CONFIDENTIAL

Bendix Commercial Vehicle Systems LLC
Elyria, OH 44036

PRODUCT SPECIFICATION BW-271-PR

ANTILOCK BRAKING SYSTEM

EC-60™ STANDARD & PREMIUM MODEL

ELECTRONIC CONTROL UNIT

NOTICE

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1.0 SCOPE

This product specification describes the functions, features, operating environment, and installation requirements of the *Bendix*® EC-60™ Electronic Control Unit, referred to as the "ECU" or "EC-60™". Brief explanations of other system components are included.

Certain functions and features described in this specification are available only in specific models of the EC-60™ .

1.1 Product Description

The EC-60™ is an Electronic Control Unit (ECU) used in an Antilock Brake System (ABS) for commercial vehicles (tractors, trucks, and bus) that utilize air brakes. It is available in various models that contain a variety of features to support a wide range of applications.

An Antilock Brake System, consisting of an EC-60™ ECU , WS-24™ Wheel Speed Sensors, and M-32™/M-32QR™ Pressure Modulator Valves is commonly referred to as *ABS6*™.

1.2 Related Specifications

1.2.1 Bendix Commercial Vehicle Systems Specifications

BW-120-A	Application Specification	Wheel Speed Sensor Customer Interface Recommendations
BW-286-D	Design Specification	EC-60 SAE J1939 Serial Communications
BW-287-D	Design Specification	EC-60 SAE J1708/J2497 Protocol Layer
BW-288-D	Design Specification	EC-60 SAE J1587/J2497 Standard Parameter Identifiers
BW-289-D	Design Specification	EC-60 SAE J1587/J2497 Public Proprietary Commands
BW-340-D	Design Specification	EC-60 Internal Stored Data
BW-100-PR	Product Specification	Relay Valves
BW-260-PR	Product Specification	WS-24 Variable Reluctance Wheel Speed Sensor
BW-269-PR	Product Specification	WS-24 Wheel Speed Sensor Clamping Sleeve
BW-273-PR	Product Specification	M-32/M-32QR Antilock Modulator
BW-275-PR	Product Specification	EC-60 Advanced Electronic Control Unit
BW-277-PR	Product Specification	Remote Diagnostic Unit
BW2489	ABS Operator's Manual	Bendix Antilock Brake Systems
SD-13-4863	Service Data Manual	EC-60 Standard and Premium Model ECUs

1.2.2 Bendix Commercial Vehicle Systems Drawings

5012225	ECU Drawing	EC-60 Standard Cab ECU
5013392	ECU Drawing	EC-60 Standard Cab ECU
5012229	ECU Drawing	EC-60 Premium Cab ECU
5013147	ECU Drawing	EC-60 Premium Cab ECU
5012227	ECU Drawing	EC-60 Standard Frame ECU
5012230	ECU Drawing	EC-60 Premium Frame ECU
5013149	ECU Drawing	EC-60 Premium Frame ECU
5012522	System Wiring	EC-60 Standard Cab ECU
5014384	System Wiring	EC-60 Standard Cab ECU (5013392)
5012523	System Wiring	EC-60 Premium Cab ECU
5012521	System Wiring	EC-60 Standard Frame ECU
5012435	System Wiring	EC-60 Premium Frame ECU
5014385	System Wiring	EC-60 Premium Cab ECU (6S/5M Installation)
5014386	System Wiring	EC-60 Premium Frame ECU (6S/5M Installation)

1.2.3 SAE Documents

SAE J400	Test for Chip Resistance of Surface Coatings
SAE J1113-13	Electromagnetic Compatibility Measurement Procedure for Vehicle Components - Immunity to Electrostatic Discharge
SAE J1455	Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design (Heavy Duty Truck)
SAE J1587	Electronic Data Interchange Between Microcomputer Systems in Heavy-Duty Vehicle Applications
SAE J1708	Serial Data Communications Between Microcomputer Systems in Heavy-Duty Vehicle Applications
SAE J1939-11	Physical Layer, 250K bits/s, Twisted Shielding Pair
SAE J1939-15	Reduced Physical Layer, 250K bits/s, Unshielded Twisted Pair
SAE J1939-71	Vehicle Application Layer
SAE J2497	Power Line Communications for Commercial Vehicles

1.2.4 Government Requirements

FMVSS 121	Department of Transportation, National Highway Traffic Safety Administration Federal Motor Vehicle Safety Standard 571.121

1.2.5 Other Documents

RP-1210A	TMC Recommended Practice for Windows™ Communications API

1.3 Abbreviations and Symbols

AA	Additional Axle
ABS	Antilock Braking System
ADL	Auxiliary Design Language
AL/AR	Additional Axle Left/Additional Axle Right
ATC	Automatic Traction Control
ATR	Antilock Traction Relay Valve
AWD	All-Wheel Drive
BATT	Battery
BC	ATC Brake Control (also referred to as differential braking)
BCVS	Bendix Commercial Vehicle Systems, LLC
CAN	Controller Area Network
CMN	Solenoid Common
DA	Drive Axle
DL/DR	Drive Axle Left/Drive Axle Right
DTC	Diagnostic Trouble Code
EC	ATC Engine Control (also referred to as engine limiting)
ECU	Electronic Control Unit
EEPROM	Electrically Erasable Programmable Read Only Memory
EOL	End of Line (programming or testing)
ESD	Electro-Static Discharge
FAM	Front Axle Module
FET	Field Effect Transistor
GND	Electrical Ground Potential
HLD	Hold Solenoid (also referred to as inlet), part of the PMV
IC	Individual Control Mode
IGN	Ignition
LED	Light Emitting Diode
MIR	Modified Individual Regulation mode
ORS	Off-Road Switch
PLC	Power Line Carrier communications
PMV	Pressure Modulator Valve (also referred to as Pressure Control Valve, or PCV)
QR	Quick Release
QRV	Quick Release Valve
RAM	Rear Axle Module
RDU	Remote Diagnostic Unit
REL	Release Solenoid (also referred to as exhaust or outlet), part of the PMV
RET	Retarder Disable Relay output
RPM	Revolutions Per Mile (used for tire size calibration)
SA	Steer Axle
SL	Select Low control mode
SL/SR	Steer Axle Left/Steer Axle Right
SLS	Stop Lamp Switch
SOL	Solenoid
TCL	Traction Control Lamp
TCS	Traction Control Switch
TCV	Traction Control Valve
WL	Warning Lamp/Dash Malfunction Indicator
WSS	Wheel Speed Sensor
xS/yM	Vehicle Configuration with x Wheel Speed Sensors and y Modulator Valves

Bendix Commercial Vehicle Systems LLC
Elyria, OH 44036

PRODUCT SPECIFICATION BW-271-PR

2.0 GENERAL PRODUCT DESCRIPTION

2.1 Antilock Braking System (ABS)

The *Bendix*® ABS is an electronic system that prevents wheel lock-up during braking to maintain optimal vehicle steerability and stability, as well as minimizing stopping distance.

ABS intervenes during braking whenever the available friction between the road and the tire of a monitored wheel is less than the braking force applied to the wheel, causing the wheel to decelerate quickly or lock-up.

The system consists of the following components.

2.1.1 Electronic Control Unit (ECU)

The ECU monitors the wheel speed sensor signals and determines when ABS intervention is required. It then actuates the appropriate pressure modulator valve(s) to optimize the brake pressure. The ECU continually monitors the system to detect and warn the driver of any malfunctions. Diagnostic Trouble Codes (DTC) are stored in the ECU and can be recalled to evaluate system status.

2.1.2 Wheel Speed Sensors (WSS)

Variable reluctance wheel speed sensors are located at the wheels to sense the instantaneous movement of the wheel. The sensor then sends an electrical signal that is directly proportional to the rotational velocity of the wheel to the ECU.

2.1.3 Pressure Modulator Valves (PMV)

Pressure modulator valves are located near the brake chambers and are controlled electrically by the ECU to decrease, hold or allow the applied brake pressure into the brake chamber.

PMVs may be supplied individually or as part of an assembly (Front Axle Module – FAM or Rear Axle Module – RAM).

2.1.4 ABS Dash Indicator

The ECU will control the ABS dash indicator as required to indicate ABS status.

The ABS dash indicator will illuminate when ignition power is applied to the ECU, and extinguish after an indicator check is performed if there are no ABS DTCs present.

WARNING

The EC-60™ must receive input voltage from a circuit fused separately from the ABS dash indicator. This is required to insure that a loss of input power to the ECU does not result in a loss of the ABS dash indicator.

2.1.5 Trailer ABS Dash Indicator

Certain models of the EC-60™ will contain Power Line Carrier (PLC) communications hardware and control the trailer ABS dash indicator as required to indicate the status of the trailer ABS.

Bendix Commercial Vehicle Systems LLC
Elyria, OH 44036

PRODUCT SPECIFICATION BW-271-PR

2.1.6 ABS Vehicle Installation Schematic (4S/4M ABS Only)
The following schematic illustrates an example of the ABS installation on a 2 axle vehicle. Four wheel speed sensors and four pressure modulator valves are used in this component configuration.

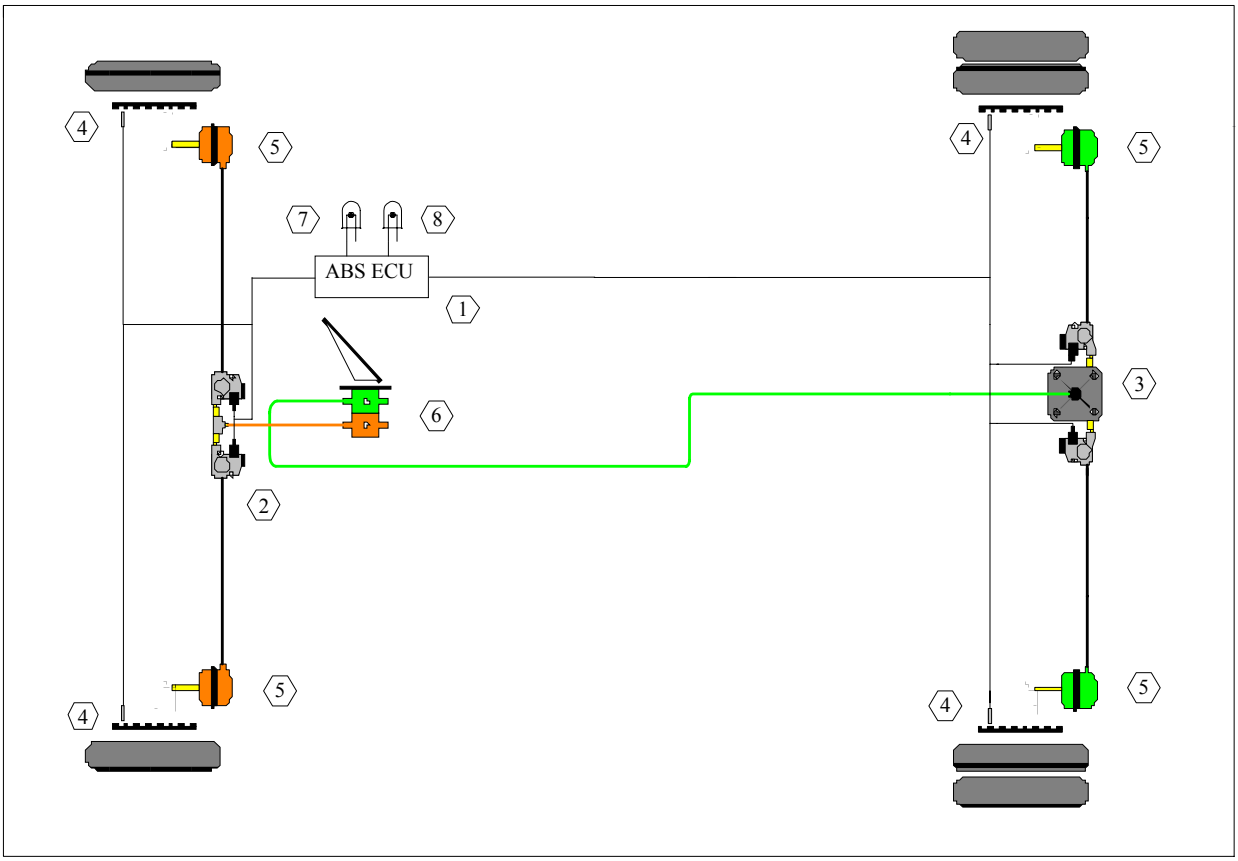


Figure 1 General Schematic of a 4S/4M ABS

1	ABS ECU	2	Front Axle Module (FAM)	3	Rear Axle Module (RAM)
4	WSS	5	Brake Chamber	6	Service Brake Valve
7	ABS Dash Indicator	8	Trailer ABS Dash Indicator		

2.2 Automatic Traction Control (ATC)

ATC is an option that helps improve vehicle traction on slippery driving surfaces by preventing excessive drive wheel spin. In addition to the components described in Section 2.1, ATC requires the following components.

2.2.1 Traction Control Valve (TCV)

The traction control valve will signal the relay valve to apply full system air pressure to the drive axle PMVs when required during an ATC brake control event. The ECU will then control the drive axle PMVs to obtain optimal drive wheel traction.

See Section 5.2.3 Brake Control (BC) for details.

The TCV may be supplied individually, as part of the relay valve, or as part of an assembly (Rear Axle Module – RAM).

2.2.2 ATC Dash Indicator

The ECU will control the ATC dash indicator as required to indicate ATC status.

The ATC dash indicator will illuminate when ignition power is applied to the ECU, and extinguish after an indicator check is performed if there are no ATC DTCs present.

2.2.3 Engine Communications

When required, the ECU will communicate with the electronic engine via the SAE J1939 serial communications link to request a reduction in engine torque during an ATC engine control event.

See Section 5.2.4 Engine Control (EC) with *Smart ATC*™ Traction Control for details.

2.2.4 ABS/ATC Vehicle Installation Schematic (6S/4M ABS/ATC)

The following schematic illustrates an example of the ABS/ATC installation on a 3 axle vehicle. Six wheel speed sensors and four pressure modulator valves are used in this component configuration, along with the traction control valve and engine communications link.

Bendix Commercial Vehicle Systems LLC
Elyria, OH 44036

PRODUCT SPECIFICATION BW-271-PR

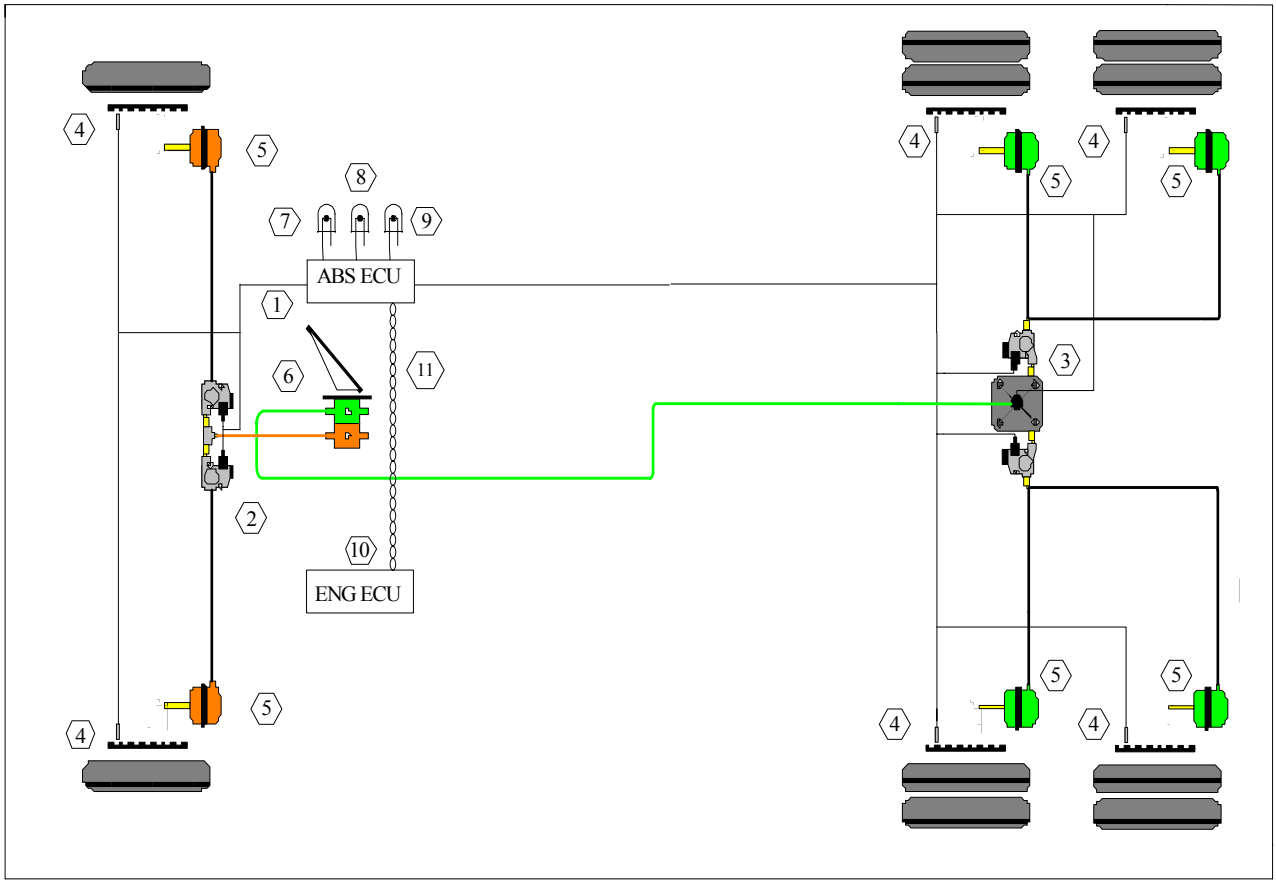


Figure 2 General Schematic of a 6S/4M ABS/ATC System

1	ABS ECU	2	Front Axle Module (FAM)	3	Rear Axle Module (RAM)[1]
4	WSS	5	Brake Chamber	6	Service Brake Valve
7	ABS Dash Indicator	8	Trailer ABS Dash Indicator	9	ATC Dash Indicator
10	Engine ECU	11	J1939 Serial Communications		

[1]TCV integral to the RAM

3.0 SYSTEM COMPONENTS

CAUTION
The EC-60™ is designed to function with the components referenced in this section. Alternate or substitute components should not be used.

3.1 WS-24™ Wheel Speed Sensor

The WS-24™ Wheel Speed Sensor consists of a coil, pole piece and permanent magnet, packaged in molded plastic and a stainless steel sheath. It works with an exciter ring (also referred to as a tone wheel) that is typically pressed on to the hub to provide wheel speed information to the EC-60™ .

Figure 3 WS-24™ Wheel Speed Sensor

The WS-24™ is available in both straight and right angle (or 90º) models, in a variety of lengths with various wire harness connectors.

The WS-24™ is typically installed in mounting blocks welded to the axle housing. The sensor must be installed with a *Bendix*® clamping sleeve (*Bendix*® part number 5012878). The clamping sleeve provides a friction fit between the mounting block bore and the WS-24™. The friction fit allows the sensor to slide back and forth under force but retain its position when the force is removed.

Figure 4 Sensor Clamping Sleeve

When the WS-24™ is inserted completely into the mounting block and the wheel is installed on the axle, the exciter ring contacts the sensor, causing the sensor to be pushed back slightly. Normal bearing end-play will also cause the sensor to be pushed slightly away from the exciter ring. These two actions establish an air gap between the sensor and exciter ring.

The exciter ring is provided by the hub supplier, and contains regularly spaced high and low areas known as "teeth". Exciter rings typically contain 100 teeth. See Section 9.5 Exciter Ring Installation Requirements for details regarding exciter rings.

The WS-24™ magnet and pole piece develop a magnetic field. When the wheel rotates, the exciter ring teeth pass through the magnetic field. This alters the magnetic field and generates an AC voltage in the sensor coil. The frequency of this AC signal is analyzed by the EC-60™ to determine the speed of the wheel. As the speed of the wheel increases, so does the frequency of the AC signal.

The voltage amplitude of the AC signal is an indication of the air gap between the WS-24™ and the exciter ring. The signal amplitude will increase as the air gap decreases.

3.1.1 WS-24™ Specifications

Parameter	Limits
Nominal Resistance	1750 Ω ± 175 Ω @ room temperature
Inductance	1.3H ± @ 1kHz/1VRMS

See BW-260-PR for details regarding the wheel speed sensor.

See BW-269-PR for details regarding the clamping sleeve.

3.2 M-32™/M-32QR™ Pressure Modulator Valve

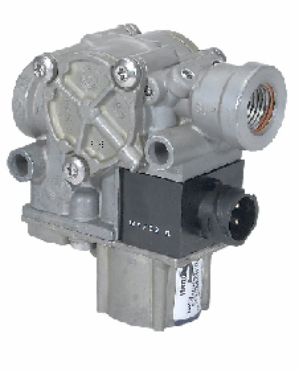
The M-32™ and M-32QR™ (Quick Release) Pressure Modulator Valves (PMV) are high capacity, on/off air valves that incorporate a pair of electrical solenoids for control. The solenoids provide the electro-pneumatic interface between the EC-60™ and the air brake system. The PMV is used to control the braking function on individual or dual service brake chambers during antilock activity. The PMVs are available in 12 volt or 24 volt models, with and without Push-to-Connect fittings.

PMVs are typically mounted on the frame or cross-member near the brake chamber it controls. It is also available as part of a Front Axle Module (FAM) assembly or Rear Axle Module (RAM) assembly. See Sections 3.3 Front Axle Module and 3.4 Rear Axle Module for details.

Bendix Commercial Vehicle Systems LLC
Elyria, OH 44036

PRODUCT SPECIFICATION BW-271-PR

The M-32QR™ includes an internal quick release (QR) function to optimize brake release timing. The M-32QR™ utilizes a shorter exhaust cover than the M-32™ (approximately 20 mm shorter), providing a visual means of identifying the two models. Samples are shown below.



M-32™

M-32QR™

Figure 5 M-32™ & M-32QR™ PMVs

The PMV consists of a die cast aluminum body and a solenoid assembly which contains one normally open solenoid (hold), one normally closed solenoid (release or exhaust), and an inlet and exhaust diaphragm valve.

PMV Port	Air Line Connection
Supply (1)	Supply from service brake valve, relay valve, or QRV
Delivery (2)	Delivery to brake chamber
Exhaust (3)	N/A

Table 1 PMV Port Connections

3.2.1 PMV Operation

The PMV operates in various states as described below. The state changes are determined by the EC-60™ and are performed in a rapid manner to prevent wheel lock-up during braking.

PMV Function	Release Solenoid	Hold Solenoid
ABS Inactive	0	0
ABS Release	1	1
ABS Hold	0	1
ABS Build	0	0

0 = De-Energized 1 = Energized

Table 2 PMV Operation

3.2.1.1 ABS Inactive

During normal, non-antilock braking both solenoids are de-energized. Brake application pressure enters the supply port of the PMV and flows out of the delivery port to the brake chamber.

3.2.1.2 Non-Antilock Exhaust Operation

Depending on the type of PMV, and the rate at which the vehicle operator releases the service brake, the PMV may exhaust air to achieve optimal brake release timing. This is accomplished by the mechanical design of the PMV without intervention of the EC-60™. Both solenoids are de-energized. See BW-273-PR for details.

3.2.1.3 ABS Release

When wheel lock is detected, the EC-60™ energizes the hold and release solenoids in the PMV. Energizing the hold solenoid prevents further delivery of air to the brake chamber, while energizing the release solenoid allows air to exhaust from the brake chamber through the exhaust port of the PMV.

3.2.1.4 ABS Hold

The EC-60™ will place the PMV into the hold position when it determines that the correct wheel speed (braking force) has been attained.

In this mode of operation, the PMV hold solenoid remains energized while the release solenoid is de-energized, preventing further exhaust of brake chamber air pressure. Because the hold solenoid remains energized, application air is prevented from flowing from the delivery port and out to the brake chamber. The PMV can enter both the exhaust or build mode from the hold mode, as commanded by the EC-60™ .

3.2.1.5 ABS Build

If the EC-60™ senses that wheel speed has increased sufficiently enough to allow re-application of braking pressure without further wheel lock-up, it de-energizes the hold solenoid. With both solenoids de-energized, the modulator re-applies air to the brake chamber in the same manner as in a non-antilock event.

3.2.2 PMV Connectors

The three pin, environmentally resistant electrical connector is an integral part of the solenoid assembly and serves to apply control signals from the EC-60™ to the PMV. The PMVs are available with the connectors shown in the table below. See BW-273-PR for details.

Connector	Part Number
DIN 72585 Twist-Lock[1]	AMP 1-967325-2
Packard 280 Series	12040977

[1]The Twist-Lock connector is available from various suppliers. The AMP part number is included for reference only.

AMP 1-967325-2

Packard 280 Series

3.2.3 M-32™/M-32QR™ Specifications

Parameter	12 Volt Models	24 Volt Models
Nominal Solenoid Resistance	5.2 Ω ± 0.3 Ω	15.1 Ω ± 1.1 Ω
Maximum Operating Pressure	150 PSI (10.3 bar)	150 PSI (10.3 bar)

See BW-273-PR for more details regarding the PMV.

3.3 Front Axle Module

PMVs may also be provided as part of a Front Axle Module (FAM) assembly. In this case, the supply ports of two PMVs are typically connected to the delivery ports of a Quick Release Valve (QRV). The delivery ports of the two PMVs would be connected to the steer axle brake chambers.

The supply port of the QRV would be connected to the secondary delivery port of the service brake valve. The QRV would assist in reducing the release timing of the steer axle brake chambers.

Some FAMs utilizing M-32QR™ PMVs may have a T-fitting in place of the QRV. In this case, the quick release feature provided by the QRV is contained inside the M-32QR™.

FAMs are available with a variety of QRVs. Contact BCVS for details.

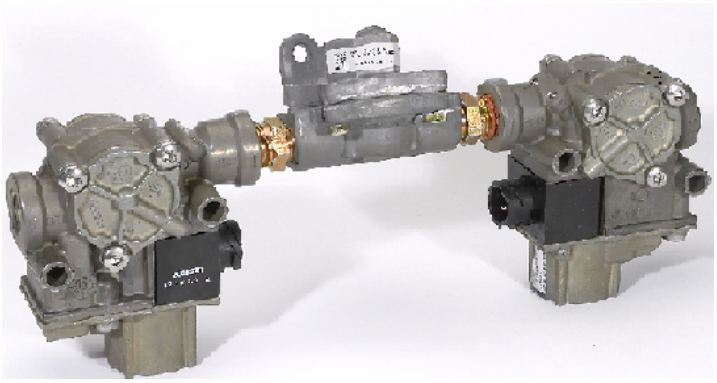


Figure 6 Front Axle Module (FAM) Assembly with QRV (Example)

3.4 Rear Axle Module

For drive and additional axles, the PMVs may be provided as part of a Rear Axle Module (RAM) assembly. In this case, the supply ports of two PMVs are connected to the delivery ports of the relay valve. The delivery ports of the two PMVs would be connected to the drive axle brake chambers.

RAMs are available with a variety of relay valves, with and without a TCV. Contact BCVS for details.

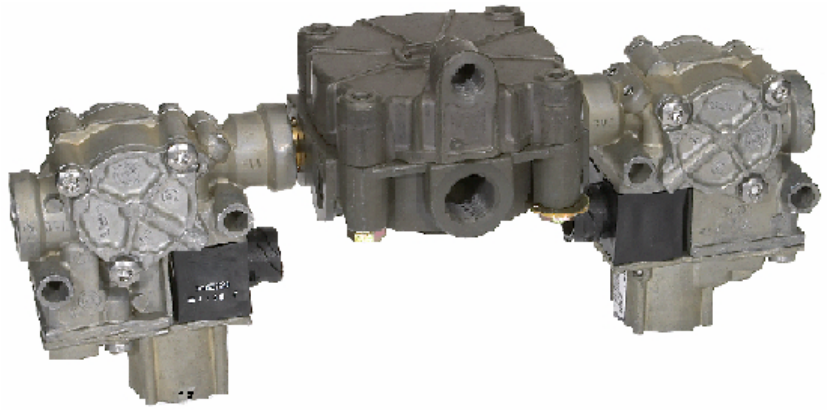


Figure 7 Rear Axle Module (RAM) Assembly without a TCV (Example)

3.5 Traction Control Valve

EC-60™ is designed to function with a variety of *Bendix*® Traction Control Valves (TCVs), which can be independent or built into a relay valve. An example of a *Bendix*® Antilock Traction Relay (ATR™) valve, with a built-in TCV is shown below. TCVs are available in both 12 volt and 24 volt models. Contact BCVS for details.

During an ATC brake control event, the EC-60™ will command the TCV to signal the relay valve to apply full system pressure to the rear PMVs. Simultaneously, the ECU will control the PMVs on the rear of the vehicle to apply air to the spinning wheel (s). The vehicle's differential will then drive the non-spinning wheel.

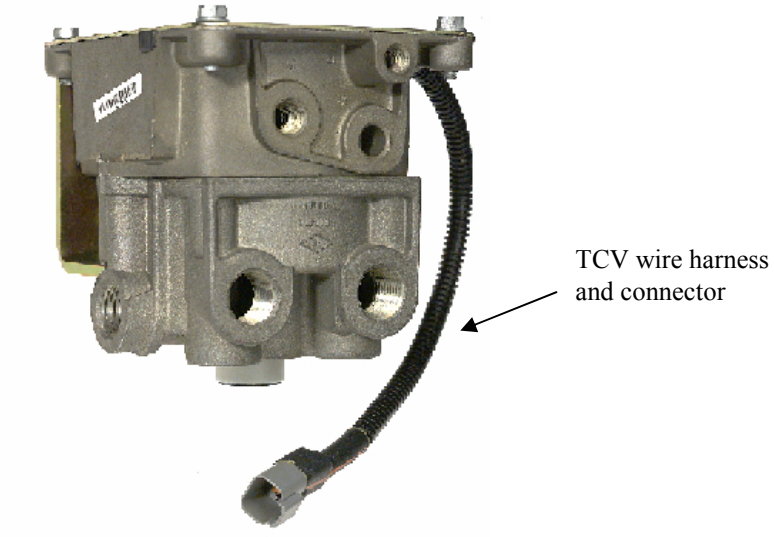


Figure 8 *Bendix*® ATR™ Valve

4.0 EC-60™ ELECTRONIC CONTROL UNIT (ECU)

4.1 General

The EC-60™ is available in various models as described in Section 4.3 EC-60™ Part Numbers and Supported Features.

EC-60™ pin assignments and connector information is contained in Section 4.5 EC-60™ Wire Harness Connector Part Numbers and Pin Assignments.

The EC-60™ may be configured to support a wide range of vehicle applications as described in Section 5.5.4 ABS Component Configurations.

The EC-60™ is protected against electrical transients, mechanical and environmental conditions as described in Section 6.0 EC-60™ Electrical Environmental Requirements and Section 7.0 EC-60™ Mechanical Environmental Requirements.

EC-60™ diagnostics is described in Section 8.0 EC-60™ Diagnostic Support.

EC-60™ installation requirements are described in Section 9.0 System Installation Requirements.

4.2 EC-60™ Operational Requirements

See Section 4.4.1 Battery and Ignition Inputs for additional input voltage requirements.

4.2.1 Operating Voltage Range (12 Volt Models)

Parameter	Value	Unit
Maximum Voltage	17.0	VDC
Minimum Voltage	9.0	VDC
Nominal Voltage	13.5	VDC
Initialization Voltage[1]	10.5	VDC

[1]When ignition power is applied to the ECU, it must detect an "Initialization Voltage" as described above. Once that condition is met, the ECU will function within the Minimum and Maximum Voltage Range.

4.2.2 Operating Voltage Range (24 Volt Models)

Parameter	Value	Unit
Maximum Voltage	33.5	VDC
Minimum Voltage	20.0	VDC
Nominal Voltage	27.5	VDC
Initialization Voltage	21.5	VDC

4.2.3 Operating Temperature Range

Parameter	Value	Unit
Maximum Temperature	+85	°C
Minimum Temperature	-40	°C

4.3 EC-60™ Part Numbers and Supported Features

EC-60™ ABS ECUs are available in various models and mounting configurations. Other ECU configurations and special functions may be available. Contact BCVS for assistance.

4.3.1 Standard Cab Mount ECUs

Part Number	Model	Mount.	Input Volt.	ATC/ Drag Torque	WSS	PMV	J1587	J1939	PLC	Blink Codes	ABS ORS	RET Relay
5012225	Standard	Cab	12		4	4	X	X		X		X
5012226	Standard	Cab	12		4	4	X	X	X	X		X
5013392[1]	Standard	Cab	12		4	4	X	X	X	X		
5016355[2]	Standard	Cab	12		4	4	X	X		X		

X = Supported

[1]5013392 supports the ABS dash indicator and the in-cab trailer ABS dash indicator via serial communications only (J1939 or J1587). Retarder disable operation is available via J1939 only.

[2]5016355 supports the ABS dash indicator via serial communications only (J1939 or J1587). Retarder disable operation is available via J1939 only.

Table 3 Standard Cab Mount ECU Supported Features

4.3.2 Standard Frame Mount ECUs

Part Number	Model	Mount.	Input Volt.	ATC/ Drag Torque	WSS	PMV	J1587	J1939	PLC	Blink Codes	ABS ORS	RET Relay
5012227	Standard	Frame	12		4	4	X	X		X		X
5012228	Standard	Frame	12		4	4	X	X	X	X		X

X = Supported

Table 4 Standard Frame Mount ECU Supported Features

NOTE

5012225, 5012226, 5012227 and 5012228 support retarder disable using a relay, but are not configured for it when delivered. ECU reconfiguration is required to support installations using a retarder disable relay. See Section 5.5.1 Reconfiguring the Standard ECU for details.

4.3.3 Premium Cab Mount ECUs

Part Number	Model	Mount.	Input Volt.	ATC/ Drag Torque	WSS	PMV	J1587	J1939	PLC	Blink Codes	ABS ORS	RET Relay
5012229	Premium	Cab	12	X	6	6	X	X	X	X	X	X
5013569[3]	Premium	Cab	12	X	6	6	X	X	X	X	X	X
5012251	Premium	Cab	24V	X	6	6	X	X		X	X	X

X = Supported
[3]5013569 is configured for 6 sensor/6 modulator ATC installations on 6x2 vehicles with a tag axle.

ECU reconfiguration is required to support installations using a retarder relay disable.

NOTE
5012229 and 5012251 support up to 6S/6M configurations, but are delivered configured for 4S/4M ATC operation. ECU reconfiguration is required to support installations utilizing 6 sensors, 5 or 6 modulators, or retarder relay disable. See Section 5.5.2 Reconfiguring the Premium ECU for details.

Table 5 Premium Cab Mount ECU Supported Features

4.3.4 Premium Frame Mount ECUs

Part Number	Model	Mount.	Input Volt.	ATC/ Drag Torque	WSS	PMV	J1587	J1939	PLC	Blink Codes	ABS ORS	RET Relay
5012230	Premium	Frame	12	X	6	6	X	X	X	X	X	X
5013570[4]	Premium	Frame	12	X	6	6	X	X	X	X	X	X

X = Supported
[4]5013570 is configured for 6 sensor/6 modulator ATC installations on 6x2 vehicles with a tag axle.

ECU reconfiguration is required to support installations using a retarder relay disable.

NOTE
5012230 supports up to 6S/6M configurations, but is delivered configured for 4S/4M ATC operation. ECU reconfiguration is required to support installations utilizing 6 sensors, 5 or 6 modulators, or retarder relay disable. See Section 5.5.2 Reconfiguring the Premium ECU for details.

Table 6 Premium Frame Mount ECU Supported Features

4.4 ECU Internal Circuit Description

4.4.1 Battery and Ignition Inputs

The ECU operates at a nominal supply voltage of 12 or 24 volts, depending on the model of the ECU. The battery input is connected through a 30 amp fuse directly to the battery. The ignition input is applied by the ignition switch circuit through a 5 amp fuse.

Specification & Condition		ECU Type						Units
		12 Volt			24 Volt			
		Min.	Typ.	Max.	Min.	Typ.	Max.	
Input Voltage (IGN & BATT)	Normal Operating Range	9	13.5	17	20	27.5	33.5	VDC
	During ABS	8		17	17		33.5	VDC
	Initialization Voltage	10.5			21.5			VDC
	Return From Low Voltage	11			22			VDC
	Return From High Voltage			16			29	VDC
Reverse Input Voltage				-24			-36	VDC
Jump Start				27			40	VDC
Ignition Input			≤ 0.5			≤ 0.5		A
Battery Input	Ignition Off			<1			<1	mA
	Operating		6	30		6	20	A

Table 7 Input Voltage Specifications

4.4.1.1 Normal Operating Range

The ECU will detect voltage DTCs when the input voltage is outside of the range shown above.

4.4.1.2 Input Voltage (During ABS)

During ABS events, the ECU will detect a low voltage DTC when the input voltage drops below the minimum voltage shown in the "During ABS" section in Table 7.

4.4.1.3 Initialization Voltage

When ignition power is applied to the ECU, it must detect an "Initialization Voltage" as described above. Once that condition is met, the ECU will function in accordance with the "Normal Operating Range".

4.4.1.4 Return From Low Voltage

The input voltage that the ECU must detect to clear a low voltage DTC and resume normal operation.

4.4.1.5 Return From High Voltage

The input voltage that the ECU must detect to clear a high voltage DTC and resume normal operation.

4.4.2 Ground Input

The EC-60™ supports one ground input. The wire must be sized properly to support the operating current requirements of the EC-60™. See the appropriate BCVS system wiring drawing (Section 1.2.2) for requirements.

4.4.3 ABS Dash Indicator Ground Input (Cab ECUs Only)

EC-60™ cab ECUs require a second ground input (X1-12) for the ABS dash indicator. The wire harness connector contains an ABS dash indicator interlock (X1-15), which shorts the ABS dash indicator circuit (X1-18) to ground if the connector is removed from the ECU. The ABS dash indicator ground input must be separate from the ECU ground input (X1-1).

WARNING

The ABS dash indicator ground input does not support the operating current requirements of the EC-60™. See Section 4.4.2 Ground Input for details.

4.4.4 Microprocessor Circuitry

The ECU contains microprocessor circuitry that calculates the vehicle speed from the signals received from the WS-24™ wheel speed sensors. The ABS/ATC algorithm is then applied to generate the control signals for the PMVs and other components.

The microprocessor circuitry also determines the status of the antilock/traction system for diagnostic purposes.

4.4.5 Speed Sensor Circuits

The ECU speed sensor input circuits are designed to interface with four or six WS-24™ variable reluctance sensors. These circuits also contain means for the microprocessor circuitry to evaluate sensor performance.

4.4.6 PMV Solenoid Drivers

Standard model ECUs contain four sets of high-side solenoid drivers for activating M-32™/M-32QR™ PMVs.

Premium model ECUs contain six sets of high-side solenoid drivers for activating M-32™/M-32QR™ PMVs.

4.4.7 Traction Control Valve Driver

Premium ECUs contain a high-side driver for activating a *Bendix*® traction control valve.

Specification	ECU Type						Units
	12Volt			24Volt			
	Min.	Typ.	Max.	Min.	Typ.	Max.	
Load Resistance	3.8		30	11		60	Ohm

4.4.8 Interaxle Differential Lock Control (AWD Transfer Case)

Premium ECUs contain a high-side driver for controlling the interaxle differential lock (AWD transfer case). This is required on AWD vehicles. See Section 5.1.7 All-Wheel Drive (AWD) Vehicles for details.

Specification	ECU Type						Units
	12Volt			24Volt			
	Min.	Typ.	Max.	Min.	Typ.	Max.	
Load Resistance	3.8		30	11		60	Ohm

4.4.9 Ground FETs

Electronic switches in the form of field-effect transistors (FETs) are used to provide the common connection (CMN) for the PMV solenoids, TCV, and Interaxle Differential Lock solenoid (AWD transfer case).

Under certain DTC conditions, the FETs interrupt the solenoid valve common connections. See Section 8.5 System Operation Under DTC Conditions for details.

4.4.10 ABS Dash Indicator Control with Optional Blink Code Switch (Cab ECUs)

Most cab mount ECUs have an ABS dash indicator output (X1-18) that uses a low-side driver to illuminate the ABS dash indicator. The ABS indicator provides an indication of system status and is used to display blink codes for diagnostic purposes. It is activated during power-up and turns off after the self test is completed providing no DTCs are present.

The output is self-conductive to insure that the ABS dash indicator will be illuminated if power is not applied to the ECU or if one ground wire is open. If the ECU is unplugged, the ABS dash indicator interlock (X1-15) shorts the ABS dash indicator ground (X1-12) to the ABS dash indicator output and illuminates the indicator.

The ABS dash indicator output also provides blink code diagnostics after the external diagnostic switch is activated. In this case, a momentary switch that grounds the ABS dash indicator output is used to place the ECU into the diagnostic blink code mode. See Section 8.0 EC-60™ Diagnostic Support for details.

The ABS dash indicator will flash continuously when the ECU is placed into the ABS off-road mode. See Section 5.1.5 Optional ABS Off-Road for details.

This output/input has an internal pull-up resistor to ignition. Therefore, the ECU cannot detect a disconnection of the wire or defect of the indicator.

Certain models of the EC-60™ will only support ABS dash indicator control over J1939. See Section 4.3 EC-60™ Part Numbers and Supported Features for details.

Specification	ECU Type						Units
	12Volt			24Volt			
	Min.	Typ.	Max.	Min.	Typ.	Max.	
Load (Bulb or LED[1])			4			4	W
Output Current			500			500	mA
Pull-Up Resistance[2]		6.81			12.1		kOhm

[1]Use of an LED indicator requires the addition of a 1 kOhm resistor in parallel to the LED to eliminate low-level illumination. The LED must also use an appropriate protective series resistor.
[2]To IGN

Table 8 Cab ECU ABS Dash Indicator Circuit Specifications

4.4.11 ABS Dash Indicator Control with Optional Blink Code Switch (Frame ECUs)
Frame mount ECUs have an ABS dash indicator output (X1-12) that is typically connected to one side of a relay coil, with the other side of the coil connected to 12 VDC. Using a low-side driver, the ECU is designed to sink this output to ground to energize the relay and extinguish the ABS dash indicator.

The ABS indicator provides an indication of system status and is used to display blink codes for diagnostic purposes. It is activated during power-up and turns off after the self test is completed providing no DTCs are present.

The relay is used to insure that the ABS dash indicator will be illuminated if power is not applied to the ECU or if the ECU is unplugged.

The ABS dash indicator output also provides blink code diagnostics after the external diagnostic switch is activated. In this case, a momentary switch that grounds the ABS dash indicator output is used to place the ECU into the diagnostic blink code mode. See Section 8.0 EC-60™ Diagnostic Support for details.

The ABS dash indicator will flash continuously when the ECU is placed into the ABS off-road mode. See Section 5.1.5 Optional ABS Off-Road for details.

This output/input has an internal pull-up resistor to ignition. Therefore, the ECU cannot detect a disconnection of the wire or defect of the indicator.

Specification	ECU Type 12Volt			Units
	Min.	Typ.	Max.	
Load (Relay)			4	W
Load Resistance[1]	35		200	Ohm
Output Current			500	mA
Pull-Up Resistance[1]		6.81		kOhm

[1]To IGN

Table 9 Frame ECU ABS Dash Indicator Circuit Specifications

4.4.12 Dash Indicator Control Using Serial Communications Links

All dash indicators (ABS, ATC, and trailer ABS) may also be controlled using serial communications links. In this case, the EC-60™ will broadcast a serial communications message over the J1939 or J1587 links indicating the status of the indicators. Another vehicle module would interpret the message and control the dash indicator(s) directly.

WARNING

When using serial communications links to control dash indicators, the vehicle module must detect DTCs involving the dash indicators, and provide power-up indicator checks as required by FMVSS 121.

The vehicle module must illuminate all dash indicators if the required serial communications messages are not received from the EC-60™ in an appropriate amount of time. Contact BCVS for assistance.

4.4.13 Trailer ABS Dash Indicator Control

Certain models of the EC-60™ contain a trailer ABS dash indicator output that utilizes a low-side driver to illuminate the trailer ABS dash indicator. See Section 4.3 EC-60™ Part Numbers and Supported Features for details.

This output has an internal pull-up resistor to ignition. Therefore, the ECU cannot detect a disconnection of the wire or defect of the indicator.

If the trailer ABS dash indicator information is transmitted via Power Line Carrier Communications (PLC), the tractor ABS PLC ECU must control the trailer ABS dash indicator that is mounted in the cab.

Certain models of the EC-60™ will only support Trailer ABS dash indicator control over J1939. See Section 4.3 EC-60™ Part Numbers and Supported Features for details.

Specification	ECU Type			Units
	12Volt			
	Min.	Typ.	Max.	
Load (Bulb or LED[1])			4	W
Load Resistance[2]	35		200	Ohm
Output Current			500	mA
Pull-Up Resistance[2]		6.81		kOhm

[1]Use of an LED indicator requires the addition of a 1kOhm resistor in parallel to the LED to eliminate low-level illumination. The LED must also use an appropriate protective series resistor.
[2]To IGN

Table 10 Trailer ABS Dash Indicator Circuit Specifications

4.4.14 Retarder Disable Relay Driver

The retarder disable output is a low-side drive output that is capable of driving a retarder disable relay. The ECU will utilize this output only when configured to do so. See sections 5.5.1 Reconfiguring the Standard ECU and 5.5.2 Reconfiguring the Premium ECU for details.

This output is not available on all ECUs. See section 4.3 EC-60™ Part Numbers and Supported Features for details.

When an ABS event occurs on a drive wheel, the ECU will sink this output to ground to energize the retarder disable relay and inhibit the use of the retarder.

Specification	ECU Type						Units
	12Volt			24Volt			
	Min.	Typ.	Max.	Min.	Typ.	Max.	
Load Resistance[1]	35		200	65		600	Ohm
Output Current			500			500	mA
Pull-up Resistance[2]		-			-		

[1]To IGN
[2]No pull-up resistor is provided

Table 11 Retarder Relay Disable Circuit Specifications

4.4.15 SAE J1708/J1587 Serial Communications

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

See BW-287-D, BW-288-D, and BW-289-D for details regarding J1587 support.

4.4.16 SAE J1939 Serial Communications

A CAN data link is provided for communication according to SAE J1939 recommended practice. This link is used for various functions, such as:

- Disable retarding devices during ABS operation
- Broadcast information such as wheel speed and ECU status information

EC-60™ Premium models utilize the J1939 data link for ATC engine control and Drag Torque Control functions.

See BW-286-D for details.

4.4.17 SAE J2497 Power Line Carrier (PLC) Communications Circuit

Certain models of the EC-60™ contain PLC communications circuitry to support the in-cab trailer ABS dash indicator (see Section 4.4.13 Trailer ABS Dash Indicator Control for details). The EC-60 PLC models operate in accordance with SAE J2497.

The vehicle OEM must insure that the Power Line Carrier (PLC) signal is present at the ignition input terminal of the ECU and meets the requirements of SAE J2497.

CAUTION

Connection of any device to the vehicle power lines along with the impedance of the wiring harness may result in loading and / or distortion of the PLC signal.

Vehicle OEMs and those involved in vehicle modification must confirm proper operation of the in-cab trailer ABS dash indicator.

See Section 4.3 EC-60™ Part Numbers and Supported Features for EC-60™s that support PLC.

4.4.18 ABS Off-Road Switch Input

WARNING
The ABS Off-Road mode should not be used on normal, paved road surfaces because vehicle stability and steerability may be adversely affected. The flashing ABS dash indicator communicates the status of this off-road mode to the driver.

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

EC-60™ Premium models have a switch input to place the ECU into the ABS off-road mode. It is intended for a low-side momentary switch and has an internal pull-up resistor.

The EC-60™ may also be placed into the ABS off-road mode using a J1939 message. See BW-286-D details.

When the ECU is placed in the ABS off-road mode, the ABS dash indicator will flash constantly to notify the vehicle operator that the off-road mode is active.

See Section 5.1.5 Optional ABS Off-Road Mode for details.

Specification	ECU Type						Units
	12Volt			24Volt			
	Min.	Typ.	Max.	Min.	Typ.	Max.	
Pull-Up Resistance[1]		21.5			20.0		kOhm
Input Low Voltage			2.0			2.5	VDC
Input High Voltage	6.0			10.0			VDC

[1]To IGN

Table 12 ABS Off-Road Mode Switch Circuit Specifications

4.4.19 ATC Indicator Output/ATC Off-Road Switch Input
EC-60™ Premium models have an output that utilizes a low-side driver to control the ATC dash indicator. This pin is shared with the ATC Off-Road Switch.

- ATC Indicator Operation
  The ATC indicator is activated during power-up and turns off after the self test is completed providing no DTCs are present. It will be illuminated when ATC is disabled for any reason. The indicator will flash at a rate of 100 msec on, 300 msec off when an ATC event is underway.

When the ECU is placed in the ATC off-road mode, the ATC dash indicator will flash at a rate of 1.0 seconds on, 1.5 seconds off to notify the vehicle operator that the off-road mode is active.

- ATC Off-Road Switch Operation
  This switch input is typically used to place the ECU into the ATC off-road mode, which increases the target slip for both brake and engine control ATC. See Section 5.2.5 Optional ATC Off-Road Mode for details. It is intended for a low-side momentary switch and has an internal pull-up resistor.

  The EC-60™ may also be placed into the ATC off-road mode using a J1939 message. See BW-286-D details.

This output/input has an internal pull-up resistor to ignition. Therefore, the ECU cannot detect a disconnection of the wire or defect of the indicator.

Specification	ECU Type						Units
	12Volt			24Volt			
	Min.	Typ.	Max.	Min.	Typ.	Max.	
Load (Bulb or LED[1])			4			4	W
Load Resistance[2]	35		200	65		200	Ohm
Output Current			500			500	mA
Pull-Up Resistance[2]		6.81			12.1		kOhm
Input Low Voltage			2.0			2.0	VDC
Input High Voltage	6.0			6.0			VDC

[1]Use of an LED indicator requires the addition of a 1kOhm resistor in parallel to the LED to eliminate low-level illumination. The LED must also use an appropriate protective series resistor.
[2]To IGN

Table 13 ATC Indicator/ATC Off-Road Switch Circuit Specifications

4.4.20 Stop Lamp Switch Input

This input detects the state of the vehicle stop lamp switch (12 volts with brakes applied, open circuit or ground through the stop lamp with brakes released).

Certain features (ATC and AWD vehicles) require stop lamp switch input information. This may be provided via the ECU input or J1939 communications. See BW-286-D for details.

Specification	ECU Type						Units
	12Volt			24Volt			
	Min.	Typ.	Max.	Min.	Typ.	Max.	
Pull-Up Resistance[1]		-			-		kOhm
Input Low Voltage			2.0			2.0	VDC
Input High Voltage	6.0			6.0			VDC

[1]No pull-up resistor is provided

Table 14 Stop Lamp Switch Circuit Specification

4.4.21 Input / Output Circuit 2 & 3 (Premium ECUs Only)

Premium ECUs have two Input / Output circuits available for control of special auxiliary functions that can be activated utilizing the Bendix patent-pending Auxilary Design Language (ADL).

Utilizing the ADL feature, these circuits may be configured as a high-side driver output or a digital input.

See Section 5.6 Auxiliary Design Language (ADL) for additional details.

Specification	ECU Type			Units
	12Volt			
	Min.	Typ.	Max.	
Load			77	W
Load Resistance	3.8	5	30	Ohm
Output Current	0.3	2.7	4.7	A
Pull-Up Resistance		47		kOhm
Input Low Voltage	-0.4	0.0	1.6	VDC
Input High Voltage	3.4	13.5	17.0	VDC

Table 15 Input / Output Circuits 2 & 3 Specification

4.4.22 Input / Output Circuit 4 (Premium Frame ECUs Only)

Premium frame ECUs have an additional Input / Output circuit available for control of special auxiliary functions that can be activated utilizing the Bendix patent-pending Auxilary Design Language (ADL).

Utilizing the ADL feature, this circuit may be configured as a low-side driver output or a digital input.

See Section 5.6 Auxiliary Design Language (ADL) for additional details.

Specification	ECU Type			Units
	12Volt			
	Min.	Typ.	Max.	
Load			4	W
Load Resistance	35	100	200	Ohm
Output Current	0.04	0.14	0.5	A
Pull-Up Resistance		6.81		kOhm
Input Low Voltage	-0.4	0.0	2.0	VDC
Input High Voltage	6.0	13.5	17.0	

Table 16 Input / Output Circuit 4 Specification

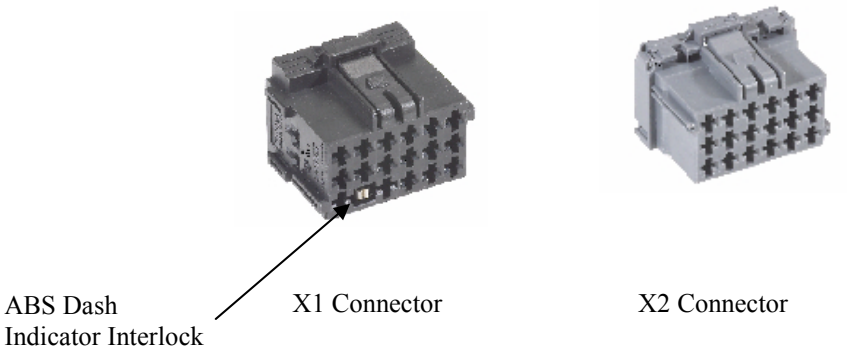
4.5 EC-60™ Wire Harness Connector Part Numbers and Pin Assignments

4.5.1 Standard Cab Model

EC-60™ 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

Table 17 Standard Cab ECU Wire Harness Connectors



4.5.1.1 Standard Cab X1 Connector Pin Assignments

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

4.5.1.2 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 (-)

4.5.1.3 Standard Cab ECU Wiring Schematic
See Bendix drawing 5012522 for details.

4.5.2 Premium Cab Model
EC-60™ 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

Table 18 Premium Cab ECU Wire Harness Connectors

ABS Dash Indicator Interlock

X1 Connector

X2 Connector

X3 Connector

4.5.2.1 Premium Cab X1 Connector Pin Assignments

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

4.5.2.2 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 (-)

4.5.2.3 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 (-)

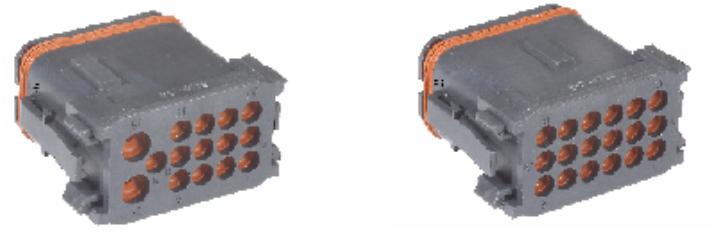
[1]AWD vehicles only. (AWD Transfer Case)

4.5.2.4 Premium Cab ECU Wiring Schematic
See Bendix drawing 5012523 for details.

4.5.3 Standard Frame Model
EC-60™ 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

Table 19 Standard Frame ECU Wire Harness Connectors



X1 Connector X2 Connector

4.5.3.1 Standard Frame X1 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	J1587 (B)	6	J1939 High	11	Trailer ABS Dash Indicator
2	J1939 Low	7	WSS SA Left (-)	12	ABS Dash Indicator
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

4.5.3.2 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

4.5.3.3 Standard Frame ECU Wiring Schematic
See Bendix drawing 5012521 for details.

4.5.4 Premium Frame Model
EC-60™ premium frame models utilize three Deutsch enactors 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

Table 20 Premium Frame ECU Wire Harness Connectors

X1 Connector

X2 Connector

X3 Connector

4.5.4.1 Premium Frame X1 Connector Pin Assignments

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

Bendix Commercial Vehicle Systems LLC
Elyria, OH 44036

PRODUCT SPECIFICATION BW-271-PR

4.5.4.2 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	Stop Lamp Switch	11	PMV DA Left HLD	17	PMV DA Right HLD
6	ABS ORS	12	PMV DA Left REL	18	PMV DA Right REL

4.5.4.3 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)

4.5.4.4 Premium Frame ECU Wiring Schematic
See Bendix drawing 5012435 for details.

4.6 ECU Enclosures

4.6.1 Standard Cab ECU Enclosure

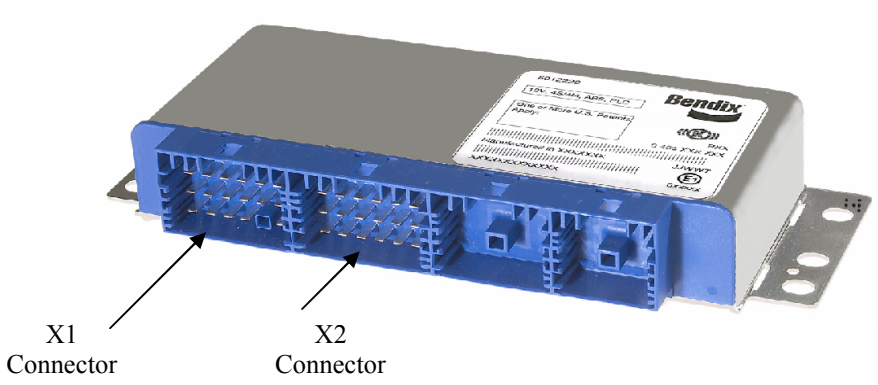


Figure 9 Standard Cab ECU

4.6.2 Premium Cab ECU Enclosure

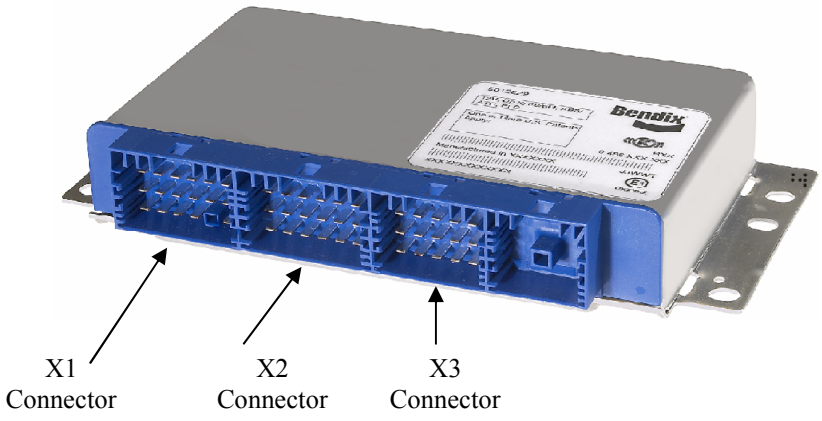


Figure 10 Premium Cab ECU

4.6.3 Standard Frame ECU Enclosure

Figure 11 Standard Frame ECU (Connector Cover Installed)

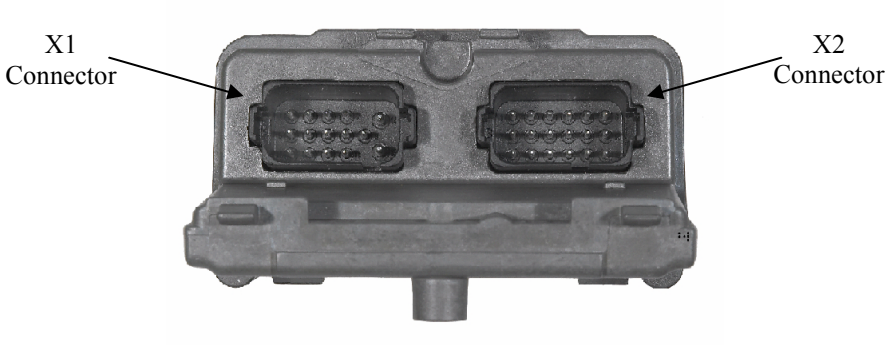


Figure 12 Standard Frame ECU (Connector Cover Removed)

4.6.4 Premium Frame ECU Enclosure

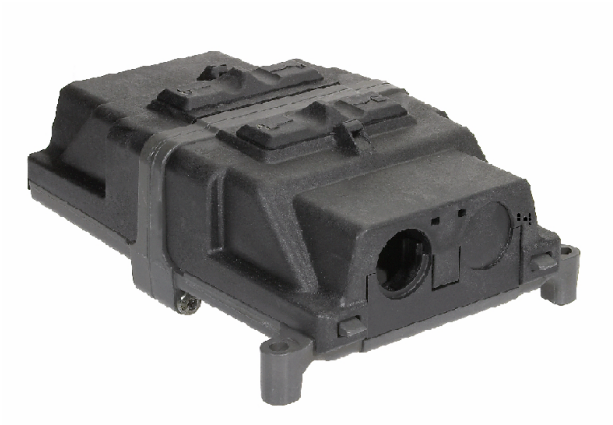


Figure 13 Premium Frame ECU (X3 End) with Connector Cover Installed

Figure 14 Premium Frame ECU (X3 End) with Connector Cover Removed

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PRODUCT SPECIFICATION BW-271-PR

4.6.5 Frame ECU Connector Covers

Frame ECUs are provided with covers that must be removed to permit connection of the vehicle wiring harness.

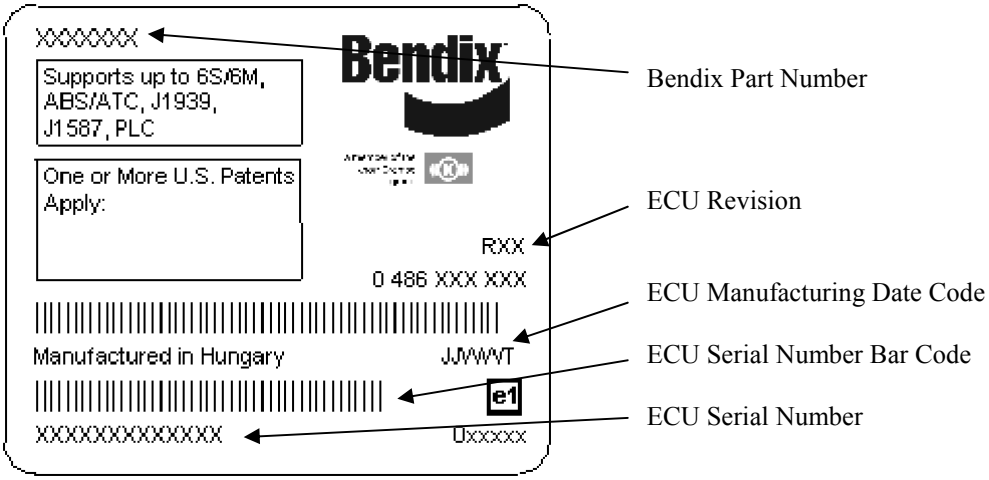
The covers provide strain relief and connector protection of the vehicle wire harness and will accept round convoluted conduit with an I.D. of 19 mm. The cover can be removed by sliding the slide lock mechanism to the unlock position.

It is recommended that the cover also be secured in place with a small cable tie.

WARNING
Frame ECUs should not be installed on a vehicle without the connector covers properly locked in place.

4.6.6 ECU Label

All EC-60™s are provided with a label (see example below). Other customer-specific labels may also be installed.



The ECU Manufacturing Date Code consists of five numbers containing the year, week, and day that the ECU was manufactured. The first two digits indicate the year of manufacture, the second two digits the calendar week of manufacture, and the last digit indicates the day of manufacture.

Example: Manufacturing Date Code of 05363:

Year of Manufacture = 2005 → 05363 ← Day of Manufacture = Day 3

↑

Calendar Week of Manufacture = Week 36

5.0 EC-60™ SYSTEM OPERATION & FEATURES

This section will describe details of system operation, features, and control modes.

5.1 ABS Control Modes

There are several ABS control modes that can be utilized for monitoring and controlling the individual wheels of the vehicle.

5.1.1 Individual Control (IC)

Each individually controlled wheel has its own wheel speed sensor and pressure modulator valve. The optimum brake pressure is applied to each individually controlled wheel. While individual control at all wheel ends results in the shortest stopping distances, this control method may effect the vehicle yaw and steering moments. For these reasons, individual control is typically used only on the rear axle(s).

5.1.2 Modified Individual Regulation (MIR)

In this form of control, both wheels of an axle have their own wheel speed sensor and pressure modulator valve. However, both wheels are controlled based on the wheel on the low coefficient surface, minimizing yaw and steering moments.

This type of control is typically used on steer axles.

As the vehicle speed decreases, MIR will switch to individual control when the vehicle reaches 12 MPH, thus improving low-speed deceleration rates while not impacting steerability.

5.1.3 Select Low (SL)

With this form of control, two wheels each have their own wheel speed sensor but they share one pressure modulator valve. The pressure applied to both wheels is identical and is determined by whichever wheel is showing a tendency to lock. While under certain circumstances stopping distance may be impacted, yaw and steering moments are minimized with this control method. On uniform surfaces, there is no appreciable difference in stopping distances compared to individual control.

5.1.4 Indirect

Non-sensed wheels (a wheel without a wheel speed sensor) are normally indirect controlled. This is typically utilized on tandem axles with one PMV controlling the brake chambers on the same side of the vehicle, with only one of the wheels having a wheel speed sensor installed.

With this type of control, it is not always possible to prevent the non-sensed wheel from locking.

5.1.5 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.

EC-60™ Premium ECUs have an optional control mode that takes advantage of 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 adversely affected. The flashing ABS dash indicator communicates the status of this mode to the driver.

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

The vehicle operator can activate the Off-Road function with a switch on the dash panel that momentarily connects the ABS ORS pin to ground. A flashing ABS dash indicator indicates to the driver that the ABS Off-Road function is engaged.

The ECU will exit the ABS Off-Road Mode when power is removed.

The EC-60™ may also be placed in the ABS Off-Road Mode using a J1939 message. See BW-286-D for details.

Off-Road ABS function is dependent on vehicle speed.

Vehicle Speed	ABS Control
> 25 MPH	Normal ABS Control
9 – 25 MPH	Deep Cycle Mode with Selective Wheel Lock
< 9 MPH	Locking Wheel Mode

Table 21 Optional ABS Off-Road Function

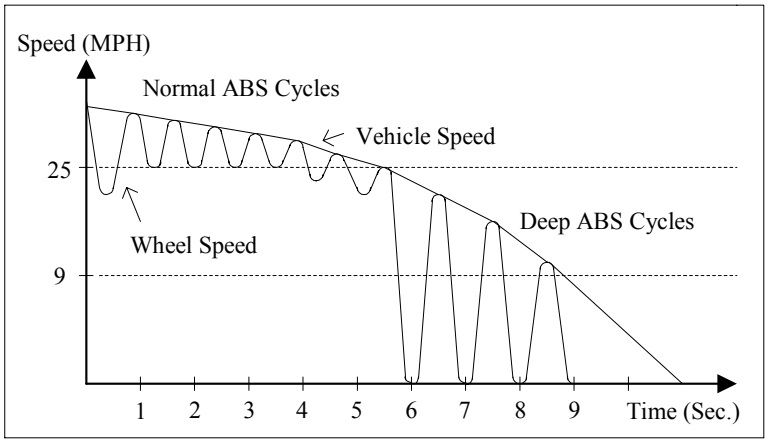


Figure 15 Optional ABS Off-Road Function

5.1.6 Retarder Brake System Control

On low-coefficient surfaces, application of the retarder can lead to high levels of brake slip at the driven wheels, which can adversely affect vehicle stability.

To avoid this, the EC-60™ switches off the retarder as soon as a lock-up is detected at one (or more) of the drive wheels. This may be accomplished using J1939 communications as described in BW-289-D, or utilizing the EC-60™ Retarder Disable output, described in Section 4.4.14 Retarder Disable Relay Driver.

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.

5.1.7 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.

Premium ECUs can be programmed specifically for this configuration to control the differential lock/unlock solenoid (AWD transfer case). Stop lamp switch information is required, and may be provided to the ECU using the SLS input or J1939. See Section 4.4.20 Stop Lamp Switch Input for details.

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 concluded.

See Section 5.5.8 Interaxle Differential Lock (AWD Transfer Case) Control Configuration for details.

5.2 Automatic Traction Control

5.2.1 ATC Functional Overview

The goal of ATC is to avoid spinning the drive wheels in order to increase traction during acceleration and to gain vehicle lateral stability while driving through curves.

ATC is integrated in the ABS system on selected models and utilizes common ABS components (such as sensors and PMVs).

ATC consists of two independent working control loops:

- Brake Control (BC)
- Engine Control (EC)

WARNING
ATC must be disabled prior to conducting any dynamometer testing.

5.2.2 ATC Application Notes

5.2.2.1 ATC Availability

ATC is available only on EC-60™ Premium Models.

5.2.2.2 Stop Lamp Switch Input

The ECU must receive information regarding the stop lamp switch position for ATC to function. This can be provided using the SLS input or J1939. See Section 4.4.20 Stop Lamp Switch Input for details.

5.2.2.3 ATC Operation at Power-Up

When power is applied to the ECU, ATC may be disabled until the driver applies and releases the service brake. In this case, the ATC indicator will be illuminated and the ECU will generate a "Stop Lamp Switch Not Detected" diagnostic message until the ECU detects the application of the service brake.

5.2.2.4 ATC Operation with the Service Brake Applied

The ECU will not perform ATC when the stop lamp switch indicates that the service brakes are applied.

5.2.2.5 ATC Status with the Vehicle Parked

ATC will be disabled if the ECU receives an indication (over J1939) that the vehicle is parked. See BW-286-D for details.

5.2.2.6 ATC on AWD Vehicles

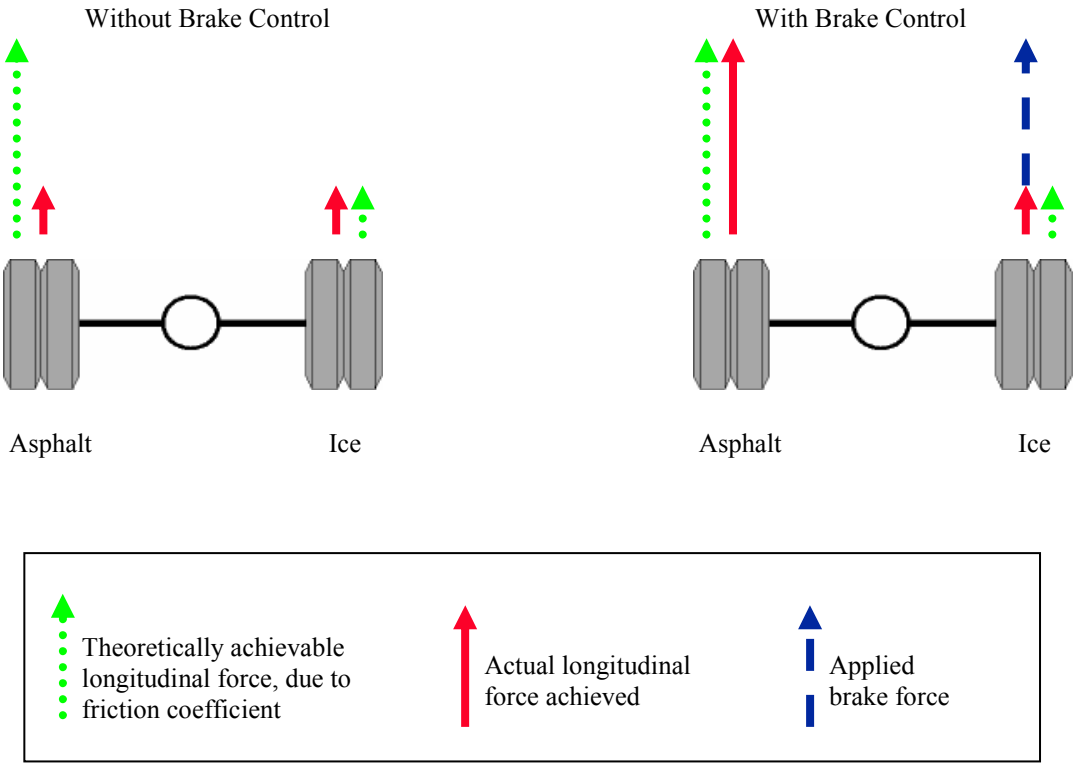
> **WARNING**
> The use of ATC on AWD vehicles is not permitted, unless an interlock is added to the vehicle that disables ATC during the AWD mode. This interlock must insure that ATC is activated only if the AWD vehicle is in a 4x2 or 6x4 mode (only rear axles driven).
>
> Do not use ATC on AWD vehicles without an interlock as described above.

5.2.3 Brake Control (BC)

Brake Control is automatically activated when drive wheel(s) on one side of the vehicle are spinning, which typically occurs on a split-coefficient surface (such as asphalt and ice). The traction system will then lightly apply the brake to the spinning drive wheel(s). The vehicle differential will then drive the wheels on the other side of the vehicle.

Brake Control is available at vehicle speeds up to 25 MPH.

The figure below shows the traction enhancement typical for driving on a split coefficient surface.



5.2.3.1 Disabling ATC Brake Control

ATC brake control will be disabled under the following conditions:

- In response to a serial communications request from an off-board tool.
- At power-up until the ECU detects a service brake application.
- If the ECU receives a J1939 message indicating that the vehicle is parked.
- If the dynamometer test mode is active. This may be accomplished via an off-board tool or the diagnostic blink code switch. See Section 5.4 Dynamometer Test Mode for details.
- To avoid overheating of the brakes when brake control is active. Figure 16 ATC Brake Fade Timing shows an example with the default parameter setting.
- When certain DTC conditions are detected. See Section 8.5 System Operation Under DTC Conditions for details.

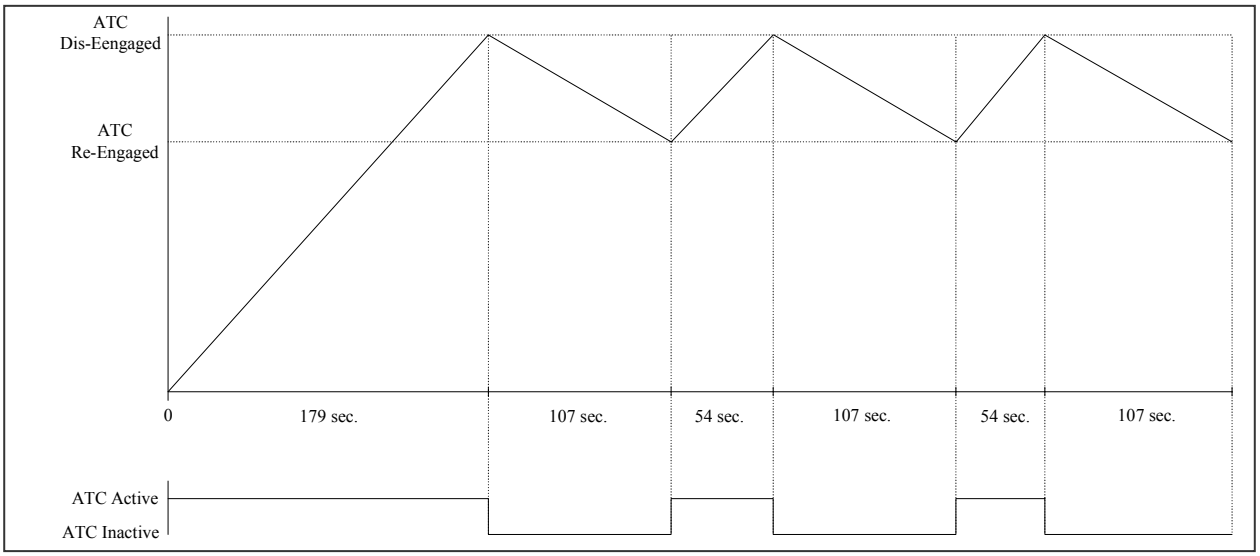


Figure 16 ATC Brake Fade Timing

5.2.4 Engine Control (EC) with *Smart ATC*™ Traction Control
Engine Control is automatically activated to control the wheel slip of the driven axle(s). This is accomplished by sending a J1939 torque limitation request to the engine ECU.

Engine Control must follow SAE J1939 protocol. BCVS approval is required for all new applications.

Engine Control is available at all vehicle speeds.

5.2.4.1 *Bendix*® *Smart ATC*™ Traction Control
EC-60™ has an additional feature known as *Smart ATC*™ traction control. It provides optimum traction and vehicle stability. This is achieved by adapting the target slip of the drive wheels to the driving situation.

The *Smart ATC*™ function monitors the accelerator pedal position (via J1939) and allows higher wheel slip when the accelerator pedal is applied above a pre-set level. This serves to match the ATC performance with the driver's intention.

The target slip will be decreased when driving through a curve for maximum stability.

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

- In response to a serial communications request from an off-board tool.
- At power-up until the ECU detects a service brake application.
- If the ECU receives a J1939 message indicating that the vehicle is parked.
- If the dynamometer test mode is active. This may be accomplished via an off-board tool or the diagnostic blink code switch. See Section 5.4 Dynamometer Test Mode for details.
- When certain DTC conditions are detected. See Section 8.5 System Operation Under DTC Conditions for details.

5.2.5 Optional ATC Off-Road Mode
In some road conditions, the vehicle operator may desire additional drive wheel slip when ATC is active. The EC-60™ Premium ECU 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 momentarily connecting the ATC Indicator Output/ATC Off-Road Switch Input pin to ground. A flashing ATC dash indicator confirms to the driver that the Off-Road ATC function is engaged.

The ECU will exit the ATC Off-Road Mode when power is removed.

The EC-60™ may also be placed in the ATC Off-Road Mode using a J1939 message. See BW-286-D for details.

5.3 Drag Torque Control

5.3.1 Functional Overview

Premium ECUs 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-coefficient surfaces during down-shifting or retarder braking.

5.3.2 Required Inputs

Drag Torque Control requires information regarding the status of the driveline. Drag Torque Control will be disabled if the transmission is in neutral position.

The information must be provided over the J1939 serial communications link. See BW-286-D for details.

5.3.3 Engine ECU Requirements

The engine ECU must accept torque commands up to a maximum of 30% for an unlimited time from the EC-60™. See BW-286-D for details.

5.3.4 Drag Torque Control Operation

Drag Torque Control will be disabled:

- When the transmission is in neutral.
- When the vehicle speed is less than approximately 7 MPH
- If ABS is active on the steer axle
- Whenever ATC (brake or engine control) is disabled

When Drag Torque Control is activated:
All retarders are disabled, and will be re-activated when Drag Torque Control event is concluded.

5.4 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 is 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 purposes.

The Dynamometer Test Mode may be activated by the diagnostic blink code switch or an off-board diagnostic tool. See Section 8.6.8 Dynamometer Test Mode for details.

ATC and Drag Torque Control will be disabled until the dynamometer test mode DTC is cleared. This may be accomplished using the diagnostic blink code switch or an off-board diagnostic tool.

CAUTION
Cycling ignition power will not cause the ECU to exit the dynamometer test mode.

5.5 ECU Configuration

5.5.1 Reconfiguring the Standard ECU

When commanded to do so, EC-60™ standard ECUs will perform a reconfiguration event regarding the retarder relay disable operation. During the reconfiguration process, if the ECU determines that the vehicle contains a retarder disable relay, it will configure itself to control the relay.

The configuration of the J1939 serial communications link (for items such as retarder disable) is independent from the reconfiguration process.

A reconfiguration event may be initiated in two ways:

- Blink Code Switch
  With ignition power removed from the EC-60™, depress the blink code switch. After the application of ignition power, releasing the switch and then depressing and releasing it seven times will initiate a reconfiguration event. See Section 8.6.9 ECU Reconfiguration for additional details.

- Off-Board Diagnostic Tool
  A reconfiguration event may be initiated using an off-board diagnostic tool communicating with the ECU over the SAE J1587 diagnostic link. See BW-289-D for details.

5.5.2 Reconfiguring the Premium ECU

When commanded to do so, EC-60™ premium ECUs will perform a reconfiguration event regarding the number of wheel speed sensors and PMVs along with the ATC feature and retarder disable relay operation. During the reconfiguration process, the ECU will determine the number of sensors and PMVs installed and configure itself accordingly. If the ECU determines that the vehicle contains a retarder disable relay and/or ATC components, it will also configure itself to control these devices.

The configuration of the J1939 serial communications link (for non-ATC items such as retarder disable) is independent from the reconfiguration process.

The reconfiguration event is initiated in the same manner as discussed in Section 5.5.1 Reconfiguring the Standard ECU above.

5.5.2.1 6S/5M Configuration

EC-60™ Premium ECUs 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	AA Right Hold
Release	AA Left Release
Common	AA Right Common

See Bendix drawings 5014385 (cab ECU) and 5014386 (frame ECU) for details on 6S/5M wiring installations.

5.5.3 Modifying ABS Configurations

Certain ECU configurations cannot be changed using the reconfiguration process, and can only be changed using an off-board diagnostic tool transmitting *Bendix*® proprietary messages over the SAE J1587 diagnostic link. See BW-289-D for details.

An example would be a 6S/6M ATC configuration for vehicle applications with one drive axle (6x2).

CAUTION
Any modifications must be documented by changing the ECU part number or installation of a label describing the change. Contact BCVS for assistance.

Any unregistered or incorrect configuration will cause the ECU to generate a DTC code, and the configuration will not be changed.

The assignment of the drive axles is related to the configuration. This is important for the ATC, Drag Torque Control, retarder and lift axle function.

Sensor/PMV Configuration	Number of Drive Axles	Vehicle Type
4S/4M	1	4x2, 6x4
6S/4M	2	6x4
6S/5M	1	6x2
6S/6M	2	6x4[1]
6S/6M	1	6x2[1]

[1]As described above, ATC configuration with 6S/6M for one or two drive axles cannot be modified by initiating a reconfiguration process.

5.5.4 ABS Component Configurations

A number of component configurations are needed to meet the requirements of various vehicle designs. The configurations utilize various arrangements of sensors and valves along with appropriate wiring harnesses. The various component arrangements and the related ABS control modes are shown in the figures below.

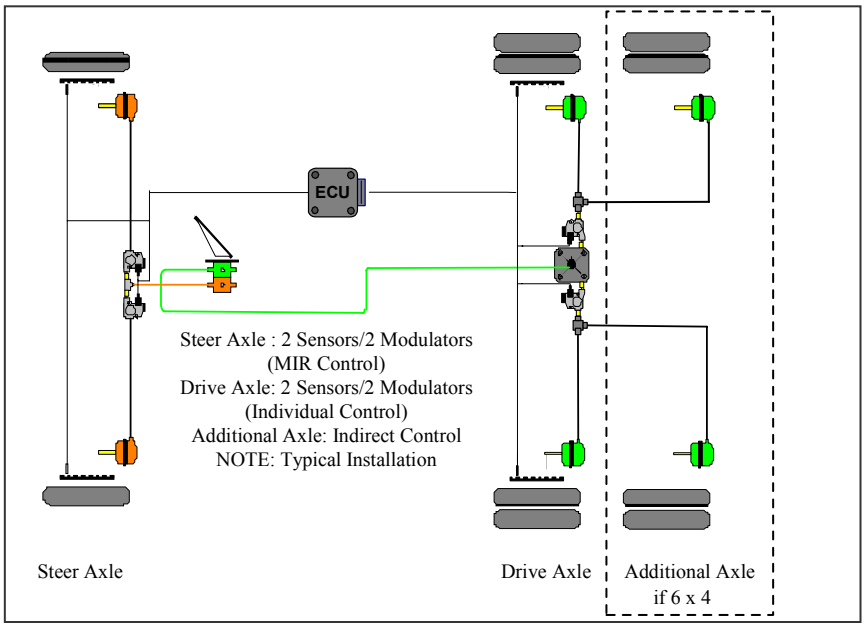


Figure 17 4S/4M Configuration

NOTE

If the additional axle is a drive axle (6x4 vehicle), and a 4S/4M system is installed, the drive axle sensors must be installed on the axle which will have the lightest load.

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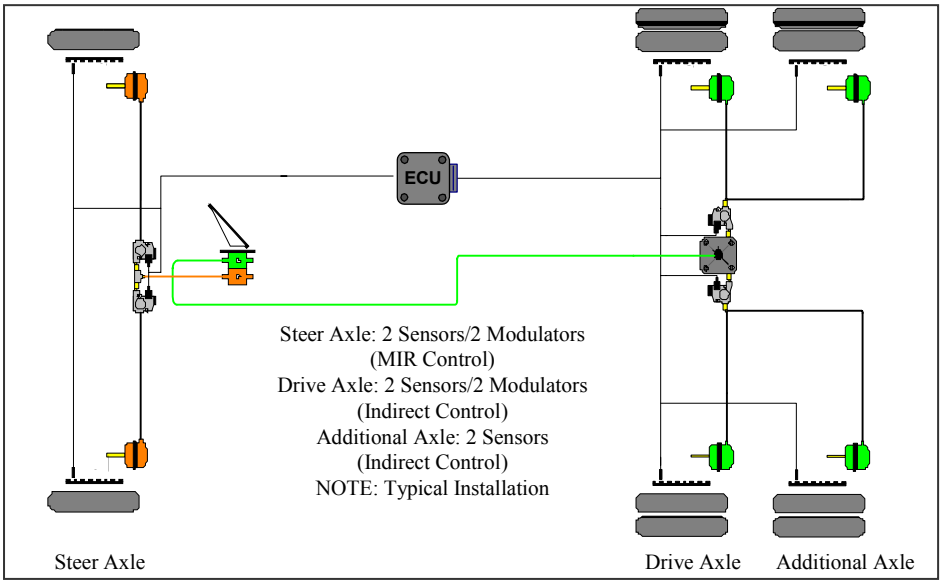

Figure 18 6S/4M Configuration

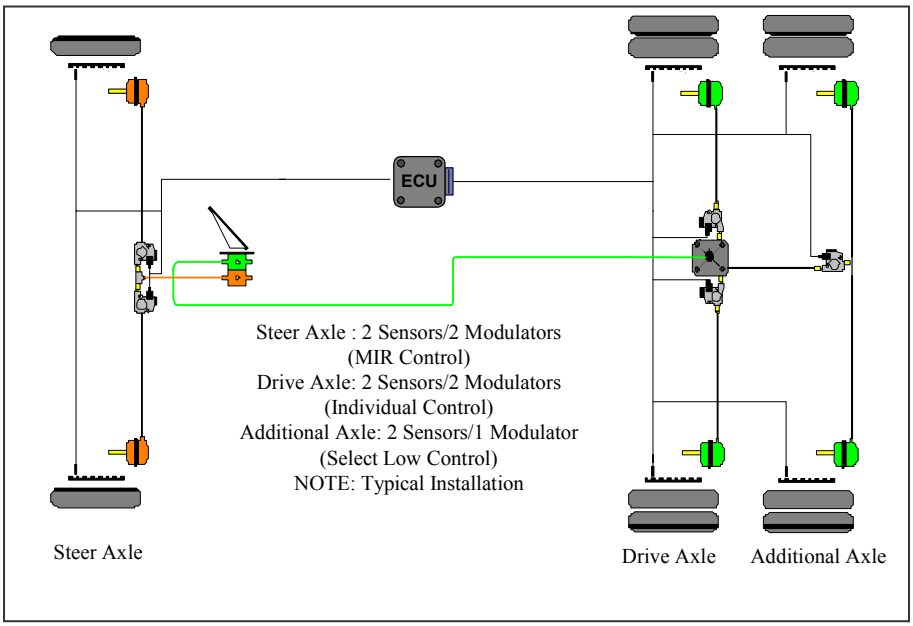

Figure 19 6S/5M Configuration

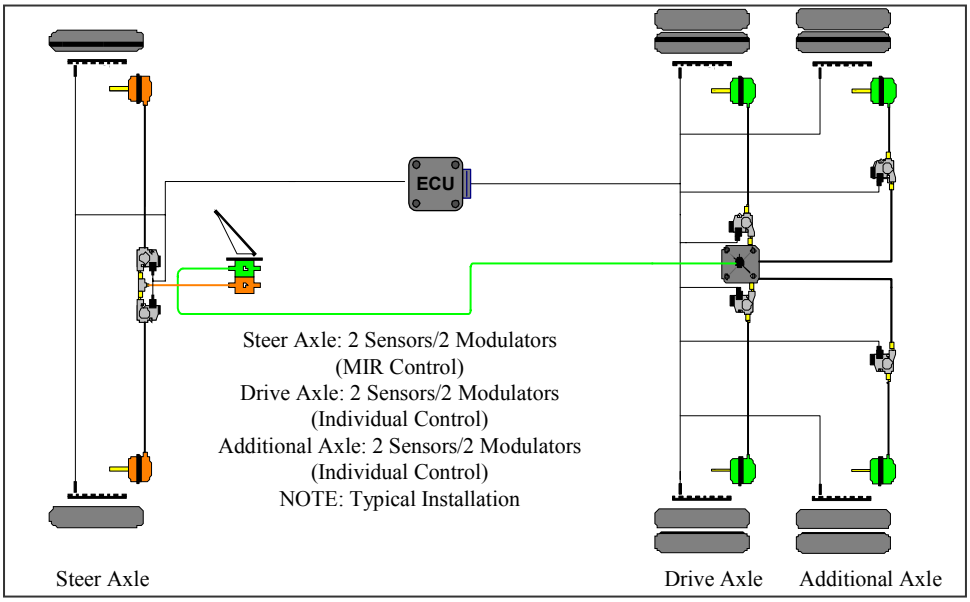

Figure 20 6S/6M Configuration

5.5.5 Retarder Disable Configurations

The retarder brake system can be controlled via the SAE J1939 serial communications link or an electrical retarder relay.

5.5.5.1 J1939 Retarder Disable

The EC-60™ will automatically configure for retarder disable using J1939 when it detects an ERC1 message from one of the retarders in the table below.

Retarder	Address (Decimal)
Engine	15
Transmission	3
Exhaust	41
Driveline	16

Once the EC-60™ has configured itself for J1939 retarder disable operation, it will generate a J1939 retarder DTC and illuminate the ABS dash indicator if it stops receiving ERC1 from the retarder.

The EC-60™ will transmit TSC1 to the detected retarder during active retarder disable events. See BW-286-D for details.

5.5.5.2 Retarder Disable Relay Output

The EC-60™ will configure for control of a retarder disable relay if one is detected during a re-configuration event.

If the ECU is configured for retarder disable relay operation, DTC detection will be enabled on the retarder disable relay output.

5.5.6 Traction Control Configurations

If supported by the ECU, the traction control function (both engine and brake control) will be configured during a reconfiguration event when the ECU detects the presence of the traction control valve.

If desired, engine and brake control can be configured independently using an off-board diagnostic tool transmitting *Bendix*® proprietary messages using the SAE J1587 diagnostic link. See BW-289-D for details.

5.5.7 Lift Axle Configuration

The lift axle configuration is standard with 6S/5M configuration. It may be disabled using the appropriate *Bendix*® proprietary message over the J1587 link.

See BW-289-D for details.

5.5.8 Interaxle Differential Lock (AWD Transfer Case) Control Configuration

Control of the interaxle differential lock (AWD transfer case) driver may be configured using the appropriate *Bendix*® proprietary message over the J1587 link.

This is used to disengage the interaxle differential lock on all wheel-drive vehicles during ABS.

See BW-289-D for details.

5.5.9 Torque Converter Lock-Up Disable

The EC-60™ will automatically configure for torque converter lock-up disable using J1939 when it detects an ETC1 message from a transmission controller.

The EC-60™ will broadcast TC1 to the transmission controller to disable the torque converter lock-up during ABS events.

See BW-286-D for details.

5.6 Auxiliary Design Language (ADL)

The patent-pending Bendix Auxiliary Design Language (ADL) is a proprietary programming language that enables the premium ECU to provide special auxiliary features in addition to ABS and ATC. Examples of special auxiliary features include cargo door monitoring and trailer low pressure indication.

Contact Bendix for additional details regarding ADL or support in developing a special auxiliary feature.

5.7 ECU Operation at Power-Up

WARNING

The vehicle operator should verify proper operation of all installed dash indicators (ABS, ATC, and trailer ABS) when applying ignition power and during vehicle operation.

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

5.7.1 ABS Dash Indicator Operation

The ECU will illuminate the ABS dash indicator for approximately three seconds when ignition power is applied, after which the indicator will extinguish if no DTCs are detected.

The ECU will illuminate the ABS dash indicator whenever full ABS operation is not available due to a DTC condition. In most cases, partial ABS is still available.

5.7.2 ATC Dash Indicator Operation

The ECU will illuminate the ATC dash indicator for approximately 2.5 seconds when ignition power is applied, after which the indicator will extinguish if no DTCs are detected.

The ECU will illuminate the ATC dash indicator whenever ATC is disabled due to a DTC.

5.7.3 Trailer ABS Dash Indicator Operation

Certain models of the EC-60™ will control the Trailer ABS dash indicator when it detects a PLC signal from a trailer ABS ECU.

Control of the indicator is in accordance with SAE J2497.

5.7.4 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.

The ECU will not perform the configuration test when wheel speeds are detected.

5.7.5 PMV Chuff Test

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

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

The EC-60™ 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 speeds are detected.

5.8 Speed Sensor Signal Evaluation

5.8.1 Speed Range

Parameter	Min	Max	Unit
Wheel Speed Range	0.5	100	MPH
ABS Operating Speed	4.0	100	MPH
ATC Brake Control Operating Speed	0.5	25	MPH
ATC Engine Control Operating Speed	0.5	100	MPH

Notes:

1. The minimum thresholds may increase if excessive air gaps exist between the speed sensor and exciter ring.
2. Values are approximate and based on standard tire sizes.

5.8.2 Allowable Tire Size

The speed calculation for an exciter ring with 100 teeth is based on a default tire size of 510 Revolutions Per Mile (RPM). This figure is based on the actual rolling circumference of the tires, which is the circumference resulting from tire size, tire wear, tire pressure, vehicle loading, etc. Other tire sizes and exciter ring teeth counts can be handled by customer request.

The ABS response sensitivity is reduced when the actual rolling circumference is excessive on all 4 wheels. If the actual rolling circumference is outside of the range shown below, adaptation must take place by changing the number of teeth on the exciter ring. The table below shows the range of the rolling circumference covered by a certain number of teeth.

No. of Exciter Ring Teeth	Tire Revolutions Per Mile (RPM)		
	Min.	Nominal	Max.
100	426	510	567

Table 22 Permissible Tire Size

The ratio of the effective rolling circumference of the steer axle tires and those of the drive axle tires must be inside the following range:

$$\frac{\text{Effective Rolling Circumference, Steer Axle}}{\text{Effective Rolling Circumference, Drive Axle}} = 0.85 - 1.15$$

These figures are based upon the assumption that the individual axles are each fitted with tires of the same size. Even if the steer axle tires are of a different size compared to those on the drive axle, the rolling circumference of each wheel must still be inside the permissible range.

The ECU will set DTCs if tire sizes are out of range. See Section 8.5 System Operation Under DTC Conditions for details.

5.8.3 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:

- Rolling-circumference ratio is within the permissible range.
- Vehicle speed is greater than approximately 12 MPH.
- No acceleration or deceleration is taking place.
- There are no active speed sensor DTCs.

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.

The ECU will set DTCs if tire sizes are out of range. See Section 8.5 System Operation Under DTC Conditions for details.

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PRODUCT SPECIFICATION BW-271-PR

6.0 EC-60™ ELECTRICAL ENVIRONMENTAL REQUIREMENTS

EC-60™s are designed to withstand the electrical environment described in this section. The ECU may not function properly if the electrical environment exceeds that which is contained in this section.

6.1 Load Dump

Transient "Load Dump" pulses (similar to SAE J1455 Section 4.11.2.2.1) will be applied to the ECU. The pulses are applied to the ignition and battery input circuits only. The ECU shall operate normally after all pulses are applied.

Parameter	Value	Unit
Applied Pulse	$14 + 86e^{(-t/0.4)} \pm 10$	V
Source Impedance	0.4 ± 0.1	Ohms
Total Pulses	5	Pulses
Time Between Pulses	1	min

6.2 Inductive Load Switching

Transient "Inductive Load Switching" pulses (similar to SAE J1455 Section 4.11.2.2.2) will be applied to the ECU. The ECU shall operate normally after all pulses are applied.

Parameter	Value	Unit
Applied Pulse	$14 \pm 600e^{(-t/0.001)} \pm 5\%$	V
Source Impedance	≤ 20	Ohms
Total Pulses	10	Pulses
Time Between Pulses	≤ 20	sec

6.3 Mutual Coupling

Transient "Mutual Coupling" pulses (similar to SAE J1455 Section 4.11.2.2.3) will be applied to the ECU. The ECU shall operate normally after all pulses are applied.

Parameter	Value	Unit
Applied Pulse	$14 \pm 300e^{(-t/0.000015)} \pm 10\%$	V
Source Impedance	50 ± 5	Ohms
Total Pulses	10	Pulses
Time Between Pulses	≤ 20	sec

6.4 Power Line Noise

The battery input will be modulated with an AC signal as described below. The ECU will operate normally or indicate an abnormal voltage condition with the AC signal applied.

Parameter	Value	Unit
Amplitude	5 ± 0.5	Vp-p
Frequency	50 to 10,000	Hz
Signal Type	Sine	Wave
Application rate	200 ± 10	Hz/sec

6.5 Electrostatic Discharge (ESD)

The ECU will be subjected to ESD testing similar to SAE J1113-13 Section 5 (Non-Powered Mode Test). The ECU shall operate normally after all pulses are applied.

Parameter	Value	Unit
Capacitor Source	150	pF
Output Resistance	2000	ohm

Test Sequence	Discharge Type	Test Voltage Level	Unit	Number of Discharges
1	Contact	±4	kV	3
2	Contact	±6	kV	3
3	Air	±8	kV	3
4	Contact	±8	kV	3
5	Air	±15	kV	3

6.6 Over-Voltage During Jump Start

Parameter	Value	Unit
Input Voltage	48 ± 0.5	VDC
Current Limit	30	Amps
Application Time	5	min

The ECU can sustain damage and need not function normally when the voltage is returned to normal, but must be in a "fail safe" condition: no short from VIGN or VBATT to ground, no valves activated, and no undetected DTCs.

6.7 Component Level Electromagnetic Compatibility

The system (which includes ECU, PMVs, wheel speed sensors, and wiring) will be subjected to EMI field testing from 10 kHz to 18 GHz.

Parameter	Value	Unit
Minimum Frequency	10	kHz
Maximum Frequency	18	GHz
Test Level	150	V/m
Modulation (Sine Wave AM)[1]	1 @ 80%	kHz
Modulation (Square Wave)[2]	1 @ 100%	kHz

[1]Sine wave modulation between 10 kHz to 200 MHz.
[2]Square wave modulation between 200 MHz to 18 GHz.

Test Level	Acceptance Criteria
100 to 150 V/m	Unit may deviate from design but must return to normal operation after the field has been removed and power cycled. No false cycling of PMVs is allowed.
<100 V/m	Unit will operate as designed during and after exposure. No false cycling of PMVs is allowed.

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Elyria, OH 44036

PRODUCT SPECIFICATION BW-271-PR

7.0 EC-60™ MECHANICAL ENVIRONMENTAL REQUIREMENTS

CAUTION
Unless otherwise noted, the mechanical environmental requirements contained in this section are applicable to both cab and frame ECUs. Note that some requirements are specific to frame ECUs only. Cab units should not be exposed to conditions identified for frame ECUs only.

7.1 Mechanical Vibration

7.1.1 Cab ECUs
Cab ECUs shall be subjected to a vibration test similar to SAE J1455, Section 4.9.3 while the unit is operational without abnormal operation.

Parameter	Value	Unit
Vibration Type	Random	
Level	1.47	grms
Number of Axis	3	
Test Time	30	Hours

7.1.2 Frame ECUs
Frame ECUs shall be subjected to a vibration test similar to SAE J1455, Section 4.9.3 while the unit is operational without abnormal operation.

Parameter	Value	Unit
Vibration Type	Random	
Level	5.3	grms
Number of Axis	3	
Test Time	12	Hours

7.2 Drop Test

The ECU shall be subjected to a shock application equivalent of dropping it on a level concrete surface, similar to SAE J1455 Section 4.10.3.1.

If visible damage to the ECU is not observed, it shall operate normally after the drop test.

If there is obvious damage that would result in part rejection (cracked enclosure, damage to the connector or terminals), the ECU unit is not required to function.

Parameter	Value	Unit
Drop Surface	Concrete	
# of Successive Drops	3	
Height	1	m

7.3 Standard Storage Temperature

The ECU shall be exposed to temperature extremes in an unpowered state. The ECU will operate normally after it has returned to the normal operating temperature.

Parameter	Value	Unit
Maximum Temperature	+125 ± 5	°C
Minimum Temperature	-40 ± 5	°C
Time @ Temperature Extremes	2	hrs

7.4 Extended Storage Temperature (Frame ECUs Only)

Frame ECUs shall be exposed to temperature extremes in an unpowered state. The ECU will operate normally after it has returned to the normal operating temperature.

Parameter	Value	Unit
Maximum Temperature	+150 ± 5	°C
Test Time	45	min

7.5 Thermal Shock

The ECU shall be subjected to temperature transition shocks similar to SAE J1455 Section 4.1.3.2. The ECU shall operate normally after application of the thermal cycles.

Parameter	Value	Unit
Maximum Temperature	+85 ± 5	°C
Minimum Temperature	-40 ± 5	°C
Time @ Temperature Extremes	2	hrs
Transition Time	<1	min
# of Cycles	10	

7.6 Combined Environment "AGREE"

The ECU will be subjected to a combined environment test consisting of temperature cycling, humidity, and vibration (applied during all temperature transitions). The total test time is equal to one product life.

ABS, ATC, and ignition cycles are performed throughout the test.

The ECU shall operate normally at the completion of testing.

7.6.1 Cab ECU Test Profile

Parameter	Value	Unit
Maximum Temperature	+85 ± 5	°C
Minimum Temperature	-40 ± 5	°C
Humidity[1]	90	%

[1]Humidity is applied at 38ºC dwell points

7.6.2 Frame ECU Test Profile

Parameter	Value	Unit
Maximum Temperature	+85 ± 5	°C
Minimum Temperature	-40 ± 5	°C
Humidity[1]	95	%

[1]Humidity is applied five out of six cycles @ maximum temperature. It is reduced to 5% on the sixth cycle.

7.7 Chemical Exposure

The ECU enclosure will be capable of withstanding splash exposure to the following chemicals. After the chemicals have been applied to the enclosure and left on for 24 hours, the ECU will be dried. The ECU shall operate normally after all exposures.

7.7.1 Cab ECUs

- Detergent
- Gasoline
- Diesel Fuel
- Methyl Alcohol

7.7.2 Frame ECUs

- Acetone
- Antifreeze
- ASTM #3 Oil
- Battery Acid
- CI-4 Engine Oil
- Diesel Fuel
- Methyl Alcohol
- Ammonia
- ASTM #1 Oil
- ASTM Type A Fuel
- Brake Fluid
- Detergent
- Gasoline
- Paint Stripper

7.8 High Pressure Wash (Frame ECUs Only)

Parameter	Value	Unit
Soapy Water Temperature	40 ± 5	°C
Soapy Water Pressure	1020	psi
Distance from ECU	8-12	in
Flow rate	150	gal/hr
Cycle Time	3 sec (of a 6 sec cycle)	
Number of Cycles	375	

The ECU shall operate normally after the exposure.

7.9 Salt Fog (Frame ECUs Only)

Frame ECUs shall be exposed to a salt fog environment as described below. The ECU shall operate normally after exposure to the salt fog.

At the completion of the Salt Fog profile, any corrosion must be less than 2/3 of the ECU surface.

Parameter	Value	Unit
Temperature	35 ± 5	°C
Relative Humidity	95 ± 5	%
Salt Fog Solution	5 ± 2	%
Test Time	240	hr

7.10 Salt Water Immersion (Frame ECUs Only)

Frame ECUs are to be subjected to hot and cold salt water immersions. The units are then placed in an environmental chamber and temperature cycled. The unit shall operate normally following exposure.

Hot Salt Water Immersion

Parameter	Value	Unit
Temperature	73.9 ± 10	°C
Salt Water Solution	5 ± 2	%

Cold Salt Water Immersion

Parameter	Value	Unit
Temperature	< 5	°C
Salt Water Solution	5 ± 2	%

Temperature Cycling

Parameter	Value	Unit
Maximum Temperature	+85 ± 5	°C
Minimum Temperature	-40 ± 5	°C

7.11 Gravel Bombardment (Frame ECUs Only)

Frame ECUs shall be bombarded with gravel for a total time of two minutes in accordance with SAE J400. The units will function normally at the completion of the test unless degraded performance can be attributed to visual damage, such as a damaged connector.

8.0 EC-60™ DIAGNOSTIC SUPPORT

8.1 DTC Detection

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

8.2 Active DTCs

The EC-60™ performs the following steps when an erroneous system condition is detected:

1. Illuminates the appropriate dash indicator (s) and disengages a portion or all of the ABS and ATC functions.
2. Places the appropriate DTC information in the ECU memory.
3. Broadcasts the appropriate DTC information over the serial communications diagnostic link as required.

All DTCs, with the exception of voltage and J1939 DTCs, will remain in an active state for the remainder of the ignition cycle.

Voltage DTCs will clear automatically when the voltage returns within the required limits (see Table 7 Input Voltage Specifications for details). All ABS and ATC functions will be re-engaged.

J1939 DTCs will clear automatically when communications are re-established.

8.2.1 Retrieving Active DTCs

All active DTCs may be retrieved using the diagnostic blink code switch or an off-board diagnostic tool such as the *Bendix® ACOM™* diagnostic software. See Section 8.6.4 Active/Inactive Diagnostic Blink Codes for details.

8.2.2 Self-Healing of Active DTCs

If the DTC condition is no longer present, most DTCs will clear (or self-heal) when ignition power is removed and re-applied, with the exception of sensor DTCs.

8.2.3 Self-Healing of Active Sensor DTCs

If the DTC condition is no longer present, sensor DTCs will clear (or self-heal) when ignition power is removed, re-applied, and the ECU detects valid wheel speed from all wheel speed sensors.

8.2.4 Clearing Active DTCs

All active DTCs may be cleared using the diagnostic blink code switch or an off-board diagnostic tool such as the *Bendix® ACOM™* diagnostic software. See Section 8.6.6 Clearing Active DTCs for details.

8.3 DTC Storage/Event History

The EC-60™ retains a record of all DTCs and comments (such as configuration changes) in non-volatile memory. This record is commonly referred to as Event History. When a DTC self-heals or is manually cleared, the DTC code remains in event history as an inactive DTC.

8.3.1 Retrieving Inactive DTCs

Inactive DTCs may be retrieved using the diagnostic blink code switch or an off-board diagnostic tool such as the *Bendix® ACOM™* diagnostic software. See Section 8.6.4 Active/Inactive Diagnostic Blink Codes for details.

8.3.2 Retrieving Event History

Event history may be retrieved using an off-board diagnostic tool such as the *Bendix® ACOM™* diagnostic software. See Section 8.8 *Bendix® ACOM™* Diagnostic Software for details.

8.3.3 Clearing Inactive DTCs & Event History

Inactive DTCs and event history may be cleared using an off-board diagnostic tool such as the *Bendix® ACOM™* diagnostic software. See Section 8.8 *Bendix® ACOM™* Diagnostic Software for details.

8.4 System DTCs and Comments

8.4.1 ECU DTCs

If an issue is detected with the microprocessor circuitry or associated components, all ABS and ATC functions will be disabled.

8.4.2 Voltage DTCs

If the input voltage (ignition or battery) is outside of the required limits, all ABS and ATC functions will be disabled. See Section 4.4.1 Battery and Ignition Inputs for details.

Low voltage DTCs are not stored in the event history.

8.4.3 Wheel Speed Sensor DTCs

8.4.3.1 Static Sensor DTCs

DTCs such as an open sensor, a short circuit condition to ground, a short circuit condition to voltage, or two sensors shorted together will be detected without vehicle movement.

8.4.3.2 Dynamic Sensor DTCs
The following DTCs can be detected while the vehicle is in motion.

Excessive Air Gap DTC
This DTC is set if the ECU calculates an excessive air gap between the wheel speed sensor and the exciter ring.

Sensor Drive-Off DTC
If the ECU receives wheel speed sensor signals from some sensors, but not others when the vehicle accelerates from a standing start, the ECU will set a sensor drive-off DTC.

This DTC will be set once the vehicle reaches a speed of approximately 15 MPH.

Multiple Sensors Backed-Out Comment
When sensor drive-off DTCs are logged on more than one sensor, this comment is also placed in the event history under the following conditions.

1. When the ECU receives no indication of wheel speed from two sensors installed on the same axle, but receives wheel speed signals from other sensors.
2. When the ECU receives no indication of wheel speed from any wheel speed sensor, but receives an indication of vehicle speed from another electronic module, such as the engine ECU. This DTC will not be set when the ECU receives indication over the J1939 link that the vehicle is parked. See BW-286-D for additional details.

This comment will be placed in the event history when no wheel speed indication is received for 80 consecutive seconds with a vehicle speed of approximately 18 MPH.

Loss of Sensor Signal DTC
This DTC is set if the ECU detects the sudden loss of a wheel speed sensor signal.

Wheel End DTC
This DTC is typically caused by an issue with the exciter ring or the wheel end.

Erratic Sensor Signal DTC
If the ECU detects an unstable signal from a wheel speed sensor, this DTC will be set.

Reversed Sensors DTC
This DTC is set when the ECU determines that the sensors are reversed on one axle compared to another axle.

Configuration DTC (Additional Axle Only)
If the ECU is configured for four sensor operation, but six sensors are detected, this DTC is set.

Tire Size Calibration DTC
This DTC is set if the ECU detects an out-of-range tire size calibration setting.

8.4.4 Pressure Modulator Valve DTCs
DTCs such as an open PMV, a short circuit condition to ground, or a short circuit condition to voltage will be detected.

If the ECU is configured for four PMVs, but six PMVs are detected, a PMV configuration DTC will be set.

8.4.5 Retarder Disable Output DTCs
DTCs such as an open circuit, a short circuit condition to ground, or a short circuit condition to voltage will be detected when the ECU is configured to use this output for retarder control.

8.4.6 SAE J1939 Serial Communications Link DTCs
The data link is monitored for time-out and bus-off errors.

8.4.7 Stop Lamp Switch DTCs
The stop lamp switch circuit is monitored for an intermittent signal and a plausibility check (vehicle accelerating and stop lamp switch activated).

8.5 System Operation Under DTC Conditions

The following tables describe system operation with a variety of DTCs, for a 6S/6M configuration.

Sensor DTCs

DTC	ABS Control							ATC			Retarder	
	Steer Left	Steer Right	Drive Left	Drive Right	Add Left	Add Right	WL	Eng. Cntrl	Brake Cntrl	WL	J1939	Relay
Sensor Steer Axle Left	No[1]	IC[1]	IC	IC	IC	IC	On	No	No	On	Yes	Yes
Sensor Steer Axle Right	IC[1]	No[1]	IC	IC	IC	IC	On	No	No	On	Yes	Yes
Sensor Drive Axle Left	MIR	MIR	No	IC	IC	IC	On	No	No	On	Yes	Yes
Sensor Drive Axle Right	MIR	MIR	IC	No	IC	IC	On	No	No	On	Yes	Yes
Sensor Add Axle Left	MIR	MIR	IC	IC	No	IC	On	No[2]	No[2]	On[2]	Yes	Yes
Sensor Add Axle Right	MIR	MIR	IC	IC	IC	No	On	No[2]	No[2]	On[2]	Yes	Yes
Sensors Reversed	No	No	No	No	No	No	On	No	No	On	No	No
Tire Size Calibration Error	No	No	No	No	No	No	On	No	No	On	No	No
Two Sensor DTCs or Sensor DTC w/PMV DTC	No	No	No	No	No	No	On	No	No	On	No	No

[1]MIR if affected wheel is on high μ side
[2]If axle is a drive axle

Table 23 System Operation With Sensor DTCs

Input Voltage DTCs

DTC	ABS Control							ATC			Retarder	
	Steer Left	Steer Right	Drive Left	Drive Right	Add Left	Add Right	WL	Eng. Cntrl	Brake Cntrl	WL	J1939	Relay
IGN or BATT Too High, Too Low, Noisy, or Open Circuit	No	No	No	No	No	No	On	No	No	On	No	No

Table 24 System Operation With Input Voltage DTCs

PMV DTCs

DTC	ABS Control							ATC			Retarder	
	Steer Left	Steer Right	Drive Left	Drive Right	Add Left	Add Right	WL	Eng. Cntrl	Brake Cntrl	WL	J1939	Relay
Steer Left Release or Hold Shorted to GND or open, Common open	No	IC	IC	IC	IC	IC	On	Yes	Yes	Off	Yes	Yes
Steer Right Release or Hold Shorted to GND or open, Common open	IC	No	IC	IC	IC	IC	On	Yes	Yes	Off	Yes	Yes
Drive Left Release or Hold Shorted to GND or open, Common open	MIR	MIR	No	IC	IC	IC	On	Yes	No	On	Yes	Yes
Drive Right Release or Hold Shorted to GND or open, Common open	MIR	MIR	IC	No	IC	IC	On	Yes	No	On	Yes	Yes
Add Left Release or Hold Shorted to GND or open, Common open	MIR	MIR	IC	IC	No	IC	On	Yes	No[1]	On[1]	Yes	Yes
Add Right Release or Hold Shorted to GND or open, Common open	MIR	MIR	IC	IC	IC	No	On	Yes	No[1]	On[1]	Yes	Yes
Any Solenoid Shorted to 12 volts	No	No	No	No	No	No	On	No	No	On	No	No
Any Solenoid Common Shorted to Ground	MIR	MIR	IC	IC	IC	IC	On	Yes	Yes	On	Yes	Yes
Two Valve DTCs or Sensor DTC w/PMV DTC	No	No	No	No	No	No	On	No	No	On	No	No

[1]If axle is a drive axle

Table 25 System Operation With PMV DTCs

J1939 DTCs

DTC	ABS Control							ATC			Retarder	
	Steer Left	Steer Right	Drive Left	Drive Right	Add Left	Add Right	WL	Eng. Cntrl	Brake Cntrl	WL	J1939	Relay
J1939 CAN bus off detected	MIR	MIR	IC	IC	IC	IC	On	No	No	On	No	Yes
Timeout or invalid data on ERC1	MIR	MIR	IC	IC	IC	IC	On	Yes	Yes	Off	No	Yes
Timeout or invalid data on EEC1/EEC2	MIR	MIR	IC	IC	IC	IC	Off	No	No	On	Yes	Yes

Table 26 System Performance With J1939 DTCs

Miscellaneous DTCs

DTC	ABS Control							ATC			Retarder	
	Steer Left	Steer Right	Drive Left	Drive Right	Add Left	Add Right	WL	Eng. Cntrl	Brake Cntrl	WL	J1939	Relay
Stop Lamp Switch Not Detected	MIR	MIR	IC	IC	IC	IC	Off	No	No	On	Yes	Yes
Stop Lamp Switch Defective	MIR	MIR	IC	IC	IC	IC	On	No	No	On	Yes	Yes
ATC Dynamometer Test Mode Active	MIR	MIR	IC	IC	IC	IC	Off	No	No	On	Yes	Yes
ABS Dash Indicator Circuit DTC	MIR	MIR	IC	IC	IC	IC	On	Yes	Yes	Off	Yes	Yes
Retarder Relay Open, Shorted to Ground or Voltage	MIR	MIR	IC	IC	IC	IC	On	Yes	Yes	Off	Yes	No
ATC Brake Fade[1]	MIR	MIR	IC	IC	IC	IC	Off	No	No	On	Yes	Yes
Tire Size Out of Range	No	No	No	No	No	No	On	No	No	On	No	No
Interaxle Diff Lock[2] Solenoid Shorted to Ground or Voltage	MIR	MIR	IC	IC	IC	IC	On	Yes	Yes	Off	Yes	Yes

[1]No DTC active according to diagnostic software
[2]AWD Transfer Case

Table 27 System Operation With Miscellaneous DTCs

ECU DTCs

DTC	ABS Control							ATC			Retarder	
	Steer Left	Steer Right	Drive Left	Drive Right	Add Left	Add Right	WL	Eng. Cntrl	Brake Cntrl	WL	J1939	Relay
ECU DTC (1B)	MIR	MIR	IC	IC	IC	IC	On	Yes	Yes	Off	Yes	Yes
All Other ECU DTCs	No	No	No	No	No	No	On	No	No	On	No	No

Table 28 System Operation With ECU DTCs

TCV DTCs

DTC	ABS Control							ATC			Retarder	
	Steer Left	Steer Right	Drive Left	Drive Right	Add Left	Add Right	WL	Eng. Cntrl	Brake Cntrl	WL	J1939	Relay
Solenoid short to ground or open	MIR	MIR	IC	IC	IC	IC	On	Yes	No	On	Yes	Yes
Solenoid short to 12 volts	No	No	No	No	No	No	On	No	No	On	No	No

Table 29 System Operation With TCV DTCs

8.6 Diagnostic Blink Code Operation

The ECU monitors the state of the blink code switch to activate one of several diagnostic modes. All information is displayed using the ABS dash indicator.

Once the dash indicator begins displaying codes, the ECU will not respond to additional blink code switch activation until all blink code messages have been displayed and the unit has returned to the normal operating mode.

The ECU will not enter the diagnostic blink code mode if wheel speeds are detected. If the ECU is in the diagnostic blink code mode and then detects wheel speeds, it will exit the blink code mode.

8.6.1 Diagnostic Blink Code Switch Activation Timing

Action	Timing
Minimum “Ignition On” time, before depressing blink code switch	2.0 sec.
“Switch On” duration range	0.1 – 5.0 sec.
“Switch Off” duration time between “Switch On” cycles	< 2.0 sec.
Max. “Switch On” duration before time-out (shorted switch detection)	5.0 sec.
Delay before blink code output begins following switch activation	3.5 sec.

8.6.2 Diagnostic Blink Code Indicator Timing

Action	Timing
Duration of indicator blink pulse (indicator on)	0.5 sec.
Duration of indicator blink pulse (indicator off)	0.5 sec.
Duration between blink code digits	1.5 sec.
Duration between blink code messages	2.5 sec.
Duration of indicator illumination at completion of messages	5.0 sec.

8.6.3 Available Diagnostic Modes

Diagnostic Mode	Switch Cycles
Active DTC Diagnostic Code Retrieval	1
Inactive DTC Diagnostic Code Retrieval	2
Clear Active DTCs	3
System Configuration Check	4
Dynamometer Test Mode	5
Reconfigure ECU	7 (at power-on)[1]

[1]Switch must be depressed prior to the application of ignition power, released after power is applied, and then cycled 7 times.

8.6.4 Active/Inactive Diagnostic Blink Codes

The ABS dash indicator will display active or inactive diagnostic blink codes when the diagnostic blink code switch is depressed and released once (active DTCs displayed) or twice (inactive DTCs displayed). The indicator will blink out diagnostic DTCs using the following patterns.

8.6.4.1 No DTCs Present

If no DTCs are present, the ABS will display the following diagnostic blink code.

1st Number
1
2nd Number
1

8.6.4.2 DTCs Present

If DTCs are present, the indicator will display them using two digits.

The first blink code number indicates the subsystem DTC.

1st Number	Subsystem
2	Sensor Steer Axle Left
3	Sensor Steer Axle Right
4	Sensor Drive Axle Left
5	Sensor Drive Axle Right
6	Power Supply
7	Modulator Steer Axle Left
8	Modulator Steer Axle Right
9	Modulator Drive Axle Left
10	Modulator Drive Axle Right
11	J1939
12	Miscellaneous
13	ECU
14	Sensor Additional Axle Left
15	Sensor Additional Axle Right
16	Modulator Additional Axle Left
17	Modulator Additional Axle Right
18	Traction Valve

Table 30 Diagnostic DTC Code Information (First Number)

The second blink code number indicates the type of DTC as follows.

Sensor DTCs

2nd Number	Description
1	Excessive Air Gap
2	Sensor Output Low @ Drive-Off
3	Sensor Open or Shorted
4	Loss of Sensor Signal
5	Wheel End
6	Erratic Sensor Signal
7	Tire Size Calibration
8	Reserved, not currently utilized
9	Reserved, not currently utilized
10	Sensor Configuration Error (Additional Axle Only)

Table 31 Diagnostic Blink Code DTCs (Sensors)

Input Voltage DTCs

2nd Number	Description
1	Battery Voltage Too Low
2	Battery Voltage Too High
3	Battery Voltage Too Low During ABS
4	Battery Voltage Input Open Circuit
5	Ignition Voltage Too Low
6	Ignition Voltage Too High
7	Ignition Voltage Too Low During ABS
8	Input Voltage Has Excessive Noise (Temporarily)
9	Input Voltage Has Excessive Noise

Table 32 Diagnostic Blink Code DTCs (Input Voltage)

PMV DTCs

2nd Number	Description
1	Release Solenoid Shorted to Ground
2	Release Solenoid Shorted to Voltage
3	Release Solenoid Open Circuit
4	Hold Solenoid Shorted to Ground
5	Hold Solenoid Shorted to Voltage
6	Hold Solenoid Open Circuit
7	PMV Common Open Circuit
8	PMV Configuration Error

Table 33 Diagnostic Blink Code DTCs (PMVs)

J1939 DTCs

2nd Number	Description
1	J1939 Serial Link
2	J1939 Retarder
3	J1939 Engine Communications

Table 34 Diagnostic Blink Code DTCs (J1939)

Miscellaneous DTCs

2nd Number	Description
1	Stop Lamp Switch Not Detected
2	Stop Lamp Switch Defective
3	Dynamometer Test Mode Active
4	Retarder Relay Open/Shorted to Ground
5	Retarder Relay Shorted to Voltage
6	ABS Dash Indicator DTC
7	PMV Common Shorted to Ground
8	PMV Common Shorted to Voltage
9	ATC Disabled to Prevent Brake Fade
10	Tire Size Out of Range (Front-to-Rear)
11	Wheel Speed Sensors Reversed on an Axle
12	Diff Lock Solenoid Shorted to Ground/Open
13	Diff Lock Solenoid Shorted to Voltage

Table 35 Diagnostic Blink Code DTCs (Miscellaneous DTCs)

ECU DTCs

2nd Number	Description
2	ECU DTC (10)
3	ECU DTC (11)
4	ECU DTC (12)
5	ECU DTC (13)
6	ECU DTC (14)
7	ECU DTC (15)
8	ECU DTC (16)
9	ECU DTC (17)
10	ECU DTC (18)
11	ECU DTC (1A)
12	ECU DTC (1B)
13	ECU DTC (80)

Table 36 Diagnostic Blink Code DTCs (ECU)

TCV DTCs

2nd Number	Description
1	Solenoid Shorted to Ground
2	Solenoid Shorted to Voltage
3	Solenoid Open Circuit
4	Valve Configuration Error

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Elyria, OH 44036

PRODUCT SPECIFICATION BW-271-PR

Table 37 Diagnostic Blink Code DTCs (TCV)

8.6.5 DTC Description and Repair Information

1st Digit	2nd Digit	DTC Description	Repair Information	J1587 SID	J1587 FMI
1	1	No DTCs	System Fully Operational - No DTCs Detected	-	-
Wheel Speed Sensor DTCs					
2	1	SA Left WSS Excessive Air Gap	Adjust sensor to contact exciter ring. Rotate wheel and verify a min. of 0.25 VAC sensor output @ ~ 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.	1	1
3	1	SA Right WSS Excessive Air Gap		2	1
4	1	DA Left WSS Excessive Air Gap		3	1
5	1	DA Right WSS Excessive Air Gap		4	1
14	1	AA Left WSS Excessive Air Gap		5	1
15	1	AA Right WSS Excessive Air Gap		6	1
2	2	SA Left WSS Output Low @ Drive-Off	Adjust sensor to contact exciter ring. Rotate wheel and verify a min. of 0.25 VAC sensor output @ ~ 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.	1	14
3	2	SA Right WSS Output Low @ Drive-Off		2	14
4	2	DA Left WSS Output Low @ Drive-Off		3	14
5	2	DA Right WSS Output Low @ Drive-Off		4	14
14	2	AA Left WSS Output Low @ Drive-Off		5	14
15	2	AA Right WSS Output Low @ Drive-Off		6	14
2	3	SA Left WSS Open or Shorted	Verify 1500 – 2500 ohms across sensor leads (with sensors @ room temperature). 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 WSS.	1	2
3	3	SA Right WSS Open or Shorted		2	2
4	3	DA Left WSS Open or Shorted		3	2
5	3	DA Right WSS Open or Shorted		4	2
14	3	AA Left WSS Open or Shorted		5	2
15	3	AA Right WSS Open or Shorted		6	2
2	4	SA Left WSS Loss of Sensor Signal	Adjust sensor to contact exciter ring. Rotate wheel and verify a min. of 0.25 VAC sensor output @ ~ 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 WSS.	1	10
3	4	SA Right WSS Loss of Sensor Signal		2	10
4	4	DA Left WSS Loss of Sensor Signal		3	10
5	4	DA Right WSS Loss of Sensor Signal		4	10
14	4	AA Left WSS Loss of Sensor Signal		5	10
15	4	AA Right WSS Loss of Sensor Signal		6	10
2	5	SA Left WSS 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.	1	7
3	5	SA Right WSS Wheel End		2	7
4	5	DA Left WSS Wheel End		3	7
5	5	DA Right WSS Wheel End		4	7
14	5	AA Left WSS Wheel End		5	7
15	5	AA Right WSS Wheel End		6	7

1st Digit	2nd Digit	DTC Description	Repair Information	J1587 SID	J1587 FMI
Wheel Speed Sensor DTCs (cont.)					
2	6	SA Left WSS Erratic Sensor Signal	Adjust sensor to contact exciter ring. Rotate wheel and verify a min. of 0.25 VAC sensor output @ ~ 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 WSS.	1	8
3	6	SA Right WSS Erratic Sensor Signal		2	8
4	6	DA Left WSS Erratic Sensor Signal		3	8
5	6	DA Right WSS Erratic Sensor Signal		4	8
14	6	AA Left WSS Erratic Sensor Signal		5	8
15	6	AA Right WSS Erratic Sensor Signal		6	8
2	7	SA Left WSS Tire Size Calibration	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.	1	13
3	7	SA Right WSS Tire Size Calibration		2	13
4	7	DA Left WSS Tire Size Calibration		3	13
5	7	DA Right WSS Tire Size Calibration		4	13
14	7	AA Left WSS Tire Size Calibration		5	13
15	7	AA Right WSS Tire Size Calibration		6	13
14	10	AA Left WSS Configuration Error	ECU is configured for four sensors, but has detected the presence of additional sensors. Verify sensor wiring and ECU configuration.	5	13
15	10	AA Right WSS Configuration Error		6	13
Power Supply DTCs					
6	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.	251	4
6	2	Battery Voltage Too High	Measure battery voltage. Insure that battery voltage is correct for the model of ECU. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.	251	3
6	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.	251	4
6	4	Battery Voltage Input 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.	251	5

1st Digit	2nd Digit	DTC Description	Repair Information	J1587 SID	J1587 FMI
Power Supply DTCs (cont.)					
6	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.	251	4
6	6	Ignition Voltage Too High	Measure ignition voltage. Insure that ignition voltage is correct for the model of ECU. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.	251	3
6	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.	251	4
6	8	Input Voltage Has Excessive Noise (Temporary)	Check alternator output for excessive noise. Check for other devices causing excessive noise.	251	2
6	9	Input Voltage Has Excessive Noise	Check alternator output for excessive noise. Check for other devices causing excessive noise.	251	14
Pressure Modulator Valve DTCs					
7	1	SA Left PMV REL 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[1]. Check for corroded/damaged wiring or connectors between and PMV.	48	4
8	1	SA Right PMV REL Solenoid Shorted to Ground		49	4
9	1	DA Left PMV REL Solenoid Shorted to Ground		50	4
10	1	DA Right PMV REL Solenoid Shorted to Ground		51	4
16	1	AA Left PMV REL Solenoid Shorted to Ground		52	4
17	1	AA Right PMV REL Solenoid Shorted to Ground		53	4
7	2	SA Left PMV REL 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[1]. Check for corroded/damaged wiring or connectors between and PMV.	48	3
8	2	SA Right PMV REL Solenoid Shorted to Voltage		49	3
9	2	DA Left PMV REL Solenoid Shorted to Voltage		50	3
10	2	DA Right PMV REL Solenoid Shorted to Voltage		51	3
16	2	AA Left PMV REL Solenoid Shorted to Voltage		52	3
17	2	AA Right PMV REL Solenoid Shorted to Voltage		53	3

[1]The resistance values given above are for 12 volt PMVs. For 24 volt PMVs, the REL to CMN & HLD to CMN should be 14.0 to 16.2 ohms, and the REL to HLD value should be 28.0 to 32.4 ohms.

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PRODUCT SPECIFICATION BW-271-PR

1st Digit	2nd Digit	DTC Description	Repair Information	J1587 SID	J1587 FMI
Pressure Modulator Valve DTCs (cont.)					
7	3	SA Left PMV REL 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[1]. Check for corroded/damaged wiring or connectors between and PMV.	48	5
8	3	SA Right PMV REL Solenoid Open Circuit		49	5
9	3	DA Left PMV REL Solenoid Open Circuit		50	5
10	3	DA Right PMV REL Solenoid Open Circuit		51	5
16	3	AA Left PMV REL Solenoid Open Circuit		52	5
17	3	AA Right PMV REL Solenoid Open Circuit		53	5
7	4	SA Left PMV HLD 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[1]. Check for corroded/damaged wiring or connectors between and PMV.	42	4
8	4	SA Right PMV HLD Solenoid Shorted to Ground		43	4
9	4	DA Left PMV HLD Solenoid Shorted to Ground		44	4
10	4	DA Right PMV HLD Solenoid Shorted to Ground		45	4
16	4	AA Left PMV HLD Solenoid Shorted to Ground		46	4
17	4	AA Right PMV HLD Solenoid Shorted to Ground		47	4
7	5	SA Left PMV HLD 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[1]. Check for corroded/damaged wiring or connectors between and PMV.	42	3
8	5	SA Right PMV HLD Solenoid Shorted to Voltage		43	3
9	5	DA Left PMV HLD Solenoid Shorted to Voltage		44	3
10	5	DA Right PMV HLD Solenoid Shorted to Voltage		45	3
16	5	AA Left PMV HLD Solenoid Shorted to Voltage		46	3
17	5	AA Right PMV HLD Solenoid Shorted to Voltage		47	3

[1]The resistance values given above are for 12 volt PMVs. For 24 volt PMVs, the REL to CMN & HLD to CMN should be 14.0 to 16.2 ohms, and the REL to HLD value should be 28.0 to 32.4 ohms

1st Digit	2nd Digit	DTC Description	Repair Information	J1587 SID	J1587 FMI
Pressure Modulator Valve DTCs (cont.)					
7	6	SA Left PMV HLD 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[1]. Check for corroded/damaged wiring or connectors between and PMV.	42	5
8	6	SA Right PMV HLD Solenoid Open Circuit		43	5
9	6	DA Left PMV HLD Solenoid Open Circuit		44	5
10	6	DA Right PMV HLD Solenoid Open Circuit		45	5
16	6	AA Left PMV HLD Solenoid Open Circuit		46	5
17	6	AA Right PMV HLD Solenoid Open Circuit		47	5
7	7	SA Left PMV 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[1]. Check for corroded/damaged wiring or connectors between the ECU and PMV.	7	5
8	7	SA Right PMV CMN Open Circuit		8	5
9	7	DA Left PMV CMN Open Circuit		9	5
10	7	DA Right PMV CMN Open Circuit		10	5
16	7	AA Left PMV CMN Open Circuit		11	5
17	7	AA Right PMV CMN Open Circuit		12	5
7	8	SA Left PMV Configuration Error	A mis-match exists between the ECU configuration and the modulator installation and wiring. Verify PMV wiring and installation. Verify ECU configuration.	7	13
8	8	SA Right PMV Configuration Error		8	13
9	8	DA Left PMV Configuration Error		9	13
10	8	DA Right PMV Configuration Error		10	13
16	8	AA Left PMV Configuration Error		11	13
17	8	AA Right PMV Configuration Error		12	13
J1939 DTCs					
11	1	J1939 Serial Link	Loss of communications between the EC-60™ 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.	231	12
11	2	J1939 Retarder	Loss of communications between the EC-60™ and a retarder over 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.	231	14
11	3	J1939 Engine Communications	Loss of communications between the EC-60™ 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.	231	2

[1]The resistance values given above are for 12 volt PMVs. For 24 volt PMVs, the REL to CMN & HLD to CMN should be 14.0 to 16.2 ohms, and the REL to HLD value should be 28.0 to 32.4 ohms

1st Digit	2nd Digit	DTC Description	Repair Information	J1587 SID	J1587 FMI
Miscellaneous DTCs					
12	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™ 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.	55	7
12	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.	55	2
12	3	Dynamometer Test Mode Active	ECU has been placed in the Dynamometer Test Mode by either the diagnostic blink code switch or an off-board diagnostic tool. ATC is disabled. To cause the ECU to exit the Dynamometer Test Mode, clear the Dynamometer Test Mode DTC using either the diagnostic blink code switch or an off-board diagnostic tool.	17	14
12	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™ and ground. Verify condition and wiring of the retarder relay.	13	2
12	5	Retarder Relay Circuit Shorted to Voltage	Check wiring between ECU and retarder relay. Verify no continuity between retarder disable output of EC-60™ and voltage. Verify condition and wiring of the retarder relay.	13	3
12	6	ABS Dash Indicator Circuit DTC	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).	23	2

1st Digit	2nd Digit	DTC Description	Repair Information	J1587 SID	J1587 FMI
Miscellaneous DTCs (cont.)					
12	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.	93	4
12	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.	93	3
12	9	ATC Disabled to Prevent Brake Fade	ATC is temporarily disabled to prevent excessive heating of the foundation brakes. See Figure 16 ATC Brake Fade Timing for details.	17	14
12	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.	79	13
12	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.	22	7
12	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.	102	5
12	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.	102	3
12	23	I / O 2 or I / O 3 Shorted High	Check for a short circuit condition between voltage and the I / O 2 or I / O 3 circuits.	154	3
ECU DTCs					
13	2	ECU DTC (10)	Check for damaged or corroded connectors. Check for damaged wiring. Clear DTCs. If DTCs return, replace the ECU.	254	12
13	3	ECU DTC (11)		254	12
13	4	ECU DTC (12)		254	2
13	5	ECU DTC (13)		254	2
13	6	ECU DTC (14)		254	12
13	7	ECU DTC (15)		254	2
13	8	ECU DTC (16)		254	13
13	9	ECU DTC (17)		254	13
13	10	ECU DTC (18)		254	12
13	11	ECU DTC (1A)		254	12
13	12	ECU DTC (1B)		254	12
13	13	ECU DTC (80)		254	12

1st Digit	2nd Digit	DTC Description	Repair Information	J1587 SID	J1587 FMI
TCV DTCs					
18	1	TCV Solenoid Shorted to Ground	Verify 7 to 19 ohms between TCV and TCV CMN. Verify no continuity between the TCV leads and ground. Check for corroded/damaged wiring or connectors between the ECU and TCV.	18	4
18	2	TCV Solenoid Shorted to Voltage	Verify 7 to 19 ohms between TCV and TCV CMN. Verify no continuity between the TCV leads and voltage. Check for corroded/damaged wiring or connectors between the ECU and TCV.	18	3
18	3	TCV Solenoid Open Circuit	Verify 7 to 19 ohms between TCV and TCV CMN. Check for corroded/damaged wiring or connectors between the ECU and TCV.	18	5
18	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.	18	13

8.6.6 Clearing Active DTCs

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

8.6.7 System Configuration Check

The ABS dash indicator will display system configuration information when the diagnostic blink code switch is depressed and released four times. The indicator will blink out configuration information codes using the following patterns.

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

Table 38 Diagnostic Blink Code System Configuration Check

8.6.8 Dynamometer Test Mode

The ECU will disable ATC and Drag Torque Control when the diagnostic blink code switch is depressed and released five times. The ATC dash indicator will be illuminated, and an appropriate diagnostic message will be broadcast on the J1587 diagnostic link.

If diagnostic blink codes are activated while the ECU is in the dynamometer test mode, a blink code of 12-3 (Dynamometer Test Mode Active) will be generated.

ATC and Drag Torque Control will be disabled until the dynamometer test mode DTC is cleared. This may be accomplished using the diagnostic blink code switch or an off-board diagnostic tool.

CAUTION
Cycling ignition power will not cause the ECU to exit the dynamometer test mode.

8.6.9 ECU Reconfiguration

The ECU may be commanded to perform a reconfiguration event using the diagnostic blink code switch. This is initiated by depressing the diagnostic blink code with ignition power removed, applying ignition power, releasing the switch and then depressing and releasing the switch seven times.

8.7 Remote Diagnostic Unit (RDU)

The *Bendix*® Remote Diagnostic Unit (RDU™) is a handheld diagnostic tool that connects to the vehicle's diagnostic connector and provides diagnostic information using LEDs. It is available in a variety of styles. See BW-277-PR for details.

The RDU is designed to mate with a nine pin diagnostic connector. An adapter harness is available for vehicles with a six pin diagnostic connector.

Figure 21 Remote Diagnostic Unit (Example)

The RDU™ also contains a magnetic reset switch to permit clearing of active DTCs and a method to initiate a reconfiguration event.

The RDU™ contains ten diagnostic LEDs to display system status.

LED	LED Definition	LED Display	LED Color
STR	Steer Axle	DTC Location	Red
ADD	Additional Axle	DTC Location	Red
DRV	Drive Axle	DTC Location	Red
RHT	Right	DTC Location	Red
LFT	Left	DTC Location	Red
TRC	Traction	DTC Type	Red
MOD	Modulator	DTC Type	Red
SEN	Sensor	DTC Type	Red
ECU	ECU	DTC Type	Red
VLT	Input Power	ECU Power	Green

8.7.1 RDU Part Numbers

RDUs are available from BCVS using the following part numbers.

RDU Application	BCVS Part Number
OEM	5012574
Aftermarket	801869

8.7.2 RDU Adapter Harness Part Numbers
The RDU adapter harness is available from BCVS using the following part numbers.

RDU Application	BCVS Part Number
OEM	5012793
Aftermarket	801872

8.8 *Bendix*® *ACOM*™ Diagnostic Software

Bendix® *ACOM*™ Diagnostic Software (version 3.0 or higher) is a RP-1210A compliant PC-based diagnostic software program that provides the highest level of diagnostic support for the EC-60™. With *Bendix*® *ACOM*™ Diagnostic Software, maintenance personnel can:

- Obtain DTC information (both active and inactive DTCs)
- Retrieve event history
- Clear inactive DTCs and event history
- Verify ECU configuration
- Perform system and component tests
- Save and print information
- Receive troubleshooting assistance

When diagnosing the EC-60™ using a PC and *Bendix*® *ACOM*™ Diagnostic Software, the computer's serial or parallel port can be connected to the vehicle's diagnostic connector through a RP-1210A compliant communications device.

Contact BCVS to obtain the diagnostic software.

8.9 Pro-Link™ Support

A Pro-Link™ device (Nexiq® part number 805013) will be available to support EC-60™ diagnostics. Contact Nexiq® for details.

8.10 Technical Assistance

8.10.1 Technical Assistance (Internet)
The EC-60™ Service Data Manual (SD-13-4863) is available for download at www.bendix.com. This manual contains descriptions, maintenance information, and troubleshooting hints to assist in the maintenance of the EC-60™ .

8.10.2 *Bendix*® Technical Assistance Team
For technical assistance, contact 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.

The *Bendix*® Technical Assistance Team may also be reached via email at tbs.techteam@bendix.com.

9.0 SYSTEM INSTALLATION REQUIREMENTS

WARNING
Failure to follow the requirements contained in this section may result in unexpected or unforeseen system performance.

9.1 Overview

While ABS and ATC can increase vehicle safety, they cannot overcome the laws of physics. The ABS and ATC functions can only optimize the utilization of the available traction between the tires and the road.

ABS and ATC cannot compensate for poor driving practices such as failing to maintain proper following distances or driving at excessive speeds.

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

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

WARNING
The EC-60™ must receive input voltage from a circuit fused separately from the ABS dash indicator. This is required to insure that a loss of input power to the ECU does not result in a loss of the ABS dash indicator.

9.2 ECU Installation Requirements

9.2.1 Cab ECUs

9.2.1.1 ECU Mounting Location Requirements

CAUTION
EC-60™s designed for cab mounting are not protected against moisture, and must be mounted in an environmentally protected area.

The product warranty for cab mount ECUs will not cover damage or malfunction of ECUs displaying the effects of moisture.

The ECU must be mounted in a location where the minimum and maximum operating temperatures (-40ºC and +85ºC) are not exceeded.

CAUTION
The ECU may not operate properly outside of the temperatures outlined above. The product warranty will not cover ECUs displaying the effects of operation outside the operating temperature range.

The ECU must be mounted in a location where it is not subjected to impact from the vehicle operator, passengers, their belongings (such as tool boxes), or vehicle accessories.

The preferred mounting location for the cab ECUs are with connectors pointed downwards.

9.2.1.2 ECU Wiring Harness Connectors

The EC-60™ cab ECUs are designed to interface with AMP MCP 2.8 connectors as referenced in Table 17 Standard Cab ECU Wire Harness Connectors and Table 18 Premium Cab ECU Wire Harness Connectors.

Follow all AMP requirements for the manufacture of wire harnesses.

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

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

9.2.2 Frame ECUs

9.2.2.1 ECU Mounting Location Requirements

EC-60™s designed for frame mounting must not be subjected to direct tire spray. The ECU should be mounted in a location so that moisture can drain away from it.

The ECU must be mounted in a location where the minimum and maximum operating temperatures (-40ºC and +85ºC) are not exceeded.

CAUTION
Operation of the ECU outside of the temperatures outlined above is not guaranteed. BCVS will not provide warranty for ECUs showing the effects of operation outside the operating temperature range.

The preferred mounting orientation for the frame ECUs is shown below (parallel to the vehicle frame).

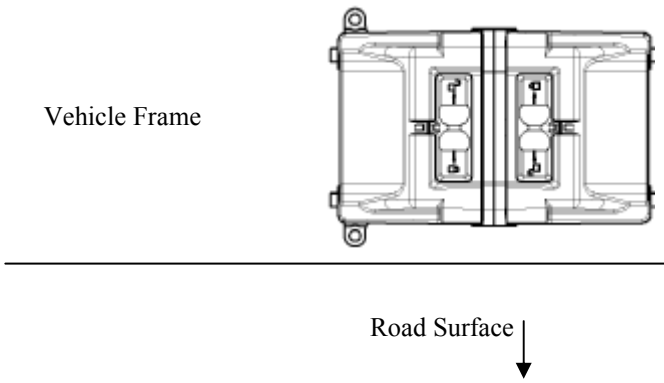

Figure 22 Frame ECU Preferred Mounting Orientation

9.2.2.2 ECU Mounting Bolts

Mounting bolt material must be selected to minimize the possibility of corrosion. The application of appropriate anti-corrosive compounds is recommended.

Torque ECU mounting bolts to 7.5 – 9Nm.

CAUTION

BCVS will not provide warranty coverage for ECUs due to corrosion (or over-torqueing) of the mounting bolts.

9.2.2.3 ECU Wiring Harness Connectors

The EC-60™ frame ECUs are designed to interface with Deutsch connectors as referenced in Table 19 Standard Frame ECU Wire Harness Connectors and Table 20 Premium Frame ECU Wire Harness Connectors.

CAUTION

The frame wire harness connectors must be properly seated with the seals intact and undamaged. Failure to do so could result in moisture or corrosion damage to the connector terminals. BCVS will not provide warranty coverage for ECUs displaying this condition.

Follow all Deutsch requirements for the manufacture of wire harnesses.

CAUTION

Vehicle OEMs must insure that the connectors are protected against paint spray during vehicle assembly.

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

9.2.2.4 Frame ECU Connector Covers
Use of the provided ECU connector covers is required for all frame mount ECUs. See Section 4.6.5 Frame ECU Connector Covers for additional details.

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

9.2.3 ECU Wiring Requirements
As a matter of good engineering practice and to insure maximum system robustness, OEMs should use the maximum size wire supported by the wire harness connectors for battery, ignition, ground, PMV, TCV, Interaxle Differential Lock and Dash Indicator circuits.

All sensor and serial communications circuits (J1587 and J1939) must use twisted pair wiring (one to two twists per inch).

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. Harnesses that are too long increase the possibility of parasitic interference and wire damage. Harnesses that are too short can cause the wire to break or can subject the wire to mechanical strain that in turn can lead to failure of the wire. Excess lengths of wire are not to be wound to form coils.

For ECU wiring requirements, see the appropriate system wiring schematic referenced in Section 4.5 EC-60™ Wire Harness Connector Part Numbers and Pin Assignments.

CAUTION

Connection of any device to the vehicle power lines along with the impedance of the wiring harness may result in loading and / or distortion of the PLC signal.

Vehicle OEMs and those involved in vehicle modification must confirm proper operation of the in-cab trailer ABS dash indicator.

9.2.4 Use of LEDs for Dash Indicators

CAUTION

Use of an LED for the ABS dash indicator (cab ECUs only), ATC dash indicator, or trailer ABS dash indicator requires the addition of a 1kOhm resistor in parallel to the LED to eliminate low-level illumination. The LED must also use an appropriate protective series resistor.

9.3 PMV/TCV Installation Requirements

9.3.1 PMV/TCV Mounting Requirements

CAUTION

Valves must be mounted with the exhaust ports facing in a downward direction. The exhaust ports must not be covered or painted over. Exhaust ports must have a minimum of 1" clearance from all obstructions.

Care must be taken to insure that valve mounting bolts, as well as all fittings installed into valve ports, are not over-torqued.

PMVs/TCV must not be subjected to direct tire spray. Insure that all valves are mounted so that moisture can drain away from them.

The PMV/TCV must be mounted in a location where the minimum and maximum operating temperatures (-40ºC and +85ºC) are not exceeded.

CAUTION

Operation of the PMV/TCV outside of the temperatures outlined above is not guaranteed.

BCVS will not provide warranty for PMVs/TCVs showing the effects of operation outside the operating temperature range.

CAUTION

PMVs installed on vehicles designed for fording require the installation of a snorkel. Contact BCVS for details.

9.3.1.1 Mounting Bolts

Mounting bolt material must be selected to minimize the possibility of corrosion. The application of appropriate anti-corrosive compounds is recommended.

CAUTION
BCVS will not provide warranty coverage for valves due to corrosion of the mounting bolts.

9.3.2 FAM/RAM Mounting Requirements

Refer to the applicable BCVS drawing for installation requirements of RAMs and FAMs.

9.3.3 PMV Pneumatic Requirements

The pneumatic installation must be such that the legally stipulated response times, release times, and pressure buildup times are complied with. This must be tested upon completion of the installation.

Optimum ABS performance takes place at pressure gradients of 290 to 435 PSI/sec when pressure is released through the PMV. The specified values are usually reached when normal brake hose lines are used. If not, the necessary changes must be made. See Figure 23 PMV Pressure Gradient.

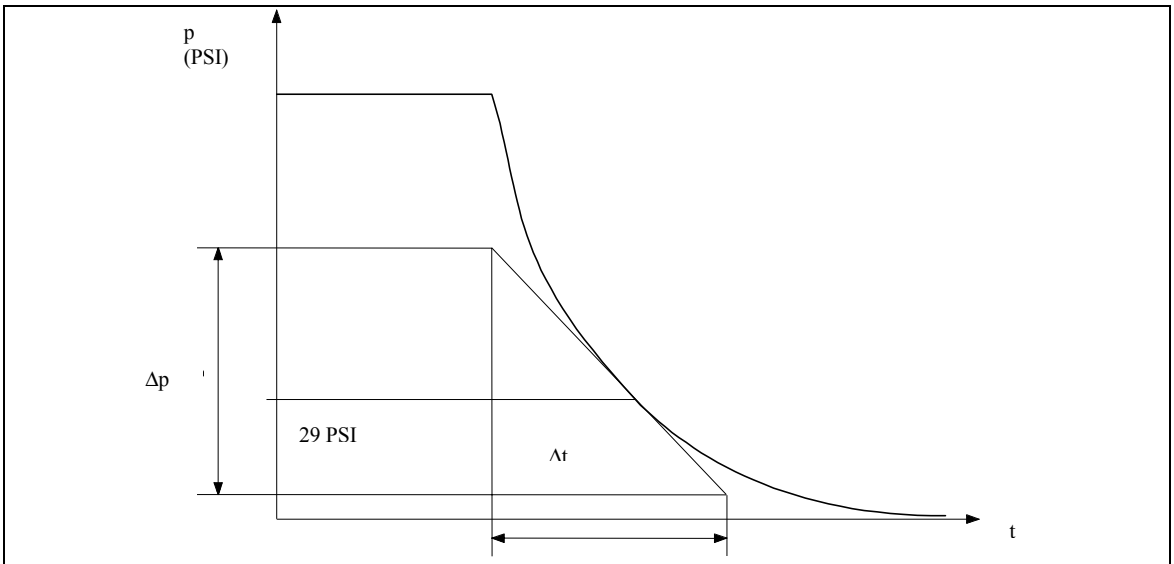

Figure 23 PMV Pressure Gradient

See BW-273-PR for details.

9.3.4 PMV/TCV Wiring Requirements

CAUTION
Vehicle OEMs must insure that the connectors are protected against paint spray during vehicle assembly.

CAUTION
The PMV/TCV wire harness connectors must be properly seated with the seals intact and undamaged and the secondary locks snapped securely in place. Failure to do so could result in moisture or corrosion damage to the connector terminals. BCVS will not provide warranty for PMVs/TCVs displaying this condition.

Follow all connector manufacturer requirements for the fabrication of all wire harnesses.

WARNING
All wires must be carefully routed to avoid contact with rotating elements. Wiring must be properly secured 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 the PMV/TCV connector for a minimum of three inches before the wire is allowed to bend.

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. Harnesses that are too long increase the possibility of parasitic interference and wire damage. Harnesses that are too short can cause the wire to break or can subject the wire to mechanical strain that in turn can lead to failure of the wire. Excess lengths of wire are not to be wound to form coils.

See BW-273-PR for details.

9.4 Wheel Speed Sensor Installation Requirements

See BW-120-A, Application Specification, Wheel Speed Sensor Customer Interface Recommendations for details.

9.4.1 Sensor Mounting Block

9.4.1.1 Material

The mounting block is typically made of steel or other ferro-magnetic material. If a different material is used, it must be analyzed for compatibility with the *Bendix*® wheel speed sensor clamping sleeve.

CAUTION

Sensor mounting blocks must be properly protected against corrosion.

BCVS will not provide warranty for wheel speed sensors and/or clamping sleeves exhibiting corrosion sustained from sensor mounting blocks.

9.4.1.2 Dimensions

The mounting block must be 30.0 mm in length with a 18.0-18.11 mm diameter through-hole.

The block should not exceed 31.0 mm in length. A mounting block length less than 29 mm may not allow the sensor to seat properly.

The sensor block height must be chosen to allow the centerline of the sensor to be aligned with the center of the exciter ring.

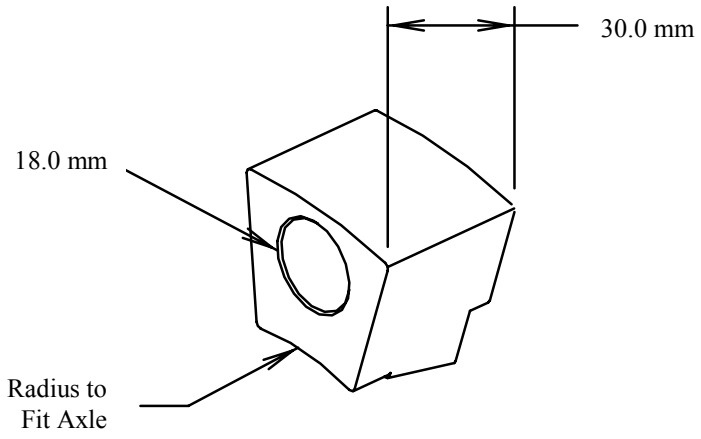

Figure 24 Wheel Speed Sensor Mounting Block

9.4.1.3 Installation

The block is usually welded longitudinally along both sides to ensure long-term mounting security. The axle or vehicle manufacturer typically supplies the sensor mounting block. The clamping sleeve or sensor must not be installed into the sensor mounting block during the welding operation.

The mounting block face must be no more that 0.156 inches (4mm) from the installed location to the face of the exciter ring teeth and the axial alignment of the through-hole must be as close to perpendicular as possible. The exciter ring and sensor should be perpendicular to each other (within ½º). The height from the bottom of the block to the centerline of the hole must be such that the centerline of the sensor is aligned to the center of the exciter ring teeth.

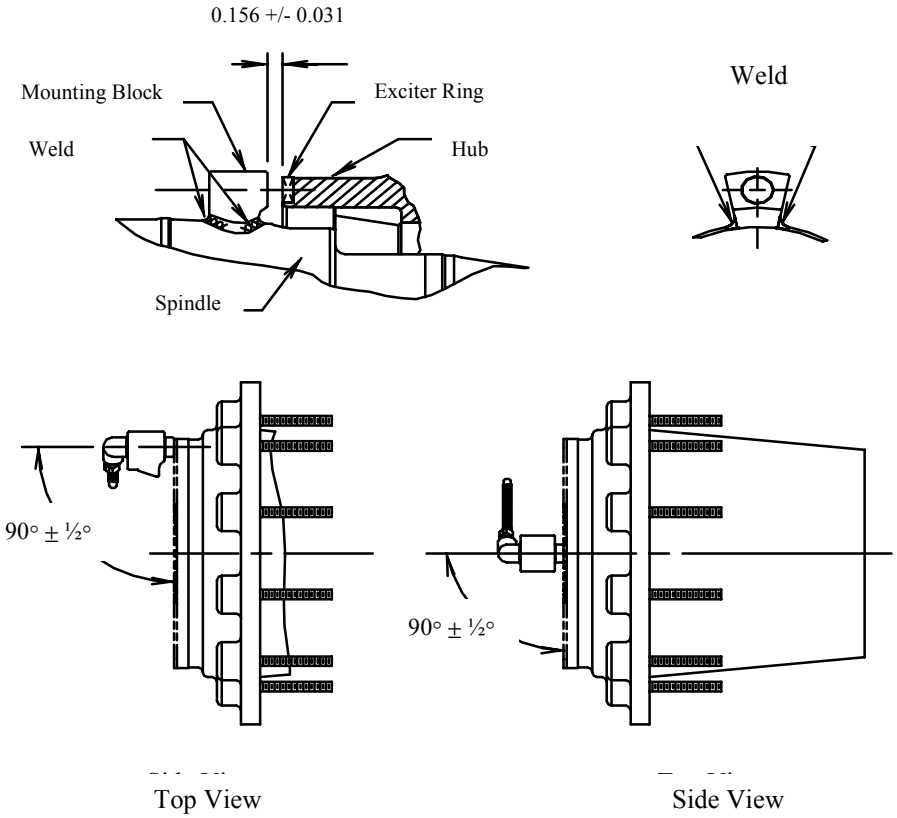

Figure 25 Wheel Speed Sensor Mounting Block Installation

9.4.1.4 Preferred Wheel Speed Sensor Mounting Block Location

The preferred location for the sensor mounting block is between the 2 to 3 o'clock or 9 to 10 o'clock positions on the spindle. This location offers the highest resistance to wheel loading flexure and helps to maintain a uniform sensor to exciter ring air gap during vehicle use.

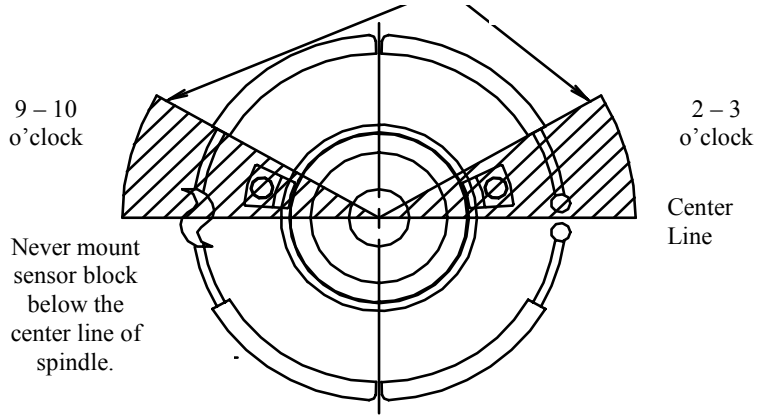

Figure 26 Preferred Wheel Speed Sensor Mounting Block Location

9.4.2 Wheel Speed Sensor Clamping Sleeve Installation

The wheel speed sensor clamping sleeve (*Bendix*® part number 5012878) is designed to firmly hold the wheel speed sensor in place while also allowing the sensor to adjust in position as the wheel and hub rotate. Wheel bearing play and heavily loaded axles will require sensors to self-adjust. Proper sensor installation begins by fully inserting the spring clip into the sensor block with the retaining tabs toward the inside of the vehicle.

CAUTION

Any device used to hold the clamping sleeve in place must be properly protected against corrosion.

BCVS will not provide warranty for wheel speed sensors and/or clamping sleeves exhibiting corrosion sustained from sensor mounting blocks or other devices.

9.4.3 Wheel Speed Sensor Installation

Lubricant may be applied to the inner diameter of the mounting block and/or to the sensor before installation. The sensor is then pushed into the clamping sleeve until it stops against the teeth of the exciter ring. Lubrication is not required for the installation of the sensor, but is recommended.

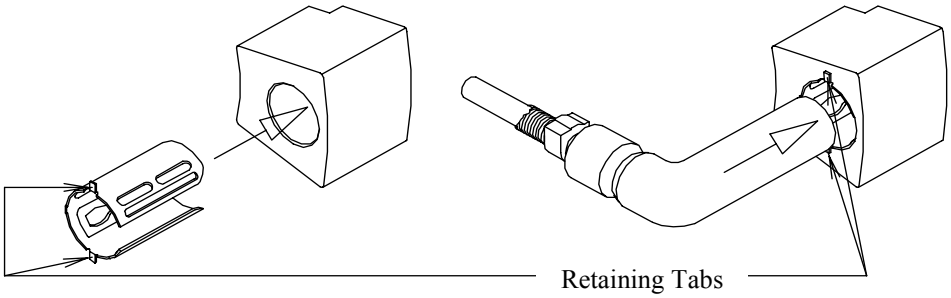

Figure 27 Sensor Clamping Sleeve and Sensor Installation

The wheel speed sensor must be utilized in applications where the minimum and maximum operating temperatures are not exceeded. See BW-260-PR for details.

CAUTION

Operation of the WS-24™ outside of the operating temperature range is not guaranteed.

BCVS will not provide warranty for WS-24™ sensors used in applications outside of the operating temperature range.

9.4.4 Sensor Displacement Force

At 68ºF, the axial force needed to move the sensor when retained with a fully inserted wheel speed sensor clamping sleeve (P/N 5012878) within the sensor mounting block is approximately 22 to 45 pounds (100 to 200N). Values less than 22 pounds could result in movement of the sensor and loss of ABS on that wheel.

9.4.5 Sensor Wiring Requirements

Proper routing and securing of sensor wiring is imperative for reliable system operation.

CAUTION

Vehicle OEMs must insure that the connectors are protected against paint spray during vehicle assembly.

CAUTION

The sensor wire harness connectors must be properly seated with the seals intact and undamaged and the secondary locks snapped securely in place. Failure to do so could result in moisture or corrosion damage to the connector terminals. BCVS will not provide warranty for sensors displaying this condition.

Follow all connector manufacturer requirements for the fabrication of all wire harnesses.

WARNING

All wires must be carefully routed to avoid contact with rotating elements. Wiring must be properly secured as described below using UV stabilized, non-metallic hose clamps or bow-tie cable ties to prevent pinching, binding or fraying.

BCVS will not provide warranty coverage for sensors with damaged wiring.

Sensor wiring coming out of the wheel ends must be routed away from moving brake components and secured to the axle to prevent excess cable length and wiring damage. When securing sensor wires to the axle, 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 securing the cable 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. Wires must be installed 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 Commercial Vehicle Systems LLC
Elyria, OH 44036

PRODUCT SPECIFICATION BW-271-PR

BCVS does not recommend using standard tie-wraps to secure wiring harnesses directly to rubber air lines. This can cause premature wiring failure from excessive expansion when air pressure is applied. Non-metallic hose clamps or bow-tie tie-wraps are preferred.

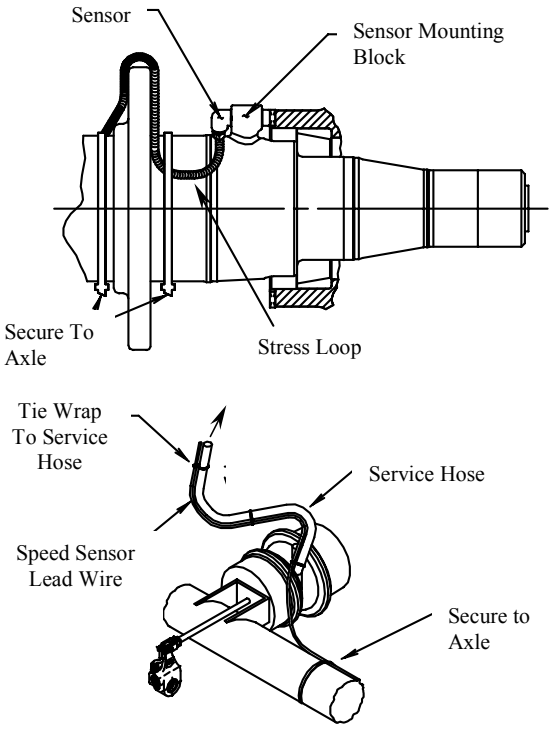

Figure 28 Wheel Speed Sensor Wire Routing

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

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.

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. Harnesses that are too long increase the possibility of parasitic interference and wire damage. Harnesses that are too short can cause the wire to break or can subject the wire to mechanical strain that in turn can lead to failure of the wire. Excess lengths of wire are not to be wound to form coils.

9.5 Exciter Ring Installation Requirements

See BW-120-A, Application Specification, Wheel Speed Sensor Customer Interface Recommendations for details.

9.5.1 Material

The exciter ring material must be permeable and of low magnetic retentively. Examples of suitable exciter ring materials include machined, quenched and drawn steels.

9.5.2 Installation

Exciter rings are typically pressed on to the hub by the hub manufacturer.

If a wheel hub is not available with an exciter ring installed, an exciter ring may be purchased separately and pressed on to a properly prepared hub. A 0.004 inch (0.10mm) interference fit is required between the outer diameter of the machined hub surface and the inner diameter of the exciter ring[1]. It is important that this relationship is established and maintained under all operating conditions.

[1]If the exciter ring is made of powdered iron (sintered), consult the manufacturer for specific instructions on how to install the ring on to the hub.

CAUTION
When altering the hub in any way, the owner assumes all warranty responsibility for the hub. All manufacturer warranties may be void. Contact the hub supplier for details.

The maximum axial runout of the exciter ring must not exceed 0.008 inch (0.2mm).

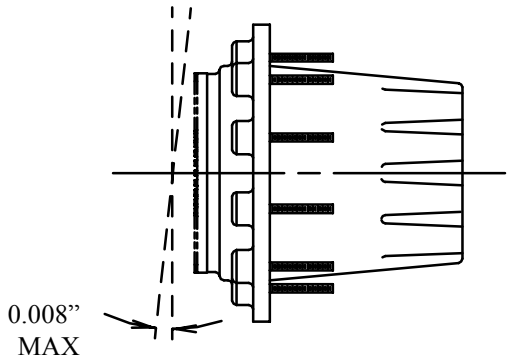

Figure 29 Maximum Exciter Ring Run-Out

9.5.3 Stamped Steel Exciter Ring

A well-designed and manufactured exciter ring produces a clean wheel speed signal. In this respect, a stamped steel exciter ring produces very good results since the teeth are defined by through-holes, and tooth definition (i.e. edge sharpness) is excellent. However, these types of rings are easily damaged before installation on the vehicle, so extra care is required to ensure that they are properly mounted and are running true.

9.5.4 Machined Steel

In the case of a steel exciter ring, the height of each tooth becomes important. Manufacturing considerations influence the solution and a tooth height of 0.078 inches (1.98mm) is common. To obtain a well-defined wheel speed signal, it is important that the sensor pole piece does not bridge the gap between one tooth and the next (nominally 0.078 inches/1.98mm) since magnetic flux saturation will occur and the signal will be degraded.

9.5.5 Oil Seals

Oil seals must clear the inside diameter of the exciter ring and must not extend beyond the face of the ring. Consult the hub supplier for further information.

9.5.6 Exciter Ring Damage

At a minimum, replace the exciter ring if any of the following conditions are detected.

- Damaged, chipped or broken teeth
- Tooth height less than 0.050 inches (1.27 mm)
- Cracked exciter ring
- Rust on exciter ring
- Exciter ring loose on hub

9.6 OEM End-of-Line Testing

System installation should be verified by the vehicle manufacturer through the performance of an End-of-Line (EOL) test.

This test should include, but is not limited to, the following:

1. Recording of the VIN.
2. Verification of the J1587 wiring between the ABS ECU and the dash diagnostic connector.
3. Verification and recording of the *Bendix*® part number of the ECU.
4. Verification and recording of the OEM part number of the ECU (if required).
5. Recording of the ECU serial number.
6. Recording of the ECU software ID.
7. Verification and recording of the ECU configuration.
8. Interrogation of the ECU active DTCs.
9. Interrogation of the ECU's inactive DTCs.
10. Verification of correct battery, ignition, and ground inputs to the ECU.
11. Verification of the correct installation of all wheel speed sensors. This must include sensor location, and verification of sensor output.
12. Verification of the correct installation of all PMVs. This must include PMV location, and proper wiring between the ECU and the PMV (hold and release wires not reversed on a PMV, for example).
13. Verification of the correct installation of the TCV, if installed.
14. Verification of the proper operation of the ABS Dash Indicator, ATC Dash Indicator (if installed), and the trailer ABS Dash Indicator (if installed).
15. Verification of the correct operation of the ABS ORS and the ATC ORS (if installed).
16. Verification of the control of the interaxle differential lock/AWD transfer case (if installed).
17. Verification of ABS performance on each wheel containing a sensor or PMV.
18. Verification of ATC performance (both brake control and engine limiting), if installed.
19. Verification of retarder disable capability.

The vehicle OEM should clear the active and inactive DTC memory of the ECU at the end of the EOL test, and verify that no DTCs exist.

The vehicle OEM should save a report of each EOL test performed for future reference.

Bendix Commercial Vehicle Systems LLC
Elyria, OH 44036

PRODUCT SPECIFICATION BW-271-PR

10.0 ANTILOCK APPLICATION CHECK LIST

Please check the following boxes to verify system integrity.

WARNING
The checklist is provided to assist in the verification of the ABS installation. It remains the responsibility of the vehicle manufacturer to ensure system performance through the performance of an EOL test.

Facility	Technician Name	Date	Job Number/VIN	Vehicle Model

Item	Reference Section	Section 1 ECU Installation (Cab ECU)	Yes	No*	N/A	Comments
1	4.2.3 9.2.1.1	Is the ECU mounted in an environmentally protected area, where it will not be subjected to moisture, temperatures of < -40°C or > +85°C, or impact from the vehicle operator, passengers, or their belongings?	☐	☐	☐	
2	9.2.1.1	Is the ECU mounted with the connectors pointing downward (preferred orientation)?	☐	☐	☐	
3	9.2.1.2	Are all unused ECU connectors covered?	☐	☐	☐	
4	N/A	Are all unused wire harness terminals plugged with sealing plugs?	☐	☐	☐	
5	9.2.4	If LEDs are being utilized for dash indicators, verify the addition of a 1kOhm resistor in parallel to the indicator. Verify that no low-level illumination of the LED occurs.	☐	☐	☐	
6	9.2.1.2	Are all ECU connectors completely latched and seated?	☐	☐	☐	
7	9.2.1.2	Are secondary locks installed in all connectors?	☐	☐	☐	

*If any of the questions were answered with a "No", the Antilock system should be reviewed by a qualified individual. For technical assistance, call the *Bendix*® Technical Assistance Team @ (800) 247-2725.

Bendix Commercial Vehicle Systems LLC
Elyria, OH 44036

PRODUCT SPECIFICATION BW-271-PR

Facility	Technician Name	Date	Job Number/VIN	Vehicle Model

Item	Reference Section	Section 2 ECU Installation (Frame ECU)	Yes	No*	N/A	Comments
8	4.2.3 9.2.2.1	Is the ECU mounted where it will not be subjected to direct wheel spray or temperatures of < -40°C or > +85°C?	☐	☐	☐	
9	9.2.2.1	Is the ECU mounted in a location where moisture can drain away from it?	☐	☐	☐	
10	9.2.2.1	Is the ECU mounted in a sideways manner (preferred orientation)?	☐	☐	☐	
11	9.2.2.2	Has the mounting bolt material been selected to minimize the possibility of corrosion?	☐	☐	☐	
12	9.2.2.2	Are the ECU mounting bolts properly torqued (7.5 – 9 Nm)?	☐	☐	☐	
13	9.2.2.3	For OEM applications, are the ECU connectors protected against paint spray?	☐	☐	☐	
14	9.2.2.3	Are all unused ECU connectors environmentally protected?	☐	☐	☐	
15	9.2.2.3	Are all unused wire harness terminals plugged with sealing plugs?	☐	☐	☐	
16	9.2.2.3	Are all ECU connectors completely latched and seated?	☐	☐	☐	
17	N/A	Are secondary locks installed in all connectors?	☐	☐	☐	
18	4.6.5	Is the proper size convoluted tubing (I.D. of 19 mm) used ?	☐	☐	☐	
19	4.6.5	Are ECU connector covers locked and tie-wrapped in place?	☐	☐	☐	

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Bendix Commercial Vehicle Systems LLC
Elyria, OH 44036

PRODUCT SPECIFICATION BW-271-PR

Facility	Technician Name	Date	Job Number/VIN	Vehicle Model

Item	Reference Section	Section 3 System Wiring	Yes	No*	N/A	Comments
20	4.4.1	Is the battery voltage applied directly to the battery input of the ECU?	☐	☐	☐	
21	4.4.1	Is the battery voltage properly fused (30A)?	☐	☐	☐	
22	4.4.1	Is the ignition voltage applied to the ECU by the ignition switch circuit?	☐	☐	☐	
23	4.4.1	Is the ignition voltage properly fused (5A)?	☐	☐	☐	
24	2.1.4 9.1	Does the ECU receive ignition power from a different circuit than the ABS dash indicator?	☐	☐	☐	
25	9.2.3	Do the battery, ground, PMV, TCV, Interaxle Diff Lock, and WL circuits utilize the largest gauge wire supported by the ECU wire harness connector?	☐	☐	☐	
26	9.2.3	Is the ground wire as short as possible? Are the connections tight, clean, and protected against moisture?	☐	☐	☐	
27	9.2.3	Does the SAE J1587 circuit utilize twisted pair wiring?	☐	☐	☐	
28	9.2.3	Does the SAE J1939 circuit utilize twisted pair wiring? Does J1939 system installation comply with SAE J1939-11 or J1939-15?	☐	☐	☐	
29	9.2.3	Does all sensor wiring utilize twisted pair?	☐	☐	☐	
30	9.4.5	Where sensor wiring comes out of the wheel end, is it routed away from moving brake components? Is it secured to the axle within 3 inches of the sensor head? Are stress loops utilized where possible?	☐	☐	☐	
31	9.4.5	Is sensor wiring then secured to the service brake hoses every 6 to 8 inches?	☐	☐	☐	

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Bendix Commercial Vehicle Systems LLC
Elyria, OH 44036

PRODUCT SPECIFICATION BW-271-PR

Facility	Technician Name	Date	Job Number/VIN	Vehicle Model

Item	Reference Section	Section 3 System Wiring (cont.)	Yes	No*	N/A	Comments
32	9.2.3	Is all wiring secured by UV stabilized, non-metallic hose clamps or bow-tie cables ties?	☐	☐	☐	
33	9.2.3	Is all wiring carefully routed to avoid rotating elements of the vehicle? Is wiring routed away from all sharp edges?	☐	☐	☐	
34	9.4.5	If the wire harness is routed through a frame member, are grommets used to prevent chaffing?	☐	☐	☐	
35	9.2.3	If the wiring is placed in convoluted tubing, is the I.D. of the tubing as close as possible to the size of the harness?	☐	☐	☐	
36	N/A	For OEM applications, are the WSS, PMV, TCV, and Interaxle Diff Lock connectors protected against paint spray?	☐	☐	☐	
37	N/A	Are all connectors completely latched and seated? Are secondary locks installed?	☐	☐	☐	
38	9.2.3	Are wires permitted to come straight out of all connectors for a minimum of 3 inches before bending?	☐	☐	☐	
39	9.2.3	Is the wire harness the proper length?	☐	☐	☐	
40	9.2.3	Is excess wire properly secured (not wound to form coils)?	☐	☐	☐	

*If any of the questions were answered with a "No", the Antilock system should be reviewed by a qualified individual. For technical assistance, call the *Bendix*® Technical Assistance Team @ (800) 247-2725.

Bendix Commercial Vehicle Systems LLC
Elyria, OH 44036

PRODUCT SPECIFICATION BW-271-PR

Facility	Technician Name	Date	Job Number/VIN	Vehicle Model

Item	Reference Section	Section 4 Pressure Modulator Valve (PMV)/Traction Control Valve (TCV) Front Axle Module (FAM)/Rear Axle Module (RAM) Installation	Yes	No*	N/A	Comments
41	9.3.1	Are all valves mounted with the exhaust port facing in a downward direction?	☐	☐	☐	
42	9.3.1	Are all valve exhaust ports unobstructed (minimum of 1" clearance)?	☐	☐	☐	
43	9.3.1	Are all valves mounted where they will not be subjected to direct wheel spray or temperatures of < -40°C or > +85°C?	☐	☐	☐	
44	9.3.1	Are all valves mounted in a location where moisture can drain away from them?	☐	☐	☐	
45	9.3.1	Are all mounting bolts properly torqued?	☐	☐	☐	
46	9.3.1.1	Has the mounting bolt material been selected to minimize the possibility of corrosion?	☐	☐	☐	
47	9.3.1	Are all fittings/brake hoses installed in the valve ports properly torqued?	☐	☐	☐	
48	9.3.1	If the vehicle is designed for fording operations, do all PMV exhaust ports contain snorkels?	☐	☐	☐	
49	9.3.3	Does the pneumatic installation comply with all FMVSS 121 requirements for brake response times, release times, and pressure build-up timing?	☐	☐	☐	
50	9.3.3	Are pressure gradients of 290 to 435 PSI/sec obtained when exhausting air through all PMV exhaust ports?	☐	☐	☐	

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Bendix Commercial Vehicle Systems LLC
Elyria, OH 44036

PRODUCT SPECIFICATION BW-271-PR

Facility	Technician Name	Date	Job Number/VIN	Vehicle Model

Item	Reference Section	Section 5 Wheel Speed Sensor Installation	Yes	No*	N/A	Comments
51	9.4.1.1	Are the sensor mounting blocks properly protected against corrosion?	☐	☐	☐	
52	9.4.1.2	Are the sensor mounting block dimensions correct? (no longer than 31.0 mm in length with a minimum of 29 mm; through-hole dimension of 18.0 to 18.11 mm)	☐	☐	☐	
53	9.4.1.2	Does the sensor block height allow the centerline of the sensor to be aligned properly with the exciter ring?	☐	☐	☐	
54	9.4.1.3	Are the sensor mounting blocks properly welded to the spindle (or properly mounted)? (mounting block face no more than 4 mm to the face of the exciter ring teeth; within ½° of perpendicular to the exciter ring)	☐	☐	☐	
55	9.4.1.4	Are the sensor mounting blocks installed in the preferred location? (between 2 to 3 o'clock or 9 to 10 o'clock)	☐	☐	☐	
56	9.4.1.4	Are the sensor mounting blocks mounted above the centerline of the spindle?	☐	☐	☐	
57	9.5.1	Are the exciter rings made out of an acceptable material? (permeable and of low magnetic retentive material)	☐	☐	☐	
58	9.5.4	Do the exciter rings contain 100 teeth? Are the teeth undamaged and well defined? Are the teeth the proper width so that the sensor pole piece does not bridge the gap between one tooth and another?	☐	☐	☐	
59	9.5.2	Are the exciter rings properly mounted to the hubs? (not loose, run-out of <0.008", interference fit of 0.004" between the O.D. of the machined hub surface and the I.D. of the exciter ring)	☐	☐	☐	
60	9.5.4	Do the exciter rings contain the correct tooth height? (typically 1.98 mm)	☐	☐	☐	

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Bendix Commercial Vehicle Systems LLC
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PRODUCT SPECIFICATION BW-271-PR

Facility	Technician Name	Date	Job Number/VIN	Vehicle Model

Item	Reference Section	Section 5 Wheel Speed Sensor Installation (cont.)	Yes	No*	N/A	Comments
61	9.5.5	Do the oil seals clear the I.D. of the exciter rings and not extend beyond the face of the ring?	☐	☐	☐	
62	9.4.2	Are the correct clamping sleeves (*Bendix*® part number 5012878) being used?	☐	☐	☐	
63	9.4.3	Are the clamping sleeves fully inserted into the sensor mounting blocks, with the retaining tabs toward the inside of the vehicle?	☐	☐	☐	
64	9.4.2	Are devices used to hold the clamping sleeves in place properly protected against corrosion?	☐	☐	☐	
65	9.4.3	Has lubricant been applied to the I.D. of the mounting blocks and/or the sensors?	☐	☐	☐	
66	9.4.3	Have all sensors been installed completely against the exciter ring?	☐	☐	☐	
67	9.4.3	Are the sensors being installed in an application that does not subject them to temperatures outside of their operating range?	☐	☐	☐	

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Bendix Commercial Vehicle Systems LLC
Elyria, OH 44036

PRODUCT SPECIFICATION BW-271-PR

Facility	Technician Name	Date	Job Number/VIN	Vehicle Model

Item	Reference Section	Section 6 System Check-Out	Yes	No*	N/A	Comments
68	5.7.5	With the brake system fully charged with air, fully apply the service brakes and hold. Apply ignition power. Does each PMV exhaust air in the following pattern (Steer Axle Right, Steer Axle Left, Drive Axle Right, and Drive Axle Left – Additional Axle Right, and Additional Axle Left - if equipped with five or six PMVs)?	☐	☐	☐	
69	5.7.5	Does each PMV exhaust air once per pattern (not twice)?	☐	☐	☐	
70	5.7.5	Does the pattern of PMV exhausts repeat?	☐	☐	☐	
71	5.7.1	Did the ABS dash indicator illuminate for a period of approximately three seconds and then extinguish? (assuming no Diagnostic Trouble Codes - DTCs are present)	☐	☐	☐	
72	4.4.3 4.4.10	Remove the X1 connector from the ECU. Is the ABS dash indicator illuminated?	☐	☐	☐	
73	5.7.2	Did the ATC dash indicator illuminate for a period of approximately 2.5 seconds and then extinguish? (assuming ATC is installed and no DTCs are present)	☐	☐	☐	
74	8.5	Does the ABS dash indicator illuminate as required when ABS is disabled due to a DTC in the system?	☐	☐	☐	
75	8.5	Does the ATC dash indicator illuminate as required when ATC is disabled due to a DTC in the system?	☐	☐	☐	

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Facility	Technician Name	Date	Job Number/VIN	Vehicle Model

Item	Reference Section	Section 6 System Check-Out (cont.)	Yes	No*	N/A	Comments
76	5.7.3	If the vehicle is equipped to tow a trailer with air brakes, is it equipped with a trailer ABS dash indicator and a Power Line Carrier (PLC) capable ECU? Does the trailer ABS dash indicator illuminate as required (may require the use of a trailer ABS ECU or a PLC test device)?	☐	☐	☐	
77	8.6.7	When the diagnostic blink code switch is depressed and released four times, does the ABS dash indicator display system configuration? Does the configuration match the vehicle configuration?	☐	☐	☐	
78	8.6.8	If the vehicle is equipped with ATC, does the ATC dash indicator illuminate when the diagnostic blink code switch is depressed and released five times? Is ATC re-enabled when the diagnostic blink code switch is depressed and released three times?	☐	☐	☐	
79	4.4.18 5.1.5	If the vehicle is equipped with the optional ABS Off-Road feature, verify that the vehicle will operate on unpaved road surfaces and/or off-road applications.	☐	☐	☐	
80	4.4.18 5.1.5	If the vehicle is equipped with the optional ABS Off-Road feature, verify that the vehicle manufacturer has taken steps to insure that the vehicle complies with FMVSS 121 and has proper operator warnings and instructions.	☐	☐	☐	
81	4.4.18 5.1.5	If the vehicle is equipped with an ABS Off-Road Switch, does the ABS dash indicator flash continuously when the switch is activated?	☐	☐	☐	
82	4.4.19 5.2.5	If the vehicle is equipped with an ATC Off-Road Switch, does the ATC dash indicator flash continuously when the switch is activated?	☐	☐	☐	
83	4.4.15	Does communications exist between the ECU and an off-board diagnostic device over the J1587 link?	☐	☐	☐	

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PRODUCT SPECIFICATION BW-271-PR

Facility	Technician Name	Date	Job Number/VIN	Vehicle Model

Item	Reference Section	Section 6 System Check-Out (cont.)	Yes	No*	N/A	Comments
84	4.3	Is the correct ECU installed? (verify ECU part number)	☐	☐	☐	
85	4.5	Are all sensors wired properly to the ECU? (for example, Steer Axle Left Sensor to Steer Axle Left Sensor ECU input)	☐	☐	☐	
86	8.6.5	Do all sensors have acceptable signal output (0.25 VAC @ 0.5 RPS)?	☐	☐	☐	
87	3.2	Are all PMVs plumbed correctly? (supply line to supply port, delivery line to delivery port)	☐	☐	☐	
88	4.5	Are all PMVs wired properly to the ECU? (for example, Steer Axle Left PMV Release to Steer Axle Left PMV Release ECU input)	☐	☐	☐	
89	4.5	If the vehicle is All Wheel Drive (AWD) capable, is the ECU configured and wired to control the Interaxle Differential Lock solenoid?	☐	☐	☐	
90	5.5.5.1	If the vehicle is equipped with a J1939 retarder, has the ECU configured itself to control the retarder?	☐	☐	☐	
91	5.5.5.2	If the vehicle is equipped with a retarder relay, is the ECU configured to control the relay?	☐	☐	☐	
92	5.2.4	Does the ECU perform ABS properly on each wheel?	☐	☐	☐	
93	5.2.3	Does the ECU perform brake ATC control properly?	☐	☐	☐	
94	5.2.4	Does the ECU perform engine ATC control properly?	☐	☐	☐	
95	5.1.7	If the vehicle is AWD capable, does the ECU use the Interaxle Differential Lock solenoid to take the vehicle out of the AWD mode when ABS is active?	☐	☐	☐	

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