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)

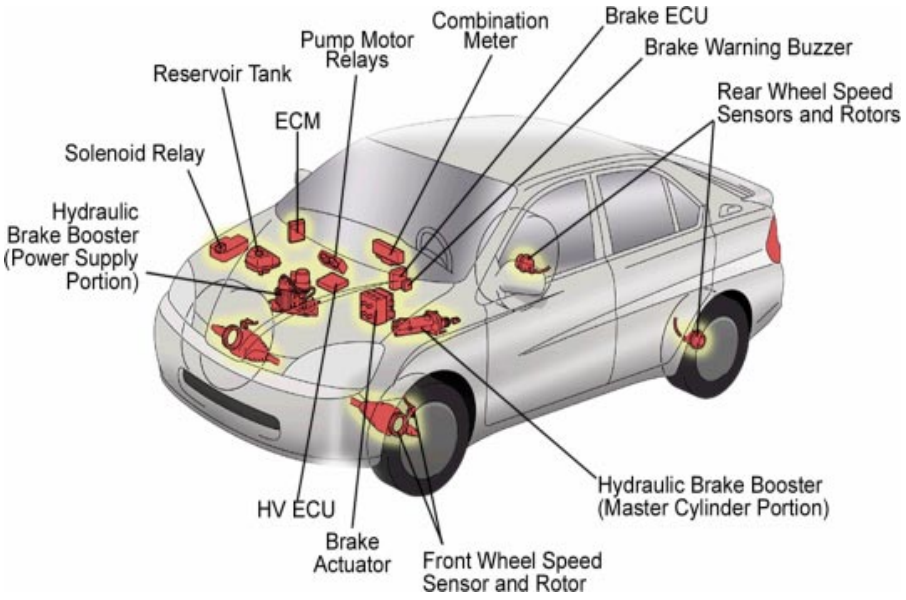


Figure 6.1 T072f601c

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

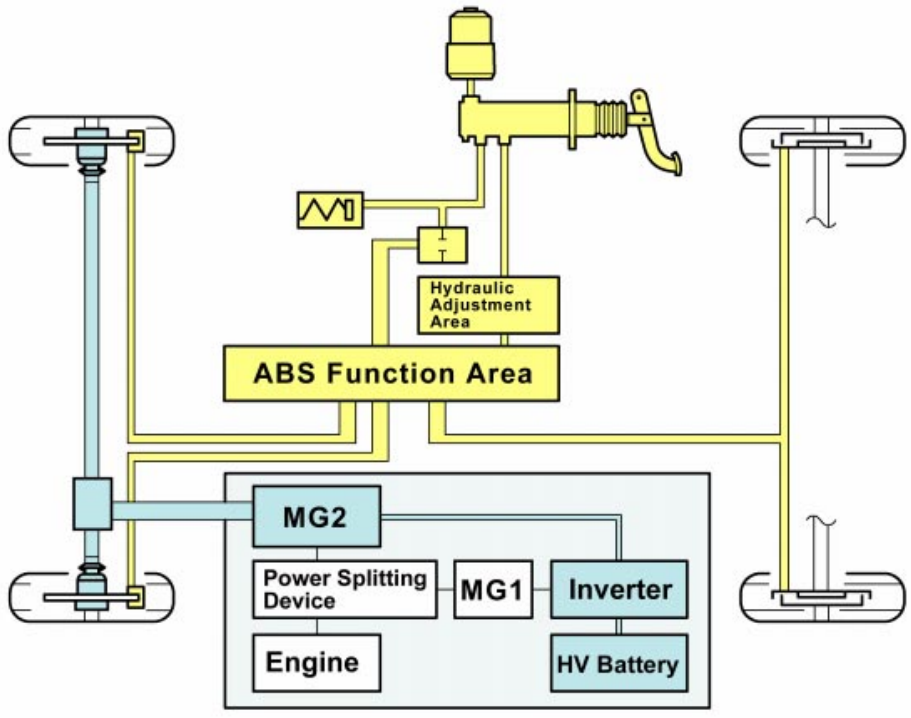


Figure 6.2 T072f602c

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.

Cooperative Control with EPS

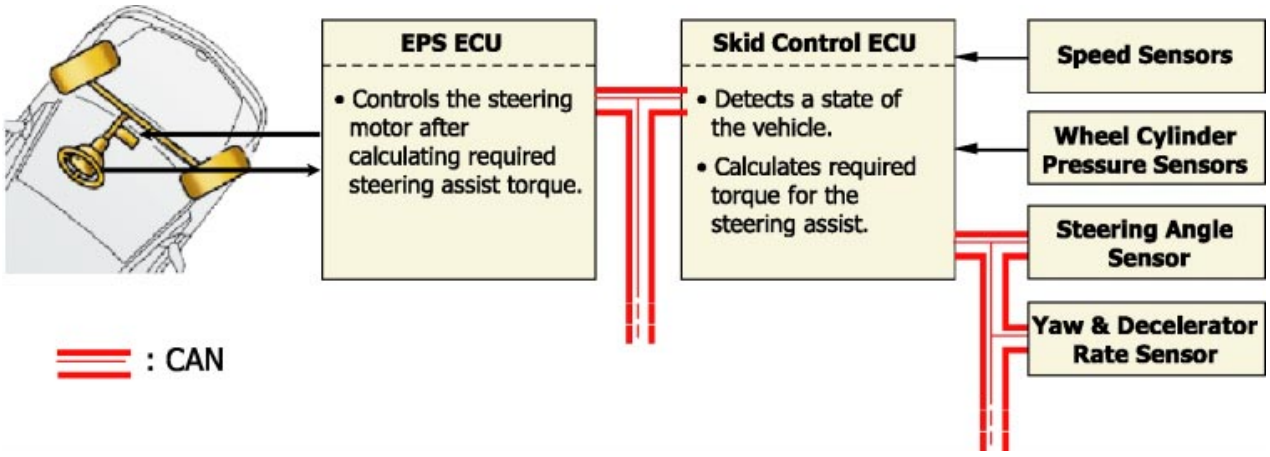


Figure 6.3 T072f603c

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

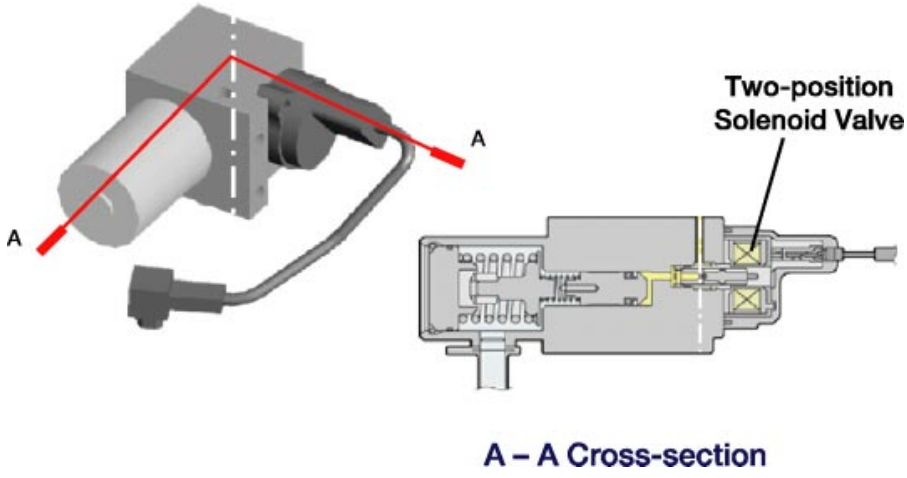


Figure 6.4 T072f604c

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

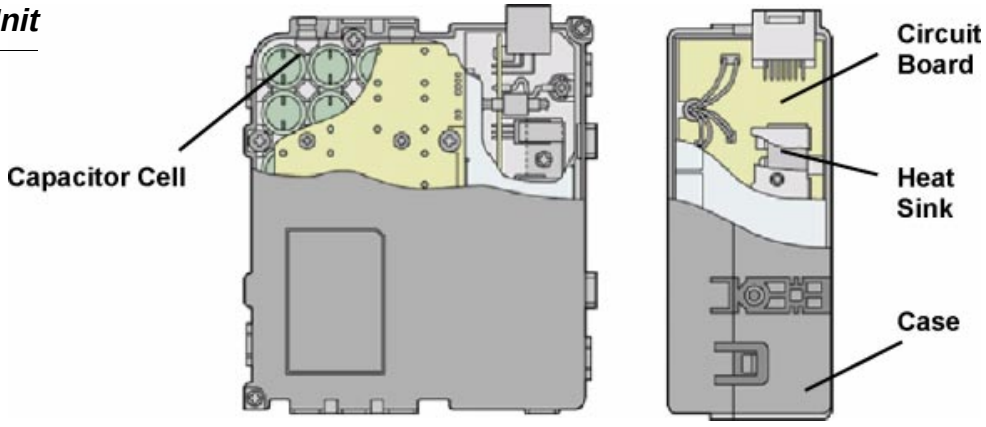


Figure 6.5 T072f605c

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.

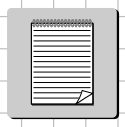
DTC C1259/59 Malfunction In HV ECU

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