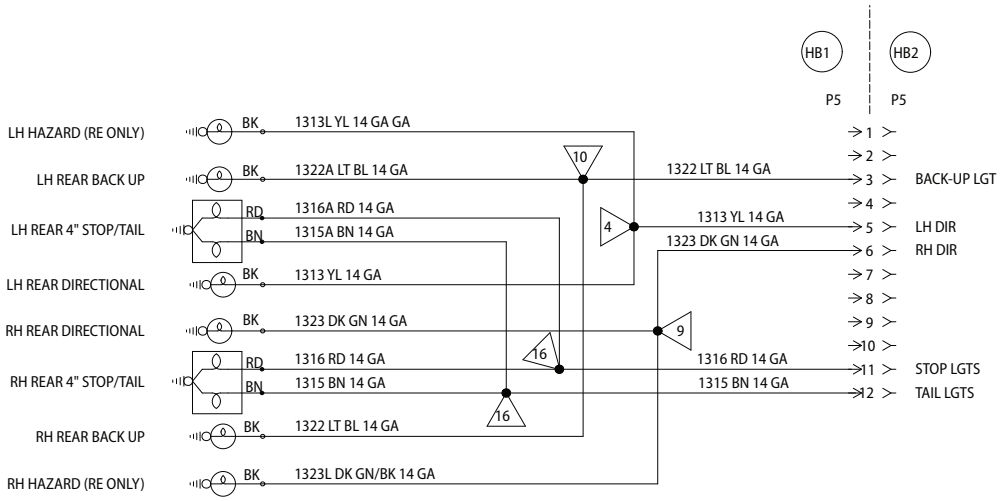
D0003105A

DIAGRAM,WRG,STANDARD EQUIPMENT

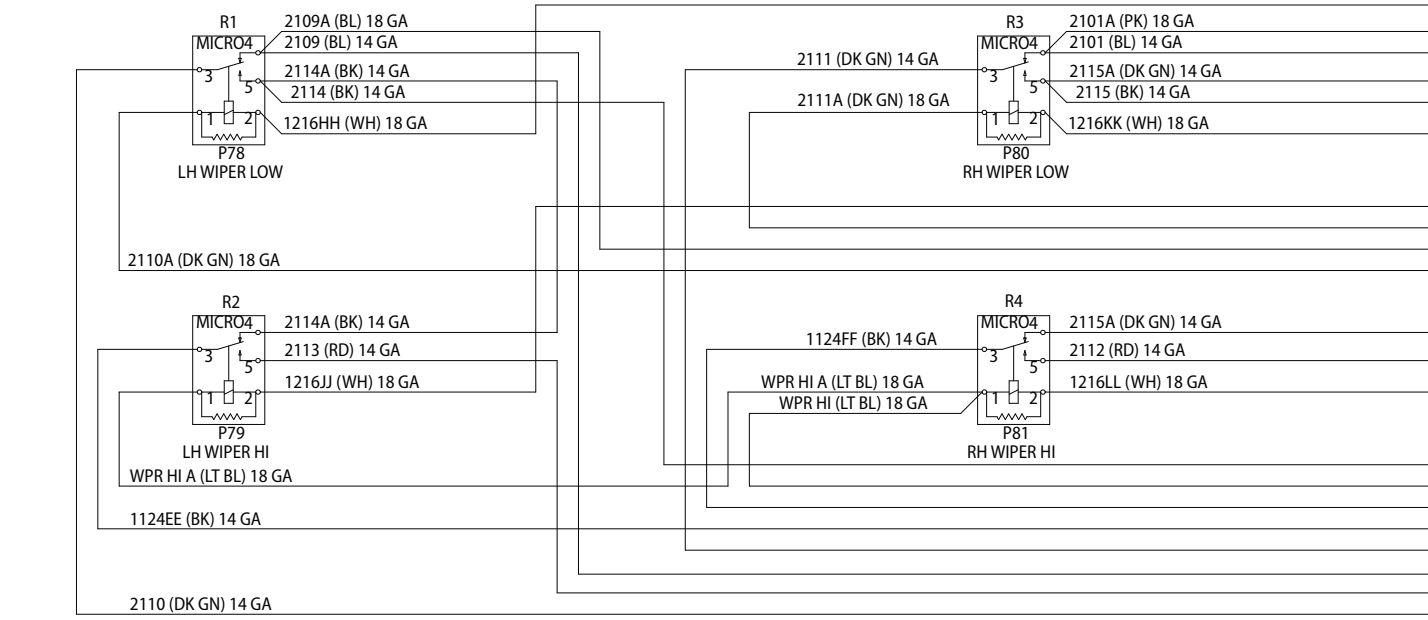


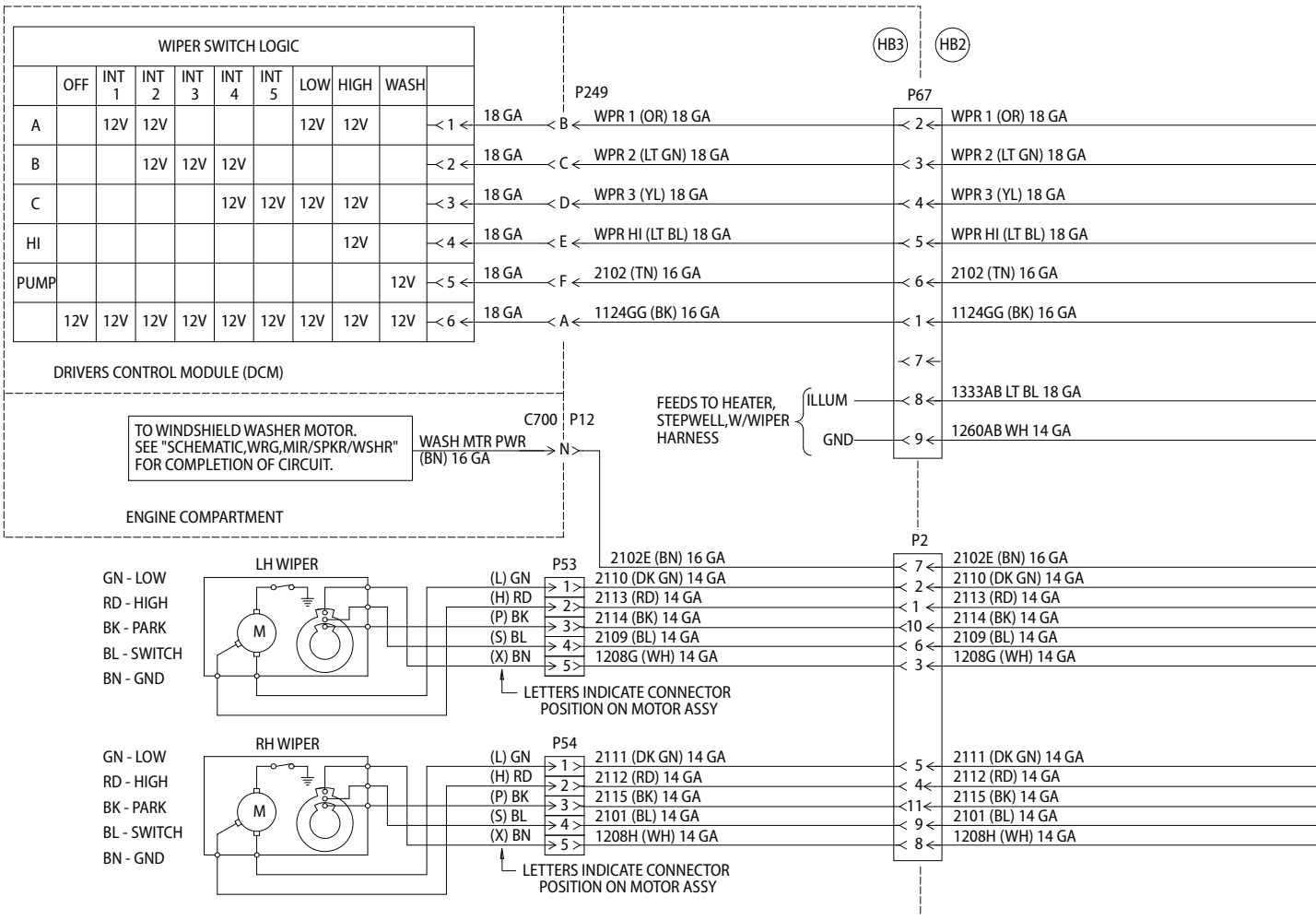
FEA 30105-04, 30101-06
LIGHTS INTERMEDIATE
REQUIRED ON UNITS
OVER 30'

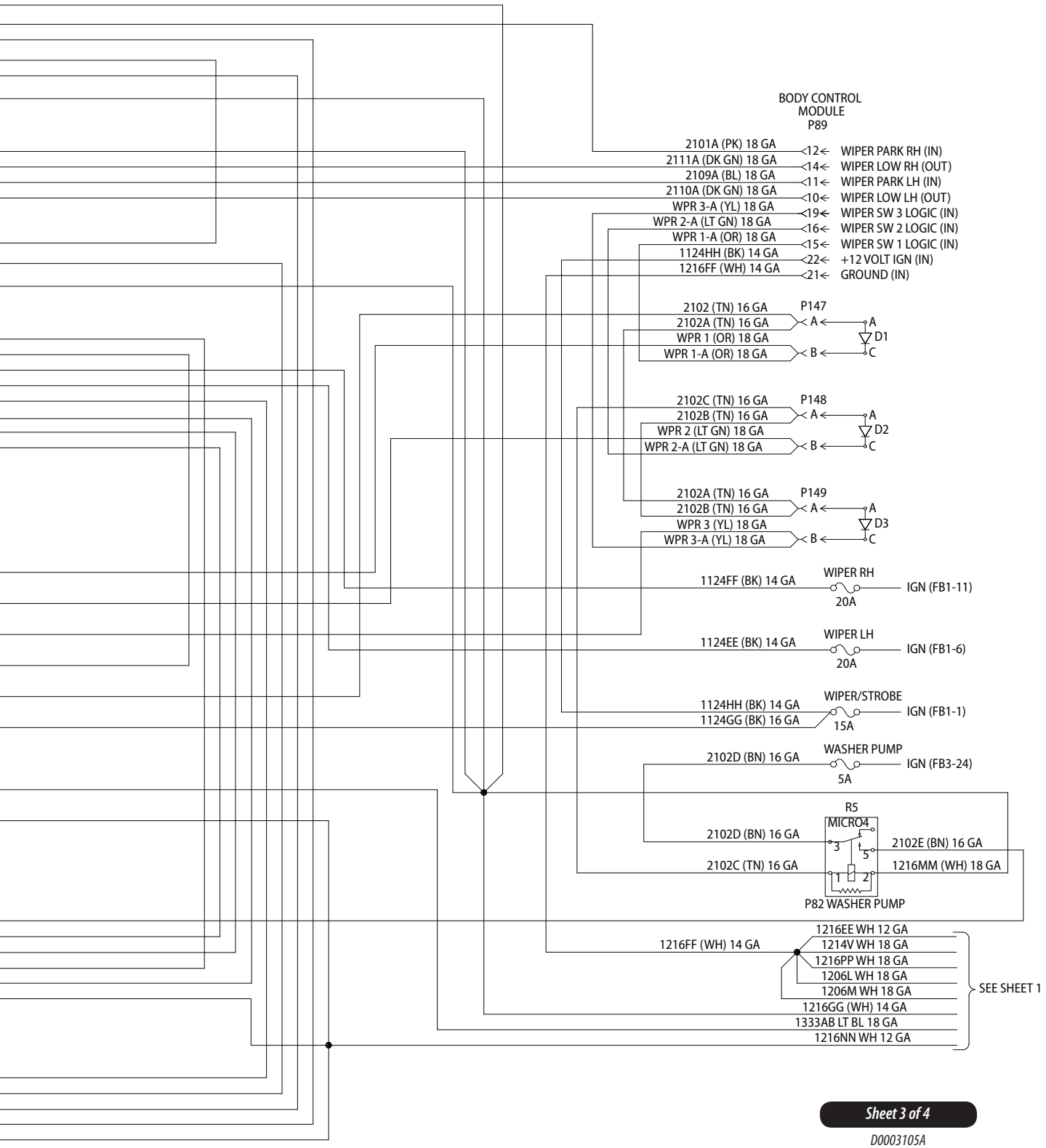
STANDARD
(CLEARANCE,MARKER,ID LIGHTS)
(FEAT 30101-03, 30102-04)
SEE SHEET 1



STANDARD
(BELTLINE LGTS)
SEE SHEET 1


R1
MICRO4
2109A (BL) 18 GA
2109 (BL) 14 GA
2114A (BK) 14 GA
2114 (BK) 14 GA
1216HH (WH) 18 GA
P78
LH WIPER LOW
R3
MICRO4
2101A (PK) 18 GA
2101 (BL) 14 GA
2111 (DK GN) 14 GA
2115A (DK GN) 14 GA
2111A (DK GN) 18 GA
2115 (BK) 14 GA
1216KK (WH) 18 GA
P80
RH WIPER LOW
2110A (DK GN) 18 GA
R2
MICRO4
2114A (BK) 14 GA
2113 (RD) 14 GA
1216JJ (WH) 18 GA
P79
LH WIPER HI
R4
MICRO4
2115A (DK GN) 14 GA
1124FF (BK) 14 GA
2112 (RD) 14 GA
WPR HI A (LT BL) 18 GA
1216LL (WH) 18 GA
WPR HI (LT BL) 18 GA
P81
RH WIPER HI
WPR HI A (LT BL) 18 GA
1124EE (BK) 14 GA
2110 (DK GN) 14 GA

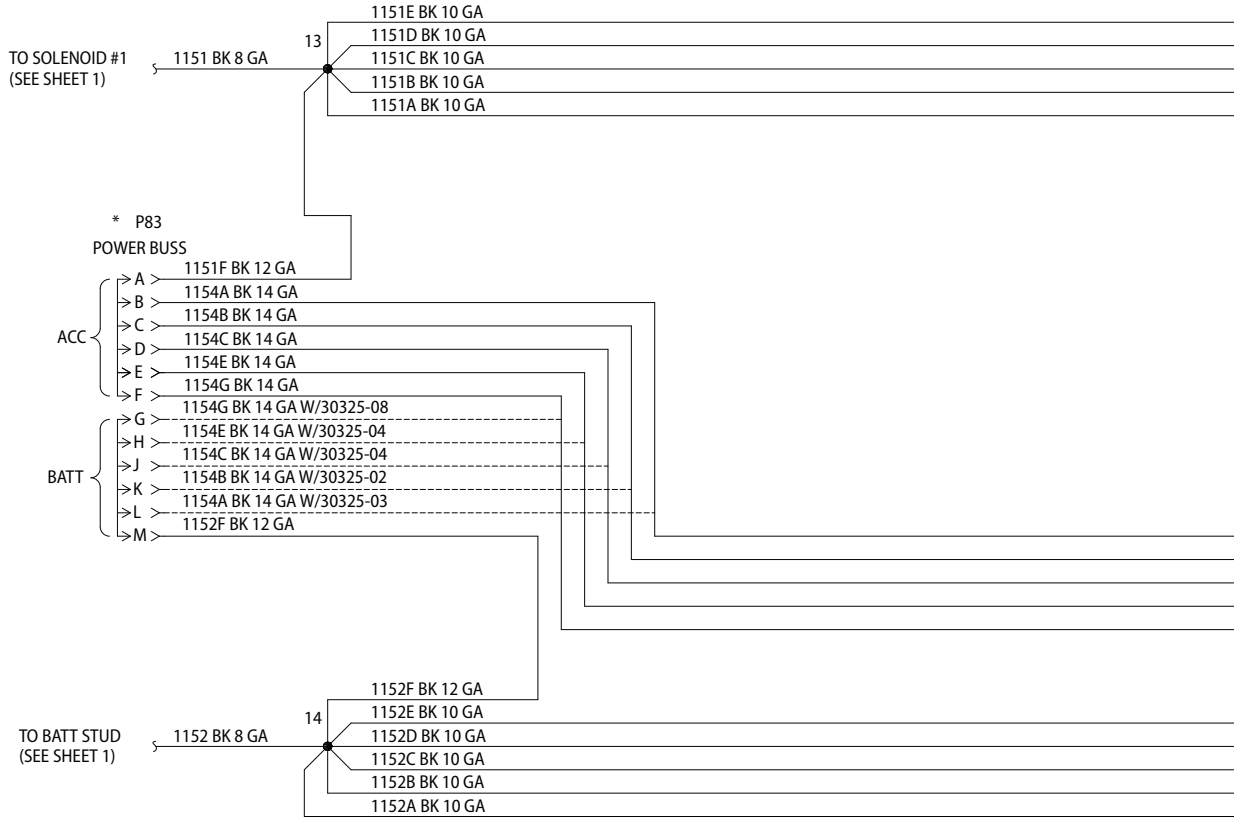

WIPER SWITCH LOGIC
OFF INT 1 INT 2 INT 3 INT 4 INT 5 LOW HIGH WASH
A 12V 12V 12V 12V
B 12V 12V 12V 12V 12V
C 12V 12V 12V 12V 12V
HI 12V 12V
PUMP 12V
12V 12V 12V 12V 12V 12V 12V 12V 12V
DRIVERS CONTROL MODULE (DCM)
HB3
HB2
P249
P67
18 GA B WPR 1 (OR) 18 GA 2 WPR 1 (OR) 18 GA
18 GA C WPR 2 (LT GN) 18 GA 3 WPR 2 (LT GN) 18 GA
18 GA D WPR 3 (YL) 18 GA 4 WPR 3 (YL) 18 GA
18 GA E WPR HI (LT BL) 18 GA 5 WPR HI (LT BL) 18 GA
18 GA F 2102 (TN) 16 GA 6 2102 (TN) 16 GA
18 GA A 1124GG (BK) 16 GA 1 1124GG (BK) 16 GA
7
FEEDS TO HEATER, STEPWELL,W/WIPER HARNESS
ILLUM 8 1333AB LT BL 18 GA
GND 9 1260AB WH 14 GA
TO WINDSHIELD WASHER MOTOR.
SEE "SCHEMATIC,WRG,MIR/SPKR/WSHR"
FOR COMPLETION OF CIRCUIT.
WASH MTR PWR (BN) 16 GA
C700 P12 N
ENGINE COMPARTMENT
P2
2102E (BN) 16 GA 7 2102E (BN) 16 GA
LH WIPER
GN - LOW
RD - HIGH
BK - PARK
BL - SWITCH
BN - GND
M
P53
(L) GN 1 2110 (DK GN) 14 GA 2 2110 (DK GN) 14 GA
(H) RD 2 2113 (RD) 14 GA 1 2113 (RD) 14 GA
(P) BK 3 2114 (BK) 14 GA 10 2114 (BK) 14 GA
(S) BL 4 2109 (BL) 14 GA 6 2109 (BL) 14 GA
(X) BN 5 1208G (WH) 14 GA 3 1208G (WH) 14 GA
LETTERS INDICATE CONNECTOR POSITION ON MOTOR ASSY
RH WIPER
GN - LOW
RD - HIGH
BK - PARK
BL - SWITCH
BN - GND
M
P54
(L) GN 1 2111 (DK GN) 14 GA 5 2111 (DK GN) 14 GA
(H) RD 2 2112 (RD) 14 GA 4 2112 (RD) 14 GA
(P) BK 3 2115 (BK) 14 GA 11 2115 (BK) 14 GA
(S) BL 4 2101 (BL) 14 GA 9 2101 (BL) 14 GA
(X) BN 5 1208H (WH) 14 GA 8 1208H (WH) 14 GA
LETTERS INDICATE CONNECTOR POSITION ON MOTOR ASSY



Sheet 3 of 4

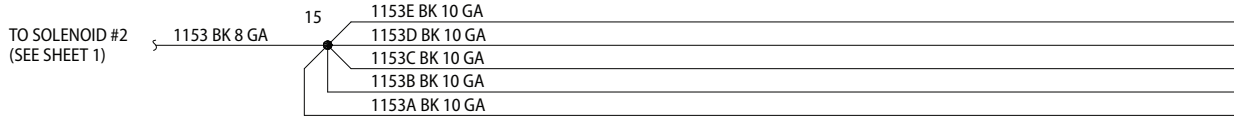
D0003105A

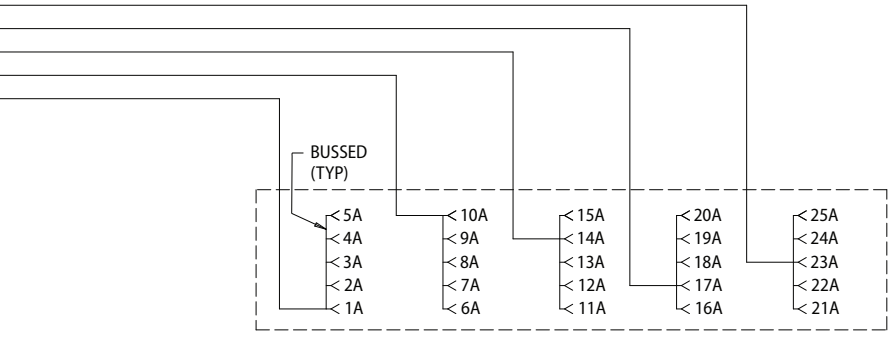
DIAGRAM,WRG,STANDARD EQUIPMENT



* CONNECTOR P83 ALLOWS SPECIFIED CIRCUITS TO BE ACCESSORY CONTROLLED OR BATTERY POWER CONTROLLED BASED ON OPTIONS. SEE CHART BELOW:

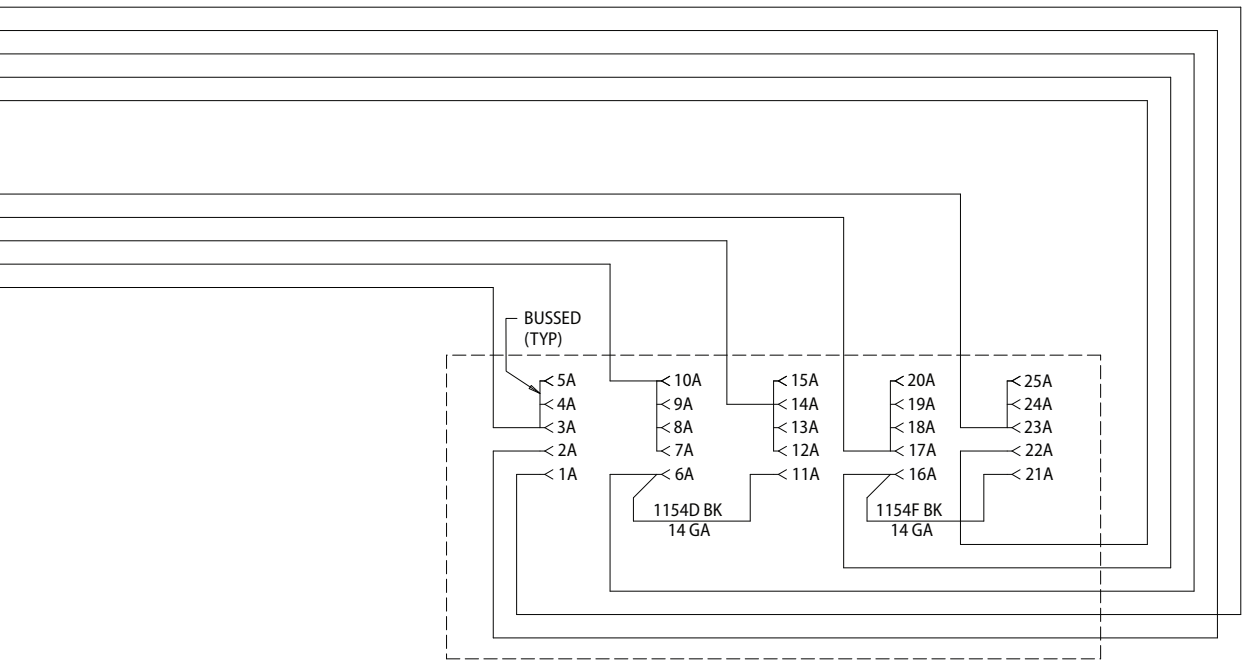
CIRCUIT	FUNCTION	FEATURE
1154A	CL/MR/ID LIGHTS	(30325-03)
1154B	WARNING LIGHT PWR	(30325-02)
1154C	DOME LIGHTS	(30325-04)
1154E	REAR SWITCHED DOME	(30325-04)
1154G	ENT DOOR PWR	(30325-08)



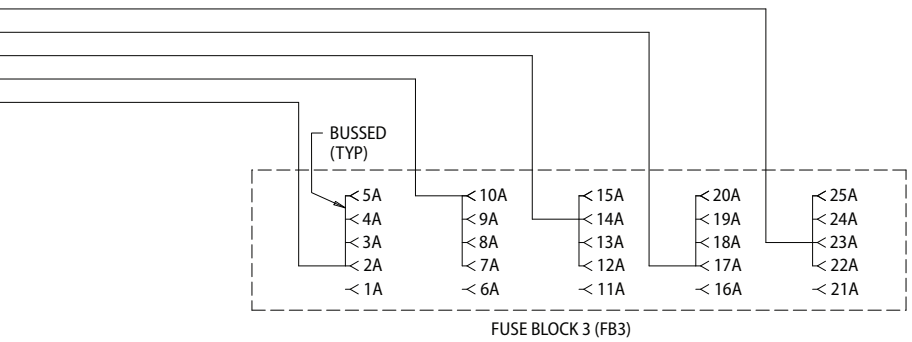


FUSE BLOCK 1 (FB1)

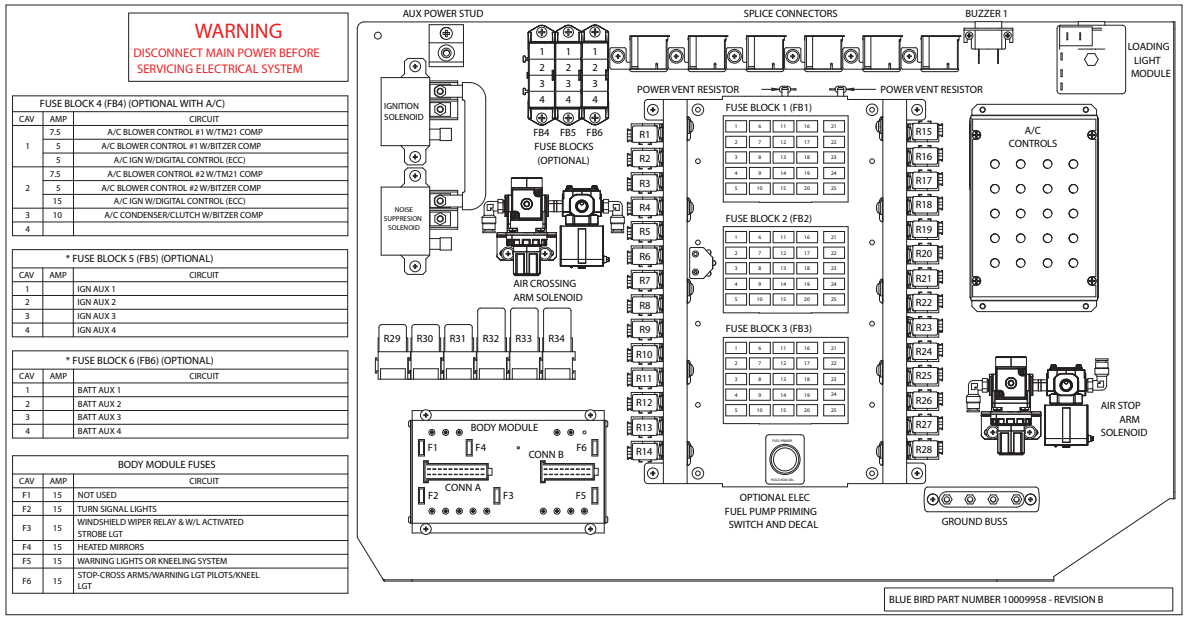
NOTE: THE NUMBERS LISTED IN THE DESIGNATED FUSE BLOCK LOCATIONS REPRESENT THE CONNECTOR POSITION FOR EACH CIRCUIT, NOT THE AMPERAGE RATINGS. EACH FUSE BLOCK HAS AN "A" POSITION AND "B" POSITION FOR EACH OF THE 25 FUSE/CIRCUIT BREAKER LOCATIONS. THE "A" POSITION IS ONLY SHOWN HERE TO REPRESENT THE PRIMARY/INPUT PORTION OF THE POWER DISTRIBUTION. THE SECONDARY/OUTPUT PORTION WILL BE SHOWN ON SHEET #1 OF THIS DRAWING AND ON OPTIONAL EQUIPMENT WIRING DIAGRAMS.



FUSE BLOCK 2 (FB2)



FUSE BLOCK 3 (FB3)



FUSE BLOCK 4 (FB4) (OPTIONAL WITH A/C)		
CAV	AMP	CIRCUIT
1	7.5	A/C BLOWER CONTROL #1 W/TM21 COMP
	5	A/C BLOWER CONTROL #1 W/BITZER COMP
	5	A/C IGN W/DIGITAL CONTROL (ECC)
2	7.5	A/C BLOWER CONTROL #2 W/TM21 COMP
	5	A/C BLOWER CONTROL #2 W/BITZER COMP
	15	A/C IGN W/DIGITAL CONTROL (ECC)
3	10	A/C CONDENSER/CLUTCH W/BITZER COMP
4		

* FUSE BLOCK 5 (FB5) (OPTIONAL)		
CAV	AMP	CIRCUIT
1		IGN AUX 1
2		IGN AUX 2
3		IGN AUX 3
4		IGN AUX 4

* FUSE BLOCK 6 (FB6) (OPTIONAL)		
CAV	AMP	CIRCUIT
1		BATT AUX 1
2		BATT AUX 2
3		BATT AUX 3
4		BATT AUX 4

BODY MODULE FUSES		
CAV	AMP	CIRCUIT
F1	15	NOT USED
F2	15	TURN SIGNAL LIGHTS
F3	15	WINDSHIELD WIPER RELAY & W/L ACTIVATED STROBE LGT
F4	15	HEATED MIRRORS
F5	15	WARNING LIGHTS OR KNEELING SYSTEM
F6	15	STOP-CROSS ARMS/WARNING LGT PILOTS/KNEEL LGT

Decal, Electrical Panel, Layout

10009958B

FUSE BLOCK 1 (FB1)					
CAV	AMP	CIRCUIT	CAV	AMP	CIRCUIT
1	15	I-O MODULE WIPER/STROBE	14		
2	10	MISC IGN	15		
3	15	2-WAY RADIO	16		
4	20	DEST SIGN	17	5	EXT LGT MONITOR
5	5	CONVECTION HTR	18	15	EXT HEATED MIRRORS
6	20	LH WIPER MTR	19	15	EXT LOADING LGTS
7	5	EMER REL - AIR DOOR IGN	20		
8	5	EXIT DOOR/NOISE SUPP WITH P.A.	21		
9	10	BACK-UP LGTS/NOISE SUPP	22	5	STEPWELL LGT
10	10	ROOF STROBE LGT	23	10	VIEDO MONITOR PWR
11	20	RH WIPER MTR	24	15	ADJUSTABLE PEDAL
12	5	LIFT PILOT	25		
13	5	TIRE CHAINS			

FUSE BLOCK 2 (FB2)					
CAV	AMP	CIRCUIT	CAV	AMP	CIRCUIT
1	15	CLPS/MRK/ID LGTS	14	5	SIDE EMERG DOOR VANDAL LOCK
2	20	W/L FLASHER PWR	15	10	SPL B/U AL ARM/LGTS
3	20	W/L EMER OVERRIDE SW	16	5	REAR SWITCHED DOME
4	5	FRONT STOP ARM MTR	17	20	STEP DE-ICER
5	5	REAR STOP ARM MTR	18	10	LUGG COMPARTMENT LGTS
6	10	STD DOME/RIGHT DOME/FRONT DOME	19	10	LIFT LOADING LGTS
7	5	CROSS ARM MTR	20	25	ROOF LOADING LGTS
8	20	ACC PWR SOCKET	21	5	DRIVERS DOME
9	20	COMPRESSOR-AIR DRS SEAT	22	5	ENT DOOR PWR (AIR)
				20	ENT DOOR PWR (ELEC)
10	30	AUX HTR	23	20	DOME LGTS ACTIVATED
11	10	LEFT DOME/REAR DOME	24	5	CHIME/REAR ALERT SIGN/LIFT DOOR ACTIVATE W/L'S
12	5	EXIT MONITOR/SCC	25		
13	5	RADIO/VCR MEM			

FUSE BLOCK 3 (FB3)					
CAV	AMP	CIRCUIT	CAV	AMP	CIRCUIT
1			14	20	L/REAR HTR MTR 1
2	5	RADIO IGN PWR	15	20	L/REAR HTR MTR 2
3	5	AUX FAN - CENTER	16		
4	30	AUX FAN - DUCTED	17	15	R/FRT HTR MTR 1
5	5	AUX FAN - LEFT	18	15	R/FRT HTR MTR 2
6			19	20	R/REAR HTR MTR 1
7	5	AUX FAN - RIGHT	20	20	R/REAR HTR MTR 2
8	20	EXHAUST FAN	21		
9	20	FRT STEPWELL HTR	22	35	MAIN HTR/DEFROSTER
10	15	HTR WATER PUPMP	23	3	REMOTE MIRRORS
11			24	5	WASHER PUMP
12	15	L/FRT HTR MTR 1	25		
13	15	L/FRT HTR MTR 2			

RELAYS/FLASHERS		
LOCATION	TYPE	DESCRIPTION
R29	MINI	FRONT LOADING LGT/CRIME ALERT/LIFT DOOR ACTIVATE W/L'S
R30	MINI	SPARE
R31	MINI	ADJ. PEDAL
R32	FLASHER	LIFT PILOT
R33	FLASHER	EXIT PILOT
R34	FLASHER	STOP ARM

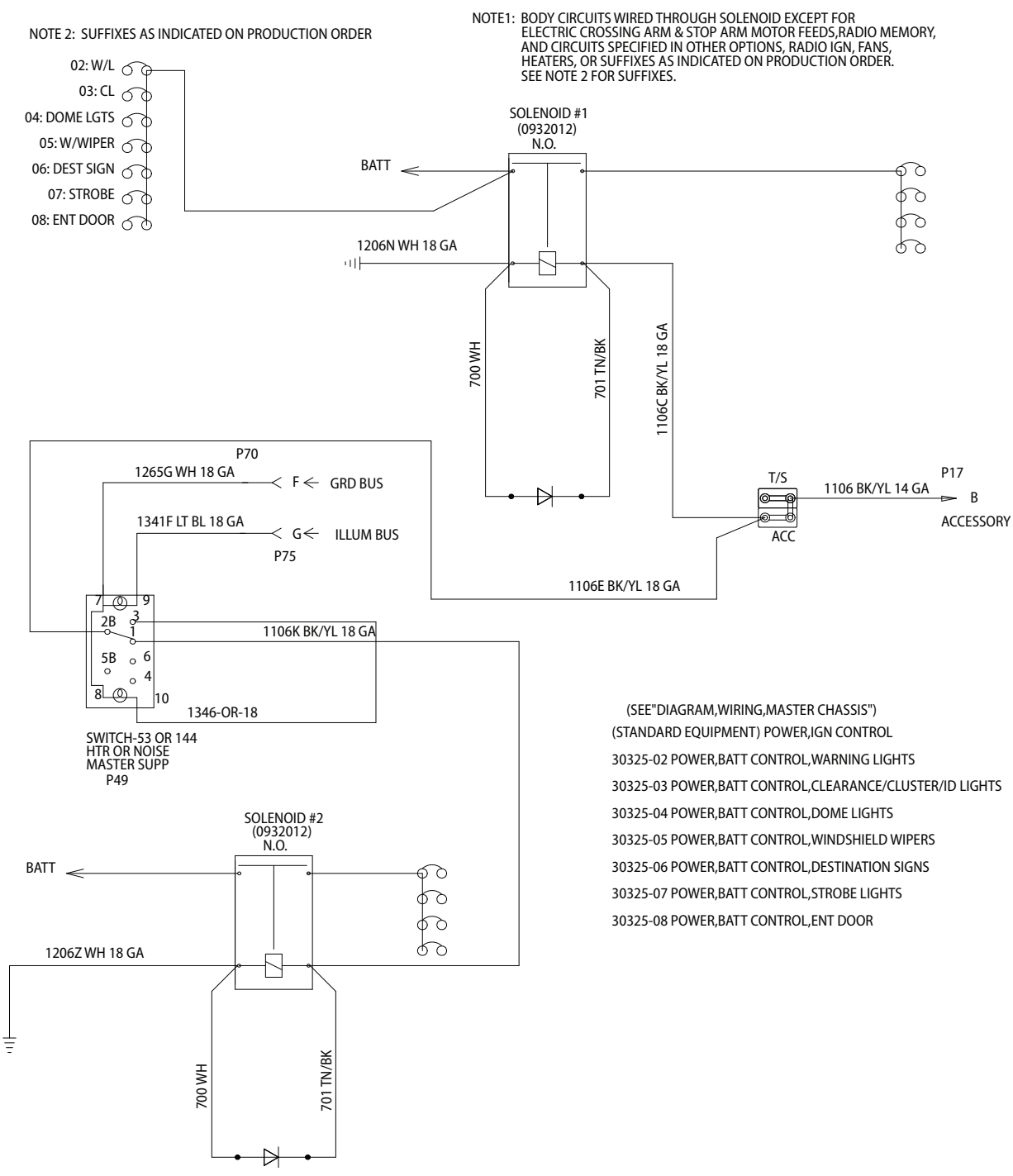
* NOTE: OPTIONAL FUSE BLOCKS FB5 & FB6 PROVIDE IGNITION AND/OR BATTERY POWER @ 20 AMPS PER POSITION. IT IS THE RESPONSIBILITY OF THE INSTALLER OF AUX CIRCUITS TO ENSURE SYSTEM AMPERAGE IS NOT EXCEEDED.

RELAY		
LOCATION	TYPE	DESCRIPTION
R1	MICRO	LH WIPER LOW
R2	MICRO	LH WIPER HIGH
R3	MICRO	RH WIPER LOW
R4	MICRO	RH WIPER HIGH
R5	MICRO	WASHER PUMP
R6	MICRO	BACK-UP LGTS
R7	MICRO	CL/MK/ID LGTS
R8	MICRO	WARNING LGT (W/L) SYSTEM PWR
R9	MICRO	W/L SWITCHING
R10	MICRO	W/L SWITCHING
R11	MICRO	STOP ARM CONTROL
R12	MICRO	W/L PILOT
R13	MICRO	W/L OVERRIDE SW
R14	MICRO	STOP ARM CANCEL
R15	MICRO	DOME LGT ACTIVATED-1 RELAY
R16	MICRO	DOME LGT ACTIVATED-2 RELAY
R17	MICRO	DOME LGT ACTIVATED-3 RELAY
R18	MICRO	FRT STEPWELL HTR
R19	MICRO	LH REAR WALL HTR MTR 1
R20	MICRO	LH REAR WALL HTR MTR 2
R21	MICRO	RH REAR WALL HTR MTR 1
R22	MICRO	RH REAR WALL HTR MTR 2
R23	MICRO	STEP DE-ICER
R24	MICRO	DOME LIGHT ACTIVATION
R25	MICRO	DESTINATION SIGN
R26	MICRO	A/C HIGH IDLE
R27	MICRO	COMPRESSOR - AIR SEAT / HEATED MIRROR TIMER RELAY
R28	MICRO	BACK-UP LGTS ACTIVATED

BLUE BIRD PART NUMBER 10010169 - REVISION B

Decal, Electrical Panel, Chart

10010169B



NOTE 3: ALL FANS. HEATERS. AND RADIO IGNITION TO BE CONNECTED THROUGH SECOND SOLENOID.

(SEE"DIAGRAM,WIRING,MASTER CHASSIS")
(STANDARD EQUIPMENT) POWER,IGN CONTROL
30325-02 POWER,BATT CONTROL,WARNING LIGHTS
30325-03 POWER,BATT CONTROL,CLEARANCE/CLUSTER/ID LIGHTS
30325-04 POWER,BATT CONTROL,DOME LIGHTS
30325-05 POWER,BATT CONTROL,WINDSHIELD WIPERS
30325-06 POWER,BATT CONTROL,DESTINATION SIGNS
30325-07 POWER,BATT CONTROL,STROBE LIGHTS
30325-08 POWER,BATT CONTROL,ENT DOOR

Charging System

The charging system provides electrical current for the lights, radio, heater blower and the engine's electrical systems. It also maintains the batteries in a charged state, recharging them as necessary to provide cranking power.

The charging system has three main components, or component areas: the alternator, the voltage regulator, and the battery.

The alternator is driven by a belt from the engine crankshaft and produces the electrical power to operate the systems on the bus. It also recharges the battery.

The voltage regulator acts as a "control valve" for the alternator output. It senses the current load and maintains a constant voltage in the charging system, independent of the current load, up to its rated output. The alternator on the Blue Bird All American has a "built in" voltage regulator as standard equipment. A remote regulator is available as an option. They are self excited (started) alternators.

The battery is the reservoir of chemical electrical power. Its primary purpose is to crank the engine. It also supplies power to the accessories for a short time when the demand is too high for the alternator alone (i.e., while the bus is at idle). Another key role of the battery is to act as a filter for the charging system by providing clean "electronic power" for the electronic control systems; ECU, ECM, TCM, and gauges.

Maintenance

Clean the alternator and all connection points. Dirt buildup restricting air flow through to the alternator will cause excessive heat and premature failure. Corrosion at any connecting point will produce resistance to current flow, heat and diminished power for the accessories.

Ensure that all the components in the charging system are mounted securely. Check the torque at all mounting bolts — both the bolts that hold the alternator in the mounting bracket and the bolts that secure the mounting brackets to the engine. The torque value for mounting bolts at the engine should be 70 - 80 ft. lbs. for a L/N and 55 - 59 ft. lbs. for a Bosch.

Blue Bird All American buses are equipped with an automatic belt tensioner. Ensure that all the grooves fit properly into the pulleys in the correct path. The drive belt should be inspected per the schedule in the maintenance chart located in the **Specs and Maintenance** chapter of this manual.

Also check:

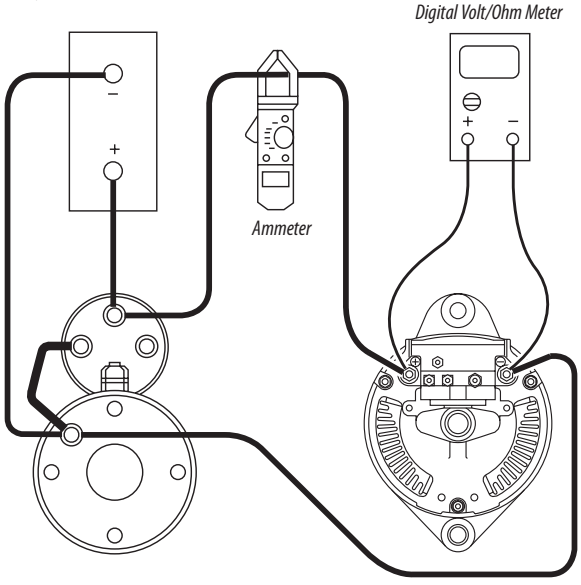
- Battery voltage
- Alternator output
- Starter current draw

Troubleshooting

Timely preventive maintenance of the charging system should keep it running smoothly. However, when a problem occurs, effective troubleshooting procedures will help locate and correct the problem quickly and economically.

WARNING ***Batteries emit an explosive gas. Never smoke while working on the charging system. Batteries can explode from a spark. Always remove the negative battery cable at the battery post before removing any other wires in the charging system. Be careful not to short the system while you are working on it. Do not wear jewelry.***

Before you begin to analyze the charging system, it is necessary that you ensure the battery is properly tested and charged to at least 75% of their rated capacity. Failure to confirm the condition of the battery will make the results of any diagnostic testing unreliable. Refer to the battery manufacturer's publications on battery maintenance and testing.



Alternator Performance Test

1. Connect a digital volt/ohmmeter (VOM) to the output terminals of the alternator.

   CAUTION ***Ensure that the test leads are connected properly. Observe the polarity and make secure connections.***

2. Connect an ammeter to the positive terminal of the alternator. Observe that the clamp on the ammeter is located at least 6 inches (15 cm) from the alternator to lessen the possibility of faulty readings due to spurious emissions.

3. Verify that the voltage output from the alternator is between 13.8 and 14.2 volts with the engine at operating RPM (1700 RPM minimum) and not idle.

4. Ensure that all "loads" are in the off position. The reading on the ammeter should be less than 20 amps.

   - If the amp reading is higher than 20 amps, ensure all accessories are turned off.

   - Ensure the battery is charged to at least 75% of their rated capacity.

5. Record the voltage. If the voltage is not within the specified range or the amperage is not within the specified range, the alternator is defective.

6. If the alternator is determined to be defective, repair or replace it in accordance with the instructions below. See Alternator Removal.

7. If the alternator is determined to be functioning properly, proceed as follows:

8. Continue to operate the engine at about 1700 RPM, and with the test equipment set up as illustrated.

9. Turn on vehicle loads (accessories) until the ammeter displays amps, 75% of the rated capacity of the alternator. Record the voltage at this point.

10. Compare the voltage reading with the voltage reading observed in Step 3 above.

11. If the alternator voltage drops more than .5 (1/2) volt, the alternator is defective.

An alternate method of checking the alternator under load is to use a carbon pile load. Connect the carbon pile across the battery and adjust it until the ammeter reads 75% of the alternator rated capacity. Record the voltage at this point, shut off the engine, and compare the readings.

Alternator Cable Tests

To test the positive alternator cable:

1. Clamp the ammeter on the positive cable at least 6 inches (15 cm) from the alternator. See Figure 2.

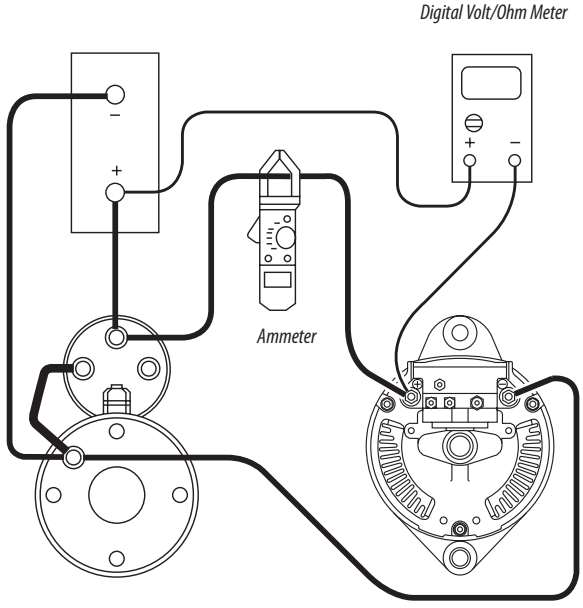
2. Connect the negative lead of the VOM to the positive post of the alternator.

3. Connect the positive lead of the VOM to the positive battery post.

4. Start the engine and let it run at about 1700 RPM.

5. Turn on accessories until the ammeter reads amps, which is 75% of the rated alternator capacity, Use a carbon pile if necessary to achieve the load.

6. Record the voltage reading on the VOM.



7. If the VOM reads more than -.25 volts, there is a problem with the positive cable.

   • Check and clean all the connections and the condition of all the cables/wires in the circuit.

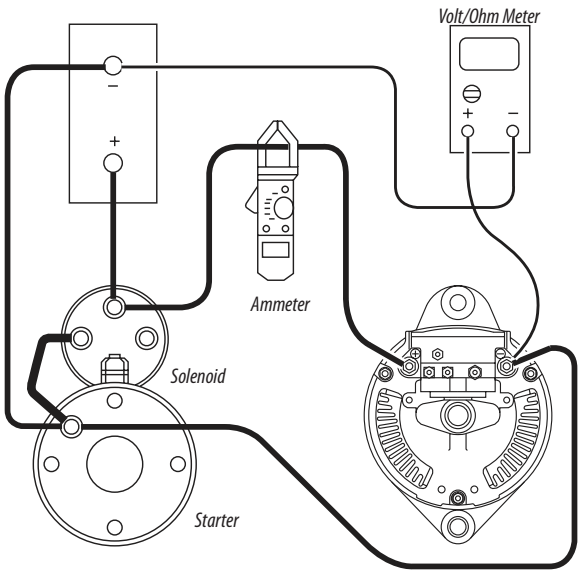
   • Re-test the circuit.

8. If the reading is less than -.25 volts, the cable and connections are good.

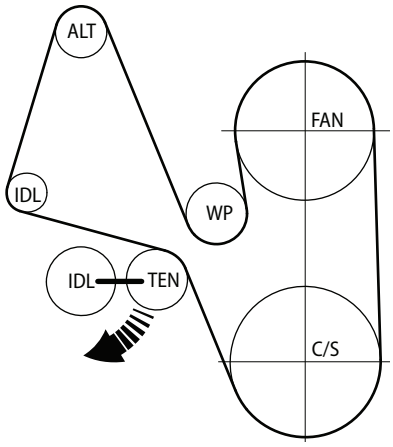
9. Connect the negative lead of the VOM to the negative terminal of the battery.

10. Connect the positive lead of the VOM to the negative terminal of the alternator.

11. Repeat Steps 4 through 8 for the negative cable.

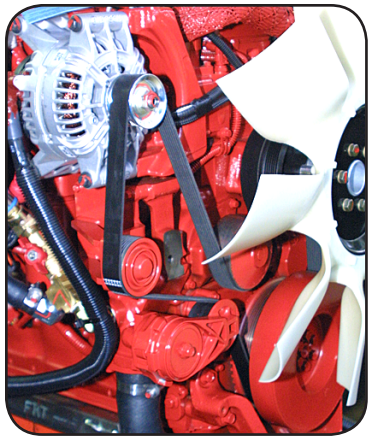


Alternator Removal



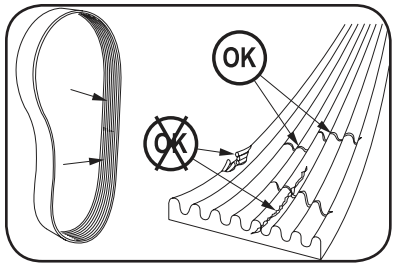
WARNING ***Always disconnect the negative (-) cable from the battery terminal first to avoid arcing, which could ignite explosive battery gases.***

1. Park the bus on a smooth, flat surface.
2. Chock the wheels in both directions.
3. Ensure the engine is not running, the ignition switch is in the "OFF" position and the key is removed.
4. Disconnect the negative (ground) cable from the battery post.
5. Using a square drive tool, position the automatic tensioner so that the drive belt can be removed.
6. Remove the drive belt.
7. Inspect the drive belt; discard it if any signs of wear are present.

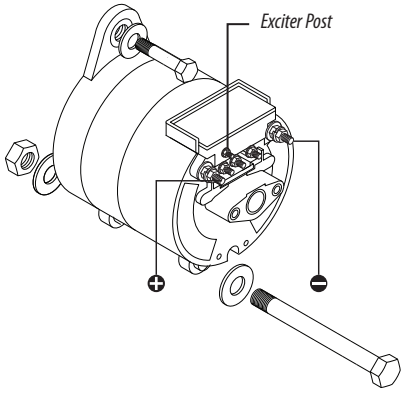


A few minor cracks across the belt are acceptable. Longitudinal cracks are NOT acceptable. Replace the drive belt when any crack is observed to be running lengthwise or with the belt, or when the belt appears frayed.

WARNING ***Always disconnect the negative (-) battery cable at the battery before removing any wiring from the alternator.***



8. Remove the negative (-) cable from the alternator.
9. Remove the positive (+) cable from the alternator.
10. Support the alternator and remove the mounting bolts.
11. Remove the alternator.



Alternator Reinstallation

Installation of the alternator is accomplished in the reverse order of the removal instructions above.

1. Position the alternator to the saddle.
2. Install the alternator mounting bolts.

3. Torque bolts to 70 - 80 ft. lbs. for Leece Neville and 55 - 59 ft. lbs. for Bosch alternators.

4. Install the positive cable on the B+ post. Carefully tighten to avoid breaking or stripping the stud.

5. Install the negative cable on the B- post. Carefully tighten to avoid breaking or stripping the stud.

6. Before installing the drive belt, inspect it closely. Replace the belt if any signs of wear are present.

7. Using a square drive tool, position the automatic tensioner so that the drive belt can be installed. Install the belt and ensure that the grooves in the belt fit properly on all the pulleys.

Automatic Belt Tensioner

The automatic tensioner is spring loaded to provide the proper tension for the drive belt.

The automatic tensioner should travel at least 71º, and the torque to move the tensioner 25º from the "at rest" position must be 9 – 11 ft lb (12.4 – 15.8 Nm). Inspect the belt tensioner for any unusual noise, excessive looseness and shaking at the bearings.

Automatic Tensioner Removal

1. Remove the drive belt in accordance with the instruc-tions above.

2. Remove the capscrew (1) from the automatic ten-sioner. See Figure 8.

To install a new automatic tensioner, reverse the removal instructions. Torque the capscrew (1) to 28 – 42 ft lb (38 – 56 Nm).

Starter

There are 5 main components or component areas in the starting system: the ignition switch, a neutral safety switch, the starter solenoid, the starter motor and the batteries.

When the key is turned to the start position, electrical current flows to the starter solenoid from the batteries. The flow is interrupted if the transmission shift lever is not in the neutral position or if the neutral sensor switch is defective.

The starter solenoid is an electromagnetic switch mounted on the starter motor. When electric current energizes coils inside the solenoid, a magnetic field is induced which pulls a plunger. At one end of this plunger is a lever. The lever is connected to the starter drive pinion of the starter motor. The plunger also connects the electrical power from the batteries to the starter motor as the drive pinion engages the flywheel ring gear.

The starter motor is a relatively small electric motor, but it can deliver large amounts of torque for a short time.

When the operator releases the ignition switch it returns to the run position. The solenoid is disconnected from the batteries and the magnetic field collapses. This allows the spring in the solenoid to move the plunger in the opposite direction, disengaging the drive pinion from the flywheel and removing electrical current from the starter motor.

The Blue Bird All American has a 12-volt electrical system.

Preventative Maintenance

There are two preventative maintenance procedures that can greatly enhance the efficiency of the starting system. These two steps are also the first two steps taken when troubleshooting a malfunctioning starting system.

- An engine that needs a tune up will be difficult to crank; over cranking will lead to starter motor failure.
- Poor connections due to road dirt, grease, corrosion, loose connectors, or broken insulation at any connecting point rob the starting system of electrical power and cause it to over-crank.

Troubleshooting

Before beginning to troubleshoot the starting system, ensure the batteries are properly maintained and charged to at least 75% of their rated capacity. A drained battery will cause any further diagnostic tests to be inaccurate. Common causes of starting system malfunction include:

1. A battery that is low, poorly charged, or defective places high demands on the starting system; voltage at the battery should be 12.6 to indicate a fully charged battery. If the batteries aren't adequately charging, a problem in the charging system. Refer to the Alternator section of this Service Manual for information on the charging system.

2. A starter motor can be damaged by heat that is generated by excessive cranking. The starter should never be engaged for more than 30 seconds. It must "rest" (cool off) a minimum of 2 minutes between starting attempts.

3. Loose, dirty, or corroded connections in the starting system rob the system of the power needed to turn the engine. The case of the starter motor is the ground or "return" connection for the starter motor and solenoid.

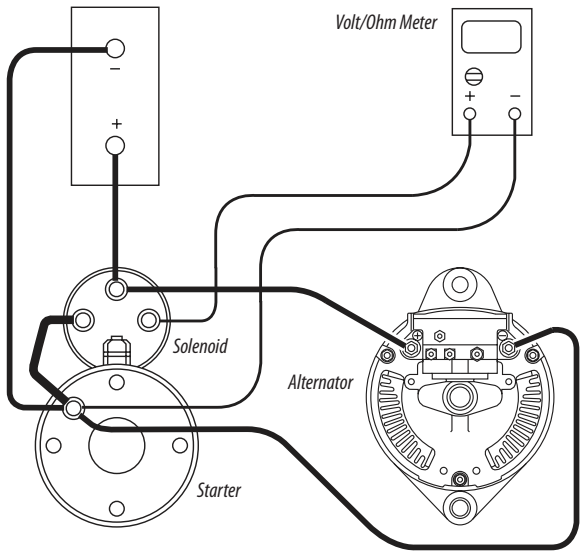
4. A loose starter motor will allow vibration that can damage the motor. In addition, the ring gear could be damaged.

5. A defective solenoid will fail to engage the starter drive pinion of the starter motor. A failed pull-in coil will cause the plunger to fail to pull in. A failed hold-in coil may cause the starter to fail to stay engaged, or may fail to switch the starter motor on. If the solinoid is suspect, test the wiring of the solenoid circuit before replacing the solenoid.

WARNING ***DO NOT use starting fluid as an aid to starting the engine. This could cause an explosion resulting in personal injury or death.***

Ignition/Run Test

Begin by determining whether the problem is with the ignition switch or the pilot relay, and their associated wiring; or if it is in the solenoid and/or starting motor. To begin with the ignition switch:



1. Connect the positive lead of a VOM to the ignition switch terminal on the solenoid.

2. Connect the negative lead of the VOM to the chassis ground.

3. While attempting to crank the engine, record the voltage displayed on the VOM. Observe the following:

   - No voltage
   - Low voltage
   - Normal voltage with slow cranking
   - Normal voltage with no cranking at all.

4. Connect a remote start switch to the positive battery post.

5. Connect the other end of the remote start switch to the ignition post of the solenoid.

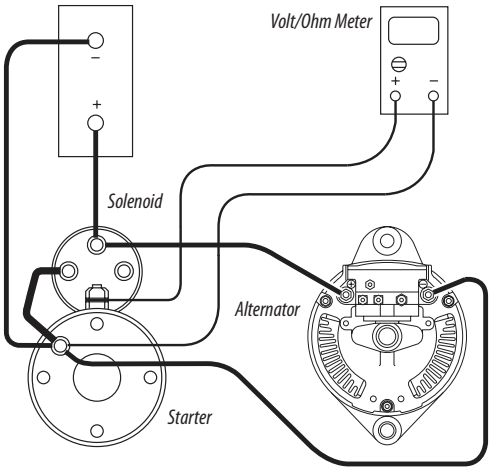
6. Attempt to crank the engine with the remote switch. Record the voltage displayed on the VOM. If there is less than 1 volt difference from the previous reading, the ignition switch is okay. If there is more than 1 volt difference, the switch is defective.

7. With the VOM negative lead connected to the chassis ground, move through the switch system one connection at a time. If your first voltage test has revealed low voltage, the starter motor may be shorted.

8. If the first voltage test indicated normal voltage, but there is slow cranking or no cranking at all, a problem with the batteries, battery cables, or a damaged starter motor is indicated.

Low Voltage Test

There are various reasons for low voltage but the troubleshooting methods are the same. If the solenoid clicks, it means that either current is flowing through the solenoid contacts but not through the main contacts; or that the current through the main contacts is insufficient due to low batteries.

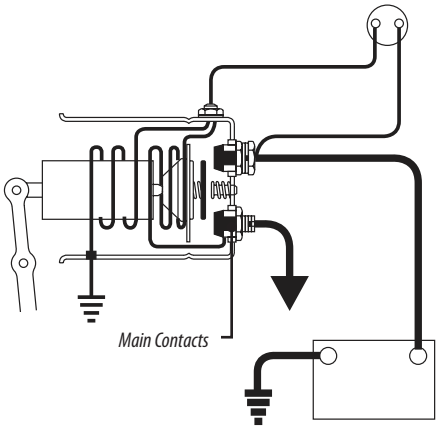


1. Connect the positive lead of the VOM to the starter motor terminal of the solenoid.

2. Connect the negative lead of the VOM to the chassis ground.

3. While attempting to crank the engine, if there is no voltage displayed on the VOM, the main contacts are not functioning properly.

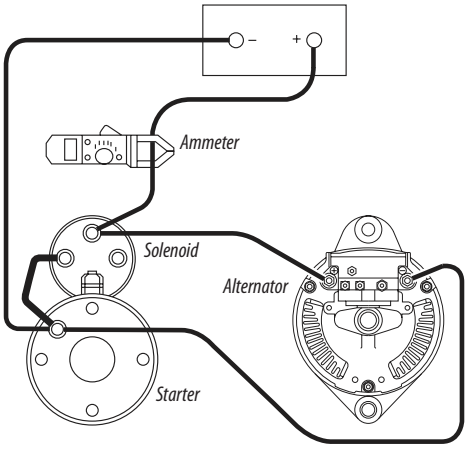
4. If there is voltage present at the solenoid terminal during Step 3, the problem is in the starter motor or its cabling.



5. If the first voltage check in Step 3 under Ignition/Run Test indicated normal voltage but slow or no cranking, the next step is to check the starter motor and its connections.

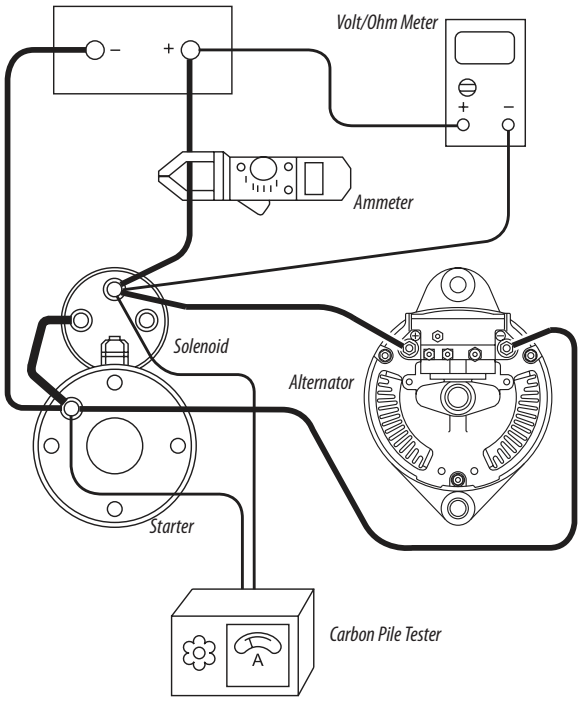
6. If the drive pinion jumps out of mesh with the flywheel ring gear, check for a broken or loose ground wire at the solenoid.

7. While attempting to crank the engine, place an ammeter on the positive battery cable. If the power drain is higher than the OEM specifications, the starter motor is defective. An exception would be if the engine was not properly tuned or is difficult to turn over; in which case, a new starter motor would be a temporary fix.



Slow Cranking

Sluggish cranking can be caused by a small amount of extra resistance in the cranking circuit. This extra resistance can come from loose or dirty (corroded) connections, or broken wires and/or cables. First check the positive cables and connections of the starter motor, then the negative circuit.



1. Connect the positive lead of a VOM to the positive battery terminal.
2. Position an ammeter between the solenoid and the positive terminal of the solenoid.
3. Connect the negative lead of the VOM to the positive terminal of the solenoid.
4. Connect the negative lead of the VOM to the negative battery post. This is the "unloaded" voltage. Record the reading; leave the VOM connected.
5. Connect one lead of a carbon pile tester to chassis ground.
6. Connect the other lead from the carbon pile tester to the positive terminal of the solenoid.
7. Adjust the carbon pile tester until the ammeter on the tester reads 500 amps.
8. Record the voltage display on the VOM; it should not be less than 0.4-volts less than the unloaded value.
9. Turn the carbon pile tester to the "OFF" position.
10. Connect the positive lead of the VOM to chassis ground.
11. Connect the negative lead of the VOM to the negative battery post. Record the reading; leave the VOM connected.
12. Position the ammeter in on the negative battery cable.
13. Turn on the carbon pile tester and adjust it to read 500 amps.
14. Record the voltage on the VOM; standard guidelines state it should not drop more than 0.5-volts from the unloaded reading. Depending on electrical options installed on the bus voltage drop may be more.

15. Turn the carbon pile tester to the OFF position.

16. If the voltage drop was more than 0.5-volts (depending on options) in step 8, the positive cabling is defective. Look for a broken cable or a loose or corroded connection.

17. If the voltage drop in step 14 is more than 0.4 volts, look for a problem in the negative cabling; look for broken or defective cables, and loose or corroded connections.

Final check at solenoid terminals.

1. Disconnect the carbon pile tester.

2. Disconnect the VOM.

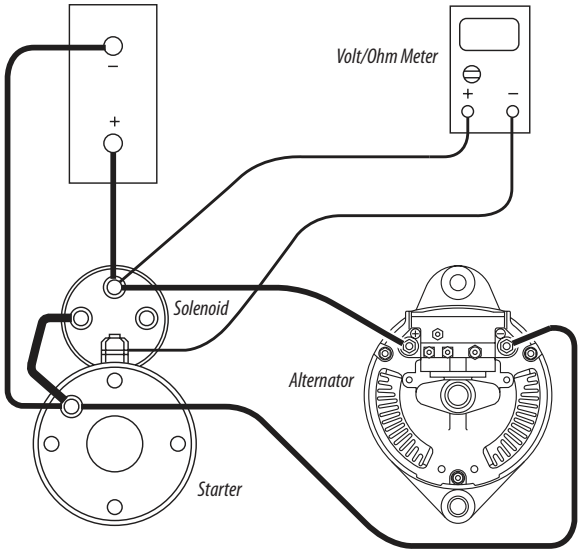
3. Remove the ammeter.

4. Connect the positive lead of the VOM to the positive (battery) terminal of the solenoid.

5. Set the VOM so that it can read the full battery volt-age; at least 14 volts.

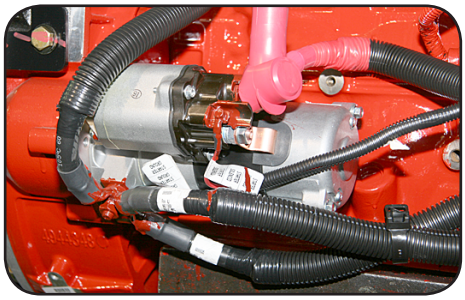
6. Connect the negative VOM lead to the starter motor terminal of the solenoid.

7. Crank the engine and record the voltage while cranking. There should be no more than 0.2 volts drop between the solenoid contacts while cranking.



8. The voltage reading in these last three tests (the positive cable check, the negative cable check and the solenoid test), should not total more than 1.0 volts. If the voltage drop is more than allowable, repeat the cable tests using a jumper cable. If the tests then indicate an acceptable drop, the cable(s) is (are) defective.

Starter Motor Removal



1. Disconnect the negative (ground) cable from the battery. Wrap it with tape or other suitable insulation to prevent shorts.
2. Disconnect positive cable from the battery. Wrap it with tape or other suitable insulation to prevent shorts.
3. Identify and tag each wire on the starter motor for reinstallation.
4. Remove all electrical connections from the starter motor. Be sure to identify and tag all electrical connection locations.
5. Remove 3 capscrews.
6. Remove starter motor from flywheel housing.

Starter Motor Installation

The starter motor is installed in the reverse order of the removal instructions above.

1. Carefully place the starter motor into position on the flywheel housing.
2. Install 3 capscrews (1). Torque to 32 ft lb (43 Nm). See Figure 8.
3. Being careful to observe the identification of the electrical wires, connect the wires to the appropriate terminal on the starter motor. See Figure 7.

WARNING ***Always remove the negative (-) cable from the battery terminal first. Always connect the negative (-) cable to the battery terminal last to avoid arcing that could ignite explosive battery gases.***

4. Install the positive cable on the battery post.
5. Install the negative cable on the battery post.

J-1939 Harness Diagnostics

1. Disconnect battery or J-1939 connector from the engine, ABS, transmission and instrument panel.

2. Measure resistance between pin A and pin B. Reading should be 60 ohms +/-1% (0.6 ohms).

3. Meassure resistance between pin A and ground. Reading should be infinity (maximum resistance).

4. Meassure resistance between pin B and ground. Reading should be infinity.

5. If all readings are correct, and problem appears to be intermittent:

   5.1 Inspect each connector for positive lock connection.

   5.2 Inspect for corrosion.

   5.3 Inspect for damage to connectors.

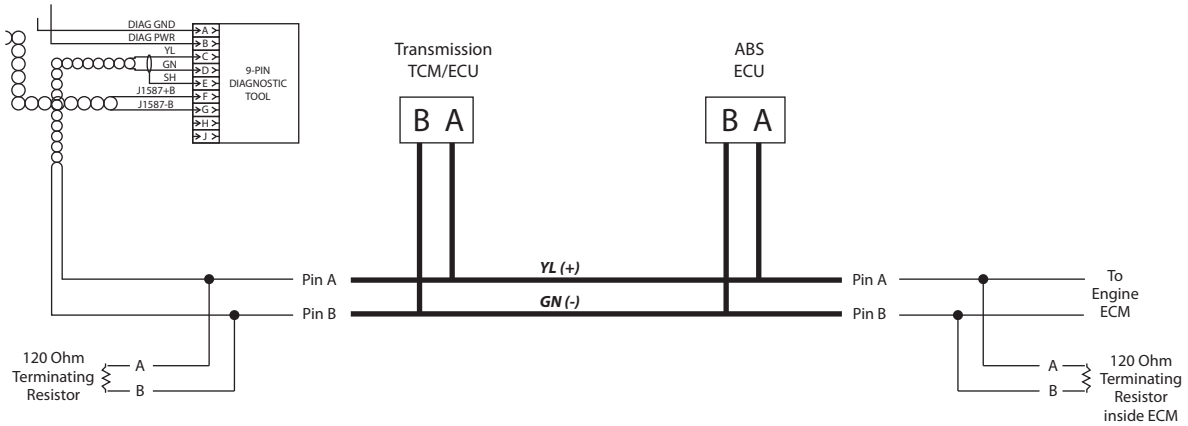
6. If resistance between pins A and B is 120 ohms, one of the terminating resistorsis missing or bad.

7. If reading between pins A and B is infinity:

   7.1 One of the connectors is unplugged.

   7.2 Both resistors are bad or missing.

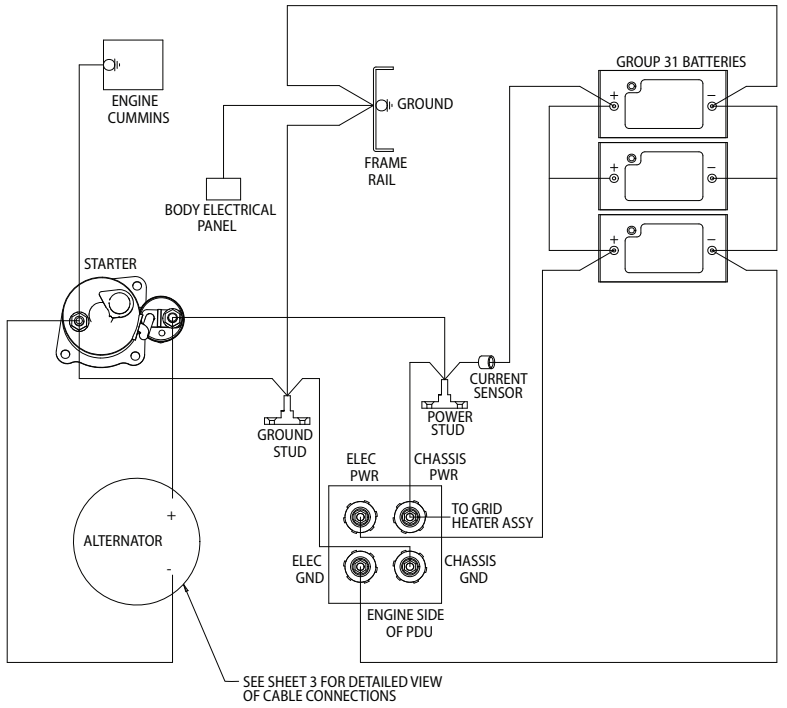
   7.3 A connector is damaged



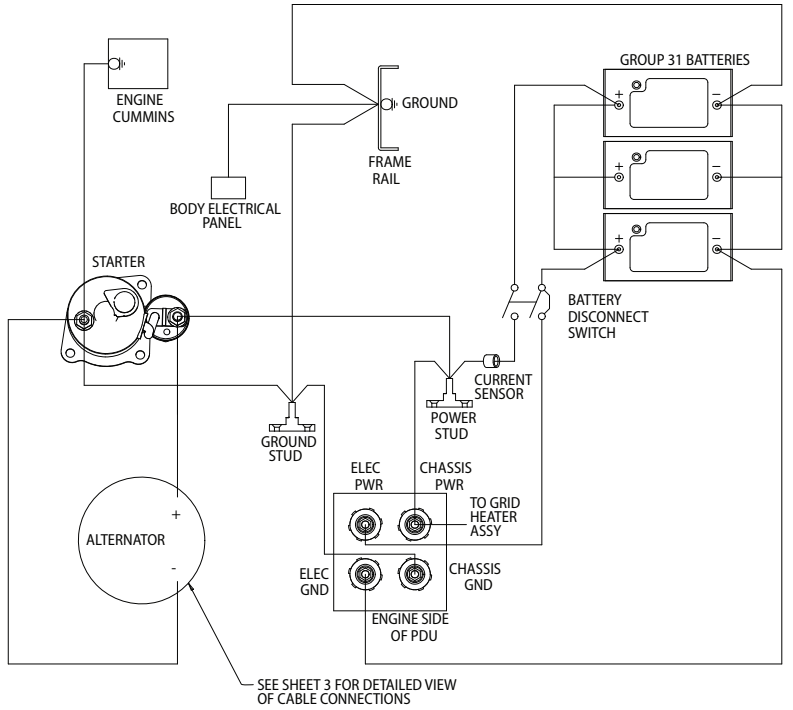
Chassis Harness Routing Diagrams

The following pages illustrate the routings of the main chassis wiring harnesses applicable to most Vision chassis.

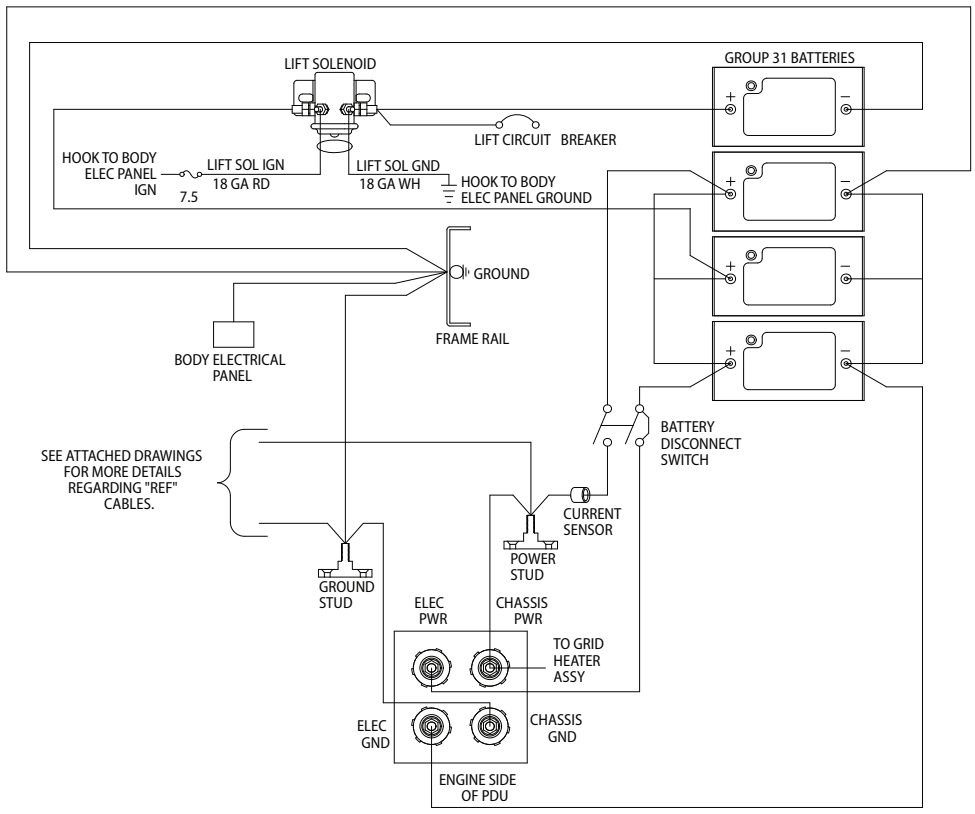
CUMMINS ENGINE, GROUP 31 BATTERIES, NO BATTERY DISCONNECT SWITCH



CUMMINS ENGINE, GROUP 31 BATTERIES, WITH BATTERY DISCONNECT SWITCH



BATTERIES, 3 GROUP 31 & 1 ISOLATED FOR LIFT



Chassis Harness Routing Sheet 1 of 7

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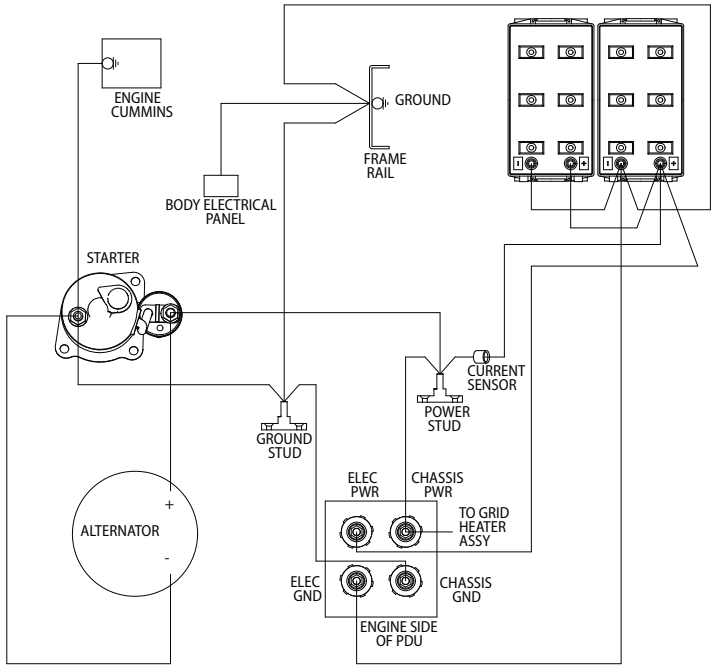
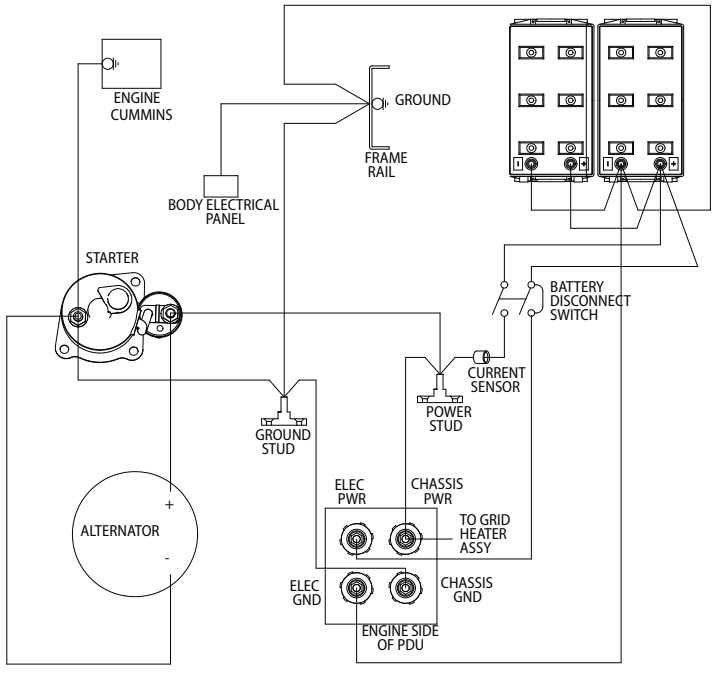
DIAGRAM, RTG, HARNESS, ISB10

CUMMINS ENGINE, 8D BATTERIES, NO BATTERY DISCONNECT SWITCH



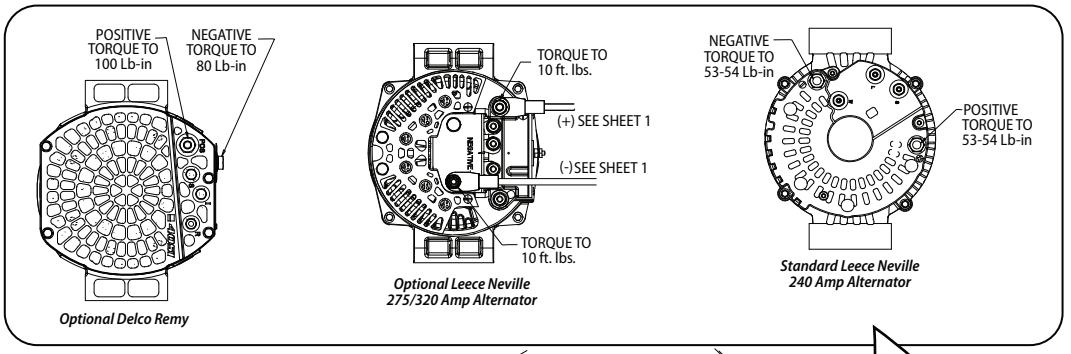
CUMMINS ENGINE, 8D BATTERIES, WITH BATTERY DISCONNECT SWITCH

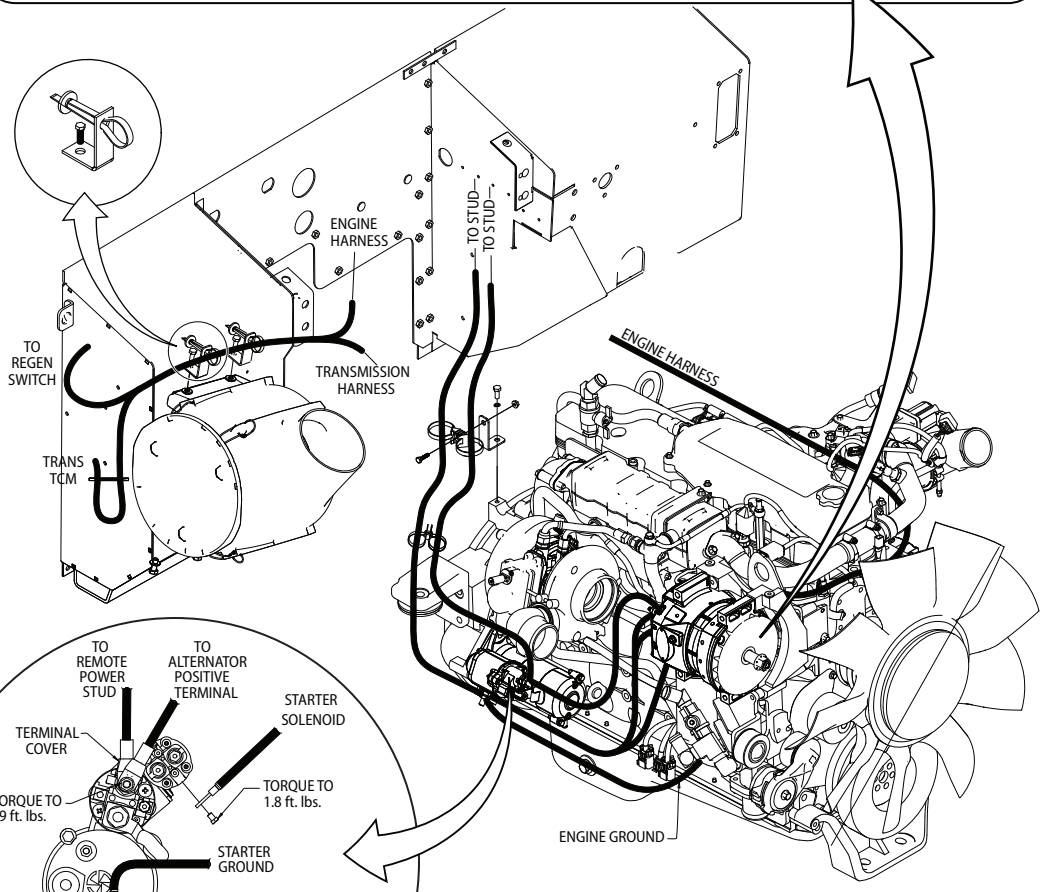


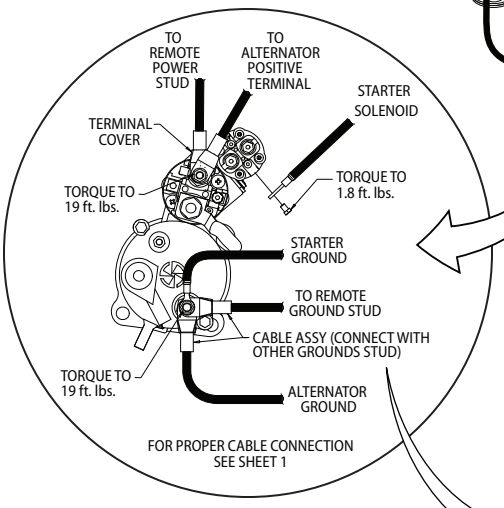
Chassis Harness Routing Sheet 2 of 7

D0003829F

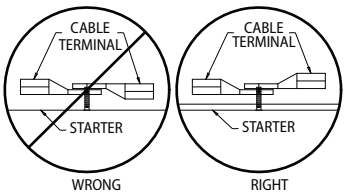
DIAGRAM, RTG, HARNESS, ISB10



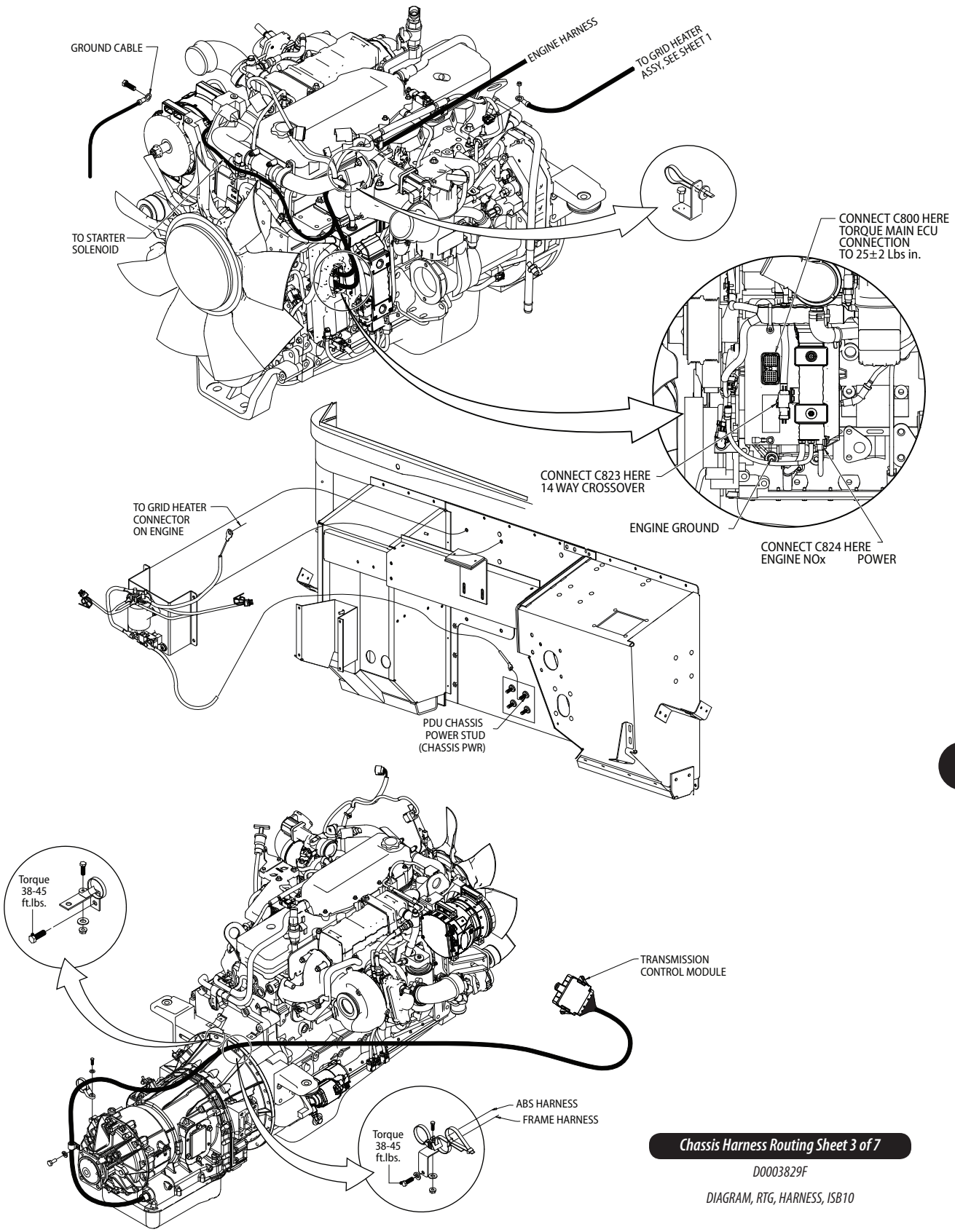




Starter Detail



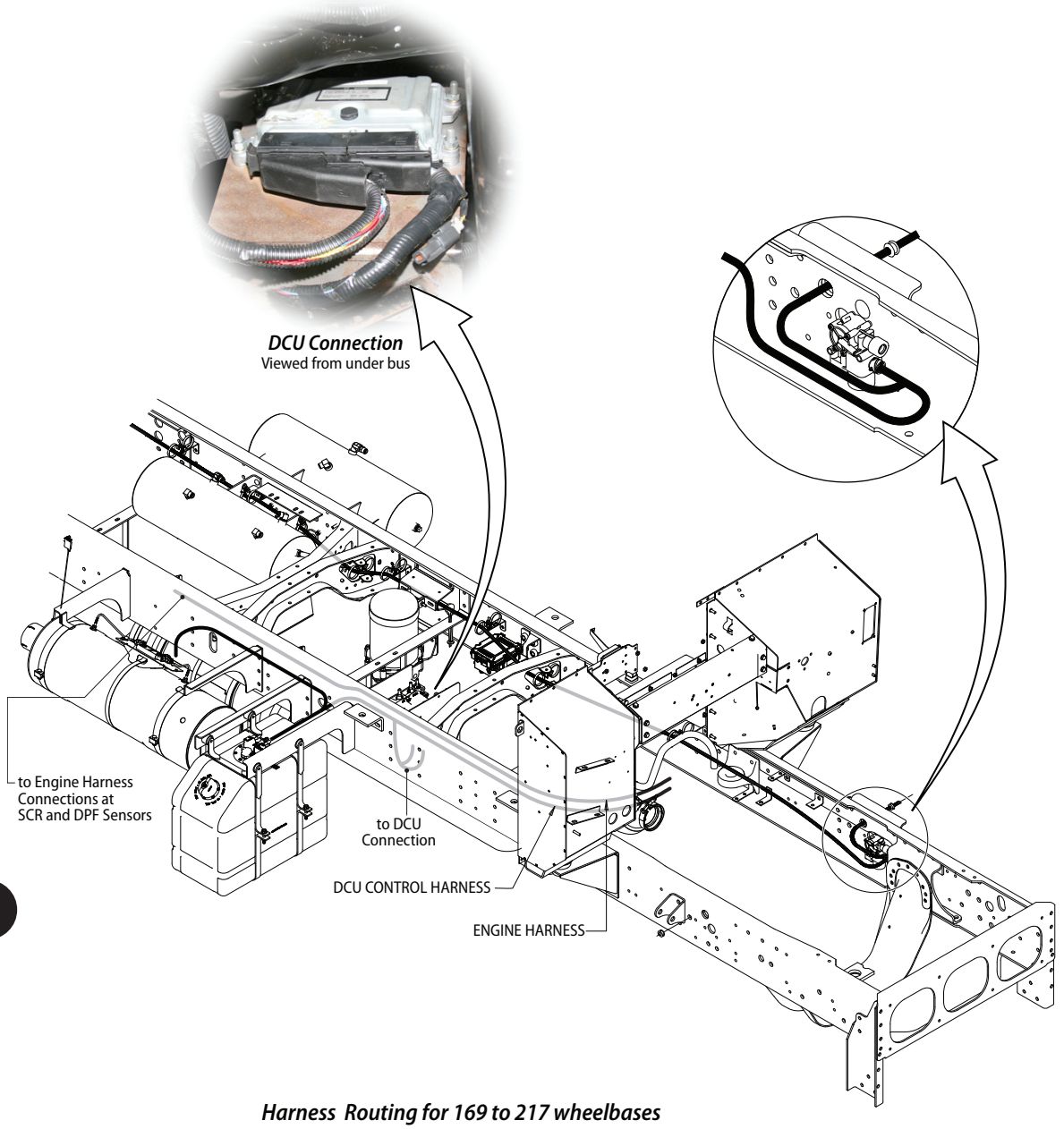
Cable Terminal Connection Detail



Chassis Harness Routing Sheet 3 of 7

D0003829F

DIAGRAM, RTG, HARNESS, ISB10



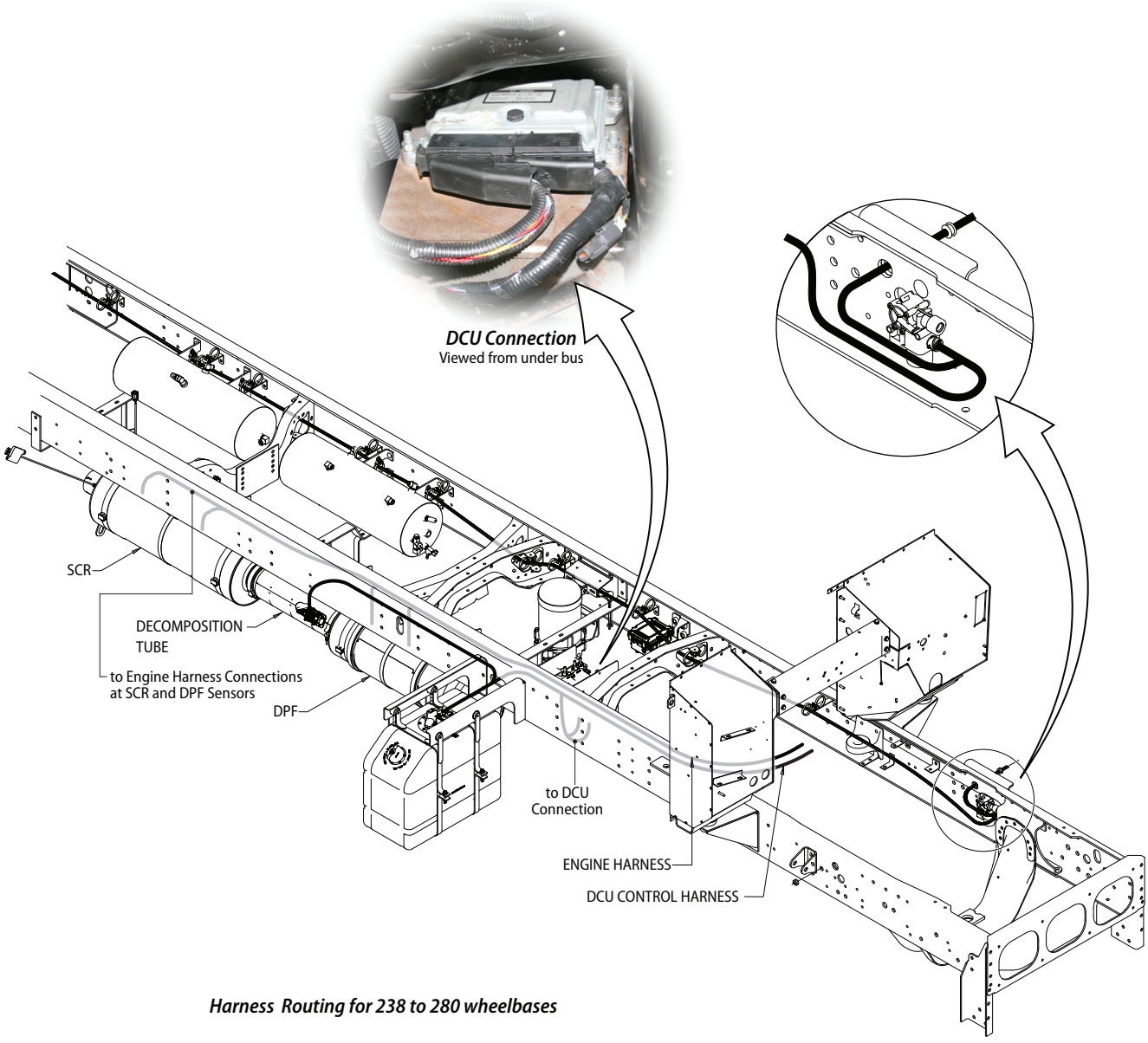
Harness Routing for 169 to 217 wheelbases

Notes:
For Harness Hanger application Details, see sheet 5.

For overhang harness routing, see sheet 5.

Warning: Battery Cables must be disconnected before servicing the DCU Connector (C1/C2). Disconnect cables, DO NOT use battery disconnect switch.

Also see *Exhaust, SCR Aftertreatment Harness* in the Intake and Exhaust chapter.



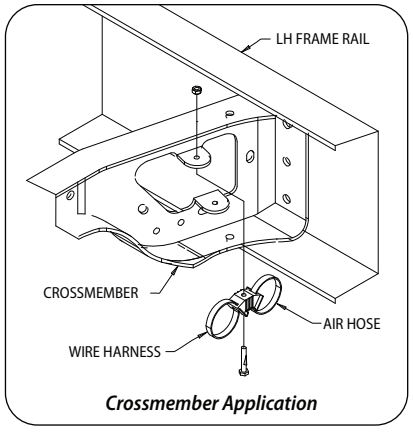
Harness Routing for 238 to 280 wheelbases

Notes:
For Harness Hanger application Details, see sheet 5.

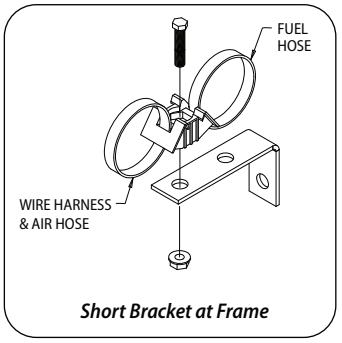
For overhang harness routing, see sheet 5.

Warning: Battery Cables must be disconnected before servicing the DCU Connector (C1/C2). Disconnect cables, DO NOT use battery disconnect switch.

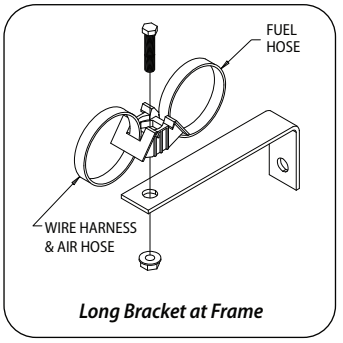
Also see *Exhaust, SCR Aftertreatment Harness* in the Intake and Exhaust chapter.



Crossmember Application

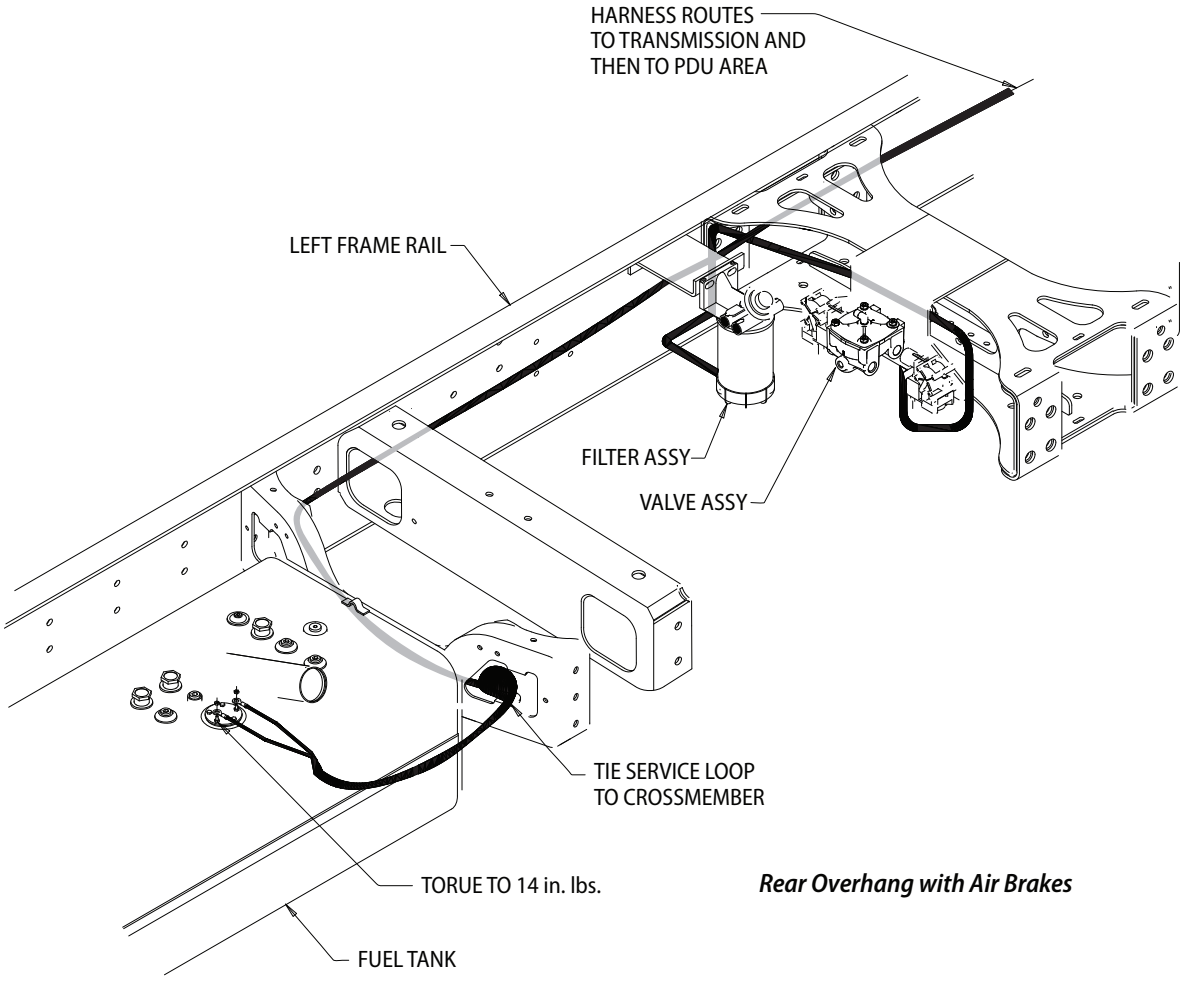


Short Bracket at Frame

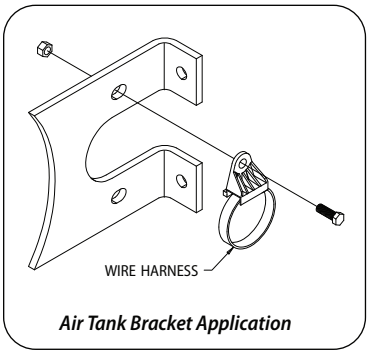


Long Bracket at Frame

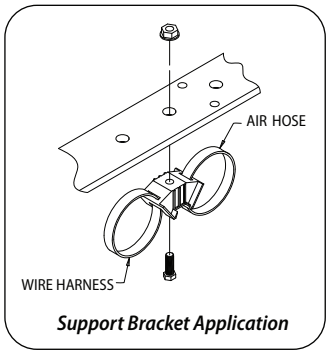
Harness Hanger Details



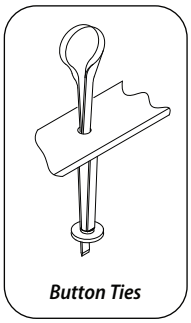
Rear Overhang with Air Brakes



Air Tank Bracket Application

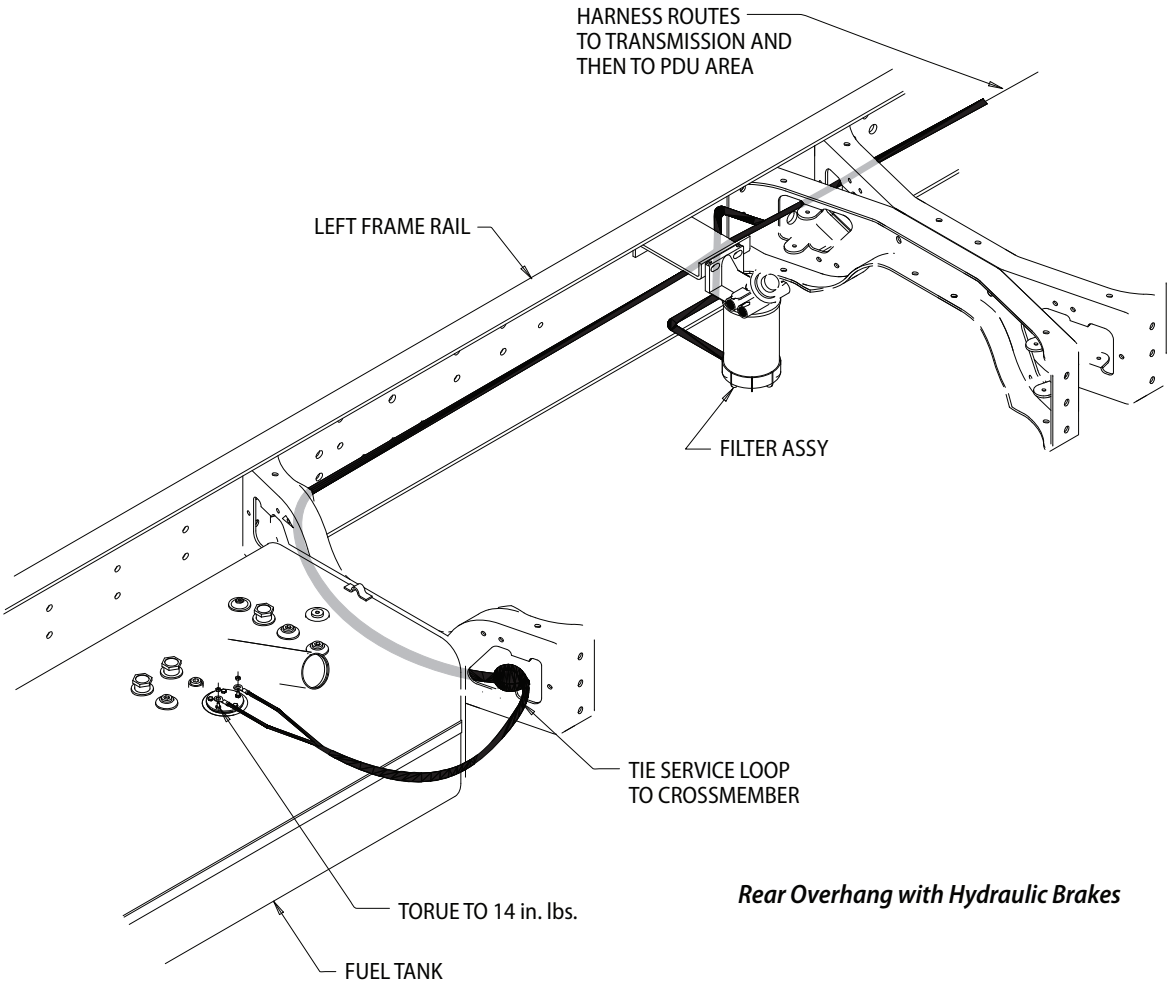


Support Bracket Application



Button Ties

Harness Hanger Details

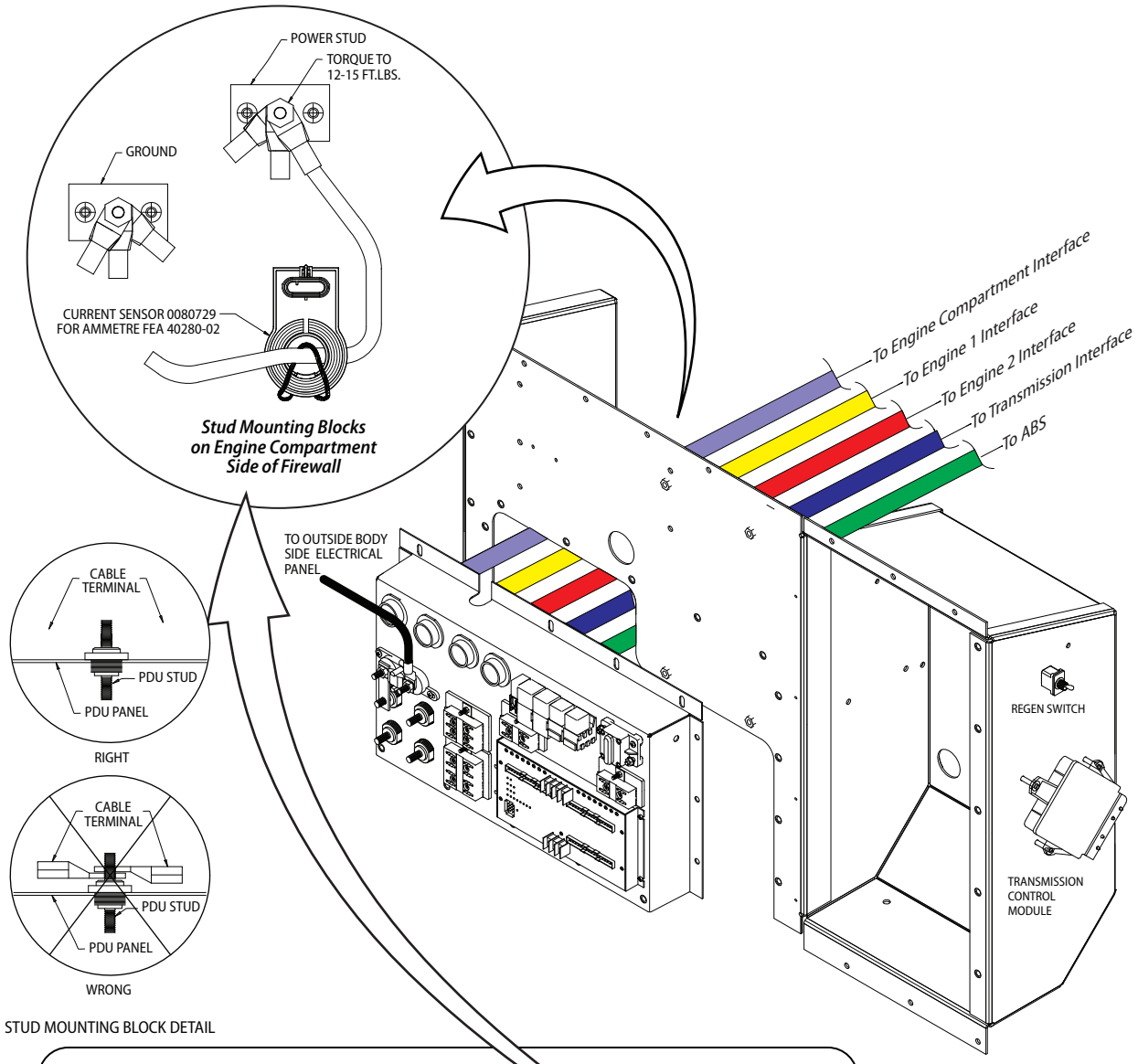


Rear Overhang with Hydraulic Brakes

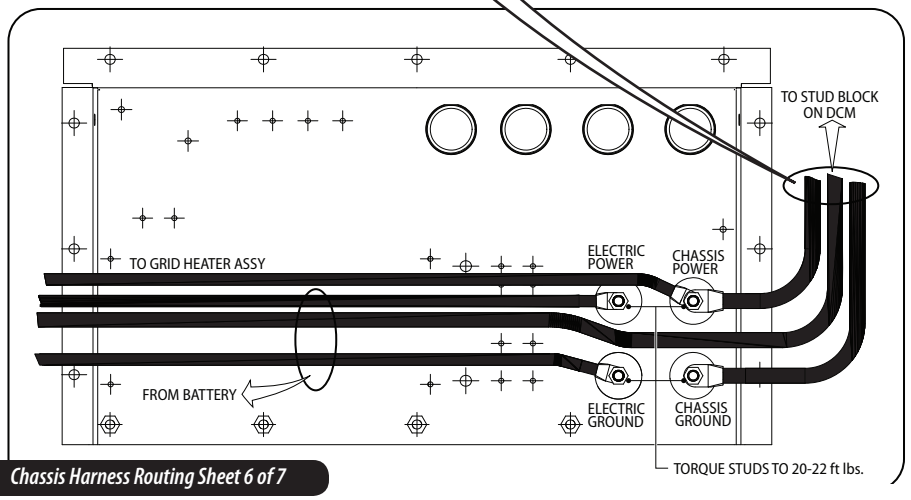
Chassis Harness Routing Sheet 5 of 7

D0003829F

DIAGRAM, RTG, HARNESS, ISB10



STUD MOUNTING BLOCK DETAIL

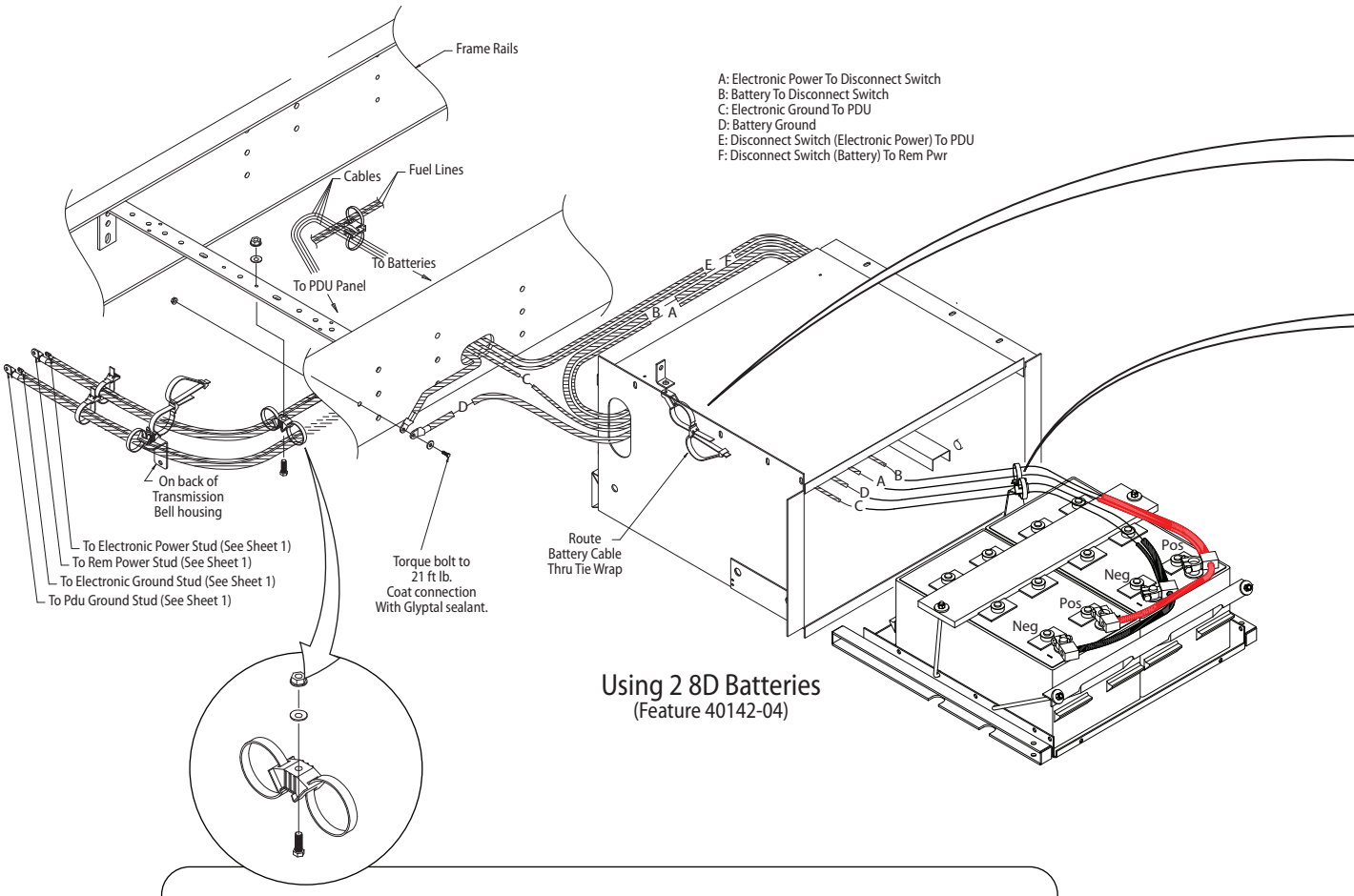


Chassis Harness Routing Sheet 6 of 7

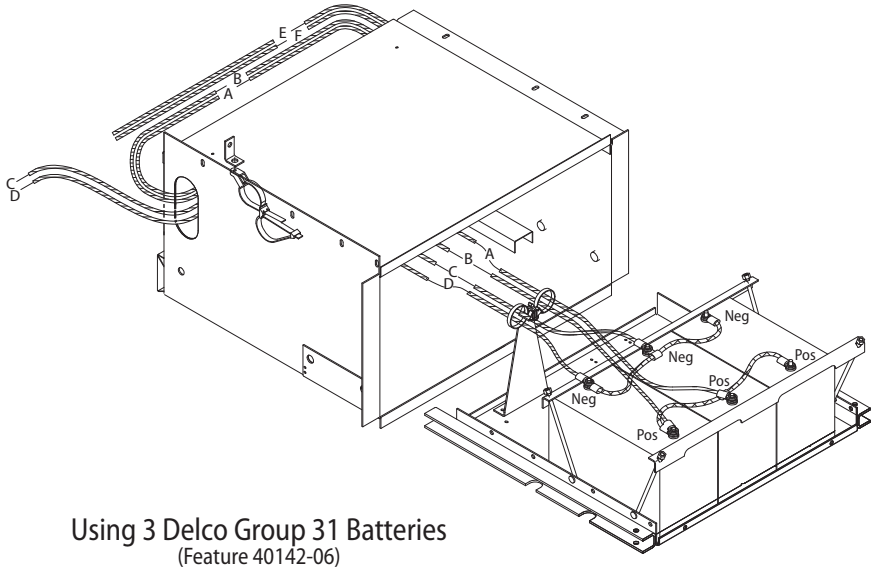
D0003829F

DIAGRAM, RTG, HARNESS, ISB10

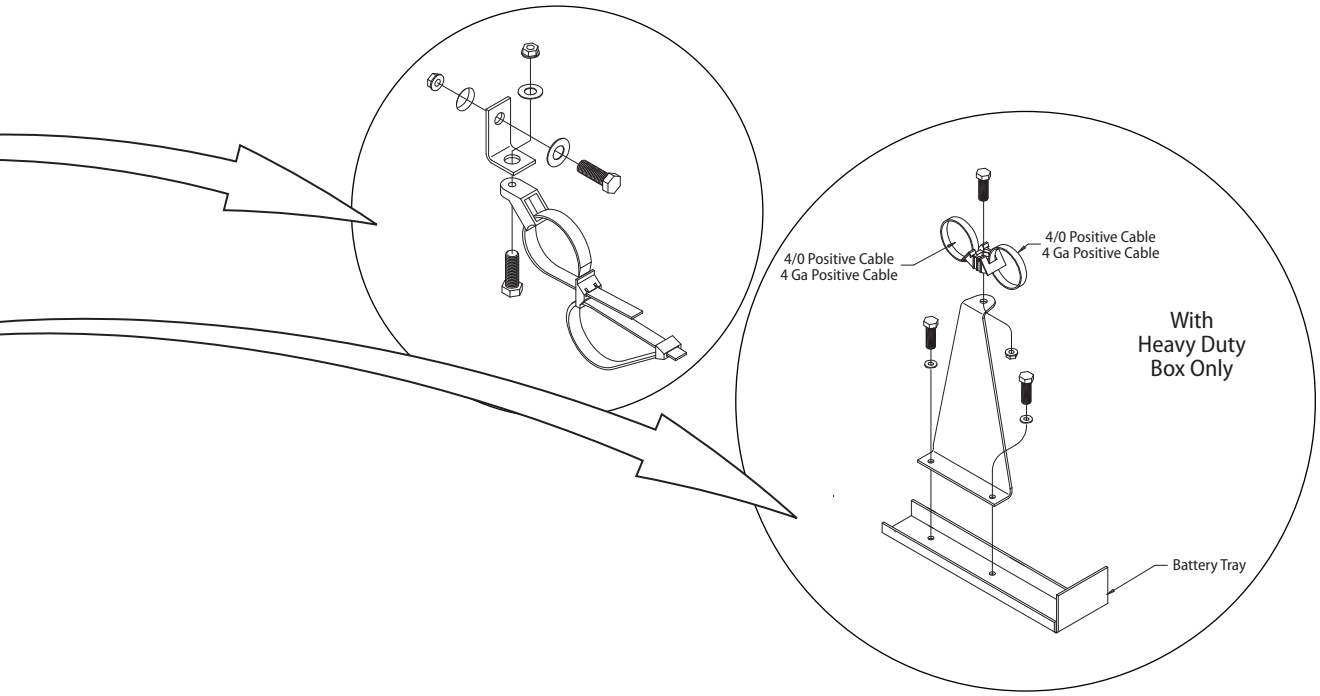
D0003829F SHEET 6

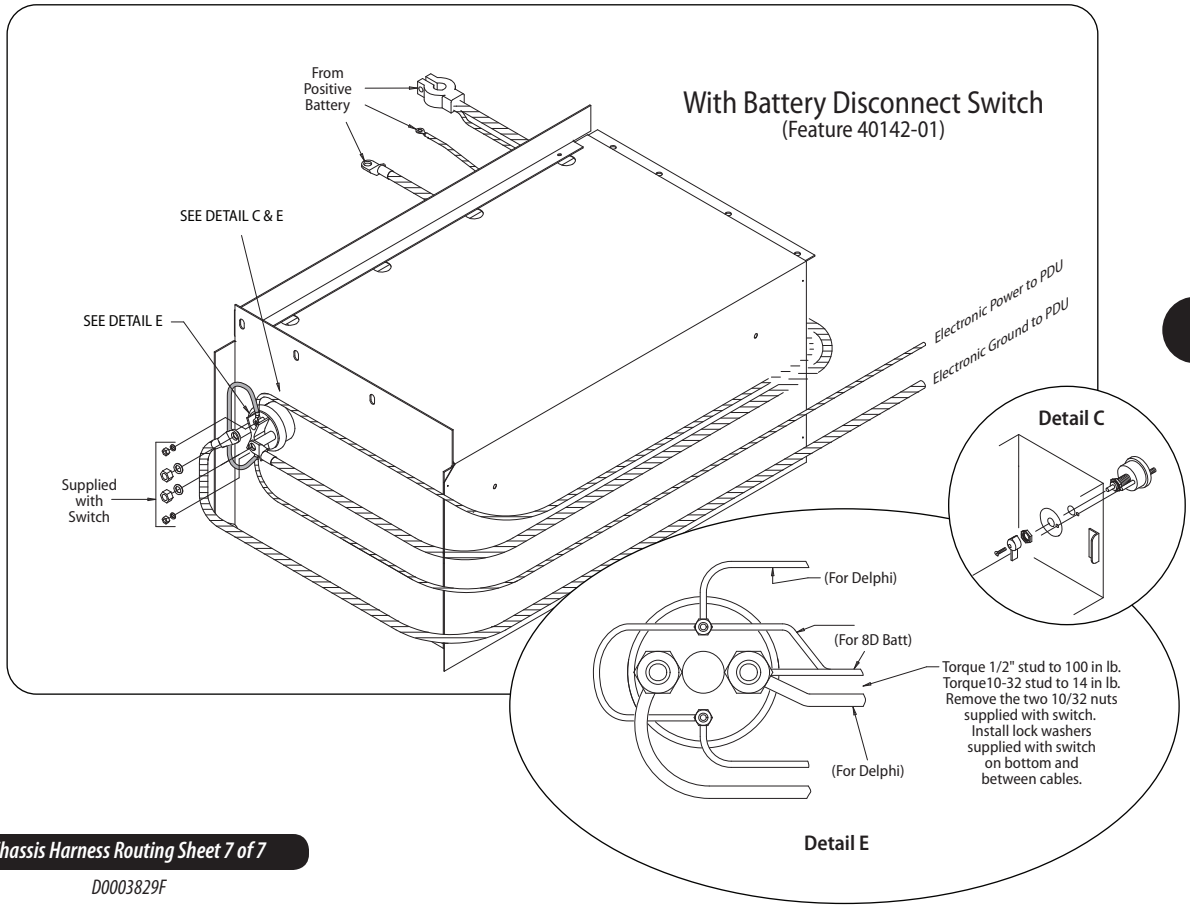


Using 2 8D Batteries
(Feature 40142-04)



Using 3 Delco Group 31 Batteries
(Feature 40142-06)





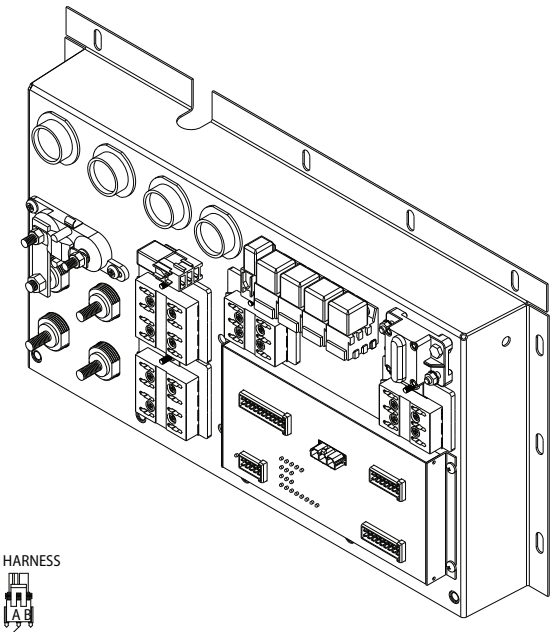
Chassis Harness Routing Sheet 7 of 7

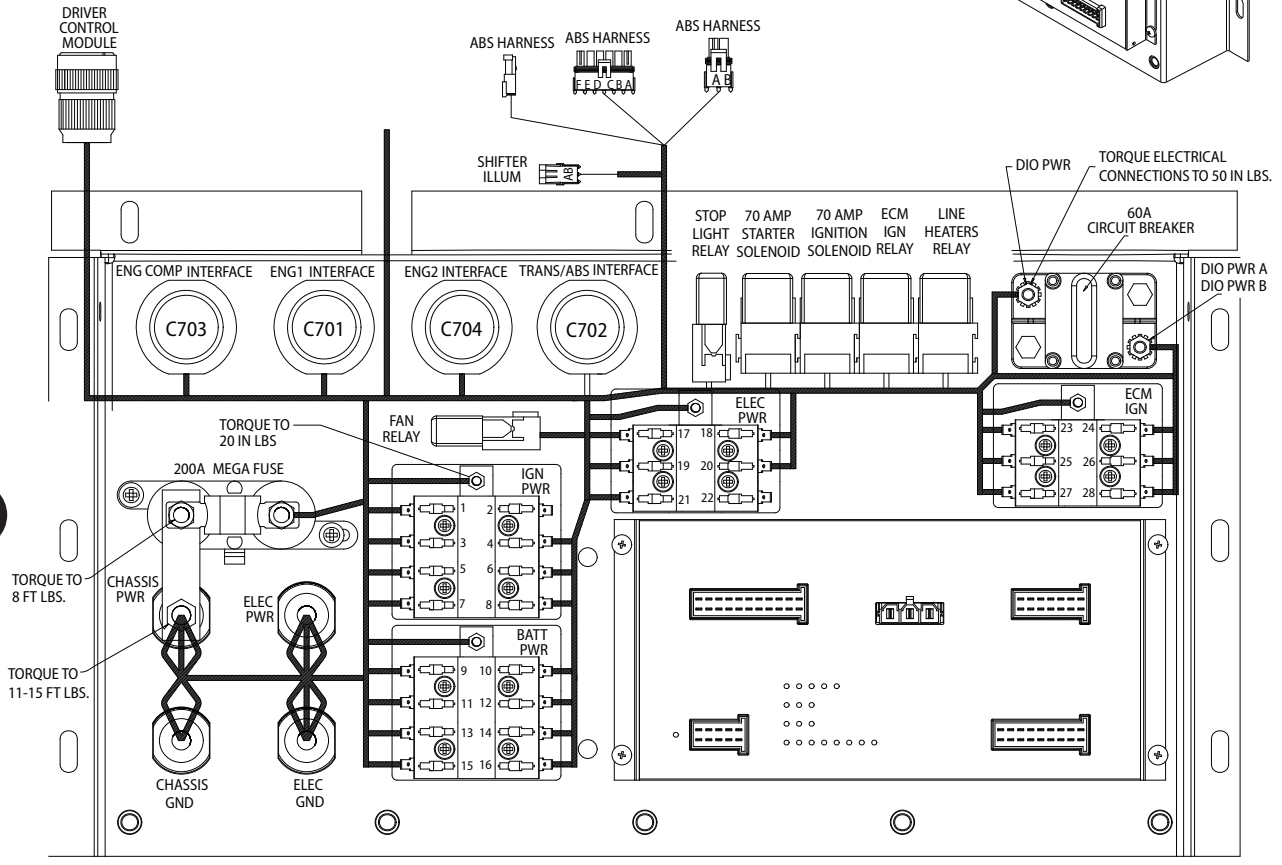
D0003829F

DIAGRAM, RTG, HARNESS, ISB10

Power Distribution Unit Layout

The PDU houses the Main Bus Controller of the Multiplex system (MPX Module), chassis fuses, relays and interface connections to some of the main chassis harnesses. The diagram shown here is representative of standard equipment Visions with air or hydraulic brakes. Although some differences occur in the cases of specific equipment options (such as circuit breakers in lieu of fuses, exhaust brake, or manual transmission), the general layout of the PDU components is the same.





IGN PWR

CB1	HTD FUEL PWR	(20A)	
F2	SPARE		
CB3	AIR DRYER PWR	(10A)	
CB4	FAN PWR	(10A)	
CB5	HTD DRAIN PWR	(20A)	
CB6	BODY IGN	(15A)	
F7	NOx ENG	(10A)	
F8	NOx SCR	(10A)	

BATT PWR

F9	BRK BOOST	(40A)	
	SPARE		Units with Air Brakes
CB10	BRAKE SW PWR	(10A)	
CB11	REV SENS+	(10A)	
CB12	STOP LIGHT PWR	(15A)	
CB13	HYD INTLK	(30A)	Units with Hydraulic Brakes
	INTLK POWER	(10A)	Units with Air Brakes
CB14	MOD PMP BATT	(30A)	Units with Hydraulic Brakes
F14	SPARE		Units with Air Brakes
CB15	DASH PWR	(7.5A)	
CB16	LINE HTR	(20A)	

ELEC PWR

F17	TRANS BATT	(10A)	
F18	EECM PWR	(30A)	
CB19	MBC BATT	(10A)	
F20	ABS BATT	(25A)	Units with Hydraulic Brakes
	ABS BATT	(30A)	Units with Air Brakes
F21	DCU BATT	(7.5)	
F22	SPARE		

ECM IGN

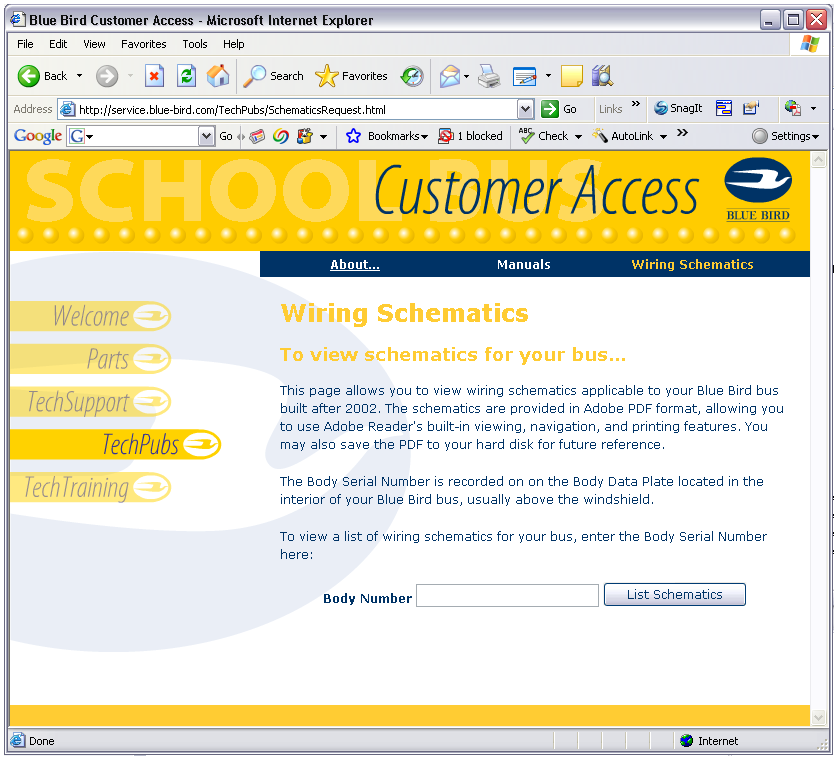
F23	ENG IGN	(5A)	
F24	TRANS IGN	(10A)	
F25	ABS IGN	(5A)	
CB26	DASH IGN	(10A)	
CB27	BRAKE WARN IGN	(7.5A)	Units with Hydraulic Brakes
F27	SPARE		Units with Air Brakes
F28	DCU 252	(5A)	

Chassis Wiring Schematics

The following pages contain the main wiring schematics applicable to most Blue Bird Vision chassis. Two sets of schematics are provided in this chapter, one set for Caterpillar-equipped Visions, and another for Cummins-equipped Visions.

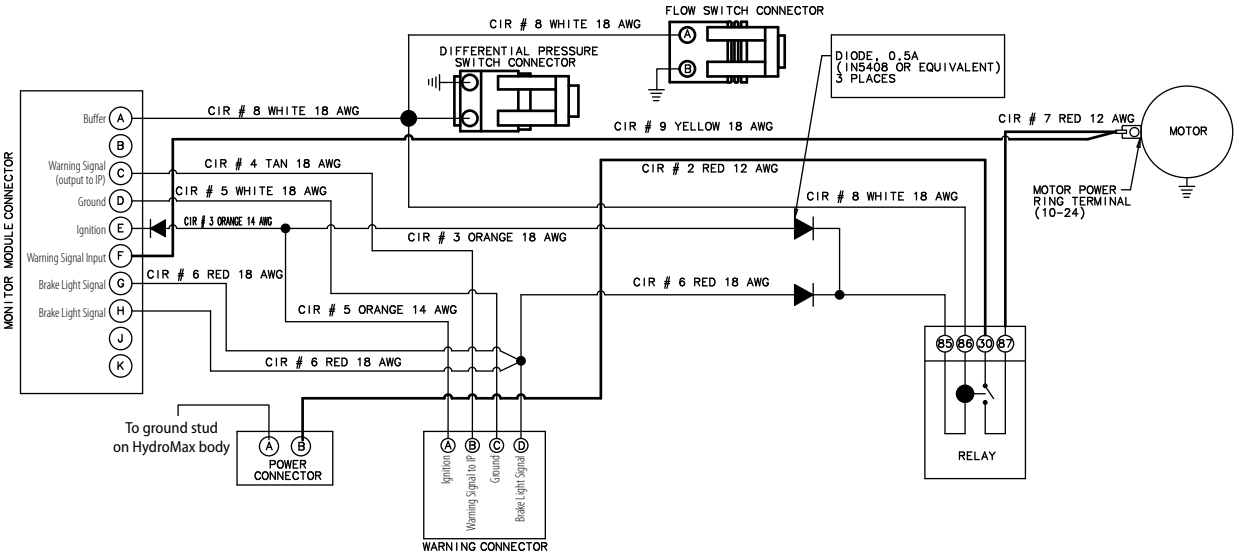
The schematics are provided for your convenience when you are limited to use of the print manual. Additional schematics specific to your bus may be viewed, printed, or downloaded in Adobe® PDF® format by pointing your web browser to the Customer Access website at:

http://service.blue-bird.com/TechPubs/SchematicsRequest.html



Hydraulic Brake Booster Harness

This schematic describes the wiring of the Bendix HydroMax brake master cylinder/ booster harness on Blue Bird Visions equipped with hydraulic brakes.



Electrical Diagrams for Cummins ISB-07 Engines

Description	Sheet	Drawing Number
Index	1	D0002350C
Starting And Charging, Cummins	3	D0002351C
Cummins ISB07 Engine	4	D0002352C
Allison Gen 4 2000 Transmission	5	D0002353A
Allison Gen 4 3000 Transmission	6	D0002354A
Backlights	7	D0002355C
ABS - Bendix (air)	8	D0002356C
ABS - Wabco (hydraulic)	9	00124967B
AA Multiplex Module	10	D0002357B
AB Multiplex Module	11	D0002358B
AC Multiplex Module	12	D0002359A
Mirror Heat / Exterior Speaker / Wiper Washer	13	00112299
Hydraulic Brake Boost	14	00112300A
Frame Components	15	D0002360A
Crossing Arm	16	00112302A
Instrument Cluster	17	D0002282E
Driver's Control Module - Air	18	D0002361F
Driver's Control Module - Hydraulic	19	D0002362D
MBC Module	20	00112306B
Body Interface	21	D0002363A
J1939 Datalink, Hydraulic	22	D0002364C
J1939 Datalink, Air	23	D0002365C

Wire Colors

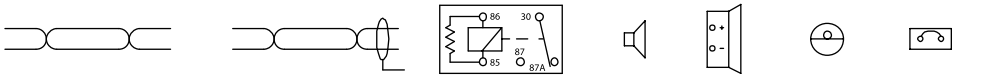
BL	BLUE
BK	BLACK
BN	BROWN
TN	TAN
WH	WHITE
YL	YELLOW
PK	PINK
OR	ORANGE
RD	RED
GN	GREEN
PU	PURPLE
GY	GRAY

Schematic Legend

PD	PDU PANEL
AC	AIR CLEANER BRACKET
IP	INSTRUMENT PANEL
FW	FIREWALL
SP	SHIFTER PANEL
DC	DCM

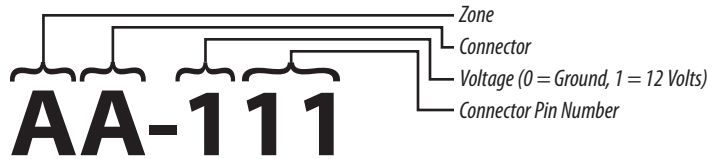
Electrical Component Index

Heavy Duty Relay *Fuse* *Voltage Stud* *Shunt* *Switch Ngr Rocker (Non-typical)* *3 Wire Twisting*

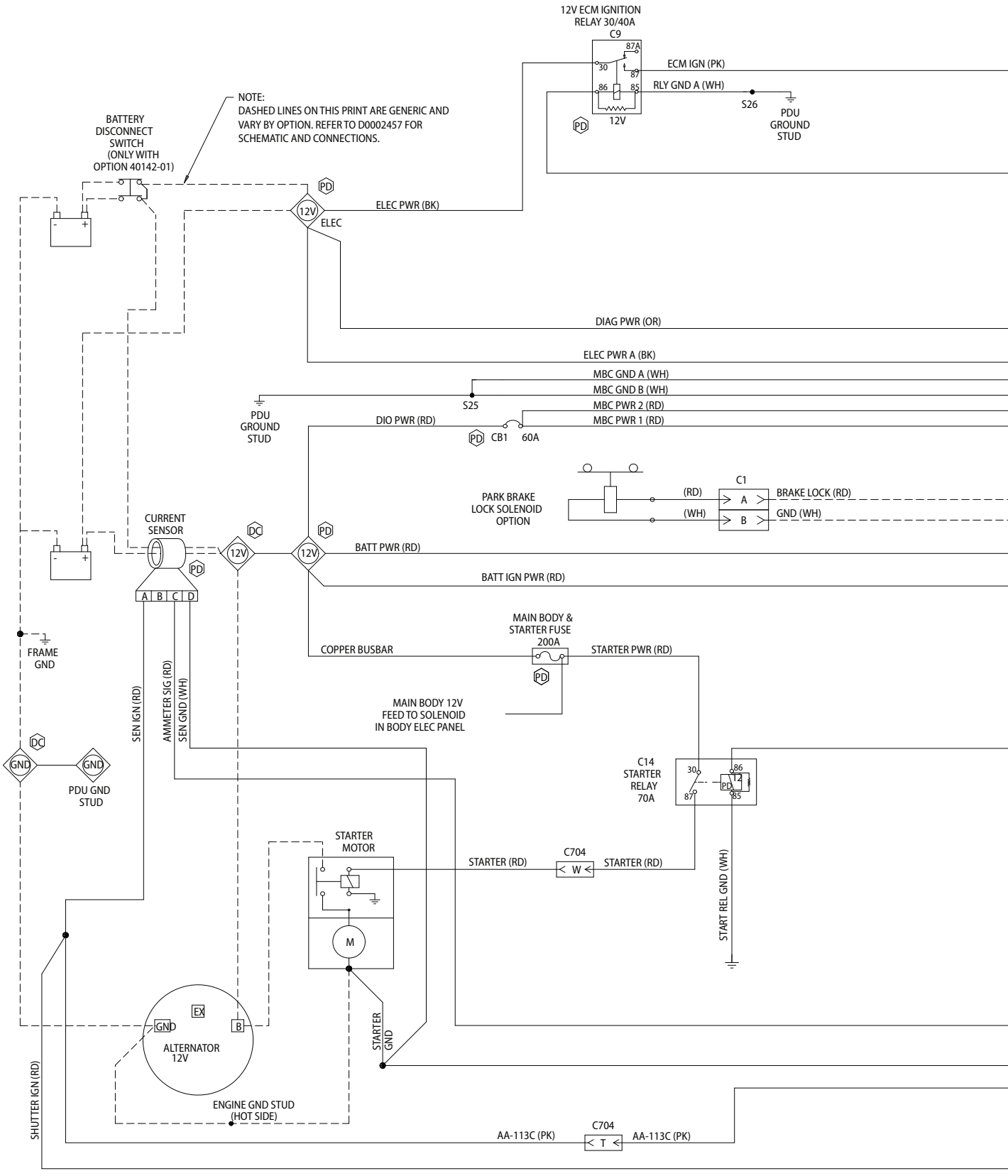


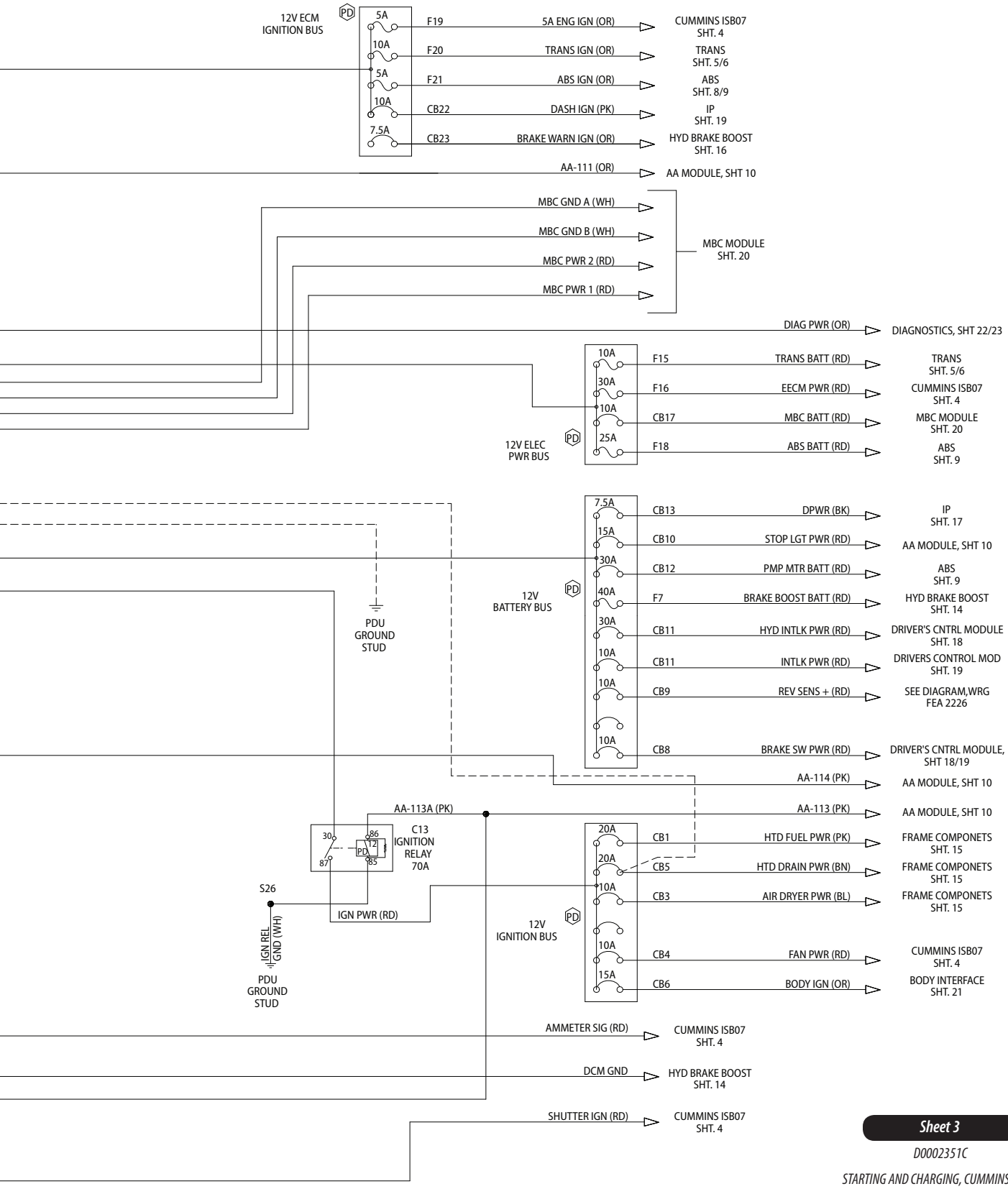
2 Wire Twisting *2 Wire Twisting with Shield* *Mini Relay* *Horn* *Speaker* *Light* *Circuit Breaker*

Multiplex Wire Indexing *(Circuit Number Code)*



Example: (Zone A, Connector A, 12 Volts, Pin #11)

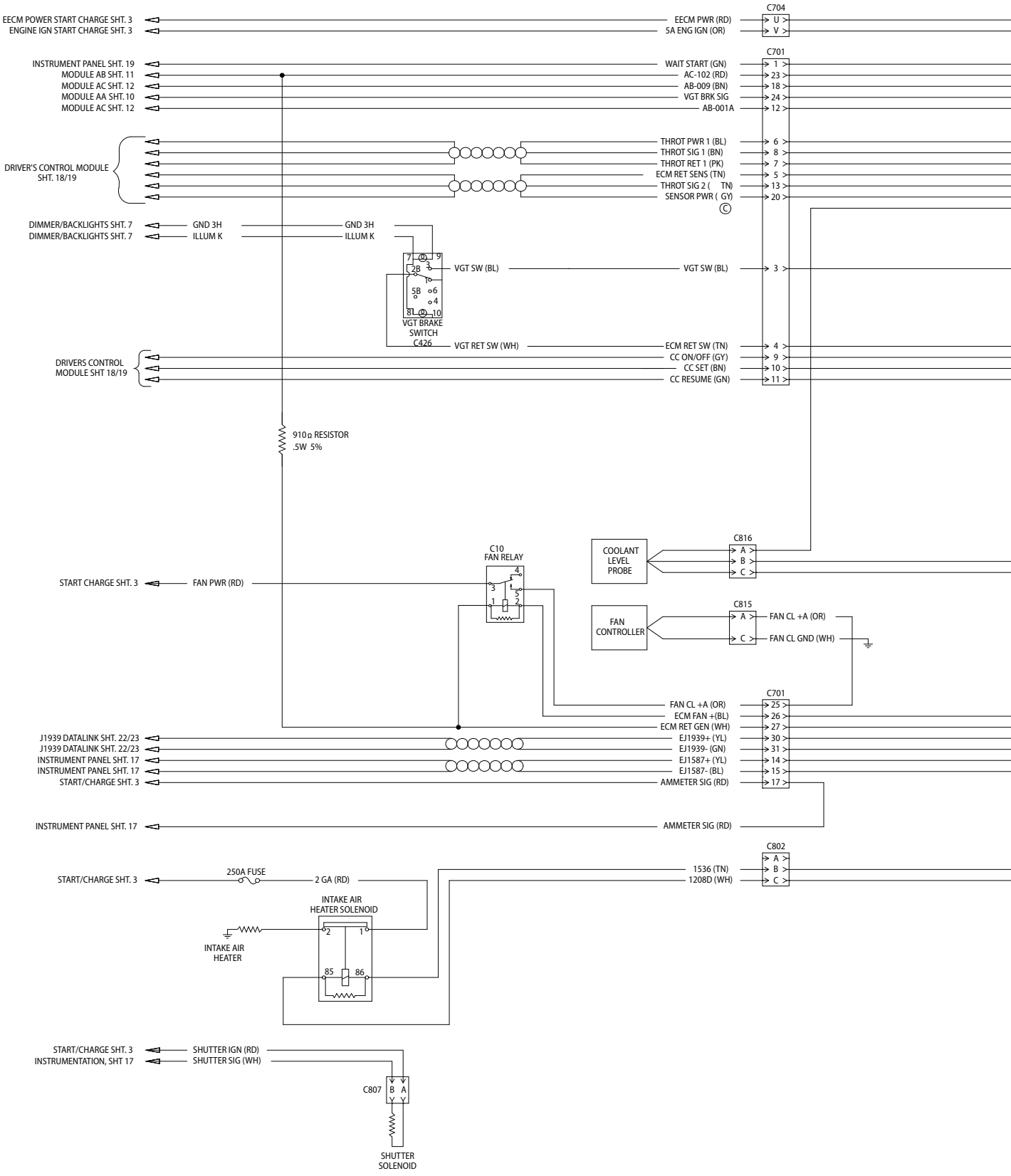

12V ECM IGNITION RELAY 30/40A
C9
87A
30
87
86
85
12V
PD
ECM IGN (PK)
RLY GND A (WH)
S26
PDU GROUND STUD
NOTE:
DASHED LINES ON THIS PRINT ARE GENERIC AND VARY BY OPTION. REFER TO D0002457 FOR SCHEMATIC AND CONNECTIONS.
BATTERY DISCONNECT SWITCH (ONLY WITH OPTION 40142-01)
ELEC PWR (BK)
ELEC
DIAG PWR (OR)
ELEC PWR A (BK)
MBC GND A (WH)
MBC GND B (WH)
S25
MBC PWR 2 (RD)
MBC PWR 1 (RD)
PDU GROUND STUD
DIO PWR (RD)
CB1
60A
PARK BRAKE LOCK SOLENOID OPTION
C1
(RD)
(WH)
A
B
BRAKE LOCK (RD)
GND (WH)
CURRENT SENSOR
DC
BATT PWR (RD)
BATT IGN PWR (RD)
A B C D
MAIN BODY & STARTER FUSE 200A
FRAME GND
COPPER BUSBAR
STARTER PWR (RD)
MAIN BODY 12V FEED TO SOLENOID IN BODY ELEC PANEL
SEN IGN (RD)
AMMETER SIG (RD)
SEN GND (WH)
GND
PDU GND STUD
C14 STARTER RELAY 70A
STARTER MOTOR
STARTER (RD)
C704
W
M
START REL GND (WH)
EX
ALTERNATOR 12V
STARTER GND
SHUTTER IGN (RD)
ENGINE GND STUD (HOT SIDE)
AA-113C (PK)
T

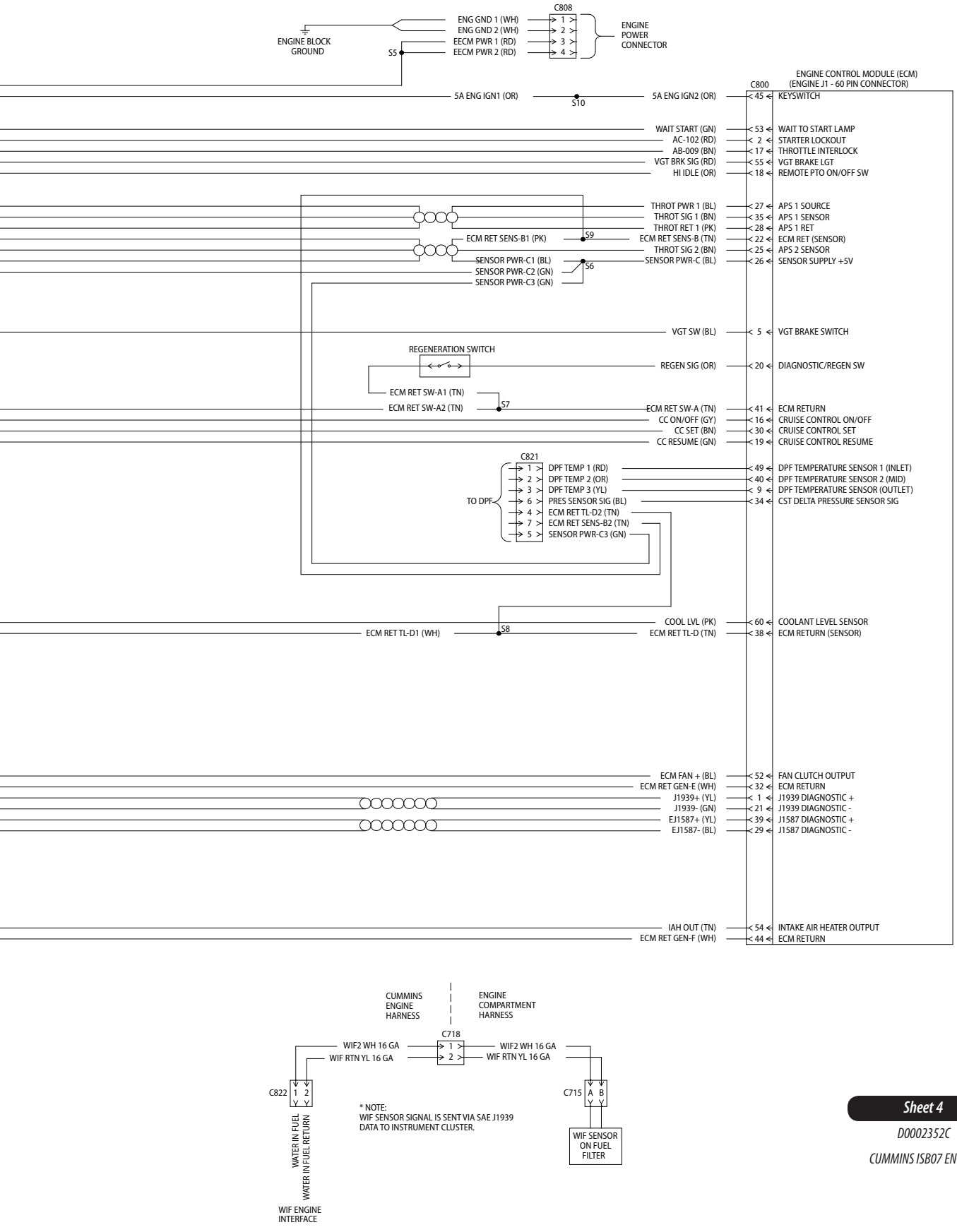


Sheet 3

D0002351C

STARTING AND CHARGING, CUMMINS ISB07

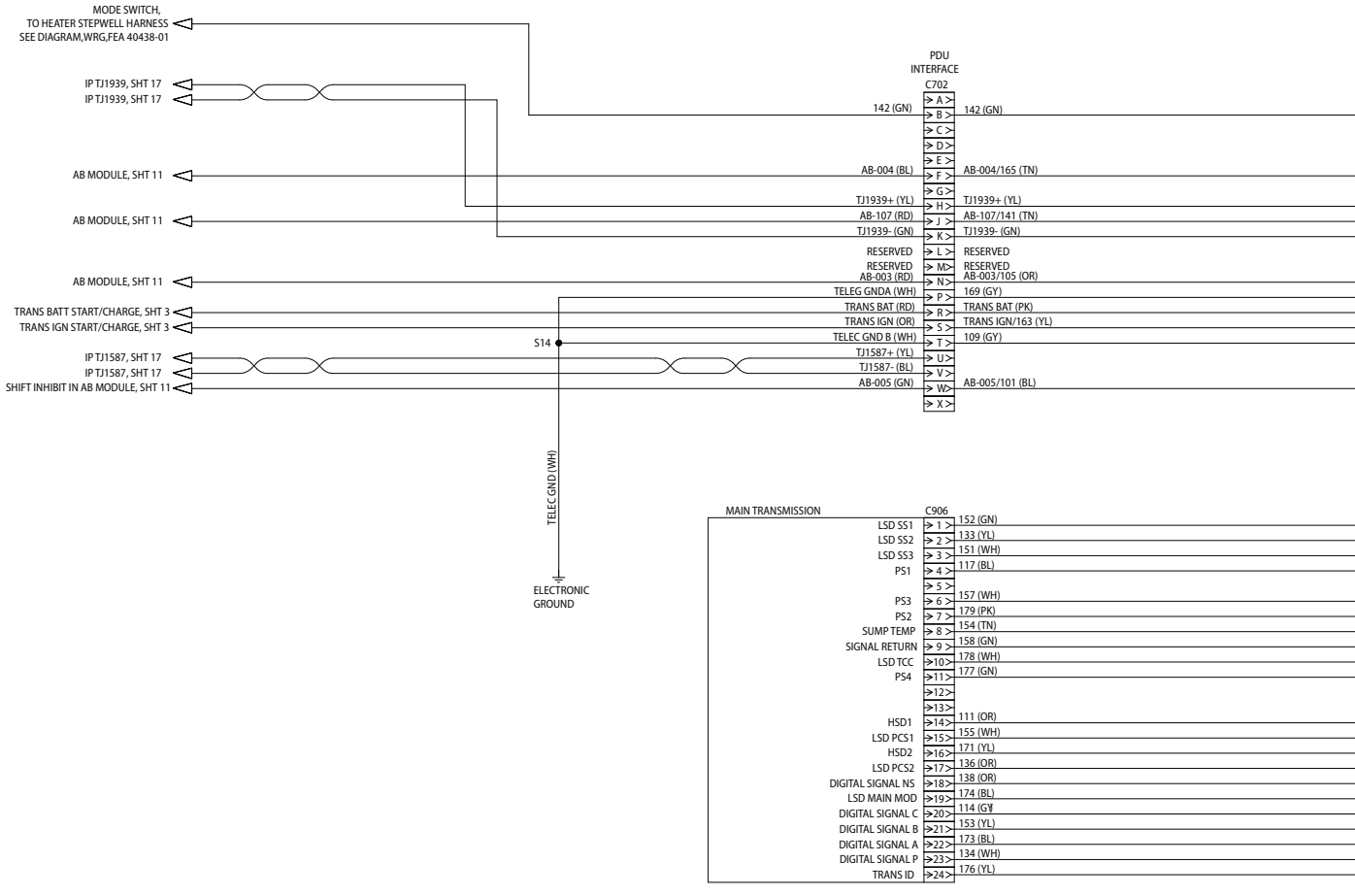

EECM POWER START CHARGE SHT. 3
ENGINE IGN START CHARGE SHT. 3
EECM PWR (RD)
5A ENG IGN (OR)
C704
U
V
INSTRUMENT PANEL SHT. 19
MODULE AB SHT. 11
MODULE AC SHT. 12
MODULE AA SHT. 10
MODULE AC SHT. 12
WAIT START (GN)
AC-102 (RD)
AB-009 (BN)
VGT BRK SIG
AB-001A
C701
1
23
18
24
12
DRIVER'S CONTROL MODULE SHT. 18/19
THROT PWR 1 (BL)
THROT SIG 1 (BN)
THROT RET 1 (PK)
ECM RET SENS (TN)
THROT SIG 2 (TN)
SENSOR PWR (GY)
6
8
7
5
13
20
DIMMER/BACKLIGHTS SHT. 7
DIMMER/BACKLIGHTS SHT. 7
GND 3H
ILLUM K
GND 3H
ILLUM K
VGT SW (BL)
VGT SW (BL)
3
VGT BRAKE SWITCH C426
VGT RET SW (WH)
ECM RET SW (TN)
CC ON/OFF (GY)
CC SET (BN)
CC RESUME (GN)
4
9
10
11
DRIVERS CONTROL MODULE SHT 18/19
910Ω RESISTOR .5W 5%
C10 FAN RELAY
C816
COOLANT LEVEL PROBE
A
B
C
START CHARGE SHT. 3
FAN PWR (RD)
C815
FAN CONTROLLER
FAN CL +A (OR)
FAN CL GND (WH)
FAN CL +A (OR)
ECM FAN +(BL)
ECM RET GEN (WH)
25
26
27
J1939 DATALINK SHT. 22/23
J1939 DATALINK SHT. 22/23
INSTRUMENT PANEL SHT. 17
INSTRUMENT PANEL SHT. 17
START/CHARGE SHT. 3
EJ1939+ (YL)
EJ1939- (GN)
EJ1587+ (YL)
EJ1587- (BL)
AMMETER SIG (RD)
30
31
14
15
17
INSTRUMENT PANEL SHT. 17
AMMETER SIG (RD)
C802
START/CHARGE SHT. 3
250A FUSE
2 GA (RD)
1536 (TN)
1208D (WH)
INTAKE AIR HEATER SOLENOID
INTAKE AIR HEATER
85
86
START/CHARGE SHT. 3
INSTRUMENTATION, SHT 17
SHUTTER IGN (RD)
SHUTTER SIG (WH)
C807
SHUTTER SOLENOID

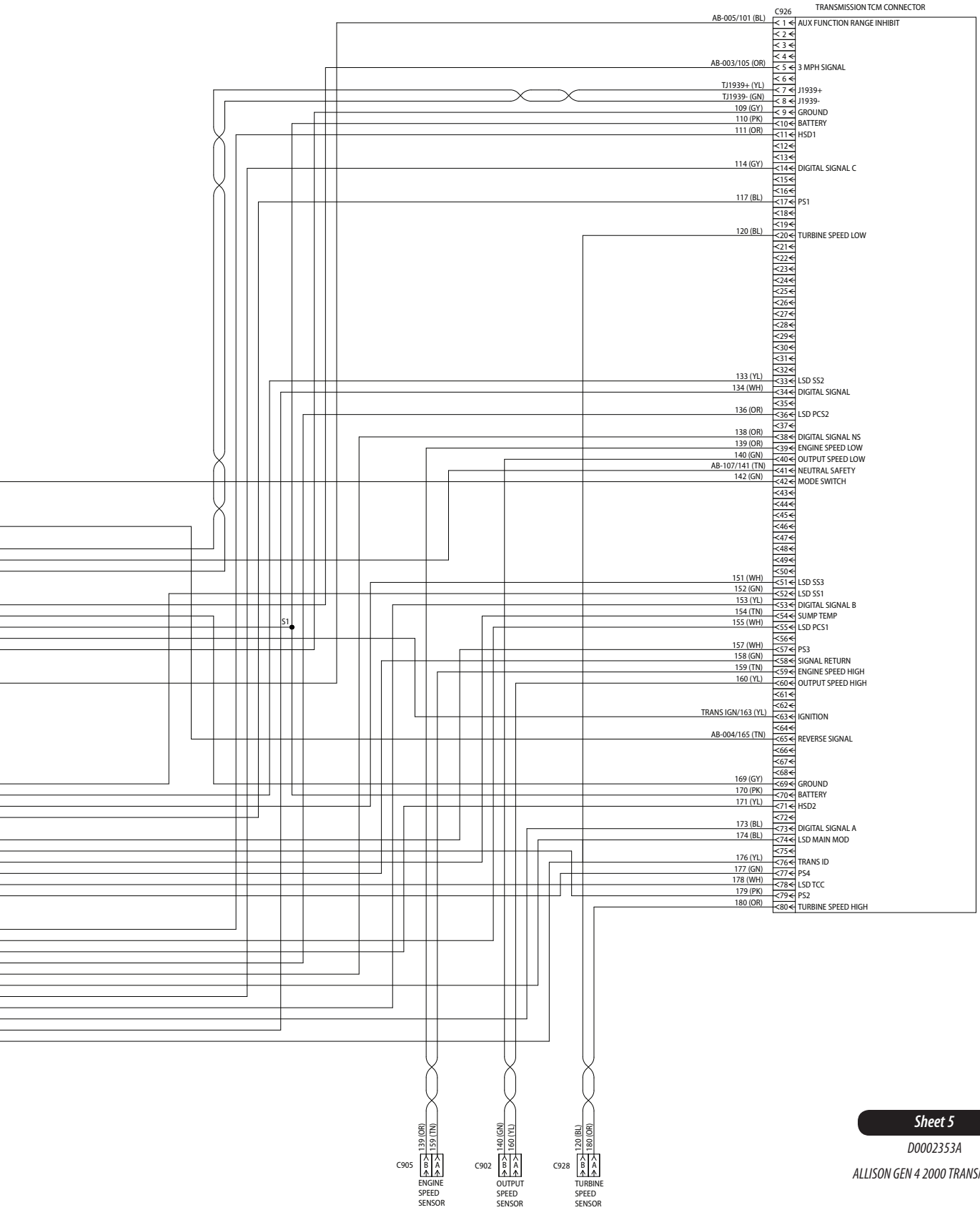


Sheet 4

D0002352C

CUMMINS ISB07 ENGINE

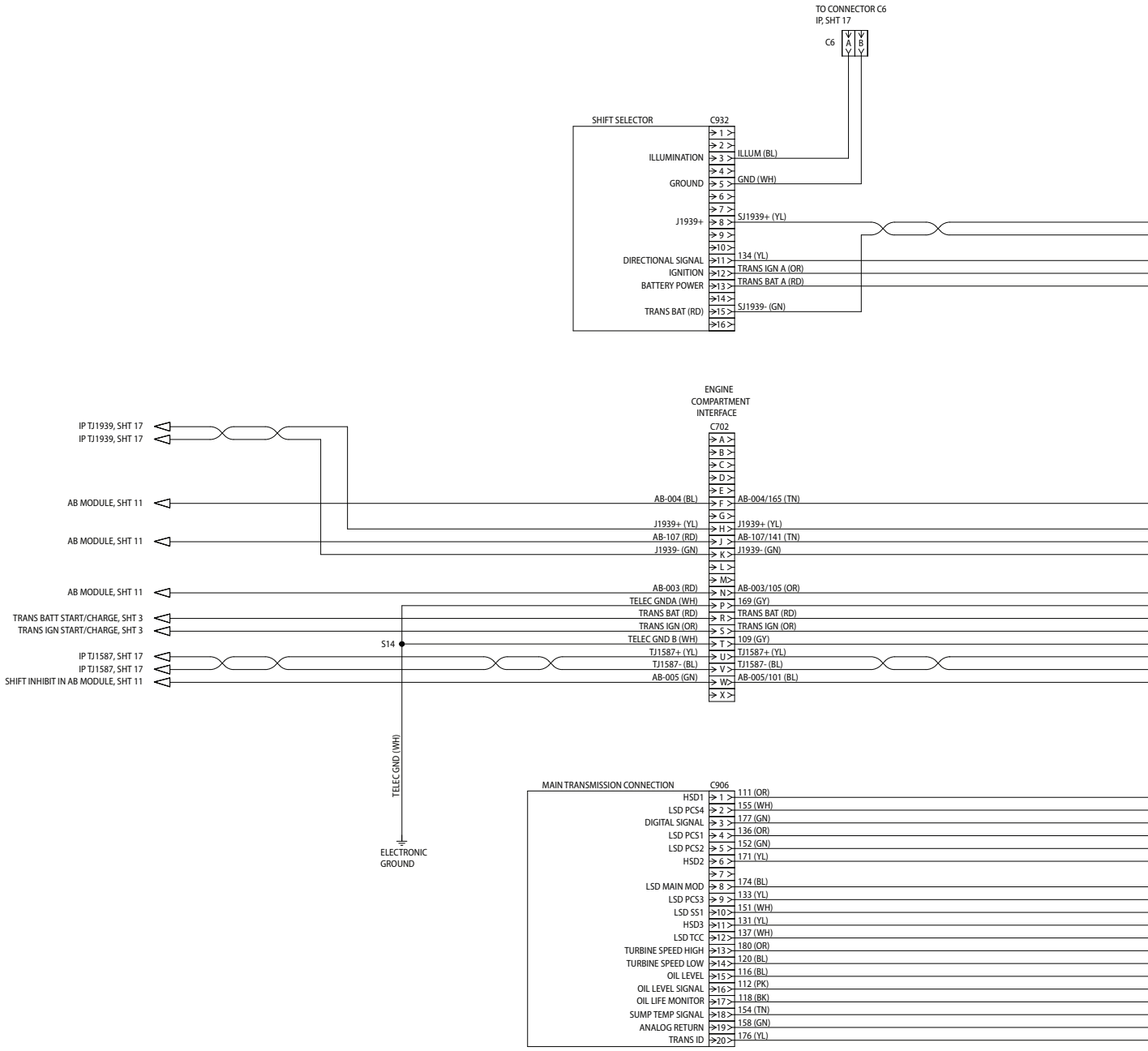

MODE SWITCH,
TO HEATER STEPWELL HARNESS
SEE DIAGRAM,WRG,FEA 40438-01
IP TJ1939, SHT 17
IP TJ1939, SHT 17
AB MODULE, SHT 11
AB MODULE, SHT 11
AB MODULE, SHT 11
TRANS BATT START/CHARGE, SHT 3
TRANS IGN START/CHARGE, SHT 3
IP TJ1587, SHT 17
IP TJ1587, SHT 17
SHIFT INHIBIT IN AB MODULE, SHT 11
S14
TELEC GND (WH)
ELECTRONIC
GROUND
PDU
INTERFACE
C702
142 (GN)
AB-004 (BL)
TJ1939+ (YL)
AB-107 (RD)
TJ1939- (GN)
RESERVED
RESERVED
AB-003 (RD)
TELEG GNDA (WH)
TRANS BAT (RD)
TRANS IGN (OR)
TELEC GND B (WH)
TJ1587+ (YL)
TJ1587- (BL)
AB-005 (GN)
142 (GN)
AB-004/165 (TN)
TJ1939+ (YL)
AB-107/141 (TN)
TJ1939- (GN)
RESERVED
RESERVED
AB-003/105 (OR)
169 (GY)
TRANS BAT (PK)
TRANS IGN/163 (YL)
109 (GY)
AB-005/101 (BL)
MAIN TRANSMISSION
C906
LSD SS1
LSD SS2
LSD SS3
PS1
PS3
PS2
SUMP TEMP
SIGNAL RETURN
LSD TCC
PS4
HSD1
LSD PCS1
HSD2
LSD PCS2
DIGITAL SIGNAL NS
LSD MAIN MOD
DIGITAL SIGNAL C
DIGITAL SIGNAL B
DIGITAL SIGNAL A
DIGITAL SIGNAL P
TRANS ID
152 (GN)
133 (YL)
151 (WH)
117 (BL)
157 (WH)
179 (PK)
154 (TN)
158 (GN)
178 (WH)
177 (GN)
111 (OR)
155 (WH)
171 (YL)
136 (OR)
138 (OR)
174 (BL)
153 (YL)
173 (BL)
134 (WH)
176 (YL)

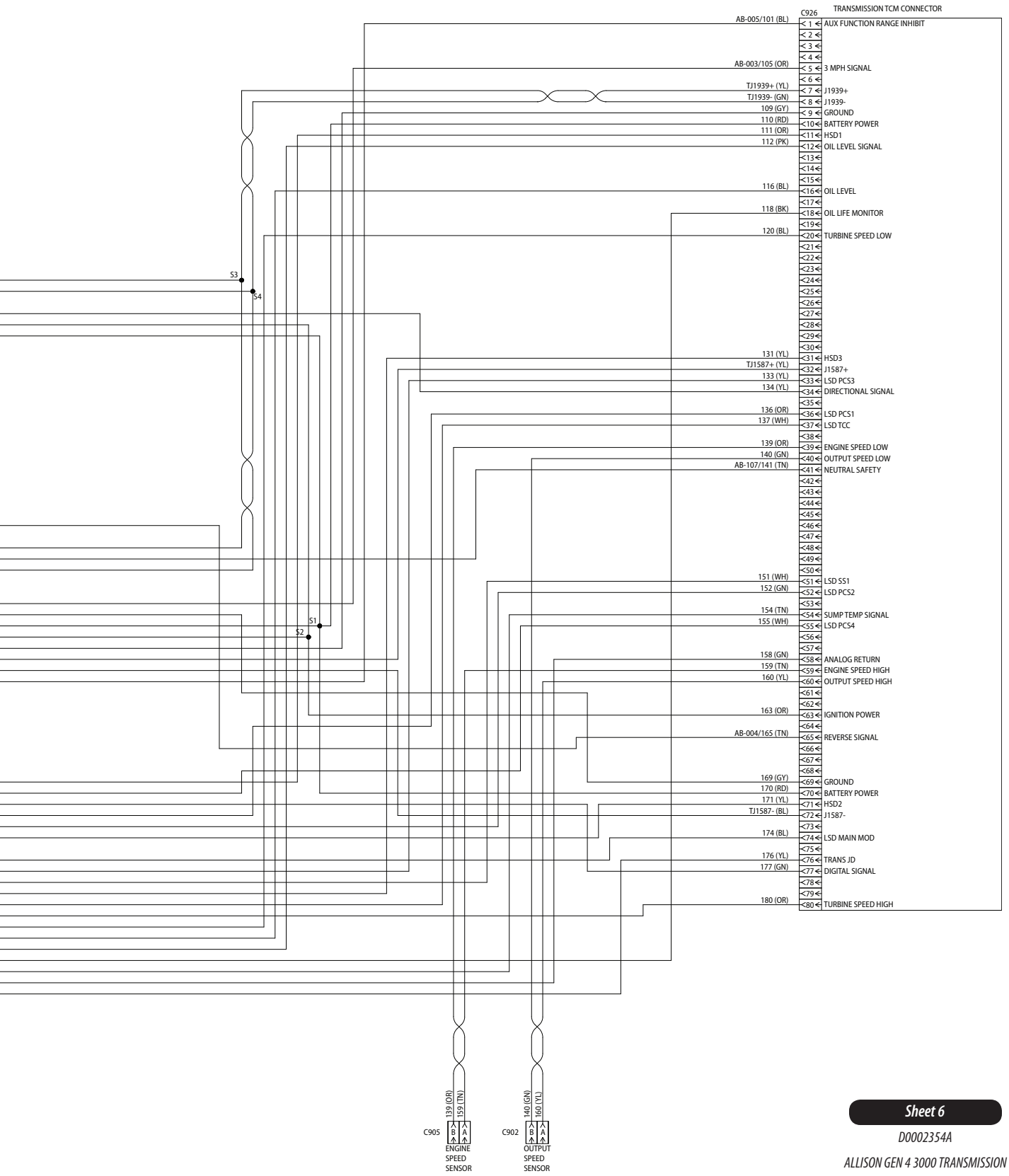


Sheet 5

D0002353A

ALLISON GEN 4 2000 TRANSMISSION

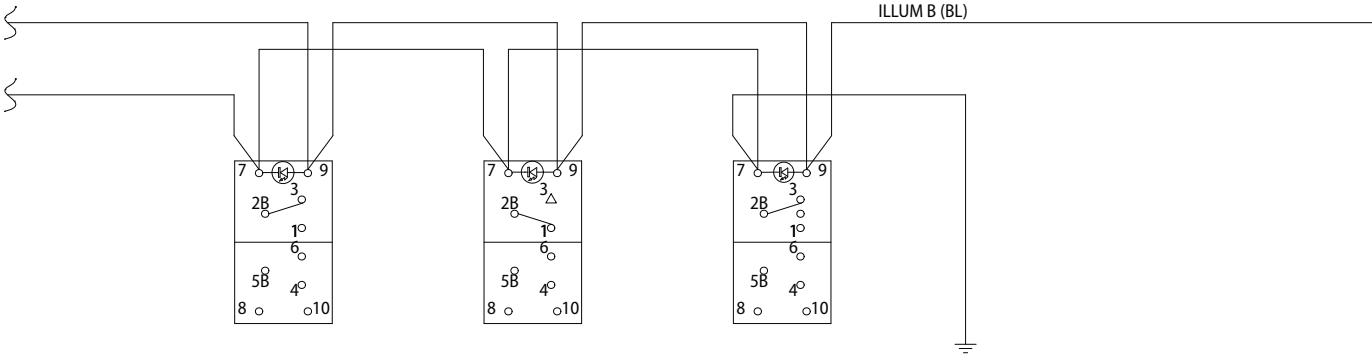

TO CONNECTOR C6
IP, SHT 17
C6
SHIFT SELECTOR
C932
ILLUMINATION
ILLUM (BL)
GROUND
GND (WH)
J1939+
SJ1939+ (YL)
DIRECTIONAL SIGNAL
134 (YL)
IGNITION
TRANS IGN A (OR)
BATTERY POWER
TRANS BAT A (RD)
TRANS BAT (RD)
SJ1939- (GN)
ENGINE COMPARTMENT INTERFACE
C702
IP TJ1939, SHT 17
IP TJ1939, SHT 17
AB MODULE, SHT 11
AB-004 (BL)
AB-004/165 (TN)
J1939+ (YL)
J1939+ (YL)
AB MODULE, SHT 11
AB-107 (RD)
AB-107/141 (TN)
J1939- (GN)
J1939- (GN)
AB MODULE, SHT 11
AB-003 (RD)
AB-003/105 (OR)
TELEC GNDA (WH)
169 (GY)
TRANS BATT START/CHARGE, SHT 3
TRANS BAT (RD)
TRANS BAT (RD)
TRANS IGN START/CHARGE, SHT 3
TRANS IGN (OR)
TRANS IGN (OR)
S14
TELEC GND B (WH)
109 (GY)
IP TJ1587, SHT 17
TJ1587+ (YL)
TJ1587+ (YL)
IP TJ1587, SHT 17
TJ1587- (BL)
TJ1587- (BL)
SHIFT INHIBIT IN AB MODULE, SHT 11
AB-005 (GN)
AB-005/101 (BL)
TELEC GND (WH)
ELECTRONIC GROUND
MAIN TRANSMISSION CONNECTION
C906
HSD1
111 (OR)
LSD PCS4
155 (WH)
DIGITAL SIGNAL
177 (GN)
LSD PCS1
136 (OR)
LSD PCS2
152 (GN)
HSD2
171 (YL)
LSD MAIN MOD
174 (BL)
LSD PCS3
133 (YL)
LSD SS1
151 (WH)
HSD3
131 (YL)
LSD TCC
137 (WH)
TURBINE SPEED HIGH
180 (OR)
TURBINE SPEED LOW
120 (BL)
OIL LEVEL
116 (BL)
OIL LEVEL SIGNAL
112 (PK)
OIL LIFE MONITOR
118 (BK)
SUMP TEMP SIGNAL
154 (TN)
ANALOG RETURN
158 (GN)
TRANS ID
176 (YL)



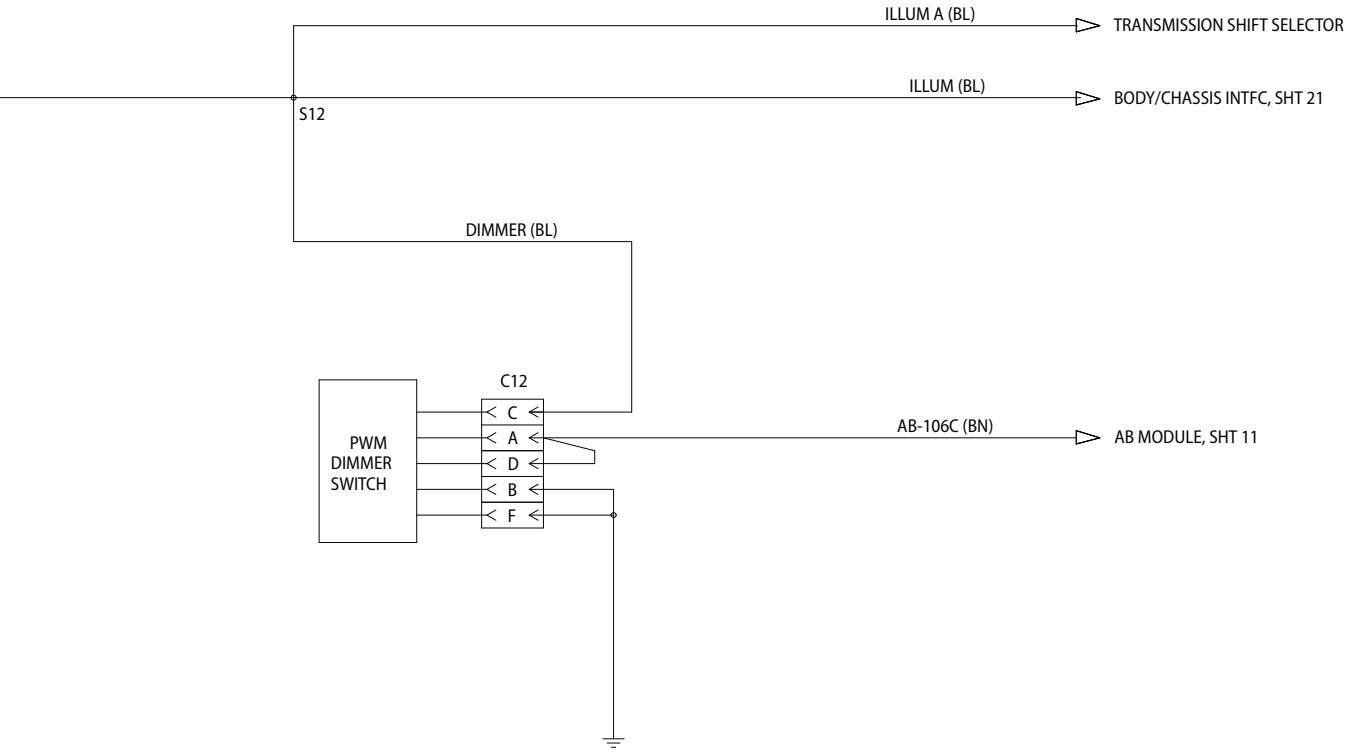
Sheet 6

D0002354A

ALLISON GEN 4 3000 TRANSMISSION



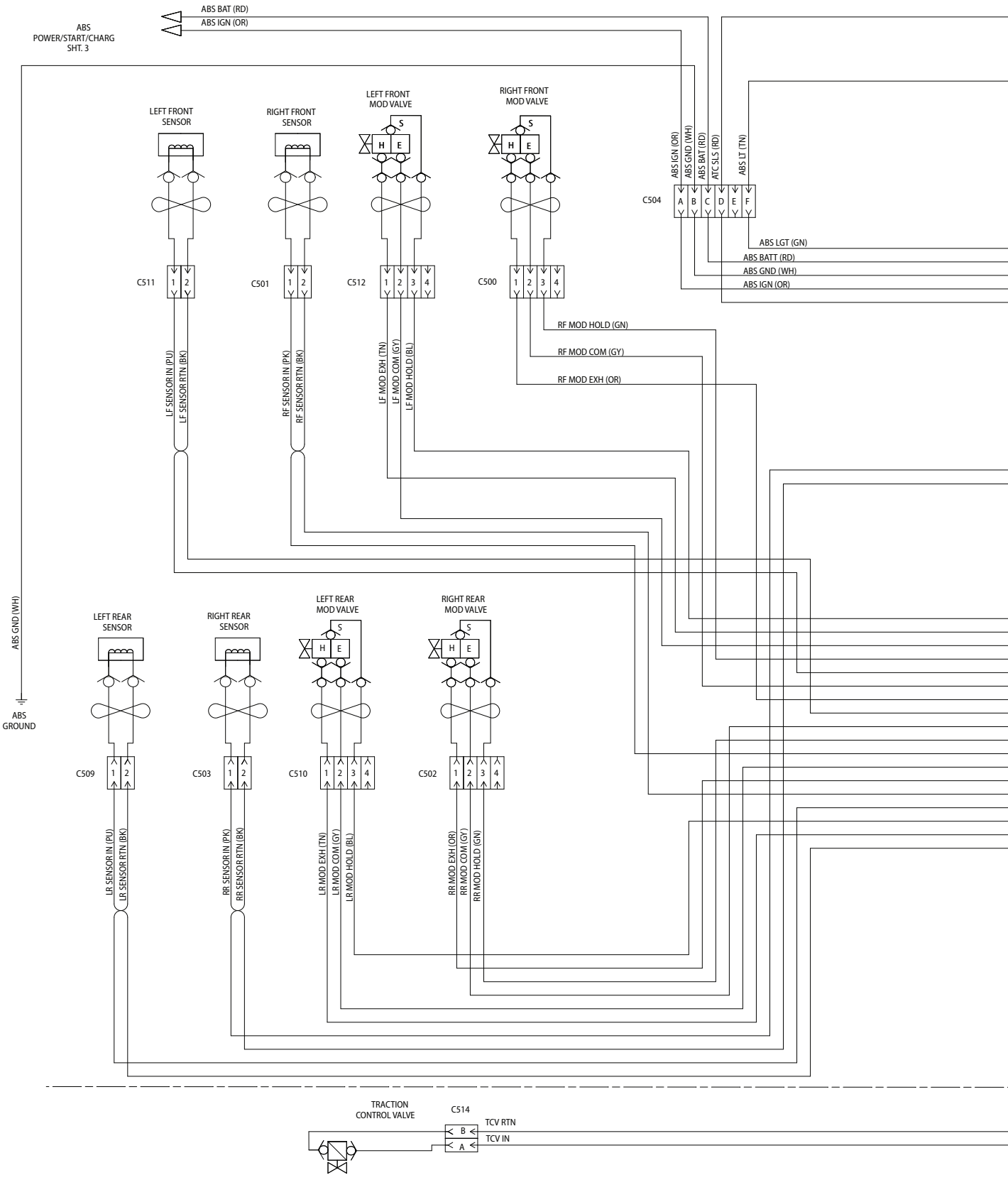
TYPICAL DASH SWITCH BACKLIGHTING CIRCUITS.
POWER AND GROUNDS CONTINUE TO LOOP FROM SWITCH TO SWITCH.

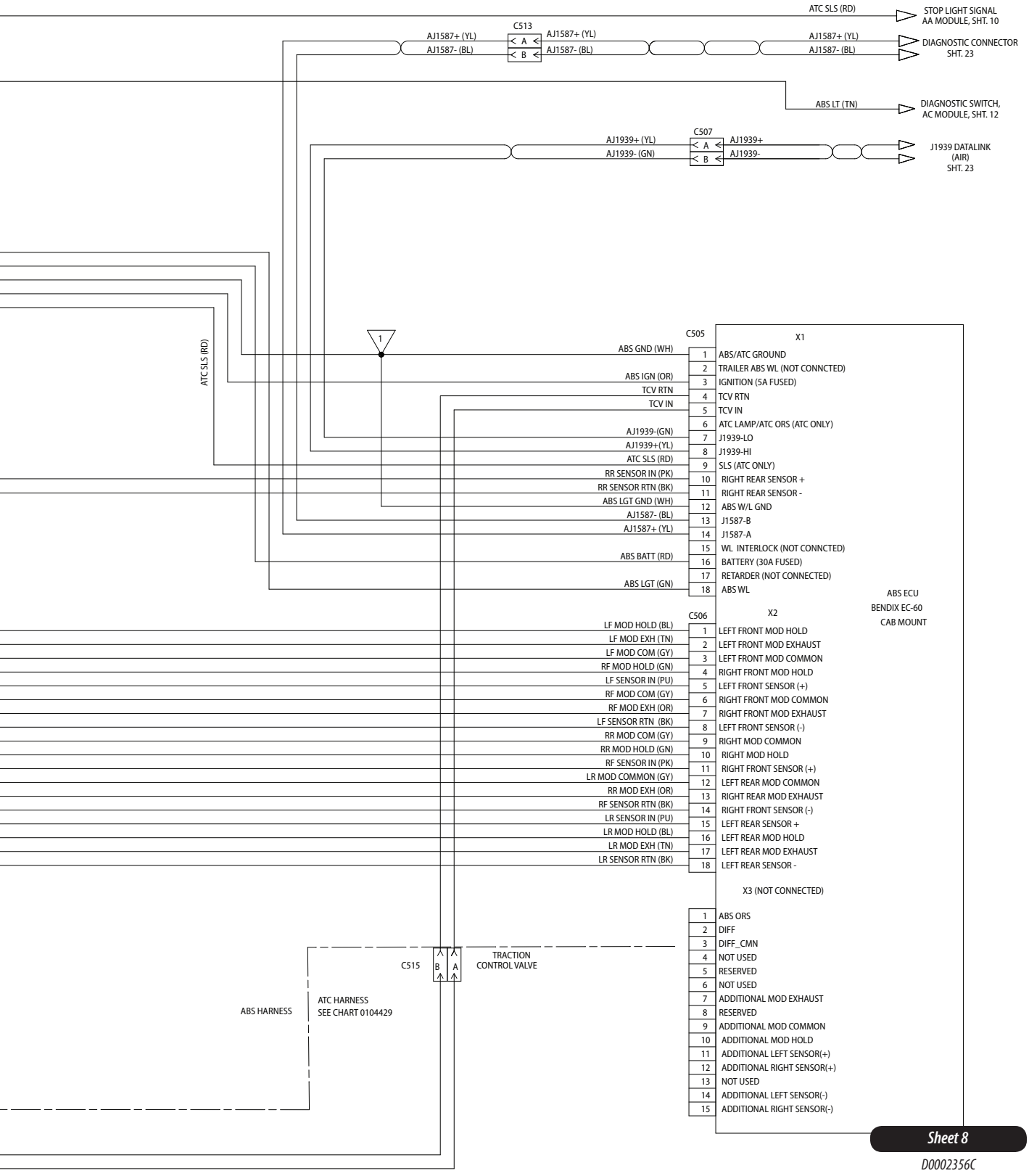


Sheet 7

D0002355C

BACKLIGHTS

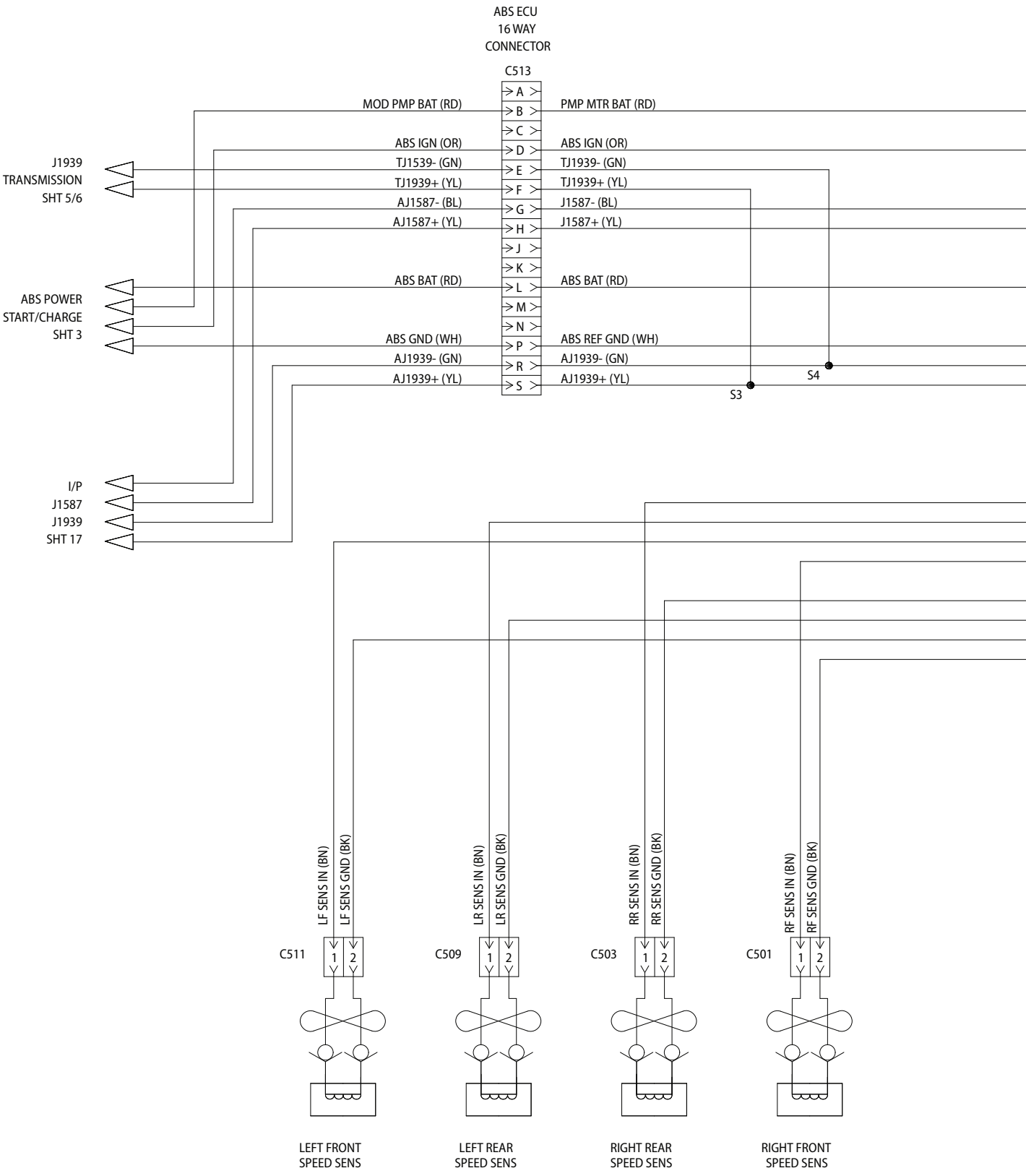

ABS BAT (RD)
ABS IGN (OR)
ABS POWER/START/CHARG SHT. 3
LEFT FRONT SENSOR
RIGHT FRONT SENSOR
LEFT FRONT MOD VALVE
RIGHT FRONT MOD VALVE
C504
ABS IGN (OR)
ABS GND (WH)
ABS BAT (RD)
ATC SLS (RD)
ABS LT (TN)
ABS LGT (GN)
ABS BATT (RD)
ABS GND (WH)
ABS IGN (OR)
C511
C501
C512
C500
LF SENSOR IN (PU)
LF SENSOR RTN (BK)
RF SENSOR IN (PK)
RF SENSOR RTN (BK)
LF MOD EXH (TN)
LF MOD COM (GY)
LF MOD HOLD (BL)
RF MOD HOLD (GN)
RF MOD COM (GY)
RF MOD EXH (OR)
ABS GND (WH)
ABS GROUND
LEFT REAR SENSOR
RIGHT REAR SENSOR
LEFT REAR MOD VALVE
RIGHT REAR MOD VALVE
C509
C503
C510
C502
LR SENSOR IN (PU)
LR SENSOR RTN (BK)
RR SENSOR IN (PK)
RR SENSOR RTN (BK)
LR MOD EXH (TN)
LR MOD COM (GY)
LR MOD HOLD (BL)
RR MOD EXH (OR)
RR MOD COM (GY)
RR MOD HOLD (GN)
TRACTION CONTROL VALVE
C514
TCV RTN
TCV IN

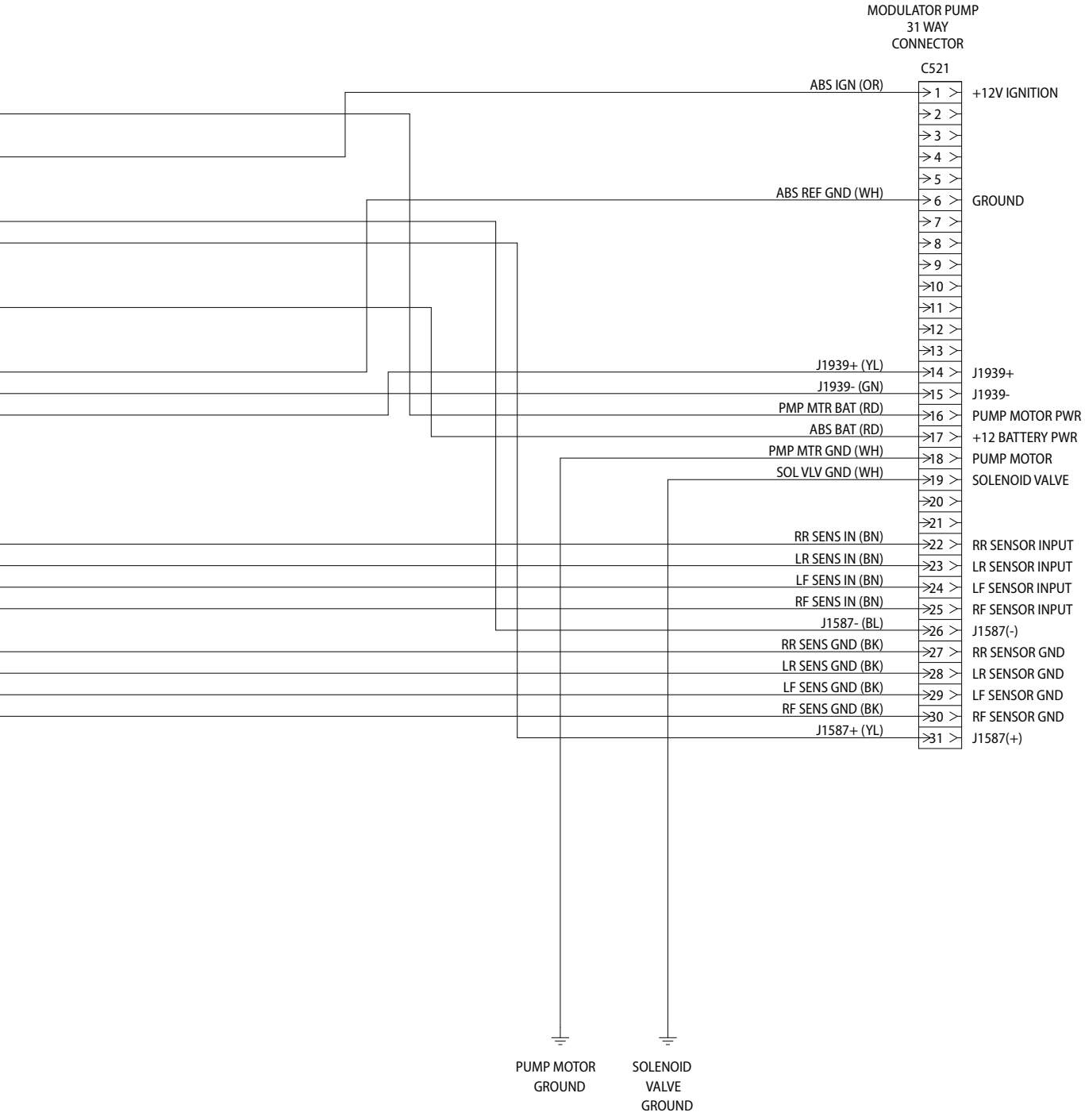


Sheet 8

D0002356C

ABS - BENDIX

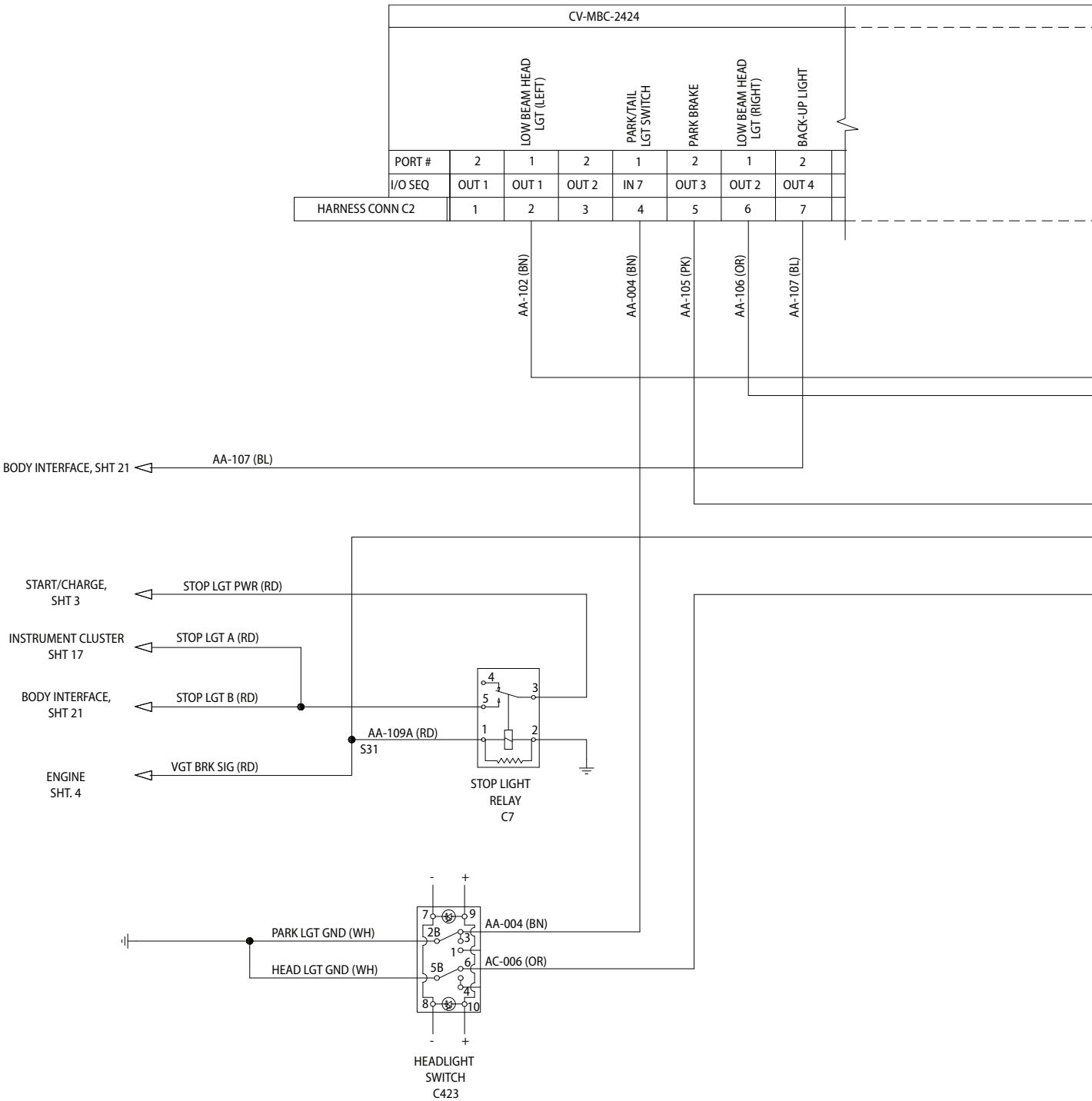

ABS ECU
16 WAY
CONNECTOR
C513
A
B
C
D
E
F
G
H
J
K
L
M
N
P
R
S
MOD PMP BAT (RD)
PMP MTR BAT (RD)
ABS IGN (OR)
ABS IGN (OR)
TJ1539- (GN)
TJ1939- (GN)
TJ1939+ (YL)
TJ1939+ (YL)
AJ1587- (BL)
J1587- (BL)
AJ1587+ (YL)
J1587+ (YL)
ABS BAT (RD)
ABS BAT (RD)
ABS GND (WH)
ABS REF GND (WH)
AJ1939- (GN)
AJ1939- (GN)
AJ1939+ (YL)
AJ1939+ (YL)
S4
S3
J1939
TRANSMISSION
SHT 5/6
ABS POWER
START/CHARGE
SHT 3
I/P
J1587
J1939
SHT 17
LF SENS IN (BN)
LF SENS GND (BK)
LR SENS IN (BN)
LR SENS GND (BK)
RR SENS IN (BN)
RR SENS GND (BK)
RF SENS IN (BN)
RF SENS GND (BK)
C511
C509
C503
C501
1
2
LEFT FRONT
SPEED SENS
LEFT REAR
SPEED SENS
RIGHT REAR
SPEED SENS
RIGHT FRONT
SPEED SENS

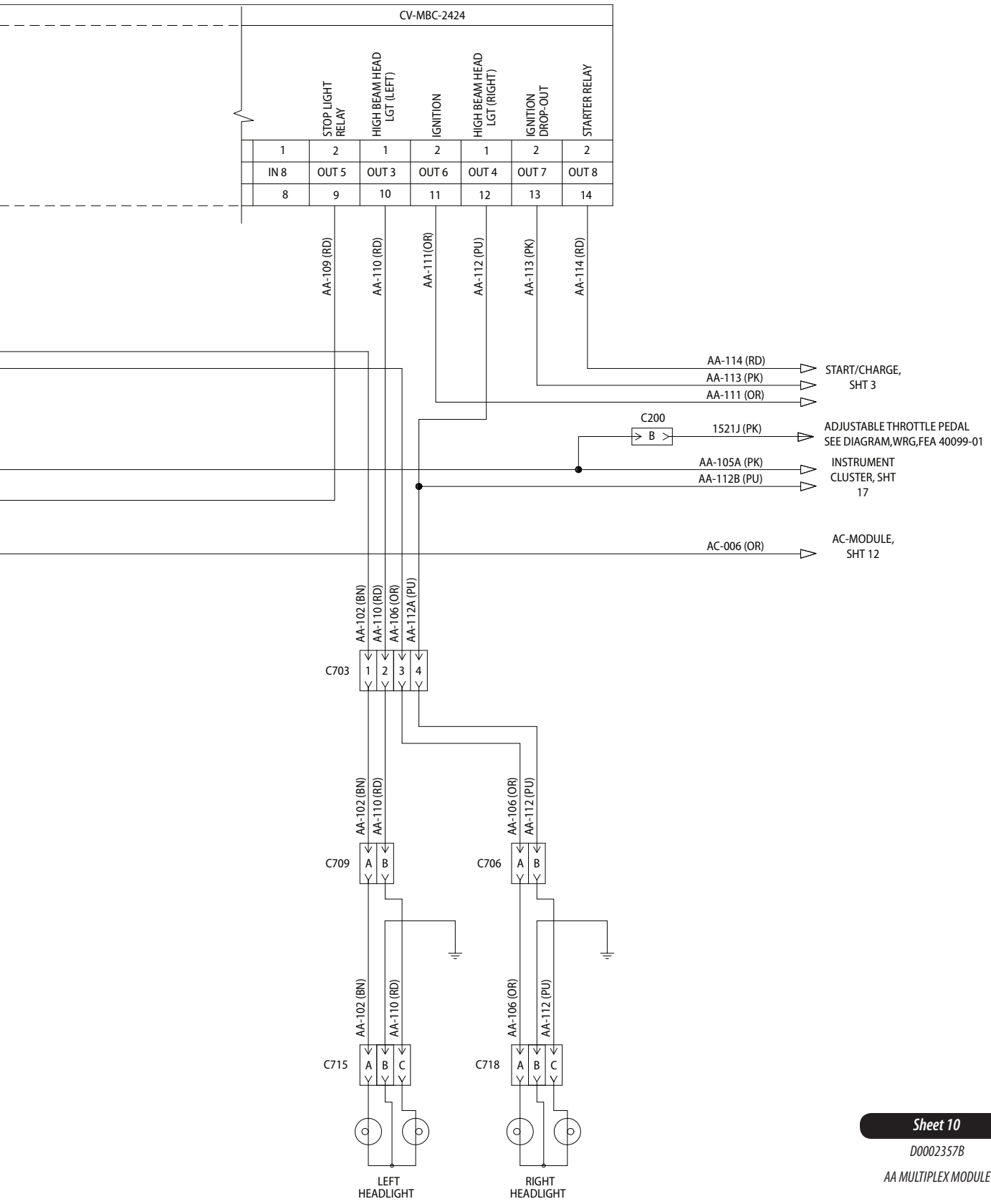


Sheet 9

00124967B

ABS - WABCO

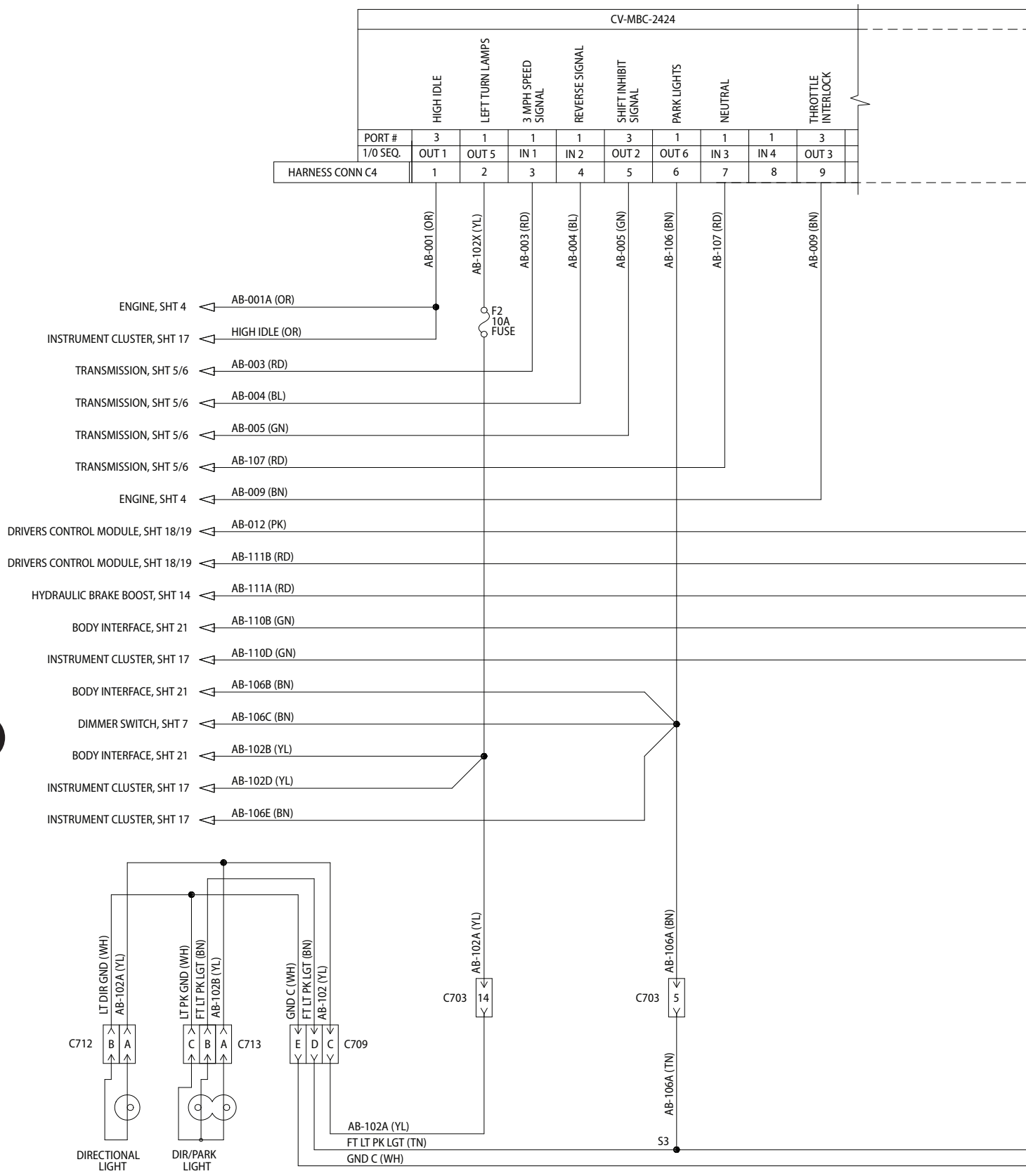

CV-MBC-2424
LOW BEAM HEAD LGT (LEFT)
PARK/TAIL LGT SWITCH
PARK BRAKE
LOW BEAM HEAD LGT (RIGHT)
BACK-UP LIGHT
PORT # 2 1 2 1 2 1 2
I/O SEQ OUT 1 OUT 1 OUT 2 IN 7 OUT 3 OUT 2 OUT 4
HARNESS CONN C2 1 2 3 4 5 6 7
AA-102 (BN)
AA-004 (BN)
AA-105 (PK)
AA-106 (OR)
AA-107 (BL)
BODY INTERFACE, SHT 21
AA-107 (BL)
START/CHARGE, SHT 3
STOP LGT PWR (RD)
INSTRUMENT CLUSTER SHT 17
STOP LGT A (RD)
BODY INTERFACE, SHT 21
STOP LGT B (RD)
AA-109A (RD)
S31
ENGINE SHT. 4
VGT BRK SIG (RD)
STOP LIGHT RELAY C7
PARK LGT GND (WH)
HEAD LGT GND (WH)
AA-004 (BN)
AC-006 (OR)
HEADLIGHT SWITCH C423

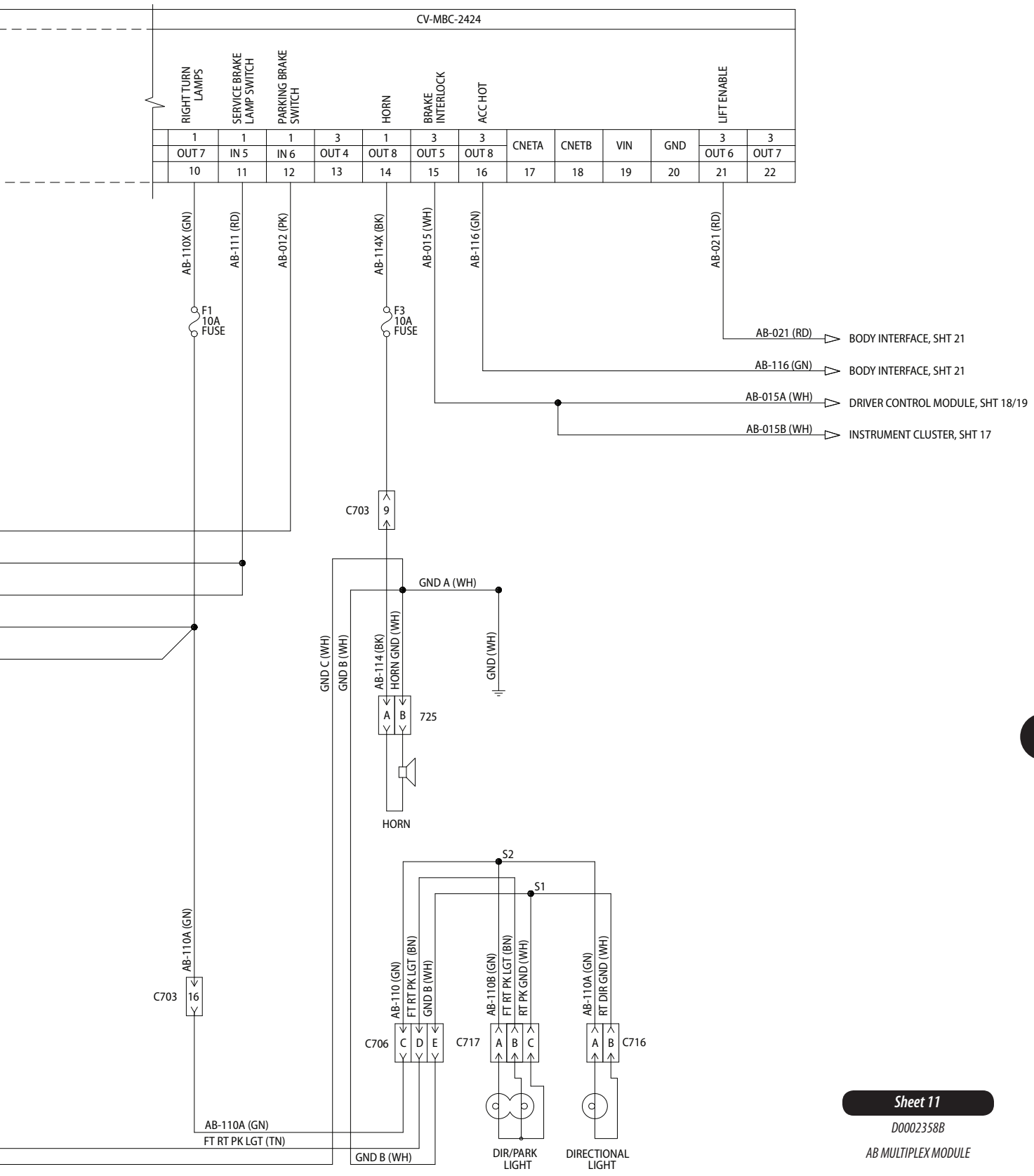


Sheet 10

D0002357B

AA MULTIPLEX MODULE

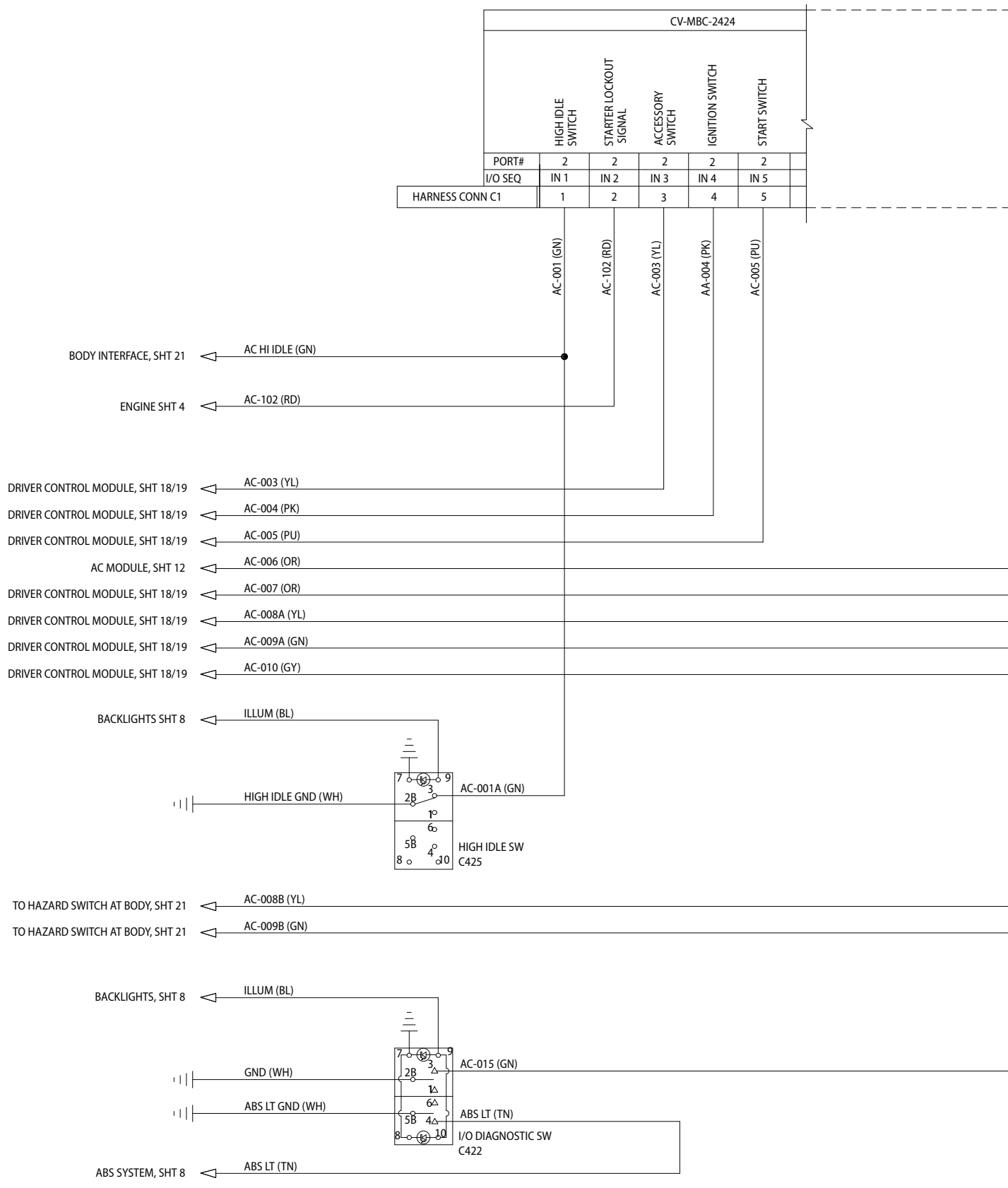

CV-MBC-2424
HIGH IDLE
LEFT TURN LAMPS
3 MPH SPEED SIGNAL
REVERSE SIGNAL
SHIFT INHIBIT SIGNAL
PARK LIGHTS
NEUTRAL
THROTTLE INTERLOCK
PORT # 3 1 1 1 3 1 1 1 3
1/0 SEQ. OUT 1 OUT 5 IN 1 IN 2 OUT 2 OUT 6 IN 3 IN 4 OUT 3
HARNESS CONN C4 1 2 3 4 5 6 7 8 9
AB-001 (OR)
AB-102X (YL)
AB-003 (RD)
AB-004 (BL)
AB-005 (GN)
AB-106 (BN)
AB-107 (RD)
AB-009 (BN)
F2 10A FUSE
ENGINE, SHT 4
AB-001A (OR)
INSTRUMENT CLUSTER, SHT 17
HIGH IDLE (OR)
TRANSMISSION, SHT 5/6
AB-003 (RD)
TRANSMISSION, SHT 5/6
AB-004 (BL)
TRANSMISSION, SHT 5/6
AB-005 (GN)
TRANSMISSION, SHT 5/6
AB-107 (RD)
ENGINE, SHT 4
AB-009 (BN)
DRIVERS CONTROL MODULE, SHT 18/19
AB-012 (PK)
DRIVERS CONTROL MODULE, SHT 18/19
AB-111B (RD)
HYDRAULIC BRAKE BOOST, SHT 14
AB-111A (RD)
BODY INTERFACE, SHT 21
AB-110B (GN)
INSTRUMENT CLUSTER, SHT 17
AB-110D (GN)
BODY INTERFACE, SHT 21
AB-106B (BN)
DIMMER SWITCH, SHT 7
AB-106C (BN)
BODY INTERFACE, SHT 21
AB-102B (YL)
INSTRUMENT CLUSTER, SHT 17
AB-102D (YL)
INSTRUMENT CLUSTER, SHT 17
AB-106E (BN)
LT DIR GND (WH)
AB-102A (YL)
LT PK GND (WH)
FT LT PK LGT (BN)
AB-102B (YL)
GND C (WH)
FT LT PK LGT (BN)
AB-102 (YL)
C712 B A
C713 C B A
C709 E D C
AB-102A (YL)
C703 14
AB-106A (BN)
C703 5
AB-106A (TN)
S3
AB-102A (YL)
FT LT PK LGT (TN)
GND C (WH)
DIRECTIONAL LIGHT
DIR/PARK LIGHT

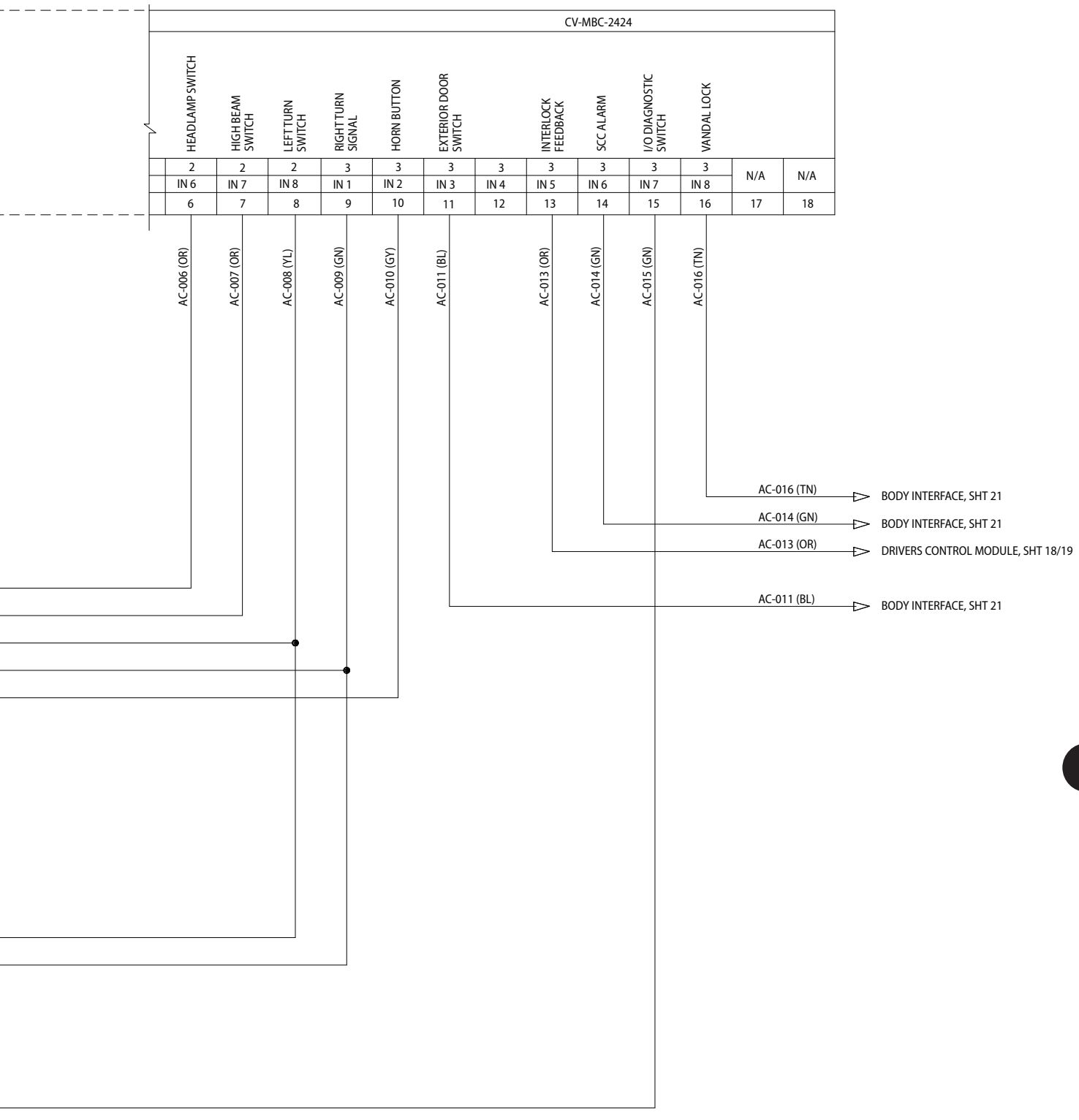


Sheet 11

D0002358B

AB MULTIPLEX MODULE

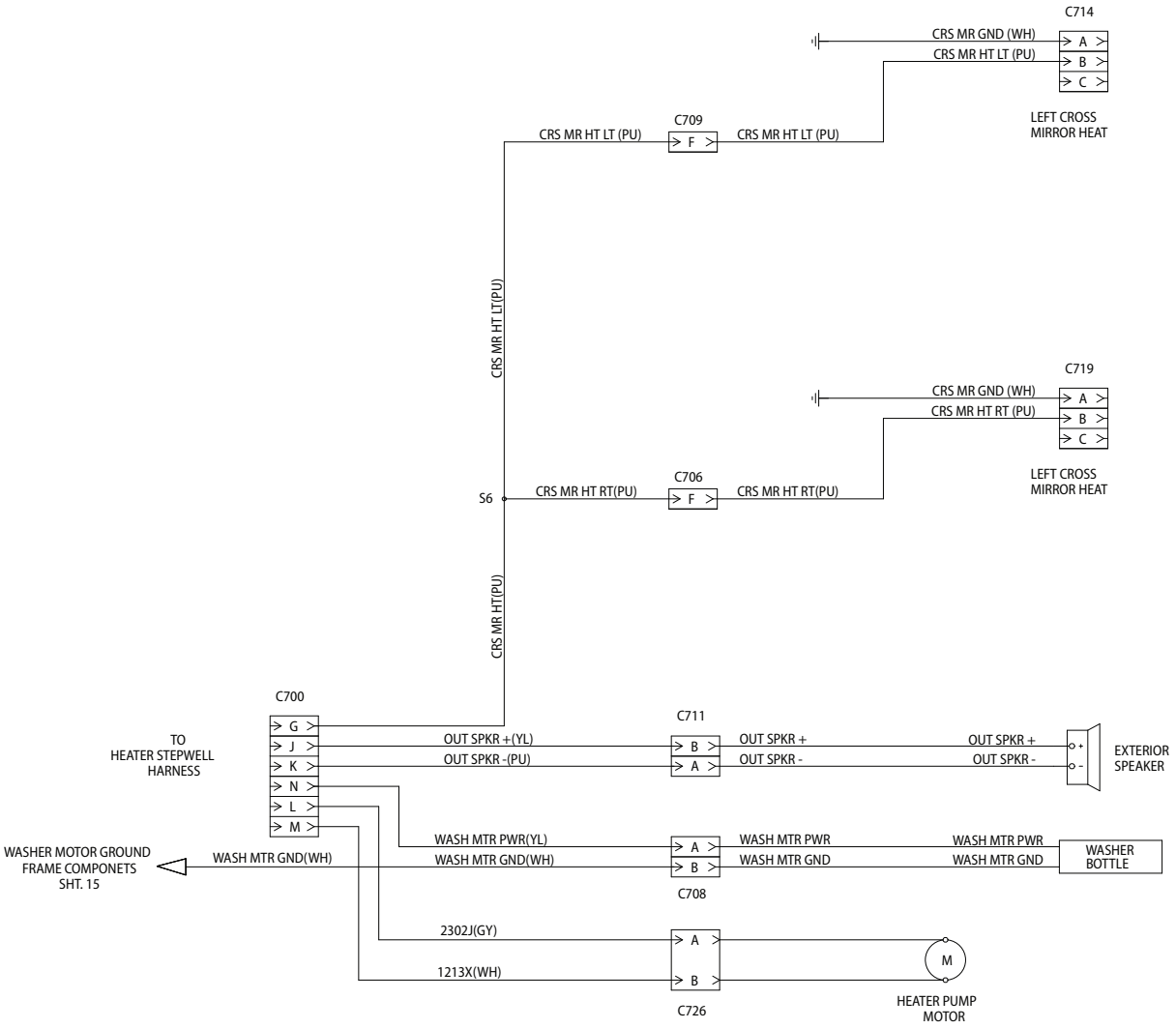

CV-MBC-2424
HIGH IDLE SWITCH
STARTER LOCKOUT SIGNAL
ACCESSORY SWITCH
IGNITION SWITCH
START SWITCH
PORT# 2 2 2 2 2
I/O SEQ IN 1 IN 2 IN 3 IN 4 IN 5
HARNESS CONN C1 1 2 3 4 5
AC-001 (GN)
AC-102 (RD)
AC-003 (YL)
AA-004 (PK)
AC-005 (PU)
BODY INTERFACE, SHT 21
AC HI IDLE (GN)
ENGINE SHT 4
AC-102 (RD)
DRIVER CONTROL MODULE, SHT 18/19
AC-003 (YL)
DRIVER CONTROL MODULE, SHT 18/19
AC-004 (PK)
DRIVER CONTROL MODULE, SHT 18/19
AC-005 (PU)
AC MODULE, SHT 12
AC-006 (OR)
DRIVER CONTROL MODULE, SHT 18/19
AC-007 (OR)
DRIVER CONTROL MODULE, SHT 18/19
AC-008A (YL)
DRIVER CONTROL MODULE, SHT 18/19
AC-009A (GN)
DRIVER CONTROL MODULE, SHT 18/19
AC-010 (GY)
BACKLIGHTS SHT 8
ILLUM (BL)
HIGH IDLE GND (WH)
AC-001A (GN)
HIGH IDLE SW
C425
TO HAZARD SWITCH AT BODY, SHT 21
AC-008B (YL)
TO HAZARD SWITCH AT BODY, SHT 21
AC-009B (GN)
BACKLIGHTS, SHT 8
ILLUM (BL)
GND (WH)
AC-015 (GN)
ABS LT GND (WH)
ABS LT (TN)
I/O DIAGNOSTIC SW
C422
ABS SYSTEM, SHT 8
ABS LT (TN)



Sheet 12

D0002359A

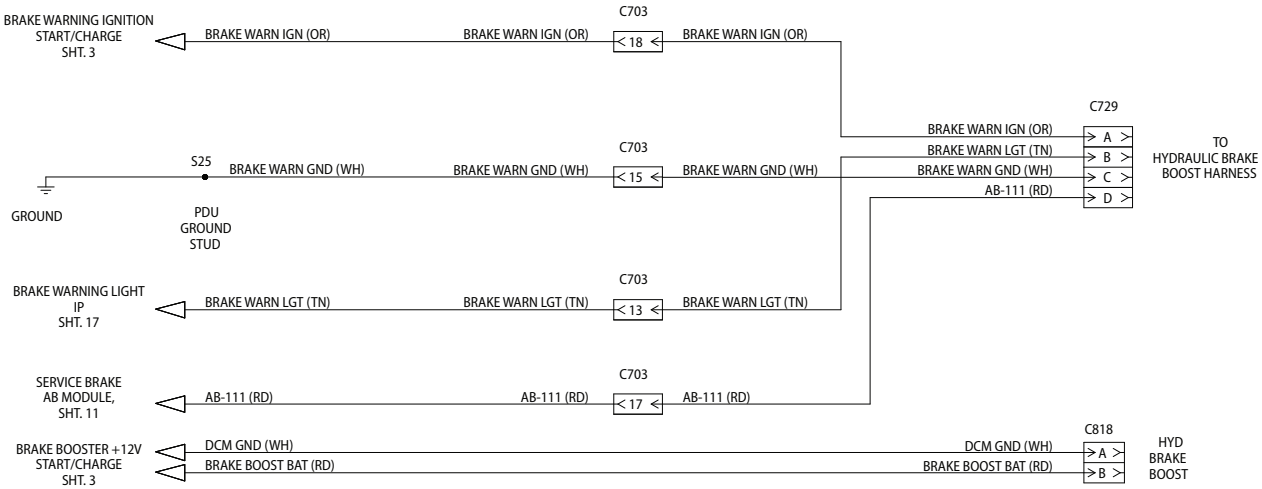
AC MULTIPLEX MODULE

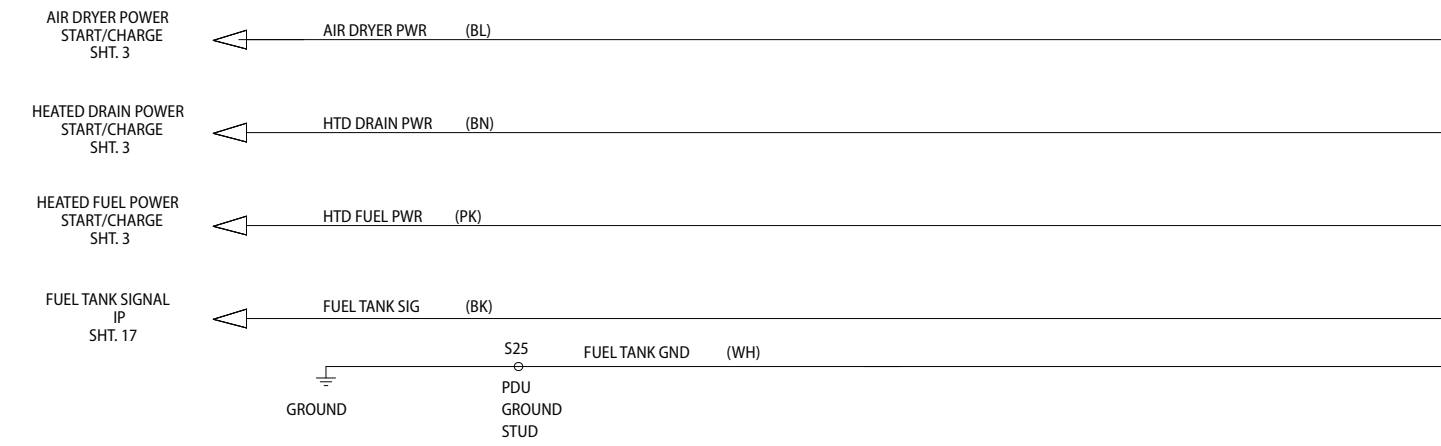


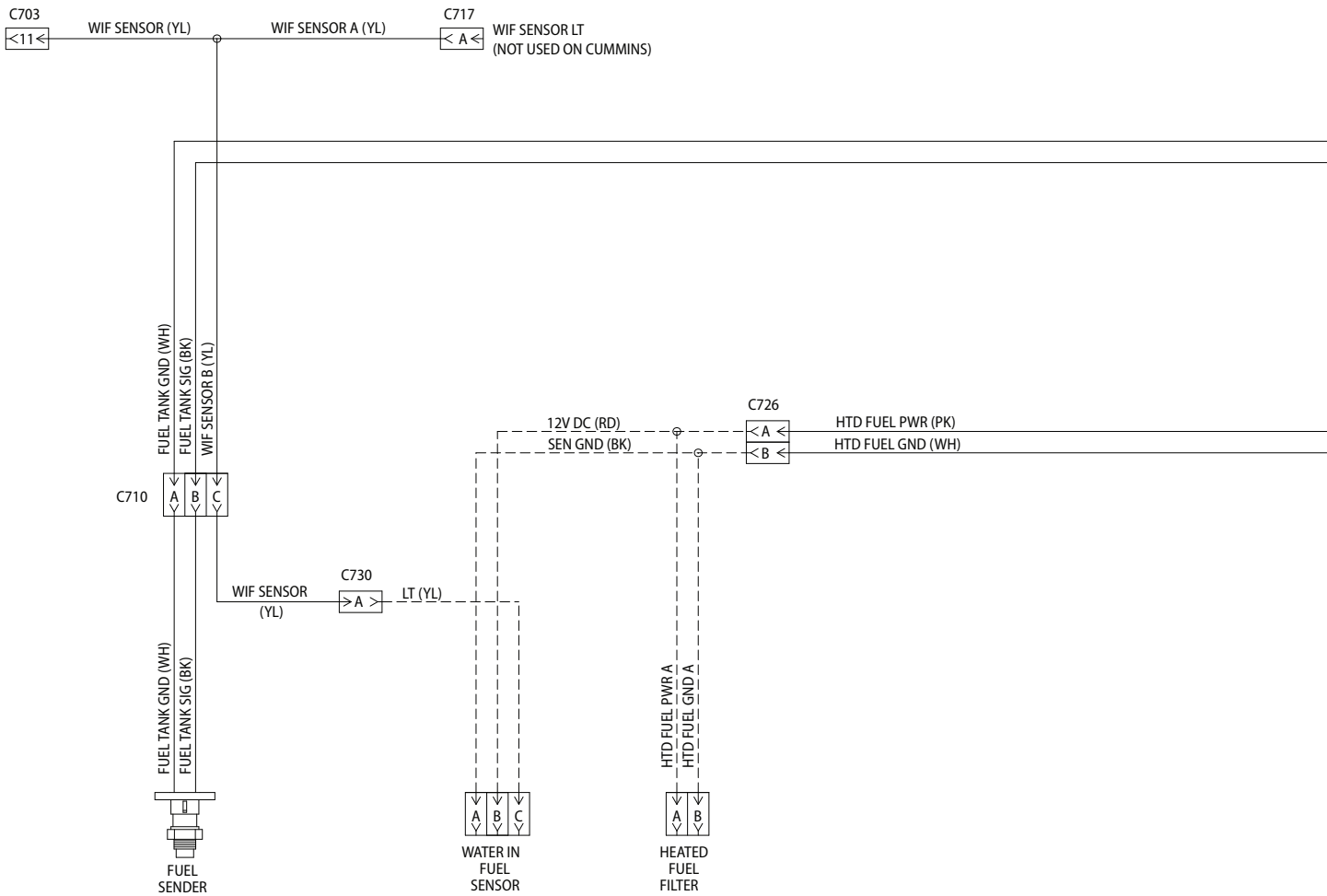
Sheet 13

0112299

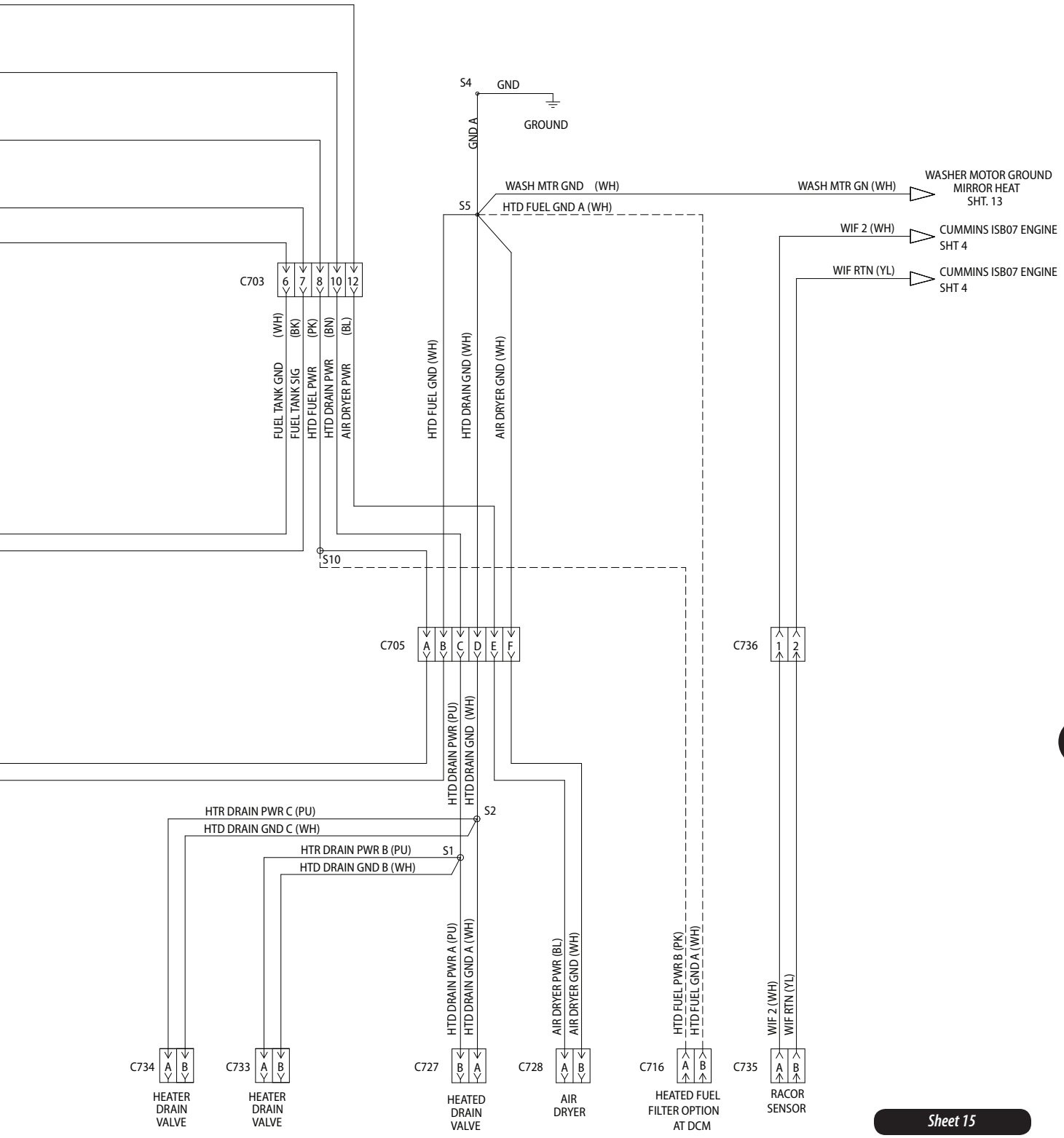
MIRROR HEAT/EXTERIOR SPEAKER/WIPER WASHER


BRAKE WARNING IGNITION
START/CHARGE
SHT. 3
BRAKE WARN IGN (OR)
BRAKE WARN IGN (OR)
C703
18
BRAKE WARN IGN (OR)
C729
BRAKE WARN IGN (OR)
A
BRAKE WARN LGT (TN)
B
BRAKE WARN GND (WH)
C
AB-111 (RD)
D
TO
HYDRAULIC BRAKE
BOOST HARNESS
S25
BRAKE WARN GND (WH)
BRAKE WARN GND (WH)
C703
15
BRAKE WARN GND (WH)
GROUND
PDU
GROUND
STUD
BRAKE WARNING LIGHT
IP
SHT. 17
BRAKE WARN LGT (TN)
BRAKE WARN LGT (TN)
C703
13
BRAKE WARN LGT (TN)
SERVICE BRAKE
AB MODULE,
SHT. 11
AB-111 (RD)
AB-111 (RD)
C703
17
AB-111 (RD)
C818
BRAKE BOOSTER +12V
START/CHARGE
SHT. 3
DCM GND (WH)
BRAKE BOOST BAT (RD)
DCM GND (WH)
BRAKE BOOST BAT (RD)
A
B
HYD
BRAKE
BOOST





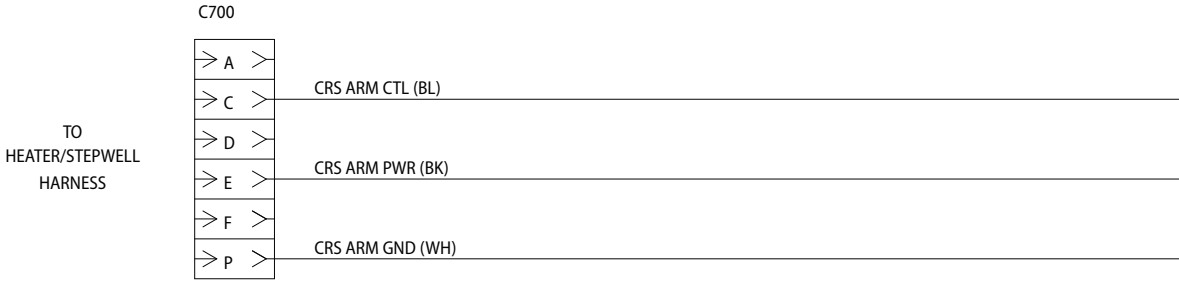
NOTE: DASHED LINES INDICATE THAT THERE IS AN ADDITIONAL HARNESS INSTALLED FOR THE WATER IN FUEL OPTION.

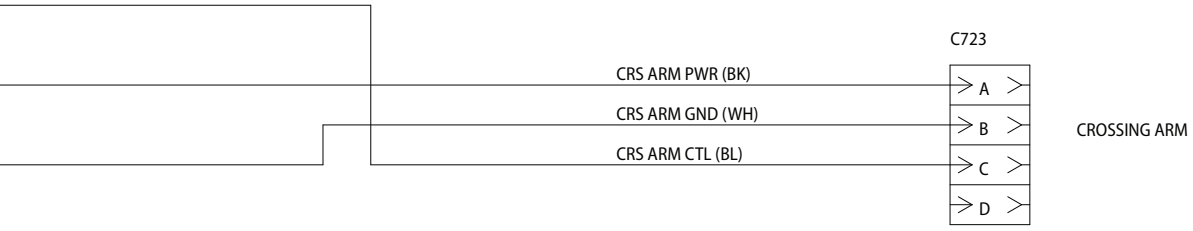


Sheet 15

D0002360A

FRAME COMPONENTS

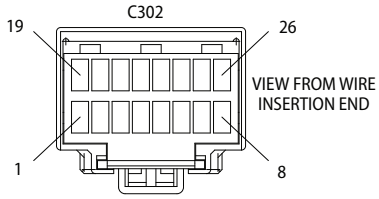

C700
A
C
D
E
F
P
TO
HEATER/STEPWELL
HARNESS
CRS ARM CTL (BL)
CRS ARM PWR (BK)
CRS ARM GND (WH)



Sheet 16

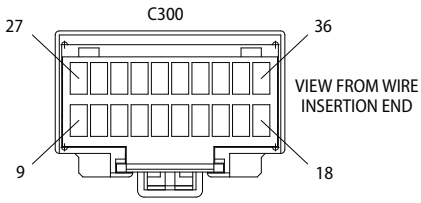
00112302A

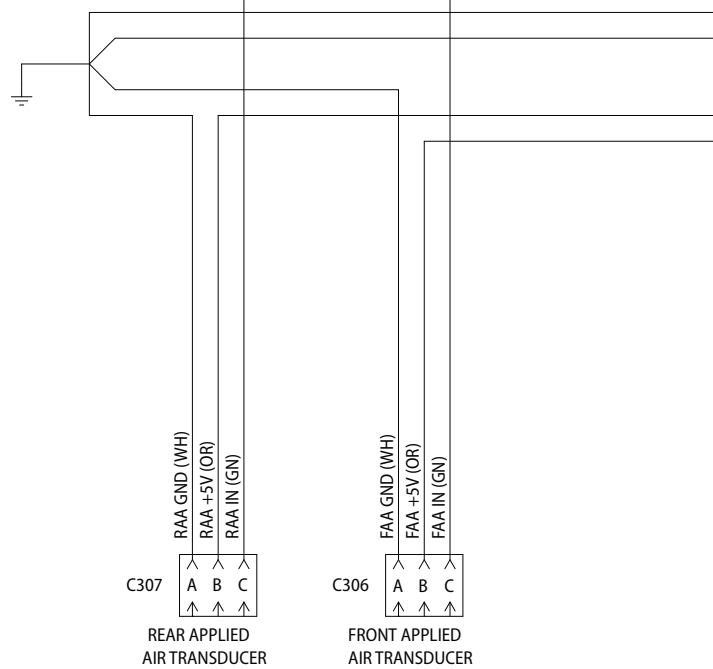
CROSSING ARM

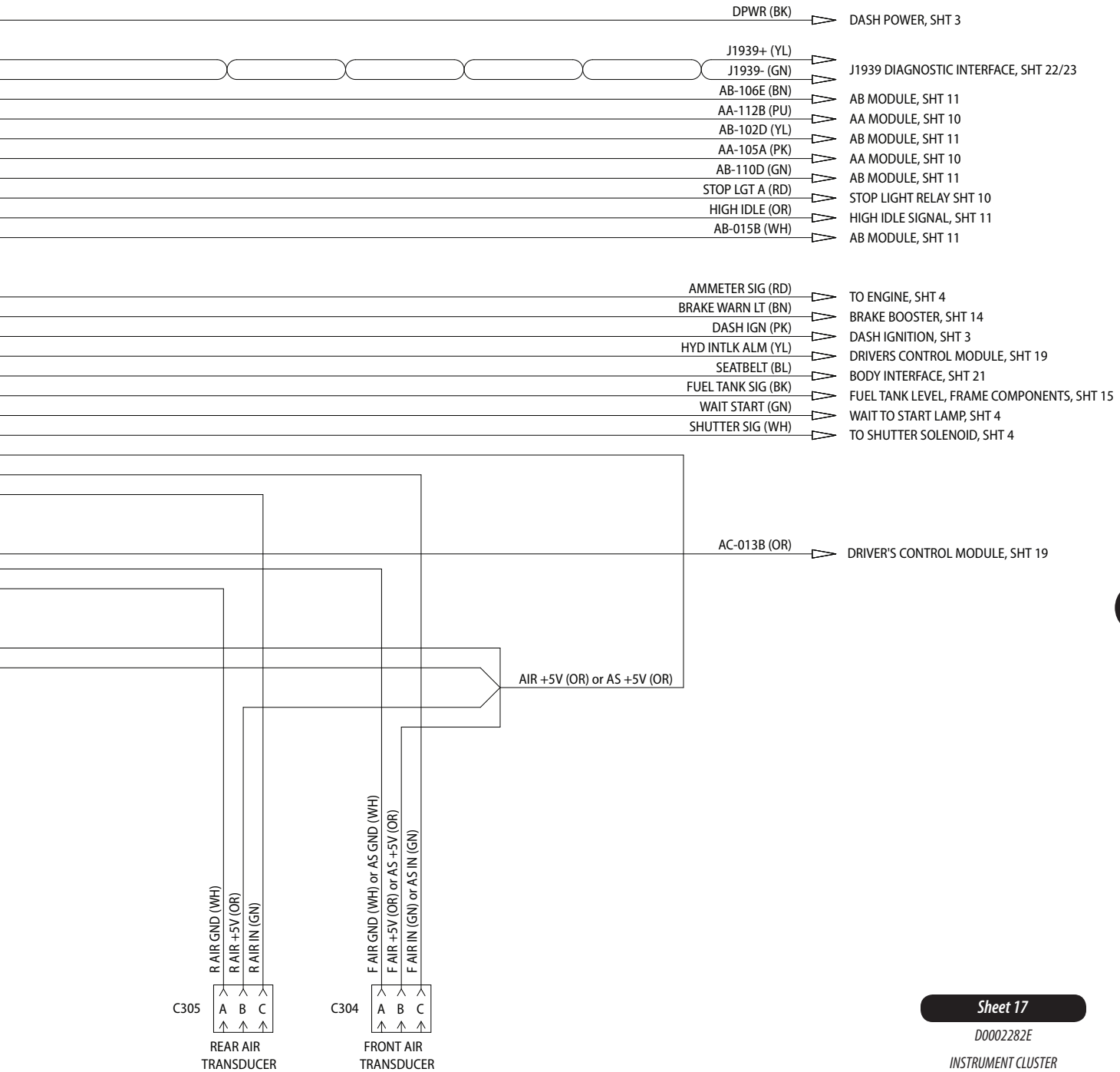


INSTRUMENT CLUSTER

	C302	
BATTERY +12V	1	DPWR (BK)
GROUND	2	DCHASS GND (WH)
SAE J1939+	3	J1939+ (YL)
SAE J1939-	4	J1939- (GN)
HEADLAMP REMINDER	19	AB-106E (BN)
HI BEAM INDICATOR	20	AA-112B (PU)
LEFT TURN INDICATOR	21	AB-102D (YL)
PARK BRAKE	22	AA-105A (PK)
RIGHT TURN INDICATOR	23	AB-110D (GN)
BRAKE SIGNAL IN	24	STOP LGT A (RD)
FAST IDLE	25	HIGH IDLE (OR)
BRAKE INTERLOCK REQUEST	26	AB-015B (WH)
	C300	
AMMETER IN	15	AMMETER SIG (RD)
HYDRAULIC BRAKE FAILURE	17	BRAKE WARN LT (BN)
IGNITION +12V	18	DASH IGN (PK)
BRAKE INTERLOCK ALARM	27	HYD INTLK ALM (YL)
SEAT BELT	32	SEATBELT (BL)
FUEL LEVEL SENDER	34	FUEL TANK SIG (BK)
WAIT TO START LAMP	36	WAIT START (GN)
SHUTTER SOLENOID	30	SHUTTER SIG (WH)
+5 VDC SENSOR POWER	9	AIR +5V (OR) or AS +5V (OR-HYD ONLY)
FRONT AIR PSI SENDER	11	F AIR IN (GN) or AS IN (GN-HYD ONLY)
REAR AIR PSI SENDER	12	R AIR IN (GN)
APPLILED FRONT AIR PSI SENSOR	13	FAA IN (GN)
APPLIED REAR AIR PSI SENSOR	14	RAA IN (GN)
INTERLOCK SET	35	AC-013B (OR)



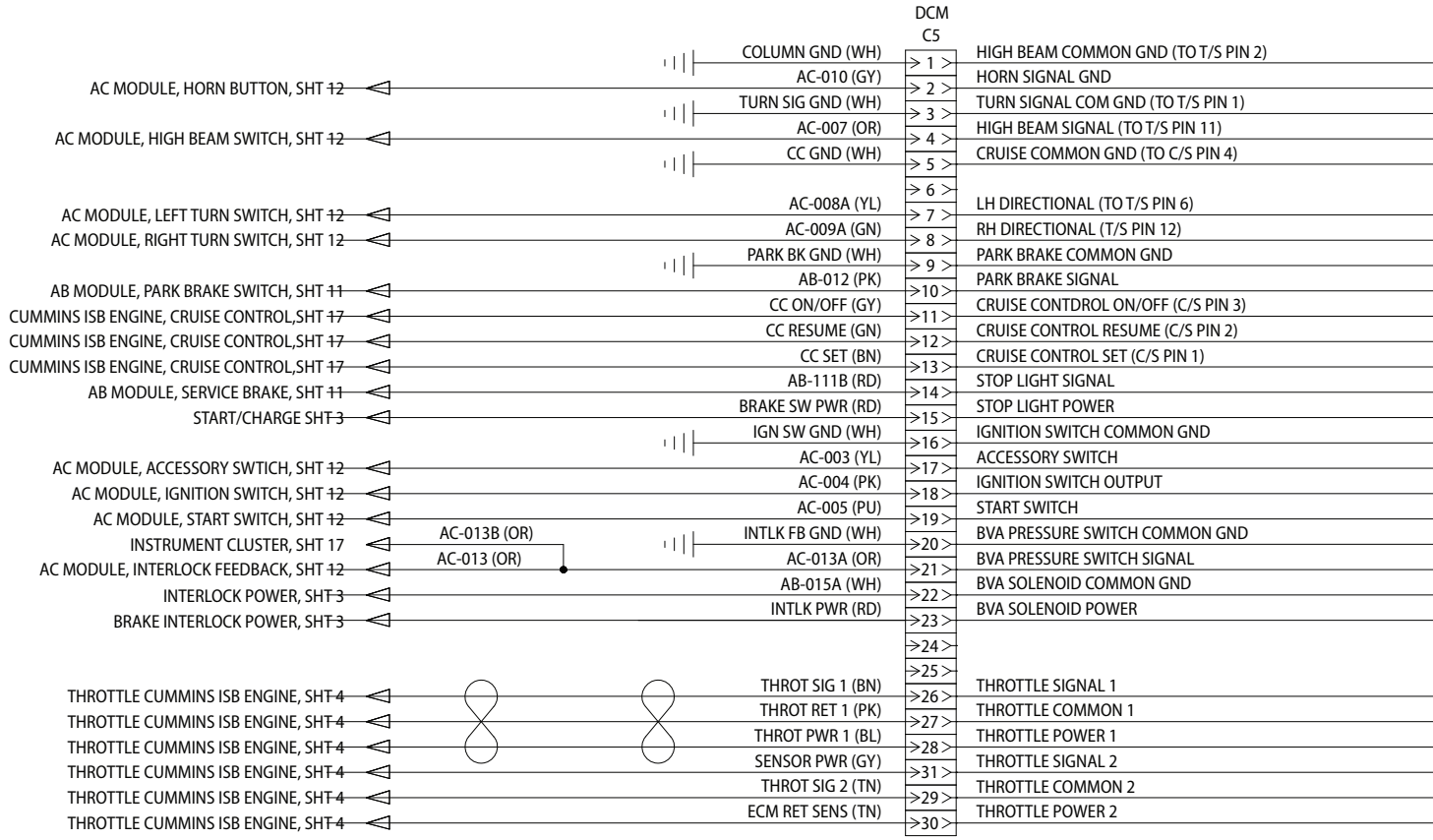


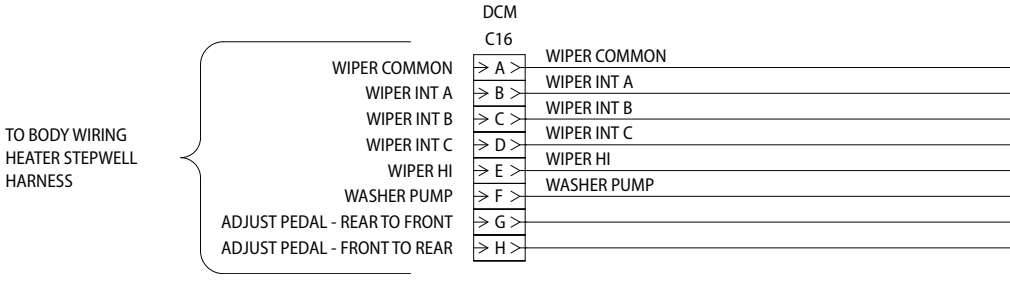


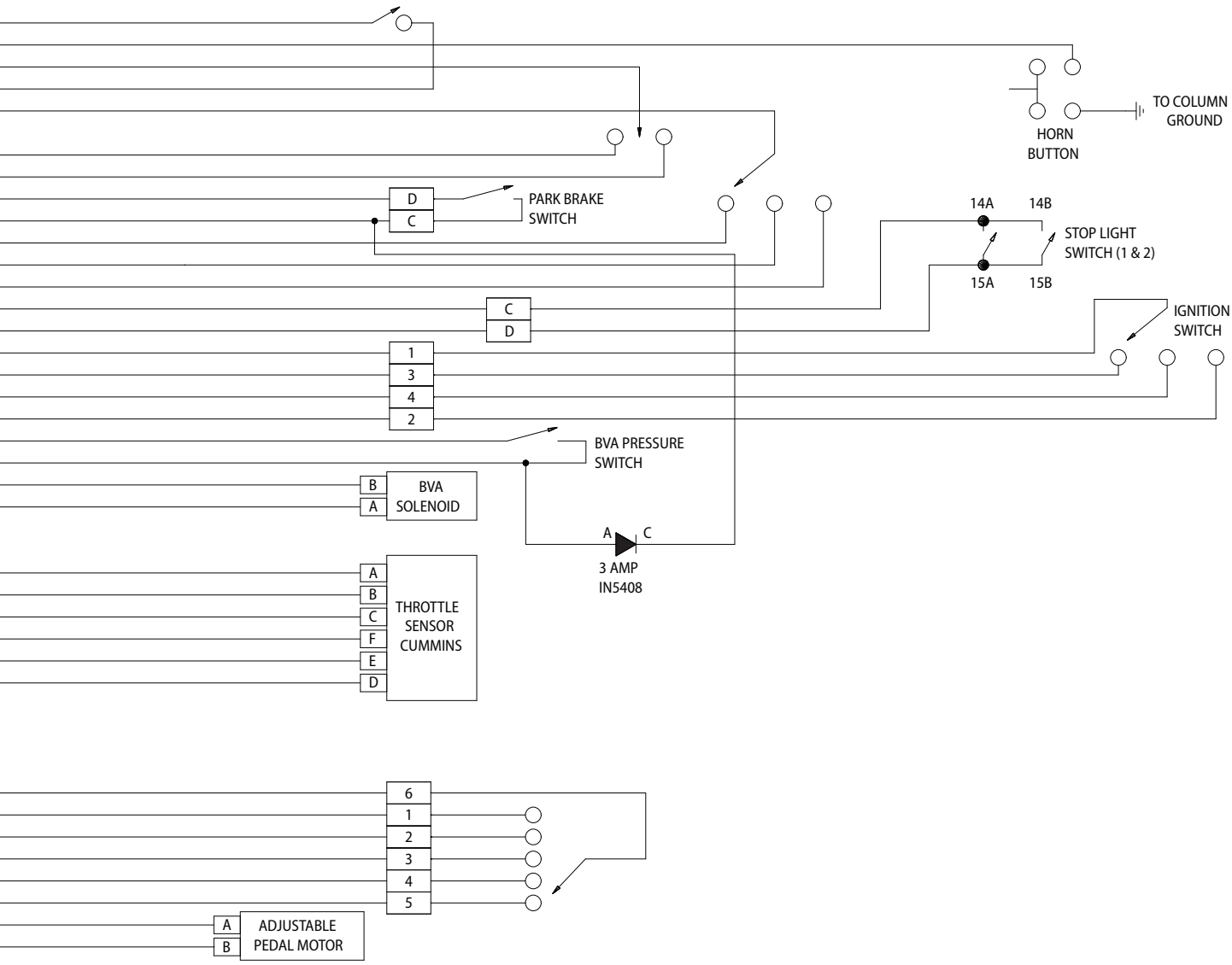
Sheet 17

D0002282E

INSTRUMENT CLUSTER


DCM
C5
COLUMN GND (WH)
AC-010 (GY)
TURN SIG GND (WH)
AC-007 (OR)
CC GND (WH)
AC-008A (YL)
AC-009A (GN)
PARK BK GND (WH)
AB-012 (PK)
CC ON/OFF (GY)
CC RESUME (GN)
CC SET (BN)
AB-111B (RD)
BRAKE SW PWR (RD)
IGN SW GND (WH)
AC-003 (YL)
AC-004 (PK)
AC-005 (PU)
INTLK FB GND (WH)
AC-013A (OR)
AB-015A (WH)
INTLK PWR (RD)
THROT SIG 1 (BN)
THROT RET 1 (PK)
THROT PWR 1 (BL)
SENSOR PWR (GY)
THROT SIG 2 (TN)
ECM RET SENS (TN)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
31
29
30
HIGH BEAM COMMON GND (TO T/S PIN 2)
HORN SIGNAL GND
TURN SIGNAL COM GND (TO T/S PIN 1)
HIGH BEAM SIGNAL (TO T/S PIN 11)
CRUISE COMMON GND (TO C/S PIN 4)
LH DIRECTIONAL (TO T/S PIN 6)
RH DIRECTIONAL (T/S PIN 12)
PARK BRAKE COMMON GND
PARK BRAKE SIGNAL
CRUISE CONTDROL ON/OFF (C/S PIN 3)
CRUISE CONTROL RESUME (C/S PIN 2)
CRUISE CONTROL SET (C/S PIN 1)
STOP LIGHT SIGNAL
STOP LIGHT POWER
IGNITION SWITCH COMMON GND
ACCESSORY SWITCH
IGNITION SWITCH OUTPUT
START SWITCH
BVA PRESSURE SWITCH COMMON GND
BVA PRESSURE SWITCH SIGNAL
BVA SOLENOID COMMON GND
BVA SOLENOID POWER
THROTTLE SIGNAL 1
THROTTLE COMMON 1
THROTTLE POWER 1
THROTTLE SIGNAL 2
THROTTLE COMMON 2
THROTTLE POWER 2
AC MODULE, HORN BUTTON, SHT 12
AC MODULE, HIGH BEAM SWITCH, SHT 12
AC MODULE, LEFT TURN SWITCH, SHT 12
AC MODULE, RIGHT TURN SWITCH, SHT 12
AB MODULE, PARK BRAKE SWITCH, SHT 11
CUMMINS ISB ENGINE, CRUISE CONTROL,SHT 17
CUMMINS ISB ENGINE, CRUISE CONTROL,SHT 17
CUMMINS ISB ENGINE, CRUISE CONTROL,SHT 17
AB MODULE, SERVICE BRAKE, SHT 11
START/CHARGE SHT 3
AC MODULE, ACCESSORY SWTICH, SHT 12
AC MODULE, IGNITION SWITCH, SHT 12
AC MODULE, START SWITCH, SHT 12
INSTRUMENT CLUSTER, SHT 17
AC MODULE, INTERLOCK FEEDBACK, SHT 12
INTERLOCK POWER, SHT 3
BRAKE INTERLOCK POWER, SHT 3
AC-013B (OR)
AC-013 (OR)
THROTTLE CUMMINS ISB ENGINE, SHT 4
THROTTLE CUMMINS ISB ENGINE, SHT 4
THROTTLE CUMMINS ISB ENGINE, SHT 4
THROTTLE CUMMINS ISB ENGINE, SHT 4
THROTTLE CUMMINS ISB ENGINE, SHT 4
THROTTLE CUMMINS ISB ENGINE, SHT 4

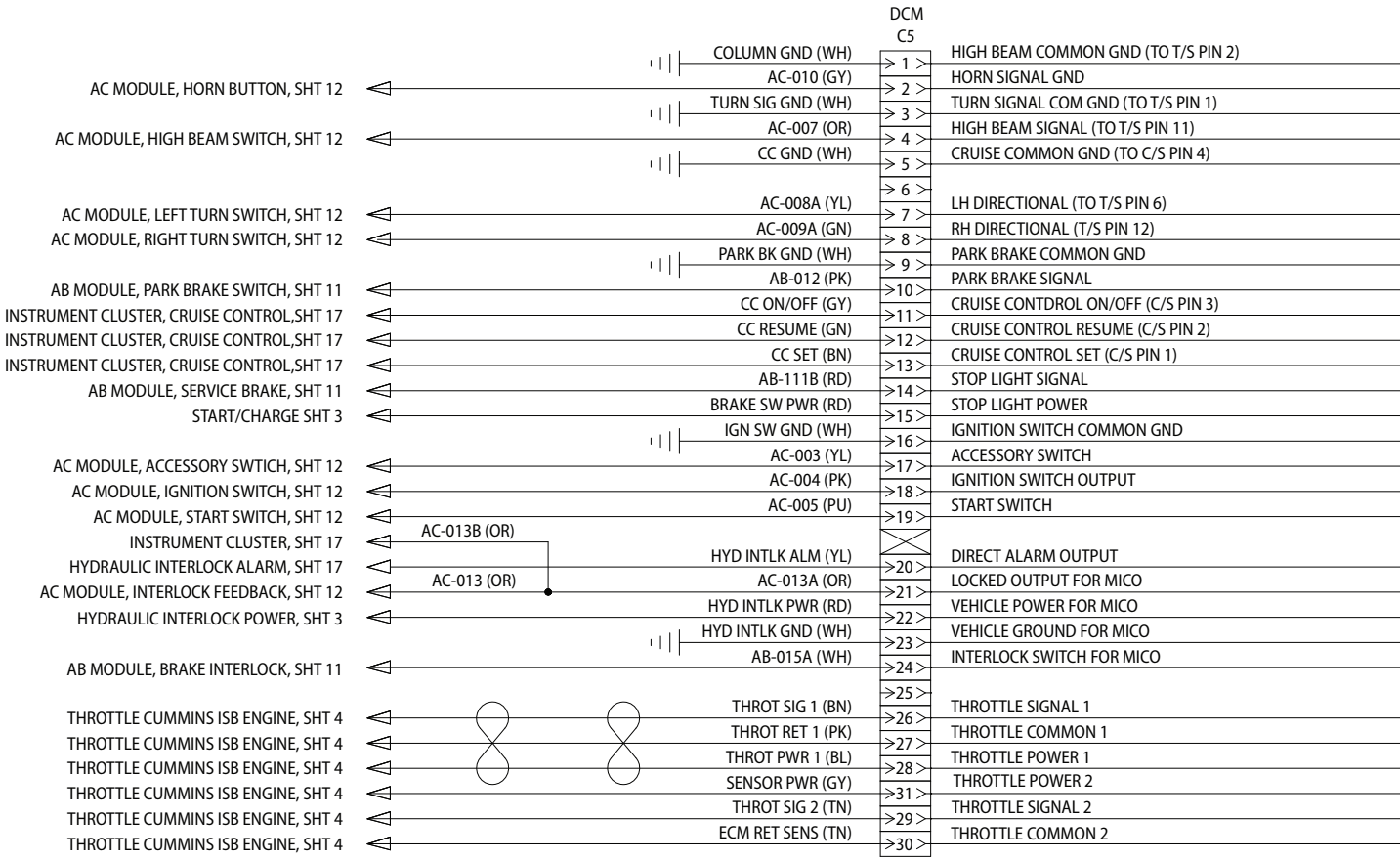

DCM
C16
TO BODY WIRING
HEATER STEPWELL
HARNESS
WIPER COMMON
WIPER INT A
WIPER INT B
WIPER INT C
WIPER HI
WASHER PUMP
ADJUST PEDAL - REAR TO FRONT
ADJUST PEDAL - FRONT TO REAR
A
B
C
D
E
F
G
H
WIPER COMMON
WIPER INT A
WIPER INT B
WIPER INT C
WIPER HI
WASHER PUMP



Sheet 18

D0002361F

DRIVER'S CONTROL MODULE, AIR


DCM
C5
COLUMN GND (WH)
AC-010 (GY)
TURN SIG GND (WH)
AC-007 (OR)
CC GND (WH)
AC-008A (YL)
AC-009A (GN)
PARK BK GND (WH)
AB-012 (PK)
CC ON/OFF (GY)
CC RESUME (GN)
CC SET (BN)
AB-111B (RD)
BRAKE SW PWR (RD)
IGN SW GND (WH)
AC-003 (YL)
AC-004 (PK)
AC-005 (PU)
AC-013B (OR)
AC-013 (OR)
HYD INTLK ALM (YL)
AC-013A (OR)
HYD INTLK PWR (RD)
HYD INTLK GND (WH)
AB-015A (WH)
THROT SIG 1 (BN)
THROT RET 1 (PK)
THROT PWR 1 (BL)
SENSOR PWR (GY)
THROT SIG 2 (TN)
ECM RET SENS (TN)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
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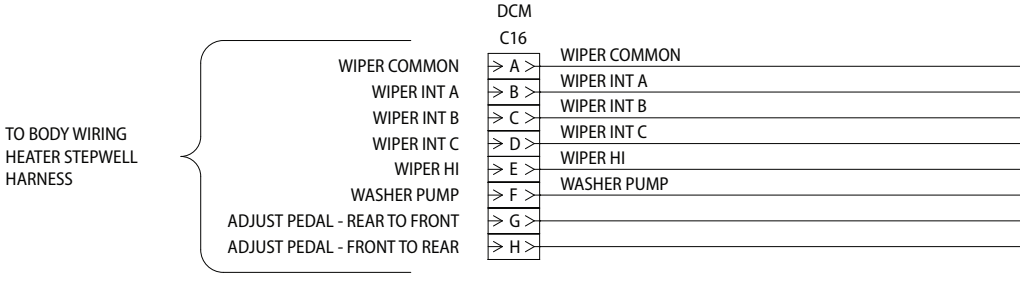
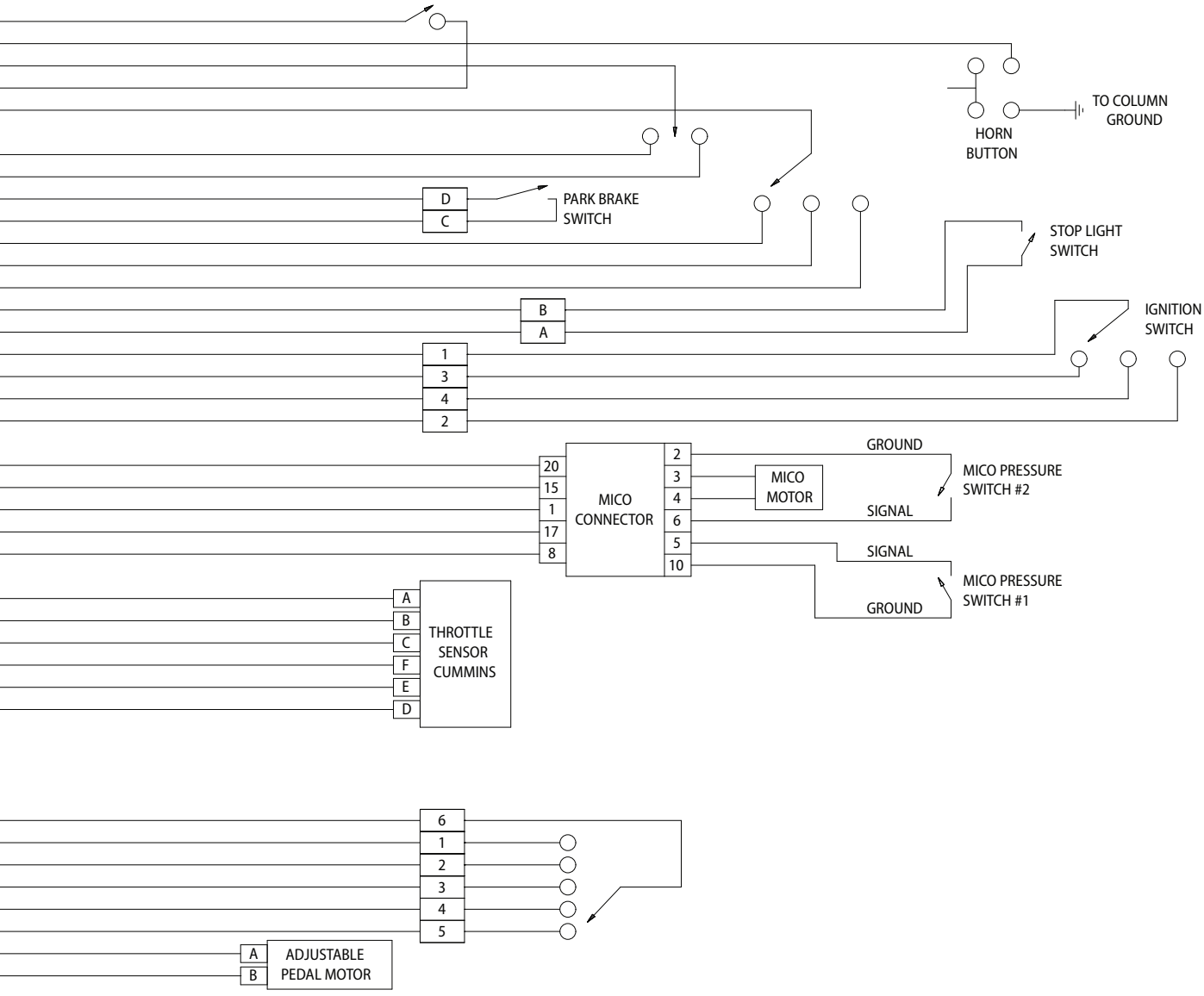
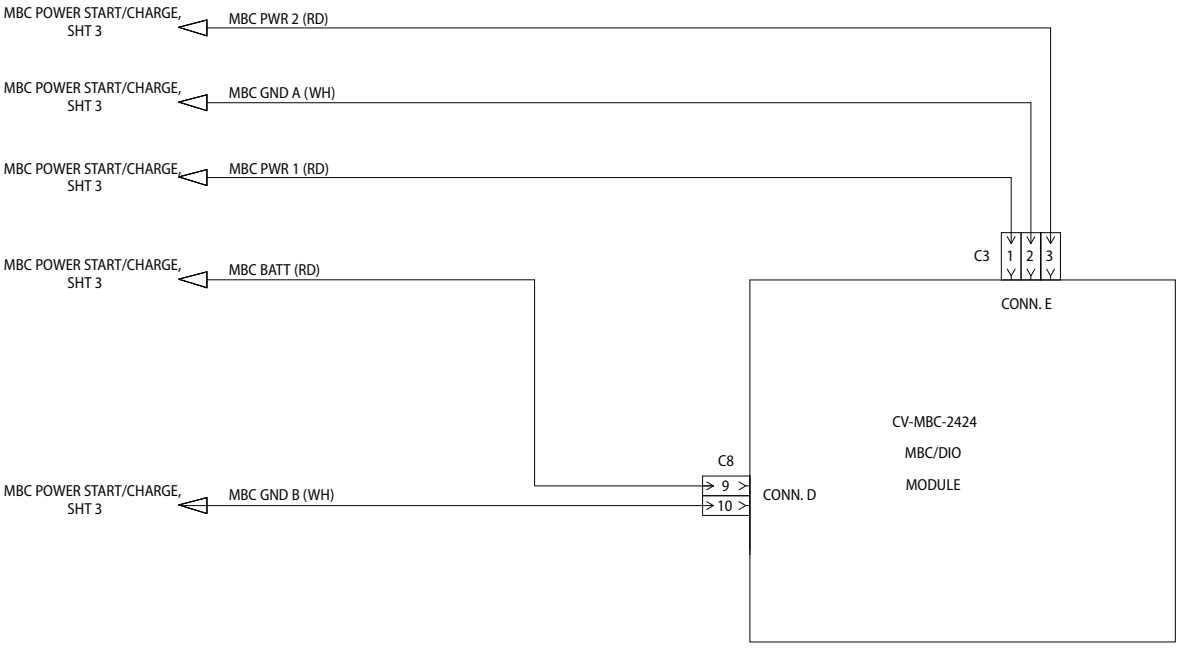
21
22
23
24
25
26
27
28
31
29
30
HIGH BEAM COMMON GND (TO T/S PIN 2)
HORN SIGNAL GND
TURN SIGNAL COM GND (TO T/S PIN 1)
HIGH BEAM SIGNAL (TO T/S PIN 11)
CRUISE COMMON GND (TO C/S PIN 4)
LH DIRECTIONAL (TO T/S PIN 6)
RH DIRECTIONAL (T/S PIN 12)
PARK BRAKE COMMON GND
PARK BRAKE SIGNAL
CRUISE CONTDROL ON/OFF (C/S PIN 3)
CRUISE CONTROL RESUME (C/S PIN 2)
CRUISE CONTROL SET (C/S PIN 1)
STOP LIGHT SIGNAL
STOP LIGHT POWER
IGNITION SWITCH COMMON GND
ACCESSORY SWITCH
IGNITION SWITCH OUTPUT
START SWITCH
DIRECT ALARM OUTPUT
LOCKED OUTPUT FOR MICO
VEHICLE POWER FOR MICO
VEHICLE GROUND FOR MICO
INTERLOCK SWITCH FOR MICO
THROTTLE SIGNAL 1
THROTTLE COMMON 1
THROTTLE POWER 1
THROTTLE POWER 2
THROTTLE SIGNAL 2
THROTTLE COMMON 2
AC MODULE, HORN BUTTON, SHT 12
AC MODULE, HIGH BEAM SWITCH, SHT 12
AC MODULE, LEFT TURN SWITCH, SHT 12
AC MODULE, RIGHT TURN SWITCH, SHT 12
AB MODULE, PARK BRAKE SWITCH, SHT 11
INSTRUMENT CLUSTER, CRUISE CONTROL,SHT 17
INSTRUMENT CLUSTER, CRUISE CONTROL,SHT 17
INSTRUMENT CLUSTER, CRUISE CONTROL,SHT 17
AB MODULE, SERVICE BRAKE, SHT 11
START/CHARGE SHT 3
AC MODULE, ACCESSORY SWTICH, SHT 12
AC MODULE, IGNITION SWITCH, SHT 12
AC MODULE, START SWITCH, SHT 12
INSTRUMENT CLUSTER, SHT 17
HYDRAULIC INTERLOCK ALARM, SHT 17
AC MODULE, INTERLOCK FEEDBACK, SHT 12
HYDRAULIC INTERLOCK POWER, SHT 3
AB MODULE, BRAKE INTERLOCK, SHT 11
THROTTLE CUMMINS ISB ENGINE, SHT 4
THROTTLE CUMMINS ISB ENGINE, SHT 4
THROTTLE CUMMINS ISB ENGINE, SHT 4
THROTTLE CUMMINS ISB ENGINE, SHT 4
THROTTLE CUMMINS ISB ENGINE, SHT 4
THROTTLE CUMMINS ISB ENGINE, SHT 4


DCM
C16
TO BODY WIRING
HEATER STEPWELL
HARNESS
WIPER COMMON
WIPER INT A
WIPER INT B
WIPER INT C
WIPER HI
WASHER PUMP
ADJUST PEDAL - REAR TO FRONT
ADJUST PEDAL - FRONT TO REAR
A
B
C
D
E
F
G
H
WIPER COMMON
WIPER INT A
WIPER INT B
WIPER INT C
WIPER HI
WASHER PUMP

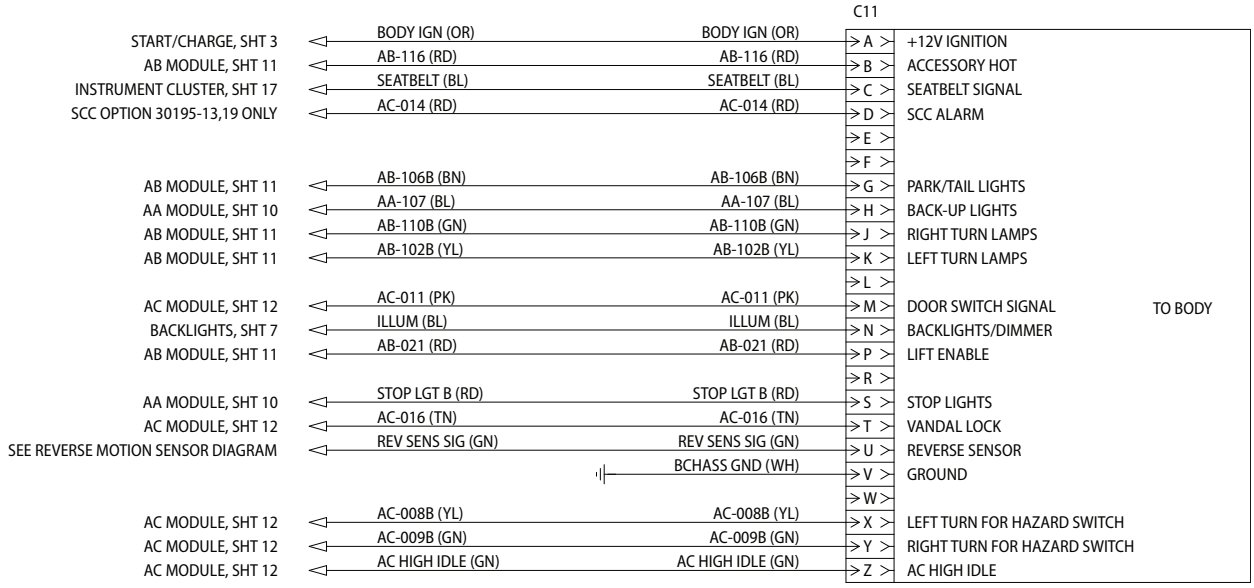

TO COLUMN GROUND
HORN BUTTON
D
C
PARK BRAKE SWITCH
STOP LIGHT SWITCH
B
A
IGNITION SWITCH
1
3
4
2
20
15
1
17
8
MICO CONNECTOR
2
3
4
6
5
10
MICO MOTOR
GROUND
MICO PRESSURE SWITCH #2
SIGNAL
SIGNAL
MICO PRESSURE SWITCH #1
GROUND
A
B
C
F
E
D
THROTTLE SENSOR CUMMINS
6
1
2
3
4
5
A
B
ADJUSTABLE PEDAL MOTOR



Sheet 20

0112306B

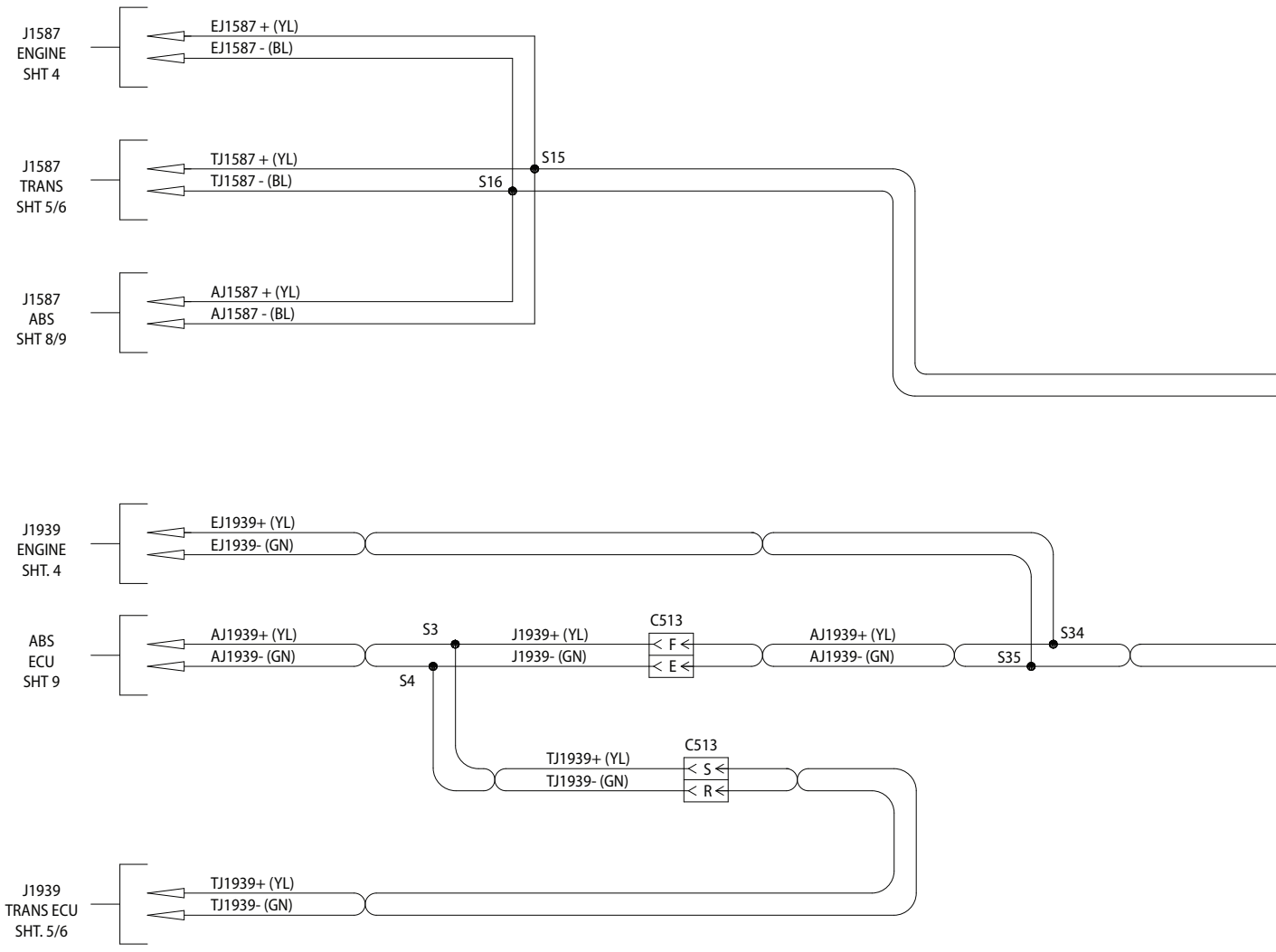
MBC MODULE

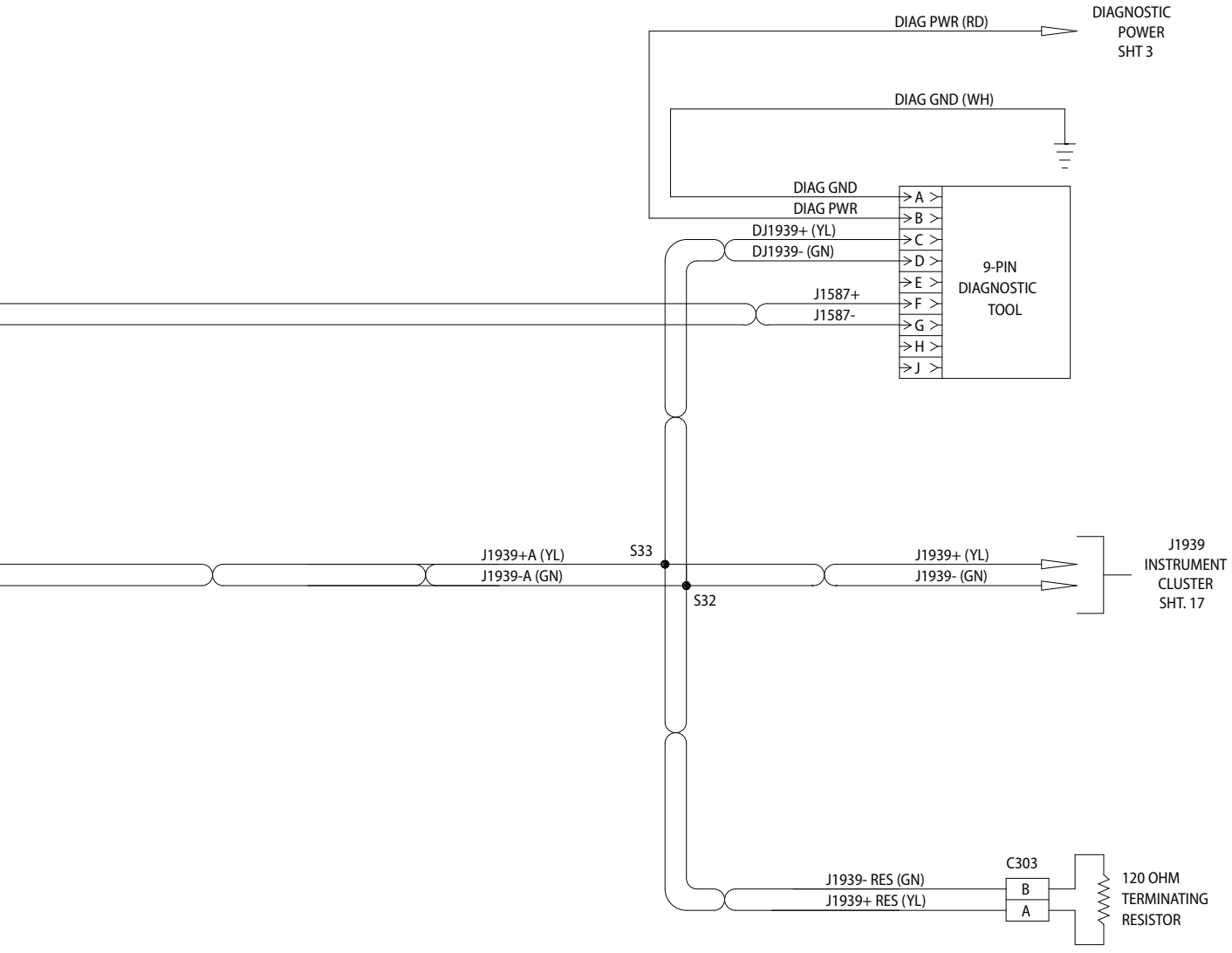


Sheet 21

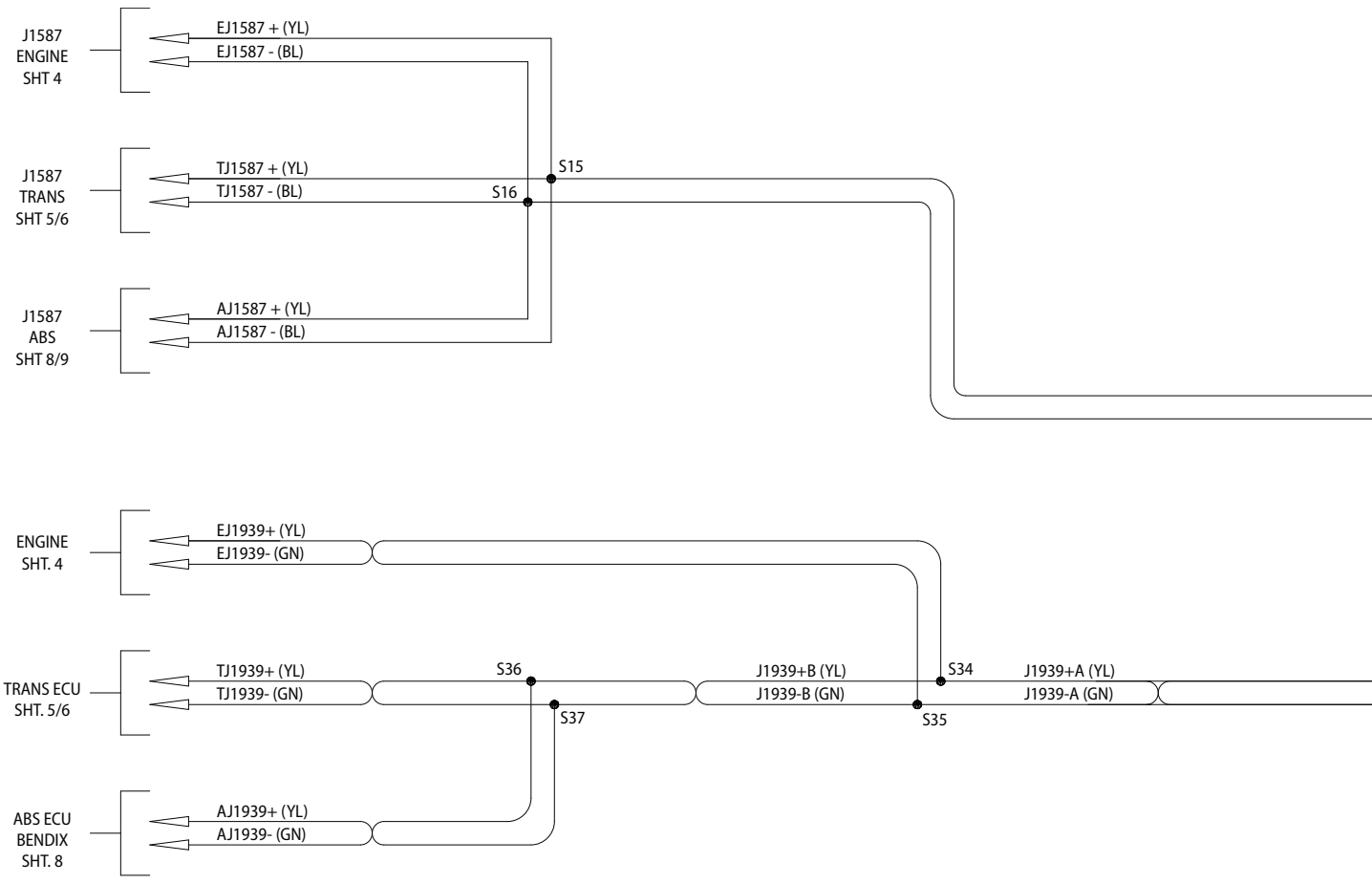
D0002363A

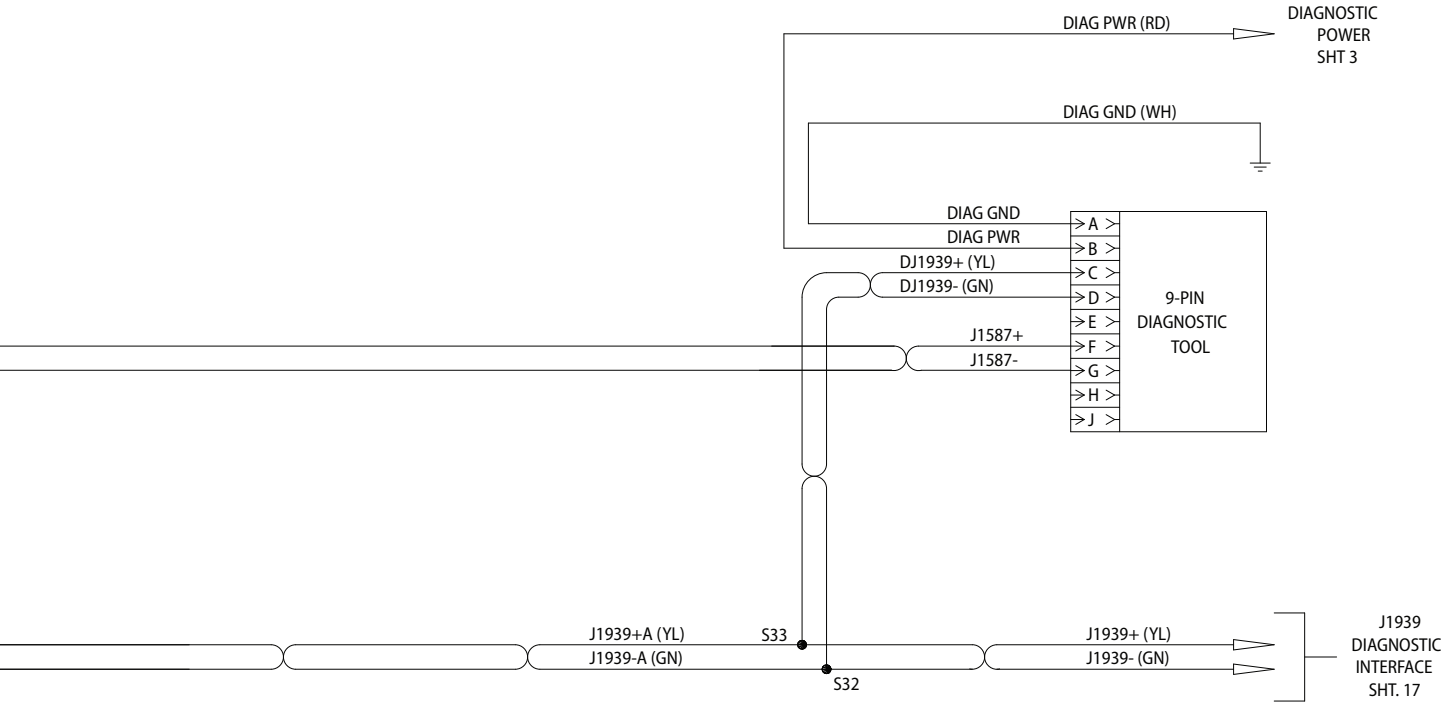
BODY INTERFACE


J1587
ENGINE
SHT 4
EJ1587 + (YL)
EJ1587 - (BL)
J1587
TRANS
SHT 5/6
TJ1587 + (YL)
TJ1587 - (BL)
S15
S16
J1587
ABS
SHT 8/9
AJ1587 + (YL)
AJ1587 - (BL)
J1939
ENGINE
SHT. 4
EJ1939+ (YL)
EJ1939- (GN)
ABS
ECU
SHT 9
AJ1939+ (YL)
AJ1939- (GN)
S3
J1939+ (YL)
J1939- (GN)
C513
F
E
AJ1939+ (YL)
AJ1939- (GN)
S34
S35
S4
C513
TJ1939+ (YL)
TJ1939- (GN)
S
R
J1939
TRANS ECU
SHT. 5/6
TJ1939+ (YL)
TJ1939- (GN)



NOTE:
SAE J1939 DATALINK UTILIZES TWO 120 OHM END OF LINE RESISTORS. THE SECOND END OF LINE RESISTOR IS INTERNAL TO THE TRANSMISSION CONTROL MOUDLE (TCM).


J1587
ENGINE
SHT 4
EJ1587 + (YL)
EJ1587 - (BL)
J1587
TRANS
SHT 5/6
TJ1587 + (YL)
TJ1587 - (BL)
S16
S15
J1587
ABS
SHT 8/9
AJ1587 + (YL)
AJ1587 - (BL)
ENGINE
SHT. 4
EJ1939+ (YL)
EJ1939- (GN)
TRANS ECU
SHT. 5/6
TJ1939+ (YL)
TJ1939- (GN)
S36
S37
J1939+B (YL)
J1939-B (GN)
S34
S35
J1939+A (YL)
J1939-A (GN)
ABS ECU
BENDIX
SHT. 8
AJ1939+ (YL)
AJ1939- (GN)



NOTE:
SAE J1939 DATALINK UTILIZES TWO 120 OHM END OF LINE RESISTORS. THE SECOND END OF LINE RESISTOR IS INTERNAL TO THE TRANSMISSION CONTROL MOUDLE (TCM).

Electrical Diagrams for Cummins ISB-10 Engines

Description	Sheet	Drawing Number
Index	1	D0003654B
Starting And Charging, Cummins	2	D0003655B
Cummins ISB10 Engine 1	3	D0003656B
Cummins ISB10 Engine 2 (Aftertreatment)	4	D0003675A
Allison Gen 4 2000 Transmission	5	D0003657A
Allison Gen 4 3000 Transmission	6	D0003658A
Backlights	7	D0003659B
ABS - Bendix (air)	8	D0003660B
ABS - Wabco (hydraulic)	9	D0003661B
AA Multiplex Module	10	D0003662B
AB Multiplex Module	11	D0003663A
AC Multiplex Module	12	D0003664A
Mirror Heat / Exterior Speaker / Wiper Washer	13	D0003665A
Hydraulic Brake Boost	14	D0003666A
Frame Components	15	D0003676A
Crossing Arm	16	D0003667A
Instrument Cluster	17	D0003668C
Driver's Control Module - Air	18	D0003669D
Driver's Control Module - Hydraulic	19	D0003670C
MBC Module	20	D0003671A
Body Interface	21	D0003672A
J1939 Datalink, Hydraulic	22	D0003673B
J1939 Datalink, Air	23	D0003674B

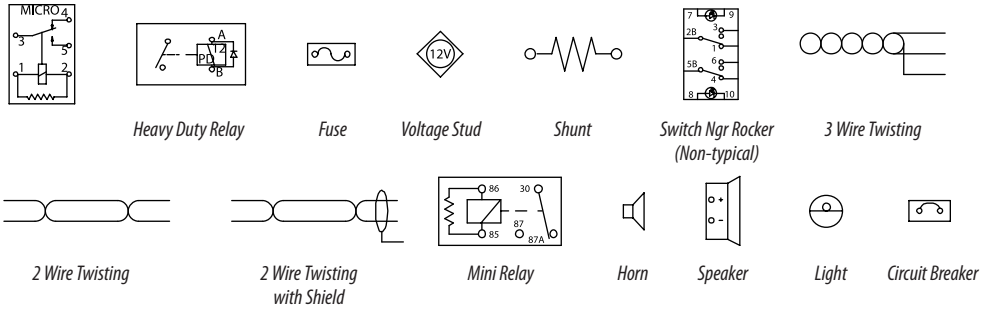
Wire Colors

BL	BLUE
BK	BLACK
BN	BROWN
TN	TAN
WH	WHITE
YL	YELLOW
PK	PINK
OR	ORANGE
RD	RED
GN	GREEN
PU	PURPLE
GY	GRAY

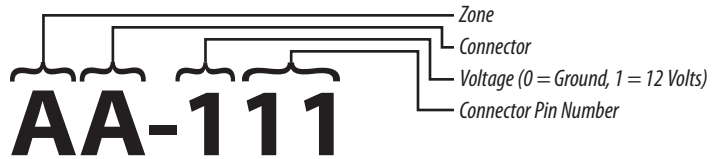
Schematic Legend

PD	PDU PANEL
AC	AIR CLEANER BRACKET
IP	INSTRUMENT PANEL
FW	FIREWALL
SP	SHIFTER PANEL
DC	DCM

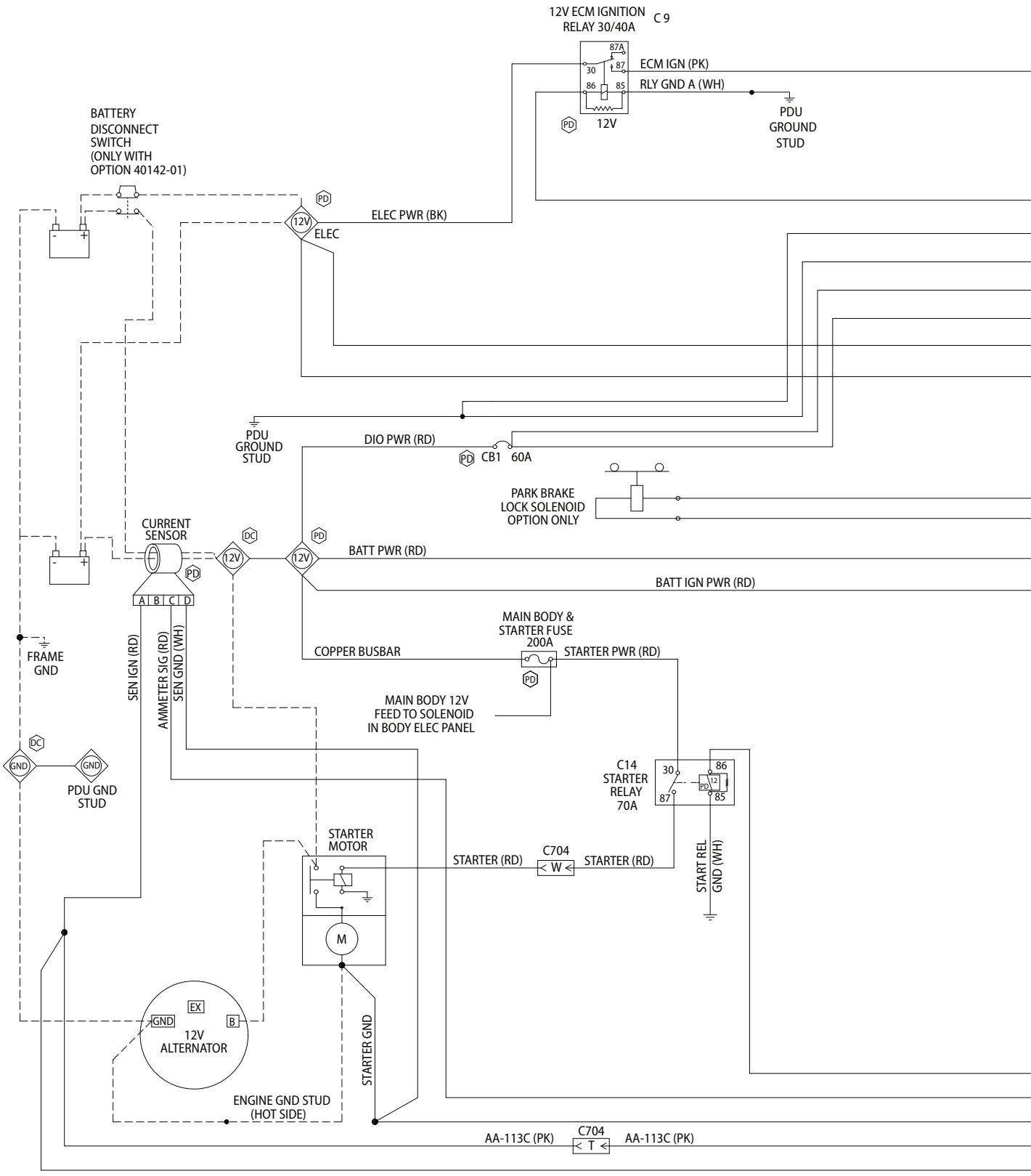
Electrical Component Index

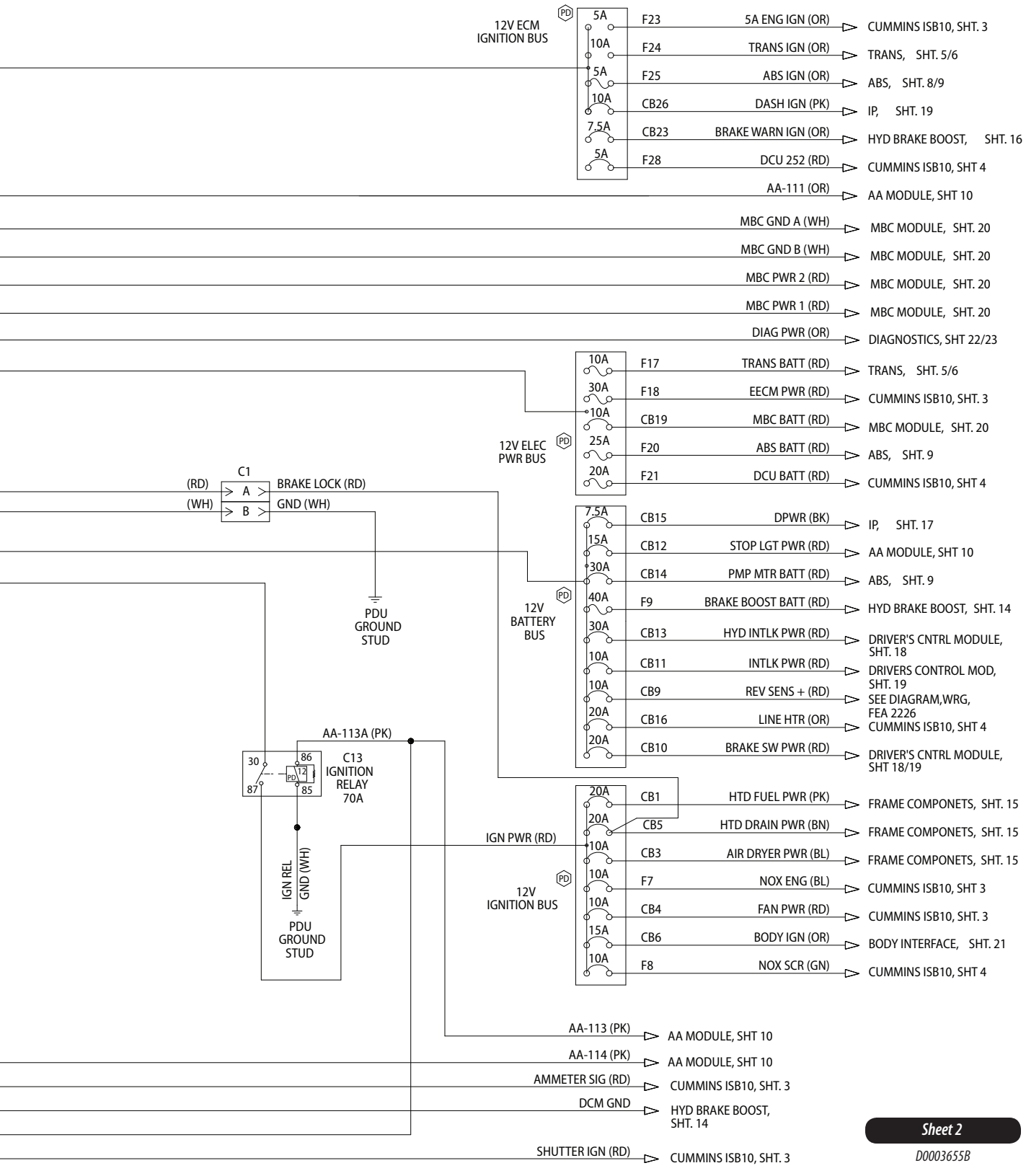


Multiplex Wire Indexing *(Circuit Number Code)*



Example: (Zone A, Connector A, 12 Volts, Pin #11)

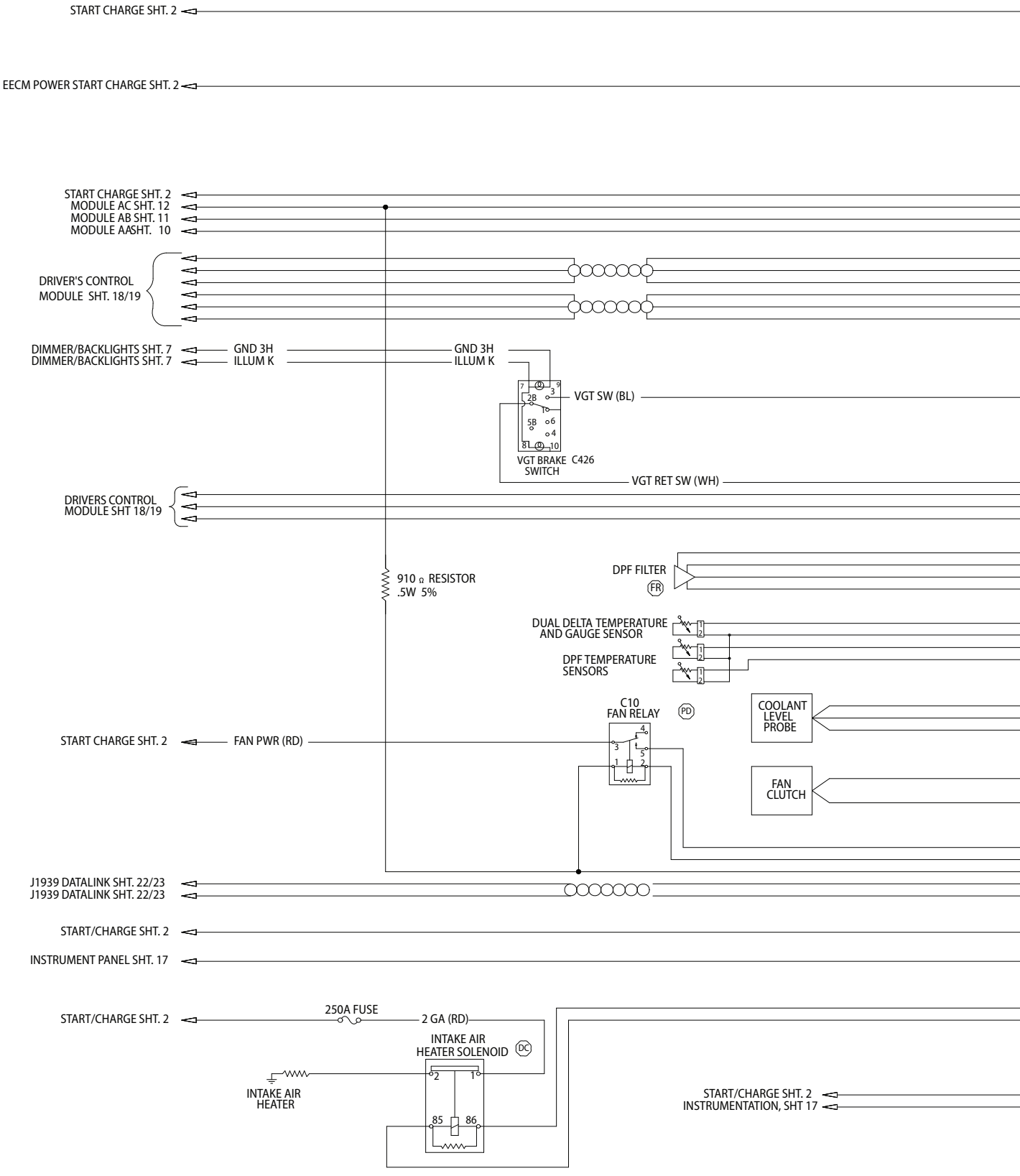

12V ECM IGNITION RELAY 30/40A
C 9
87A
87
30
86
85
ECM IGN (PK)
RLY GND A (WH)
PD
12V
PDU GROUND STUD
BATTERY DISCONNECT SWITCH (ONLY WITH OPTION 40142-01)
PD
12V
ELEC
ELEC PWR (BK)
PDU GROUND STUD
DIO PWR (RD)
PD
CB1 60A
PARK BRAKE LOCK SOLENOID OPTION ONLY
CURRENT SENSOR
DC
PD
12V
12V
BATT PWR (RD)
BATT IGN PWR (RD)
A B C D
MAIN BODY & STARTER FUSE 200A
COPPER BUSBAR
STARTER PWR (RD)
PD
FRAME GND
SEN IGN (RD)
AMMETER SIG (RD)
SEN GND (WH)
MAIN BODY 12V FEED TO SOLENOID IN BODY ELEC PANEL
DC
GND
GND
PDU GND STUD
C14 STARTER RELAY 70A
30
86
87
85
PD
STARTER MOTOR
STARTER (RD)
C704
W
STARTER (RD)
START REL GND (WH)
M
EX
GND
B
12V ALTERNATOR
STARTER GND
ENGINE GND STUD (HOT SIDE)
AA-113C (PK)
C704
T
AA-113C (PK)

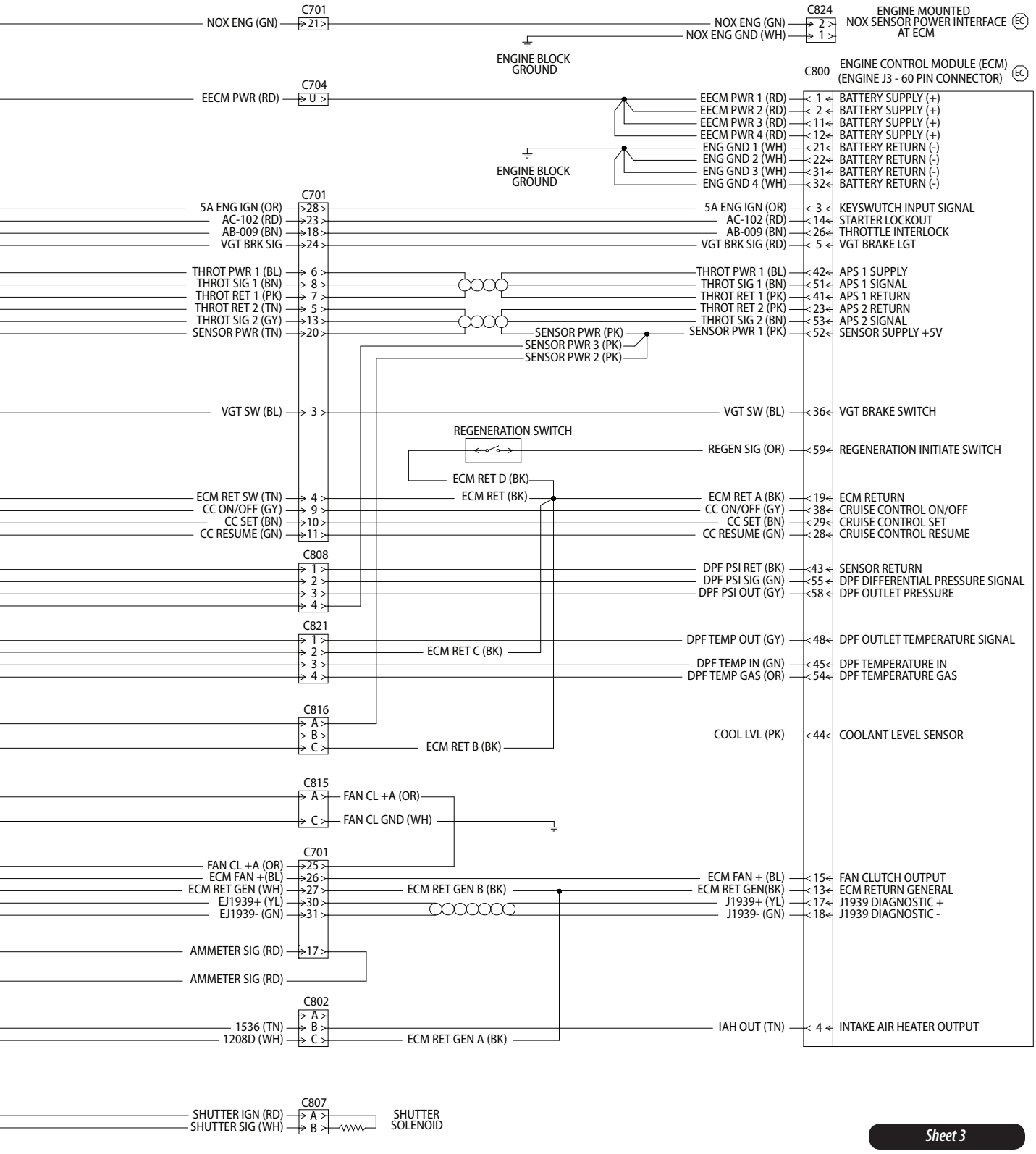


Sheet 2

D0003655B

STARTING AND CHARGING

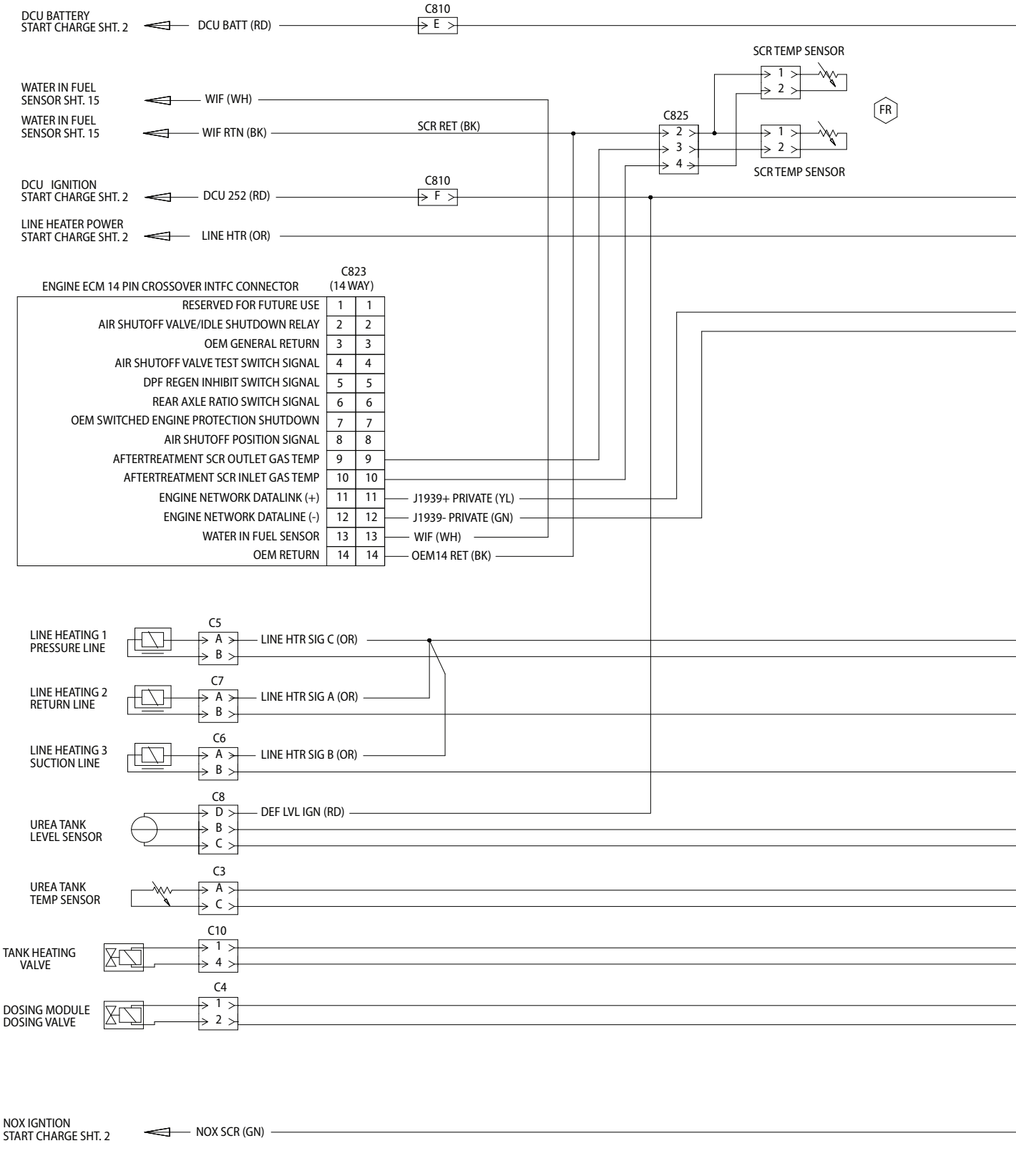

START CHARGE SHT. 2
EECM POWER START CHARGE SHT. 2
START CHARGE SHT. 2
MODULE AC SHT. 12
MODULE AB SHT. 11
MODULE AASHT. 10
DRIVER'S CONTROL
MODULE SHT. 18/19
DIMMER/BACKLIGHTS SHT. 7
DIMMER/BACKLIGHTS SHT. 7
GND 3H
ILLUM K
GND 3H
ILLUM K
VGT SW (BL)
VGT BRAKE SWITCH C426
VGT RET SW (WH)
DRIVERS CONTROL
MODULE SHT 18/19
910 Ω RESISTOR
.5W 5%
DPF FILTER
FR
DUAL DELTA TEMPERATURE
AND GAUGE SENSOR
DPF TEMPERATURE
SENSORS
C10
FAN RELAY
PD
COOLANT
LEVEL
PROBE
START CHARGE SHT. 2
FAN PWR (RD)
FAN
CLUTCH
J1939 DATALINK SHT. 22/23
J1939 DATALINK SHT. 22/23
START/CHARGE SHT. 2
INSTRUMENT PANEL SHT. 17
START/CHARGE SHT. 2
250A FUSE
2 GA (RD)
INTAKE AIR
HEATER SOLENOID
DC
INTAKE AIR
HEATER
START/CHARGE SHT. 2
INSTRUMENTATION, SHT 17

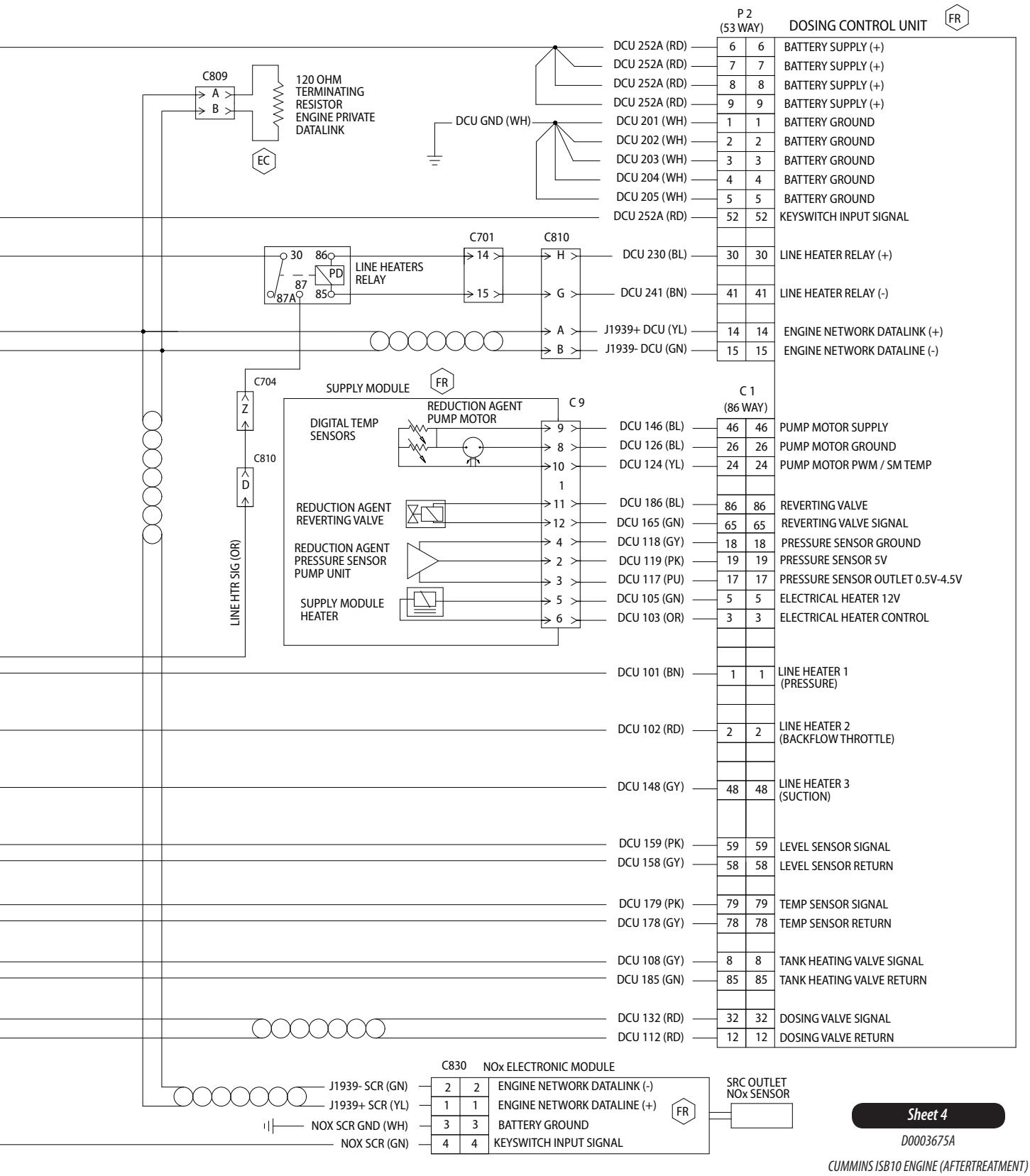


Sheet 3

D0003656B

CUMMINS ISB10 ENGINE

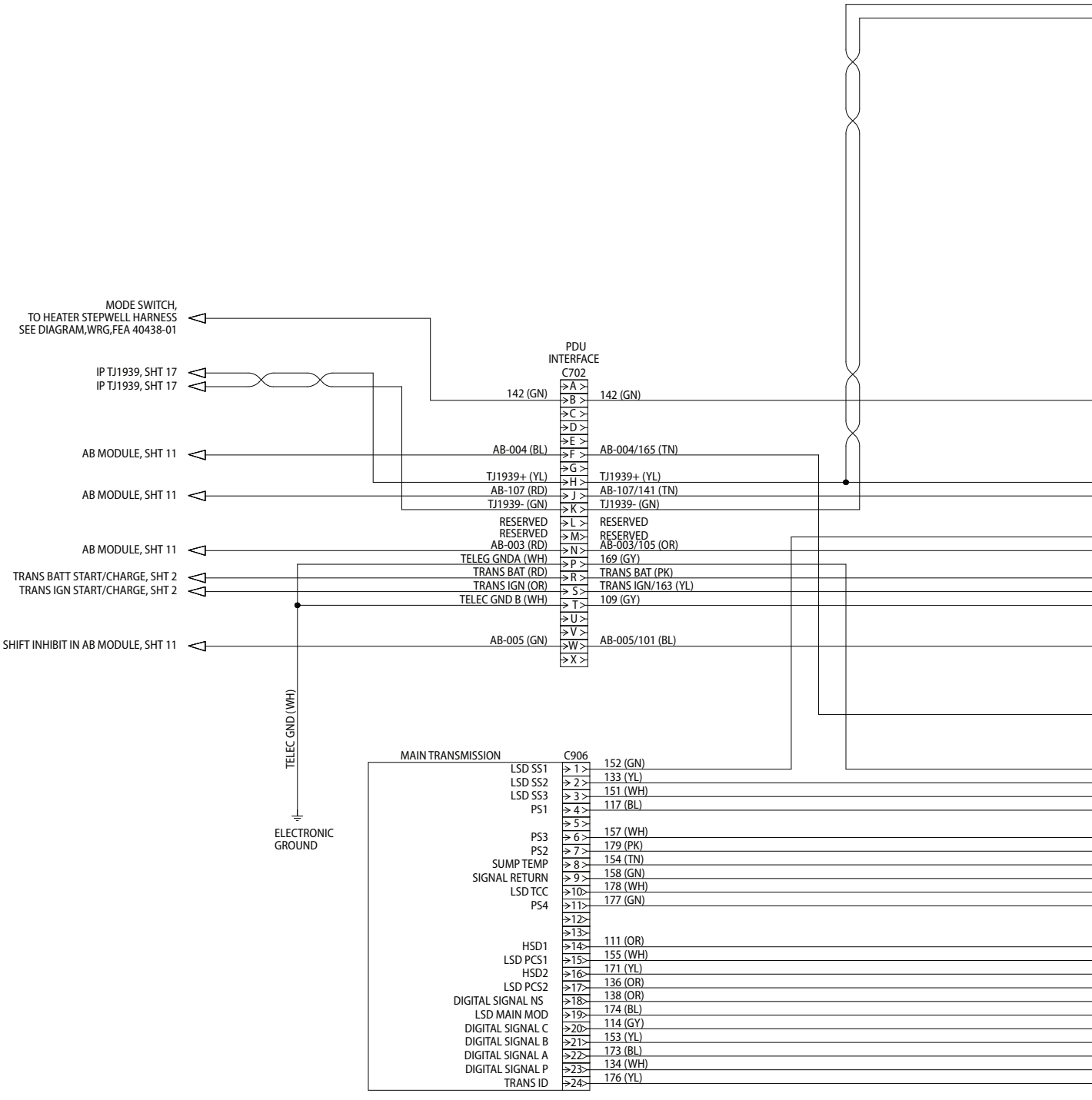

DCU BATTERY
START CHARGE SHT. 2
DCU BATT (RD)
C810
E
SCR TEMP SENSOR
1
2
FR
WATER IN FUEL
SENSOR SHT. 15
WIF (WH)
WATER IN FUEL
SENSOR SHT. 15
WIF RTN (BK)
SCR RET (BK)
C825
2
3
4
1
2
SCR TEMP SENSOR
DCU IGNITION
START CHARGE SHT. 2
DCU 252 (RD)
C810
F
LINE HEATER POWER
START CHARGE SHT. 2
LINE HTR (OR)
ENGINE ECM 14 PIN CROSSOVER INTFC CONNECTOR
C823
(14 WAY)
RESERVED FOR FUTURE USE 1 1
AIR SHUTOFF VALVE/IDLE SHUTDOWN RELAY 2 2
OEM GENERAL RETURN 3 3
AIR SHUTOFF VALVE TEST SWITCH SIGNAL 4 4
DPF REGEN INHIBIT SWITCH SIGNAL 5 5
REAR AXLE RATIO SWITCH SIGNAL 6 6
OEM SWITCHED ENGINE PROTECTION SHUTDOWN 7 7
AIR SHUTOFF POSITION SIGNAL 8 8
AFTERTREATMENT SCR OUTLET GAS TEMP 9 9
AFTERTREATMENT SCR INLET GAS TEMP 10 10
ENGINE NETWORK DATALINK (+) 11 11 J1939+ PRIVATE (YL)
ENGINE NETWORK DATALINE (-) 12 12 J1939- PRIVATE (GN)
WATER IN FUEL SENSOR 13 13 WIF (WH)
OEM RETURN 14 14 OEM14 RET (BK)
LINE HEATING 1
PRESSURE LINE
C5
A
B
LINE HTR SIG C (OR)
LINE HEATING 2
RETURN LINE
C7
A
B
LINE HTR SIG A (OR)
LINE HEATING 3
SUCTION LINE
C6
A
B
LINE HTR SIG B (OR)
UREA TANK
LEVEL SENSOR
C8
D
B
C
DEF LVL IGN (RD)
UREA TANK
TEMP SENSOR
C3
A
C
TANK HEATING
VALVE
C10
1
4
DOSING MODULE
DOSING VALVE
C4
1
2
NOX IGNTION
START CHARGE SHT. 2
NOX SCR (GN)

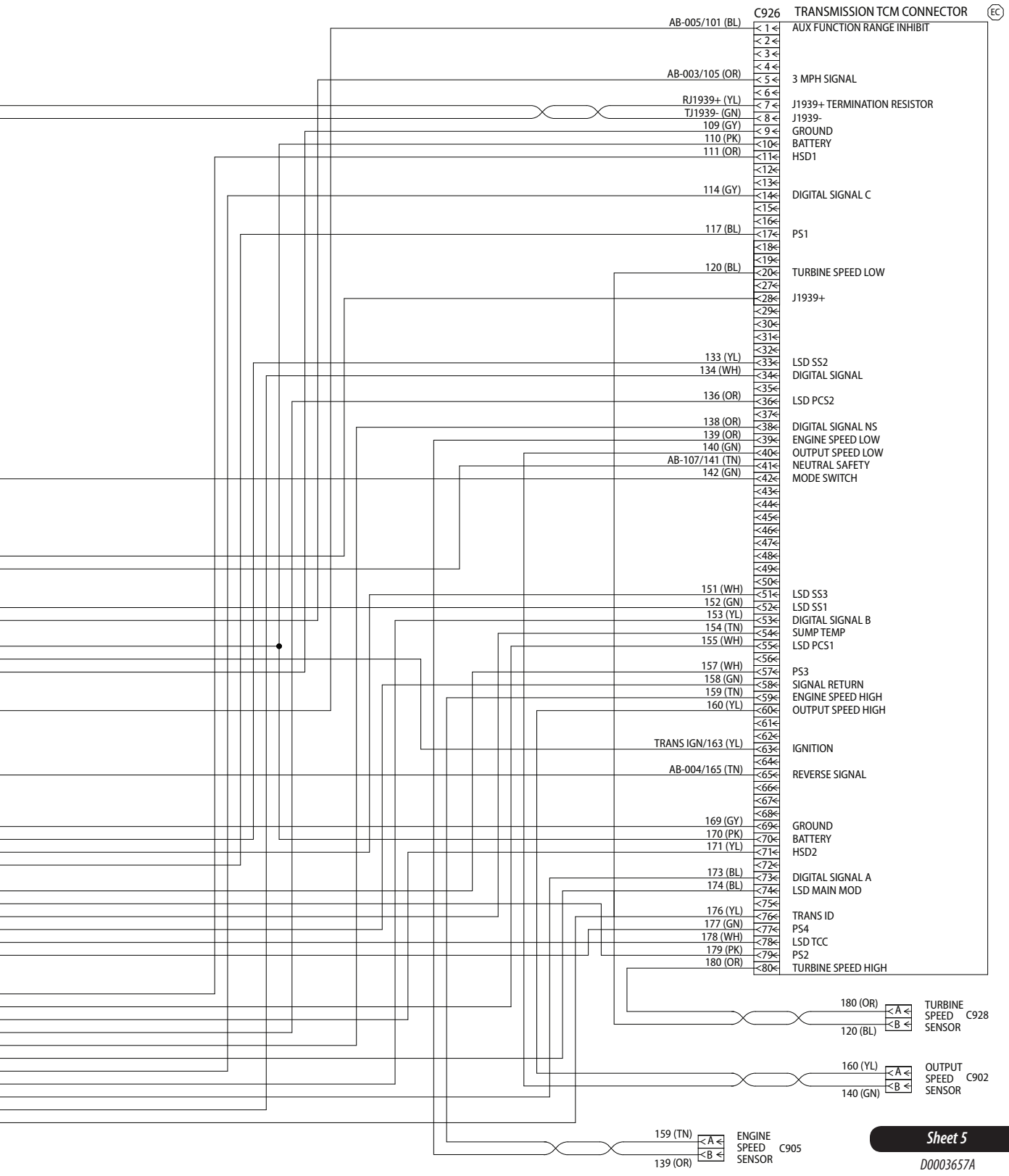


Sheet 4

D0003675A

CUMMINS ISB10 ENGINE (AFTERTREATMENT)

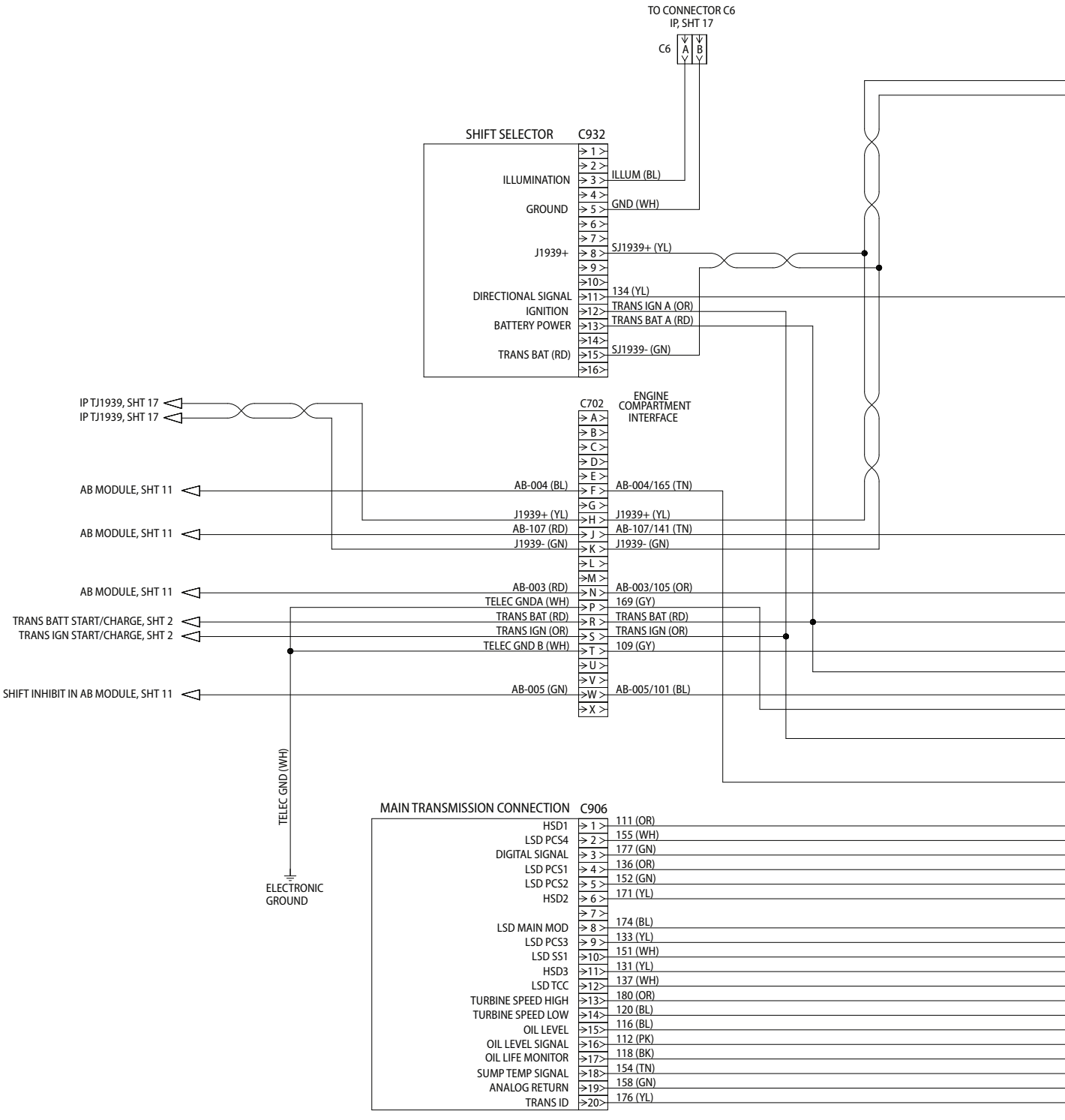

MODE SWITCH,
TO HEATER STEPWELL HARNESS
SEE DIAGRAM,WRG,FEA 40438-01
IP TJ1939, SHT 17
IP TJ1939, SHT 17
AB MODULE, SHT 11
AB MODULE, SHT 11
AB MODULE, SHT 11
TRANS BATT START/CHARGE, SHT 2
TRANS IGN START/CHARGE, SHT 2
SHIFT INHIBIT IN AB MODULE, SHT 11
PDU
INTERFACE
C702
142 (GN)
AB-004 (BL)
TJ1939+ (YL)
AB-107 (RD)
TJ1939- (GN)
RESERVED
RESERVED
AB-003 (RD)
TELEG GNDA (WH)
TRANS BAT (RD)
TRANS IGN (OR)
TELEC GND B (WH)
AB-005 (GN)
142 (GN)
AB-004/165 (TN)
TJ1939+ (YL)
AB-107/141 (TN)
TJ1939- (GN)
RESERVED
RESERVED
AB-003/105 (OR)
169 (GY)
TRANS BAT (PK)
TRANS IGN/163 (YL)
109 (GY)
AB-005/101 (BL)
TELEC GND (WH)
ELECTRONIC
GROUND
MAIN TRANSMISSION
C906
LSD SS1
LSD SS2
LSD SS3
PS1
PS3
PS2
SUMP TEMP
SIGNAL RETURN
LSD TCC
PS4
HSD1
LSD PCS1
HSD2
LSD PCS2
DIGITAL SIGNAL NS
LSD MAIN MOD
DIGITAL SIGNAL C
DIGITAL SIGNAL B
DIGITAL SIGNAL A
DIGITAL SIGNAL P
TRANS ID
152 (GN)
133 (YL)
151 (WH)
117 (BL)
157 (WH)
179 (PK)
154 (TN)
158 (GN)
178 (WH)
177 (GN)
111 (OR)
155 (WH)
171 (YL)
136 (OR)
138 (OR)
174 (BL)
114 (GY)
153 (YL)
173 (BL)
134 (WH)
176 (YL)

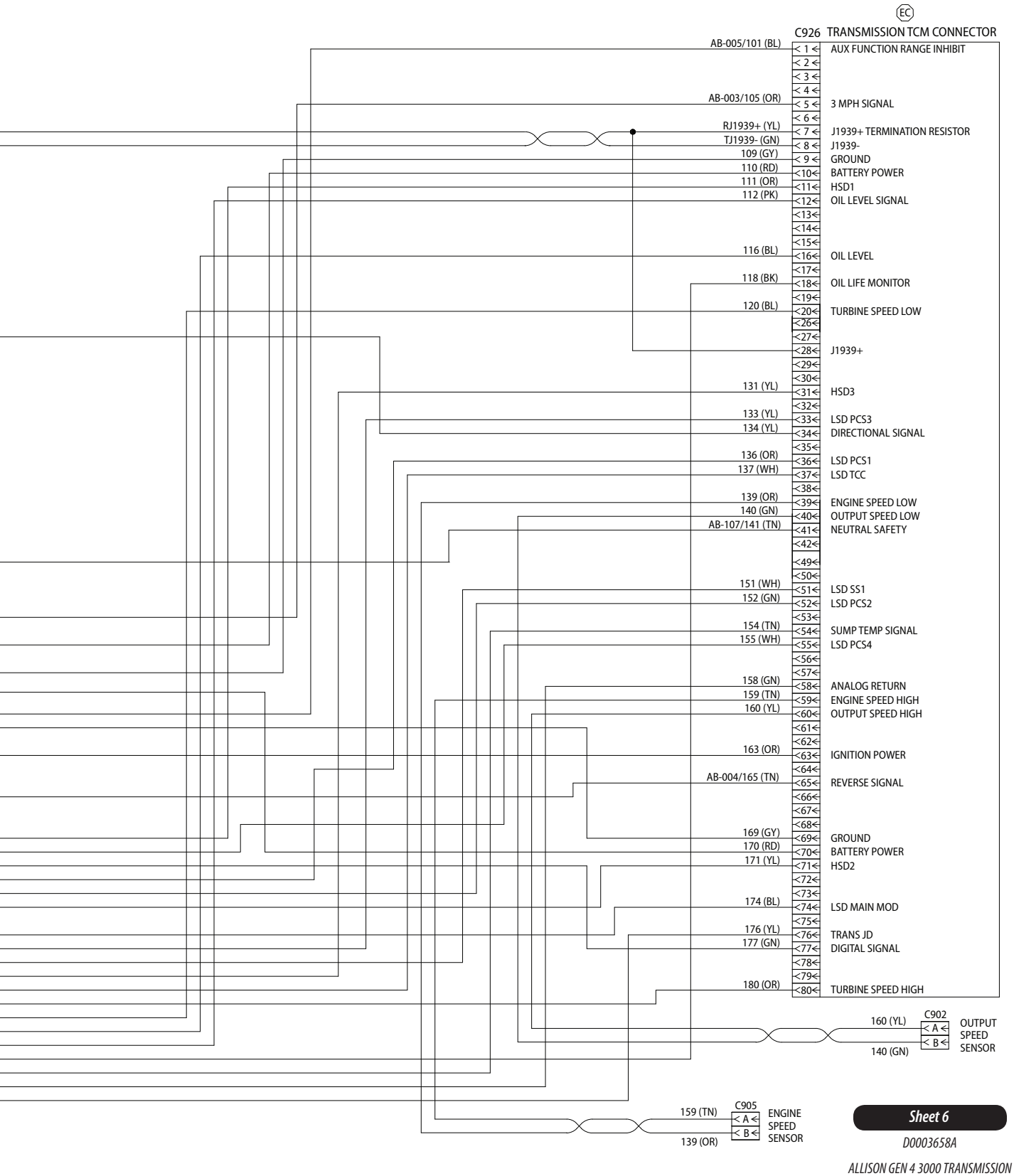


Sheet 5

D0003657A

ALLISON GEN 4 2000 TRANSMISSION

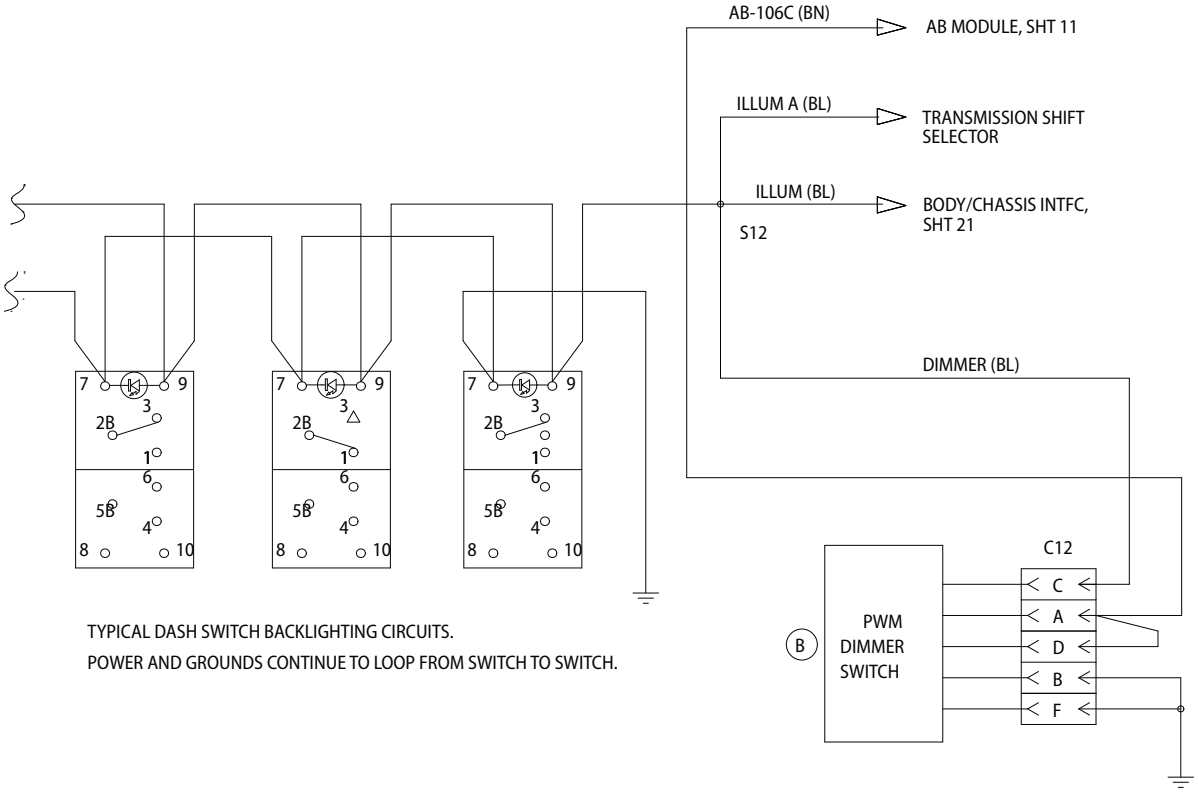

TO CONNECTOR C6
IP, SHT 17
C6
A
B
SHIFT SELECTOR
C932
ILLUMINATION
ILLUM (BL)
GROUND
GND (WH)
J1939+
SJ1939+ (YL)
134 (YL)
DIRECTIONAL SIGNAL
IGNITION
TRANS IGN A (OR)
BATTERY POWER
TRANS BAT A (RD)
TRANS BAT (RD)
SJ1939- (GN)
IP TJ1939, SHT 17
IP TJ1939, SHT 17
C702
ENGINE COMPARTMENT INTERFACE
AB MODULE, SHT 11
AB-004 (BL)
AB-004/165 (TN)
J1939+ (YL)
J1939+ (YL)
AB MODULE, SHT 11
AB-107 (RD)
AB-107/141 (TN)
J1939- (GN)
J1939- (GN)
AB MODULE, SHT 11
AB-003 (RD)
AB-003/105 (OR)
TELEC GNDA (WH)
169 (GY)
TRANS BATT START/CHARGE, SHT 2
TRANS BAT (RD)
TRANS BAT (RD)
TRANS IGN START/CHARGE, SHT 2
TRANS IGN (OR)
TRANS IGN (OR)
TELEC GND B (WH)
109 (GY)
SHIFT INHIBIT IN AB MODULE, SHT 11
AB-005 (GN)
AB-005/101 (BL)
TELEC GND (WH)
ELECTRONIC GROUND
MAIN TRANSMISSION CONNECTION
C906
HSD1
111 (OR)
LSD PCS4
155 (WH)
DIGITAL SIGNAL
177 (GN)
LSD PCS1
136 (OR)
LSD PCS2
152 (GN)
HSD2
171 (YL)
LSD MAIN MOD
174 (BL)
LSD PCS3
133 (YL)
LSD SS1
151 (WH)
HSD3
131 (YL)
LSD TCC
137 (WH)
TURBINE SPEED HIGH
180 (OR)
TURBINE SPEED LOW
120 (BL)
OIL LEVEL
116 (BL)
OIL LEVEL SIGNAL
112 (PK)
OIL LIFE MONITOR
118 (BK)
SUMP TEMP SIGNAL
154 (TN)
ANALOG RETURN
158 (GN)
TRANS ID
176 (YL)



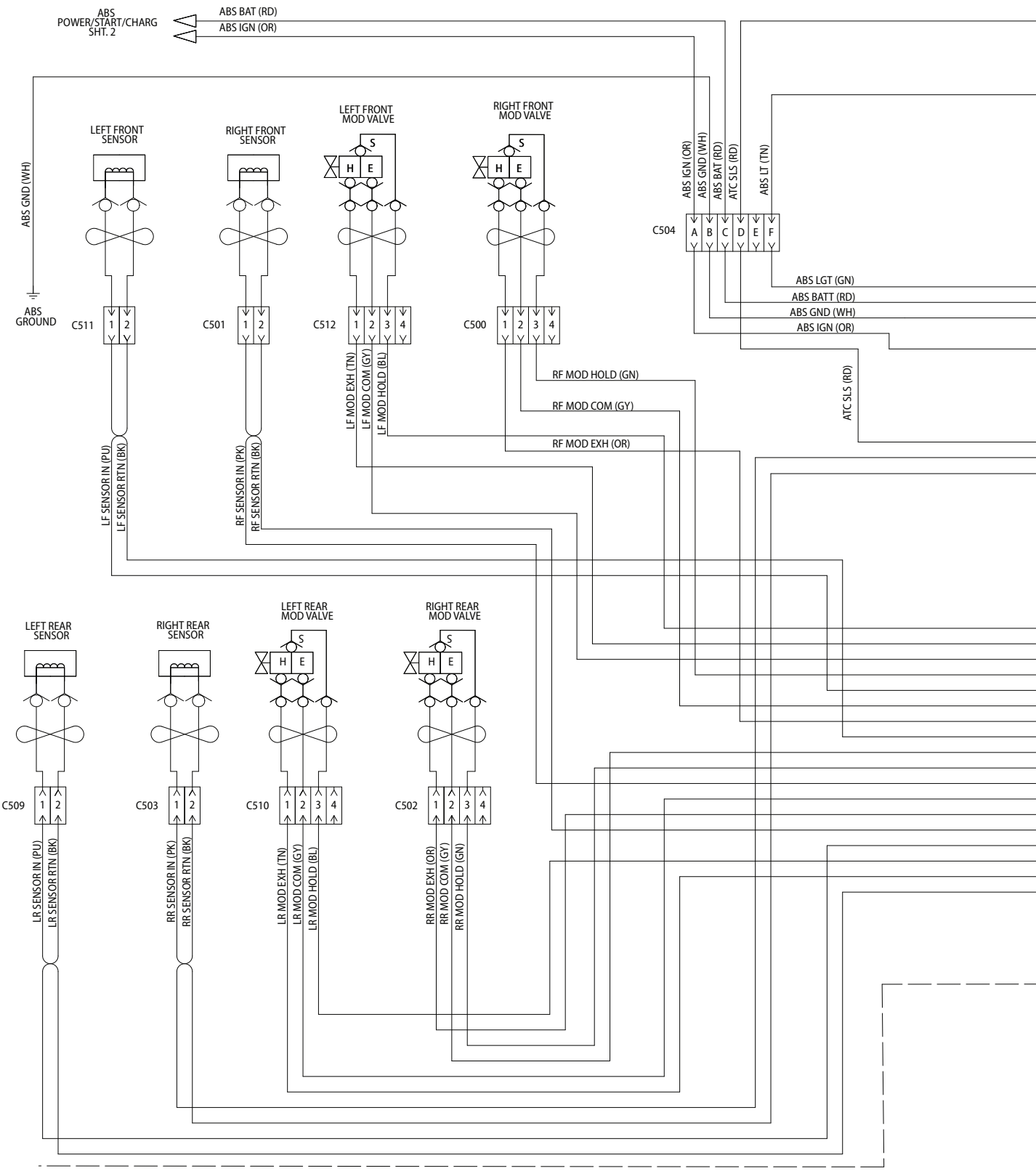
Sheet 6

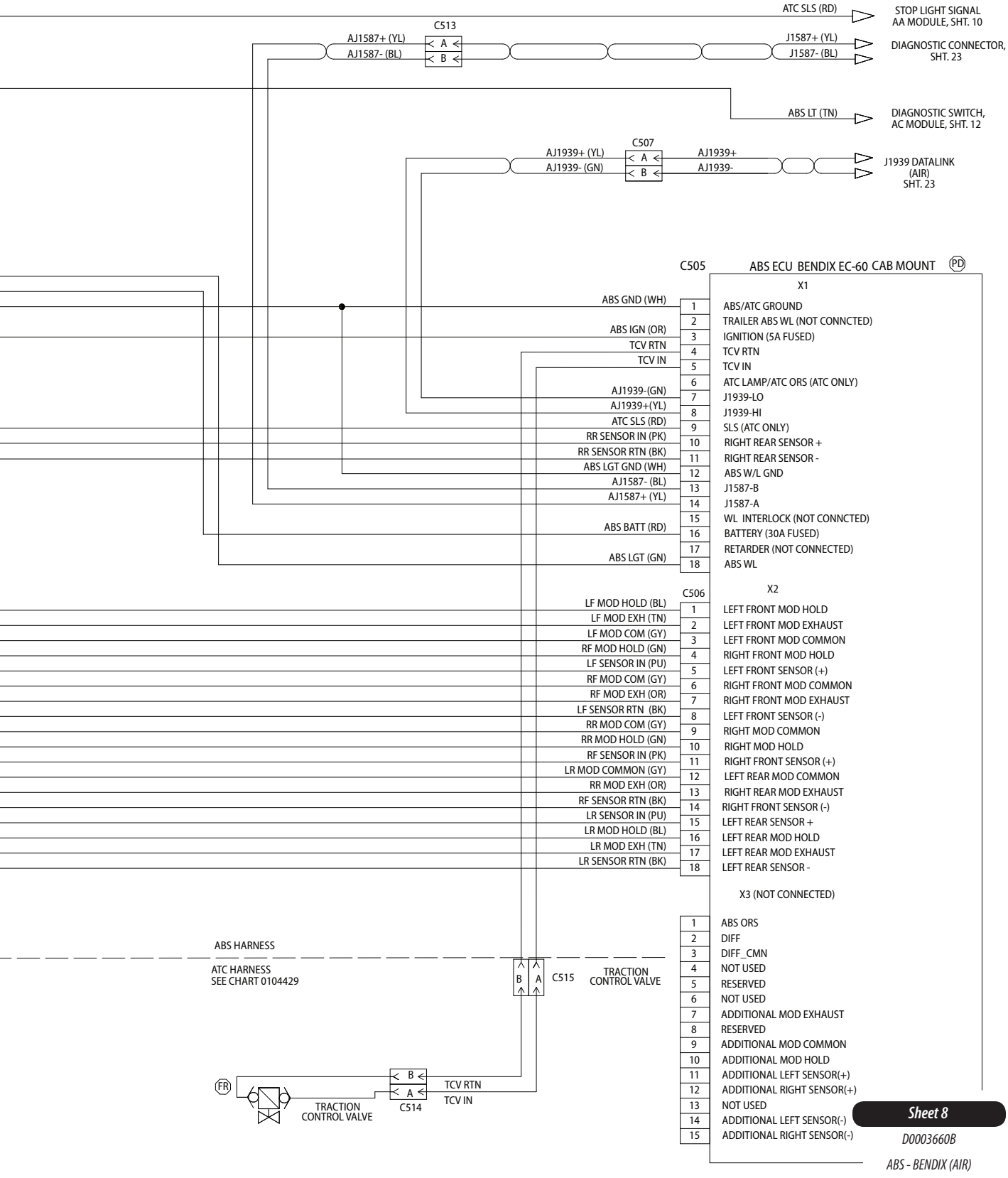
D0003658A

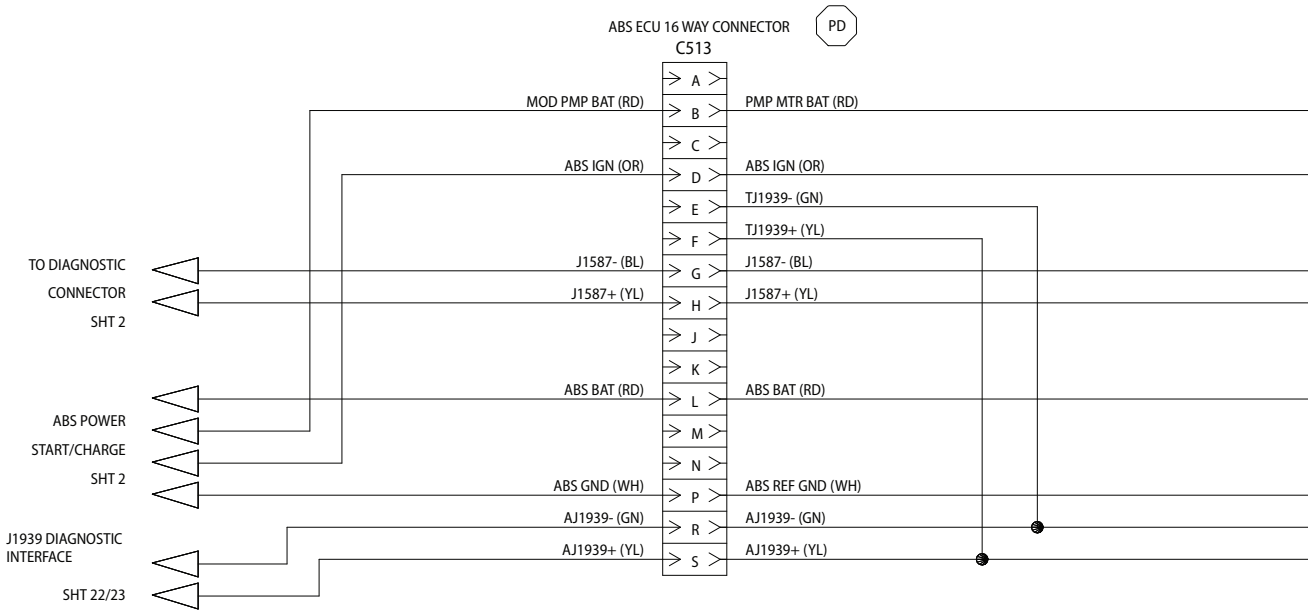
ALLISON GEN 4 3000 TRANSMISSION

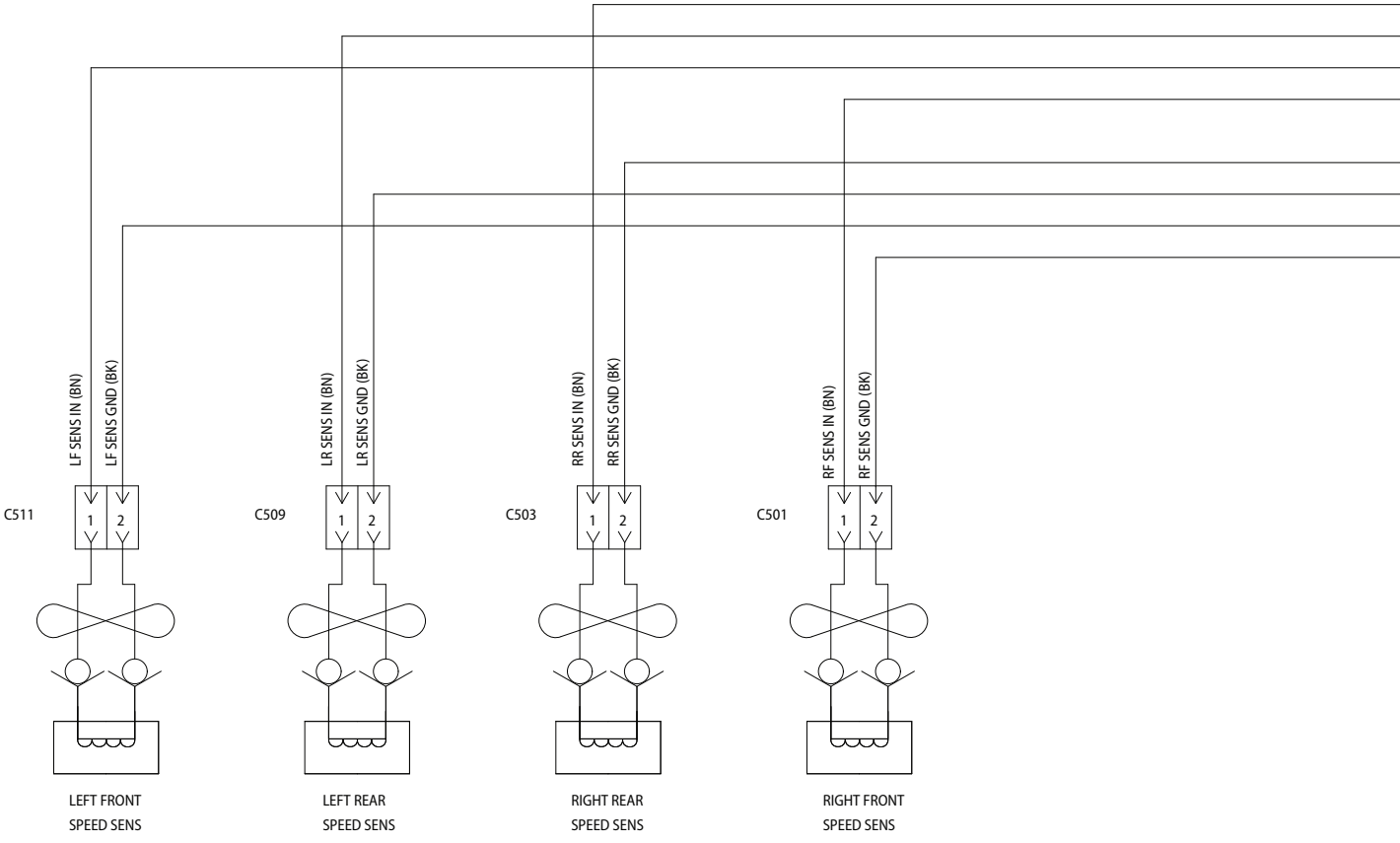


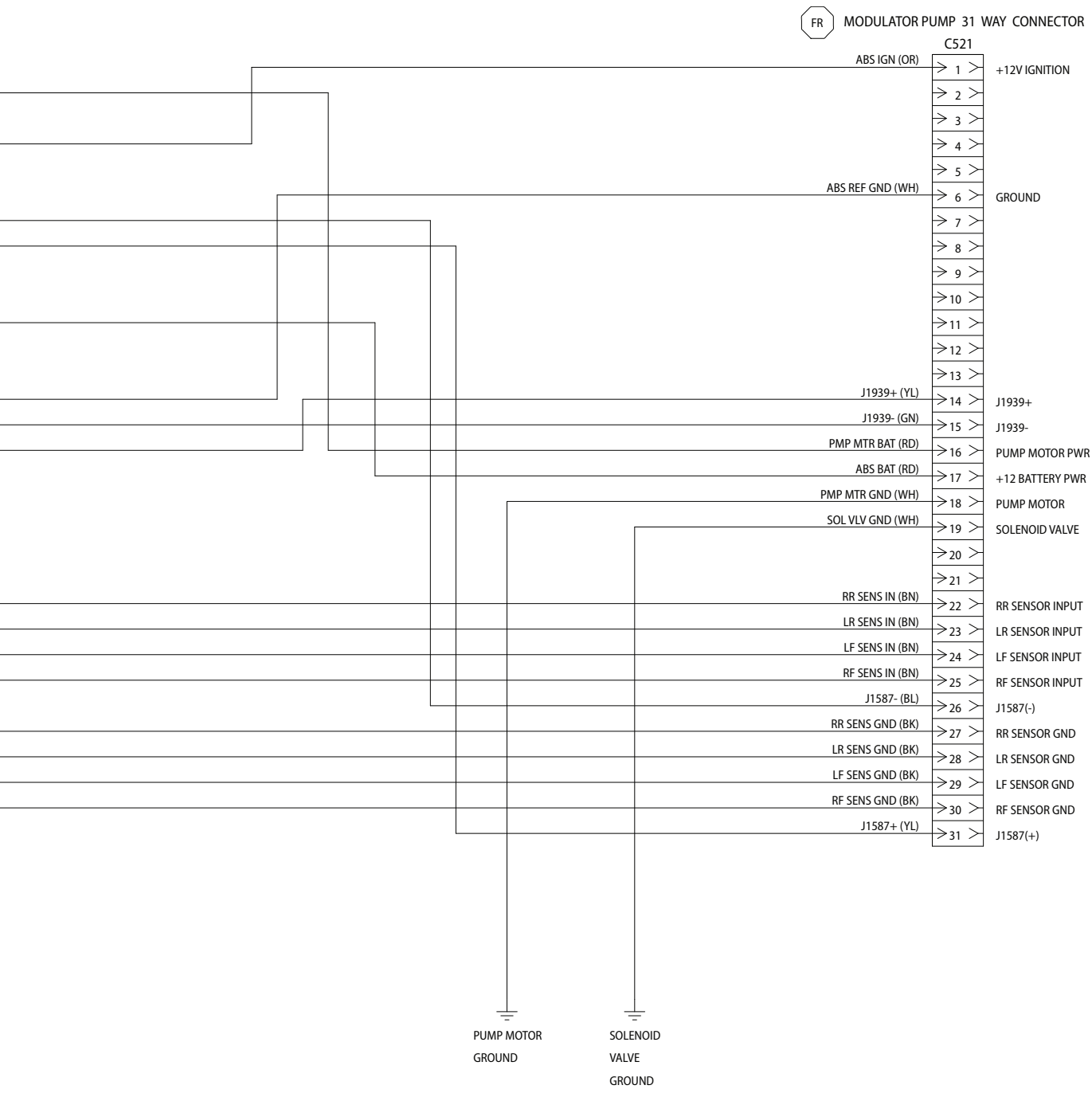
TYPICAL DASH SWITCH BACKLIGHTING CIRCUITS.
POWER AND GROUNDS CONTINUE TO LOOP FROM SWITCH TO SWITCH.


ABS POWER/START/CHARG SHT. 2
ABS BAT (RD)
ABS IGN (OR)
ABS GND (WH)
ABS GROUND
LEFT FRONT SENSOR
RIGHT FRONT SENSOR
LEFT FRONT MOD VALVE
RIGHT FRONT MOD VALVE
C511
C501
C512
C500
C504
ABS IGN (OR)
ABS GND (WH)
ABS BAT (RD)
ATC SLS (RD)
ABS LT (TN)
ABS LGT (GN)
ABS BATT (RD)
ABS GND (WH)
ABS IGN (OR)
ATC SLS (RD)
RF MOD HOLD (GN)
RF MOD COM (GY)
RF MOD EXH (OR)
LF MOD EXH (TN)
LF MOD COM (GY)
LF MOD HOLD (BL)
LF SENSOR IN (PU)
LF SENSOR RTN (BK)
RF SENSOR IN (PK)
RF SENSOR RTN (BK)
LEFT REAR SENSOR
RIGHT REAR SENSOR
LEFT REAR MOD VALVE
RIGHT REAR MOD VALVE
C509
C503
C510
C502
LR SENSOR IN (PU)
LR SENSOR RTN (BK)
RR SENSOR IN (PK)
RR SENSOR RTN (BK)
LR MOD EXH (TN)
LR MOD COM (GY)
LR MOD HOLD (BL)
RR MOD EXH (OR)
RR MOD COM (GY)
RR MOD HOLD (GN)


ATC SLS (RD)
STOP LIGHT SIGNAL
AA MODULE, SHT. 10
C513
AJ1587+ (YL)
AJ1587- (BL)
A
B
J1587+ (YL)
J1587- (BL)
DIAGNOSTIC CONNECTOR,
SHT. 23
ABS LT (TN)
DIAGNOSTIC SWITCH,
AC MODULE, SHT. 12
C507
AJ1939+ (YL)
AJ1939- (GN)
AJ1939+
AJ1939-
J1939 DATALINK
(AIR)
SHT. 23
C505
ABS ECU BENDIX EC-60 CAB MOUNT
PD
X1
ABS GND (WH) 1 ABS/ATC GROUND
2 TRAILER ABS WL (NOT CONNCTED)
ABS IGN (OR) 3 IGNITION (5A FUSED)
TCV RTN 4 TCV RTN
TCV IN 5 TCV IN
6 ATC LAMP/ATC ORS (ATC ONLY)
AJ1939-(GN) 7 J1939-LO
AJ1939+(YL) 8 J1939-HI
ATC SLS (RD) 9 SLS (ATC ONLY)
RR SENSOR IN (PK) 10 RIGHT REAR SENSOR +
RR SENSOR RTN (BK) 11 RIGHT REAR SENSOR -
ABS LGT GND (WH) 12 ABS W/L GND
AJ1587- (BL) 13 J1587-B
AJ1587+ (YL) 14 J1587-A
15 WL INTERLOCK (NOT CONNCTED)
ABS BATT (RD) 16 BATTERY (30A FUSED)
17 RETARDER (NOT CONNECTED)
ABS LGT (GN) 18 ABS WL
X2
C506
LF MOD HOLD (BL) 1 LEFT FRONT MOD HOLD
LF MOD EXH (TN) 2 LEFT FRONT MOD EXHAUST
LF MOD COM (GY) 3 LEFT FRONT MOD COMMON
RF MOD HOLD (GN) 4 RIGHT FRONT MOD HOLD
LF SENSOR IN (PU) 5 LEFT FRONT SENSOR (+)
RF MOD COM (GY) 6 RIGHT FRONT MOD COMMON
RF MOD EXH (OR) 7 RIGHT FRONT MOD EXHAUST
LF SENSOR RTN (BK) 8 LEFT FRONT SENSOR (-)
RR MOD COM (GY) 9 RIGHT MOD COMMON
RR MOD HOLD (GN) 10 RIGHT MOD HOLD
RF SENSOR IN (PK) 11 RIGHT FRONT SENSOR (+)
LR MOD COMMON (GY) 12 LEFT REAR MOD COMMON
RR MOD EXH (OR) 13 RIGHT REAR MOD EXHAUST
RF SENSOR RTN (BK) 14 RIGHT FRONT SENSOR (-)
LR SENSOR IN (PU) 15 LEFT REAR SENSOR +
LR MOD HOLD (BL) 16 LEFT REAR MOD HOLD
LR MOD EXH (TN) 17 LEFT REAR MOD EXHAUST
LR SENSOR RTN (BK) 18 LEFT REAR SENSOR -
X3 (NOT CONNECTED)
1 ABS ORS
2 DIFF
3 DIFF_CMN
4 NOT USED
5 RESERVED
6 NOT USED
7 ADDITIONAL MOD EXHAUST
8 RESERVED
9 ADDITIONAL MOD COMMON
10 ADDITIONAL MOD HOLD
11 ADDITIONAL LEFT SENSOR(+)
12 ADDITIONAL RIGHT SENSOR(+)
13 NOT USED
14 ADDITIONAL LEFT SENSOR(-)
15 ADDITIONAL RIGHT SENSOR(-)
ABS HARNESS
ATC HARNESS
SEE CHART 0104429
B
A
C515
TRACTION
CONTROL VALVE
FR
B
A
C514
TRACTION
CONTROL VALVE
TCV RTN
TCV IN
Sheet 8
D0003660B
ABS - BENDIX (AIR)


ABS ECU 16 WAY CONNECTOR
C513
PD
A
B
C
D
E
F
G
H
J
K
L
M
N
P
R
S
MOD PMP BAT (RD)
PMP MTR BAT (RD)
ABS IGN (OR)
ABS IGN (OR)
TJ1939- (GN)
TJ1939+ (YL)
J1587- (BL)
J1587- (BL)
J1587+ (YL)
J1587+ (YL)
ABS BAT (RD)
ABS BAT (RD)
ABS GND (WH)
ABS REF GND (WH)
AJ1939- (GN)
AJ1939- (GN)
AJ1939+ (YL)
AJ1939+ (YL)
TO DIAGNOSTIC
CONNECTOR
SHT 2
ABS POWER
START/CHARGE
SHT 2
J1939 DIAGNOSTIC
INTERFACE
SHT 22/23

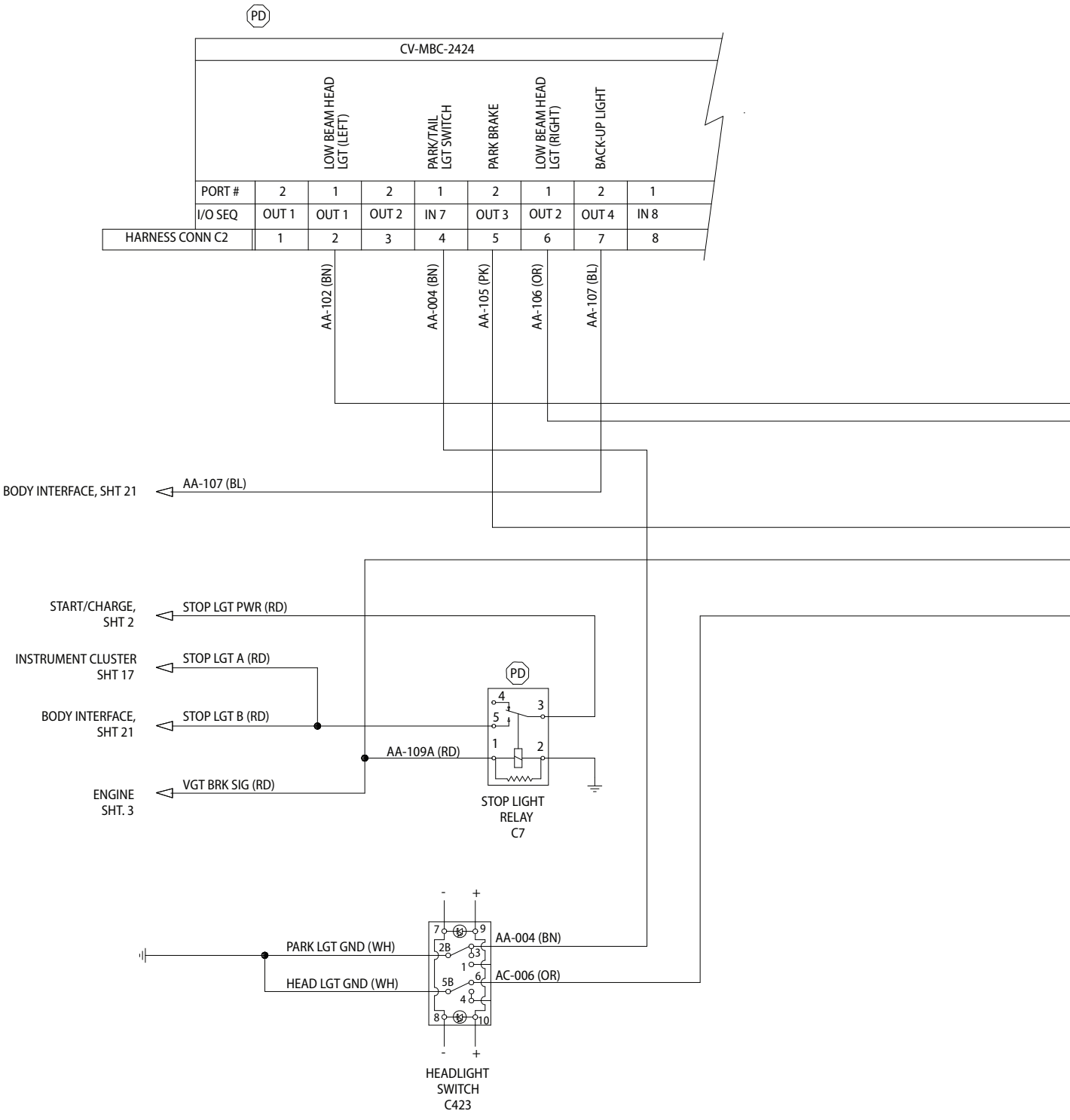

LF SENS IN (BN)
LF SENS GND (BK)
LR SENS IN (BN)
LR SENS GND (BK)
RR SENS IN (BN)
RR SENS GND (BK)
RF SENS IN (BN)
RF SENS GND (BK)
C511
C509
C503
C501
1
2
LEFT FRONT
SPEED SENS
LEFT REAR
SPEED SENS
RIGHT REAR
SPEED SENS
RIGHT FRONT
SPEED SENS

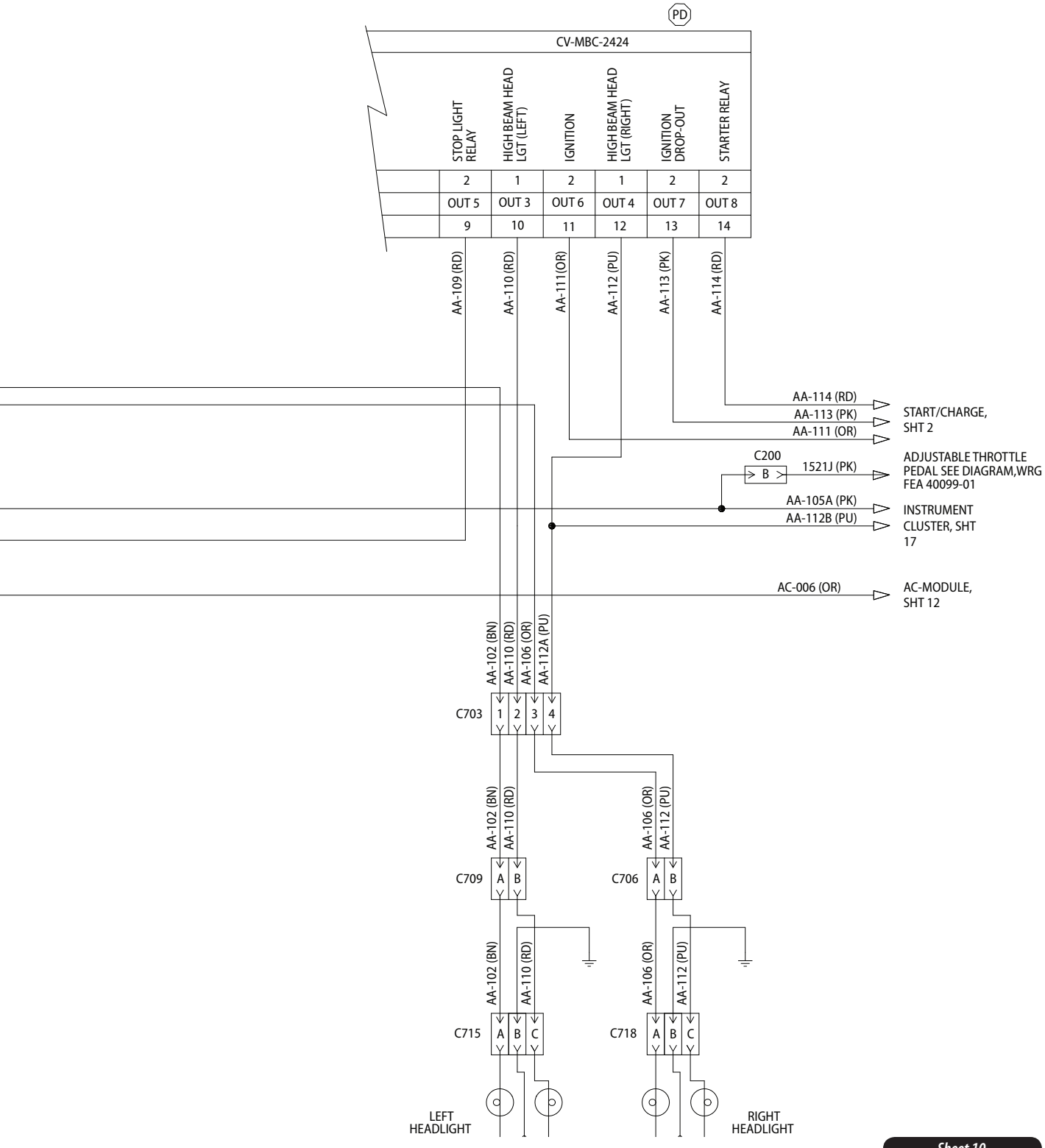


Sheet 9

D0003661C

ABS - WABCO (HYDRAULIC)

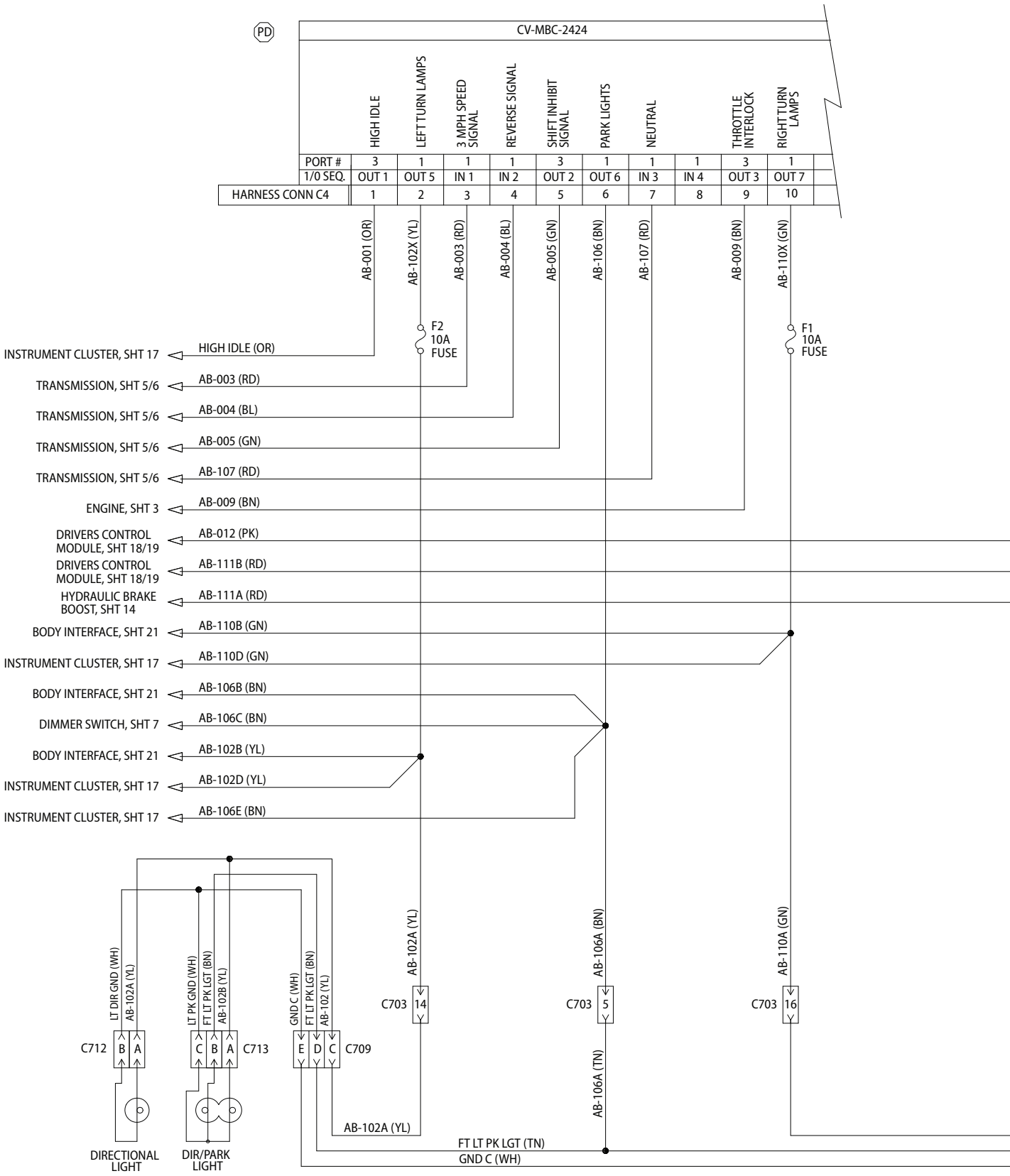

PD
CV-MBC-2424
LOW BEAM HEAD LGT (LEFT)
PARK/TAIL LGT SWITCH
PARK BRAKE
LOW BEAM HEAD LGT (RIGHT)
BACK-UP LIGHT
PORT # 2 1 2 1 2 1 2 1
I/O SEQ OUT 1 OUT 1 OUT 2 IN 7 OUT 3 OUT 2 OUT 4 IN 8
HARNESS CONN C2 1 2 3 4 5 6 7 8
AA-102 (BN)
AA-004 (BN)
AA-105 (PK)
AA-106 (OR)
AA-107 (BL)
BODY INTERFACE, SHT 21
AA-107 (BL)
START/CHARGE, SHT 2
STOP LGT PWR (RD)
INSTRUMENT CLUSTER SHT 17
STOP LGT A (RD)
BODY INTERFACE, SHT 21
STOP LGT B (RD)
AA-109A (RD)
ENGINE SHT. 3
VGT BRK SIG (RD)
PD
4
3
5
1
2
STOP LIGHT RELAY C7
PARK LGT GND (WH)
HEAD LGT GND (WH)
AA-004 (BN)
AC-006 (OR)
HEADLIGHT SWITCH C423

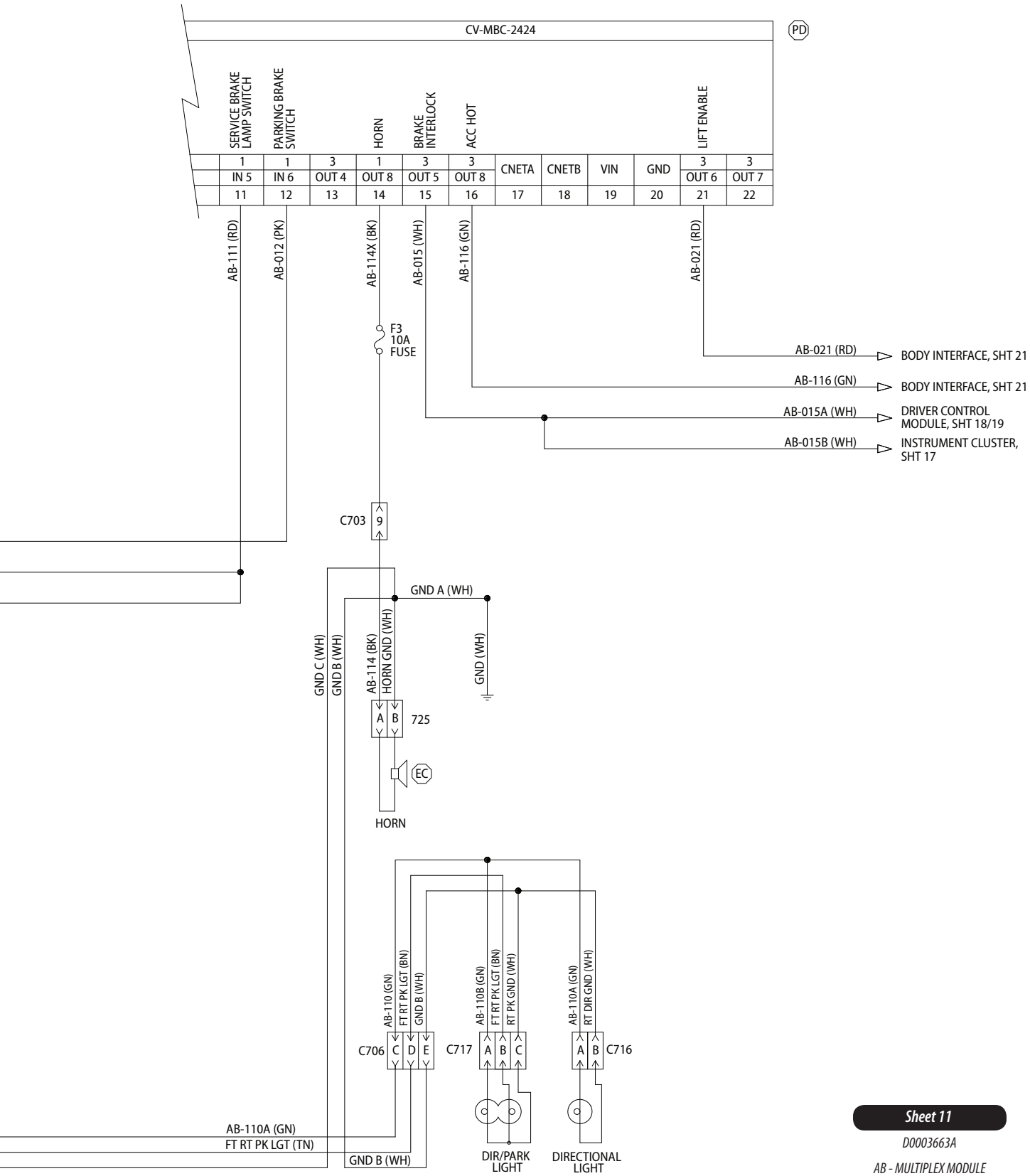


Sheet 10

D0003662B

AA MULTIPLEX MODULE

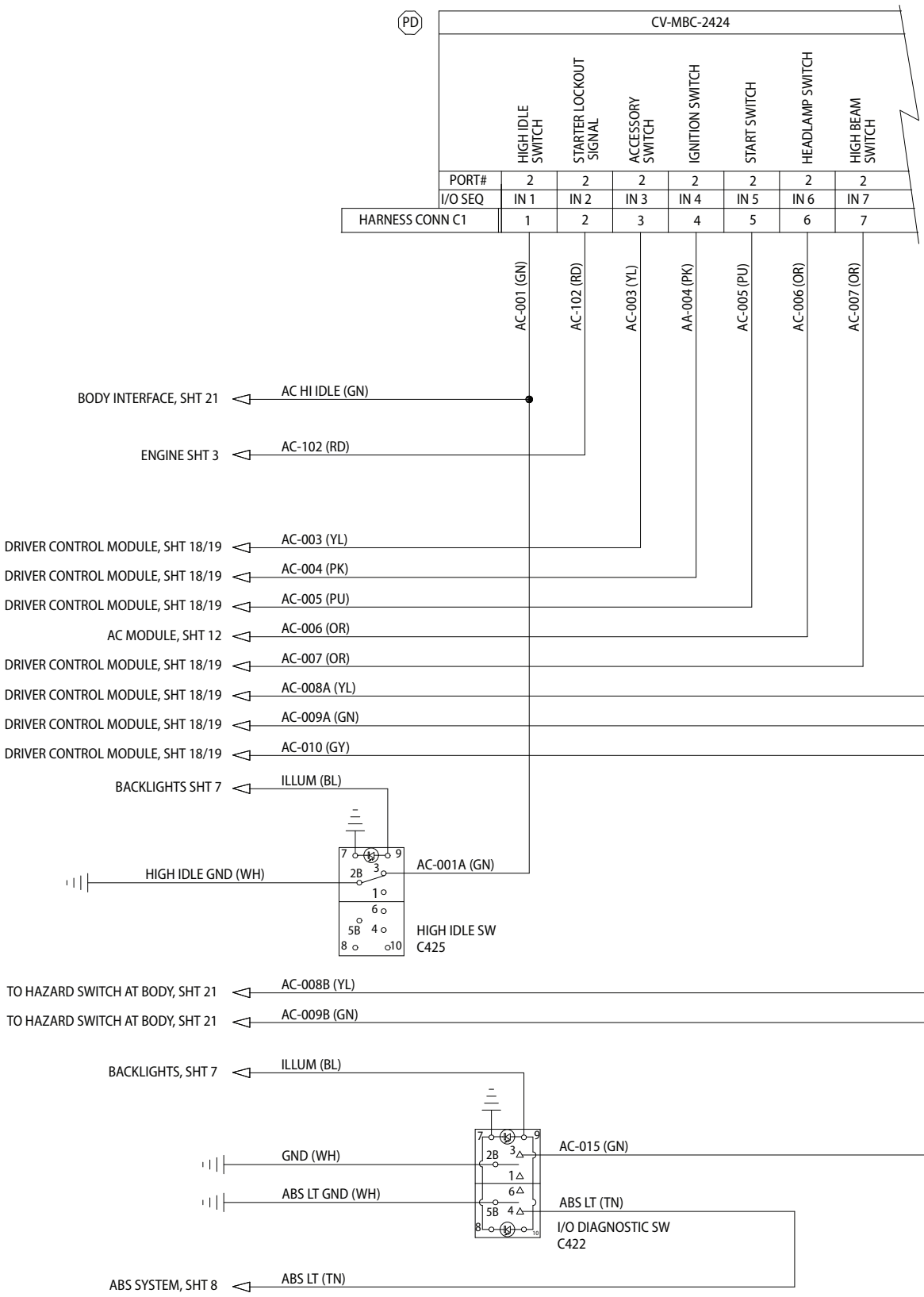

PD
CV-MBC-2424
HIGH IDLE
LEFT TURN LAMPS
3 MPH SPEED SIGNAL
REVERSE SIGNAL
SHIFT INHIBIT SIGNAL
PARK LIGHTS
NEUTRAL
THROTTLE INTERLOCK
RIGHT TURN LAMPS
PORT # 3 1 1 1 3 1 1 1 3 1
1/0 SEQ. OUT 1 OUT 5 IN 1 IN 2 OUT 2 OUT 6 IN 3 IN 4 OUT 3 OUT 7
HARNESS CONN C4 1 2 3 4 5 6 7 8 9 10
AB-001 (OR)
AB-102X (YL)
AB-003 (RD)
AB-004 (BL)
AB-005 (GN)
AB-106 (BN)
AB-107 (RD)
AB-009 (BN)
AB-110X (GN)
F2 10A FUSE
F1 10A FUSE
INSTRUMENT CLUSTER, SHT 17
HIGH IDLE (OR)
TRANSMISSION, SHT 5/6
AB-003 (RD)
TRANSMISSION, SHT 5/6
AB-004 (BL)
TRANSMISSION, SHT 5/6
AB-005 (GN)
TRANSMISSION, SHT 5/6
AB-107 (RD)
ENGINE, SHT 3
AB-009 (BN)
DRIVERS CONTROL MODULE, SHT 18/19
AB-012 (PK)
DRIVERS CONTROL MODULE, SHT 18/19
AB-111B (RD)
HYDRAULIC BRAKE BOOST, SHT 14
AB-111A (RD)
BODY INTERFACE, SHT 21
AB-110B (GN)
INSTRUMENT CLUSTER, SHT 17
AB-110D (GN)
BODY INTERFACE, SHT 21
AB-106B (BN)
DIMMER SWITCH, SHT 7
AB-106C (BN)
BODY INTERFACE, SHT 21
AB-102B (YL)
INSTRUMENT CLUSTER, SHT 17
AB-102D (YL)
INSTRUMENT CLUSTER, SHT 17
AB-106E (BN)
LT DIR GND (WH)
AB-102A (YL)
LT PK GND (WH)
FT LT PK LGT (BN)
AB-102B (YL)
GND C (WH)
FT LT PK LGT (BN)
AB-102 (YL)
AB-102A (YL)
AB-106A (BN)
AB-110A (GN)
C703 14
C703 5
C703 16
C712 B A
C713 C B A
C709 E D C
AB-106A (TN)
AB-102A (YL)
FT LT PK LGT (TN)
GND C (WH)
DIRECTIONAL LIGHT
DIR/PARK LIGHT

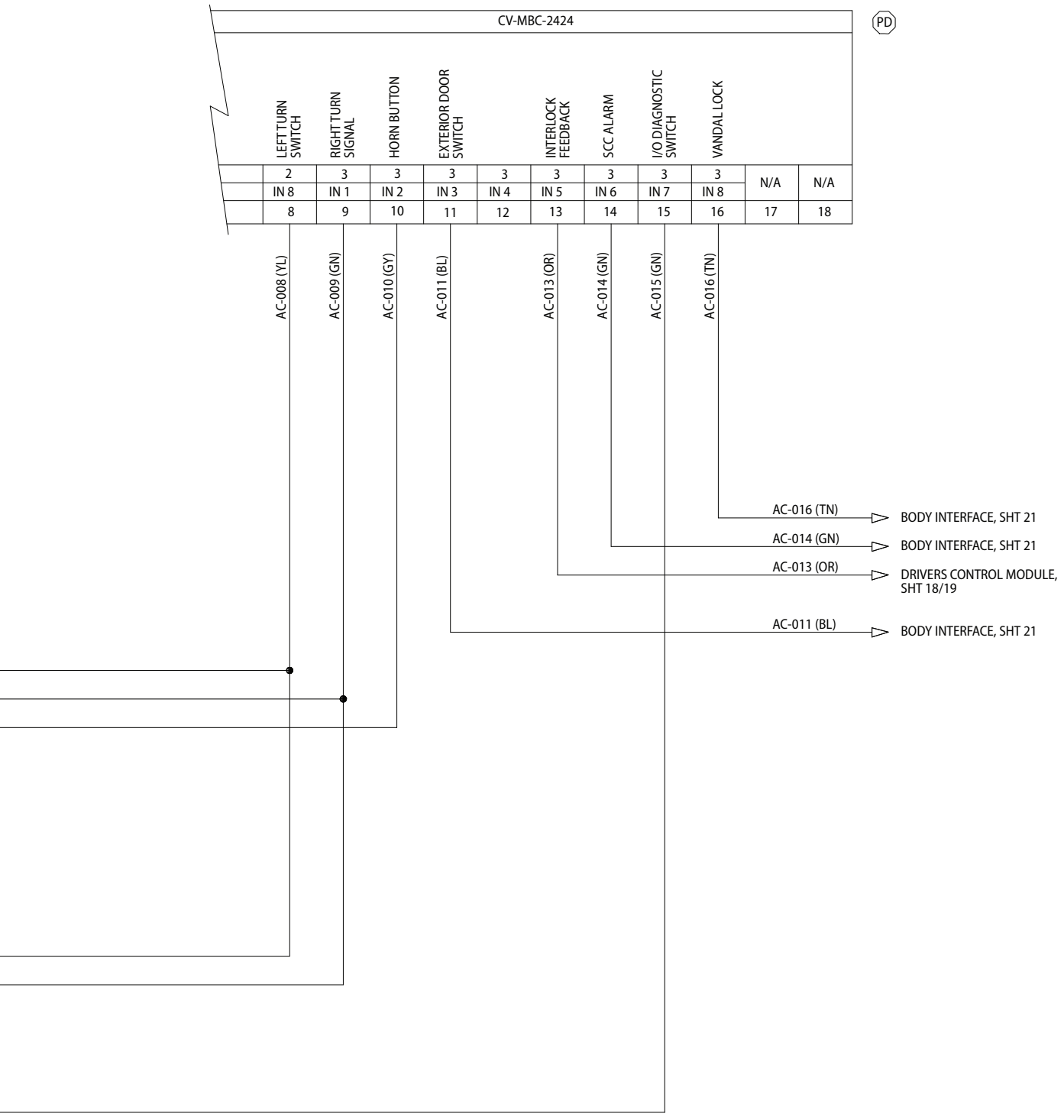


Sheet 11

D0003663A

AB - MULTIPLEX MODULE

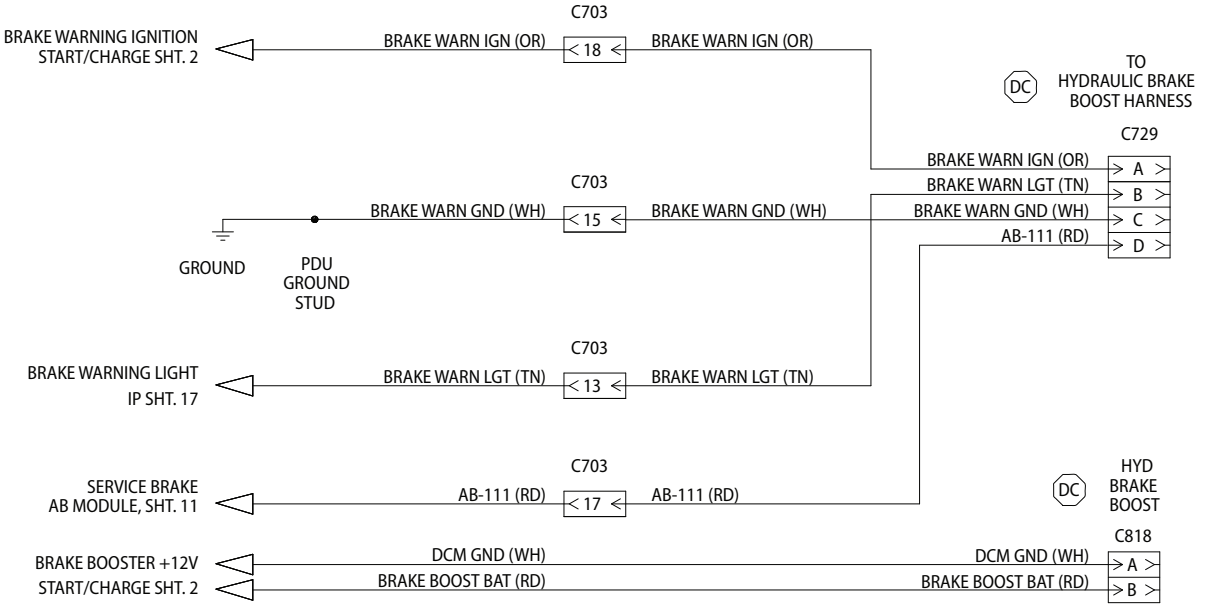

PD
CV-MBC-2424
HIGH IDLE SWITCH
STARTER LOCKOUT SIGNAL
ACCESSORY SWITCH
IGNITION SWITCH
START SWITCH
HEADLAMP SWITCH
HIGH BEAM SWITCH
PORT# 2 2 2 2 2 2 2
I/O SEQ IN 1 IN 2 IN 3 IN 4 IN 5 IN 6 IN 7
HARNESS CONN C1 1 2 3 4 5 6 7
AC-001 (GN)
AC-102 (RD)
AC-003 (YL)
AA-004 (PK)
AC-005 (PU)
AC-006 (OR)
AC-007 (OR)
BODY INTERFACE, SHT 21
AC HI IDLE (GN)
ENGINE SHT 3
AC-102 (RD)
DRIVER CONTROL MODULE, SHT 18/19
AC-003 (YL)
DRIVER CONTROL MODULE, SHT 18/19
AC-004 (PK)
DRIVER CONTROL MODULE, SHT 18/19
AC-005 (PU)
AC MODULE, SHT 12
AC-006 (OR)
DRIVER CONTROL MODULE, SHT 18/19
AC-007 (OR)
DRIVER CONTROL MODULE, SHT 18/19
AC-008A (YL)
DRIVER CONTROL MODULE, SHT 18/19
AC-009A (GN)
DRIVER CONTROL MODULE, SHT 18/19
AC-010 (GY)
BACKLIGHTS SHT 7
ILLUM (BL)
HIGH IDLE GND (WH)
AC-001A (GN)
HIGH IDLE SW
C425
TO HAZARD SWITCH AT BODY, SHT 21
AC-008B (YL)
TO HAZARD SWITCH AT BODY, SHT 21
AC-009B (GN)
BACKLIGHTS, SHT 7
ILLUM (BL)
GND (WH)
ABS LT GND (WH)
AC-015 (GN)
ABS LT (TN)
I/O DIAGNOSTIC SW
C422
ABS SYSTEM, SHT 8
ABS LT (TN)



Sheet 12

D0003664A

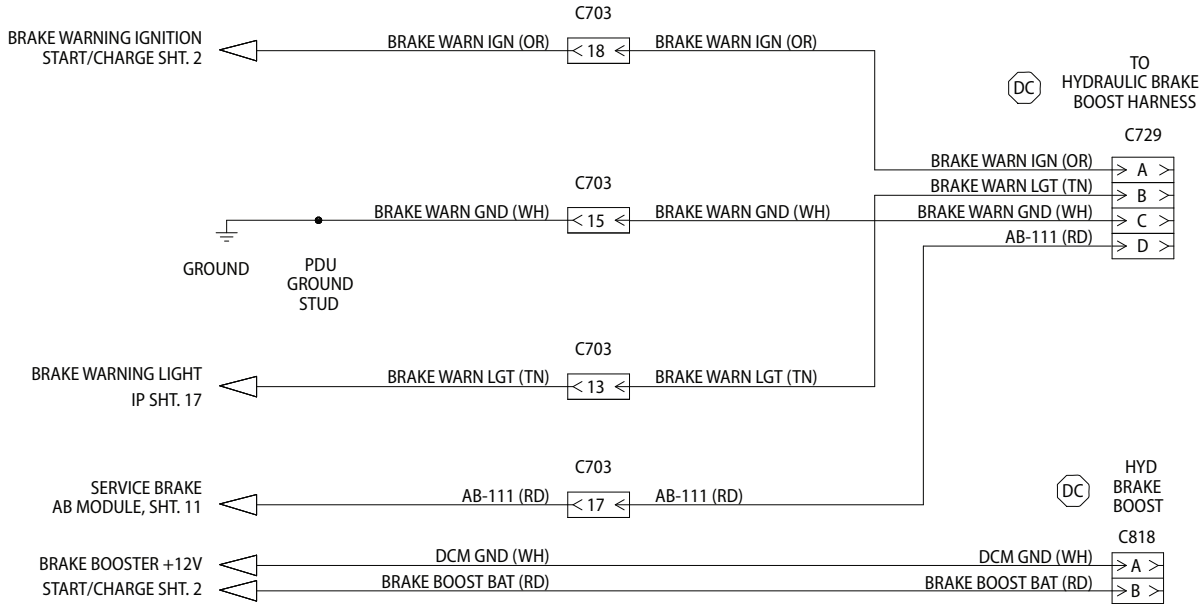
AC - MULTIPLEX MODULE

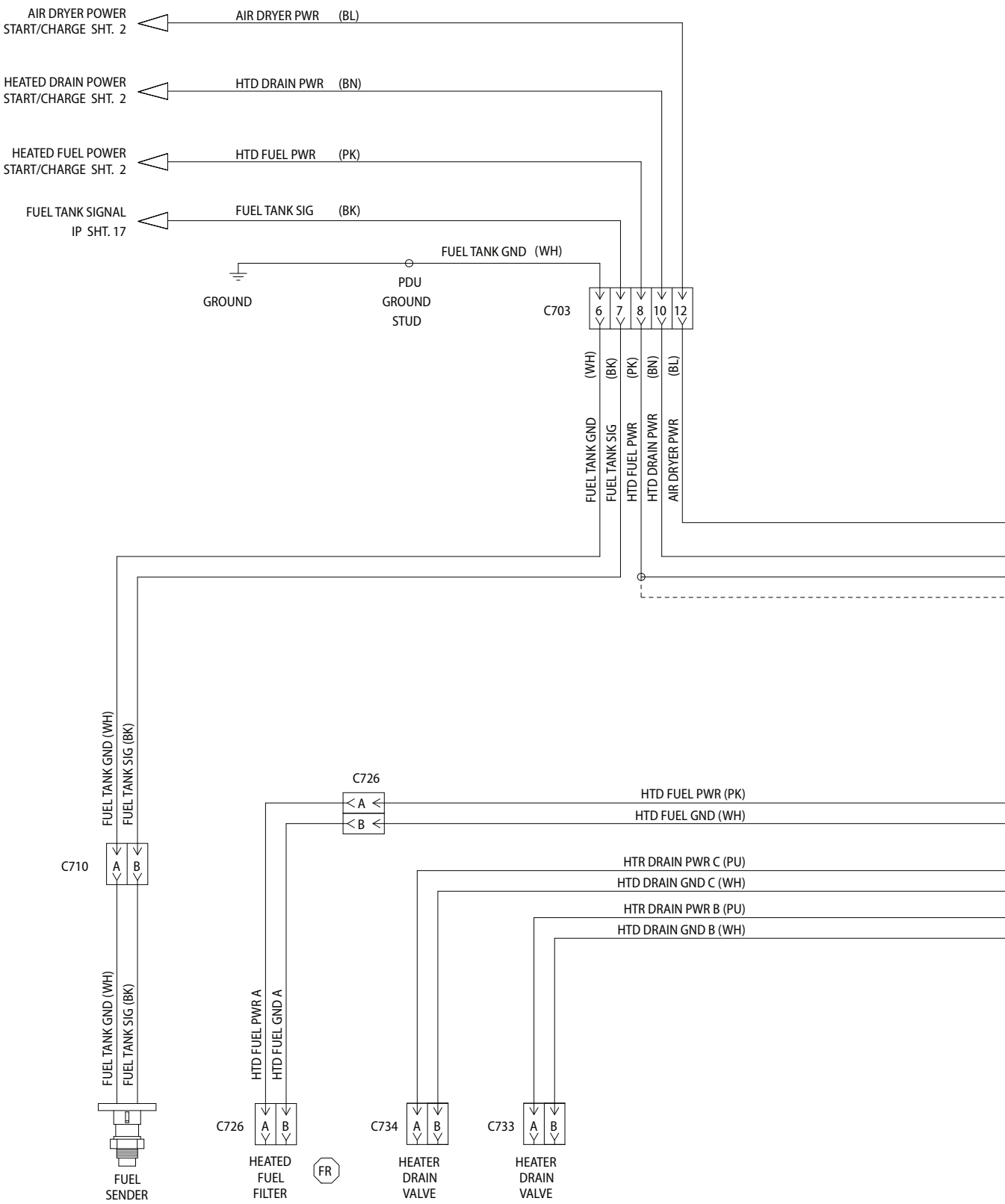


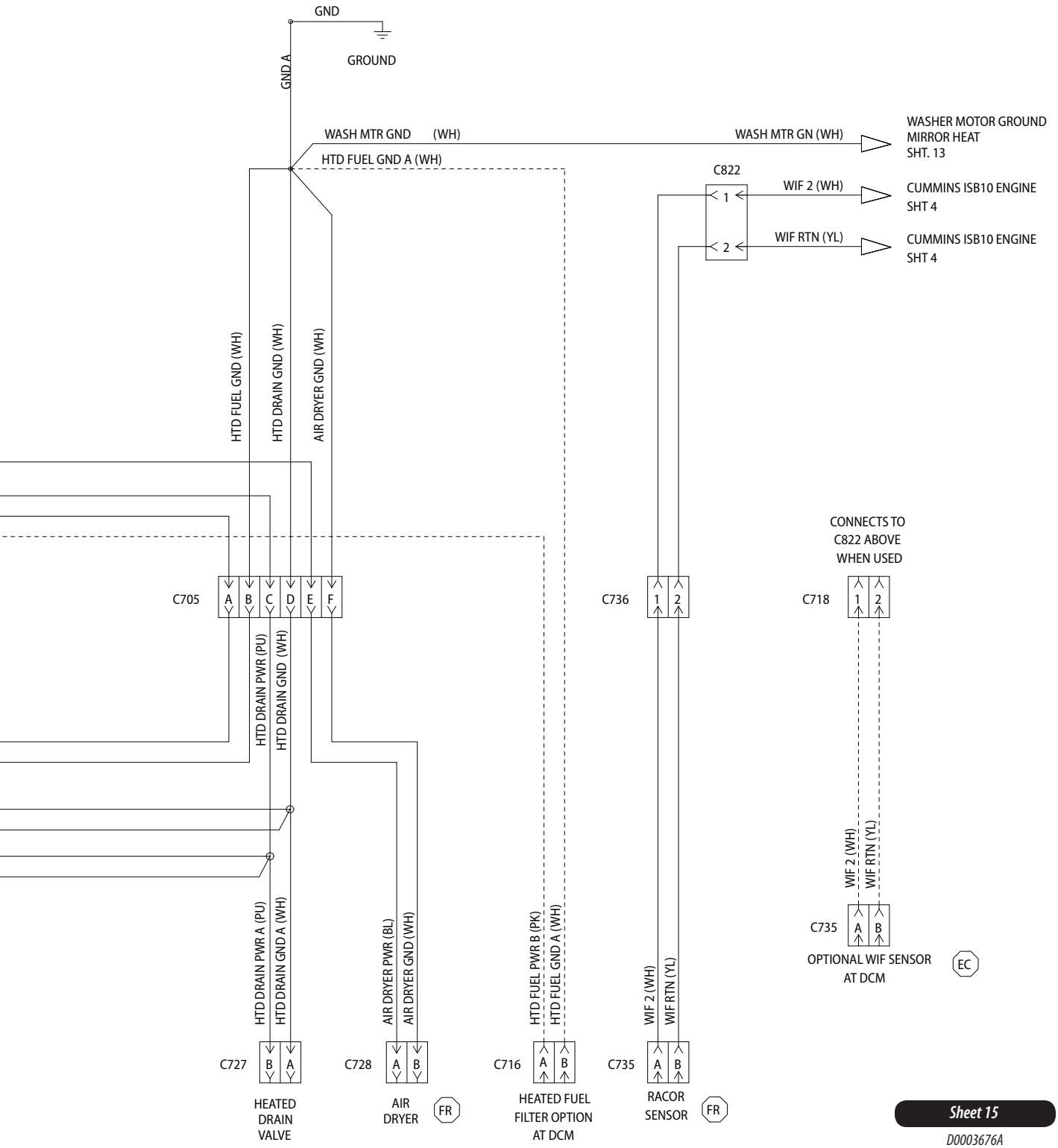
Sheet 13

D0003665A

MIRROR HEAT, EXTERIOR SPEAKER, WIPER WASHER


C703
BRAKE WARNING IGNITION
START/CHARGE SHT. 2
BRAKE WARN IGN (OR)
18
BRAKE WARN IGN (OR)
DC
TO
HYDRAULIC BRAKE
BOOST HARNESS
C729
BRAKE WARN IGN (OR)
A
BRAKE WARN LGT (TN)
B
BRAKE WARN GND (WH)
C
AB-111 (RD)
D
C703
BRAKE WARN GND (WH)
15
BRAKE WARN GND (WH)
GROUND
PDU
GROUND
STUD
C703
BRAKE WARNING LIGHT
IP SHT. 17
BRAKE WARN LGT (TN)
13
BRAKE WARN LGT (TN)
C703
SERVICE BRAKE
AB MODULE, SHT. 11
AB-111 (RD)
17
AB-111 (RD)
DC
HYD
BRAKE
BOOST
C818
BRAKE BOOSTER +12V
START/CHARGE SHT. 2
DCM GND (WH)
BRAKE BOOST BAT (RD)
DCM GND (WH)
BRAKE BOOST BAT (RD)
A
B


AIR DRYER POWER
START/CHARGE SHT. 2
AIR DRYER PWR (BL)
HEATED DRAIN POWER
START/CHARGE SHT. 2
HTD DRAIN PWR (BN)
HEATED FUEL POWER
START/CHARGE SHT. 2
HTD FUEL PWR (PK)
FUEL TANK SIGNAL
IP SHT. 17
FUEL TANK SIG (BK)
FUEL TANK GND (WH)
GROUND
PDU
GROUND
STUD
C703
6 7 8 10 12
(WH) (BK) (PK) (BN) (BL)
FUEL TANK GND
FUEL TANK SIG
HTD FUEL PWR
HTD DRAIN PWR
AIR DRYER PWR
FUEL TANK GND (WH)
FUEL TANK SIG (BK)
C710
A B
C726
A
B
HTD FUEL PWR (PK)
HTD FUEL GND (WH)
HTR DRAIN PWR C (PU)
HTD DRAIN GND C (WH)
HTR DRAIN PWR B (PU)
HTD DRAIN GND B (WH)
FUEL TANK GND (WH)
FUEL TANK SIG (BK)
HTD FUEL PWR A
HTD FUEL GND A
C726
A B
C734
A B
C733
A B
FUEL
SENDER
HEATED
FUEL
FILTER
FR
HEATER
DRAIN
VALVE
HEATER
DRAIN
VALVE



Sheet 15

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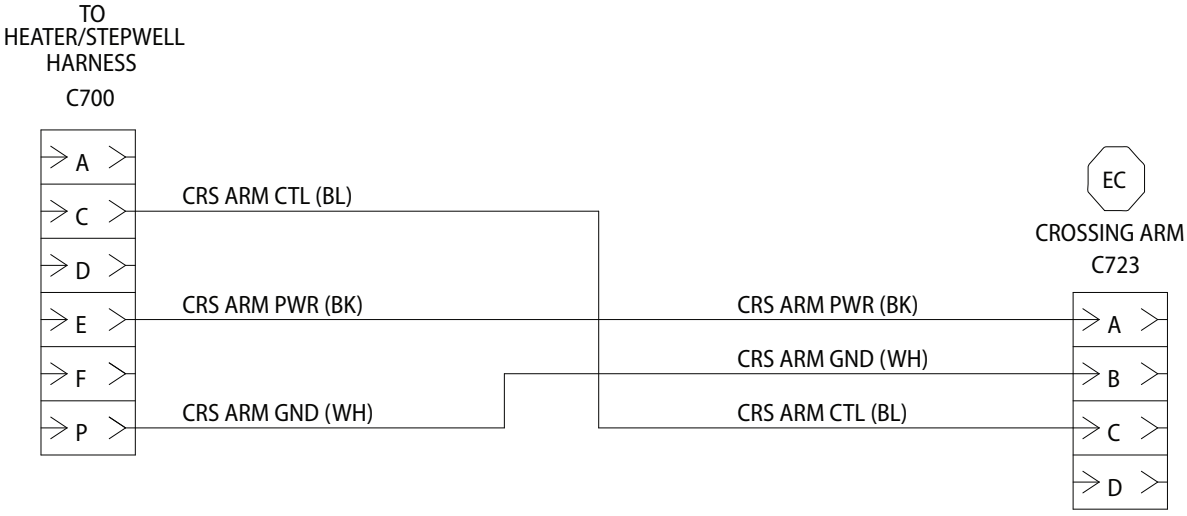
FRAME COMPONENTS



Sheet 16

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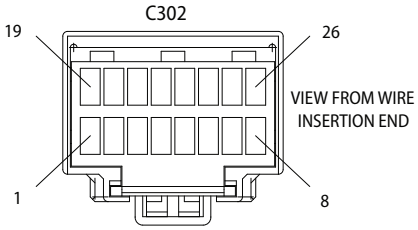
CROSSING ARM

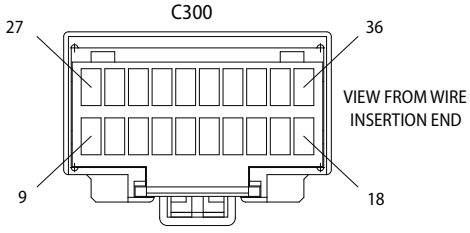


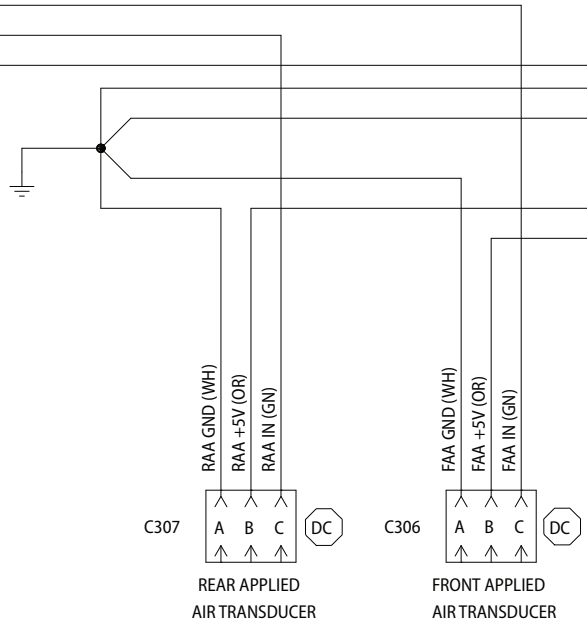
INSTRUMENT CLUSTER C302

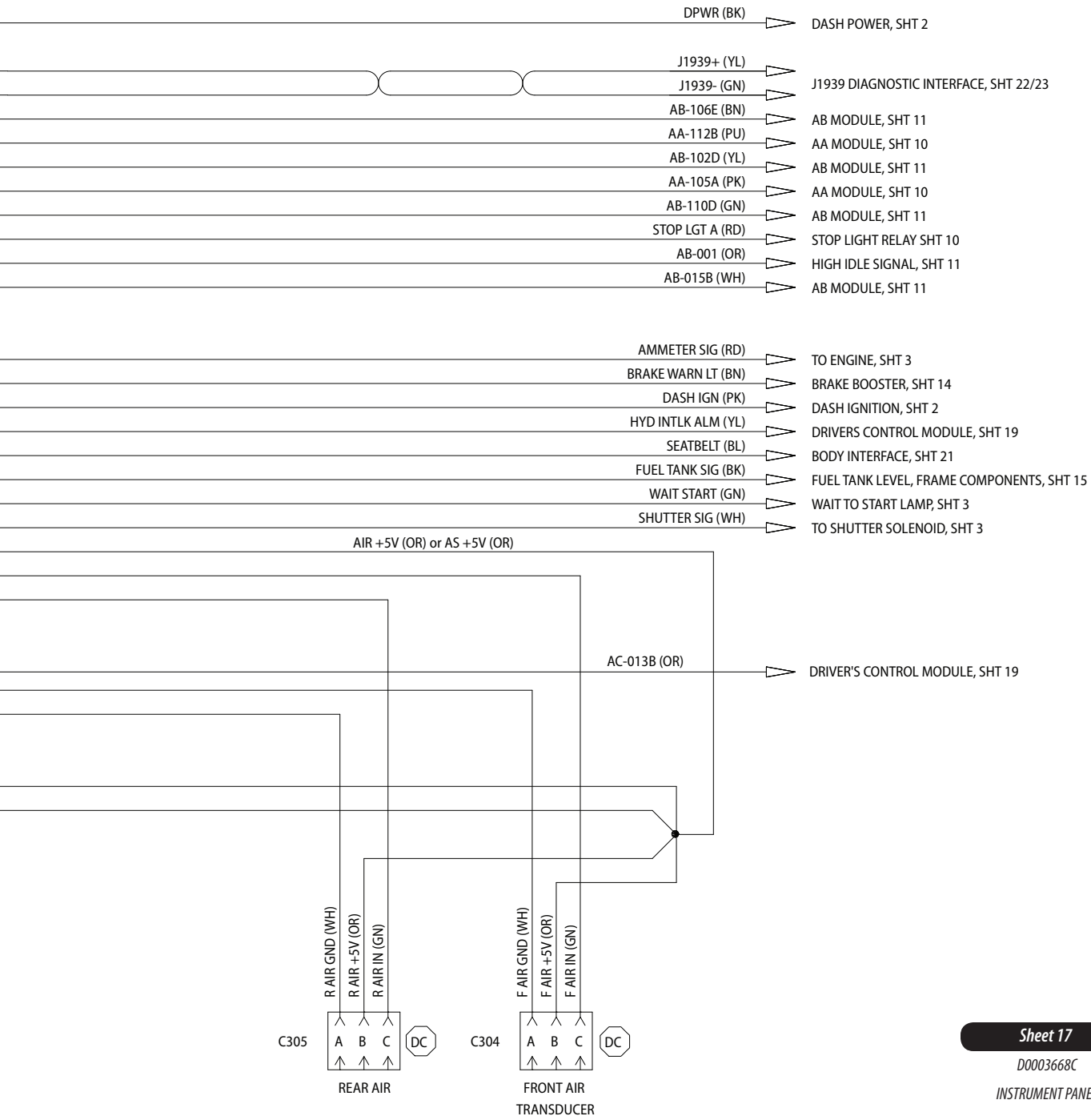
BATTERY +12V	1	DPWR (BK)
GROUND	2	DCHASS GND (WH)
SAE J1939+	3	J1939+ (YL)
SAE J1939-	4	J1939- (GN)
HEADLAMP REMINDER	19	AB-106E (BN)
HI BEAM INDICATOR	20	AA-112B (PU)
LEFT TURN INDICATOR	21	AB-102D (YL)
PARK BRAKE	22	AA-105A (PK)
RIGHT TURN INDICATOR	23	AB-110D (GN)
BRAKE SIGNAL IN	24	STOP LGT A (RD)
FAST IDLE	25	HIGH IDLE (OR)
BRAKE INTERLOCK REQUEST	26	AB-015B (WH)

C300

AMMETER IN	15	AMMETER SIG (RD)
HYDRAULIC BRAKE FAILURE	17	BRAKE WARN LT (BN)
IGNITION +12V	18	DASH IGN (PK)
BRAKE INTERLOCK ALARM	27	HYD INTLK ALM (YL)
SEAT BELT	32	SEATBELT (BL)
FUEL LEVEL SENDER	34	FUEL TANK SIG (BK)
WAIT TO START LAMP	36	WAIT START (GN)
SHUTTER SOLENOID	30	SHUTTER SIG (WH)
+5 VDC SENSOR POWER	9	AIR +5V (OR) or AS +5V (OR-HYD ONLY)
FRONT AIR PSI SENDER	11	F AIR IN (GN) or AS IN (GN-HYD ONLY)
REAR AIR PSI SENDER	12	R AIR IN (GN)
APPLILED FRONT AIR PSI SENSOR	13	FAA IN (GN)
APPLIED REAR AIR PSI SENSOR	14	RAA IN (GN)
INTERLOCK SET	35	AC-013B (OR)







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CUM ISB-10

Sheet 17

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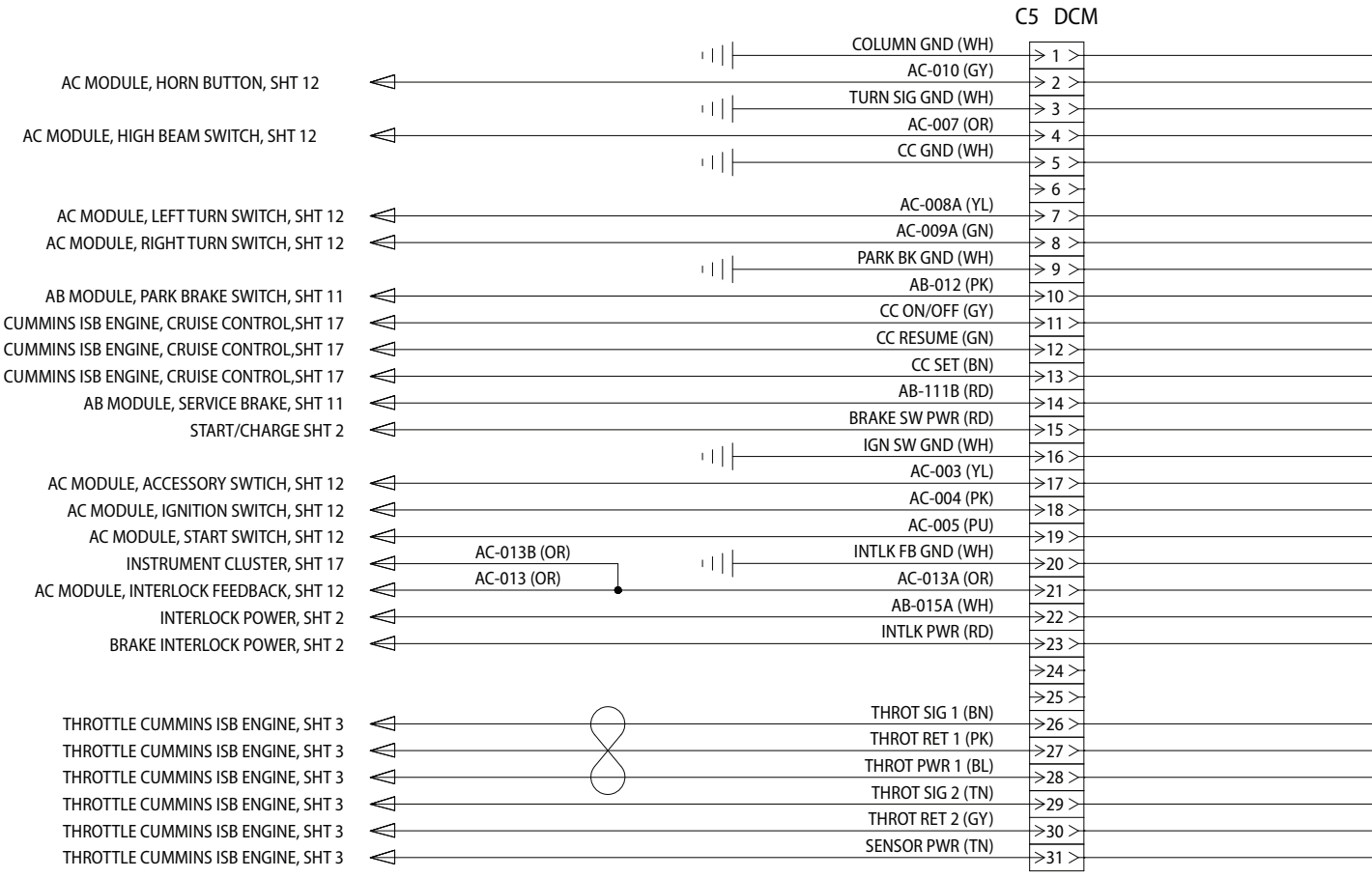
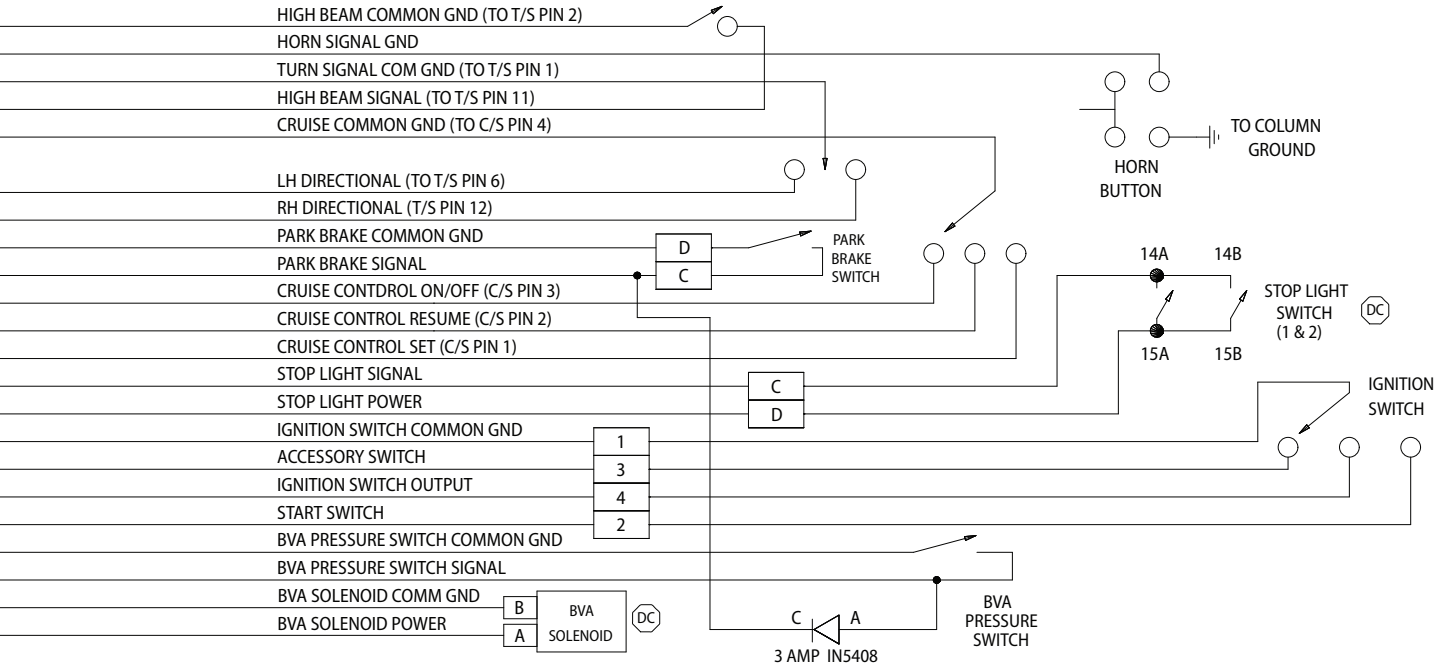
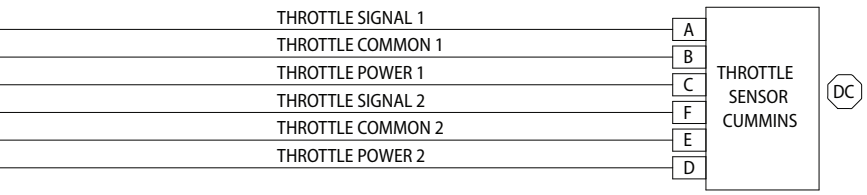
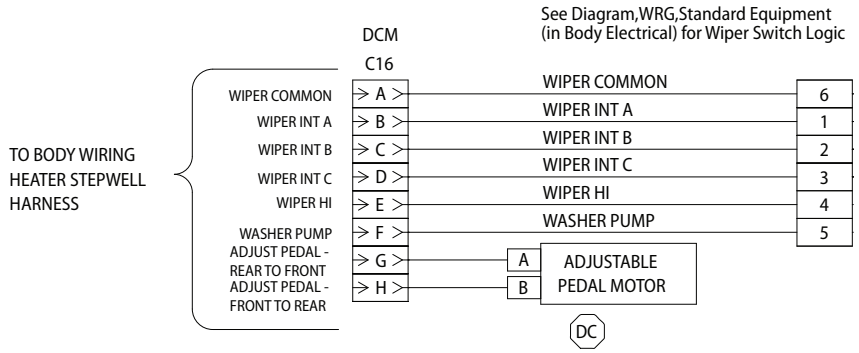
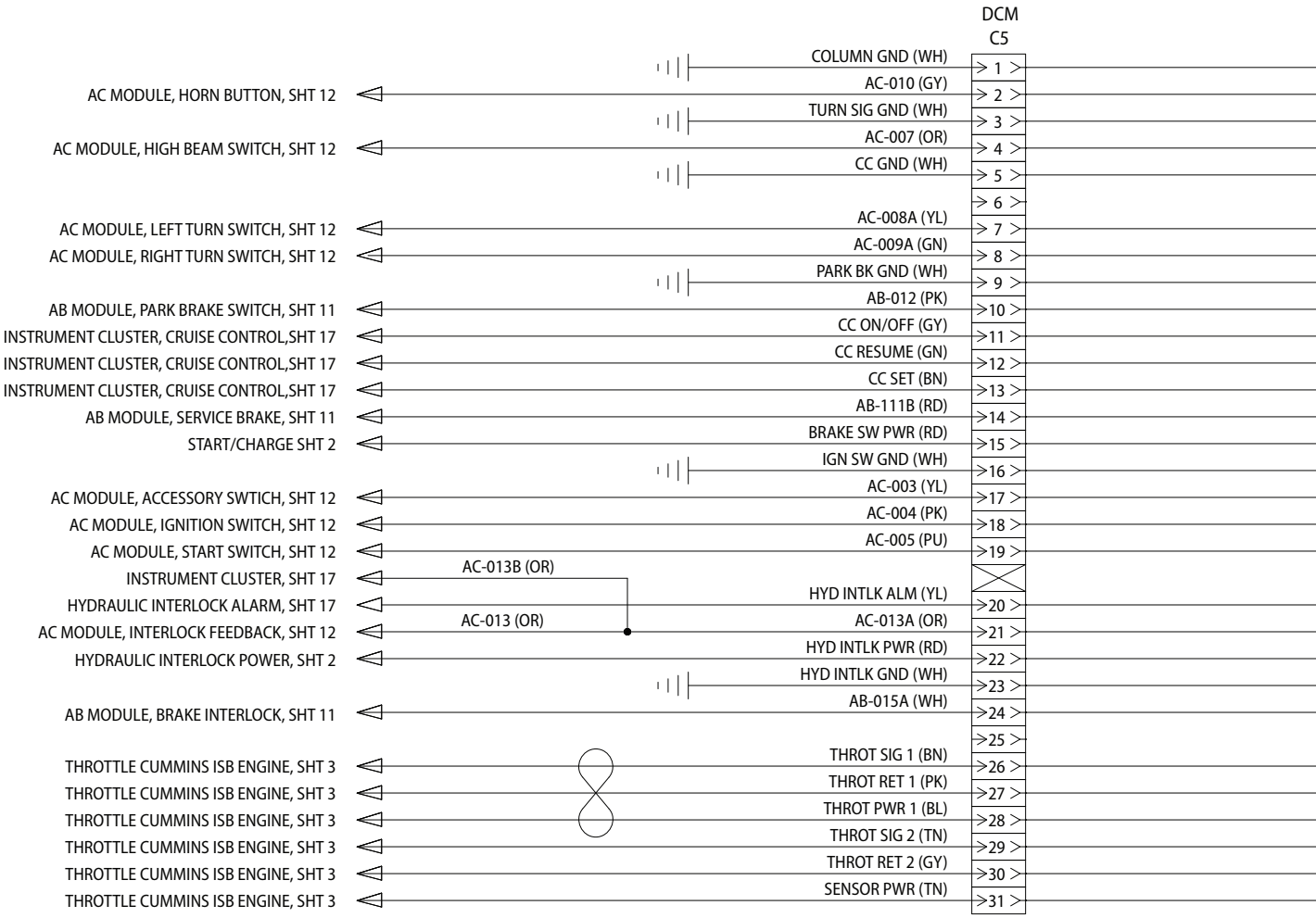
INSTRUMENT PANEL


C5 DCM
COLUMN GND (WH)
AC-010 (GY)
TURN SIG GND (WH)
AC-007 (OR)
CC GND (WH)
AC-008A (YL)
AC-009A (GN)
PARK BK GND (WH)
AB-012 (PK)
CC ON/OFF (GY)
CC RESUME (GN)
CC SET (BN)
AB-111B (RD)
BRAKE SW PWR (RD)
IGN SW GND (WH)
AC-003 (YL)
AC-004 (PK)
AC-005 (PU)
INTLK FB GND (WH)
AC-013A (OR)
AB-015A (WH)
INTLK PWR (RD)
THROT SIG 1 (BN)
THROT RET 1 (PK)
THROT PWR 1 (BL)
THROT SIG 2 (TN)
THROT RET 2 (GY)
SENSOR PWR (TN)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
AC MODULE, HORN BUTTON, SHT 12
AC MODULE, HIGH BEAM SWITCH, SHT 12
AC MODULE, LEFT TURN SWITCH, SHT 12
AC MODULE, RIGHT TURN SWITCH, SHT 12
AB MODULE, PARK BRAKE SWITCH, SHT 11
CUMMINS ISB ENGINE, CRUISE CONTROL,SHT 17
CUMMINS ISB ENGINE, CRUISE CONTROL,SHT 17
CUMMINS ISB ENGINE, CRUISE CONTROL,SHT 17
AB MODULE, SERVICE BRAKE, SHT 11
START/CHARGE SHT 2
AC MODULE, ACCESSORY SWTICH, SHT 12
AC MODULE, IGNITION SWITCH, SHT 12
AC MODULE, START SWITCH, SHT 12
INSTRUMENT CLUSTER, SHT 17
AC MODULE, INTERLOCK FEEDBACK, SHT 12
INTERLOCK POWER, SHT 2
BRAKE INTERLOCK POWER, SHT 2
THROTTLE CUMMINS ISB ENGINE, SHT 3
THROTTLE CUMMINS ISB ENGINE, SHT 3
THROTTLE CUMMINS ISB ENGINE, SHT 3
THROTTLE CUMMINS ISB ENGINE, SHT 3
THROTTLE CUMMINS ISB ENGINE, SHT 3
THROTTLE CUMMINS ISB ENGINE, SHT 3
AC-013B (OR)
AC-013 (OR)


HIGH BEAM COMMON GND (TO T/S PIN 2)
HORN SIGNAL GND
TURN SIGNAL COM GND (TO T/S PIN 1)
HIGH BEAM SIGNAL (TO T/S PIN 11)
CRUISE COMMON GND (TO C/S PIN 4)
LH DIRECTIONAL (TO T/S PIN 6)
RH DIRECTIONAL (T/S PIN 12)
PARK BRAKE COMMON GND
PARK BRAKE SIGNAL
CRUISE CONTDROL ON/OFF (C/S PIN 3)
CRUISE CONTROL RESUME (C/S PIN 2)
CRUISE CONTROL SET (C/S PIN 1)
STOP LIGHT SIGNAL
STOP LIGHT POWER
IGNITION SWITCH COMMON GND
ACCESSORY SWITCH
IGNITION SWITCH OUTPUT
START SWITCH
BVA PRESSURE SWITCH COMMON GND
BVA PRESSURE SWITCH SIGNAL
BVA SOLENOID COMM GND
BVA SOLENOID POWER
HORN BUTTON
TO COLUMN GROUND
D
C
PARK BRAKE SWITCH
14A
14B
15A
15B
STOP LIGHT SWITCH (1 & 2)
DC
C
D
IGNITION SWITCH
1
3
4
2
B
A
BVA SOLENOID
DC
C
A
3 AMP IN5408
BVA PRESSURE SWITCH


THROTTLE SIGNAL 1
THROTTLE COMMON 1
THROTTLE POWER 1
THROTTLE SIGNAL 2
THROTTLE COMMON 2
THROTTLE POWER 2
A
B
C
F
E
D
THROTTLE SENSOR CUMMINS
DC


See Diagram,WRG,Standard Equipment (in Body Electrical) for Wiper Switch Logic
DCM
C16
TO BODY WIRING HEATER STEPWELL HARNESS
WIPER COMMON
WIPER INT A
WIPER INT B
WIPER INT C
WIPER HI
WASHER PUMP
ADJUST PEDAL - REAR TO FRONT
ADJUST PEDAL - FRONT TO REAR
A
B
C
D
E
F
G
H
WIPER COMMON
WIPER INT A
WIPER INT B
WIPER INT C
WIPER HI
WASHER PUMP
6
1
2
3
4
5
A
B
ADJUSTABLE PEDAL MOTOR
DC


DCM
C5
COLUMN GND (WH)
AC-010 (GY)
TURN SIG GND (WH)
AC-007 (OR)
CC GND (WH)
AC-008A (YL)
AC-009A (GN)
PARK BK GND (WH)
AB-012 (PK)
CC ON/OFF (GY)
CC RESUME (GN)
CC SET (BN)
AB-111B (RD)
BRAKE SW PWR (RD)
IGN SW GND (WH)
AC-003 (YL)
AC-004 (PK)
AC-005 (PU)
AC-013B (OR)
AC-013 (OR)
HYD INTLK ALM (YL)
AC-013A (OR)
HYD INTLK PWR (RD)
HYD INTLK GND (WH)
AB-015A (WH)
THROT SIG 1 (BN)
THROT RET 1 (PK)
THROT PWR 1 (BL)
THROT SIG 2 (TN)
THROT RET 2 (GY)
SENSOR PWR (TN)
1
2
3
4
5
6
7
8
9
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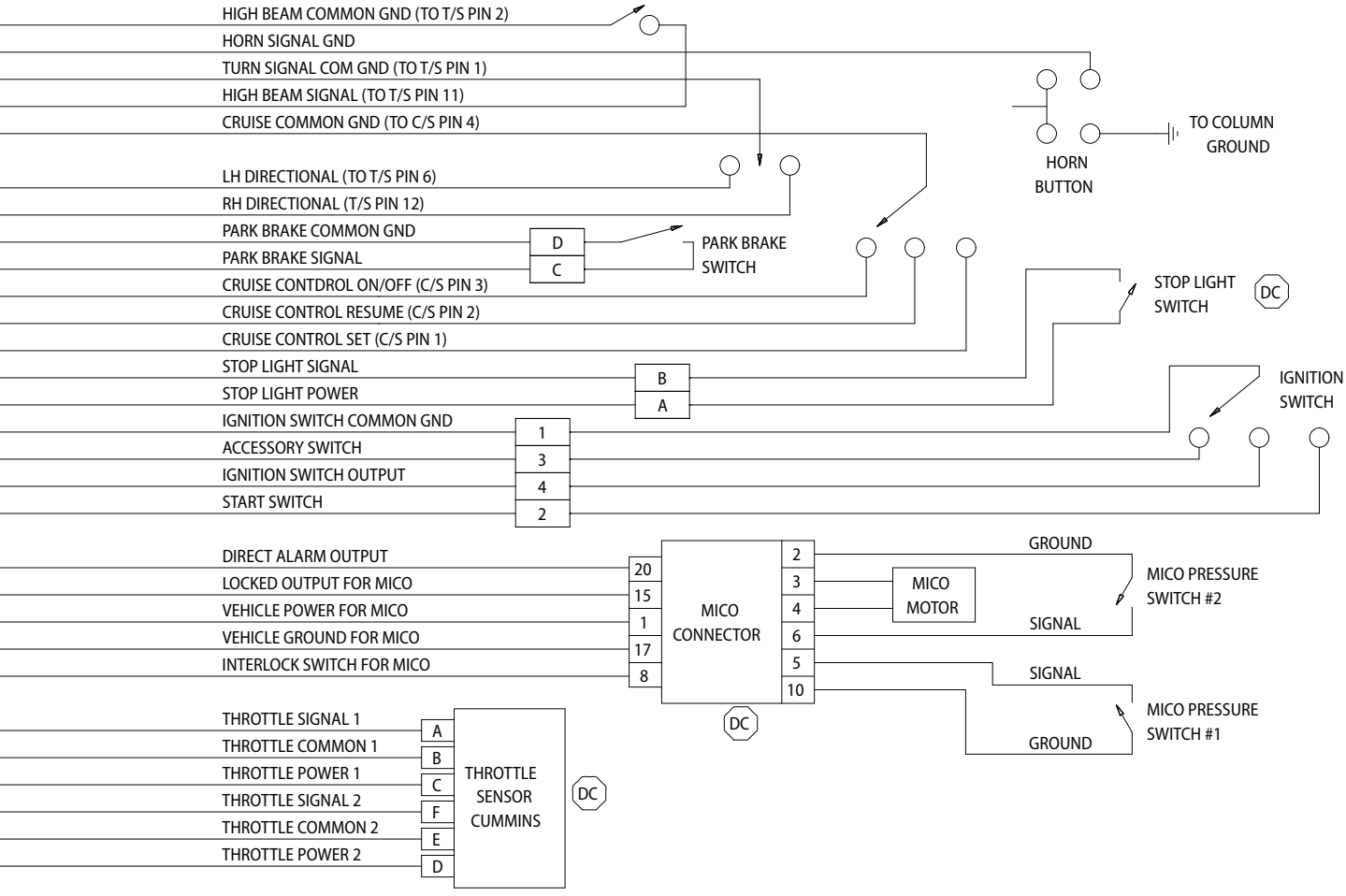
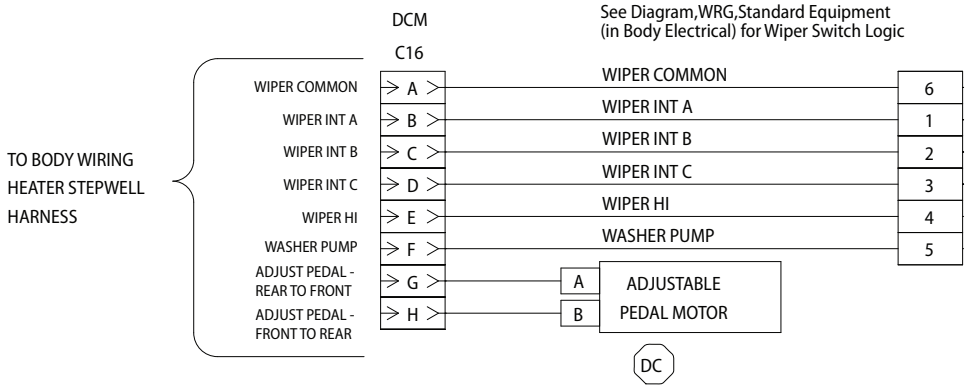
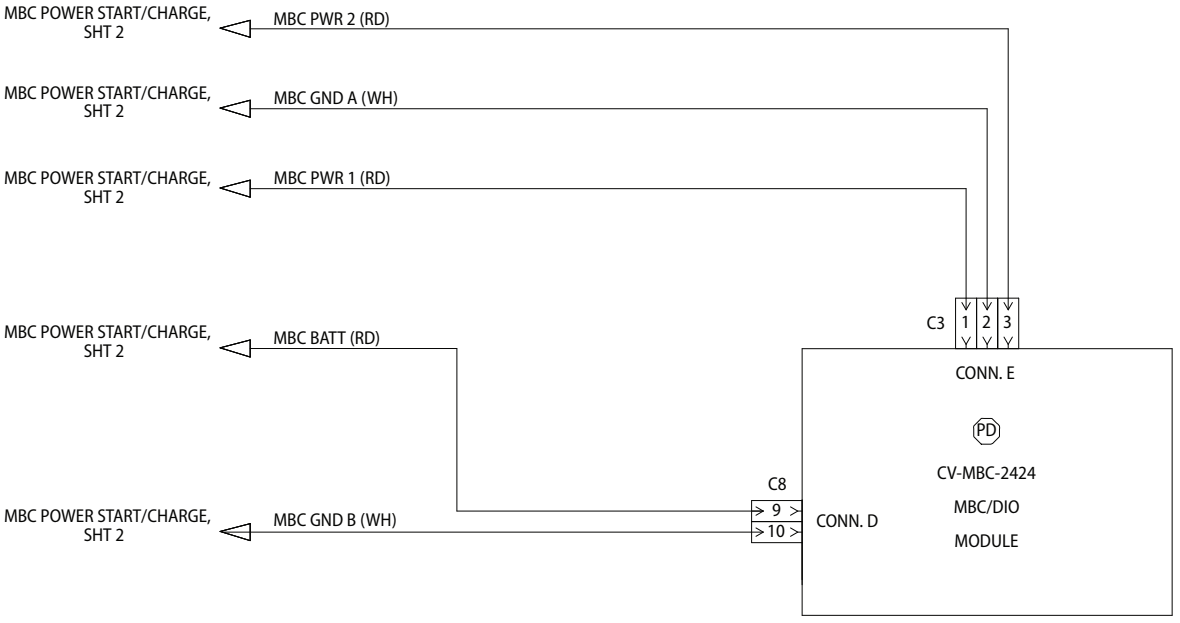
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
AC MODULE, HORN BUTTON, SHT 12
AC MODULE, HIGH BEAM SWITCH, SHT 12
AC MODULE, LEFT TURN SWITCH, SHT 12
AC MODULE, RIGHT TURN SWITCH, SHT 12
AB MODULE, PARK BRAKE SWITCH, SHT 11
INSTRUMENT CLUSTER, CRUISE CONTROL,SHT 17
INSTRUMENT CLUSTER, CRUISE CONTROL,SHT 17
INSTRUMENT CLUSTER, CRUISE CONTROL,SHT 17
AB MODULE, SERVICE BRAKE, SHT 11
START/CHARGE SHT 2
AC MODULE, ACCESSORY SWTICH, SHT 12
AC MODULE, IGNITION SWITCH, SHT 12
AC MODULE, START SWITCH, SHT 12
INSTRUMENT CLUSTER, SHT 17
HYDRAULIC INTERLOCK ALARM, SHT 17
AC MODULE, INTERLOCK FEEDBACK, SHT 12
HYDRAULIC INTERLOCK POWER, SHT 2
AB MODULE, BRAKE INTERLOCK, SHT 11
THROTTLE CUMMINS ISB ENGINE, SHT 3
THROTTLE CUMMINS ISB ENGINE, SHT 3
THROTTLE CUMMINS ISB ENGINE, SHT 3
THROTTLE CUMMINS ISB ENGINE, SHT 3
THROTTLE CUMMINS ISB ENGINE, SHT 3
THROTTLE CUMMINS ISB ENGINE, SHT 3


HIGH BEAM COMMON GND (TO T/S PIN 2)
HORN SIGNAL GND
TURN SIGNAL COM GND (TO T/S PIN 1)
HIGH BEAM SIGNAL (TO T/S PIN 11)
CRUISE COMMON GND (TO C/S PIN 4)
LH DIRECTIONAL (TO T/S PIN 6)
RH DIRECTIONAL (T/S PIN 12)
PARK BRAKE COMMON GND
PARK BRAKE SIGNAL
CRUISE CONTDROL ON/OFF (C/S PIN 3)
CRUISE CONTROL RESUME (C/S PIN 2)
CRUISE CONTROL SET (C/S PIN 1)
STOP LIGHT SIGNAL
STOP LIGHT POWER
IGNITION SWITCH COMMON GND
ACCESSORY SWITCH
IGNITION SWITCH OUTPUT
START SWITCH
D
C
PARK BRAKE SWITCH
HORN BUTTON
TO COLUMN GROUND
STOP LIGHT SWITCH
DC
B
A
IGNITION SWITCH
1
3
4
2
DIRECT ALARM OUTPUT
LOCKED OUTPUT FOR MICO
VEHICLE POWER FOR MICO
VEHICLE GROUND FOR MICO
INTERLOCK SWITCH FOR MICO
20
15
1
17
8
MICO CONNECTOR
2
3
4
6
5
10
DC
MICO MOTOR
GROUND
SIGNAL
MICO PRESSURE SWITCH #2
SIGNAL
GROUND
MICO PRESSURE SWITCH #1
THROTTLE SIGNAL 1
THROTTLE COMMON 1
THROTTLE POWER 1
THROTTLE SIGNAL 2
THROTTLE COMMON 2
THROTTLE POWER 2
A
B
C
F
E
D
THROTTLE SENSOR CUMMINS
DC


DCM
C16
See Diagram,WRG,Standard Equipment (in Body Electrical) for Wiper Switch Logic
TO BODY WIRING HEATER STEPWELL HARNESS
WIPER COMMON
WIPER INT A
WIPER INT B
WIPER INT C
WIPER HI
WASHER PUMP
ADJUST PEDAL - REAR TO FRONT
ADJUST PEDAL - FRONT TO REAR
A
B
C
D
E
F
G
H
WIPER COMMON
WIPER INT A
WIPER INT B
WIPER INT C
WIPER HI
WASHER PUMP
6
1
2
3
4
5
A
B
ADJUSTABLE PEDAL MOTOR
DC



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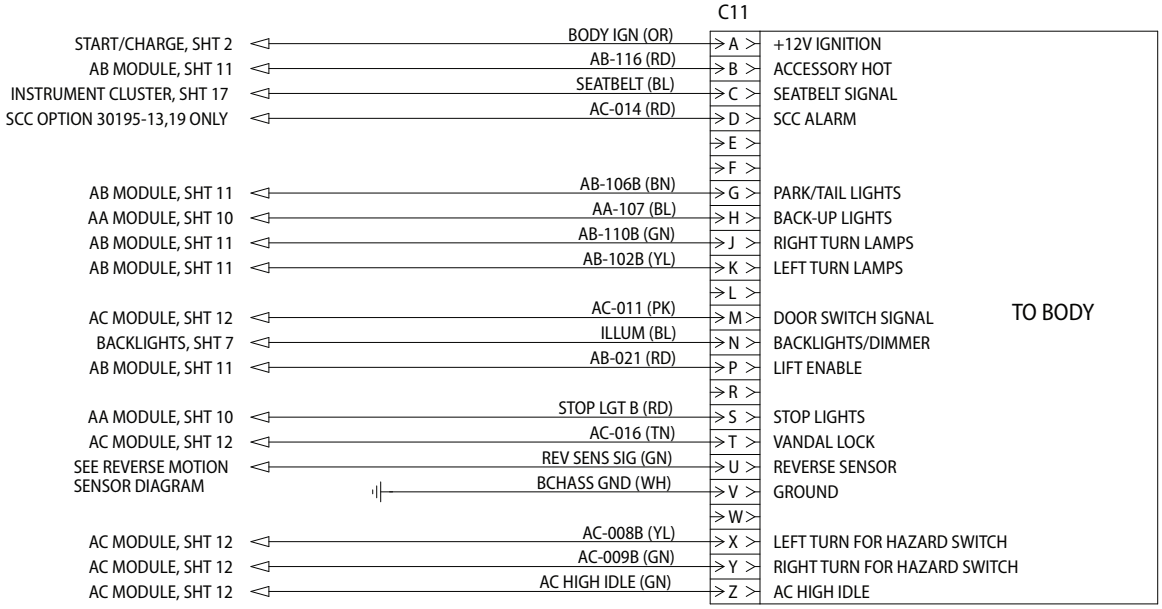
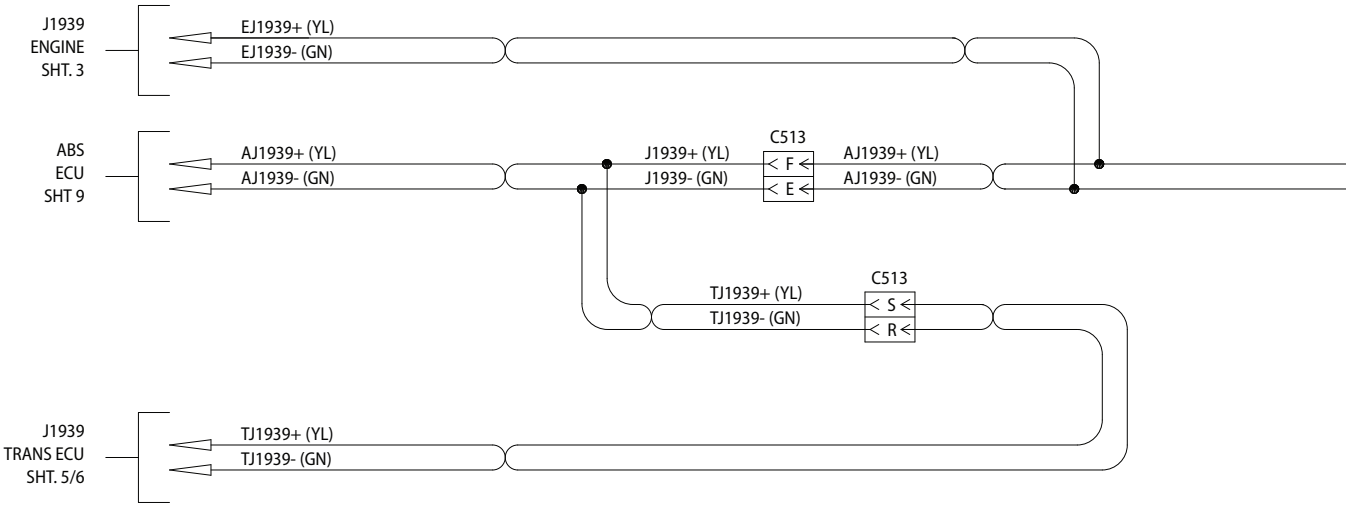
MBC MODULE

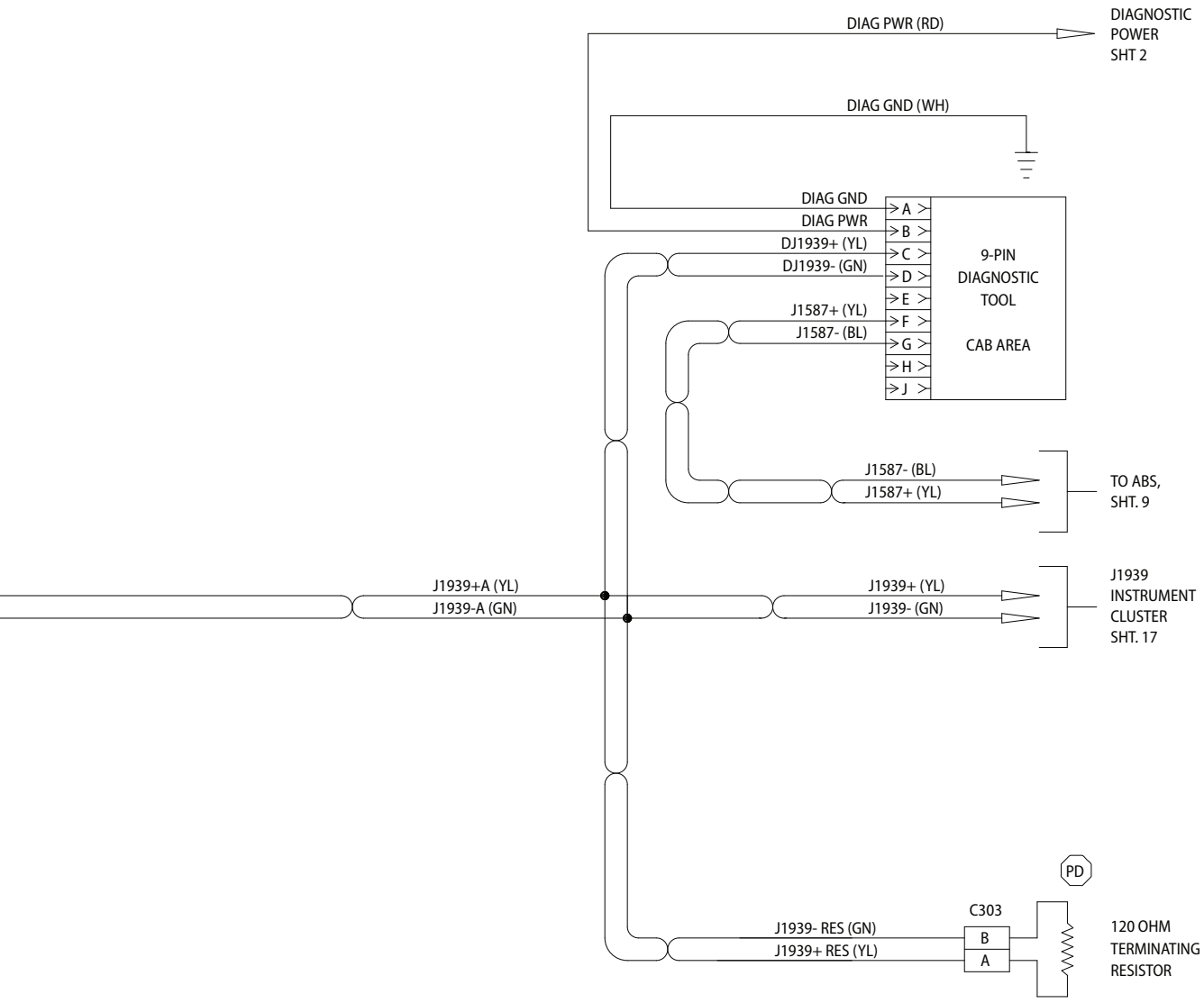


Sheet 21

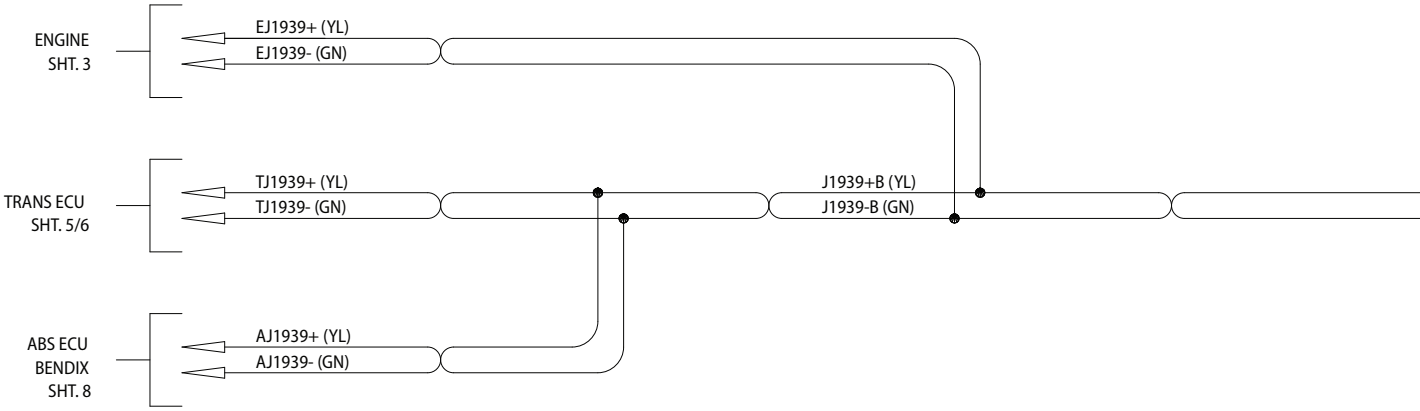
D0003672A

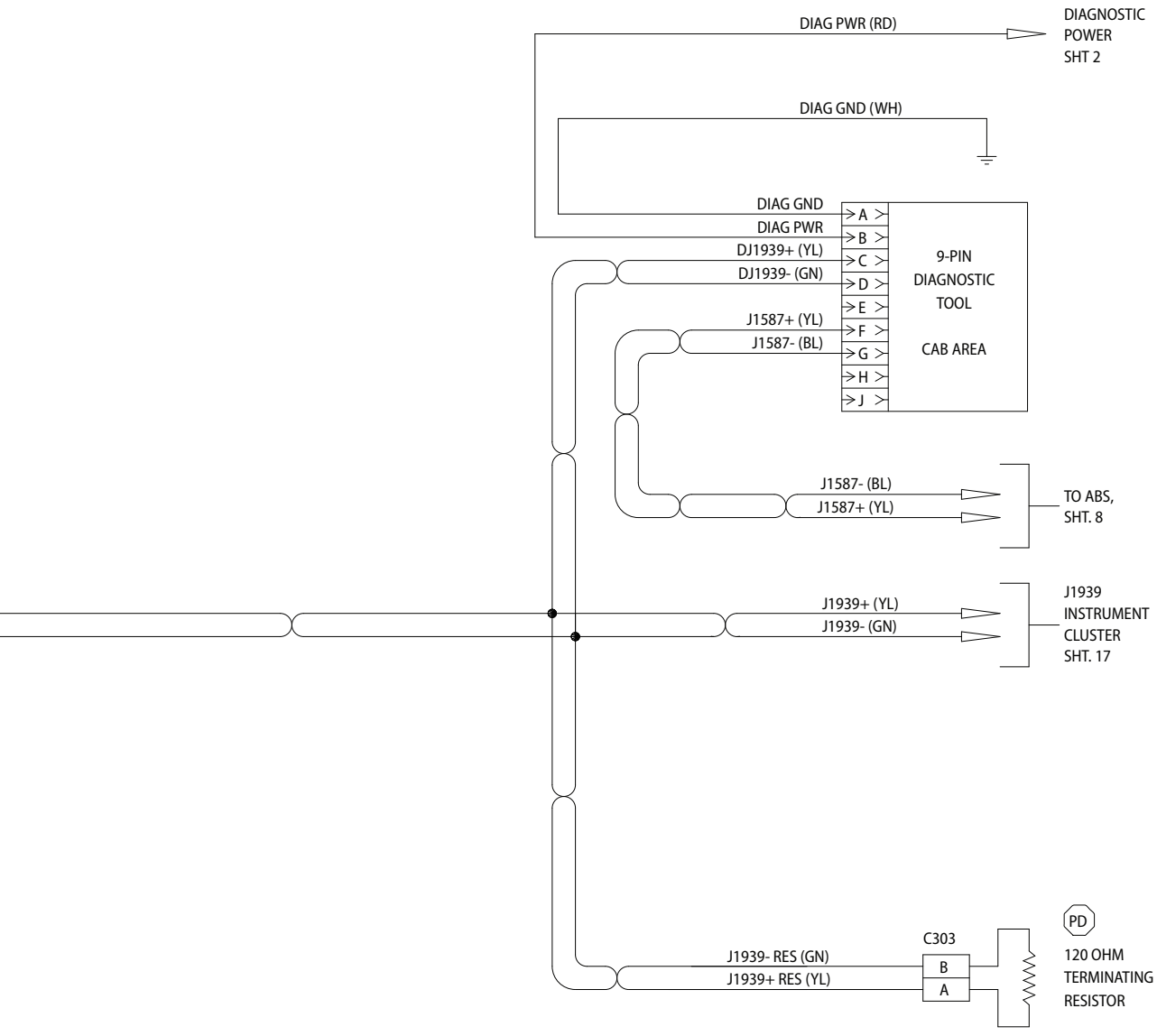
BODY INTERFACE


J1939
ENGINE
SHT. 3
EJ1939+ (YL)
EJ1939- (GN)
ABS
ECU
SHT 9
AJ1939+ (YL)
AJ1939- (GN)
J1939+ (YL)
J1939- (GN)
C513
F
E
AJ1939+ (YL)
AJ1939- (GN)
C513
TJ1939+ (YL)
TJ1939- (GN)
S
R
J1939
TRANS ECU
SHT. 5/6
TJ1939+ (YL)
TJ1939- (GN)



NOTE: SAE J1939 DATALINK UTILIZES TWO 120 OHM END OF LINE RESISTORS. THE SECOND END OF LINE RESISTOR IS INTERNAL TO THE TRANSMISSION CONTROL MODULE (TCM)


ENGINE
SHT. 3
EJ1939+ (YL)
EJ1939- (GN)
TRANS ECU
SHT. 5/6
TJ1939+ (YL)
TJ1939- (GN)
J1939+B (YL)
J1939-B (GN)
ABS ECU
BENDIX
SHT. 8
AJ1939+ (YL)
AJ1939- (GN)



NOTE: SAE J1939 DATALINK UTILIZES TWO 120 OHM END OF LINE RESISTORS. THE SECOND END OF LINE RESISTOR IS INTERNAL TO THE TRANSMISSION CONTROL MODULE (TCM)

Sheet 23

D0003674B

J1939 DATALINK, AIR

Overview

This section will address those parts of the steering system related to the:

- Steering wheel
- Steering column
- Power steering fluid requirements
- Steering gear (THP 60)
- Hydraulic steering pump

Appendixes In This Chapter

Appendix 1. TRW Flushing the Steering System. This two page exerpt from TRW's Steering System Maintenance Guidelines includes full details and instructions on flushing the steering system.

Appendix 2. TRW Air Bleeding the Steering System. This two page exerpt from TRW's Steering System Maintenance Guidelines includes full details and instructions on bleeding air from the steering system.

Appendix 3. TRW Steering Maintenance. This TRW publication, entitled *Chart Your Way To Easy Steering,* provides a solid overview of potential steering problems, their diagnosis and correction.

Appendix 4. THP Steering Gear Service Manual. This TRW Service Manual includes design features, fluid information, an exploded parts diagram, torque specifications, general information and on-vehicle service for the THP steering gear.

Appendix 5. Poppet Adjustment. This TRW publication explains what poppets are, how they work and readjustment procedures.

WARNING ***Hydraulic fluid must be handled, stored and disposed of in a manner consistent with all the applicable local, state, and federal guidelines concerning hazardous materials.***

The hydraulic pump for the power steering assist is flange mounted to the engine and gear driven. The configuration of hydraulic lines from the pump to the steering gear is dependent on whether the bus has a hydraulic brake or air brake system.

On Visions equipped with air brakes, the power steering fluid flows from the reservoir to the pump, then to the steering gear, and returns directly to the reservoir.

On Visions equipped with hydraulic brakes, the power steering fluid flows from the reservoir to the pump, to the power steering gear and then to the hydraulic brake power assist (booster). From there, the fluid returns to the reservoir.

WARNING ***The power steering fluid and the brake fluid are not the same. They must be kept separate. Use DOT–3 for the brake system and use Dexron III for the power steering fluid.***

There are a number of acceptable hydraulic fluids approved for use in the power steering system, the system must be drained and flushed to use a different type of fluid (See **Appendix 3. THP Steering Gear Service Manual** for approved hydraulic fluids). Do not mix oils or fluids if you change the fluid.

The steering reservoir on an Vision Forward Engine can be accessed by opening the drivers side front access panel. The hydraulic brake reservoir is located in the same area.

***WARNING** The hydraulic fluid for the steering system and the brake fluid used in the brake master cylinder are not compatible and could result in a loss of steering or a loss of braking if incorrect fluids are used in either system.*

Steering System Operation

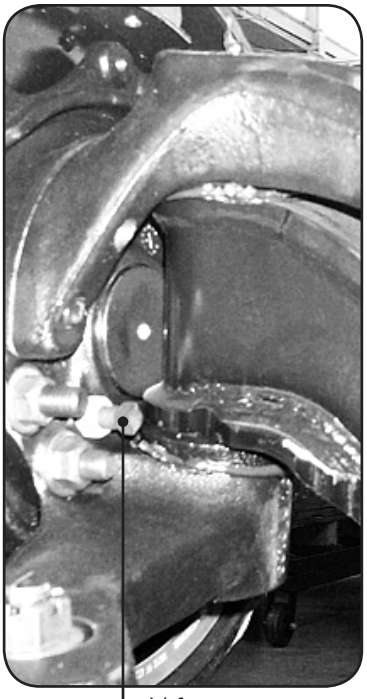
The speed at which the driver can turn the steering wheel with power assist is dependent upon the rate of flow provided by the hydraulic pump. (Normal flow rate is 3.6 - 6.3 gpm, Minimum flow rate is 2.9 gpm.) As the driver turns the steering wheel faster or slower, more or less oil flow is required by the gear. The pressure of the hydraulic fluid is used to overcome the resistance in the system. The higher the pressure, the more work it can perform. (Maximum operating pressure is 2,682 psi.)

The steering wheel is connected to the steering column shaft. The steering column shaft is connected to the steering gear input shaft. When the driver turns the steering wheel, the input shaft and worm shaft rotate. The worm shaft is in turn connected to a rack piston through the recirculating ball mechanism. This rotational movement moves the rack piston axially in the gear housing cylinder bore. The rack piston turns the sector shaft, which is connected by linkage to the wheels on the front axle.

As resistance is encountered in the steering effort, pressure in the steering hydraulic system will increase proportionally to assist the movement of the rack piston thus reducing the effort needed to steer the bus. As the input shaft is turned the control valve spool mounted on the torsion shaft (the torsion shaft connects the input shaft to the worm shaft) shifts and redirects oil flow to either side of the rack piston. A relief valve mounted on the valve housing limits maximum pressure to protect the power steering system. This is the primary pressure relief valve for the steering system. A secondary pressure relief valve is located in the hydraulic pump assembly on Vision Forward Engine units.

Objectionable kickback is prevented due to the geometry of the steering gear. If the wheels receive a shock load from hitting rough areas in the road it is transmitted back through the sector shaft, rack piston, and worm gears. This load is neutralized by the control valve, which sends oil flow to the correct side of the rack piston to resist the shock forces. By absorbing the shock forces hydraulically the steering gear prevents objectionable kickback at the steering wheel and driver.

The steering gear is equipped with two poppet valves, one on each end of the rack piston. The poppet valves are set specifically to the turning radius of each bus after the axle stop adjustment has been made. When the steering wheels are turned



and approach the axle stop, one poppet valve (depending on the direction of turn) trips. The tripped poppet valve opens allowing oil flow to bypass the piston which reduces pressure in the gear and helps reduce heat buildup in the hydraulic system. At the same time, the valves also reduce forces on the steering linkage.

Careful preliminary checks should be done to identify a steering problem and its symptoms before deciding the steering gear has failed. In most cases, the steering gear should be the last component suspected as cause of a steering problem.

Refer to the Appendixes in this chapter for detailed step by step troubleshooting procedures.

Steering System Maintenance

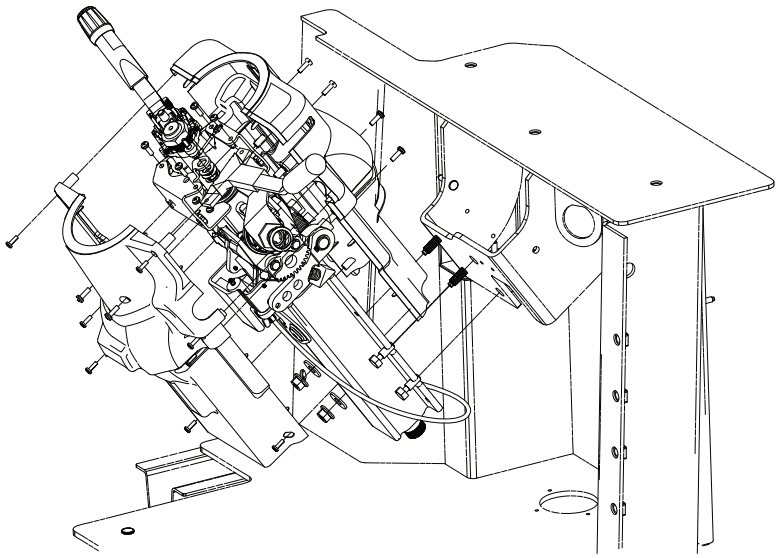
Before attempting to work on the steering gear, or any portion of the steering system, you must stabilize the vehicle. Read and understand the Warnings and Cautions in the General Maintenance chapter of this manual.

Regularly check the fluid level in the power steering reservoir. Change the fluid and replace the filter at the intervals specified in the Specs & Maintenance chapter. Clean around the reservoir filler cap before removing it. Dirt and other foreign matter can damage the hydraulic system.

Do not bend or straighten any steering component or linkage. Never attempt to weld any broken steering component. Do not use a torch to remove any steering component. Use only original equipment replacement parts.

Never use high pressure or steam to clean the power steering gear. Doing so can force contaminants inside the gear and lead to malfunction.

Proper alignment of the steering column is important to assure smooth steering. Correct the cause of any free play, rattle, or shimmy immediately to avoid damage to the steering system. Record and report any malfunctions or accidents which may have damaged steering components.



Steering Column Assembly

Setting the Steering Poppets

To adjust the steering poppets, refer to **Appendix 5 Steering Poppets** in this chapter.

Refer to the Front Axle Appendix located in the axle chapter of this manual for the following steering related adjustments and lubrication points:

Axle Stop Adjustment
Caster and Camber Adjustments
Toe-in Adjustment
King-Pin Lubrication
Te-Rod Lubrication

Steering Column & Steering Wheel

Steering Column

The Vision steering column offers a tilt/telescoping range of movement, allowing the steering wheel and stem controls to be placed with-in a comfort range of the driver. Adjustment of the steering wheel is accomplished by actuating a tile/telescoping control lever, located at the bottom center of the steering column, and moving the steering wheel into a new position. The control lever is actuated by pulling downward until the lever rolls over center and locks in the release position. With the control lever in the released position the steering wheel and column moves freely within its range of travel. When the steering wheel has been placed in the desired position push the control lever upward to lock the position. Actuating the control lever allows up and down movement of the steering wheel for tilt control and in and out movement of the steering column for telescopic control.

When the control lever is actuated a set of lock paws in the tilt locking mechanism is released allowing the steering wheel and upper steering column to be position up or down in one of 9 detents (positions). When the control lever arm is released the lock paws reengages the detent providing a positive lock in the position selected. At the same time the tilt lock paw is released the telescoping lock pad is released allowing the upper steering column to slide in and out of the lower steering column support. This function provides an almost infinite height control (within its range of travel) of the steering wheel and upper column. When the tilt/telescoping control is released a friction pad mounted on the lower stationary support column makes contact with the upper column providing a non-incremental positive lock of the telescoping mechanism

The steering column and its control mechanism is a self contained unit. Although the it provides tilt and telescoping adjustment of the steering wheel and column there are no adjustments to steering column control mechanism. The steering column requires no lubrication and is considered a non-serviceable component.

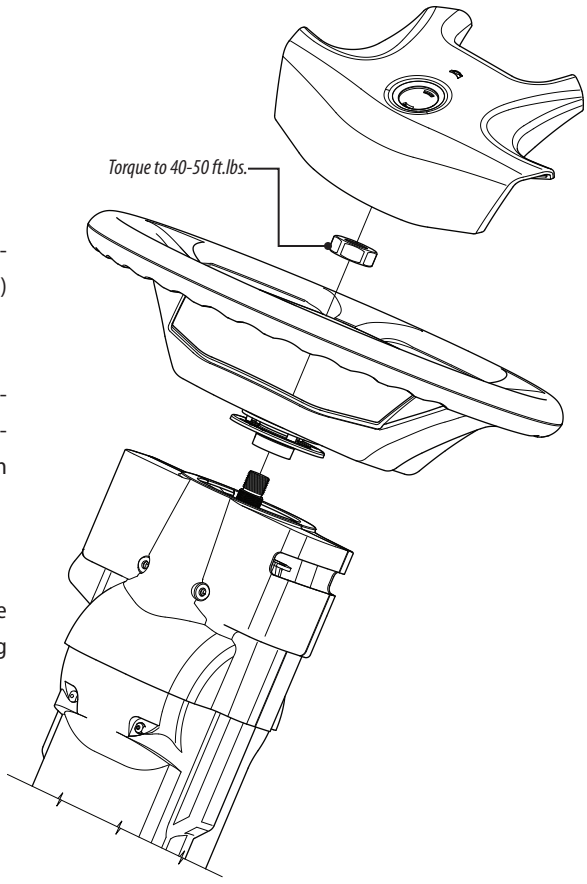
Some components attached to the steering column are serviceable i.e., turn signal switch, cruise control, ignition switch, and the horn brush contact.

Steering Wheel Removal.

1. Remove the screws retaining the steering wheel cover.
2. Lift the cover and disconnect any electrical circuits.
3. Check the alignment marks on the steering shaft and steering wheel flange (make new alignment marks if necessary) and remove the steering wheel nut.
4. Remove the steering wheel. The steering shaft and the mating flange on the steering wheel has splines but are not tapered. A rubber hammer may be required to provide enough force to loosen the connection.

Steering Wheel Reinstallation

To replace the steering wheel assembly, reverse the procedure above. Making sure the steering wheel is aligned with the steering shaft. Torque the steering wheel nut to 40 to 50 ft. lbs.



Steering Wheel Installation
(Stems Not Illustrated)

Steering Gear

The THP 60 is an integral hydraulic power steering unit. The steering gear contains a manual steering mechanism, a hydraulic control valve, and a hydraulic power cylinder. The control valve senses steering requirement from the driver and directs oil flow to the appropriate cylinder cavity at the proper flow rate thus providing a smooth power assist steering.

The speed at which the driver can turn the steering wheel with power assist is dependent upon the rate of flow provided by the hydraulic pump. (Normal flow rate is 3.6 to 6.3 gpm, Minimum flow rate is 2.9 gpm.) As the driver turns the steering wheel faster or slower, more or less oil flow is required by the gear. The pressure of the hydraulic fluid is used to overcome the resistance in the system. The higher the pressure, the more work it can perform. (Maximum operating pressure is 2,682 psi.)

The steering wheel is connected to the steering gear input shaft. The input shaft is connected to a worm shaft. When the driver turns the steering wheel, the input shaft and worm shaft rotate. The worm shaft is in turn connected to a rack piston through the recirculating ball mechanism. This rotational movement moves the rack piston axially in the gear housing cylinder bore. The rack piston turns the sector shaft, which is connected by linkage to the wheels on the front axle.

As resistance is encountered in the steering effort, pressure in the steering hydraulic system will increase proportionally to assist the movement of the rack piston, thus reducing the effort needed to steer the bus. As the input shaft is turned, the control valve spool mounted on the torsion shaft (the torsion shaft connects the input shaft to the worm shaft) shifts and redirects oil flow to either side of the rack piston. A relief valve, mounted on the valve housing, limits maximum supply pressure to protect the power steering system. This is the primary pressure protection for the steering system. (A secondary pressure relief valve is located in the hydraulic pump assembly.)

Objectionable kickback is prevented due to the geometry of the steering gear. If the wheels receive a shock load, it is transmitted back through the sector shaft, rack piston, and worm gears. This load is neutralized by the control valve, which sends oil flow to the correct side of the rack piston to resist the shock forces. By absorbing the shock forces hydraulically, the steering gear prevents objectionable kickback at the steering wheel and driver.

The steering gear is equipped with two poppet valves, one on each end of the rack piston. The poppet valves are set specifically to the turning radius of each bus after the axle stop adjustment has been made. When the steering wheels are turned and approach the axle stop, one poppet valve (depending on the direction of turn) trips. The tripped poppet valve opens, allowing oil flow to bypass the piston, which reduces pressure in the gear and helps reduce heat buildup in the hydraulic system. At the same time, the valves also reduce forces on the steering linkage.

Careful preliminary checks should be done to identify a steering problem and its symptoms before deciding to tear down the steering gear. In most cases, the steering gear should be the last component suspected as cause of a steering problem.

Refer to Appendix 3, 4, and 5 in this chapter for detailed step by step troubleshooting procedures.

Steering Pump

The hydraulic steering pump on the Blue Bird Vision Forward Engine is a positive displacement pump with an integrated pressure relief valve and a flow regulator valve.

When troubleshooting, it is important to remember to always do the simple steps first. Look for obvious signs of leaking, component wear or damage, and hose problems, before removing the power steering pump. Special attention should be given to the supply hose for signs of clasping or routing issues creating kinks in the hose that could restrict oil flow to the pump.

Using a flow meter, determine whether the pump is providing the necessary flow for proper steering. The steering pump should provide a flow of approximately 3.6 to 6.3 (minimum 2.9) gallons per minute (GPM). It is recommended that you use a Power Steering System Analyzer (PSSA) to assist in the diagnosis of steering system problems.

For details on troubleshooting the steering system, see **Appendix 4, TRW Steering Maintenance** in this chapter.

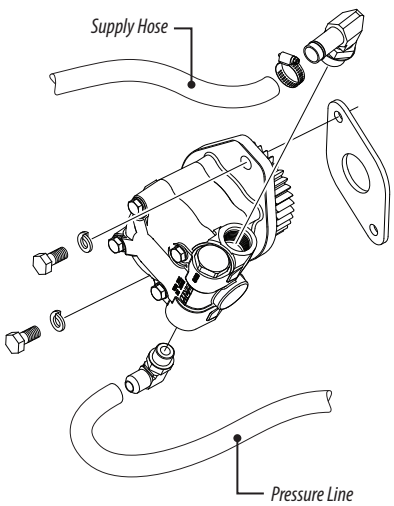
Steering Pump Removal (Vision With Air Brakes)

1. Drain the system of fluid in a manner consistent with all local, state and federal laws. Wear protective gear when working with hydraulic fluids including eye protection.
2. Remove the supply hose .
3. Remove the pressure hose from the fitting at the output port of the pump.
4. Secure the pressure line safely out of the way.
5. Remove two capscrews from the hydraulic pump mounting flange.
6. Remove and discard the gasket.

Steering Pump Reinstallation (Vision With Air Brakes)

Installation is accomplished in the reverse order of the removal instructions. Always install a new hydraulic pump gasket. Also install a new split ring lock washer and torque the mounting capscrews to 53–58 ft. lbs. (71.86–78.64 Nm).

After filling the reservoir, start and run the engine at idle for 10 seconds then switch the ignition off, refill the reservoir, start the engine and run for another 20 seconds, repeat this process until the reservoir maintains a full oil level. With the front wheels off the floor, (refer to **Jacking Procedures in the Specs & Maintenance** section of this manual) lifting by the axle not the wheels, start the engine and turn the steering wheel one direction and then the other direction a couple of times; then stop the engine and refill the reservoir. Perform this cycle until the reservoir maintains a full oil level.



Test drive the bus and let the power steering fluid warm to operating temperature; then check the fluid level again. Check for leaks in the system.

Steering Pump Removal (Vision With Hydraulic Brakes)

1. Drain the system of fluid in a manner consistent with all local, state and federal laws. Wear protective gear when working with hydraulic fluids including eye protection.
2. Remove the supply hose.
3. Remove the pressure line from the fitting at the output port of the pump.
4. Secure the pressure line safely out of the way.
5. Remove two capscrews from the hydraulic pump mounting flange.
6. Remove and discard the o-ring.

Steering Pump Reinstallation (Vision With Hydraulic Brakes)
Install the pump in the reverse order of the removal. Ensure that a new o-ring is installed. Install a new split ring lock washer and torque the mounting capscrews to 53–58 ft. lbs. (33.32–44.74 Nm).

Pitman Arm

Pitman Arm Removal
Remove the Pitman arm end of the draglink and secure it safely out of the way. Then remove and discard the nut and bolt assembly from the upper end of the Pitman. Being very careful of the spline on the steering gear, remove the Pitman arm by pulling with a wheel puller.

Pitman Arm Installation

1. Position the Pitman arm so that the index mark aligns with the mark on the output spline of the steering gear.

2. The Pitman arm offset must be inward, and at the bottom.

3. Press the Pitman onto the output spline of the steering gear.

4. Install new hardware (¾–10 Grade 8), and torque to 250–282 ft. lbs. (339–382 Nm).

5. Attach the drag link to the Pitman arm. Position the drag link journal into the lower hole in the Pitman. Torque the castle nut to 110–125 ft. lbs. (149.14–169.48 Nm), then align a castle nut slot with the cotter pin hole. If necessary, tighten further just enough to align. Install a new cotter pin and bend each end at least 45° to hold it in position.

Drag Link

Drag Link Removal

1. Remove and discard the cotter pin from the castle nut on the each end of the drag link.

2. Remove the castle nut from the Pitman arm end and secure the drag link.

3. Remove the castle nut from the axle end of the drag link, and then remove the drag link journal from the Pitman arm. Be sure to wrap and protect the journal surfaces of the draglink.

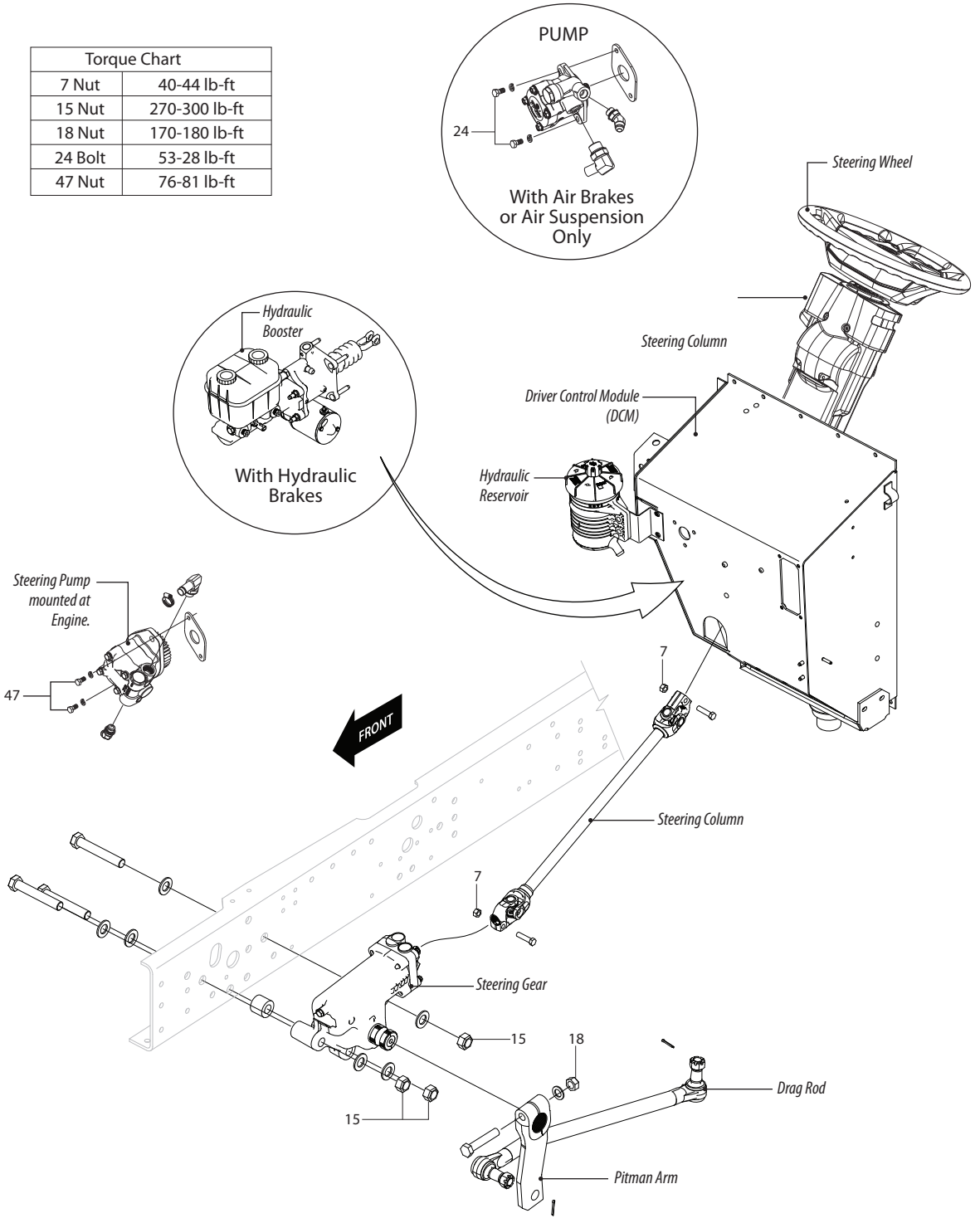
Drag Link Reinstallation

Ensure the bend in the drag link is toward the front of the vehicle. Installation then becomes the reversal of the removal instructions, above. Torque each castle nut to 110–125 ft. lbs. (149.14–169.48 Nm), then align a castle nut slot with the cotter pin hole. Tighten further just enough to align if necessary. Install a new cotter pin and bend each end at least 45° to hold it in position.

Refer to the Hendrickson™ SteerTek service manual included as an appendix to the Front Axle & Steering chapter for further information regarding removal and installation of steering axle suspension components. Additional information is available at Hendrickson's website at www.hendrickson-intl.com.

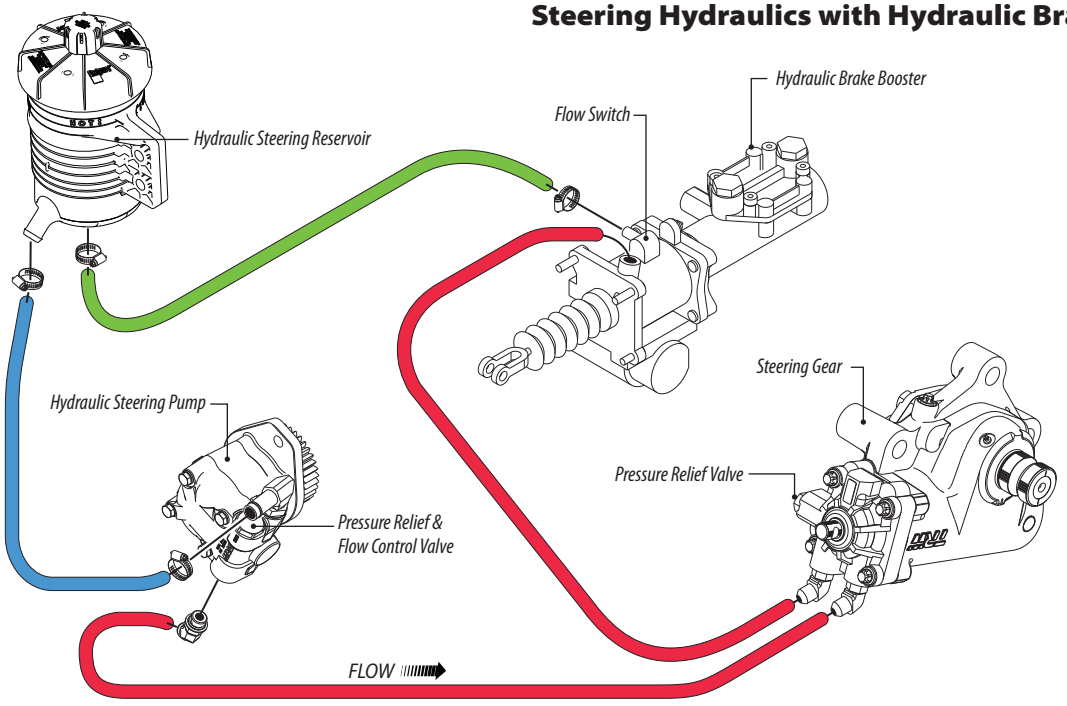
Steering Components and Schematics

Torque Chart	
7 Nut	40-44 lb-ft
15 Nut	270-300 lb-ft
18 Nut	170-180 lb-ft
24 Bolt	53-28 lb-ft
47 Nut	76-81 lb-ft

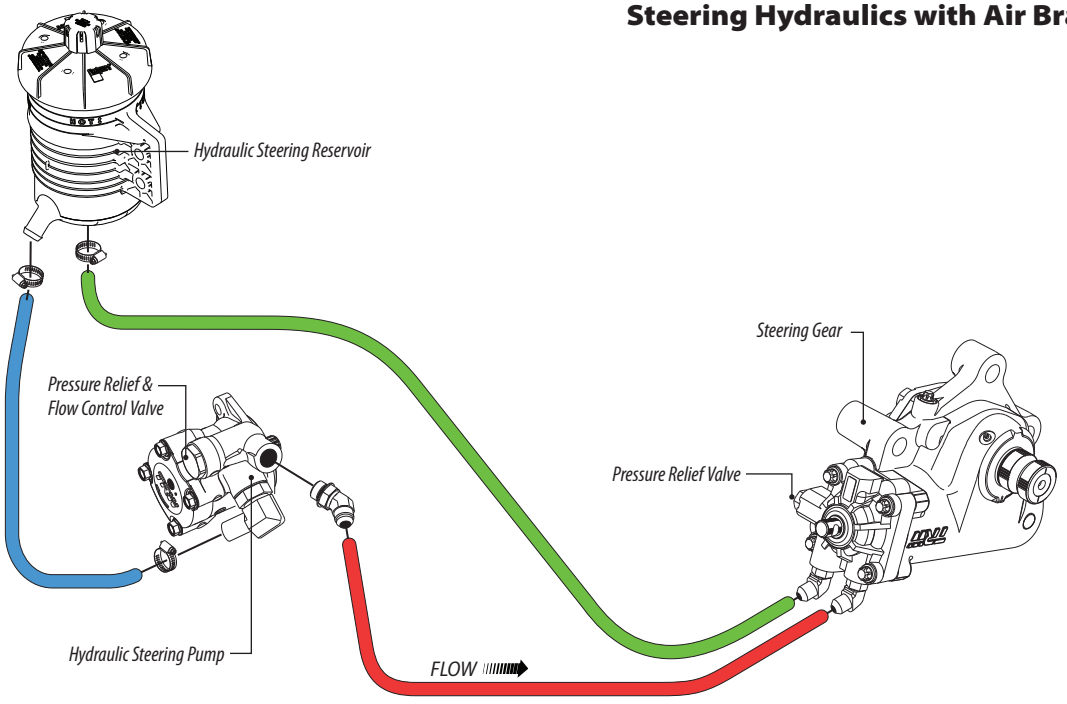


Steering Components

Steering Hydraulics with Hydraulic Brakes



Steering Hydraulics with Air Brakes



Steering Schematics

Flushing the Steering System

The steering system must be flushed every time a gear, pump, or reservoir gets replaced, regardless if the components are new or are remanufactured.

1. Set parking brake on vehicle and block rear wheels.
2. Raise the front end off the ground.
3. Take vehicle out of gear and put into neutral position.
4. Raise hood and wipe down area around the steering gear and the hydraulic lines related to the steering system.
5. Place a drip pan under the steering gear to catch the oil.
6. Remove both the pressure and return lines (Figure 1) from the steering gear and allow the oil to drain into the empty container.
7. Remove filter (Figure 2) from the power steering fluid reservoir and discard. Disconnect the supply line from the reservoir.
8. Rinse and clean the inside of the reservoir with an approved solvent, then air dry. Do not use a shop rag to wipe the inside of the reservoir and make sure that none of the solvent enters the rest of the steering system. If the reservoir is made from plastic inspect for cracks and damage. Replace if necessary.
9. Turn steering wheel from full left to full right 3-4 times. Collect the drained oil in the same container as in Step 6. This will purge the oil from the steering gear.
10. Reconnect pressure and return lines to the steering gear. Connect the supply line to the reservoir and then tighten all fittings.
11. Install new filter element into the reservoir.
12. Clean reservoir filler cap with an approved solvent. Inspect gasket and replace if necessary.
13. Inspect all hydraulic hoses (Figure 3) for cracks, soft or sweat spots and signs of local collapse (remove all covers/corrugated tubing from hoses to do this) and replace any that are found to be defective.
14. Check any banjo fittings and connectors for blockage. Clear any blockages using an appropriate method.
15. Filter contaminated oil through a coffee filter and examine for metal and foreign particles. Fine metal particles are evidence of normal wear and tear.

Figure 1

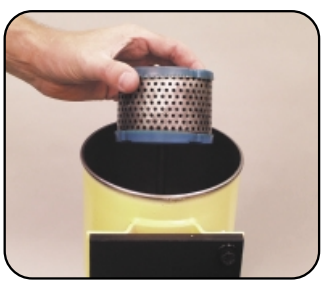


Figure 2

Figure 3

- Metal chips signify that the power steering pump needs to be replaced.
- If black rubber particles are present; the inner lining of the pressure, return or suction lines may be disintegrating. Replace all three hoses.

16. Fill reservoir with approved replacement fluid and reinstall the filler cap (Figure 5).

Figure 5

17. Start engine for 10 seconds, stop, and check reservoir fluid level and top off if necessary. You may need to repeat this procedure 3 or 4 times.

18. Upon completion of filling the reservoir, start the engine and let it idle. At engine idle, steer full right and full left (Figure 6) once and return to straight ahead. Stop engine and check power steering reservoir level and top off if required.

Figure 6

⚠ CAUTION
Do not hold steering wheel at full turn for longer than 10 seconds as this will cause system to overheat.

19. Restart engine and steer full turns each direction 3 or 4 times.

20. Stop engine and recheck reservoir fluid level and adjust to correct level, if needed.

21. Inspect system for leaks and correct if necessary.

22. Bleed air from the system, if required.

23. Remove drip pan and lower vehicle. Remove blocks from wheels and return vehicle for normal service.

TRW Automotive
Commercial Steering Systems
P.O. Box 60
Lafayette, Indiana 47902

Tel 765.423.5377
Fax 765.429.1868
http://trucksteering.trw.com
http://www.trucksteering.com

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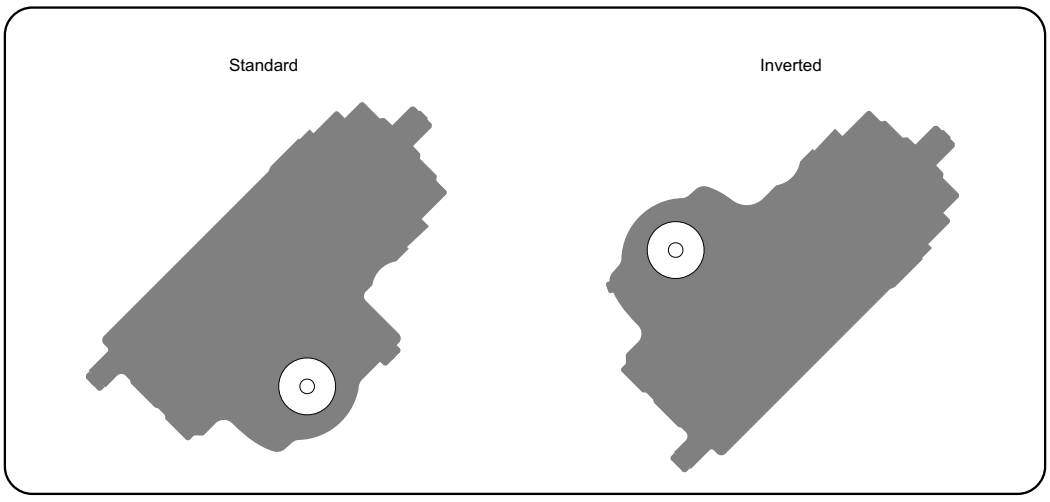
Air Bleeding the Steering System

Visual Identification

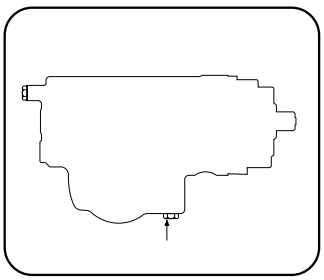
When you air bleed a steering system, you are simply allowing air trapped in the cavities of the steering gear to escape. As a general rule, if your steering gear is a “standard mount”, you should use the Automatic Bleed method. If your gear is an “inverted mount”, you will need to use the Manual Bleed method to purge the trapped air from the gear.



Gear Mounting Configurations

Automatic Bleed Gears

1. Fill the reservoir.
2. Start the engine, let it run for 10 seconds - without steering, then shut it off.
3. Check the reservoir, and refill if the fluid level has dropped.
4. Repeat at least three times, checking and refilling the reservoir each time if necessary.

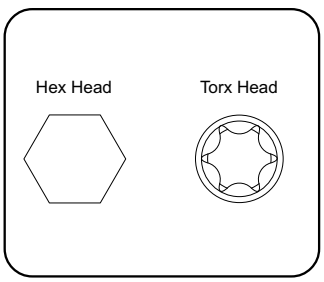


Auto Bleed Plug Location

NOTE

Do not allow the fluid level to drop significantly or run out of the reservoir. This may induce air into the system.

5. Start the engine and let it idle for 2 minutes - without steering. Shut off the engine and check the fluid level in the reservoir. Refill if required.
6. Start the engine again. Steer the vehicle from full left to full right several times. Automatic bleed systems should now be free from trapped air.
7. Finally, be sure to check the fluid level in the reservoir. Refill if necessary before returning the vehicle to service.



Auto Bleed Plug Styles

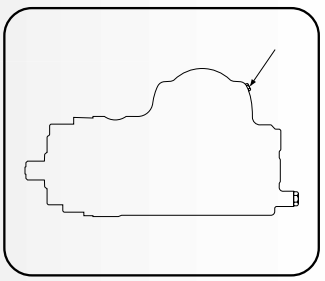
Manual Bleed Gears

1. Fill the reservoir.
2. Start the engine, let it run for 10 seconds - without steering, then shut it off.
3. Check the reservoir, and refill if the fluid level has dropped.
4. Repeat this process at least three times, checking and refilling the reservoir each time if necessary.

NOTE
Do not allow the fluid level to drop significantly or run out of the reservoir. This may induce air into the system.

5. Start the engine and let it idle for 2 minutes - without steering. Shut off the engine and check the fluid level in the reservoir. Refill if required.
6. Start the engine again. Steer the vehicle from full left to full right several times.
7. Again, check the fluid level in the reservoir.
8. With the engine idling, steer from full left turn to full right turn several times. Stop steering with the wheels pointed straight ahead and loosen the manual bleed screw 2-3 turns.
9. Allow air and aerated fluid to “bleed out” until fluid appears without bubbles.
10. Close the bleed screw, refill the reservoir if required.
11. Repeat this process three or four times until all the air is discharged. Torque manual bleed screw to 45 in•lb.

⚠CAUTION
Do not turn steering wheel with bleed screw loosened.



Manual Bleed Screw Location

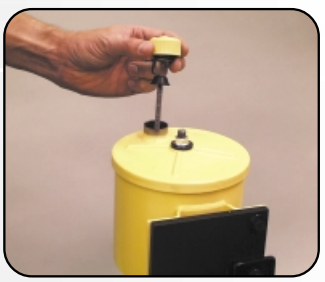
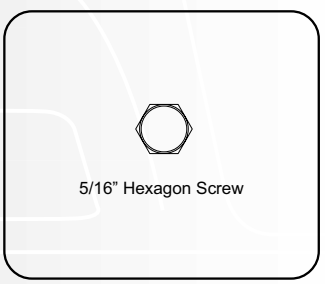


Figure 1

Figure 1



Manual Bleed Screw Style

TRW Automotive
Commercial Steering Systems
P.O. Box 60
Lafayette, Indiana 47902

Tel 765.423.5377
Fax 765.429.1868
http://trucksteering.trw.com
http://www.trucksteering.com

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BLUE BIRD

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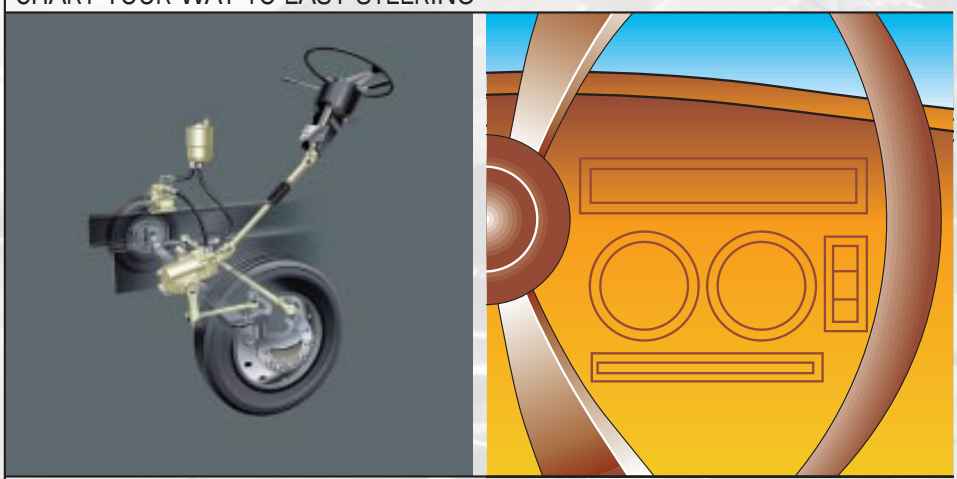
Commercial Steering Systems

Steering Diagnostics Service Manual

CHART YOUR WAY TO EASY STEERING



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⚠ WARNING	**A warning describes hazards or unsafe practices which could result in severe personal injury or death.**
⚠ CAUTION	**A caution describes hazards or unsafe practices which could result in personal injury or product or property damage.**
NOTE	A note gives key information to make following a procedure easier or quicker.

Notice

This guide was prepared for the purpose of providing general advice concerning the diagnosis and correction of commercial vehicle steering related problems. This guide is intended for the use of properly trained, professional mechanics, NOT "Do-it-Yourselfers". Also, this guide should be used in conjunction with service manuals provided by both the vehicle and component manufacturers. Diagnosis and correction of commercial vehicle steering related problems should only be handled by properly trained, professional mechanics who have the proper equipment, tools, instructions and know-how to perform the work properly and safely.

Power Steering System Analyzer (PSSA) Gauge

Some of the tests in this manual require the use of a PSSA. This device is a combination flow meter, shut-off valve, and pressure gauge. This tool will allow you to measure flow and pressure, and provide a load on the pump through the hydraulic lines of the steering system. This tool is required to correctly analyze a steering system. TRW recommends that you **DO NOT BEGIN TROUBLESHOOTING A STEERING SYSTEM WITHOUT THE USE OF A PSSA.** If you are not sure how to use a PSSA, you may refer to the video available through our website at: *www.trucksteering.com*. This video compliments the tests in this book which require the use of the PSSA.

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⚠ WARNING

Throughout this troubleshooting guide, test procedures are recommended to help locate the cause of each complaint. While performing these tests, TRW advises that you TAKE NECESSARY PRECAUTIONS when working with internal vehicle components and hot hydraulic fluids.

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- Reading the Flow Charts
- Warranty

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- Hard Steering
- Reduced Wheelcut
- Steering Wheel Kick
- Binding, Darting, and Oversteer
- Directional Pull
- Road Wander/Loose Steering
- Non-Recovery
- Shimmy
- Noise
- External Leakage

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Introduction

Understanding the Complaint

Steering systems for heavy duty trucks are made up of many components from the steering wheel to the road wheel. The purpose of the steering system is to give the driver directional control of the vehicle.

When a driver feels the steering control over his/her vehicle is not like it should be, it is up to you to determine if there is a problem, and if so, figure out what is causing it. It is always easier to fix something if you really understand the complaint. Some ways you could do this are:

- Talk to the driver and ask a lot of questions like "what, when, where, and how"
- Make sure you can feel or see the problem. Have the driver show you exactly what he/she means.
- Walk around the truck, looking for anything that may be an obvious cause of the problem.

To make your job easier and faster this manual has both the flow charts and test procedures/comments, each in their own section. Once you have a good understanding of what the complaint is, choose the flow chart that best matches the symptoms described to you. Because there are different ways to say the same thing, we have provided our definitions of the 10 most common complaints in this book. Use these to determine which section of the manual would be helpful to begin diagnosing the steering system.

Reading the flow charts:

Start the chart at the **BEGIN** box. Follow the lines to the next box answer the question or perform the test to verify the cause of the complaint, then proceed to the next step. These boxes are arranged in order of likelihood of being the cause of the driver's complaint. **It is important to complete the tests, in order, and follow the flow of the chart**. Locate correct test number in the TEST PROCEDURES section, and follow the test procedure. When you are done with the test, note the results and correct the root cause. If condition still exists, keep going through the chart (if necessary, to correct the problem). The results of some tests will need to be recorded. Use the TEST RESULTS section to record these values.

If you identify a problem through a test procedure it is important that you retest the vehicle to make sure the condition has been corrected.

Warranty

If you have identified that a steering component on your vehicle needs to be replaced, this does not always mean it is warrantable. Please read your manufacturer's warranty carefully before submitting a steering component for warranty consideration.

Definitions

1. Hard Steering

Hard Steering is when steering effort at the steering wheel is more than 200 inch pounds (typically 18-22 lbs at the rim of the steering wheel). Steering is still possible, but there is not enough power assist.

Common phrases used:

- Won't turn
- Locks-up
- Shuts-down
- Turns hard
- Hangs-up
- No assist
- Won't turn unless moving

2. Reduced Wheelcut

Common phrases used:

- Too great of turning radius required
- Wheelcut restricted
- Not enough turns lock to lock

3. Steering Wheel Kick

Steering Wheel Kick is when the road wheels hit a bump that the steering wheel reacts to. The kick is usually dampened out quickly.

Common phrases used:

- Kickback
- Backlash
- Bump steer

4. Binding, Darting and Oversteer

Binding is a change or increase in steering wheel effort. Binding will usually not require the effort levels described in Hard Steering, unless it is severe. Darting and oversteer are words that mean the driver suddenly gets more turning than he/she wants.

5. Directional Pull

Common phrases used:

- Steering pulls to the right (or left)
- Truck pulls to the right (or left)
- A constant force is required to keep the truck going straight

Definitions

6. Road Wander/Loose Steering

Common phrases used:

- Lash in steering
- Lost motion in steering
- Continual corrections are needed at the steering wheel to keep the vehicle from wandering

7. Non-Recovery

Common phrases used:

- Wheels don't return to straight ahead

8. Shimmy

A severe Shimmy condition can be felt at the steering wheel. Typically once something triggers a Shimmy condition to occur it is sustained until the driver does something (such as slow down) to dampen out the condition.

Common phrases used:

- Shake at steering wheel

9. Noise

Common phrases used:

- Steering is noisy
- Clicking or clunking sound is heard when steering

10. External Leakage

Common phrases used:

- Loss of steering fluid
- Continual adding of fluid in reservoir required

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Section 2 Flow Chart Diagrams

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Binding, Darting, and Oversteer 11
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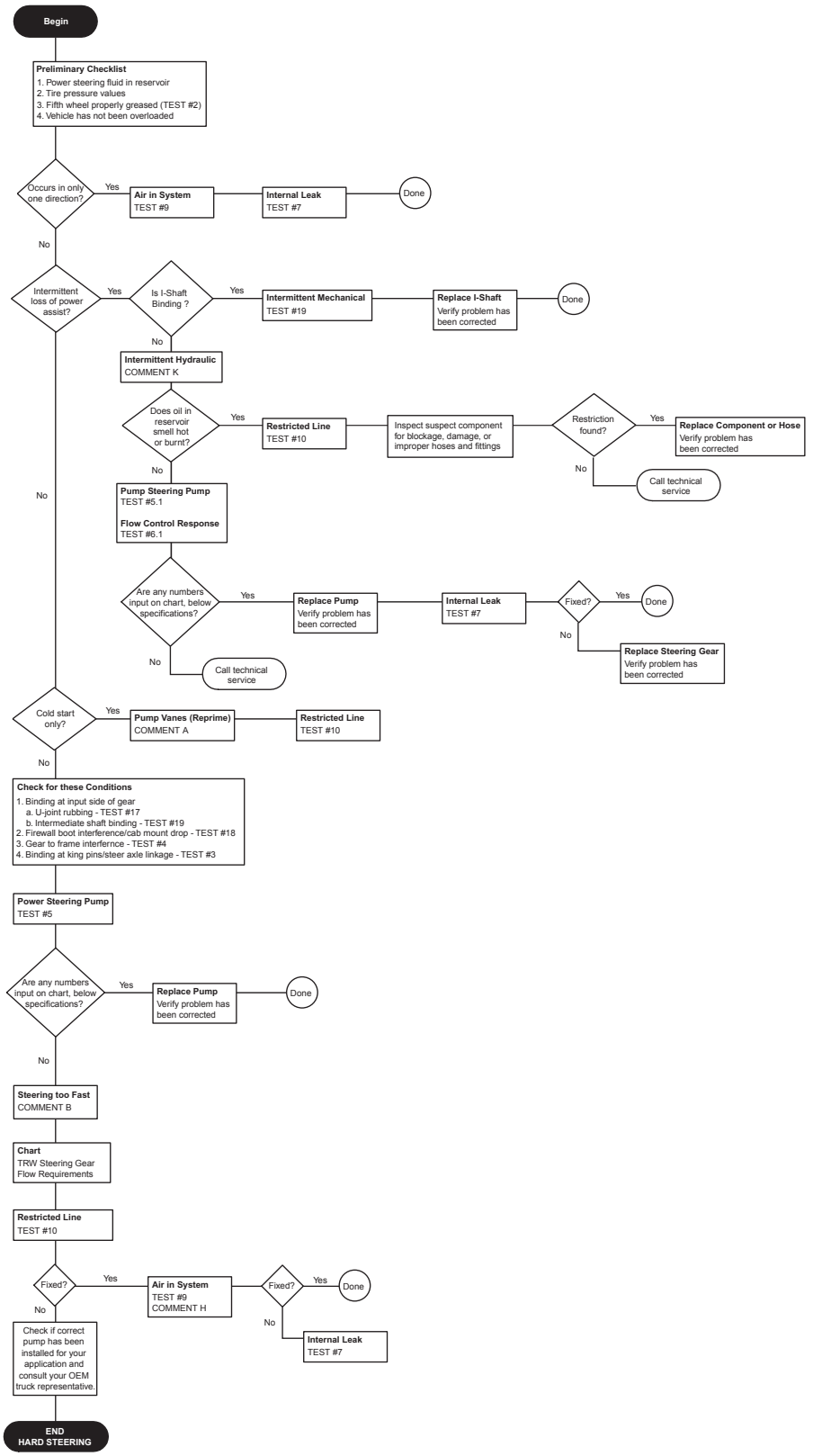
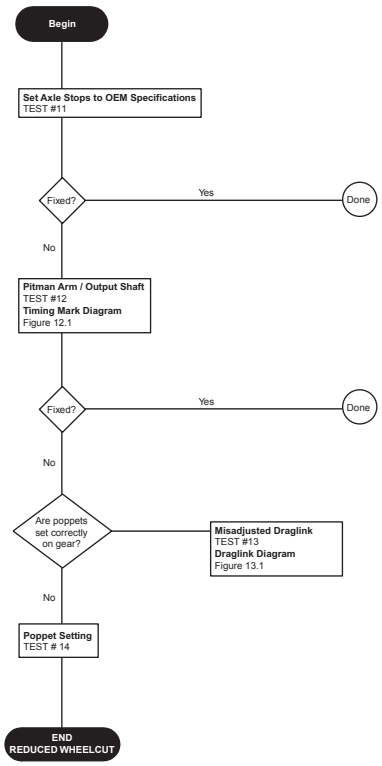
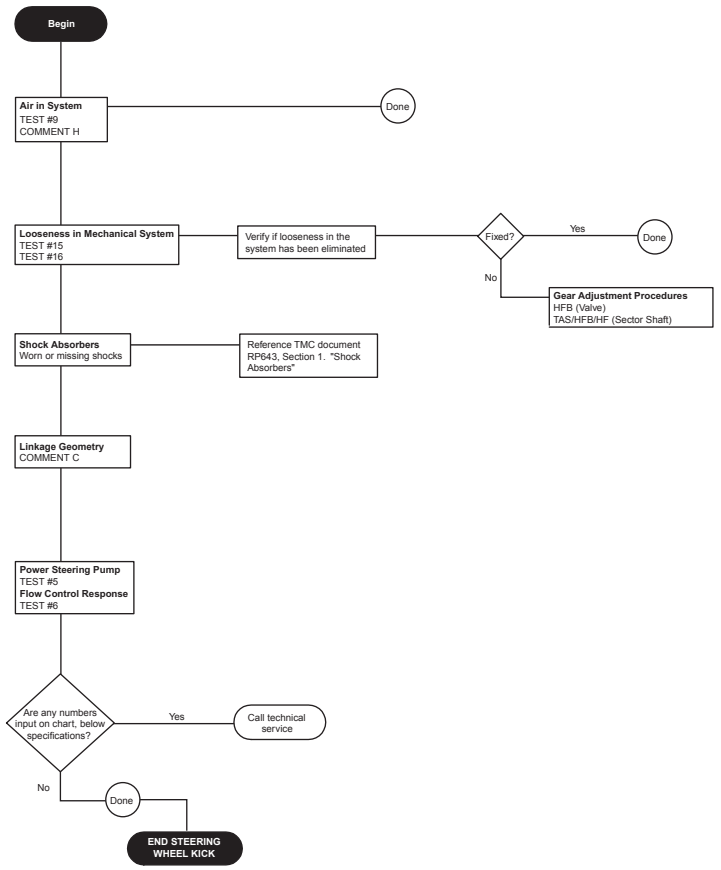
Hard Steering



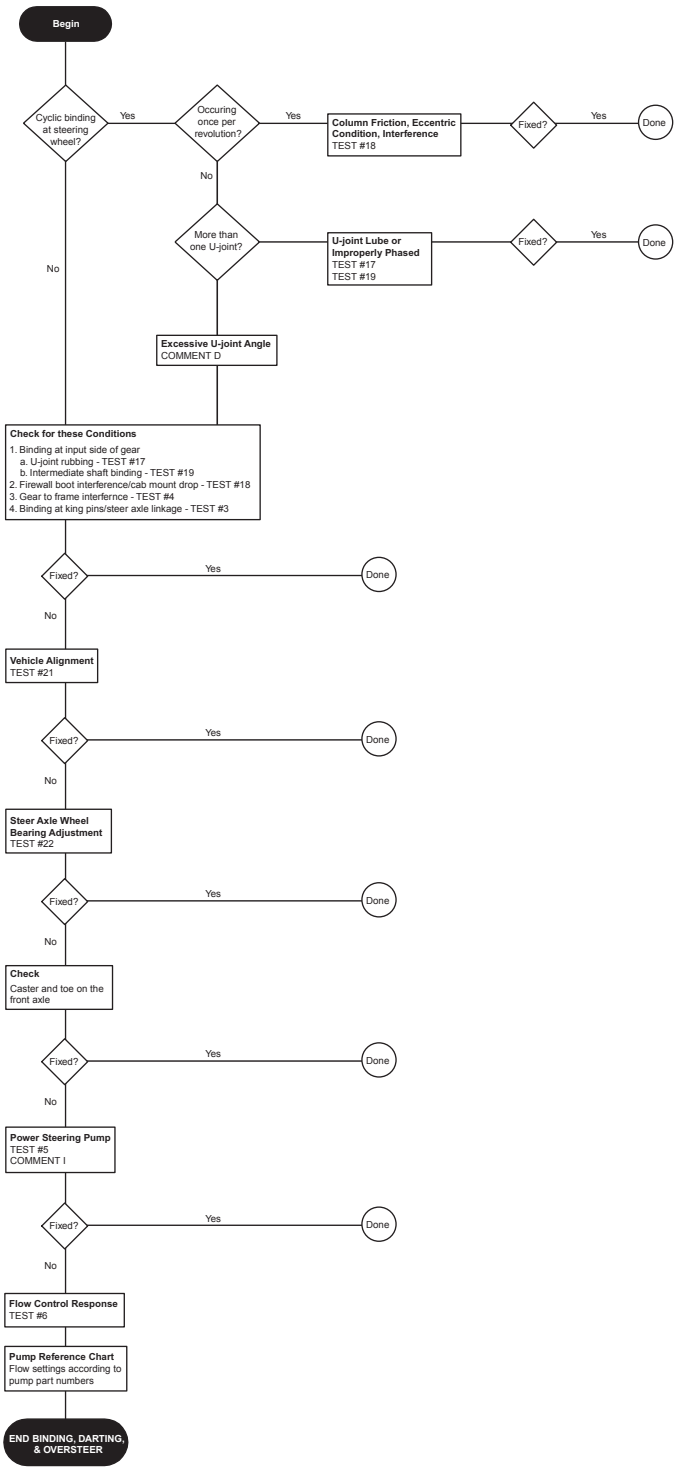
Reduced Wheelcut



Steering Wheel Kick



Binding, Darting, and Oversteer



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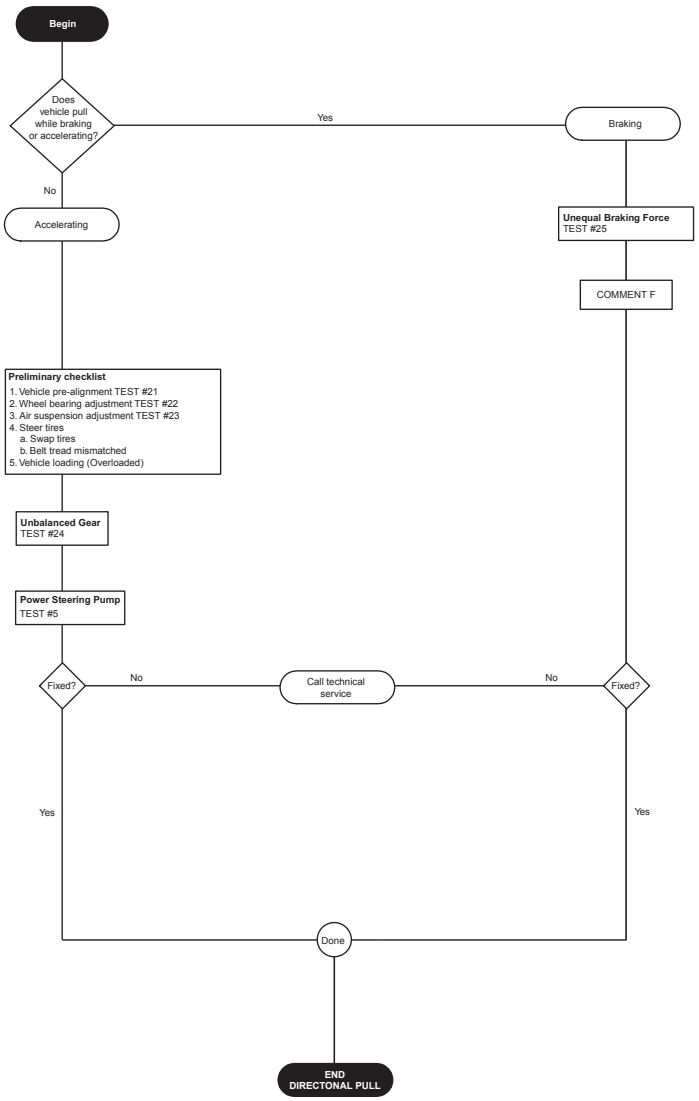
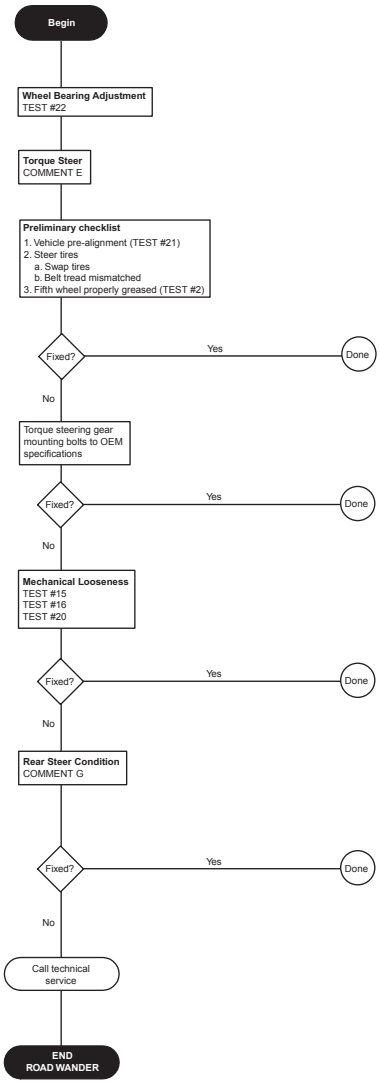
Directional Pull

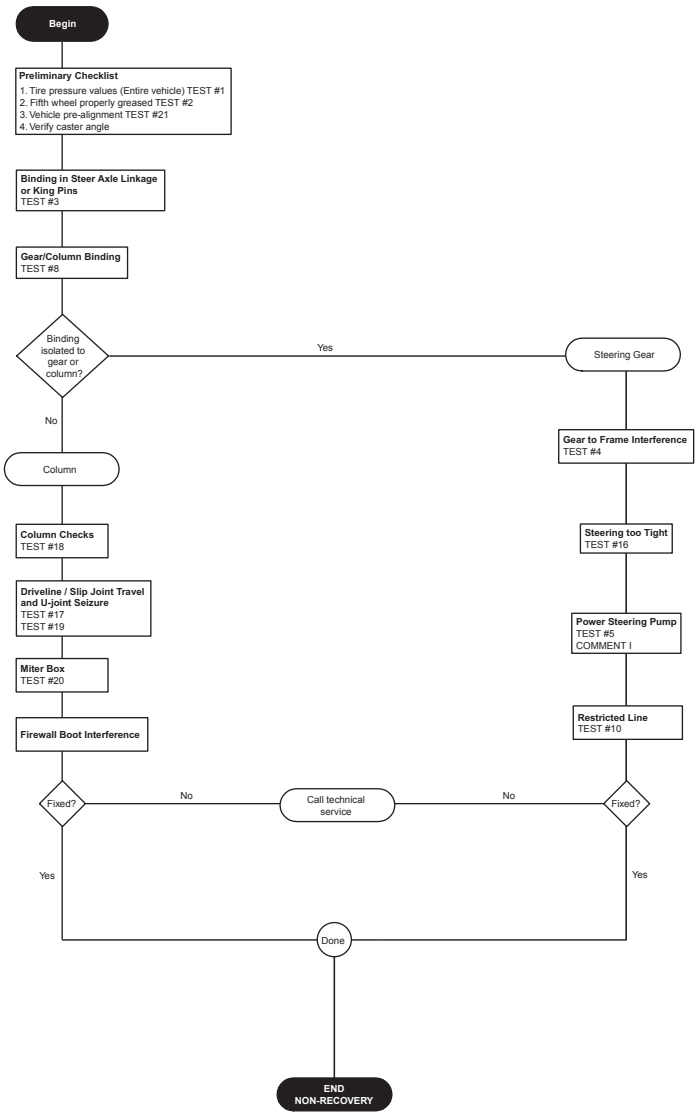


BLUE BIRD

Road Wander/Loose Steering

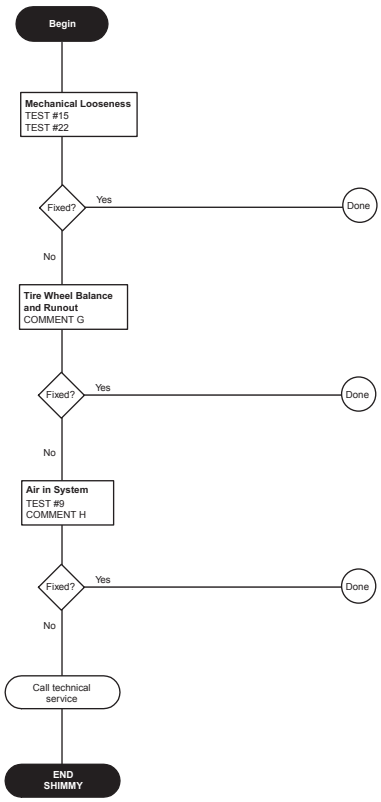


Non-Recovery

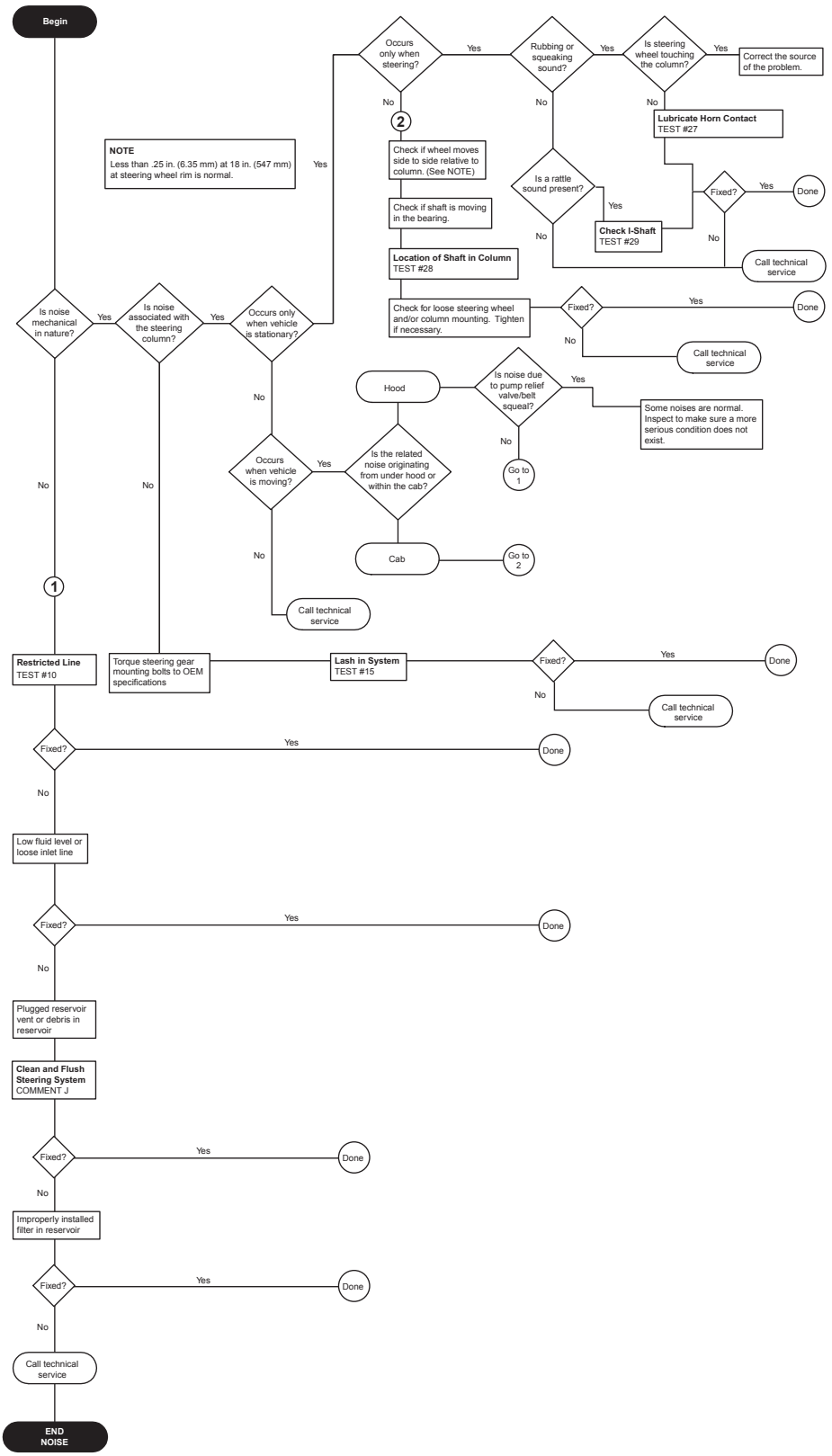


BLUE BIRD

Shimmy

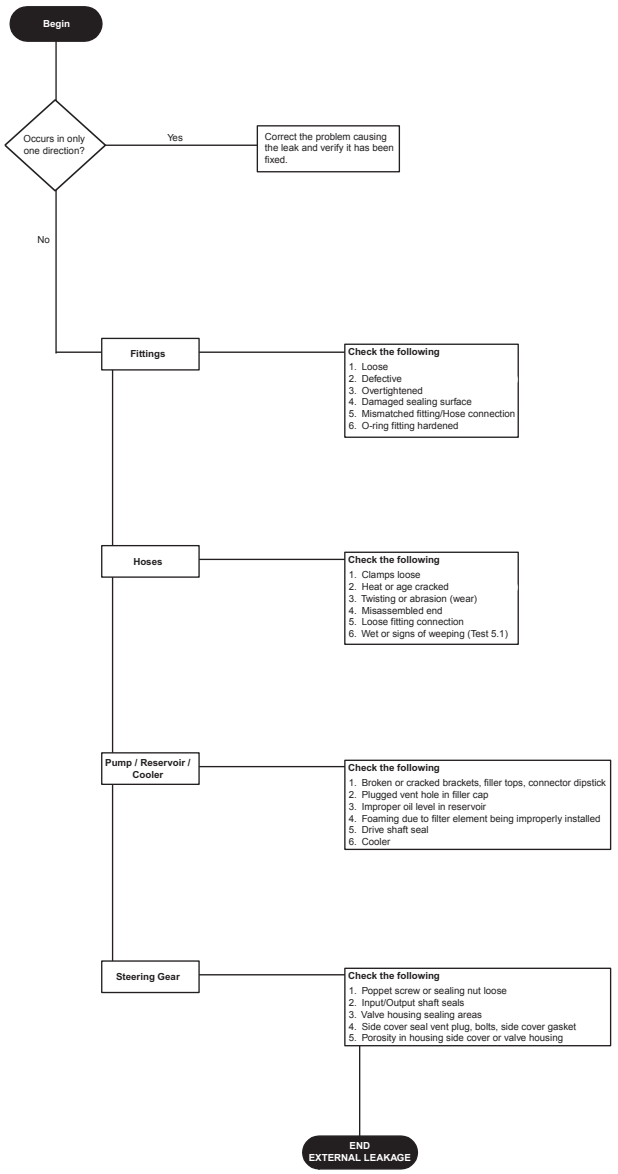


Noise


Begin
Occurs only when steering?
Yes
Rubbing or squeaking sound?
Yes
Is steering wheel touching the column?
Yes
Correct the source of the problem.
No
No
No
2
Lubricate Horn Contact TEST #27
NOTE
Less than .25 in. (6.35 mm) at 18 in. (547 mm) at steering wheel rim is normal.
Yes
Check if wheel moves side to side relative to column. (See NOTE)
Is a rattle sound present?
Yes
Fixed?
Yes
Done
Check if shaft is moving in the bearing.
Check I-Shaft TEST #29
No
No
Location of Shaft in Column TEST #28
Call technical service
Is noise mechanical in nature?
Yes
Is noise associated with the steering column?
Yes
Occurs only when vehicle is stationary?
Check for loose steering wheel and/or column mounting. Tighten if necessary.
Fixed?
Yes
Done
No
Call technical service
Hood
Is noise due to pump relief valve/belt squeal?
Yes
Some noises are normal. Inspect to make sure a more serious condition does not exist.
No
No
No
Occurs when vehicle is moving?
Yes
Is the related noise originating from under hood or within the cab?
Go to 1
No
Cab
Go to 2
1
Call technical service
Restricted Line TEST #10
Torque steering gear mounting bolts to OEM specifications
Lash in System TEST #15
Fixed?
Yes
Done
No
Call technical service
Fixed?
Yes
Done
No
Low fluid level or loose inlet line
Fixed?
Yes
Done
No
Plugged reservoir vent or debris in reservoir
Clean and Flush Steering System COMMENT J
Fixed?
Yes
Done
No
Improperly installed filter in reservoir
Fixed?
Yes
Done
No
Call technical service
END NOISE

BLUE BIRD

External Leakage



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Section 3 Test Procedures

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Test #1
Steer Tire Check

1. Look for: Tire damage, Uneven or extreme tread wear, mismatched tires or other wear indicators that would cause the problem. *Figure 1.1.*

2. Check tire pressures on steer axle tires. *Figure 1.2.*

Figure 1.1

Figure 1.2

Test #2
Fifth Wheel and Trailer Plate

1. Look for dry fifth-wheel or trailer plate. *Figure 2.1.*

2. Look for damage to fifth-wheel or trailer plate. *Figure 2.2.*

3. Inspect fifth-wheel for looseness.

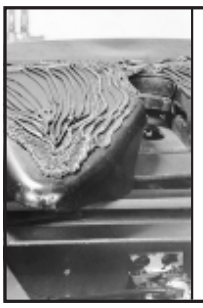
Figure 2.1

Figure 2.2

Test #3
Steer Axle and Linkage Binding

1. With vehicle steer tires on radius plates (turntables) or equivalent, disconnect the drag link or pitman arm from the steering gear, (and linkage from assist cylinder if there is one on the vehicle). *Figure 3.1.*

⚠ CAUTION **Do not steer the gear with linkage removed, as misadjustment of automatic poppets may result.**

2. By hand, pull the tire to one axle stop and release (engine off). The tire should self-return to near straight ahead. *Figure 3.2.*

3. Repeat the test in the opposite direction.

4. If tire does not self-return to near straight ahead, a problem is likely in steer axle king pin bushings/bearings or linkage.

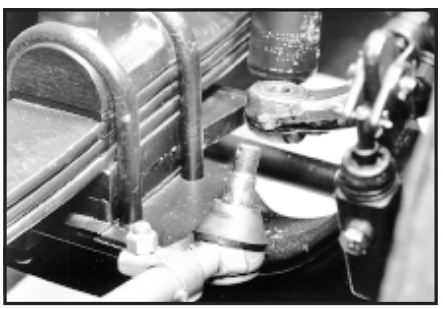
Figure 3.1

Figure 3.2

Test #4
Steering Gear Mounting

1. Look for anything between the steering gear and frame that could cause a binding problem. For example: hoses or brackets that have been routed, or are interfering between the steering gear and frame, frame flanges or spring mounting points. *Figure 4.1.* Mounting pads lower than steering gear housing, lack of clearance between frame and steering gear valve housing adapter, sector shaft adjusting screw and nut contact with access adjustment hole in frame. If interference is found, correct the problem.

2. If the steering gear has been mounted to the frame in a way that causes the gear to distort (not be flat), it may cause a steering problem. *Figure 4.2.* Checking to see if distortion is present on the vehicle may require the following test:

3. With vehicle parked and engine running, steer the wheel slowly checking for a binding-type of feel at the steering wheel. When binding is felt (stop engine loosen one mounting bolt restart engine) and steer the vehicle again. Continue to loosen one mounting bolt at a time, shutting off engine each time, and check for improvement in the binding condition. If improvement is made by loosening the bolts, determine by inspection the condition causing the gear to distort and correct the problem. Distortion of .030" (.80 mm) or less is acceptable. If greater than .030" (.80 mm) surface flatness, condition must be corrected.

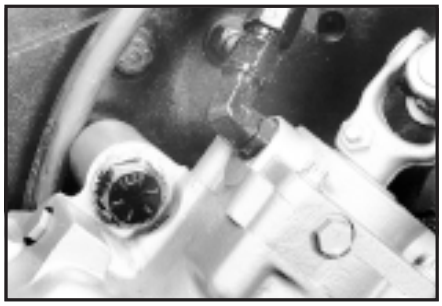
Figure 4.1

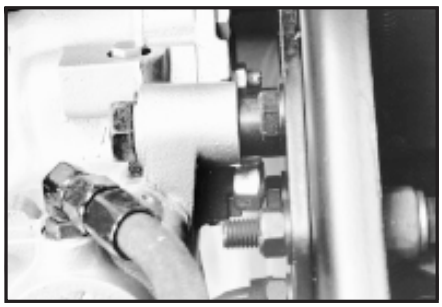
Figure 4.2

Test #5
Power Steering Pump Test

IMPORTANT: Read the following instructions below before completing **Table 5**, located in the "TEST RESULTS" section.

Verify Engine Idle speed per your OEM specifications.

1. Install temperature gauge in reservoir. *Figure 5.1.* Install PSSA in pressure line with shut-off valve fully open. *Figure 5.2.*

2. Run the engine at 1000 rpm.

⚠ CAUTION	**When closing the PSSA shut off valve, do so slowly and keep an eye on the pressure gauge. Do not allow the system to exceed 3000 psi (207 bar) for safety of personnel and to prevent damage to the vehicle.**

⚠ CAUTION	**Do not keep the load valve closed for more than 5 seconds at a time because damage to the system may result from excessive heat build- up.**

3. Measure and record the following flow and pressure readings (see chart) by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed. *Figures 5.3-5.7.*

4. Now with the load valve fully open, increase the engine speed to governed RPM and measure and record the following flow and pressure readings by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed.

5. Determine the recommended flow range and maximum allowable system pressure for the steering system being used by referring to your service manual.

6. Compare the minimum and maximum flows (and the relief pressure you measured) to gear and pump specifications.

7. If the minimum measured pump flow is less than the minimum recommended flow for the steering gear used (see **Steering Gear Flow Requirements** chart), the pump may not be putting out enough flow for an adequate steering speed. If the maximum system pressure is lower than that specified for the pump (check your manual), it may not be developing enough pressure to steer. If either case exists, the pump needs to be repaired or replaced.

NOTE	When hydraulic tests are completed and fluid lines are reconnected, check fluid level and bleed the air from the hydraulic system.

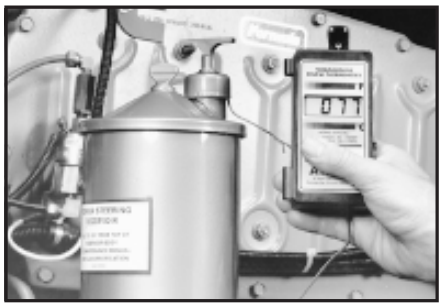
Figure 5.1

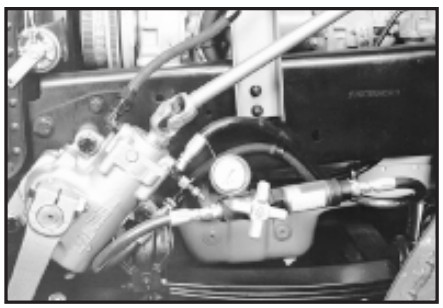
Figure 5.2

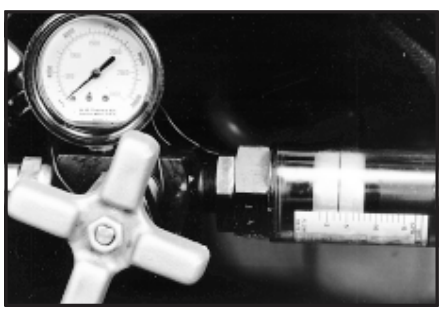
Figure 5.3

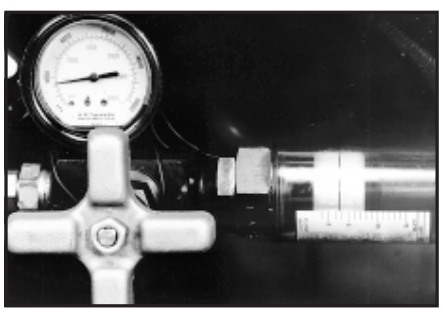
Figure 5.4

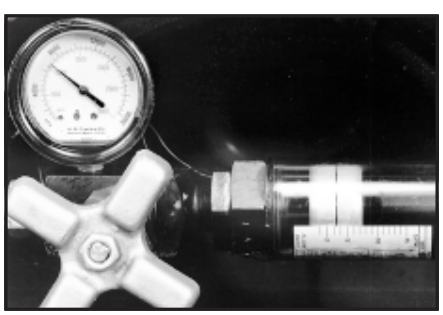
Figure 5.5

Test #5.1
40 Minute Power Steering Pump Test

IMPORTANT: Read the following instructions below before completing **Table 5.1** in the "Test Results" section.

Verify Engine Idle speed per your OEM specifications

1. Install temperature gauge in reservoir. *Figure 5.1.* Install PSSA in pressure line with shut-off valve fully open. *Figure 5.2.* Park the vehicle outside. Record ambient temperature. Run the engine at governed RPM for 40 minutes to bring the fluid up to an elevated testing temperature. Measure and record the fluid temperature at the start and at 10, 20, 30 and 40 minutes. Do not allow the temperature to exceed 250° F (121° C).

NOTE	If the temperature goes over 250° F (121° C) , or 150° F (66° C) above the surrounding temperature (ambient) at any time during the test, stop the test. This temperature level is considered extreme and steering system performance and life will be seriously affected. Damage to hoses, seals, and other components may result if operated at extreme temperature. If the steering system is operating above the recommended temperatures, the heat problem may be the root cause of the complaint.

2. Run the engine at idle speed.

⚠ CAUTION	**When closing the PSSA shut off valve, do so slowly and keep an eye on the pressure gage. Do not allow the system to exceed 3000 psi (207 BAR) for safety of personnel and to prevent damage to the vehicle.**

⚠ CAUTION	**Do not keep the load valve closed for more than 5 seconds at a time because damage to the system may result from excessive heat build-up.**

3. Measure and record the following flow and pressure readings (see chart) by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed. *Figures 5.3-5.7.*

4. Now with the load valve fully open, increase the engine speed to governed RPM and measure and record the following flow and pressure readings by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed.

5. Determine the recommended flow range and maximum allowable system pressure for the steering system being used by referring to your service manual.

6. Compare the minimum and maximum flows, and the relief pressure you measured to gear and pump specifications.

7. If the minimum measured pump flow is less than the minimum recommended flow for the steering gear used (see **Steering Gear Flow Requirements** chart), the pump may not be putting out enough flow for an adequate steering speed. If the maximum

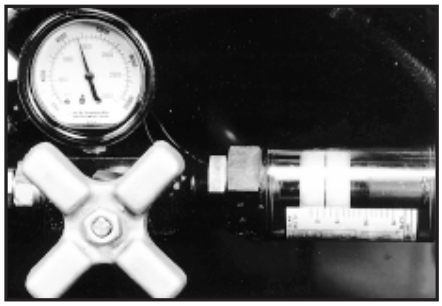
Figure 5.6

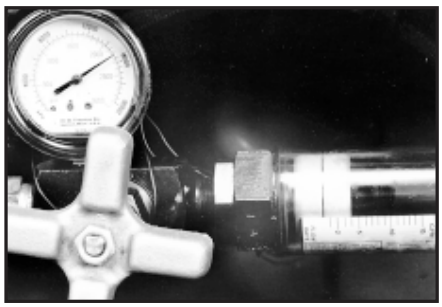
Figure 5.7

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system pressure is lower than that specified for the pump (refer to your OEM service manual), it may not be developing enough pressure to steer. If either case exists, the pump needs to be repaired or replaced.

NOTE	When hydraulic tests are completed and fluid lines are reconnected, check fluid level and bleed the air from the hydraulic system.

Test #6
Pump Flow Control Response

IMPORTANT: Read the following instructions below before completing **Table 6**, in the "Test Results' section

1. Install temperature gauge in reservoir. *Figure 6.1.* Install PSSA in pressure line with shut-off valve fully open. *Figure 6.2.*

NOTE	If the temperature goes over 250° F (121° C) , or 150° F (66° C) above the surrounding temperature (ambient) at any time during the test, stop the test. This temperature level is considered extreme and steering system performance and life will be seriously affected. Damage to hoses, seals, and other components may result if operated at extreme temperature. If the steering system is operating above the recommended temperatures, the heat problem may be the root cause of the complaint.

⚠ CAUTION	**Do not keep the load valve closed for more than 5 seconds at a time because damage to the system may result from excessive heat build-up. (Do not allow the pressure to exceed 3000 psi (207 bar).**

2. With the engine at idle, note the flow rate. Fully close the load valve until the flow drops to zero. Quickly open the load valve observing the flow meter. The flow rate must instantly return to the reading you noted above.

3. With the load valve open run the engine to governed speed and note the flow rate. Fully close the load valve until the flow drops to zero. Quickly open the load valve observing the flow meter. The flow rate must instantly return to the reading noted above.

4. Conduct this pump response test three times at idle and three times at 1500 RPM. If the flow rate does not return immediately, the pump is malfunctioning, which can result in momentary loss of power assist.

NOTE	When hydraulic tests are completed and fluid lines are reconnected, check fluid level and bleed the air from the hydraulic system.

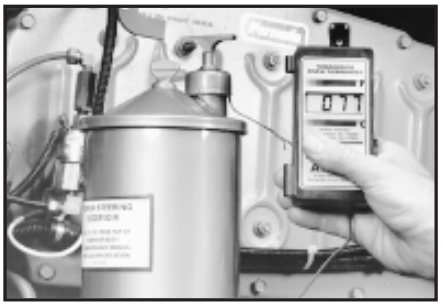

Figure 6.1

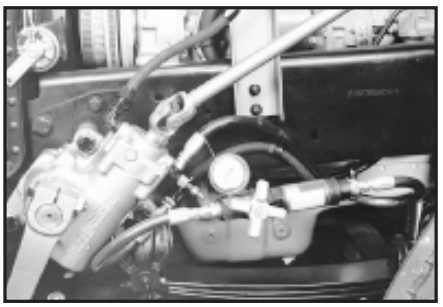

Figure 6.2

Test #6.1
40 Minute Pump Flow Control Response

Read the following instructions below before completing **Table 6.1** in the "Test Results' section

1. Install temperature gauge in reservoir. *Figure 6.1.* Install PSSA in pressure line with shut-off valve fully open. *Figure 6.2.* Park the vehicle outside. Record ambient temperature. Run the engine at governed RPM for 40 minutes to bring the fluid up to an elevated testing temperature. Measure and record the fluid temperature at the start and at 10, 20, 30, and 40 minutes. Do not allow the temperature to exceed 250° (121°C)

NOTE	If the temperature goes over 250° F (121° C) , or 150° F (66° C) above the surrounding temperature (ambient) at any time during the test, stop the test. This temperature level is considered extreme and steering system performance and life will be seriously affected. Damage to hoses, seals, and other components may result if operated at extreme temperature. If the steering system is operating above the recommended temperatures, the heat problem may be the root cause of the complaint.

⚠ CAUTION	**Do not keep the load valve closed for more than 5 seconds at a time because damage to the system may result from excessive heat build-up. (Do not allow the pressure to exceed 3000 psi (207 bar).**

2. With the engine at idle, note the flow rate. Fully close the load valve until the flow drops to zero. Quickly open the load valve observing the flow meter. The flow rate must instantly return to the reading you noted above.

3. With the load valve open run the engine to governed speed and note the flow rate. Fully close the load valve until the flow drops to zero. Quickly open the load valve observing the flow meter. The flow rate must instantly return to the reading noted above.

4. Conduct this pump response test three times at idle and three times at 1500 RPM. If the flow rate does not return immediately, the pump is malfunctioning, which can result in momentary loss of power assist

NOTE	When hydraulic tests are completed and fluid lines are reconnected, check fluid level and bleed the air from the hydraulic system.

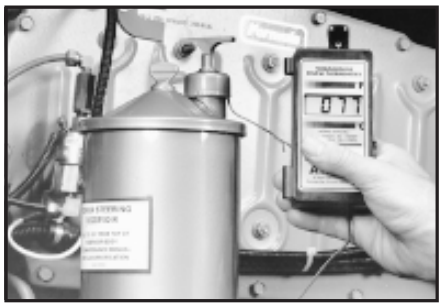

Figure 6.1

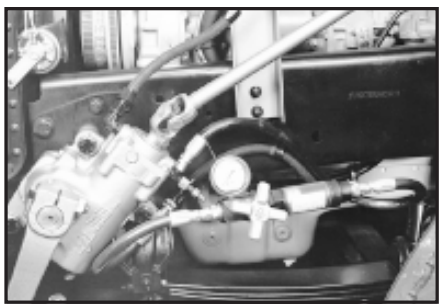

Figure 6.2

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Test #7
Measured Internal Leakage

1. Install temperature gauge in reservoir. *Figure 7.1.* Install PSSA in pressure line with shut-off valve fully open. *Figure 7.2.*

⚠ WARNING	**THIS TEST CAN BE DANGEROUS IF NOT PERFORMED CORRECTLY. KEEP YOUR FINGERS CLEAR OF THE AXLE STOPS AND SPACER BLOCK DURING THIS TEST. MAKE SURE THAT THE SPACER BLOCK CONTACTS THE AXLE STOP SQUARELY. CONTACT THAT IS NOT SQUARE COULD BREAK THE AXLE STOPS OR DANGEROUSLY THROW OR EJECT THE SPACER BLOCK.**

2. To test the steering gear for internal leakage, you must first prevent operation of the gear's internal unloading (poppet) valves or relief valve (or both, in some gears). This will allow full pump relief pressure to develop. To prevent operation of the poppets, place an unhardened steel spacer block, about one inch thick and long enough to keep your fingers clear between the axle stop at one wheel. *Figures 7.3-7.4.* To prevent operation of the relief valve, remove the relief valve cap, o-ring and two piece relief valve, if equipped, from valve housing. Install the relief valve plug, special tool number J37130 in its place.

NOTE	Be sure you reinstall the relief valve and valve cap with new o-ring, back onto the gear after leakage test.

⚠ CAUTION	**When running this test, do not hold the steering wheel in the full turn position for longer than 5 to 10 seconds at a time to avoid damaging the pump.**

⚠ WARNING	**KEEP YOUR FINGERS CLEAR OF THE AXLE STOPS AND SPACER BLOCK DURING THIS TEST. MAKE SURE THAT THE SPACER BLOCK CONTACTS THE AXLE STOP SQUARELY. CONTACT THAT IS NOT SQUARE COULD BREAK THE AXLE STOPS OR DANGEROUSLY THROW OR EJECT THE SPACER BLOCK.**

3. With the fluid temperature between 125-135° F (52-57° C), turn the steering wheel until the axle stop bolt contacts the spacer block.

4. Apply 20 pounds of force to the rim of the steering wheel during this test to be sure that the steering gear control valve is fully closed. *Figure 7.5.* The pressure gauge should now read pump relief pressure, as noted during the Flow Control Response Test (Test #6). You can now read steering gear internal leakage on the flow meter.

5. Repeat this test for the opposite direction of turn.

6. If internal leakage is greater than 1 gpm (3.8 lpm) and there is no auxiliary hydraulic linear or rotary cylinder in the system, repair or replace the gear. If the internal leakage is greater than 2 gpm (7.6 lpm), and there is an auxiliary hydraulic linear or rotary cylinder in the system, controlled by the gear, isolate the auxiliary cylinder from the system by disconnecting the auxiliary cylinder hydraulic

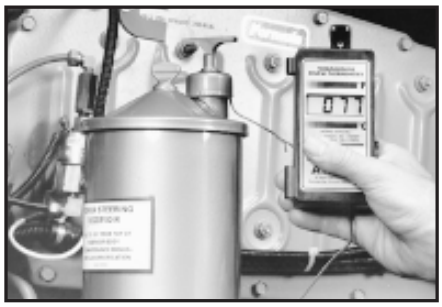
Figure 7.1

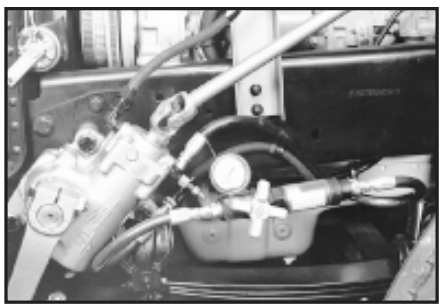
Figure 7.2

Figure 7.3

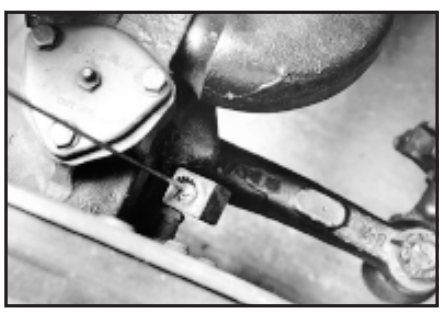
Figure 7.4

Figure 7.5

lines at the gear auxiliary ports. Plug the steering gear ports with suitable steel or high pressure plugs or caps.

In the event that a rotary cylinder is used in the system, connect the disconnected lines together with a suitable union fitting. In the case of a linear cylinder, first plug the disconnected lines and then disconnect the cylinder from the steering linkage, making sure it will clear the steered axle. *Figures 7.6-7.7.*

Repeat the internal leakage test. If the internal leakage is less than 1 gpm (3.8 lpm), repair or replace the auxiliary cylinder. If the internal leakage is greater than 1 gpm (3.8 lpm), repair or replace the gear.

NOTE	When hydraulic tests are completed and fluid lines are reconnected, check fluid level and bleed the air from the hydraulic system.

Test #8
Steering Column Binding

1. With the vehicle parked, the engine off, and the steer axle jacked-up, slowly steer the vehicle until the binding position is located.

2. With the steering gear at this position, remove the steering column assembly from the steering gear. Note the correct position of the column and steering gear for reassembly after test. *Figure 8.1*

3. Rotate the steering gear input shaft no more than 1/4 turn each direction and check if binding is still present. *Figure 8.2* If binding is not felt, correct the steering column problem.

Test #9
Air in Hydraulic System

1. Inspect reservoir for foaming or air bubbles. *Figure 9.1* If foaming or bubbles are seen, air is being sucked into the system through cracks or loose fittings. Look for oil level changes engine off versus engine on, if fluid level increases when the vehicle is shut off, there is an air pocket trapped in the steering gear. The increase may not be noticeable, depending on the size of the pocket.

2. Bleed the steering gear (if there is a manual bleed screw at the top of the gear). With system at normal operating temperature and engine at proper idle speed and running, open the bleed screw and wait until clean, clear oil begins to flow from the gear. Close the bleed screw and steer the vehicle completely from stop to stop.

3. Repeat the bleeding operation three times, and recheck oil level in reservoir to make sure there is enough oil for the system to operate properly.

Figure 7.6

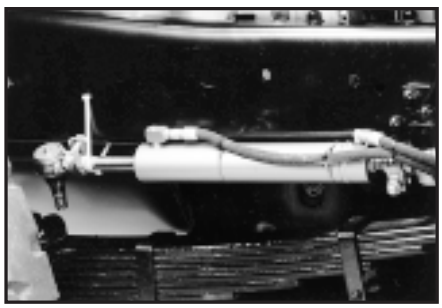
Figure 7.7

Figure 8.1

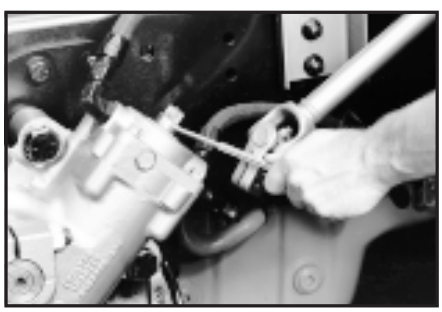
Figure 8.2

Figure 9.1

Test #10
Restricted Hydraulic Line

Read the following instructions below before completing **Table 10**, in the "Test Results' section

1. Look at the supply line that goes to the pump to check for kinking or any other obstructions or irregularities on the inside of the hose. *Figure 10.1.*

2. Install PSSA with load valve fully open. *Figures 10.2-10.3.* Insert temperature gauge into reservoir. With oil between 125-135 °F (52-57 °C), determine a test engine speed (RPM) that causes pump to deliver 3, 4, 5 or 6 gpm (11, 15, 19, or 23 lpm) (whichever is easier) and note this speed.

3. Remove the PSSA and install a low pressure gauge (200-300 psi (14-21 bar)) maximum with approximately 10 psi (.70 bar) per division) in the pressure line to the steering gear at the pump end. Install a temperature gauge in the power steering reservoir.

⚠ CAUTION	**Do not allow system pressure to exceed the rating of the gauge during the following procedure or damage to the gauge will result. Extremely high restrictions may be indicated with the PSSA gauge as installed with load valve fully open.**

NOTE	Be sure that the steering gear input shaft is not being restrained from recentering because this will cause a false steering gear pressure drop. If there is any question, conduct this test with the steering column removed.

4. Bring the power steering fluid temperature to 125-135 °F (52-57 °C), at engine idle, with no steering force applied to the steering wheel. *Figure 10.4.*

5. At the test engine speed selected from step 2 above, measure and record the gauge reading and shut off the engine. This measures total system pressure.

6. Remove the pressure and return lines from the steering gear and connect them together with a fitting that will not restrict the flow. *Figure 10.5.*

7. Start the engine, and run at the RPM identified in step 2 with the fluid temperature between 125-135 °F (52-57 °C).

8. Measure and record gauge reading and shut off engine. This is hydraulic line/reservoir pressure.

9. The difference between the total system pressure gauge reading and the hydraulic line/reservoir pressure gauge reading is the steering gear pressure drop. For a TRW steering gear, at a flow of 3, 4, 5 or 6 gpm (11, 15, 19, or 23 lpm), the drop should not be greater than 30, 40, 55 or 70 psi (2.0, 2.8, 3.8, 4.8 bar) respectively. The line/reservoir pressure drop for a flow of 3, 4, 5 or 6 gpm (11, 15, 19, or 23 lpm) should not be greater than 20, 20, 25 or 25 psi (1.4, 1.4, 1.7, 1.7 bar) respectively.

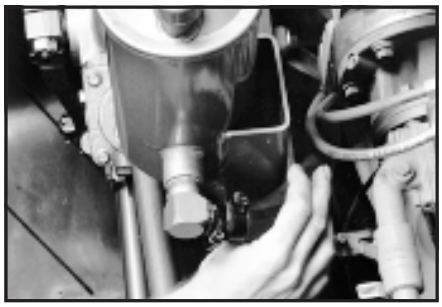
Figure 10.1

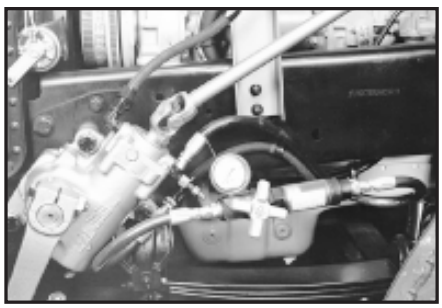
Figure 10.2

Figure 10.3

Figure 10.4

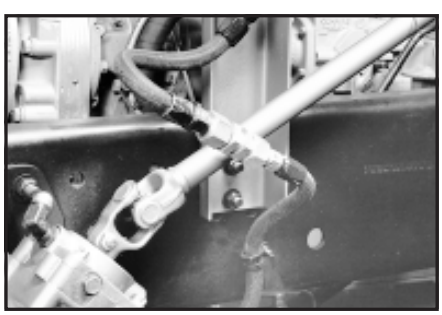
Figure 10.5

Test #11
Axle Stop Setting

Put vehicle steer tires on radius plates (turntables). Check to make sure axle stops are set to manufacturer's specifications. *Figure 11.1.*

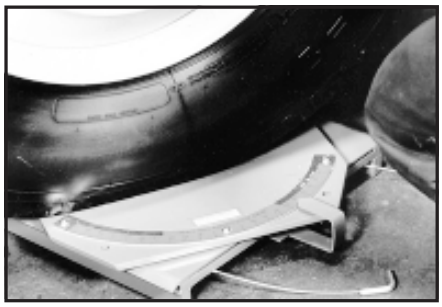
Figure 11.1

Test #12
Pitman Arm and Output Shaft Alignment

Look to make sure the output shaft timing mark is lined up with the pitman arm timing mark. Some pitman arms have more than one mark, so make sure the right one is used. *Figure 12.1.*

Figure 12.1

Test #13
Misadjusted Drag Link

The length of the drag link must be correct for the steering system. Check the length after you make sure the pitman arm/ shaft timing marks are aligned, the gear is at its center position, and the road wheels are straight ahead. *Figure 13.1.*

Test #14
Poppet Setting Procedure

1. If you are working on a newly-installed TAS steering gear, refer to the service manual to correctly set the poppets. If you are working on a steering gear, other than a TAS series, refer to the OEM's service manual for correct poppet setting instructions.

2. To set poppets on a TAS series gear using the adjustable service kit, refer to your steering gear service manual.

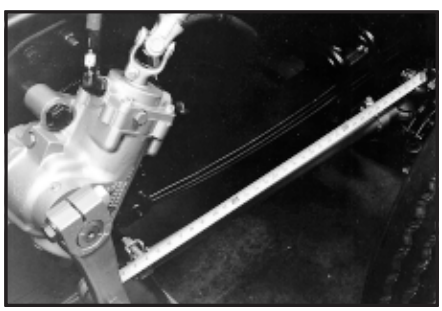
Figure 13.1

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Test #15
Lash in Steering System

Two people are needed for this test. One person will slowly turn the steering wheel back and forth one-quarter turn each way from center with the engine idling. The other person should check for looseness at each of the following areas from steering wheel to road wheels: *Figures 15.1-15.5.*

* Steering wheel to steering column
* U-joints, or slip-joint and/or miter boxes
* Steering column to steering gear input shaft
* Steering gear input shaft to steering gear output shaft
* Pitman arm to output shaft
* Drag link to pitman arm connection
* Drag link ends (sockets) and adjustable areas
* Axle arm to drag link connection
* King pin axle connections (bushings)
* Tie rod arms to tie rod connection
* Tie rod ends (sockets) and adjustable areas
* Steering spindle
* Wheel bearings
* Lug nuts
* Spring pin connectors
* Front axle u-bolts
* Spring hanger brackets/rear shackles

NOTE	Cracked or broken components can cause symptoms similar to loose components but may be more difficult to find.

NOTE	Be sure to check rear drive axles for any looseness and inspect tires for signs of abnormal wear.

Test #16
Steering Gear Adjustment

Check and adjust according to the appropriate service manual for your steering gear if necessary

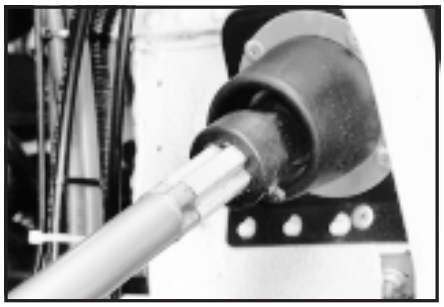
Figure 15.1

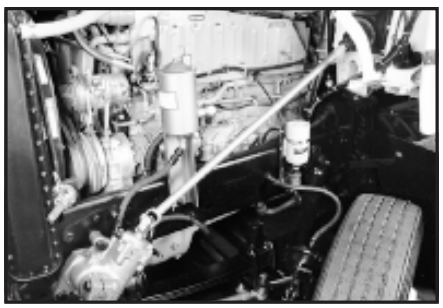
Figure 15.2

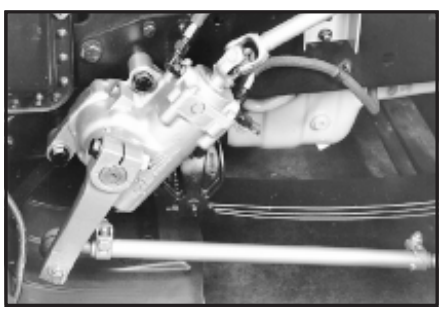
Figure 15.3

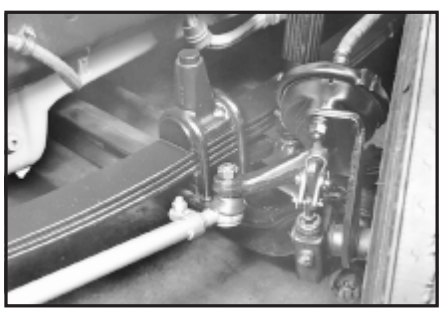
Figure 15.4

Figure 15.5

Test #17
U-Joint Phasing and Lubrication

1. Make sure u-joints are properly lubricated.

2. Steering column assemblies with more than one universal joint (cardan type) can cause a cyclic binding feel or torque variation at the steering wheel if the u-joints are not in phase with each other. *Figure 17.1-17.2*. If a steering column assembly with multiple u-joints is taken apart, it must be reinstalled with the timing marks for slip mechanisms aligned. This is true for both the cross-type and the splined-type two-piece intermediate shaft.

Figure 17.1

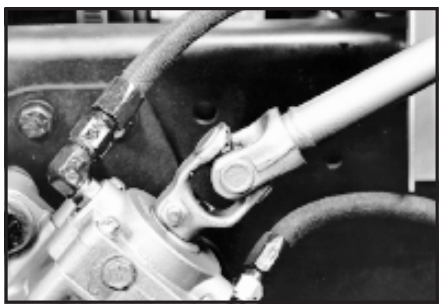
Figure 17.2

Test #18
Steering Column Interference

Position steering wheel at the location where steering wheel interference is noticed, and look for something interfering or rubbing on the rotating column assembly such as brackets, bolts, floorboard, boot, etc.

Test #19
Intermediate Column Interference

1. Check the slip column by looking to make sure there is proper travel allowance when in use. *Figure 19.1.*

2. Look for wear or galling. *Figure 19.2.*

3. Check slip column for too much slip force

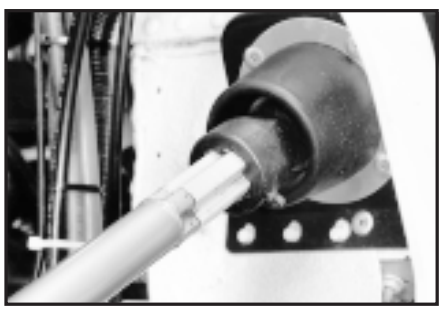
Figure 19.1

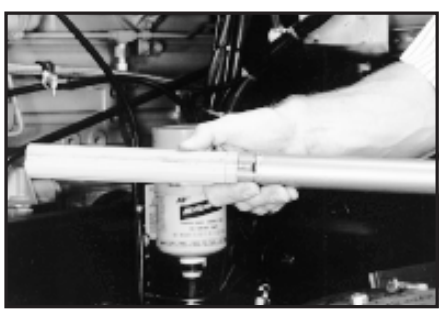
Figure 19.2

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Test #20
Miter Box Misadjusted (if equipped)

Check and adjust per manufacturer's instructions. *Figure 20.1.*

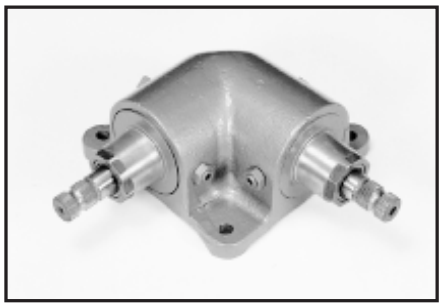

Figure 20.1

Test #21
Vehicle Alignment

Check alignment of steered axle and rear drive axles, and trailer axles (if problem only exists with trailer). *Figure 21.1.*

Figure 21.1

Test #22
Wheel Bearing Adjustment

Verify that adjustment is made according to manufacturer's specification. *Figure 22.1.*

Figure 22.1

Test #23
Air Suspension Adjustment

Check and set to manufacturer's specifications

Test #24
Gear Imbalance

1. Install a low pressure gauge (200-300 psi (14-21 bar) maximum with approximately 10 psi (.70 bar) per division) in the pressure line from pump to gear. *Figure 24.1.*

⚠ CAUTION **Do not allow system pressure to exceed the rating of the gauge in the following procedure or damage to the gauge will result.**

2. At engine idle, slightly turn the steering wheel one direction until a pressure rise is observed at the gauge. *Figure 24.2.*
3. Stop steering and gently allow the steering wheel to recenter.
4. Next slightly turn the steering wheel the opposite direction while observing the gauge and determine if pressure initially rises or falls with initiation of a turn.
5. Repeat test a few times in each direction.
6. If a consistent fall in pressure is associated with the initiation of a turn in one direction, the steering gear's control valve is unbalanced and needs to be replaced.

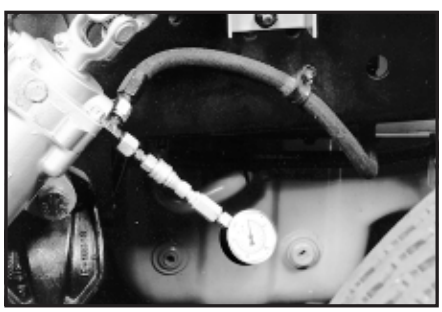

Figure 24.1

Test #25
Unequal Brake Force

Visually inspect brake assemblies for oil/grease on braking surfaces, and overall condition of brake surfaces. Adjust or replace brakes if necessary.

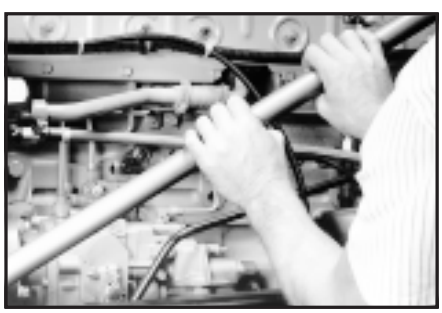

Figure 24.2

Test #26
Tire Balance / Runout

Have wheel assemblies balanced and checked for lateral and radial run out per manufacturer's specifications. Preferred method for checking balance is with wheels still on the vehicle. Balance includes total rotating assembly.

TEST #27
Steering Column Noise

If column does not include a clockspring, remove steering wheel and add dielectric grease to the horn contact. The grease TRW uses is Model No. K-5/X Semifluid CA, product code 134613, from Century Lubricants. If noise continues, check steering wheel and shroud (not applicable to columns with clockspring).

TEST #28
Steering Column Bearing

Check upper bearing gaskets. Gaskets should cover bearing.

TEST #29
Intermediate Column Lash

Check intermediate column (I-Shaft) for torsional lash in U-Joints of slip section. Replace intermediate column if necessary.

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Section 4 Comments

Comment A - H 36
Comment I - K 37

Comment A
Some power steering pumps have a temporary state during which the pumping element vanes do not extend. Usually increasing engine speed briefly will correct the problem.

Comment B
The maximum speed of steer with power assist for a power steering gear is limited by the pump flow and internal leakage. Example: Recommended minimum flow for a new TAS65 steering gear is 3.0 gpm (11.4 lpm), and is based on a maximum steering speed capability of 1.5 steering wheel turns per second.

Comment C
Vehicle linkages are designed to minimize the affect at the steering gear and steering wheel during normal steered axle/suspension movements. Be sure that linkage used is as specified by vehicle manufacturer.

Comment D
A single u-joint operating at an angle will cause a cyclic torque variation at the steering wheel. The amount of torque variation increases with the amount of operating angle. A secondary couple that side loads the input shaft also increases with increased u-joint angles. U-joint operating angles of 15 degrees or less will minimize the torque variation felt at the steering wheel.

Comment E
Deflections in the suspension and linkage, front and rear, due to high engine generated torque levels can cause a steering effect. This most often occurs at lower vehicle speeds while accelerating.

Comment F
The location of the axle arm ball center is important during spring wind-up conditions such as severe braking. A steering arm different from that specified by the manufacturer could cause a steering effect while braking.

Comment G
Soft or loosely supported rear suspensions may allow the rear driving axles to become non-square with the centerline of the chassis during load shifting or trailer roll which will tend to produce a steering effect.

Comment H
Power steering pump cavitation

Pump cavitation is defined as a "wining" or noisy power steering pump. Usually, pump cavitation is most noticed during engine start-up at low temperature extremes. However, other conditions can cause the power steering pump to continually cavitate and cause internal pump damage, and ultimately, failure. These conditions are:

1. Twisted, loose, or cracked inlet line
2. Inlet line blockage due to:
    a. Contamination - dirt and foreign material
    b. Damaged filters
    c. Reservoir components
    d. Inner hose liner separation
3. Displaced (improper or improperly installed) filters
4. Reservoir cap "vent" plugged

Comment I
Excessive Flow

TRW steering gears are rated for 8 gpm maximum power steering pump flow. Although the gears have the capability to handle this maximum flow, it is not always a system need or requirement. When using combinations of dual gears or a single gear with a hydraulic linear cylinder, supply flows for both components should be considered (See Steering Gear Flow Requirements). Single gear applications have a recommended flow at engine idle. For acceptable steering speed performance, again, refer to the Steering Gear Flow Requirements. Increasing the engine idle flow by more than 50% of the recommended flow can cause power steering system overheating, vehicle directional control problems (Darting), and steer axle returnability (Non-recovery). If you measure idle flows above the 50% limit, consult your OEM for guidance and recommendations.

Comment J
Flushing and Air Bleeding the System

IMPORTANT: Clean the area around the reservoir, steering gear and pump thoroughly before beginning this procedure.

1. Set parking brake on vehicle and block rear wheels.
2. Raise the front end off the ground
3. Take vehicle out of gear and put into neutral position
4. Raise hood and place a drip pan under the steering gear
5. Remove both the pressure and return lines from the steering gear
6. Remove filter from the power steering fluid reservoir and discard

IMPORTANT: Discard only the filter, other components may be required to hold filter element in place inside the reservoir.

7. Clean the inside of the reservoir
8. Turn steering wheel from full left to full right 3-4 times. This will purge the oil from the steering gear.
9. Reconnect pressure and return lines to the steering gear and tighten
10. Install new filter element into the reservoir
11. Clean reservoir filler cap with an approved solvent. Inspect gasket and replace if necessary.
12. Fill reservoir with approved replacement fluid and reinstall the filler cap
13. Start engine for 10 seconds, stop, and check reservoir fluid level and top off if necessary. You may need to repeat this procedure 3 or 4 times.
14. Upon completion of filling the reservoir, start the engine and let it idle. At engine idle, steer full right and full left once and return to straight ahead. Stop engine and check power steering reservoir level and top off if required.
15. Restart engine and steer full turns each direction 3 or 4 times.
16. Stop engine and recheck reservoir fluid level and adjust to correct level, if needed.
17. Inspect system for leaks and correct if necessary
18. Bleed air from the system if required (Refer to your steering gear service manual for recommended air bleeding procedures.)
19. Remove drip pan and lower vehicle. Remove blocks from wheels and release vehicle for normal service.

Comment K
Identifying “Burnt Oil”

Sometimes the power steering reservoir oil supply will become hotter than the normal operating temperature and overheat. This condition may result in an intermittent loss of power assist and also cause deterioration of the power steering hoses and component seals. TRW recommends that the power steering hoses be examined for deterioration due to overheated oil, which can be identified by wet hoses, and determine the condition of the reservoir fluid by looking for signs of “burnt oil.”

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Section 5 Test Results

Test 5 - Power Steering Pump Test 40
Test 5.1 - 40 Minute Power Steering Pump Test 40
Test 6 - Flow Control Response Test 41
Test 6.1 - 40 Minute Flow Control Response Test 41
Test 10 - Restricted Hydraulic Line Test 42
Steering Gear Flow Requirements 43
Pump Part Number Reference Guide 44

Test 5.0 - Power Steering Pump Test

Relief Pressure: _____ PSI/BAR

Engine(RPM)	No Load	1000PSI
Idle		
1500		

Table 5.0

Test 5.1 - 40 Minute Power Steering Pump Test

Ambient	
Start	
10 Minutes	
20 Minutes	
30 Minutes	
40 Minutes	
Unit of Measure	˚F or ˚C

Relief Pressure: _____ PSI/BAR

Engine(RPM)	No Load	1000PSI
Idle		
1500		

Table 5.1

Test 6.0 - Pump Flow Control Response Test

Unit of Measure	PSI or BAR
Pump Relief #1 (Idle)	
Pump Relief #2 (Idle)	
Pump Relief #3 (Idle)	

Unit of Measure	PSI or BAR
Pump Relief #1 (1500 RPM)	
Pump Relief #2 (1500 RPM)	
Pump Relief #3 (1500 RPM)	

Table 6.0

Test 6.1 - 40 Minute Pump Flow Control Response Test

Ambient	
Start	
10 Minutes	
20 Minutes	
30 Minutes	
40 Minutes	
Unit of Measure	°F or °C

Unit of Measure	PSI or BAR
Pump Relief #1 (Idle)	
Pump Relief #2 (Idle)	
Pump Relief #3 (Idle)	

Unit of Measure	PSI or BAR
Pump Relief #1 (1500 RPM)	
Pump Relief #2 (1500 RPM)	
Pump Relief #3 (1500 RPM)	

Table 6.1

Test 10.0 - Restricted Hydraulic Line Test

With PSSA @ 125 - 135 F (52 - 57 C)	RPM	GPM or LPM
With pressure gauge at pressure line to steering gear at pump end	RPM	GPM or LPM
Remove pressure and return lines and measure pressure with gauge at pump outlet	RPM	PSI or BAR

Table 10.0

Steering Gear Flow Requirements

Single Gear

Gear	GPM	LPM
TAS40, THP/PCF45, HFB52	2.2	8.3
TAS55, THP/PCF60	2.6	9.8
TAS65 or HFB64	3.0	11.4
TAS85 or HFB70	3.6	13.6
RCS40	2.2	8.3
RCS55	2.6	9.8
RCS65	3.0	11.4
RCS85	3.6	13.6

Dual Gear

Gear	GPM	LPM
TAS65 w/ RCS65	6.0	22.7
TAS65 w/ Linear Cylinder	6.5	24.6
TAS85 w/ RCS85	7.0	26.5
TAS85 w/ RCS65	6.5	24.6
TAS85 w/ Linear Cylinder	6.5	24.6
HFB70 w/ RCB70	7.0	26.5
HFB70 w/ RCB64	6.5	24.6
HFB70 w/ Linear Cylinder	6.5	24.6

Pump Part Number Reference Guide

Check the part number on your TRW power steering pump and note the pump relief setting shown in the example below. (See illustration on where to find the pump part number). If the values that you have recorded are within +/- 100 psi (+/- 7 bar) your pump is functioning properly. If the values recorded are below the negative tolerance, your pump is malfunctioning and should be replaced.

For TRW power steering pumps, the relief setting will be the 5th and 6th numbers in the pump part number.

EV 18 12 15 R 1 01 00

Family designation
PS = PS Pump
EV = EV Pump

Displacement per revolution
18 = 18 cc (1.10 cir)
22 = 22 cc (1.34 cir)
25 = 25 cc (1.53 cir)
28 = 28 cc (1.71 cir)

Flow control
12 = 12 lpm (3.17 gpm)
14 = 14 lpm (3.70 gpm)
16 = 16 lpm (4.23 gpm)
20 = 20 lpm (5.28 gpm)
24 = 24 lpm (6.34 gpm)

Relief setting
09 = 90 bar (1305 psi)
10 = 100 bar (1450 psi)
12 = 120 bar (1740 psi)
14 = 140 bar (2030 psi)
15 = 150 bar (2175 psi)
16 = 160 bar (2320 psi)
17 = 170 bar (2465 psi)
18 = 185 bar (2683 psi)

Direction of rotation
R = clockwise rotation
L = counterclockwise rotation

Shaft type
1 = 11 tooth 16/32 spline
2 = .625 dia. woodruf key

Housing
Varies between PS and EV Series pump

Customer version
00 = Standard

TRW Automotive
Commercial Steering Systems
800 Heath Street
Lafayette, IN 47904
Tel 765.423.5377
Fax 765.429.1868
http://www.trucksteering.com
http://trucksteering.trw.com

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TRW1250 Rev. 4/02

BLUE BIRD

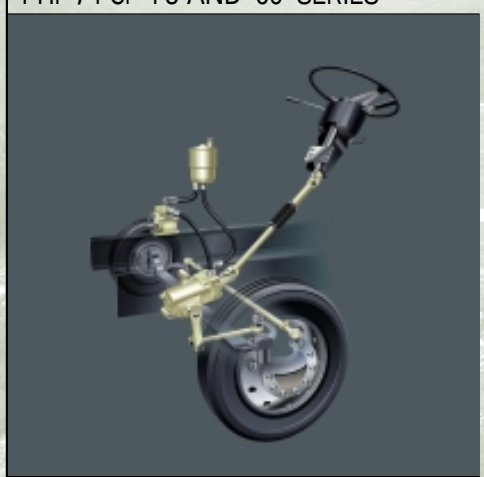
TRW

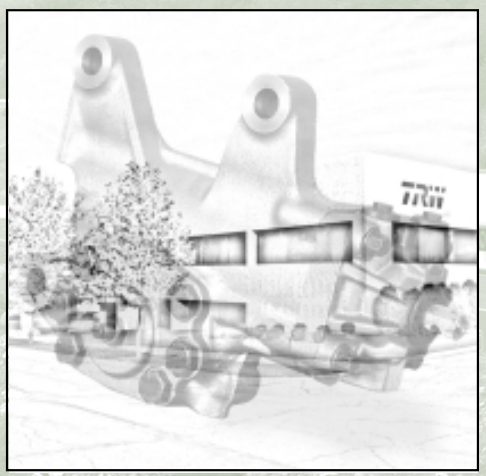
TRW Automotive

Commercial Steering Systems

THP/PCF Steering Gear Service Manual

THP / PCF 45 AND 60 SERIES





1013

Hazard Warning Definitions

⚠ WARNING	**A warning describes hazards or unsafe practices which could result in severe personal injury or death.**
⚠ CAUTION	**A caution describes hazards or unsafe practices which could result in personal injury or product or property damage.**
NOTE	A note gives key information to make following a procedure easier or quicker.

Disclaimer

This Service Manual has been prepared by TRW Commercial Steering Systems for reference and use by mechanics who have been trained to repair and service steering components and systems on heavy commercial vehicles. TRW Commercial Steering Systems has exercised reasonable care and diligence to present accurate, clear and complete information and instructions regarding the TRW Commercial Steering THP/PCF Series Integral Power Steering Gears. Since this is a general service manual, the photographs and illustrations may not look exactly like the steering gear being serviced. The procedures, therefore , must be carefully read and understood before servicing.

If inspection or testing reveals evidence of abnormal wear or damage to the THP/PCF steering gear or if you encounter circumstances not covered in the Manual, STOP - Consult the vehicle manufacturer's Service Manual and warranty. Do not try to repair or service a THP/PCF steering gear which has been damaged or includes any part that shows excessive wear unless the damaged and worn parts are replaced with original TRW replacement and service parts and the unit is restored to TRW's specifications for the THP/PCF steering gear.

1014

It is the responsibility of the mechanic performing the maintenance, repairs or service on a particular THP/PCF steering gear to (a) inspect the steering gear for abnormal wear and damage, (b) choose a repair procedure which will not endanger his/her safety, the safety of others, the vehicle, or the safe operation of the vehicle, and (c) fully inspect and test the THP/PCF steering gear and the vehicle steering system to ensure that the repair or service of the steering gear has been properly performed and that the steering gear and system will function properly.

Patents

TRW Commercial Steering Systems THP/PCF power steering gears are covered by several United States and foreign patents, either issued or pending.

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Design Features

1 **Size -** Reduced package size for increased wheelcut

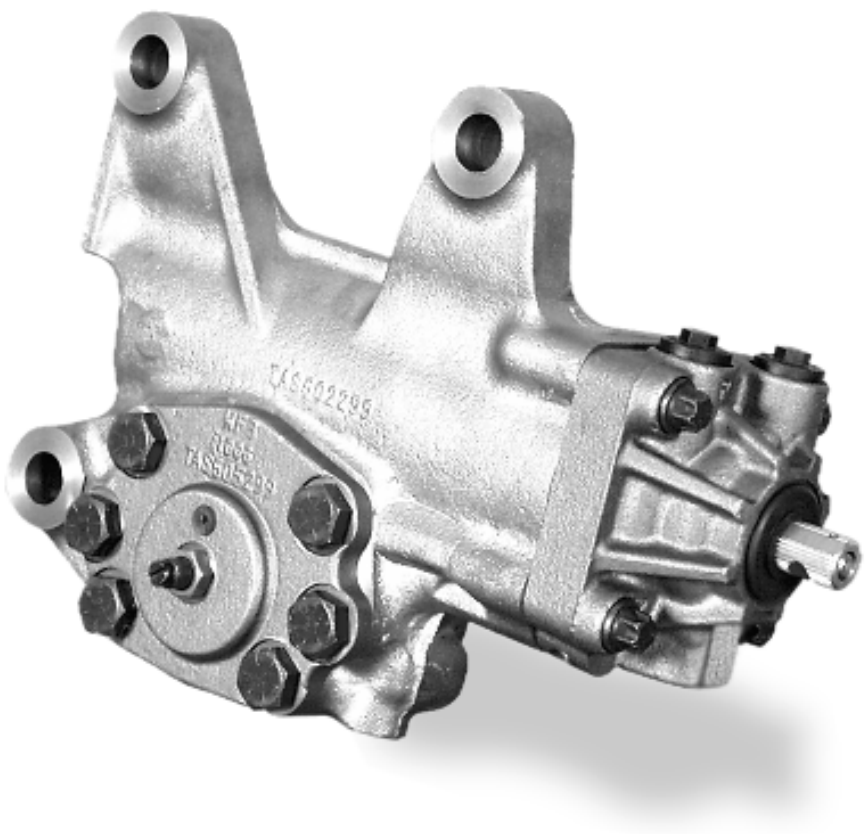
2 **Weight -** Reduced weight for improved vehicle efficiency.

3 **Improved Steering Performance**
- Faster steering ratio for improved handling and lower lock to lock turns
- Low internal friction for better return to center

4 **High Pressure Capability -** Provides for the smallest and lightest package

5 **Positive Center Feel (Optional)**
- Provides steering precision through improved straight ahead torque feedback (more stiffness) and improved position feedback control (less hysterisis)
- Allows separation of parking efforts from on-highway efforts
- Premium performance steering gear designed for line haul vehicles

6 **Design -** THP/PCF gear is based on the TAS model's proven steering gear technology plus:
- Improved side cover design that reduces weight, package size, more robust seal, and a roller bearing to reduce friction and wear
- Material and design changes made to operate at the higher pressure



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⚠ WARNING **All steering mechanisms are safety critical items. As such, it is imperative that the instructions in this booklet be followed to the letter. Failure to observe the procedures set forth in this pamphlet may result in a loss of steering.**

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Introduction

This THP/PCF Service Manual applies to all TRW THP45, PCF45, THP60 and PCF60 steering gears.

This service manual reflects TRW's commitment to provide easily usable material and highly recognizable hazard notices. Some of the updates are:

- Caution and warning definitions
- Torque, force, pressure and flow notations that provide metric equivalents
- Service manual divided into sections for easier reference.
- Uninterrupted resealing instructions. Reference to damage section allows you to repair or replace damaged parts and return to the resealing procedures easily.

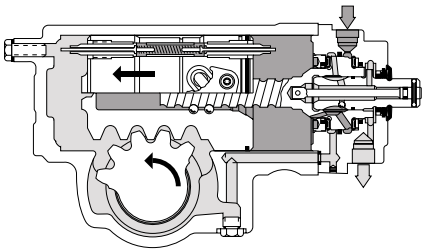
The three-column format used in the service manual will also help make it easy for you to service a steering gear. Column 1 illustrates the procedure with photographs, column 2 gives a brief key as well as tools to be used for each procedure, and column 3 explains in detail the procedure you should follow. **Pay special attention to the notes, cautions and warnings.**

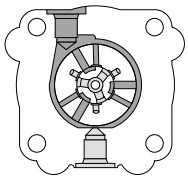
Item numbers on the exploded view correspond with item numbers in ( ), that are used throughout the service manual.

As you gain experience in servicing THP/PCF series steering gears, you may find that some information in this service manual could be clearer and more complete. If so, let us know about it. Don't try to second-guess the service manual; if you do not understand a procedure, or are stuck, contact our Field Service Department at 317.423.5377. Servicing THP/PCF series steering gears should be safe and productive.

Oil Flow Illustration

Left Hand Lead

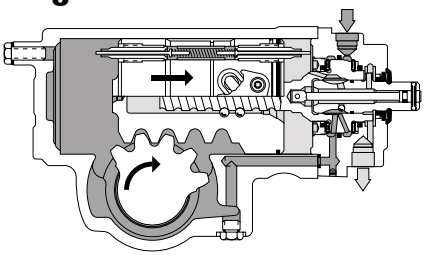


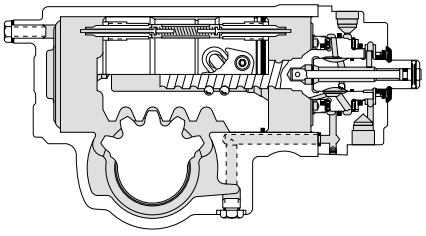


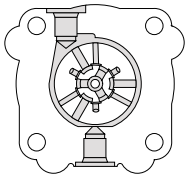
Right Hand Turn

Steering Wheel Input:
Clockwise Rotation

Right Hand Lead

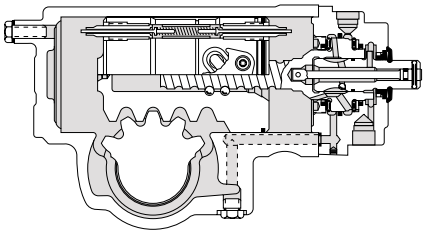


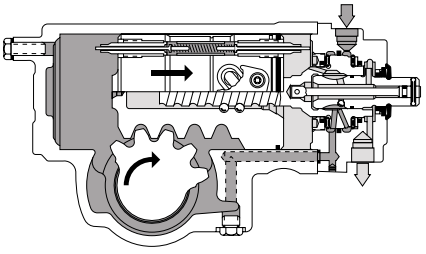


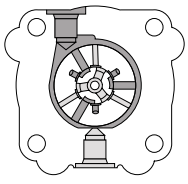


Straightline Running

No Steering Action

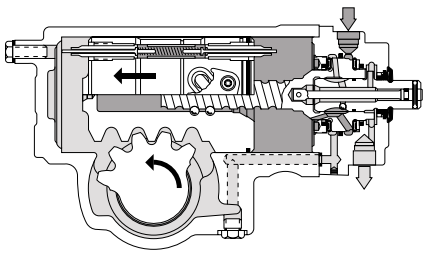






Left Hand Turn

Steering Wheel Input:
Counter-Clockwise Rotation



Supply Pressure

Return Pressure

General Design

Integral Power Steering

THP/PCF power steering gears are the latest design in the TRW Commercial Steering Systems' family of integral hydraulic power steering gears. Integral hydraulic power steering means that the gear contains a manual steering mechanism, a hydraulic control valve, and a hydraulic power cylinder, all in a single, compact package.

Rotary Control Valve

The rotary control valve combines simplicity of construction with desirable performance characteristics. The speed at which the driver can turn the steering wheel with power assist is dependent upon the pump flow (measured in gallons per minute or liters per minute) directed to a cylinder cavity. The control valve controls flow through the steering gear.

The pressure (measured in pounds per square inch, or bar) required for the gear to steer the vehicle is created by the power steering pump to overcome resistance at the steered wheels. The control valve senses these requirements and directs fluid to the appropriate cylinder cavity in the steering gear (and in the auxiliary cylinder if it is a dual steering system) at the proper flow rate and pressure.

Pressure Means Work, Flow Means Speed

The higher pressure a steering gear can withstand, the more work it can perform. The maximum operating pressure for all THP/PCF gears is 2685 psi (185 bar), maximum flow rate for all THP/PCF gears is 6 gpm (22.7 lpm).

The THP/PCF series gears can steer a vehicle within its front-end weight rating through a turn at low speed and engine idle. As the driver turns the steering wheel faster or slower, more or less fluid will be required by the gear. THP/PCF series vehicle front-end weight ratings are as follows:

Gear	Front Axle Rating
THP/PCF45	9,000 lb (4,100 kg)
THP/PCF60	14,300 lb (6,500 kg)

The recommended minimum flow at 1½ steering wheel turns per second is as follows:

Gear	Minimum Flow Rate
THP/PCF45	2.2 gal/min (8.3 L/min)
THP/PCF60	2.6 gal/min (9.8 L/min)

If the steering gear valve is controlling an auxiliary cylinder, increased minimum flow is required (generally at least 75%) based on the size of the auxiliary cylinder and the vehicle's steering geometry.

Maximum internal leakage for all THP/PCF gears is 1.2 gpm (4.5 lpm)

General Operation

What Happens During a Steering Maneuver

When the driver turns the steering wheel, he transmits force from the steering wheel to the steering gear input shaft. A torsion bar, pinned at its one end to the input shaft and at its other end to the worm shaft, turns with the input shaft and exerts a rotational force on the worm shaft. In response to this rotational force, the worm shaft, acting through the recirculating ball mechanism, tries to move the rack piston axially through the gear housing cylinder bore.

The rack piston's axial movement is resisted by its engagement to the sector shaft, which is connected by linkage to the steered wheels. Because of this resistance, the torsion bar is twisted by the input shaft, thereby actuating the control valve. Pressurized fluid, directed by the control valve, assists in moving the rack piston axially through the cylinder bore. The rack piston then turns the sector shaft to steer the vehicle.

Shock Loads to the Gear

If the steered wheels receive a shock load, the shock forces are transmitted through the sector shaft to the rack piston, and on to the worm shaft. The internal geometry of the steering gear causes the control valve to send high-pressure fluid to the correct cylinder cavity to resist the shock forces. By absorbing the shock forces hydraulically, the steering gear prevents objectionable kickback at the steering wheel.

Unloading (Poppet) Valves

Most THP/PCF gears are equipped with two unloading valves, one at each end of the rack piston. One valve or the other, depending on the direction of turn, will trip as the steered wheels approach the axle stops (which must be set according to manufacturer's specification). The tripped valve reduces pressure in the gear and helps to reduce heat generated by the pump. At the same time, the valves also reduce forces on the steering linkage. These valves are automatically set to axle stops after installation in vehicle at first full right and left turn.

Relief Valve

Some THP/PCF gears, (with or without poppets), are supplied with a relief valve. The relief valve limits maximum supply pressure to protect the power steering gear, but it does not reduce pressure as the steered wheels approach the axle stops.

Bleed Systems

Some THP/PCF gears which are mounted with the output shaft above the rack piston bore are equipped with either an automatic bleed system or a manual bleed screw.

The procedure for air bleeding the system is on page 16 of this manual. Replacement of damaged automatic bleed plugs, and manual bleed screws is described on page 61.

Approved Hydraulic Fluids

Automatic Transmission Fluid Dexron II
Automatic Transmission Fluid Type "E" or "F"
Chevron 10W-40
Chevron Custom 10W-40 Motor Oil
Chevron Torque 5 Fluid
Exxon Nuto H32 Hydraulic Fluid
Fleetrite PSF (Can #990625C2)
Ford Spec. M2C138CJ
Mack EO-K2 Engine Oil
Mobil ATF 210
Mobil Super 10W-40 Motor Oil
Premium Blue 2000 - SAE 15W-40
Texaco 10W-40
Texaco TL-1833 Power Steering Fluid
Union 10W-40
Union 15W-40
Unocal Guardol 15W-40 Motor Oil

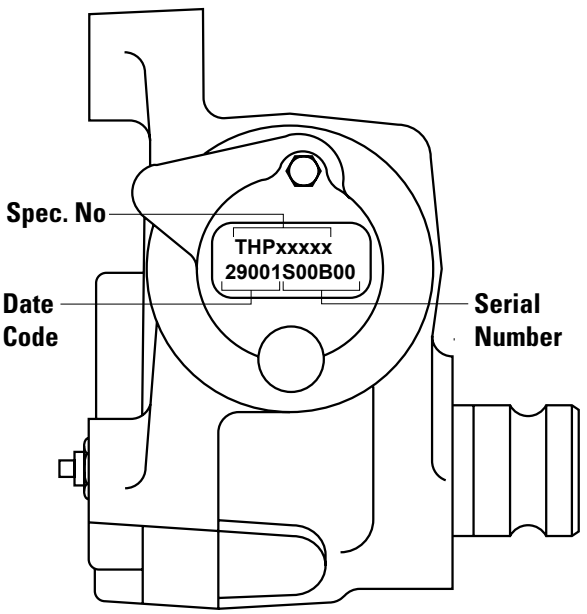
The steering system should be kept filled with one of the above fluids.

⚠ WARNING **Completely flush the steering system with one of the recommended fluids above only. Do not mix oil types. Any mixture or any unapproved oil could lead to seal deterioration and leaks. A leak could ultimately cause the loss of fluid, which could result in a loss of power steering assist.**

Approved Grease

Exxon Polyrex* EP2 (P/N 045422)

Gear Specification Numbers



The steering gear specification number and date code are stamped on a machined surface opposite the input shaft of every THP/PCF gear.

An example date code would be 29001; this means the gear was built on the 290th day of 2001.

A letter suffix at the end of the specification number indicates a design level for the gear.

*Trademark of Exxon Oil Corporation

Torque Chart

Part Name	Item #	Torque Range Dry	Torque Range Lubricated
Valve housing bolts	1		118-138 ft•lb (160-187 N•m)
Auxiliary port plug	7	25-35 ft•lb (34-48 N•m)	
Relief valve cap	10	25-35 ft•lb (34-48 N•m)	
Bearing adjuster	20		11-15 ft•lb (15-20 N•m)*
Locknut	21		101-122 ft•lb (137-165 N•m)**
Poppet sleeve assembly	27	16-20 ft•lb (22-27 N•m)	
Torx screw	33	14-22 ft•lb (19-29 N•m)	
Plug, auto bleed	37	38-58 ft•lb (52-79 N•m)	
Poppet fixed stop screw	38	38-42 ft•lb (52-57 N•m)	
Sector shaft adjusting screw jam nut	46	40-45 ft•lb (54-61 N•m)	
Side cover bolts	48		180-220 ft•lb (244-298 N•m)
Poppet sealing nut, service	n/s	33-37 ft•lb (45-50 N•m)	
Manual bleed screw	n/s	40-50 in•lb (3.1-3.7 N•m)	

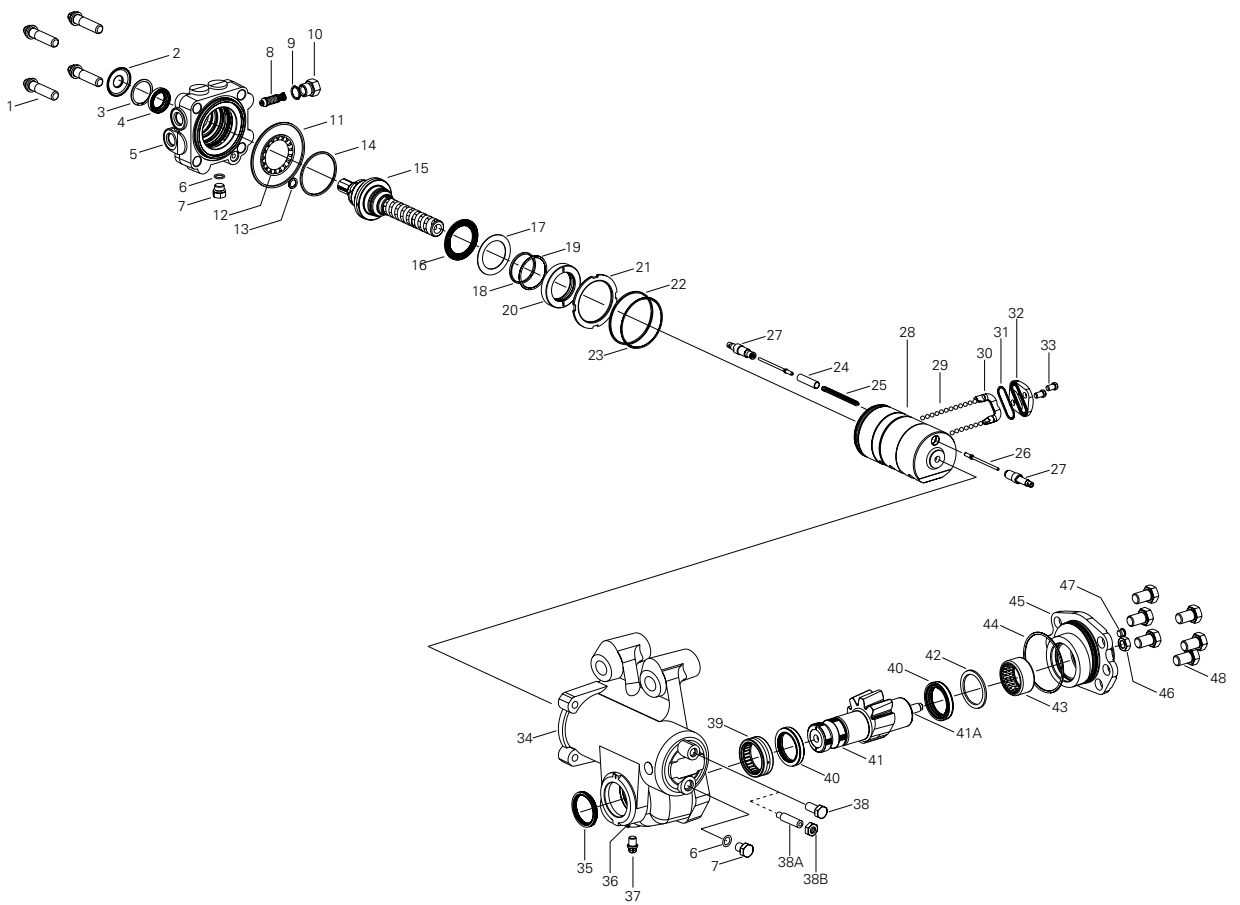
Item numbers referenced are shown on the exploded view located on page 8.

* After tightening to this torque value, the adjuster must be backed off ¼ to ½ of a turn as described in step 20 on page 57.

** Torque value indicated is using recommended tools.

Special tools can be purchased through:
SPX Corporation
Kent-Moore Tool Group
28635 Mound Road
Warren, MI 48092
1-800-328-6657

THP/PCF Exploded View



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Item	Description
1	Valve Housing Bolts (4)
*2	Dirt and Water Seal 13/16" Serr.
*2B	Dirt and Water Seal 7/8" Serr.
*2C	Dirt and Water Seal 1" Serr.
*3	Retaining Ring
*4	Seal (Input Shaft)
5	Valve Housing Assembly
*6	Auxilliary Port O-ring (2)
7	Auxilliary Port Plugs (2)
8	Relief Valve (2 Piece)
*9	O-ring
10	Relief Valve Cap
*11	O-ring (Valve Housing)
12	Bearing Assembly
*13	O-ring
*14	Seal Ring
15	Worm and Valve Assembly
16	Thrust Bearing
17	Thrust Washer
*18	Seal Ring
*19	O-ring
20	Bearing Adjuster
*21	Lock Nut
*22	O-ring
*23	Seal Ring
24	Push Tube
25	Poppet Spring
26	Poppet (2)
27	Poppet Seat & Sleeve Assy. (2)
28	Rack Piston
29	Balls
30	Ball Return Guide
*31	Seal (Cap)
32	Ball Return Guide Cap
*33	Torx Screw (2)
34	Housing
*35	Dirt and Water Seal (Trunnion)
36	Grease Fitting
37	Plug (Auto Bleed)
38	Fixed Stop Screw (Poppet)
38A	Poppet Adjusting Screw
38B	Nut, Poppet Adjusting Screw
39	Bearing, Roller
*40	Seal (2-Output)
41	Sector Shaft Assembly
41A	Sector Shaft Adjusting Screw
42	Washer
43	Bearing, Roller
*44	Side Cover O-ring
45	Side Cover Assembly
46	Jam Nut
*47	Vent Plug (Side Cover)
48	Bolts, Side Cover (6)

*These items are included in complete seal kits along with 045422 lubricant and a service bulletin.

THP/PCF Service Parts List

Common Parts

Item	Description	Part Number
1	Bolts (4-Valve Housing)	023037
2	Dirt and Water Seal 13/16" Serr.	478044
2B	Dirt and Water Seal 7/8" Serr.	478060
2C	Dirt and Water Seal 1" Ser	478050
3	Retaining Ring	401637
4	Seal (Input Shaft)	478076
6	O-ring (2-Aux. Port Plug)	032229
7	Auxiliary Port Plug (2)	415437-A1
9	O-ring (Relief Valve)	032200-153
10	Cap, Relief Valve	411061
11	Seal Ring	032829
12	Ball Bearing Assy.	400152-A1
13	Seal Ring (Valve Housing)	032823
14	Seal Ring (Valve Housing)	029128
16	Thrust Bearing	070027
17	Thrust Washer	400144
18	Seal Ring	029123
19	O-ring	032200-158
20	Bearing Adjuster	400149
21	Adjuster Locknut	027007
24	Push Tube	080154
25	Poppet Spring	401662
26	Poppet (2)	040248
27	Poppet Seat and Sleeve Assy. (2)	409118-A2
29	Balls	213684-X1
31	Cap, Seal	478042
32	Ball Return Guide Cap	400177
33	Torx Screws (2)	020228
36	Grease Fitting	037032
37	Plug, (Auto Bleed)	021397
37A	Screw, Manual Bleed	213705
38	Screw, Fixed Stop	021426
38A	Screw, Poppet Adjusting	
38B	Nut, Poppet Adjusting Screw	
44	O-ring, Sidecover	032856
46	Nut, Jam	025150
47	Plug, Vent (Side Cover)	036201
48	Bolts, Side Cover	021434

Parts Vary by Specification*

Item	Description
5	Valve Housing
8	Relief Valve
15	Input Shaft, Valve, Worm Assy.
28	Rack Piston
34	Housing
41	Sector Shaft (Includes 41A)
45	Side Cover Assembly (Includes 40, 42, 43)

*Contact Service/Sales for part numbers

Kits

Items	Description	Part Number
6 & 7	Port Plug & O-ring	415437-A1
9 & 10	Relief Valve Cap & O-ring	411061-A1
38A & 38B	Adj. Screw & Jam Nut	
	THP/PCF45 Kit	023045-X1
	THP/PCF60 Kit	021407-X1
2, 2B, 2C, 3, 4	Input Shaft Seal Kit	THP000001
	THP/PCF45 Seal Kit	THP450001
	THP/PCF60 Seal Kit	THP600001

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Parts Vary by Gear Size

Item	Description	THP/PCF45	THP/PCF60
22	Rack Piston Seal Ring	032828	032830
23	Rack Piston O-ring	032827	032831
30	Ball Return Guide Halves (2) R.H.	400158	400172
	L.H.	400159	400173
35	Dirt and Water Seal (Trunnion)	478098	478095
39	Roller Bearing (Trunnion)	070030	071033
40	Output Seal (2)	478105	478104
42	Washer	028561	028557
43	Side Cover Roller Bearing	070031	071035
38	Fixed Stop Screw	023044	021426
38A	Poppet Adjusting Screw	023045	021407
38B	Poppet Adjusting Screw Nut	027018	025119

Section 2 Initial Installation

THP/PCF Installation 13
Initial Poppet Setting 13
Maintenance Tips 14

Initial THP/PCF Installation

- Bolt steering gear to frame, torque bolts to vehicle manufacturer's recommendation.
- Connect return line to THP/PCF gear return port.
- Connect hydraulic line from pump to pressure port on THP/PCF unit.
- Connect steering column to input shaft, torque pinch bolt to vehicle manufacturer's recommendation.
- Install pitman arm on output shaft, torque bolt to vehicle manufacturer's recommendation.

Initial Poppet Setting

For this procedure to work correctly, you must have: A new gear received from TRW or your vehicle manufacturer's aftermarket system, **or** a used gear on which poppet seats have been replaced or reset during gear disassembly procedures. **ALSO:** A fixed stop screw installed in the housing, or a poppet adjusting screw installed so that it duplicates the fixed stop screw length.

⚠ CAUTION **The axle stops and all steering linkage must be set according to vehicle manufacturer's specifications, and the pitman arm must be correctly aligned on the sector shaft for poppets to be set correctly.**

Full turn in one direction

1. With the engine at idle and the vehicle unloaded, turn the steering wheel to full travel in one direction until axle stop contact is made. Maximum input torque to be applied during this procedure is 40 lb rim pull (178 N) on a 20 in. (508mm) diameter steering wheel.

NOTE If you encounter excess rim pull effort, allow the vehicle to roll forward or jack up the vehicle at the front axle.

Full turn in other direction

2. Follow the same procedure while turning the steering wheel in the other direction. The poppets are now positioned to trip and reduce pressure as the steered wheels approach the axle stops in either direction.

Maintenance Tips

Never high-pressure wash or steam clean a power steering gear while on or off the vehicle. Doing so could force contaminants inside the gear and cause it to malfunction.

Make sure vehicle wheel cut or clearances meet manufacturer's specifications, and make sure pitman arm timing marks are aligned properly to **prevent internal bottoming** of the steering gear.

Regularly check the fluid and the fluid level in the power steering reservoir.

Keep tires inflated to correct pressure.

Never use a torch to remove pitman arm.

Investigate and immediately **correct the cause of any play, rattle, or shimmy** in any part of the steering system.

Make sure the steering column is aligned properly.

Encourage drivers to report any malfunctions or accidents that could have damaged steering components.

Do not attempt to weld any broken steering component. Replace the component with original equipment only.

Do not cold straighten, hot straighten, or bend any steering system component.

Always **clean off around the reservoir filler cap** before you remove it. Prevent dirt or other foreign matter from entering the hydraulic system.

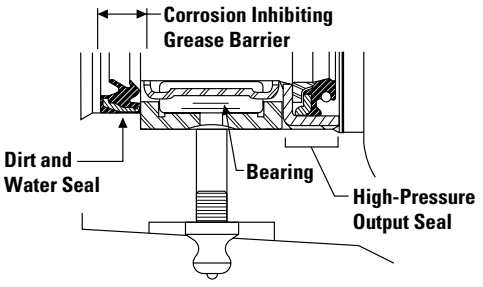
Investigate and correct any external leaks, no matter how minor.

Replace reservoir filters according to requirements.

If you feel the vehicle is developing excessively **high hydraulic fluid temperatures**, consult with your vehicle manufacturer for recommendations.

Maintain grease pack behind the output shaft dirt and water seal as a general maintenance procedure at least twice a year, in the Spring and Fall. Grease fitting is provided in housing trunnion. Use Exxon Polyrex EP2 (P/N 045422 or NLGI grade 2 or 3 multipurpose chassis lube, and use only a hand operated grease gun on fitting. Add grease until it begins to extrude past the sector shaft dirt and water seal.

THP/PCF Gear



Section 3 On-Vehicle Service

Filling and Air Bleeding the System 16
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Filling and Air Bleeding the System

Tools Required	Materials Required
5/16" Socket in•lb Torque wrench	Hydraulic fluid

⚠ CAUTION **Make sure poppets are set correctly before beginning this procedure.**

Run engine for 10 seconds, turn off and fill reservoir

Hydraulic fluid

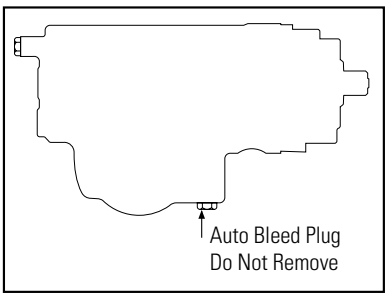
1. Fill the reservoir nearly full. Do not steer. Start and run the engine for 10 seconds, then shut it off. Check and refill the reservoir. Repeat at least three times, checking the reservoir each time.

⚠ CAUTION **Do not allow the fluid level to drop significantly or run out of the reservoir. This may induce air into the system.**

Run engine for 2 minutes, turn off and fill reservoir

Hydraulic fluid

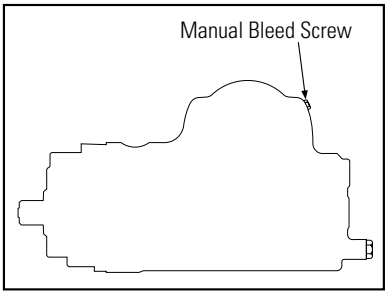
2. Start the engine and let it idle for 2 minutes. Do not steer. Shut off the engine and check the fluid level in the reservoir. Refill as required.



Steer vehicle

3. Start the engine again. Steer the vehicle from full left to full right several times. Add fluid, as necessary, to the full line on the dip stick.

   Automatic bleed systems should now be free from trapped air. **Manual bleed systems continue with step 4.**



Allow air to bleed out from bleed screw

in•lb Torque wrench
5/16" Socket

4. With engine idling, steer from full left turn to full right turn several times. Stop steering and loosen the manual bleed screw about one turn. Allow air and aerated fluid to "bleed out" until only clear fluid is seen. Close the bleed screw, refill the reservoir if required.

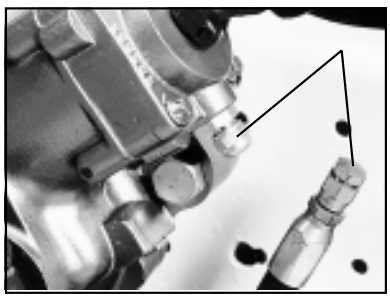
   Repeat step 4 three to four times until all the air is discharged. Torque manual bleed screw to **45 in•lb.**

⚠ CAUTION **Do not turn steering wheel with bleed screw loosened.**

Input Shaft Seal Replacement

Tools Required	Materials Required
Hammer J37073 Seal Driver Screwdriver	Clean cloth Drip pan High pressure fitting Hydraulic fluid Plug Shop towel

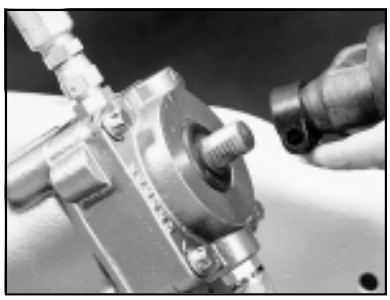
This procedure uses the vehicle's power steering pump to force out the input shaft seal. To use this procedure, the power steering pump should have a minimum of 1,500 psi available.



Disconnect return line

High pressure fitting
Plug

1. Disconnect return line from the steering gear and plug the line. Also cap the return port of the gear with a high pressure fitting.

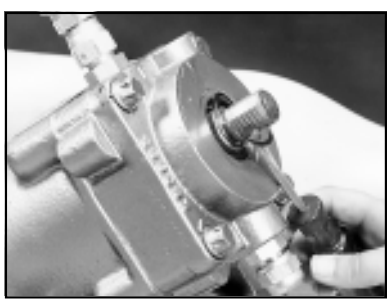


Disconnect column

2. Remove the steering column from the gear input shaft.

Remove dirt & water seal

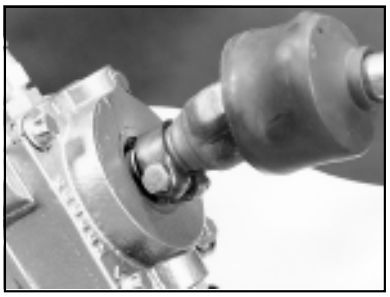
3. Remove the dirt and water seal from the steering gear. Save this seal to match the new seal to the correct size.



Remove retaining ring

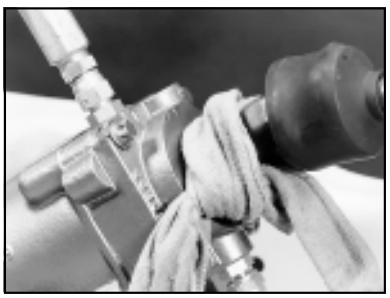
Clean cloth
Screwdriver

4. Wipe out the grease and then remove the spiral retaining ring. Use a screwdriver inserted into the notch formed in the end of the ring. Be careful not to scratch the bore with the screwdriver.



Replace column

5. Slip the steering column back onto the input shaft with the pinch bolt installed, but not tightened.



Wrap exposed area

Drip pan
Shop towel

6. Tie or wrap a shop towel around the input shaft area and place a drip pan under the vehicle to catch the oil.

Fill reservoir

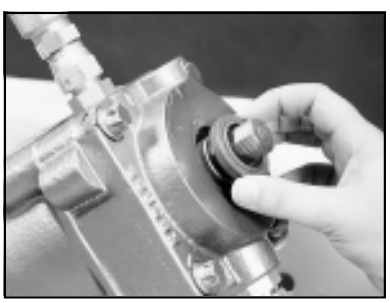
Hydraulic fluid

7. Add fluid as necessary, to the full line on the dip-stick. Do not mix fluid types.

⚠ WARNING **Any mixture of fluid types, or use of any unapproved fluid could lead to seal deterioration and leaks. A leak could ultimately cause the loss of fluid, which could result in a loss of power steering assist.**

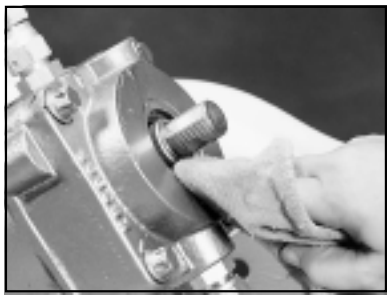
Force out the seal

8. With the vehicle in neutral, momentarily turn the starter (quickly turn off the engine if it starts).



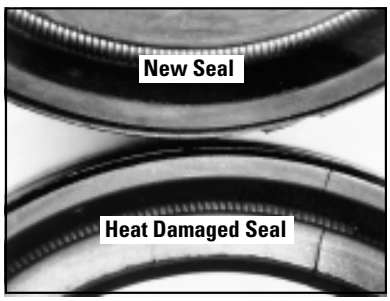
Remove input shaft seal

9. Remove the shop towel. Disconnect the steering column, and remove the input shaft seal.



Inspect seal area

10. Check the seal area of the valve housing for any seal fragments. Remove any that are found.



Inspect old seal

11. Check the seal for heat damage. If the seal is stiff and brittle, and not pliable like the new seal, it is probably heat damaged. Determine and fix the cause of excessive heat in the vehicle.

Install new seal

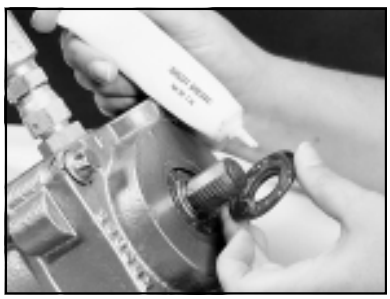
Hammer
J37073 Seal Driver

12. Put clean grease 045422 on the inside dia. of the new input shaft seal, and place it over the input shaft. With the small dia. of tool J37073 against the seal, tap the tool until the tool shoulder is square against the valve housing. Remove any seal material that may have sheared off in the seal bore or retaining ring groove.

⚠ CAUTION **Do not use a socket to install this seal because you will not be able to control seal installation depth, possibly causing a leak.**

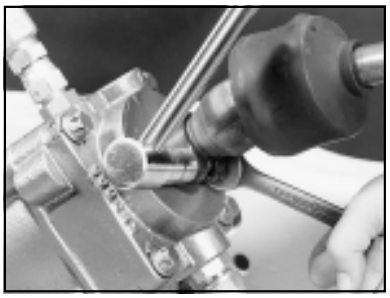
Install retaining ring

13. Insert new retaining ring into the groove.



Install dirt & water seal

14. Pack the end of the valve housing bore around the input shaft with grease 045422. Choose the correct size dirt & water seal by comparing the choices to the old seal, or by measuring the major diameter of the input shaft serrations (see chart next page). Apply more grease 045422 to the new dirt & water seal and install it over the input shaft. Seat it in the groove behind the serrations and against the valve housing.



Reconnect column

15. Reconnect the steering column to the input shaft and tighten the pinch bolt to torque level specified.

Reconnect return line

16. Reconnect the return line to the steering gear return port.

Air bleed system

17. Air bleed the system using the procedure on pg. 16.

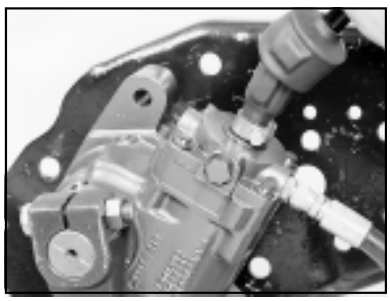
Seal Part No.	Serration Size	Major Serration Dia.
478044	13/16" x 36	0.807 / 0.799
478060	7/8 x 36	0.866 / 0.857
478050	1" x 36	0.987 / 0.977
478050	1" x 79	1.008 / 1.000

Sector Shaft Adjustment

Tools Required	Materials Required
Screwdriver ¾" Socket ¾" Open end wrench	

This adjustment can only be completed on the vehicle if the adjusting screw jam nut is accessible. This nut is located on the side cover.

Photos in this section were taken on a mock frame rail for clarity.



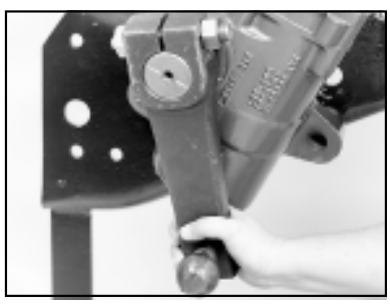
Center the sector shaft

1. With the engine on, rotate the steering wheel (input shaft) until the timing mark on the sector shaft lines up with the mark on the housing. The line on the sector shaft should be at a 90° angle from the input shaft. The sector shaft is now on its "center of travel". Turn the vehicle off.

Remove the drag link

2. Remove the drag link from the pitman arm.

> **⚠ CAUTION** **To avoid resetting the poppets, do not rotate the input shaft more than 1½ turns from the "center of travel" position while the drag link is disconnected.**



Check for sector shaft lash

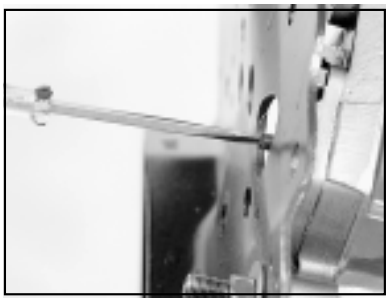
3. From the "center of travel" position, grasp the pitman arm and gently try to rotate it back and forth. If looseness or lash is felt at this point, the sector shaft is out of adjustment.

Loosen jam nut

¾" Socket

4. Loosen the jam nut.

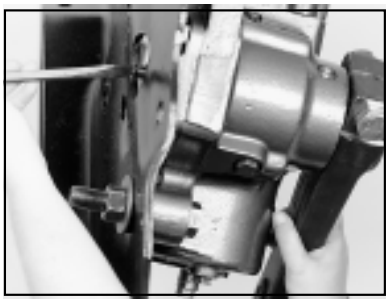
> **NOTE** If the gear is removed from the vehicle to adjust the lash:
> - Leave the pitman arm connected to the gear.
> - Best option is to follow the Final Adjustment procedure on page 62.
> - Alternate option is to continue with step 5 of this procedure.



Position adjusting screw

Screwdriver

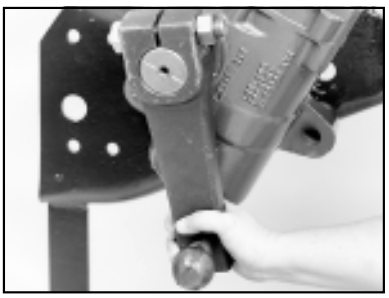
5. If no lash was detected in step 3, turn the shaft adjusting screw counterclockwise until you feel lash at the output shaft.



Adjust shaft

Screwdriver
¾" Open end wrench

6. Slowly turn the shaft adjusting screw clockwise until you feel no lash at the output shaft without using more than **10 ft•lb** (14 N•m) of torque. From this position, turn the screw clockwise ⅛ to 3⁄16 of a turn more. Hold the adjusting screw in place, and tighten the jam nut. Final jam nut torque **43 ft•lb** (58 N•m).



Recheck for lash

7. Turn the steering wheel ¼ turn each side of center, then back to center and recheck the pitman arm for lash. You should feel no lash; if there is lash, repeat steps 4, 6 and 7.

Connect drag link

8. Reconnect the drag link to the pitman arm according to manufacturer's specifications.

⚠ CAUTION **Maintain grease in the sector shaft bearing through the grease fitting in the housing using only a hand operated grease gun. Add grease until it begins to extrude past the dirt and water seal. Do not use a power grease gun because it will supply grease too fast; this could adversely affect the high pressure seal and contaminate the hydraulic fluid.**

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Poppet Readjustment - Single Gears

Tools Required

THP/PCF45
6mm Allen wrench
19mm Open end wrench
19mm Socket
18mm Open end wrench
THP/PCF60
7/32" Allen wrench
3/4" Open end wrench
3/4" Socket
5/8" Open end wrench
ft•lb Torque wrench

Materials Required

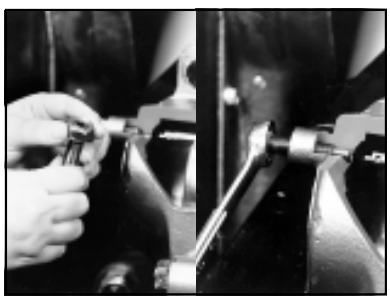
Hydraulic fluid
Jack

This resetting procedure will work in most cases with at least 1¾ hand-wheel-turns from each side of center. If you're making a large reduction in wheelcut and this procedure does not work, you may have to replace or internally reset the poppets using the procedure described in the Poppet Component section of this Service Manual.

Set axle stops, warm-up system

1. Set the axle stops to vehicle manufacturer's wheelcut or clearance specifications.

   Start the engine and allow the vehicle to idle for 5-10 minutes to warm the hydraulic fluid. Shut off the engine.



Assemble adjusting screw into nut

2. If a new poppet adjusting screw and nut are being used, turn the screw into the non-sealing end of the jam nut until the drive end of screw is flush with the nut.

   Your steering gear will have either a fixed stop bolt or an adjusting screw. If the adjusting screw is already part of the steering gear, back the nut off of the adjusting screw until it is flush with the end of the adjusting screw.

Remove poppet stop bolt

THP/PCF45
18mm Open end wrench
THP/PCF60
5/8" Open end wrench

3. Make sure the engine is off and the road wheels are in straight ahead position. Remove and discard the poppet fixed stop bolt (if equipped) and washer (if equipped) from the lower end of the housing.

   If the unit has a poppet adjusting screw and sealing nut that need to be replaced, remove and discard them.

Turn adjusting screw assembly into housing

THP/PCF45
6mm Allen wrench
19mm Wrench
THP/PCF60
7/32" Allen wrench
3/4" Wrench

4. Turn the adjusting screw and sealing nut assembly, without rotating the nut on the screw, into the housing until the nut is firmly against the housing using a 6mm (THP/PCF45) or 7/32" (THP/PCF60) Allen wrench. Tighten the sealing nut against the housing.

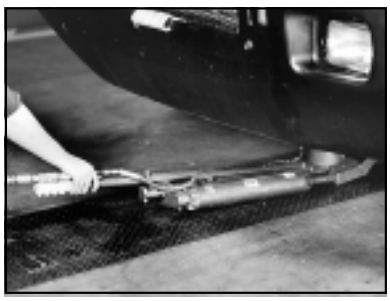
⚠ CAUTION **If the drive end of the screw is below the face of the nut, the poppet seat flange will break during step 7d.**

Refill reservoir

Hydraulic fluid

5. Refill the system reservoir with approved hydraulic fluid.

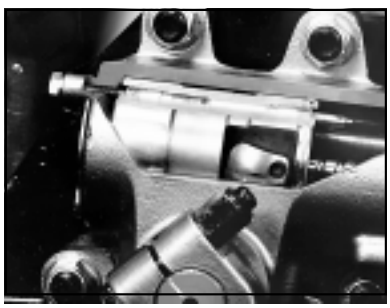
⚠ CAUTION **Do not mix fluid types. Mixing of transmission fluid, motor oil, or other hydraulic fluids will cause seals to deteriorate faster.**



Jack up vehicle

Jack

6. Place a jack under the center of the front axle and jack up the front end of the vehicle so the steer axle tires are off the ground.

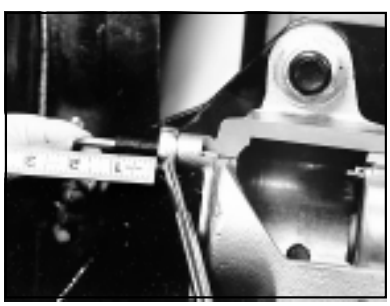


Push upper poppet out to prepare it for setting

7. **a)** Start the engine and let it run at idle speed.
   b) Note which output shaft timing mark is nearest the housing piston bore.
   c) Turn the steering wheel in the direction that makes this timing mark move toward the adjusting screw just installed. Turn in this direction until axle stop contact is made.
   d) Pull hard on the steering wheel (put up to 40 lb rim pull on a 20" dia. steering wheel) after the axle stop is contacted.

Set upper poppet

8. **a)** Turn the steering wheel in the opposite direction (end of timing mark away from adjusting screw) until the other axle stop is contacted.
   b) Pull hard on the steering wheel (put up to 40 lb rim pull on a 20" dia. steering wheel).
   c) Release the steering wheel and shut off the engine.



Back out adjusting screw

THP/PCF45
6mm Allen wrench
19mm Wrench
THP/PCF60
7/32" Allen wrench
3/4" Wrench

9. Loosen the sealing nut and back out the adjusting screw until 1" is past the nut. Tighten the sealing nut against the housing.

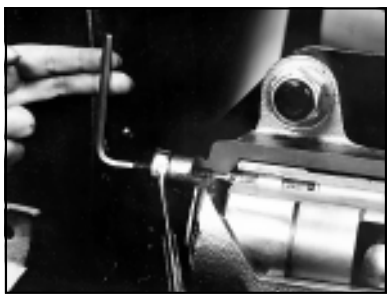
⚠ CAUTION **Do not hold the steering wheel at full turn for more than 10 seconds at a time; the heat build-up at pump relief pressure may damage components.**

Set lower poppet

10. **a)** Start the engine and let it idle.

b) Turn the steering wheel in the original direction (end of timing mark toward adjusting screw), until axle stop contact is made.

c) Hold the steering wheel in this position (with up to 40 lb rim pull) for 10 seconds, then release. Repeat this hold and release process as many times as necessary while completing step 11.



Position adjusting screw

THP/PCF45
6mm Allen wrench
19mm Wrench
19mm Socket
THP/PCF60
7⁄32" Allen wrench
¾" Wrench
¾" Socket
ft•lb Torque wrench

11. **a)** With steering wheel held tightly at full turn loosen the jam nut and hold it in place with a wrench.

b) Turn the adjusting screw in (clockwise) using **finger-pressure only (don't use a ratchet)**, until the Allen wrench stops. Do not attempt to turn it in further. Pause the turning-in process each time the driver releases the steering wheel; continue turning only while the wheel is held at full turn.

c) Back off the adjusting screw 3¼ turns and tighten the sealing nut. Torque sealing nut to **35 ft•lb**. (48 N•m)

The procedure is complete

12. The poppets have now been completely reset. Lower the vehicle. Check the reservoir and fill if required.

⚠ WARNING **The length of the adjusting screw beyond the nut must be no more than 1 1⁄16" for proper thread engagement.**

NOTE The length of adjusting screw beyond the sealing nut may be different for each vehicle.

Poppet Readjustment - Dual Gears

Mirror Image Systems and Reversed Image Systems

Before setting poppets on a dual gear system, you must determine whether the system has mirror image gears or reversed image gears. The procedures are slightly different for each type of system.

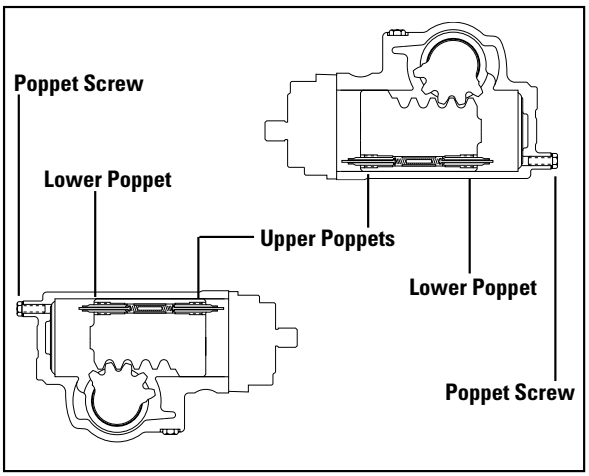
1. Park the vehicle with the wheels turned all the way to the axle stop in either direction. Turn the vehicle off.

2. Look at the output shaft timing mark nearest the housing piston bore on the master gear. Is this mark pointing toward the poppet screw or away from it?

3. Now check the same timing mark on the rotary cylinder. Does it point toward the poppet screw or away from it?

   If they point to opposite ends of the gears you have a mirror image system, see pg. 27.

   If they both point toward the poppet screws or both point toward the end opposite the poppet screws, you have a reversed image system, see pg 29.



Poppet Readjustment - Dual Gears - Mirror Image

Tools Required

THP/PCF45
6mm Allen wrench
19mm Open end wrench
19mm Socket
18mm Open end wrench
THP/PCF60
7/32" Allen wrench
3/4" Open end wrench
3/4" Socket
5/8" Open end wrench
ft•lb Torque wrench

Materials Required

Hydraulic fluid
Jack

This resetting procedure will work in most cases with at least 1¾ hand-wheel-turns from each side of center. If you're making a large reduction in wheelcut and this procedure does not work, you may have to replace or internally reset the poppets using the procedure described in the Poppet Component section of this Service Manual.

1. Set the axle stops to vehicle manufacturer's wheelcut or clearance specifications.

   Start the engine, and allow the vehicle to idle for 5-10 minutes to warm the hydraulic fluid. Shut off the engine.

2. If new poppet adjusting screws and nuts will be used, turn each screw into the non-sealing end of the jam nut until the drive end of screw is flush with the nut.

   Your steering gear and rotary cylinder will both have either fixed stop bolts or adjusting screws. If the adjusting screw is already part of the gear or cylinder, back the nut off of the adjusting screw until it is flush with the end of the adjusting screw.

3. Make sure the engine is off and the road wheels are in straight ahead position. Remove and discard the poppet fixed stop bolt (if equipped) and washer (if equipped) from the lower end of housing on both the gear and the cylinder.

   If either unit has a poppet adjusting screw and sealing nut that need to be replaced, remove and discard them.

4. On both the master gear and the rotary cylinder, turn the adjusting screw and sealing nut assembly, without rotating the nut on the screw, into the housing until the nut is firmly against the housing using a 6mm (THP/PCF45) or 7/32" (THP/PCF60) allen wrench. Tighten the sealing nut against the housing.

5. Refill system reservoir with approved hydraulic fluid.

   ⚠ CAUTION **Do not mix fluid types. Mixing of transmission fluid, motor oil, or other hydraulic fluids will cause seals to deteriorate faster.**

6. Place a jack under the center of the front axle and jack up the front end of the vehicle so the steer axle tires are off the ground.

7. **a)** Start the engine and let it run at idle speed.

   b) Turn the steering wheel in the direction that makes the timing mark on the master gear move toward the adjusting screw just installed. Turn in this direction until axle stop contact is made.

   c) Pull hard on the steering wheel (put 40 lbs. rim pull on a 20" dia. steering wheel) after the axle stop is contacted.

8. **a)** Turn the steering wheel in the opposite direction (end of timing mark on the master gear away from adjusting screw) until the other axle stop is contacted.

   b) Pull hard on the steering wheel (put 40 lbs. rim pull on a 20" dia. steering wheel).

   c) Release the steering wheel and shut off the engine.

9. Loosen the sealing nut and back out the adjusting screw on the master gear until 1" is past the nut. Tighten the sealing nut against the housing.

   ⚠ CAUTION **Do not hold the steering wheel at full turn for more than 10 seconds at a time; the heat build-up at pump relief pressure may damage components.**

10. **a)** Start the engine and let it idle.

    b) Turn the steering wheel in the original direction (end of timing mark on the gears toward adjusting screw), until axle stop contact is made.

    c) Hold the steering wheel in this position (with 40 lbs. rim pull) for 10 seconds, then release. Repeat this hold and release process as many times as necessary while completing steps 11 & 12.

11. **a)** With steering wheel held at full turn, loosen the jam nut on the master gear and hold it in place with a wrench.

    b) Turn the adjusting screw in (clockwise) using **finger- pressure only** (don't use a ratchet), until the Allen wrench comes to a stop. Do not attempt to turn it in farther. Pause the turning-in process each time the driver releases the steering wheel; Continue turning only while the wheel is held at full turn.

    c) Back off the adjusting screw 3¼ turns and tighten the sealing nut. Torque the sealing nut to **33-37 ft•lb.** (45-50 N•m)

    d) Release the steering wheel and shut off the engine.

12. Loosen the sealing nut and back out the adjusting screw on the rotary cylinder until 1" is past the nut. Tighten the sealing nut against the housing.

13. **a)** Start the engine and let it idle.

    b) Turn the steering wheel in the opposite direction (end of timing mark on master gear away from adjusting screw), until axle stop contact is made.

    c) Hold the steering wheel in this position (put up to 40 lb. rim pull on a 20" dia. steering wheel) for 10 seconds, then release. Repeat this hold and release process as many times as necessary while completing step 14

14. **a)** With steering wheel held at full turn, loosen the jam nut on the rotary cylinder and hold it in place with a wrench.

    b) Turn the adjusting screw in (clockwise) using **finger- pressure only** (don't use a ratchet), until the Allen wrench comes to a stop. Do not attempt to turn it in farther. Pause the turning-in process each time the driver releases the steering wheel; Continue turning only while the wheel is held at full turn.

    c) Back off the adjusting screw 3¼ turns and tighten the sealing nut. Torque the sealing nut to **33-37 ft•lb.** (45-50 N•m)

    d) Release the steering wheel and shut off the engine.

15. The poppets have now been completely reset. Lower the vehicle . Check the reservoir and fill if required.

⚠ WARNING **The length of the adjusting screw beyond the nut must be no more than 1 1/16" for proper thread engagement.**

NOTE The length of adjusting screw beyond the sealing nut may be different for each vehicle.

Poppet Readjustment - Dual Gears - Reversed Image

Tools Required

THP/PCF45
6mm Allen wrench
19mm Open end wrench
19mm Socket
18mm Open end wrench
THP/PCF60
7/32" Allen wrench
3/4" Open end wrench
3/4" Socket
5/8" Open end wrench
ft•lb Torque wrench

Materials Required

Hydraulic fluid
Jack

This resetting procedure will work in most cases with at least 1¾ hand-wheel-turns from each side of center. If you're making a large reduction in wheelcut and this procedure does not work, you may have to replace or internally reset the poppets using the procedure described in the Poppet Component section of this Service Manual.

1. Set the axle stops to vehicle manufacturer's wheelcut or clearance specifications.

   Start the engine, and allow the vehicle to idle for 5-10 minutes to warm the hydraulic fluid. Shut off the engine.

2. If new poppet adjusting screws and nuts are being used, turn the screws into the non-sealing end of the jam nuts until the drive end of screw is flush with the nut.

   Your steering gear and rotary cylinder will have either fixed stop bolts or adjusting screws. If the adjusting screw is already part of the steering gear or cylinder, back the nut off of the adjusting screw until it is flush with the end of the adjusting screw.

3. Make sure the engine is off and the road wheels are in straight ahead position. Remove and discard the poppet fixed stop bolts (if equipped) and washers (if equipped) from the lower end of housing on both the master gear and the rotary cylinder.

   If the unit has poppet adjusting screws and sealing nuts that need to be replaced, remove and discard them.

4. Turn the adjusting screws and sealing nut assemblies, without rotating the nut on the screw, into the housing until the nut is firmly against the housing, on both the master gear and the rotary cylinder, using a6mm (THP/PCF45) or 7/32" (THP/PCF60) allen wrench. Tighten the sealing nut against the housing.

5. Refill system reservoir with approved hydraulic fluid.

   ⚠ CAUTION **Do not mix fluid types. Mixing of transmission fluid, motor oil, or other hydraulic fluids will cause seals to deteriorate faster.**

6. Place a jack under the center of the front axle and jack up the front end of the vehicle so the steer axle tires are off the ground.

7. **a)** Start the engine and let it run at idle speed.

   b) Note which output shaft timing mark is nearest the housing piston bore.

   c) Turn the steering wheel in the direction that makes this timing mark move toward the adjusting screws just installed on both the gear and the cylinder. Turn in this direction until axle stop contact is made.

   d) Pull hard on the steering wheel (put 40 lbs. rim pull on a 20" dia. steering wheel) after the axle stop is contacted.

8. **a)** Turn the steering wheel in the opposite direction (end of timing mark away from adjusting screw) until the other axle stop is contacted.

   b) Pull hard on the steering wheel (put 40 lbs. rim pull on a 20" dia. steering wheel).

   c) Release the steering wheel and shut off the engine.

9. Loosen the sealing nut and back out the adjusting screw until 1" is past the nut on both the master gear and the rotary cylinder. Tighten the sealing nuts against both housings.

   ⚠ CAUTION **Do not hold the steering wheel at full turn for more than 10 seconds at a time; the heat build-up at pump relief pressure may damage components.**

10. **a)** Start the engine and let it idle.

    b) Turn the steering wheel in the original direction (end of timing mark toward adjusting screw), until axle stop contact is made.

    c) Hold the steering wheel in this position (with 40 lbs. rim pull) for 10 seconds, then release. Repeat this hold and release process as many times as necessary while completing steps 11 and 12, first on the master gear, then on the rotary cylinder.

11. **a)** With steering wheel held at full turn, loosen the jam nut on the master gear, and hold it in place with a wrench.

    b) Turn the adjusting screw in (clockwise) using **finger- pressure only** (don't use a ratchet), until the Allen wrench comes to a stop. Do not attempt to turn it in farther. Pause the turning-in process each time the driver releases the steering wheel; Continue turning only while the wheel is held at full turn.

    c) Back off the adjusting screw 3¼ turns and tighten the sealing nut. Torque nut to **33-37 ft•lb.** (45-50 N•m)

12. **a)** With steering wheel held at full turn, loosen the jam nut on the rotary cylinder and hold it in place with a wrench.

    b) Turn the adjusting screw in (clockwise) using **finger- pressure only** (don't use a ratchet), until the Allen wrench comes to a stop. Do not attempt to turn it in farther. Pause the turning-in process each time the driver releases the steering wheel; Continue turning only while the wheel is held at full turn.

    c) Back off the adjusting screw 3¼ turns and tighten the sealing nut. Torque nut to **33-37 ft•lb.** (45-50 N•m)

13. The poppets on both the master gear and rotary cylinder have now been completely reset. Lower the vehicle . Check the reservoir and fill if required.

⚠ WARNING **The length of the adjusting screw beyond the nut must be no more than 1 1/16" for proper thread engagement.**

NOTE The length of adjusting screw beyond the sealing nut may be different for each vehicle.

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Section 4 Reseal & Repair

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- Valve Housing Worm Screw Disassembly 53
- Roller Bearing or Retaining Ring Replacement 60
- Replace Housing Port Plugs, Screws, and Fittings .. 61

Final Adjustments 63

Disassembly Preparation

Stop the vehicle with wheels pointed straight ahead.

Clean off all outside dirt from around fittings and hose connections before you remove the gear.

Remove input and output shaft connections per vehicle manufacturer's instructions.

⚠ WARNING **When using a chisel to spread a pinch bolt-type pitman arm boss for assembly or removal from the shaft, maintain a firm grip on the chisel at all times. Failure to do this may result in the chisel flying loose which could cause an injury. Never leave the chisel wedged in the pitman arm boss. If you cannot remove the pitman arm from the shaft with a chisel and your hands, remove the chisel from the arm boss and use a puller only to remove pitman arm.**

⚠ CAUTION **Do not use a hammer on the pitman arm to remove it from sector shaft as internal damage to steering gear could result. Be sure there is no spreading wedge left in the pitman arm boss before tightening pitman arm clamp bolt after assembly on sector shaft. Do not pound the universal joint or input shaft coupling on or off the input shaft as internal damage to the steering gear can result.**

⚠ CAUTION **Unless the poppet adjuster seat and sleeve assemblies (27) are to be removed and replaced or reset for automatic poppet adjustment, or a manual adjustment with a service poppet adjuster screw (38A) and nut (38B) is anticipated, do not allow the input shaft on a steering gear with the automatic poppet adjustment feature to rotate more than 1.5 input shaft revolutions from "straight ahead position" when the output shaft is disconnected from the vehicle steering linkage; this could disrupt the poppet setting achieved at initial installation. The steering gear is in the "straight ahead position" when the timing marks on the end of the housing trunnion and sector shaft are aligned.**

Remove the supply and return lines from the gear, and immediately plug all port holes and fluid lines.

⚠ WARNING **THP/PCF steering gears can weigh up to 70 pounds dry. Exercise caution when you remove, lift, carry, or fix in a bench vise.**

Remove the steering gear from the vehicle and take it to a clean work surface.

Clean and dry the gear before you start to disassemble it.

As you disassemble the gear, clean all parts in clean, OSHA approved solvent, and air blow-dry them only.

⚠ WARNING **Because they are flammable, be extremely careful when using any solvents. Even a small explosion or fire could cause injury or death.**

⚠ WARNING **Wear eye protection and be sure to comply with OSHA or other maximum air pressure requirements.**

⚠ CAUTION **Never steam clean or high-pressure wash hydraulic steering components. Do not force or abuse closely fitted parts. Use care that bearing and sealing surfaces are not damaged by the assembly and disassembly procedures.**

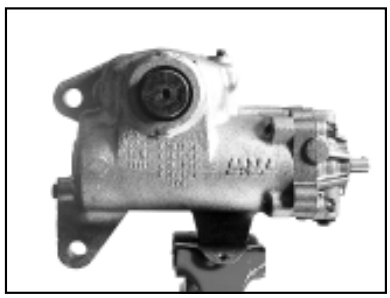
Keep each part separate to avoid nicks and burrs.

Discard all seals, o-rings, and gaskets removed from the gear. Replace them with new parts only.

The steering gear should be identified to the vehicle from which it was removed. The poppet adjuster seat and sleeve assemblies are set for that particular vehicle only.

Disassembly

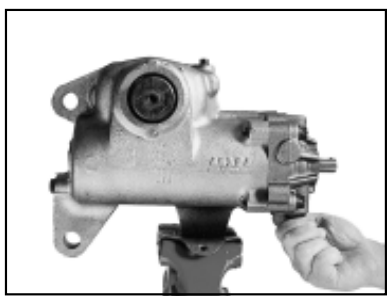
Tools Required		Materials Required
Allen wrenches Pocket knife Ratchet Rolling head pry bar Rubber mallet	Screwdriver Sockets: •Standard •Torx Vise	Emery cloth Masking tape



Position gear in vise

1. Put the steering gear in a vise, clamping firmly against the housing mounting flange or boss. Input shaft should be horizontal; side cover and valve housing are accessible for disassembly.

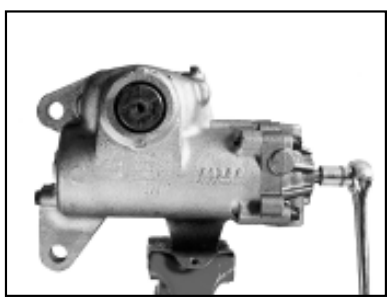
⚠ CAUTION **Do not clamp against body of housing. If mounting boss or flange is not accessible, fabricate and attach a mounting plate to the housing mounting bosses.**



Unplug ports

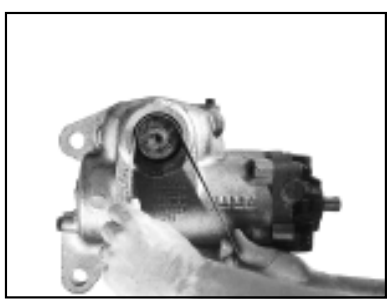
Appropriate size socket or open-end wrench

2. Prepare for fluid drainage and unplug hydraulic ports.



Position sector shaft

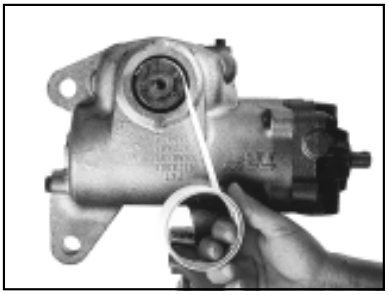
3. Rotate the input shaft until the timing mark on the end of the sector shaft is in line with the timing mark on the end of the housing. This will position the sector shaft for removal.



Clean sector shaft

Fine grade emery cloth

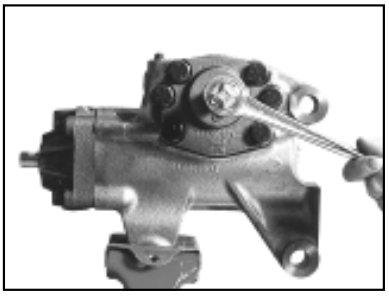
4. Remove any paint or corrosion from the exposed area of the sector shaft (41).



Tape sector shaft

Masking tape

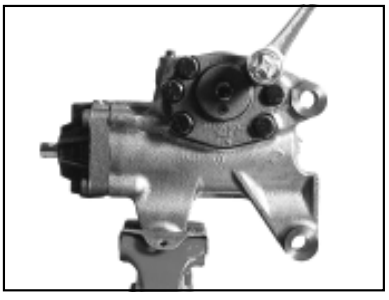
5. Tape the serrations and bolt groove of the sector shaft with one layer of masking tape. The tape should not extend onto the sector shaft bearing diameter.



Remove jam nut

¾" Socket

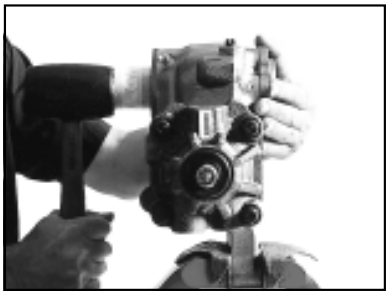
6. Remove the sector shaft adjusting screw jam nut (46).



Remove side cover bolts

15⁄16" Socket

7. Be prepared for more fluid drainage and remove the six bolts (48) from the side cover (45).



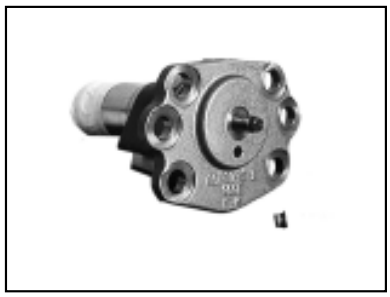
Remove side cover

Soft mallet

8. Be prepared for more fluid drainage and remove the side cover and sector shaft assembly from the gear. You may start the shaft and cover assembly removal by tapping the end of the shaft lightly with a soft mallet or wooden hammer handle.

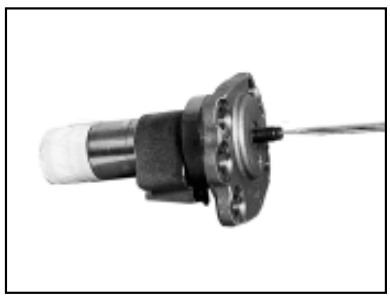
Discard O-ring

9. Remove and discard the side cover o-ring (44).



Remove vent plug

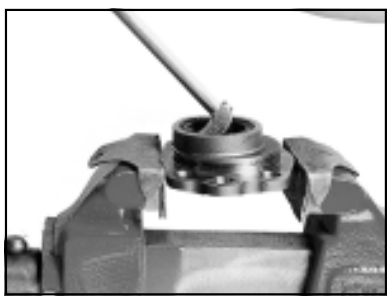
10. Remove and discard the vent plug (47).



Remove sector shaft from cover

Screwdriver

11. Turn sector shaft adjusting screw (41A) clockwise through the side cover and pull the sector shaft out of the side cover.



Remove side cover seal and washer

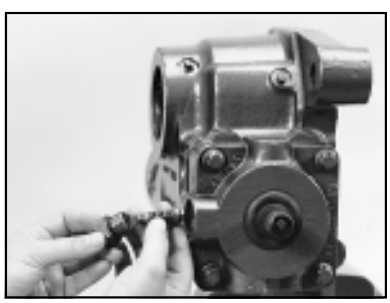
⅜" Drive socket
Rolling head pry bar

12. **⚠ CAUTION** **Don't damage the bore or bearing when removing the seal.**

Clamp the side cover in a vise. Place a standard ⅝" or 11⁄16" - ⅜ drive socket in the center of the side cover. Pry the seal (40) out with a rolling head pry bar, using the socket for support. Discard the seal and remove the socket. Remove washer (42).

Inspect adjusting screw and retainer

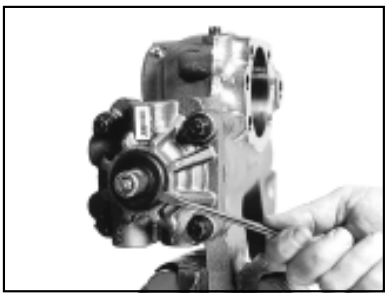
13. Inspect the sector shaft assembly for damaged adjusting screw threads. The retainer (41B, not shown) must be securely staked in place. The adjusting screw must rotate by hand with no perceptible end play (lash).



Remove relief valve components

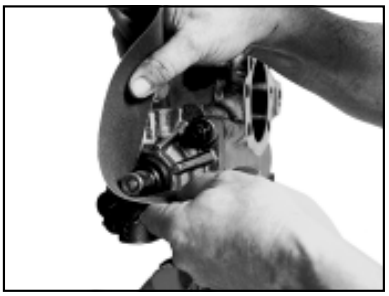
⅞" Socket

14. If equipped, remove relief valve cap (10), o-ring (9) and two-piece relief valve (8) from the valve housing. Discard the o-ring.



Remove dirt & water seal

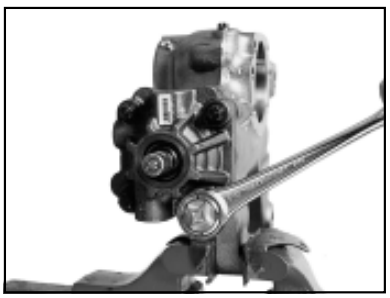
15. Remove and discard the dirt & water seal (2, 2B or 2C) from the input shaft worm and valve assembly. Save this seal for comparison with the new seal.



Clean input shaft

Fine grade emery cloth

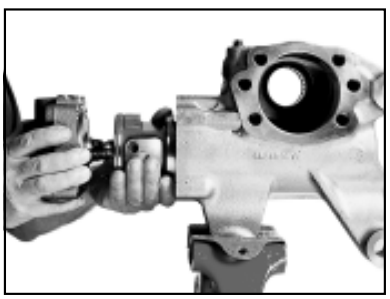
16. Clean any paint or corrosion from the exposed area of the input shaft.



Remove valve housing bolts

E-18 Torx socket

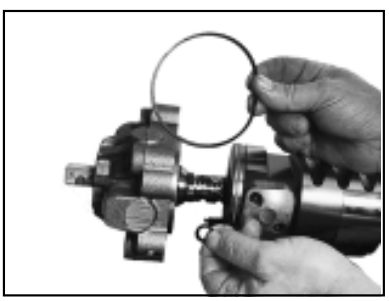
17. Remove the four torx head valve housing bolts (1).



Remove valve housing, worm and rack subassembly

18. Be prepared for more fluid drainage and remove the rack piston subassembly. Place the assembly on a clean cloth.

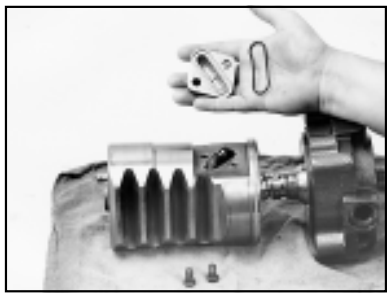
⚠ CAUTION **The set position of poppet seat and sleeve assemblies (27) must not be disturbed if the poppets are not going to be replaced or reset during disassembly.**



Remove seals

19. Remove and discard the valve housing seal rings (11& 13).

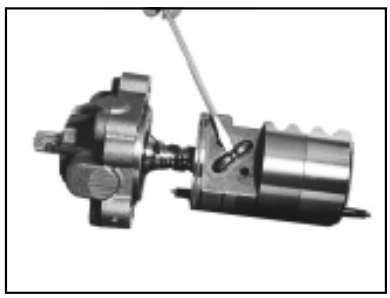
⚠ CAUTION **Do not remove the input shaft, valve worm assembly or balls from the rack piston until the ball return guides are removed as damage to the ball guides will occur.**



Remove ball return guide cap

T-30 Torx wrench

20. Remove and discard the two special sealing screws (33). Remove the ball return cap (32) and seal (31), discard the seal.



Remove ball return guides

Screwdriver

21. Make sure the rack piston is on a cloth so the steel balls that fall out won't roll very far. Remove ball return guide (30) by carefully inserting a screwdriver between the rack piston and guides.

NOTE Left hand ball return guide halves are plated with copper or zinc chromate for identification. Right hand guides are not plated. **Retain the guides for reassembly**.

Remove steel balls

22. Remove the steel balls (29) from the rack piston (28) by rotating the input shaft, valve worm assembly until the balls fall out. Place the balls and return guides in a cup or other container. Count the balls, and make sure all have been removed.

⚠ CAUTION **The steel balls are a matched set. If any are lost, the set must be replaced by service balls. Number of factory balls installed: THP/PCF45 - 29 balls, THP/PCF60 - 31 balls.**

Separate rack piston from worm subassembly

23. Remove the input, worm, and valve housing subassembly from the rack piston.

Remove seal ring and o-ring

Pocket knife

24. Cut and remove the Teflon seal ring (23) and o-ring (22) from the rack piston.

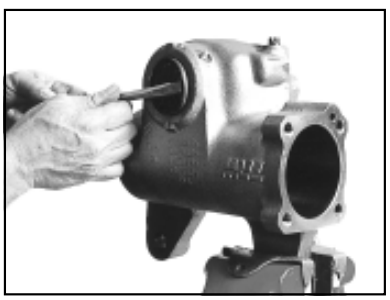
Inspect poppet assemblies

25. Push poppet stems, they should spring back. Push poppet seat, it should not move by hand. If components are bent or broken, poppet stems don't spring back, or poppet seat moves by hand, go to **Poppet Component Replacement** section on page 51. Otherwise, proceed to step 26.

NOTE TRW recommends the poppet adjuster seat and sleeve assemblies (27) not be removed unless replacement of poppet components is required.

Inspect valve housing and worm screw

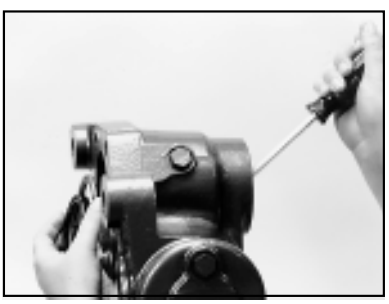
26. Inspect valve housing/worm screw subassembly for heat damage or bearing roughness. If these conditions are present, or if there was excessive internal leakage, or if preload adjustment is required, go to **Valve Housing/Worm Screw Disassembly** procedures on page 53. If not, proceed to step 27.



Remove dirt seal

Screwdriver

27. Remove and discard the dirt and water seal (40).

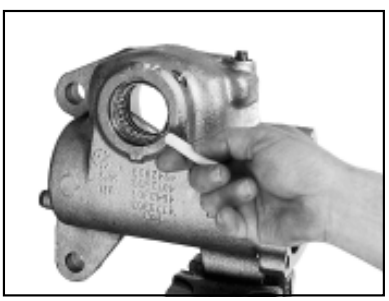


Remove pressure seal

Screwdriver

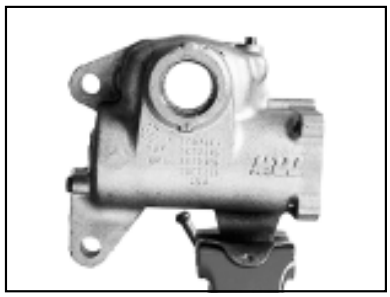
28. Insert a screwdriver through the trunnion opening, and carefully push the seal (40) out ***without damaging the sealing area of the bore***. Discard the seal.

NOTE A special hook groove has been machined into the bore to hold the seal in position. Clean out rubber from groove prior to installing new seal.



Inspect roller bearing

29. Inspect the roller bearing (39) for brinelling or spalling. If replacement is required, go to **Roller Bearing Replacement -** on page 60. If not, proceed to step 30.



Inspect housing screws, and plugs

30. Inspect the following for damage:

- Poppet fixed stop screw (38)
- Poppet adjusting screw (38A) and sealing nut (38B)
- Auto-bleed plug (37)
- Manual bleed screw (Not shown)
- Auxiliary port plugs (7) and o-rings (6)

If any are damaged, go to **Replace Housing Port Plugs and Screws** on page 61. If not, proceed to the Inspection Section.

Inspection

Make sure all sealing surfaces and seal cavities are free from nicks and corrosion. Any nicked or corroded surface requires part replacement to ensure proper sealing.

Wash all parts in clean, OSHA approved solvent. Air blow them dry only.

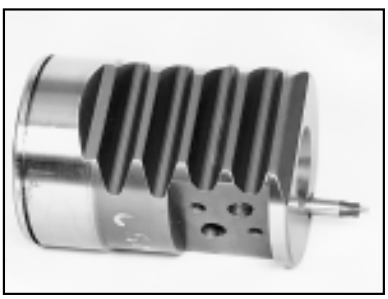
⚠ WARNING **Because they are flammable, be extremely careful when using any solvents. Even a small explosion or fire could cause injury or death.**

⚠ WARNING **Wear eye protection and be sure to comply with OSHA or other maximum air pressure requirements.**

⚠ WARNING **Any of the following conditions present in the steering gear indicates impact damage.**

Condition	Area
Brinelling	**• Ball track grooves of rack piston** **• Ball track grooves of worm screw** **• Bearing area of sector shaft** **• Thrust washer and bearing in valve housing** **• Ball cup and bearing in valve housing**
Cracks or Breaks	**• Bearing area of sector shaft** **• Sector shaft teeth** **• Rack piston teeth** **• Housing** **• Thrust washer and bearing in valve housing** **• Worm screw** **• Ball cup and bearing in valve housing**
Twisted serrations	**• Output shaft serrations**

If one of these conditions is found in one component, be sure to inspect all components carefully for signs of impact damage. Replace components noted in individual inspection steps below if you suspect impact damage. Failure to replace all damaged components could result in a serious vehicle accident.



Inspect rack piston teeth

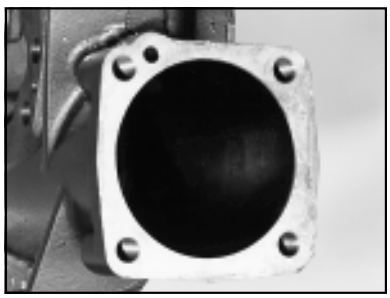
1. Inspect the rack piston (28) teeth for cracks or obvious damage. If teeth are damaged, replace the rack piston, sector shaft (41) and set of balls (29).

Inspect rack piston and worm ball track grooves

2. Inspect the rack piston (28) ball track grooves for brinelling or spalling. If either condition exists, replace the input shaft valve/worm assembly (15), valve housing (5), rack piston subassembly (28) and balls (29).

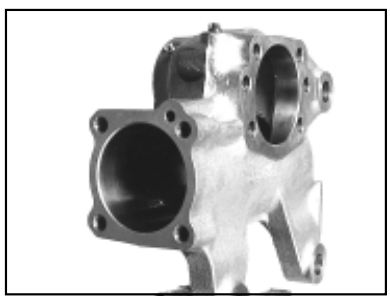
Inspect input shaft, valve/worm assembly sealing areas

3. Inspect the sealing area of input shaft and valve (15) for nicks, and damage. Inspect for discoloration from excess heat. Inspect input shaft ball-track grooves for brinelling or spalling. If any of these conditions exist, replace the input shaft, valve worm assembly, valve housing and balls. Also replace rack piston if brinelling or spalling is found.



Inspect housing cylinder bore

4. Inspect the housing (34) cylinder bore. some scoring marks are normal. If there was internal leakage greater than 1.2 gpm (4.5 lpm), make sure there are no damaged seals before replacing the housing.

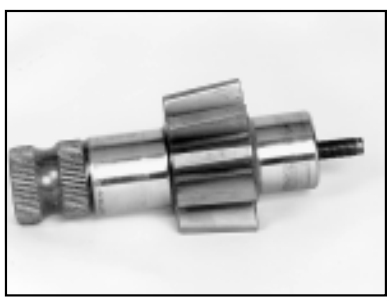


Inspect valve housing surface

5. Inspect the valve housing mating surface for nicks that would prevent proper sealing. Replace the gear housing if these nicks are present and cannot be easily removed with a fine-tooth flat file without changing the dimensional characteristics.

Inspect side cover bearing

6. Inspect roller bearing in side cover assembly (45) for brinelling or spalling. If either condition exists, replace the side cover and bearing assembly.



Inspect sector shaft assembly

7. Inspect the sector shaft (41) bearing and sealing areas and sector teeth contact surfaces for brinelling, spalling or cracks. Run your fingernail edge across these areas to detect steps. Remove masking tape from the shaft and inspect for twisted or otherwise damaged serrations. If any of these conditions exist, replace the sector shaft.

NOTE A service sector shaft will come assembled with the adjusting screw (41A) and retainer (Not shown).

Assembly Preparation

Wash all parts in clean, OSHA approved solvent. Air blow-dry them only.

⚠ WARNING **Because they are flammable, be extremely careful when using any solvents. Even a small explosion or fire could cause injury or death.**

⚠ WARNING **Wear eye protection and be sure to comply with OSHA or other maximum air pressure requirements.**

Replace all seals, seal rings, and gaskets with new ones each time you disassemble the gear.

TRW Commercial Steering Division makes complete seal kits available. These parts can be purchased through most OEM parts distributors. Contact your local dealer for availability.

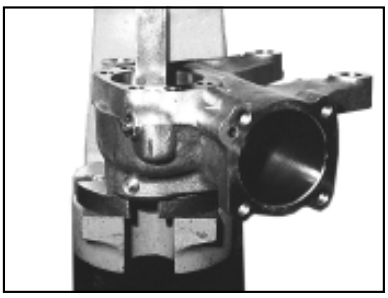
Assembly

Tools Required

Hammer
J37705 (THP/PCF45)
J37071 (THP/PCF60)
Press
Punch
Ratchet
Screwdriver
Sockets
Torx sockets
Vise
Torque wrench

Materials Required

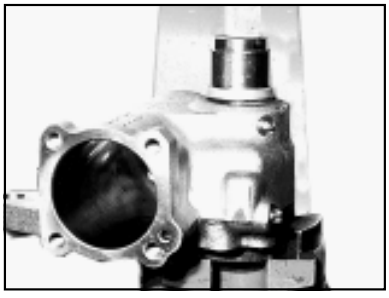
ATF oil
Grease (Exxon Polyrex* EP2
Masking tape
14mm x 2.0mm All Thread
Seal kit: THP450001
THP600001



Press seal into housing

J37705
(THP/PCF45)
J37071
(THP/PCF60)

4. **All gears** - Assemble new seal (40) onto bearing and seal tool (short end) so the lip with the garter spring is toward the shoulder of the tool. Working from the side cover side of the housing, pilot the seal tool into the washer and bearing and press with a force of 100-800 lb (445-3,560 N) until the seal is seated firmly.

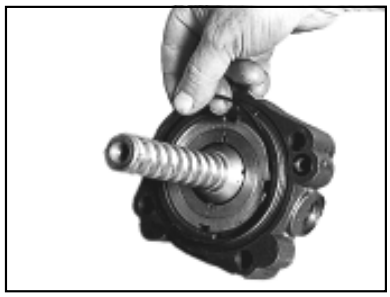


Install dirt & water seal

J37071
Press

6. Install the dirt & water seal (35) with the bearing and seal tool (long end), making sure it is not cocked. **Press the seal only until it seats against the bearing, don't push it in farther.**

Liberally pack the roller bearing and new seals with clean, high temperature industrial grease, Exxon Polyrex EP (P/N 045422).



Assemble seal rings

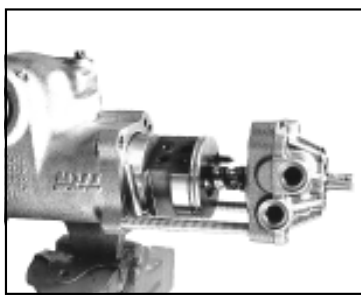
3. Lightly oil new seal ring (11) and assemble in valve housing mounting face groove. Then, oil new seal ring (10) and assemble in valve housing (5) mounting face groove.

Install rack piston o-ring and seal ring

4. Install a new backup o-ring (22) and then a new Teflon seal ring (23) on rack piston (19). Do not over-stretch these rings as you install them. Do not allow the Teflon seal ring to be twisted.

Position rack piston in housing

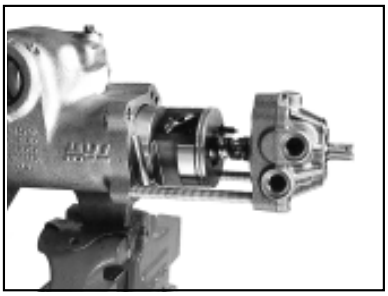
5. Apply clean oil to housing cylinder bore. Place the rack piston (28) in the housing piston bore with ball return guide holes up.



Insert worm and valve assembly into rack piston

14mm x 2.0mm
All Thread

6. Insert the worm screw into the rack piston close to maximum depth, without the valve housing making contact with the poppet stem. Insert two 14 mm x 2.0 mm All Threads through valve housing bolt holes and tighten into housing to support the worm screw. Line up rack piston ball guide holes with the worm ball track grooves by rotating the input shaft.



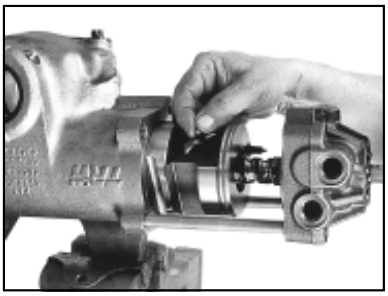
Assemble ball return guide halves

7. Assemble the ball return guide (30) into the rack piston until seated, rotate the input shaft slightly if necessary.

⚠ WARNING **Do not seat guides with a hammer. Damage to guides can result in subsequent lockup or loss of steering.**

⚠ CAUTION **If a new rack piston (28) or a new input shaft, valve, worm subassembly (15) is being assembled, the balls (29) removed from the unit must be discarded and a service ball kit utilized. The balls in a service ball kit are sized to function in the ball track guide path as altered by component replacement.**

⚠ CAUTION **When using the service ball kit, use the correct quantity of service balls: THP/PCF45 - 29 balls, THP/PCF60 - 31 balls.**



Assemble balls

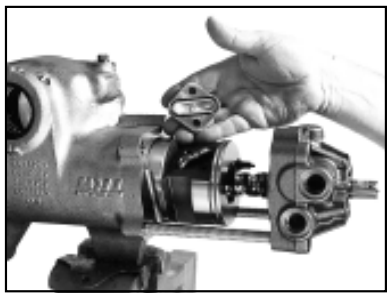
8. **Hold the ball return guide (30) firmly in place during this entire procedure.** Insert as many of the steel balls as you can through the hole in the top of the ball return guides. Rotate the input shaft to pull the balls down and around the ball track guide path. Continue until the correct number of balls are in the ball track guide path.

⚠ WARNING **Hold down the ball return guides until cap is reinstalled. Failure to hold the guides will result in a trapped ball or balls, which could cause a vehicle accident. If the ball guide becomes unseated (raises) at any time, repeat the procedure starting at step 7.**

⚠ WARNING **The correct number of balls are required for proper gear operation. Count the balls and insert each carefully as in step 7. Number required: THP/PCF45 - 29 balls, THP/PCF60 - 31 balls.**

⚠ CAUTION **Do not allow valve housing to contact the poppet stem or move more than 2½ inches (69.1 mm) from upper end of rack piston during these procedures. This could incorrectly reset the poppet, or back out worm beyond closed ball loop, trapping balls.**

⚠ CAUTION **Remove any fluid present in the two screw holes. Fluid in these holes could cause improper clamp load when torquing the cap.**

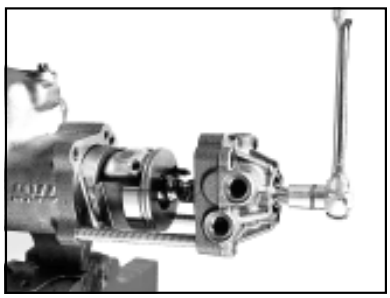


Assemble ball return guide cap

T-30 Torx socket
in•lb Torque wrench
Grease

9. Place a new ball return guide cap seal (31) in the seal groove of the cap (32). Make sure the seal makes full contact with the rack piston surface. Install two new Torx head screws (33) and torque each screw alternately until a final torque of **18 ft•lb** (24.5 N•m) is achieved.

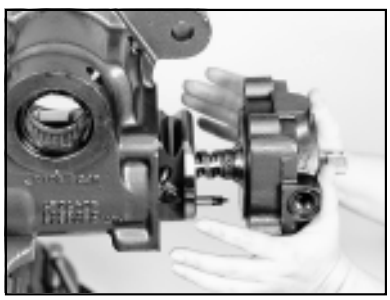
⚠ CAUTION **Ball cap seal is greased to hold seal in groove while assembling. Be sure not to trap the seal outside of the groove during reassembly.**



Rotate input shaft to check for proper installation of balls

10. Rotate the input shaft from one end of travel to the other without contacting the poppet stem to the valve housing, and without moving the valve housing face more than 2½" (69.1 mm) from input end (upper end) of rack piston. If you cannot rotate the input shaft, remove the balls and reassemble them.

⚠ WARNING **If you install a gear on a vehicle with the worm shaft unable to rotate, the gear will not function correctly. Steering and gear failure may result.**



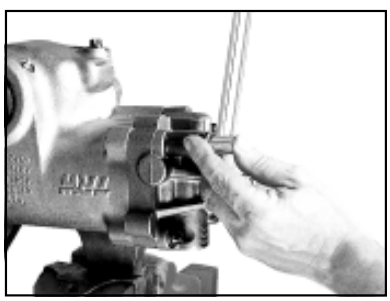
Install rack piston, worm, valve assembly

Oil

11. Apply clean oil to Teflon seal ring (23) on rack piston. Make sure there is a space of ⅜ - ½" (10.0-13.0 mm) between valve housing (5) and poppet stem to prevent poppet contact at either end. Remove the All Threads, and push the rack piston assembly into the housing with the rack piston teeth toward the sector shaft cavity. Line up the valve housing cylinder feed hole with the gear housing feed hole. Make sure both o-rings in the valve housing remain in position.

⚠ CAUTION **Do not damage the seal ring (23) while installing the rack piston into housing.**

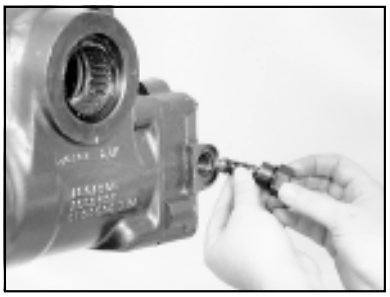
⚠ CAUTION **The poppet seat and sleeve assemblies (27) must not bottom against the internal poppet stops in the steering gear until the gear is installed on the vehicle and the poppet adjustment procedures are performed.**



Install valve housing bolts

E-18 Torx socket
ft•lb Torque wrench

12. Lubricate and install the four valve housing bolts (1) into the housing. Torque the bolts to **118-138 ft•lb** (160-187 N•m).



Install relief valve parts

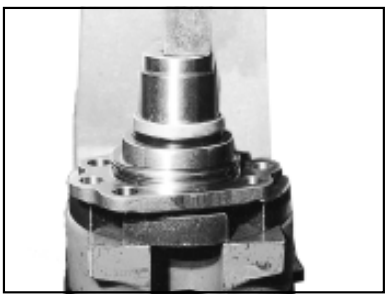
⅞" Socket
ft•lb Torque wrench

13. If the gear is equipped with a relief valve, assemble a new o-ring (9) on relief valve cap (10). Assemble the small end of tapered spring onto the pin on the relief valve cartridge and insert the assembly (8), (large end of tapered spring end first) into the relief valve cap cavity. Turn the relief valve cap as assembled into the valve housing and torque to **30 ft•lb** (41 N•m).

Lubricate side cover bearing

14. Apply a generous amount of Exxon Polyrex* EP2 (TRW P/N 045422, do not substitute another type of grease) to the caged bearing assembly inside the side cover. Next, install washer (42) on top of bearing before inserting the seal (40).

⚠ CAUTION **This bearing is sealed and will receive no lubrication from the hydraulic fluid in the gear. Failure to use the proper grease could result in premature bearing wear.**



Press seal in side cover

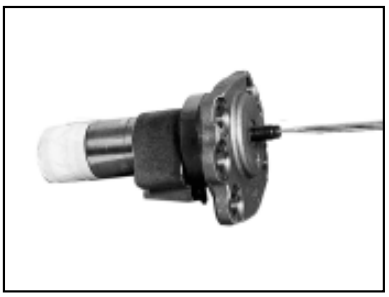
J37705
(THP/PCF45)
J37071
(THP/PCF60)
Press

15. Grease and assemble new seal (40) onto installation tool so the side with the garter spring is against the shoulder of the tool. Pilot the tool into the side cover (45) with a force of 100-800 lb (445-3560 N) until it is seated against the bearing or bushing.

⚠ CAUTION **Make sure the OD of the seal, and the ID of the bore are free from grease and dust, for proper engagement of the seal.**

Lubricate sector shaft

16. Apply a generous amount of Exxon Polyrex EP2 (P/N 045422) to the short bearing area of the sector shaft.

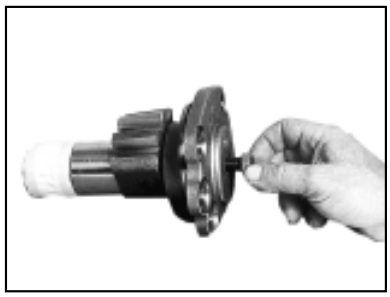


Install sector shaft into side cover

Screwdriver

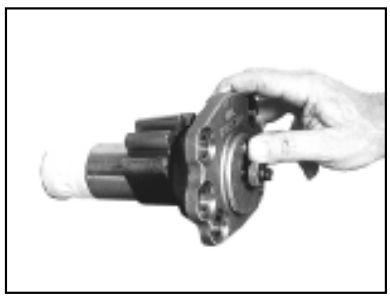
17. Insert the sector shaft (41) into the side cover subassembly (45), and turn the sector shaft adjusting screw (41A) counterclockwise into the side cover until the screw reaches solid height.

Rotate the adjusting screw clockwise one half turn so the side cover will rotate freely on the sector shaft.



Install jam nut

18. Install the sector shaft adjusting screw jam nut (46) onto the sector shaft adjusting screw (41A) a few threads. Final adjustment will be made later.



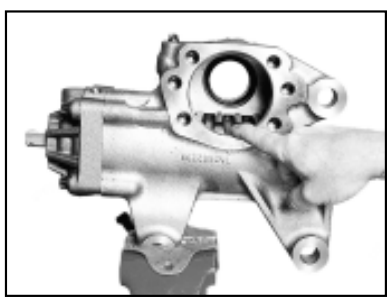
Assemble vent plug

19. Press the new vent plug (47) into the hole provided in the side cover until the plug is bottomed.

⚠ WARNING **Do not weld or otherwise plug this hole in any permanent manner. This is a safety vent which functions only if the side cover seal fails. If the seal fails and the plug cannot vent, the steering gear may lock-up or otherwise malfunction.**

Install side cover o-ring

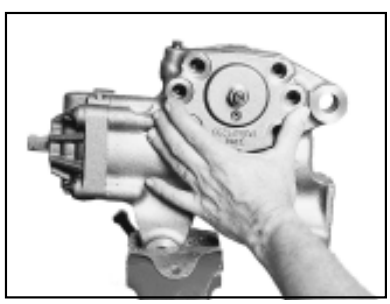
20. Apply clean oil to the new side cover o-ring (44) and assemble it onto the side cover (45).



Center rack piston

21. There are four teeth on the rack piston. Rotate input shaft to position the rack piston so the space between the second and third tooth is in the center of the sector shaft opening. This will center the rack piston for assembly of sector shaft.

⚠ WARNING **If the rack piston is not centered when sector shaft is installed, gear travel will be severely limited in one direction. This could result in an accident.**

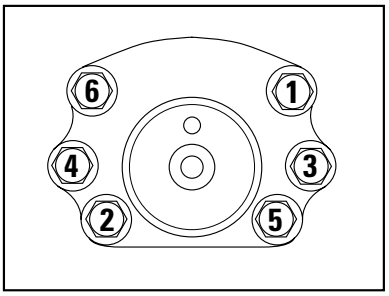


Install sector shaft and side cover into housing

Masking tape

22. Clean off any old tape on the serrations. Reapply one layer of masking tape. Install the sector shaft assembly into the housing. The center tooth of the sector shaft must engage the center space (between the second and third tooth) of the rack piston. Lightly tap on sidecover with a rubber hammer to seat cover against housing face.

⚠ CAUTION **If the serrations are not properly taped, they will damage the output seal (41) in housing, causing the seal to leak.**

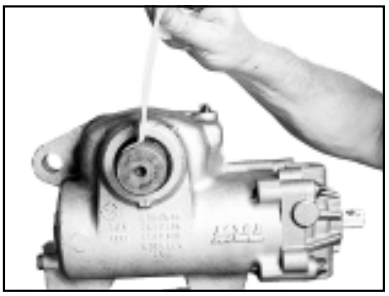


Install side cover bolts

15/16" Socket
Torque wrench

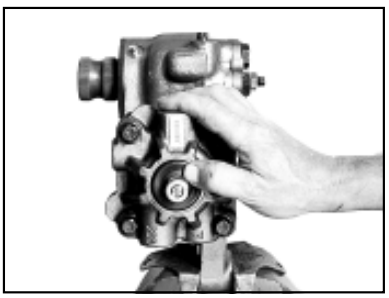
23. Install bolts in positions 3 and 4 first, by hand. Then, install the remaining side cover bolts (48) into the side cover and torque them in the sequence shown. If bolts must be replaced, use bolts of the same design, type and length as those you removed. **Do not use a substitute.**

    Lubricate side cover bolts and torque bolts to **180-220 ft•lb** (244-298 N•m).



Remove tape

24. Remove tape from the sector shaft (41).



Install dirt & water seal

Grease

25. Pack the end of the valve housing bore around the input shaft with clean, high temperature industrial grease, Exxon Polyrex EP2. (P/N 045422). Apply more of the grease to the inside of a new dirt and water seal (2, 2B or 2C) and install it over the input shaft. Seat the seal in the groove behind the serrations and against the valve housing.

    This step may have already been completed if you disassembled the valve housing and worm screw for repair.

Proceed to Final Adjustments on page 62

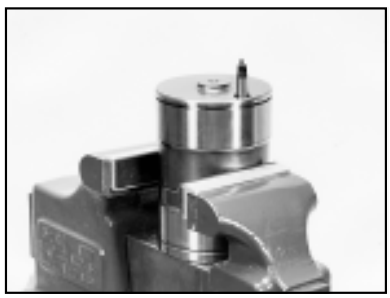
Poppet Component Replacement

Tools Required

2 lb Sledge
ft•lb Torque wrench
J36452-A
Press
3/8" x 6" drill rod
Ratchet
Soft-jawed vise

Materials Required

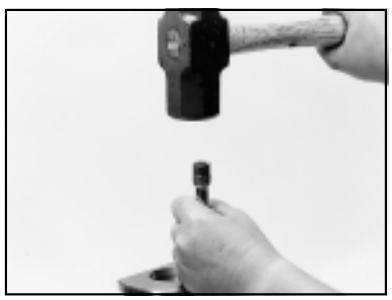
Locquic "T" primer
Loctite RC680



Place rack piston in vise

Soft-jawed vise

1. If the poppet assemblies are to be removed for replacement, place rack piston in a soft-jawed vise.



Loosen poppet adjuster seat

J36452-A
2 Lb Sledge

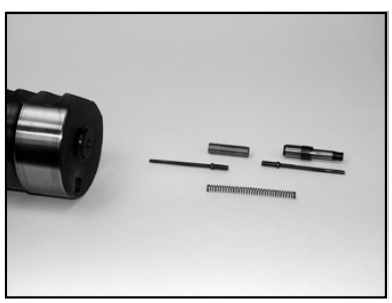
2. Slide special tool #J36452-A over the seat of poppet adjuster seat and sleeve assembly (27) and engage tool in the slots in the threaded sleeve. Hit the end of the tool firmly four or five times with a 2 lb sledge hammer to loosen Loctite.

⚠ CAUTION **Poppet adjuster seat and sleeve assemblies (27) are retained by Loctite applied to the threads which makes the assemblies difficult to remove.**

Remove poppet adjuster seat

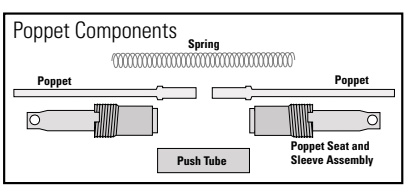
J36452-A

3. With a ratchet applied to the tool, turn one adjuster seat and sleeve assembly out of the rack piston. If the ratchet does not turn easily, strike the adjuster removal tool again with a hammer. If the engaging tangs won't stay in place while torquing, it might be necessary to hold in place with an arbor press while applying loosening torque. Discard poppet seat and sleeve assembly.



Remove poppet components

4. Remove the two poppets (26), spring (25), and push tube (24).

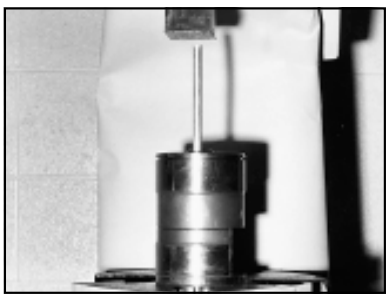


1063

Remove other seat & sleeve if necessary

5. Remove and discard remaining poppet seat and sleeve assembly only if required.

NOTE It is possible to reset one poppet adjuster seat and sleeve assembly for automatic poppet adjustment while it is in the rack piston if one adjuster seat and sleeve assembly and the poppets, spring, spacer rod and push tube are removed.



Reset remaining poppet seat and sleeve assembly

Press
⅜" X 6" Drill rod

6. If one poppet seat and sleeve assy. (27) was left in rack piston, it can be reset for automatic poppet adjustment by inserting a ⅜" (9.52 mm) diameter X 6" (152.4 mm) drill rod down through the poppet seat hole at the opposite end of the rack piston and against the adjuster seat to press the seat in until it bottoms against the adjuster sleeve.

Apply Locquic "T" primer and Loctite RC680

Locquic "T" primer
Loctite RC680

7. Carefully apply Locquic "T" primer to the threads in poppet holes, and threads on the new seat and sleeve assemblies (27). Allow to dry for ten minutes; then carefully apply Loctite® RC680 to same threads.

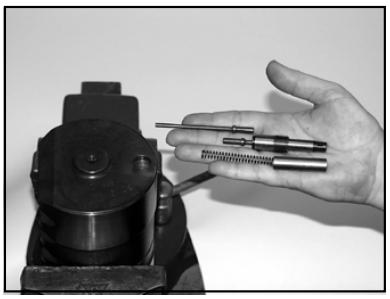
⚠ CAUTION **Do not allow Loctite or Locquic to get on the adjuster seat component of the adjuster seat and sleeve assembly. The poppets will not function properly.**

Install one poppet seat and sleeve assembly

Soft-jawed vise

8. **⚠ WARNING** **Wear eye protection while assembling poppets, as spring loaded poppets could eject and cause eye injury.**

Place rack piston (28) in a soft-jawed vise and turn one new poppet adjuster seat and sleeve assembly (27), (slotted end out) into the poppet hole in one end of rack piston.

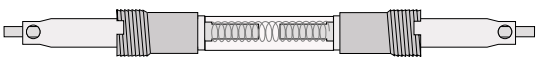


Install remaining poppet components

J36452-A
ft•lb Torque wrench

9. From the other end of the poppet hole in the rack piston, install: one poppet (26), poppet spring (25), push tube (24), other poppet (26), and the other new poppet adjuster seat and sleeve assembly (27). The new components will stack up as shown below.

Torque both poppet seat and sleeve assemblies to **18 ft•lb** (25 N•m).



Return to step 25, page 40.

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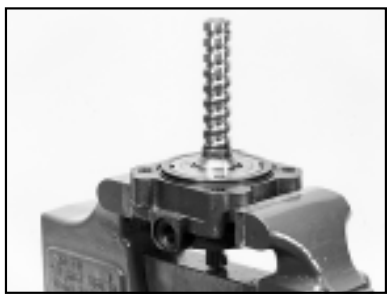
Valve Housing/Worm Screw Disassembly

Tools Required

Hammer
ft•lb Torque wrench
Punch, center
Punch, roll pin
in•lb. Torque wrench
J37464
J37070
J37073
Screwdriver
Small probe or pick
Sockets
12-point sockets

Materials Required



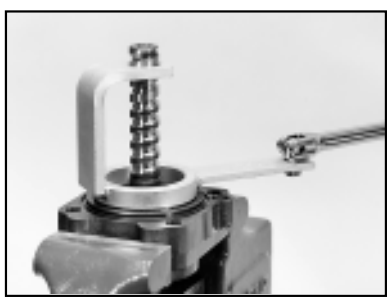
Place valve housing and valve assembly in vise

1. With worm vertical, place the valve housing (5), input shaft valve/worm assembly (15) in a vise.

Unstake adjuster locknut

Roll pin punch
Hammer

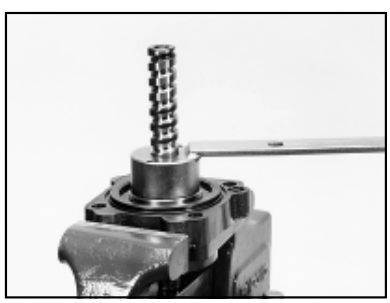
2. Unstake the valve housing (5) where it was upset into the adjuster locknut (21) slot. Also unstake adjuster nut from adjuster (20).



Remove bearing adjuster locknut

J37464

3. Turn bearing adjuster locknut (21) out of the valve housing.



Remove bearing adjuster

J37070

4. Turn bearing adjuster (20) out of the valve housing.

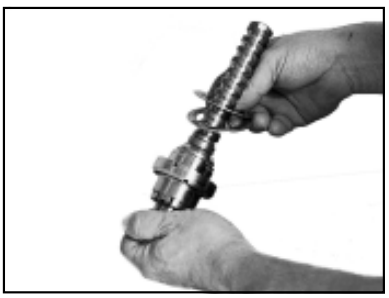
Remove seal ring and o-ring

Small probe or pick

5. Remove and discard seal ring (18) and o-ring (19) from bearing adjuster.

Remove input shaft

6. Remove the input shaft valve/worm assembly (15) from the valve housing (5).



Remove thin washer and bearing

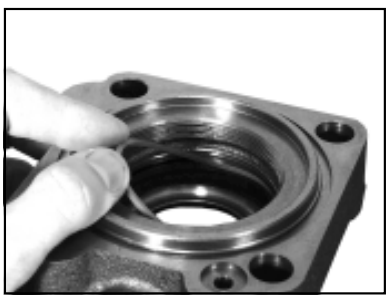
7. Remove thin thrust washer (17) and thrust bearing (16) from input shaft (15).

⚠ CAUTION **Input shaft, valve worm assembly must not be disassembled further. The components were a select fit at assembly and are available only as part of this subassembly. If disassembled further, the subassembly must be replaced.**

Remove ball bearing

8. Remove bearing (12) from valve housing.

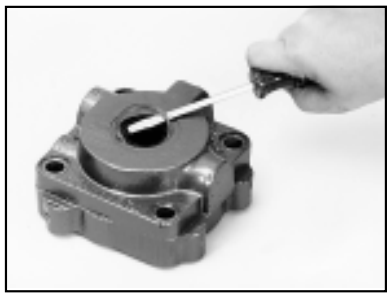
⚠ WARNING **Do not remove the ball cup that the bearing (12) rides on. Do not remove the special spacer seal behind the ball cup.**



Remove seal ring

Small probe or pick

9. Remove and discard seal ring (14) from valve housing (5).



Remove retaining ring

Screwdriver

10. Turn over valve housing and remove retaining ring (3).

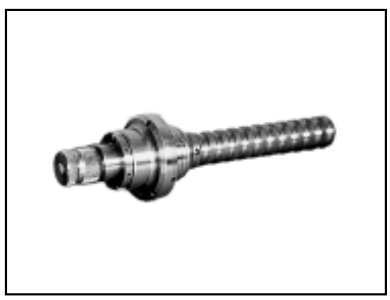
Remove seal

1⅛" Socket
Hammer

11. **⚠ CAUTION** **Exercise special care when removing seal (4) to prevent damaging the valve housing seal bore.**

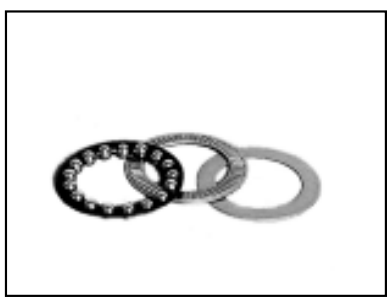
Tap input shaft seal (4) out of valve housing. Discard seal.

NOTE The valve housing also utilizes a ball plug for manufacturing purposes that must not be removed.



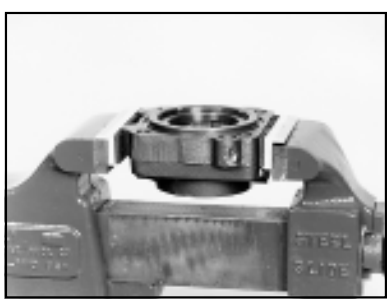
Inspect input shaft, valve worm assembly sealing areas

12. Inspect the sealing areas of input shaft and valve (15) for nicks and run your fingernail edge across the sealing surfaces to detect steps. Inspect for discoloration from excess heat. Inspect input shaft ball-track grooves for brinelling or spalling. If any of these conditions exist, you must replace the input shaft valve/worm assembly, valve housing and balls. Also replace rack piston if brinelling or spalling is found.



Inspect thrust washer and bearings

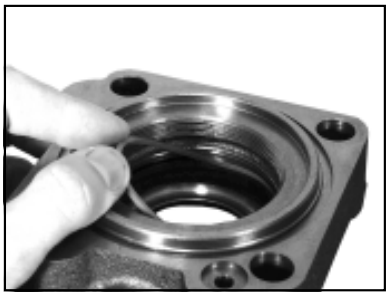
13. Inspect the thrust bearing (16) rollers and ball bearing (12) for any deterioration. Inspect thrust washer (17) and ball bearing race in the valve housing for brinelling, spalling, or cracks. Replace any part with these conditions.



Place valve housing in vise

14. Place valve housing (5) firmly in a vise so the input shaft, valve/worm assembly (15) can be assembled vertically with the worm end up.

⚠ CAUTION **Do not clamp against threaded port hole or relief valve hole sealing faces when placing valve housing in vise.**



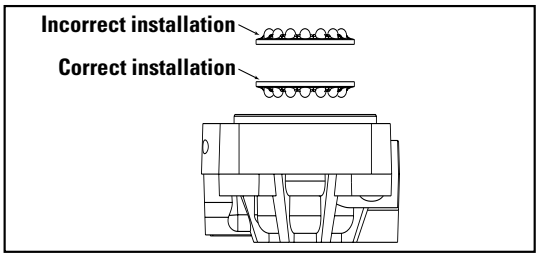
Assemble seal ring

15. Lightly oil and assemble new seal ring (14) into the large diameter seal ring groove in valve housing, bending and working it in and smoothing it out as necessary.

NOTE The seal ring must be smoothed out or it may be damaged when the worm is installed.

Install ball bearing into valve housing

16. Install ball bearing (12) into valve housing (5).



Assemble input shaft, valve worm.

17. Dip the input end of the input shaft, valve, worm assembly (15) into oil up to the worm lead. Assemble the input shaft end of the assembly into the valve housing (5) until it is firmly seated.

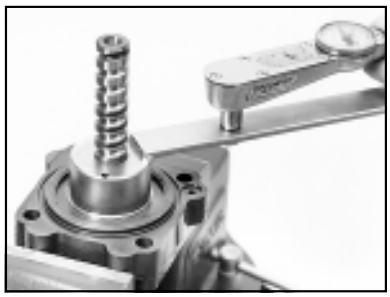
Assemble bearing and thrust washer

18. Apply oil and assemble the other thrust bearing (16) then the thin thrust washer (17) over the ball groove end of worm, and seat them against the shoulder of input shaft valve worm assembly (15).

Assemble seals in bearing adjuster

19. Lightly oil a new o-ring (19) and assemble into the seal groove in bearing adjuster (20). Oil and work a new seal ring (18) into the same groove and smooth it out.

NOTE Be sure the valve housing, adjuster locknut and bearing adjuster threads are clean and free of any staking burrs that would impede the locknut from turning freely on adjuster or the adjuster turning freely in valve housing.



Assemble bearing adjuster

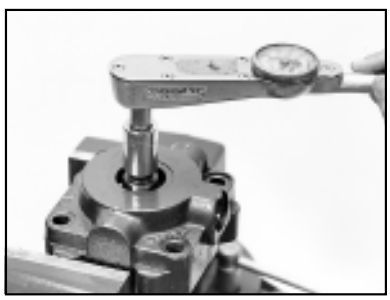
J37070
ft•lb Torque wrench

20. Lightly oil and assemble bearing adjuster (20) over worm and into valve housing. Torque adjuster to **13 ft•lb** (18 N•m) indicated torque using a torque wrench inserted in adjuster tool #J37070. This will seat the components. Back off adjuster ¼ to ½ of a turn.

Assemble new locknut

J37464

21. Lightly oil and assemble new locknut (21) onto bearing adjuster (20) with radius (slightly rounded) side down. Tighten slightly to keep the bearing adjuster in place.



Adjust to required input torque

¾" or 11⁄16" 12-point socket
in•lb Torque wrench

22. Reverse assembly in vise so the worm end is down. With an inch pound torque wrench on the input shaft, note torque required to rotate the input shaft 360° in each direction. Tighten the bearing adjuster to increase the maximum torque at the input shaft **5-10 in•lb** (.5-1.0 N•m) over that which was previously noted.

Torque locknut

J37070
J37464
ft•lb Torque wrench

23. Again reverse the assembly in vise. Torque locknut while holding bearing adjuster in position established in step 22 with appropriate adjuster tool. When using a torque wrench in locknut tool J37464, the torque wrench reading should be **112 ft•lb** (152 N•m).

Check input shaft torque

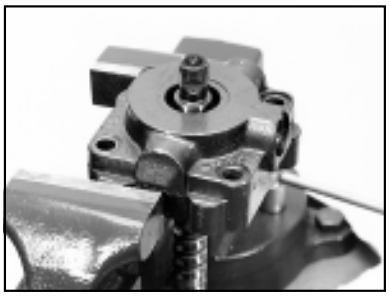
24. Recheck input shaft torque. It should match torque measured in step 22. Repeat steps 22 and 23 if necessary.

Stake valve housing and locknut

Center punch
Hammer
13/16" Socket
in•lb Torque wrench

25. Stake valve housing into the clockwise most corner of two opposing slots in lock nut (21). Stake the locknut into the adjuster (20) in two places (180° apart) at threaded area. Choose areas that have not been previously staked.

    After staking, torque required to rotate input shaft must be between **5-10 in•lb** (.5-1.0 N•m) **greater** than the torque noted in step 22. Torque value must **not exceed 22 in•lb** (2.5 N•m). Unstake and readjust if necessary.



Reposition subassembly in vise

26. Reposition worm screw/valve housing subassembly in soft-jawed vise, clamping tightly against valve housing, so the worm screw is pointing down.

Install input shaft seal

J37073
Hammer

27. Apply clean grease (Exxon Polyrex EP2, P/N 045422) to the outside and inside diameters (fill cavity between the lips) of the new input shaft seal (4) and assemble it, garter spring side first over the input shaft. Align seal in the valve housing seal bore.

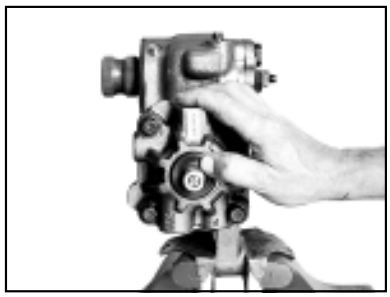
    Place seal installer tool #J37073, small diameter end first, over the input shaft and against the seal. Tap the seal installer tool until the tool shoulder is squarely against the valve housing. This will correctly position the seal in the housing bore just beyond the retaining ring groove.

⚠ CAUTION **Remove any seal material that may have sheared off and is in seal bore and retaining ring groove.**

⚠ CAUTION **The input shaft seal must be square in the seal bore and installed to the correct depth.**

Insert retaining ring

28. Insert new retaining ring (3) into its groove in valve housing (5).



Install dirt & water seal

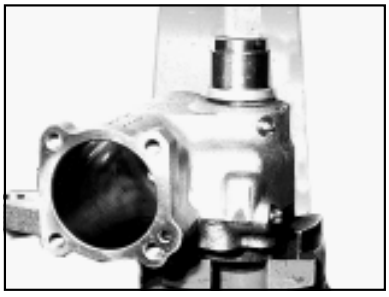
Grease

29. Pack the end of the valve housing bore around the input shaft with clean, high temperature industrial grease, Exxon Polyrex EP2 (P/N 045422). Apply more of the grease to the inside of a new dirt and water seal (2, 2B or 2C) and install it over the input shaft. Seat the seal in the groove behind the serrations and against the valve housing.

Return to step 26, page 40.

Roller Bearing Replacement

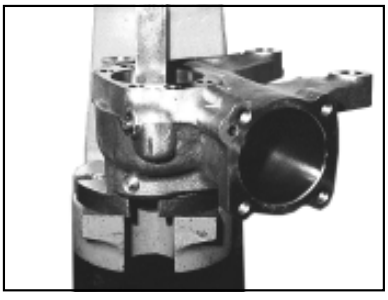
Tools Required	Materials Required
Press J37705 (THP/PCF45) J37071-A (THP/PCF60)	



Remove roller bearing if required

J37705
THP/PCF45
J37071-A
THP/PCF60
Press

1. If roller bearing (39) in housing needs to be replaced, place the bearing removal end (long end) of the bearing and seal tool against the trunnion end of the bearing and press it out of the side cover end of the bearing bore. Discard bearing.



Press in housing roller bearing

J37705
THP/PCF45
J37071-A
THP/PCF60
Press

2. Press the new roller bearing (39) into the housing from the side cover end of the bearing bore until it is seated against the step bore. Be sure the housing is square with the press base and the bearing is not cocked.

⚠ CAUTION **Use the bearing <u>installation end</u> of the tool (short end). If the bearing <u>removal end</u> of the bearing & seal tool is used to press in bearing, the cage on the new bearing may be damaged.**

NOTE If the unmachined trunnion face is not square, use shims to square it before pressing in the bearing.

Return to step 29, page 40.

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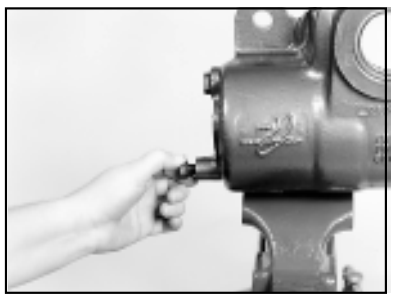
Replace Housing Port Plugs, Screws, and Fittings

Tools Required

Allen wrench
Torx sockets
SAE/Metric sockets
Open end wrench
in•lb Torque wrench
ft•lb Torque wrench

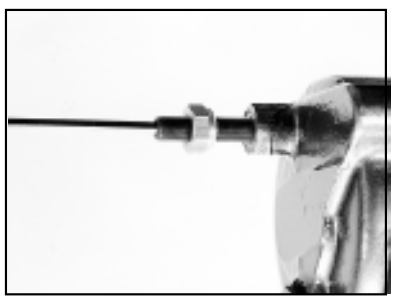
Materials Required



Replace poppet fixed stop screw

THP/PCF45
18mm Socket
THP/PCF60
5/8" Socket
ft•lb Torque wrench

1. If damaged, remove and replace the poppet fixed stop screw (38) and washer (Not shown) if equipped. Replace with poppet fixed stop screw (38), discard the washer. Torque to **48 ft•lb** (65 N•m).

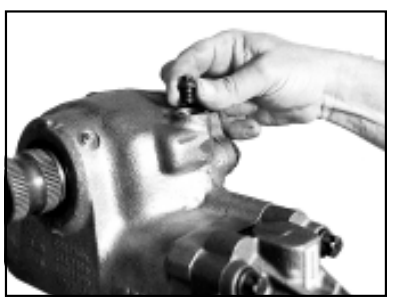


Replace poppet adjusting screw

THP/PCF45
6mm Allen wrench
18mm Socket
19mm Wrench
THP/PCF60
7/32" Allen wrench
5/8" Socket
3/4" Wrench
ft•lb Torque wrench

2. If damaged, remove poppet adjusting screw (38A) and sealing nut (38B) without allowing the nut to change its position on the screw.

   Assemble the new nut onto the new adjusting screw, matching its position to the nut and screw removed. Torque sealing nut to **35 ft•lb** (47 N•m).



Replace automatic bleed screw, and aux. port plugs

E-14 Torx socket
ft•lb Torque wrench

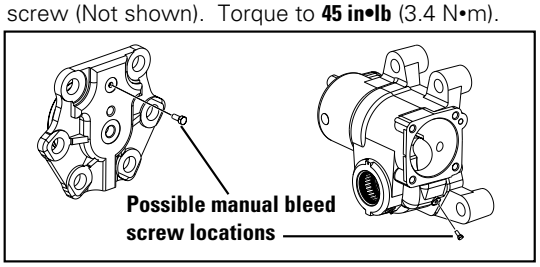
3. If damaged, remove and replace automatic bleed plug (38). Torque to **48 ft•lb** (65 N•m).

   If damaged, remove and replace permanent auxiliary port plugs (7) and o-rings (6). Assemble new o-rings on port plugs and torque to their respective ports in the housing or valve housing to **30 ft•lb** (41 N•m).

Replace manual bleed screw

5/16" Hex socket
in•lb Torque wrench

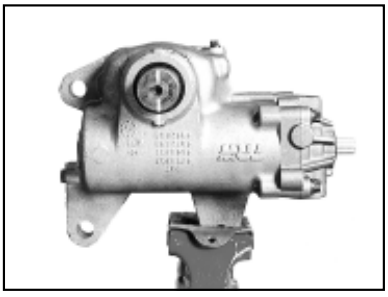
4. If damaged, remove and replace manual bleed screw (Not shown). Torque to **45 in•lb** (3.4 N•m).



Return to inspection section, page 42.

Final Adjustments

Tools Required		Materials Required
Box-end wrench ft•lb Torque wrench in•lb. Torque wrench	Screwdriver Sockets	



Center steering gear

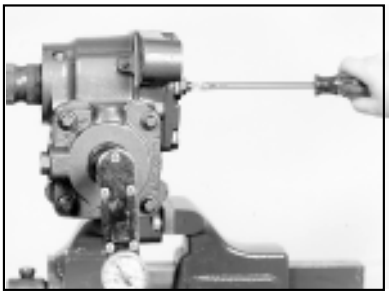
¾" and 11⁄16" Socket or box end wrench

1. To center the steering gear, rotate input shaft valve worm assembly (15) until the timing mark on the end of the sector shaft (41) is in line with the timing mark on the end of housing trunnion.

⚠ CAUTION **Do not rotate the input shaft more than 1.5 revolutions from center position until the steering gear is installed, during poppet setting procedure. Doing so could make the automatic poppets inoperative, which would require disassembly of steering gear to reposition poppet seat and sleeve assemblies.**

NOTE Initial poppet contact will occur at less than one input shaft rotation in one direction from steering gear center position, if new or reset poppet adjuster seat and sleeve assemblies are assembled in the unit.

NOTE Worm preload adjustment was set when input shaft, valve and worm were assembled into valve housing.

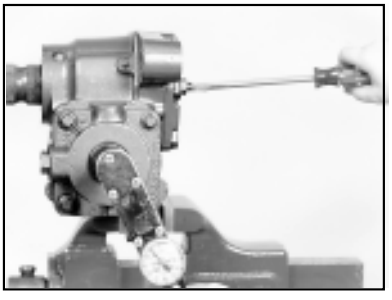


Tighten adjusting screw

in•lb Torque wrench
Screwdriver
11⁄16" or ¾" Socket

2 With adjusting screw jam nut (46) loose, turn sector shaft adjusting screw (41A) clockwise to provide **45-50 in•lb** (5-5.5 N•m) of torque required to rotate the input shaft valve/worm assembly (15) through one half turn (180°) each side of center.

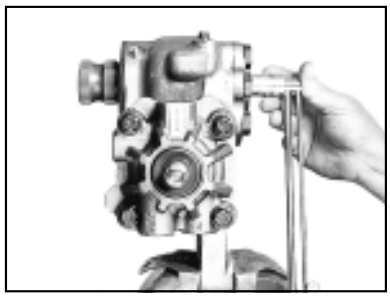
NOTE This procedure will properly mesh and seat the rack piston and sector shaft teeth for final adjustments.



Loosen adjusting screw and note torque

in•lb Torque wrench
Screwdriver
11⁄16" Socket

3. Turn sector shaft adjusting screw (41A) counter-clockwise one half turn and **note maximum torque** required to rotate the input shaft, valve/worm assembly through one half turn (180°) each side of center.



Adjust adjusting screw

¾" Socket
$^{11}/_{16}$" Socket
ft•lb Torque wrench
in•lb Torque wrench

4. Adjust sector shaft adjusting screw (41A) clockwise **to increase** maximum torque noted in step 3 by **7 in•lb** (.8 N•m). Tighten jam nut (47) firmly against side cover while holding the adjusting screw in position. Finally, torque jam nut to **43 ft•lb** (58 N•m) and check input shaft valve/worm assembly torque again. Readjust if input shaft torque exceeds **40 in•lb** (4.5 N•m).

Section 5 Reinstallation

Reinstallation 65
Poppet Resetting 65

Glossary 66

Reinstallation

- Verify that axle stops are set to manufacturer's wheelcut or clearance specifications.
- Bolt gear to frame, torque to vehicle manufacturer's recommendation.
- Connect return line to reservoir in THP/PCF return port.
- Connect hydraulic line from pump to pressure port in THP/PCF unit.
- Connect steering column to input shaft, torque pinch bolt to vehicle manufacturer's recommendation.
- Install pitman arm on output shaft, with timing marks aligned. Torque bolt to vehicle manufacturer's recommendation.
- Connect drag link to pitman arm.

Poppet Resetting

IF Poppets remain unchanged from when gear was removed from vehicle, and gear is being installed on the same vehicle with no change in axle stops or linkage.	After installation, check to make sure poppets relieve in both turns just before axle stop contact is made. If not, use resetting procedure beginning on page 23.
IF Poppets were replaced with new components or reset during gear disassembly, and are ready for automatic positioning.	Use poppet setting procedure on page 13.
IF Poppets may have been moved during disassembly or reassembly procedures, or gear is being installed on a different vehicle.	Use poppet resetting procedure beginning on page 23.

Glossary

Aerated Fluid
Fluid with air bubbles

Automatic Bleed Systems
Gears are mounted in such a way that trapped air can be forced out of the system "automatically" without loosening bleed screw.

Axial
In-out movement along an axis (imaginary straight line on which an object moves)

Brinelling
Dents

Date Code
Date the steering gear was built (Julian date)

Discoloration
Change in color

External Leakage
Fluid Leaking out of the system or steering gear

Full Turn
Hub contacts axle stop

Integral Power Steering
Steering gear has manual steering mechanism, hydraulic control valve, and hydraulic power cylinder all within gear housing.

Impact
The application of torques and forces to steering gear components during accidents or other similar events which exceed the hydraulic capacity of the steering gear

Internal Leakage
Fluid leaking inside the gear

Lash
Free play

Manual Bleed Systems
Gears are mounted in such a way that an air pocket could form in one end of the steering gear. The bleed screw is positioned so trapped air can be forced out when loosened.

OSHA
Occupational Safety and Health Administration

PCF
Positive Center Feel - option available on THP series steering gears.

Poppets
Unloading valves, reduce pressure in full turns.

Relief Valve
Limits maximum supply pressure

Return Line
Line that connects steering gear to reservoir to recirculate hydraulic fluid

Rotary Control Valve
Controls flow in internal cavities

Scoring
Scratch

Shock Load
Shake or jar

Spalling
Flaking or chipping

Subassembly
An assembled unit that fits into a larger unit

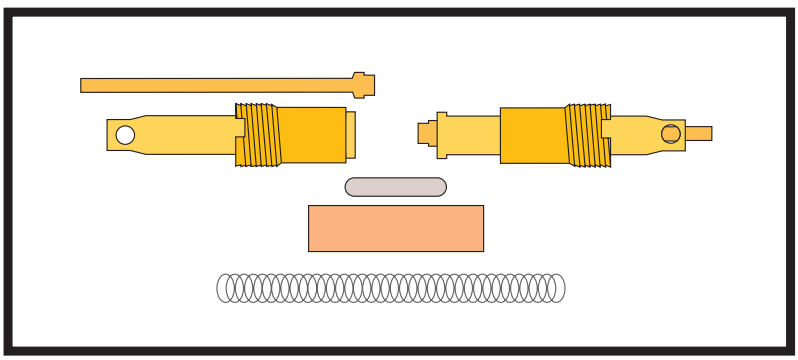
Supply Line
Line that connects pump to steering gear

Twisted Serrations
Output shaft serrations damaged by impact overload. Serrations can be twisted at the area between the large diameter of the shaft and the end of the serrations.

TRW Automotive
CommercialSteering Systems

TAS Poppets

A Workbook and Self-Test
to be used with the
TRW TAS Poppet SettingVideo



Follow all precautions and warnings in Service Manual when setting or resetting poppets

What Poppets Are:

Poppets reduce pressure in full right and left turns

- Reduces hydraulic system heat
- Reduces force on linkage components

Pressure and heat build up in the steering system during turning maneuvers.

High temperatures can deteriorate the hydraulic system over time.

High pressure could put a lot of stress on linkage components over time.

How Poppets Work:

Rotating input shaft causes rack piston to move

Lower poppet in rack piston contacts fixed stop bolt or adjusting screw

Upper poppet in rack piston contacts valve housing

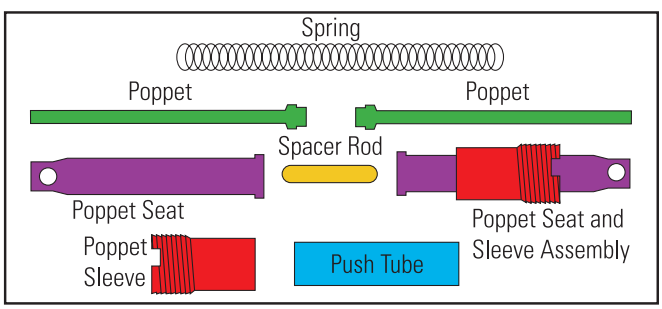
Contact of poppet and screw or valve housing pushes poppet away from it's seat.

Gap between poppet and seat allows fluid to pass through the rack piston, reducing pressure.

Poppet should contact screw or valve housing just before axle contacts axle stop.

TAS Poppet Components:

- Two Poppet Seat and Sleeve Assemblies
- Two Poppets
- Spring
- Nylon Spacer Rod
- Push Tube



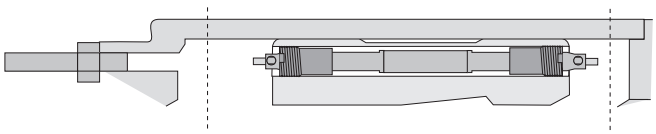
Setting poppets means pushing the poppet seat into the poppet sleeve. This backs off the poppet so it will contact the screw or valve housing just before axle contacts axle stop

TAS Factory Setting:
(or New Aftermarket Gear)

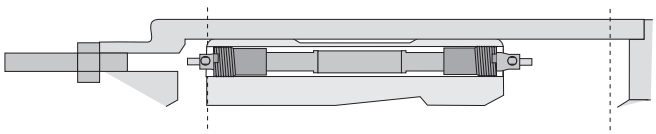
- Set axle stops
- Raise front axle
- Turn full right - engine on
- Turn full left - engine on

New steering gear poppet components look like this before setting. At this point, they are ready for automatic adjustment.

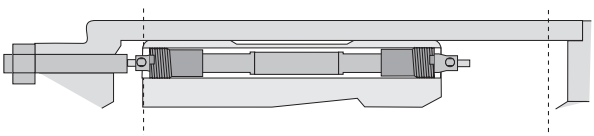
The amount of gear travel is determined on each vehicle by the axle stop settings. End of gear travel is marked in these diagrams by dotted lines The rack piston will stop when it reaches these points because the axle stops will not allow the road wheels to travel further.



On the first full turn after installation on a vehicle, the poppet seat will make contact internally, and be pushed into the sleeve. Since the rack piston has travelled to its farthest point for the vehicle, the poppet seat, in its new set position, has also reached its farthest point of travel.

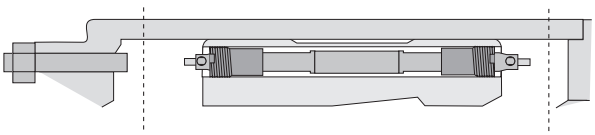


In the second full turn, the remaining poppet seat will be pushed in the amount required for that vehicle. Since the poppet seat and sleeve assemblies are a pressed fit, both poppet seats will now remain in this set position until they are reset using the procedure that follows.



Notice that the poppets were adjusted along with the poppet seat. In all subsequent turns, the poppet will be pushed off the seat to reduce pressure, and the poppet seat should never again make contact with the housing or the fixed stop screw.

When the poppet makes contact, pressure is reduced which also reduces the power assist felt at the steering wheel. Axle to axle stop contact can still be achieved, but with manual steering only.



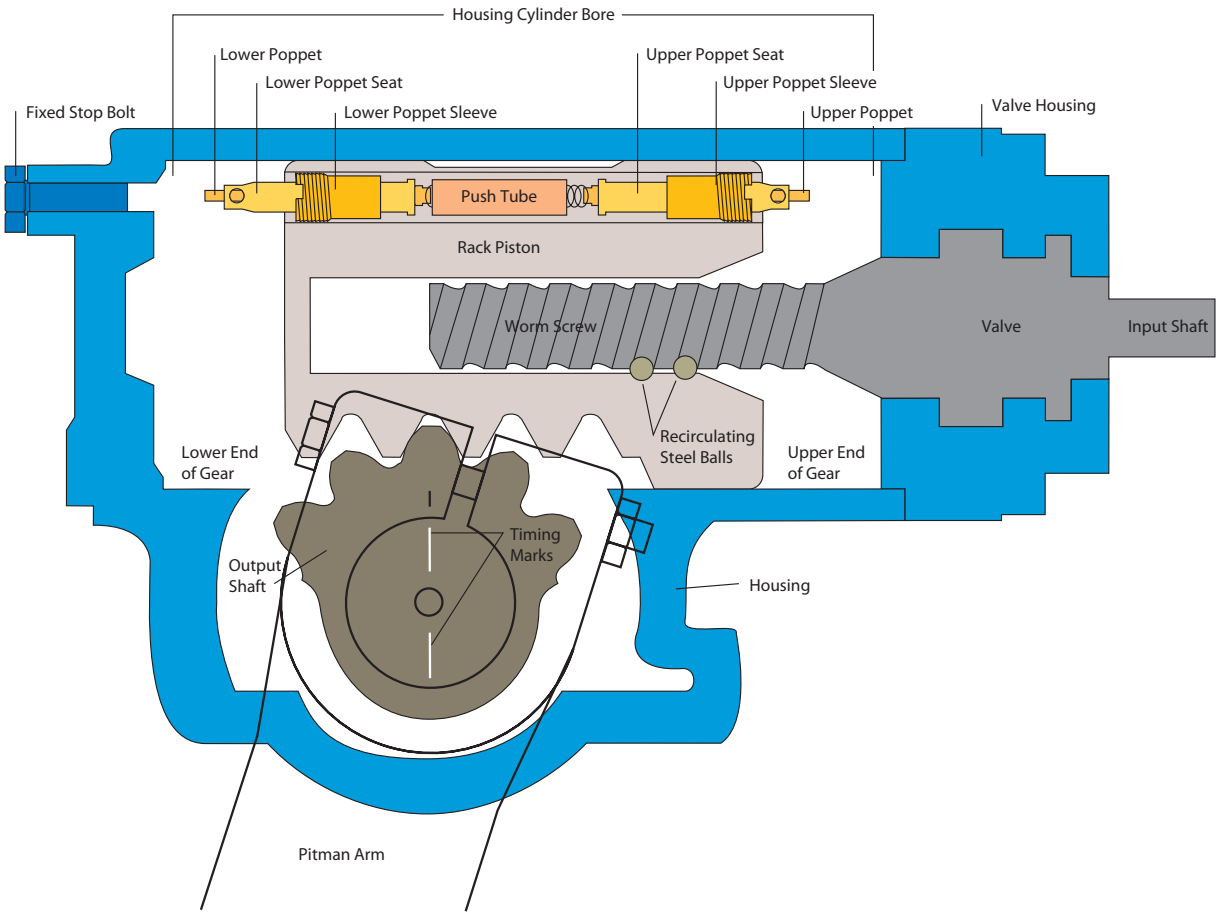
Reasons for Resetting Poppets:

- Changing to larger tires
- Reducing wheelcut for any reason
- If the steer axle u-bolts were bent or broken
- If the pitman arm was mistimed
- Axle stop bolts were damaged
- Steering gear is mounted on a different vehicle

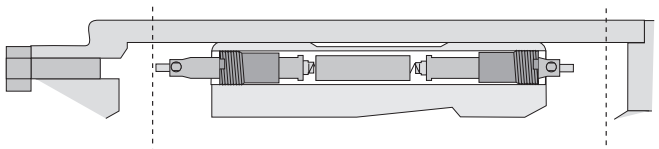
TAS Resetting:

- Set axle stops
- Install adjusting screw
- Raise Front Axle
- Start Engine
- Turn in the direction that moves the inner output shaft timing mark toward adjusting screw
- Pull hard on the steering wheel
- Turn in opposite direction, pull hard on the steering wheel
- Turn off engine
- Back out adjusting screw until 1" is past the nut
- Start engine
- Turn steering wheel in original direction, pull hard when axle stop contact is made
- Screw in adjusting screw until it stops
- Back out adjusting screw 3 1/4 turns
- Torque jam nut
- Turn off engine, lower vehicle

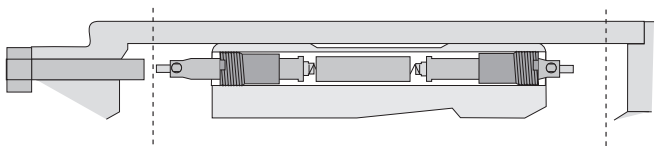
Introduction to Internal Components



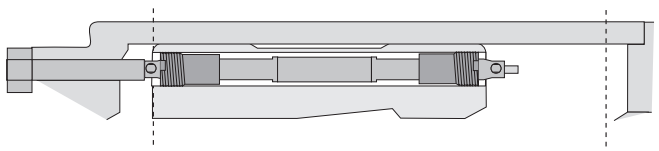
Axle stops have been reset in this diagram. They have been moved in, indicating that wheel cut has been reduced.



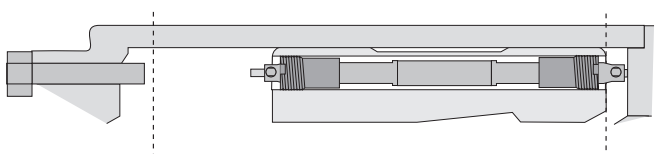
An adjusting screw is installed in the gear for the resetting process so the poppet components can be forced together to push on one another. Once the poppet components are pushed together, they will stay that way. The adjusting screw will also remain as part of the gear. Do not try to reuse the fixed stop screw after resetting poppets.



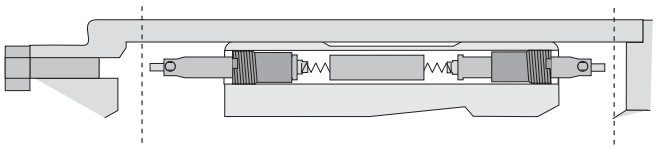
Turning in a direction that makes the rack piston move toward the lower end of the steering gear will force the lower poppet seat against the adjusting screw. The lower poppet seat then contacts the push tube and forces it against the upper poppet seat. This will force the upper poppet seat out so it can be set automatically on the next turn.



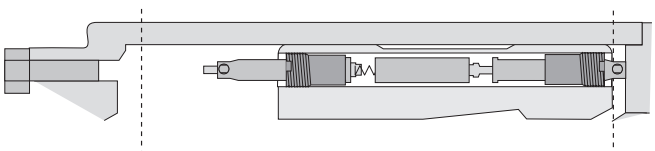
This turn sets the upper poppet seat in just the same way as it was set when the gear was new. Notice that since the poppet components are still forced together, the upper poppet seat is now forcing the push tube against the lower poppet seat to push it out.



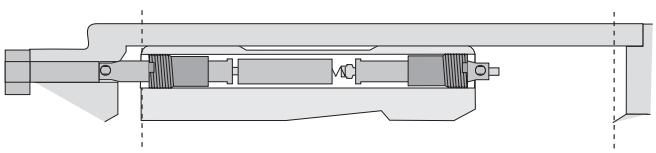
The adjusting screw is backed out of the way, so the poppet seat will not contact it on the next turn.



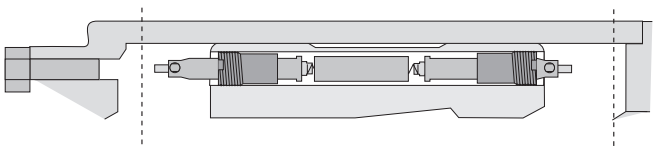
Holding the wheel at full turn places the poppet seat in the proper position for setting.



The adjusting screw is then turned in to meet the lower poppet seat and backed-out 3 1/4 turns.



The adjusting screw remains in this position, and acts as the contact point for the lower poppet until poppets need to be reset again.



Self-Test:

1. Poppets reduce system pressure:
   A. After full turn
   B. When axle stop contact is made
   C. Just before full turn

2. Reducing pressure lessens:
   A. Temperature in the hydraulic system
   B. Stress on the linkage
   C. Both

3. A good reason to reset poppets would be:
   A. Wheelcut has been reduced
   B. Loose Steering
   C. Wheel kick

4. Always set axle stops before setting poppets.
   A. True
   B. False

5. If the sector shaft timing mark points toward the upper poppet, you should set the lower poppet.
   A. True
   B. False

Glossary of Terms:

Gear Families - TAS Family = TAS40, TAS55, TAS65, TAS85 (RCS cylinders are TAS gears without worm and valve). HFB Family = HFB52, HFB64, HFB70 (RCB cylinders are HFB gears without worm and valve) HF Family = HF54, HF64

Linear Cylinder - A cylinder with a piston rod that provides in/out thrust.

Lower End - End of cylinder bore farthest from the input shaft.

Master Gear - Main steering gear, located on driver's side of vehicle.

Pressed Fit - The fitting of two components that allows a controlled movement between them, but will not allow them to move during normal operational actions.

Pump Relief Pressure - Maximum pressure of the power steering pump.

Rim Pull - Force used to turn the steering wheel, measured in pounds at the rim of the steering wheel.

Slave Gear - Auxiliary gear on passenger side of vehicle. Has no worm screw, ball-nut mechanism, or control valve.

Steering System - Includes mechanical and hydraulic components: steering wheel, column, u-joints, slip joints, miter box, steering gear, pump, reservoir, hoses and connections, pitman arm, drag link and sockets, axle arm, king pin, bushings, tie rod arms and ends, steering spindle, wheel bearings, springs and spring pin connectors, spring hanger brackets, front axle, u-bolts.

Steering Wheel Travel - Number of times the steering wheel can rotate between full turns.

Thread Engagement - The amount of contact between threads on screw and nut.

Timing Marks - Use the output shaft timing mark nearest the cylinder bore to judge which poppet to set.

Upper End - End of cylinder bore nearest the input shaft.

Answers to the Self-Test:

1. C
2. C
3. A
4. A
5. B

TAS Poppet Workbook

TRW Commercial Steering Systems
800 Heath Street
Lafayette, IN 47904
Phone: 765/423-5377
Fax: 765/423-4453

TRW1102
Electronic Version February 2001

Body Glass

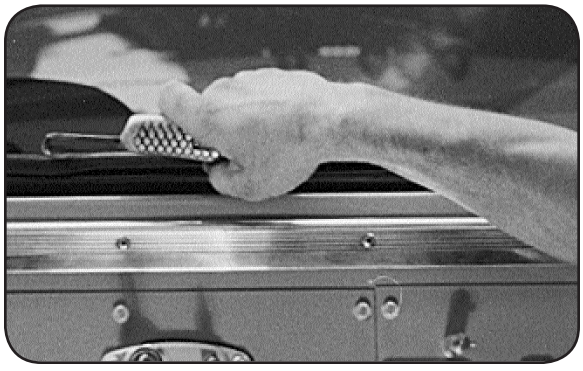
Glass replacement should meet standards in specification FMVSS 205 and 217.

WARNING ***When replacing broken or damaged glass, use extreme care at all times to prevent personal injury. Use proper replacement parts, tools and personal protective equip-ment, such as gloves and safety goggles.***

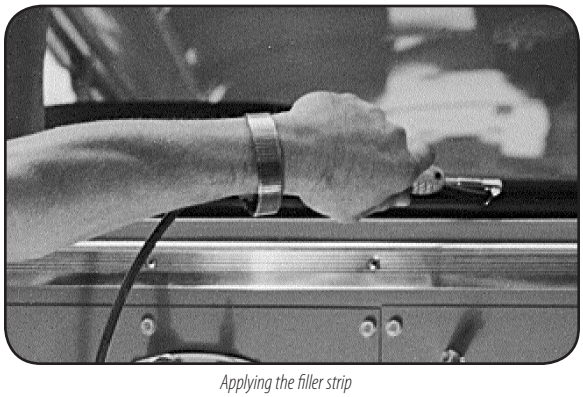
Windshield Glass Replacement

Remove vertical filler strip in glazing rubber on each side of broken glass. Remove horizontal filler strip in glazing rubber on top and bottom of broken glass. It will be necessary to cut the horizontal filler strip after it is pulled past the glass.

1. Starting at a corner, push glass free of glazing rubber from inside of bus outward and remove.
2. Position new glass in glazing rubber.
3. Using installation tool, work glass into glazing rubber.
4. Seal glass to glazing rubber from outside of the bus with an adhesive sealant, such as Silastic 732 RTV Adhesive/ Sealant.
5. Apply soapy solution to filler strip channel on glazing rubber to act as a lubricant for easier installation of filler strip.
6. Using filler strip tool, insert fillet strip into channel on glazing rubber.



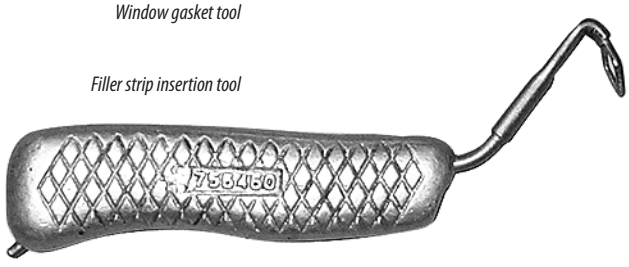
Using glazing tool to help work gasket around windshield



Applying the filler strip

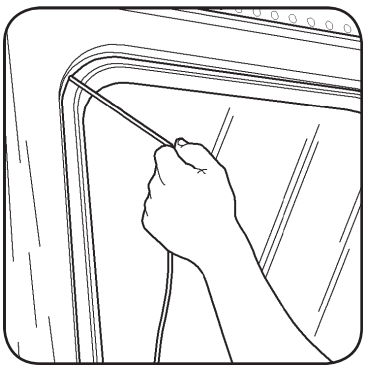
Window gasket tool

Filler strip insertion tool

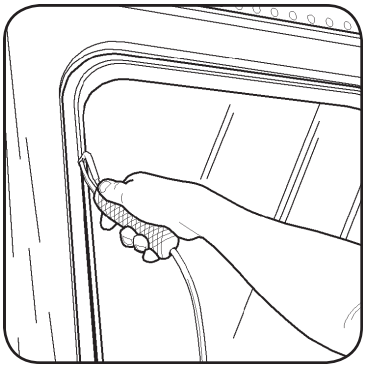


Rear Vision Glass Replacement

1. Remove filler strip from channel in glazing rubber.
2. Apply pressure against glass from the outside of the bus starting at a corner, push glass and glazing rubber off metal flange.
3. Remove glazing rubber from glass.
4. Put glazing rubber on new glass.
5. Apply a soapy solution to the flange on the bus body and to the filler strip channel on glazing rubber. This acts as a lubricant for easier installation.
6. Wrap a cord around the glazing rubber and rest the glass on the bottom window flange from the inside of the bus body. See Figure 6.
7. Apply pressure from the inside of the bus body to ensure glass is seated properly. Pull cord slowly and work glazing rubber onto the window flange.
8. Using a filler strip tool, insert the filler strip into the channel on the glazing rubber. The filler strip tool is available from your distributor. See Figure 7.
9. Apply clear caulking around glass and window flange on the outside of bus body to ensure that no leaks occur.



Using a cord to help install gasket around glass



Applying Filler Strip

Transit Sliding Window Removal

1. Remove screws in outside aluminum extrusion.

2. Loosen sealer between window frame with putty knife.

CAUTION ***Do not pry window frame from body without loosening sealer. Unless sealer is loosened, window frame will be bent.***

3. Pry out using screwdriver.

4. Reverse procedure for installation.

Transit Window Glass Replacement

On push out windows, when hinge screws are removed and interior latch released, window sash may be removed from frame.

1. Release window lever (1) located inside the bus at the bottom of each push-out window.

2. Remove hinge screws (2) on outside of body.

3. Lift and pull window out of section.

4. To remove stationary transit sliding window, remove all screws between inner frame (4) and outer frame (5).

5. Lift and pull window out of section.

6. Remove four screws and take out vertical brace (6) located in the center of the window.

7. Remove two window stops (one on each side of the top of window).

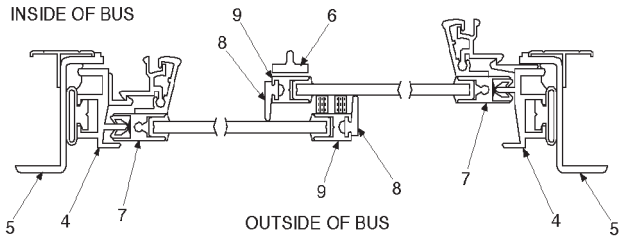
8. Slide glass to the center of the window. Spread apart the inner frame (4) just enough to lift glass frame (7) out.

9. To remove glass from frame, slide rubber seal (8) out of vertical rail (9) exposing two screws. Window glass is removable after screws are removed. Remove glass.

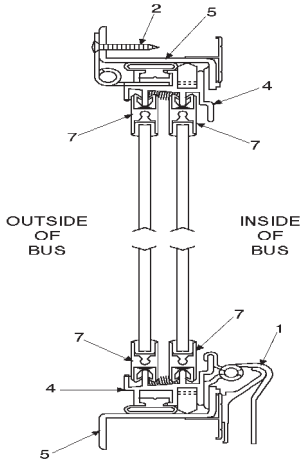
10. To replace glass, slip glazing vinyl seal around glass and slide into frame.

11. Reassemble by reversing procedure.

Transit Sliding Window

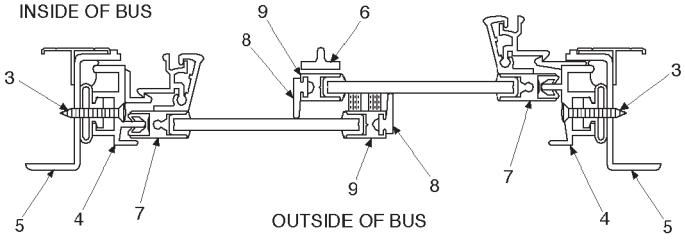


**HORIZONTAL SECTION THRU
TRANSIT SLIDING WINDOW PUSH OUT WINDOW**

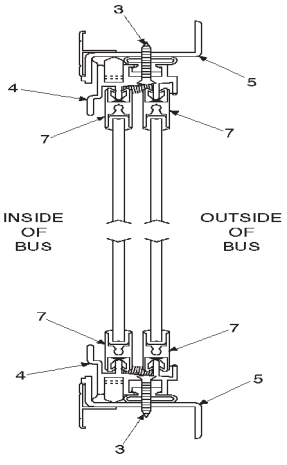


**VERTICAL SECTION THRU
TRANSIT SLIDING
PUSH OUT WINDOW**

Pushout Transit Sliding Window



**HORIZONTAL SECTION THRU
TRANSIT SLIDING WINDOW**



**VERTICAL SECTION
THRU TRANSIT
SLIDING WINDOW**

Outward Opening Entrance Door

The outward opening door panels are hung in a prefabricated framework before mounting into the body construction. The doors are suspended from sealed ball bearings located at the upper corners of the door. These components are accessible only from inside the body.

The bronze bearings at the lower corners of the door assembly are not weight bearing, but serve to hold the bottom of the assembly in position. These bronze bearing are permanently lubricated and should require little maintenance during the service life of the door assembly, which exceeds 300,000 cycles.

The interlink between the door panels is installed as a single assembly in the door header, and is adjustable for maintaining proper opening/closing tension.

Interlink Adjusment

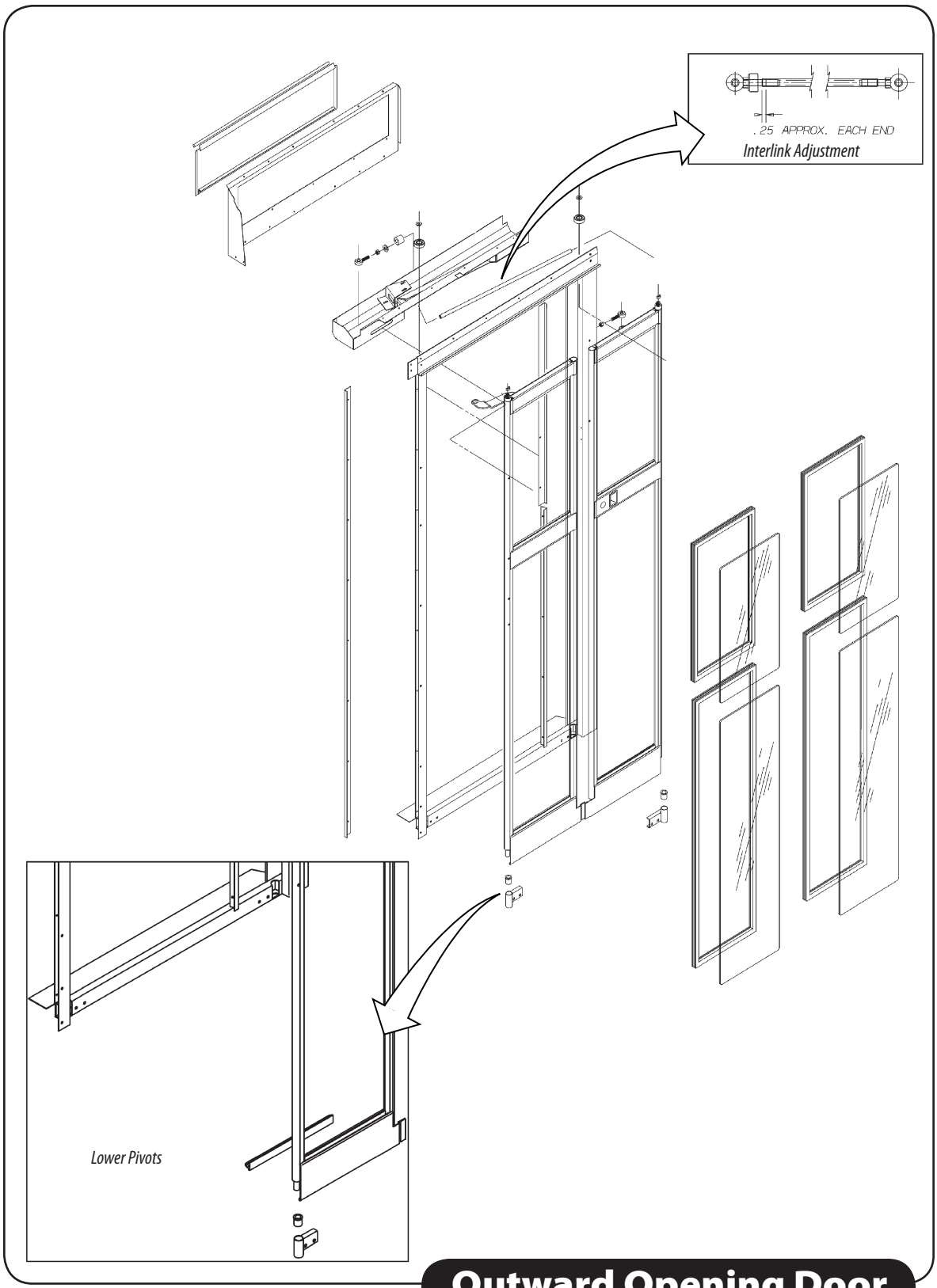
The mechanical link between the doors (the interlink rod) should be adjusted so that the rearward door closes and seats first. One of the spherical bearing, rod end connectors has a right-hand thread; the other has a left-hand thread. This allows for length adjustment by simply turning the interlink rod. The forward door panel then closes with an overlap to the rear of the bus, helping to reduce the intrusion of outside air while the bus is in motion. The forward door pivots across the centerline of a cam, thus locking the rear door panel in position.

When properly adjusted, the door should begin to require more energy to close as the trailing edge of the front door panel gets to within 2 or 3 inches of the closed position. When the mechanism is properly adjusted, you should only be able to push the door open by pressing on the forward door panel from the inside. The rearward panel should be locked into position and will not move until the forward panel moves.

1. With the doors open, loosen the jam nut at the forward end of the interlink rod. The jam nut on the rearward end of the interlink assembly is to hold the bumper in position and is located inside the access panel over the door.

2. Turn the interlink tube until, by trial and error, the door mechanism operates properly.

3. Tighten the jam nut securely.



Outward Opening Door

Manual Door Control

Manual Door Control Arm Removal

The manual door control rod does not need to be removed to adjust or remove the door panel assemblies. However, the clevis pin must be removed when removing the door panels.

1. Remove the cotter pin and clevis pin securing the control arm to the door.

2. If the control arm is in the way of your work, remove it by removing the pivot bolt, nut, and spacer from the handle.

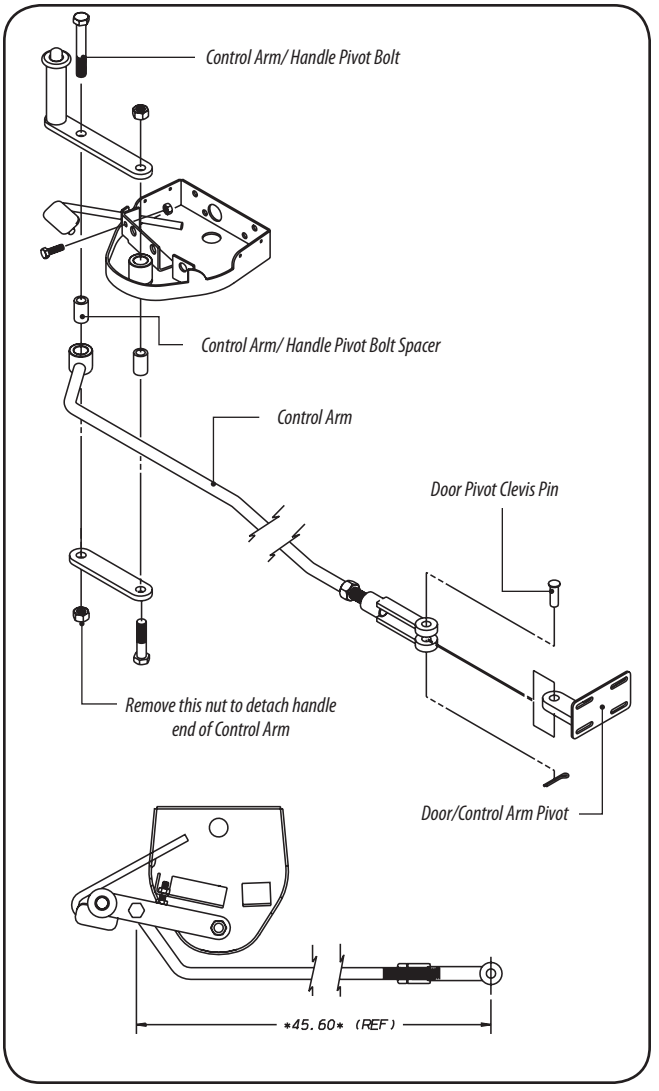
Manual Door Control Reinstallation

If the length of the manual control rod assembly is moved, the nominal length for outward opening doors should be set to 45.60 inches (115.82 cm). Then adjust to close with proper tension. When the door operates satisfactorily, tighten all hardware securely.

1. If necessary, install the door/control arm pivot. Snug up so it will not move. Do not tighten securely at this time.

2. With the doors in the closed position, pre-assemble the control arm to the approximate length required.

3. Attach the clevis to the door pivot and insert the clevis pin. Do not install the cotter pin at this time.



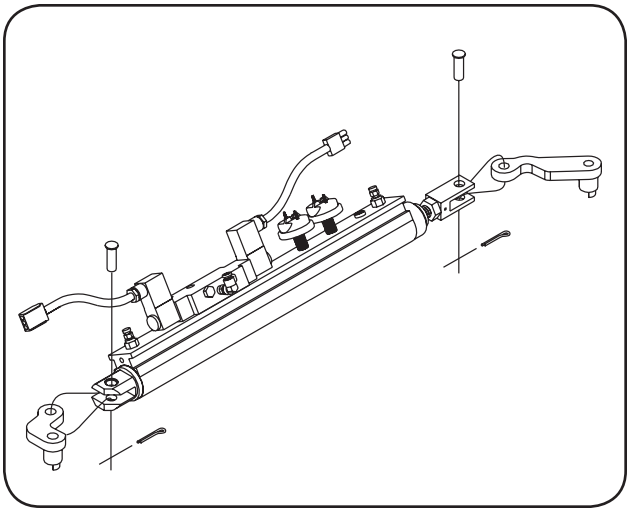
4. Assemble the opposite end of the control arm to the handle and tighten the locknut securely.

7. By trial and error, adjust the length of the rod assembly by removing the clevis pin and turning the clevis. Adjust the rod assembly length so that the control assembly handle passes through the center of the control assembly's cam action as the doors reach the fully open position.

8. When the door opening mechanism operates properly, tighten all hardware securely. Install the cotter pin into the clevis pin. Tighten the jam nut at the clevis in the rod assembly.

Pneumatic Door Opener

The pneumatically operated outward opening door operates similarly to the manual door described above but uses an air cylinder mechanism located inside the door header to actuate the door.



Pneumatic Door Opener Removal

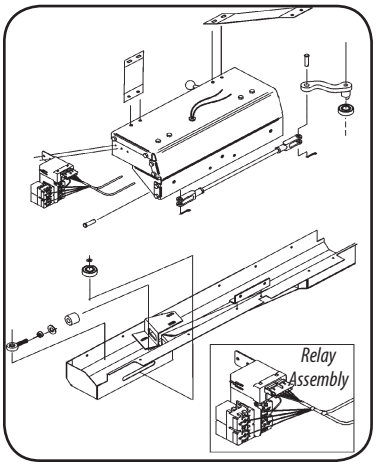
1. Remove the cotter pins and clevis pins from each end of the actuator.
2. Disconnect the electrical connectors.
3. Remove the pneumatic tubing. Identify the tubing as you remove it and replace it in the same positions.
4. Carefully remove the actuator from the compartment.

Pneumatic Door Opener Reinstallation

Installation of the pneumatic door actuator is accomplished in the reverse order of the removal instructions, above.

An air flow control valve located at each end of the actuator assembly allows adjustment of the speed of the door operation. Properly operating doors should cycle open or close in 3 seconds. If the doors do not operate properly, refer to "Adjustment of Outward Opening Door Mechanism", above.

Electric Door Opener



Electric Door Opener Removal

1. Remove hardware holding access panel over the door assembly.
2. Remove the nut and capscrew assembly from 10 places.
3. Disconnect electrical connectors at the relay assembly.
4. Remove the clevis pin from forward door lever.
5. Remove the clevis pin from rearward door lever.
6. Remove the actuator assembly.

Electric Door Opener Reinstallation

Install the electrically operated door actuator in the reverse order of the removal instructions above.

1. Pre-install the relay assembly on the actuator housing.
2. Preset the length of the actuator rod assembly to 18.50 inches (46.99 cm). Be sure the clevis pinholes are properly oriented.
3. Install the actuator assembly by installing bolt and locknut in 10 places. Tighten securely.
4. Install the actuator rod assembly clevis to the lever on the electrically operated actuator.
5. Install the actuator rod clevis to the forward door operating lever.
6. Check for proper operation of the actuator. It may be necessary to adjust the length of the actuator rod assembly so the door will stop before the motor crosses center.
7. If necessary, install the emergency release lever.
8. Move the open position stop to its rearmost position to prevent the motor driven actuator from rotating too far rearward.
9. After adjusting for proper operation, position cam on the rotating shaft to operate limit switch when the door is in the open position.

Door Panels

Door Panels Removal

If so equipped, optional safety equipment attached to the door panel's assembly must be disconnected and/or removed before continuing. Access to the door mechanism is provided over the door opening, inside the bus.

1. Remove the access panel cover or header.
2. If equipped with pneumatic door actuator, refer to Removal of Optional Pneumatic Door Opener above.
3. If equipped with electrically operated door actuator, disconnect the actuator rod clevis from the front door operating lever.
4. Remove Allen head machine screws and lock nuts from spherical bearing (at each end of the connector link).
5. Remove the connecting link.
6. Remove the nut, lock washer and flat washer from the bearing at the top outside corners of the door panels.
7. Support the door panels and remove two carriage bolts from the lower outside corner of each door panel.
8. Lift the door panel and slide the bottom, with bracket and bronze bushing attached, away from the stepwell. Some manipulation of the rearward door panel may be necessary to remove the door lever from the header.
9. Lower the door panel until it clears the header.
10. Set the door panel aside and remove the forward door panel in the same manner.
11. Remove the sealed ball bearings from the outside corners of the door header.
12. Remove the flanged bronze bearing and bracket from the bottom of each door panel.

Door Panels Reinstallation

Installation of the outward opening door panels is accomplished, in the reverse order of the removal instructions above.

1. Install the sealed ball bearings at two places in the header, at the outside corners.

2. Install the bronze bearings and brackets at the bottom outside corner of each door panel.

3. Install the rearmost door panel first. Some manipulation may be necessary to install the rear door panel control lever into the header.

4. Support the door panel and install the lower door pivot bracket and bronze bearing.

5. Install two carriage bolts to secure the pivot assembly in the stepwell.

6. Install the upper spacer.

7. Install the upper pivot through the upper support bearing. Install flat washer. Wipe pivot threads clean and coat the bottom 3 to 5 threads with Loctite™. Install lock washer and nut to hang door panel in frame. Torque to 30 ft-lbs (3.38 Nm).

8. Install forward door panel bronze bearing and bottom pivot bracket onto the door panel.

13. Install the upper pivot through the sealed ball bearing.

14. Lift and support the door panel while installing two carriage bolts to secure the bottom pivot to the stepwell. Install the flat washer. Wipe top pivot threads clean and apply Loctite™ to the bottom 3 to 5 threads. Install lock washer and nut. Torque to 30 ft-lbs (3.38 Nm).

Door Panel Glass Replacemement

With the old glass and the rubber gasket removed, clean the inside edges of the door panel opening. Using a new rubber gasket of the proper size:

1. Install a new rubber gasket onto the new glass.

2. Place a sash cord, or other suitable string, around the outside groove of the glass assembly.

3. Pull the string tight to make sure it seats fully into the groove. Leave the ends of the sash cord hanging down from bottom corners of new glass assembly. Do not lubricate the new gasket material.

4. Install the glass assembly into the door panel, from the inside, placing the bottom groove of the rubber gasket properly straddling the bottom of the opening in the door panel. Be sure the ends of the sash cord are on the outside of the door panel, protruding from the lower corners of the opening.

5. From the inside of the door assembly, press and hold the glass assembly securely into the hole.

6. From the outside of the door assembly, carefully pull the sash cord, causing the outer edge of the gasket to pop into place.

Stop Arms

Federal Motor Vehicle Safety Standard 131 requires all school buses in the United States to be equipped with a Stop Arm. The specific requirements for the blade, lights, lettering and reflectivity of the Stop Arms vary from state to state. Blue Bird provides Stop Arms as kits to match requirements for each state from which the school bus was ordered. Stop arms are available as either electric or air-operated.

Usually, the Stop Arm is located on the left side of the bus, at the front under the driver's window. In some cases, there is another Stop Arm on the left, toward the rear of the bus.

The driver most commonly controls Stop Arms manually via a switch. Some states require that Stop Arms be operated in concert with the Warning Lights when the bus is preparing to stop. Some states allow the lights to be on while the Stop Arm is retracted. In such case, the electronic controls are wired into the lighting system, and operation is automatic when the driver activates the warning light switch. In these cases, the driver will be alerted by an audible signal.

Air Operated Stop Arm

For pneumatically operated (air pressure) Stop Arms, the electric control switch operates an air valve solenoid which controls the flow of air to operate the Stop Arm. The air-operated system is dependant on the air brake system for pressure to operate.

The air stop arm may require periodic air pressure adjustment. The air regulator is accessible from the electrical panel located under the driver's window at the outside of the bus. To adjust the air pressure, remove the wire retaining clip and pull downward on the red lock ring. Turn the knob counterclockwise to decrease the airflow, and then slowly increase the air pressure until the Stop Arm is fully extended. Push the red lock ring upward and install the wire retaining clip.

Electric Stop Arm

Stop Arms may also be electrically operated. There may be a discrete switch for the driver, or the system may be wired into the warning light circuit.

Stop Arm Maintenance

Monthly, lubricate the breakaway hinge at the four pivot points using a high performance penetrating lubricant such as Triflow™ with Teflon.™ Ensure that the Stop Arm moves freely. Check all the fasteners for security and tighten as necessary. Quarterly, remove the covers (both front and rear) to inspect the security of the internal fasteners. Tighten as necessary.

Overview

The seating in your Blue Bird Vision bus is designed for your safety and comfort. The placement and installation of school bus passenger seats is governed by federal regulations. The bus seating meets or exceeds FMVSS222 School Bus Passenger Seating and Crash Protection.

WARNING ***Do not attempt to modify the location of the passenger seats in your Blue Bird Vision without reading the FMVSS222 specifications.***

Driver's Seat

Driver's Seat Adjustment

WARNING ***Do not attempt to adjust the driver's seat while vehicle is in motion. A sudden, unexpected adjustment to the driver's seat while vehicle is in motion could result in serious injury or death.***

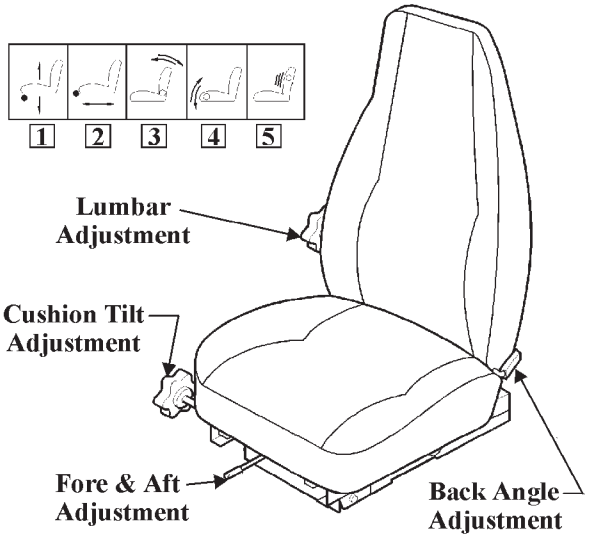
Weight and Height Adjustment. To adjust, push valve knob in to raise seat and pull out to lower seat. When properly adjusted, the seat should neither top nor bottom against the end limits of the vertical travel, under normal driving conditions. Adjustment position should also provide for driving visibility and vehicle control.

Fore and Aft Adjustment. Hold lever to the left to adjust seat position forward or backward.

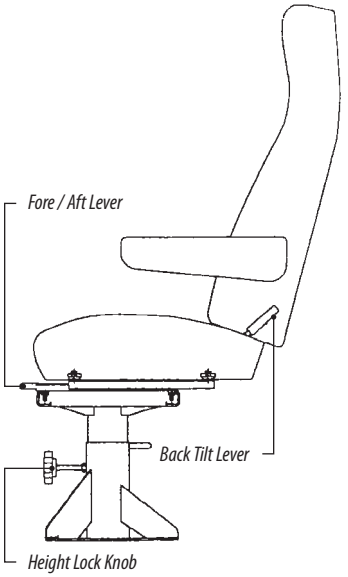
Back Angle Adjustment. Lean forward slightly to remove pressure from seat back. Hold the handle rearward to adjust to any position within the seat's range.

Cushion Tilt Adjustment. Rotate seat tilt knob to decrease or to increase seat tilt.

Lumbar Adjustment. Rotate knob forward to increase or rearward to decrease the support in the lumbar area.



Manually Operated Driver's Seat



Manually Operated Driver's Seat Adjustment

Fore and Aft Adjustment. Hold lever to the left to adjust seat position forward or backward.

Height Adjustment. Loosen height lock knob in front. Lift height adjust handle on side. Slowly sit or stand to position seat at desired height. Release height adjust handle before applying full weight. Tighten handle in front. Fasten and adjust seat belt.

Back Tilt Adjustment. Lean forward slightly to remove pressure from seat back. Hold the handle (Figure 2, C) rearward to adjust to any position within the seat's range.

Driver's Seat Lubrication

CAUTION ***Lubricants can damage vinyl. Use caution around upholstery.***
The moving parts of the driver's seat require occasional lubrication for ease of operation, and longevity of the seat. White lithium-based grease in an aerosol can is recommended. Motor oil 10W30 or 10W40 will provide adequate lubrication, although it may not be as easy to apply.

Seat Care and Cleaning Tips

Dirt and Soil. Most dirt and soil may be removed with soap and warm water solution. If a stain is persistent, a stiff bristle brush may be used. Fabric covered seats should be rinsed with clean water after stain is removed.

Paint, Tar and Asphalt. Paint, tar and asphalt stains may become permanent if not cleaned immediately. Remove stain immediately, using a damp cloth and kerosene. Rub the stain gently, using small strokes.

Nail Polish and Lacquer-based Stains. Immediately soak up as much as possible with a dry cloth. Any remaining stain may be removed with a non-flammable cleaning fluid, such as Tuff Stuff™ or Ar-morall™ cleanser. Rinse thoroughly with clean water.

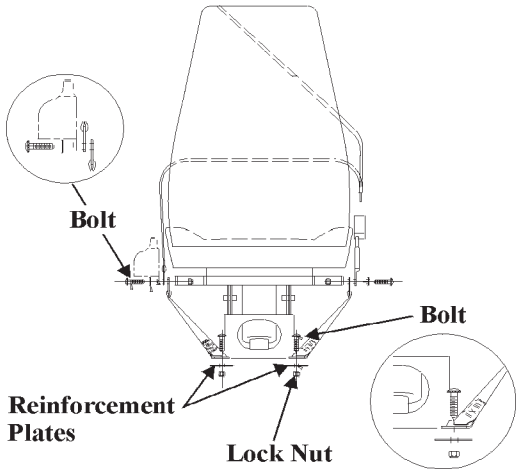
Gum, Grease and Shoe Polish. Immediately remove as much as possible. Shoe polish can permanently stain, if left unattended for a long period. Clean any remaining stain with a Tuff Stuff™ or Armorall™ cleanser.

Ink. Immediately remove stain using a damp cloth and alcohol.

Driver's Seat Removal

1. Remove two (2) bolts and washers from seat belt tether assembly, if equipped. See Figure 3—Driver's Seat Attachment Points.

2. Remove six (6) bolts from seat base mount and floor.



Driver's Seat Reinstallation

1. Clean the six (6) bolts, removing dirt and grease.

2. Apply Loctite™ 242 Blue to five or six threads.

3. Install six (6) bolts and washers into the driver's seat mount.

4. Torque the six (6) bolts 15 to 20 foot-pounds.

Driver's Seat Belt Tether Installation (Air Seat Only)

1. Install two (2) washers and two (2) bolts.

2. Hand-tighten two (2) bolts.

CAUTION ***If washers are not installed, belt will not function as designed.***

Passenger DOT Seats

Blue Bird seats are built to meet Federal Motor Vehicle Safety Standards. School bus seats are equipped with a special foam back pad. When the pad is damaged, replace with an approved replacement part.

Passenger DOT Seat Maintenance

- Inspect and retighten seat leg and wall side mounting bolts every 90 days.
- Inspect and retighten cushion attachments with a Phillips head screwdriver each week.
- Inspect upholstery for cuts and tears every 90 days. If torn, remove upholstery by removing the staples at the bottom front of seat back, or bottom of cushion.

WARNING ***If seat cushions are removed for maintenance, they must be reinstalled using the following instructions. Failure to comply with these instructions could result in injury from unattached seat cushions in the event of an accident.***

Passenger DOT Seat Cushion Removal

1. Loosen (do not remove) the two front swivel type clamps at the front underside of the cushion, with a Phillips tip screwdriver.
2. Rotate the swivel clamps to clear the front retaining channel frame.
3. Lift the forward edge of seat cushion 2 to 3 inches and pull cushion forward to remove.

Passenger DOT Seat Cushion Reinstallation

1. Place the rear edge of cushion down on the base portion of the seat frame, lifting the forward edge 2 to 3 inches.
2. Slide the cushion to the rear edge to engage the positive type clamp into the rear-retaining channel.
3. Lower the forward edge to the frame, making sure the swivel clamps are inside the frame and the posi-tive type clamps are secure on the rear-retaining channel.
4. Rotate the swivel clamp to engage the forward retaining channel frame.
5. Tighten with a Phillips tip screwdriver until clamps no longer rotate.

Track Mounted Passenger Seats

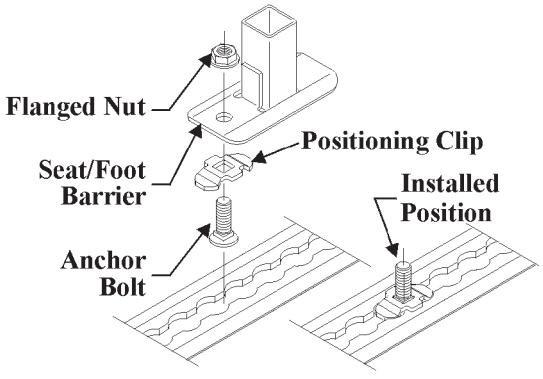
If your Blue Bird Vision bus is equipped with track mounted passenger seats and you relocate a row of seats to accommodate wheelchairs, you must observe rules of spacing and placement. See FMVSS222 School Bus Passenger Seating and Crash Protection.

Track-Mounted Passenger Seat Removal

1. Remove flange nut from the anchor bolt at the seat/barrier foot.
2. Lift seat frame up and off of the anchor bolt.

Track-Mounted Passenger Seat Reinstallation

1. Set seat/barrier down on the anchor bolt and positioning clip.
2. Torque flange nut 34 to 37 foot-pounds.



Seat Belts & Shoulder Harnesses

Seat Belt Inspection and Maintenance

The seat belts, buckles and their attachments must be inspected weekly basis to ensure proper condition, security and operation. If necessary, lubricate seat belt buckles with a graphite lubricant. If a seat belt buckle is found inoperable, replace immediately. If there are any defects in the webbing of the seat belt (i.e., torn or frayed), replace before use. Hand-wash seat belt webbing with warm water and a mild soap. Rinse thoroughly and dry in shaded area.

CAUTION ***Do not bleach or re-dye the seat belt webbing. Such processing may severely weaken the belt.***

Driver's Seat Belt Operation

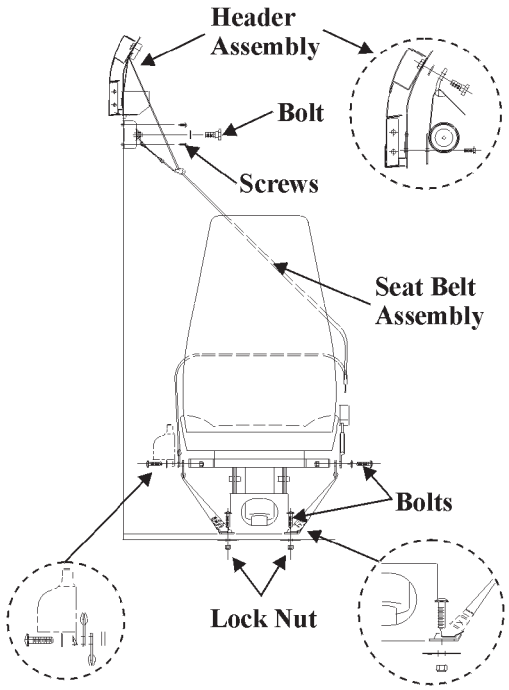
The driver's seat belt should be worn at all times when the vehicle is being driven. Blue Bird drivers' seat belts have automatic locking retractors and are self-adjusting. The seat belts also have an anti-cinch device to prevent the belt from tightening uncomfortably.

WARNING ***Be sure the lap belt is fitted snugly around the hips and not the waist. Failure to do so may increase the chance of injury in the event of a collision.***

The driver's seat belt shoulder harness is an emergency locking belt. The harness may be either emergency locking or automatic locking, depending on the seat belt option chosen. The emergency locking retractor used for all shoulder harness, and specified lap belts, is dual sensitive, engaging when the vehicle tips 15 degrees or if the belt speed exceeds a preset rate.

Automatic locking retractors for specified lap belts are self-adjusting. Adjust the shoulder belt bracket upward for taller drivers downward for shorter drivers, or until maximum comfort is achieved.

To use, withdraw an ample length of seat belt from retractor(s) to allow engagement of buckle halves. Engage buckle halves and allow retractor to draw belt to a snub, comfortable fit. The seat can be released by pushing button in center of buckle.



Driver's Seat Belt Removal

1. Remove one (1) capscrew and flat washer at seat belt retractor. See Figure 5—Driver's Seat Belt Attach Points.

2. Remove one (1) shoulder bolt and flat washer at the header assembly.

3. Remove two (2) screws at the header assembly.

4. Remove one (1) bolt from the mounting bracket. See Figure 5—Driver's Seat Belt Attach Points.

5.Remove two (2) bolts and washers from seat belt tether assembly. See Figure 5—Seat Belt Attach Points.

6. Remove one (1) lock nut, one (1) reinforcement plate and one (1) bolt from floor.

Driver's Seat Belt Reinstallation

1. Clean bolt, removing dirt and grease.

2. Apply Loctite™ 242 Blue to five (5) or six (6) threads.

3. Install one (1) bolt, one (1) reinforcement plate, lock nut and washer into floor.

4. Torque nut on bolt 15 to 20 foot-pounds.

5. Install two (2) bolts and washers at the rear of the driver's seat. See Figure 5—Driver's Seat Belt At-tach Points.

6. Install one (1) bolt at the mount bracket. See Fig-ure 5—Driver's Seat Belt Attach Points.

7. Install one (1) flat washer and one (1) shoulder bolt at the header assembly.

8. Install one (1) capscrew and flat washer at seat belt retractor. See Figure 5—Driver's Seat Belt Attach Points.

9. Install two (2) screws at the header assembly.

Passenger Seat Belts

Individual lap belts for passengers are retractable or non-retractable, depending upon the option chosen. Insert the catch into the buckle, test for assurance of latch fit and pull loose end of strap until belt fits snugly across the lower hips, and not the waist.

WARNING ***Be sure the lap belt is fitted snugly around the hips and not the waist. Failure to do so may increase the chance of injury in the event of a collision.***

The seat belt buckle can be released by pushing button in center of buckle. Turning the strap 90 degrees and pulling can move the adjustable end outward.

Passenger Seat Belt Removal

1. Remove ten screws from seat belt cover on cross bar at the rear of seat on the aisle side and wall side.

2. Remove one flange head screw from rear frame under seat on the aisle side and wall side.

Passenger Seat Belt Installation

1. Install one flange head screw to rear frame under seat on the aisle side and wall side.

2. Torque head screw 15 to 20 foot-pounds.

3. Install ten screws from seat belt cover on cross bar at the rear of seat on the aisle side and wall side. Screws are for the cover only, not the belt. Make sure they are in the plywood-tacking strip. Exposed screw points are not allowed inside back of seat.

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