Module 4: Climate Control

- AIR-CONDITIONING ELECTRONIC CONTROL UNIT (ECU)
- CONTROLLING CABIN AIR TEMPERATURE
- SERVO MOTORS
- ELECTRIC SERVO MOTORS
- AUTOMATIC CLIMATE CONTROL SENSORS
- EVAPORATIVE TEMPERATURE SENSOR
- BLOWER SPEED CONTROL
- VENTILATION SYSTEMS

Air-Conditioning Electronic Control Unit (ECU)

READY FOR REVIEW

- 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

READY FOR REVIEW

- 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
    - Flows through the air-conditioning evaporator core
    - Heat is removed.
- 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

READY FOR REVIEW

- 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

READY FOR REVIEW

- 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

READY FOR REVIEW

- 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

READY FOR REVIEW

- 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)
- Result of the readings
  - The heater tap opens fully.
  - The blend door moves to maximum air flow across the heater core.
  - The fan speed is slow and steady.
- Sun load sensor
  - Also called a solar sensor
  - Located on the dash panel
  - Exposed to the light entering through the vehicle windscreen
  - The photo diode becomes more conductive as the light intensity increases.
  - When connected to the ECU, the change in light intensity is registered as a change in voltage.
- Operator's control panel
  - Other inputs to the ECU from the operator's control panel are:
    - Where to deliver the air (switches producing an on-off type signal)
    - Instructions regarding the desired cabin temperature
- ECU and desired temperature selection
  - The desired temperature selection tells the ECU what the temperature operator wants for the inside of the vehicle.
  - The ECU adjusts the position of the valves and flaps to achieve the desired temperature.

Blower Speed Control

READY FOR REVIEW

- 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

READY FOR REVIEW

- 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
- Air filtering
  - 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.
- Set to recirculate air
  - Closes entry to the outside
  - Opens the duct that directs the cabin air to the fan
  - 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.

- 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.