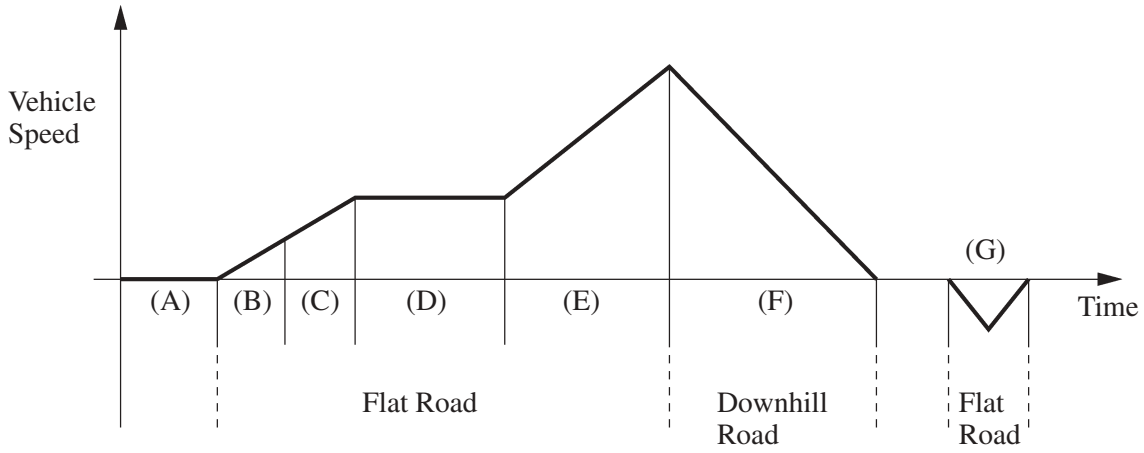
■SYSTEM OPERATION

1. General

- The THS II uses two sources of motive force, the engine and MG2, and uses MG1 as a generator. The system optimally combines these forces in accordance with the various driving conditions.
- The THS ECU constantly monitors the SOC condition, the HV battery temperature, the coolant temperature, and the electrical load condition. If any one of the monitored items fails to satisfy the requirements when the READY indicator is ON and the shift lever is in the “P” position, or the vehicle is driven in reverse, the THS ECU to starts the engine to drive MG1, and then charges the HV battery.
- The THS II drives the vehicle by optimally combining the operations of the engine, MG1, and MG2 in accordance with the driving conditions listed below.
  The vehicle conditions listed below are examples of typical vehicle running conditions.



Driving Condition

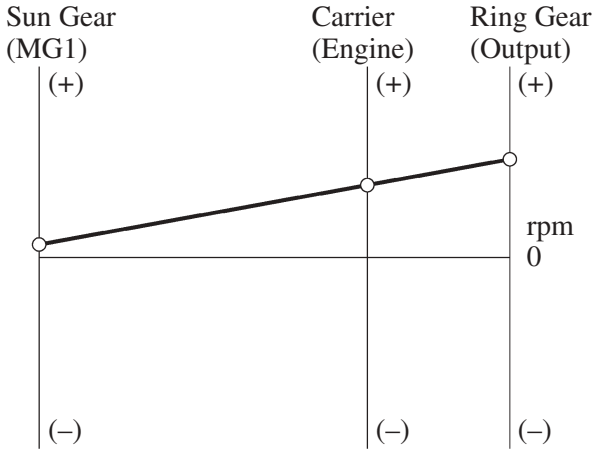
02DTH85Y

(A): READY ON State
(B): Starting with MG2 (See Page TH-13)
(C): Running with MG2 and Engine (See Page TH-14)
(D): During Low Load and Constant-Speed Cruising (See Page TH-15)
(E): During Full Throttle Acceleration (See Page TH-16)
(F): During Deceleration Driving (See Page TH-17)
(G): During Reverse Driving (See Page TH-18)

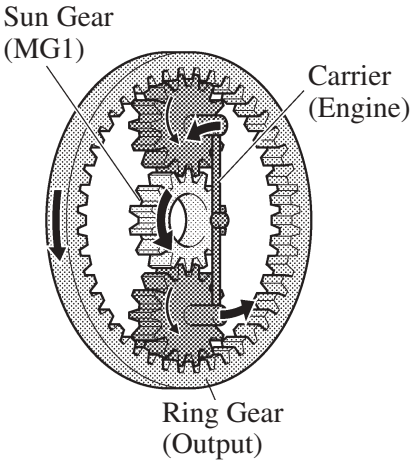
2. How to Read a Nomographic Chart

- The nomographic chart below gives a visual representation of the planetary gear's rotational direction, rotational speed, and torque balance.
- In the nomographic chart, a straight line is used to represent the relationship between the rotational speeds of the 3 gears in the power split planetary gear unit. The rotational speed of each gear is indicated by the distance from the 0 rpm point. Due to the structure of the power split planetary gear unit, the relationship between the rotational speeds of the 3 gears is always expressed by a straight line.
- The relationship between the gear rotation directions and the torque that acts on each gear is as described below.
  Due to the structure of this hybrid transaxle, the MG2 motive force acts on the ring gear via the motor speed reduction planetary gear unit. The illustrations of the power split planetary gear unit operation on the following pages, represent the rotational direction, rotational speed and torque condition that act on the ring gear.
- The nomographic charts and the illustrations of the power split planetary gear unit operation for each vehicle running condition shown on the following pages represent one situation as an example.

▶ Nomographic Chart ◀



▶ Power Split Planetary Gear Unit Operation ◀



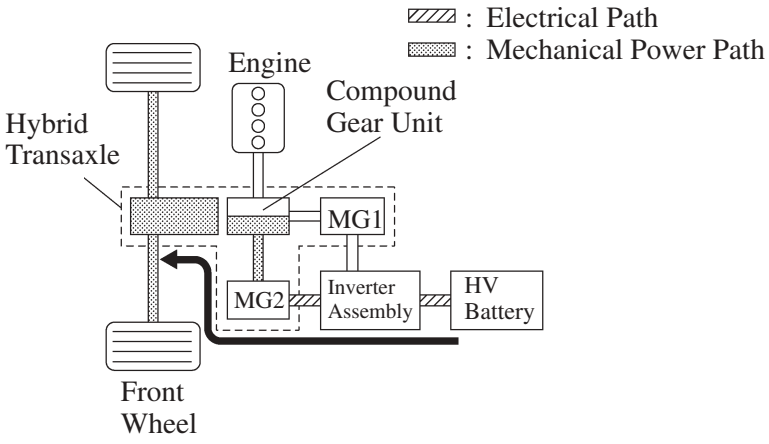
▶ Condition of Power Split Planetary Gear Unit ◀

	Sun Gear (MG1)	Carrier (Engine)	Ring Gear (Output)
Rotational Direction	+	+	+
Torque Condition	–	+	–

Normal Driving (During Low Load and Constant-speed Cruising)

3. Starting with MG2/(B)

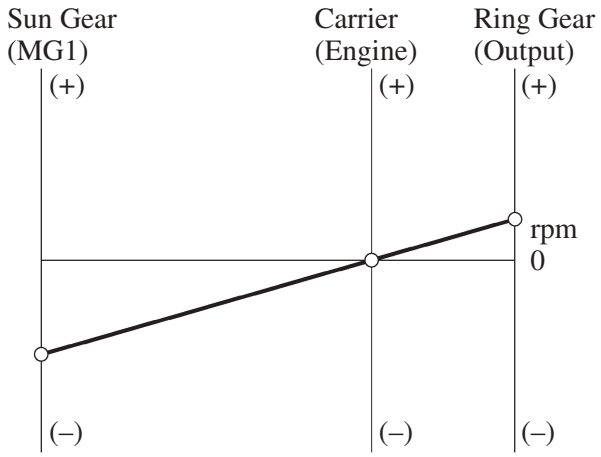
- When the vehicle is started off, the vehicle operates powered only by the MG2.



02HTH11TE

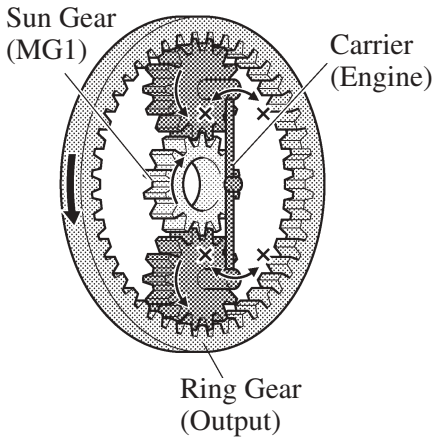
- When the vehicle starts off under normal conditions, it runs using the motive force of MG2. While running under this condition, the rotational speed of the carrier is 0 rpm due to the engine being inactive. In addition, since MG1 does not generate any torque, no torque acts on the sun gear. However, the sun gear rotates freely in the (–) direction balancing the rotating ring gear (Output).

▶ Nomographic Chart ◀



02DTH86Y

▶ Power Split Planetary Gear Unit Operation ◀



02DTH99Y

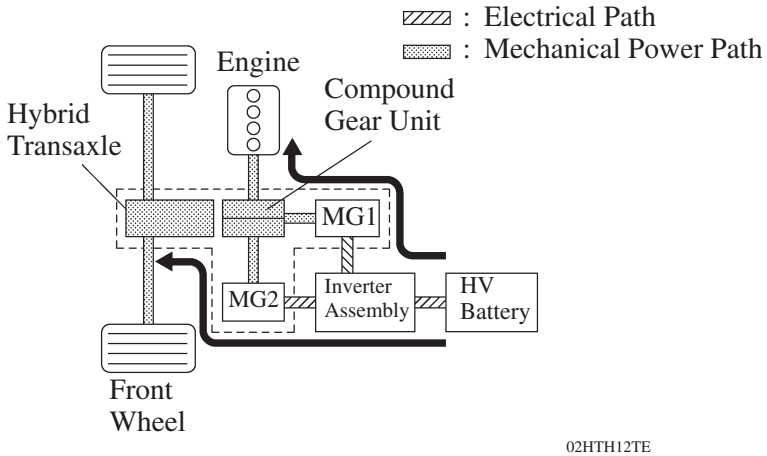
▶ Condition of Power Split Planetary Gear Unit ◀

	Sun Gear (MG1)	Carrier (Engine)	Ring Gear (Output)
Rotational Direction	–	0	+
Torque Condition	0	0	+

TH

4. Running with MG2 and Engine / (C)

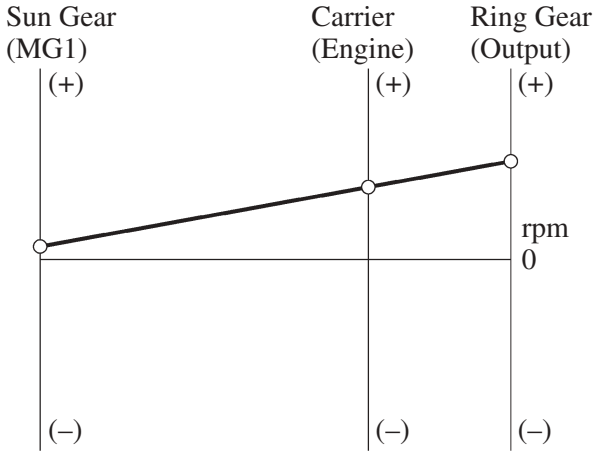
- If the required drive torque increases when running with MG2 only, MG1 is activated to start the engine. In addition, if any one of the items monitored by the THS ECU such as the SOC condition, the battery temperature, the engine coolant temperature or the electrical load condition deviates from the specified level, MG1 is activated to start the engine.



02HTH12TE

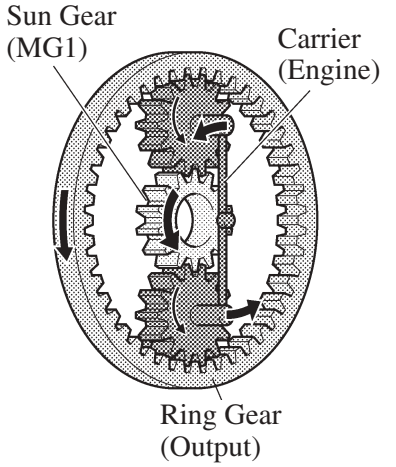
- Only when running with MG2, when the engine starts with MG1, the torque acts on the sun gear (MG1) in the (+) direction, the carrier (Engine) rotates in the (+) direction in reaction to the torque transmitted by the sun gear. The ring gear rotates in the (+) direction in reaction to the carrier rotation.
- The nomographic charts and the illustrations of the power split planetary gear unit operation for each vehicle running condition shown on the following pages represent one situation as an example.

▶ Nomographic Chart ◀



02DTH90Y

▶ Power Split Planetary Gear Unit Operation ◀



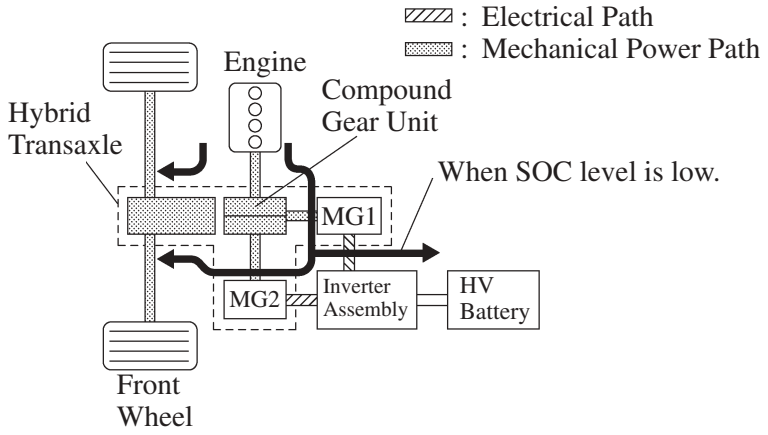
02DTH97Y

▶ Condition of Power Split Planetary Gear Unit ◀

	Sun Gear (MG1)	Carrier (Engine)	Ring Gear (Output)
Rotational Direction	+	+	+
Torque Condition	+	–	+

5. During Low Load and Constant-Speed Cruising / (D)

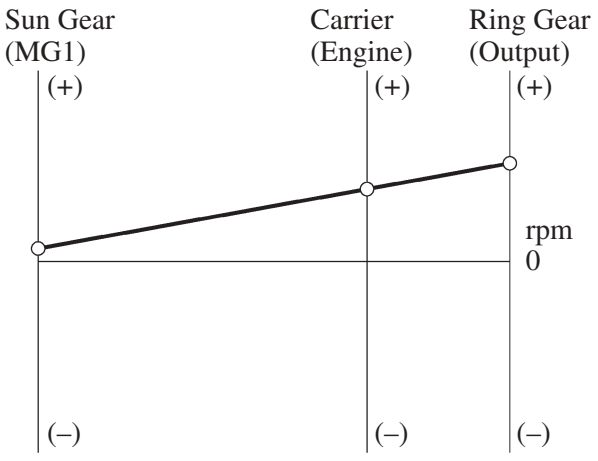
- When the vehicle is running under low load and constant-speed cruising conditions, the motive force of the engine is transmitted by the planetary gears. Some of this motive force is output directly, and the remaining motive force is used for generating electricity through MG1. Through the use of the electrical path of an inverter, this electrical power is transmitted to MG2 to be output as the motive force of MG2. If the SOC level of the HV battery is low, it is charged by MG1 driven by the engine.



02HTH14TE

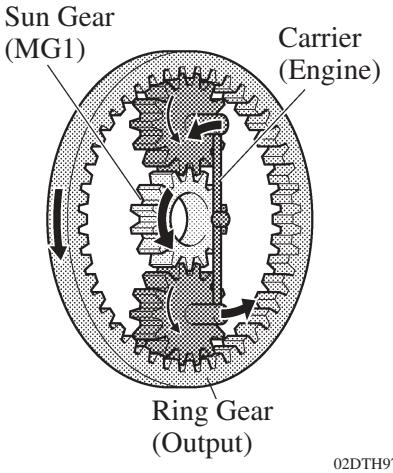
- The following represents an example of the power split planetary gear unit operation under normal driving conditions. The sun gear, carrier and ring gear rotate in the (+) direction. The torque from the engine acts on the carrier (Engine) in the (+) direction, causing the sun gear and ring gear to react in the (–) direction. MG1 generates electricity by harnessing the (–) torque that acts on the sun gear.
- The nomographic charts and the illustrations of the power split planetary gear unit operation for each vehicle running condition shown on the following pages represent one situation as an example.

▶ Nomographic Chart ◀



02DTH90Y

▶ Power Split Planetary Gear Unit Operation ◀



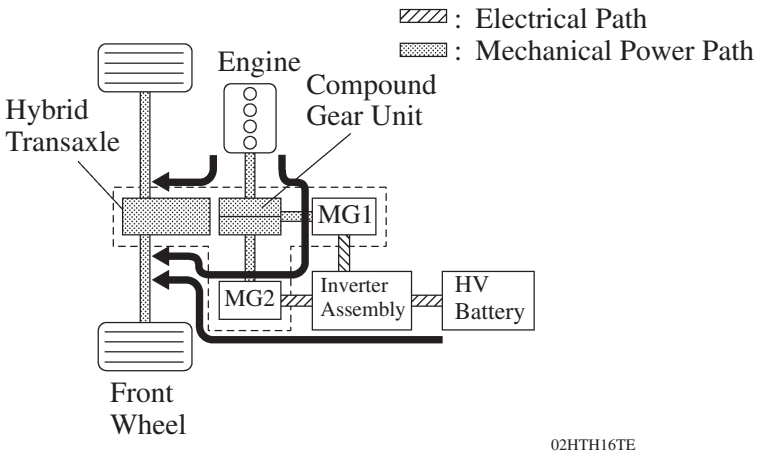
02DTH97Y

▶ Condition of Power Split Planetary Gear Unit ◀

	Sun Gear (MG1)	Carrier (Engine)	Ring Gear (Output)
Rotational Direction	+	+	+
Torque Condition	–	+	–

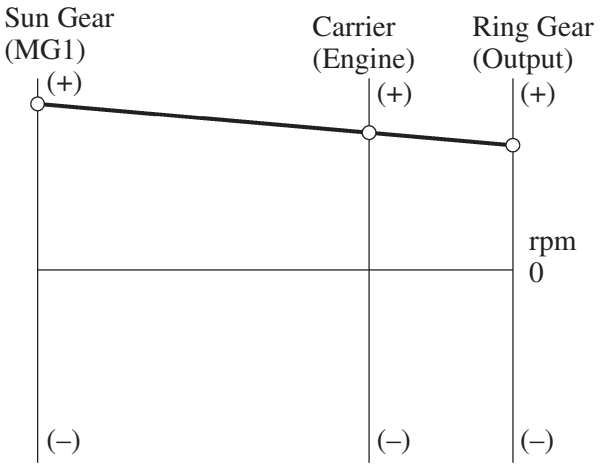
6. During Full Throttle Acceleration / (E)

- When the vehicle driving condition changes from low load cruising to full-throttle acceleration, the system supplements the motive force of MG2 with electrical power from the HV battery.

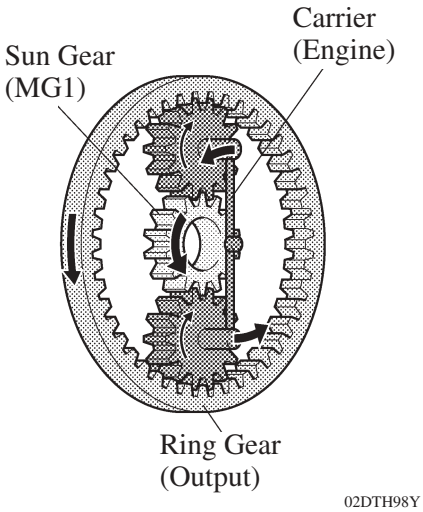


- When more engine power is required, in order to increase the engine speed, the rotation speeds of the related gears change as follows. The directions in which the torque acts on each gear are the same as those described in “During Low Load and Constant-speed Cruising”.

▶ Nomographic Chart ◀



▶ Power Split Planetary Gear Unit Operation ◀



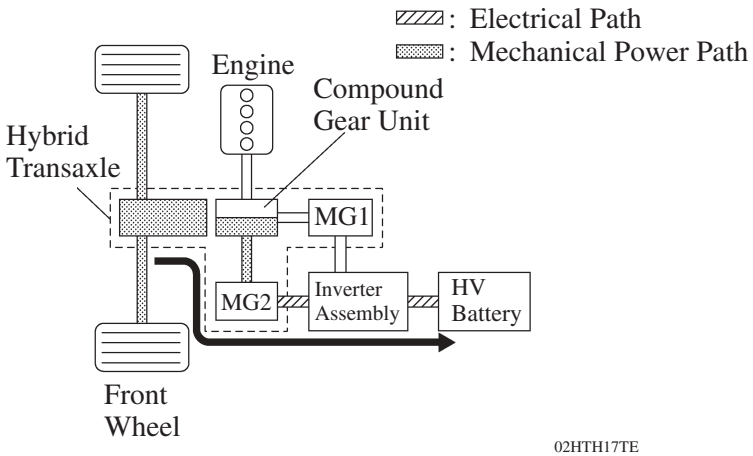
▶ Condition of Power Split Planetary Gear Unit ◀

	Sun Gear (MG1)	Carrier (Engine)	Ring Gear (Output)
Rotational Direction	+	+	+
Torque Condition	–	+	+

7. During Deceleration Driving / (F)

Deceleration in "D" Range

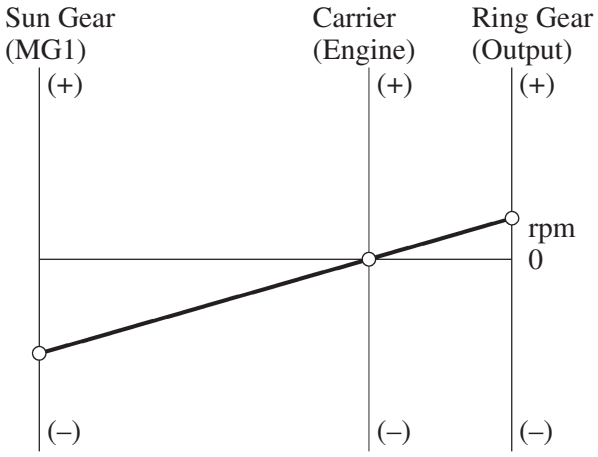
- While the vehicle is decelerated with the shift lever in the D position, the engine is turned OFF and the motive force changes to zero. At this time, the wheels drive MG2, causing MG2 to operate as a generator, charging the HV batteries.
- If the vehicle decelerates from a higher speed, the engine maintains a predetermined speed without stopping, in order to protect the planetary gear unit.



02HTH17TE

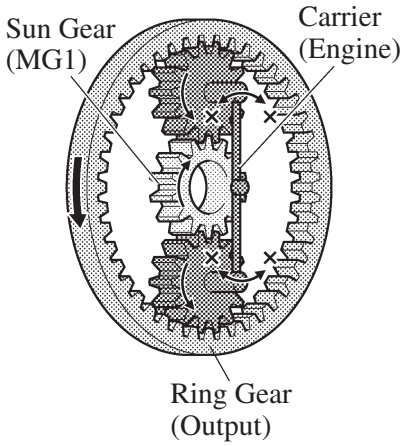
- During deceleration, the ring gear is rotated by the rear wheels. Under this condition, due to the engine being inactive, the rotational speed of the carrier is 0 rpm. In addition, since MG1 does not generate any torque, no torque acts on the sun gear. However, the sun gear (MG1) rotates freely in the (–) direction balancing the rotating ring gear (Output).

▶ Nomographic Chart ◀



02DTH86Y

▶ Power Split Planetary Gear Unit Operation ◀



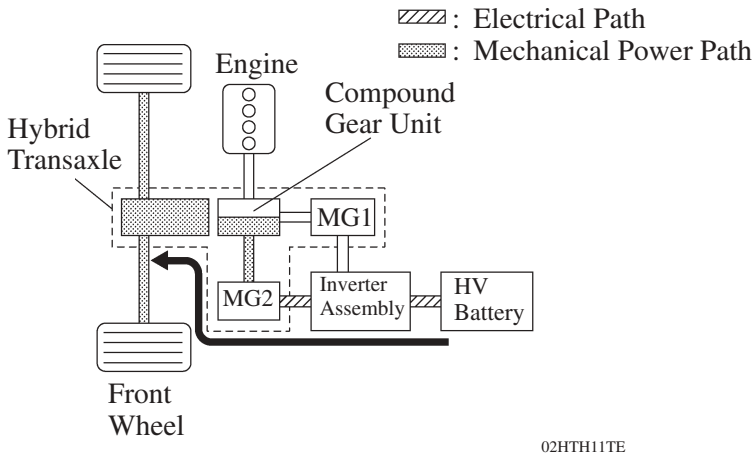
02DTH99Y

▶ Condition of Power Split Planetary Gear Unit ◀

	Sun Gear (MG1)	Carrier (Engine)	Ring Gear (Output)
Rotational Direction	–	0	+
Torque Condition	0	0	0

8. During Reverse Driving / (G)

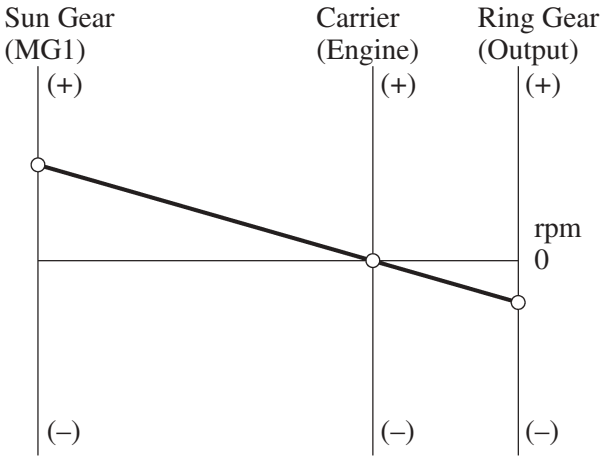
- When the vehicle is being driven in reverse, the required power is supplied by MG2. At this time, MG2 rotates in the opposite direction, the engine remains stopped, and MG1 rotates in the normal direction without generating any electricity.
- During reverse driving, when any of the SOC condition, battery temperature, engine coolant temperature and electrical load condition reaches a specified level, the engine may start. The following illustration represents the condition when the engine is not running.



02HTH11TE

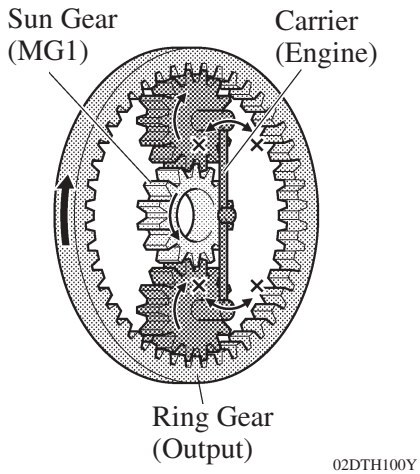
- The conditions of the planetary gear are opposite to those described in "Starting and Running with MG2". Due to the engine being inactive, the rotational speed of the carrier is 0 rpm but the sun gear (MG1) rotates freely in the (+) direction balancing the rotating ring gear (Output).

▶ Nomographic Chart ◀



02DTH94Y

▶ Power Split Planetary Gear Unit Operation ◀



02DTH100Y

▶ Condition of Power Split Planetary Gear Unit ◀

	Sun Gear (MG1)	Carrier (Engine)	Ring Gear (Output)
Rotational Direction	+	0	–
Torque Condition	0	0	–