

Bendix® Gen 4™ and Gen 5™ ABS for Trucks, Tractors, and Buses



FIGURE 1 - Bendix® ABS Controller Assemblies

GEN 4™ AND GEN 5™ ABS INTRODUCTION

This manual describes both the cab mount and the frame mount versions of the Bendix® Gen 4™ and Gen 5™ Antilock Brake System/Automatic Traction Control (ABS/ATC) systems.

Both cab and frame mount versions are designed for:

- Tractors
- Trucks
- Buses and
- Motor Coaches and
- RVs.

This manual covers:

- ABS/ATC Operation
- System Components
- Service Procedures
- Diagnosis and
- Troubleshooting Procedures.

For information on disassembly, installation, and service of related axle and brake components, refer to their individual Bendix Service Manuals.

For assistance in your area call Bendix at 1-800-247-2725 or RoadRanger® at 1-800-826-4357.

These ABS controllers and systems were originally marketed by Eaton Corporation under the Eaton® brand name. For more information contact Bendix, your local authorized Bendix dealer, or RoadRanger®.

Document Revision Level

This document is subject to revision. For updates, please visit www.bendix.com.

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ANTILOCK BRAKING SYSTEM (ABS)

ABS-controlled braking ensures optimum vehicle stability while minimizing the stopping distance. During vehicle operation, the ABS Electronic Control Unit (ECU) continuously monitors all wheel speed sensors. Data input from the wheel speed sensors allows the ECU to:

- Detect impending wheel lock.
- Maintain optimum wheel slip during braking.
- Maximize vehicle stability while maintaining braking effectiveness.

ABS Operation

The ABS controls braking by operating the Pressure Modulator Valves. The ECU makes a new assessment of conditions and updates the control signal to the pressure modulator valves at the rate of 100 times per second.

When inactive, the pressure modulator valves provide straight-through-passages for supply air to the brake chambers. During ABS operation (an ABS “event”), the control unit operates the valves to override the supply of air to the chambers. During an ABS release, supply air is held off while the chambers are vented to the atmosphere. In hold mode, supply air is held off and chamber air is held constant. When required, air is applied to the chamber at a controlled rate by modulating the hold side of the modulator valve.

The ABS system itself does not apply additional braking power. Rather, the purpose of ABS is to limit brake torque to prevent locking that results in loss of lateral stability and increased stopping distances. Cautious driving practices such as maintaining adequate distances from the vehicle ahead are still essential to safe vehicle operation.

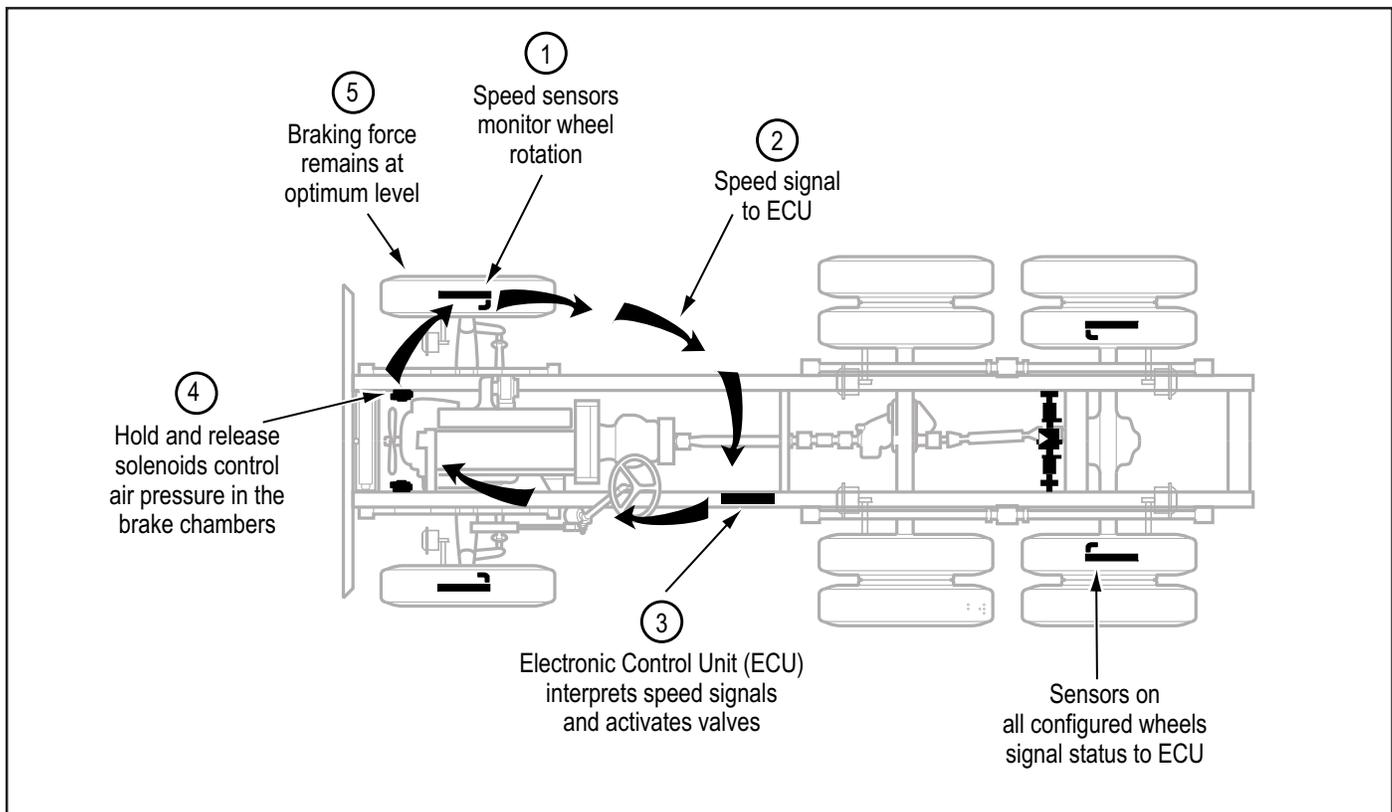


FIGURE 2 - Overview of ABS Operation

ABS Component Function

The ABS system operates as follows (see Figure 2).

1. Speed sensors on each wheel monitor wheel rotation.
2. Each speed sensor communicates wheel rotation pulses to the central Electronic Control Unit (ECU).
3. The ECU receives speed sensor input, interprets the signal pulses, and calculates speed and acceleration rates for the wheels and the vehicle.
4. Based on speed sensor input with the brakes applied, the ECU detects impending wheel lock and operates the ABS modulator valves as required for proper control. The modulator valves can be operated in either a release or a hold mode to regulate air pressure in the brake chambers.
5. Braking force is applied at a level which minimizes stopping distance while maintaining as much lateral stability as possible.

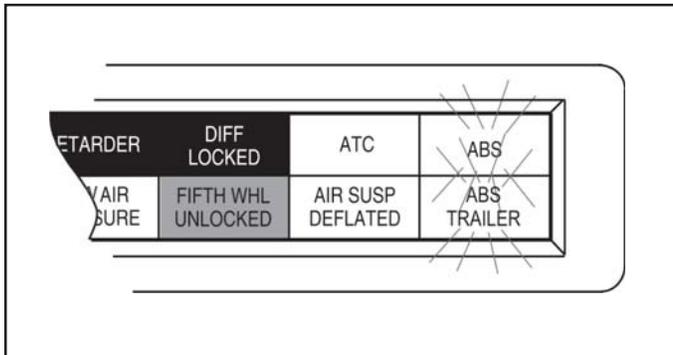


FIGURE 3 - ABS Indicator Lamps

ABS Indicator Lamp

This lamp is the primary indicator of the ABS status.

- The ABS lamp illuminates steadily for a two second bulb-check whenever the switched ignition is ON. The ABS lamp turns OFF after the bulb-check if there are no ABS malfunctions present.
- The ABS lamp flashes on and off continuously when the off-highway mode is selected. (Special option for military and off-highway vehicles.)
- If the Indicator Lamp remains ON, after the bulb-check, there is an ABS diagnostic trouble code that requires service.

NOTE: In the case of a speed sensor failure which has been corrected, the indicator lamp will remain on until sensor output has been verified by the control unit. In this case it is necessary to move the vehicle above 5 mph before the indicator lamp will turn off.

ABS Trailer Indicator Lamp

Tractor/Towing vehicles manufactured on or after March 1, 2001 are equipped with a cab mounted "ABS Trailer" indicator lamp.

When an ABS equipped trailer with Power Line Carrier (PLC) communications capability is connected to the tractor, the ABS Trailer indicator lamp will illuminate for a two second bulb check after the ignition is switched on. The ABS lamp turns OFF after the bulb-check if there are no ABS malfunctions present on the trailer ABS.

If the trailer is NOT equipped with ABS or ABS with PLC capability, the ABS trailer indicator lamp in the cab will not illuminate.

Automatic Traction Control (ATC) System

The ATC system is available on all Standard ABS ECU's. ATC is not available on Basic ECU's. It helps improve traction on slippery or unstable driving surfaces by preventing excessive wheel spin. ATC also enhances vehicle stability by prevention of power spin-out.

ATC requires:

1. ATC valve - Either a stand alone valve or a Rear Axle Valve Assembly with integral ATC solenoid may be used.
2. SAE J1922 or J1939 engine interface (the ABS ECU serial data interface must match the engine controller interface).
3. Brake Light Switch input.
4. ATC Indicator Lamp.

The Electronic Control Unit (ECU) must be configured for ATC operation either by using the diagnostic switch, an MPSI ProLink® hand-held tester or Eaton's ServiceRanger PC software.

ATC Operation

During periods of wheel slip, the Electronic Control Unit enters an Automatic Traction Control mode. There are various modes of Automatic Traction Control.

System operation:

- At speeds above 25 mph, the engine is throttled back via the SAE J1922 or SAE J1939 data link to control spin out.
- At speeds below 25 mph, both engine control and differential brake control are activated as required to control wheel slip. Once triggered, differential braking mode remains active regardless of vehicle speed.
- An optional mud and snow switch allows greater wheel spin (more torque) when activated. It is intended for adverse conditions, usually off-highway. Except for special cases, the switch is programmed for momentary operation. ATC reverts to normal operation when the switch is cycled a second time and whenever the system goes through a power-up cycle.

Component Function

When brake control is utilized, the ATC valve is activated, diverting supply tank air to the Modulator Valves on the drive axle(s). The Electronic Control Unit then activates the appropriate solenoids in order to apply a brake force to the spinning wheel. The Automatic Traction Control System cannot increase traction to a particular wheel; it can only utilize the available traction.

Thermal (Brake Heat) Protection

To prevent excessive brake and drum temperature resulting from brake activity, ATC incorporates a brake temperature estimation algorithm to determine when differential braking mode should be suspended. The differential braking function is re-enabled after a cool-down period.

ATC Indicator Lamp

The ATC indicator lamp operates when a vehicle is equipped with the optional Automatic Traction System.

- Gen 4™ ABS – Lights at key-ON and remains lit with ATC inactive until the driver presses the brake pedal.
- Gen 5™ ABS – Lights at key-ON and turns off after a 2 second lamp check. ATC is active after the lamp check.
- Flashes *rapidly* to indicate that ATC is active.
- Flashes *slowly* when the "mud-and-snow" mode is selected and then flashes more *rapidly* when the automatic traction control system operates.
- Remains ON if an engine data link failure occurs.

NOTE: Some non-ATC equipped vehicles have an ATC lamp that is labeled as a spin light. It indicates when a low traction condition has been encountered. No control action is taken.

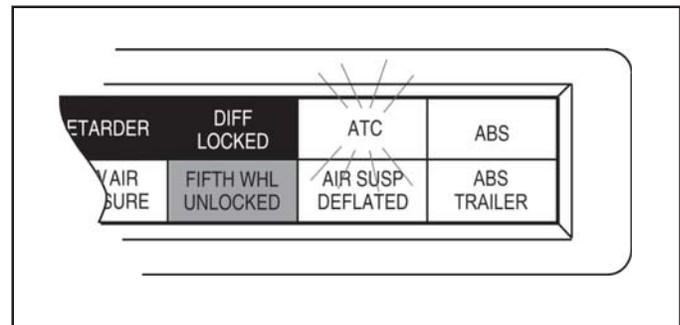


FIGURE 4 - ATC Indicator Lamp

Component Overview

Bendix ABS components include:

- **Electronic Control Unit (ECU):** The ECU monitors and controls the ABS. It also diagnoses ABS malfunctions and stores specific diagnostic trouble codes.
- **Pressure Modulator Valve (PMV):** This component regulates brake chamber air pressure. It houses the hold and release solenoids. A modulator valve is located near each brake chamber or pair of brake chambers that make up an ABS controlled wheel site.
- **Rear Axle Valve Assembly:** An assembly made up of two pressure modulator valves and a relay valve.
- **Wheel End Speed Sensor:** Single point variable reluctance (magnetic) sensor that generates an alternating voltage signal in response to the movement of teeth on a tone wheel.
- **ABS Lamp (Yellow):** This indicator lamp, located on the driver instrument panel, warns the driver of ABS malfunctions. It is also capable of blinking diagnostic fault codes when the ECU is in the self-diagnostic mode.
- **In-Cab ABS Trailer Lamp:** This indicator lamp, located on the driver instrument panel, warns the driver of trailer ABS malfunctions. It is not capable of blinking diagnostic trouble codes.
- **ATC Valve:** The traction control valve applies full system pressure to the relay valve during traction control operation to provide differential (side to side) braking at controlled drive axles.
- **ATC Lamp:** This indicator lamp, located on the driver instrument panel, lights to indicate loss of traction which is being managed by the Automatic Traction Control System.
- **Relay/Breaker Panel:** The OEM provides two circuit breakers and either one or two relays as part of the ABS. One relay is used for indicator lamp control. A second (optional) relay may be used to control a retarder and/or lockup torque converter.
- **Diagnostic Port Connector:** The diagnostic port connector is an industry standard connector that is used to connect to the J1587 diagnostic link. This connector also provides power and ground for diagnostic test equipment.

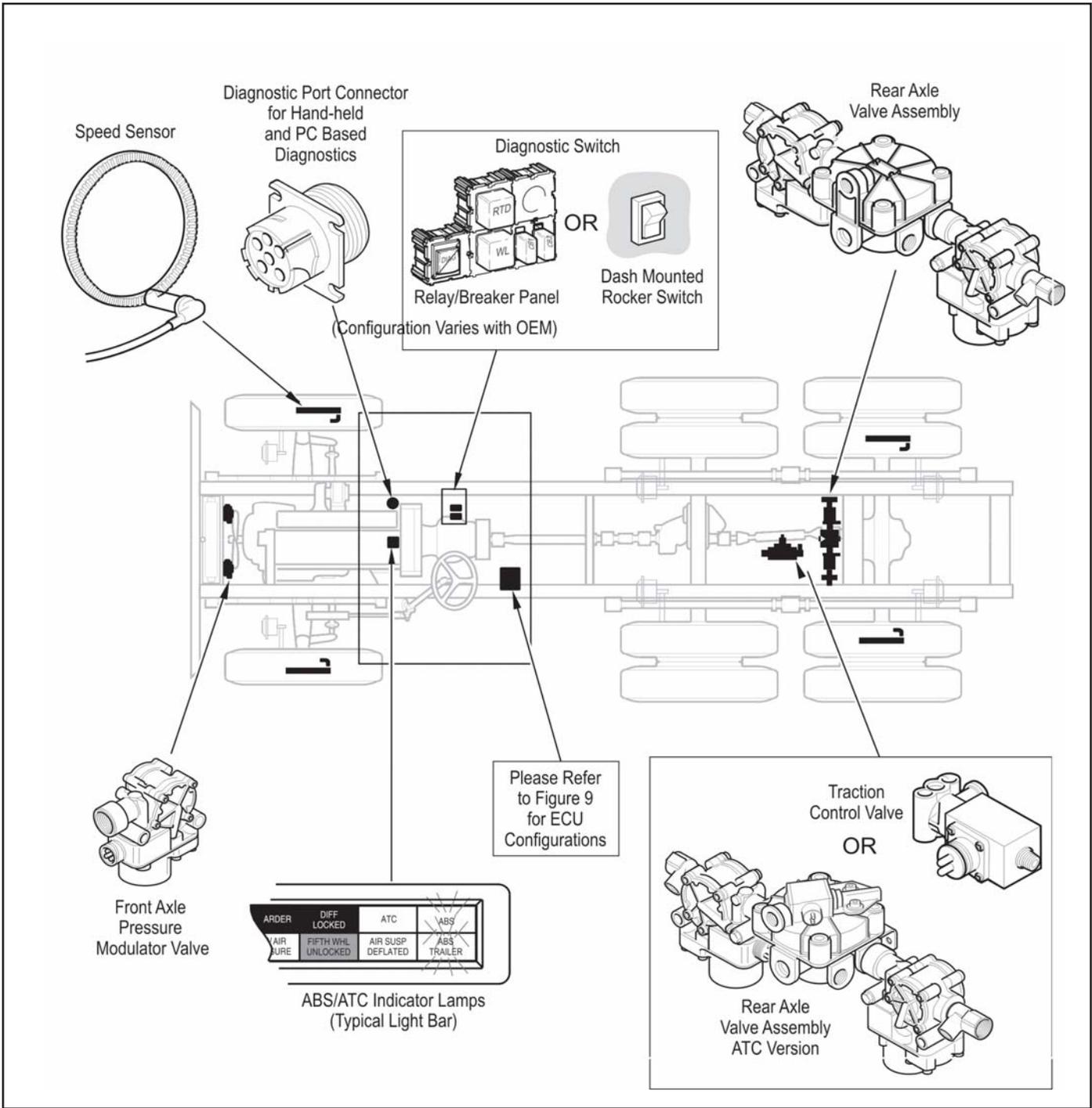


FIGURE 5 - ABS Components

Electronic Control Units (ECUs)

Identification

Frame mount ECUs are environmentally packaged versions of the related Gen 4™ & Gen 5™ ABS cab-mounted units (Standard, Basic). The circuitry and software is the same. Gen 5™ ABS units incorporate power line carrier (PLC) hardware. ECUs are available in 4 and 6-channel versions with either J1922 or J1939 data links. There is also a 24-volt version. Further service information is available on www.bendix.com.

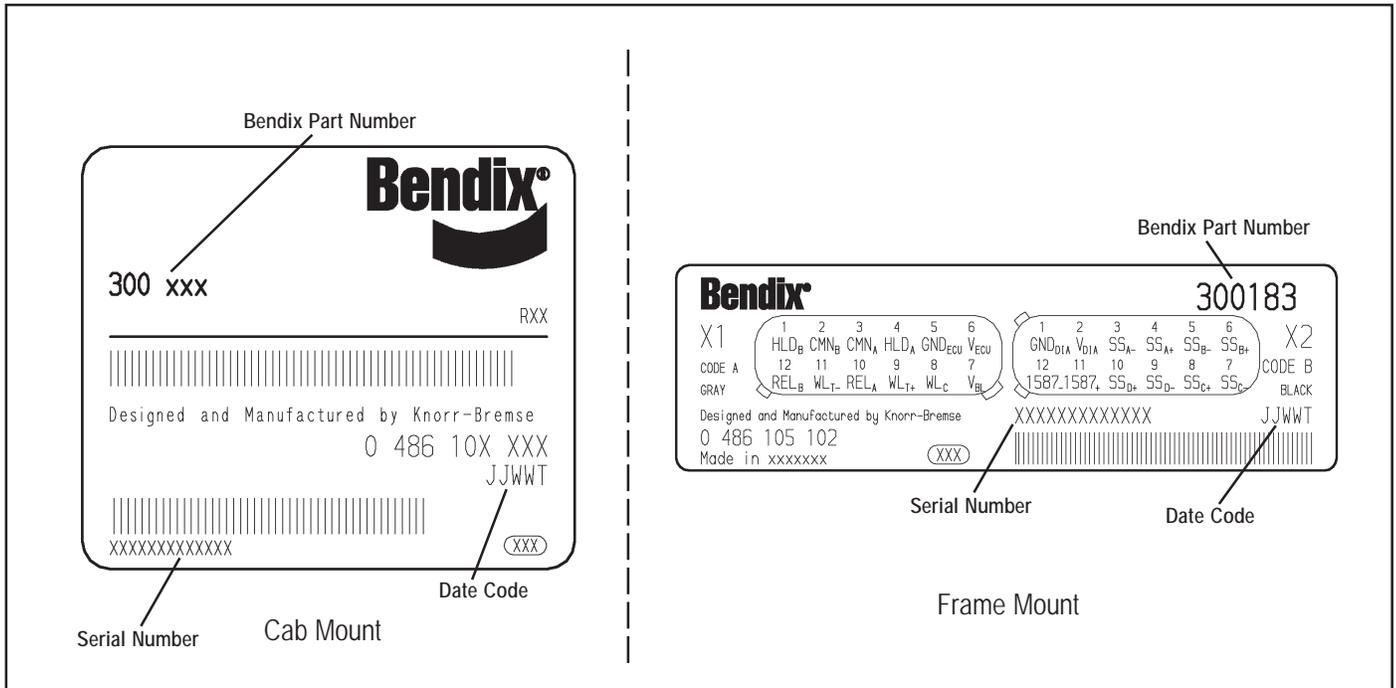
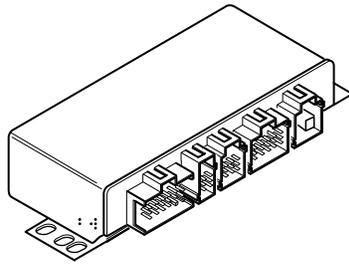
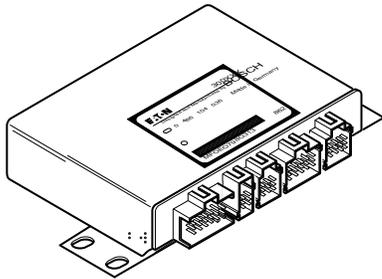


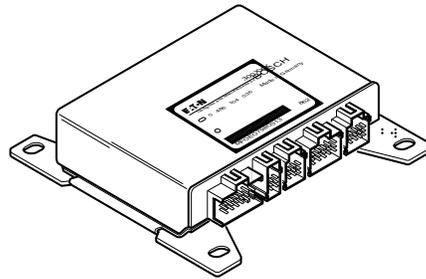
FIGURE 6 - Electronic Control Unit Identification Tags



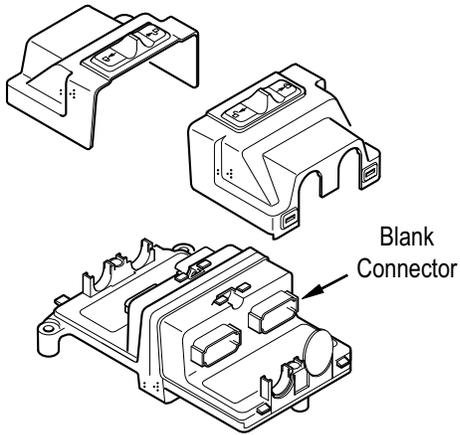
Gen 4™ & Gen 5™ ABS - Basic Cab Mount



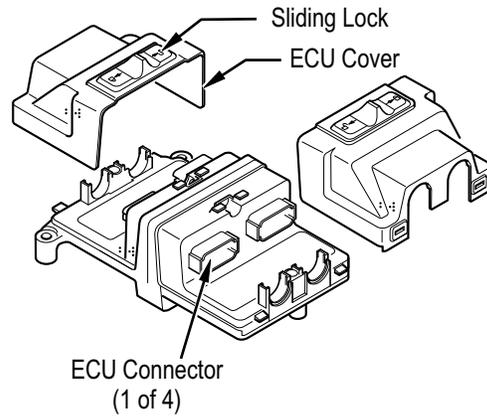
Gen 5™ ABS – Standard Cab Mount



Gen 4™ ABS – Standard Cab Mount



Gen 5™ ABS (PLC - Basic Frame Mount)



Gen 4™ & Gen 5™ ABS – Standard Frame Mount

FIGURE 7 - Available Bendix ABS Electronic Control Units

ABS Valves

The ABS modulator valve controls air pressure to individual brake assemblies. Depending on the particular ABS configuration, a system may utilize three, four or six modulator valves. See Figure 8.

Each modulator valve contains two air control solenoids, which act as pilots to the hold and release diaphragms. The hold solenoid blocks inlet air to brake chambers; the release solenoid removes pressure from the brake. The 3-pin threaded connector has pins for the hold and release solenoid and a third, common terminal.

Rear Axle Valve Assemblies

Rear Axle Valve Assemblies are available for some applications depending on OEM preferences. They are combinations of two modulator valves and a relay valve. The assemblies are available in 4.0 and 5.5 PSIG versions, with or without an integral ATC solenoid.

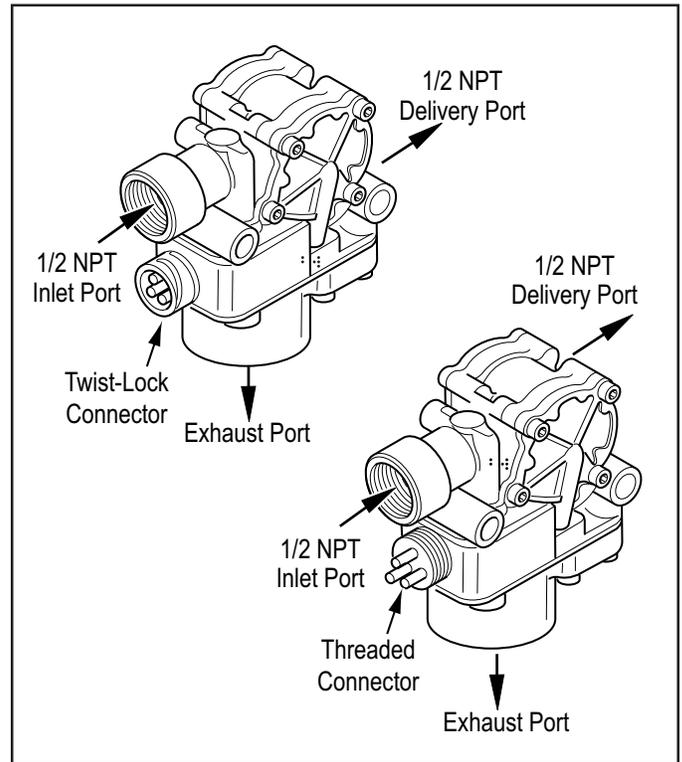


FIGURE 8 - Modulator Valve

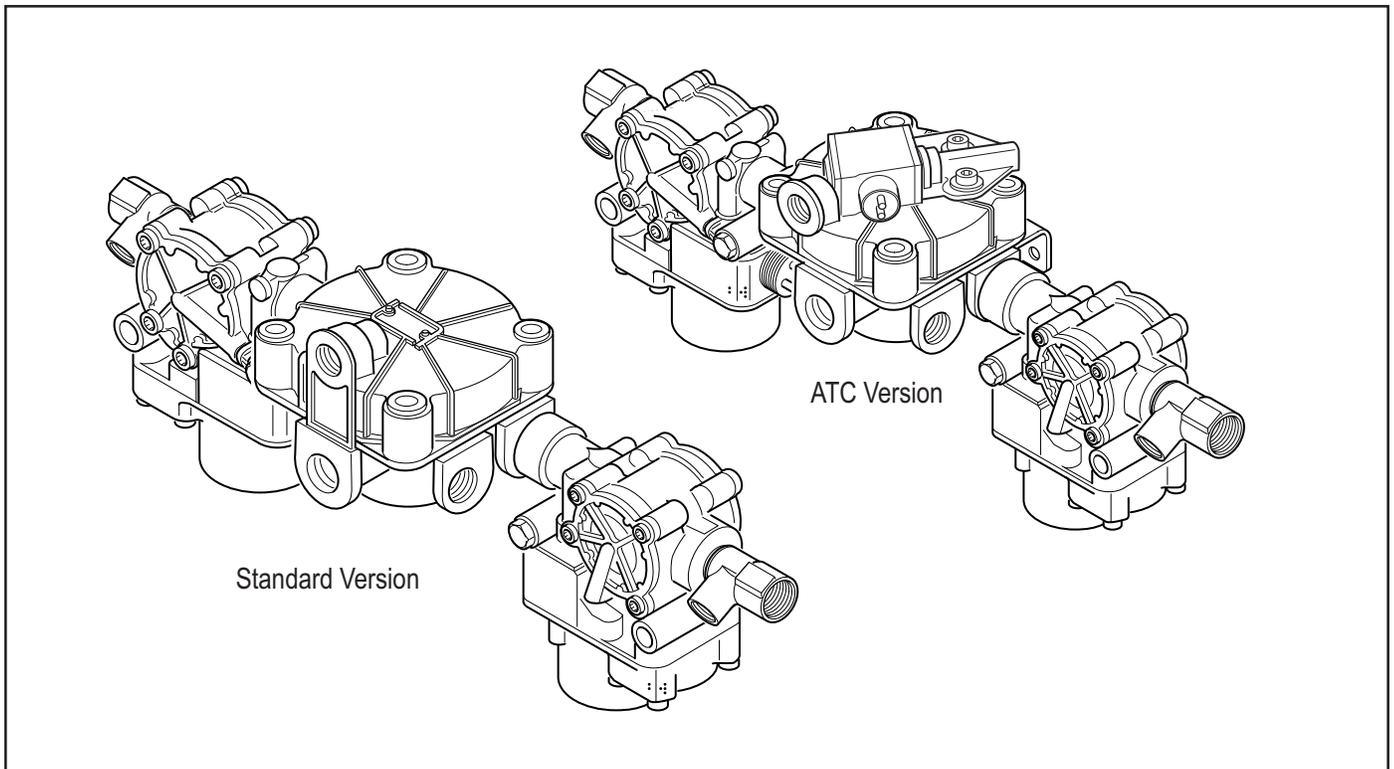


FIGURE 9 - Rear Axle Valve Assemblies, 4-Port ABS and ABS/ATC Versions Shown

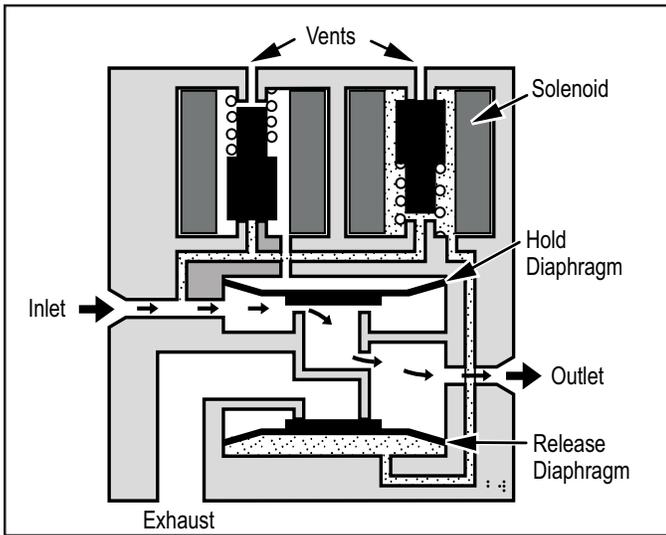


FIGURE 10 - Normal Apply and ABS/ATC Apply

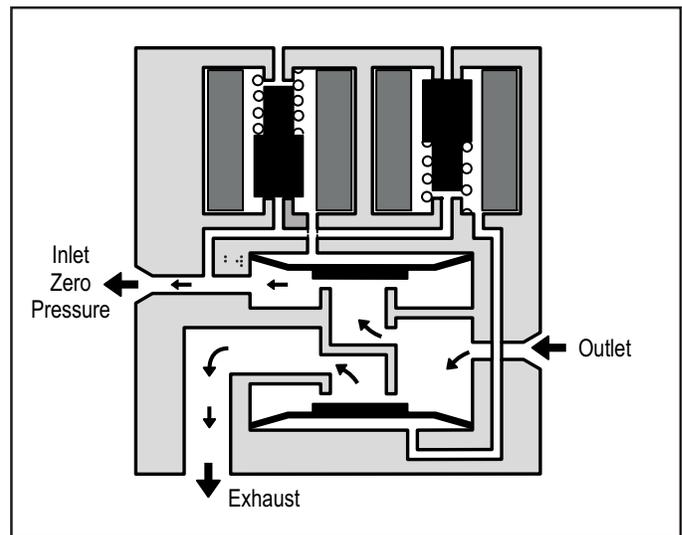


FIGURE 11 - Normal Release

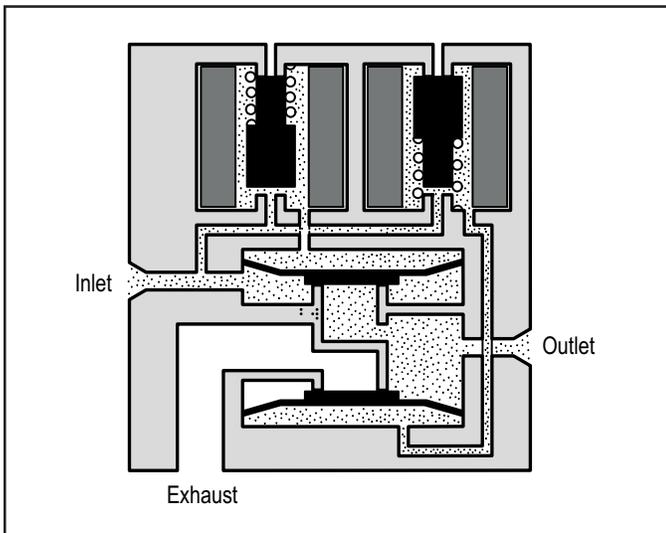


FIGURE 12 - ABS/ATC Hold

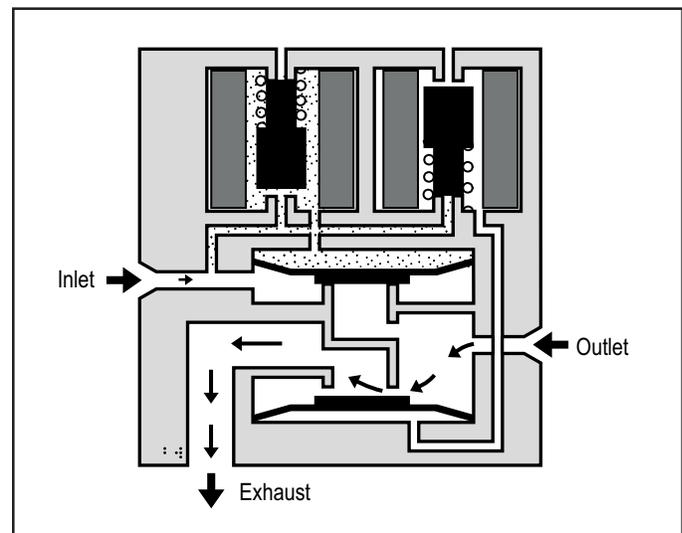


FIGURE 13 - ABS/ATC Release

Modulator Valve Operation Modes

1. **Apply**—Air flows straight through valve. Hold diaphragm is vented to allow air flow. Inlet pressure feeds behind release diaphragm to block the exhaust port. No solenoids are activated.
2. **Normal Release**—With quick release function, hold diaphragm is vented and there is no pressure at the inlet port. Air is allowed to flow from outlet to inlet. Since release diaphragm is not pressurized, air also flows out the exhaust port. No solenoids are activated.
3. **ABS/ATC Hold**—The hold solenoid is activated. Both diaphragms are pressurized. No air flows through the valve.
4. **ABS/ATC Release**—Both solenoids are activated. The hold diaphragm is pressurized, blocking the inlet air. The release diaphragm is vented, allowing air to flow from the outlet port back through the exhaust port.

Optional Front Axle Modules

An optional front axle module is available. It is an assembly of two modulator valves and a quick release valve. Three crack pressure settings are available:

- 0-1 PSIG
- 3-4 PSIG
- 6-8 PSIG.

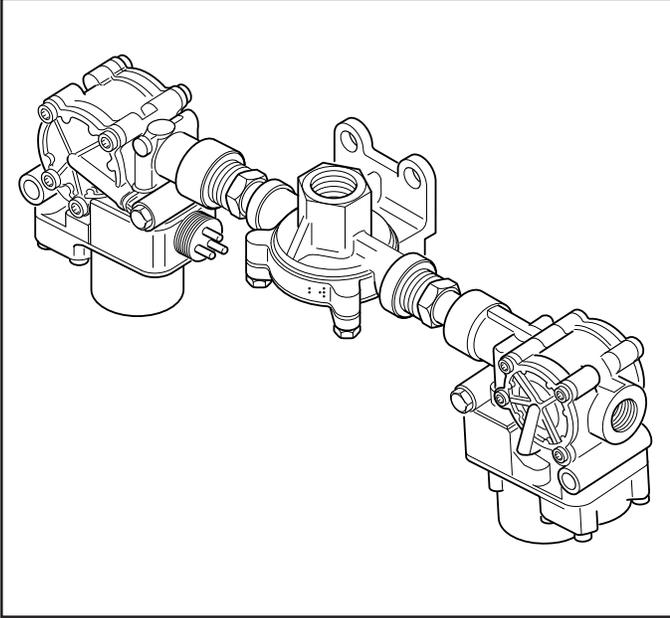


FIGURE 14 - Front Axle Module

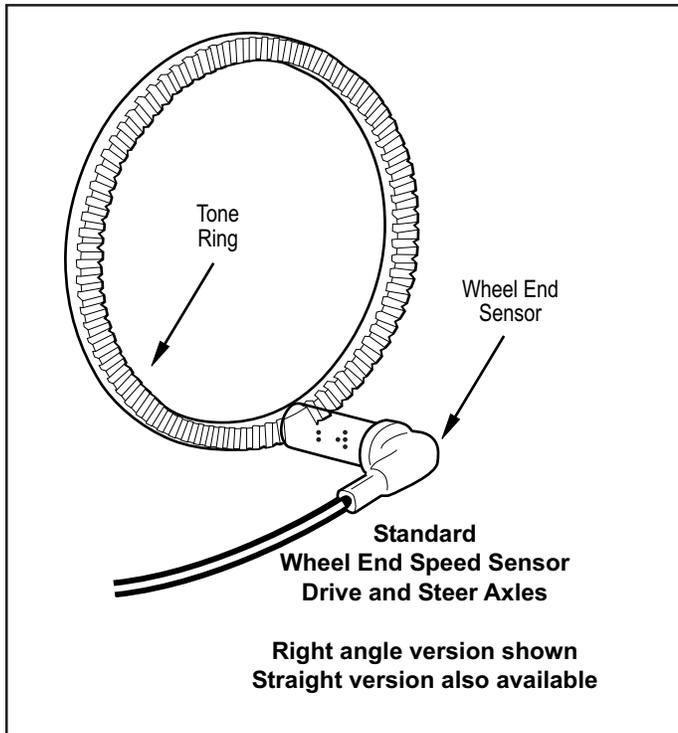


FIGURE 15 - Sensor Assembly

Speed Sensors

Each wheel of an axle under direct ABS control is monitored by a speed sensor. Speed sensors for drive axles and steer axles may be different styles and installed in different locations.

Wheel End Sensors

For most applications, Bendix ABS uses standard wheel end sensors (see figure 15). The front sensor is accessible on the inboard side of the steering knuckle. The rear drive axle sensor is accessible by removing the wheel and drum assembly.

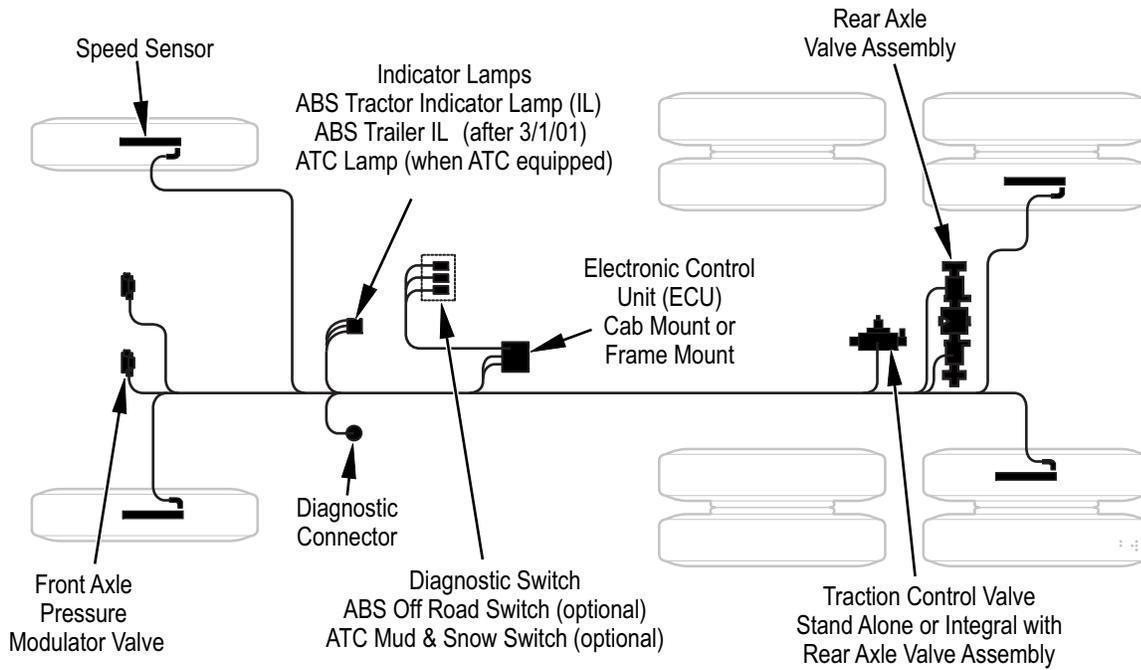
Wheel-end sensors are conventional, single point, variable reluctance sensors. These are often referred to as "magnetic sensors" or "magnetic pickups." These sensors consist of a rod or pole piece surrounded by a coil of wire. A magnet is closely coupled to the pole piece and circulates a magnetic field through the coil. As the teeth of the tone ring rotate past the pole piece, the resistance (reluctance) to the magnetic field varies. The variable reluctance causes variations in the magnetic field which in turn induce a varying voltage in the coils which are wound around the pole piece.

Some general characteristics of variable reluctance, magnetic sensors are:

- The output voltage decreases as the air gap increases.
- The output voltage increases with the speed of the teeth past the pole piece.
- The output voltage waveform is independent of the direction of wheel rotation.

Wheel-End Sensors are protected with stainless steel metal sheaths. They are designed to fit within beryllium-copper friction sleeves which give them a self-adjustment feature.

Electrical Layout



Pneumatic Layout

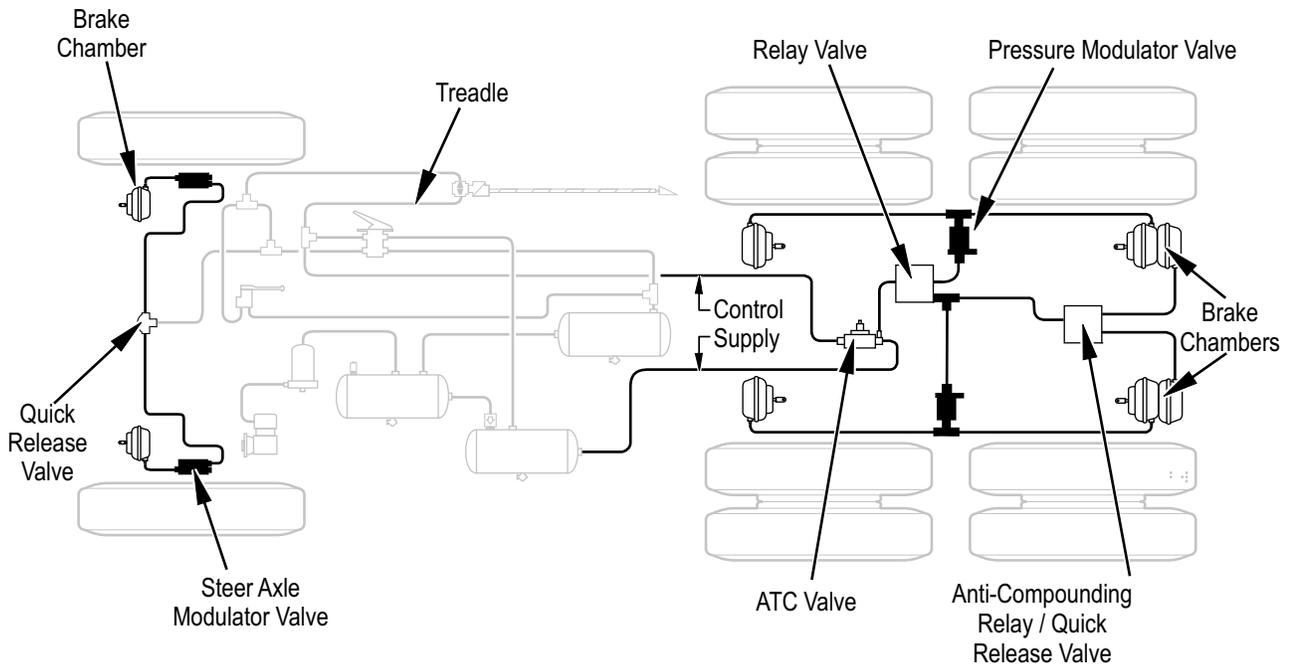


FIGURE 16 - Typical Electrical and Pneumatic Layouts

DIAGNOSTICS

An important feature of Bendix ABS is the system diagnostic capability. This section describes how to retrieve configuration information and error codes to troubleshoot ABS system diagnostic trouble codes. There are three ways to retrieve and display ABS configuration information and trouble codes:

- **ServiceRanger PC software:** Displays configuration information and diagnostic trouble codes on the PC monitor. Refer to the ServiceRanger PC software information later in this section.
- **ProLink hand-held tester:** Displays configuration information and diagnostic trouble codes on the hand-held tester display. Refer to the hand-held tester information later in this section.
- **Diagnostic switch:** Flashes configuration code and diagnostic trouble codes on the ABS indicator lamp. Refer to page 18 for operation of the diagnostic switch.

WARNING! PLEASE READ AND FOLLOW THESE INSTRUCTIONS TO AVOID PERSONAL INJURY OR DEATH:

When working on or around a vehicle, the following general precautions should be observed at all times.

1. Park the vehicle on a level surface, apply the parking brakes, and always block the wheels. Always wear safety glasses.
2. Stop the engine and remove ignition key when working under or around the vehicle. When working in the engine compartment, the engine should be shut off and the ignition key should be removed. Where circumstances require that the engine be in operation, **EXTREME CAUTION** should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated or electrically charged components.
3. Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
4. If the work is being performed on the vehicle's air brake system, or any auxiliary pressurized air systems, make certain to drain the air pressure from all reservoirs before beginning **ANY** work on the vehicle. If the vehicle is equipped with an AD-IS™ air dryer system or a dryer reservoir module, be sure to drain the purge reservoir.

5. Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that safely removes all electrical power from the vehicle.
6. Never exceed manufacturer's recommended pressures.
7. Never connect or disconnect a hose or line containing pressure; it may whip. Never remove a component or plug unless you are certain all system pressure has been depleted.
8. Use only genuine Bendix® replacement parts, components and kits. Replacement hardware, tubing, hose, fittings, etc. must be of equivalent size, type and strength as original equipment and be designed specifically for such applications and systems.
9. Components with stripped threads or damaged parts should be replaced rather than repaired. Do not attempt repairs requiring machining or welding unless specifically stated and approved by the vehicle and component manufacturer.
10. Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.
11. For vehicles with Antilock Traction Control (ATC), the ATC function must be disabled (ATC indicator lamp should be ON) prior to performing any vehicle maintenance where one or more wheels on a drive axle are lifted off the ground and moving.

Troubleshooting Procedures

Figure 17 shows an organized approach to troubleshooting ABS trouble codes. Follow the steps listed below to locate and correct ABS component and wiring problems.

1. Check that the ABS ECU configuration corresponds to the ABS components installed on the vehicle. Reconfigure the ECU if the configuration does not match the installed ABS components.
2. Access active diagnostic trouble code(s). Inactive (historical) diagnostic trouble codes are also reported and may provide additional information to aid in troubleshooting.
3. Look up the code description, the possible causes and the repair procedures provided in this section.
4. Perform the recommended repair procedures.
5. After the repairs are completed, clear all codes and check for any additional codes.

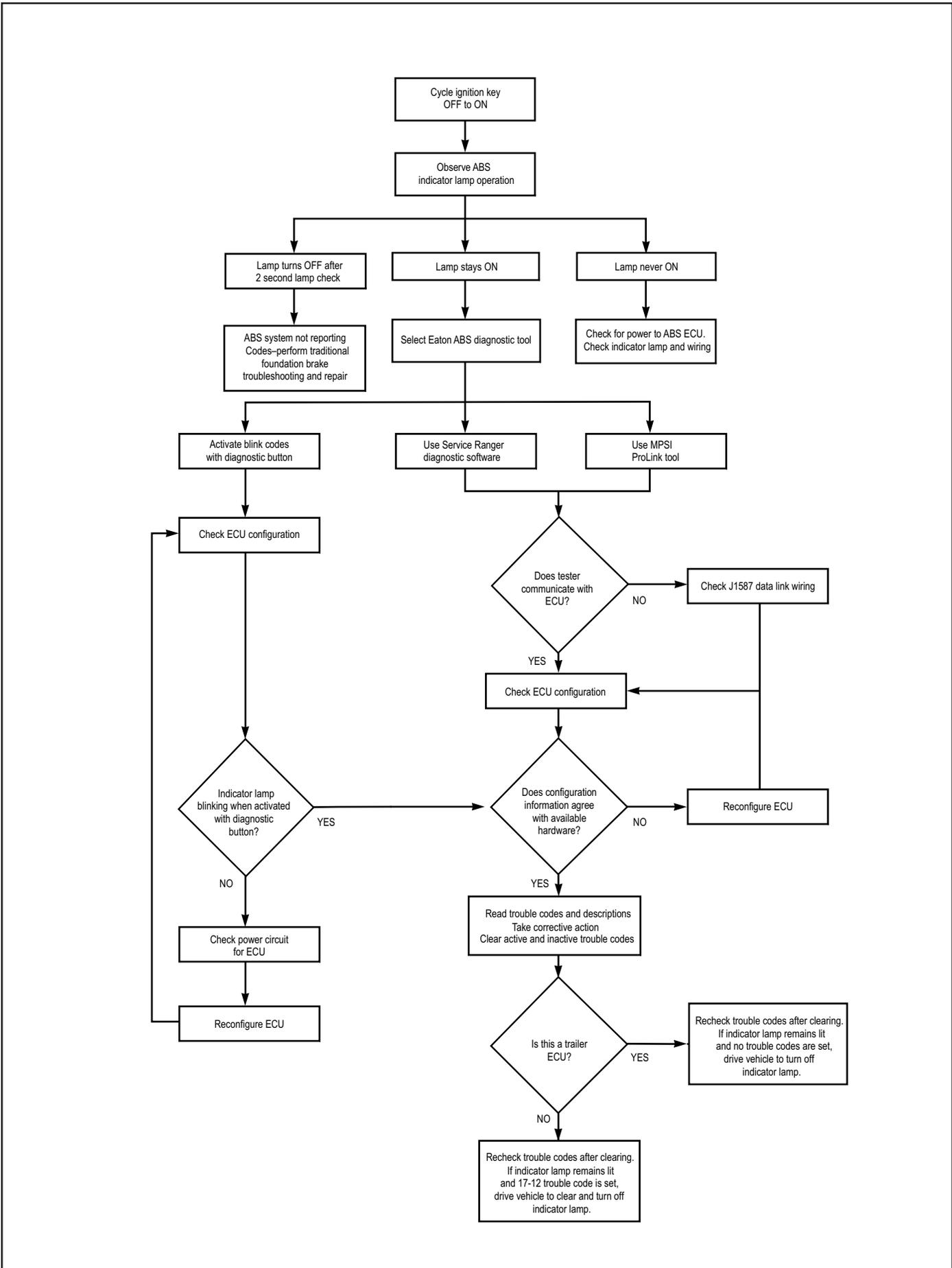


FIGURE 17 - Antilock Brake System Troubleshooting Chart

SYSTEM CONFIGURATIONS

Available Configurations

A wide variety of system configurations are available (refer to Figure 17). It is important to be able to read system configurations and to be able to properly reconfigure a system when necessary.

When to Configure

ECUs are factory configured for the most common requirements. Basic systems are setup for 4s-4m operation with retarder control via retarder relay. Standard systems are setup for 6s-4m operation with retarder control via engine data link. For applications other than these factory configurations (for example use of a retarder control relay, 4s-3m operation, 6s-6m operation or traction control), it is necessary to perform a configuration or “setup” process. This process sets up the ECU for the components that are installed so that proper control and fault tolerance will be

implemented. The diagnostic switch, MPSI Pro-Link® tool or ServiceRanger PC software may be used to configure to a higher level (add components or functionality). If it is desired to move the configuration downward (fewer components than standard), the ProLink tool or ServiceRanger PC software must be used.

How to Configure

Use the “SYSTEM SETUP” menu with the MPSI ProLink® tool, the diagnostic switch (refer to page 25 for procedure) or ServiceRanger PC software. Use of the “SETUP” function will also clear inactive trouble codes from the system. However it is recommended that the “CLEAR TROUBLE CODES” function be used for clearing inactive codes.

Verification

It is important to verify that the intended configuration has been obtained. Refer to Figure 20 (page 17) for proper interpretation of configuration blink codes.

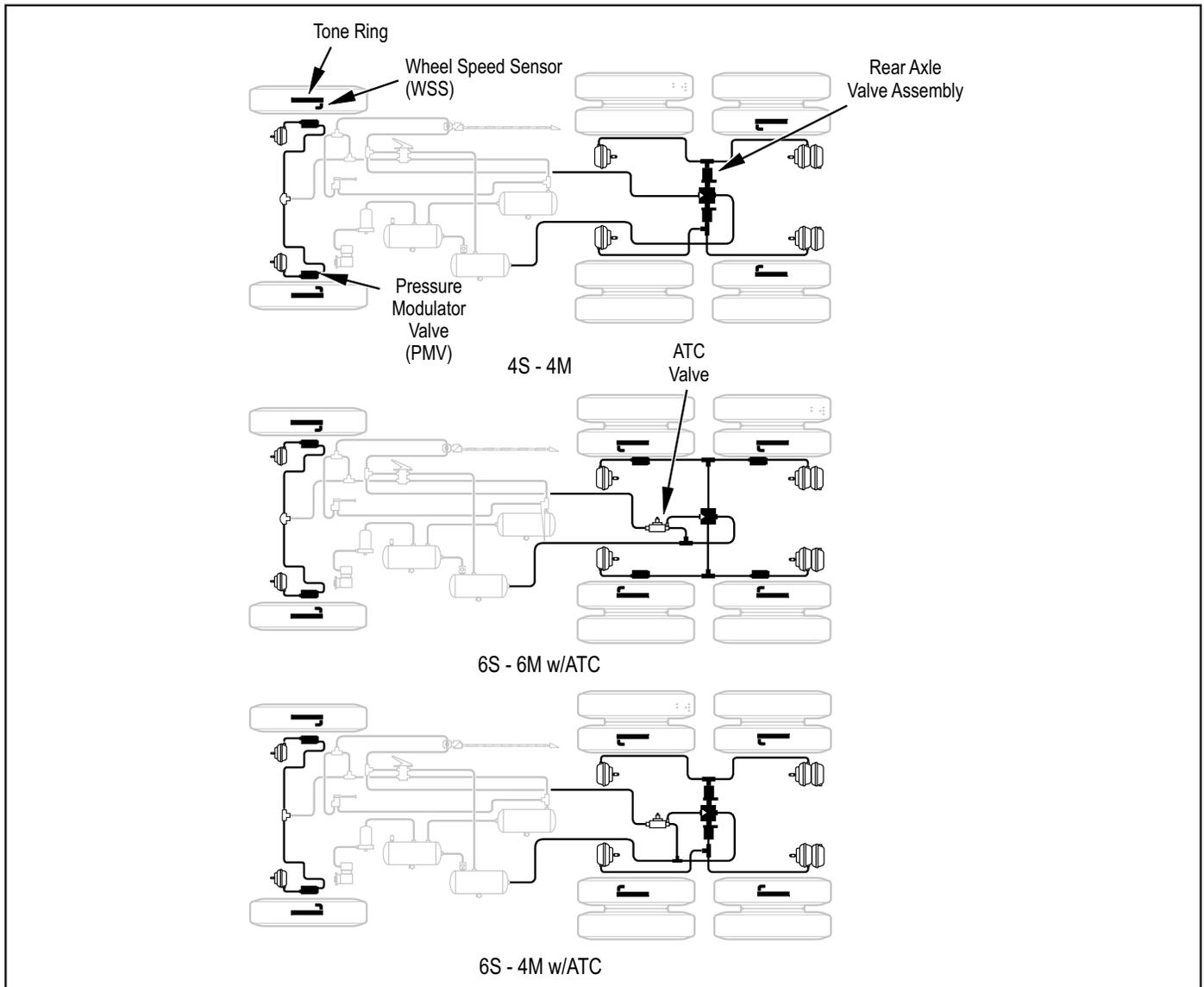


FIGURE 18 - Typical ABS Configurations

Test Equipment

Bendix recommends the use of the following products to troubleshoot the ABS system:

- A multimeter or digital volt-ohmmeter (DVOM).
- Eaton ServiceRanger PC software or an MPSI ProLink® hand-held tester.

Multimeter

A multimeter can be used to check:

- Speed sensor circuit resistance.
- PMV and ATC valve solenoid resistances.
- ABS power circuit voltages.
- Engine data link voltages.
- Retarder control relay.
- Wiring harness diagnostic trouble codes.

ServiceRanger PC Software

ServiceRanger PC software can be used to read and clear error codes and obtain a short description of failures. The software can initiate test sequences for controller outputs and can also read system data such as voltage at the ECU, wheel speeds and cutout speeds.

CAUTION: Eaton ServiceRanger PC software can activate output tests for all output devices. Since these tests can affect operation of the vehicle braking system, the ECU incorporates special safety protection. One axle must show zero speed or the test will be halted.

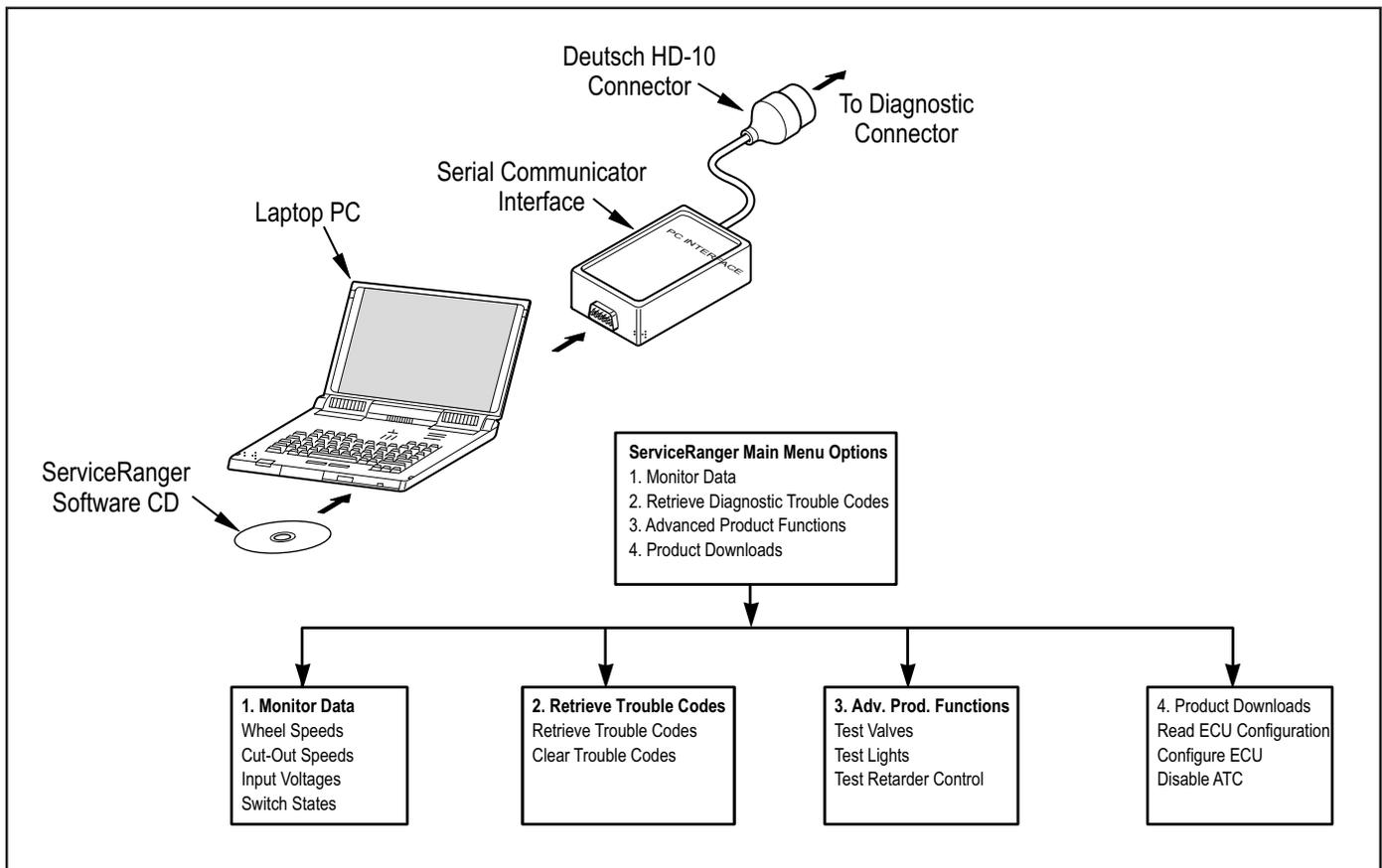


FIGURE 19 - ServiceRanger Menus & Hardware Setup

Hand-Held Tester

An MPSI ProLink® hand-held tester with Bendix proprietary cartridge can be used to read and clear error codes and obtain a short description of failures. The tester can initiate test sequences for controller outputs and can also read system data such as voltage at the ECU, wheels speeds and cutout speeds. A standard heavy duty truck cartridge may also be used, but cannot initiate test sequences.

CAUTION: The ProLink hand-held tester can activate output tests for all output devices. Since these tests can affect operation of the vehicle braking system, the ECU incorporates special safety protection. One axle must show zero speed or the test will be halted.

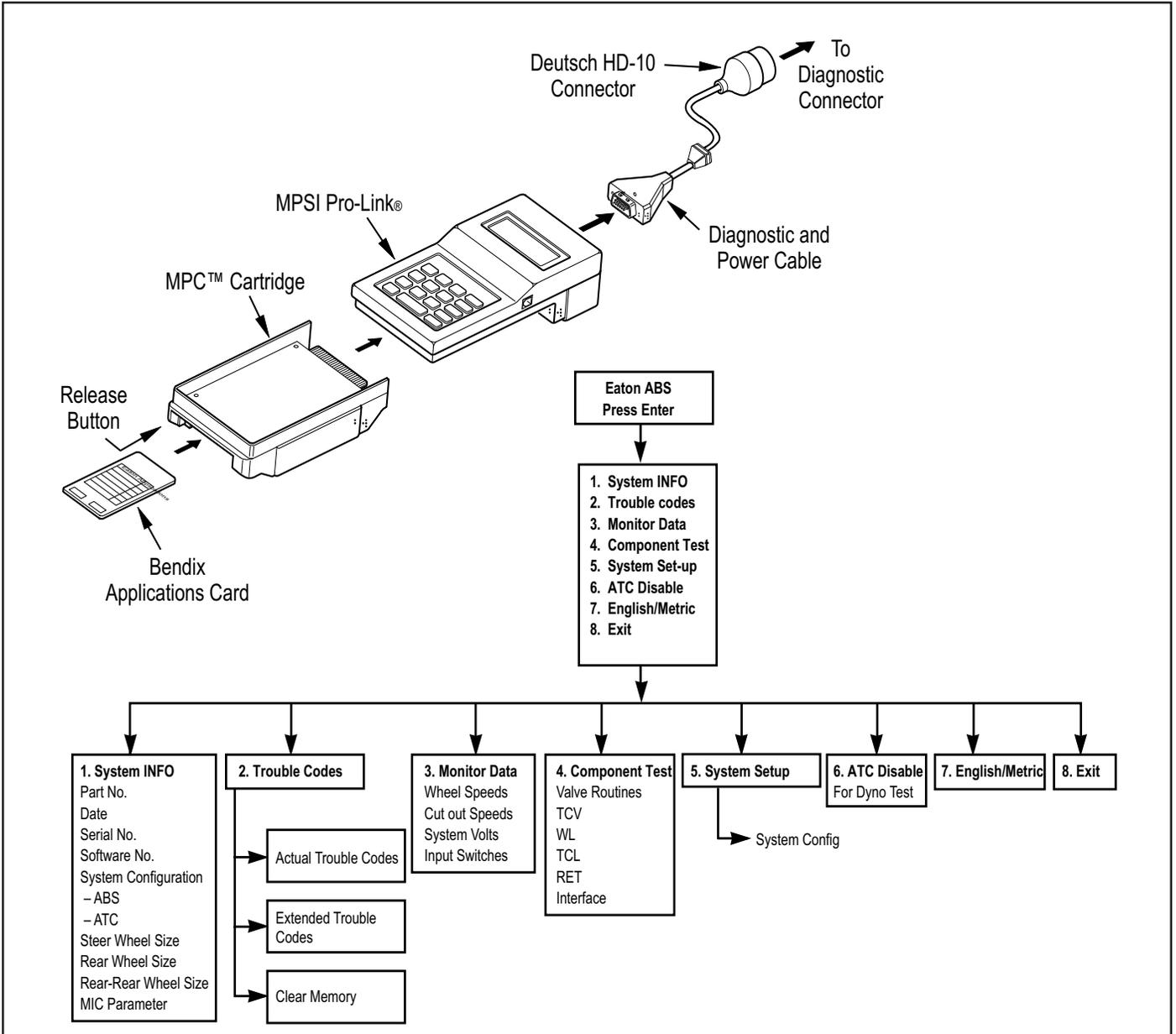


FIGURE 20 - Hand-Held Tester Menus and Set-Up

Diagnostic Switch

Blink Codes – System Configuration and System Faults.

By properly actuating the ABS diagnostic button, configuration codes and diagnostic trouble codes can be retrieved as blinked sequences on the ABS indicator lamp. Configuration codes are sequences of four blinked digits while diagnostic trouble codes appear as two blinked numbers. Refer to the charts beginning on page 19 for a description of these codes. To perform any of the activities listed below, simply follow the steps as given. If you make a mistake during one of the steps, stop and start over at the beginning of the procedure.

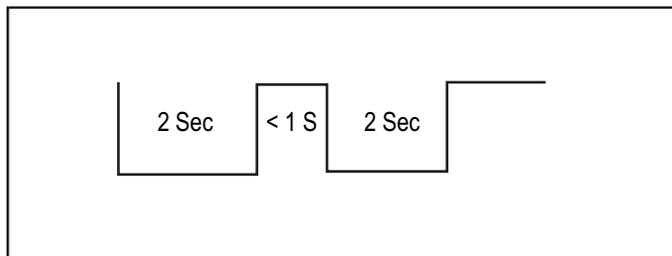
All blink codes are displayed by the ABS indicator lamp only. The ATC lamp does not display blink codes.

Note: Before attempting any repairs:

1. Retrieve the configuration codes and diagnostic trouble codes (write them down).
2. Reconfigure the ECU if the configuration does not agree with the installed hardware. The ECU cannot be configured downward (components removed) with the diagnostic button. For example, a 6S-4M cannot be configured to 4S-4M. Downward configurations require the use of a ProLink tool or ServiceRanger software.
3. If the configuration is correct, clear the diagnostic trouble codes. The process for clearing the trouble codes and reconfiguring the ECU is the same when using the diagnostic button.
4. Once again retrieve the diagnostic trouble codes. Only active codes will now be displayed.

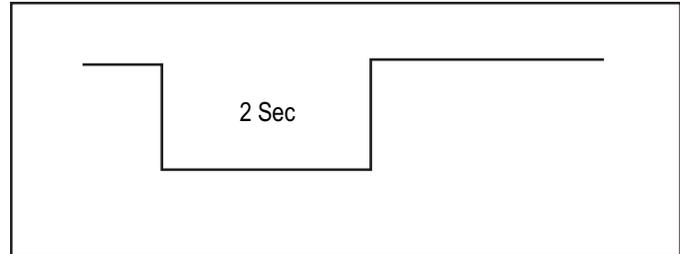
Reading Configuration Codes

- Turn the ignition key to “ON.”
- Press and hold the diagnostic button for two seconds and release.
- Without pause, press the diagnostic button a 2nd time for two seconds and release.
- Four-digit configuration code is retrieved and displayed.



Retrieving Diagnostic Trouble Codes

- Turn the ignition key to “ON.”
- If vehicle is equipped with ATC, apply and release brakes once before proceeding.
- Press and hold the diagnostic button for two seconds and release.
- Two-number blink codes are retrieved and displayed.



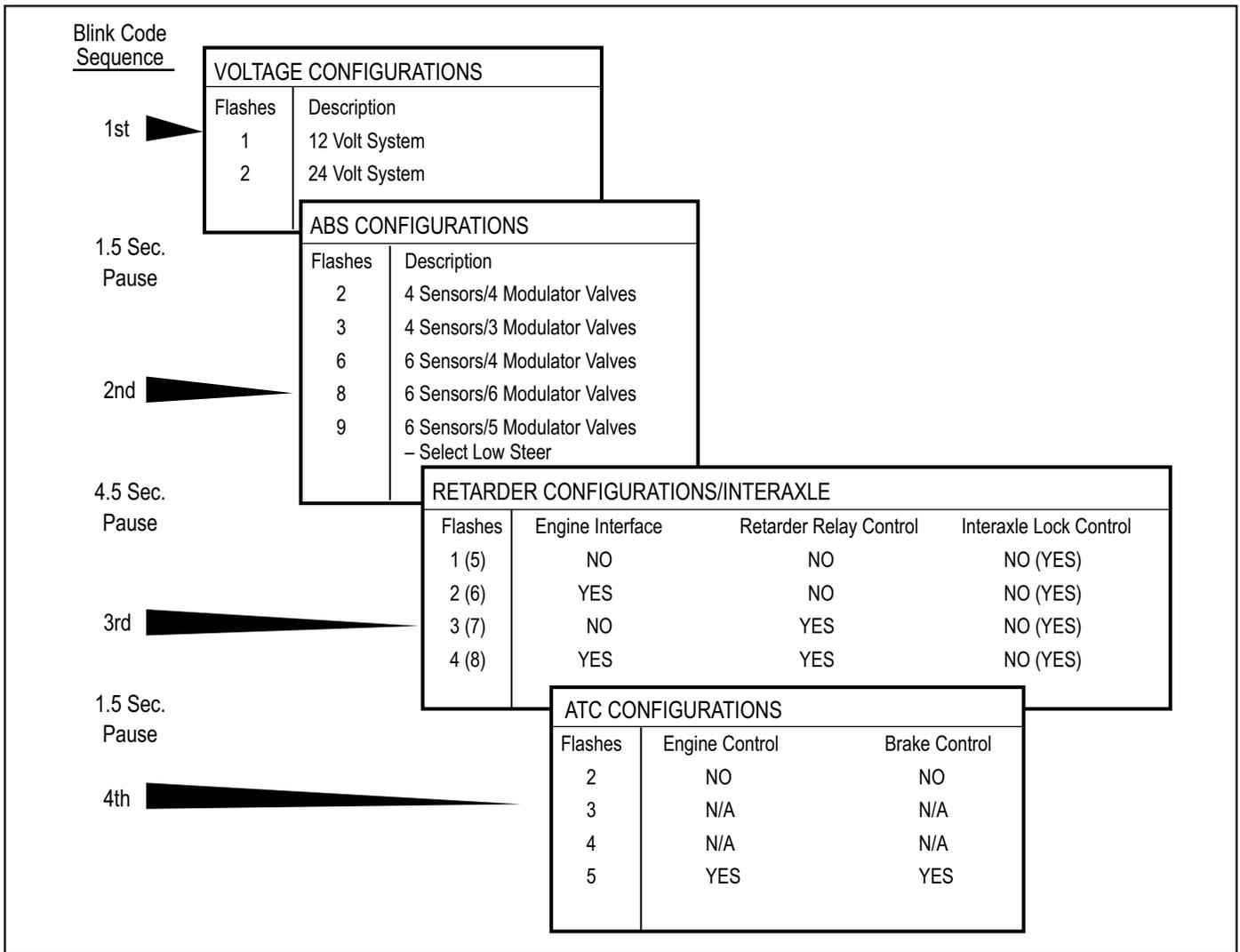
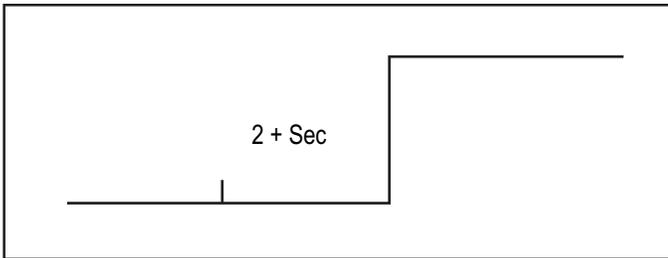


FIGURE 21 - Reading ABS Configuration Codes

Clearing Diagnostic Trouble Codes and/or System Configuration

- With the ignition “OFF” press and hold the diagnostic button.
- Turn the ignition key to “ON” while pressing the diagnostic button.
- Wait two seconds and release the diagnostic button.
- Press and release the brake pedal.
- ECU is reconfigured to match connected components and diagnostic trouble codes are cleared.
- Repeat the “Retrieving Diagnostic Trouble Codes” procedure to verify that the trouble codes are cleared.



Disabling ATC for Dyno Testing

- Turn the ignition key to “ON.”
- Press and hold the diagnostic button for at least 3 seconds and release.
- ATC light turns “ON” and ABS light blinks 17 • 8 indicating ATC is disabled.
- At the next ignition cycle ATC will be reactivated.

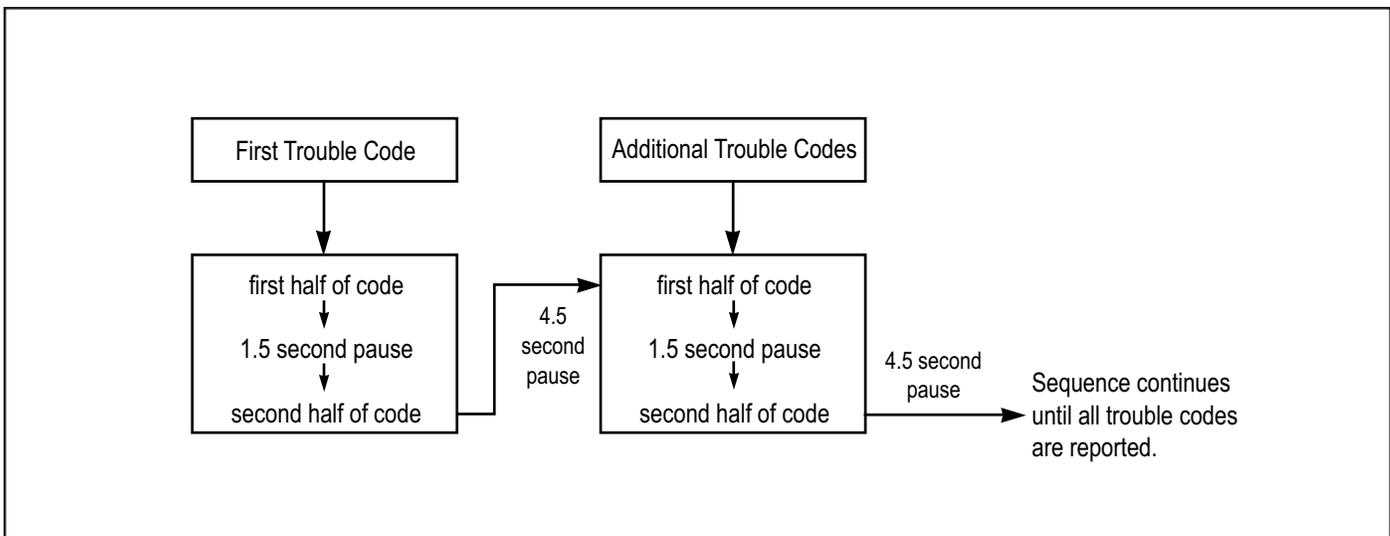
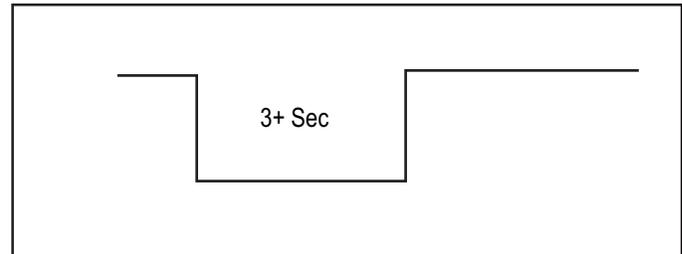


FIGURE 22 - Typical Blink Code Report

Blink Codes		MID 136 SID/FMI	Description	Location
1st.	2nd.			
1	1	-/-	No Trouble Found	
2	1	001/000	Sensor air gap too large.	Left Steer Sensor
2	2	001/008	Air gap too large or sensor shorted.	
2	3	001/010	Speed Sensor signal is noisy.	
2	4	001/008	Wheel locked too long during an ABS cycle.	
2	5	001/008	High deceleration rate at wheel site or sensor shorted.	
2	6	001/012	Sensor shorted low or high or sensor open.	
2	7	001/012	Internal error at the sensor port of the ECU.	
2	8	001/002	Sensor in the wrong location for the system configuration.	
3	1	002/000	Sensor air gap too large.	Right Steer Sensor
3	2	002/008	Air gap too large or sensor shorted.	
3	3	002/010	Speed Sensor signal is noisy.	
3	4	002/008	Wheel locked too long during an ABS cycle.	
3	5	002/008	High deceleration rate at wheel site or sensor shorted.	
3	6	002/012	Sensor shorted low or high or sensor open.	
3	7	002/012	Internal error at the sensor port of the ECU.	
3	8	002/002	Sensor in the wrong location for the system configuration.	
4	1	003/000	Sensor air gap too large.	Left Rear Sensor.
4	2	003/008	Air gap too large or sensor shorted.	
4	3	003/010	Speed Sensor signal is noisy.	
4	4	003/008	Wheel locked too long during an ABS cycle.	
4	5	003/008	High deceleration rate at wheel site or sensor shorted.	
4	6	003/012	Sensor shorted low or high or sensor open.	
4	7	003/012	Internal error at the sensor port of the ECU.	
4	8	003/002	Sensor in the wrong location for the system configuration.	
5	1	004/000	Sensor air gap too large.	Right Rear Sensor.
5	2	004/008	Air gap too large or sensor shorted.	
5	3	004/010	Speed Sensor signal is noisy.	
5	4	004/008	Wheel locked for too long during an ABS cycle.	
5	5	004/008	High deceleration rate at a wheel site or sensor shorted.	
5	6	004/012	Sensor shorted low or high or sensor open.	
5	7	004/012	Internal error at the sensor port of the ECU.	
5	8	004/002	Sensor in the wrong location for the system configuration.	

Blink Codes		MID 136 SID/FMI	Description	Location
1st.	2nd.			
6	1	005/000	Sensor air gap too large.	Left Rear Sensor.
6	2	005/008	Air gap too large or sensor shorted.	
6	3	005/010	Speed Sensor signal is noisy.	
6	4	005/008	Wheel locked for too long during an ABS cycle.	
6	5	005/008	High deceleration rate at wheel site or sensor shorted.	Left Rear Sensor.
6	6	005/012	Sensor shorted low or high or sensor open.	(continued).
6	7	005/012	Internal error at the sensor port of the ECU.	
6	8	005/002	Sensor in the wrong location for the system configuration.	
7	1	006/000	Sensor air gap too large.	Right Rear Sensor.
7	2	006/008	Air gap too large or sensor shorted.	
7	3	006/010	Speed Sensor signal is noisy.	
7	4	006/008	Wheel locked too long during an ABS cycle.	
7	5	006/008	High deceleration rate at wheel site or sensor shorted.	
7	6	006/012	Sensor shorted low or high or sensor open.	
7	7	006/012	Internal error at the sensor port of the ECU.	
7	8	006/002	Sensor in the wrong location for the system configuration.	
8	1	007/003	Short circuit from the release solenoid to voltage.	Left Steer Axle PMV.
8	2	007/004	Short circuit from the release solenoid to ground.	
8	3	007/005	Open circuit at the release solenoid.	
8	4	007/005	Open circuit on the common line to the valve.	
8	5	007/003	Short circuit from the hold solenoid to voltage.	
8	6	007/004	Short circuit from the hold solenoid to ground.	
8	7	007/005	Open circuit at the hold solenoid.	
8	8	007/002	System configuration is incorrect.	
8	10	151/014	Inter-axle differential control circuit shorted high.	IAD Circuit.
8	10	151/014	Inter-axle differential control circuit shorted low or open.	
9	1	008/003	Short circuit from the release solenoid to voltage.	Right Steer Axle PMV.
9	2	008/004	Short circuit from the release solenoid to ground.	
9	3	008/005	Open circuit at the release solenoid.	
9	4	008/005	Open circuit on the common line to the valve.	
9	5	008/003	Short circuit from the hold solenoid to voltage.	
9	6	008/004	Short circuit from the hold solenoid to ground.	
9	7	008/005	Open circuit at the hold solenoid.	
9	8	008/002	System configuration is incorrect.	

Blink Codes		MID 136 SID/FMI	Description	Location
1st.	2nd.			
10	1	009/003	Short circuit from the release solenoid to voltage.	Left Rear Axle PMV.
10	2	009/004	Short circuit from the release solenoid to ground.	
10	3	009/005	Open circuit at the release solenoid.	
10	4	009/005	Open circuit on the common line to the valve.	
10	5	009/003	Short circuit from the hold solenoid to voltage.	
10	6	009/004	Short circuit from the hold solenoid to ground.	
10	7	009/005	Open circuit at the hold solenoid.	Left Rear Axle PMV (cont.).
10	8	009/002	System configuration is incorrect.	
10 or 11	9	014/003	Common side of valves – stray voltage detected.	PMV Commons.
10 or 11	10	014/003	Common side of valves shorted high.	
10 or 11	11	014/004	Common side of the valves shorted to ground.	
11	1	010/003	Short circuit from the release solenoid to voltage.	Right Rear Axle PMV.
11	2	010/004	Short circuit from the release solenoid to ground.	
11	3	010/005	Open circuit at the release solenoid.	
11	4	010/005	Open circuit on the common line to the valve.	
11	5	010/003	Short circuit from the hold solenoid to voltage.	
11	6	010/004	Short circuit from the hold solenoid to ground.	
11	7	010/005	Open circuit at the hold solenoid.	
11	8	010/002	System configuration is incorrect.	
12	1	011/003	Short circuit from the release solenoid to voltage	Left Rear Axle PMV.
12	2	011/004	Short circuit from the release solenoid to ground.	
12	3	011/005	Open circuit at the release solenoid.	
12	4	011/005	Open circuit on the common line to the valve.	
12	5	011/003	Short circuit from the hold solenoid to voltage.	
12	6	011/004	Short circuit from the hold solenoid to ground.	
12	7	011/005	Open circuit at the hold solenoid.	
12	8	011/002	System configuration is incorrect.	
13	1	012/003	Short circuit from the release solenoid to voltage.	Right Rear Axle PMV.
13	2	012/004	Short circuit from the release solenoid to ground.	
13	3	012/005	Open circuit at the release solenoid.	
13	4	012/005	Open circuit on the common line to the valve.	
13	5	012/003	Short circuit from the hold solenoid to voltage.	
13	6	012/004	Short circuit from the hold solenoid to ground.	
13	7	012/005	Open circuit at the hold solenoid.	
13	8	012/002	System configuration is incorrect.	

Blink Codes		MID 136 SID/FMI	Description	Location
1st.	2nd.			
14	5	018/003	Solenoid in ATC valve shorted high.	ATC Valve.
14	6	018/004	Solenoid in ATC valve shorted to ground.	
14	7	018/005	ATC valve open circuit.	
14	8	018/002	ATC valve found when it should not be present.	
14	12	249/002 or 231/002	Time-out or no connection to engine link (J1922/1939).	Data Link.
15	1	254/012	ECU internal trouble code.	ECU.
15	2	253/012	ECU internal trouble code.	
15	3	253/013	ECU internal trouble code.	
15	4	253/012	ECU internal trouble code.	ECU (cont.).
15	5	254/002	ECU internal trouble code.	
15	6	254/002	ECU internal trouble code.	
15	7	254/002	ECU internal trouble code.	
15	8	253/013	ECU internal trouble code.	
15	9	231/012	ECU internal trouble code.	
15	10	254/012	ECU internal trouble code.	
15	11	254/012	ECU internal trouble code.	
16	1 or 5	251/004	Excessive voltage on PMV Power.	Power Circuits.
16	2 or 6	251/003	Low voltage found on PMV Power.	
16	3 or 7	251/005	No voltage found on PMV Power.	
16	4 or 8	251/005	Open circuit found on PMV Ground.	
16	9	251/004	Excessive voltage found on ECU Power.	
16	10	251/003	Low voltage found on ECU Power.	
16	11	251/002	Voltage difference between PMV Power inputs is too high.	
17	1	013/003	Retarder control relay shorted high or open circuit.	
17	2	013/004	Retarder control relay shorted to ground.	
17	3	249/002 or 231/002	J1922/1939 date link not functioning.	
17	4	249/002 or 231/002	J1922/1939 date link time out.	
17	5	253/013	Tire size, front to rear out of range.	
17	6	253/013	Tire size out of range or parameter fault.	
17	7	—	Brake light switch not pushed at this power cycle.	
17	8	—	ATC system is disabled for dynamometer test.	
17	10	023/014	Indicator lamp circuit is faulty.	
17	12	151/014	Sensor memory bit set, (A sensor trouble code has occurred, the ECU must read wheel speeds on all wheels to clear this trouble code.)	

Speed Sensor Troubleshooting

Follow the steps listed below to locate and correct sensor related ABS trouble codes.

1. Access active trouble code(s) using either the Blink Code procedure, with ServiceRanger or the Hand-held Tester procedure.
2. Lookup the code description, the possible causes and the repair procedures provided in this section.
3. Perform the recommended repair procedures.
4. After the repairs are completed, clear all codes and check for any additional codes.
5. If a sensor related trouble code has occurred, a code 17•12 will remain in the system until the vehicle has been driven.

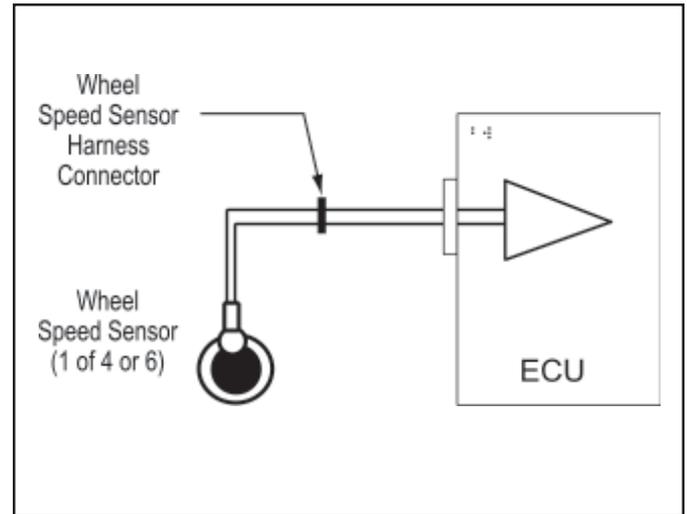


FIGURE 23 - Typical Wheel Speed Sensor Circuit

TOP - Looking into harness connector

E D C B A

X1 Grey X2 Black X3 Green X4 Brown

Harness Connector	PIN	Circuit Description
B (6-Way)	4	Speed Sensor (+) Left Steer
	5	Speed Sensor (-) Left Steer
C (9-Way)	4	Speed Sensor (+) Right Steer
	5	Speed Sensor (-) Right Steer
D (15-Way)	5	Speed Sensor (+) Left Rear
	6	Speed Sensor (-) Left Rear
	8	Speed Sensor (+) Right Rear
	9	Speed Sensor (-) Right Rear
E (12-Way) 6-channel Only	5	Speed Sensor (+) Left Rear Rear*
	6	Speed Sensor (-) Left Rear Rear*
	8	Speed Sensor (+) Right Rear Rear*
	9	Speed Sensor (-) Right Rear Rear*

*Not Used On Basic System

Harness Connector	PIN	Circuit Description
X2 (Black)	5	Speed Sensor (-) Right Steer
	6	Speed Sensor (+) Right Steer
	7	Speed Sensor (-) Left Steer
X3 (Green)	8	Speed Sensor (+) Left Steer
	1	Speed Sensor (-) Left Rear
	2	Speed Sensor (+) Left Rear
	3	Speed Sensor (-) Right Rear
X4 (Brown) 6-channel Only	4	Speed Sensor (+) Right Rear
	3	Speed Sensor (-) Left Rear Rear*
	4	Speed Sensor (+) Left Rear Rear*
Only	5	Speed Sensor (-) Right Rear Rear*
	6	Speed Sensor (+) Right Rear Rear*

*Not Used On Basic System

Speed Sensor Resistance Test

The correct resistance for the speed sensor circuit is between 950 ohms and 1900 ohms.

Measure resistance at the wheel location to check the speed sensor.

Measure resistance at the appropriate ECU harness connector pins to check the cable and speed sensor.

Note: Refer to the chart for pin identification.

FIGURE 24 - Wheel Speed Sensor Harness Circuit Descriptions and Resistance Test

The 17•12 Sensor Memory Diagnostic Trouble Code

The ABS indicator lamp indication and 17•12 diagnostic trouble code are provided to remind the service technician of the need to verify the performance of the ABS wheel speed sensors by driving the vehicle after servicing the sensors. ABS wheel speed sensors do not generate signals unless the wheels are turning. Because of this, certain sensor codes can only be detected when the vehicle is in motion.

The trouble code 17•12 is generated *after the initial sensor codes are cleared*. The ABS indicator lamp remains lit. The trouble codes must be rechecked after clearing the sensor codes in order to see 17•12 reported.

A 17•12 trouble code and ABS indicator lamp signal for sensor code *cannot* be cleared using a ProLink, ServiceRanger software or the diagnostic button. *They can only be cleared by driving the vehicle*. The ABS ECU will clear the 17•12 blink code and turn off the ABS indicator lamp when all active sensor code issues are resolved and the vehicle is driven above 5 mph. The ABS ECU must detect speeds at all monitored wheels for the condition to clear.

Procedure:

1. Check trouble codes.
2. Troubleshoot and eliminate causes for all trouble codes.
3. Clear trouble codes.
4. Check trouble codes again (17•12 will be reported if sensor codes are cleared).
5. If 17•12 error code is reported, drive vehicle above 5 mph (ABS indicator lamp will go out and 17•12 trouble code will be cleared after a short period if all sensor signals are acceptable).

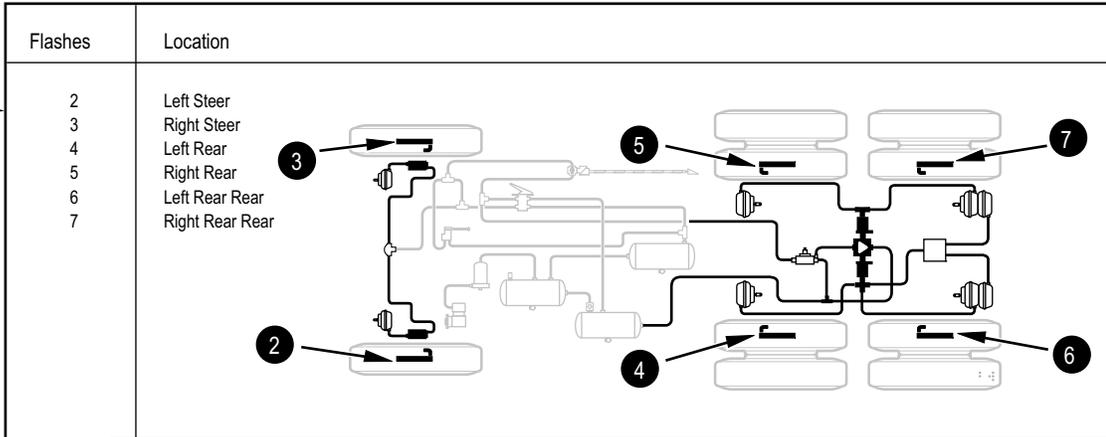
Note: If sensor codes still exist, the ABS indicator lamp will remain lit. The trouble codes will be logged once again after driving the vehicle. If more than one sensor site is affected, the codes may not be re-logged by the ECU until the vehicle has been driven and held above 20 mph for 3-5 minutes.

For more detailed troubleshooting, monitor the wheel speeds and cut-out speeds with ServiceRanger or a ProLink hand-held diagnostic tool. Troubleshoot and repair any speed sensor not reporting a wheel speed or showing a high cut-out speed.

Cut-out speeds are an indication of the strength of the sensor signal to the ECU and are proportional to air gap. Cut-out speeds should be in the range of 3-8 mph. Lower numbers indicate a stronger and better signal than higher numbers. High values indicate a sensor with an unreliable or non-existent signal.

Blink Code Sequence

1st



1.5 Sec. Pause

2nd

Flashes	Condition	Action
1	Sensor air gap too large.	If necessary, clean and lubricate sensor. Press into mounting hole until it bottoms against tone wheel. Clear trouble code and verify that code is corrected by test driving the vehicle. The indicator lamp will remain on until proper sensor output is detected even though the code has been cleared.
2	Air gap too large or sensor shorted.	Check sensor resistance. If sensor resistance is out of range, replace sensor. Clean and lubricate sensor. Press into mounting hole until it bottoms against tone wheel. Clear trouble code and verify that code is corrected by test driving the vehicle. The indicator lamp will remain on until proper sensor output is detected even though the code has been cleared. Use approved lubricant.
3	Speed sensor signal is noisy.	Examine tone ring for damage. Replace tone ring and/or hub if necessary. Check wheel bearing adjustment. Adjust wheel bearings if necessary. Clear trouble code and verify that code is corrected by test driving the vehicle. The indicator lamp will remain on until proper sensor output is detected even though the code has been cleared.
4	Wheel locked for excessive period of time during an ABS cycle.	Check mechanical function of brake. Check for kinked or restricted hoses. Clear trouble code and verify that code is corrected by test driving the vehicle. The indicator lamp will remain on until proper sensor output is detected even though the code has been cleared.
5	Excessive rate of deceleration found at a wheel site.	Check for damaged tone ring or excessive run out. Repair tone ring and/or adjust wheel bearings. Clear trouble code and test drive the vehicle. The indicator lamp will remain on until proper sensor output is detected even though the trouble code has been cleared.
6	Sensor connection shorted low or high or sensor is open.	Use an ohm meter to verify proper sensor resistance (Fig 24). Check harness for shorts or opens. Repair harness and/or replace sensor as necessary. Clear trouble code and verify that code is corrected by test driving the vehicle. The indicator lamp will remain on until proper sensor output is detected even though the trouble code has been cleared.
7	There is an internal error at the sensor port of the ECU.	Clear trouble code and test drive the vehicle. The indicator lamp will remain on until proper sensor output is detected even though the code has been cleared. If trouble code recurs, or cannot be cleared, replace ECU.
8	A sensor has been found in the wrong location.	Check the control unit configuration and verify that sensors are wired in the proper location for the configuration (Refer to Schematic).

FIGURE 25 - Speed Sensor Diagnostic Trouble Code Troubleshooting Guide

Wheel End Speed Sensor Repair

Front Axle Speed Sensor

The front axle speed sensor is located on the inboard side of the steering knuckle.

CAUTION: Block wheels before beginning this procedure. Follow all standard safety procedures, outlined by, but not limited to, the General Precautions listed on page 13 of this document.

CAUTION: Do not work under a vehicle supported by a jack.

Removal

1. Disconnect sensor cable from harness.
2. Remove the sensor from the sensor bushing. (Do not pull on cable.)
3. Remove the speed sensor friction sleeve from the steer knuckle.

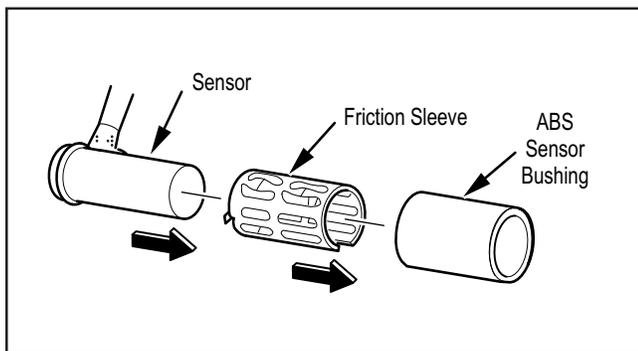


FIGURE 26 - Front Speed Sensor Components

Installation

1. Install the sensor bushing with the flange stops towards the inboard side of the vehicle.
2. Apply high-temperature silicon-based grease to the body of the speed sensor.
3. Push the speed sensor completely into sensor bushing by hand until it stops against the tone ring. The speed sensor is properly installed and adjusted when it is touching the tone ring.

NOTE: The speed sensor must slide freely in and out of the mounting sleeve bore. Operating the vehicle with seized components will damage the speed sensor and the tone ring.

4. Test the installation.
5. Check the cable routing and connections.
6. Clear the trouble codes. A 17•12 trouble code will remain in the system until the vehicle has been driven.
7. Test drive the vehicle and verify that the ABS warning lamp operates properly.

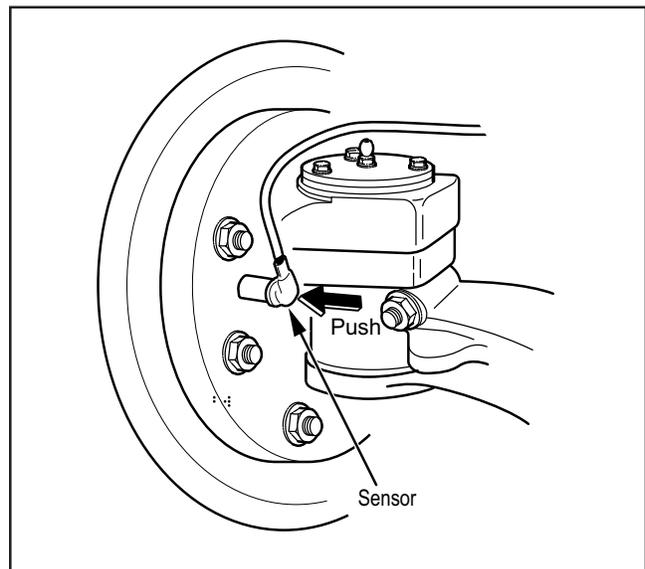


FIGURE 27 - Wheel Speed Sensor Installation

Rear Axle Speed Sensor

The rear axle speed sensor located inside the brake drum and is only accessible by removing the wheel and drum assembly.

NOTE: For diagnostic and service information on in-axle speed sensors, please contact Dana Corporation.

CAUTION: Block wheels before beginning this procedure. Follow all standard safety procedures, outlined by, but not limited to, the General Precautions listed on page 13 of this document.

CAUTION: Do not work under a vehicle supported by a jack.

Removal

1. Back off the slack adjuster to release the brake shoes.
2. Remove the wheel and tire assembly from the axle.
3. Remove the brake drum.
4. Remove the speed sensor with bushing from the mounting block on the axle housing. Use twisting motion and avoid pulling on the cable.
5. Disconnect any fasteners that hold sensor cable to other components and disconnect the speed sensor from the harness.

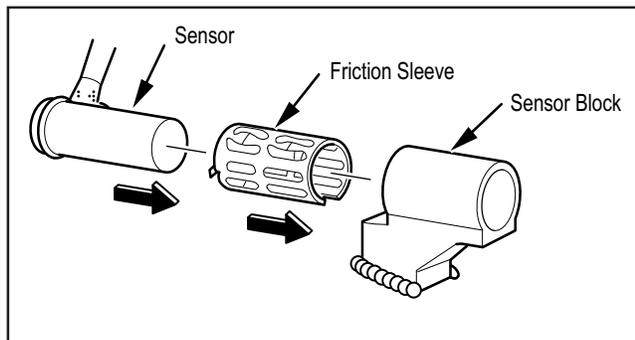


FIGURE 28 - Rear Speed Sensor Components

Installation

1. Install the sensor bushing with the flange stops toward the inboard side of the vehicle.
2. Apply a non-conductive grease lubricant to the body of the speed sensor.
3. Push the speed sensor completely into sensor bushing by hand until it stops against the tone ring. The speed sensor is properly installed and adjusted when it is touching the tone ring.

NOTE: The speed sensor must slide freely in and out of the mounting sleeve bore. Operating the vehicle with seized components will damage the speed sensor and the tone ring.

4. Route the cable to the frame.
5. Connect sensor cable to harness and install fasteners to hold the sensor cable in position.
6. Install the brake drum on the wheel hub.
7. Adjust the rear axle brakes.
8. Install the wheel and tire assembly and tighten the wheel nuts.
9. Test the installation.
10. Check the cable connections.
11. Clear the trouble codes. A 17•12 trouble code will remain in the system until the vehicle has been driven.
12. Test drive the vehicle and verify that the ABS indicator lamp operates properly.

Pressure Modulator Valve (PMV)

Troubleshooting

Follow the steps listed below to locate and correct ABS modulator valve problems.

1. Access active trouble code(s) using either the Blink Code procedure or the hand-held tester procedure.
2. Lookup the code description, the possible causes and the repair procedures provided in this section.
3. Perform the recommended repair procedures.
4. After the repairs are completed, clear all codes and check for any additional codes.

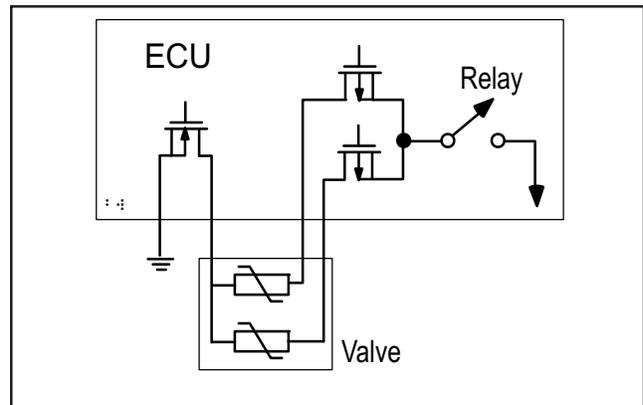


FIGURE 29 - Typical PMV Circuit

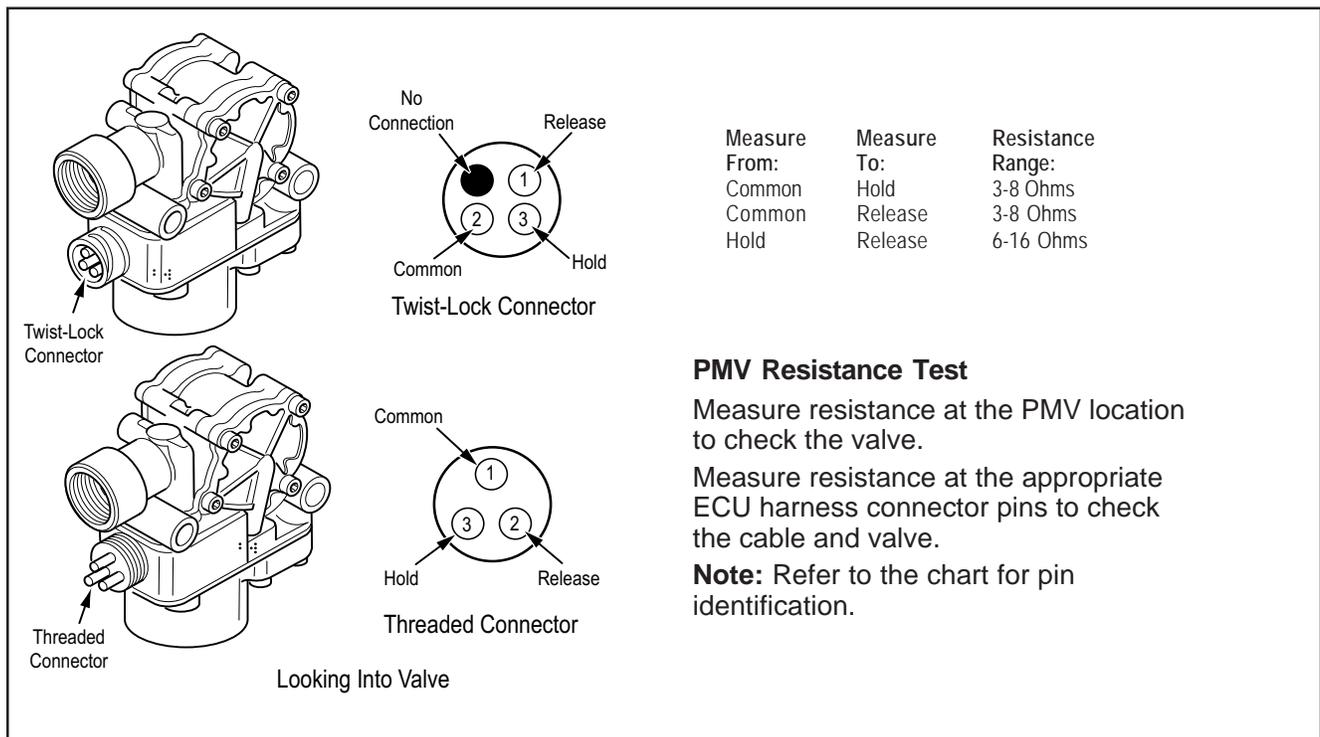


FIGURE 30 - PMV Harness Circuit Descriptions and Resistance Test

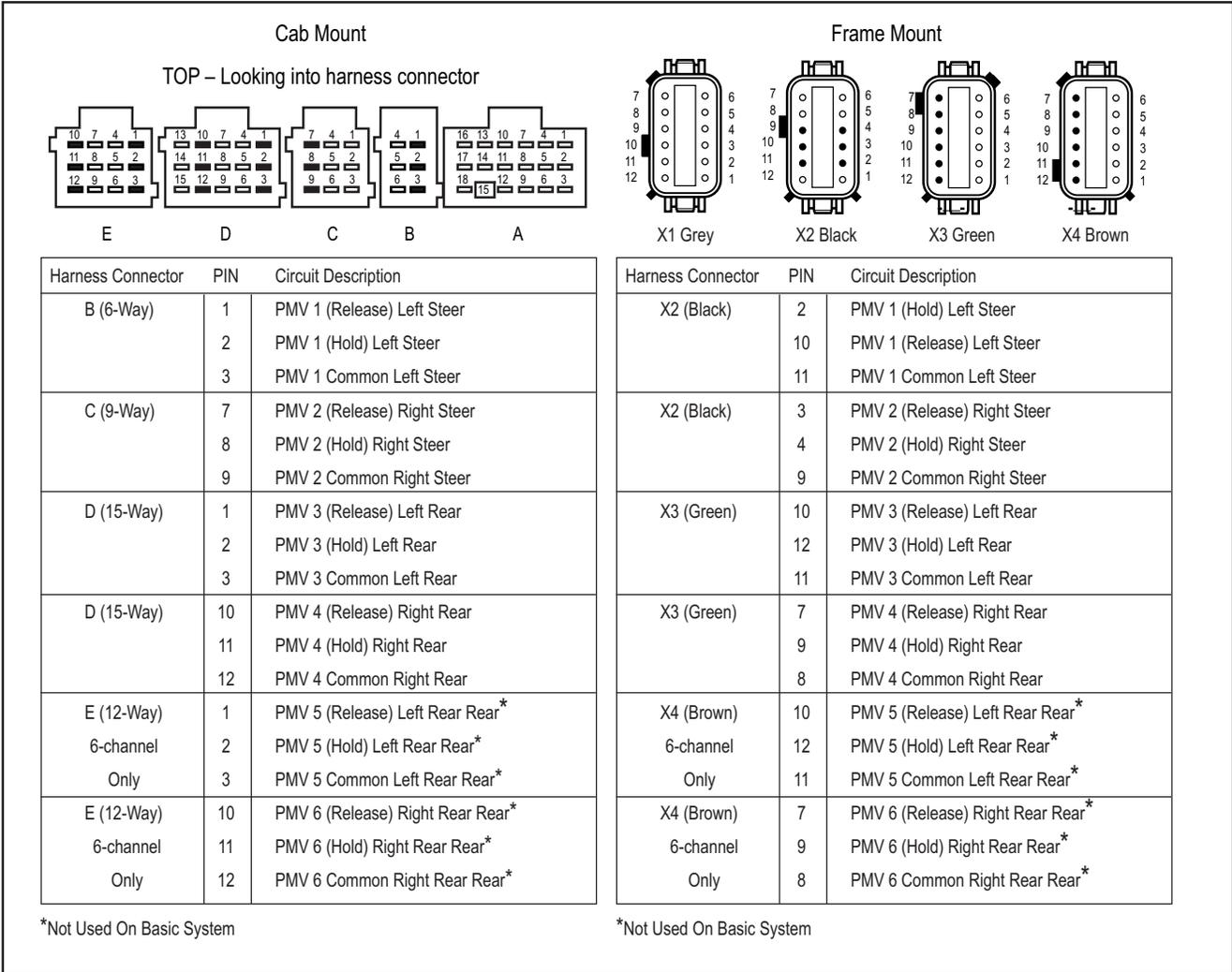


FIGURE 31 - PMV Harness Circuit Descriptions and Resistance Test

Blink Code Sequence

		Flashes	Location	Flashes	Location
1st	▶	8	PMV 1 Left Steer	11	PMV4 Right Rear
		9	PMV 2 Right Steer	12	PMV5 Left Rear Rear
		10	PMV 3 Left Rear	13	PMV6 Right Rear Rear
1.5 Sec. Pause					
2nd	▶	Flashes	Condition	Action	
		1	There is a short between the release solenoid and supply voltage.	Use multimeter to check that valve resistances are correct. If valve is OK check harness for short in wiring.	
		2	The is a short between the release solenoid and ground.	Use multimeter to check that valve resistances are correct. If valve is OK check harness for short in wiring.	
		3	There is an open circuit at the release solenoid.	Use multimeter to check that valve resistances are correct. If valve is OK check harness for open in wiring.	
		4	There is an open circuit in the common line to the valve.	Use multimeter to check that valve resistances are correct. If valve is OK check harness for open in wiring.	
		5	There is a short between the hold solenoid and supply voltage.	Use multimeter to check that valve resistances are correct. If valve is OK check harness for short in wiring.	
		6	The is a short between the hold solenoid and ground.	Use multimeter to check that valve resistances are correct. If valve is OK check harness for short in wiring.	
		7	There is an open circuit at the hold solenoid.	Use multimeter to check that valve resistances are correct. If valve is OK check harness for open in wiring.	
8	A valve has been found wired in the wrong location.	Check the control unit configuration and verify that valves are wired in the proper location for the configuration (Refer to Schematic).			

		Flashes	Location	
1st	▶	10 or 11	PMV Commons	
1.5 Sec. Pause				
2nd	▶	Flashes	Condition	Action
		9	Stray voltage has been found on the common line of one or more of the valves	Unplug ECU and check for voltage on the PMV common pins. If voltage is found, repair harness. If no problem is found in harness, replace ECU. Note: Before replacing ECU clear trouble codes and verify that trouble code is still present (Refer to Schematic).
		10	A short to supply voltage has been found on the common line of one or more of the valves	Unplug ECU and check for short to 12 volts on PMV common pins. If any are shorted to supply, repair harness. If no short is found in harness, replace ECU. Note: Before replacing ECU, clear trouble codes and verify that trouble code is still present (Refer to Schematic).
		11	A short to ground has been found on the common line of one or more of the valves	Unplug ECU and check for short to ground on PMV common pins. If any are shorted to ground, repair harness. If no short is found in harness, replace ECU. Note: Before replacing ECU, clear trouble codes and verify that trouble code is still present (Refer to Schematic).

FIGURE 32 - PMV Diagnostic Trouble Code Troubleshooting Guide

ABS Modulator Valve

Removal

1. Turn ignition switch to the OFF position, and apply parking brake.

CAUTION: Block wheels before beginning this procedure. Follow all standard safety procedures, outlined by, but not limited to, the General Precautions listed on page 13 of this document.

2. Disconnect the wiring connector from the ABS valve.
3. Disconnect the air lines from the supply and delivery ports of the ABS valve.
4. Disconnect the valve mounting fasteners.
5. Remove the ABS valve.

NOTE: To service either modular valve or the relay valve, remove the entire assembly and then replace the individual components (valve).

Installation

1. Install the valve. Torque fasteners to manufacturers specification.
2. Connect air lines.
 - Supply to port 1 on valve.
 - Service brake chamber to delivery port 2.
3. Connect the wiring connector to the ABS valve.
4. Test the installation:
 - Modulator Valve Leak Test—Make and hold brake application. No audible air leaks are permitted.
 - Modulator Valve Component Test with Hand-Held Diagnostic Tool—Select valve routines. Verify proper valve location and operation with tool. Drive the vehicle and verify ABS indicator lamp operates properly.
5. Make several brake applications and check for prompt brake chamber applications and release at all wheels. Check the cable connections.
6. Clear codes.
7. Drive the vehicle and verify that the ABS indicator lamp operates properly.

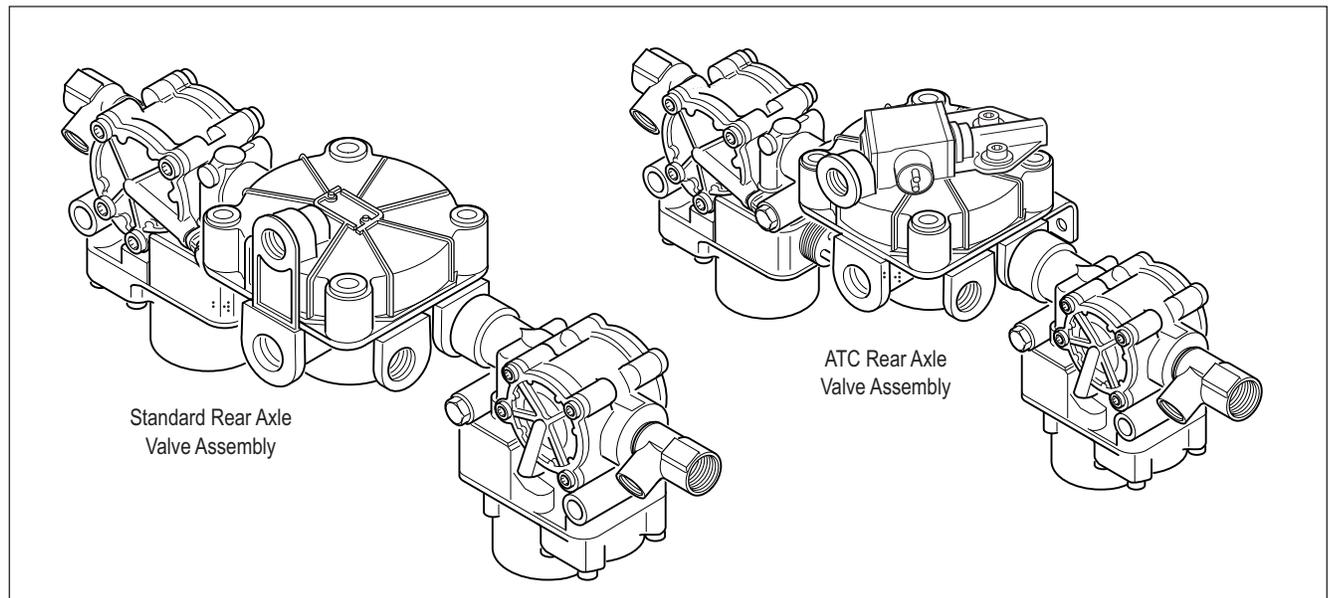


FIGURE 33 - Rear Axle Valve Assemblies – Standard and ATC Version Shown

Performance Test of the Relay Valve

CAUTION: Block wheels before beginning this procedure. Follow all standard safety procedures, outlined by, but not limited to, the General Precautions listed on page 13 of this document.

1. Park vehicle on level surface and block wheels.
2. Release parking brake and fully charge the air system (governor cut out point).
3. Turn the engine OFF. Apply the service brake several times, then hold and check for prompt brake air chamber application and release at all wheels.
4. Apply brake, then hold. Coat outside of relay valve (where cover joins body) and connection between modulator valve and relay valve with a soap solution. No leakage is permitted.
5. If a sluggish response is noted at all wheels, inspect for kinked or obstructed air line leading to or from valve.
6. Increase system air pressure to governor cutoff. With the brakes released, coat exhaust port of relay valve with a soap solution. Leakage of a 1" bubble in 5 seconds is permissible.
7. Depress foot valve and keep depressed. Coat exhaust port with a soap solution. Leakage of a 1" bubble in 3 seconds is permissible.

Automatic Traction Control (ATC) Valve Troubleshooting

The following ATC troubleshooting pages provide the basic information necessary to: identify the diagnostic trouble code; locate the problem; review the possible cause(s); select the correct solution and utilize proper repair procedures.

Follow the steps listed below to locate and correct ATC problems.

1. Access active diagnostic trouble code(s) using either the Blink Code procedure or the hand-held tester procedure.
2. Lookup the code description, the possible causes and the repair procedures provided in this section.
3. Perform the recommended repair procedures.
4. After the repairs are completed, clear all codes and check for any additional codes.

Whether the ATC Valve is used as a stand-alone valve as shown in Figure 34 or is integrated into the cover of a relay valve as shown in Figure 33, the troubleshooting procedure is the same.

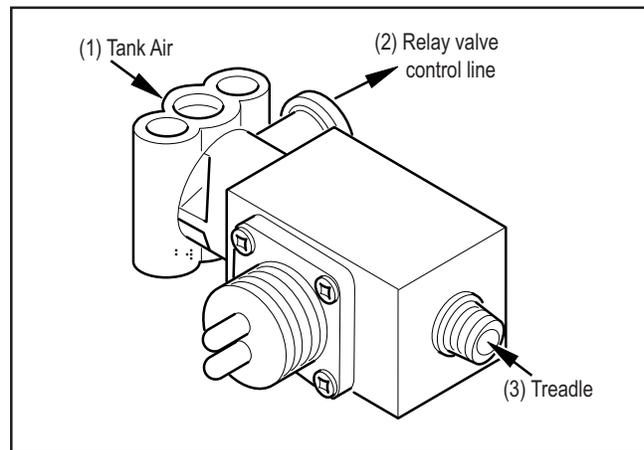


FIGURE 34 - ATC Valve

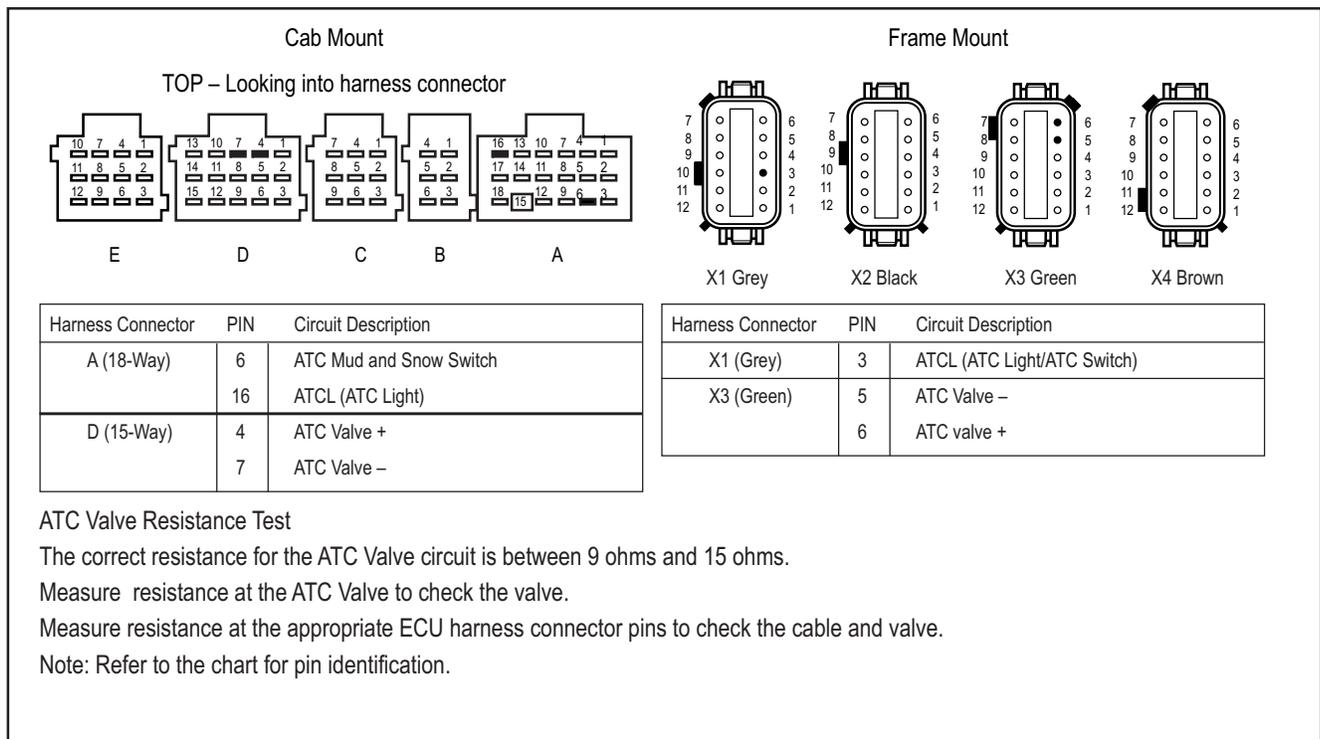


FIGURE 35 - ATC Harness Circuit Descriptions and Resistance Test

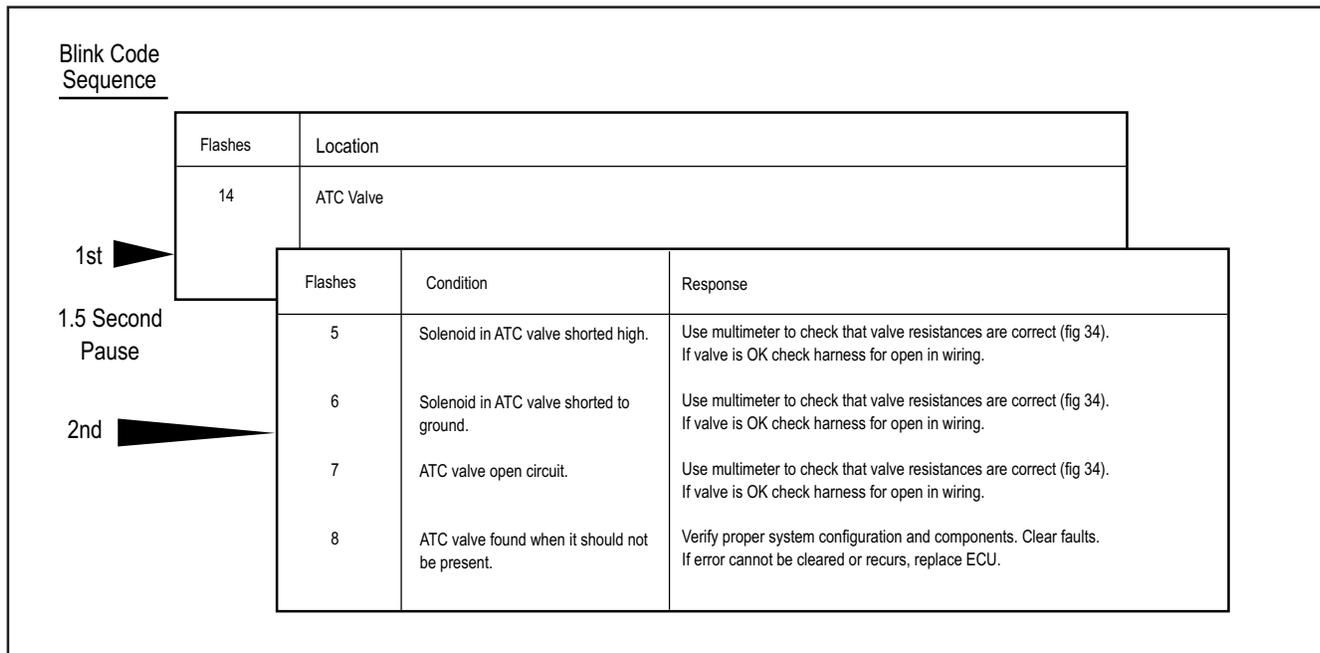


FIGURE 36 - ATC Diagnostic Trouble Code Troubleshooting Guide

ATC Valve Removal

CAUTION: Block wheels before beginning this procedure. Follow all standard safety procedures, outlined by, but not limited to, the General Precautions listed on page 13 of this document.

1. Disconnect the wiring connector from the ATC valve.
2. Disconnect the air lines from the supply (port 1) and delivery port (port 2) and treadle (port 3) of the ATC valve.
3. Disconnect the valve mounting fasteners, and remove the valve.

Installation

1. Install the ATC valve. Torque fasteners to manufacturers specification.
2. Connect Air lines supply (port 1) delivery port (port 2) and treadle (port 3) of the ATC valve.

3. Install the wiring connector to the ATC valve.

4. Test the installation.

- Traction Control Valve – Leak Test:

Make and hold brake application. No audible air leaks are permitted.

- Traction Control Valve Component Test with Hand-Held Diagnostic Tool:

Select Traction Control Valve

Verify Traction control light operation

Drive the vehicle and verify ABS indicator lamp operates properly.

CAUTION: Do not start and engage the transmission with one wheel raised from the floor. With ATC, power will go to the wheel on the floor and cause the vehicle to move. See page 20 to disable ATC for dyno testing.

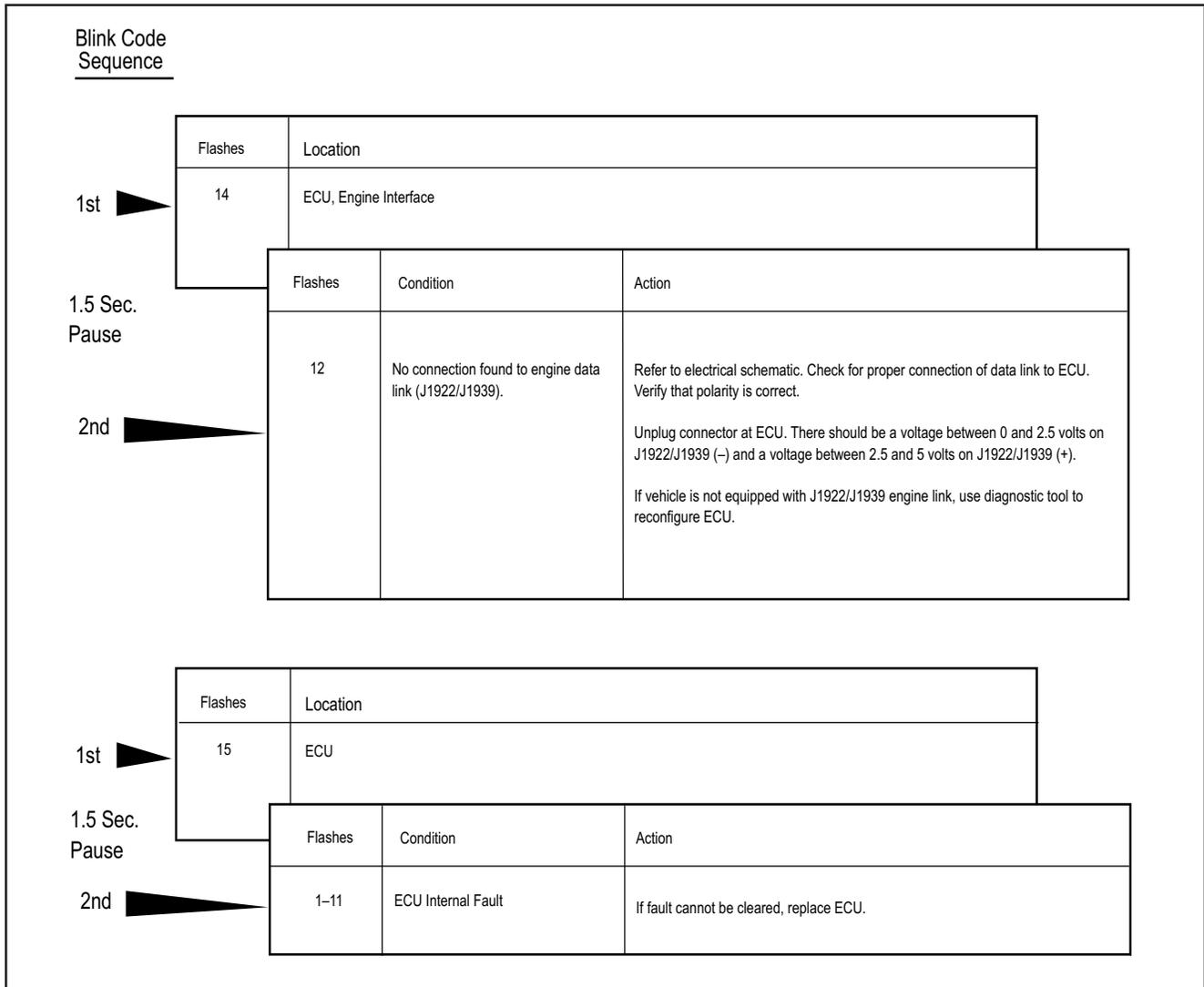


FIGURE 37 - System and ECU Diagnostic Trouble Codes Troubleshooting Guide

Blink Code Sequence	Flashes	Location	Flashes	Condition	Action
1st 	16	Power Circuits			
1.5 Sec. Pause					
2nd 			1 or 5	Excessive voltage on PMV Power	Verify that vehicle system voltage is OK (i.e. 9 to 16 volts). If voltage is out of range, correct system problem. Unplug connector at ECU and turn on ignition switch. If the voltage on PMV Power is different than system voltage, repair wiring. Clear trouble codes and verify that the indicator lamp turns out after bulb check.
			2 or 6	Low voltage on PMV Power	Verify that vehicle system voltage is OK (i.e. 9 to 16 volts). If voltage is out of range, correct system problem. Unplug connector at ECU and turn on ignition switch. If the voltage on PMV Power is different than system voltage, repair wiring. Clear trouble codes and verify that the indicator lamp turns out after bulb check.
			3 or 7	No voltage found on PMV Power	Verify that vehicle system voltage is OK (i.e. 9 to 16 volts). If voltage is out of range, correct system problem. Unplug connector at ECU and turn on ignition switch. If the voltage on PMV Power is different than system voltage, repair wiring. Clear trouble codes and verify that the indicator lamp turns out after bulb check.
			4 or 8	Open circuit on PMV Ground	Unplug connector at ECU and check for continuity to ground on PMV Ground. If continuity to ground is not present, repair harness.
			9	Excessive voltage found on ECU Power	Verify that vehicle system voltage is OK (i.e. 9 to 16 volts). If voltage is out of range, correct system problem. Unplug connector at ECU and turn on ignition switch. If the voltage on pin A-8 is different than system voltage, repair wiring. Clear trouble codes and verify that the indicator lamp turns out after bulb check.
			10	Low voltage found on ECU Power	Verify that vehicle system voltage is OK (i.e. 9 to 16 volts). If voltage is out of range, correct system problem. Unplug connector at ECU and turn on ignition switch. If the voltage on PMV Power is different than system voltage, repair wiring. Clear trouble codes and verify that the indicator lamp turns out after bulb check.
			11	Voltage difference between PMV Power inputs is too high	Verify that vehicle system voltage is OK (i.e. 9 to 18 volts). If voltage is out of range, correct system problem. Unplug connector at ECU and turn on ignition switch. If the voltage on one PMV Power pin differs from the other by greater than 0.5 volts, repair wiring. (Check circuit breakers and/or fuses on diagonal supply line.) Clear trouble codes and verify that the indicator lamp turns out after bulb check.

FIGURE 38 - Power Circuit Diagnostic Trouble Codes Troubleshooting Guide

Blink Code Sequence

Flashes	Location
17	Miscellaneous

Flashes	Condition	Action
1	Retarder control relay shorted high or open circuit.	Use multimeter to verify proper voltage at the retarder control relay.
2	Retarder control relay shorted low. or open circuit	Use multimeter to verify proper voltage at the retarder control relay.
3	J1922/1939 data link not functioning. (Retarder)	Unplug connector at ECU. There should be a voltage between 0 and 2.5 volts on J1939/J1922 (-) and a voltage between 2.5 and 5.0 volts on J1939/J1922 (+). Refer to schematic and correct wiring harness as required.
4	J1922/1939 data link time out.	Unplug connector at ECU. There should be a voltage between 0 and 2.5 volts on J1939/J1922 (-) and a voltage between 2.5 and 5.0 volts on J1939/J1922 (+). Refer to schematic and correct wiring harness as required.
5	Tire size, front to rear out of range.	There is too great a difference in the rolling radius of the front and rear tires. Steer axle tire radius cannot be more than 20% above rears or 10% below. If the static loaded radius of the rear tires is outside the range 15.9 to 21.5 inches the ECU must be recalibrated using a diagnostic tool.
6	Tire size out of range or parameter fault.	There is too great a difference in the rolling radius of the front and rear tires. Steer axle tire radius cannot be more than 20% above rears or 10% below. If the static loaded radius of the rear tires is outside the range 15.9 to 21.5 inches the ECU must be recalibrated using a diagnostic tool.
7	Brake light switch not pushed at this power cycle.	Press brake pedal. If error does not clear, check for missing connection at brake light switch. If the brake is not applied you should measure the resistance of the brake light bulb (bulb broken?). If the brake is applied, you should measure vehicle system voltage. (i.e. 9...16v)
8	ATC system is disabled for dynamometer test.	Cycle ignition switch and ATC will be re-enabled.
10	Warning light short, low or open	Diagnostic switch may have been pressed for an excessive period of time (>30 seconds). If not check wiring associated with indicator lamp.
12	Sensor memory bit is set	This trouble code should clear when the vehicle is driven and the ECU is able to read sensor output voltage. If this does not happen, verify that the sensors are properly adjusted (pressed full in to tone wheels.)

Note: For codes 17•3 and 17•4 the problem may be within the engine controller, another controller on the data link or within the wiring or connectors.

FIGURE 39 - Miscellaneous Diagnostic Trouble Codes Troubleshooting Guide

Cab Mount ECU Pin Identification

This section shows how to identify Cab Mount ECU harness connectors and pin locations. The charts provide a brief description of the signal carried by each pin.

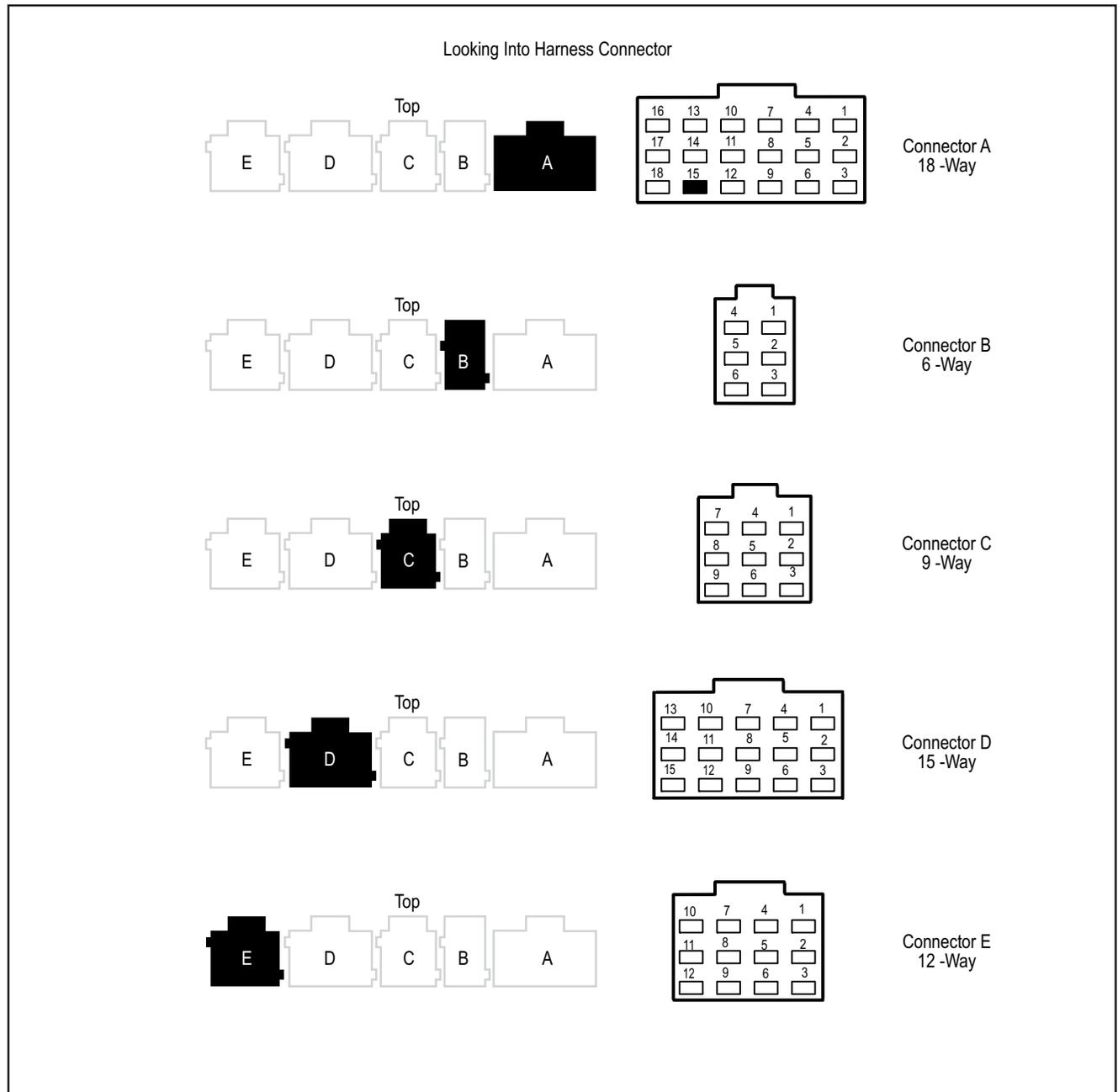


FIGURE 40 - Cab Mount ECU – Connector Layout

ECU CONNECTOR	PIN	DESCRIPTION
A (18-Way)	1	J1922/J1939 -
	2	Gen 4™ ABS J1939 Shld/Gen 5™ ABS TIL
	3	J1922/J1939 +
	4	NC
	5	Off Road ABS Switch (ORS)
	6	ATC Mud & Snow Switch
	7	Ignition, Switched
	8	V Bat 2
	9	V Bat 1
	10	Ground - ECU
	11	Ground - Diagonal 2
	12	Ground - Diagonal 1
	13	SAE J1587-
	14	SAE J1587+
	15	NC, Interlock
	16	ATC Light
	17	Retarder Relay
	18	Indicator Lamp/Diagnostic Switch
B (6-Way)	1	PMV1 (Left Steer), Rel Solenoid
	2	PMV1 (Left Steer), Hold Solenoid
	3	PMV1 (Left Steer), Common
	4	Speed Sensor 2 (Left Steer) +
	5	Speed Sensor 2 (Left Steer) -
	6	Brake Light Switch
C (9-Way)	1	NC
	2	NC
	3	NC
	4	Speed Sensor 3 (Right Steer) +
	5	Speed Sensor 3 (Right Steer) -
	6	NC
	7	PMV2 (Right Steer), Rel Solenoid
	8	PMV2 (Right Steer), Hold Solenoid
	9	PMV2 (Right Steer), Common

ECU CONNECTOR	PIN	DESCRIPTION
D (15-Way)	1	PMV3 (Left Rear), Rel Solenoid
	2	PMV3 (Left Rear), Hold Solenoid
	3	PMV3 (Left Rear), Common
	4	ATC Valve -
	5	Speed Sensor 4 (Left Rear) +
	6	Speed Sensor 4 (Left Rear) -
	7	ATC Valve +
	8	Speed Sensor 5 (Right Rear) +
	9	Speed Sensor 5 (Right Rear) -
	10	PMV4 (Right Rear), Rel Solenoid
	11	PMV4 (Right Rear), Hold Solenoid
	12	PMV4 (Right Rear), Common
	13	NC
	14	NC
	15	NC
E (12-Way)	1	PMV5 (Left Rear Rear), Rel Solenoid
	2	PMV5 (Left Rear Rear), Hold Solenoid
	3	PMV5 (Left Rear Rear), Common
	4	NC
	5	Speed Sensor 6 (Left Rear Rear) +
	6	Speed Sensor 6 (Left Rear Rear) -
	7	NC
	8	Speed Sensor 7 (Right Rear Rear) +
	9	Speed Sensor 7 (Right Rear Rear) -
	10	PMV6 (Right Rear Rear), Rel Solenoid
	11	PMV6 (Right Rear Rear), Hold Solenoid
	12	PMV6 (Right Rear Rear), Common

FIGURE 41 - Cab Mount ECU – Pin Identification Chart

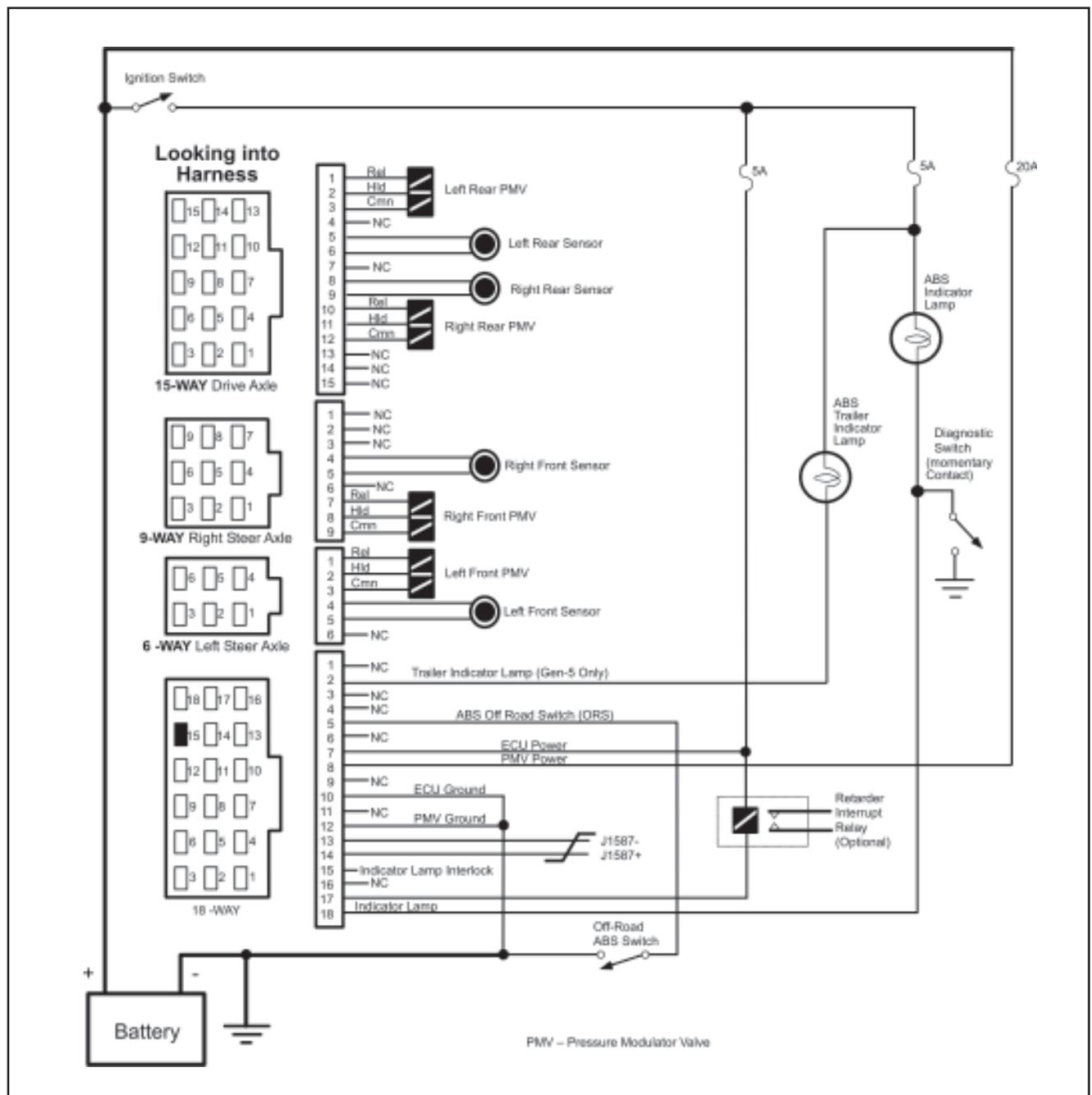


FIGURE 42 - Gen 4™ and Gen 5™ Basic Cab Mount ABS Electrical Schematic

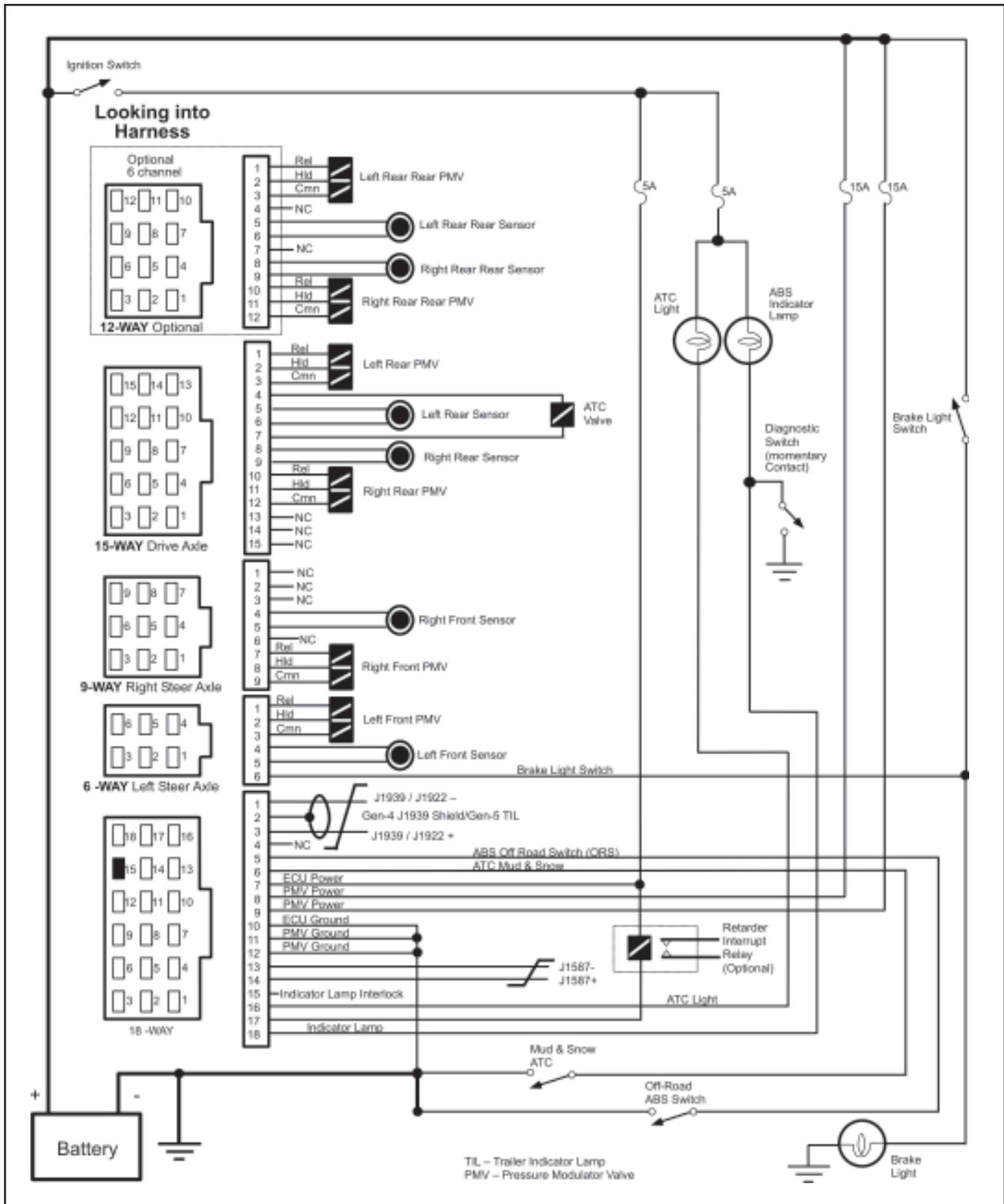


FIGURE 43 - Gen 4™ and Gen 5™ Standard Cab Mount ABS Electrical Schematic

Frame Mount ECU Pin Identification

This section shows how to identify Frame Mount ECU harness connectors and pin locations. The charts provide a brief description of the signal carried by each pin.

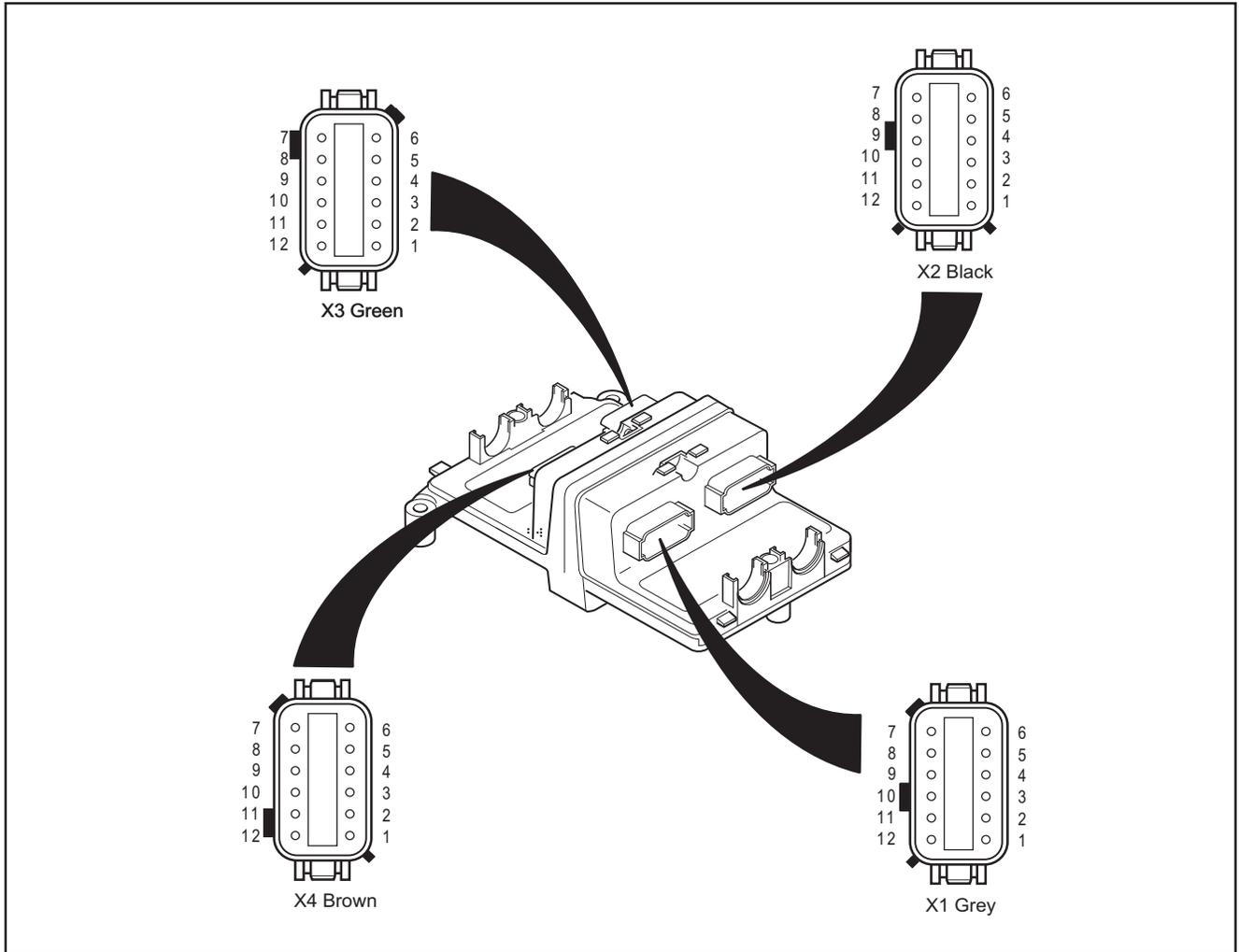


FIGURE 44 - Cab Mount ECU – Pin Identification Chart

X1 Grey

Pin	Signal	Description
X1-1	IGN ₁	Ignition-1
X1-2	IGN ₂	Ignition-2
X1-3	ATCL	ATC Light/ATC Switch
X1-4	1587 ₊	J1587+
X1-5	RET	Retarder Control
X1-6	ENG ₋	J1922/1939 Engine Control Link-
X1-7	ENG ₊	J1922/1939 Engine Control link+
X1-8	SHLD/TIL	Gen 4™ ABS J1939 Shield/Gen 5™ ABS TIL
X1-9	1587 ₋	J1587-
X1-10	WL	ABS WL/Diagnostic Switch
X1-11	GND ₂	Ground
X1-12	GND ₁	Ground

X3 Green

Pin	Signal	Description
X3-1	SS _{LR}	Speed Sensor, Left Rear-
X3-2	SS _{LR}	Speed Sensor, Left Rear+
X3-3	SS _{RR}	Speed Sensor, Right Rear-
X3-4	SS _{RR}	Speed Sensor, Right Rear+
X3-5	ATCV ₋	Traction Control Valve-
X3-6	ATCV ₊	Traction Control Valve+
X3-7	REL _{RR}	Release Sol, Right Rear
X3-8	CMN _{RR}	Common, Right Rear
X3-9	HLD _{RR}	Hold Sol, Right Rear
X3-10	REL _{LR}	Release Sol, Left Rear
X3-11	CMN _{LR}	Common, Left Rear
X3-12	HLD _{LR}	Hold Sol, Left Rear

X2 Black

Pin	Signal	Description
X2-1	BLS	Brake Light Switch
X2-2	HLD _{LS}	Hold Sol, Left Steer
X2-3	REL _{RS}	Release Sol, Right Steer
X2-4	HLD _{RS}	Hold Sol, Right Steer
X2-5	SS _{RS}	Speed Sensor, Right Steer-
X2-6	SS _{BS}	Speed Sensor, Right Steer+
X2-7	SS _{LS}	Speed Sensor, Left Steer-
X2-8	SS _{LS}	Speed Sensor, Left Steer+
X2-9	CMN _{RS}	Common, Right Steer Valve
X2-10	REL _{LS}	Release, Left Steer Valve
X2-11	CMN _{LS}	Common, Left Steer Valve
X2-12	ORS	Off Road Switch

X4 Brown

Pin	Signal	Description
X4-1	DLC ₋	Diff Lock Control-
X4-2	DLC ₊	Diff Lock Control+
X4-3	SS _{LRR}	Speed Sensor Left Rear Rear-
X4-4	SS _{LRR}	Speed Sensor Left Rear Rear+
X4-5	SS _{RRR}	Speed Sensor Right Rear Rear-
X4-6	SS _{RRR}	Speed Sensor Right Rear Rear+
X4-7	REL _{RRR}	Release Sol, Right Rear Rear
X4-8	CMN _{C+}	Common, Right Rear Rear
X4-9	HLD _{RRR}	Hold Sol, Right Rear Rear
X4-10	REL _{LRR}	Release Sol, Left Rear Rear
X4-11	CMN _{LRR}	Common, Left Rear Rear
X4-12	HLD _{LRR}	Hold Sol, Left Rear Rear

FIGURE 45 - Frame Mount ECU – Pin Identification Chart

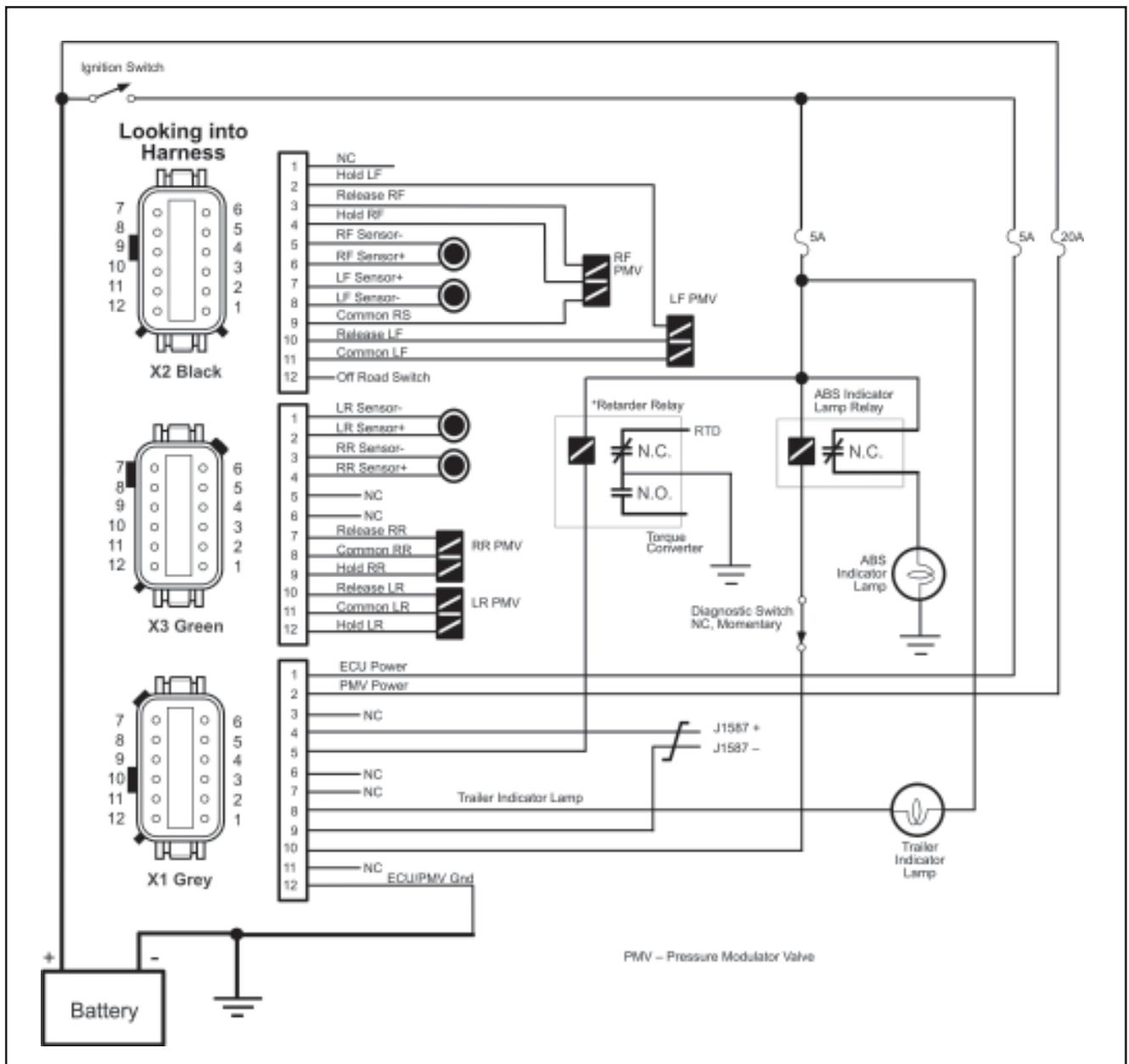


FIGURE 46 - Gen 5™ Basic Frame Mount ABS Electrical Schematic

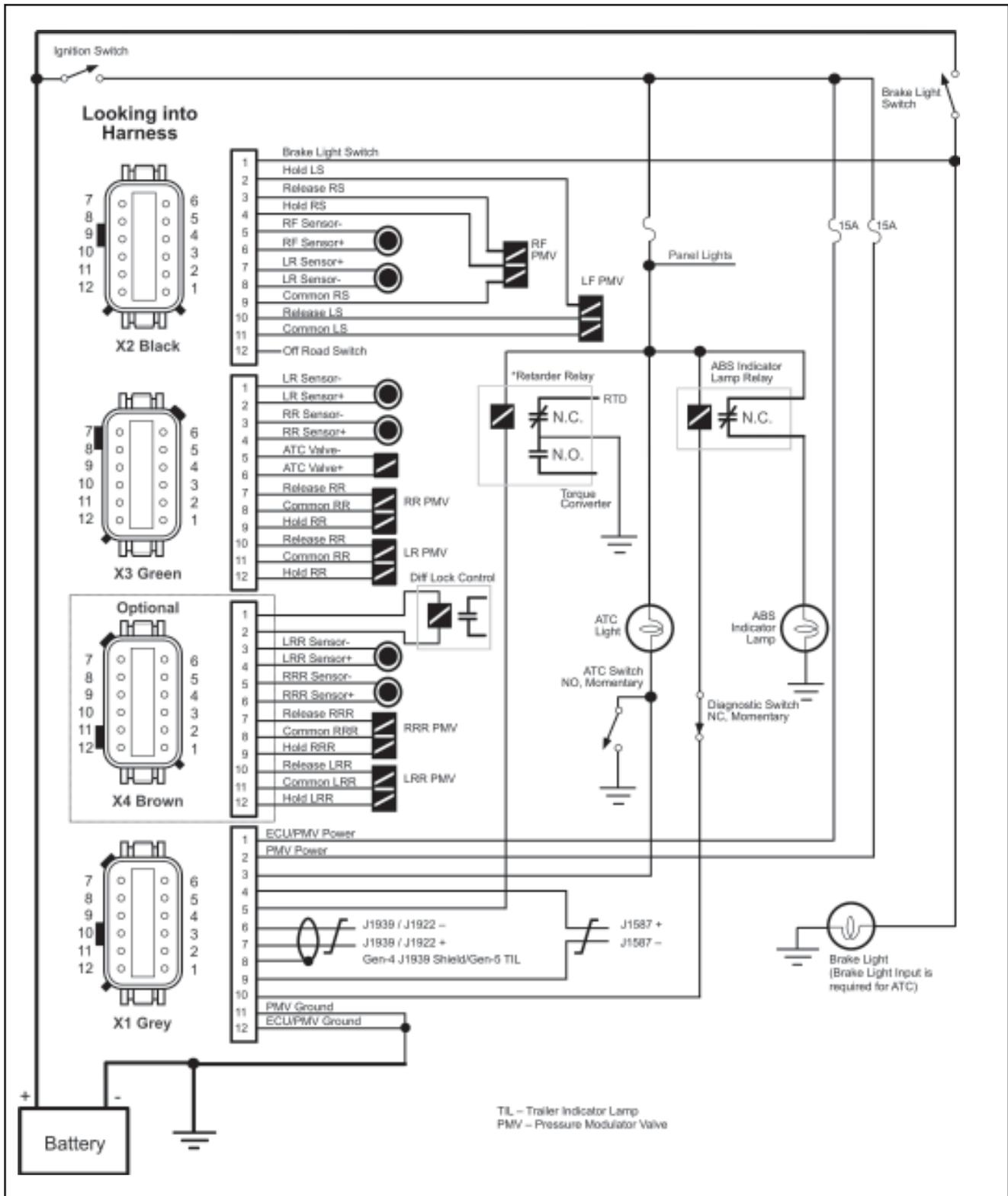


FIGURE 47 - Gen 4™ and Gen 5™ Standard Frame Mount ABS Electrical Schematic

Glossary

ABS — Antilock Brake System.

ABS Event — Impending wheel lock situation that causes the ABS controller to activate the modulator valve(s).

Air Gap — Distance between the Sensor and tone ring.

Anti-Compounding Valve — Prevents the application of the service and spring brakes at the same time. Depending on vehicle design, the anti-compounding valve may be installed in combination with a relay valve or quick release valve.

Apply Timing — The time from the movement of the service brake control for each brake chamber to reach 60 psi, with an initial service reservoir pressure of 100 PSI.

ASR — Automatic Slip Regulation. Another name for traction control.

ATC — Automatic Traction Control. An additional ABS function in which engine torque is controlled and brakes are applied differentially to enhance vehicle traction.

ATC Light — A light that indicates when traction control is operating.

Channel — A controlled wheel site.

CAN — Controller Area Network. J1939 is an SAE version of the CAN link.

Clear Codes — System to erase historical faults from the ECU, from either the Diagnostic Button or from a hand-held diagnostic tool (only repaired faults may be cleared).

Coefficient of Friction — The horizontal force required to move a body (on a relatively smooth level surface) divided by the weight of the body.

Configuration — The primary objective is to identify a “normal” set of sensors and modulators for the Electronic Control Unit, so that it will identify future missing sensors and modulators.

Crack Pressure — The ascending input pressure or input force to an air valve required to initiate output pressure of flow.

Diagonal Control — ABS is configured with two diagonal circuits. Diagonal control allows each control circuit to provide electrical control of modulator valves on opposite sides of the vehicle.

Diagnostic Connector — Diagnostic receptacle in vehicle cab for connection of J1587 hand-held or PC based test equipment. The tester can initiate test sequences, and can also read system parameters.

Diagnostic Switch — A switch used to activate blinks codes.

Diagnostic Trouble Code — A condition that interferes with the generation or transmission of response or control signals in the vehicle's ABS system that could lead to the functionality of the ABS system becoming inoperable in whole or in part.

Differential Braking — Application of brake force to a spinning wheel so that torque can be applied to wheels which are not slipping.

ECU — Electronic Control Unit.

FMVSS-121 — Federal Motor Vehicle Safety Standard which regulates air brake systems.

Friction Sleeve — A beryllium copper sleeve which has fingers cut into it. It is pressed between an ABS sensor and mounting hole to hold the sensor in place.

Indicator Lamp — An amber light which indicates the operating status of an antilock system. When the indicator lamp is on, ABS is disabled and the vehicle reverts to normal brake operation.

IR — Independent Regulation. A control method in which a wheel is controlled at optimum slip, a point where retardation and stability are maximized. The brake pressure that is best for the wheel in question is directed individually into each brake chamber.

J1587 — The SAE heavy duty standard diagnostic data link.

J1708 — An SAE standard which defines the hardware and software protocol for implementing 9600 baud heavy vehicle data links. Both J1587 and J1922 are versions of J1708 data links.

J1922 — The SAE heavy vehicle data link which operates according to J1708 protocol. It is generally used for ATC or automatic transmission interface to an engine.

J1939 — A high speed 250,000 baud data link which is expected to replace J1922.

MIR — Modified Independent Regulation. A method of controlling the opposite sides of a steer axle during ABS operation so that torque steer and stopping distance are minimized. Usually control begins at pure select low and moves towards independent control as the cycle progresses.

PLC — Power Line Carrier. The serial communication protocol used to communicate with the trailer over the blue full time power wire.

PMV — Pressure Modulator Valve. An air valve which is used to vent or block air to the brake chambers to limit or reduce brake torque.

QR — Quick Release. Quick release Valves allow faster release of air from the brake chamber after a brake application. To balance the system, quick release valves have hold off springs that produce higher crack pressures (when the valves open).

Relay Valve — Increases the application speed of the service brake. Installed near brakes with larger air chambers (type 24 or 30). The treadle valve activates the relay valve with an air signal. The relay valve then connect its supply port to its delivery ports. Equal length air hose must connect the delivery ports of the relay valve to the brake chambers.

Release Timing — The measurement in time from initial brake movement to reach 5 psi with 95 psi initial pressure at the brake chambers.

Retarder Relay — A relay which is used to disable a retarder when ABS is triggered.

Select High — A method of ABS control in which the brake torque is released at several wheels when the last wheel begins to lock.

Select Low — The brake pressures level is the same on both wheels of a given axle. The pressure level is based on the wheel which is running at the lower friction coefficient.

Select Smart — The difference in pressure between the left and right brake chamber does not exceed a certain amount. This leads to the wheel which is running at the high friction coefficient being braked less strongly.

Sensor Bushing — A bushing which is pressed into steer axles to hold a wheel speed sensor and friction sleeve.

Stored Faults — A Fault that occurred.

TCS — Traction Control System, another name for ATC or ASR.

Tone Ring — A ring that is usually pressed into a wheel hub that has a series of teeth (usually 100) and provides actuation for the speed sensor. Note maximum run out is .008.

