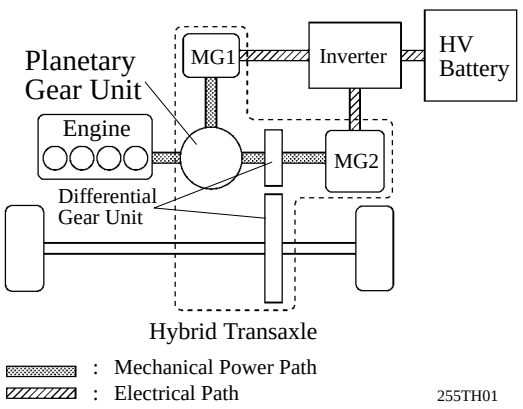
■FEATURES OF THS-II

1. General

- The hybrid system is a type of power-train that uses a combination of two types of motive forces, such as an engine and a MG2. This system is characterized by its skillful use of two types of motive forces according to the driving conditions. It maximizes the strengths of each of the motive forces and complements their weaknesses. Thus, it can achieve a highly responsive, dynamic performance, as well as a dramatic reduction in fuel consumption and exhaust gas emissions. The THS-II can be broadly divided into two systems: the series hybrid system, and the parallel hybrid system.



255TH01

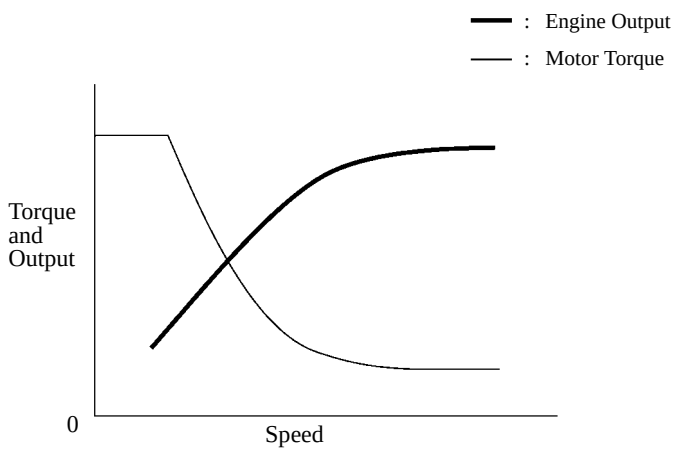


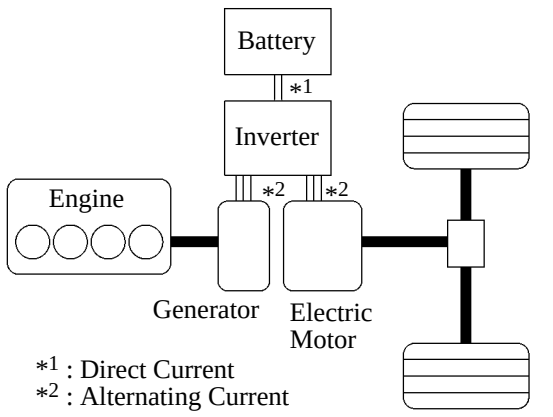
Diagram of the Conceptual Image of the System Performance Curve

255TH02

— REFERENCE —

Series Hybrid System

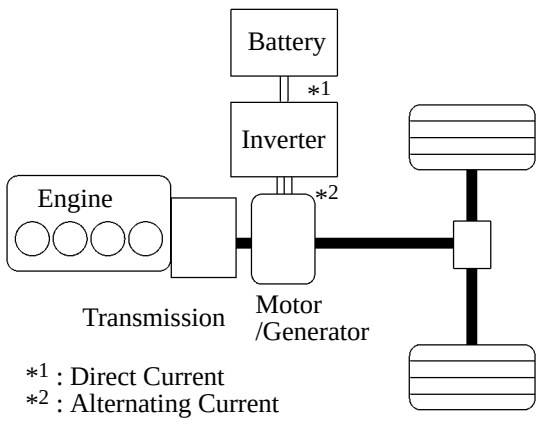
In the series hybrid system, the engine runs a generator, and the generated electricity enables the electric motor to drive the wheels. This type of vehicle can be described as an electric car that is equipped with an engine-driven generator.
Equipped with a low-output engine, the engine is operated at a practically constant speed in its most effective range, in order to efficiently recharge the battery while the vehicle is in motion.



182TH01

Parallel Hybrid System

This system uses both the engine and the electric motor to directly drive the wheels is called the parallel hybrid system. In addition to supplementing the motive force of the engine, the electric motor in this system can also serve as a generator to recharge the battery while the vehicle is in motion.

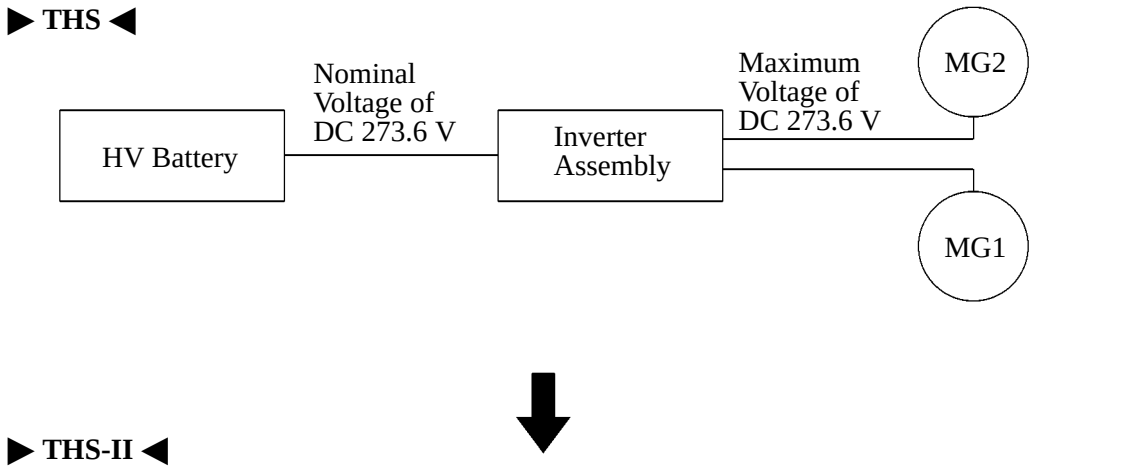


182TH02

2. High-voltage Power Supply System

General

In the THS-II of the ’04 Prius, a boost converter has been newly adopted inside the inverter assembly. The boost converter enables the THS-II to provide the power source voltage of 500V at a maximum to MG1 and MG2 (the maximum of the THS on the ’03 Prius is 273.6V), thus electric power is supplied with lower current and high efficiency is realized.



Power Calculation

Power (P) = Voltage (V) × Current (I)

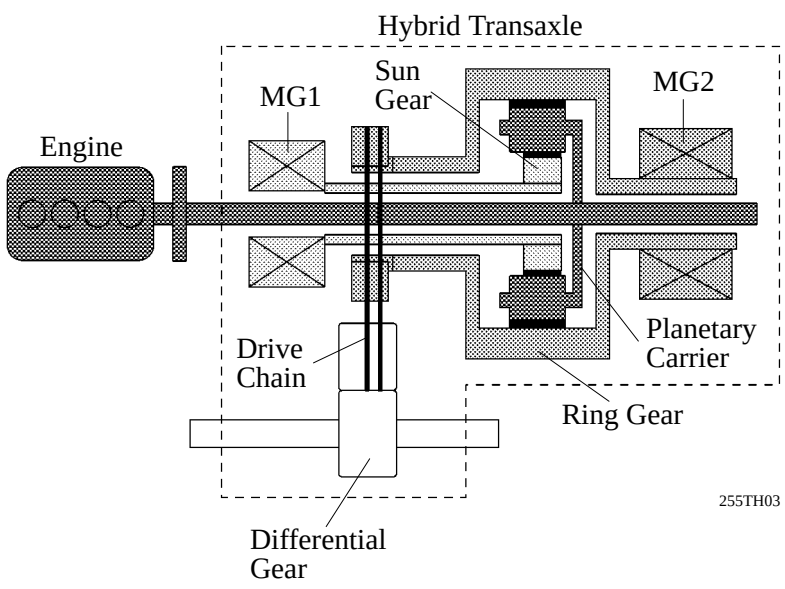
- Power, which expresses the work performed by electricity within a give amount of time, is calculated by multiplying voltage by current. If the power necessary for driving the motor is held constant, the above formula indicates that doubling the voltage reduce the current by 1/2.
- Next, by following Joule’s Law (Calorie = Current^2 × Resistance), the power loss in terms of calories is reduced to 1/4 (1/2 Current × 1/2 Current) if the resistance is held constant. The high-voltage power circuit (boost converter) in THS-II increases power by increasing the voltage while keeping the current constant. Furthermore, for the same power level, increasing the voltage and reducing the current reduces energy loss, resulting in high efficiency.

3. Hybrid Transaxle

General

- While this system efficiently combines and operates the two types of motive forces, the engine and MG2, in accordance with the driving conditions of the vehicle, the basic motive force is provided by the engine. The motive force of the engine is divided into two areas: the motive force applied to the wheels by the planetary gear unit in the hybrid transaxle, and the motive force to operate MG1 as a generator.
- The hybrid transaxle, which contains MG1, MG2, and a planetary gear unit, uses these units to achieve a smooth drive realized through stepless shifting.
- The engine, MG1, and MG2 are mechanically joined via the planetary gear unit.
- MG2 and the differential gear (for the drive wheels) are joined via a drive chain and gears.

For details, refer to P112 Hybrid Transaxle on page CH-2.



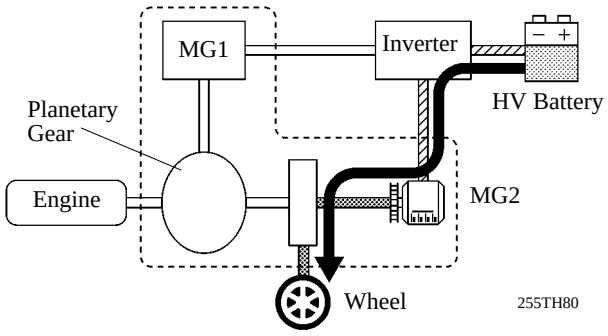
Clutch-Less System

A clutch-less system has been adopted to mechanically link the front wheels and MG2 via gears and a chain. To disengage the motive force in the neutral position, the shift position sensor outputs an N position signal to turn OFF all the power transistors in the inverter (which connects MG1 and MG2). As a result, the operation of MG1 and MG2 shuts down, thus rendering the motive force at the wheels to zero. In this state, even if MG1 is rotated by the engine or MG2 is rotated by the drive wheels, no generation of electricity occurs because both MG1 and MG2 are inactive. As a result, the SOC (state of charge) of the HV battery decreases as the shift position remains in the “N” position.

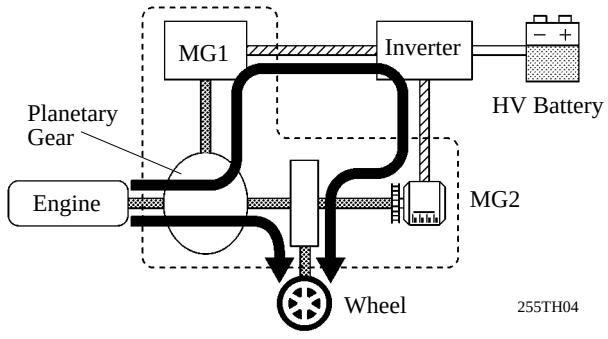
4. Basic Operation

- This system controls the following modes in order to achieve the most efficient operations to match the driving conditions:

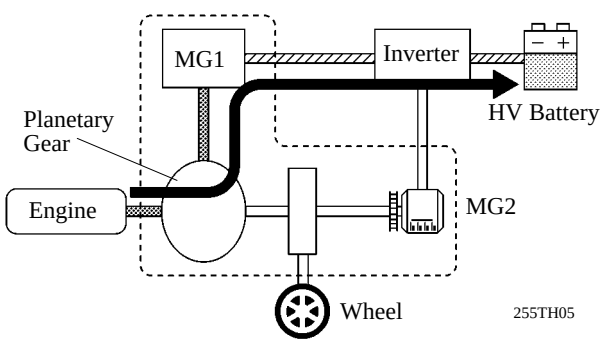
(1) Supply of electrical power from the HV battery to MG2 provides force to drive the wheels.



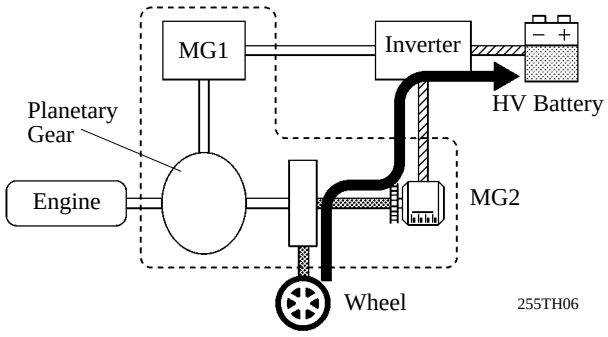
(2) While the wheels are being driven by the engine via the planetary gears, MG1 is rotated by the engine via the planetary gears, in order to supply the generated electricity to MG2.



(3) MG1 is rotated by the engine via the planetary gears, in order to charge the HV battery.



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



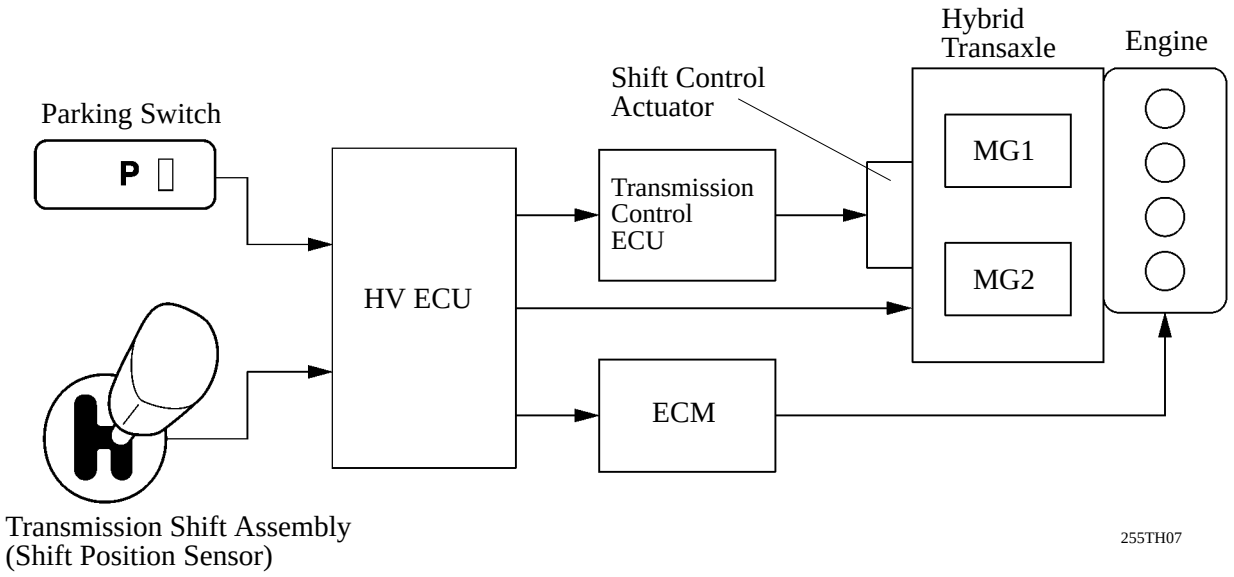
- The HV ECU switches between these modes ((1), (2), (3), (1)+(2)+(3), or (4)) according to the driving conditions. However, when the SOC (State of Charge) of the HV battery is low, the HV battery is charged by the engine by turning MG1.
  As a result, it achieves far greater fuel economy compared to conventional gasoline engine vehicles, at a reduced level of exhaust gas emissions. Furthermore, this revolutionary power-train has eliminated the constraints that are associated with electric vehicles (such as their short cruising range or their reliance on external recharging units).

5. Regenerative Brake

The regenerative brake function operates MG2 as a generator while the vehicle is decelerating or braking and stores this electrical energy in the HV battery. At the same time, it utilizes the operating resistance, which MG2 exerts during the generation of electricity, as a braking force. For details, refer to the Outline of Regenerative Brake Cooperative Control in the Brake Control System, on page CH-36.

6. Link-Less

- As on the ’03 Prius, the ’04 Prius has adopted the shift-by-wire technology. This is a link-less type that does not use a shift cable. A shift position sensor is provided in the transmission shift assembly to detect the shift position and send a corresponding signal to the HV ECU. Upon receiving this signal, the HV ECU optimally combines the operation of the engine, MG1, and MG2, in order to produce the respective shift positions (“R”, “N”, “D”, and “B”).
  When the driver presses the Parking switch located on the top of the transmission shift assembly, the “P” position control actuates the shift control actuator located in the hybrid transaxle in order to mechanically lock the counter driven gear, which engages the parking lock. For details, refer to Shift Control Actuator in P112 Hybrid Transaxle on page CH-14.



- As on the ’03 Prius, the ’04 Prius has adopted the ETCS-i (Electronic Throttle Control System-intelligent). This is a link-less system that does not use an accelerator cable. Instead, it uses an accelerator pedal position sensor and a throttle position sensor to detect the accelerator pedal position and the throttle position.
  The HV ECU calculates the target engine speed and required engine motive force in accordance with the signals provided by the accelerator pedal position sensor, vehicle driving conditions, and the SOC (state of charge) of the battery, and sends a control signal to the ECM. Based on the control signal, the ECM optimally controls the throttle valve.