Module 4: Climate Control

Air-Conditioning Electronic Control Unit (ECU)

What is an automatic air conditioner?
- A manual air conditioner and heating system equipped with sensors that detect changes in:
  - Ambient temperature
  - Cabin temperature
  - Solar radiation

What does the ECU do?
- Evaluates the signals from sensors to determine the operating conditions
- Controls the actuators to move the dampers and valves
- These control the volume, temperature, and direction of the air delivered by the system.

Manual mode
- The climate control system can be operated in manual mode.
- Operation is similar to the normal heater and air-conditioner system.
- The driver determines:
  - Where air is delivered
  - The volume of air delivered
  - Air temperature

Full automatic mode
- The ECU receives signals from the sensors.
- Controls the flaps and valves of two systems
- Creates a blend of air that matches the temperature selected by the occupants
- The ECU's microcomputer
- The ECU contains a microcomputer.
- Constructed from a printed circuitry
- Has a large number of electrical components and electronic devices
- Normally housed in a metal or plastic container
- In some systems, the control panel is part of the ECU.

Signals from the sensors
- The ECU receives signals in the form of voltages from:
  - Ambient air temperature sensor
  - Cabin air temperature sensor
  - Coolant temperature sensor
  - Evaporator temperature sensor
  - Sun load sensor
  - Control panel

Comparison of voltage values
- The ECU compares the voltage values from the sensors with values stored in its memory.
- If there is a difference in values, the ECU changes the position of the actuators.

Actuators
- Electric solenoids and electric motors
- Control the position of the doors and taps either directly, or by vacuum servos

Speed of the interior ventilation fan
- The ECU controls the speed of the interior ventilation fan.
- The speed of the fan is infinitely variable between a stopped condition and the fan's maximum speed.

Feedback signal to the ECU
- Some actuators provide a feedback signal to the ECU.
- In the form of a voltage signal
- The signal is used by the ECU to determine:
  - Position the actuators are in
  - Whether or not the actuators are moving
Controlling Cabin Air Temperature

In automatic mode, the ECU:
- Uses the last operator desired cabin setting of 75.2°F (24°C)
- Checks the temperature of the outside air ("ambient air" temperature)
- Registered by the ambient air temperature sensor at 82.4°F (28°C)

Parked in bright sunlight
- Radiation from the sun heats the cabin air temperature to 113°F (45°C).
- The sun load sensor registers when the vehicle is in bright sunlight.

The engine starts.
- When the engine starts and the climate control system is functioning:
  - The ECU switches on the air-conditioning compressor.
  - Increases the speed of the interior ventilation fan

Air flow
- Air is drawn into the fan:
  - From outside the vehicle
  - From within the cabin

Cold air-conditioned air
- Directed by flaps and ducts throughout the cabin of the vehicle
- Absorbs heat from the vehicle cabin and its occupants
- Lowers the temperature

Cabin air temperature
- Continually measured by the cabin air temperature sensor
- The temperature lowers to within approximately 35.6°F (2°C) of the desired selection.
- Fan speed gradually reduces.

Achieving final control
- The heater circuit may be opened and the blend door moved.
- Directs some of the cold air-conditioned air through the heater core
- Provides fine temperature control
- Both the fan speed and the blend door openings are variable.

Servo Motors

The function of servo motors
- Used to control the flaps and valves in the heater and air-conditioning systems
- Repositioning of the flaps and valves
- The output temperatures is adjusted to the temperature desired by the vehicle occupants.

Types of servo motors
- Vacuum servos
- Electrical servos

Vacuum servo construction
- The sealed housing is divided by a flexible diaphragm.
- The diaphragm seals the housing into two separate chambers.

Two sides of the chambers
- One side is opened to the atmosphere.
- The other side is sealed with fitting for the vacuum hose connection.
- A spring forces the diaphragm towards one side when no vacuum is applied to the diaphragm.

Diaphragm linkage
- Linkage from the diaphragm
- Connects it to the component to be moved

Supplying the vacuum to the sealed side
- The vacuum is supplied to the sealed side of the diaphragm.
- A difference in air pressure occurs across the diaphragm.
- The force developed overcomes the spring force.
- The diaphragm moves.
- The spring is compressed and the linkage is moved.

Admitting air to the vacuum side
- Admitting air to the vacuum side of the diaphragm allows the spring to return the diaphragm to a rest position.

Applying the vacuum for movement, when movement is desired
- The vacuum is applied to one side of the diaphragm.
- Atmospheric air pressure is applied to the other side.

Controlling the vacuum
- The vacuum delivered to the diaphragm chamber is controlled by the solenoid valve.
Moving a damper
- For the ECU to move a damper flap:
  - Grounds the electrical circuit for solenoid winding
  - The vacuum from the storage tank is applied through the solenoid valve to the diaphragm.

Releasing the diaphragm
- The ECU open-circuits the solenoid.
- The diaphragm returns to a rest position.

Other diaphragms
- Some diaphragms use two sealed chambers.
- Neither end opens directly to the atmosphere.

Electric Servo Motors

Moving the flaps and valves
- Movement of the flaps and valves is achieved with electrical motors.
- Responds to output signals from the ECU

Moving the blend door
- The electrical servo motor is used to move the blend door.
- Incorporates the limit switches
- Opens the circuit motor when the maximum travel of the door is reached
- Stops the motor from burning out

Utilizing a potentiometer
- Some electrical servos utilize carbon film potentiometers.
- It signals to the ECU the position of the blend door and if it is moving in the direction in which it is traveling.

Applying voltage
- Voltage from the ECU is applied across the potentiometer.
- The wiper is connected by a signal wire to the ECU.

Achieving maximum cooling
- The blend door moves to stop the air flow through the heater core.
- In this position, the voltage signal back to the ECU is at the lowest value.
- As the blend door moves to allow the air flow through the heater core, the voltage at the signal wire progressively increases.
- At the maximum heat position, the voltage signal is at its highest.

Monitoring by the control unit
- Blend door position
- Movement
- Direction of travel

Automatic Climate Control Sensors

ECU and temperatures
- The ECU needs to know the temperatures of:
  - Outside air
  - Cabin air
  - Air-conditioning evaporator
  - Coolant circulating through the heater core
  - If the vehicle is in bright sunlight

Temperature sensors
- Most temperature sensors used in the climate control air-conditioning system are thermistors.
- May vary in appearance
- The general operating characteristics are the same.

About thermistors
- Solid state electronic devices
- Change the resistance in response to the temperature
- As the temperature of the sensor increases, the resistance decreases.
- Have a negative temperature coefficient (NTC)
- Known as NTC resistors

ECU and sensor voltages
- When connected into the circuit, the sensor changes the voltage at the ECU.
- The ECU reads the sensor voltage as a temperature.
- Compares the reading with information stored in its memory

Ambient air temperature sensor
- Measures the temperature of the outside air
- Usually located in front of the air-conditioning condenser
- The forward motion of the vehicle and the action of the condenser fans force air over the sensor.

If the outside air is cold
- The ambient air temperature sensor resistance is high.
- The voltage at the ECU is also high.

If the outside air is hot
- The ambient air temperature sensor resistance is low.
- The voltage at the ECU is also low.
Cabin air temperature sensor
- Mounted in the tube-type device called the aspirator
- The one end of the tube is open to the cabin air.
- The other end is connected to the interior fan.
- Operation of the interior fan creates a flow of air through the aspirator.
- The temperature of the cabin air flowing through the aspirator controls a signal sent to the ECU.

Evaporative Temperature Sensor

Location of the sensor
- Located in the air stream where the air leaves the evaporator
- Signals to the control unit the temperature of the air

Signal sent by the coolant temperature sensor
- The coolant temperature sensor for the engine management system signals to climate control the ECU temperature of the coolant flowing in the heater core.
- Some climate control systems have a separate coolant temperature sensor.
- Usually located near the engine management coolant sensor

Other sensor signals controlling the heater and fan operation
- To control heater and fan operation, signal from the coolant temperature sensor used with signals from:
  - Ambient air sensor
  - Sun load sensor
  - Cabin air temperature sensor

The ECU registers readings from the sensors.
Example: The ECU registers the following readings:
- Coolant temperature: 60.8°F (16°C)
- Ambient Air temperature: 32°F (0°C)
- Sun load: 0
- Cabin air temperature: 32°F (0°C)

Blower Speed Control

The blower motor supplies the air flow to move air around the inside of the passenger compartment.

The blower motor is located in the ventilation system before the air-conditioning evaporator.

Manual air-conditioner switch and motor operation
- The switch connects the resistors in the series with the motor to control its speed.
- The higher the resistance connected in the series with the motor, the slower the motor operates.
- Reducing the series resistance increases the motor operating speed.

Fan motor speeds
- Most systems use two resistors.
- Gives three driver-selectable speeds of the fan motor
- In climate control systems, the speed of the fan motor is controlled electronically.
- The control unit modulates the pulse width signal.
- The longer pulse width produces a higher fan speed.

ECU and temperature
- The ECU changes the fan motor speed automatically.
- The speed depends on the difference between the interior cabin temperature and the set temperature.
• With a large difference in temperature, the fan speed increases.
• Greater air circulation through the cabin
• With a decreased difference in temperature, the fan motor speed decreases.

Ventilation Systems

Infinitely variable fan speed between zero and the maximum speed
Change is progressive.

Ventilation System Function
• Fitted to vehicles to make the environment in the cabin comfortable for the occupants
  • Ducts:
    ° Air to the windshield for defrosting
    ° Temperature-controlled air to the foot well and to the face and side vents for occupant comfort

Air Sources
• From outside the vehicle, usually via apertures located below the windshield
• Recirculated from within the cabin

Air Movement
• Air is drawn over the fan and directed over the air-conditioning evaporator (if fitted).
• Moves through the heater core
• Directed to the desired outlets by ducting and control doors
• Fresh air normally flows through the cabin when the vehicle is moving.
• A fan is used to assist air movement.

Dashboard Ventilation Switches
• A set of switches located on the dashboard control:
  ° Fresh or recirculated air
  ° Mode switch
  ° Fan speed switch
  ° Air temperature
  ° Air-conditioning operation

Set to fresh air
• Outside air is drawn from the front of the vehicle.
• Ducted through the cabin
• Exhausted to the outside through a flap located in the rear of the passenger compartment

Set to recirculate air
• Closes entry to the outside
• Opens the duct that directs the cabin air to the fan

Ventilation Systems

Ready for Review

No assistance from the vehicle moving through the air
The fan must be operating to circulate the air.

Mode Switch
• Controls the outlet or combination of outlets for airflow
• Air is guided by a series of ducts to the doors.
• The doors open and close to direct the air to the desired outlet.
• May have modes to direct the flow:
  ° Towards the face or feet
  ° To the front or rear of the compartment
  ° To other places

Demisting
• The mode switch always has a position for windshield defrosting.
• Directs air onto the inside of the windshield
• Clears any fogging

Fan Speed Switch
• Controls the electric motor with a barrel-type fan attached
• Forces air at a chosen speed through the ducting into the passenger compartment via heating and cooling components

Air Temperature (Manual)
• Occupants make selections and adjustments manually.
• Uses a combination of fan speed and heating or cooling for the preferred comfort level

Air Temperature (Automatic)
• Occupants simply choose the preferred temperature.
• The control system automatically heats or cools the air.
• Boosts the fan speed temporarily until the vehicle has reached a target comfort level
• Maintains in that condition

Rear Passengers
• Many vehicles separately duct the air through to the rear passengers.
• Normally, passengers only determine the direction of airflow.
• Some vehicles are fitted with additional temperature and mode switches.

Dashboard Ventilation Switches

Air Pickup
• Air pickup may direct air through the filter.
  ° Prevents dust, dirt, and pollen from entering the cabin
  ° Air is directed to the electric fan.
  ° The fan is activated if more airflow is needed.
  ° The movement of the vehicle through the air is usually enough to provide adequate airflow.

Air Filtering
• Air is drawn over the fan and directed over the air-conditioning evaporator (if fitted).
• Moves through the heater core
• Directed to the desired outlets by ducting and control doors
• Fresh air normally flows through the cabin when the vehicle is moving.
• A fan is used to assist air movement.

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• Normally, passengers only determine the direction of airflow.
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Air-conditioning operation
- All vehicles can direct the air over the heater core to warm the air entering the cabin.
- Air conditioning is becoming common as a standard fitting in many countries.
- Still an optional extra on many vehicles
- When fitted, the air-conditioning evaporator chills the incoming air to cool the occupants if required.
- Some vehicles automatically activate the air conditioning when the windshield defroster is selected.
- The air exiting the evaporator is very dry, speeding the defrosting process.

Driver comfort and safety: air conditioning
- Highly desirable in warmer climates
- The interior of the vehicle in direct sunlight heats up very quickly.
- Safe driving is best performed when the driver is comfortable and not stressed by excessive heat or cold.