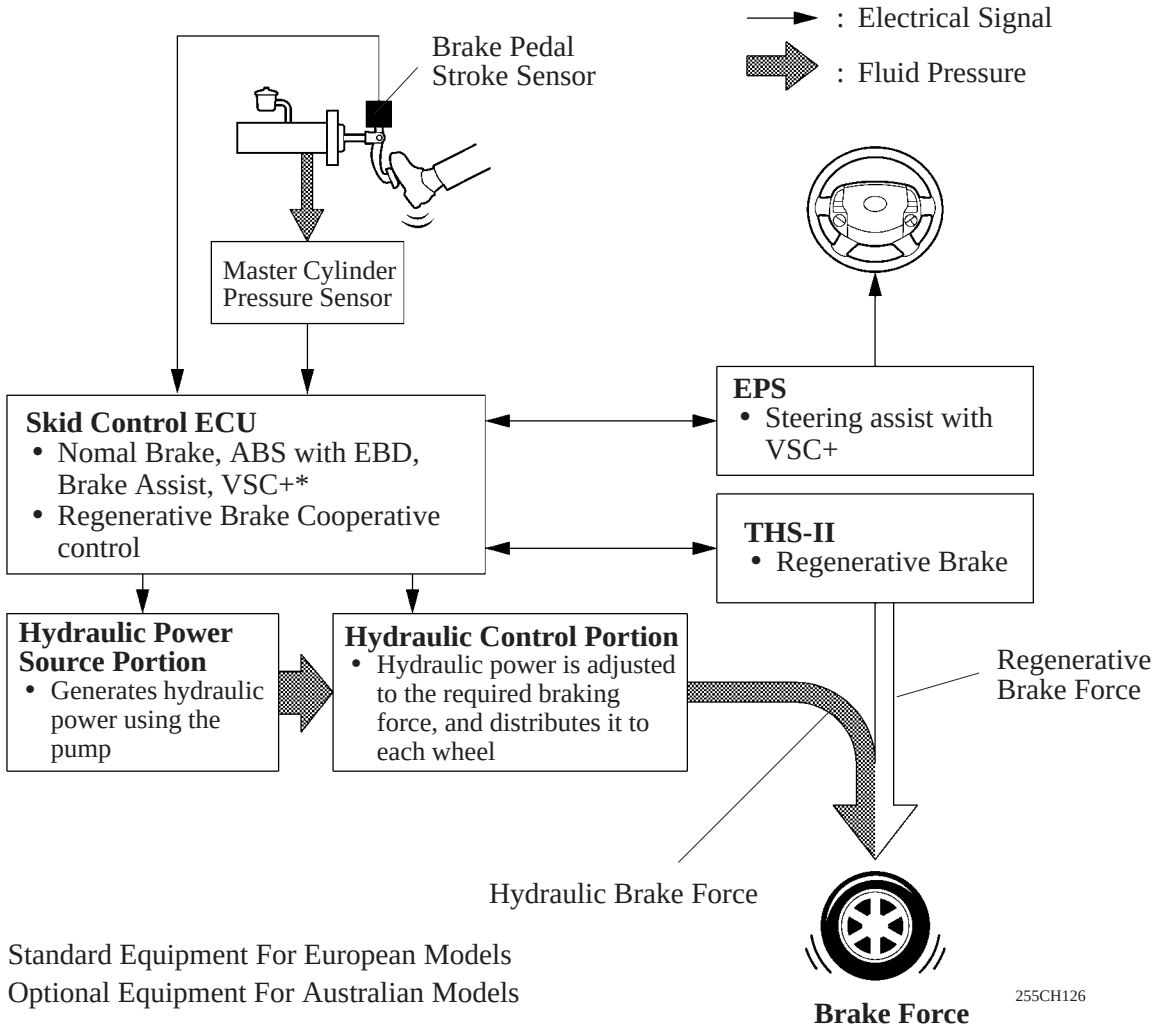
■BRAKE CONTROL SYSTEM

1. General

- An ECB (Electronically Controlled Brake) system has been adopted in the brake control system of the new Prius. The ECB system calculates the required braking force based on the amount of pedal effort and force applied by the driver. Then, this system applies the required braking force (which consists of a regenerative brake force generated by MG2 and a brake force generated by the hydraulic brake system) and effectively absorbs the energy.
- The ECB ECU, which controls this system, is integrated into the skid control ECU, and effects comprehensive control together with the hydraulic brake control system (consisting of ABS with EBD, brake assist and VSC+*).
- A brake control system warning light has been newly adopted accompanied by the adoption of the ECB system.
- The VSC+* system provides the steering assist in order to facilitate steering operation of the driver depending on vehicle situations by effecting cooperative control in conjunction with EPS, in addition to the VSC system that gives the general braking control function.
- On the new Prius, the motor traction control system has been adopted. This system minimizes a slippage of the drive wheels and generates the appropriate drive force for road surface condition by applying the hydraulic brake control to the wheels in slipping, in addition to the control function protecting the planetary gear and the motor that has been provided by the THS system on the previous model.
  For details, refer to HV ECU control in THS-II section on page TH-46.
- On the new Prius, the conventional brake booster portion has been discontinued. Instead, it consists of brake input, power supply, and hydraulic pressure control portions.
  During normal braking, the fluid pressure generated by the master cylinder does not directly actuate the wheel cylinders, but serves as a hydraulic pressure signal. Instead, the actual control pressure is obtained by regulating the fluid pressure of the hydraulic power source in the brake actuator, which actuates the wheel cylinders.
- The brake system of the new Prius starts with one of the actions that the power switch is turned ON, etc.
- The skid control ECU maintains communication with the EPS ECU and the HV ECU via CAN (Controller Area Network). For details, refer to Multiplex Communication on page BE-46.
- The skid control ECU has been changed from 16-bit CPU to 32-bit CPU to increase the for processing the signals.

*: Standard Equipment For European Models
Optional Equipment For Australian Models

▶ Outline of Brake Control System ◀



*: Standard Equipment For European Models
Optional Equipment For Australian Models

The brake system of the new Prius has a following function:

Brake Control System	Function	Outline
ECB System	Regenerative Brake Cooperative Control	Controls the hydraulic brake in order to recover the electrical energy by utilizing the regenerative brake of the THS-II system as much as possible.
	VSC+* (Vehicle Stability Control +)	• The VSC+ system helps prevent the vehicle from slipping sideways as a result of strong front wheel skid or strong rear wheel skid during cornering. • Effects cooperative control with the EPS ECU in order to provide steering assist in accordance with the operating conditions of the vehicle.
	ABS (Anti-lock Brake System)	The ABS helps prevent the wheels from locking when the brakes are applied firmly or when braking on a slippery surface.
	EBD (Electronic Brake force Distribution)	The EBD control utilizes ABS, realizing the proper brake force distribution between front and rear wheels in accordance with the driving conditions. In addition, during cornering braking, it also controls the brake forces of right and left wheels, helping to maintain the vehicle behavior.
	Brake Assist	The Brake Assist has two functions: • To increase the braking force if the brake pedal operation is not sufficient when urgent braking is needed. • To increase the braking force if stronger brake force is required.

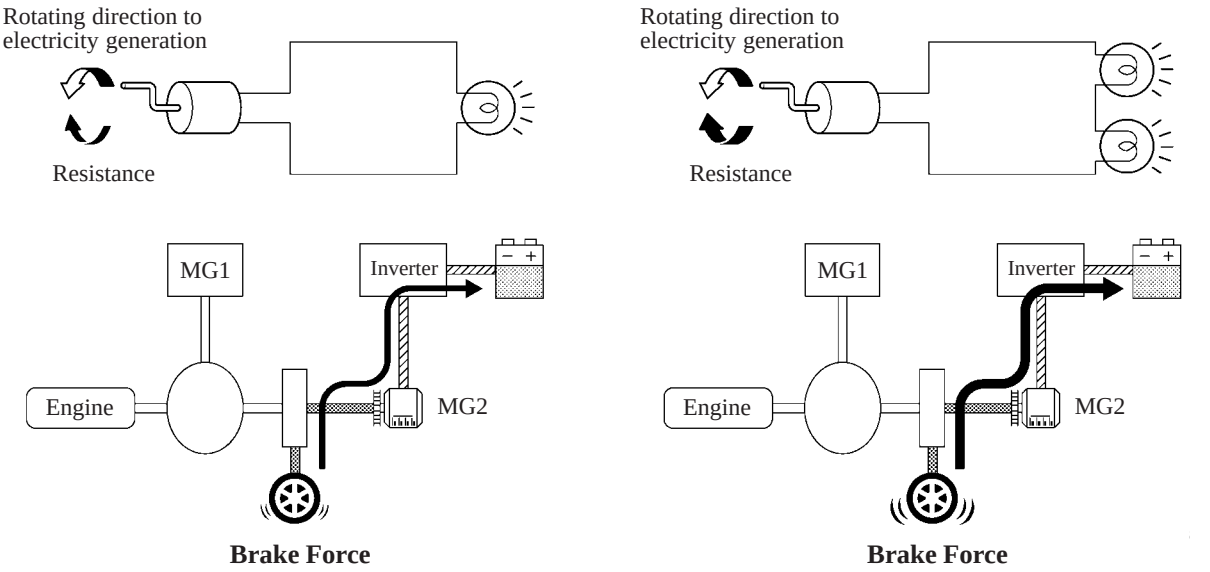
*: Standard Equipment For European Models
Optional Equipment For Australian Models

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2. Outline of Regenerative Brake Cooperative Control

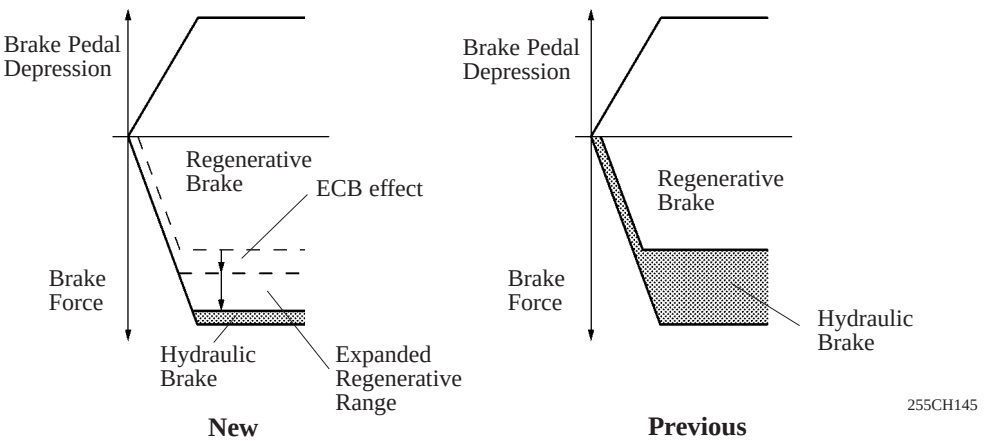
General

- Regenerative brake consists of a resistance force that is generated at the rotational axle in the reverse direction of the rotation of the generator (MG2) that is generating electricity. The greater the generated amperage (battery charging amperage), the greater will be the resistance force.



- The drive axle and MG2 are joined mechanically. When the drive wheels rotate MG2 and cause it to operate as a generator, a regenerative brake force of MG2 is transmitted to the drive wheels. This force is controlled by the THS-II system, which controls the generation of electricity.
  The regenerative brake cooperative control does not rely solely on the braking force of the hydraulic brake system to supply the brake force required by the driver. Instead, by effecting cooperative control with the THS-II system, this control provides a joint braking force provided by the regenerative brake and the hydraulic brake. As a result, this control minimizes the loss of the kinetic energy associated with the normal hydraulic brake, and recovers this energy by converting it into electrical energy.
- On the new Prius, the power output of MG2 has increased through the adoption of the THS-II system, which has resulted in improving the regenerative brake force. In addition, the distribution of the brake force has been improved through the adoption of the ECB system, effectively increasing the use range of the regenerative brake. These attributes enhance the system's ability to recover electrical energy, which contributes to fuel economy.

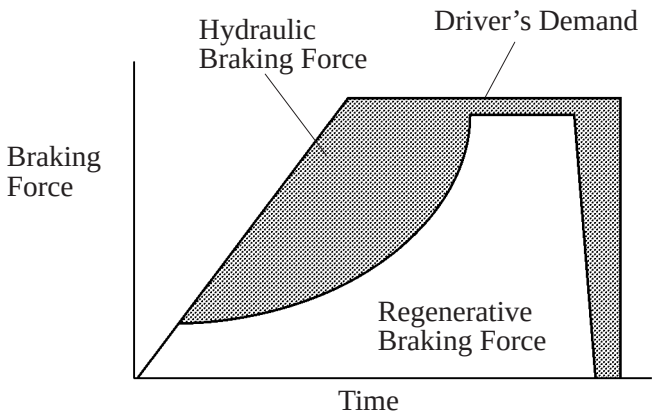
▶ Improved Regenerative Brake ◀



Apportioning of the Brake Force

- The apportioning of the brake force between the hydraulic brake and the regenerative brake varies by the vehicle speed and time.
- The apportioning of the brake force between the hydraulic brake and the regenerative brake is accomplished by controlling the hydraulic brake so that the total brake force of the hydraulic brake and the regenerative brake matches the brake force required by the driver.
- If the regenerative brake becomes inoperative due to a malfunction in the THS-II system, the brake system effects control so that the entire brake force required by the driver is supplied with the hydraulic brake system.

▶ Imagery Drawing ◀



255CH129

Changes in Braking Force Apportionment

3. Outline of EBD Control

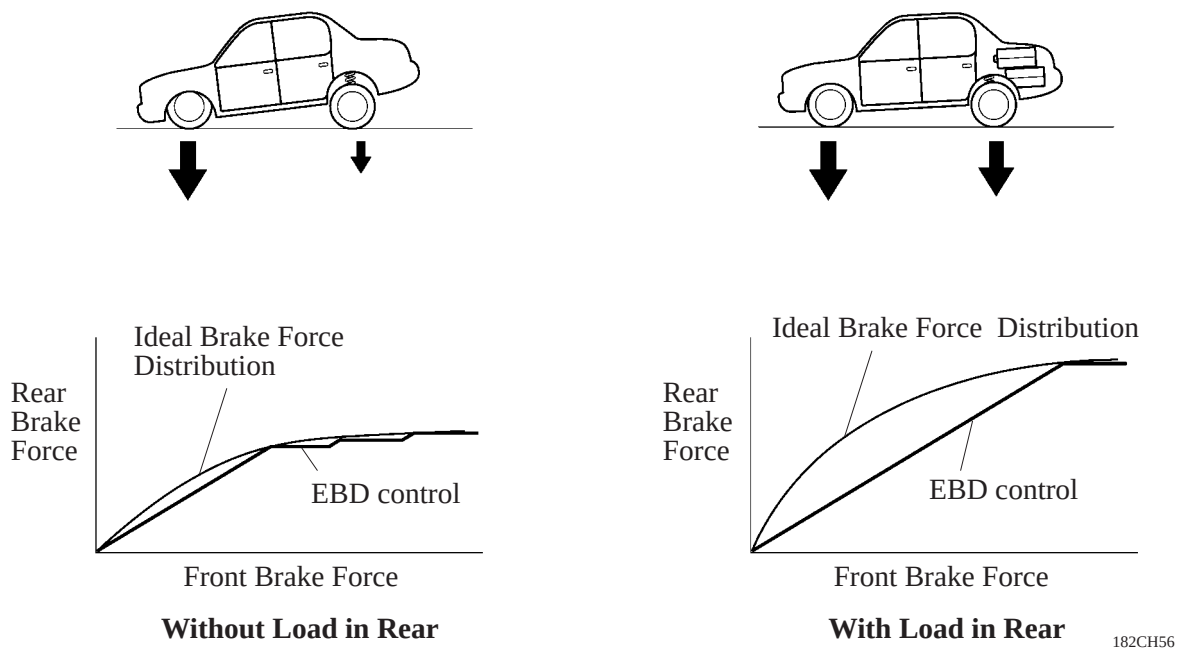
General

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

Front/ Rear Wheels Brake Force Distribution

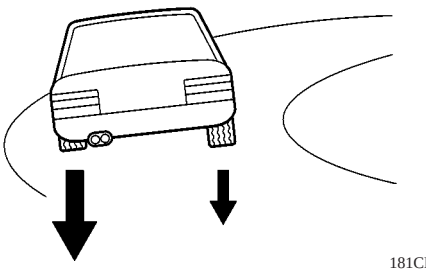
If the brakes are applied while the vehicle is moving straight forward, the transfer of the road reduces the load that is applied to the rear wheels. The skid control ECU determines this condition by way of the signals from the speed sensor, and the brake actuator regulates the distribution of the brake force of the rear wheels to optimally control.
For example, the amount of the brake force that is applied to the rear wheels during braking varies whether or not the vehicle is carrying a load. The amount of the brake force that is applied to the rear wheels also varies in accordance with the extent of the deceleration.
Thus, the distribution of the brake force to the rear is optimally controlled in order to effectively utilize the braking force of the rear wheels under these conditions.

▶ EBD Control Concept ◀



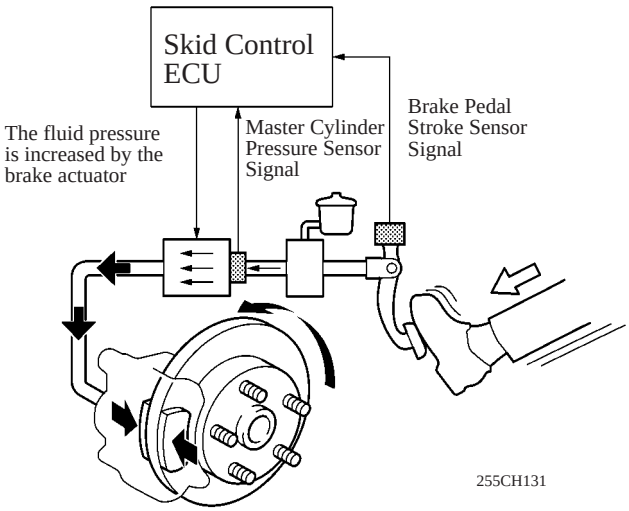
Right/Left Wheels Brake Force Distribution (During Cornering Braking)

When the brakes are applied while the vehicle is cornering, the load that applied to the inner wheel decreases to the outer wheel increases.
The skid control ECU determines this condition by way of the signals from the speed sensor, and the brake actuator regulates the brake force in order to optimally control the distribution of the brake force to the inner wheel and outer wheel.

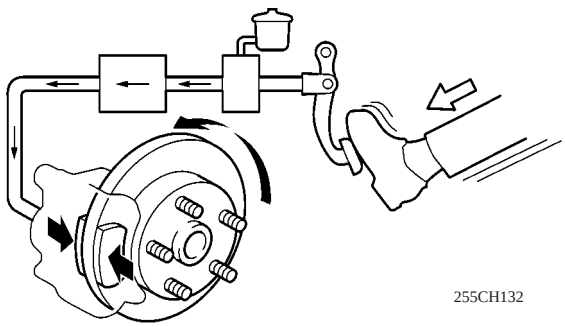


4. Outline of Brake Assist System

- The Brake Assist System interprets a quick push of the brake pedal as emergency braking and supplements the braking power applied if the driver has not stepped hard enough on the brake pedal. In emergencies, drivers, especially inexperienced ones, often panic and do not apply sufficient pressure on the brake pedal. Based on the signals from the master cylinder pressure sensors and the brake pedal stroke sensor, the skid control ECU calculates the speed and the amount of the brake pedal application and then determines the intention of the driver to make an emergency braking. If the skid control ECU determines that the driver intends emergency braking, the system activates the brake actuator to increase the brake fluid pressure. The Brake Assist System in combination with ABS helps ensure the vehicle's brake performance.
  A key feature of 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. When the driver intentionally eases up on the brake pedal, the system reduces the amount of assistance it provides.
- In case that the vehicle is fully loaded, stronger brake force may be required even if the brakes are not applied quickly. Then, the brake assist system also operates to increase brake force.

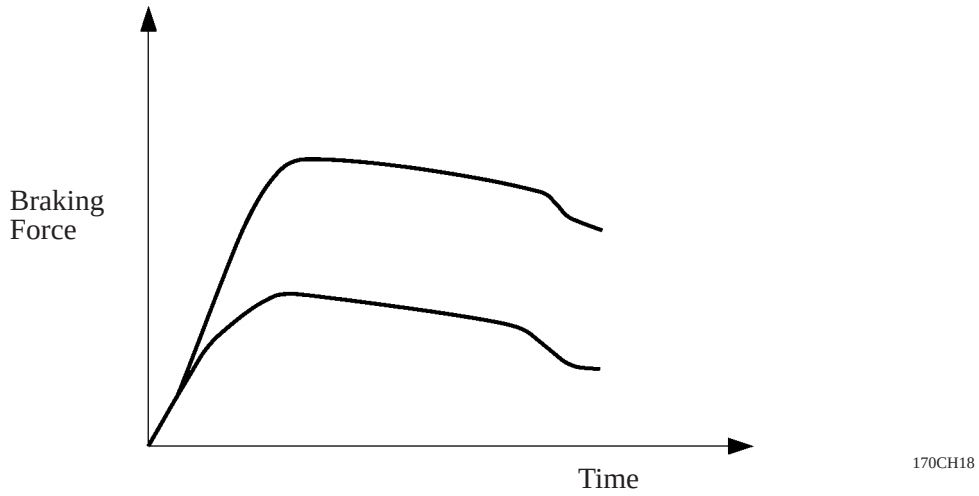


with Brake Assist System



without Brake Assist System

◆: There is no difference of the maximum brake performance between the vehicles with and without brake assist system.



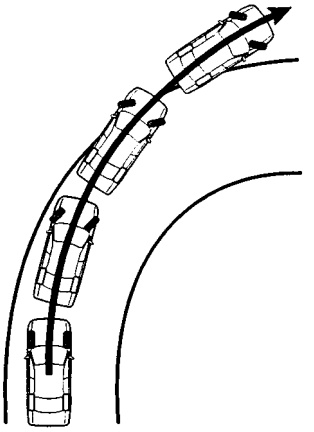
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5. Outline of VSC+ System

General

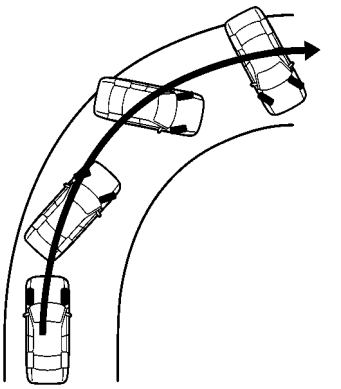
The followings are two examples that can be considered as circumstances in which the tires exceed their lateral grip limit.
The VSC+ system is designed to help control the vehicle behavior by controlling the motive force and the brakes at each wheel when the vehicle is under one of the conditions indicated below.

- When the front wheels lose grip in relation to the rear wheels (front wheel skid tendency).
- When the rear wheels lose grip in relation to the front wheels (rear wheel skid tendency).



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Front Wheel Skid Tendency



189CH100

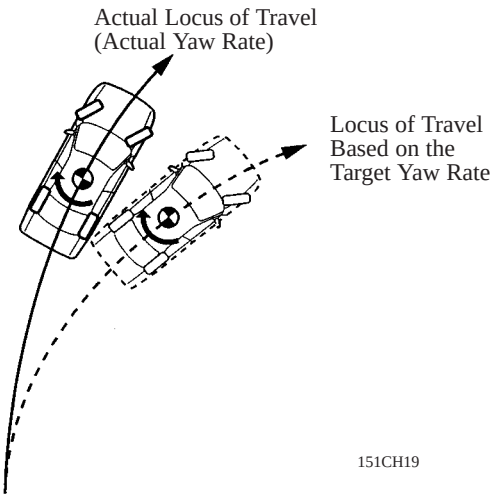
Rear Wheel Skid Tendency

Method for Determining the Vehicle Condition

To determine the condition of the vehicle, sensors detect the steering angle, vehicle speed, vehicle's yaw rate, and the vehicle's lateral acceleration, which are then calculated by the skid control ECU.

1) Determining Front Wheel Skid

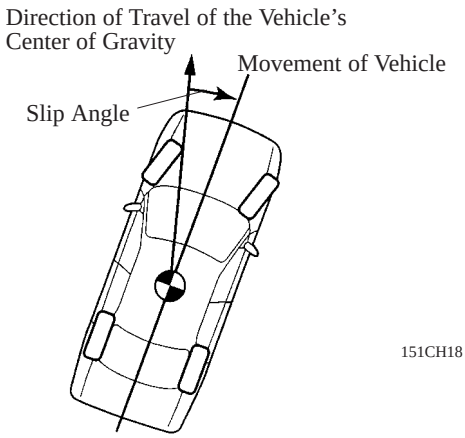
Whether or not the vehicle is in the state of front wheel skid is determined by the difference between the target yaw rate and the vehicle's actual yaw rate.
When the vehicle's actual yaw rate is smaller than the yaw rate (a target yaw rate that is determined by the vehicle speed and steering angle) that should be rightfully generated when the driver operates the steering wheel, it means the vehicle is making a turn at a greater angle than the locus of travel.
Thus, the skid control ECU determines that there is a large tendency to front wheel skid.



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2) Determining Rear Wheel Skid

Whether or not the vehicle is in the state of rear wheel skid is determined by the values of the vehicle's slip angle and the vehicle's slip angular velocity (time-dependent changes in the vehicle's slip angle). When the vehicle's slip angle is large, and the slip angular velocity is also large, the skid control ECU determines that the vehicle has a large rear wheel skid tendency.



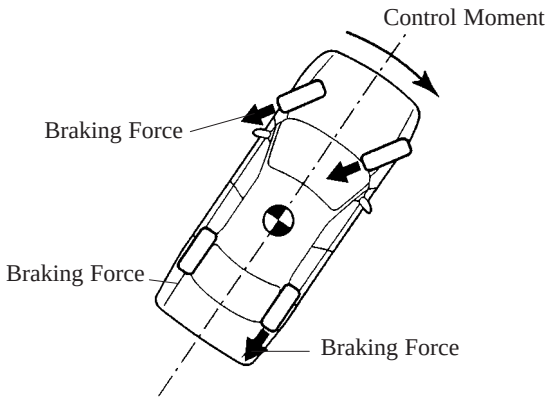
Method for VSC+ Operation

When the skid control ECU determines that the vehicle exhibits a tendency to front wheel skid or rear wheel skid, 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 VSC+ is described below. However, the control method differs depending on the vehicle's characteristics and driving conditions.

CH

1) Dampening a Front Wheel Skid

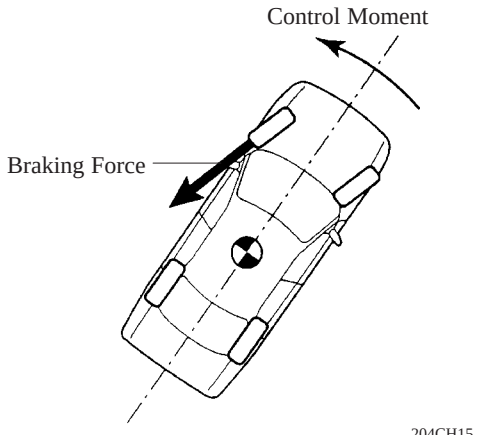
When the skid control ECU determines that there is a large front wheel skid tendency, it counteracts in accordance with the extent of that tendency. The skid control ECU controls the motive power output and applies the brakes of the front wheel of the outer circle in the turns and rear wheels in order to restrain the front wheel skid tendency.



Making a Right Turn

2) Dampening a Rear Wheel Skid

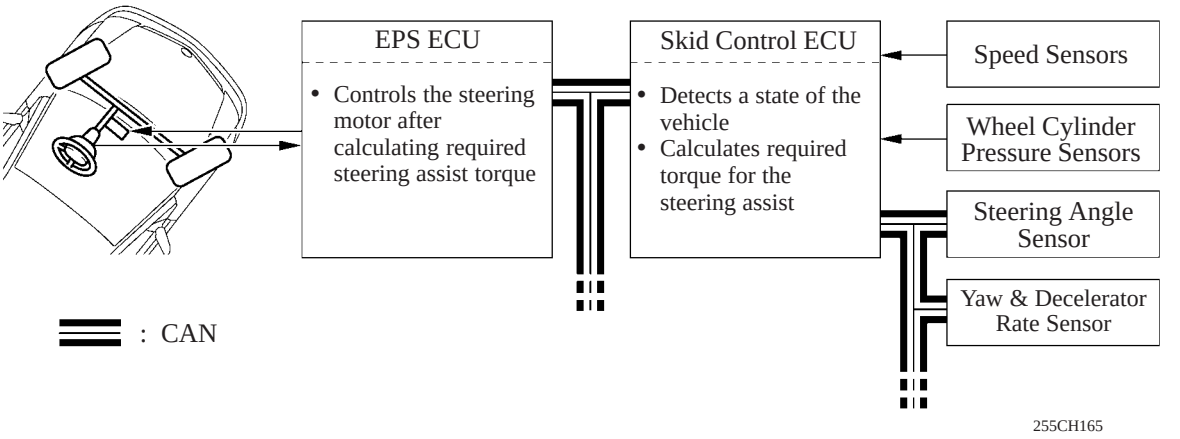
When the skid control ECU determines that there is a large rear wheel skid tendency, it counteracts in accordance with the extent of that tendency. It applies the brakes of the front wheel of the outer circle of the turn, and generates an outward moment of inertia in the vehicle, in order to restrain the rear wheel skid tendency. Along with the reduction in the vehicle speed caused by the braking force, the excellent vehicle's stability is ensured.
In some cases, the skid control ECU applies the brake of the rear wheels, as necessary.



Making a Right Turn

Cooperative Control with EPS

VSC+ provides the steering assist in order to facilitate steering operation of the driver depending on vehicle situations by coordination of cooperative control with EPS, in addition to the general VSC control.

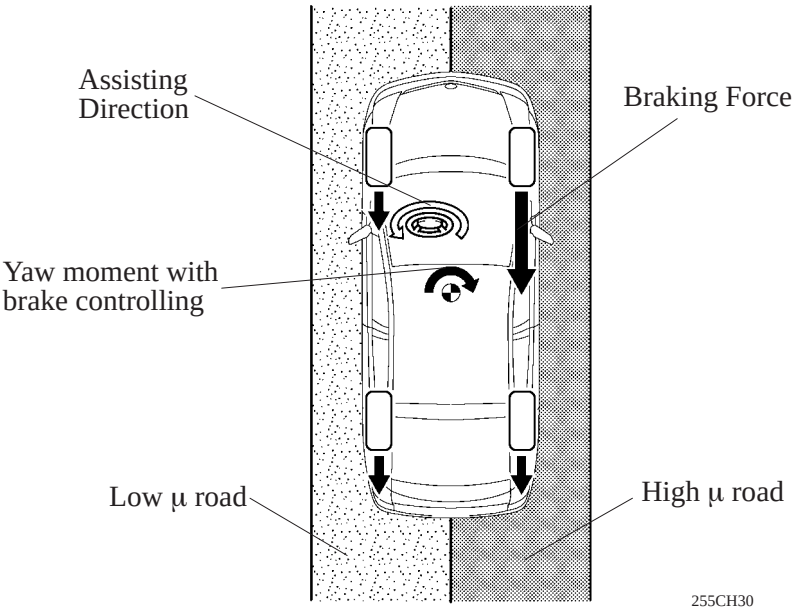


Operation in a wheel skid tendency

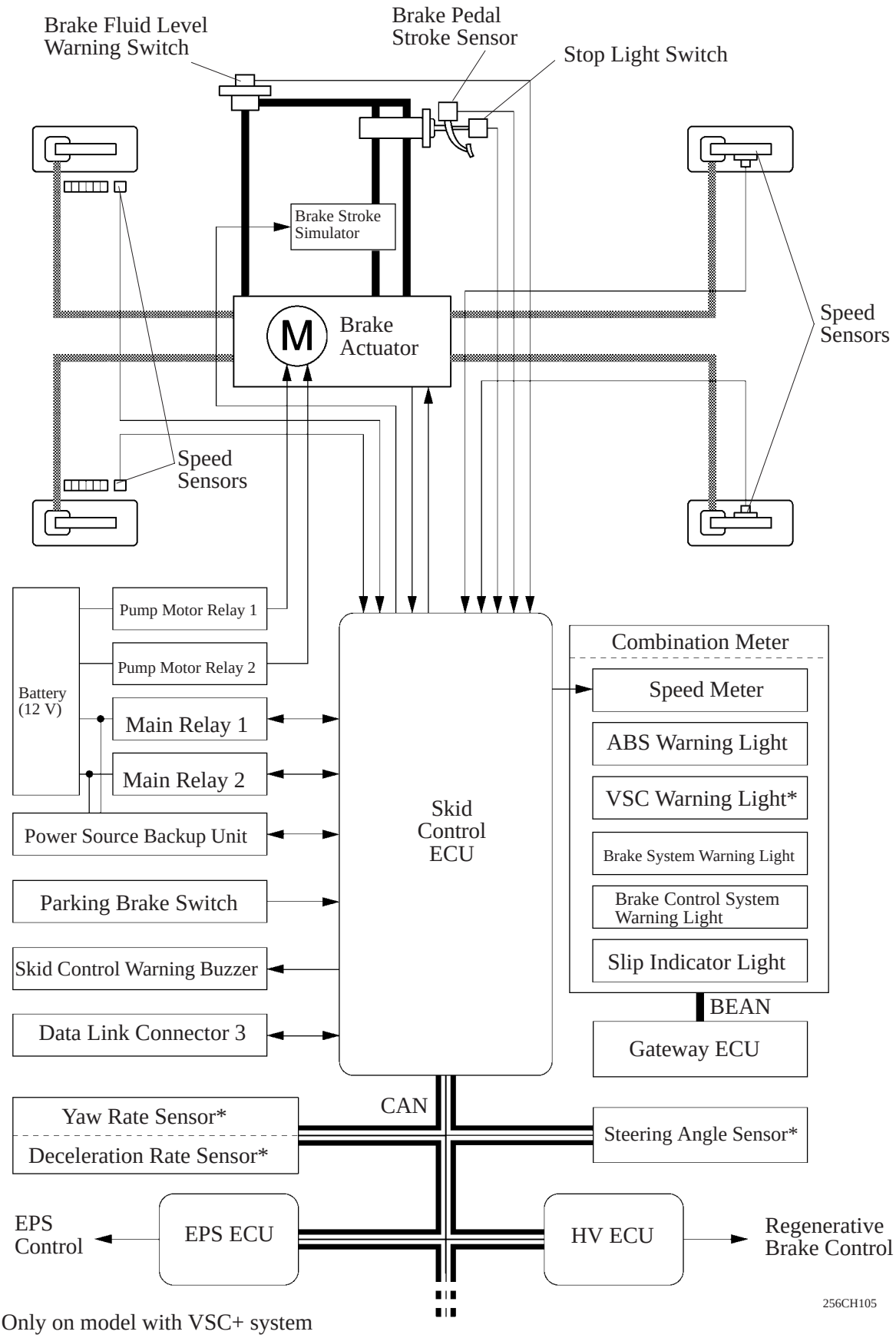
- When the rear wheels lose grip, this system control the brake force and the motive force. At the same time, the system controls the steering torque to facilitate the steering effort of the driver.
- When the front wheels exhibit the tendency to skid, the driver could turn the steering wheel excessively, which could worsen the situation. To prevent this, VSC+ provides steering torque assist.

Operation in braking when surface resistance differs to both sides of the wheels

If the vehicle is braking while its right and left wheels are on surfaces with a different resistance, a difference will be created in the braking force applied to the right and left wheels, depending on the strength of the braking force. This will generate a yaw moment, which could require a steering maneuver. In this situation, VSC+ can effect cooperative control jointly with the EPS ECU, and provide a steering torque assist in the direction to cancel out the generated moment. By operating the EPS in this manner and facilitating the steering effort of the driver, VSC+ helps to make the vehicle stable.



6. System Diagram

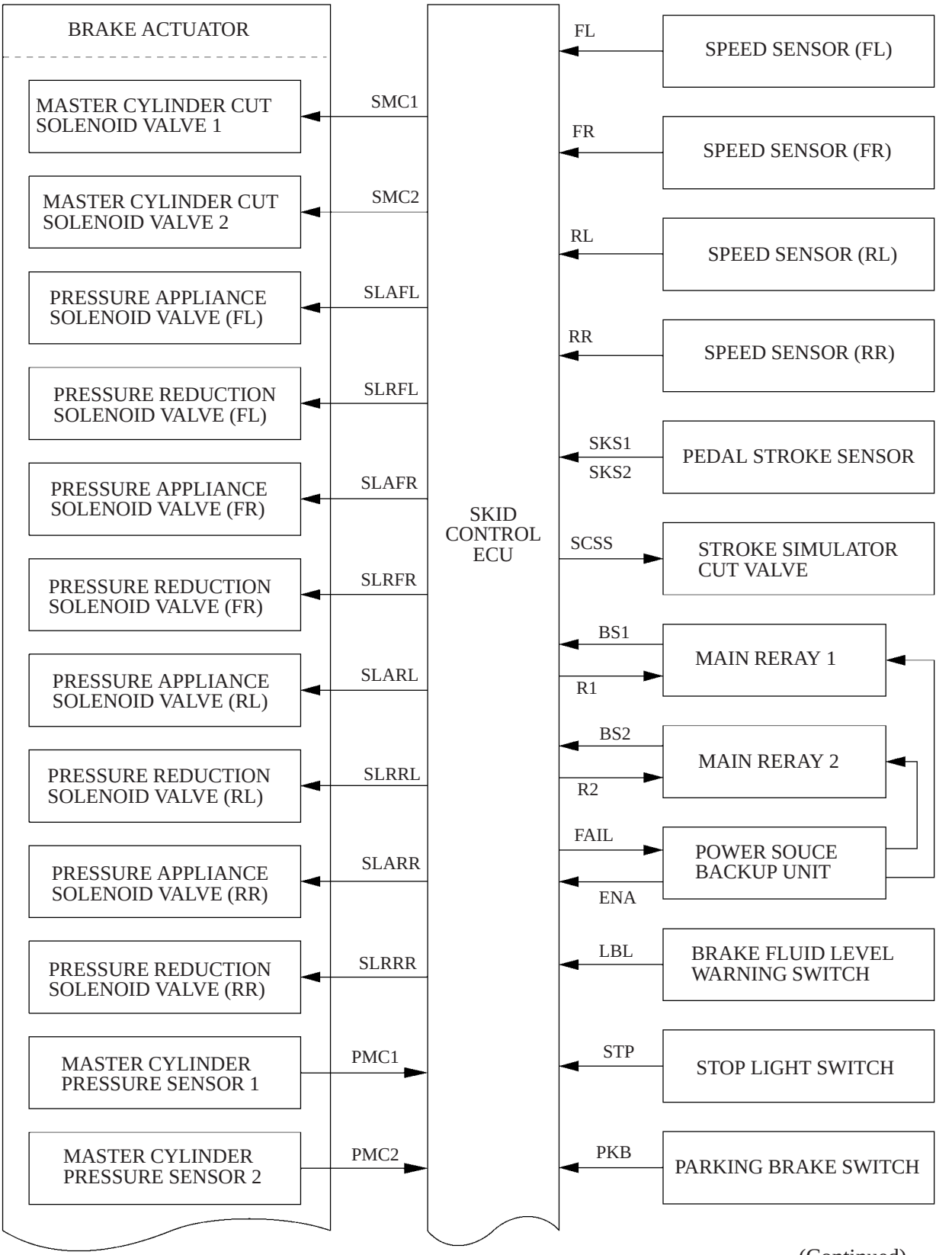


*: Only on model with VSC+ system

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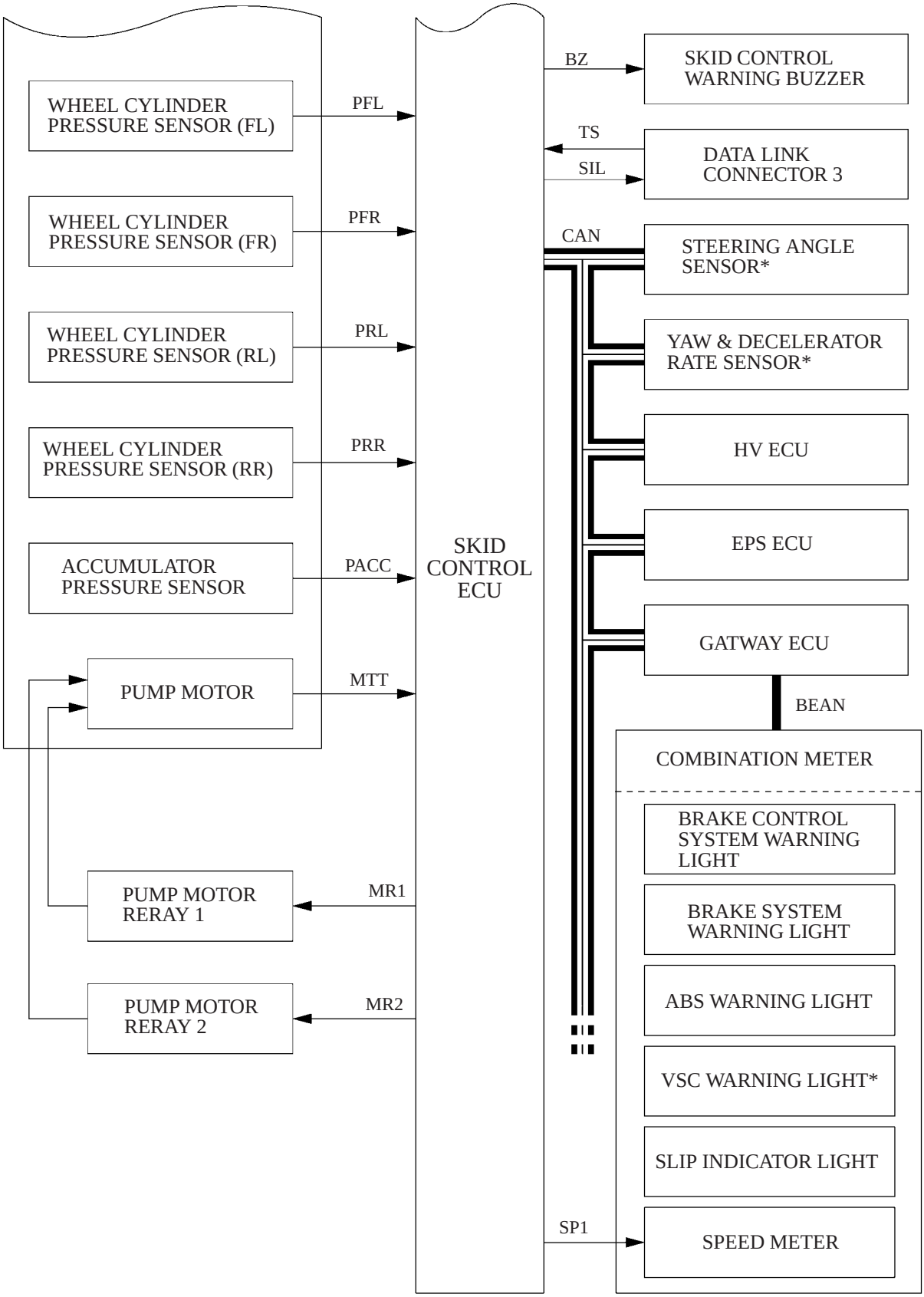
7. Construction

The configuration of the brake control system on the new Prius is as shown in the following chart.



(Continued)

255CH162

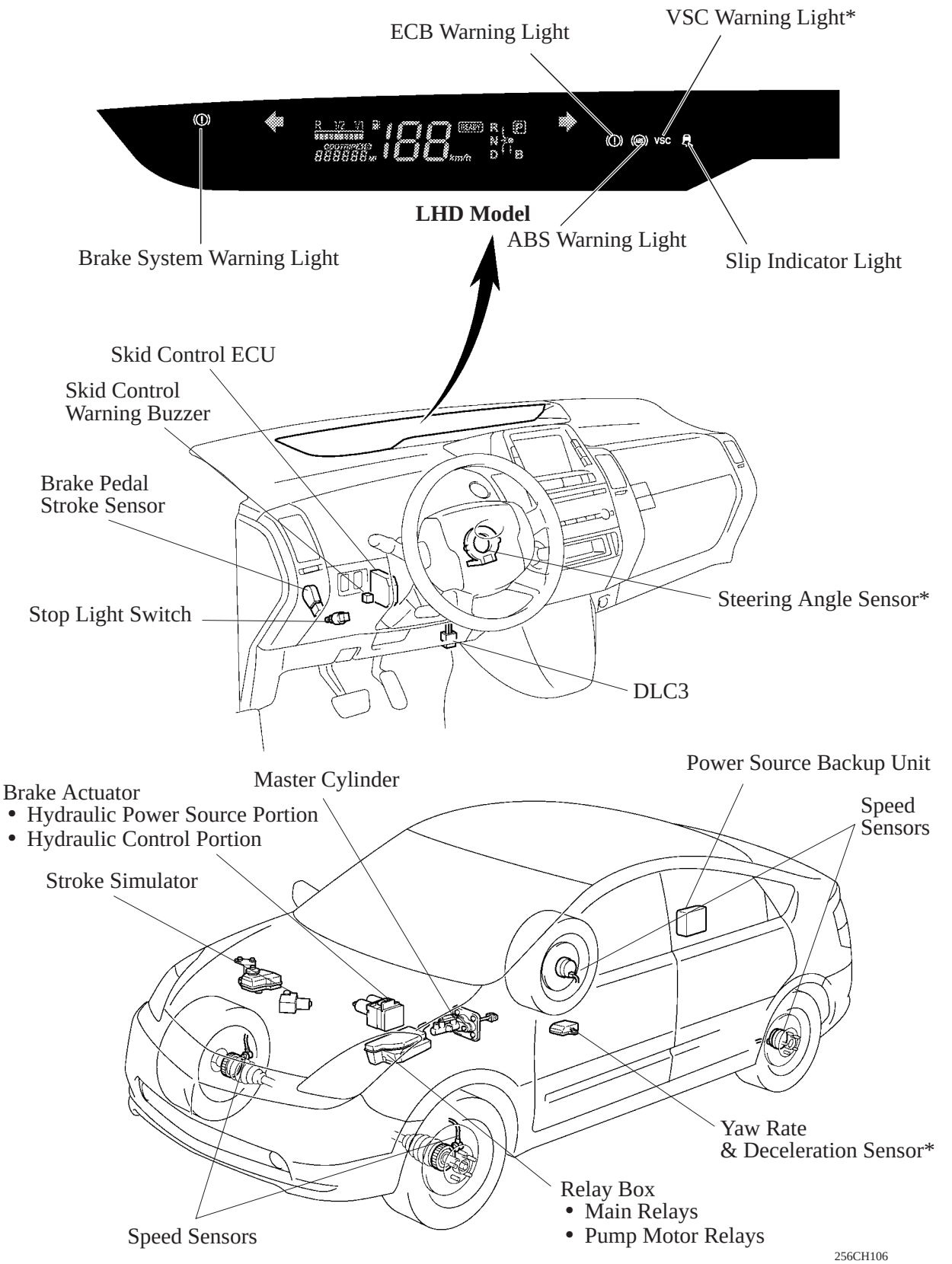


*: Only on model with VSC+ system

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8. Layout of Main Component



*: Only on model with VSC+ system

9. Function of Main Components

Component		Function
Brake Actuator	Hydraulic Power Source Portion	• Consisting of a pump, pump motor, accumulator, relief valve, and accumulator pressure, the hydraulic power source portion generates and stores the hydraulic pressure, which the skid control ECU uses for controlling braking. • The accumulator pressure sensor is installed in the brake actuator.
	Hydraulic Control Potion	• Consists of 2 master cylinder cut solenoid valves, 4 pressure appliance solenoid valves, and 4 pressure reduction solenoid valves. • The 2 master cylinder cut solenoid valves, which are the two-position type, are controlled by the skid control ECU to open and close the passage between the master cylinder and the wheel cylinders. • The 4 pressure appliance solenoid valves and the 4 pressure reduction solenoid valves are the linear type. They are controlled by the skid control ECU to increase and decrease the fluid pressure in the wheel cylinders. • The master cylinder pressure sensors and the wheel cylinder pressure sensors are installed in the brake actuator.
Skid Control ECU		• Processes various sensor signals, regenerative brake signal, to execute control of the regenerative brake coordination control, the ABS with EBD, VSC+, Brake assist, and normal brake. • Judges the vehicle driving condition based on signals from each sensor, and control the brake actuator.
Brake Master Cylinder		When a malfunction occurs in the power supply portion, the brake master cylinder supplies the fluid pressure (which is generated by the brake pedal effort) directly to the wheel cylinders.
Brake Pedal Stroke Sensor		Directly detects the extent of the brake pedal stroke operated by the driver.
Stroke Simulator		Generates a pedal stroke during braking in accordance with the driver's pedal effort.
Combination Meter	ABS Warning Light	Lights up to alert the driver when the skid control ECU detects the malfunction in the ABS, EBD, or Brake Assist system.
	VSC Warning Light*	Lights up to alert the driver when the skid control ECU detects the malfunction in the VSC+ system.
	Slip Indicator Light	Blinks to inform the driver when the ABS system, the VSC+ system or the motor traction control is operated.
	Brake Control System Warning Light	Lights up to alert the driver when a minor malfunction occurs in the brake system, which does not affect the braking force (such as a malfunction in the regenerative brake).
	Brake System Warning Light	• Lights up to alert the driver when the skid control ECU detect the malfunction in the apportioning of the brake. • Lights up to inform the driver when the parking brake is ON or the brake fluid level is low.

(Continued)

Component		Function
Skid control warning buzzer		• This buzzer sounds continuously to inform the driver when there is a malfunction in the hydraulic pressure or a failure in the power supply. • On a model equipped with VSC+, this buzzer sounds intermittently to inform the driver that the VSC+ is active.
HV ECU		• Actuates the regenerative brake on receiving signal from the skid control ECU. • Sends the actual regenerative brake control value to the skid control ECU. • Controls the motive force based on output control request signal from the skid control ECU when the VSC+ system is operating. • Sends the rear brake actuation signal to the skid control ECU when brake control is required during the up hill assist control.
Reservoir Tank		Stores the brake fluid.
	Brake Fluid Level Warning Switch	Detects the low brake fluid level.
Stop Light Switch		Detects the brake pedal-depressing signal.
Yaw Rate & Decelerator Rate Sensor*		• Detects the vehicle's yaw rate. • Detects the vehicle's acceleration in the forward, rearward, and lateral.
Steering Angle Sensor*		Detects the steering direction and angle of the steering wheel.
Pump Motor relay 1,2 (See Page CH-51)		• Two types of pump motor relays with different pump actuation speeds. • If one relay fails, the other relay operates to actuate the pump.
Main Relays		Controlled by the skid control ECU, the main relay supplies or cuts off power to the solenoid valves in the brake actuator and the skid control ECU.
Power Source Backup Unit		• An auxiliary power supply to provide stable power to the brake system. • Complements the supply of power to the brake system by discharging the electric charge that is stored in the unit when the voltage of the (12 V) power supply of the vehicle is low.

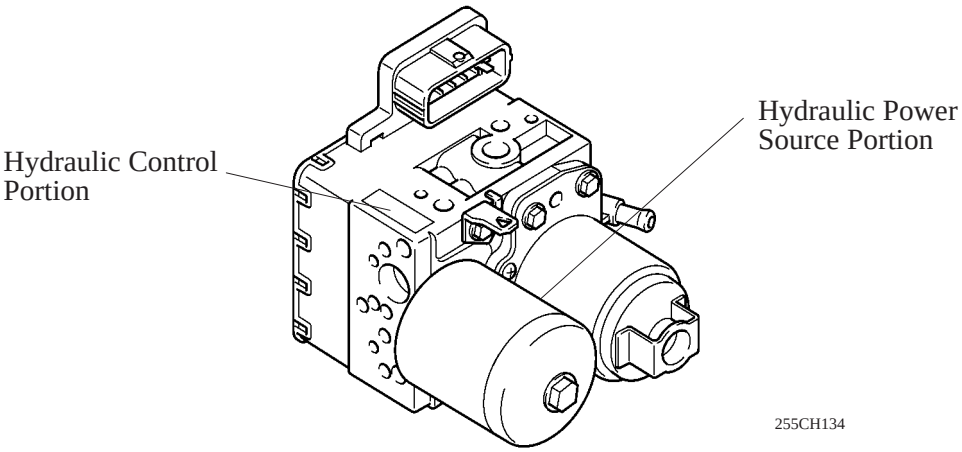
*: Only on model with VSC+ system

10. Construction and Operation of Main Component

Brake Actuator

1) General

- The brake actuator of the new Prius consists of hydraulic control and hydraulic power source portions.
- The two master cylinder pressure sensors, four wheel cylinder pressure sensors, and an accumulator pressure sensor are installed in the brake actuator.



▶ Function of Main Components ◀

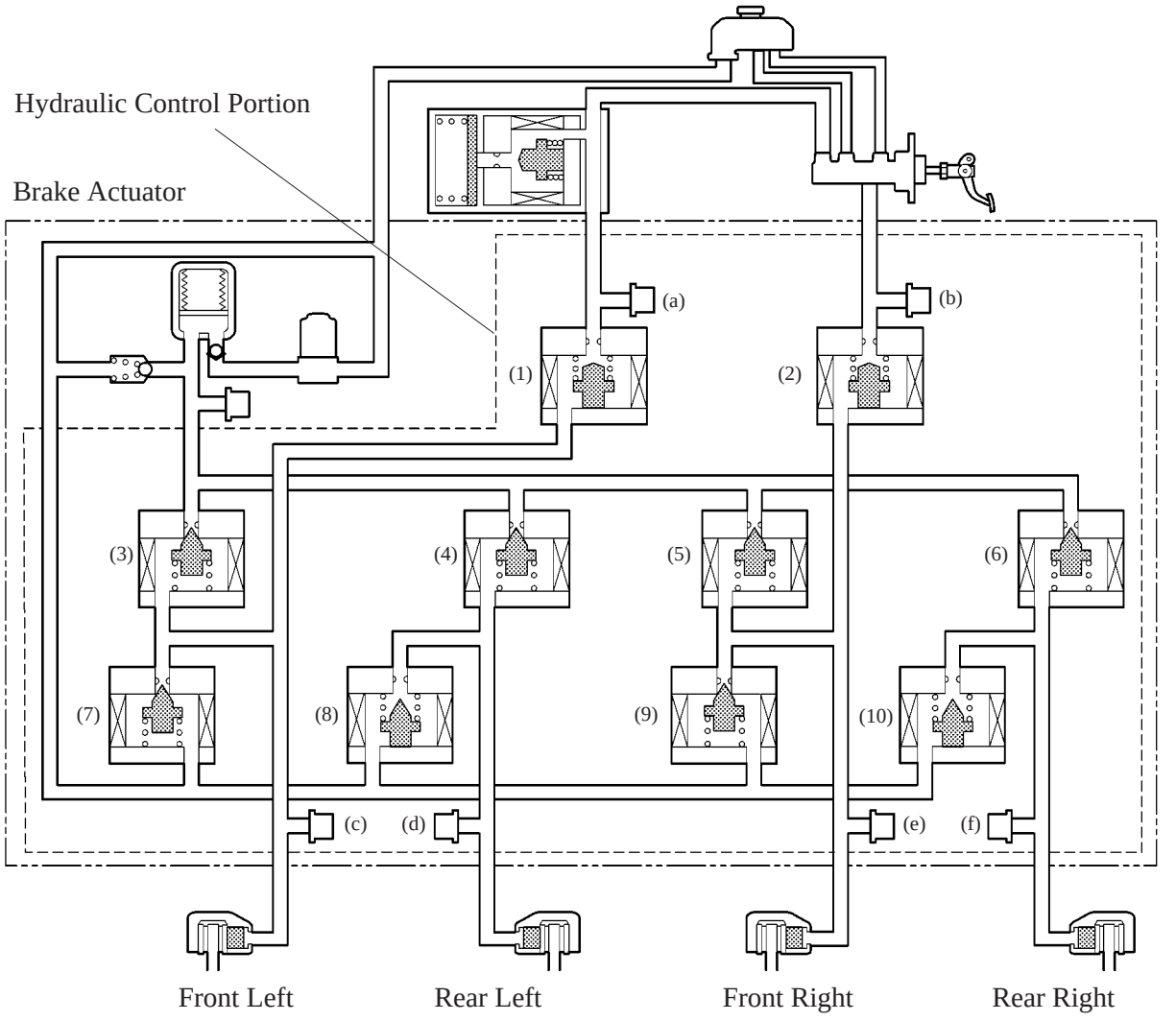
Component	Function
Master Cylinder Cut Solenoid Valve (2-position Type)	• When the brake system is started, this valve cuts the hydraulic passage between the master cylinder and the wheel cylinder. • When the brake system is stopped or a failure occurs in the hydraulic power source portion, the valve opens to maintain the hydraulic passage to the front wheel cylinders and ensure braking. However, a greater effort than normal is required to press the brake pedal.
Pressure Appliance Solenoid Valve (Linear Type)	This valve, which is controlled by the skid control ECU, regulates the fluid pressure from the accumulator in order to amplify the fluid pressure to the wheel cylinder.
Pressure Reduction Solenoid Valve (Linear Type)	This valve, which is controlled by the skid control ECU, regulates the fluid pressure in order to reduce the fluid pressure to the wheel cylinder.
Master Cylinder Pressure Sensors	The master cylinder pressure sensor converts the fluid pressure generated by the master cylinder into electrical signals and transmits them to the skid control ECU. Accordingly, the skid control ECU determines the braking force required by the driver.
Wheel Cylinder Pressure Sensors	These sensors detect the fluid pressure that acts on the respective wheel cylinders and transmits them to the skid control ECU in the form of feedback. Accordingly, the skid control ECU monitors the fluid pressure of the wheel cylinders and controls the pressure appliance solenoid valve and the pressure reduction solenoid valve, in order to achieve the optimal wheel cylinder pressures.
Accumulator Pressure Sensor	The accumulator pressure sensor constantly detects the brake fluid pressure in the accumulator and transmits the signals to the skid control ECU. Accordingly, the skid control ECU controls the pump motor.
Pump and Pump Motor	Draws up the brake fluid from the reservoir tank and provides high hydraulic pressure to the accumulator.
Accumulator	Stores the hydraulic pressure that was generated by the pump. The accumulator is filled with high pressure nitrogen gas.
Relief Valve	Returns the brake fluid to the reservoir tank to prevent excessive pressure if the pump operates continuously due to a malfunction of the accumulator pressure sensor.

2) Hydraulic Control Portion

The 10 solenoid valves and 6-pressure sensors consists of the following:

- 2 master cylinder cut solenoid valves [(1), (2)]
- 4 pressure appliance valves [(3), (4), (5), (6)]
- 4 pressure reduction valves [(7), (8), (9), (10)]
- 2 master cylinder pressure sensor [(a), (b)]
- 4 wheel cylinder pressure sensor [(c), (d), (e), (f)]

▶ Hydraulic Circuit ◀



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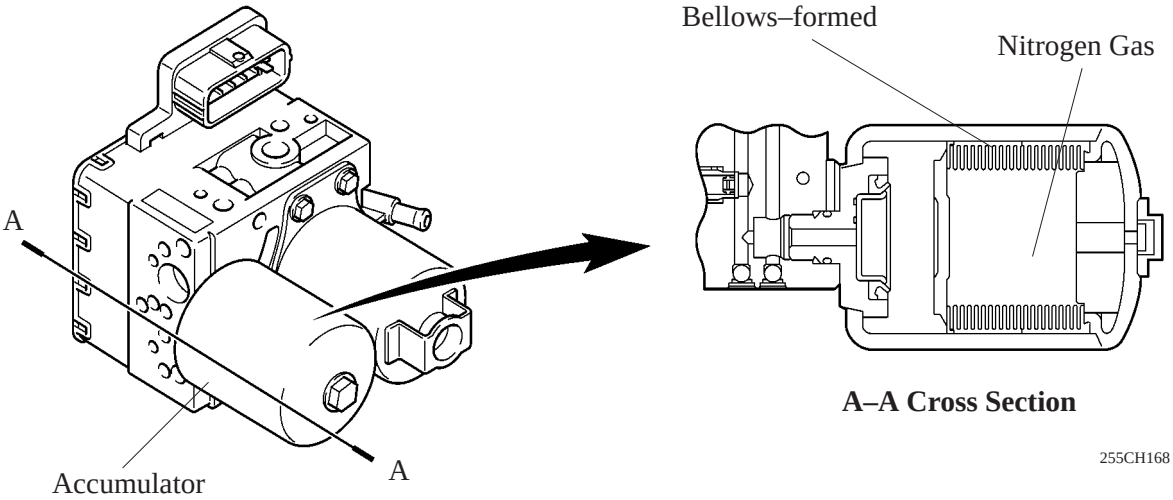
3) Hydraulic Power Source Portion

a. General

The hydraulic power source portion consists of pump, pump motor, accumulator, relief valve, 2 motor relays, and accumulator pressure sensor.

b. Accumulator

Inside the accumulator of the new Prius, as same as the previous model, the high-pressurized nitrogen gas is charged and sealed. On the new Prius, metallic bellows-formed tube has been adopted, in order to enhance the gastight performance of the accumulator.

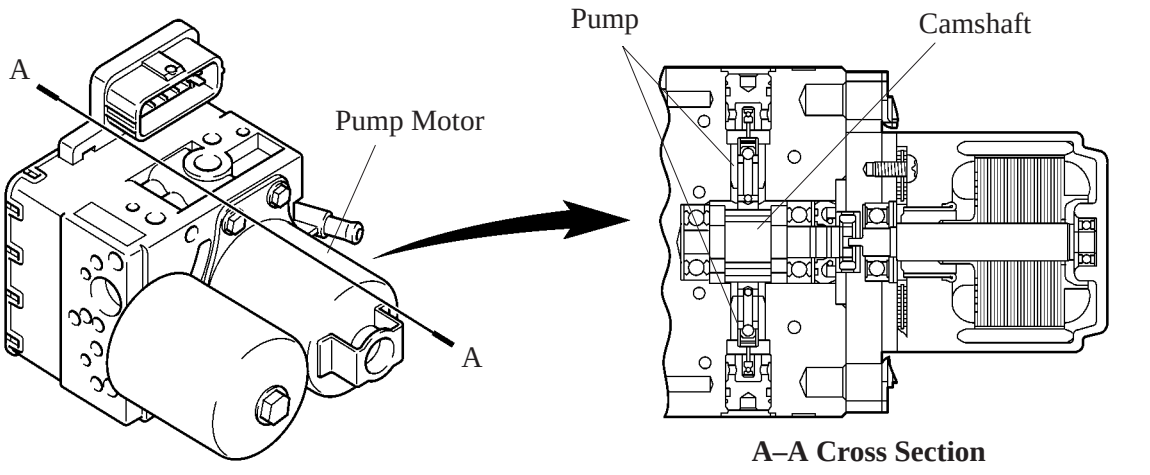


A–A Cross Section

255CH168

c. Pump and Pump Motor

A plunger type pump has been adopted. This pump is operated by the rotation of the camshaft driven by the motor, and then supplies high-pressurized fluid to the accumulator.

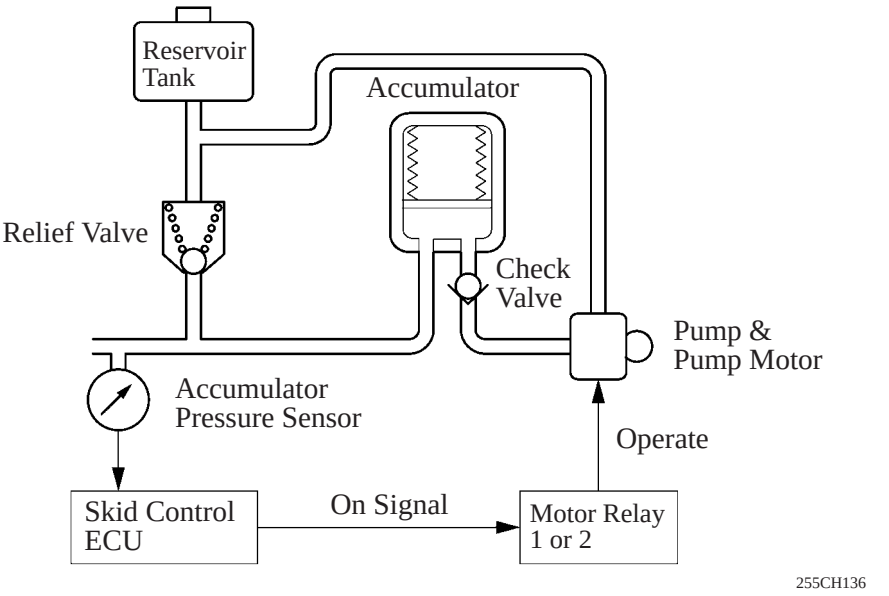


A–A Cross Section

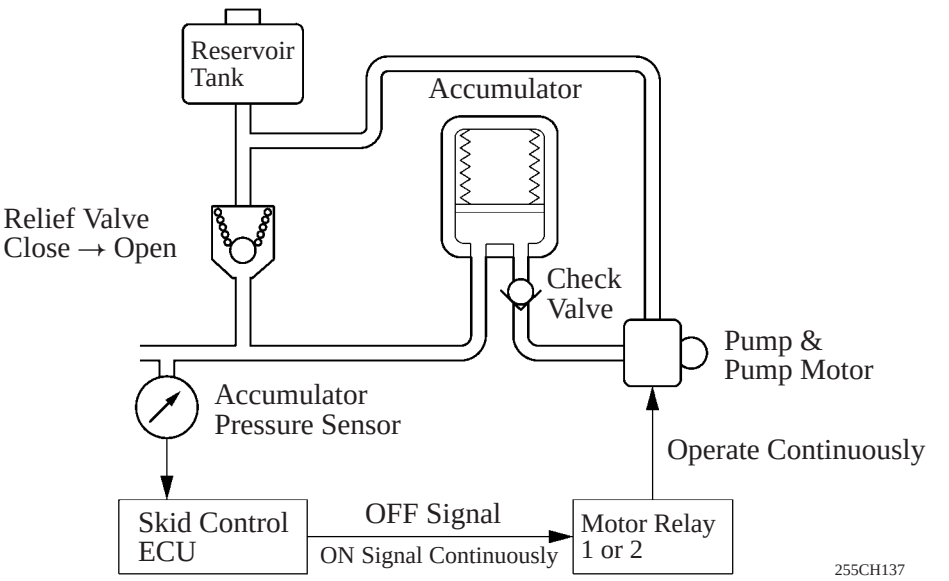
255CH169

d. Operation

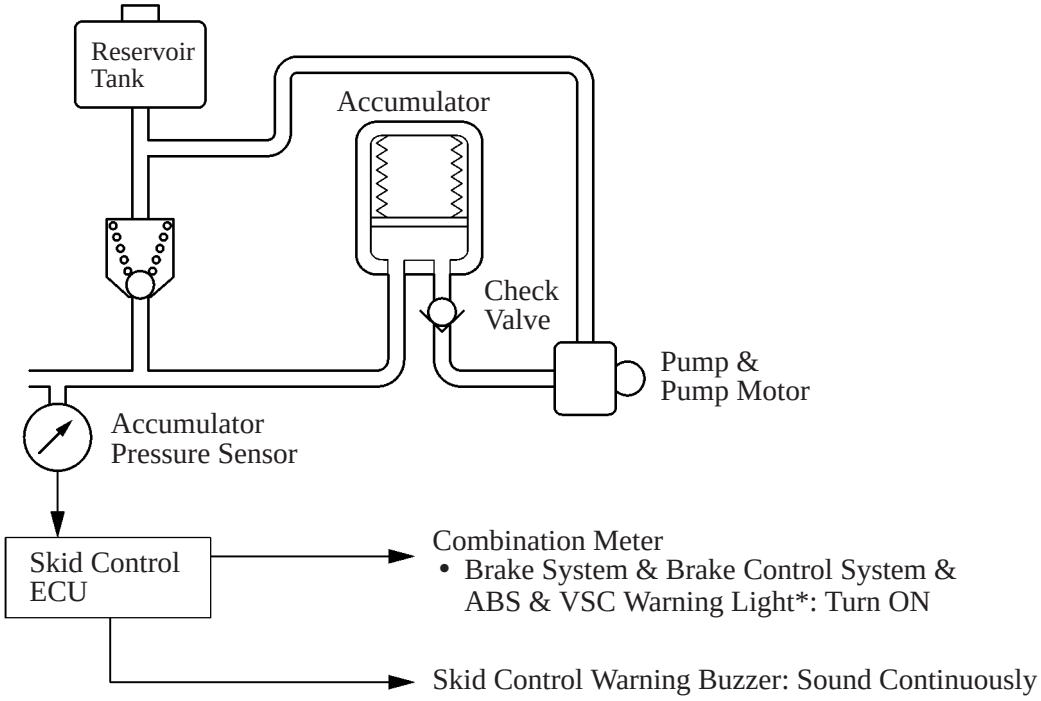
- The brake fluid that is discharged by the pump passes through the check valve and is stored in the accumulator. The hydraulic pressure that is stored in the accumulator is used for providing the hydraulic pressure that is needed for normal braking and for operating the brake control.
- The motor relays consist of the following relays with different pump actuation speeds: relay 1 (low speed) and relay 2 (high speed). Normally, relay 1 with the slow pump speed is used. When the fluid pressure drops quickly because more fluid pressure is required, such as in ABS fluid pressure control, relay 2 with the fast pump speed is used. If one of the relays malfunctions, the other is used for actuating the pump.
- The accumulator pressure sensor constantly monitors the pressure in the accumulator and transmits it to the skid control ECU. If the accumulator pressure drops below the set pressure, the skid control ECU sends an activation signal to the motor relay in order to actuate the pump motor until the pressure in the accumulator reaches the set pressure.



- If the pump and the pump motor continue to operate unintendedly, creating a high pressure in the accumulator, and accumulator sensor faild, the relief valve opens to return the brake fluid to the reservoir tank, in order to reduce the accumulator pressure.



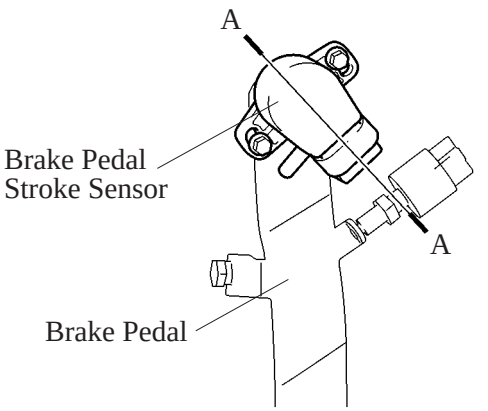
- If the accumulator pressure drops abnormally to a level below the pressure set at the ECU, the skid control ECU illuminates the brake system warning light, brake control system warning light, ABS warning light, and the VSC warning light and sounds a skid control warning buzzer to alert the driver of the abnormal fluid pressure.

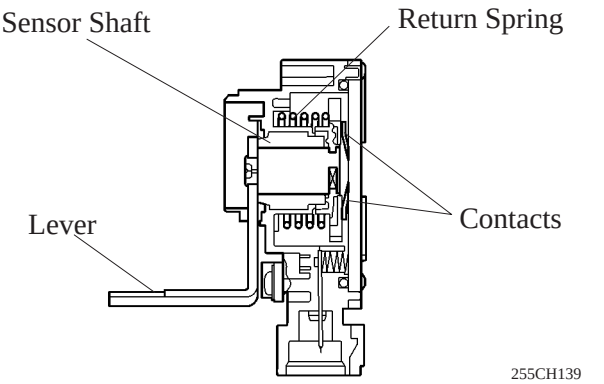


*: Only on model with VSC+ system

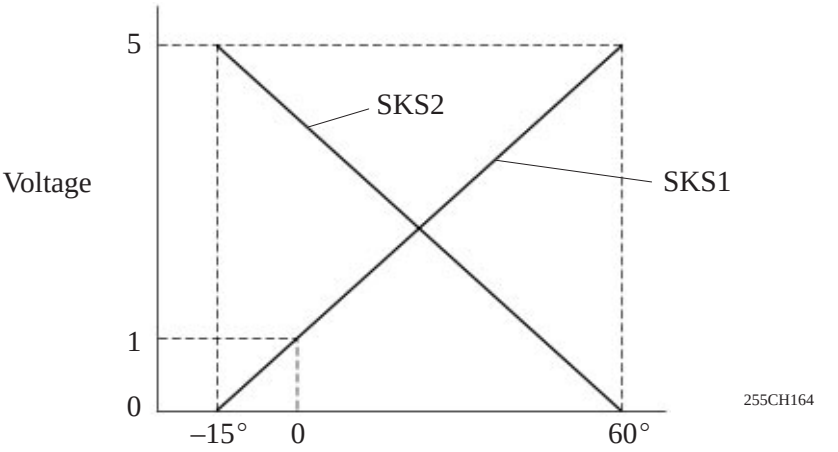
Brake Pedal Stroke Sensor

This sensor, which contains a contact type variable resistor, detects the extent of the brake pedal stroke and transmits it to the skid control ECU.





A–A Cross Section



Sensor Lever Rotational Angle

Service Tip

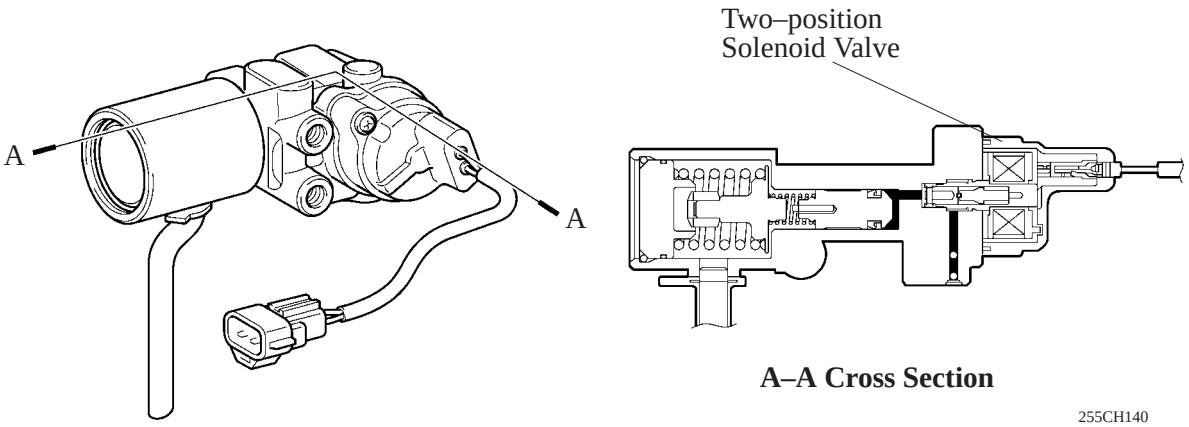
To install a brake pedal stroke sensor, which is available as a service part, perform as follows:

- 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.

For the actual procedure, refer to the Prius Repair Manual (Pub. No. RM1076E).

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 2 types of coil springs with different spring constants, the stroke simulator provides pedal stroke characteristics in 2 stages in relation to the master cylinder pressure.

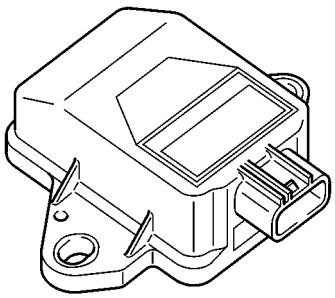


A–A Cross Section

255CH140

Yaw Rate Sensor (With VSC+ system)

A deceleration rate sensor is built into the yaw rate sensor. This sensor detects the yaw rate and lateral acceleration, and sends this signal to the skid control ECU.



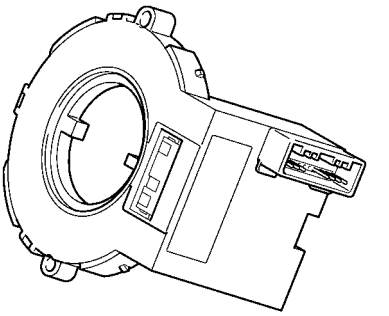
255CH141

Service Tip

After replacing the yaw rate sensor or the skid control ECU, initialization of both deceleration sensor and yaw rate sensor must be required on the skid control ECU side.
For the actual procedure, refer to the Prius repair manual (Pub. No. RM1076E).

Steering Angle Sensor (With VSC+ system)

This steering angle sensor detects the steering direction and angle, and sends this signal to the skid control ECU.
The sensor contains 3 photo interrupters with phases, and a slotted disk interrupts the light to turn the photo IC ON and OFF to detect the steering direction and angle.



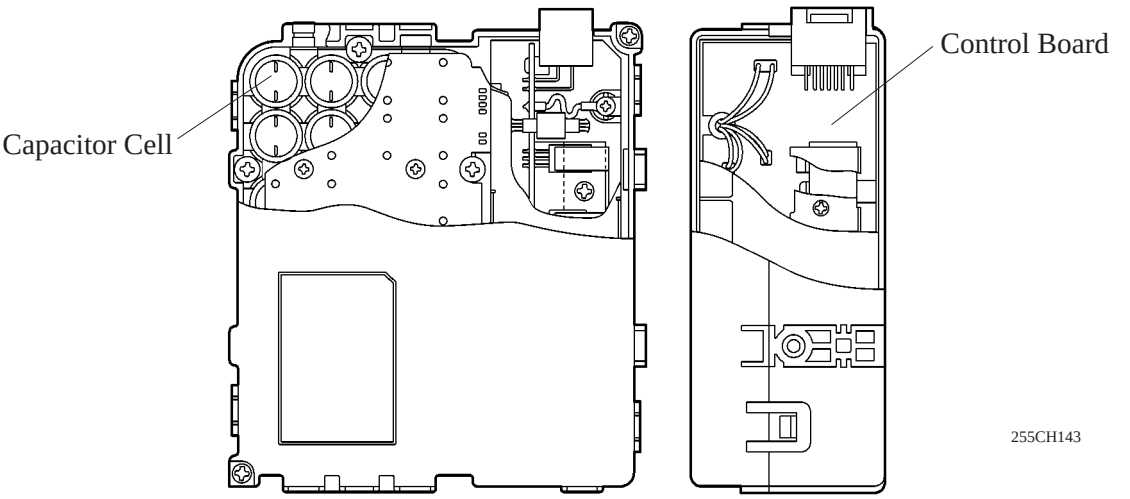
255CH142

Service Tip

The steering angle sensor will be automatically calibrated after repairing or replacing the steering angle sensor or steering column assembly.

Power Source Backup Unit

- The power source backup unit has been adopted as an auxiliary power source, in order to supply power to the brake system in a stable manner
- This unit contains 28 capacitor cells, which store an electrical charge provided by the (12 V) vehicle power supply. When the voltage of the (12 V) 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.



255CH143

Service Tip

Immediately after the power switch is turned OFF, this unit is in the discharging state, and some voltage remains in the capacitors. Therefore, make sure to check for residual voltage and discharge it if necessary, before removing the power source backup unit from the vehicle or opening and inspecting the inside of the power source backup unit case.
For details, refer to Prius Repair Manual (Pub. No. RM1076E).

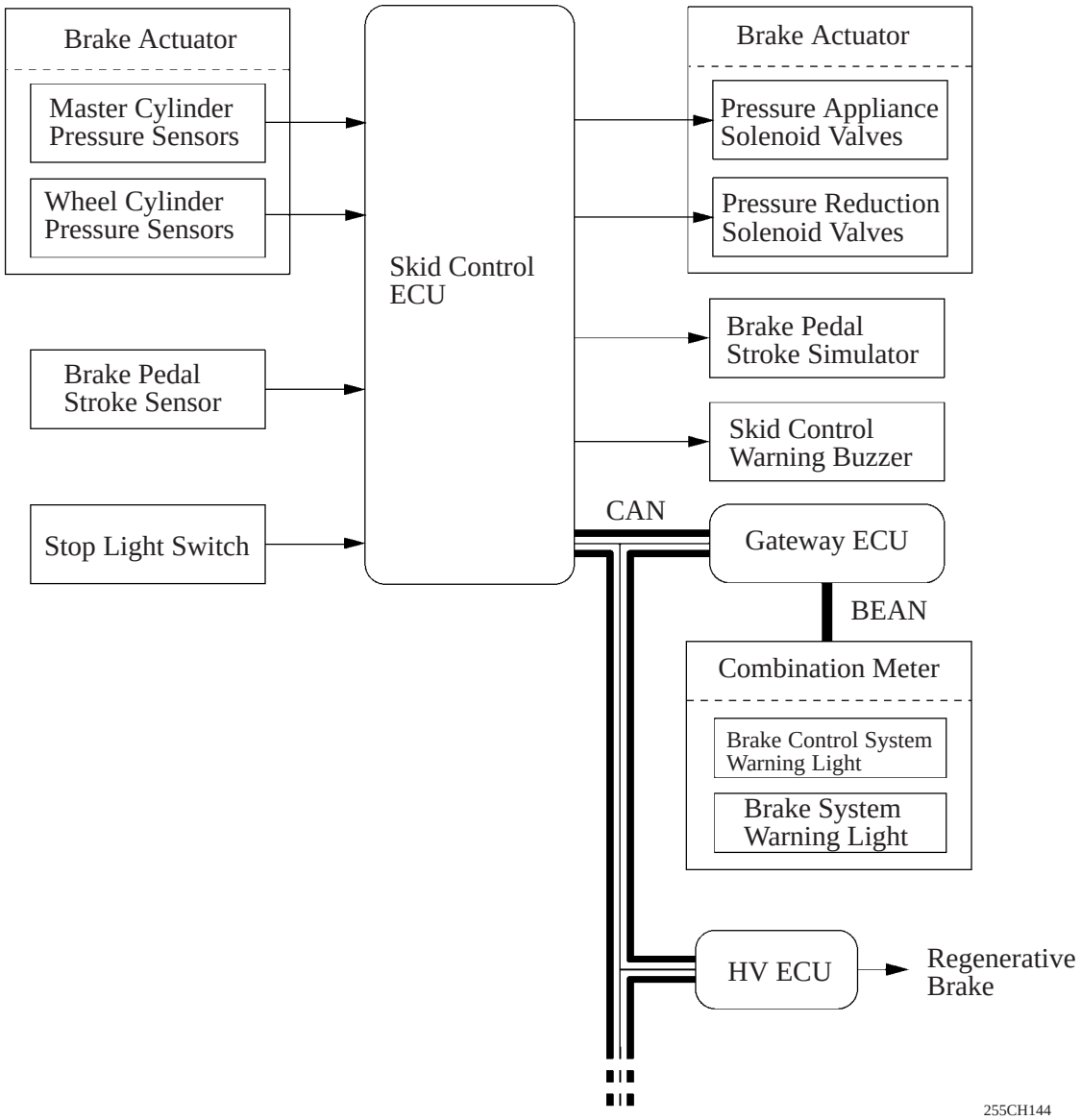
11. System Operation

Normal Brake Operation (With Regenerative Brake Cooperative Control)

1) General

- During normal braking, the master cylinder cut solenoid valves are closed and the fluid pressure circuits to the wheel cylinders remain independent. Accordingly, the fluid pressure generated by the master cylinder will not directly cause the wheel cylinders to actuate.
- The skid control ECU calculates the braking force required by the driver in accordance with the signals received from the master cylinder pressure sensors and the brake pedal stroke sensor. Then, the skid control ECU calculates the regenerative brake force value out of the required brake force and transmits the calculated value to the HV ECU. Upon receiving the value, the HV ECU generates a regenerative brake force. At the same time, the HV ECU transmits the actual regenerative brake force value to the skid control ECU. The skid control ECU controls the solenoid valves in order to cause the hydraulic brake system to generate a brake force value (which is obtained by subtracting the regenerative brake force from the brake force value required by the driver).

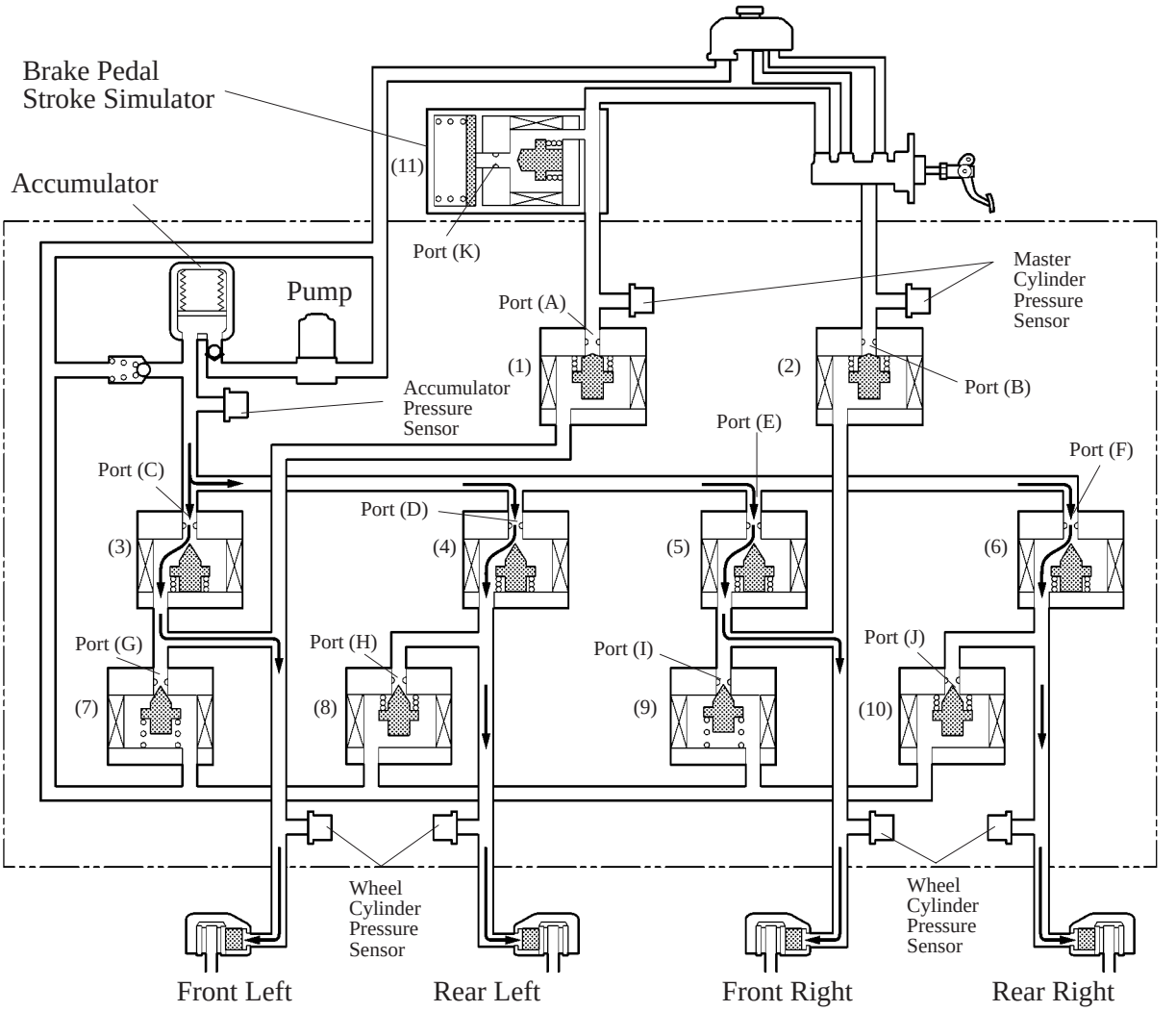
▶ System Diagram ◀



CH

2) Pressure Increase

The skid control ECU calculates the target wheel cylinder pressure (equivalent to the brake force required by the driver) in accordance with the signals received from the master cylinder pressure sensor and the brake pedal stroke sensor. The skid control ECU compares the wheel cylinder pressure sensor signal and the target wheel cylinder pressure. If the target wheel cylinder pressure is lower, the skid control ECU boosts the pressure in the brake actuator. Accordingly, the fluid pressure in the accumulator is fed into the wheel cylinder. Moreover, this operation is the same when the hydraulic brake force must be increased in order to effect cooperative control in accordance with the changes in the regenerative brake force.



256CH108

Item		Normal Braking Increase Mode
(1), (2)	Master Cylinder Cut Solenoid Valve	ON (Close)
	Port: (A), (B)	
(3), (4), (5), (6)	Pressure Appliance Solenoid Valve	ON (Half-Open*)
	Port: (C), (D), (E), (F)	
(7), (9)	Pressure Reduction Solenoid Valve	OFF (Close)
	Port: (G), (I)	
(8), (10)	Pressure Reduction Solenoid Valve	ON (Close)
	Port: (H), (J)	
(11)	Stroke Simulator Cut Solenoid Valve	ON (Open)
	Port: (K)	

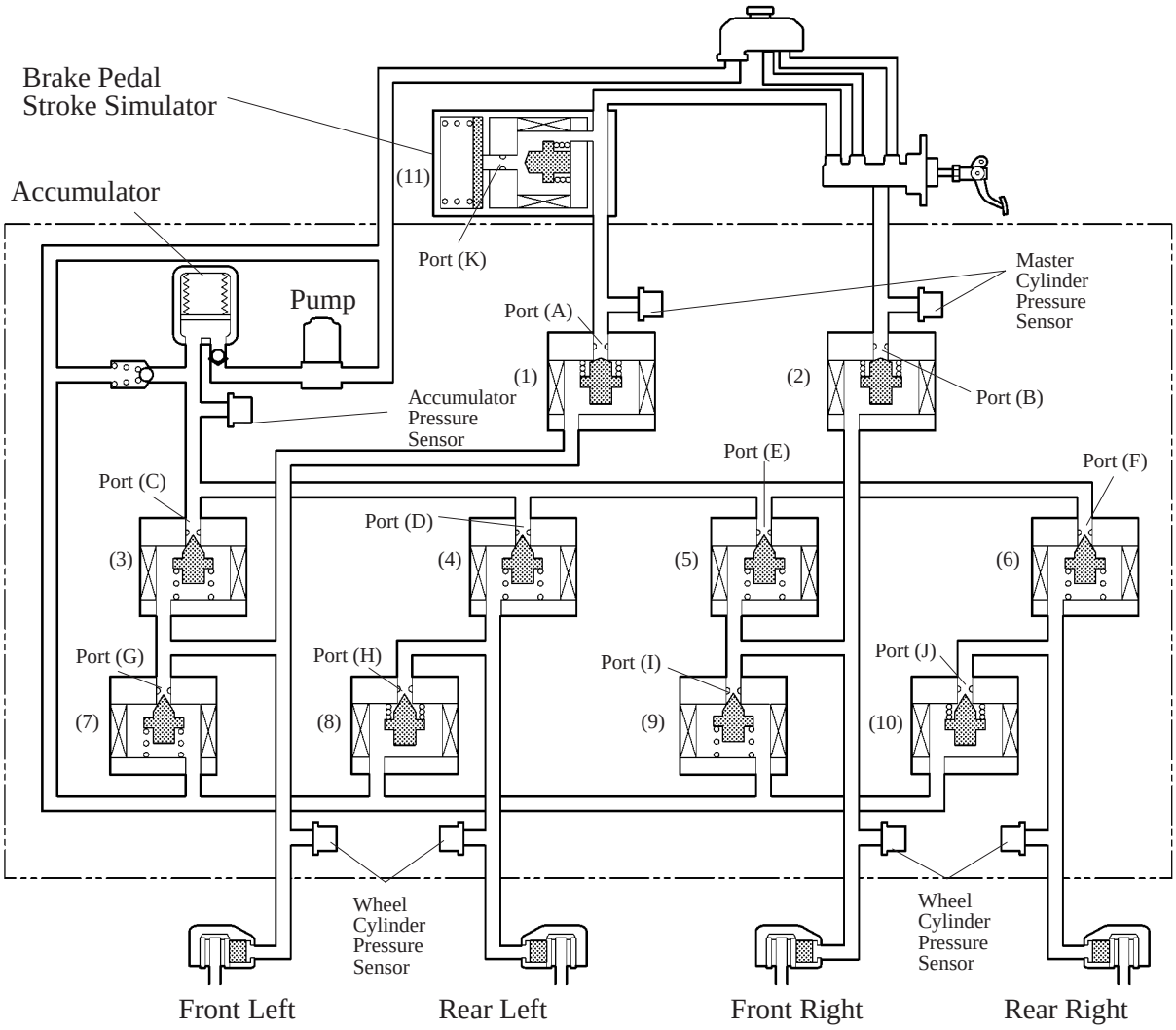
*: The solenoid valve constantly regulates the amount of opening of the port in accordance with the use conditions in order to control the fluid pressure.

3) Holding

The skid control ECU calculates the target wheel cylinder pressure (equivalent to the brake force required by the driver) in accordance with the signals received from the master cylinder pressure sensor and the brake pedal stroke sensor.

The skid control ECU compares the wheel cylinder pressure signal with the target wheel cylinder pressure. If they are equal, the skid control ECU controls the brake actuator in the hold state.

Accordingly, the wheel cylinder will be held at a constant pressure.



256CH109

Item		Normal Braking Hold Mode
(1), (2)	Master Cylinder Cut Solenoid Valve	ON (Close)
	Port: (A), (B)	
(3), (4), (5), (6)	Pressure Appliance Solenoid Valve	OFF (Close)
	Port: (C), (D), (E), (F)	
(7), (9)	Pressure Reduction Solenoid Valve	OFF (Close)
	Port: (G), (I)	
(8), (10)	Pressure Reduction Solenoid Valve	ON (Close)
	Port: (H), (J)	
(11)	Stroke Simulator Cut Solenoid Valve	ON (Open)
	Port: (K)	

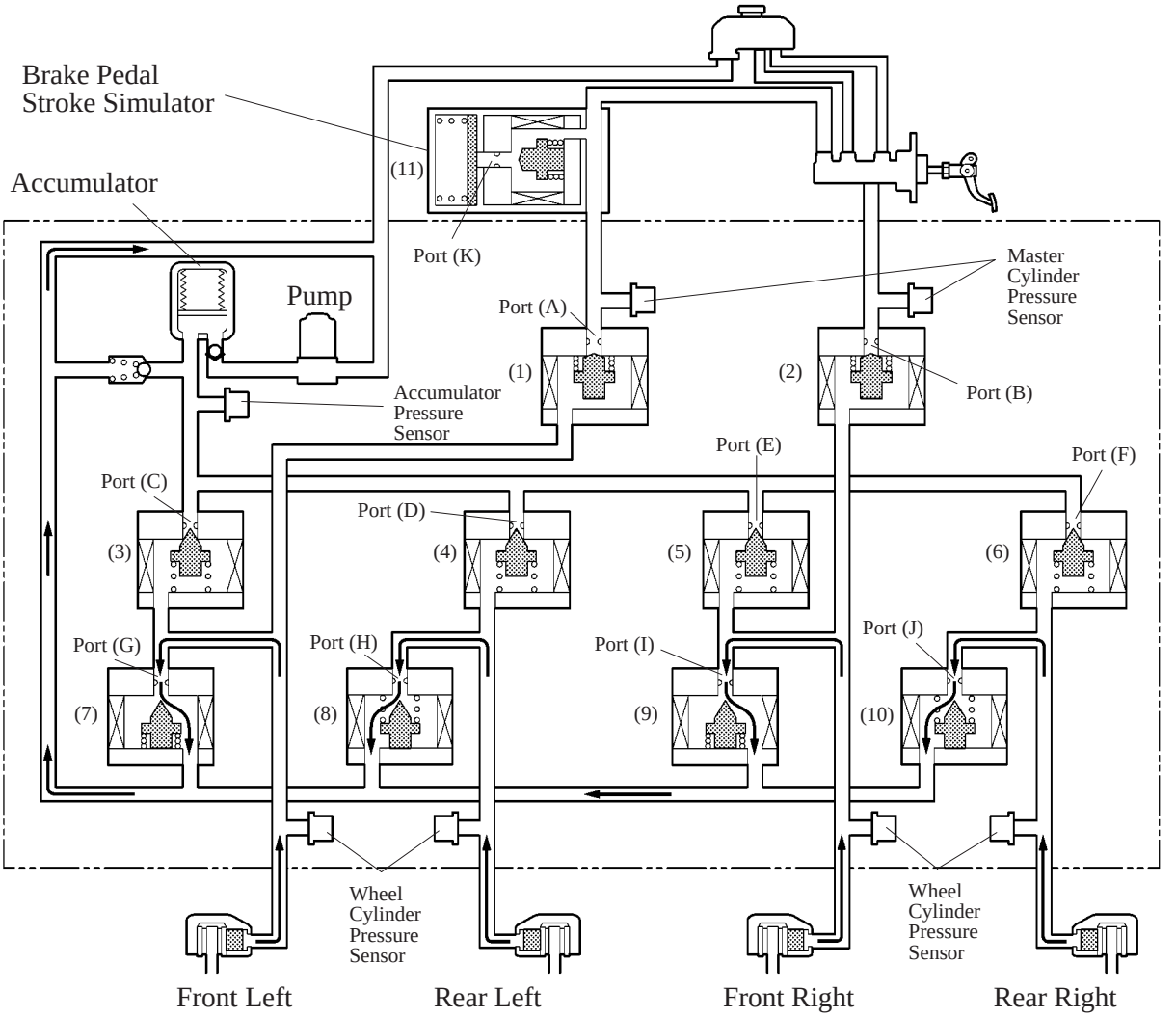
CH

4) Pressure Reduce

The skid control ECU calculates the target wheel cylinder pressure (equivalent to the brake force required by the driver) in accordance with the signals received from the master cylinder pressure sensor and the brake pedal stroke sensor.

The skid control ECU compares the wheel cylinder pressure signal with the target wheel cylinder pressure. If the target wheel cylinder pressure is higher, the skid control ECU reduces the pressure in the brake actuator. Accordingly, the pressure in the wheel cylinder decreases.

Moreover, this operation is the same when the hydraulic brake force must be decreased in order to effect cooperative control in accordance with the changes in the regenerative brake force.

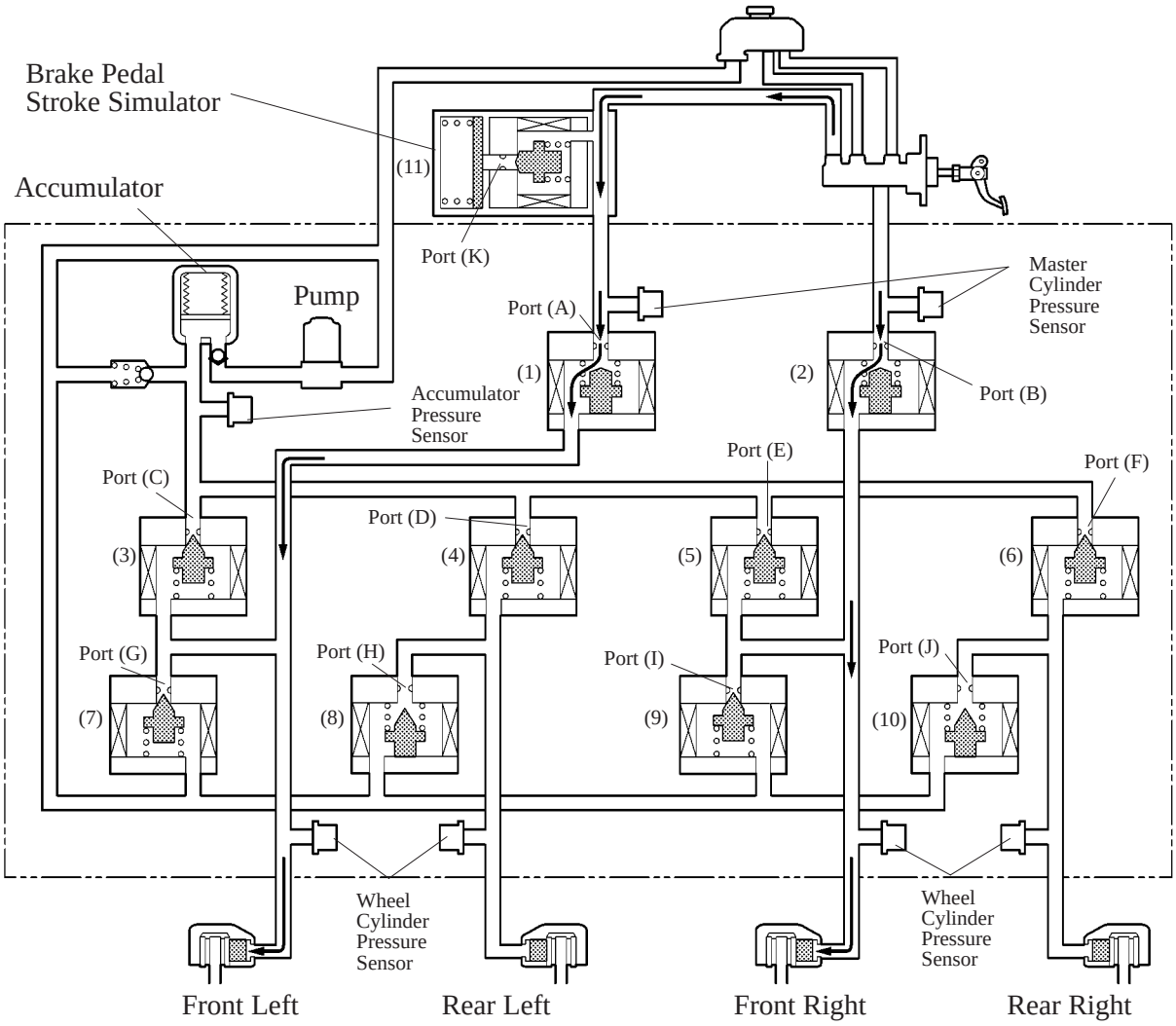


Item		Normal Braking Reduce Mode
(1), (2)	Master Cylinder Cut Solenoid Valve	ON (Close)
	Port: (A), (B)	
(3), (4), (5), (6)	Pressure Appliance Solenoid Valve	OFF (Close)
	Port: (C), (D), (E), (F)	
(7), (9)	Pressure Reduction Solenoid Valve	ON (Half-Open*)
	Port: (G), (I)	
(8), (10)	Pressure Reduction Solenoid Valve	ON (Half-Open*)
	Port: (H), (J)	
(11)	Stroke Simulator Cut Solenoid Valve	ON (Open)
	Port: (K)	

*: The solenoid valve constantly regulates the amount of opening of the port in accordance with the use conditions in order to control the fluid pressure.

5) Brake System Stops or During Power Supply Malfunction

If the brake system stops or no accumulator pressure is supplied due to some malfunction, the skid control ECU operates the fail-safe function. This function opens the master cylinder solenoid valve in the brake actuator, in order to secure a fluid passage between the master cylinder and the wheel cylinder. Thus, the brakes can be applied by operating only the front wheel cylinders under the fluid pressure generated by the master cylinder. At this time, port (K) of the stroke simulator cut solenoid valve closes in order to prevent the fluid pressure generated by the master cylinder from being negatively affected by the operation of the stroke simulator.



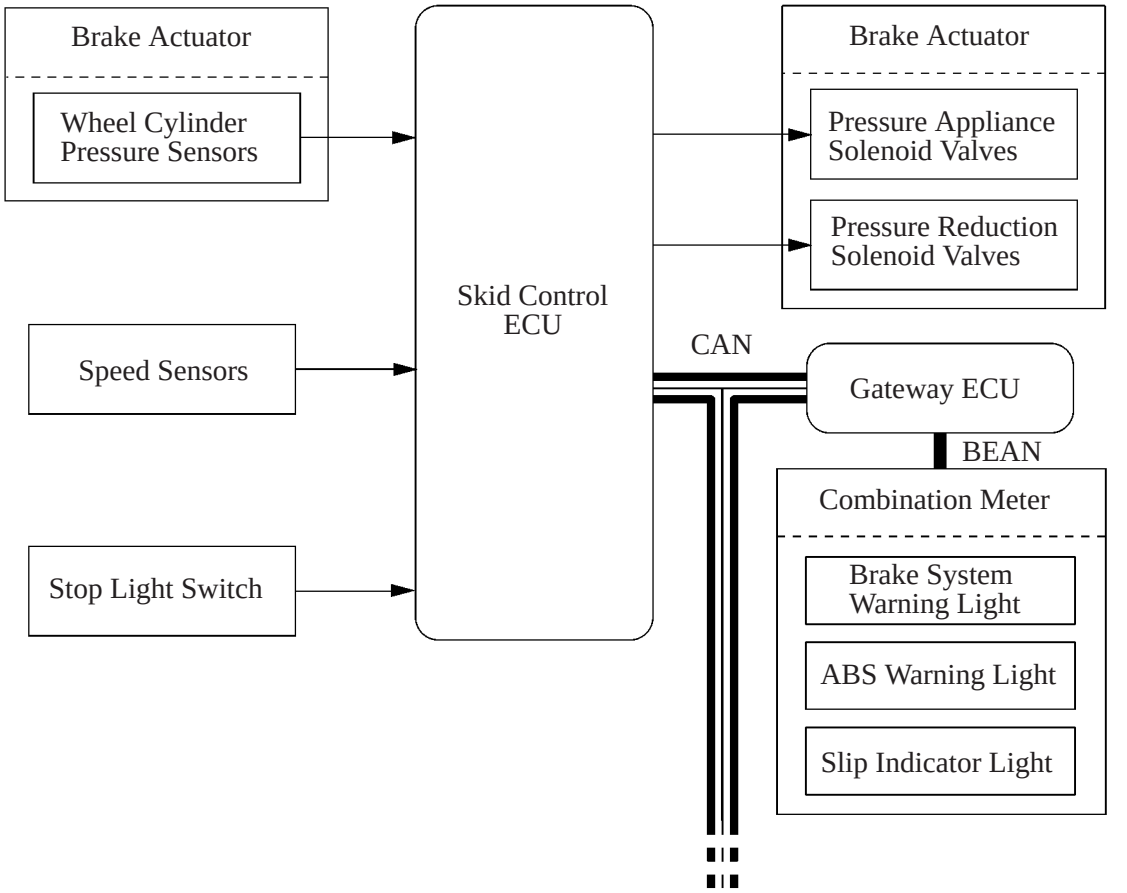
256CH111

Item		System OFF & Fail-Safe Mode
(1), (2)	Master Cylinder Cut Solenoid Valve	OFF (Open)
	Port: (A), (B)	
(3), (4), (5), (6)	Pressure Appliance Solenoid Valve	OFF (Close)
	Port: (C), (D), (E), (F)	
(7), (9)	Pressure Reduction Solenoid Valve	OFF (Close)
	Port: (G), (I)	
(8), (10)	Pressure Reduction Solenoid Valve	OFF (Open)
	Port: (H), (J)	
(11)	Stroke Simulator Cut Solenoid Valve	OFF (Close)
	Port: (K)	

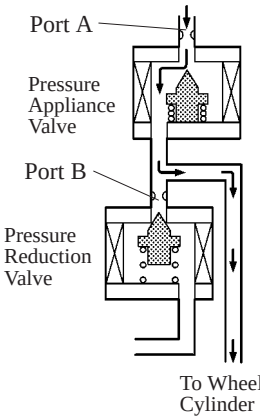
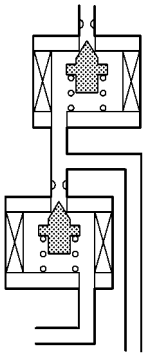
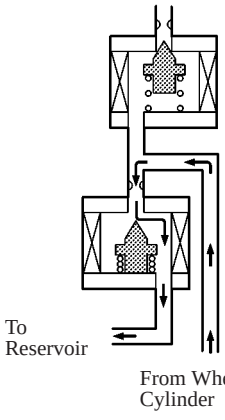
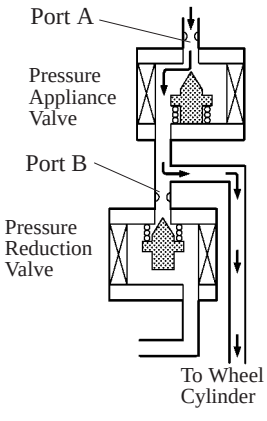
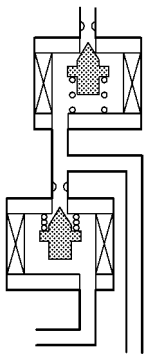
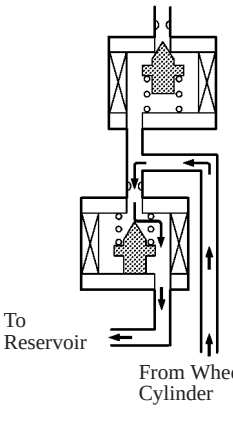
ABS with EBD Operation

Based on the signals received from the 4wheel speed sensors, the skid control ECU calculates each wheel speed and deceleration, and checks wheel slipping conditions. And according to the slipping condition, the skid control ECU controls the pressure appliance valve and pressure reduction valve in order to adjust the fluid pressure of the each wheel cylinder in the following 3 modes: pressure reduction, pressure holding, pressure increase modes.

▶ System Diagram ◀



255CH150

Not Activated		Normal Braking	—	—
Activated		Increase Mode	Holding Mode	Reduction Mode
Hydraulic Circuit		 255CH151	 255CH152	 255CH153
Front	Pressure Appliance Solenoid Valve (Port A)	ON (Half-Open*)	OFF (Close)	OFF (Close)
	Pressure Reduction Solenoid Valve (Port B)	OFF (Close)	OFF (Close)	ON (Half-Open*)
Hydraulic Circuit		 255CH159	 255CH160	 255CH161
Rear	Pressure Appliance Solenoid Valve (Port A)	ON (Half-Open*)	OFF (Close)	OFF (Close)
	Pressure Reduction Solenoid Valve (Port B)	ON (Close)	ON (Close)	ON (Half-Open*)
Wheel Cylinder Pressure		Increase	Hold	Reduction

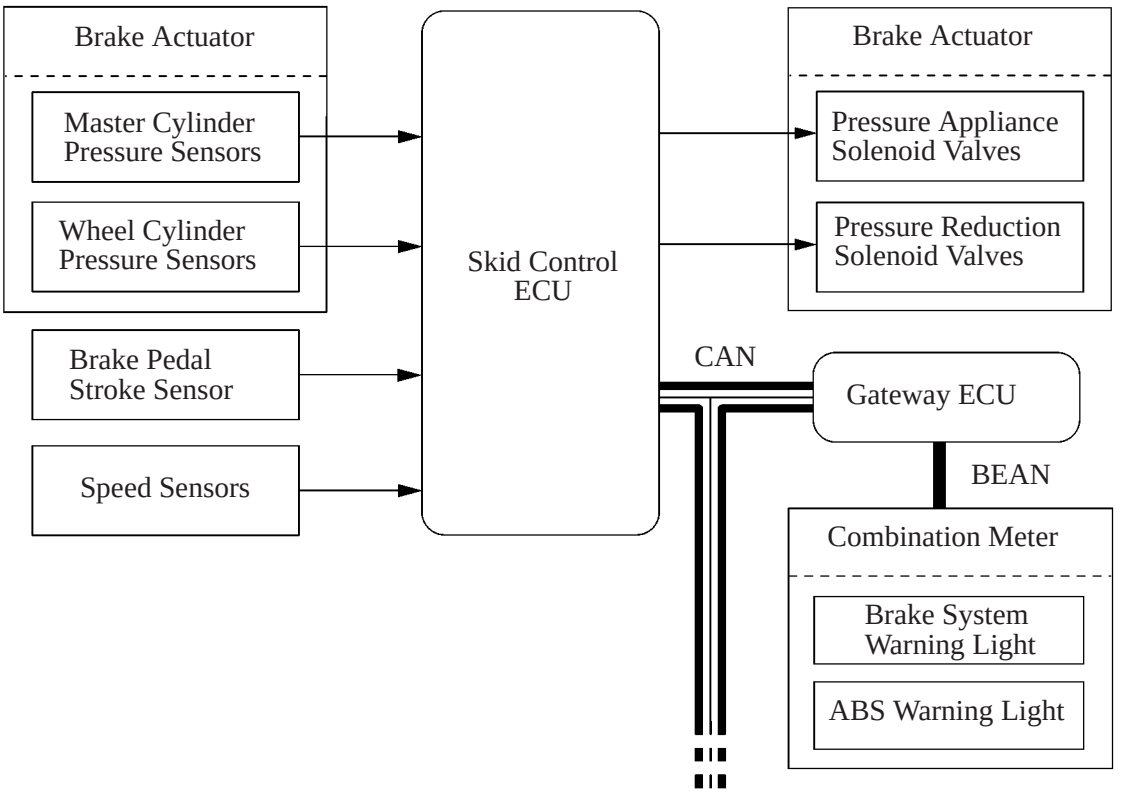
*: The solenoid valve constantly regulates the amount of opening of the port in accordance with the use conditions in order to control the fluid pressure.

Brake Assist Operation

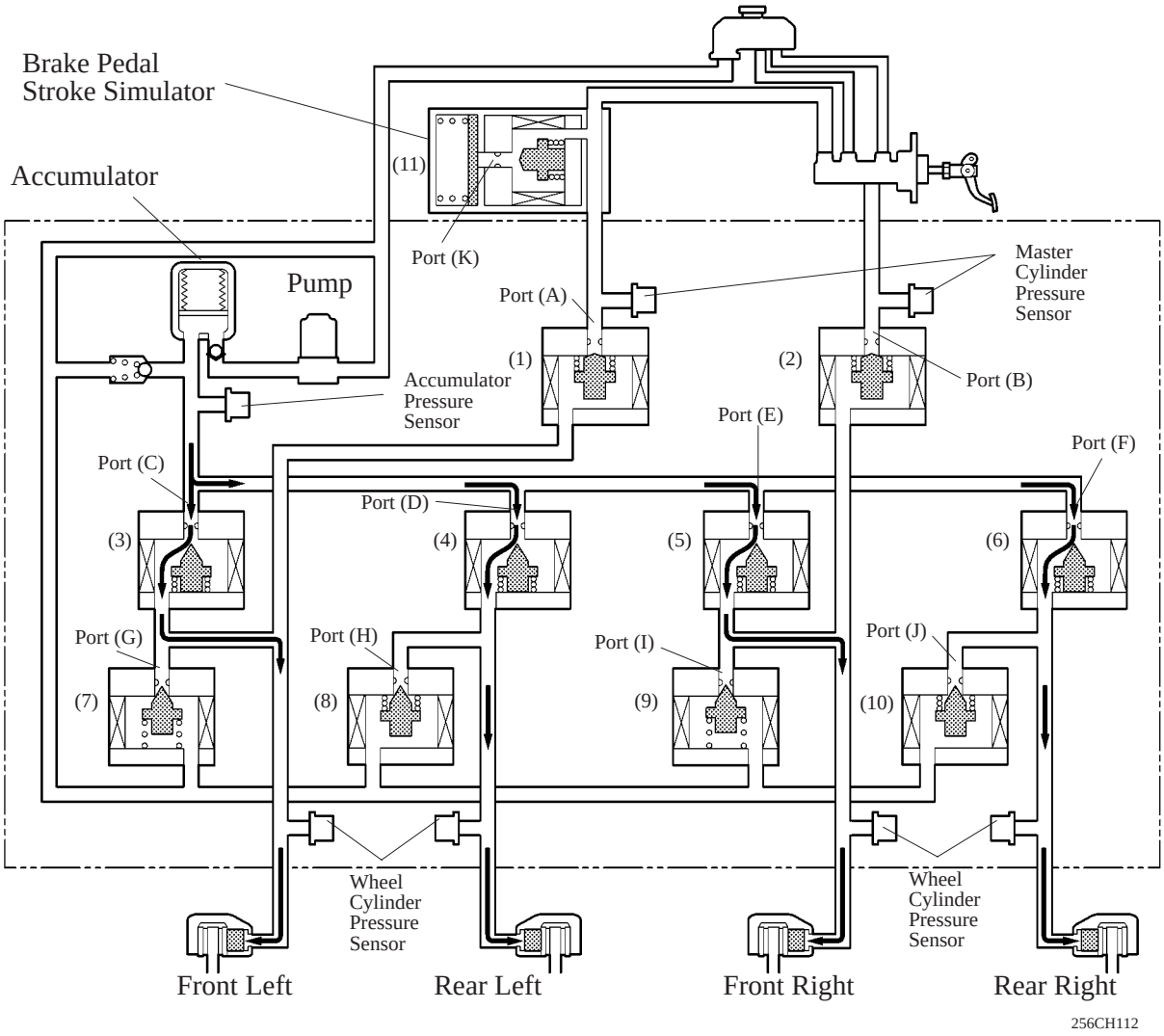
In the event of emergency braking, the skid control ECU detects the driver's intention based on the speed of the pressure increase in the master cylinder determined by the pressure sensor signal. If the ECU judges the need for the additional brake assist, the fluid pressure is generated by the pump in the actuator and directed to the wheel cylinder to apply a greater.
Also in the following cases, the skid control ECU provides brake assist.

- In the event the vehicle is fully loaded, the skid control ECU detects the condition using the master cylinder pressure sensor and vehicle speed signal.

▶ System Diagram ◀



255CH154



Item		Normal Braking Increase Mode	Brake Assist Activated
(1), (2)	Master Cylinder Cut Solenoid Valve Port: (A), (B)	ON (Close)	ON (Close)
(3), (4), (5), (6)	Pressure Appliance Solenoid Valve Port: (C), (D), (E), (F)	ON (Half-Open*)	ON (Half-Open*)
(7), (9)	Pressure Reduction Solenoid Valve Port: (G), (I)	OFF (Close)	OFF (Close)
(8), (10)	Pressure Reduction Solenoid Valve Port: (H), (J)	ON (Close)	ON (Close)
(11)	Stroke Simulator Cut Solenoid Valve Port: (K)	ON (Open)	ON (Open)

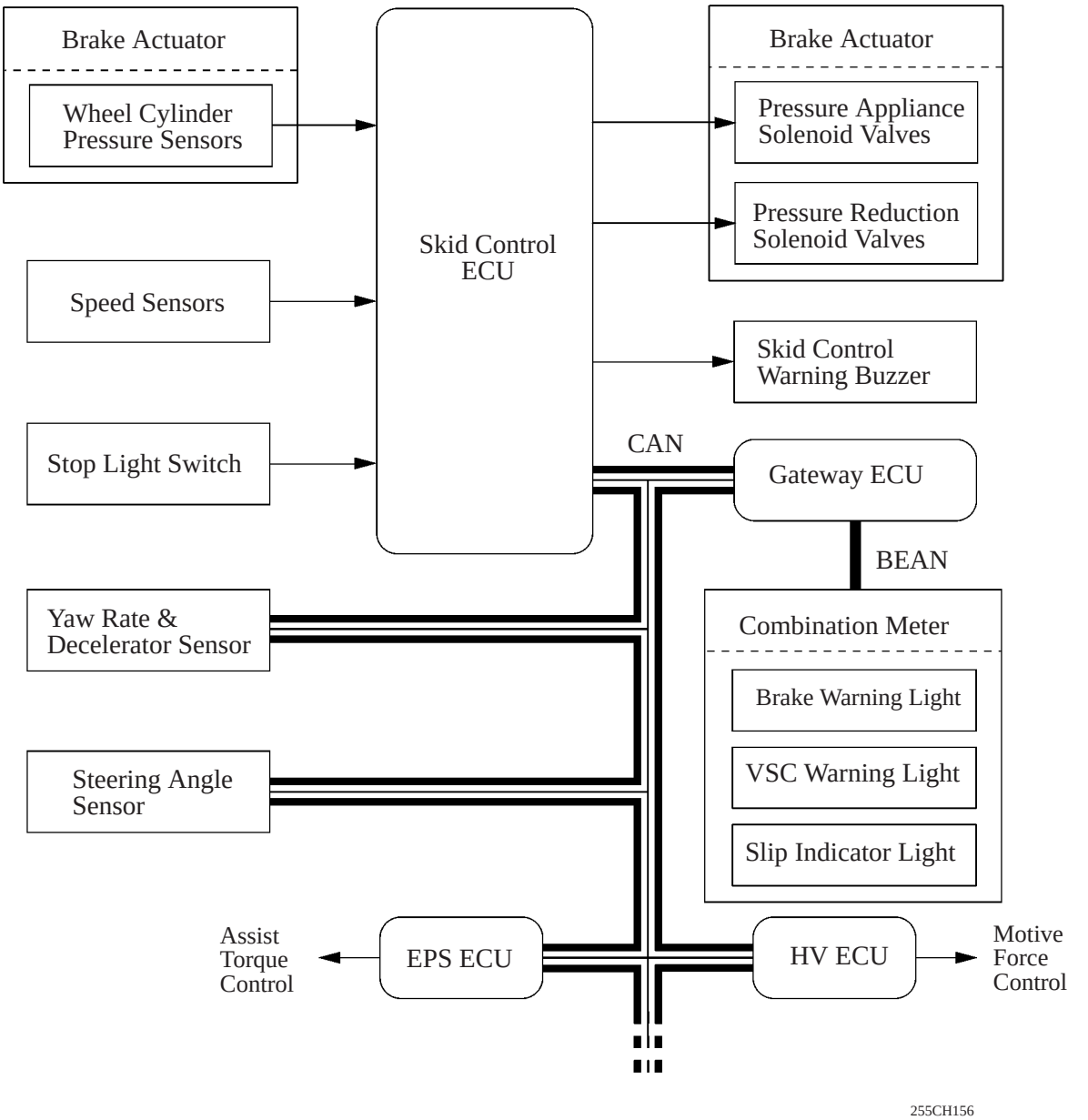
*: The solenoid valve constantly regulates the amount of opening of the port in accordance with the use conditions in order to control the fluid pressure.

VSC+ Operation

1) General

The VSC+ system controls the solenoid valves in order to send the fluid pressure stored in the accumulator to the brake wheel cylinders at the respective wheels, through routes that are different from those used during normal braking. Thus, the system operates in the following 3 modes: pressure reduction, pressure holding, and pressure increase. As a result, the tendency of the front wheels or the rear wheels to skid is restrained.

▶ System Diagram ◀



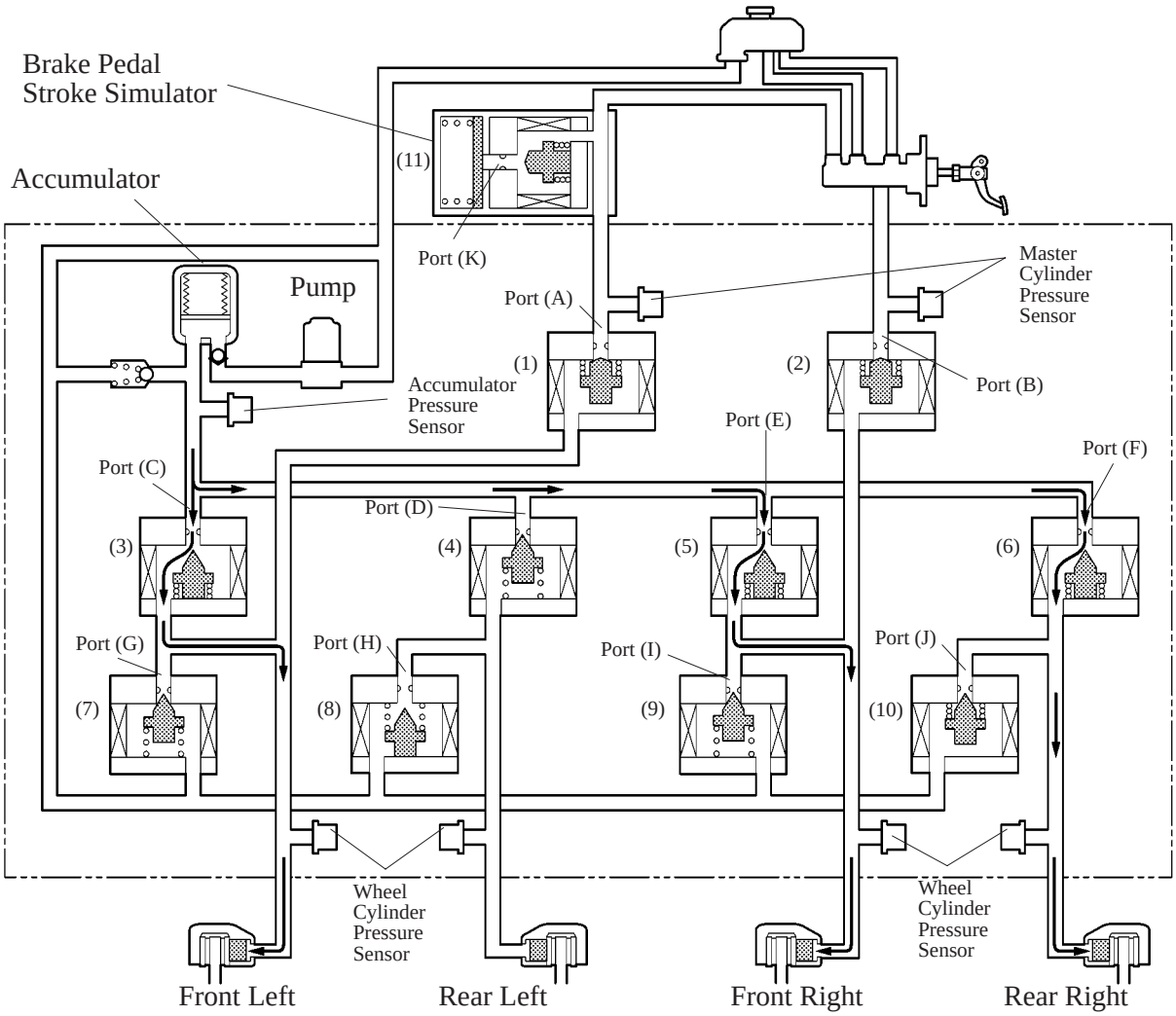
2) Front Wheel Skid Restraining (Turning to the Right)

In the front wheel skid control, the brake of the front wheels and rear wheel of the inner side of the turn is applied.

Also, depending on whether the brake is ON or OFF and the condition of the vehicle, there are circumstances in which the brake might not be applied to the wheels even if those wheels are targeted for braking.

The diagram below shows the hydraulic circuit in the pressure increase mode, as it restrains the front wheel skid condition while the vehicle makes a right turn.

The pressure Appliance valve and the pressure reduction valve are turned ON/OFF according to the ABS operation pattern.



Increase Mode

256CH113

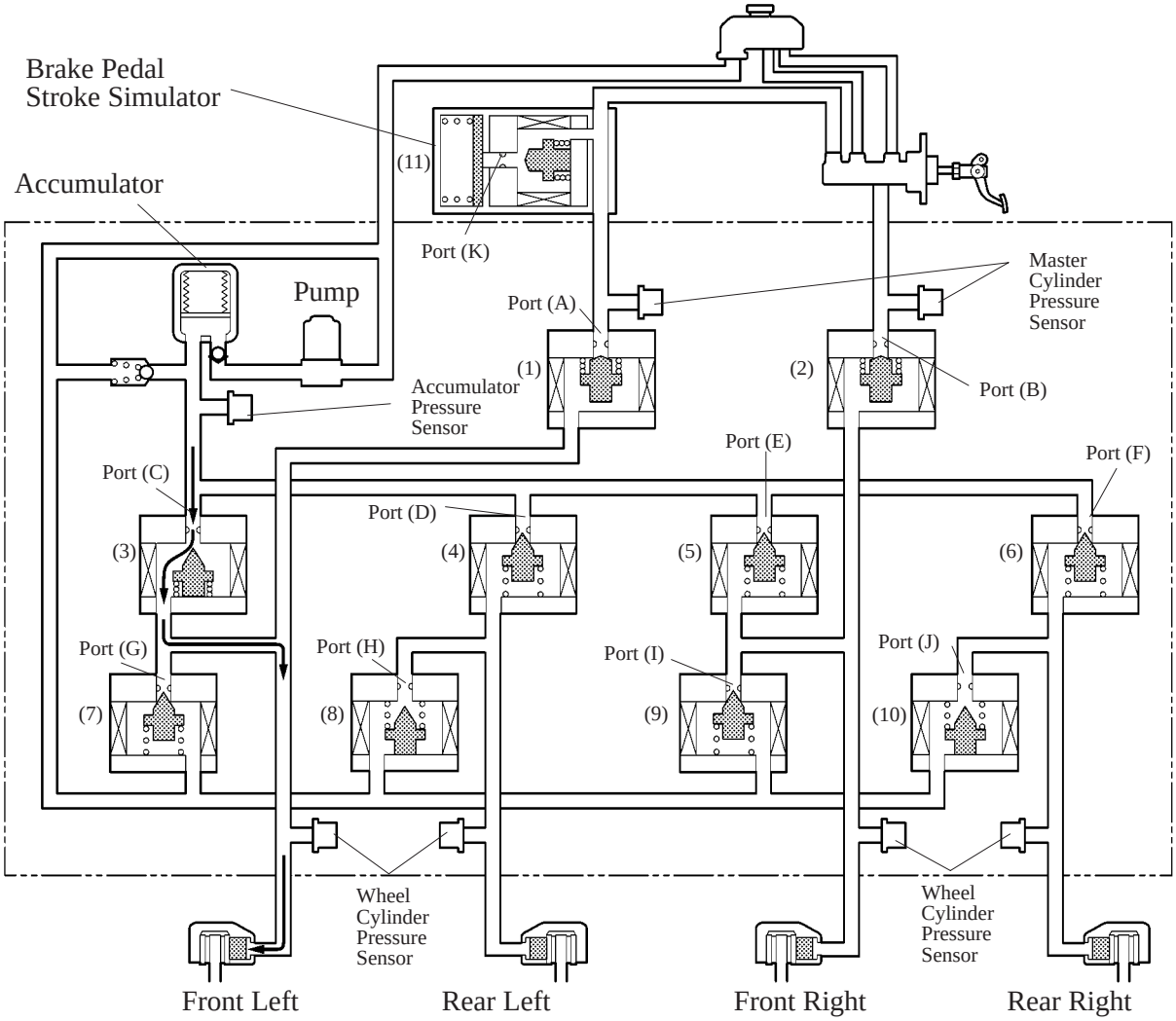
CH

Item			VSC+ not Activated	VSC+ Activated		
				Increase Mode	Hold Mode	Reduction Mode
(1), (2)	Master Cylinder Cut Solenoid Valve Port: (A), (B)		ON (Close)	ON (Close)	ON (Close)	ON (Close)
Front Brake	(3)	Pressure Appliance Solenoid Valve Port: (C)	OFF (Close)	ON (Half-Open*)	OFF (Close)	OFF (Close)
	(5)	Pressure Appliance Solenoid Valve Port: (E)	OFF (Close)	ON (Half-Open*)	OFF (Close)	OFF (Close)
	(7)	Pressure Reduction Solenoid Valve Port: (G)	OFF (Close)	OFF (Close)	OFF (Close)	ON (Half-Open*)
	(9)	Pressure Reduction Solenoid Valve Port: (I)	OFF (Close)	OFF (Close)	OFF (Close)	ON (Half-Open*)
	Wheel Cylinder Pressure	Right Left	—	Increase	Hold	Reduction
Rear Brake	(4)	Pressure Appliance Solenoid Valve Port: (D)	OFF (Close)	OFF (Close)	OFF (Close)	OFF (Close)
	(6)	Pressure ApplianceSolenoid Valve Port: (F)	OFF (Close)	ON (Half-Open*)	OFF (Close)	OFF (Close)
	(8)	Pressure Reduction Solenoid Valve Port: (H)	OFF (Open)	OFF (Open)	OFF (Open)	OFF (Open)
	(10)	Pressure Reduction Solenoid Valve Port: (J)	OFF (Open)	ON (Close)	ON (Close)	ON (Half-Open*)
	Wheel Cylinder Pressure	Right	—	Increase	Hold	Reduction
		Left	—	—	—	—
(11)	Stroke Simulator Cut Solenoid Valve Port: (K)		ON (Open)	ON (Open)	ON (Open)	ON (Open)

*: The solenoid valve constantly regulates the amount of opening of the port in accordance with the use conditions in order to control the fluid pressure.

3) Rear Wheel Skid Restrain (Turning to the Right)

In rear wheel skid restrain, the brake of the front and rear wheels of the outer circle of the turn is applied. As an example, the diagram below shows the hydraulic circuit in the pressure increase mode, as it restrains the rear wheel skid condition while the vehicle make a right turn.
As in front wheel skid restrain the pressure Appliance valve and the pressure reduction valve are turned ON/OFF according to the ABS operating pattern.



Increase Mode

256CH114

CH

Item			VSC+ not Activated	VSC+ Activated		
				Increase Mode	Hold Mode	Reduction Mode
(1), (2)	Master Cylinder Cut Solenoid Valve Port: (A), (B)		ON (Close)	ON (Close)	ON (Close)	ON (Close)
Front Brake	(3)	Pressure Appliance Solenoid Valve Port: (C)	OFF (Close)	ON (Half-Open*1)	OFF (Close)	OFF (Close)
	(5)	Pressure Appliance Solenoid Valve Port: (E)	OFF (Close)	OFF (Close)	OFF (Close)	OFF (Close)
	(7)	Pressure Reduction Solenoid Valve Port: (G)	OFF (Close)	OFF (Close)	OFF (Close)	ON (Half-Open*1)
	(9)	Pressure Reduction Solenoid Valve Port: (I)	OFF (Close)	OFF (Close)	OFF (Close)	OFF (Close)
	Wheel Cylinder Pressure	Right	—	—	—	—
		Left	—	Increase	Hold	Reduction
Rear Brake	(4)	Pressure Appliance Solenoid Valve Port: (D)	OFF (Close)	OFF (Close) [ON (Half-Open *1)]*2	OFF (Close)	OFF (Close)
	(6)	Pressure Appliance Solenoid Valve Port: (F)	OFF (Close)	OFF (Close) [ON (Half-Open *1)]*2	OFF (Close)	OFF (Close)
	(8)	Pressure Reduction Solenoid Valve Port: (H)	OFF (Open)	ON (Close)	ON (Close)	ON (Close) [ON (Half-Open *1)]*2
	(10)	Pressure Reduction Solenoid Valve Port: (J)	OFF (Open)	ON (Close)	ON (Close)	ON (Close) [ON (Half-Open *1)]*2
	Wheel Cylinder Pressure	Right Left	—	—	—	—
(11)	Stroke Simulator Cut Solenoid Valve Port: (K)		ON (Open)	ON (Open)	ON (Open)	ON (Open)

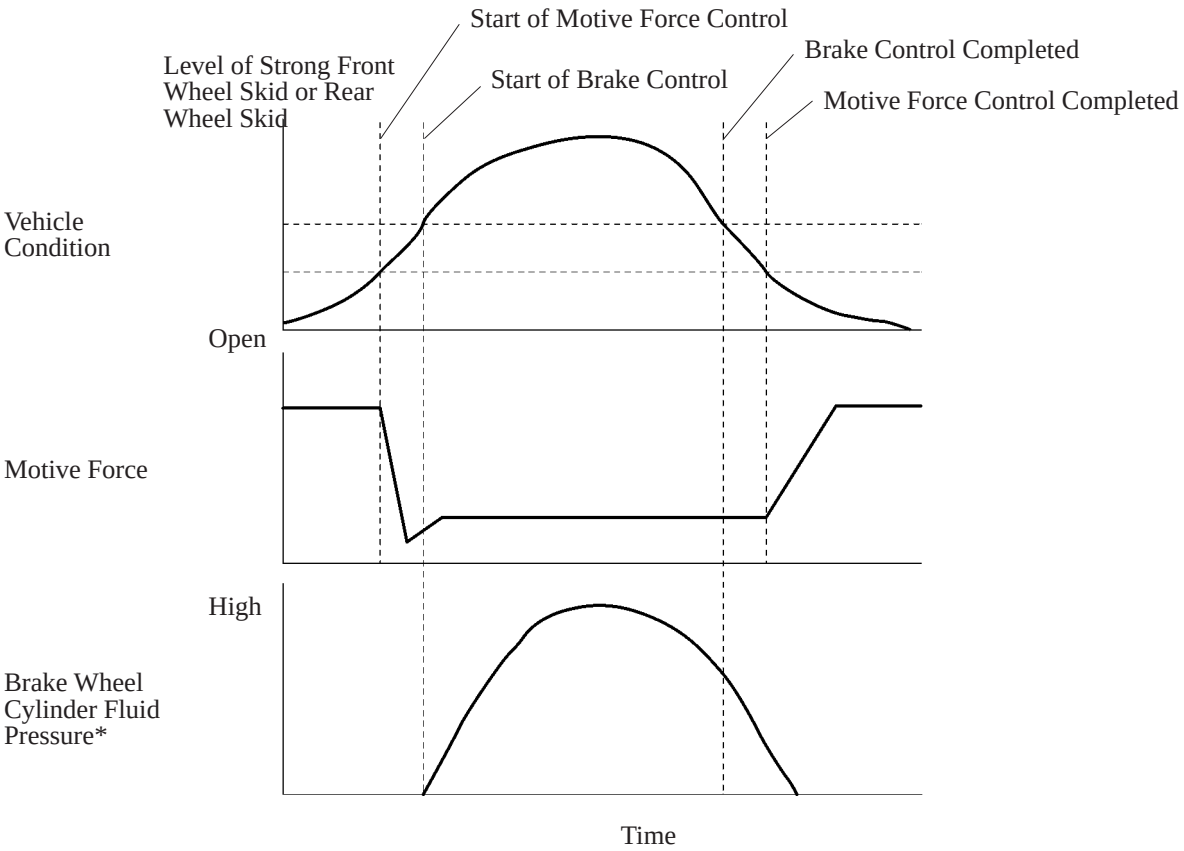
*1: The solenoid valve constantly regulates the amount of opening of the port in accordance with the use conditions in order to control the fluid pressure.

*2: In some cases, the skid control ECU applies the brake of the rear wheel, as necessary.

12. Skid Control ECU

VSC+

Based on the 4 type of sensor signals received from the speed sensors, yaw rate sensor, deceleration sensor and steering sensor, the skid control ECU calculates the amount of vehicle condition.
If a strong front wheel skid or rear wheel skid tendency is created during an emergency avoidance maneuver or cornering, and the skid control ECU determines that the amount of vehicle condition exceeds a prescribed value, it controls the motive force and the brake fluid pressure according to the amount of the vehicle condition.



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*: The wheel cylinder that activates varies depending on the condition of the vehicle.

Self-Diagnosis

- If the skid control ECU detects a malfunction in the ECB, Regenerative Brake, ABS with EBD, Brake Assist, and VSC+ systems, the brake control system, ABS, brake system and VSC warning lights that corresponds to the function in which the malfunction has been detected indicates or lights up, as indicated in the table below, to alert the driver of the malfunction.

○: Light ON —: Light OFF

Item	Regenerative Brake Cooperative Control	ABS	EBD	Brake Assist	VSC+*1	ECU
Brake Control System Warning Light	○	○	○	○	—	○*2
Brake System Warning Light	—	—	○	○	—	○
ABS Warning Light	—	○	○	○	—	○
VSC Warning Light*1	—	○	○	○	○	○*2

*1: Only on model with VSC+ System
*2: May not be illuminated

- At the same time, the DTC (Diagnostic Trouble Code) are stored in memory. The DTC can be read by connecting the SST (09843-18040) between the Tc and CG terminals DLC3, and observing the blinking of the brake control system warning light, ABC warning light and VSC warning light or by connecting the intelligent tester II.
- This system has a sensor signal check (test mode) function. This function is activated by connecting the SST (09843-18040) between the Ts and CG terminals of the DLC3 or by connecting the intelligent tester II.
- If the skid control ECU detects a malfunction during a sensor check, it stores the DTC in its memory. This DTC can be read during a sensor signal check operation by connecting the Tc and CG terminals of the DLC3 and observing the blinking of the brake control system warning light, the ABS warning light and the VSC warning light, or on the intelligent tester II.
- If the CAN has communication error ECU or sensors, multiple DTCs (Diagnostic Trouble Codes) are output simultaneously to indicate the malfunction location.
- All the DTCs have been made to correspond to the SAE controlled codes. Some of the DTCs have been further divided into smaller detection areas than in the past, and new DTCs have been assigned to them. Additionally, DTCs have been added to correspond to items, which had been newly adopted.
- 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.

For details on the DTC that are stored in skid control ECU memory and the DTC that are output through the sensor signal check function, see the Prius Repair Manual (Pub. No. RM1076E).

Fail-Safe

- In the event of a malfunction in the THS-II and/or S-VSC, the skid control ECU prohibits the VSC+ operations.
- In the event of a malfunction in the ABS and/or Brake Assist, the skid control ECU prohibits the ABS with EBD, Brake Assist, and VSC+ operations.
- In the event of the malfunction in the EBD control, skid control ECU prohibits the EBD control. Thus, the brake and fuel injection cut off control will be opened in the same condition as in condition without the ABS with EBD, Brake Assist, and VSC+.