ASE 7 - Heating, Ventilation, & Air Conditioning

Module 3
AC Controls
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Module 3 – AC Controls

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Introduction

This module will cover the various controls that are used on air conditioning systems. These controls may be controls that enable compressor operation, controls that prevent compressor operation, or controls that control compressor operation under various operating conditions. These control devices can usually be classified into one of three categories:

1. Control devices that command the compressor on and off. These would include control modules such as control heads, Body Control Modules (BCM), Engine Control Modules (ECM), Powertrain Control Modules (PCM), and AC programmers.

2. Devices that control or prevent compressor operation such as low and high pressure cut-off switches, temperature or refrigerant pressure sensors, and pressure cycling switches.

3. Devices that control compressor operation to maintain engine driveability such as power steering pressure switches or wide operation throttle relays.

Objectives

1. Have knowledge of the various control modules used on GM vehicles to control compressor operation.

2. Be able to explain the operation of various controls that are used to prevent or enable compressor operation.

3. Be able to explain the operation of various controls that are used to maintain engine driveability during AC operation.

4. Given a vehicle and the appropriate service information, be able to identify and test various compressor controls.

NATEF Area VII.

1. Diagnose AC system conditions that cause the protection devices (pressure, thermal, and PCM) to interrupt system operation, determine necessary action.

2. Test and diagnose AC compressor clutch control systems; determine necessary action.

3. Diagnose malfunctions in the electrical controls of heating, ventilation,
Lesson 1. AC Control Modules

Control of the AC compressor can be accomplished through a variety of methods. Since the introduction of electronic control modules few compressors are directly controlled by a switch on the dash. In most cases when the driver request AC compressor operation a request is sent to an electronic module. The module will then engage the compressor based on a variety of inputs. Because the operation of the AC compressor can impact the driveability of the vehicle in most cases the engagement of the compressor is controlled by the ECM or PCM. However, in some applications this may be another control module. Any of the following control modules have been or are used to engage the AC compressor:

- ECM or PCM
- Body Control Module (BCM)
- HVAC Control Head
- HVAC Controller or Programmer

**ECM or PCM**

Since ECM (PCM) control is the most common way used to control the operation of the AC compressor we will look at a typical ECM controlled compressor circuit, Figure 3-1.

Note: While this represents a typical ECM controlled AC compressor there are many variations to this example. Make sure that you refer to the service manual before you begin your diagnosis of an inoperative compressor.

![Figure 3-1, A typical ECM controlled Compressor](image)
Starting at the Heater and AC Control assembly voltage is supplied from the IP fuse block to the control head. Whenever MAX, NORM, BILEVEL, or DEFOG is selected this voltage is sent to the AC High Pressure Cut-Out Switch. This switch should normally be closed except when excessively high pressures are present. From there the voltage is directed to the Pressure Cycling Switch. This switch should be closed if there is at least 40 to 45 psi present in the system. From the Pressure Cycling Switch the voltage is applied to the ECM as the AC compressor request signal. The ECM now knows that it has been requested to turn the compressor on. Based on certain operating parameters that the ECM is monitoring such as engine RPM, coolant temperature, throttle position, and others, it will determine if the AC compressor should be engaged. If the vehicle operating parameters are within the acceptable ranges for AC operation the ECM will provide a ground for the AC compressor control relay coil. When this ground to the relay is provided, the relay will energize and switch voltage to the AC compressor clutch coil. As long as the request is present at the ECM and the operating parameters are within acceptable limits the AC compressor will continue to run. If the AC pressures rise too high the high pressure cut-out switch will open and remove the request signal from the ECM, thus disengaging the compressor clutch. In addition the pressure cycling switch will open the AC request signal to the ECM when the low-side pressures drop below 20 to 25 psi. The compressor will disengage until the low side pressures rise to above 40 to 45 psi. The compressor will then re-engage.

While the above example illustrates one method of using the ECM (PCM) to control compressor operation, there are many variations to this circuit. Depending on the application, the PCM may use different inputs to determine if compressor operation is warranted. In other applications the AC request may be sent to the PCM using serial data. It is important that you understand the differences between vehicles before you start your diagnosis. Studying the compressor control schematics and reading the theory of operation will aid you in your diagnostics.
HVAC Control Head

While less common, some vehicles use the HVAC control head to control the operation of the AC compressor clutch. This was commonly used on many light duty truck applications. Refer to Figure 3-2. In this application the AC compressor clutch relay is controlled by the HVAC control head. When the driver request AC operation the control head provides a ground for the AC compressor relay. Voltage is then sent to the evaporator control switch which would normally be closed above 25 psi. From there voltage is applied to the AC high pressure cut-out switch which should normally be closed. Voltage is then applied to the AC compressor clutch engaging the AC compressor. In addition voltage is sent to the PCM as an AC on input to let the PCM know that the compressor is engaged. In this case the PCM has no direct control of the AC compressor. It does, however, know that the AC compressor is engaged so it may modify engine operating parameters based on operation of the air conditioning.

Figure 3-2, HVAC Control Head Compressor Control (1994 C/K Truck)
Body Control Module

In some applications the BCM provides the request for AC compressor operation, Figure 3-3. While it may not directly control the operation of the AC compressor it receives and processes the AC request from the control head. In turn it sends an AC request signal to the PCM utilizing the serial data Class 2 line. Depending on the application the BCM may play a role in determining if compressor should be allowed based on other inputs to the BCM. Other applications it will simply determine if the AC request is present and send this request signal to the PCM. The PCM will determine if the AC compressor should be engaged based on operating parameters. It will then ground the AC compressor relay to engage the AC compressor.

![Figure 3-3, AC Request Using the BCM to Communicate with the PCM](image-url)
HVAC Controller (Programmer)

The A/C compressor is used to operate the refrigeration system. On most systems, the Powertrain Control Module (PCM) controls the operation of the A/C compressor. The PCM controls the compressor based on the request from the HVAC controller and refrigeration system inputs, Figure 3-4 and 3-5. When A/C compressor operation is requested and compressor enable criteria are met, the PCM will energize the coil side of the compressor relay. This causes the relay switch to close and provide power to the compressor clutch. Energizing the compressor clutch allows engine power to drive the compressor. The initial command to operate the compressor originates from the HVAC controller. The command on newer systems is issued on the Class 2 data line. The HVAC controller determines the need for compressor operation based on the selected mode of operation and HVAC system inputs. After the PCM receives the request from the HVAC controller, it will monitor the following inputs:

- Control Switches and Sensors (high and low pressure switches, temperature switches)
- Vehicle Speed Sensor
- Engine Speed
- Engine Coolant Temperature (ECT) Sensor
- Transmission Fluid Temperature (TFT) Sensor

Figure 3-4, Automatic HVAC System Compressor Control
These inputs provide the PCM with information that allows it to determine if the refrigeration system can be operated efficiently without damaging the compressor. Low ambient temperatures (below approximately 40°F) or incorrect refrigerant pressures will prevent the PCM from operating the refrigeration system since efficient heat transfer will not occur. This could also result in the evaporator experiencing "freeze-up" and the compressor ingesting liquid refrigerant.

When certain conditions exist, the PCM will change its strategy for compressor control. The following are the different strategies (modes of operation) that the PCM uses; not all modes are available to every PCM:

- Stall Prevention
- Slugging Prevention
- Wide Open Throttle Disengagement
- Extended Compressor at Idle
- Minimum Compressor ON Time

Compressor operation can be prevented by certain DTCs related to engine coolant temperature, low refrigerant or catastrophic refrigerant loss. The compressor will remain OFF until the condition no longer exists.

*Figure 3-5, Automatic HVAC System Compressor Control (1998 Park Avenue)*
Stall Prevention
The PCM can command the compressor OFF when there is a rapid increase in steering input voltage to prevent engine stalling. The rapid increase in steering input voltage causes high reference power steering pressure. This places a heavy load on the engine at low speeds. To reduce the load on the engine and the potential of engine stalling, the PCM will turn the compressor OFF.

Slugging Prevention
When the refrigeration system is not operating, liquid refrigerant can migrate to the inlet side of the compressor. Drawing liquid refrigerant inside the compressor at high speeds can damage compressor components. During engine cranking, the PCM can energize the compressor to help remove the liquid refrigerant from the inlet side of the compressor. Since the compressor is operating at a low speed, the potential for damage to the compressor is decreased. This will prevent the slugging that would occur if the compressor was initially operated at higher engine speeds. This mode of operation will not be performed during every cranking event. Specific criteria must be met before the slugging prevention mode will occur.

Wide Open Throttle Disengagement
When the throttle is moved to the Wide Open Throttle (WOT) position, the PCM will command the compressor OFF to decrease the load on the engine and provide maximum engine power to the drivetrain. If the throttle is in the WOT position for an extended period of time, the PCM will re-engage the compressor after approximately six seconds if the maximum compressor speed has not been exceeded. The PCM will disengage the compressor during each additional WOT maneuver if 15 seconds has elapsed since the previous WOT maneuver. If 15 seconds has not elapsed, the PCM will not disengage the compressor.

Extended Compressor On Time At Idle
Cycling clutches can cause erratic engine idle. To prevent this, some systems will allow the compressor to remain ON during extended engine idle times to maintain a smoother idle. The PCM extends the minimum clutch ON time during this mode of operation to 45 seconds (vehicle dependent) when vehicle speed drops below 15 mph.
Minimum Compressor On Time

On some vehicles (DeVille), the compressor will be ON for a minimum of 4-6 seconds at vehicle speeds above 20 mph before the HVAC controller will allow the clutch to be disengaged. The compressor clutch may remain engaged for longer periods of time if the low side temperature is higher than 28°F (-2°C) - the turn-off temperature. If the low side reaches the turn-off temperature, the controller commands the compressor OFF and will not command the compressor ON until the low side reaches 50°F (10°C) - the turn-on temperature.
Lesson 2. Compressor Controls

Various controls are used to enable or disable the compressor. These controls are used to prevent compressor or system damage during certain operating conditions. The compressor and other components could be damaged when:

- The refrigeration system pressure rises above or falls below safe operating parameters.
- The refrigerant level is too low.
- The ambient temperature is too low or high.

Any of these conditions could cause compressor and/or system damage if the compressor were allowed to continue to operate. In the case of low refrigerant conditions, compressor damage results due to the lack of oil circulation. Low refrigerant conditions also mean that not enough oil is being circulated which can lead to compressor damage.

Ambient temperatures that are too low can lead to compressor damage by allowing liquid refrigerant to be drawn into the compressor. Ambient temperatures that are too high could lead to system damage as a result of excessively high pressures.

Different devices are used to prevent compressor operation under any of the above conditions. These devices vary depending on application and the type of refrigeration system the vehicle is equipped with. These devices include any of the following:

- High- and Low-Pressure Cut-Off Switches
- Pressure Cycling Switch
- Compressor Pressure Switch
- Thermostatic Switch
- AC Refrigerant Pressure Sensor
- AC Evaporator Temperature Sensor
- High and Low-Side Refrigerant Temperature Sensors
High and Low Pressure Switches

The high- and low-pressure switches may be located in the rear head of the compressor, refer to Figure 3-6. These switches may also be located on the refrigerant lines utilizing Schrader valve fittings. They are used to prevent compressor operation when the refrigerant pressure is excessively high or low. These switches are used to protect the compressor from damage. The switches can be in series with either the compressor clutch or the A/C request signal. Both switches are connected to the high side of the refrigeration system and are normally closed, allowing current flow until the switch opens. The low-pressure switch prevents compressor operation when the ambient air temperature is low or the system pressure is low due to a refrigerant loss.

![Figure 3-6, High and Low-Pressure Cut-off Switches](image-url)
Pressure Cycling Switch

The pressure cycling switch is a spring-loaded, diaphragm-type pressure switch that is referenced to atmospheric pressure. Opening and closing the pressure cycling switch controls compressor operation, Figure 3-7. The switch can be in series with either the HVAC controller A/C request signal to the PCM or it can be in series with the compressor clutch circuit, Figure 3-8. The pressure cycling switch is sometimes called the Evaporator Control Switch.

Pressure cycling switches are often located on the accumulator. While the location may vary, the switch is always located in the low pressure side of the refrigerant system and indicates evaporator pressure. The switch is usually located on a Schrader valve low-side fitting.

The pressure cycling switch serves both dynamic and static functions:

• Dynamically, it uses a diaphragm and spring to regulate the pressure of the evaporator and prevent evaporator freeze-up.

• Statically, it prevents compressor operation when refrigeration system pressure drops too low. This protects the compressor from the damage that could result from operation with partial charge, insufficient lubrication, or low ambient temperature.

![Figure 3-7, Pressure Cycling Switch Location](image-url)
Figure 3-8, Compressor Circuit with a Pressure Cycling Clutch (1998 C/K Truck)
Compressor Pressure Switch

The compressor pressure switch is typically used on light duty trucks. It is a normally open switch that monitors the high-side pressure. The switch closes when the high-side pressure reaches approximately 325-350 psi and will open when the pressure falls to approximately 250 psi. The switch is used to control the operation of the inlet air door. When the switch is closed, the inlet air door moves to the recirculation position to decrease the heat load on the refrigeration system and decrease pressures.

On 1988 to 1990 light duty trucks, the switch has direct control of the inlet air door. The door will move to the recirculation position when the switch is closed. The inlet air door moves to the recirculation position when the switch is open. The selections on the control head cannot position the inlet air door in the recirculation position.

Later model light duty trucks also have a compressor pressure switch that controls the air inlet door, Figure 3-9. However, the control head on these systems also has the ability to position the inlet air door in the recirculation position (by pressing the MAX or RECIRC buttons). On these systems, the compressor pressure switch overrides (when closed) a control head signal to move the inlet air door to the outside air position. After the compressor pressure switch has closed, the compressor pressure switch will not allow the inlet air door to move to the outside air position until the high-side pressure drops to approximately 250 psi, regardless of the selected mode of operation. This can cause customer concerns related to "loud blower operation" or "the MAX display stays ON even after the MAX button is pressed to cancel it."

A closed compressor pressure switch will cause the auxiliary cooling fans to operate on the 7.4L engine application.
Figure 3-9, Compressor Pressure Switch Circuit (1998 C/K Truck)
AC Refrigerant Pressure Sensor (Transducer)

The A/C refrigerant pressure sensor (sometimes called a pressure transducer) is an input to the PCM that provides a voltage signal proportional to the high-side pressure, Figure 3-10. This sensor has three circuits which connect it to the PCM (5 volt reference, signal and ground). The signal voltage typically ranges from 0.1 volt (at 0 psi) to 4.9 volts (at 450+ psi).

The sensor information is used by the PCM to determine the following:

- Low system pressure
- Low ambient temperatures
- A/C system load on the engine
- Temperature/heat load at the condenser
- Excessive pressure

Since it is an input to the PCM, there are scan tool diagnostics available, and the PCM can store DTCs for circuit malfunctions. The sensor signal voltage to the PCM can also be viewed on the data list.

The following can be used to easily test the sensor circuits:

- Disconnect the sensor and view the sensor voltage on the scan tool (it should drop to 0 volts).
- Measure the DC volts between the 5 volt reference and ground circuits (it should be 5 volts). This checks both the 5 volt reference and ground circuits.
- If these circuits test okay, then jumper the 5 volt reference circuit to the signal circuit. The scan tool should display 5 volts on the signal circuit. This verifies the integrity of the signal circuit.

Figure 3-10, AC Refrigerant Pressure Sensor Circuit (1998 Y-Car)
**AC Evaporator Temperature Sensor**

The A/C evaporator temperature sensor is mounted to the HVAC air delivery module and has a probe that is inserted into the evaporator between the fins. The sensor measures evaporator temperature and sends a signal to the PCM. Inside the probe is a thermistor that changes resistance with changes in evaporator temperature. The sensor is used by the PCM to disable compressor operation before the evaporator reaches "freeze-up."

The sensor is connected to the PCM by three circuits (5 volt reference, signal and ground). The 5 volts on the reference circuit is used by the internal sensor circuits as a power supply rather than a reference voltage, Figure 3-11. The PCM signal circuit is pulled up to 5 volts within the PCM (similar to ECT or IAT). The sensor's internal circuitry pulls the signal circuit to ground as the evaporator temperature rises. Low evaporator temperatures cause high signal voltage and high evaporator temperatures cause low signal voltage.

*Figure 3-11, Evaporator Temperature Sensor Circuit (1997 F-Car)*
High and Low-Side Refrigerant Temperature Sensors

Cadillac has used high-side and low-side temperature sensors on many applications over the years, Figure 3-12. Instead of sensing pressure these sensors are thermistors that are inserted into the refrigerant stream to sense high-side and low-side temperature. Remember that there is a direct relationship between temperature and pressure in the refrigeration system. If the pressure is known then refrigerant temperature is known. Conversely if the temperature of the refrigerant is known then the pressure can be determined. Knowing the low-side and high-side temperature allows the HVAC controller to control the compressor the same as if pressure sensors were used.

Figure 3-12, Automatic HVAC System Compressor Control
Lesson 3. Other Controls

In addition to the compressor controls just discussed above there are other controls that are used on air conditioning systems. These controls may be used to control compressor operation. In most cases these additional controls are used to modify the air delivery or temperature of the incoming air into the vehicle. These controls may be any of the following:

- Outside Air Temperature Sensor
- Inside Air Temperature Sensor
- Upper AC and Lower (Heater) Outlet Temperature Sensors
- Solar (Sunload) Sensors
- Infrared Temperature Sensors

Outside Air Temperature Sensor

The Outside Air Temperature (OAT) or Ambient Air Temperature (AAT) sensor is mounted in the grille area of the vehicle, Figure 3-13. In this position, it is exposed to the airflow through the grille before it enters the radiator. This provides a sample of the outside (ambient) temperature. The HVAC controller uses this sensor as an input for determining heating and cooling requirements and as an input for the outside air temperature display.

This sensor is a thermistor. Its resistance changes with the temperature. When the temperature is low, the resistance of the sensor will be high (at -40°F the resistance will be 169,400 ohms). When the temperature is high, the resistance of the sensor will be low (at 140°F the resistance will be 1245 ohms). The HVAC controller is connected to the sensor by a reference circuit and a ground circuit. Inside the HVAC controller, 5 volts is supplied to the reference circuit through a fixed resistance. The fixed resistance inside the controller makes the sensor circuit a series circuit. As the resistance of the sensor changes, the amount of voltage that it drops (or uses) also changes since it is in series with the fixed resistance inside the controller. The HVAC controller measures the voltage drop across the sensor to determine the resistance of the sensor and to calculate the temperature. The signal provided by this sensor is often filtered when determining the outside air temperature. There are conditions (city traffic and idle) which cause the sensor to produce a signal that is not proportional to the outside air temperature. In these situations, the controller will perform calculations to determine the outside air temperature. The outside air temperature displayed on the control head is a result of these calculations.
As part of the outside air temperature calculation, the controller stores in its memory a baseline temperature reading during engine restarts when either the engine coolant temperature is lower (by a specific amount) than the OAT sensor reading or the two-hour ignition off timer has expired. The stored baseline reading is used during all restarts where the coolant temperature is greater than the OAT sensor reading, regardless of the number of ignition cycles that have passed since the baseline temperature was updated. This baseline temperature is displayed on the control head until adjustments to the outside air temperature calculation are made.

Adjustments to the outside air temperature calculations are based on the stored baseline temperature reading. The amount of adjustment will depend on the vehicle operating conditions. If the sensor reading is higher than the baseline temperature, adjustments to the outside air temperature calculation will be slower since the sensor reading may be affected by the engine temperature. Often in this situation, a certain vehicle speed must be achieved before any updates will occur. If the sensor reading is lower than the baseline, adjustments occur quickly and the temperature display on the control head is rapidly updated.

The controller also uses the "raw" input from the outside air temperature sensor. The controller uses the "raw" input to determine the temperature of the air surrounding the condenser. This provides the controller with an indication of the amount of heat exchange that will occur at the condenser. This information is very important when the vehicle is stopped or moving slowly and the airflow through the condenser is low.

On some vehicles, the scan tool can be used to instantly update the outside air temperature displayed on the control head. On other vehicles, the display can be updated by pushing specific control head buttons (AUTO, A/C and RECIRC simultaneously; or, on Buick, VENT and RECIRC). There are DTCs related to this sensor that can indicate an open or shorted circuit. These DTCs will cause the controller to use a default value (typically 50°F).
Figure 3-13, Outside Air Temperature Sensor Location and Operation
Inside Air Temperature Sensor

The inside air temperature sensor is located behind a small grille inside the passenger compartment. It is exposed to the air that is present in the passenger compartment, Figure 3-14. This provides the controller with a sample of the inside air temperature. The HVAC controller uses this sensor as an input in determining heating and cooling requirements.

This sensor is a thermistor. Its resistance changes with the temperature. When the temperature is low, the resistance of the sensor will be high. When the temperature is high, the resistance of the sensor will be low. The HVAC controller is connected to the sensor by a reference circuit and a ground circuit. Inside the HVAC controller, 5 volts is supplied to the reference circuit through a fixed resistance. The fixed resistance inside the controller makes the sensor circuit a series circuit. As the resistance of the sensor changes, the amount of voltage it drops (or uses) also changes since it is in series with the fixed resistance inside the controller. The HVAC controller measures the voltage drop across the sensor to determine the resistance of the sensor and to calculate the temperature.

After initial start-up, the controller uses the temperature input from the inside air temperature sensor as the primary input for determining passenger compartment air temperature. Eventually, the controller will use the upper (A/C) and lower (heater) outlet temperature sensors (if equipped) as the primary inputs, instead of the inside air temperature sensor.

On most applications, a hose connected to the inside air temperature sensor continually draws passenger compartment air over the sensor to increase the accuracy of the temperature reading. Other systems (1998 S/T truck) utilize a fan, located in the in-vehicle air temperature sensor housing, to continually draw passenger compartment air over the sensor.

A substitute temperature value of approximately 75°F (24°C) is used when this sensor fails to allow the HVAC system to continue to operate.
Upper (AC) and Lower (Heater) Outlet Temperature Sensors

The upper (A/C) and Lower (Heater) outlet temperature sensors are used to monitor the discharge temperatures from the heater and A/C outlets on some systems, Figure 3-15. These sensors are located in the ducts of the heater and A/C outlets. Their function is similar to the inside air temperature sensor and are used as controller inputs for determining heating and cooling requirements.
Solar (Sunload Sensors)

The solar sensors are located on top of the instrument panel where sunlight can reach them. They provide the controller with an indication of the amount of sunlight that is entering the passenger compartment, Figure 3-16. With this input, the controller can adjust the cooling requirement based on the heat load that the sun is placing on the HVAC system.

The solar sensor is a photoconductive diode (photodiode), meaning it is sensitive to light. A photodiode is like any other p-n junction diode, except that it is designed to allow reverse current flow when exposed to light. The amount of current flow is based on the intensity of the light. If the light is very intense, the resistance of the photodiode to reverse current flow is very low. As the intensity of the light decreases, the resistance increases.

The HVAC controller is connected to the sensor by a reference circuit and a ground circuit. Inside the HVAC controller, 5 volts is supplied to the reference circuit through a fixed resistance. The fixed resistance inside the controller makes the sensor circuit a series circuit. As the resistance of the sensor changes, the amount of voltage that it drops (or uses) also changes since it is in series with the fixed resistance inside the controller. The HVAC controller measures the voltage drop across the sensor to determine the sun load.

Two solar sensors are used on dual zone systems. The sensors are located on top of the instrument panel mounted on either side of the defroster grille. This allows the controller to determine the sunload for both sides of the vehicle. Since the sunload can vary, the discharge air temperatures on dual zone systems can vary from side to side if the sunload is greater on one side.

It is important to note that the operation of the sun load sensor(s) will be affected if covered. This will also impact how the controller determines the cooling requirements. Always make sure the solar sensors are not obstructed when diagnosing an automatic HVAC system.

Certain applications (Catera) will use a solar/twilight sensor (four-wire sensor). This is a photo-electric cell, which means it will produce voltage when exposed to light. On these applications, the photo-electric cell provides two inputs to the HVAC controller. One input is used for solar load and the other circuit is used for the twilight sentinel.
The auxiliary inside air temperature sensor is an infrared sensor. This component is integral to the rear auxiliary HVAC control module, Figure 3-17. There is a lens on the front face plate of the rear auxiliary HVAC control module to cover the sensor. If the sensor lens is covered, the sensor can not make a proper indication of heat. The sensor does not set a DTC. The sensor helps in making the proper automatic calculations to position the auxiliary mode and temperature doors.

Figure 3-16, Sunload Sensor Locations and Circuits
Infrared Temperature Sensors

The auxiliary inside air temperature sensor is an infrared sensor. This component is integral to the rear auxiliary HVAC control module, Figure 3-17. There is a lens on the front face plate of the rear auxiliary HVAC control module to cover the sensor. If the sensor lens is covered, the sensor can not make a proper indication of heat. The sensor does not set a DTC. The sensor helps in making the proper automatic calculations to position the auxiliary mode and temperature doors.

Instead of sensing air temperature the infrared temperature sensor senses surface temperature such as the seat cushion. It is important that these sensors not be sprayed with cleaners. Any cleaner that clouds the sensor lens may cause the sensor to obtain inaccurate readings.
Post Test

Read each question carefully and choose the correct response.

1. Which component controls the ON command for the relay controlling the compressor clutch?
   a. HVAC Control Assembly
   b. Pressure Cycling Switch
   c. PCM
   d. Either a or c

2. The Pressure Cycling Switch is located in/on the:
   a. control head
   b. high pressure side
   c. compressor
   d. low pressure side

3. The Pressure Cycling Switch does all of the following except:
   a. prevent compressor operation when pressures are low.
   b. prevent evaporator freeze-up.
   c. prevent compressor damage due to insufficient lubricant.
   d. signal PCM with high-side pressure

4. Evaporator Temperature Sensors are:
   a. used to prevent evaporator freeze-up
   b. used to regulate the air temperature going into the passenger compartment
   c. used on all AC systems
   d. used to sense the air temperature coming into the evaporator.

5. The reference voltage for the in-car temperature sensors is:
   a. 0 - 12V variable
   b. 5V
   c. 8V
   d. 12V
6. Sunload sensors are located in the:
   a. roof
   b. dash
   c. rear view mirror
   d. rear window

7. The outside air temperature, or ambient air temperature sensor is mounted in the:
   a. grill area
   b. cowl area
   c. roof
   d. passenger compartment

8. Which of the following is located on top of the instrument panel?
   a. Ambient air temperature sensor
   b. Inside air temperature sensor
   c. Outlet air temperature sensor
   d. Sunload sensor

9. If the in-car temperature sensor fails, the default temperature value used by the HVAC controller:
   a. is 65°F
   b. is 75°F
   c. reverts to manual operation
   d. shuts down
10. When a DTC relating to a shorted or open outside air temperature sensor is present, the default value is typically:
   a. 35°F
   b. 50°F
   c. 65°F
   d. 80°F

11. The primary function of the sunload sensor is to provide the controller with:
   a. the ability to determine the amount of sunlight entering the vehicle.
   b. information about instrument panel overheating.
   c. information about the ambient temperature.
   d. information about the temperature inside the vehicle.
Lesson 1 Exercise 1

AC Control Modules

Directions: Answer the following questions using the module 3 workbook.

1. List four different control modules that may be used to control compressor operation.
   Page: _________
   ______________________________________________________
   ______________________________________________________

2. What type of vehicles have used the control head to control AC compressor operation?
   Page: _________
   ______________________________________________________
   ______________________________________________________

3. On some applications the _____________ will process the AC request signal and send it to the PCM.
   Page: _________

4. List four monitored parameters that the HVAC controller monitors.
   Page: _________
   ______________________________________________________
   ______________________________________________________

5. Certain operating conditions may cause the PCM to change its strategy for compressor control. List five of these modes.
   Page: _________
   ______________________________________________________
   ______________________________________________________
Customer Complaint: AC does not get cold.

Technician Preliminary Checks: Functional test indicates blower, air delivery modes, and temperature blend door are correct. Technician has verified that the refrigerant static pressure is greater than 50 psi. The technician observes no AC compressor operation. All fuses test good.

1. With the engine running and the AC selector on, a technician places a DMM at the AC compressor clutch request input at the ECM. What should the DMM read if the signal is present?

   _________________________________

2. The AC high pressure cut-out switch is a normally __________ switch?
3. With the engine running and the AC selector on, a DMM is placed at the AC compressor clutch input. The DMM reads 0 volts. List the possible causes.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

4. Both 12 volt feeds to the AC compressor relay have been measured and 12 volts is present. There is 0 volts present at the relay terminal feeding the AC compressor clutch. The DMM shows 12 volts on the AC compressor control relay control lead at the ECM. What would this indicate?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Lesson 2 Exercise 1

Compressor Controls

Directions: Answer the questions below using the module 3 workbook.

1. List five different compressor protection controls that may be used on vehicles.
   Page: _________
   ____________________________________________________________
   ____________________________________________________________

2. What are the two conditions that may exist that would cause the low pressure cut-out switch to open?
   Page: _________
   ____________________________________________________________
   ____________________________________________________________

3. List two functions of the pressure cycling switch.
   Page: _________
   ____________________________________________________________
   ____________________________________________________________

4. What is the typical range of the AC pressure sensor?
   Page: _________
   ____________________________________________________________
   ____________________________________________________________

5. At low evaporator temperatures, the AC evaporator sensor should produce a signal voltage.
   Page: _________
   ____________________________________________________________
   ____________________________________________________________

6. ___________ sensors may be used instead of pressure sensors on some vehicles.
Lesson 2 Exercise 2

Compressor Controls

Directions: Provided with a vehicle equipped with an AC pressure sensor and a scan tool, answer the following questions below.

1. With the engine not running record the AC pressure sensor readings with the scan tool.
   ___________ Volts  ________________ psi

2. With the vehicle running and the AC compressor operating, record the AC pressure sensor readings.
   ___________ Volts  ________________ psi

3. Disconnect the AC pressure sensor and record the sensor readings.
   ___________ Volts  ________________ psi

4. Using the correct jumper connect the 5 volt reference signal wire to the AC pressure sensor signal wire, record the readings.
   ___________ Volts  ________________ psi

5. If the scan tool did not show 5 volts in question number 4 above what are the possible causes?
   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________

6. Can the AC pressure sensor be replaced without recovering the refrigerant from the vehicle? ___________________________
Lesson 2 Exercise 3

Compressor Controls

Directions: Using the vehicle assigned to you by your instructor and service information, identify the various compressor controls that the vehicle is equipped with. Be very specific about their location on the vehicle.

1. Pressure Cycling Switch. Yes No
   Location: ______________________________________________

2. AC Pressure Sensor: Yes No
   Location: ______________________________________________

3. Low Pressure Cut-Out Switch. Yes No
   Location: ______________________________________________

4. High Pressure Cut-Out Switch. Yes No
   Location: ______________________________________________

5. Evaporator Temperature Sensor: Yes No
   Location: ______________________________________________

6. High-side Refrigerant Temperature Sensor: Yes No
   Location: ______________________________________________

7. Low-side Refrigerant Temperature Sensor: Yes No
   Location: ______________________________________________

8. Thermostatic Cycling Switch: Yes No
   Location: ______________________________________________
Lesson 3 Exercise 1

Other Controls

**Directions:** Answer the following questions using the module 3 workbook.

1. List five sensors that may be used other than compressor controls as previously covered.
   
   Page: ______
   
   ______________________________________________________
   
   ______________________________________________________

2. The outside air temperature control may be used as an input for ___________ and ________________.
   
   Page: ______

3. On some vehicles the __________ tool may be used to update the outside air temperature reading that is displayed on the control head.
   
   Page: ______

4. Automatic temperature control systems usually use an __________ temperature sensor.
   
   Page: ______

5. The solar sensor is usually located _________________________.
   
   Page: ______

   Some rear auxiliary HVAC controls use a (an) _____________ sensor.
   
   Page: ______
Lesson 3 Exercise 2

Other Controls

Directions: Using service information and the vehicle provided to you by your instructor identify the any controls other than compressor controls that your vehicle is equipped with. If equipped identify the location of the control.

1. Outside Air Temperature Sensor: Yes No
   Location: ______________________________________________

2. Solar Sensor: Yes No
   Location: ______________________________________________

3. Inside Air Temperature Sensor: Yes No
   Location: ______________________________________________

4. Infrared Temperature Sensor: Yes No
   Location: ______________________________________________

5. Upper AC Outlet Temperature Sensor: Yes No
   Location: ______________________________________________

6. Lower Heater Outlet Temperature Sensor: Yes No
   Location: ______________________________________________