Chassis

Overview

Toyota hybrid vehicles use a number of specialized chassis systems including:

- A shift-by-wire system with electronic transmission control.
- A regenerative braking system that recovers much of the energy normally lost to heat and friction during braking.
- An Electric Power Steering (EPS) system that improves fuel economy because it only consumes energy when it is in use.

Shift Control ('01-'03 Prius)

The '01-'03 Prius uses a shift-by-wire system. The shift position sensor is connected to a column-mounted shift lever and outputs two voltage signals: a main signal and a sub signal. Both contain information about shift position. The HV ECU determines shift position when both signals match.

Shift Control ('04 & later Prius)

The '04 & later Prius uses a different shift-by-wire system. It uses two sensors to monitor shift lever movement: a Select Sensor that detects the lateral movement and a Shift Sensor that detects the longitudinal movement. The combination of these signals is used to determine shift position. When shift selection is complete, the reactive force of a spring returns the lever to its home position.

Shift Control

('01-'03 Prius)

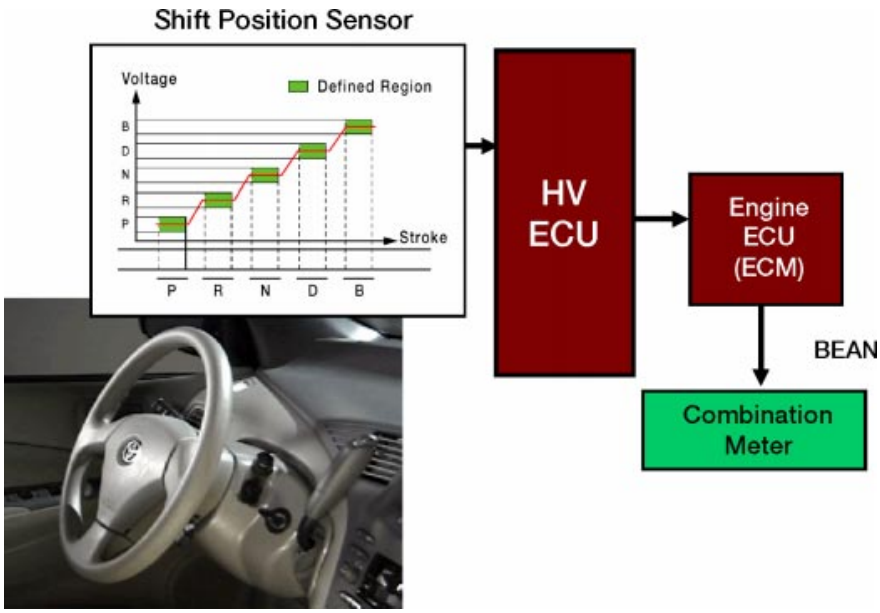

Figure 5.1 T071f501c

Shift Lock

('01-'03 Prius)

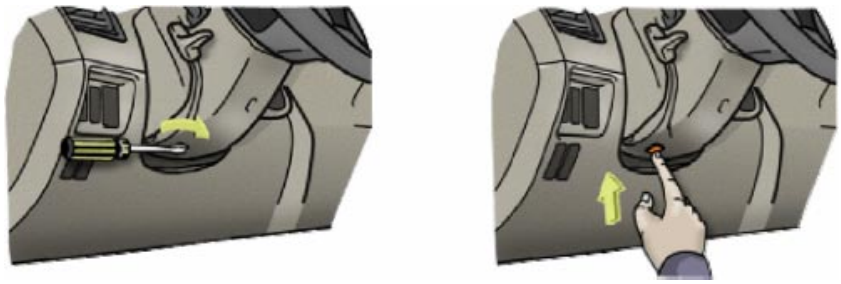

Figure 5.2 T071f502c

Shift Assembly

('04 & later Prius)

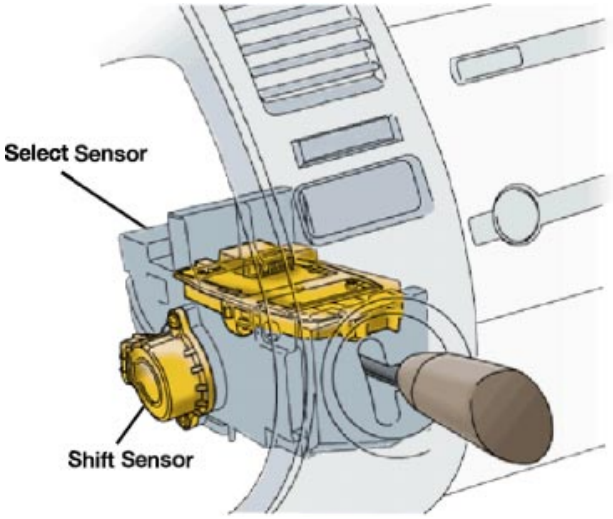

Figure 5.3 T072f107c

Shift Control Actuator ('04 & later Prius)

The '04 & later Prius uses an electronic Shift Control Actuator to engage the parking pawl. When the Shift Control Actuator receives a lock signal from the transmission ECU it rotates, which moves the parking lock rod and forces the parking lock pawl to engage the parking gear. The Shift Control Actuator detects its own position when the battery is reconnected, so it does not require initialization.

Shift Control Actuator

('04 & later Prius)

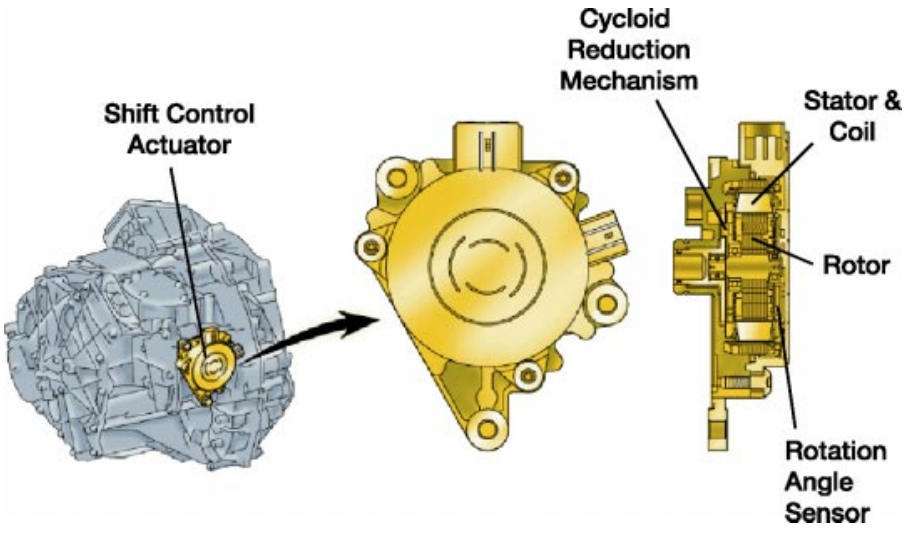

Figure 5.4 T072f406c

SERVICE TIP

If there is a malfunction in the shift control actuator, the vehicle will not go into park. The Master Warning Light will illuminate, the shift position indicators on the dash will flash, and the Park button light will flash.

In this case, the vehicle cannot be turned OFF unless the parking brake is applied. Then the vehicle can be turned OFF but cannot be turned back ON again.

Cycloid Reduction Mechanism ('04 & later Prius)

The Shift Control Actuator includes a cycloid gear reduction mechanism that increases the actuator's torque, ensuring that the parking lock will release when the vehicle is parked on a slope.

This mechanism consists of an eccentric plate mounted on the motor's output shaft, a 61-tooth fixed gear that is secured to the motor housing and a 60-tooth driven gear. As the output shaft rotates, the eccentric plate presses the driven gear against the fixed gear. The driven gear, which has one tooth less than the fixed gear, rotates one tooth for every complete rotation of the eccentric plate. The result is a gear reduction ratio of 61:1, along with an equivalent increase in torque.

Cycloid Reduction Mechanism

1. Eccentric shaft rotates with motor shaft, pressing driven gear against fixed gear.

2. Driven gear rotates one tooth for every full rotation of the motor shaft.

3. Reduction Ratio: 61:1.

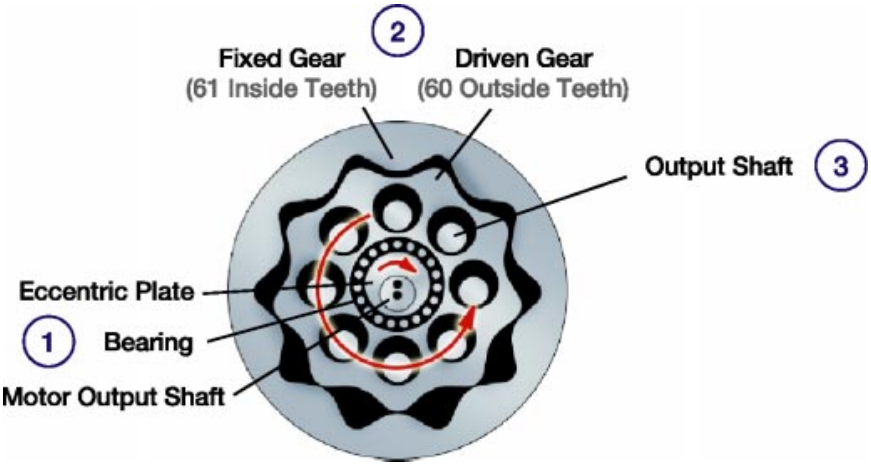

Figure 5.5 T071f505c

SERVICE TIP

The Diagnostic Tester cannot turn off the shift control system. To power down the system remove the 30-amp main fuse located on the left side of the fuse box on the driver's side of the engine compartment. This may be necessary if the vehicle needs to be pushed out of the shop.

Fuse Location

Removing the 30A PCON MTR fuse disables the shift control system.

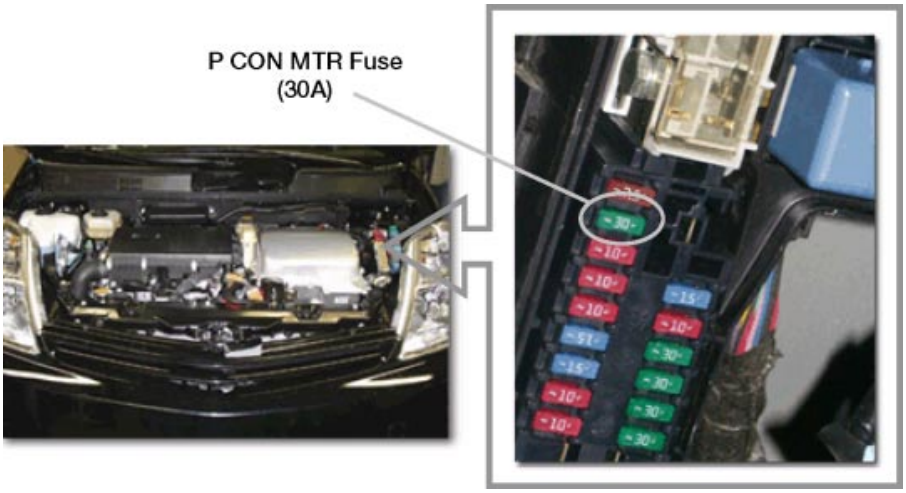

Figure 5.6 T071f506c

Brake System

The hybrid vehicle brake system includes both hydraulic brakes and a unique regenerative braking system that uses the vehicle's momentum to recharge the HV 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 HV battery. 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. At this time there is no way for the driver to know the limit of regenerative energy recovery.

Brake System Components

('01-'03 Prius)

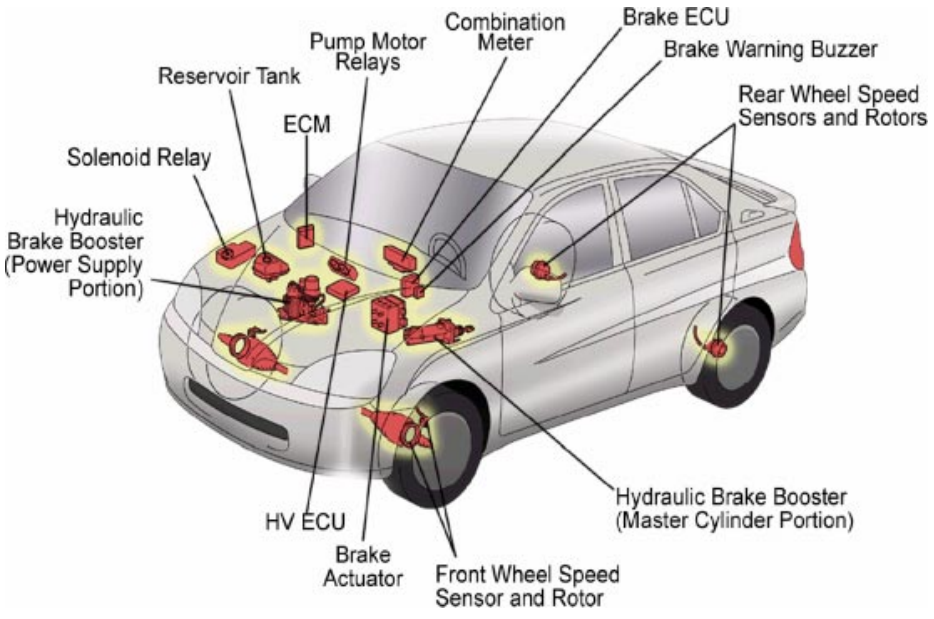

Figure 5.7 T071f507c

Brake System Diagram

('01-'03 Prius)

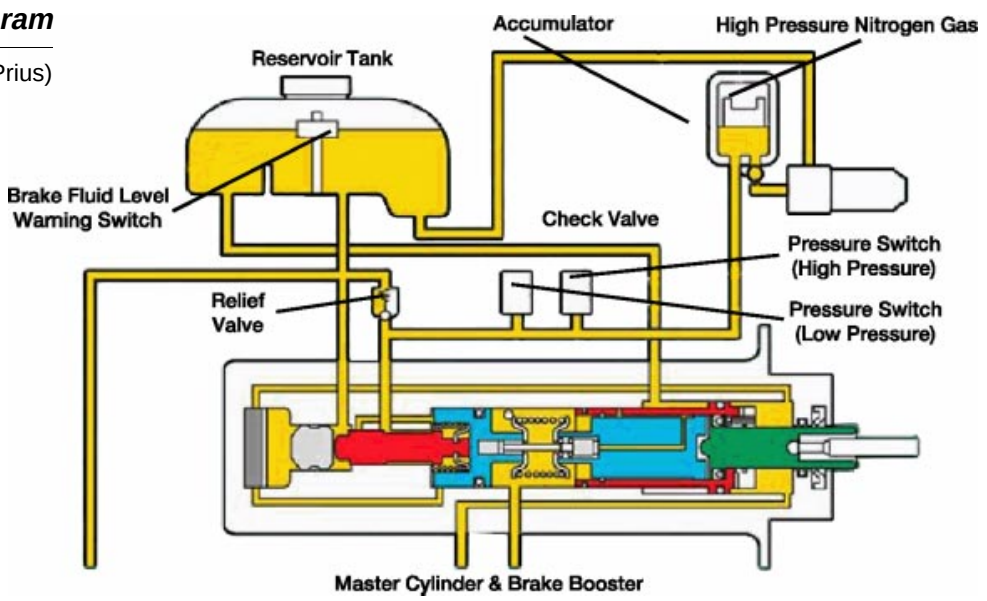

Figure 5.8 T071f508c

Hydraulic Brake Booster ('01-'03 Prius)

The '01-'03 Prius applies hydraulic pressure from the master cylinder directly to the front brakes. For the rear brakes, it uses a hydraulic brake booster to increase brake force. Within the hydraulic brake booster, a pump draws brake fluid from the reservoir tank and forces it into the accumulator under high pressure. The accumulator stores the high-pressure fluid until it is needed.

To make sure system pressure stays at the right level, two pressure switches monitor hydraulic pressure coming from the accumulator:

- Pressure Switch PH - controls pump activation.
- Pressure Switch PL – generates a warning when system pressure is too low.

If one of the pressure switches malfunctions it can cause the pump to operate continuously, creating excessive pressure in the system. If that happens, a relief valve shunts brake fluid to the reservoir tank to relieve the excess pressure.

If the brake booster fails, the Brake System Warning Light and Buzzer will illuminate. Pressing the brake pedal repeatedly may turn ON the Brake System Warning Light and Buzzer briefly. If the brake booster is operating normally, the light and buzzer will turn OFF after a few seconds after start up.

Brake Actuator ('04 & later Prius)

In the '04 & later Prius, the conventional brake booster has been replaced by a hydraulic power source that is controlled by the Skid Control ECU.

The hydraulic power source uses many of the same components used on the previous system, including a pump, pump motor, accumulator, relief valve, 2 motor relays, and an accumulator pressure sensor. To improve the system, the accumulator has been made more gas-tight, and a plunger-type pump has been adopted.

The control portion of the brake actuator includes:

- 2 master cylinder solenoid valves
- 4 pressure appliance valves
- 4 pressure reduction valves
- 2 master cylinder pressure sensors
- 4 wheel cylinder pressure sensors

Brake ECU ('01-'03 Prius)

In the '01-'03 Prius, the Brake ECU controls the following brake functions:

- Conventional brake control
- ABS with EBD control
- Regenerative brake cooperative control

The Brake ECU exchanges sensor information with the HV ECU.

Brake Control Components

('01-'03 Prius)

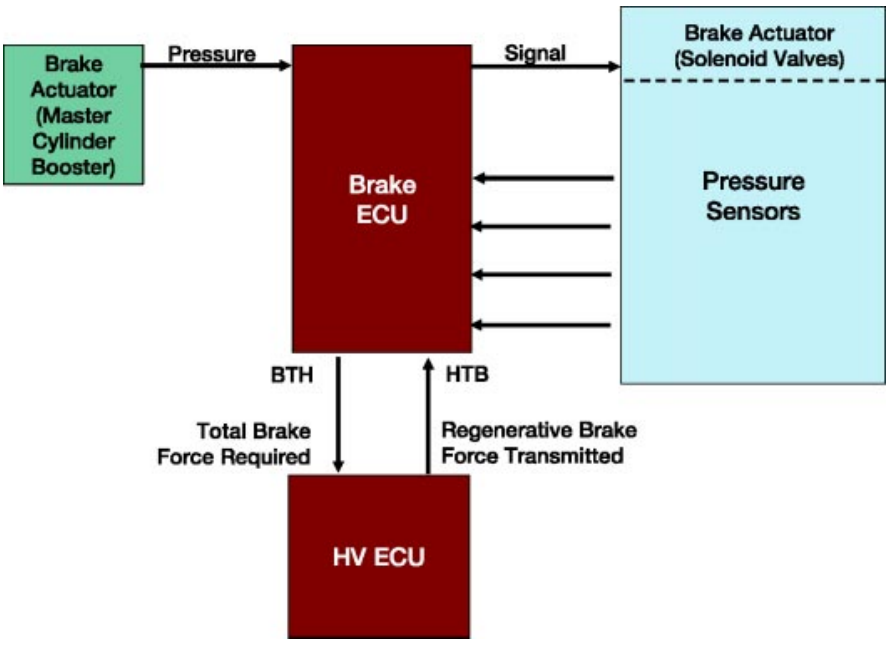

Figure 5.9 T071f509c

Skid Control ECU ('04 & later Prius)

In the '04 & later Prius, brake control processing is moved to the Skid Control ECU, which handles:

- Conventional brake control
- ABS with EBD control
- Brake Assist
- Enhanced VSC
- Regenerative brake cooperative control

The Skid Control ECU exchanges sensor information EPS ECU and the HV ECU.

Brake Control Components

('04 & later Prius)

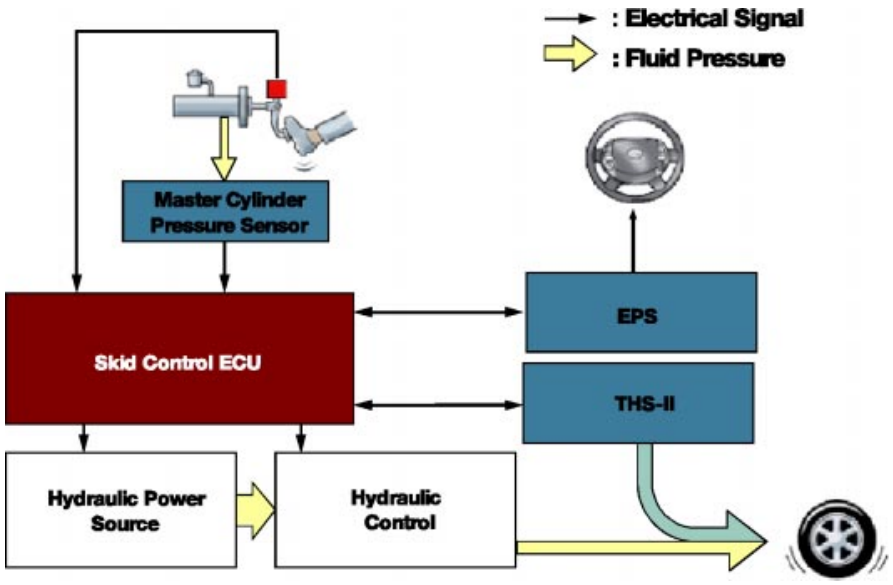

Figure 5.10 T071f510c

Brake Pedal Stroke Sensor ('04 & later Prius)

The '04 & later Prius uses an Electronically Controlled Brake (ECB) system. To determine the amount of brake force requested, the Brake Pedal Stroke Sensor uses a variable resistor to detect the amount of brake pedal movement, and then transmits that information to the Skid Control ECU.

SERVICE TIP

When installing a Brake Pedal Stroke Sensor:

- Initially, the sensor lever is locked into the "0" stroke position by a small pin. **Do not detach the pin** until the installation has been completed.
- Install the sensor.
- Then, firmly press the brake pedal once to break off the pin.
- Make sure the broken pin does not remain in the sensor lever.

Brake Pedal Stroke Sensor

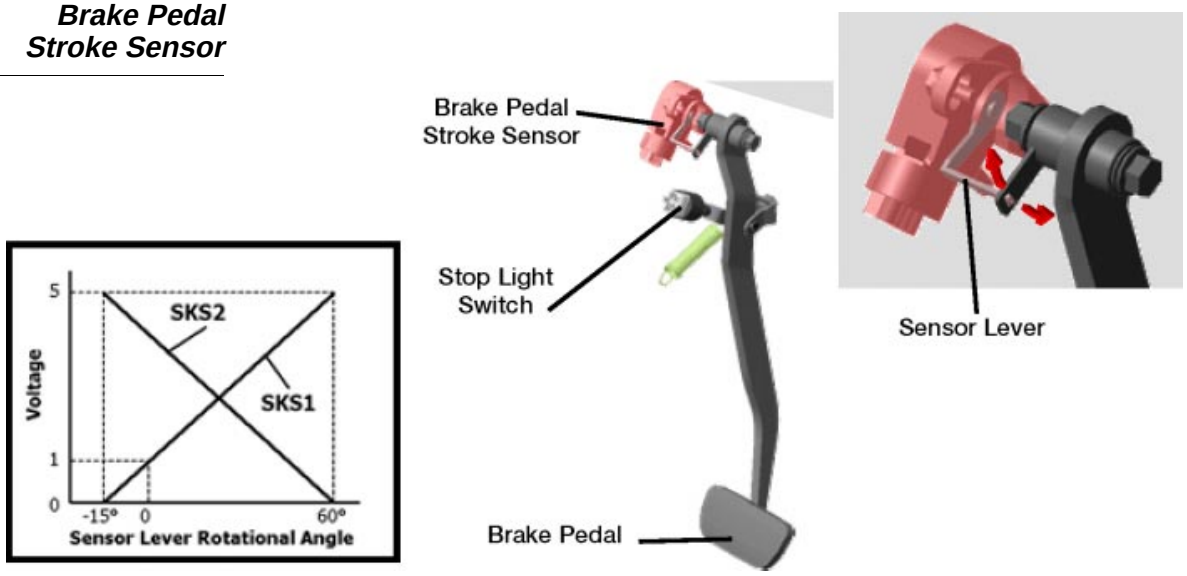

Figure 5.11 T071f511c

Stroke Simulator

During regenerative braking fluid flow to the front calipers is limited. To retain a normal pedal stroke during regenerative braking, the Stroke Simulator consumes some of the fluid flow from the master cylinder so that the pedal can move normally.

The stroke simulator is located between the master cylinder and the brake actuator. It uses two coil springs with different spring constants to provide pedal stroke characteristics in two stages.

Stroke Simulator

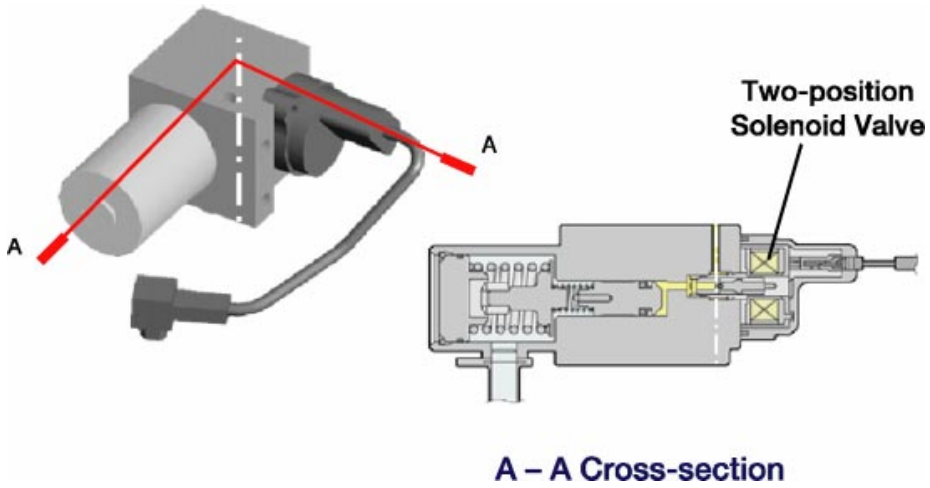

Figure 5.12 T072f112c

Power Source Backup Unit ('04 & later Prius)

In the '04 & later Prius a Power Source Backup Unit has been added so that the ECB will function long enough to stop the vehicle even if the 12V battery is compromised. The unit contains 28 capacitor cells that store an electrical charge provided by the vehicle's 12V power supply. The capacitor cells discharge when the power switch is turned OFF.

If the Power Source Backup Unit is removed, it must first be checked for residual voltage.

Power Source Backup Unit

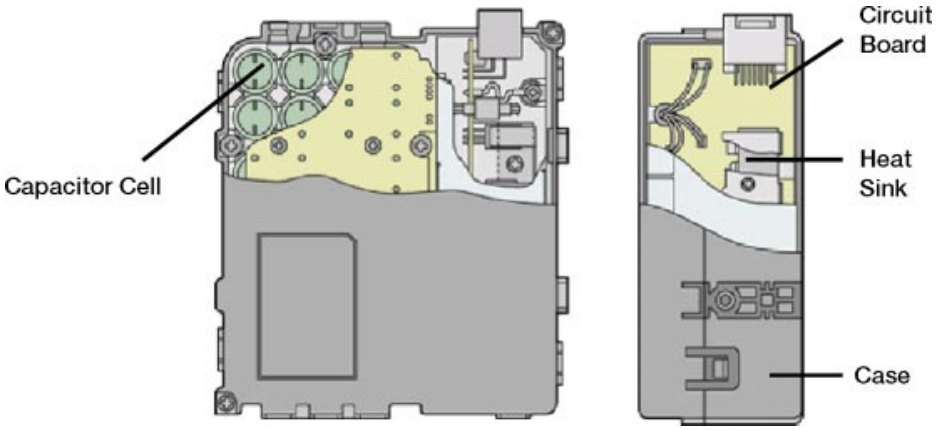

Figure 5.13 T072f605c

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.

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 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

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 amperage (battery charging amperage), the greater the resistance.

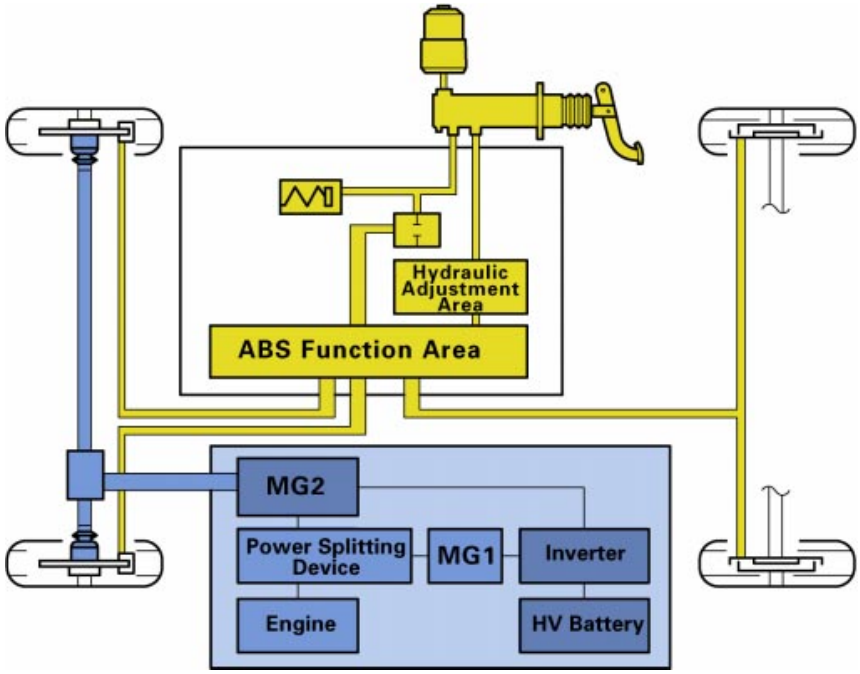

Figure 5.14 T072f047c

Electronic Brake Distribution (EBD) Control ('04 & later Prius)

In the '04 & later Prius, brake force distribution (which was performed mechanically in the past) is now performed under electrical control of the skid control ECU. The skid control ECU precisely controls the braking force in accordance with the vehicle's driving conditions.

Brake Force Distribution - Front/Rear ('04 & later Prius)

Generally, when the brakes are applied the vehicle's weight shifts forward, reducing the load on the rear wheels. When the Skid Control ECU senses this condition (based on speed sensor output) it signals the brake actuator to regulate rear brake force so that the vehicle will remain under control during the stop. The amount of brake force applied to the rear wheels varies based the amount of deceleration. The amount of brake force that is applied to the rear wheels also varies based on whether or not the vehicle is carrying a load.

Front/Rear Brake Force Disk

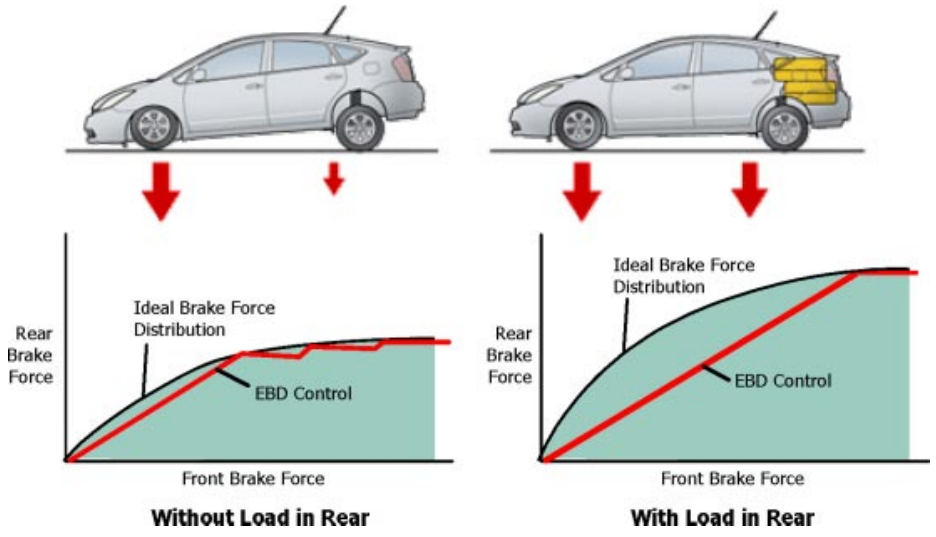

Figure 5.15 T072f511c

Brake Force Distribution - Left/Right ('04 & later Prius)

When the brakes are applied while the vehicle is cornering, the load applied to the inner wheel decreases while the load applied to the outer wheel increases. When the Skid Control ECU senses this condition (based on speed sensor output) it signals the brake actuator to regulate brake force between the left and right wheels to prevent a skid.

Brake Assist System ('04 & later Prius)

In emergencies, drivers often panic and do not apply sufficient pressure to the brake pedal. So on the '04 & later Prius, the Brake Assist system interprets a quick push of the brake pedal as emergency braking and supplements braking power accordingly.

To determine the need for an emergency stop, the Skid Control ECU looks at the speed and the amount of brake pedal application based on signals from the master cylinder pressure sensors and the brake pedal stroke sensor. If the Skid Control ECU determines that the driver is attempting an emergency stop it signals the brake actuator to increase hydraulic pressure.

A key feature of the Brake Assist system is that the timing and the degree of braking assistance are designed to ensure that the driver does not discern anything unusual about the braking operation. As soon as the driver eases up on the brake pedal, the system reduces the amount of assistance it provides.

Brake Assist

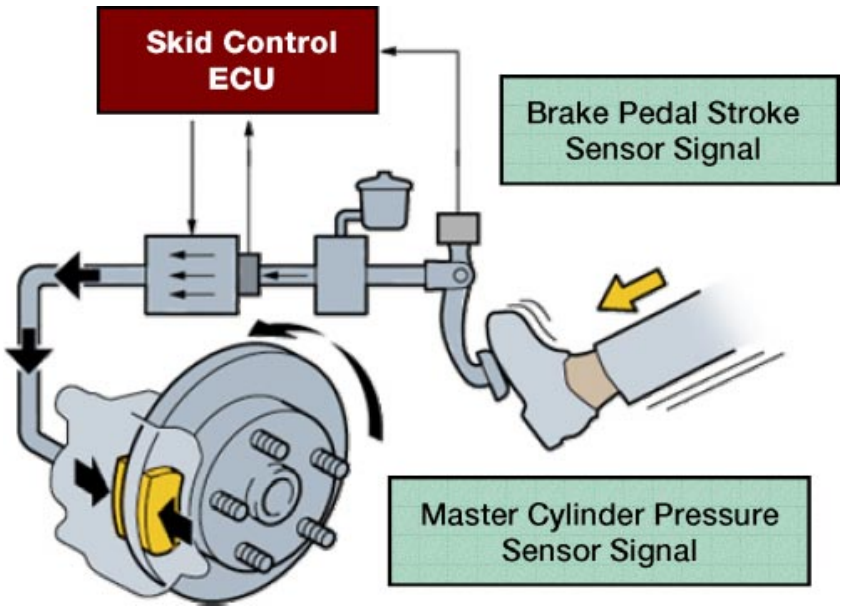

Figure 5.16 T072f512c

Enhanced VSC System ('04 & later Prius)

The Enhanced VSC system available on the '04 & later Prius helps maintain stability when the vehicle's tires exceed their lateral grip. The system helps control the vehicle by adjusting the motive force and the brakes at each wheel when:

- The front wheels lose traction but the rear wheels don't. (front wheel skid tendency known as 'understeer')
- The rear wheels lose traction but the front wheels don't. (rear wheel skid tendency, or 'oversteer')

When the Skid Control ECU determines that the vehicle is in understeer or oversteer, it decreases engine output and applies the brakes to the appropriate wheels individually to control the vehicle.

- When the skid control ECU senses understeer, it brakes the front and rear inside wheel. This slows the vehicle, shifts the load to the outside front wheel and limits front wheel skid.
- When the skid control ECU senses oversteer, it brakes the front and rear outside wheel. This restrains the skid and moves the vehicle back toward its intended path.

Cooperative Control with EPS ('04 & later Prius)

Enhanced VSC provides the appropriate amount of steering assist based on driving conditions by coordinating EPS and VSC control.

Cooperative Control with EPS

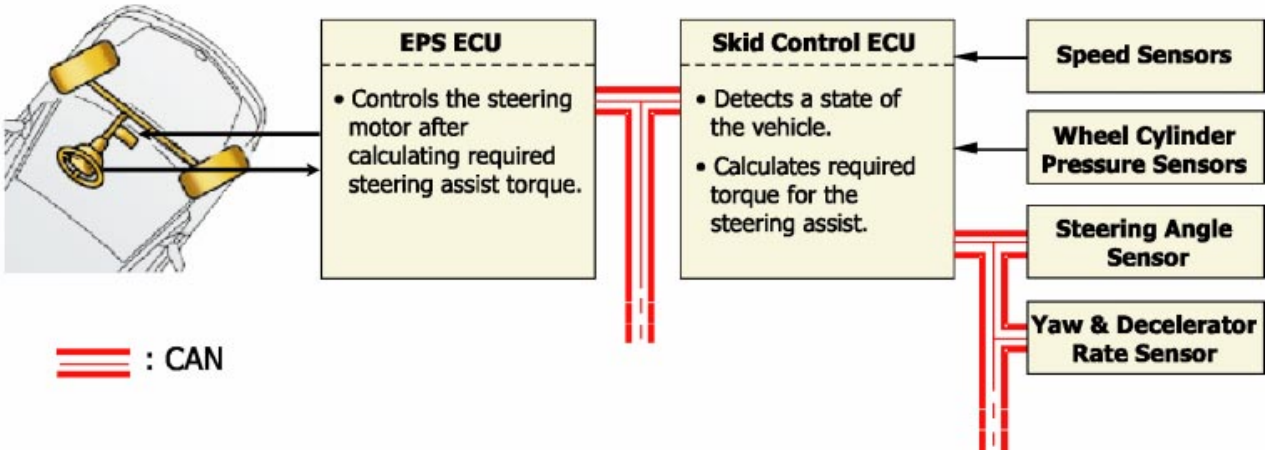

Figure 5.17 T072f111c

Electric Power Steering

A 12V motor powers the EPS system so that steering feel is not affected when the engine shuts off. The EPS ECU uses torque sensor output along with information from the Skid Control ECU about vehicle speed and torque assist demand to determine the direction and force of the power assist. It then actuates the DC motor accordingly.

EPS Parts Location

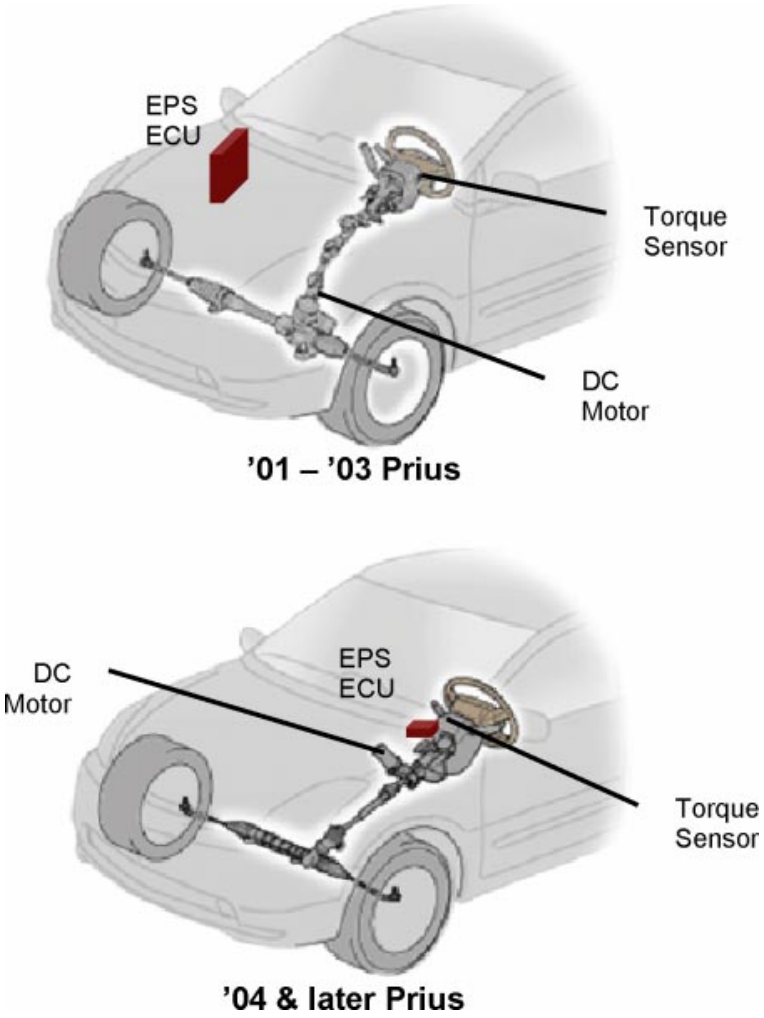

Figure 5.18 T072f114c

EPS ECU

The EPS ECU uses signals from the torque sensor to interpret the diver's steering intentions. It combines this information with data from other sensors regarding current vehicle conditions to determine the amount of steering assist that will be required. It can then control the current to the DC motor that provides steering assist current to the DC motor that provides steering assist.

EPS Steering System

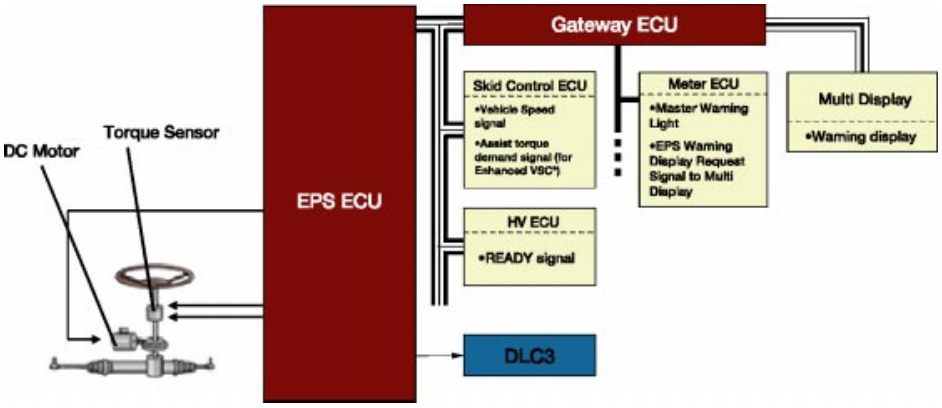

Figure 5.19 T072f049c

Power Steering System

When the steering wheel is turned, torque is transmitted to the pinion causing the input shaft to rotate. The torsion bar that links the input shaft and the pinion twists until the torque and the reaction force equalize. The torque sensor detects the twist of the torsion bar and generates an electrical signal that is proportional to the amount of torque applied to the torsion bar. The EPS ECU uses that signal to calculate the amount of power assist the DC motor should provide.

The ’01-‘03 Prius torque sensor is a surface-contact resistor and the ’04 & later Prius uses an induction-type torque sensor.

DC Motor

The DC motor uses a worm gear to transmit the motor’s torque to the column shaft.

Torque Sensor

(‘01-‘03 Prius)

Figure 5.20 T071f520p

Torque Sensor

('04 & later Prius)

Detection Ring 1 and 2 are mounted on the input shaft and Detection Ring 3 is mounted on the output shaft. When torque is applied to the torsion bar the detection rings move in relationship to each other. The detection coil senses a change in inductance that is proportional to the amount of torque applied.

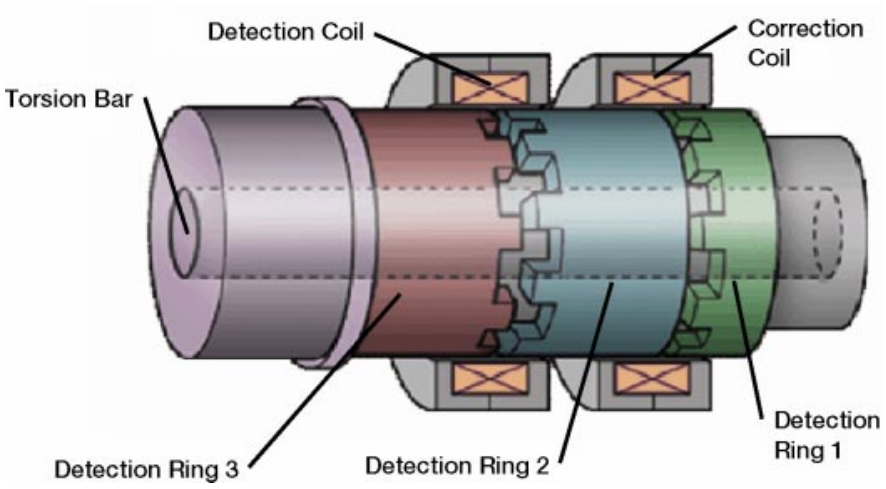

Figure 5.21 T072f049c

Reduction Mechanism ('01-'03 Prius)

For '01 to '03, the reduction mechanism transmits power assist from the motor to the pinion shaft. The reduction mechanism consists of a pinion gear integrated with the motor shaft and a ring gear that is secured to the pinion shaft.

Reduction Mechanism ('04 & later Prius)

For '04 & later, the reduction mechanism transmits power assist from the motor to the column shaft. The reduction mechanism consists of a worm gear integrated with the motor shaft and wheel gear that is connected to the column shaft.

Fail Safe If the EPS ECU detects a malfunction in the EPS system, a warning light illuminates to alert the driver. The EPS ECU will store the DTC(s) and the system will power down, however the system still provides the ability to steer manually.

DC Motor

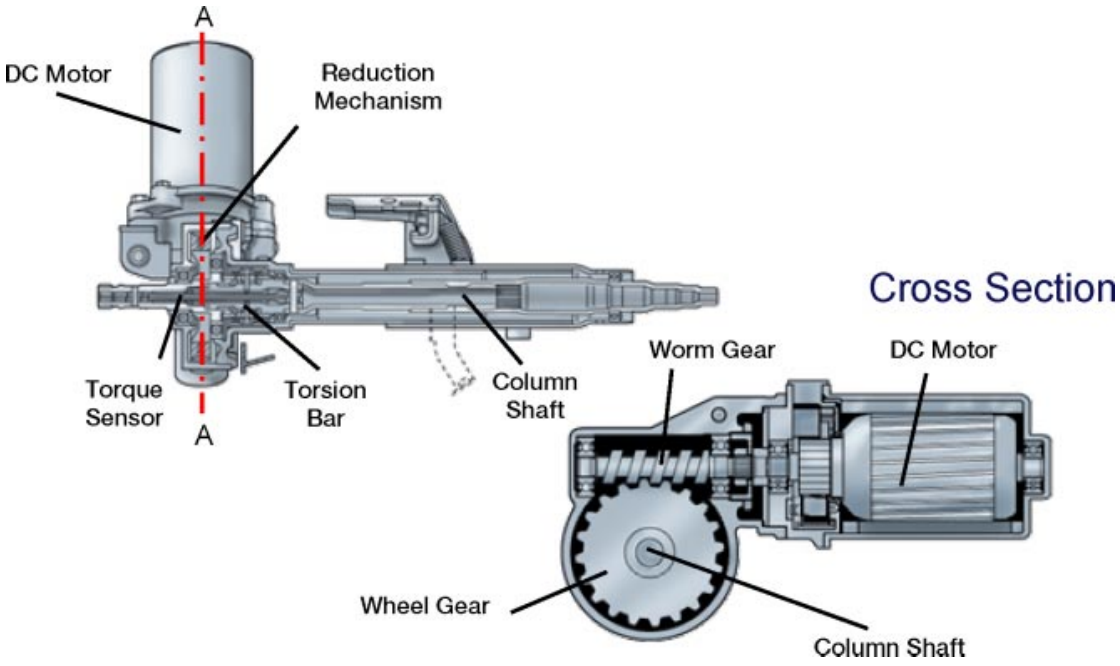

Figure 5.22 T071f522p

Notes