Section 1

Hybrid System Overview

Overview

Prius is a Latin word meaning “to go before.” Toyota chose this name because the Prius vehicle is the predecessor of 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 long-standing 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 CO2.

When the Prius was first released, it was selected as the world’s best-engineered passenger car for 2001. The car was chosen because it is the first hybrid vehicle that seats four to five people plus their luggage, and it is one of the most economical and environmentally friendly vehicles available. Then in 2004, the second generation Prius won the prestigious Motor Trend Car of the Year award and best-engineered vehicle of 2004.

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**	

- 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 Components

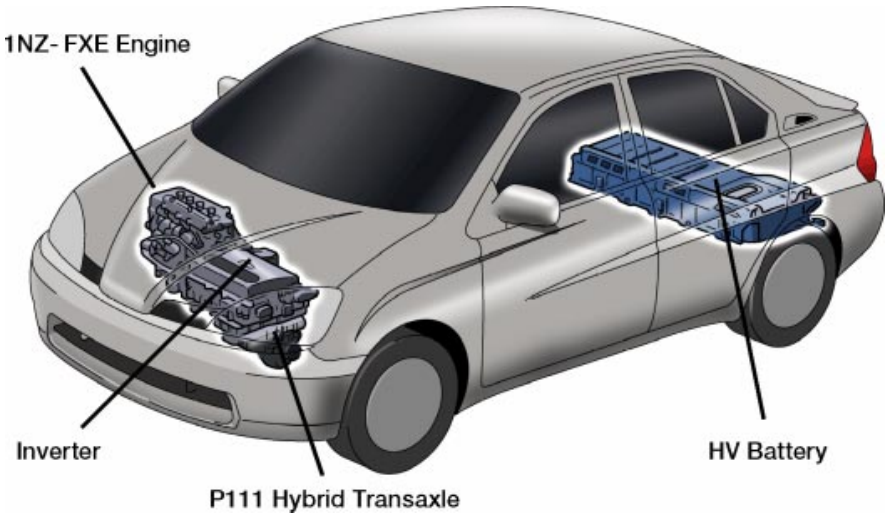


Figure 1.2 T071f102c

Hybrid System

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

IC Engine

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

1NZ-FXE

Figure 1.3 T071f103p

Motor Generator 1 (MG1)

Motor Generator 1 (MG1) operates as the control element for the power splitting planetary gear set. It recharges 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.

Motor Generator 1 (MG1)

MG1 generates electrical power and starts the engine.

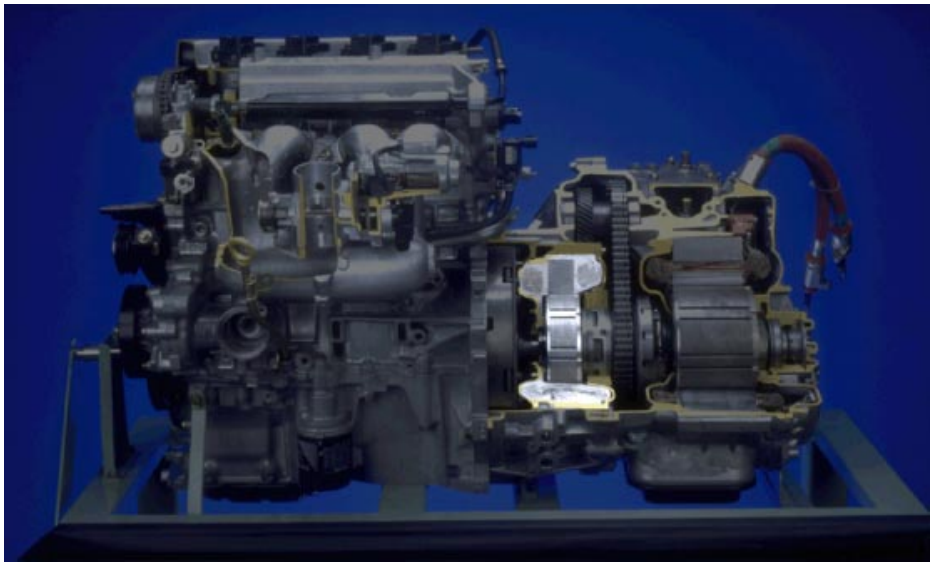


Figure 1.4 T071f104p

Motor Generator 2 (MG2)

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.

Motor Generator 2 (MG2)

MG2 drives the vehicle.

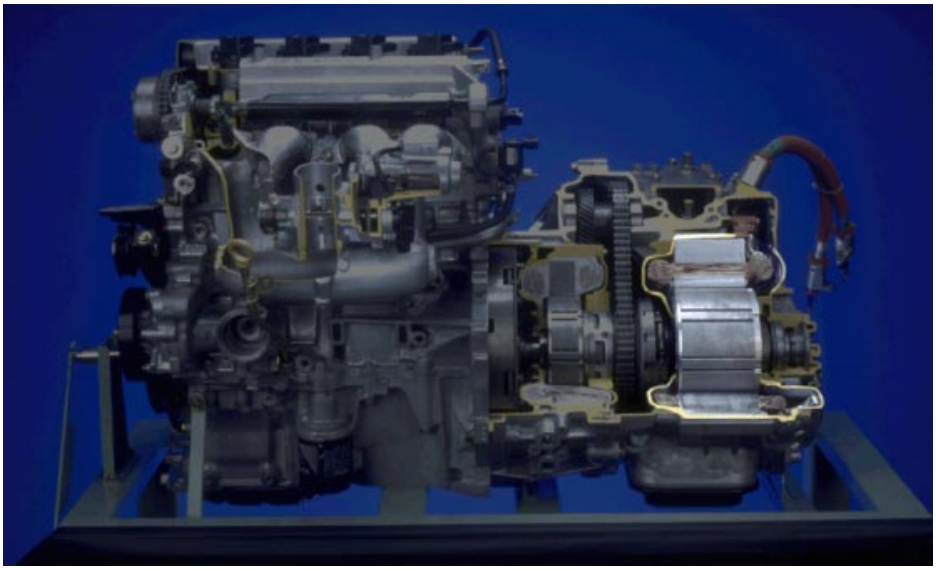


Figure 1.5 T071f105p

Planetary Gear Unit

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 planetary carrier. These components are used to combine power delivery from the engine and MG2, and to recover energy to the HV battery.

Planetary Gear Unit

A single Planetary Gear Unit splits the torque between MG1, MG2, and the engine.

Figure 1.6 T071f106p

Inverter

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.

Inverter Assembly

A device that converts the high-voltage DC (HV battery) into AC (MG1 and MG2) and vice versa.

Figure 1.7 T071f107p

HV 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

HV Battery

Supplies electric power to MG2 during start-off, acceleration and uphill driving.

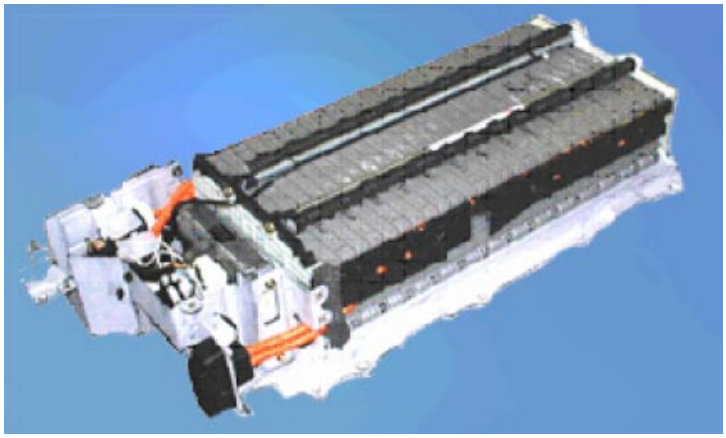


Figure 1.8 T071f108p

Hybrid System Control Modes

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.

Stopped If the vehicle is fully charged and it not moving, the engine may stop. The engine will start up automatically if the HV battery needs charging. Also, if MAX A/C is selected on a 2001 – 2003 Prius, the engine will run continuously due to the engine driven compressor. The 2004 & later Prius use an electric compressor.

Stopped

The engine may stop when the vehicle is not moving and the HV battery is fully charged.

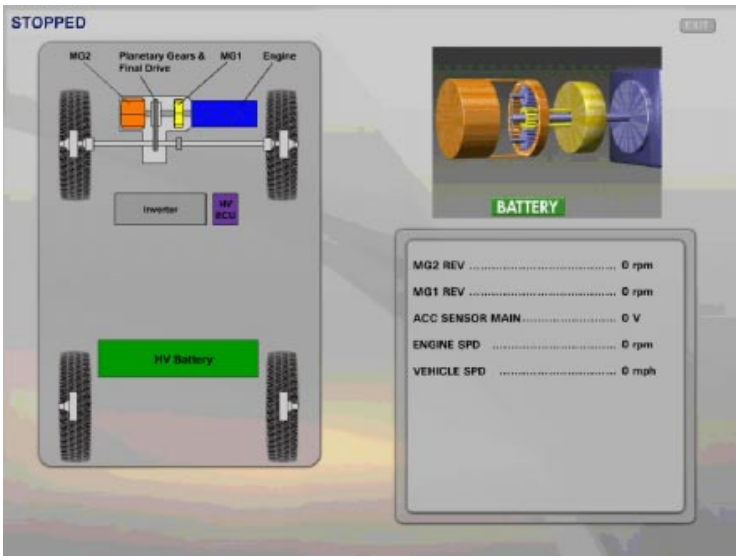


Figure 1.9 T071f109c

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.

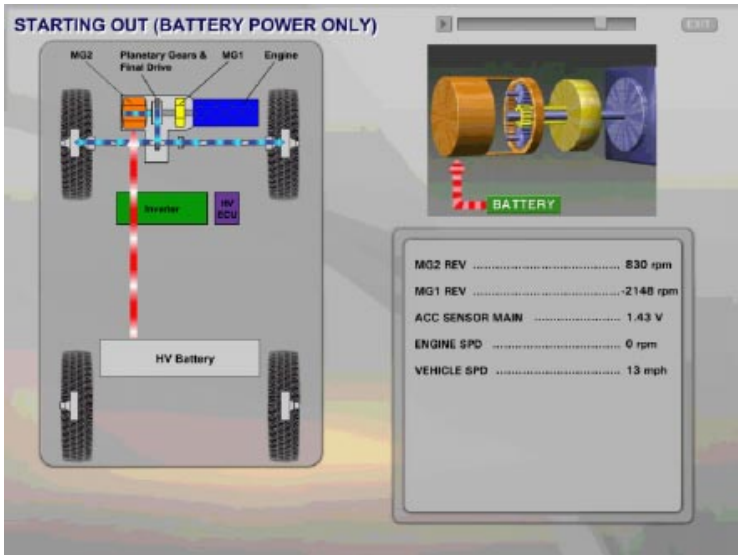


Figure 1.10 T072f103c

Normal Driving

During normal low-speed driving (15 – 40mph), 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.

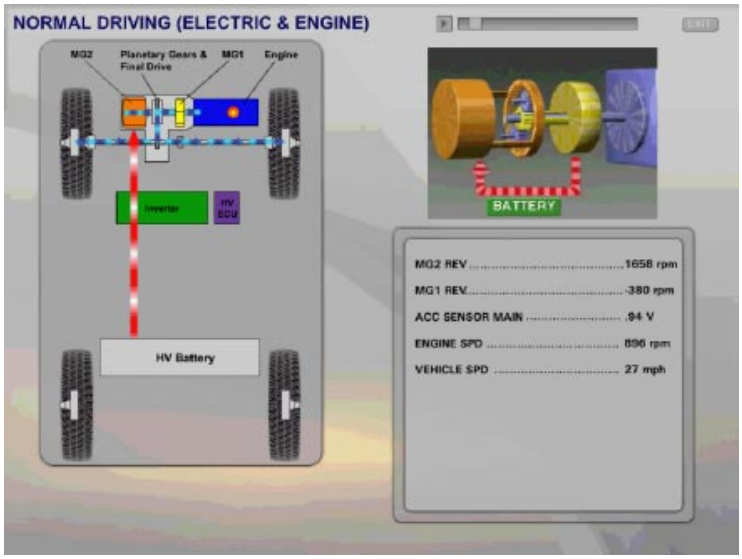


Figure 1.11 T072f104c

Full Throttle Acceleration and High Speed Cruise

For maximum acceleration or speed (over 100mph), 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.

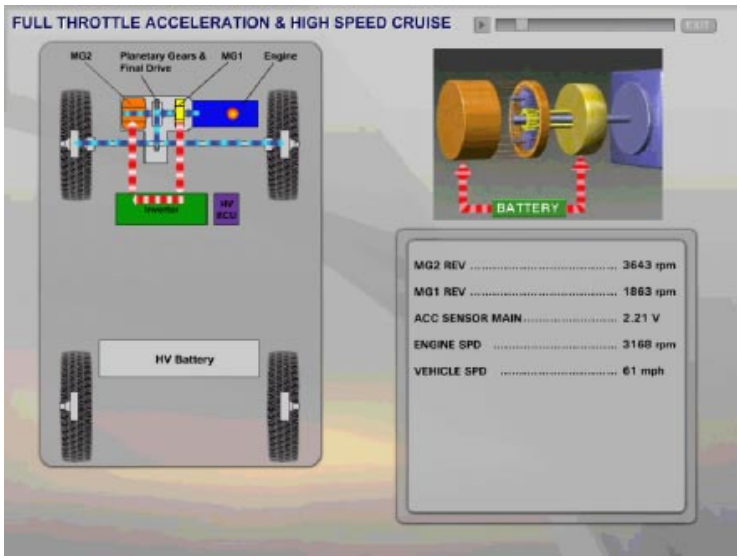


Figure 1.12 T072f105c

Deceleration and Braking

As soon as the driver releases the accelerator pedal, 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 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 in to electrical energy and used to recharge the HV battery by means of MG2.

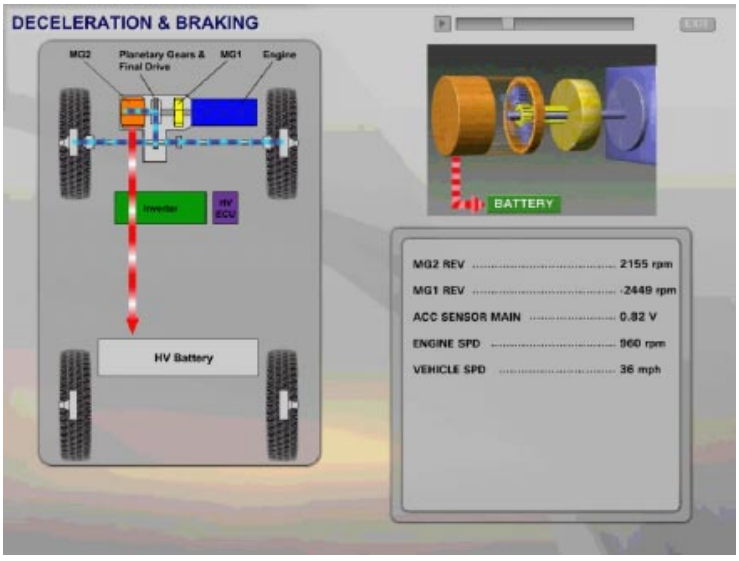


Figure 1.13 T072f106c

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.

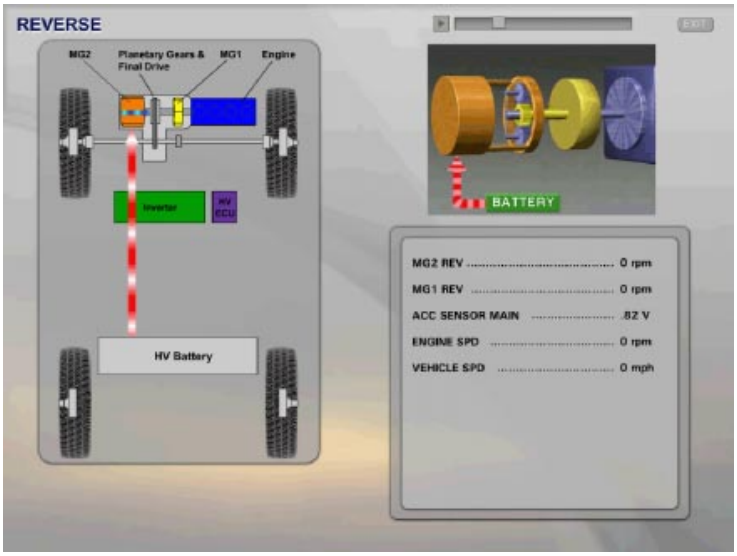


Figure 1.14 T072f107c

Multi Display

A multi display is provided on the center cluster panel as standard equipment. The 7.0-inch LCD screen has a pressure sensitive panel for easy function accessibility.

Energy Monitor

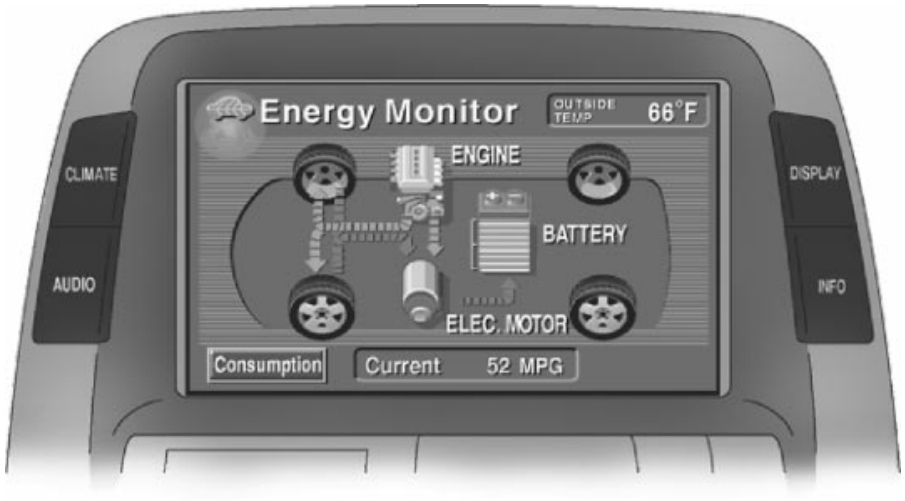


Figure 1.15 T071f115c

Fuel Consumption Screen

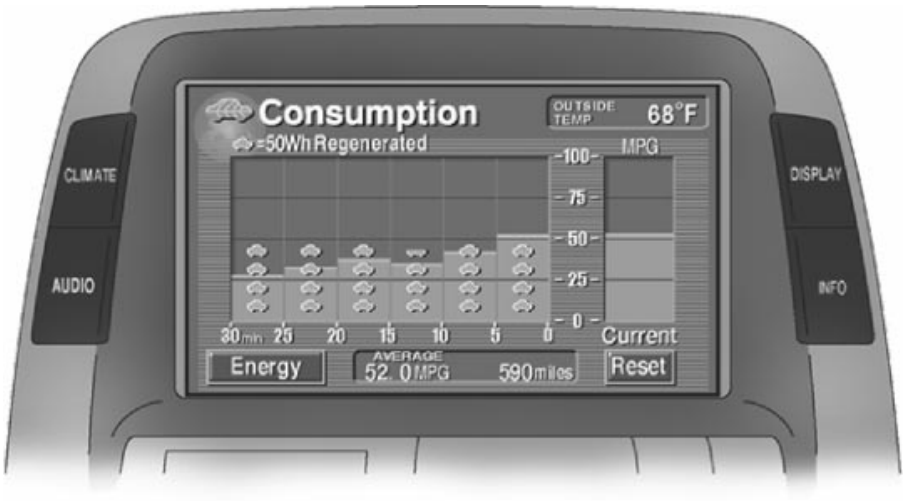


Figure 1.16 T071f116c

Smart Entry and Start System

In addition to the conventional mechanical key function and wireless door lock remote control function, this system provides a smart key with a bi-directional communication function. By enabling the smart ECU to recognize the presence of the smart key within the detection area, this system can lock or unlock the doors, or start the hybrid system without the use of the key, as long as the user has the smart key in their possession.

Door Open

Using smart entry by opening the door with smart key in pocket. The touch sensor is located on the back of the door handle.

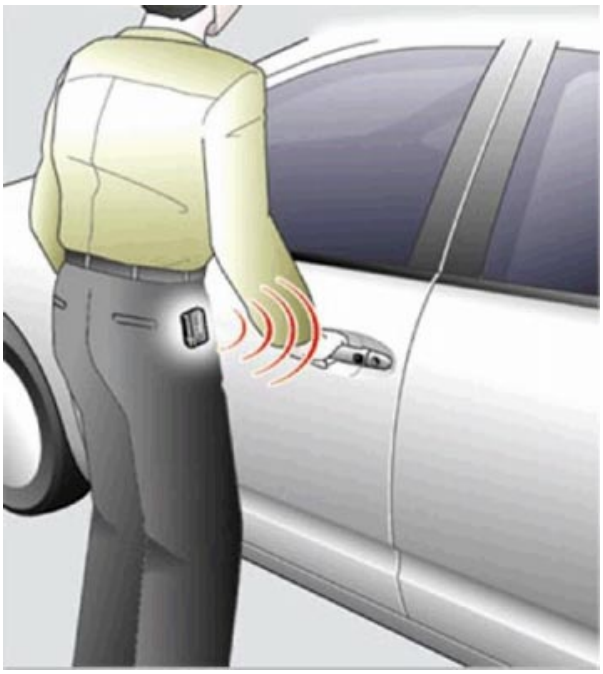


Figure 1.17 T071f117c

Hybrid System Start

On the ’01-‘03 Prius, an ignition key is used to operate the key cylinder (containing the ignition switch), in order to switch the power mode of the vehicle and start the system.

On the ’04 & later Prius, a push button start system operates the power switch by inserting a key in a key slot or by the driver keeping a key in their possession (models with smart entry and start system).

Power Mode

A power mode (OFF, ACC, IG-ON, or READY) can be selected by pressing the power switch. The indicator on this switch will tell you the power mode, which varies depending if the brake pedal is depressed or not while the switch is operated.

Push Button Start

(’04 & later Prius)

Figure 1.18 T071f118c

Hybrid System Start

Using smart start system by pressing the Power button with foot on brake and key in pocket.

Figure 1.20 T071f120c

Smart Cancel Switch

('04 & later Prius)

To cancel smart key and smart on a '04 & later Prius. Simply press the smart cancel switch under the steering column.

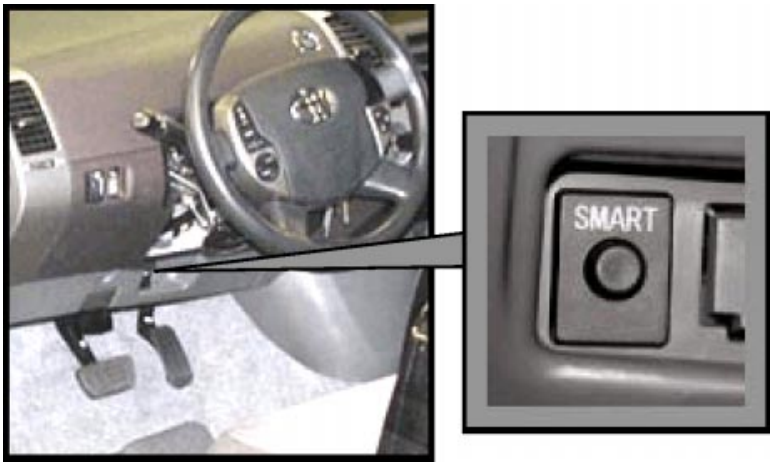


Figure 1.19 T071f119c

Power Mode – OFF or READY

Indicator light is OFF.

Figure 1.21 T071f121c

Power Mode - ACC

Indicator light is green.

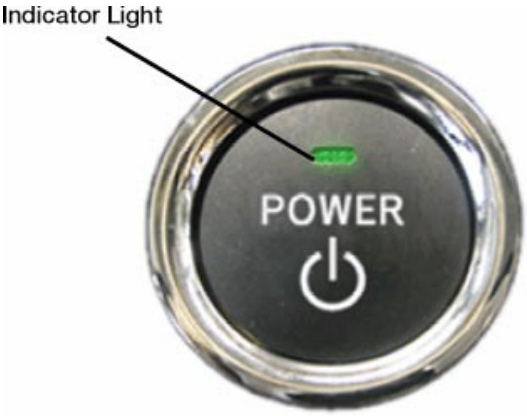


Figure 1.22 T071f122c

Power Mode – IG-ON

Indicator light is amber.

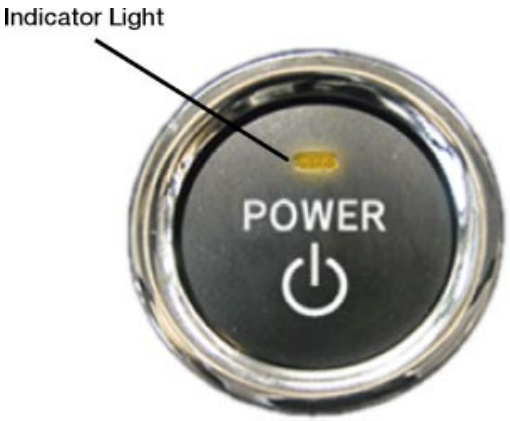
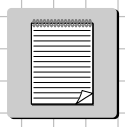


Figure 1.23 T071f123c

Combination Meter

('04 & later Prius)

Figure 1.24 T071f124c



Notes

WORKSHEET 1-1
Hybrid System Overview

Vehicle	Year/Prod. Date	Engine	Transmission

Worksheet Objectives

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

Tools and Equipment

- Vehicle
- Repair Manual
- New Car Features

Section 1: Hybrid Overview

1. On the multi display screen, view the fuel consumption screen. What different types of information are displayed on this screen?

2. Unlike a conventional vehicle, the Prius may or may not start the engine when the vehicle is turned ON. What alerts the driver that the vehicle is ready to drive?

3. What is the primary motive force when starting, backing up or under light loads?

4. While driving, what do you think happens when you shift into the “B” position?

5. When the vehicle is decelerating or braking, what kind of energy from the wheels is recovered and converted into electrical energy to recharge the HV Battery?

6. Where is the 12V auxiliary battery located and what is its function? Can the 12V battery be jump-started?

7. How can you tell if the vehicle has smart key and smart start?

8. Does the vehicle you are working on have navigation? Does it have Bluetooth? How can you tell?

9. Where is the intake duct for the HV battery cooling system?

Section 2: Driving Characteristics

1. Make sure the parking brake is engaged. Will the vehicle start in neutral?

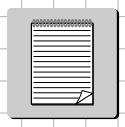
2. When the vehicle begins to move forward after the release of the parking brake and brake pedal, what power source is being used to move the vehicle?

3. On a 2004 and later Prius, how do you start the vehicle (READY light ON) with the Power button? With and without smart key?

4. What is unique about the steering system?

5. The engine may turn OFF periodically. List two conditions that will cause the engine to turn back ON.

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



Notes

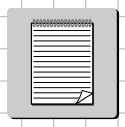
SELF-ASSESSMENT 1-1
Hybrid System Overview

Name:	Date:

Self-assessment Objectives

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

Topic			Comment
Locate power button.			
Access the READY light.			
Use smart key & smart start.			
Locate the 12V battery.			
Locate the Navigation & Bluetooth functions.			



Notes