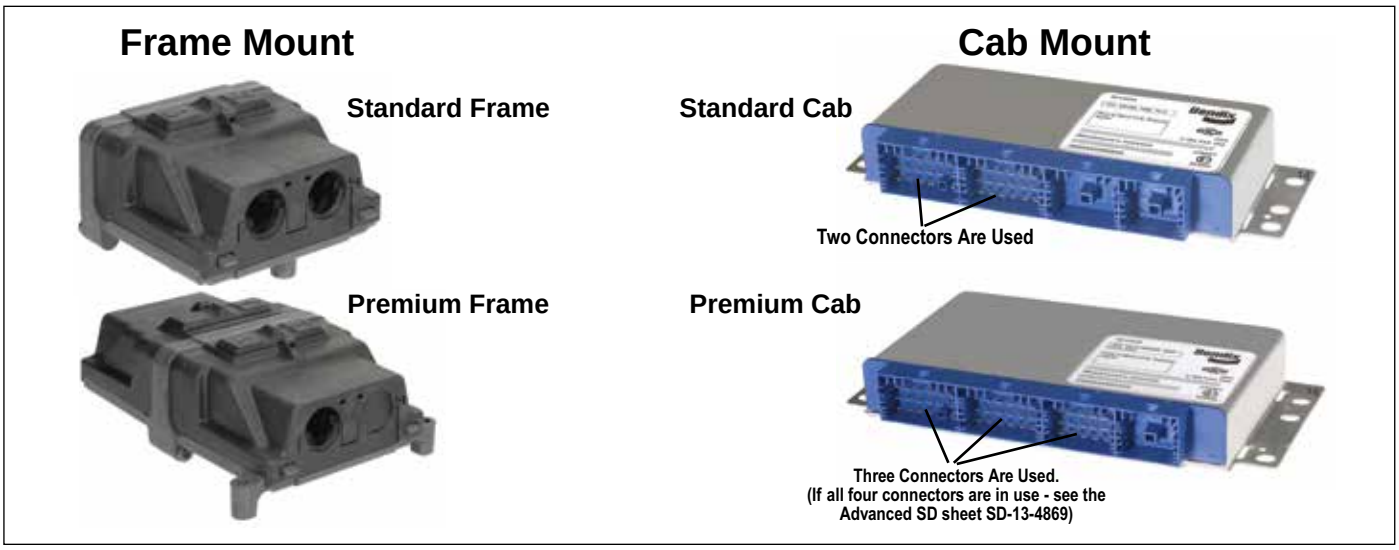
Bendix®

Service Data

SD-13-4863

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



See SD-13-4869 for Advanced Controllers

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**

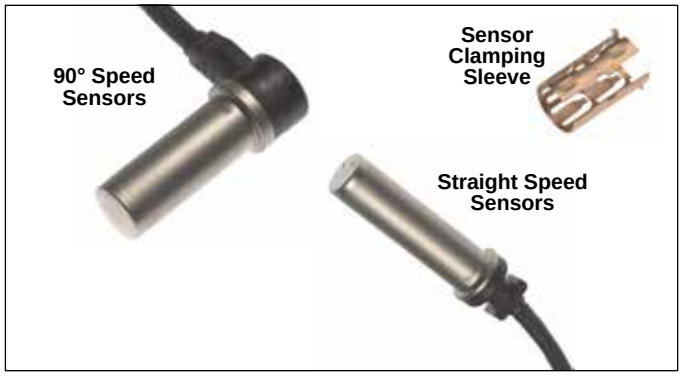


FIGURE 2 - *BENDIX® WS-24™ WHEEL SPEED SENSORS*

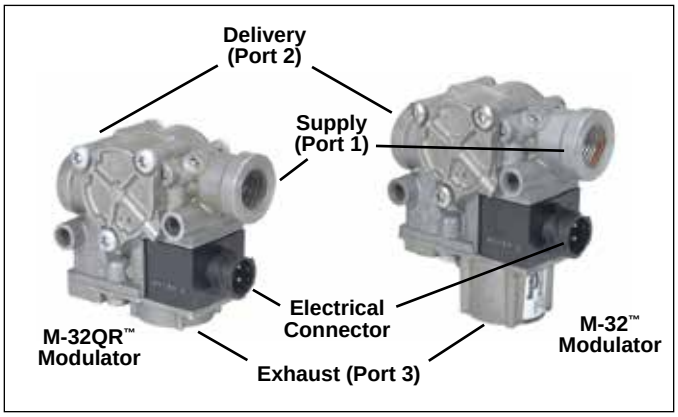


FIGURE 3 - *M-32™ AND M-32QR™ MODULATORS*

COMPONENTS

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

- Bendix® WS-24™ wheel speed sensors (4 or 6, depending on ECU 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 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 ECUs - 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

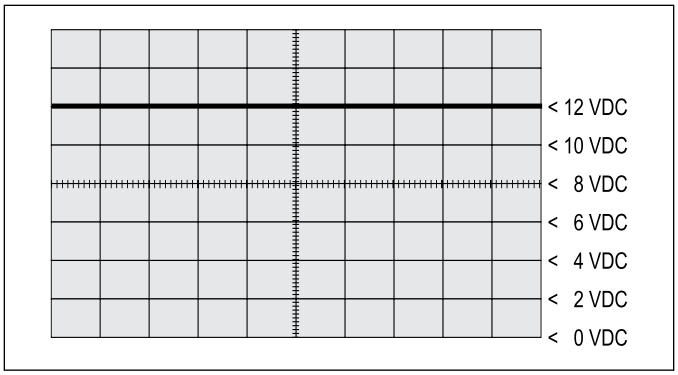


FIGURE 4 - *POWER LINE WITHOUT PLC SIGNAL*

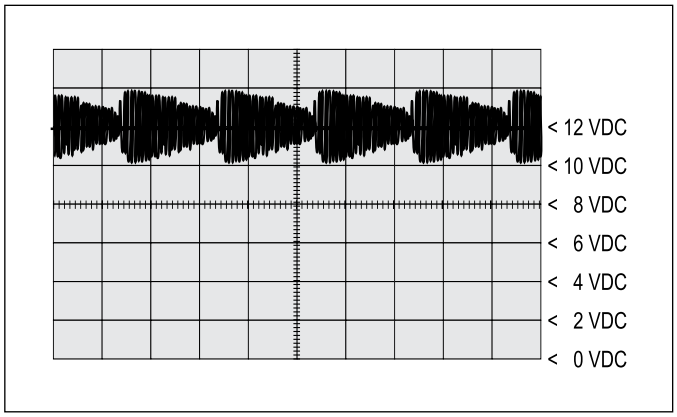


FIGURE 5 - *POWER LINE WITH PLC SIGNAL*

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 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 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 5.0 mVp-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 ECU 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 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 that the torque converter disable 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.

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.

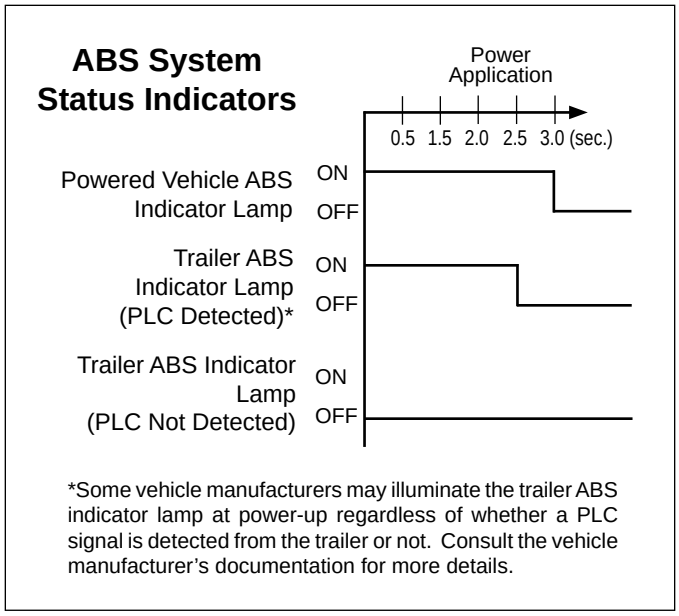


FIGURE 6 - ***ABS DASH LAMP START UP SEQUENCE***

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.

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 ABS@bendix.com for more details.

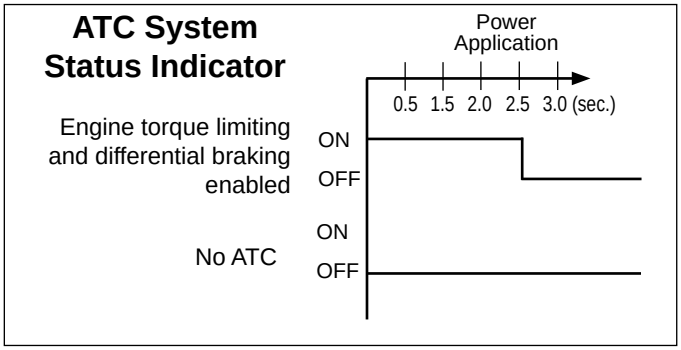


FIGURE 7 - ***ATC INDICATOR LAMP START UP SEQUENCE***

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. See Figures 6 and 7.

Lamps that do not illuminate as expected when ignition power is applied, or remain illuminated, 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.

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.

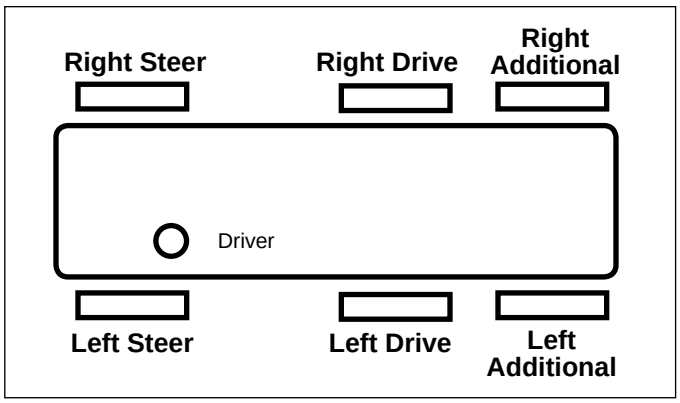


FIGURE 8 - ***VEHICLE ORIENTATION (TYPICAL)***

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 ensuring 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 of 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 RECONFIGURATION

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

Reconfiguring 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 communicates 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

GENERAL SAFETY GUIDELINES

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 a Bendix® 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® brand eplacement 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 Automatic 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. Ibs). 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 wiring 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).

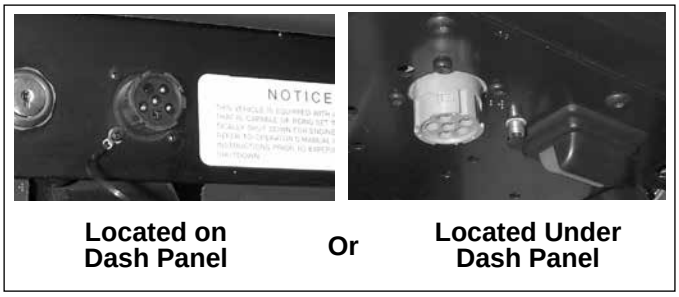


FIGURE 9 - ***TYPICAL VEHICLE DIAGNOSTIC CONNECTOR LOCATIONS (J1708/J1587, J1939)***

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.

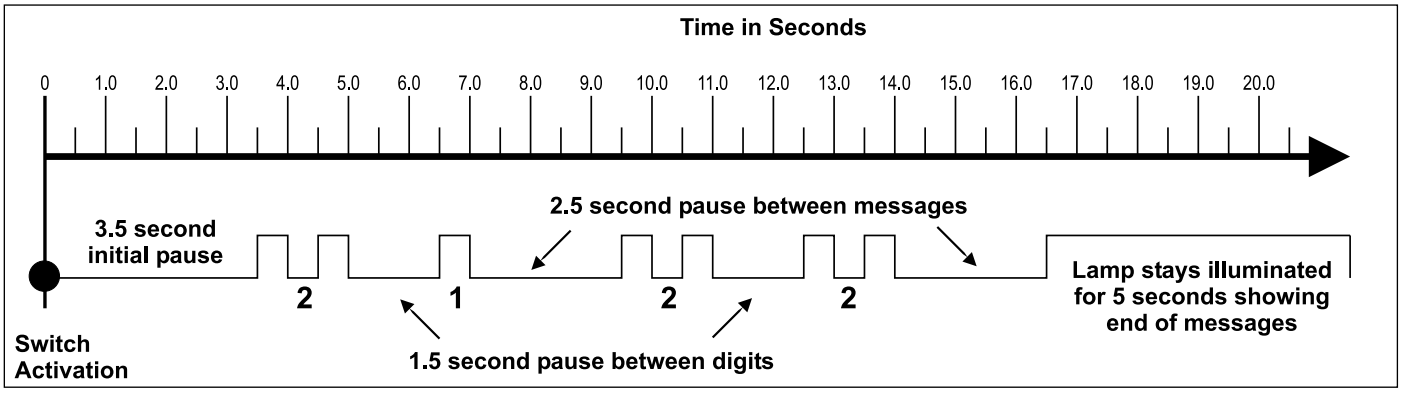


FIGURE 10 - ***EXAMPLE OF BLINK CODE MESSAGE***

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 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.

See Figure 10 for an example showing the message:

2,1 followed by 2,2.

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).

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*

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.

Troubleshooting: Using Hand-Held or PC-Based Diagnostic Tools

USING HAND-HELD OR PC-BASED DIAGNOSTICS

Troubleshooting and diagnostic trouble code clearing (as well as reconfiguration) may also be carried out using hand-held or PC-based diagnostic tools such as the Bendix® Remote Diagnostic Unit (RDU™), Bendix® ACom® Diagnostics software, or the ProLink tool.

FIGURE 11 - *THE BENDIX® REMOTE DIAGNOSTIC UNIT*

Bendix® RDU™ (Remote Diagnostic Unit)

The Bendix® RDU™ tool provides the technician with a visual indication of Antilock Braking System (ABS) component **Diagnostic Trouble Code (DTC)** information. The RDU™ tool is specifically designed for use with Bendix® ABS systems and Bendix makes no claims for its operation and/or usability with other brands of ABS systems.

Features of the Bendix® RDU™ Tool

The RDU™ tool attaches to the 9 pin diagnostic connector in the cab of the vehicle. An adapter cable (Bendix part number 5012793) is available to connect the RDU to vehicles with a 6-pin diagnostic connector. (See Figure 11.)

The RDU™ tool allows the technician to:

- Troubleshoot ABS system component problems using Diagnostic Trouble Code reporting via LEDs.
- Reset Diagnostic Trouble Codes on Bendix® ABS ECUs by holding a magnet over the reset in the center of the RDU™ tool for less than 6 seconds.
- Enter the Self-Configuration Mode used by Bendix® ABS ECUs by holding a magnet over the reset area for greater than 6 seconds but less than 30 seconds.

How the Bendix® RDU™ Operates

See Figure 9 for typical vehicle connector locations.

When the RDU™ tool is plugged into the diagnostic connector, all the LEDs will illuminate, and the green LED will flash 4 times to indicate communications have been established.

If the ABS ECU has no active Diagnostic Trouble Codes, only the green LED will remain illuminated.

If the ABS ECU has at least one active Diagnostic Trouble Code the RDU™ tool displays the first diagnostic trouble code by illuminating the red LEDs, indicating the malfunctioning ABS component and its location on the vehicle. (See Figure 11.) If there are multiple diagnostic trouble codes on the ABS system, the RDU™ tool will display one diagnostic trouble code first, then once that Diagnostic Trouble Code has been repaired and cleared, the next code will be displayed.

- Right steer sensor
- Left steer sensor
- Right drive sensor
- Left drive sensor
- Right additional sensor
- Left additional sensor
- Right steer modulator
- Left steer modulator
- Right drive modulator
- Left drive modulator
- Right additional modulator
- Left additional modulator
- Traction modulator
- ECU
- Engine serial communication

Typical Combination Diagnostic Trouble Codes are:

- MOD red LED illuminated, shows the “Common” connection of one or more modulators is shorted to battery or ground
- VLT (Flashing indicates either over- or under-voltage condition)

To pinpoint the root cause and to ensure that the system diagnostic trouble code has been properly corrected, additional troubleshooting may be necessary.

Bendix® RDU™ Reset Function

The magnetic reset switch is located in the center top of the RDU™ tool. Activation requires a magnet with 30 gauss minimum.

The reset operations are:

1. If the magnet is held over the switch for less than 6 seconds the “clear diagnostic trouble codes” command is sent.
2. If the magnet is held over the switch for more than 6 seconds, but less than 30 seconds, the Bendix® ABS “self-configuration command” is sent.

Additionally, it is recommended at the end of any inspection that the user switches off and restores the power to the ABS ECU, then check the ABS Indicator Lamp operation and RDU™ tool to see if they indicate any remaining Diagnostic Trouble Codes.

LED Diagnostic Trouble Codes

LFT -	Left	ECU -	ABS Controller
RHT -	Right	SEN -	Wheel Speed Sensor
DRV -	Drive Axle		
ADD -	Additional	MOD -	Pressure Modulator Valve
STR -	Steer Axle		
VLT -	Power	TRC -	Traction Control

Example: If the Diagnostic Trouble Code is "Right Steer Axle Sensor", the RDU™ unit will display one green and three red LEDs

LEDs
Green
VLT
Red
SEN
STR
RHT

FIGURE 12 - *DIAGNOSTIC TROUBLE CODES*

Bendix® RDU™ Communication Problems

If the ABS ECU does not respond to the RDU™ tool's request for diagnostic trouble codes, the RDU™ tool will illuminate each red LED in a clockwise pattern. This pattern indicates the loss of communication and will continue until the ABS ECU responds and communication has been re-established.

Possible sources of communication problems are:

1. A problem with the J1587 link at the in-cab off-board diagnostic connector (9 or 6 Pin).
2. The ECU does not support PID194.
3. No power is being supplied to the ECU and/or the diagnostic connector.
4. The J1587 bus is overloaded with information and the RDU can not arbitrate access.
5. A malfunctioning RDU™ tool.

Nexiq Bendix Application Card

Nexiq provides a Bendix application card for use with the ProLink tool. It can also be used to diagnose the EC-30™, EC-17™, Gen 4™ and Gen 5™, and MC-30™ ABS Controllers. For more information on the Bendix application card visit www.bendix.com, Nexiq at www.nexiq.com, or your local authorized Bendix parts outlet.

Pro-Link

Heavy Duty
Multi Protocol
Cartridge

PC Card MPSI
Part Number
805013

FIGURE 13 - *NEXIQ (MPSI) PRO-LINK TOOL*

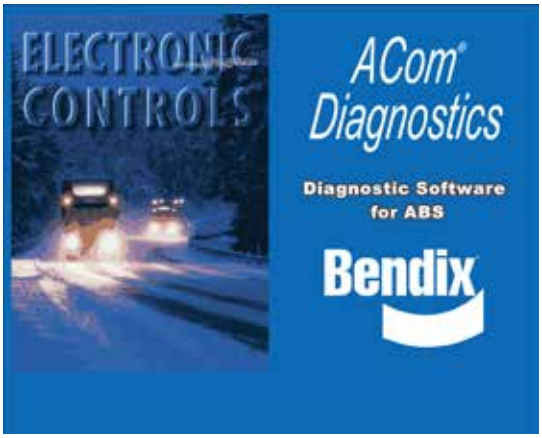


FIGURE 14 - *BENDIX® ACOM® DIAGNOSTICS*

Bendix® ACom® Diagnostics Software

Bendix® ACom® Diagnostics is a PC-based software program and is designed to meet RP-1210 industry standards. This software provides the technician with access to all the available ECU diagnostic information and configuration capability, including:

- ECU information
- Diagnostic trouble codes and repair information
- Configuration (ABS, ATC, and more)
- Wheel speed information
- Perform component tests
- Save and print information

When using ACom® Diagnostics software to diagnose the EC-60 ABS ECU, the computer's serial or parallel port needs to be connected to the vehicle's diagnostic connector.

For more information on ACom® Diagnostics software or RP1210 compliant tools, go to www.bendix.com or visit your local authorized Bendix parts outlet.

See Page 42 for Appendix A: J1587 SID and FMI codes and their Bendix blink code equivalents.

www.bendix.com

For the latest information, and for free downloads of the Bendix® ACom® Diagnostics software, and its User Guide, visit the Bendix website at www.bendix.com.

Bendix Technical Assistance Team

For direct telephone technical support, call the Bendix technical assistance team at:

1-800-AIR-BRAKE (1-800-247-2725),

Monday through Friday, 8:00 A.M. to 6:00 P.M. EST, and follow the instructions in the recorded message.

Or, you may e-mail the Bendix technical assistance team at: techteam@bendix.com.

Active or Inactive Diagnostic Trouble Codes:

INDEX

How to interpret the first digit of messages received when Active or Inactive Diagnostic Trouble Code Mode is entered.

1st Blink Code Number	Go Here for Troubleshooting Tests
1	No faults (1,1)
2	Wheel Speed Sensors - page 18
3	Wheel Speed Sensors - page 18
4	Wheel Speed Sensors - page 18
5	Wheel Speed Sensors - page 18
6	Power Supply - page 23
7	Pressure Modulator Valves - page 20
8	Pressure Modulator Valves - page 20
9	Pressure Modulator Valves - page 20
10	Pressure Modulator Valves - page 20
11	J1939 Serial Communications - page 24
12	Miscellaneous - page 26
13	ECU - page 25
14	Wheel Speed Sensors - page 18
15	Wheel Speed Sensors - page 18
16	Pressure Modulator Valves - page 20
17	Pressure Modulator Valves - page 20
18	Traction Control Valves - page 22

Example: For a message sequence of:

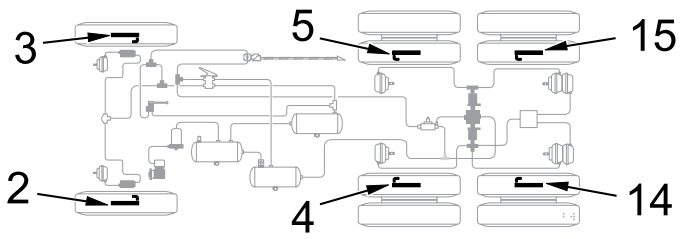
3, 2 12, 4

For the first sequence go to page 18 and
for the second sequence go to page 26.

See Page 42 for Appendix A: J1587 SID and FMI Codes and their Bendix Blink Code Equivalents

Troubleshooting Diagnostic Trouble Codes: Wheel Speed Sensors

1st. Blink Code	Location
2	Left Steer Axle Sensor
3	Right Steer Axle Sensor
4	Left Drive Axle Sensor
5	Right Drive Axle Sensor
14	Left Additional Axle Sensor
15	Right Additional Axle Sensor



2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	Excessive Air Gap	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~ 0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing endplay. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping.
2	Output Low at Drive-off	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~ 0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end-play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping.
3	Open or Shorted	Verify 1500 – 2500 ohms across sensor leads. Verify no continuity between sensor leads and ground or voltage. Verify no continuity between sensor leads and other sensors. Check for corroded/damaged wiring or connectors between the ECU and the wheel speed sensor.
4	Loss of Sensor Signal	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~ 0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end-play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping. Check for corroded/damaged wiring or connectors between the ECU and the wheel speed sensor.
5	Wheel End	Verify mounting of exciter ring and condition of teeth. Verify proper bearing end-play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping. Check mechanical function of brake. Check for kinked or restricted air lines.
6	Erratic Sensor Signal	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~ 0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end-play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping. Check for corroded/damaged wiring or connectors between the ECU and the wheel speed sensor.
7	Tire Size Calibration	Verify correct tire size as desired. Verify proper tire inflation. Verify correct number of exciter ring teeth.
10	Configuration Error	ECU is configured for four sensors, but has detected the presence of additional sensors. Verify sensor wiring and ECU configuration.

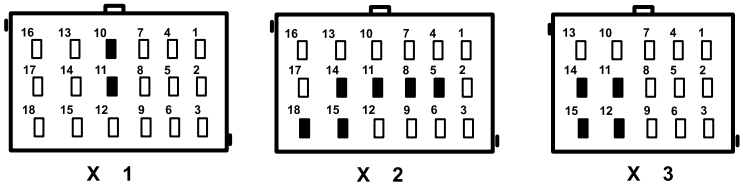
Speed Sensor Repair Tests:

1. Take all measurements at ECU harness connector pins in order to check wire harness and sensor. Probe the connector carefully so that the terminals are not damaged.
2. Wheel speed sensor measurements should read:

Location	Measurement
Sensor	1500 - 2500 Ohms
Sensor to voltage or ground	Open Circuit (no continuity)
Sensor output voltage	>0.25 of VAC sensor output at ~ 0.5 revs/sec.

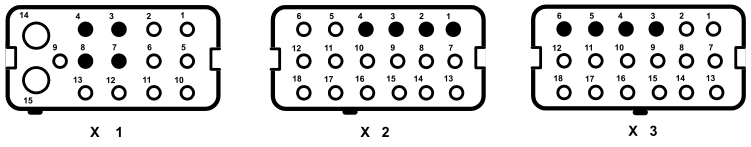
3. Clear DTC after issue is corrected. The sensor DTC will remain until the power is cycled to the ABS ECU and vehicle is driven above 15 MPH or DTC was cleared using either the diagnostic blink code switch or diagnostic tool.

Cab-mount ECU: Looking into wire harness connector



Connector	Pin	Wheel Speed Sensor Location
X1 18 Way	10	Right Drive Axle (+)
	11	Right Drive Axle (-)
X2 18 Way	5	Left Steer Axle (+)
	8	Left Steer Axle (-)
	11	Right Steer Axle (+)
	14	Right Steer Axle (-)
	15	Left Drive Axle (+)
	18	Left Drive Axle (-)
X3 15 Way (if Premium ECU is configured for 6 sensors)	11	Left Additional Axle (+)
	14	Left Additional Axle (-)
	12	Right Additional Axle (+)
	15	Right Additional Axle (-)

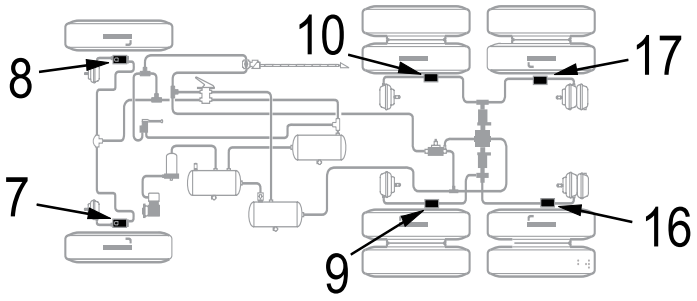
Frame-mount ECU: Looking into wire harness connector



Connector	Pin	Wheel Speed Sensor Location
X1 15 Way	3	Left Steer Axle (+)
	7	Left Steer Axle (-)
	4	Right Steer Axle (+)
	8	Right Steer Axle (-)
X2 18 Way	1	Left Drive Axle (+)
	2	Left Drive Axle (-)
	3	Right Drive Axle (+)
	4	Right Drive Axle (-)
X3 18 Way (if Premium ECU is configured for 6 sensors)	3	Left Additional Axle (+)
	4	Left Additional Axle (-)
	5	Right Additional Axle (+)
	6	Right Additional Axle (-)

Troubleshooting Diagnostic Trouble Codes: Pressure Modulator Valves

1st. Blink Code	Location
7	Left Steer Axle
8	Right Steer Axle
9	Left Drive Axle
10	Right Drive Axle
16	Left Additional Axle
17	Right Additional Axle



2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	Release Solenoid Shorted to Ground	Verify no continuity between PMV leads and ground. Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between ECU and PMV.
2	Release Solenoid Shorted to Voltage	Verify no continuity between PMV leads and voltage. Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between ECU and PMV.
3	Release Solenoid Open Circuit	Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between ECU and PMV.
4	Hold Solenoid Shorted to Ground	Verify no continuity between PMV leads and ground. Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between ECU and PMV.
5	Hold Solenoid Shorted to Voltage	Verify no continuity between PMV leads and voltage. Verify 4.9 to 5.5 ohms from REL to CMN & HLD CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between ECU and PMV.
6	Hold Solenoid Open Circuit	Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between the ECU and PMV.
7	CMN Open Circuit	Verify 4.9 to 5.5 ohms from REL to CMN & HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded/damaged wiring or connectors between the ECU and PMV.
8	Configuration Error	A mis-match exists between the ECU configuration and the modulator installation and wiring. Verify PMV wiring and installation. Verify ECU configuration.

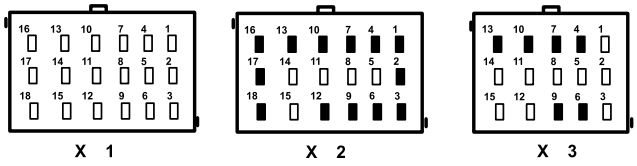
Pressure Modulator Valve Repair Tests:

1. Take all measurements at ECU harness connector pins in order to check wire harness and PMV. Probe the connector carefully so that the terminals are not damaged.
2. Pressure modulator resistance should read:

Location	Measurement
Release to Common	4.9 to 5.5 Ohms
Hold to Common	4.9 to 5.5 Ohms
Release to Hold	9.8 to 11.0 Ohms
Release, Hold, Common to Voltage or Ground	Open Circuit (no continuity)

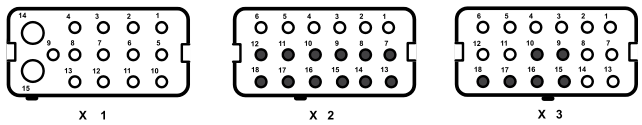
Caution: When troubleshooting modulator trouble codes, check inactive trouble codes and event history for over-voltage or excessive noise trouble codes. If one of these is found, troubleshoot these trouble codes first before the PMV.

Cab-mount ECU: Looking into wire harness connector



Connector	Pin	PMV Location
X2 18 Way	1	Left Steer Axle Hold
	2	Left Steer Axle Release
	3	Left Steer Axle Common
	4	Right Steer Axle Hold
	6	Right Steer Axle Common
	7	Right Steer Axle Release
	9	Right Drive Axle Common
	10	Right Drive Axle Hold
	13	Right Drive Axle Release
	12	Left Drive Axle Common
	16	Left Drive Axle Hold
	17	Left Drive Axle Release
X3 15 Way (if Premium ECU is configured for 6 sensors)	4	Left Additional Axle Hold
	6	Left Additional Axle Common
	7	Left Additional Axle Release
	9	Right Additional Axle Common
	10	Right Additional Axle Hold
	13	Right Additional Axle Release

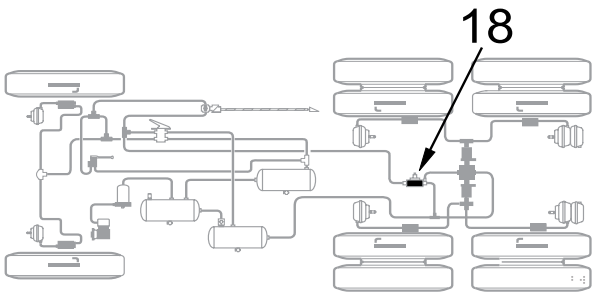
Frame-mount ECU: Looking into wire harness connector



Connector	Pin	PMV Location
X2 18 Way	7	Left Steer Axle Hold
	8	Left Steer Axle Release
	13	Left Steer Axle Common
	9	Right Steer Axle Hold
	10	Right Steer Axle Release
	14	Right Steer Axle Common
	11	Left Drive Axle Hold
	12	Left Drive Axle Release
	15	Left Drive Axle Common
	16	Right Drive Axle Common
	17	Right Drive Axle Hold
	18	Right Drive Axle Release
X3 15 Way (if Premium ECU is configured for 6 sensors)	9	Left Additional Axle Hold
	10	Left Additional Axle Release
	15	Left Additional Axle Common
	16	Right Additional Axle Common
	17	Right Additional Axle Hold
	18	Right Additional Axle Release

Troubleshooting Diagnostic Trouble Codes: Traction Control Valves

1st. Blink Code	Location
18	Traction Control Valve



2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	TCV Solenoid Shorted to Ground	Verify 7 to 19 ohms between TCV and TCV common. Verify no continuity between TCV leads and ground. Check for corroded/damaged wiring or connectors between ECU and TCV.
2	TCV Solenoid Shorted to Voltage	Verify 7 to 19 ohms between TCV and TCV common. Verify no continuity between TCV leads and voltage. Check for corroded/damaged wiring or connectors between ECU and TCV.
3	TCV Solenoid Open Circuit	Verify 7 to 19 ohms between TCV and TCV common. Check for corroded/damaged wiring or connectors between ECU and TCV.
4	TCV Configuration Error	The ECU is not configured for ATC, but has detected the presence of a TCV. Verify TCV wiring. Inspect for the presence of a TCV. Verify ECU configuration.

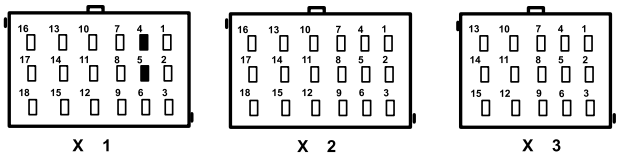
Traction Control Valve Repair Tests:

1. Take all measurements at ECU harness connector pins in order to check wire harness and traction control valve. Probe the connector carefully so that the terminals are not damaged.
2. Tractor Control Valve resistance measurements should read:

Location	Measurement
TCV to TCV Common	7 to 19 Ohms
Release, Hold, Common to Voltage or Ground	Open Circuit (no continuity)

Cab-mount ECU:

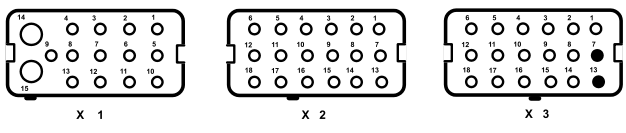
Looking into wire harness connector



Connector	Pin	Traction Control Test
X1	4	Traction Control Valve Common
18 Way	5	Traction Control Valve

Frame-mount ECU:

Looking into wire harness connector



Connector	Pin	Traction Control Test
X3	7	Traction Control Valve
18 Way	13	Traction Control Valve Common

Troubleshooting Diagnostic Trouble Codes: Power Supply

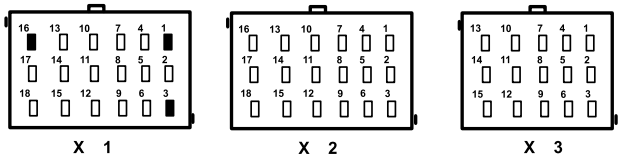
1st. Blink Code	Location
6	Power Supply

2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	Battery Voltage Too Low	Measure battery voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
2	Battery Voltage Too High	Measure battery voltage under load. Ensure that battery voltage is correct for the ECU. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
3	Battery Voltage Too Low During ABS	Measure battery voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
4	Battery Voltage Open Circuit	Measure battery voltage under load. Check condition of fuse. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
5	Ignition Voltage Too Low	Measure ignition voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections. Check condition of fuse.
6	Ignition Voltage Too High	Measure ignition voltage. Ensure that ignition voltage is correct for the ECU. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
7	Ignition Voltage Too Low During ABS	Measure ignition voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
8	Input Voltage Has Excessive Noise (Temporary)	Check alternator output for excessive noise. Check for other devices causing excessive noise.
9	Input Voltage Has Excessive Noise	Check alternator output for excessive noise. Check for other devices causing excessive noise.

Power Supply Tests:

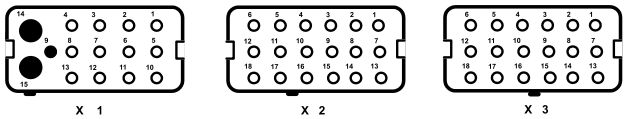
1. Take all measurements at ECU harness connector.
2. Place a load (e.g. an 1157 stop lamp) across battery or ignition and ground connection, measure ignition and battery voltage with the load. Ignition to Ground should measure between 9 to 17 VDC. Battery to Ground should also measure between 9 to 17 VDC.
3. Check for damaged wiring, damaged or corroded connectors and connections.
4. Check condition of vehicle battery and associated components, ground connection good and tight.
5. Check alternator output for excessive noise.

Cab-mount ECU:
Looking into wire harness connector



Connector	Pin	Power Supply Test
X1 18 Way	1	Ground
	3	Ignition
	16	Battery

Frame-mount ECU:
Looking into wire harness connector



Connector	Pin	Power Supply Test
X1 15 Way	9	Ignition
	14	Battery
	15	Ground

Troubleshooting Diagnostic Trouble Codes: J1939 Serial Communications

1st. Blink Code	Location
11	J1939

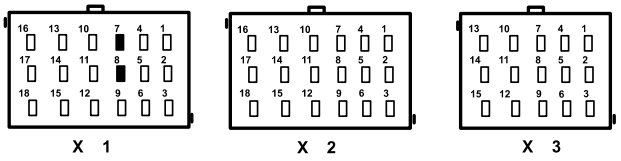
2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	J1939 Serial Link	Loss of communications between the EC-60™ controller and other devices connected to the J1939 link. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify ECU Configuration. Check for other devices inhibiting J1939 communications.
2	J1939 Retarder	Loss of communications between the EC-60™ controller and other devices connected to the J1939 link. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify presence of retarder on the J1939 link. Verify ECU Configuration. Check for other devices inhibiting J1939 communications.
3	J1939 Engine Communications	Loss of communications between the EC-60™ controller and the engine ECU over the J1939 link. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify presence of engine ECU on the J1939 link. Verify ECU Configuration. Check for other devices inhibiting J1939 communications.

J1939 Troubleshooting Tests:

1. Take all measurements at ECU harness connector
2. Check for damaged or reversed J1939 wiring
3. Check for corroded or damaged wiring connector problems such as (opens or shorts to voltage or ground)
4. Check for other J1939 devices which may be loading down (inhibiting) J1939 communication

Cab-mount ECU:

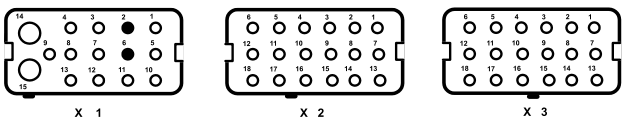
Looking into wire harness connector



Connector	Pin	J1939
X1	7	J1939 Low
18 Way	8	J1939 High

Frame-mount ECU:

Looking into wire harness connector



Connector	Pin	J1939
X1	2	J1939 Low
18 Way	6	J1939 High

Troubleshooting Diagnostic Trouble Codes: ECU

1st. Blink Code	Location
13	ECU

2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
2	ECU (10)	ALL: Check for damaged or corroded connectors. Check for damaged wiring. Clear trouble codes. If diagnostic trouble codes return, replace the ECU.
3	ECU (11)	
4	ECU (12)	
5	ECU (13)	
6	ECU (14)	
7	ECU (15)	
8	ECU (16)	
9	ECU (17)	
10	ECU (18)	
11	ECU (1A)	
12	ECU (1B)	
13	ECU (80)	

Troubleshooting Diagnostic Trouble Codes: Miscellaneous

1st. Blink Code	Location
12	Miscellaneous

2nd. Blink Code	Diagnostic Trouble Code Description	Repair Information
1	Stop Lamp Switch Not Detected	ECU has not detected the presence of the stop lamp switch since ignition power was applied (note that stop lamp switch input may be applied to the EC-60™ controller using either hardwire input or J1939). Apply and release service brake. Check for brake switch input into ECU (see system wiring schematic). With service brake released, check for presence of the stop lamp bulb. With service brake applied, verify system voltage is now present at the stop lamp switch input to the ECU. Check for damaged wiring between ECU, stop lamp switch and bulb. Check for corroded or damaged connectors. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors on J1939 link. Verify presence of engine ECU on the J1939 link. Verify ECU configuration.
2	Stop Lamp Switch Defective	Apply and release service brake. Check for brake switch input into ECU (see system wiring schematic). With service brake released, check for presence of the stop lamp bulb. With service brake applied, verify system voltage is now present at the stop lamp switch input to the ECU. Check for damaged wiring between ECU, stop lamp switch and bulb. Check for corroded or damaged connectors. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors on J1939 link. Verify presence of engine ECU on the J1939 link. Verify ECU configuration.
3	ATC Disabled or Dynamometer Test Mode Active	ECU has been placed in the Dynamometer Test Mode by either the diagnostic blink code switch or a hand-held or PC-based diagnostic tool. ATC is disabled.
4	Retarder Relay Open Circuit or Shorted to Ground	Verify vehicle contains a retarder relay. Verify ECU configuration. Check wiring between ECU and retarder relay. Verify no continuity between retarder disable output of EC-60™ controller and ground. Verify condition and wiring of the retarder relay.
5	Retarder Relay Circuit Shorted to Voltage	Check wiring between ECU and retarder relay. Verify no continuity between retarder disable output of EC-60™ controller and voltage. Verify condition and wiring of the retarder relay.
6	ABS Indicator Lamp Circuit Fault	Check operation of diagnostic blink code switch. Check wiring of diagnostic blink code switch, ABS WL, and ABS WL relay (frame ECUs only). Verify ABS WL ground input (cab ECUs only).
7	PMV Common Shorted to Ground	Verify no continuity between the CMN of all PMVs, TCV, and Diff Lock Solenoid and ground. Check for corroded/damaged wiring or connectors between the ECU and CMN of all PMVs, TCV, and Diff Lock Solenoid.
8	PMV Common Shorted to Voltage	Verify no continuity between the CMN of all PMVs, TCV, and Diff Lock Solenoid and voltage. Check for corroded/damaged wiring or connectors between the ECU and CMN of all PMVs, TCV, and Diff Lock Solenoid.
9	ATC Disabled to Prevent Brake Fade	ATC is temporarily disabled to prevent excessive heating of the foundation brakes.
10	Tire Size Out of Range (Front to Rear)	Verify correct tire size as desired. Verify proper tire inflation. Verify correct number of exciter ring teeth. Verify that the ECU has the proper tire size settings.
11	Wheel Speed Sensors Reversed on an Axle	Sensors are reversed (left to right) on one of the axles. Verify proper installation, connection, and wiring of the sensors.
12	Diff. Lock Solenoid Shorted to Ground or Open Circuit	Verify no continuity between the Diff Lock Solenoid and ground. Check for corroded/damaged wiring or connectors between the ECU and Diff Lock Solenoid.
13	Diff. Lock Solenoid Shorted to Voltage	Verify no continuity between the Diff Lock Solenoid and voltage. Check for corroded/damaged wiring or connectors between the ECU and Diff Lock Solenoid.
23	I/O 2 or I/O 3 Shorted High	Check for short circuit condition between voltage and the I/O 2 and I/O 3 circuits

Miscellaneous Troubleshooting

For all tests below, take all measurements at ECU harness connector pins in order to check wire harness and sensor. Probe the connector carefully so that the terminals are not damaged.

Stop Lamp Switch Test

1. With the service brake applied, measure the system voltage (9 to 17 VDC) stop lamp switch input to ECU.

Test	Measurement
Stop Lamp Switch to Ground	9 to 17 VDC

2. Apply and release service brake, does lamp extinguish?
3. Verify brake lamp switch is connected to ECU via hard wire or J1939.
4. With service brake released, check for presence of stop lamp bulb.

Dynamometer Test Mode (ATC Indicator Lamp Continuously Illuminated)

1. Clear the dynamometer test mode by depressing and releasing the blink code switch three times (or use an off-board diagnostic tool).

ABS Indicator Lamp

1. Verify diagnostic blink code switch is open when not activated.

Retarder Relay

1. Measure resistance between retarder disable output of EC-60™ controller and voltage / ground.

Test	Measurement
Retarder disable to Voltage or Ground	Open Circuit (no continuity)

2. Verify vehicle has retarder relay.
3. Verify proper wiring from ECU to retarder relay.

PMV Commons

1. Measure resistance between any common (PMV, TCV, and Diff.) and voltage or ground.

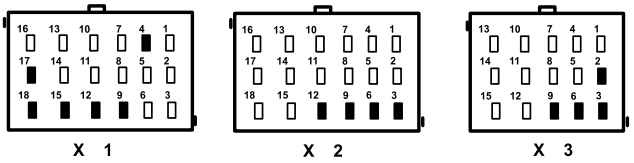
Test	Measurement
Any PMV, TCV, or Diff. Common to Voltage or Ground	Open Circuit (no continuity)

Differential Lock Solenoid

1. Measure resistance between Diff lock solenoid and voltage or ground.

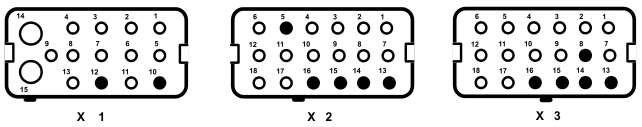
Test	Measurement
Diff. Lock Solenoid to Voltage or Ground	Open Circuit (no continuity)

Cab-mount ECU: Looking into wire harness connector



Connector	Pin	PMV Location
X1 18 Way	4	TCV Common
	9	Stop Lamp Switch
	12	ABS WL Ground
	15	ABS WL Interlock
	17	Retarder
	18	ABS WL
X2 18 Way	3	PMV Left Steer Axle Common
	6	PMV Right Steer Axle Common
	9	PMV Right Drive Axle Common
	12	PMV Left Drive Axle Common
X3 15 Way	2	Diff Lock Solenoid
	3	Diff Lock Solenoid Common
	6	PMV Left Additional Axle Common
	9	PMV Right Additional Axle Common

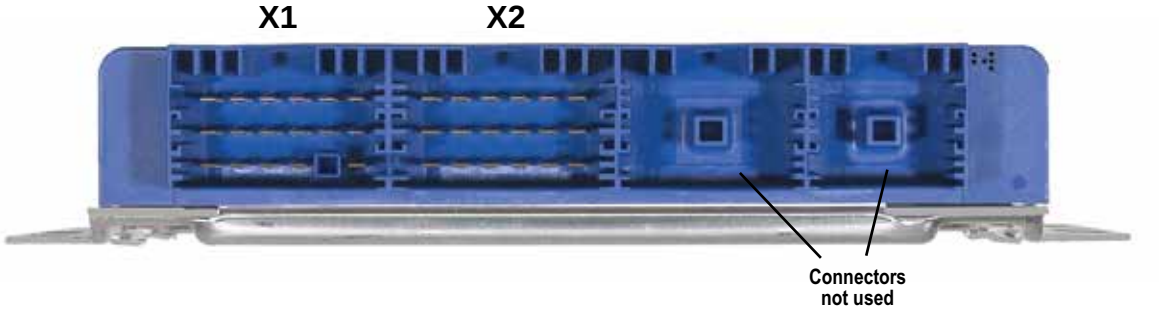
Frame-mount ECU: Looking into wire harness connector



Connector	Pin	PMV Location
X1 18 Way	10	Retarder
	12	ABS WL
X2 18 Way	5	Stop Lamp Switch
	13	PMV Left Steer Axle Common
	14	PMV Right Steer Axle Common
	15	PMV Left Drive Axle Common
	16	PMV Right Drive Axle Common
X3 15 Way	8	Diff. Lock Solenoid
	13	TCV Common
	14	Diff. Lock Solenoid Common
	15	PMV Left Additional Axle Common
	16	PMV Right Additional Axle Common

Troubleshooting: Connectors and Harnesses

EC-60™ Controller Wire Harness Connector Part Numbers and Pin Assignments: STANDARD CAB



Standard Cab EC-60™ Controller

Standard cab models utilize two AMP connectors for wire harness connections.

Connector Designation	Number of Contacts	AMP Part Number
X1	17	1718091-1
X2	18	8-968974-1

Standard Cab X1 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	Ground	7	J1939 Low	13	J1587 (B)
2	Trailer ABS WL	8	J1939 High	14	J1587 (A)
3	Ignition	**9**	**Not Used**	15	ABS WL Interlock
4	**Not Used**	10	WSS DA Right (+)	16	Battery
5	**Not Used**	11	WSS DA Right (-)	17	Retarder
6	**Not Used**	12	ABS WL Ground	18	ABS WL

Standard Cab X2 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	PMV SA Left HLD	7	PMV SA Right REL	13	PMV DA Right REL
2	PMV SA Left REL	8	WSS SA Left (-)	14	WSS SA Right (-)
3	PMV SA Left CMN	9	PMV DA Right CMN	15	WSS DA Left (+)
4	PMV SA Right HLD	10	PMV DA Right HLD	16	PMV DA Left HLD
5	WSS SA Left (+)	11	WSS SA Right (+)	17	PMV DA Left REL
6	PMV SA Right CMN	12	PMV DA Left CMN	18	WSS DA Left (-)

EC-60™ Controller Wire Harness Connector Part Numbers and Pin Assignments: STANDARD FRAME

X1 X2

Standard Frame EC-60™ Controller

Standard frame models utilize two Deutsch connectors for wire harness connections.

Connector Designation	Number of Contacts	Deutsch Part Number
X1	15	DT16-15SA-K003
X2	18	DT16-18SB-K004

Standard Frame X1 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	J1587 (B)	6	J1939 High	11	Trailer ABS WL
2	J1939 Low	7	WSS SA Left (-)	12	ABS WL
3	WSS SA Left (+)	8	WSS SA Right (-)	**13**	**Not Used**
4	WSS SA Right (+)	9	Ignition	14	Battery
5	J1587 (A)	10	Retarder	15	Ground

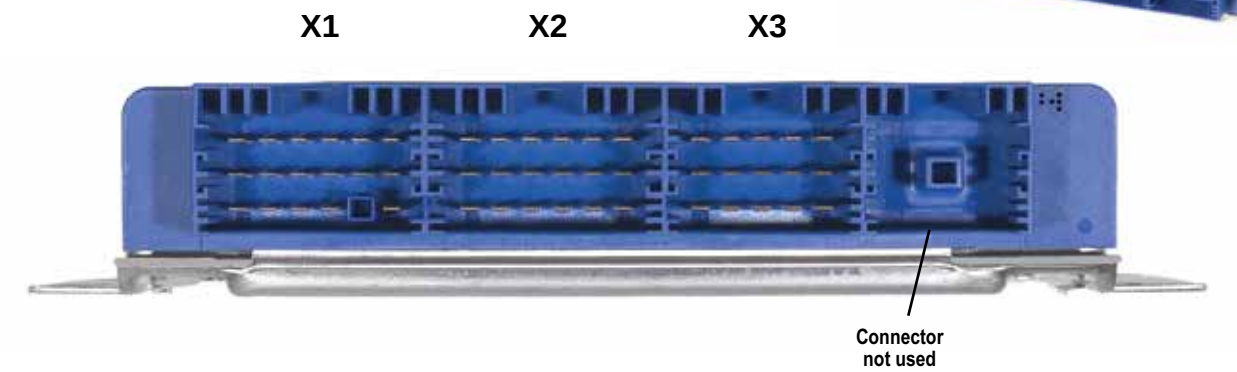
Standard Frame X2 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	WSS DA Left (+)	7	PMV SA Left HLD	13	PMV SA Left CMN
2	WSS DA Left (-)	8	PMV SA Left REL	14	PMV SA Right CMN
3	WSS DA Right (+)	9	PMV SA Right HLD	15	PMV DA Left CMN
4	WSS DA Right (-)	10	PMV SA Right REL	16	PMV DA Right CMN
5	**Not Used**	11	PMV DA Left HLD	17	PMV DA Right HLD
6	**Not Used**	12	PMV DA Left REL	18	PMV DA Right REL

Troubleshooting: Connectors and Harnesses (Continued)

EC-60™ Controller Wire Harness Connector Part Numbers and Pin Assignments:

PREMIUM CAB



Premium Cab EC-60™ Controller

Premium cab models utilize three AMP connectors for wire harness connections.

Connector Designation	Number of Contacts	AMP Part Number
X1	17	1718091-1
X2	18	8-968974-1
X3	15	8-968973-1

Premium Cab X1 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	Ground	7	J1939 Low	13	J1587 (B)
2	Trailer ABS WL	8	J1939 High	14	J1587 (A)
3	Ignition	9	SLS	15	ABS WL Interlock
4	TCV CMN	10	WSS DA Right (+)	16	Battery
5	TCV	11	WSS DA Right (-)	17	Retarder
6	ATC Lamp/ATC ORS	12	ABS WL Ground	18	ABS WL

Premium Cab X2 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	PMV SA Left HLD	7	PMV SA Right REL	13	PMV DA Right REL
2	PMV SA Left REL	8	WSS SA Left (-)	14	WSS SA Right (-)
3	PMV SA Left CMN	9	PMV DA Right CMN	15	WSS DA Left (+)
4	PMV SA Right HLD	10	PMV DA Right HLD	16	PMV DA Left HLD
5	WSS SA Left (+)	11	WSS SA Right (+)	17	PMV DA Left REL
6	PMV SA Right CMN	12	PMV DA Left CMN	18	WSS DA Left (-)

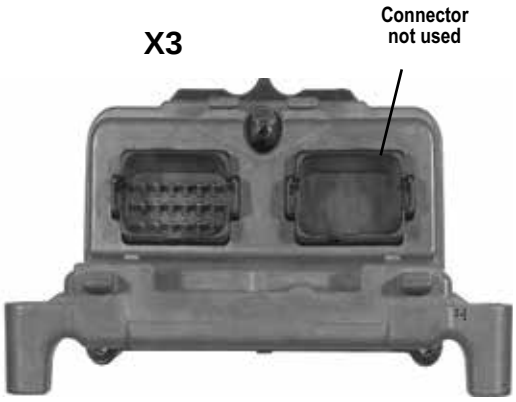
Premium Cab X3 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	ABS ORS	6	PMV AA Left CMN	11	WSS AA Left (+)
2	Diff. Lock SOL[1]	7	PMV AA Left REL	12	WSS AA Right (+)
3	Diff. Lock SOL CMN[1]	8	Input/Output 3	13	PMV AA Right REL
4	PMV AA Left HLD	9	PMV AA Right CMN	14	WSS AA Left (-)
5	Input/Output 2	10	PMV AA Right HLD	15	WSS AA Right (-)

[1]AWD vehicles only. (AWD Transfer Case)

EC-60™ Controller Wire Harness Connector Part Numbers and Pin Assignments:

PREMIUM FRAME



Premium Frame EC-60™ Controller

Premium frame models utilize three Deutsch connectors for wire harness connections.

Connector Designation	Number of Contacts	Deutsch Part Number
X1	15	DT16-15SA-K003
X2	18	DT16-18SB-K004
X3	18	DT16-18SC-K004

Premium Frame X1 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	J1587 (B)	6	J1939 High	11	Trailer ABS WL
2	J1939 Low	7	WSS SA Left (-)	12	ABS WL
3	WSS SA Left (+)	8	WSS SA Right (-)	13	ATC Lamp/ATC ORS
4	WSS SA Right (+)	9	Ignition	14	Battery
5	J1587 (A)	10	Retarder	15	Ground

Premium Frame X2 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	WSS DA Left (+)	7	PMV SA Left HLD	13	PMV SA Left CMN
2	WSS DA Left (-)	8	PMV SA Left REL	14	PMV SA Right CMN
3	WSS DA Right (+)	9	PMV SA Right HLD	15	PMV DA Left CMN
4	WSS DA Right (-)	10	PMV SA Right REL	16	PMV DA Right CMN
5	SLS	11	PMV DA Left HLD	17	PMV DA Right HLD
6	ABS ORS	12	PMV DA Left REL	18	PMV DA Right REL

Premium Frame X3 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	Input/Output 4	7	TCV	13	TCV CMN
2	Not Used	8	Diff. Lock SOL[1]	14	Diff. Lock SOL CMN[1]
3	WSS AA Left (+)	9	PMV AA Left HLD	15	PMV AA Left CMN
4	WSS AA Left (-)	10	PMV AA Left REL	16	PMV AA Right CMN
5	WSS AA Right (+)	11	Input/Output 2	17	PMV AA Right HLD
6	WSS AA Right (-)	12	Input/Output 3	18	PMV AA Right REL

[1]AWD vehicles only. (AWD Transfer Case)

Troubleshooting: Wiring

ABS/ATC WIRING

CAB ECU Wiring Harness Connectors

The in-cab EC-60™ controllers are designed to interface with AMP MCP 2.8 connectors as referenced in Chart 4. Follow all AMP requirements for the repair of wire harnesses.

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

CAUTION: All unused ECU connectors must be covered and receive proper environmental protection.

Frame ECU Wiring Harness Connectors

Frame-mount EC-60™ controllers are designed to interface with Deutsch connectors as referenced in Chart 4.

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. Secondary locks must be snapped securely in place.

Follow all Deutsch requirements for the repair of wire harnesses.

CAUTION: All unused connector terminals must be plugged with the appropriate sealing plugs.

Frame ECU Connector Covers

Frame ECUs are provided with covers that must be removed to permit connection of the vehicle wiring harness. The cover can be removed by sliding the slide lock mechanism to the unlock position.

The covers provide strain relief and connector protection of the vehicle wire harness and will accept round convoluted conduit with an I.D. of 19 mm.

ABS Wiring Requirements

As a matter of good practice and to ensure maximum system robustness, always use the maximum size wire supported by the wire harness connectors for battery, ignition, ground, PMV, TCV, Interaxle Differential Lock and indicator lamp circuits.

All sensor and serial communications circuits (J1587 and J1939) must use twisted pair wiring (one to two twists per inch). See the appropriate SAE document for additional details.

WARNING: All wires must be carefully routed to avoid contact with rotating elements. Wiring must be properly secured approximately every 6 to 12 inches using UV stabilized, non-metallic hose clamps or bow-tie cable ties to prevent pinching, binding or fraying.

It is recommended that wires be routed straight out of a connector for a minimum of three inches before the wire is allowed to bend.

Battery and ground wires should be kept to a minimum length.

If convoluted tubing is used, its I.D. must match the size of the wire bundle as closely as possible.

CAUTION: Wire harness lengths must be carefully selected for the vehicle. Harnesses that are too long increase the possibility of electrical interference and wire damage. Excess lengths of wire are **not** to be wound to form coils, instead re-route, repair or replace wire harness. Do not attempt to stretch harnesses that are too short, since mechanical strain can result in wire breakage.

ABS Component	Connector	Wire Terminal	Wire Seal/ Plug	Terminal Lock	Terminal Crimp Tool
In-Cab Controller Harness 17-Way AMP MCP 2.8 (X1)	 1718091-1	 927768-9 1 - 2.5 mm^2 X1-12 & 18	N/A	 967634	 539723-2
In-Cab Controller Harness 18-Way AMP MCP 2.8 (X2)	 8-968974-1	 968874 2.5 - 4 mm^2	N/A	N/A	
In-Cab Controller Harness 15-Way AMP MCP 2.8 (X3)	 8-968973-1	 968873 1.0 - 2.5 mm^2	N/A	N/A	
Frame Controller Harness 15-Way Deutsch (X1)	 DT16-15SA-K003	 0462-203-12XX (Solid) (or alternatively use 1062-12-01) 12 AWG X1- 14 & 15  0462-201-16XX (Solid) (or alternatively use a stamped and formed version: 1062-16-06) 16-18 AWG	N/A	N/A	 HDT-48-00
Frame Controller Harness 18-Way Deutsch (X2)	 DT16-18SB-K004		N/A	N/A	
Frame Controller Harness 18-Way Deutsch (X3)	 DT16-18SC-K004		N/A	N/A	
ABS Modulator Harness AMP Twist-Lock (Bayonet)	 1-967325-2	 929975-1	N/A	N/A	 539635-1
ATC Modulator Harness AMP Twist-Lock (Bayonet)	 1-967325-3		N/A	N/A	
ABS Modulator Harness 3-pin Packard Metri-Pack 280 Series	 12040977	 12077411	 12015323	 12034145	 12155975

WS-24™ Wheel Speed Sensor Connectors


Packard GT 150 series


Packard Metripack 150.2 series


Deutsch DTM06 series


Packard Metripack 280 series (female)


Packard Metripack 280 series (male)


Deutsch DT04 series


Standard round two pin

CHART 4 - *EC-60™ CONTROLLER COMPONENT CONNECTORS*

Troubleshooting: Wiring (Continued)

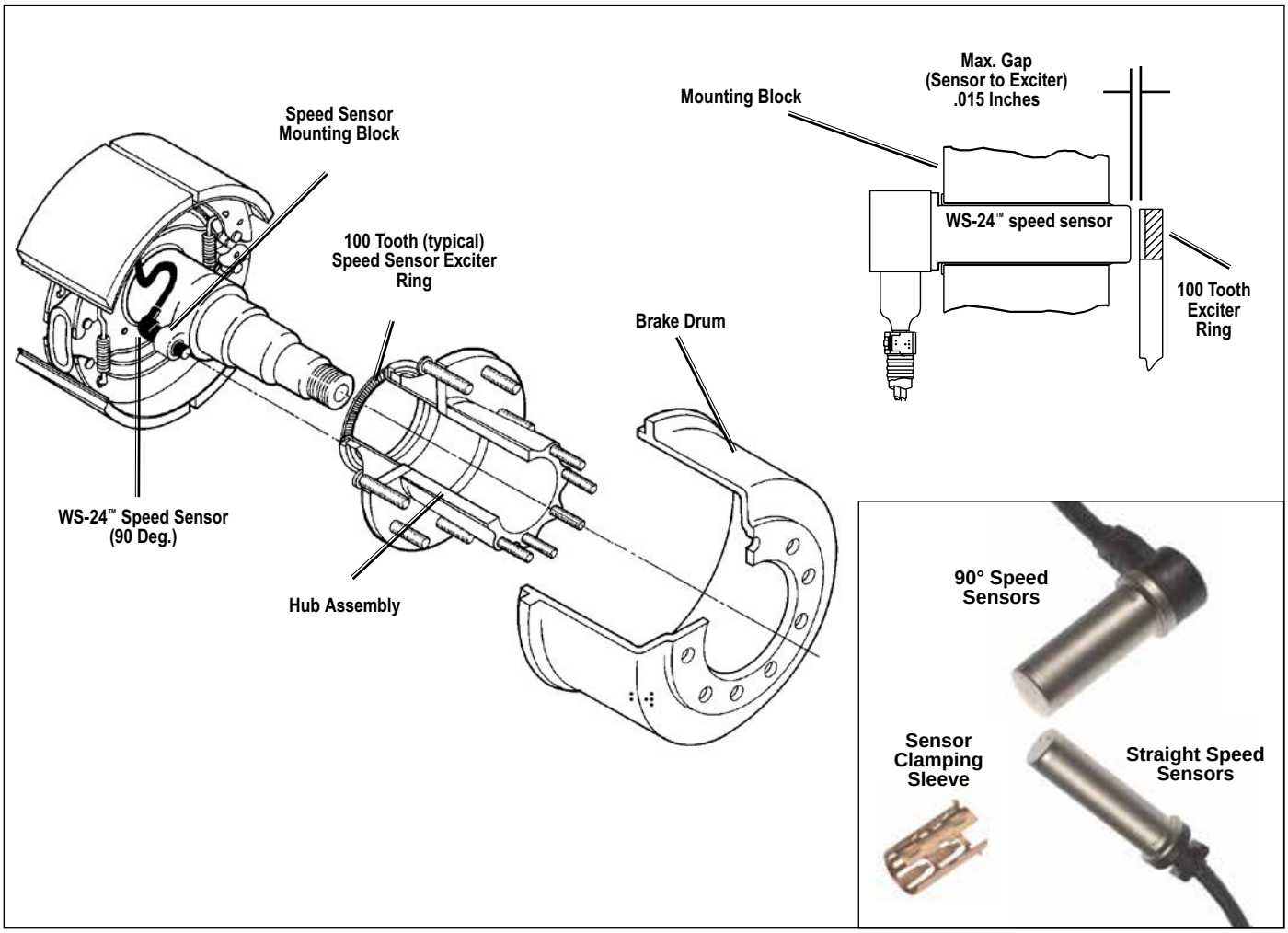


FIGURE 15 - ***WS-24™ WHEEL SPEED SENSOR INSTALLATION***

Wheel Speed Sensor Wiring

Route sensor wiring coming out of the wheel ends away from moving brake components. Sensor wiring needs to be secured to the axle to prevent excess cable length and wiring damage. It is required that cable ties be installed to the sensor wire within 3 inches (76.2 mm) of the sensor head to provide strain relief.

Following the axle, the sensor wires must be attached along the length of the service brake hoses using cable ties with ultraviolet protection and secured every 6 to 8 inches (152 to 203 mm). Sufficient – but not excessive – cable length must be provided to permit full suspension travel and steering axle movement. Install wires so that they cannot touch rotating elements such as wheels, brake discs or drive shafts. Radiation protection may be necessary in the area of brake discs.

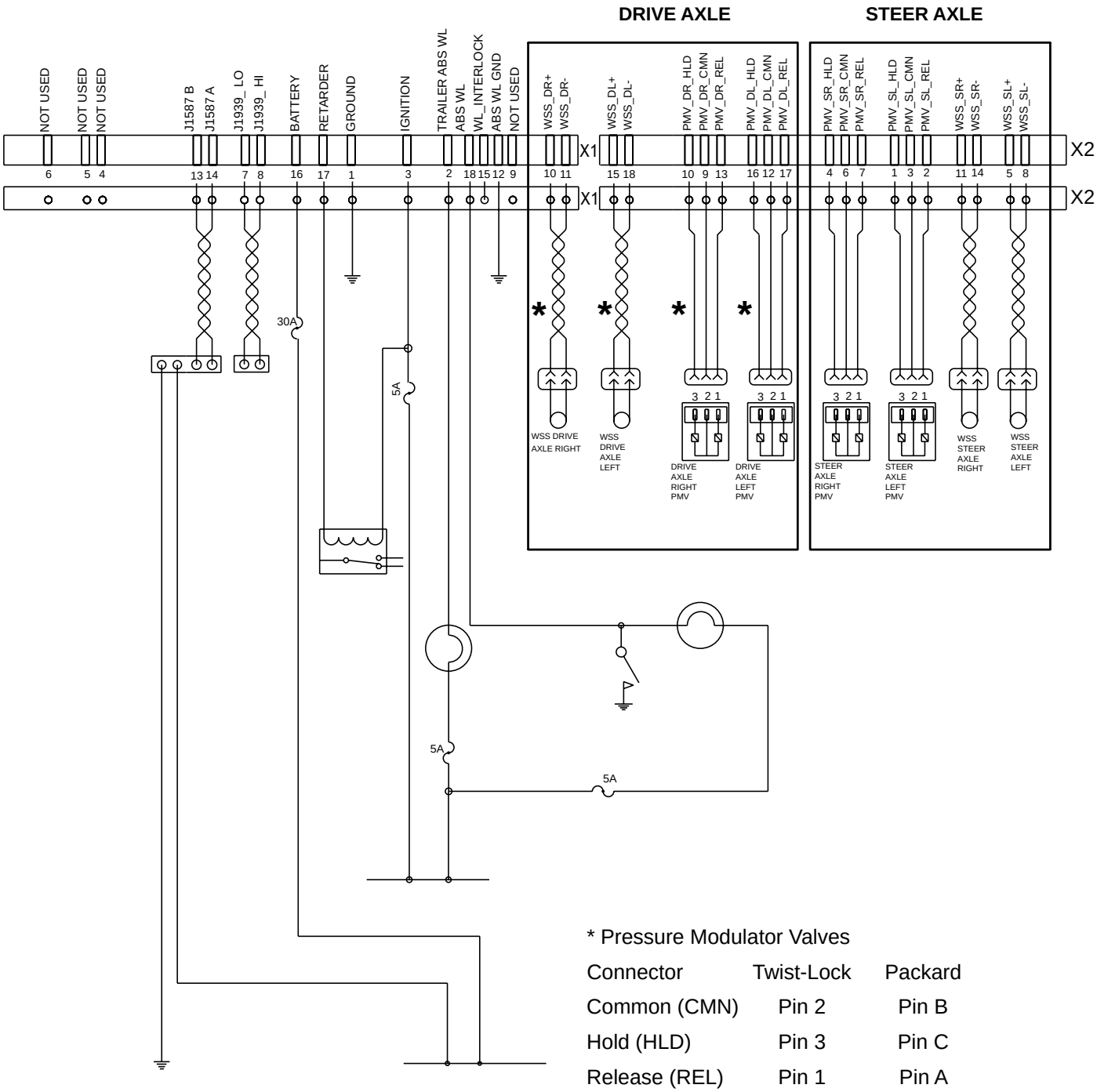
Bendix does not recommend using standard tie-wraps to secure wiring harnesses directly to rubber air lines. This may cause premature wiring failure from the pressure exerted on the wiring when air pressure is applied through the air line. Non-metallic hose clamps or bow-tie tie-wraps are preferred.

The use of grommets or other suitable protection is required whenever the cable must pass through metallic frame members.

All sensor wiring must utilize twisted pair wire, with approximately one to two twists per inch.

It is recommended that wires be routed straight out of a connector for a minimum of three inches before the wire is allowed to bend.

Troubleshooting: Standard Cab Wiring Schematic (4S/4M)



* Pressure Modulator Valves

Connector	Twist-Lock	Packard
Common (CMN)	Pin 2	Pin B
Hold (HLD)	Pin 3	Pin C
Release (REL)	Pin 1	Pin A

FIGURE 16 - ***STANDARD CAB WIRING SCHEMATIC (4S/4M)***

Troubleshooting: Premium Cab Wiring Schematic (6S/6M)

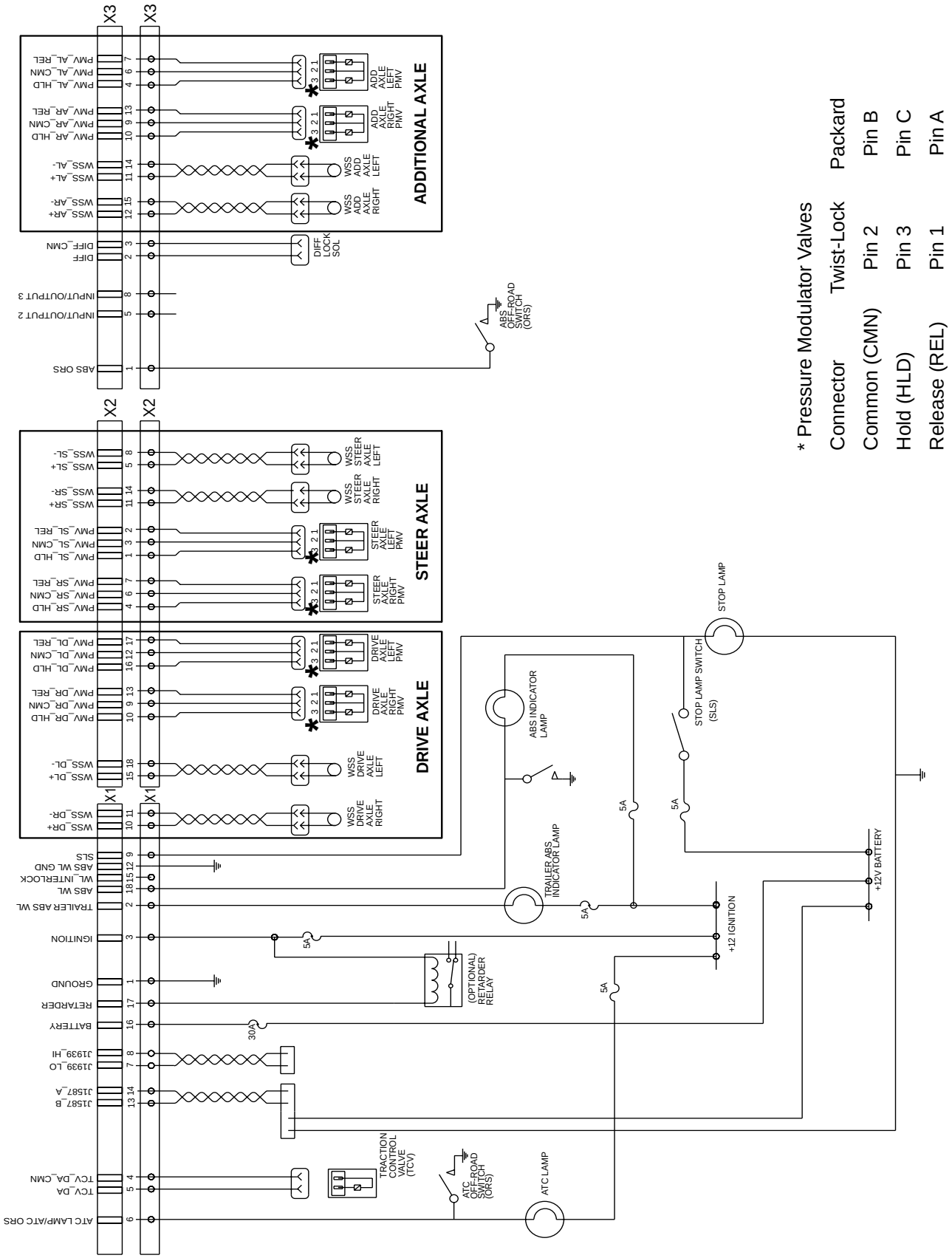


FIGURE 17 - ***PREMIUM CAB WIRING SCHEMATIC (6S/6M)***

Troubleshooting: Premium Cab Wiring Schematic (6S/5M)

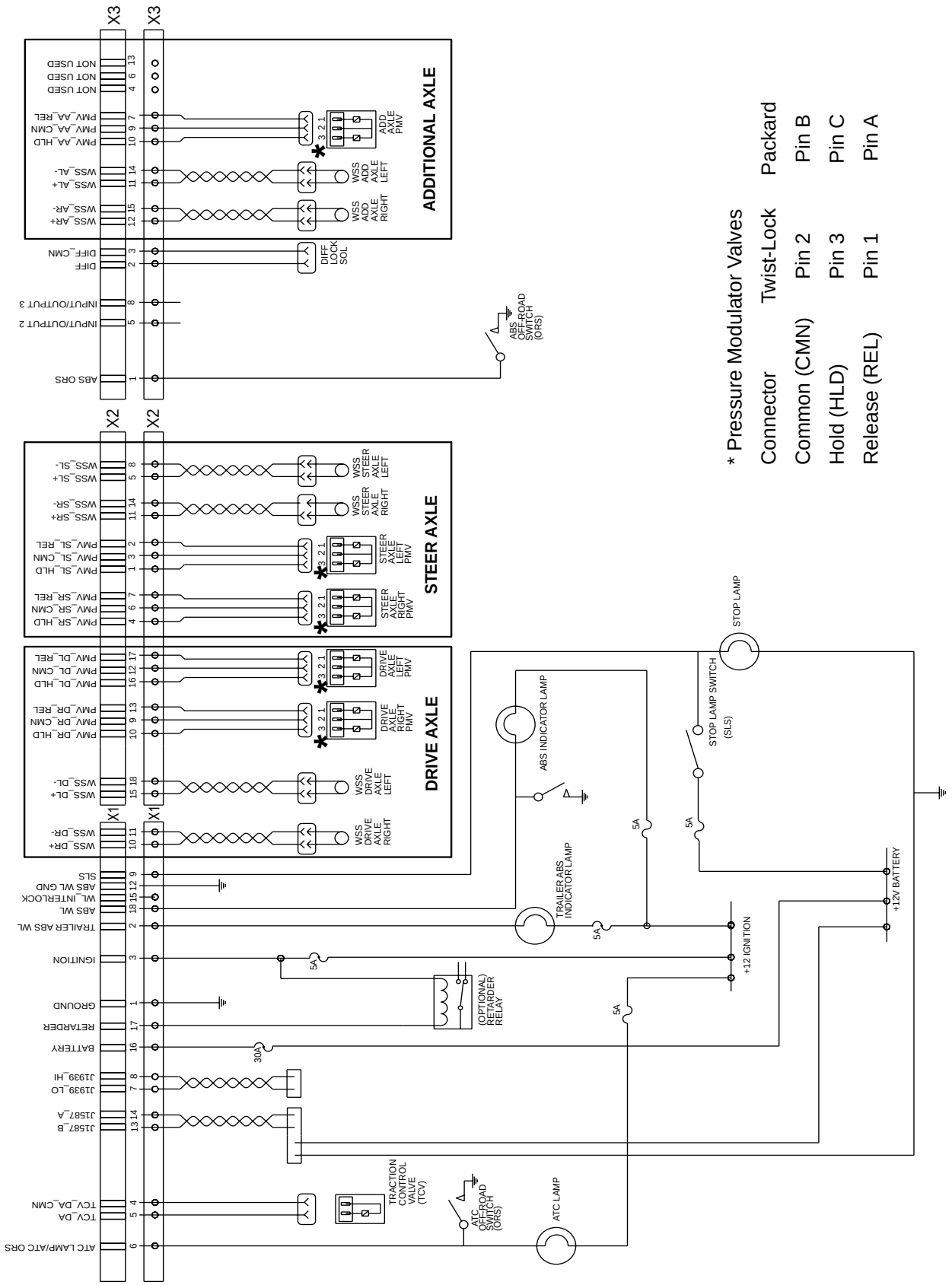
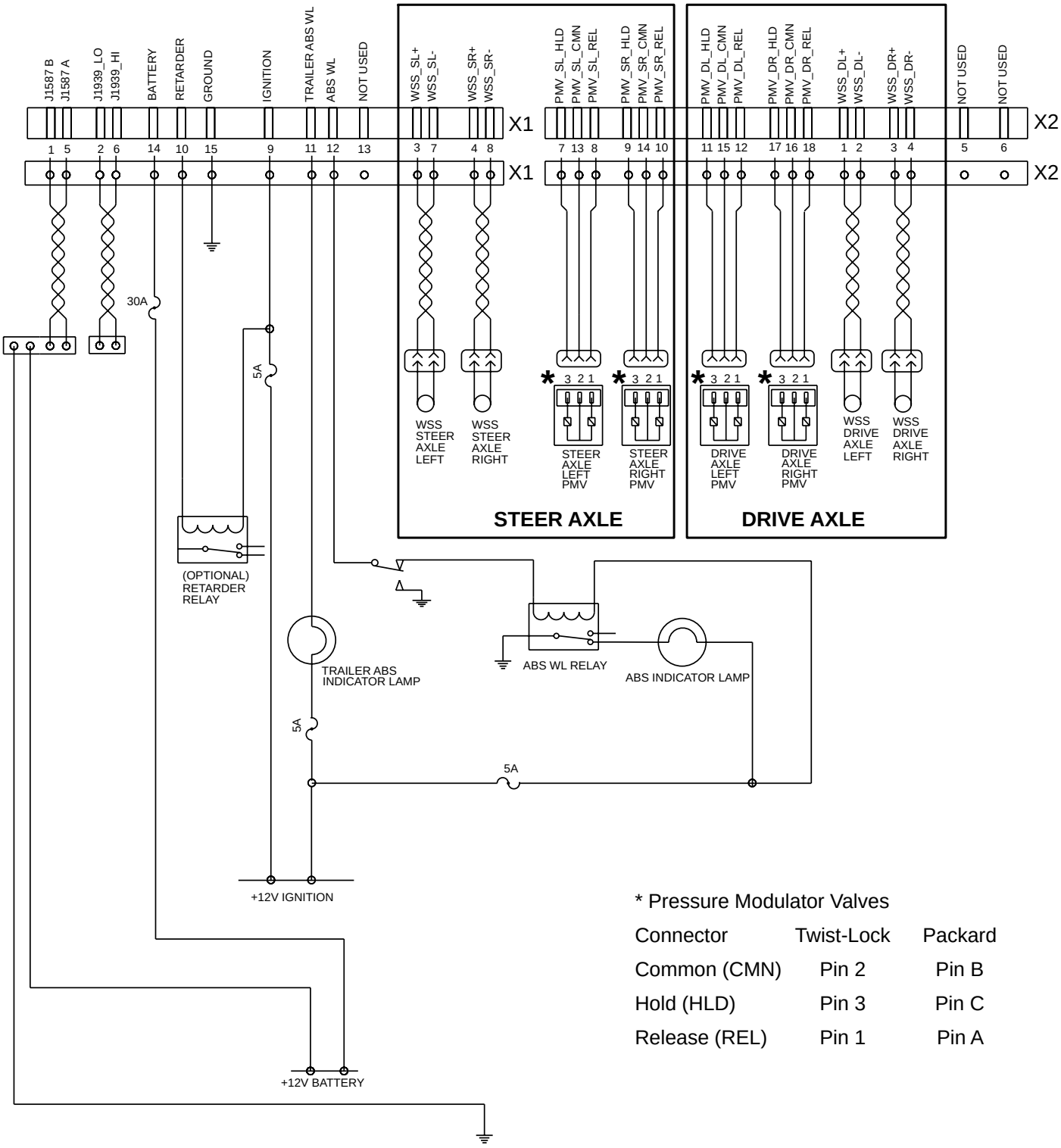


FIGURE 18 - ***PREMIUM CAB WIRING SCHEMATIC (6S/5M)***

Troubleshooting: Standard Frame Wiring Schematic (4S/4M)



* Pressure Modulator Valves

Connector	Twist-Lock	Packard
Common (CMN)	Pin 2	Pin B
Hold (HLD)	Pin 3	Pin C
Release (REL)	Pin 1	Pin A

FIGURE 19 - ***STANDARD FRAME WIRING SCHEMATIC (4S/4M)***

Troubleshooting: Premium Frame Wiring Schematic (6S/6M)

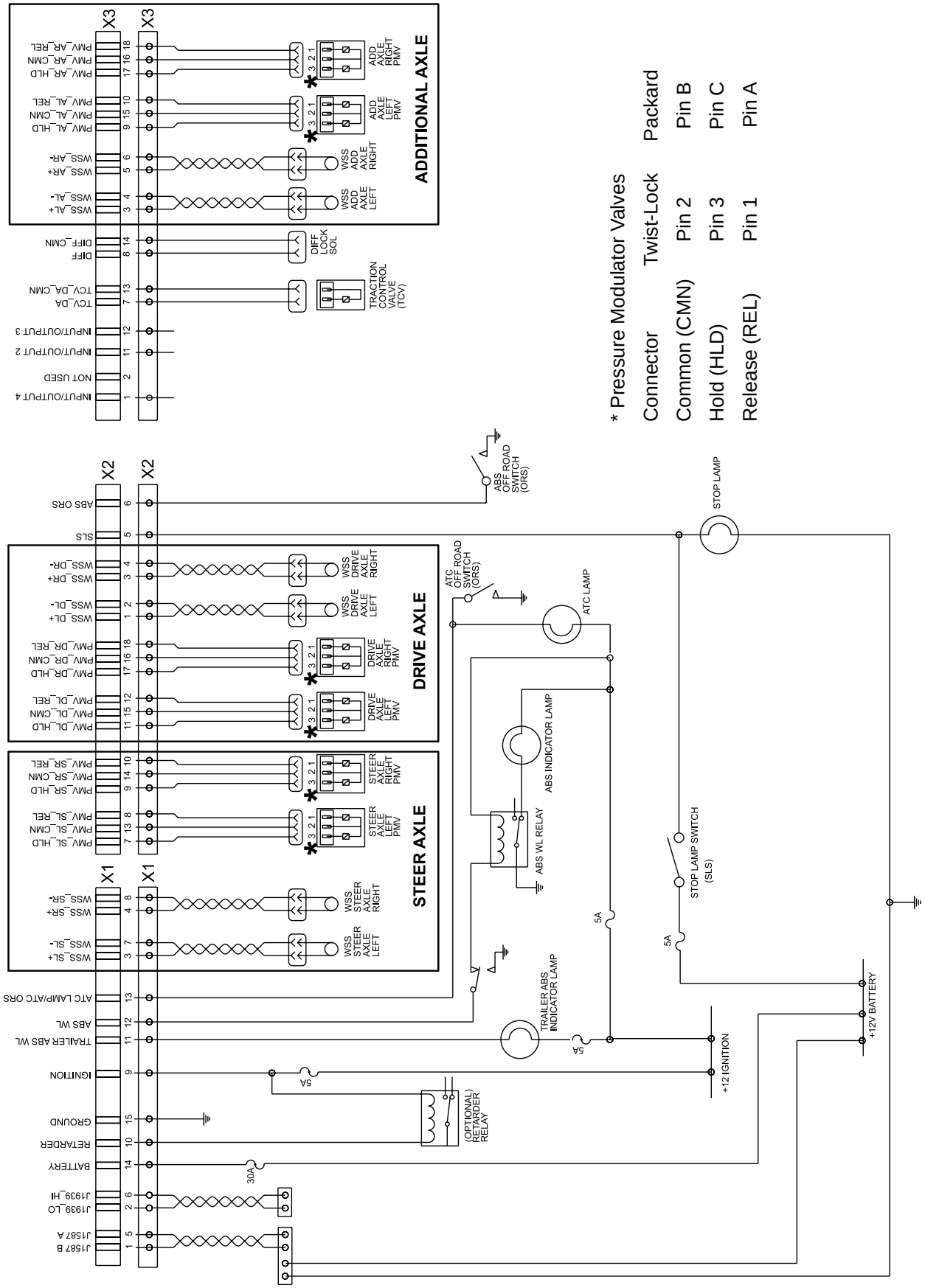


FIGURE 20 - ***PREMIUM FRAME WIRING SCHEMATIC (6S/6M)***

Troubleshooting: Premium Frame Wiring Schematic (6S/5M)

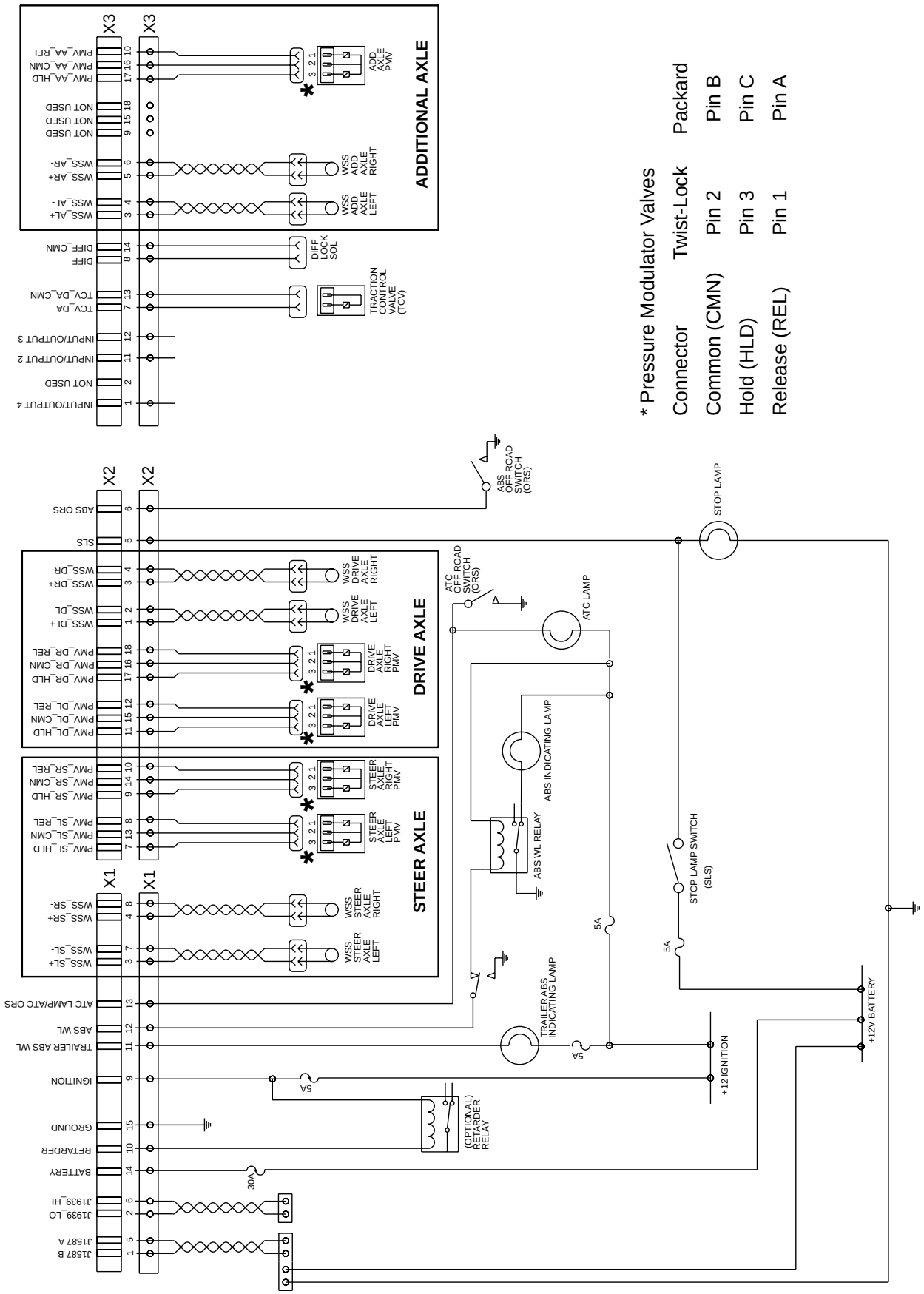


FIGURE 21 - ***PREMIUM FRAME WIRING SCHEMATIC (6S/5M)***

GLOSSARY

ABS — Antilock Brake System.

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

ABS Indicator Lamp — An amber lamp 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.

Air Gap — Distance between the Sensor and tone ring.

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 Lamp — A lamp 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 diagnostic trouble codes from the ECU, from either the Diagnostic Switch or from a hand-held diagnostic tool (only repaired diagnostic trouble codes may be cleared).

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.

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.

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.

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.

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

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. J1587 version of a J1708 data link.

J1939 — A high speed data link used for communications between the ABS ECU engine, transmission and retarders.

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.

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 connects its supply port to its delivery ports. Equal length air hose must connect the delivery ports of the relay valve to the brake chambers.

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

Sensor Clamping 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.

Stored Diagnostic Trouble Codes — A diagnostic trouble code 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.

APPENDIX A: J1587 SID and FMI Codes and their Bendix Blink Code Equivalents					
SID (J1587)	FMI (J1587)	General	Bendix Blink Code Equivalent(s)		Diagnostic Trouble Code Description
			(1st Digit)	(2nd Digit)	
1	1	Wheel Speed Sensor	2	1	SA Left WSS Excessive Air Gap
1	2	Wheel Speed Sensor	2	3	SA Left WSS Open or Shorted
1	7	Wheel Speed Sensor	2	5	SA Left WSS Wheel End
1	8	Wheel Speed Sensor	2	6	SA Left WSS Erratic Sensor Signal
1	10	Wheel Speed Sensor	2	4	SA Left WSS Loss of Sensor Signal
1	13	Wheel Speed Sensor	2	7	SA Left WSS Tire Size Calibration
1	14	Wheel Speed Sensor	2	2	SA Left WSS Output Low @ Drive-Off
2	1	Wheel Speed Sensor	3	1	SA Right WSS Excessive Air Gap
2	2	Wheel Speed Sensor	3	3	SA Right WSS Open or Shorted
2	7	Wheel Speed Sensor	3	5	SA Right WSS Wheel End
2	8	Wheel Speed Sensor	3	6	SA Right WSS Erratic Sensor Signal
2	10	Wheel Speed Sensor	3	4	SA Right WSS Loss of Sensor Signal
2	13	Wheel Speed Sensor	3	7	SA Right WSS Tire Size Calibration
2	14	Wheel Speed Sensor	3	2	SA Right WSS Output Low @ Drive-Off
3	1	Wheel Speed Sensor	4	1	DA Left WSS Excessive Air Gap
3	2	Wheel Speed Sensor	4	3	DA Left WSS Open or Shorted
3	7	Wheel Speed Sensor	4	5	DA Left WSS Wheel End
3	8	Wheel Speed Sensor	4	6	DA Left WSS Erratic Sensor Signal
3	10	Wheel Speed Sensor	4	4	DA Left WSS Loss of Sensor Signal
3	13	Wheel Speed Sensor	4	7	DA Left WSS Tire Size Calibration
3	14	Wheel Speed Sensor	4	2	DA Left WSS Output Low @ Drive-Off
4	1	Wheel Speed Sensor	5	1	DA Right WSS Excessive Air Gap
4	2	Wheel Speed Sensor	5	3	DA Right WSS Open or Shorted
4	7	Wheel Speed Sensor	5	5	DA Right WSS Wheel End
4	8	Wheel Speed Sensor	5	6	DA Right WSS Erratic Sensor Signal
4	10	Wheel Speed Sensor	5	4	DA Right WSS Loss of Sensor Signal
4	13	Wheel Speed Sensor	5	7	DA Right WSS Tire Size Calibration
4	14	Wheel Speed Sensor	5	2	DA Right WSS Output Low @ Drive-Off
5	1	Wheel Speed Sensor	14	1	AA Left WSS Excessive Air Gap
5	2	Wheel Speed Sensor	14	3	AA Left WSS Open or Shorted
5	7	Wheel Speed Sensor	14	5	AA Left WSS Wheel End
5	8	Wheel Speed Sensor	14	6	AA Left WSS Erratic Sensor Signal
5	10	Wheel Speed Sensor	14	4	AA Left WSS Loss of Sensor Signal
5	13	Wheel Speed Sensor	14	7	AA Left WSS Tire Size Calibration
5	13	Wheel Speed Sensor	14	10	AA Left WSS Configuration Error
5	14	Wheel Speed Sensor	14	2	AA Left WSS Output Low @ Drive-Off
6	1	Wheel Speed Sensor	15	1	AA Right WSS Excessive Air Gap
6	2	Wheel Speed Sensor	15	3	AA Right WSS Open or Shorted
6	7	Wheel Speed Sensor	15	5	AA Right WSS Wheel End
6	8	Wheel Speed Sensor	15	6	AA Right WSS Erratic Sensor Signal
6	10	Wheel Speed Sensor	15	4	AA Right WSS Loss of Sensor Signal
6	13	Wheel Speed Sensor	15	7	AA Right WSS Tire Size Calibration
6	13	Wheel Speed Sensor	15	10	AA Right WSS Configuration Error
6	14	Wheel Speed Sensor	15	2	AA Right WSS Output Low @ Drive-Off
7	5	Pressure Modulator Valve	7	7	SA Left PMV CMN Open Circuit
7	13	Pressure Modulator Valve	7	8	SA Left PMV Configuration Error
8	5	Pressure Modulator Valve	8	7	SA Right PMV CMN Open Circuit
8	13	Pressure Modulator Valve	8	8	SA Right PMV Configuration Error
9	5	Pressure Modulator Valve	9	7	DA Left PMV CMN Open Circuit
9	13	Pressure Modulator Valve	9	8	DA Left PMV Configuration Error
10	5	Pressure Modulator Valve	10	7	DA Right PMV CMN Open Circuit
10	13	Pressure Modulator Valve	10	8	DA Right PMV Configuration Error
11	5	Pressure Modulator Valve	16	7	AA Left PMV CMN Open Circuit
11	13	Pressure Modulator Valve	16	8	AA Left PMV Configuration Error

APPENDIX A: J1587 SID and FMI Codes and their Bendix Blink Code Equivalents					
SID (J1587)	FMI (J1587)	General	Bendix Blink Code Equivalent(s)		Diagnostic Trouble Code Description
			(1st Digit)	(2nd Digit)	
12	5	Pressure Modulator Valve	17	7	AA Right PMV CMN Open Circuit
12	13	Pressure Modulator Valve	17	8	AA Right PMV Configuration Error
13	2	Miscellaneous	12	4	Retarder Relay Open Circuit or Shorted to Ground
13	3	Miscellaneous	12	5	Retarder Relay Circuit Shorted to Voltage
17	14	Miscellaneous	12	3	ATC Disabled or Dynamometer Test Mode Active
17	14	Miscellaneous	12	9	ATC Disabled to Prevent Brake Fade
18	13	TCV	18	4	TCV Configuration Error
18	3	TCV	18	2	TCV Solenoid Shorted to Voltage
18	4	TCV	18	1	TCV Solenoid Shorted to Ground
18	5	TCV	18	3	TCV Solenoid Open Circuit
22	7	Miscellaneous	12	11	Wheel Speed Sensors Reversed on an Axle
23	2	Miscellaneous	12	6	ABS Warning Lamp Circuit
42	3	Pressure Modulator Valve	7	5	SA Left PMV HLD Solenoid Shorted to Voltage
42	4	Pressure Modulator Valve	7	4	SA Left PMV HLD Solenoid Shorted to Ground
42	5	Pressure Modulator Valve	7	6	SA Left PMV HLD Solenoid Open Circuit
43	3	Pressure Modulator Valve	8	5	SA Right PMV HLD Solenoid Shorted to Voltage
43	4	Pressure Modulator Valve	8	4	SA Right PMV HLD Solenoid Shorted to Ground
43	5	Pressure Modulator Valve	8	6	SA Right PMV HLD Solenoid Open Circuit
44	3	Pressure Modulator Valve	9	5	DA Left PMV HLD Solenoid Shorted to Voltage
44	4	Pressure Modulator Valve	9	4	DA Left PMV HLD Solenoid Shorted to Ground
44	5	Pressure Modulator Valve	9	6	DA Left PMV HLD Solenoid Open Circuit
45	3	Pressure Modulator Valve	10	5	DA Right PMV HLD Solenoid Shorted to Voltage
45	4	Pressure Modulator Valve	10	4	DA Right PMV HLD Solenoid Shorted to Ground
45	5	Pressure Modulator Valve	10	6	DA Right PMV HLD Solenoid Open Circuit
46	3	Pressure Modulator Valve	16	5	AA Left PMV HLD Solenoid Shorted to Voltage
46	4	Pressure Modulator Valve	16	4	AA Left PMV HLD Solenoid Shorted to Ground
46	5	Pressure Modulator Valve	16	6	AA Left PMV HLD Solenoid Open Circuit
47	3	Pressure Modulator Valve	17	5	AA Right PMV HLD Solenoid Shorted to Voltage
47	4	Pressure Modulator Valve	17	4	AA Right PMV HLD Solenoid Shorted to Ground
47	5	Pressure Modulator Valve	17	6	AA Right PMV HLD Solenoid Open Circuit
48	3	Pressure Modulator Valve	7	2	SA Left PMV REL Solenoid Shorted to Voltage
48	4	Pressure Modulator Valve	7	1	SA Left PMV REL Solenoid Shorted to Ground
48	5	Pressure Modulator Valve	7	3	SA Left PMV REL Solenoid Open Circuit
49	3	Pressure Modulator Valve	8	2	SA Right PMV REL Solenoid Shorted to Voltage
49	4	Pressure Modulator Valve	8	1	SA Right PMV REL Solenoid Shorted to Ground
49	5	Pressure Modulator Valve	8	3	SA Right PMV REL Solenoid Open Circuit
50	3	Pressure Modulator Valve	9	2	DA Left PMV REL Solenoid Shorted to Voltage
50	4	Pressure Modulator Valve	9	1	DA Left PMV REL Solenoid Shorted to Ground
50	5	Pressure Modulator Valve	9	3	DA Left PMV REL Solenoid Open Circuit
51	3	Pressure Modulator Valve	10	2	DA Right PMV REL Solenoid Shorted to Voltage
51	4	Pressure Modulator Valve	10	1	DA Right PMV REL Solenoid Shorted to Ground
51	5	Pressure Modulator Valve	10	3	DA Right PMV REL Solenoid Open Circuit
52	3	Pressure Modulator Valve	16	2	AA Left PMV REL Solenoid Shorted to Voltage
52	4	Pressure Modulator Valve	16	1	AA Left PMV REL Solenoid Shorted to Ground
52	5	Pressure Modulator Valve	16	3	AA Left PMV REL Solenoid Open Circuit
53	3	Pressure Modulator Valve	17	2	AA Right PMV REL Solenoid Shorted to Voltage
53	4	Pressure Modulator Valve	17	1	AA Right PMV REL Solenoid Shorted to Ground
53	5	Pressure Modulator Valve	17	3	AA Right PMV REL Solenoid Open Circuit
55	2	Miscellaneous	12	2	Stop Lamp Switch Defective
55	7	Miscellaneous	12	1	Stop Lamp Switch Not Detected
79	13	Miscellaneous	12	10	Tire Size Out of Range (Front to Rear)
93	3	Miscellaneous	12	8	PMV/TCV/Diff Lock Common Shorted to Voltage
93	4	Miscellaneous	12	7	PMV/TCV/Diff Lock Common Shorted to Ground

APPENDIX A: J1587 SID and FMI Codes and their Bendix Blink Code Equivalents					
SID (J1587)	FMI (J1587)	General	Bendix Blink Code Equivalent(s)		Diagnostic Trouble Code Description
			(1st Digit)	(2nd Digit)	
102	3	Miscellaneous	12	13	Diff Lock Solenoid Shorted to Voltage
102	5	Miscellaneous	12	12	Diff Lock Solenoid Shorted to Ground or Open Circuit
154	13	Miscellaneous	12	23	I/O 2 or I/O 3 Shorted High
231	2	J1939	11	3	J1939 Engine Communications
231	12	J1939	11	1	J1939 Serial Link
231	14	J1939	11	2	J1939 Retarder
251	2	Power Supply	6	8	Input Voltage Has Excessive Noise (Temp)
251	3	Power Supply	6	2	Battery Voltage Too High
251	3	Power Supply	6	6	Ignition Voltage Too High
251	4	Power Supply	6	1	Battery Voltage Too Low
251	4	Power Supply	6	3	Battery Voltage Too Low During ABS
251	4	Power Supply	6	5	Ignition Voltage Too Low
251	4	Power Supply	6	7	Ignition Voltage Too Low During ABS
251	5	Power Supply	6	4	Battery Voltage Input Open Circuit
251	14	Power Supply	6	9	Input Voltage Has Excessive Noise
254	2	ECU	13	4	ECU (12)
254	2	ECU	13	5	ECU (13)
254	2	ECU	13	7	ECU (15)
254	12	ECU	13	2	ECU (10)
254	12	ECU	13	3	ECU (11)
254	12	ECU	13	6	ECU (14)
254	12	ECU	13	10	ECU (18)
254	12	ECU	13	11	ECU (1A)
254	12	ECU	13	12	ECU (1B)
254	12	ECU	13	13	ECU (80)
254	13	ECU	13	8	ECU (16)
254	13	ECU	13	9	ECU (17)