■ BRAKE CONTROL SYSTEM

1. General

The brake control system has the following system/functions:

System/Function	Outline
Electronically Controlled Brake System [See page CH-39]	The electronically controlled brake system detects the amount that the brake pedal is depressed based on signals from the brake pedal stroke sensor. The system uses the skid control ECU to adjust the pressure supplied from the hydraulic pressure source for each wheel, generating optimal braking force.
Regenerative Braking Cooperative Control [See page CH-40]	This control performs cooperative control with regenerative braking that is specific to hybrid vehicles to efficiently charge the HV battery.
VDIM (Vehicle Dynamics Integrated Management) [See page CH-42]	The VDIM integrally controls THS-II output and braking in coordination with steering control to ensure vehicle running, cornering and stopping performance for active safety.
Steering Cooperative Control	Effects cooperative control with the power steering 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 proper brake force distribution between the front and rear wheels in accordance with the driving conditions. In addition, during braking while cornering, it also controls the brake forces of the right and left wheels, helping maintain vehicle behavior.
Brake Assist	The primary purpose of Brake Assist is to provide an auxiliary brake force to assist a driver who cannot generate a large brake force during emergency braking, thus helping ensure the vehicle's braking performance.
TRAC (Traction Control)	The TRAC helps restrain the slippage of the drive wheels if the driver depresses the accelerator pedal excessively when starting off or accelerating on a slippery surface.
VSC (Vehicle Stability Control)	The VSC helps restrain sideways slippage of the vehicle during a strong front wheel skid or strong rear wheel skid, such as may occur while cornering.
Hill-start Assist Control	The Hill-start Assist Control generates four-wheel hydraulic pressure when the brake pedal is further depressed while the vehicle is stationary in order to prevent the vehicle from moving backward.

2. Outline of EBD Control Function

General

The EBD control distributes the braking force in accordance with the vehicle's driving conditions. The skid control ECU electrically controls the control solenoid valves to distribute the braking force.

- Braking force distribution is divided into two main categories: one is to the front and rear wheels, and the other is to the right to left sides (braking while cornering).

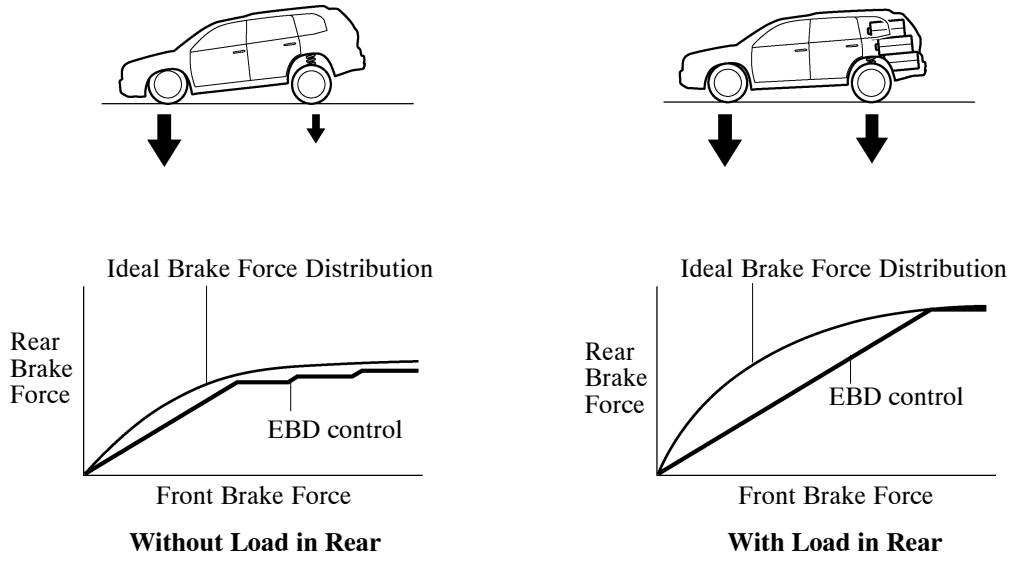
Front/Rear Wheels Brake Force Distribution

If the brakes are applied while the vehicle is moving straight forward, the weight transfer reduces the load that is applied to the rear wheels. The skid control ECU determines this condition by way of the signals from the wheel speed sensors, and the brake actuator regulates the distribution of the brake force of the rear wheels to effect optimal control.

For example, the amount of the brake force that is applied to the rear wheels during braking varies depending on 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 ◀

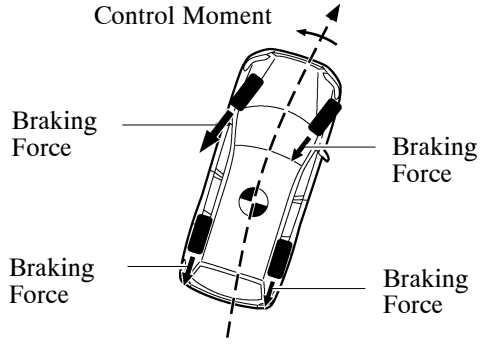


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Right/Left Wheels Brake Force Distribution (During Braking while Cornering)

When the brakes are applied while the vehicle is cornering, the load that is applied to the inner wheels decreases and the load that is applied to the outer wheels increases.

The skid control ECU determines this condition by way of the signals from the wheel speed sensors, and the brake actuator regulates the brake force in order to optimally control the distribution of the brake force to the inner wheels and outer wheels.

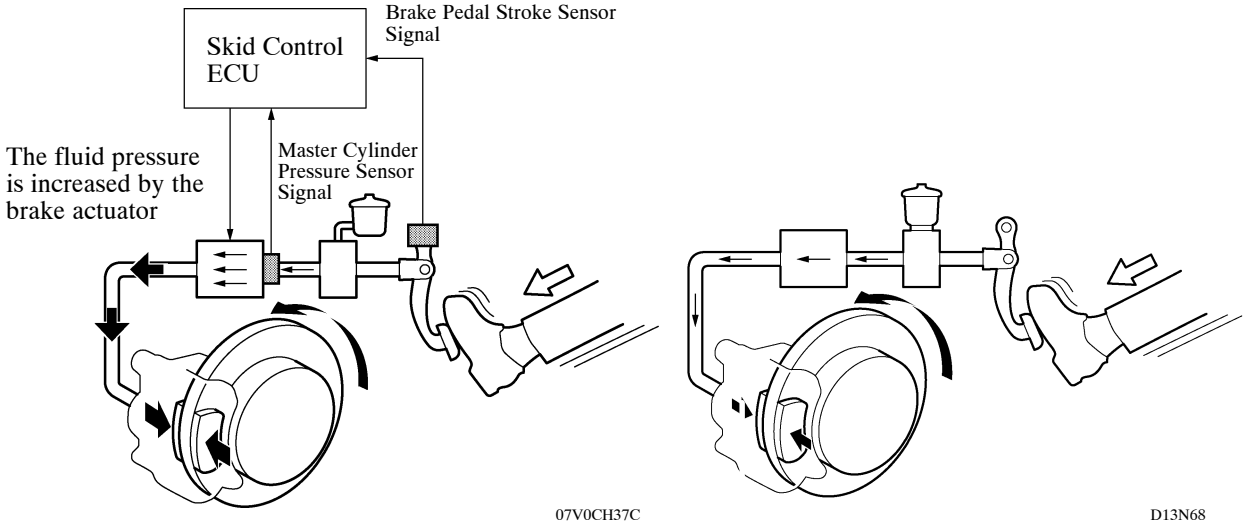


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3. Outline of Brake Assist Function

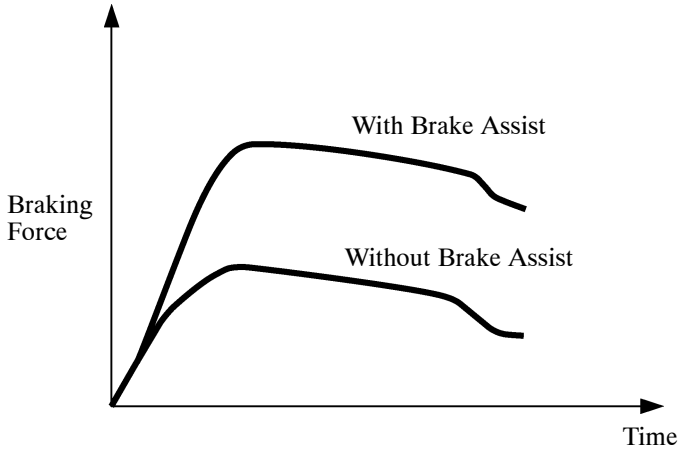
- The Brake Assist, in combination with ABS, helps improve the vehicle's brake performance.
- The Brake Assist interprets a quick push of the brake pedal as emergency braking and supplements the brake power applied if the driver has not stepped hard enough on the brake pedal. In emergencies, drivers, especially inexperienced ones, often panic and do not apply sufficient pressure to the brake pedal.
- A key feature of the Brake Assist is that the timing and the degree of braking assistance are designed to help 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.
- Based on the signals from the master cylinder pressure sensors and brake pedal stroke sensor, the skid control ECU calculates the speed and the amount of brake pedal application and then determines the intention of the driver to perform 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, which increases the braking force.

▶ In case that the driver's depressing force is small when applying emergency braking ◀



With Brake Assist **Without Brake Assist***

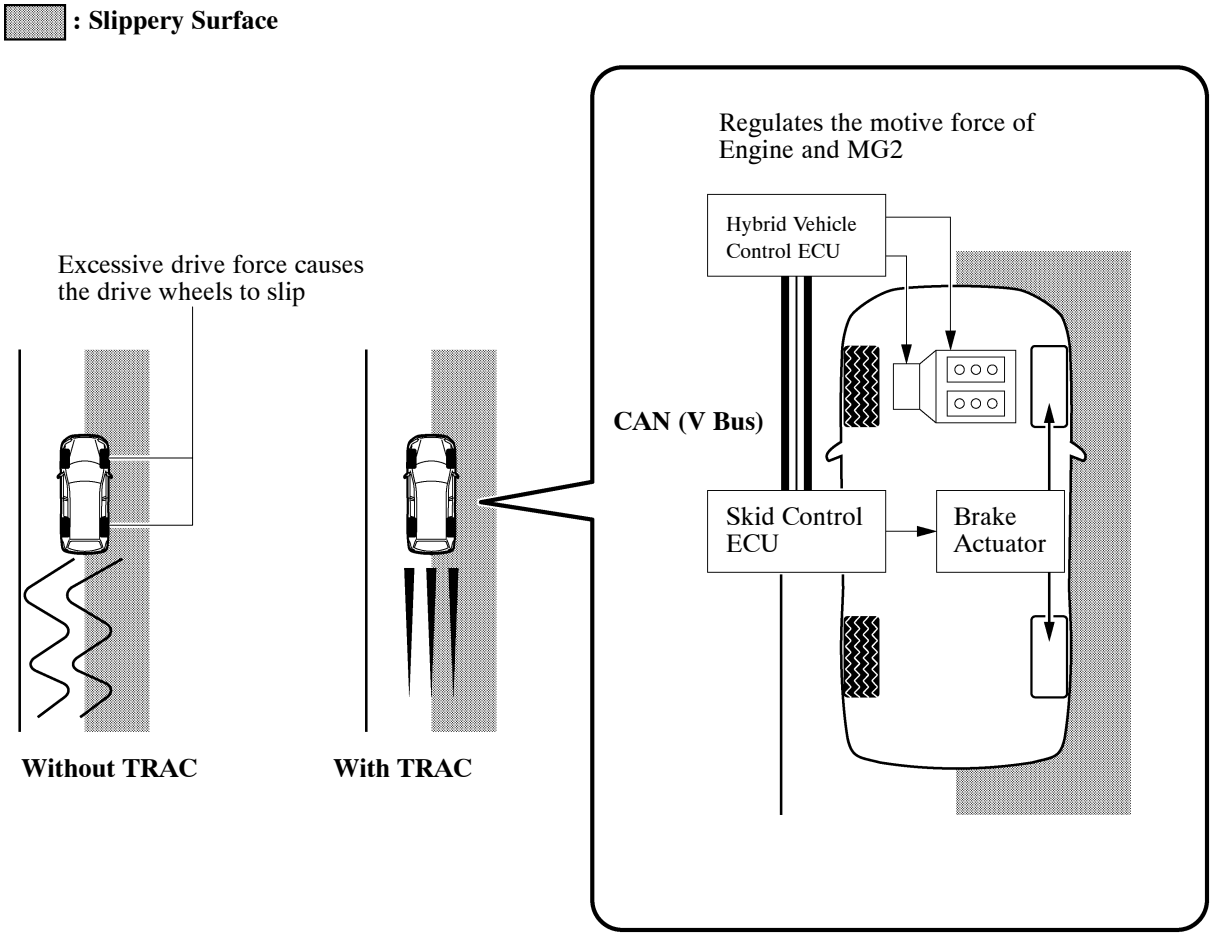
*: The fundamental performance capability of the brakes is the same as that of models with Brake Assist.



4. Outline of TRAC Function

- If the driver presses the accelerator pedal aggressively when starting off or when accelerating on a slippery surface, the drive wheels could slip due to the excessive amount of torque that is generated. By applying hydraulic brake control to the drive wheels and regulating the throttle to control the engine output, TRAC helps minimize the slippage of the drive wheels, thus generating the drive force that is appropriate for the road surface conditions.
- For example, a comparison may be made between two vehicles, one with the TRAC function and the other without. If the driver of each vehicle operates the accelerator pedal in a rough manner while driving over a surface with different surface friction characteristics, drive wheels on the slippery surface could slip as illustrated. As a result, the vehicle could become unstable.
  However, when the vehicle is equipped with the TRAC function, the skid control ECU determines the state of the vehicle and operates the brake actuator in order to apply the brake of the slipping drive wheel. Furthermore, the hybrid vehicle control ECU receives the signals from the skid control ECU and regulates the throttle in order to control the engine output. Thus, this function can constantly maintain a stable vehicle posture.

▶ Driving behavior on roads with different surface friction characteristics ◀



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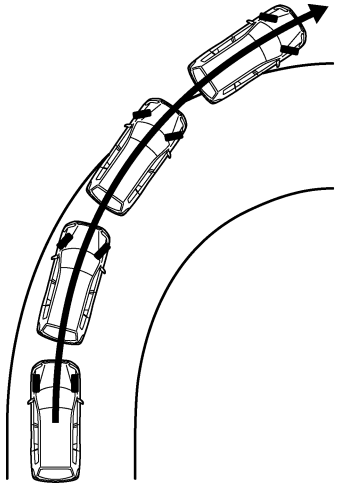
CH

5. Outline of VSC Function

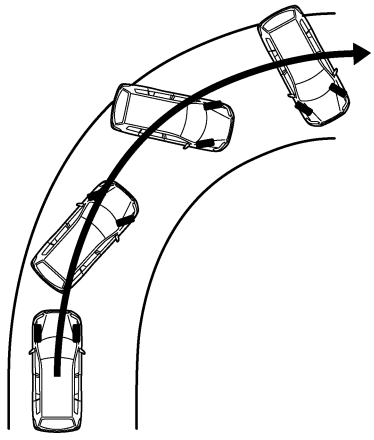
General

The following are two examples that can be considered as circumstances in which the tires exceed their lateral grip limit.
The VSC function is designed to help control the vehicle behavior by controlling the engine output and the brakes at each wheel when the vehicle experiences one of the conditions indicated below.

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



Front Wheel Skid Tendency



Rear Wheel Skid Tendency

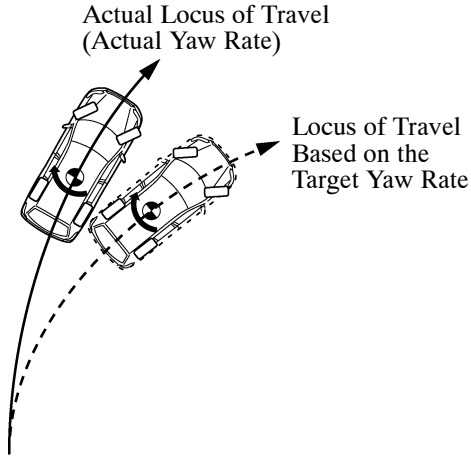
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Method for Determining the Vehicle Condition

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 a Front Wheel Skid

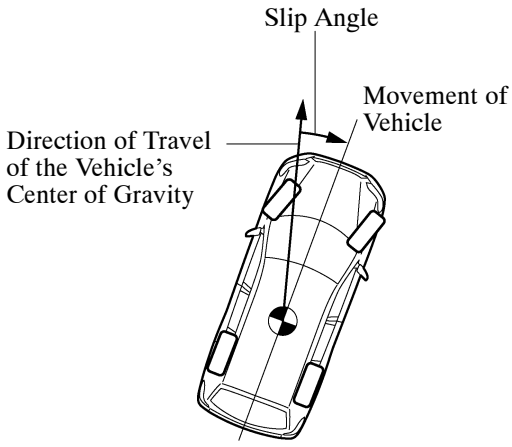
Whether or not the vehicle is experiencing a front wheel skid is determined by the difference between the target yaw rate and the vehicle's actual yaw rate.
When the vehicle's actual yaw rate is smaller than the target yaw rate (a target yaw rate is determined based on the vehicle speed and steering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



06J0CH46C

2) Determining a Rear Wheel Skid

Whether or not the vehicle is experiencing a 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.



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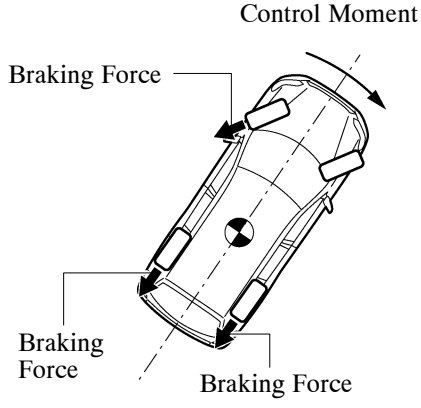
Method for VSC Operation

When the skid control ECU determines that the vehicle exhibits a tendency to experience a front wheel skid or a rear wheel skid, it decreases the engine output and applies the brakes of front or rear wheels 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 Strong Front Wheel Skid

When the skid control ECU determines that there is a large front wheel skid tendency, it takes countermeasures in accordance with the extent of that tendency. The skid control ECU controls the engine output and applies the brakes of the rear wheels and front wheel of the outer circle of the turn in order to help restrain the front wheel skid tendency.

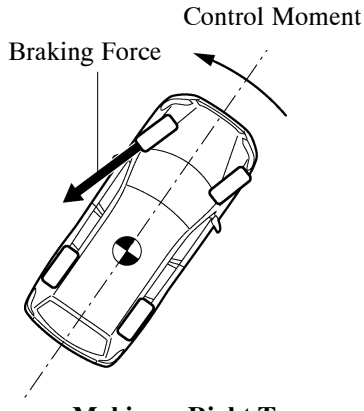


Making a Right Turn

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2) Dampening a Strong Rear Wheel Skid

When the skid control ECU determines that there is a large rear wheel skid tendency, it takes countermeasures 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, excellent vehicle stability is ensured.
In some cases, the skid control ECU applies the brake of the rear wheels, as necessary.

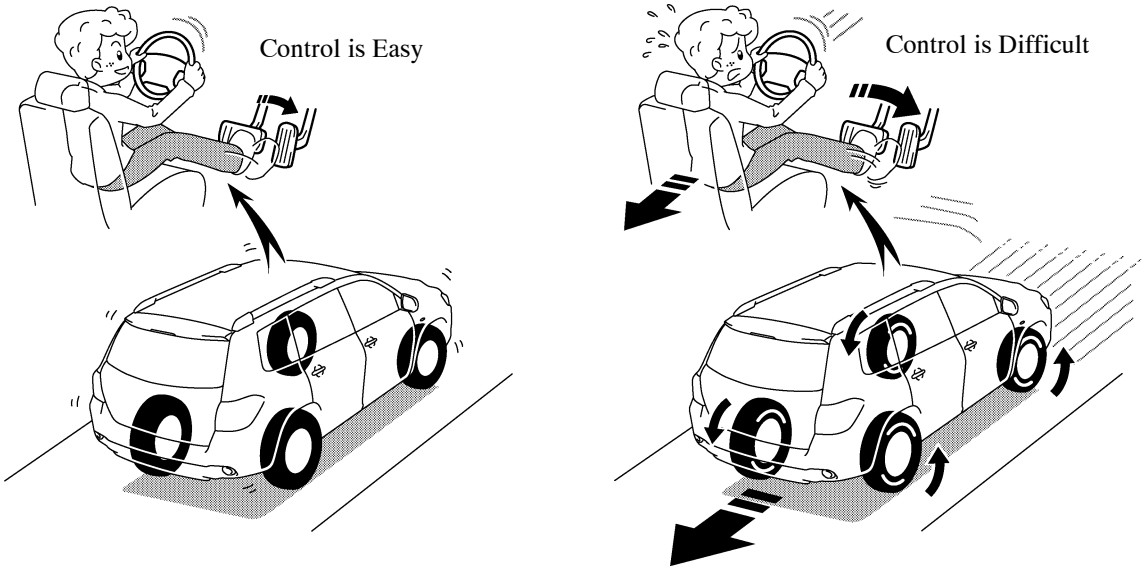


Making a Right Turn

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6. Outline of Hill-start Assist Control Function

- When the vehicle starts off on a steep or slippery hill, the vehicle could descend backward while the driver switches from the brake pedal to the accelerator pedal, thus making it difficult for the vehicle to start off. To prevent this from occurring, Hill-start Assist Control temporarily (for approximately a few seconds) applies the brakes to all the wheels in order to reduce the backward speed of the vehicle.
- Without Hill-start Assist Control, the driver must quickly and precisely switch from the brake pedal to the accelerator pedal. With Hill-start Assist Control however, the driver can start off easily and operate the pedal in a relaxed manner because Hill-start Assist Control prevents the vehicle from descending.



Prevents the vehicle from descending backward

With Hill-start Assist Control

The backward speed of the vehicle increases

Without Hill-start Assist Control

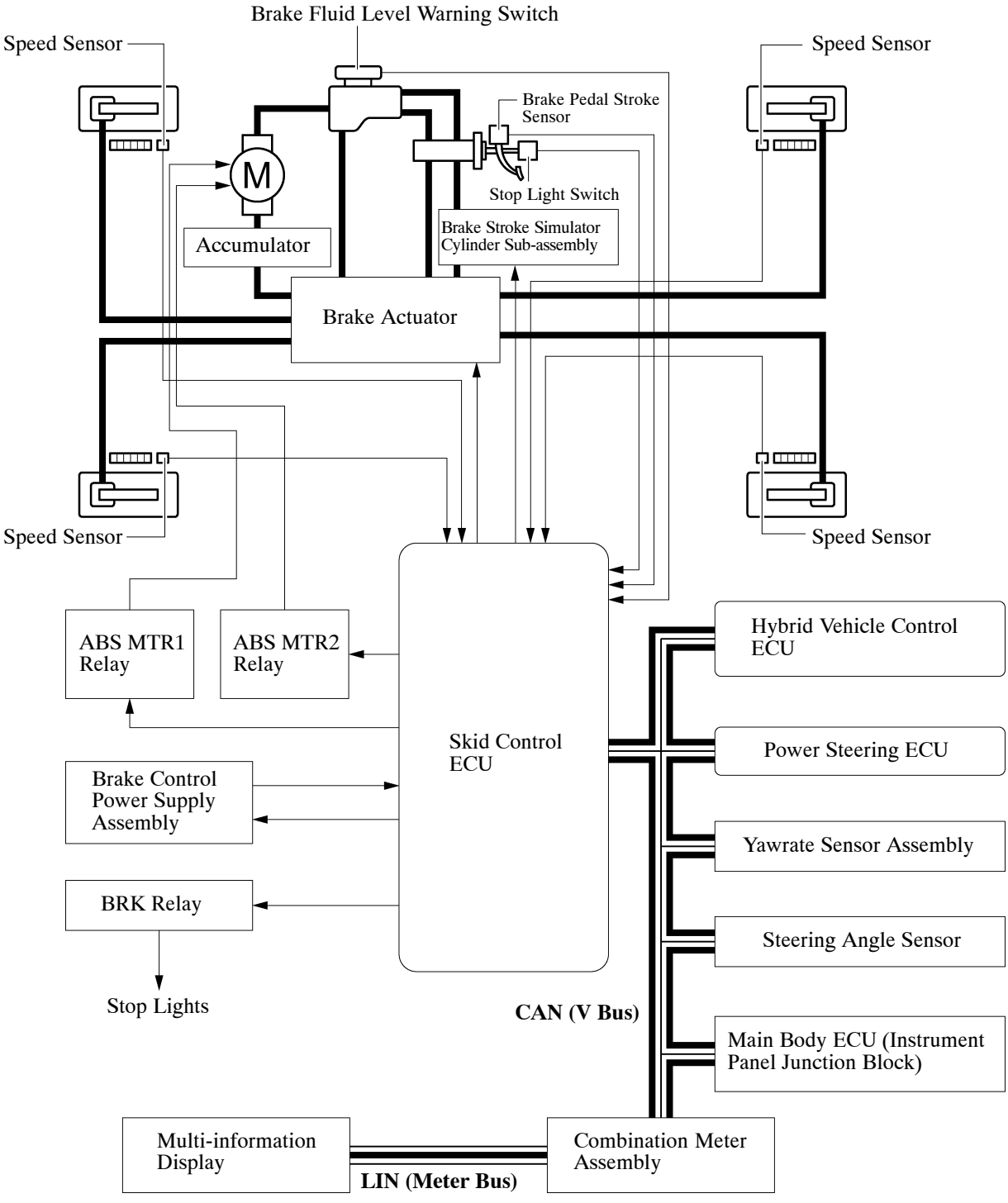
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- Hill-start Assist Control will operate when the brake pedal is further depressed while all of the following conditions are met.

Hill-start Assist Control Operating Conditions	• Shift lever is in R, N, D, or B (in a position other than P). • The accelerator pedal is not depressed. • The vehicle is at a standstill. • The parking brake is not applied.

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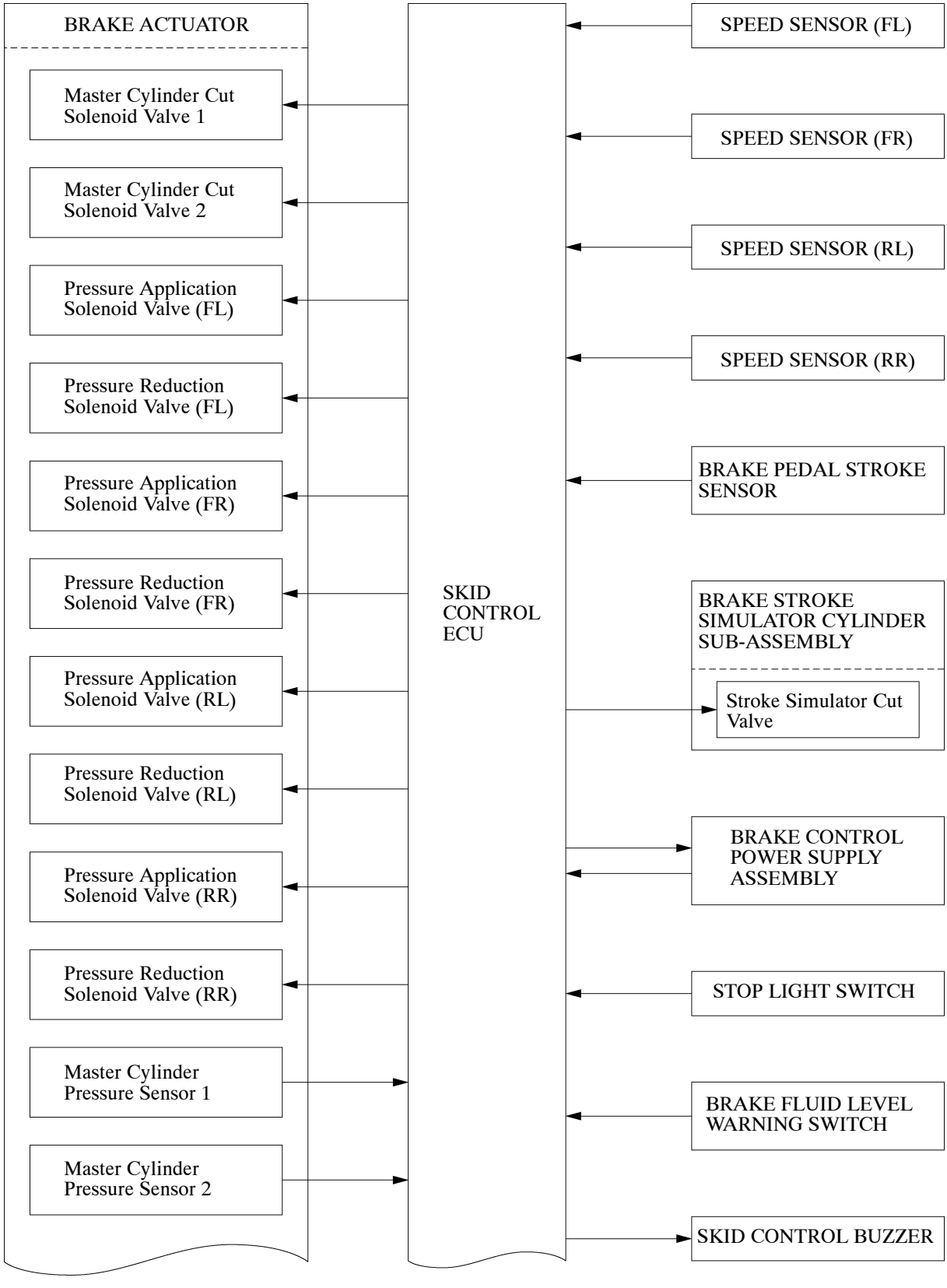
7. System Diagram



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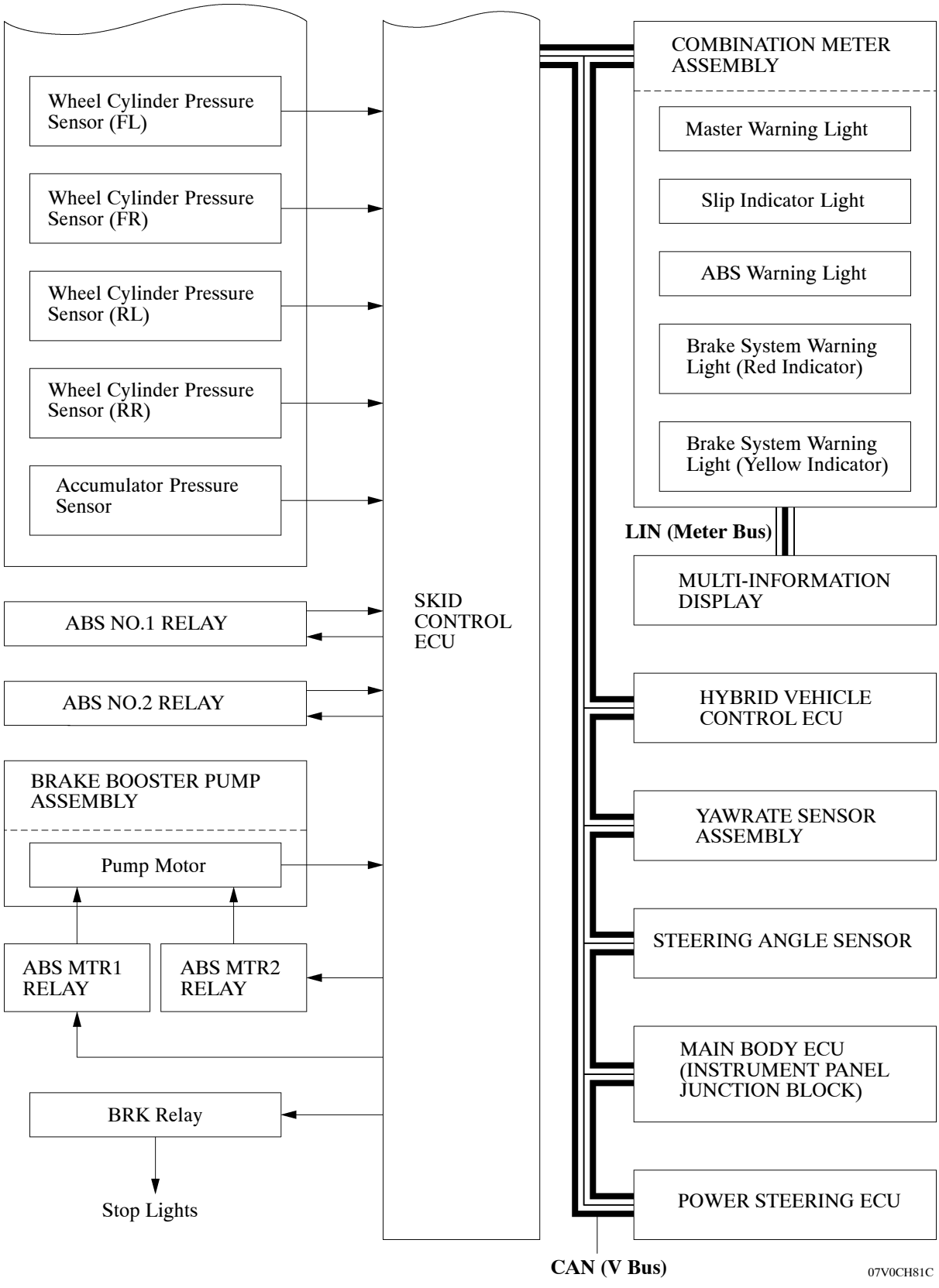
8. Construction

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

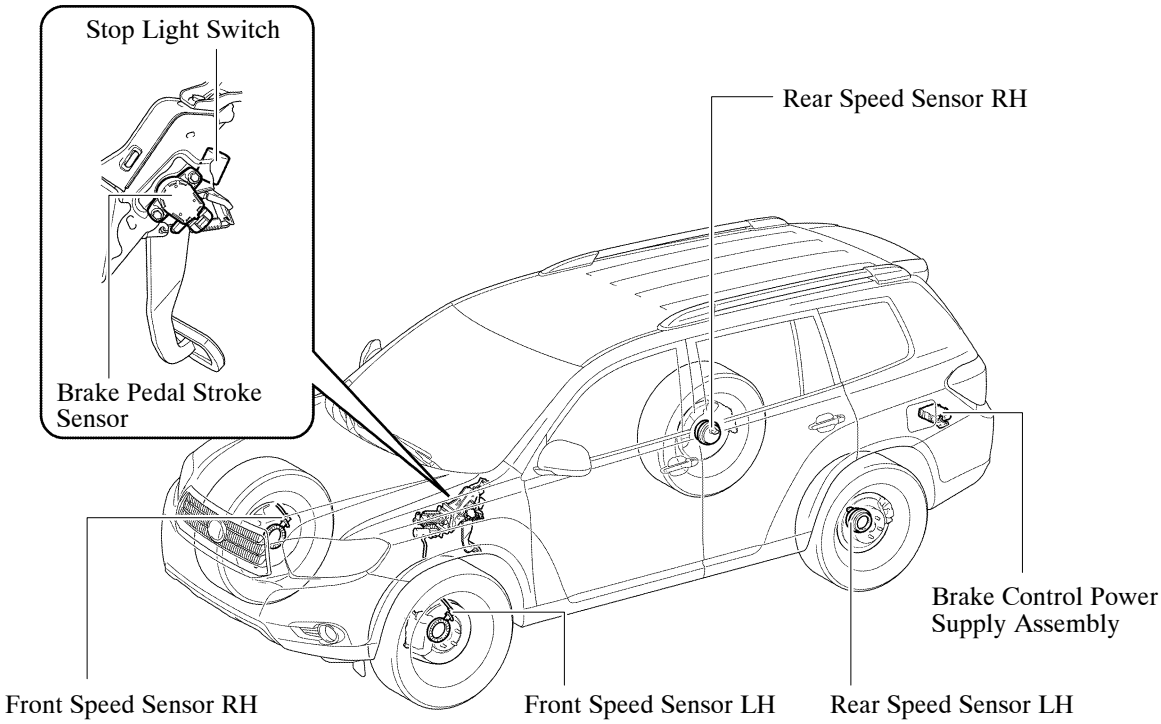


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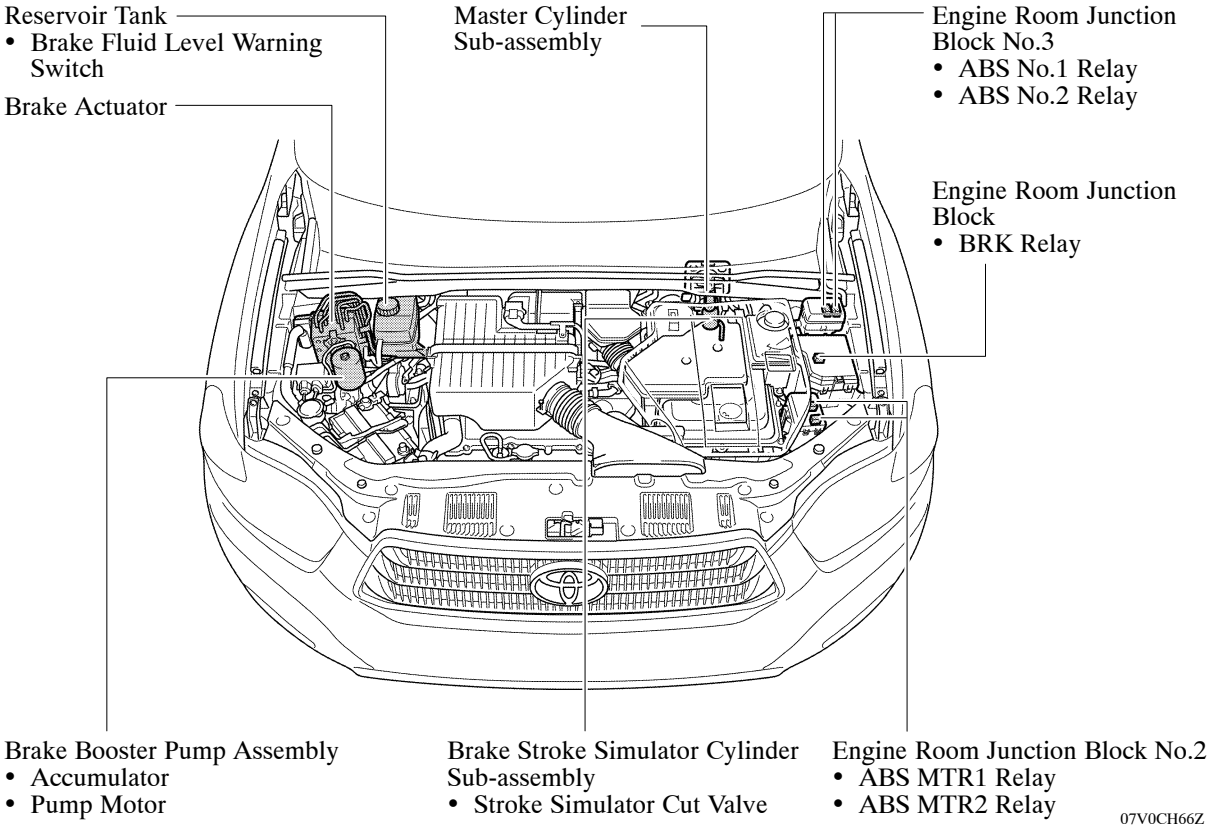
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Wheel Cylinder Pressure Sensor (FL)
Wheel Cylinder Pressure Sensor (FR)
Wheel Cylinder Pressure Sensor (RL)
Wheel Cylinder Pressure Sensor (RR)
Accumulator Pressure Sensor
ABS NO.1 RELAY
ABS NO.2 RELAY
BRAKE BOOSTER PUMP ASSEMBLY
Pump Motor
ABS MTR1 RELAY
ABS MTR2 RELAY
BRK Relay
Stop Lights
SKID CONTROL ECU
COMBINATION METER ASSEMBLY
Master Warning Light
Slip Indicator Light
ABS Warning Light
Brake System Warning Light (Red Indicator)
Brake System Warning Light (Yellow Indicator)
LIN (Meter Bus)
MULTI-INFORMATION DISPLAY
HYBRID VEHICLE CONTROL ECU
YAWRATE SENSOR ASSEMBLY
STEERING ANGLE SENSOR
MAIN BODY ECU (INSTRUMENT PANEL JUNCTION BLOCK)
POWER STEERING ECU
CAN (V Bus)
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9. Layout of Main Components



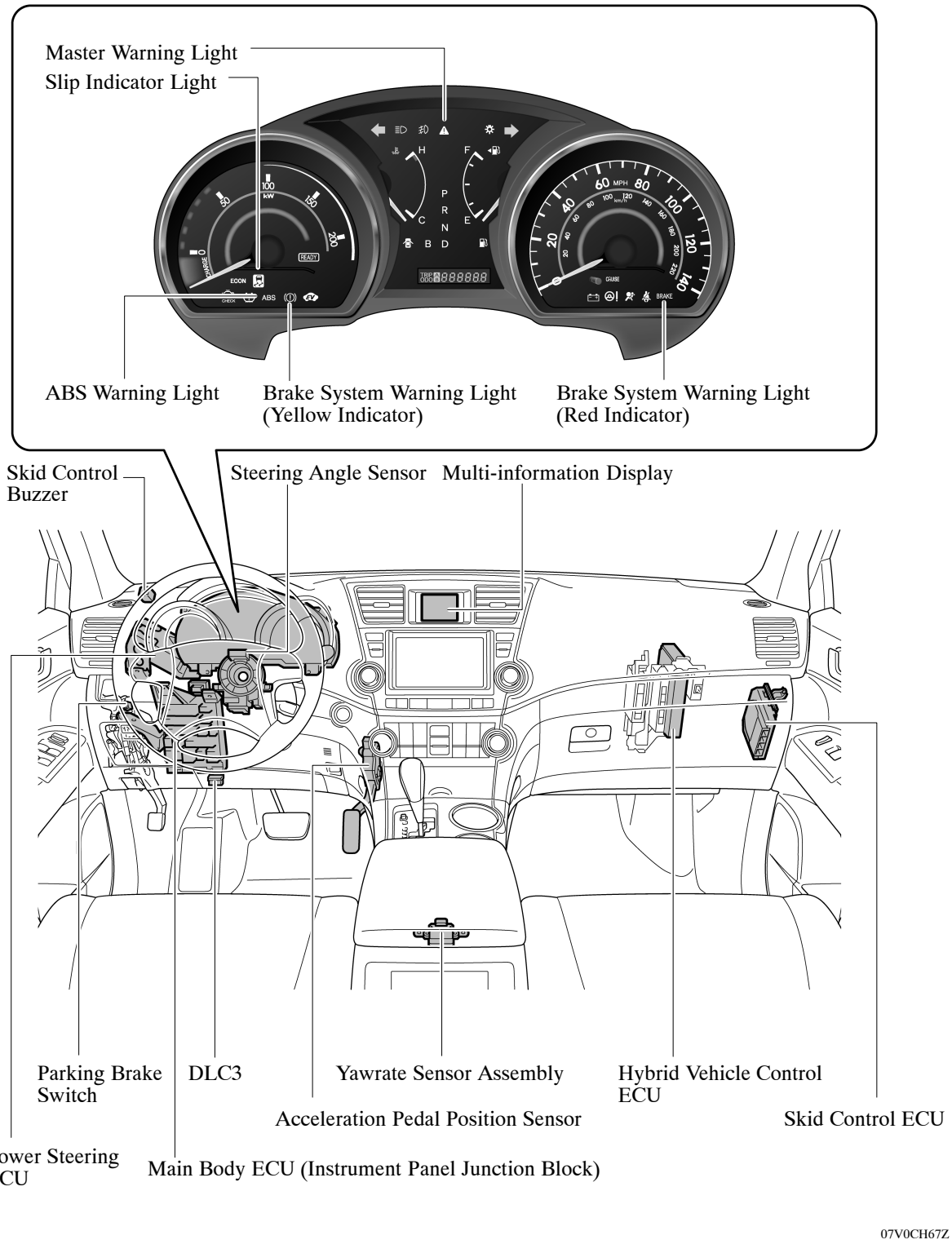
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Combination Meter Assembly



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10. Function of Main Components

Component		Function
Brake Actuator [See page CH-61]		• Consists of 2 master cylinder cut solenoid valves, 4 pressure application solenoid valves, and 4 pressure reduction solenoid valves. • The master cylinder pressure sensors, the accumulator pressure sensor, the wheel cylinder pressure sensors and the relief valve are installed in the brake actuator.
Brake Booster Pump Assembly	Accumulator	Stores the hydraulic pressure that was generated by the pump. The accumulator is filled with high pressure nitrogen gas.
	Pump and Pump Motor	Draws up the brake fluid from the reservoir tank and provides high hydraulic pressure to the accumulator.
Skid Control ECU		Monitors the driving conditions of the vehicle in accordance with the signals received from the sensors and through cooperative control with the hybrid vehicle control ECU and power steering ECU calculates the required amount of braking force, and controls the brake actuator.
Master Cylinder Sub-assembly		• Generates hydraulic pressure in accordance with the amount of effort applied to the brake pedal by the driver. • When a malfunction occurs in the power supply portion of the brake actuator, the brake master cylinder supplies the fluid pressure (which is generated by brake pedal effort) directly to the wheel cylinders.
Combination Meter Assembly	Brake System Warning Light (Red Indicator)	• Lights up to alert the driver that the skid control ECU detects the malfunction in the apportioning of the brake. • Lights up to inform the driver when the parking brake is ON or the brake fluid is low.
	Brake System Warning Light (Yellow Indicator)	Lights up to alert the driver that a minor malfunction which does not affect the braking force has occurred in the brake system.
	ABS Warning Light	Lights up to alert the driver when the skid control ECU detects a malfunction in the ABS or Brake Assist.
	Slip Indicator Light	Blinks to inform the driver when the ABS, TRAC, VSC, or Hill-start Assist Control operates.
	Master Warning Light	Lights up to alert the driver when the skid control ECU detects a malfunction in the brake control system.
Multi-information Display		Shows a warning message to alert the driver when the skid control ECU detects a malfunction in the brake control system.
Brake Pedal Stroke Sensor		Directly detects the extent of the brake pedal stroke operated by the driver.
Brake Stroke Simulator Cylinder Sub-assembly		Provides a pedal stroke during braking in accordance with the driver's pedal effort.
	Stroke Simulator Cut Valve	Allows the fluid pressure generated by the master cylinder sub-assembly to flow into the brake stroke simulator cylinder sub-assembly while the electronically controlled brake system operates.
ABS No.1 Relay and ABS No.2 Relay		Supplies power to the skid control ECU and solenoid valves in the brake actuator.
ABS MTR1 Relay and ABS MTR2 Relay		• These are two types of pump motor relays with different pump actuation speeds. • If one relay fails, the other relay operates to actuate the pump.
BRK Relay		Turns on the stop lights during Hill-start Assist Control operation.

(Continued)

Component		Function
Skid Control Buzzer		• The skid control buzzer emits a warning sound to inform the driver during VSC operation. • Sounds continuously to inform the driver if there is a malfunction in the hydraulic pressure or a failure in the power supply.
Reservoir Tank		Stores the brake fluid.
	Brake Fluid Level Warning Switch	Detects low brake fluid level.
Stop Light Switch		Detects brake pedal depression.
Parking Brake Switch		Detects parking brake application.
Yawrate Sensor Assembly		• Detects the vehicle's yaw rate. • Detects the vehicle's longitudinal and lateral acceleration and deceleration.
Steering Angle Sensor		Detects the steering direction and angle of the steering wheel.
Accelerator Pedal Position Sensor		Detects the accelerator pedal depression angle.
Front and Rear Speed Sensors (4)		Detect the wheel speed of each of the 4 wheels.
Brake Control Power Supply Assembly		• An auxiliary power supply to provide stable electrical power to the brake system. • When the voltage of the auxiliary battery is low, the power source backup unit supplements the supply of power to the brake system by providing the electric charge that is stored in the unit.
Hybrid Vehicle Control ECU		• Actuates regenerative braking upon receiving a signal from the skid control ECU. • Sends the actual regenerative braking control value to the skid control ECU. • Controls the motive force based on an output control request signal received from the skid control ECU while the VSC function or TRAC function is operating.
Power Steering ECU		The power steering ECU performs cooperative control with the skid control ECU, in order to control the steering assist force in accordance with information received from the skid control ECU.
Main Body ECU (Instrument Panel Junction Block)		Transmits the parking brake signal to the skid control ECU.

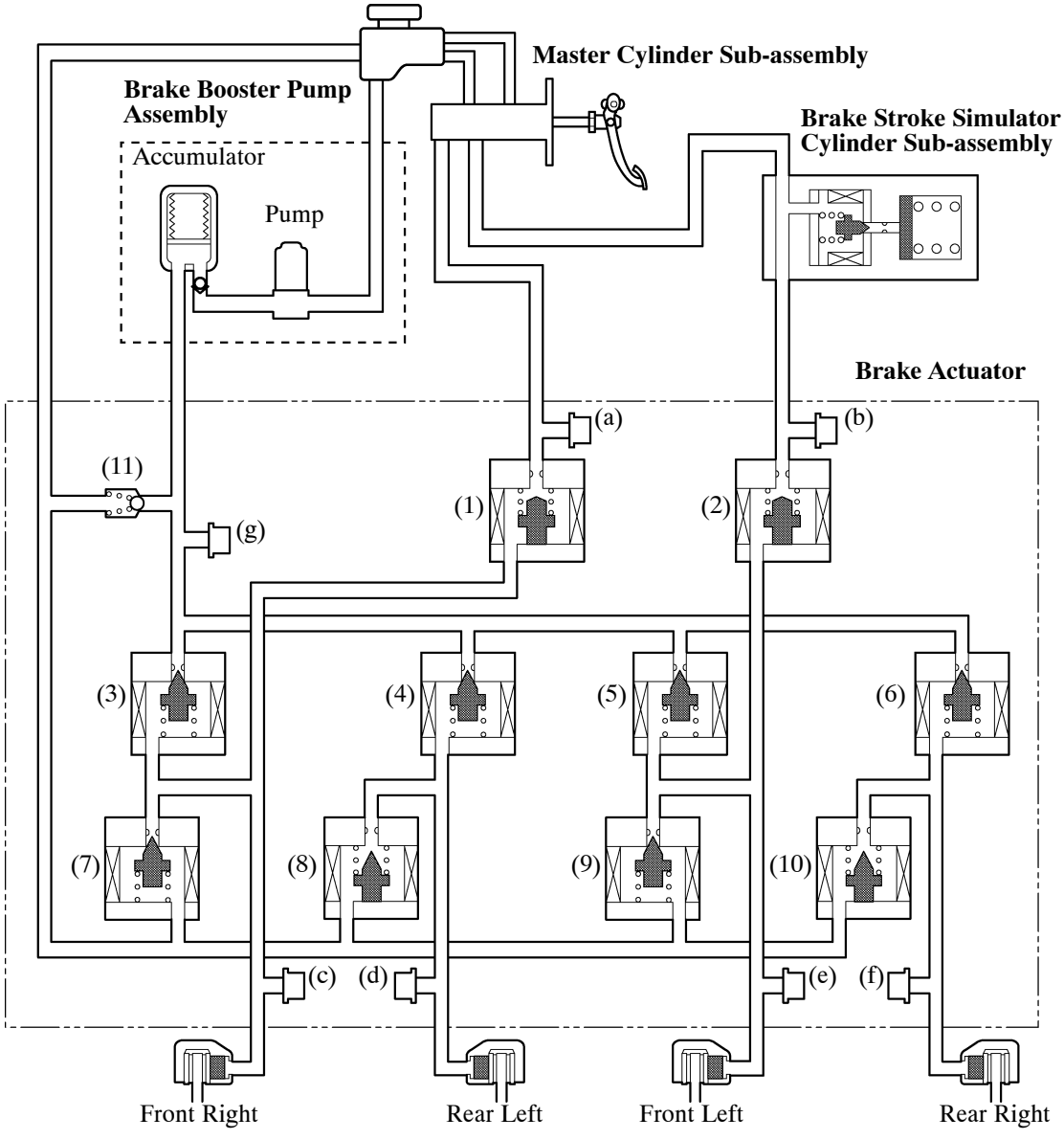
11. Brake Actuator

General

The construction of the brake actuator, and the role of each part, is as follows.

Components		Outline
(1), (2)	Master Cylinder Cut Solenoid Valve (2-position Type)	• When the brake pedal is depressed, this valve cuts the hydraulic passage between the master cylinder and its wheel cylinder. • When the brake pedal is not depressed or a failure occurs in the hydraulic power source portion, the valves open to maintain the hydraulic passage to the front wheel cylinders and ensure braking. • When a failure occurs, a greater effort than normal is required to depress the brake pedal.
(3), (4), (5), (6)	Pressure Application Valve (Linear Type)	These valves, which are controlled by the skid control ECU, regulate the fluid pressure from the accumulator in order to amplify the fluid pressure to the wheel cylinders.
(7), (8), (9), (10)	Pressure Reduction Valve (Linear Type)	These valves, which are controlled by the skid control ECU, regulate the fluid pressure in order to reduce the fluid pressure to the wheel cylinders.
(11)	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.
(A), (B)	Master Cylinder Pressure Sensor	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.
(C), (D), (E), (F)	Wheel Cylinder Pressure Sensor	These sensors detect the fluid pressure that acts on their respective wheel cylinders and transmits the pressure to the skid control ECU to provide feedback. Accordingly, the skid control ECU can monitor the fluid pressure of the wheel cylinders and control the pressure application solenoid valves and the pressure reduction solenoid valves, in order to achieve the optimal wheel cylinder pressures.
(G)	Accumulator Pressure Sensor	The accumulator pressure sensor constantly monitors the brake fluid pressure in the accumulator and transmits a signal to the skid control ECU. Accordingly, the skid control ECU controls the pump motor.

Hydraulic Circuit



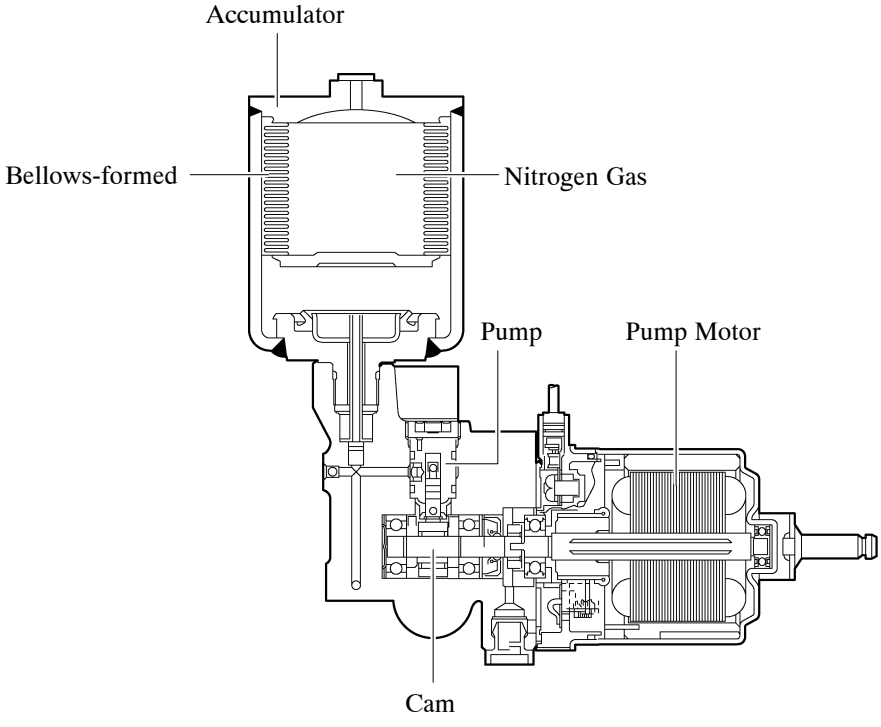
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12. Brake Booster Pump Assembly

General

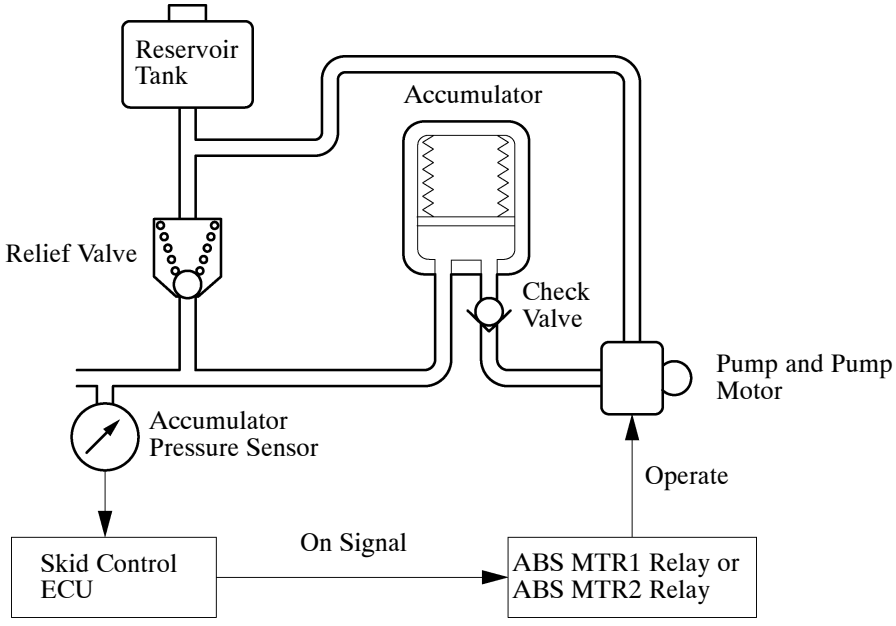
The brake booster pump assembly consists of a pump, pump motor, and accumulator.

- Inside the accumulator, the high-pressurized nitrogen gas is charged and sealed. In addition, metallic bellows-formed tube is used, in order to enhance the gastight performance of the accumulator.
- A plunger type pump is used. This pump is operated by the rotation of a motor driven cam, to supply high-pressure fluid to the accumulator.



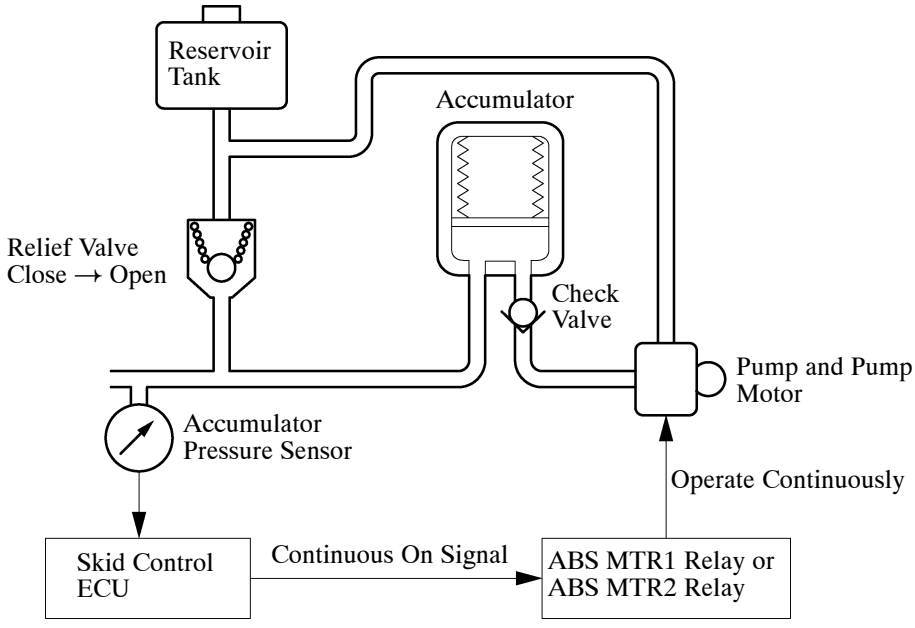
Operation

- 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 pump motor is activated upon receipt of signals from the skid control ECU to turn on the ABS MTR1 and MTR2 relays.
- 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.

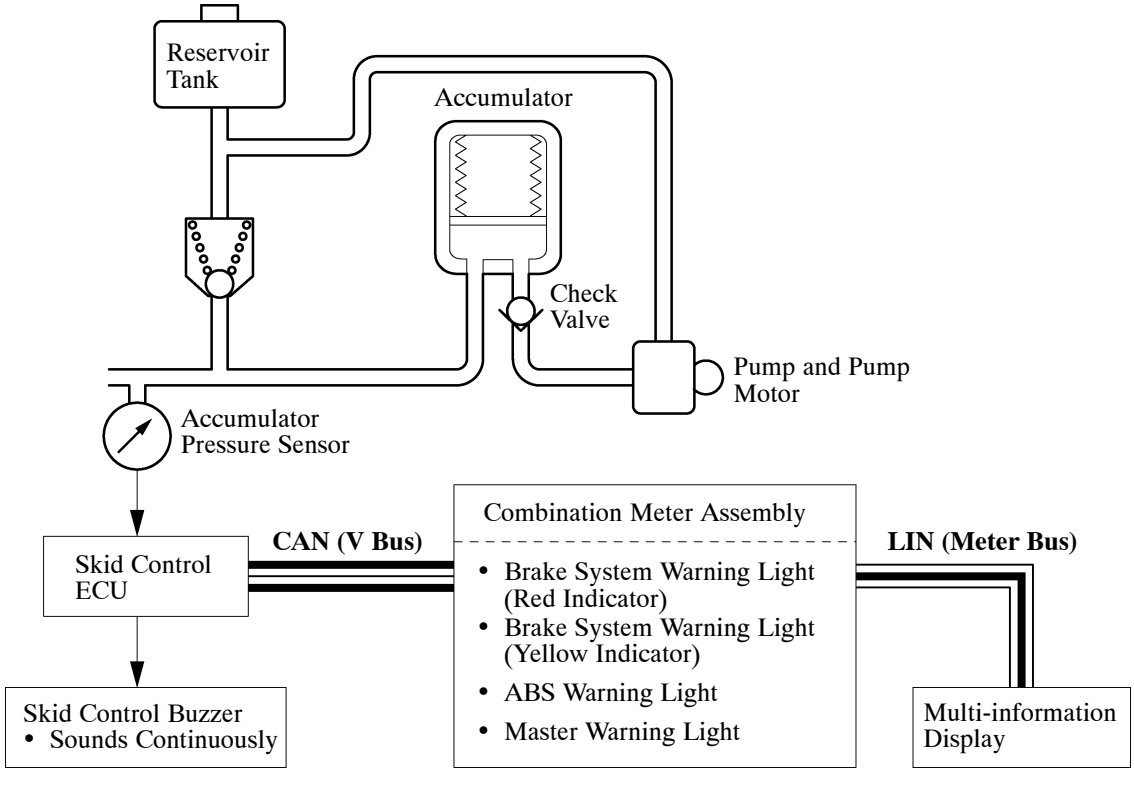


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- If the pump and the pump motor continue to operate unintendedly, such as due to the failure of the accumulator sensor, a high pressure would be created in the accumulator. At this time, the relief valve will open to return the brake fluid to the reservoir tank, to limit the accumulator pressure.



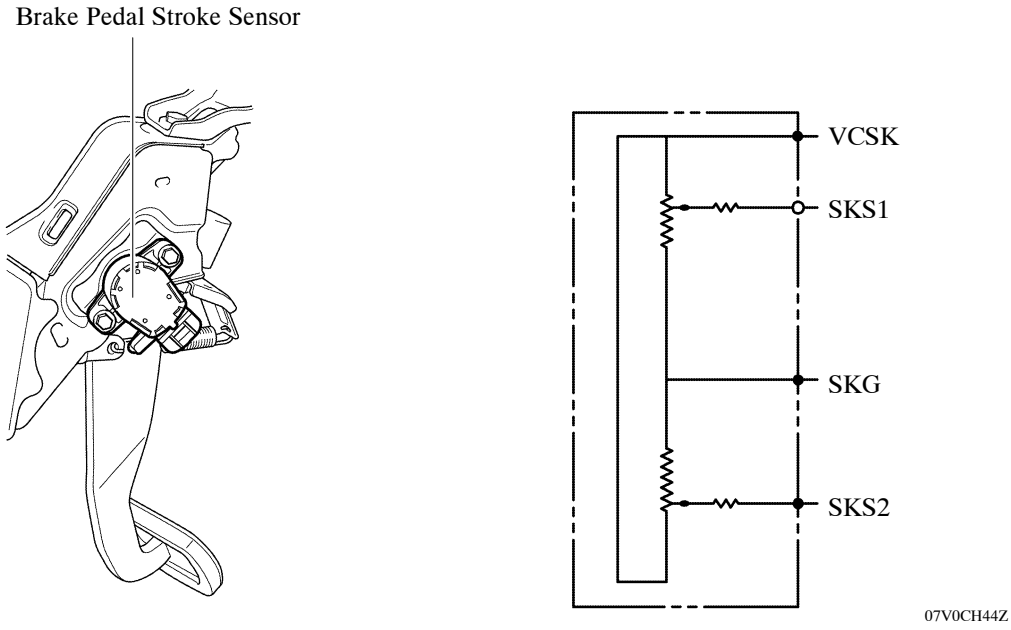
- If the accumulator pressure drops abnormally to a level below the pressure set at the ECU, the skid control ECU illuminates the brake system warning light (red indicator), the brake system warning light (yellow indicator), ABS warning light and the master warning light. Then, a warning message appears on the multi-information display, and the skid control buzzer sounds to alert the driver of the malfunction.

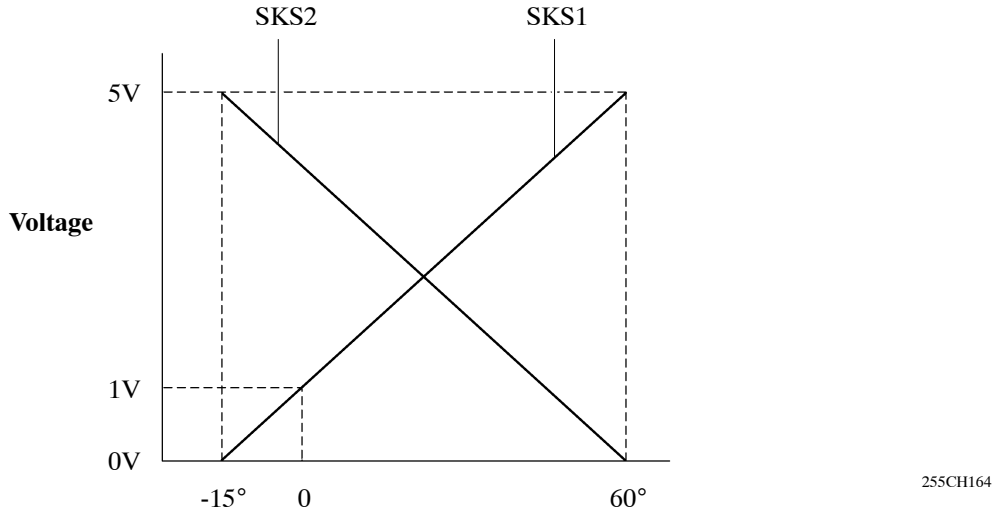


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13. Brake Pedal Stroke Sensor

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.





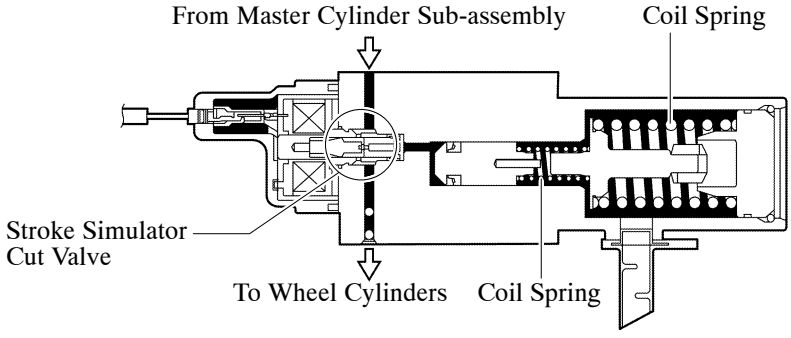
Service Tip

- To install a brake pedal stroke sensor, which is available as a service part, perform the following:
  - 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.
- After replacing the brake pedal stroke sensor, initialization of brake pedal stroke sensor is required on the skid control ECU side.
- For details, see the 2008 HIGHLANDER HYBRID VEHICLE Repair Manual (Pub. No. RM07V0U).

14. Brake Stroke Simulator Cylinder Sub-assembly

The brake stroke simulator cylinder sub-assembly consists of 2 types of coil springs with different spring constants and a stroke simulator cut valve.

- The brake stroke simulator cylinder sub-assembly provides a pedal stroke in accordance with the driver's pedal effort during braking. Containing two types of coil springs with different spring constants, the brake stroke simulator cylinder sub-assembly provides pedal stroke characteristics in two stages in relation to the master cylinder pressure.

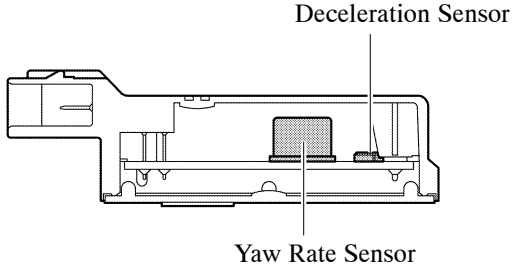


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15. Yawrate Sensor Assembly

The yawrate sensor assembly consists of a deceleration sensor and yaw rate sensor. This sensor detects the yaw rate and lateral and longitudinal acceleration, and sends this signal to the skid control ECU.



07V0CH46Z

Service Tip

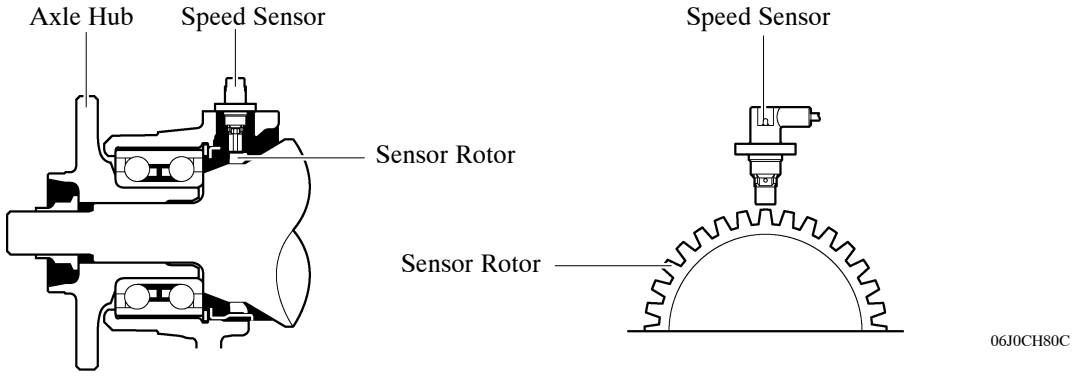
After replacing the yawrate sensor assembly, or the skid control ECU, zero point calibration of the yawrate sensor assembly is required.
For details, see the 2008 HIGHLANDER HYBRID VEHICLE Repair Manual (Pub. No. RM07V0U).

16. Speed Sensors

General

The following types of speed sensors are used.

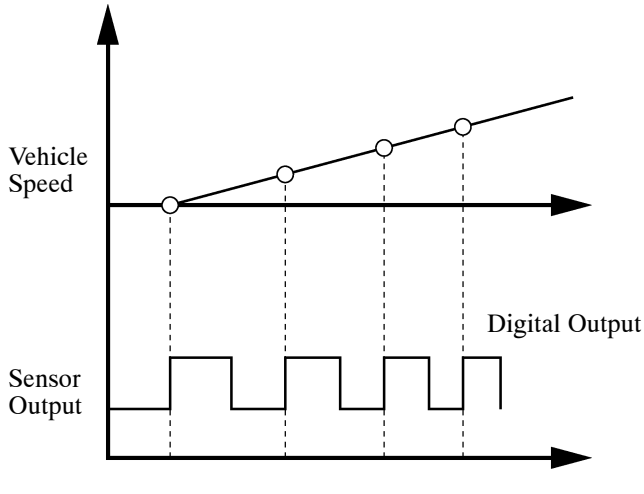
Item		Outline
Front Speed Sensor	Type	Active/Hall IC
	Sensor Rotor	Gear (48 teeth)/Integrated with the front drive shaft assembly.
	Signal Output	Digital
Rear Speed Sensor	Type	Active/Hall IC
	Sensor Rotor	Gear (48 teeth)/Integrated with the rear drive shaft assembly.
	Signal Output	Digital



Vehicle Speed Detection Method

The Hall IC type speed sensor use the frequency of output pulses to detect the vehicle speed.

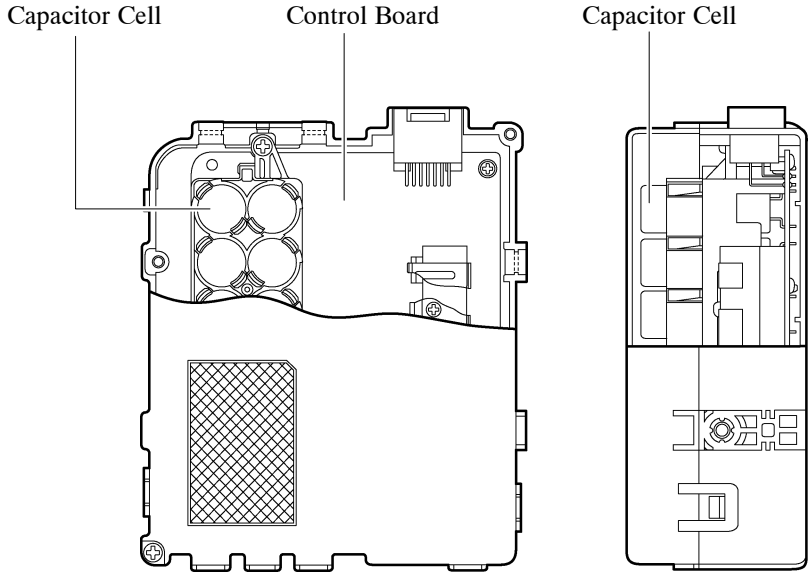
- Because the sensor outputs digital pulses, it can detect vehicle speeds even when the vehicle is nearly stationary.



17. Brake Control Power Supply Assembly

The brake control power supply assembly is used as an auxiliary power source, in order to supply power to the brake system in a stable manner.

- This supply assembly contains 12 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 for the brake system.



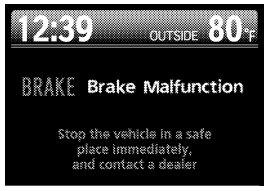
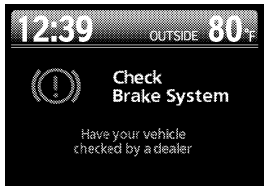
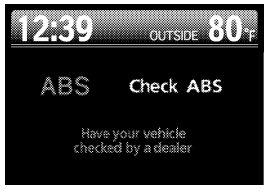
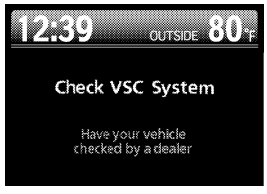
Service Tip

Immediately after the power switch is turned OFF, this supply assembly 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 brake control power supply assembly from the vehicle or opening and inspecting the inside of the brake control power supply assembly case.
For details, see the 2008 HIGHLANDER HYBRID VEHICLE Repair Manual (Pub. No. RM07V0U).

18. Combination Meter Assembly and Multi-information Display

- The combination meter assembly illuminates or flashes various warning lights in accordance to the electronically control brake system conditions.
- The multi-information display displays warning messages on the multi-information display in accordance to the electronically controlled brake system conditions.

As for details regarding the warning lights illuminates and flashes and warning message displays, see the following table.

Combination Meter Assembly		Multi-information Display	Detail
Warning Light	Buzzer		
Brake System Warning Light (Red Indicator)	Sounds	 06J0BE180C	Brake system is malfunctioning.
Brake System Warning Light (Yellow Indicator)	Sounds	 07V0CH47C	Brake system minor malfunction.
ABS Warning Light	Sounds	 06J0BE179C	ABS is malfunctioning.
Master Warning Light	Sounds	 06J0BE178C	TRAC and VSC are malfunctioning.

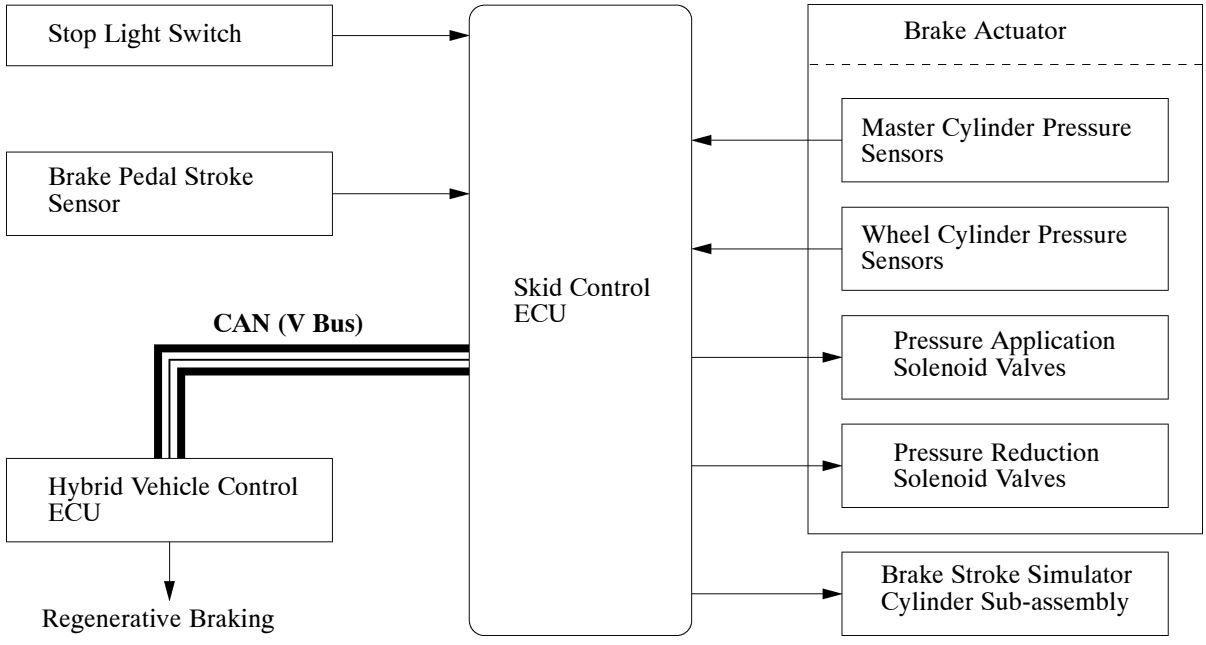
19. System Operation

Normal Brake Operation (with Regenerative Braking 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 ECU-request regenerative brake force value out of the required brake force and transmits this calculated value to the hybrid vehicle control ECU. Upon receiving the value, the hybrid vehicle control ECU generates a regenerative brake force.
- At the same time, the hybrid vehicle control ECU transmits the actual regenerative brake force value (regenerative braking execution 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 which is obtained by subtracting the regenerative braking execution value from the brake force value required by the driver.

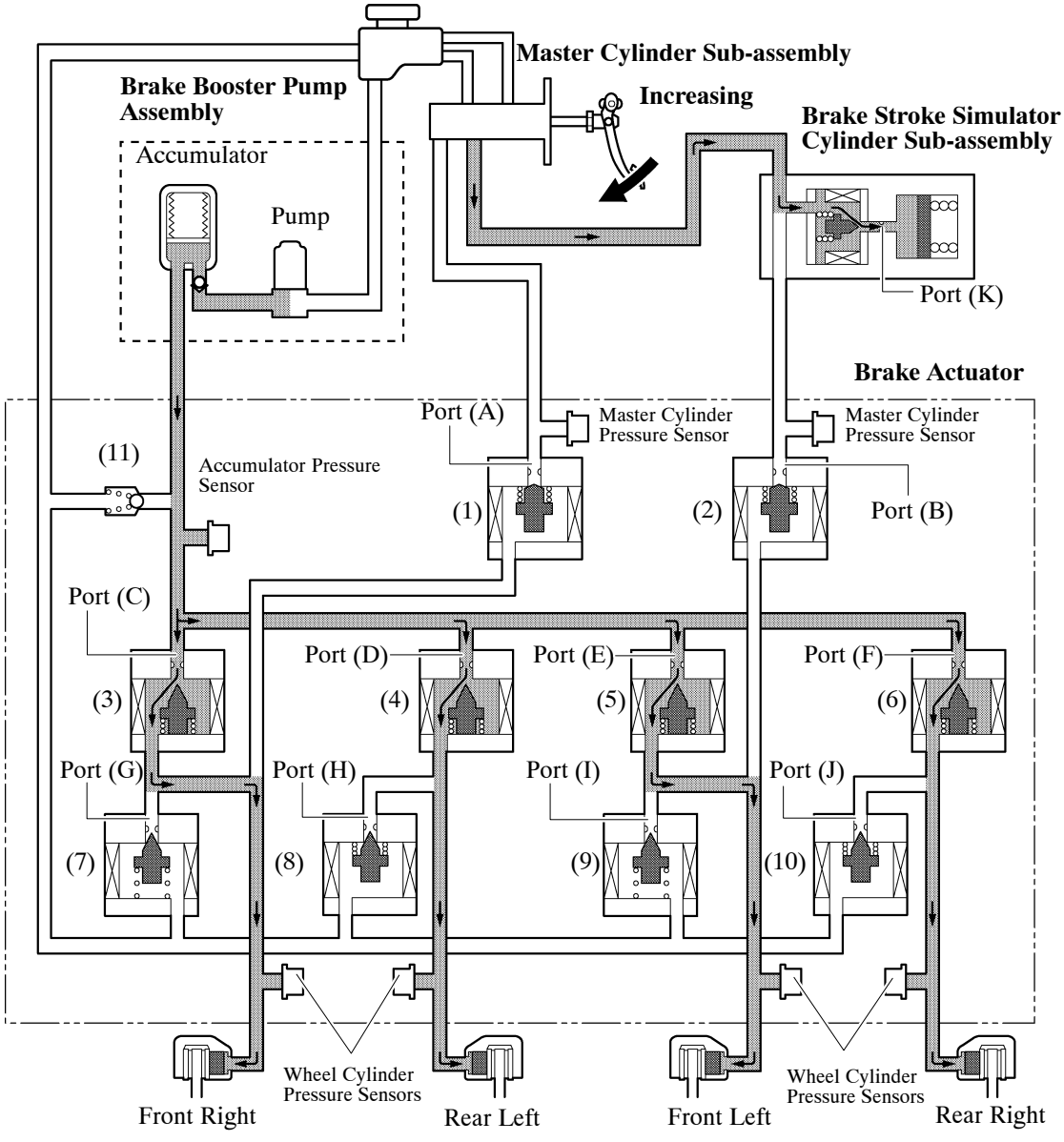
▶ System Diagram ◀



07V0CH48C

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 wheel cylinder pressure is lower than the target, the skid control ECU boosts the pressure using 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 perform cooperative control in accordance with changes in the regenerative braking force.



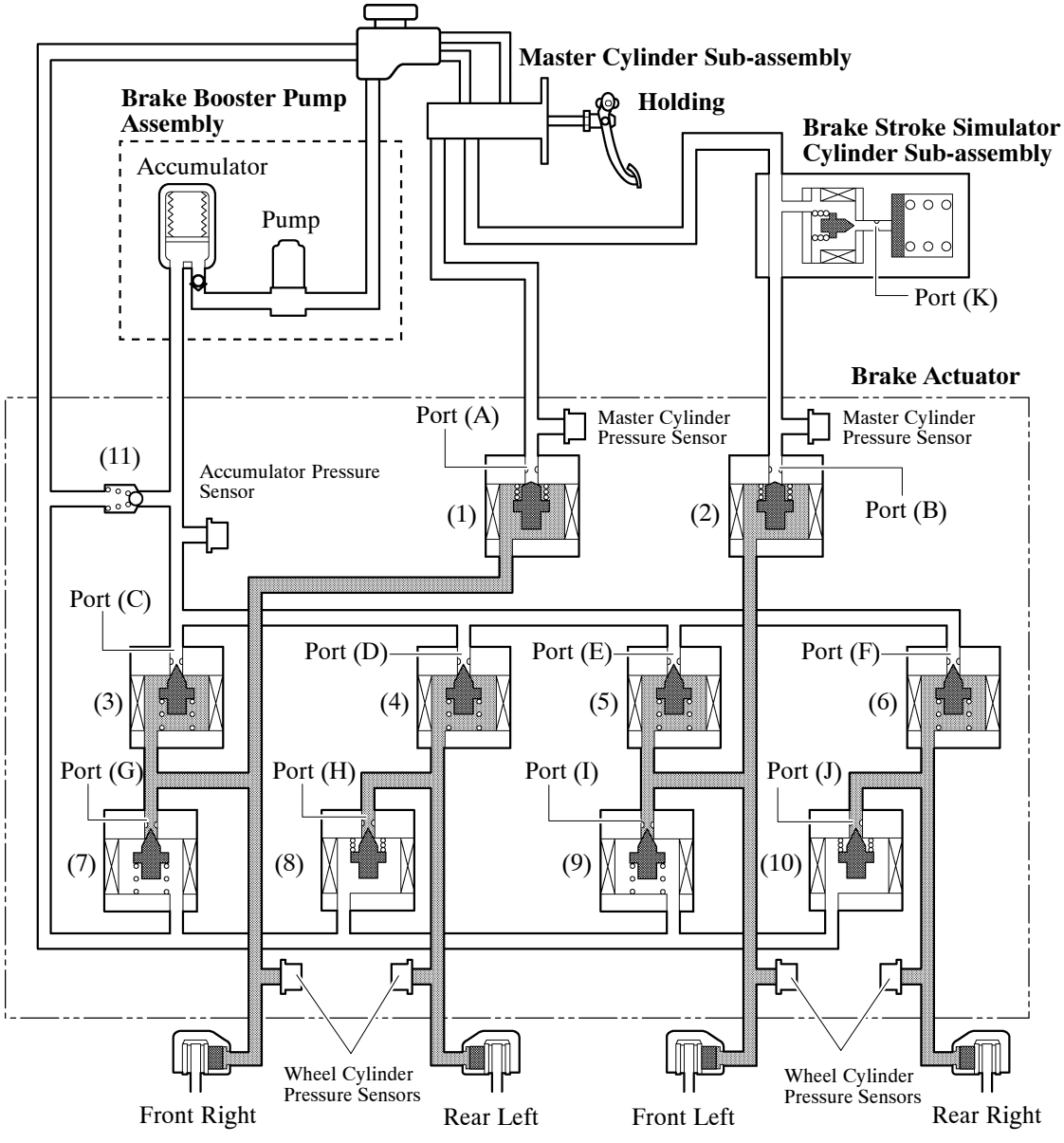
07V0CH49C

Item		Normal Braking Increase Mode
(1), (2)	Master Cylinder Cut Solenoid Valve	ON (Closed)
	Port: (A), (B)	
(3), (4), (5), (6)	Pressure Application Valve (Linear Type)	ON*
	Port: (C), (D), (E), (F)	
(7), (9)	Pressure Reduction Valve (Linear Type)	OFF (Closed)
	Port: (G), (I)	
(8), (10)	Pressure Reduction Valve (Linear Type)	ON (Closed)
	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 order to control the fluid pressure.

3) Pressure Hold

- 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.

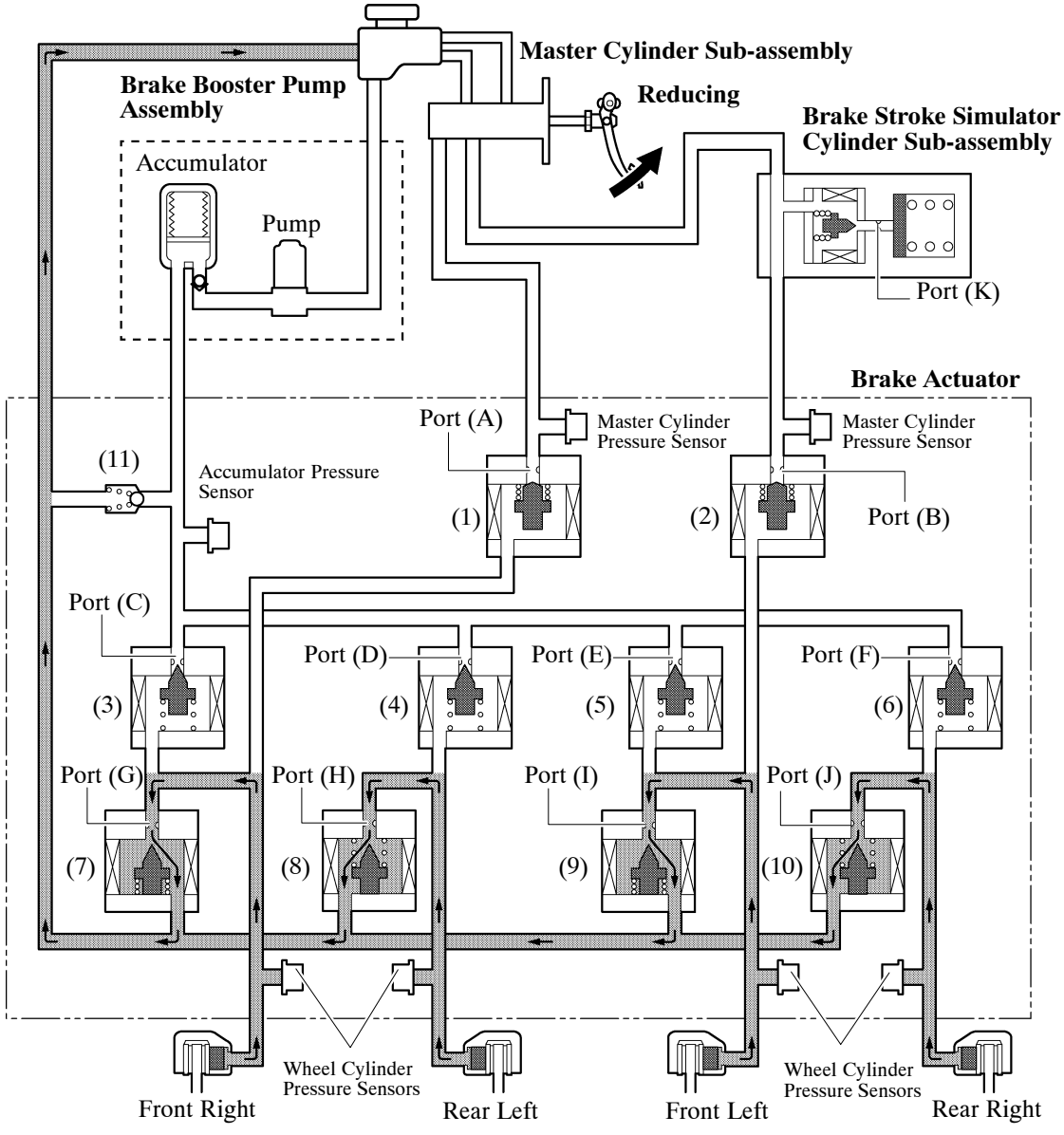


07V0CH50C

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

4) Pressure Reduction

- 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 wheel cylinder pressure is higher than the target, the skid control ECU reduces the pressure using 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 perform cooperative control in accordance with changes in the regenerative braking force.



07V0CH51C

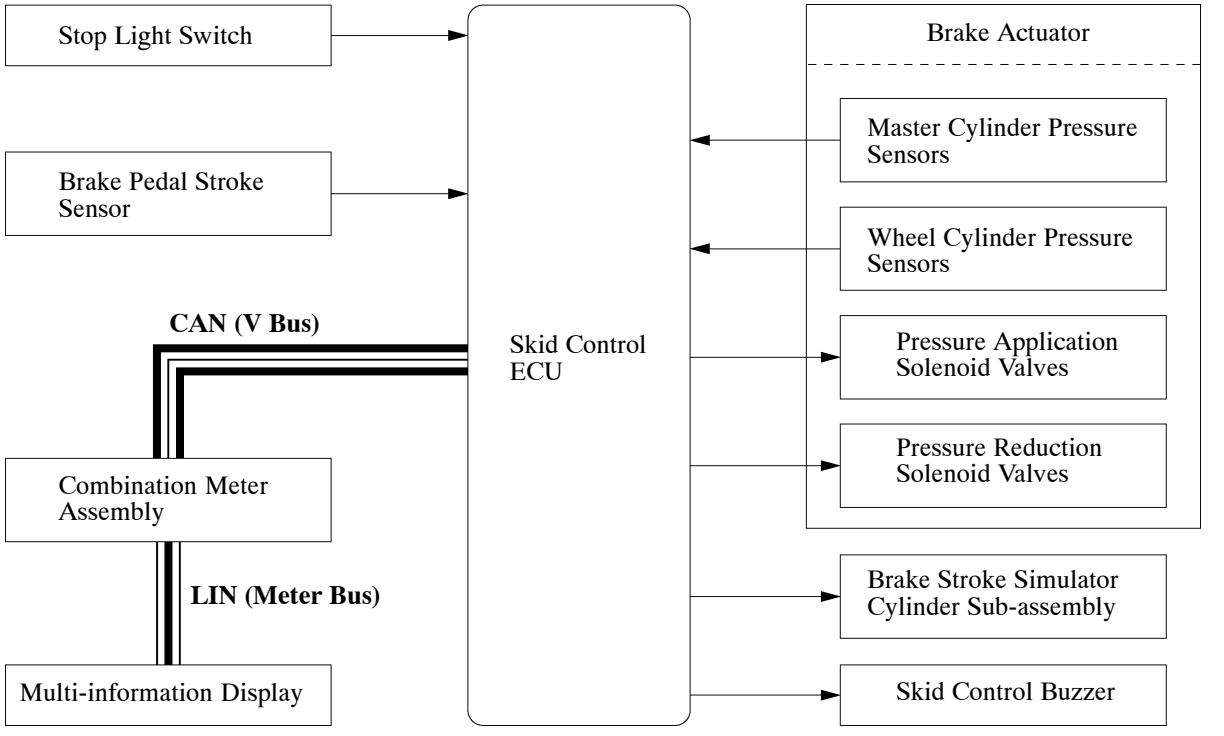
Item		Normal Braking Reduction Mode
(1), (2)	Master Cylinder Cut Solenoid Valve	ON (Closed)
	Port: (A), (B)	
(3), (4), (5), (6)	Pressure Application Valve (Linear Type)	OFF (Closed)
	Port: (C), (D), (E), (F)	
(7), (9)	Pressure Reduction Valve (Linear Type)	ON*
	Port: (G), (I)	
(8), (10)	Pressure Reduction Valve (Linear Type)	ON*
	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 order to control the fluid pressure.

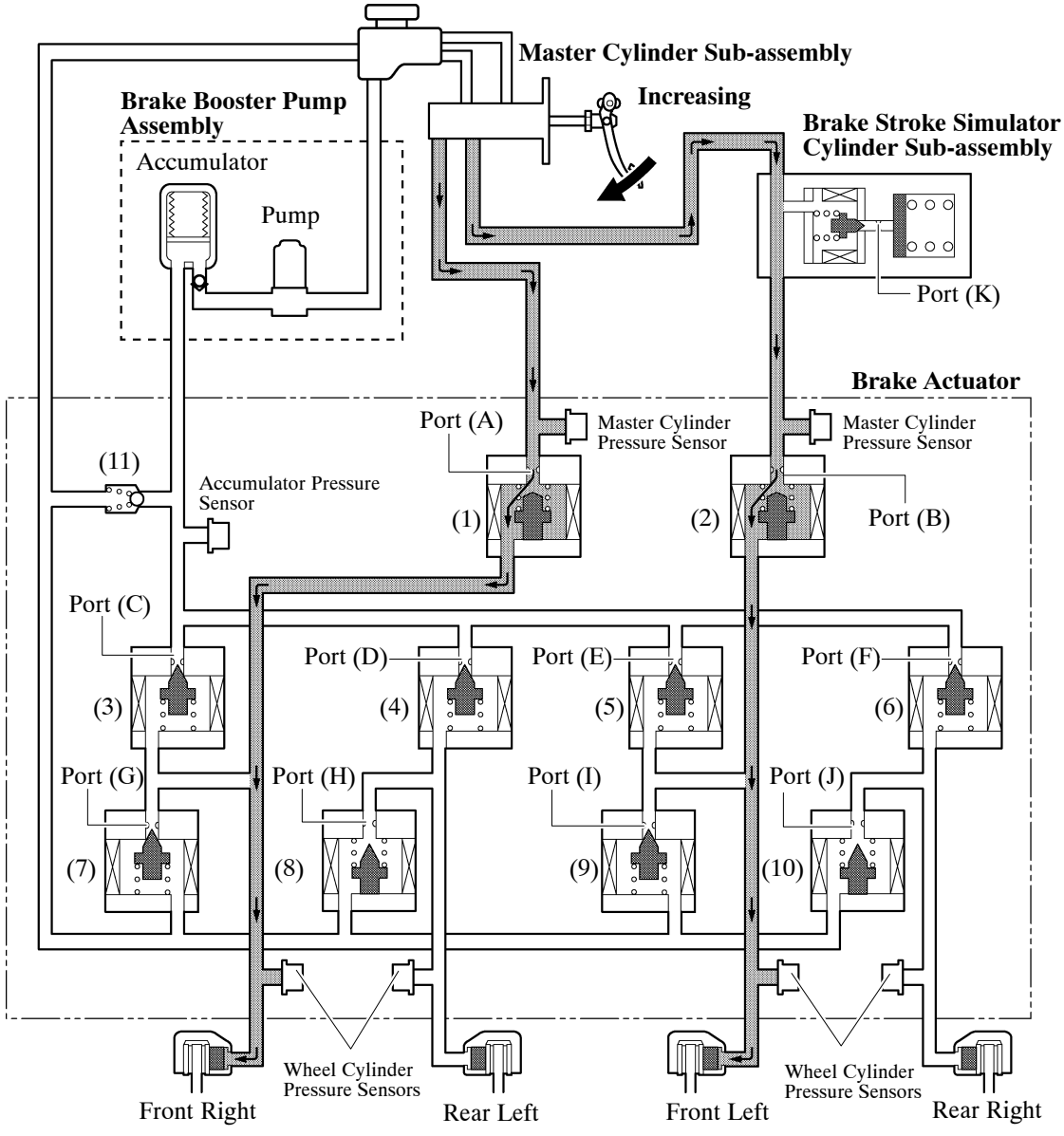
Electronically Controlled Brake System Stops or During Power Supply Malfunction

- If the electronically controlled 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 using 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.
- In addition, to inform the driver, the skid control ECU sends a warning signal to the combination meter assembly, in addition to sounding the skid control buzzer.

▶ System Diagram ◀



07V0CH52C



07V0CH53C

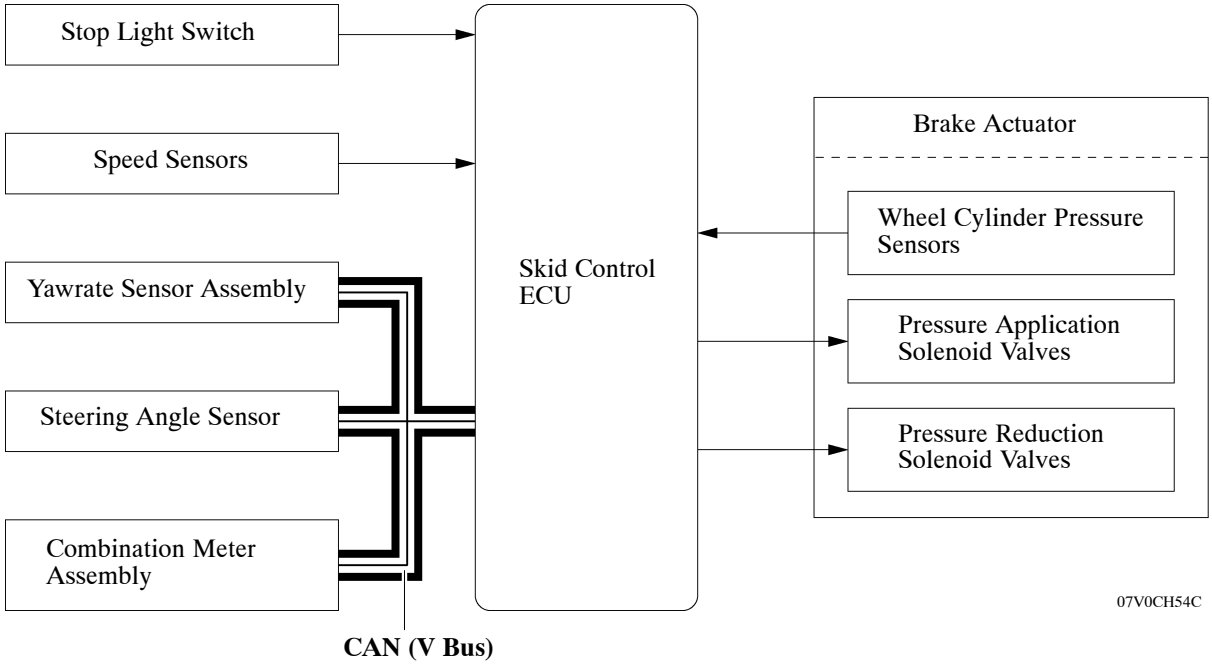
CH

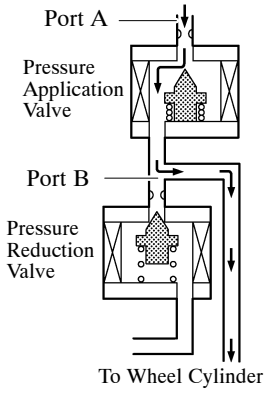
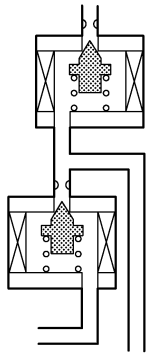
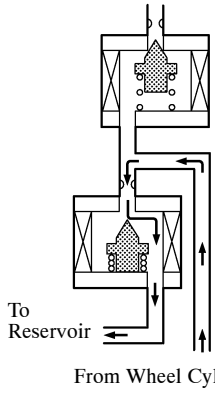
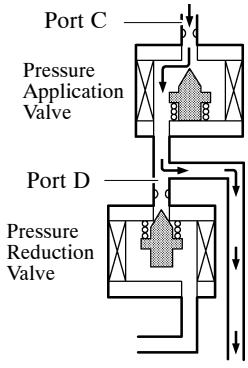
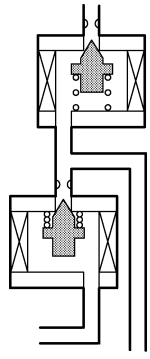
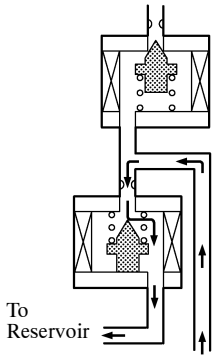
Item		Fail-safe Mode
(1), (2)	Master Cylinder Cut Solenoid Valve	OFF (Open)
	Port: (A), (B)	
(3), (4), (5), (6)	Pressure Application Valve (Linear Type)	OFF (Closed)
	Port: (C), (D), (E), (F)	
(7), (9)	Pressure Reduction Valve (Linear Type)	OFF (Closed)
	Port: (G), (I)	
(8), (10)	Pressure Reduction Valve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

ABS with EBD Operation

Based on the signals received from the four speed sensors, the skid control ECU calculates each wheel speed and deceleration, and checks for wheel slippage. According to wheel slippage, the skid control ECU controls each pressure increase 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 ◀



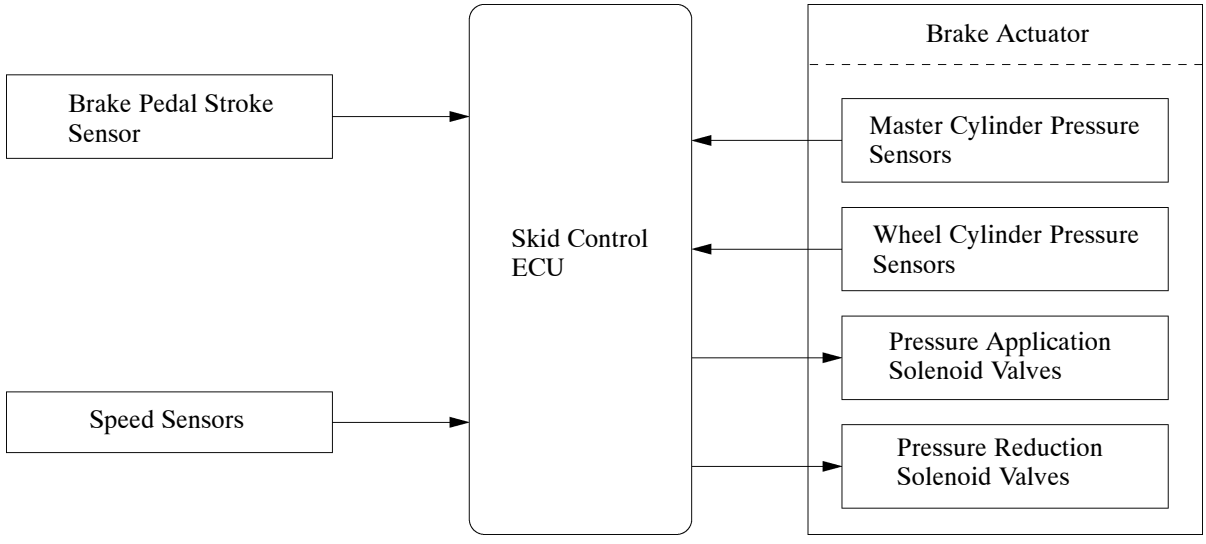
Not Activated		Normal Braking	-	-
Activated		Increase Mode	Holding Mode	Reduction Mode
Hydraulic Circuit		 255CH151	 255CH152	 255CH153
Front	Pressure Application Valve (Port A)	ON*	OFF (Closed)	OFF (Closed)
	Pressure Reduction Valve (Port B)	OFF (Closed)	OFF (Closed)	ON*
Hydraulic Circuit		 07V0CH83C	 07V0CH84C	 255CH161
Rear	Pressure Application Valve (Port C)	ON*	OFF (Closed)	OFF (Closed)
	Pressure Reduction Valve (Port D)	ON (Closed)	ON (Closed)	ON*
Wheel Cylinder Pressure		Increase	Hold	Reduction

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

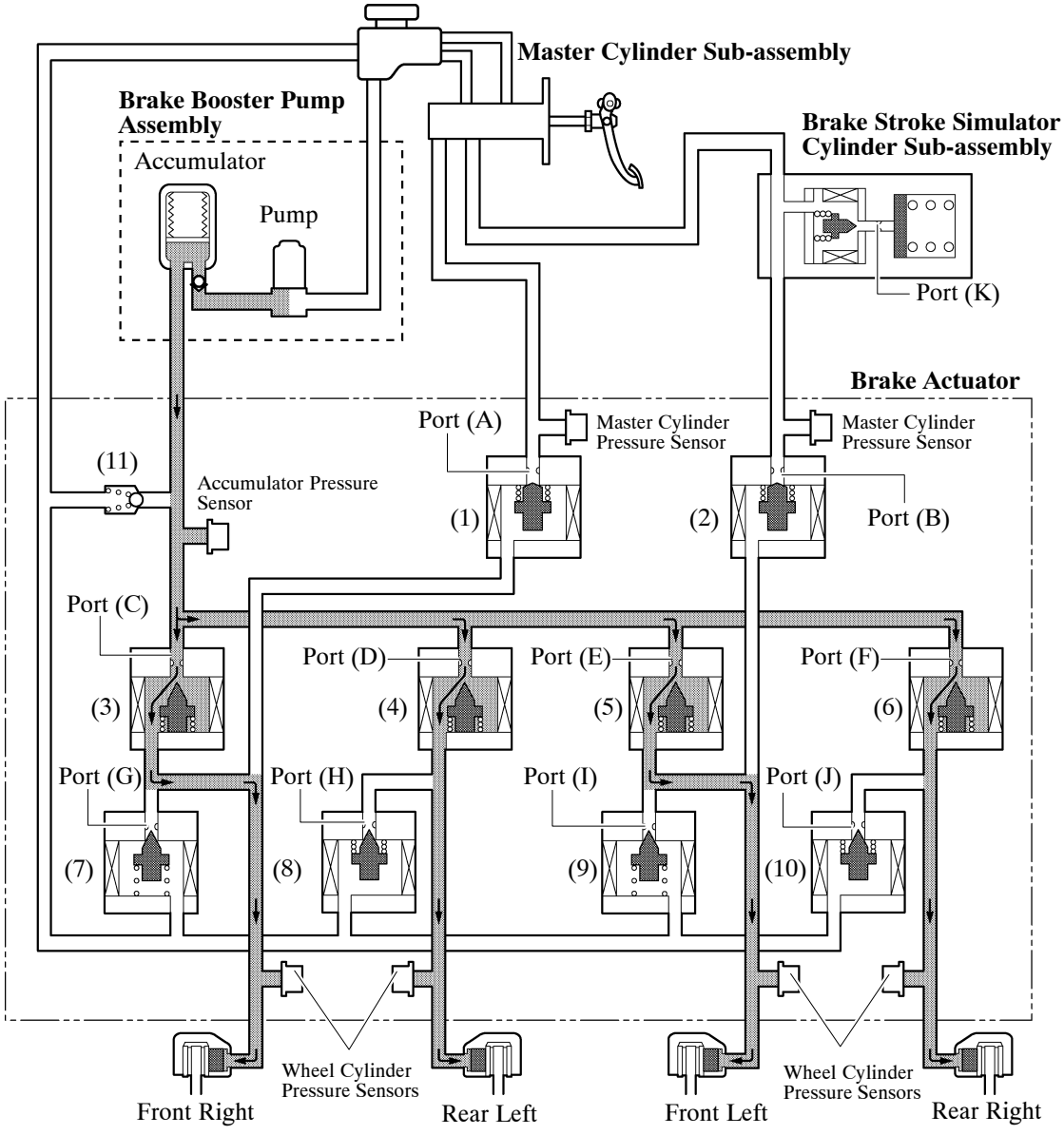
Brake Assist Operation

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 signals. If the ECU judges the need for the additional brake assist, additional fluid pressure is generated by the pump in the actuator and directed to the wheel cylinders.

▶ System Diagram ◀



07V0CH55C


Master Cylinder Sub-assembly
Brake Booster Pump Assembly
Accumulator
Pump
Brake Stroke Simulator Cylinder Sub-assembly
Port (K)
Brake Actuator
Port (A)
Master Cylinder Pressure Sensor
Master Cylinder Pressure Sensor
(11)
Accumulator Pressure Sensor
(1)
(2)
Port (B)
Port (C)
Port (D)
Port (E)
Port (F)
(3)
(4)
(5)
(6)
Port (G)
Port (H)
Port (I)
Port (J)
(7)
(8)
(9)
(10)
Wheel Cylinder Pressure Sensors
Wheel Cylinder Pressure Sensors
Front Right
Rear Left
Front Left
Rear Right

07V0CH56C

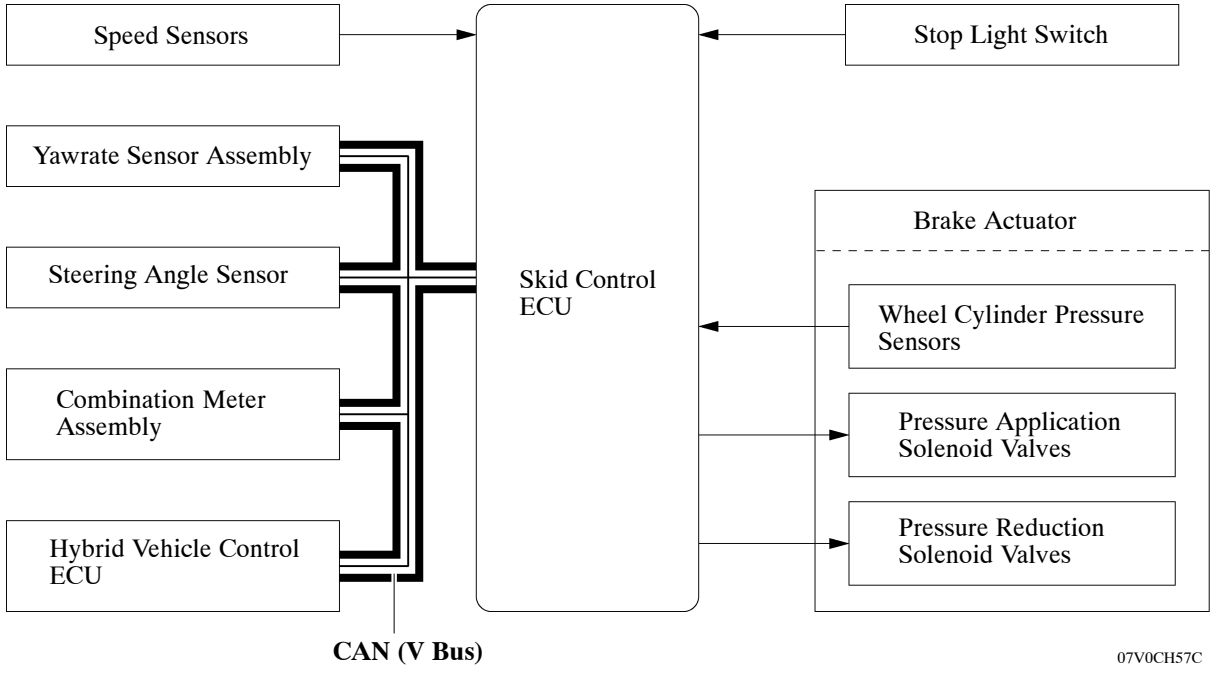
Item		Normal Braking Increase Mode	Brake Assist Activated
(1), (2)	Master Cylinder Cut Solenoid Valve	ON (Closed)	ON (Closed)
	Port: (A), (B)		
(3), (4), (5), (6)	Pressure Application Valve (Linear Type)	ON*	ON*
	Port: (C), (D), (E), (F)		
(7), (9)	Pressure Reduction Valve (Linear Type)	OFF (Closed)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

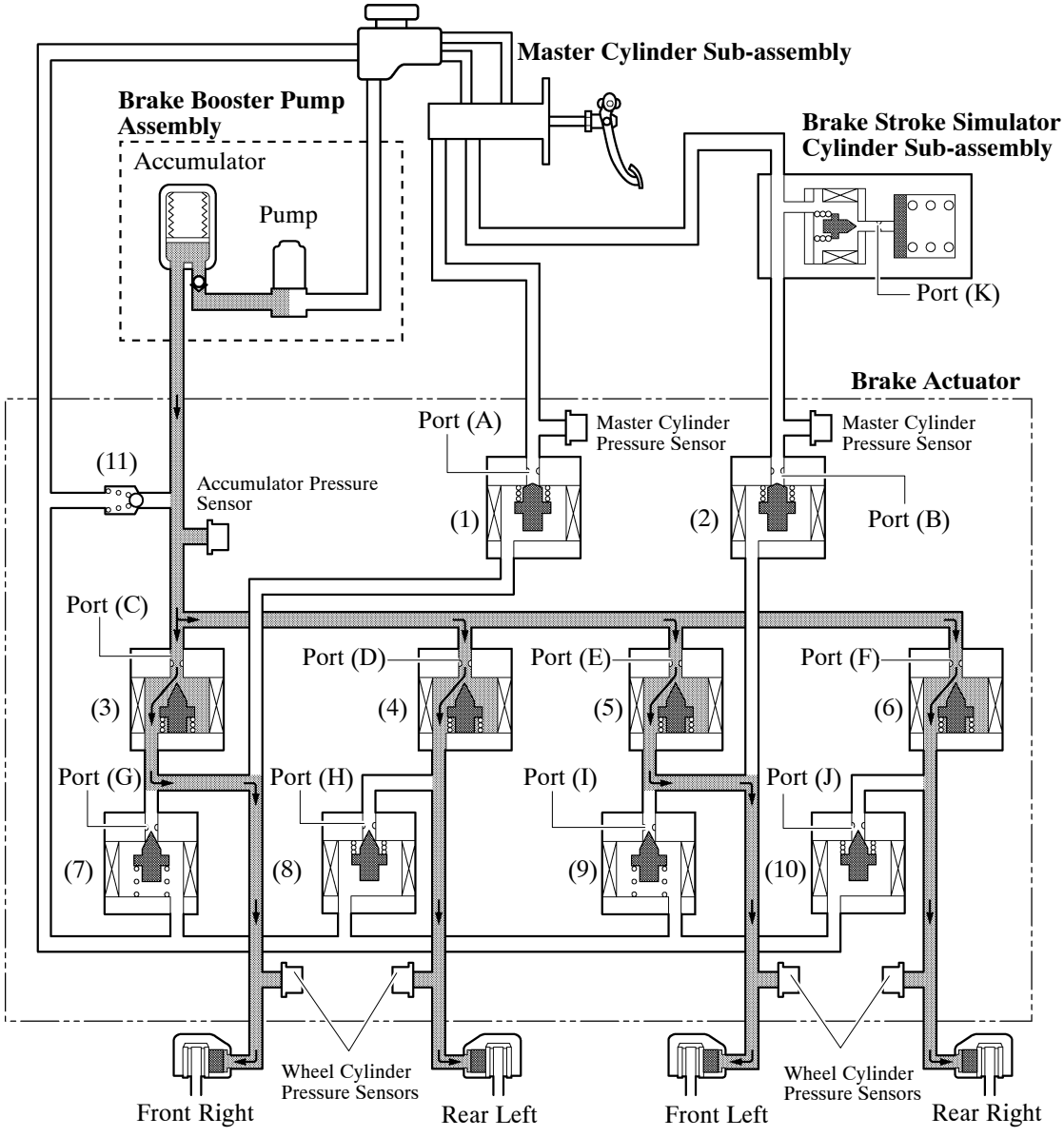
*: The solenoid valve constantly regulates the amount of opening of the port in order to control the fluid pressure.

TRAC Operation

- The fluid pressure generated by the pump is regulated by the pressure application solenoid valve and pressure reduction solenoid valve to the required pressure. Thus, the wheel cylinders of the drive wheels are controlled in the following 3 modes: pressure reduction, pressure holding, and pressure increase modes, to restrain the slippage of the drive wheels.
- The pressure application valve and the pressure reduction valve are turned ON/OFF according to the ABS operation pattern.
- The diagram on the next page shows the hydraulic circuit in the pressure increase mode when the TRAC function is activated.

▶ System Diagram ◀





07V0CH56C

CH

Item			TRAC not Activated	TRAC Activated		
				Increase Mode	Holding Mode	Reduction Mode
(1), (2)	Master Cylinder Cut Solenoid Valve		ON (Closed)	ON (Closed)	ON (Closed)	ON (Closed)
	Port: (A), (B)					
Front Brake	(3), (5)	Pressure Application Valve (Linear Type)	OFF (Closed)	ON*	OFF (Closed)	OFF (Closed)
		Port: (C), (E)				
	(7), (9)	Pressure Reduction Valve (Linear Type)	OFF (Closed)	OFF (Closed)	OFF (Closed)	ON*
		Port: (G), (I)				
	Wheel Cylinder Pressure		-	Increase	Hold	Reduce
Rear Brake	(4), (6)	Pressure Application Valve (Linear Type)	OFF (Closed)	ON*	OFF (Closed)	OFF (Closed)
		Port: (D), (F)				
	(8), (10)	Pressure Reduction Valve (Linear Type)	OFF (Open)	ON (Closed)	ON (Closed)	ON*
		Port: (H), (J)				
	Wheel Cylinder Pressure		-	-	-	-
(11)	Stroke Simulator Cut Solenoid Valve		ON (Open)	ON (Open)	ON (Open)	ON (Open)
	Port: (K)					

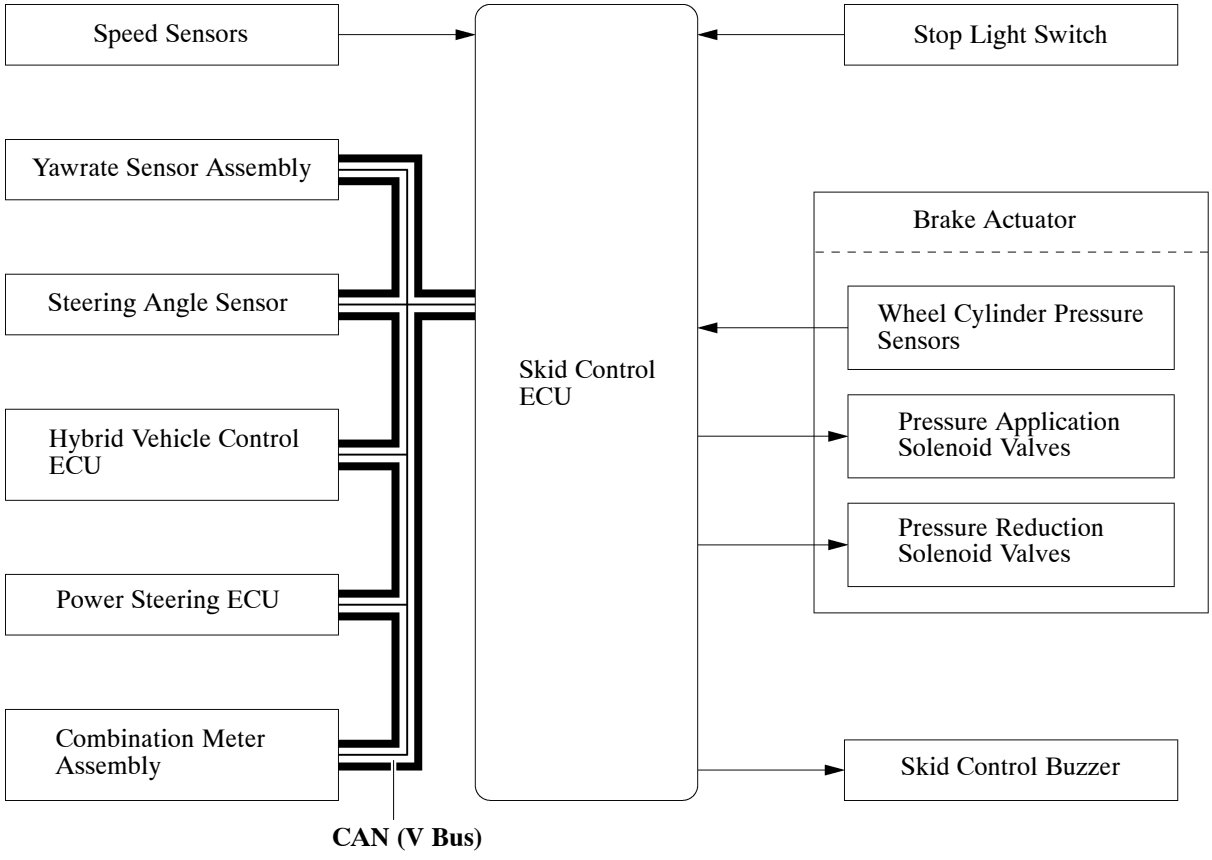
*: The solenoid valve constantly regulates the amount of opening of the port in order to control the fluid pressure.

VSC Operation

1) General

The VSC function 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 function 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 ◀

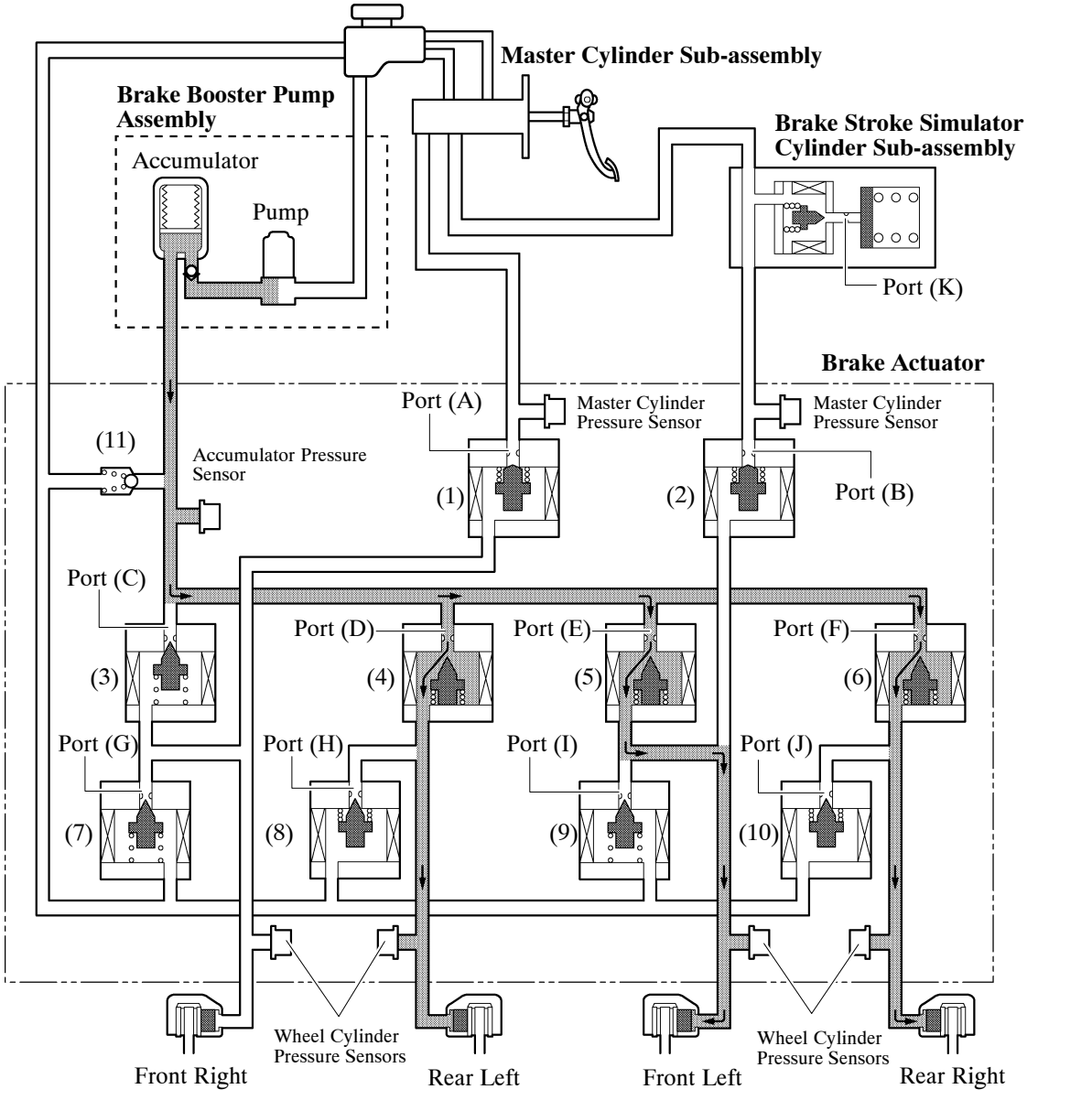


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2) Front Wheel Skid Restraint Control (Turn to the Right)

- In the front wheel skid tendency, this management function applies the brake to the rear wheels and front wheel of the outer side of the turn. 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 application valve and the pressure reduction valve are turned ON/OFF according to the ABS operation pattern.



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Increase Mode

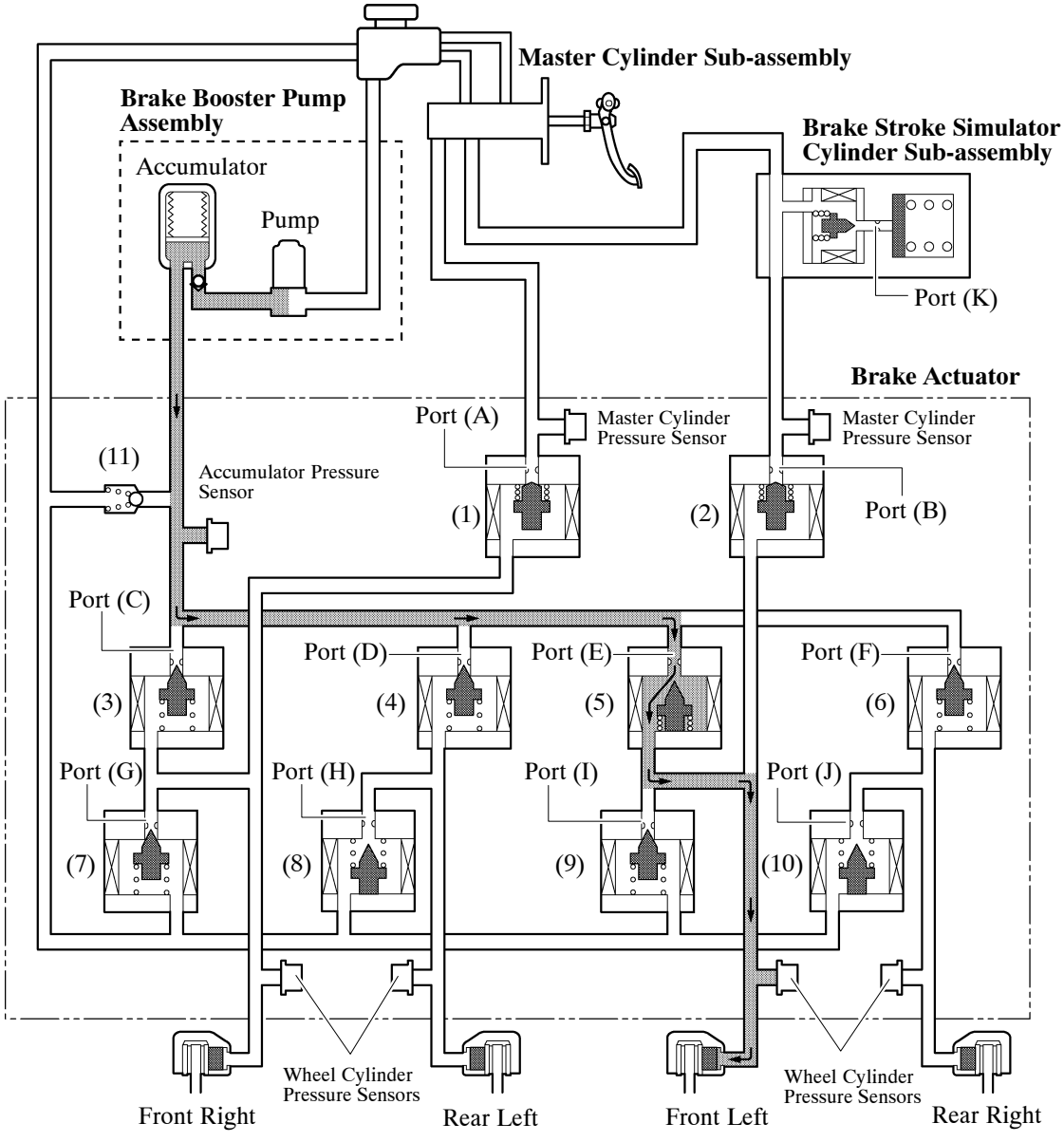
Item				VSC not Activated	VSC Activated		
					Increase Mode	Holding Mode	Reduction Mode
(1), (2)	Master Cylinder Cut Solenoid Valve			ON (Closed)	ON (Closed)	ON (Closed)	ON (Closed)
	Port: (A), (B)						
Front Brake	(3)	Pressure Application Valve (Linear Type)		OFF (Closed)	OFF (Closed)	OFF (Closed)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

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

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3) Rear Wheel Skid Restraint Control (Turn to the Right)

- In rear wheel skid tendency, this management function applies the brake to the front wheel of the outer circle of the turn. In some cases, the skid control ECU applies the brake to the rear wheels, as necessary. 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 makes a right turn.
- As in front wheel skid restraint control, the pressure application valve and the pressure reduction valve are turned ON/OFF according to the ABS operating pattern.



Increase Mode

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

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

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

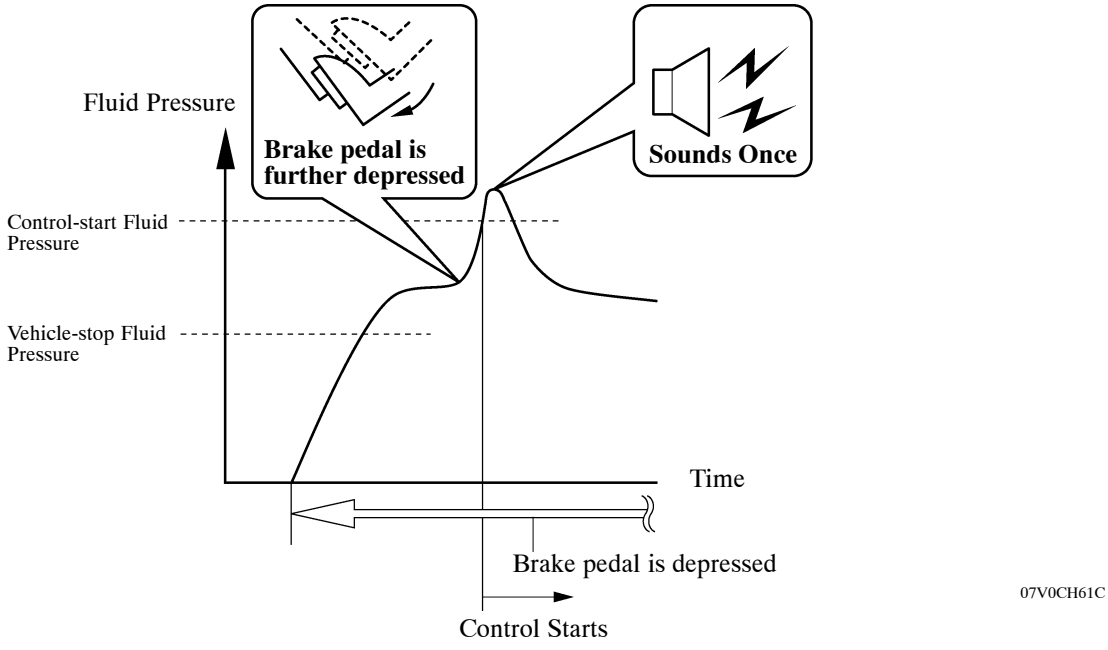
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Hill-start Assist Control Operation

When Hill-start Assist Control is operating, the skid control ECU controls the brake fluid pressure generated by the pump and applies it using solenoid valves to the wheel cylinders using pressure holding and pressure reduction modes.

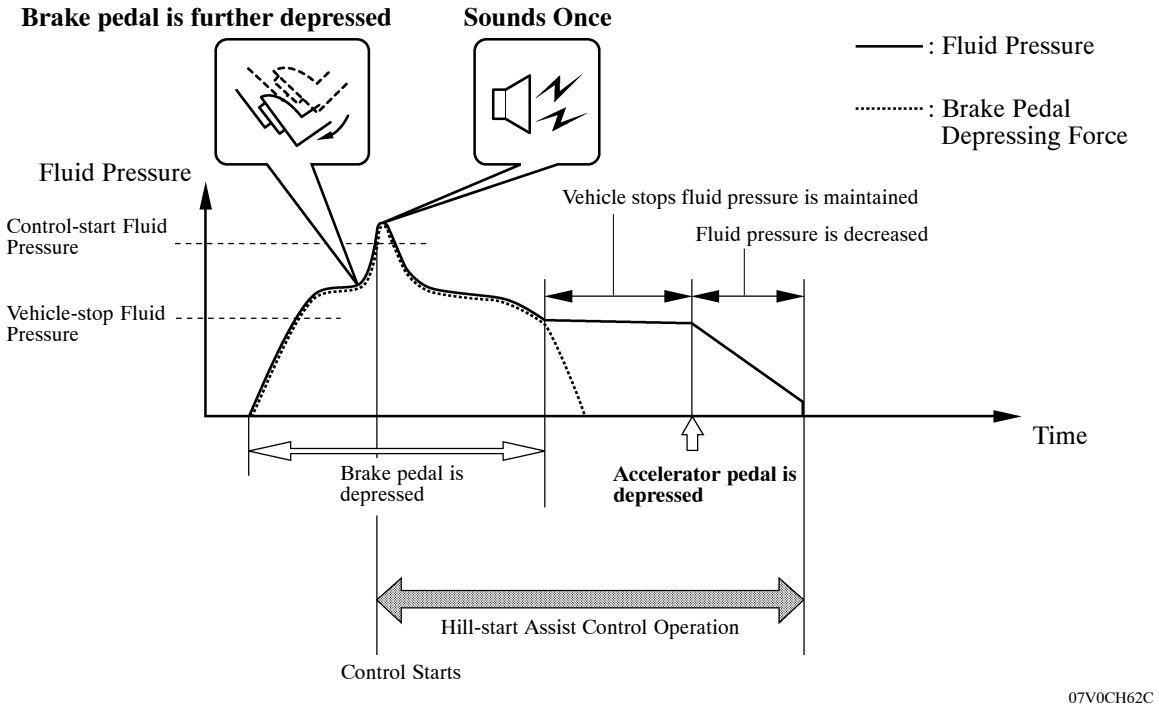
- Based on the information provided by various sensors, switches, and the hybrid vehicle control ECU, the skid control ECU detects if Hill-start Assist Control can operate.
- When Hill-start Assist Control operation starts, the skid control buzzer will sound once. During Hill-start Assist Control operation, the slip indicator light blinks and the stop lights are illuminated.
- The skid control ECU starts the Hill-start Assist Control operation when the operating conditions below are met and the driver further depresses the brake pedal, causing the fluid pressure to exceed the control-start fluid pressure.

Hill-start Assist Control Operating Conditions	• Shift lever is in R, N, D, or B (in a position other than P). • The accelerator pedal is not depressed. • The vehicle is at a standstill. • The parking brake is not applied.

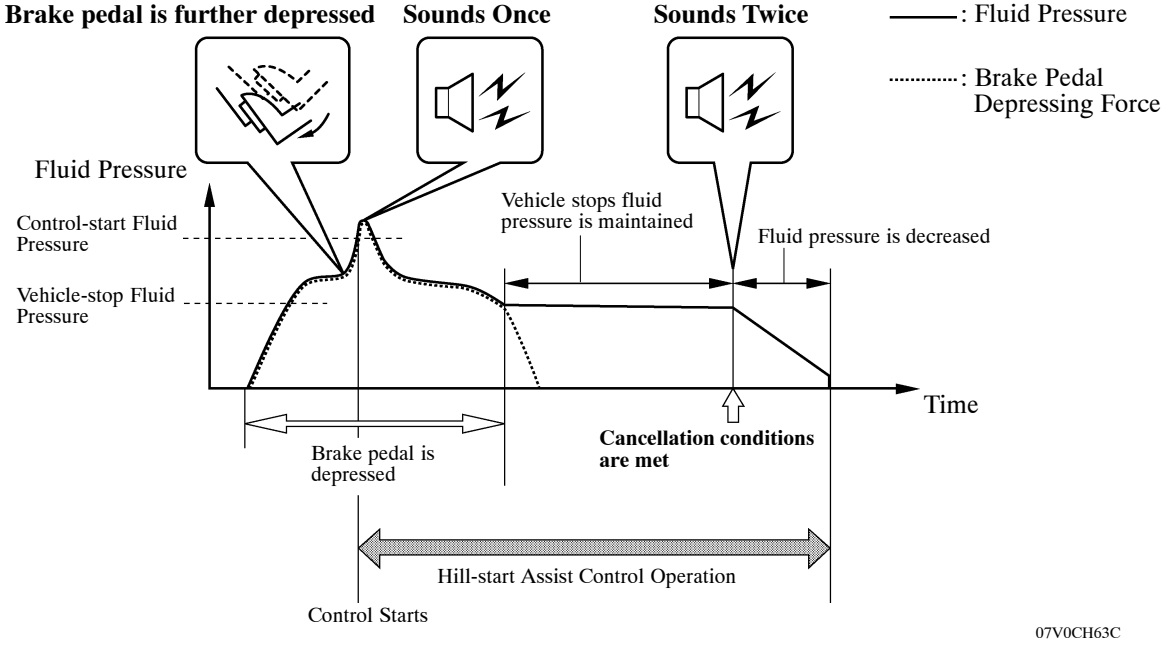


- If any one of the below conditions is met during Hill-start Assist Control operation, Hill-start Assist Control will be cancelled causing the slip indicator light to turn off. There are conditions which may result in control being cancelled. In these cases, the skid control buzzer will be sounded to inform the driver.

Skid Control Buzzer		Cancellation Condition
(a)	Does Not Sound	The driver depresses the accelerator pedal.
(b)	Sounds Twice	• The driver moves the shift lever to the P position. • The driver depresses the parking brake pedal. • The driver depresses the brake pedal. • The driver releases the brake pedal for several seconds. • The driver keeps the brake pedal depressed continually for 3 minutes.



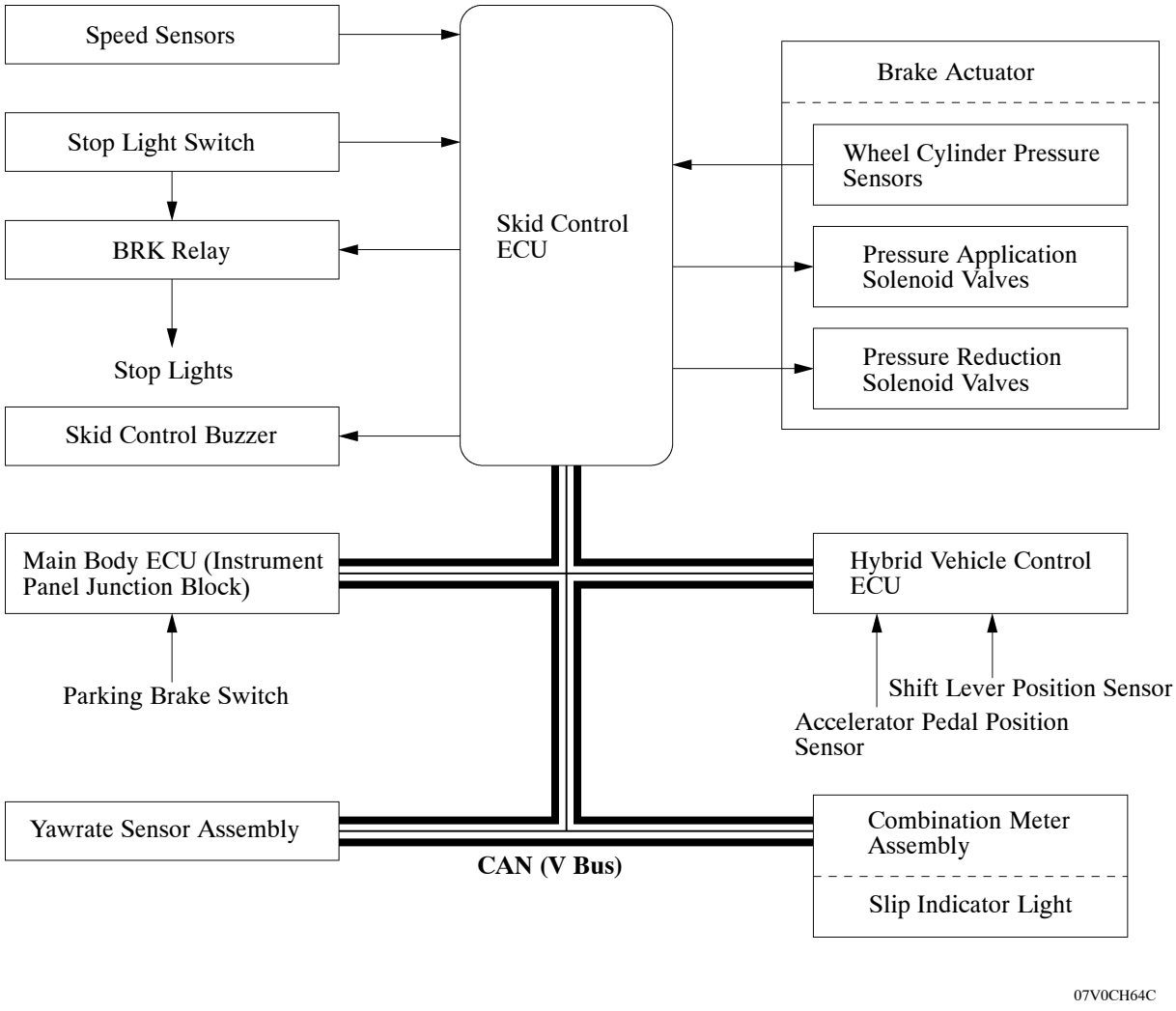
(a) Skid Control Buzzer not Sounds

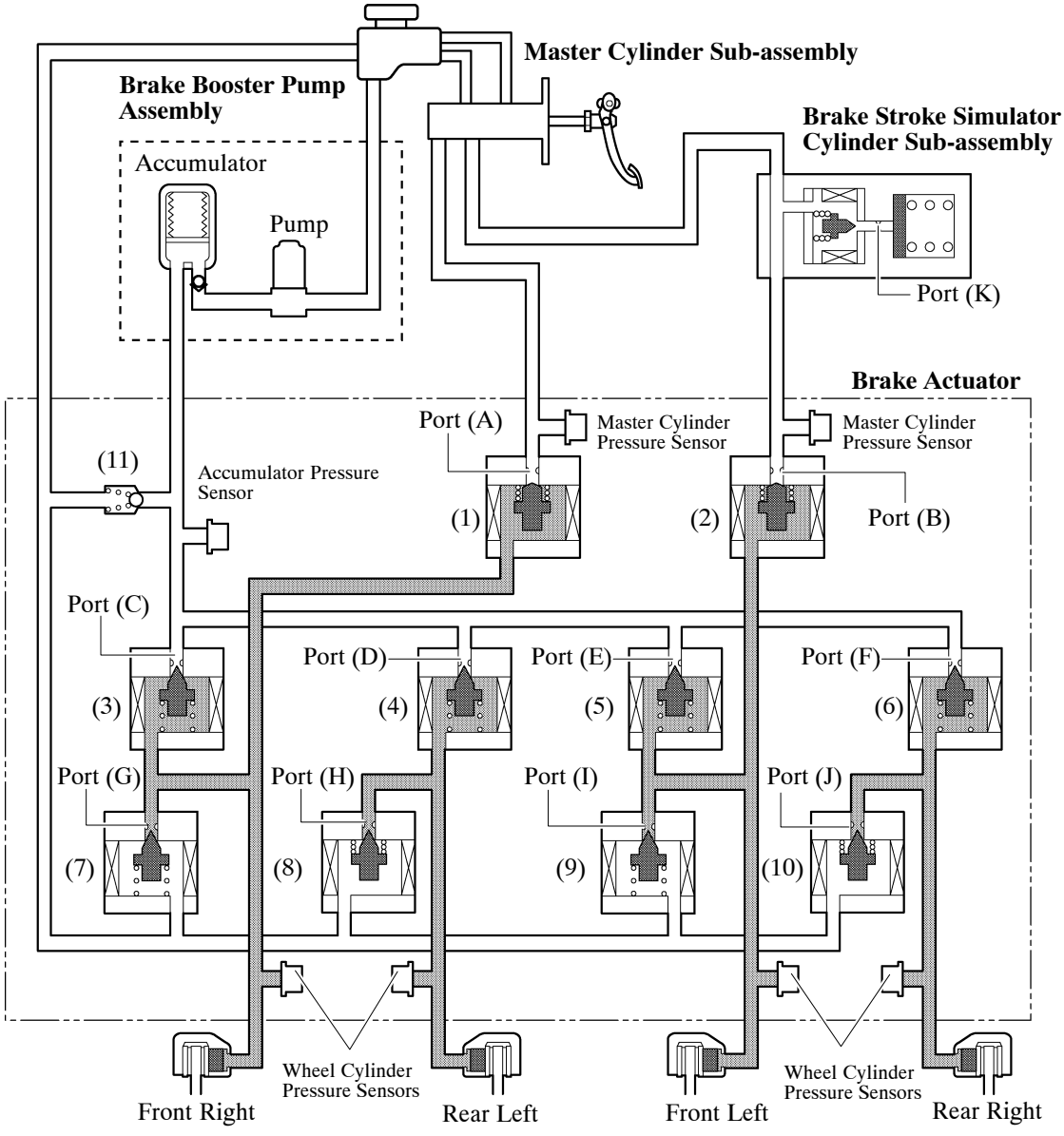


(b) Skid Control Buzzer Sounds Twice

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▶ System Diagram ◀





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Item			Hill-start Assist Control not Activated	Hill-start Assist Control Activated	
				Holding Mode	Reduction Mode
(1), (2)	Master Cylinder Cut Solenoid Valve Port: (A), (B)		ON (Closed)	ON (Closed)	ON (Closed)
Front Brake	(3)	Pressure Application Valve (Linear Type) Port: (C)	OFF (Closed)	OFF (Closed)	OFF (Closed)
	(5)	Pressure Application Valve (Linear Type) Port: (E)	OFF (Closed)	OFF (Closed)	OFF (Closed)
	(7)	Pressure Reduction Valve (Linear Type) Port: (G)	OFF (Closed)	OFF (Closed)	ON (Open)
	(9)	Pressure Reduction Valve (Linear Type) Port: (I)	OFF (Closed)	OFF (Closed)	ON (Open)
Rear Brake	(4)	Pressure Application Valve (Linear Type) Port: (D)	OFF (Closed)	OFF (Closed)	OFF (Closed)
	(6)	Pressure Application Valve (Linear Type) Port: (F)	OFF (Closed)	OFF (Closed)	OFF (Closed)
	(8)	Pressure Reduction Valve (Linear Type) Port: (H)	OFF (Open)	ON (Closed)	OFF (Open)
	(10)	Pressure Reduction Valve (Linear Type) Port: (J)	OFF (Open)	ON (Closed)	OFF (Open)
(11)	Stroke Simulator Cut Solenoid Valve Port: (K)		ON (Open)	ON (Open)	ON (Open)

20. Diagnosis

If the skid control ECU detects a malfunction in the brake control system, the warning lights in the combination meter assembly light up and warning message on the multi-information display displays to alert the driver of the malfunction. At the same time, the skid control ECU stores DTCs (Diagnostic Trouble Codes) in memory.

- These DTCs can be read by connecting SST (09843-18040) between the TC and CG terminals of DLC3 and observing the blinks of the ABS warning light or the brake system warning light, or by connecting Techstream to DLC3.
- If the skid control ECU detects a malfunction during a sensor signal check (test mode), it stores the DTCs in its memory.

For details, see the 2008 HIGHLANDER HYBRID VEHICLE Repair Manual (Pub. No. RM07V0U).

21. Fail-safe

- If a failure occurs in the skid control ECU, sensors, or brake actuators, the system continues performing brake control by excluding the failed area and using only the areas that are operating normally.
- If the regenerative brake becomes unusable due to a failure in communication with the hybrid vehicle control ECU, the skid control ECU uses the hydraulic brake force to control the entire braking force.