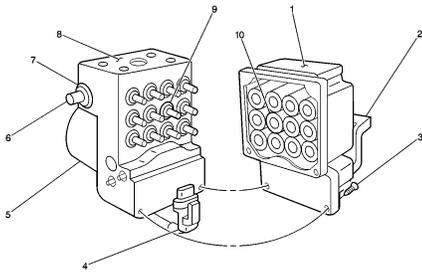


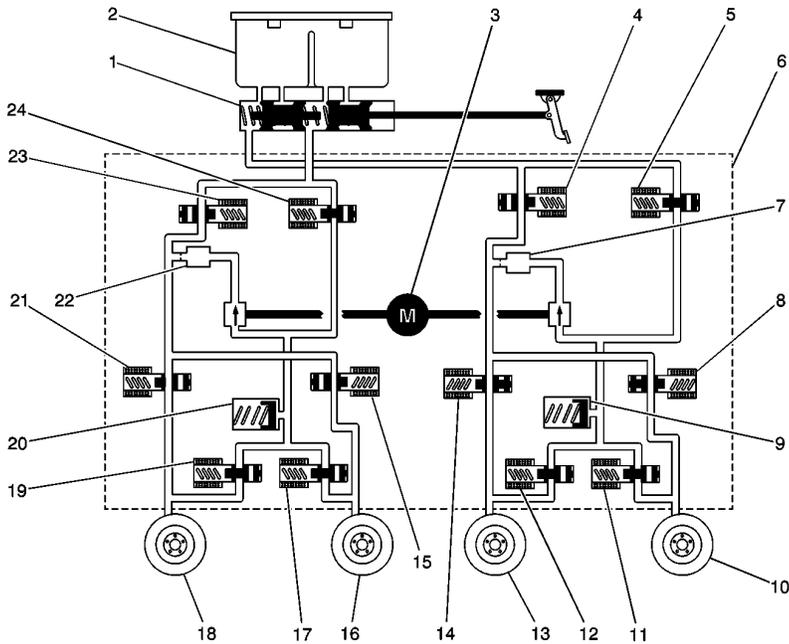
## ABS Description and Operation

### BPMV and EBCM



- (1) Electronic Brake Control Module (EBCM)
- (2) EBCM Electrical Connector
- (3) EBCM to Brake Pressure Modulator Valve (BPMV) Screw
- (4) BPMV Electrical Connector
- (5) BPMV Pump Motor
- (6) BPMV Bracket Bolts
- (7) Rubber Isolator
- (8) BPMV
- (9) BPMV Solenoid Valves
- (10) EBCM Solenoid Valve Coils

### BPMV Hydraulic Flow



- (1) Master Cylinder
- (2) Master Cylinder Reservoir
- (3) Pump
- (4) Rear Master Cylinder Isolation Valve
- (5) Rear Prime Valve
- (6) Brake Pressure Modulator Valve (BPMV)
- (7) Damper
- (8) Right Rear Inlet Valve
- (9) Accumulator
- (10) Right Rear Brake

- (11) Right Rear Outlet Valve
- (12) Left Rear Outlet Valve
- (13) Left Rear Brake
- (14) Left Rear Inlet Valve
- (15) Left Front Inlet Valve
- (16) Left Front Brake
- (17) Left Front Outlet Valve
- (18) Right Front Brake
- (19) Right Front Outlet Valve
- (20) Accumulator
- (21) Right Front Inlet Valve
- (22) Damper
- (23) Front Master Cylinder Isolation Valve
- (24) Front Prime Valve

This vehicle is equipped with the Delco/Bosch 5.3 antilock braking system.

The vehicle is equipped with the following braking systems:

- Antilock Brake System (ABS)
- Dynamic Rear Proportioning (DRP)
- Traction Control System (TCS)
- Vehicle Stability Enhancement System (VSES) (w/JL4)

The following components are involved in the operation of the above systems:

- Electronic Brake Control Module (EBCM) - The EBCM controls the system functions and detects failures. The EBCM contains the following components:
  - System Relay - The system relay is energized when the ignition is ON and no ABS DTCs are present. It supplies battery positive voltage to the solenoid valves and pump motor.
  - Vent Tube - The vent tube, located in the EBCM connector, is an opening to the internal cavity of the EBCM. It allows ventilation of the EBCM internals.
- Brake Pressure Modulator Valve (BPMV) - The BPMV contains the hydraulic valves and pump motor that are controlled electrically by the EBCM. The BPMV uses a 4 circuit configuration with a front/rear split. The BPMV directs fluid from the reservoir of the master cylinder to the front wheels and fluid from the other reservoir to the rear wheels. The circuits are hydraulically isolated so that a leak or malfunction in one circuit will allow continued braking ability on the other.

**Important:** There is a rubber isolator located under the BPMV and on the mounting studs. The rubber isolators protect the BPMV and the EBCM from vehicle vibrations.

- The BPMV contains the following components:
  - Pump Motor
  - Inlet Valves (one per wheel)
  - Outlet Valves (one per wheel)
  - Master Cylinder Isolation Valves (one per drive wheel)
  - Prime Valves (one per drive wheel)
- Wheel Speed Sensors (WSS) - As the wheel spins, the wheel speed sensor produces an AC signal. The EBCM uses this AC signal to calculate wheel speed. The wheel speed sensors are replaceable only as part of the wheel hub and bearing assemblies.
- Traction Control Switch - The TCS is manually disabled or enabled using the traction control switch.
- Stoplamp Switch - The EBCM uses the stoplamp switch as an indication that the brake pedal is applied.
- Lateral Accelerometer Sensor (w/JL4) - The EBCM uses the lateral accelerometer sensor as an indication of the lateral acceleration of the vehicle.
- Yaw Rate Sensor (w/JL4) - The EBCM uses the yaw rate sensor as an indication of the yaw rate of the vehicle.
- Steering Wheel Position Sensor (SWPS) (w/JL4) - The EBCM uses the SWPS as an indication of the position and rotation of the steering wheel.
- Brake Fluid Pressure Sensor (w/JL4) - The brake fluid pressure sensor is attached to the BPMV. The EBCM uses the brake fluid pressure sensor as an indication of the brake fluid pressure in the BPMV.

#### Initialization Sequence

The EBCM performs 1 initialization test each ignition cycle. The initialization of the EBCM occurs when 1 set of the following conditions occur:

Both of the following conditions occur:

- The EBCM detects that there is a minimum of 500 RPM from the PCM via a serial data message.
- The stop lamp switch is not applied.

OR

Both of the following conditions occur:

- The vehicle speed is greater than 16 km/h (10 mph).
- The stop lamp switch is applied.

The initialization sequence may also be commanded with a scan tool.

The initialization sequence cycles each solenoid valve and the pump motor, as well as the necessary relays, for approximately 1.5 seconds to check component operation. The EBCM sets a DTC if any error is detected. The initialization sequence may be heard and felt while it is taking place, and is considered part of normal system operation.

The EBCM defines a drive cycle as the completion of the initialization sequence.

### Antilock Brake System

When wheel slip is detected during a brake application, the ABS enters antilock mode. During antilock braking, hydraulic pressure in the individual wheel circuits is controlled to prevent any wheel from slipping. A separate hydraulic line and specific solenoid valves are provided for each wheel. The ABS can decrease, hold, or increase hydraulic pressure to each wheel brake. The ABS cannot, however, increase hydraulic pressure above the amount which is transmitted by the master cylinder during braking.

During antilock braking, a series of rapid pulsations is felt in the brake pedal. These pulsations are caused by the rapid changes in position of the individual solenoid valves as the EBCM responds to wheel speed sensor inputs and attempts to prevent wheel slip. These pedal pulsations are present only during antilock braking and stop when normal braking is resumed or when the vehicle comes to a stop. A ticking or popping noise may also be heard as the solenoid valves cycle rapidly. During antilock braking on dry pavement, intermittent chirping noises may be heard as the tires approach slipping. These noises and pedal pulsations are considered normal during antilock operation.

Vehicles equipped with ABS may be stopped by applying normal force to the brake pedal. Brake pedal operation during normal braking is no different than that of previous non-ABS systems. Maintaining a constant force on the brake pedal provides the shortest stopping distance while maintaining vehicle stability.

### Pressure Hold

The EBCM closes the inlet valve and keeps the outlet valve closed in order to isolate the system when wheel slip occurs. This holds the pressure steady on the brake so that the hydraulic pressure does not increase or decrease.

### Pressure Decrease

The EBCM decreases the pressure to individual wheels during a deceleration when wheel slip occurs. The inlet valve is closed and the outlet valve is opened. The excess fluid is stored in the accumulator until the return pump can return the fluid to the master cylinder.

### Pressure Increase

The EBCM increases the pressure to individual wheels during a deceleration in order to reduce the speed of the wheel. The inlet valve is opened and the outlet valve is closed. The increased pressure is delivered from the master cylinder.

### Dynamic Rear Proportioning (DRP)

The dynamic rear proportioning (DRP) is a control system that replaces the hydraulic proportioning function of the mechanical proportioning valve in the base brake system. The DRP control system is part of the operation software in the EBCM. The DRP uses active control with existing ABS in order to regulate the vehicle's rear brake pressure.

The red brake warning indicator is illuminated when the dynamic rear proportioning function is disabled.

### Traction Control System (TCS) (NW9)

When drive wheel slip is noted while the brake is not applied, the EBCM will enter traction control mode.

First, the EBCM requests the PCM to reduce the amount of torque to the drive wheels via the requested torque signal circuit. The PCM reduces torque to the drive wheels by retarding spark timing and turning off fuel injectors. The PCM reports the amount torque delivered to the drive wheels via the delivered torque signal circuit.

If the engine torque reduction does not eliminate drive wheel slip, the EBCM will actively apply the drive wheel brakes. During traction control braking, hydraulic pressure in each drive wheel circuit is controlled to prevent the drive wheels from slipping. The master cylinder isolation valve closes in order to isolate the master cylinder from the rest of the hydraulic system. The prime valve then opens in order to allow the pump to accumulate brake fluid in order to build hydraulic pressure for braking. The drive wheel inlet and outlet solenoid valves then open and close in order to perform the following functions:

- Pressure hold
- Pressure increase
- Pressure decrease

### Vehicle Stability Enhancement System (VSES)

The vehicle stability enhancement system (VSES) includes an additional level of vehicle control to the EBCM. The VSES is activated by the EBCM calculating the desired yaw rate and comparing it to the actual yaw rate input. The desired yaw rate is calculated from measured steering wheel position, vehicle speed, and lateral acceleration. The difference between the desired yaw rate and actual yaw rate is the yaw rate error, which is a measurement of oversteer or understeer. If the yaw rate error becomes too large, the EBCM will attempt to correct the vehicle's yaw motion by applying differential braking to the left or right front wheel.

The amount of differential braking applied to the left or right front wheel is based on both the yaw rate error and side slip rate error. The side slip rate error is a function of the lateral acceleration minus the product of the yaw rate and vehicle speed. The yaw rate error and side slip rate error are combined to produce the total delta velocity error. When the delta velocity error becomes too large and the VSES system activates, the driver's steering inputs combined with the differential braking will attempt to bring the delta velocity error toward zero.

The EBCM also uses the input from the brake fluid pressure sensor for more accurate braking control during VSES.

The VSES activations generally occur during aggressive driving, in the turns or bumpy roads without much use of the accelerator pedal. When braking during VSES activation, the brake pedal will feel different than the ABS pedal pulsation. The brake pedal pulsates at a higher frequency during VSES activation.

### Rear Stability Control

When the vehicle performs a high speed turn or curve, the EBCM will enter rear stability control mode. The vehicle speed is greater than 48 km/h (30 mph) and the vehicle lateral acceleration is greater than 0.6 g. The vehicle will exit rear stability control when the vehicle speed is less than 40 km/h (25 mph) or the vehicle lateral acceleration is less than 0.4 g.

During a rear stability control event, the EBCM performs a pressure increase on the outside rear brake and a pressure hold on the inside rear brake. The driver may hear the pump motor run and may feel a vibration in the brake pedal.

### Brake System Indicator(s)

#### **BRAKE**

The IPC illuminates the brake indicator when the following occurs:

- The IPC detects a low brake fluid condition (signal circuit is low).
- The IPC detects the park brake is engaged (signal circuit low).
- The IPC performs the displays test at the start of each ignition cycle. The indicator illuminates for approximately 3 seconds.
- There is a Dynamic Rear Proportioning (DRP) failure.

#### **LOW BRAKE FLUID**

The IPC illuminates the LOW BRAKE FLUID indicator in the message center when the IPC receives a hardwire input from the brake fluid level sensor (signal is low).

### ABS Indicator(s)

#### **ABS**

The IPC illuminates the ABS indicator when the following occurs:

- The electronic brake control module (EBCM) detects a malfunction with the antilock brake system. The IPC receives a class 2 message from the EBCM requesting illumination.
- The driver information center displays the SERVICE ABS message, SERVICE ACTIVE HNDLG message, TRAC/ACT HNDLG-ON/OFF message, TRACTION SYS ACTIVE message, or the TRACTION SYSTEM-ON/OFF message.
- The IPC performs the displays test at the start of each ignition cycle. The indicator illuminates for approximately 3 seconds.

#### **ABS ACTIVE**

The IPC illuminates the ABS ACTIVE indicator in the message center when the electronic brake control module (EBCM) detects the antilock brake system is on. The IPC receives a class 2 message from the EBCM requesting illumination. The DIC displays this message for 3.5 seconds.

#### **SERVICE ABS**

The IPC illuminates the SERVICE ABS indicator in the message center when the following occurs:

- The EBCM detects no anti-lock brakes on the vehicle. The IPC receives a class 2 message from the EBCM requesting illumination.
- The IPC also illuminates the ABS indicator and the traction control and active handling system indicator along with a chime when this message is on.

### Traction Control and Active Handling System Indicator(s)

#### **ACT HNDLG-WARMING UP**

The IPC illuminates the ACT HNDLG-WARMING UP indicator in the message center when the following occurs:

- The active handling option needs to be present in order for this indicator to appear. The EBCM detects that the engine is on and the vehicle speed is at 6 mph (10 km/h) or below. The IPC receives a class 2 message from the EBCM. The DIC will display this message for 3.5 seconds and then turn off. A chime will sound will this message is displayed.
- When this message is displayed the traction control and active handling system indicator turns on.

#### **ACTIVE HANDLING**

The active handling option needs to be present in order for this indicator to appear. The IPC illuminates the ACTIVE HANDLING indicator in the message center when the EBCM detects that the vehicle stability enhancement system is on. The IPC receives a class 2 message from the EBCM. The DIC will display this message for 3.5 seconds and then turn off.

#### **COMPETITIVE DRIVING**

The IPC illuminates the COMPETITIVE DRIVING indicator in the message center when the following occurs:

- The active handling option needs to be present in order for this indicator to appear. The EBCM detects that competitive driving is on. The IPC receives a class 2 message from the EBCM.
- When competitive driving is on and this message is displayed the traction control and active handling system indicator turns off.
- When competitive driving is on and this message is displayed the TRAC/ACT HNDLG-ON/OFF message will be turned off in the message center, unless the TRAC/ACT HNDLG-ON was on before the COMPETITIVE DRIVING message turned on. If the TRAC/ACT HNDLG-ON was on before the COMPETITIVE DRIVING message then after the COMPETITIVE DRIVING message is displayed the TRAC/ACT HNDLG-OFF message

will turn on.

### **SERVICE ACTIVE HNDLG**

The IPC illuminates the SERVICE ACTIVE HNDLG indicator in the message center when the following occurs:

- The active handling option needs to be present in order for this indicator to appear. The EBCM detects a problem with the active handling system. The IPC receives a class 2 message from the EBCM.
- The IPC also illuminates the ABS indicator and the traction control and active handling system indicator along with a chime when this message is on.

### **SERVICE TRACTION SYSTEM**

The IPC illuminates the SERVICE TRACTION SYSTEM indicator in the message center when the following occurs:

- The EBCM detects that there is a problem with the traction control system. The IPC receives a class 2 message from the EBCM.
- When the traction system is on and this message is displayed the traction control and active handling system indicator turns on.
- The IPC will also illuminate the SERVICE ACTIVE HNDLG indicator after the SERVICE TRACTION SYSTEM indicator is displayed in the message center, when the active handling system is present.

### **Traction Control and Active Handling**

The IPC illuminates the TRACTION indicator when the following occurs:

- The electronic brake control module (EBCM) detects a traction control event. The IPC receives a class 2 message from the EBCM requesting illumination.
- The driver information center displays the SERVICE ABS, the ACT HNDLG-WARMING UP, the SERVICE ACTIVE HNDLG, the SERVICE TRACTION SYSTEM, the TRAC/ACT HNDLG-ON/OFF, or the TRACTION SYSTEM-ON/OFF message.
- The IPC performs the display test at the start of each ignition cycle. The indicator illuminates for approximately 3 seconds.

### **TRAC/ACT HNDLG-ON/OFF**

The IPC illuminates the TRAC/ACT HNDLG-ON/OFF indicator in the message center when the following occurs:

- The active handling option needs to be present in order for this indicator to appear. The EBCM detects that the traction/active control system switch is pressed on the console. The IPC receives a class 2 message from the EBCM. When the traction/active system is on, the DIC will display this message for 5 seconds and then turn off. If the traction/active system is off, the DIC will display this message continuously until the traction system is turned on.
- When the traction/active system is on and this message is displayed the ABS indicator and the traction control and active handling system indicator turn on.
- If the active handling system is inoperative, the IPC reverts to and illuminates the TRACTION SYSTEM-ON/OFF indicator after the SERVICE ACTIVE HNDLG message is displayed in the message center.

### **TRACTION SYS ACTIVE**

The IPC illuminates the TRACTION SYS ACTIVE indicator in the message center when the electronic brake control module (EBCM) detects the traction control system is limiting wheel spin. The IPC receives a class 2 message from the EBCM requesting illumination. The DIC displays this message for 3.5 seconds. The ABS indicator also turns on when the TRACTION SYS ACTIVE indicator is on.

### **TRACTION SYSTEM-ON/OFF**

The IPC illuminates the TRACTION SYSTEM-ON/OFF indicator in the message center when the following occurs:

- The EBCM detects that the traction control system switch is pressed on the console. The IPC receives a class 2 message from the EBCM. When the traction system is on, the DIC will display this message for 5 seconds and then turn off. If the traction system is off, the DIC will display this message continuously until the traction system is turned on.
- When the traction system is on and this message is displayed the ABS indicator and the traction control and active handling system indicator turn on.
- The IPC illuminates the TRACTION SYSTEM-ON/OFF indicator after the SERVICE ACTIVE HNDLG message is displayed in the message center, when the active handling system is inoperative.

### **WARM UP COMPLETE**

The active handling option needs to be present in order for this indicator to appear. The IPC illuminates the WARM UP COMPLETE indicator in the message center when the EBCM has completed the functional check of the active handling system. The IPC receives a class 2 message from the EBCM. The DIC will display this message for 3.5 seconds and then turn off. A chime will sound with this message is displayed.