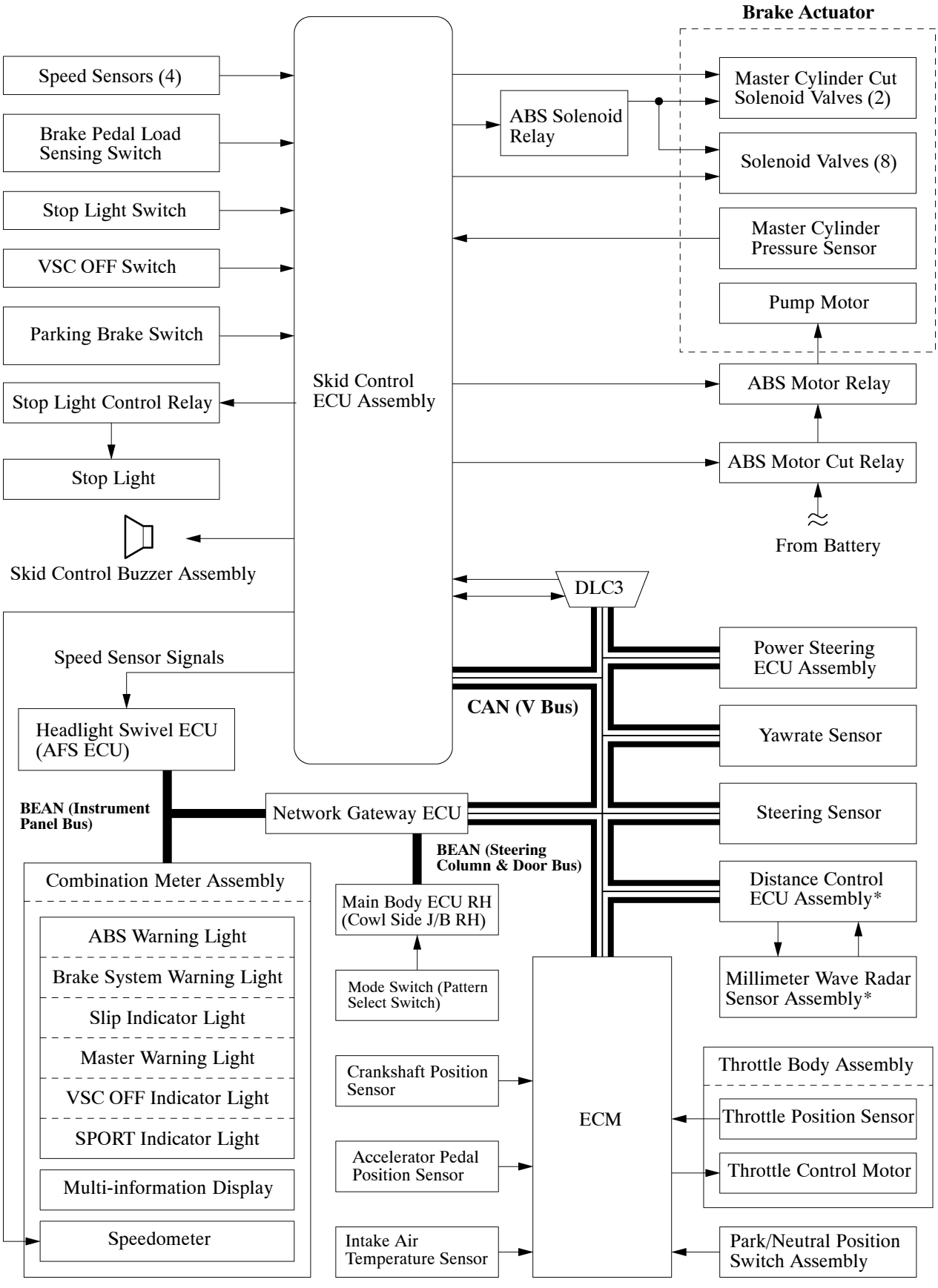
■BRAKE CONTROL SYSTEM

1. General

The brake control system has the following system/functions:

System/Function	Outline
VDIM (Vehicle Dynamics Integrated Management) [See page CH-90]	VDIM integrally controls engine 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 assembly in order to provide steering assist in accordance with the operating conditions of the vehicle.
Automatic Transmission Cooperative Control	The automatic transmission cooperative control controls the upshift timing in order to stabilize the behavior of the vehicle on slippery road surfaces.
Engine Output Cooperative Control	The engine output cooperative control controls the throttle in order to stabilize the behavior of the vehicle on slippery road surfaces.
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)	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)	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.
LSD (Limited Slip Differential) Function	The LSD function of VDIM detects vehicle turning condition and wheel slippage. Then, brake force is applied to the inner wheel to limit slippage and to transmit power to the outer wheels, ensuring acceleration performance during a vehicle turn.
VSC (Vehicle Stability Control)	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	Hill-start Assist Control generates four-wheel hydraulic pressure when the brake pedal is further depressed while the vehicle is stationary. This pressure is generated in order to prevent the vehicle from moving backward.

2. System Diagram



*: With Dynamic Radar Cruise Control System

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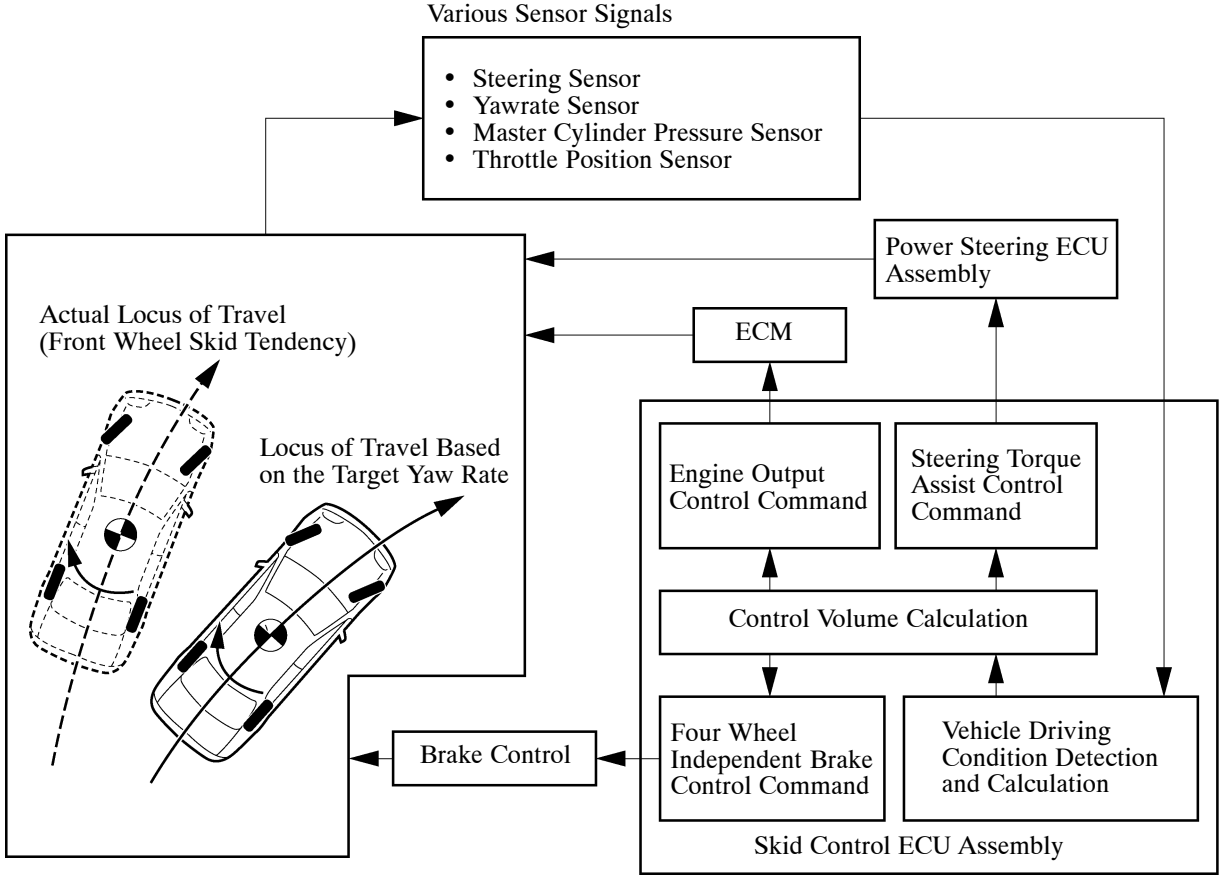
3. Outline of Steering Cooperative Control

General

- VDIM effects coordinated control consisting of VSC (Vehicle Stability Control) and EPS (Electric Power Steering). By integrating these preventive safety functions, VDIM ensures excellent driving stability and maneuverability of the vehicle.
- VDIM coordinates EPS and the brake control systems to perform braking control on split friction roads, rear wheel skid control and front wheel skid control.
- If the vehicle loses stability due to wheel slippage, this function effects brake control by applying brake pressure to the wheels. At the same time, the EPS provides steering torque assist control to facilitate the driver's steering maneuver.



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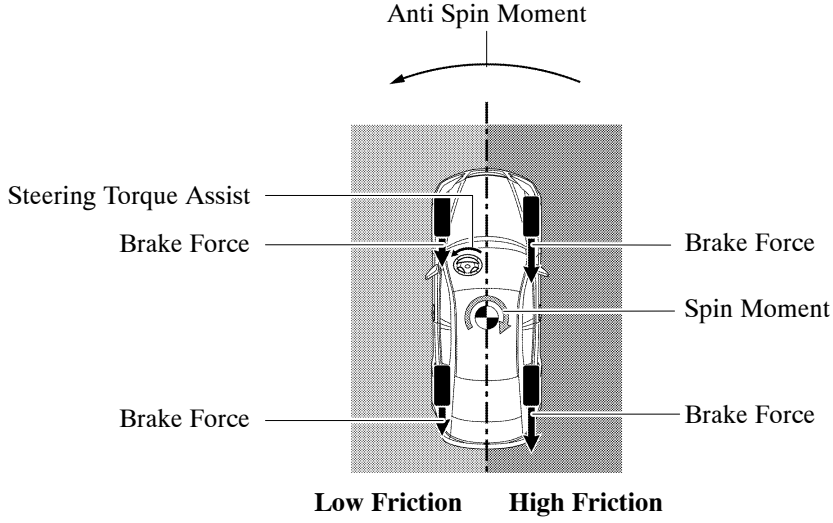
Braking Control on Split Friction Roads

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. For VDIM, the power steering ECU assembly receives command signals from the skid control ECU assembly. Based on these signals, the power steering ECU assembly 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 operate the steering wheel to make steering corrections easily.



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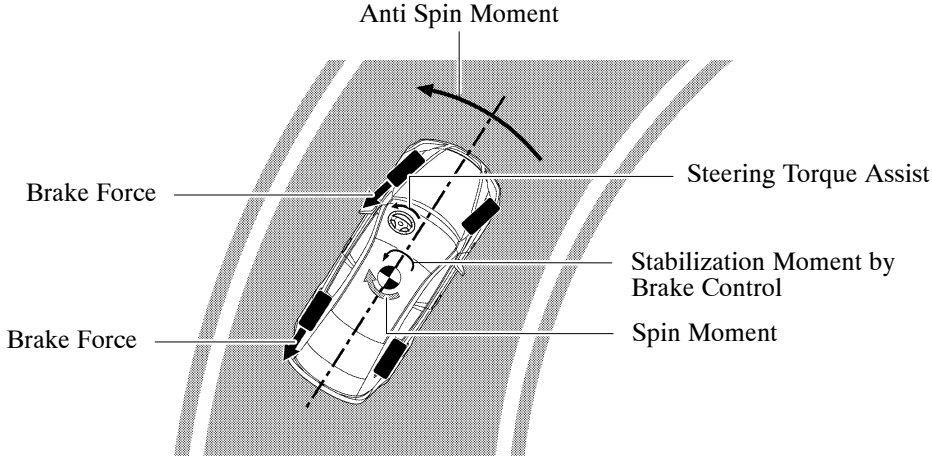
Rear Wheel Skid Control

- 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.
- For VDIM, the power steering ECU assembly receives command signals from the skid control ECU assembly. Based on these signals, the power steering ECU assembly 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 easily.



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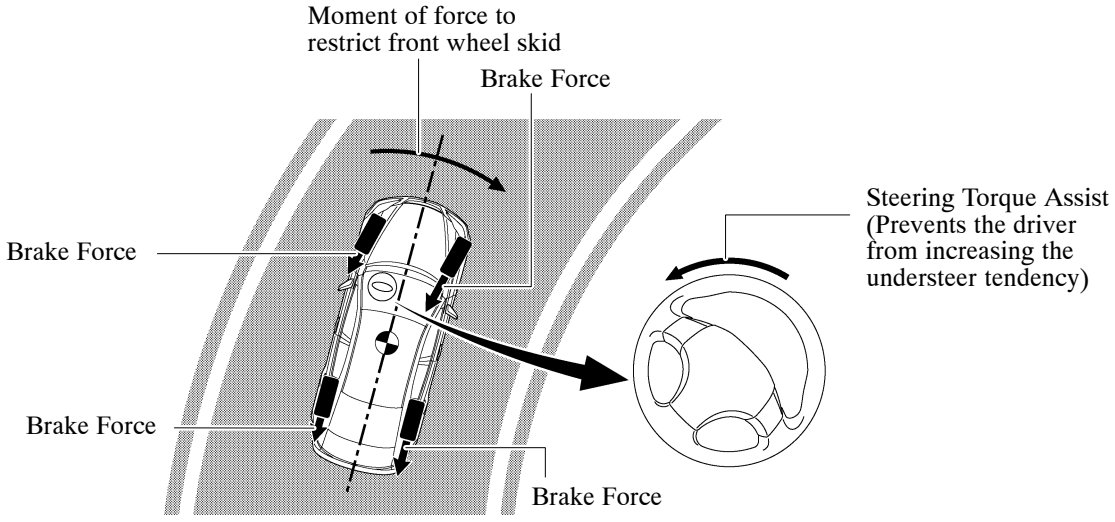
Front Wheel Skid Control

- 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, the steering torque will be light as a signal to the driver.
- For VDIM, if the driver turns the steering wheel excessively, the power steering ECU assembly will receive command signals from the skid control ECU assembly. Based on these signals, the power steering ECU assembly will operate to reduce the steering assist. This prevents the driver from increasing the understeer tendency.

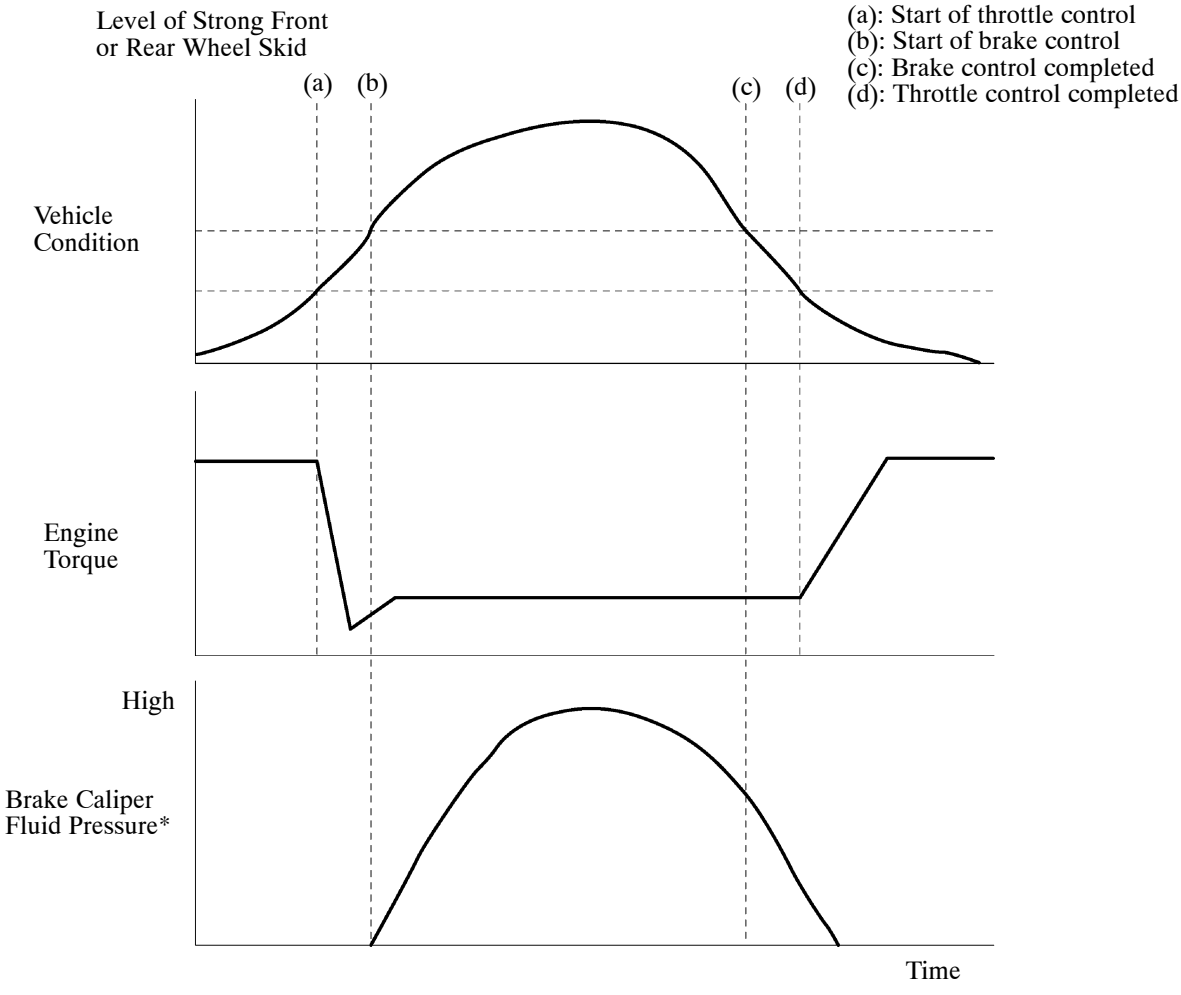


4. Outline of Automatic Transmission Cooperative Control

To start off or accelerate on a slippery road surface, the skid control ECU assembly transmits a signal to the ECM to shift up earlier than normal, and controls the engine output. This suppresses the slippage of the drive wheels when starting off or accelerating, in order to stabilize the behavior of the vehicle.

5. Outline of Engine Output Cooperative Control

During a brake control operation (TRC or VSC function), the skid control ECU assembly outputs an engine output control request signal to the ECM. Upon receiving this signal, the ECM performs throttle control to regulate the engine output.



151CH31

*: The caliper that activates varies depending on the driving conditions experienced by the vehicle.

6. Outline of EBD Control

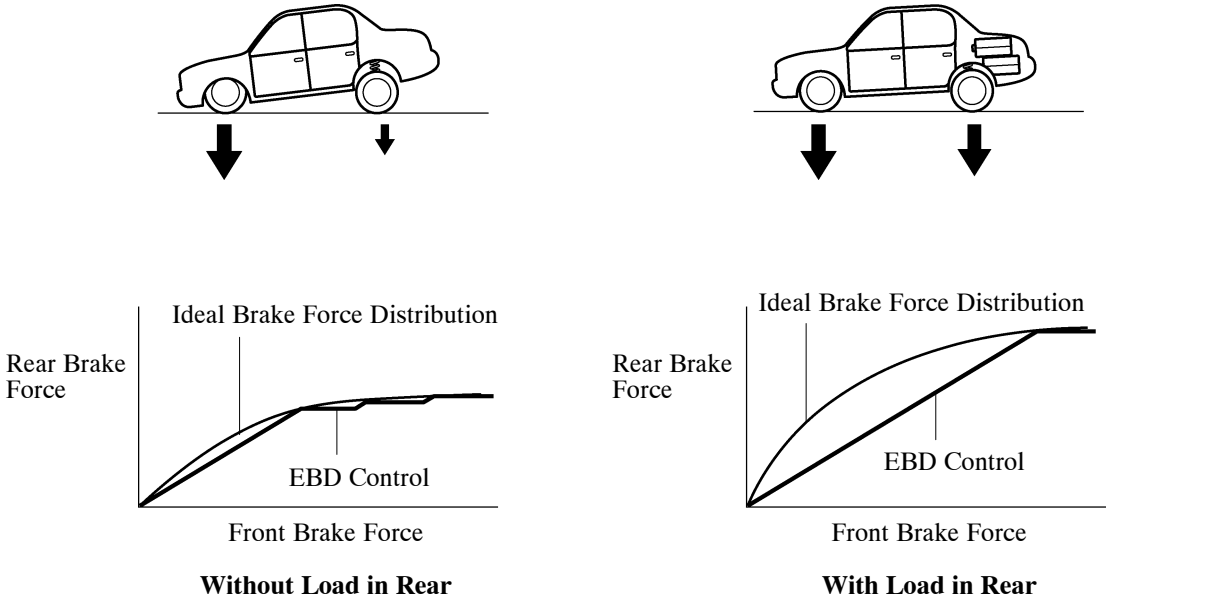
General

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

Front/Rear Wheel Brake Force Distribution

If the brakes are applied while the vehicle is moving straight forward, the transfer of load due to braking reduces the load that is applied to the rear wheels. The skid control ECU assembly determines this condition by way of the signals from the speed sensor, and the brake actuator regulates the distribution of the brake force of the rear wheels to optimally control brake balance.
For example, the amount of the brake force that can be applied to the rear wheels during braking varies depending on whether 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 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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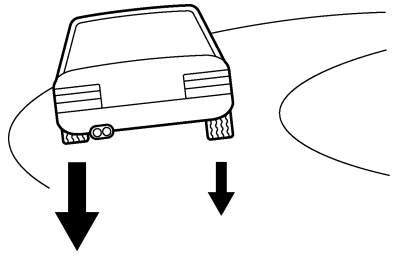
Right/Left Wheel Brake Force Distribution (During Cornering Braking)

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



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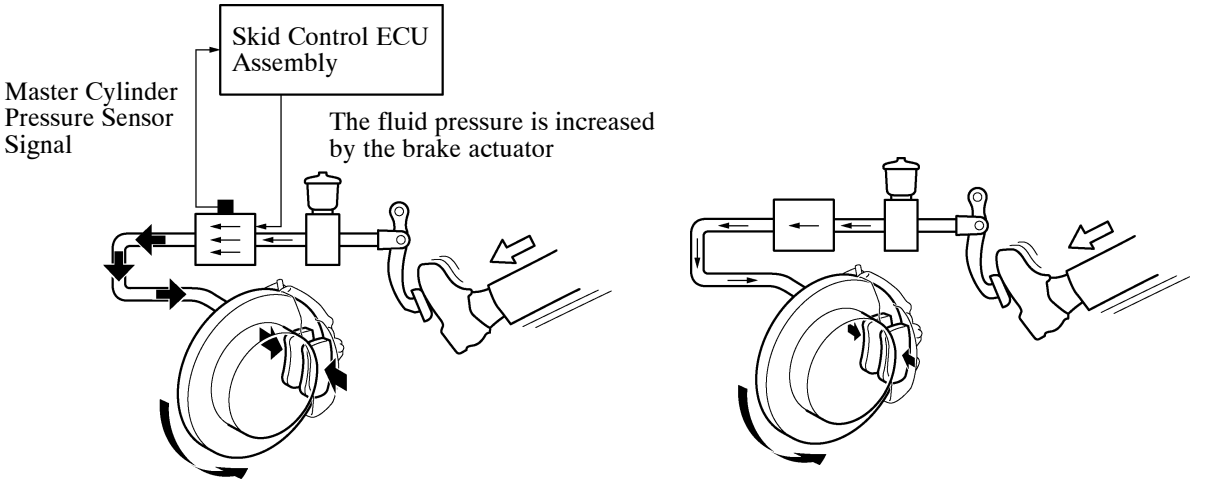
7. Outline of Brake Assist

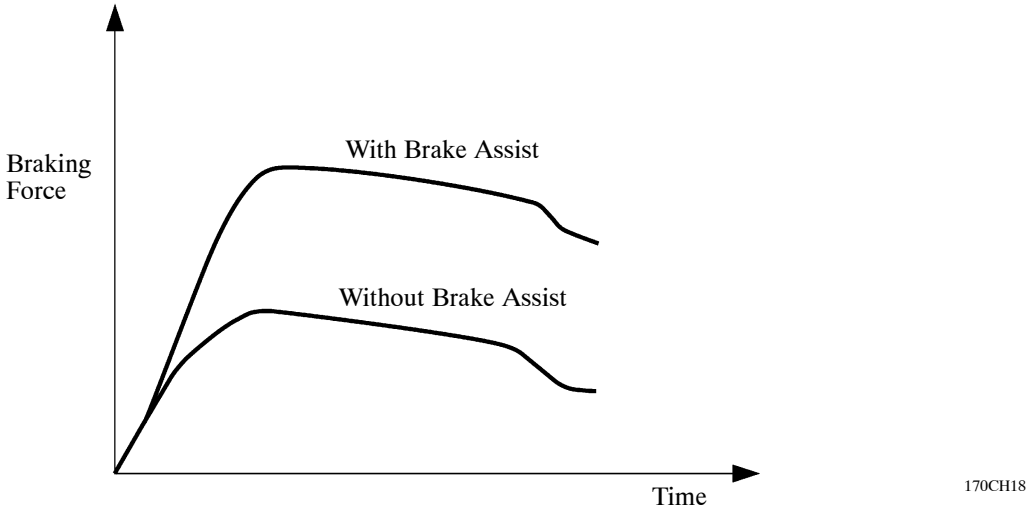
- Brake Assist, in combination with ABS, helps improve the vehicle's brake performance.
- Brake Assist interprets a quick push of the brake pedal as emergency braking and supplements the brake power applied if the driver has not stepped hard enough on the brake pedal. In emergencies, drivers, especially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

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



With Brake Assist 08D0CH36C **Without Brake Assist*** 08D0CH37C

*: The fundamental ability of the brakes is the same as models

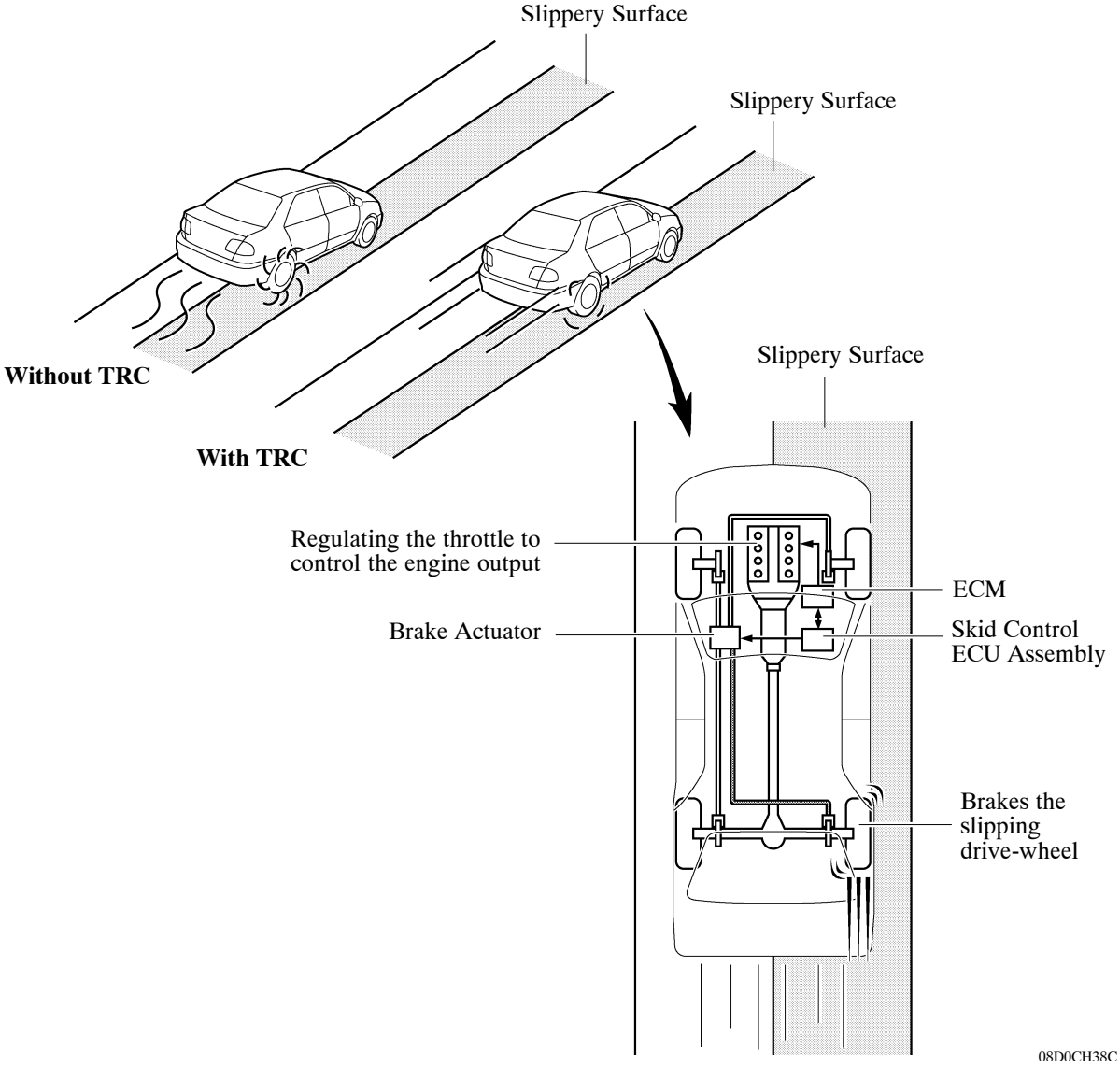


170CH18

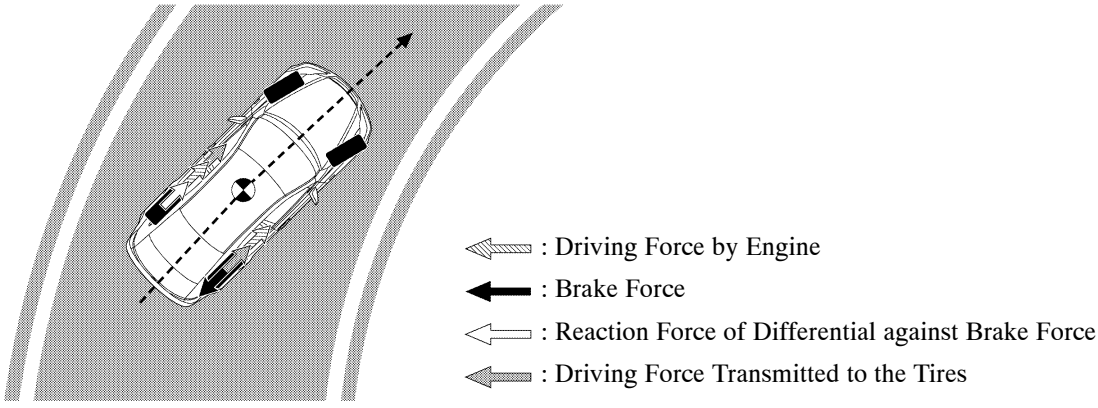
8. Outline of TRC

- If the driver presses the accelerator pedal aggressively when initially accelerating 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 TRC 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, the drive wheel on the slippery surface could slip as illustrated. As a result, the vehicle can not start accelerating smoothly.
  However, when the vehicle is equipped with TRC, the skid control ECU assembly instantly determines the state of the vehicle and operates the brake actuator in order to apply the brakes to the slipping drive wheel. Furthermore, the ECM receives the signals from the skid control ECU assembly and regulates the throttle in order to control the engine output. Thus, TRC can constantly help the driver to maintain stability while accelerating.

▶ Driving condition on road with different surface friction characteristics ◀



- When the vehicle accelerates around a turn, the load shifts to the outside of the turn. This hinders the transfer of the drive force from the inner wheel to the road surface, allowing the inside wheel to spin.
- Upon detecting a turning condition and wheelspin, the LSD function applies the brake to the inner drive wheel. This suppresses the spinning, transfers drive force to the outer wheel, and thus realizes the intended acceleration of the driver.
- When the engine output is restricted on muddy roads and in deep snow, etc. and a drop occurs in escape performance, engine output control can be stopped by pressing the VSC OFF switch, and departure performance can be ensured.



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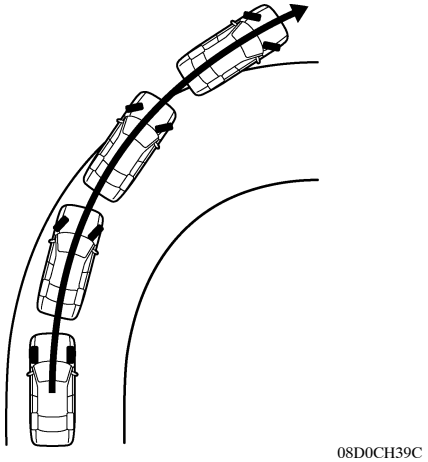
9. Outline of VSC

General

The followings 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).



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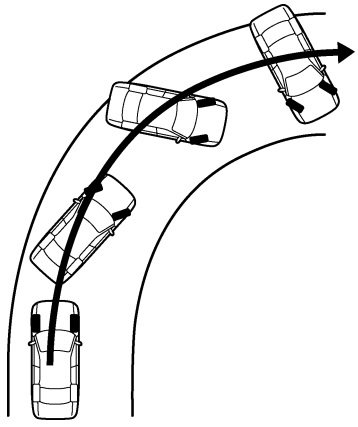
Front Wheel Skid Tendency



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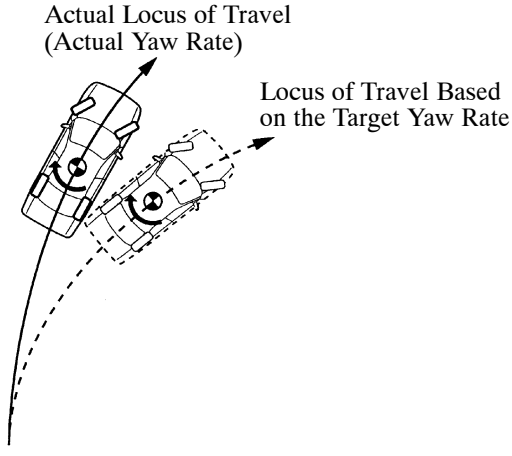
Rear Wheel Skid Tendency

Method for Determining the Vehicle Condition

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

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 that is determined by the vehicle speed and steering angle) that should be rightfully generated when the driver operates the steering wheel, it means the vehicle is making a turn at a greater angle than the target locus of travel.
Thus, the skid control ECU assembly determines that there is a large front wheel skid tendency.



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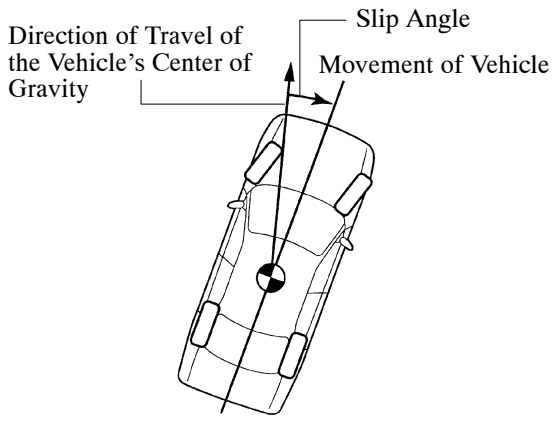
2) Determining a Rear Wheel Skid

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 assembly determines that the vehicle has a large rear wheel skid tendency.



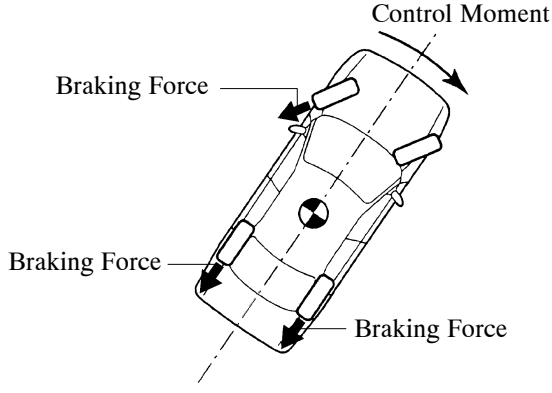
08D0CH42C

Method for VSC Operation

When the skid control ECU assembly determines that the vehicle exhibits a tendency to front wheel skid or rear wheel skid, it decreases the engine output and applies the brake to a front or rear wheel to control the vehicle's yaw moment.
The basic operation of the VSC is described below. However, the control method may differ depending on the vehicle's characteristics and driving conditions.

1) Dampening a Strong Front Wheel Skid

When the skid control ECU assembly determines that there is a large front wheel skid tendency, it attempts to counteract the tendency based on the extent of that tendency. The skid control ECU assembly controls the engine power output and applies the brakes of the front wheel of the outer circle in the turn and rear wheels in order to restrain the front wheel skid tendency.



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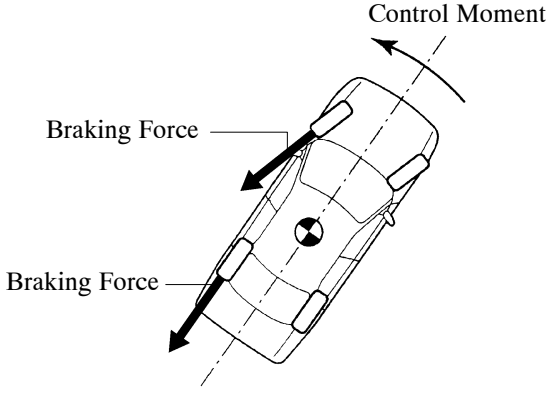
Making a Right Turn

2) Dampening a Strong Rear Wheel Skid

When the skid control ECU assembly determines that there is a large rear wheel skid tendency, it attempts to counteract the tendency based on the extent of that tendency. It applies the brakes of the front and rear wheels 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 assembly applies the brake of the rear wheels, as necessary.



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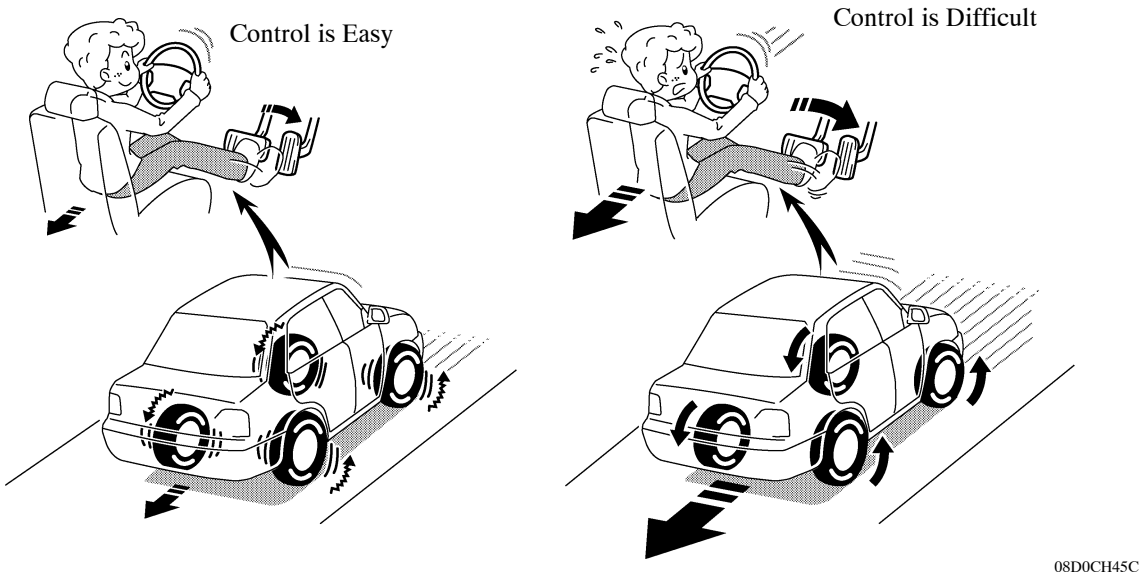
Making a Right Turn

10. 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 (approximately 5 seconds at the maximum) 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

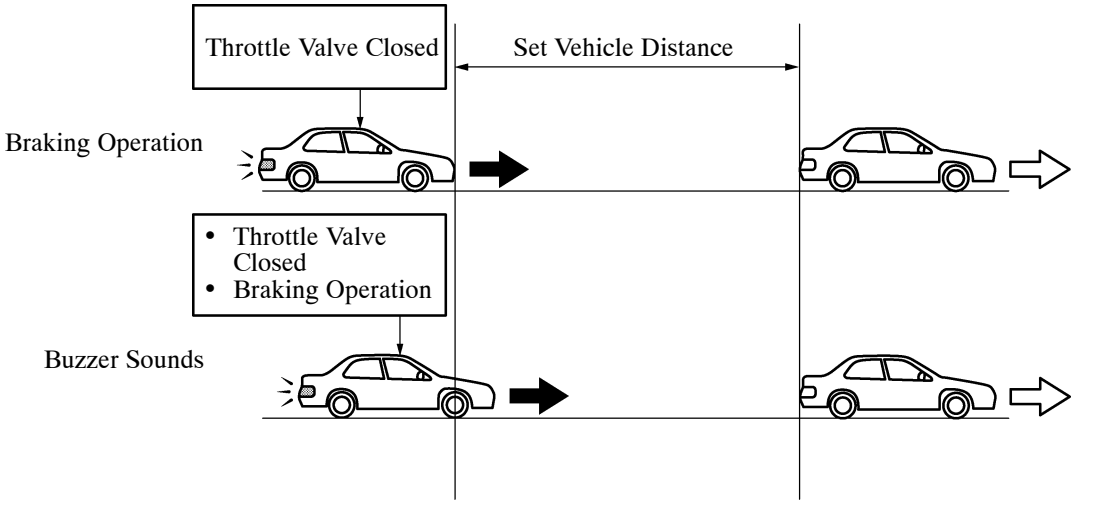
- Hill-start Assist Control operates when all of the following conditions have been met:

Hill-start Assist Control Operate Condition	• Shift lever position is D or M position. • The brake pedal is not pressed. • The skid control ECU assembly has detected the backward movement of the vehicle when the driver is starting off on a hill.

CH

11. Outline of Brake Control (Models with Dynamic Radar Cruise Control System)

During dynamic radar cruise control system operation, if the distance to the vehicle being driven ahead is reduced, and if a sufficient deceleration cannot be attained by fully closing the throttle valve, the skid control ECU assembly activates the brake actuator to apply the brakes according to the distance control ECU assembly's request. As a result, the stoplights illuminate.
If further deceleration is required, the system sounds a skid control buzzer assembly to alert the driver, so that the driver will apply the brakes.



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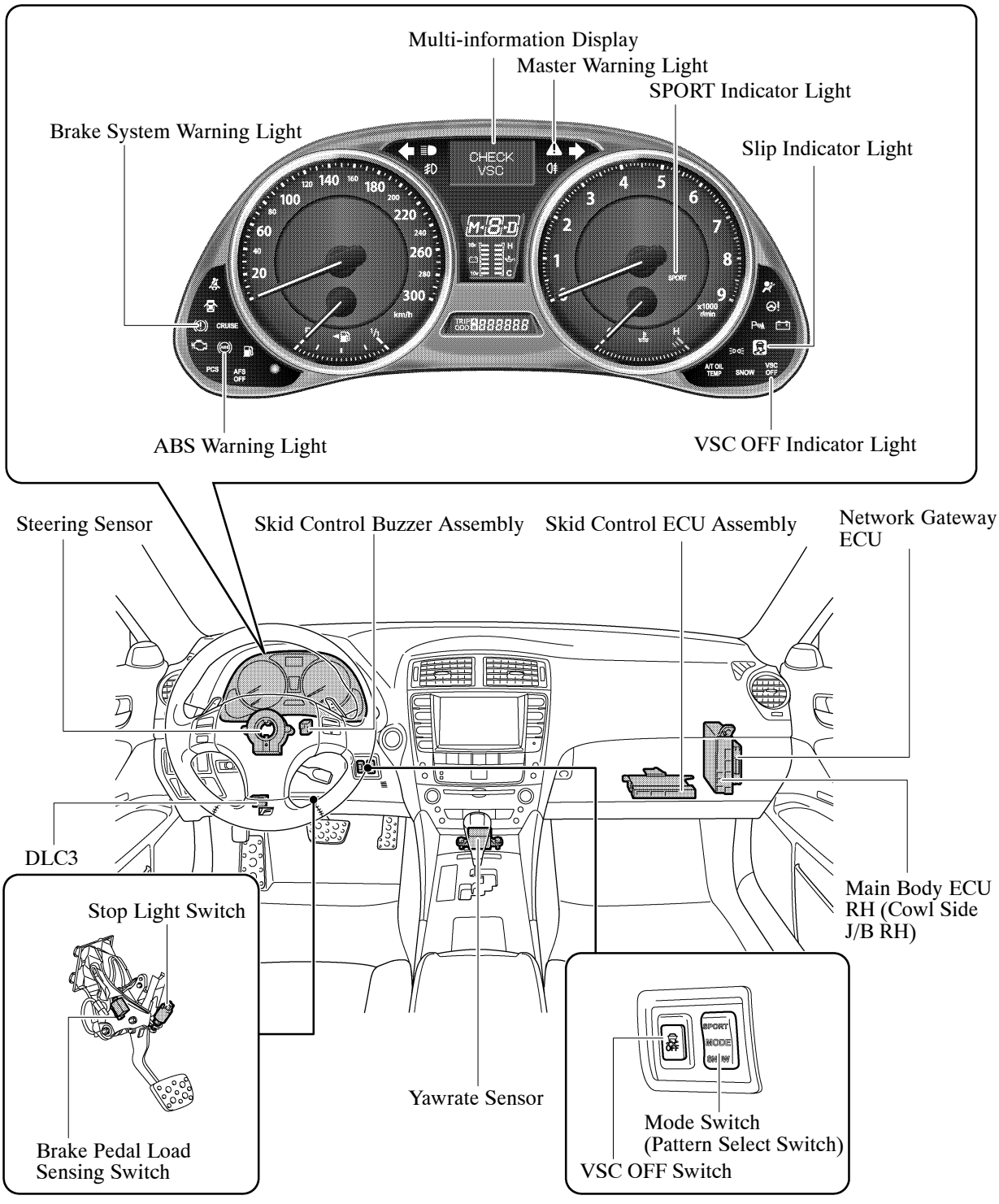
12. Layout of Main Components

Combination Meter Assembly



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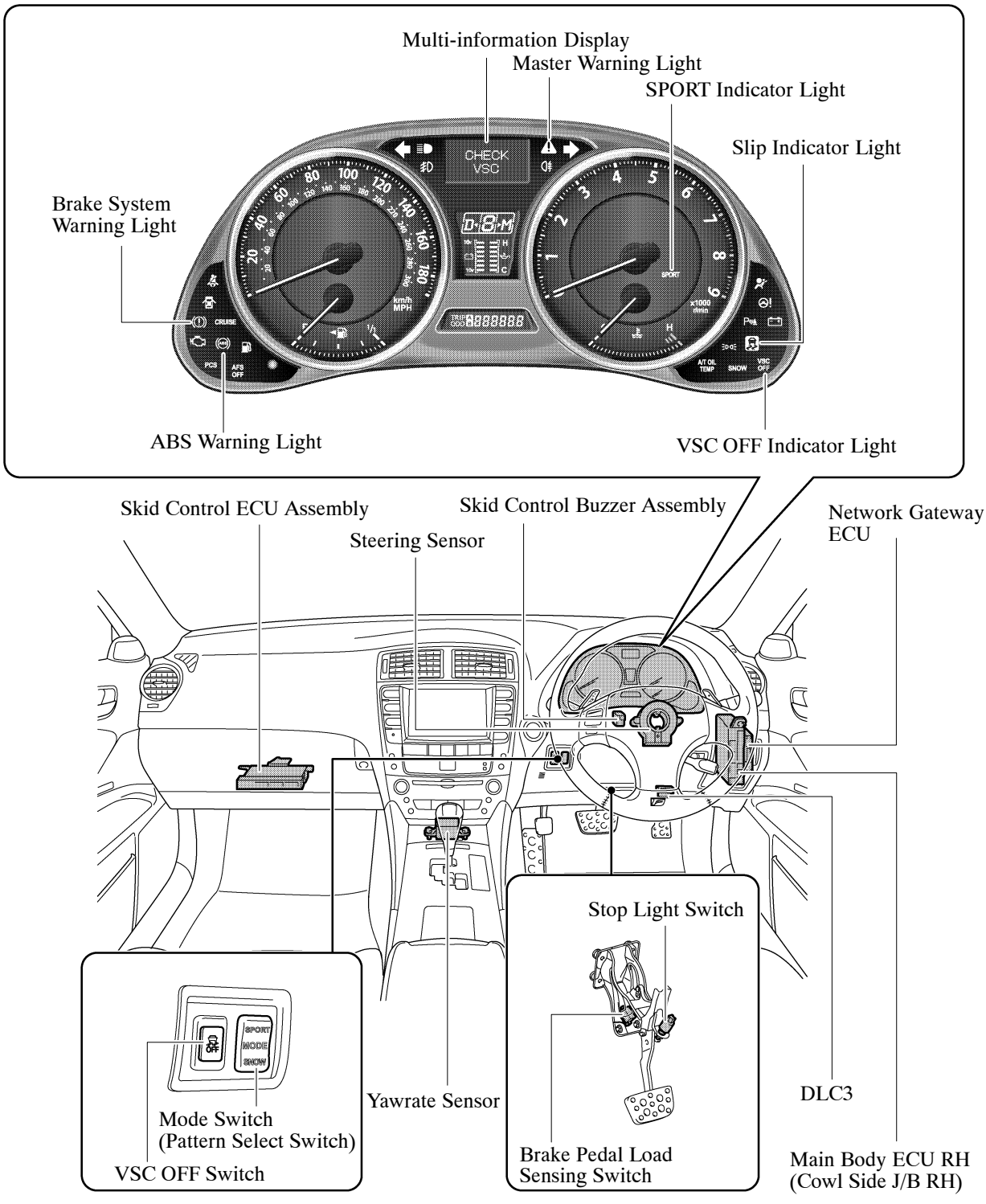
LHD Models

CH

Combination Meter Assembly



RHD Models

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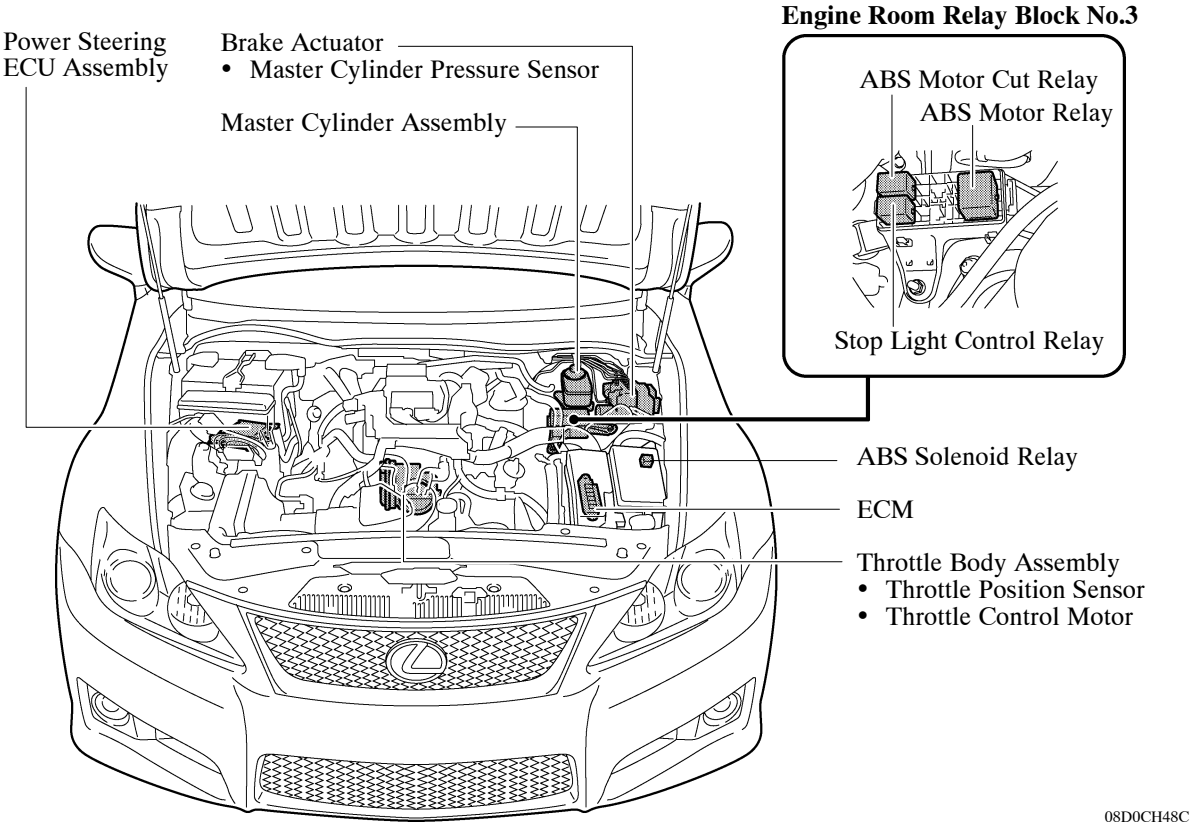
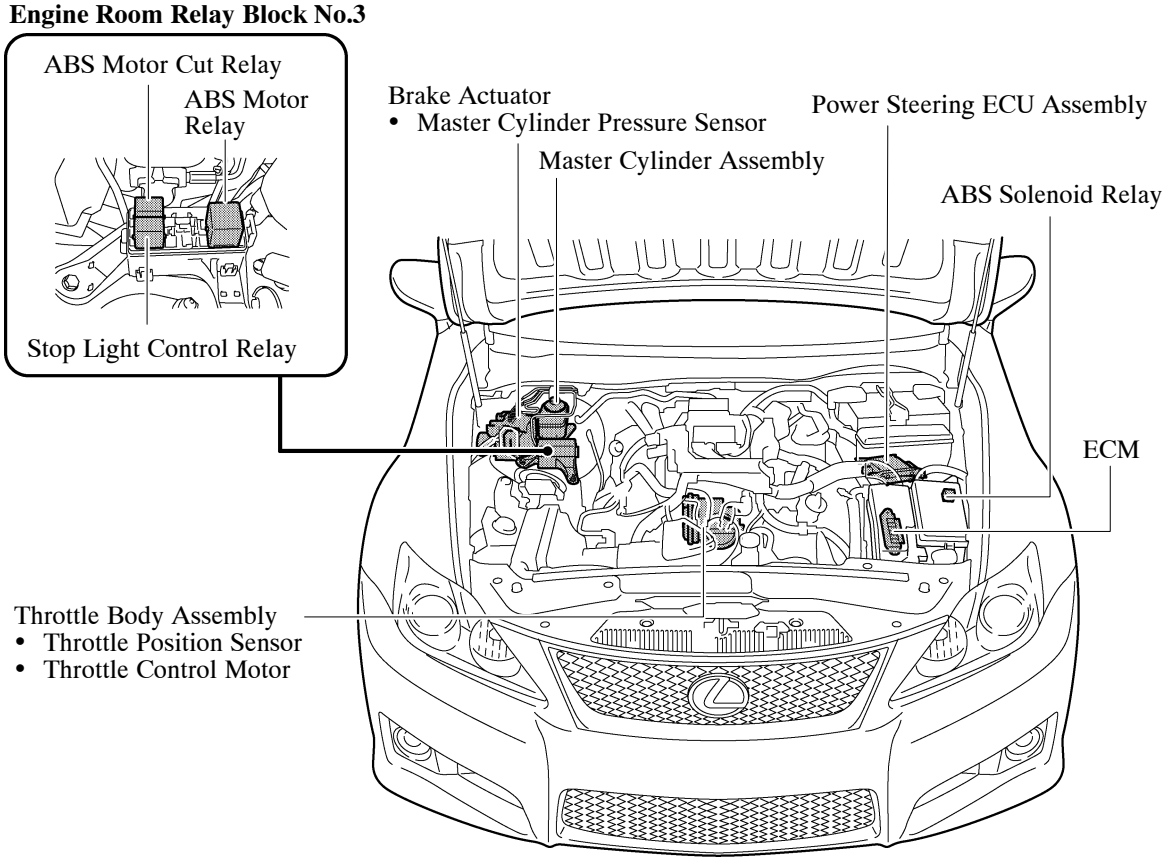
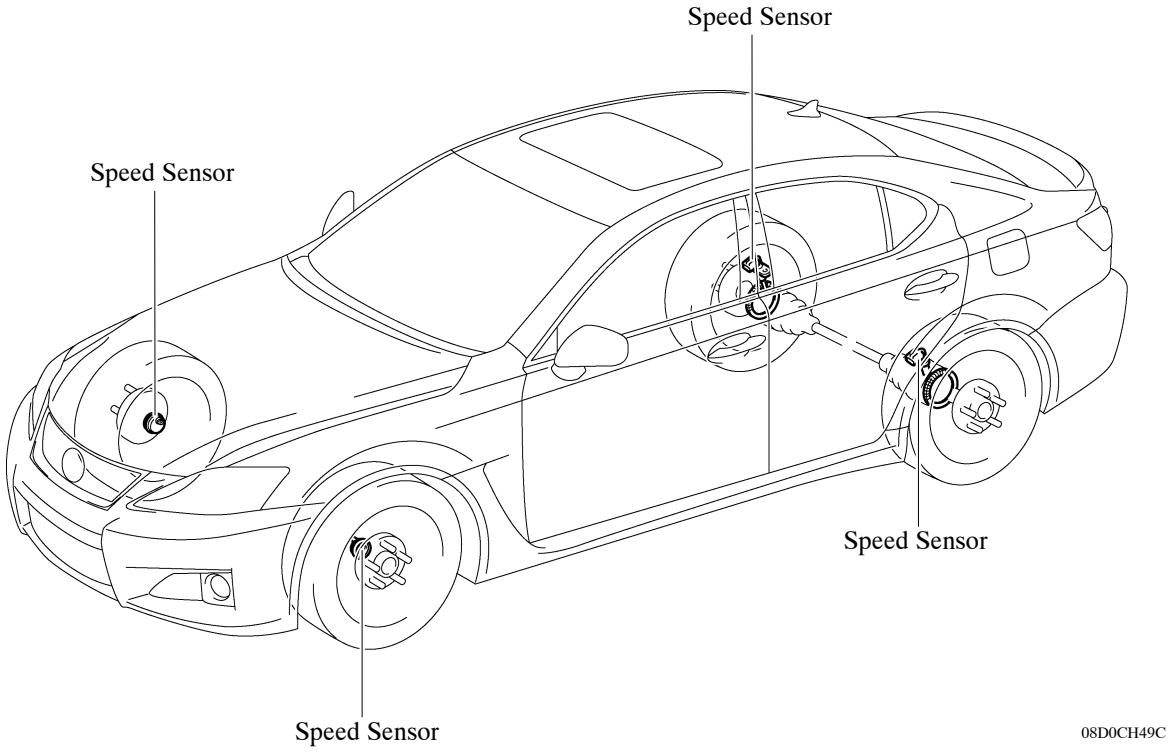


LHD Models



RHD Models

CH


Speed Sensor
Speed Sensor
Speed Sensor
Speed Sensor
08D0CH49C

13. Function of Main Components

Component		Function
Combination Meter Assembly	ABS Warning Light	Lights up to alert the driver when the skid control ECU assembly detects a malfunction in the ABS, EBD or Brake Assist system.
	Slip Indicator Light	• Blinks to inform the driver when the TRC system, VSC system or the Hill-start Assist Control system is operated. • Light up to inform the driver when the TRC system is turned off using the VSC OFF switch.
	Brake System Warning Light	• Lights up together with the ABS warning light to alert the driver when the skid control ECU assembly detects a malfunction in the EBD control or when a malfunction occurs in the brake booster. • Lights up to alert the driver when the brake fluid level is low. • Lights up to alert the driver when the parking brake pedal is depressed.
	Master Warning Light	Illuminates to alert the driver when the skid control ECU assembly detects a malfunction in the TRC or VSC system.
	VSC OFF Indicator Light	Lights up to inform the driver when the VSC is turned off using the VSC OFF switch.
	SPORT Indicator Light	Lights up to inform the driver when SPORT mode is turned on using the mode switch (pattern select switch).
	Multi-information Display	Displays a warning message “CHECK VSC” to alert the driver when the skid control ECU assembly detects a malfunction in the TRC or VSC system.
Speed Sensors (4)		Detects the wheel speed of all 4 wheels.
Yawrate Sensor		• Detects the vehicle’s yaw rate. • Detects the vehicle’s longitudinal and lateral acceleration.
Steering Sensor		Detects the steering direction and angle of the steering wheel.
ABS Solenoid Relay		Supplies power to the solenoid valves.
ABS Motor Relay		Supplies power to the pump motor in the brake actuator.
ABS Motor Cut Relay		Cuts the power to the pump motor in the brake actuator.
Stop Light Control Relay		Turn on the stop light during Hill-start Assist Control or dynamic radar cruise control system operation.
Skid Control Buzzer Assembly		Emits an intermittent sound to inform the driver that the skid control ECU assembly detects a strong front skid tendency or a strong rear skid tendency.
Millimeter Wave Radar Sensor Assembly*		Emits millimeter waves forward, and uses the reflected millimeter waves to measure the distance and the direction of the object in front, as well as to calculate the relative speed.
Brake Actuator		Changes the fluid path based on the signals from the skid control ECU assembly during the operation of the ABS with EBD, Brake Assist, TRC, VSC & Hill-start Assist Control system, in order to control the fluid pressure that is applied to the brakes for the different wheels.
	Master Cylinder Pressure Sensor	Assembled in the brake actuator and detects the master cylinder pressure.

*: Models with Dynamic Radar Cruise Control

(Continued)

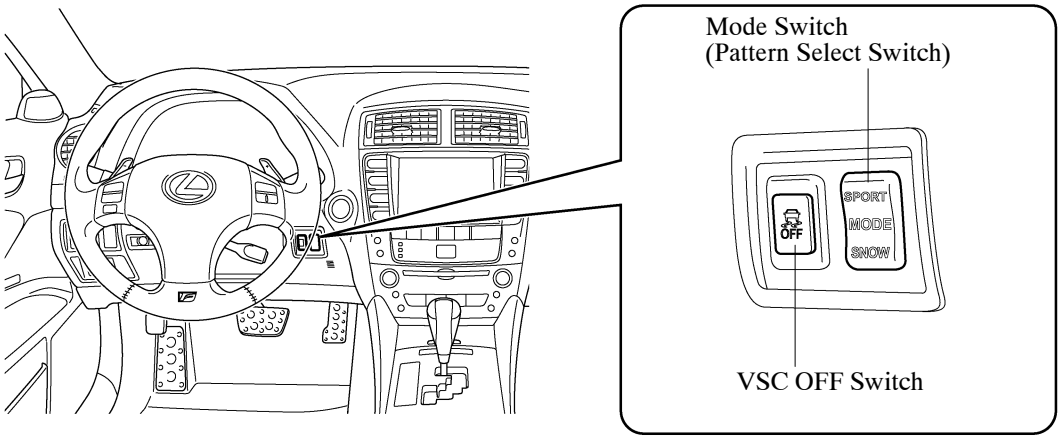
Component	Function
Skid Control ECU Assembly	• Judges the vehicle operating conditions based on signals from different sensors, and sends brake control signals to the brake actuator. • Judges the vehicle operating conditions based on signals from different sensors, and calculates the amount of steering torque assist required. The skid control ECU assembly transmits command signals to the power steering ECU assembly. • Judges the vehicle operating conditions based on signals from different sensors, and calculates the amount of engine output adjustment required. The skid control ECU assembly transmits command signals to the ECM.
Brake Pedal Load Sensing Switch	Detects the brake pedal depressing force.
Mode Switch (Pattern Select Switch)	Allows the VDIM control mode to be switched between two modes (SPORT mode and NORMAL mode).
VSC OFF Switch	Cancels TRC or VSC operation only: it does not apply to other systems.
Parking Brake Switch	Detects parking brake pedal application.
Stop Light Switch	Detects brake pedal application.
Park/Neutral Position Switch Assembly	Detects the “D” position.
ECM	• Sends the throttle valve angle signal, accelerator pedal position signal, engine speed signal, and intake air temperature signal to the skid control ECU assembly. • Receives an engine output adjustment command signal from the skid control ECU assembly. Based on this signal, the ECM operates the throttle valve to control engine output.
Power Steering ECU Assembly	Receives a steering torque assist command signal from the skid control ECU assembly during steering coordination control. Based on this signal, the power steering ECU assembly operates the motor for electric power steering to provide a level of steering assist that will allow the driver to operate the steering so as to stabilize the vehicle.
Headlight Swivel ECU (AFS ECU)	Receives front speed sensor signals that are output from the skid control ECU assembly.
Distance Control ECU Assembly*	Transmits a signal to the skid control ECU assembly via the ECM, in order to activate brake control when the ECU has determined that the distance to the vehicle being driven ahead has been shortened based on signals from the millimeter wave radar sensor assembly.

*: Models with Dynamic Radar Cruise Control

14. Construction and Operation of Main Components

Mode Switch (Pattern Select Switch) and VSC OFF Switch

- Pushing the VSC OFF switch once turns TRC off and pushing and holding it for 3 seconds or more turns VSC off. Push the VSC OFF switch again to turn the system back on.
- The mode switch (pattern select switch) allows the VDIM control mode to be switched between two modes (SPORT mode and NORMAL mode).



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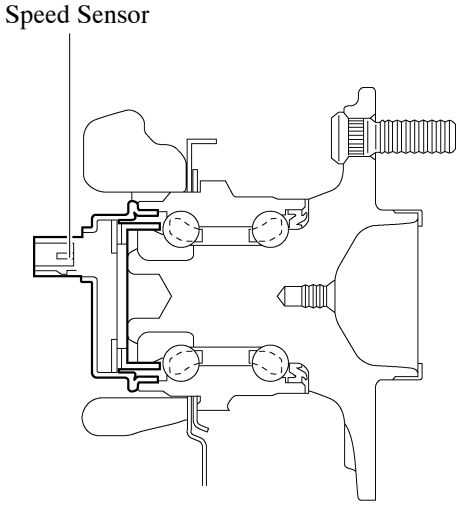
- These switches affect the brake controls and warnings as shown below.

Switch	Mode	Brake Control					Warning	
		ABS with EBD	Brake Assist	TRC	VSC	Steering Cooperative Control	Slip Indicator Light	Skid Control Warning Buzzer Assembly
Mode Switch	SPORT	On	On	On*1	On*1	On	Blinks	Does not Sound
	NORMAL	On	On	On	On	On	Blinks	Sounds
	SNOW	On	On	On	On	On	Blinks	Sounds
VSC OFF Switch	TRC OFF	On	On	Off*2, *3	On/On*1	On	Blinks	Sounds
	VSC OFF	On	On	Off*3	Off	–	Turns on*4	Does not Sound

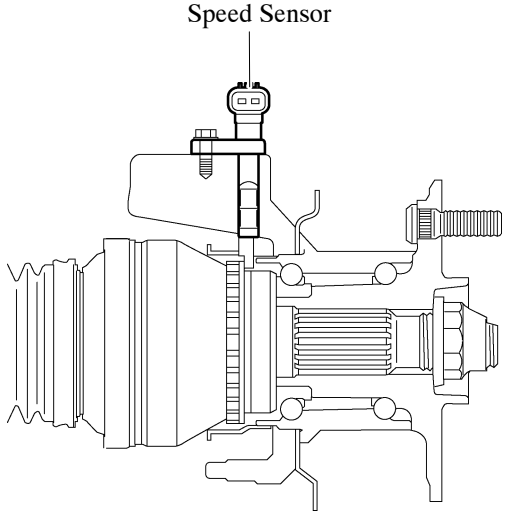
*1: Activated (SPORT Mode)
*2: Automatically re-activated when the vehicle speed reaches 50 km/h (31 mph)
*3: Only the LSD function remains on
*4: Blinks when LSD is functioning

Speed Sensor

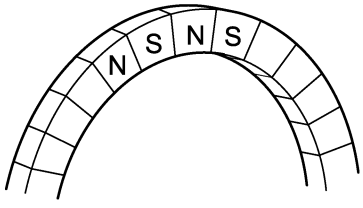
- An active type speed sensor is used. This sensor contains a sensor IC, which consists of two MREs (Magnetic Resistance Elements).
- The sensor rotor, which consists of N and S poles that are arranged in a circle, is integrated with the hub bearing inner race.



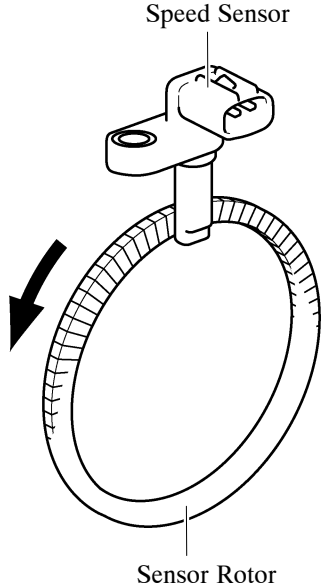
Front Axle 08D0CH51C



Rear Axle 08D0CH52C



Arrangement of N and S Poles



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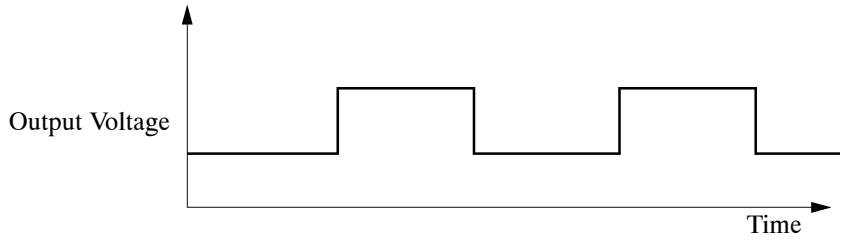
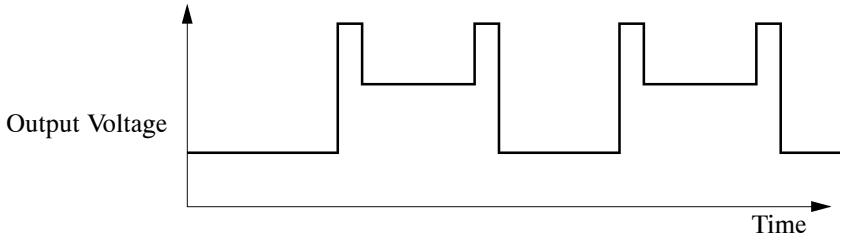
- Along with the rotational movement of the sensor rotor, the N and S poles of the sensor rotor pass alternately near the sensing portion of the speed sensor. This speed sensor outputs magnetic flux as a current value. The skid control ECU assembly detects the changes in the output current to determine the wheel speed.



Forward



Backward

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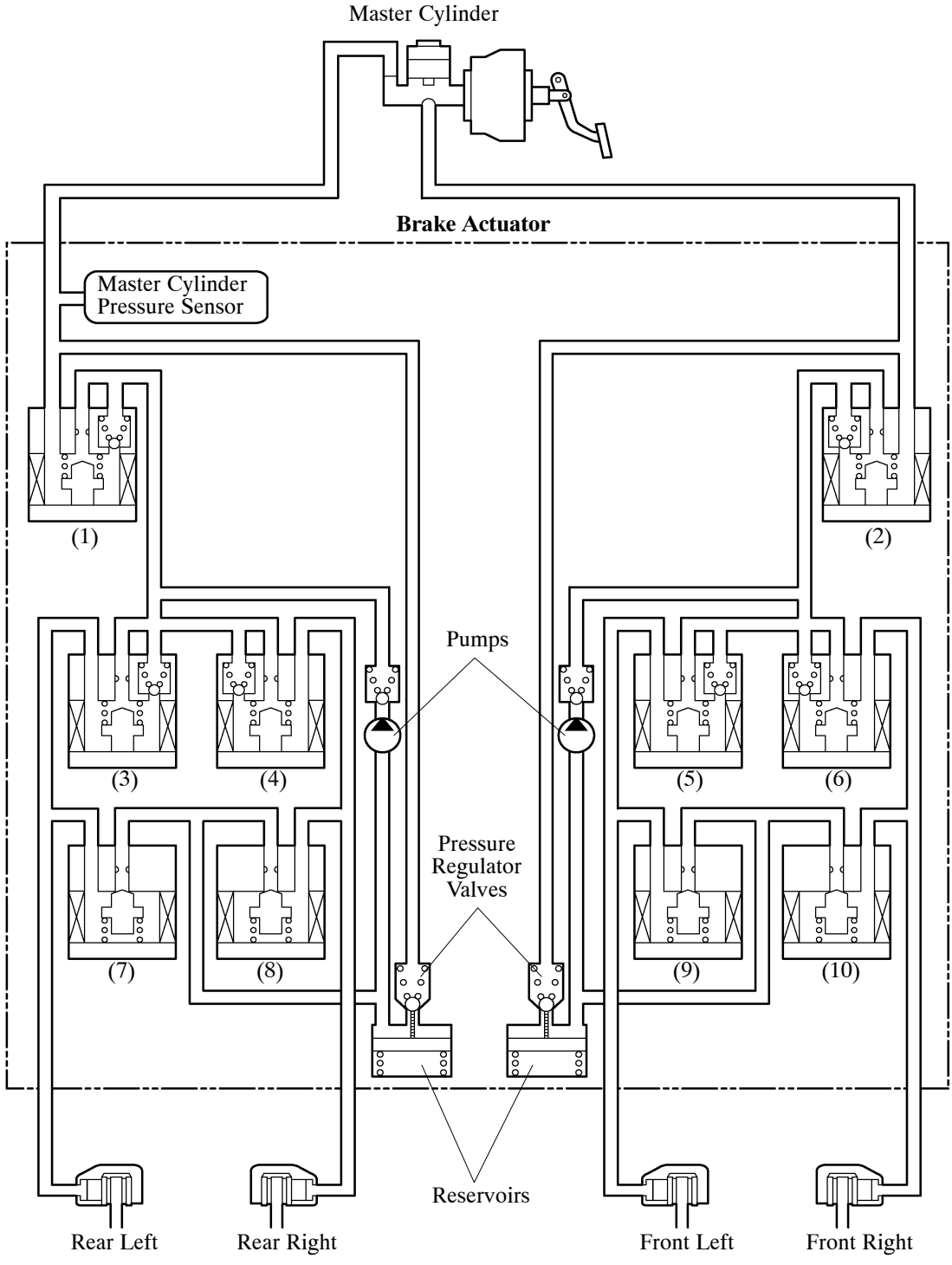
Brake Actuator

The brake actuator consists of the actuator, skid control ECU assembly, pump motor, and master cylinder pressure sensor.

- The actuator portion consists of ten solenoid valves, two pressure regulator valves, two pump, 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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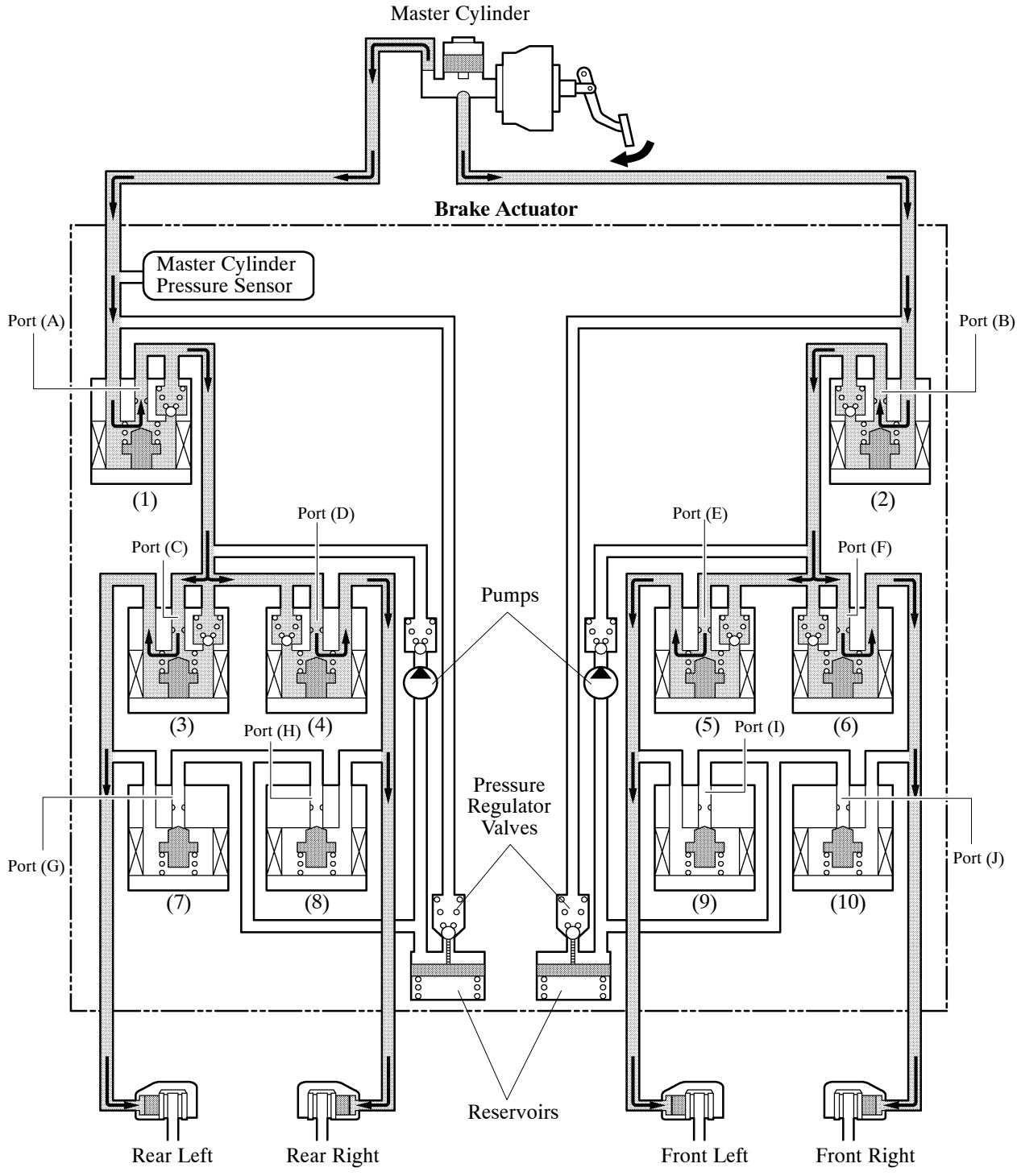
15. System Operation

Normal Braking Operation

During normal braking, all solenoid valves remain OFF.



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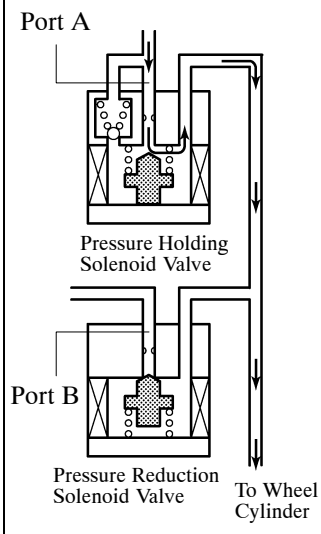
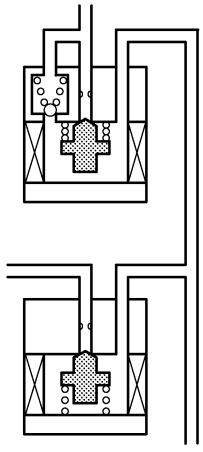
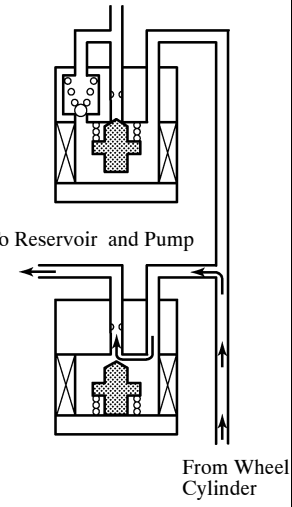
ABS with EBD Operation

Based on the signals received from the four wheel speed sensors and yawrate sensor, the skid control ECU assembly calculates the wheel rotation speed and deceleration for each wheel, in order to check for a wheel slippage condition. According to the slippage condition, the ECU controls the pressure holding solenoid valves and pressure reduction solenoid valves in order to adjust the fluid pressure of the brakes for each of the wheels in the following three modes: pressure reduction, pressure holding, and pressure increase modes.

Not Activated	Normal Braking	—	—
Activated	Pressure Increase Mode	Pressure Holding Mode	Pressure 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
Pressure	Increase	Hold	Reduce

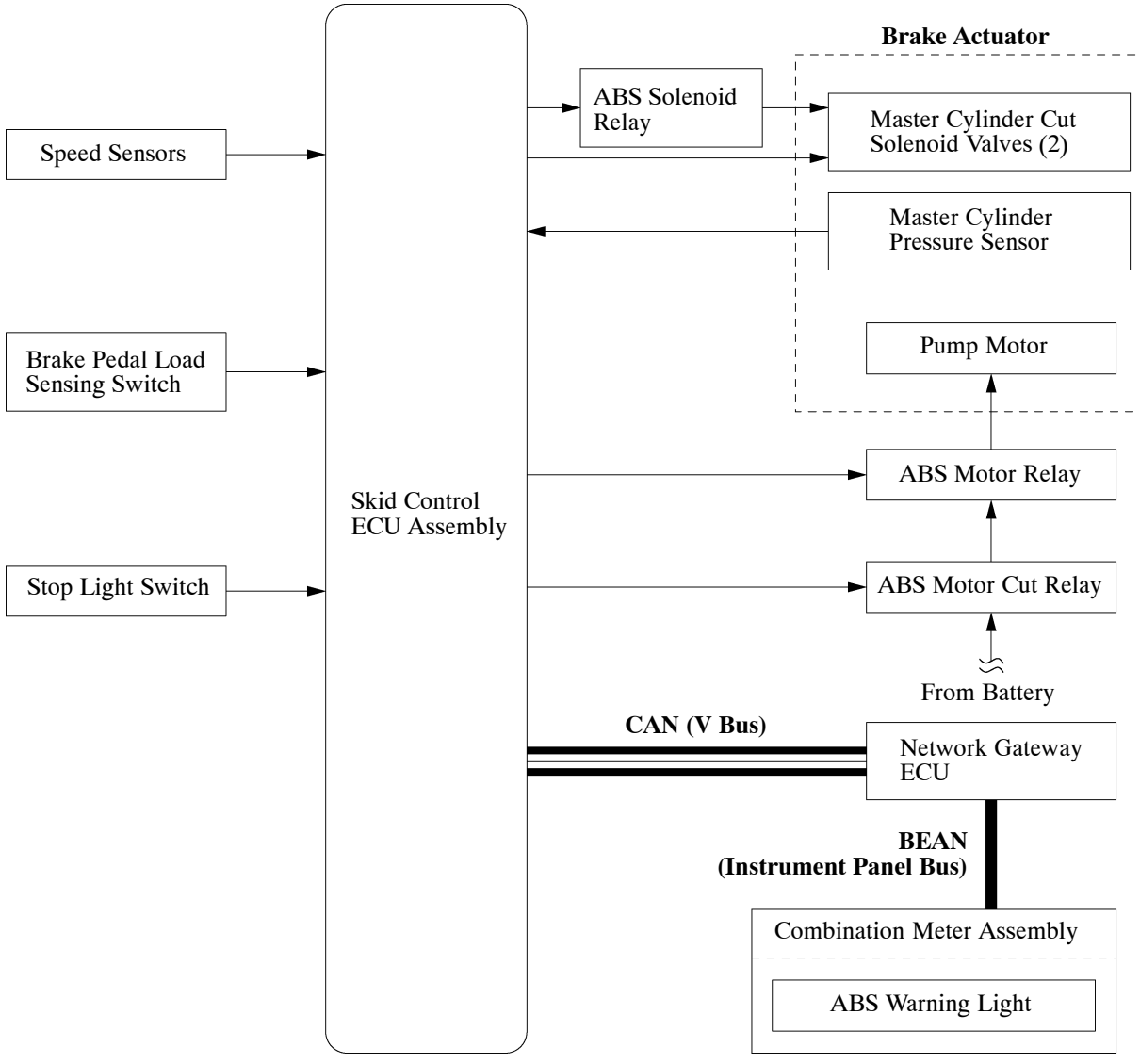
Brake Assist Operation

In the event of emergency braking, the skid control ECU assembly detects the driver's intention based on the speed of the pressure increase in the master cylinder which is based on the master cylinder pressure sensor signals. If the ECU judges the need for additional Brake Assist, pressure is generated by the pump in the brake actuator and directed to the brakes to apply a greater fluid pressure than is present in the master cylinder.

Also, in the following cases, the system provides Brake Assist.

- When greater braking force is needed than normal, such as when the vehicle is fully loaded or driving downhill, etc., the skid control ECU assembly judges the need for Brake Assist using the master cylinder pressure sensor.
- In the event of a brake booster failure, the skid control ECU assembly judges the failure using the brake load sensing switch and master cylinder pressure sensor signals.

▶ System Diagram ◀



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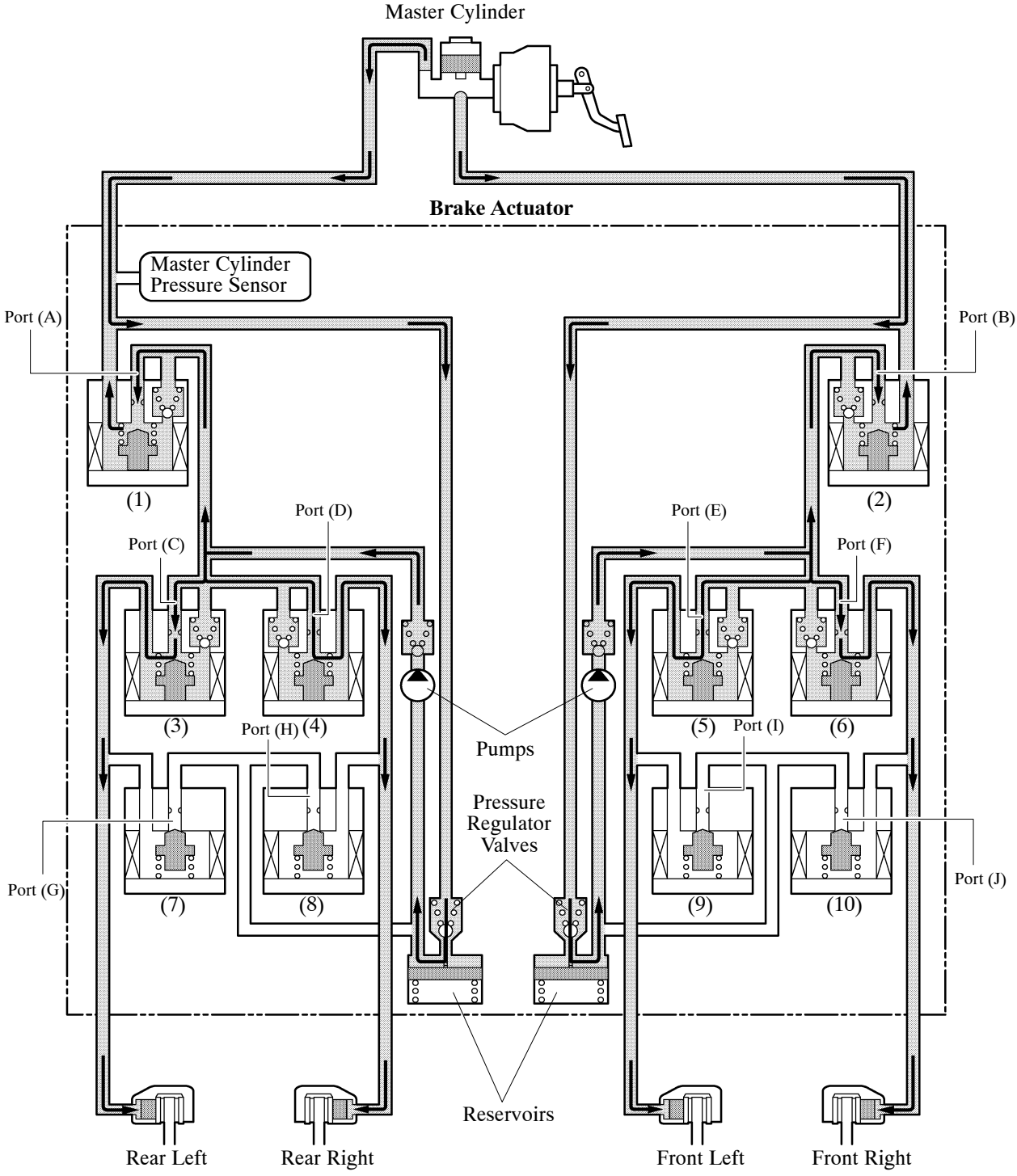

Brake Assist Activated

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

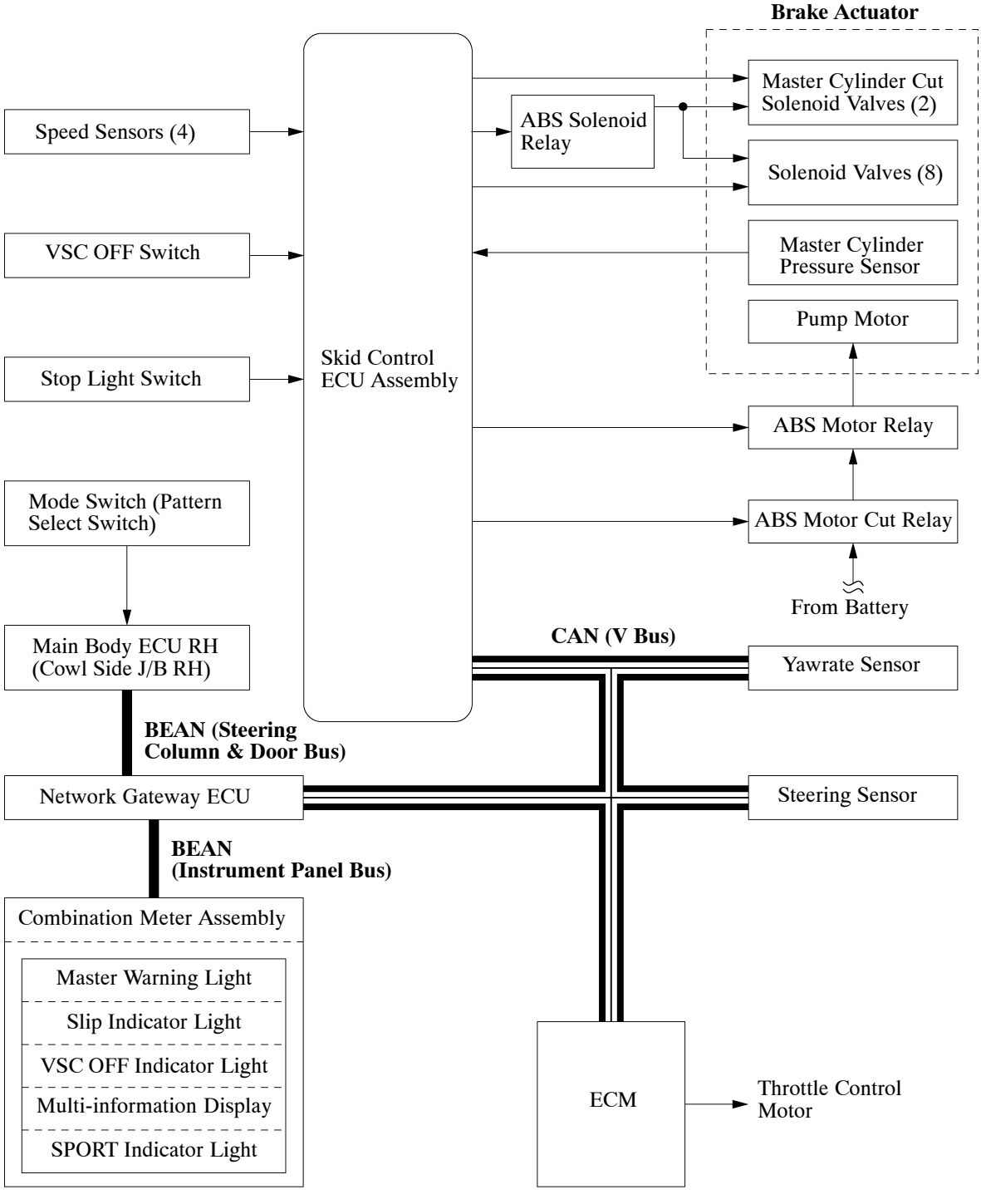
*: The solenoid valves control the hydraulic pressure by cycling continually between “open” and “closed” according to the operating conditions.

TRC Operation

The fluid pressure generated by the pump is regulated by the master cylinder cut solenoid valve to achieve the required pressure. Thus, the brakes for the drive wheels are controlled in the following 3 modes: pressure reduction, pressure holding, and pressure increase modes, to control slippage of the drive wheels.

- The diagram below shows the hydraulic circuit in the pressure increase mode when the TRC system is activated.
- The pressure holding solenoid valve and the pressure reduction solenoid valve are turned ON/OFF according to the ABS operation pattern described on the previous page.

▶ System Diagram ◀



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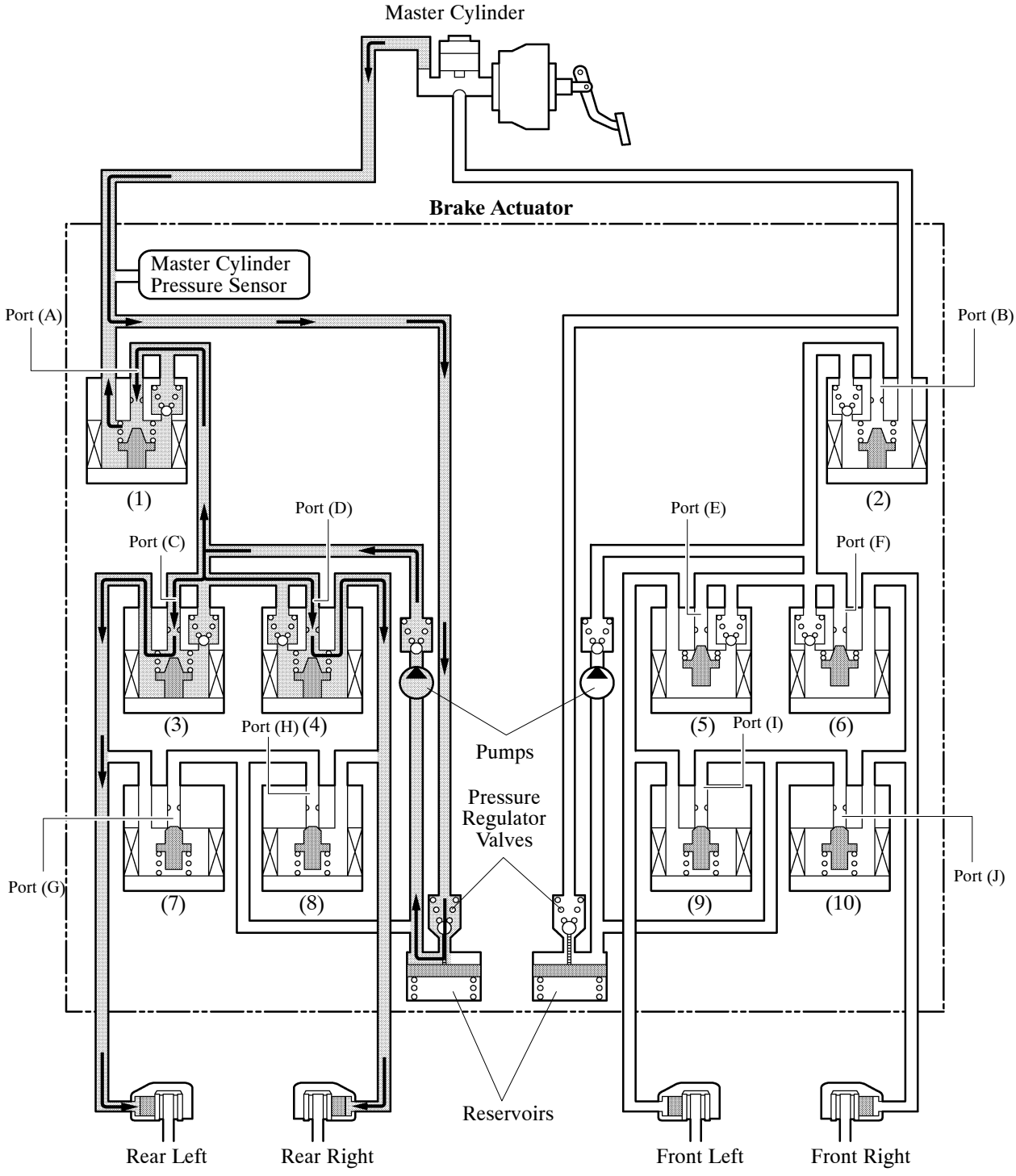

Pressure Increase Mode

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Item			TRC Not Activated	TRC Activated		
				Pressure Increase Mode	Pressure Holding Mode	Pressure Reduction Mode
(1)	Master Cylinder Cut Solenoid Valve Port: (A)		OFF/Open	ON*	←	←
(2)	Master Cylinder Cut Solenoid Valve Port: (B)		OFF/Open	←	←	←
Front Brake	(5), (6)	Pressure Holding Valve Port: (E), (F)	OFF/Open	ON/Closed	←	←
	(9), (10)	Pressure Reduction Valve Port: (I), (J)	OFF/Closed	←	←	←
	Wheel Cylinder Pressure		—	—	—	—
Rear Brake	(3), (4)	Pressure Holding Valve Port: (C), (D)	OFF/Open	←	ON/Closed	←
	(7), (8)	Pressure Reduction Valve Port: (G), (H)	OFF/Closed	←	←	ON/Open
	Wheel Cylinder Pressure		—	Increase	Hold	Reduce

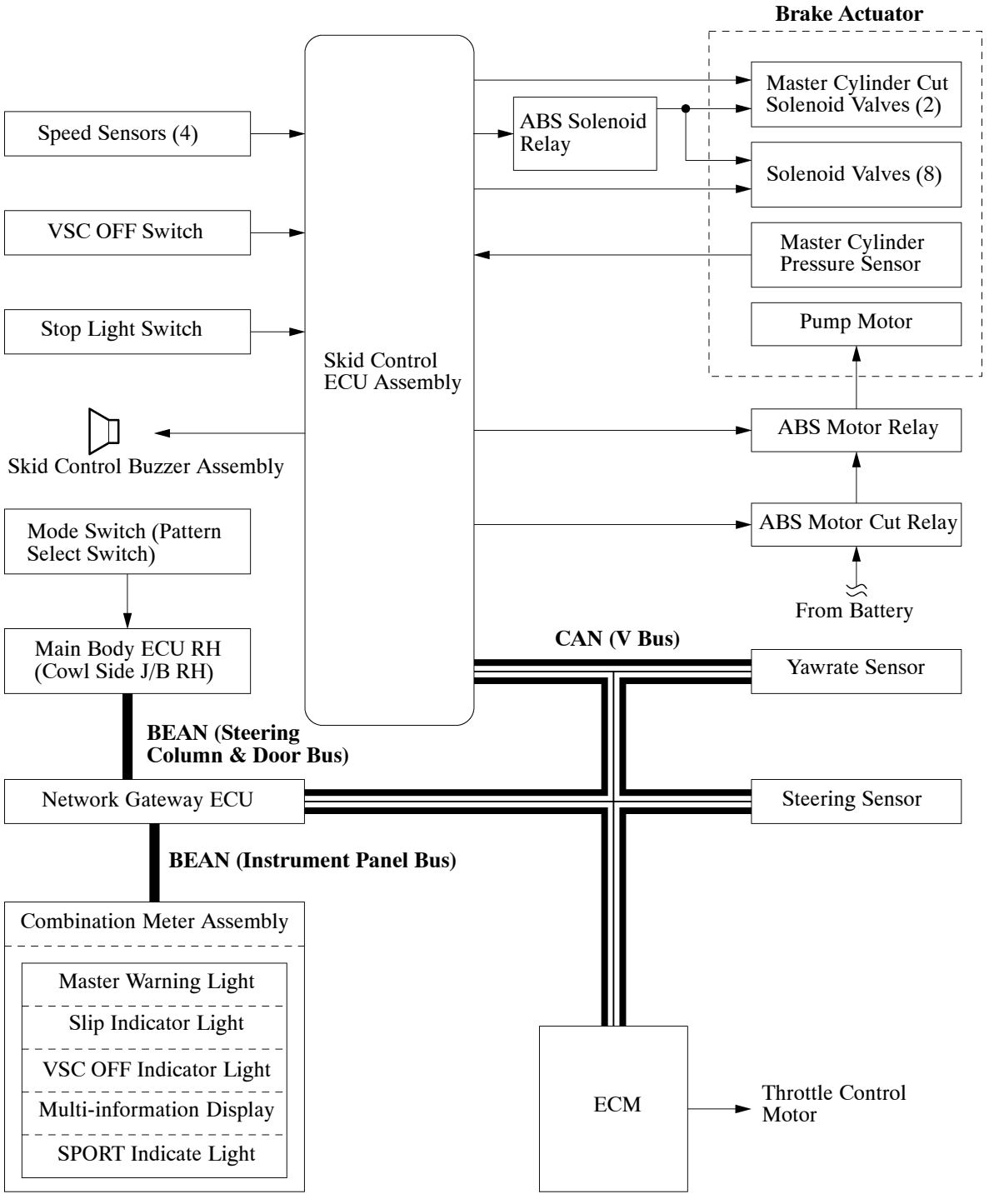
*: The solenoid valve controls the hydraulic pressure between “open” and “closed” according to the operating condition by adjusting continually.

VSC Operation

1) General

The VSC, by way of solenoid valves, controls the fluid pressure that is generated by the pump and applies it to the brake wheel cylinder of each wheel in the following 3 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 ◀



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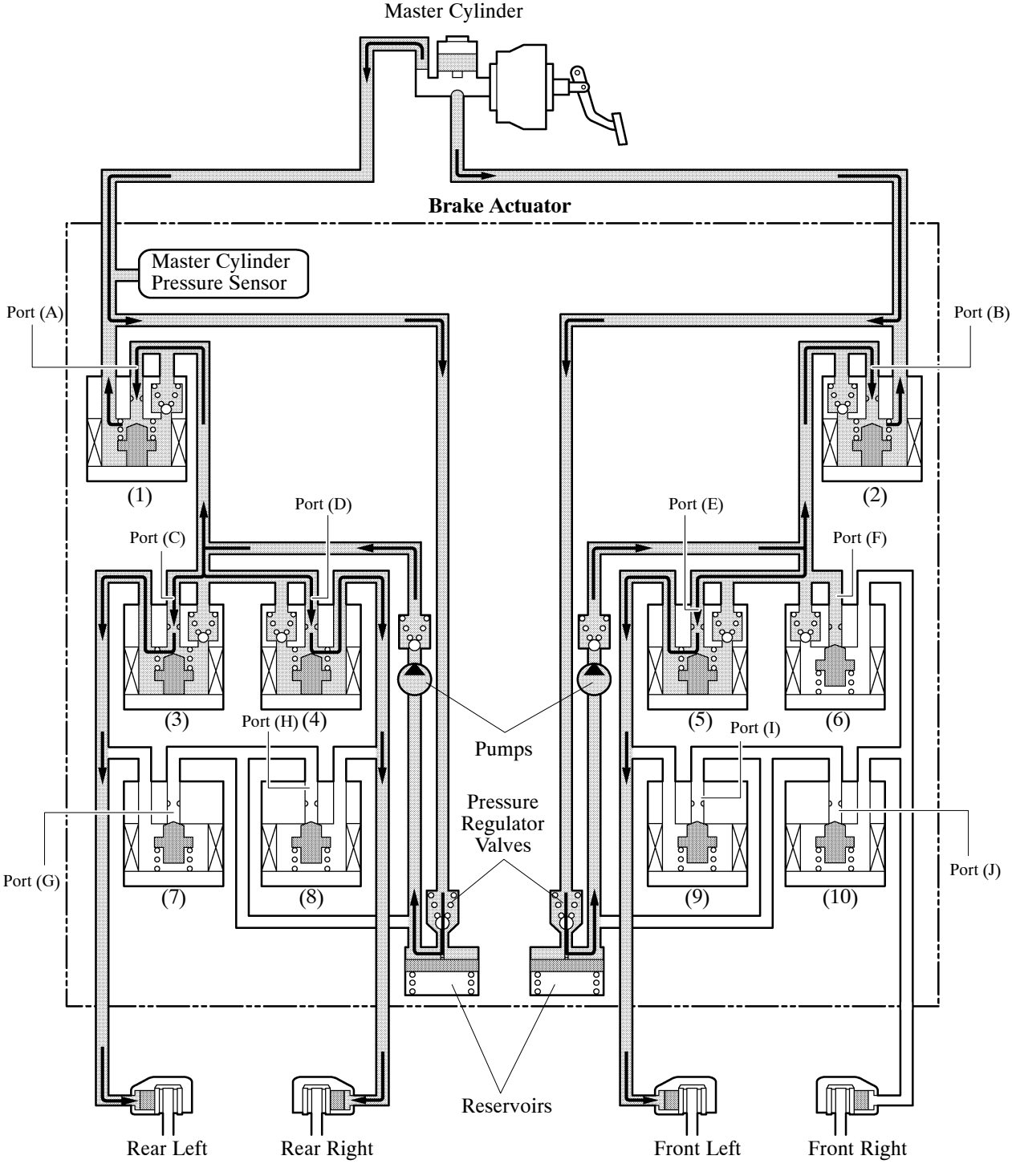
2) Front Wheel Skid Restraining Control (Right Turn)

For front wheel skid restraining control, the brakes of the front wheel of the outer side of the turn and the rear wheels are applied. Also, depending on whether the brake is ON or OFF and the condition of the vehicle, there are circumstances in which the brake might not be applied to the wheels even if those wheels are targeted for braking.

- The diagram below shows the hydraulic circuit in the pressure increase mode, as it controls the front 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 with EBD operation pattern.



Pressure Increase Mode

08D0CH113C

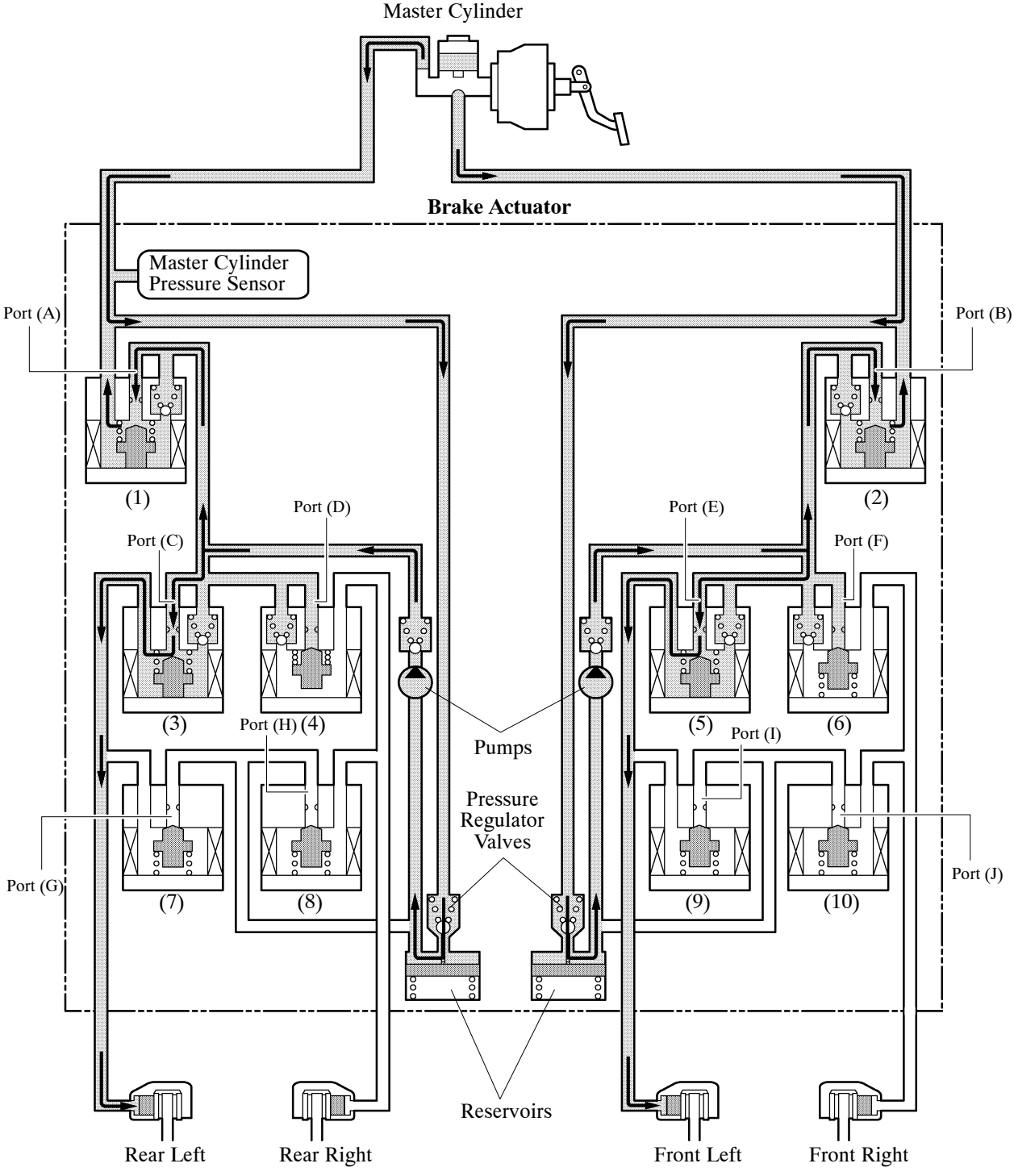
Item			VSC Not Activated	VSC Activated		
				Pressure Increase Mode	Pressure Holding Mode	Pressure Reduction Mode
(1), (2)	Master Cylinder Cut Solenoid Valve		OFF/Open	ON*	←	←
	Port: (A), (B)					
Front Brake	(5)	Pressure Holding Valve	OFF/Open	←	ON/Closed	←
		Port: (E)				
	(6)	Pressure Holding Valve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

*: The solenoid valve controls the hydraulic pressure between “open” and “closed” according to the operating condition by adjusting continually.

3) Rear Wheel Skid Restraining Control (Right Turn)

For rear wheel skid restraining control, the brake of the front and rear wheels of the outer side 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 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 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 with EBD operation pattern.



Pressure Increase Mode

08D0CH114C

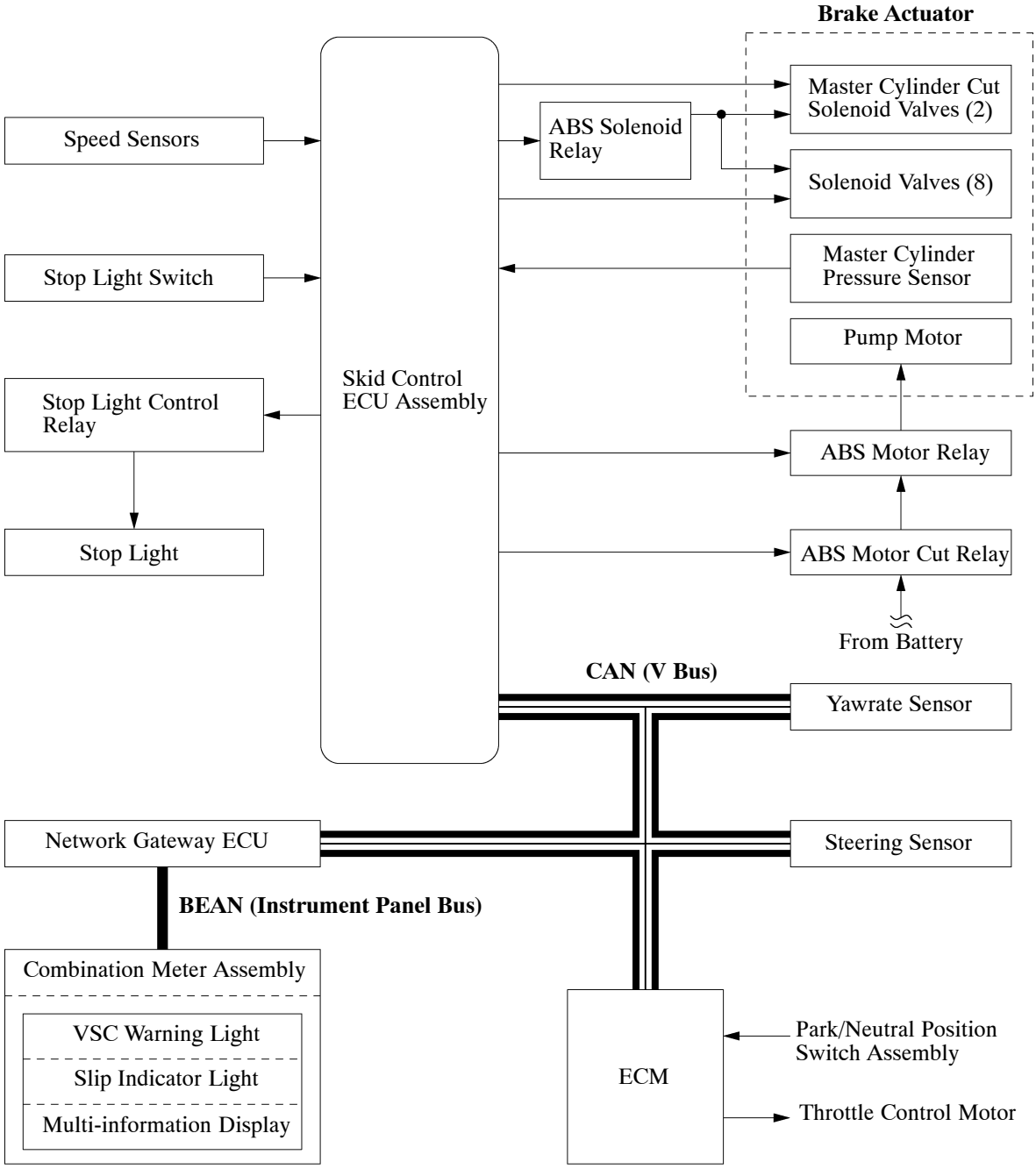
Item			VSC Not Activated	VSC Activated		
				Pressure Increase Mode	Pressure Holding Mode	Pressure Reduction Mode
(1), (2)	Master Cylinder Cut Solenoid Valve Port: (A), (B)		OFF/Open	ON*	←	←
Front Brake	(5)	Pressure Holding Valve Port: (E)	OFF/Open	←	ON/Closed	←
	(6)	Pressure Holding Valve Port: (F)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

*: The solenoid valve controls the hydraulic pressure between “open” and “closed” according to the operating condition by adjusting continually.

Hill-start Assist Control Operation

- For Hill-start Assist Control operation, the hydraulic pressure generated by the pump is distributed to the wheel cylinders in order to apply the brakes. Thus, this operation reduces the ability of the vehicle to roll backward while Hill-start Assist Control operation is being performed.
- The system controls the hydraulic pressure to the brakes by changing the hydraulic paths to the brakes at each wheel in the following modes: pressure reduction, pressure holding, and pressure increase modes.
- The operating conditions of the valves and the flow of the brake fluid during the pressure increase mode of the Hill-start Assist Control operation are described on the next page.
- The pressure holding valves and the pressure reduction valves are turned ON/OFF according to the ABS with EBD operation pattern described on the previous page.

▶ System Diagram ◀



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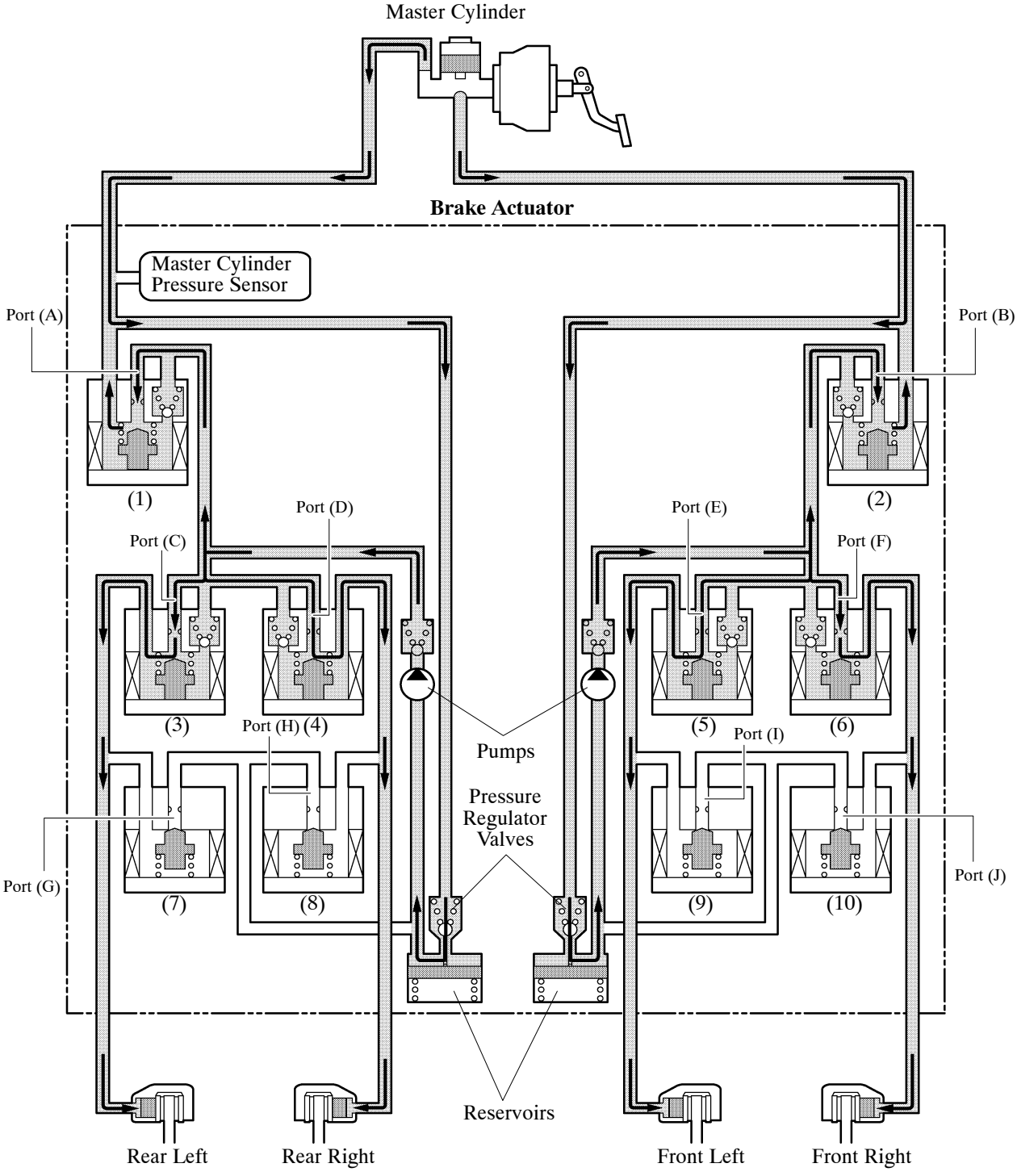

Pressure Increase Mode

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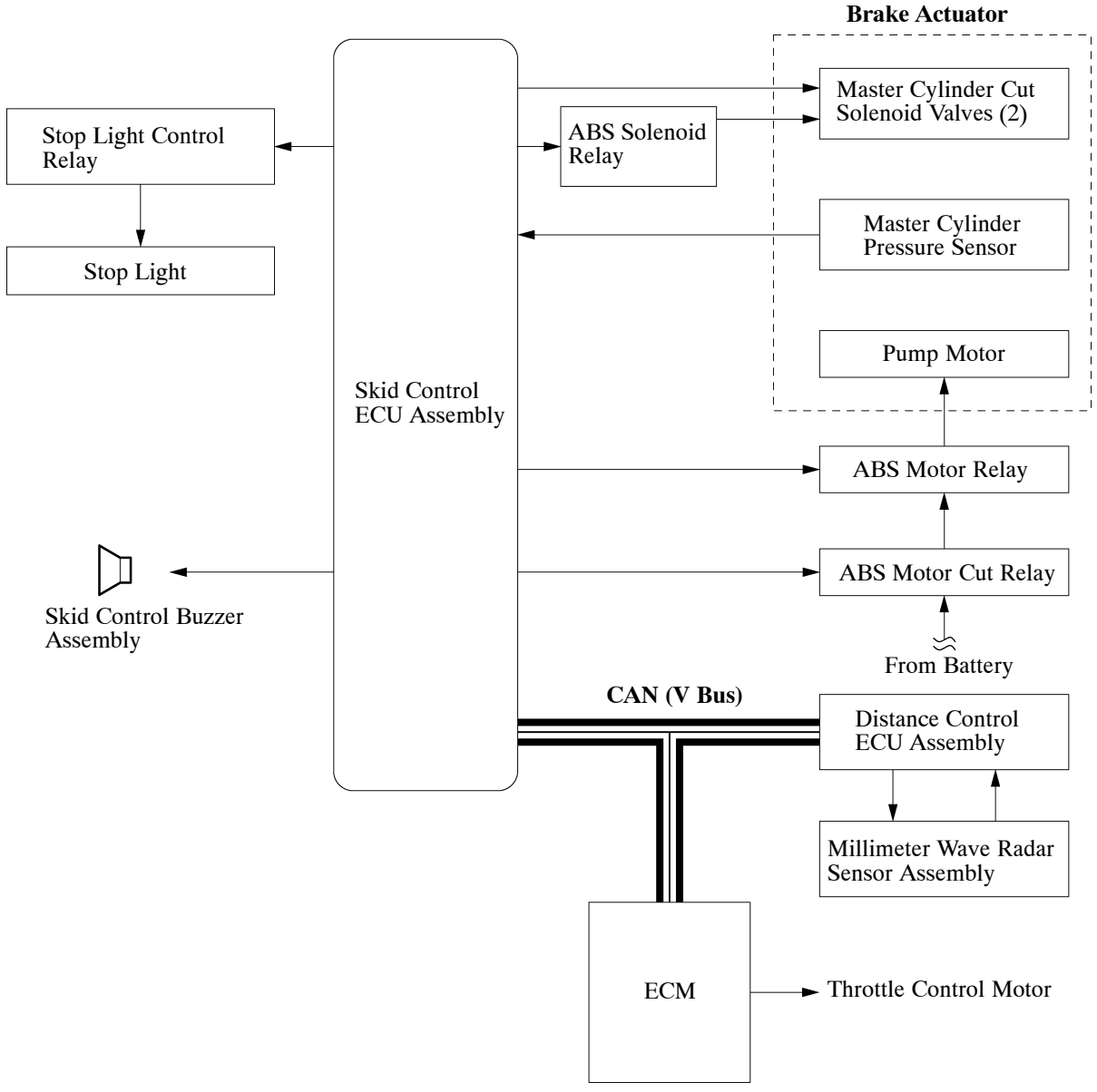
Item			Hill-start Assist Control Not Activated	Hill-start Assist Control Activated		
				Pressure Increase Mode	Pressure Holding Mode	Pressure Reduction Mode
(1), (2)	Master Cylinder Cut Solenoid Valve		OFF/Open	ON*	←	←
	Port: (A), (B)					
Front Brake	(5), (6)	Pressure Holding Valve	OFF/Open	←	ON/Closed	←
		Port: (E), (F)				
	(9), (10)	Pressure Reduction Valve	OFF/Closed	←	←	ON/Open
		Port: (I), (J)				
	Wheel Cylinder Pressure		—	Increase	Hold	Reduce
Rear Brake	(3), (4)	Pressure Holding Valve	OFF/Open	←	ON/Closed	←
		Port: (C), (D)				
	(7), (8)	Pressure Reduction Valve	OFF/Closed	←	←	ON/Open
		Port: (G), (H)				
	Wheel Cylinder Pressure		—	Increase	Hold	Reduce

*: The solenoid valve controls the hydraulic pressure between “open” and “closed” according to the operating condition by adjusting continually.

Brake Control Operation (Models with Dynamic Radar Cruise Control System)

The fluid pressure that is generated by the pump in the brake actuator is directed to the brakes.

▶ System Diagram ◀



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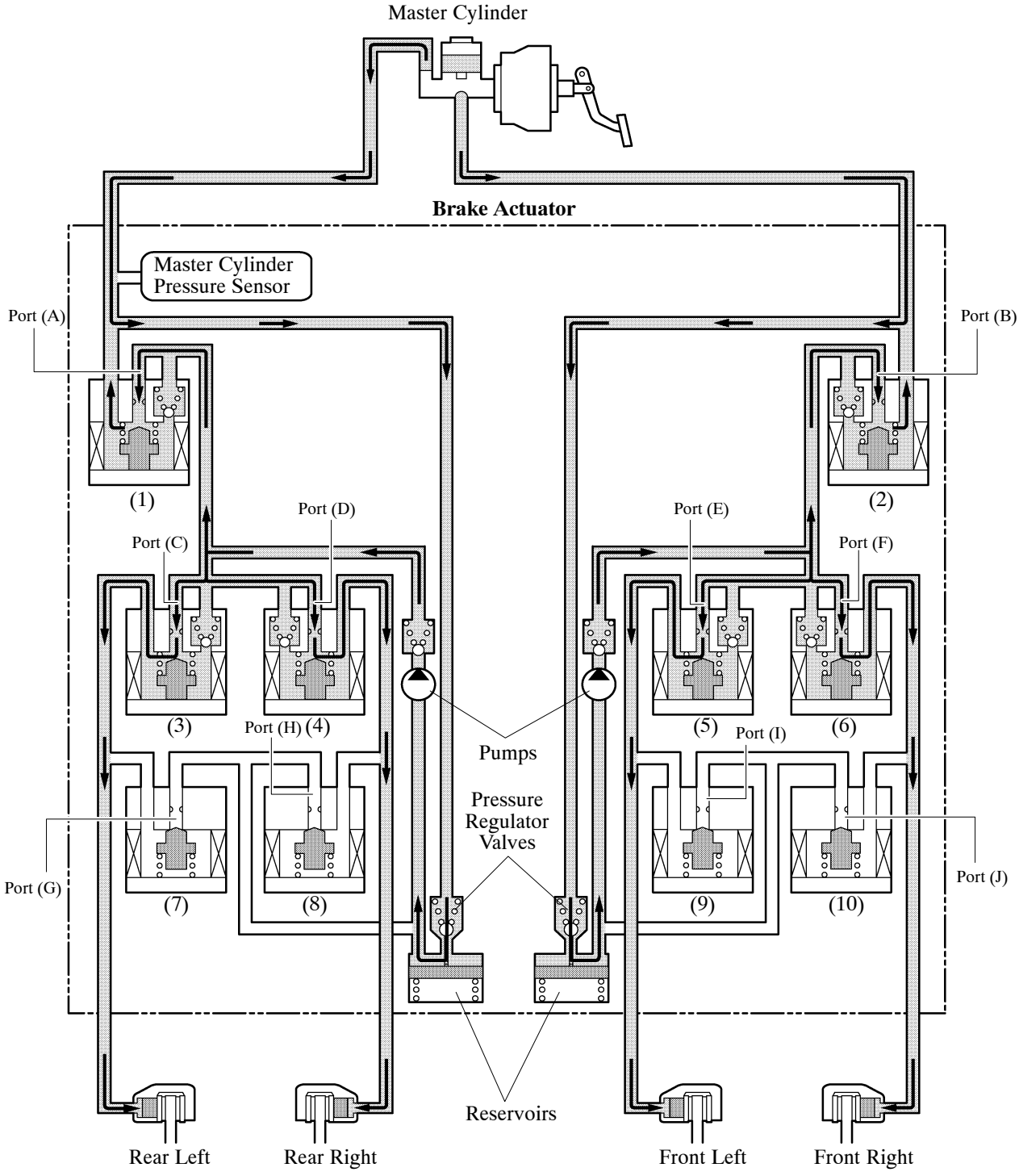

Pressure Increase Mode

08D0CH115C

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

*: The solenoid valve controls the hydraulic pressure between “open” and “closed” according to the operating condition by adjusting continually.

Initial Check

Each time the engine switch is turned on (IG), and the vehicle reaches a speed of approximately 6 km/h (4 mph) or more, the skid control ECU assembly performs an initial check. The functions of each solenoid valve and pump motor in the brake actuator are checked in sequence.

16. CAN (Controller Area Network)

CAN communication is used between the skid control ECU assembly, steering sensor, yawrate sensor, ECM, network gateway ECU, distance control ECU assembly, power steering ECU assembly and DLC3. For details on CAN communication, refer to page BE-7.

17. Diagnosis

If the skid control ECU assembly 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 assembly 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 an intelligent tester to DLC3.
- If the skid control ECU assembly detects a malfunction during a sensor signal check (test mode), it stores the DTCs in its memory.

For details, see the LEXUS IS F Repair Manual (Pub. No. RM08E0E).

18. Fail-safe

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