Heating and Air Conditioning: Description and Operation
Air Temperature

AIR TEMPERATURE DESCRIPTION AND OPERATION

The air temperature controls are divided into 5 areas:
- HVAC Control Components
- Heating and A/C Operation
- Automatic Operation
- Engine Coolant
- A/C Cycle

HVAC CONTROL COMPONENTS

HVAC Control Module

Feature	Availability
Afterblow	No
Purge	No
Personalization	Yes
Actuator Calibration	Yes

The HVAC control module is a class 2 device that interfaces between the operator and the HVAC system to maintain air temperature and distribution settings. The battery positive voltage circuit provides power that the control module uses for keep alive memory (KAM). If the battery positive voltage circuit loses power, all HVAC DTCs and settings will be erased from KAM. The body control module (BCM), which is the vehicle mode master, provides a device on signal. The control module supports the features.

Air Temperature Actuator
The air temperature actuators are a 5-wire bi-directional electric motor that incorporates a feedback potentiometer. Ignition 3 voltage, low reference, control, **5 volt** reference and position signal circuits enable the actuator to operate. The control circuit uses either a **0, 2.5 or 5 volt** signal to command the actuator movement. When the actuator is at rest, the control circuit value is **2.5 volts**. A **0 or 5 volt** control signal commands the actuator movement in opposite directions. When the actuator shaft rotates, the potentiometer's adjustable contact changes the door position signal between **0-5 volts**.

The HVAC control module uses a range of 0-255 counts to index the actuator position. The door position signal voltage is converted to a 0-255 count range. When the module sets a commanded, or targeted value, the control signal is changed to either **0 or 5 volts** depending upon the direction that the actuator needs to rotate to reach the commanded value. As the actuator shaft rotates the changing position signal is sent to the module. Once the position signal and the commanded value are the same, the module changes the control signal to **2.5 volts**.

Air Temperature Sensors
The air temperature sensors are a 2-wire negative temperature co-efficient thermistor. The vehicle uses the following air temperature sensors:
- Ambient Air Temperature Sensor
- Inside Air Temperature Sensor Assembly
- Upper Left Air Temperature Sensor
- Upper Right Air Temperature Sensor
- Lower Left Air Temperature Sensor
- Lower Right Air Temperature Sensor

A signal and a low-reference circuit enables the sensor to operate. As the air temperature surrounding the sensor increases, the sensor resistance decreases. The sensor signal voltage decreases as the resistance decreases. The sensor operates within a temperature range between **-40°C (-40°F) to 101°C (215°F)**. The sensor signal varies between **0-5 volts**.

The input of the duct air temperature sensors are different from the ambient and inside sensors. The HVAC control module converts the signal to a range between 0-255 counts. As the air temperature increases the count value will decrease.

If the HVAC control module detects a malfunctioning sensor, then the control module software will use a defaulted air temperature value. The default value for the ambient and inside air temperature sensors will be displayed on the scan tool. The default value for the duct air temperature sensors will not be displayed on the scan tool. The scan tool parameter for the duct air temperature sensors are the actual state of the signal circuit. The default action ensures that the HVAC system can adjust the inside air temperature near the desired temperature until the condition is corrected.

Condition	Display
At start up with the engine off less than 2 hours	Displays last stored temperature
At start up with the engine off more than 2 hours	Displays real-time temperature
Engine coolant temperature is less than 28°C (50°F) above the ambient air temperature	Displays real-time temperature
Vehicle speed above 32 km/h (20 mph) for a minimum of 80 seconds	Displays real-time temperature
Vehicle speed above 72 km/h (45 mph)	Displays real-time temperature
Sensor reading is less than the last displayed value	Displays real-time temperature

The ambient air temperature sensor mounts underhood and can be affected by city traffic, by idling, and by restarting a hot engine. Therefore, the HVAC control module filters the value of the ambient air temperature sensor for temperature display. The ambient air temperature value is updated under the conditions.

The scan tool has the ability to update the displayed ambient air temperature. To update the ambient air temperature display on the HVAC control module, perform the following procedure: Simultaneously press the MODE, FRONT DEFROST and REAR DEFROST switches.

1. Turn ON the ignition.
2. Simultaneously press the MODE, FRONT DEFROST and REAR DEFROST switches.

Sunload Sensor Assembly

The sunload sensor is a 2-wire photo diode. The vehicle uses left and right sunload sensors. The 2 sensors are integrated into the sunload sensor assembly. Low reference and signal circuits enable the sensor to operate. As the light shining upon the sensor gets brighter, the sensor resistance increases. The sensor signal decreases as the resistance increases. The sensor operates within an intensity range between completely dark and bright. The sensor signal varies between **0-5 volts**. The HVAC control module converts the signal to a range between 0-255 counts.

The sunload sensor provides the HVAC control module a measurement of the amount of light shining on the vehicle. Bright or high intensity light causes the vehicles inside temperature to increase. The HVAC system compensates for the increased temperature by diverting additional cool air into the vehicle.

If the HVAC control module detects a malfunctioning sensor, then the control module software will use a defaulted sunload value. This value will not be displayed on the scan tool. The default action ensures that the HVAC system can adjust the inside air temperature near the desired temperature until the condition is fixed. The scan tool parameter for the sunload sensor is the actual state of the signal circuit.

A/C Refrigerant Pressure Sensor

The A/C refrigerant pressure sensor is a 3-wire piezoelectric pressure transducer. A **5 volt** reference, low reference, and signal circuits enable the sensor to operate. The A/C pressure signal can be between **0-5 volts**. When the A/C refrigerant pressure is low, the signal value is near **0 volts**. When the A/C refrigerant pressure is high, the signal value is near **5 volts**. The PCM converts the voltage signal to a pressure value.

The A/C refrigerant pressure sensor protects the A/C system from operating when an excessively high pressure condition exists. The PCM disables the compressor clutch if the A/C pressure is more than **2957 kPa (429 psi)**. The clutch will be enabled after the pressure decreases to less than **1578 kPa (229 psi)**.

A/C Low Pressure Switch

The A/C low pressure switch protects the A/C system from a low pressure condition that could damage the A/C compressor or cause evaporator icing. The HVAC control module applies **5 volts** to the A/C low pressure switch signal circuit. The switch will open when the A/C low side pressure reaches **124 kPa (18 psi)**. This prevents the A/C compressor from operating. The switch will then close when A/C low pressure side reaches **275 kPa (40 psi)**. This enables the A/C compressor to turn back ON.

Heating and A/C Operation

The purpose of the heating and A/C system is to provide heated and cooled air to the interior of the vehicle. The A/C system will also remove humidity from the interior and reduce windshield fogging. The vehicle operator can determine the passenger compartment temperature by adjusting the air temperature switch. The vehicle passenger can offset the passenger temperature as much as **16.7°C (30°F)**. Regardless of the temperature setting, the following can effect the rate that the HVAC system can achieve the desired temperature:

- Recirculation actuator setting
- Difference between inside and desired temperature
- Difference between ambient and desired temperature
- Blower motor speed setting
- Mode setting

The control module makes the following actions when automatic operation is not selected, and an air temperature setting is selected:

- When the air temperature switch is placed in the warmest position, the control module commands the air temperature door to divert maximum air past the heater core.
- When the air temperature switch is placed in the coldest position, the control module commands the air temperature door to direct air to bypass the heater core.
- When the air temperature switch is placed between the warmest and coldest positions, the control module monitors the following sensor inputs to

determine the air temperature door position that diverts the appropriate amount of air past the heater core in order to achieve the desired temperature:
- Sunload
- Duct temperatures
- Ambient temperature
- Inside temperature

The A/C system can be engaged by either pressing the A/C switch or during automatic operation. The HVAC control module sends a class 2 message to the PCM for A/C compressor engagement. The PCM will provide a ground for the A/C compressor relay enabling it to close its internal contacts to send battery voltage to the A/C compressor clutch coil. The A/C compressor diode will prevent a voltage spike, resulting from the collapse of the magnetic field of the coil, from entering the vehicle electrical system when the compressor is disengaged.

The following conditions must be met in order for the A/C compressor clutch to turn on:
- The ambient air temperature is above **4°C (40°F)**.
- The A/C low pressure switch signal circuit is grounded.
- The A/C refrigerant pressure sensor parameter is less than **2957 kPa (429 psi)**.
- The PCM receives an A/C request from the HVAC control module.
- The engine coolant temperature (ECT) is less than **121°C (250°F)**.
- The engine rpm is more than **550 rpm**.
- The throttle position is less than **100%**.

The HVAC control module monitors the A/C low pressure switch signal circuit. If the voltage signal on this circuit has no voltage drop the module will interpret this condition as a low pressure, disabling the A/C request. The A/C low pressure switch will open its internal contacts at **151 kPa (22 psi)**. Then close the contacts at **275 kPa (40 psi)** to resume A/C operation. This switch assists in cycling the A/C compressor and prevents A/C compressor operation if system has a low refrigerant level.

The PCM monitors the A/C refrigerant pressure sensor signal circuit. The voltage signal on this circuit is proportional to the refrigerant pressure inside the A/C high side pressure line. As the pressure inside the line increases, so does the voltage signal. If the pressure is above **2957 kPa (429 psi)**, the A/C compressor output is disabled. When the pressure lowers to **1578 kPa (229 psi)**, the PCM enables the compressor to operate.

The sensor information is used by the PCM to determine the following:
- The A/C high side pressure
- An A/C system load on the engine
- An excessive A/C high side pressure
- The heat load at the A/C condenser

Once engaged, the compressor clutch will be disengaged for the following conditions:
- The ambient air temperature is less than **4°C (40°F)**.
- The throttle position is **100%**.
- The A/C low pressure switch is open.
- The A/C high side pressure is more than **2957 kPa (429 psi)**.
- The A/C low side pressure is less than **151 kPa (22 psi)**.
- The engine coolant temperature (ECT) is more than **121°C (250°F)**.
- The engine speed is more than **5500 rpm**.
- Transmission shift
- The PCM detects excessive torque load.
- The PCM detects insufficient idle quality.
- The PCM detects a hard launch condition.

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

To place the HVAC system in Automatic mode, the following is required:
- The Auto switch must be activated
- The air temperature switch must be in any other position other than full hot or full cold position

Once the desired temperature is reached, the blower motor, mode, recirculation and temperature actuators will automatically be adjusted to maintain the temperature selected. The HVAC control module performs the following functions to maintain the desired air temperature:
- Monitor the following sensors:
  - Inside Air Temperature Sensor
  - Ambient Air Temperature Sensor
  - Lower Left Air Temperature Sensor
  - Lower Right Air Temperature Sensor
  - Upper Left Air Temperature Sensor

  - Upper Right Air Temperature Sensor
- Regulate blower motor speed
- Position the air temperature actuator
- Position the mode actuator
- Position the recirculation actuator
- Request A/C operation

Engine Coolant
Engine coolant is the essential element of the heating system. The thermostat controls the normal engine operating coolant temperature. The thermostat also creates a restriction for the cooling system that promotes a positive coolant flow and helps prevent cavitation.

Coolant enters the heater core through the inlet heater hose, in a pressurized state. The heater core is located inside the HVAC module. The ambient air drawn through the HVAC module absorbs the heat of the coolant flowing through the heater core. Heated air is distributed to the passenger compartment, through the HVAC module, for passenger comfort. Opening or closing the air temperature door controls the amount of heat delivered to the passenger compartment. The coolant exits the heater core through the return heater hose and recirculated back through the engine cooling system.

A/C Cycle
Refrigerant is the key element in an air conditioning system. R-134a is presently the only EPA approved refrigerant for automotive use. R-134a is an very low temperature gas that can transfer the undesirable heat and moisture from the passenger compartment to the outside air.

The A/C compressor is belt driven and operates when the magnetic clutch is engaged. The compressor builds pressure on the vapor refrigerant. Compressing the refrigerant also adds heat to the refrigerant. The refrigerant is discharged from the compressor, through the discharge hose, and forced to flow to the condenser and then through the balance of the A/C system. The A/C system is mechanically protected with the use of a high pressure relief valve. If the A/C refrigerant pressure sensor were to fail or if the refrigerant system becomes restricted and refrigerant pressure continued to rise, the high pressure relief will pop open and release refrigerant from the system.

Compressed refrigerant enters the condenser in a high temperature, high pressure vapor state. As the refrigerant flows through the condenser, the heat of the refrigerant is transferred to the ambient air passing through the condenser. Cooling the refrigerant causes the refrigerant to condense and change from a vapor to a liquid state.

The condenser is located in front of the radiator for maximum heat transfer. The condenser is made of aluminum tubing and aluminum cooling fins, which allows rapid heat transfer for the refrigerant. The semi-cooled liquid refrigerant exits the condenser and flows through the liquid line, to the orifice tube.

The orifice tube is located in the liquid line between the condenser and the evaporator. The orifice tube is the dividing point for the high and the low pressure sides of the A/C system. As the refrigerant passes through the orifice tube, the pressure on the refrigerant is lowered. Due to the pressure differential on the liquid refrigerant, the refrigerant will begin to vaporize at the orifice tube. The orifice tube also meters the amount of liquid refrigerant that can flow into the evaporator.

Refrigerant exiting the orifice tube flows into the evaporator core in a low pressure, liquid state. Ambient air is drawn through the HVAC module and passes through the evaporator core. Warm and moist air will cause the liquid refrigerant boil inside of the evaporator core. The boiling refrigerant absorbs heat from the ambient air and draws moisture onto the evaporator. The refrigerant exits the evaporator through the suction line and back to the compressor, in a vapor state, and completing the A/C cycle of heat removal. At the compressor, the refrigerant is compressed again and the cycle of heat removal is repeated.

The conditioned air is distributed through the HVAC module for passenger comfort. The heat and moisture removed from the passenger compartment will also change form, or condense, and is discharged from the HVAC module as water.