■THS II CONTROL SYSTEM

1. General

The THS II control system contains the following components.

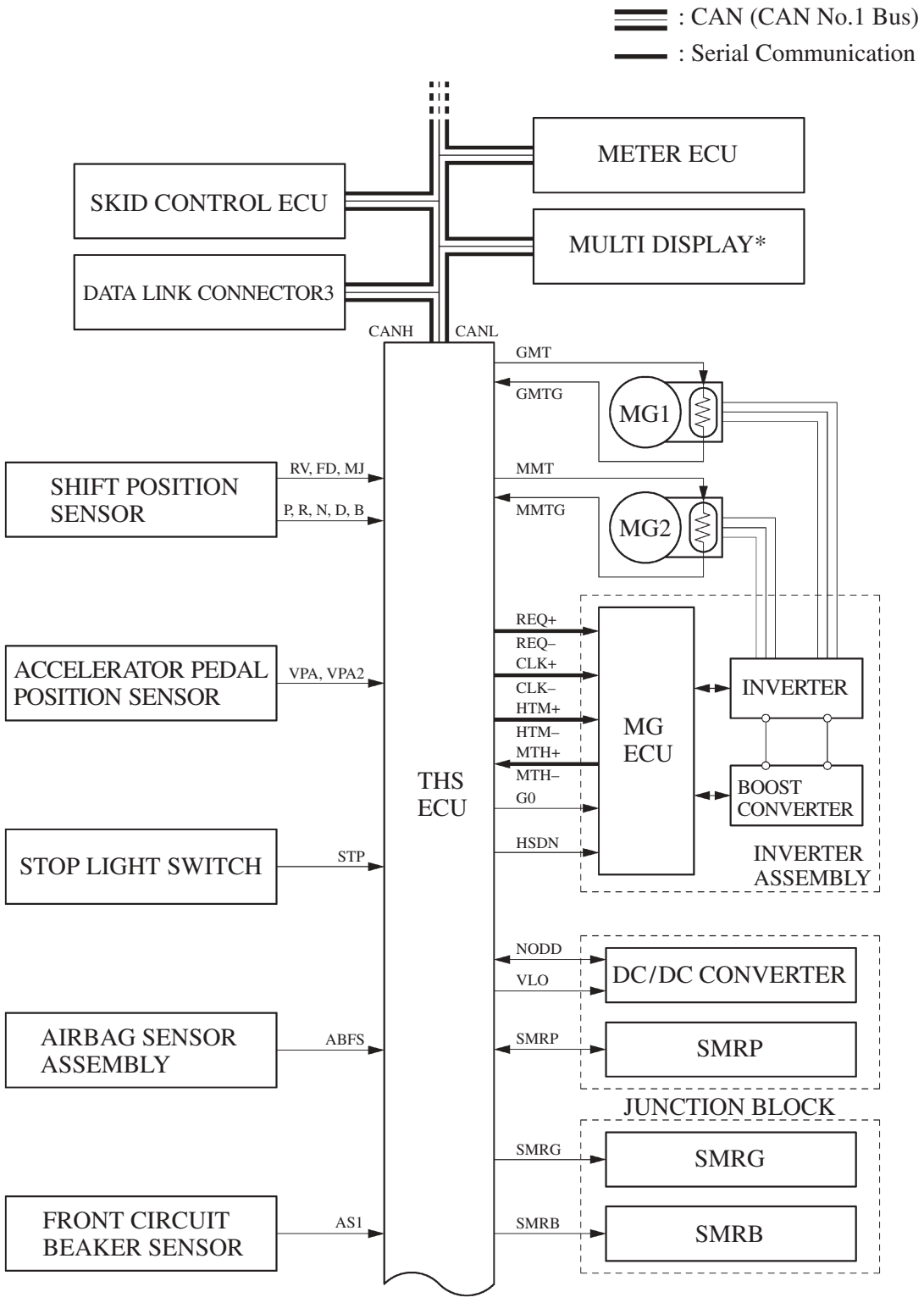
Item	Outline
THS ECU Control (See page TH-40)	● The THS ECU calculates the target motive force based on the shift position, the degree to which the accelerator pedal is depressed, and the vehicle speed. It effects control in order to create the target motive force by optimally combining the power of MG1, MG2, and the engine. ● The THS ECU calculates the engine motive force based on the target motive force, which has been calculated based on the requirements of the driver and the conditions of the vehicle. In order to create this motive force, the THS ECU appropriately controls the ETCS-i (Electronic Throttle Control System-intelligent) system, fuel injection volume, injection timing, and VVT-i (Variable Valve Timing-intelligent) system. ● The THS ECU monitors the SOC of the HV battery and the temperature of the HV battery, MG1, and MG2, in order to optimally control these items. ● The THS ECU effects monitor control to monitor the conditions of the HV batteries and cooling fan control to keep the HV battery and DC/DC converter at a predetermined temperature. Thus, it optimally controls these components. ● When the shift lever is in the N position, the THS ECU effects shut down control to electrically stop MG1 and MG2. ● For the purpose of protecting the circuit from high voltages and ensuring the reliability of the circuit shut down, the THS ECU effects SMR control through the use of 3 relays to connect and shut down the high-voltage circuit. ● The THS ECU calculates the SOC by estimating the charging and discharging amperage of the HV battery, in order to effect condition control. ● The THS ECU uses the temperature sensors that are provided on the HV battery module to monitor the temperature of the HV battery module and controls its temperature by optimally controlling the dedicated cooling fan. ● The THS ECU controls the DC/DC converter in accordance with the temperature of the auxiliary battery, in order to control the charging of the auxiliary battery.
MG1 and MG2 Main Control (See page TH-47)	● MG1, which is driven by the engine, generates a high voltage (alternating current) in order to operate MG2 and charge the HV battery. It Also functions as a starter to start the engine. ● MG2, which is driven by electrical power from MG1 or the HV battery, generates a motive force for the front wheels. ● MG2 generates electricity to charge the HV battery (regenerative brake control) during braking, and when the accelerator pedal is not being depressed. ● Speed sensors (resolvers) detect the speeds and the rotor positions of MG1 and MG2, and output them to the THS ECU via the MG ECU. ● Temperature sensors mounted on MG1 and MG2 detect the temperatures and transmit them to the THS ECU.

(Continued)

Item		Outline
Inverter Assembly Control (See page TH-49)		● The inverter converts the direct current from the HV battery into an alternating current for MG1 and MG2, or vice versa, in accordance with the signals provided by the THS ECU via the MG ECU. In addition, the inverter supplies the alternating current from the MG1 power to MG2. ● Via the MG ECU, the THS ECU sends the signal to the power transistor in the inverter to switch between the U, V, and W phases of MG1 and MG2, in order to drive MG1 and MG2. ● The THS ECU shuts down if it receives an overheating, over-current, or fault voltage signal from the inverter.
	Boost Converter Control	● The boost converter boosts the HV battery nominal voltage of DC 244.8 V up to a maximum voltage of DC 650 V, in accordance with the signals provided by the THS ECU via the MG ECU. ● The inverter converts the alternating current generated by MG1 or MG2 into a direct current. The boost converter reduces the DC 650 V to DC 244.8 V (for the HV battery) in accordance with the signals provided by the THS ECU via the MG ECU.
DC/DC Converter Control		● The DC/DC converter reduces the nominal voltage of DC 244.8 V to DC 12 V in order to supply electricity to the body electrical components, as well as to recharge the auxiliary battery (DC 12 V). ● This converter controls the voltage of the auxiliary battery to keep it constant.
Skid Control ECU Control (See page TH-52)		During braking, the skid control ECU calculates the required regenerative brake force and transmits it to the THS ECU. Upon receiving this signal, the THS ECU transmits the actual regenerative brake control value to the skid control ECU. Based on this result, the skid control ECU calculates and executes the required hydraulic pressure brake force.
Battery Control (See page TH-53)		The battery smart unit monitors the voltage, current and temperature of the HV battery module and the voltage of the cooling fan, and transmits them to the THS ECU.
Shift Control (See page CH-12)		The THS ECU detects the shift position (P, R, N, D, or B) in accordance with the signal provided by the shift position sensor, and controls MG1, MG2, and the engine, in order to create the driving conditions that suit the selected shift position.
During Collision Control (See page TH-54)		During a collision, if the THS ECU receives an airbag deployment signal from the airbag sensor assembly or an actuation signal from the circuit breaker sensor located in the inverter, it turns OFF the SMR (System Main Relay), in order to shut off the entire power supply.
Cruise Control System Operation Control		When the cruise control ECU that is enclosed in the THS ECU receives a cruise control switch signal, it optimally regulates the engine, MG1 and MG2 in order to obtain the target vehicle speed, as determined through the driver control, from the combination of their motive forces.
Indicator and Warning Light Illumination Control (See page TH-55)		The THS ECU informs the driver about the vehicle conditions and any system malfunctions by illuminating or blinking the indicator lights and warning lights located in the combination meter and using the warning indication of the multi-information display or the radio and player with display.
Diagnosis (See page TH-58)		When the THS ECU detects a malfunction, it performs a diagnosis and stores the values relating to the failure.
Fail-Safe (See page TH-58)		When the THS ECU detects a malfunction, the THS ECU stops or controls the actuators and other ECUs in accordance with the data already stored in the memory.

2. Construction

The configuration of the THS II control system in the ’07 Camry Hybrid model is shown in the following chart.



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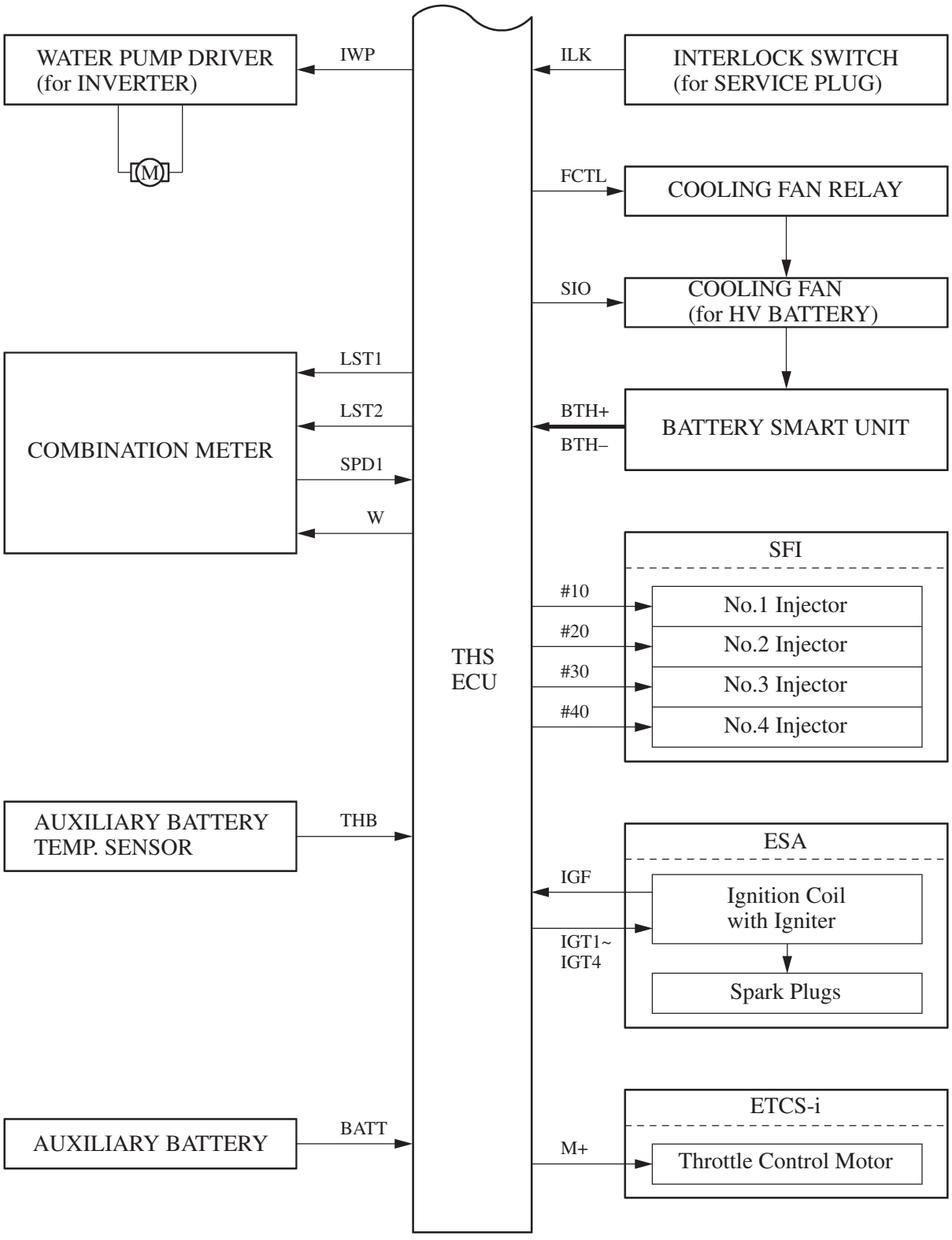
02HTH34TE


WATER PUMP DRIVER
(for INVERTER)
IWP
M
INTERLOCK SWITCH
(for SERVICE PLUG)
ILK
FCTL
COOLING FAN RELAY
SIO
COOLING FAN
(for HV BATTERY)
BATTERY SMART UNIT
BTH+
BTH–
COMBINATION METER
LST1
LST2
SPD1
W
SFI
#10
#20
#30
#40
No.1 Injector
No.2 Injector
No.3 Injector
No.4 Injector
THS
ECU
AUXILIARY BATTERY
TEMP. SENSOR
THB
ESA
IGF
IGT1~
IGT4
Ignition Coil
with Igniter
Spark Plugs
AUXILIARY BATTERY
BATT
ETCS-i
M+
Throttle Control Motor
02HTH35TE

TH

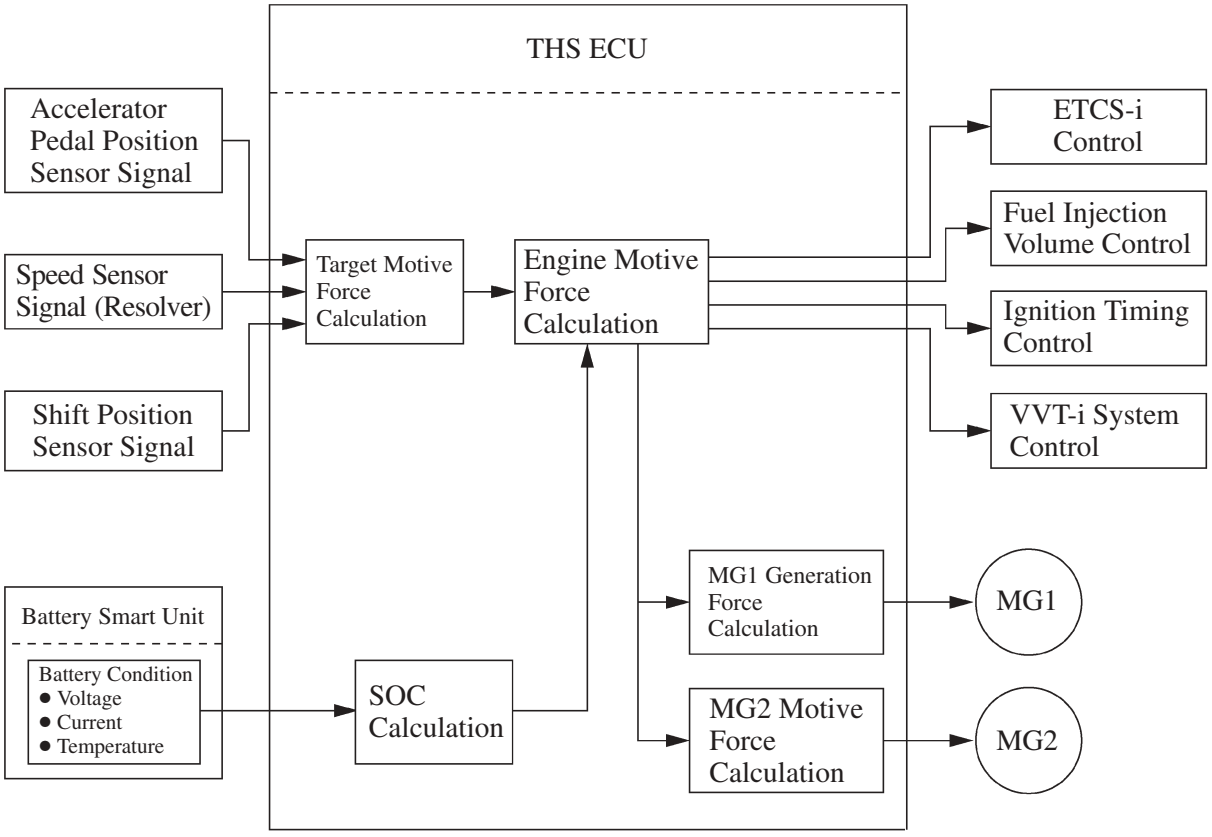
3. THS ECU Control

General

- The THS ECU detects the amount of effort applied to the accelerator pedal in accordance with the signals provided by the accelerator pedal position sensor. The THS ECU receives signals from the speed sensor (resolver) in the MG1 and MG2, and detects the shift position signal from the shift position sensor. The THS ECU determines the driving conditions of the vehicle in accordance with these pieces of information, and optimally controls the motive forces of MG1, MG2, and the engine. Furthermore, the THS ECU optimally controls the output and torque of these motive forces in order to realize lower fuel consumption and cleaner exhaust emissions.
- The THS ECU calculates the engine motive force based on the calculated target motive force, and by taking the SOC and the temperature of the HV battery module into consideration. The value obtained by subtracting the engine motive force from the target motive force is the MG2 motive force.
- The THS ECU realizes the required engine motive force by properly effecting ETCS-i control, fuel injection volume control, injection timing control, and VVT-i system control. Furthermore, the THS ECU appropriately operates MG1 and MG2 in order to realize the required MG2 motive force.

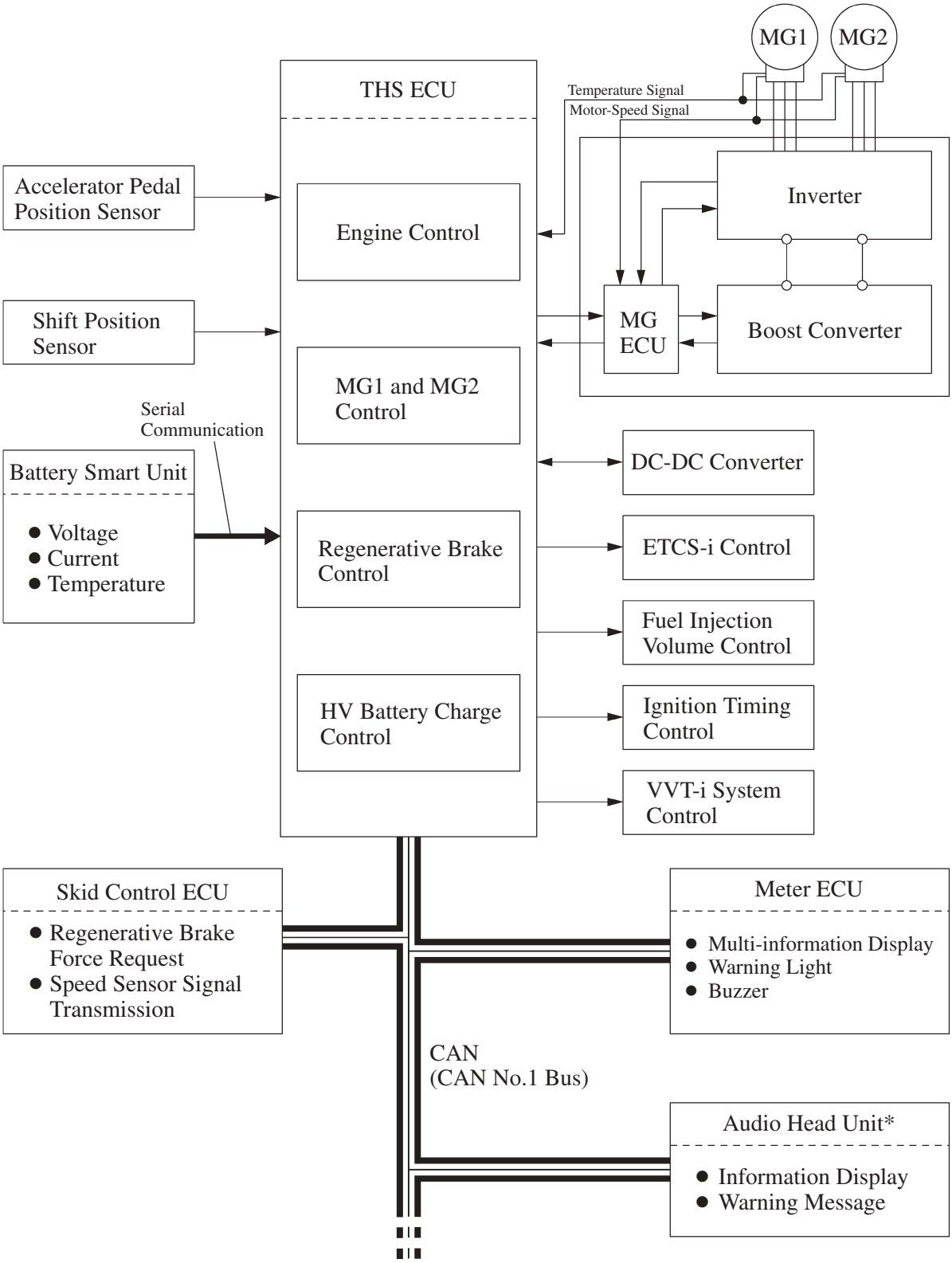
▶ Flow of Motive Force Calculation ◀

(Target Motive Force) – (Engine Motive Force) = (MG2 Motive Force)



277TH65

▶ System Diagram ◀



02HTH36Y

*: Optional equipment

TH

System Monitoring Control

- The THS ECU constantly monitors the SOC (state of charge) of the HV battery. When the SOC is below the lower level, the THS ECU increases the power output of the engine to operate MG1, which charges the HV battery. When the engine is stopped, MG1 operates to start the engine, then the engine operates MG1 to charge the HV battery.
- If the SOC is low, or the temperature of the HV battery module, MG1 or MG2 is higher than the specified value, the THS ECU restricts the motive force applied to the drive wheels until it is restored to the normal value.

Shut Down Control

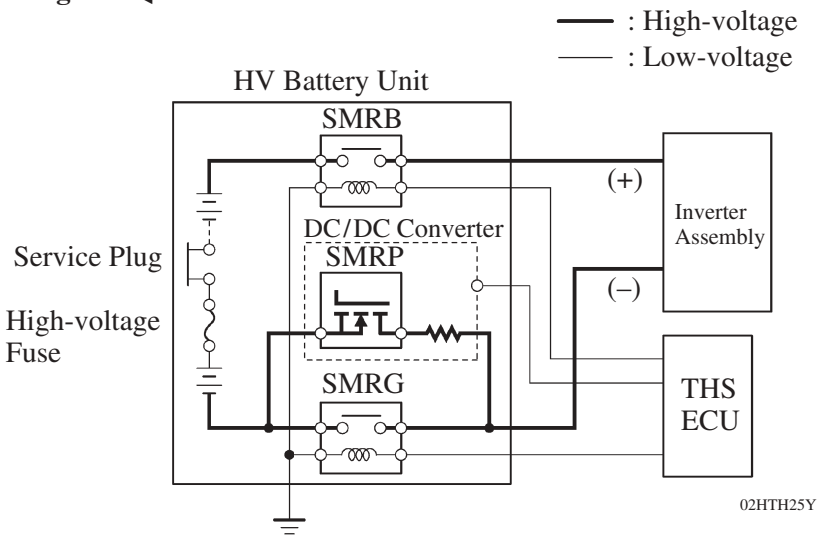
The MG1 and MG2 are shut down when the shift position is in the N position. This is because MG1 and MG2 must be stopped electrically as a means of shutting down the motive force, since MG2 is mechanically joined to the front wheels.

SMR (System Main Relay) Control

1) General

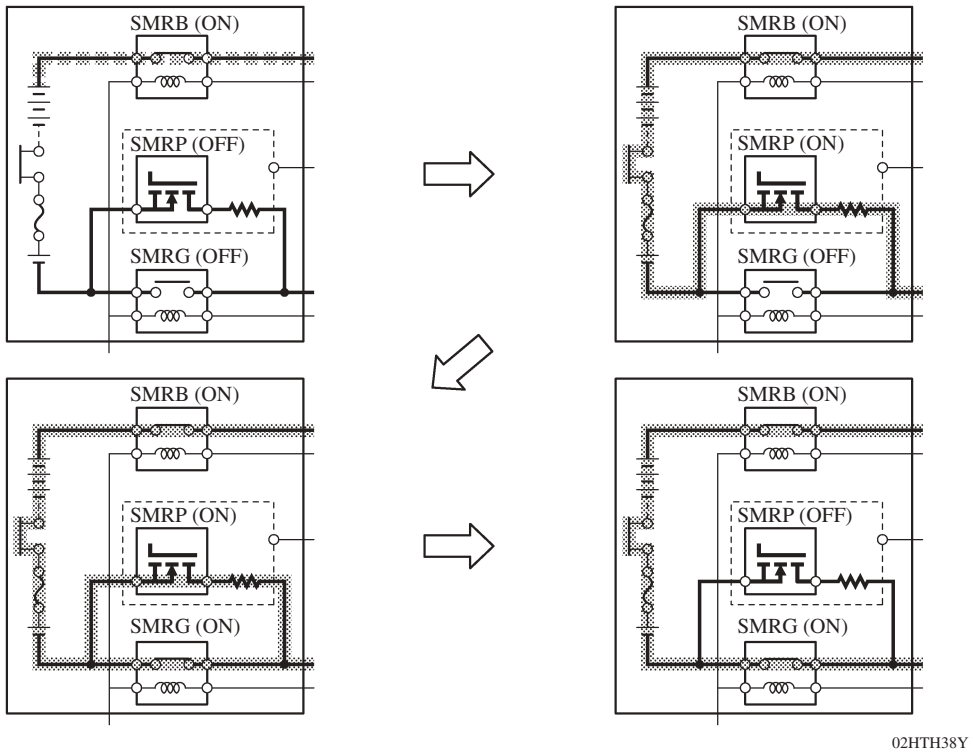
The SMR is a relay that connects and disconnects the power source of the high-voltage circuit upon receiving a command from the THS ECU.
A total of three relays are used: one (SMRB) at the positive side, and two (SMRP and SMRG) at the negative side. One (SMRP) of the relays at the negative side is a semiconductor relay, which is integrated in the DC/DC converter. The other two are contact point type relays, which are mounted on the junction box in the HV battery module.

▶ System Diagram ◀



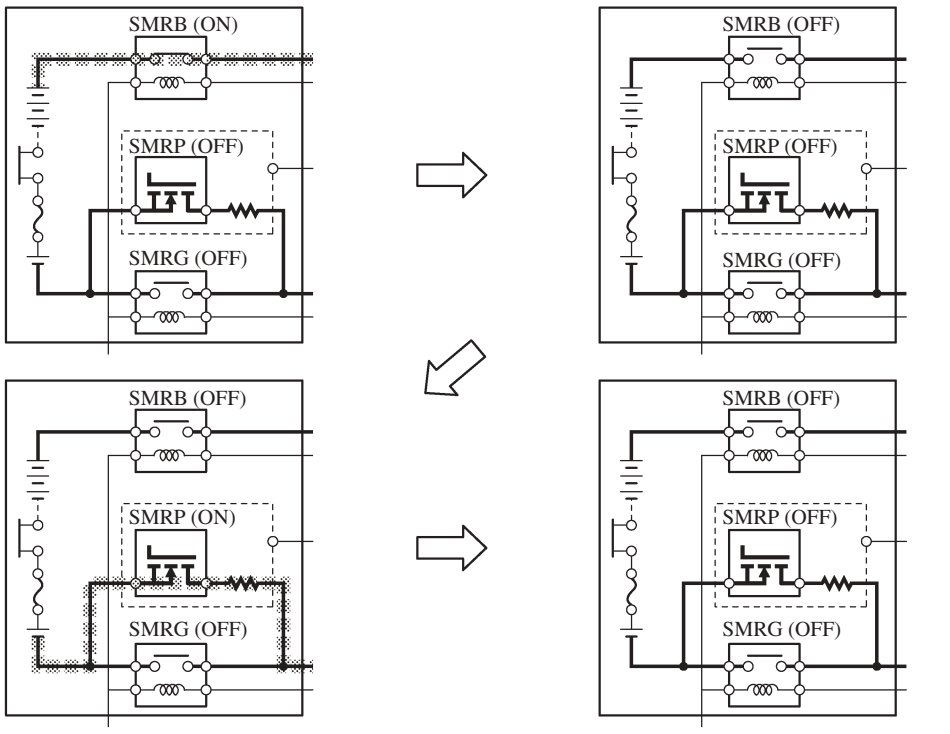
2) Power is ON

The THS ECU turns the SMRB ON. After that, it turns the SMRP ON.
After the THS ECU has turned the SMRG ON, it turns the SMRP OFF.
As the controlled current is initially allowed to pass through a resistor in this manner, the contact point in the circuit is protected from damage that could be caused by a rush current.



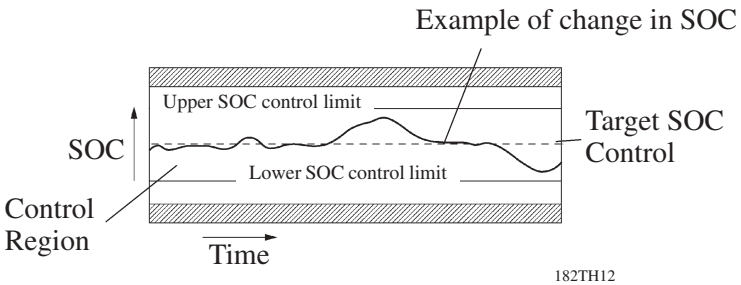
3) Power is OFF

- First, the THS ECU turns the SMRG OFF. After it has determined whether the contact points of the SMRG are stuck, it turns the SMRB OFF.
- Afterwards, the THS ECU turns the SMRP ON in order to determine whether the contact points of the SMRB are stuck. Then, it turns the SMRP OFF.
- If the THS ECU detects that the contact points are stuck, it illuminates the master warning light and indicates “CHECK HYBRID SYSTEM” on the multi-information display, and stores a DTC (Diagnostic Trouble Code) in memory.



SOC Control

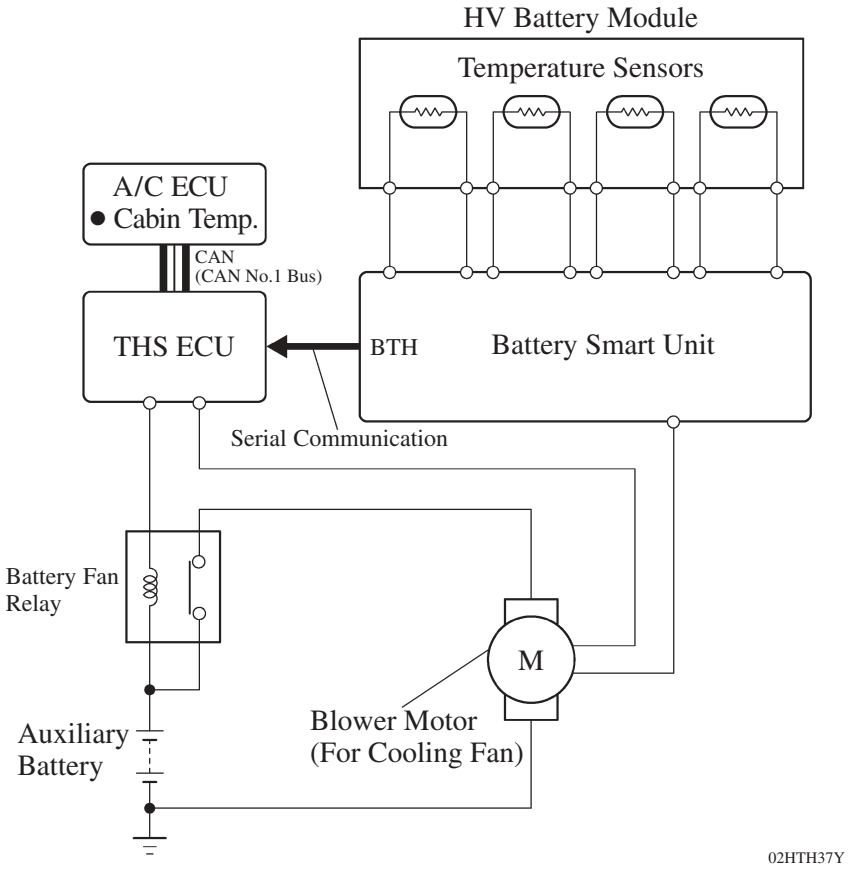
- The THS ECU calculates the SOC (state of charge) of the HV battery by estimating its charging and discharging amperages, in order to effect condition control.
- While the vehicle is in motion, the HV battery undergoes repetitive charging/discharging cycles, as it becomes discharged by the MG2 during acceleration and charged by the regenerative brake during deceleration. The THS ECU calculates the SOC based on charging/discharging levels detected by the current sensor. The THS ECU performs the charging/discharging control based on the calculated value in order to steady the SOC at its target level anytime.



Cooling Fan Control for HV Battery

- The THS ECU monitors rises in the battery temperature through the four temperature sensors in the HV battery module. Then, the THS ECU steplessly actuates the cooling fan under duty cycle control, in order to maintain the temperature of the HV battery module within the specified range.
- While the air conditioning system is operating to cool the cabin, if the HV battery module temperature is within a normal range, the THS ECU turns the battery cooling fan OFF or changes the fan speed to low speed. The purpose of this control is to give priority to cooling down the cabin, which also provides cooling to the battery module through the intake duct located on the center of the rear package tray trim.

▶ System Diagram ◀

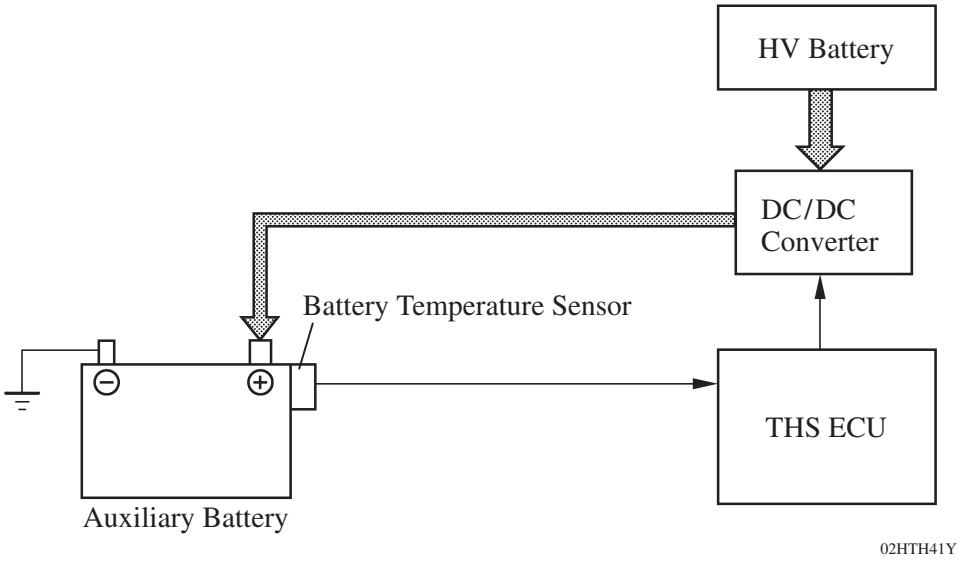


Auxiliary Battery Charging Control

1) General

The THS ECU controls the DC/DC converter in accordance with the signals from the battery temperature sensor of the auxiliary battery, in order to control the charging voltage to the auxiliary battery.

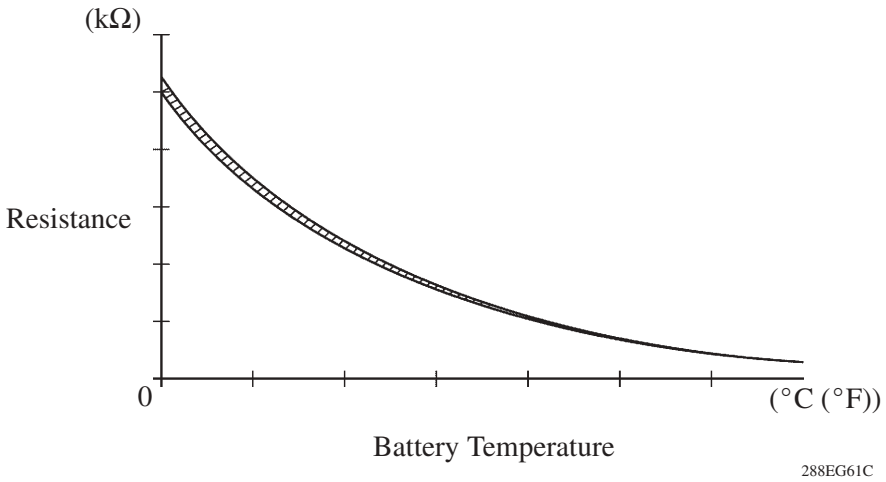
▶ System Diagram ◀



2) Battery Temperature Sensor

The battery temperaturesensor is installed on the battery.
The battery characteristic (battery internal resistance) of taking in current for charging varies according to battery electrolyte temperature. If the electrolyte temperature is too low, the battery internal resistance will increase, resulting in early deterioration. To prevent this, the battery temperature sensor changes its resistance as shown below to detect the temperature.

▶ Characteristic of Battery Temperature Sensor ◀



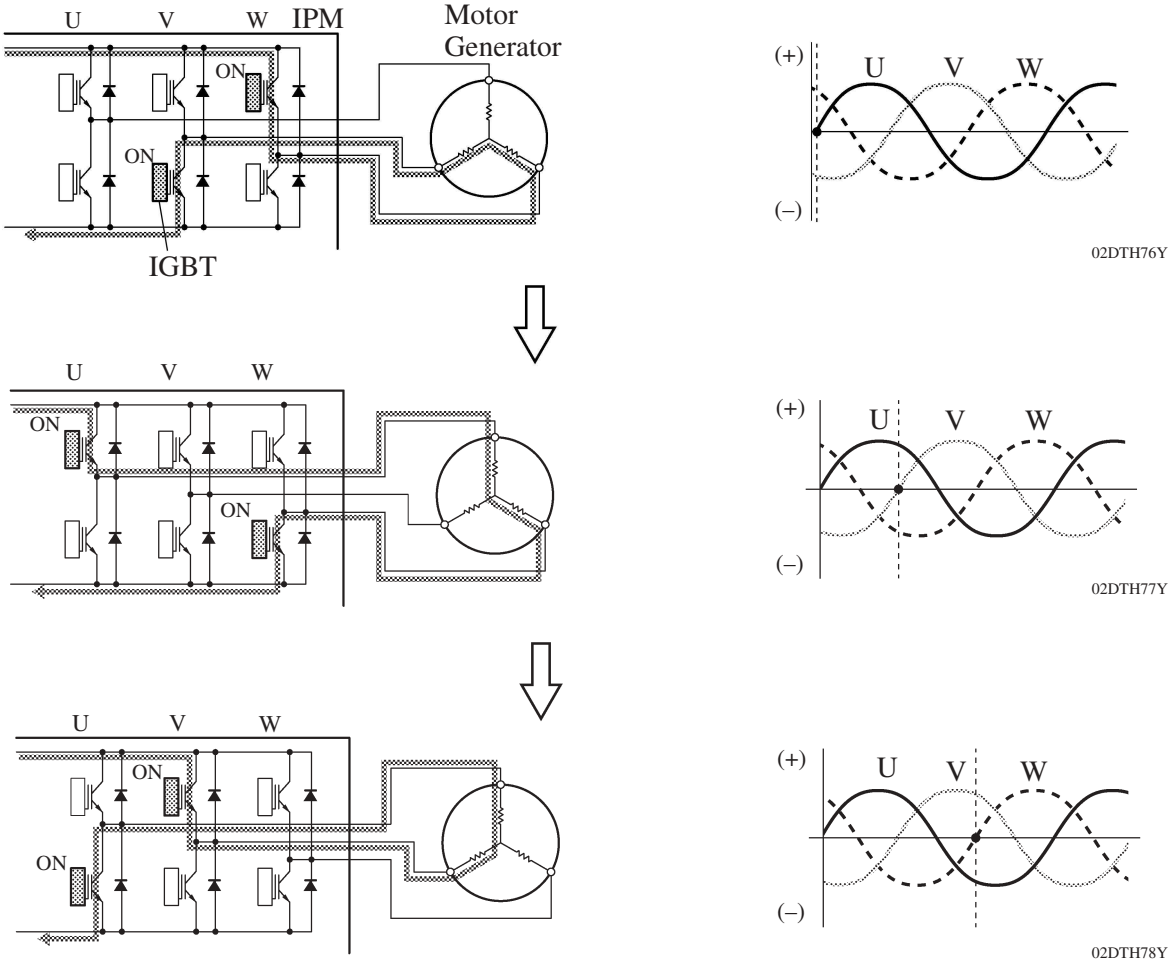
4. MG1 and MG2 Main Control

General

- MG1, which is rotated by the engine, generates high voltage (alternating current) in order to operate MG2 and charge the HV battery. Also, it functions as a starter to start the engine.
- MG2 is driven by electrical power from MG1 or HV battery, and generates motive force for the front wheels.
- MG2 generate electricity to charge the HV battery (regenerative brake control) during braking, or when the accelerator pedal is not being depressed.
- The MG ECU, which follows the commands of the THS ECU, controls MG1 and MG2 via the IPM (Intelligent Power Module), for driving the vehicle. Six IGBTs (Insulated Gate Bipolar Transistors) switch ON and OFF to control the individual motors in accordance with the driving or generation operation.

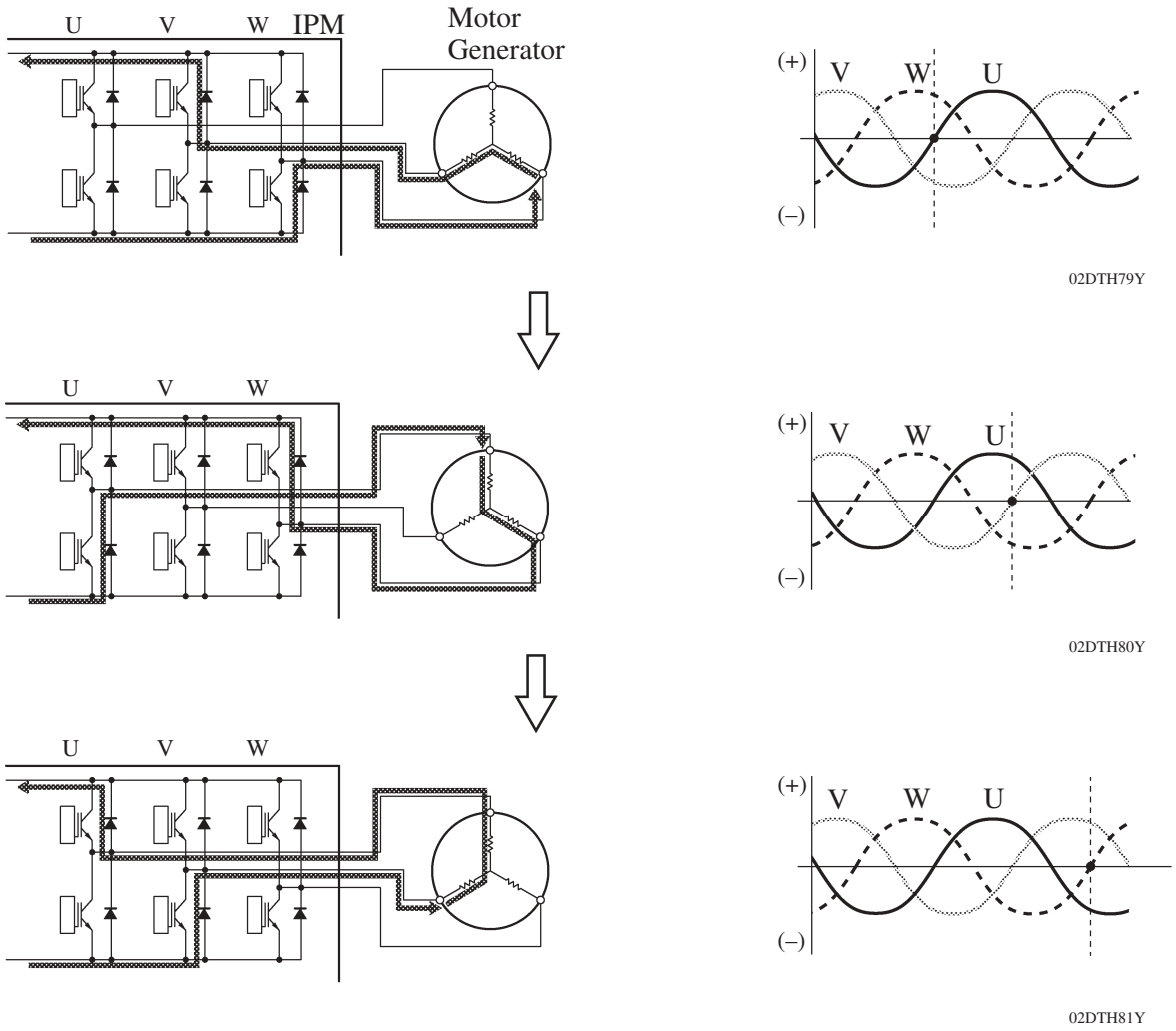
Motor Drive Operation

- The illustration below describes the basic control for driving a motor. The IGBTs (Insulated Gate Bipolar Transistors) in the IPM switch ON and OFF to supply a three-phase alternating current to the motor.
- In order to create the motive force required of the motor generator as calculated by the THS ECU, the MG ECU switches the IGBTs ON and OFF and controls the speed, in order to control the speed of the motor generator.



Motor Generation Operation

The illustration below describes the basic control for the motor to generate electricity. The current that is generated sequentially by the three phases of the motor, which is driven by the wheels, is utilized to charge the HV battery or drive another motor generator.

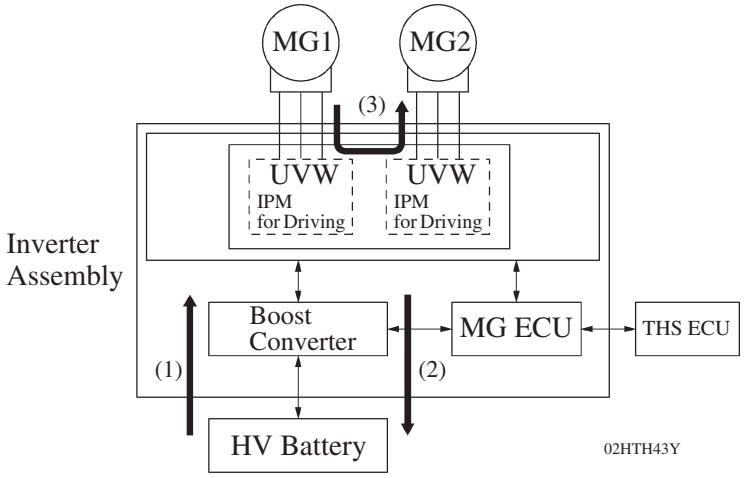


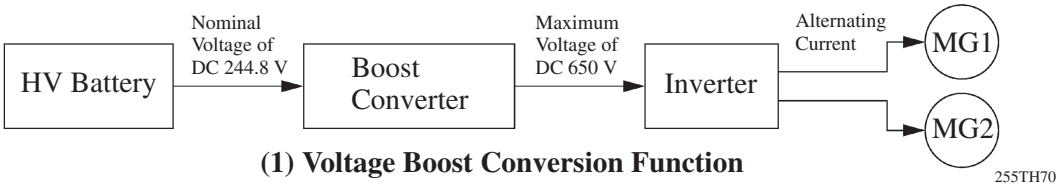
5. Inverter Assembly Control

General

- The inverter converts the direct current from the HV battery into an alternating current for MG1 and MG2, or vice versa, in accordance with the signals provided by the THS ECU via the MG ECU. In addition, the inverter supplies the alternating current from the MG1 power to the alternating current for MG2. However, the electricity that is supplied by MG1 to MG2 is converted into DC inside the inverter.
- Via the MG ECU, the THS ECU transmits a signal to the power transistor in the inverter for switching the U, V, and W phases of stator coil of MG1 and MG2 based on the rotor position information sent by MG1 and MG2, and the SOC of the HV battery sent by the battery smart unit.
- When the shift lever is in the N position, or the THS ECU has received an over-heating, over-current, or fault voltage signal from the inverter, the THS ECU transmits a shut down control signal to the inverter, in order to disengage the electrical connection to MG1 and MG2.

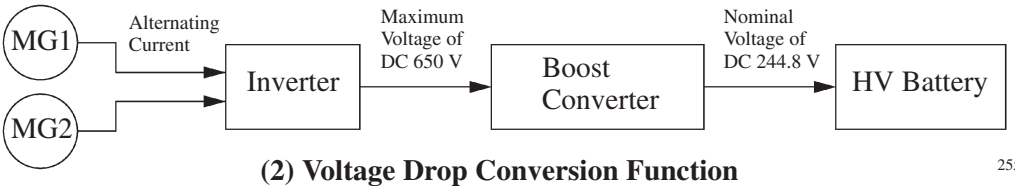
▶ System Diagram ◀





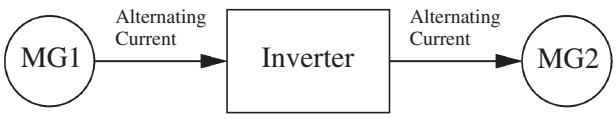
(1) Voltage Boost Conversion Function

255TH70



(2) Voltage Drop Conversion Function

255TH71



(3) Electrical Power Supply Function

255TH72

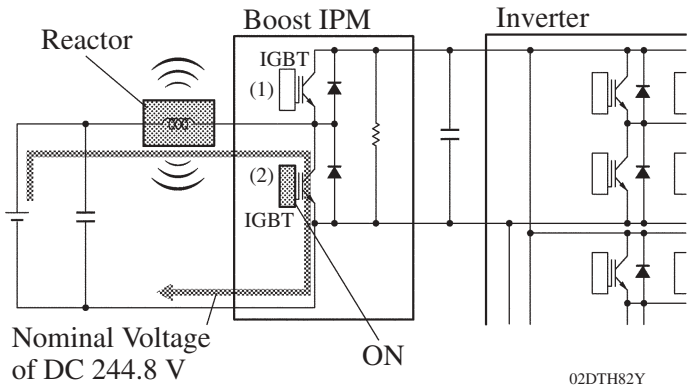
Boost Converter Control

1) General

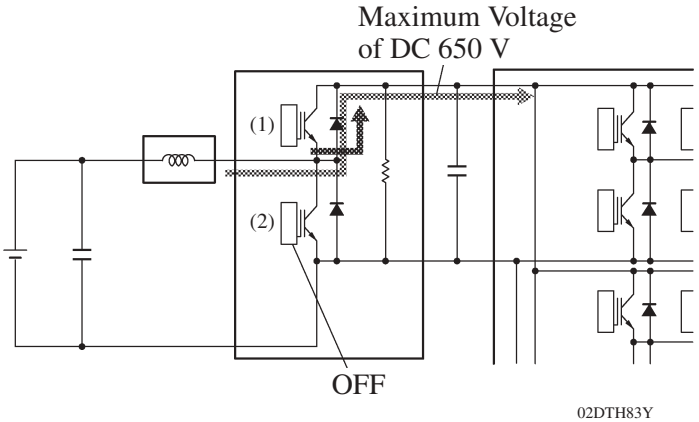
- The boost converter boosts the nominal voltage of DC 244.8 V (for the HV battery) up to a maximum voltage of DC 650 V, in accordance with the signals provided by the THS ECU via the MG ECU.
- The inverter converts the alternating current generated by MG1 or MG2 into a direct current. The boost converter drops the maximum voltage of DC 650 V to nominal voltage of DC 244.8 V (for the HV battery) in accordance with the signals provided by the THS ECU via the MG ECU.
- The boost converter consists of a boost IPM (Intelligent Power Module) with built-in IGBTs (Insulated Gate Bipolar Transistors) that effect switching control, and a reactor that stores (and charges) electrical power.

2) Voltage Boost Conversion Function

- The function of the boost converter to boost the nominal voltage of the HV battery from DC 244.8 V to maximum voltage of DC 650 V flows as described below.
- The IGBT (2) turns ON, causing the electrical power of the HV battery (nominal voltage of DC 244.8 V) to charge the reactor. As a result, the voltage in the reactor rises.

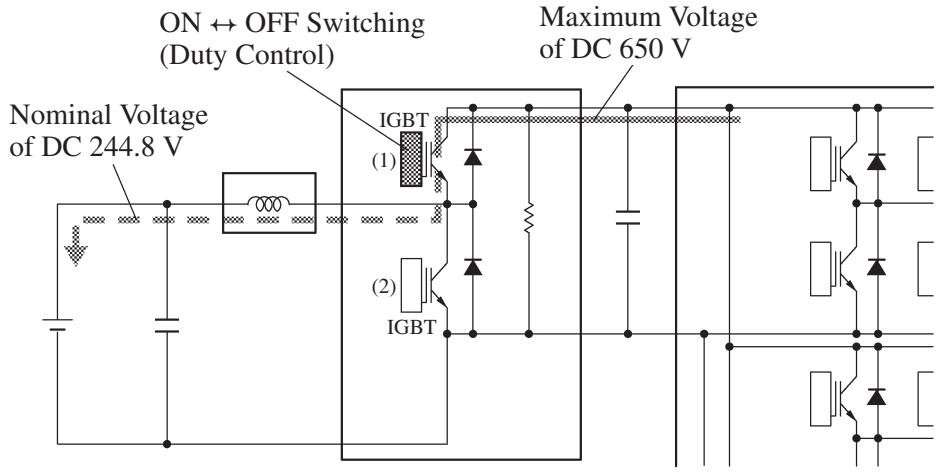


- In the next stage, when the voltage in the reactor rises to maximum voltage of DC 650 V, the IGBT (2) turns OFF, causing a counter electromotive force to be created.
- Induced by the counter electromotive force that is created, the electrical power (maximum voltage of DC 650 V) that is charging the reactor flows into the inverter.



3) Voltage Drop Conversion Function

The alternating current, which is generated by MG1 or MG2 for the purpose of charging the HV battery, is converted into maximum voltage of DC 650 V by the inverter. Then, a function of the boost converter drops the voltage to nominal voltage of DC 244.8 V. This is accomplished by the IGBT (1) switching ON and OFF through duty cycle control, which intermittently interrupts the electrical power provided by the inverter.

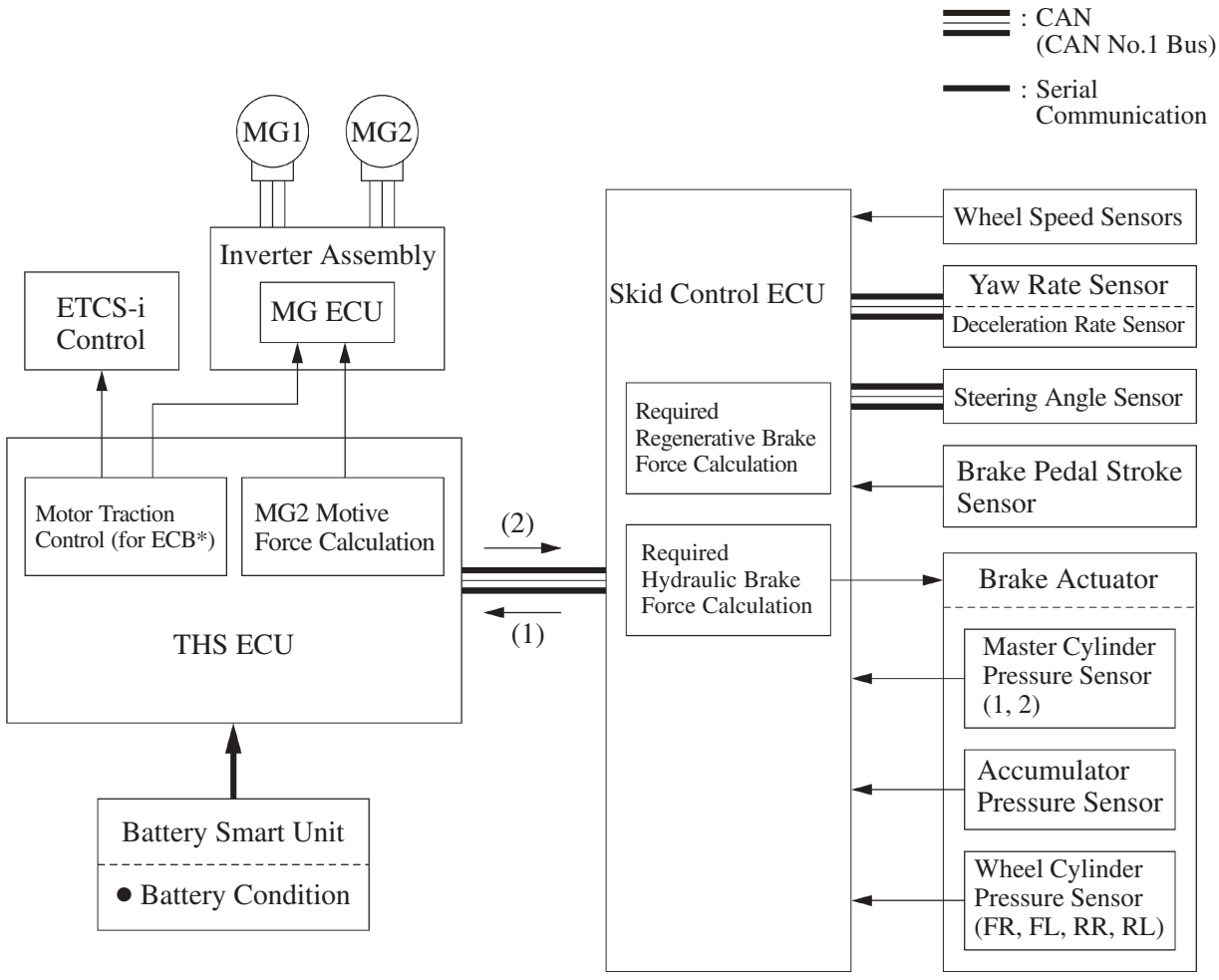


02DTH74Y

6. Skid Control ECU Control

- The skid control ECU calculates the total braking force needed, based on the master cylinder pressure in the brake actuator and brake pedal stroke sensor generated when the driver depresses the brake pedal.
- The skid control ECU computes a part for the required regeneration brake force from the total braking force, and sends the result to the THS ECU.
- The THS ECU executes to the minus torque to MG2, and carries out the regenerative brake functions. The skid control ECU controls the brake actuator solenoid valves and generates the wheel cylinder pressure, which is the actual regenerative brake control value subtracted from the total braking force.
- The skid control ECU outputs a request to the THS ECU to effect motor traction control while the vehicle is operating under TRAC or VSC function control. The THS ECU controls the engine, MG1, and MG2 in accordance with the present driving conditions in order to suppress the motive force.

▶ System Diagram ◀



(1) : ● Required regenerative brake force
● Required motive force (for TRAC or VSC Function)
(2) : ● Actual Regenerative Brake Control Value

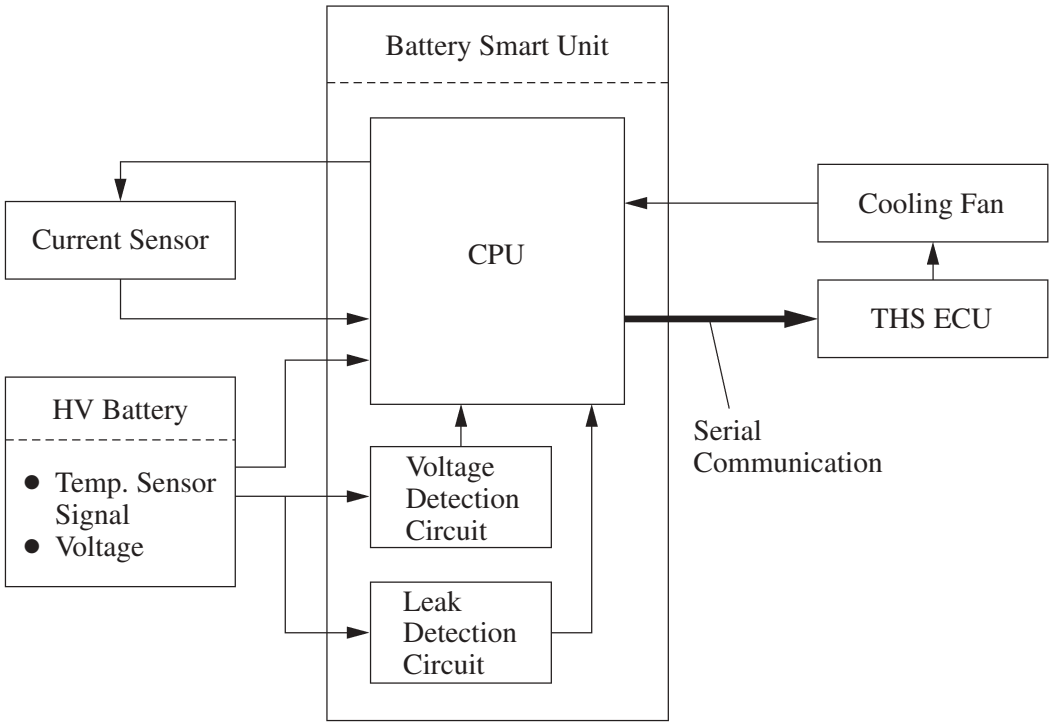
*: ECB (Electronically Controlled Brake System)

02HTH46TE

7. Battery Control

- The battery smart unit detects and transmits the HV battery condition signals (voltages, currents, and temperatures), which are used to determine charging or discharging values, to the THS ECU.
- The battery smart unit also detects and transmits the cooling fan voltage signals which are necessary to effect cooling fan control, to the THS ECU.
- A leak detection circuit is provided in the battery smart unit in order to detect any excessive current draw from the HV battery.

▶ System Diagram ◀



02HTH47TE

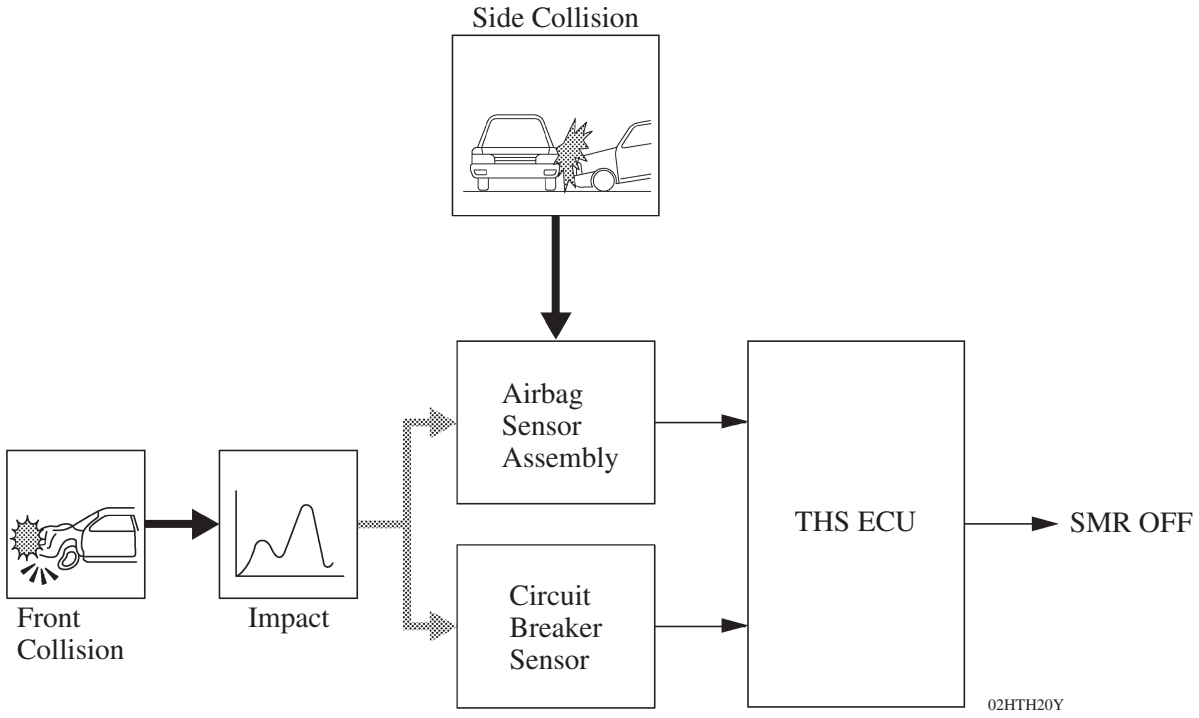
8. During Collision Control

General

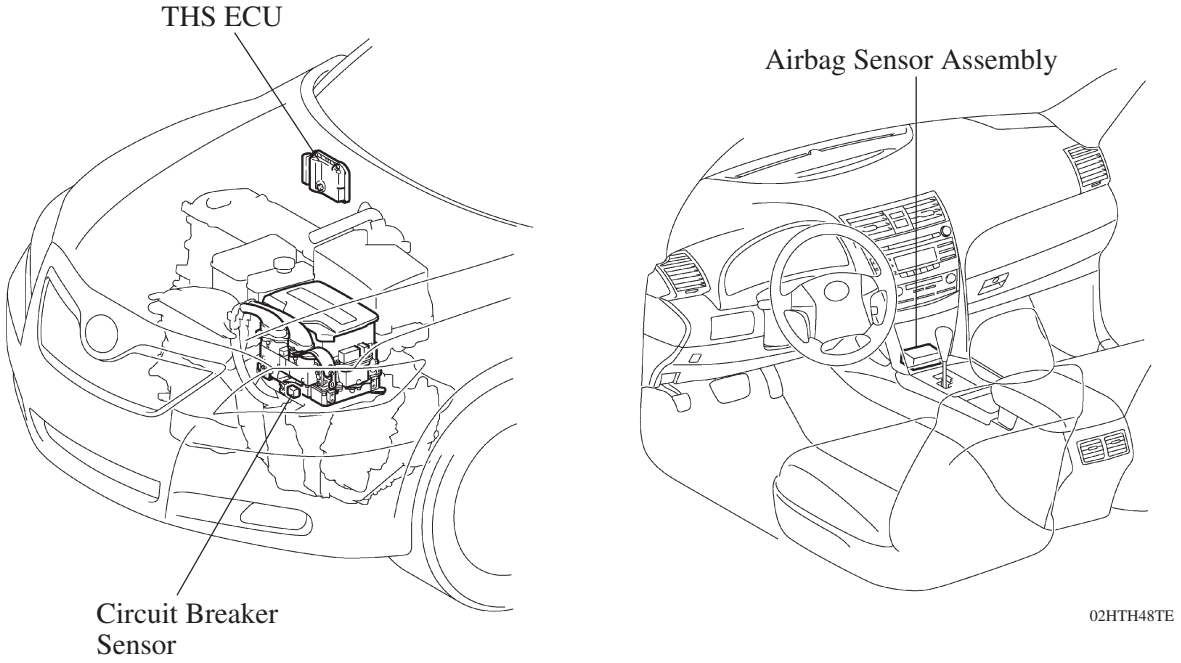
If the vehicle encounters one of the situations described below, the THS ECU will shut down the entire power supply by turning the SMR (System Main Relay) OFF, in order to ensure safety.

- The THS ECU receives an airbag deployment signal from the airbag sensor assembly during a frontal collision, or side collision.
- The THS ECU receives an actuation signal for the circuit breaker sensor, which is provided in the inverter, during a frontal collision.

▶ System Diagram ◀



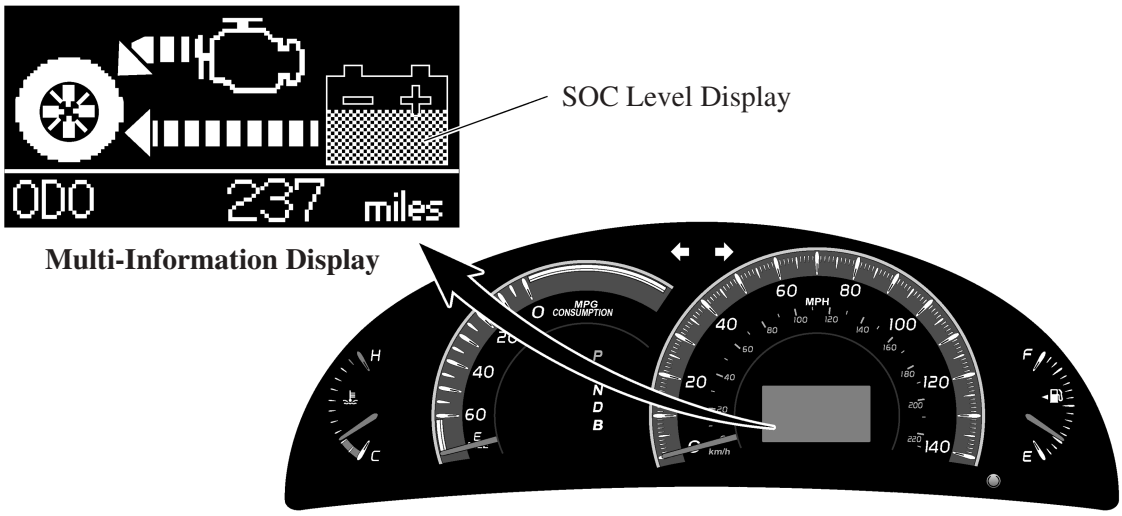
Layout of Main Components



9. Indicator and Warning Light Illumination Control

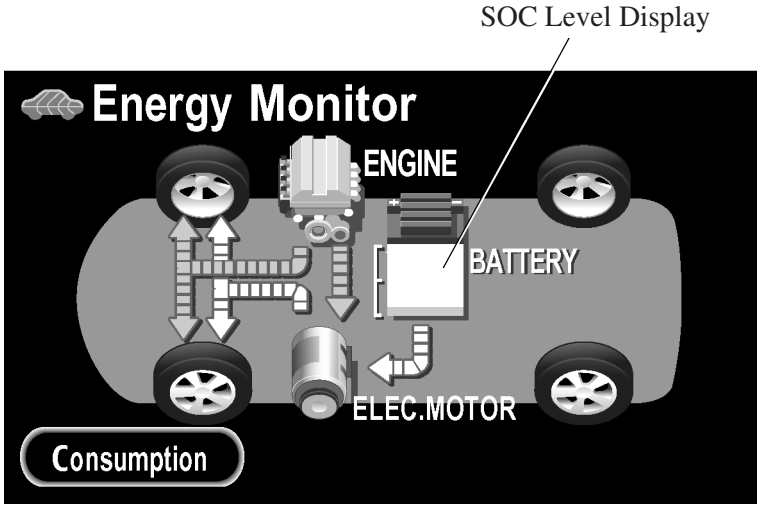
Energy Monitor

- On the ’07 Camry Hybrid model, the multi-information display located on the combination meter has a function to display the energy flow, which enables the driver to monitor the driving conditions of the vehicle. The energy flow, which appears in the form of an arrow, also shows the SOC (state of charge) of the HV battery in 8 levels.



02HTH49Y

- A radio and player with display, which is available as optional equipment, has a function to display the energy flow with a style that differs from the multi-information display. This display also shows the energy flow in the form of an arrow, and shows the SOC (state of charge) of the HV battery in 8 levels.

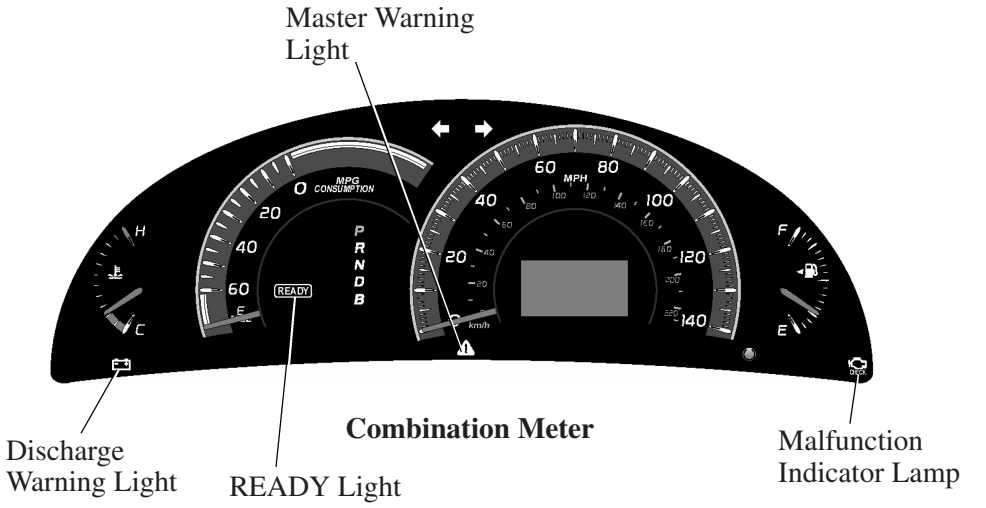


02HTH50Y

Indicator and Warning Light

1) Combination Meter

In particular, the indicator and warning lights associated with the THS II are described below.



Combination Meter

02HTH51Y

Item	Outline
READY Light	This light blinks when the driver simultaneously presses the brake pedal and turns on the power switch while the shift lever is in the P position. Thereafter, the light changes to illumination when the system starts, thus informing the driver that the vehicle is drivable.
Master Warning Light	The primary function of this warning light, which illuminates simultaneously with the sounding of a warning buzzer, is to inform the driver in case of a malfunction in the THS II system or other systems, or when the SOC of the HV battery is lower than the standard.
Malfunction Indicator Lamp	Turns on when there is a malfunction in the engine control system.
Discharge Warning Light	Turns on when there is a malfunction in the DC 12 V charging system (converter assembly).

2) Multi-Information Display

- This warning display indicates to the driver that the SOC is lower than the minimum standard value (%). At the same time, the master warning light blinks and the buzzer sounds.

02HTH52TE

Multi-Information Display

- This warning display indicates to the driver that a malfunction has occurred in the THS II system. At the same time, the master warning light illuminates and the buzzer sounds. However, these are inactive for 5 seconds after the power source is turned to IG ON.

02HTH53TE

Multi-Information Display

- This warning display indicates to the driver that the temperatures of any parts related to the THS II system exceed the standard value. At the same time, the master warning light illuminates and the buzzer sounds.

02HTH54TE

Multi-Information Display

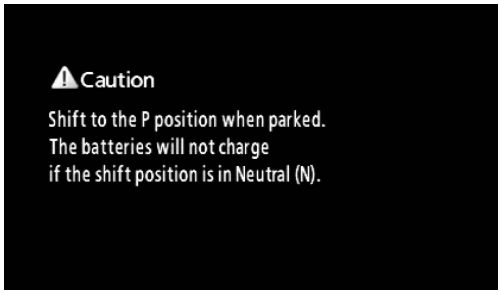
3) Multi-Information Display and Radio and Player with Display

- Under the condition described below, the message prompt shown on the left below appears on the multi-information display screen. In addition, when the radio and player with display is fitted (only on models with the navigation with AV system), the caution message shown on the right below appears on that screen as well. These messages are accompanied by the blinking of the master warning light and continuous sounding of the buzzer.

◆ The READY light is illuminated, the shift position is in the N position, and the HV battery is discharged.

02HTH55TE

Multi-Information Display



02HBE49Y

Radio and Player with Display

TH

10. Diagnosis

- In the THS II, if the THS ECU detects a malfunction, the ECU performs a diagnosis and memorizes failed sections. Furthermore, to inform the driver of the malfunction, the ECU illuminates or blinks the MIL (Malfunction Indicator Lamp), master warning light, which pertains to the ECU.
- The THS ECU will restore the respective DTC of the malfunctions.
- Three-digit information codes have been provided in the conventional DTC as subset of a primary five-digit code. This enables the troubleshooting procedure to further narrow down a trouble area to identify a problem.
- The DTC can be accessed through the use of the hand-held tester with CAN VIM (Dedicated adapter).

For details, refer to the 2007 Camry Hybrid Vehicle Repair Manual (Pub. No. RM02H0U).

11. Fail-Safe

If the THS ECU detects a malfunction in the THS II, it will control the system in accordance with the data that is stored in its memory.
For details, refer to the 2007 Camry Hybrid Vehicle Repair Manual (Pub. No. RM02H0U).