Section 1

Principles of Operation

Overview

Prius is a Latin word meaning "to go before." Toyota chose this name because the Prius vehicle is the predecessor of the cars to come. Rapid population growth and economic development in recent decades have resulted in a sharp increase in fossil fuel consumption on a global scale. Faced with the challenges to create an earth-friendly vehicle, Toyota has produced the world's first mass produced hybrid automobile.

The hybrid system is the wave of the future, and now there are more incentives to purchase one. Owners of the Prius or any other hybrid gas-and-electric vehicle, may be eligible for a federal income tax deduction. According to the Internal Revenue Service, hybrid vehicles qualify for a longstanding tax deduction that applies to vehicles powered by clean-burning fuels. The policy allows a one-time deduction which can be claimed by the consumer for the year the car was first put in use.

In its simplest form, a hybrid system combines the best operating characteristics of an internal combustion engine and an electric motor. More sophisticated hybrid systems, such the Toyota Hybrid System, recover energy otherwise lost to heat in the brakes and use it to supplement the power of its fuel-burning engine. These sophisticated techniques allow the Toyota Hybrid System to achieve superior fuel efficiency and a massive reduction in CO^2.

Upon its release in 2001, the Prius was selected as the world's bestengineered passenger car. The car was chosen because it is the first hybrid vehicle that holds four to five people and their luggage. It is also one of the most economical and environmentally friendly vehicles available. In 2004 the second generation Prius won the prestigious Motor Trend Car of the Year Award.

The Toyota Hybrid System (THS) powertrain in the original Prius and the Toyota Hybrid System II (THS-II) powertrain in the second generation Prius both provide impressive EPA fuel economy numbers and extremely clean emissions:

THS (2001-2003 Prius)		**THS-II (2004 & Later)**	
City:	52 mpg	City:	60 mpg
Highway:	45 mpg	Highway:	51 mpg
SULEV		**AT-PZEV (California Spec.)**	

- SULEV standards are about 75% more stringent than ULEV and nearly 90% cleaner than LEV for smog forming exhaust gases.
- SULEV vehicles will emit less than a single pound of hydrocarbons during 100,000 miles of driving (about the same as spilling a pint of gasoline).
- AT-PZEV vehicles use advanced technology capable of producing zero emissions during at least part of the vehicle's drive cycle.

CARB Emission Ratings

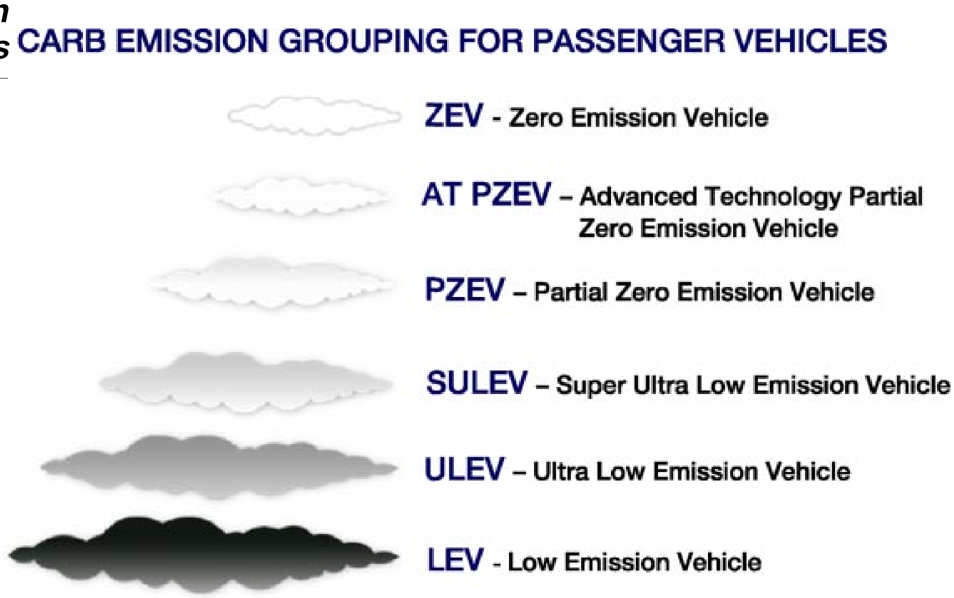

Figure 1.1 T072f101c

Hybrid System Component

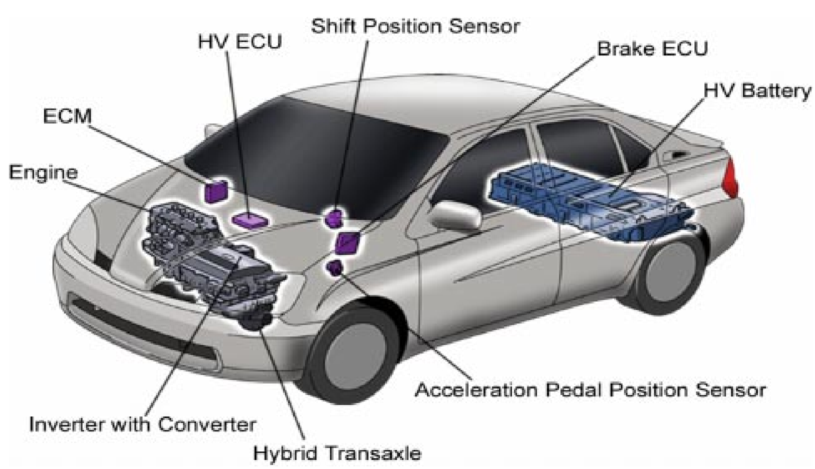

Figure 1.2 T072f102c

Principles of Operation

The main components of the hybrid system are:

- IC Engine
- Motor Generator 1 (MG1)
- Motor Generator 2 (MG2)
- Planetary Gear Set
- Inverter
- HV Battery
- HV ECU

The 1NZ-FXE 1.5-liter gasoline engine employs VVT-i variable valve timing and ETCS-i electronic throttle control.

Motor Generator 1 (MG1) operates as the control element for the power splitting planetary gear set. It ges the HV battery and also supplies electrical power to drive Motor Generator 2 (MG2). MG1 effectively controls the continuously variable transmission function of the transaxle and operates as the engine starter. MG2 is used for motive force at low speeds and supplemental force at high speeds. It provides power assist to the engine output as needed and helps the vehicle achieve excellent dynamic performance. It also functions as a generator during regenerative braking.

The planetary gear unit is a power splitting device. MG1 is connected to the sun gear, MG2 is connected to the ring gear and the engine output shaft is connected to the planet carrier. These components are used to combine power delivery from the engine and MG2 and to recover energy to the HV battery. Current between MG1, MG2 and the HV battery is controlled by the inverter. The inverter converts high-voltage battery DC to AC power and it rectifies high-voltage AC from MG1 and MG2 to recharge the high-voltage battery.

The battery stores power recovered by MG2 during regenerative braking and power generated by MG1. The battery supplies power to the electric motor when starting off or when additional power is required.

THS (2001-2003 Prius)	**THS-II (2004 and later Prius)**
38 Nickel Metal Hydride modules	28 Nickel Metal Hydride modules
Total voltage: 273.6V	Total voltage: 201.6V

When starting off and traveling at low speeds, MG2 provides the primary motive force. The engine may start immediately if the HV battery State- of-Charge (SOC) is low. As speed increases above 15 to 20 mph the engine will start.

When driving under normal conditions the engine's energy is divided into two paths; a portion drives the wheels and a portion drives MG1 to produce electricity. The HV ECU controls the energy distribution ratio for maximum efficiency.

During full acceleration power generated by the engine and MG1 is supplemented by power from the HV battery. Engine torque combined with MG2 torque delivers the power required to accelerate the vehicle.

During deceleration or braking the wheels drive MG2. MG2 acts as a generator for regenerative power recovery. The recovered energy from braking is stored in the HV battery pack.

Hybrid Control Modes

The hybrid system uses various modes to achieve the most efficient operation in response to the driving conditions. The following graphics review each of these modes.

Starting Out

When starting out under light load and light throttle only MG2 turns to provide power. The engine does not run and the vehicle runs on electric power only. MG1 rotates backwards and just idles; it does not generate electricity.

Starting Out

The electric power supply from the HV battery to MG2 provides force to drive the wheels.

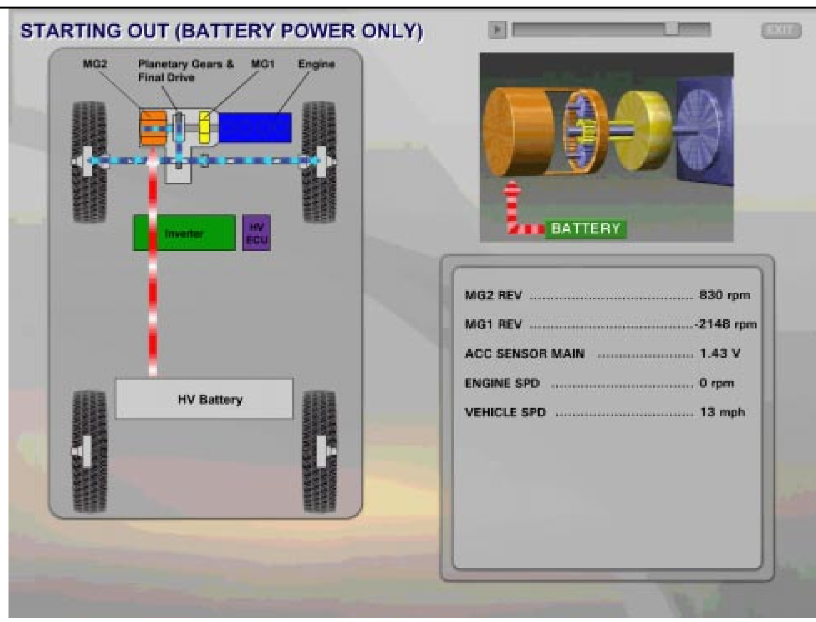

Figure 1.3 T072f103c

Normal Driving

Above approximately 14 mph during normal low-speed driving the engine runs and provides power. MG2 turns and runs as a motor and provides an electric assist. MG1 is turned in the same direction by the engine as a generator and provides electricity for MG2.

Normal Driving

While the engine drives the wheels via the planetary gears, MG1 is driven via the planetary gears to supply electricity to MG2.

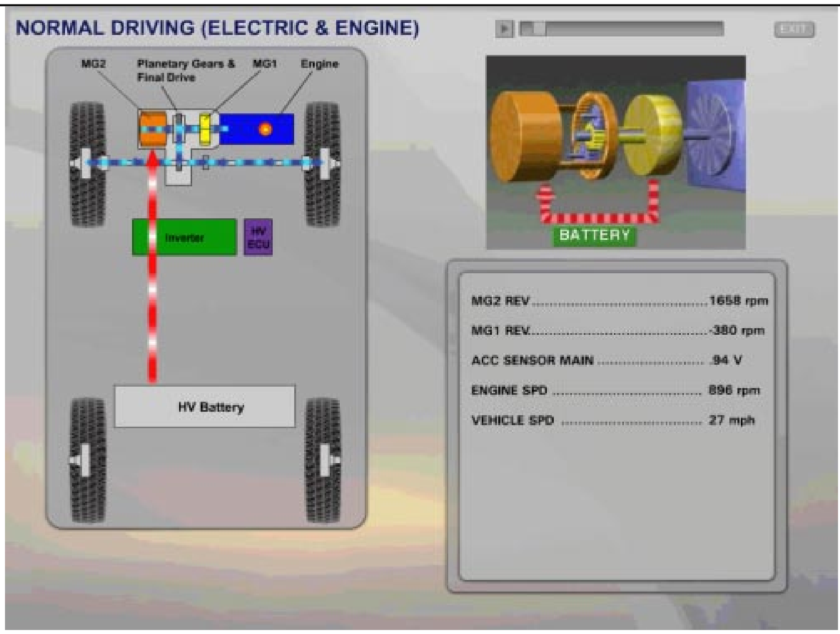

Figure1.4 T072f104c

Full Throttle Acceleration and High Speed Cruise

For maximum acceleration or speed, electric drive power from MG2 supplements engine power. The HV battery provides electricity to MG2. MG1 also receives electrical power from the HV battery and turns in the reverse direction to create an overdrive ratio for maximum speed.

Full Throttle Acceleration and High Speed Cruise

MG2 supplements engine power for maximum acceleration or speed.

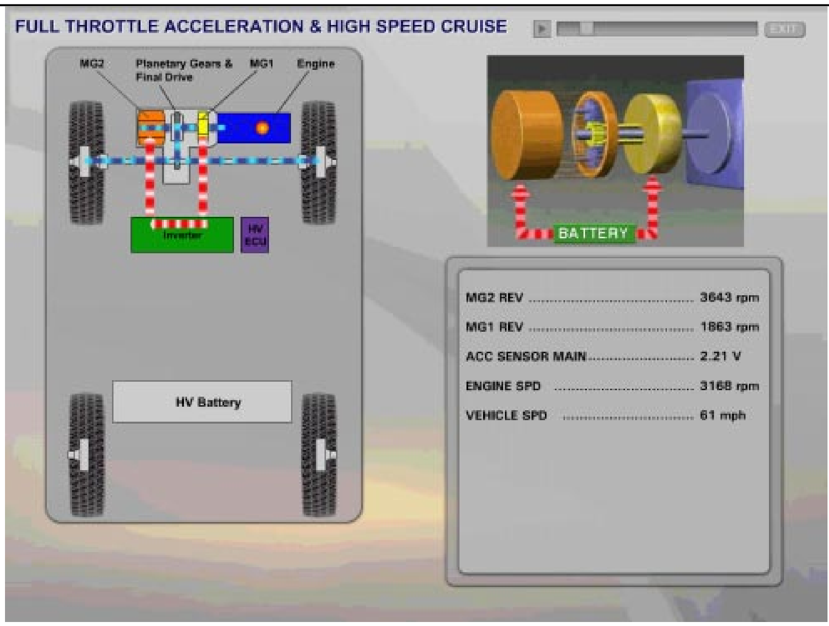

Figure 1.5 T072f105c

Deceleration and Braking

As soon as the accelerator pedal is released by the driver MG2 becomes a generator. MG2 is turned by the drive wheels and generates electricity to recharge the HV battery. This process is called Regenerative Braking. As the vehicle decelerates, the engine stops running and MG1 turns backwards to maintain the gear ratio.

When the brake pedal is depressed most of the initial braking force comes from Regenerative Braking and the force required to turn MG2 as a generator. The hydraulic brakes provide more stopping power as the vehicle slows.

Deceleration and Braking

When the vehicle decelerates, kinetic energy from the wheels is recovered and converted into electrical energy and used to recharge the HV battery by means of MG2.

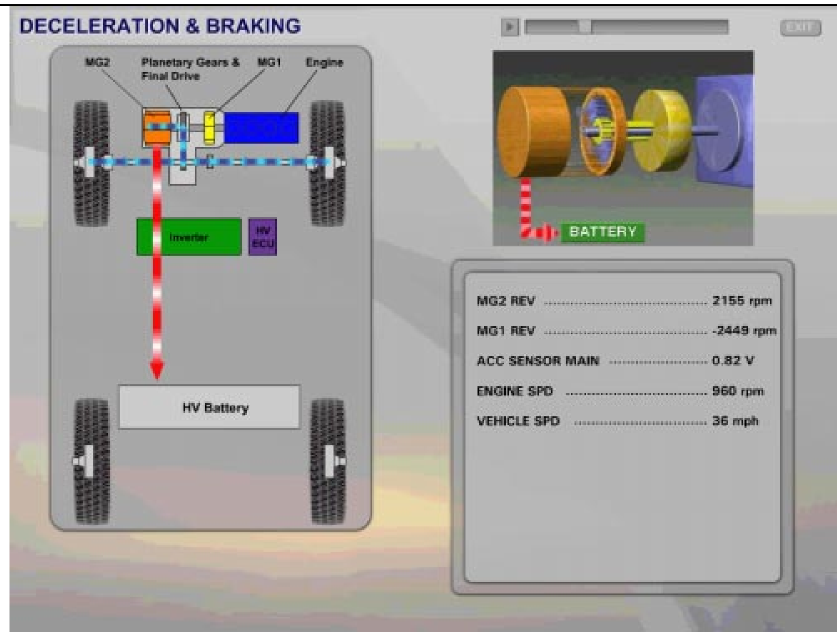

Figure 1.6 T072f106c

Reverse When the vehicle moves in reverse, MG2 turns in reverse as an electric motor. The engine does not run. MG1 turns in the forward direction and just idles; it does not generate electricity.

Reverse

MG2 rotates backwards to move the vehicle in reverse.The engine does not run.

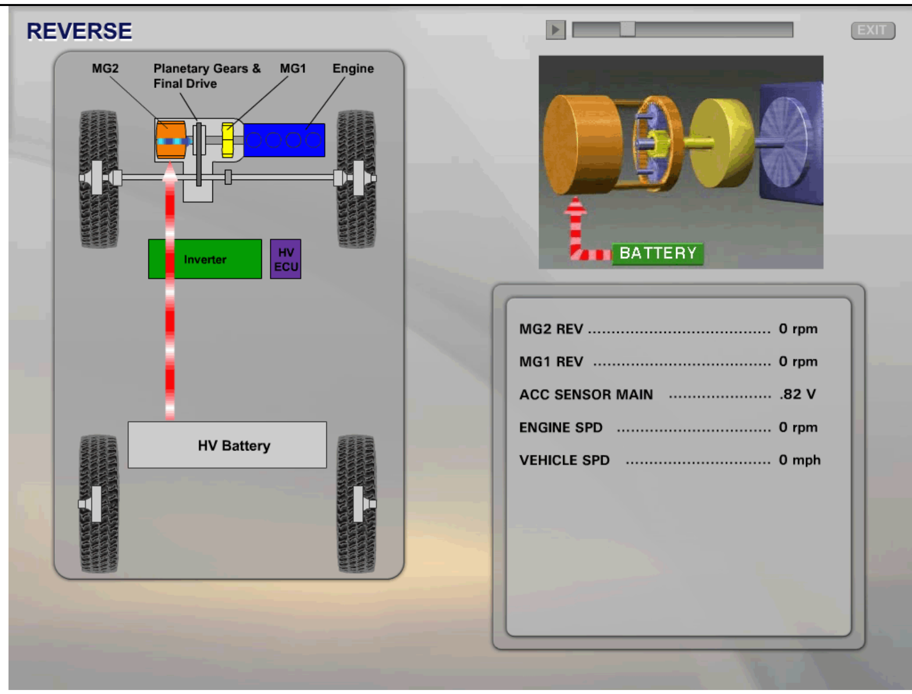

Figure 1.7 T072f107c

Notes

WORKSHEET 1-1
Data List Test Drive

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

In this worksheet you will use the Diagnostic Tester and TechView to obtain and view relevant information and observe data lists while driving the vehicle. You will then relate this information to the different components and technologies of the hybrid system.

Tools and Equipment

- Vehicle
- Diagnostic Tester
- TIS Machine w/TechView

Section 1 - Data Lists

1. Connect the Diagnostic Tester to DLC3. Start the vehicle (READY light ON).
2. Go to HV ECU, Data List.
3. Create a User Data List with the following items:
    - MG1 REV
    - MG2 REV
    - MG1 TORQ
    - MG2 TORQ
    - POWER RQST
    - ENGINE SPD
    - VEHICLE SPEED

Note: Remember that when REV and TORQ are the same (both + positive or both - negative) the component is being used as a MOTOR. When REV and TORQ are different (i.e. REV + & TORQ -) the component is a GENERATOR.

4. From a stop, lightly accelerate to 20mph. Record the following values:

MG1 REV-	MG1 TORQ -
MG2 REV -	MG2 TORQ -
ENGINE SPD-	

5. Is MG1 being used as motor or a generator?

____

6. Is MG2 being used as a motor or generator?

____

7. Is the engine running?

____

8. Bring vehicle speed up to approximately 35 mph. Record the following values:

MG1 REV-	MG1 TORQ -
MG2 REV -	MG2 TORQ -
ENGINE SPD-	

9. Is MG1 being used as motor or a generator?

____

10. Is MG2 being used as a motor or generator?

____

11. Is the engine running?

____

12. Bring vehicle speed up to approximately 45 mph. Record the following values:

MG1 REV-	MG1 TORQ -
MG2 REV -	MG2 TORQ -
ENGINE SPD-	

13. Is MG1 being used as motor or a generator?

____

14. Is MG2 being used as a motor or generator?

____

15. Is the engine running?

____

Section 2 - Snapshot & TechView Data

1. While braking, take a snapshot of:
   - MG1 REV
   - MG1 TORQ
   - MG2 REV
   - MG2 TORQ
   - ENGINE SPD
   - VEHICLE SPD
   - ACC SENSOR MAIN
2. Drive at low speeds in reverse and take a snapshot of:
   - MG1 REV
   - MG1 TORQ
   - MG2 REV
   - MG2 TORQ
   - ENGINE SPD
   - VEHICLE SPD
   - ACC SENSOR MAIN
3. Take a snapshot of while in the “B” Mode:
   - MG1 REV
   - MG1 TORQ
   - MG2 REV
   - MG2 TORQ
   - ENGINE SPD
   - VEHICLE SPD
   - ACC SENSOR MAIN

4. Return to the shop and load the snapshots on TechView. Play the snapshots back for the instructor using one of the graphing functions.

5. While braking, what are MG1 & MG2 doing? Why?

6. While in reverse, what are MG1 & MG2 doing? Why?

7. While in the “B” mode, what are MG1 & MG2 doing? Why?

Section 2

Engine Control Systems

Overview

The 1NZ-FXE engine is optimized for its role as one of two sources of motive power in the Prius. The system controls the distribution of the engine and motor drive energy and the most efficient engine operation zone will automatically be selected. The engine may stop automatically when the vehicle is starting out and traveling at low speed to reduce fuel consumption and emissions.

Atkinson Cycle

The Prius engine operates on the Atkinson Cycle, which allows the compression and expansion ratios to be independently set. The Atkinson Cycle engine achieves high thermal efficiency and has a high expansion ratio cycle. When the Atkinson Cycle is combined with the VVT-i system, it provides the benefits of a variable stroke engine. In the fully retarded position, the effective compression stroke nearly matches the power stroke. Late closing of the intake valve causes the compression stroke to begin later. The disadvantage is that positive pulses are discharged into the intake manifold resulting in low intake manifold vacuum. The power stroke remains the same allowing a longer amount of time to capture the energy of the expanding gases.

Engine Components

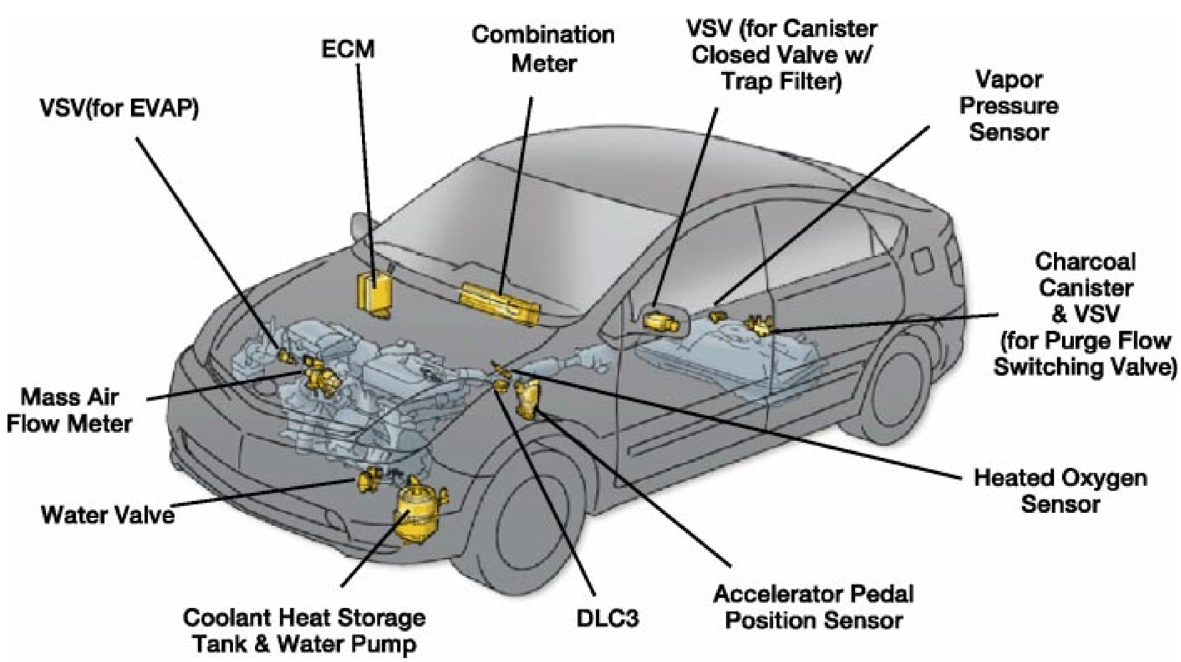

Figure 2.1 T072f201c

Engine Control System Sensors

Mass Air Flow Meter

The Mass Air Flow Meter uses a platinum hot wire and a control circuit installed in a plastic housing. The meter is mounted in the air inlet just above the throttle body.

The hot wire is in the circuit that measures the amount of air entering the engine intake. The temperature of the hot wire is maintained at a constant value by controlling the current flow through the hot wire. Incoming air tends to cool the hot wire. As airflow increases, current flow through the wire is also increased to maintain the hot wire set temperature. This current flow is then measured and reported to the ECM as the output voltage of the air flow meter.

Intake Air Temperature Sensor

The Intake Air Temperature Sensor is built into the Mass Air Flow Meter and senses the temperature of intake air. An NTC Thermistor changes resistance as the intake air temperature changes. As intake air temperature increases, the Thermistor resistance value and the signal voltage to the ECM decrease.

Engine Coolant Temperature Sensor

The Engine Coolant Temperature Sensor is located in the engine block and senses the temperature of the engine coolant. An NTC Thermistor changes resistance as the coolant temperature changes. As coolant temperature increases, the Thermistor resistance value and the signal voltage to the ECM decrease.

Accelerator Pedal Position Sensor

The Accelerator Pedal Position Sensor is mounted on the accelerator pedal assembly. Two separate Hall Effect sensors are used to detect accelerator pedal position. Due to the characteristics of the Hall elements, different signals are output depending on whether the pedal is being depressed or released. The HV ECU receives the signals and compares them for reliability.

Throttle Position Sensor

The Throttle Position Sensor is mounted on the throttle body and converts the throttle valve opening into two electrical signals which are inputs VTA and VTA2 to the ECM. The signals have different voltage values. The ECM compares the two output signals from the two sensors for reliability.

The ECM drives the throttle control motor by determining the target throttle valve opening in response to driving conditions.

Idle Speed Control

Engine idle speed is controlled entirely by throttle valve opening and the ETCS-i. No separate idle speed control system is required. The system includes idle-up control during cold engine operation, intake air volume control to improve the startability of the engine and load compensation for changes such as when the A/C is turned ON or OFF.

Knock Sensor

The Knock Sensor is mounted on the cylinder block and detects detonation or knocking in the engine. This sensor contains a piezoelectric element which generates a voltage when it becomes deformed. Cylinder block vibrations due to knocking deform the sensor element. If engine knocking occurs the ignition timing is retarded to suppress it.

Crankshaft Position Sensor

The Crankshaft Position Sensor (NE signal) consists of a toothed signal plate and an inductive pick up coil. The signal plate has 34 teeth, with one gap created by missing teeth. The plate is mounted on the crankshaft. The NE sensor generates a 34-pulse waveform for every crankshaft revolution. Since this is an inductive sensor, both the frequency and amplitude of the generated signal increase with increasing engine rpm. The ECM uses the NE signal to determine engine rpm and also for misfire detection.

Camshaft Position Sensor

The Camshaft Position Sensor (G2 signal) consists of a signal plate with a single tooth and a pick up coil. The G2 signal plate tooth is on the exhaust camshaft. The G2 sensor generates one-pulse waveform for every revolution of the exhaust camshaft. Since this is an inductive sensor, both the frequency and amplitude of the generated signal increase with increasing engine rpm. The ECM uses the G2 signal to determine the position of the no.1 piston for the ignition firing order.

Heated O2 Sensors

The O2 Heater Control maintains the temperature of the O2 Sensors at an appropriate level to increase accuracy of detection of the oxygen concentration in the exhaust gas. On the ’01-’03 Prius, the sensors include:

- Bank 1, Sensor 1*
- Bank 1, Sensor 2*

*Sensor 1 - refers to the sensor ahead of the catalytic converter. This sensor measures the oxygen content of the engine exhaust gases. The ECM uses this input to adjust fuel trim.

*Sensor 2 - refers to the sensor after the catalytic converter. This sensor is used to measure catalyst efficiency.

Note: The ’04 and later Prius includes several new DTCs for the Bank 1 Sensor 2 Oxygen Sensor:

- P0136 - Oxygen Sensor Circuit Malfunction
- P0137 - Oxygen Sensor Circuit Low Voltage
- P0138 - Oxygen Sensor Circuit High Voltage

Air/Fuel Ratio Sensor

On the ’04 and later Prius, the Bank 1 Sensor 1 O2 Sensor is replaced by an A/F Sensor. The A/F Sensor detects the air/fuel ratio over a wider range, allowing the ECM to further reduce emissions.

The A/F Sensor used is the planar type. Compared to the conventional cup type, the sensor and heater portions of the planar type are narrower overall. Because the heat of the heater acts directly on the alumina and zirconia it accelerates the activation of the sensor.

Cooling System

The engine cooling system is a pressurized, forced-circulation type. A thermostat with a bypass valve is located on the water inlet housing to control coolant flow and maintain suitable temperature distribution in the cooling system. The flow of engine coolant makes a U-turn in the cylinder block to ensure even heat distribution. The radiator for the engine and the A/C condenser have been integrated to minimize space requirements.

Cooling System

The coo/ing system has changed for the ’04 Prius. The coo/ant heat storage tank can store hot coo/ant up to three days. This allows for quick engine warm up and reduces emissions.

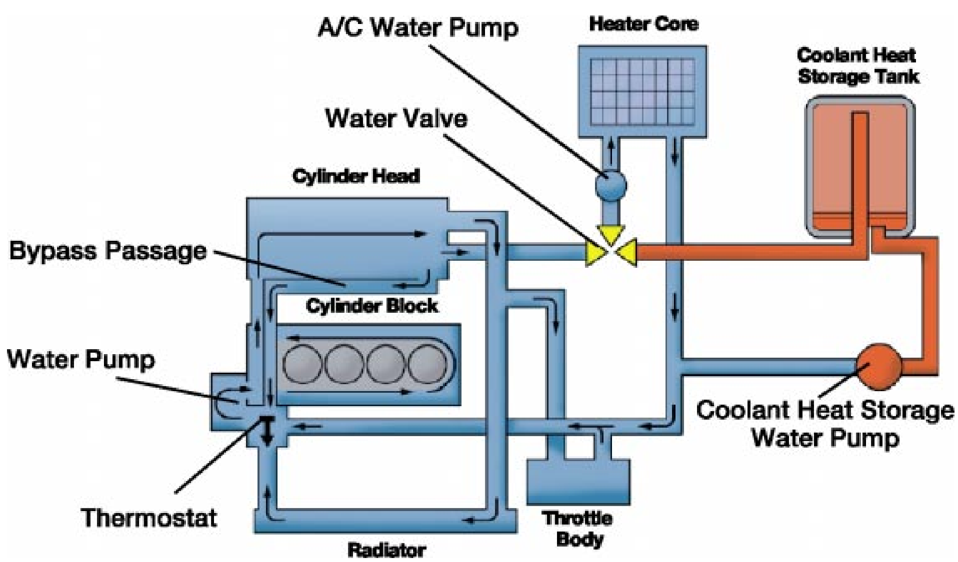

Figure 2.2 T072f202c

Coolant Heat Storage

Starting on the '04 Prius, the cooling system includes a Coolant Heat Storage Tank that can store hot coolant at 176°F for up to three days. When starting a cold engine the system uses an auxiliary water pump to force the hot coolant into the engine. This 'preheating' of the engine reduces HC exhaust emissions.

DTC P1151 Coolant Heat Storage Tank

For DTC P1151, the Repair Manual recommends replacing the coolant heat storage tank. But there is also a note in the manual pointing out that this DTC can be set if there are air bubbles in the system.

Note: To avoid replacing the tank unnecessarily, check for the sound of air bubbles flowing through the heater core, which can be heard from the passenger compartment. If air bubbles are present, bleed the air from the system following the Repair Manual instructions. Clear the code and drive the vehicle for two trips. The code should not return. If it does, *then* you should replace the coolant heat storage tank.

Coolant Heat Storage Tank

The storage tank is a large vacuum insulated container located near the left front bumper.

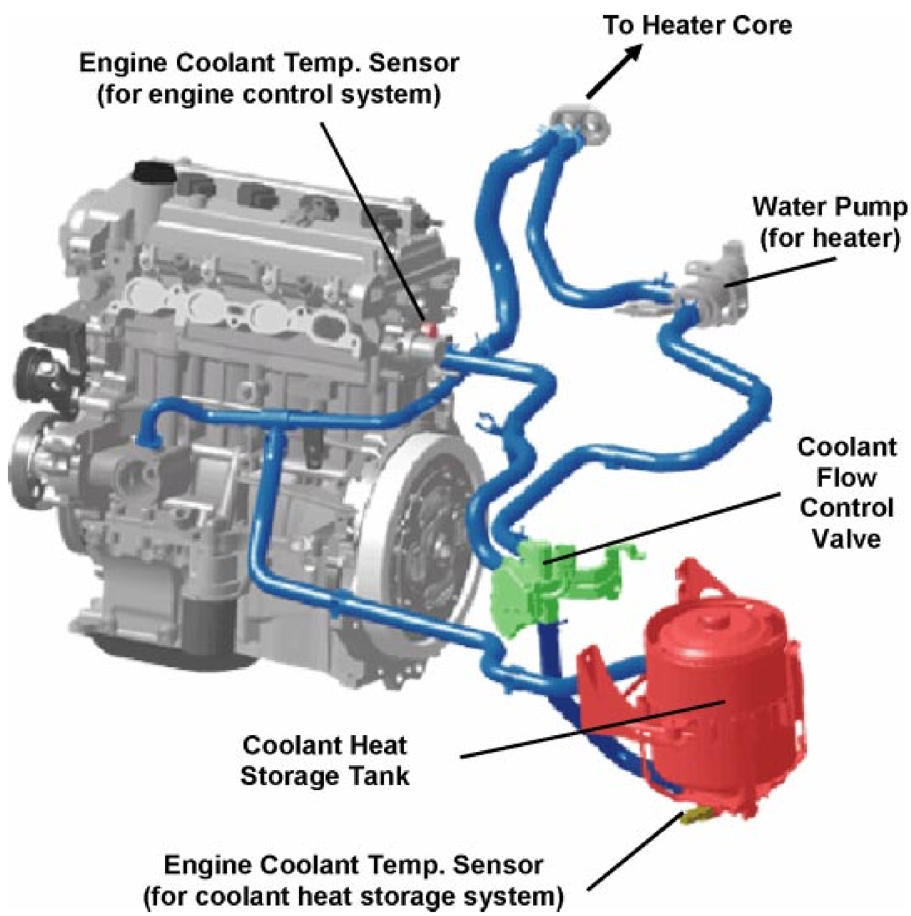

Figure 2.3 T072f203c

Coolant Heat Storage Tank

Coolant Drain Plug

Outlet Temp Sensor

Figure 2.4 T072f204p

Coolant Heat Storage Tank

Water Pump

Figure 2.5 T072f205p

SERVICE TIPS

When servicing the coolant system on the ’04 and later Prius:

- Disconnect the coolant heat storage water pump connector
- Drain the engine coolant
- Operate the coolant heat storage water pump when refilling to help the inflow of coolant into the tank

Rotary Water Valve

Switches between three positions to control flow of coolant in and out of coolant heat storage system.

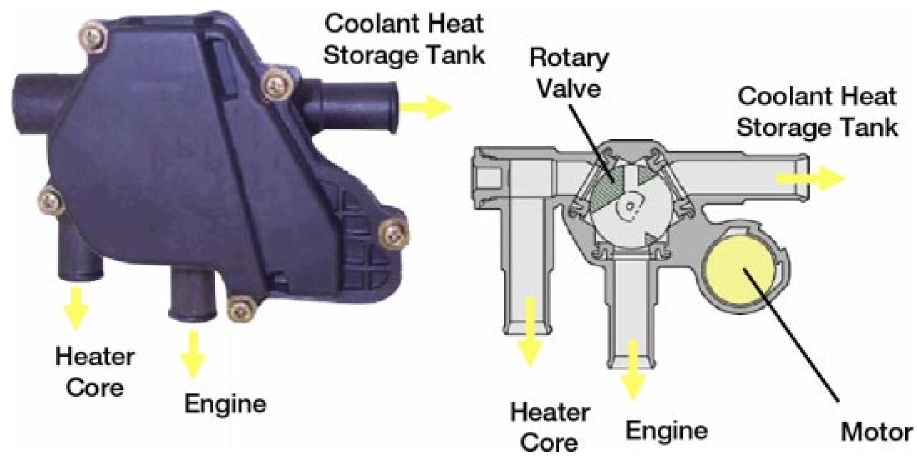

Figure 2.6 T072f206c

Water Valve Positions

Position	Purpose	V DC
Water Flow Valve (VLV)3	Preheat & Storage after Power OFF	2.5V
Water Flow Valve (VLV)4	Storage after Engine ON	3.5V
Water Flow Valve (VLV)5	Engine Warm Up	4.5V

DTC P0300 Random/Multiple Cylinder Misfire

The ECM uses the crankshaft position sensor and camshaft position sensor to monitor changes in the rate of crankshaft rotation as each cylinder fires. The crankshaft accelerates when a cylinder fires and slows down if the cylinder misfires. The ECM counts the number of times that the crankshaft slows down and then indicates that a misfire has occurred. When the misfire rate equals or exceeds the count indicating that the engine condition has deteriorated, the MIL illuminates. If the misfire rate is high enough and the driving conditions will cause catalyst overheating, the MIL blinks when misfire is detected. Below are some basic tips when diagnosing a vehicle with DTC P0300.

Get details from the customer:

- When did the MIL illuminate?
- Did the customer recently refuel? What brand and octane of fuel did they purchase?

NOTE

The Prius is designed to run on 87 octane. The use of premium fuel may cause starting problems.

- With the Diagnostic Tester check and record DTCs and Freeze Frame data.
- Evaluate engine performance while monitoring the Diagnostic Tester. Refer to the DI section of the repair manual to further diagnose symptoms.

Misfire DTCs

When two or more codes for misfiring cylinders are recorded repeatedly, but no random misfire code is recorded, it indicates that the misfires were detected and recorded at different times.

DTC No.	DTC Detecting Condition	Trouble Area
P0300 P0301 P0302 P0303 P0304	Misfiring of random cylinders is detected during any particular 200 or 1,000 revolutions. For any particular 200 revolutions for the engine, misfiring is detected which can cause catalyst overheating (This causes the MIL to blink)	• Open or short in engine wire • Connector connection • Vacuum hose connection • Ignition system • Injector • Fuel pressure • Manifold absolute pressure sensor • Engine coolant temp. sensor • Compression pressure • Valve clearance • Valve timing • ECM • PCV piping

DTC P1128 Throttle Control Motor Lock Malfunction

The throttle motor opens and closes the throttle valve on commands from the ECM. The opening angle of the throttle valve is detected by the throttle position sensor which is mounted on the throttle body. This sensor provides feedback to the ECM in order for the throttle valveopening angle to properly respond to the driving condition. If DTC P1128 is stored, the ECM shuts down the power to the throttle motor and the throttle valve is fully closed by the return spring.

DTC P3190 Poor Engine Performance & DTC P3191 Engine Does Not Start

The ECM receives data from the HV ECU such as engine power output requirement (required output), estimated torque produced by the engine (estimated torque), target engine RPM, and whether the engine is in start mode or not. Then, based on the required output and target RPM, the ECM calculates a target torque that is to be produced by the engine and compares it with the estimated torque. If the estimated torque is low compared to the target torque or if the engine start mode continues at the engine RPM for the duration calculated by water temperature, an abnormal condition is detected.

Some 2001 and 2002 Prius may exhibit a Master, Hybrid and MIL warning if low engine power output is detected during a particular THS drive cycle. After starting the car (READY light ON), P3191 and P3101 with Information Code 205 may set in the engine ECM. After the READY light is ON and the vehicle has transitioned from an electric drive mode to one where the engine power is required, P3190 and P3101 with Information Code 204 may set in the engine ECM and the HV ECU.

Out of Fuel

Many factors can prevent the engine from starting, including the Fuel Injection System, Ignition System, Engine Compression, Air Induction System, and Fuel Quality (Unleaded fuel only). But one of the most common causes is simply running out of gas. Running out of gas on the Prius can cause any of the following DTCs:

- P3190 - Poor Engine Power
- P3191 - Engine Does Not Start
- P3193 - Fuel Run Out
- P0A0F - Engine Failed To Start

NOTE The codes listed above may be recorded alone or in combination.

NOTE If the injectors need to be replaced remember to bleed fuel pressure! If the pressure is not bled the fuel will drain into cylinders and hydrolock will occur!

HC Adsorption Catalyst System (HCAC)

The purpose of the HCAC system on the Prius is to adsorb and retain unburned hydrocarbons (HC) in the exhaust produced by the engine during and following a cold start. The stored HC is then released and purged through the warm three-way catalyst. This improves exhaust emissions at low temperatures.

In the front three-way catalytic converter (TWC) the ceramic matrix wall thickness has been reduced and the passage density increased. This decreases thermal mass and speeds the heating of the catalyst.

Operation

Before the engine is started, the bypass valve is open. When the engine is started the ECM outputs a signal to the HCAC VSV. Vacuum is applied to the HCAC actuator, closing the bypass valve. Immediately after the engine has started the exhaust gases pass through the HC adsorber where HC is stored until the temperature of the HC adsorber rises. This prevents HC from being emitted when catalyst temperatures are low.

After the TWC has warmed up, the VSV closes and the bypass valve opens. Stored HC is now purged and flows through the TWC where it is oxidized.

During deceleration, the VSV is turned on, closing the bypass valve. This scavenges HC that remains in the HC adsorber.

HCAC - Cold Engine

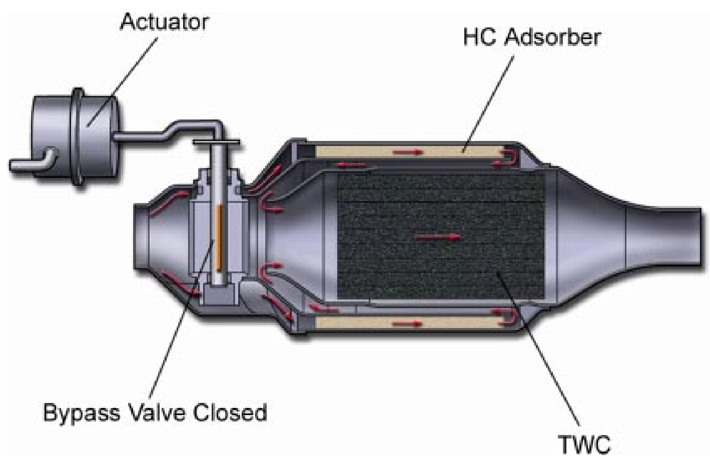

Figure 2.7 T072f207c

HCAC - Purge

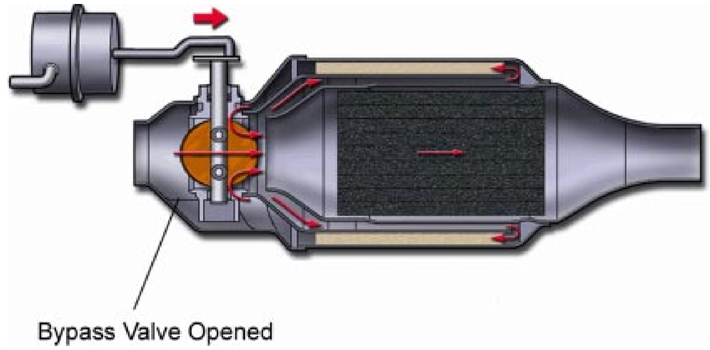

Figure 2.8 T072f208c

HCAC - Scavenge During Deceleration

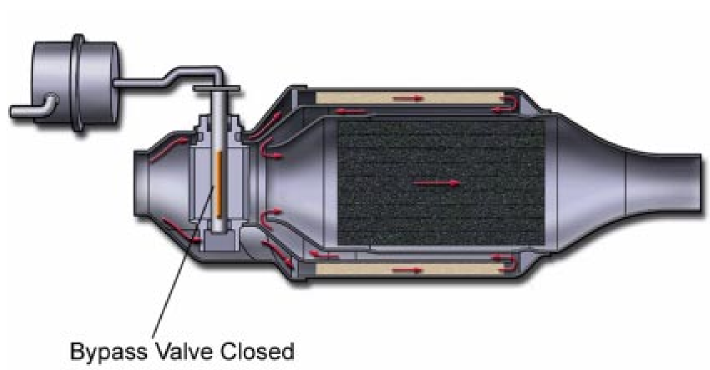

Figure 2.9 T072f209c

DTC P1436 Bypass Valve Malfunction

The system monitors bypass valve operation. DTC P1436 will set if the bypass valve does not perform normally under the following conditions. During a cold start (with coolant and air temperatures starting at -10°C (14°F) to 40°C (104°F) and after coolant temperature has reached at least 45°C (113°F) and the engine load factor exceeds 30%.

Repair Process

Certain 2001 and 2002 model year Prius vehicles that are operated in areas where road salt is used may set DTC P1436. Check the HCAC bypass valve for smooth operation. The front exhaust pipe assembly may have to be replaced if any shaft binding is evident.

DTC P0420 Catalyst System Efficiency

The ECM compares the waveform of the O2 Sensor located before the catalyst (Bank 1, Sensor 1) with the waveform of the O2 Sensor located behind the catalyst (Bank 1, Sensor 2) to determine whether or not catalyst performance has deteriorated.

Below Threshold

A/F ratio feedback compensation keeps the waveform of the O2 Sensor before the catalyst repeatedly changing back and forth from rich to lean.

If the catalyst is functioning normally, the waveform of the O2 Sensor behind the catalyst should be flat and should not mimic the front O2 Sensor. When both waveforms change at a similar rate, it indicates that catalyst performance has deteriorated.

Ask the customer if they have driven through deep water. If the catalyst is submerged, cooling will affect efficiency.

Catalyst Waveform

If the catalyst is normal, the waveform of the O2 Sensor behind the catalyst should be flat and should not mimic the front O2 Sensor.

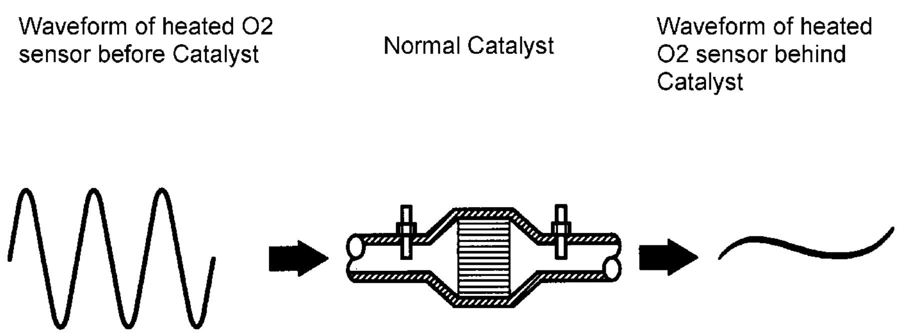

Figure 2.10 T072f210

OX Signal Waveform

Drive the vehicle at >55 mph for >5 minutes. Confirm that the waveform of O2 Sensor, Bank 1 Sensor 1 (OX1) oscillates around 0.5V during feedback to the ECM and that the waveform of O2 Sensor, Bank 1 Sensor 2 (OX2) is relatively constant at 0.6V to 0.7V.

HINT

There are some cases where even though a malfunction exists the MIL may not illuminate. Normal waveform of OX2 is a smooth line of 0.6V or 0.7V.

Check for an open or short in the harness and connector between both heated O2 Sensors and the ECM. If the problem still occurs replace the three-way catalytic converter.

OX Signal Waveform

If there is a malfunction in the system, the waveform of the O2 Sensor, Bank 1 Sensor 2 (OX2) will look similar to the waveform shown here.

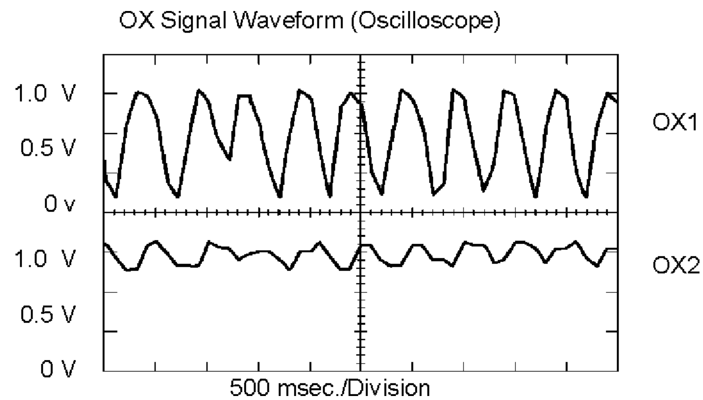

Figure 2.11 T072f211

Normal Engine Operating Conditions

When using the Diagnostic Tester to determine engine control status, refer to the Normal Engine Operation Conditions chart for quick and easy diagnosis. This chart is located in the Appendix of this book.

The values given for “Normal Conditions” are representative values. A vehicle’s engine may still be normal even if its values vary from those listed.

OBD Diagnostic Trouble Codes

The diagnostic system in the Prius performs a variety of functions. The first function is the Diagnostic Trouble Code Check. This test detects malfunctions in the signal circuits connected to the ECU. These malfunctions are stored in ECU memory at the time of the occurrence and are output by the technician during troubleshooting.

Another function is the Input Signal Check which checks to see if signals from various switches are correctly sent to the ECU. By using these check functions the problem areas can be narrowed down quickly and troubleshooting can be performed effectively. Diagnostic functions are incorporated in the following systems in the Prius.

System Confirmation and Diagnostic Trouble Code Check

System	Diagnostic Trouble Code Check	Input Signal Check (Sensor Check)	Diagnostic Test Mode (Active Test)
SFI System	O (w/ Check Mode)	O	O
Hybrid Control System	O		O
HV Battery System	O		O
Electronically Controlled Brake System	O	O	O
Shift Control System (Parking Lock Control)	O		
Electronic Power Steering System	O	O	
Air Conditioning System	O		O
Supplemental Restraint System	O	O	
Audio System	O	O	
Navigation System		O	
Power Window Control System	O		O
Power Door Lock Control System	O		O
Smart Entry System			O
Wireless Door Lock Control System	O		O
Engine Immobilizer System	O		O
Push Button Start System	O		O
Multiplex Communication System	O		
CAN Communication System	O		O
Cruise Control System	O		O

When performing the Diagnostic Trouble Code check it is important to determine whether the problem indicated by the DTC is present or occurred in the past and has returned to normal. The DTC should be checked before and after the symptom confirmation to determine the current conditions as shown in the following figure.

If this procedure is not followed it may result in unnecessary troubleshooting for normally operating systems, make it more difficult to locate the problem or cause unnecessary repairs. Always follow the procedure in the correct order and perform the DTC check.

Diagnostic Trouble Code Check Procedure

<table>
<tr><th>Diagnostic Trouble Code Chart (make a note of DTC and then clear)</th><th>Confirmation of Symptoms</th><th>Diagnostic Trouble Code Check</th><th>Problem Condition</th></tr>
<tr><td rowspan="3">Diagnostic Trouble Code Display</td><td rowspan="2">Problem symptoms exist</td><td>Same DTC is displayed</td><td>Problem still occurring in the diagnostic circuit</td></tr>
<tr><td rowspan="2">Normal code is displayed</td><td>Problem still occurring in a place other than in the diagnostic circuit (The DTC displayed first is either for a past problem or it is a secondary</td></tr>
<tr><td>No problem symptom exists</td><td>Problem occurred in the diagnostic circuit in the past</td></tr>
<tr><td rowspan="2">Normal code display</td><td>Problem symptoms exists</td><td>Normal code is displayed</td><td>Problem still occurring in a place other than in the diagnostic circuit</td></tr>
<tr><td>No problem symptom exists</td><td>Normal code is displayed</td><td>Problem occurred in a place other than in the diagnostic circuit in the past</td></tr>
</table>

DTC Cycles

OBD II Trouble Codes have been standardized by the SAE. They indicate the circuit and the system in which a fault has been detected. When a malfunction occurs and meets the criteria to set a DTC, the MIL illuminates and remains illuminated as long as the fault is detected. Once the condition returns to normal the MIL will be turned off after 3 warm-up cycles. The DTC remains stored for 40 drive cycles. After 40 cycles the code will automatically be erased, but will remain in ECM history until cleared.

Data List & Extended Data List

When selecting **OBD/MOBD** the **Data List** mode located under the **Engine and ECT** screen provides access to current engine related data. All input values displayed are current values. Extended Data is also available under the same **Engine and ECT** screen. This mode contains even more engine related real-time data.

Data List vs. Extended Data List

The Extended Data List contains more diagnostic information.

Data List

```
INJECTOR.................0.0ms
IGN ADVANCE.............5.0deg
CALC LOAD...................0%
MAF......................0gm/s
ENGINE SPD................0rpm
COOLANT TEMP...........145.4°F
INTAKE AIR..............98.6°F
THROTTLE POS...............14%
VEHICLE SPD...............0MPH
O2S B1 S1................0.00V
O2S B1 S2................0.00V
SHORT FT #1..............-0.1%
LONG FT #1................1.5%
TOTAL FT #1...............1.01
O2FT B1 S1...............-0.1%
FUEL SYS #1.................OL
FUEL SYS #2.............UNUSED
MIL.........................ON
O2 LR B1 S1................0ms
O2 RL B1 S1................0ms
A/C CUT SIG.................ON
FUEL PUMP / SPD........OFF/M,L
EVAP VSV...................OFF
VVT CTRL B1................OFF
IGNITION.....................0
CYL #1......................0%
CYL #2......................0%
CYL #3......................0%
CYL #4......................0%
BATTERY..................11.8V
INJECTOR.................0.0ms
INJ VOL FB................1.09
FUEL FB COEF..............1.01
A/F LEARN.................1.5%
PURGE LEARN...............0.0%
KCS FEEDBACK..............0.0°
REQ ENG POWER..............0KW
RAM MONITOR.............INCMPL
ENG RUN SIG................OFF
ACC RACING SIG.............OFF
ENG WARM UP SIG.............ON
ENG RUN PERM...........PROHIBT
FC STATUS................*UNK*
ENG STP LIMIT..........ISC LRN
```

Extended Data List

```
INJECTOR.................0.0ms
IGN ADVANCE.............5.0deg
CALC LOAD...................0%
MAF......................0gm/s
ENGINE SPD................0rpm
COOLANT TEMP...........143.6°F
INTAKE AIR..............98.6°F
THROTTLE POS...............50%
VEHICLE SPD...............0MPH
THROTTLE POS #2..........0.00V
THROTTLE TARGT...........0.00V
THROTL OPN DUTY.............0%
THROTL CLS DUTY.............0%
THROTTLE MOT...............OFF
ETCS MAG CLUTCH............OFF
+BM........................OFF
ACCEL IDL POS..............OFF
THROTTL IDL POS............OFF
FAIL #1....................OFF
FAIL #2....................OFF
THROTTL INITIAL..........0.00V
THROTTLE MOT..............0.0A
O2S B1 S1................0.01V
O2S B1 S2................0.76V
VAPOR PRESS..........731mmHg-a
SHORT FT #1..............-0.1%
LONG FT #1................1.5%
TOTAL FT #1...............0.50
O2FT B1 S1...............-0.1%
FUEL SYS #1.................OL
FUEL SYS #2.............UNUSED
MIL.........................ON
O2 LR B1 S1................0ms
O2 RL B1 S1................0ms
A/C CUT SIG................OFF
FUEL PUMP / SPD........OFF/M,L
EVAP VSV...................OFF
VVT CTRL B1................OFF
IGNITION.....................0
CYL #1......................0%
CYL #2......................0%
CYL #3......................0%
CYL #4......................0%
MISFIRE RPM...............0rpm
MISFIRE LOAD.........0.00g/rev
O2 RL B1 S2................0ms
# CODES......................0
CHECK MODE.................OFF
40 CYCLES................COMPL
SPD TEST.................COMPL
NSW TEST.................COMPL
AS TEST..................COMPL
MISFIRE TEST.............COMPL
OXS2 TEST................COMPL
OXS1 TEST................COMPL
#CARB CODES.................02
OBD CERT..................OBD2
EGR MON..................COMPL
O2S(A/FS) HTR...........INCMPL
O2S(A/FS) MON...........INCMPL
A/C MON..................COMPL
2nd AIR MON..............COMPL
EVAP MON................INCMPL
HTD CAT MON..............COMPL
CAT MON.................INCMPL
BATTERY..................11.8V
INJECTOR.................0.0ms
INJ VOL FB................1.09
FUEL FB COEF..............1.01
A/F LEARN.................1.5%
PURGE LEARN...............0.0%
KCS FEEDBACK..............0.0°
REQ ENG POWER..............0KW
RAM MONITOR.............INCMPL
ENG RUN SIG................OFF
ACC RACING SIG.............OFF
ENG WARM UP SIG.............ON
ENG RUN PERM...........PROHIBT
FC STATUS................*UNK*
ENG STP LIMIT..........ISC LRN
```

Figure 2.12 T072f212

Using Freeze Frame Data

The Freeze Frame data screen provides information on conditions that were present at the time the DTC was recorded in memory. By recreating the vehicle speed, engine RPM and engine load, as well as other conditions, the technician can verify the customer's concerns.

NOTE Print the freeze frame data before deleting the code(s)! The TAS line needs this information in order to assist you.

Accessing Freeze Frame Data

The Diagnostic Tester screens show a stored DTC. Freeze Frame Data can be viewed when the DTC has an asterisk (*) next to it.

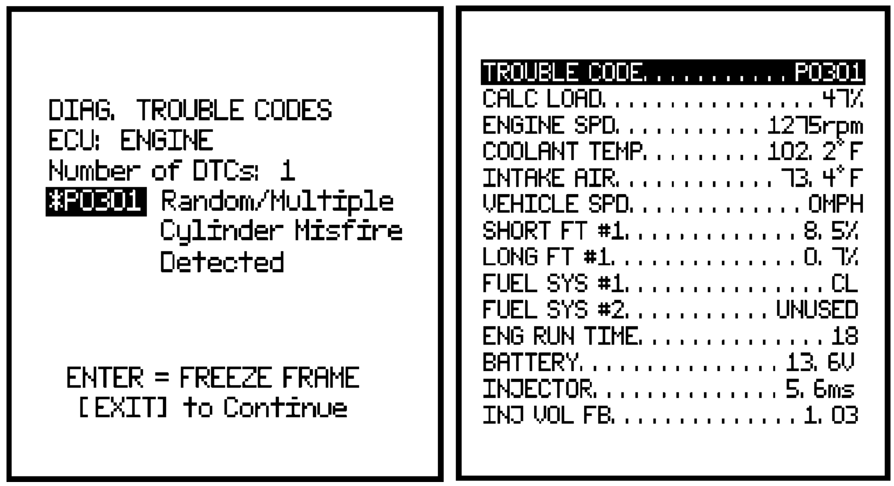

Figure 2.13 T072f213

Engine Active Tests

The Prius has a unique way of performing a compression test. Using the Diagnostic Tester, go to **HV ECU Active Test**. Select **Cranking Request** on the tester and when ready, turn the ignition key to start. The engine will crank at 250 rpm and will allow for the measurement of compression pressure. If there is lack of power, excessive oil consumption or poor fuel economy, measure the compression pressure.

To perform an Idle Speed inspection activate **Inspection Mode** on the Diagnostic Tester, **Active Test**. Follow the procedures of the tester to check the idle speed, which should be 1,000 ± 50 rpm with the cooling fan OFF.

WORKSHEET 2-1
Coolant Heat Storage Tank

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

This worksheet will help you diagnose the Coolant Heat Storage Tank and the electric Coolant Heat Storage Water Pump on the 2004 and later Prius.

Tools and Equipment

- Vehicle
- Diagnostic Tester
- Repair Manual or TIS
- New Car Features

Section 1: Components

1. Raise the vehicle and locate the Coolant Heat Storage Tank.
2. When changing the engine coolant, what drain valve(s) are used to completely drain the system?
3. Locate the water valve. What is the purpose of the water valve?

Section 2: System Activation

1. Even when the engine is cold, why must you be careful when working on the cooling system?

2. When servicing the cooling system, what should always be disconnected?

3. Connect the Diagnostic Tester to DLC3.

4. Select Engine and ECT, Active Test and then Water Pump. Turn on the water pump.

5. When replacing the engine coolant, why does the electric water pump need to be activated with the Diagnostic Tester?

6. What will cause DTC P1151 or P2601 to be stored?

7. List the other cooling system component that can be controlled by the Active Tests.

8. Listen to the water valve as you activate each valve position with the Diagnostic Tester. Did the valve activate to all three positions?

Refer to the Technician Handbook to answer the following questions.

9. List the function of each individual valve position below.

10. When diagnosing the valve positions, what are the proper voltage readings to look for?

Return all cars to the original state and return to the classroom.

Notes

WORKSHEET 2-1
Coolant Heat Storage Tank

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

This worksheet will help you diagnose the Coolant Heat Storage Tank and the electric Coolant Heat Storage Water Pump on the 2004 and later Prius.

Tools and Equipment

- Vehicle
- Diagnostic Tester
- Repair Manual or TIS
- New Car Features

Section 1: Components

1. Raise the vehicle and locate the Coolant Heat Storage Tank.

2. When changing the engine coolant, what drain valve(s) are used to completely drain the system?

____

____

____

3. Locate the water valve. What is the purpose of the water valve?

____

____

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9. List the function of each individual valve position below.

10. When diagnosing the valve positions, what are the proper voltage readings to look for? **Return all cars to the original state and return to the classroom.**

Return all cars to the original state and return to the classroom.

Notes

WORKSHEET 2-2
Engine Active Tests

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

In this worksheet you will use Inspection Mode and the Diagnostic Tester to perform a compression test and an idle speed inspection.

Tools and Equipment

- Vehicle
- Repair Manual or TIS
- Diagnostic Tester
- Compression Gauge

Section 1 - Compression Test

1. Allow the engine to warm up to normal operating temperature. Stop the engine.
2. Remove the air cleaner assembly, the ignition coils and the spark plugs.
3. Connect the Diagnostic Tester to DLC 3.
4. Go to OBD/MOBD, HV ECU, ACTIVE TEST, CRANKING RQST.
5. Insert a compression gauge into the spark plug hole.
6. Follow the Diagnostic Tester’s on-screen instructions.
7. Turn CRANKING RQST ON and then start the vehicle. If the engine stops, hold the accelerator pedal to finish the test.

Note: In Cranking Mode, the engine speed is automatically controlled at 250 rpm and the throttle valve is also automatically opened fully. This measurement must be done in as short a time as possible.

8. Record the cranking compression pressure for each cylinder:

9. To stop cranking, turn the ignition key to OFF. On the Diagnostic Tester, press the EXIT button.

10. Using TIS or the Repair Manual, what is the specification for compression pressure? Minimum pressure? Difference between each cylinder?

____

____

____

11. Compare your measurements with the specifications. Are all cylinder compression pressures acceptable? If NO, explain:

____

____

____

Reinstall the spark plugs, ignition coils and air cleaner assembly.

Section 2 - Idle Speed Inspection

1. Place the vehicle in Park and engage the emergency brake. This test will only work with the emergency brake engaged. Turn the A/C switch OFF.

2. Start the vehicle and warm up the engine. Race the engine at 2,250 rpm for about 90 seconds.

3. Using the Diagnostic Tester, go to OBD/MOBD, HV ECU, ACTIVE TEST, INSPECTION MODE and follow the on-screen instructions.

4. Turn Inspection Mode ON, and then start the vehicle. This mode allows the engine to continuously run.

Note: When the accelerator pedal position is depressed 60% or greater, the engine speed is controlled at 2,250 rpm.

5. What warning light is ON?

   ____

6. Why do you think this warning light is ON?

   ____

7. What is the specified idle speed with cooling fan off?

   ____

8. Allow the engine to idle. What is the idle speed?

   ____

9. List two possible causes for the low engine idle speed:

   ____

   ____

   ____

Note: The Idle Speed Inspection test allows for maintenance inspections such as IG Timing, Noise Isolation, etc.

Section 2a - Idle Speed Inspection Without Diagnostic Tester

1. Perform the following steps (2 - 5) within 60 seconds.
2. Turn the Power switch ON.
3. Fully depress the accelerator pedal twice while in Park.
4. Fully depress the accelerator pedal twice while in Neutral.
5. Fully depress the accelerator pedal twice with the transmission while in Park.
6. What error warning light is now flashing?
7. Is this normal?

   ___

8. Start the vehicle (READY ON).
9. Where in the Repair Manual is this information found?

   ___

10. Turn Inspection Mode OFF. Driving the vehicle without deactivating Inspection Mode may damage the transaxle.

Return the vehicle to Its normal condition.

Fuel and EVAP System

Overview

The EVAP system is designed to store and dispose of fuel vapors normally created in the fuel system and to help prevent their escape into the atmosphere.

The returnless fuel system helps reduce these evaporative emissions. Integrating the pressure regulator and the fuel filter with the fuel pump assembly has made it possible to discontinue the return of fuel from the engine area and prevent temperature rise inside the fuel tank.

Regulations require that the EVAP system be monitored for system performance and leak detection. Measuring the pressure of the EVAP system at various stages checks leaks, restrictions and components.

Bladder Fuel Tank

A bladder fuel tank is used to reduce fuel vapors generated when the vehicle is parked, during refueling or while driving. This system includes a resin vapor reducing fuel storage tank within a sealed metal outer tank. The resin tank expands and contracts with the volume of the fuel. By reducing the space in which fuel can evaporate, fuel vapors are minimized.

NOTE

At low ambient temperatures the capacity of the vapor reducing fuel tank is reduced due to the resin material from which it is made. If the outside temperature is at 14°F (-10°C) the size of the tank is reduced by approximately five liters.

Fuel Bladder

The resin bladder in the Prius fuel tank expands and contracts with the changing quantity of fuel.

Figure 3.1 T072f301c

Fuel Gauge

The direct acting fuel gauge is located in the sub tank. This gauge consists of a pipe surrounded by a coil. A float in the pipe moves up and down with changes in the fuel level. A magnet is attached to the float. The up and down movement of the float causes a change in the magnetic field. The flow of current through the coil creates a potential difference and the resultant voltage is transmitted to the meter ECU.

NOTE

The fuel pump module assembly is integral with the fuel tank and is not serviced separately.

Inclination Sensors

There are two inclination sensors located in the meter ECU to detect vehicle longitudinal and latitudinal inclinations and to correct the fuel level calculation. Corrections are made by the signals from the inclination sensors and the ambient temperature sensor located in the fuel tank.

The inclinometer must be reset if the customer complains that they can only pump a few gallons of gas into their tank or that they run out of gas with three or four bars left on the fuel meter. The inclinometer must also be reset if the Prius is refilled on an excessive slope or if the fuel gauge becomes inaccurate. Please refer to the Prius Repair Manual for the inclinometer calibration procedure.

Fuel Gauge Inclination Sensors

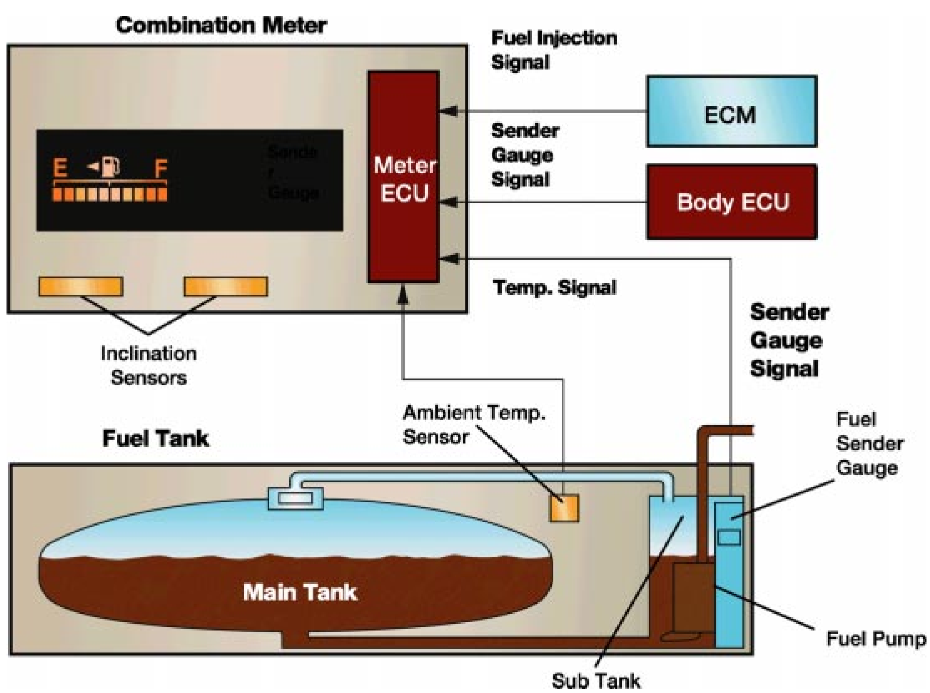


Figure 3.2 T072f302c

Fuel Capacity

Variations in the size and shape of the bladder fuel tank change the overall capacity of the tank. As fuel is added during refueling the bladder expands. Actual fuel capacity varies for several reasons.

- Temperature of the bladder - A cold bladder is stiff and will not expand to maximum capacity.
- Temperature of the fuel - Cold fuel will expand the bladder less, hot fuel more.
- Nozzle fit in the Prius filler neck - The Prius fuel filler neck is equipped with a rubber seal to improve bladder expansion with gas pump pressure. Some gas pump nozzles may be dented, scratched or gouged. Poor fit of the pump nozzle in the filler neck reduces fuel tank capacity.
- Overfilling - Trying to force additional fuel into the tank pushes excess fuel into the EVAP system. This may cause an EVAP DTC and may even require the replacement of some EVAP system components.

Energy Monitor

The Energy Monitor which includes a historical bar graph and total trip fuel economy (MPG) is very accurate. Multiple, comparative calculations are performed by several computers.

Fuel usage and fuel economy are calculated by monitoring fuel injector duration and operating frequency. The ECU compares these values with miles traveled to calculate miles per gallon.

The battery ECU closely monitors energy consumption in Watts. By calculating the amount of energy spent, recovered and stored, the computer can calculate the required fuel burn. Fuel required to create this amount of energy is compared against the engine ECU fuel injection calculation to insure accuracy.

Driving pattern, speed and load characteristics are stored in the HV ECU as “Historical Data”. Historical Data is used to further refine the MPG calculation. This data takes from three to six weeks to accumulate after “battery disconnect” or computer replacement.

Fuel Type

Use only UNLEADED gasoline in the Prius. The Prius has a smaller fuel tank opening to help prevent nozzle mix-ups. The special nozzle on pumps with unleaded fuel will fit, but the larger standard nozzle on pumps with leaded gas will not.

Octane Rating

At a minimum, the gasoline used should meet the specifications of ASTM D4814 in the United States. For the Prius, use only UNLEADED gasoline with an Octane Rating 87.

NOTE Do not use premium gasoline. It may cause starting problems with the Prius. There is no gas mileage benefit when using premium gas!

NOTE Starting may occur many times in a single drive cycle unlike conventional vehicles compounding potential “hot soak” issues.

Evaporative System Control

A vacuum test method has been adopted to detect leaks in the EVAP system. This method detects leaks by introducing the purge vacuum into the entire system and monitoring changes in pressure.

In order to detect EVAP leaks from the vapor reducing fuel tank, a density method has been adopted. This system uses an O2 sensor to measure HC density in the exhaust gases in order to detect leaks. Added HC from a leak will cause a reduction in exhaust oxygen content.

EVAP Parts Location

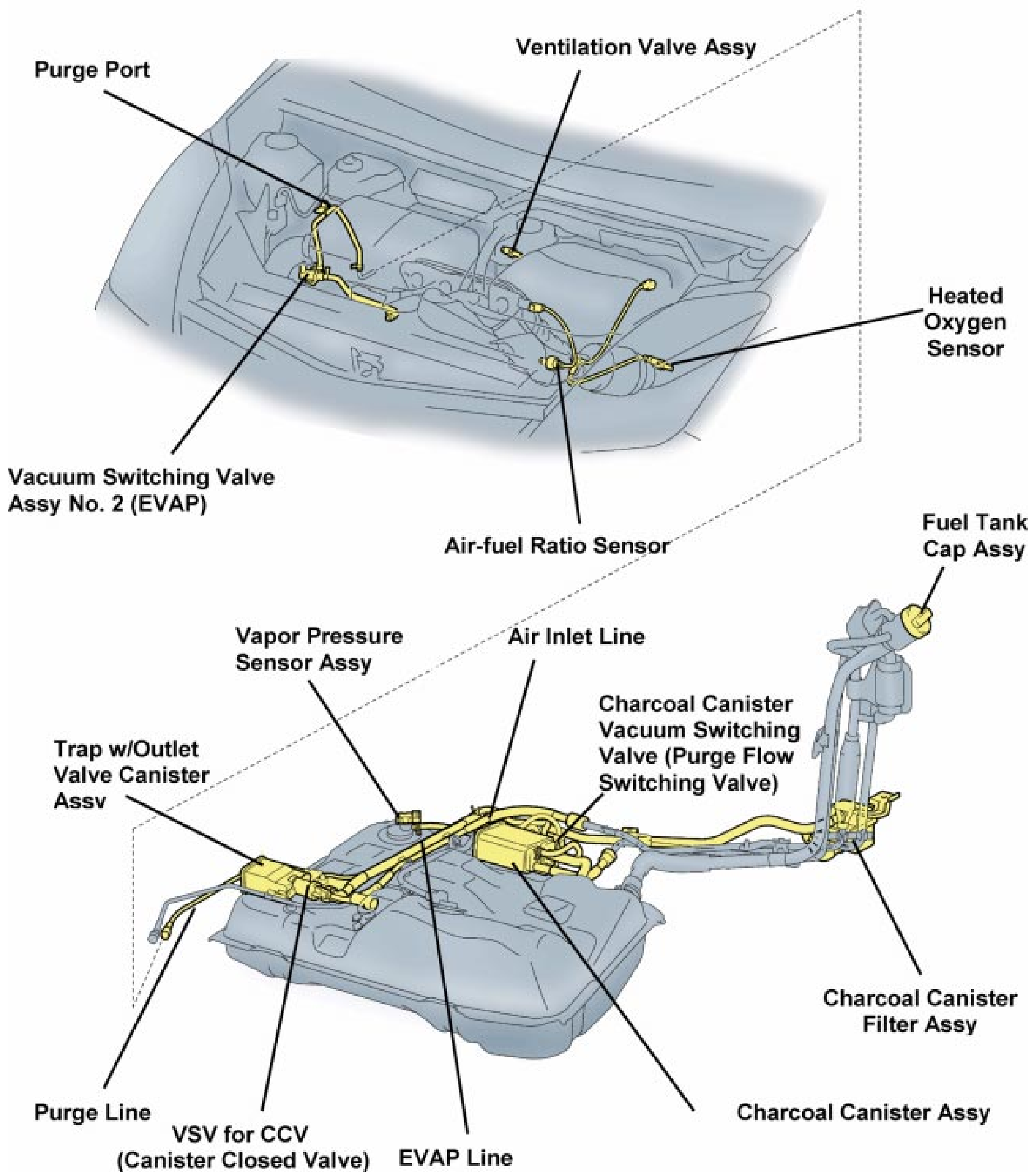


Figure 3.3 T072f303c

EVAP Components

The EVAP system consists of the following main components:

Canister Closed Valve

Canister Closed Valve VSV - This **normally open** valve is located between the fresh air line and the fuel tank. This VSV stops airflow into the EVAP system to seal the system and enable leak detection. It is also known as the CAN CTRL VSV or the CCV VSV.

Canister Closed Valve Location

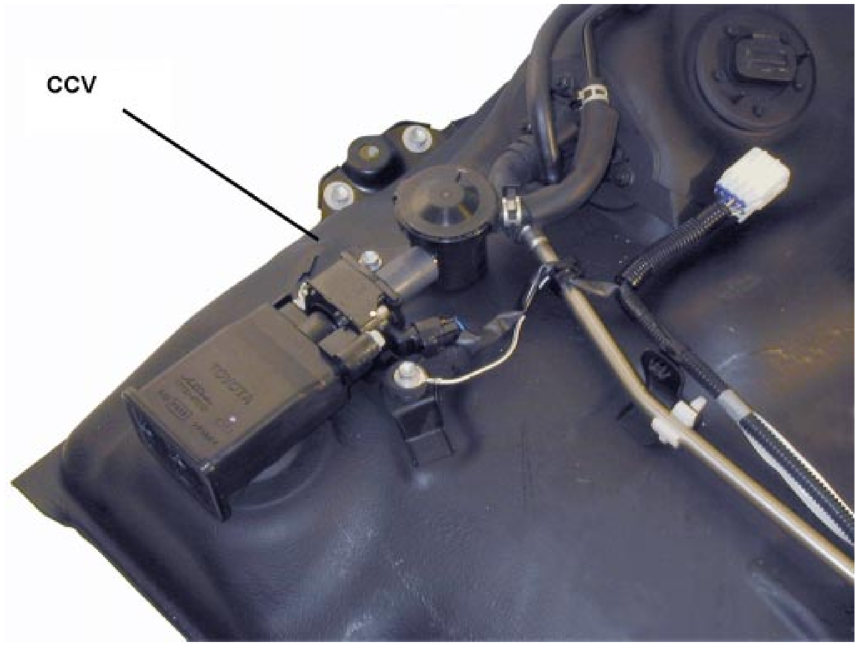


Figure 3.4 T072f304c

Fresh Air Valve Allows air to exhaust from the system during ORVR refueling. The valve is located near the Canister Closed Valve.

Fresh Air Valve Location

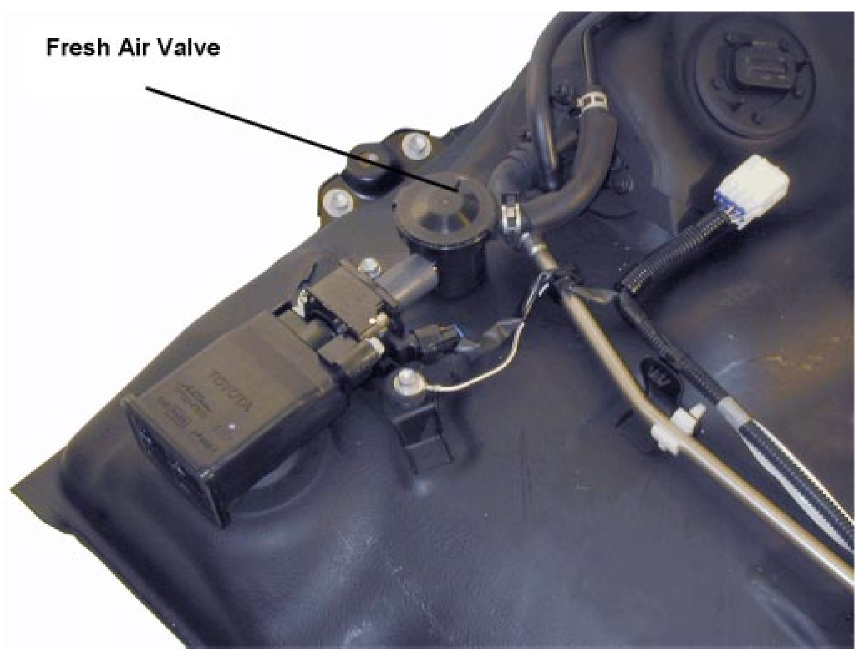


Figure 3.5 T072f305c

The Purge Flow Switching Valve

The Purge Flow Switching Valve VSV - This **normally open** VSV is located on the charcoal canister. It allows vacuum from the EVAP VSV (or Purge VSV) to flow through the canister. When activated by the ECM during internal fuel bladder leak detection, it switches airflow from the canister to the outer tank bladder only. This VSV is also known as the Tank Bypass VSV when using the Diagnostic Tester.

Purge Flow Switching Valve Location

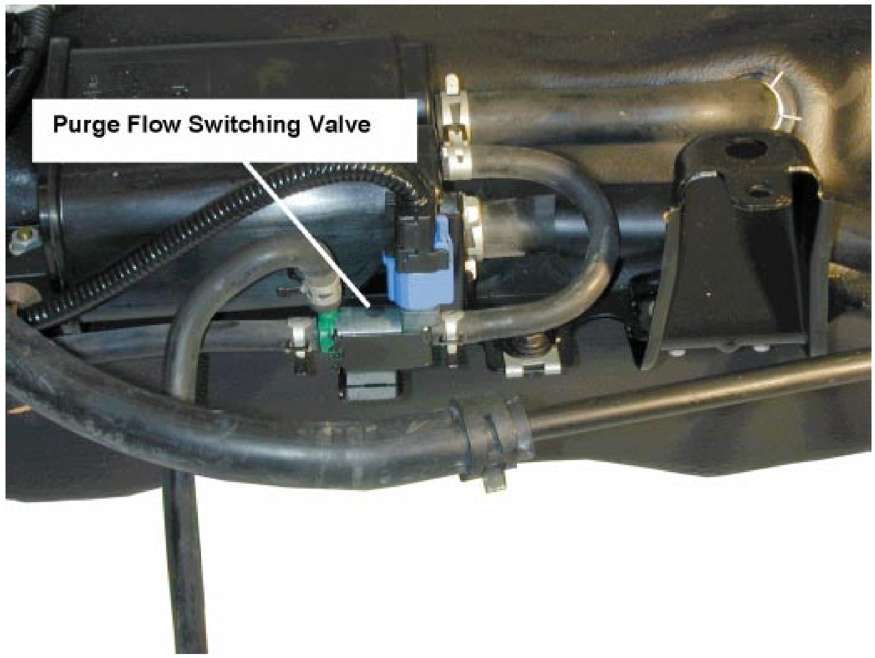


Figure 3.6 T072f306c

EVAP (Alone)

EVAP (Alone) VSV - This **normally closed** VSV is duty-cycle controlled by the ECM. It is used to control engine vacuum to the EVAP system in order to remove stored hydrocarbons from the charcoal canister. It’s also used for system leak detection and may be referred to as the Purge VSV.

EVAP VSV Location

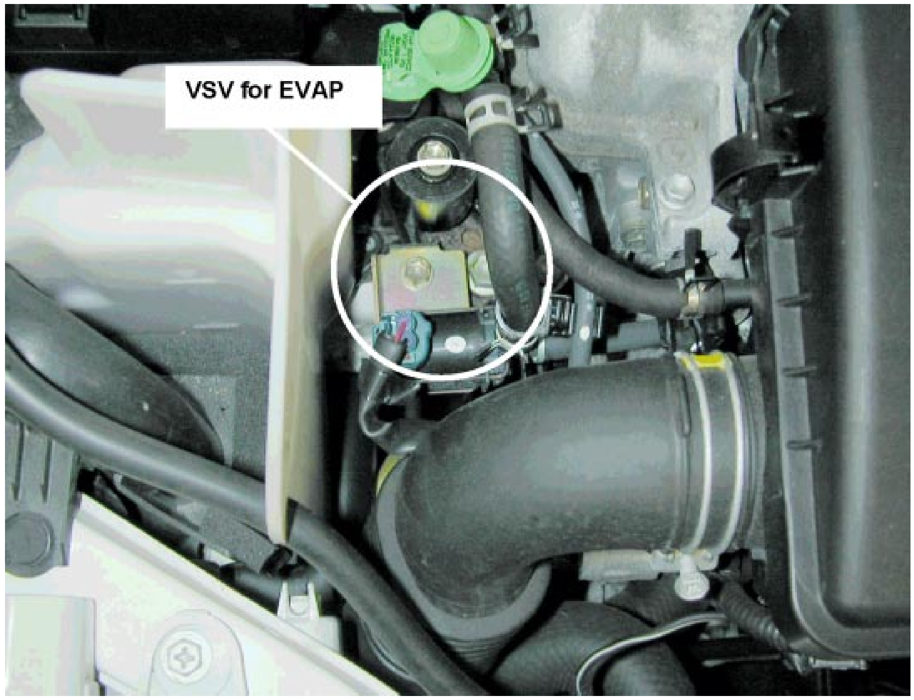


Figure 3.7 T072f307c

Vapor Pressure Sensor

Vapor Pressure Sensor (VPS) - The VPS is located on the fuel tank to precisely measure the vapor pressure in the EVAP system. The ECU provides a 5V signal and ground to the Vapor Pressure Sensor. The VPS sends a voltage signal back to the ECU, which varies between 0.1V - 4.9V in response to tank pressure.

NOTE

Check all hoses for proper connection, restrictions and leaks. Apply the specified pressure and check voltage output. The VPS is calibrated for the pressure found in the EVAP system. Apply the specified amount to prevent damaging the sensor.

Vapor Pressure Sensor Location

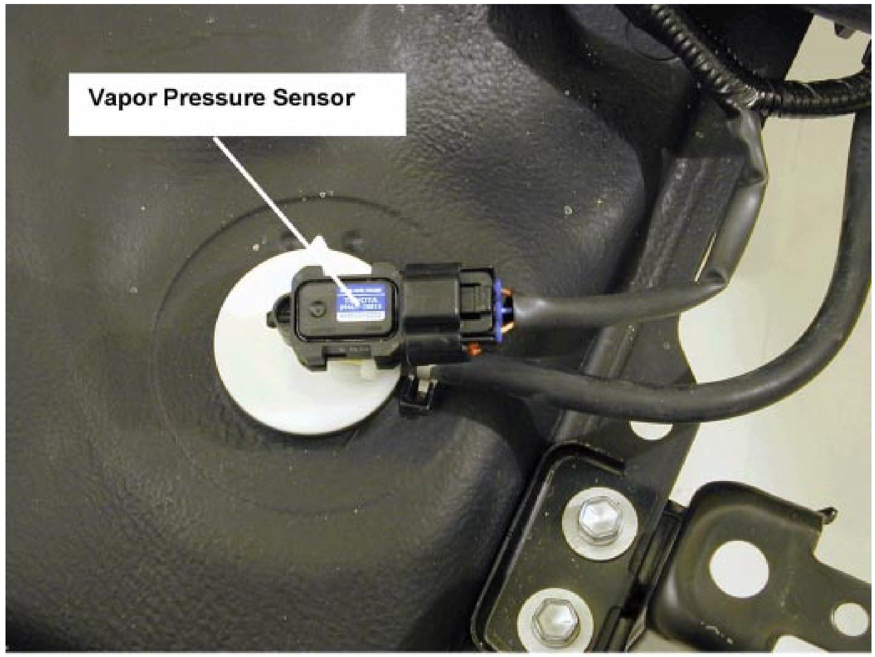


Figure 3.8 T072f308c

Fuel Cutoff Valve Fuel Cutoff Valve - Located on the upper end of the fuel filler pipe. Causes the filler nozzle to shut off when the fuel tank is full to prevent overfilling.

Fuel Cutoff Valve Location

Figure 3.9 T072f309c

Fuel Check Valve Refuel Check Valve - Located on the upper end of the fuel filler pipe. An anti-siphon valve which prevents fuel from entering EVAP system lines.

Refuel Check Valve Location

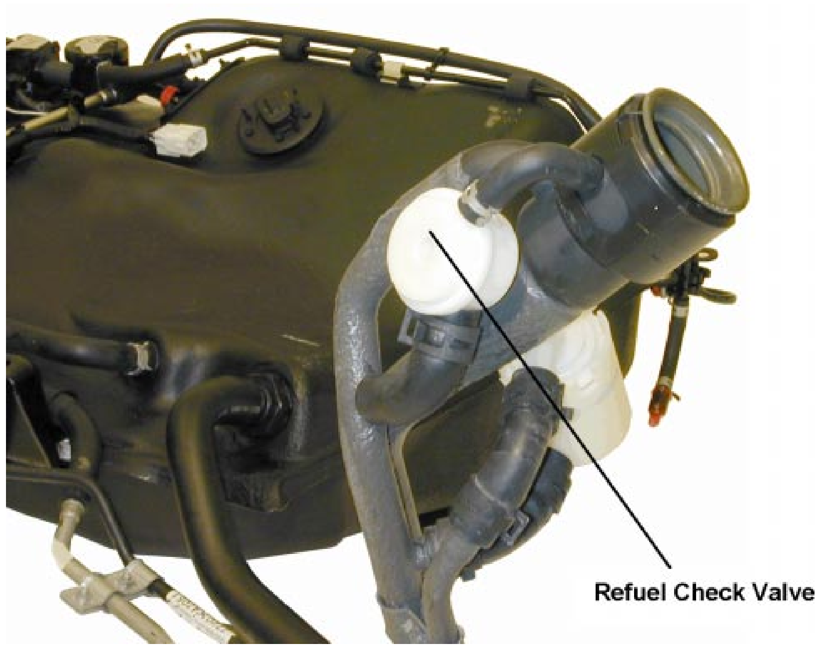


Figure 3.10 T072f310c

NOTE

The following VSVs are referred to by several different names in some Toyota repair information:

- CAN CTRL VSV - Canister Closed Valve or CCV VSV
- Tank Bypass VSV - Purge Flow Switching Valve
- EVAP VSV (Alone) - Purge VSV

EVAP Control Components

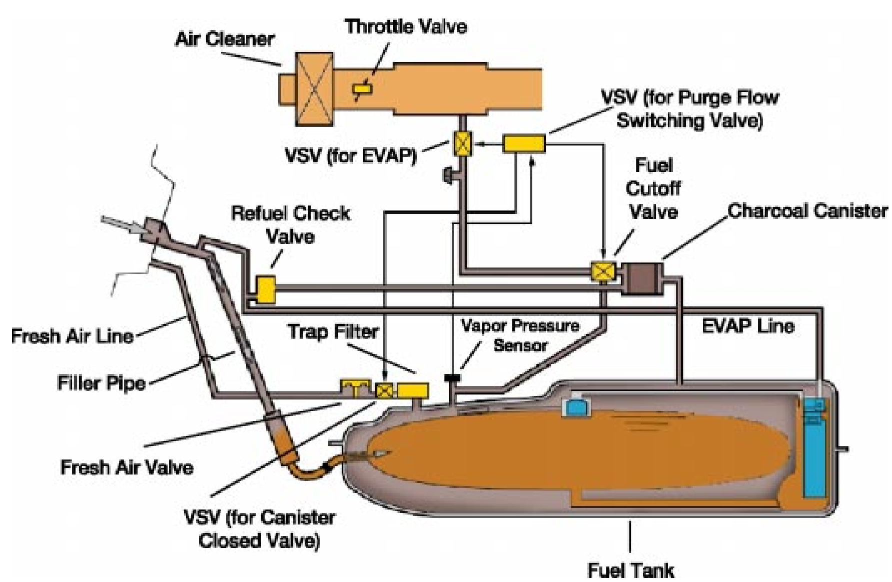


Figure 3.11 T072f311c

Operation - ORVR Refueling

When refueling, the engine is OFF and the EVAP VSV is CLOSED (OFF). The resin bladder expands as fuel enters, so there is virtually no vapor space above the fuel. Hydrocarbon (HC) vapor flows from the secondary tank and fuel pump through the EVAP line to the charcoal canister. The HC is absorbed by and stored in the charcoal canister.

Air flows from the charcoal canister to the airspace between the metal outer tank and bladder and to the Canister Closed Valve. The Canister Closed Valve (CCV) is OPEN, allowing air to exit from the Fresh Air Valve. The Refuel Check Valve and Fuel Cutoff Valve work together to prevent overfilling and liquid fuel from entering the charcoal canister.

ORVR Refueling

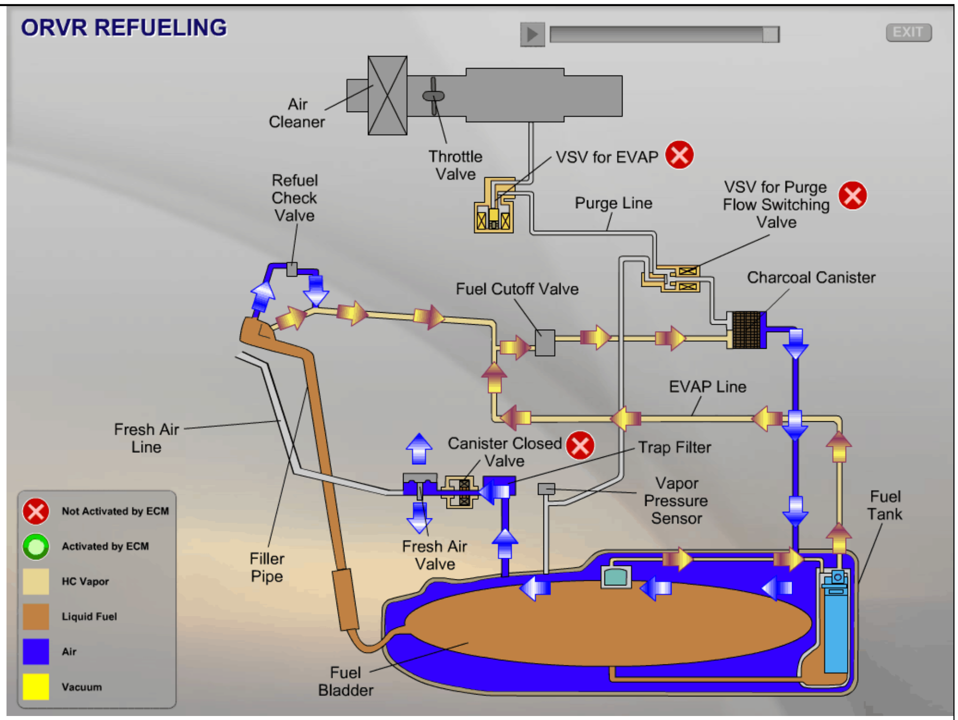


Figure 3.12 T072f312c

Purging

During normal purge operation the engine is running and the ECM duty cycles the EVAP VSV ON and OFF, allowing vacuum from the intake manifold to pull air through the EVAP system. The Purge Flow Switching Valve is OFF, opening the connection between the charcoal canister and the EVAP VSV. HC vapor flows from the charcoal canister to the EVAP VSV and into the intake manifold.

The Canister Closed Valve (CCV) is OPEN, allowing fresh air to enter from the air cleaner and flow through the airspace between the metal outer tank and bladder and up to the charcoal canister. As this air passes through the canister, it purges the HC.

Purging

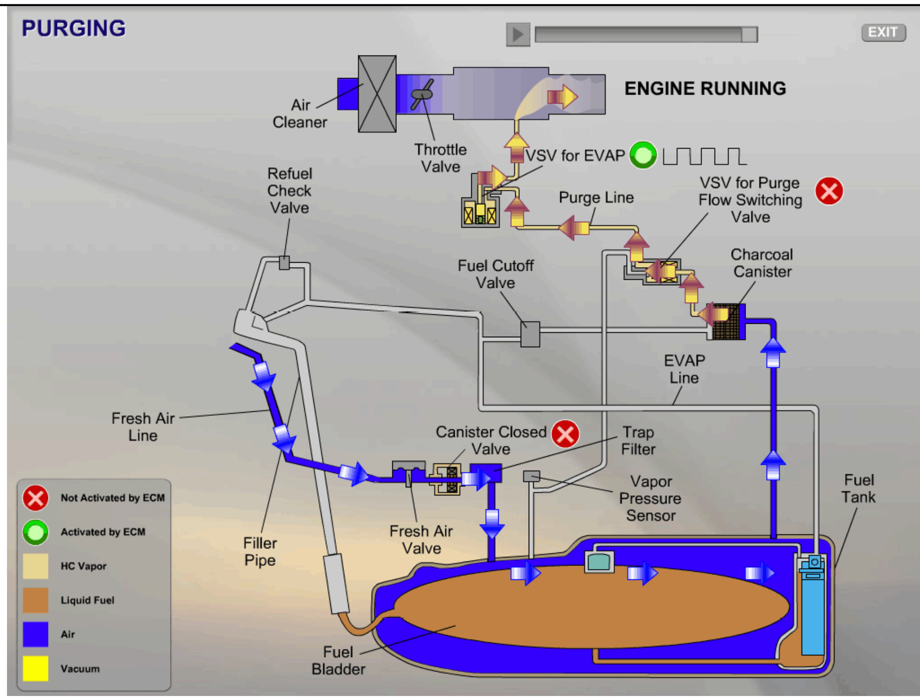


Figure 3.13 T072f313c

Tank Bladder Leak Check

To monitor the tank bladder for internal leaks the ECM controls the VSVs similar to purging except that the Purge Flow Switching VSV is activated (ON). The airflow then switches from flowing through the canister to flowing only to the outer bladder of the tank. If there is a leak in the inner tank the fuel vapor will create a rich engine condition. The O2 sensor measures the presence of HC in the exhaust gases. If the O2 sensor indicates a rich condition, a leak is assumed and the MIL will illuminate.

During the tank bladder leak check the engine is running. The EVAP VSV is turned ON and OFF on a duty cycle. The Canister Closed Valve (CCV) is OPEN, allowing fresh air to flow from the air cleaner through the airspace between the metal outer tank and bladder and to the Vapor Pressure Sensor, the EVAP VSV and intake manifold.

Tank Bladder Leak Check

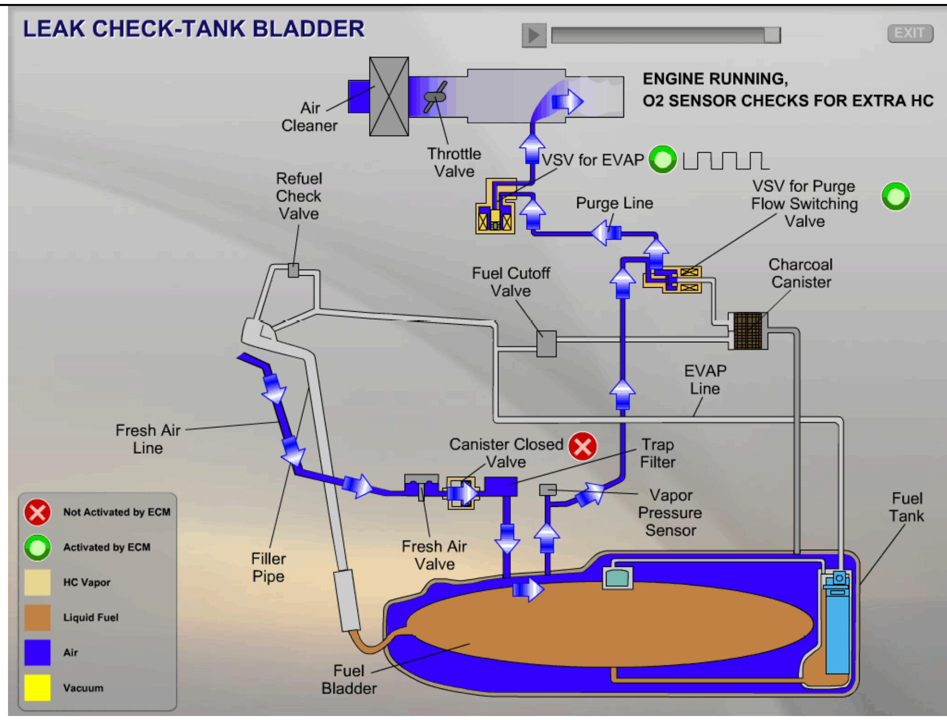


Figure 3.14 T072f314c

Leak Check Complete System

A leak check of the complete EVAP system is performed with the engine running. The Canister Closed Valve is CLOSED and the Purge Flow Switching Valve is OFF, opening the connection between the charcoal canister and the EVAP VSV.

The EVAP VSV is OPEN (ON) until EVAP system pressure drops at least 20mmHg. This should take no more than 10 seconds. The EVAP VSV then CLOSES to seal the system and the Vapor Pressure Sensor monitors system pressure. If pressure rises too rapidly, a leak is assumed. A DTC is set if the leak exceeds a hole diameter of 1mm (0.040 in.).

Leak Check Complete System

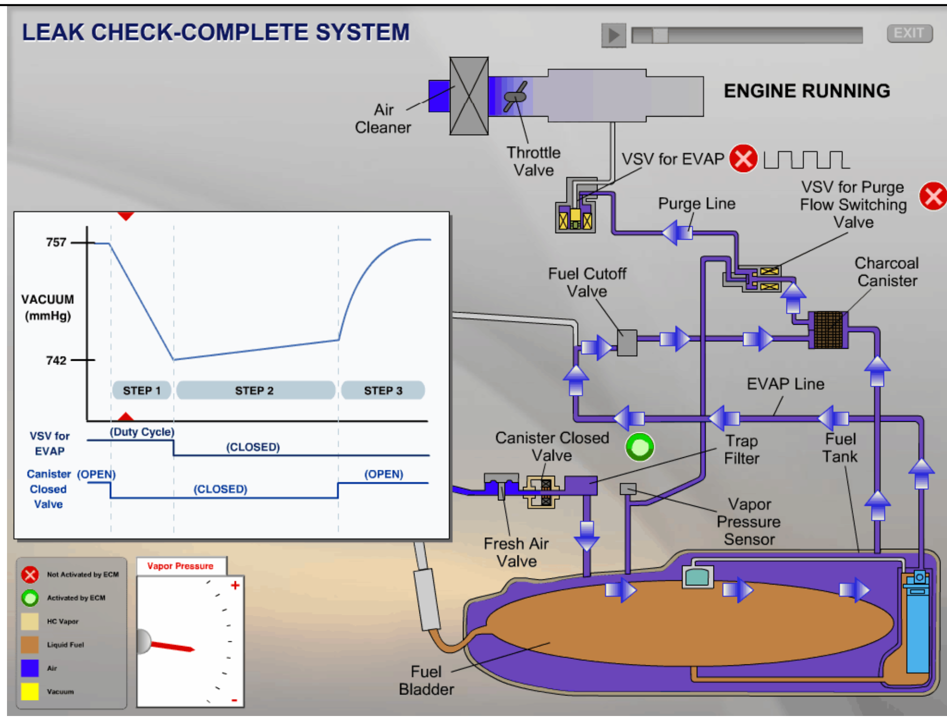


Figure 3.15 T072f315c

DTC P0440 Evaporative Emission Control System Malfunction

The ECM records DTC P0440 when an EVAP system leak is detected or when the Vapor Pressure Sensor malfunctions. The Vapor Pressure Sensor VSV for Canister Closed Valve (CCV) and VSV for Purge Flow Switching Valve are used to detect abnormalities in the EVAP system. The ECM decides whether there is an abnormality based on the Vapor Pressure Sensor signal.

The ECM turns the CCV ON, closing the EVAP system to fresh air. The ECM turns the EVAP VSV ON allowing manifold vacuum to drop EVAP system pressure. When pressure drops 20mmHg the Purge VSV is shut OFF, sealing the entire system in a vacuum.

The ECM monitors the level of vacuum in the sealed system to check for leaks. If pressure rises faster than the specification the system is judged to be leaking.

DTC P0441 Evaporative Emission Control System Incorrect Purge Flow

The ECM monitors the Vapor Pressure Sensor signal to check for abnormalities in the evaporative emissions control system. DTCs P0441 and P0446 are recorded by the ECM when evaporative emissions components do not perform as expected.

The ECM turns the EVAP (Purge) VSV ON with the CCV ON and closed. The ECM checks the Purge VSV performance:

- If pressure does not drop at least 20mmHg, the EVAP VSV is judged to be stuck closed.

When pressure drops, the ECM shuts off the EVAP VSV at 20mmHg. If pressure continues to drop more than 20mmHg, the EVAP VSV is judged to be stuck open.

DTC P0446 Evaporative Emission Control System Vent Control Malfunction

For P0446, the ECM cycles the EVAP VSV and CCV ON and OFF. The ECM checks CCV performance:

Purge is momentarily turned ON and OFF to raise and lower the tank pressure slightly (approx 10mmHg). Pressure in the tank should go up and down.

When the CCV is activated the pressure should drop rapidly. If pressure continues to go up and down the CCV is judged to be stuck open.

When the EVAP VSV ON/OFF cycle is started, if pressure immediately drops to minimum, the CCV is judged to be stuck closed.

DTC P1455 Vapor Reducing Fuel Tank System Leak Detected (Small Leak)

Based on the signals sent from the O2 sensor (Bank 1 Sensor 1) while the VSV for Purge Flow Switching Valve is ON, the ECM determines if fuel has leaked from the bladder tank or during purge operation. This condition is detected when the VSV for Purge Flow Switching Valve is ON and the vapor density of air which flows from the VSV for EVAP into the intake manifold is high.

DTC P1455 can occur from overfilling the vehicle which can cause raw fuel to collect in the lines. In extreme cases the fuel may run back down the vapor pressure port and contaminate the outer tank. The most common cause for this code is “topping off” the fuel tank or not fully inserting the nozzle into the filler neck during refueling.

In either case, excess pressure during refueling can force fuel through the vents at the top of the filler neck or the Fuel Cut-Off Valve, and can get into the Charcoal Canister or outer area of the Bladder Tank. If you get this code remove the Vapor Pressure Sensor and sample the tank with an emissions or 134a sniffer.

If HCs are detected, replace the fuel tank, canister and lines. It is important to educate the customer about proper refueling to eliminate this problem.

EVAP Component Test Tips

The tests below will help to identify potential problems while components are still installed on the vehicle. If you suspect a failure in an EVAP component from these tests, remove the component and follow the Repair Manual for complete diagnosis.

Canister Closed Valve Inspection:

1. Connect the EVAP Pressure Tester to the EVAP service port.
2. Set the pump hold switch to OPEN and the vent switch to CLOSE.
3. Turn the EVAP Pressure Tester pump ON. At this time, the pressure should not rise.
4. Using the Diagnostic Tester, **Active Test**, activate the Canister Closed Valve (ON). Pressure should begin to rise on the EVAP Pressure Tester.
5. When the Canister Closed Valve is turned OFF, the pressure in the system should drop.

Fresh Air Valve Inspection:

1. Remove the Air Inlet Hose from the side of the air cleaner.
2. Using the Diagnostic Tester, **Active Test**, turn the Canister Closed Valve (ON).
3. Attach a hand vacuum pump to the Air Inlet Hose and GENTLY apply light vacuum (less than 5in.hg). The Air Valve should hold a vacuum. **(Applying vacuum too quickly can “unstick” a stuck diaphragm and falsify the test.)**
4. Remove the hand pump and GENTLY blow into the Air Inlet Hose. You should hear the pressure escape from under the valve.

Purge Flow Switching Valve (Tank Bypass VSV) Inspection:

1. Remove the hose coming from the EVAP Purge VSV and attach a hand vacuum pump to the Purge Flow Switching Valve.
2. Using the Diagnostic Tester, Active Test, turn the Purge Flow Switching Valve (ON).
3. Clamp the hose going from the Purge Flow Switching Valve to the Vapor Pressure Sensor and begin to apply vacuum with the hand pump. The Purge Flow Switching Valve should hold vacuum.
4. Turn the Purge Flow Switching Valve Active Test OFF.
5. The pressure should now release into the hose going to the Charcoal Canister.

Fuel Cutoff Valve Inspection:

The Fuel Cutoff Valve helps prevent fuel from contacting the end of the nozzle. If the vehicle has been overfilled or refueled with the nozzle insufficiently inserted into the filler neck, fuel may flow past this valve and into the Charcoal Canister. To check for this condition and confirm proper operation do the following:

1. Carefully remove the valve from the filler neck. Try not to tip it so you can inspect it for liquid fuel.
2. If fuel is present the tank could have been overfilled or the fuel pump nozzle was not inserted properly during refueling.
3. Drain the fuel from the valve and inspect the Charcoal Canister for excessive fuel.
4. The valve should pass air through both ports easily when held upright (as installed on the vehicle). If the valve is turned upside down, it should prevent airflow through the ports. Replace the valve if it does not.

Refuel Check Valve Inspection:

When refueling, fuel traveling down the filler pipe can create a siphoning effect through the EVAP line connected to the inner bladder of the fuel tank. This siphoning effect can cause liquid fuel to be drawn up through the EVAP line and possibly into the Charcoal Canister. The refuel check valve is designed to vent air from the top of the filler neck above the lip seal into the EVAP line preventing this siphoning effect and preventing liquid fuel from splashing.

1. To test the Refuel Check Valve, blow low-pressure air into the larger of the two ports. Air should not flow freely through this port and you will hear the valve release as pressure increases. Air should flow easily from the small port through the large port. Replace the valve if it does not pass either of these tests.

Refuel Check Valve Inspection

The refuel check valve is designed to vent air from the top of the filler neck, above the lip seal into the EVAP line, preventing a siphoning effect.

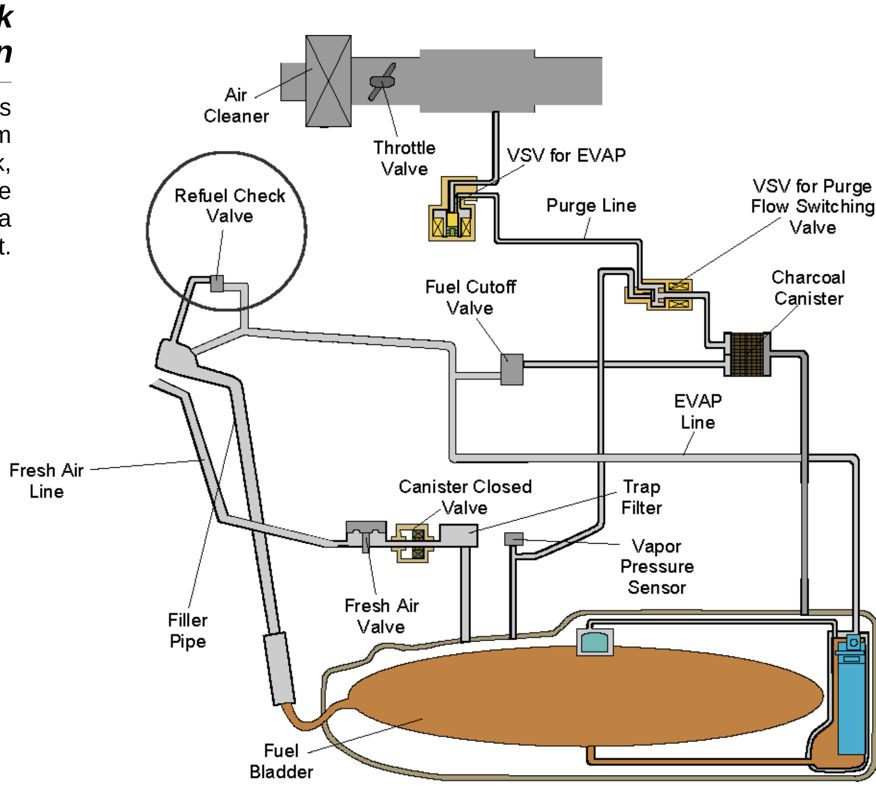


Figure 3.16 T072f316c

WORKSHEET 3-1
EVAP System Test

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

In this worksheet you will familiarize yourself with the Prius EVAP components and their locations. You will use the Diagnostic Tester and EVAP Pressure Tester to test the system's integrity as well as determine the condition of the components.

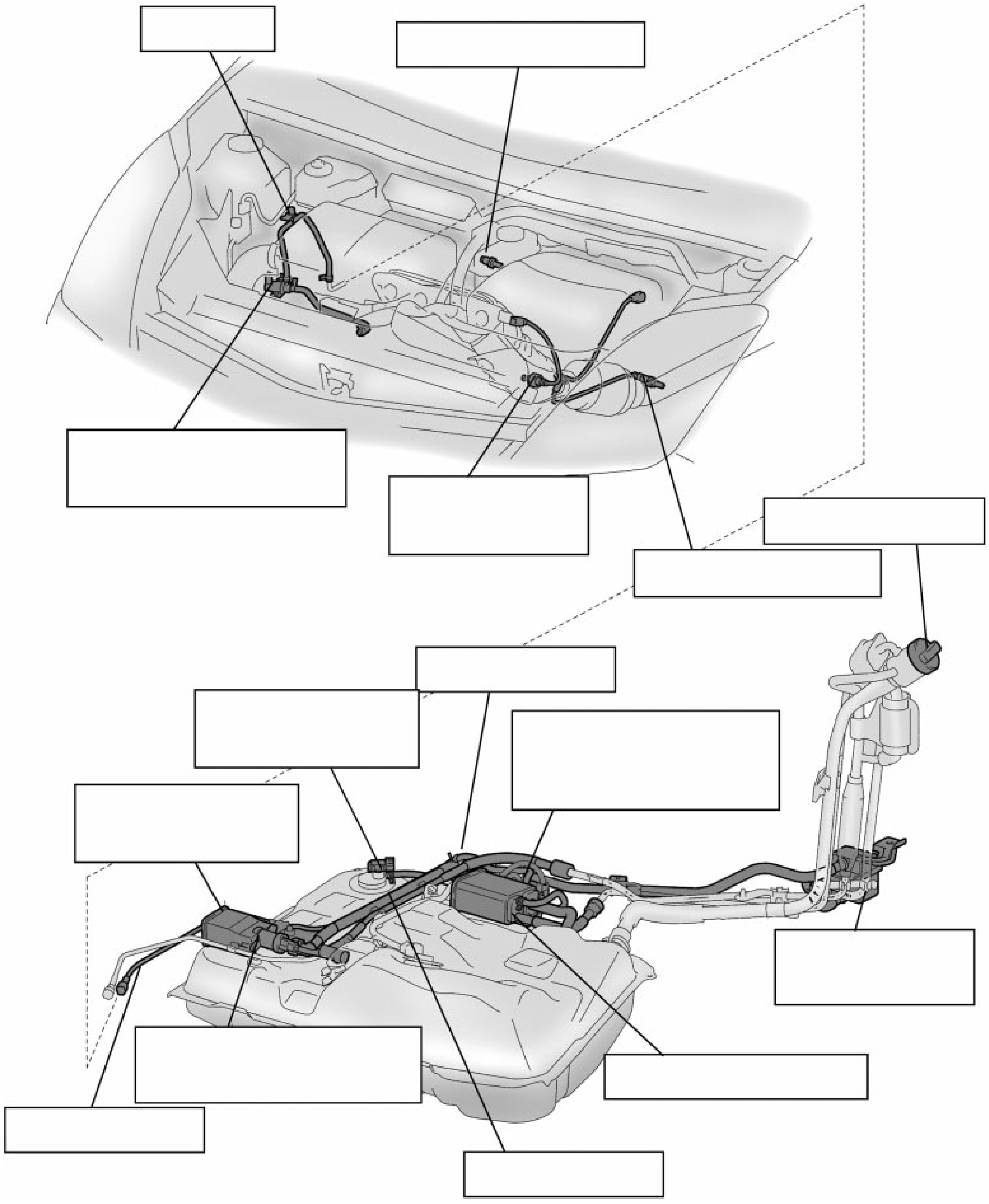
Tools and Equipment

- Vehicle
- Repair Manual or TIS
- EVAP Pressure Tester
- Diagnostic Tester
- EWD

Section 1 - Fuel System & EVAP Components

1. Using the vehicle and the Repair Manual, label Figure 1 on the next page to familiarize yourself with all EVAP components and locations.

Figure 1



Section 2 - Check VSV Operation

1. Using the Diagnostic Tester, go to OBD/MOBD, ENGINE AND ECT, ACTIVE TEST, and activate the VSVs below. Listen for a clicking noise when they are turned ON and OFF.

Note: The following VSVs are referred to by other names in some Toyota repair information. The names below in bold are used on the Diagnostic Tester:

- CAN CTRL VSV (Canister Closed Valve or CCV VSV)
- Tank Bypass VSV (Purge Flow Switching Valve)
- EVAP VSV (ALONE) (Purge VSV)

2. Did each VSV activate when tested?

____

Section 3 - Vacuum Test

1. Connect the Diagnostic Tester to DLC3.
2. Go to SETUP and select UNIT CONVERSION.
3. Under VAPOR PRESSURE, select ABS for absolute pressure, and mmHg for millimeters of mercury.
4. Go back to the FUNCTION SELECT menu and select OBD/MOBD.
5. Start the vehicle (READY light ON) and select MAX A/C to keep the engine running. Make sure the engine is warm.
6. Using the Diagnostic Tester, go to OBD/MOBD, ENGINE AND ECT, ACTIVE TEST, USER DATA. Select and record the VAPOR PRESSURE SENSOR reading.

   ____

7. Go to ACTIVE TEST and activate the EVAP VSV (ALONE). What is the VAPOR PRESSURE SENSOR reading now?

   ____

8. With the EVAP VSV active or grand pin 2 of IK1 (’04 and later Prius), clamp the Air Inlet Hose on the air box or on ’01 - ’03 Prius. Allow pressure to drop to about 740 mmHg. If the pressure does not drop, what does this mean?

   ____

9. With the IK1 still grounded or the Air Inlet Hose still clamped, turn OFF the EVAP VSV (ALONE). Is the pressure holding? Does the pressure hold for two minutes?

   ____

10. Remove the jumper wire or clamp.

Section 4 - Pressure Test

1. Connect the EVAP Pressure Tester to the EVAP service port and power the tester.

2. Set the pump pressure hold switch to OPEN and the vent switch to CLOSE.

3. Using the Diagnostic Tester, go to ENGINE AND ECT, ACTIVE TEST, CAN CTRL VSV, USER DATA and turn ON the CAN CTRL VSV.

4. Turn the EVAP Pressure Tester pump ON and increase pressure by at least 1.6kPa (0.232 psi, 12 mmHg, 6.4 in HO).

Note: The Prius pressure sensor can sense 775 mmHg max.

5. What is the VAPOR PRESSURE SENSOR reading?

   ____

6. Turn the pump pressure hold switch to CLOSE and shut off the pump.

7. Verify that the pressure holds for 30 seconds. If it does not hold, there is a leak in the system.

8. Remove the fuel cap. What is the VAPOR PRESSURE SENSOR reading now on the Diagnostic Tester?

   ____

9. What are the main differences between this EVAP system and other Toyota EVAP systems? Return vehicle to normal condition.

   ____

   ____

   ____

   ____

Return vehicle to normal condition.

WORKSHEET 3-2
EVAP Component Tests

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

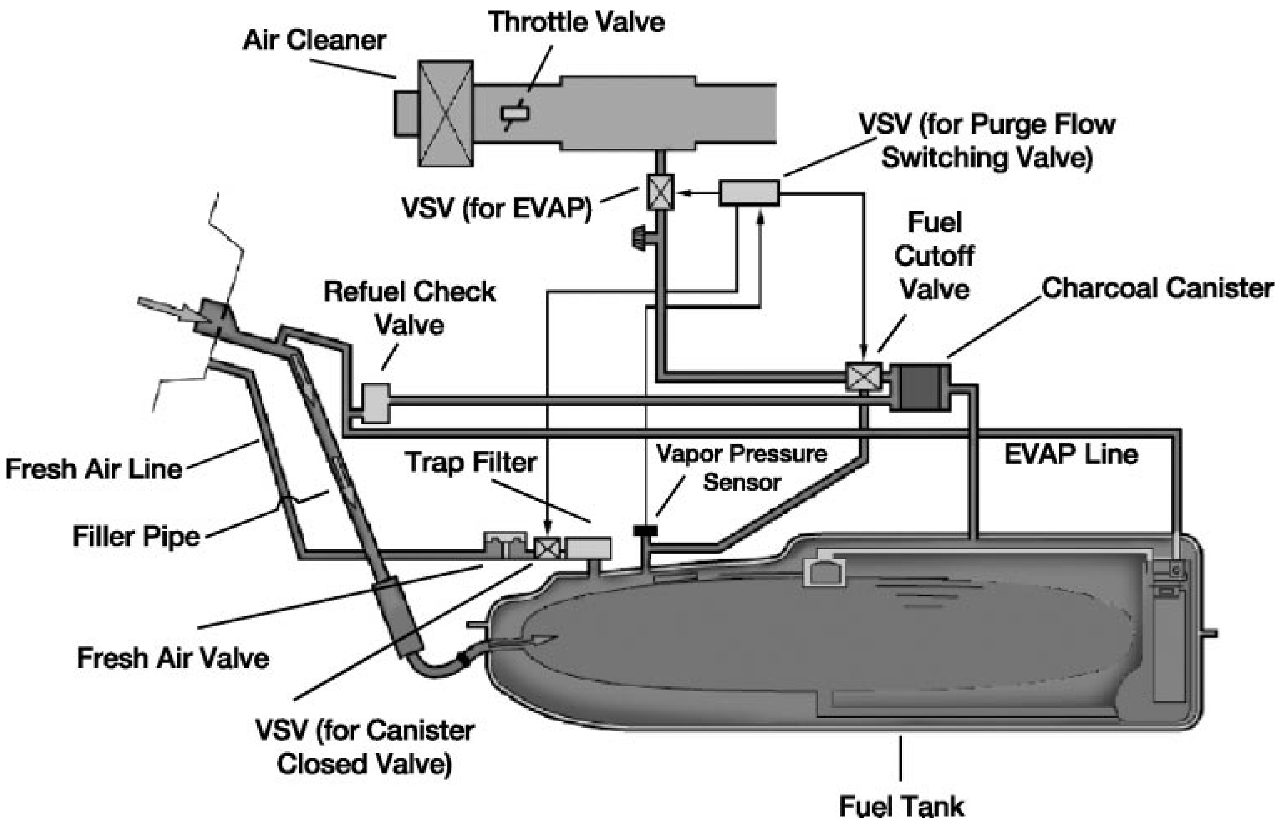
In this worksheet you will test several EVAP components to help identify and locate component failure.

Tools and Equipment

- Vehicle
- Repair Manual or TIS
- Diagnostic Tester
- Hand Vacuum Pump
- EVAP Pressure Tester

Section 1 - Component & DTC Test Tips:

The following tests will help identify potential problems with components installed on the vehicle. If these tests indicate a faulty EVAP component, remove the component and follow the Repair Manual procedure for complete diagnosis.



1. Canister Closed Valve
   - Connect the EVAP Pressure Tester to the EVAP service port.
   - Set the pump hold switch to OPEN and the vent switch to CLOSE.
   - Turn the EVAP Pressure Tester pump ON for 15 seconds, then turn the Tester pump OFF.
   - The tester gauge pressure should drop and should not hold pressure.
   - Using the Diagnostic Tester, ACTIVE TEST, USER DATA, turn the Canister Closed Valve ON.
   - Turn the EVAP Pressure Tester pump ON again for 15 seconds, then turn the Tester pump OFF.
   - This time the tester gauge pressure should hold pressure.
   - Using the Diagnostic Tester, turn the Canister Closed Valve OFF. Pressure in the system should now decrease.

   Did the Canister Closed Valve operate correctly?

2. Fresh Air Valve ('01 - '03 Prius)

- Remove the Air Inlet Hose from the side of the air cleaner.
- Using the Diagnostic Tester, ACTIVE TEST, USER DATA, turn the Canister Closed Valve ON.
- Attach a hand vacuum pump to the Air Inlet Hose and GENTLY apply light vacuum (less than 5 in.Hg). The Fresh Air Valve should hold a vacuum. Applying vacuum too quickly can "unstick" a stuck diaphragm and falsify the test.
- Remove the hand pump and gently blow into the Air Inlet Hose. You should hear the pressure escape from the underside of the valve.

Did the Fresh Air Valve operate correctly?

---

3. Purge Flow Switching Valve (Tank Bypass Valve)

- Remove the hose from the EVAP Purge VSV and attach a hand vacuum pump to the Purge Flow Switching Valve.
- Using the Diagnostic Tester, ACTIVE TEST, turn the Tank Bypass VSV ON.
- Raise the vehicle.
- Clamp the hose from the Purge Flow Switching Valve to the Vapor Pressure Sensor and apply vacuum with the hand pump. The Purge Flow Switching Valve should hold vacuum.
- When the Purge Flow Switching Valve is turned OFF, vacuum should be released. Did the Purge Flow Switching Valve operate correctly?

---

4. Fuel Cutoff Valve

- Remove the Fuel Cutoff Valve from the fuel filler neck assembly. Keep the valve upright, do not tip it.
- The valve should not contain any liquid fuel. If there is fuel in the valve, drain it and also check the charcoal canister.
- Gently blow light air pressure through both ports on the upright valve. Air should pass through both ports with the valve upright.
- Turn the valve upside down and again gently blow through both ports. Air should <u>not</u> pass through either port with the valve upside down.

Did the Fuel Cutoff Valve operate correctly?

---

5. Refuel Check Valve

- Remove the Refuel Check Valve from the fuel filler neck assembly.
- The valve should not contain any liquid fuel. If there is fuel in the valve, drain it and also check the charcoal canister.
- Gently blow light air pressure through the larger port on the valve. Air should <u>not</u> pass easily through the larger port.
- Gently blow light air pressure through the smaller port on the valve. Air <u>should</u> pass easily through the smaller port.

Did the Refuel Check Valve operate correctly?

____

Return vehicle to normal condition.

Section 4

Hybrid Vehicle Control System

Overview

The Hybrid Vehicle Control System monitors and adjusts all aspects of the hybrid powertrain.

- It regulates the engine, MG1 and MG2 to meet the driving demands signaled by shift position, accelerator pedal position and vehicle speed.
- It controls the operation of the hybrid transaxle.
- It oversees the operation of the inverter and converter as they balance the power requirements of the vehicle's many 12-volt components and the high voltage components of the hybrid system powertrain.

Before we look at the components that make up the Hybrid Vehicle Control System, let's review the special safety precautions that must be taken to ensure safe servicing of the HV system.

Safety Procedures

Repairs performed incorrectly on the Hybrid Control System could cause electrical shock, leakage or explosion. Be sure to perform the following procedures:

- Remove the key from the ignition. If the vehicle is equipped with a smart key, turn the smart key system OFF.
- Disconnect the negative (-) terminal cable from the auxiliary battery.
- Wear insulated gloves.
- Remove the service plug and **do not make any repairs for five minutes**.

If the key cannot be removed from the key slot in the case of an accident, be sure to perform the following procedures:

- Disconnect the auxiliary battery
- Remove the HEV fuse (20A yellow fuse in the engine compartment junction block). When in doubt, pull all four fuses in the fuse block.

NOTE

In order for your insulated gloves to provide proper protection, the insulating surface must be intact.

To check the integrity of the glove's surface, blow air into the glove and fold the base of the glove over to seal the air inside. Then slowly roll the base of the glove towards the fingers.

- If the glove holds pressure, its insulating properties are intact.
- If there is an air leak, high voltage electricity can find its way back through that same hole and into your body! Discard the glove and start over until you have a pair of intact gloves that can fully protect you from the vehicle's high voltage circuits.

WARNING

Due to circuit resistance, it takes at least five minutes before the high voltage is discharged from the inverter circuit**.**

Even after five minutes have passed the following safety precautions should be observed:

- Before touching a high voltage cable or any other cable that you cannot identify, use the tester to confirm that the voltage in the cable is 12V or less.
- After removing the service plug cover the plug connector using rubber or vinyl tape.
- After removing a high voltage cable be sure to cover the terminal using rubber or vinyl tape.
- Use insulated tools when available.
- Do not leave tools or parts (bolts, nuts, etc.) inside the cabin.
- Do not wear metallic objects. (A metallic object may cause a shortcircuit.)

Submerged Vehicle Safety

To safely handle a Prius that is fully or partially submerged in water, disable the high voltage electrical system and SRS airbags. Remove the vehicle from the water. Drain the water from vehicle if possible. Then follow the extrication and vehicle disable procedures below:

- Immobilize vehicle.
- Chock wheels and set parking brake.
- Remove the key from key slot.
- If equipped with a smart key, use the smart cancel switch underneath the steering column to disable the system.
- Keep the electronic key at least 16 feet (5 meters) away from the vehicle.
- Disconnect the 12V auxiliary battery.
- Remove the HEV fuse in the engine compartment. When in doubt, pull all four fuses in the fuse block.

WARNING

After disabling the vehicle, power is maintained for 90 seconds in the SRS system and five minutes in the high voltage electrical system. If either of the disable steps above cannot be performed, proceed with caution as there is no assurance that the high voltage electrical system, SRS, or fuel pump are disabled. Never cut orange high voltage power cables or open high voltage components.

Hybrid Transaxle

The Hybrid Transaxle contains:

- Motor Generator 1 (MG1) that generates electrical power.
- Motor Generator 2 (MG2) that drives the vehicle.
- A planetary gear unit that provides continuously variable gear ratios and serves as a power splitting device.
- A reduction unit consisting of a silent chain, counter gears and final gears.
- A standard 2-pinion differential.

P111 Transaxle ('01-'03) Prius

The '01-'03 Prius uses the P111 hybrid transaxle.

Transaxle Cutaway

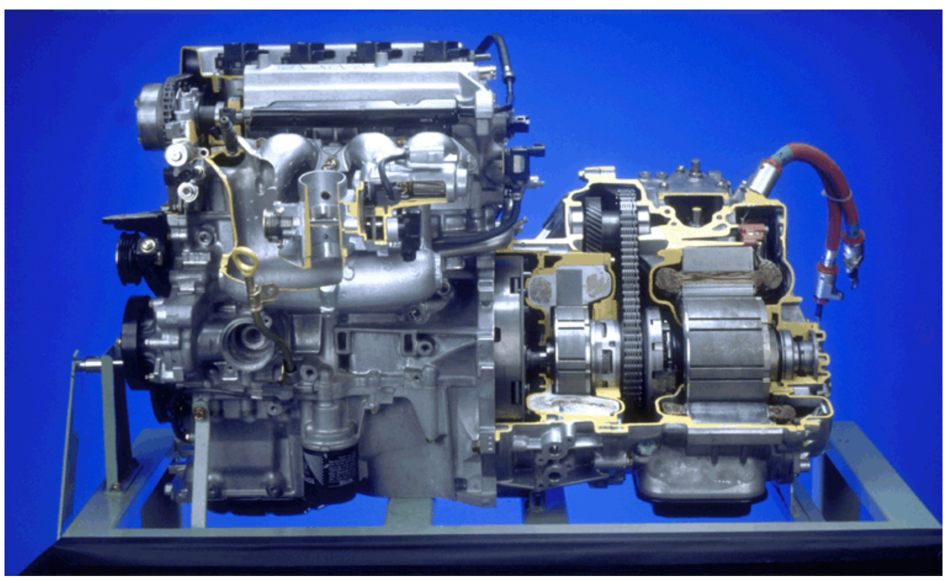


Figure 4.1 T072f401p

P112 Transaxle ('04 & later Prius)

The '04 and later Prius uses the P112 transaxle. The P112 is based on the P111, but offers a higher RPM range, V-shaped permanent magnets in the rotor of MG2 and a newly designed over-modulation control system.

Transaxle Damper

A coil spring damper with low torsion characteristics transmits the drive force from the engine. Also, a torque fluctuation absorbing mechanism that uses a dry-type single-plate friction material is used.

On the ‘04 and later Prius the spring rate characteristics of the coil spring have been reduced further to improve its vibration absorption performance. Also, the shape of the flywheel has been optimized for weight reduction.

Hybrid Transaxle Specifications

		’03 Model	’04 Model
Transaxle Type		P111	P112
Planetary Gear	The No. of Ring Gear Teeth	78	←
	The No. of Pinion Gear Teeth	23	←
	The No. of Sun Gear Teeth	30	←
Differential Gear Ratio		4.113	3.905
Chain	Number of Links	72	74
	Drive Sprocket	36	39
	Driven Sprocket	35	36
Counter Gear	Drive Gear	30	←
	Driven Gear	44	←
Final Gear	Drive Gear	26	←
	Driven Gear	75	←
Fluid Capacity	Liters (US qts, Imp qts)	3.8 (4.0, 3.3)	4.6 (4.9, 4.0)
Fluid Type		ATF WS or equivalent	ATF Type T-IV or equivalent

MG1 & MG2 (Motor Generator 1 & Motor Generator 2)

Both MG1 and MG2 function as both highly efficient alternating current synchronous generators and electric motors. MG1 and MG2 serve as the source for supplemental motive force that provides power assistance to the engine as needed.

MG1 Description

MG1 recharges the HV battery and supplies electrical power to drive MG2. In addition, by regulating the amount of electrical power generated (thus varying the generator’s rpm), MG1 effectively controls the continuously variable transmission function of the transaxle. MG1 also serves as the engine starter.

MG2 Description

MG2 serves as the supplemental motive force that provides power assist to the engine output. It helps achieve excellent dynamic performance that includes smooth start-off and acceleration. During regenerative braking, MG2 converts kinetic energy into electrical energy which is then stored by the HV battery.

NOTE

Towing a damaged Prius with its front wheels on the ground may cause the motor to generate electricity. The electrical insulation could leak and cause a fire. Always tow the vehicle with the front wheels off of the ground or on a flat bed.

Power Splitting Device

The planetary gear unit is used as a power splitting device. The sun gear is connected to MG1, the ring gear is connected to MG2, and the planetary carrier is connected to the engine output shaft. The motive force is transmitted from the chain drive sprocket drive to the reduction unit via a silent chain.

Power Splitting Device

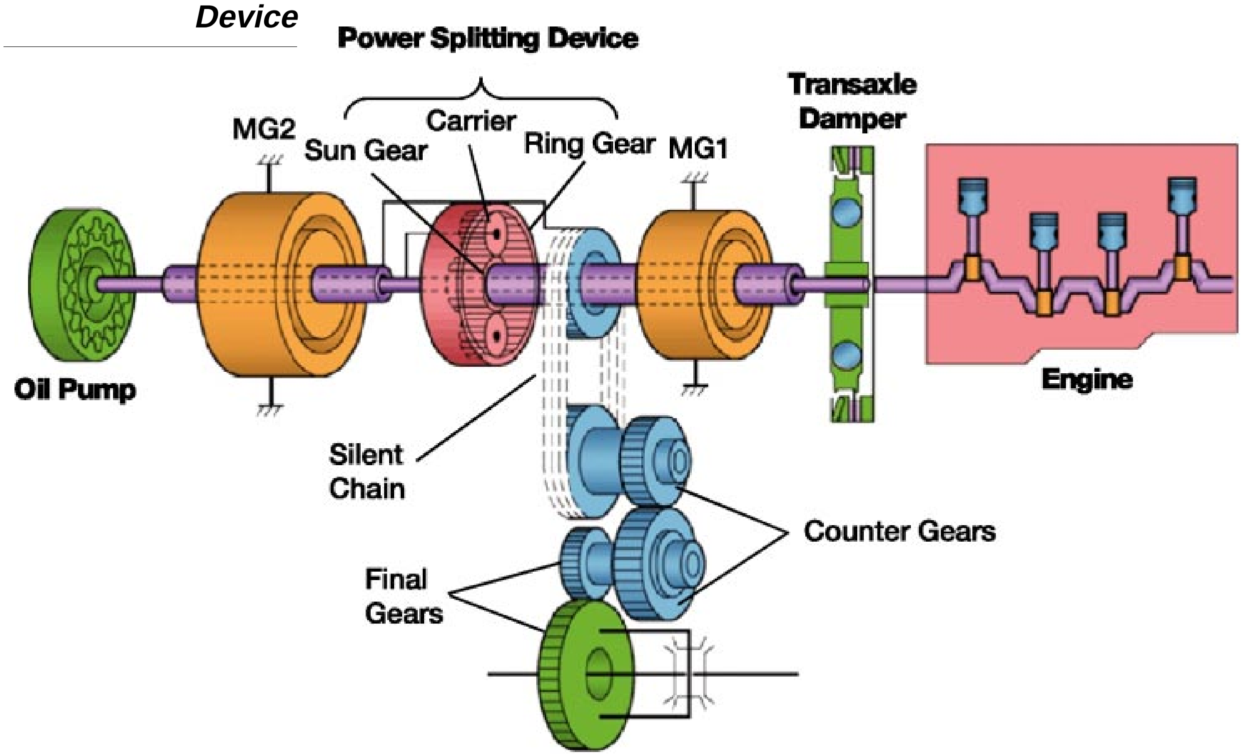


Figure 4.2 T072f402c

Planetary Gear Connection

Item	Connection
Sun Gear	MG1
Ring Gear	MG2
Carrier	Engine Output Shaft

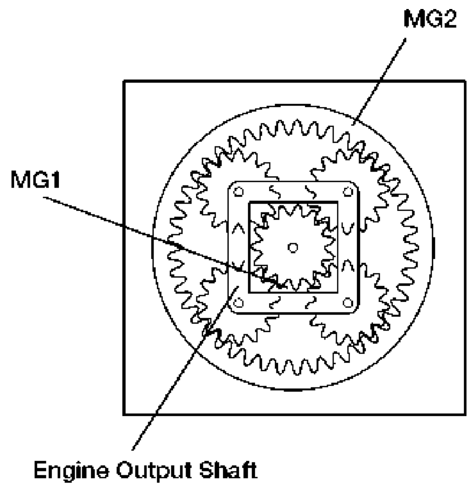


Figure 4.3 T072f403

Permanent Magnet Motor

When three-phase alternating current is passed through the threephase windings of the stator coil, a rotating magnetic field is created in the electric motor. By controlling this rotating magnetic field according to the rotor's rotational position and speed, the permanent magnets in the rotor become attracted by the rotating magnetic field, thus generating torque. The generated torque is for all practical purposes proportionate to the amount of current and the rotational speed is controlled by the frequency of the alternating current.

A high level of torque can be generated efficiently at all road speeds by properly controlling the rotating magnetic field and the angles of the rotor magnets.

On the '04 & later Prius the built-in permanent magnets have been changed to a V-shaped structure to improve both power output and torque. This improvement provides about 50% more power than previous models.

Speed Sensor (Resolver)

This reliable and compact sensor precisely detects the magnetic pole position, which is indispensable for ensuring the efficient control of MG1 and MG2.

The sensor's stator contains three coils. Since the rotor is oval, the gap between the stator and the rotor varies with the rotation of the rotor.

In addition, the HV ECU uses this sensor as an rpm sensor calculating the amount of positional variance within a predetermined time interval.

DTC P0A4B Generator Position Sensor Circuit

('04 & later Prius)

DTC P0A4B will set when the HV ECU detects output signals that are out of normal range or specification concluding that there is a malfunction of the generator resolver. The following Information Codes can help isolate the problem:

- 253 - Interphase short in resolver circuit
- 513 - Resolver output is out of range
- 255 - Open or short in resolver circuit

DTC P1525 Resolver Malfunction

('01 & '03 Prius)

DTC P1525 will set when vehicle speed signals are not input from the resolver for 16 seconds or more while running at a speed of 20km/h or more. The trouble areas could include the:

- ECM
- HV ECU
- Wire Harness

Speed Sensor (Resolver) Operation

Output coils B and C are electrically staggered 90 degrees. Because the rotor is oval, the distance of the gap between the stator and the rotor varies with the rotation of the rotor. By passing an alternating current through coil A, output that corresponds to the sensor rotor's position is generated by coils B and C. The absolute position can then be detected from the difference between these outputs.

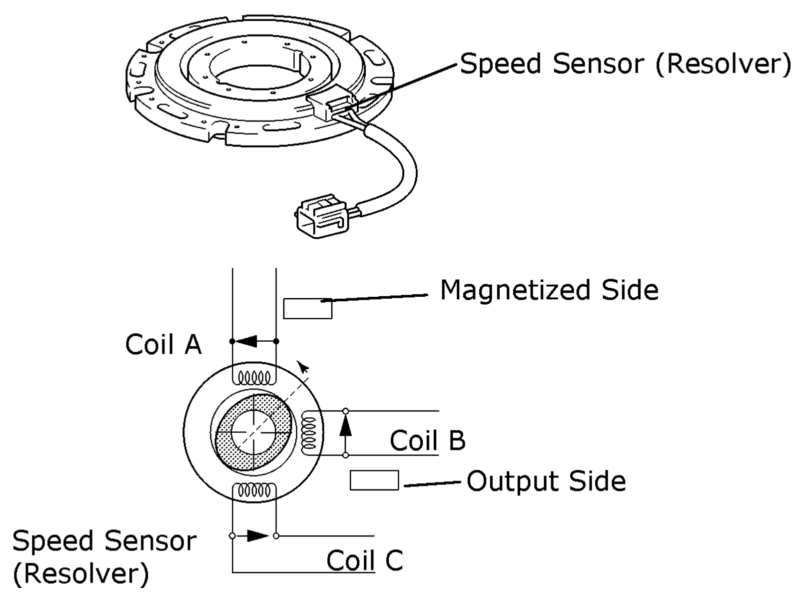


Figure 4.4 182TH09

Shift Assembly
('04 & later Prius)

The shift position sensors consist of a select sensor that detects the lateral movement of the selector lever and a shift sensor that detects the longitudinal movement. A combination of these signals is used to detect the shift position.

Shift Assembly

('04 & later Prius)

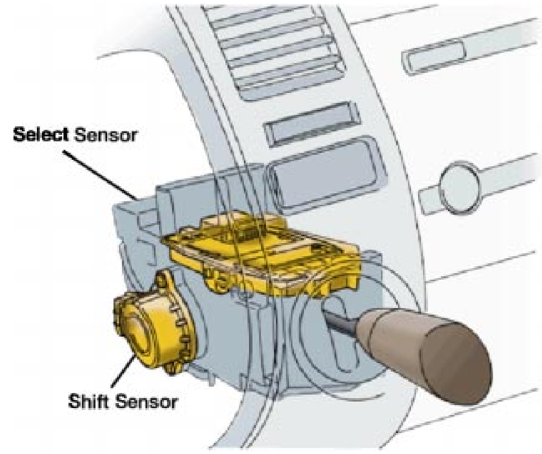


Figure 4.5 T072f405c

Shift Control Actuator
('04 & later Prius)

The motor in the actuator rotates to move the parking lock rod, which slides into the parking lock pawl, causing it to engage with the parking gear. This actuator detects its own position when a battery is reinstalled, so it does not require initialization.

Shift Control Actuator

('04 & later Prius)

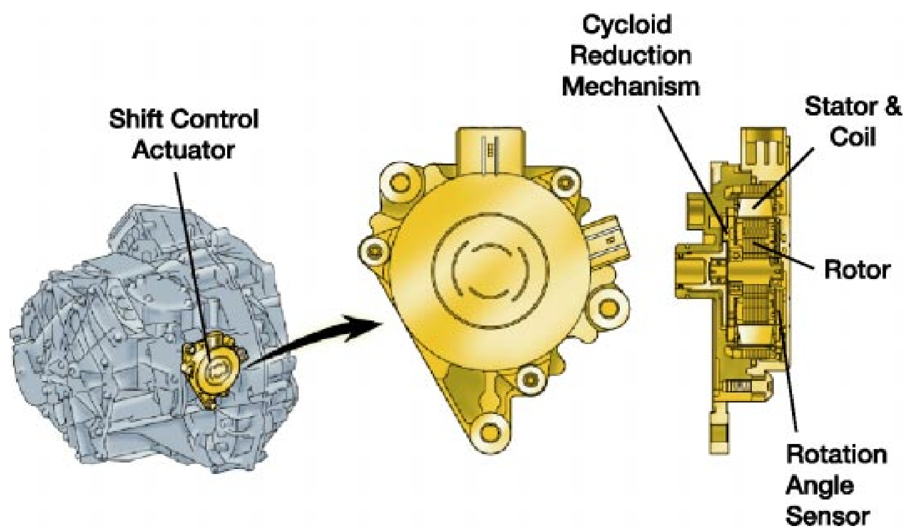


Figure 4.6 T072f406c

Cycloid Reduction Mechanism ('04 & later Prius)

The Shift Control Actuator includes a cycloid gear reduction mechanism that increases the actuator's torque, ensuring that the parking lock will release when the vehicle is parked on a slope.

This mechanism consists of an eccentric plate mounted on the motor's output shaft, a 61-tooth fixed gear that is secured to the motor housing and a 60-tooth driven gear. As the output shaft rotates, the eccentric plate presses the driven gear against the fixed gear. The driven gear, which has one tooth less than the fixed gear, rotates one tooth for every complete rotation of the eccentric plate. The result is a gear reduction ratio of 61:1, along with an equivalent increase in torque.

Cycloid Reduction Mechanism

1. Eccentric shaft rotates with motor shaft, pressing driven gear against fixed gear.
2. Driven gear rotates one tooth for every full rotation of the motor shaft.
3. Reduction Ratio: 61:1.

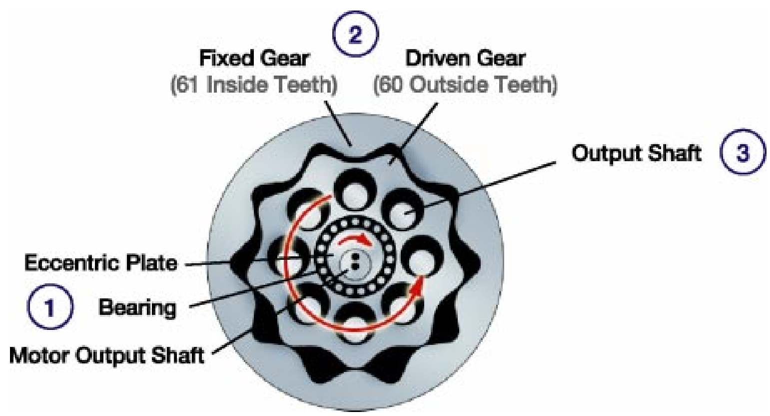


Figure 4.7 255CH13

SERVICE TIP

If there is a malfunction in the shift control actuator the vehicle will not go into park. The Master Warning Light will illuminate, the shift position indicators on the dash will flash and the Park light button will flash. In this case, the vehicle cannot be turned OFF.

To get the vehicle to shut off, stop the vehicle and apply the parking brake. The vehicle can be turned OFF but cannot be turned back ON.

SERVICE TIP

A diagnostic tester cannot turn off the shift control system so remove the 30 amp fuse located on the left side of the fuse box on the driver's side.

Opened Inverter Assembly

('04 & later Prius)

Figure 4.8 T072f408p

Inverter

The Inverter converts the high voltage direct current of the HV battery into three-phase alternating current of MG1 and MG2. The activation of the power transistors is controlled by the HV ECU. In addition, the inverter transmits information that is needed to control current such as the output amperage or voltage, to the HV ECU.

The inverter, MG1, and MG2 are cooled by a dedicated radiator and coolant system that is separate from the engine coolant system. The HV ECU controls the electric water pump for this system. In the '04 & later Prius, the radiator has been simplified and the space it occupies has been optimized.

Boost Converter ('04 & later Prius)

The boost converter boosts the nominal voltage of DC 201.6V that is output by the HV battery to the maximum voltage of DC 500V. The converter consists of the boost Integrated Power Module (IPM) with a built-in Insulated Gate Bipolar Transistor (IGBT) which performs the switching control and the reactor which stores energy. By using these components the converter boosts the voltage.

When MG1 or MG2 acts as a generator the inverter converts the alternating current (range of 201.6V to 500V) generated by either of them into direct current. The boost converter then drops it to DC 201.6V to charge the HV battery.

Converter

Power for auxiliary equipment in the vehicle such as lights, the audio system, the A/C cooling fan, and ECUs is based on a DC 12V system.

On the '01-'03 Prius, the THS generator voltage is DC 273.6V. The converter is used to transform the voltage from DC 273.6V to DC 12V in order to recharge the auxiliary battery.

On the '04 Prius and later the THS-II generator voltage outputs at nominal voltage of DC 201.6V. The converter is used to transform the voltage from DC 201.6V to DC 12V in order to recharge the auxiliary battery.

A/C Inverter ('04 & later Prius)

An A/C inverter, which supplies power for driving the electric inverter compressor of the A/C system, has been included in the inverter assembly. This inverter converts the HV battery's nominal voltage of DC 201.6V into AC 201.6V and supplies power to operate the compressor of the A/C system.

HV ECU

The HV ECU controls the motor and engine based on torque demand and the HV battery SOC. Factors that determine motor and engine control are:

- Shift position
- Accelerator pedal position
- Vehicle speed

DTC P3120 HV Transaxle Malfunction

('04 & later Prius)

The HV ECU checks the energy balance and detects an abnormality if the magnetism in the motor or generator greatly decreases.

There are many Information Codes associated with this DTC. Refer to the DI section of the Repair Manual.

DTC P3125 Converter & Inverter Assembly Malfunction

If the vehicle is being driven with a DC-to-DC converter malfunction the voltage of the auxiliary battery will drop and it will be impossible to continue driving. Therefore, the HV ECU checks the operation of the DC-to-DC converter and provides a warning to the driver if a malfunction is detected. DTC P3125 will be stored.

NOTE

A vehicle which has set both P3120 and P3125 may be difficult to diagnose. The reason both codes may set is because two independent current sensors are evaluating inverter and motor-generator performance. If a tire slips or a motor-generator mechanically binds or fails current flow values will be high. The inverter current sensor may detect the high current first and assume that the high current flow is caused by the inverter instead of the motor-generator.

Diagnostic Procedures:

- In most transaxle cases the engine will not start or makes a strange whining sound when cranking. If MG1 operates, swap the HV ECU. If the DTC resets, replace the inverter.
- If MG1 does not crank the engine, replace the inverter first.

DTC P3000 HV Battery Malfunction

The HV ECU warns the driver and performs the fail-safe control when an abnormal signal is received from the battery ECU.

If Information Codes 123 or 125 are output, check and repair the applicable DTC. After repairs, record the DTC of the HV ECU, Freeze Frame data, and Operation History. Then clear the DTC and check one more time after starting the system again, (READY light ON).

If Information Code 388 is output, check for other Information Codes. Check and repair applicable codes. After that, confirm that there is sufficient gasoline to crank the engine.

If Information Code 389 is output, check for other Information Codes. Check and repair applicable codes. After that, replace the main battery and crank the engine.

DTC P3009 Insulation Leak Detected

DTC P3009 sets when there is a leak in the high-voltage system insulation, which may seriously harm the human body. (Insulation resistance of the power cable is 100 k ohms or less.) If no defect is identified at inspection, entry of foreign matter or water into the battery assembly or converter and inverter assembly may be the possible cause. Use a Megger Tester to measure the insulation resistance between the power cable and body ground.

Diagnostic Procedure:

If a Megger Tester is not available, try these diagnostic procedures to help isolate the problem.

- With the key ON, and Ready light OFF, clear the DTC. Cycle the key and check for DTCs again. If the DTC appears again unplug the HV battery cable from the battery. If the DTC still resets the problem is in the HV Battery ECU or related cables, connectors, etc. If the DTC does not set again the problem is in the front half of the vehicle including cables, transaxle, inverter, etc.

- To isolate front components, reconnect HV cables and start unplugging the farthest component (such as MG1 and MG2).

DTC P3009 Information Codes

DTC P3009 can alert you to a short circuit in several different areas of the high-voltage system. The information code retrieved with the DTC helps you pinpoint the exact area of the short circuit. The diagram below shows the specific circuits associated with each of the following information codes:

- 526 - Vehicle Insulation Resistance Reduction
- 611 - A/C Area
- 612 - HV Battery Area
- 613 - Transaxle Area
- 614 - High Voltage DC Area

CAUTION

Before inspecting the high-voltage system take safety precautions to prevent electrical shock such as wearing insulated gloves and removing the service plug. After removing the service plug put it in your pocket to prevent other technicians from reconnecting it while you are servicing the high-voltage system.

After disconnecting the service plug wait at least five minutes before touching any of the high-voltage connectors or terminals because it takes five minutes to discharge the high-voltage condenser inside the inverter.

High-Voltage Circuit

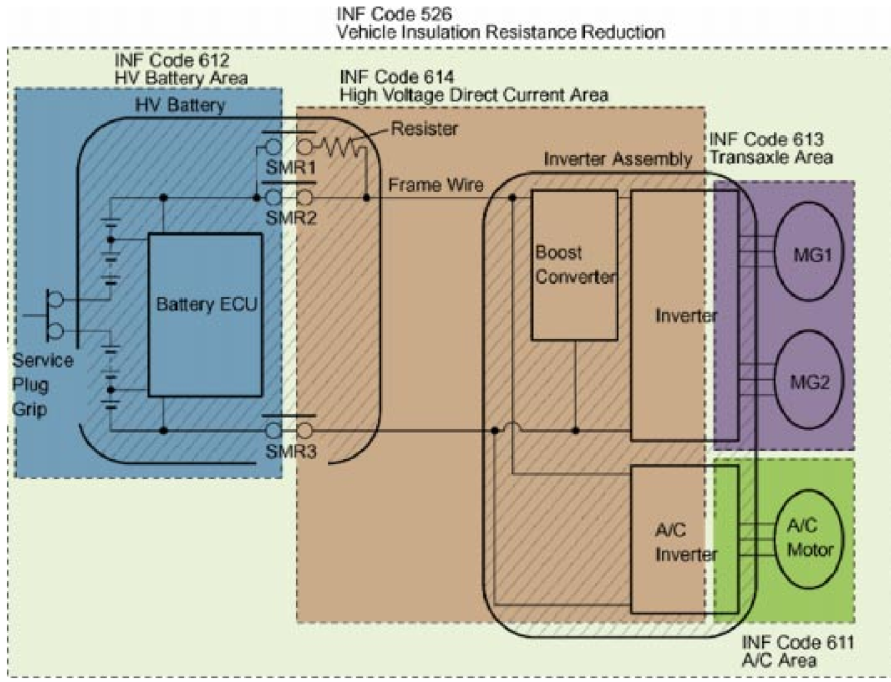


Figure 4.9 T072f409c

DTC P3101 Engine System Malfunction

('01-'03 Prius)

The HV ECU performs the fail-safe control when the ECM detects an error, which will affect the THS control. Information Codes 204, 205, and 238 may set with this DTC. Information Code 204 detects an abnormal signal from the ECM (abnormal engine output). Information Code 205 detects an abnormal signal from the ECM (engine unable to start). Information Code 238 detects when the engine does not start when cranked. If this code is output, investigate what has increased revolution resistance in the transaxle or engine. Check the engine and transaxle lubrication systems, check the engine and transaxle coolant and check for any mechanical breakdowns in the engine and transaxle.

This DTC is likely to occur together with DTC P3190/P3191.

DTC P3115 System Main Relay Malfunction

The HV ECU checks that the system main relay (No. 1, No. 2, No. 3) is operating normally and detects a malfunction. Information Codes 224-229 may be present. (Refer to the Repair Manual for each description.)

Confirm that there is no open circuit in the wire harness. If battery voltage is always applied to the HV ECU Cont1, Cont2 and Cont3 terminals with ignition ON (READY light OFF), the system main relay has a +B short.

If the vehicle exhibits a Master, Hybrid and MIL Warning Light, the condition can occur under the following circumstances:

- While decelerating with a slight accelerator pedal opening and with many electrical accessories in use, DTC P3115 will set in the HV Battery ECU and P3000 in the HV ECU.
- After turning the IG key to Start for the first trip after a cold soak in ambient temperatures below 32ºF, Diagnostic Trouble Code P3115 will set in the HV ECU.

HINT

DTC P3115 may show up in the HV ECU section or the HV battery section of the Diagnostic Tester. Test SMR values to help locate the problem.

Using Information Codes

Information Codes are a three-digit sub-set of codes that provide data pertaining to HV ECU DTCs. They provide additional information and freeze frame data to help diagnose the vehicle's condition. These codes can be found using the Diagnostic Tester in the **HV ECU** screen. For a detailed description of each Information Code, refer to the DI section of the Repair Manual. Refer to the following screen flow to access Information Codes on the Diagnostic Tester.

Accessing Information Codes

Follow the screen flow to access the Information Codes.

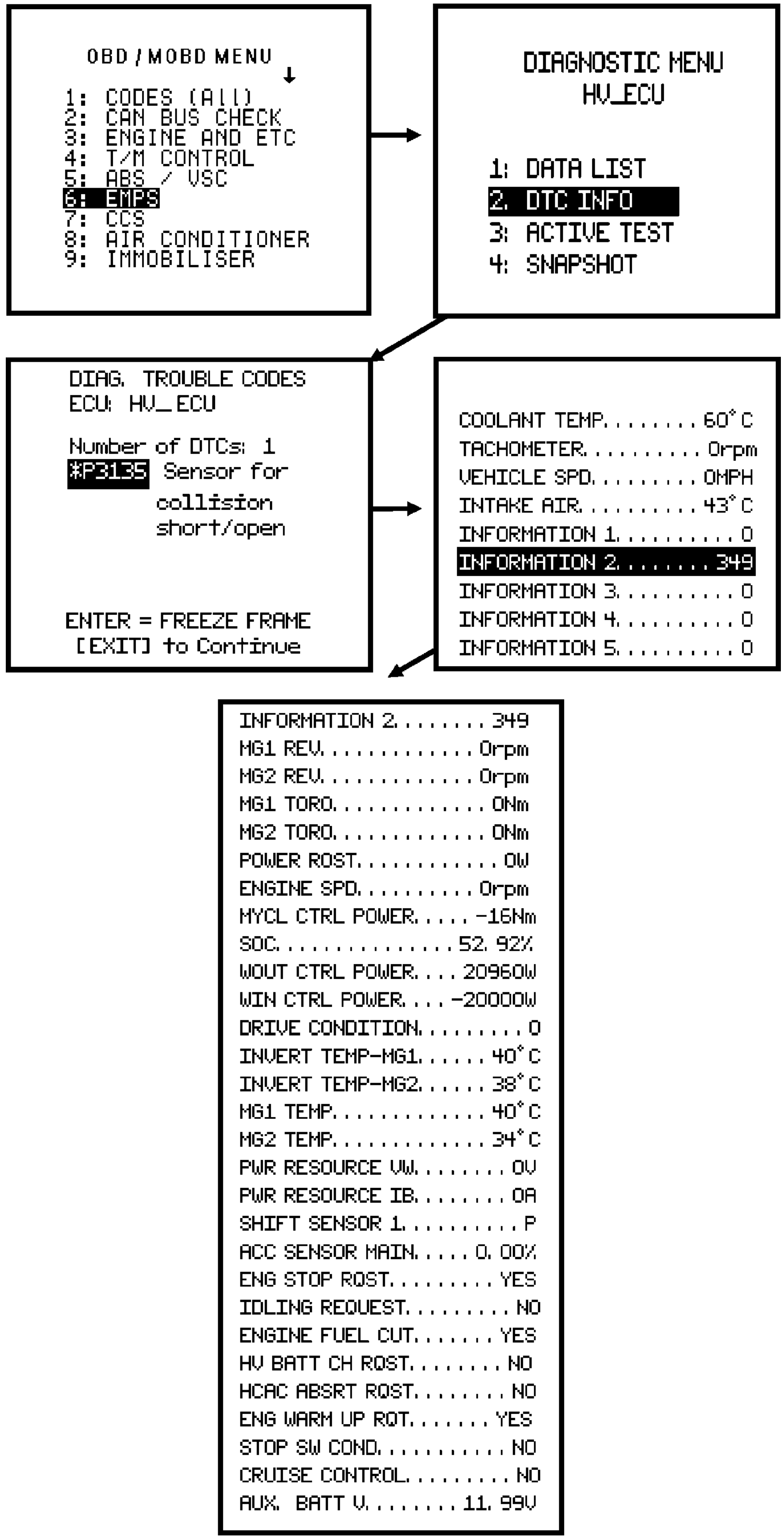


Figure 4.10 T072f410

Using Operation History Data

Sometimes symptoms caused by the customer's driving habits may be mistaken for problems in the Prius. Operation History Data can be used for explaining that these symptoms may not indicate problems. It also can be used to view the driving patterns of the customer so that the concern can be diagnosed and fixed.

To view Operation History Data using the Diagnostic Tester:

- Connect the Diagnostic Tester to the DLC3.
- Turn the power switch ON (IG).
- Enter the following menus:
- DIAGNOSIS / ENHANCED OBD II / HV ECU / DATA LIST.
- Select the menu to view the number of special operations or controls that have been affected.

HINT

- LATEST OPER: Among the past occurrences, the number of special operations or controls that have been effected during the most recent 1 trip detection.
- LATEST TRIP: The number of trips after the occurrence of LATEST OPER.
- BEF LATST OPER: The number of occurrences 1 previously from the LATEST OPER.
- BEF LATST TRIP: The number of trips after the occurrence of BEF LATST OPER.

Operation History Data

Hand-held Tester Display	Count Condition
SHIFT BEF READY	Selector lever moved with READY lamp blinking
N RANGE CTRL 1	-
N RANGE CTRL 2	N position control effected due to frequent shifting operation
STEP ACCEL IN N	Accelerator pedal depressed in N position
AUX. BATT LOW	Auxiliary battery voltage below 9.5 V
HV INTERMITTENT	Instantaneous open at IGSW terminal of HV control ECU
MG2 (NO1) TEMP HIGH	Motor temperature climbed above 174○C (345○F)
MG2 (NO2) TEMP HIGH	Transaxle fluid temperature climbed above 162○C (324○F)
MG2 INV TEMP HIGH	Motor inverter temperature climbed above 111○C (232○F)
MG1 INV TEMP HIGH	Generator inverter temperature climbed above 111○C (232○F)
MAIN BATT LOW	Battery state of charge dropped below 30%
RESIST OVR HEAT	Limit resistor forecast temperature climbed above 120○C (248○F)
COOLANT HEAT	Inverter coolant forecast temperature climbed above 65○C (149○F)
CONVERTER HEAT	Boost converter temperature climbed above 111○C (232○F)
SHIFT P IN RUN	Shifted to P while driving
BKWRD DIR SHIFT	Shifted to R while moving forward or to D or B while moving in reverse
PREVENT STAYING	Engine speed resonance frequency band

Accessing Operation History Data

Follow the screen flow to access Operation History. From the Select Data screen, select the type of information you want to review.

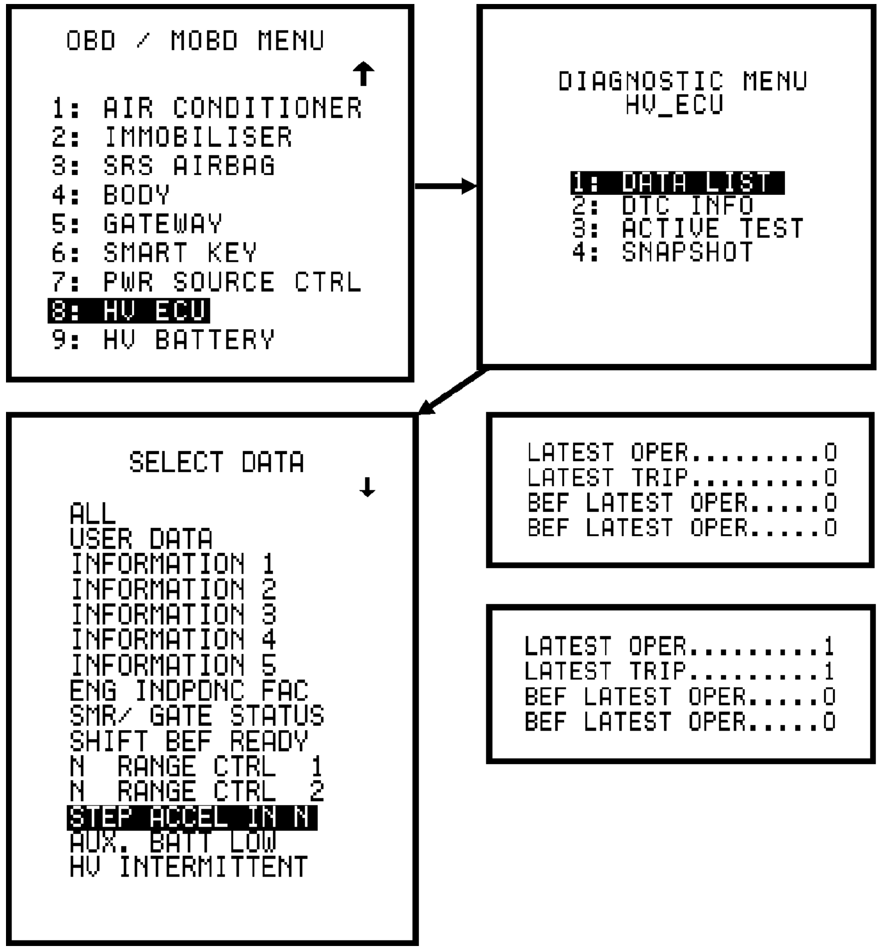


Figure 4.11 T072f411

NOTE For more information regarding Operation History data, refer to the Appendix located in the back of this book.

HV ECU Active Tests

The following are useful HV ECU active tests which can be accessed when using the Diagnostic Tester:

Inspection Mode 1

- Used to check its operation while the engine is still running. Also used to disable traction control while performing a speedometer test.
- This mode runs the engine continuously in the P position. It also cancels the traction control that is affected when the rotational difference between the front and rear wheels is excessive other than the P position.
- The test condition is power switch ON (IG), HV system normal, not in inspection mode, and other active tests not being executed.

Inspection Mode 2

- Used to disable traction control while performing a speedometer test or the like.
- This mode cancels the traction control that is affected when the rotational difference between the front and rear wheels is excessive other than the P position.
- The test condition is power switch ON (IG), HV system normal, not in inspection mode, and other active tests not being executed.

Inverter Stop

- Used to determine if there is an internal leak in the inverter or the HV control ECU.
- This mode keeps the inverter power transistor actuation ON.
- The test condition is power switch ON (IG), P position, HV system normal, inverter actuation not being disabled, shutting down inverter, and other active tests not being executed.

Cranking Request

- Used to crank the engine continuously in order to measure the compression.
- This mode allows the engine to continuously crank by activating the generator continuously.
- The test condition is power switch ON (IG), HV system normal, not in cranking mode, and other active tests not being executed.

Prius General Diagnostic Flow

When diagnosing the Prius, follow the diagnostic procedures below. Always put the DTCs in a logical hierarchy. For example, an engine control problem that sets a Check Engine light may eventually cause HV ECU codes.

1. What warning lights are ON? (Critical Information!)
2. What is the customer's complaint?
3. What is the condition of the vehicle?
4. Do steps 1-3 agree with each other?
5. Always use "ALL CODES" and print DTCs from each ECU.
6. For multiple DTCs, check the occurrence order.
7. What power source was affected first?
8. How were the other power sources or systems affected?
9. Isolate the system affected first.

NOTE

ALWAYS print Freeze Frame Data! This is important, especially when calling TAS.

Notes

WORKSHEET 4-1
Hybrid Malfunction Diagnosis

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

In this worksheet you will diagnose hybrid malfunctions by viewing DTCs, Information Codes and driving the vehicle for diagnostic confirmation.

Tools and Equipment

- Vehicle
- Repair Manual or TIS
- Diagnostic Tester
- Printer
- High Voltage insulated gloves

Section 1 - Hybrid Diagnosis

Hybrid Diagnosis #1

1. Turn the vehicle ON (READY Mode). Are there any warning lights illuminated? If so, list them below.

2. Connect the Diagnostic Tester to DLC3.
3. Select CODES ALL to check all the ECUs for DTCs.
4. How many systems are checked using Codes All?

5. Record which systems have codes. Highlight each system with a NG and press enter.

6. Try to clear the codes. Can the codes be cleared or do they reset immediately?
   Hint: To clear DTCs, you must exit out of ALL CODES and enter each section individually.

7. If needed, test-drive the vehicle to see if the warning lights illuminate.

8. Return to the shop area and check to see if the codes have reset. If they have, list them below.

   ____

   ____

   ____

   ____

9. In the case that the vehicle has multiple codes, where would you begin your diagnosis? Why?

   ____

   ____

   ____

10. Is there Freeze Frame Data or Information Codes associated with these codes?

   ____

11. Using TIS or a Repair Manual, look up the DTC and any relating Information Codes. Record them below.

   ____

   ____

   ____

12. Based on the information above and from the data lists, which circuit is malfunctioning?

   ____

13. Rotate to another vehicle. Hybrid Diagnosis #2

Hybrid Diagnosis #2

1. Turn the vehicle ON (READY Mode). Are there any warning lights illuminated? If so, list them below.

   ____

   ____

   ____

2. Connect the Diagnostic Tester to DLC3.

3. Select CODES ALL to check all the ECUs for DTCs.

4. How many systems are checked using Codes All?

5. Record which systems have codes. Highlight each system with a NG and press enter.

6. Try to clear the codes. Can the codes be cleared or do they reset immediately?
   Hint: To clear DTCs, you must exit out of ALL CODES and enter each section individually.

7. If needed, test-drive the vehicle to see if the warning lights illuminate.

8. Return to the shop area and check to see if the codes have reset. If they have, list them below.

9. In the case that the vehicle has multiple codes, where would you begin your diagnosis? Why?

10. Is there Freeze Frame Data or Information Codes associated with these codes?

11. Using TIS or a Repair Manual, look up the DTC and any relating Information Codes. Record them below.

12. Based on the information above and from the data lists, which circuit is malfunctioning?

13. Rotate to another vehicle.

Hybrid Diagnosis #3

1. Turn the vehicle ON (READY Mode). Are there any warning lights illuminated? If so, list them below.

2. Connect the Diagnostic Tester to DLC3.

3. Select CODES ALL to check all the ECUs for DTCs.

4. How many systems are checked using Codes All?

5. Record which systems have codes. Highlight each system with a NG and press enter.

6. Try to clear the codes. Can the codes be cleared or do they reset immediately?
   Hint: To clear DTCs, you must exit out of ALL CODES and enter each section individually.

7. If needed, test-drive the vehicle to see if the warning lights illuminate.

8. Return to the shop area and check to see if the codes have reset. If they have, list them below.

9. In the case that the vehicle has multiple codes, where would you begin your diagnosis? Why?

10. Is there Freeze Frame Data or Information Codes associated with these codes?

11. Using TIS or a Repair Manual, look up the DTC and any relating Information Codes. Record them below.

12. Based on the information above and from the data lists, which circuit is malfunctioning?

Return the vehicle to its normal condition and clear any DTCs.

Notes

WORKSHEET 4-2
Operation History Data

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

In this worksheet you will utilize Operation History Data to help diagnosis simple customer complaints that may be a normal condition.

Tools and Equipment

- Vehicle
- Repair Manual or TIS
- Diagnostic Tester
- Printer

Section 1 - Setting Operation History Data

1. Using the Diagnostic Tester, go to Operation History Data. Where is Operation History Data found?

Hint: Refer to your Technician Handbook for the location of Operation History Data in the Diagnostic Tester. Also refer to the Appendix for a complete list of Operation History Data.

2. Using the tester, select STEP ACCEL IN N. Record or print the information.

3. Move the shift lever to Neutral. Step on the accelerator pedal several times.
4. Turn the vehicle OFF and then back ON again. In Neutral step on the accelerator pedal again.
5. Using the tester, view STEP ACCEL IN N. Record or print the information.

6. What does this data tell you?

7. Drive the vehicle to an open area. Slowly drive the vehicle and shift into park. What happens?

   ____

8. In Operation History Data, select Shift P in Run. What is recorded?

   ____

9. When would this information be useful?

   ____

10. When do you think Aux. Batt Low would be useful?

   ____

11. Review the entire list of Operation History Data. What items would be helpful when diagnosing customer complaints? Remember that many of these items help substantiate that the concern was a normal condition or caused by the customer's driving characteristics.

   ____

   ____

WORKSHEET 4-3
Hybrid Diagnosis (Customer Concern)

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

In this worksheet you will diagnose a customer concern using an actual TAS case. To diagnose the concern, you will use the provided DTCs, Freeze Frame Data and Information Codes.

Tools and Equipment

- Repair Manuals or TIS

Section 1 - DTC Diagnosis

Repair Order

VIN JT2BK12U610019736	Year/Make/Model 01/Toyota/Prius	Production Date 1/10/01	RO Number 319901
Air Cond. Y	PS Y	Trans A	Mileage 2,069
Time Received 9:57am	Date/Time Promised 5/01/02 6:00pm	Priority 4	
Comments: Customer states the check engine light came on and had enough power to get to the side of the road. Claims she did not run out of gas, meter reads full.			

1. View the Repair Order along with the DTCs, Information Codes and Freeze Frame data provided by the instructor to diagnose the customer's complaint above.

2. List all the DTCs and Information Codes along with their descriptions. Then put the codes in the proper hierarchy to help diagnose problem.

3. What information should you look for in the Freeze Frame data for P3000 and Info Codes 388 & 389?

4. What information should you look for in the Freeze Frame data for P3106 and Info Code 211 ?

5. What information should you look for in the HV Battery Data List?

6. What information should you look for in the P1128 Data List?

7. Why did DTC C1259 set?

8. What is the vehicle diagnosis?

DTC P1128 & C1259

```
DIAG. TROUBLE CODES
ECU: ENGINE
Number of DTCs: 1
*P1128 Throttle control
       Motor lock
       Malfunction

ENTER = FREEZE FRAME
[EXIT] to Continue
```

```
DIAG. TROUBLE CODES
ECU: ABS/VSC
Number of DTCs: 1
C1259 HV system
      Regenerative
      Malfunction

[EXIT] to Continue
```

TROUBLE CODE	P1128
CALC LOAD	76%
ENGINE SPD	1545rpm
COOLANT TEMP	145.4°F
INTAKE AIR	57.2°F
VEHICLE SPD	60MPH
SHORT FT #1	-7.1%
LONG FT #1	1.5%
FUEL SYS #1	CL
FUEL SYS #2	UNUSED
STOP LIGHT SW1	OFF
STOP LIGHT SW1	OFF
ENG RUN TIME	255
BATTERY	13.7V
INJECTOR	4.8ms
INJ VOL FB	1.00
FUEL FB COEF	0.95
A/F LEARN	-98.5%
PURGE LEARN	-100.0%
KCS FEEDBACK	63.5°
REQ ENG POWER	14KW
RAM MONITOR	INCMPL
ENG RUN SIG	OFF
ACC RACING SIG	OFF
ENG WARM UP SIG	ON
ENG RUN PERM	PROHIBT
FC STATUS	NO
ENG STP LIMIT	ISC LRN

DTC P3000 - Information Code 388

```
DIAG. TROUBLE CODES
ECU: HV_ECU
Number of DTCs: 2
*P3000 Battery control
       system malfunction

*P3106 Communication
       malfunction
       <Engine -> HV>

 ENTER = FREEZE FRAME
  [EXIT] to Continue
```

```
COOLANT TEMP..........87.8°F
TACHO METER..........1248rpm
VEHICLE SPD.............0MPH
INTAKE AIR............84.2°F
INFORMATION 1..............0
INFORMATION 2............388
INFORMATION 3............389
INFORMATION 4..............0
INFORMATION 5..............0
```

```
INFORMATION 2............388
MG1 REV..............4480rpm
MG2 REV.................0rpm
MG1 TORQ.................4Nm
MG2 TORQ.................8Nm
POWER RQST................0W
ENGINE SPD...........1216rpm
MCYL CTRL POWER..........0Nm
SOC....................9.80%
WOUT CTRL POWER...........0W
WIN CTRL POWER........-20000W
DRIVE CONDITION............2
INVERT TEMP-MG1.......96.8°F
INVERT TEMP-MG2.......82.4°F
MG1 TEMP..............84.2°F
MG2 TEMP..............80.6°F
PWR RESOURCE VW..........270V
PWR RESOURCE IB...........12A
SHIFT SENSOR 1.............1
ACC SENSOR MAIN.........0.00%
ENG STOP RQST..............NO
IDLING REQUEST...........YES
ENGINE FUEL CUT..........YES
HV BATT CH RQST..........YES
HCAC ABSRT RQST...........NO
ENG WARM UP RQT..........YES
STOP SW COND..............NO
CRUISE CONTROL............NO
AUX. BATT V...........13.87V
EXCLUSIVE INFO 1........-127
EXCLUSIVE INFO 2........-127
EXCLUSIVE INFO 3........-127
EXCLUSIVE INFO 4........-127
EXCLUSIVE INFO 5........-127
EXCLUSIVE INFO 6........-127
LOAD CONDITION...........MG2
DRIVING PATTEN 1.......LO SPD
DRIVING PATTEN 2.......LO SPD
DRIVING PATTEN 3.......LO SPD
IG OFF IN DRVIN............NO
SG B IN REDUCIN............NO
SG N IN REDUC/P............NO
STEP ACC&BRAKE.............NO
IF OFF TIME.............0min
OCCURENCE ORDR.............1
```

DTC P3000 - Information Code 389

INFORMATION 3	389
MG1 REV	0rpm
MG2 REV	0rpm
MG1 TORQ	0Nm
MG2 TORQ	0Nm
POWER RQST	0W
ENGINE SPD	0rpm
MCYL CTRL POWER	0Nm
SOC	14.50%
WOUT CTRL POWER	0W
WIN CTRL POWER	0W
DRIVE CONDITION	2
INVERT TEMP-MG1	73.4°F
INVERT TEMP-MG2	66.2°F
MG1 TEMP	71.6°F
MG2 TEMP	69.8°F
PWR RESOURCE VW	186V
PWR RESOURCE IB	2A
SHIFT SENSOR 1	1
ACC SENSOR MAIN	0.00%
ENG STOP RQST	NO
IDLING REQUEST	YES
ENGINE FUEL CUT	YES
HV BATT CH RQST	YES
HCAC ABSRT RQST	NO
ENG WARM UP RQT	YES
STOP SW COND	NO
CRUISE CONTROL	NO
AUX. BATT V	13.72V
EXCLUSIVE INFO 1	-127
EXCLUSIVE INFO 2	-127
EXCLUSIVE INFO 3	-127
EXCLUSIVE INFO 4	-127
EXCLUSIVE INFO 5	-127
EXCLUSIVE INFO 6	-127
LOAD CONDITION	MG2
DRIVING PATTEN 1	LO SPD
DRIVING PATTEN 2	LO SPD
DRIVING PATTEN 3	LO SPD
IG OFF IN DRVIN	NO
SG B IN REDUCIN	NO
SG N IN REDUC/P	NO
STEP ACC&BRAKE	NO
IF OFF TIME	0min
OCCURENCE ORDR	3

DTC P3106 - Information Code 211

```
DIAG. TROUBLE CODES
ECU: HV_ECU
Number of DTCs: 2
*P3000 Battery control
       system malfunction

*P3106 Communication
       malfunction
       <Engine -> HV>

  ENTER = FREEZE FRAME
  [EXIT] to Continue
```

```
COOLANT TEMP.......... 73.4°F
TACHO METER.............0rpm
VEHICLE SPD.............0MPH
INTAKE AIR............71.6°F
INFORMATION 1...........211
INFORMATION 2.............0
INFORMATION 3.............0
INFORMATION 4.............0
INFORMATION 5.............0
```

```
INFORMATION 1............211
MG1 REV.................0rpm
MG2 REV.................0rpm
MG1 TORQ.................0Nm
MG2 TORQ.................0Nm
POWER RQST................0W
ENGINE SPD..............0rpm
MCYL CTRL POWER.........-16Nm
SOC....................0.00%
WOUT CTRL POWER...........0W
WIN CTRL POWER........-20000W
DRIVE CONDITION.............2
INVERT TEMP-MG1.......73.4°F
INVERT TEMP-MG2.......66.2°F
MG1 TEMP..............71.6°F
MG2 TEMP..............69.8°F
PWR RESOURCE VW..........216V
PWR RESOURCE IB............2A
SHIFT SENSOR 1..............1
ACC SENSOR MAIN.........0.00%
ENG STOP RQST..............NO
IDLING REQUEST............YES
ENGINE FUEL CUT...........YES
HV BATT CH RQST...........YES
HCAC ABSRT RQST............NO
ENG WARM UP RQT...........YES
STOP SW COND...............NO
CRUISE CONTROL.............NO
AUX. BATT V...........13.72V
EXCLUSIVE INFO 1.........-127
EXCLUSIVE INFO 2.........-127
EXCLUSIVE INFO 3.........-127
EXCLUSIVE INFO 4.........-127
EXCLUSIVE INFO 5.........-127
EXCLUSIVE INFO 6.........-127
LOAD CONDITION............MG2
DRIVING PATTEN 1.......LO SPD
DRIVING PATTEN 2.......LO SPD
DRIVING PATTEN 3.......LO SPD
IG OFF IN DRVIN............NO
SG B IN REDUCIN............NO
SG N IN REDUC/P............NO
STEP ACC&BRAKE.............NO
IF OFF TIME..............0min
OCCURENCE ORDR..............2
```

HV Battery ECU Data List

```
BATTERY SOC............31.5%
WIN..................-20.0KW
WOUT...................0.0KW
DELTA SOC.............20.0%
IB MAIN BATTERY......-128.00A
BAT BLOCK MIN V........13.03V
MIN BAT BLOCK #...........16#
BAT BLOCK MAX V........13.52V
MAX BAT BLOCK #...........19#
BATT TEMP 1............73.4°F
BATT TEMP 2............75.2°F
BATT TEMP 3............75.2°F
BATT TEMP 4............71.6°F
BATT INSIDE AIR.......68.0°F4
NORMAL STATUS............YES
PRE ONBOARD CH............NO
ONBOARD CHARGE............NO
OFF AVE CHG ST.............NO
COOLING FAN LO............ON
COOLING FAN MID...........OFF
COOLING FAN HI...........OFF
VMF FAN VOLTAGE.......8.125V
SBLW FAN ST RQS...........OFF
AUX. BATT V...........11.640V
EQTR CHARGE ST............OFF
EQCO DF RELAY.............OFF
CCTL......................ON
ET OFF CHR HR..........0.0Hr
BATT BLOCK V1..........0.00V
BATT BLOCK V2.........13.39V
BATT BLOCK V3.........13.27V
BATT BLOCK V4.........13.20V
BATT BLOCK V5.........13.26V
BATT BLOCK V6.........13.55V
BATT BLOCK V7.........13.33V
BATT BLOCK V8.........13.26V
BATT BLOCK V9.........13.11V
BATT BLOCK V10........13.12V
BATT BLOCK V11........13.22V
BATT BLOCK V12........13.21V
BATT BLOCK V13........13.24V
BATT BLOCK V14........13.08V
BATT BLOCK V15........13.27V
BATT BLOCK V16........13.03V
BATT BLOCK V17........13.24V
BATT BLOCK V18........13.27V
BATT BLOCK V19........13.52V
INSIDE RESIST1......0.020ohm
INSIDE RESIST2......0.021ohm
INSIDE RESIST3......0.020ohm
```

```
INSIDE RESIST4......0.020ohm
INSIDE RESIST5......0.020ohm
INSIDE RESIST6......0.020ohm
INSIDE RESIST7......0.020ohm
INSIDE RESIST8......0.020ohm
INSIDE RESIST9......0.020ohm
INSIDE RESIST10.....0.020ohm
INSIDE RESIST11.....0.021ohm
INSIDE RESIST12.....0.021ohm
INSIDE RESIST13.....0.021ohm
INSIDE RESIST14.....0.021ohm
INSIDE RESIST15.....0.020ohm
INSIDE RESIST16.....0.020ohm
INSIDE RESIST17.....0.020ohm
INSIDE RESIST18.....0.021ohm
INSIDE RESIST19.....0.020ohm
ONB CHARGE TIME.......1times
BATTERY LO TIME.......2times
DC INHIBIT TIME......10times
BATTERY TOO HI........0times
IG OFF HOUR.............15Hr
IG ON HOUR............0.31Hr
DTC.......................0
XTEST SW SIG..........NORMAL
ECU CODE #1...............4
ECU CODE #2...............7
ECU CODE #3...............0
ECU CODE #4...............3
ECU CODE #5...............0
ECU CODE #6...............A
```

Notes

Section 5

HV Battery Control Systems

Overview

The principal role of the hybrid battery system is to monitor the condition of the HV battery assembly through the use of the battery ECU. That information is then transmitted to the HV Control ECU. The battery ECU calculates the SOC (State of Charge) of the HV battery based on voltage, current and temperature. It then sends the results to the HV Control ECU. As a result, the proper charge and discharge control is performed.

This system also controls the battery blower motor controller in order to maintain a proper temperature at the HV battery assembly. To do this while the vehicle is being driven, the battery ECU determines and controls the operating mode of the battery blower assembly in accordance with the temperature of the HV battery assembly.

SAFETY TIP

ALWAYS wear high-voltage insulated gloves when diagnosing the Hybrid System. Check your gloves before wearing! Even a tiny pinhole can be dangerous, as electricity will find its' way in. To check your gloves, blow air into each glove, hold the glove tight like a balloon and make sure no air escapes.

High-voltage insulated gloves can be ordered from the Toyota SPX/OTC SST catalog under part numbers:

Small gloves - 00002-03100-S

Medium gloves - 00002-03200-M

Large gloves - 00002-03300-L

NOTE

Careless handling of this hybrid system may result in electrocution or electrical leakage. When servicing the hybrid system strictly follow the instructions found in the Repair Manual.

HV - Nickel Metal Hydride Battery

In the HV battery pack, six nickel metal hydride type 1.2V cells are connected in series to form one module.

In the '01-03 Prius, 38 modules are divided into two holders and connected in series. Thus, the HV battery contains a total of 228 cells and has a rated voltage of 273.6V.

In the '04 and later Prius, 28 modules are connected for a rated voltage of 201.6V. The cells are now connected in two places, reducing the internal resistance of the battery.

The electrode plates in the HV battery are made of porous nickel and metal hydride alloy.

NOTE

For battery recycling information, please refer to the Warranty Policy and Procedure manual.

HV Battery Pack Information

HV Battery Pack	’04 Prius and Later	’01 -‘03 Prius
Battery pack voltage	201.6V	273.6V
Number of NiMH battery modules in the pack	28	38
Number of cells	168	228
NiMH battery module voltage	7.2V	←

System Main Relay (SMR)

The System Main Relay (SMR) connects and disconnects the power source of the high-voltage circuit on command from the HV ECU. A total of three relays, one for the negative side and two for the positive side, are provided to ensure proper operation.

When energized, SMR1 and SMR3 are turned ON. Next, SMR2 is turned ON and SMR1 is turned OFF. By allowing a controlled current via the resistor to pass through initially in this manner, the circuit is protected against inrush current.

When de-energized, SMR2 and SMR3 are turned OFF in that order, and the HV ECU verifies that the respective relays have been properly turned OFF.

System Main Relay (SMR)

The SMR connects and disconnects the power source of the high-voltage circuit. A total of three relays, one for the negative side and two for the positive side, are provided to ensure proper operation.

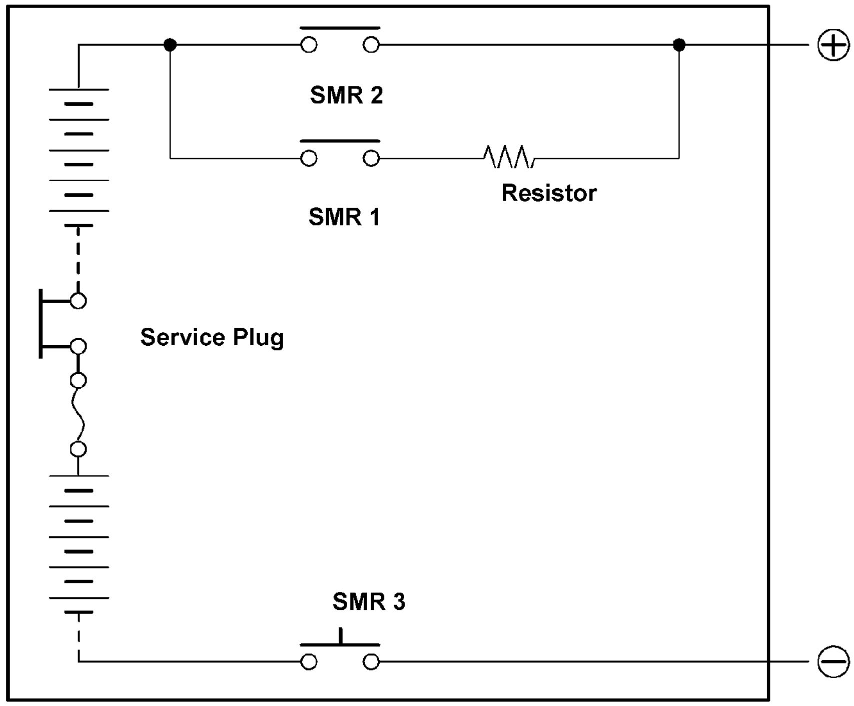


Figure 5.1 T072f501c

State of Charge (SOC)

The battery ECU constantly monitors HV battery temperature, voltage and amperage. It also checks for leaks in the HV battery.

While the vehicle is in motion, the HV battery undergoes repetitive charge/discharge cycles as it becomes discharged by MG2 during acceleration, and charged by the regenerative brake during deceleration. The battery ECU outputs charge/discharge requests to the HV ECU so that the SOC can be constantly maintained at a median level by estimating the charge/discharge amperage.

The target SOC is 60%. When the SOC drops below the target range, the battery ECU informs the HV ECU. The HV ECU then signals the engine ECM to increase power to charge the HV battery. If the SOC is below 20%, the engine is not producing power.

Delta SOC

The Delta SOC should not exceed 20%. Normal low to high deviation is 20% in order to calculate the SOC from one module to the next across the battery group. When the Delta SOC exceeds 20%, this means that the HV Battery ECU cannot correct or maintain the SOC difference within the acceptable range.

DTC P3006 Battery SOC Uneven

('01-'03 Prius)

The charging rate of each battery is monitored through the battery voltage detection line. Since the stall test suggested in the Repair Manual is not a reliable test, drive the vehicle under load while viewing the Min/Max voltage on the Diagnostic Tester. For example, drive up a steep hill very slowly. This kind of load stresses the battery and will allow detection of weak modules.

CAUTION

This is a two-person test. One person should drive the vehicle while the other monitors the Diagnostic Tester.

If P3006 is the only DTC, refer to the Repair Manual to do a stall test. Monitor the swing and the difference in voltage between the data MAX V and MIN V.

HV Battery Cooling System

The battery ECU detects the rise in the battery temperature via three temperature sensors in the HV battery and one intake air temperature sensor. Then the battery ECU actuates the cooling fan under duty cycle control in order to maintain the temperature of the HV battery within the specified range.

The battery ECU keeps the fan OFF or running at LO if:

- The A/C is being used to cool the vehicle.
- Some margin is left in the temperature of the battery.

This gives priority to cooling down the cabin, which is important because on the '04 & later Prius the cooling system draws intake air from the cabin.

DTC P3076 Abnormal Battery Cooling Fan Air Flow

('01-'03 Prius)

If foreign matter clogs the duct, the HV battery might not be able to cool sufficiently. Insufficient cooling will cause the output control warning light to illuminate and may cause DTC P3076.

NOTE

In the '01-03 Prius, the fresh air duct permits the flow of cooling air when the vehicle is stopped after driving. When washing the car, do not allow large quantities of water to enter the duct.

HV Battery Malfunction Monitoring

The HV Battery Malfunction Monitoring function in the battery ECU monitors the temperature and voltage of the HV battery. If a malfunction is detected, the battery ECU restricts or stops the charging and discharging of the HV battery. In addition, this function illuminates the warning light, outputs DTCs and stores them in memory.

HV Battery Diagnosis

When a HV battery malfunction occurs, the system sets a Master Warning light and illuminates the battery symbol on the Malfunction Indicator. Use the Diagnostic Tester to view the HV Battery Data List. The Data List provides battery system information down to a module pair level.

NOTE

Check for external contamination when a battery malfunction occurs. Find out where the customer works, where they park, etc. There may be excessive foreign matter entering into the vent.

High-Voltage Component Service Safety

During high-voltage component service:

- ALWAYS disconnect the auxiliary battery before removing the high-voltage service plug.
- ALWAYS use high-voltage insulated gloves when disconnecting the service plug.
- ALWAYS use a DVOM to confirm that high-voltage circuits have 0V before performing any service operation.
- ALWAYS confirm that you have the service plug in your pocket before performing any service operations.
- ALWAYS use the Repair Manual diagnostic procedures.

NOTE

ALWAYS assume that high-voltage circuits are energized.

Remember that removal of the service plug does not disable the individual high-voltage batteries.

High-Voltage Battery Service

During high-voltage battery service:

- ALWAYS use high-voltage insulated gloves and safety glasses when disassembling the high-voltage battery.
- Remove ALL metal objects that may touch the workbench.
- Understand the voltage potential that is within your reach.

High-Voltage Battery Charger

When a HV battery needs to be recharged, a special high-voltage battery charger must be used. These battery chargers come from Japan and are not sold to dealers. Your regional FTS or FPE will bring the charger to your dealership and perform the charging operation. **ONLY FTSs and FPEs are authorized to use the charger!**

When using the charger, the immediate area must be secured with warning tape and the vehicle must be outside. This tool will charge the battery from below 15% SOC to 40-50% SOC in approximately three hours. Target SOC is 60%.

NOTE

The power connector on the high voltage charger can be physically plugged into a standard 110V AC - 60 Hz socket, but the charger is **NOT** an 110V device. Therefore, you must **ALWAYS** use the transformer box!

High-Voltage Battery Charger

The small orange cable is the 300-volt DC output. The small black cable powers the 12V system for battery cooling fans and computer.

IMPORTANT: The power connector on the high voltage charger can be physically plugged into a standard 110V AC-60 Hz socket, but the charger is **NOT** a 110V device. **You must ALWAYS** use the transformer box shown on the left side of the photo when powering up the charger.

Figure 5.2 T072f502p

Connection Wires

In the vehicle, the mating connector for the orange wire is inside the left end of the battery pack, under the cover. Use care when pulling out the plug in the battery pack. The wires are not heavily insulated and the sheet metal case is sharp.

Figure 5.3 T072f503p

Control Panel

The unit will charge the battery pack from below 15% SOC to a "startable" 40-50% SOC in about 3 hours.

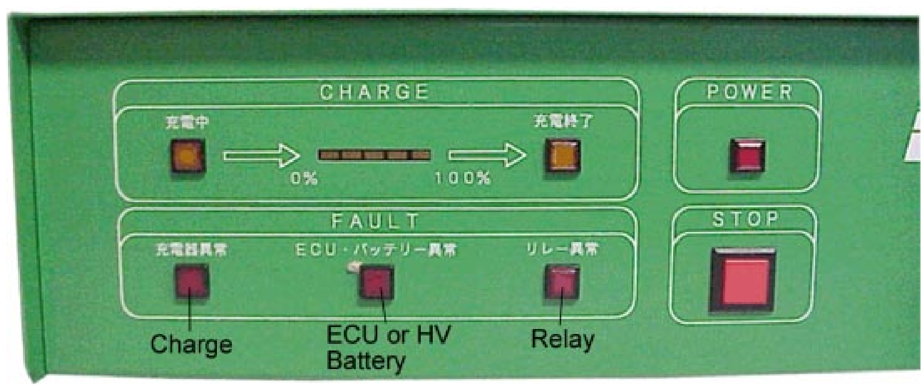


Figure 5.4 T072f504p

Charging HV Battery The photo below shows the high-voltage battery charger connected to a '01-'03 Prius.

CAUTION Before connecting the charger, wear insulated gloves and remove the service plug. Keep the ignition key in your pocket for safety.

HV Battery Charger

('01 - '03 Prius)

HV Battery Charger connected to the vehicle.

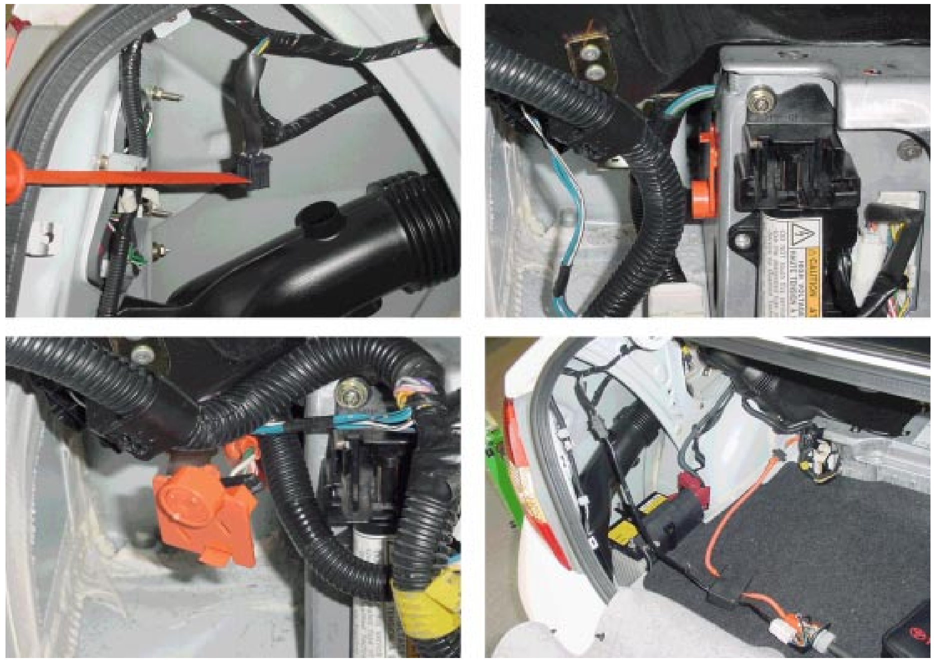


Figure 5.5 T072f505p

Charging HV Battery ('04 & later Prius)

The '04 & later Prius uses the same battery charger as earlier models, but uses a wiring harness specifically designed for the newer model. The charger connection points have changed.

Before connecting the charger, wear insulated gloves and remove the service plug. Keep the ignition key and service plug in your pocket.

The software logic on the '04 Prius has changed to help prevent customers from running the HV battery low enough to where the charger is needed. The vehicle simply will not crank after the customer has tried several times after running out of gas for example. If the charger is needed, call your regional FTS or FPE for assistance. Refer to the graphic below for the HV battery charger connection points.

HV Battery Charging

('04 & later Prius)

ALWAYS use the transformer box when connecting the HV battery charger.

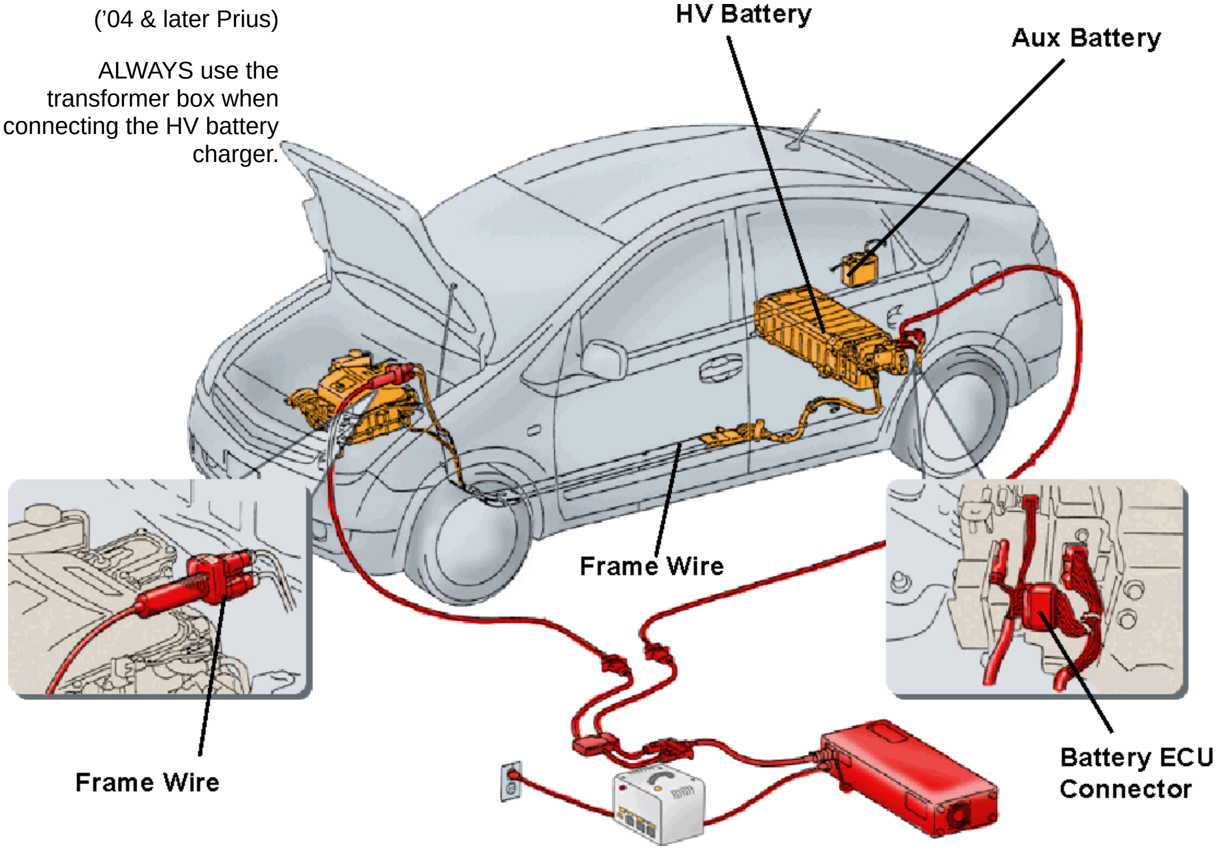


Figure 5.6 T072f506c

Notes

WORKSHEET 5-1
HV Battery Diagnosis (Customer Concern)

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

In this worksheet you will diagnose two HV Battery concerns. You will use the provided HV battery DTCs, Freeze Frame Data and Information Codes.

Section 1 - DTC Diagnosis

Repair Order

VIN JT2BK18U930071601	Year/Make/Model 03/Toyota/Prius	Production Date 8/10/02	RO Number 319902
Air Cond. Y	PS Y	Trans A	Mileage 3,075
Time Received 10:58am	Date/Time Promised 5/01/03 6:00pm	Priority 4	
Comments: The customer complains that there was a loss of power, and warning lights turned ON.			

1. View the Repair Order above along with the DTCs, Information Codes and Freeze Frame data provided by the instructor to diagnose the customer's complaint.

2. List all the DTCs and Information Codes along with their descriptions. Then put the codes in the proper heirarchy to help diagnose the problem.

3. What information should you look for in the Freeze Frame data for P3006?

4. Can you predict what the diagnosis might be?

DIAG. TROUBLE CODES
ECU: HV_ECU
Number of DTCs: 1
*P3000 Battery control system malfunction

ENTER = FREEZE FRAME
[EXIT] to Continue

COOLANT TEMP	73.4°F
TACHO METER	0rpm
VEHICLE SPD	0MPH
INTAKE AIR	77.0°F
INFORMATION 1	0
INFORMATION 2	123
INFORMATION 3	0
INFORMATION 4	0
INFORMATION 5	0

INFORMATION 2	123
MG1 REV	0rpm
MG2 REV	0rpm
MG1 TORQ	0Nm
MG2 TORQ	0Nm
POWER RQST	0W
ENGINE SPD	0rpm
MCYL CTRL POWER	-16Nm
SOC	0.00%
WOUT CTRL POWER	0W
WIN CTRL POWER	-20000W
DRIVE CONDITION	0
INVERT TEMP-MG1	62.6°F
INVERT TEMP-MG2	78.8°F
MG1 TEMP	68.0°F
MG2 TEMP	66.2°F
PWR RESOURCE VM	0V
PWR RESOURCE IB	-2A
SHIFT SENSOR 1	1
ACC SENSOR MAIN	0.00%
ENG STOP RQST	YES
IDLING REQUEST	NO
ENGINE FUEL CUT	YES
HV BATT CH RQST	NO
HCAC ABSRT RQST	NO
ENG WARM UP RQT	YES
STOP SW COND	NO
CRUISE CONTROL	NO
AUX. BATT V	11.76V
EXCLUSIVE INFO 1	0
EXCLUSIVE INFO 2	0
EXCLUSIVE INFO 3	0
EXCLUSIVE INFO 4	0
EXCLUSIVE INFO 5	0
EXCLUSIVE INFO 6	0
LOAD CONDITION	MG2
DRIVING PATTEN 1	LO SPD
DRIVING PATTEN 2	LO SPD
DRIVING PATTEN 3	LO SPD
IG OFF IN DRVIN	NO
SG B IN REDUCIN	NO
SG N IN REDUC/P	NO
STEP ACC&BRAKE	NO
IF OFF TIME	0min
OCCURENCE ORDR	1

```
DIAG. TROUBLE CODES
ECU: HV_BATTERY
Number of DTCs: 1
*P3006 Batteries levels
       are unusually
       different.


 ENTER = FREEZE FRAME
  [EXIT] to Continue
```

```
TROUBLE CODE...........P3006
BATTERY SOC.............0.0%
WIN.................-20.0kW
WOUT..................0.0kW
DELTA SOC..............45.0%
IB MAIN BATTERY.......-14.15A
BATT TEMP 1...........80.6°F
BATT TEMP 2...........77.0°F
BATT TEMP 3...........77.0°F
BATT TEMP 4...........77.0°F
BATT INSIDE AIR........78.8°F
NORMAL STATUS............YES
PRE ONBOARD CH............NO
ONBOARD CHARGE............NO
OFF AVE CHG ST............NO
COOLING FAN LO...........OFF
COOLING FAN MID..........OFF
COOLING FAN HI...........OFF
SBLW FAN ST RQS..........OFF
AUX. BATT V...........14.062V
EQTR CHARGE ST...........OFF
EQCO DF RELAY............OFF
CCTL......................ON
BATT BLOCK V1..........15.56V
BATT BLOCK V2..........15.47V
BATT BLOCK V3..........15.44V
BATT BLOCK V4..........15.47V
BATT BLOCK V5..........15.50V
BATT BLOCK V6..........15.48V
BATT BLOCK V7..........15.48V
BATT BLOCK V8..........15.47V
BATT BLOCK V9..........15.47V
BATT BLOCK V10.........15.53V
BATT BLOCK V11.........15.47V
BATT BLOCK V12.........15.46V
BATT BLOCK V13.........15.50V
BATT BLOCK V14.........15.48V
BATT BLOCK V15.........15.47V
BATT BLOCK V16.........20.00V
BATT BLOCK V17..........9.92V
BATT BLOCK V18.........15.51V
BATT BLOCK V19.........15.52V
```

Section 6

Brake System

Overview

The hybrid vehicle brake system includes both standard hydraulic brakes and a unique regenerative braking system that uses the vehicle's momentum to recharge the battery. As soon as the accelerator pedal is released, the HV ECU initiates regenerative braking. MG2 is turned by the wheels and used as a generator to recharge the batteries. During this phase of braking, the hydraulic brakes are not used. When more rapid deceleration is required, the hydraulic brakes are activated to provide additional stopping power. To increase energy efficiency the system uses the regenerative brakes whenever possible. Selecting "B" on the shift lever will maximize regenerative efficiency and is useful for controlling speeds downhill. In 'B' mode about 30% of the energy is recovered.

If either the regenerative or hydraulic braking system fails, the remaining system will still work. However, the brake pedal will be harder to press and the stopping distance will be longer. In this situation, the brake system warning light will illuminate.

NOTE

The battery will accept charge up to an instantaneous rate of 20 to 21 KWH. Much of the energy from light braking at high speeds and harder braking at lower speeds can be recovered. Excess energy over the charging limits is wasted as heat in the brakes just as in other cars. At this time there is no way for the customer to know the limit of regenerative energy recovery.

Brake System Components

('01 -'03 Prius)

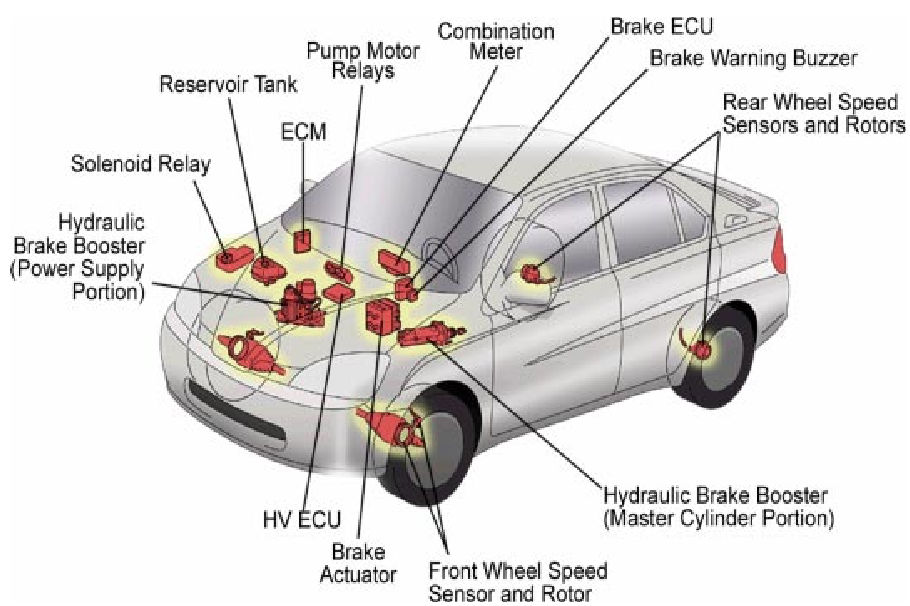


Figure 6.1 T072f601c

Regenerative Brake Cooperative Control

Regenerative brake cooperative control balances the brake force of the regenerative and hydraulic brakes to minimize the amount of kinetic energy lost to heat and friction. It recovers the energy by converting it into electrical energy.

To convert kinetic energy to electrical energy the system uses MG2 as a generator. The drive axle and MG2 are joined mechanically. When the drive wheels rotate MG2 it tends to resist the rotation of the wheels, providing both electrical energy and the brake force needed to slow the vehicle. The greater the battery charging amperage, the greater the resistance.

On the '04 & later Prius, the increased power output of MG2 provides increased regenerative brake force. In addition, the distribution of the brake force has been improved through the adoption of the Electronically Controlled Brake (ECB) system, effectively increasing the range of the regenerative brake. These attributes enhance the system's ability to recover electrical energy which contributes to fuel economy.

Regenerative Brake System

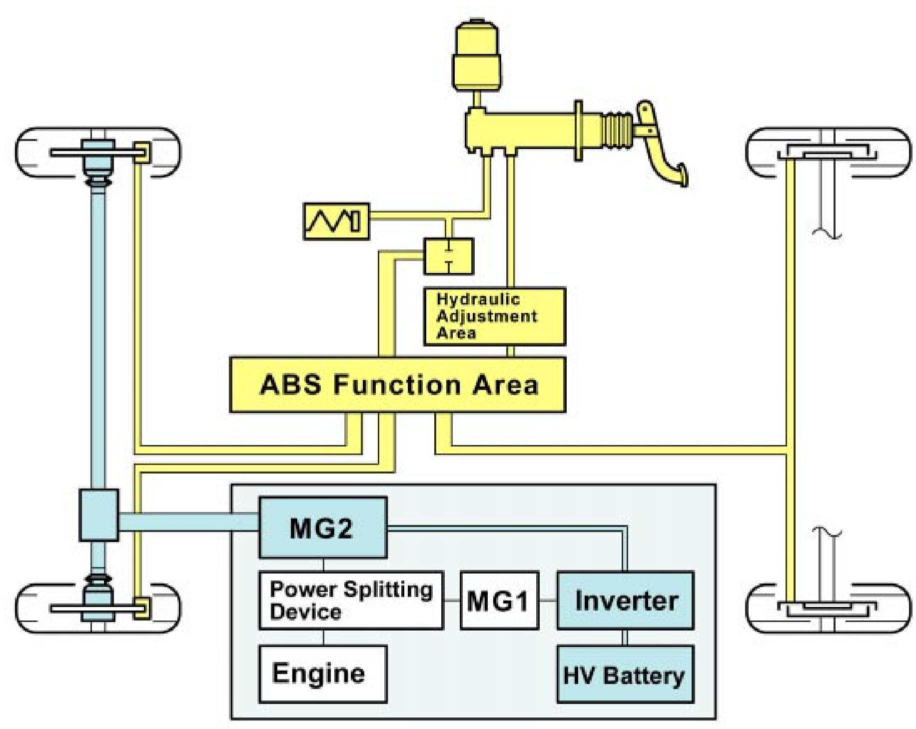


Figure 6.2 T072f602c

Brake ECU ('01-'03 Prius)

In the '01-'03 Prius, the Brake ECU communicates with the HV ECU based on signals received from sensors. The controls include:

- Conventional brake control
- ABS with EBD control
- Regenerative brake cooperative control

Skid Control ECU ('04 & later Prius)

In the '04 & later Prius, brake control processing is moved to the Skid Control ECU which maintains communication with the EPS ECU and the HV ECU based on signals received from sensors. The controls include:

- Conventional brake control
- ABS with EBD control
- Brake Assist
- Enhanced VSC
- Regenerative brake cooperative control

Enhanced VSC System ('04 & later Prius)

The Enhanced VSC system is available on the '04 & later Prius. The following are two examples that can be considered as circumstances in which tires exceed their lateral grip limit. The Enhanced VSC system is designed to help control the vehicle behavior by controlling the motive force and the brakes at each wheel when the vehicle is meets one of these two conditions:

- When the front wheels lose grip in relation to the rear wheels (front wheel skid tendency known as 'understeer')
- When the rear wheels lose grip in relation to the front wheels (rear wheel skid tendency, or 'oversteer')

Enhanced VSC Operation ('04 & later Prius)

When the skid control ECU determines that the vehicle exhibits a tendency to understeer or oversteer, it decreases the engine output and applies the brake of a front or rear wheel to control the vehicle's yaw moment. The basic operation of the Enhanced VSC is described below. However, the control method differs depending on the vehicle's characteristics and driving conditions.

When the skid control ECU determines that there is a large front wheel skid tendency, it counteracts in accordance with the extent of that tendency. The skid control ECU controls the motive power output and applies the brakes of the front wheel of the outer circle in the turns and rear wheels in order to restrain the front wheel skid tendency.

When the skid control ECU determines that there is a large rear wheel skid tendency, it counteracts in accordance with the extent of that tendency. It applies the brakes of the front wheel of the outer circle of the turn and generates an outward moment of inertia in the vehicle, in order to restrain the rear wheel tendency. Along with the reduction in the vehicle speed caused by the braking force, the vehicle's stability is ensured. In some cases the skid control ECU applies the brake of the rear wheels, as necessary.

Cooperative Control with EPS ('04 & later Prius)

Enhanced VSC provides the steering assist to facilitate steering operation for the driver depending on vehicle situations. This is accomplished through coordination of cooperative control with EPS in addition to the general VSC control.

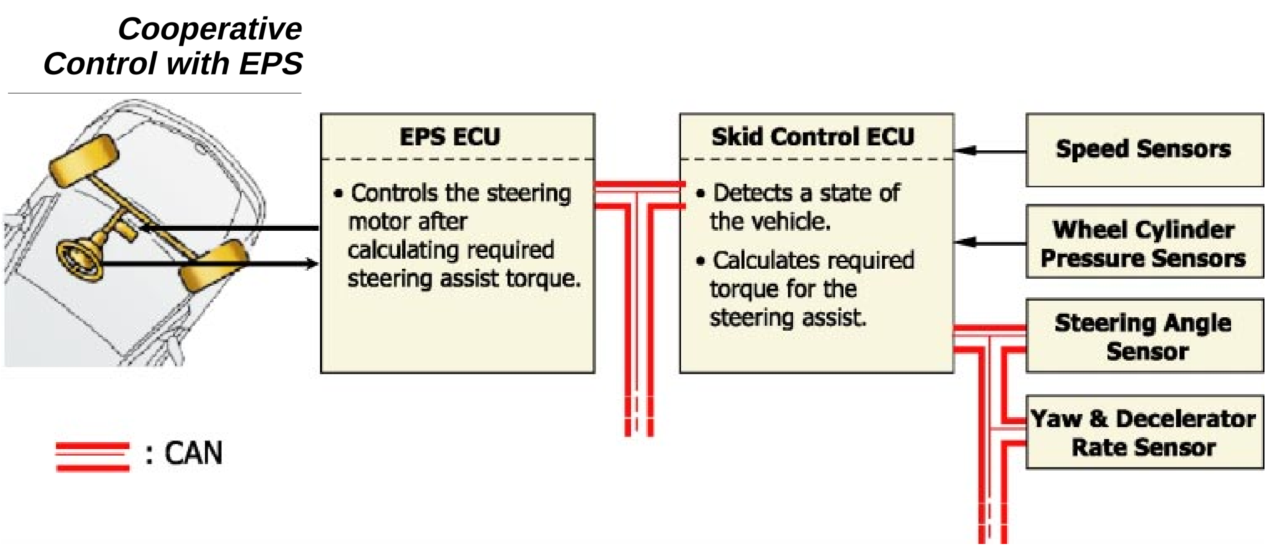


Figure 6.3 T072f603c

Brake Pedal Stroke Sensor ('04 & later Prius)

In the '04 & later Prius, this sensor contains a contact variable resistor and detects the extent of the brake pedal stroke and transmits it to the skid control ECU.

SERVICE TIP

To install a brake pedal stroke sensor, which is available as a service part, perform the following procedures:

- The sensor lever is secured with a pin to “0” stroke. (Do not detach the pin until the installation has been completed.)
- In this state, install the sensor on the brake pedal (in the OFF state) on the vehicle.
- After completing the installation, firmly press the brake pedal once to break off the pin that is securing the sensor in place.
- Make sure the broken pin does not remain in the sensor lever.

Stroke Simulator

The stroke simulator is located between the master cylinder and the brake actuator. It generates a pedal stroke in accordance with the driver’s pedal effort during braking. Containing two types of coil springs with different spring constants, the stroke simulator provides pedal stroke characteristics in two stages in relation to the master cylinder pressure.

Stroke Simulator

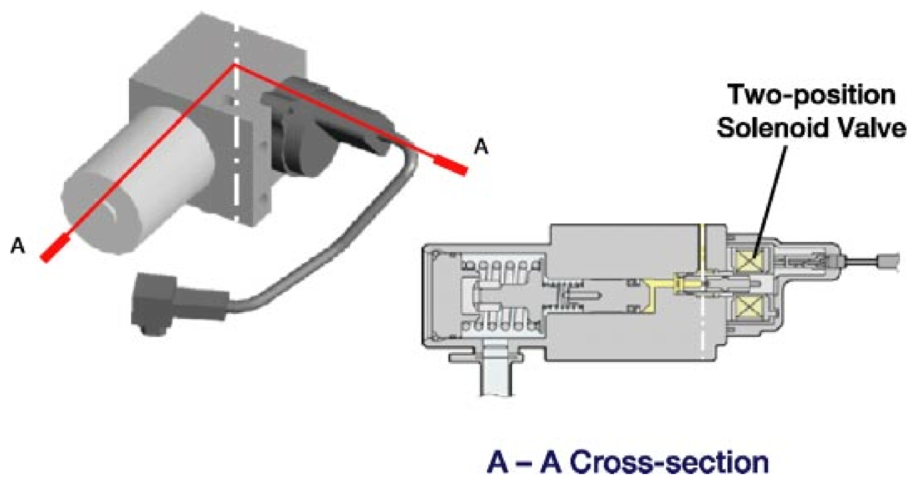


Figure 6.4 T072f604c

Power Source Backup Unit ('04 & later Prius)

In the '04 & later Prius, the power source backup unit has been adopted as an auxiliary power source in order to supply power to the brake in a stable manner. This unit contains 28 capacitor cells, which store an electrical charge provided by the (12V) vehicle power supply. When the voltage of the (12V) vehicle power supply drops, the electrical charge stored in the capacitor cells is used as an auxiliary power supply to the brake system. The electrical charge stored in the capacitor cells becomes discharged when the HV system stops operating after the power switch is turned OFF.

Power Source Backup Unit

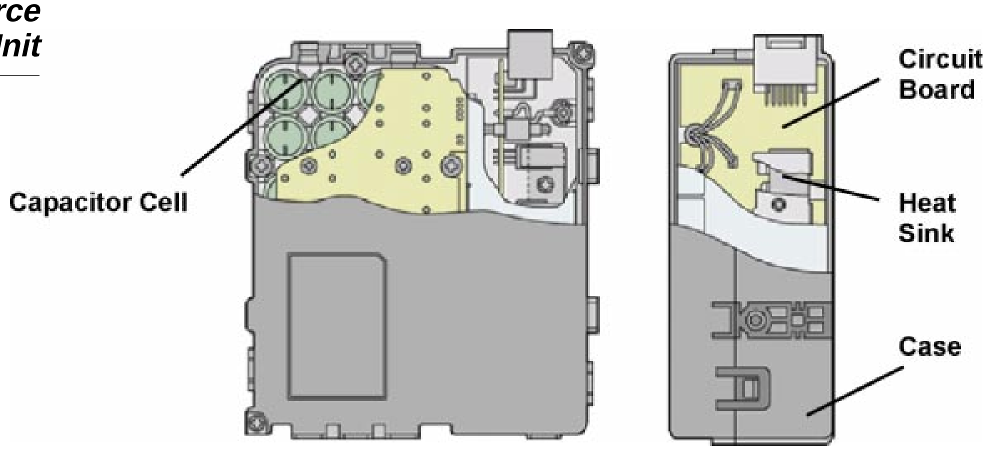


Figure 6.5 T072f605c

Fail-Safe

If the ABS, Enhanced VSC or Brake Assist System malfunctions, the Skid Control ECU disables that system but allows the other systems to function normally.

DRC C1215/15, C1216/16 Linear Solenoid Positive Voltage Malfunction

DTC C1215/15 may be detected when the ignition switch is ON, the voltage of terminal +BS in the brake ECU is 2.5V or less, and continues for 0.5 seconds or more. It also may be detected while a vehicle is driven at a speed 5-mph or more, the voltage of terminal +BS in the brake ECU is 9V or less and continues for 10 seconds or more.

DTC C1216/16 may be detected when the ignition switch is ON, the voltage of the terminal +BS in the brake ECU is 17V or more, and continues for 1.2 seconds or more. For both codes check the battery, the charging system and the power source circuit.

The trouble areas for both codes may include the battery, the charging system or the power source circuit.

DTC C1259/59 Malfunction In HV ECU

If any trouble occurs in the HV control system, the ECU prohibits Regenerative Braking System (RBS) control. If the conditions below continue for 0.02 seconds DTC C1259/59 will set:

- The voltage of the terminal IG2 in the brake ECU is 10.5V or less and continues for 1.5 seconds.
- Regenerative malfunction occurs on the HV ECU side.

NOTE

This DTC is set with most HV ECU codes and is usually the lowest priority when sent with other DTCs.

Notes

Section 7

Electric Power Steering

Overview

Electric Power Steering (EPS) provides power assist even when the engine is stopped. It also improves fuel economy because it is lightweight and the DC motor consumes energy only when power assist is required. The EPS is powered by a 12V motor and is not dependent on the engine for its power source so steering feel is not affected when the engine is shut OFF.

The EPS ECU uses the torque sensor output and information from the Skid Control ECU about vehicle speed and torque assist demand to determine the direction and force of the power assist. It then actuates the DC motor accordingly.

EPS Parts Location

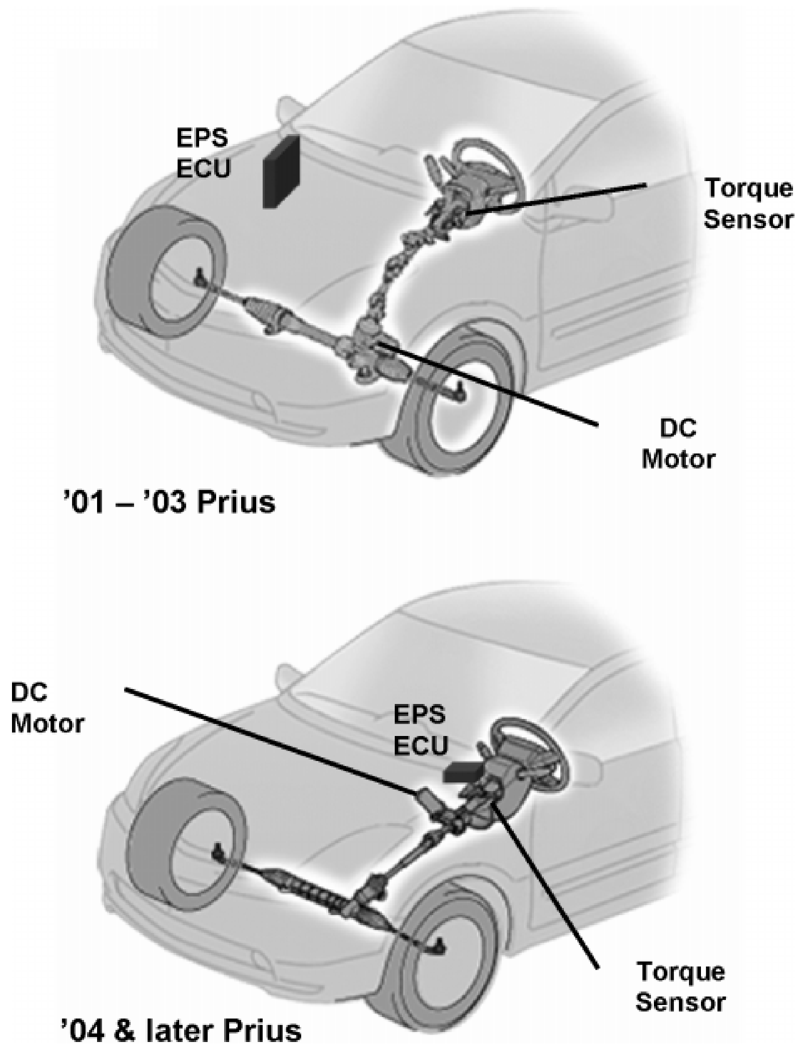


Figure 7.1 T072f701c

Steering Gear

When the steering wheel is turned, torque is transmitted to the pinion causing the input shaft to rotate. The torsion bar that links the input shaft and the pinion twists until the torque and the reaction force equalize. The torque sensor detects the twist of the torsion bar and converts the torque applied to the torsion bar into an electrical signal.

DC Motor

The DC motor uses a worm gear to transmit the motor's torque to the column shaft.

Reduction Mechanism

The reduction mechanism transmits motor power assist to the pinion shaft. The reduction mechanism consists of the ring gear that is secured to the pinion shaft and the pinion gear that is integrated with the motor shaft. The power assist of the motor is transmitted by the reduction mechanism to the pinion shaft which provides power assist to the steering effort.

Torque Sensor

The torque sensor detects the twist of the torsion bar and converts the applied torque into an electrical signal. The EPS ECU uses that signal to calculate the amount of power assist the DC motor should provide.

('04 & later Prius)

The '04 & later Prius uses an induction-type torque sensor. Detection Ring 1 and 2 are mounted on the input shaft and Detection Ring 3 is mounted on the output shaft. When torque is applied to the torsion bar the detection rings move in relationship to each other. The detection coil senses a change in inductance that is proportional to the amount of torque applied.

EPS CPU

The EPS ECU receives signals from various sensors, judges the current vehicle condition and determines the assist current to be applied to the DC motor.

Fail Safe

If the EPS ECU detects a malfunction in the EPS system a warning light illuminates to alert the driver. The EPS ECU will store the DTC(s) and the system will power down, however, the system still provides the ability to steer manually.

EPS Steering System

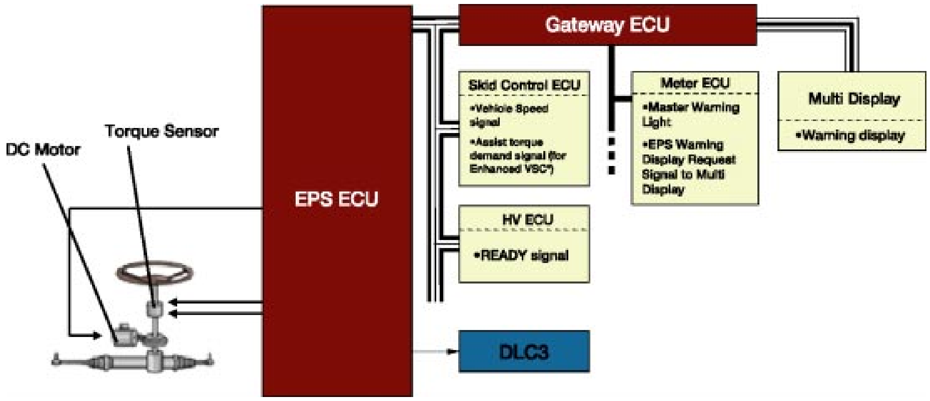


Figure 7.2 T072f702c

Torque Sensor

'01 - '03 Prius

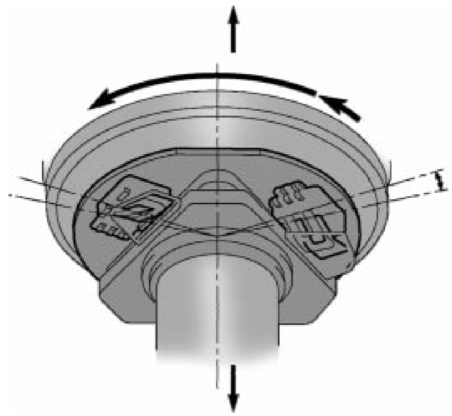


Figure 7.3 T072f703c

Torque Sensor

'04 & later Prius

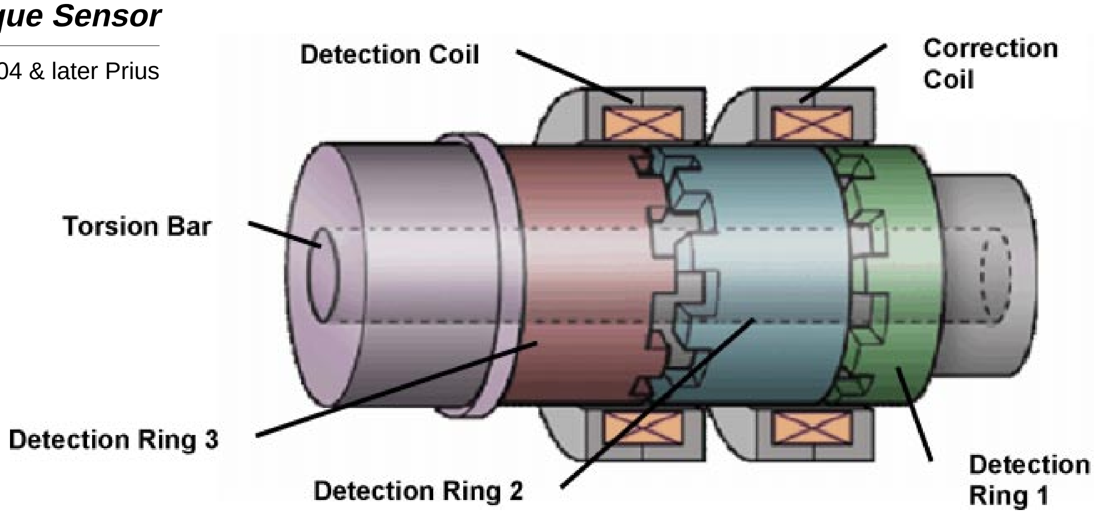


Figure 7.4 T072f704c

Calibration of Torque Sensor Zero Point

The Torque Sensor Zero Point should be calibrated whenever you remove and replace the:

- Steering column assembly (containing the torque sensor)
- Power steering ECU assembly
- Steering wheel
- Steering gear assembly
- Or if there is a difference in steering effort between right and left

DTC C1515/15 Torque Sensor Zero Point Calibration Not Performed

DTC C1515 does not indicate a problem. This DTC is set when the Torque Sensor Zero Point calibration is not performed. Calibrate the Torque Sensor Zero Point and then delete the DTC.

DTC C1515/15 Torque Sensor Zero Point Incomplete

DTC C1516 also does not indicate a problem. It is set when the Torque Sensor Zero Point calibration is not completed normally. Try the procedure again and delete the DTC when finished.

DTC C1524/24 Motor Circuit Malfunction

DTC C1524/24 is set when there is a short-circuited motor terminal or abnormal voltage or current in the motor circuit. The most common fault is caused by circuit corrosion. Trouble areas include the power steering gear assembly and the EPS ECU.

DTC U0073 and DTC U0121 CAN Communiction

DTC U0073 and U0121 set when there is a problem in the CAN communication circuit. DTC U0121 indicates a communication fault with the skid control ECU, while U0073 indicates a general malfunction of the CAN communication system.

Intermittent EPS Malfunctions

Intermittent EPS malfunctions can be recorded in the Diagnostic Tester with no DTCs set. In the Diagnostic Menu for EPS, select **RECORDS CLEAR** to view recorded information relating to **MTR OVERHEAT** and **MTR LOW POWER**. Typically no codes will set when the values are recorded. This is only available for intermittent EPS problems.

Intermittent EPS Records

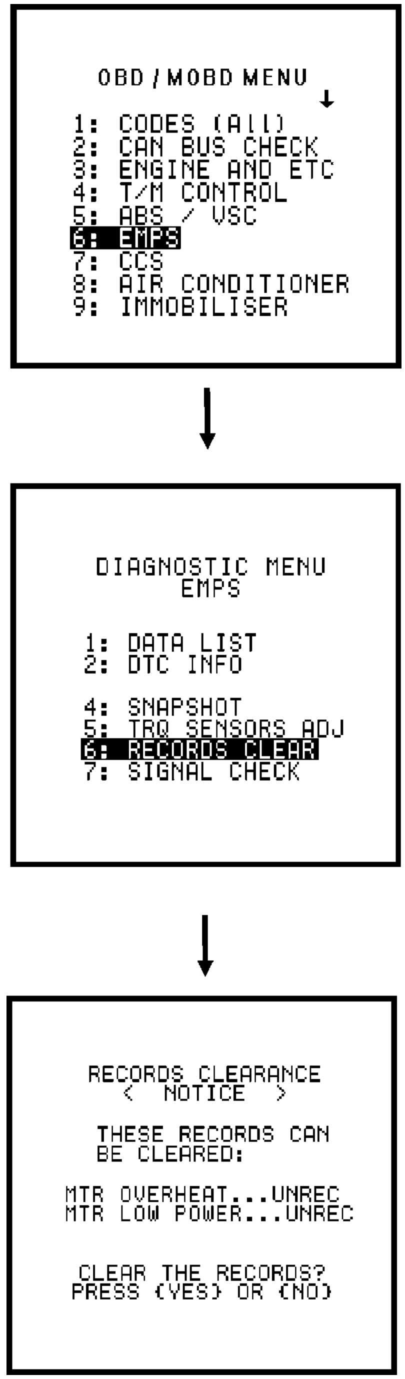


Figure 7.5 T072f705c

EPS Data List

This screen print from the Diagnostic Tester represents normal condition for the EPS system.

```
TRQ1.................2.53V
TRQ2 ................2.51V
TRQ3 ................2.34V
SPD ..................0MPH
MOTOR ACTUAL ...........0A
COMMAND VALUE ..........0A
THERMISTOR TEMP ......21°C
PIG SUPPLY ..........12.1V
IG SUPPLY ...........11.9V
TRQ1 ZERO VAL .......2.51V
TRQ2 ZERO VAL .......2.49V
TRQ3 ZERO VAL .......2.37V
MTR TERMINAL (+) .....5.8V
MTR TERMINAL (-) .....5.8V
MTR OVERHEAT ........Unrec
MTR LOW POWER .......Unrec
CONTROL MODE ........$010E
IG ON/OFF TIMES .. 255times
#CODES ..................0
ASSIT MAP ..............02
ECU I.D. ...............01
TEST MODE STAT......NORMAL
READY STATUS ..........OFF
```

Figure 7.6 T072f706

There may be cases where customers complain that the steering is too sensitive. This is usually a normal condition. To check the EPS system using the Diagnostic Tester, go to the **EPS Data List**. Always check the Motor Actual amperage and the Torque voltage. Refer to the EPS section of the Repair Manual specifications. The screen print above shows normal conditions with the vehicle ON, and the steering wheel in the center position.

WORKSHEET 7-1
Electrical Power Steering

Worksheet Objectives

In this worksheet you will view the EPS Data List and will determine if EPS voltage and amperage values are normal. You will also become familiar with where to find intermittent problem data and how to perform a Torque Sensor Adjustment.

Tools and Equipment

- Vehicle
- Diagnostic Tester
- Repair Manual or TIS
- SST 09843-18040

Section 1 - Electric Power Steering Data List

1. Connect the Diagnostic Tester to DLC3 and start the vehicle (READY ON). Go to the EPMS, DATA LIST.

2. In the chart below, fill in the voltages for TRQ1 and TRQ2 while the steering wheel is at center, right and left.

Steering Position	TRQ1	TRQ2
Center		
Right		
Left		

Note: TRQ 3 Is the calculated value of the ECU and is for engineering purposes only. For diagnostic purposes use TRQ 1 & 2.

3. Are the readings normal? Where did you find the normal readings?

4. What does the MOTOR ACTUAL amperage value represent?

5. Turn the steering wheel to the left lock and then to the right lock. Record the amperage of MOTOR ACTUAL while turning the steering wheel in each direction.

   Turning Left:

   ____

   Turning Right:

   ____

6. Raise the vehicle so that the tires are off the ground.

7. Again turn the steering wheel to left lock and then to right lock. Again record the amperage of MOTOR ACTUAL while turning the steering wheel in each direction.

   Turning Left:

   ____

   Turning Right:

   ____

8. Compare these values with the values you obtained with the wheels on the ground.

   ____

   ____

9. How can reading the voltage and amperage values help to diagnose the EPS system?

   ____

   ____

10. Lower vehicle so that wheels are on the ground.

Section 2 - Torque Sensor Zero Point Adjustment (Diagnostic Tester)

1. Using the Diagnostic Tester, select OBD/MOBD, EMPS, TRQ SENSOR ADJ.
2. Select and execute ZERO POINT INIT.
3. What display on the vehicle now indicates that ZERO POINT ADJUST is required?

   ____

4. Using the Diagnostic Tester, follow the procedures to complete the ZERO POINT ADJUST.
5. What display on the vehicle now indicates that ZERO POINT ADJUST is complete?

   ____

Section 2a - Torque Sensor Zero Point Adjustment (Manual)

1. Perform the Zero Point Initialization and the ZERO POINT ADJUST using the Repair Manual procedures.
2. What pages in the Repair Manual are these procedures located?

   ____

3. When is the Zero Point Adjustment procedure necessary? Return vehicle to normal condition.

   ____

   ____

Return vehicle to normal condition.

Notes

Section 8

Other Systems

Air Conditioning System

The A/C unit houses the multi-tank type evaporator and straight flow heater core which are placed in the vehicle's longitudinal direction. The 2-way flow heater type A/C unit can accomplish both heating and de-misting at the same time. This unit introduces external air and internal air simultaneously and discharges warm internal air to the foot well area and the fresh, dry external air to the upper area. Both heating and de-misting performance are excellent.

On the '04 & later Prius, the air conditioning system can be controlled from either the air conditioning screen on the multi display or from switches on the steering pad.

On the '01-'03 Prius, the air conditioning is only controlled at the air conditioning control panel.

Construction

A partition divides the inside of the A/C unit into two parts, the external air passage and the internal air passage. By separately controlling the external air door and the internal air door, external air and internal air are introduced into the cabin in the three modes: fresh-air mode, recirculation mode and fresh-air/recirculation (2-way flow) mode.

The heat exchange efficiency has been improved through the use of a sub-cool condenser. The condenser is integral with the radiator to minimize the space in the engine compartment.

Heater Core and PTC Heater

Two Positive Temperature Coefficient (PTC) electric heaters are built into the heater core. The PTC heaters are located in the air duct at the foot well outlet in front of the A/C unit. The honeycomb shaped PTC Thermistor directly warms the air that flows in the duct.

Sub-Cool Cycle

Refrigerant first passes through the condensing portion of the condenser. Liquid and gaseous refrigerant that were not liquefied are cooled again in the super-cooling portion of the condenser. Therefore, refrigerant sent to the evaporator is almost completely liquefied.

NOTE

The point at which the air bubbles disappear in the refrigerant of the sub-cool cycle is lower than the proper amount of refrigerant with which the system must be filled. Therefore, if the system were recharged with refrigerant based on the point at which the air bubbles disappear, the amount of refrigerant would be insufficient. As a result, the cooling performance of the system will be affected. For the proper method of verifying the amount of the refrigerant and to recharge the system with refrigerant, see the Prius Repair Manual.

Sub-Cool Cycle

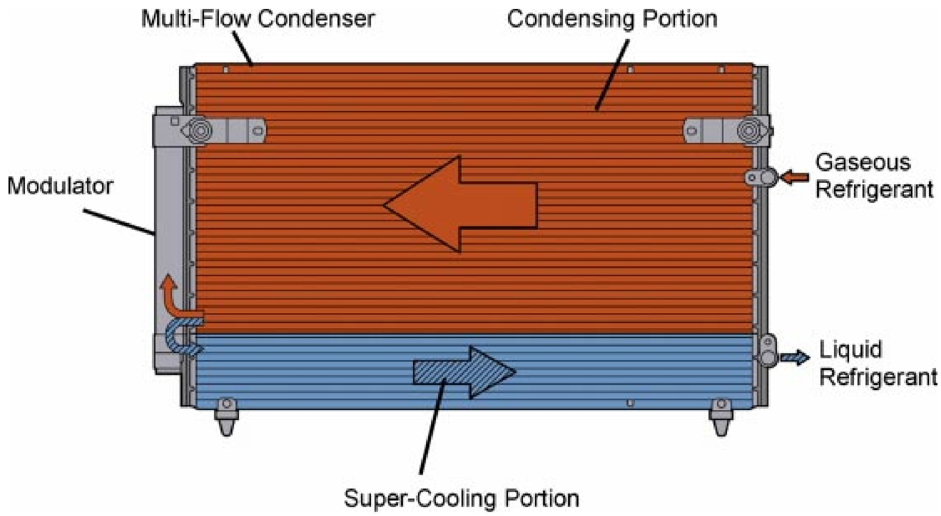


Figure 8.1 T072f052c

Electric A/C Compressor

('04 & later Prius)

Figure 8.2 T072f118p

Electric Compressor ('04 & later Prius)

The '04 & later Prius has an ES 18 electric compressor actuated by a built-in electric motor. Except for the portion that is actuated by the electric motor, the basic construction and operation is the same as the scroll compressor in the '01-'03 Prius. The electric motor is actuated by the alternating current power (201.6V) supplied by the A/C inverter integrated into the hybrid system inverter. As a result, the air conditioning system is actuated without depending on the operation of the engine.

The electric compressor consists of a spirally wound fixed scroll and variable scroll that form a pair, a brushless motor, an oil separator, and a motor shaft. The built-in oil separator is used to divide the compressor oil that is intermixed with the refrigerant. The oil then circulates in the refrigeration cycle, thus realizing a reduction in the oil circulation rate.

To insure proper insulation of the internal high voltage portion of the compressor and the compressor housing, the '04 Prius has adopted compressor oil (ND11) with a high level of insulation performance. Therefore, **NEVER** use 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.

Compressor ('01-'03 Prius)

On the '01-03 Prius, a scroll compressor with an oil separator is used. When the A/C is operated in the MAX position, the engine will always run to maintain the operation of the A/C compressor. If the HV battery becomes too warm while the recirculation mode in ON, the HV battery ECU will switch to FRESH in order to increase the flow of air across the battery.

The refrigerant gas that is discharged from the discharge port flows by rotation around the cylindrical pipe in the oil separator. At this time, the centrifugal force that is created during the rotation separates the refrigerant gas and the compressor oil due the difference in their specific gravity. The lighter refrigerant gas passes through the inside of the pipe and travels from the discharge service port to the outside of the compressor. The heavier compressor oil is discharged through the oil discharge hole in the shutter and is stored in the oil storage chamber. The compressor oil travels back to the compressor and circulates inside the compressor.

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

A humidity-sensor function has been added to the room temperature sensor. By enabling the detection of humidity in the vehicle interior this function optimizes the dehumidification effort during the operation of the air conditioning system. As a result, the power consumption of the compressor has been reduced and a comfortable level of humidity has been realized in the vehicle interior.

The humidity-sensing resistance film that is built into the humidity sensor absorbs and releases the humidity in the vehicle interior. During the absorption and releasing processes, the humidity-sensing resistance film expands (during the absorption of humidity) and contracts (during drying). When the clearance between the carbon particles in the humidity-sensing resistance film expands and contracts, it changes the resistance between the electrodes. The A/C ECU determines the humidity in the vehicle interior through the changes in the output voltage of the humidity-sensor.

Humidity Sensor

('04 & later Prius)

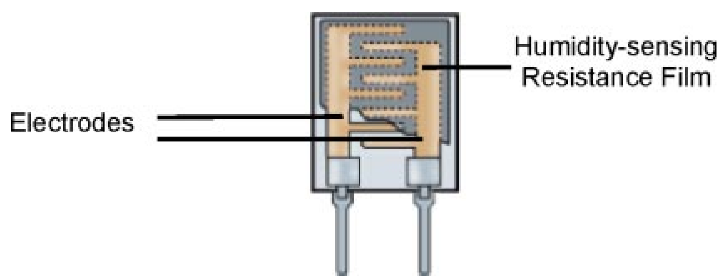


Figure 8.3 T072f119c

Water Pump

The electric water pump provides stable heater performance even if the engine is stopped. When the engine is running the water pump does not operate. On the '01-'03 Prius, the bypass valve opens to minimize the flow resistance of the coolant that is pumped by the engine water pump.

The bypass valve has been discontinued on the '04 & later Prius because a new pump design minimizes water flow resistance.

Water Pump Coolant Flow

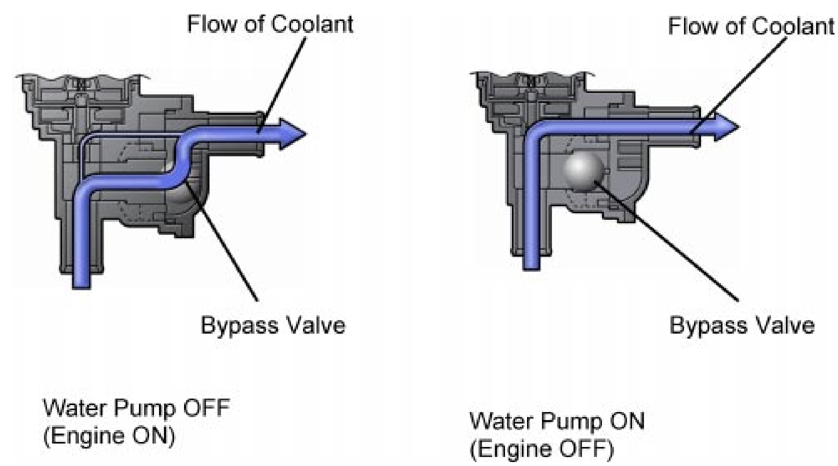


Figure 8.4 T072f053c

NOTE

If all keys are lost, a new transponder key ECU must be purchased. No additional keys can be duplicated if all the keys are lost. If at least one key remains, new keys can be purchased and then programmed to the vehicle. Programming and erasing procedures are located in the BE section of the Repair Manual.

Also refer to the BE section to perform a pre-check and find out if a particular key is registered as a master or sub.

Multiplex Communication System

The Prius primarily uses three types of multiplex communication systems. The Controller Area Network (CAN) networks the vehicle control systems (engine electrical, chassis electrical and hybrid system) and maintains communication between the ECUs.

The Body Electronics Area Network (BEAN) networks the ECUs of the body electric system control and maintains communication between ECUs.

The Audio Visual Communication - Local Area Network (AVC-LAN) networks the ECUs of the audio visual system and the audio visual devices and maintains communication between the devices and the ECUs.

The gateway ECU is provided with communication circuits that support the three types of multiplex communication systems connected to it.

Multiplex Communication

('04 & later Prius)

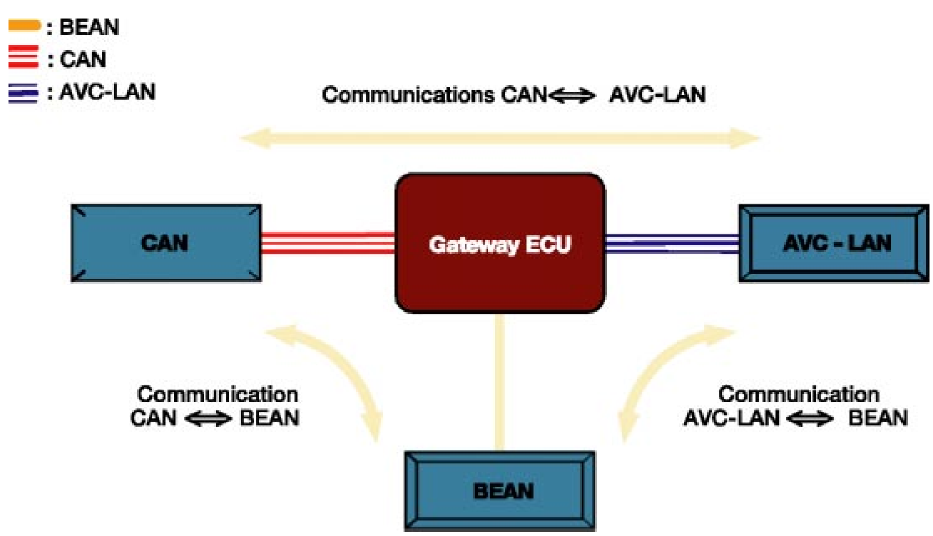


Figure 8.5 T072f120c

CAN System Diagram

('04 & later Prius)

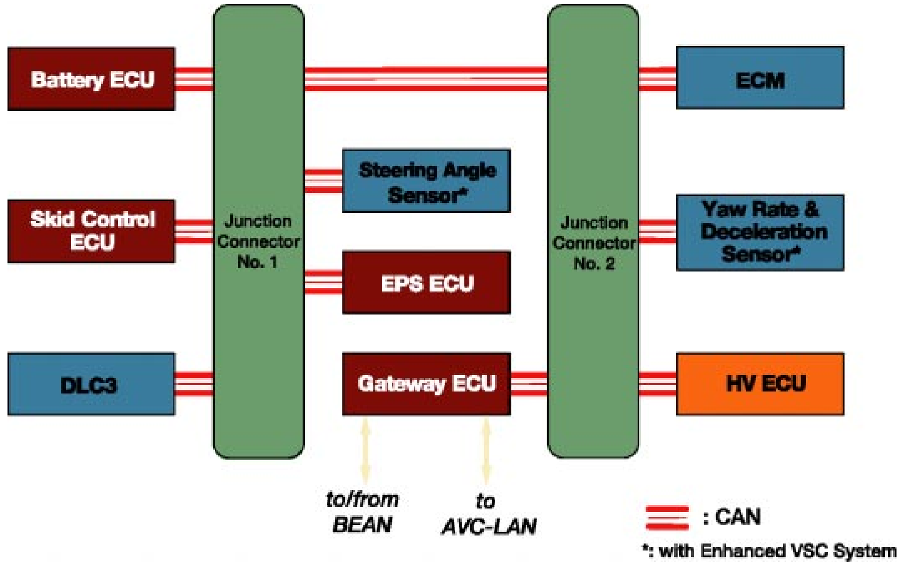


Figure 8.6 255BE02

CAN, BEAN & AVC-LAN Chart

('04 & later Prius)

Control	**Chassis Electrical System Control**	**Body Electrical System Control**	
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 8.7 T072f121c

Notes

Appendix A

Engine Operating Conditions

The values given below for “Normal Condition” are representative values. A vehicle may still be normal even if its value varies from that listed below.

CARB Mandated Signals

Diagnostic Tester Display	Measurement Item	Normal Condition*
FUEL SYS #1	Fuel System Bank 1: OPEN: Air/Fuel ratio feedback stopped CLOSED: Air/Fuel ratio feedback operating	Idling after warming up: CLOSED
CALC LOAD	Calculated Load: Current intake air volume as a proportion of max. intake air volume	Idling: 5.4 -19.2% Racing without load (2,250rpm): 6.9 - 16.2%
COOLANT TEMP	Engine Coolant Temp. Sensor Value	After warming up: 80 - 95°C (176 - 203°F)
SHORT FT #1	Short-term Fuel Trim Bank 1	0±20%
LONG FT #1	Long-term Fuel Trim Bank 1	0±20%
ENGINE SPD	Engine Speed	Idling: 1,000 rpm
VEHICLE SPD	Vehicle Speed	Vehicle Stopped: 0 km/h (0 mph)
IGN ADVANCE	Ignition Advance: Ignition Timing of Cylinder No.1	Idling: BTDC 7-15
INTAKE AIR	Intake Air Temp. Sensor Value	Equivalent to Ambient Temp.
MAF/AFM	Air Flow Rate Through Mass Flow Meter	Idling: 1.11 -4.38 gm/sec. Racing without load (2,250 rpm): 3.38 - 7.88 gm/sec.
THROTTLE POS	Voltage Output of Throttle Position Sensor Calculated as a percentage: 0V->0%, 5V->100%	Throttle Fully Closed: 0 - 5% Throttle Fully Open: 90 - 100%
O2S B1, S1	Voltage Output of Heated O2 Sensor Bank 1, Sensor 1	Idling: 0.1 - 0.9V
O2FT B1, S1	Heated O2 Sensor Fuel Trim Bank 1, Sensor 1 (Same as SHORT FT #1)	0±20%
O2S B1, S2	Voltage Output of Heated O2 Sensor Bank 1, Sensor 2	Driving at 50 km/h (31 mph): 0.1 - 0.9V

*If no conditions are specifically stated for “Idling”, it means the shift lever is at P position, the A/C switch if OFF and all accessory switches are OFF.

TOYOTA Enhanced Signals

Diagnostic Tester Display	Measurement Item	Normal Condition*
MISFIRE RPM	Engine RPM for first misfire range	Misfire 0:0 rpm
MISFIRE LOAD	Engine load for first misfire range	Misfire 0:0 g/r
INJECTOR	Fuel injection time for cylinder No.1	Idling: 1.0 - 3.0 ms
CYL#1, CYL#2, CYL#3, CYL#4	Abnormal revolution variation for each cylinder	0%
IGNITION	Total number of ignition for every 1,000 revolutions	0-2,000
FUEL PUMP	Fuel Pump Signal	Idling: ON
EVAP (PURGE) VSV	EVAP VSV Signal	VSV operating: ON
VAPOR PRESS VSV	Vapor Pressure VSV Signal	VSV operating: ON
TOTAL FT B1	Total Fuel Trim Bank 1: Average value for fuel trim system of Bank 1	Idling: 0.8 - 1.2V
O2 LR B1, S1*	Heated O2 Sensor Lean Rich Bank 1, Sensor 1 response time for O2 Sensor output to switch from lean to rich.	Idling after warmed up: 0 - 1,000 msec.
02 RL B1, S1*	Heated O2 Sensor Rich Lean Bank 1, Sensor 1 response time for O2 Sensor output to switch from rich to lean.	Idling after warmed up: 0 - 1,000 msec.
AF FT B1 S1	Short term fuel trim associated with the bank 1 sensor 1/ Min.: 0, Max: 19999	• Value less than 1 (0.000 to 0.999) = Lean • Stoichiometric air-fuel ratio = 1 • Value greater than 1 (1.001 to 1.999) = Rich
AFS B1 S1	A/F sensor output for bank 1 sensor 1/ Min.: 0, Max: 7.999	Idling 2.8 to 3.8V (Inspection Mode)

*If no conditions are specifically stated for “Idling”, it means the shift lever is at P position, the A/C switch if OFF and all accessory switches are OFF.

Operation History Data List

Items	Count Condition	Example of Customer Concern	Actual Status
SHIFT BEF READY	The number of times of shift operation while the Ready lamp is flashing (just after turning to ST). Flashes if cooling water temp. is -10C or less. Illuminates if cooling water temperature is above -10C.	Engine starts and immediately stops in the morning. Couldn't drive the vehicle.	Engine was in cranking condition and Ready lamp was flashing, however, the costumer judged the engine as running from the generator noise by mistake.
N RANGE CTRL 2	The number of times of shifting from R to D. (Shift into R range when driving D range or vice versa.)	Shifting into R range, but vehicle went ahead.	Shift lever was in N range while going ahead at 11km/h.
STEP ACCEL IN N	The number times of stepping on the accelerator pedal in N range. No driving force is supplied due to shift in N range condition at accelerator operation.	Sometimes power isn't generated when driving.	Stepping on the accelerator when in the N range. Because it is under N range control, torque is not generated.
AUX. BATT LOW	The number of times of N range control when voltage of the 12V auxiliary battery falls to 9.5V or less.	Acceleration didn't work suddenly.	
HV INTERMITTENT	Instantaneous open at IGSW terminal of HV control ECU.	Suddenly the vehicle stopped, but ran as usual after operating key again.	If HV ECU power supply line was disconnected, system itself stopped and power supply was shut down before fixing abnormal occurrence. Consequently, the DTC was not stored and it is impossible to judge what occurred. From this experience, system was modified so as to record momentary shutting down.
MG2 (NO1) TEMP HIGH	The number of times the water temperature warning lamp is ON due to MG2 temperature rise. Lamp illuminates if motor temperature rises above 174°C (345°F). DTC is not stored because it is not a problem even if warning lamp in ON.	Warning Lamp ON.	Specification if motor/generator/inverter temperature rises to illuminate turtle lamp ('01 - '03 Prius). It is difficult to identify what caused lamp illumination. From this experience, it is modified to record the number of times of symptoms occurrence by parts. It is also modified to assign a role of warning of such temperature rise to water temperature indicator.
MG2 (NO2) TEMP HIGH	The number of times the water temperature warning lamp turns ON due to MG1 temperature rise. Lamp illuminates transaxle fluid temperature rises above 162°C (324°F). DTC is not stored because it is not a problem even if warning lamp in ON.	Warning Lamp turns on.	

Items	Count Condition	Example of Customer Concern	Actual Status
MG2 INV TEMP HIGH	Motor inverter temperature rose above 111°C (232°F).		Specification if motor/generator/inverter temperature rises to illuminate turtle lamp. It is difficult to identify what caused lamp illumination. From this experience, it is modified to record the number of times of symptoms occurrence by parts. It is also modified to assign a role of warning of such temperature rise to water temperature indicator.
MG1 INV TEMP HIGH	The number of times the water temp warning lamp turns ON due to MG2 temperature sensor rise in the inverter. Lamp illuminates if MG2 temperature rises above 111°C (232°F) without storing any DTCs because of the problem.	Warning Lamp turns on.	
MAIN BATT LOW	Battery temperature rises to 57C and over or falls to -15C less. SOC becomes 35% or less in R range and WOUT is controlled to be 2000W.	Loss of power momentarily. (Turtle light turns ON '01 - 03 Prius.)	Battery output/input is controlled when battery temperature is abnormal and SOC is Lo. But as it is not a problem, indicate no DTC.
RESIST OVR HEAT	The number of times of heating up the resistance for SMR1. Limit resistor forecast temperature rose above 120°C (248°F).	Vehicle will not start.	Prohibits system starting to prevent from overheating SMR, which limits resistance due to repletion of system starting operation for a short time.
COOLANT HEAT	Inverter coolant forecast temperature rose above 65°C (149°F).	Limited power from vehicle.	
CONVERTER HEAT	Boost converter temperature rose above 111°C (232°F).	Limited power from vehicle.	
SHIFT P IN RUN	Shifted to Park while driving.	Vehicle went into Neutral.	Vehicle will automatically shift into Neutral when the Park button is pressed while driving over 3mph
BKWRD DIR SHIFT	Shifted to R while moving forward or to D or B while moving in reverse.	Vehicle went into Neutral.	Vehicle will automatically shift into Neutral when another shift position is selected while moving over 3mph.
PREVENT STAYING	Engine speed stays in resonance frequency band.		

Appendix C
Hybrid Control System Information

Similar to freeze frame data, information records operating condition of the HV system and components at the time of detection of a DTC.

a) Select one which has an INF Code from among INFORMATION 1 to 5.

b) Check the information of the DTC.

Information:

Hand-held Tester Display	Measurement Item/Range (Display)	Suspected Vehicle Status When Malfunction Occurs
INFORMATION N	Information code	Indication of system with malfunction
MG1 REV	MG1 revolution/ Min.: -16,384 rpm, Max.: 16,256 rpm	MG1 speed • Forward rotation appears as "+" • Backward rotation appears as "-"
MG2 REV	MG2 revolution/ Min.: -16,384 rpm, Max.: 16,256 rpm	MG2 speed (proportionate to vehicle speed) • Forward rotation appears as "+" • Backward rotation appears as "-" Moving direction of vehicle • Forward direction appears as "+" • Backward direction appears as "-"
MG1 TORQ	MG1 torque/ Min.: -512 Nm, Max.: 508 Nm	When MG1 rotation in + direction: • Torque appears as "+" while MG1 discharges • Torque appears as "-" while MG1 charges When MG1 rotation in - direction: Torque appears as "-" while MG1 discharges • Torque appears as "+" while MG1 charges
MG2 TORQ	MG2 torque/ Min.: -512 Nm, Max.: 508 Nm	When MG2 rotation in + direction: • Torque appears as "+" while MG2 discharges • Torque appears as "-" while MG2 charges When MG2 rotation in -direction: • Torque appears as "-" while MG2 discharges • Torque appears as "+" while MG2 charges
INVERT TEMP-MG1	MG1 inverter temperature/ Min.: -50°C, Max.: 205°C	MG1 inverter temperature
INVERT TEMP-MG2	MG2 inverter temperature/ Min.: -50°C, Max.: 205°C	MG2 inverter temperature
MG2 TEMP (No2)	Transaxle fluid temperature/ Min.: -50°C, Max.: 205°C	Transaxle fluid temperature
MG2 TEMP (No1)	MG2 temperature/ Min.: -50°C, Max.: 205°C	MG2 temperature
POWER RQST	Request engine power/ Min.: 0 W, Max.: 255 kW	Engine power output requested to ECM
ENGINE SPD	Engine speed/ Min.: 0 rpm, Max.: 16,320 rpm	Engine speed
MCYL CTRL POWER	Master cylinder control torque/ Min.: -512 Nm, Max.: 508 Nm	Brake force requested by driver
SOC	Battery state of charge/ Min.: 0%, Max.: 100%	State of charge of HV battery
WOUT CTRL POWER	Power value discharge control/ Min.: 0 W, Max.: 81,600 W	Discharge amount of HV battery
WIN CTRL POWER	Power value charge control/ Min.: -40,800 W, Max.: 0 W	Charge amount of HV battery
DRIVE CONDITION	Drive condition ID • Engine stopped: 0 • Engine about to be stopped: 1 • Engine about to be started: 2 • Engine operated or operating: • Generating or loading movement: • Revving up with P position: 6	Engine operating condition

Hand-held Tester Display	Measurement Item/Range (Display)	Suspected Vehicle Status When Malfunction Occurs
PWR RESOURCE VB	HV battery voltage/ Min.: 0 V, Max.: 510V	HV battery voltage
PWR RESOURCE IB	HV battery current/ Min.: -256 A, Max.: 254 A	Charging/discharging state of HV battery • Discharging amperage indicated by a positive value • Charging amperage indicated by a negative value
SHIFT POSITION	Shift position (P, R, N, D or B position)	Shift position
ACCEL SENSOR MAIN	Accelerator pedal position sensor main/ Min.: 0%, Max.: 100%	Idling, accelerating, or decelerating
AUX. BATT V	Auxiliary battery voltage/ Min.: 0 V, Max.: 20V	State of auxiliary battery
CONVERTER TEMP	Boost converter temperature/ Min.: -50°C, Max.: 205°C	Boost converter temperature
VL	High voltage before it is boosted/ Min.: 0 V, Max.: 510V	High voltage level before it is boosted
VH	High voltage after it is boosted/ Min.: 0 V, Max.: 765 V	High voltage level after it is boosted
IG ON TIME	The time after power switch ON (IG)/ Min.: 0 min, Max.: 255 min	Time elapsed with power switch ON (IG)
VEHICLE SPD-MAX	Maximum vehicle speed/ Min.: -256 km/h, Max.: 254 km/h	Maximum vehicle speed
A/C CONSMPT PWR	A/C consumption power/ Min.: 0 kW, Max.: 5 kW	A/C load
ENG STOP RQST	Engine stop request/ NO or YES	Presence of engine stop request
IDLING REQUEST	Engine idling request/ NO or YES	Presence of idle stop request
ENGINE FUEL CUT	Engine fuel cut request/ NO or YES	Presence of fuel cut request
HV BATT CH RQST	HV battery charging request/ NO or YES	Presence of HV battery charging request
ENG WARM UP RQT	Engine warming up request/ NO or YES	Presence of engine warm-up request
STOP SW COND	Stop lamp switch ON condition/ NO or YES	Brake pedal depressed or released
CRUISE CONTROL	Cruise control active condition/ NO or YES	Operation under cruise control ON or OFF
EXCLUSIVE INFO 1 to 7	Exclusive information (in form of numerical data)	Exclusive Information linked to Information
OCCURRENCE ORDER	Occurrence sequence of information	Occurrence sequence of information
INV TTMP-MG1 IG	MG1 inverter temperature after power switch ON (IG)/ Min.: -50°C, Max.: 205°C	MG1 inverter temperature soon after power switch ON (IG)
INVT TMP-MG2 IG	MG2 inverter temperature after power switch ON (IG)/ Min.: -50°C, Max.: 205°C	MG2 inverter temperature soon after power switch ON (IG)
MG2 TEMP IG	MG2 temperature after power switch ON (IG)/ Min.: -50°C, Max.: 205°C	MG2 temperature soon after power switch ON (IG)
CONVRTR TEMP IG	Boost converter temperature after power switch ON (IG)/ Min.: -50°C, Max.: 205°C	Boost converter temperature soon after power switch ON (IG)
SOC IG	Battery state of charge after power switch ON (IG)/ Min.: 0 %, Max.: 100 %	Battery state of charge soon after power switch ON (IG)
INVT TMP-MG1 MAX	MG1 inverter maximum temperature/ Min.: -50°C, Max.: 205°C	Overheating state of MG1 inverter
INVT TMP-MG2MAX	MG2 inverter maximum temperature/ Min.: -50°C, Max.: 205°C	Overheating state of MG2 inverter
MG2 TEMP MAX	MG2 maximum temperature/ Min.: -50°C, Max.: 205°C	Overheating state of MG2
CONVRTR TMP MAX	Boost converter maximum temperature/ Min.: -50°C, Max.: 205°C	Overheating state of boost converter
SOC MAX	Maximum status of charge/ Min.: 0 %, Max.: 100%	Over-charging of HV battery
SOC MIN	Minimum status of charge/ Min.: 0 %, Max.: 100%	Over-discharging of HV battery

Appendix D
Hybrid Control Data List

Using DATA LIST displayed by the hand-held tester, you can read the value of the switches, sensors, actuators and so on without parts removal. Reading DATA LIST as a first step of troubleshooting is one method to shorten diagnostic time.

a) Connect the hand-held tester to the DLC3.

b) Turn the power switch ON (IG).

c) Turn the hand-held tester ON.

d) On the hand-held tester, enter the following menus: DIAGNOSIS / ENHANCED OBD II / HV ECU / DATA LIST.

e) According to the display on the tester, read DATA LIST.

NOTICE:

The values of DATA LIST could vary significantly with slight differences in measurement, differences in the environment in which the measurements are obtained, or the aging of the vehicle.

Definite standards or judgment values are unavailable. There may be a malfunction even if a measured value is within the reference range.

In case of intricate symptoms, collect sample data from another vehicle of the same model operating under identical conditions in order to reach an overall judgment by comparing all the items of DATA LIST.

Hand-held Tester Display	Measurement Item/Range (Display)	Reference Range	Diagnostic Note
COOLANT TEMP	Engine coolant temperature/ Min.: -40°C, Max.: 140°C	After warming up: 80 to 100°C (176 to 212°F)	• If the value is -40°C (-40°F): Open in sensor circuit • If the value is 140 °C (284 °F): Short in sensor circuit
VEHICLE SPD	Vehicle speed/ Min.: 0 km/h, Max.: 255 km/h	Vehicle stopped: 0 km/h (0 mph)	—
ENG RUN TIME	Elapsed time after starting engine/ Min.: 0 s, Max.: 65,535 s	—	—
+B	Auxiliary battery voltage/ Min.: 0 V, Max.: 65.535 V	Constant: Auxiliary battery voltage 3 V	—
ACCEL POS #1	Accelerator pedal position sensor No. 1/ Min.: 0 %, Max.: 100 %	Accelerator pedal depressed: Changes with accelerator pedal pressure	—
ACCEL POS #2	Accelerator pedal position sensor No. 2/ Min.: 0 %, Max.: 100 %	Accelerator pedal depressed: Changes with accelerator pedal pressure	—
AMBIENT TEMP	Ambient air temperature/ Min.: -40°C, Max.: 215°C	Power switch ON (IG): Same as ambient air temperature	—
INTAKE AIR TEMP	Intake air temperature/ Min.: -40 C, Max.: 140 C	Constant: Auxiliary battery voltage 3 V	—

Hand-held Tester Display	Measurement Item/Range (Display)	Reference Range	Diagnostic Note
DTC CLEAR WARM	The number of times engine is warmed up after clearing DTCs/ Min.: 0, Max.: 255	MIL OFF, engine coolant temperature increases from below 22°C (71.6°F) before starting the engine to above 70°C (158°F) after starting the engine: Increases once	—
DTC CLEAR RUN	Drive distance after clearing DTCs/ Min.: 0 km, Max.: 65,535 km	—	—
DTC CLEAR MIN	Elapsed time after clearing DTCs/ Min.: 0 min, Max.: 65,535 min	—	—
MIL ON RUN DIST	Drive distance after malfunction occurrence/ Min.: 0 km, Max.: 65,535 km	—	—
MIL ON ENG TIME	Elapsed time after starting engine with MIL ON/ Min.: 0 min, Max.: 65,535 min	—	—
MIL Status	MIL status/ ON or OFF	MIL ON: ON	Constant ON: Repair in accordance with detected DTCs
MG2 REV	MG2 revolution/ Min.: -16,383 rpm, Max.: 16,383 rpm	—	—
MG2 TORQ	MG2 torque/ Min.: -500 Nm, Max.: 500 Nm	—	—
MG2 TRQ EXC VAL	MG2 torque execution value/ Min.: -512 Nm, Max.: 508 Nm	After full-load acceleration with READY lamp ON and engine stopped: Less than ±20 % of MG2 TORQ	—
MG1 REV	MG1 revolution/ Min.: -16,383 rpm, Max.: 16,383 rpm	—	—
MG1 TORQ	MG1 torque/ Min.: -500 Nm, Max.: 500 Nm	—	—
MG1 TRQ EXC VAL	MG1 torque execution value/ Min.: -512 Nm, Max.: 508 Nm	1 second has elapsed after the engine was started automatically with READY lamp ON, engine stopped, A/C fan Hi, head lamp ON and the P position: Less than ±20 % of MG1 TORQ	—
REGEN EXEC TORQ	Regenerative brake execution torque/ Min.: 0 Nm, Max.: 186 Nm	—	—
REGEN RQST TORQ	Regenerative brake request torque/ Min.: 0 Nm, Max.: 186 Nm	Vehicle speed 30 km/h (19 mph) and master cylinder hydraulic pressure -200 Nm: Changes with brake pedal pressure	—
MG1 INVERT TEMP	MG1 inverter temperature/ Min.: -50°C, Max.: 205°C	• Undisturbed for 1 day at 25°C (77°F): 25°C (77°F) • Street driving: 25 to 80°C (77 to 176°F)	• If the value is -50°C (-58°F): +B short in sensor circuit • If the value is 205°C (401°F): Open or GND short in sensor circuit
MG2 INVERT TEMP	MG2 inverter temperature/ Min.: -50°C, Max.: 205°C	• Undisturbed for 1 day at 25°C (77°F): 25°C (77°F) • Street driving: 25 to 80°C (77 to 176°F)	• If the value is -50°C (-58°F): +B short in sensor circuit • If the value is 205°C (401 °F): Open or GND short in sensor circuit
MOTOR2 TEMP	Transaxle fluid temperature/ Min.: -50°C, Max.: 205°C	• Undisturbed for 1 day at 25°C (77°F): 25°C (77°F) . • Street driving: 25 to 80°C (77 to 176°F)	• If the value is -50°C (-58°F): Open or +B short in sensor circuit • If the value is 205°C (401°F): GND short in sensor circuit

Hand-held Tester Display	Measurement Item/Range (Display)	Reference Range	Diagnostic Note
MOTOR1 TEMP	MG2 motor temperature/ Min.: -50°C, Max.: 205°C	• Undisturbed for 1 day at 25°C (77°F): 25°C (77°F) • Street driving: 25 to 80°C (77 to 176°F)	• If the value is -50°C (-58°F): Open or +B short in sensor circuit • If the value is 205°C (401°F): GND short in sensor circuit
CONVERTER TEMP	Boost converter temperature/ Min.: -50°C, Max.: 205°C	• Undisturbed for 1 day at 25°C (77°F): 25°C (77°F) • Street driving: 25 to 60°C (77 to 140°F)	• If the value is -50°C (-58°F): +B short in sensor circuit • If the value is 205°C (401°F): Open or GND short in sensor circuit
ACCEL DEG	Accelerator pedal depressed angle/ Min.: 0%, Max.: 100%	Accelerator pedal depressed: Changes with accelerator pedal pressure	—
POWER RQST	Engine power output request value/ Min.: 0 W, Max.: 320,000 W	—	—
TARGET ENG SPD	Target engine speed/ Min.: 0 rpm, Max.: 8,000 rpm	—	—
ENGINE SPD	Engine speed/ Min.: 0 rpm, Max.: 8,000 rpm	Idling*: 950 to 1,050 rpm	—
VEHICLE SPD	Resolver vehicle speed/ Min.: -256 km/h, Max.: 254 km/h	Driving at 40 km/h (25 mph): 40 km/h (25 mph)	—
MCYL CTRL POWER	Braking torque that is equivalent to the master cylinder hydraulic pressure/ Min.: -512 Nm, Max.: 508 Nm	Brake pedal depressed: Changes with brake pedal pressure	—
SOC	Battery state of charge/ Min.: 0 %, Max.: 100 %	Constant: 0 to 100 %	—
WOUT CTRL POWER	Discharge control power value/ Min.: 0 W, Max.: 81,600 W	21,000 W or less	—
WIN CTRL POWER	Charge control power value/ Min.: -40,800 W, Max.: 0 W	-25,000 W or more	—
DCHG RQST SOC	Discharge request to adjust SOC/ Min.: -20,480 W, Max.: 20,320 W	• Uniform on-board charging: -4,400 W • Usually: 0 W	—
PWR RESOURCE VB	HV battery voltage/ Min.: 0 V, Max.: 510 V	READY lamp ON and P position: 150 to 300 V	—
PWR RESOURCE IB	HV battery current/ Min.: -256 A, Max.: 254 A	—	—
VL	High voltage before it is boosted/ Min.: 0 V, Max.: 510 V	Power switch ON (READY): Practically the same as the HV battery voltage	• If the value is 0 V: Open or GND short in sensor circuit • If the value is 510 V: +B short in sensor circuit
VH	High voltage after it is boosted/ Min.: 0 V, Max.: 765 V	Engine revved up in P position: HV battery voltage to 500 V	• If the value is 0 V: Open or GND short in sensor circuit • If the value is 765 V: +B short in sensor circuit
RAIS PRES RATIO	Boost ratio/ Min.: 0%, Max.: 100%	The pre-boost voltage and the post-boost voltage are equal: 0 to 10 %	—
DRIVE CONDITION	Drive condition ID/ Min.: 0, Max.: 6	• Engine stopped: 0 • Engine about to be stopped: 1 • Engine about to be started: 2 • Engine operated or operating: 3 • Generating or loading movement: 4 • Revving up with P position: 6	—

Hand-held Tester Display	Measurement Item/Range (Display)	Reference Range	Diagnostic Note
M SHIFT SENSOR	Output voltage of the shift position sensor (main)/ Min.: 0 V, Max.: 5 V	• Selector lever in home position: 2.0 to 3.0 V • Shifting into R position: 4.0 to 4.8 V • Shifting into B or D position: 0.2 to 1.0 V	—
S SHIFT SENSOR	Output voltage of the shift position sensor (sub)/ Min.: 0 V, Max.: 5 V	• Selector lever in home position: 2.0 to 3.0 V • Shifting into R position: 4.0 to 4.8 V • Shifting into B or D position: 0.2 to 1.0 V	—
SM SHIFT SENSOR	Output voltage of the select position sensor (main)/ Min.: 0 V, Max.: 5 V	• Selector lever in home position: 0.5 to 2.0 • Shifting into R, N or D position: 3.0 to 4.85 V	—
SS SHIFT SENSOR	Output voltage of the select position sensor (sub)/ Min.: 0 V, Max.: 5 V	• Selector lever in home position: 0.5 to 2.0 V • Shifting into R, N or D position: 3.0 to 4.85 V	—
SHIFT POSITION	Shift position	P, R, N, D or B	—
CRANK POS	Crankshaft position/ Min.: -90 deg, Max.: 90 deg	—	—
A/C CONSMPT PWR	A/C consumption power/ Min.: 0 kW, Max.: 5 kW	—	—
DRIVE CONDITION	Driving condition	• MG1 load: MG1 • MG2 load: MG2	—
SHORT WAVE HIGH	Waveform voltage in leak detection circuit in battery ECU/ Min.: 0 V, Max.: 5 V	READY lamp is left ON for 2 minutes, and the pre-boost voltage and the post-boost voltage are equal: 4 V or more	—
MG1 CTRL MODE	MG1 control mode/ ON or OFF	—	—
MG1 CARRIR FREQ	MG1 carrier frequency/ 5 kHz or 10 kHz	—	—
MG2 CTRL MODE	MG2 control mode/ ON or OFF	—	—
MG2 CARRIR FREQ	MG2 carrier frequency/ 1.25 kHz or 5 kHz	—	—
ECU TYPE	Type of ECU	HV ECU	—
CURRENT DTC	The number of current DTCs/ Min.: 0, Max.: 255	—	—
HISTORY DTC	The number of history DTCs/ Min.: 0, Max.: 255	—	—
CHECK MODE	Check mode/ ON or OFF	—	—
ENG STOP RQST	Engine stop request/ NO or RQST	Requesting engine stop: RQST	—
IDLING REQUEST	Engine idling request/ NO or RQST	Requesting idle: RQST	—
HV BATT CH RQST	HV battery charging request/ NO or RQST	Requesting HV battery charging: RQST	—
ENG STP INHIBIT	Engine stop inhibit request/ NO or RQST	Requesting engine intermittent prohibition: RQST	—
AIRCON REQUEST	Engine starting request from A/C amplifier/ NO or RQST	Requesting engine start from A/C amplifier: RQST	—
ENG WARM UP RQT	Engine warm-up request/ NO or RQST	Requesting engine warm-up: RQST	—
SMR CONT1	Operating condition of system main relay No. 1/ ON or OFF	Power switch ON (READY): OFF	—

Hand-held Tester Display	Measurement Item/Range (Display)	Reference Range	Diagnostic Note
SMR CONT2	Operating condition of system main relay No. 2/ ON or OFF	Power switch ON (READY): ON	—
SMR CONT3	Operating condition of system main relay No. 3/ ON or OFF	Power switch ON (READY): ON	—
MG1 GATE	MG1 gate status/ ON or OFF	ON	—
MG2 GATE	MG2 gate status/ ON or OFF	Shutting down motor inverter: ON	—
CNV GATE	Boost converter gate status/ ON or OFF	Shutting down boost converter: ON	—
A/C GATE	A/C gate status/ ON or OFF	Shutting down A/C inverter: ON	—
SMARTKEY	Electronic key ID code check status/ ON or OFF	When electronic key ID code corresponds to ID code registered in ECU: ON	—
CNV CARIER FREQ	Boost converter carrier frequency/ 5 kHz or 10 kHz	—	—

*: If no conditions are specifically stated for “Idling”, it means the engine for inspection mode, the shift position is in P, the A/C switch is OFF, and accelerator pedal is not depressed.

High Voltage Warning Card

Person in charge:________________

OPERATION.
NOT TOUCH DURING
HIGH VOLTAGE. DO
CAUTION:

CAUTION:
HIGH VOLTAGE. DO NOT TOUCH DURING OPERATION.

Person in charge:________________