ASE 7 - Heating, Ventilation & Air Conditioning

Module 4
Manual HVAC Systems
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Introduction

This module will cover the operations and features of manual HVAC systems. The differing air distribution styles along with their respective operating components will be discussed. With the wide range of customer expectations for the control of the interior temperature and comfort, a number of specialized HVAC system designs have been incorporated into GM vehicles. The manual dual zone and rear HVAC systems are examples of these special designs we will examine.

This module will further explore:
1. The modes of operations - A/C, Heat, Recirculation, Econ, Defog, Defrost, and Bi-level
2. The variety of HVAC control heads
3. Mechanical, vacuum and electrical actuators
4. Blower operation
5. Air filtration
6. Ductwork designs

With any HVAC system, things go wrong. We will apply Strategy Based Diagnostics (SBD) processes to troubleshoot manual HVAC system customer concerns.

Objectives

1. Be able to identify and explain the basic functions, controls and designs of a manual HVAC system.
2. Be able to identify the basic air door configurations.
3. Be able to explain the function and operation of a manual dual zone air distribution system.
4. Obtain knowledge of the components and operations of a manual rear air distribution system.
5. Be able to explain blower operation.
6. Given the parameters of a particular manual HVAC customer concern, a student will be able to apply strategy based diagnostic procedures to resolve the problem.
NATEF Area VII.

1. Diagnose temperature control problems in the heater/ventilation system; determine necessary action.
2. Diagnose malfunctions in the electrical controls of heating, ventilation, and A/C (HVAC) systems; determine necessary action.
3. Inspect and test A/C heater blower, motors, resistors, switches, relays, wiring and protection devices; perform necessary action.
4. Diagnose malfunctions in the vacuum and mechanical components and controls of the heating, ventilation, and A/C (HVAC) system; determine necessary action.
5. Inspect and test A/C heater control panel assembly; determine necessary action.
6. Inspect and test A/C heater control cables and linkages; perform necessary action.
7. Inspect A/C heater ducts, doors, hoses, cabin filters and outlets; perform necessary action.

STC Tasks:

1. Describe the air distribution system used in HVAC systems.
2. Describe the components and operation used in rear HVAC systems.
3. Understand manual HVAC system components, function, design and operation.
4. Locate manual HVAC system components.
5. Understand the cause of manual HVAC system malfunctions.
6. Describe the components, function, design and operation of manual dual-zone HVAC systems.
7. Apply the GM SBD process to manual and dual-zone HVAC concerns.
Lesson 1: Manual HVAC System Overview

Manual HVAC control systems have been used for many years. Currently, there are two basic types of controls used for air distribution systems.

• Manual Control
• Automatic Control

The manual systems require the vehicle operator to provide manual adjustment for the outlet (mode) doors, temperature door and the blower speed. These selections are inputs to the HVAC control head, which then positions the doors and operates the blower at the correct speed. Manual cables, vacuum actuators or electric motors can control the air doors/valves in these systems.

The automatic systems only require the vehicle operator to input the desired temperature (in auto mode). After the desired temperature is input, the control system positions the doors and operates the blower to achieve this temperature. The automatic systems are electronic systems that require various inputs from sensors that indicate climate conditions to achieve the desired temperature. Vacuum actuators and/or electric motors control the air doors/valves in these systems.

Compressor operation in the manual systems typically consists of a PCM controlled relay that is energized when an A/C request and other enable criteria are met.

Figure 4-1, Manual and Automatic Control
Air Distribution System Components

The air distribution system is designed to control the climate inside the passenger compartment. To achieve this, the air distribution system is required to control the airflow path, the air temperature and the force of the air entering the passenger compartment. To control these three functions, the air distribution system uses the following components (see Figure 4-2):

- Air distribution ductwork
- Blower
- Blower control
- Air doors/valves
- Air door/valve control unit
- Evaporator
- Heater Core
- Water Control Valve

Certain air distribution systems that are electronically controlled also use sensors to provide more accurate control of the climate inside the passenger compartment. Air distribution systems can vary in component use and arrangement. It is important that the appropriate Owner's Manual and Service Information are consulted for air distribution system operation.

![Figure 4-2, Air Distribution System Components](image)
Air Distribution System Ductwork

Air distribution systems provide a sealed path for airflow from the air inlets to the appropriate air outlets. Currently designed air distribution systems have two air inlets (see Figure 4-3). The outside air inlet brings outside air into the passenger compartment from the cowl below the windshield. The recirculation air inlet allows air inside the passenger compartment to recirculate through the air distribution system. Within the ductwork are the evaporator, heater core and blower. The blower controls the airflow, and the heater core and the evaporator are used to change the temperature of the air. All air leaving the blower is directed through the evaporator and an air door/valve controls the amount of air passing through the heater core. Air distribution systems have several air outlets that are connected to vents in the passenger compartment. The following are the air outlets of a typical air distribution system (see Figure 4-3):

- Defrost/windshield outlets
- Panel/air conditioning outlets
- Floor/heater outlets
- Side window outlets/demisters (some applications)

Many of today’s GM vehicles utilize a replaceable passenger compartment air filter that is placed in the inlet side of the HVAC module unit. The filter is designed to prevent dirt and debris from entering the module unit and passenger compartment. The access point for removing and replacing the filter can be located in the glove compartment or through an access panel in the cowl panel under the hood. In some cases special charcoal filters are added to aid in the reduction of passenger compartment odors.
Air Door/Valve Configuration

The air doors or air valves within the ductwork direct the airflow through the air distribution system. The air doors/valves can be varied in position to get a desired air distribution. Most air distribution systems have the same air door/valve configuration up to the heater core (see Figure 4-4).

The outside air/recirculation door/valve is used to control which air inlet is used. Most systems are designed to prevent complete blockage of the outside air inlet. This allows a minimum airflow from the outside to enter the passenger compartment even when the outside air/recirculation door/valve is in the recirculation position.

The temperature door/valve is used to control the airflow through the heater core. This is a variable position door/valve. When the door/valve is in the cool position, airflow bypasses the heater core. The air temperature exiting the air distribution system will be either outside air temperature or cooler as a result of A/C operation. When the door/valve is in the warm position, the air is warmed as it passes through the heater core.

Certain air distribution systems will also have a heater shut-off air valve to further block the airflow through the heater core during A/C operation. Some systems use a water control valve instead of this air door/valve. The water control valve prevents heated coolant from entering the heater core. Air door/valve configurations can be grouped by the number of doors they have controlling airflow to the outlets. The following are four air door/valve configurations currently in production:

- Two outlet-door system
- Three outlet-door system
- Individual outlet-door system
- Film valve outlet system

*Figure 4-4, Air Door/Valves Common to Most Air Distribution System*
Two Outlet-Door Systems

The two outlet-door system uses two air door/valves to control the airflow through the outlets. One style of two outlet-door system uses a door to control air flow through the floor/heater outlet and a second door to control the air flow through both the windshield/defrost outlet and the panel/air conditioning outlet (see Figure 4-5, view A).

The second style of two outlet-door system uses one door to control air flow through the panel/air conditioning outlet and a second door to control the air flow through both the defrost/windshield outlet and the floor/heater outlet (see Figure 4-5, view B).

Figure 4-5, Two Outlet-Door Systems
Three Outlet-Door Systems

The three outlet-door system uses one air door/valve to control airflow between the windshield/defrost outlet and the heater outlet. Two other doors are used to control the airflow through the panel/air-conditioning outlet (see Figure 4-6). The panel/air conditioning door/valve is used to direct airflow through the panel/air conditioning outlet and block airflow from exiting through other outlets. The Bi-Level door/valve is used to allow airflow to go through both the panel/air conditioning outlet and other outlets.

Figure 4-6, Three Outlet-Door System
Individual Outlet-Door System

The individual outlet-door system uses air doors/valves for each outlet (see Figure 4-7). Each door controls the airflow through a specific outlet. All mode doors are controlled by a single electric motor and linkage assembly.

Figure 4-7, Individual Outlet-Door System
Film Valve Outlet System

New for 2004 is the implementation of a film valve system that utilizes a perforated film on an electronically controlled roller that moves to open or close mode openings in the HVAC module. The film is adjusted via only one control motor, rather than the previous multiple mode motor design.

As shown in Figure 4-8, the yellow highlighted areas are revealing slotted openings in the film that will allow air to pass. The film rolls up or down opening or closing the slots. The other two larger outlets are closed. (No slots showing). The HVAC module uses a separate temperature door with a two-wire electronic actuator motor.

The Buehler actuator that is used to move the film valve and one for the temperature door is a 2 wire bi-directional electric motor. While the film or door can be moved and stopped at any position by the HVAC control module, the controller will determine the proper position by counting motor pulses on the control circuits. These small pulses are created by voltage fluctuations of the brushes shorting across 2 commutator contacts as the motor rotates. The HVAC control module converts the pulses to counts of 0-255. These counts are used to index film valve mode position and the temperature door position.

The film valve system has several operating characteristics:

- The cycle time for a mode change will vary based on the starting point of the film valve relative to the requested position.
- The maximum time to achieve a mode change will occur when the film valve travels between vent and defrost. However, the speed of mode changes can vary based on variations in system blower speed, temperature and voltage.
- Recalibration will typically occur when the engine is OFF. The actuator noise heard during recalibration may be more noticeable than during normal operation.

Figure 4-8, Film Valve Mode System (Grand Prix)
Lesson 2: Typical Manual Modes of Operation

Each HVAC system has its own modes of operation. These modes are listed in both the Owner's Manual and the Service Manual for that specific vehicle. In general, HVAC systems have at a minimum the following modes of operation:

- Air Conditioning/Recirculation Mode
- Bi-Level Mode
- Vent Mode
- Heater Mode
- Defrost Mode

Air Conditioning/Recirculation Mode

When Recirc (or MAX A/C) is selected, the air inlet valve is positioned to the recirculated air position. In this position, air from the passenger compartment is recirculated through the air-delivery ductwork. This function allows for maximum air conditioning performance. The use of Recirc in cold and damp or humid weather will cause the windows to fog up, therefore recirculation is not available in defrost mode.

Some applications like the C/K trucks utilize an A/C high-pressure recirculation switch that can cause the HVAC system to recirculate air. If the switch is pressed into the ON position when the mode switch is in an unavailable mode position, then the recirculation switch LED will flash 3 times. When the high side pressure reaches 2206-2620 Kpa (320-380 psi), the PCM will place the HVAC system in recirculation mode. The high side pressure is lowered when the inside air cools the refrigerant within the A/C evaporator. When the high-side pressure reaches 1447-1861 Kpa (210-270 psi), the PCM will place the HVAC system out of recirculation mode.

![Figure 4-9, Air Conditioning/Recirc Mode in an Air-Delivery System](image)
**Bi-Level Mode**

When selecting the Bi-Level mode, air enters the ductwork or module and passes through the evaporator core. This mode selection turns on the air conditioning compressor; the air flowing through the evaporator is cooled and dehumidified. (Some HVAC systems have a Bi-Level Mode that does not automatically turn on the A/C compressor.) Depending on the temperature lever position, some air may pass through the heater core. This air will then mix with the cooler air and be discharged through the instrument panel and heater outlets. Airflow design characteristics of the ductwork will divert most of this tempered air out of the instrument panel outlets, with air from the heater outlet being slightly warmer.

*Figure 4-10, Bi-Level Mode in an Air-Delivery System*
Vent Mode

When Vent is selected, outside air enters the ductwork or module. This mode selection does not turn on the air conditioning compressor. After the airflows through the evaporator (without being cooled or dehumidified), it passes through the mode valve(s) and out into the passenger compartment through the instrument panel outlets. Depending on the temperature lever position, some or all of this air may pass through the heater core. The temperature lever can be set to the desired heat level.

Heater Mode

When selecting the Heater mode, with Recirc OFF, outside air enters the ductwork or module and passes through the evaporator core. With the air conditioning compressor OFF, the air becomes no cooler or drier than when it entered. When the temperature lever is moved from cold to hot, the temperature valve directs some or all of the air from the evaporator through the heater core, warming the air passing through it. The mode valve(s) closes and directs most of the warmed air to the lower and rear outlets. A small amount of bleed air may exit through the defroster ducts.
Regardless of the make or model, most manufacturers recommend that the heater fan control switch be set to a lower speed during engine warm-up in extremely cold weather. While the heater works with the cooling system's thermostat closed during warm-up, the available amount of heat is limited. Running the heater fan on high will divert too much of the heat needed for engine warm-up. The engine's coolant temperatures will quickly decrease and only cool air may flow from the heater outlets.

Defrost Mode

When the Defrost mode is selected, outside air enters the module or ductwork and passes through the evaporator core. The air then passes through the heater core where it is heated. For maximum defrosting, or when operating an air-delivery system in high humidity conditions, the Recirc position should not be used. After the air passes through the heater core, most of the air is directed through the mode valve(s) to the defroster outlets. A small amount of bleed air will pass by the mode valve(s) and out the lower air outlets. Adjusting the temperature determines how much or little of the air goes through the heater core.
Some vehicles have a combination Defrost/Defog mode or separate modes for each. In the Defog position more airflow is allowed to the floor outlets than in the Defrost mode. Specific procedures are usually recommended for setting the mode lever to regulate airflow and temperature under different conditions.

Figure 4-13, Defrost Mode in an Air-Delivery System
Lesson 3: Manual HVAC System Controls

The manual air distribution system contains air doors/valves that control the air inlets and outlets (mode doors) and a door valve that controls the temperature (temp/blend/mix door). The different modes of operation (MAX A/C, NORM A/C, BI-LEVEL, HEAT, DEFROST and so on) determine the position of the mode doors. The temperature door controls the amount of air that flows through or bypasses the heater core.

There are three control methods used to control the air doors:

- Mechanical
- Vacuum
- Electronic

Some manual systems use different control methods to control different doors. Therefore, it is common to see a manual air distribution system with mode doors controlled by vacuum and a temperature door controlled electronically.

The following are examples of the air door/valve control combinations common to manual air distribution systems:

- Vacuum Rotary Valve (mode doors) and Manual Cable Actuator (temp door)
- Vacuum Rotary Valve (mode doors) and Electric Motor (temp door)
- Vacuum Solenoids (mode doors) and Electric Motor (temp door)
- Electric Motors (to control all doors)

Figure 4-14, Manual Air Distribution System Using Vacuum Solenoids and Electric Motor
Mechanical Control

The mechanical control method uses mechanical linkages (cables) to connect the control head directly to the air doors/valves. In Figure 4-15, the temperature door/valve is manually controlled. When the temperature slide or knob on the control head is moved, the linkage will move the temperature door/valve an equal amount. This controls the amount of air that flows through or bypasses the heater core. When the mode door switch is moved a cable will move a series of cams and levers to adjust the mode door(s). This will direct the air to exit the defrost, vents or heater outlets or a combination.

Figure 4-15, Mechanical Cable Control Temperature Door/Valve (Vibe)
Rotary Vacuum Valve

When a rotary vacuum valve (see Figure 4-17) is used to control vacuum actuated air doors, the control head selector rotates a vacuum valve when a mode is selected. This aligns the vacuum passages in the valve so that vacuum is applied to the appropriate vacuum actuator(s) for the selected mode.

Figure 4-16 shows an example of a HVAC system that uses a vacuum rotary valve. When diagnosing systems with this type of air door control, make sure that the vacuum source is providing sufficient vacuum and is not damaged.

Check the vacuum reservoir and check valves if used. Also make certain that the rotary valve is directing the vacuum to the correct actuator. This involves finding the vacuum routing illustrations in Service Information. After determining that the vacuum lines are correctly routed, make sure that the actuator holds the vacuum by using a vacuum pump. If a manual temperature door is used, there is a cable adjustment procedure in the Service Information which is used to make sure correct door position is assured and that a temperature control problem in the vehicle does not occur.

Figure 4-16, Rotary Vacuum Valve Controlled Air Doors/Valves
Vacuum Control

The vacuum control method uses vacuum actuators to position the air doors/valves. The vacuum control system uses either engine manifold vacuum or a vacuum pump. The vacuum is applied to the correct actuator by one of two methods:

- Rotary Vacuum Valve
- Vacuum Solenoids

Figure 4-17, Rotary Vacuum Control Valve

Figure 4-18, Vacuum Actuator and Vacuum Control Solenoid
真空电磁阀

大多数手动系统使用真空电磁阀时使用一个电磁阀箱（见图4-18）。该电磁阀箱包含五个单独的电磁阀（一组放在一个紧凑的单元中）共用一个电源。每个电磁阀都有一个单独的接地电路，连接到控制头。

控制头开关的位置决定哪些电磁阀被激活。激活的电磁阀允许真空应用到正确的执行器（见图4-19）。只有激活的电磁阀允许真空应用到它们的真空管。它允许真空在失电时通风，将执行器定位在休息位置。激活/失电电磁阀的组合决定了操作模式。

图4-19，真空电磁阀控制的空气门/阀
The system in Figure 4-20 uses a solenoid switch assembly. The switch assembly contains the vacuum solenoids and solenoid control circuits. The HVAC control head provides the switch assembly with signals based on the selection made by the vehicle operator. These signals command the switch assembly to energize specific solenoids. The control head normally applies 12 volts to the signal circuit. It removes the 12 volts to request the switch assembly to energize the solenoid for the requested circuit. To de-energize the solenoid, the control head will re-apply 12 volts to the signal circuit.

Figure 4-20, Air Distribution System using a Solenoid Switch Assembly
Electronic Control Actuators

The electronic control method of air door/valve control uses electric motors to provide variable positioning of air doors/valves. The settings input into the control head determine door/valve positioning. Electric motors are controlled by one of two control methods. In one method, the control head controls the drive motor circuits (providing power and ground to the motor windings). In the other method, the control head provides the motor with an input, and the motor positions the air door based on the input. The type of control method used is based on the control head and the motor used. The following are the four types of motors used (based on the number of circuits connected to the motor):

- Two Wire Motor/Actuator
- Three Wire Motor/Actuator
- Five Wire Motor/Actuator (old type)
- Five Wire Motor/Actuator (new type)

Figure 4-21, Two, Three, and Five Wire Actuator Motors
Two Wire Motor/Actuator

A two-wire motor/actuator is a bi-directional permanent magnet electric motor. The control head has two circuits connected to the motor. Both circuits are at ground potential when the motor is at rest (not moving). When a change of position is required (based on vehicle operator input), the control head applies approximately 8 volts to one circuit and the other circuit remains connected to ground. The control head determines which wire receives the 8 volts based on the direction that the motor must turn. To reverse the direction, the control head reverses the polarity of the wires.

The control head provides power to the circuit for a set time period. This time period is determined by the manufacturer and is sufficient for the motor to completely change the position of the air door/valve. The two wire motor/actuators can only be used with air doors that have only two positions.

Unlike some of the other motors, this motor does not provide feedback to the control head, and therefore the control head cannot determine the position of the motor.

![Figure 4-22, Two-Wire Motor/Actuator](image-url)
New Two-Wire Motor/Actuator (Buehler)

The latest innovation to the two-wire actuator is its use to control an air temperature door on vehicles such as: Cadillac automatic HVAC systems and the 2004, Grand Prix manual HVAC system. This air temperature actuator is a two-wire bi-directional electric motor. Two control circuits enable the actuator to operate. The control circuits use either a 0 or 12-volt value to coordinate the movement. When the actuator is at rest, both control circuits have a value of 12 volts. In order to move the actuator, the HVAC control module grounds the appropriate control circuit for the commanded direction. The HVAC control module reverses the polarity of the control circuits to move the actuator in the opposite direction.

The HVAC control module determines the door position by counting motor pulses on one of the control circuits. These pulses are small voltage fluctuations that occur when a brush is shorted across two commutator contacts as the motor rotates. As the actuator shaft rotates, the HVAC control module monitors the voltage drop across an internal resistance to detect the pulses. The HVAC control module uses a range of 0-255 counts to index the actuator position.

![Figure 4-23, Two-Wire Actuator Circuit to Control Air Temperature Door (Cadillac/Grand Prix)](image)
Three Wire Motor/Actuator

A three-wire motor/actuator is a bi-directional permanent magnet electric motor with logic circuits used to control the positioning of the motor/actuator. These motors have a power, ground and signal circuit. The signal circuit provides the motor with the desired position from the control head. The control head provides a variable voltage on the signal circuit. Based on the voltage, the motor will move in the correct direction.

A common example of this type of motor is the temperature control motor/actuator in Figure 4-24. The temperature lever in the control head is linked mechanically to a potentiometer. When the lever is in the full hot position, the output from the potentiometer will be near 12 volts. When the lever is in the full cold position, the output will be near 0 volts. This output voltage is applied to the signal wire of the motor/actuator. The logic circuits inside the motor correlate the voltage with a specific air door position and will rotate the motor until the air door position matches the desired position.

When diagnosing this actuator, using a voltmeter across the motors circuit would check the integrity of power and ground. When checking the signal circuit a 0-12 volt reading should be seen depending on the control head setting. If the signal circuit becomes grounded or open, the actuator will stop in whatever position it was in when the fault occurred. Remember, some control circuits will only provide two voltages, for example the inlet air door on C/K trucks.

![Figure 4-24, Three-Wire Motor/Actuator](image-url)
Five Wire Motor/Actuator (Old Type)

The old type of five-wire motor/actuator is very similar to the two-wire motor/actuator. It is a bi-directional permanent magnet electric motor that rotates based on the polarity of the control circuit provided by the control head. The motor also has three additional circuits that are connected to a gear driven feedback potentiometer. These circuits provide the control head with feedback on the actual position of the air door. When a change in door position is needed, the control head powers the control circuit until the feedback circuit indicates that the door is in the desired position. Unlike the two-wire motor, this type of motor allows the control head to command the air door to various positions.

To diagnose this type of actuator, measure the voltage across the two motor control circuits. Command the motor to move in both directions. The voltage will be either +7.5 volts or -7.5 volts based on the commanded direction of rotation. Check the integrity of the potentiometer circuit by placing the voltmeter across the 5-volt reference and ground circuits. Then check the voltage output on the feedback from the potentiometer in the various motor positions. They should correspond with the voltages that are assigned to the different positions.

![Figure 4-25, Five-Wire Motor/Actuator (Old Type)](image_url)
Five Wire Motor/Actuator (New Type)

The new type of five-wire motor/actuator is controlled by the signal provided by the signal circuit. It also contains a feedback potentiometer similar to the old type five wire motor. The logic circuits inside the motor control the bi-directional electric motor based on the input voltage provided by the control head on the signal wire. When 0 volts is applied to the signal circuit, the motor logic circuits rotate the motor in one direction. When 5 volts is applied to the signal circuit, the motor logic circuit rotates the motor in the other direction. If 2.5 volts is applied to the signal circuit, the motor will stop rotating.

The feedback potentiometer is geared to the motor. These circuits provide the control head with feedback on the actual position of the air door. When the control head signals the motor to rotate, it monitors the feedback circuits. When the potentiometer indicates that the correct air door position has been achieved, the control head will apply 2.5 volts to the signal circuit, stopping the motor. These types of motors are typically used on automatic HVAC systems.

![Five-Wire Motor/Actuator (New Type)](image)

Figure 4-26, Five-Wire Motor/Actuator (New Type)
Blower Controls

The blower is responsible for creating an airflow through the air distribution system. The blower is an electric motor with a fan that is controlled by the control head. Two types of blower controls are currently used in the manual HVAC systems:

- Resistor pack
- Relay controlled

While the resistor pack type is generally used for most overall applications, the relay type is almost exclusively used for controlling rear blower operation for late model vehicles that have rear HVAC. The relay controlled blower circuits will be discussed in the Rear HVAC section.

Resistor Pack

There are two types of resistor packs presently used on GM Vehicles;

- Metal Coil type
- Resistive Element type

The Metal Coil type is a series of resistant wire that is wound into coils of varying sizes to provide different resistances.

The "Resistive Element type" is a small board with printed circuit resistance segments.

---

**METAL COIL TYPE**

**RESISTIVE ELEMENT TYPE**

*Figure 4-27, Resistor pack and resistive element (Saturn)*
The thermal limiter (Figure 4-28) is a non-serviceable circuit protection device located within the resistor pack. It acts like a fuse to protect blower motor circuit from excessive current flow. The thermal limiter opens when the air temperature across the resistors becomes excessive. When the thermal limiter opens, the resistor pack must be replaced. In addition, the airflow restriction that caused it to open must be corrected.

![Figure 4-28, Thermal Limiter in a Resistor Pack](image)

When the blower is controlled through a resistor pack, a three or four position switch in the control head sets the speed of the blower. Adding and removing resistance in the blower circuit will achieve these speeds. Two resistors provide three speeds and three resistors provide four speeds. The resistor pack can be placed in either the ground or power side of the blower motor circuit.

When the switch is in the LO position, the total resistance of the resistor pack is placed in series with the blower, and the blower operates at slow speed. Each additional position of the switch causes some of the resistance in the resistor pack to be by-passed, resulting in a faster blower speed. In the HI position, the blower switch bypasses the resistor pack.

The voltage is typically directed to the coil side of a relay. When energized, the relay allows battery voltage to be applied to the blower, and the blower will run at its highest speed. This prevents the fan switch from handling the high current flow in maximum speed. Figure 4-29, shows a manual system with a four-speed fan switch and the resistor pack on the power side of the blower motor circuit.
The voltage is typically directed to the coil side of a relay. When energized, the relay allows battery voltage to be applied to the blower, and the blower will run at its highest speed. This prevents the fan switch from handling the high current flow in maximum speed. Figure 4-29, shows a manual system with a four-speed fan switch and the resistor pack on the power side of the blower motor circuit.

Figure 4-29, Resistor Pack in the Power Side of Blower Circuit (N-Car)
Figure 4-30 shows a manual system with a four-speed fan switch and the resistor pack on the groundside of the blower motor circuit. A relay is not used in maximum speed; the control head is designed to handle the current flow.

Figure 4-30, Resistor Pack in the Ground Side of the Blower Circuit (J-Car)
Figure 4-31 shows a manual system with a four-speed fan switch and the resistor pack on the power side of the blower motor circuit. This system is unique because the low position of the fan speed switch does not provide a circuit to the blower resistor pack. When the control head is in any mode except OFF, the mode selector provides power to the blower resistor pack, which flows through the entire resistance to the blower motor.

Figure 4-31, Blower Motor Control Circuit (S/T Truck)
Lesson 4: Manual HVAC Dual Zone System

The dual zone air distribution system has a separate temperature adjustment for the passenger. Dual zone systems can be controlled by either an automatic climate control system or manual control system. The passenger can adjust temperature of the air exiting the vents on the passenger side. The passenger control on the manual system is completely independent of the driver-selected temperature.

![Manual Dual Zone Control Head (2003 Impala)](image)

The dual zone system uses separate driver-side and passenger-side ductwork (Figure 4-33). There are two temperature doors that are operated by separate electric motors. The driver side temperature selection does not affect the position of the passenger side temperature door. The passenger temperature can be adjusted as much as 30°F difference from the driver's side of the vehicle. The mode selections control both the driver and passenger side mode doors congruently.

![Manual Dual Zone System Temperature Door Control](image)
The air distribution system contains a blower motor and fan that is used to circulate the air. The control of the mode doors and temperature doors use vacuum or electronic control methods. The manual dual zone system in figure 4-34 uses mode doors controlled by vacuum solenoids and the temperature doors controlled electronically.

Figure 4-34, Manual Dual Zone System using Vacuum Solenoids (Impala)
Figure 4-35 shows a manual dual zone air distribution system that uses electric motors to control both the mode doors and the temperature doors. All of these motors are the new style five-wire motors. These motors have logic circuits (solid state) that move the motor based on a signal from the HVAC control head. A signal voltage of 0 or 5 volts causes the motor to rotate in a specific direction. The control head provides 2.5 volts on the signal circuit to stop the motor when the desired air door position is achieved.

The control head uses the feedback potentiometer inside the motor to determine when the air door is in the correct position. The sense circuit provides the feedback signal.
On U-Van manual dual zone systems three wire actuator motors are used throughout.

Manual dual zone systems do not use sensors to provide inputs for making automatic adjustments to the temperature door. All adjustments to interior temperature will have to be manually provided by the vehicle occupants through adjusting the temperature selector, blower speed, and mode selection.

![Diagram of Manual Dual Zone using Three-Wire Actuator Motors (U-Van)](image)

*Figure 4-36, Manual Dual Zone using Three-Wire Actuator Motors (U-Van)*
Lesson 5: Manual Rear HVAC Systems

Overview

The interior space of large trucks and vans place a large load on the front heating and cooling systems in extreme temperatures. Because of this, many of these vehicles can be equipped with rear heating and/or cooling systems. These systems aid the front HVAC system in heating or cooling the interior. The type of rear systems that are available is based on the vehicle:

- C/K Truck (Suburban) and G-Van
  - Rear Heating System
  - Rear Cooling System
  - Rear Heating and Cooling System (Rear HVAC)
- M-Van
  - Rear Heating System
  - Rear Cooling System
  - Both Rear Heating and Cooling System (the systems are separate)
- U-Van
  - Rear Heating and Cooling System (Rear HVAC)

The rear air systems are either floor mounted or roof mounted. The rear cooling systems have refrigerant lines and a control device that is connected in parallel to the front refrigeration system. These systems cannot control the operation of the compressor. They can only provide cooling when the compressor is commanded ON by the front HVAC system. The heating systems have a heater core and heater hose that are connected in parallel with the front heater hoses.

The control for blower and air door (on systems with doors) operation varies with the system and application. Some applications allow for both front and rear seat passenger control. Other systems, allow either front or rear seat passenger control.
C/K Truck and G-Van Rear Systems

The C/K trucks and G-Vans can be equipped with rear air distribution systems that can provide rear heating (RPO C36), rear cooling (RPO C69) or a combination rear heating and cooling (RPO C36+ C69). The rear air distribution system can have the following components (dependent on the system, refer to Figure 4-37):

- Blower
- Mode and Temperature Doors
- Evaporator
- Heater Core
- Control Panel(s)
- Controller

The rear systems that provide only heating or cooling do not have temperature or outlet mode doors. These systems have a control panel for blower speed that is accessible to the rear seat passengers. The cooling-only system also has a front control panel for rear blower control. When the front control panel switch is in the REAR position, it allows the rear blower switch to control the operation of the rear blower. Heat-only systems do not have an evaporator and the cooling-only systems do not have a heater core.

The systems that provide heating and cooling have an outlet mode door for directing the air to either the upper or lower vents and a temperature door to control the air temperature. These systems have both front and rear control panels for controlling the rear air distribution system. The control panels allow selection of the blower speed, temperature door position and mode door position.

*Figure 4-37, C/K Truck Rear Air Distribution System*
The rear refrigerant system is connected in parallel to the front refrigerant system. A thermal expansion valve (TXV) is used to control refrigerant flow through the evaporator. The rear HVAC controls cannot command the operation of the compressor. The rear refrigerant system can only provide cooling when the front HVAC system has commanded the compressor ON.

![Figure 4-38, Rear HVAC Refrigerant System](image-url)
The rear heating and cooling systems are also equipped with a rear HVAC controller. This controller contains logic that allows it to determine which control panel inputs (front or rear) to use when controlling the rear HVAC system (refer to Figure 4-39). If the front control panel blower switch is in the REAR position, the controller will allow the rear control panel to control the operation of the rear HVAC system. If the front control panel blower switch is in any other position, the controller will operate the rear blower and doors based on the front control panel.

The rear HVAC controller module is not contained within a case like other controllers. Because of this, its circuits and components are exposed and must be handled with care when replacing.

Figure 4-39, C/K Truck Control Panels and Rear HVAC Controller
Relay Controlled Blower

The rear blower is controlled by three relays. These relays control the amount of resistance in the blower motor circuit. The relays are controlled by either the front control panel or rear control panel blower switch. The rear blower switch can only control the operation of the blower relays when the front blower switch is in the REAR position. The blower switches control the groundside of the relay coils. When the front blower switch is in the REAR position, it provides the rear blower switch with a path to ground. Figure 4-40 shows blower control using the front blower switch. Figure 4-41 shows blower control using the rear blower switch.

Figure 4-40, Blower Control using the Front Control Panel Blower Switch
Figure 4-41, Blower Control using the Rear Control Panel Blower Switch
Door Control

The front control panel operates the rear HVAC mode doors when the front blower switch is in any position other than REAR (refer to Figure 4-42). When it is in the REAR position, the front panel blower switch provides the rear HVAC controller with a ground path (refer to Figure 4-43). This ground path causes the controller to allow the rear control panel to operate the rear HVAC mode doors.

The rear HVAC doors are controlled by three-wire motors. The motors will position the doors based on the signal circuit voltage. The signal circuit voltage is varied by either the potentiometer in the front or rear control panel (dependent on front blower switch position). The potentiometer can vary the voltage on the signal circuit from 0 volts to 12 volts.

Figure 4-42, C/K Truck Door Control using the Front Control Panel
Figure 4-43, C/K Truck Door Control using the Rear Control Panel
M-Van Rear HVAC Systems

The M-Vans can be equipped with rear heating and/or rear cooling systems. These two systems are completely separate units and operate independently of each other (refer to Figure 4-44). The floor-mounted rear heater assembly is located behind the driver seat in the left body side inner panel. The heater hoses are connected in parallel to the front heater hoses. No temperature door is used on this system. The rear A/C unit is also floor-mounted and is located at the left rear corner of the vehicle. It has ducts that direct the airflow up to the headliner where it exits through vents. The rear refrigerant system is connected in parallel to the front system and has a thermal expansion valve (TXV) to control refrigerant flow through the rear evaporator. It can only provide cooling when the compressor is operated by the front HVAC system.

Figure 4-44, M-Van Heater System and Cooling System Locations
M-Van Rear Heater System

The rear heater system has a control panel located in the center of the instrument panel. The system has a heater core, blower motor, resistor pack, heater hoses and a water valve. The heater hoses extend from the rear heater system to a vacuum or solenoid-operated water valve. The water valve connects the rear heater core to the front heater hoses. The rear heater control switch provides vacuum control for the water valve assembly and circuits for blower control. In later vehicles, the water valve utilizes an electrical solenoid controlled by the HVAC module to open and close a vacuum supply to the bypass valve.

![Diagram of M-Van Water Valve Vacuum Control](image)

*Figure 4-45, M-Van Water Valve Vacuum Control*
When the rear passenger moves the rear blower switch to LO, MEDIUM, or HIGH some of the resistance of the resistor pack is bypassed causing the blower to run at the set speed. In Figure 4-46 the rear passenger has selected MEDIUM blower speed.

At the same time as the blower motor is turned on, the circuit for the water bypass valve solenoid is activated. Coolant then flows through the rear heater assembly and warms the rear of the vehicle.

Figure 4-46, M-Van Rear Heater Blower and Solenoid Water Valve Control
When the A/C rear blower switch is operated, only blower speed is controlled. The A/C system must be operating in order for rear cooling to occur. If the passenger moves the rear blower control to HIGH, the resistor pack is bypassed and the motor operates at maximum speed.

*Figure 4-47, M-Van Rear A/C Blower Control*
U-Van Rear Systems

The U-Vans can be equipped with a rear heating and cooling system. The rear HVAC system has heater hoses that are connected in parallel to the front heater hoses. The rear refrigerant system is connected in parallel to the front system and has a thermal expansion valve (TXV) to control refrigerant flow through the rear evaporator. It can provide cooling when the front HVAC control panel operates the compressor.

The auxiliary HVAC system allows the driver to adjust the amount of air directed to either the floor or to the overhead outlets. The mode door is controlled by the operation of the front mode switch. To direct air to the rear of the vehicle using the floor vents, set the mode switch on the HVAC control module to the FLOOR, DEFROST, or MIX-BLEND modes. To direct air through the headliner vents, set the mode switch on the HVAC control module to BI-LEVEL or VENT modes. On the older U-Van rear HVAC systems a vacuum controlled water valve was used to allow hot water to enter the heater core and therefore control the heating portion of the system. Since 2001, the control of temperature in the rear system is now accomplished through the use of a temperature door located in the rear HVAC module unit.
The rear HVAC system allows the back seat passenger to adjust the temperature of the rear flow of air. The A/C function is only available to the rear system when the HVAC control module is in A/C mode. When the front control panel is not set in the REAR mode the rear HVAC system is disabled. For maximum cooling operation of the HVAC system, the rear fan control must be set to 0 or OFF if no rear passengers are present. The rear passenger’s comfort is achieved by setting the rear fan control to the number 3 setting. Setting the front panel - rear blower control to the "R" setting will allow the rear passengers to control rear blower and temperature settings.
The system has both front and rear-mounted rear blower control switches. These switches control the groundside of the blower motor circuit and determine the amount of resistance in the blower circuit. The rear-mounted blower switch can only control blower operation when the front-mounted auxiliary blower switch is in the REAR position (refer to Figure 4-52). The rear blower motor speed control circuit delivers voltage through the rear blower motor relay and through the rear blower resistor assembly. Depending on the speed selected the voltage passes through one or two resistors and is then grounded through the rear blower control switch. The illustration below shows the blower circuit activated for MEDIUM blower speed.

![Blower Circuit Diagram](image)

Figure 4-52, U-Van Rear Blower Control Circuit (Medium speed)
Lesson 6: Manual HVAC System Diagnosis

General Motors provides specific A/C system "Strategy Based Diagnostic" charts and procedures for their various models and model years. These should always be referred to during system diagnosis and repair because of the many changes that may occur by vehicle model, manufacturing year or A/C system content and configuration.

Figure 4-53, Strategy Based Diagnosis Chart
Yet for the purposes of training, several standard charts can serve as a basic foundation for more specific system testing. These include a "Diagnostic Starting Point" Chart - (Heating, Ventilation and Air Conditioning), a "Diagnostic System Check" Chart and Symptoms Diagnosis Chart.

The A/C system visual inspection and diagnostic charts can identify conditions within the air-delivery system. For instance, insufficient discharge air may indicate conditions within the blower motor or fan system. A malfunctioning mode control selector, sticking or damaged air doors/valves, or restrictions in the outlets themselves, may cause improper outlet selection. Not achieving desired temperature settings might be caused by an inoperative temperature door valve or the controls that open or close it.

On systems with manual controls, various air-delivery conditions and their possible causes include the following:

- Incorrect mode selection may be caused by a malfunctioning control head or by stuck or damaged mode control doors/valves.
- Improper temperature control can be caused by a broken or binding control cable, inoperative vacuum actuators/electric motors or defective compressor controls or cooling system problems.
- A malfunctioning blower may cause insufficient discharge air motor/fan switch, open blower resistor, or malfunctioning relays. Too much discharge air points to switch and/or electrical malfunctions. In either case, blower motor/fan conditions usually require electrical diagnosis.

Vehicle "Service Information" (SI) contains diagnosis and service procedures for malfunctions in the air-delivery system. Most often, these conditions can be traced to either electrical control causes and, more rarely, mechanical malfunctions within the HVAC module.

Proper performance of the cooling and air-delivery sub-systems in an HVAC system is essential for proper operation of the refrigeration subsystem.
Diagnostic Starting Point Chart - Heating, Ventilation and Air Conditioning

The Heating, Ventilation and Air Conditioning (HVAC) system is divided into three sections. The first, Heating, Ventilation and Air Conditioning, has all procedures that pertain to a HVAC component or function that are not specifically associated with an automatic or manual control system. The second, HVAC Systems-Manual, has all procedures specific to the manual control system. The third, HVAC Systems-Automatic, has all the procedures specific to the automatic control system.

For systems with DTCs, begin the system diagnosis with the following procedures:

• Diagnostic System Check - HVAC Systems - Automatic in HVAC Systems-Automatic

The Diagnostic System Check will provide the following information:

• The identification of the control modules, which command the system.
• The ability of the control modules to communicate through the Class 2 serial data circuit.

The use of the Diagnostic System Check will identify and lead the technician to the correct diagnostic procedure.

Review the Description and Operation information to help you determine the correct symptom diagnostic procedure when a malfunction exists. Reviewing the Description and Operation information will also help you determine if the condition described by the customer is normal operation. The HVAC Description and Operation information is divided into:

• Air Delivery Description and Operation in HVAC Systems-Manual
• Air Temperature Description and Operation in HVAC Systems-Manual
• Air Delivery Description and Operation in HVAC Systems-Automatic
• Air Temperature Description and Operation in HVAC Systems-Automatic

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The Air Delivery Description and Operation contains the following topics:

- HVAC Control Components
- Air Speed
- Air Distribution
- Recirculation Operation
- Automatic Operation

The Air Temperature Description and Operation contains the following topics:

- HVAC Control Components
- Heating and A/C Operation
- Automatic Operation
- Engine Coolant
- A/C Cycle
### Diagnostic System Check Chart - HVAC Systems - Manual

#### Test Description

The numbers below refer to the step numbers on the diagnostic table.

3. Lack of communication may be due to a partial malfunction of the class 2 serial data circuit or due to a total malfunction of the class 2 serial data circuit. The specified procedure will determine the particular condition.

4. Determine if the powertrain control module has set DTCs which may affect HVAC operation are present.

5. The presence of DTCs which begin with "U" indicate some other module is not communicating. The specified procedure will compile all the available information before tests are performed.

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Did you review A Diagnostic Starting Point - Heating, Ventilation and Air Conditioning?</td>
<td>Go to Step 2</td>
<td>Go to Diagnostic Starting Point - Heating, Ventilation and Air Conditioning</td>
</tr>
<tr>
<td>2</td>
<td>Install a scan tool. Does the scan tool power up?</td>
<td>Go to Step 3</td>
<td>Go to Scan Tool Does Not Power Up in Data Link Communications</td>
</tr>
<tr>
<td>3</td>
<td>1. Turn ON the ignition, with the engine OFF. 2. Attempt to establish communication with the powertrain control module. Does the scan tool communicate with the powertrain control module?</td>
<td>Go to Step 4</td>
<td>Go to Scan Tool Does Not Communicate with Class 2 Device in Data Link Communications</td>
</tr>
<tr>
<td>4</td>
<td>Select the powertrain control module display DTCs function on the scan tool. Does the scan tool display any DTCs?</td>
<td>Go to Step 5</td>
<td>Go to Symptoms - HVAC Systems - Manual</td>
</tr>
<tr>
<td>5</td>
<td>Does the scan tool display any DTCs which begin with a &quot;U&quot;?</td>
<td>Go to Scan Tool Does Not Communicate with Class 2 Device in Data Link Communications</td>
<td>Go to Step 6</td>
</tr>
<tr>
<td>6</td>
<td>Does the scan tool display any DTCs which begin with a &quot;P&quot; that are associated with the HVAC system?</td>
<td>Go to Diagnostic Trouble Code (DTC) List in Engine Controls - 3.8 L</td>
<td></td>
</tr>
</tbody>
</table>
Symptoms Chart - HVAC Systems - Manual

Important
Review the system operation in order to familiarize yourself with the system functions. Refer to:

- Air Delivery Description and Operation
- Air Temperature Description and Operation

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the HVAC System. Refer to Checking Aftermarket Accessories in Wiring Systems.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.
- Verify the A/C compressor clutch turns freely and is not seized.
- The A/C compressor will not operate in cold ambient air temperatures. Refer to Air Temperature Description and Operation

Intermittent
Faulty electrical connections or wiring may be the cause of intermittent conditions. Refer to Testing for Intermittent and Poor Connections in Wiring Systems.

Symptom List
Refer to a symptom diagnostic procedure from the following list in order to diagnose the symptom:

- HVAC Compressor Clutch Does Not Engage
- HVAC Compressor Clutch Does Not Disengage
- Blower Motor Always On
- Blower Motor Inoperative
- Blower Motor Malfunction
- Too Hot in Vehicle
- Too Cold in Vehicle
- Air Delivery Improper
- Air Recirculation Malfunction
- Leak Testing in Heating, Ventilation and Air Conditioning
• Noise Diagnosis - Blower Motor in Heating, Ventilation and Air Conditioning
• Noise Diagnosis - Air Conditioning (A/C) System in Heating, Ventilation and Air Conditioning
• Noise Diagnosis - HVAC Module in Heating, Ventilation and Air Conditioning
• Odor Diagnosis in Heating, Ventilation and Air Conditioning Top of Form
• The following conditions may cause window fogging:
  – Wet carpet or mats
  – High humidity
  – Interior water leak
  – Blocked A/C evaporator drain tube
  – Maximum passenger capacity
  – Blocked body pressure relief valves
• Inspect the air distribution system for causes of reduced air flow:
  – Obstructed or dirty passenger compartment air filter, if equipped
  – Blocked or damaged air inlet or outlet vents
Post-Test

Read each question carefully and choose the correct response.

1. The new type five-wire motor actuator differs from the old type in that:
   a. The new type has a feedback circuit; the old type does not.
   b. The new type is a bi-directional permanent magnet electrical motor; the old type is not.
   c. The new type is controlled by the PCM; the old type is controlled by logic in the motor assembly.
   d. The new type is controlled by a 0-5 volt signal from the HVAC controller to the logic circuit of the actuator. The old style has no logic circuit and is controlled by the polarity of an 8-volt signal from the HVAC controller.

2. Which mode selection does not turn on the A/C compressor:
   a. Bi-Level
   b. Vent
   c. Defrost
   d. A/C

3. Which of the following statements accurately describes the rear C/K truck and G-Van HVAC systems?
   a. They can only be controlled from the instrument panel.
   b. They are available in rear heating, rear cooling, and a combination of rear heating and cooling configurations.
   c. They can only be controlled from the rear control panel.
   d. They are only available as an integrated rear heating and cooling system.

4. Air distribution can be controlled by all of the following EXCEPT:
   a. Pressure control switches
   b. Vacuum actuators
   c. Electric motors
   d. Vacuum solenoids
5. Where is the passenger side temperature control located?
   a. On the Instrument panel or on the armrest.
   b. Always on the passenger side instrument panel.
   c. Always on the control head.
   d. Always on the armrest.

6. The passenger side temperature door on manual dual zone systems:
   a. Operates only when A/C is requested.
   b. Operates in conjunction with the driver side temperature door.
   c. Operates completely independent of the driver side temperature door.
   d. Operates in conjunction with mode doors.

7. None of the modes are functioning in an A/C system that has a rotary vacuum valve, which of the following is most likely to be responsible:
   a. A leak in a vacuum actuator.
   b. A blown fuse.
   c. Absence of source vacuum.
   d. Unwanted resistance.

8. Which motor is used with two position mode doors:
   a. Four wire motor.
   b. Five wire motor.
   c. Two wire motor.
   d. Three wire motor.

9. Which component works by aligning vacuum passages so vacuum is applied to the proper actuators:
   a. Vacuum solenoid box.
   b. Resistor pack.
   c. Rotary vacuum valve.
   d. Three wire motor.
10. The U-Van rear HVAC control system water valve is controlled by:
   a. Electrical motor.
   b. A logic module.
   c. Vacuum actuator.
   d. Vacuum.

11. Which of the following rear HVAC control systems has a logic module?
   a. S-Truck
   b. U-Van
   c. M-Van
   d. C/K Truck

12. On manual dual zone systems, the passenger side temperature door operates:
   a. Only when A/C is requested.
   b. In conjunction with mode doors
   c. Independently of the driver side temperature door
   d. In conjunction with the driver side temperature door.

13. Which of the following statements is true of the resistor pack?
   a. The number of resistors in the circuit depends on the mode selected.
   b. Resistor packs only contain wire wound resistors.
   c. An open in the circuit will make all speeds inoperative.
   d. Resistors are used either singly or in multiples to change blower motor circuit resistance.

14. The passenger side temperature control, in manual dual zone HVAC system, is a:
   a. vacuum actuator.
   b. potentiometer.
   c. thermistor.
   d. On/OFF switch
15. Which of the following statements is FALSE regarding a three-wire motor?
   a. It operates until it reaches the requested position.
   b. It has a feedback circuit.
   c. It contains a logic module.
   d. Its input is a variable voltage signal.

16. Which of the following is an actuator?
   a. Control head.
   b. PCM.
   c. HVAC Controller.
   d. Vacuum motor.

17. The thermal limiter, used in a manual HVAC blower circuit, performs which of the following functions?
   a. Protects the circuit from excessive temperature
   b. Limits compressor ON time
   c. Acts like a fuse to protect the compressor
   d. Prevents the evaporator from freeze-up

18. The blower motor in a vehicle equipped with a manual HVAC system operates at high speed only. What is the most likely cause?
   a. The blower switch is shorted between the switch and motor
   b. The blower relay is OPEN and blower speed is set to HI
   c. The blower relay is CLOSED and the operator selects AUTO
   d. An open exist between the resistor pack and the motor

19. The compartment air filter is located at the:
   a. Instrument panel outlets
   b. defrost outlets
   c. floor outlets
   d. air distribution box inlet
20. The film door HVAC system used on the 2004 Grand Prix uses:
   a. one control motor to adjust the perforated film roller
   b. one motor to control the temperature door and the film roller together
   c. no swinging mode or temperature door like the other HVAC module boxes
   d. cables to control the film roller

Use the following diagram to answer questions 21 and 22.

21. In this diagram, with an open in circuit 1199 at terminal A8 of the HVAC control module, the left air temperature actuator would:
   a. not operate at all
   b. only allow max cool
   c. not be affected and operate normally
   d. only allow max heat

22. In this diagram, with circuit 1199 shorted to ground at terminal 4 of the left air temperature actuator, the actuator would:
   a. not operate at all
   b. only allow max cool
   c. not be affected and operate normally
   d. only allow max heat
Lesson Exercise 1 & 2
Manual HVAC System Overview and Operation Modes

Directions: Answer the following questions using the module 4 workbook.

1. What is the function of the air distribution system?
   Page: __________
   ______________________________
   ______________________________________

2. What are the two types of the air distribution control systems?
   Page: __________
   ______________________________
   ______________________________________

3. What are the four outlet door configurations currently used?
   Page: __________
   ______________________________
   ______________________________________

4. On the Film Valve Outlet configuration, what control method is used to move the film valve?
   Page: __________
   ______________________________
   ______________________________________

5. On the individual outlet-door configuration, how are the individual doors controlled?
   Page: __________
   ______________________________
   ______________________________________

6. What is the purpose of today's vehicles utilizing compartment filters?
   Page: __________
   ______________________________
   ______________________________________

7. In the MAX A/C mode, what is the position of the inlet air door?
   Page: __________
   ______________________________
   ______________________________________
8. Will the refrigeration system operate in the VENT mode?
   Page: __________

9. Describe the airflow path in HEATER mode.
   Page: __________

10. What is the difference between the DEFROST and DEFOG modes?
    Page: __________
Lesson Exercise 3
Manual HVAC System Controls

Directions: Answer the following questions using the module 4 workbook.

1. What are the three control methods used to control the position of the air doors on manual HVAC systems?
   Page: __________ ________________________________

2. Using Figure 4-14 of the course book, which solenoids are ON (provided ground) when the mode selection switch is in the BI-LEV mode?
   Page: __________ ________________________________

3. Using Figure 4-16 describe the air flow path when the vacuum source is disabled.
   Page: __________ ________________________________

4. Can a two wire motor/actuator motor be used to control the temperature door? Why or why not?
   Page: __________ ________________________________

5. How does the control head control the position of a three-wire motor/actuator?
   Page: __________ ________________________________

6. If the feedback circuit from a five-wire motor/actuator (old type) to the control head is open can the control head correctly position the door? Why or why not?
   Page: __________ ________________________________
7. Using Figure 4-29 of the student workbook, is it normal for the blower motor to drop less than 12 volts when the blower switch is in the #3 position? Why or why not?

Page: __________

8. Use Figure 4-30. If there is a short to ground in circuit #64, will the blower motor operate when the blower switch is in position #4? Why or why not?

Page: __________
Lesson Exercise 4

Manual Dual Zone Overview

Directions: Use module 4 of the student workbook to answer the following questions.

1. What are the two ways that dual zone air distribution systems can be controlled?
   Page: __________ ________________________________
   ________________________________

2. How does the dual zone systems differ from the single zone systems?
   Page: __________ ________________________________
   ________________________________

3. Can the passenger side controls command compressor or blower operation?
   Page: __________ ________________________________
   ________________________________

4. Does the manual dual zone systems use sensors?
   Page: __________ ________________________________

5. During passenger control, on the manual dual zone system, how much can the passenger side temperature vary from the driver side temperature?
   Page: __________ ________________________________

6. What type of motors are used to control manual dual zone HVAC temperature doors?
   Page: __________ ________________________________

7. How is the passenger temperature door controlled on the manual dual zone systems?
   Page: __________ ________________________________
   ________________________________
8. Can the mode doors on the manual dual zone HVAC systems be controlled by the passenger controls?

9. Use Figure 4-34. If circuit 1791 is shorted to ground, will the driver temperature door operate?

10. Use Figure 4-35. If the sense circuit of the passenger door motor is open (1236), will the motor still operate correctly?
Lesson Exercise 5
Rear HVAC Systems Overview

Directions: Use module 4 of the student workbook to answer the following questions.

1. Does the C36 system on the C/K truck use a temperature door?
   Page: __________ ________________________________
   ____________________________________________

2. Does the C69 system on the C/K truck use a mode door?
   Page: __________ ________________________________
   ____________________________________________

3. On the C/K rear HVAC system, what will be the blower speed if the front control panel is in LO position and the rear control panel is in the HI position?
   Page: __________ ________________________________
   ____________________________________________

4. How does the logic module determine which control panel will be allowed to control the positions of the doors?
   Page: __________ ________________________________

5. What is the function of the water control valve on an M-Van?
   Page: __________ ________________________________

6. Does the rear A/C in an M-Van use a temperature door?
   Page: __________ ________________________________

7. Can the rear controls request the operation of the A/C compressor on any of the rear HVAC systems?
   Page: __________ ________________________________
   ____________________________________________
8. How is the mode door in the U-Van rear HVAC system controlled?
   Page: __________  ______________________________________
   ________________________________________________________

9. Can the rear passengers control blower and temperature settings when the front auxiliary control is set to position 1?
   Page: __________  ______________________________________
   ________________________________________________________

10. Use Figure 4-53. If circuit #1176 is open and the auxiliary blower speed is put in position #3. Will the auxiliary blower work?
    Page: __________  ______________________________________
           ________________________________________________________
Lesson Exercise 6

Manual HVAC Controls Diagnosis

Directions: Answer the following questions using the (SI) Service Information and a systematic procedure of “Strategy Based Diagnosis.” Diagnose and repair the following vehicle problem that has been set-up by your instructor.

Customer Concern: Owner of a 2002 Two Wheel Drive Silverado

- Air only comes out of the floor outlets no matter where controls are set.
- Condition has been consistent for past several weeks
- No problem with temperature

Step 1: Verify Customer Concern(s)

Does air come out of floor outlets? YES NO

Does Temperature of air change when setting is changed? YES NO

Does the air come out the floor vents intermediately? YES NO

Step 2: Preliminary Checks

Inspect the fuses and electrical connections.

Any problems found? YES NO

If so, describe problem._________________________________________________

________________________________________________________________________
Step 3: Perform Diagnostic System Check

Perform a diagnostic system check as outlined in service information. Confirm system for proper and improper operation. You already know that air exits the floor vents only and from no other outlets. Blower and temperature controls work properly.

Connect a scan tool to the DLC

Any trouble code(s) found? YES NO

If so, what code(s) was found? ________________________________

If no code(s) found, according to the diagnostic system check, where would you proceed next? ________________________________

Step 4: Check for Bulletins

Check for bulletins using “Service Information” (SI).

Were any bulletins found related to the customers concern? YES NO

If so, what bulletin? ________________________________

Step 5: Diagnosis

You will now proceed to troubleshoot the problem by using the appropriate chart. Keep in mind, you have already checked for DTC codes and have found.

What chart will you be using to diagnose the problem? ______________

________________________________________________________
As you progress through the chart, you connected a test light to circuit #341 (BRN) on the mode door motor disconnected connector.

With the ignition key ON and test light on brown wire of the connector, it lights.

What does this mean? ______________________________________
________________________________________________________

The next step of the diagnosis process asks you to connect the test light to a positive battery source and touch circuit # 2450 (BLK) at the mode door motor connector.

Does the test lamp light?

What does this mean? ______________________________________
________________________________________________________
As you progress through the flow chart, it tells you to turn off the ignition and reconnect the mode door connector.

Turn ignition back on and connect a voltmeter between circuit #119 (WHT) of the mode door connector and a good ground. Put blower switch in LO speed position.

Observe voltmeter as you move the mode switch from floor to defrost. Voltage reading is ________________ volts to ________________ volts.

Is the voltage within specifications? YES NO

What does the voltage readings indicate about the circuit? ___________ ________________________________________________________________

The next step of the flow chart tells you to check the mode door for binding, obstruction or excessive travel and then check the mode door motor for disconnected or binding linkage and broken or poor electrical connections.

Is there any observable problem with the mode door or mode door motor? YES NO

**Step 6: Isolate the Root Cause**

The final step of the chart indicates a problem with: (Final solution to problem) _______________________________________________________________

**Step 7: Repair and Verify Fix**

Check with the instructor as to repairing the problem.