



Service Data

SD-13-4757

Bendix® A-18™ Trailer ABS (Gen 4™ and Gen 5™ ABS)



FIGURE 1 - ABS Controller Assemblies

GEN 4™ AND GEN 5™ ABS INTRODUCTION

This manual describes the Bendix® A-18™ trailer ABS system and contains two primary sections:

- Installation
- Service

The Installation section provides the information required for the proper installation of a FMVSS-121 compliant trailer air brake systems that incorporate the Bendix Trailer ABS system and complementary trailer components.

The Service section of the manual includes the information necessary to properly maintain, troubleshoot and repair the A-18™ trailer ABS system.

Following the installation, service, and troubleshooting procedures contained in this manual will produce a high performance, long life, low maintenance antilock braking system.

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

Benefits of Trailer ABS

ABS-controlled trailer braking ensures optimum vehicle stability while minimizing the stopping distance. During vehicle operation, the trailer 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.
- Minimize tendencies for trailer swing out during hard braking conditions.

Document Revision Level

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

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Tractor and trailer ABS systems operate independently of each other. Therefore, systems will work together properly even if they are not supplied by the same manufacturer.

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 under the Eaton® Brand name. For more information, contact Bendix or refer to your local authorized Bendix dealer, or RoadRanger®.

Power Requirements for ABS

Since March 1998 the trailer wiring systems provide two sources of power for the antilock system.

The two power sources are:

1. Full-time power (when ignition is on) must be provided by the tractor. This full-time power source may be shared with other trailer circuits. The SAE J560 Blue (AUX) circuit is commonly used as the full-time power source. In other cases, a separate ISO3731 connector is provided.
2. Brake light power is provided as a secondary source of power in cases where an older tractor that does not provide full-time power is used to operate an ABS equipped trailer.

The industry requires that the tractor provide at least 10 amps at 12 volts at the trailer end of the SAE J560 or ISO cable on all ABS power circuits. These specifications meet TMC RP-137 and are consistent with SAE-2247.

There are no formal requirements. However, suppliers of Trailer ABS have agreed to provide for proper antilock brake operation down to a minimum of 8.5 volts (at which time the warning lamp will activate). A new TMC RP (Recommended Practice) is being developed which recommends that trailer manufacturers provide a 1.0 volt safety margin over the 8.5 volt minimum.

System current requirements will not exceed 0.5 amps per control unit and three amps per valve.

A-18™ trailer ABS system modulators have a nominal resistance of 5.5 ohms and require approximately two amps to operate. The control unit is designed to power warning lamps with a typical current of 300mA for trailer mounted warning lamps and 100mA for cab mounted warning lamps.

Trailer Mounted ABS Warning Light

Rules for the location, color, labeling, intensity and photometrics for external ABS warning lamps have been established by the National Highway Transportation Safety

Administration (NHTSA). These requirements were effective as of March 1, 1998.

Location

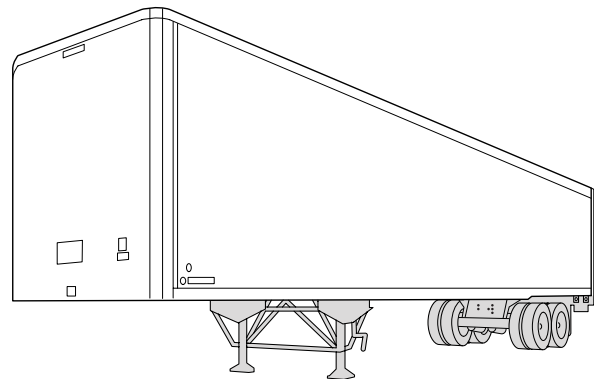
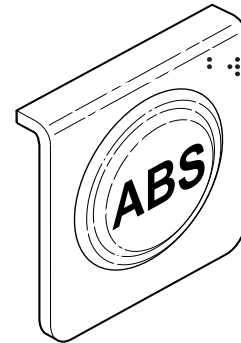
The lamp mounting location shall be near the left side rear of the trailer, no closer than 150 mm (5.9 inches) and not more than 600 mm (23.6 inches) from the rear red side marker indicator lamp. (Refer to Figure 22.) On a converter dolly, the lamp mounting location shall be on a permanent structure of the dolly at least 375 mm (14 inches) above the road surface.

Color and Labeling

The malfunction indicator lamp must be yellow in color and identified with the letters "ABS" to distinguish the lamp from other yellow side markers. The letters may be on the lens, on the lens housing, or on the trailer itself, near the lamp.

Intensity and Photometric Requirements

The external ABS malfunction indicator lamp must conform to SAE-J592 JUN92. Trailers shall use a combination clearance/side marker lamps marked with a "PC" or "P2". These lamps offer a widely diffused beam pattern throughout a full 180-degree left and right range.



General Air Brake Requirements

Basic design requirements for trailer air brake systems are set forth in FMVSS-121. FMVSS-121 covers requirements for new construction. Once put into operation, the trailer's brake systems must be maintained in accord with the following FHWA/OMC standards.

- FMCSR 393 - Covers required equipment
- FMCSR 396 - Covers inspection and repair

Air Timing Requirements

FMVSS-121 specifies the maximum times that are permitted for application and release of brake chamber pressure. Refer to Figure 2. ABS equipped trailers must meet the same air timing requirements as prior, non-ABS equipped trailers.

Reservoirs

Trailers must be equipped with air reservoirs that provide a volume of air eight times that of the service brake chambers.

For example: a type 30 air chamber has an effective surface area of 30 sq. in. For short stroke type 30 air chambers, the volume is typically 89 CID. For a typical two axle trailer, the minimum required volume is therefore 2848 CID.

Reservoir size requirements for non-ABS and ABS equipped systems are the same.

Air Consumption

During ABS activation there is a loss of reservoir pressure. There are no specific requirements limiting air consumption in the U.S. (In Europe Regulation R13 states specific limitations). ABS manufacturers take air consumption into account when developing and evaluating ABS control algorithms. There has been no need to change reservoir size requirements as a result of the ABS mandate.

Vehicle Classification	Application Time (seconds)		Release Time (seconds)	
	From pedal movement for chambers to reach 60 PSI	Pedal movement to reach 60 PSI at 50 cu. Res at gladhand	From pedal movement to reach 5 PSI (w/95 PSI initial chamber pressure)	From movement of the pedal until 50 cu. in. reservoir reaches 5 PSI (With 95 PSI initial chamber pressure)
Tractors, Trailers and Buses	.45	.35	.55	.75
Towing Trailer	.50	.50	1.00	1.00
Converter Dolly	.55	.55	1.10	1.10
Single Trailer	.60	—	1.20	—

Note: A 50 cubic inch reservoir is used to simulate the towed trailer volume at the gladhands of towing units.

FIGURE 2 - Air Timing Requirements Chart

Brake Priority Options

In prior years, there were requirements for a protected reservoir, separate from the main reservoir. The purpose of the protected reservoir was to hold off the spring brakes in the event of a failure of the service brake system.

In 1994, FMVSS-121 was revised to allow other approaches to reservoir management. The protected reservoir approach, although not required, is still acceptable. Conventional trailers are designed for either:

- Spring Brake Priority or
- Service Brake Priority.

Spring Brake Priority—The advantage of spring brake priority is that the parking brakes (spring brake) can be released quickly to permit moving the trailer at start up. However, spring brake priority systems have failure modes under which the parking brakes can be released and the vehicle operated without functional service brakes.

Service Brake Priority—The advantage of the service brake priority system is that it assures that the service brakes have adequate air pressure available to them before release of the spring brakes is allowed. However, service brake priority systems require more time to bring a vehicle up to operational level.

The Bendix® A-18™ trailer ABS system is compatible with both Spring Brake Priority and Service Brake Priority systems and does not require special installation procedures. A number of spring brake control valves are suitable for meeting current requirements. Bendix offers spring brake valves suitable for a range of applications.

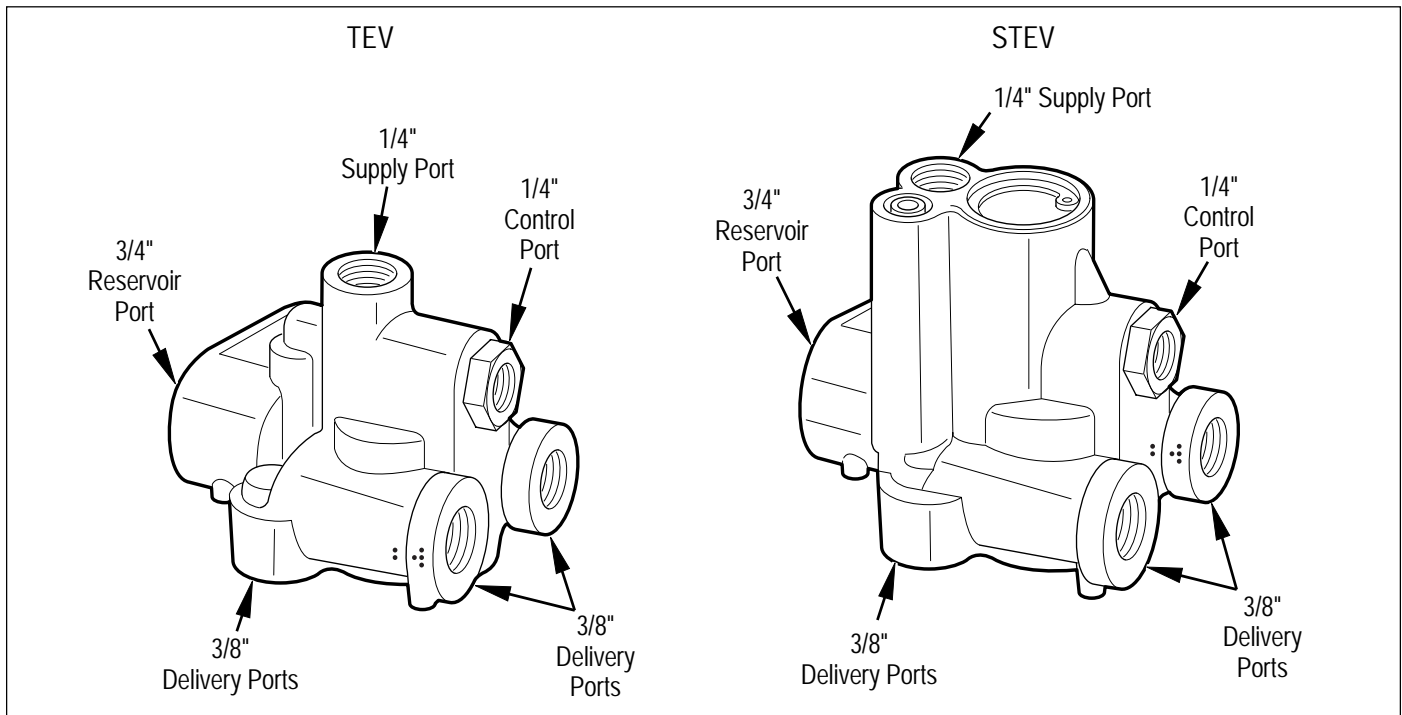


FIGURE 3 - Spring Brake Control Valves

ABS PERFORMANCE CHARACTERISTICS

Routine Braking

During routine braking operations, there is no indication of excessive wheel slip. The electronic control unit interprets this condition as normal and ABS remains inactive.

ABS Controlled Braking

The control unit continuously monitors all available wheel speed sensors. Data from the sensors is used to calculate values of wheel speed and wheel slip and to make a best estimate of the true vehicle speed. This data allows the control unit to detect impending wheel lock and to hold the wheel slip at an optimum value to maximize braking effectiveness. The best possible vehicle stability is assured while stopping distance is minimized.

Control is accomplished by operation of relay based modulator valves. The control unit makes a new assessment of conditions and updates the control signal to the modulator valves at a rate of approximately 100 times per second.

Under normal (non-ABS) conditions, trailer ABS relay valves operate exactly like conventional mechanical relay valves. (Refer to Figures 11 through 14.) 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 blocked 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 valve.

The antilock system 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. With ABS installed, vehicle operation is safer, resulting in improved protection of driver, cargo and equipment.

ABS Component Function

Figure 4 shows an overview of the operation of the Bendix® A-18™ trailer ABS system.

Speed sensors (1) monitor wheel rotation and provide information (2) on wheel rotation to the central electronic control unit.

The Electronic Control Unit (3) receives the sensor signal, interprets the pulse information, and constantly calculates the relationship of speed, acceleration, and deceleration. A control signal (4) is sent to the ABS relay valve (5), which then controls the pressure to the air chambers.

System Designs

When operating on high traction surfaces with a loaded vehicle, there is little difference between types of ABS control. Performance differences appear when vehicles are lightly loaded and operating on variable and poor traction surfaces. Examples of poor traction surfaces are ice and combinations of ice, snow and asphalt. Operating a vehicle in a curve highlights differences in stability between various systems.

ABS system designs provide compromises between stability and stopping distance while addressing cost, complexity and reliability issues.

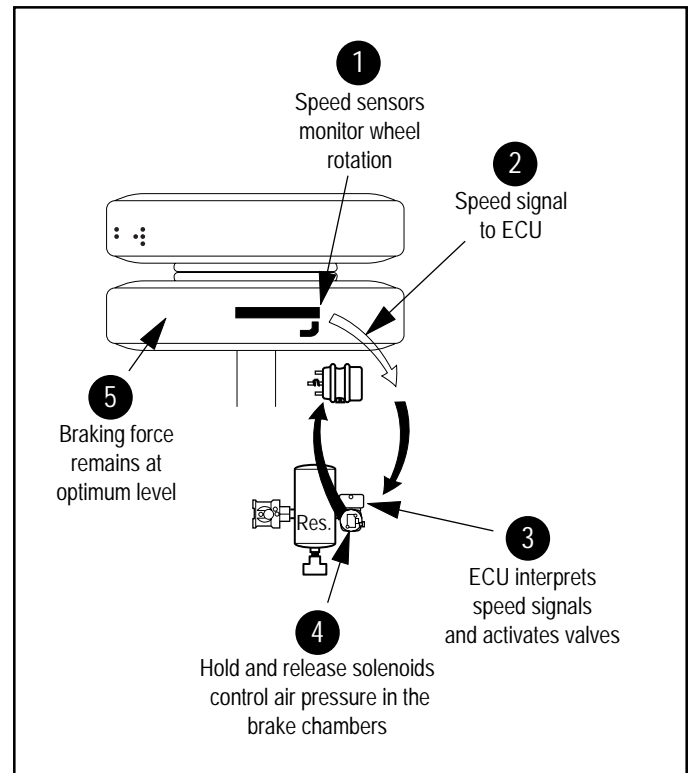


FIGURE 4 - Overview of Trailer ABS Operation

Independent Regulation

The most obvious control concept is independent wheel control. In this case a single sensor controls a valve that operates the brakes at one wheel site. Individual control makes the best trade off between stability and stopping distance. However, these systems have greater complexity and higher cost with potentially lower reliability than less complex systems. In many cases it is necessary to control a single valve with inputs from two sensors.

Select Low

Select low systems monitor several wheels and controls them with a single valve. Control is based on the wheel that is at the lowest speed. Select low systems are very stable but sacrifice stopping distance on split coefficient surfaces. Modified select low systems incorporate a delay before releasing to reduce the bias slightly away from the low speed wheel.

Select High

Select high systems also monitor several wheels and control them with a single valve. Control is based on the wheel which is at the highest speed. Modified select high systems activate a release before the low speed wheel becomes severely locked. Select high systems generally have good stopping distances at the expense of stability. These systems may also have an increased risk of tire flat spotting.

Select Smart

Select Smart systems operate as select low systems when there is little difference in traction between wheel control sites. They operate as select high systems when there is a significant difference in traction between sites. These systems offer many of the advantages of individual control systems while using a simpler design and fewer components.

Bendix® A-18™ Trailer ABS Control Strategy

Select Smart is used for the most common applications. Select low is used on the standard system 4S/2M Axle Control configuration and is available as an option on the basic system.

TRAILER ABS CONFIGURATIONS

Application Recommendations

Refer to the chart on page 8 to determine a recommended ABS installation for your application.

Basic System (2S/1M)

The basic system includes two speed sensors and one modulator valve for direct control of one axle and indirect control of an additional axle. Other features of the basic system include one ECU connector and a single-pin diagnostic lead.

Standard System (2S/1M, 2S/2M and 4S/2M)

Bendix's standard systems offer either two or four speed sensors and up to two modulator valves. Standard systems can directly control one or two axles and allow full diagnostics via J1587. The standard system may be configured in one of four ways to function as follows:

- 2S/1M—This configuration uses two sensors and one modulator valve to directly control one axle and indirectly control an additional axle.
- 2S/2M—This configuration uses two speed sensors and two modulator valves for direct control of one axle and indirect control of up to three additional axles.
- 4S/2M—This configuration uses four speed sensors and two modulator valves for direct control of two axles and indirect control of up to two additional axles.
- 4S/2M Axle Control—Special configuration for full trailers and widely spaced axles. This configuration uses the select low strategy.

Sensor Placement

When more than one wheel is controlled by a single valve, sensors should be mounted at the axle which tends to lock first. For spring suspensions this is usually the forward axle. For air suspensions this is usually the rear most axle.

Lift Axles

- Gen-4™ ABS: Sensor inputs "C" and "D" of the control unit may be used for lift axle wheel speed sensing.
- Gen-5™ ABS: Direct lift axle control is not available. Use indirect control.

Reading Configuration Codes

On Basic systems, the jumper method must be used to access the configuration. On Standard systems, access to configuration information can be achieved by any of the three methods:

- ServiceRanger diagnostic software on a PC
- Hand-held tester
- Jumper method.

For more information on accessing configuration codes, refer to Accessing Codes on page 30.













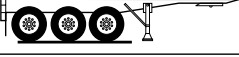







System Application Chart					
Trailer Type		2S/1M	2S/2M	4S/2M Side Control	4S/2M Axle Control
Semi Trailer or 1st Trailer		(1)	or (1)		
		(1)	or (1)	or (1)	
				(1)	or (1)
			(1)	or (1)	
				(1)	
			(1)		
			(2)	or (2)	
			(2)	or (2)	
			(2)	or (2)	
		(2)	and (1)	or (2)	or (2)
		(2)	and (1)		
1st 2nd or 3rd Trailer			(1)	or (1)	
			(1)	or (1)	
		(1)	or (1)	or (1)	
		(1)	or (1)		
				(1)	or (1)
			(2)	or (2)	
Trailer Dolly		(1)			
		(1)			
			(1)		

FIGURE 5 - System Application Chart

Trailer ABS Component Overview

Bendix® A-18™ trailer ABS system includes the following components:

- **Electronic Control Unit (ECU):** The ECU monitors wheel speeds and controls the trailer ABS valves. It also diagnoses ABS malfunctions and stores failure-specific fault codes. The ECU is usually attached to a relay valve with a mounting bracket. The ECU may also be directly frame mounted. One ECU can monitor either two or four speed sensors and control either one or two relay valves. If necessary more than one ECU may be used on a single trailer.
- **Relay Valve:** This component regulates brake chamber air pressure. It houses the hold and release solenoids. Each relay valve can control either two or four brake chambers on an ABS equipped trailer. A relay valve can have the ECU mounted to it (valve A in the installation diagrams) or be a stand alone relay valve (valve B in the installation diagrams) that is controlled remotely by the ECU mounted on valve A.
- **Trailer Mounted ABS Warning Lamp:** This indicator lamp, located on the “Road Side” near the rear of the trailer, warns the driver of ABS malfunctions (steady “ON”). It is also capable of blinking diagnostic fault codes.
- **Cab Mounted ABS Warning Lamp:** This indicator lamp, located on the driver instrument panel, also warns the driver of ABS malfunctions. It is not capable of blinking diagnostic fault codes.
- **Wheel End Speed Sensor and Tone Wheel:** Single point variable reluctance (magnetic) sensor that generates an alternating current signal in response to the movement of teeth on a tone wheel. The signal is interpreted by the ECU to monitor wheel speed.
- **Diagnostic Port Connector:** The diagnostic port connector is an industry standard connector which is used to provide a connection to the J1587 diagnostic link. This connector also provides power and ground for diagnostic test equipment.
- **Gladhand:** The gladhands used on the ABS system are the same as those used on non-ABS trailers.
- **Seven Way Main Electrical Connector:** The seven way receptacle is the same as those used on non-ABS systems. This receptacle provides full-time power, backup power via the brake light switch and ground for the ABS electrical system.
- **Optional ISO 3731 connector:** This is a 7-pin connector similar to the J560 connector. The most noticeable difference is that the ground terminal has a gender opposite that of the other terminals. The primary use for ISO 3731 is for the lighting connections on European trailers. However, this connector is used to provide interface to trailer ABS in some U.S. applications. (In Europe another connector designated as ISO 7638 is used to provide interface to the trailer braking system.)

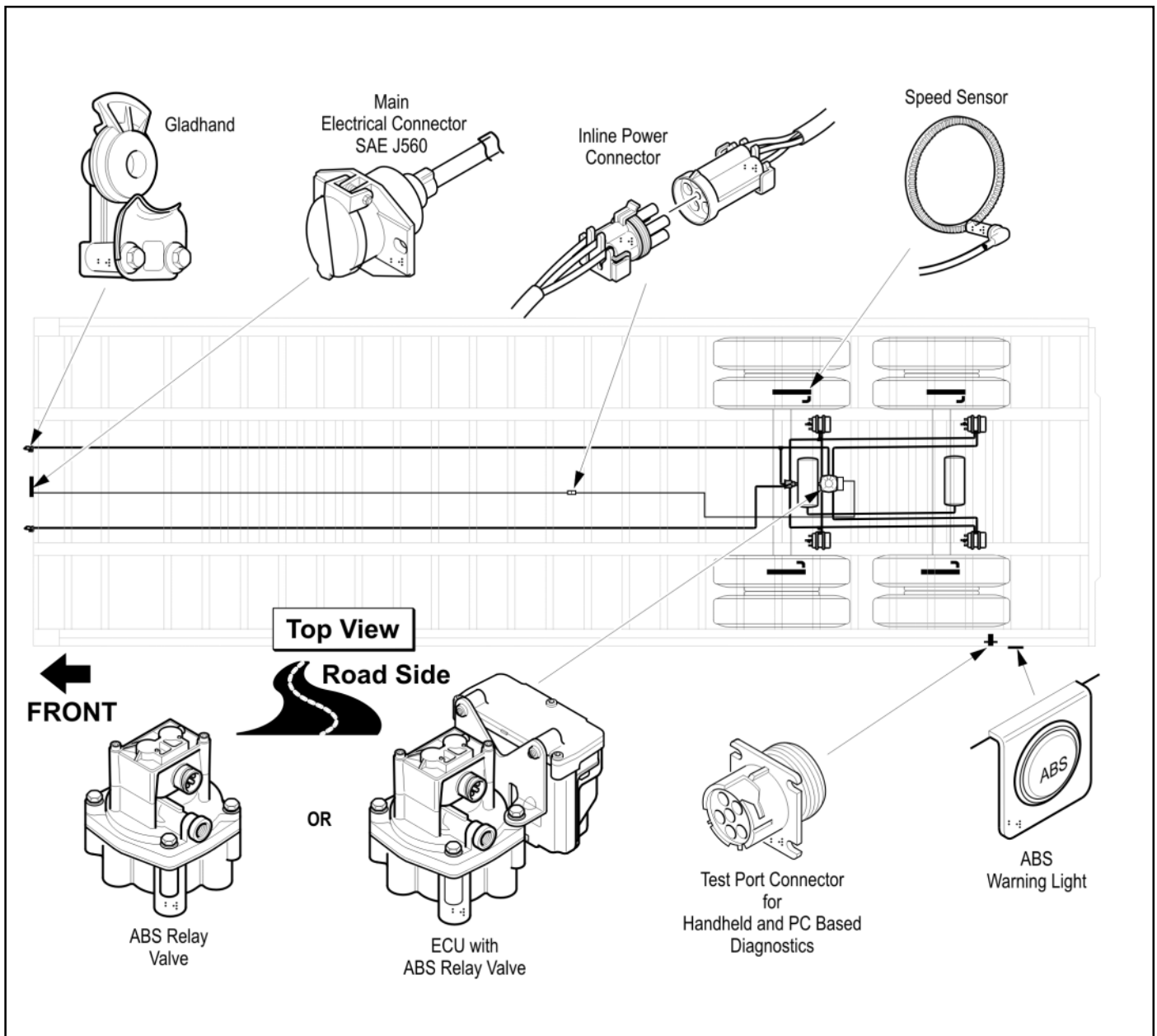


FIGURE 6 - ABS Trailer Components

Electronic Control Unit (ECU)

The Bendix® A-18™ ECU is the trailer ABS control center.

Identification

Identification information for the ECU is located on the connector pinout label (refer to Figure 7). The label is located under the ECU cover. Refer to the label for the:

- Part Number
- Serial Number
- Date Code.

Depending on configuration, the A-18™ trailer ABS system ECUs may be equipped with either one connector (basic system) or two connectors (standard system). Refer to Figure 8.

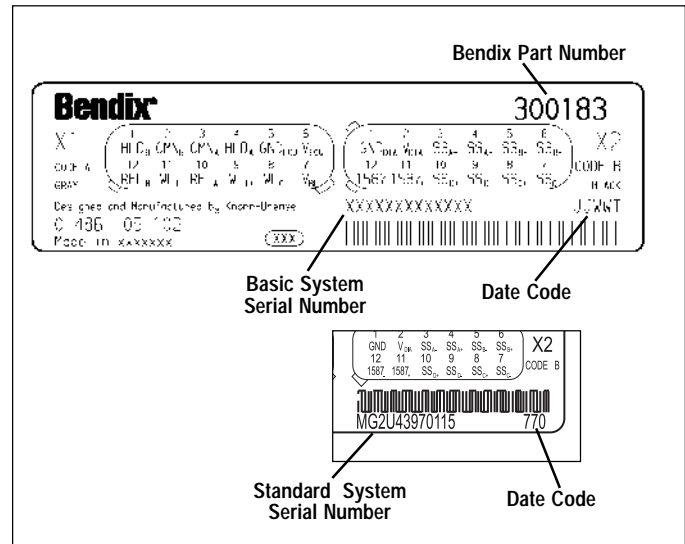


FIGURE 7 - Electronic Control Unit Identification Tags

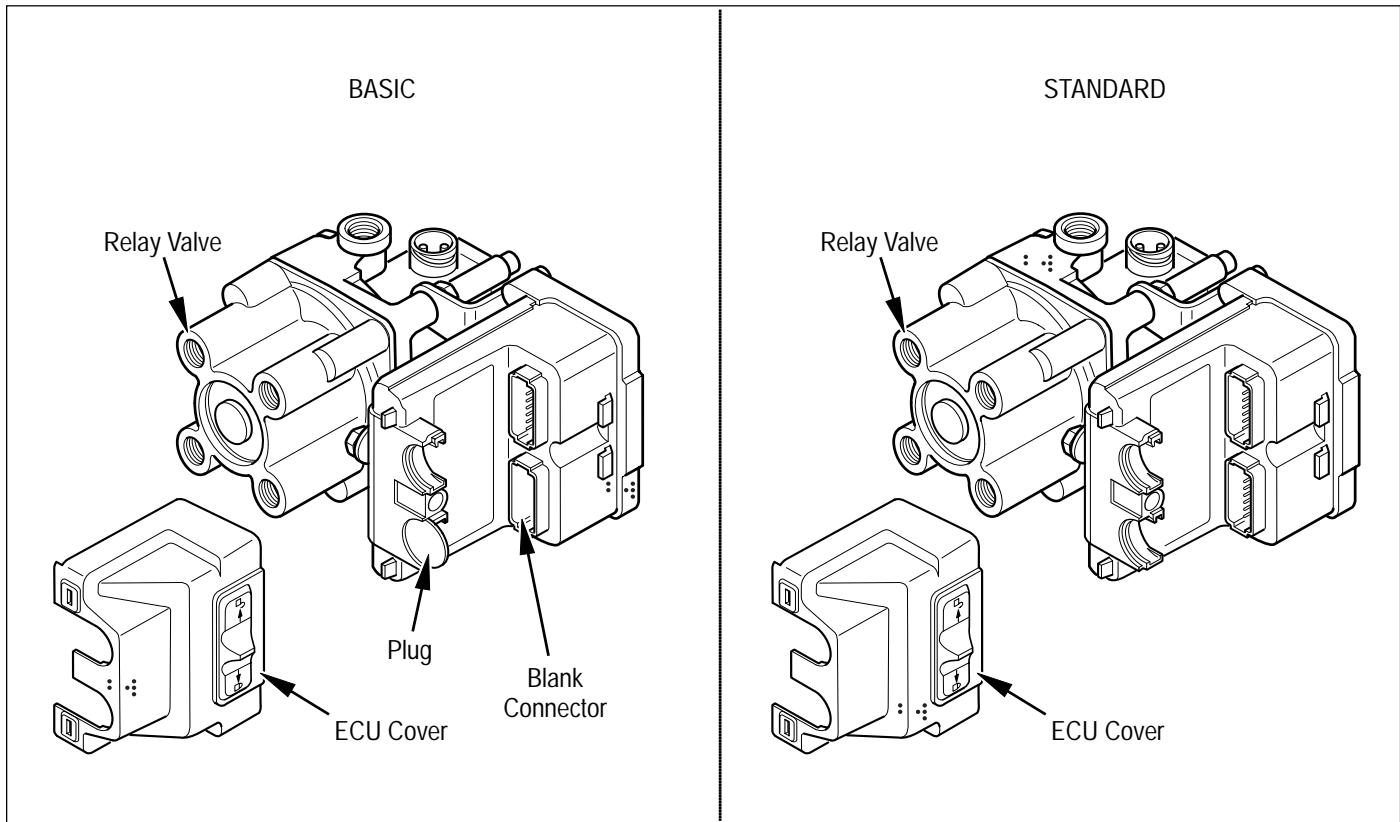


FIGURE 8 - Trailer ABS ECU Configurations

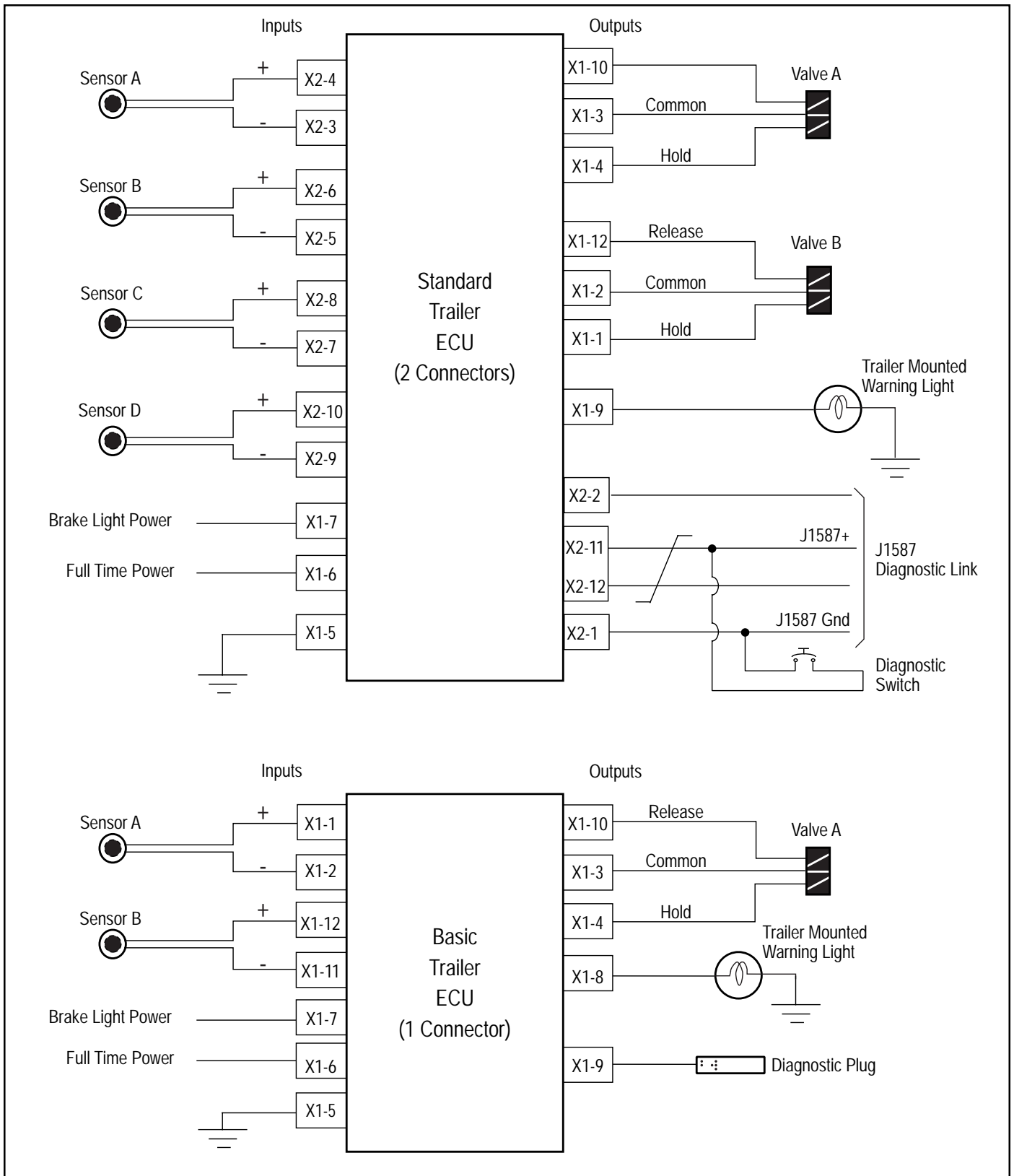


FIGURE 9 - Standard and Basic ECU Block Diagrams

Relay Valve

The trailer ABS relay valve controls air pressure to individual brake assemblies, and functions as a standard relay valve when there are no ABS control signals. Depending on the particular ABS configuration, a system may utilize one or two relay valves. See Figure 10.

Each relay 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 the relay valve(s) for air hold and release by activating the appropriate solenoid.

Each relay valve has a three-pin terminal for connection to the Electronic Control Unit.

Delivery Ports

Both 2-port and 4-port versions of the relay valve are available. These are all tapped for 3/8 NPT fittings.

Crack Pressure

Standard valves are available with 4.0 PSI \pm 0.5 PSI crack pressure. Other crack pressures can be provided. For example, 6.0 PSI valves may be used with wedge brakes.

Bracket, Valve, ECU combinations

Various combinations of mounting brackets, ECUs and valves are available preassembled to facilitate system installation on a variety of vehicles. Refer to the Bendix® A-18™ trailer ABS Illustrated Parts List for further information.

Port Orientation

If necessary, the control and supply ports of the valve can be reoriented with respect to each other. Remove the four assembly bolts. Rotate top with respect to bottom as required. Use care to maintain cleanliness of valve interior. Retorque bolts to 10.0 lb-ft (13.6 N•m). Do not exceed 12.0 lb-ft (16.3 N•m).

Pipe Fitting Torques

Refer to the following torque specifications when installing pipe nipples. Torques are for NPT threads with thread sealant applied. Do not use thread tape. Contamination by thread tape can cause component failure.

Tighten pipe nipples as follows:

- With Thread Sealant - Finger tight plus 1 1/2 turns
- Without Thread Sealant - Finger tight plus 2 turns

Clamping

A fixture may be necessary to hold the relay valve when reorienting ports or when attaching fittings. If a vise is used, there is a potential danger of distorting the barrel and piston within the valve rendering the valve inoperative. It is recommended that a fixture be used that avoids the potential for stressing the valve.

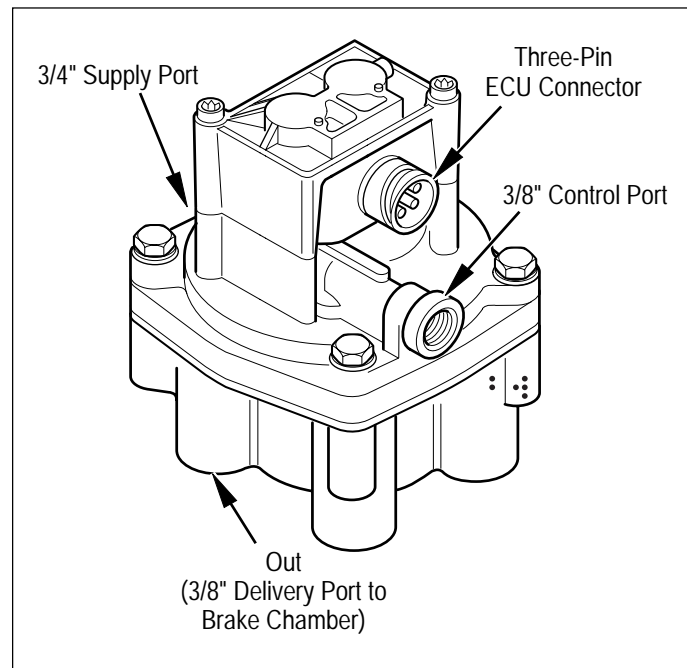


Figure 10 - Relay Valve

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.

Relay Valve Operation Modes

1. **Apply**—Treadle pressure is applied to the top of the piston. The sleeve is depressed until the outlet pressure matches the pressure at the top of the piston.
2. **Normal Release**—Pressure at the top of the piston is vented through the treadle valve. The sleeve rises to block the inlet while allowing the chamber air to exhaust through the center of the sleeve.
3. **ABS Hold**—Hold solenoid blocks treadle pressure. The piston stabilizes, holding the chamber pressure at the same level as that which is above the piston.
4. **ABS Release**—The release solenoid vents air at the top of the piston while blocking treadle pressure. The sleeve rises to block the inlet while allowing the chamber air to exhaust through the center of the sleeve.

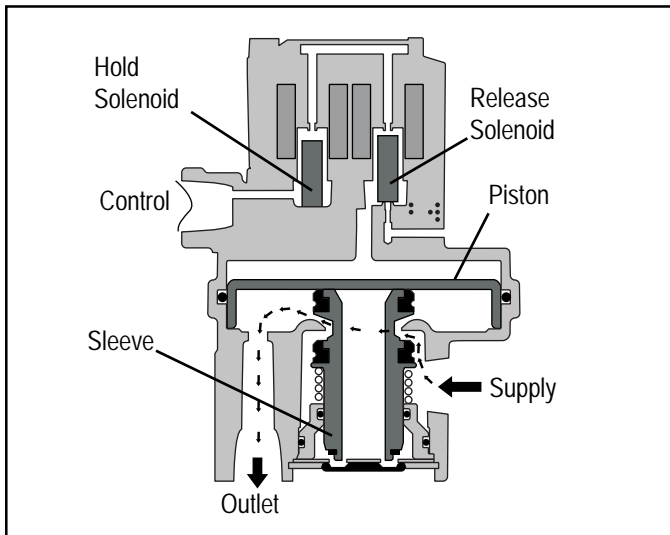


FIGURE 11 - Normal Apply and ABS Apply

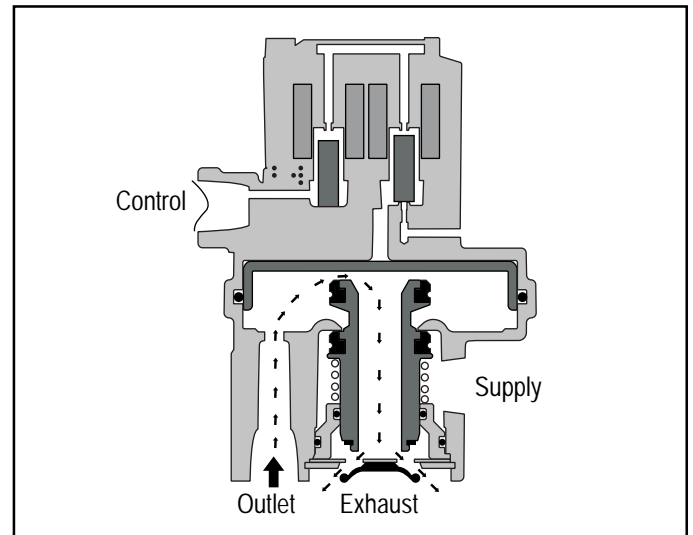


FIGURE 12 - Normal Release

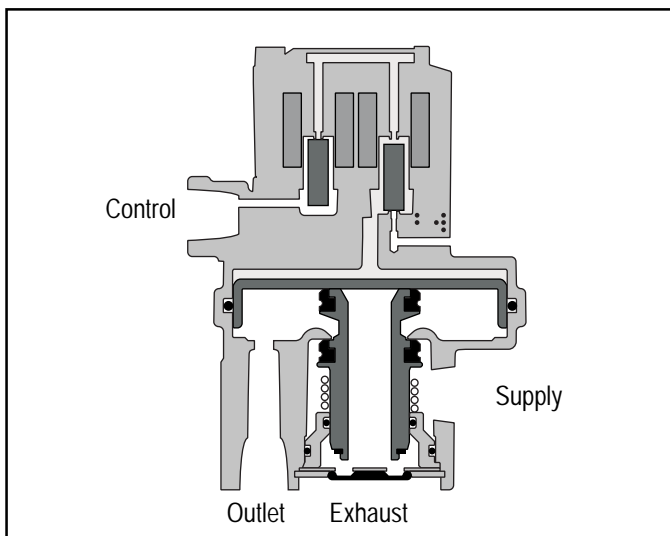


FIGURE 13 - ABS Hold

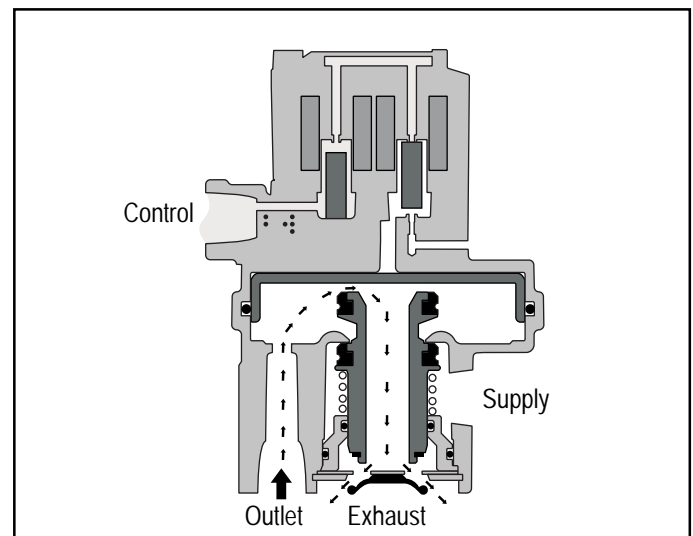


FIGURE 14 - ABS Release

Installation

Installation of the Bendix® A-18™ trailer ABS system is similar from one configuration to another. All systems use the same speed sensors and valves. The differences are in placement and quantity and the type of ECU, either standard or basic. Refer to the following general component instructions and to the wiring and plumbing diagrams for specific system configuration.

Suggested Order Of Installation

Following is a suggested order of installation of the A-18™ trailer ABS.

1. Install Wheel Speed Sensors (often part of a dressed axle).
2. Install Relay Valve(s)/ECU assembly.
3. Install the Power Cable, but do not apply power until the installation is complete.
4. Route and connect the main ABS Harness.
5. Install the Diagnostic Port Connector.
6. Install the trailer-mounted ABS Warning Lamp.
7. Perform the End-of-Line Checkout.

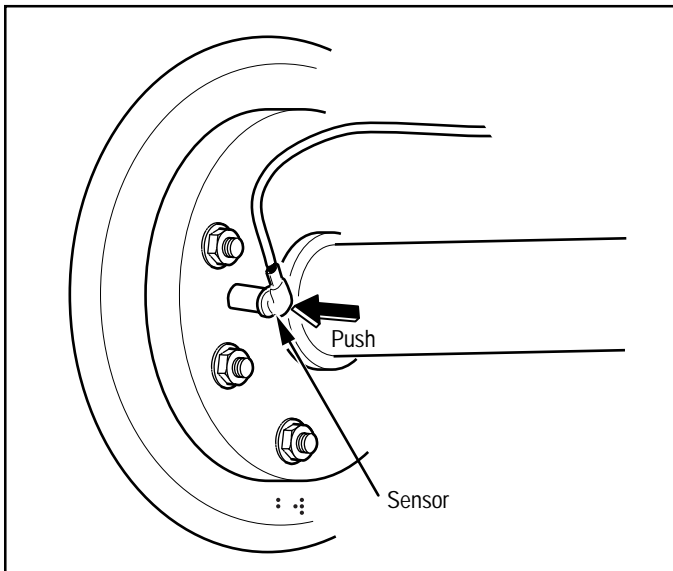


FIGURE 15 - Speed Sensor Installation

Install the Wheel Speed Sensors and Sensor Friction Sleeves

Refer to the appropriate diagram for your system and locate the wheel speed sensors. Refer to Figures 23-26.

1. Install the sensor friction sleeve 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 friction sleeve by hand until it stops against the tone ring. The speed sensor is properly installed and adjusted when it is touching the tone ring. Allowable TIR for the tone ring is 0.008 inches.

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

4. Route the cable to the frame. Use tie wraps as required to restrain cable. *Use care not to stress sensor cables.*
5. Connect sensor cable to harness and install fasteners to hold the sensor cable in position.

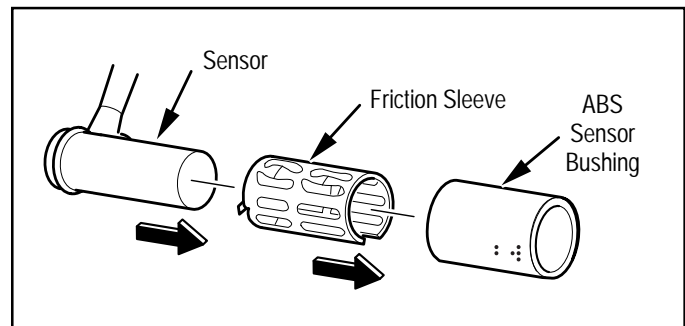


FIGURE 16 - Wheel Speed Sensor Components

Install the ECU/Relay Valve and Stand Alone Relay Valve

In all installations, the ECU/Relay Valve assembly appears as Relay Valve "A" in the diagrams. The Stand Alone Relay Valve is identical to the ECU/Relay Valve except it does not have the ECU and ECU mounting bracket. The relay valves may be installed on the reservoirs or a frame member.

The Stand Alone Relay Valve is the second relay valve in systems with two relay valves and is labeled Relay Valve "B" in the diagrams.

Pipe Fitting Torques

Refer to the following torque specifications when installing pipe nipples. Torques are for NPT threads with thread sealant applied. Do not use thread tape. Contamination by thread tape can cause component failure.

Tighten pipe nipples as follows:

- With Thread Sealant - Finger tight plus 1 1/2 turns
- Without Thread Sealant - Finger tight plus 2 turns

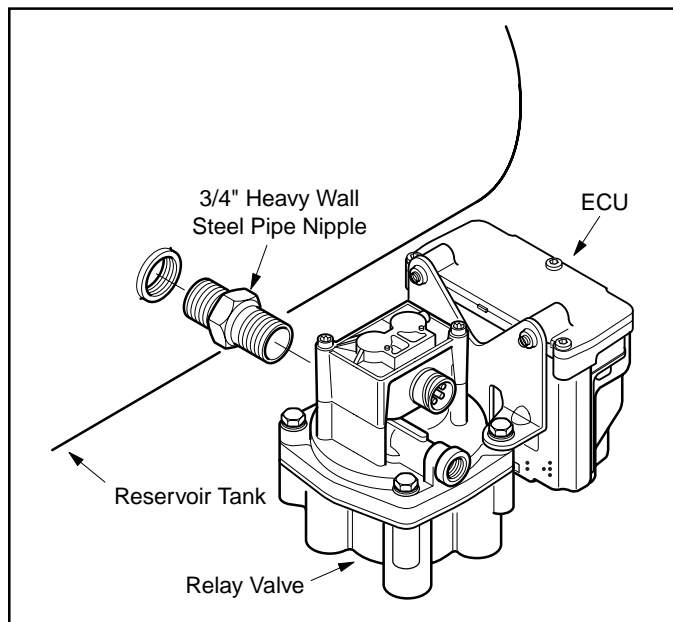


FIGURE 17- Tank Mounted ECU/Relay Valve

Leak and Performance Test

1. Park vehicle on level surface and block wheels.
2. Make and hold brake application. No audible air leaks are permitted.
3. Release parking brake and fully charge the air system (governor cut out point).
4. Turn engine OFF. Apply the service brake several times, then hold and check for prompt brake air chamber application and release at all wheels.
5. Apply brake, then hold. Coat outside of relay valve with a soap solution. No leakage is permitted.

NOTE: 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 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.

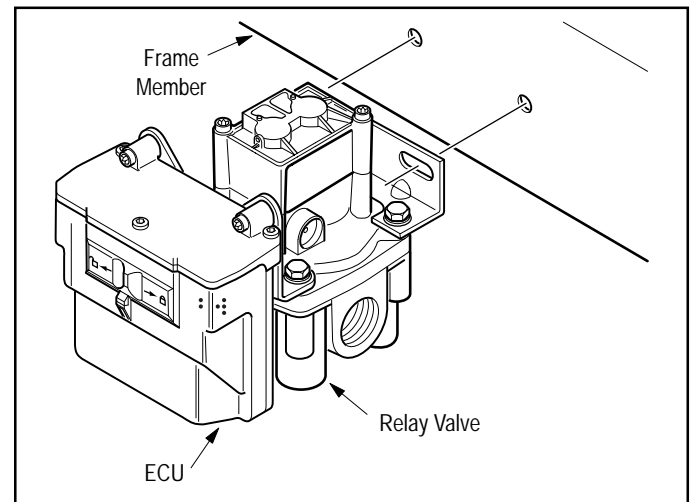


FIGURE 18 - Frame Mounted Relay Valve

Install the Inline Power Connector

The inline power connector is on the end of the main ABS harness and connects the ABS system to the trailer electrical system.

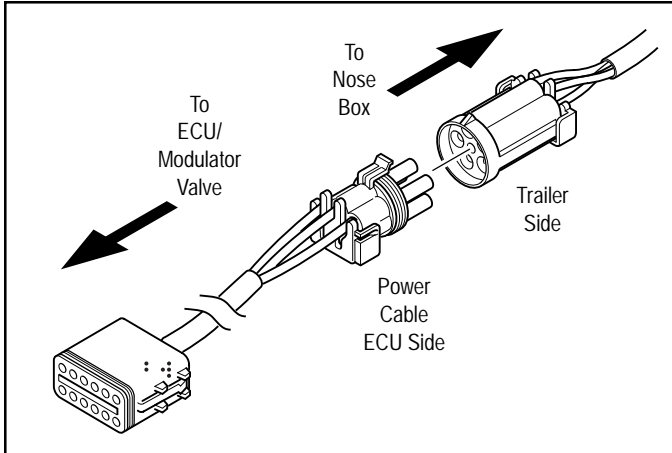


FIGURE 19 - Inline Power Connector

Install the Main ABS Harness

1. Remove power from the trailer.
2. Unlock the ECU cover and remove.
3. Install the ECU connectors as follows:

Standard: Plug the grey harness connector into the ECU connector labeled "X1". The connector is keyed and can only fit in one direction. Plug the black harness connector into the ECU connector labeled "X2". This connector is also keyed.

Basic: Plug the green harness connector into the ECU connector labeled "X1". This connector is also keyed and is the only connector on the ECU.

4. Install the ECU cover by first engaging the alignment tabs and then hinging the cover closed, ensuring that the convoluted tubing is captured in the strain relief slots. Slide the cover lock to the locked position. An optional tie wrap may be used to lock the cover in place.
5. Route harness to designated locations. Make sure that the harness is properly routed and secured to prevent damage to the harness.

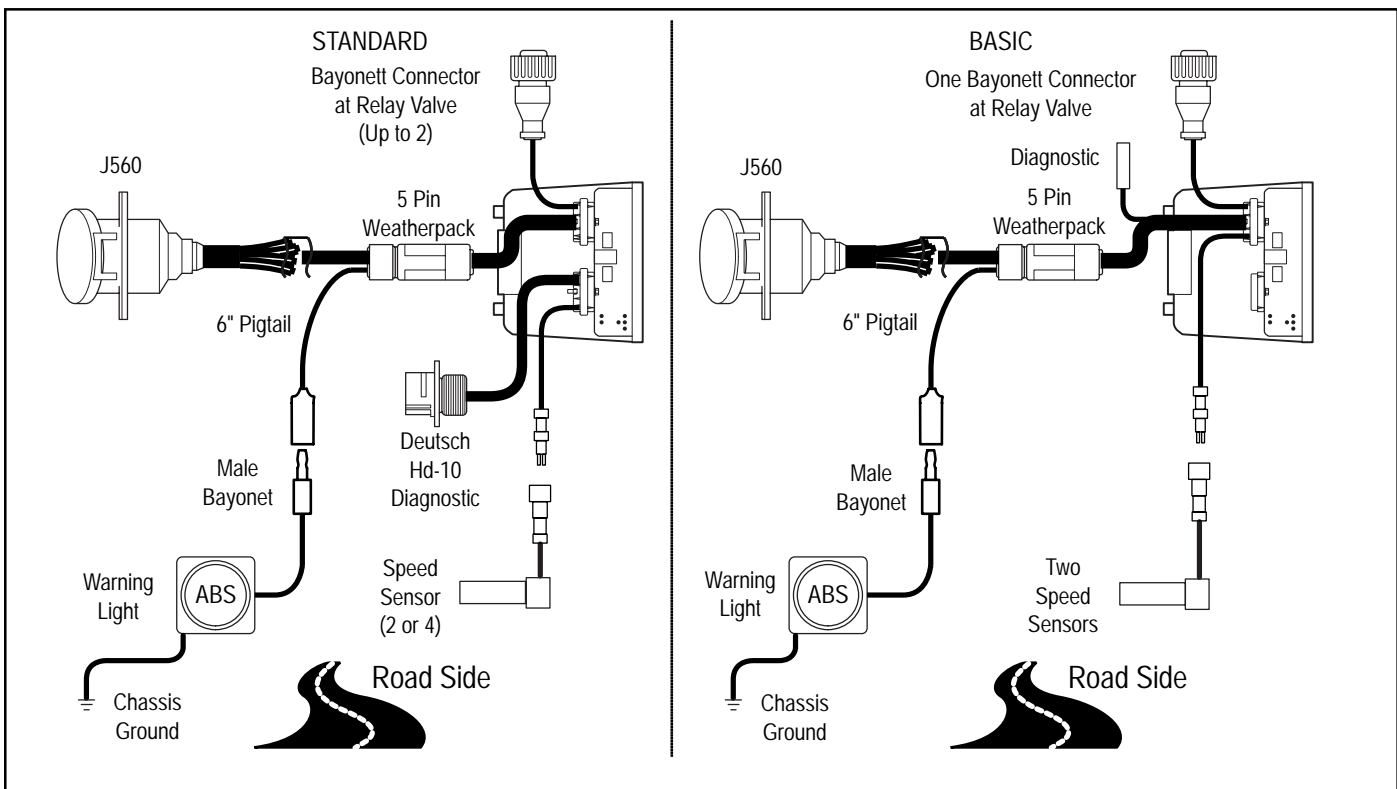


FIGURE 20 - Standard and Basic ABS Harnesses

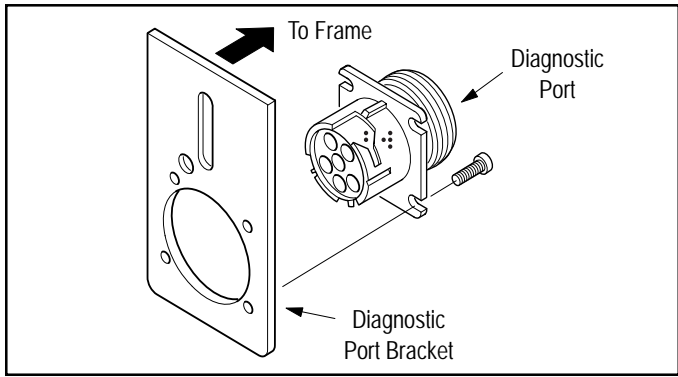


FIGURE 21 - Diagnostic Port Installation (Standard)

Install the Diagnostic Port (Standard System)

On standard systems, the diagnostic port is installed on the road side of the trailer, on the frame forward of the trailer axle(s). To install the diagnostics port, bolt or weld the diagnostic port bracket to the trailer frame.

Install the Trailer Mounted Warning Light

The warning light is mounted on the road side of the trailer, forward of the marker light according to the following drawing.

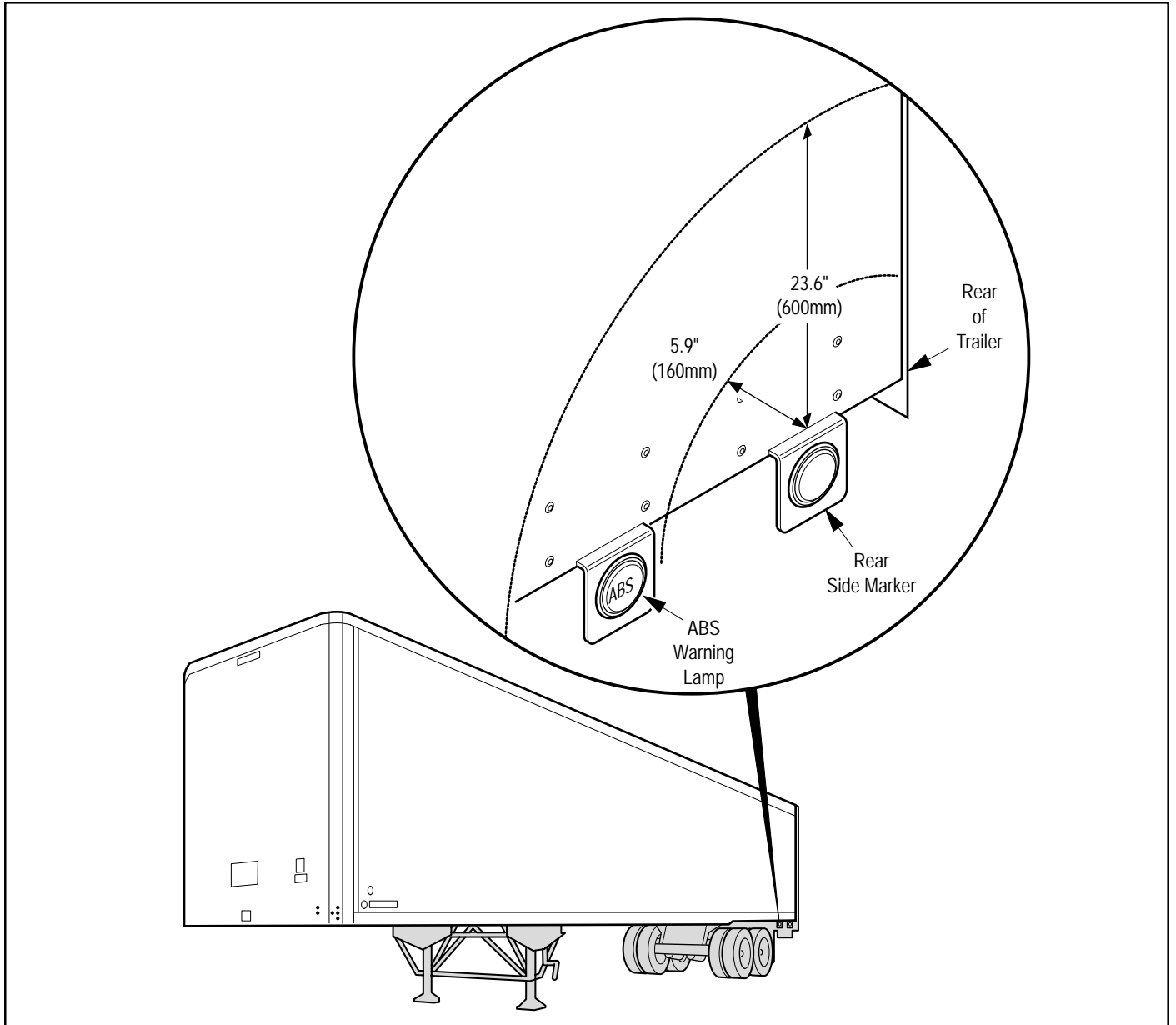
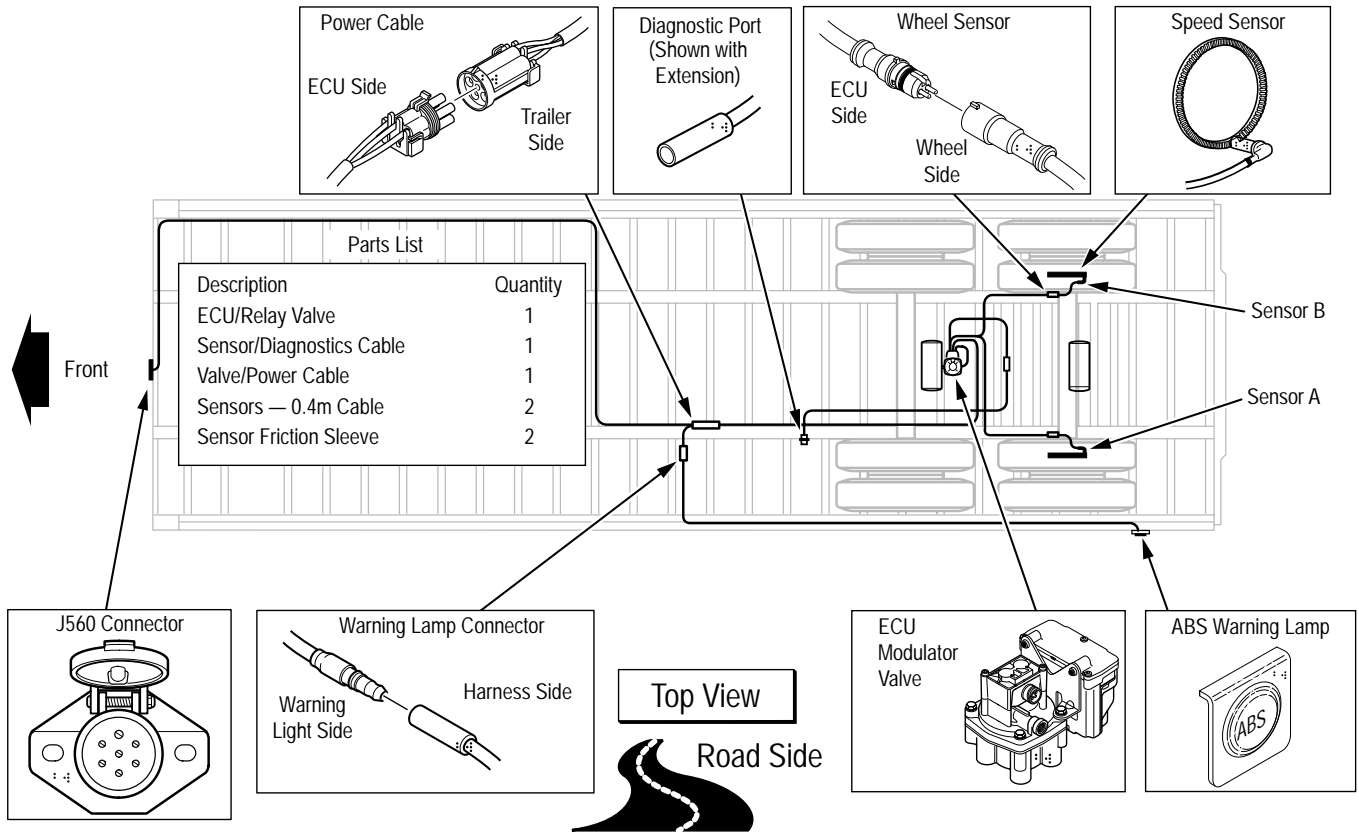


FIGURE 22 - Warning Light Location

2S-1M Electrical Configuration (Top View)



2S-1M Air System Configuration (Top View)

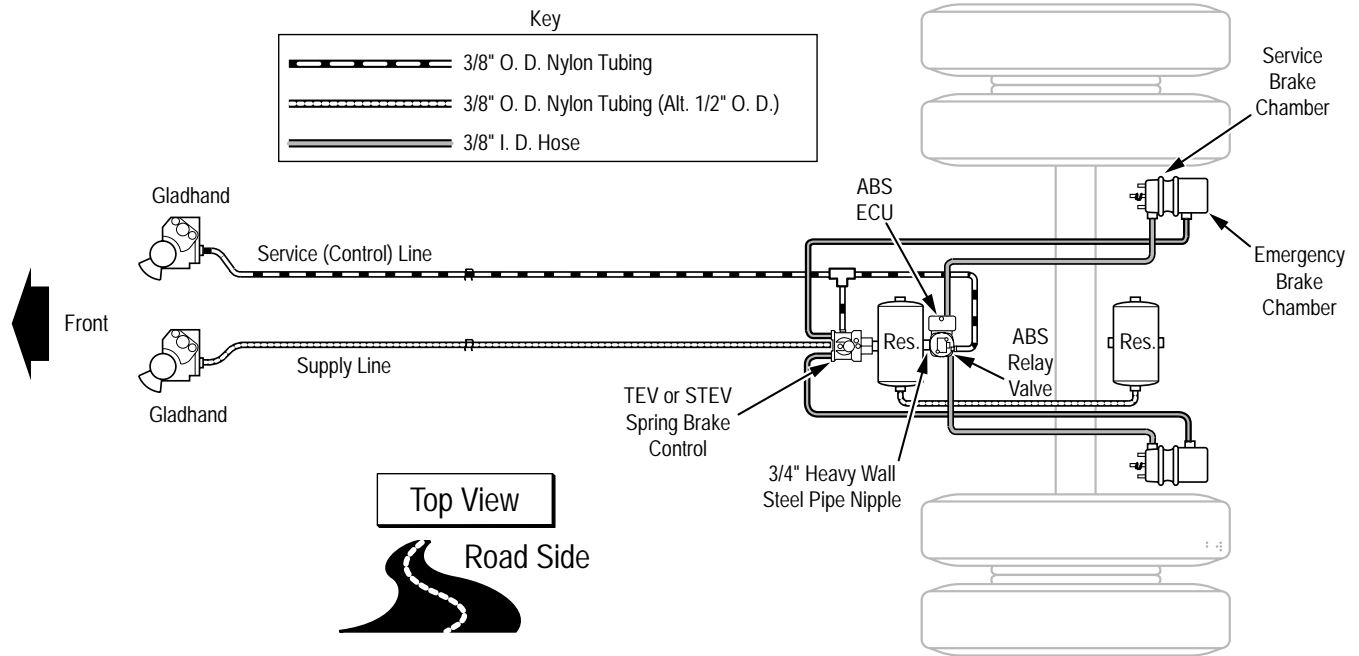
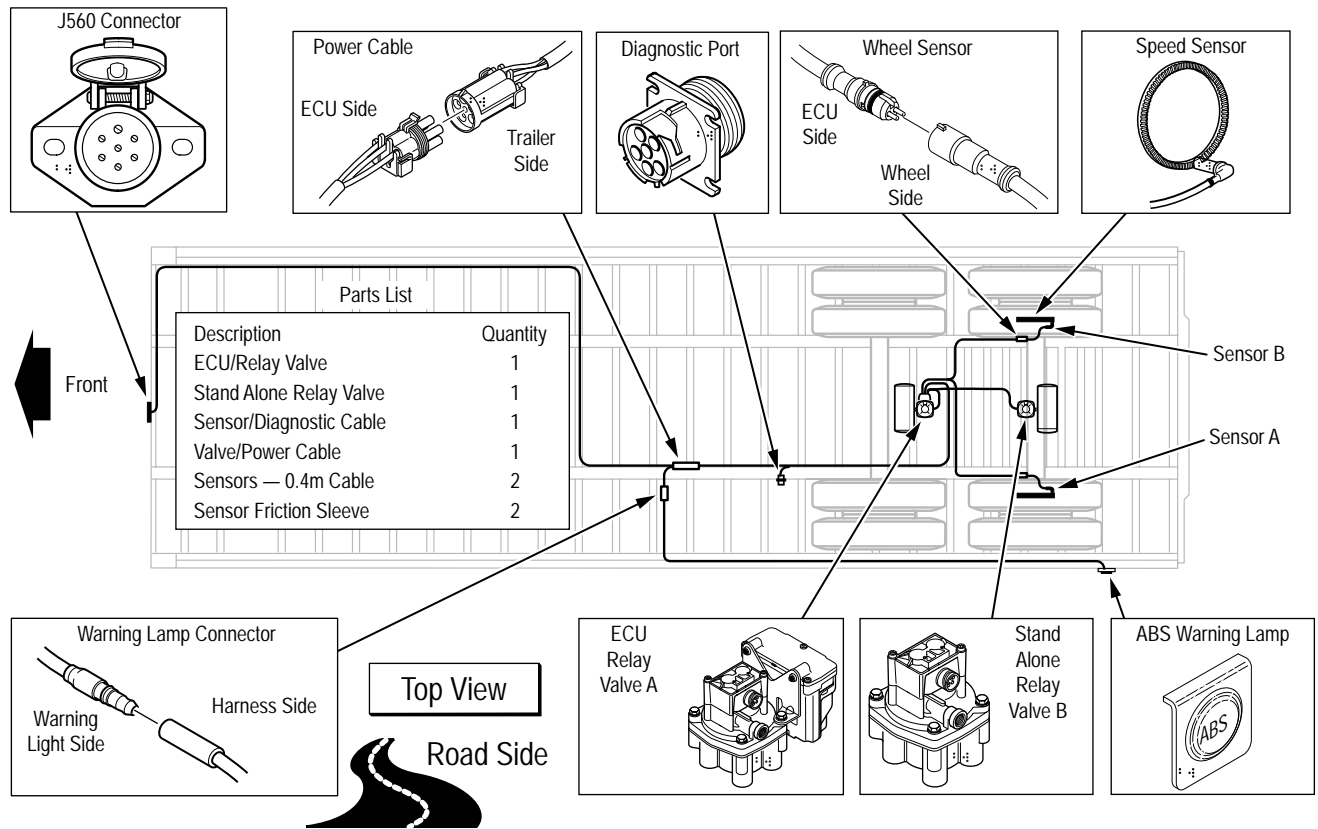


FIGURE 23 - Typical 2S-1M ABS Electrical and Air System

2S-2M Electrical Configuration (Top View)



2S-2M Air System Configuration (Top View)

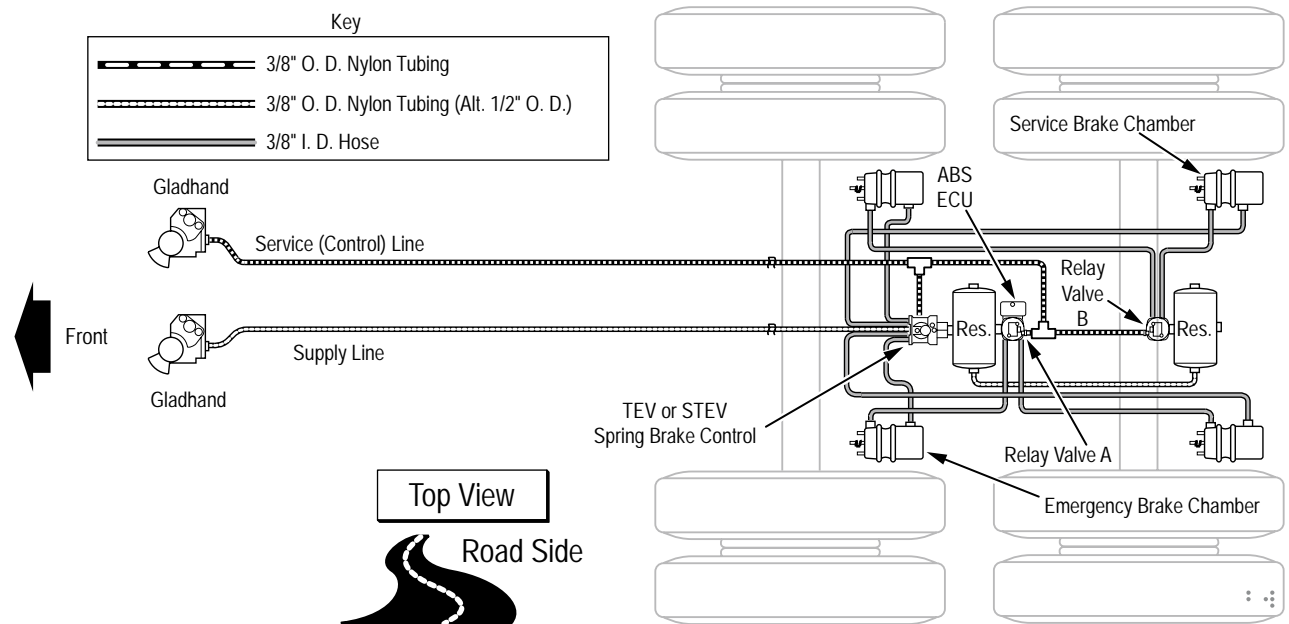
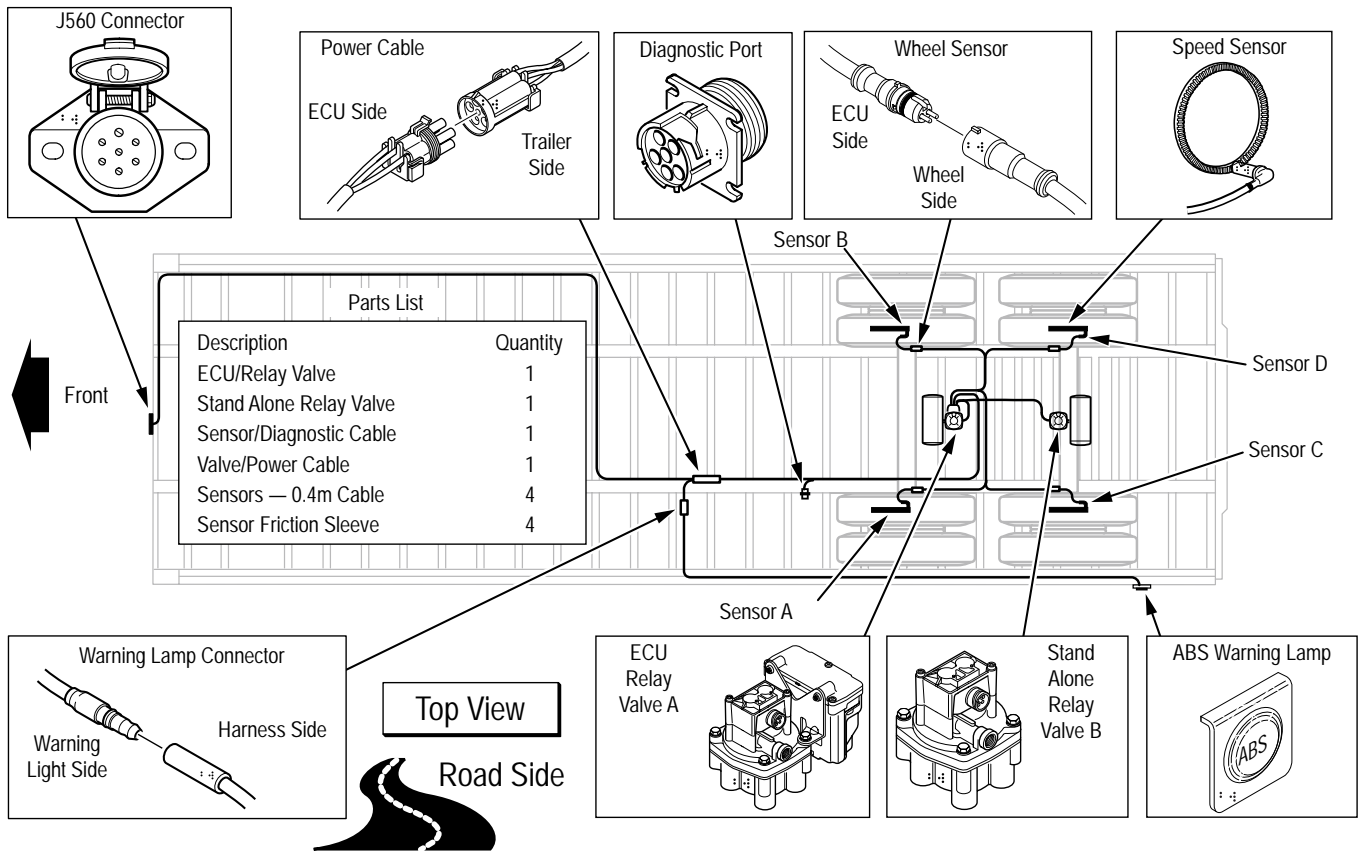


FIGURE 24 - Typical 2S-2M ABS Electrical and Air System

4S-2M Side Control Electrical Configuration (Top View)



4S-2M Side Control Air System Configuration (Top View)

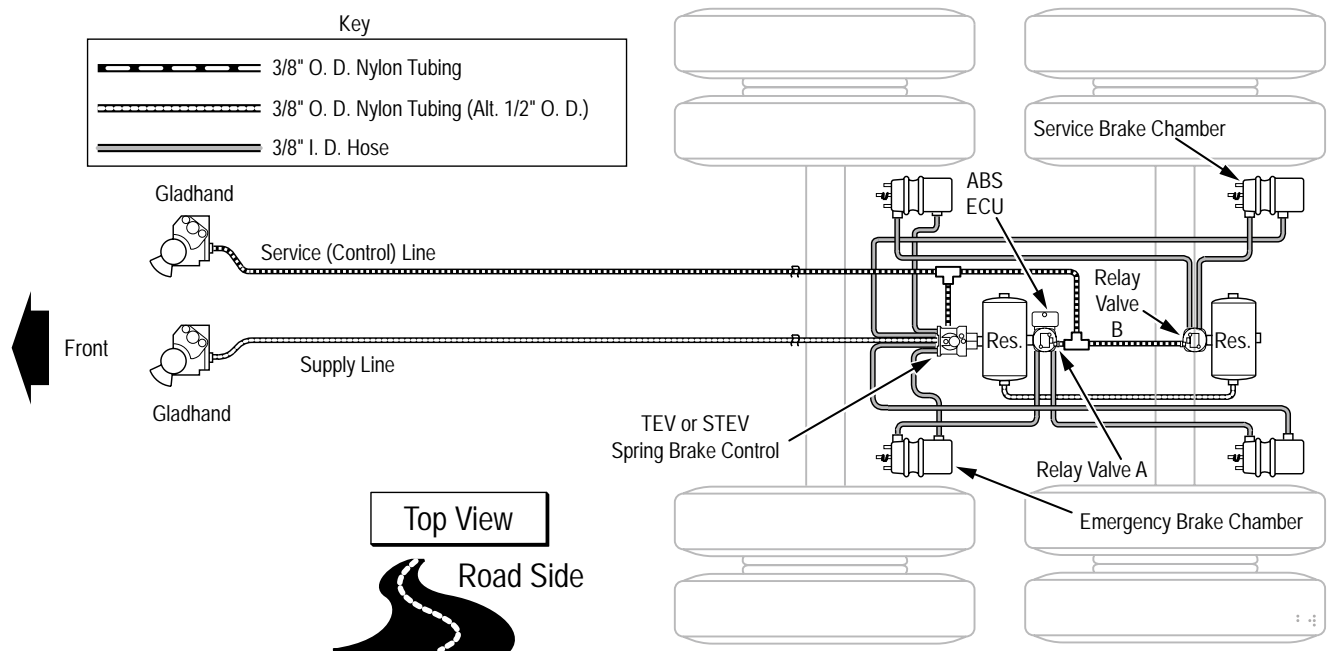


FIGURE 25 - Typical 4S-2M Side Control ABS Electrical and Air System (Top View)

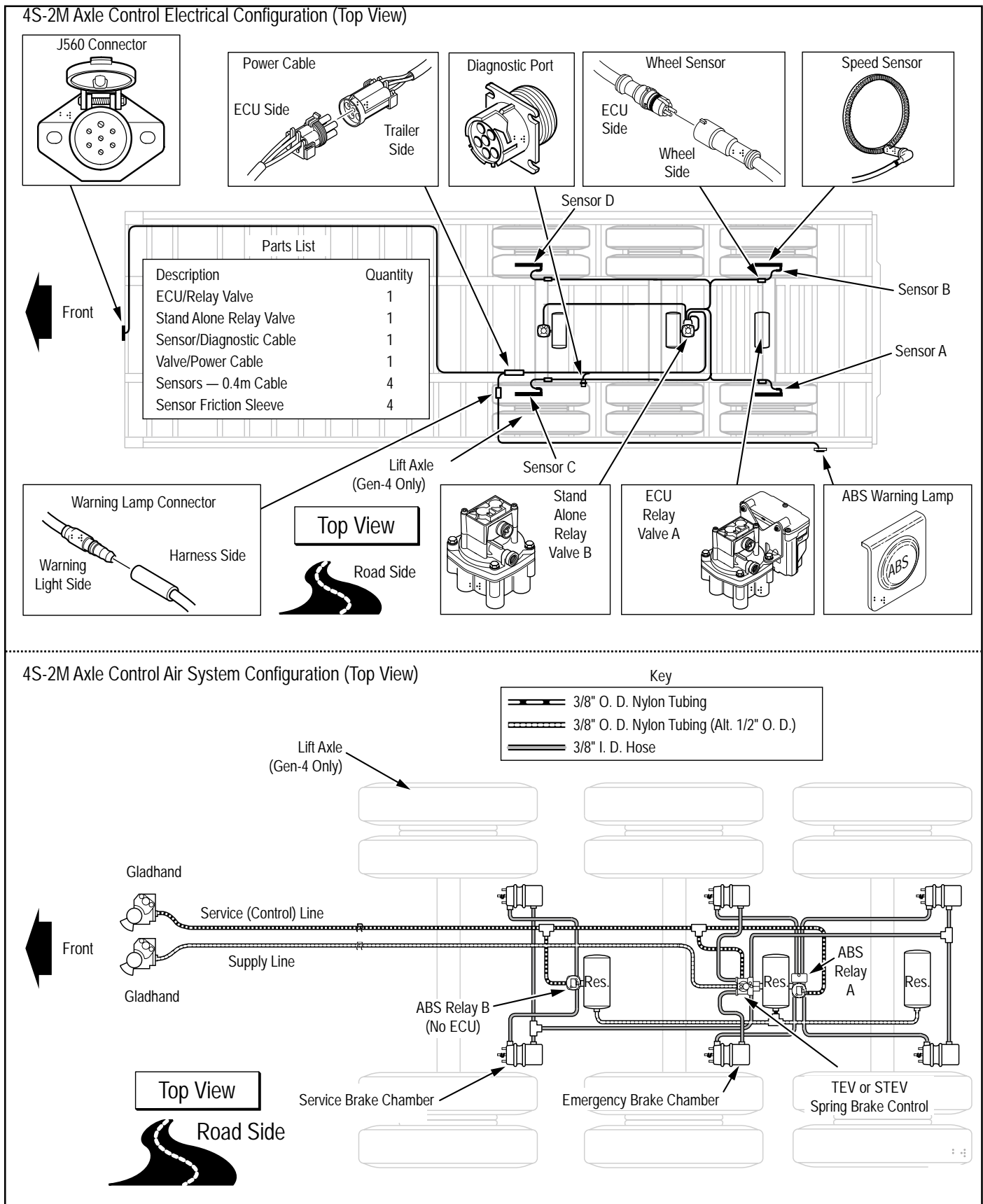


FIGURE 26 - Typical 4S-2M Axle Control ABS Electrical and Air System (Tank Mount Shown) (Top View)

End-Of-Line Diagnostics

Automatic System Configuration:

The Bendix® A-18™ trailer ABS system automatically configures itself to any valid ABS system installed on the trailer. The automatic configuration process occurs each time the system receives power at the permanent power input. In most cases this ECU input is connected to the SAE J560 connector AUX connection. During the automatic configuration process, the ECU will only configure upwards. That is, it will add but not subtract components from its configuration.

The configuration can be checked by using the hand held diagnostic tool or by activating the blink code as described in the “End-of-Line Checkout Procedure” listed below. Compare the two part blink code with the chart. Part 1 of the blink code is the current system configuration.

Use of Hand Held Tool for Configuration

The system always configures upwards depending on the components which are found connected to it. If a lower configuration is desired, a hand held tester must be used to reconfigure the system.

End-of-Line Checkout Procedure (Standard):

Note: For 2S/1M systems, it is not possible to miswire the components. Therefore it is only necessary to perform step 6 of the end-of-line checkout.

1. Apply power to ECU (do not use a battery charger as a power source).
2. Remove the weather cap from the trailer diagnostic port.
3. Connect either a hand-held tester with a Bendix Diagnostic Card or a PC Based Diagnostic system with ServiceRanger's End-of-Line Software Package to the trailer diagnostic port.
4. Follow the appropriate menu selections to verify:
 - a. That the sensors and valves are connected in their proper locations.
 - b. That the proper system configuration has been obtained.
 - c. That there are no faults. If necessary, clear historic faults.
5. After completion of the End-of-Line checkout procedure, disconnect the tool or PC from the trailer diagnostic port.
6. Verify that the ABS warning light turns off and remains off after the bulb test. If there was a past speed sensor fault in the system, the warning light will not turn off until the trailer has been operated at a speed sufficiently high to be read at the ECU, typically 3 to 5 mph.

End-of-Line Checkout Procedure (Basic):

Note: It is not possible to miswire the components on a 2S/1M (Basic) system. Therefore, the checkout procedure does not require the use of a hand-held tester.

1. Apply power to ECU (do not use a battery charger as a power source).
2. Verify that the ABS warning light turns OFF and remains OFF after the bulb test.

Note: If there was a past speed sensor fault in the system, the warning light will not turn OFF until the trailer has been operated at a speed sufficiently high to be read at the ECU, typically 3 to 5 mph.

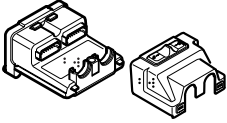
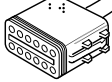

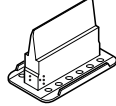

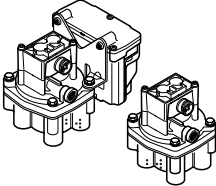
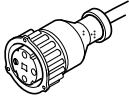
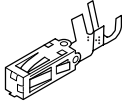

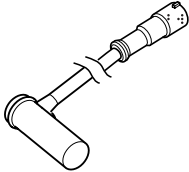
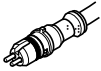
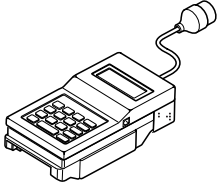
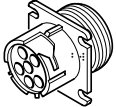


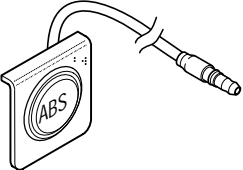

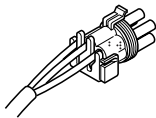
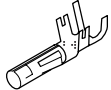


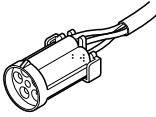
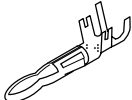


ABS Component	Harness Connector Shell	Harness Terminal	Wire Seal	Lock	Plug										
ECU 	Deutsch DT (Deutsch) DT06 12SA-BK01 (Grey) DT06 12SB-BK01 (Black) DT06 12SC-B016 (Green) 	Socket (Deutsch) 0462-201-16141 	N/A	W12S-P012 (Deutsch) 	114017 (Deutsch) 										
Relay Valve 	Bayonett 	Socket (Amp) 26570 	Seal (Amp) 14414-627-626 	N/A	N/A										
Wheel End Sensor 	2-Pin Kostal w/overmold <table border="1" data-bbox="435 680 630 783"> <tr> <td>Length</td> <td>Eaton Part No.</td> </tr> <tr> <td>2 meters</td> <td>300090</td> </tr> <tr> <td>3 meters</td> <td>300091</td> </tr> <tr> <td>5 meters</td> <td>300092</td> </tr> <tr> <td>8 meters</td> <td>300093</td> </tr> </table> 	Length	Eaton Part No.	2 meters	300090	3 meters	300091	5 meters	300092	8 meters	300093	N/A	N/A	N/A	N/A
Length	Eaton Part No.														
2 meters	300090														
3 meters	300091														
5 meters	300092														
8 meters	300093														
MPSI Scan Tool 	Diagnostic Port (Deutsch) HD10-6-12P 	Pin (Deutsch) 0460-204-12141 	N/A	N/A	114017 (Deutsch) 										
Warning Light 		N/A	N/A	N/A	N/A										
N/A	Power Cable (Packard) ECU Side 12034342 	Socket (Packard) 12124580 	Seal (Packard) 12015323 12010293 	N/A	12010300 (Packard) 										
N/A	Power Cable (Packard) Trailer Harness Side 12065158 	Pin (Packard) 12124582 	Seal (Packard) 12015323 12010293 	N/A	12010300 (Packard) 										

FIGURE 27 - ABS Parts Identification Chart

Troubleshooting and Fault Codes

An important feature of the Bendix® A-18™ trailer ABS system is the diagnostics that are reported via the Electronic Control Unit. This section describes how to use error codes to identify ABS system operating problems.

There are three ways to retrieve and display trailer ABS fault codes:

- **ServiceRanger PC software:** Displays configuration information and fault codes on the PC monitor. Refer to the ServiceRanger PC software information later in this section.

- **Automatic retrieval via a hand-held tester:** Displays fault codes on the hand-held tester's display. Refer to the hand-held tester information later in this section to retrieve and display fault codes. The low-cost diagnostic cable provided with the 2S/1M system does not accommodate the hand held tester.
- **Manual blink code diagnostics:** Flashes the codes on the ABS indicator lamp. Refer to the blink codes in this section.

Before the ABS system can be properly diagnosed and repaired, the foundation brake system must be eliminated as a possible cause of the problem. Follow the troubleshooting chart in Figure 28 to isolate and identify the brake problem.

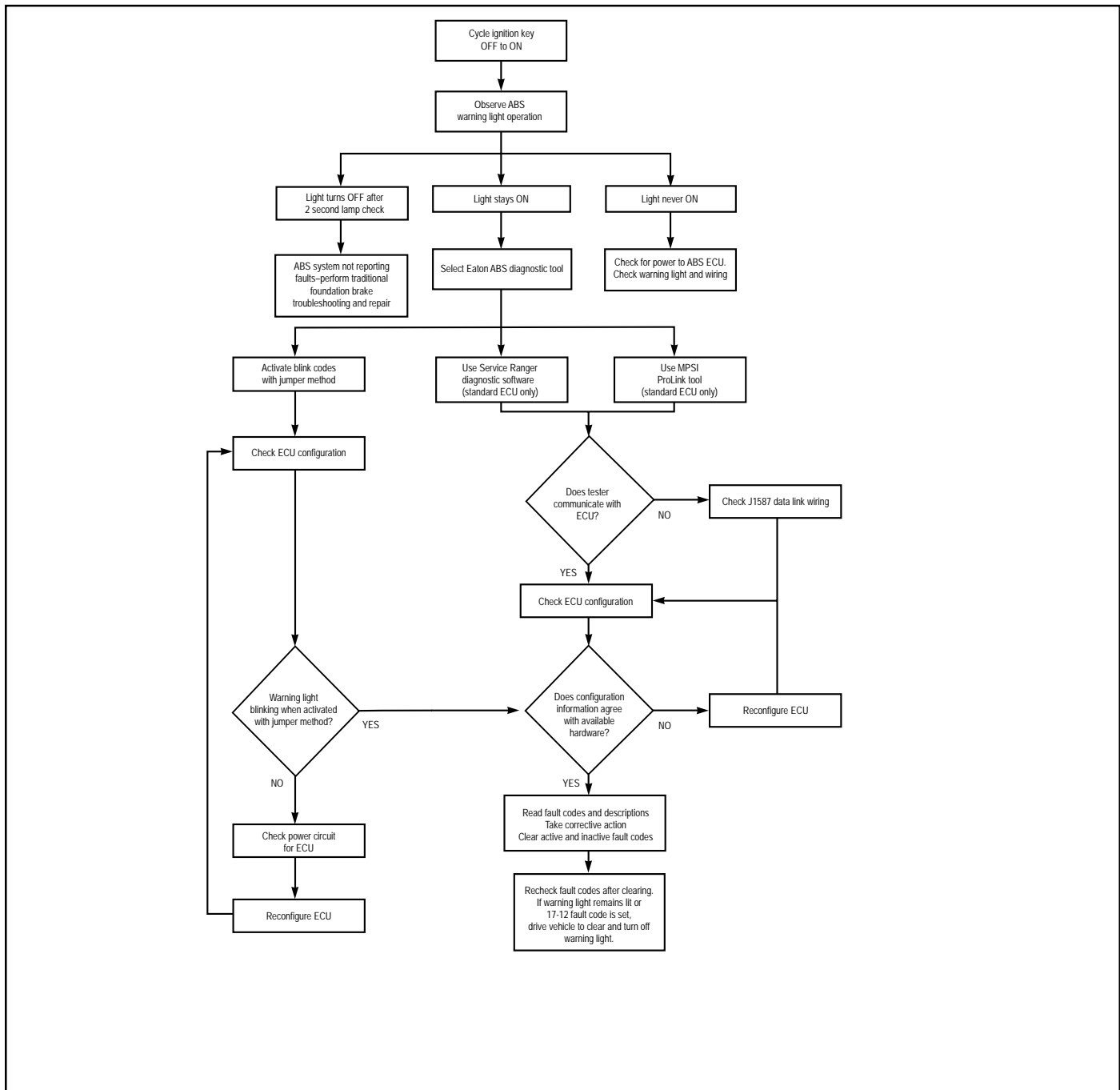


FIGURE 28 - Brake System Troubleshooting Chart

Test Equipment

Eaton 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.

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 Bendix proprietary cartridge can be used to read and clear error codes and obtain a

short description of failures. The tester can initiate valve test sequences and can also read system parameters (example: wheel speeds).

Note: 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 29 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 defects.

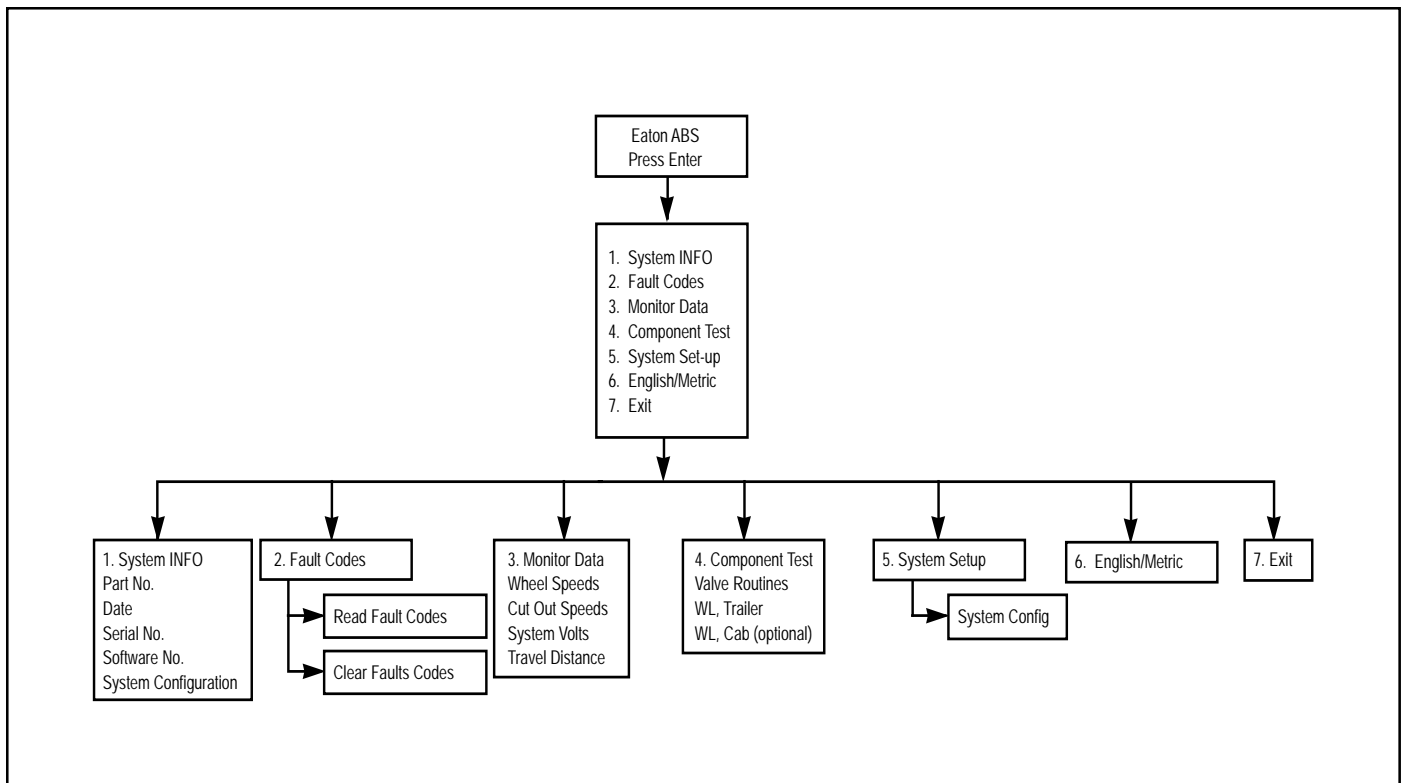


FIGURE 29 - Hand-Held Tester Operation Procedures

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: 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.

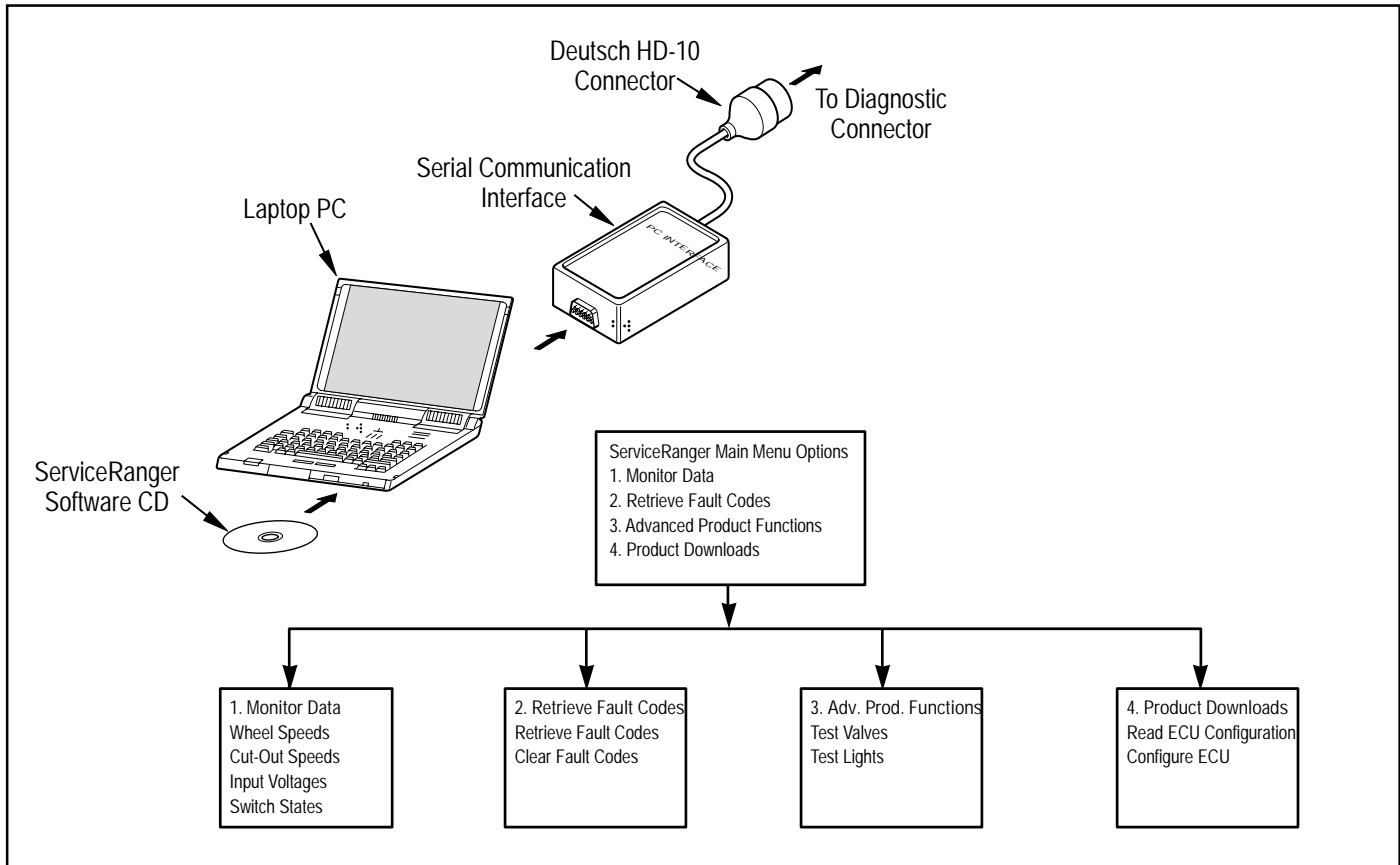


FIGURE 30 - ServiceRanger Menus & Hardware Setup

Troubleshooting Procedures

ABS Valve Troubleshooting

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

1. Access active fault code(s) using the blink code procedure, the hand-held tester or ServiceRanger software.

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.

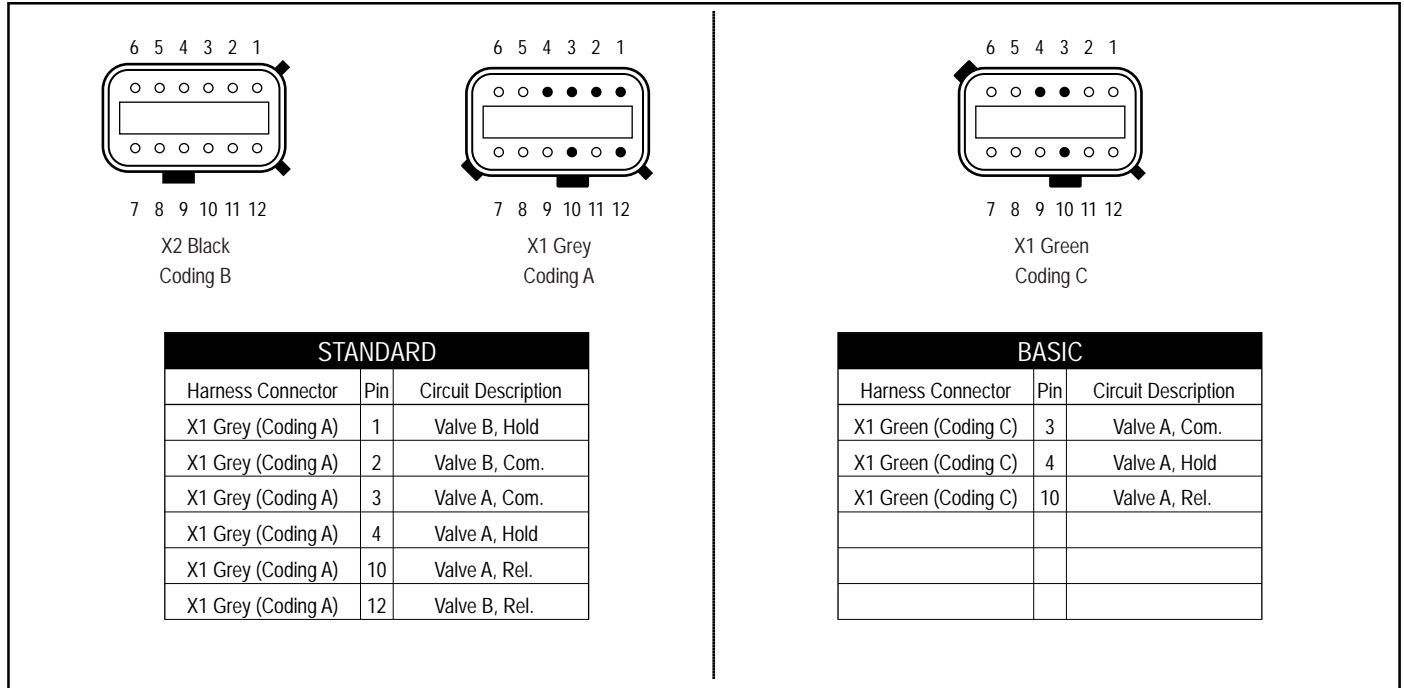


FIGURE 31 - ABS Valve Pin Identification

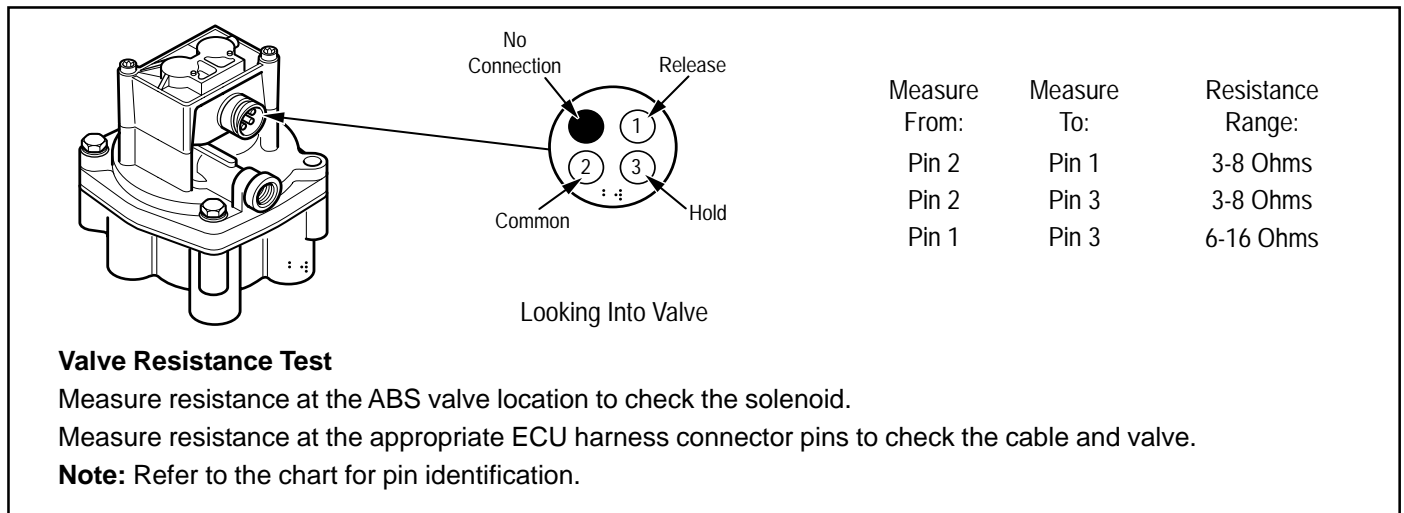


FIGURE 32 - Valve Pin Identification and Resistance Chart

Speed Sensor Troubleshooting

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

1. Access active diagnostic trouble code(s) using the blink code procedure, the hand-held tester or ServiceRanger software.
2. Look up 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.

Note: Drive the vehicle. The indicator lamp will remain on until proper sensor output is detected, even though the diagnostic trouble code has been cleared.

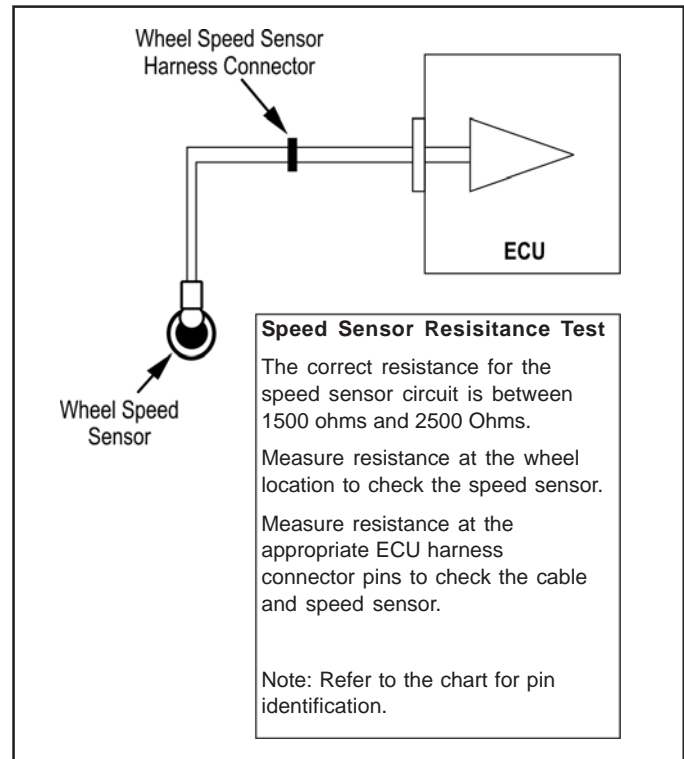


FIGURE 33 - Typical Wheel Speed Sensor Circuit

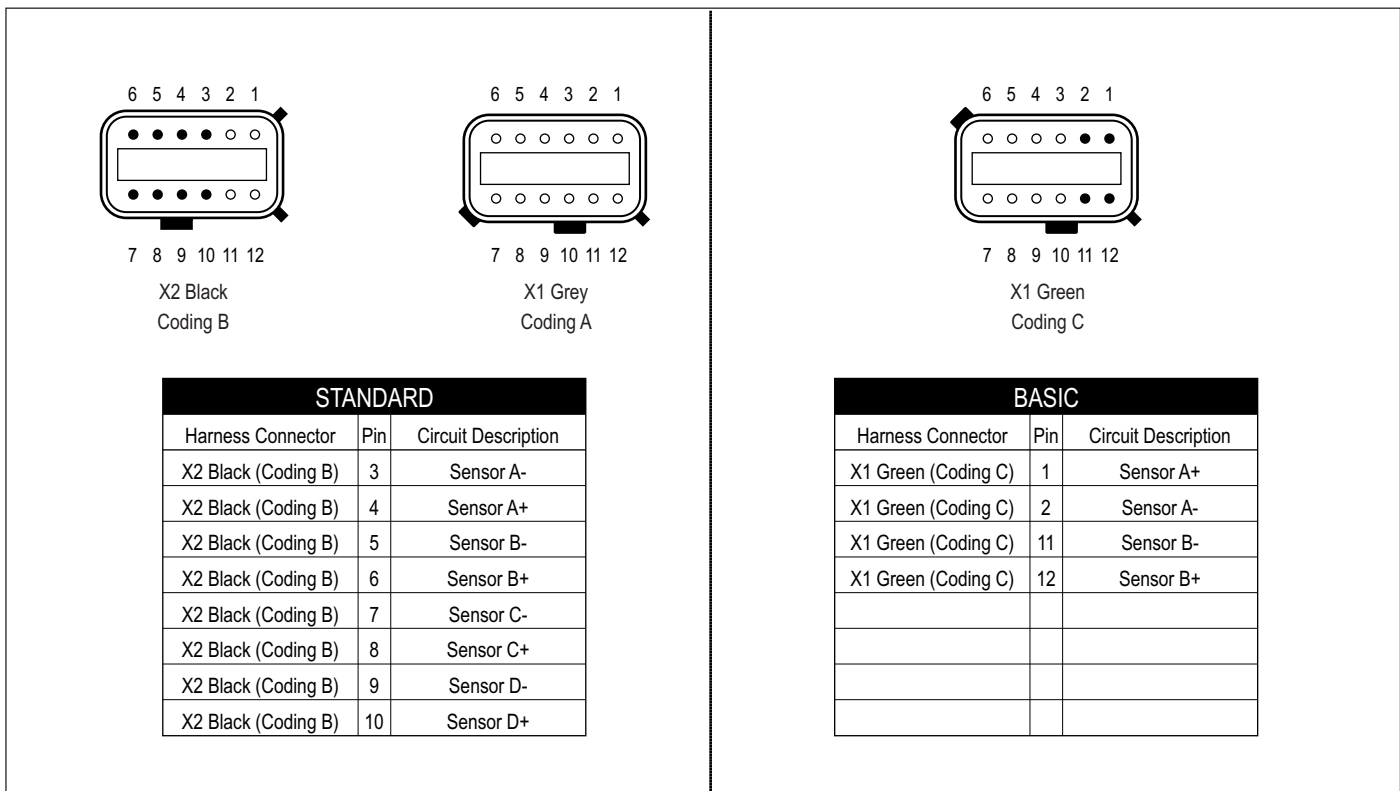


FIGURE 34 - Sensor Pin Identification

Accessing Codes

The ABS Warning Lamp outputs a two-part blink code. To interpret the blink code, record the number of flashes in each part and compare with the Gen-4™ or Gen-5™ ABS charts.

On Gen-4™ ABS systems, the first part of the flash sequence indicates the configuration, while the second part of the flash sequence indicates any fault codes that exist.

Example: A blink code of three flashes, a pause, then three more flashes (3-3) indicates a 4S-2M side control configuration with a fault on Sensor B.

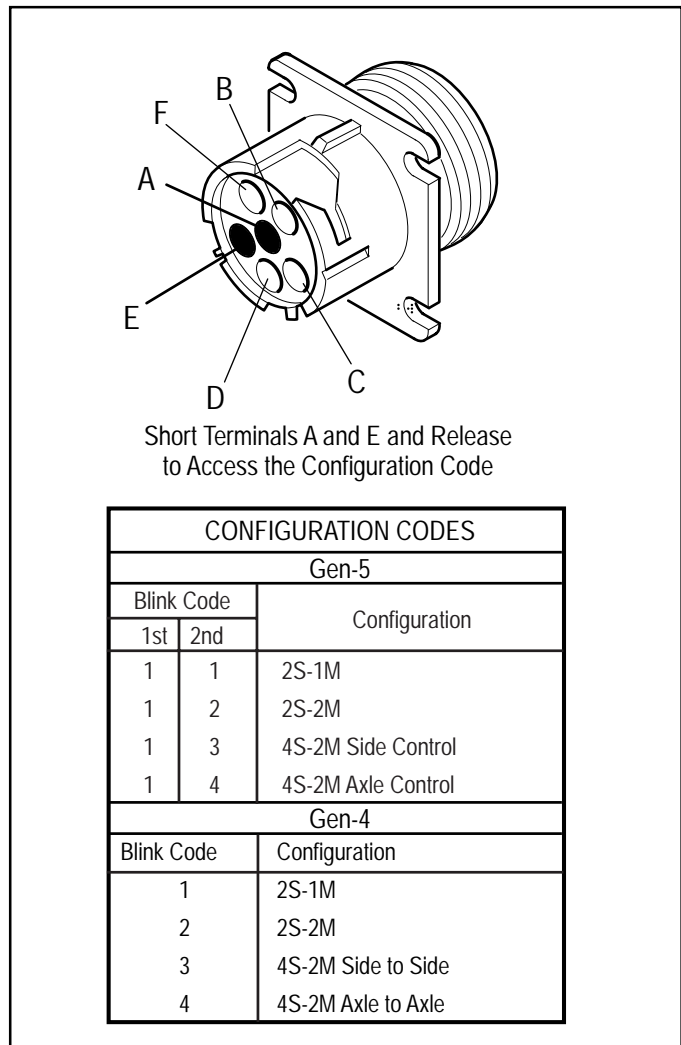


FIGURE 35 - Accessing Trailer ABS Configuration Codes

On Gen-5™ ABS systems, both the configuration codes and the fault codes are reported separately as two-part blink codes. There are different procedures for retrieving configuration and fault codes. Refer to the retrieving codes section of this manual.

Example: A blink code of one flash, a pause, then one more flash (1-1) indicates a 2S-1M system configuration when retrieving configuration codes. However, 1-1 indicates No Trouble Found when retrieving fault codes.

Retrieving Configuration Codes Live Feed (Gen-5™ ABS PLC Capable ECUs)

1. Turn ignition key ON.
2. Use appropriate jumper method. Apply the jumper for 2 seconds and remove.
3. Immediately apply the jumper again for 2 seconds and remove.
4. Record the 2-digit blink code as it is flashed on the external trailer warning light.

Retrieving Configuration Codes (Gen-4™ ABS)

1. Turn ignition key ON.
2. Use appropriate jumper method. Apply the jumper for 2 seconds and remove.
3. Two-digit blink codes are retrieved and displayed.

Fault Code Charts

Fault codes can be retrieved as two-digit blink codes. Refer to Figures 37 and 38 for a description of these codes.

Blink codes are retrieved by jumping pins A and E on Standard Systems and jumping the diagnostic bullet to the frame on basic systems. The jumping method can also be used to clear codes. To perform 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 using the jumping method 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 and 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 Live Feed

(Gen-5™ ABS PLC Capable ECUs)

1. Turn ignition key ON.
2. Use appropriate jumper method. Apply the jumper for 2 seconds and remove.
3. Record the 2-digit blink codes as they are flashed on the external trailer warning lamp.

Retrieving Fault Codes (Gen-4™ ABS)

1. Turn ignition key ON.
2. Use appropriate jumper method. Apply the jumper for 2 seconds and remove.
3. Two-digit blink codes are retrieved and displayed.

Clearing Fault Codes

1. With the power OFF, use the appropriate jumping method.
2. Turn the power ON while continuing to apply the jumper.
 - Wait at least 3 seconds and remove the jumper.
 - Blink fault codes are cleared.
 - Repeat the “Retrieving Fault Codes” procedure to verify that fault codes are cleared.
 - Active fault codes will be re-established until corrected action has been taken.

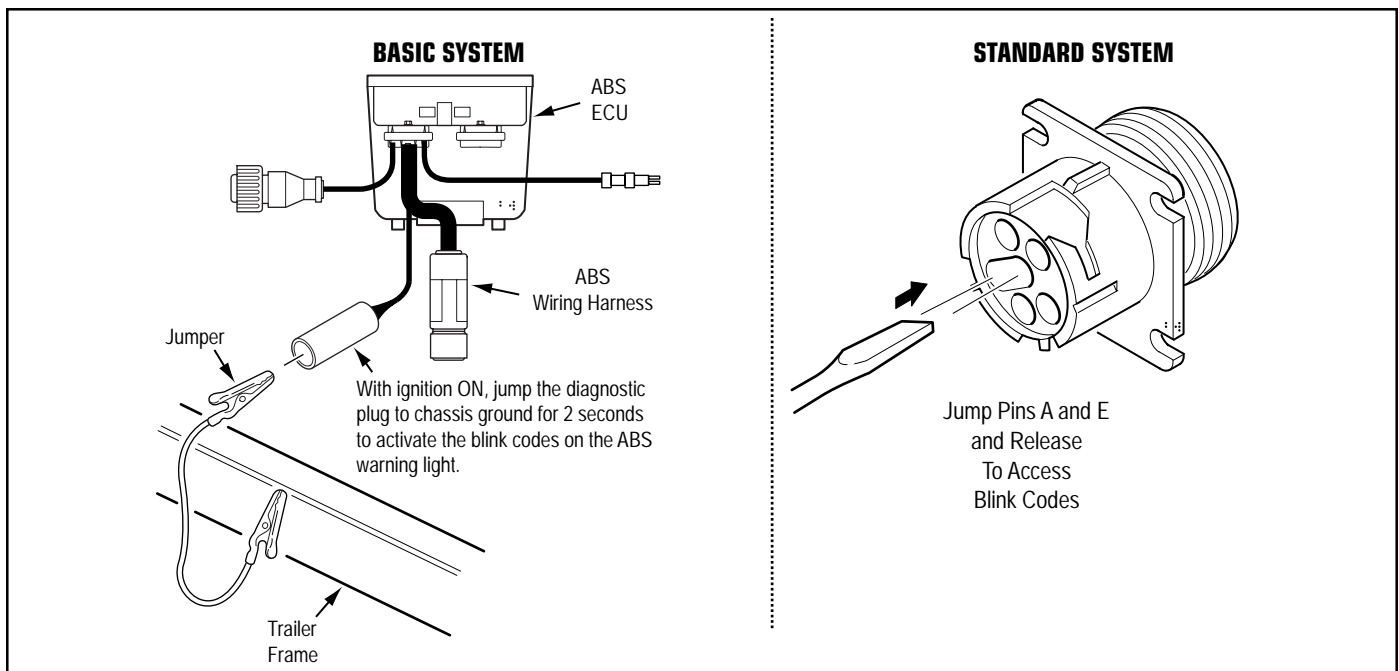




FIGURE 36 - Jumper Method of Accessing Blink Codes

Blink Code Sequence	CONFIGURATION CODES		
	Flashes	Description	
	1st 	1	2S-1M (Select Smart)
		2	2S-2M (IR Side Control)
		3	4S-2M Side Control (IR Side Control)
	4	4S-2M Axle Control (Select Low)	
1.5 Sec. Pause	DIAGNOSTIC TROUBLE CODES		
	Flashes	Description	Action
	1	Configuration OK (no fault)	
	2	Sensor A Code	Sensor Codes-
	3	Sensor B Code	• Check sensor resistance (1500-2500 ohms).
	4	Sensor C Code	• If sensor resistance is out of range, replace sensor.
2nd 	5	Sensor D Code	• Clean and lubricate sensor.
			• Press sensor into mounting hole until it bottoms against tone wheel.
			• Examine tone ring for damage. Replace tone ring and/or hub if necessary.
			• Check wheel bearing adjustment. Adjust wheel bearings if necessary.
			• Check mechanical function of brake.
			• Check for kinked or restricted hoses.
			• Clear fault code and test drive the vehicle.
			NOTE: Drive the vehicle. The indicator lamp will remain on until proper sensor output is detected even though the trouble code has been cleared.
	8	Valve A Code	Valve Codes-
	9	Valve B Code	• Check valve resistance with multimeter. Replace valve if resistance is incorrect.
			• If resistance is correct, check harness for short in wiring. (See Figure 32.)
	11, 14	ECU Internal Error	ECU Internal Error-
			• Clear diagnostic trouble code and test drive vehicle.
			• If diagnostic trouble code recurs, or cannot be cleared, replace ECU.
	12	Faulty Supply Voltage	Faulty Supply Voltage-
			• Clear diagnostic trouble code and power the system. If trouble code recurs:
			• Check supply voltage and ground with multimeter.
			• Check connectors for corrosion.

Low Voltage Operation

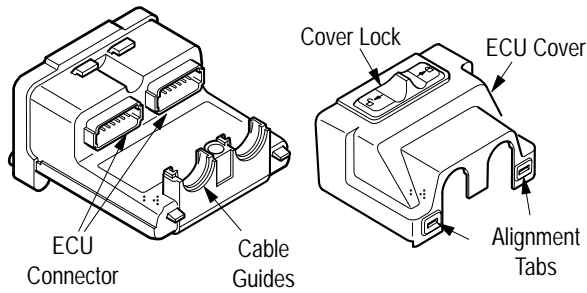
- If the system powers up with a voltage below 8.5 volts, a low voltage trouble code (code 12) is logged and the indicator lamp remains on until the system is re-powered at a proper voltage level as measured at the ECU.
- If the system voltage drops below 8.5 volts after the initial check-out phase, no trouble code is logged but the indicator lamp turns on, indicating that ABS is no longer operational. If the voltage recovers, the indicator lamp turns off and normal operation resumes.

FIGURE 37 - Gen 4™ ABS Diagnostic Trouble Code Chart

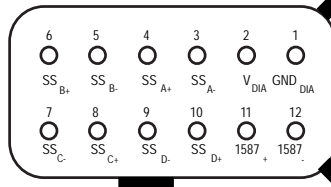
Blink Code		Description	Location
1st	2nd		
1	1	No trouble found.	
2	1	Sensor air gap too large.	Sensor A
2	2	Sensor air gap too large or sensor shorted.	
2	3	Noisy signal, check tone ring.	
2	4	Excessive wheel lock.	
2	5	Intermittent sensor signal.	
2	6	Sensor shorted or open.	
3	1	Sensor air gap too large.	
3	2	Sensor air gap too large or sensor shorted.	
3	3	Noisy signal, check tone ring.	
3	4	Excessive wheel lock.	
3	5	Intermittent sensor signal.	
3	6	Sensor shorted or open.	
4	1	Sensor air gap too large.	Sensor C
4	2	Sensor air gap too large or sensor shorted.	
4	3	Noisy signal, check tone ring.	
4	4	Excessive wheel lock.	
4	5	Intermittent sensor signal.	
4	6	Sensor shorted or open.	
5	1	Sensor air gap too large.	Sensor D
5	2	Sensor air gap too large or sensor shorted.	
5	3	Noisy signal, check tone ring.	
5	4	Excessive wheel lock.	
5	5	Intermittent sensor signal.	
5	6	Sensor shorted or open.	
8	1	Short circuit from the release solenoid to voltage.	Valve A
8	2	Short circuit from the release solenoid to ground.	
8	3	Open circuit at the release solenoid.	
8	4	Open circuit on the common line to the valve.	
8	5	Short circuit from the hold solenoid to voltage.	
8	6	Short circuit from the hold solenoid to ground.	
8	7	Open circuit at the hold solenoid.	
8	8	System configuration is incorrect.	
9	1	Short circuit from the release solenoid to voltage.	Valve B
9	2	Short circuit from the release solenoid to ground.	
9	3	Open circuit at the release solenoid.	
9	4	Open circuit on the common line to the valve.	
9	5	Short circuit from the hold solenoid to voltage.	
9	6	Short circuit from the hold solenoid to ground.	
9	7	Open circuit at the hold solenoid.	
9	8	System configuration is incorrect.	
10	9	Common side of valve(s) - stray voltage detected.	Valve(s)
10	10	Common side of valve(s) shorted high.	
10	11	Common side of valve(s) shorted to ground.	
15	all	ECU internal error.	ECU
16	1	Over voltage on ECU power line.	ECU Power Line
16	2	Low voltage on ECU power line.	
17	10	Warning light shorted high or J1587+ shorted to ground.	Warning Light or J1587+
17	12	Sensor signal check required. Pull trailer or turn wheels one after the other.	Sensors

FIGURE 38 - Gen-5™ ABS Fault Code Chart

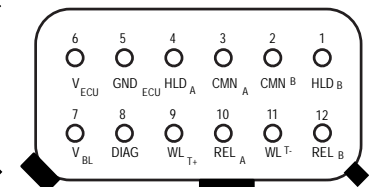
STANDARD SYSTEM



Top-Looking into Harness Connector



X2-CODING B
(BLACK)

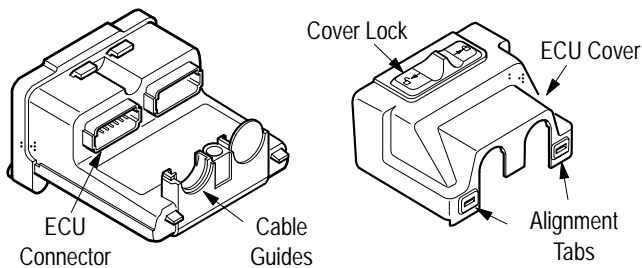


X1-CODING A
(GREY)

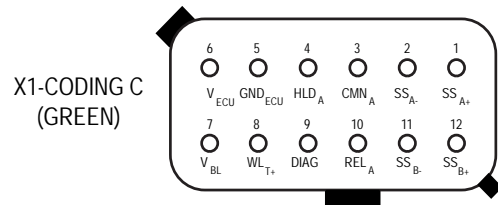
Pin#	Ref.	Description
1	GND DIA	Diagnostic Port Ground
2	V DIA	Diagnostic Port Power (12V)
3	SSA-	Speed Sensor A, Negative
4	SSA+	Speed Sensor A, Positive
5	SSB-	Speed Sensor B, Negative
6	SSB+	Speed Sensor B, Positive
7	SSC-	Speed Sensor C, Negative
8	SSC+	Speed Sensor C, Positive
9	SSD-	Speed Sensor D, Negative
10	SSD+	Speed Sensor D, Positive
11	1587+	Diagnostic Link, Positive
12	1587-	Diagnostic Link, Negative

Pin#	Ref.	Description
1	HLD B	Valve B, Hold Solenoid
2	CMN B	Valve B, Common
3	CMN A	Valve A, Common
4	HLD A	Valve A, Hold Solenoid
5	GNDECU	ECU Ground
6	VECU	ECU Continuous Power (with Ignition ON)
7	VBL	Brake Light Power (Secondary Power Source)
8	NCC	No Connection
9	WLT+	Warning Light Power, Trailer Mounted
10	RELA	Valve A, Release Solenoid
11	NC	No Connection
12	RELB	Valve B, Release Solenoid

BASIC SYSTEM



Top-Looking into Harness Connector



X1-CODING C
(GREEN)

Pin#	Ref.	Description
1	SSA+	Speed Sensor A, Positive
2	SSA-	Speed Sensor A, Negative
3	CMNA	Valve A, Common
4	HLDA	Valve A, Hold Solenoid
5	GNDECU	ECU Ground
6	VECU	ECU Continuous Power (with Ignition ON)

Pin#	Ref.	Description
7	VBL	Brake Light Power (Secondary Power Source)
8	WLT+	Warning Light Power, Trailer Mounted
9	DIAGC	Diagnostic Plug
10	RELA	Valve A, Release Solenoid
11	SSB-	Speed Sensor B, Negative
12	SSB+	Speed Sensor B, Positive

FIGURE 39 - ECU Pin Identification Chart

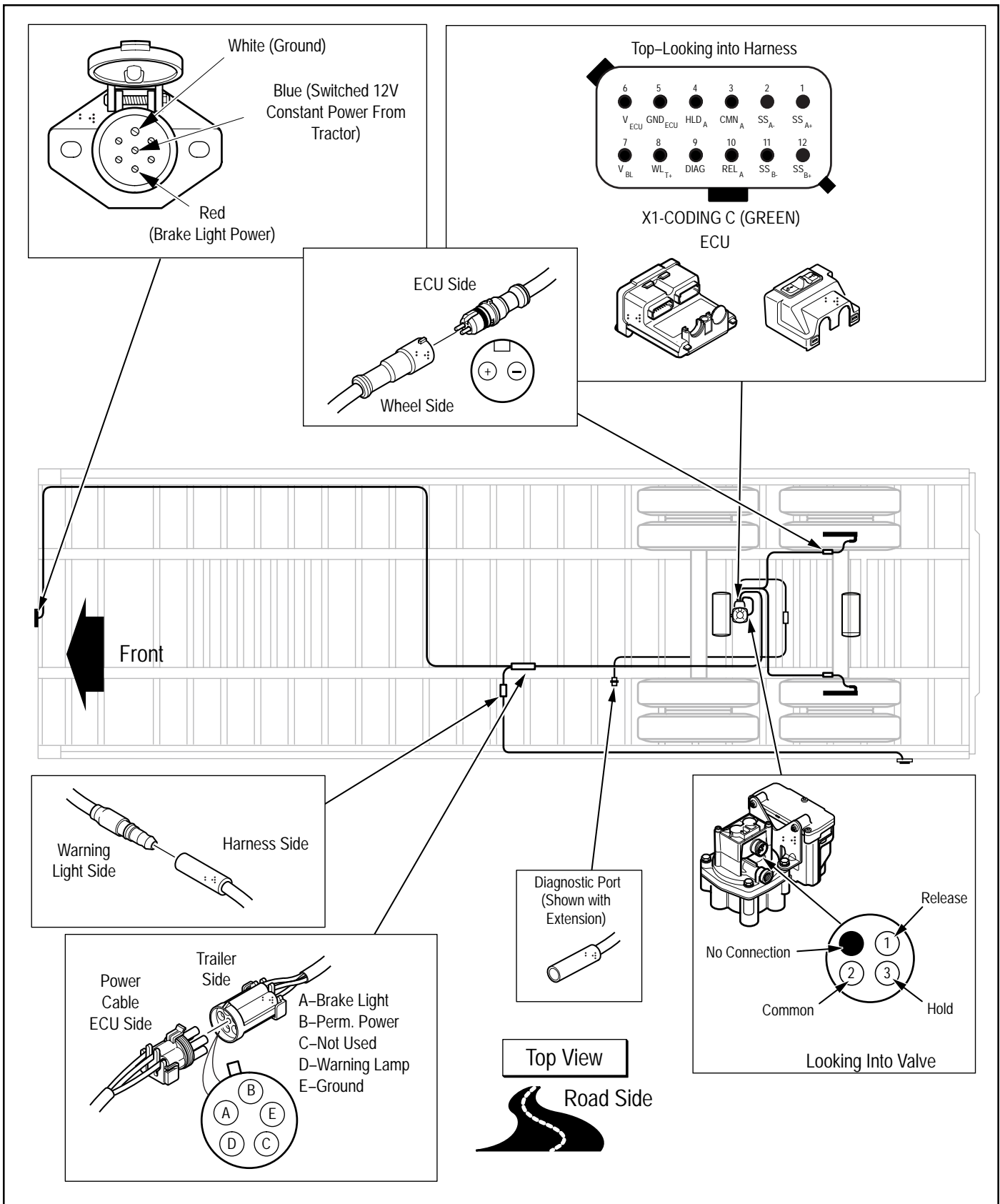


FIGURE 40 - 2S-1M Electrical Connections

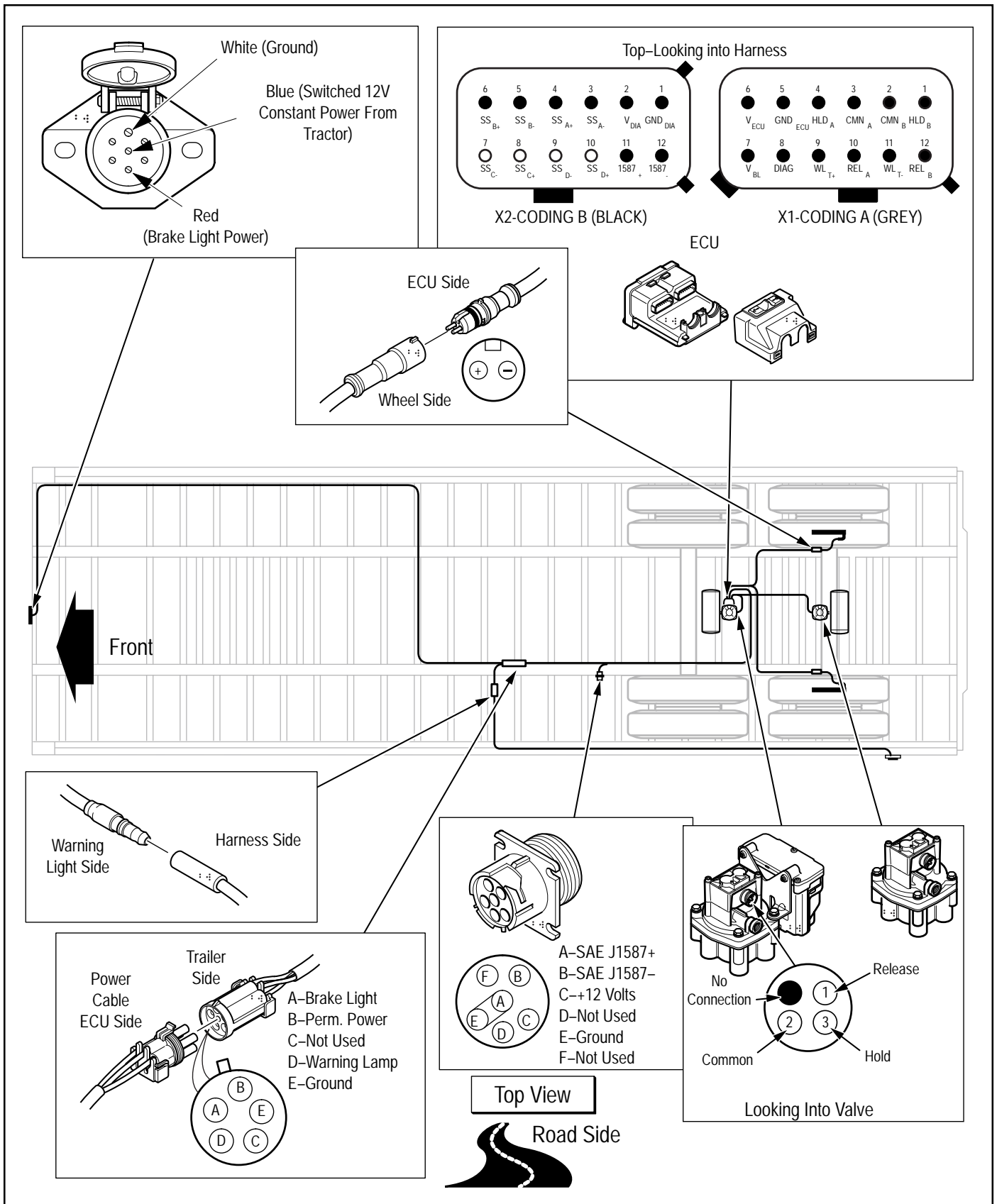


FIGURE 41 - 2S-2M Electrical Connections

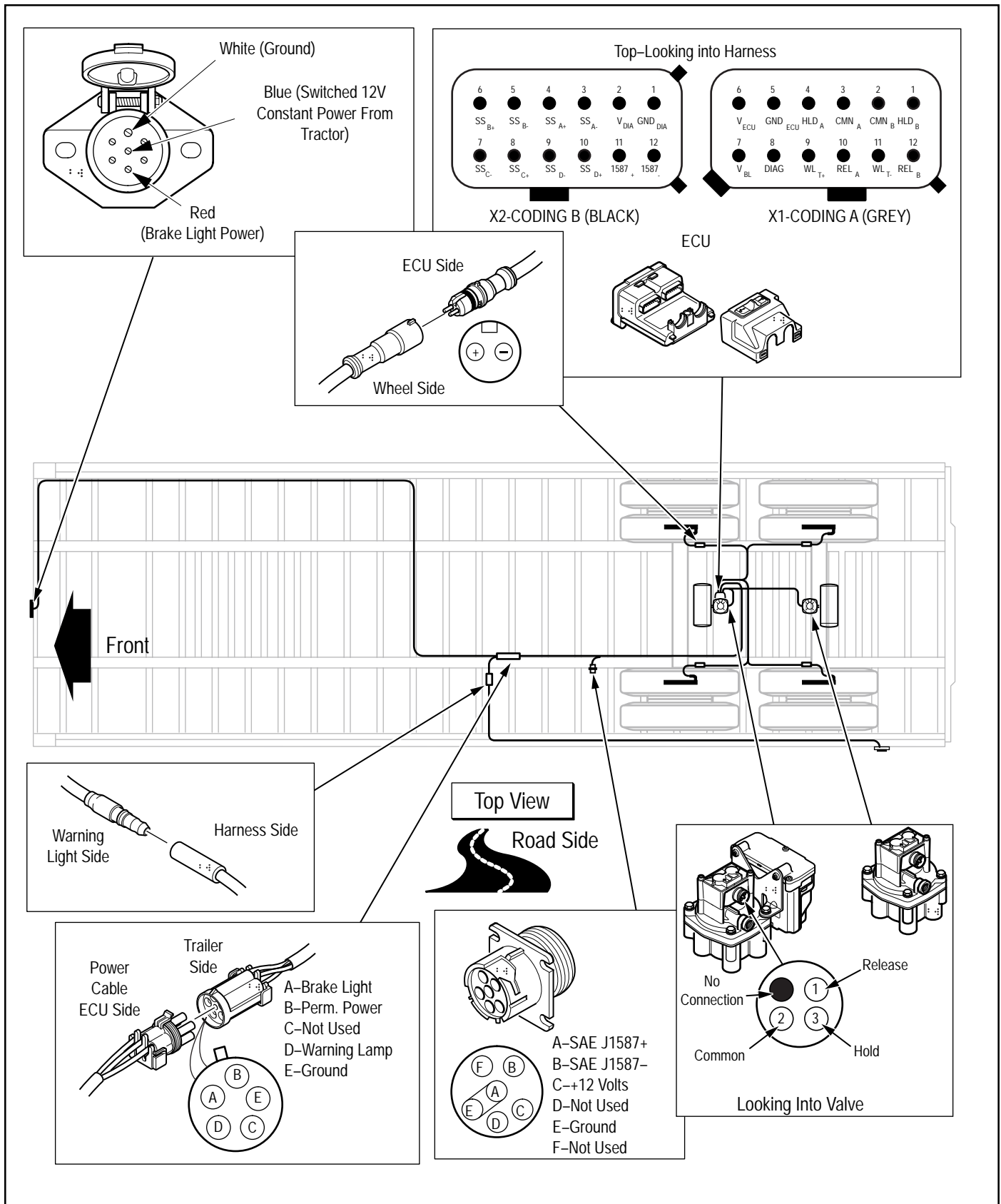
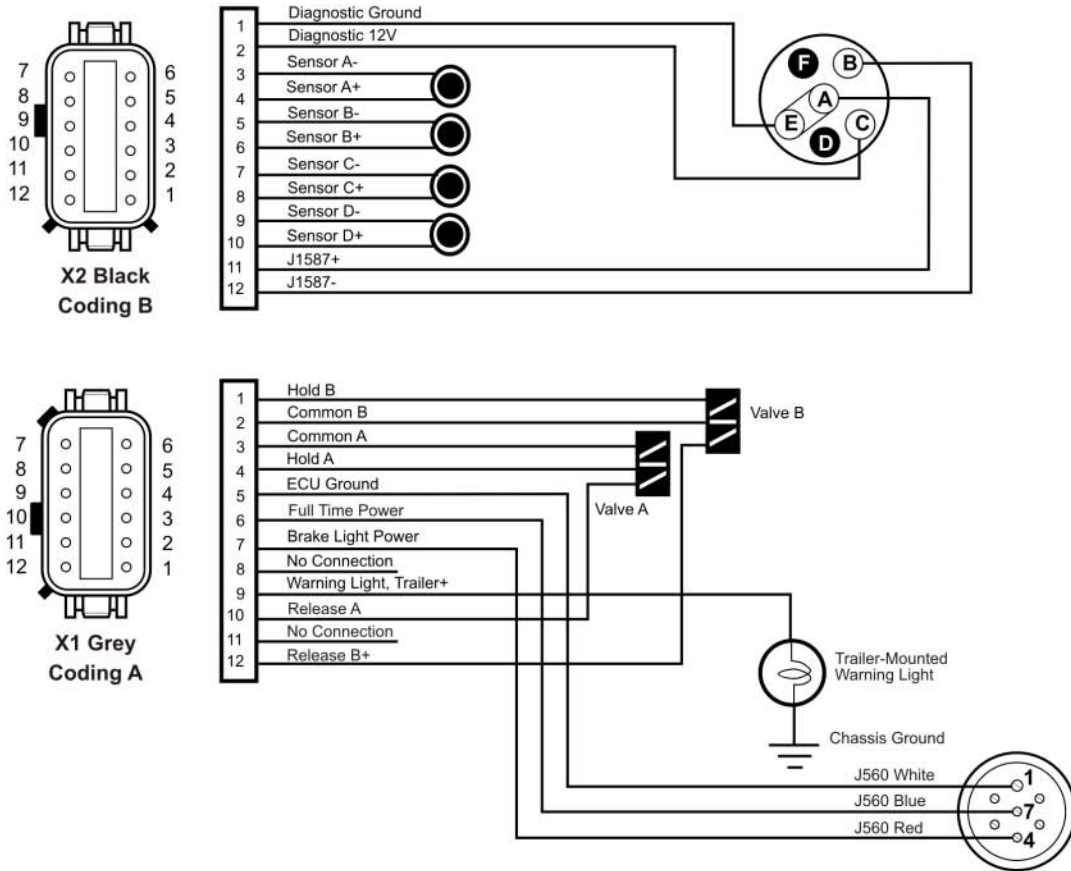


FIGURE 42 - 4S-2M Side Control and Axle Control Electrical Connections

STANDARD SYSTEM

All Views Looking into Harness Connectors



BASIC SYSTEM

All Views Looking into Harness Connectors

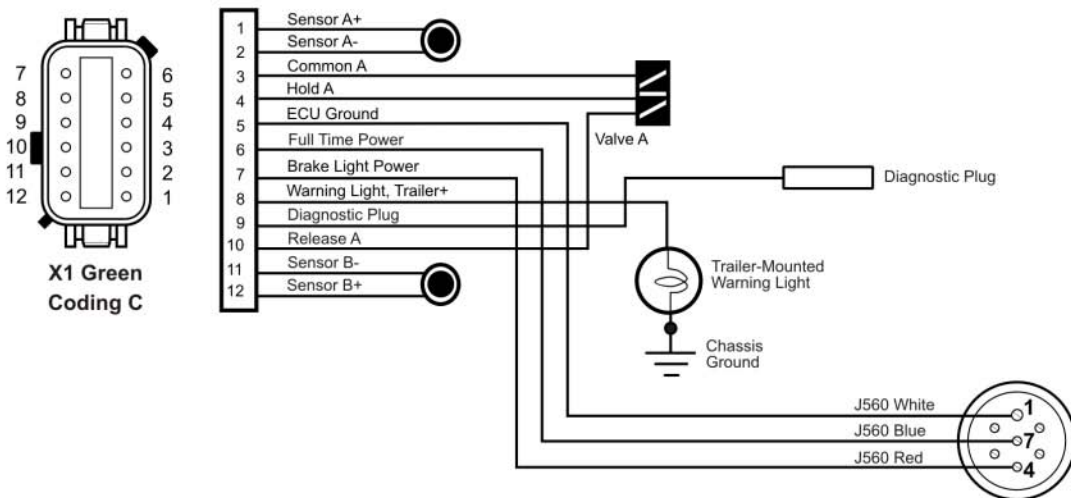


FIGURE 43 - Electrical Schematic

Glossary

ABS — Antilock Brake System. A control system that maintains wheel slip at a level that minimizes stopping distance while maintaining lateral stability to the extent possible.

Air Gap — Distance between the sensor pole piece and tone ring.

Anti-Compounding — A method to prevent the application of the service brakes and spring brakes at the same time to prevent excessive stress on brake components.

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

Channel — A controlled wheel site.

CAN — Controller Area Network.

Clear Codes — Method for erasing historical faults from the ECU, using either the diagnostic switch input or 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 — Process of identifying a “normal” set of sensors and modulators for the Electronic Control Unit, so that it can 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.

Diagnostic Connector — Deutsch HD-10 Series connector used for interface to hand-held testers or PC based diagnostic equipment based on the J1587 protocol. The tester can initiate test sequences, and can also read system parameters.

Directly Controlled Wheel — A wheel that is sensed to be slipping, and is adjusted to correct for that slip.

ECU — Electronic Control Unit.

FMVSS-121 — Federal Motor Vehicle Safety Standard that 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.

Full-Treadle Brake Application — A brake application in which the treadle valve pressure in any of the valve’s output circuits reaches 100 psi within 0.2 seconds after the application is initiated.

Independently Controlled Wheel — Directly controlled wheel for which the modulator does not adjust the brake actuating forces for any other wheel on the axle.

Indirectly Controlled Wheel — A wheel whose braking is adjusted in response to wheel speed information from an adjacent wheel.

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.

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.

Peak Friction Coefficient (PFC) — The ratio of the maximum value of braking test wheel longitudinal force to the simultaneous vertical force occurring prior to wheel lockup, as the braking torque is progressively increased.

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 may have hold off springs that produce higher crack pressures (when the valves open).

Relay Valve — A pneumatic amplifier. A relay valve provides large quantities of air from supply reservoirs located nearby in response to a low flow control signal originating from a remote source. Relay valves have an associated crack pressure. No pressure is delivered until the control pressure reaches the crack pressure.

Release Timing — The time from initial brake pedal movement (release), for a set of brake chambers initially at 95 PSI to reach 5 PSI.

Select High — An ABS control strategy in which several sensed wheels are controlled by a single valve. The pressure at both wheels is controlled by the wheel that has the least tendency towards locking.

Select Low — An ABS control strategy in which several sensed wheels are controlled by a single valve. The pressure at both wheels is controlled by the wheel that has the greatest tendency towards locking.

Select Smart — An ABS control strategy in which several sensed wheels are controlled by a single valve. If the wheels are determined to be on significantly different surfaces (e.g. ice on one side and asphalt on the other) select high operation is chosen. If the surfaces are close to homogeneous a select low strategy is chosen.

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

Stored Faults — A fault that occurred.

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 TIR.

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.

