

## Section 6

# Body Electrical

---

**Overview** The body electrical system includes special technology to increase fuel efficiency and accommodate the special requirements of a hybrid powertrain. For instance, the 2004 & later Prius uses an electric compressor so that A/C operation is not dependent on the engine. It also uses a humidity sensor to make cabin dehumidification more efficient.

To maintain communication between the vehicle's many electronic control components, hybrid vehicles use three types of multiplex communication: CAN, BEAN and AVC-LAN. A Gateway ECU is used to link the three circuits.

**Air Conditioning System** The Prius A/C unit provides 2-way flow so it can recirculate warm internal air in the foot well while simultaneously introducing fresh, dry external air to the upper part of the cabin. This allows it to effectively heat the vehicle and demist the windshield at the same time.

- The '01-'03 Prius air conditioning is controlled from the air conditioning control panel.
- The '04 & later Prius air conditioning system can be controlled either from the air conditioning screen on the multi display or from switches on the steering pad.

The system includes several components to meet the special requirements of a hybrid vehicle.

- The '04 & later Prius includes an electric compressor that is powered by the inverter and does not draw any power unless it is needed to run the A/C.
- The hybrid vehicle A/C system also uses two Positive Temperature Coefficient (PTC) heaters embedded in the heater core to supplement the heat provided by the engine.

The A/C control circuits include special logic tailored to support the hybrid powertrain. If the HV battery becomes too warm with recirculation ON, the HV battery ECU will switch to FRESH in order to increase the flow of air across the battery.

### A/C Main Components

(\*04 later Prius)

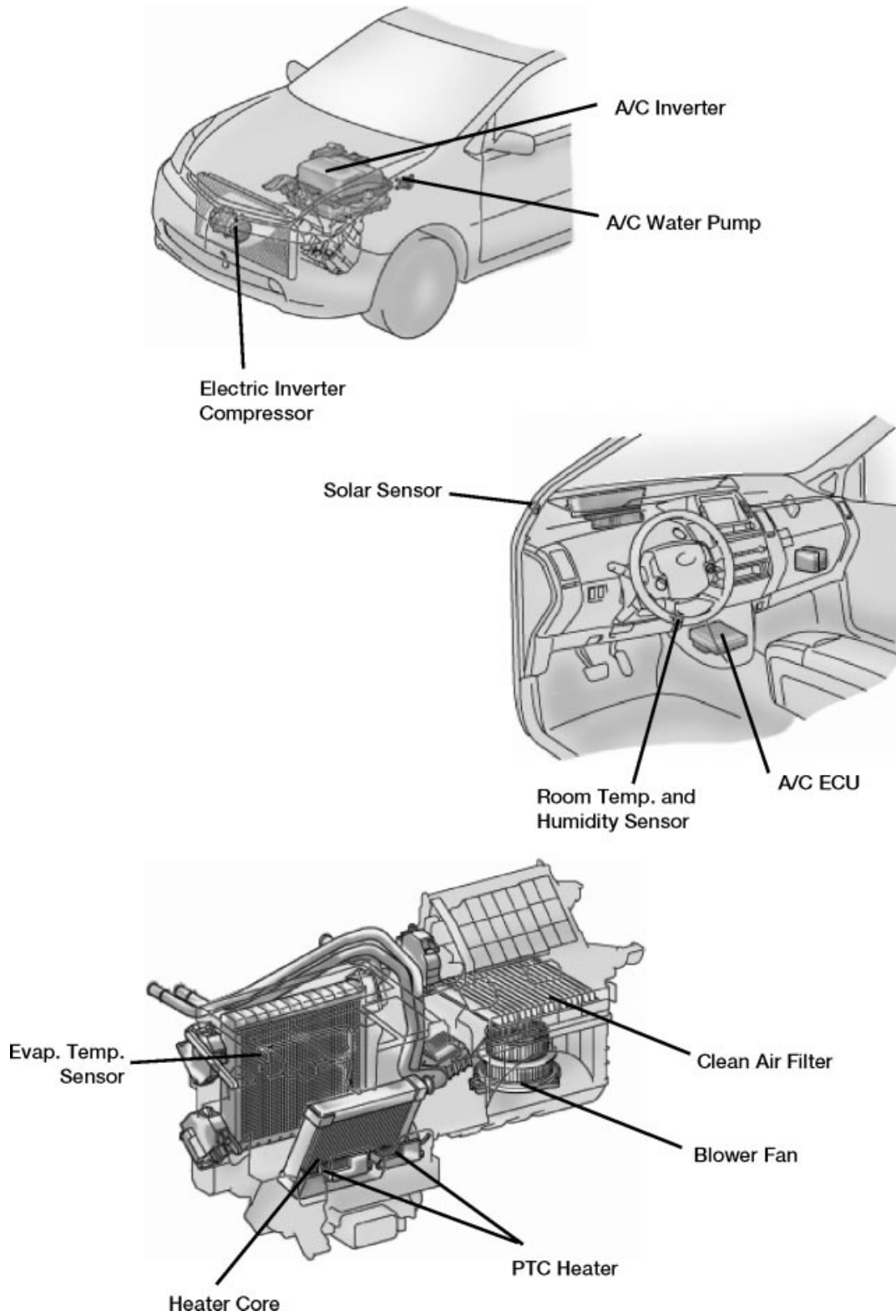
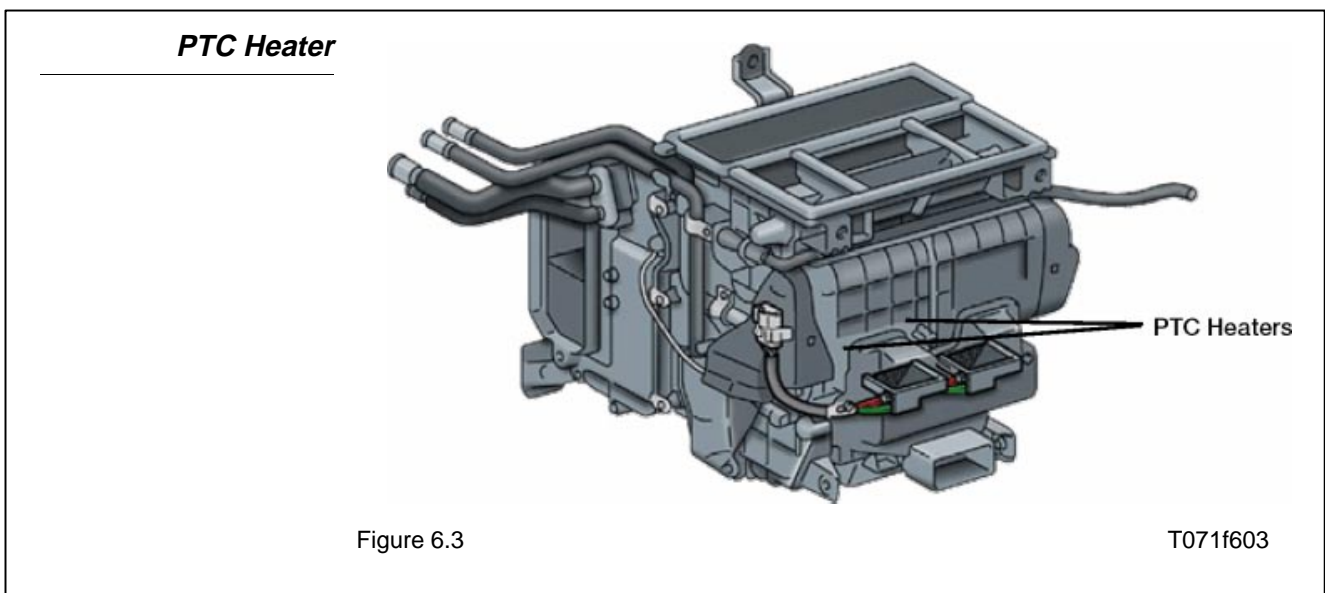
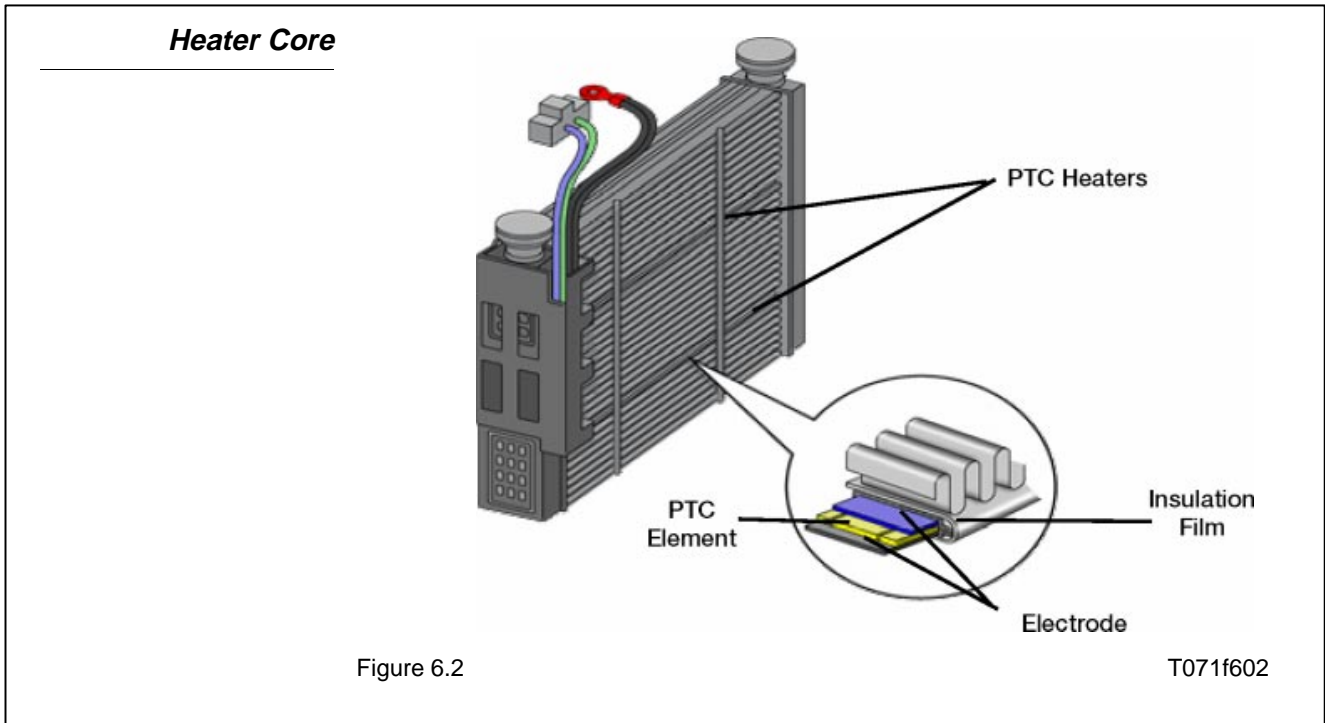


Figure 6.1

T071f601c

**Heater Core and PTC Heater**

The hybrid vehicle's gasoline engine is small, thermally efficient, and runs only when needed. Therefore, engine coolant may not always be hot enough to heat the cabin to a comfortable temperature. To address this, two 165-Watt PTC heater elements are embedded in the heater core and used to supplement engine heat when warming the vehicle.

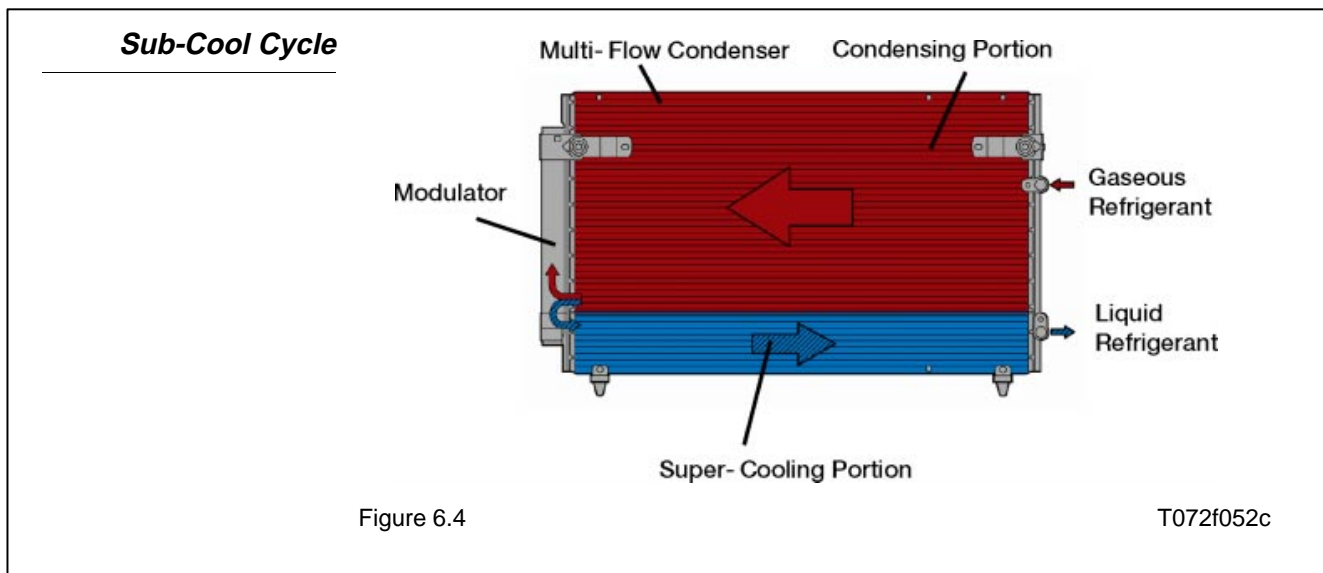


### Condenser and Sub-Cool Cycle

The Prius A/C condenser includes a sub-cooler that improves heat exchange efficiency. After the refrigerant passes through the condensing portion of the condenser, both the liquid refrigerant and any gaseous refrigerant that was not liquefied during condensation are cooled again in the super-cooling portion of the condenser. Because of this two-step approach the refrigerant sent to the evaporator is almost completely liquefied.

#### NOTE

When recharging most cooling systems, air bubbles disappear from the refrigerant when the system is full. With this system, however, air bubbles will disappear from the refrigerant *before* the system is full. See the Prius Repair Manual for the proper method of recharging this system.



### Compressor ('01-'03 Prius)

The '01-'03 Prius uses a scroll compressor with an oil separator that reduces the circulation of compressor oil in the system.

#### NOTE

When diagnosing the A/C, you may need to force the A/C system to remain on. Setting the controls to the MAX A/C position will cause the engine to remain on, maintaining A/C compressor operation.

### ***A/C Compressor***

Selecting MAX A/C on the '01-'03 Prius will cause the engine to run continuously



Figure 6.5

T071f605p

### **Electric Compressor ('04 & later Prius)**

The '04 & later Prius uses an electric compressor driven by an integrated motor. The motor runs on 201.6V AC supplied by the A/C inverter so compressor operation does not depend on the engine.

The electric compressor consists of a spirally wound fixed scroll and variable scroll, a brushless motor, and an oil separator. The oil separator reclaims most of the compressor oil that is intermixed with the refrigerant. To insure proper insulation between the compressor housing and the high-voltage components inside the compressor, the '04 Prius uses a special high insulation value ND11 compressor oil. **NEVER** use any compressor oil other than ND11.

#### **NOTE**

The A/C compressor is powered by 201.6V AC. So when servicing the A/C compressor you should use the same high voltage safety procedures you would use for the vehicles other high voltage circuits.

### ***Electric A/C Compressor***

('04 & later Prius)



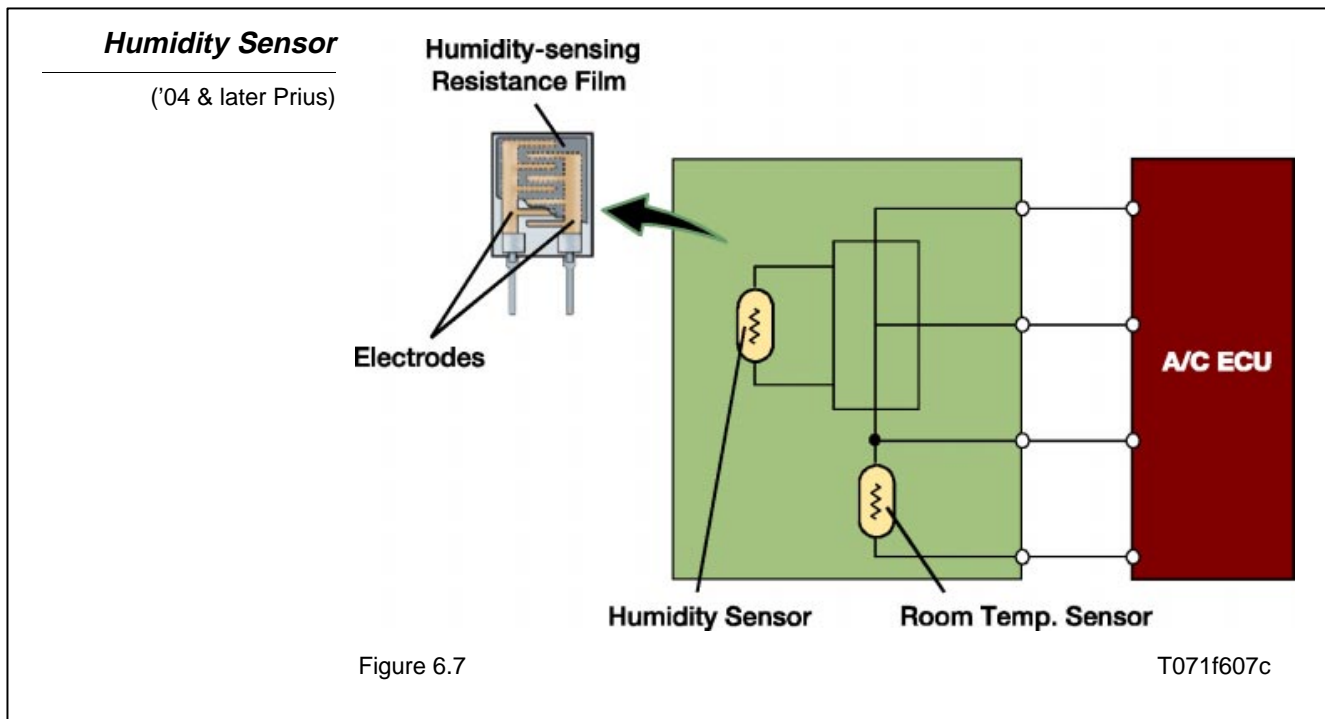
Figure 6.6

T071f606p

**Room Temperature Sensor and Humidity Sensor ('04 & later Prius)**

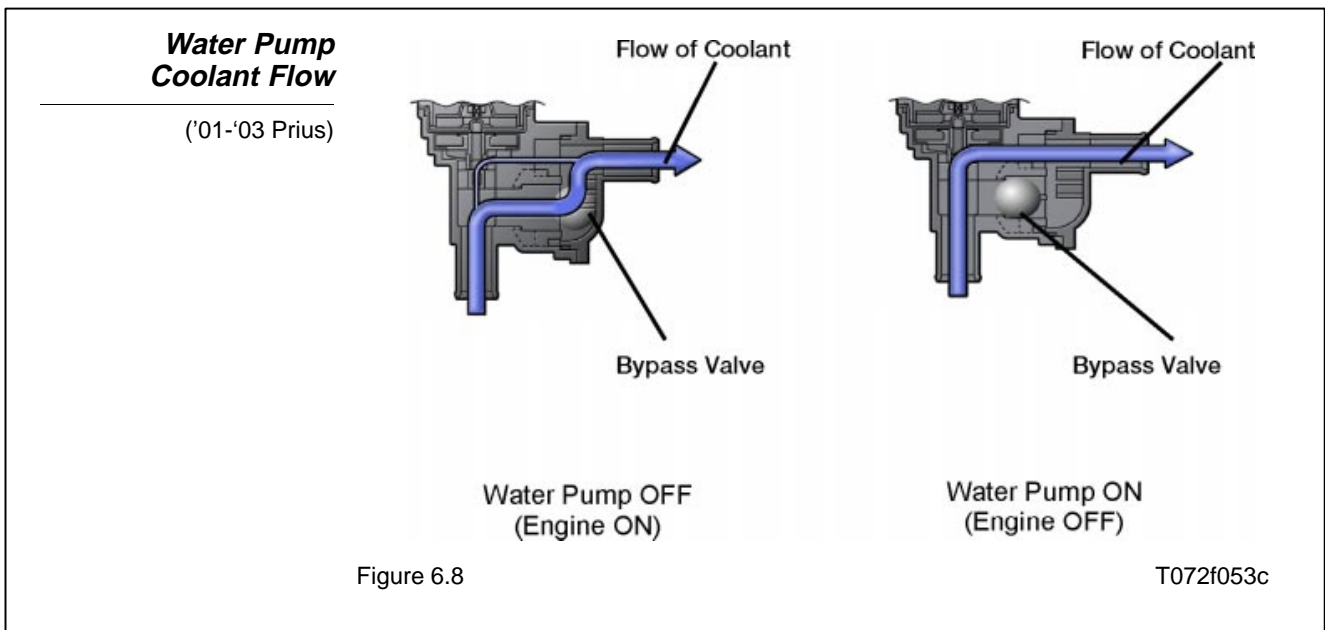
The room temperature sensor includes a humidity sensor to help make the A/C system's dehumidification process more effective. As a result, compressor power consumption has been reduced while still maintaining a comfortable humidity level within the cabin.

The humidity-sensing resistance film contains small carbon particles. As humidity in the cabin changes the hydroscopic film expands and contracts, changing the distance between the carbon particles. This changes the resistance of the film and sensor output voltage.



**Water Pump** The electric water pump provides stable heater performance even when the engine is stopped. When the engine is running the engine's water pump is forcing coolant through the system so the electric water pump does not operate.

On the '01-'03 Prius, when the engine's water pump is operating a bypass valve opens to minimize flow resistance. The bypass valve has been discontinued on the '04 & later Prius because a new pump design minimizes water flow resistance.

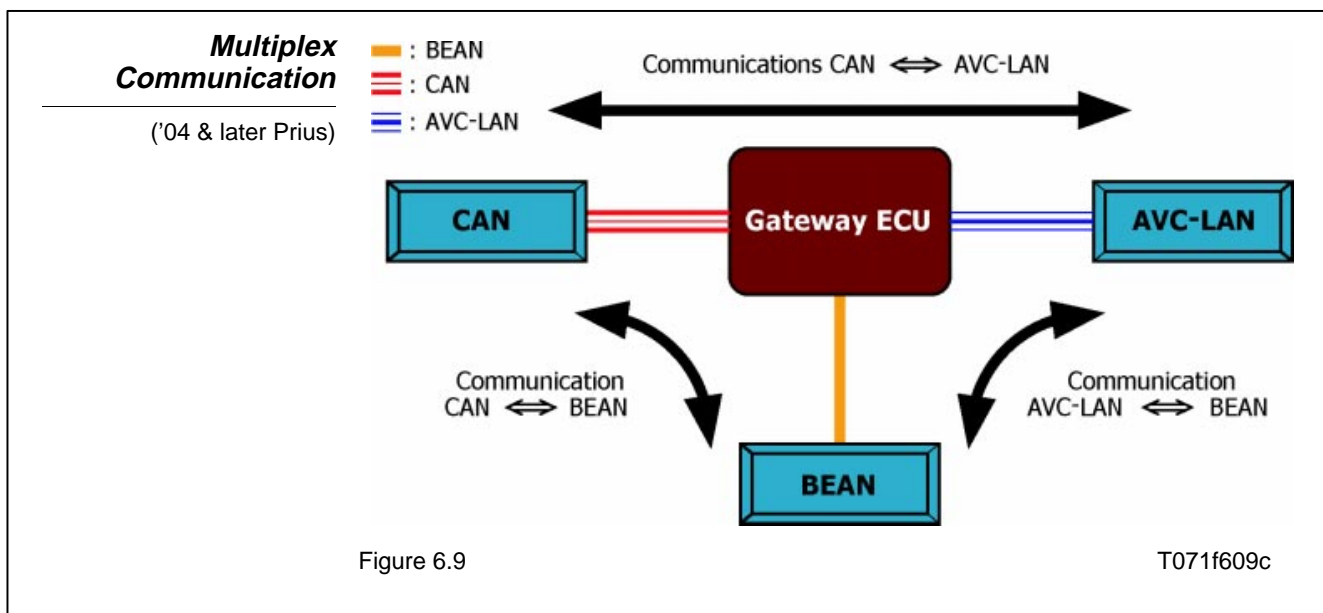


### Multiplex Communication System

The Prius uses the following communication systems to coordinate vehicle activities:

- The Controller Area Network (CAN) links vehicle control systems that require high-speed communication, such as the ECM, HV ECU, Skid Control ECU and others.
- The Body Electronics Area Network (BEAN) connects the body control systems.
- The Audio Visual Communication – Local Area Network (AVC-LAN) links the audiovisual system ECUs and devices.

The Gateway ECU contains communication circuits that allow the CAN, BEAN and AVC-LAN systems to connect with each other.





**CAN System Diagram**

CAN communication speed is 500 k bps ('04 & later Prius)

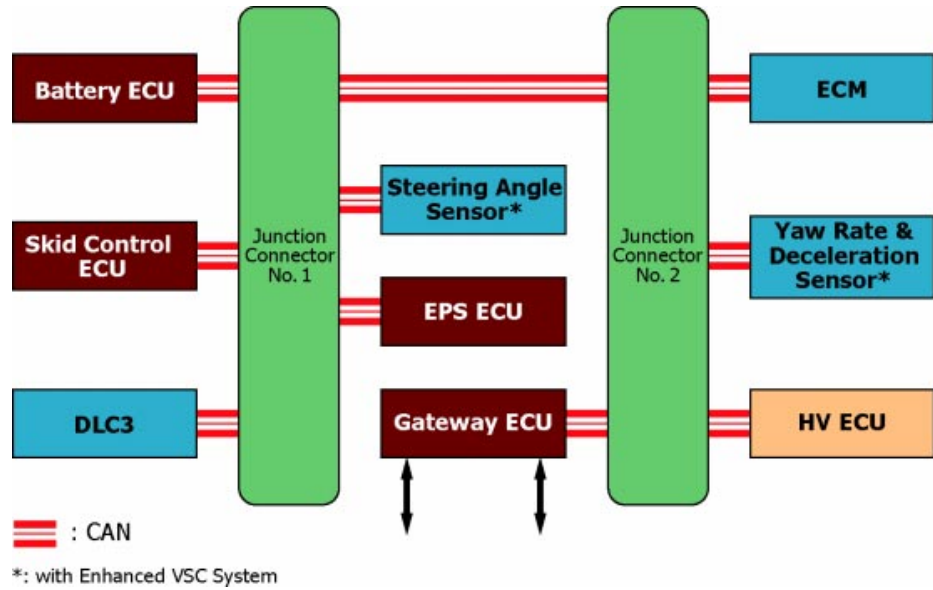


Figure 6.10

T071f610c

**CAN, BEAN & AVC-LAN Chart**

('04 & later Prius)

| Control             | Chassis Electrical System Control |                           | Body Electrical System Control |  |
|---------------------|-----------------------------------|---------------------------|--------------------------------|--|
|                     | CAN (ISO Standard)                | BEAN (TOYOTA Original)    | AVC-LAN (TOYOTA Original)      |  |
| Protocol            | CAN (ISO Standard)                | BEAN (TOYOTA Original)    | AVC-LAN (TOYOTA Original)      |  |
| Communication Speed | 500 k bps (Max. 1 M bps)          | Max. 10 k bps             | Max. 17.8 k bps                |  |
| Communication Wire  | Twisted-pair Wire                 | AV Single Wire            | Twisted-pair Wire              |  |
| Drive Type          | Differential Voltage Drive        | Single Wire Voltage Drive | Differential Voltage Drive     |  |
| Data Length         | 1-8 Byte (Variable)               | 1-11 Byte (Variable)      | 0-32 Byte (Variable)           |  |

Figure 6.11

T071f611

**Warranty** The SULEV 2001-2003 Prius warranty offers:

- Basic - 3 years / 36,000 miles
- Powertrain (Engine, Transaxle with motors) - 5 years / 60,000 miles
- Hybrid System (HV Battery, HV Battery ECU, Hybrid ECU, Inverter and Converter) – 8 years / 100,000 miles

The AT-PZEV 2004 & later Prius, the warranty offers:

- Basic - 3 years / 36,000 miles
- Powertrain (Engine, Transaxle with motors) - 5 years / 60,000 miles
- Hybrid System – 8 years / 100,000 miles
- Emission Performance, Emission Defects, and Hybrid Battery Pack – 150,000 miles



**WORKSHEET 6-1**  
***Electric Air Conditioning System***

|         |                 |        |              |
|---------|-----------------|--------|--------------|
| Vehicle | Year/Prod. Date | Engine | Transmission |
|---------|-----------------|--------|--------------|

**Worksheet Objectives**

This worksheet will familiarize you with the operation of the high voltage A/C compressor on the 2004 and later Prius using Active Tests and viewing the high and low pressures. You will also become familiar with the customize modes on the Diagnostic Tester, which allow A/C functions to be modified to suit customer needs.

**Tools and Equipment**

- Vehicle
- Pressure Gauges
- Diagnostic Tester
- Repair Manual
- New Car Features

**Section 1: A/C Compressor**

1. Describe the A/C compressor. What drives the compressor? What type of compressor is it?

---



---



---

2. What type of compressor oil is used and why is it unique to this system?

---



---

3. List the safety precautions that should be followed when servicing the A/C System.

---



---



---



---



---

### Section 2: Refrigerant Pressure

1. Turn the A/C OFF and then turn the vehicle OFF.
2. Connect the pressure gauges to the high and low-pressure service ports.
3. Restart the vehicle, verifying it is in READY mode.
4. Connect the Diagnostic Tester to DLC3.
5. Select Active Test and COMPRS TARG SPD. Start at zero and note the refrigerant pressure. Increase the RPM to 4000 and note the pressure. Increase the RPM to 6000 and note the pressure.

|                   |                    |                     |
|-------------------|--------------------|---------------------|
| Compressor Speed: | Low Side Pressure: | High Side Pressure: |
| Compressor Speed: | Low Side Pressure: | High Side Pressure: |
| Compressor Speed: | Low Side Pressure: | High Side Pressure: |

### Section 3: Humidity Sensor

1. What is the purpose of the humidity sensor?  

---

2. Where is the humidity sensor located?  

---

3. Is the humidity sensor located on the A/C Data List?  

---

### Section 4: A/C Data List

1. Select the A/C Data List using the Diagnostic Tester. Under User Data select EVAPORATOR TEMP, ROOM TEMP, HUMIDITY SENSOR, COMPRESSOR SPEED, and COMPRESSOR TARGET SPEED.
2. What is the relationship of the room temperature to the evaporator temperature when the A/C is OFF and then with the A/C ON?

---

---

3. What happens to the humidity sensor reading when the A/C is turned ON?

---

---

4. What happens to the compressor target speed when the humidity sensor and evaporator temperature sensor values drop?

---

### Section 5: Customize Mode

1. The **Customize Mode** allows air conditioning functions to be modified to suit the customers needs. Modes are changed using the Diagnostic Tester.
2. With the Diagnostic Tester connected to DLC3, enter the **Customize Mode** located on the second screen after you turn the tester ON.
3. Select **Individual Change**. List at least three A/C climate control modes that can be customized.

---

---

---

**Note:** Return all cars to the original state and return to the classroom.



**Notes**



**SELF-ASSESSMENT 6-1**  
***Electric Air Conditioning System***

|       |       |
|-------|-------|
| Name: | Date: |
|-------|-------|

**Self-assessment Objectives**

Review this sheet as you are doing the Electric Air Conditioning worksheet. Check off either category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The **Comments** section is for you to write notes on where to find the information, questions, etc.

I have questions

I know I can

| Topic   |  |  | Comment |
|---|--|--|---------|
| Describe the electric A/C compressor.                                     |  |  |         |
| Describe the safety precautions of why ND11 oil must be used.             |  |  |         |
| List the safety precautions to be followed when servicing the A/C system. |  |  |         |
| Access Active Test and select compressor speed.                           |  |  |         |
| Locate the humidity sensor using TIS or the repair manual.                |  |  |         |
| View the A/C Data List.   |  |  |         |
| Locate and use Customize Mode for A/C.                                    |  |  |         |
|   |  |  |         |
|   |  |  |         |
|   |  |  |         |
|   |  |  |         |
|   |  |  |         |
|   |  |  |         |
|   |  |  |         |



**Notes**