15

Body Accessory Systems Operation

LEARNING OBJECTIVES

Upon completion and review of this chapter, you should be able to:

- Identify the components of the automotive HVAC (Heater Ventilator and Air Conditioning System) and explain the operation.
- Identify radio and/or entertainment system components and explain their operation.
- Explain the operation of the rear window defroster/defogger and heated windshields.
- Explain the operation of power windows and seats.
- Explain the operation of Power Door Locks, Trunk Latches, and Seat Back Releases.
- Identify the different types of REMOTE/Keyless Entry Systems and explain their operation.
- Identify the different types of Theft Deterrent Systems and explain their operation.
- Explain the operation of cruise control systems.
- Explain the operation of the Supplemental Restraint System (SRS).

KEY TERMS

Air Bag Module
Automatic Door Lock (ADL)
Data Link
Defroster
Heater fan
Inflator Module
Igniter Assembly
Safing sensor
Servomotor
Servo Unit
Transducer

INTRODUCTION

Electrical accessories provide driver and passenger comfort, convenience, and entertainment. New electrical accessories are introduced every year, but some systems have been common for many years. Such systems increasingly are being automated with computer control. This chapter will explain the electrical operation of some common accessory systems.

HEATING AND AIR-CONDITIONING SYSTEMS

Although heating and air-conditioning systems rely heavily on mechanical and vacuum controls, a good deal of electrical circuitry also is involved. Since the late 1970s, air-conditioning systems have become increasingly "smart," relying on solid-state modules or microprocessors for their operation. This also has complicated the job of servicing such systems.

Heater Fan

Heating systems use a **heater fan** attached to a permanent-magnet, variable-speed blower motor to force warm air into the passenger compartment (Figure 15-1). The higher the voltage applied to the motor, the faster it runs. A switch mounted on the instrument panel controls the blower operation (Figure 15-2). In most heating systems, the switch controls blower speed by directing the motor ground circuit current through or around the coils of a resistor block (Figure 15-3) mounted near the motor.

When the switch is off, the ground circuit is open and the blower motor does not run. (Some systems used in the 1970s, however, were wired so that the blower motor operated on low speed whenever the ignition was on). When the switch is turned to its low position, voltage is applied across all of the resistor coils and the motor runs at a low speed. Moving the switch to the next position bypasses one of the resistor coils. This allows more current to the blower motor, increasing its speed. When the switch is set to the highest position, all of the resistors are bypassed and

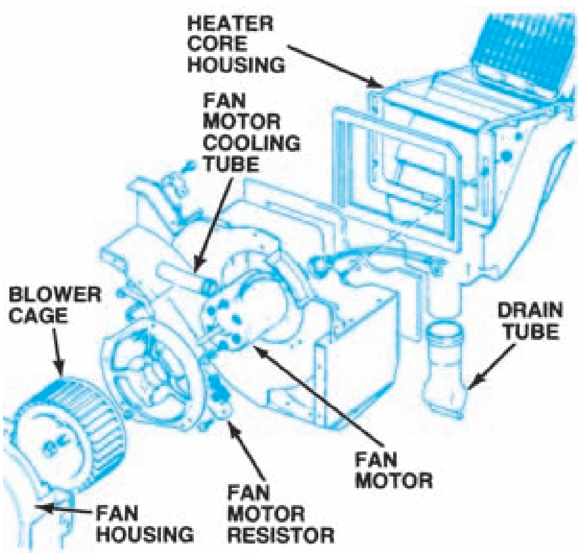

Figure 15-1. An electric motor drives the heater fan.

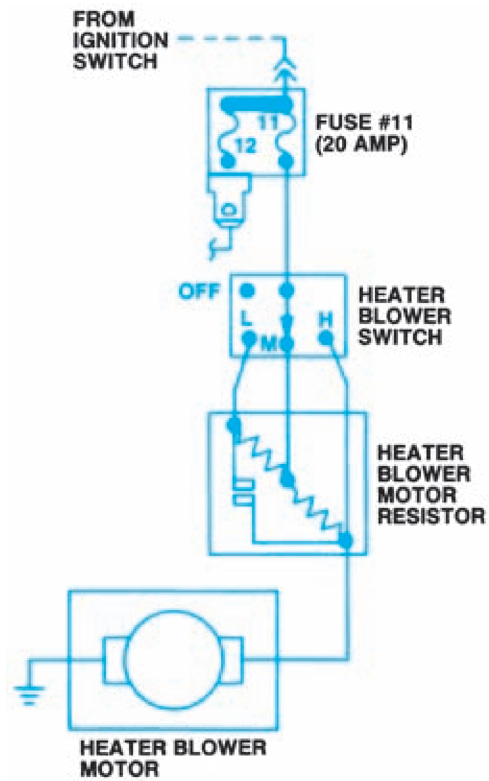

Figure 15-2. The fan control switch routes current through paths of varying resistance to control motor speed. (DaimlerChrysler Corporation)

STEPPED RESISTOR

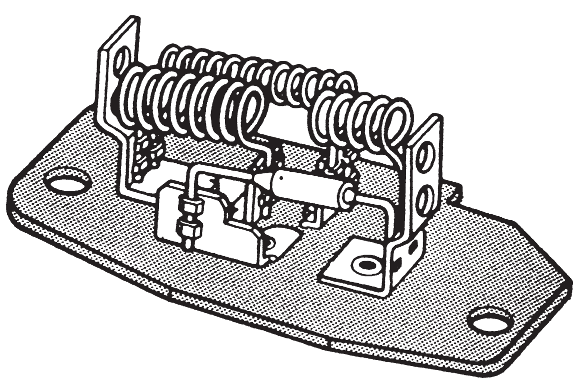

Figure 15-3. Blower motor resistors are installed on a "block" near the motor. Some resistor blocks have a thermal limiter.

full current flows to the motor, which then operates at full speed.

In some GM systems, a relay is used between the high switch position and the blower motor. Ford incorporates a thermal limiter in its resistor block, as shown in Figure 15-3. Current flows through the limiter at all blower speeds. If current passing through the limiter heats it to 212°F (100°C), the limiter opens and turns off the blower motor. When this happens, the entire resistor block must be replaced.

Air-Conditioning Fan and Compressor Clutch

Air-conditioning fan controls are similar to heater controls. In most cars that have both heating and air-conditioning systems, the same blower motor is shared by both systems (Figure 15-4). One or more switches route current through different resistors to control the blower motor speed.

In addition to the fan switch, the control assembly in the passenger compartment contains a driver-controlled air-conditioning clutch switch and an integral clutch switch activated when the function selector lever is set to the defrost position. These switches are used to operate the belt-driven compressor. A compressor that operates constantly wastes energy. To use energy more efficiently, the compressor has an electromagnetic clutch (Figure 15-5). This clutch locks and unlocks the compressor pulley with the compressor shaft. The compressor will operate only when the clutch switch is closed and the electromagnetic clutch is engaged.

Most recent air-conditioning systems use a clutch-cycling pressure switch or a pressure-cycling switch to control compressor clutch operation. This pressure-operated electric switch generally is wired in series with the clutch field

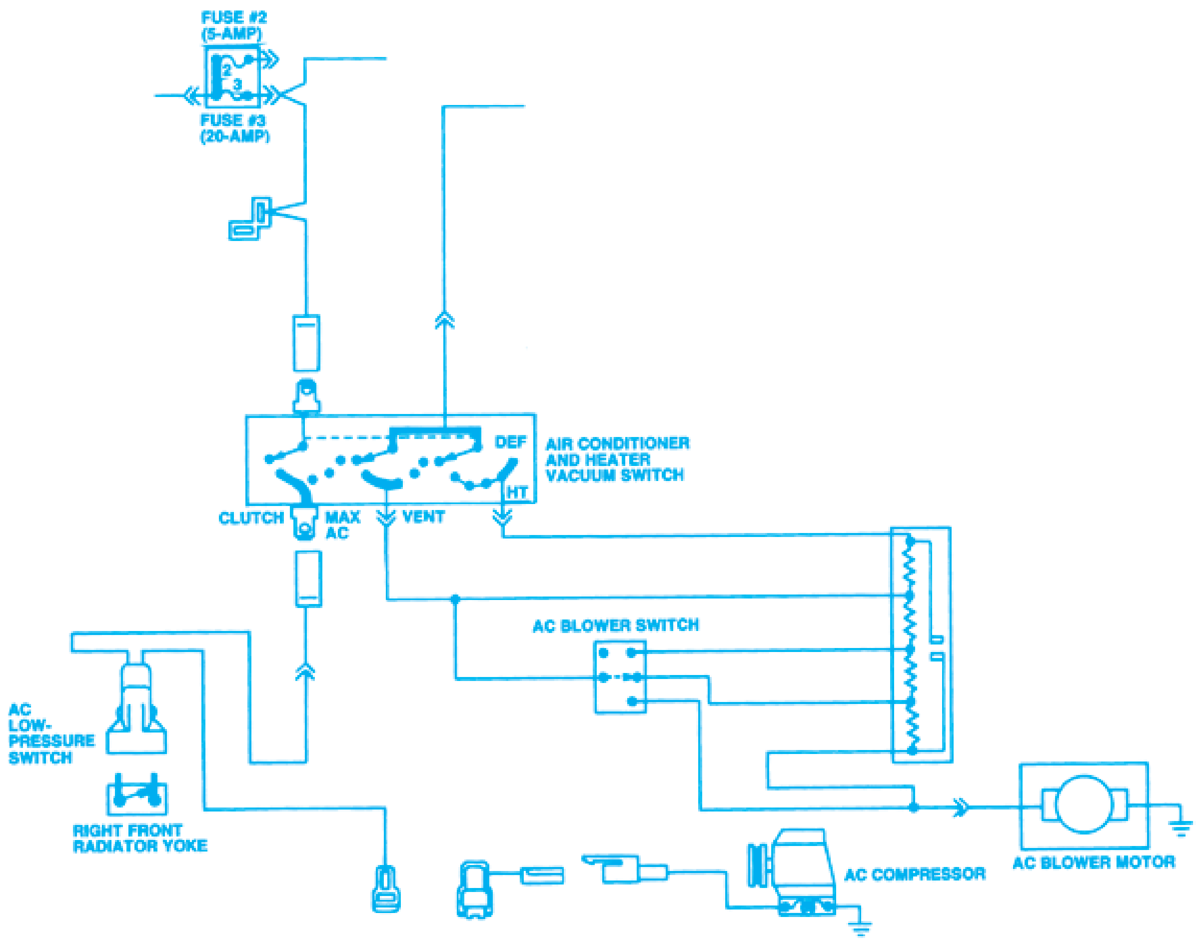

Figure 15-4. The AC system and heater system share the same fan. (DaimlerChrysler Corporation)

coil. The switch closes when the pressure on the low side of the refrigerant system rises to a specified value, engaging the clutch. When system pressure drops to a predetermined value, the switch opens to shut off the compressor. The switch operates to control evaporator core pressure and prevent icing of the evaporator cooling coils.

Air-conditioning systems may also use low- and high-pressure switches as safety devices, as follows:

- The low-pressure switch is closed during normal compressor operation and opens only when refrigerant is lost or ambient temperature is below freezing.
- The high-pressure switch is normally closed to permit compressor operation. However, if system pressure becomes excessive (generally 360–400 psi or 2,480–2,760 kPa), the switch acts as a relief valve and opens to shut off the compressor. Once pressure drops to a safe level, the switch will close again and permit the compressor to operate.
- A pressure relief valve on the compressor high-pressure side may be used instead of a high-pressure switch. Some systems have a diode installed inside the compressor clutch connector to suppress any voltage spikes that might be produced by clutch circuit interruption.

Other compressor clutch controls may include the following:

- A power-steering pressure or cutout switch to shut the compressor off whenever high power-steering loads are encountered, as during parking. The switch senses line pressure and opens or closes the circuit to the compressor clutch accordingly.
- A wide-open throttle (WOT) switch on the throttle body or accelerator pedal to open the circuit to the compressor clutch during full acceleration.
- A pressure-sensing switch in the transmission to override the WOT switch when the transmission is in high gear.

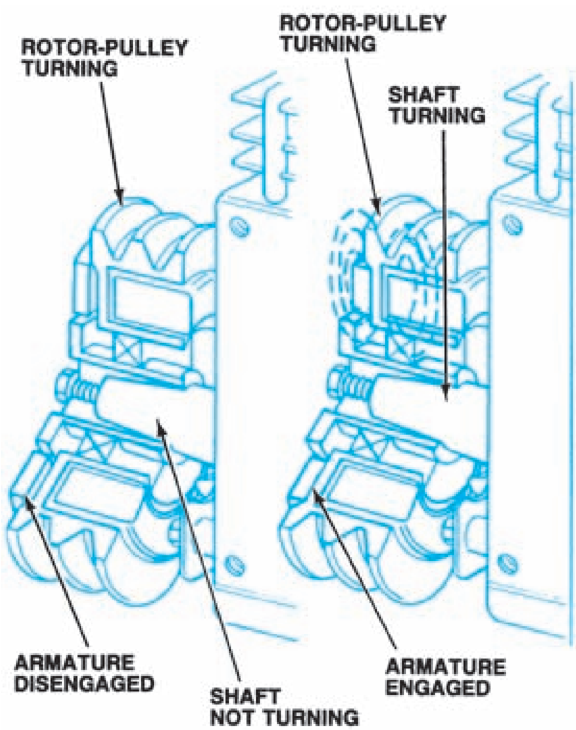

Figure 15-5. The electromagnetic clutch in this air-conditioning compressor prevents the compressor from wasting energy.

Temperature Control

The basic electrical components of most air-conditioning systems have already been described. As we have seen, they provide input to, and protection for, the refrigeration system.

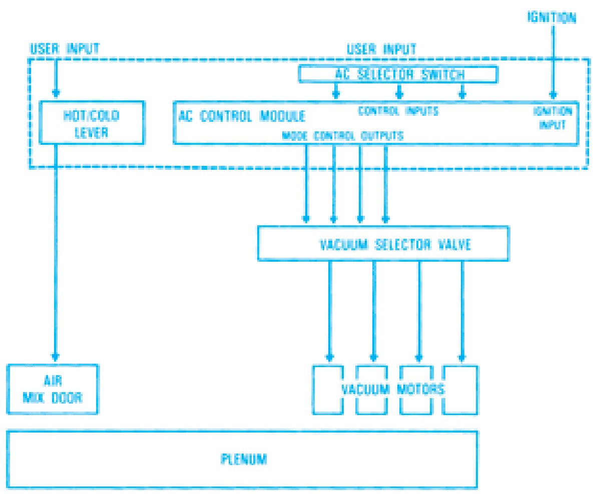

Figure 15-6. Manual air conditioning system block diagram. (GM Service and Parts Operations)

All input to the air-conditioning system begins with the control assembly mounted in the instrument panel. Temperature control can take the following forms:

- Manual control
- Semiautomatic control (programmer controlled)
- Fully automatic control (microprocessor or body computer controlled)

A manual temperature control system does not provide a method by which the system can function on its own to maintain a preset temperature. The user, through the mechanical control assembly, must make system input. Once the air-conditioning switch is turned on, the temperature selection made, and the blower speed set, the system functions with vacuum-operated mode door actuators and a cable-actuated air-mix door. Figure 15-6 is a block diagram of such a system.

Automatic Temperature Control (ATC)

With a semiautomatic temperature control system, the user still selects the mode but the actuators are electrically operated. Selecting the mode does not directly control the actuator; it creates an electrical input to an independent module or programmer (Figure 15-7). On Chrysler vehicles, the electronic **servomotor** performs the programmer function (Figure 15-8). Two sensors are added to inform the programmer of ambient temperature and in-car temperature (Figure 15-9). The programmer calculates the resistance values provided by the temperature dial setting and the two additional sensors

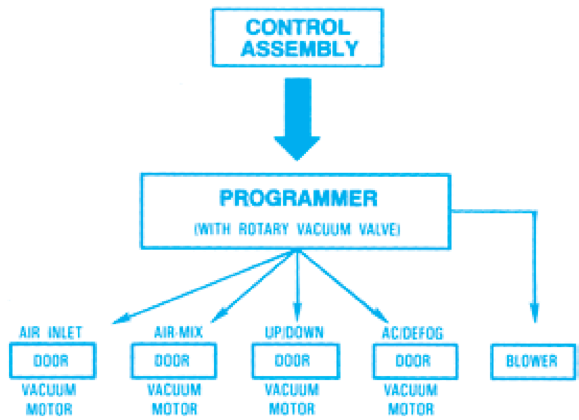

Figure 15-7. Semiautomatic AC systems use an electronic programmer to translate mechanical control movement into actuator signals. (GM Service and Parts Operations)

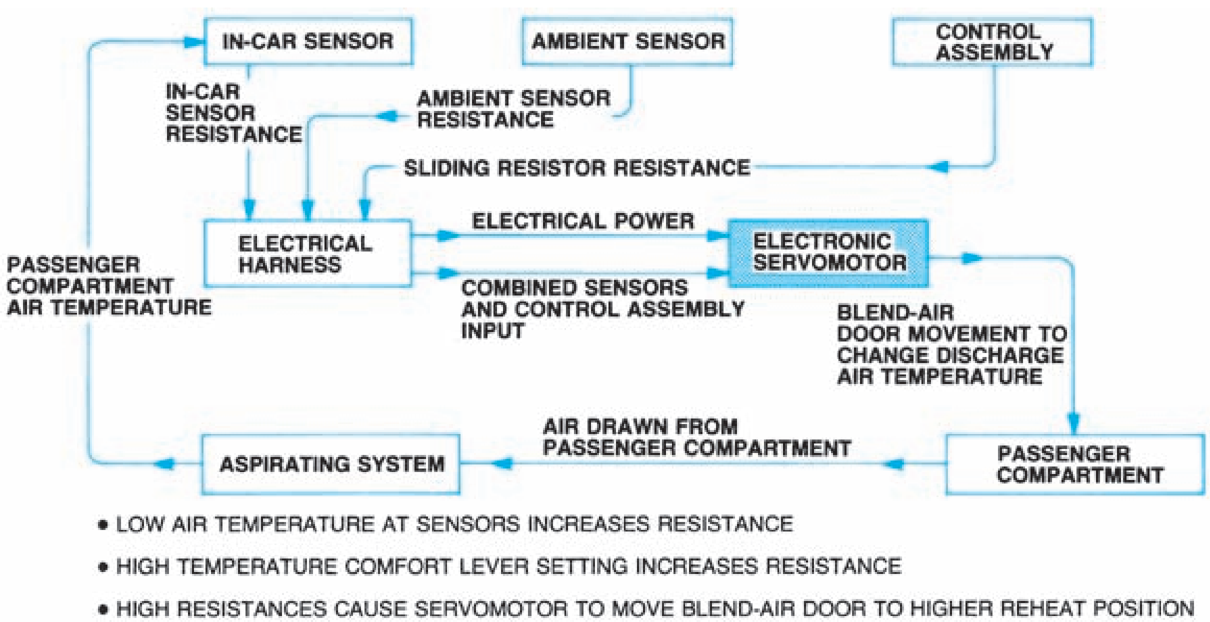

Figure 15-8. An electronic servomotor takes the place of a programmer in DaimlerChrysler's semiautomatic AC system. (DaimlerChrysler Corporation)

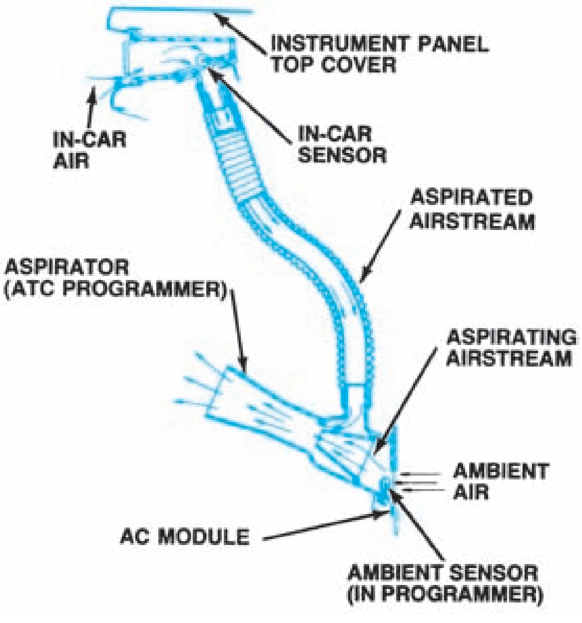

Figure 15-9. Resistance values from in-car and ambient temperature sensors are coupled with the resistance provided by the control assembly temperature dial to direct the programmer. (GM Service and Parts Operations)

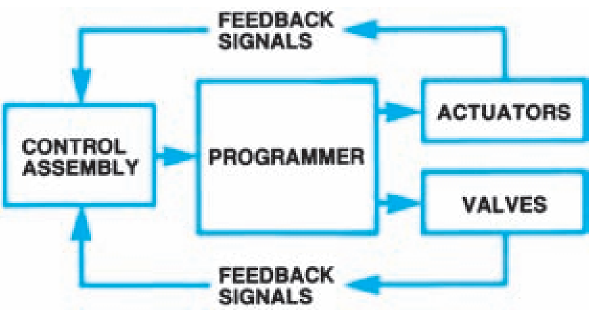

Figure 15-10. The actuators used in fully automatic AC systems provide feedback signals that allow the control assembly to monitor system operation. (GM Service and Parts Operations)

and adjusts cables or vacuum selector valves to maintain the preset temperature. The semiautomatic temperature control system differs from a manual system primarily in the use of the programmer; actuators and doors are still moved by mechanical linkage and cables.

In a fully automatic temperature control system, the control assembly is electronic instead of manual. The user selects the mode and the temperature. The control assembly microprocessor sends the appropriate signals to the programmer to operate the system. Electric servomotors are used as actuators to send a feedback signal to the electronic control assembly (Figure 15-10). This lets the control assembly monitor the system and make whatever adjustments are required to maintain the desired system temperature.

Since the control assembly is constantly monitoring the system, it knows when a malfunction occurs and can transmit this information to the service technician.

Semiautomatic Control (Programmer Controlled)

The GM C61 system is representative of a semiautomatic control system. Once the user has selected the mode and temperature, the system automatically controls blower speed, air temperature, air delivery, system turn-on, and compressor operation. It does this with a programmer inserted between the control assembly and the actuators (Figure 15-7), as well as two temperature sensors. The ambient sensor installed in the programmer is exposed to ambient airflow through a hole in the module wall; the in-car sensor is located under the instrument panel top cover. Figure 15-9 shows the sensor locations. Both sensors are disc-type thermistors that provide a return voltage signal to the programmer based on variable resistance. The programmer is built into the air-conditioning control assembly (Figure 15-11) and contains the following:

- A DC amplifier that receives a weak electrical signal from the sensors and control assembly and sends a strong output signal proportional to the input signal it receives
- A transducer that converts the amplifier signal to a vacuum signal that actuates the vacuum motor
- A vacuum checking relay that has a check valve to maintain a constant vacuum signal to the vacuum motor and the rotary vacuum valve
- A vacuum motor to actuate the rotary shaft that drives the air-mix door link
- A rotary vacuum valve to route vacuum to control the mode doors and operate the heater water valve; this valve does the same job as a vacuum selector valve in a manual system

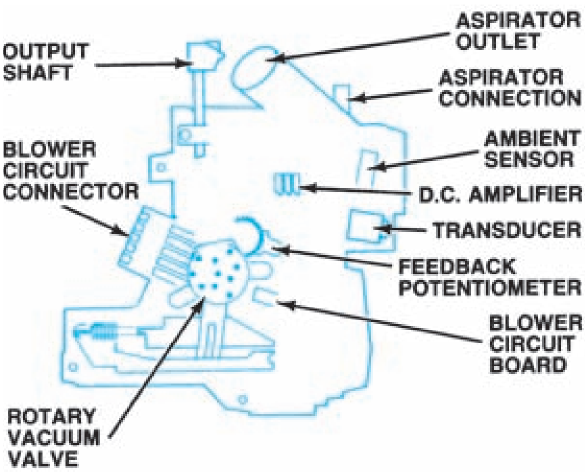

Figure 15-11. Components of the programmer used in GM's C61 AC system. (GM Service and Parts Operations)

- A feedback potentiometer to inform the programmer of system corrections required by changing temperature demands

A circuit board electrical switch is mounted on the base of the control assembly. The rotary switch contacts are positioned by the mode-select lever to provide the correct electrical path to the compressor clutch. The temperature dial varies the resistance of a wire-wound rheostat installed directly above it. The programmer uses the total resistance provided by the temperature dial and temperature sensors to calculate how the system should function.

To use this type of system, the driver need only set the control assembly in the auto mode and select a temperature. From this point on, the programmer controls the system operation by automatically setting the mode and blower speed and adjusting the air-mix doors to maintain the desired air temperature. Note that we have added nothing to the underhood portion of the air-conditioning system; we have only modified the operation of the control system by adding a device to maintain temperature within a selected narrow range.

Fully Automatic Control (BCM Controlled)

The electronic climate control (ECC) system used by Cadillac (Figure 15-12) is similar to the ETCC system just described. When used with a body control computer (BCM), the control assembly contains an electronic circuit board, but the BCM acts as the microprocessor. The BCM is constantly in touch with the climate control panel on the control assembly through a **data link,** or digital signal path (serial data line) provided for communication. The panel transfers user requests to the BCM, which sends the correct data to the panel for display.

Like the other semiautomatic and fully automatic systems we have looked at, the user selects the mode and temperature. The system automatically controls blower speed, air temperature, air delivery, system turn-on, and compressor operation. Although the ECC system functions similarly to the ETCC system, there are differences in compressor cycling methods. In a system without BCM control, the compressor clutch is grounded through the low-pressure switch. The power module thus cycles power to the compressor clutch (Figure 15-14A). In a BCM-controlled system, the compressor clutch current is received through a fuse and the power steering cutout switch or diode; the power module cycles the ground circuit for the compressor, Figure 15-14B.

The electronic comfort control (ECC) system used by Oldsmobile is BCM controlled and can be used as either a fully automatic or a manual system. When used manually, the driver can control blower speed and air delivery mode, but the system will continue to control temperature automatically. In addition to the BCM, power module, programmer, and control panel assembly used in other BCM-controlled systems, the ECC system uses inputs from the engine (electronic) control module (ECM). This allows the BCM to check several engine and compressor conditions before it turns the compressor on.

The BCM communicates with the ECM, the ECC panel, and the programmer on the serial data line to transmit data serially (one piece after another). The serial data line acts like a party telephone line; while the BCM is communicating with the ECM, the programmer and the ECC panel can "hear" and understand the conversation. They also can process and use the information communicated, but they cannot cut in on the transmission. For example, suppose the ECM is sending engine data to the BCM. The ECC panel computer, which needs to display engine rpm to the driver, "listens" in on the conversation, picks

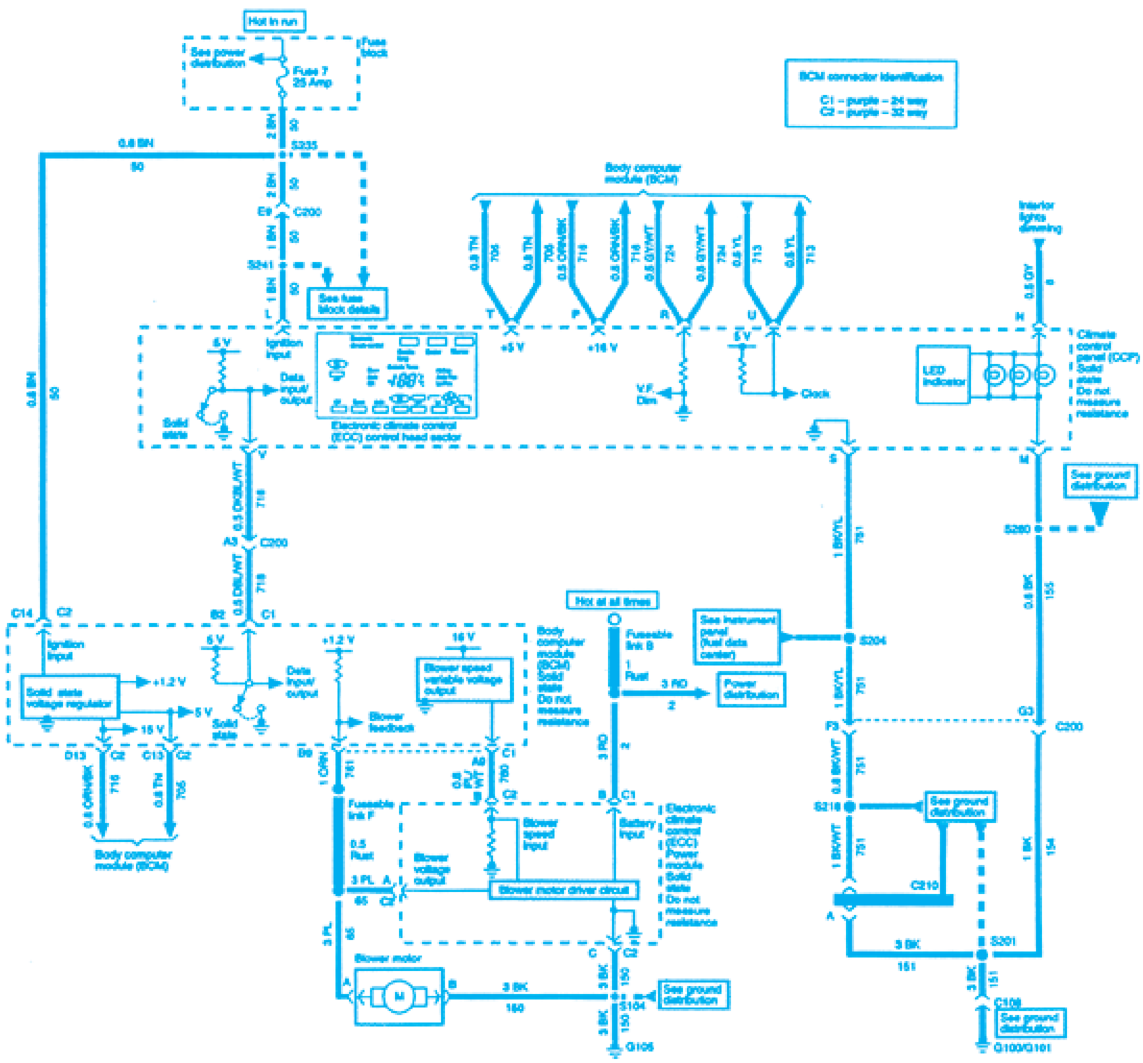

Figure 15-12. BCM-controlled HBAC system schematic. (GM Service and Parts Operations)

up the data it needs, and displays it on its panel. When the ECM is finished, it momentarily transmits a 5-volt signal to declare the line idle and the BCM opens a conversation with the next device it needs to talk with.

The programmer controls air delivery and temperature on instructions from the BCM, using a series of vacuum solenoids that control the mode door operation. The programmer also has a motor that controls the air-mix door position to regulate temperature. When directed to change blower speed by the BCM, the programmer sends a variable voltage signal to the power module, which sends the required voltage to the blower motor.

The ECC system is the most complex of the ones we've discussed, and this is reflected in the diagnostic sequence designed into the overall system network. When any subsystem exceeds its programmed limits, the system sets a trouble code and in some cases provides a backup function. The instrument panel cluster and the ECC panel (Figure 15-13) are used to access and control the self-diagnostic features. When the technician accesses the diagnostic mode, any stored BCM and ECM codes are displayed, along with various BCM and ECM parameters, discrete inputs and outputs, and any BCM output-override information.

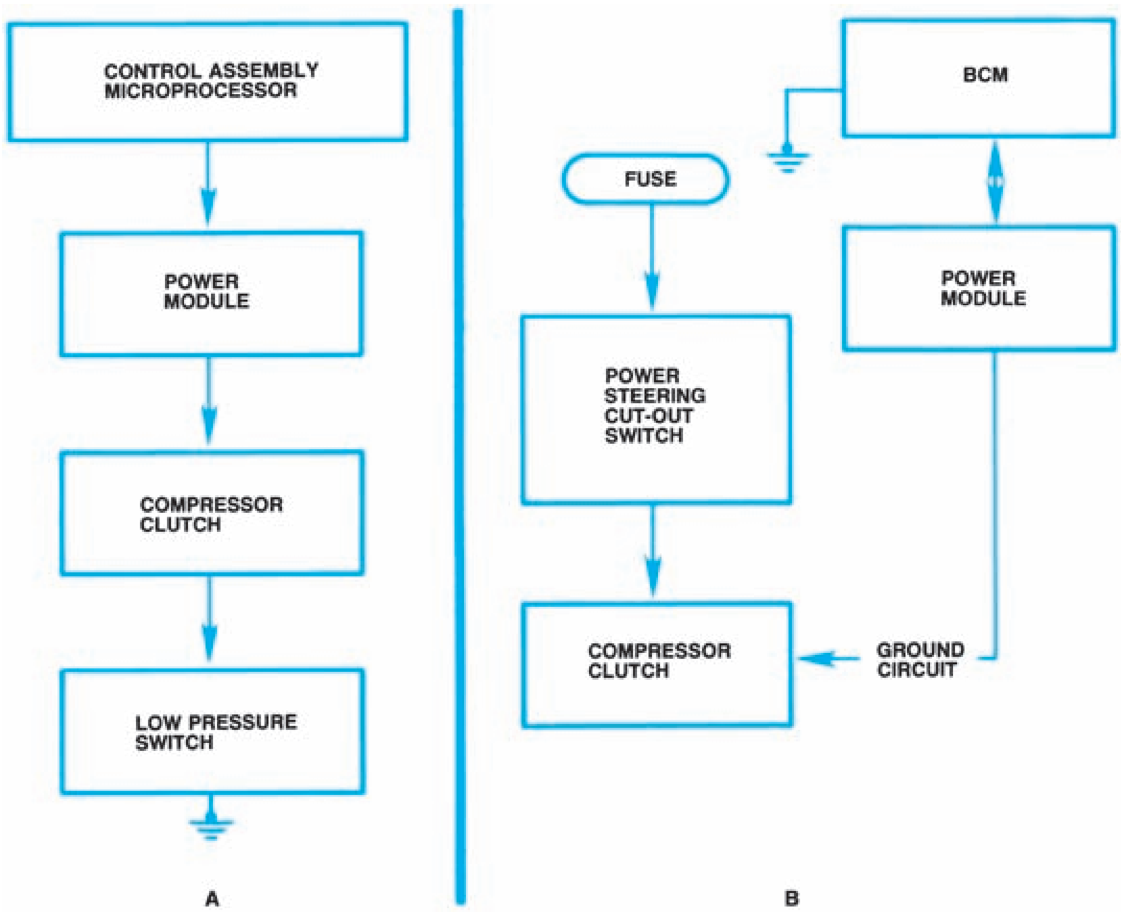

Figure 15-13. Non-BCM-controlled ECC systems ground the compressor clutch through the low-pressure switch and provide power through the power module (A). BCM-controlled ECC systems send power through a fuse and a power steering cutout switch, and cycle the ground through the power module (B). (GM Service and Parts Operations)

CLASS 2 IPM-CONTROLLED HVAC SYSTEMS

GM Electronically Controlled Blower Motor

HVAC Module

Most of the luxury model cars, including GM, have automatic *heating, ventilating, and air conditioning (HVAC)* systems that are computer controlled (Figure 15-14). The HVAC control module is a computer device that interfaces between the operator and the HVAC system to maintain air temperature and distribution settings. The control module sends switch input data to the instrument panel module (IPM) and receives display data from the IPM through signal and clock circuits. The control module does not retain any HVAC DTCs (diagnostic trouble codes) or settings.

Instrument Panel Module (IPM)

A function of the IPM operation is to process HVAC system inputs and outputs. Also, the IPM acts as the HVAC control module's Class 2 interface. The battery positive voltage circuit provides power that the IPM uses for Keep-Alive Memory (KAM). If the battery positive voltage circuit loses power, then all HVAC DTCs and settings will be erased from KAM. The ignition voltage circuit provides a device on signal. The IPM supports the following features:

- Driver set temperature
- Passenger set temperature

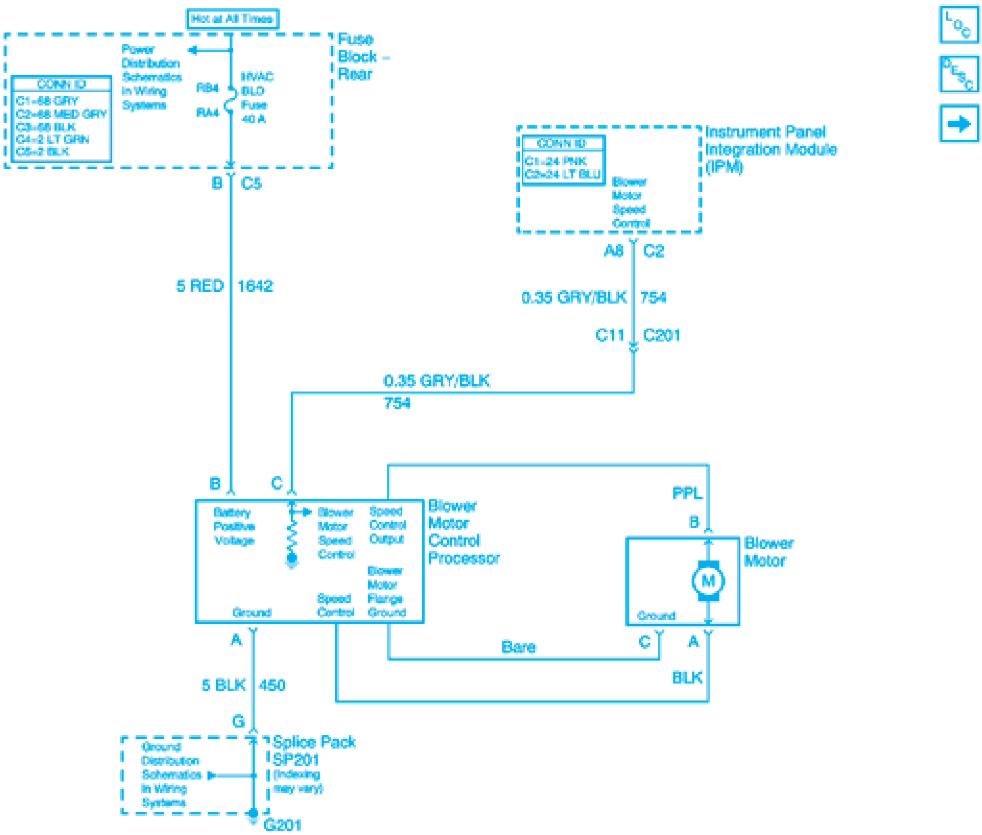

Figure 15-14. Cadillac Deville electronically controlled blower motor schematic. (GM Service and Parts Operations)

- Mode
- Blower motor speed
- A/C compressor request, auto ON or A/C OFF

This information will be stored inside the HVAC control module (IPM) memory. When a different driver identification button is selected, the HVAC control module will recall the appropriate driver settings. When the HVAC control module (IPM) is first turned on, the last stored settings for the current driver will be activated, except for the rear defrost and heated seat settings.

In automatic operation, the HVAC control module will maintain the comfort level inside of the vehicle by controlling the A/C compressor clutch, the blower motor, the air temperature actuators, the mode actuator, and recirculation.

To place the HVAC system in automatic mode, the following is required:

- The blower motor switch must be in the AUTO position.
- The air temperature switch must be in any other position besides 60 or 90 degrees.
- The mode switch must be in the AUTO position.

Once the desired temperature is reached, the blower motor, mode, recirculation, and temperature actuators will automatically adjust to maintain the temperature selected (except in the extreme temperature positions). The HVAC control module performs the following functions to maintain the desired air temperature:

- Regulate blower motor speed
- Position the air temperature actuator
- Position the mode actuator
- Position the recirculation actuator
- Request A/C operation

When the warmest position is selected in automatic operation, the blower speed will increase gradually until the vehicle reaches normal operating temperature. When normal operating temperature is reached, the blower will stay on high speed and the air temperature actuators will stay in the full heat position. When the coldest position is selected in automatic operation, the blower will stay on high and the air temperature actuators will stay in the full cold position.

In cold temperatures, the automatic HVAC system will provide heat in the most efficient manner. The vehicle operator can select an extreme temperature setting but the system will not warm the vehicle any faster. In warm temperatures, the automatic HVAC system will also provide air conditioning in the most efficient manner. Selecting an extreme cool temperature will not cool the vehicle any faster.

RADIOS AND ENTERTAINMENT SYSTEMS

Entertainment radios (Figure 15-15) are available in a wide variety of models. The complexity of systems varies from the basic AM radio to the compact disc (CD) player with high power amplifiers and multiple speakers. However, the overall operation of the radio itself, electrically, is basically the same. The major components in a basic AM system are a radio receiver and speaker. In the more complex stereo systems, the major components are an AM/FM radio receiver, a stereo amplifier, a sound amplifier switch, several speakers, and possibly a power antenna system.

In addition, many of the newer designs utilize a control module to aid in system diagnostics, memory presets, and other advanced features. The use of a scan tool and the appropriate service manual will enable the technician to determine the correct repair.

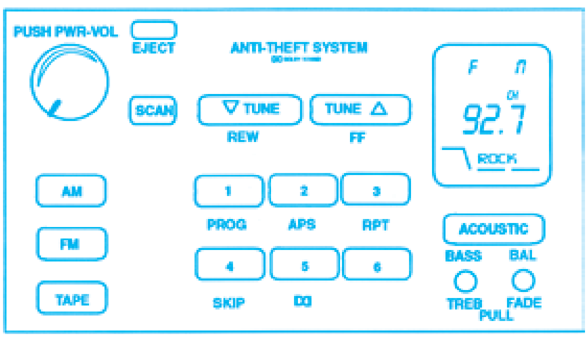

Figure 15-15. Radio face panel.

The inner circuitry of radios, tape players, CD players, power amplifiers, and graphic equalizers is beyond the scope of this text. However, a technician must understand the external circuitry of sound systems in order to troubleshoot them. Most sound units and speakers are grounded. In a few four-speaker systems, the speakers are insulated from their mountings. Current flows from the sound unit, through all of the speakers, and back to ground.

Entertainment System Diagnostics

Internal diagnostic examination of the radio should be left to the authorized radio service center. However, the automotive technician should be able to analyze and isolate radio reception conditions to the area of the component causing the condition. All radio conditions can be isolated to one of five general areas:

- Antenna system
- Radio chassis (receiver)
- Speaker system
- Radio noise suppression equipment
- Sound system

Radio Operation

Operation of the AM radio requires only that power from the fuse panel be available at the radio. The radio intercepts the broadcast signals with its antenna and produces a corresponding input to the system speaker. In addition, some radios have built-in memory circuits to ensure that the radio returns to the previously selected station when the radio or ignition switch is turned off and back on again. Some of these memory circuits require an additional power input from the fuse panel that remains hot at all times. The current draw is very small and requires no more power than a clock. However, if battery power is removed, the memory circuit has to be reset.

The service manual and owner's guide for the vehicle contain detailed information concerning radio operation. If the radio system is not working, check the fuse. If the fuses are okay, refer to the service manual. Remember, the radio chassis (receiver) itself should only be serviced by a qualified radio technician or specialty radio service shop. If you determine that the radio itself is the problem, remove the radio and send it to a qualified radio technician.

Antitheft Audio Systems

Most radio systems have built-in devices that make the audio system soundless if stolen. If the power source for the audio system is cut, the antitheft system operates so that even if the power source is reconnected, the audio system will not produce any sound. Some systems require an ID number selected by the customer to be entered. When performing repairs on vehicles equipped with this system, the customer should be asked for the ID number prior to disconnecting the battery terminals or removing the audio system. After the repairs, the technician or customer must input the ID number to regain audio system operation.

Other systems sense a specific code from the control module to allow the audio system to operate. This means the radio will not operate unless it is installed in the correct vehicle. Always refer to the vehicle service manual before removing a stereo to determine if it is equipped with any antitheft devices and the procedures for removal.

Noise Suppression

The vehicle's ignition system is a source of radio interference. This high-voltage switching system produces a radio frequency electromagnetic field that radiates at AM, FM, and CB frequencies. Although components have been designed into the vehicle to minimize this concern, the noise is more noticeable if the radio is turned slightly off channel when listening to FM programs. Vehicle electrical accessories and owner add-on accessories may also contribute to radio interference. Furthermore, many noise sources are external to the vehicle, such as power lines, communication systems, ignition systems of other vehicles, and neon signs.

In addition to resistance-type spark plugs and cables, automobiles use capacitors and ground straps to suppress radio static or interference caused by the ignition and charging systems. Capacitors may be mounted as follows:

- Inside the alternator (Figure 15-16)
- Behind the instrument panel, near the radio (Figure 15-17)

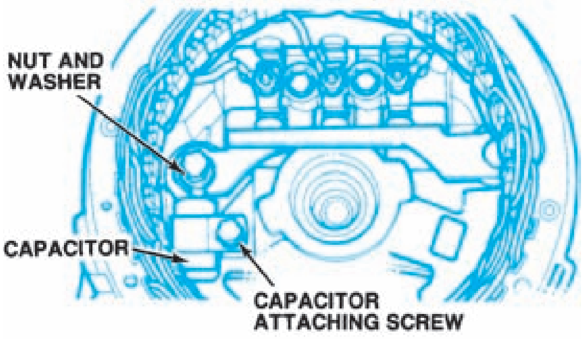

Figure 15-16. RFI capacitors can be installed inside the alternator. (DaimlerChrysler Corporation)

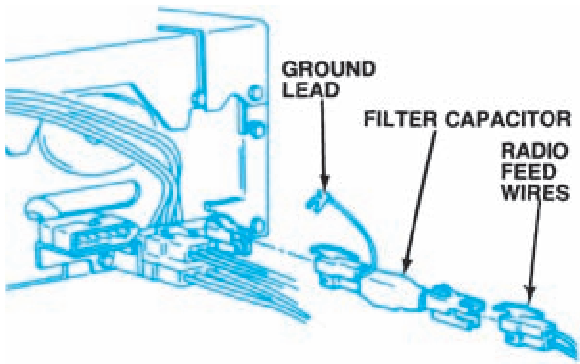

Figure 15-17. An RFI capacitor may be installed near the radio. (GM Service and Parts Operations)

- At the ignition coil with the lead connected to the coil primary positive terminal (Figure 15-18A)
- In a module mounted at the wiper motor and connected in series between the motor and wiring harness (Figure 15-18B)

Ground straps are installed to conduct small, high-frequency electrical signals to ground. They require a large, clean, surface-contact area. Such ground straps are installed in various locations depending upon the vehicle. Some common locations are as follows:

- Radio chassis to cowl
- Engine to cowl
- Across the engine mounts
- From air-conditioning evaporator valve to cowl

The small bulb that lights the sound unit controls may be part of the instrument panel

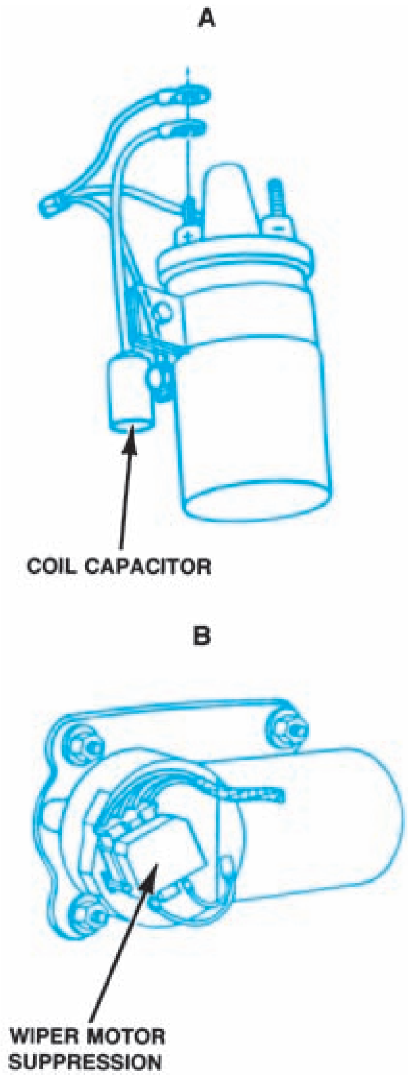

Figure 15-18. RFI capacitors may be installed on the ignition coil or wiper motor. (DaimlerChrysler Corporation)

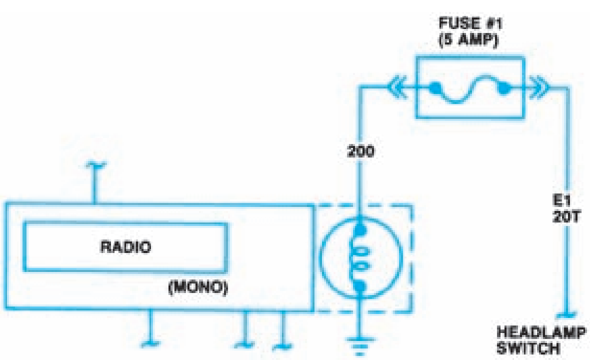

Figure 15-19. The radio illumination bulb is controlled by the IP light circuit. (DaimlerChrysler Corporation)

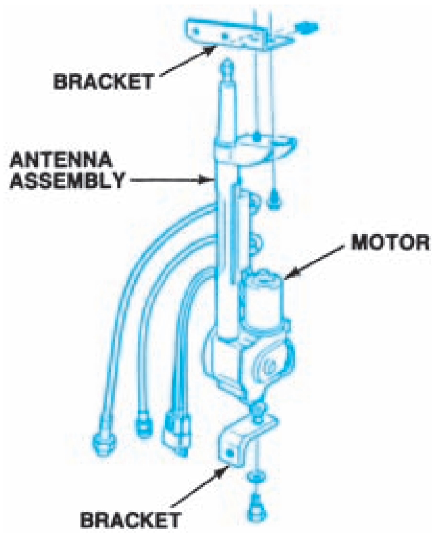

Figure 15-20. The motor of an electrically extended radio antenna is usually installed inside the wheel well under a protective cover. (GM Service and Parts Operations)

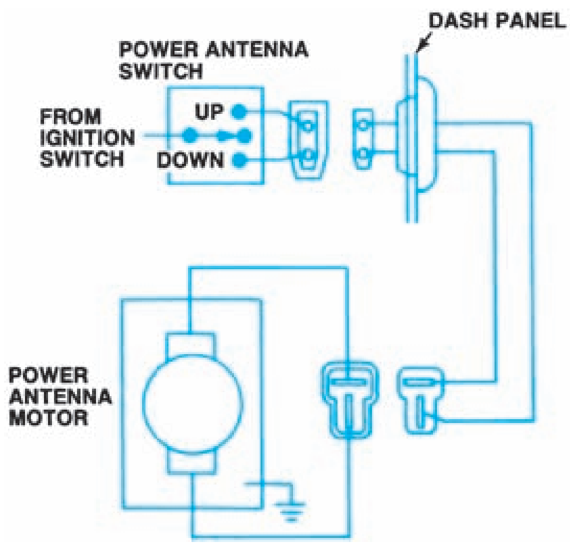

Figure 15-21. A separate switch can control power antennas. (DaimlerChrysler Corporation)

circuitry (Figure 15-19) or part of the sound unit's internal circuitry. Some cars use electrically extended radio antennas (Figure 15-20). The antenna motor may be automaticalIy activated when the radio is turned on, or a separate switch (Figure 15-21) may control it. A relay may control current to the antenna motor.

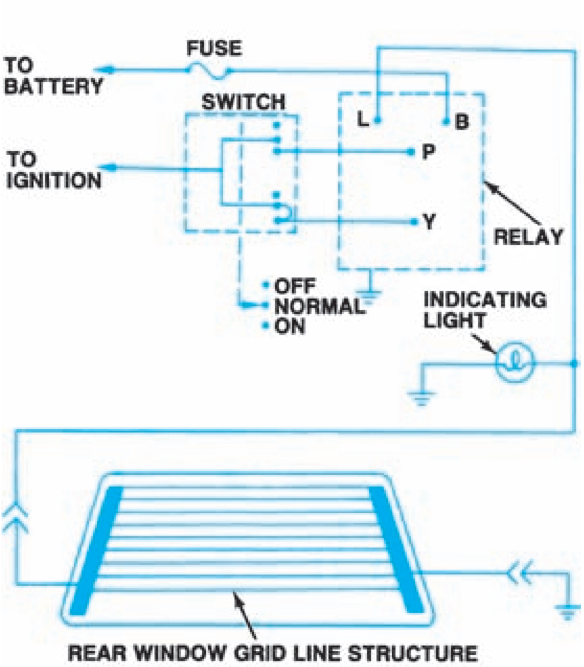

Figure 15-22. Defroster circuit with grid. (DaimlerChrysler Corporation)

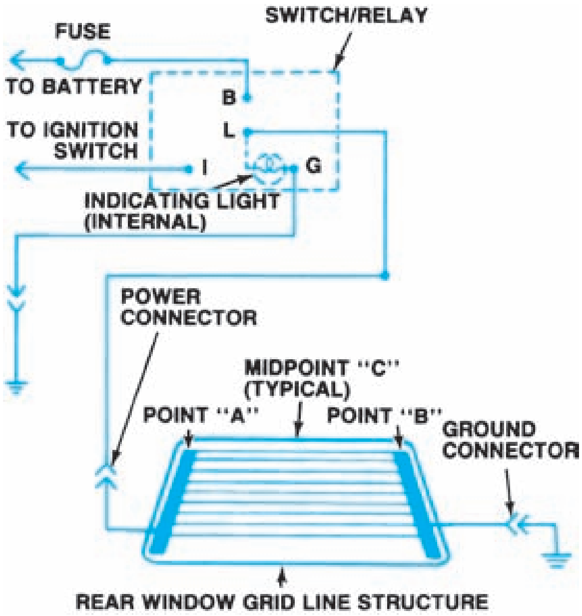

Figure 15-23. Late-model system with a solid-state timing module that turns off the defroster current automatically. (DaimlerChrysler Corporation)

REAR-WINDOW DEFOGGER AND DEFROSTER

Some older vehicles have a rear-window defogger, which is a motor-driven fan similar to that used in the heating system but mounted behind the rear seat near the rear window. It is controlled by a separate switch that routes current through circuits of varying resistance (like a heater fan) to change motor speed. Heat is provided electrically by a length of resistance wire in the defogger unit. The resistance heater is connected in parallel with the motor so that it heats when the motor is running at either high or low speed.

Rear Window Defroster

A **defroster** is a grid of electrical heating conductors that is bonded to the rear window glass (Figure 15-22). The defroster grid is sometimes called a defogger. Current through the grid may be controlled by a separate switch and a relay (Figure 15-22) or by a switch-relay combination (Figure 15-23). In both designs, when the switch is closed, the relay is energized and an indicator lamp is lit. The relay contact points conduct current to the rear window grid.

Most late-model systems have a solid-state timing module that turns off the defroster current automatically. In the system shown in Figure 15-23, the switch ON position energizes the relay's pull-in and hold-in coils. The switch NORMAL position keeps the hold-in coil energized so that the relay points remain closed. Cleaning the inside rear glass should be done carefully to avoid scratching the grid material and causing an open in the circuit.

POWER WINDOWS

Car doors can contain motors to raise and lower the window glass (Figure 15-24). The motors usually are the permanent-magnet type and are insulated at their mounting and grounded through the control switch (Figure 15-25) or the master switch. Each control switch operates one motor, except for the driver's door switch. This is a master switch that can control any of the motors. Some systems have a mechanical locking device that allows only the driver's switch to control any of the motors.

The single-motor control switches each have one terminal that is connected to battery voltage. Each of the other two switch terminals is con-

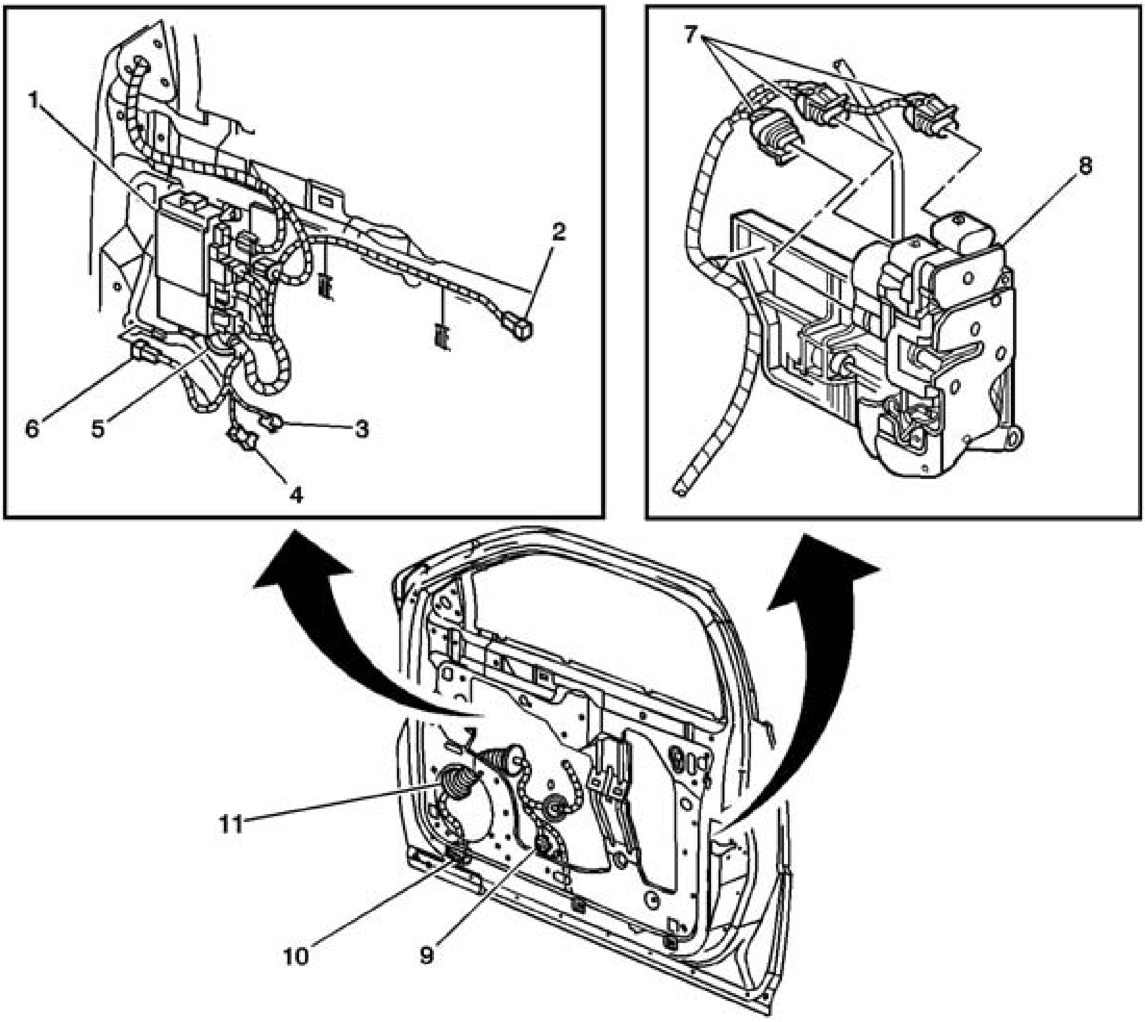

Figure 15-24. The motor in this door can raise and lower the window. (GM Service and Parts Operations)

nected to one of the two motor brushes. The window is moved up or down by reversing the direction of motor rotation. Motor rotation is controlled by routing current into one brush or the other. Each individual window switch is connected in series with the driver's master switch. Current from the motor must travel through the master switch to reach ground.

POWER SEATS

Electrically adjustable seats can be designed to move in several ways, as follows:

- Two-way systems move forward and backward.
- Four-way systems move forward, backward, and front edge up and down.
- Six-way systems, used in most late-model applications, move the entire seat forward, backward, up, and down; tilt the upper cushion forward and backward, and move the lower cushion front edge up and down, and rear edge up and down.

GM makes a typical two-way power seat system, as shown in Figure 15-26. The series-connected motor has two electromagnetic field windings that are wound in opposite directions. One winding receives current from the forward switch position. The second winding receives current from the rear switch position. Current through one winding will make the motor turn in

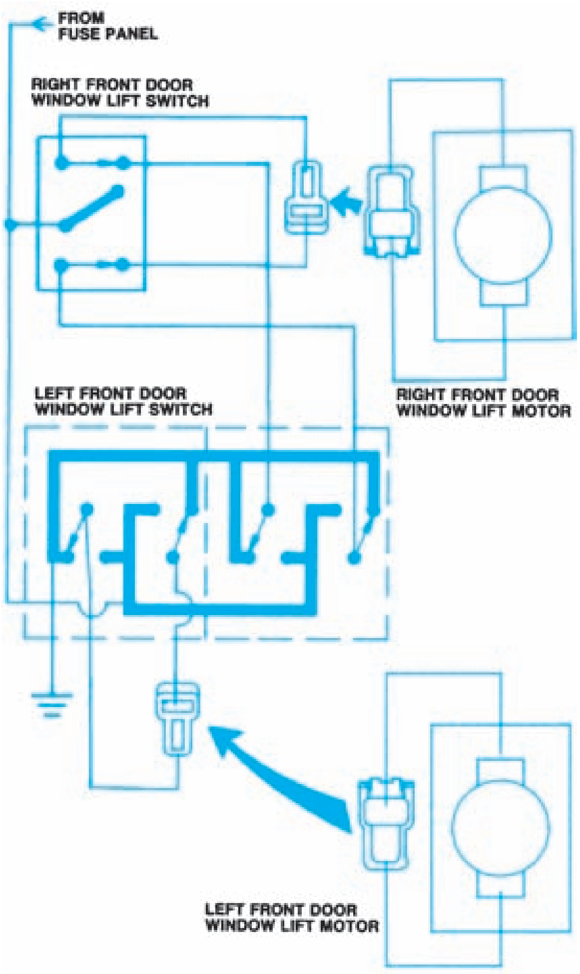

Figure 15-25. Typical power window control circuit. (DaimlerChrysler Corporation)

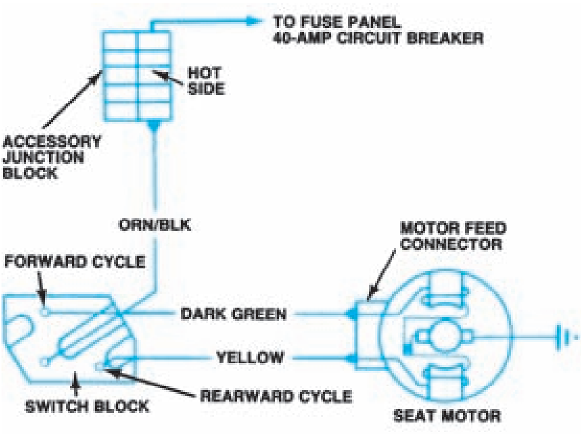

Figure 15-26. A GM two-way power seat has a motor with electromagnetic fields; current through the fields determines the direction of the motor and thus the movement of the seat. (GM Service and Parts Operations)

one direction; current through the opposite winding will make the motor turn in the opposite direction. The motor armature is linked to the seat mounting by a transmission that translates this rotary motion into seat motion.

Ford and GM have made four-way power seat systems that contain two reversible motor armatures in one housing. Ford's motors have permanent-magnet fields, while GM's motors have series-connected electromagnetic fields. One motor is linked to a transmission that moves the seat forward and backward. The other motor's transmission tilts the front edge of the seat. A single four-position switch controls both motors. The switch contacts shift current to different motor brushes (Ford) or to different field windings (GM) to control motor reversal.

Early GM six-way power seat systems use one reversible motor that can be connected to one of three transmissions. Transmission hookup is controlled by three solenoids (Figure 15-27). The control switch is similar to that used by Ford and Chrysler, but the circuitry differs. Current must flow through one of the solenoids to engage a transmission, then through a relay to ground. The relay points conduct current to the motor brushes. Additional switch contacts conduct current to the electromagnetic motor windings.

Chrysler, Ford, and late-model GM six-way power seat systems use three reversible motor

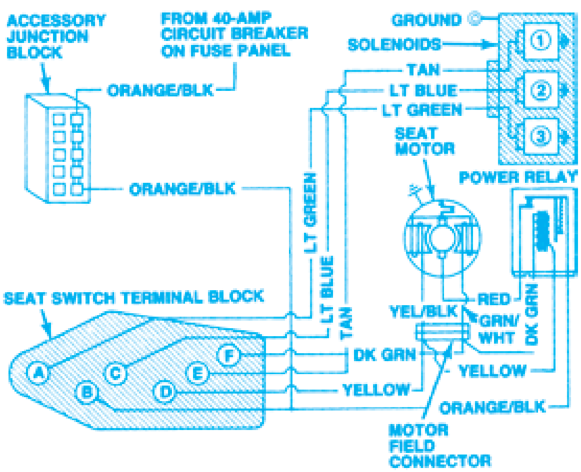

Figure 15-27. GM's early six-way power seat systems use one reversible motor that can be connected to one of three transmissions. Transmission hookup is controlled by three solenoids. (GM Service and Parts Operations)

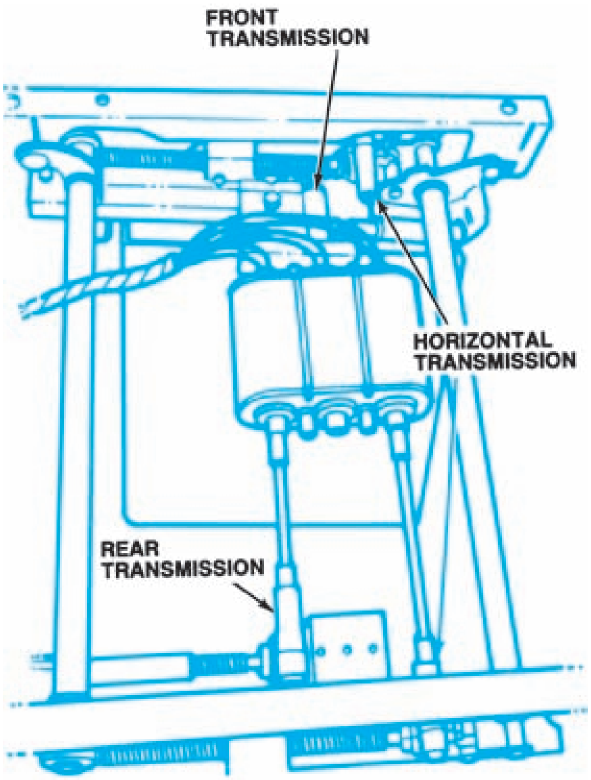

Figure 15-28. Chrysler, Ford, and late-model GM six-way power seat systems use three reversible motor armatures in one housing. (DaimlerChrysler Corporation)

armatures in one housing (Figure 15-28). The control switches have two two-position knobs that control edge tilt and a four-position knob that controls forward, backward, up and down seat movement. The switch contacts shift the current to different motor brushes to control motor reversal. The permanent-magnet motors are grounded through the switch and may contain an internal circuit breaker.

HEATED SEATS

Most manufacturers of premium cars and SUVs offer heated front seats, and in some cases back seats as well (Figure 15-29). Most vehicle heated seat systems consist of four heated seats: two in the front and two in the rear. Figure 15-30 shows a typical heated seat system schematic. Most heated seat systems consist of the following components:

- Heated seat module or controller
- Heated seat switch
- Seat back heating element
- Seat cushion heating element

The rear integration module (RIM), driver door module (DDM), left rear door module

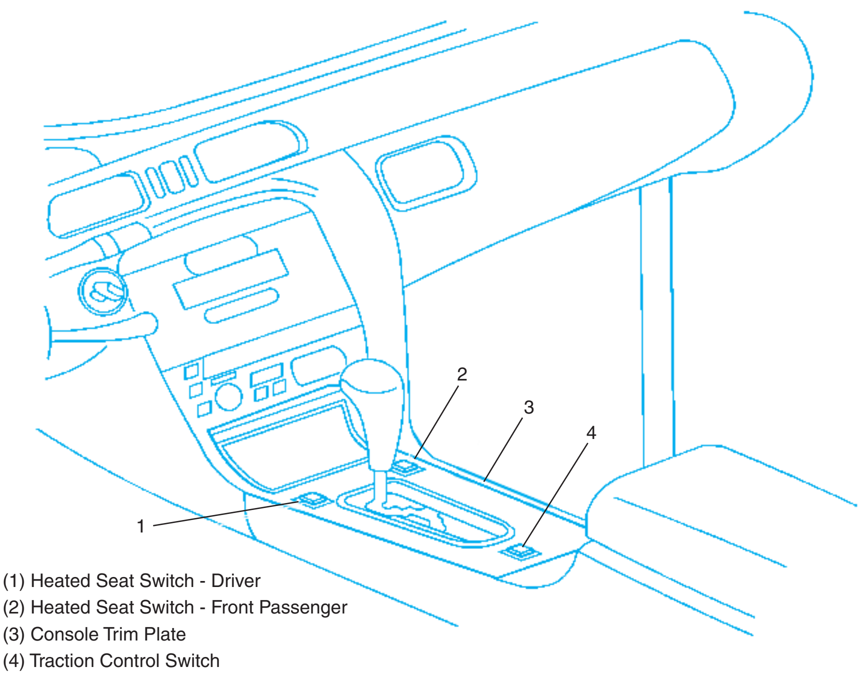

Figure 15-29. Heated seat controls. (GM Service and Parts Operations)

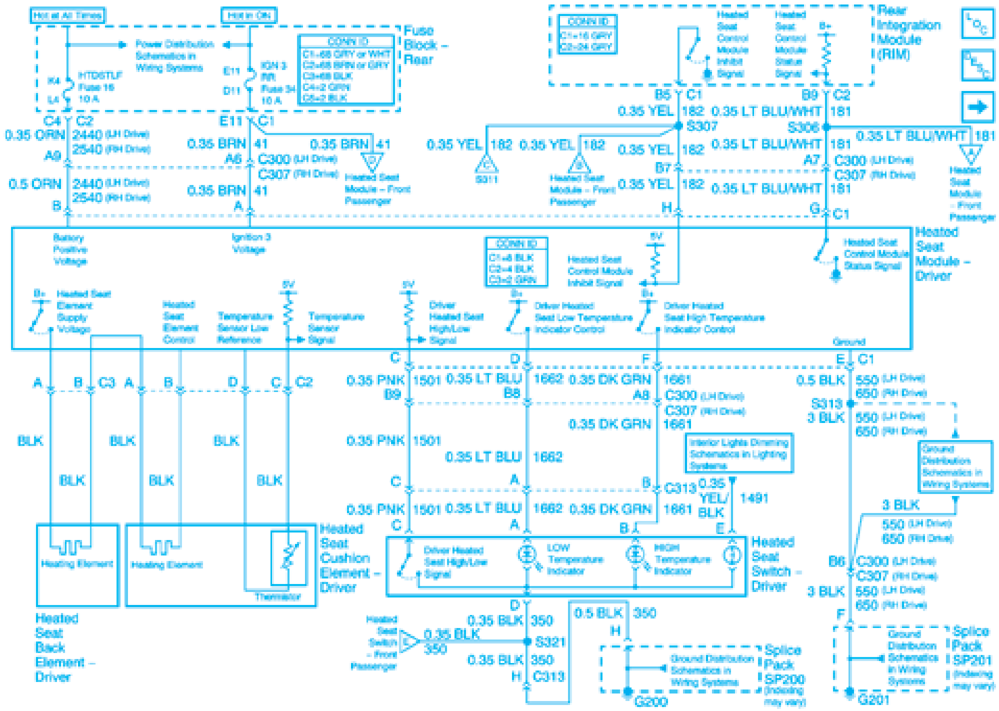

Figure 15-30. Heated seat circuit. (GM Service and Parts Operations)

(LRDM), and right rear door module (RRDM) are also involved in the operation of the heated seats. The system is functional only with the ignition switch in the ON position.

Power and Grounds

Battery positive voltage is supplied to the front and rear heated seat module through the ignition 3 voltage circuit and the IGN 3 fuse located in the rear fuse block. This voltage is used to power up the module. Battery positive voltage is also supplied at all times to all four heated seat modules from the fuses located in the rear fuse block.

The modules to apply voltage to the seat heating elements use this battery voltage. The left and right front heated seat modules are grounded through the module ground circuit and G302. The left and right rear heated seat modules are grounded through the module ground circuit and G301. The left and right front heated seat switches are grounded through the switch ground circuit and G200. The left and right rear heated seat switches are grounded through the switch ground circuit provided by the associated door module.

Temperature Regulation

The heated seat system is designed to warm the seat cushion and seat back to approximately 42°C (107.6°F) when in the high position, and 37°C (98.6°F) when in the low position. The heated seat module monitors the seat temperature through the temperature sensor signal circuit and the temperature sensor (thermistor) that is located in the seat cushion. The temperature sensor is a variable resistor: its resistance changes as the temperature of the seat changes. When the temperature sensor resistance indicates to the heated seat module that the seat has reached the desired temperature, the module opens the ground path of the seat heating elements through the heated seat element control circuit. The module will then cycle the element control circuit open and closed in order maintain the desired temperature.

Front Heated Seat Operation

When the heated seat switch is first pressed, the heated seat high/low signal circuit of the heated seat module is momentarily grounded through the HI/LO switch contacts, indicating a high heat command. In response to this signal, the heated seat module applies battery positive voltage to the seat cushion/back heating elements, setting the temperature level to high heat. When the heated seat switch is pressed a second time, the heated seat high/low signal circuit of the heated seat module is again momentarily grounded through the HI/LO switch contacts, indicating a low heat command. In response to this second signal, the heated seat module then sets the temperature level to low heat. When the heated seat switch is pressed a third time, the heated seat high/low signal circuit of the heated seat module is again momentarily grounded through the HI/LO switch contacts, indicating a heat off command. In response to this signal, the heated seat module removes battery voltage from the seat heating elements.

Front Heated Seat Switch Indicators

When the heated seat is off and the front heated seat switch is pressed once, the heated seat temperature is set to high heat. The heated seat module applies 5 volts through the heated seat high temperature indicator control circuit to the heated seat switch, illuminating the high temperature indicator. When the switch is pressed a second time the heated seat temperature is set to low heat. The heated seat module applies 5 volts through the heated seat low temperature indicator control circuit to the heated seat switch, illuminating the low temperature indicator. After the switch is pressed a third time, the heated seat is turned off, and the front heated seat module removes the voltage from the low temperature indicator.

Rear Heated Seat Operation

When the heated seat switch is first pressed, the heated seat switch signal circuit of the rear door module is momentarily grounded through the switch contacts, indicating a high heat command. The rear door module then sends a simple buss interface (SBI) message to the driver's door module (DDM), indicating the high heat command. The DDM then sends out a Class 2 message to the rear integration module (RIM), indicating the high heat command. The RIM momentarily sends a 35-millisecond one-shot pulse signal that is pulled low through the heated seat switch signal circuit of the rear heated seat module, indicating the high heat command. In response to this signal, the heated seat module will then apply battery positive voltage to the seat cushion/back heating elements, setting the temperature level to high heat.

When the switch is pressed a second time, the heated seat switch signal circuit of the rear door module is again momentarily grounded, indicating a low heat command. The rear door module then sends out a SBI message to the DDM, indicating the low heat command. The DDM then sends out a Class 2 message to the RIM, indicating the low heat command. The RIM again momentarily sends a 35-millisecond one-shot pulse signal that is pulled low through the heated seat switch signal circuit of the heated seat module, indicating the low heat command. In response to this signal, the heated seat module then sets the temperature level to low heat.

After the switch is pressed a third time, the heated seat switch signal circuit of the rear door module is again momentarily grounded, indicating a heat off command. The rear door module then sends out a SBI message to the DDM, indicating the heat off command. The DDM then sends out a Class 2 message to the RIM, indicating the heat off command. The RIM again momentarily sends a 35-millisecond one-shot pulse signal that is pulled low through the heated seat switch signal circuit of the heated seat module, indicating the heat off command. In response to this signal, the heated seat module then removes the battery voltage from the seat heating elements, turning off the heated seats.

Rear Heated Seat Switch Indicators

When the heated seat is off and the rear heated seat switch is pressed once, the heated seat temperature is set to high heat. The rear door module applies battery positive voltage through the heated seat high temperature indicator control circuit to the heated seat switch, illuminating the high temperature indicator. When pressed a second time, the heated seat temperature is set to low heat. The rear door module the applies battery positive voltage through the heated seat low temperature indicator control circuit to the heated seat switch, illuminating the low temperature indicator. After the switch is pressed a third time, the heated seat is turned off, and the rear door module removes the battery voltage from the low temperature indicator.

Load Management

Three levels of load management are controlled by the DIM. The DIM sends the status of the load management to the RIM via a Class 2 message. The ON/OFF status of the heated seats is reported to the RIM through the status-signal circuit of each heated seat module. The RIM inhibits the heated seat function for the heated seats through the heated seat module inhibit-signal circuit, according to the level of load management. During load shed level 00, the RIM leaves the heated seat inhibit-signal circuit open so that each heated seat module is in the normal mode of operation. During load shed level 01, the RIM will cycle the signal from High to Low every 0.25 second to set the heat level to the low setting. During load shed level 02, the RIM will supply a constant ground through the heated seat module inhibit-signal circuit to the heated seat modules. In response to this signal, the heated seat module then removes the battery voltage from the seat heating elements. The instrument cluster will display a Battery Saver Active message.

POWER DOOR LOCKS, TRUNK LATCHES, AND SEAT-BACK RELEASES

Solenoids and motors are used to control door, trunk, and seat-back latches, and locks. Door and trunk systems are usually controlled by separate switches mounted near the driver. Door-jamb switches usually control seat-back latches.

In some GM door lock systems, current flows through a solenoid winding to ground (Figure 15-31) when the driver closes the switch. The solenoid core movement either locks or unlocks the door, depending upon which switch position is selected. Some Ford and Chrysler electric door locks use a relay-controlled circuit as shown in Figure 15-32.

Current from the control switch flows through the relay coil, closing the relay contacts. The contacts route current directly from the fuse panel to the solenoid windings. Other Ford, Chrysler, and GM power door locks use an electric motor to move the locking mechanism. The electric motor receives current through a relay (Figure 15-32)

Power trunk latches use an insulated switch and a grounded solenoid coil (Figure 15-33). Power seat-back releases can be automatically controlled by grounding door-jamb switches (Figure 15-34). Opening one of the front doors energizes a relay; the relay contacts conduct current to solenoids, which unlatch both seat backs.

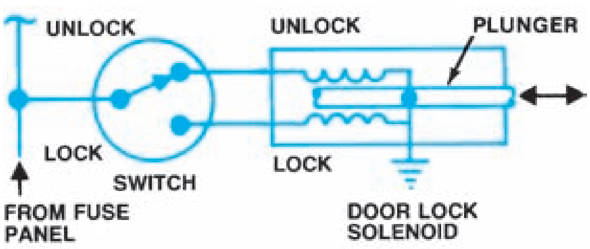

Figure 15-31. GM power door lock system. (GM Service and Parts Operations)

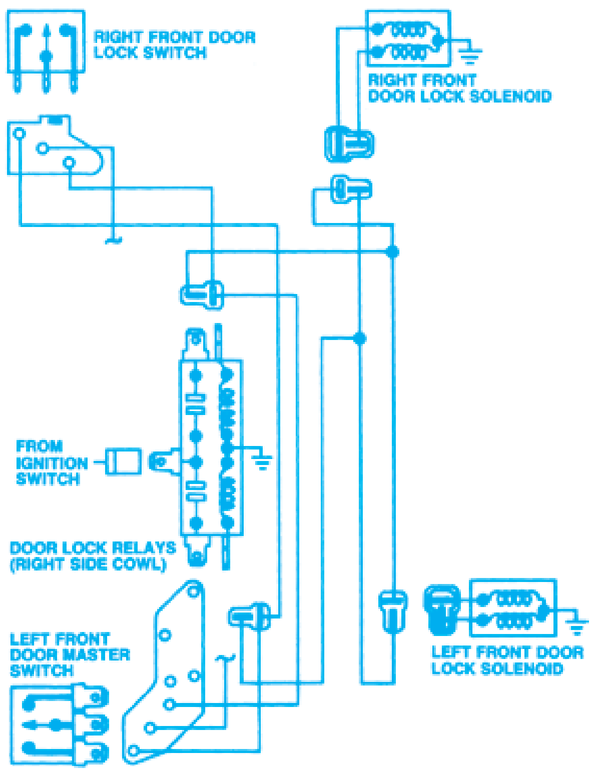

Figure 15-32. DaimlerChrysler power door lock system. (DaimlerChrysler Corporation)

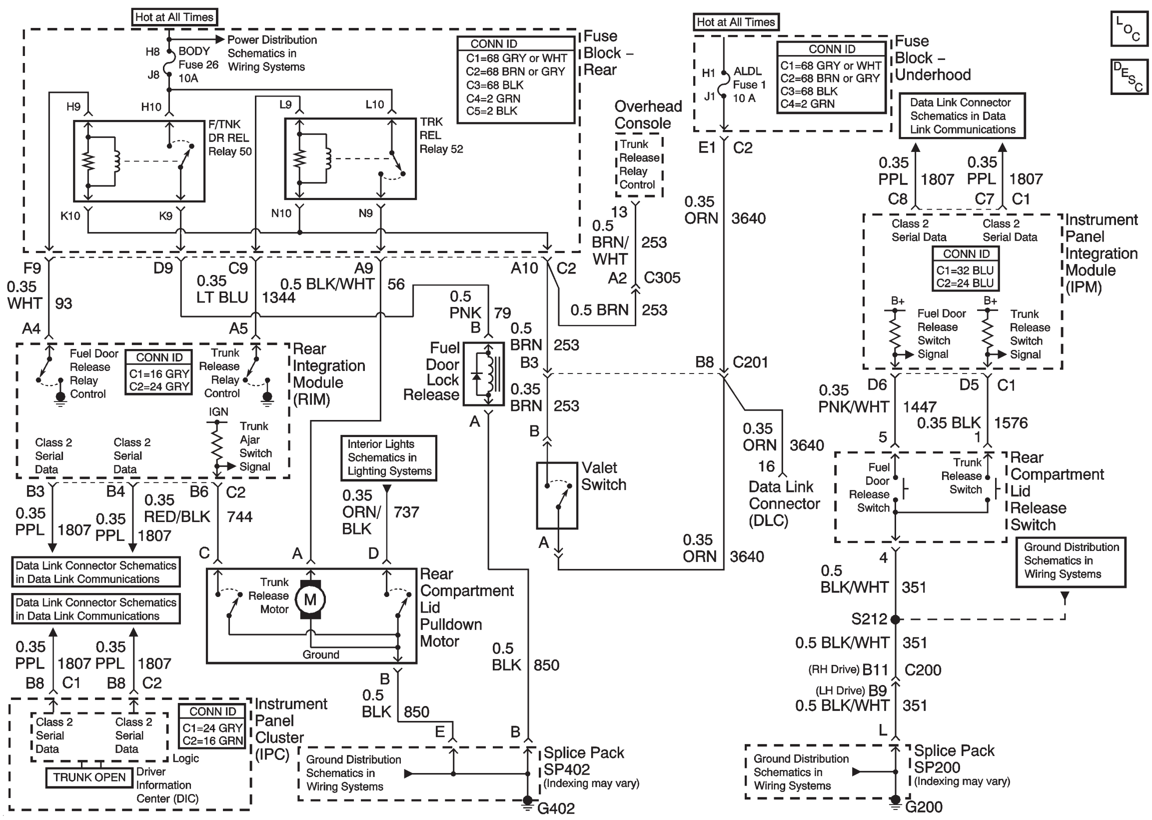

Figure 15-33. Typical power trunk lid latch system. (GM Service and Parts Operations)

AUTOMATIC DOOR LOCK (ADL) SYSTEM

General Motors and Ford both use an **automatic door lock (ADL)** system in the power door lock system on some of their models, as a safety and convenience feature. Ford ADL systems are an integral part of the keyless entry system, while General Motors ADL systems are available on vehicles regardless of whether they have keyless entry.

On GM vehicles with automatic transaxles, placing the gear selector in Drive automatically locks all vehicle doors when the ignition is ON. All doors unlock automatically when the gear selector is returned to the Park position. Individual doors can be unlocked manually from the inside, the front doors can be unlocked with the key from outside, or all the doors can be unlocked electrically while in Drive.

System Operation

The ADL feature may be a function of the chime module, an ADL controller, or a multifunction alarm module, depending on the vehicle model. In a typical General Motors ADL circuit, voltage is applied to the chime module, ADL controller, or alarm module. When the doors are closed, the ignition is in the Run position, and the gear selector is placed in Drive, the module or controller sends current to ground through the lock relay coil in the ADL relay (Figure 15-35). Current passes through the relay, door lock motors, and unlock relay to ground, locking the doors. The module or controller then removes current from the relay coil to prevent damage to the lock motors. When the vehicle stops and the gear selector is returned to Park, voltage is sent to the unlock relay coil in the ADL relay. The doors are unlocked by current passing through the relay, door lock motors, and lock relay to ground.

REMOTE/KEYLESS ENTRY SYSTEMS

In the late 1970s, Ford developed the first keyless entry system used on domestic vehicles. Chrysler and GM both offer keyless entry options on some

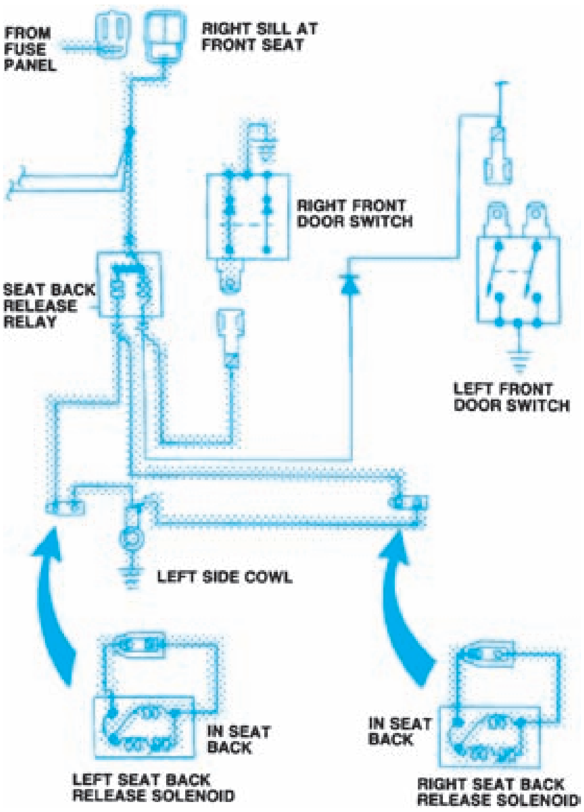

Figure 15-34. Power seat back releases can be automatically controlled by grounding door-jamb switches. (DaimlerChrysler Corporation)

current models. Since their applications differ substantially in design, concept, and operation, we will look at the Ford version first.

Ford

Ford's keyless entry system has remained substantially unchanged since its introduction. It provides a convenient entry method when the vehicle keys have been forgotten, or accidentally locked inside. The system consists of a five-button keypad secured to the outer panel on the driver's door, a microprocessor-relay control module, and connecting wiring.

The keyless entry system incorporates two additional subsystems: one for illuminated entry and the other for automatic door locks. Operating as a single system, it performs the following functions:

- Unlocks the driver's door
- Unlocks other doors or the deck lid when a specific keypad button is depressed within five seconds after unlocking the driver's door
- Locks all doors from outside the vehicle when the required keypad buttons are depressed simultaneously
- Turns on the interior lamps and the illuminated keyhole in the driver's door
- Automatically locks all doors when they are closed, the driver's seat is occupied, the ignition switch is on, and the gear selector is moved through the reverse position.

A linear keypad using calculator-type buttons is installed in the driver's door and used to input a numerical code to the control module. The five-keypad buttons are numbered 1-2, 3-4, 5-6, 7-8, and 9-0 from left to right. The numerical code used to open the door, however, is a derivative of a five-digit keypad code stamped on the control module and printed on a sticker attached to the inside of the deck lid. This code refers to the location of the five buttons on the keypad, not the keypad button number. For example, if the module number is 23145, the doors will unlock only if the keys are depressed in that order. If the module requires replacement, a sticker bearing the new module number is applied over the old sticker on the deck lid.

The control module's program operates the keyless entry, illuminated entry, and ADL systems. Two 14-pin connectors (one brown and one gray) connect the wiring harness to the control module; the brown connector also connects the keypad harness to the module. The following components provide inputs to the control module:

- Keypad buttons
- Door handles
- Courtesy lamp switch
- Driver's seat sensor
- Transmission backup lamp switch
- Ignition switch
- Door lock and unlock switches
- Door-ajar switch

The following components receive output signals from the control module:

- Keypad lamps
- Interior courtesy lamps
- Door lock LEDs
- Deck-lid-release solenoid
- Door lock solenoids

Ford added a remote keyless entry feature on some models, which uses a handheld radio transmitter with three buttons for door lock control from outside the vehicle. If the vehicle is equipped

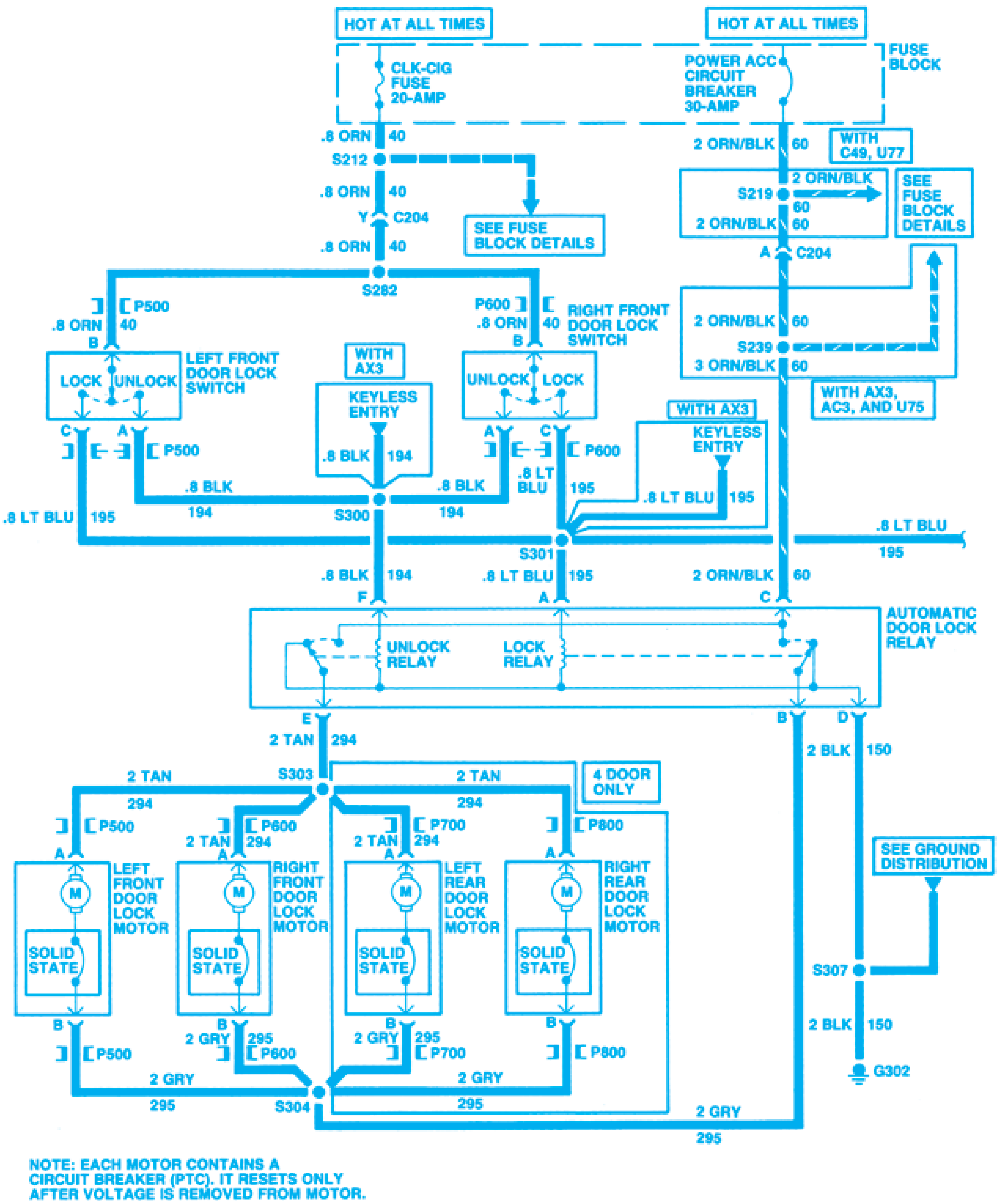

Figure 15-35. ADL (automatic door lock) circuit diagram. (GM Service and Parts Operations)

with the Ford antitheft system, a four-button transmitter is used. The additional button is marked "Panic" and allows the driver to activate the alarm in an emergency. The system operates essentially the same as the Delco RKE system described in the following section.

GM Keyless Entry Systems

In 1993, GM introduced a Passive Keyless Entry (PKE) system on the Corvette. In this system, a key-fob transmitter locks the doors as the person carrying it walks away from the car, and unlocks them when the carrier comes close to the car again. The owner does not even need to push a button.

Other GM vehicles use the Delco Remote Keyless Entry (RKE) or Remote Lock Control (RLC) system. The key fob contains a radio transmitter with three buttons (Figure 15-36) that allow the driver to lock or unlock the doors and trunk lid from outside the car. The transmitter contains a random 32-bit access code stored in a PROM; the same code is stored in a receiver module located in the trunk. This receiver detects and decodes UHF signals from the transmitter within a range of approximately 33 feet (10 meters).

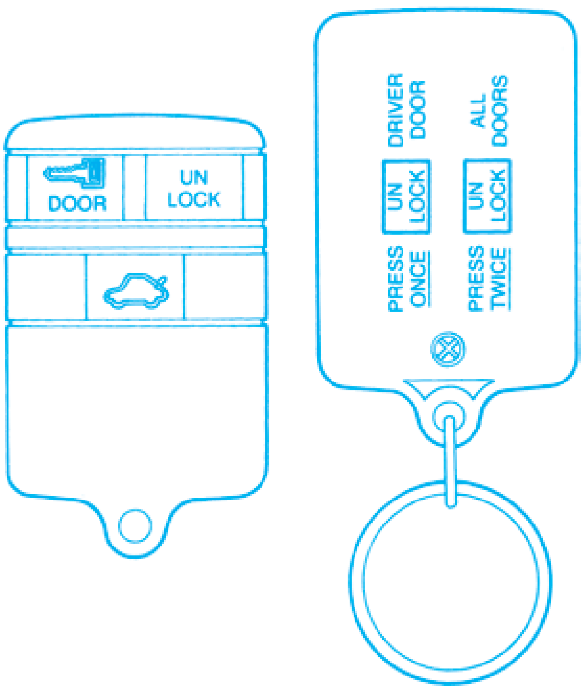

Figure 15-36. Delco Remote Keyless Entry (RKE) or Remote Lock Control (RLC) system radio transmitter. (Delphi Automotive Systems)

Depressing the DOOR button on the transmitter sends a signal to the receiver. If the signal contains a valid access code (VAC), the receiver supplies battery voltage to the lock relay coil. This energizes the lock relay, which sends current to the door lock motors. The LH door lock motor is grounded through receiver terminal B and internal contacts; all other motors are grounded through the unlock relay contacts in the door lock relay (Figure 15-37). When the lock function is used, the receiver grounds circuit 156, turning on the interior lights for two seconds to indicate that the doors are locked.

If the transmitter UNLOCK button is depressed once, the receiver sends battery voltage to the LH door lock motor, which is grounded through the lock relay contacts in the door lock relay, and only the LH door is unlocked. To unlock all doors, the UNLOCK button must be depressed twice. At this signal, the receiver also sends battery voltage to the unlock relay coil in the door lock relay. This energizes the unlock relay, which sends current to the other three door lock motors. The lock relay contacts in the door lock relay provide ground for the motors, which unlock the doors. When the unlock function is used, the receiver also grounds circuit 156 to turn on the interior lights for approximately 40 seconds, or until the ignition switch is turned to the RUN position.

Depressing the trunk lid release button on the transmitter signals the receiver to supply battery voltage at terminal H. This current energizes the trunk lid release solenoid, allowing the trunk lid to be opened. However, if the ignition is on and the transaxle position switch is not in Park, battery voltage is not supplied and the trunk lid cannot be opened.

Current 2002-2003 GM Keyless Entry Systems

The keyless entry system (Figure 15-38) is a supplementary vehicle entry device; use the keyless entry system in conjunction with a door lock key. Radio frequency interference (RFI) or discharged batteries may disable the system.

Keyless entry allows you to operate the following components:

- The door locks
- The rear compartment lid release

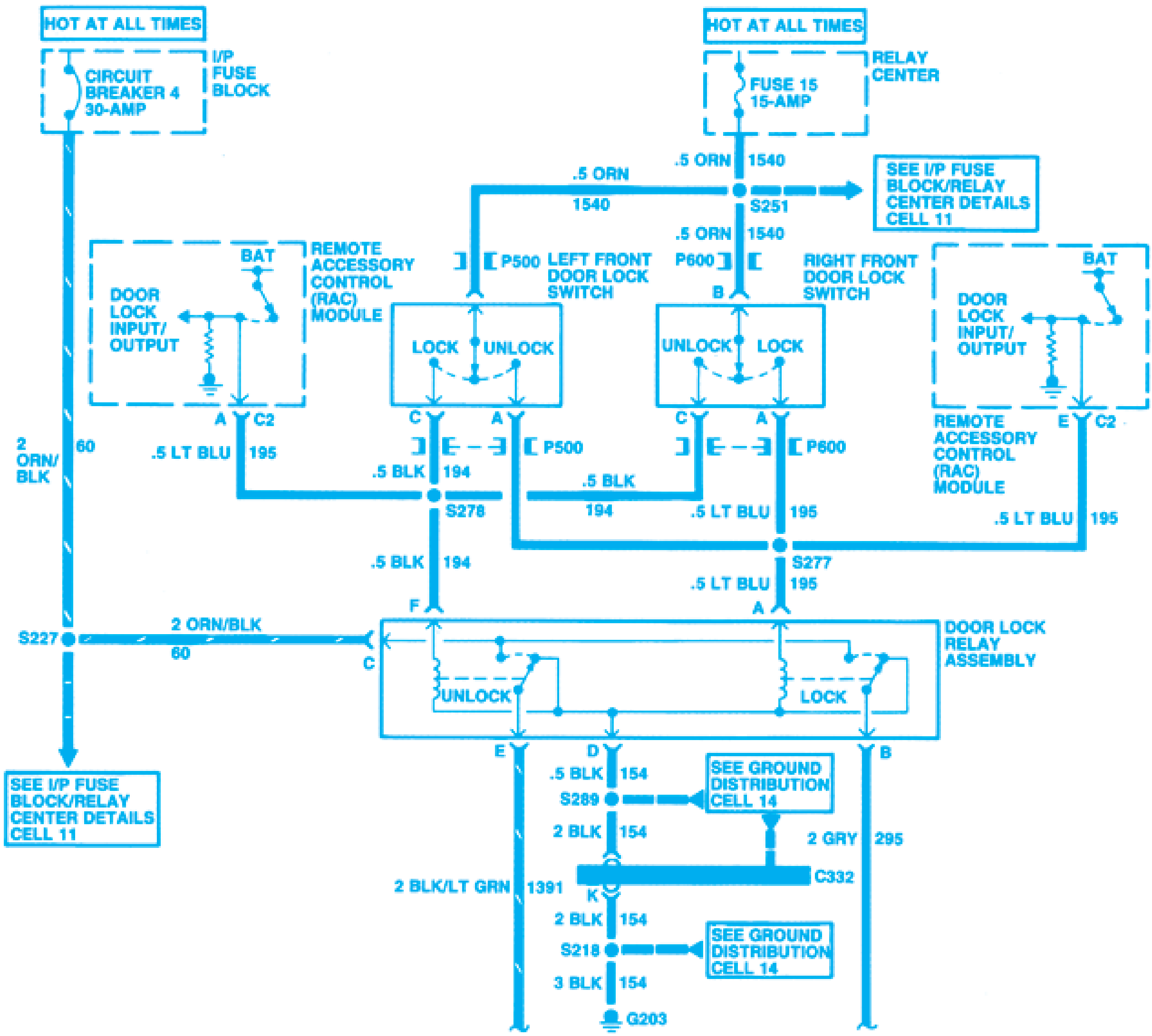

Figure 15-37. GM Remote keyless entry system. (GM Service and Parts Operations)

- The illuminated entry lamps
- The fuel door release

The keyless entry system has the following main components:

- The transmitters
- The remote control door lock receiver (RCDLR)

When you press a button on a transmitter, the transmitter sends a signal to the RCDLR. The RCDLR interprets the signal and activates the requested function via a Class 2 message over the serial data line.

Unlock Driver's Door Only

Momentarily press the UNLOCK button in order to perform the following functions:

- Unlock the driver's door only.
- Illuminate the interior lamps for approximately 40 seconds or until the ignition is turned ON.
- Flash the exterior lights, if selected ON in personalization.
- Disarm the content theft deterrent (CTD) system, if equipped.
- Deactivate the CTD system when in the Alarm Mode.

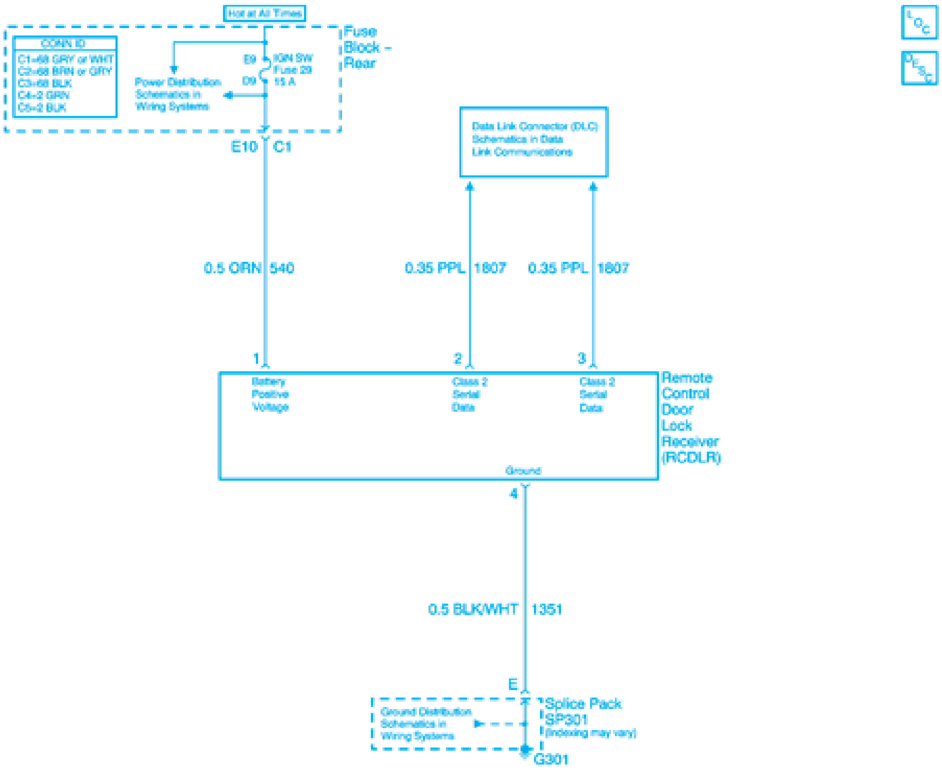

Figure 15-38. 2002 GM Cadillac Seville keyless entry system schematic. (GM Service and Parts Operations)

Unlock All Doors—Second Operation

Momentarily press the UNLOCK button a second time, within four seconds of the first press, in order to perform the following functions:

- Unlock the remaining doors.
- Illuminate the interior lamps for approximately 40 seconds or until the ignition is turned ON.
- Flash the exterior lights, if selected ON in personalization.
- Chirp the horn, if selected ON in personalization.

Lock All Doors

Press the LOCK button in order to perform the following functions:

- Lock all of the doors and immediately turn off the interior lamps.
- Flash the exterior lights, if selected ON in personalization.
- Chirp the horn, if selected ON in personalization.
- Arm the content theft deterrent (CTD) system.

Rear Compartment Lid Release

If the vehicle transaxle is in Park or Neutral and the ignition is in the OFF position, a single press of the rear compartment release button will open the rear compartment lid. The interior lamps will not illuminate.

Fuel Door Release

If the vehicle transaxle is in PARK or NEUTRAL and the ignition is in the OFF position, a single press of the fuel-door release button will open the fuel door.

Keyless Entry Personalization

The exterior lamps and horn chirp may be personalized for two separate drivers as part of the remote activation verification feature.

Rolling Code

The keyless entry system uses rolling code technology. Rolling code technology prevents anyone from recording the message sent from the transmitter and using the message in order to gain entry to the vehicle. The term *rolling code* refers to the way that the keyless entry system sends and receives the signals. The transmitter sends the signal in a different order each time. The transmitter and the remote control door lock receiver (RCDLR) are synchronized to the appropriate order. If a programmed transmitter is out of synchronization, it sends a signal that is not in the order that the RCDLR expects. This will occur after 256 presses of any transmitter button that is out of range of the vehicle.

Automatic Synchronization

The keyless entry transmitters do not require a manual synchronization procedure. If needed, the transmitters automatically resynchronize when any button on the transmitter is pressed within range of the vehicle. The transmitter will operate normally after the automatic synchronization.

DaimlerChrysler Keyless Entry Systems

The DaimlerChrysler keyless entry system also uses a key fob-style radio transmitter, (Figure 15-39) to unlock and lock the vehicle doors and deck lid. This multipurpose system is similar to many aftermarket theft-deterrent systems, since it turns on the interior lamps, disarms the factory-installed antitheft system, and chirps the horn whenever it is used.

The transmitter attaches to the key ring and has three buttons for operation within 23 feet (7 meters) of the vehicle module receiver. The transmitter has its own code stored in the module memory. If the transmitter is lost or stolen, or an additional one is required, a new code must be stored in module memory. Figure 15-40 shows the integration of the keyless entry, illuminated entry, vehicle theft security, and power door lock systems with the BCM.

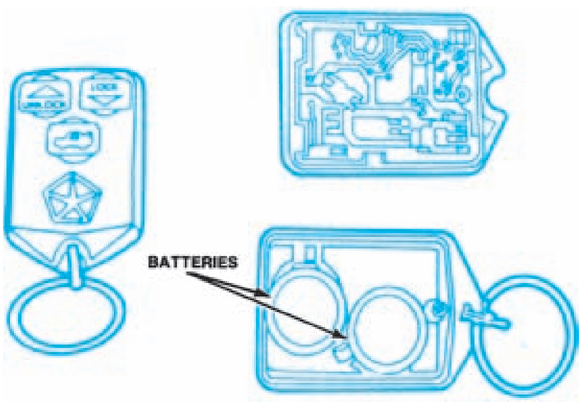

Figure 15-39. DaimlerChrysler keyless entry system key fob-style radio transmitter. (DaimlerChrysler Corporation)

THEFT DETERRENT SYSTEMS

Antitheft systems are usually aftermarket installations, although in recent years, some manufacturers have offered factory-installed systems on the luxury vehicles in their model line. Basic antitheft systems provide a warning when a forced entry is attempted through the car doors or the trunk lid. A starter interlock feature is incorporated on some models.

System functioning relies on strategically located switches installed in the door jambs, the door lock cylinders, and the trunk lock cylinder (Figure 15-41). After the system is armed, any tampering with the lock cylinders or an attempt to open any door or the trunk lid without a key causes the alarm controller to trigger the system.

Once a driver has closed the doors and armed the system, an indicator lamp in the instrument cluster comes on for several seconds, and then goes out. The system is disarmed by unlocking a front door from the outside with the key or turning the ignition on within a specified time. If the alarm has been set off, the system can be disarmed by unlocking a front door with the key.

Delphi (Delco) UTD System

The Delphi universal theft deterrent (UTD) system was introduced on some 1980 GM models and offered as an option until it was superseded by the personal automotive security system (PASS). The circuitry, logic, and power relays that operate the system are contained within a controller module.

When the system is armed by the driver, a security system warning lamp in the instrument panel glows for four to eight seconds after the doors have been closed, then shuts off. The system can be disarmed without sounding the alarm by unlocking a front door from the outside with a key, or by turning the ignition switch on. If the alarm has sounded, it can be shut off by unlocking one of the front doors with a key.

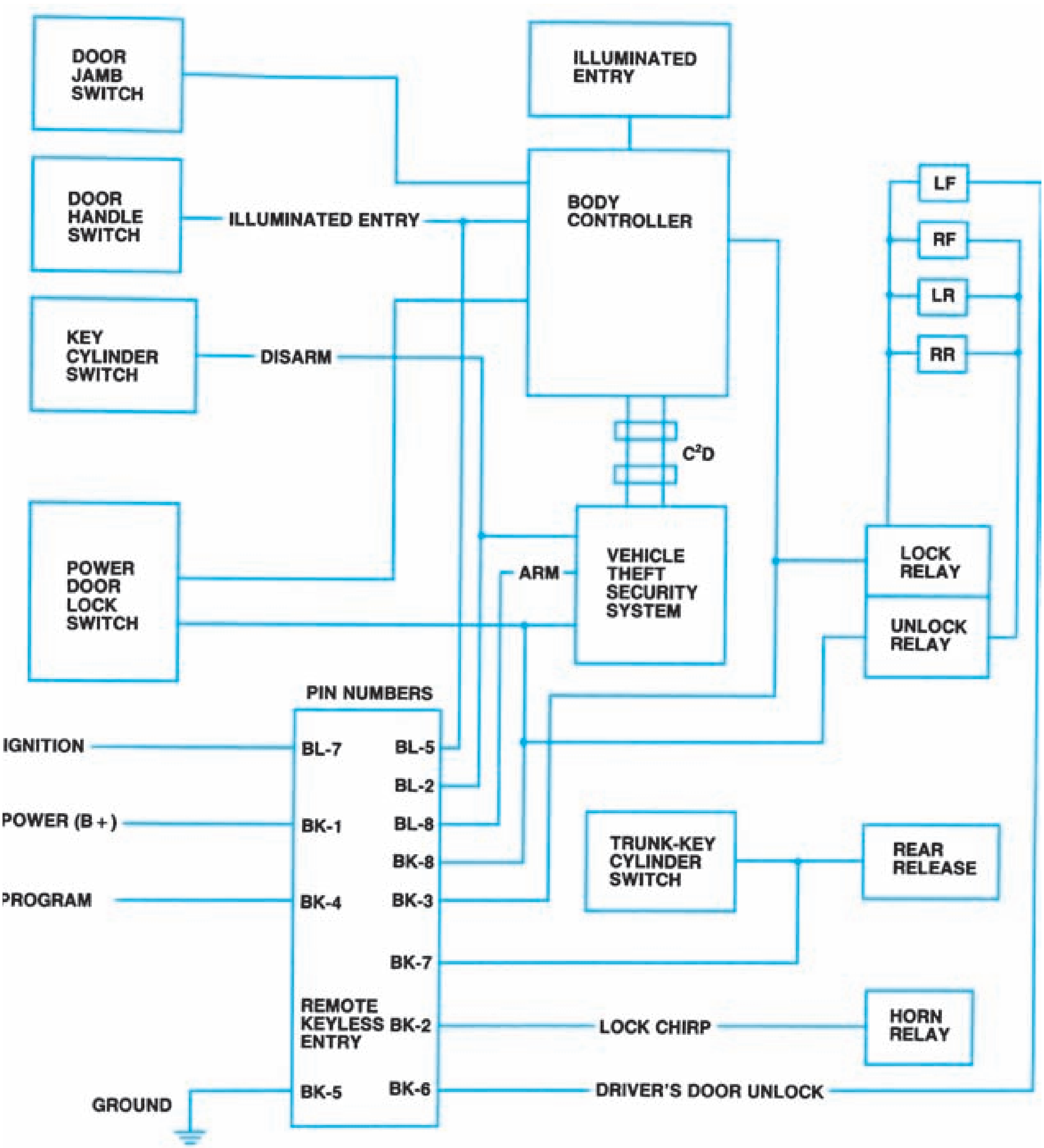

Figure 15-40. DaimlerChrysler keyless entry system schematic. (DaimlerChrysler Corporation)

If the system is armed and a door is opened forcibly, a two-terminal doorjamb switch activates the alarm through one terminal. The other switch terminal operates the interior lights. On vehicles with power door locks, the circuits are separated by a diode. Tamper switches are installed in all door locks and the trunk lid lock (Figure 15-42). The switches are activated by any rotation or in-and-out movement of the lock cylinders during a forced entry. A disarm switch in the LH door cylinder (Figure 15-43) allows the owner to deactivate the system without sounding the alarm before entering the vehicle. All tamper switches should be kept clean, as corrosion can cause the system to activate without apparent reason.

Exact wiring of the UTD system depends on the particular vehicle and how it is equipped. To understand just how the system works on a given vehicle, you must have the proper wiring diagram.

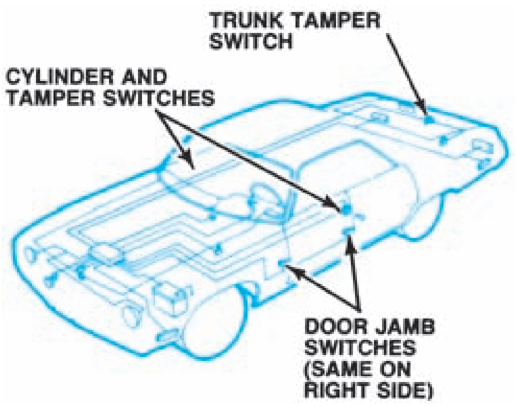

Figure 15-41. System functioning relies on strategically located switches installed in the door jambs, the door lock cylinders, and the trunk lock cylinder. (GM Service and Parts Operations)

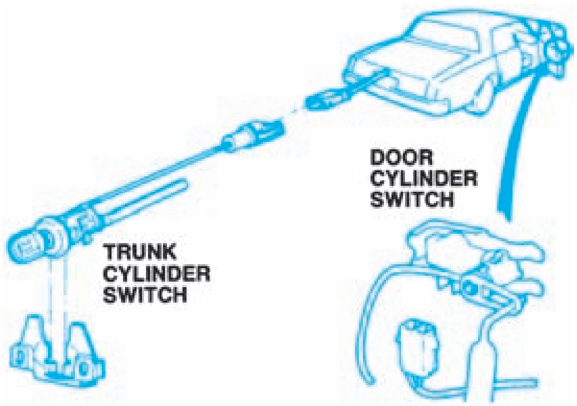

Figure 15-42. Tamper switches are installed in all door locks and the trunk lid lock. (GM Service and Parts Operations)

Delphi (Delco) VATS/PASS-Key II™ System

The Delco (Delphi) vehicle antitheft system (VATS), introduced as standard equipment on the 1986 Corvette (Figure 15-44) functions as an ignition-disable system. It is not designed to prevent a forced entry, but to protect the steering column lock if an intruder breaks into the vehicle. When used on Corvettes with the UTD system, the combination is called the forced entry alarm system (FES). When used on other GM vehicles, VATS is called PASS-Key II™. The system (Figure 15-45) consists of the following components:

- Resistor ignition key
- Steering column lock cylinder with resistor-sensing contact
- VATS or PASS-Key II™ decoder module

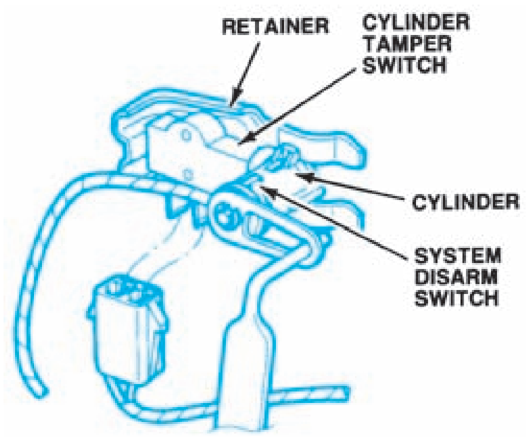

Figure 15-43. The UTD disarm switch is part of the LH door lock cylinder. (GM Service and Parts Operations)

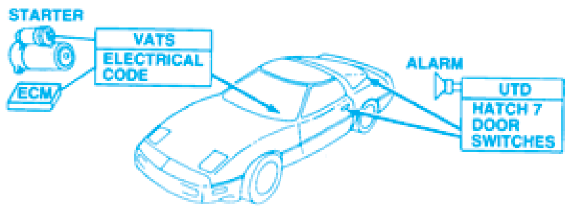

Figure 15-44. Delphi (Delco) VATS system. (GM Service and Parts Operations)

- Starter enable relay
- PCM
- Wiring harness

A small resistor pellet embedded in the ignition key contains one of 15 different resistance values. The key is coded with a number that indicates which resistor pellet it contains. Resistor pellet resistance values vary according to key code and model year. To operate the lock, the key must have the proper mechanical code (1 of 2,000); to close the starter circuit, it must also have the correct electrical code (1 of 15).

Inserting the key in the ignition lock cylinder brings the resistor pellet in contact with the resistor sensing contact. Rotating the lock applies battery power to the decoder module (Figure 15-45). The sensing contact sends the resistance value of the key pellet to the decoder module, where it is compared to a fixed resistance value stored in memory. If the resistor code and the fixed value are the same, the decoder module energizes the starter enable relay, which closes the circuit to the starter solenoid and allows the engine to crank. At the same time, the module sends a pulse-width modulated (PWM) cranking fuel-enable signal to the PCM.

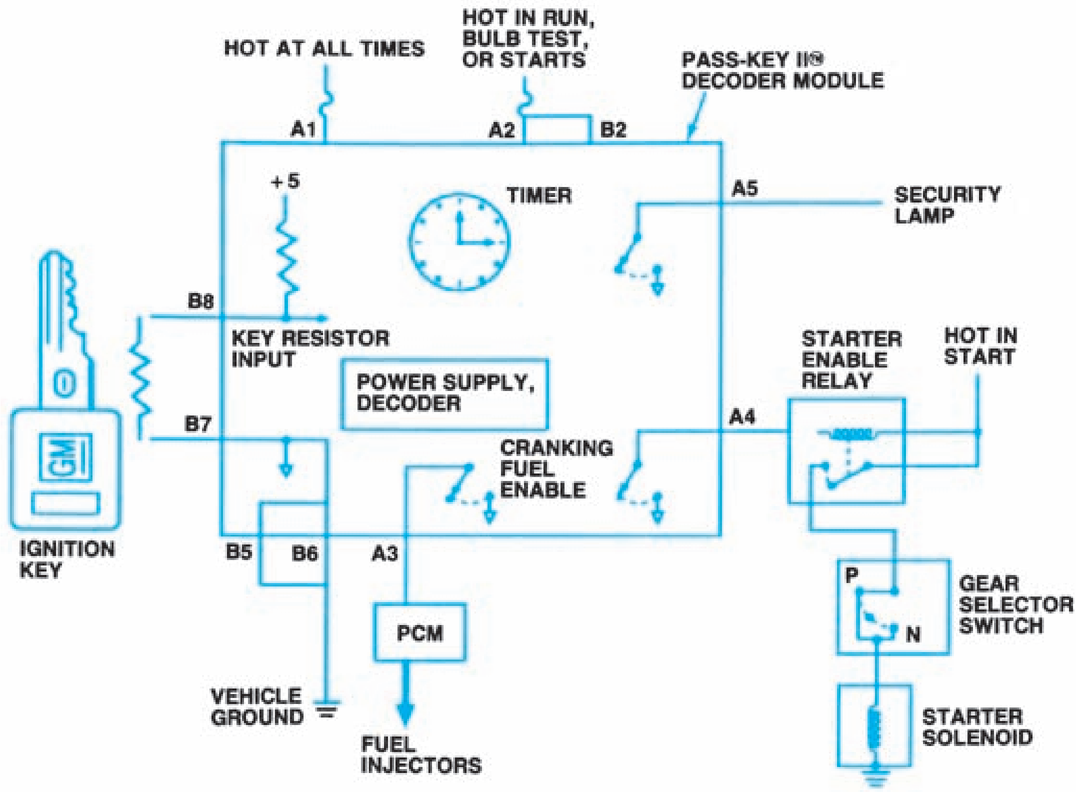

Figure 15-45. PASS-Key circuit diagram. (GM Service and Parts Operations)

If the key resistor code and the module's fixed resistance value do not match, the module shuts down for two to four minutes. Repeating the attempt to start the vehicle with the wrong key will result in continued module shutdowns. During vehicle operation, the key resistor pellet inputs are continually read. If the module sees an open, short, or incorrect resistance value for 60 consecutive seconds, a Security indicator lamp comes on and remains lighted until the fault is corrected. The lamp also comes on for five seconds when the ignition is first turned on. This serves as a bulb check and indicates that the system is functioning properly.

DaimlerChrysler Antitheft Security System

This passive-arming theft-deterrent system (Figure 15-46) is factory installed on high-line Chrysler models and functions like many aftermarket alarm installations. When combined with the Remote Keyless Entry (Figure 15-40), the system becomes an active arming system. Once armed, the doors, hood, and trunk lid all are monitored for unauthorized entry.

The system is passively armed by activating the power door locks before closing the driver's door; it will not arm if the doors are locked manually. The system is actively armed if the doors are locked with the RKE transmitter. A SET lamp in the instrument cluster flashes for 15 seconds during the arming period. If a forcible entry is attempted while the system is armed, it responds by sounding the horn, flashing the park and taillamps, and activating an engine kill feature.

The system is passively disarmed by unlocking either front door with the key, or actively disarmed by using the RKE transmitter. If the alarm has been activated during the driver's absence, the horn will blow three times when the vehicle is disarmed as a way of informing the driver of an attempted entry or tampering.

Ford Antitheft System

This antitheft system bears many similarities to the Delco UTD theft-deterrent system. It is installed on luxury models, uses many of the

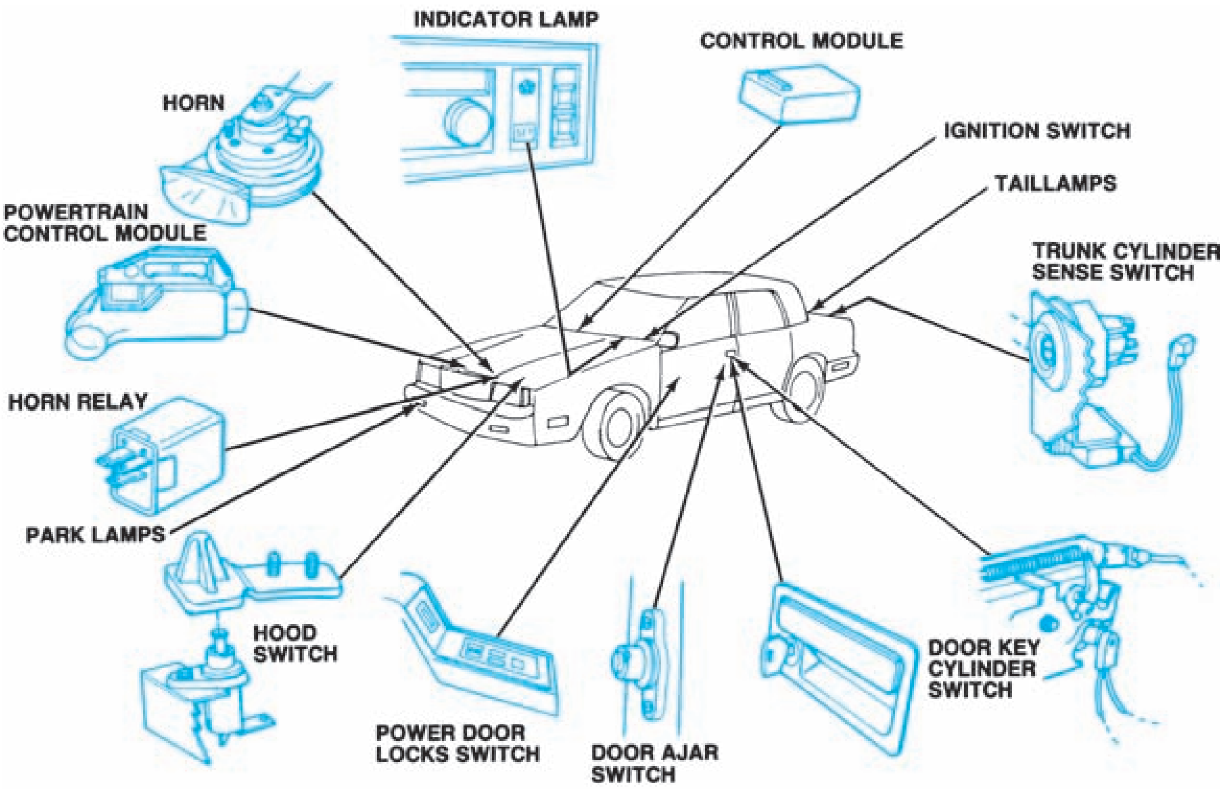

Figure 15-46. DaimlerChrysler antitheft security system. (DaimlerChrysler Corporation)

same components, and functions in essentially the same way. Once the system is armed, any tampering with the doors, hood, or trunk lid signals the control module. Once triggered, the system flashes the low-beam headlamps, the parking lamps, and alarm indicator lamp on and off; sounds the horn; and interrupts the starter circuit. The system is composed of the following components:

- Antitheft control module
- Antitheft warning indicator
- Door-key unlock switches
- Hood switch
- Trunk-lid lock-cylinder tamper switch
- Ignition-key lock-cylinder sensor

It also incorporates the following components from other systems:

- Power door lock switches
- Door-ajar switches
- Horn relay
- Low-beam headlamps
- Parking lamps
- Keyless entry module
- Starter relay

CRUISE CONTROL SYSTEMS

The *cruise control system* is one of the most popular electronic accessories installed on today's vehicles. During open-road driving it can maintain a constant vehicle speed without the continued effort of driver. This helps reduce driver fatigue and increases fuel economy. Several override features built into the cruise control system allow the vehicle to be accelerated, slowed, or stopped.

Problems with the system can vary from no operation, to intermittent operation, to not disengaging. To diagnose these system complaints, today's technicians must rely on their knowledge and ability to perform an accurate diagnosis. Most of the system is tested using familiar diagnostic procedures; build on this knowledge and ability to diagnose cruise control problems. Use system schematics, troubleshooting diagnostics, and switch continuity charts to assist in isolating the cause of the fault.

Most vehicle manufacturers have incorporated self-diagnostics into their cruise control systems. This allows some means of retrieving trouble codes to assist the technician in locating system faults.

On any vehicle, perform a visual inspection of the system. Check the vacuum hoses for disconnects, pinches, loose connections, etc. Inspect all wiring for tight, clean connections. Also, look for good insulation and proper wire routing. Check the fuses for opens and replace as needed. Check and adjust linkage cables or chains, if needed. Some manufacturers require additional preliminary checks before entering diagnostics. In addition, perform a road test (or simulated road test) in compliance with the service manual to confirm the complaint.

CAUTION: When servicing the cruise control system, you will be working close to the air bag and antilock brake systems. The service manual will instruct you when to disarm and/or depressurize these systems. Failure to follow these procedures can result in injury and additional costly repairs to the vehicle.

When engaged, the cruise control components set the throttle position to the desired speed. The speed is maintained unless heavy loads and steep hills interfere. The cruise control is disengaged whenever the brake pedal is depressed. The common speed or cruise control system components function in the following manner.

Cruise Control Switch

The cruise control switch (Figure 15-47) is located on the end of the turn signal lever or near the center or sides of the steering wheel. There are usually several functions on the switch, including off-on, resume, and engage buttons. The switch is different for resume and non-resume systems.

The **transducer** is a device that controls the speed of the vehicle. When the transducer is engaged, it senses vehicle speed and controls a vacuum source (usually the intake manifold). The vacuum source is used to maintain a certain position on a servo. The speed control is sensed from the lower cable and casing assembly attached to the transmission.

The **servo unit** is connected to the throttle by a rod or linkage, a bead chain, or a Bowden cable. The servo unit maintains the desired car speed by receiving a controlled amount of vacuum from the transducer. The variation in vacuum changes the position of the throttle. When a vacuum is applied, the servo spring is compressed and the throttle is positioned correctly. When the vacuum is released, the servo spring is relaxed and the system is not operating.

Two switches are activated by the position of the brake pedal. When the pedal is depressed, the brake-release switch disengages the system.

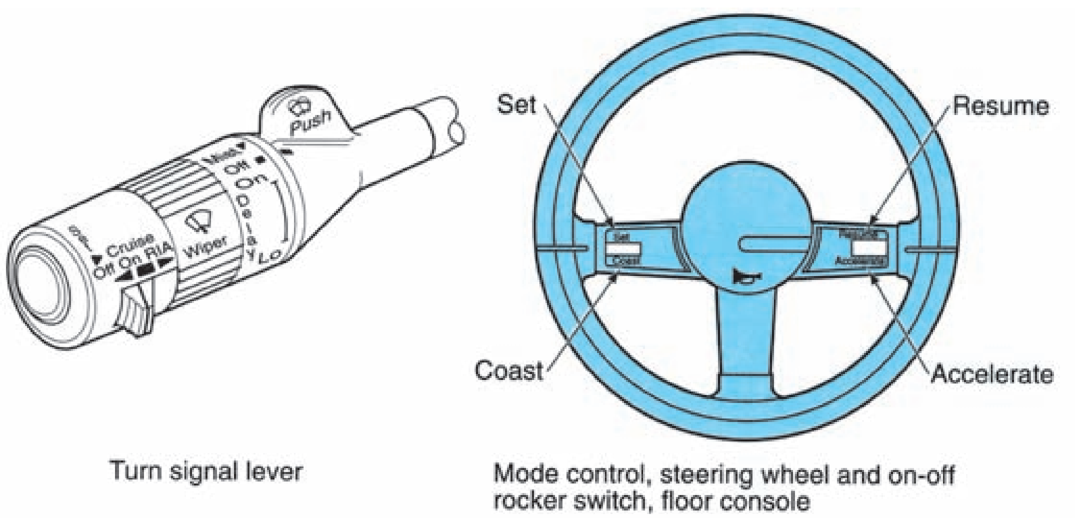

Figure 15-47. Cruise control switch.

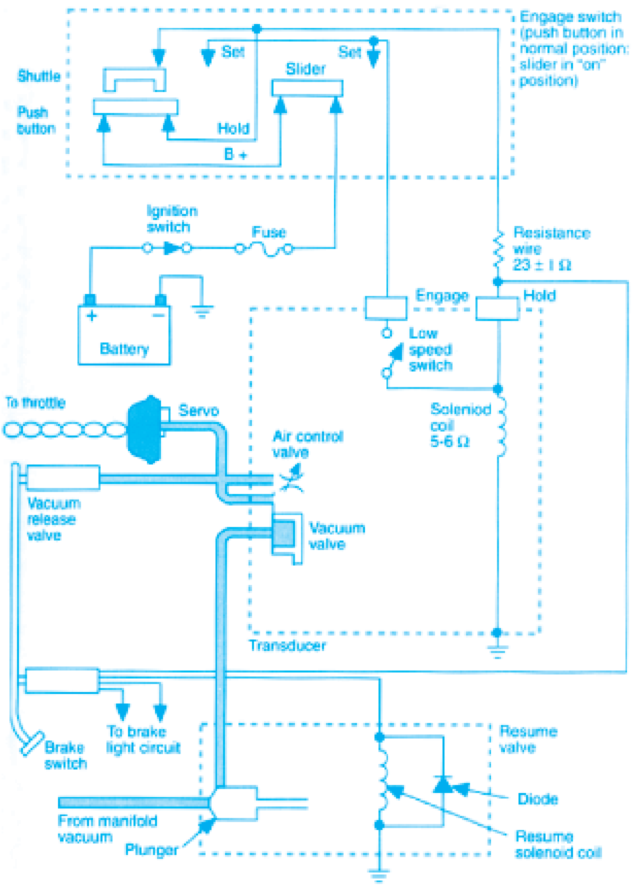

Figure 15-48. Cruise control system schematic. (GM Service and Parts Operations)

A vacuum-release valve is also used to disengage the system when the brake pedal is depressed.

Electrical and Vacuum Circuits

Figure 15-48 shows an electrical and vacuum circuit diagram. The system operates by controlling vacuum to the servo through various solenoids and switches.

Electronic Cruise Control Components

Cruise control can also be obtained by using electronic components rather than mechanical components. Depending on the vehicle manufacturer, several additional components may be used.

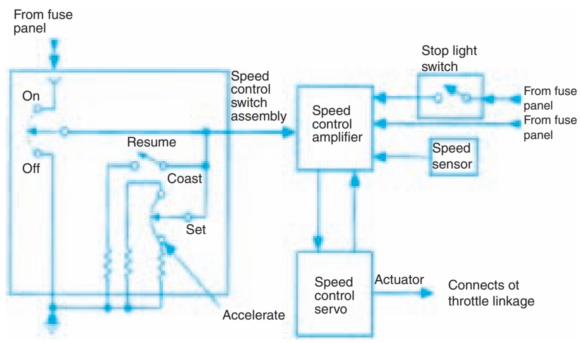

Figure 15-49. Cruise control system component circuit. (GM Service and Parts Operations)

The electronic control unit is used to control the servo unit. The servo unit is again used to control the vacuum, which in turn controls the throttle. The vehicle speed sensor (VSS) *buffer amplifier* is used to monitor or sense vehicle speed. The signal created is sent to the electronic control module. A generator speed sensor may also be used in conjunction with the VSS. The clutch switch is used on vehicles with manual transmissions to disengage the cruise control when the clutch is depressed. The accumulator is used as a vacuum storage tank on vehicles that have low vacuum during heavy load and high road speed.

Figure 15-49 shows how electronic cruise control components work together. The servo unit controls the throttle position, using a vacuum working against spring pressure to operate an internal diaphragm. The controller controls the servo unit vacuum circuit electronically. The controller has several inputs that help determine how it will affect the servo, including a brake-release switch (clutch-release switch), a speedometer, a buffer amplifier (generator speed sensor), a turn signal lever mode switch, and speed-control switches on the steering wheel.

SUPPLEMENTAL RESTRAINT SYSTEMS

A typical *supplemental inflatable restraint (SIR)* or air bag system (Figure 15-50) includes three important elements: the electrical system, air bag module, and knee diverter. The electrical system includes the impact sensors and the electronic control module. Its main functions are

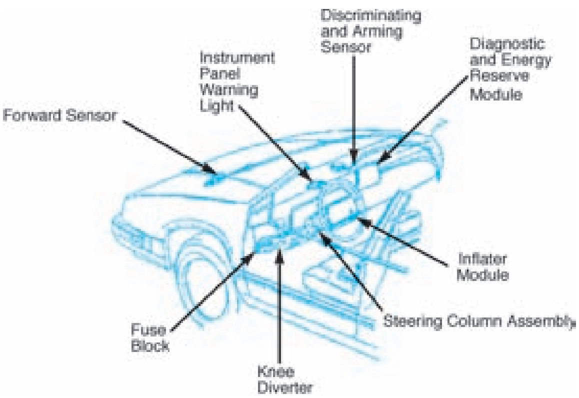

Figure 15-50. SRS components. (DaimlerChrysler Corporation)

CAUTION: When servicing the air bag system, the service manual will instruct you when and how to disarm the system. Failure to follow these procedures can result in injury and additional costly repairs to the vehicle.

to conduct a system self-check to let the driver know that it is functioning properly, to detect an impact, and to send a signal that inflates the air bag. The air bag module is located in the steering wheel for the driver and in the dash panel for passengers; it contains the air bag and the parts that cause it to inflate. The knee diverter cushions the driver's knee from impact and helps prevent the driver from sliding under the air bag during a collision. It is located underneath the steering column and behind the steering column trim.

Electrical System Components

The electrical system generally has the following parts:

Diagnostic Monitor Assembly

The diagnostic monitor contains a microcomputer that monitors the electrical system components and connections. The monitor performs a self-check of the microcomputer internal circuits and energizes the system readiness indicator during prove-out and whenever a fault occurs. System electrical faults can be detected and translated into coded indicator displays. If a certain fault occurs, the microcomputer disables the system by opening a thermal fuse built into the monitor. If a system fault exists and the indicator is malfunctioning, an audible tone signals the need for service. If certain faults occur, the system is disarmed by a firing circuit disarm device incorporated within the monitor or diagnostic module.

Trouble codes can be retrieved through the use of a scan tool or flash codes, and on some models through the digital panel cluster (if equipped). As with all diagnostics, consult the appropriate service manual for the correct procedures.

An air-bag-system backup power supply is included in the diagnostic monitor to provide air bag deployment power if the battery or battery cables are damaged in an accident before the crash sensors close. The power supply depletes its stored energy approximately one minute after the positive battery cable is disconnected.

Sensors

The sensors detect impact (Figure 15-51) and signal the air bag to inflate. At least two sensors must be activated for the air bag to inflate. There are usually five sensors: two at the radiator support, one at the right-hand fender apron, one at the left-hand fender apron, and one at the cowl in the passenger compartment. However, a few systems use only two sensors—one in front of the radiator and another in the passenger compartment. There is an **interlock** between the sensors, so two or more must work together to trigger the system. Keep in mind that air bag systems are designed to deploy in case of frontal collisions

CAUTION: The backup power supply energy must be depleted before any air bag component service is performed. To deplete the backup power supply energy, disconnect the positive battery cable and wait one minute.

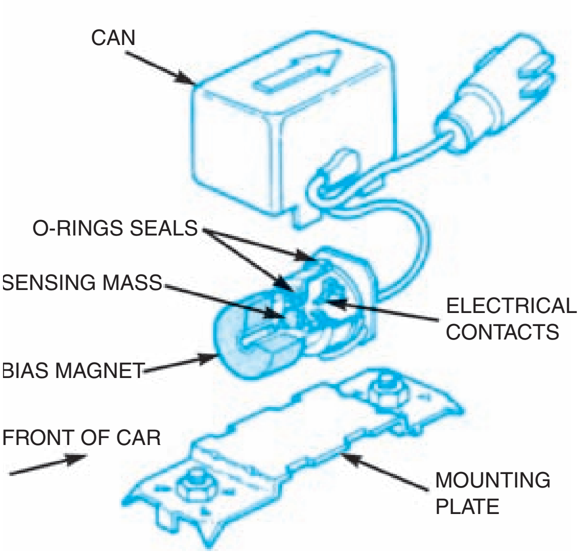

Figure 15-51. SRS sensors. (DaimlerChrysler Corporation)

only. Although the design of individual systems varies, the vehicle must be traveling a minimum of 12–28 mph before the system is armed and ready for deployment.

All the sensors use some type of *inertia switching mechanism* that provides for the breakaway of a metal ball from its captive magnet. This function causes a signal to activate a portion of the deployment program set up in the control processor. The system is still capable of directly applying battery power to the squib or detonator. At least two sensors, one safing sensor and one front crash sensor, must be activated to inflate the air bag.

Safing Sensors

An integrated version of this network includes a **safing sensor** (Figure 15-52), sometimes attached to the original crash sensor. This device confirms the attitude and magnitude of the frontal deceleration forces and offers the microprocessor a second opinion before actual deployment. This is all it takes to complete the firing sequence, and the bag will deploy.

Wiring Harness

The wiring harness connects all system components into a complete unit. The wires carry the electricity that signals the air bag to inflate. The harness also passes the signals during the self-diagnosis sequence.

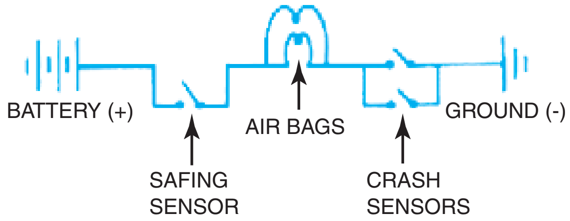

Figure 15-52. Safing sensor. (GM Service and Parts Operations)

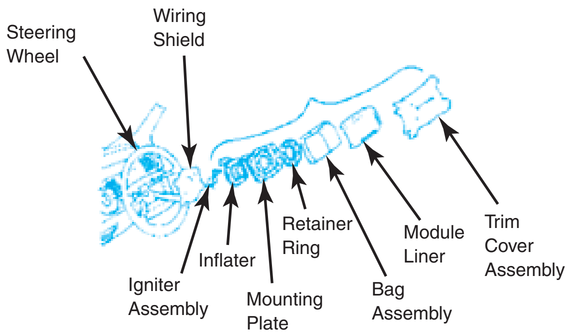

Figure 15-53. Air bag module. (DaimlerChrysler Corporation)

SIR or Air Bag Readiness Light

This light lets the driver know the air bag system is working and ready to do its job. The readiness lamp lights briefly when the driver turns the ignition key from OFF to RUN. A malfunction in the air bag system causes the light to stay on continuously or to flash, or the light might not come on at all. Some systems have a tone generator that sounds if there is a problem in the system or if the readiness light is not functioning.

Air Bag Module

The bag itself is composed of nylon and is sometimes coated internally with neoprene. All the **air bag module** (Figure 15-53) components are packaged in a single container, which is mounted in the center of the steering wheel or in the dash panel on the passenger side. The entire assembly must be serviced as one unit when repair of the air bag system is required. The air bag module is made up of the following components.

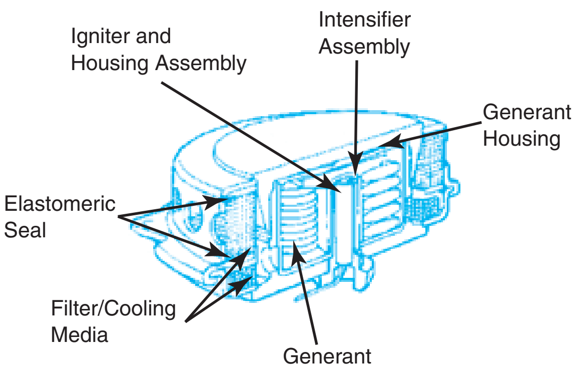

Figure 15-54. Igniter assembly. (GM Service and Parts Operations)

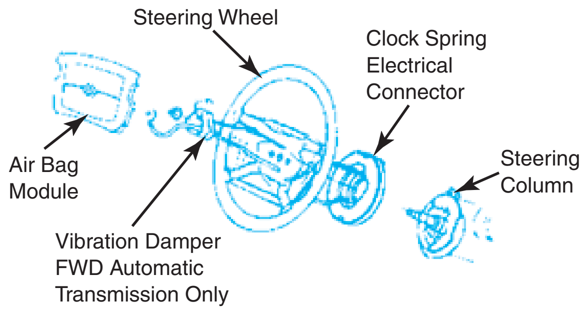

Figure 15-55. Liner and steering wheel trim cover. (GM Service and Parts Operations)

Igniter Assembly (Figure 15-55)

Inflation of the air bag is caused by an explosive release of gas. For the explosion to occur, a chemical reaction must be started. The **igniter assembly** does this when it receives a signal from the air bag monitor. Actually, the igniter is a two-pin bridge device: When the electrical current is applied, it arcs across the two pins, creating a spark that ignites a squib (canister of gas) that generates zirconic potassium perchlorate (ZPP). This material ignites the propellant. Some newer model air bags now use solid propellant and argon. This gas has a stable structure, cools more quickly, and is inert as well as non-toxic.

Inflator Module

The *inflator module* contains the ZPP. Once it triggers the igniter, the propellant charge is progressive, burning sodium azide, which converts to nitrogen gas as it burns. It is the nitrogen gas that fills the air bag.

Almost as soon as the bag is filled, the gas is cooled and vented, deflating the assembly as the collision energy is absorbed. The driver is cradled in the envelope of the supplemental restraint bag instead of being propelled forward to strike the steering wheel or be otherwise injured by follow-up inertia energy from seat belt restraint systems. In addition, a certain degree of facial protection against flying objects is obtained just when it is needed.

It is important to remember that only the tandem action of at least one main sensor and a safing sensor initiates safety restraint system activation. The micro-controller also provides failure data and trouble codes for use in servicing various aspects of most systems.

Mounting Plate and Retainer Ring

The *mounting plate and retainer ring* attach the air bag assembly to the inflator. They also keep the entire air bag module connected to the steering wheel.

Liner and Steering Wheel Trim Cover (Figure 15-56)

The liner houses the air bag; the trim cover goes over the exterior of the steering wheel hub. Passenger-side air bags are very similar in design to the driver's unit. The actual capacity of gas required to inflate the bag is much greater because the bag must span the extra distance between the occupant and the dashboard at the passenger seating location. The steering wheel and column make up this difference on the driver's side.

WARNING: When the air bag is deployed, a great deal of heat is generated. Although the heat is not harmful to passengers, it may damage the clock spring electrical connector. When replacing a deployed air bag module, examine all of the electrical connections for signs of scorching or damage. If damage exists, it must be repaired.

SUMMARY

Heating and air-conditioning systems share a motor-driven fan. The motor speeds usually are controlled by varying the resistance in the motor circuit. Air-conditioning systems also have an electromagnetic clutch on the compressor. The clutch is energized by the air-conditioning system control switch. A clutch-cycling pressure switch turns the compressor clutch on and off as needed to maintain desired evaporator pressure and temperature. Other switches are used in the clutch circuit to protect the system from high or low pressure, or to shut the clutch off under certain conditions, such as wide-open throttle.

Older vehicles may use a fan and motor as a rear-window defogger; this system is similar to the heating system. A rear-window defroster or defogger on late-model vehicles is a grid of conductors attached to the rear window. A relay usually controls current to the conductors. Ford's heated windshield system uses current directly from the alternator.

The parts of a sound system that concern most service technicians include the way the sound unit and the speakers are mounted, interference capacitors, panel illumination bulbs, and power antennas.

Power windows are moved by a reversible motor. Motor direction is controlled by current through different brushes. The driver's-side master switch controls all of the windows, because each individual switch is grounded through the master switch.

Power seats can be moved by one, two, or three motors and various transmission units. Permanent-magnet motors or electromagnetic field motors can be used. Current to the motors sometimes is controlled by a relay.

Power door locks, trunk latches, and seat-back releases can be moved by solenoids or motors. Relays are often used to control current to the solenoid or motor.

ADL systems are a safety feature integrated with the power door locks. They automatically lock all doors before the vehicle is driven. Keyless entry systems are both convenience and safety features: They allow a driver access to a vehicle by entering a code through a keypad on the driver's door, or by depressing a button on a key chain transmitter.

Theft-deterrent systems such as the Delco UTD and Ford Antitheft System are factory installed on luxury cars. Such systems use other vehicle systems to sound an alarm when the car is tampered with. The Delco VATS/PASS-Key II™ system uses a resistor ignition key that is "read" by the lock cylinder when inserted. If the resistance and the memory value do not match, the system shuts down the ignition and the starter.

When engaged, the cruise control components set the throttle position to the desired speed. The speed is maintained unless heavy loads and steep hills interfere. The cruise control is disengaged whenever the brake pedal is depressed. The cruise control switch is located on the end of the turn signal lever or near the center or sides of the steering wheel. There are usually several functions on the switch, including off-on, resume, and engage buttons. The switch is different for resume and non-resume systems.

The transducer is a device that controls the speed of the vehicle. When the transducer is engaged, it senses vehicle speed and controls a vacuum source (usually the intake manifold). The vacuum source is used to maintain a certain position on a servo. The speed control is sensed from the lower cable and casing assembly attached to the transmission. The servo unit is connected to the throttle by a rod or linkage, a bead chain, or a Bowden cable. The servo unit maintains the desired car speed by receiving a controlled amount of vacuum from the transducer. The variation in vacuum changes the position of the throttle. When a vacuum is applied, the servo spring is compressed and the throttle is positioned correctly. When the vacuum is released, the servo spring is relaxed and the system does not operate.

Two switches are activated by the position of the brake pedal. When the pedal is depressed, the brake release switch disengages the system. A vacuum release valve is also used to disengage the system when the brake pedal is depressed.

The Supplemental Inflatable Restraint (SIR) or air bag system includes three important elements. The electrical system includes the impact sensors and the electronic control module. Its main functions are to conduct a system self-check to let the driver know that it is functioning properly, to detect an impact, and to send a signal that inflates the air bag. The air bag module is located in the steering wheel for the driver and in the dash panel for passengers. It contains the air bag and the parts that cause it to inflate. The knee diverter cushions the driver's knee from impact and helps prevent the driver from sliding under the air bag during a collision. It is located underneath the steering column and behind the steering column trim. Newer vehicles contain SIR systems in the side panels and headliner or curtains.

Review Questions

1. Technician A says an electronic climate control (ECC) system with BCM control cycles the power to the compressor clutch. Technician B says an electronic climate control (ECC) system without BCM control cycles the ground circuit to the compressor clutch. Who is right?
   a. A only
   b. B only
   c. Both A and B
   d. Neither A nor B
2. Technician A says Ford's heated windshield system uses a conductive grid bonded to the outside surface of the glass. Technician B says the conductive grid is applied to the back of the outer glass layer before it is laminated to the inner glass layer. Who is right?
   a. A only
   b. B only
   c. Both A and B
   d. Neither A nor B
3. Constant operation of the compressor in automotive air-conditioning systems is prevented by:
   a. A solenoid
   b. A servomagnet
   c. An electromagnetic clutch
   d. A one-way clutch
4. Individual switches on automobile power window circuits must be connected in ______ with the driver's side master switch.
   a. Series
   b. Shunt
   c. Parallel
   d. Series-parallel
5. The air-conditioning compressor clutch can be controlled by:
   a. A power steering cutout switch
   b. A pressure cycling switch
   c. Both A and B
   d. Neither A nor B
6. Technician A says the user selects the mode in a semiautomatic temperature control system, but the actuators are electrically operated. Technician B says a semiautomatic temperature control system uses in-car and ambient temperature sensors. Who is right?
   a. A only
   b. B only
   c. Both A and B
   d. Neither A nor B
7. Technician A says the body control module (BCM) talks to other computers in an ECC system on a serial data line. Technician B says the ECC system programmer activates the actuators on a serial data line. Who is right?
   a. A only
   b. B only
   c. Both A and B
   d. Neither A nor B
8. GM power seat system motors use:
   a. Permanent-magnet fields
   b. Electromagnetic fields
   c. Both A and B
   d. Neither A nor B
9. The Delphi (Delco) vehicle antitheft system (VATS) uses a _________ in the ignition key.
   a. Thermistor
   b. Potentiometer
   c. Magnet
   d. Resistor
10. Power window systems use:
    a. Unidirectional motors
    b. Reversible motors
    c. Stepper motors
    d. Servomotors
11. Technician A says Ford's heated windshield system will work only if the in-car temperature is above 40°F (4°C). Technician B says the heated windshield module can control the EEC-IV module under certain circumstances. Who is right?
    a. A only
    b. B only
    c. Both A and B
    d. Neither A nor B
12. Technician A says a keyless entry system incorporates the function of an illuminated entry system. Technician B says moving the gear selector into Drive with the ignition on activates an ADL system. Who is right?
    a. A only
    b. B only

c. Both A and B
d. Neither A nor B

13. Technician A says the Delco Remote Keyless Entry (RKE) and the Remote Lock Control (RLC) are different keyless entry systems. Technician B says the RKE and RLC systems are subsystems of the VAT and PASS systems. Who is right?
 a. A only
 b. B only
 c. Both A and B
 d. Neither A nor B

14. Technician A says if the resistance value of the ignition key in the PASS system does not match the UHF value stored in the receiver's memory, the vehicle will not start. Technician B says a factory-installed theft-deterrent system is a complex multiple-circuit system. Who is right?
 a. A only
 b. B only
 c. Both A and B
 d. Neither A nor B

15. In a cruise control system, which component controls the amount of vacuum that is applied to the servo unit?
 a. The throttle body
 b. The cruise control switch
 c. The transducer
 d. The brake pedal position switch

16. Which of the following actions will deactivate cruise control operation?
 a. Applying the accelerator pedal
 b. Applying the brake
 c. Driving up a steep hill
 d. Releasing the accelerator pedal

17. In an electronically controlled cruise control system, what component is used to monitor vehicle speed?
 a. Wheel speed sensor
 b. Generator speed sensor
 c. Turbine speed sensor
 d. Vehicle speed sensor

18. What enables an air bag to deploy in an accident, even if the battery becomes disconnected during the crash?
 a. A mechanical push-arm igniter
 b. A backup power supply
 c. The velocity versus solid object sensor
 d. A "sudden stop" signal received from the vehicle speed sensor

19. Though different manufacturers have different specifications, how fast must a vehicle be moving before the air bag system is armed and ready to deploy if needed?
 a. Any speed above zero
 b. Between 3 and 10 mph
 c. Between 12 and 28 mph
 d. At least 45 mph

20. When servicing an air bag, what is the first step you should take?
 a. Disconnect the battery negative cable.
 b. Disconnect the clockspring electrical connector.
 c. Take resistance measurements at all electrical connectors.
 d. Disconnect the impact sensors.