■BRAKE CONTROL SYSTEM (VSC WITH EPS-VSC INTEGRATED CONTROL, HILL-START ASSIST CONTROL AND DOWNHILL ASSIST CONTROL)

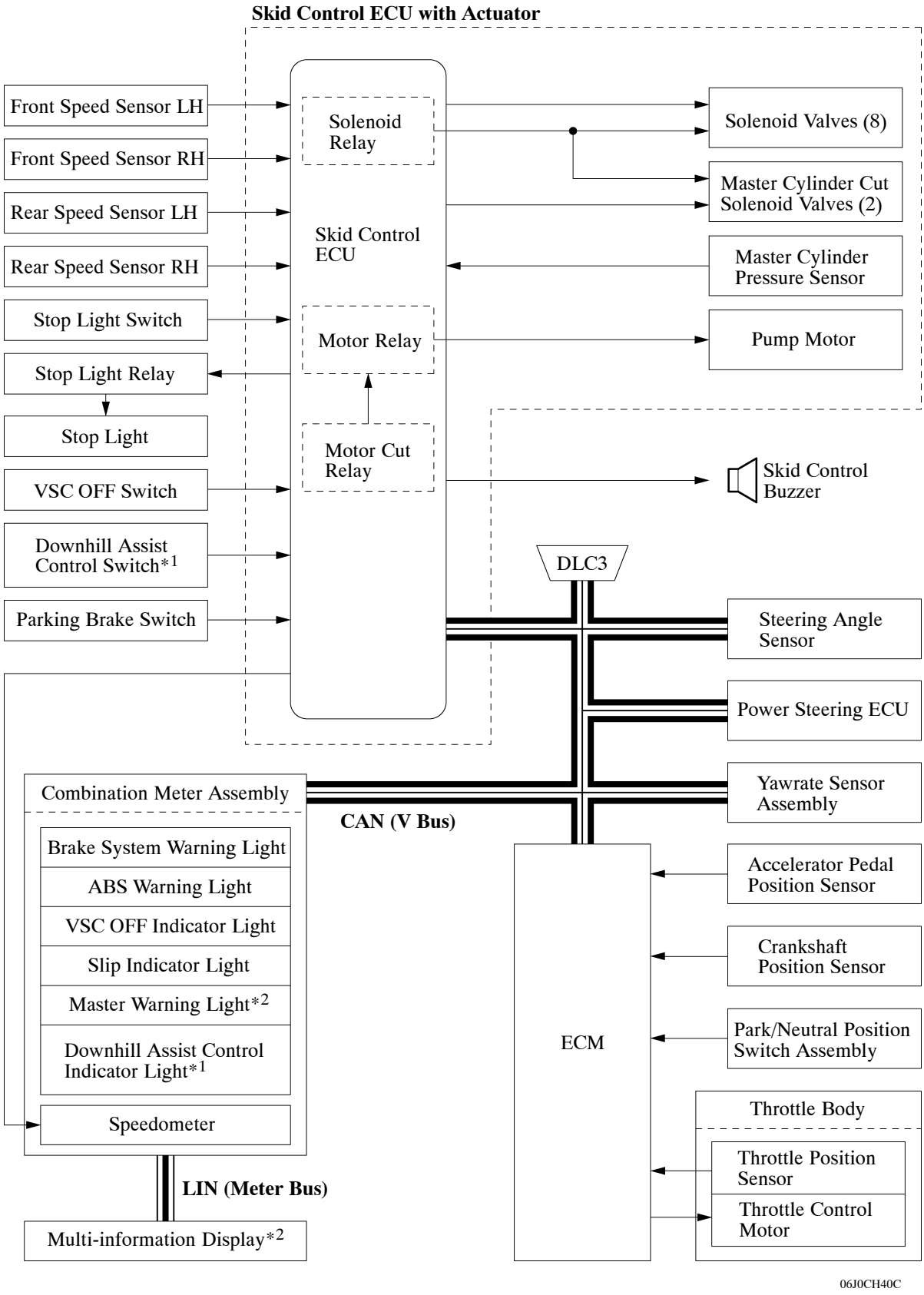
1. General

The VSC with EPS-VSC integrated control, Hill-start Assist Control and Downhill Assist Control has the following functions:

Brake Control System		Outline
VSC with EPS-VSC Integrated Control		Control of the VSC and EPS is coordinated to ensure drivability.
	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.
	TRC (Traction Control)	The TRC 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.
Downhill Assist Control*		The Downhill Assist Control generates four-wheel hydraulic pressure when the downhill assist control switch is pressed and the accelerator and brake pedals are not depressed in order to maintain a constant low vehicle speed without causing the wheels to lock.

*: Only for 4WD Models

2. System Diagram

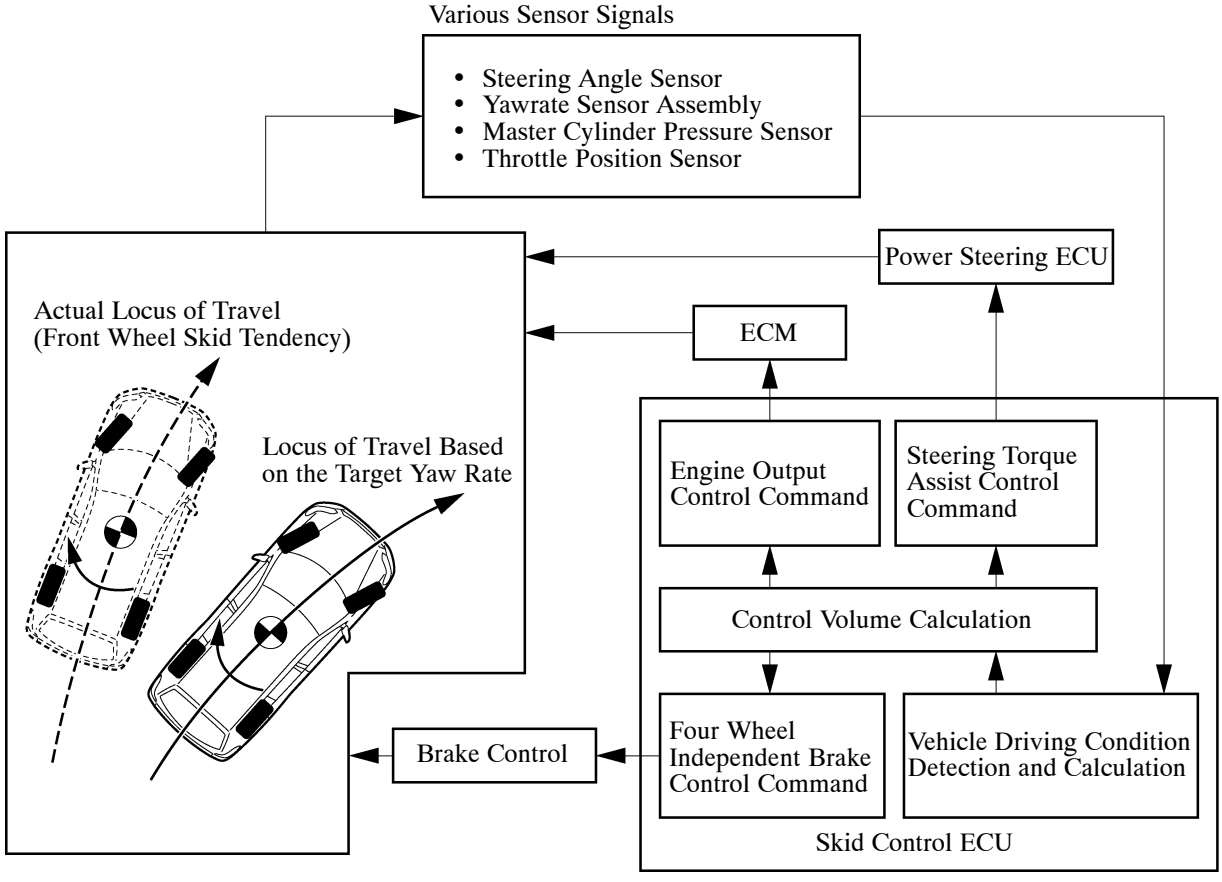


*1: Only for 4WD Models
*2: Models with Multi-information Display

3. VSC with EPS-VSC Integrated Control

General

- VSC with EPS-VSC integrated control performs coordinated control consisting of VSC (Vehicle Stability Control) and EPS (Electric Power Steering). By integrating these preventive safety functions, VSC with EPS-VSC integrated control ensures driving stability and maneuverability of the vehicle.
- If the vehicle loses stability due to wheel slippage, this function performs brake control by applying brake pressure to the wheels. At the same time, EPS provides steering torque assist control to facilitate the driver's steering maneuvers.

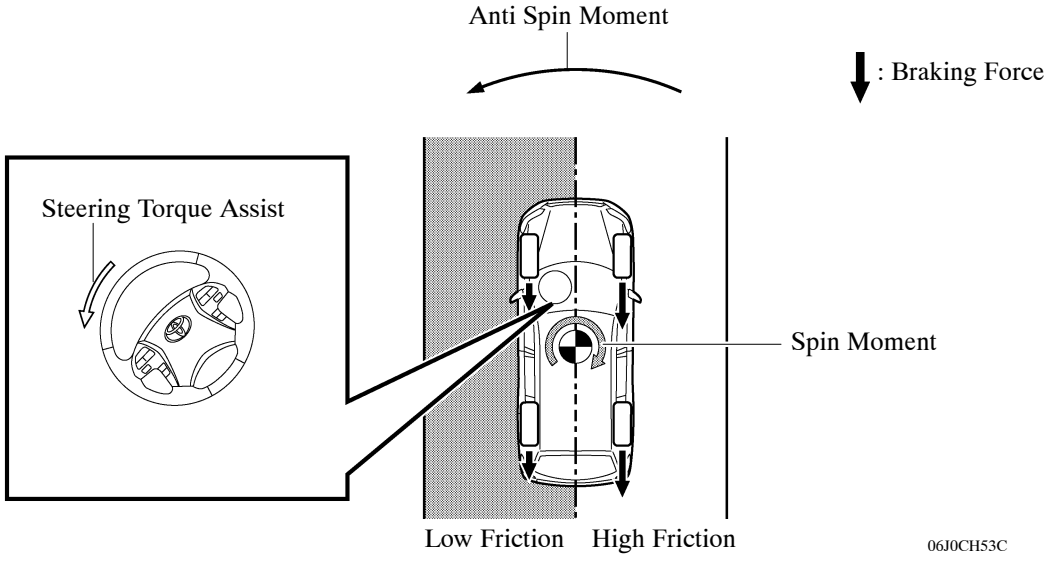


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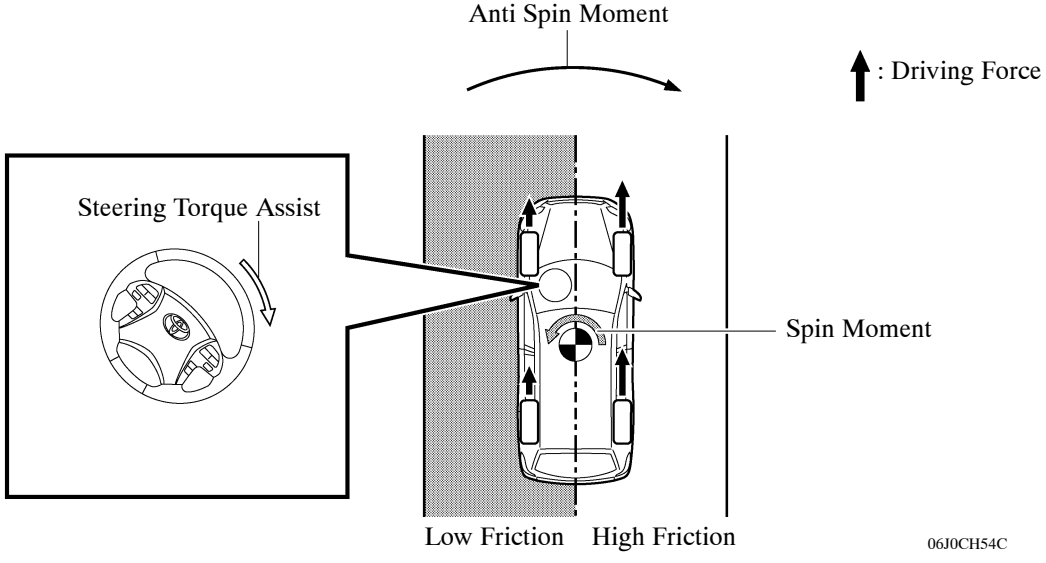
Braking Control on Split Friction Roads

When braking on a split friction road, the vehicle tends to deflect toward the higher friction side due to the difference between the braking forces on the left and right sides. With VSC with EPS-VSC integrated control, the Power Steering ECU receives command signals from the Skid Control ECU. Based on these signals, the Power Steering ECU operates the motor for the electric power steering to reduce the effect of the difference between the braking forces on the left and right sides, assisting steering operation. This enables the driver to make steering corrections more easily.



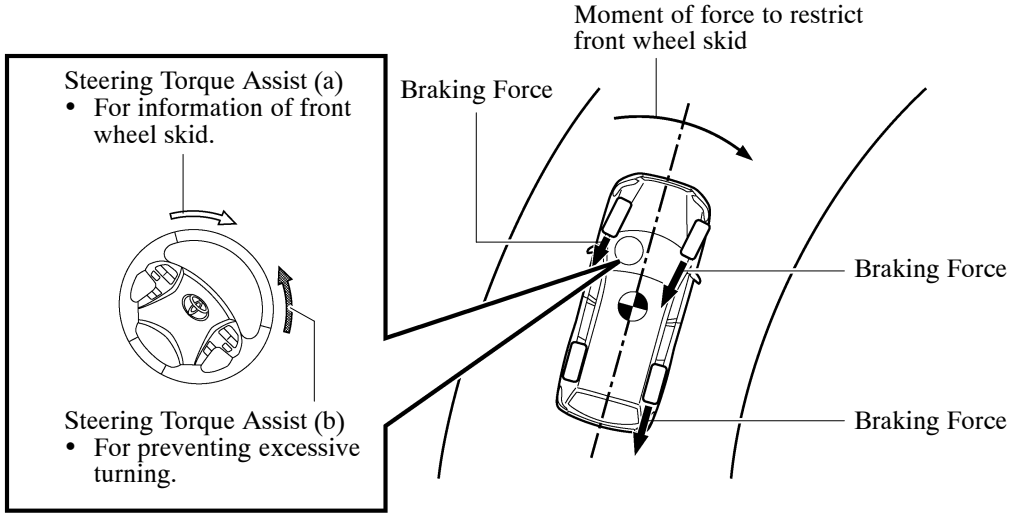
Accelerating when Surface Resistance Differs between Both Sides of Wheels

When accelerating on a split friction road, the vehicle tends to deflect toward lower friction side due to the driving force difference between the left and right sides. With VSC with EPS-VSC integrated control, the Skid Control ECU performs braking control of the drive wheel on the low friction side (TRC function) and transmits command signals to the Power Steering ECU. Based on these signals, the Power Steering ECU operates the motor for the EPS to reduce the effect of the driving force difference between the left and right sides, assisting steering operation. As a result, proper motive force and vehicle stability is ensured.



Front Wheel Skid Control

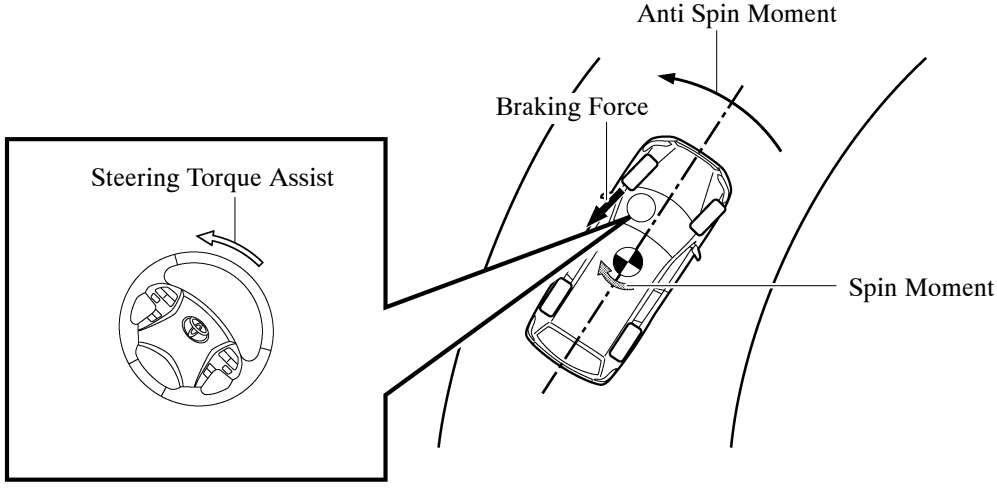
- When front wheel skidding is detected, engine output is limited and braking control is performed based on the amount of understeer tendency. Accordingly, a moment of force is generated in the vehicle turning direction to limit front wheel skid tendency.
- In the case of a front wheel skid tendency, steering torque assist (a) is provided to inform the driver of the front wheel skid.
- If the driver turns the steering wheel excessively, steering torque assist (b) is provided. This enables the driver to prevent the steering wheel excessive operation.



06J0CH55C

Rear Wheel Skid Control

- When rear wheel skidding is detected, brake force is applied to mainly the outer wheels according to the amount of oversteer tendency. Accordingly, an anti-spin moment is generated to limit the rear wheel skid tendency.
- With VSC with EPS-VSC integrated control, the Power Steering ECU receives command signals from the Skid Control ECU. Based on these signals, the Power Steering ECU operates the motor for the electric power steering to provide steering assist to help the driver compensate for the rear wheel skid tendency. This enables the driver to operate the steering wheel more easily.



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4. Outline of EBD Control

General

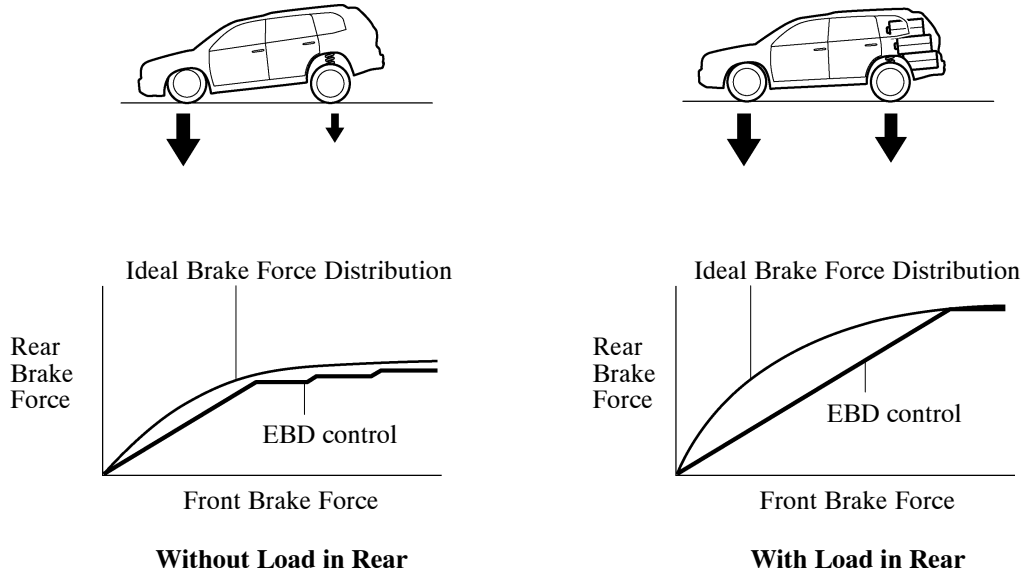
The EBD control distributes the braking force in accordance with the vehicle's driving conditions. The Skid Control ECU electrically controls the control solenoid valves to distribute the braking force.

- 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.

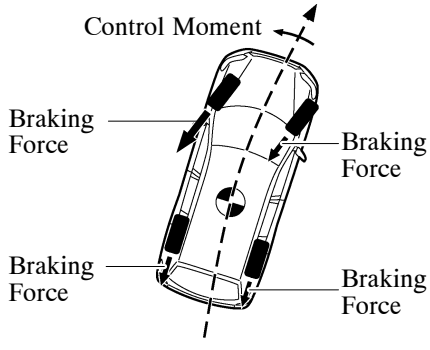
▶ EBD Control Concept ◀



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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.

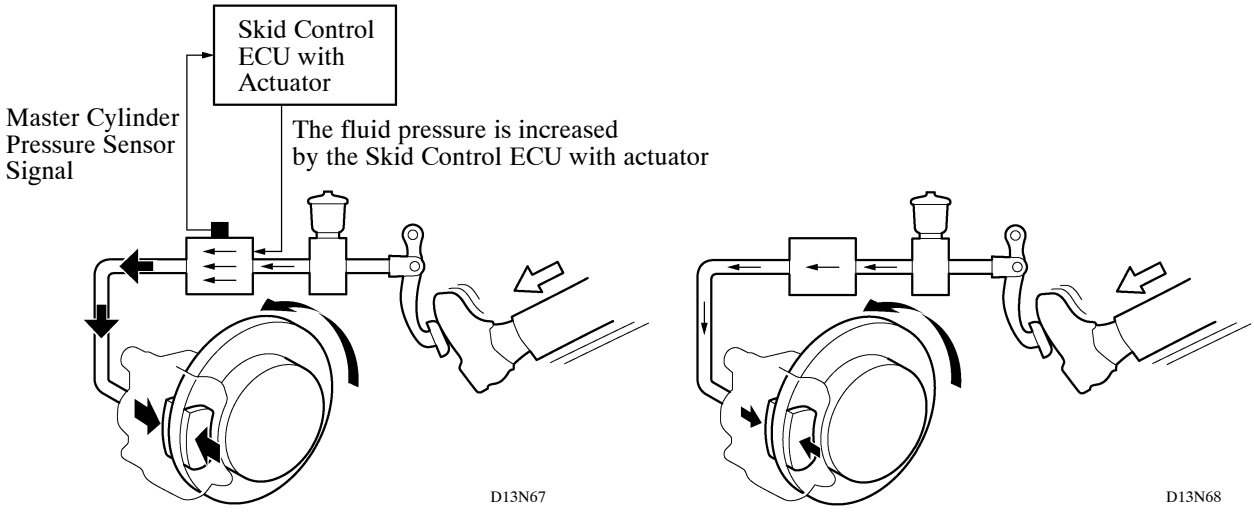


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5. Outline of Brake Assist

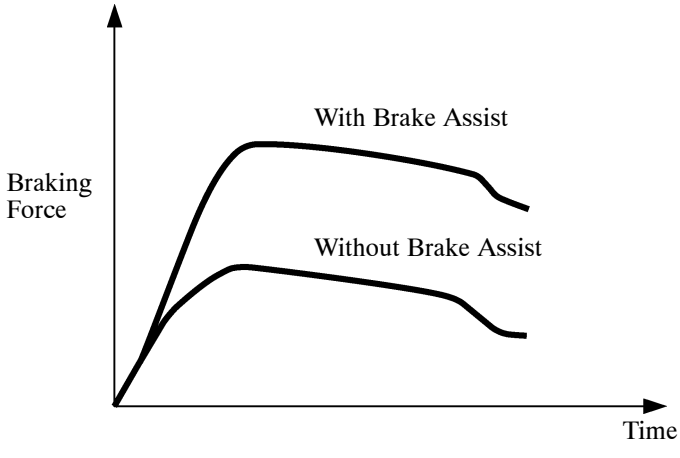
- The Brake Assist in combination with ABS helps improve the vehicle's brake performance.
- The Brake Assist interprets a quick push of the brake pedal as emergency braking and supplements the brake power applied if the driver has not stepped hard enough on the brake pedal. In emergencies, drivers, especially 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 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 the 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 **Without Brake***

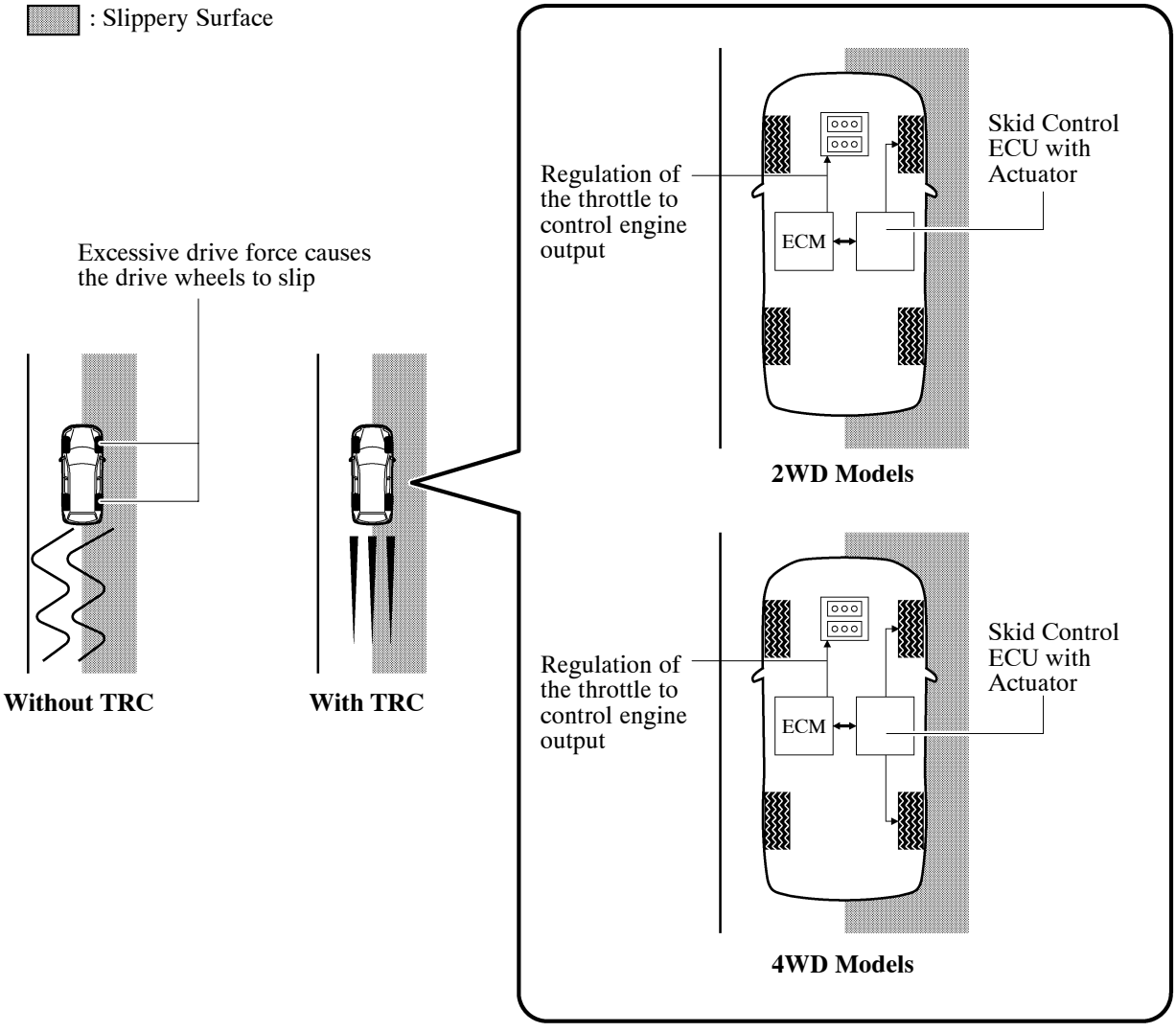
*: The fundamental performance capability of the brakes is the same as that of models with Brake Assist.



6. Outline of TRC

- 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, TRC 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 TRC 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 TRC 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 ECM 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 ◀



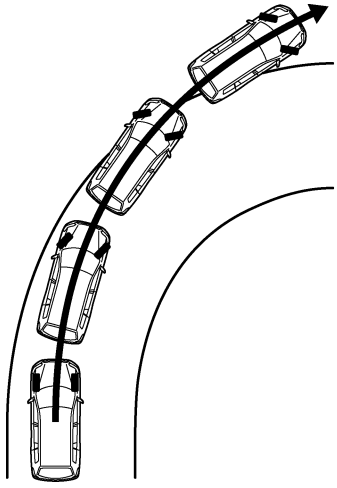
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7. Outline of VSC

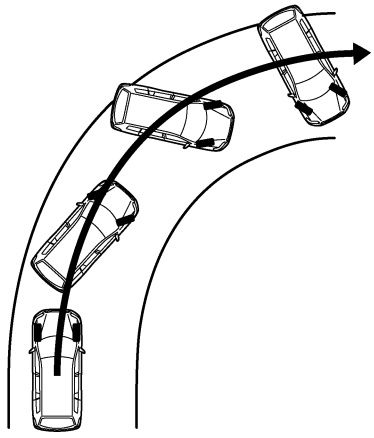
General

The following are two examples that can be considered as circumstances in which the tires exceed their lateral grip limit.
The VSC 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

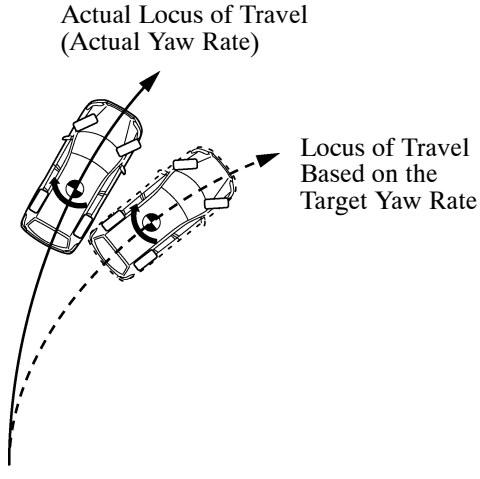
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Method for Determining the Vehicle Condition

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

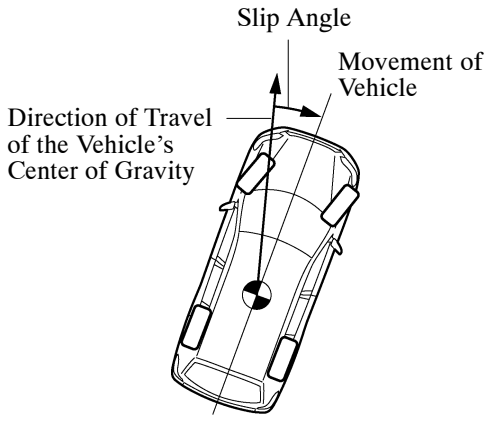
Whether or not the vehicle is experiencing a front wheel skid is determined by the difference between the target yaw rate and the vehicle's actual yaw rate.
When the vehicle's actual yaw rate is smaller than the target yaw rate (a target yaw rate is determined based on the vehicle speed and steering 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.



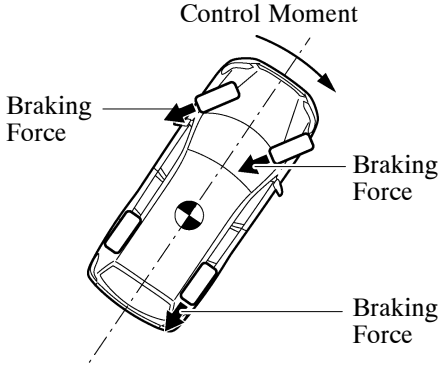
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Method for VSC Operation

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.

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 front wheels and rear wheel of the inner circle of the turn in order to help restrain the front wheel skid tendency.

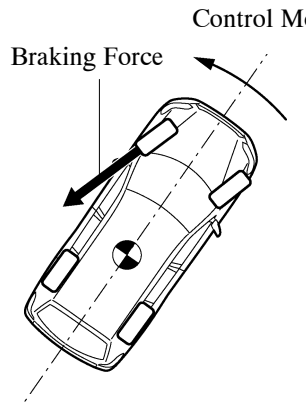


Making a Right Turn

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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.

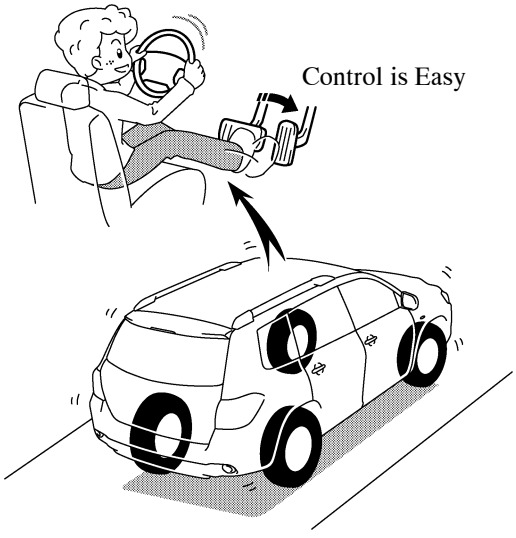


Making a Right Turn

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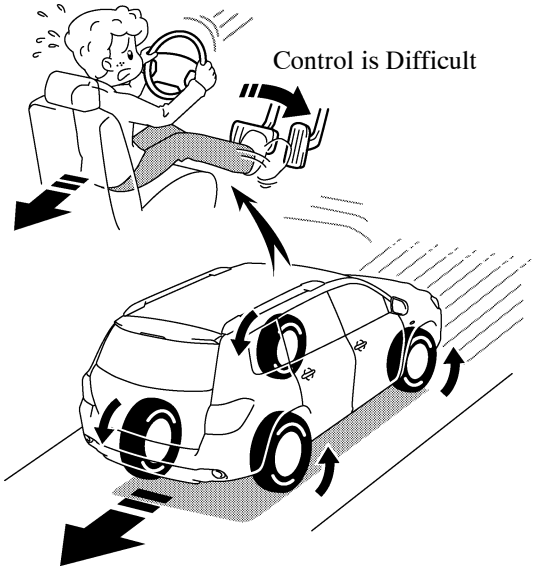
8. Outline of Hill-start Assist Control

- 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 reduces the backward speed of the vehicle.



The backward speed of the vehicle is reduced

With Hill-start Assist Control



The backward speed of the vehicle increases

Without Hill-start Assist Control

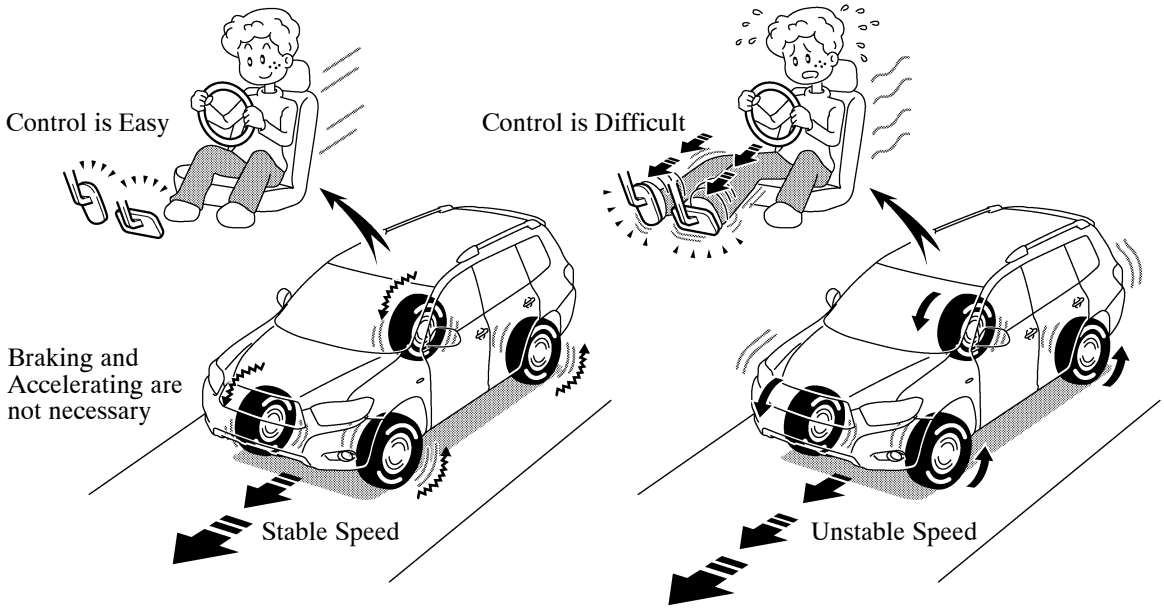
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- Hill-start assist Control will operate when the brake pedal is further depressed while all of the following conditions are met.

Hill-start Assist Control Operating Conditions	• Shift lever is in a position other than P. • The accelerator pedal is not depressed. • The vehicle is at a standstill. • The parking brake is not applied.

9. Downhill Assist Control

- When the vehicle is descending a steep hill and engine braking alone cannot provide a sufficient deceleration force while the transaxle is in the S1 range or R position, the Downhill Assist Control effects four wheel brake control to maintain a constant, low vehicle speed. Thus, the vehicle is able to descend in a stable manner without causing the wheels to lock.
- When the vehicle descends a steep hill without the Downhill Assist Control, the driver must pay close attention to the brake and accelerator pedal operation. However, with Downhill Assist, the driver can concentrate on the steering operation, without accelerator and brake pedals operation.



With Downhill Assist Control **Without Downhill Assist Control**

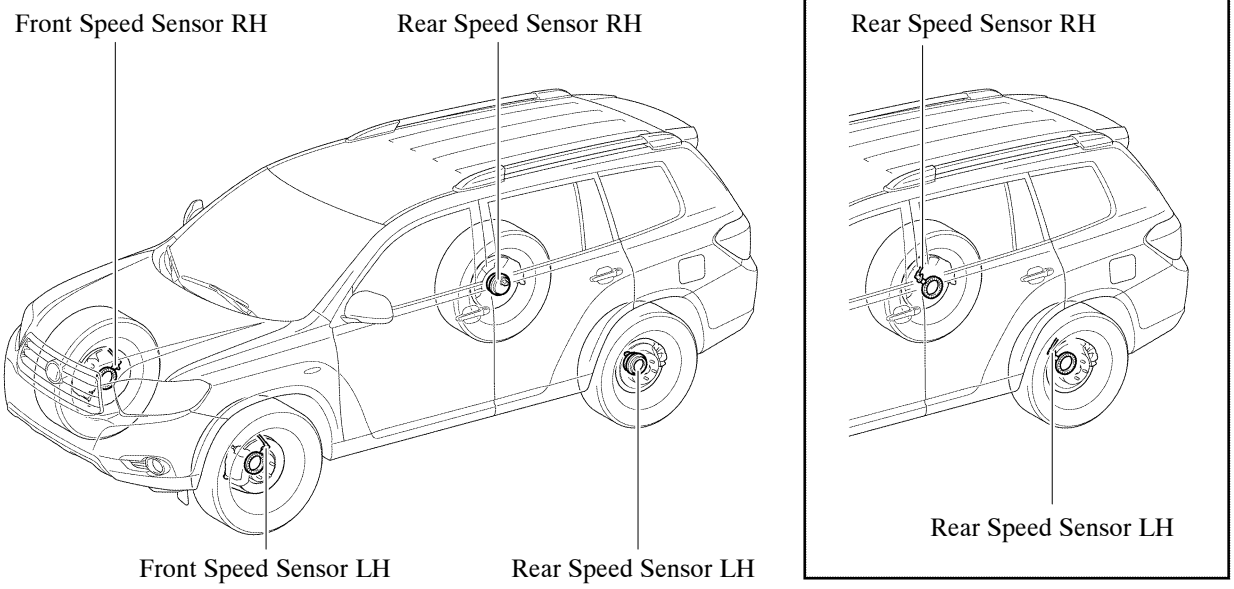
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- The Downhill Assist Control operates when all of the following conditions are met:

Downhill Assist Control Operation Conditions	• Downhill Assist Control switch is ON • Shift lever is in the S1 or R position. • Accelerator pedal and brake pedal are not depressed. • Vehicle is descending a hill at a speed of 25 km/h (16 mph) or less.

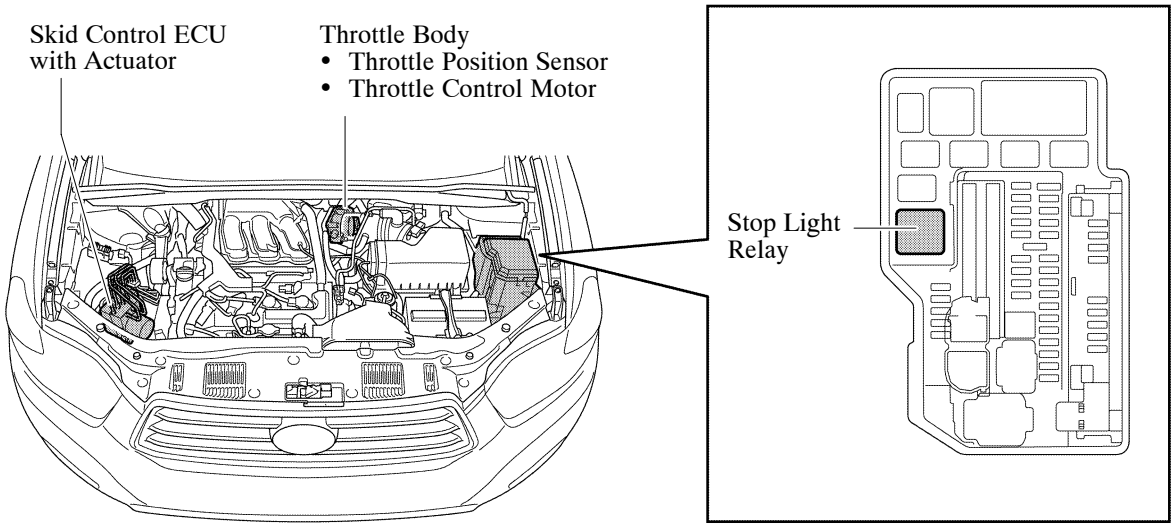
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10. Layout of Main Components



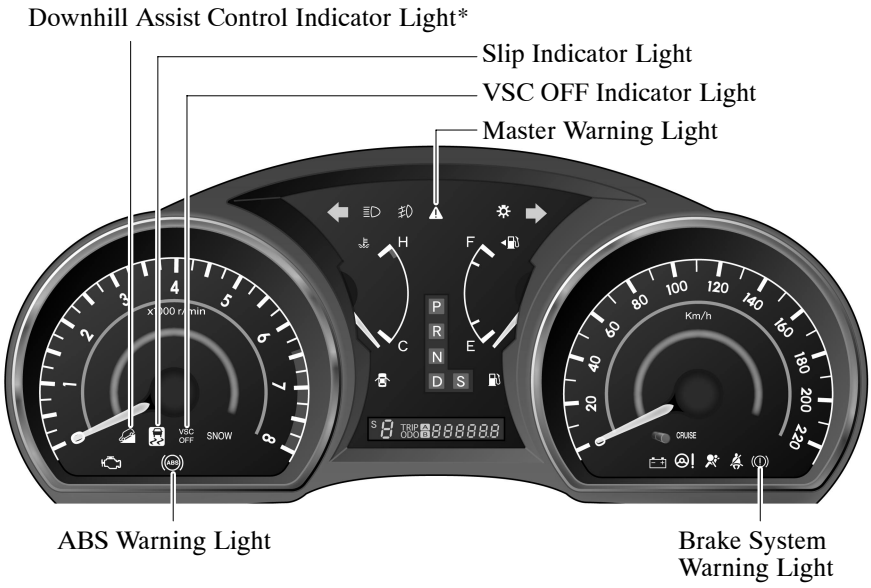
2WD Models **4WD Models**

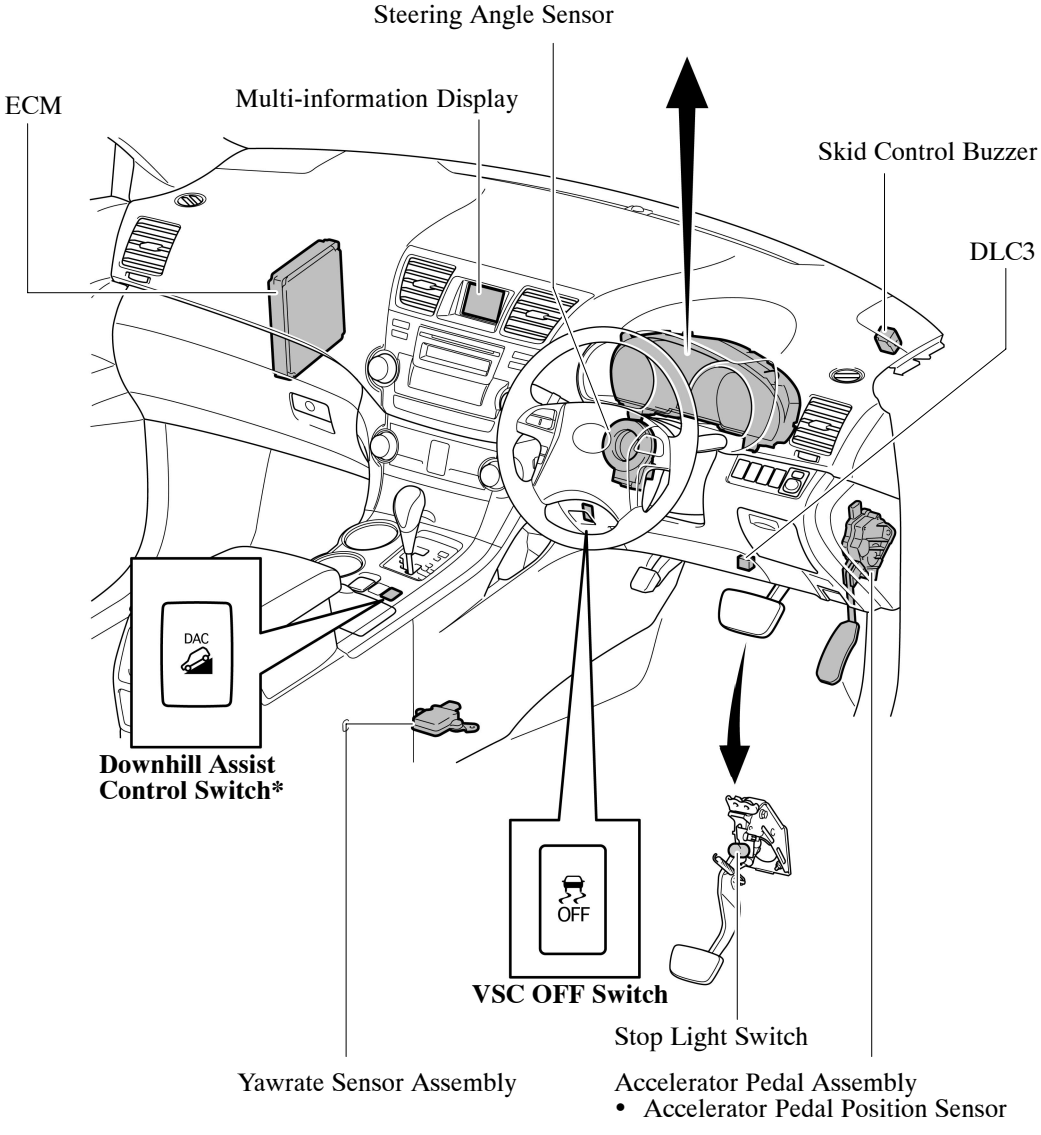
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▶ Models for Australia ◀

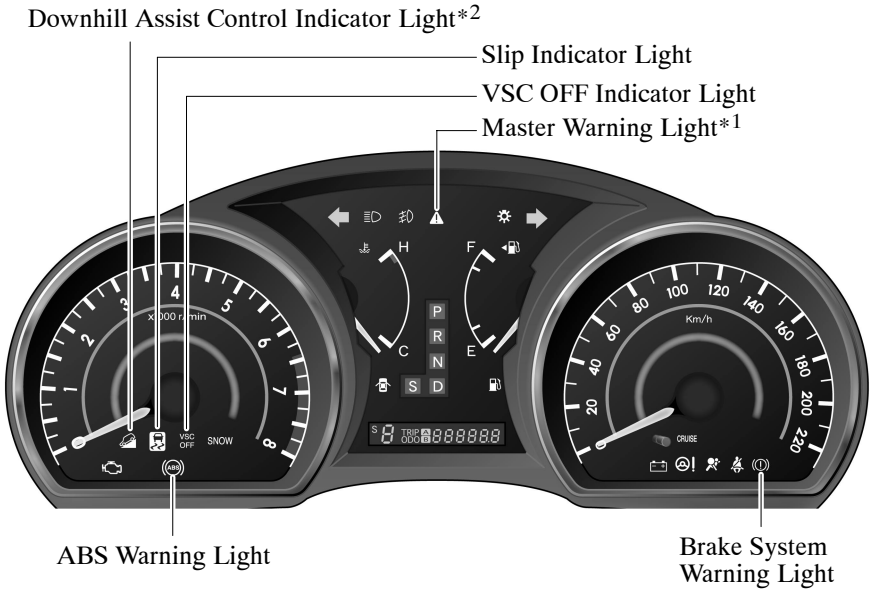


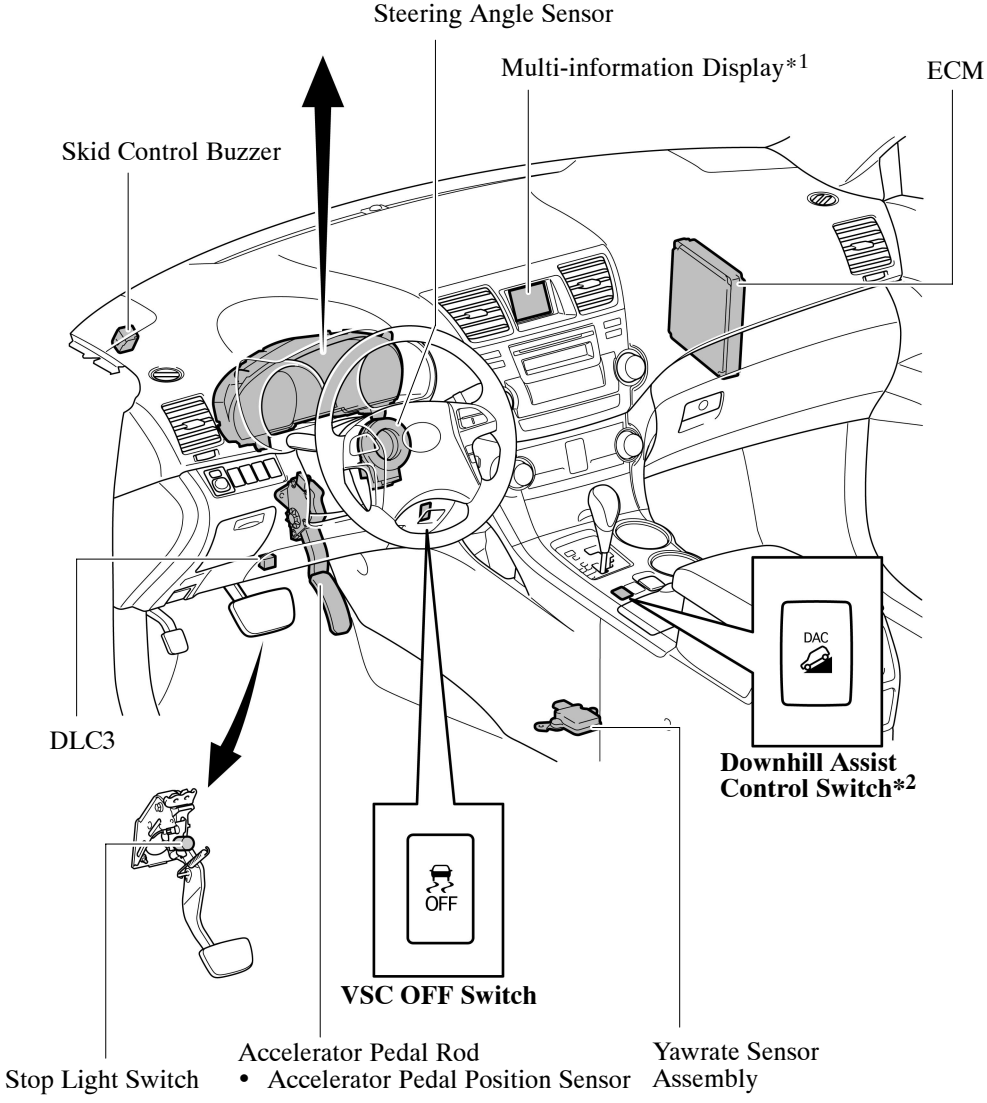


*: Only for 4WD Models

CH

▶ Models for China ◀





*1: Models with Multi-information Display

*2: Only for 4WD Models

11. Function of Main Components

Component			Function
Combination Meter Assembly	Brake System Warning Light		• Lights up together with the ABS warning light to alert the driver when the Skid Control ECU detects an EBD control malfunction. • Lights up to inform the driver when the parking brake is ON.
	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 TRC, VSC, Hill-start Assist Control or Downhill Assist Control operates. • Lights up together with the VSC OFF indicator light to alert the driver when the Skid Control ECU detects a malfunction in TRC, VSC, Hill-start Assist Control or Downhill Assist Control.
	VSC OFF Indicator Light		• Lights up to inform the driver when the VSC-OFF mode is entered using the VSC OFF switch. • Blinks to alert the driver when the Skid Control ECU detects a malfunction in the TRC, VSC, Hill-start Assist Control or Downhill Assist Control.
	Master Warning Light*1		Lights up to alert the driver when the Skid Control ECU detects a malfunction in the brake control system.
	Downhill Assist Control Indicator Light*2		• Light up to inform the driver when the Downhill Assist Control operates. • When the Downhill Assist Control switch is on but not all operating conditions are met, the Downhill Assist Control indicator light blinks to inform the driver.
Skid Control Buzzer			The skid control buzzer emits a warning sound to inform the driver during VSC operation.
Front and Rear Speed Sensors (4)			Detect the wheel speed of each of the four wheels.
Stop Light Switch			Detects the brake pedal depression signal.
Parking Brake Switch			Detects parking brake application.
Accelerator Pedal Position Sensor			Detects the accelerator pedal depression angle.
VSC OFF Switch			• Cancels the TRC or VSC. • Selects any of the three modes (Normal mode, TRC-OFF mode, VSC-OFF mode).
Downhill Assist Control Switch*2			Selects the driver to turn Downhill Assist Control ON or OFF.
Skid Control ECU with Actuator			Changes the internal fluid paths based on signals from the Skid Control ECU during the operation of the ABS with EBD, Brake Assist, TRC, VSC, Hill-start Assist Control and Downhill Assist Control in order to control the fluid pressure that is applied to the brake wheel cylinders.
	Master Cylinder Pressure Sensor		Located in the brake actuator to detect the master cylinder pressure.
	Skid Control ECU		Judges the vehicle driving condition based on signals from each sensor, and sends a brake control signal to the brake actuator.
		Solenoid Relay	Supplies power to the solenoid valves.
		Motor Relay	Supplies power to the pump motor in the brake actuator.
		Motor Cut Relay	Cuts the power to the pump motor in the brake actuator.

*1: Models with Multi-information Display

*2: Only for 4WD Models

CH

Component	Function
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.
ECM	• Sends the throttle valve angle signal, accelerator pedal position signal, engine speed signal, and shift lever position signal to the Skid Control ECU. • Receives the signal of throttle control request from the Skid Control ECU.
Multi-information Display	• Shows a warning message to alert the driver when the Skid Control ECU detects a malfunction in the brake control system. • Shows the Downhill Assist Control operating conditions when the Downhill Assist Control switch is on but not all operating conditions are met.

12. Speed Sensors

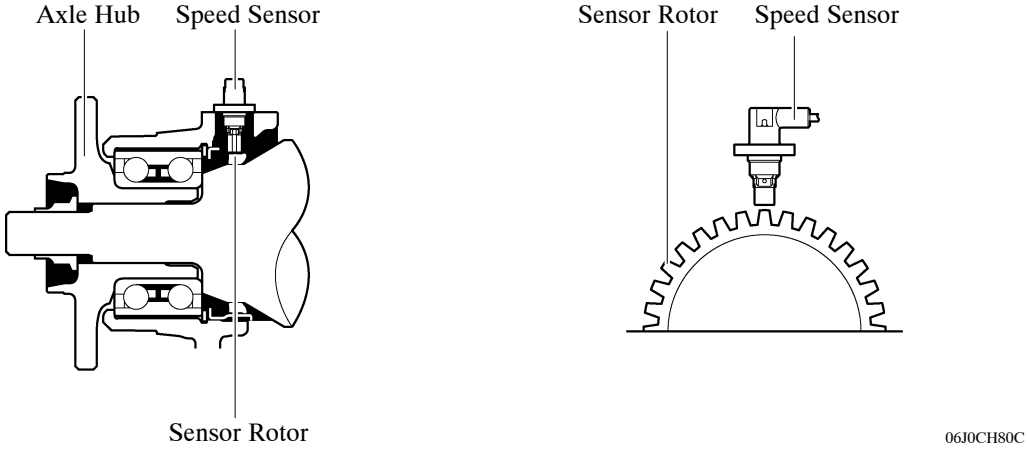
General

The following types of speed sensors are used.

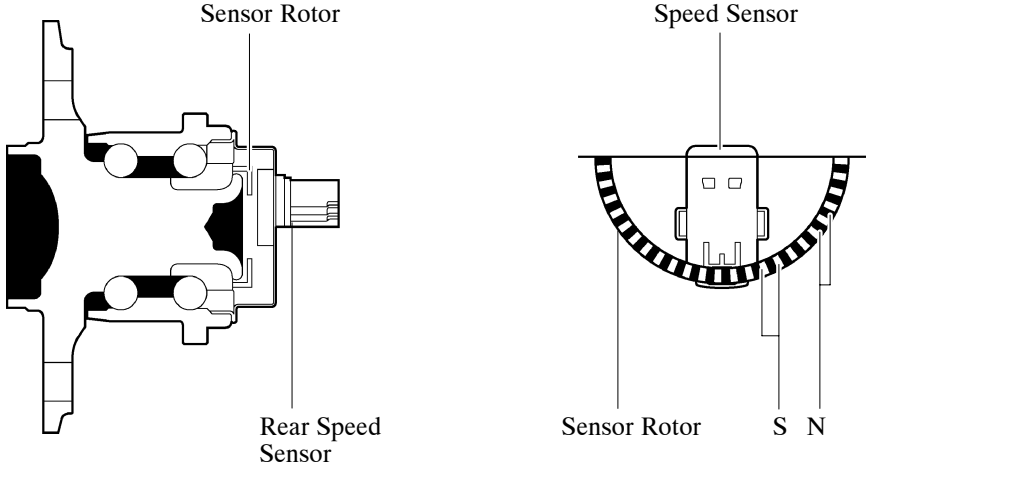
Models		2WD	4WD
Front Speed Sensor	Type	Active/Hall IC	Active/Hall IC
	Sensor Rotor	Gear (48 teeth) • Integrated with the front drive shaft assembly.	Gear (48 teeth) • Integrated with the front drive shaft assembly.
	Signal Output	Digital	Digital
Rear Speed Sensor	Type	Active/Hall IC	Active/Hall IC
	Sensor Rotor	Magnet (N and S poles are arranged in a circle.) • Integrated with the inner race of the hub bearing.	Gear (48 teeth) • Integrated with the rear drive shaft assembly.
	Signal Output	Digital	Digital

CH

▶ Front/Rear (4WD Models) Speed Sensor ◀



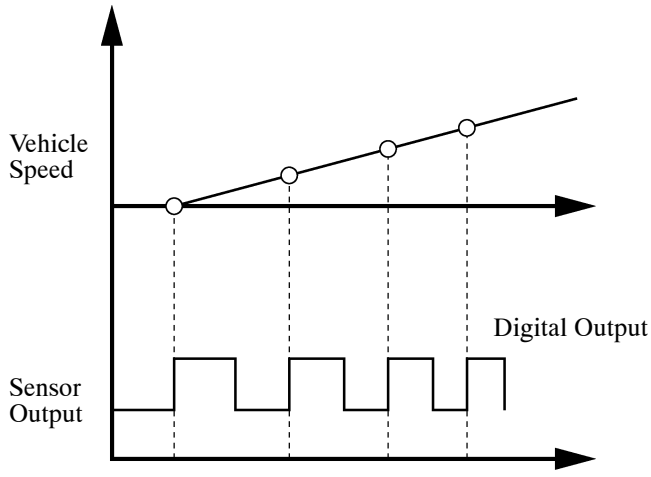
▶ Rear Speed Sensor (2WD Models) ◀



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.



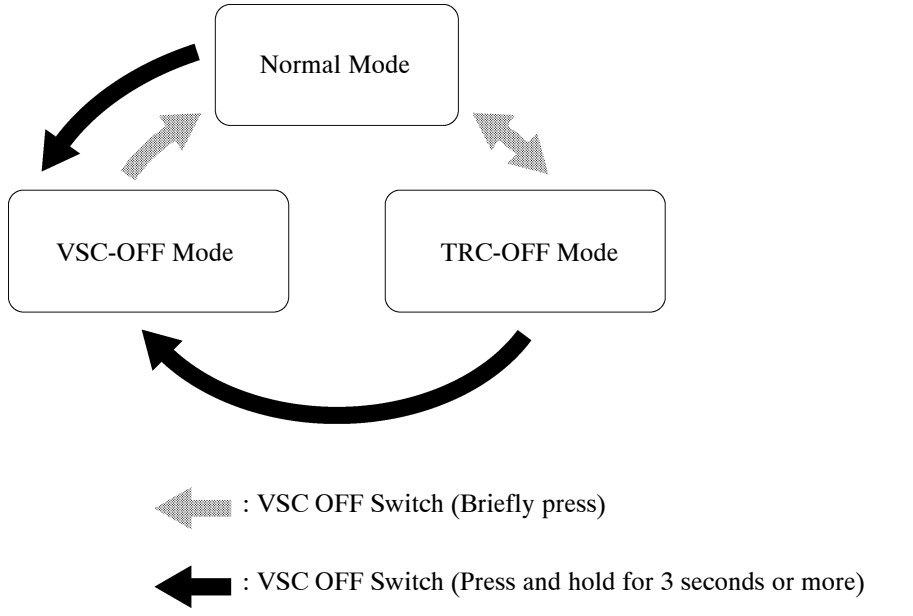
06J0CH118C

13. VSC OFF Switch

The operation of the VSC and TRC functions can be stopped by the VSC OFF switch. This switch can select any of the three modes (Normal mode, TRC-OFF mode, VSC-OFF mode).

- Briefly pressing the VSC OFF switch in normal mode enters TRC-OFF mode.
- Pressing and holding the VSC OFF switch for 3 seconds or more with the vehicle stopped enters VSC-OFF mode, disabling TRC and VSC functions.
- Briefly pressing the VSC OFF switch in TRC-OFF or VSC-OFF mode or turning the ignition switch (engine switch)* off returns to normal mode.

*: Models with Smart Entry and Start System



- The operation of the brake control functions and the illumination state of the respective indicator lights in each mode are as follows:

○: ON -: OFF

Item	Brake Control Function		Slip Indicator Light	VSC OFF Indicator Light
	TRC	VSC	 03NCH005Y	VSC OFF 03NCH006Y
Normal Mode	Controlled	Controlled	-	-
TRC-OFF Mode	Not Controlled	Controlled	○	-
VSC-OFF Mode	Not Controlled	Not Controlled*	○	○

*: In case the yaw rate is large during braking, the VSC will operate even in VSC-OFF mode.

14. Downhill Assist Control Switch

The Downhill Assist Control switch can select the driver to turn Downhill Assist Control function ON or OFF.

- The Downhill Assist Control switch is an alternate-type switch.
- The operation of the Downhill Assist Control functions and the illumination state of the respective indicator lights in each mode are as follows:

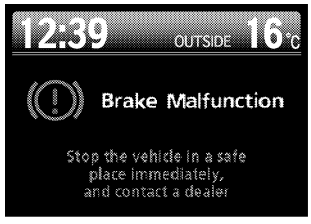
○: ON ●: Blinks -: OFF

Item		Downhill Assist Control Indicator Light  06J0CH78C	Slip Indicator Light  03NCH005Y
Downhill Assist Control Switch Condition	Downhill Assist Control Operating Condition		
OFF	Does Not Operate	-	-
ON	Does Not Operate	●	-
	Operates	○	●

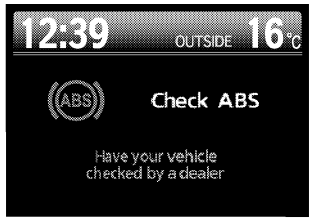
15. Multi-information Display

The multi-information display shows warning messages to inform the driver that there is a malfunction in the brake control system.

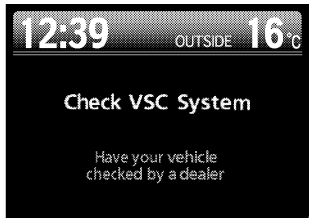
▶ Models for Australia ◀



Brake Malfunction



ABS Malfunction



TRC or VSC Malfunction

06K0CH21C

▶ Models for China ◀



Brake Malfunction



ABS Malfunction



TRC or VSC Malfunction

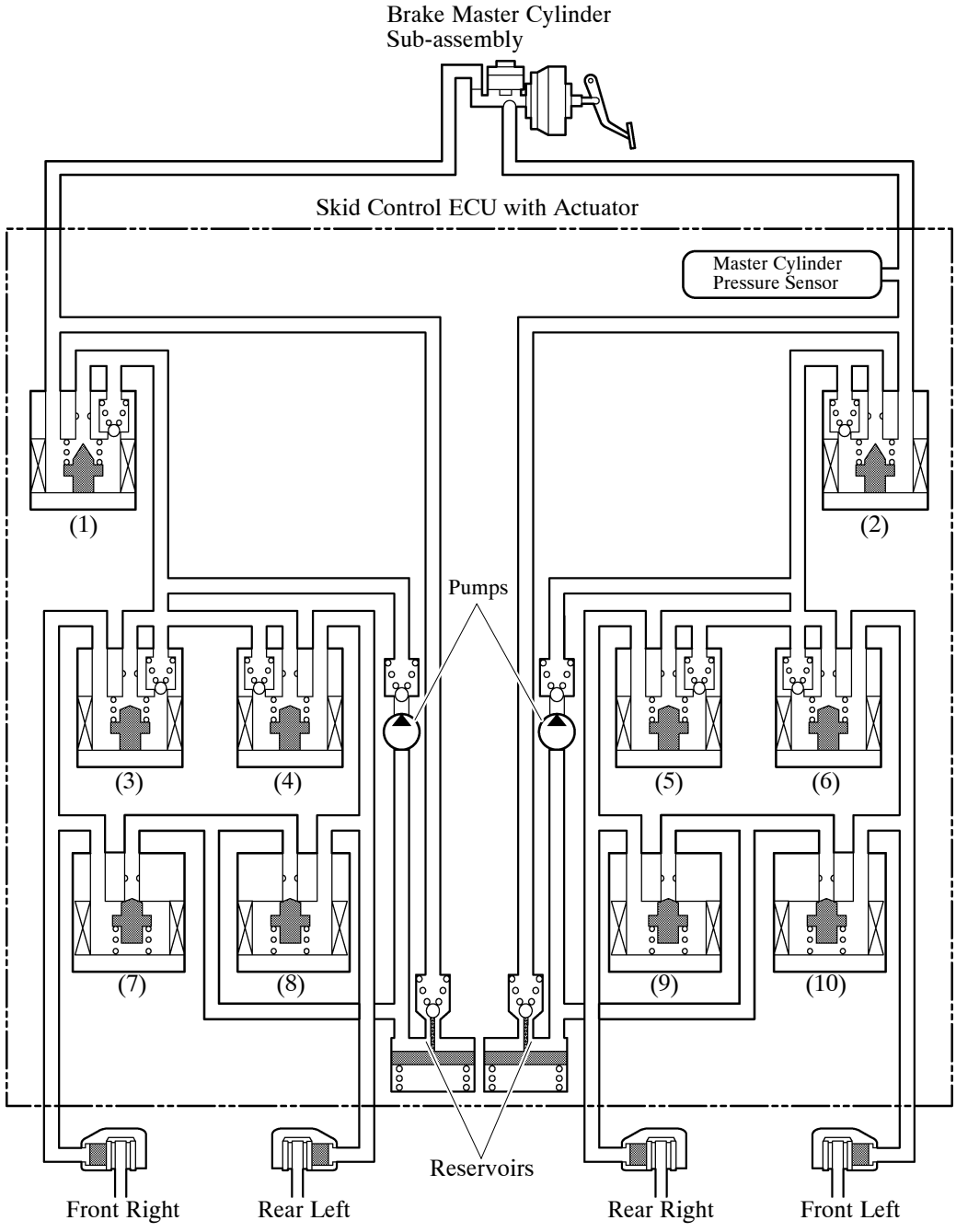
06K0CH22C

16. Skid Control ECU with Actuator

The brake actuator consists of the actuator portion, Skid Control ECU and master cylinder pressure sensor.

- The actuator portion consists of ten solenoid valves, pump motor, two pumps, two reservoirs, and master cylinder pressure sensor.
- The ten solenoid valves consist of two master cylinder cut solenoid valves [(1), (2)], four pressure holding solenoid valves [(3), (4), (5), (6)], and four pressure reduction solenoid valves [(7), (8), (9), (10)].

▶ Hydraulic Circuit ◀

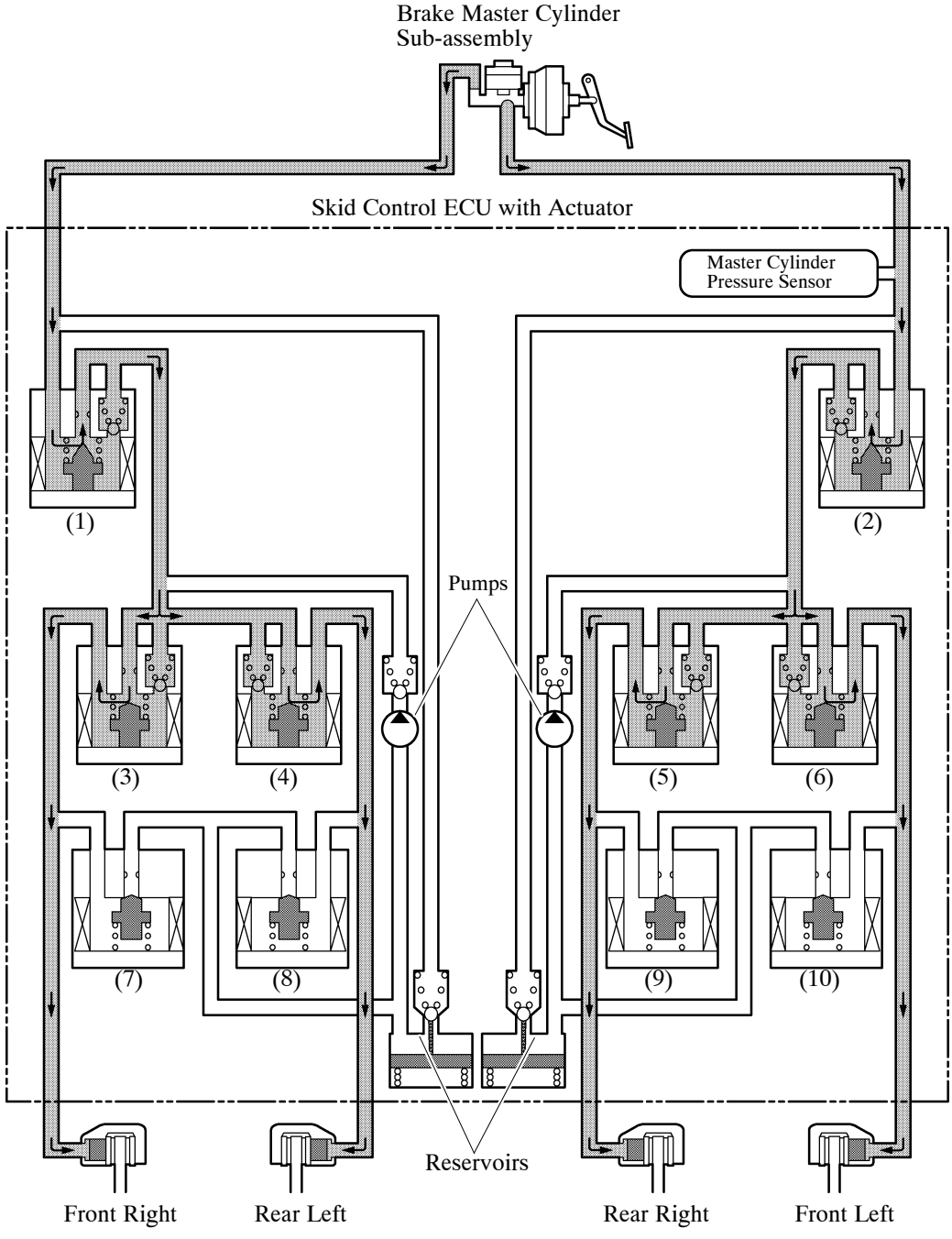


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17. System Operation

Normal Operation

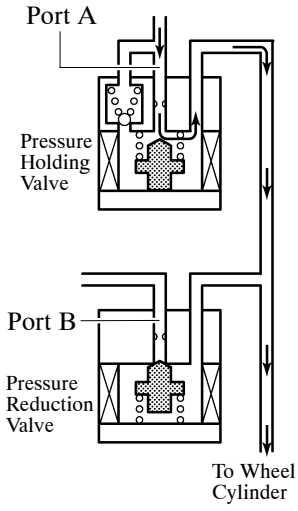
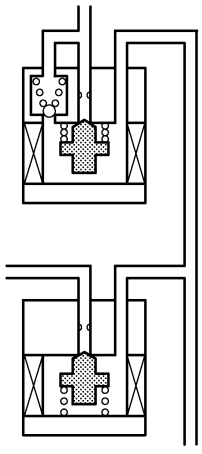
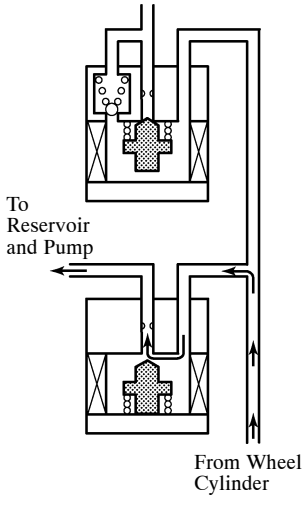
During normal braking, all solenoid valves are turned OFF.



06J0CH116C

ABS and EBD Operation

Based on the signals received from the front and rear speed sensors, the Skid Control ECU calculates each wheel speed and deceleration, and checks to see if a wheel has lost grip. According to the condition at each wheel, the Skid Control ECU controls the pressure holding valve and pressure reduction valve in order to adjust the fluid pressure of each brake wheel cylinder in the following three modes: pressure reduction, pressure holding, and pressure increase modes.

Not Activated	Normal Braking	—	—
Activated	Increase Mode	Holding Mode	Reduction Mode
Hydraulic Circuit			
Pressure Holding Valve (Port A)	OFF (Open)	ON (Closed)	ON (Closed)
Pressure Reduction Valve (Port B)	OFF (Closed)	OFF (Closed)	ON (Open)
Brake Wheel Cylinder Pressure	Increased	Held	Reduced

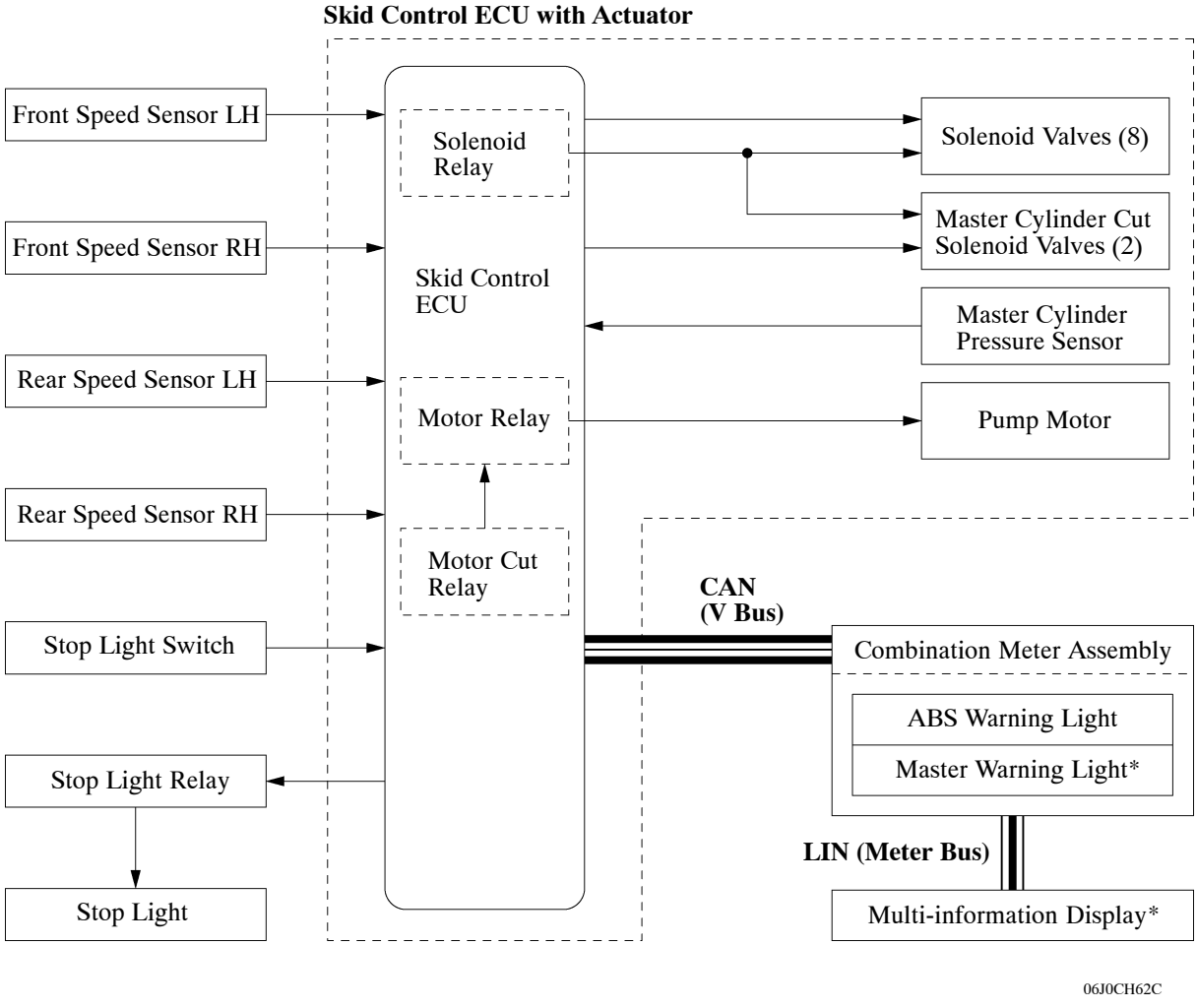
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Brake Assist Operation

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 from the master cylinder pressure sensor signal. If the Skid Control ECU judges that the driver intends emergency braking, additional pressure is generated by the pump in the brake actuator and directed to the brake wheel cylinders to supplement the fluid pressure from the brake master cylinder sub assembly. Based on this, the Skid Control ECU provides Brake Assist.

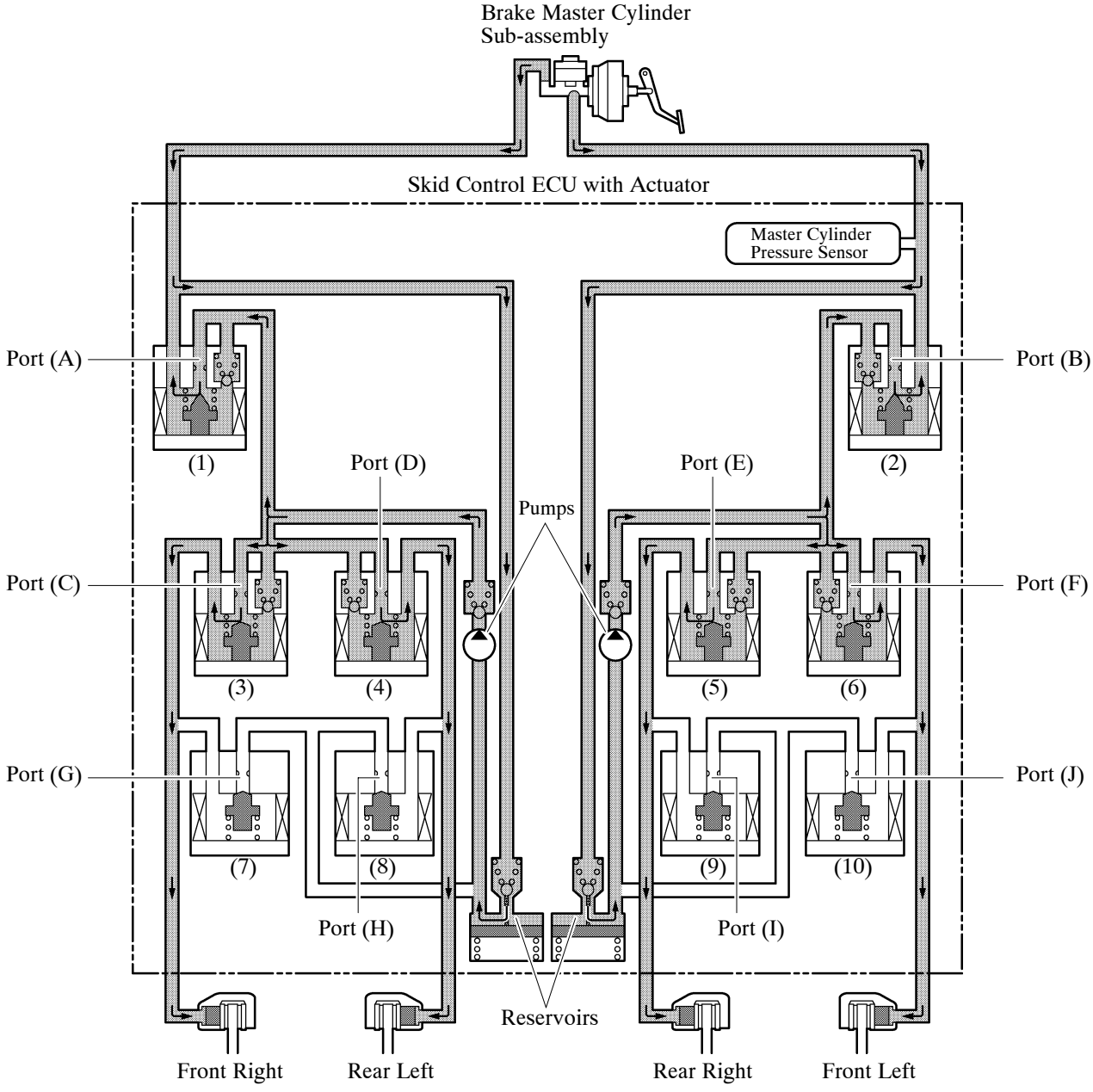
- When the Brake Assist is activated, the solenoid valves operate as shown in the table on the next page.

▶ System Diagram ◀



*: Models with Multi-information Display

▶ Brake Assist Operation ◀



Item		Port	Brake Assist Not Activated	Brake Assist Activated
Master Cylinder Cut Solenoid Valves	(1), (2)	(A), (B)	OFF (Open)	ON*
Pressure Holding Solenoid Valves	(3), (4), (5), (6)	(C), (D) (E), (F)	OFF (Open)	OFF (Open)
Pressure Reduction Solenoid Valves	(7), (8), (9), (10)	(G), (H) (I), (J)	OFF (Closed)	OFF (Closed)
Pump			OFF	ON

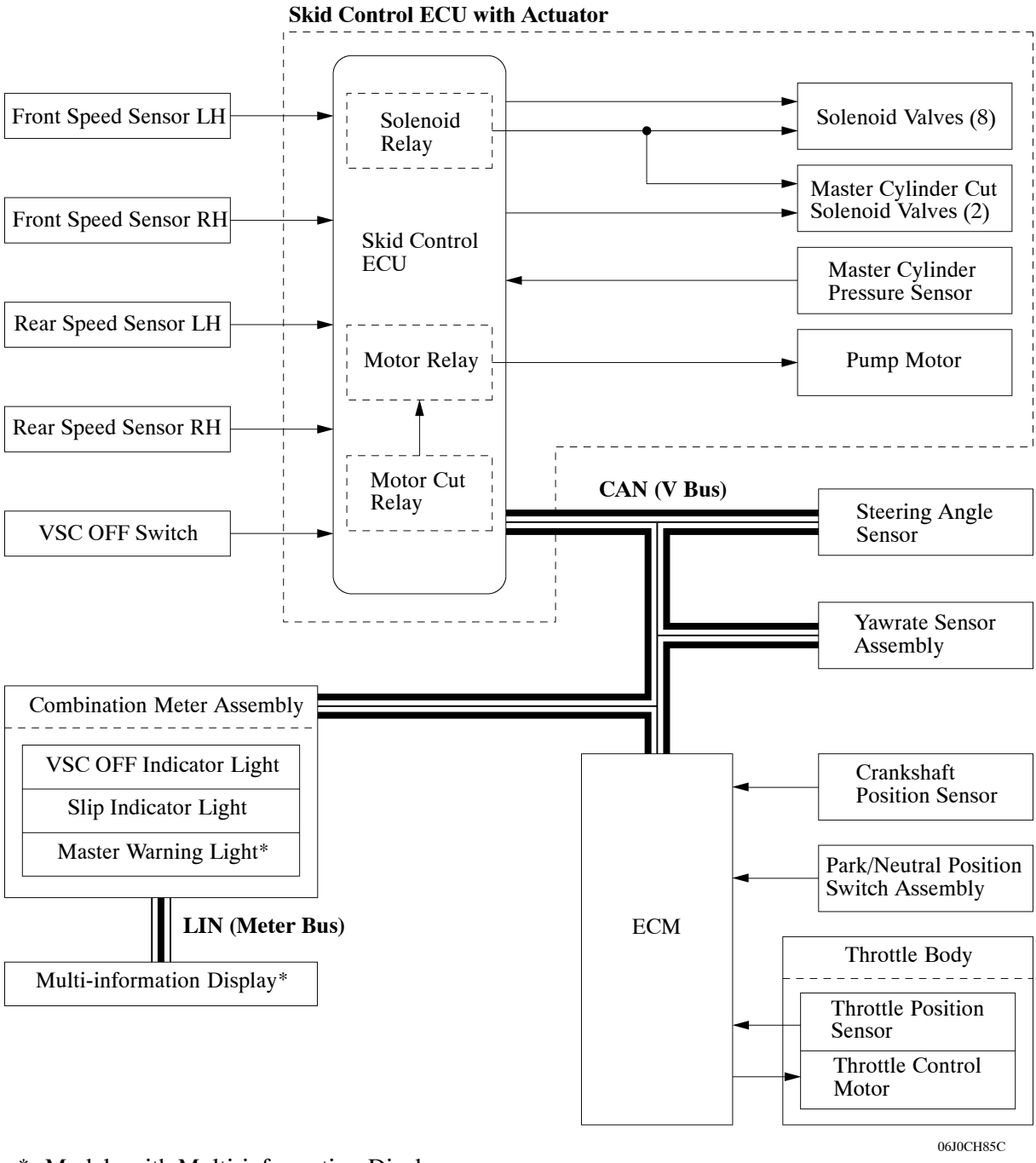
*: Hydraulic pressure is controlled by continuously cycling the solenoid valves between open and closed, according to the operating conditions.

TRC Operation

The fluid pressure generated by the pump is regulated by the master cylinder cut solenoid valve to the required pressure. Thus, the brake wheel cylinders of the drive wheels are controlled in the following three modes: pressure reduction, pressure holding, and pressure increase modes to control the slippage of the drive wheels.

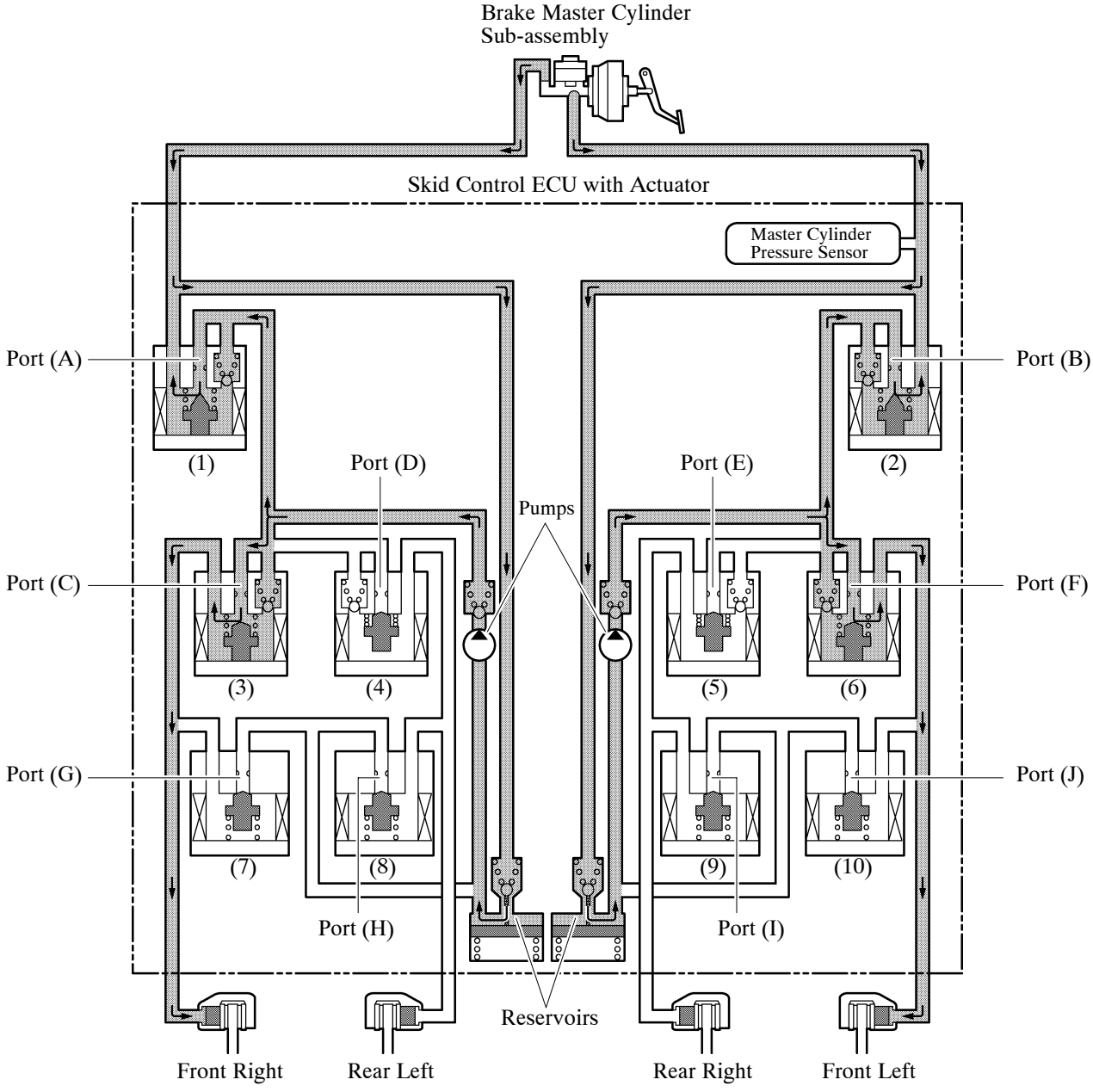
- The diagram on the next page shows the hydraulic circuit in the pressure increase mode when TRC is activated.
- The pressure holding solenoid valves and the pressure reduction solenoid valves are turned ON/OFF according to the ABS and EBD operation pattern described on the previous page.
- TRC is activated and the solenoid valves operate as shown in the table on page CH-88 (for 2WD models) or CH-90 (for 4WD models).

▶ System Diagram ◀



*: Models with Multi-information Display

▶ TRC Operation (2WD Model) ◀



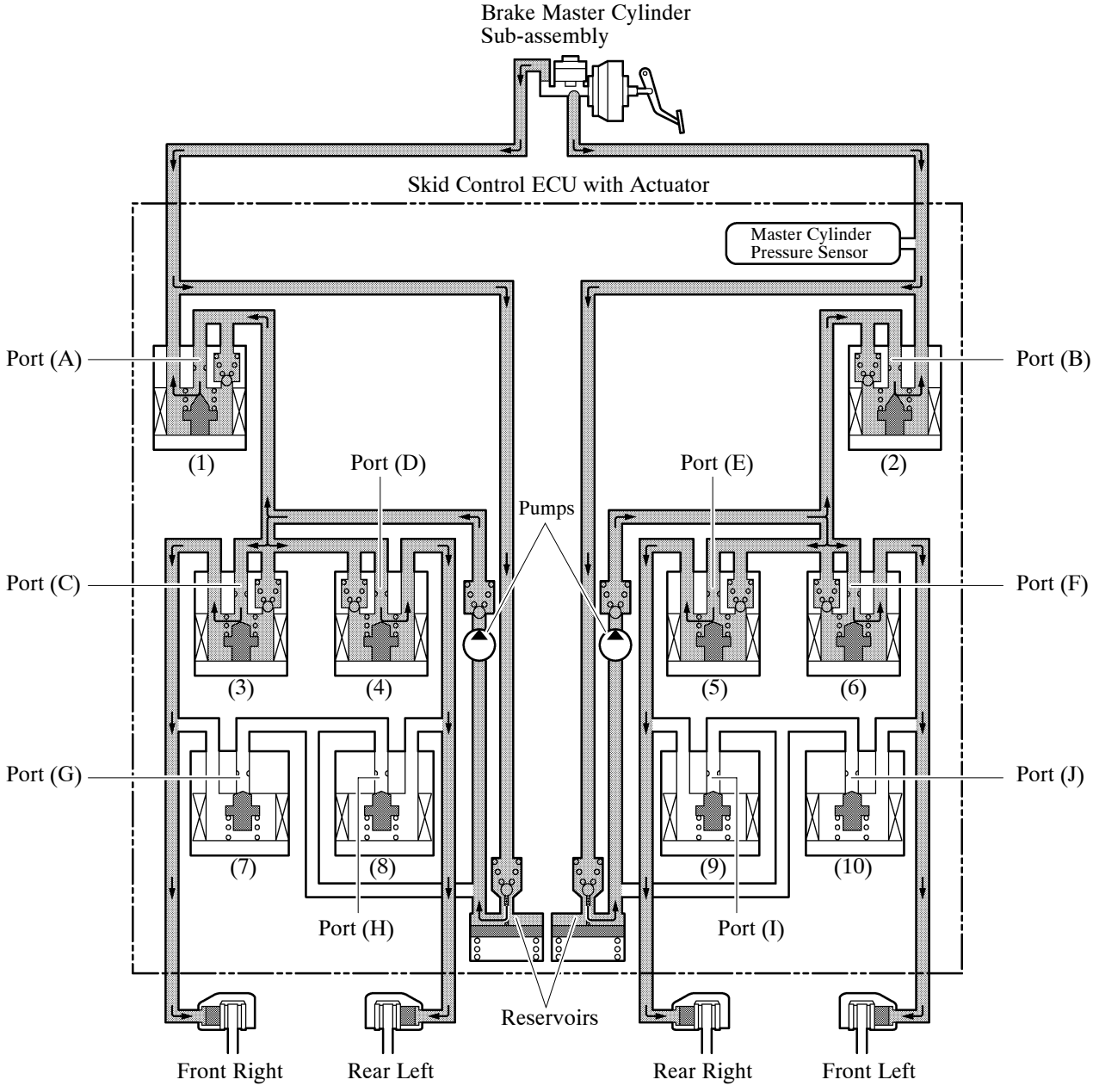
06J0CH64C

CH

Item				Port	TRC Not Activated	TRC Activated		
						Increase Mode	Holding Mode	Reduction Mode
Master Cylinder Cut Solenoid Valves			(1) (2)	(A) (B)	OFF (Open)	ON*	ON*	ON*
Front Brakes	Pressure Holding Solenoid Valves		(3) (6)	(C) (F)	OFF (Open)	OFF (Open)	ON (Closed)	ON (Closed)
	Pressure Reduction Solenoid Valves		(7) (10)	(G) (J)	OFF (Closed)	OFF (Closed)	OFF (Closed)	ON (Open)
	Brake Wheel Cylinder Pressure	Right	—	—	—	Increased	Held	Reduced
		Left	—	—	—	Increased	Held	Reduced
Rear Brakes	Pressure Holding Solenoid Valves		(4) (5)	(D) (E)	OFF (Open)	ON (Closed)	ON (Closed)	ON (Closed)
	Pressure Reduction Solenoid Valves		(8) (9)	(H) (I)	OFF (Closed)	OFF (Closed)	OFF (Closed)	OFF (Closed)
	Brake Wheel Cylinder Pressure	Right	—	—	—	—	—	—
		Left	—	—	—	—	—	—
Pump					OFF	ON	ON	ON

*: Hydraulic pressure is controlled by continuously cycling the solenoid valves between open and closed, according to the operating conditions.

▶ TRC Operation (4WD Model) ◀



06J0CH63C

CH

Item				Port	TRC Not Activated	TRC Activated		
						Increase Mode	Holding Mode	Reduction Mode
Master Cylinder Cut Solenoid Valves			(1) (2)	(A) (B)	OFF (Open)	ON*	ON*	ON*
Front Brakes	Pressure Holding Solenoid Valves		(3) (6)	(C) (F)	OFF (Open)	OFF (Open)	ON (Closed)	ON (Closed)
	Pressure Reduction Solenoid Valves		(7) (10)	(G) (J)	OFF (Closed)	OFF (Closed)	OFF (Closed)	ON (Open)
	Brake Wheel Cylinder Pressure	Right	—	—	—	Increased	Held	Reduced
		Left	—	—	—	Increased	Held	Reduced
Rear Brakes	Pressure Holding Solenoid Valves		(4) (5)	(D) (E)	OFF (Open)	OFF (Open)	ON (Closed)	ON (Closed)
	Pressure Reduction Solenoid Valves		(8) (9)	(H) (I)	OFF (Closed)	OFF (Closed)	OFF (Closed)	ON (Open)
	Brake Wheel Cylinder Pressure	Right	—	—	—	Increased	Held	Reduced
		Left	—	—	—	Increased	Held	Reduced
Pump					OFF	ON	ON	ON

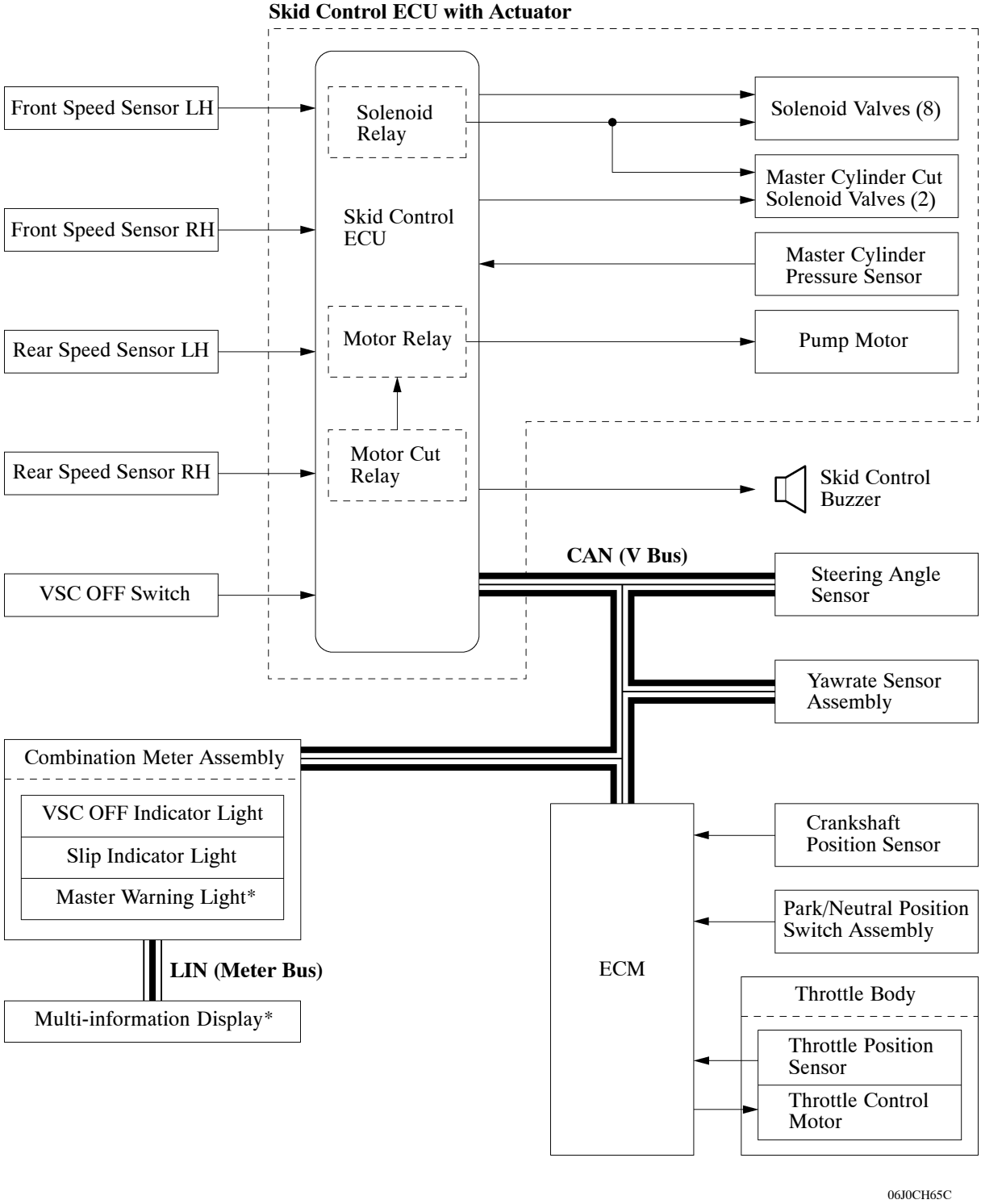
*: Hydraulic pressure is controlled by continuously cycling the solenoid valves between open and closed, according to the operating conditions.

VSC Operation

1) General

The VSC system, by way of solenoid valves, controls the fluid pressure that is generated by the pump and applies it to the brake wheel cylinder of the wheels in the following three modes: pressure reduction, pressure holding, and pressure increase modes. As a result, the tendency of the vehicle to experience a front wheel skid or rear wheel skid is controlled.

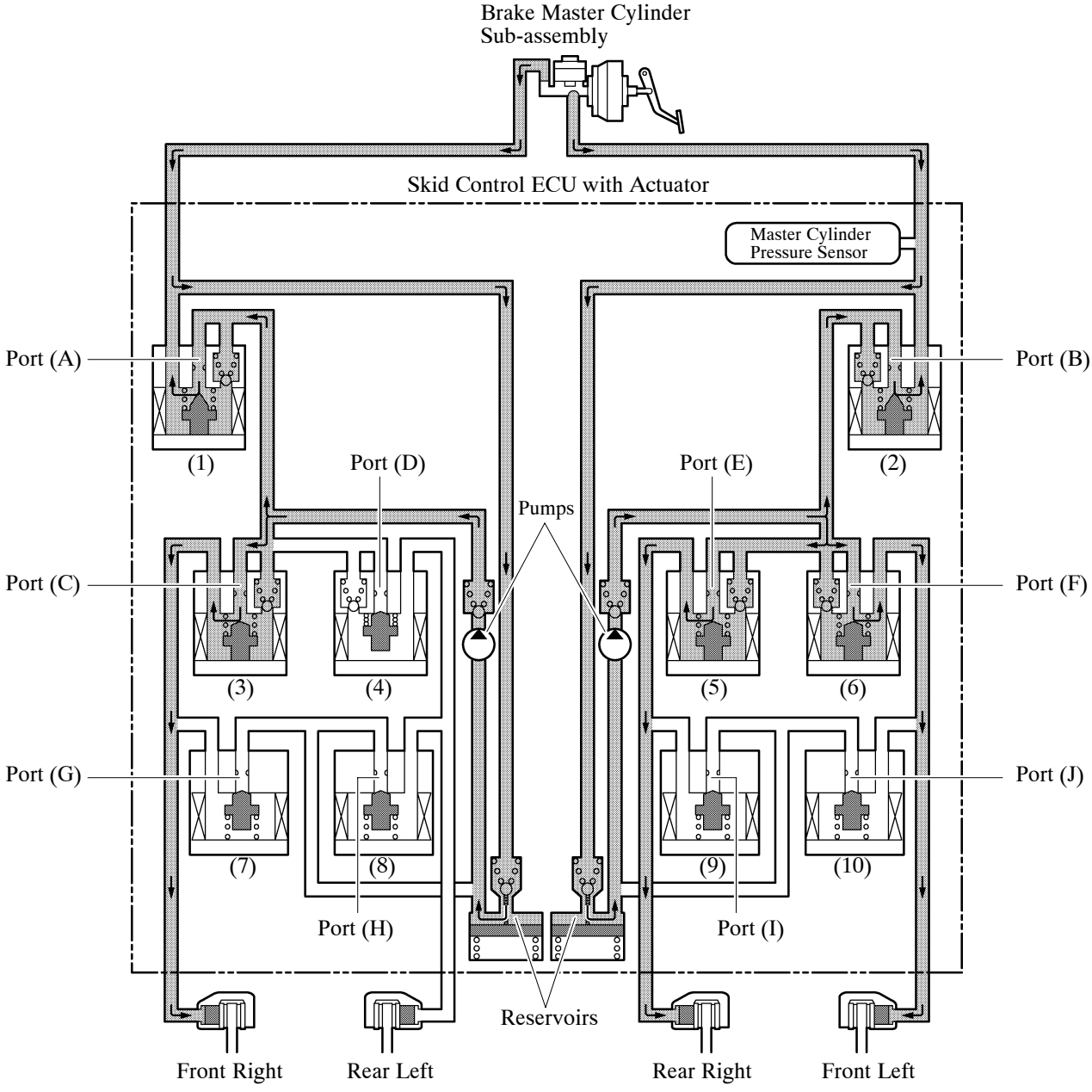
▶ System Diagram ◀



*: Models with Multi-information Display

2) Front Wheel Skid Restraining Control (Making a Right Turn)

In the front wheel skid restraining control, the brakes of the wheels of the inner circle of the turn are applied. Also, depending on whether the brake is ON or OFF and the condition of the vehicle, there are circumstances in which the brakes might not be applied to a wheel even if the wheel is targeted for braking. The diagram below shows the hydraulic circuit in the pressure increase mode, as it controls the front wheel skid condition while the vehicle makes a right turn. In other operating mode, the pressure holding valve and the pressure reduction valve are turned ON/OFF according to the ABS and EBD operation pattern. When the front wheel skid restraining control is activated, the solenoid valves operate as shown in the table on the next page.



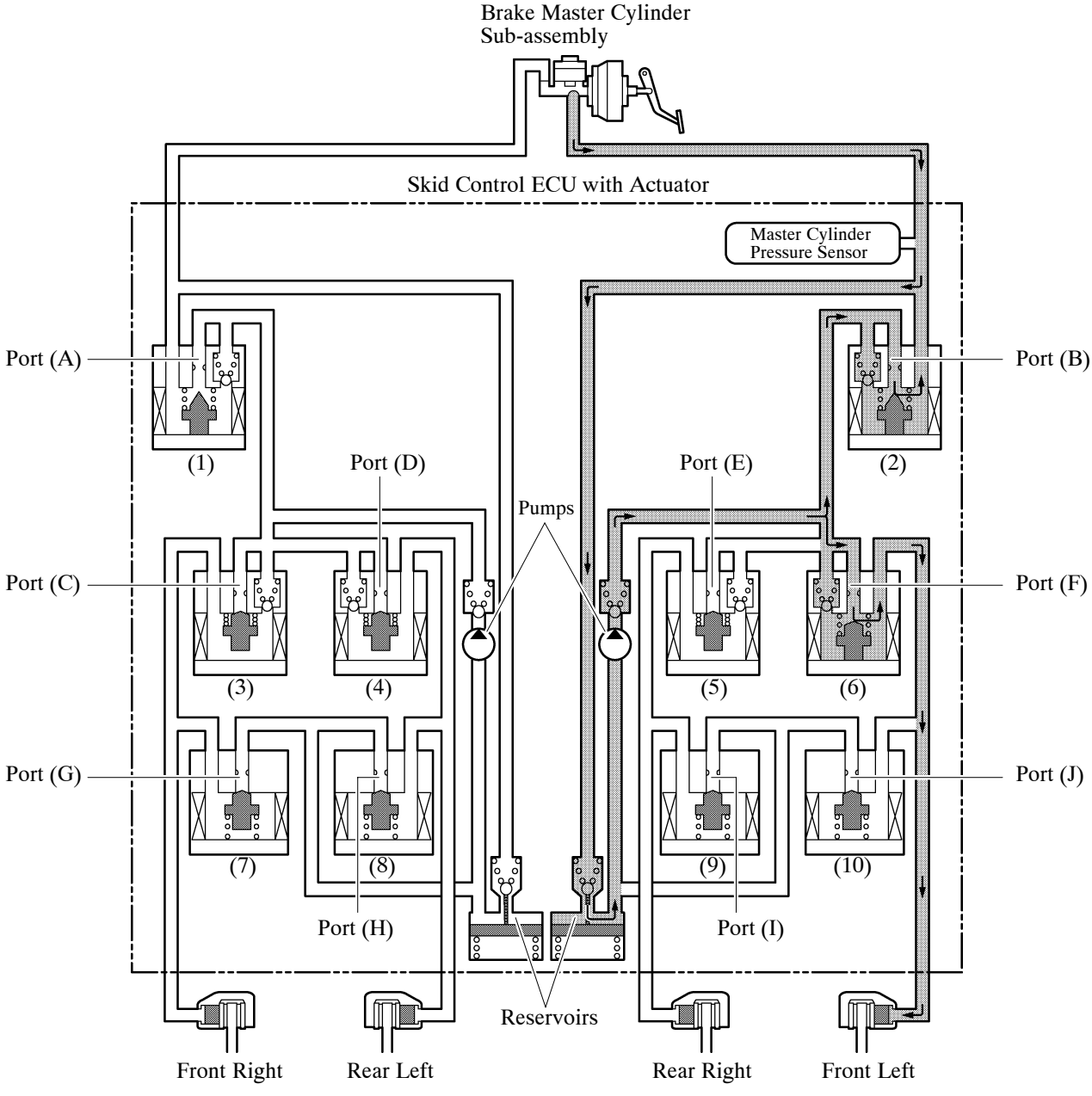
06J0CH66C

Item				Port	VSC Not Activated	VSC Activated		
						Increase Mode	Holding Mode	Reduction Mode
Master Cylinder Cut Solenoid Valves			(1) (2)	(A) (B)	OFF (Open)	ON*	ON*	ON*
Front Brakes	Pressure Holding Solenoid Valves		(3)	(C)	OFF (Open)	OFF (Open)	ON (Closed)	ON (Closed)
			(6)	(F)	OFF (Open)	OFF (Open)	ON (Closed)	ON (Closed)
	Pressure Reduction Solenoid Valves		(7)	(G)	OFF (Closed)	OFF (Closed)	OFF (Closed)	ON (Open)
			(10)	(J)	OFF (Closed)	OFF (Closed)	OFF (Closed)	ON (Open)
	Brake Wheel Cylinder Pressure	Right	—	—	—	Increased	Held	Reduced
		Left	—	—	—	Increased	Held	Reduced
Rear Brakes	Pressure Holding Solenoid Valves		(4)	(D)	OFF (Open)	ON (Closed)	ON (Closed)	ON (Closed)
			(5)	(E)	OFF (Open)	OFF (Open)	ON (Closed)	ON (Closed)
	Pressure Reduction Solenoid Valves		(8)	(H)	OFF (Closed)	OFF (Closed)	OFF (Closed)	OFF (Closed)
			(9)	(I)	OFF (Closed)	OFF (Closed)	OFF (Closed)	ON (Open)
	Brake Wheel Cylinder Pressure	Right	—	—	—	Increased	Held	Reduced
		Left	—	—	—	—	—	—
Pump					OFF	ON	ON	ON

*: Hydraulic pressure is controlled by continuously cycling the solenoid valves between open and closed, according to the operating conditions.

3) Rear Wheel Skid Restraining Control (Making a Right Turn)

In the rear wheel skid restraining control, the brakes of the wheels of the outer circle of the turn are applied. Also, depending on whether the brake is ON or OFF and the condition of the vehicle, there are circumstances in which the brakes might not be applied to a wheel even if the wheel is targeted for braking. The diagram below shows the hydraulic circuit in the pressure increase mode, as it controls the rear wheel skid condition while the vehicle makes a right turn. In other operating modes, the pressure holding valve and the pressure reduction valve are turned ON/OFF according to the ABS and EBD operation patterns. When the rear wheel skid restraining control is activated, the solenoid valves operate as shown in the table on the next page.



06J0CH67C

Item				Port	VSC Not Activated	VSC Activated		
						Increase Mode	Holding Mode	Reduction Mode
Master Cylinder Cut Solenoid Valves			(1)	(A)	OFF (Open)	OFF (Open)	OFF (Open)	OFF (Open)
			(2)	(B)	OFF (Open)	ON*	ON*	ON*
Front Brakes	Pressure Holding Solenoid Valves		(3)	(C)	OFF (Open)	ON (Closed)	ON (Closed)	ON (Closed)
			(6)	(F)	OFF (Open)	OFF (Open)	ON (Closed)	ON (Closed)
	Pressure Reduction Solenoid Valves		(7)	(G)	OFF (Closed)	OFF (Closed)	OFF (Closed)	OFF (Closed)
			(10)	(J)	OFF (Closed)	OFF (Closed)	OFF (Closed)	ON (Open)
	Brake Wheel Cylinder Pressure	Right	—	—	—	—	—	—
		Left	—	—	—	Increased	Held	Reduced
Rear Brakes	Pressure Holding Solenoid Valves		(4)	(D)	OFF (Open)	ON (Closed)	ON (Closed)	ON (Closed)
			(5)	(E)	OFF (Open)	ON (Closed)	ON (Closed)	ON (Closed)
	Pressure Reduction Solenoid Valves		(8)	(H)	OFF (Closed)	OFF (Closed)	OFF (Closed)	OFF (Closed)
			(9)	(I)	OFF (Closed)	OFF (Closed)	OFF (Closed)	OFF (Closed)
	Brake Wheel Cylinder Pressure	Right	—	—	—	—	—	—
		Left	—	—	—	—	—	—
Pump					OFF	ON	ON	ON

*: Hydraulic pressure is controlled by continuously cycling the solenoid valves between open and closed, according to the operating conditions.

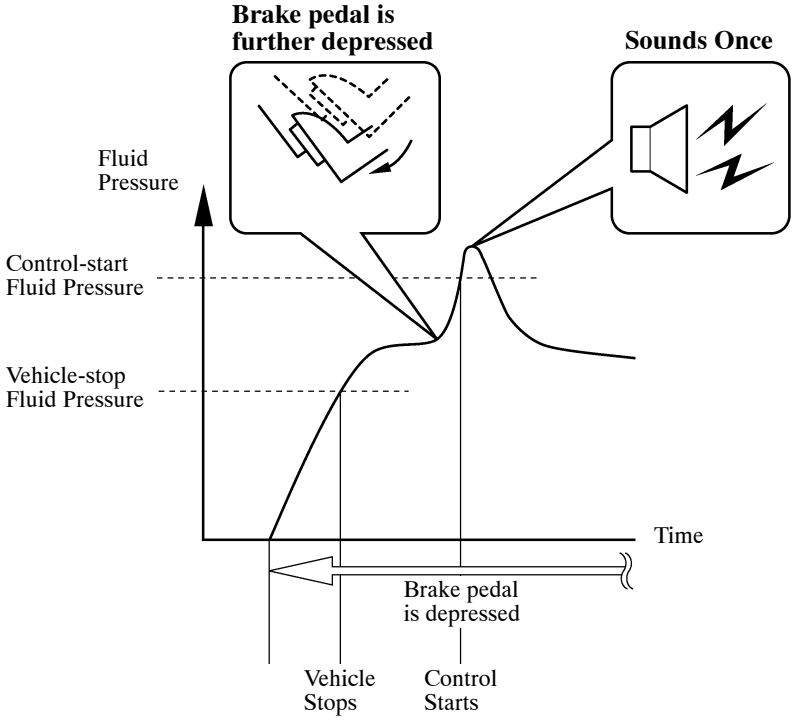
CH

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 ECM, the Skid Control ECU detects if Hill-start Assist Control can operate.
- 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.
- When Hill-start Assist Control operation starts, the skid control buzzer will sound once.

Hill-start Assist Control Operating Conditions	• Shift lever is in a position other than P. • The accelerator pedal is not depressed. • The vehicle is at a standstill. • The parking brake is not applied.

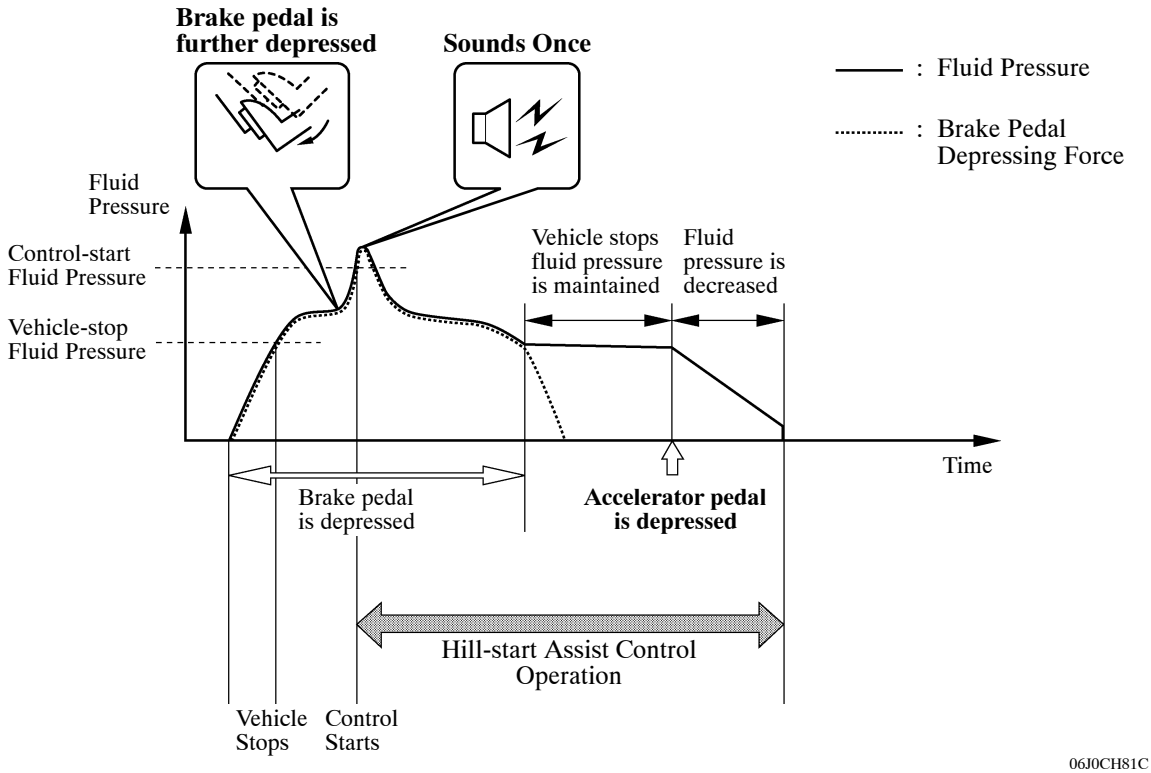


06J0CH111C

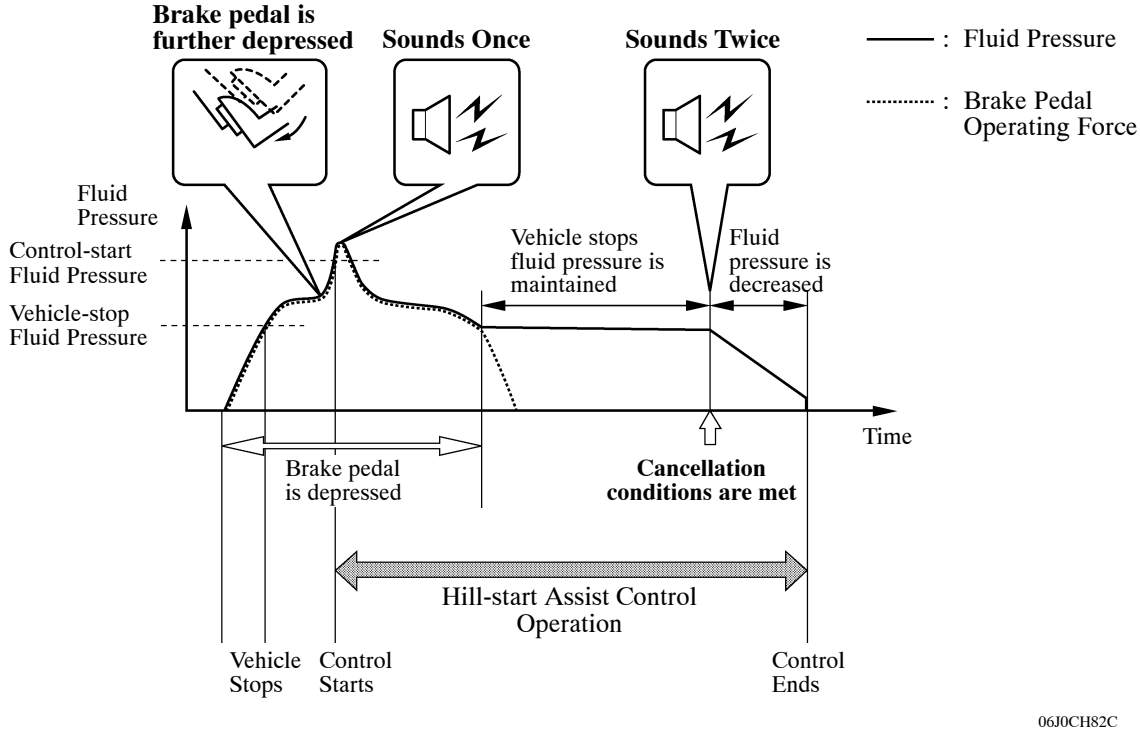
- During Hill-start Assist Control, the slip indicator light blinks and the stop lights are illuminated.
- If any one of the below conditions is met during Hill-start Assist Control operation, Hill-start Assist Control will be cancelled causing the slip indicator light to turn off.
- The skid control buzzer will operate as indicated below when Hill-start Assist Control is cancelled.

Conditions which cause Hill-start Assist Control operation to be canceled	a) Skid control buzzer does not sound	• The driver depresses the accelerator pedal.
	b) Skid control buzzer 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) Hill-start Assist Control is canceled without skid control buzzer sounding

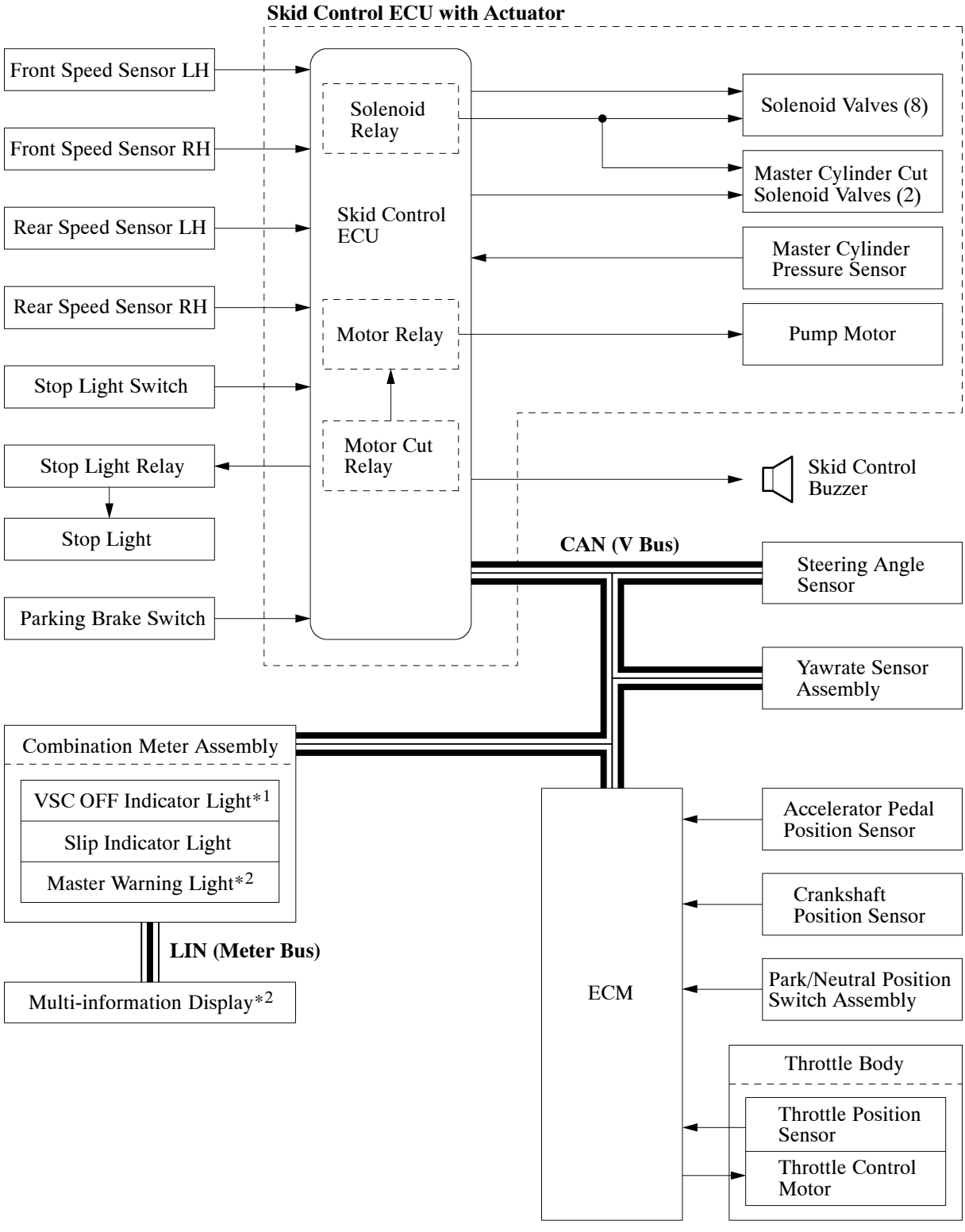


b) Hill-start Assist Control is canceled with skid control buzzer sounding twice



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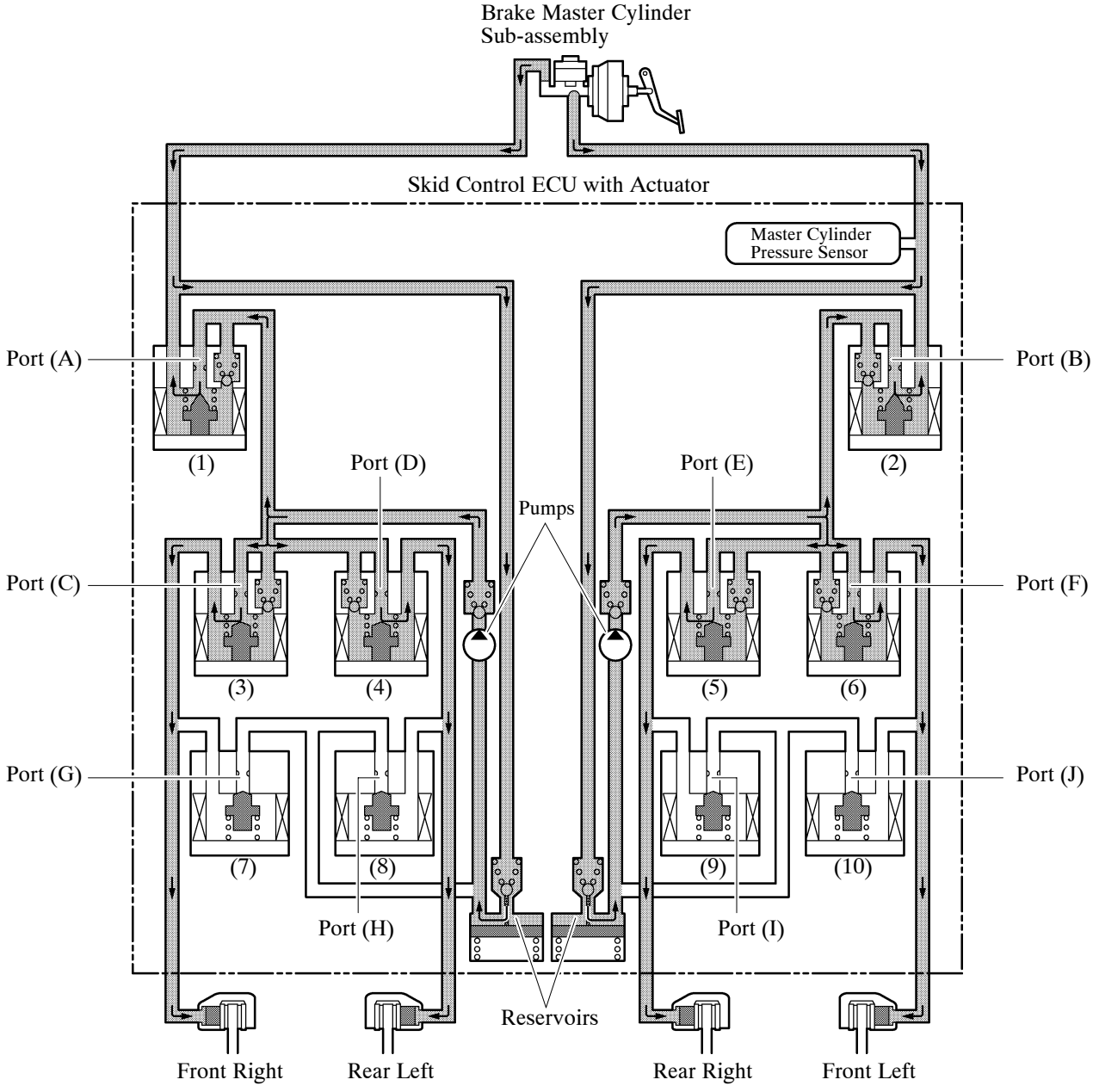
▶ System Diagram ◀



06J0CH68C

*1: Models without Multi-information Display
*2: Models with Multi-information Display

▶ Hill-start Assist Control Operation ◀



06J0CH63C

CH

Item				Port	Hill-start Assist Control Not Activated	Hill-start Assist Control Activated	
						Holding Mode	Reduction Mode
Master Cylinder Cut Solenoid Valves			(1) (2)	(A) (B)	OFF (Open)	ON*	ON*
Front Brake	Pressure Holding Solenoid Valves		(5) (6)	(E) (F)	OFF (Open)	ON (Closed)	ON (Closed)
	Pressure Reduction Solenoid Valves		(9) (10)	(I) (J)	OFF (Closed)	OFF (Closed)	ON (Open)
	Brake Wheel Cylinder Pressure	Right	—	—	—	Held	Reduced
		Left	—	—	—	Held	Reduced
Rear Brake	Pressure Holding Solenoid Valves		(3) (4)	(C) (D)	OFF (Open)	ON (Closed)	ON (Closed)
	Pressure Reduction Solenoid Valves		(7) (8)	(G) (H)	OFF (Closed)	OFF (Closed)	ON (Open)
	Brake Wheel Cylinder Pressure	Right	—	—	—	Held	Reduced
		Left	—	—	—	Held	Reduced
Pump					OFF	ON	ON

*: Hydraulic pressure is controlled by continuously cycling the solenoid valves between open and closed, according to the operating conditions.

Downhill Assist Control Operation

When Downhill 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, pressure reduction, and pressure increase modes.

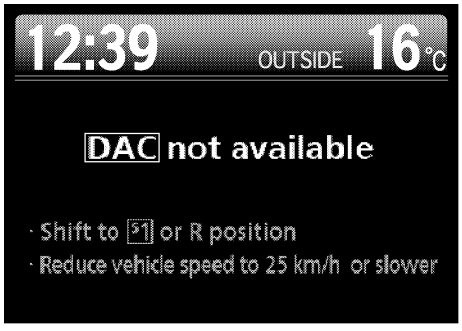
- During Downhill Assist Control, the slip indicator light blinks, the Downhill Assist Control indicator light illuminates and the stop lights illuminate.
- The Skid Control ECU determines the vehicle speed, travel direction, and the gradient of the hill in accordance with the signals from the speed sensor and the yawrate sensor assembly, and operates brake control to attain the target vehicle speed. The target vehicle speed is determined by the direction of the vehicle.

Travel Direction	Target Vehicle Speed
Forward	5 to 9 km/h (3 to 6 mph)
Backward	3 to 7 km/h (2 to 4 mph)

- If the temperature of the brake actuator reaches a specified level during Downhill Assist Control operation, Downhill Assist Control will be suspended temporarily in order to protect the system. In this event, the Skid Control buzzer will sound continuously to inform the driver.

Service Tip

When the Downhill Assist Control switch is on but not all operating conditions are met, Downhill Assist Control will not operate. In this case, the Downhill Assist Control indicator light will blink to inform the driver. In addition, for models with multi-information display, the required Downhill Assist Control operation conditions will be shown.



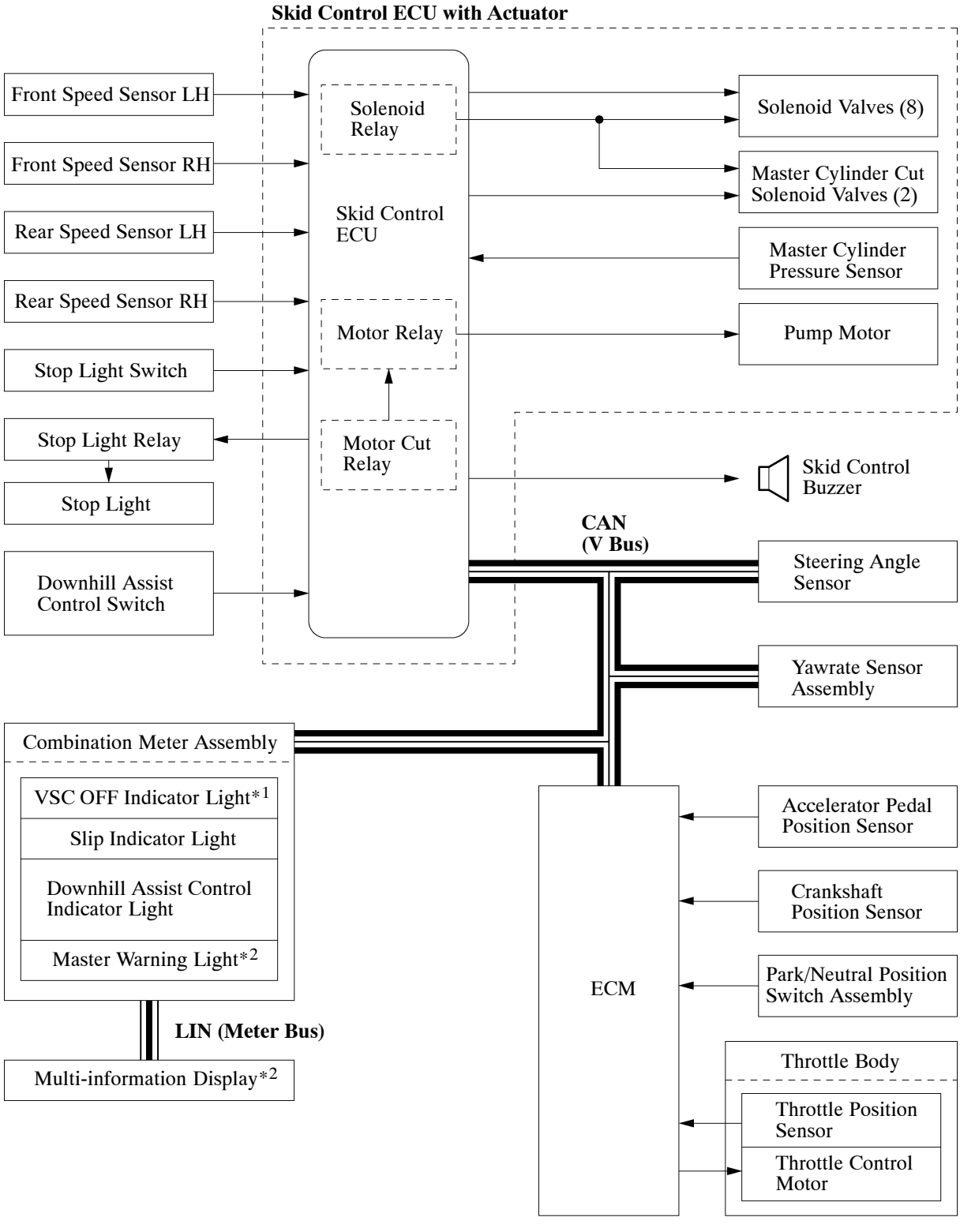
Models for Australia



Models for China

06K0CH23C

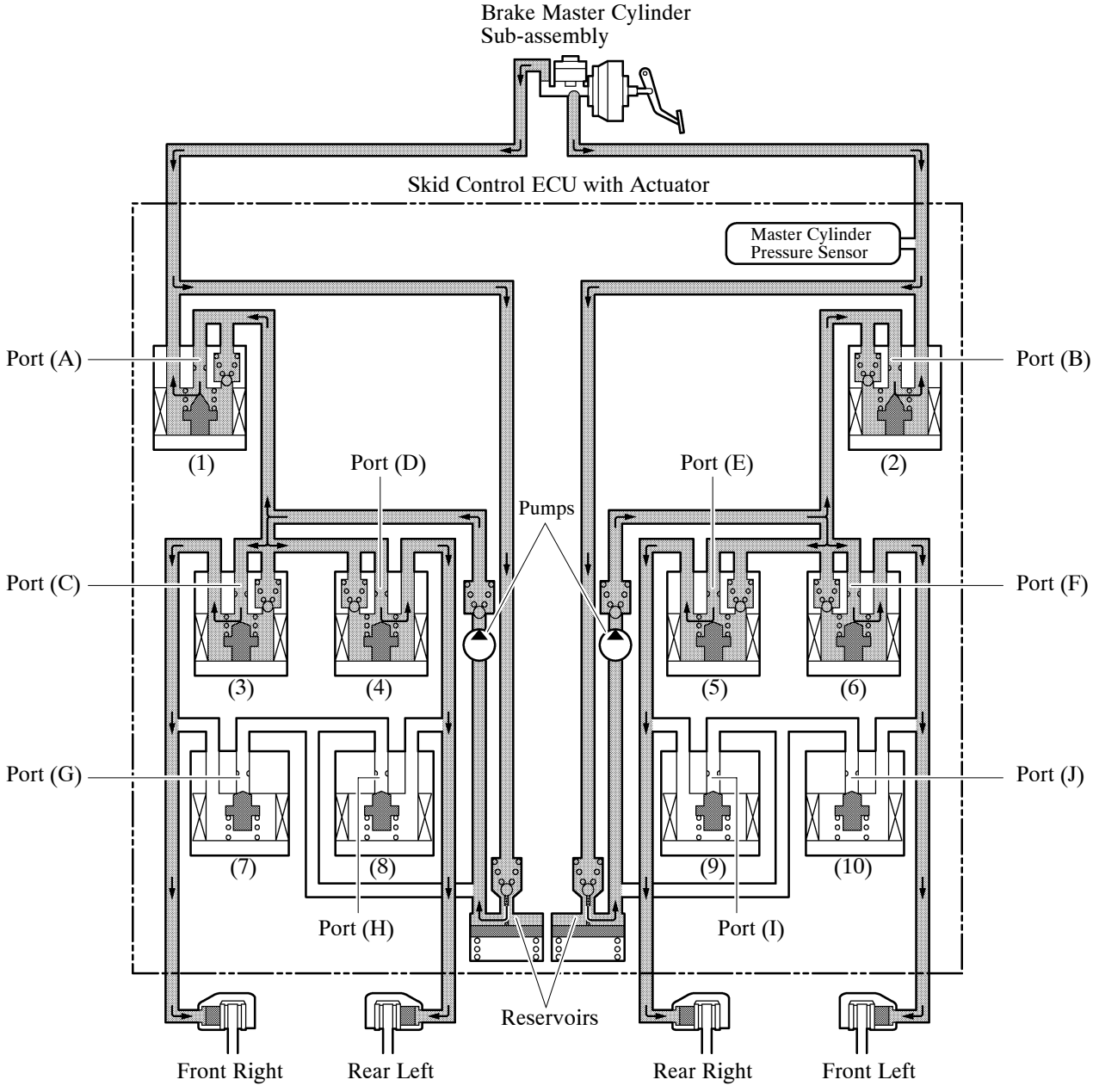
▶ System Diagram ◀



06J0CH69C

*1: Models without Multi-information Display
*2: Models with Multi-information Display

▶ Downhill Assist Control Operation ◀



06J0CH63C

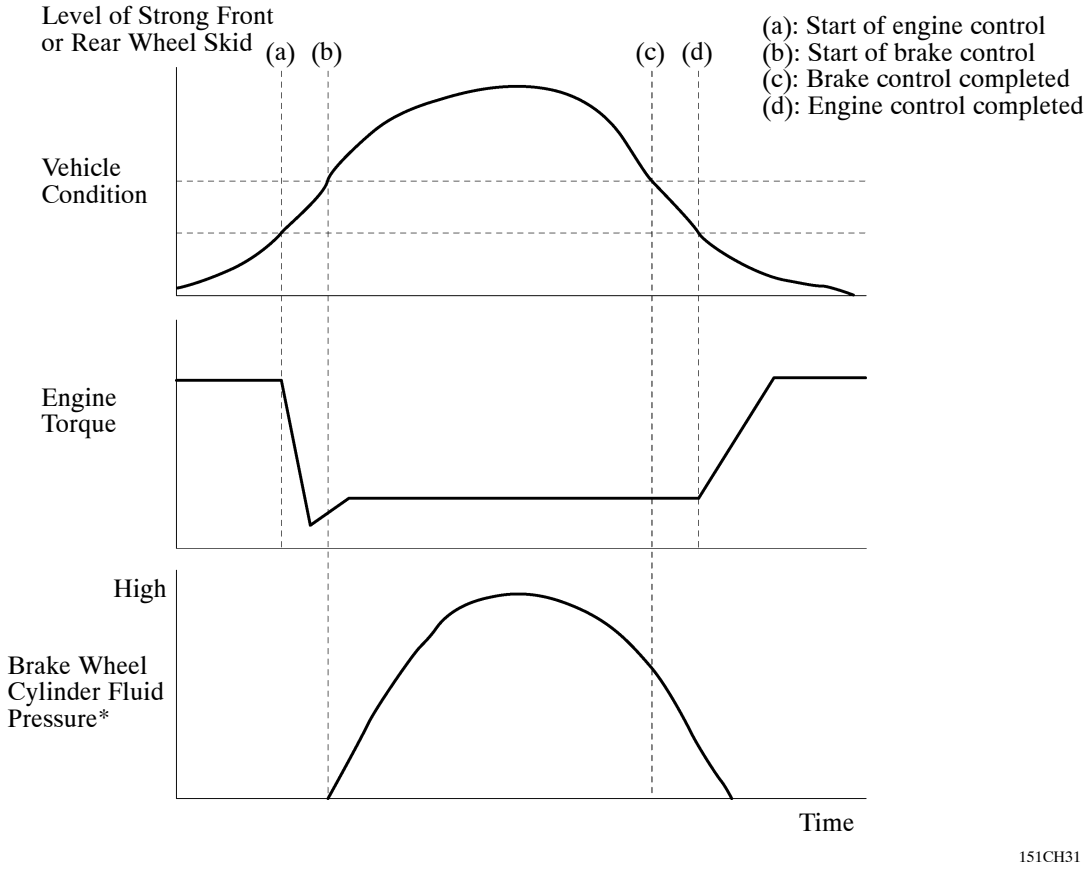
CH

Item				Port	Downhill Assist Control Not Activated	Downhill Assist Control Activated		
						Increase Mode	Holding Mode	Reduction Mode
Master Cylinder Cut Solenoid Valves			(1) (2)	(A) (B)	OFF (Open)	ON*	ON*	ON*
Front Brake	Pressure Holding Solenoid Valves		(3) (6)	(C) (F)	OFF (Open)	OFF (Open)	ON (Close)	ON (Closed)
	Pressure Reduction Solenoid Valves		(7) (10)	(G) (J)	OFF (Closed)	OFF (Closed)	OFF (Close)	ON (Open)
	Wheel Cylinder Pressure	Right	—	—	—	Increased	Held	Reduced
		Left	—	—	—	Increased	Held	Reduced
Rear Brake	Pressure Holding Solenoid Valves		(4) (5)	(D) (E)	OFF (Open)	OFF (Open)	ON (Closed)	ON (Closed)
	Pressure Reduction Solenoid Valves		(8) (9)	(H) (I)	OFF (Closed)	OFF (Closed)	OFF (Closed)	ON (Open)
	Wheel Cylinder Pressure	Right	—	—	—	Increased	Held	Reduced
		Left	—	—	—	Increased	Held	Reduced
Pump					OFF	ON	ON	ON

*: Hydraulic pressure is controlled by continuously cycling the solenoid valves between open and closed, according to the operating conditions.

18. Engine Output Control

During TRC or VSC operation, the Skid Control ECU outputs an engine output control signal to the ECM. Upon receiving this signal, the ECM regulates engine output.



*: The brake wheel cylinder that is activated varies depending on the condition of the vehicle.

19. Initial Check

Each time the power source is changed to IG ON*, and the vehicle reaches a speed of approximately 6 km/h (4 mph) or more, the Skid Control ECU performs an initial check. The functions of each solenoid valve and pump motor in the brake actuator are checked in sequence.

*: The power source condition can be changed by operating the engine switch on models with the smart entry and start system, and the ignition switch on models without the smart entry and start system.

20. CAN (Controller Area Network)

CAN communication is used among the Skid Control ECU, steering angle sensor, yawrate sensor assembly, Power Steering ECU, combination meter assembly, ECM and DLC3. For details, see page BE-9.

21. Diagnosis

If the Skid Control ECU detects a malfunction in the brake control system, the warning light or indicator light lights up 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 the SST (09843-18040) between the TC and CG terminals of DLC3 and observing the blinks of the ABS warning light or the VSC OFF indicator light, or by connecting an intelligent tester to DLC3.
- If the Skid Control ECU detects a malfunction during a sensor signal check (test mode), it stores the DTCs in its memory.
- These DTCs can be read during a sensor check operation by connecting the SST (09843-18040) to the TC and CG terminals of the DLC3 and observing the blinking of the ABS warning light or the VSC OFF indicator light. These DTCs can also be read by connecting a intelligent tester.

Service Tip

The Skid Control ECU uses the CAN protocol for diagnostic communication. Therefore, an intelligent tester and the CAN VIM (Vehicle Interface Module) are required for accessing diagnostic data. For details, see the HIGHLANDER Repair Manual (Pub. No. RM06K0E).

22. Fail-safe

- In the event of a malfunction in the ABS and/or Brake Assist controls, the Skid Control ECU prohibits ABS, Brake Assist, TRC, VSC, Hill-start Assist Control and Downhill Assist Control operation.
- In the event of a malfunction in the EBD control, the Skid Control ECU prohibits EBD operation. Even in this case, normal braking performance excluding the brake control system electronic controls (ABS with EBD, Brake Assist, TRC, VSC, Hill-start Assist Control and Downhill Assist Control) is maintained.
- In the event of a malfunction in the TRC and/or VSC, the Skid Control ECU prohibits TRC and VSC operation.
- If a communication malfunction occurs among the Skid Control ECU, the steering angle sensor, the yawrate sensor assembly or ECM, the Skid Control ECU stops the TRC, VSC, Hill-start Assist Control and Downhill Assist Control.
- When the ECM detects an engine control the DTC, it will disable the ABS, Brake Assist, TRC, VSC Hill-start Assist Control and Downhill Assist Control operation.