Roadranger®

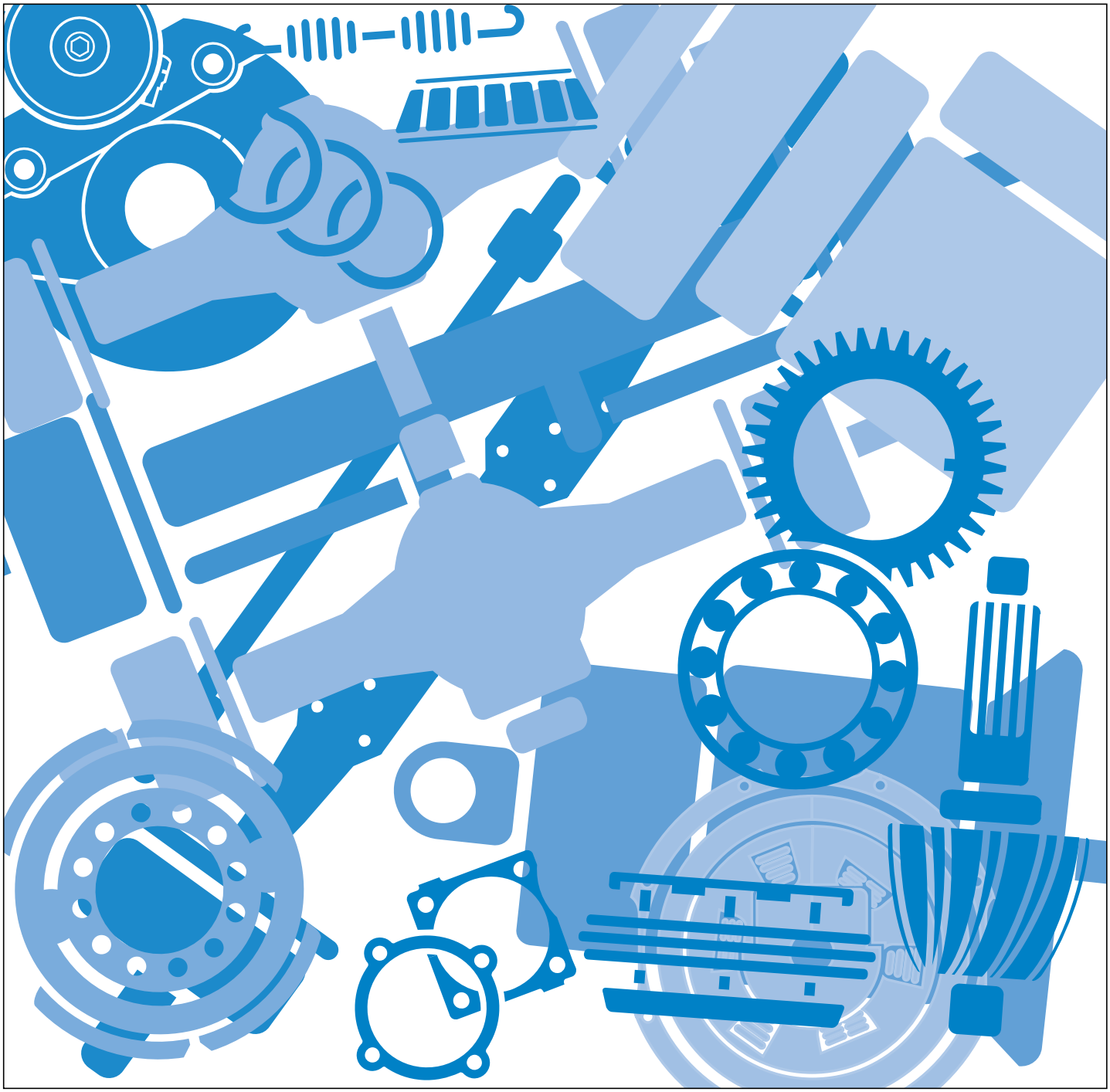
Bendix® Anti-Lock Brake Systems

Automatic Traction Control
(Generation 4)

DANA | EATON

One Great Drivetrain from Two Great Companies

Service Manual BRSM-0110 June 1999



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IMPORTANT NOTICE

This symbol is used throughout this manual to call attention to procedures where carelessness or failure to follow specific instructions may result in personal injury and/or component damage.

Departure from the instructions, choice of tools, materials and recommended parts mentioned in this publication may jeopardize the personal safety of the service technician or vehicle operator.

WARNING: Failure to follow indicated procedures creates a high risk of personal injury to the servicing technician.

CAUTION: Failure to follow indicated procedures may cause component damage or malfunction.

NOTE: Additional service information not covered in the service procedures.

Tip: Helpful removal and installation procedures to aid in the service of this unit.

Always use genuine Eaton replacement parts.

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Purpose of Manual

This manual describes the Eaton Antilock Brake System/ Automatic Traction Control (ABS/ATC) and details system diagnosis and troubleshooting procedure. It includes ABS/ATC operation and system components, installation, service procedures, and related information required to support Eaton's ABS/ATC system. For information on disassembly, installation, and service of axle and brake components, refer to specific service manuals.

For assistance in your area call 1-800-826-4357.

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.
- Maximize overall 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.

The normal state of the pressure modulator valves is to provide a straight-through supply of air to the brake chambers. During ABS operation 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, it controls air pressure to release and hold brake torque, thereby increasing a vehicle's capacity for quick, straight stops. ABS is no substitute for safe driving. Cautious driving practices such as maintaining adequate distances from the vehicle ahead are key to safe operation.

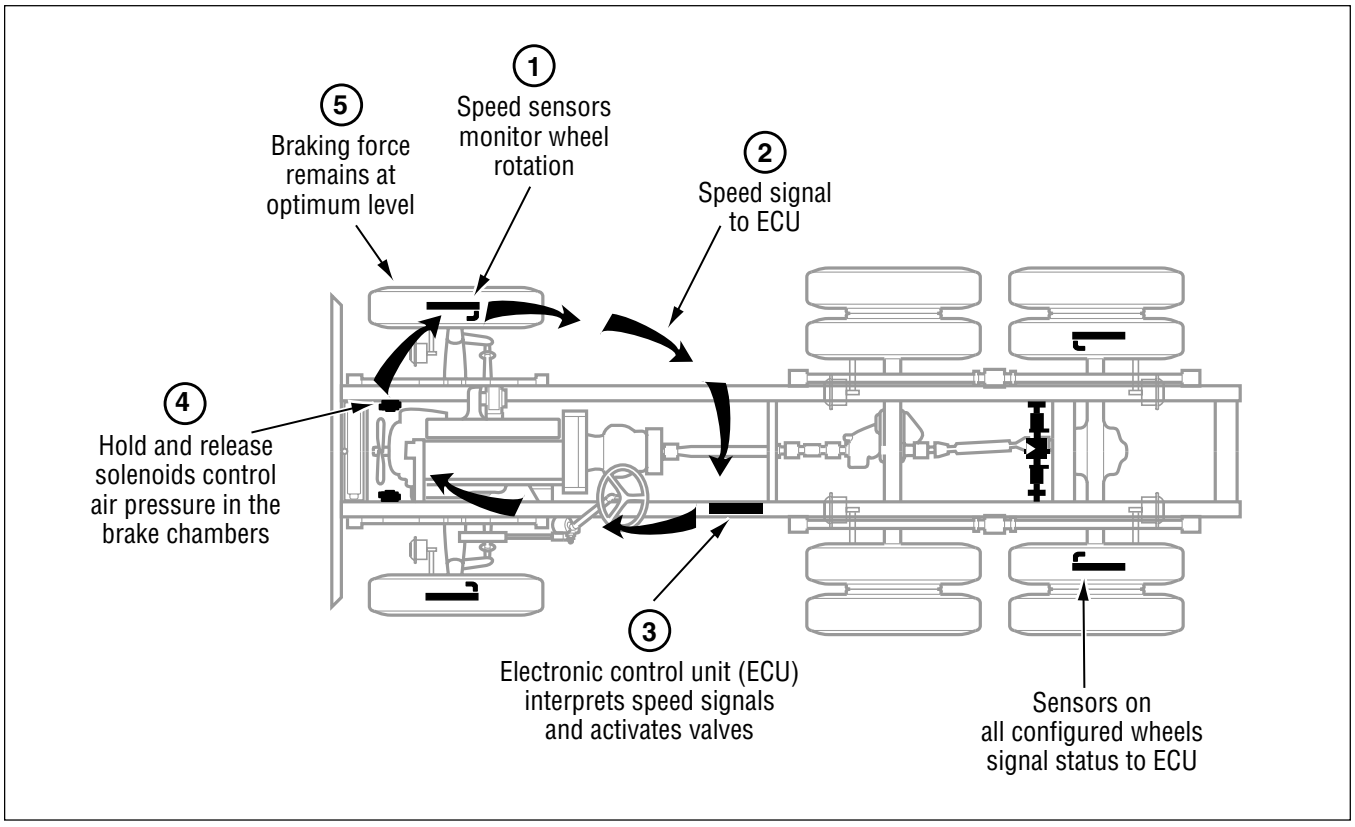


Figure 1. Overview of ABS Operation

ABS Component Function

The ABS system operates as follows (see Figure 1).

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 constantly calculates the relationship of speed acceleration and deceleration.
4. Based on speed sensor input, the ECU operates the ABS modulator valves. Each modulator valve uses a hold and release solenoid to regulate air pressure in the brake chambers.
5. Braking force is applied to achieve and maintain optimum results.

ABS Indicator Lamp

This lamp is the primary indicator of ABS system condition. Under normal conditions, the ABS lamp lights 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. If the indicator remains ON, after the bulb-check, or lights during vehicle operation, it indicates the ABS requires service.

In the case of a speed sensor failure which has been corrected, the warning light 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 warning light will turn off.

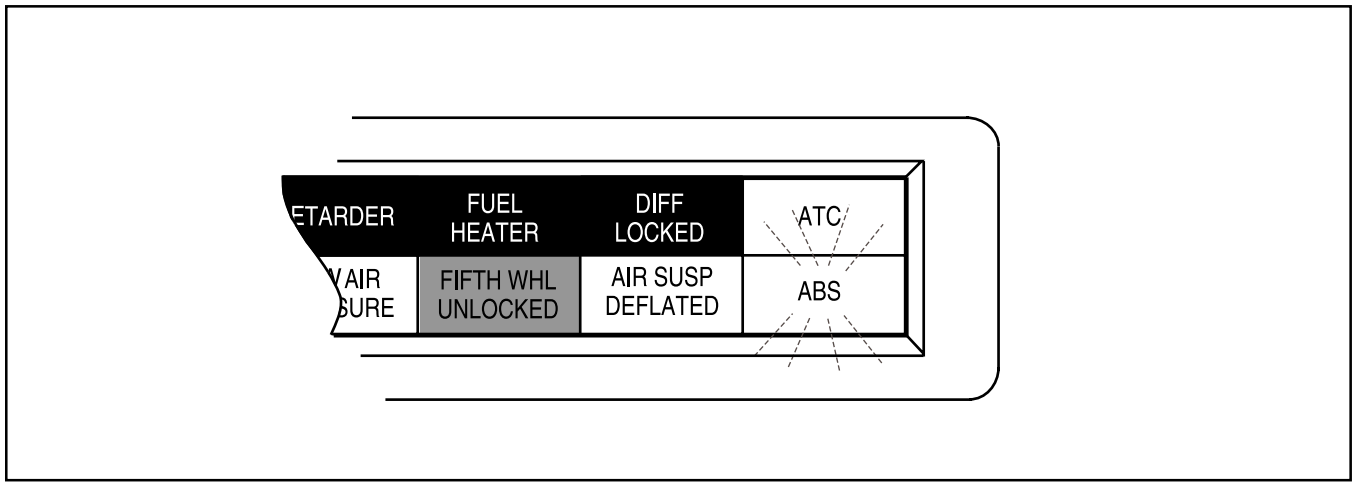


Figure 2. ABS Indicator Light

Automatic Traction Control (ATC) System

The ATC system is an option for all ABS applications. 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 RAM valve with integral ATC solenoid may be used.
2. SAE J1922 or J1939 engine interface.
3. Brake Light Switch input.
4. ATC Indicator Light

The Electronic Control Unit must be configured for ATC operation either by using the diagnostic switch (refer to page 24) or with the ProLink 9000 hand held tester.

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.
- Mud and snow switch (optional): when activated, this mode allows greater wheel spin (more torque). 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.

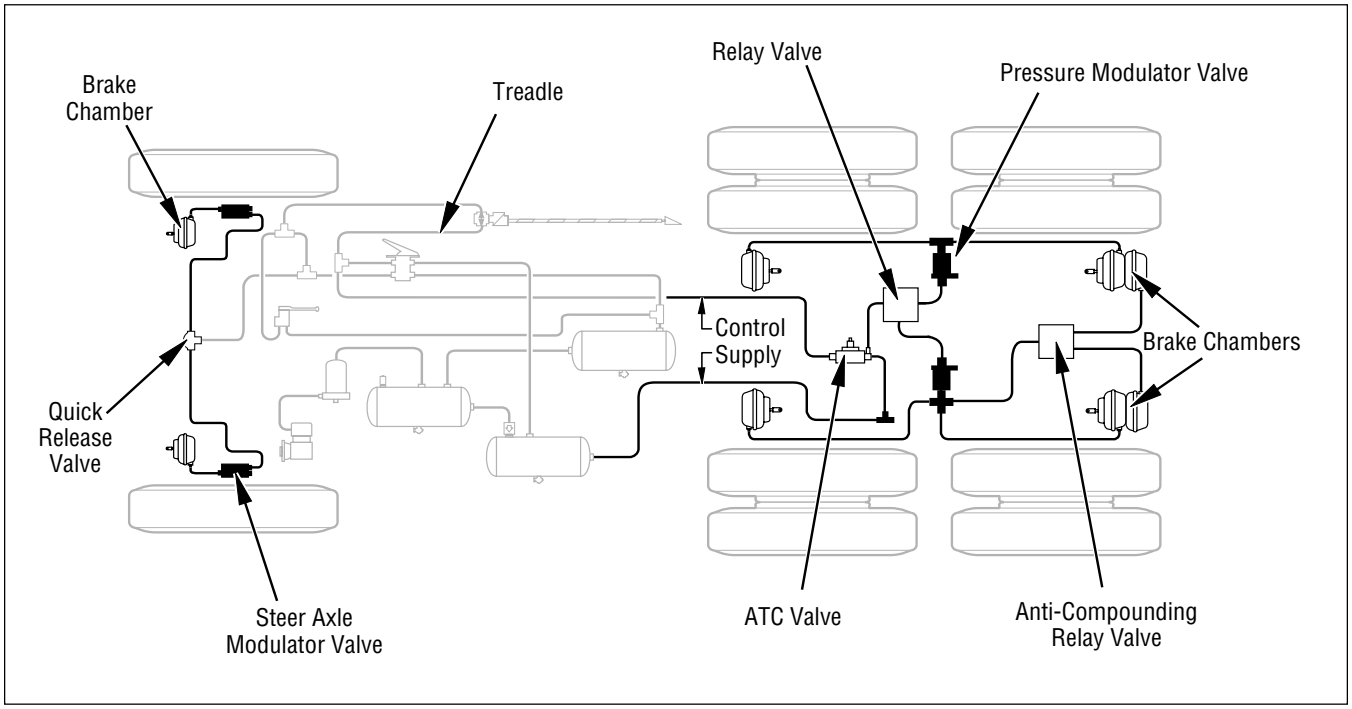


Figure 3. Typical 4-Channel ABS/Traction Control

Thermal 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.

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 can not increase traction to a particular wheel; it can only utilize the available traction.

ATC Indicator Light

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

- Lights at key-ON and remains lit until the driver presses the brake pedal. (When operating as a "spin" indicator the light turns off after a 1.8 Sec lamp check. See note below.)
- Flashes *slowly* when the "mud-and-snow" mode is selected and then flashes more *rapidly* when the automatic traction control system operates.
- Lights continuously to indicate that ATC is active but the "mud-and-snow" mode has not been activated.
- Remains on if an engine data link failure occurs.

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

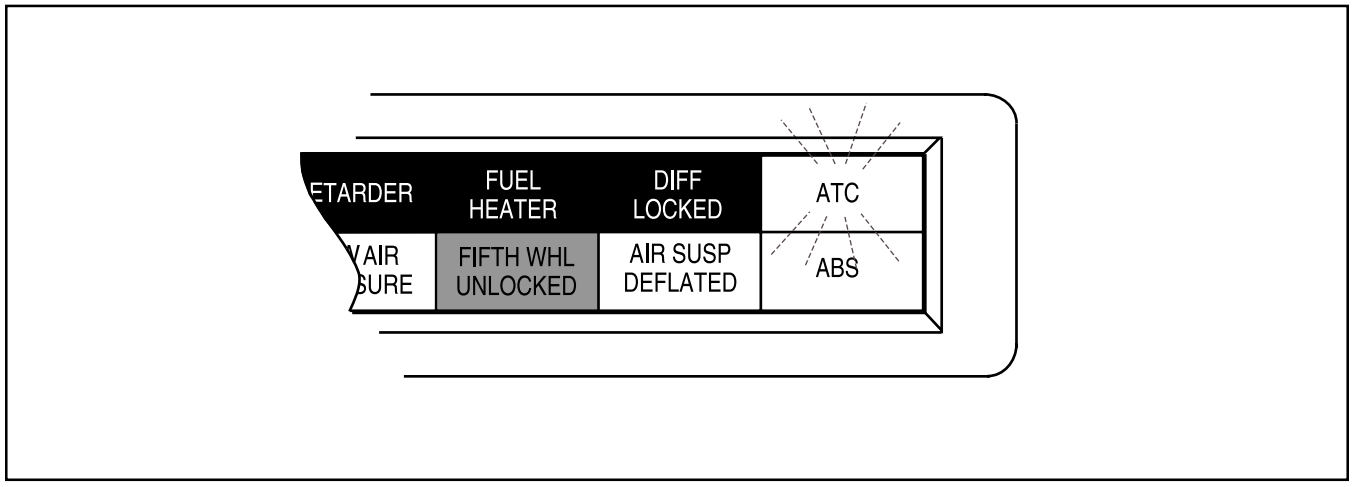


Figure 4. ATC Indicator Light

System Configuration

Available Configurations

A wide variety of system configurations are available (refer to Figure 5). It is important to be able to read system configurations and to be able to properly reconfigure a system when necessary.

When to Configure

ECU's are factory configured for the most common requirements. Four-channel systems are setup for 4s-4m operation with retarder control via engine data link. Six-channel systems are setup for 6s-4m operation with retarder control via engine data link. For applications other than these standard 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. Either diagnostic switch or the ProLink 9000 tool 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 must be used.

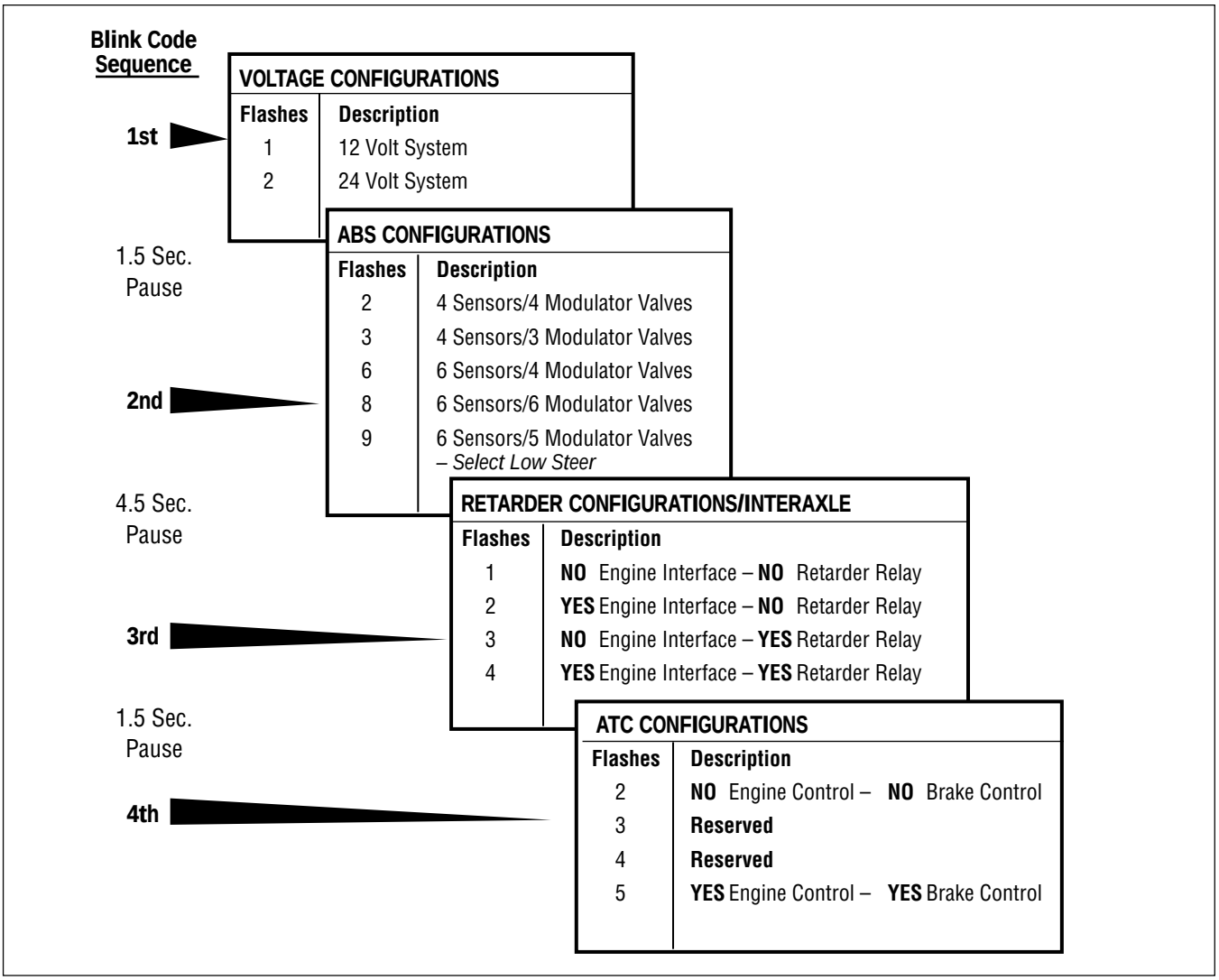


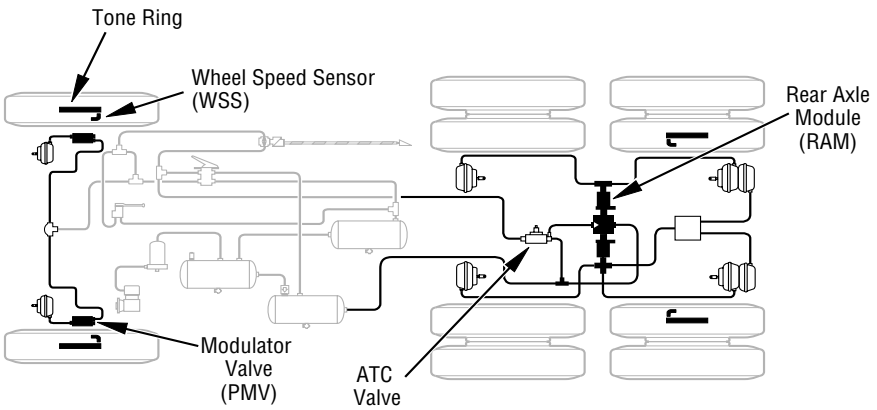
Figure 5. ABS Configuration Codes

How to Configure

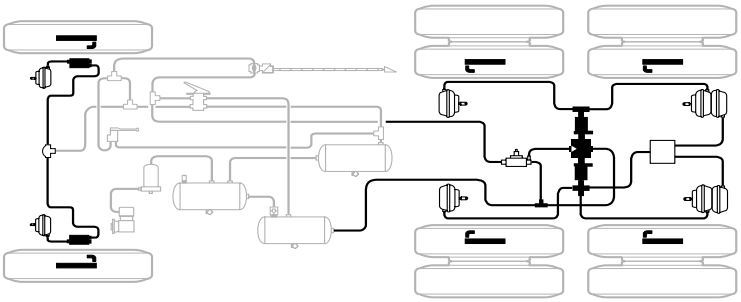
Use the "SYSTEM SETUP" menu with the ProLink 9000® tool or the diagnostic switch (refer to page 24 for procedure). Use of the "SETUP" function will also clear inactive fault codes from the system. However it is recommended that the "CLEAR FAULT CODES" function be used for clearing inactive codes.

Verification

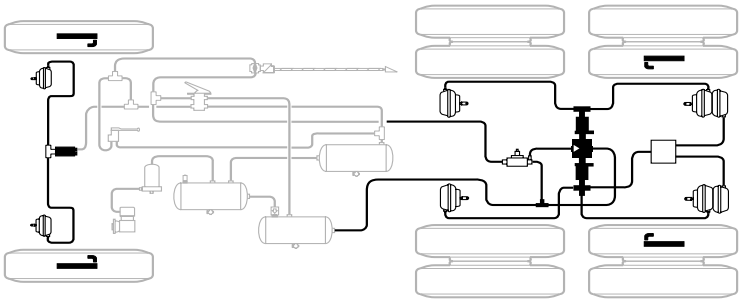
It is important to verify that the intended configuration has been obtained. Refer to Figure. 5 for proper interpretation of configuration blink codes.



4S - 4M (ABS Configuration 2)



6S - 4M (ABS Configuration 6)



4S - 3M (ABS Configuration 3)

Figure 6. ABS Configurations

Component Overview

Eaton ABS components include:

- **Electronic Control Unit (ECU)**: The ECU monitors and controls the ABS. It also diagnoses ABS malfunctions and stores failure-specific fault 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 Module (RAM):** 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.
- **In-Axle, 100-Tooth, Multi-Point Sensor**: Monitors wheel speed and sends a pulsed-signal to the ECU. This type of sensor is located inside the axle. IASS is an optional feature, usually specified for vehicles operating under adverse conditions.
- **ABS Light** *(Amber)*: 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.
- **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 Light:** 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 warning light 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.

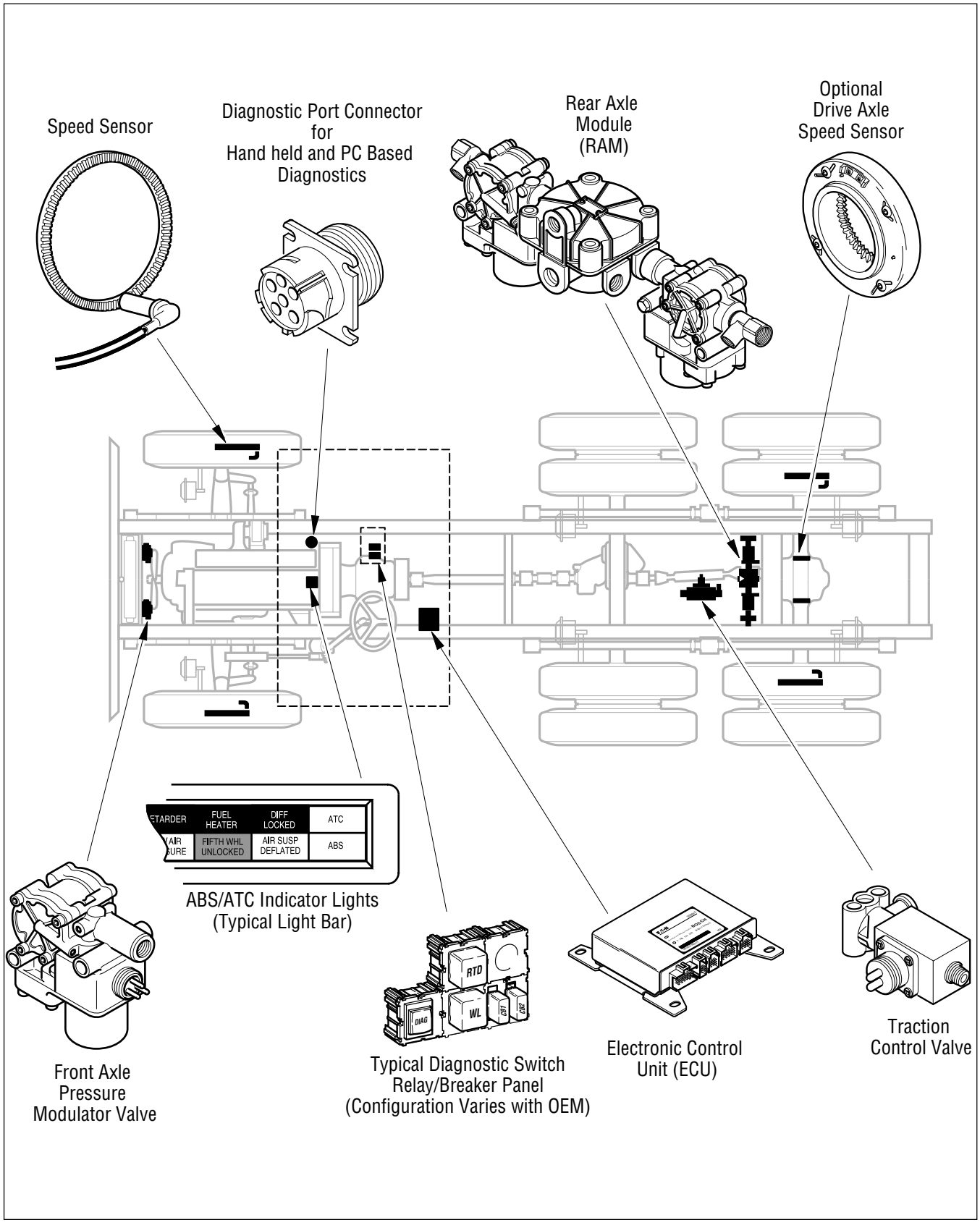


Figure 7. ABS Components

Electronic Control Unit (ECU)

This manual covers the Generation 4 Cab Mount and Cab Mount basic control units. These are also referred to by the code names U12 and 2X respectively.

Service of the older Gamma 2S cab mount unit is covered in BRSM-0100.

The frame mount commercial version is covered by service manual BRSM 0113, Military systems (24-volt Generation 4 frame mount controllers) are covered in BRSM-0111. The Generation 4 frame mount controllers are also referred to as the U16 controllers.

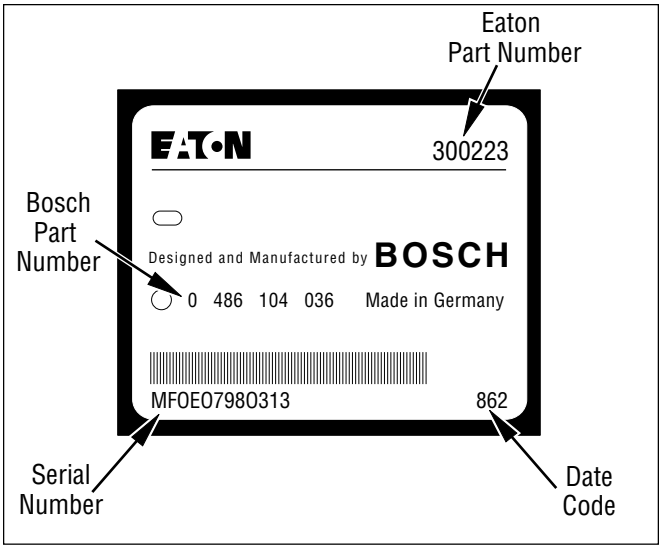


Figure 8 Electronic Control Unit Identification Tag

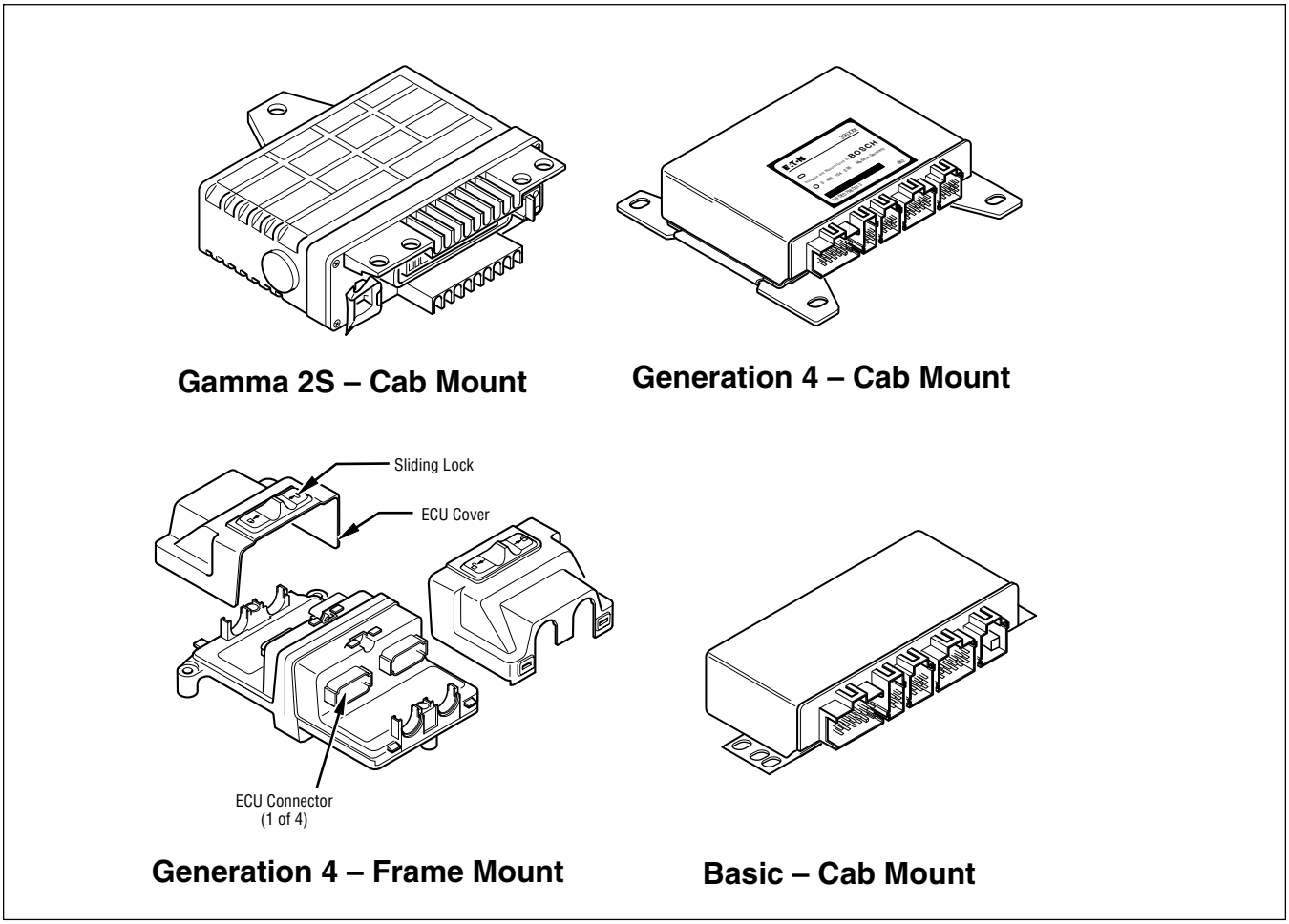


Figure 9. ABS Control Units–Generation 4

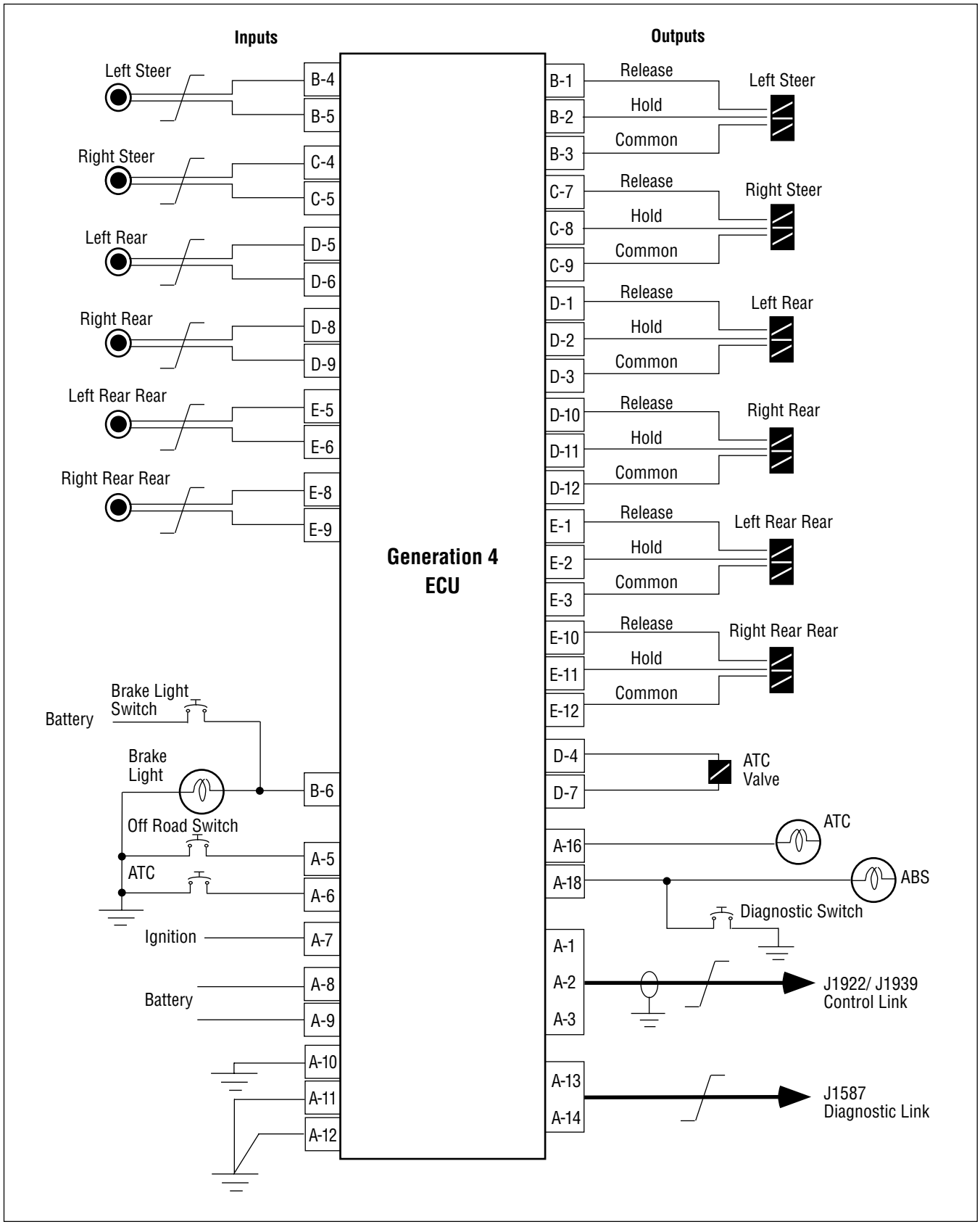


Figure 10. ECU Block Diagram

Pressure Modulator Valve

The ABS air 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 12.

Each modulator valve contains two solenoids for air control. The hold solenoid maintains air pressure; the release solenoid removes pressure from the brake. The Electronic Control Unit signals each modulator valve for air hold and release by activating the appropriate solenoid.

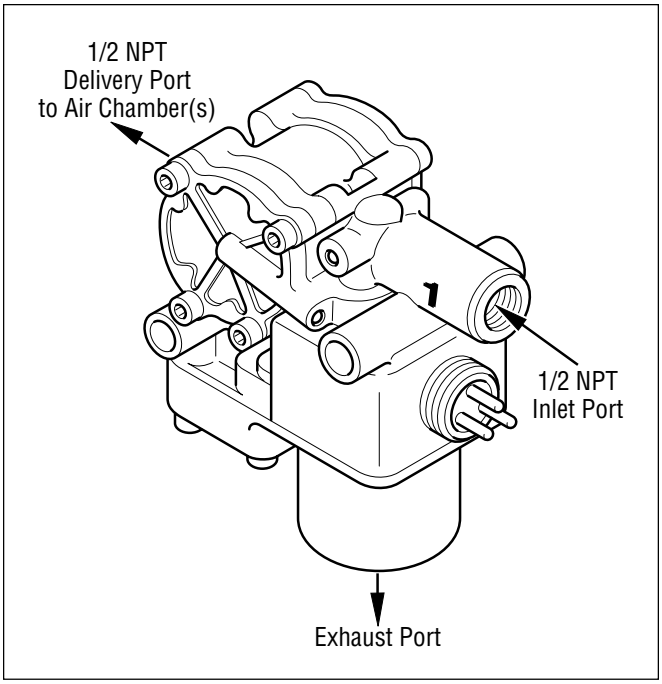


Figure 11. Modulator Valve

Rear Axle Module (RAM)

Rear Axle Modules are available for some applications depending on OEM preferences. These are assemblies of a standard relay valve and two pressure modulator valves. Rear Axle Modules are available with crack pressure settings of 4.0 and 5.5 PSI. The crack pressure is identified on a stamped washer mounted on the relay valve. The new 4-port relay valve is also available with an integral ATC valve.

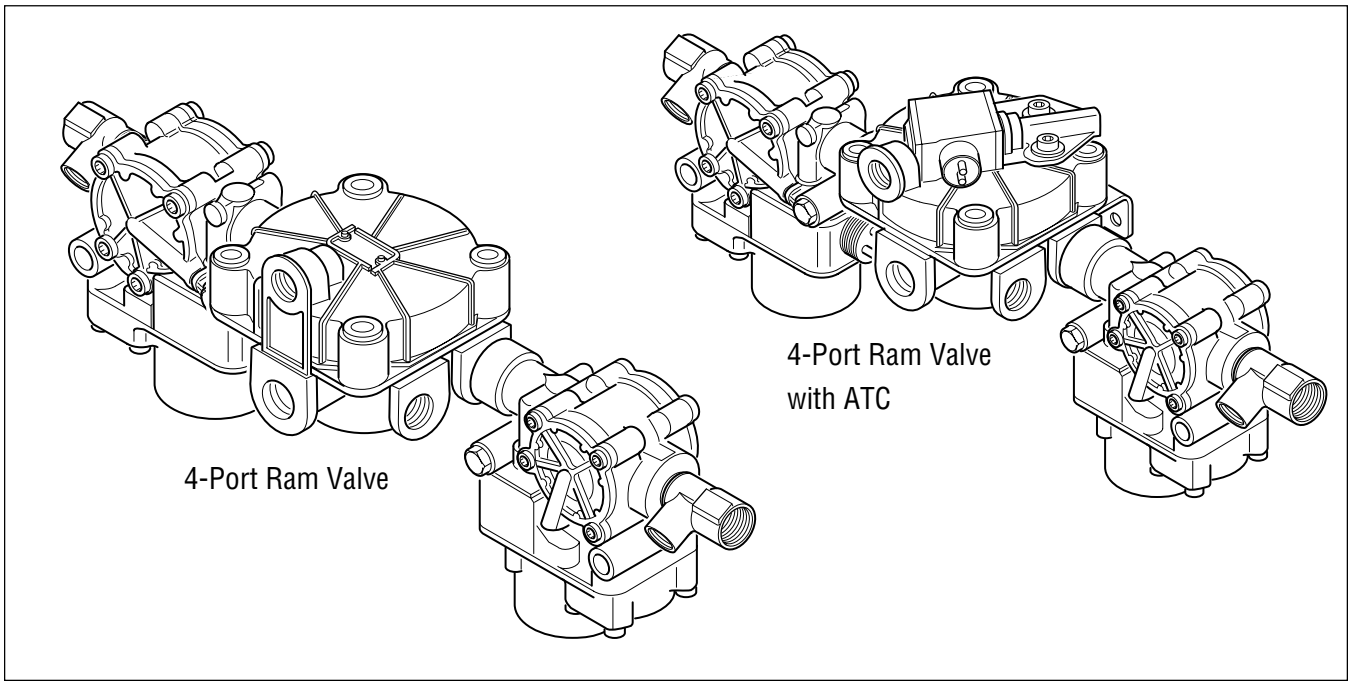


Figure 12. Rear Axle Modules, 4-port ABS and ABS/ATC versions Shown

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.

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.

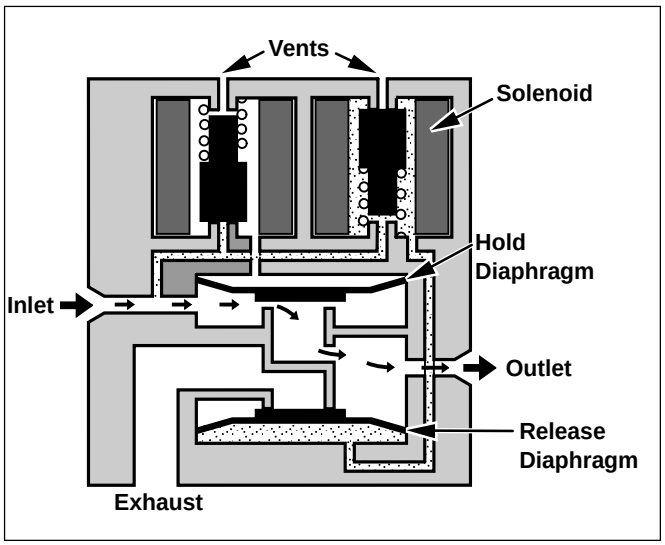


Figure 13. Normal Apply and ABS Apply

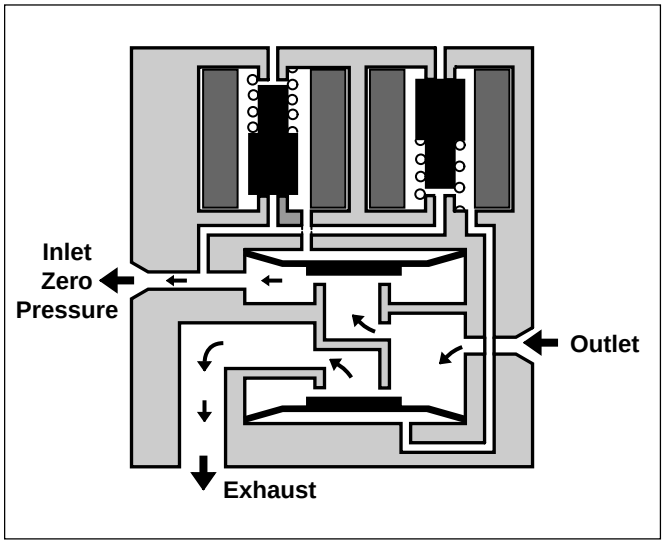


Figure 14. Normal Release

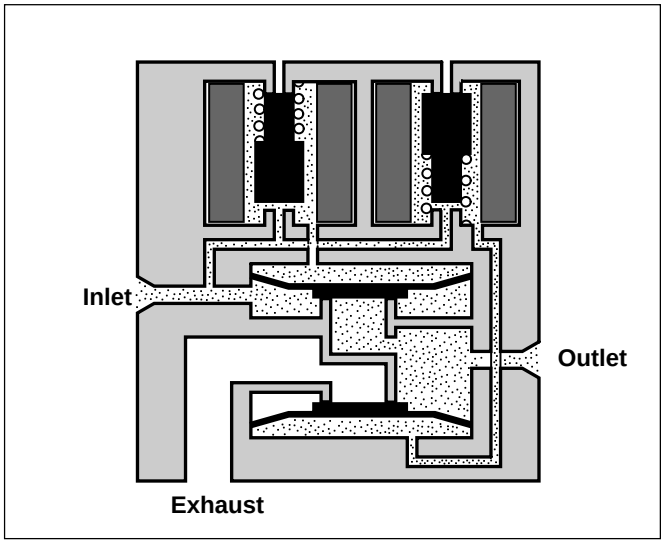


Figure 15. ABS Hold

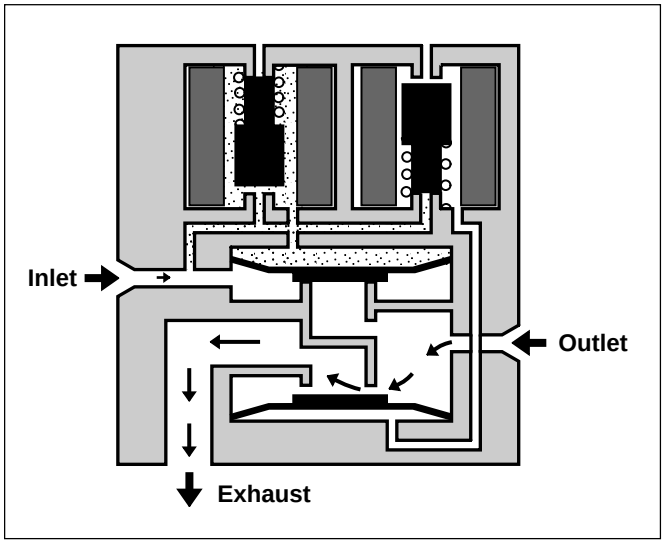


Figure 16. ABS Release

3. **ABS Hold–**Both diaphragms are pressurized. No air flows through the valve.

4. **ABS 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

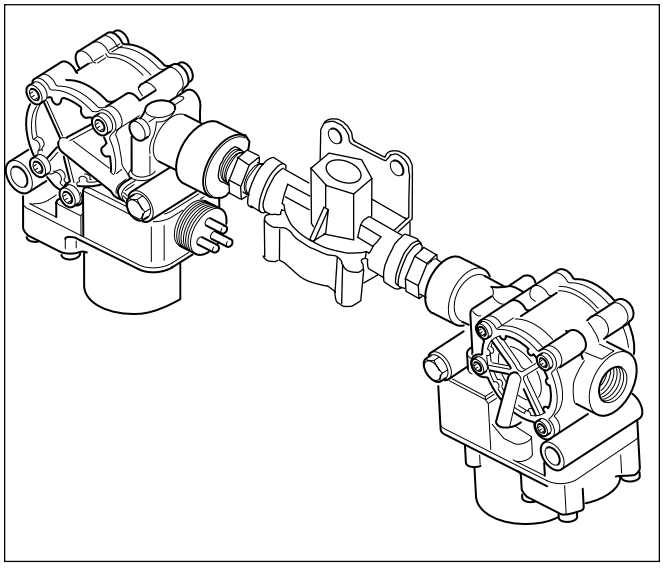


Figure 17. Front Axle Module

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, Eaton ABS uses standard wheel end sensors (see figure 18). 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 voltage is larger for larger diameter wheels and increases with wheel speed.
- The output voltage waveform is independent of the direction of wheel rotation.

Eaton 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.

Optional Drive Axle Sensor

Optional in-axle speed sensors (see figure 18) are available on certain Eaton drive axle models. The speed sensors are integrated into the differential. Axle shafts equipped with in-axle speed sensors are designed with extended splines that drive the rotors of these sensors.

In-axle speed sensors are variable reluctance magnetic sensors with characteristics similar to those of wheel end speed sensors. Important differences are:

- In-axle speed sensors are multi-point sensors. Each has 100 pole pieces and 100 actuating teeth.
- In-axle speed sensors require no adjustment.

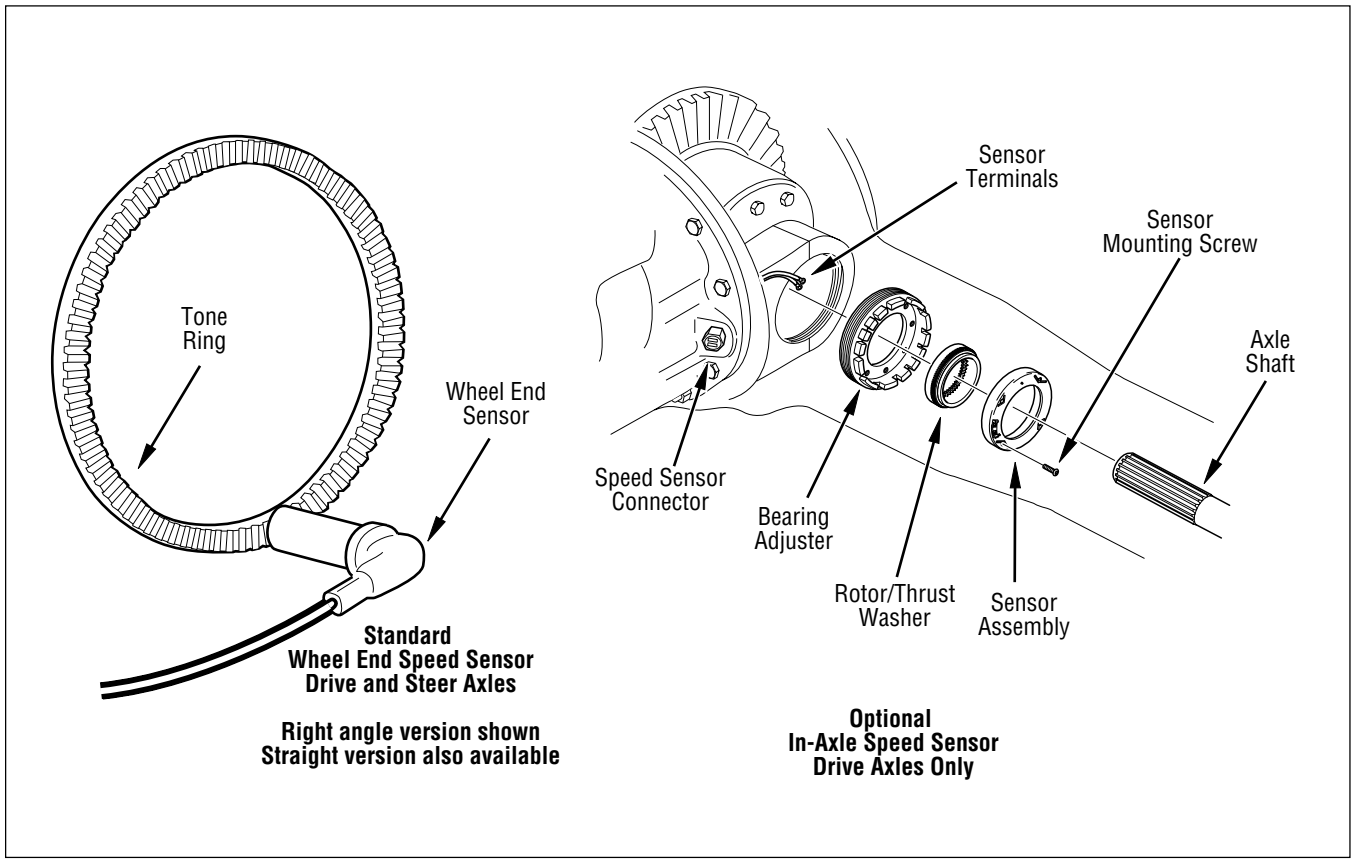


Figure 18. Sensor Assemblies

Fault Codes

An important feature of the Eaton ABS is system diagnostics reported via the Electronic Control Unit. This section describes how to use error codes to identify system operating problems.

There are two ways to retrieve and display ABS fault codes:

- **Automatic retrieval via a hand-held tester**: Displays fault codes on the hand-held tester's display. Refer to the held-held tester information later in this section to retrieve and display fault codes.
- **Manual blink code diagnostics**: Flashes the codes on the ABS indicator lamp. Refer to the Blink Codes in this section.

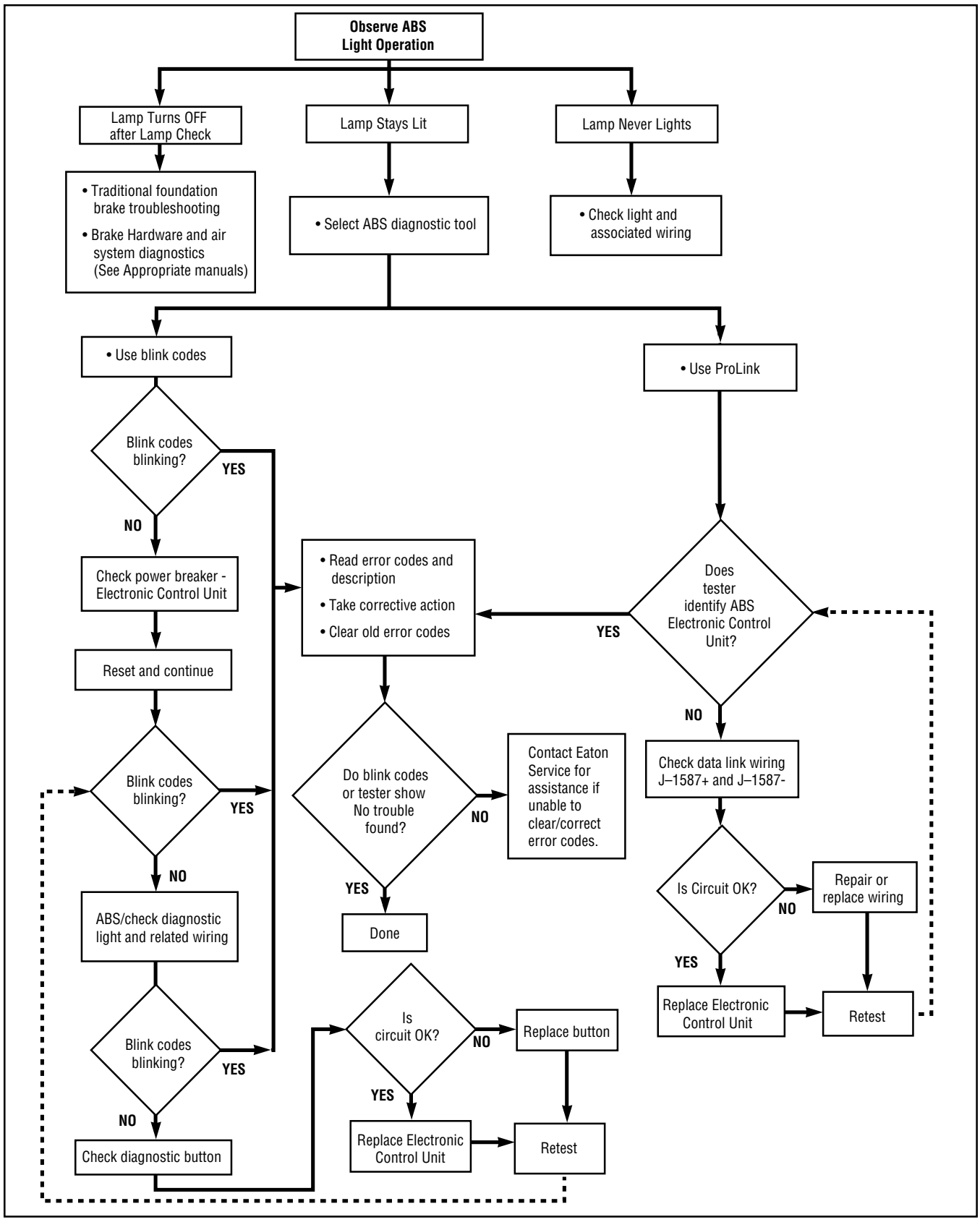


Figure 19. Brake System Troubleshooting Chart

Test Equipment

Eaton recommends the use of two instruments to troubleshoot the ABS system:

- A hand-held tester, and
- A multimeter or digital volt-ohmmeter (DVOM)

This section covers the use of test tools and equipment to find and correct system problems.

Hand-Held Tester

The hand-held tester employs menu-driven tests for reading ABS fault codes. See the documentation provided with the tool for more information.

An MPSI hand-held tester with Eaton 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 such system parameters (example: wheel speeds).

WARNING: The hand-held tester activates output tests for all output devices. Since these tests can affect operation of the vehicle's braking system, the test units incorporate special safety protection. At least one axle must show zero speed or the test will be halted.

A standard heavy duty truck cartridge may also be used, but cannot initiate test sequences.

Figure 20 shows hand-held tester menu option.

Multimeter

Schematics, error codes, and a multimeter can be used to check sensor and solenoid resistances and to find wiring harness faults. A test adapter may be required to use of the multimeter.

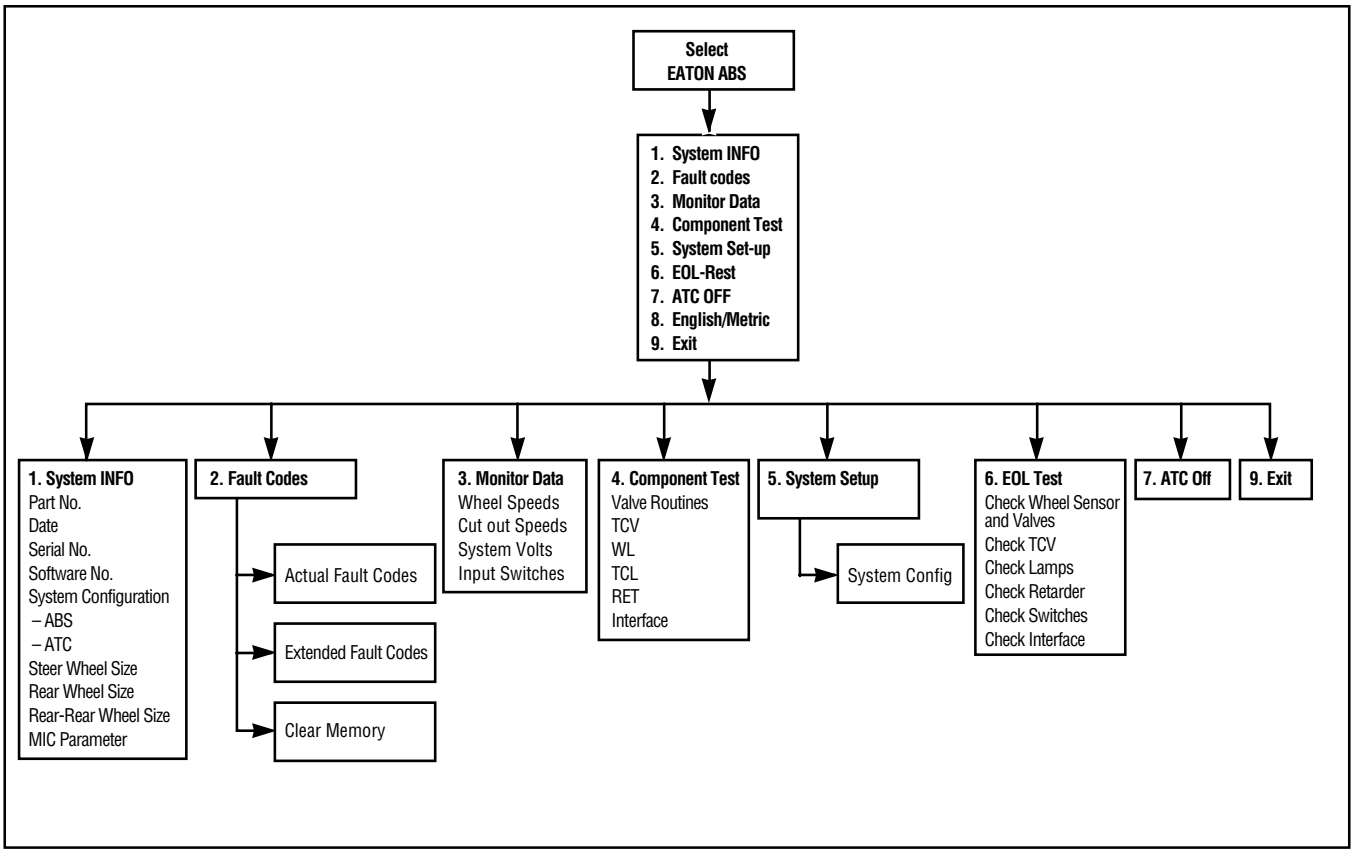


Figure 20. Hand-Held Tester Operation Procedures

Hand-held Tester Set-up

Cable Installation

1. Align the 15-pin connector with the socket on the back of the hand-held tester.
2. Install the connector carefully and secure with the attached thumbscrews.
3. Connect the other end of the cable to the diagnostic connector.

Note: Before connecting the test cartridge to the hand-held tester, disconnect the vehicle adapter, containing the 12 volt power feed, from the vehicle.

MPC Installation

1. Hold the cartridge flat and slide it onto the back of the hand-held tester. Do not hold the cartridge at an angle—it must sit flat.
2. Slide the cartridge forward until it locks into place.

MPC Removal

1. Place your thumb on the slanted surface of the keyboard and your fingers on the cartridge.
2. Make a motion similar to snapping your fingers. The retention latches will release the MPC Cartridge.
3. Continue sliding the cartridge straight out until the edgeboard is clear of the connector in the hand-held tester.

Card Installation

1. Align the application card with the slot in the bottom of the MPC cartridge with the chart side of the card facing up.

Note: Do not force the card, it will only go in one way.

Card Removal

1. Push the release button and remove the card.

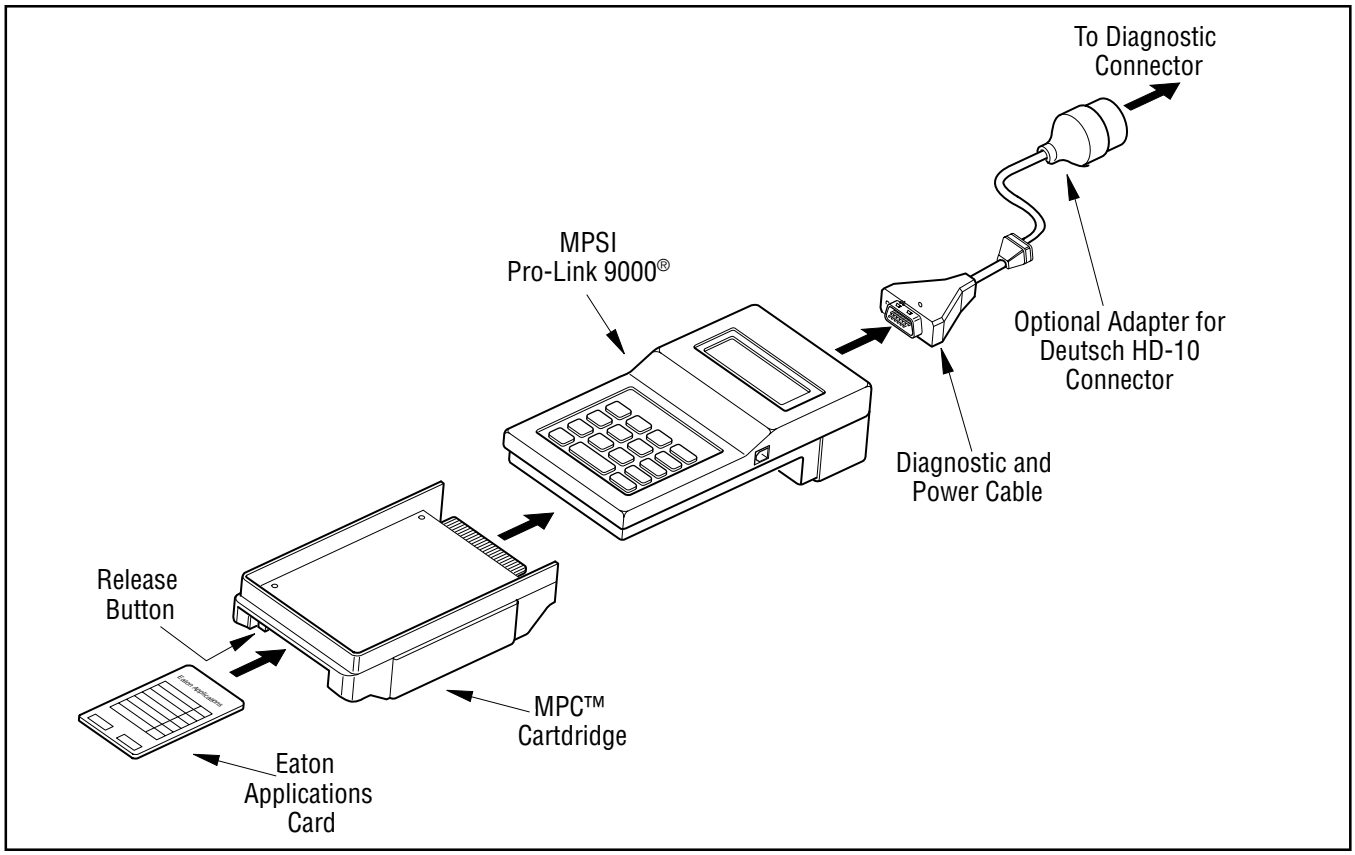


Figure 21. Hand-held Tester Set-up

Diagnostic Switch

Fault Code Charts

Fault codes can be retrieved as two-digit blink codes. Refer to the charts beginning on page 26 for a description of these codes.

Blink codes are retrieved by using the diagnostic switch. The diagnostic switch can also be used for other operations. To perform any of the activities listed below, follow the steps exactly as given. If you make a mistake during one of the steps, stop and start over at the beginning of the procedure.

Note: When pressing the diagnostic switch for a designated amount of time to retrieve blink codes, use a method such as counting–one thousand one, one thousand two. This will allow more accurate fault code retrieval and reduce the possibility of misreading blink code information.

Before attempting any repairs first retrieve the Fault Codes, (write them down). Next clear the fault codes. Then once again retrieve the fault codes. Only active codes will now be displayed.

Retrieving Fault 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 at least **one** second but less than **three** seconds and release. (Remember count one-thousand-one.)
- Two-digit blink codes are retrieved and displayed.

Clearing Fault Codes (inactive codes)

- 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.
- Blink fault codes are cleared.
- Repeat the "Retrieving Fault Codes" procedure to verify that fault codes are cleared.
- Active fault codes will be reestablished until corrected action has been taken.

Configuring the system

- 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.
- This procedure also clears inactive (historical) fault codes.

Reading Configuration Codes

- Turn the ignition key to "ON".
- Press and hold the diagnostic button for at least **one** second but less than **three** seconds and release. (Remember count one-thousand-one.)
- Wait for less than one second then press the diagnostic button a 2nd time for at least **one** second but less than **three** seconds and release.
- Four-digit configuration code is retrieved and displayed. (Refer to page 10 for description).

Disabling ATC for Dyno Testing

- Turn the ignition key to "ON".
- Press and hold the diagnostic button for at least **three** 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.

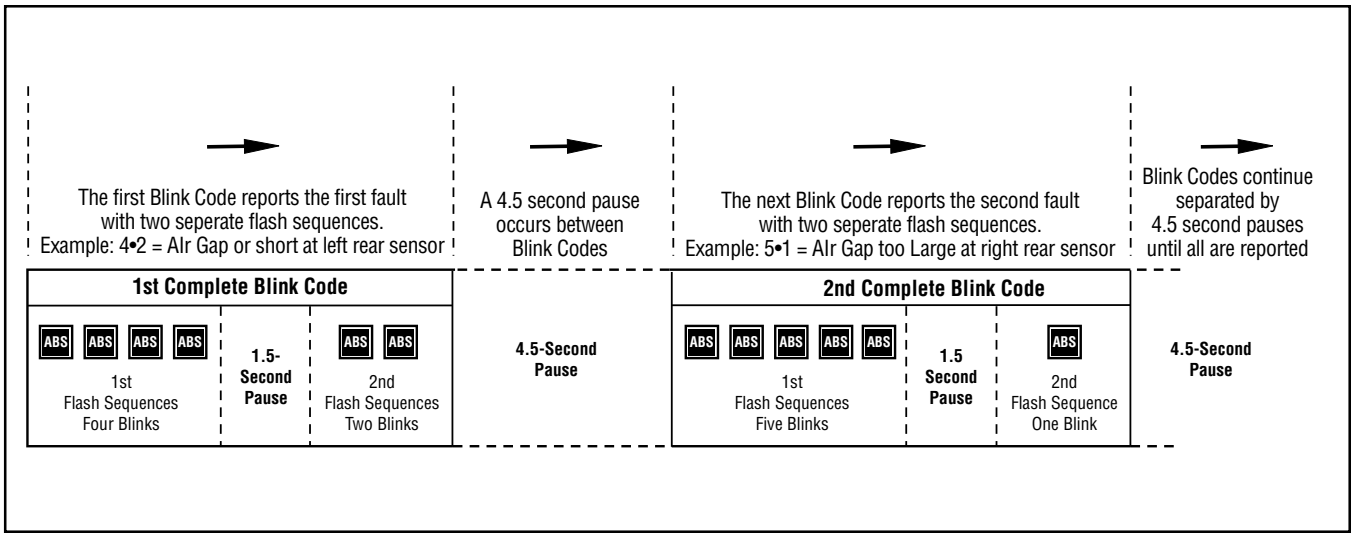


Figure 22. Typical Blink Code Report

Blink Codes		Description	Location	Reference
1st	2nd			
1	1	No Trouble Found		
2	1	Sensor air gap too large	Left Steer Sensor	page 30
2	2	Air gap too large or sensor shorted		
2	3	Speed Sensor is noisy		
2	4	Wheel locked for excessive period of time during an ABS cycle		
2	5	Excessive rate of deceleration found at a wheel site or sensor shorted		
2	6	Sensor connection shorted low or high or sensor open		
2	7	There is an internal error at the sensor port of the ECU		
2	8	A sensor has been found in the wrong location		
3	1	Sensor air gap too large	Right Steer Sensor	page 30
3	2	Air gap too large or sensor shorted		
3	3	Speed Sensor is noisy		
3	4	Wheel locked for excessive period of time during an ABS cycle		
3	5	Excessive rate of deceleration found at a wheel site or sensor shorted		
3	6	Sensor connection shorted low or high or sensor open		
3	7	There is an internal error at the sensor port of the ECU		
3	8	A sensor has been found in the wrong location		
4	1	Sensor air gap too large	Left Rear Sensor	page 30
4	2	Air gap too large or sensor shorted		
4	3	Speed Sensor is noisy		
4	4	Wheel locked for excessive period of time during an ABS cycle		
4	5	Excessive rate of deceleration found at a wheel site or sensor shorted		
4	6	Sensor connection shorted low or high or sensor open		
4	7	There is an internal error at the sensor port of the ECU		
4	8	A sensor has been found in the wrong location		
5	1	Sensor air gap too large	Right Rear Sensor	page 30
5	2	Air gap too large or sensor shorted		
5	3	Speed Sensor is noisy		
5	4	Wheel locked for excessive period of time during an ABS cycle		
5	5	Excessive rate of deceleration found at a wheel site or sensor shorted		
5	6	Sensor connection shorted low or high or sensor open		
5	7	There is an internal error at the sensor port of the ECU		
5	8	A sensor has been found in the wrong location		
6	1	Sensor air gap too large	Left Rear Rear Sensor	page 30
6	2	Air gap too large or sensor shorted		
6	3	Speed Sensor is noisy		
6	4	Wheel locked for excessive period of time during an ABS cycle		

Blink Codes		Description	Location	Reference
1st	2nd			
6	5	Excessive rate of deceleration found at a wheel site or sensor shorted	Left Rear Rear Sensor	page 30
6	6	Sensor connection shorted low or high or sensor open	(continued)	
6	7	There is an internal error at the sensor port of the ECU		
6	8	A sensor has been found in the wrong location for the system configuration		
7	1	Sensor air gap too large	Right Rear Rear Sensor	page 30
7	2	Air gap too large or sensor shorted		
7	3	Speed Sensor is noisy		
7	4	Wheel locked for excessive period of time during an ABS cycle		
7	5	Excessive rate of deceleration found at a wheel site or sensor shorted		
7	6	Sensor connection shorted low or high or sensor open		
7	7	There is an internal error at the sensor port of the ECU		
7	8	A sensor has been found in the wrong location for the system configuration		
8	1	There is a short between the release solenoid and supply voltage	Left Steer Axle Valve	page 34
8	2	There is a short between the release solenoid and ground		
8	3	There is an open circuit at the release solenoid		
8	4	There is an open circuit in the common line to the valve		
8	5	There is a short between the hold solenoid and supply voltage		
8	6	There is short between the hold solenoid and ground		
8	7	There is an open circuit at the hold solenoid		
8	8	A valve was found wired in the wrong location for the system configuration		
9	1	There is a short between the release solenoid and supply voltage	Right Steer Axle Valve	page 34
9	2	There is a short between the release solenoid and ground		
9	3	There is an open circuit at the release solenoid		
9	4	There is an open circuit in the common line to the valve		
9	5	There is a short between the hold solenoid and supply voltage		
9	6	There is a short between the hold solenoid and ground		
9	7	There is an open circuit at the hold solenoid		
9	8	A valve was found wired in the wrong location for the system configuration		
10	1	There is a short between the release solenoid and supply voltage	Left Rear Axle Valve	page 34
10	2	There is a short between the release solenoid and ground		
10	3	There is an open circuit at the release solenoid		
10	4	There is an open circuit in the common line to the valve		
10	5	There is a short between the hold solenoid and supply voltage		
10	6	There is a short between the hold solenoid and ground		
10	7	There is an open circuit at the hold solenoid		
10	8	A valve was found wired in the wrong location for the system configuration		

Blink Codes		Description	Location	Reference
1st	2nd			
10	10	Diagonal 1 (common side of Valves SR.LR,LRR) shorted to bat	Diagonal 1	page 34
10	11	Diagonal 1 (common side of Valves SR,LR,LRR) shorted to ground		
11	1	There is a short between the release solenoid and supply voltage	Right Rear Axle Valve	page 34
11	2	There is a short between the release solenoid and ground		
11	3	There is an open circuit at the release solenoid		
11	4	There is an open circuit in the common line to the valve		
11	5	There is a short between the hold solenoid and supply voltage		
11	6	There is a short between the hold solenoid and ground		
11	7	There is an open circuit at the hold solenoid		
11	8	A valve has been found wired in the wrong location for the system config.		
11	10	Diagonal 2 (common side of Valves SL, RR, RRR) shorted to bat	Diagonal 2	page 34
11	11	Diagonal 2 (common side of Valves SL, RR, RRR) shorted to ground		
12	1	There is a short between the release solenoid and supply voltage	Left Rear Rear Axle Valve	page 34
12	2	There is a short between the release solenoid and ground		
12	3	There is an open circuit at the release solenoid		
12	4	There is an open circuit in the common line to the valve		
12	5	There is a short between the hold solenoid and supply voltage		
12	6	There is a short between the hold solenoid and ground		
12	7	There is an open circuit at the hold solenoid		
12	8	A valve has been found wired in the wrong location for the system config.		
13	1	There is a short between the release solenoid and supply voltage	Right Rear Rear Axle Valve	page 34
13	2	There is a short between the release solenoid and ground		
13	3	There is an open circuit at the release solenoid		
13	4	There is an open circuit in the common line to the valve		
13	5	There is a short between the hold solenoid and supply voltage		
13	6	There is a short between the hold solenoid and ground		
13	7	There is an open circuit at the hold solenoid		
13	8	A valve has been found wired in the wrong location for the system config.		
14	1	Reserved	ATC Valve	page 38
14	2	Reserved		
14	3	Reserved		
14	4	Reserved		
14	5	Solenoid in ATC valve shorted high		
14	6	Solenoid in ATC valve shorted to ground		
14	7	ATC valve open circuit		
14	8	ATC valve found when it should not be present		

Blink Codes		Description	Location	Reference
1st	2nd			
14	9	Not used in U.S.		
14	10	Not used in U.S.		
14	11	Not used in U.S.		
14	12	Timeout or no connection found to engine link (J1922 or 1939)	Engine Data Link	Page 40
15	1	ECU internal fault	ECU	page 40
15	2	ECU internal fault		
15	3	ECU internal fault		
15	4	ECU internal fault		
15	5	ECU internal fault		
15	6	ECU internal fault		
15	7	ECU internal fault		
15	8	ECU internal fault		
15	9	ECU internal fault		
15	10	ECU internal fault		
15	11	ECU internal fault		
16	1	Excessive voltage on diagonal 1 (Pin A-9)	ECU Power Supply and	page 42
16	2	Low voltage found on diagonal 1 (Pin A-9)	Ground Connectors	
16	3	No voltage found on diagonal 1 (Pin A-9)		
16	4	No ground found on diagonal 2 (Pin A-11)		
16	5	Excessive voltage on diagonal 2 (Pin A-8)		
16	6	Low voltage found on diagonal 2 (Pin A-8)		
16	7	No voltage on diagonal 2 (Pin A-8)		
16	8	No ground found on diagonal 1 (Pin A-12)		
16	9	Excessive voltage found on switched ignition point (Pin A-7)		
16	10	Low voltage found on switched ignition input (Pin A-7)		
16	11	Voltage between diag. 1 and diag. 2 supply is too high (Pin A-9 to A-8)		
17	1	Retarder control relay shorted high or open circuit		page 43
17	2	Retarder control relay shorted low		
17	3	J1922/1939 date link not functioning		
17	4	J1922/1939 date link time out		
17	5	Tire size, front to rear out of range		
17	6	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	12	Sensor fault memory bit is set. The ECU must read speeds on all wheels before this code will clear.		

Speed Sensor Troubleshooting

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

1. Access active fault 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.
5. If a sensor related fault has occurred, a code 17-12 will remain in the system until the vehicle has been driven.

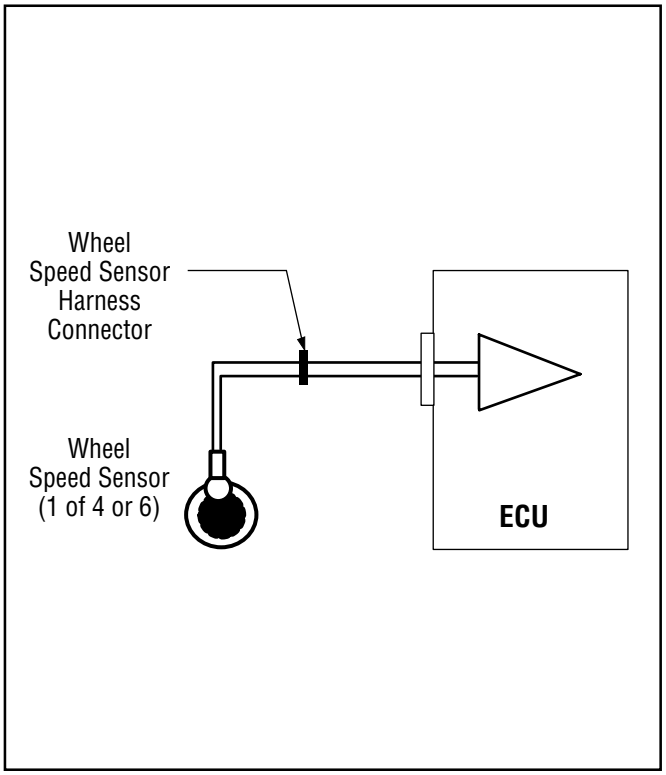
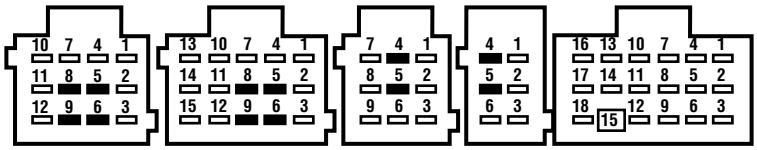


Figure 23. Typical Wheel Speed Sensor Circuit



HARNESS CONNECTOR	PIN	CIRCUIT DESCRIPTION
B (6-Way)	4	Speed Sensor (+) Left Steer
B (6-Way)	5	Speed Sensor (-) Left Steer
C (9-Way)	4	Speed Sensor (+) Right Steer
C (9-Way)	5	Speed Sensor (-) Right Steer
D (15-Way)	5	Speed Sensor (+) Left Rear
D (15-Way)	6	Speed Sensor (-) Left Rear
D (15-Way)	8	Speed Sensor (+) Right Rear
D (15-Way)	9	Speed Sensor (-) Right Rear
E (12-Way)	5	Speed Sensor (+) Left Rear Rear
E (12-Way)	6	Speed Sensor (-) Left Rear Rear
E (12-Way)	8	Speed Sensor (+) Right Rear Rear
E (12-Way)	9	Speed Sensor (-) Right Rear Rear

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.

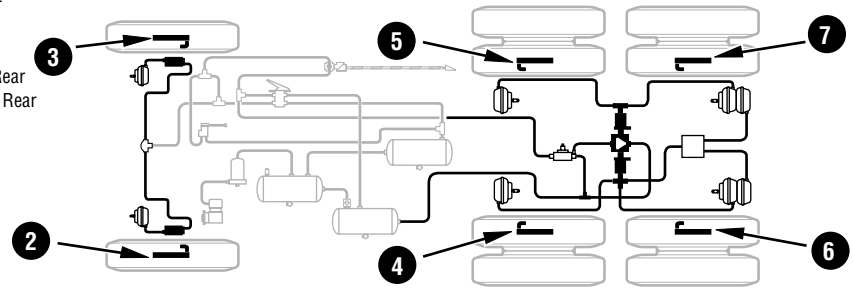
Note: Refer to the chart for pin identification.

Figure 24. Wheel Speed Sensor Harness Circuit Descriptions and Resistance Test

Blink Code Sequence

1st

Flashes	Location
2	Left Steer
3	Right Steer
4	Left Rear
5	Right Rear
6	Left Rear Rear
7	Right Rear Rear



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 fault code and verify that fault is corrected by test driving the vehicle. The warning light will remain on until proper sensor output is detected even though the fault 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 fault code and verify that fault is corrected by test driving the vehicle. The warning light will remain on until proper sensor output is detected even though the fault 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 fault code and verify that fault is corrected by test driving the vehicle. The warning light will remain on until proper sensor output is detected even though the fault 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 fault code and verify that fault is corrected by test driving the vehicle. The warning light will remain on until proper sensor output is detected even though the fault has been cleared.
5	Excessive rate of deceleration found at a wheel site.	Clear fault code and test drive the vehicle. The warning light will remain on until proper sensor output is detected even though the fault has been cleared. If fault recurs, check for damaged tone ring or excessive run out. Repair tone ring and/or adjust wheel bearings.
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 fault code and verify that fault is corrected by test driving the vehicle. The warning light will remain on until proper sensor output is detected even though the fault has been cleared.
7	There is an internal error at the sensor port of the ECU.	Clear fault code and test drive the vehicle. The warning light will remain on until proper sensor output is detected even though the fault has been cleared. If fault 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 Fault 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.

WARNING: Block wheels before beginning this procedure.

WARNING: 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.

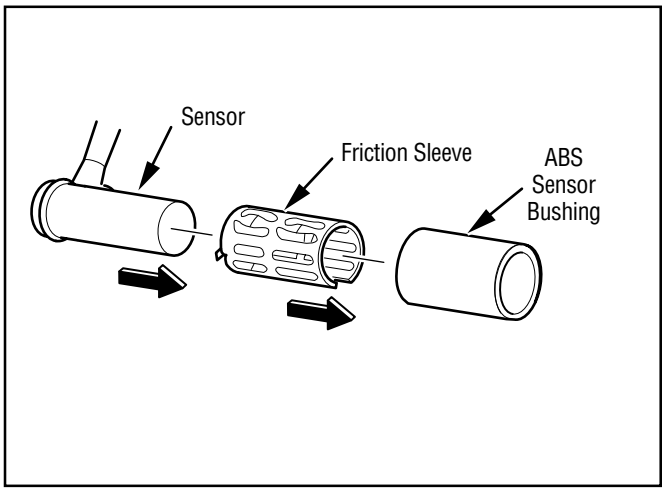


Figure 26. Front Speed Sensor Components

Installation

1. Install the Sensor Bushing with the flange stops towards the inboard side of the vehicle.
2. Apply lubricant to the body of the speed sensor. Use one of the following lubricants or equivalents.
   - Penzoil 707L
   - Valvoline LP
   - Mobil HP
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 connections.
6. Clear the codes. A 17•12 code will remain until the vehicle has been driven.
7. Test drive the vehicle and verify that the ABS warning lamp operates properly.

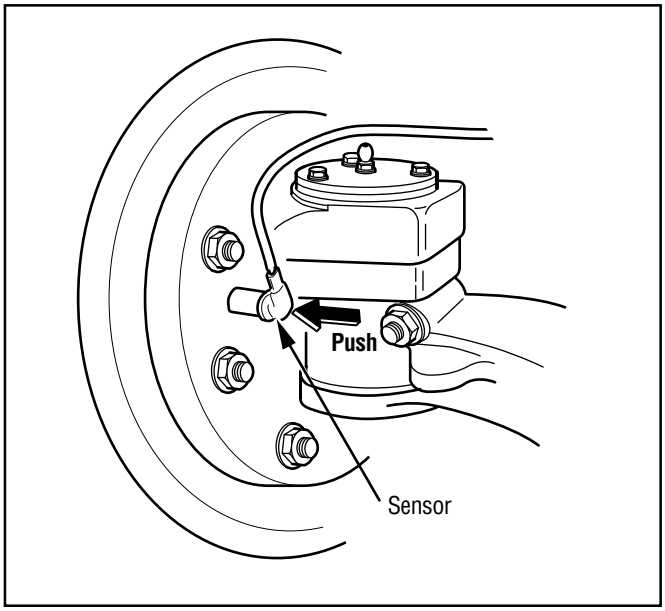


Figure 27. Wheel Speed Sensor Installation

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: To service In-Axle Speed Sensors, Refer to AXSM-0034 for diagnostic and service.

WARNING: Block wheels before beginning this procedure

WARNING: 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.

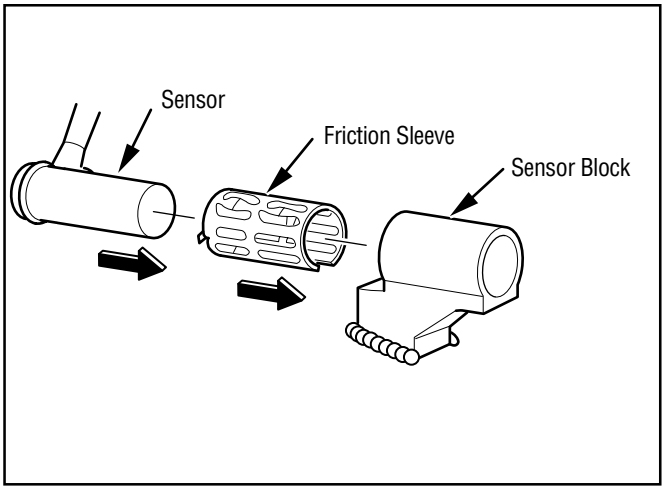


Figure 28. Rear Speed Sensor Components

Installation

1. Install the Sensor Bushing with the flange stops towards the inboard side of the vehicle.
2. Apply lubricant to the body of the speed sensor. Use one of the following lubricants or equivalents.
   - Penzoil 707L
   - Valvoline LP
   - Mobil HP
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 sensor the 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 codes. A 17•12 code will remain and the warning light will remain lit until the vehicle has been driven so that the ECU can read sensor voltages.
12. Test drive the vehicle and verify that the ABS warning lamp operates properly.

Pressure Modulator Valve (PMV) Troubleshooting

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

1. Access active fault 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.

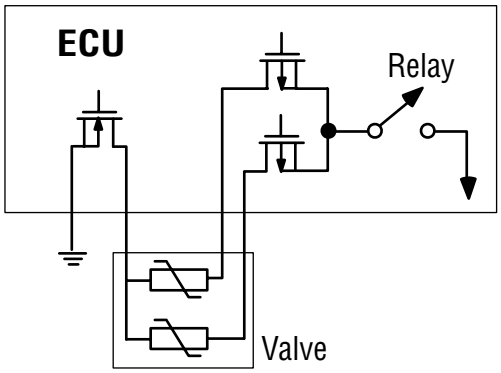
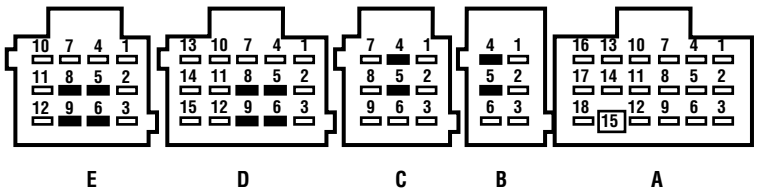
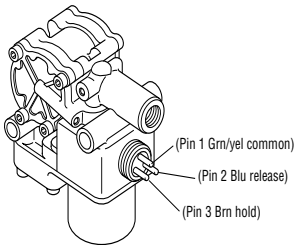


Figure 29. Typical PMV Circuit

TOP – Looking into harness connector



HARNESS CONNECTOR	PIN	CIRCUIT DESCRIPTION
B (6-Way)	1	PMV 1 (Release) Left Steer
B (6-Way)	2	PMV 1 (Hold) Left Steer
B (6-Way)	3	PMV 1 Common Left Steer
C (9-Way)	7	PMV 2 (Release) Right Steer
C (9-Way)	8	PMV 2 (Hold) Right Steer
C (9-Way)	9	PMV 2 Common Right Steer
D (15-Way)	1	PMV 3 (Release) Left Rear
D (15-Way)	2	PMV 3 (Hold) Left Rear
D (15-Way)	3	PMV 3 Common Left Rear
D (15-Way)	10	PMV 4 (Release) Right Rear
D (15-Way)	11	PMV 4 (Hold) Right Rear
D (15-Way)	12	PMV 4 Common Right Rear
E (12-Way)	1	PMV 5 (Release) Left Rear Rear
E (12-Way)	2	PMV 5 (Hold) Left Rear Rear
E (12-Way)	3	PMV 5 Common Left Rear Rear
E (12-Way)	10	PMV 6 (Release) Right Rear Rear
E (12-Way)	11	PMV 6 (Hold) Right Rear Rear
E (12-Way)	12	PMV 6 Common Right Rear Rear



Measure From:	Measure To:	Resistance Range:
Pin 1	Pin 2	3-8 Ohms
Pin 1	Pin 3	3-8 Ohms
Pin 2	Pin 3	6-16 Ohms

PMV Resistance Test

Measure resistance at the PMV location to check the valve.

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

Note: Refer to the chart for pin identification.

Figure 30. PMV Harness Circuit Descriptions and Resistance Test

Blink Code Sequence

1st

Flashes	Location		Flashes	Location	
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 (fig 30). 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 (fig 30). 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 (fig 30). 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 (fig 30). 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 (fig 30). 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 (fig 30). 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 (fig 30). 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).

1st

Flashes	Location
10	Diagonal 1

1.5 Sec. Pause

2nd

Flashes	Condition	Action
10	A short to supply voltage has been found on the common line of one or more of the valves that are connected to the diagonal two circuit. (right steer, left rear and left rear-rear valves)	Unplug ECU and check for short to 12 volts on pins C9,D3,E3. If any are shorted to supply, repair harness. If no short is found in harness, replace ECU. Note: Before replacing ECU clear fault codes and verify that fault is still presentation (Refer to Schematic).
11	A short to ground has been found on the common line of one or more of the valves that are connected to the diagonal two circuit. (right steer, left rear and left rear-rear valves)	Unplug ECU and check for short to ground on pins C9,D3,E3. If any are shorted to ground, repair harness. If no short is found in harness, replace ECU. Note: Before replacing ECU clear fault codes and verify that fault is still present.

1st

Flashes	Location
11	Diagonal 2

1.5 Sec. Pause

2nd

10	A short to supply voltage has been found on the common line of one or more of the valves that are connected to the diagonal one circuit. (Left steer, right rear and right rear-rear valves)	Unplug ECU and check for short to 12 volts on pins B3.D12,E12. If any are shorted to supply, repair harness. If no short is found in harness, replace ECU. Note: Before replacing ECU clear fault codes and verify that fault is still present.
11	A short to ground has been found on the common line of one or more of the valves that are connected to the diagonal one circuit. (Left steer, right rear and right rear-rear valves)	Unplug ECU and check for short to ground on pins B3,D12,E12. Alternatively check at the valve connectors for a short to ground.If a short is found, repair harness.If no short is found in harness, replace ECU. Note: Before replacing ECU clear fault codes and verify that fault is still present.

Figure 31. PMV Fault Code Troubleshooting Guide

ABS Modulator Valve and Rear Axle Module

Removal

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

WARNING: Block wheels before beginning this procedure.

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

WARNING: Vent supply tank before removing any fittings!

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 RAM as an 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 warning 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 warning lamp operates properly.

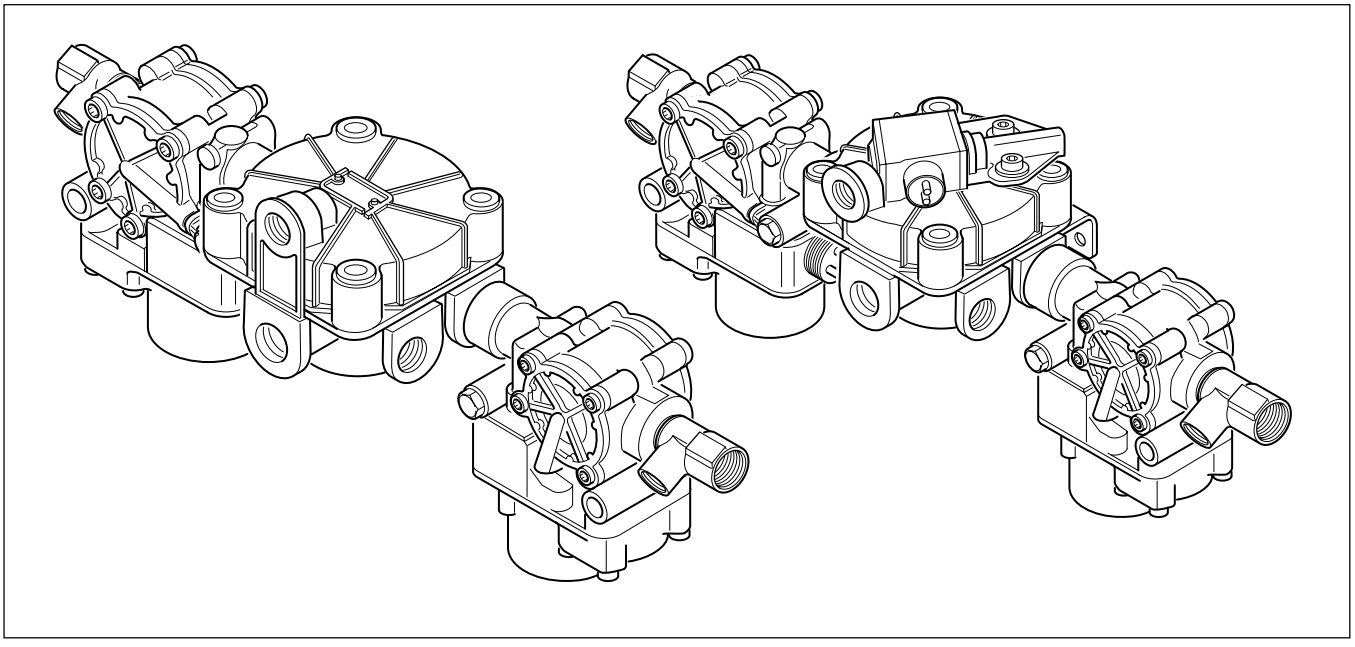


Figure 32. Rear Axle Module (RAM), Standard and ATC Versions Shown

Performance Test of the Relay Valve

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 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 with a soap solution (where cover joins body) and the connection between modulator valve and relay valve. 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 cut-off. With brakes released coat exhaust port of relay valve with a soap solution. Leakage of a one-inch bubble in five seconds is permissible.
7. Depress foot valve and keep depressed. Coat exhaust port with a soap solution. Leakage of a one-inch bubble in three seconds is permissible.

Automatic Traction Control (ATCV) Troubleshooting

The following ATC troubleshooting pages provide the basic information necessary to:

- Identify the fault code
- Locate the problem
- Review possible cause(s)
- Select the correct solution and
- Utilize proper repair procedures.

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

1. Access active fault 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.

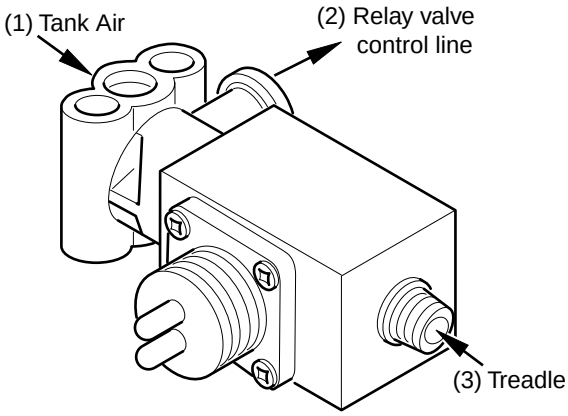
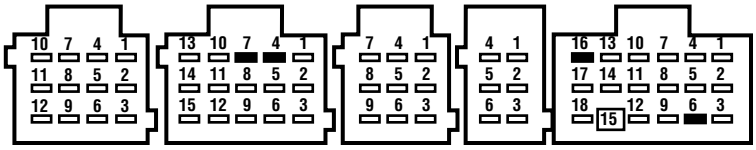


Figure 33. Automatic Traction Control (ATC) Valve



HARNESS CONNECTOR	PIN	CIRCUIT DESCRIPTION
A (18-Way)	6	ATC Mud and Snow Switch
A (18-Way)	16	ATCL (ATC Light)
D (15-Way)	4	ATC Valve +
D (15-Way)	7	ATC Valve -

ATC Valve Resistance Test

The correct resistance for the ATC Valve circuit is between 9 ohms and 15 ohms.

Measure resistance at the ATC Valve to check the valve.

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

Note: Refer to the chart for pin identification.

Figure 34. ATC Harness Circuit Descriptions and Resistance Test

Blink Code Sequence

Flashes	Location
14	ATC Valve

1st

1.5 Second Pause

2nd

Flashes	Condition	Response
5	Solenoid in ATC valve shorted high.	Use multimeter to check that valve resistances are correct (fig 34). If valve is OK check harness for open in wiring.
6	Solenoid in ATC valve shorted to ground.	Use multimeter to check that valve resistances are correct (fig 34). If valve is OK check harness for open in wiring.
7	ATC valve open circuit.	Use multimeter to check that valve resistances are correct (fig 34). If valve is OK check harness for open in wiring.
8	ATC valve found when it should not be present.	Verify proper system configuration and components. Clear faults. If error cannot be cleared or recurs, replace ECU.

Figure 35. ATC Fault Code Troubleshooting Guide

ATC Valve Removal

WARNING: Block wheels before beginning this procedure.

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

WARNING: Vent supply tank before removing any fittings!

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

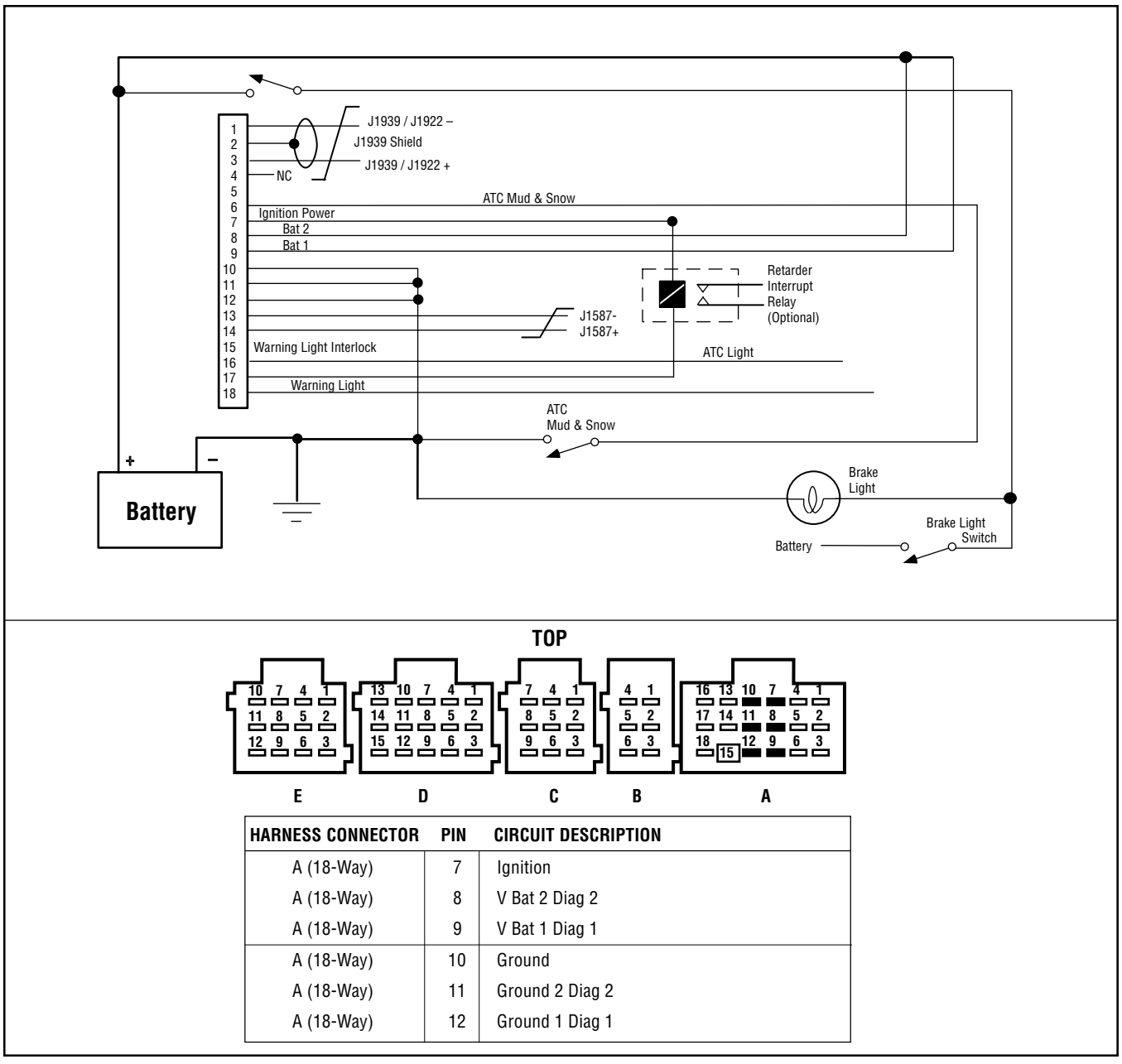
1. Install the ATC valve. Torque fasteners to manufacturers specification.
2. Connect Air lines supply (port 1) delivery port (port 2) and treadle (port 3) of the ATC valve.
3. Install the wiring connector to the ATC valve
4. Test the installation.
   - Traction Control Valve – Leak Test
     Make and 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 warning 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 24 to disable ATC for dyno testing.

System and ECU Troubleshooting

Follow the steps listed below to locate and correct ABS faults.

1. Access active fault 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.
5. If it is necessary to replace a control unit follow the procedures on page 10 and 24 to configure the system and read back the configuration.



HARNESS CONNECTOR	PIN	CIRCUIT DESCRIPTION
A (18-Way)	7	Ignition
A (18-Way)	8	V Bat 2 Diag 2
A (18-Way)	9	V Bat 1 Diag 1
A (18-Way)	10	Ground
A (18-Way)	11	Ground 2 Diag 2
A (18-Way)	12	Ground 1 Diag 1

Figure 36. System and ECU Harness Circuit Descriptions

Blink Code Sequence

Flashes	Location
14	ECU, Engine Interface

1st

1.5 Sec. Pause

2nd

Flashes	Condition	Action
9	Engine interface shorted to ground or supply voltage	Use multimeter to check for vehicle harness for shorts. Refer to vehicle wiring schematic. If wiring is ok and fault cannot be cleared, replace ECU.
10	Error reported from engine data link	Check engine control unit for proper diagnostic link function.
11	Engine interface shorted to ground or supply voltage	Use multimeter to check vehicle harness for shorts. Refer to vehicle wiring schematic. If wiring is ok and fault cannot be cleared, replace ECU
12	No connection found to engine line out (J1922/1939).	Check for proper connection to data link (pins A-1 and A-3 of ABS harness. Verify that polarity is correct. If vehicle is not equipped with J1922/1939 engine link, use diagnostic tool to reconfigure ECU.

Flashes	Location
15	ECU

1st

1.5 Sec. Pause

2nd

Flashes	Condition	Action
1	ECU Internal Fault	If fault cannot be cleared replace ECU.
2	ECU Internal Fault	If fault cannot be cleared replace ECU.
3	ECU Internal Fault	If fault cannot be cleared replace ECU.
4	ECU Internal Fault	If fault cannot be cleared replace ECU.
5	ECU Internal Fault	If fault cannot be cleared replace ECU.
6	ECU Internal Fault	If fault cannot be cleared replace ECU.
7	ECU Internal Fault	If fault cannot be cleared replace ECU.
8	ECU Internal Fault	If fault cannot be cleared replace ECU.
9	ECU Internal Fault	If fault cannot be cleared replace ECU.
10	ECU Internal Fault	If fault cannot be cleared replace ECU.
11	ECU Internal Fault	If fault cannot be cleared replace ECU.

Figure 37. System and ECU Fault Codes Troubleshooting Guide, 1 of 3

Blink Code Sequence

Flashes	Location
16	Battery

1st

1.5 Sec. Pause

2nd

Flashes	Condition	Action
1	Excessive voltage on Bat 1 (A-9)	Verify that vehicle system voltage is OK (i.e. 9 to 16 volts). If voltage is out of range, correct system problem. Unplug connector A at ECU and turn on ignition switch. If the voltage on pin A-9 is different than system voltage, repair wiring. Clear faults and verify that the warning light turns out after bulb check.
2	Low voltage found on Bat 1 (A-9)	Verify that vehicle system voltage is OK (i.e. 9 to 16 volts). If voltage is out of range, correct system problem. Unplug connector A at ECU and turn on ignition switch. If the voltage on pin A-9 is different than system voltage, repair wiring. Clear faults and verify that the warning light turns out after bulb check.
3	No voltage found on Bat 1 (A-9)	Verify that vehicle system voltage is OK (i.e. 9 to 16 volts). If voltage is out of range, correct system problem. Unplug connector A at ECU and turn on ignition switch. If the voltage on pin A-9 is different than system voltage, repair wiring. Clear faults and verify that the warning light turns out after bulb check.
4	No ground found on Ground 2 (A-11)	Unplug connector A at ECU and measure resistance to ground at A-11. If continuity to ground is not present, repair harness.
5	Excessive voltage on Bat 2 (A-8)	Verify that vehicle system voltage is OK (i.e. 9 to 16 volts). If voltage is out of range, correct system problem. Unplug connector A at ECU and turn on ignition switch. If the voltage on pin A-8 is different than system voltage, repair wiring. Clear faults and verify that the warning light turns out after bulb check.
6	Low voltage found on Bat 2 (A-8)	Verify that vehicle system voltage is OK (i.e. 9 to 16 volts). If voltage is out of range, correct system problem. Unplug connector A at ECU and turn on ignition switch. If the voltage on pin A-8 is different than system voltage, repair wiring. Clear faults and verify that the warning light turns out after bulb check.
7	No voltage found on Bat 2 (A-8)	Verify that vehicle system voltage is OK (i.e. 9 to 16 volts). If voltage is out of range, correct system problem. Unplug connector A at ECU and turn on ignition switch. If the voltage on pin A-8 is different than system voltage, repair wiring. Clear faults and verify that the warning light turns out after bulb check.
8	No ground found on Ground 1 (A-12)	Unplug connector A at ECU and measure resistance to ground at A-12. If continuity to ground is not present repair harness.
9	Excessive voltage found on switched ignition input	Verify that vehicle system voltage is OK (i.e. 9 to 16 volts). If voltage is out of range, correct system problem. Unplug connector A at ECU and turn on ignition switch. If the voltage on pin A-7 is different than system voltage, repair wiring. Clear faults and verify that the warning light turns out after bulb check.
10	Low voltage found on switched ignition input	Verify that vehicle system voltage is OK (i.e. 9 to 16 volts). If voltage is out of range, correct system problem. Unplug connector A at ECU and turn on ignition switch. If the voltage on pin A-7 is different than system voltage, repair wiring. Clear faults and verify that the warning light turns out after bulb check.
11	Voltage difference between diagonal 1 and diagonal 2 supply 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 A at ECU and turn on ignition switch. If the voltage on pin A-8 is different than voltage at A-9 by greater than 0.5 volts, repair wiring. (Check circuit breakers and/or fuses on diagonal supply line.) Clear faults and verify that the warning light turns out after bulb check.

Figure 37. 2 of 3

Blink Code Sequence

1st

Flashes	Location
17	Miscellaneous

1.5 Sec. Pause

2nd

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.	Use multimeter to verify proper voltage at the retarder control relay.
3	J1922/1939 data link not functioning. (Retarder)	Unplug connector A. There should be a voltage between 0 and 2.5 volts on pin A-1 and a voltage between 2.5 and 5.0 volts on pin A-3. Refer to schematic and correct wiring harness as required.
4	J1922/1939 data link time out.	Unplug connector A. There should be a voltage between 0 and 2.5 volts on pin A-1 and a voltage between 2.5 and 5.0 volts on pin A-3. A positive voltage should be read when measuring at A-3 with respect to A-2. If the voltage is negative the polarity is reversed. 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 key to reenable ATC
		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 37. 3 of 3

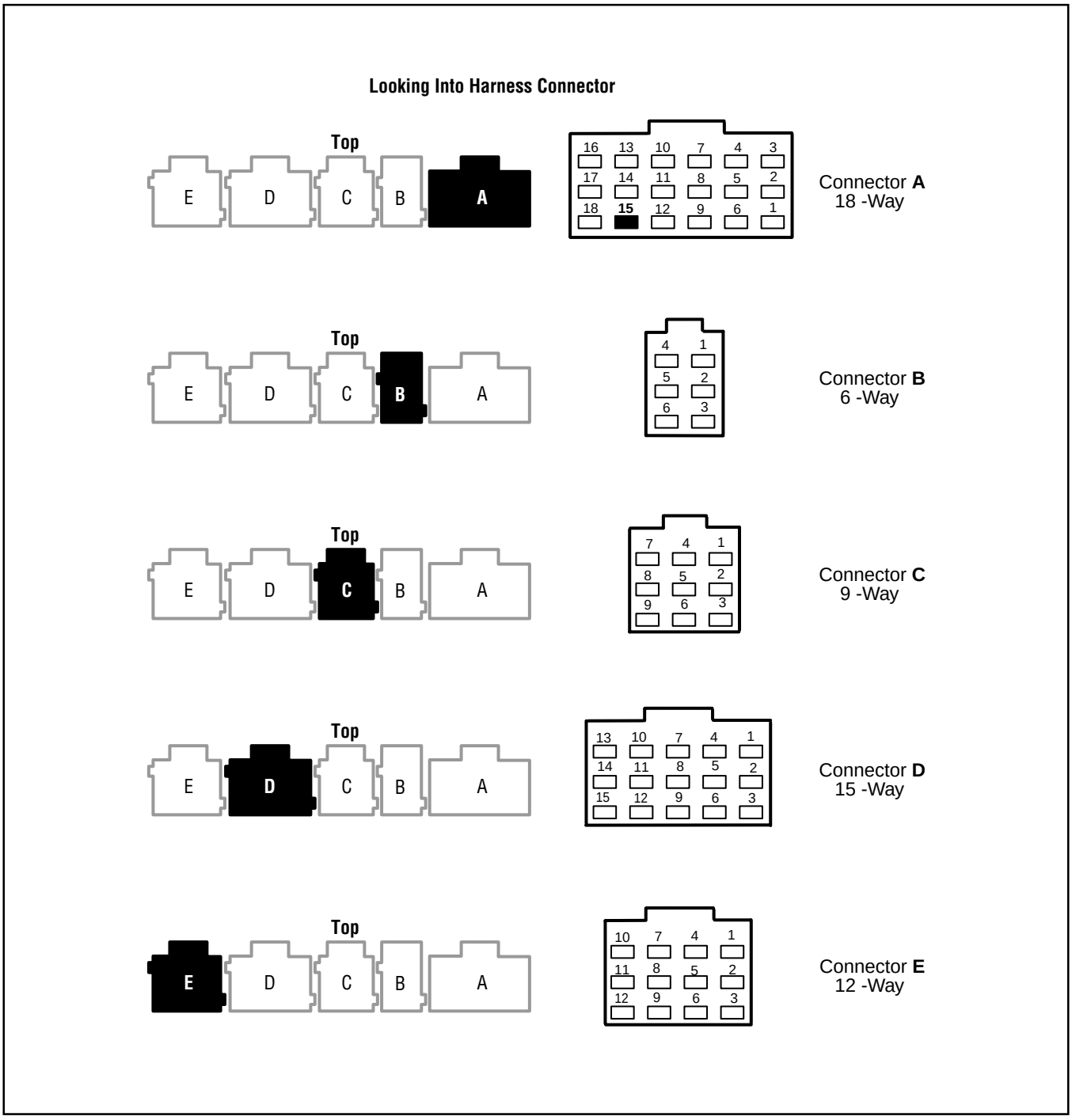


Figure 38. ECU Connector–Harness Pin Identification

ECU CONNECTOR	PIN	DESCRIPTION
A (18-Way)	1	SAE 1922/1939 -
A (18-Way)	2	SAE 1939 Shld
A (18-Way)	3	SAE 1922/1939 +
A (18-Way)	4	NC
A (18-Way)	5	Off Road ABS Switch (ORS)
A (18-Way)	6	ATC Mud & Snow Switch
A (18-Way)	7	Ignition, Switched
A (18-Way)	8	V Bat 2
A (18-Way)	9	V Bat 1
A (18-Way)	10	Ground - ECU
A (18-Way)	11	Ground - Diagonal 2
A (18-Way)	12	Ground - Diagonal 1
A (18-Way)	13	SAE J1587+
A (18-Way)	14	SAE J1587-
A (18-Way)	15	NC, Interlock
A (18-Way)	16	ATC Light
A (18-Way)	17	Retarder Relay
A (18-Way)	18	Warning Light/Diagnostic Switch
B (6-Way)	1	PMV1 (Left Steer), Rel Solenoid
B (6-Way)	2	PMV1 (Left Steer), Hold Solenoid
B (6-Way)	3	PMV1 (Left Steer), Common
B (6-Way)	4	Speed Sensor 2 (Left Steer) +
B (6-Way)	5	Speed Sensor 2 (Left Steer) -
B (6-Way)	6	Brake Light Switch
C (9-Way)	1	NC
C (9-Way)	2	NC
C (9-Way)	3	NC
C (9-Way)	4	Speed Sensor 3 (Right Steer) +
C (9-Way)	5	Speed Sensor 3 (Right Steer) -
C (9-Way)	6	NC
C (9-Way)	7	PMV2 (Right Steer), Rel Solenoid
C (9-Way)	8	PMV2 (Right Steer), Hold Solenoid
C (9-Way)	9	PMV2 (Right Steer), Common

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

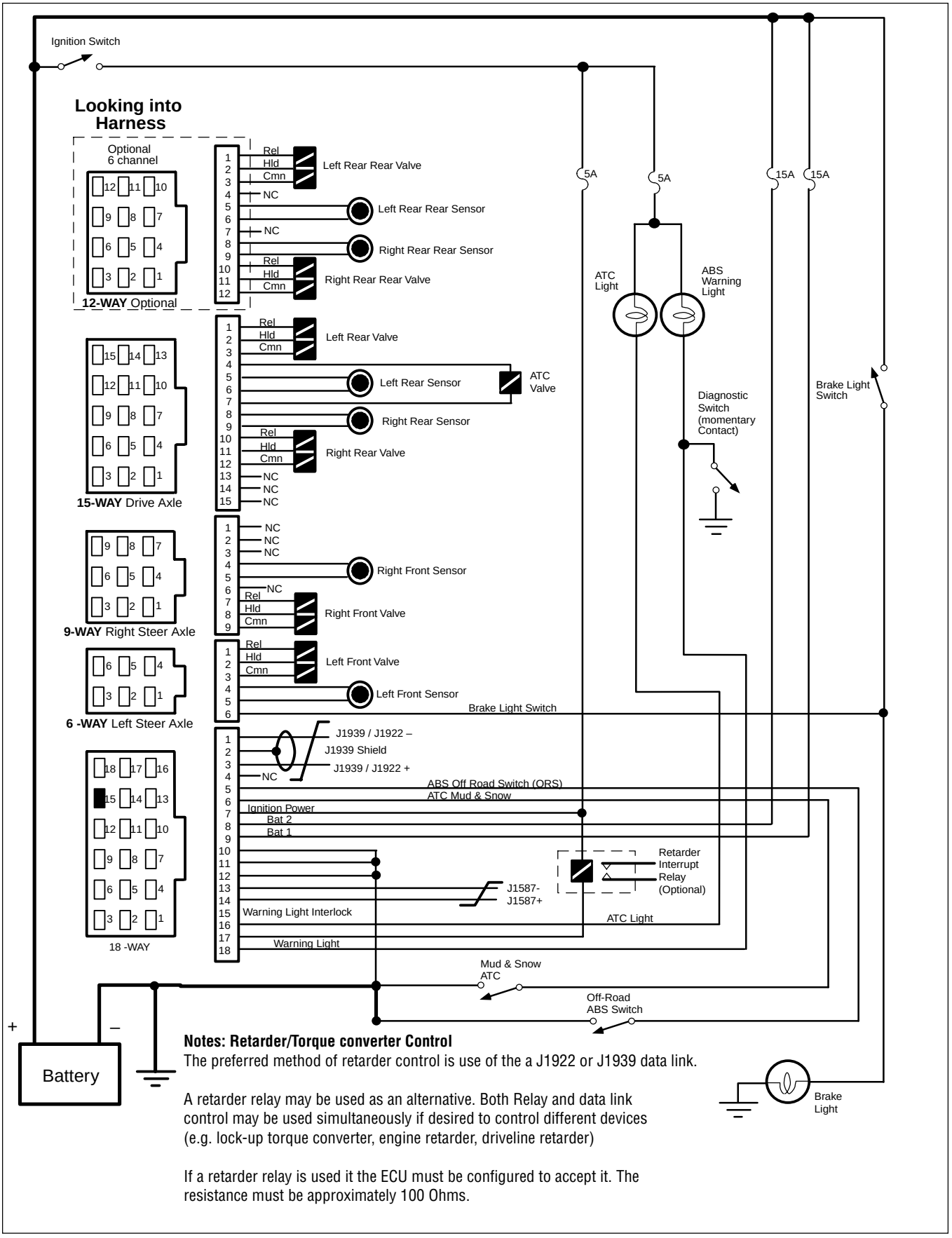


Figure 39. ABS Electrical Schematic

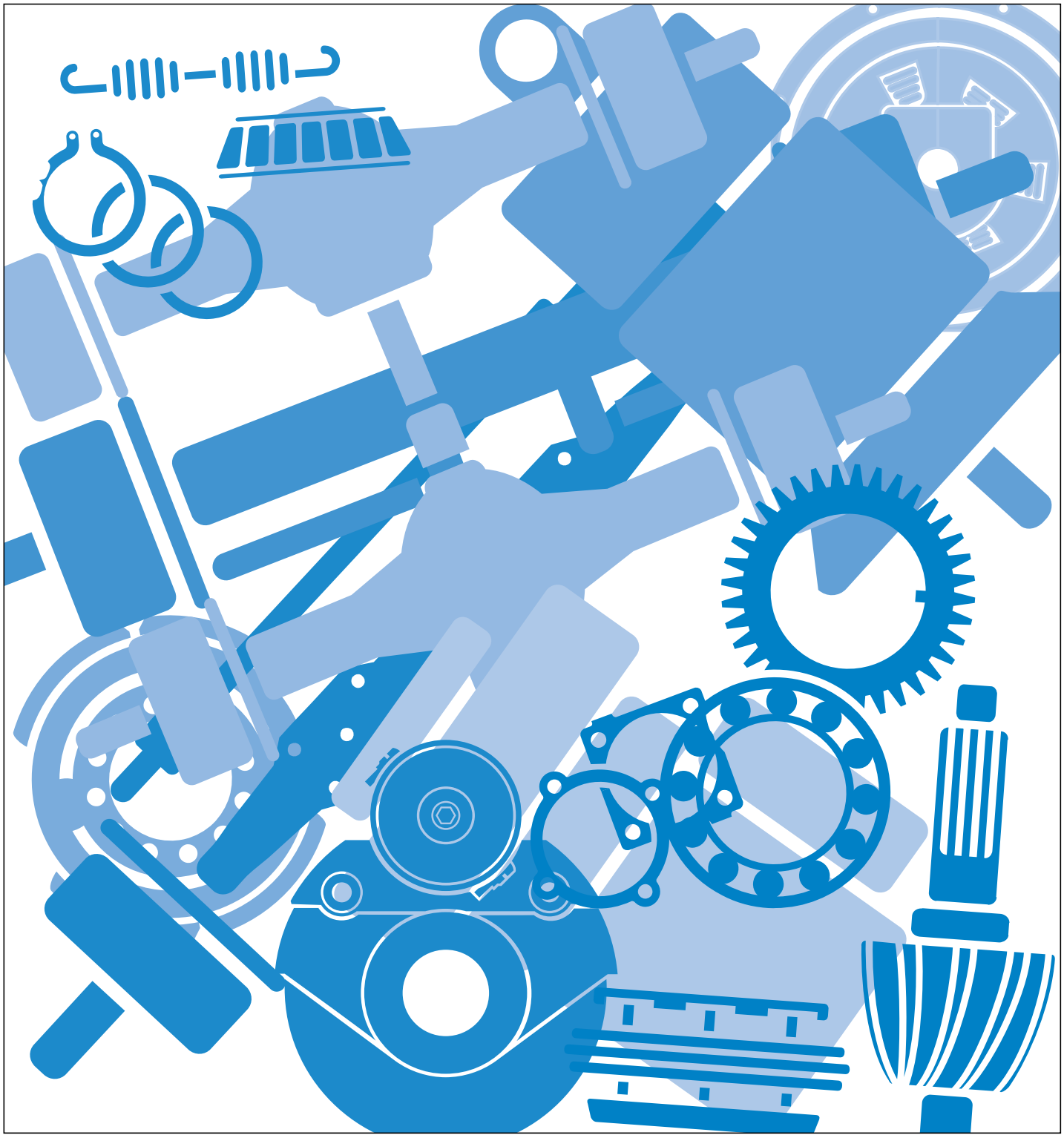
Glossary

ABS	Antilock Brake System.
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	With an initial service reservoir pressure of 100 PSI, the measurement in time from the movement of the service brake control for each brake chamber to reach 60 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 which indicates when traction control is operating.
Channel	A controlled wheel site.
CAN	Controller Area Network. The CAN link was originally developed as a venture between Robert Bosch and Intel. 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 hand-held testers. The tester can initiate test sequences, and can also read system parameters, J1587.
Diagnostic Switch	A switch used to activate blinks codes.
Differential Braking	Application of brake force to a spinning wheel so that torque can be applied to wheels which are not slipping.

Glossary

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.
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 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	A 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.
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 it 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.
Warning Light	An amber light which indicates the operating status of an antilock system. When the warning lamp is on, ABS is disabled and the vehicle reverts to normal brake operation.



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