8. Connect the parking brake linkage to the adjusting lever.
9. Install the yoke. Refer to the procedure in this section.
10. Install the brake shoes. Refer to the procedure in this section.

T Series Parking Brake

Brake Shoes

1. Lubricate the anchor pins and the bushings. Refer to Section 7.
2. If removed, install the cam rollers into the shoe. Place the roller into the shoe. Install the shaft through the shoe and the roller. Align the set screw slot in the shaft with the hole in the shoe. Install and tighten the set screw. Figure 5.19.

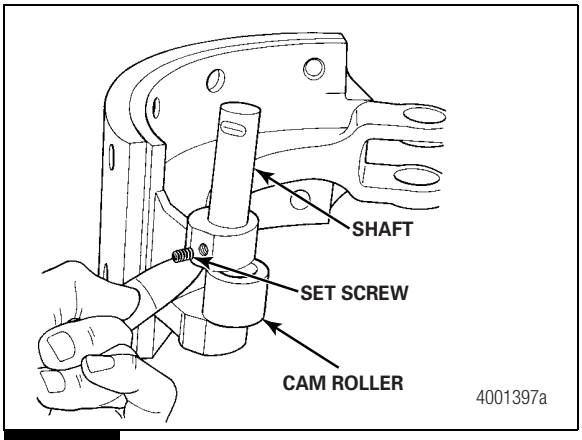


Figure 5.19

3. Place the brake shoes onto the bearing cage.
4. Install the anchor pins into the brake shoes. Verify that the flat side of the pin is installed toward the lock screw in the shoe. Figure 5.20.

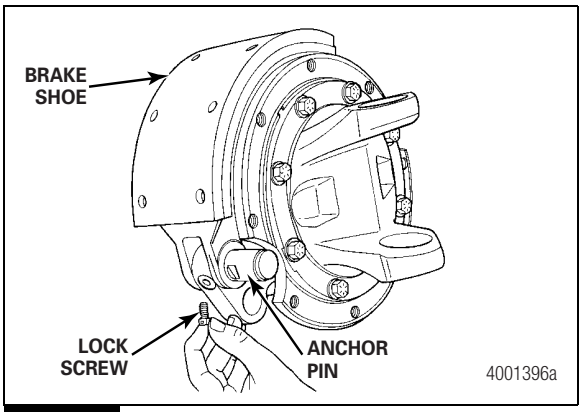


Figure 5.20

5. Use a hammer and a brass drift to install the anchor pins into the shoes. Figure 5.20.
6. Tighten the lock screws. Install the lock wire onto the anchor pin.
7. Install the oil seal and the oil seal retainers onto the anchor pins. Install the snap ring. Figure 5.21.

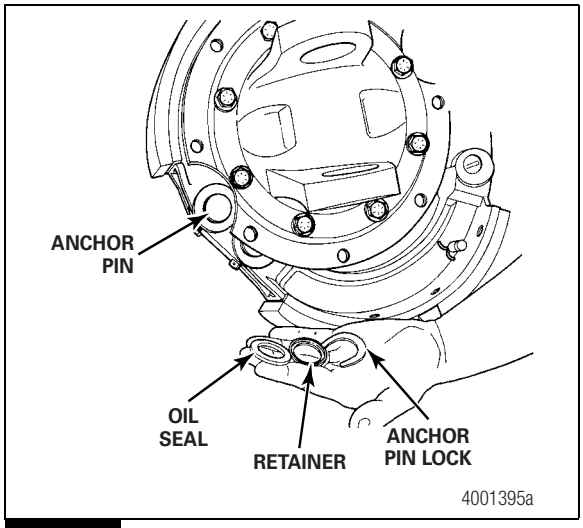


Figure 5.21

8. Place the brake shoes against the cam. Use brake spring pliers to install the return spring onto the shoes. Verify that the rollers in the brake shoes are against the low points of the cam. Figure 5.22.

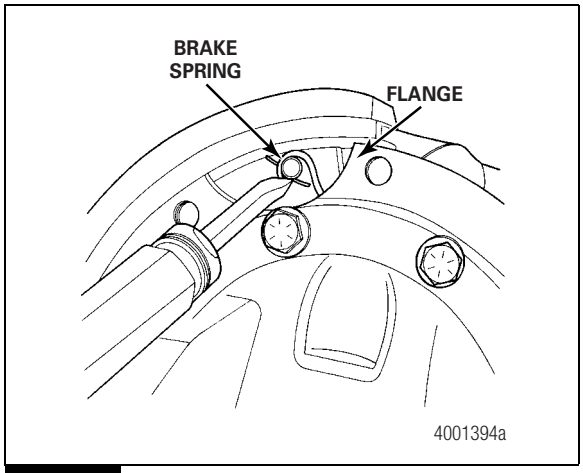


Figure 5.22

5 Assembly and Installation

9. Lubricate the cam and the rollers. Refer to Section 7.
10. Install the brake drum onto the yoke flange. Install the nuts and the washers. Tighten the nuts to 85-115 lb-ft (116-155 N•m). Figure 5.23.

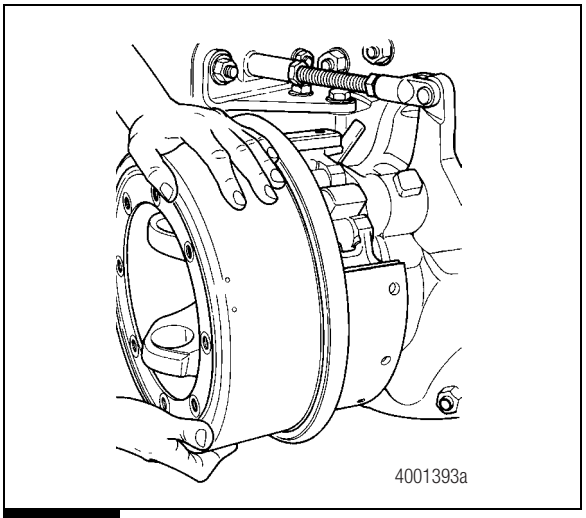


Figure 5.23

11. If removed, connect the drive shaft to the yoke.
12. Adjust the parking brake linkage and the lining-to-drum clearance. Refer to the procedures in this section.

Adjust the Lining-to-Drum Clearance

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Release the parking brake.
3. Remove all dirt from the adjusting lever and the back of the drum.
4. Use a feeler gauge to measure the clearance between the lining and the drum. Figure 5.24.

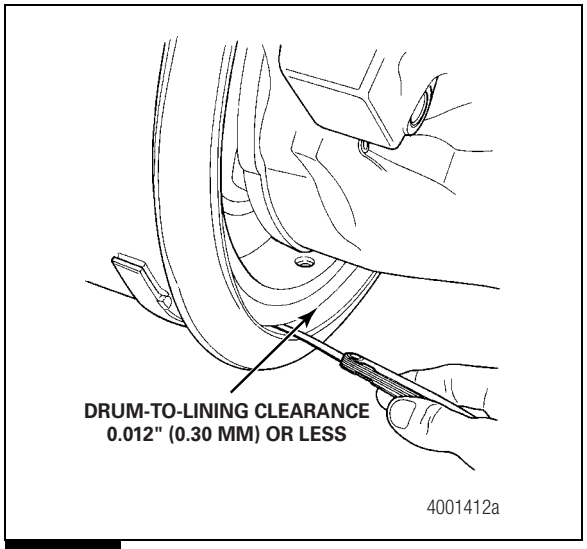


Figure 5.24

5. If the clearance is more than 0.012-inch (0.30 mm), turn the adjusting bolt adjusting lever until the clearance is correct. Figure 5.25.

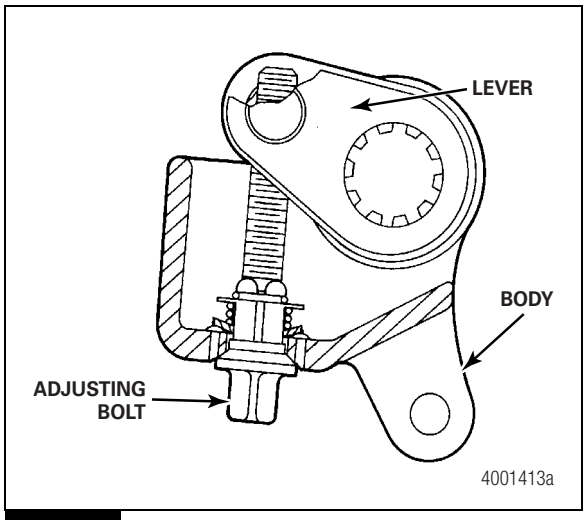


Figure 5.25

6. Operate the parking brake. Check for correct operation.

Adjust the Linkage

⚠ WARNING

Before you service a spring chamber, carefully follow the manufacturer's instructions to compress and lock the spring to completely release the brake. Verify that no air pressure remains in the service chamber before you proceed. Sudden release of compressed air can cause serious personal injury and damage to components.

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Release the brake system air pressure.
3. Tighten the spring chamber caging sleeve until the sleeve touches the non-pressure plate in the housing.
4. Remove and discard the cotter pin and the clevis pin. Disconnect the clevis from the slack adjuster. Loosen the clevis jam nut.
5. Rotate the push rod clevis until the center of the clevis pin hole is 10-inches (254 mm) from the chamber non-pressure plate. Tighten the jam nut. Figure 5.26.

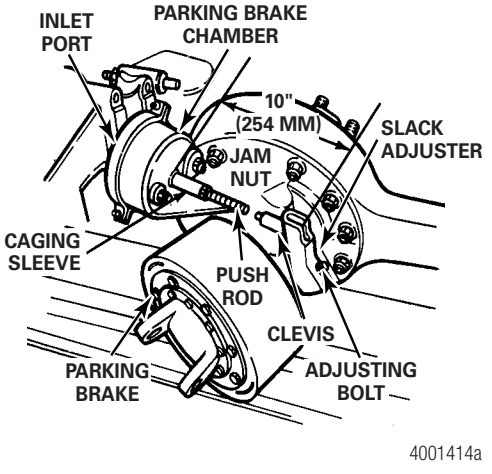


Figure 5.26

6. Apply the brake system air pressure.
7. Move the slack adjuster to connect the clevis. Install the clevis pin and a new cotter pin to fasten the clevis to the slack adjuster.
8. Adjust the lining-to-drum clearance. Refer to the procedure in this section.

Lubrication

Fill the Axle with Lubricant

NOTE: For additional lubrication information, refer to Maintenance Manual 1, Preventive Maintenance and Lubrication. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. The axle lubricant capacity changes when the drive pinion angle changes.
2. Remove the fill plug from the side of the axle housing bowl cover.
3. Add the axle lubricant through the fill plug hole. Fill the axle with the lubricant until the lubricant level is even with the bottom of the fill plug hole. Refer to Section 8.
4. Install the fill plug. Tighten the plug to 35 lb-ft (47 N•m) minimum. When correctly installed, one complete thread of the fill plug is visible between the housing and the plug head.
5. Road test the vehicle in an unloaded condition for 1-2 miles (1.6-3.2 km) at speeds not more than 25 mph (40 km/h). Recheck the lubricant levels and all of the fasteners.

6 Diagnostics

Troubleshooting

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Table B: T Series Parking Brake

Condition	Possible Causes	Actions Required
Parking brake does not apply or there is not enough braking force.	The camshaft is worn or damaged.	Remove and replace the camshaft.
	The air chamber is not installed correctly.	Install the air chamber correctly.
	There is a leak or restriction in the air lines.	Repair the air lines.
	The air chamber air diaphragm is damaged.	Repair or replace the air chamber.
	The parking brake is not adjusted correctly.	Adjust the parking brake.
	There is grease or other contamination on the brake linings.	Replace the brake linings.
	The linings are worn, damaged or missing.	Replace the brake linings.
Parking brake does not release when air pressure is released.	The air chamber power spring is not fully released (spring is caged).	Release the power spring in the air chamber and uncage the spring.
	The air pressure that holds the springs in a compressed position is not fully released.	Repair the air system.
	The parking brake is not adjusted correctly.	Adjust the parking brake.
	The power springs in the air chamber are weak or broken.	Replace the air chamber.
	There is grease or other contamination on the brake linings.	Replace the brake linings.
Parking brake is dragging.	There is not enough air pressure to hold the spring.	Repair the air system.
	The air lines are connected to the wrong ports.	Connect lines to the correct ports.
	There are leaks in the air lines.	Repair or replace the air lines.
	There are leaks in the spring brake assembly.	Repair or replace the spring brake.
	The drum has too much runout.	Repair or replace the drums.
	The shoe return spring is weak, damaged or missing.	Replace the shoe return spring.
	The camshaft is damaged.	Remove and replace the camshaft.
	The rollers are damaged.	Remove and replace the rollers.

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

During lubrication procedures, if grease flows from the seal near the camshaft head, replace the seal. Remove all grease or oil from the camshaft head, rollers and brake linings. Always replace linings contaminated with grease or oil, which can increase stopping distances. Serious personal injury and damage to components can result.

Lubrication

Camshaft Bushings

Specification

Multi-purpose chassis grease, 6% 12-hydroxy lithium stearate grease, NLGI Grade 1, Meritor specification O-617-A or equivalent

Multi-purpose chassis grease, 8% 12-hydroxy lithium stearate grease, NLGI Grade 2, Meritor specification O-617-B or equivalent

Schedule

Lubricate the camshaft bushings every 50,000 miles (80 000 km) or when necessary.

Procedure

Lubricate the camshaft bushings through the fittings in the differential carrier and the fitting in the drive pinion bearing cage. Figure 7.1.

Camshaft Splines

Specification

Metallic-base, temperature resistant anti-seize compound, Meritor specification O-637 or equivalent

Schedule

Lubricate the camshaft splines when necessary or when the brake is disassembled.

Procedure

Apply the lubricant to the camshaft splines. Figure 7.1.

Anchor Pins

Specification

Anchor pin grease, non-melting grease with Bentone thickeners, NLGI Grade 2, Meritor specification O-616 or equivalent

Schedule

Lubricate the anchor pins when necessary or when the brake is disassembled.

Procedure

Apply the lubricant to the anchor pins where the pins touch the brake shoes. Figure 7.1.

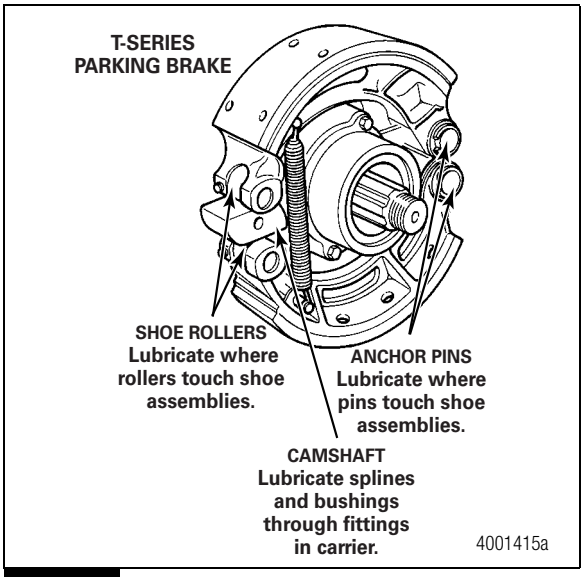


Figure 7.1

Shoe Rollers

Specification

Multi-purpose chassis grease, 6% 12-hydroxy lithium stearate grease, NLGI Grade 1, Meritor specification O-617-A or equivalent

Multi-purpose chassis grease, 8% 12-hydroxy lithium stearate grease, NLGI Grade 2, Meritor specification O-617-B or equivalent

Schedule

Lubricate the shoe rollers when necessary or when the brake is disassembled.

Procedure

Apply the lubricant to the roller pins where the pins touch the brake shoes. DO NOT put the lubricant on the part of the roller that touches the cam head. Figure 7.1.

7 Lubrication

Axle

Table C: Oil Specifications

	Gear Oil Type	A.P.I. Specification	SAE Grade	Meritor Specification	Military/SAE Specification	Outside Temperature
Non-Extended Drain Lubricants	Petroleum with EP Additives	GL-5	85W/140	0-76A	MIL-PRF-2105E and SAE J2360	Above +10°F (–12°C)
			80W/140	0-76B		Above –15°F (–26°C)
			80W/90	0-76D		Above –15°F (–26°C)
			75W/90	0-76E		Above –40°F (–40°C)
			75W	0-76J		From –40°F (–40°C) to 35°F (2°C)
			75W/140	0-76L		Above –40°F (–40°C)
Extended Drain Lubricants	Petroleum with Extended Drain Additives	GL-5	80W/90	—	MIL-PRF-2105E and SAE J2360	Above –15°F (–26°C)
	Semi-Synthetic		80W/90	—		Above –15°F (–26°C)
	Full Synthetic		75W/140	0-76M		Above –40°F (–40°C)
	Full Synthetic		75W/90	0-76N		Above –40°F (–40°C)

Table D: Lubricant Schedule

Type of Service	Check Oil Level	Oil Change Interval
Bus and Coach	Every 3,000 miles (4828 km)	Less than 60,000 miles (96 558 km) a year: Change two times per year
City Service		More than 60,000 miles (96 558 km) a year: Change every 25,000-30,000 miles (40 233-48 279 km)
Coach	Every 3,000 miles (4828 km)	Petroleum-based oil Initial drop at 1,000 miles (1609 km)
Highway Operation (Inter-city)		100,000 miles (160 930 km) or once per year, whichever is first
		Synthetic-based oil
		No initial drop required
		Change every 250,000 miles (402 325 km)

Table E: Lubricant Capacities

Axle Model	U.S. Pints *	Liters *
59722	30.5	14.4
59723	30.5	14.4
59732	30.5	14.4
59733	30.5	14.4
59752	30.5	14.4
59753	30.5	14.4
59842	30.5	14.4
59843	30.5	14.4
61042	41.0	19.4
61043	41.0	19.4
61052	41.0	19.4
61053	41.0	19.4
61063	44.0	20.8
61142	41.0	19.4
61143	41.0	19.4
61152	41.0	19.4
61153	41.0	19.4
61163	44.0	20.8
71063	44.0	20.8
71163	44.0	20.8
RC-23-160	41.0	19.4

* These quantities are approximate. Fill the housing with oil up to the bottom of the oil fill hole in the housing cover. If the wheel ends have been disassembled, oil must be provided to the wheel ends before the vehicle is placed back into service.

Fill Procedure for Axle Shafts and Hubs with Oil Fill Plugs

1. Rotate the hub until the fill plugs are at the top.
2. Remove the oil fill plugs. Fill each hub cavity with two pints (1 L) of rear axle lubricant.
3. Install and tighten the fill plugs to 10 lb-ft (13.8 N•m) minimum.

Axle Shafts and Hubs Without Oil Fill Plugs

1. Slowly drive each side of the vehicle over a six-inch (152.4 mm) raised surface so that the oil can flow out to the hubs.
2. Check the oil level in the housing and refill to the bottom of the fill plug.

7 Lubrication

T Series Parking Brake

Table F: Lubricant Specifications

Description	Lubricant Specification
Camshaft Bushings Shoe Rollers	Multi-purpose chassis grease, 6% 12-hydroxy lithium stearate grease, NLGI Grade 1, Meritor specification O-617-A, or equivalent
	Multi-purpose chassis grease, 8% 12-hydroxy lithium stearate grease, NLGI Grade 2, Meritor specification O-617-B, or equivalent
Anchor Pin	Anchor pin grease, non-melting grease with Bentone thickeners, Meritor specification O-616, or equivalent
Camshaft Splines	Metallic-base, temperature resistant anti-seize compound, Meritor specification O-637, or equivalent

Grease-Lubricated Wheel Ends

Table G: Lubricant Specifications

Description	Lubricant Specifications
Hub Cavity Bearing Cones	Multi-purpose chassis grease, 6% 12-hydroxy lithium stearate grease, NLGI Grade 1, Meritor specification O-617-A, or equivalent
	Multi-purpose chassis grease, 8% 12-hydroxy lithium stearate grease, NLGI Grade 2, Meritor specification O-617-B, or equivalent

Torque Specifications

Table H: 59000 Series Rear Axle and Parking Brake

		Torque Range	
Description	**Size**	**Lb-ft**	**N•m**
Axle Shaft-to-Flange Capscrew	0.312"-24	18-24	24-33
	0.50"-13	85-115	115-156
Axle Shaft-to-Flang Nut	0.438"-20	50-75	68-102
Plain Nut	0.50"-20	75-115	102-156
	0.312"-18	110-165	149-224
	0.625"-18	150-230	203-312
Axle Shaft-to-Flange Nut	0.438"-20	40-65	54-88
Locknut	0.50"-20	65-100	88-136
	0.562"-18	100-145	136-197
	0.625"-18	130-190	176-258
Breather Vent	0.375"-18	20 Min.	27 Min.
Drain Plug	0.75"-14	35 Min.	47 Min.
Carrier-to-Housing Nut	0.375"-16	35-50	48-68
	0.438"-14	60-75	81-102
	0.50"-13	85-115	115-156
	0.562"-12	130-165	176-224
	0.625"-11	180-230	244-312
Carrier-to-Housing Capscrew	0.50"-13	75-100	102-136
	0.50"-20	85-115	115-156
	0.625"-11	150-190	203-258
	0.625"-18	180-230	244-312
Cage-to-Carrier Nut	0.375"-16	30-50	41-68
	0.438"-14	50-75	68-102
	0.50"-13	75-115	102-156
	0.438"-12	110-165	149-224
	0.625"-11	150-230	203-312
Drum-to-Yoke Flange Nut	0.50"-20	85-115	115-156
Drive Pinion Nut	0.875"-20	200-275	271-373
	1.00"-20	300-400	407-542
	1.25"-12	700-900	949-1220
	1.25"-18	700-900	949-1220
	1.50"-12	800-1100	1085-1491
	1.50"-18	800-1100	1085-1491
	1.75"-12	900-1200	1220-1627
Brake Spider-to-Housing	0.625"-18	180-230	244-312
Wheel Stud-to-Hub	0.875"-14	175-250	237-339
Axle Shaft Oil Fill Plug		10 Min.	13.5 Min.

8 Specifications

Table I: 61000, 71000, RC-23-160 and RC-26-700 Series Rear Axle

		Torque Range	
Description	**Size**	**Lb-ft**	**N•m**
Axle Shaft-to-Flange Nut	0.438"-20	50-75	68-102
Plain Nut	0.50"-20	75-115	102-156
	0.312"-18	110-165	149-224
	0.625"-18	150-230	203-312
Axle Shaft-to-Flange Nut	0.438"-20	40-65	54-88
Locknut	0.50"-20	65-100	88-136
	0.312"-18	100-145	136-197
	0.625"-18	130-190	176-258
Hubcap Nuts	0.5625"-18	20-28	27-38
	0.625"-18	20-28	27-38
Breather Vent	0.375"-18	20 Min.	27 Min.
Drain Plug	0.75"-14	35 Min.	47 Min.
	M24x1.5	25 Min.	35 Min.
Carrier-to-Housing Nut	0.625"-11	180-230	244-312
Carrier-to-Housing Capscrew	0.625"-11	150-190	203-258
	0.625"-18	180-230	244-312
	M16x2	180-230	244-312
Drive Pinion Nut	M45 x 1.5	1000-1230	1360-1670
Brake Spider-to-Housing	0.625"-18	180-230	244-312
	M16x2	180-230	244-312
Wheel Stud-to-Hub	0.875"-14	175-250	237-339
Axle Shaft Oil Fill Plug		10 Min.	13.5 Min.
Brake Rotor-to-Hub Capscrew	0.625"-18	180-230	244-312
Torque Rod Bracket Capscrew	M20x2.5	340-400	460-540
ABS Sensor Mount Block Capscrew	M6x1	8-12	11-16

Meritor Heavy Vehicle Systems, LLC
2135 West Maple Road
Troy, MI 48084 USA
800-535-5560
arvinmeritor.com

Printed in USA

Revised 03-05
Maintenance Manual 23A (16579/24240)

ArvinMeritor™

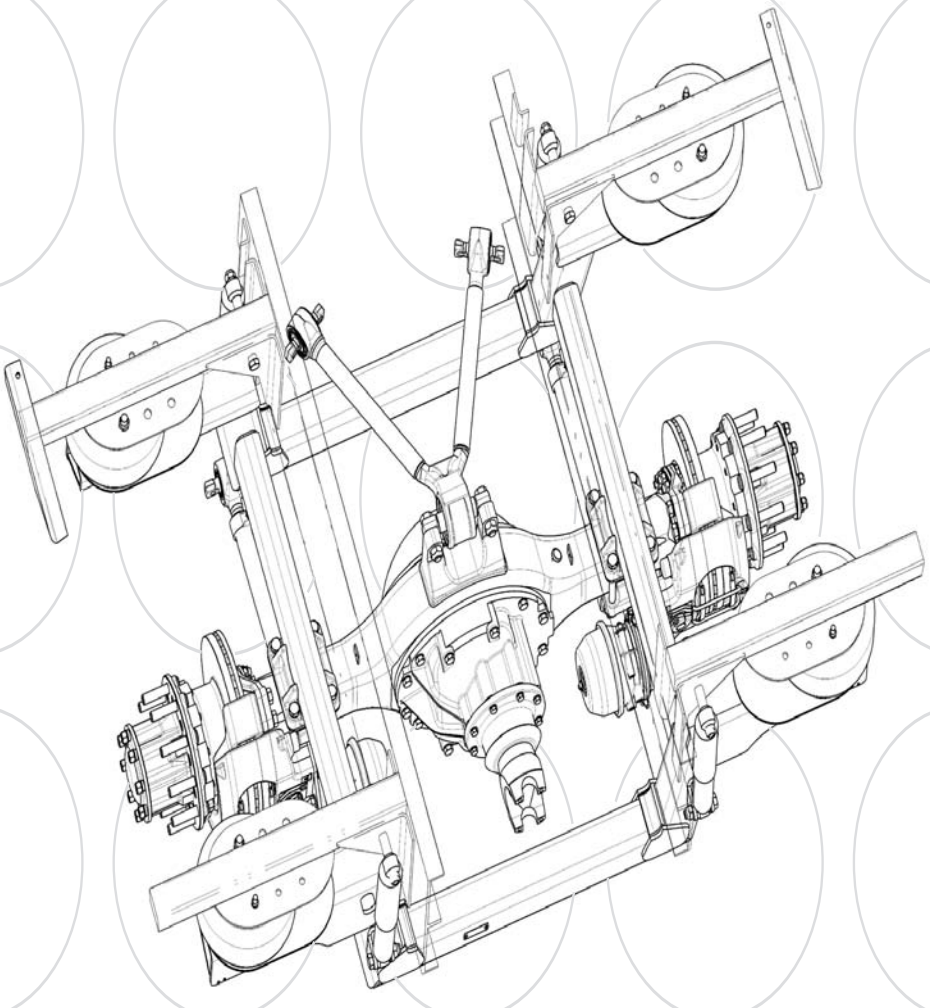
MERITOR®

an *ArvinMeritor* brand

Maintenance Manual MM-0374

RideStar™ RFA Series Rear Air Suspension System

Issued 06-04



Service Notes

About This Manual

This publication provides maintenance and service procedures for the Meritor RideStar™ RFA Series rear air suspension system.

Before You Begin

1. Read and understand all instructions and procedures before you begin to service components.
2. Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.
3. Follow your company's maintenance and service, installation, and diagnostics guidelines.
4. Use special tools when required to help avoid serious personal injury and damage to components.

Hazard Alert Messages and Torque Symbols

⚠ WARNING

A Warning alerts you to an instruction or procedure that you must follow exactly to avoid serious personal injury and damage to components.

⚠ CAUTION

A Caution alerts you to an instruction or procedure that you must follow exactly to avoid damage to components.

This symbol alerts you to tighten fasteners to a specified torque value.

How to Obtain Additional Maintenance and Service Information

On the Web

Visit the DriveTrain Plus™ by ArvinMeritor Tech Library at arvinmeritor.com to easily access product and service information. The Library also offers an interactive and printable Literature Order Form.

ArvinMeritor's Customer Service Center

Call ArvinMeritor's Customer Service Center at 800-535-5560.

Technical Electronic Library on CD

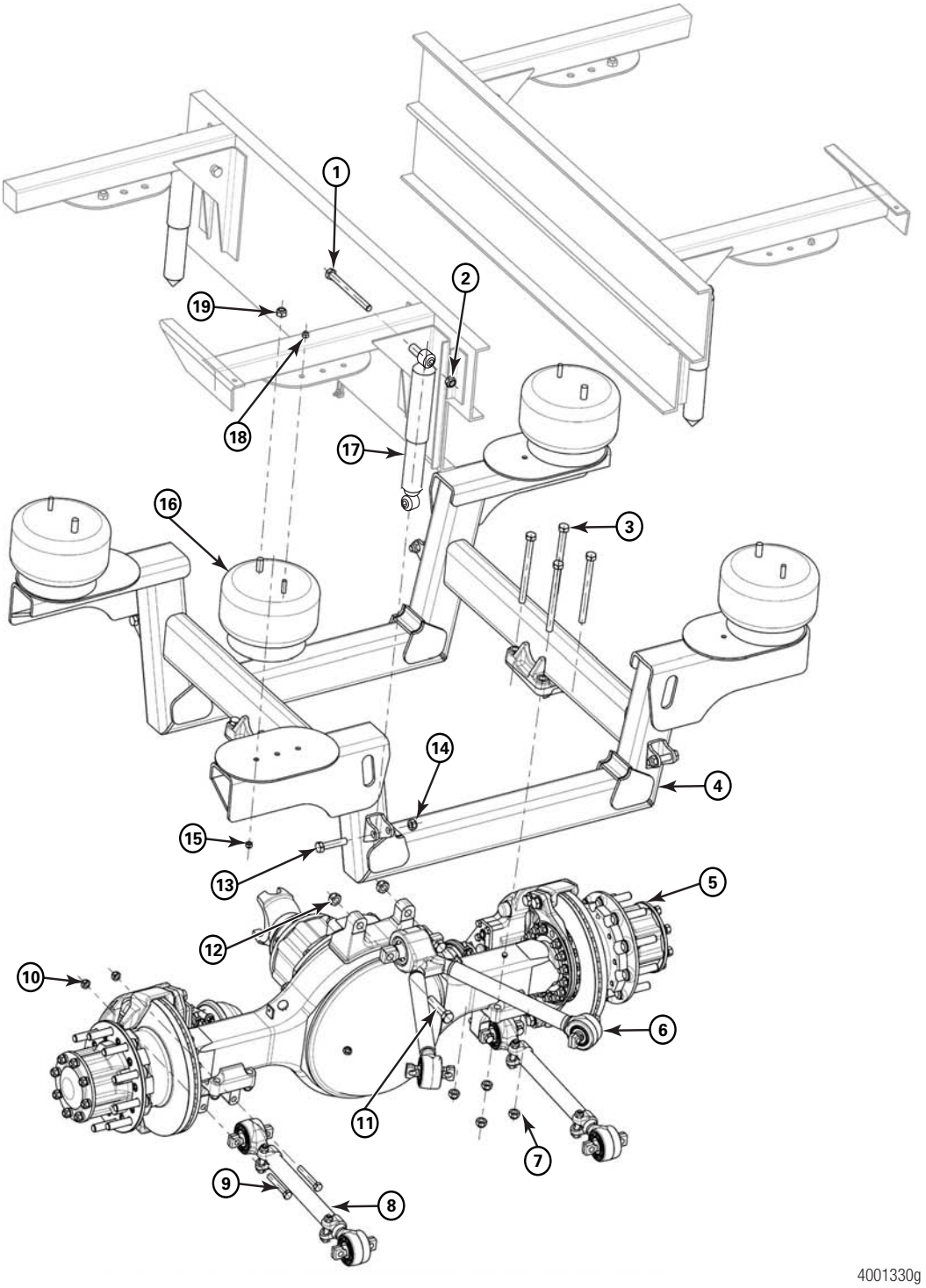
The DriveTrain Plus™ by ArvinMeritor Technical Electronic Library on CD contains product and service information for most Meritor and Meritor WABCO products. $20. Specify TP-9853.

How to Obtain Tools and Supplies Specified in This Manual

Call ArvinMeritor's Commercial Vehicle Aftermarket at 888-725-9355 to obtain Meritor tools and supplies.

Contents

1 Exploded View



1 Exploded View

Item	Description
1	Shock Absorber Upper Capscrew
2	Shock Absorber Upper Locknut
3	Axle Mounting Capscrew
4	Frame Assembly
5	Axle Assembly
6	Upper Torque Rod Assembly
7	Axle Mounting Locknut
8	Lower Torque Rod
9	Lower Torque Rod Capscrew
10	Lower Torque Rod Locknut
11	Upper Torque Rod Capscrew
12	Upper Torque Rod Locknut
13	Shock Absorber Lower Capscrew
14	Shock Absorber Lower Locknut
15	Air Spring Lower Locknut
16	Air Spring
17	Shock Absorber
18	Air Spring Upper 1/2″ Locknut
19	Air Spring Upper 3/4″ Locknut

2 Introduction

Description

Meritor RideStar™ RFA Series rear air suspension systems have a parallelogram design with four air springs and four links. The suspension has a "V" style, upper torque rod assembly and two longitudinal lower torque rods. The RFA is an integrated system that includes a Meritor drive axle and brakes. For information about the other Meritor components, refer to the appropriate maintenance manual. To obtain these publications, refer to the Service Notes page on the front inside cover of this manual.

Components

Key inspection and maintenance areas of the RFA suspension are:

- Frame and frame welds
- Upper and lower torque rods
- Shock absorbers
- Air springs

Refer to the appropriate Meritor maintenance manuals and technical bulletins for axle and brake component inspection and maintenance procedures. To obtain these publications, refer to the Service Notes page on the front inside cover of this manual.

Features

The RFA suspension features:

- A 23,000 lb. (10 430 kg) capacity single rear axle air suspension
- A four link, four air spring base construction
- A nominal ride height of 8.94-inches (227 mm) with 7.13-inches (181 mm) of total travel, 3.7-inches (94 mm) of jounce and 3.43-inches (87 mm) of rebound

Identification

The suspension identification tag is located on the front of the frame assembly, near the middle of the crossmember. Figure 2.1.

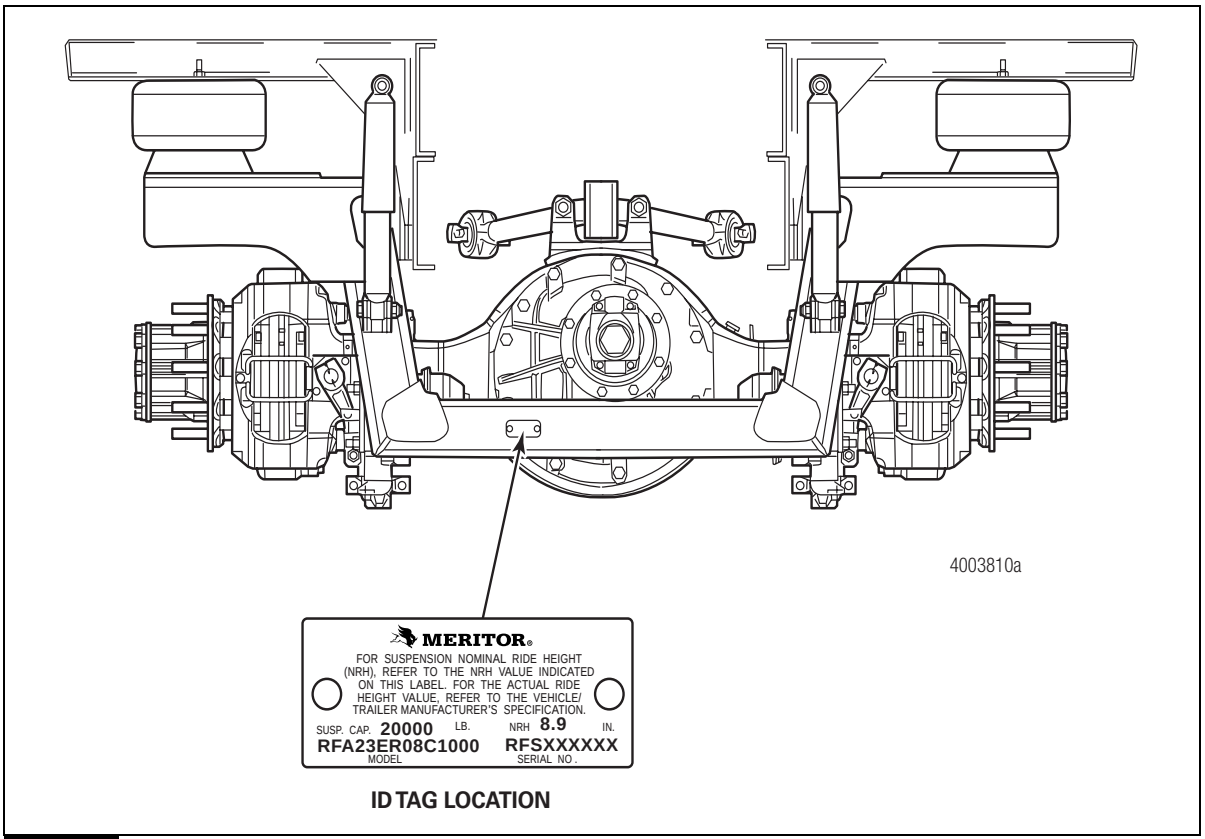


Figure 2.1

Model Numbers and Designations

The model number on the identification tag provides suspension and axle information. Figure 2.2.

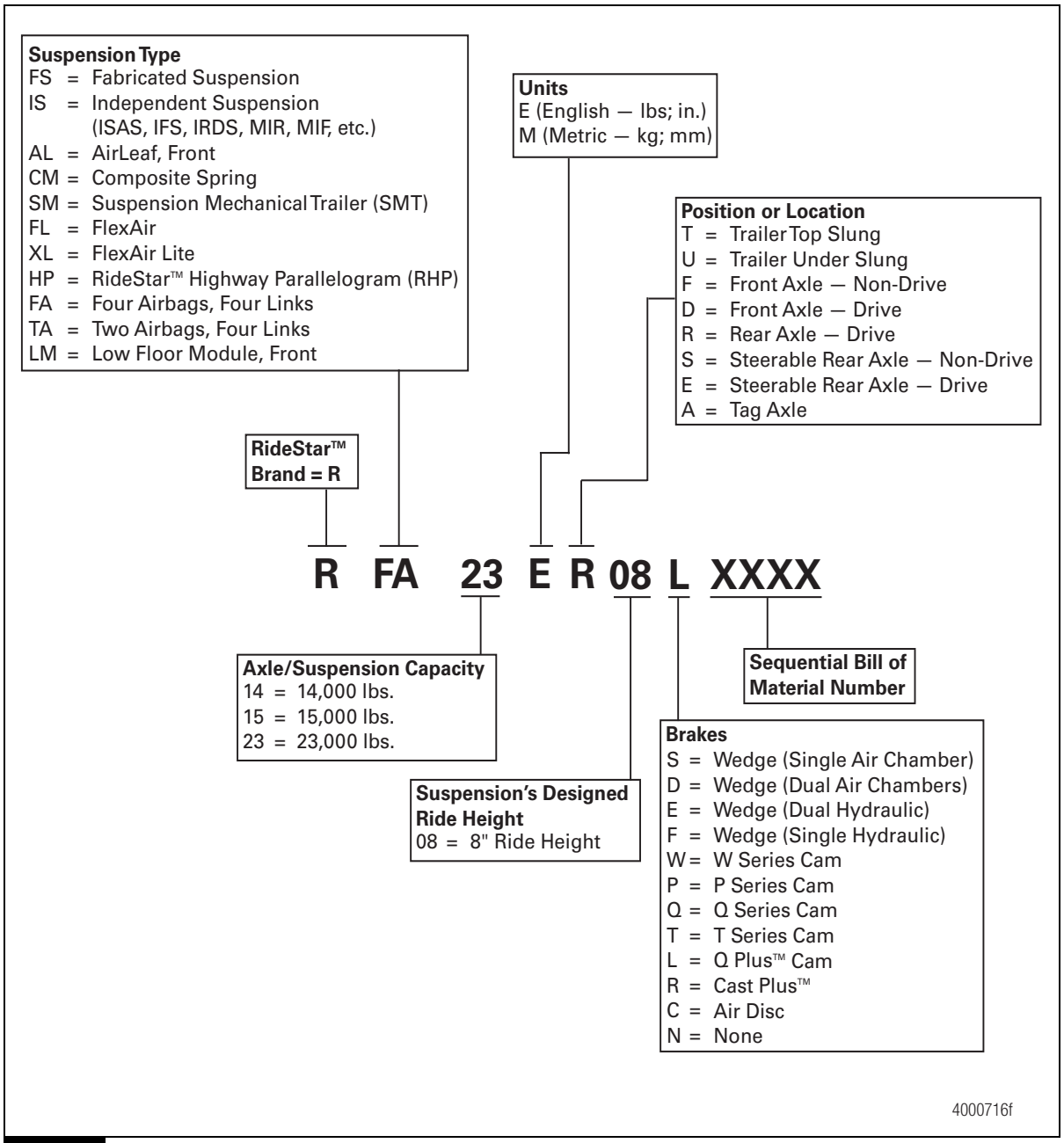


Figure 2.2

3 Suspension Ride Height, Travel and Tire Clearance

Suspension Ride Height

Suspension ride height is the distance from the centerline of the axle to the underside of the vehicle frame. Figure 3.1.

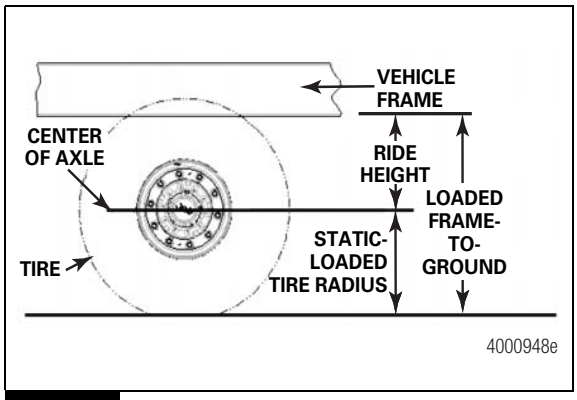


Figure 3.1

All Meritor air suspensions are designed to operate at a specific ride height, which must be maintained during the life of the suspension. Otherwise incorrect loading can occur, which can affect suspension performance, shorten component life and void the Meritor warranty.

Operating a vehicle with ride height higher than specified by the application can cause the vehicle to be over the legal height limit, depending on the type of vehicle and payload.

To obtain the correct ride-height specification, check the suspension's identification tag located on the rear of the frame assembly. Also refer to Section 2.

How to Determine the Correct Ride Height

Consider the following factors when you determine the correct suspension ride height.

Vehicle Frame-to-Ground Distance

You must measure the distance from the bottom of the vehicle frame to the ground at each suspension location. Figure 3.2. This measurement determines the required vehicle height. Refer to the vehicle manufacturer's information for ride height specifications and adjustment procedures.

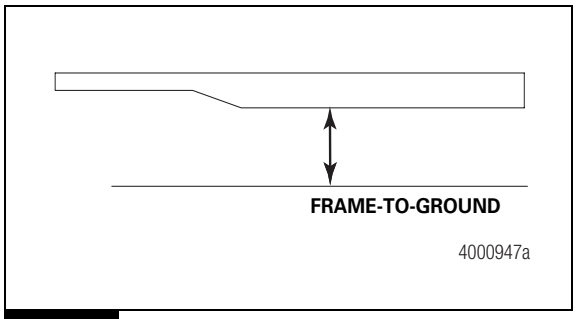


Figure 3.2

Suspension Ride Height Calculation

To calculate the required suspension ride height, subtract the tire's static-loaded radius from the loaded frame-to-ground dimension. Figure 3.1.

Suspension Travel

Jounce and Rebound

Jounce is the amount of upward axle travel from the suspension's designed ride-height position. Figure 3.3. The RFA suspension has 3.7-inches (94 mm) of jounce.

Rebound is the amount of downward axle travel from the suspension's designed ride-height position. Figure 3.3. The RFA suspension has 3.43-inches (87 mm) of rebound.

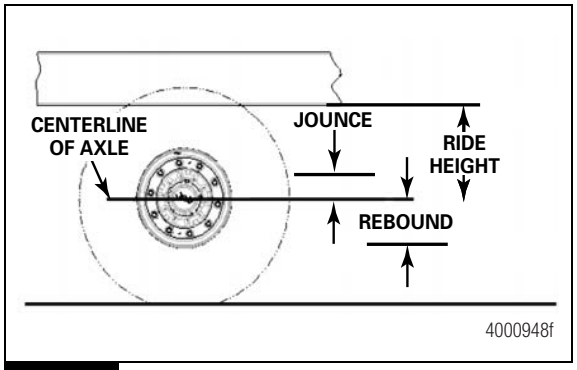


Figure 3.3

Tire Clearance

Meritor's RFA air suspension requires 1.5-inches (38 mm) minimum tire clearance between the top of the tire and the vehicle frame structure above the tire when the suspension is at full jounce. Figure 3.4.

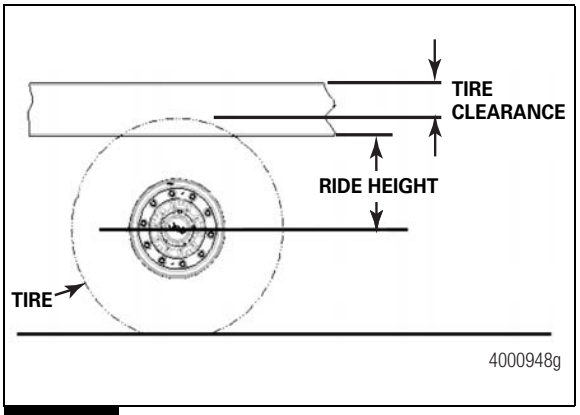


Figure 3.4

How to Determine Tire Clearance

Determine tire clearance by adding the specified tire clearance to the suspension jounce. This sum is the distance required between the top of the tire and the top of the vehicle frame when the suspension is at its designed ride height.

Example

- Jounce = 3.7-inches (94 mm)
- Tire Clearance = 1.5-inches (38 mm)

Calculation

3.7-inches (94 mm) + 1.5-inches (38 mm) = 5.2-inches (132 mm) = Space required above the tire at ride height

A 2-inch (51 mm) clearance is required between the inside of the tire and the vehicle frame on each side. This clearance allows for both lateral movement of the suspension and tire deflection. Figure 3.5.

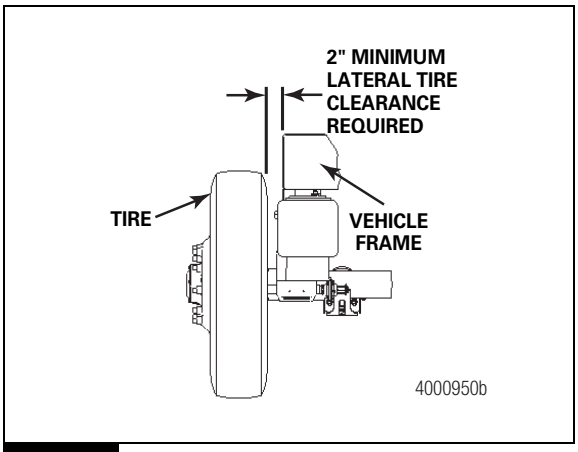


Figure 3.5

4 Inspection

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Replace damaged or out-of-specification suspension components. Do not bend, repair or recondition suspension components by welding or heat-treating. Serious personal injury and damage to components can result.

Intervals

Inspect the suspension and air suspension components annually or at regular intervals during normal operation.

Before each trip, visually inspect the suspension system and listen for air leaks.

Inspect the shock absorbers, air springs and rubber bushings when the axle or brakes are inspected. Replace the components as necessary.

After 1,000 miles (1609 km) of service on a new vehicle and after component replacement, tighten all fasteners to the specified torque. Refer to Section 7 for torque specifications.

At each preventive maintenance inspection, or annually, visually inspect all fasteners for looseness or movement. Tighten loose fasteners to the specified torque. Refer to Section 7 for torque specifications.

Replace damaged fasteners to maintain the specified torque and to comply with warranty requirements.

NOTE: When replacing any suspension component, never reuse capscrews, washers or locknuts.

Shock Absorbers

The following conditions may indicate that the shock absorbers should be replaced. If any of these conditions exist, inspect the shock absorbers and repair or replace parts as necessary.

- Uneven tire wear. Check balance before replacing the shock absorbers.
- Poor ride quality
- Excess vibration
- Premature wear on electrical and cooling system components
- Damaged air springs
- Leaking shock absorber

Inspection

Inspect the shock absorbers for the following conditions. If any of these conditions exist, repair or replace parts as necessary. Figure 4.1.

- Damaged upper or lower mount
- Damaged upper or lower bushing
- Incorrect installation
- Damaged dust tube
- Bent or dented shock absorber body

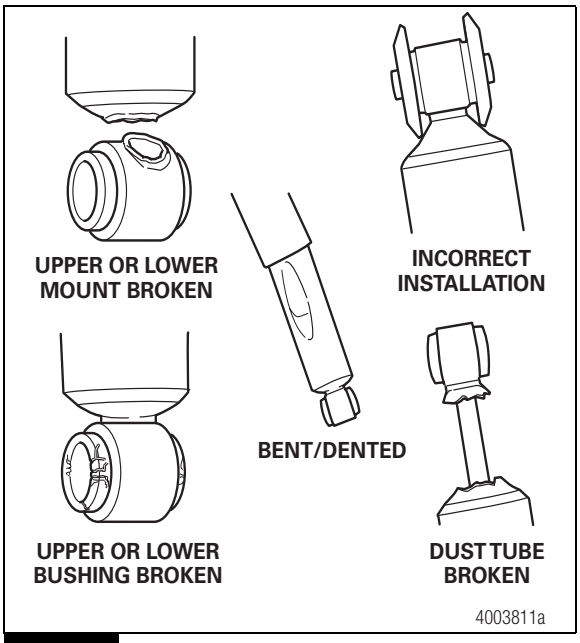


Figure 4.1

Leaking Shock Absorbers

Misting shock absorbers are often misdiagnosed as leaking shock absorbers. Misting occurs when very small amounts of shock absorber fluid evaporate at high operating temperatures through the shock absorber upper seal. When the mist reaches the cooler outside air, it condenses and forms a film on the outside of the shock absorber body.

When mixed with road debris and dust, a grime will often coat the entire body of the shock absorber. Misting is a normal and necessary function of the shock absorber. The evaporating fluid lubricates the seal. A leaking shock absorber will have fluid leaking in streams from the upper seal. Inspect the shock absorbers for leaking when the shock absorber is fully extended. Figure 4.2.

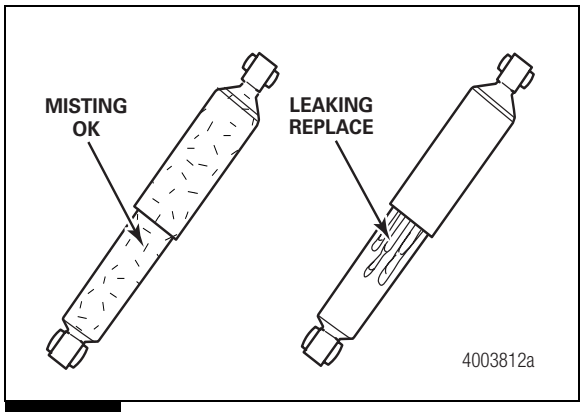


Figure 4.2

Heat Test

Shock absorbers operate at temperatures between ambient and 350°F (177°C). Shock absorbers should be slightly warm or hot after normal use. If poor ride quality exists and you suspect the shock absorber is not operating correctly, perform the following heat test.

1. Drive the vehicle at moderate speeds for at least 15 minutes.
2. Within a few minutes of driving the vehicle, touch the chassis near the shock absorber and then carefully touch each shock absorber body below the dust cover or tube. All shock absorbers should be warmer than the chassis.
    - **If a shock absorber is cooler than the chassis or the shock absorber on the other end of the axle:** Inspect the shock absorber for possible damage. If necessary, remove the cooler shock absorber.
3. Shake the shock absorber to check it for internal damage. Listen for metal parts rattling inside the shock absorber. Loose metal parts inside the shock absorber can indicate internal damage.

Torque Rods

Torque rods maintain the axle position. The upper torque rod maintains the lateral, axial and rotational position. The lower torque rods maintain the axial and rotational position. Worn torque rods can cause more than jerky stops and starts. They can also cause excessive tire wear, seal leaks, axle housing fatigue, ring and pinion gear wear and U-joint/driveline failures.

The mounting bracket that attaches the torque rod to the chassis is supplied by the vehicle manufacturer. It is important to check the tightening torque of the capscrew and locknuts during each preventive maintenance inspection. Refer to the vehicle manufacturer's information and Section 7 for torque specifications.

Bar Pin Bushings

Inspect all of the bar pin bushings in the upper and lower torque rods. Use a two-foot (61cm) pry bar to check the arm pivot bushings for looseness and wear. Replace the bushings if any free play is detected. Check each location in both axial and radial directions.

Separation of the elastomer off the bar pin is permissible up to a third (1/3) of the circumference.

Replacement is also necessary if the following wear characteristics are determined:

1. Cracks or fracture of the metal parts of the bushing. Figure 4.3.

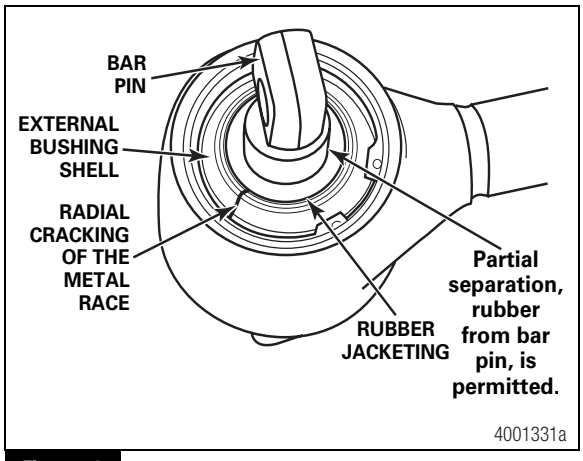


Figure 4.3

4 Inspection

2. Plastic deformation of the sheet-metal race
3. Inadequate bolted connection, i.e., loosened, broken or lost bolt
4. Damage to the circlip, circlip detached from the groove, broken or lost

- **If damage to the inner housing contour or the circlip groove is determined during replacement of the elastomeric bearing:** Replace the entire torque rod.

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

Verify that all personnel are clear of the vehicle before you inflate or deflate the air springs. The air suspension system has various pinch points that can cause serious personal injury.

Removal

Air Spring

NOTE: When you replace the air springs on an RFA series suspension, you must install Meritor components or components purchased from a Meritor-approved distributor. Use of non-approved components will affect suspension performance and void the Meritor warranty.

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Raise the vehicle so that the suspension is at or above the designed ride height. Support the rear of the vehicle with safety stands. Refer to the vehicle manufacturer's instructions for the correct safety stand placement locations.
3. Drain the air pressure from the air system.
4. Disconnect the air line from the air spring.
5. Remove the locknuts from the top and bottom of the air spring. Discard the locknuts.
6. Compress the air spring until the studs clear the upper and lower mounting plates.
7. Remove the air spring from the vehicle.

Shock Absorber

⚠ WARNING

The suspension is equipped with gas-pressurized shock absorbers. Heat or flame can cause the shock absorbers to extend unassisted. Do not apply heat or flame to the shock absorbers during removal or component servicing. Failure to follow these instructions can result in serious personal injury.

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.

NOTE: Shock absorbers act as suspension rebound stops. Do not remove the shock absorbers if the vehicle is raised and the axle is not supported.

2. Remove the shock absorber upper capscrew and locknut. Discard the capscrew and locknut.
3. Remove the shock absorber lower capscrew and locknut. Discard the capscrew and locknut.
4. Remove the shock absorber from the vehicle.

Upper Torque Rod

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Raise the rear of the vehicle until the rear wheels are off the ground. Support the rear of the vehicle and the rear axle with safety stands. Refer to the vehicle manufacturer's instructions for the correct safety stand placement locations.
3. Remove the two capscrews and locknuts that secure the upper torque rod assembly to the axle housing. Discard the capscrews and locknuts.
4. Refer to the vehicle manufacturer's instructions to remove the fasteners that secure each upper torque rod arm to the frame crossmember.
5. Remove the upper torque rod assembly from the vehicle.

5 Removal

Lower Torque Rod

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Raise the rear of the vehicle until the rear wheels are off the ground. Support the rear of the vehicle and the rear axle with safety stands. Refer to the vehicle manufacturer's instructions for the correct safety stand placement locations.
3. Remove the two capscrews and locknuts that secure each lower torque rod to the axle housing. Discard the capscrews and locknuts.
4. Refer to the vehicle manufacturer's instructions to remove the fasteners that secure each lower torque rod to the vehicle.
5. Remove the lower torque rods from the vehicle.

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

Verify that all personnel are clear of the trailer before you inflate or deflate the air springs. The air suspension system has various pinch points that can cause serious personal injury.

Installation

Lower Torque Rod

1. Position the lower torque rods onto the axle housing.
2. Install two new capscrews and locknuts into each lower torque rod and axle housing. Tighten the locknuts to 150-190 lb-ft (203-258 N•m).
3. If the torque rod is adjustable, adjust the length of the new torque rod to match the length of the old torque rod that is being replaced. Tighten the adjustment clamp fasteners to 85-100 lb-ft (115-135 N•m).
4. Refer to the vehicle manufacturer's instructions to install the fasteners that secure each lower torque rod to the vehicle.

Upper Torque Rod

1. Position the upper torque rods onto the axle housing.
2. Install two new capscrews and locknuts into the upper torque rod assembly and axle housing. Tighten the locknuts to 450-550 lb-ft (610-746 N•m).
3. Refer to the vehicle manufacturer's instructions to install the fasteners that secure each upper torque rod arm to the frame crossmember.

Shock Absorber

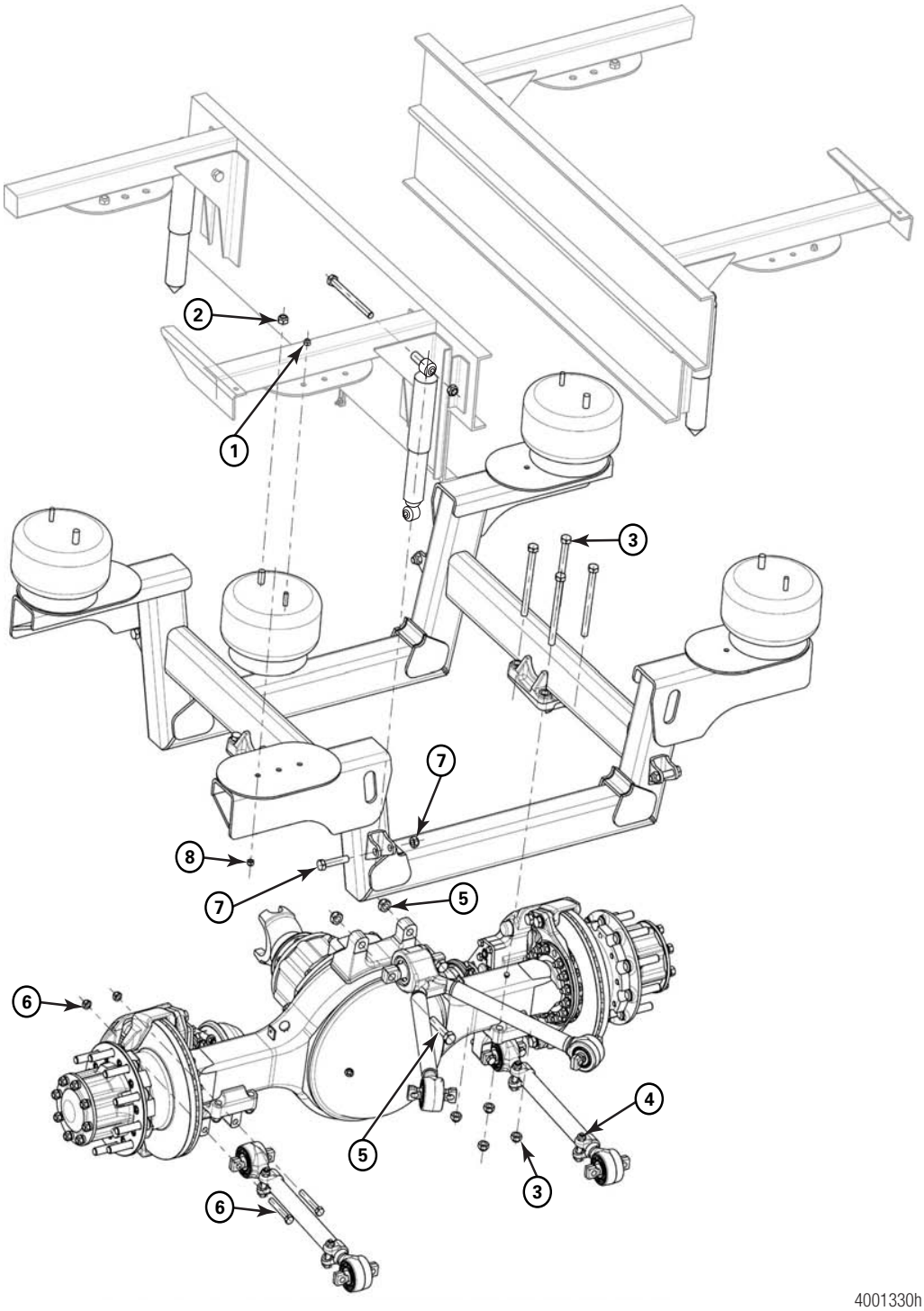
1. Refer to the vehicle manufacturer's instructions to install the shock absorber at the upper mount location on the frame.
2. Compress or extend the shock absorber until the lower fastener point is aligned with the lower mount on the suspension.
3. Install a new capscrew and locknut to secure the shock absorber in the lower mount. Tighten the locknut to 270-350 lb-ft (366-474 N•m).

Air Spring

1. Support the vehicle with safety stands. Refer to the vehicle manufacturer's instructions for the correct safety stand placement locations.
2. Compress the air spring and install it between the upper and lower air spring plates.
3. Install a new locknut onto the mounting stud on the bottom of the air spring. Tighten the locknut to 20-30 lb-ft (27-41 N•m).
4. Refer to the vehicle manufacturer's instructions to secure the air spring to the upper mounting locations.
5. Connect the air line to the air spring.

7 Specifications

Torque Specifications

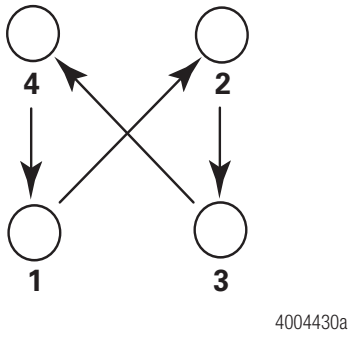


4001330h

7 Specifications

Item	Description	Size	Torque Value	
			Lb-Ft	N•m
1	Air Spring Upper Locknut	1/2″	20-30	27-41
2	Air Spring Lower Locknut	3/4″	40-50	54-68
3	Axle Mounting Capscrew and Locknut	3/4″ x 9.5″	300-350[1]	407-474
4	Lower Torque Rod Adjusting Clamp Capscrew and Locknut	5/8″ x 11″	85-100	115-135
5	Upper Torque Rod Assembly Capscrew and Locknut	7/8″ x 3.75″	450-550	610-746
6	Lower Torque Rod Capscrew and Locknut	5/8″ x 4″	150-190	203-258
7	Shock Absorber Lower Capscrew and Locknut	3/4″ x 3.5″	270-350	366-474
8	Air Spring Lower Locknut	1/2″	20-30	27-41

[1] Tighten all eight axle mounting capscrews and locknuts hand tight. Then progressively tighten to specification in a crossing pattern as shown in Figure 7.1.



AXLE MOUNTING CAPSCREW AND LOCKNUT TIGHTENING SEQUENCE

Figure 7.1

NOTE: After tightening, verify the torque on all fasteners. If one is low, retighten all fasteners.

Meritor Heavy Vehicle Systems, LLC
2135 West Maple Road
Troy, MI 48084 USA
800-535-5560
arvinmeritor.com

Printed in USA

Issued 06-04
Maintenance Manual MM-0374 (16579/24240)

ArvinMeritor™

TP-02173
Revised 11-04

MERITOR®

Technical Bulletin

DiscPlus™ DX195 and DX225 Air Disc Brakes

Inspection, Installation and Diagnostics

Air Disc Brake Inspection Intervals and Procedures

⚠ ASBESTOS AND NON-ASBESTOS FIBERS WARNING

Some brake linings contain asbestos fibers, a cancer and lung disease hazard. Some brake linings contain non-asbestos fibers, whose long-term effects to health are unknown. You must use caution when you handle both asbestos and non-asbestos materials.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

Intervals

Periodically inspect the brakes. Check the stroke length and inspect the brake components for signs of wear and damage.

Use the schedule below that gives the most frequent inspections.

- Fleet chassis lubrication schedule
- Chassis manufacturer lubrication schedule
- At least four times during lining life
- At tire replacement

Check the Push Rod Travel or Adjusted Chamber Stroke Length

Use the following procedure to check the in-service push rod travel or adjusted chamber stroke.

1. Wear safe eye protection. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. The engine must be OFF. Check the gauges in the cab to verify that the air pressure in the tanks is 90-100 psi (620-689 kPa).
3. Release the parking brake.
4. Measure the distance from the bottom of the air chamber to the center of the clevis pin while the brakes are released. This distance should be approximately 1.46-inches (37 mm). Figure 1.
   - **If the distance is greater than 1.62-inches (41 mm):** Refer to the diagnostics table in this bulletin to determine the cause and correct the condition.

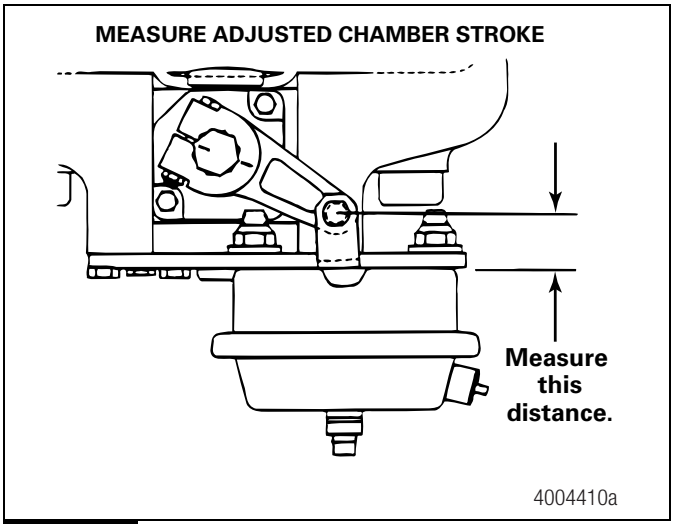


Figure 1

5. Have another person apply and hold the brakes one full application. Measure the distance from the bottom of the air chamber to the center of the clevis pin while the brakes are applied.
6. Subtract the measurement you obtained in Step 4 from the measurement you obtained in Step 5. The difference is the push rod travel or adjusted chamber stroke.
   - **If push rod travel or adjusted chamber stroke is greater than two-inches (51 mm):** Refer to the diagnostics table in this bulletin.
   - **If push rod travel or adjusted chamber stroke is less than 0.88-inches (22 mm):** Readjust the brake. Refer to the initial brake adjustment procedure in this bulletin.

Caliper Assembly Inspection

1. Remove the adjuster plug and washer. Figure 2.

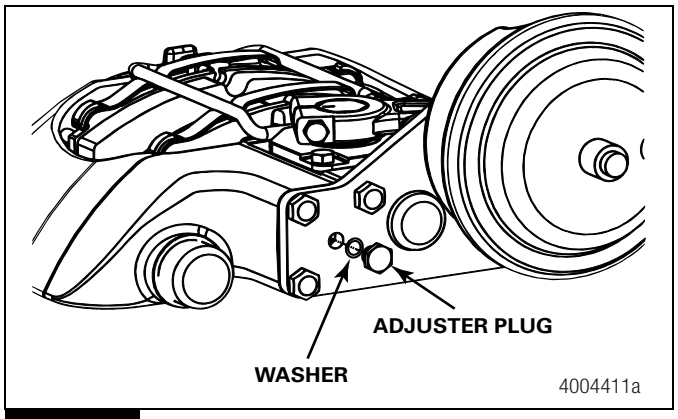


Figure 2

⚠ CAUTION

Always use a 6 mm Allen wrench to manually adjust and de-adjust the brake. Do not use air or power tools. Damage to components can result.

2. Use a 6 mm Allen wrench to de-adjust the brake. Stop turning the Allen wrench when you feel resistance. When you feel resistance, adjust the brake 1/4 turn to ensure that automatic adjustment will occur. Figure 3. Note the location of the air chamber with respect to the adjustment direction.

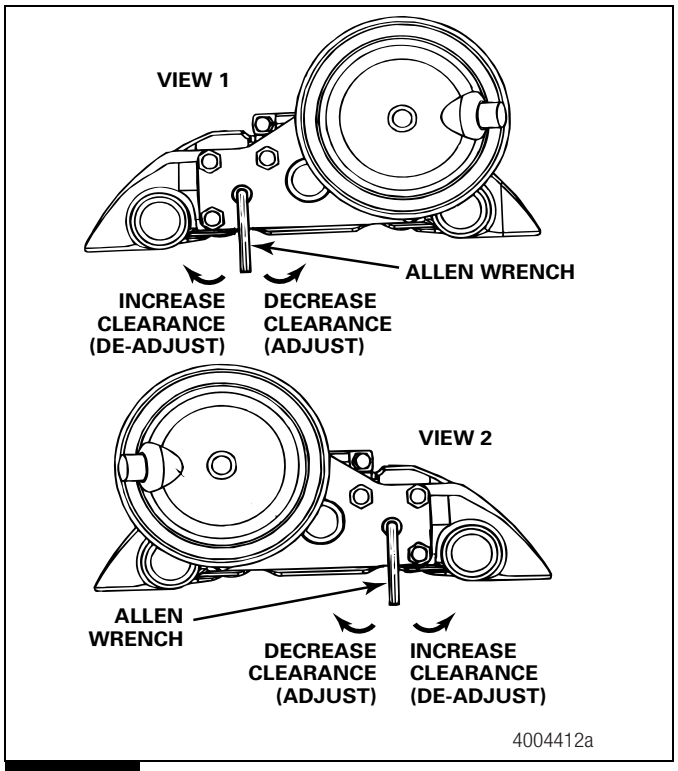


Figure 3

3. Remove the stabilizer bar retainer and cotter pin. Open the bar so that it is out of the way. Figure 4.

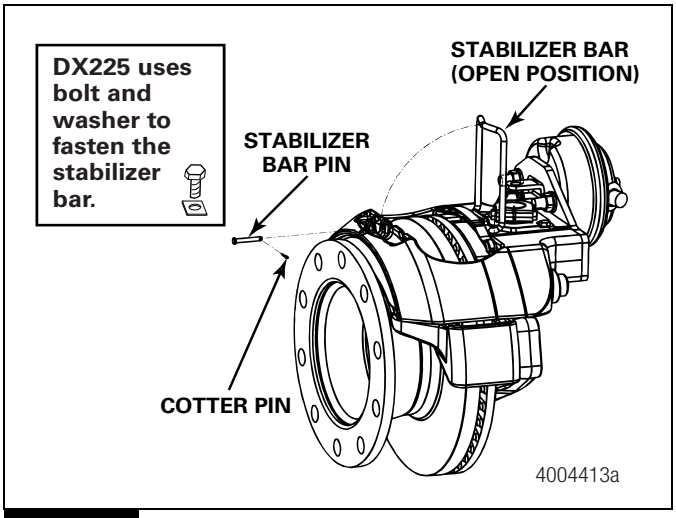


Figure 4

4. Lift the INBOARD brake pad out of the caliper assembly. Mark the brake pad INBOARD. Figure 5.

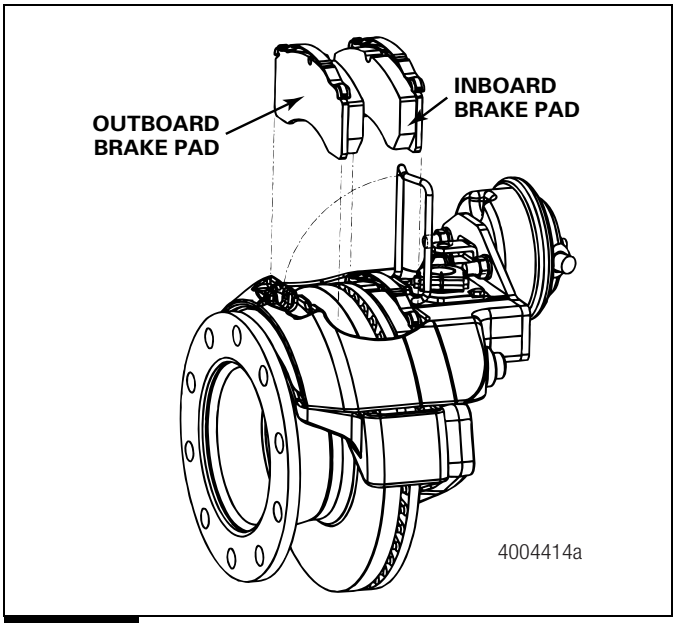


Figure 5

5. Slide the caliper OUTWARD and remove the OUTBOARD brake pad. Mark the brake pad OUTBOARD. Figure 5.

6. Inspect the brake pads for cracked friction material (lining). Check if the friction material is loose or detached from the backing plate. Inspect the anti-rattle springs attached to the brake pad. Replace bent, cracked or broken springs. Figure 6.

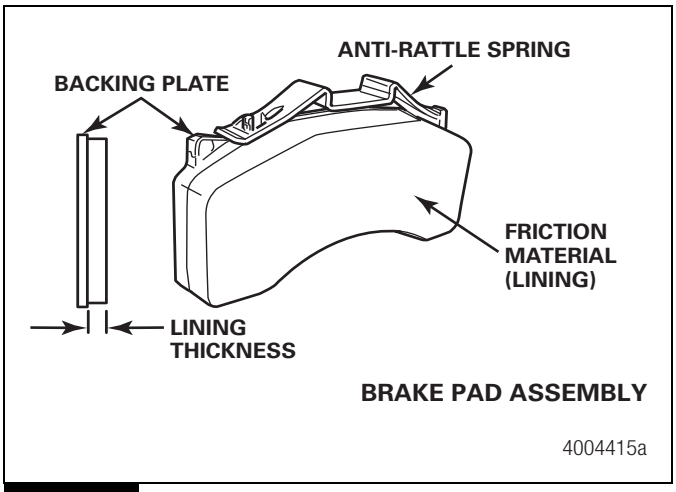


Figure 6

7. Measure the friction material (lining) thickness. Replace the brake pad assembly before the lining thickness reaches 0.200-inch (5.1 mm). Figure 6.
8. Remove dirt or dust from the brake pad contact surfaces of the saddle abutments.
9. Verify that the caliper slides freely on the slide pins. Figure 7.

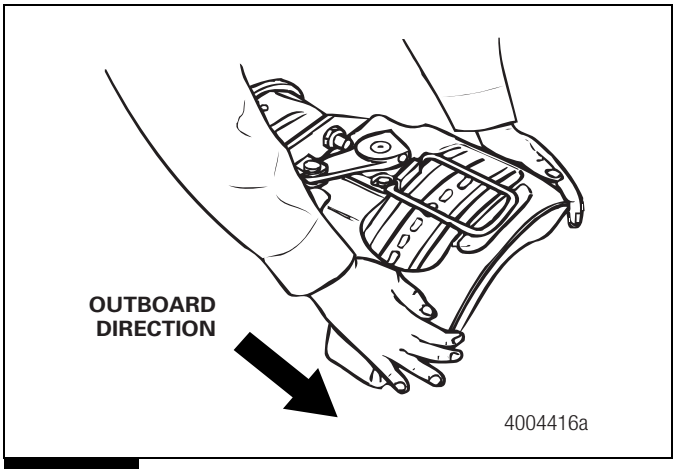


Figure 7

10. Inspect the caliper boots. If the boots are damaged, replace the caliper. Figure 8.
    - **If you are replacing the calipers:** Refer to the caliper assembly removal and installation procedures in this bulletin.

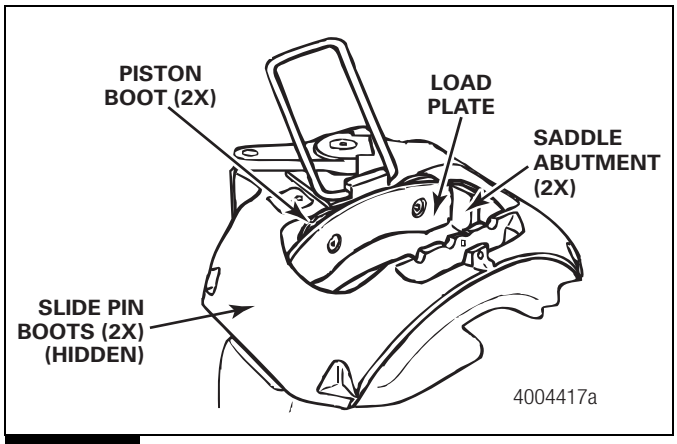


Figure 8

Disc or Rotor Inspection

With the pads removed, rotate the wheel and inspect the rotor. Inspect both sides of the rotor for cracks and heat checks. Replace the rotor, if necessary.

Cracks

⚠ WARNING

Always replace a cracked rotor to avoid serious personal injury and damage to components.

When the crack extends through a section of the rotor, replace the rotor. Figure 9.

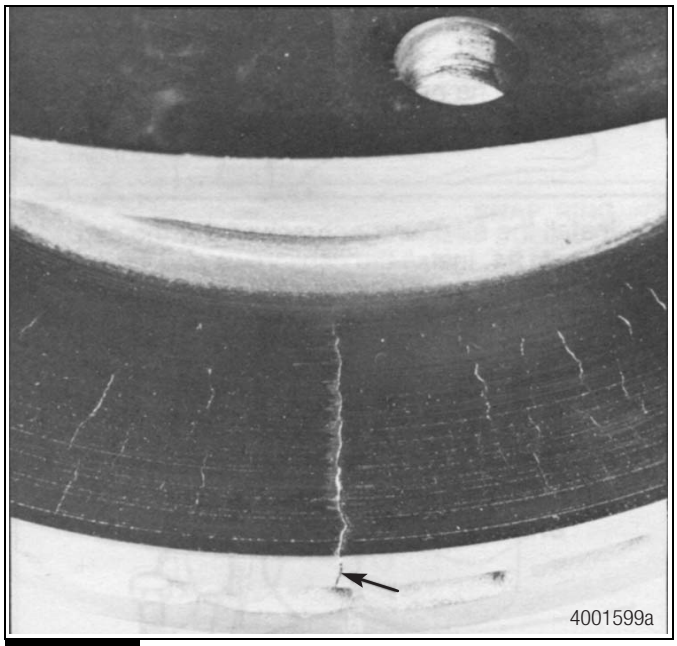


Figure 9

Heat Checking

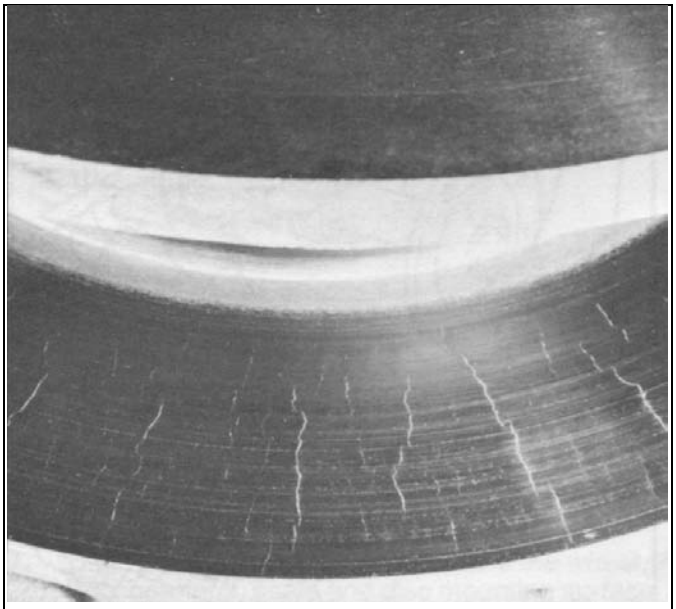
Heat checks are short, thin, sometimes numerous, radial interruptions of the rotor braking surfaces. They are the result of disc brake operation. They are caused by the heating and cooling that occurs as the brakes are applied time after time. Heat checks will frequently wear away and reform, or they may become braking surface cracks, depending on such factors as the lining and rotor wear rate, brake balance, and how hard the brakes are used. There are two kinds of heat checking: light and heavy.

Light Heat Checking

Cracks on the surface of the rotor that result from light heat checking are small and fine and do not require rotor replacement.

Heavy Heat Checking

Heavy heat checking is surface cracks that have width and depth. Figure 10. If you find heavy heat checking, replace the rotor.

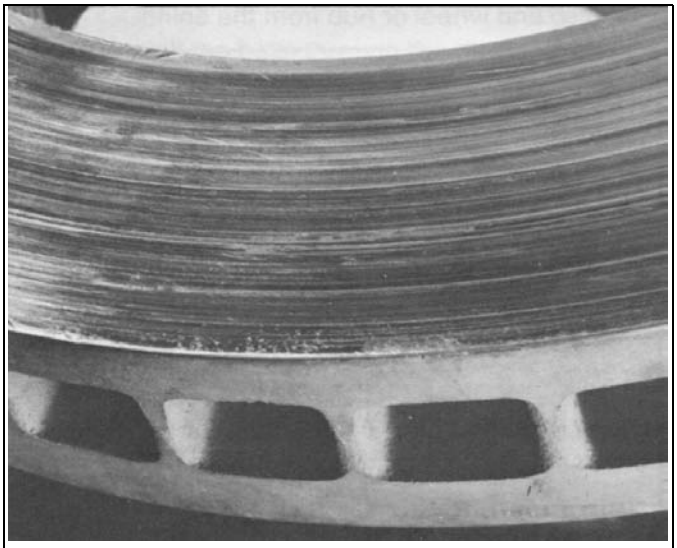


4001600a

Figure 10

Deep Grooves or Scores

Inspect both sides of the rotor. If you find deep grooves or scores, replace the rotor. Figure 11. If the grooves or scores are not too deep, you may continue to use the rotor.

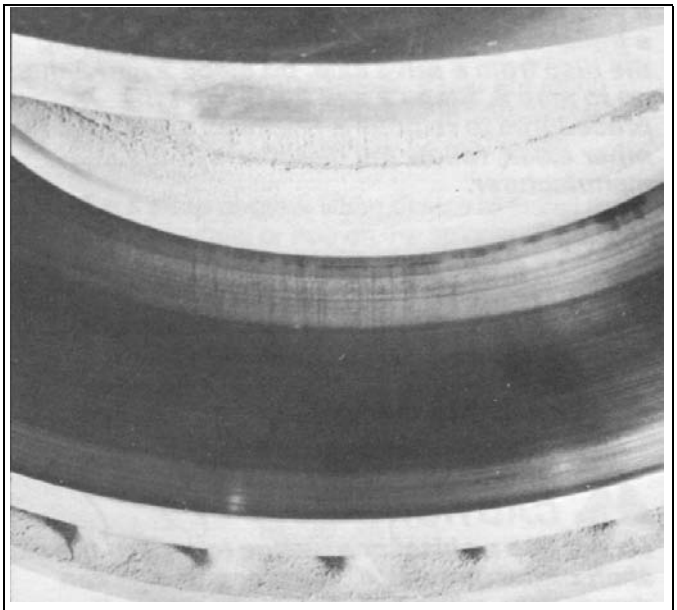


4001601a

Figure 11

Blue Marks or Bands

Blue marks or bands indicate that the rotor was very hot. Refer to the diagnostics table in this bulletin to determine the cause and correct the condition. Figure 12.



4001602a

Figure 12

Measure the Rotor Thickness

Use a micrometer to measure the rotor thickness. The rotor must be at least 1.626-inches (41.3 mm). Figure 13.

- **If the rotor thickness is less than the specification:** Replace the rotor.

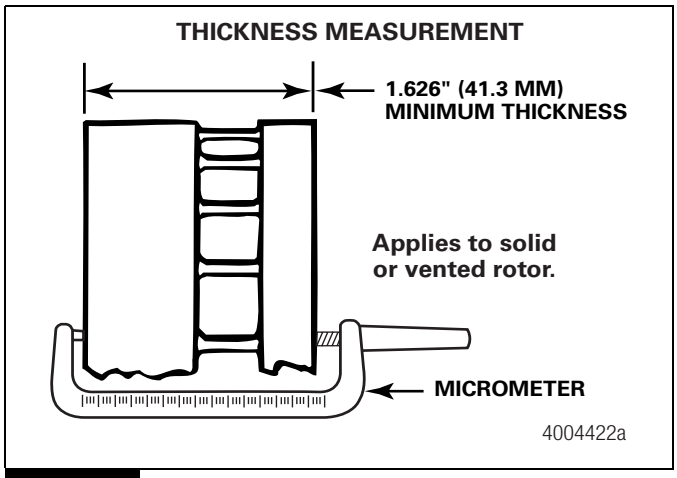


Figure 13

Install the Brake Pads

⚠ CAUTION

Replace the pads on both brakes of a single axle or on all four brakes of a tandem axle at the same time. If you do not replace all the pads at the same time, poor brake performance can occur.

1. Slide the caliper OUTWARD. Install the OUTBOARD pad and spring assembly into the OUTBOARD side of the caliper. Confirm that the load plate is correctly located between the saddle abutments. Figure 8.
2. Slide the caliper INWARD. Install the INBOARD pad and spring assembly into the INBOARD side of the caliper.
3. Close the stabilizer bar. Install the stabilizer bar pin and cotter pin or tighten the hex-head bolt to 23-29 lb-ft (30-40 N•m).

Initial Brake Adjustment

⚠ CAUTION

You must adjust the initial brake pad-to-rotor clearance or an inefficient, dragging brake can occur. Damage to components can result.

1. Use the following procedure to adjust the initial brake pad-to-rotor clearance. The air chamber must be installed and attached to the lever with the clevis pin before you proceed with the initial brake adjustment procedure.
   A. Use a 6 mm Allen wrench to adjust the caliper by reducing the brake pad-to-rotor clearance to ZERO. Figure 3.
   B. Verify that the load plate is in full contact with the brake pad backing plate. Figure 6 and Figure 8.
   C. Increase the brake pad-to-rotor clearance 10 clicks or 3/4 turn (de-adjust) to set the initial clearance. Figure 3.
2. Install the adjuster plug and washer. Tighten to 8-12 lb-ft (11-17 N•m). Figure 2.
3. Have another person make 10 or more brake applications to set the brake pad-to-rotor running clearance. Verify that all air chambers and calipers correctly apply and release during the brake applications.

Remove the Caliper Assembly

⚠ CAUTION

Do not use the stabilizer bar to lift the caliper onto or off of the axle. Damage to the stabilizer bar can result.

1. Remove the clevis pin from the lever.
2. Remove the air chamber.
3. Remove the four saddle bolts. Figure 14.

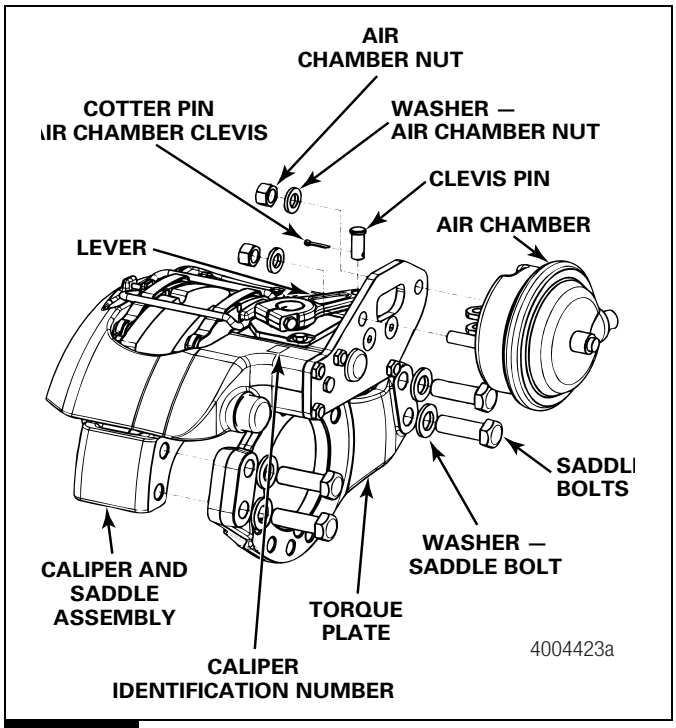


Figure 14

4. Lift the caliper and saddle assembly away from the rotor.

Replace the Rotor

1. Remove the caliper assembly. Refer to the procedure in this bulletin.
2. Remove the hub and rotor assembly. Refer to the axle manufacturer's service manual.

⚠ WARNING

Use a brass or synthetic mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off. Serious personal injury and damage to components can result.

3. Detach the rotor from the hub. Use one of the following procedures.
   - **For stud-mounted rotors:** Use a brass or synthetic mallet to remove the hub-to-rotor studs. Figure 15. Be careful not to damage the studs during this process.
   - **For bolt-mounted rotors:** Unscrew the hub-to-rotor bolts. Figure 16.

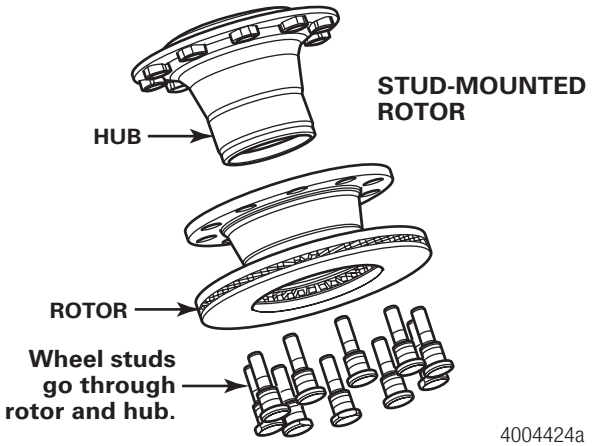


Figure 15

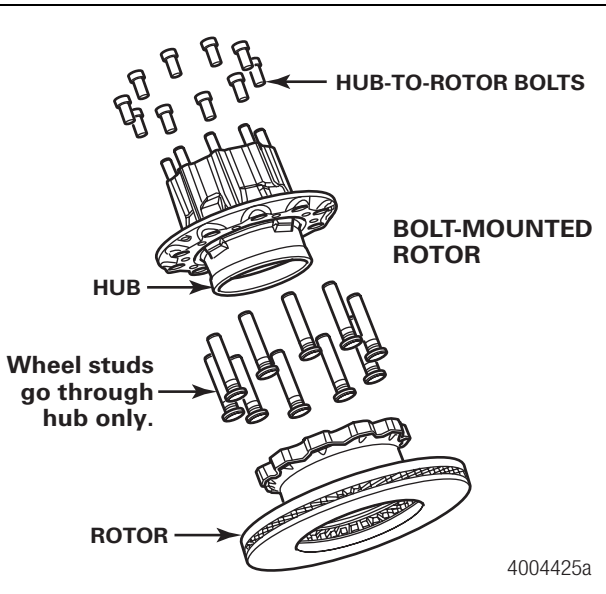


Figure 16

4. Attach a new rotor to the hub.
   - **For stud-mounted rotors:** Press or pull the wheel studs through the rotor into the hub. Figure 15.
   - **For bolt-mounted rotors**: Tighten the hub-to-rotor bolts to 175-195 lb-ft (238-265 N•m). Figure 16. ❶
5. Install the hub and rotor assembly. Refer to the axle manufacturer's service manual.
6. Install the caliper assembly. Refer to the procedure in this bulletin.

Install the Caliper Assembly

1. Place the caliper assembly over the rotor.
2. Align the caliper saddle bolt holes and assemble to the torque plate using saddle bolts and washers.
3. Tighten the saddle bolts to 400-500 lb-ft (544-680 N•m). ❶
4. Mount the air chamber to the caliper assembly. Tighten the air chamber nuts and washers to 133-155 lb-ft (180-210 N•m). ❶
5. Apply a coating of anti-seize compound to the clevis pin. Install the clevis pin and cotter pin.
6. Install the brake pads. Refer to the procedure in this bulletin.

Air Disc Brake Troubleshooting

Diagnostics

DX195 and DX225 Air Disc Brakes

Conditions	Possible Causes	Check For	Corrections
Air chamber exceeds 2″ (51 mm) at 90-100 psi (620-689 kPa) in cab.	Incorrect initial adjustment or inoperative automatic adjuster	Recheck chamber stroke after 20 brake applications.	If the air chamber still overstrokes, then replace the caliper and saddle assembly.
Brake drag	Incorrect initial adjustment	Correct pad-to-rotor clearance	Readjust to set the correct rotor-to-pad clearance.
	Incorrect pad-to-rotor clearance		
	Spring or service brake not releasing	Correct operation of air system or air chamber	Refer to the vehicle manufacturer's instructions. Repair or replace parts as required.
	Vehicle air system malfunction		
	Brake not releasing	Damaged slide pin boots, caliper should move back and forth by hand with linings removed	Replace the caliper assembly.
		Corroded pin in chamber clevis and lever	Clean or replace the clevis pin (apply anti-seize compound before reassembly).
		Incorrect position of load plate between saddle abutments	Remove the brake pads and reinstall. Refer to the procedure in this bulletin.
		Water entry or seized operation shaft, internal	Replace the caliper assembly and air chamber.
	Air line too short	Correct air line length	Replace the air line. Refer to the vehicle manufacturer's instructions.
Short brake pad lining life	Refer to Brake drag.	Refer to Brake drag.	Refer to Brake drag.
	Caliper seized or sticking on slide pins	Damaged slide pin boots, caliper should move back and forth by hand with linings removed	Replace the caliper assembly.
	Damaged rotor surface	Cracks or heavy heat checking	Replace the rotor.
	Vehicle overload	Refer to the weight limitations on the vehicle identification plate.	Observe the vehicle manufacturer's load recommendations.
	Companion brakes do not work correctly	Inspect the companion vehicle brakes and air system.	Adjust or repair as required.
Smoking brakes	High brake temperature	Refer to Brake drag and Short brake pad lining life.	Refer to Brake drag and Short brake pad lining life. Can be a temporary situation with new or low mileage pads.
	Contamination on the linings or rotor	Grease, oil, undercoating, paint, etc., on the linings or rotor	• Inspect the hub seal. Replace as required. • Clean the rotor and caliper assembly. • Replace the pads.

Conditions	Possible Causes	Check For	Corrections
Poor stopping power • **Long stopping distances** • **Poor driver feel** • **High brake pressures** • **Vehicle pulls to one side**	Vehicle air system malfunction	Correct air pressure at the chamber inlet	Have the air system evaluated by a qualified brake system specialist.
	Contamination on the linings or rotor	Grease, oil, undercoating, paint, etc., on the linings or rotor	• Inspect the hub seal. Replace as required. • Clean the rotor and caliper assembly. • Replace the pads.
	Brakes out-of-adjustment	Excessive pad-to-rotor clearance	Readjust to set the correct pad-to-rotor clearance.
	Vehicle overload	Refer to the weight limitations on the vehicle identification plate.	Observe the vehicle manufacturer's load recommendations.
	Companion brakes not working correctly	Inspect the companion vehicle brakes and air system.	Adjust or repair as required.
	Incorrect pads installed	Refer to the vehicle manufacturer for the correct pads.	Replace the pads.
Brake noise	Incorrect pad installation	Friction material facing the rotor surface	Correct the pad installation. Replace the pads and rotor, if necessary.
	Brake pads not free to move in the caliper	Corrosion or debris on the pads or carrier abutments	Clean or replace the pads, if necessary. Clean the pad abutments on the carrier.
	Worn brake pads	Lining thickness	Replace the pads, if necessary.
	Brake component attachments are not installed to specification	Check for loose connections and fasteners.	Tighten the connections and fasteners to the specified torque.
	Rotor cracks or excessive runout	Excessive cracking, heat checking or runout	Replace the rotor.
	Pad spring damaged or not installed	Correct pad spring installation	Install the pad springs.
	Incorrect pads installed	Refer to the vehicle manufacturer for the correct pads.	Replace the pads.
	Bent or loose pad retainer	Bent pad retainer or loose pad retainer bolt	Replace or tighten the pad retainer.

ArvinMeritor™

Meritor Heavy Vehicle Systems, LLC
2135 West Maple Road
Troy, MI 48084 USA
800-535-5560
arvinmeritor.com

TP-02173
Revised 11-04
(16579/24240)

Bendix

Service Data

SD-13-4746

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

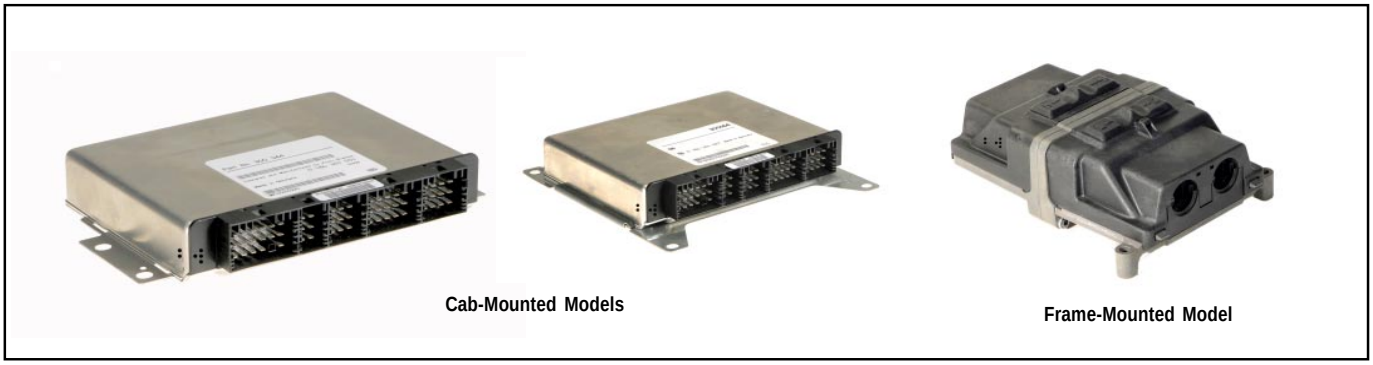


FIGURE 1 - Bendix® ABS Controller Assemblies

GEN 4™ AND GEN 5™ ABS INTRODUCTION

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

Both cab and frame mount versions are designed for:

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

This manual covers:

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

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

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

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

Document Revision Level

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

Table of Contents

ANTILOCK BRAKING SYSTEM (ABS)

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

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

ABS Operation

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

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

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

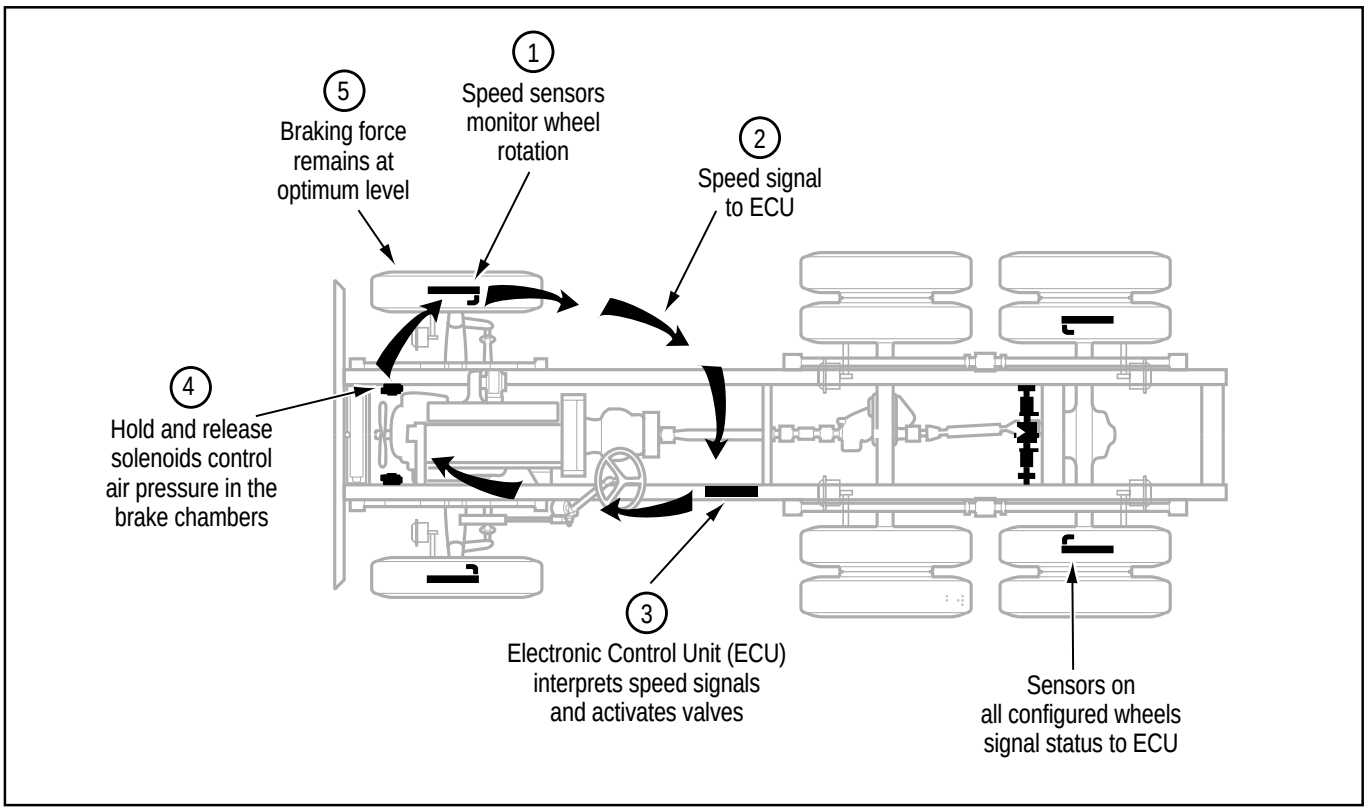


FIGURE 2 - Overview of ABS Operation

ABS Component Function

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

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

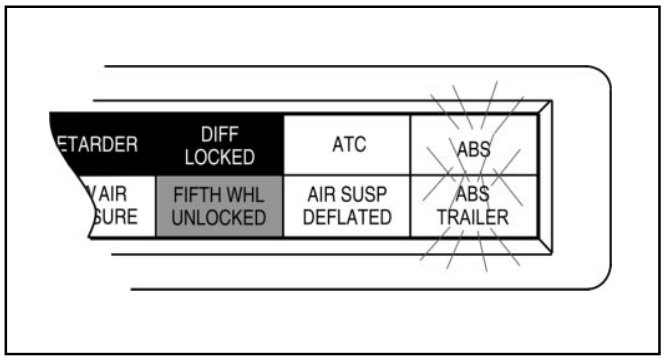


FIGURE 3 - ABS Indicator Lamps

ABS Indicator Lamp

This lamp is the primary indicator of the ABS status.

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

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

ABS Trailer Indicator Lamp

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

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

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

Automatic Traction Control (ATC) System

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

ATC requires:

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

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

ATC Operation

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

System operation:

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

Component Function

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

Thermal (Brake Heat) Protection

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

ATC Indicator Lamp

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

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

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

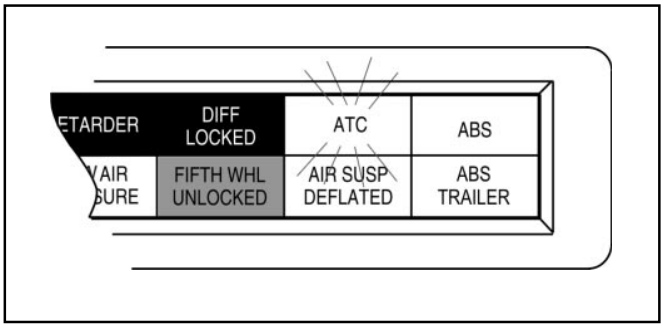


FIGURE 4 - ATC Indicator Lamp

Component Overview

Bendix ABS components include:

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

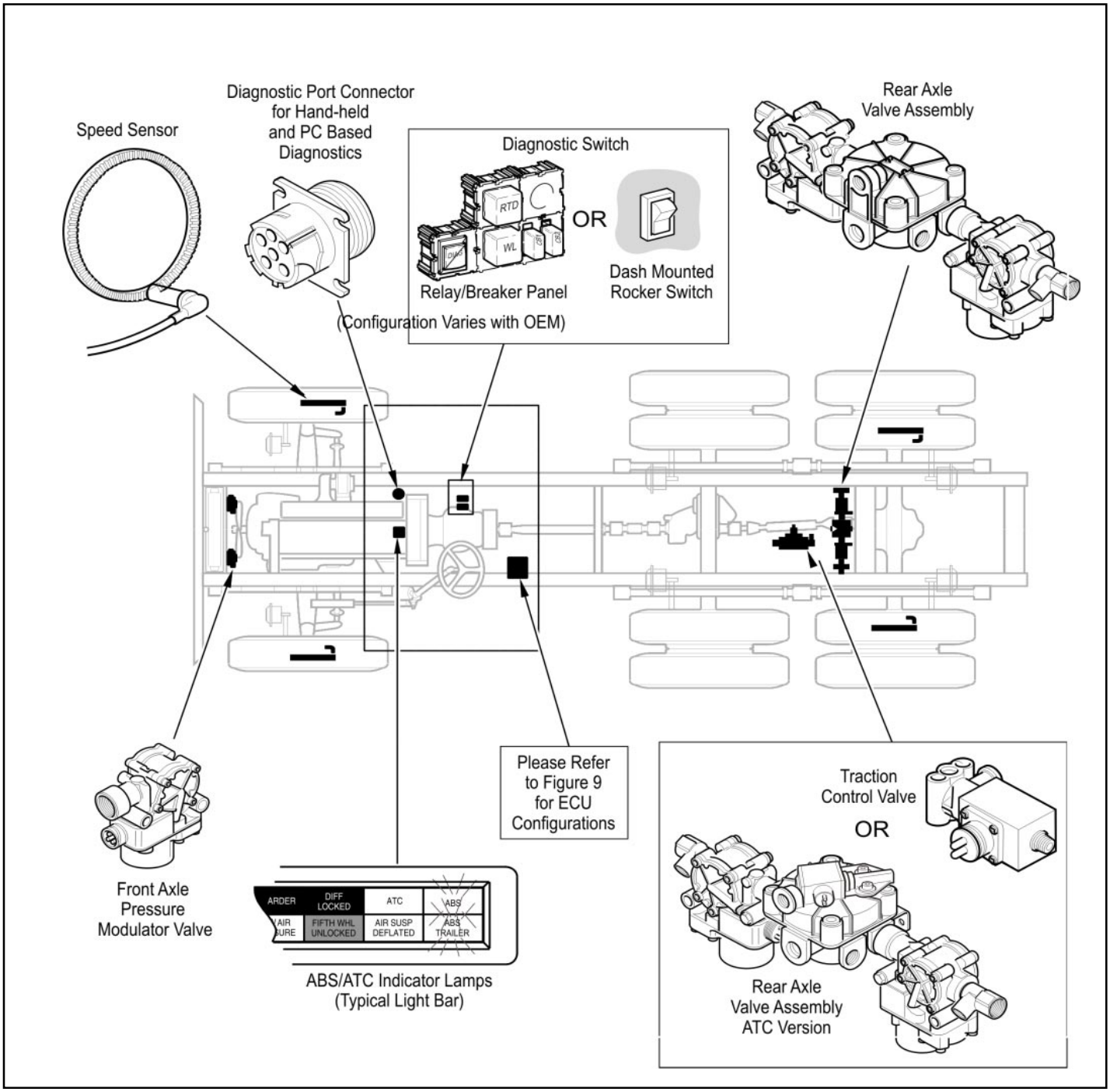


FIGURE 5 - ABS Components

Electronic Control Units (ECUs)

Identification

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

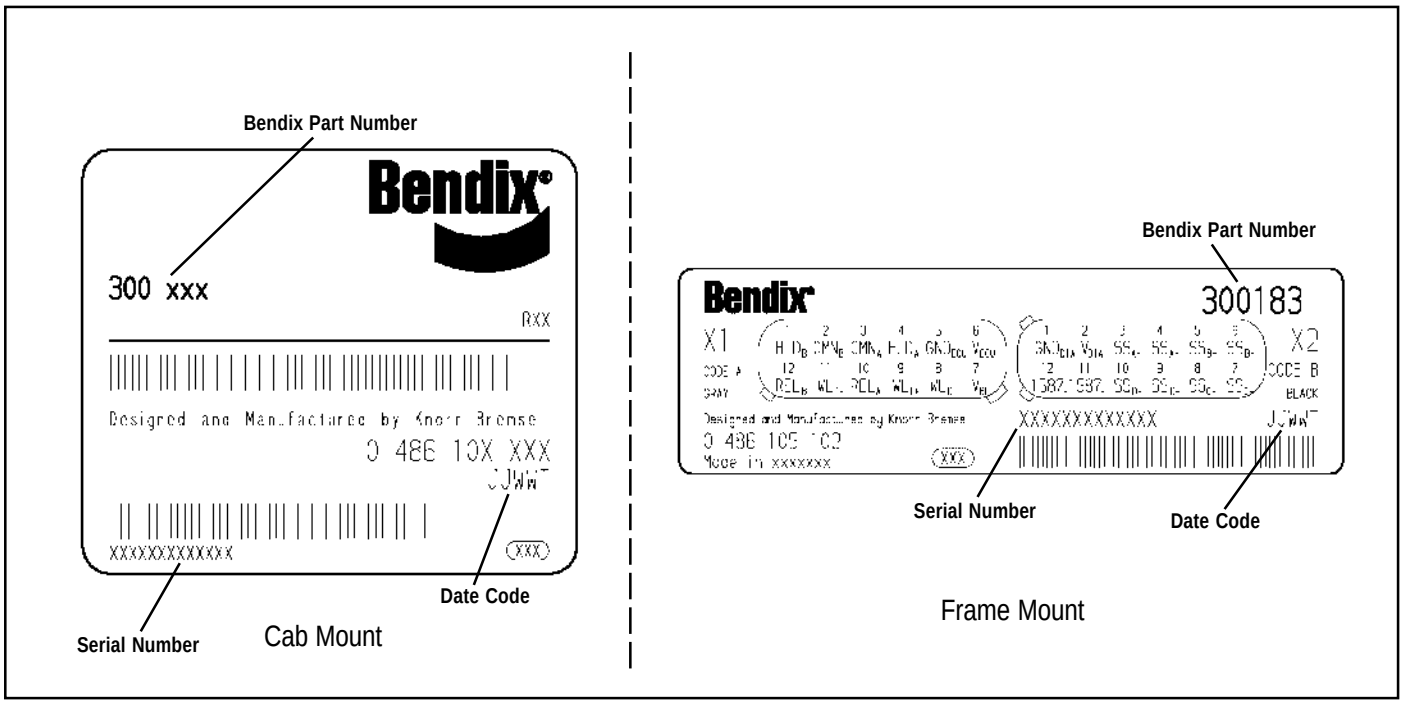
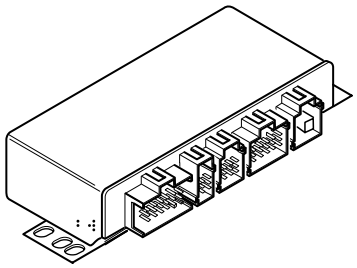
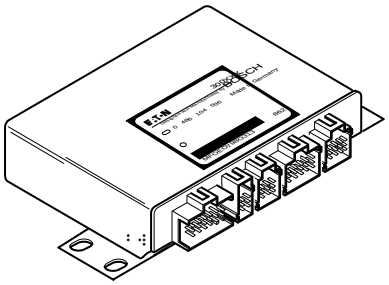


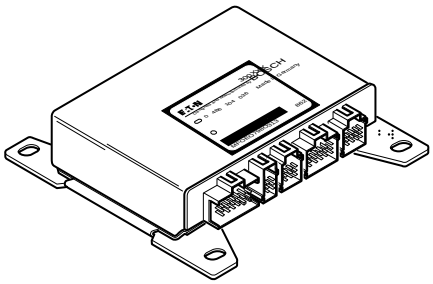
FIGURE 6 - Electronic Control Unit Identification Tags



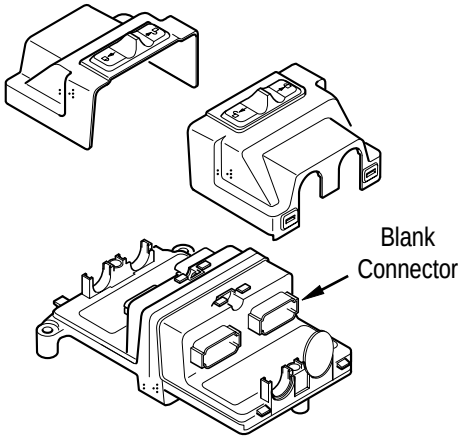
Gen 4™ & Gen 5™ ABS - Basic Cab Mount



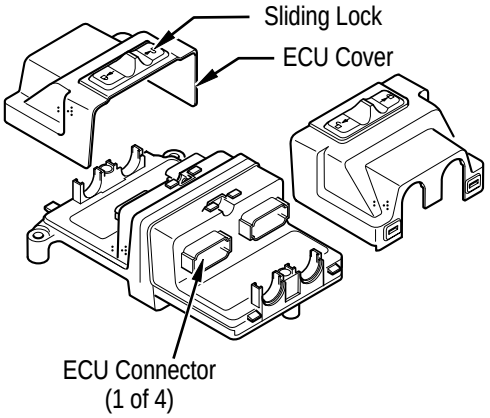
Gen 5™ ABS – Standard Cab Mount



Gen 4™ ABS – Standard Cab Mount



Gen 5™ ABS (PLC - Basic Frame Mount)



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

FIGURE 7 - Available Bendix ABS Electronic Control Units

ABS Valves

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

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

Rear Axle Valve Assemblies

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

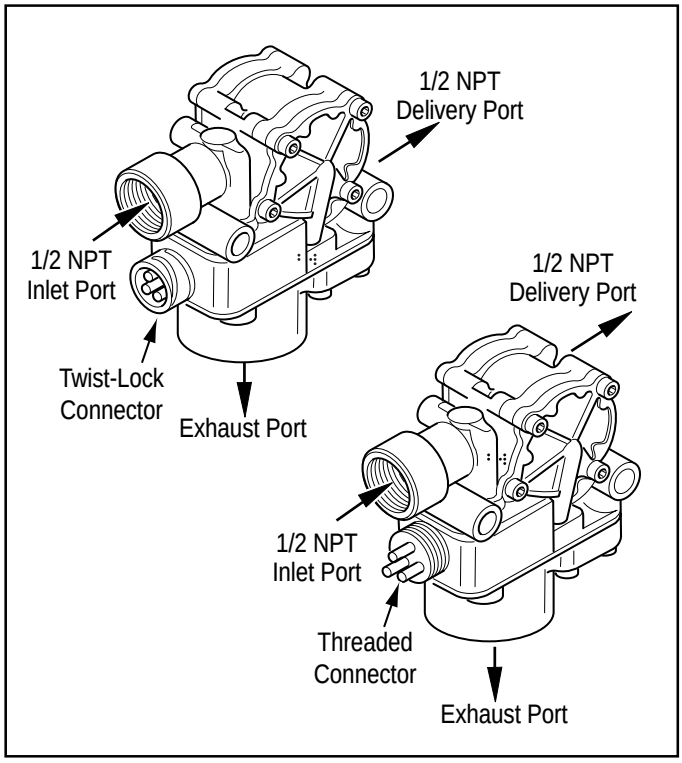


FIGURE 8 - Modulator Valve

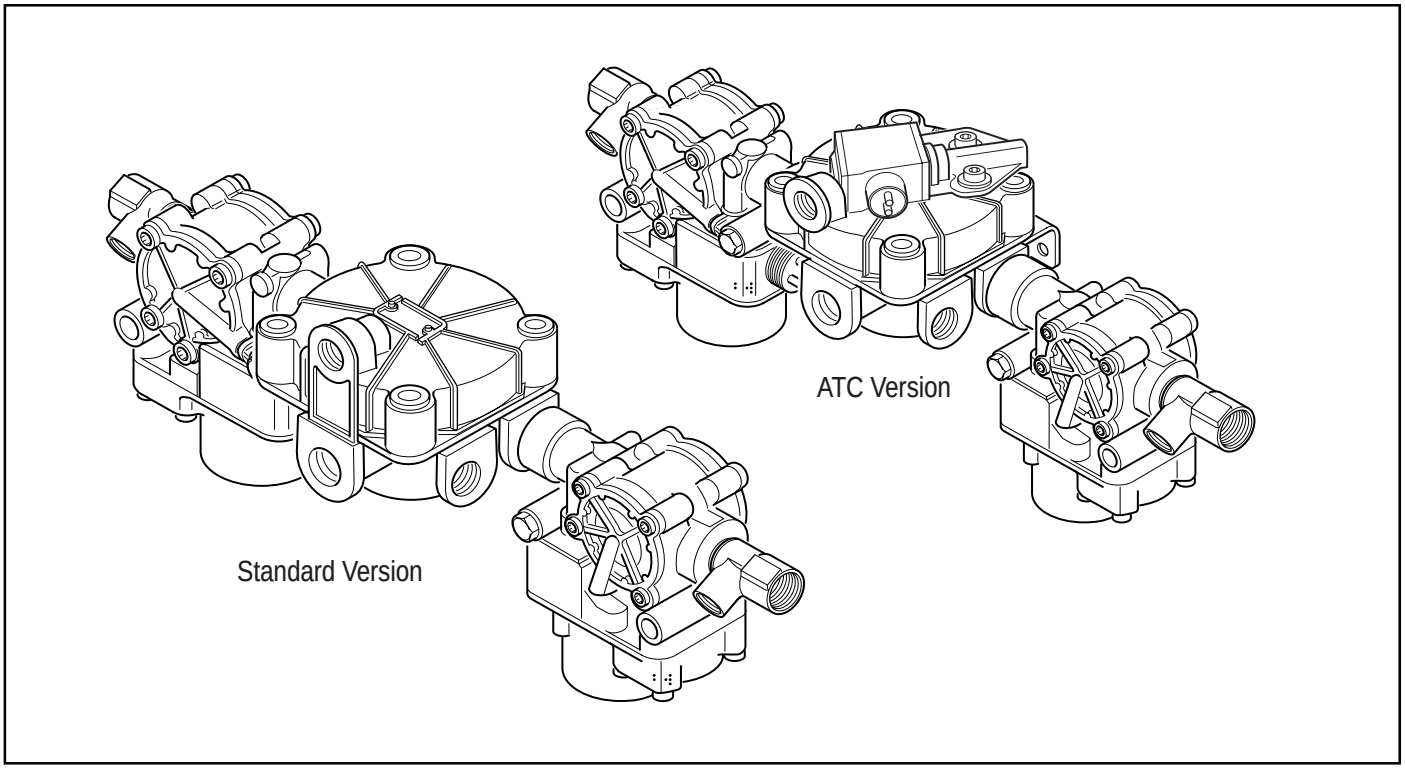


FIGURE 9 - Rear Axle Valve Assemblies, 4-Port ABS and ABS/ATC Versions Shown

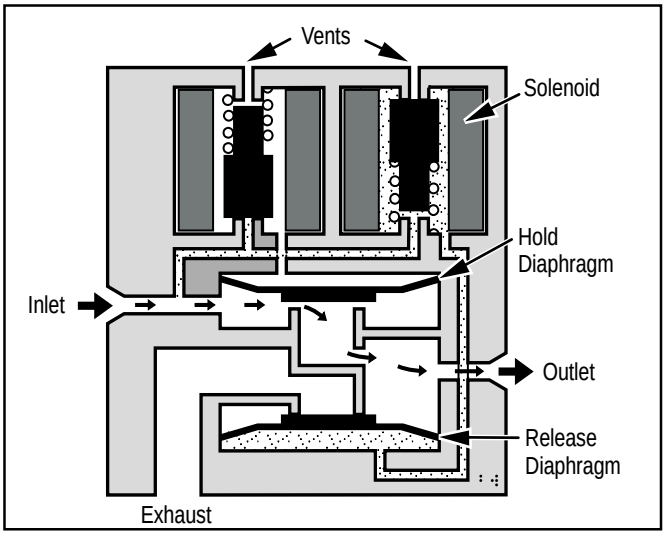


FIGURE 10 - Normal Apply and ABS/ATC Apply

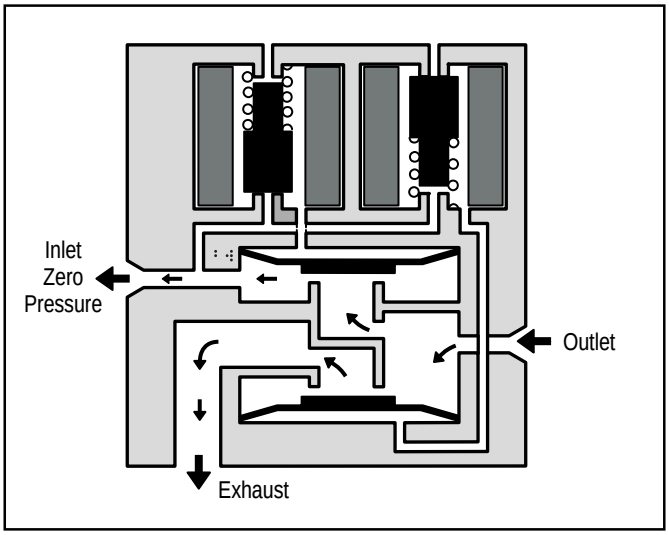


FIGURE 11 - Normal Release

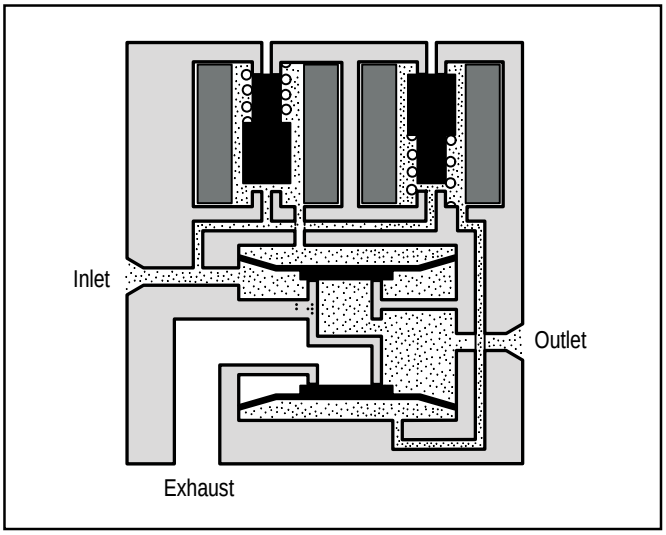


FIGURE 12 - ABS/ATC Hold

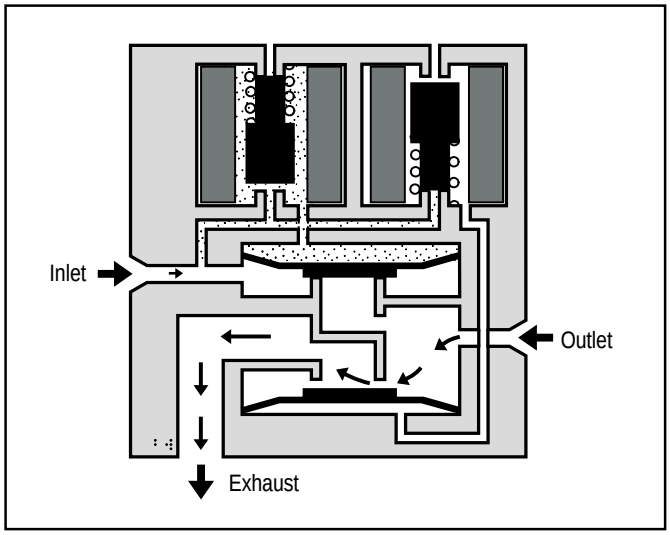


FIGURE 13 - ABS/ATC Release

Modulator Valve Operation Modes

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

Optional Front Axle Modules

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

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

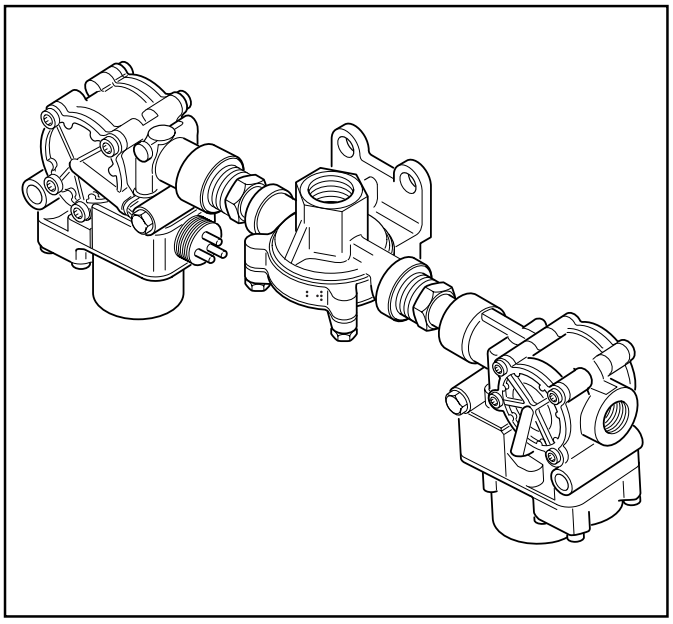


FIGURE 14 - Front Axle Module

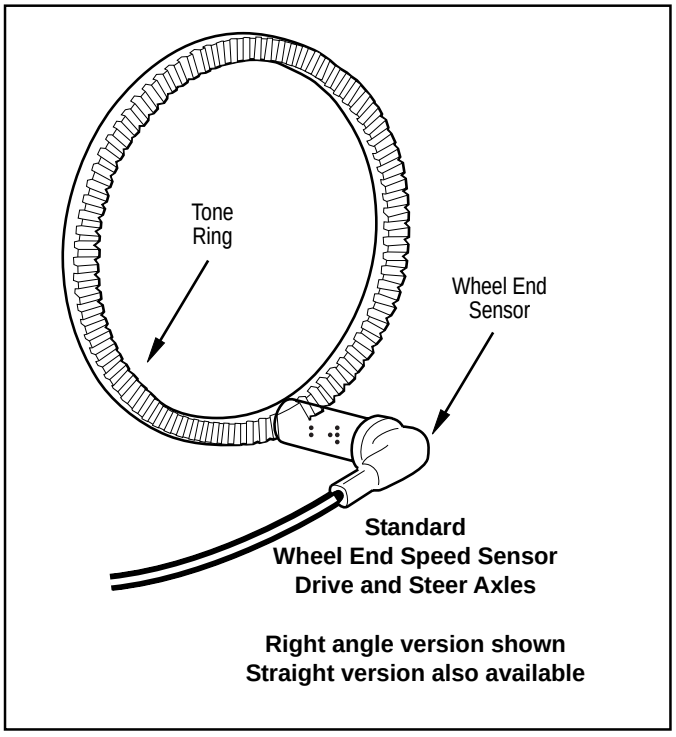


FIGURE 15 - Sensor Assembly

Speed Sensors

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

Wheel End Sensors

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

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

Some general characteristics of variable reluctance, magnetic sensors are:

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

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

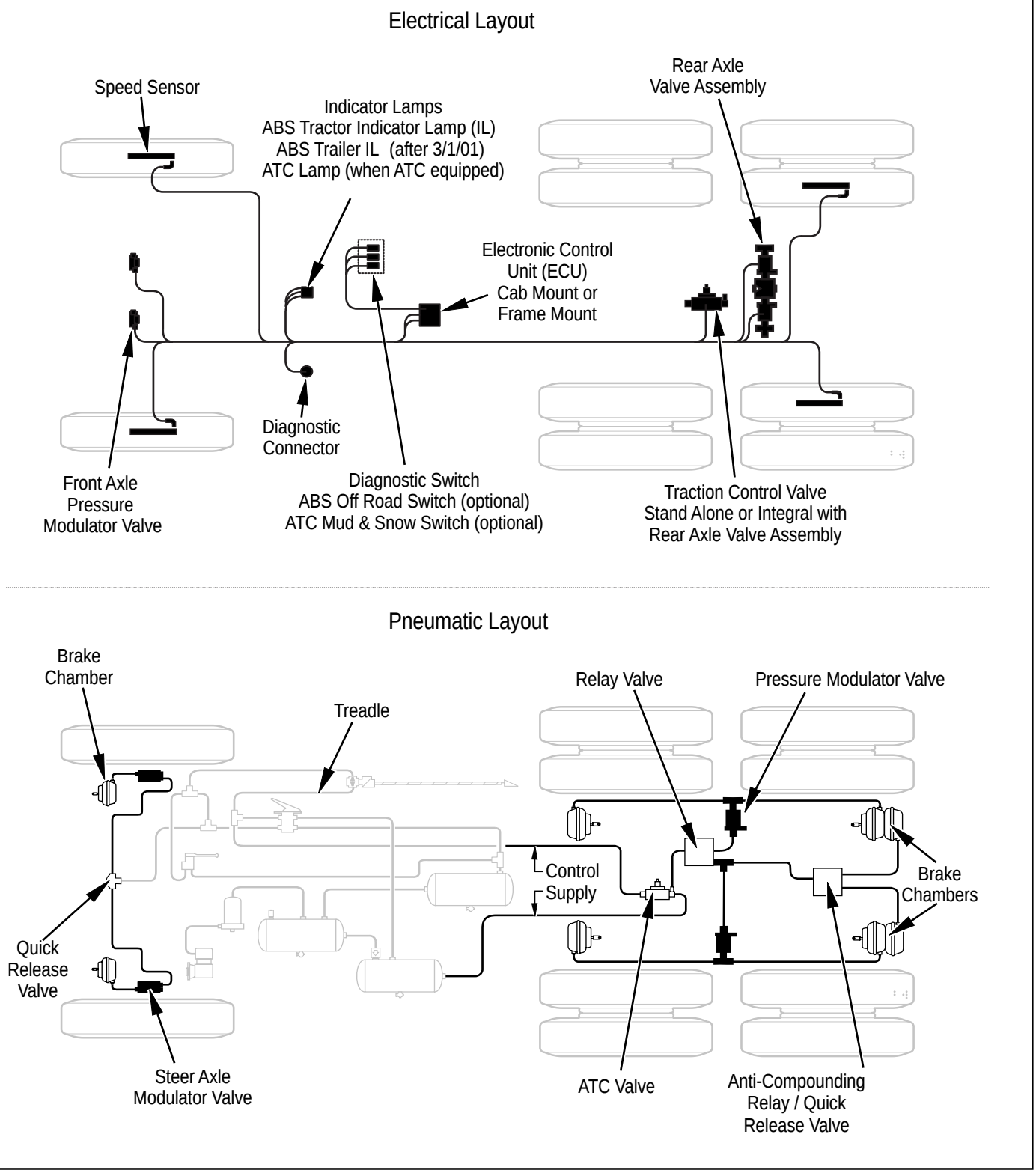


FIGURE 16 - Typical Electrical and Pneumatic Layouts

DIAGNOSTICS

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

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

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

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

1. **Park the vehicle on a level surface, apply the parking brakes, and always block the wheels. Always wear safety glasses.**
2. **Stop the engine and remove ignition key when working under or around the vehicle. When working in the engine compartment, the engine should be shut off and the ignition key should be removed. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated or electrically charged components.**
3. **Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.**
4. **If the work is being performed on the vehicle's air brake system, or any auxiliary pressurized air systems, make certain to drain the air pressure from all reservoirs before beginning ANY work on the vehicle. If the vehicle is equipped with an AD-IS™ air dryer system or a dryer reservoir module, be sure to drain the purge reservoir.**
5. **Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that safely removes all electrical power from the vehicle.**
6. **Never exceed manufacturer's recommended pressures.**
7. **Never connect or disconnect a hose or line containing pressure; it may whip. Never remove a component or plug unless you are certain all system pressure has been depleted.**
8. **Use only genuine Bendix® replacement parts, components and kits. Replacement hardware, tubing, hose, fittings, etc. must be of equivalent size, type and strength as original equipment and be designed specifically for such applications and systems.**
9. **Components with stripped threads or damaged parts should be replaced rather than repaired. Do not attempt repairs requiring machining or welding unless specifically stated and approved by the vehicle and component manufacturer.**
10. **Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.**
11. **For vehicles with Antilock Traction Control (ATC), the ATC function must be disabled (ATC indicator lamp should be ON) prior to performing any vehicle maintenance where one or more wheels on a drive axle are lifted off the ground and moving.**

Troubleshooting Procedures

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

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

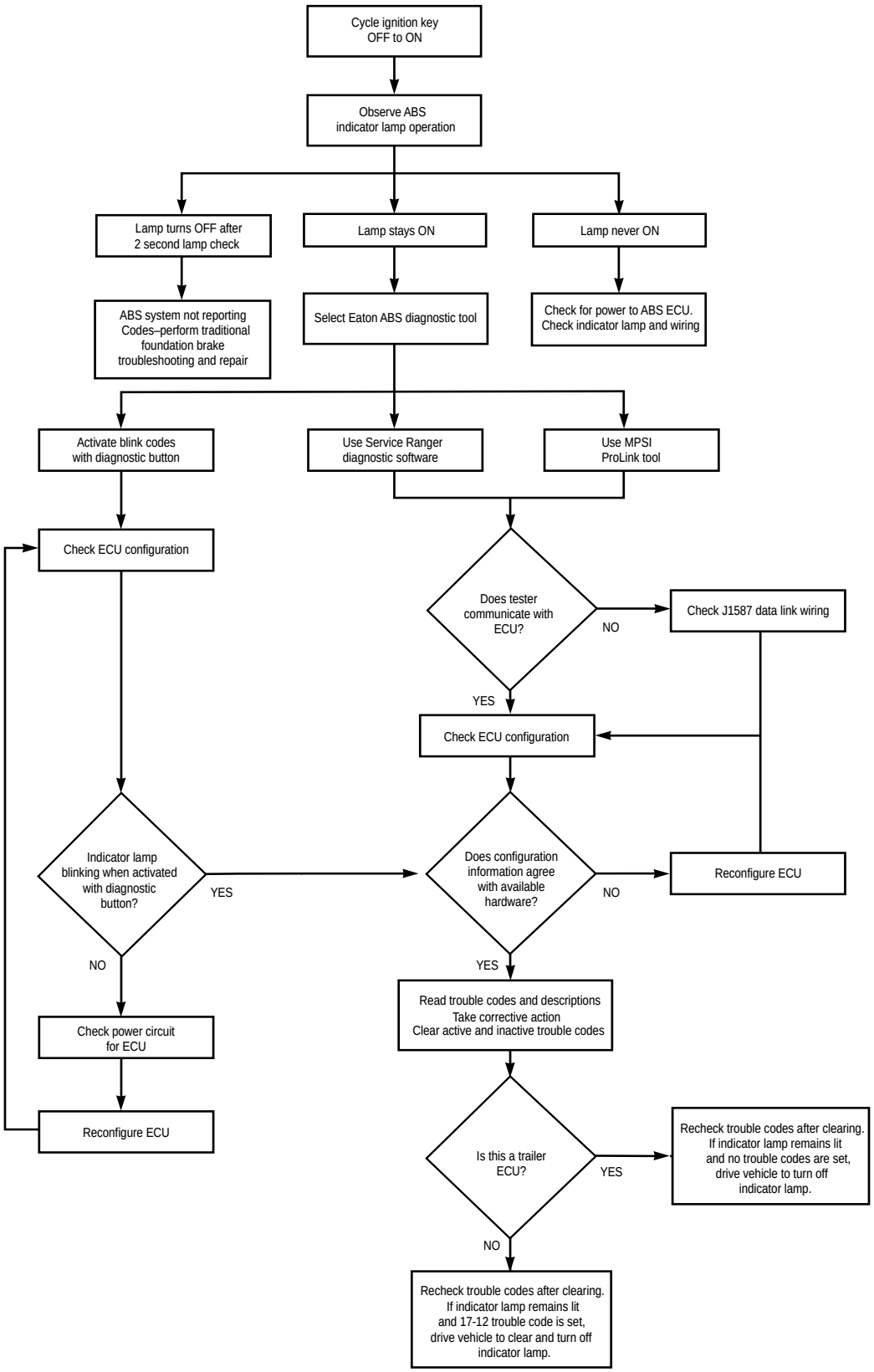


FIGURE 17 - Antilock Brake System Troubleshooting Chart

SYSTEM CONFIGURATIONS

Available Configurations

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

When to Configure

ECUs are factory configured for the most common requirements. Basic systems are setup for 4s-4m operation with retarder control via retarder relay. Standard systems are setup for 6s-4m operation with retarder control via engine data link. For applications other than these factory configurations (for example use of a retarder control relay, 4s-3m operation, 6s-6m operation or traction control), it is necessary to perform a configuration or "setup" process. This process sets up the ECU for the components that are installed so that proper control and fault tolerance will be implemented. The diagnostic switch, MPSI Pro-Link® tool or ServiceRanger PC software may be used to configure to a higher level (add components or functionality). If it is desired to move the configuration downward (fewer components than standard), the ProLink tool or ServiceRanger PC software must be used.

How to Configure

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

Verification

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

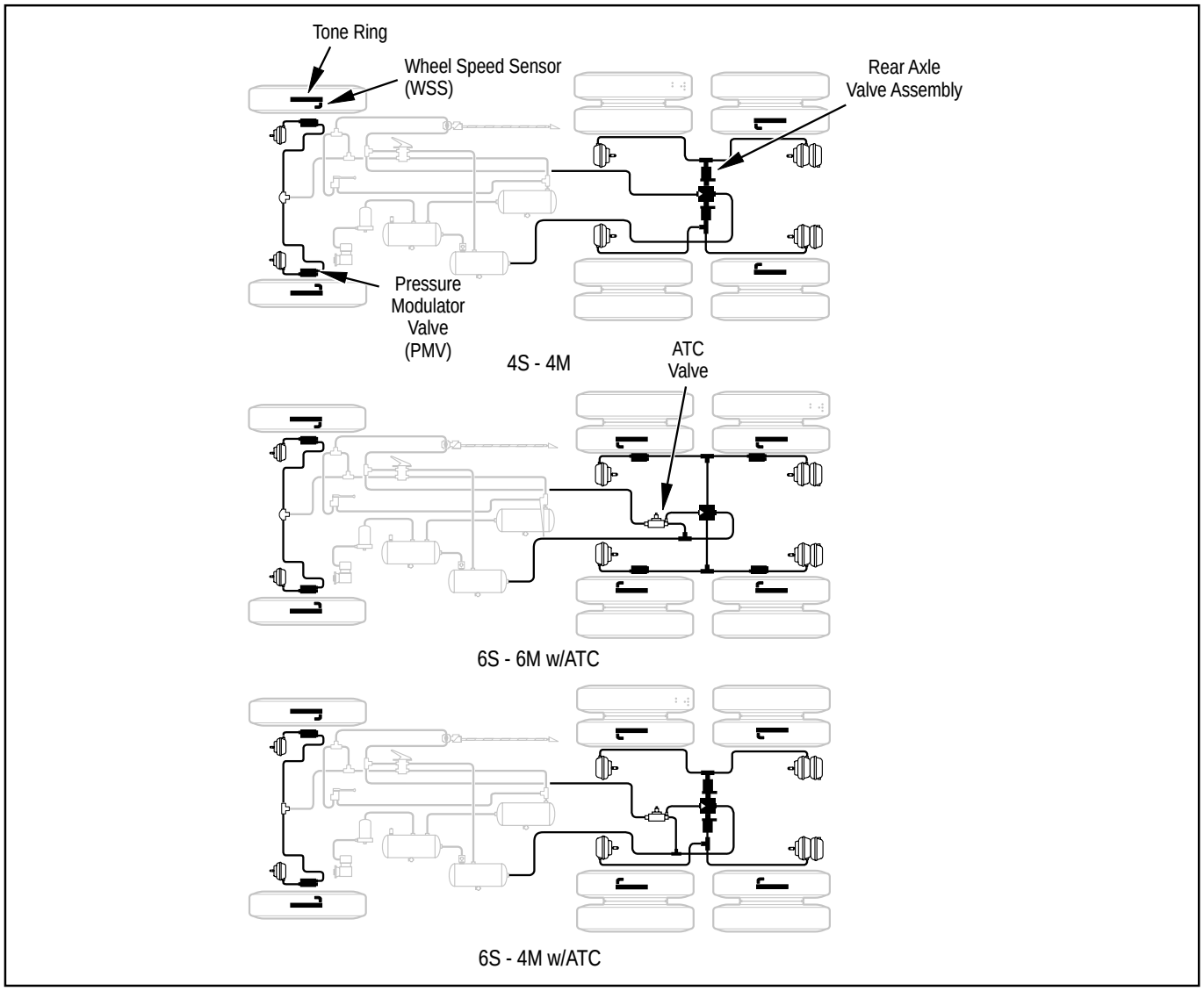


FIGURE 18 - Typical ABS Configurations

Test Equipment

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

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

Multimeter

A multimeter can be used to check:

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

ServiceRanger PC Software

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

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

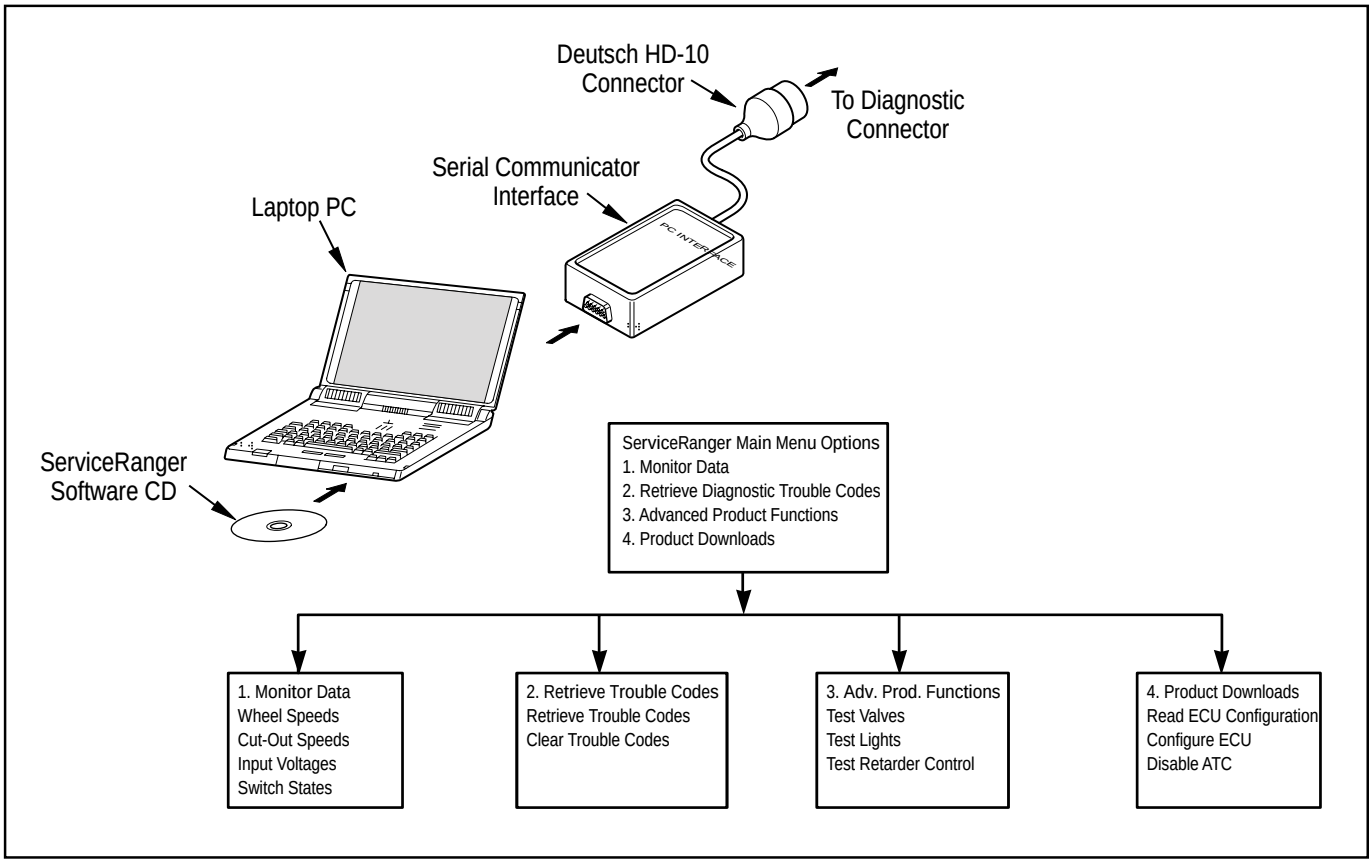


FIGURE 19 - ServiceRanger Menus & Hardware Setup

Hand-Held Tester

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

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

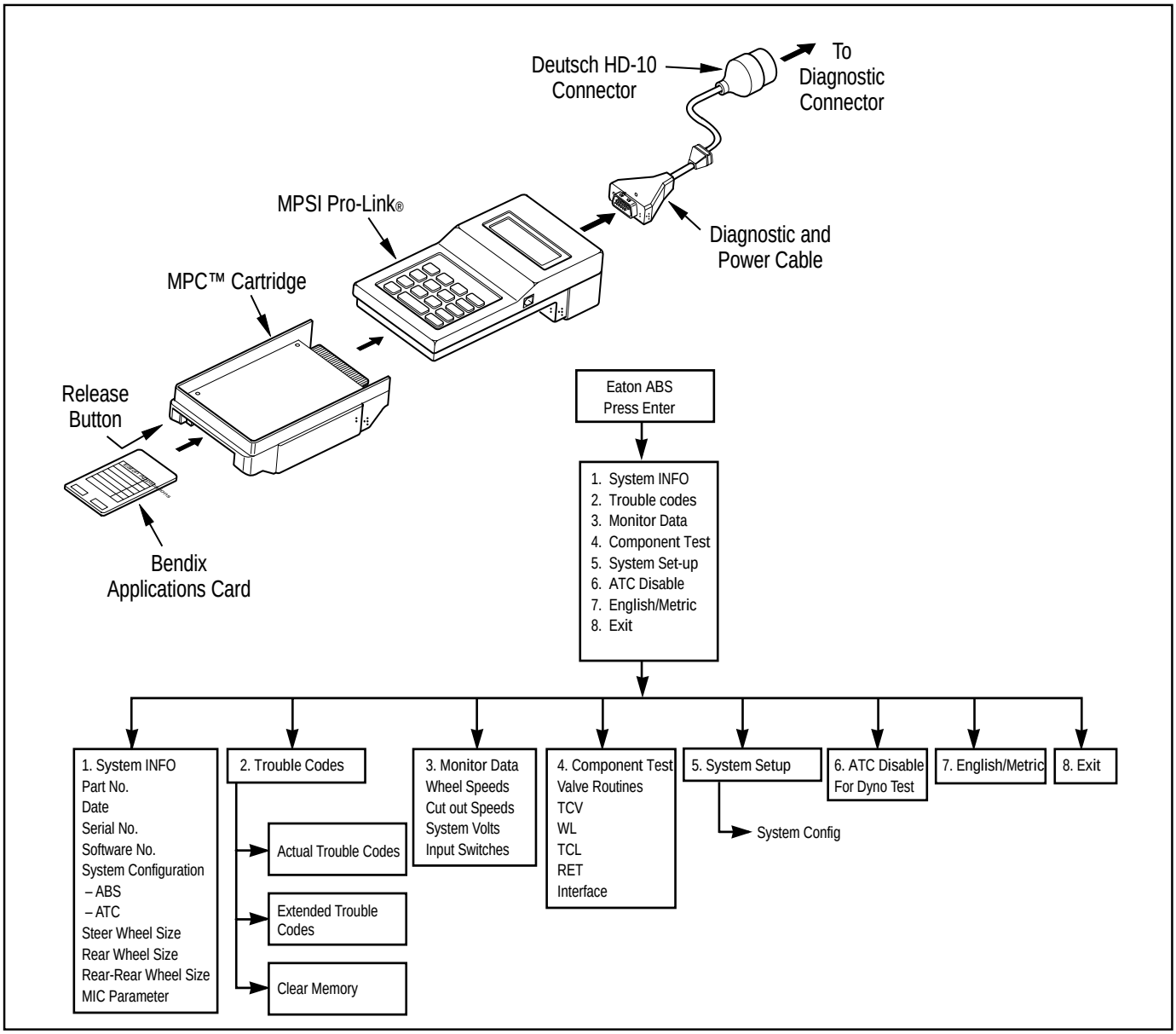


FIGURE 20 - Hand-Held Tester Menus and Set-Up

Diagnostic Switch

Blink Codes – System Configuration and System Faults.

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

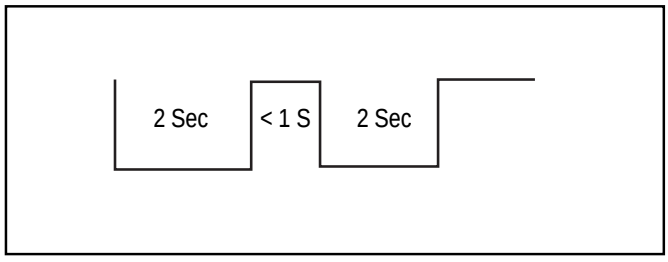
All blink codes are displayed by the ABS indicator lamp only. The ATC lamp does not display blink codes.

Note: Before attempting any repairs:

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

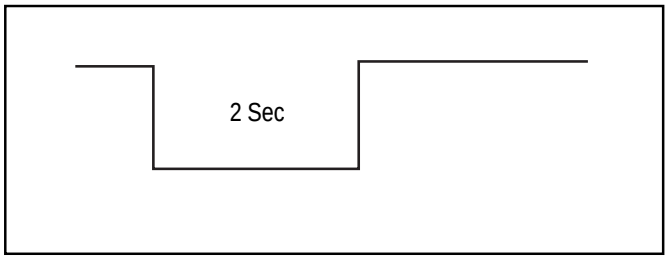
Reading Configuration Codes

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



Retrieving Diagnostic Trouble Codes

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



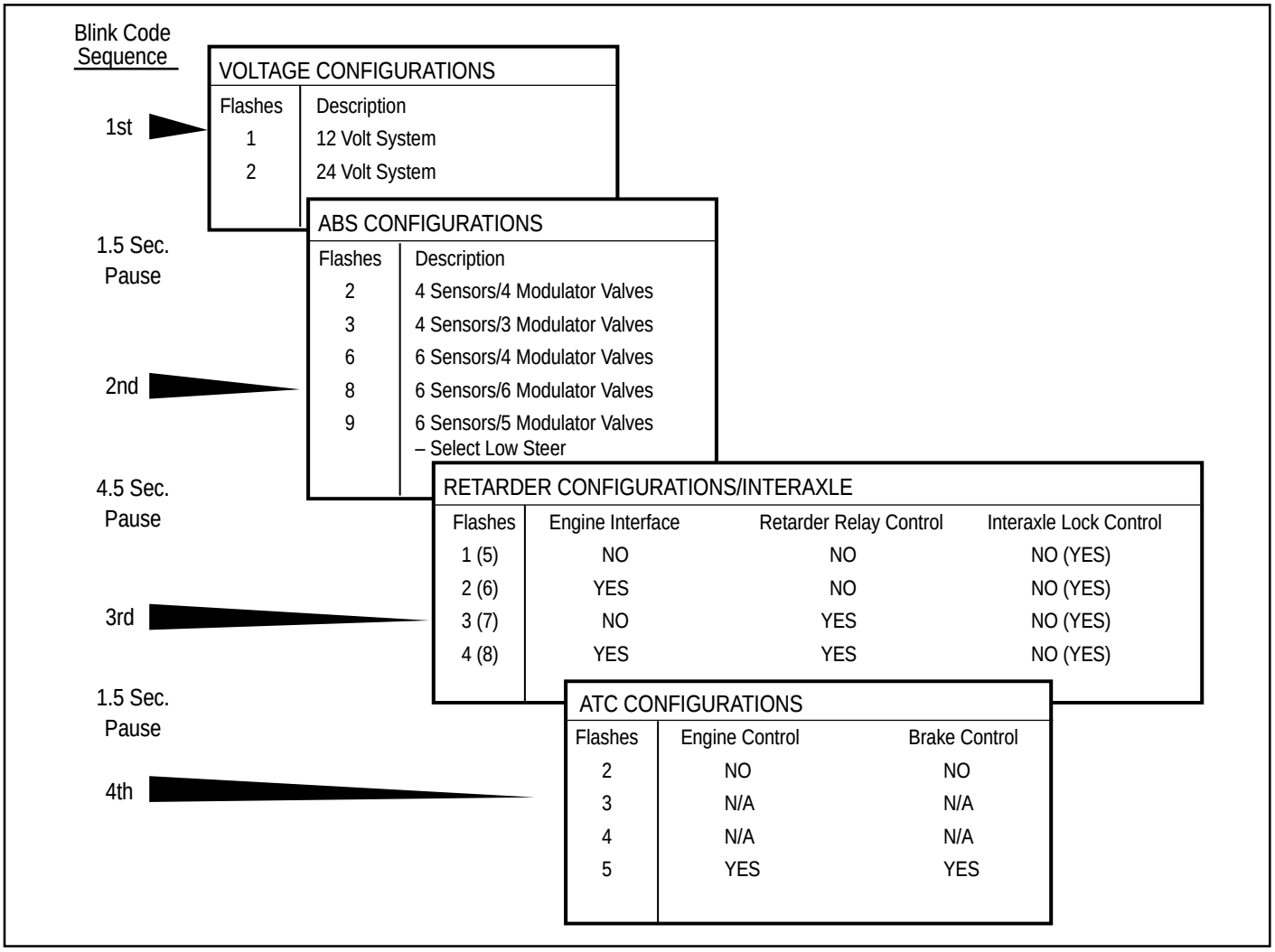
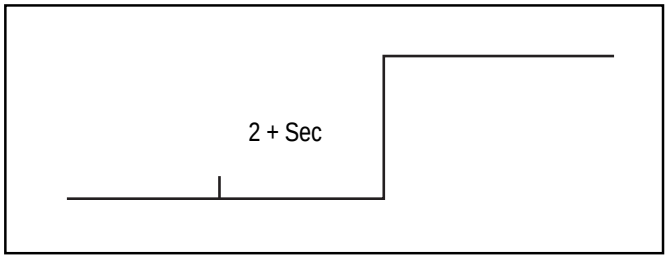


FIGURE 21 - Reading ABS Configuration Codes

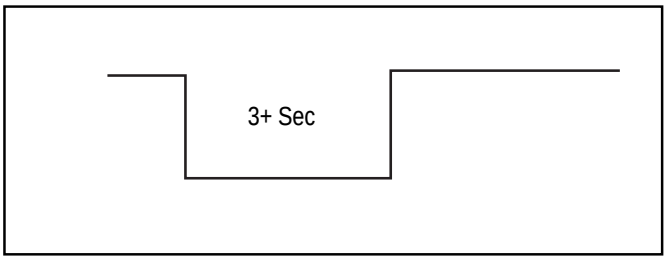
Clearing Diagnostic Trouble Codes and/or System Configuration

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



Disabling ATC for Dyno Testing

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



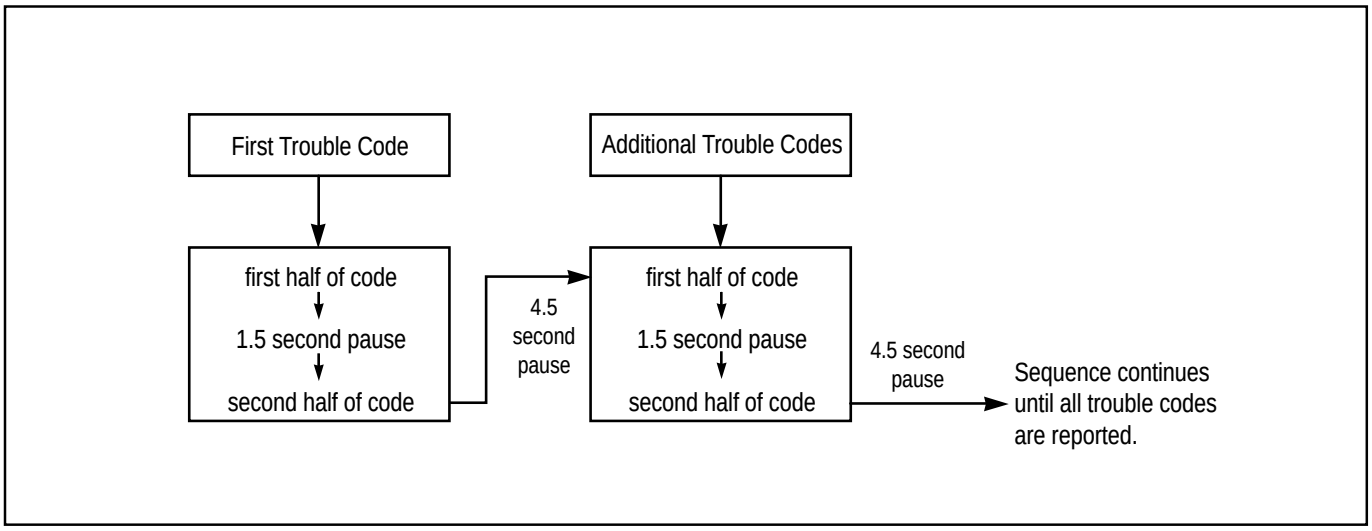


FIGURE 22 - Typical Blink Code Report

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

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

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

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

Speed Sensor Troubleshooting

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

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

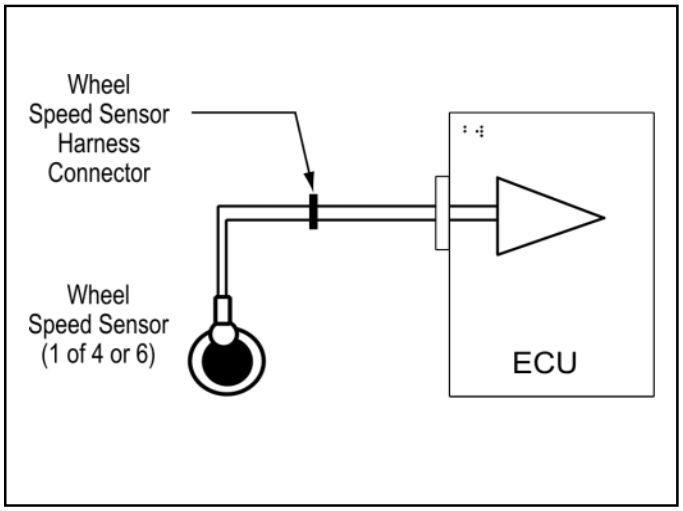
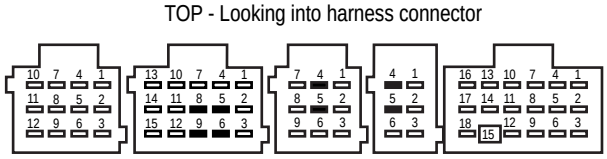
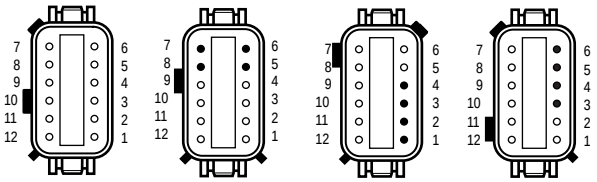


FIGURE 23 - Typical Wheel Speed Sensor Circuit





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

*Not Used On Basic System

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

*Not Used On Basic System

Speed Sensor Resistance Test

The correct resistance for the speed sensor circuit is between 1550 ohms and 2500 ohms.

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

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

Note: Refer to the chart for pin identification.

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

The 17•12 Sensor Memory Diagnostic Trouble Code

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

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

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

Procedure:

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

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

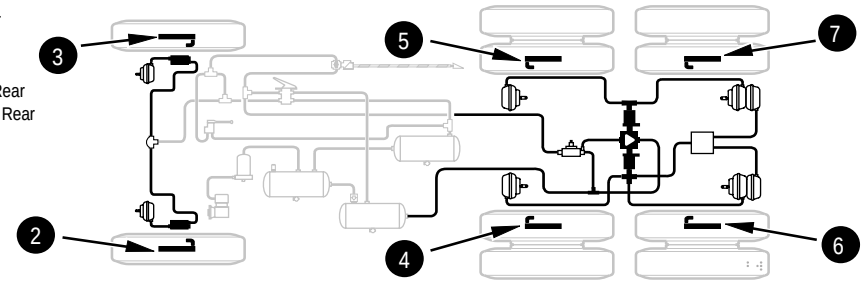
For more detailed troubleshooting, monitor the wheel speeds and cut-out speeds with ServiceRanger or a ProLink hand-held diagnostic tool. Troubleshoot and repair any speed sensor not reporting a wheel speed or showing a high cut-out speed.

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

Blink Code Sequence

1st

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

FIGURE 25 - Speed Sensor Diagnostic Trouble Code Troubleshooting Guide

Wheel End Speed Sensor Repair

Front Axle Speed Sensor

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

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

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

Removal

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

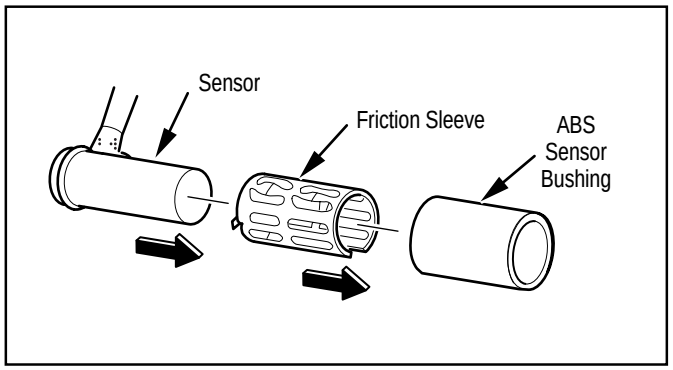


FIGURE 26 - Front Speed Sensor Components

Installation

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

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

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

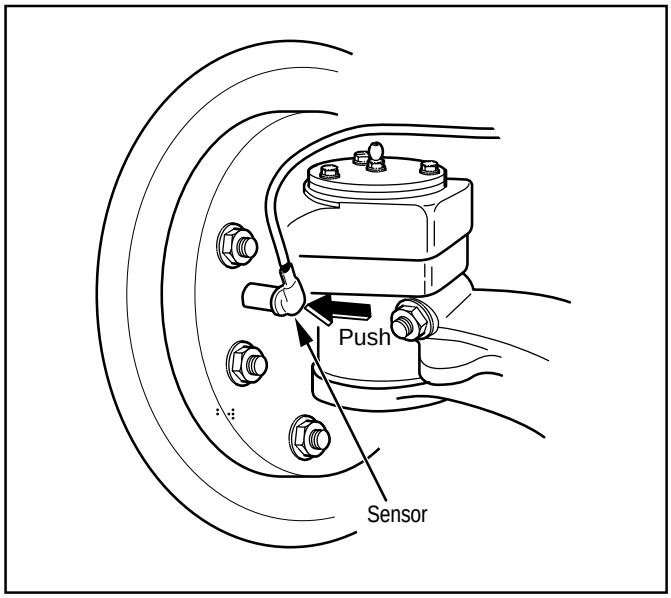


FIGURE 27 - Wheel Speed Sensor Installation

Rear Axle Speed Sensor

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

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

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

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

Removal

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

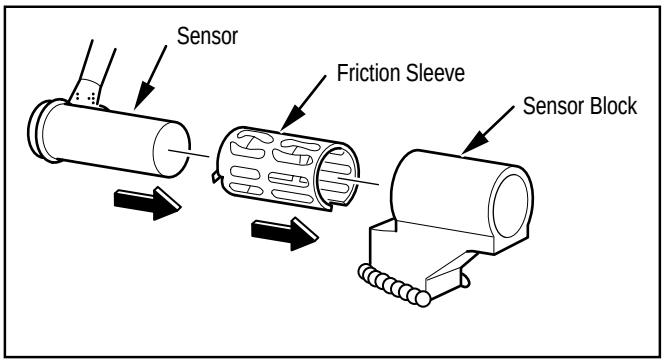


FIGURE 28 - Rear Speed Sensor Components

Installation

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

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

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

Pressure Modulator Valve (PMV) Troubleshooting

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

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

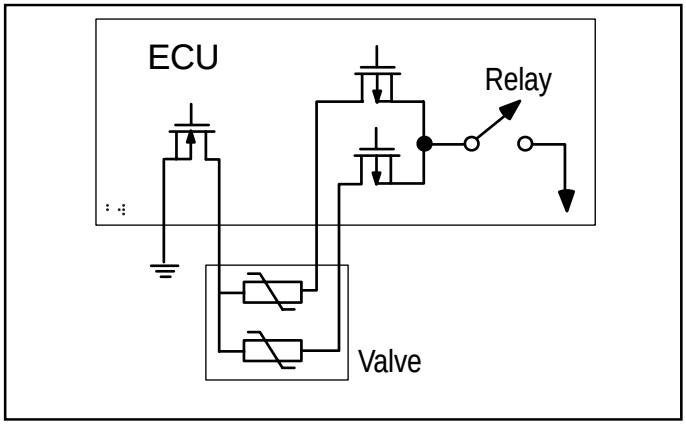
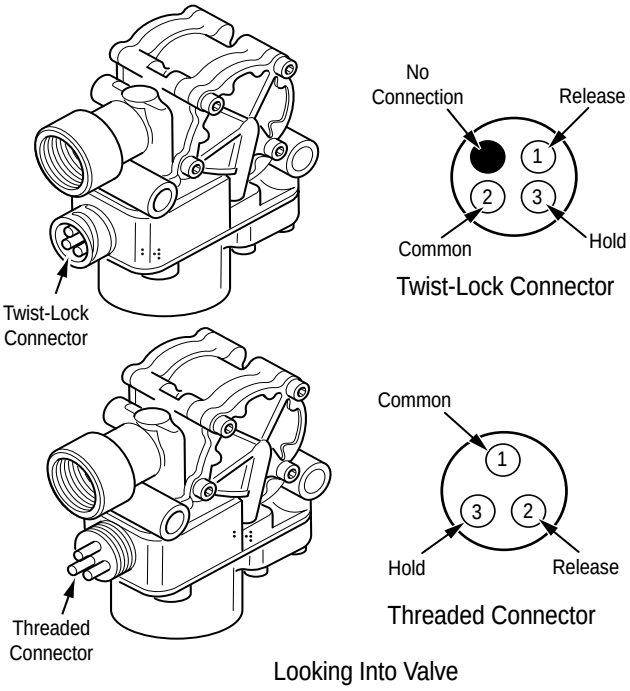


FIGURE 29 - Typical PMV Circuit



Measure From:	Measure To:	Resistance Range:
Common	Hold	3-8 Ohms
Common	Release	3-8 Ohms
HoldRelease	6-16 Ohms	

PMV Resistance Test

Measure resistance at the PMV location to check the valve.

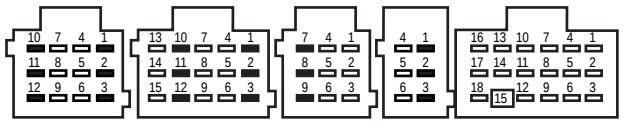
Measure resistance at the appropriate ECU harness connector pins to check the cable and valve.

Note: Refer to the chart for pin identification.

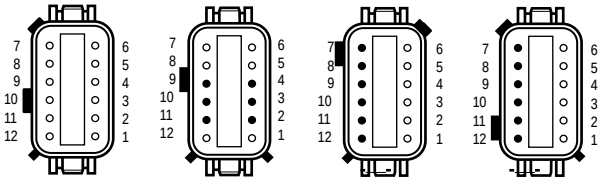
FIGURE 30 - PMV Harness Circuit Descriptions and Resistance Test

Cab Mount

TOP – Looking into harness connector



Frame Mount



Harness Connector	PIN	Circuit Description
B (6-Way)	1	PMV 1 (Release) Left Steer
	2	PMV 1 (Hold) Left Steer
	3	PMV 1 Common Left Steer
C (9-Way)	7	PMV 2 (Release) Right Steer
	8	PMV 2 (Hold) Right Steer
	9	PMV 2 Common Right Steer
D (15-Way)	1	PMV 3 (Release) Left Rear
	2	PMV 3 (Hold) Left Rear
	3	PMV 3 Common Left Rear
D (15-Way)	10	PMV 4 (Release) Right Rear
	11	PMV 4 (Hold) Right Rear
	12	PMV 4 Common Right Rear
E (12-Way)	1	PMV 5 (Release) Left Rear Rear*
6-channel	2	PMV 5 (Hold) Left Rear Rear*
Only	3	PMV 5 Common Left Rear Rear*
E (12-Way)	10	PMV 6 (Release) Right Rear Rear*
6-channel	11	PMV 6 (Hold) Right Rear Rear*
Only	12	PMV 6 Common Right Rear Rear*

*Not Used On Basic System

Harness Connector	PIN	Circuit Description
X2 (Black)	2	PMV 1 (Hold) Left Steer
	10	PMV 1 (Release) Left Steer
	11	PMV 1 Common Left Steer
X2 (Black)	3	PMV 2 (Release) Right Steer
	4	PMV 2 (Hold) Right Steer
	9	PMV 2 Common Right Steer
X3 (Green)	10	PMV 3 (Release) Left Rear
	12	PMV 3 (Hold) Left Rear
	11	PMV 3 Common Left Rear
X3 (Green)	7	PMV 4 (Release) Right Rear
	9	PMV 4 (Hold) Right Rear
	8	PMV 4 Common Right Rear
X4 (Brown)	10	PMV 5 (Release) Left Rear Rear*
6-channel	12	PMV 5 (Hold) Left Rear Rear*
Only	11	PMV 5 Common Left Rear Rear*
X4 (Brown)	7	PMV 6 (Release) Right Rear Rear*
6-channel	9	PMV 6 (Hold) Right Rear Rear*
Only	8	PMV 6 Common Right Rear Rear*

*Not Used On Basic System

FIGURE 31 - 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. If valve is OK check harness for short in wiring.
2	The is a short between the release solenoid and ground.	Use multimeter to check that valve resistances are correct. If valve is OK check harness for short in wiring.
3	There is an open circuit at the release solenoid.	Use multimeter to check that valve resistances are correct. If valve is OK check harness for open in wiring.
4	There is an open circuit in the common line to the valve.	Use multimeter to check that valve resistances are correct. If valve is OK check harness for open in wiring.
5	There is a short between the hold solenoid and supply voltage.	Use multimeter to check that valve resistances are correct. If valve is OK check harness for short in wiring.
6	The is a short between the hold solenoid and ground.	Use multimeter to check that valve resistances are correct. If valve is OK check harness for short in wiring.
7	There is an open circuit at the hold solenoid.	Use multimeter to check that valve resistances are correct. If valve is OK check harness for open in wiring.
8	A valve has been found wired in the wrong location.	Check the control unit configuration and verify that valves are wired in the proper location for the configuration (Refer to Schematic).

1st

Flashes	Location
10 or 11	PMV Commons

1.5 Sec. Pause

2nd

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

FIGURE 32 - PMV Diagnostic Trouble Code Troubleshooting Guide

ABS Modulator Valve

Removal

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

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

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

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

Installation

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

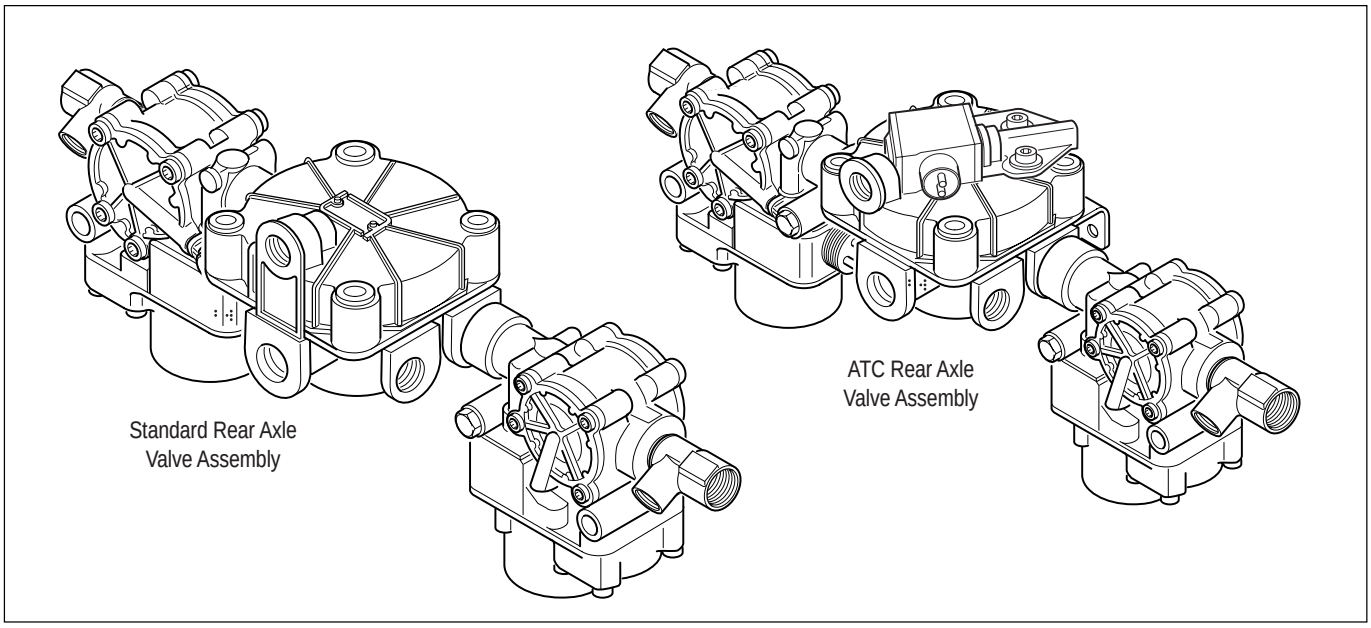


FIGURE 33 - Rear Axle Valve Assemblies – Standard and ATC Version Shown

Performance Test of the Relay Valve

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

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

Automatic Traction Control (ATC) Valve Troubleshooting

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

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

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

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

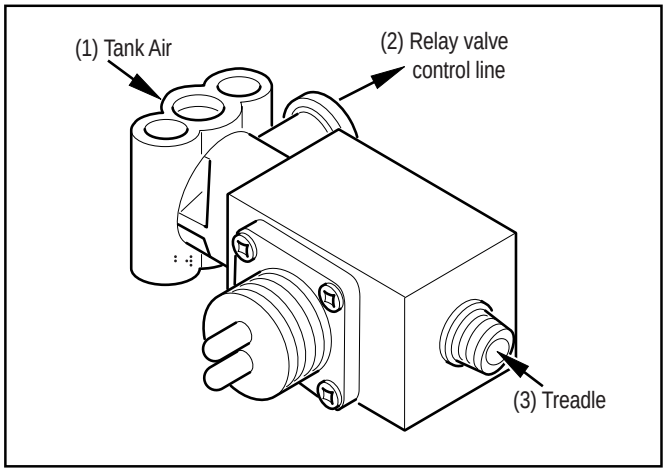
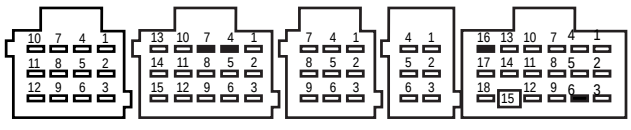


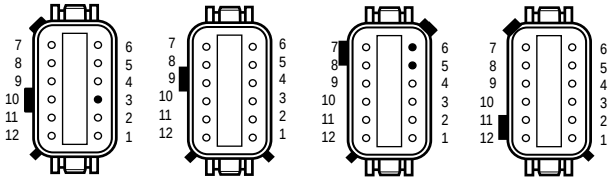
FIGURE 34 - ATC Valve

Cab Mount

TOP – Looking into harness connector



Frame Mount



Harness Connector	PIN	Circuit Description
A (18-Way)	6	ATC Mud and Snow Switch
	16	ATCL (ATC Light)
D (15-Way)	4	ATC Valve +
	7	ATC Valve –

Harness Connector	PIN	Circuit Description
X1 (Grey)	3	ATCL (ATC Light/ATC Switch)
X3 (Green)	5	ATC Valve –
	6	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 35 - 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 36 - ATC Diagnostic Trouble Code Troubleshooting Guide

ATC Valve Removal

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

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

Installation

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

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

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

Select Traction Control Valve

Verify Traction control light operation

Drive the vehicle and verify ABS indicator lamp operates properly.

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

Blink Code Sequence

1st

Flashes	Location
14	ECU, Engine Interface

1.5 Sec. Pause

2nd

Flashes	Condition	Action
12	No connection found to engine data link (J1922/J1939).	Refer to electrical schematic. Check for proper connection of data link to ECU. Verify that polarity is correct. Unplug connector at ECU. There should be a voltage between 0 and 2.5 volts on J1922/J1939 (–) and a voltage between 2.5 and 5 volts on J1922/J1939 (+). If vehicle is not equipped with J1922/J1939 engine link, use diagnostic tool to reconfigure ECU.

1st

Flashes	Location
15	ECU

1.5 Sec. Pause

2nd

Flashes	Condition	Action
1–11	ECU Internal Fault	If fault cannot be cleared, replace ECU.

FIGURE 37 - System and ECU Diagnostic Trouble Codes Troubleshooting Guide

Blink Code Sequence

Flashes	Location
16	Power Circuits

1st

1.5 Sec. Pause

2nd

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

FIGURE 38 - Power Circuit Diagnostic Trouble Codes Troubleshooting Guide

Blink Code Sequence

Flashes	Location
17	Miscellaneous

1st

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

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

FIGURE 39 - Miscellaneous Diagnostic Trouble Codes Troubleshooting Guide

Cab Mount ECU Pin Identification

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

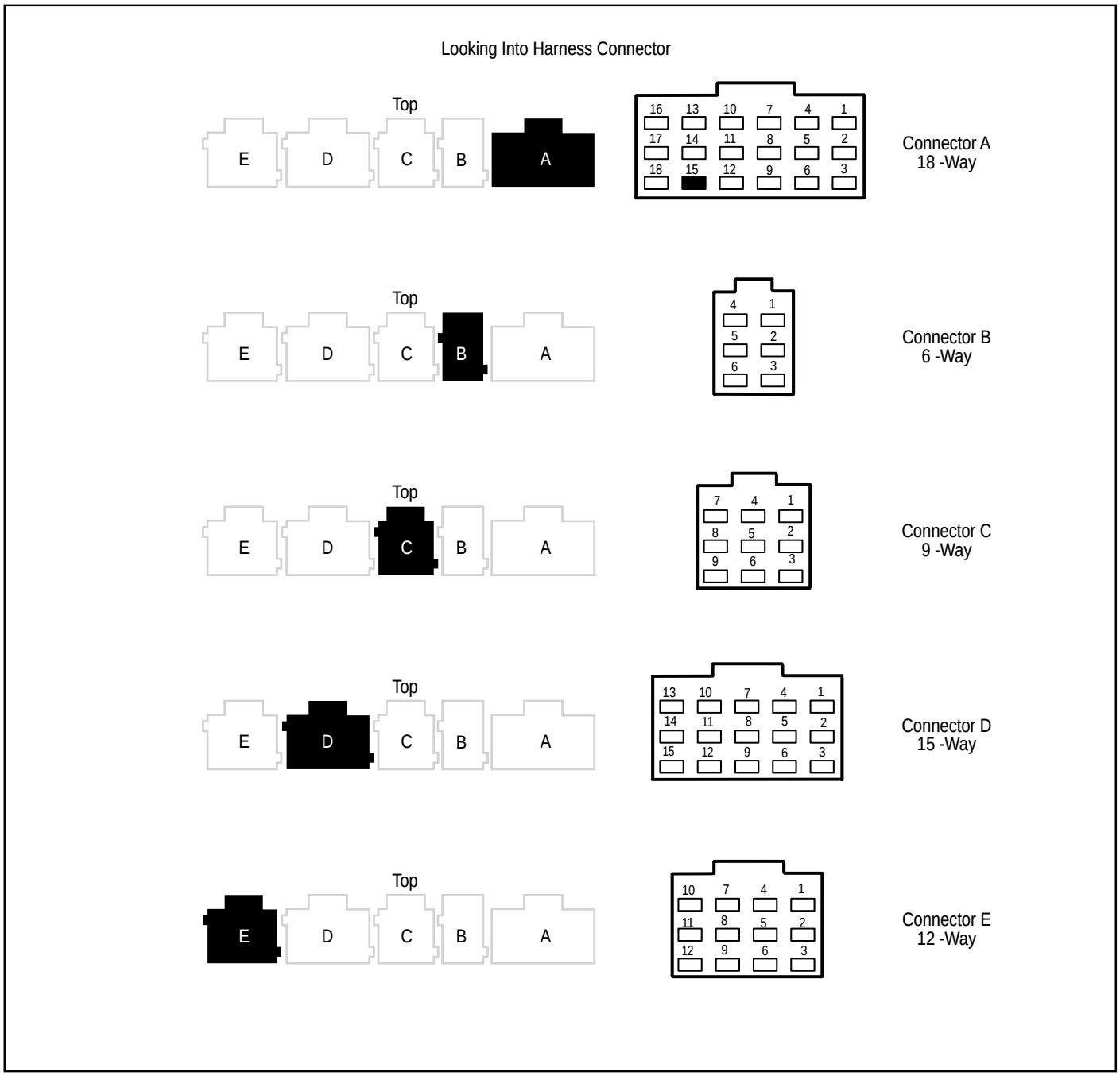


FIGURE 40 - Cab Mount ECU – Connector Layout

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

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

FIGURE 41 - Cab Mount ECU – Pin Identification Chart

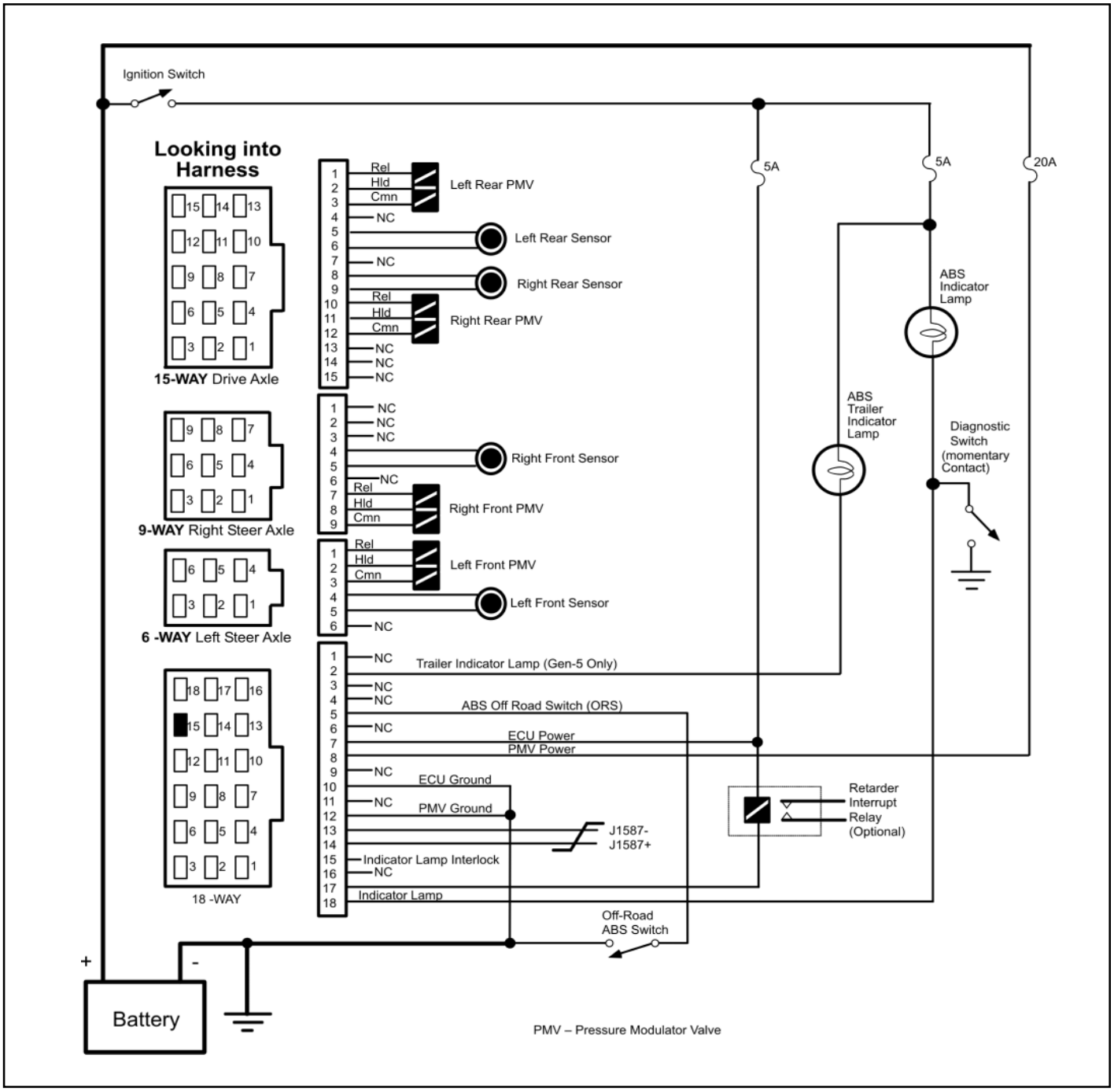


FIGURE 42 - Gen 4™ and Gen 5™ Basic Cab Mount ABS Electrical Schematic

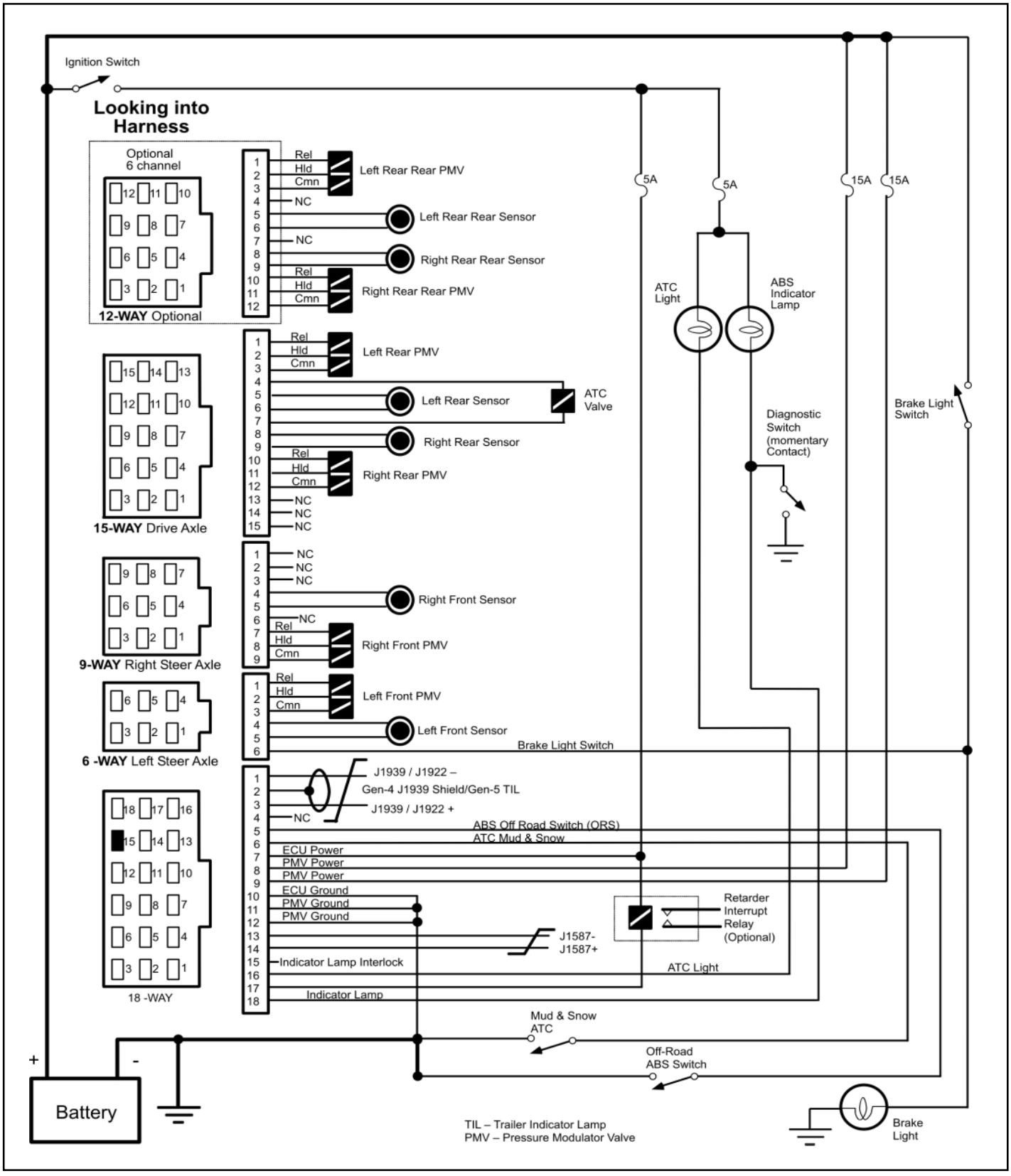


FIGURE 43 - Gen 4™ and Gen 5™ Standard Cab Mount ABS Electrical Schematic

Frame Mount ECU Pin Identification

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

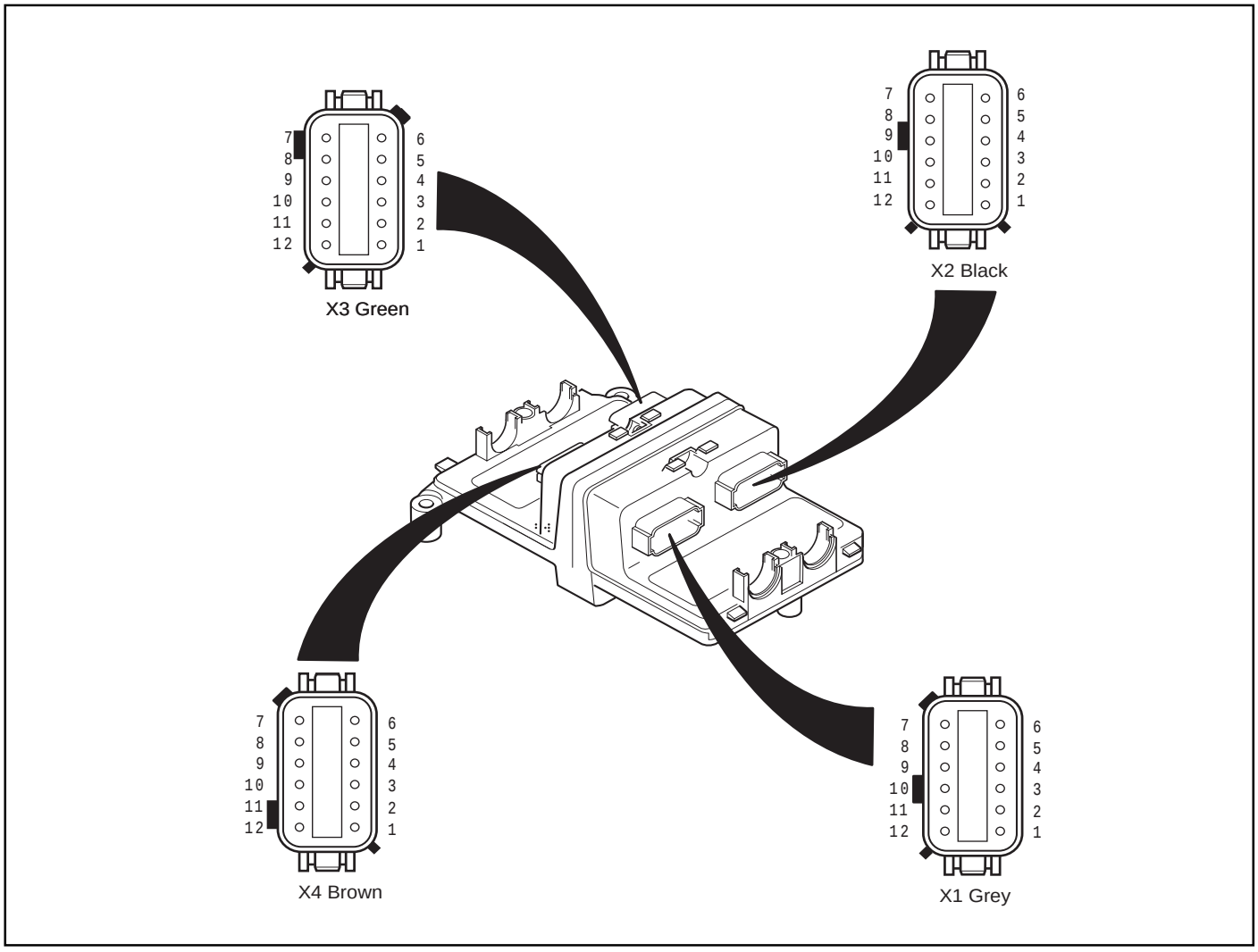


FIGURE 44 - Cab Mount ECU – Pin Identification Chart

X1 Grey

Pin	Signal	Description
X1-1	IGN_1	Ignition-1
X1-2	IGN_2	Ignition-2
X1-3	ATCL	ATC Light/ATC Switch
X1-4	1587_+	J1587+
X1-5	RET	Retarder Control
X1-6	ENG_-	J1922/1939 Engine Control Link-
X1-7	ENG_+	J1922/1939 Engine Control link+
X1-8	SHLD/TIL	Gen 4™ ABS J1939 Shield/Gen 5™ ABS TIL
X1-9	1587_-	J1587-
X1-10	WL	ABS WL/Diagnostic Switch
X1-11	GND_2	Ground
X1-12	GND_1	Ground

X3 Green

Pin	Signal	Description
X3-1	SS_{LR}	Speed Sensor, Left Rear-
X3-2	SS_{LR}	Speed Sensor, Left Rear+
X3-3	SS_{RR}	Speed Sensor, Right Rear-
X3-4	SS_{RR}	Speed Sensor, Right Rear+
X3-5	$ATCV_-$	Traction Control Valve-
X3-6	$ATCV_+$	Traction Control Valve+
X3-7	REL_{RR}	Release Sol, Right Rear
X3-8	CMN_{RR}	Common, Right Rear
X3-9	HLD_{RR}	Hold Sol, Right Rear
X3-10	REL_{LR}	Release Sol, Left Rear
X3-11	CMN_{LR}	Common, Left Rear
X3-12	HLD_{LR}	Hold Sol, Left Rear

X2 Black

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

X4 Brown

Pin	Signal	Description
X4-1	DLC_-	Diff Lock Control-
X4-2	DLC_+	Diff Lock Control+
X4-3	SS_{LRR}	Speed Sensor Left Rear Rear-
X4-4	SS_{LRR}	Speed Sensor Left Rear Rear+
X4-5	SS_{RRR}	Speed Sensor Right Rear Rear-
X4-6	SS_{RRR}	Speed Sensor Right Rear Rear+
X4-7	REL_{RRR}	Release Sol, Right Rear Rear
X4-8	CMN_{C+}	Common, Right Rear Rear
X4-9	HLD_{RRR}	Hold Sol, Right Rear Rear
X4-10	REL_{LRR}	Release Sol, Left Rear Rear
X4-11	CMN_{LRR}	Common, Left Rear Rear
X4-12	HLD_{LRR}	Hold Sol, Left Rear Rear

FIGURE 45 - Frame Mount ECU – Pin Identification Chart

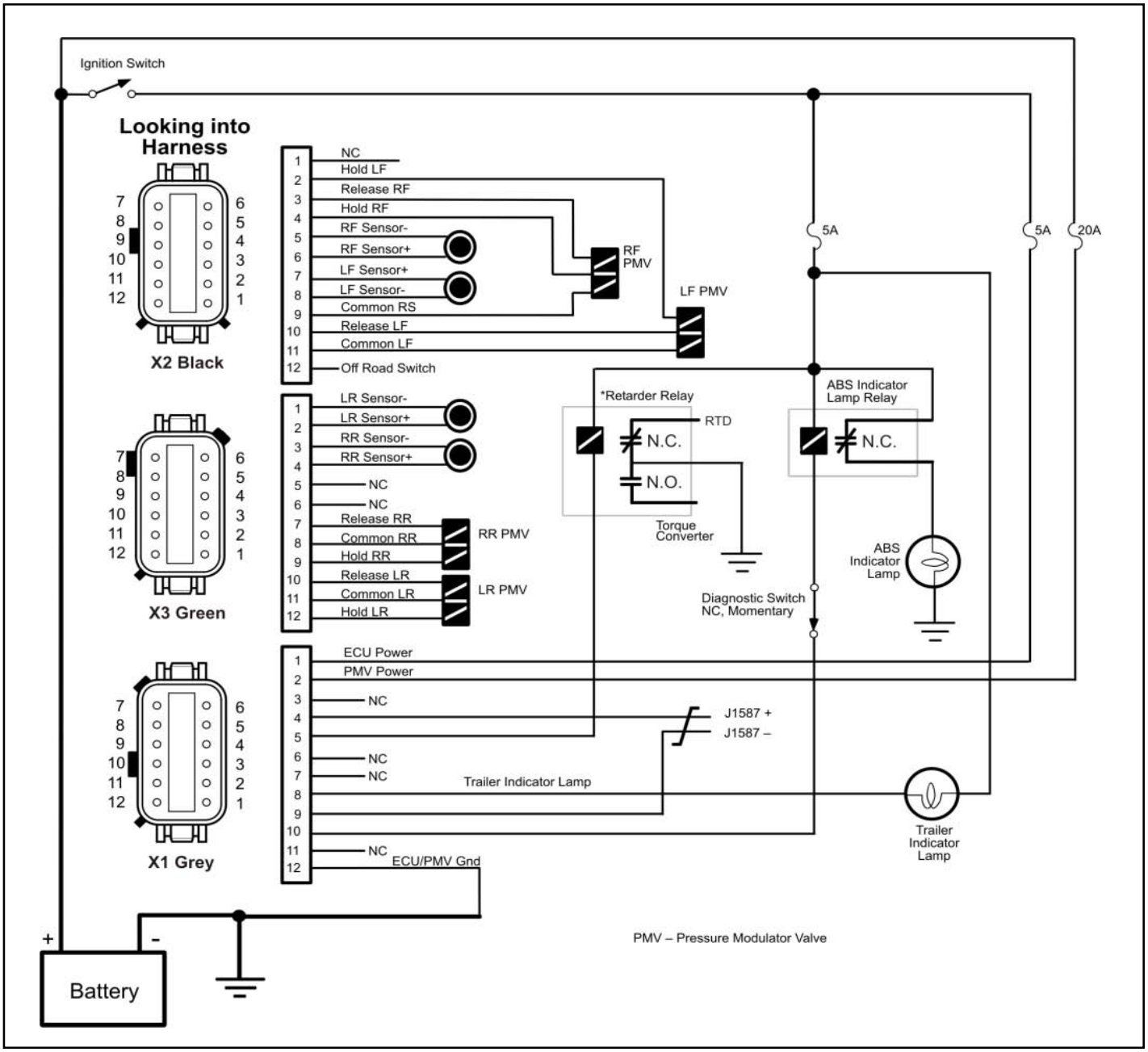


FIGURE 46 - Gen 5™ Basic Frame Mount ABS Electrical Schematic

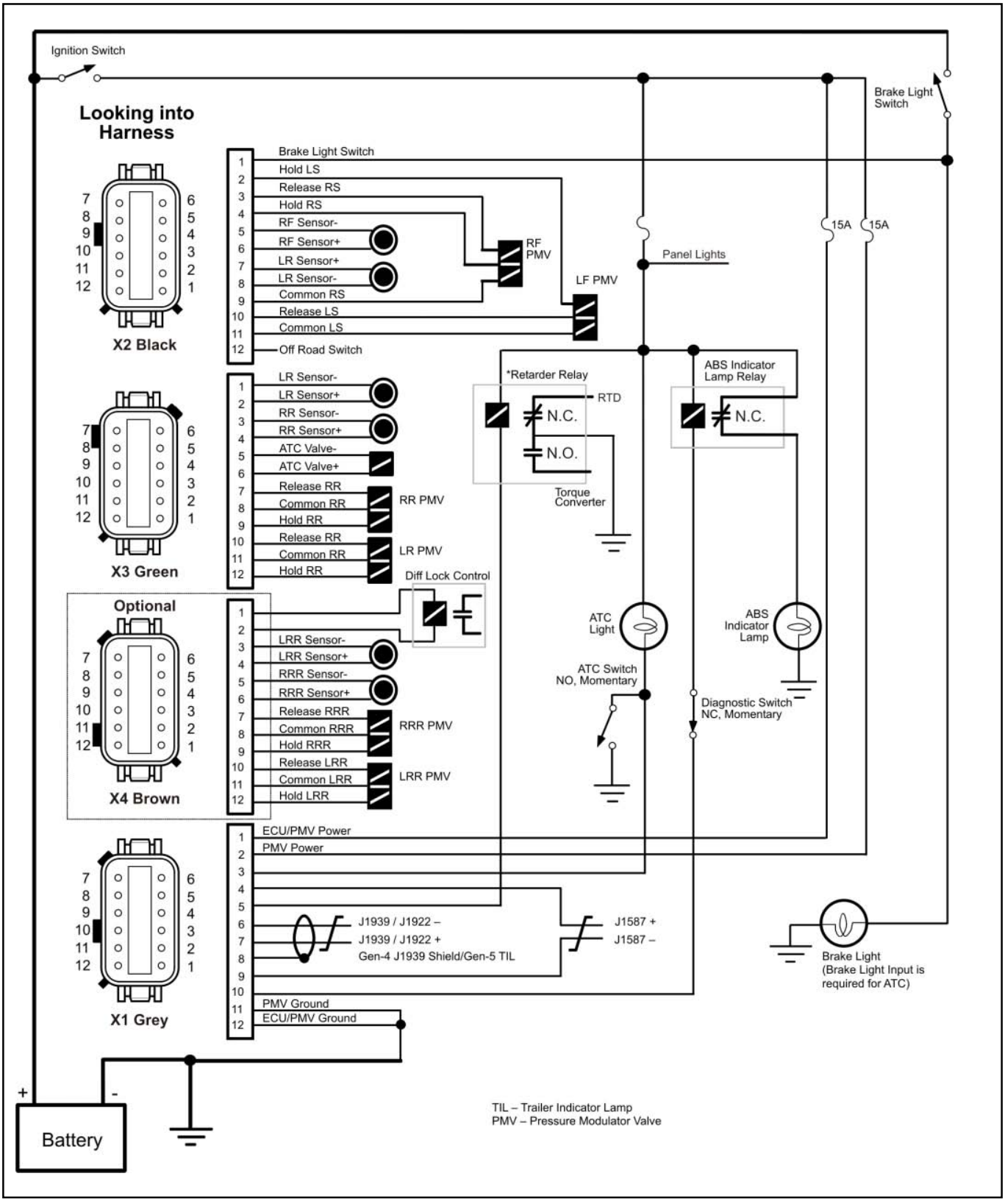


FIGURE 47 - Gen 4™ and Gen 5™ Standard Frame Mount ABS Electrical Schematic

Glossary

ABS — Antilock Brake System.

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

Air Gap — Distance between the Sensor and tone ring.

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

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

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

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

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

Channel — A controlled wheel site.

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

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

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

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

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

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

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

Diagnostic Switch — A switch used to activate blinks codes.

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

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

ECU — Electronic Control Unit.

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

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

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

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

J1587 — The SAE heavy duty standard diagnostic data link.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Stored Faults — A Fault that occurred.

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

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

Bendix

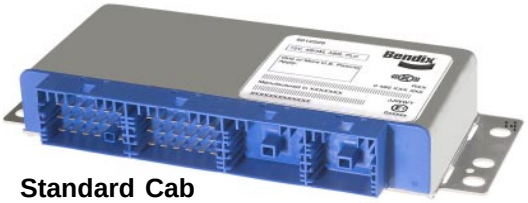
Service Data

SD-13-4863

Bendix® EC-60™ ABS / ATC Controllers (Standard & Premium Models)

Frame and Cab Mount

Standard Frame



Standard Cab

Premium Frame

Premium Cab

FIGURE 1 - EC-60™ CONTROLLERS

INTRODUCTION

Bendix® EC-60™ controllers are members of a family of electronic **Antilock Braking System (ABS)** devices designed to help improve the braking characteristics of air braked vehicles - including heavy and medium duty buses, trucks, and tractors. ABS controllers are also known as **Electronic Control Units (ECUs)**.

Bendix ABS uses wheel speed sensors, ABS modulator valves, and an ECU to control either four or six wheels of a vehicle. By monitoring individual wheel turning motion during braking, and adjusting or pulsing the brake pressure at each wheel, the EC-60™ controller is able to optimize slip between the tire and the road surface. When excessive wheel slip, or wheel lock-up, is detected, the EC-60™ controller will activate the Pressure Modulator Valves to simulate a driver pumping the brakes. However, the EC-60™ controller is able to pump the brakes on individual wheels (or pairs of wheels), independently, and with greater speed and accuracy than a driver.

In addition to the ABS function, premium models of the EC-60™ controller provide an **Automatic Traction Control (ATC)** feature. Bendix ATC can improve vehicle traction during acceleration, and lateral stability while driving through curves. ATC utilizes **Engine Torque Limiting (ETL)** where the ECU communicates with the engine's controller and/or **Differential Braking (DB)** where individual wheel brake applications are used to improve vehicle traction.

Premium EC-60™ controllers have a drag torque control feature which reduces driven-axle wheel slip (due to driveline inertia) by communicating with the engine's controller and increasing the engine torque.

TABLE OF CONTENTS PAGE

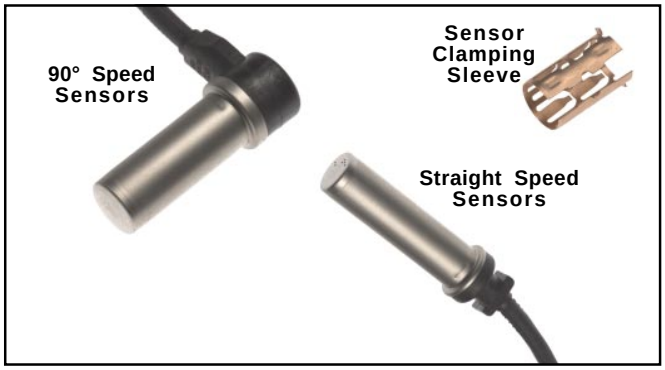


FIGURE 2 - BENDIX® WS-24™ WHEEL SPEED SENSORS

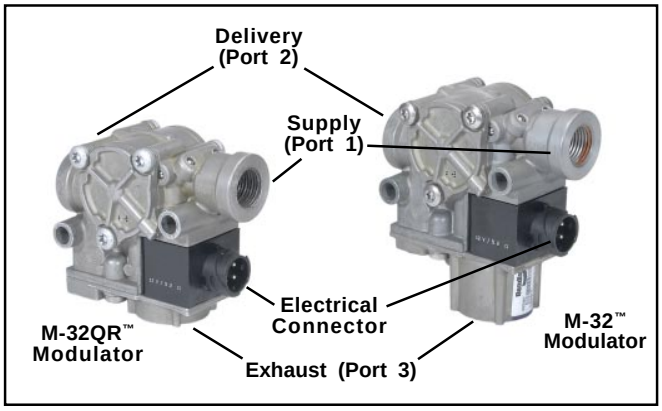


FIGURE 3 - M-32™ AND M-32QR™ MODULATORS

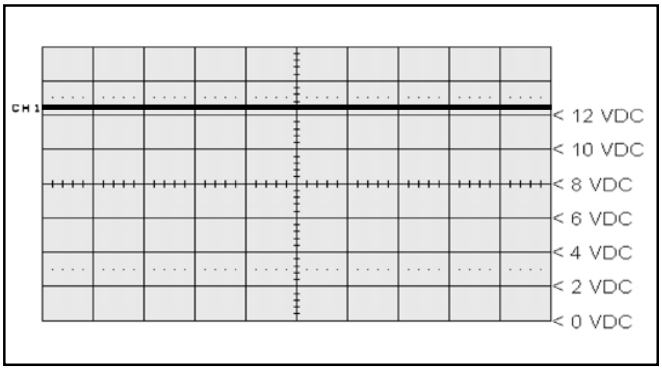


FIGURE 4 - POWER LINE WITHOUT PLC SIGNAL

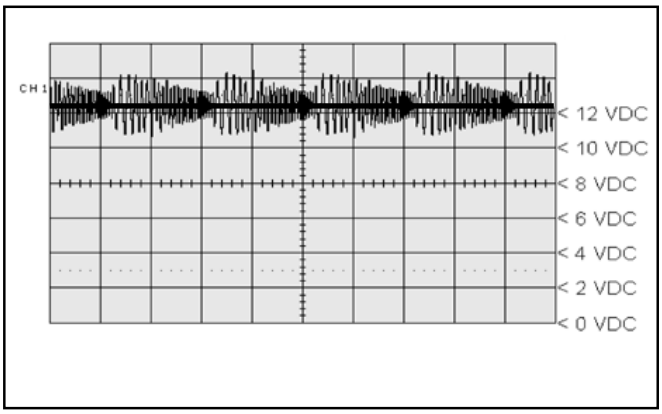


FIGURE 5 - POWER LINE WITH PLC SIGNAL

COMPONENTS

The EC-60™ controller's ABS function utilizes the following components:

- Bendix® WS-24™ wheel speed sensors (4 or 6, depending on ECU model and configuration). Each sensor is installed with a Bendix Sensor Clamping Sleeve
- Bendix® M-32™ or M-32QR™ Pressure Modulator Valves (4, 5, or 6 depending on ECU model and configuration)
- Dash-mounted tractor ABS Indicator Lamp
- Service brake relay valve
- Dash-mounted trailer ABS Indicator Lamp (used on all towing vehicles manufactured after March 1, 2001)
- Optional blink code activation switch
- Optional ABS off-road switch. (Off-road feature is not available on all models - See Chart 1.)

The EC-60™ controller ATC function utilizes the following additional components:

- Traction control valve (may be integral to the service brake relay valve or a stand-alone device)
- Dash-mounted ATC status/indicator lamp
- J1939 serial communication to engine control module
- Stop lamp switch input (may be provided using the ECU hardware input or J1939)
- Optional ATC off-road switch

ECU MOUNTING

Cab ECUs

Cab-mounted EC-60™ controllers are not protected against moisture, and must be mounted in an environmentally protected area.

All wire harness connectors must be properly seated. The use of secondary locks is strongly recommended.

CAUTION: All unused ECU connectors must be covered and receive any necessary protection from moisture, etc.

Cab ECUs utilize connectors from the AMP MCP 2.8 product family.

Frame ECUs

Frame-mounted EC-60™ controllers may be mounted on the vehicle frame, but only in locations where they will not be subjected to direct tire spray. ECU mounting bolts must be torqued to 7.5 to 9 Nm.

CAUTION: The frame wire harness connectors must be properly seated with the seals intact (undamaged). All unused connector terminals must be plugged with the appropriate sealing plugs. Failure to properly seat or seal the connectors could result in moisture or corrosion damage to the connector terminals. ECUs damaged by moisture and/or corrosion are not covered under the Bendix warranty.

Frame ECUs utilize Deutsch connectors.

ECU Model	Mounting	Input Voltage	Sensors	PMVs	ATC	Blink Codes	Serial Communication		PLC	ABS Off-Road	ATC Off-Road	Retarder Relay
							J1587	J1939				
Standard	Cab Frame	12	4	4		✔	✔	✔				✔
Standard PLC	Cab Frame	12	4	4		✔	✔	✔	✔			✔
Premium	Cab Frame	12	4/6	4/5/6	✔	✔	✔	✔	✔	✔	✔	✔
Premium	Cab	24	4/6	4/5/6	✔	✔	✔	✔		✔	✔	✔

CHART 1 - EC-60™ CONTROLLERS AVAILABLE

HARDWARE CONFIGURATIONS

Standard Models

Standard model EC-60™ controllers support four sensor/four modulator (4S/4M) applications. Certain models support Power Line Carrier (PLC) communications, with all models supporting 12 volt installations. *See Chart 1 for more details.*

Premium Models

Premium model EC-60™ controllers support applications up to six sensor/six modulator (6S/6M) installations with ATC and drag torque control. All 12 volt models support PLC. 24 volt models do not support PLC. *See Chart 1 for more details.*

EC-60™ CONTROLLERS WITH PLC

Since March 1, 2001, all towing vehicles must have an in-cab trailer ABS Indicator Lamp. Trailers transmit the status of the trailer ABS over the power line (the blue wire of the J560 connector) to the tractor using a Power Line Carrier (PLC) signal. See Figures 4 and 5. Typically the signal is broadcast by the trailer ABS ECU. The application of PLC technology for the heavy vehicle industry is known as "PLC4Trucks." The Standard PLC EC-60™ controller and the Premium EC-60™ controller (12 volt versions) support PLC communications in accordance with SAE J2497.

Identifying an EC-60™ Controller with PLC

Refer to the information panel on the ECU label to see if the controller provides PLC.

An oscilloscope can be used to measure or identify the presence of a PLC signal on the power line. The PLC signal is an amplitude and frequency modulated signal. Depending on the filtering and load on the power line, the PLC signal amplitude can range from 5.0mVp-p to 7.0 Vp-p. Suggested oscilloscope settings are AC coupling, 1 volt/div, 100 µsec/div. The signal should be measured at the ignition power input of the EC-60™ controller.

Note: An ABS trailer equipped with PLC, or a PLC diagnostic tool, must be connected to the vehicle in order to generate a PLC signal on the power line.

Alternatively, the part number shown on the ECU label can be identified as a PLC or non-PLC model by calling the Bendix TechTeam at 1-800-AIR-BRAKE (1-800-247-2725).

EC-60™ CONTROLLER INPUTS

Battery and Ignition Inputs

The ECU operates at a nominal supply voltage of 12 or 24 volts, depending on the model of the ECU. The battery input is connected through a 30 amp fuse directly to the battery.

The ignition input is applied by the ignition switch through a 5 amp fuse.

Ground Input

The EC-60™ controller supports one ground input. See pages 35 to 40 for system schematics.

ABS Indicator Lamp Ground Input (Cab ECUs Only)

EC-60™ cab ECUs require a second ground input (X1-12) for the ABS indicator lamp. The X1 wire harness connector contains an ABS indicator lamp interlock (X1-15), which shorts the ABS indicator lamp circuit (X1-18) to ground if the connector is removed from the ECU.

Bendix® WS-24™ Wheel Speed Sensors

Wheel speed data is provided to the EC-60™ controller from the WS-24™ wheel speed sensor (see Figure 2). Vehicles have an exciter ring (or "tone ring") as part of the wheel assembly, and as the wheel turns, the teeth of the exciter ring pass the wheel speed sensor, generating an AC signal. The EC-60™ controller receives the AC signal, which varies in voltage and frequency as the wheel speed changes.

Vehicle axle configurations and ATC features determine the number of WS-24™ wheel speed sensors that must be used. A vehicle with a single rear axle requires four wheel speed sensors. Vehicles with two rear axles can utilize six wheel speed sensors for optimal ABS and ATC performance.

Diagnostic Blink Code Switch

A momentary switch that grounds the ABS Indicator Lamp output is used to place the ECU into the diagnostic blink code mode and is typically located on the vehicle's dash panel.

ABS Off-Road Switch and Indicator Lamp Operation

WARNING: The ABS off-road mode should not be used on normal, paved road surfaces because vehicle stability and steerability may be affected. When the ECU is placed in the ABS off-road mode, the ABS Indicator Lamp will flash constantly to notify the vehicle operator that the off-road mode is active.

Premium EC-60™ controllers use a dash-mounted switch to place the ECU into the ABS off-road mode. In some cases, ECUs may also be put into the ABS off-road mode by one of the other vehicle control modules, using a J1939 message to the EC-60™ controller.

(If you need to know if your EC-60™ controller uses a J1939 message to operate the lamp, e-mail ABS@bendix.com, specifying the ECU part number, or call 1-800-AIR-BRAKE and speak to the Bendix TechTeam.)

Stop Lamp Switch (SLS)

The Premium EC-60™ controller monitors the vehicle stop lamp status. Certain vehicle functions, such as ATC and All-Wheel Drive (AWD), use the status of the stop lamp to know the driver's intention. This can be provided to the ECU via J1939 communications, or hardware input.

EC-60™ CONTROLLER OUTPUTS

Bendix® M-32™ and M-32QR™ Pressure Modulator Valves (PMV)

The Bendix® M-32™ and M-32QR™ pressure modulator valves (PMV) are operated by the EC-60™ controller to modify driver applied air pressure to the service brakes during ABS or ATC activation (See pages 6-8). The PMV is an electro-pneumatic control valve and is the last valve that air passes through on its way to the brake chamber. The modulator hold and release solenoids are activated to precisely modify the brake pressure during an antilock braking event. The hold solenoid is normally open and the release solenoid is normally closed.

Traction Control Valve (TCV)

Premium EC-60™ controllers will activate the TCV during differential braking ATC events. The TCV may be a separate valve or integrated into the rear axle relay valve.

ABS Indicator Lamp Control with Optional Diagnostic Blink Code Switch (Cab and Frame ECUs)

Cab and frame-mount EC-60™ controllers have internal circuitry to control the ABS Indicator Lamp on the dash panel.

The ABS Lamp Illuminates:

1. During power up (e.g. when the vehicle is started) and turns off after the self test is completed, providing no **Diagnostic Trouble Codes (DTCs)** are present on the tractor.
2. If the ECU is unplugged or has no power.
3. When the ECU is placed into the ABS off-road mode (the lamp flashes rapidly).
4. To display blink codes for diagnostic purposes after the external diagnostic switch is activated.

Certain models of the EC-60™ controller communicate with other vehicle control modules to operate the ABS Indicator Lamp using serial communications. (If you need to know if your EC-60™ controller uses serial communications to operate the lamp, e-mail ABS@bendix.com, specifying the ECU part number, or call 1-800-AIR-BRAKE and speak to the Bendix TechTeam.)

Indicator Lamp Control Using Serial Communications Links

As mentioned above, depending on the vehicle manufacturer, the dash indicator lamps (ABS, ATC, and trailer ABS) may be controlled using serial communications links. In these cases, the EC-60™ controller will send a serial communications message over the J1939 or J1587 links indicating the required status of the lamp(s). Another vehicle control module receives the message and controls the indicator lamp(s).

Retarder Relay Disable Output

The retarder relay disable output may be used to control a retarder disable relay.

When configured to use this output, the ECU will energize the retarder disable relay and inhibit the use of the retarder as needed.

SAE J1939 Serial Communications

A Controller Area Network (CAN) data link (SAE J1939) is provided for communication. This link is used for various functions, such as:

- To disable retarding devices during ABS operation
- To request torque converter lock-up during ABS operation
- To share information such as wheel speed and ECU status with other vehicle control modules

Premium EC-60™ controllers utilize the J1939 data link for ATC and drag torque control functions.

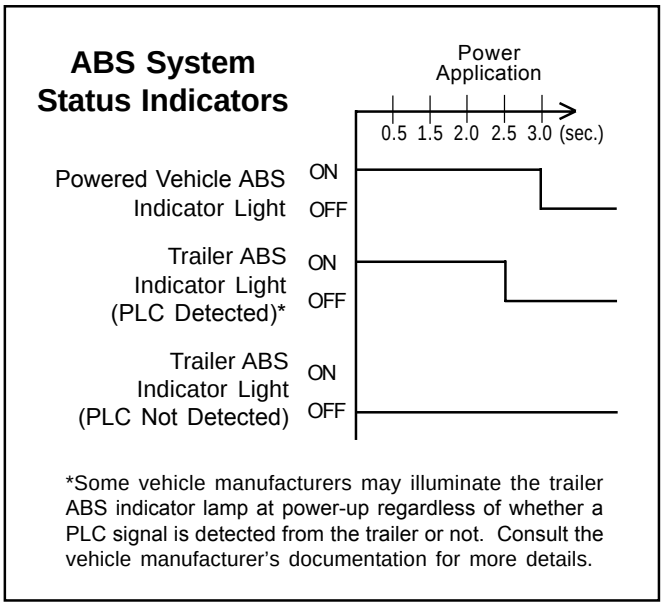


FIGURE 6 - ABS DASH LIGHTS START UP SEQUENCE

Trailer ABS Indicator Lamp Control

Certain models of the EC-60™ controller activate a trailer ABS Indicator Lamp (located on the dash panel) that indicates the status of the trailer ABS unit on one, or more trailers, or dollies. Typically, the EC-60™ controller directly controls the trailer ABS Indicator Lamp based on the information it receives from the trailer ABS.

Alternatively, some vehicles require the EC-60™ controller to activate the trailer ABS Indicator Lamp by communicating with other vehicle controllers using serial communications. (If you need to know if your EC-60™ controller uses a serial communications message to operate the lamp, e-mail ABS@bendix.com, specifying the ECU part number, or call 1-800-AIR-BRAKE and speak to the Bendix TechTeam.)

SAE J1708/J1587 Serial Communications

An SAE J1708 data link, implemented according to SAE J1587 recommended practice, is available for diagnostic purposes, as well as ECU status messages.

ATC Lamp Output/ATC Off-Road Switch Input

Premium ECUs control the ATC dash lamp.

The ATC Lamp Illuminates:

1. During power up (e.g. when the vehicle is started) and turns off after the self test is completed, providing no diagnostic trouble codes are present.
2. When ATC is disabled for any reason.
3. During an ATC event (the lamp will flash rapidly).
4. When the ECU is placed in the ATC off-road mode (the lamp will flash slowly at a rate of 1.0 seconds on, 1.5 seconds off). This notifies the vehicle operator that the off-road mode is active.

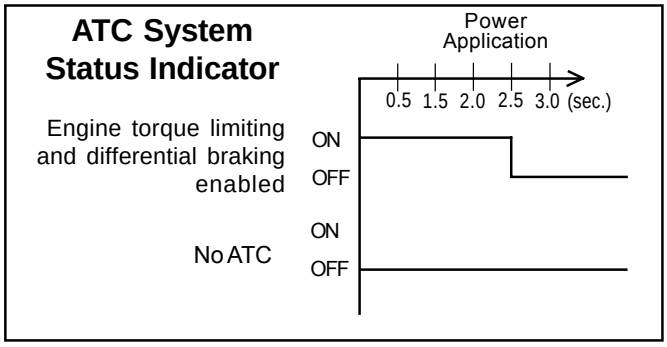


FIGURE 7 - ATC INDICATOR LIGHT START UP SEQUENCE

Interaxle Differential Lock Control (AWD Transfer Case)
Premium ECUs can control the interaxle differential lock (AWD transfer case). This is recommended on AWD vehicles, but the ECU must be specially configured to provide this feature. E-mail to ABS@bendix.com for more details.

POWER-UP SEQUENCE

WARNING: The vehicle operator should verify proper operation of all installed indicator lamps (ABS, ATC, and trailer ABS) when applying ignition power and during vehicle operation.

Lamps that do not illuminate as required when ignition power is applied, or remain illuminated after ignition power is applied, indicate the need for maintenance.

ABS Indicator Lamp Operation

The ECU will illuminate the ABS Indicator Lamp for approximately three seconds when ignition power is applied, after which the lamp will extinguish if no diagnostic trouble codes are detected.

The ECU will illuminate the ABS Indicator Lamp whenever full ABS operation is not available due to a diagnostic trouble code. In most cases, partial ABS is still available.

ATC Status/Indicator Lamp Operation

The ECU will illuminate the ATC lamp for approximately 2.5 seconds when ignition power is applied, after which the lamp will extinguish, if no diagnostic trouble codes are detected.

The ECU will illuminate the ATC Indicator Lamp whenever ATC is disabled due to a diagnostic trouble code.

Trailer ABS Indicator Lamp Operation

Certain models of the ECU will control the Trailer ABS Indicator Lamp when a PLC signal (SAE J2497) from a trailer ABS ECU is detected.

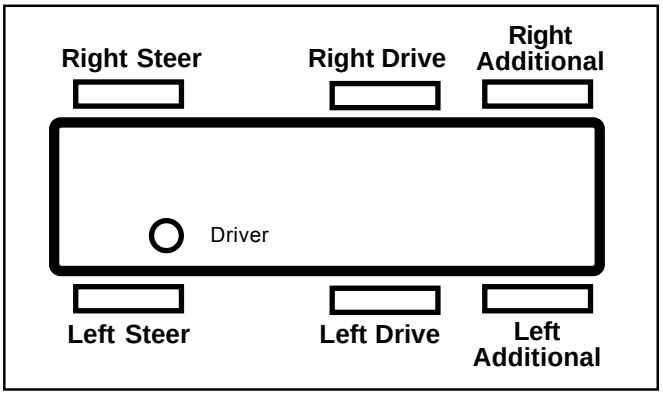


FIGURE 8 - VEHICLE ORIENTATION (TYPICAL)

ECU Configuration Test

Within two seconds of the application of ignition power, the ECU will perform a test to detect system configuration with regards to the number of wheel speed sensors and PMVs. This can be audibly detected by a rapid cycling of the PMVs. (Note: The ECU will not perform the configuration test when wheel speed sensors show that the vehicle is in motion.)

Pressure Modulator Valve Chuff Test

After the performance of the configuration test, the EC-60™ controller will perform a Bendix-patented PMV Chuff Test. The Chuff Test is an electrical and pneumatic PMV test that can assist maintenance personnel in verifying proper PMV wiring and installation.

With brake pressure applied, a properly installed PMV will perform one sharp audible exhaust of air by activating the hold solenoid twice and the release solenoid once. If the PMV is wired incorrectly, it will produce two exhausts of air or none at all.

The EC-60™ controller will perform a PMV chuff test on all installed modulators in the following order:

- Steer Axle Right PMV
- Steer Axle Left PMV
- Drive Axle Right PMV
- Drive Axle Left PMV
- Additional Axle Right PMV
- Additional Axle Left PMV

The pattern will then repeat itself.

The ECU will not perform the PMV Chuff Test when wheel speed sensors show that the vehicle is in motion.

ABS OPERATION

Bendix ABS uses wheel speed sensors, ABS modulator valves, and an ECU to control either four or six wheels of a vehicle. By monitoring individual wheel turning motion during braking, and adjusting or pulsing the brake pressure at each wheel, the EC-60™ controller is able to optimize slip between the tire and the road surface. When excessive wheel slip, or wheel lock-up, is detected, the EC-60™ controller will activate the Pressure Modulator Valves to simulate a driver pumping the brakes. However, the EC-60™ controller is able to pump the brakes on individual wheels (or pairs of wheels), independently, and with greater speed and accuracy than a driver.

Steer Axle Control

Although both wheels of the steer axle have their own wheel speed sensor and pressure modulator valve, the EC-60™ controller blends the applied braking force between the two steering axle brakes. This Bendix patented brake application control, called Modified Individual Regulation (MIR), is designed to help reduce steering wheel pull during an ABS event on road surfaces with poor traction (or areas of poor traction, e.g. asphalt road surfaces with patches of ice).

Single Drive Axle Control (4x2 Vehicle)

For vehicles with a single rear drive axle (4x2), the brakes are operated independently by the EC-60™ controller, based on the individual wheel behavior.

Dual Drive Axle Control (4S/4M Configuration)

For vehicles with dual drive axles (6x4) using a 4S/4M configuration, one ABS modulator controls both right-side rear wheels and the other modulator controls both left-side rear wheels. Both wheels on each side receive equal brake pressure during an ABS stop. The rear wheel speed sensors must be installed on the axle with the lightest load.

Dual Rear Axle Control (6S/6M Configuration)

For vehicles with dual rear axles (6x4, 6x2) using a 6S/6M configuration, the rear wheels are controlled independently. Therefore, brake application pressure at each wheel is adjusted according to the individual wheel behavior on the road surface.

6x2 Vehicles with 6S/5M Configuration

6x2 vehicles can utilize a 6S/5M configuration, with the additional axle (a non-driven rear axle) having two sensors, but only one Pressure Modulator Valve. In this case, the PMV controls both wheels on the additional axle. The additional axle wheels would receive equal brake pressure, based on the wheel that is currently experiencing the most wheel slip.

Normal Braking

During normal braking, brake pressure is delivered through the ABS PMV and into the brake chamber. If the ECU does not detect excessive wheel slip, it will not activate ABS control, and the vehicle stops with normal braking.

Retarder Brake System Control

On surfaces with low traction, application of the retarder can lead to high levels of wheel slip at the drive axle wheels, which can adversely affect vehicle stability.

To avoid this, the EC-60™ controller switches off the retarder as soon as a lock-up is detected at one (or more) of the drive axle wheels.

When the ECU is placed in the ABS off-road mode, it will switch off the retarder only when ABS is active on a steer axle wheel and a drive axle wheel.

Optional ABS Off-Road Mode

On some road conditions, particularly when the driving surface is soft, the stopping distance with ABS may be longer than without ABS. This can occur when a locked wheel on soft ground plows up the road surface in front of the tire, changing the rolling friction value. Although vehicle stopping distance with a locked wheel may be shorter than corresponding stopping distance with ABS control, vehicle steerability and stability is reduced.

Premium EC-60™ controllers have an optional control mode that more effectively accommodates these soft road conditions to shorten stopping distance while maintaining optimal vehicle steerability and stability.

WARNING: The ABS off-road mode should not be used on normal, paved road surfaces because vehicle stability and steerability may be reduced. The flashing ABS Indicator Lamp communicates the status of this mode to the driver.

The vehicle manufacturer should provide the optional ABS off-road function only for vehicles that operate on unpaved surfaces or that are used in off-road applications, and is responsible for insuring that vehicles equipped with the ABS off-road function meet all FMVSS-121 requirements and have adequate operator indicators and instructions.

The vehicle operator activates the off-road function with a switch on the dash panel. A flashing ABS Indicator Lamp indicates to the driver that the ABS off-road function is engaged. To exit the ABS off-road mode, depress and release the switch.

All-Wheel Drive (AWD) Vehicles

AWD vehicles with an engaged interaxle differential (steer axle to rear axle)/AWD transfer case may have negative effects on ABS performance. Optimum ABS performance is achieved when the lockable differentials are disengaged, allowing individual wheel control.

Premium EC-60™ controllers can be programmed specifically for this configuration to control the differential lock/unlock solenoid in the AWD transfer case. When programmed to do so, the ECU will disengage the locked interaxle/AWD transfer case during an ABS event and reengage it once the ABS event has ended.

ATC OPERATION

ATC Functional Overview

Just as ABS improves vehicle stability during braking, ATC improves vehicle stability and traction during vehicle acceleration. The EC-60™ controller ATC function uses the same wheel speed information and modulator control as the ABS function. The EC-60™ controller detects excessive drive wheel speed, compares the speed of the front, non-driven wheels, and reacts to help bring the wheel spin under control. The EC-60™ controller can be configured to use engine torque limiting and/or differential braking to control wheel spin. For optimal ATC performance, both methods are recommended.

ATC Lamp Operation

The ATC Lamp Illuminates:

1. During power up (e.g. when the vehicle is started) and turns off after the self test is completed, providing no diagnostic trouble codes are present.
2. When ATC is disabled for any reason.
3. During an ATC event (the lamp will flash rapidly). When ATC is no longer active, the ATC active/indicator lamp turns off.
4. When the ECU is placed in the ATC off-road mode (the lamp will flash at a rate of 1.0 seconds on, 1.5 seconds off). This notifies the vehicle operator that the off-road mode is active.

Differential Braking

Differential braking is automatically activated when drive wheel(s) on one side of the vehicle are spinning, which typically occur on asphalt road surfaces with patches of ice. The traction system will then lightly apply the brake to the drive wheel(s) that are spinning. The vehicle differential will then drive the wheels on the other side of the vehicle.

Differential braking is available at vehicle speeds up to 25 MPH.

Disabling ATC Differential Braking

ATC differential braking is disabled under the following conditions:

1. During power up (e.g. when the vehicle is started), until the ECU detects a service brake application.
2. If the ECU receives a J1939 message indicating that the vehicle is parked.
3. When the dynamometer test mode is active. The dynamometer test mode is entered using the diagnostic blink code switch or by using a diagnostic tool (such as Bendix® ACom™ Diagnostics).

4. In response to a serial communications request from a diagnostic tool.
5. During brake torque limiting to avoid overheating of the brakes.
6. When certain diagnostic trouble code conditions are detected.

Engine Torque Limiting (ETL) with *Smart ATC*™ Traction Control

The EC-60™ controller uses Engine Torque Limiting to control drive axle wheel slip. This is communicated to the engine control module (using J1939), and is available at all vehicle speeds.

Bendix® *Smart ATC*™ Traction Control

The EC-60™ controller has an additional feature known as *Smart ATC*™ traction control. *Smart ATC*™ traction control monitors the accelerator pedal position (using J1939) to help provide optimum traction and vehicle stability. By knowing the driver's intention and adapting the target slip of the drive wheels to the driving situation, the *Smart ATC*™ traction control allows higher wheel slip when the accelerator pedal is applied above a preset level.

The target wheel slip is decreased when driving through a curve for improved stability.

Disabling ATC Engine Control and *Smart ATC*™ Traction Control

ATC Engine Control and *Smart ATC*™ traction control will be disabled under the following conditions:

1. In response to a serial communications request from an off-board tool.
2. At power-up until the ECU detects a service brake application.
3. If the ECU receives a J1939 message indicating that the vehicle is parked.
4. If the dynamometer test mode is active. This may be accomplished via an off-board tool or the diagnostic blink code switch.
5. When certain diagnostic trouble code conditions are detected.

Optional ATC Off-Road Mode

In some road conditions, the vehicle operator may desire additional drive wheel slip when ATC is active. The Premium EC-60™ controller has an optional control mode to permit this desired performance.

The vehicle operator can activate the off-road function with a switch on the dash panel. Alternately, a J1939 message may be used to place the vehicle in this mode. The ATC Indicator Lamp will flash continually to confirm that the off-road ATC function is engaged.

To exit the ATC off-road mode, depress and release the ATC off-road switch.

Drag Torque Control Functional Overview

Premium EC-60™ controllers have a feature referred to as drag torque control which reduces wheel slip on a driven axle due to driveline inertia. This condition is addressed by increasing the engine torque to overcome the inertia.

Drag torque control increases vehicle stability on low-traction road surfaces during down-shifting or retarder braking.

Dynamometer Test Mode

WARNING: ATC must be disabled prior to conducting any dynamometer testing. When the Dynamometer Test Mode is enabled, ATC brake control and engine control along with drag torque control are turned off. This test mode is used to avoid torque reduction or torque increase and brake control activation when the vehicle is operated on a dynamometer for testing purpose.

The Dynamometer Test Mode may be activated by pressing and releasing the diagnostic blink code switch five times or by using a hand-held or PC-based diagnostic tool.

The Dynamometer Test Mode will remain active even if power to the ECU is removed and re-applied. Press and release the blink code switch three times, or use a hand-held or PC-based diagnostic tool to exit the test mode.

Automatic Tire Size Calibration

The ECU requires a precise rolling circumference ratio between steer axle and drive axle tires in order for ABS and ATC to perform in an optimal manner. For this reason, a learning process continuously takes place in which the precise ratio is calculated. This calculated value is stored in the ECU memory provided the following conditions are met:

1. Rolling-circumference ratio is within the permissible range.
2. Vehicle speed is greater than approximately 12 MPH.
3. No acceleration or deceleration is taking place.
4. There are no active speed sensor diagnostic trouble codes.

The ECU is provided with a ratio value of 1.00 as a default setting. If the automatic tire size alignment calculates a different value, this is used to overwrite the original figure in the memory. This process adapts the ABS and ATC function to the vehicle.

Acceptable Tire Sizes

The speed calculation for an exciter ring with 100 teeth is based on a default tire size of 510 revolutions per mile. This figure is based on the actual rolling circumference of the tires, which varies with tire size, tire wear, tire pressure, vehicle loading, etc.

The ABS response sensitivity is reduced when the actual rolling circumference is excessive on all wheels. For a 100 tooth exciter ring, the minimum number of tire revolutions

per mile is 426, and the maximum is 567. The ECU will set diagnostic trouble codes if the number or revolutions are out of this range.

In addition, the size of the steer axle tires compared to the drive axle tires also has to be within the ABS system design. To avoid diagnostic trouble codes, the ratio of the effective rolling circumference of the steer axle, divided by the effective rolling circumference of the drive axle, must be between 0.85 to 1.15.

ABS PARTIAL SHUTDOWN

Depending which component the trouble code is detected on, the ABS and ATC functions may be fully or partially disabled. Even with the ABS indicator lamp on, the EC-60™ controller may still provide ABS function on wheels that are not affected. The EC-60™ controller should be serviced as soon as possible.

Steer Axle ABS Modulator Diagnostic Trouble Code

ABS on the affected wheel is disabled. ABS and ATC on all other wheels remains active.

Drive Axle/Additional Axle ABS Modulator Diagnostic Trouble Code

ATC is disabled. ABS on the affected wheel is disabled. ABS on all other wheels remains active.

Steer Axle Wheel Speed Sensor Diagnostic Trouble Code

The wheel with the diagnostic trouble code is still controlled by using input from the remaining wheel speed sensor on the front axle. ABS remains active on the rear wheels. ATC is disabled.

Drive Axle/Additional Axle Wheel Speed Sensor Diagnostic Trouble Code

ATC is disabled. In a four sensor system, ABS on the affected wheel is disabled, but ABS on all other wheels remains active.

In a six sensor system, ABS remains active by using input from the remaining rear wheel speed sensor on the same side.

ATC Modulator Diagnostic Trouble Code

ATC is disabled. ABS remains active.

J1939 Communication Diagnostic Trouble Code

ATC is disabled. ABS remains active.

ECU Diagnostic Trouble Code

ABS and ATC are disabled. The system reverts to normal braking.

Voltage Diagnostic Trouble Code

While voltage is out of range, ABS and ATC are disabled. The system reverts to normal braking. When the correct voltage level is restored, full ABS and ATC function is available. Operating voltage range is 9.0 to 17.0 VDC.

Reconfiguring EC-60™ Controllers

SYSTEM CONFIGURATION

The EC-60™ controller is designed to allow the technician to change the default system settings (chosen by the vehicle OEM) to provide additional or customized features. When replacing an ECU, be sure to use an equivalent Bendix replacement part number so that the standard default settings are provided.

Depending on the model, the customizable features include ABS control settings, engine module communication etc. Many of these settings can be reconfigured using a hand-held or PC-based software, such as the Bendix® ACom™ Diagnostics program.

ECU RECONFIGURATION

Reconfiguring Standard ECUs

Reconfigurating an EC-60™ controller may be carried out by using the Blink Code Switch or by using a hand-held or PC-based diagnostic tool.

Note: During the reconfiguration process, and independently from any reconfiguration being carried out by the technician, standard ECUs automatically check the J1939 serial link and communicate with other vehicle modules. In particular, if the serial link shows that the vehicle has a retarder device present, the ECU will configure itself to communicate with the retarder device for improved ABS performance. For example, if the ECU detects the presence of a retarder disable relay during a reconfiguration, it will configure itself to control the relay to disable the retarding device as needed.

Reconfiguring Premium ECUs

As with standard ECUs, the Premium EC-60™ controller also carries out, independently from any reconfiguration being carried out by the technician, an automatic check of the J1939 serial link and communicate with other vehicle modules. This includes checking for ATC and retarder disable relay operation. In addition, premium EC-60™ controllers will determine the number of wheel speed sensors and PMVs installed and configure itself accordingly.

6S/5M Configuration

Premium EC-60™ controllers will configure for 6S/5M operation when a reconfiguration event is initiated and the ECU detects that an additional axle PMV is wired as follows:

PMV Connector	ECU Connector
Hold	Right Additional Axle Hold
Release	Left Additional Axle Release
Common	Right Additional Axle Common

See 6S/5M System Schematics (pages 37 & 40) for details.

Reconfiguration Using the Blink Code Switch

The reconfiguration event is the same for both Standard and Premium ECUs. With ignition power removed from the EC-60™ controller, depress the blink code switch. After the ignition power is activated, depress and release the switch seven times to initiate a reconfiguration event.

Diagnostic Tool

A reconfiguration event may be initiated using a hand-held or PC-based diagnostic tool to communicate with the ECU over the SAE J1587 diagnostic link.

Troubleshooting: General

SAFE MAINTENANCE PRACTICES

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

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

1. **Park the vehicle on a level surface, apply the parking brakes, and always block the wheels. Always wear safety glasses.**
2. **Stop the engine and remove ignition key when working under or around the vehicle. When working in the engine compartment, the engine should be shut off and the ignition key should be removed. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated or electrically charged components.**
3. **Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.**
4. **If the work is being performed on the vehicle's air brake system, or any auxiliary pressurized air systems, make certain to drain the air pressure from all reservoirs before beginning ANY work on the vehicle. If the vehicle is equipped with an AD-IS® air dryer system or a dryer reservoir module, be sure to drain the purge reservoir.**
5. **Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that safely removes all electrical power from the vehicle.**
6. **Never exceed manufacturer's recommended pressures.**
7. **Never connect or disconnect a hose or line containing pressure; it may whip. Never remove a component or plug unless you are certain all system pressure has been depleted.**
8. **Use only genuine Bendix® replacement parts, components and kits. Replacement hardware, tubing, hose, fittings, etc. must be of equivalent size, type and strength as original equipment and be designed specifically for such applications and systems.**
9. **Components with stripped threads or damaged parts should be replaced rather than repaired. Do not attempt repairs requiring machining or welding unless specifically stated and approved by the vehicle and component manufacturer.**
10. **Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.**
11. **For vehicles with Antilock Traction Control (ATC), the ATC function must be disabled (ATC indicator lamp should be ON) prior to performing any vehicle maintenance where one or more wheels on a drive axle are lifted off the ground and moving.**

REMOVING THE EC-60™ CONTROLLER ASSEMBLY

1. Turn vehicle ignition off.
2. Remove as much contamination as possible prior to disconnecting air lines and electrical connections.
3. Note the EC-60™ controller assembly mounting position on the vehicle.
4. Disconnect the electrical connectors from the EC-60™ controller.
5. Remove and retain the mounting bolts that secure the EC-60™ controller.

INSTALLING A NEW EC-60™ CONTROLLER

CAUTION! When replacing the EC-60™ controller, verify that the unit you are installing has the correct default settings. Failure to do so could result in a loss of features, such as ATC and PLC, or noncompliance with U.S. regulations such as FMVSS 121. It is recommended to use only the correct replacement part number. However, most configuration settings can be altered using the Bendix ACom™ ABS Diagnostic Software program.

Verify correct operation of the EC-60™ controller system and indicator lamps prior to putting the vehicle back into service. Towing vehicles manufactured after March 1, 2001 must support the trailer ABS indicator lamp located on the dash.

For further information, contact either the vehicle manufacturer, Bendix or your local authorized Bendix dealer.

1. Position and secure the EC-60™ controller in the original mounting orientation using the mounting bolts retained during removal. On frame-mount ECUs, torque the mounting bolts to 7.5 to 9 NM (66-80 in. lbs). For cab-mount units use no more torque than is necessary to firmly secure the ECU into position. Over-tightening the mounting hardware can cause damage to the EC-60™ controller.
2. Reconnect the electrical connectors to the EC-60™ controller.
3. Apply power and monitor the EC-60™ controller power-up sequence to verify proper system operation.

See Troubleshooting: Wiring section beginning on page 32 for more information on wire harnesses.

Troubleshooting: Blink Codes and Diagnostic Modes

ECU DIAGNOSTICS

The EC-60™ controller contains self-testing diagnostic circuitry that continuously checks for the normal operation of internal components and circuitry, as well as external ABS components and wiring.

Active Diagnostic Trouble Codes

When an erroneous system condition is detected, the EC-60™ controller:

1. Illuminates the appropriate indicator lamp(s) and disengages part or all of the ABS and ATC functions. (See page 9.)
2. Places the appropriate trouble code information in the ECU memory.
3. Communicates the appropriate trouble code information over the serial communications diagnostic link as required. Hand-held or PC-based diagnostic tools attach to the vehicle diagnostic connector, typically located on or under the dash (see Figure 9).

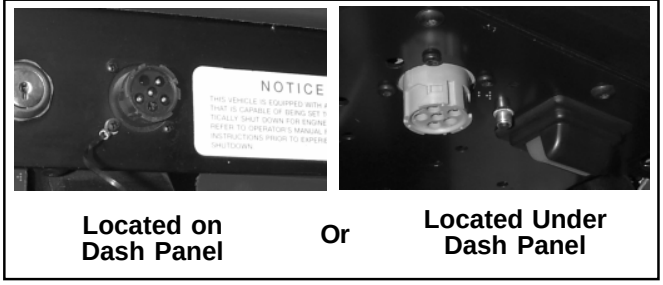


FIGURE 9 - TYPICAL VEHICLE DIAGNOSTIC CONNECTOR LOCATIONS (J1708/J1587, J1939)

BLINK CODES

Blink codes allow a technician to troubleshoot ABS problems without using a hand-held or PC-based diagnostic tool. Instead, information about the ABS system is communicated by the ECU using the ABS indicator lamp to display sequences of blinks.

Note: The ECU will not enter the diagnostic blink code mode if the wheel speed sensors show that the vehicle is in motion. If the ECU is in the diagnostic blink code mode and then detects vehicle motion, it will exit the blink code mode.

In addition, by operating the blink code switch as described below, one of several diagnostic modes can be entered. See Diagnostic Modes below.

Blink Code Switch Activation

When activating the blink code switch:

1. Wait at least two seconds after “ignition on.” (Except when entering Reconfiguration Mode - see Reconfiguration section on page 10)
2. For the ECU to recognize that the switch is activated “on,” the technician must press for at least 0.1 seconds, but less than 5 seconds. (If the switch is held for more than 5 seconds, the ECU will register a malfunctioning switch.)
3. Pauses between pressing the switch when a sequence is required, (e.g. when changing mode) must not be longer than 2 seconds.
4. After a pause of 3.5 seconds, the ECU will begin responding with output information blinks. See Figure 10 for an example.

Blink Code Timing

The ECU responds with a sequence of blink codes. The overall blink code response from the ECU is called a “message.” Each message includes, depending on the

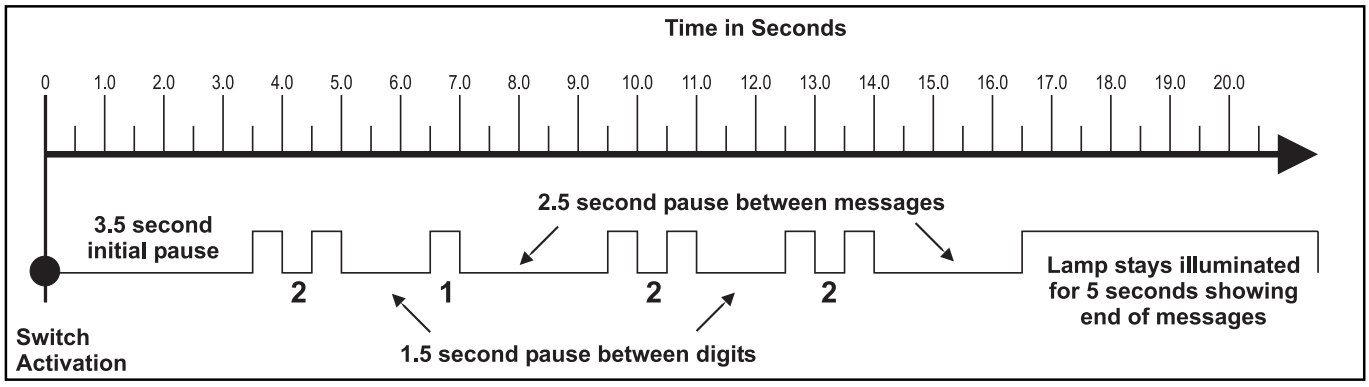


FIGURE 10 - EXAMPLE OF BLINK CODE MESSAGE

mode selected by the technician, a sequence of one or more groups of blinks. Simply record the number of blinks for each sequence and then use the troubleshooting index on page 17 for active or inactive trouble codes and you will be directed to the page that provides troubleshooting information.

NOTE:

1. Sequences of blinks illuminate the ABS indicator lamp for half a second, with half-second pauses between them.
2. Pauses between blink code digits are 1.5 seconds.
3. Pauses between blink code messages are 2.5 seconds.
4. The lamp remains on for 5 seconds at the end of messages.

Once the ABS indicator lamp begins displaying a sequence of codes, it continues until all blink code messages have been displayed and then returns to the normal operating mode. During this time, the ECU will ignore any additional blink code switch activation.

All trouble codes, with the exception of voltage and J1939 trouble codes, will remain in an active state for the remainder of the power cycle.

Voltage trouble codes will clear automatically when the voltage returns within the required limits. All ABS functions will be re-engaged.

J1939 trouble codes will clear automatically when communications are re-established.

DIAGNOSTIC MODES

In order to communicate with the ECU, the controller has several modes that the technician can select, allowing information to be retrieved, or other ECU functions to be accessed.

Diagnostic Modes

To enter the various diagnostic modes:

No. of Times to Press the Blink Code Switch	System Mode Entered
1	Active diagnostic trouble code retrieval
2	Inactive diagnostic trouble code retrieval
3	Clear active diagnostic trouble codes
4	System configuration check
5	Dynamometer Test Mode
7*	Reconfigure ECU

***** To enter the Reconfiguration Mode, the switch must be held in before the application of ignition power. Once the power is supplied, the switch is released and then pressed seven times.

CHART 2 - DIAGNOSTIC MODES

Active Diagnostic Trouble Code Mode

For troubleshooting, typically the Active and Inactive Diagnostic Trouble Retrieval Modes are used. The technician presses the blink code switch once and the ABS indicator lamp flashes a first group of two codes, and if there are more trouble codes recorded, this is followed by a second set of codes, etc. (See page 17 for a directory of these codes.) All active trouble codes may also be retrieved using a hand-held or PC-based diagnostic tool, such as the Bendix® ACom™ Diagnostics software.

To clear active diagnostic trouble codes (as problems are fixed), simply clear (or “self-heal”) by removing and re-applying ignition power. The only exception is for wheel speed sensor trouble codes, which clear when power is removed, re-applied, and the ECU detects valid wheel speed from all wheel speed sensors. Alternately, codes may be cleared by pressing the diagnostic blink code switch 3 times (to enter the Clear Active Diagnostic Trouble Code Mode) or by using a hand-held or PC-based diagnostic tool. Hand-held or PC-based diagnostic tools are able to clear wheel speed sensor trouble codes without the vehicle being driven.

Inactive Diagnostic Trouble Code Mode

The ECU stores past trouble codes and comments (such as configuration changes) in its memory. This record is commonly referred to as “event history.” When an active trouble code is cleared, the ECU stores it in the event history memory as an inactive trouble code.

Using blink codes, the technician may review all inactive trouble codes stored on the ECU. The ABS indicator lamp will display inactive diagnostic blink codes when the diagnostic blink code switch is depressed and released two times. See page 17 for the index showing trouble codes and the troubleshooting guide page to read for help.

Inactive trouble codes, and event history, may be retrieved and cleared by using a hand-held or PC-based diagnostic tool, such as the Bendix® ACom™ Diagnostics software.

Clearing Active Diagnostic Trouble Codes

The ECU will clear active trouble codes when the diagnostic blink code switch is depressed and released three times.

System Configuration Check Mode

The ABS indicator lamp will display system configuration information when the diagnostic blink code switch is depressed and released four times. The lamp will blink out configuration information codes using the following patterns. (See Chart 3). In this mode the ECU tells the technician, by means of a series of six blink codes, the type of ABS system that the ECU has been set up to expect. For example, if the fourth blink code is a three, the technician knows that a 6S/5M sensor/modulator configuration has been set.

Dynamometer Test Mode

The Dynamometer Test Mode is used to disable ATC when needed (e.g. when performing any vehicle maintenance where the wheels are lifted off the ground and moving, including dyno testing). This mode is not reset by power off, power on, cycling. Instead a hand-held or PC-based diagnostic tool must be used to change the setting. Alternatively, depressing and releasing the blink code switch three times will cause the ECU to exit the blink code mode.

Reconfigure ECU Mode

Vehicle reconfiguration is carried out by using the Reconfigure ECU Mode. (See page 10.) Note: To enter the Reconfiguration Mode, the blink code switch must be held in before the application of ignition power. Once the power is supplied, the switch is released and then pressed seven times.

1st Number	System Power
1	12 Volts
2	24 Volts
2nd Number	**Wheel Speed Sensors**
4	4 Sensors
6	6 Sensors
3rd Number	**Pressure Modulator Valves**
4	4 Modulators
5	5 Modulators
6	6 Modulators
4th Number	**ABS Configuration**
1	4S/4M or 6S/6M
2	6S/4M
3	6S/5M
5th Number	**Traction Control Configuration**
2	No ATC
3	ATC Engine Control Only
4	ATC Brake Control Only
5	Full ATC (Engine Control & Brake Control)
6th Number	**Retarder Configuration**
1	No Retarder
2	J1939 Retarder
3	Retarder Relay
4	J1939 Retarder, Retarder Relay

CHART 3 - SYSTEM CONFIGURATION CHECK