Road Sensing Suspension System

General Description

A **continuously variable road sensing suspension (CVRSS) system** adjusts shock absorber and strut damping in relation to road and driving conditions.

The powertrain control module (PCM) is a computer that controls such output functions as electronic fuel injection, spark advance, emission devices, and transaxle shifting.

A **wheel position sensor** sends a voltage signal to the control module in relation to the amount and velocity of vertical wheel movement.

The **continuously variable road sensing suspension (CVRSS) system** is referred to as a real time damping (RTD) system in the onboard diagnostics.

The CVRSS controls damping forces in the front struts and rear shock absorbers in response to various road and driving conditions. The CVRSS system changes shock and strut damping forces in 10 to 12 milliseconds, whereas other suspension damping systems require a much longer time interval to change damping forces. It requires about 200 milliseconds to blink your eye. This gives us some idea how quickly the CVRSS system reacts.

The CVRSS module receives inputs regarding vertical acceleration, wheel-to-body position, speed of wheel movement, vehicle speed, and lift/dive (Figure 8-45). The CVRSS module evaluates these inputs and controls a solenoid in each shock or strut to provide suspension damping control. The solenoids in the shocks and struts can react much faster compared with the strut actuators explained previously in some systems.

The CVRSS module also controls the speed dependent steering system called MagnaSteer® and the electronic level control (ELC). This MagnaSteer® system is similar to the electronic variable orifice (EVO) steering explained in Chapter 12 under conventional and electronic rack and pinion steering gears.

Inputs

Position Sensors. A **wheel position sensor** is mounted at each corner of the vehicle between a control arm and the chassis (Figures 8-46 and 8-47). These sensor inputs provide analog voltage signals to the CVRSS module regarding relative wheel-to-body movement and the velocity of wheel movement (Figure 8-48). The rear position sensor inputs also provide rear suspension height information to the CVRSS module, and this information is used by the module to control the rear suspension trim height. All four position sensors have the same design.

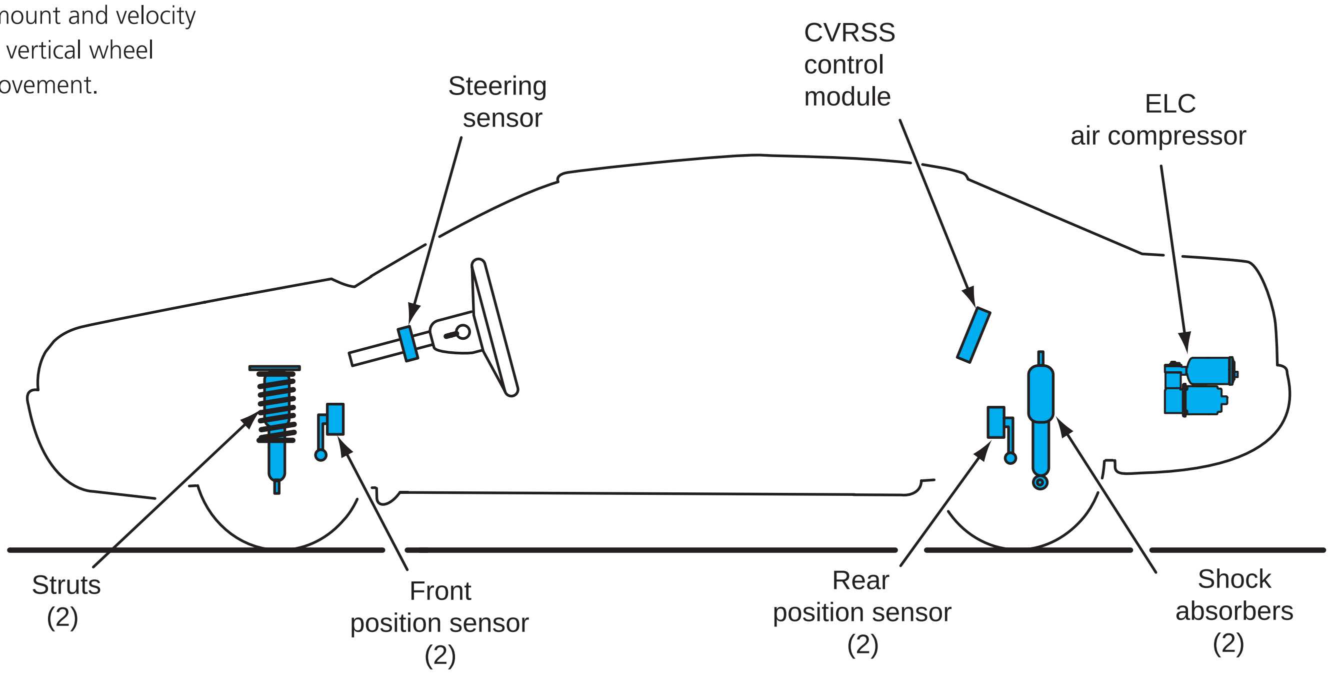

Figure 8-45 Continuously variable road sensing suspension (CVRSS) system components.

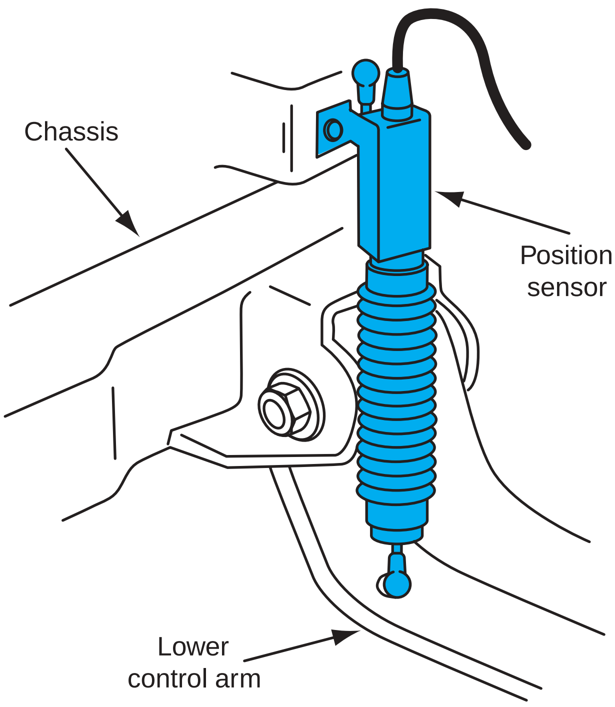

Figure 8-46 Front wheel position sensor.

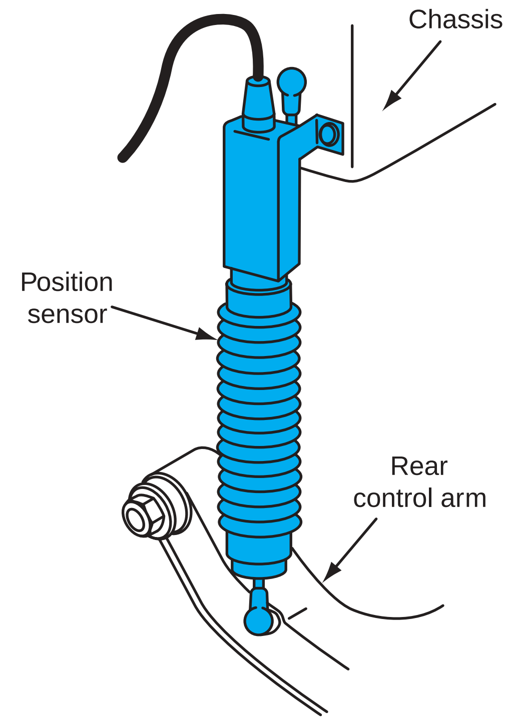

Figure 8-47 Rear wheel position sensor.

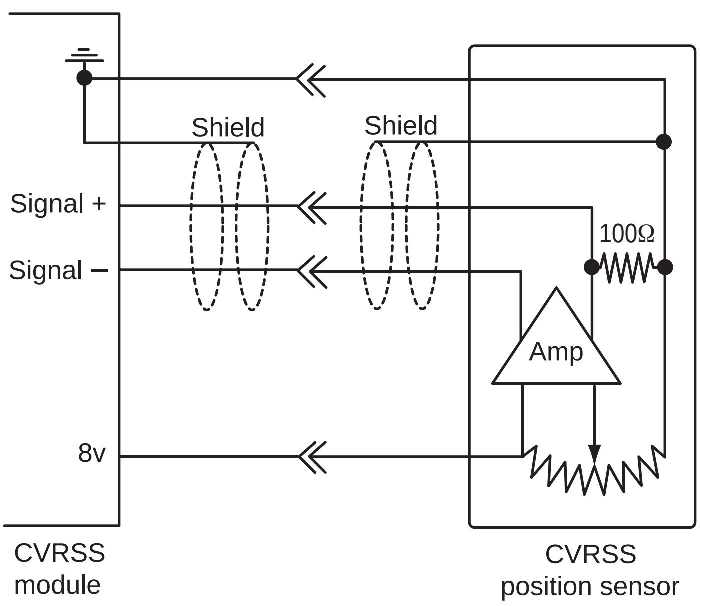

Figure 8-48 Position sensor internal design and wiring diagram.

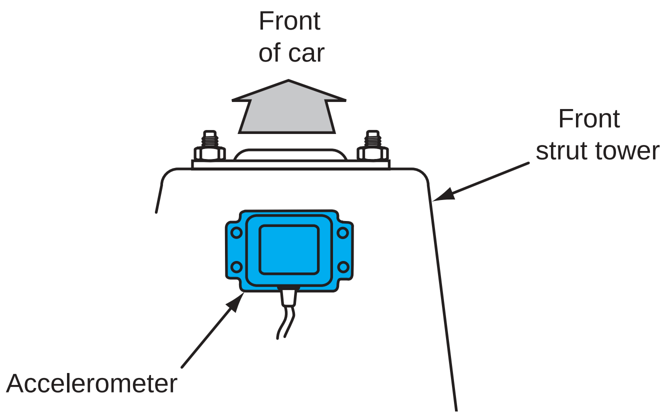

Figure 8-49 Front accelerometer mounting location.

Accelerometer. An accelerometer is mounted on each corner of the vehicle. These inputs send information to the CVRSS module in relation to vertical acceleration of the body. The front accelerometers are mounted on the strut towers (Figure 8-49), and the rear accelerometers are located on the rear chassis near the rear suspension support (Figure 8-50). All four accelerometers are similar in design, and they send analog voltage signals to the CVRSS module (Figure 8-51). On some later model vehicles, the four accelerometers are replaced by a single accelerometer under the driver's seat.

The **vehicle speed sensor (VSS)** is usually mounted in the transaxle case. This sensor produces a voltage signal in relation to vehicle speed.

Vehicle Speed Sensor. The **vehicle speed sensor (VSS)** is mounted in the transaxle. This sensor sends a voltage signal to the powertrain control module (PCM) in relation to vehicle speed (Figure 8-52). The VSS signal is transmitted from the PCM to the CVRSS module.

The **lift/dive input** is a voltage signal sent to the control module in relation to the lifting or lowering of the front of the chassis.

Lift/Dive Input. The **lift/dive input** is sent from the PCM to the CVRSS module (Figure 8-53). Suspension lift information is obtained by the PCM from the throttle position, vehicle speed, and transaxle gear input signals. The PCM calculates suspension dive information from the rate of vehicle speed change when decelerating.

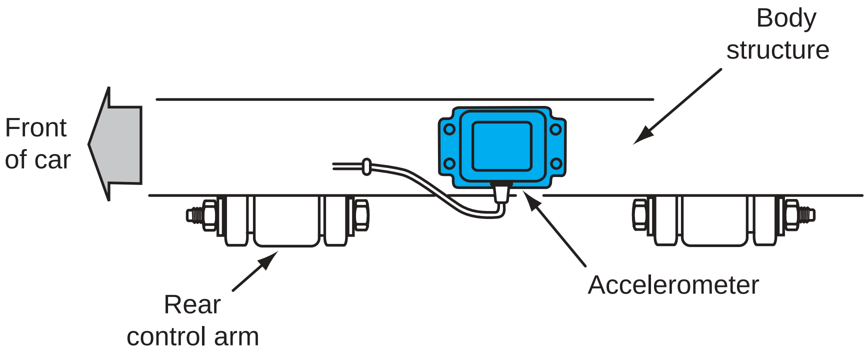

Figure 8-50 Rear accelerometer position.

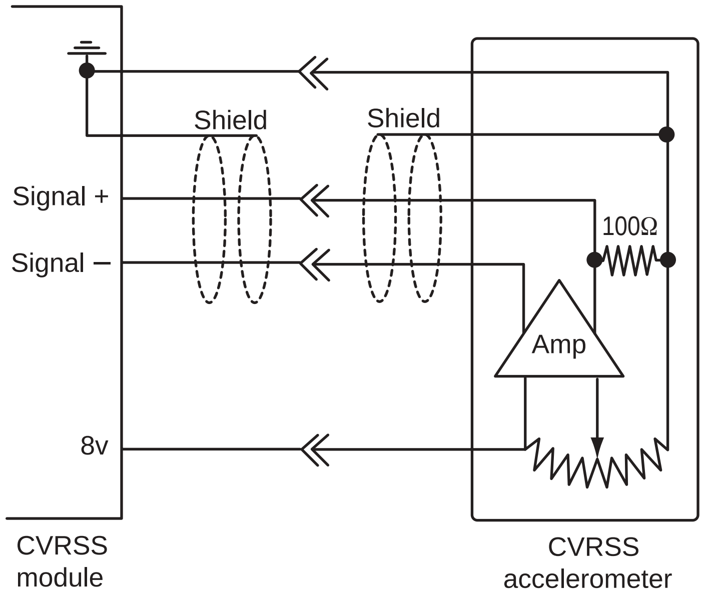

Figure 8-51 Accelerometer internal design and wiring diagram.

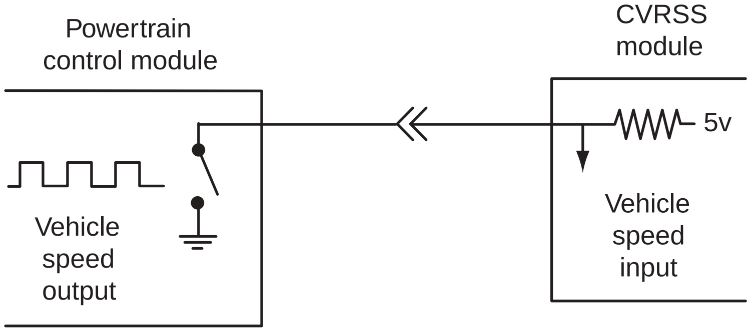

Figure 8-52 The vehicle speed sensor (VSS) signal is sent to the powertrain control module (PCM), and transmitted to the CVRSS module.

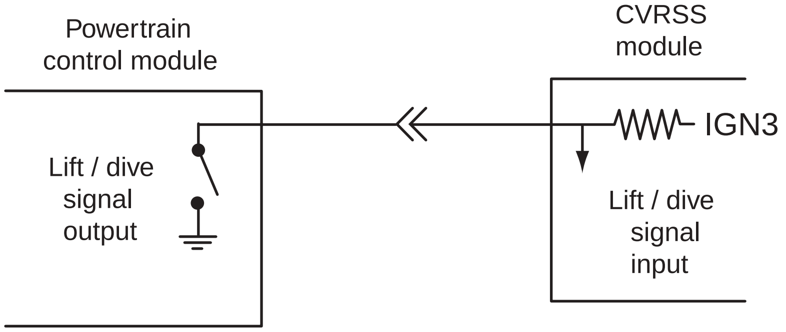

Figure 8-53 The lift-dive signal is sent from the powertrain control module (PCM) to the CVRSS module.

Continuously Variable Road Sensing Suspension Module

The continuously variable road sensing suspension (CVRSS) module contains three microprocessors that control the CVRSS, speed sensitive steering (SSS), and electronic level control (ELC). The CVRSS module is mounted on the right side of the electronics bay in the trunk. Extensive self-diagnostic capabilities are programmed into the CVRSS module.

Outputs

The **damper solenoid valve** is an internal solenoid that controls strut or shock absorber damping.

Damper Solenoid Valves. Each strut or shock damper contains a solenoid that is controlled by the CVRSS module. Each **damper solenoid valve** provides a wide range of damping forces between soft and firm levels. Strut or shock absorber damping is controlled by the amount of current supplied to the damper solenoid in each strut or shock absorber. The damper relay is mounted in the microrelay center located in the trunk. Battery voltage is supplied through a fuse to the damper relay winding and contacts (Figure 8-54). The CVRSS module grounds the damper relay winding to energize the relay winding and close the relay contacts. When these contacts are closed, voltage is supplied from the CVRSS module to the damper solenoids in the struts or shock absorbers. If the damper relay and damper solenoids are not energized, the struts provide minimum damping force. When the damper relay is closed and damper solenoids are energized, the struts provide increased damping force for a firmer ride. The CVRSS module switches the voltage supplied to the damper solenoid in each strut on and off very quickly with a 2.0 kilohertz pulse width modulated (PWM) action. If the CVRSS module keeps the damper solenoid in a strut energized longer on each cycle, current flow is increased through the strut damper solenoid. Under this condition, strut damping force is increased to provide a firmer ride. The CVRSS module provides precise, variable control of the current flow through each strut or shock damper solenoid to achieve a wide range of damping forces in the struts.

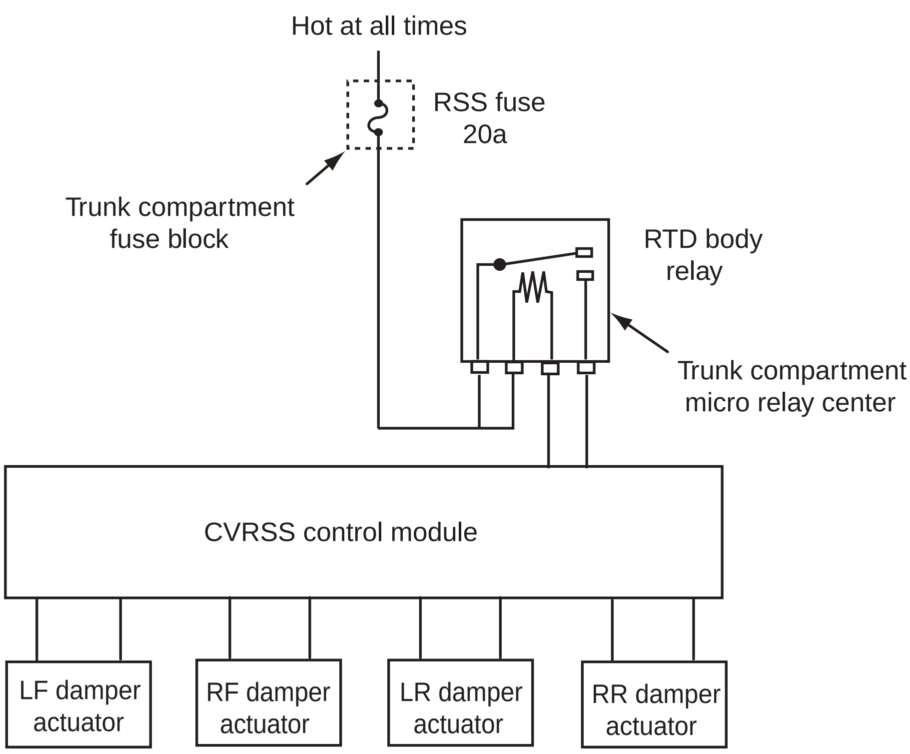

Figure 8-54 Strut damper solenoids and damper relay wiring diagram.

Each damper solenoid is an integral part of the damper assembly and is not serviced separately. The CVRSS system operates automatically without any driver-controlled inputs. The fast reaction time of the CVRSS system provides excellent control over ride quality and body lift or dive, which provides improved vehicle stability and handling. Since the position sensors actually sense the velocity of upward and downward wheel movements and the damper solenoid reaction time is 10 to 12 milliseconds, the CVRSS module can react to these position sensor inputs very quickly. For example, if a road irregularity drives a wheel upward, the CVRSS module switches the damper solenoid to the firm mode before that wheel strikes the road again during the downward movement.

Resistor Module. In some older models, the resistor module contains four resistors encapsulated in a ceramic material. This resistor module is mounted in the right rear quarter panel inside the trunk (Figure 8-55).

When the CVRSS module switches a damper solenoid on, the module provides a direct ground for the solenoid, and full voltage is dropped across the solenoid winding to energize the solenoid very quickly. Under this condition, a higher current flow is supplied through the damper solenoid winding and the CVRSS module to ground. Since it is undesirable to maintain this higher current flow through the damper solenoid for any longer than necessary, the CVRSS module switches a resistor in the resistor module into the damper solenoid circuit after this circuit is energized for 15 milliseconds (Figure 8-56). On later model vehicles, the resistor module is discontinued because the CVRSS module controls the strut damper solenoids with a PWM signal.

This resistor reduces the voltage drop across the damper solenoid, which lowers the current flow. This lower current flow is high enough to hold the damper solenoid in the On mode. Each damper solenoid circuit is basically the same.

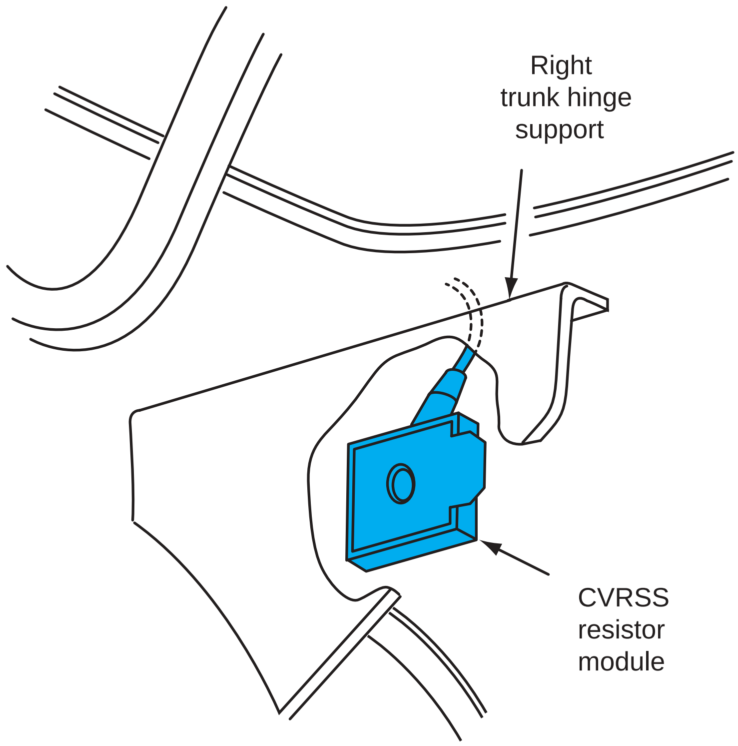

Figure 8-55 Resistor module mounting location.

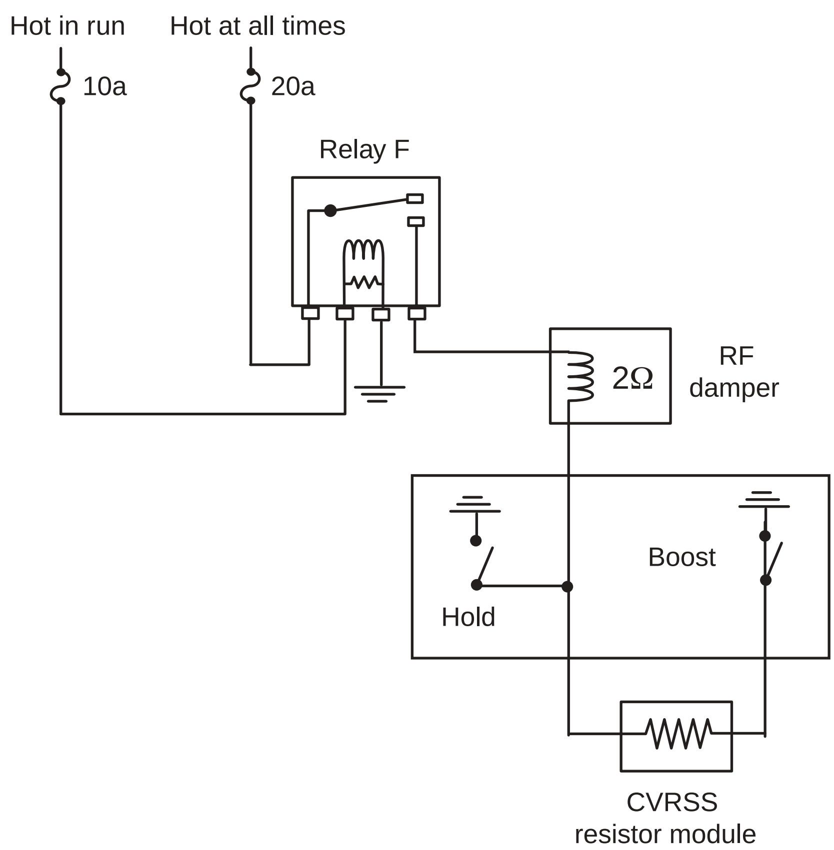

Figure 8-56 Damper solenoid circuit.

AUTHOR'S NOTE: In the last decade, we have experienced very rapid advancement of electronics technology in the automotive industry. The pace of electronic developments continues to increase each year. Electronics affects all areas of the vehicle including the suspension system. During the 2002 model year, the CVRSS suspension system on the Cadillac Seville touring sedan (STS) will be updated to a MagneRide suspension system. In the MagneRide system, the shock absorbers or struts do not contain any electromechanical solenoids or valves. In place of these components, the shock absorbers or struts are filled with a magneto-rheological (MR) fluid. The MR fluid is a synthetic oil containing suspended iron particles. Each shock absorber or strut contains a winding that is energized by the MagneRide module. When the strut winding is not energized, the iron particles are dispersed randomly in the MR fluid. Under this condition, the MR fluid has a mineral oil-like consistency, and this fluid flows easily through the strut orifices to provide a soft ride quality.

If the MagneRide module energizes the strut winding, the magnetic field around this winding aligns the iron particles in the MR fluid into fibrous structures. In this condition, the MR fluid has a jelly-like consistency for a firm ride (Figure 8-57). Based on the MagneRide system inputs from the wheel position sensors and steering wheel position sensor (SWPS), the module supplies current at rates up to 1,000 times per second to the windings in the appropriate shock absorber or strut. Therefore, the MagneRide module provides an almost infinite variation in strut damping. The struts can change the damping characteristics of the MR fluid in 1 millisecond (ms).

The MagneRide system provides closer control of pitch and roll body motions which improve road-holding capabilities, steering control, and safety.

These rapid advances in suspension technology emphasize the fact the you, as an automotive technician, require frequent update training to accurately diagnose and service the vehicles of today and tomorrow.

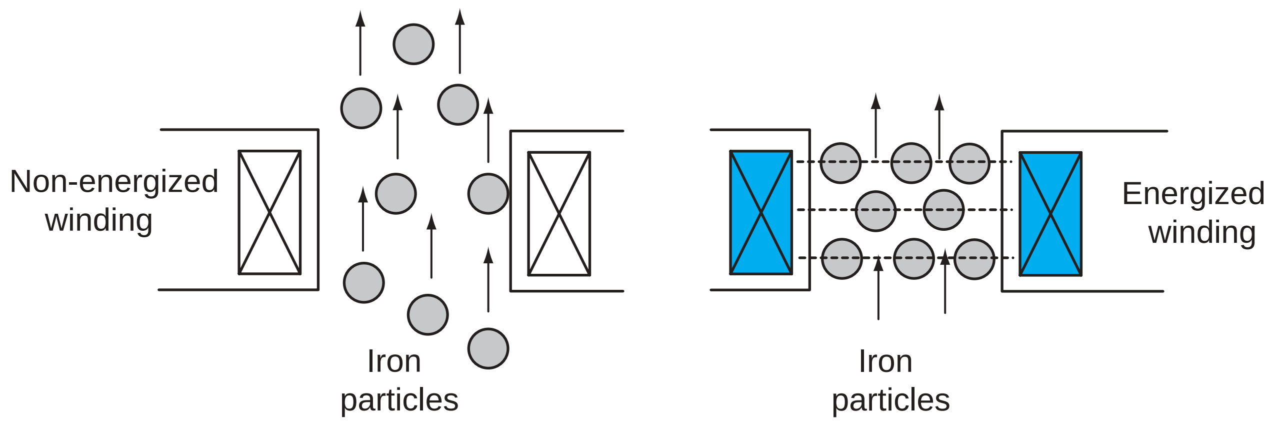

Figure 8-57 Magneto-rheological fluid action in strut or shock absorber.

Rear Electronic Level Control

The **electronic level control (ELC)** system maintains the rear suspension trim height regardless of the rear suspension load. If a heavy object is placed in the trunk, the rear wheel position sensors send below trim height signals to the CVRSS module. When this signal is received, the CVRSS module grounds the ELC relay winding and closes the relay contacts that supply voltage to the compressor motor (Figure 8-58).

The **electronic level control (ELC)** system maintains the rear suspension trim height regardless of the rear suspension load.

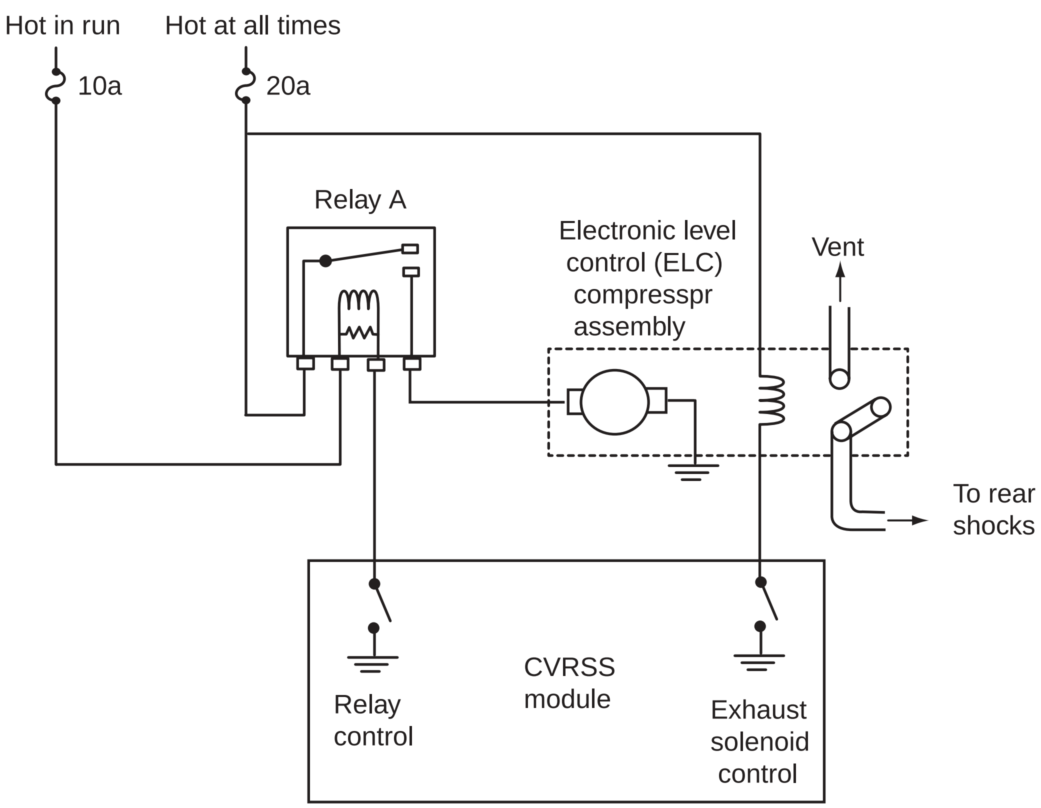

Figure 8-58 Rear electronic level control system.

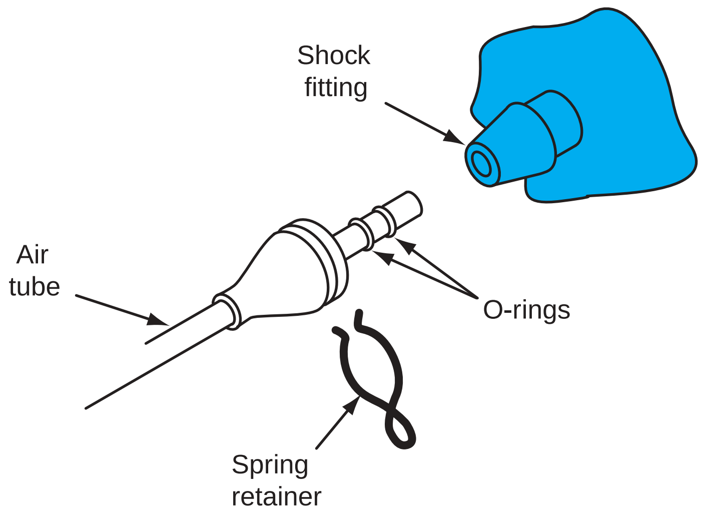

Figure 8-59 Nylon air line and rear shock air line fitting.

Once the compressor starts running, it supplies air through the nylon lines to the rear air shocks and raises the rear suspension height (Figure 8-59). When trim height signals are received from the rear wheel position sensors, the CVRSS module opens the compressor relay winding circuit and stops the compressor.

If a heavy object is removed from the trunk, the rear wheel position sensors send above trim height signals to the CVRSS module. Under this condition, the CVRSS module energizes the exhaust solenoid in the compressor assembly, and this action releases air from the rear air shocks. When the rear wheel position sensors send rear suspension trim height signals to the CVRSS module, this module shuts off the exhaust solenoid.

An independent ELC system is used on cars without the CVRSS system. In these systems, the computer is not required and a single suspension height sensor is used. This height sensor contains electronic circuits that control the compressor relay and the exhaust solenoid. This electronic circuit limits the compressor run time and the exhaust solenoid on time to 7 minutes.

The **speed sensitive steering (SSS) system** controls steering effort in relation to vehicle speed.

Pulse width modulation (PWM) is a term applied to computer control when the computer varies the on time of an output.

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Speed Sensitive Steering System

The CVRSS module operates a solenoid in the **speed sensitive steering (SSS) system** to control the power steering pump pressure in relation to vehicle speed (Figure 8-60). This action varies the power steering assist levels.

The CVRSS module varies the on time of the steering solenoid. This action may be referred to as **pulse width modulation (PWM).** When the solenoid is in the Off mode, the power steering pump supplies full power assist. Below 10 mph (16 km/h), the computer operates the steering solenoid to provide full power steering assist (Figure 8-61). This action reduces steering effort during low-speed maneuvers and parking.

As the vehicle speed increases, the CVRSS module operates the steering solenoid so the power steering assist is gradually reduced to provide increased road feel and improved handling.

On later model cars, the speed sensitive steering (SSS) is called speed dependent steering or MagnaSteer®. The module that controls the MagnaSteer® is contained in the electronic brake and traction control module (EBTCM).

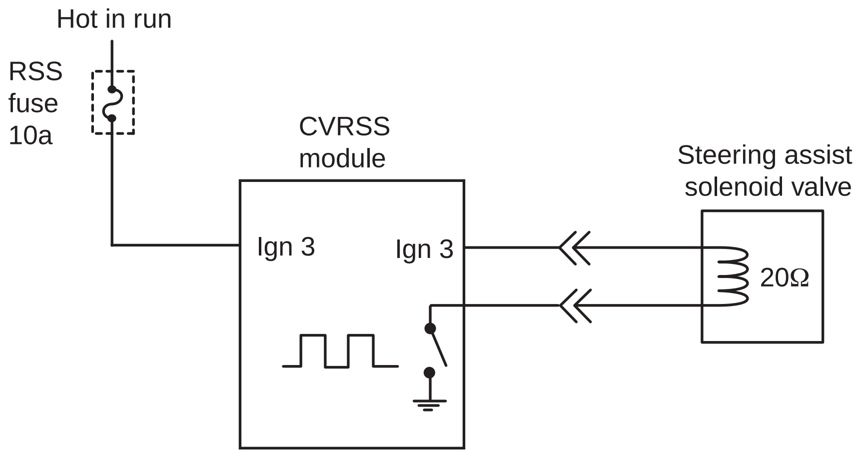

Figure 8-60 Steering solenoid and CVRSS module wiring diagram.

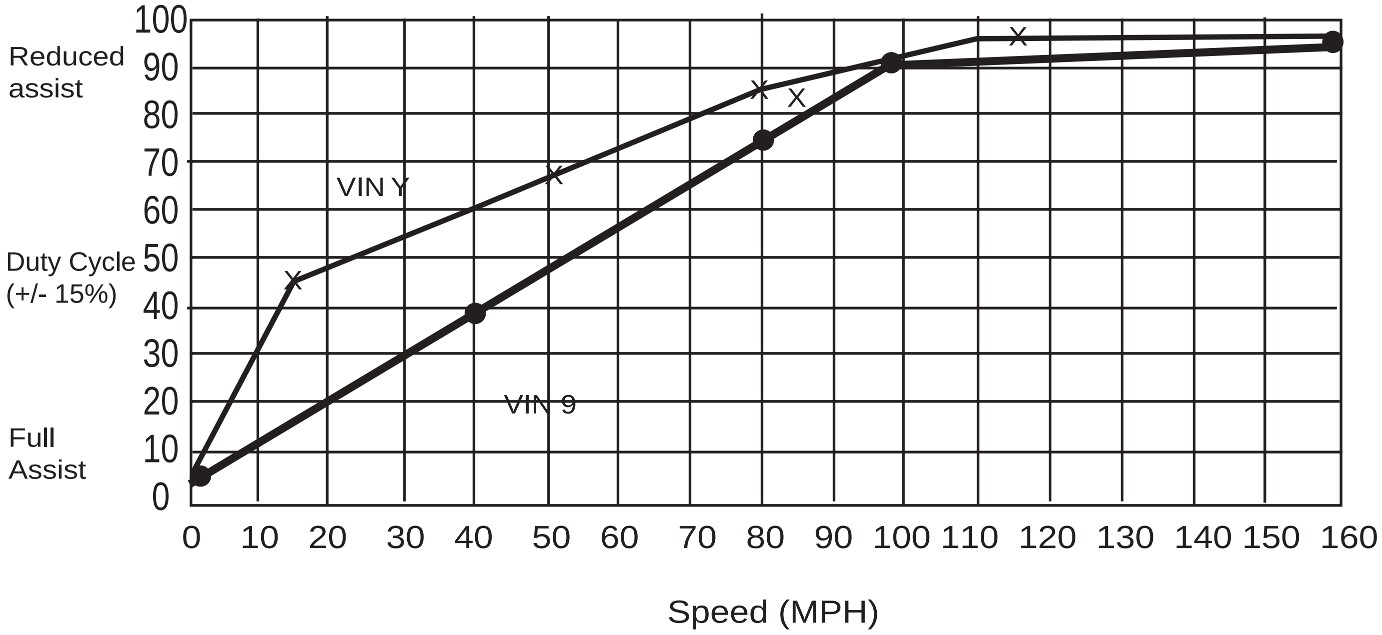

Figure 8-61 Power steering assist in relation to vehicle speed.

Integrated Electronic Systems

Advantages of Integrated Electronic Systems

With the rapid advances in electronic technology, there is a trend toward integrating some computer-controlled automotive systems. Rather than having a separate computer for each electronic system, several of these systems may be controlled by one computer. Vehicles without any integrated electronic systems may have up to 12 individual modules and computers. Since computers must have some protection from excessive temperature changes, extreme vibration, magnetic fields, voltage spikes, and oil contamination, it becomes difficult for engineers to find a suitable mounting place for this large number of computers. Integration of several electronic systems into one computer solves some of these computer mounting problems and reduces the length of wiring harness. The continuously variable road sensing suspension (CVRSS) explained in this chapter is an example of an integrated electronic system with suspension ride control, suspension level control, and speed sensitive steering controlled by one computer. We have also mentioned in this chapter that some Ford vehicles have combined suspension and electronic variable orifice (EVO) steering systems.

Vehicle Stability Control

Many vehicles manufactured in recent years are equipped with a vehicle stability control system. A **vehicle stability control system** provides improved control if the vehicle begins to swerve sideways because of slippery road surfaces, excessive acceleration, or a combination of these two conditions. Therefore, a vehicle stability control system provides increased vehicle safety. Vehicle stability control systems have various brand names depending on the vehicle manufacturer. For example, on General Motors vehicles the vehicle stability control system is called **Stabilitrak®**. The Stabilitrak® system is available on many General Motors cars and some SUVs. The module that controls the Stabilitrak® system is combined with the **antilock brake system (ABS)** module and **traction control system (TCS)** module (Figure 8-62). This three-in-one module assembly is referred to as the **electronic brake and traction control module (EBTCM)**. The EBTCM is attached to the **brake pressure modulator valve (BPMV)** and this assembly is mounted in the left front area in the engine compartment. A data link is connected between all the computers including the EBTCM and the CVRSS module (Figure 8-63). The combined EBTCM and CVRSS systems may be referred to as the integrated chassis control system 2 (ICCS2). Some sensors such as the **steering wheel position sensor (SWPS)** are hard-wired to

The **vehicle stability control system** prevents the vehicle from swerving side ways.

The **Stabilitrak®** system is a type of vehicle stability control.

The **antilock brake system (ABS)** prevents wheel lockup during a brake application.

The **traction control system (TCS)** prevents drive wheel slippage.

The **electronic brake and traction control module (EBTCM)** controls ABS, TCS, and Stabilitrak® functions.

The **brake pressure modulator valve (BPMV)** controls brake fluid pressure to the wheel calipers or cylinders.

The **steering wheel position sensor** supplies a voltage signal in relation to the amount and speed of steering wheel rotation.

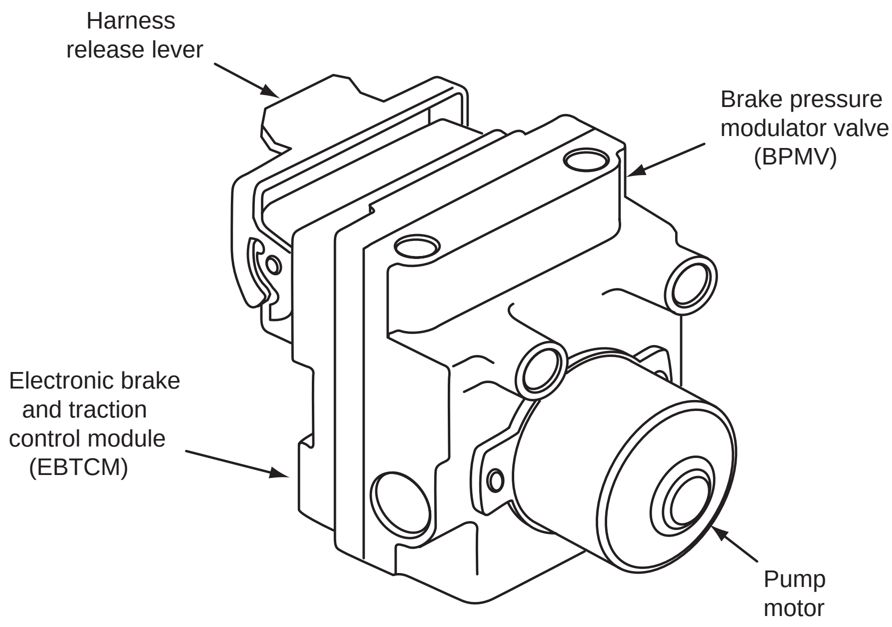

Figure 8-62 The electronic brake and traction control module (EBTCM) contains the antilock brake system (ABS) traction control system, and Stabilitrak® modules.

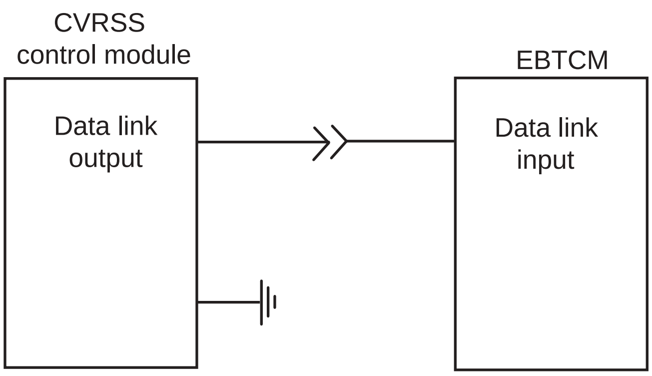

Figure 8-63 Data link between the EBTCM and CVRSS modules.

both the EBTCM and the CVRSS module (Figure 8-64). The signals from other sensors may be sent to one of these modules and then transmitted to the other module on the data link. The data link also transmits data from these modules to the instrument panel cluster (IPC) during system diagnosis. This allows the IPC to display diagnostic information.

This book is concerned with suspension and steering systems. Because the Stabilitrak® system operates in cooperation with the ABS and TCS systems, a brief description of these systems is necessary.

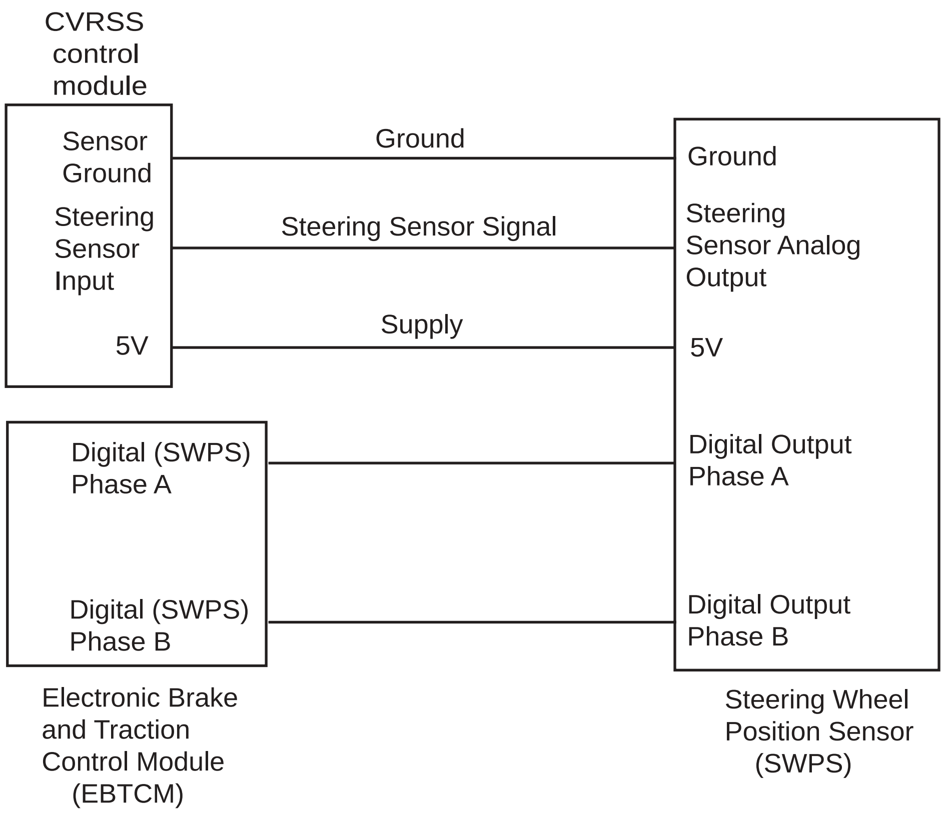

Figure 8-64 The steering wheel position sensor (SWPS) is connected to both the CVRSS and EBTCM modules.

Figure 8-65 Wheel speed sensor.

Antilock Brake System (ABS) Operation

Wheel speed sensors supply voltage signals in relation to the speed of wheel rotation.

Wheel speed sensors are mounted at each wheel. In this ABS system, the wheel speed sensors are integral with the front or rear wheel bearing hubs. These wheel bearing hubs with the integral wheel speed sensors are nonserviceable (Figure 8-65). Each wheel speed sensor contains a toothed ring that rotates past a stationary electromagnetic wheel speed sensor. This sensor contains a coil of wire surrounding a permanent magnet. As the toothed ring rotates past the sensor, an alternating current (AC) voltage is produced in the sensor. This voltage signal from each wheel speed sensor is sent to the EBTCM. As wheel speed increases, the frequency of AC voltage produced by the wheel speed sensor increases proportionally. During a brake application, the wheels slow down, and the frequency of AC voltage in the wheel speed sensors also decreases. If a wheel is nearing a lockup condition during a hard brake application, the frequency of the AC voltage from that wheel speed sensor becomes very slow. The EBTCM detects impending wheel lockup from the frequency of AC voltage signals sent from the wheel speed sensors.

A **hold valve** opens and closes the fluid passage to each wheel caliper.

When energized, a **release valve** reduces pressure in a wheel caliper.

The brake pressure modulator valve (BPMV) contains a number of electrohydraulic valves. These valves are operated electrically by the EBTCM. These valves in the BPMV are connected hydraulically in the brake system. A **hold valve** and a **release valve** are connected in the brake line to each wheel (Figure 8-66). If a wheel speed sensor signal indicates an impending wheel lockup condition, the EBTCM energizes the normally open hold solenoid connected to the wheel that is about to lock up. This action closes the solenoid and isolates the wheel caliper from the master cylinder to prevent any further increase in brake pressure. If the wheel speed sensor signal still indicates an impending wheel lockup, the EBTCM keeps the hold solenoid closed and opens the normally closed release solenoid momentarily. This action reduces wheel caliper pressure to reduce brake application force and prevent wheel lockup. The EBTCM pulses the hold and the release solenoids on and off to supply maximum braking force without wheel lockup.

When the hold and the release valves are pulsated during a prolonged antilock brake function, the brake pedal fades downward as brake fluid flows from the release valves into the accumulators. To maintain brake pedal height during an antilock brake function, the EBTCM

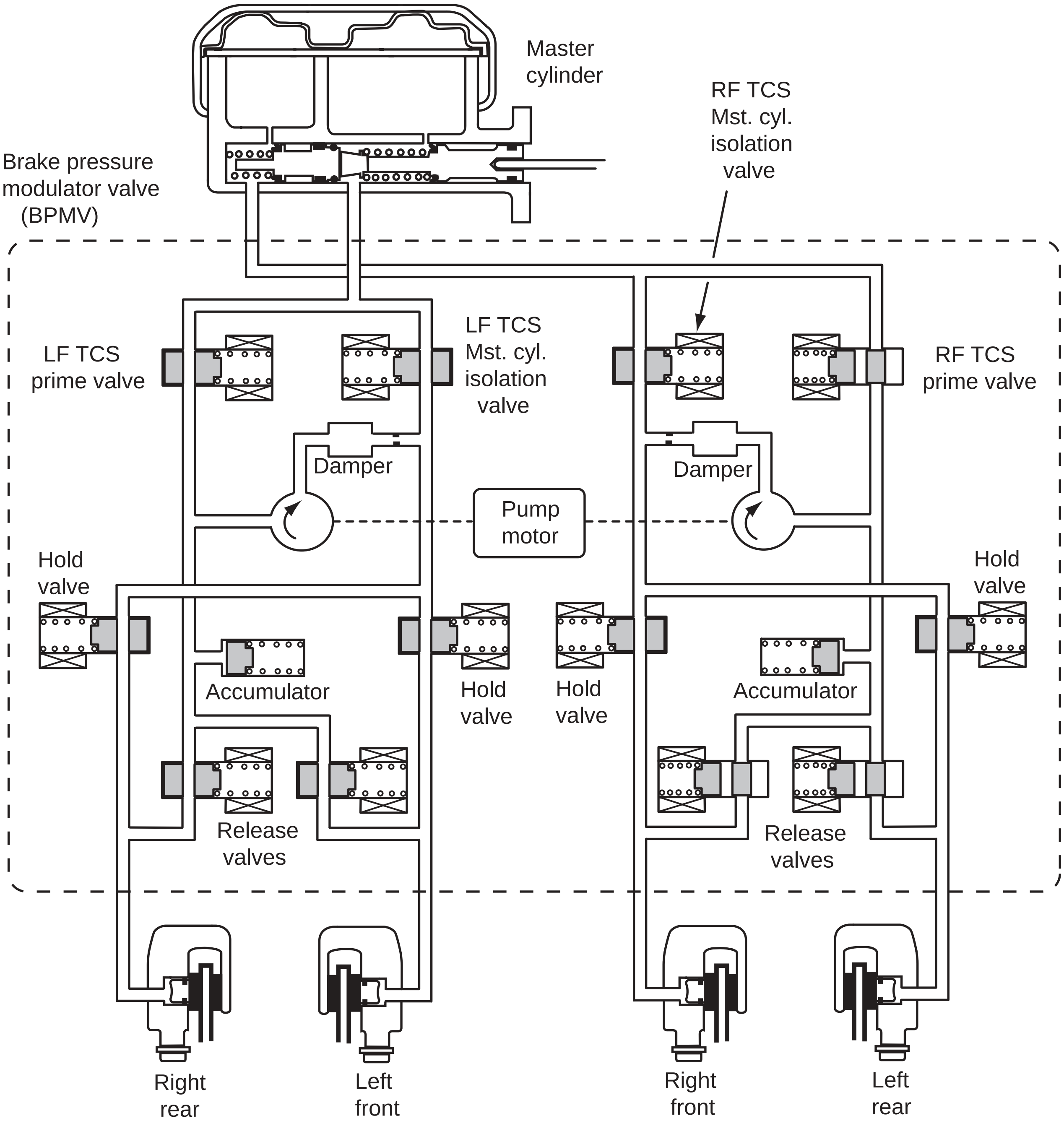

Figure 8-66 Brake pressure modulator valve (BPMV).

starts the pump in the BPMV at the beginning of an antilock function. When the pump motor is started, the pump supplies brake fluid pressure to the hold valves and wheel calipers. Pump motor pressure is also supplied back to the master cylinder. Under this condition, the driver may feel a firmer brake pedal and pedal pulsations and may hear the clicking action of the hold and the release solenoids.

ANTILOCK and BRAKE warning lights are mounted in the instrument panel. Both of these lights are illuminated for a few seconds after the engine starts. If the amber ANTILOCK light is on with the engine running, the EBTCM has detected an electrical fault in the ABS system.

Under this condition, the EBTCM no longer provides an ABS function, but normal power-assisted brake operation is still available. When the red BRAKE warning light is illuminated with the engine running, the parking brake may be on, the master cylinder may be low on brake fluid, or there may be a fault in the ABS system.

Traction Control System (TCS) Operation

The EBTCM detects drive wheel spin by comparing the two drive wheel speed sensor signals. Wheel spin on both drive wheels is detected by comparing the wheel speed sensor signals on the drive wheels and non-drive wheels. If one or both drive wheels begin to spin on the road surface, the EBTCM energizes the normally closed prime valve, closes the normally open isolation valve, and starts the pump in the BPMV. Under this condition, the prime valve opens and the pump begins to move brake fluid from the master cylinder through the prime valve to the pump inlet. The closed isolation valve prevents the pump pressure from being applied back to the master cylinder. Under this condition, the pump pressure is supplied through the normally open hold valve to the brake caliper on the spinning wheel. This action stops the wheel from spinning. If both drive wheels are spinning on the road surface, the EBTCM operates both prime valves and isolation valves to supply brake fluid pressure to both drive wheel brake calipers. During a TCS function, the EBTCM pulses the hold and the release solenoids on and off to control wheel caliper pressure. The EBTCM limits the traction control function to a short time period to prevent overheating brake components. During a TCS function, these messages may be displayed in the driver information center (DIC).

1. TRACTION ENGAGED is displayed after the TCS is in operation for 3 seconds.
2. TRACTION SUSPENDED is displayed if the EBTCM has discontinued the TCS function to prevent brake component overheating.
3. TRACTION OFF is displayed if the driver places the TCS switch on the instrument panel in the Off position.
4. TRACTION READY is displayed if the TCS switch is turned from Off to On.

During a TCS function, the EBTCM sends a signal through the data link to the powertrain control module (PCM). When this signal is received, the PCM disables some of the fuel injectors to reduce engine torque. This action also helps to prevent drive wheel spin. The PCM disables the two injectors at the beginning of the firing order and in the center of the firing order. Depending on the speed of drive wheel spin, the PCM may disable every second injector in the firing order. The injectors are disabled for a very short time period. The TCS system improves drive wheel traction, and this system also prevents the tendency for the vehicle to swerve sideways when one drive wheel is spinning. Therefore, the TCS system increases vehicle safety.

A **lateral accelerometer** supplies a voltage signal in relation to sideways movement of the chassis.

Yaw is erratic, side-to-side deviation from a course. The **yaw rate sensor** supplies a voltage signal in relation to rotational chassis speed during a sideways swerve.

Vehicle Stability Control

To provide stability control, the EBTCM uses two additional input signals from the **lateral accelerometer** and the **yaw rate sensor**. The lateral accelerometer is mounted under the front passenger's seat (Figure 8-67). The EBTCM sends a 5V reference voltage to the lateral accelerometer. If the vehicle is driven straight ahead, the chassis has zero lateral acceleration. Under this condition, the lateral accelerometer provides a 2.5V signal to the EBTCM. If the vehicle begins to swerve sideways because of slippery road conditions, high-speed cornering, or erratic driving, the lateral accelerometer signal to the EBTCM varies from 0.25V to 4.75V, depending on the direction and severity of the swerving action.

The yaw rate sensor is mounted under the rear package shelf (Figure 8-68). Some yaw rate sensors contain a precision metal cylinder whose rim vibrates in elliptical shapes. The vibration and rotation of this metal cylinder is proportional to the rotational speed of the vehicle around the center of the cylinder.

Figure 8-67 Lateral accelerometer.

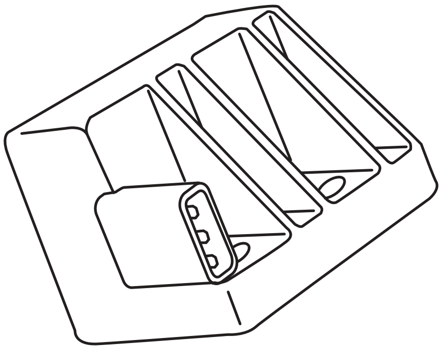

Figure 8-68 Yaw rate sensor.

The EBTCM sends a 5V reference voltage to the yaw rate sensor. If the vehicle chassis experiences zero yaw rate, the yaw rate sensor sends a 2.5V signal to the EBTCM module. If the vehicle begins to swerve sideways, the yaw rate sensor provides a 0.25 V to 4.75V signal to the EBTCM, depending on the direction and severity of the swerve. The EBTCM also uses the wheel speed sensor signals for stability control. If the vehicle begins to swerve sideways, the EBTCM energizes the normally closed prime valve and closes the normally open isolation valve connected to the appropriate front wheel; then it starts the pump in the BPMV. Under this condition, the prime valve opens and the pump begins to move brake fluid from the master cylinder through the prime valve to the pump inlet. The closed isolation valve prevents the pump pressure from being applied back to the master cylinder. Under this condition, the pump pressure is supplied through the normally open hold valve to the brake caliper on the appropriate front wheel. Applying the brake on the front wheel pulls the vehicle out of the swerve and prevents the complete loss of steering control. If the EBTCM detects an electrical fault in the stability control system, STABILITY REDUCED is displayed in the DIC. If the EBTCM enters the stability control mode, STABILITY ENGAGED is indicated in the DIC.

In Figure 8-69, two vehicles driving side-by-side are negotiating a lane change to the left. The vehicle on the right has vehicle stability control, and the vehicle on the left does not have this system. As the vehicle on the left begins to turn, the rear of the vehicle begins to swing around. When the vehicle on the right starts to turn, the rear of the vehicle swerves slightly and the right front brake is applied by the vehicle stability control system to prevent this swerve. Further into the turn, the driver attempts to steer the car on the left, but this car enters into an uncontrolled swerve with loss of steering control. As the car on the right continues into the turn, the rear of the vehicle swerves slightly, but the vehicle stability control system again applies the right front brake momentarily to prevent this swerve. The car with the stability control system completes the turn while maintaining directional stability, but the vehicle without stability control

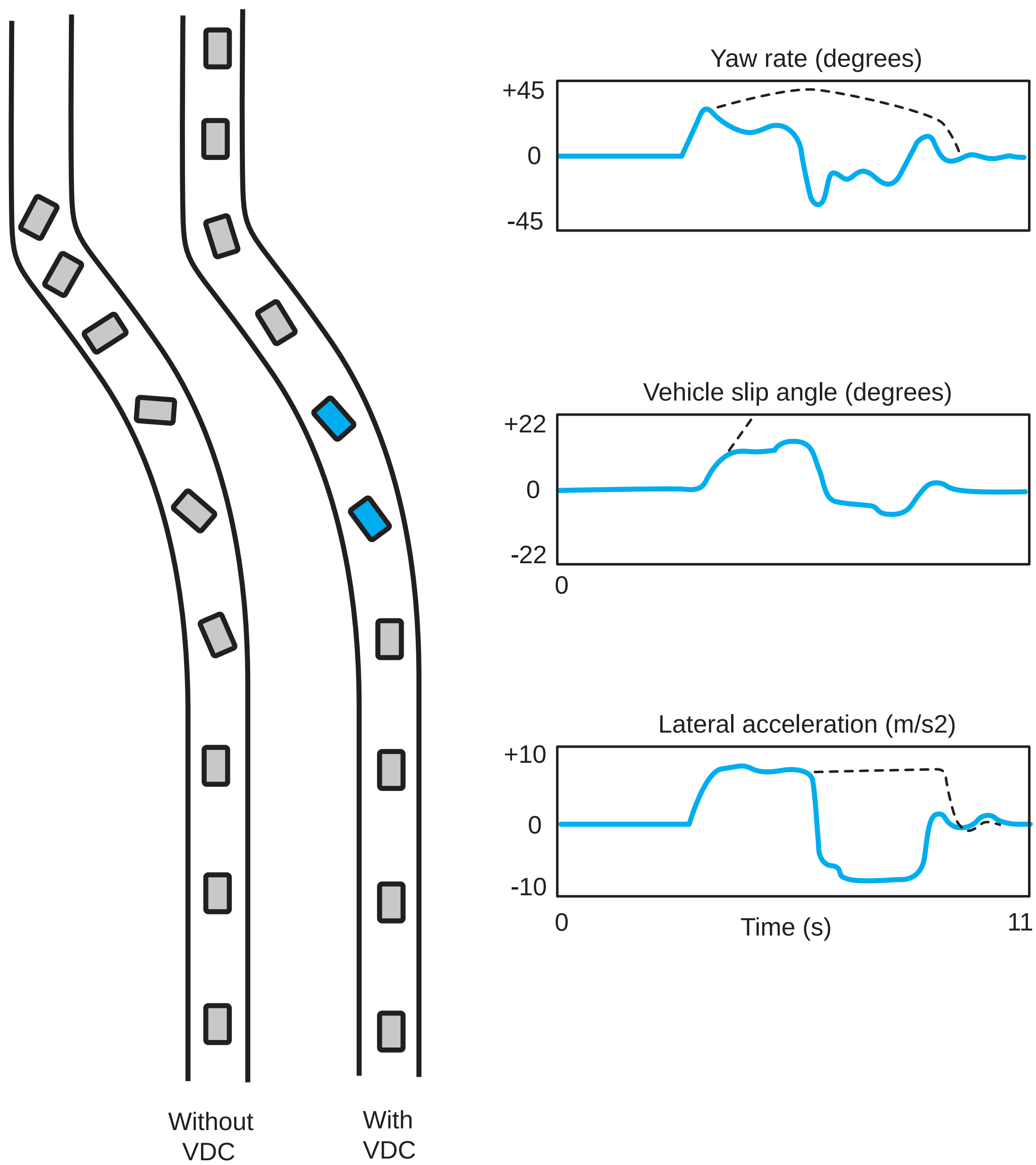

Figure 8-69 Comparison during a turn between a vehicle with a stability control system and a vehicle with no stability control system.

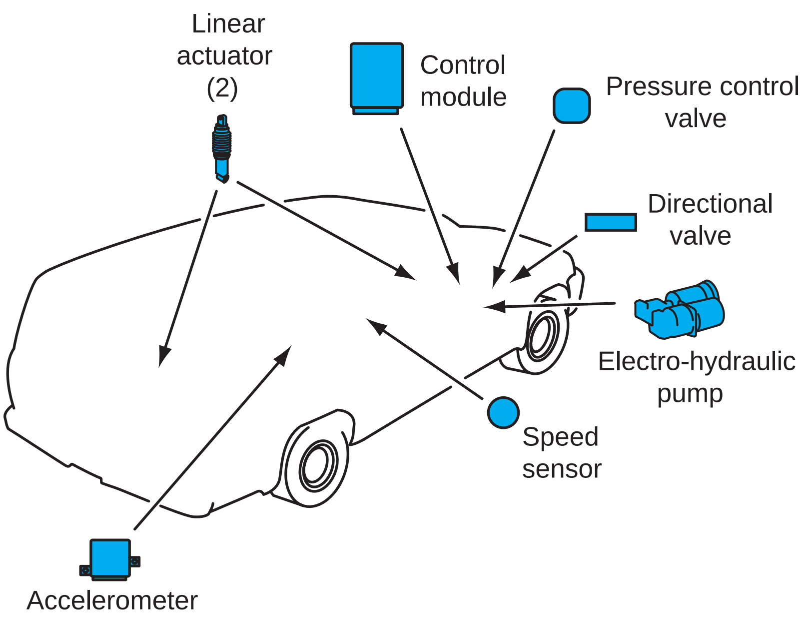

Figure 8-70 Active roll control system components.

goes into an uncontrolled swerve with complete loss of directional control. The vehicle stability control system improves vehicle safety! The other charts in Figure 8-69 indicate that yaw rate, vehicle slip angle, and lateral acceleration are greatly reduced on a vehicle with a stability control system.

Active Roll Control Systems

Two independent automotive component manufacturers have developed active roll control systems in response to concerns about sport utility vehicles (SUVs) that roll over more easily compared with cars because of the SUVs' higher center of gravity. The active roll control systems were developed in response to this concern. The active roll control system contains a control module, accelerometer, speed sensor, fluid reservoir, electrohydraulic pump, pressure control valve, directional control valve, and a hydraulic actuator in both the front and rear stabilizer bars (Figure 8-70). The accelerometer and speed sensor may be common to systems other than the active roll control. The electrohydraulic pump may also be used as the power steering pump. The active roll control system has not been used as standard or optional equipment to date. When this system is installed on vehicles by an original equipment manufacturer (OEM), it will be integrated with other electronic systems such as ABS, TCS, and stability control systems.

When the vehicle is driven straight ahead, the active roll control system does not supply any hydraulic pressure to the linear actuators in the stabilizer bars. Under this condition, both stabilizer bars move freely until the linear actuators are fully compressed. This action provides improved individual wheel bump performance and better ride quality. If the chassis begins to lean while cornering, the module operates the directional valve so it supplies fluid pressure to the linear actuators in the stabilizer bars. This action stiffens the stabilizer bar and reduces body lean (Figure 8-71). The active roll control system increases safety by reducing body lean, which decreases the possibility of a vehicle rollover.

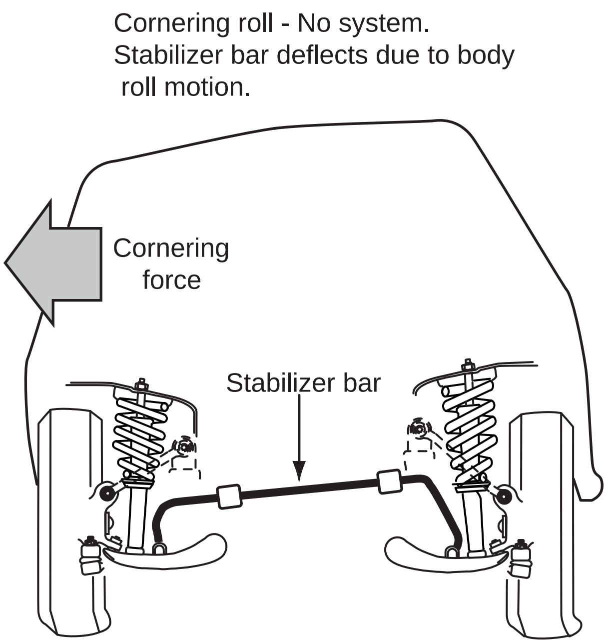

Figure 8-71 Active roll control system operation while cornering.

Summary

Terms to Know

Accelerometer
Actuator
Air spring solenoid valve
Air springs
Antilock brake system (ABS)
Brake pressure modulator valve (BPMV)
Brake pressure switch
Computer command ride (CCR) system
Continuously variable road sensing suspension system (CVRSS)
Damper solenoid valve
Electronic brake and traction control module (EBTCM)

- ❑ In a PRC system, the steering sensor informs the control module regarding the amount and speed of steering wheel rotation.
- ❑ The PRC system switches from the Normal to the Firm mode during high-speed operation, braking, hard cornering, and fast acceleration.
- ❑ The struts and shock absorbers in some PRC systems provide three times as much damping action in the firm mode as in the normal mode.
- ❑ The accelerometer in a CCR system contains a mercury switch and this accelerometer sends a vehicle acceleration signal to the control module.
- ❑ In a CCR system, the accelerometer signal or the vehicle speed signal may inform the control module to switch from the normal to the firm mode.
- ❑ An electronic air suspension system maintains a constant vehicle trim height regardless of passenger or cargo load.
- ❑ To exhaust air from an air spring, the air spring solenoid valve and the vent valve in the compressor head must be energized.
- ❑ To force air into an air spring, the compressor must be running and the air spring solenoid valve must be energized.
- ❑ The air spring valves are retained in the air spring caps with a two-stage rotating action much like a radiator cap.
- ❑ An air spring valve must never be loosened until the air is exhausted from the spring.
- ❑ Voltage is supplied through the compressor relay points to the compressor motor. This relay winding is grounded by the control module to close the relay points.
- ❑ The on/off switch in an electronic air suspension system supplies 12V to the control module. This switch must be off before the car is hoisted, jacked, towed, or raised off the ground.

- ❑ If a car door is open, the control module does not respond to lower vehicle commands in an electronic air suspension system.
- ❑ When the brake pedal is applied and the doors are closed in an electronic air suspension system, the control module ignores all requests from the height sensors.
- ❑ In an electronic air suspension system, if the doors are closed and the brake pedal is released, all requests to the control module are serviced by a 45-second averaging method.
- ❑ If the control module in an electronic air suspension system cannot complete a request from a height sensor in three minutes, the control module illuminates the suspension warning lamp.
- ❑ In an automatic air suspension system, the control module controls suspension height and strut damping automatically without any driver controlled inputs.
- ❑ Rotary height sensors in automatic air suspension systems contain Hall elements. These sensors send voltage signals to the control module in relation to the amount and speed of wheel jounce and rebound.
- ❑ Some air suspension systems reduce trim height at speeds above 65 mph (105 km/h) to improve handling and fuel economy.
- ❑ Automatic ride control (ARC) systems on four-wheel-drive vehicles increase suspension ride height when the driver selects four-wheel-drive high or four-wheel-drive low.
- ❑ Automatic ride control (ARC) systems on four-wheel-drive vehicles have the capability to provide firmer shock absorber valving in relation to transfer case mode selection, vehicle speed, and operating conditions.
- ❑ The continuously variable road sensing suspension system changes shock and strut damping forces in 10 to 12 milliseconds.
- ❑ In the continuously variable road sensing suspension system, the module controls suspension damping, rear electronic level control, and speed sensitive steering automatically without any driver operated inputs.
- ❑ A vehicle stability control system applies one of the front brakes if the rear of the car begins to swerve out of control. This action maintains vehicle direction control.

Terms to Know (Continued)

Electronic level control (ELC)
Electronic rotary height sensors
Electronically erasable programmable read only memory (EEPROM)
Firm relay
Hall element
Height sensors
Hold valve
Lateral accelerometer
Lift/dive input
Light-emitting diodes (LEDs)
Lower vehicle command
Photo diodes
Programmed ride control (PRC) system
Pulse width modulation (PWM)
Raise vehicle command
Release valve
Soft relay
Speed sensitive steering (SSS) system
Stabilitrak®
Steering sensor
Steering wheel position sensor (SWPS)
Throttle position sensor (TPS)
Traction control system (TCS)
Trim height
Vehicle speed sensor (VSS)
Vehicle stability control system
Vent valve
Wheel position sensor
Wheel speed sensors
Yaw rate sensor

Review Questions

Short Answer Essays

1. Describe the operation of the steering sensor in a PRC system.
2. Describe the purpose of the accelerometer in a CCR system.
3. Explain how air is forced into an air spring in a rear load-leveling air suspension system.
4. Describe the action taken by the control module if the control module in an electronic air suspension system receives a lower vehicle command from a rear suspension sensor with the doors closed, the brake pedal released, and the vehicle travelling at 60 mph (100 km/h).
5. Describe the action taken by the control module if the engine is running with a door open, and the control module receives a lower vehicle command from the height sensor in a rear load-leveling air suspension system.
6. List the conditions when the on/off switch in an electronic air suspension system must be turned off.
7. Describe the conditions required for the control module to turn on the suspension warning lamp continually with the engine running in an electronic air suspension system.

8. Explain why the control module in an electronic air suspension system services all commands by a 45-second averaging method when the doors are closed and the brake pedal is released.
9. Explain why the suspension warning lamp in an electronic air suspension system may not indicate a defect immediately when the engine is started.
10. Explain how a vent solenoid is damaged by reversed battery polarity in a rear load-leveling air suspension system.

Fill-in-the-Blanks

1. The armature response time is __________________ milliseconds in a PRC system strut.
2. In a PRC system, if the car is accelerating with the throttle wide open, the PRC system is in the __________________ mode.
3. When the PRC mode switch is in the Auto position, the control module changes to the firm mode if lateral acceleration exceeds __________________ .
4. In a CCR system, the control module senses vehicle lift, dive, and roll from the __________________ input.
5. In a rear load-leveling air suspension system, the control module energizes the compressor relay when a __________________ __________________ command is received.
6. Two height sensors are mounted on the __________________ suspension in an electronic air suspension system.
7. In an electronic air suspension system two hours after the ignition switch is turned off, __________________ __________________ commands are completed, but __________________ __________________ commands are ignored.
8. In a rear load-leveling air suspension system, if the on/off switch in the trunk is off, the system is __________________ .
9. An electronic rotary height sensor contains a __________________ __________________ .
10. In a continuously variable road sensing suspension system, the module senses vehicle lift and dive from some of the _______________ _______________ _______________ inputs.

Multiple Choice

1. While discussing a programmed ride control (PRC) system:
   A. the brake system pressure must be 300 psi (2,068 kPa) before this mode change occurs.
   B. a PRC system switches from the Auto mode to Firm mode if the vehicle accelerates with 90 percent throttle opening.
   C. the PRC system switches to the Firm mode if lateral acceleration exceeds 0.25 g.
   D. the mode indicator light in the tachometer is illuminated in the plush ride mode.
2. While discussing a computer command ride (CCR) system:
   A. the CCR system does not prevent front suspension lift during hard acceleration.
   B. the accelerometer is mounted behind the grille in the front of the vehicle.
   C. a Hall element in the accelerometer sends a voltage signal to the control module.
   D. light-emitting diodes (LEDs) in the driver select switch inform the driver about switch position.

3. While discussing an electronic air suspension system: *Technician A* says when servicing an air spring, the air spring valve must be rotated to the first position to release air from the spring. *Technician B* says during normal operation in the spring exhaust mode, the control module opens the air spring valve and the air vent valve. Who is correct?
   A. A only
   B. B only
   C. Both A and B
   D. Neither A nor B

4. While discussing an electronic air suspension system when the brakes are applied at 50 mph (80 km/h): *Technician A* says the control module will complete a raise front suspension command. *Technician B* says the control module will complete a lower rear suspension command under this condition. Who is correct?
   A. A only
   B. B only
   C. Both A and B
   D. Neither A nor B

5. While discussing an electronic air suspension system: *Technician A* says the control module will complete raise vehicle commands if the ignition switch has been off for two hours on a vehicle with an electronic air suspension system. *Technician B* says during this condition, compressor run time is limited to 30 seconds for front springs. Who is correct?
   A. A only
   B. B only
   C. Both A and B
   D. Neither A nor B

6. While discussing a continuously variable road sensing suspension system: *Technician A* says this system has three wheel position sensors. *Technician B* says the wheel position sensors send a signal to the module in relation to the amount and velocity of wheel to body movement. Who is correct?
   A. A only
   B. B only
   C. Both A and B
   D. Neither A nor B

7. While discussing a continuously variable road sensing suspension system: *Technician A* says the module changes the damping solenoid modes in 10 to 12 milliseconds. *Technician B* says this system has an accelerometer at each corner of the vehicle. Who is correct?
   A. A only
   B. B only
   C. Both A and B
   D. Neither A nor B

8. All of these statements about a rear load-leveling suspension system are true EXCEPT:
   A. The on/off switch is mounted in the vehicle trunk.
   B. The control module operates the compressor relay.
   C. If a door is open, the control module completes lower suspension height commands.
   D. The rear suspension has one, nonserviceable suspension height sensor.

9. In an automatic ride control (ARC) system:
   A. the suspension height is increased 2 in (50.8 mm) when the driver selects the four-wheel-drive high mode.
   B. the ARC module places the air shock absorbers in the Firm mode if four-wheel-drive low is selected.
   C. the ARC module controls a solenoid and a bypass valve to regulate air shock absorber firmness.
   D. the rear gate solenoid prevents rapid air exhausting from the rear air shock absorbers.

10. While discussing automatic ride control (ARC) system operation:
   A. during hard acceleration in two-wheel drive, the ARC system may switch to the Firm mode.
   B. while travelling at 35 mph (56 km/h) in four-wheel-drive low, the suspension height should be 2 in (50.8 mm) above the base suspension height.
   C. air pressure in the air shock absorbers helps support the chassis weight while driving in two-wheel drive.
   D. the ARC module leaves the air shock absorbers in the Soft mode during hard braking.