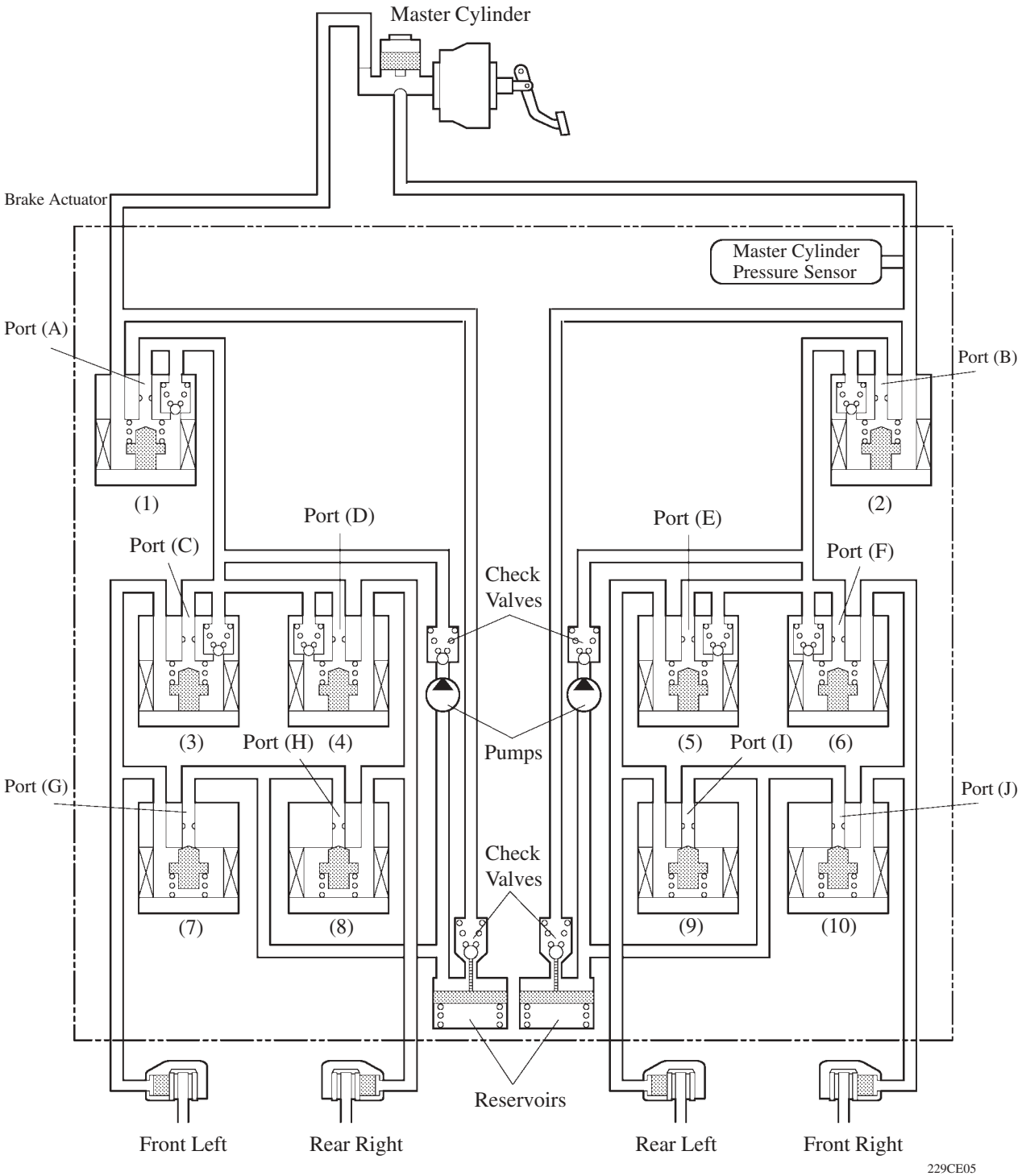
9. Brake Actuator

General

The brake actuator consists of 10 two-position valves, 4 check valves, 2 pump motor, 2 reservoirs, and master cylinder pressure sensor.
The 10 two-position solenoid valves consists of the following:

- 2 master cylinder cut solenoid valves (linear type) [(1), (2)]
- 4 pressure holding valves [(3), (4), (5), (6)]
- 4 pressure reduction valves [(7), (8), (9), (10)]

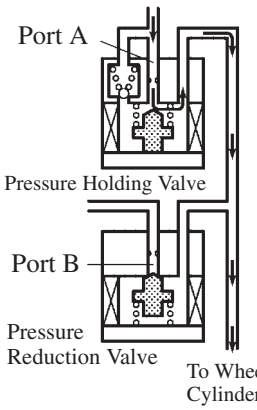
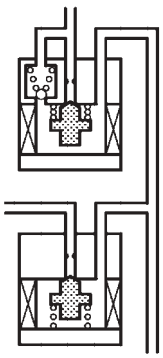
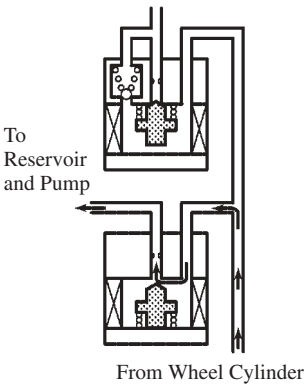


▶ Function of Main Components ◀

Component		Function
(1), (2)	Master Cylinder Cut Solenoid Valve (Linear Type)	To effect the respective brake controls of the Brake Assist, TRC, and VSC system, a combination of the ON/OFF conditions of the master cylinder cut solenoid valve is used to appropriately vary the fluid pressure.
(3), (4), (5), (6)	Pressure Holding Valve	Each wheel cylinder contains a pressure holding valve and a pressure reduction valve. A combination of the ON/OFF conditions of the respective valves is used in order to change the increase mode, holding mode, or the reduction mode during the operation of the ABS with EBD, Brake Assist, TRC, and VSC system.
(7), (8), (9), (10)	Pressure Reduction Valve	
Master Cylinder Pressure Sensor		The master cylinder pressure sensor converts the brake fluid pressure that the master cylinder applies to the brake actuator into an electrical signal and sends it to the skid control ECU. The skid control ECU can thus monitor the brake fluid pressure that is applied to the brake actuator in accordance with this signal.
Reservoir		While effecting the reduction mode during the operation of the ABS with EBD, Brake Assist, TRC, and VSC system, the reservoir stores the brake fluid that has returned from the wheel cylinders. It also functions as an accumulator.
Pump		Pumps the brake fluid that is stored in the reservoir and returns it to the master cylinder. While effecting the increase mode during the operating of the Brake Assist, TRC, and VSC system, the pump operates in order to apply brake fluid pressure to the wheel cylinders.
Check Valve		Check valves are located before and after the between the pump and reservoir. They open only in one direction to prevent the brake fluid from flowing backwards.

ABS with EBD Operation

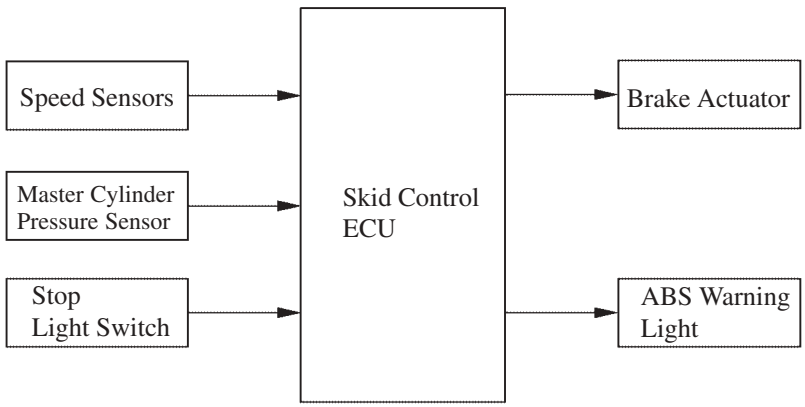
Based on the signals received from the 4 wheel speed sensors, the skid control ECU calculates each wheel speed and deceleration, and checks wheel slipping condition. And according to the slipping condition, the ECU controls the pressure holing valve and pressure reduction valve in order to adjust the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

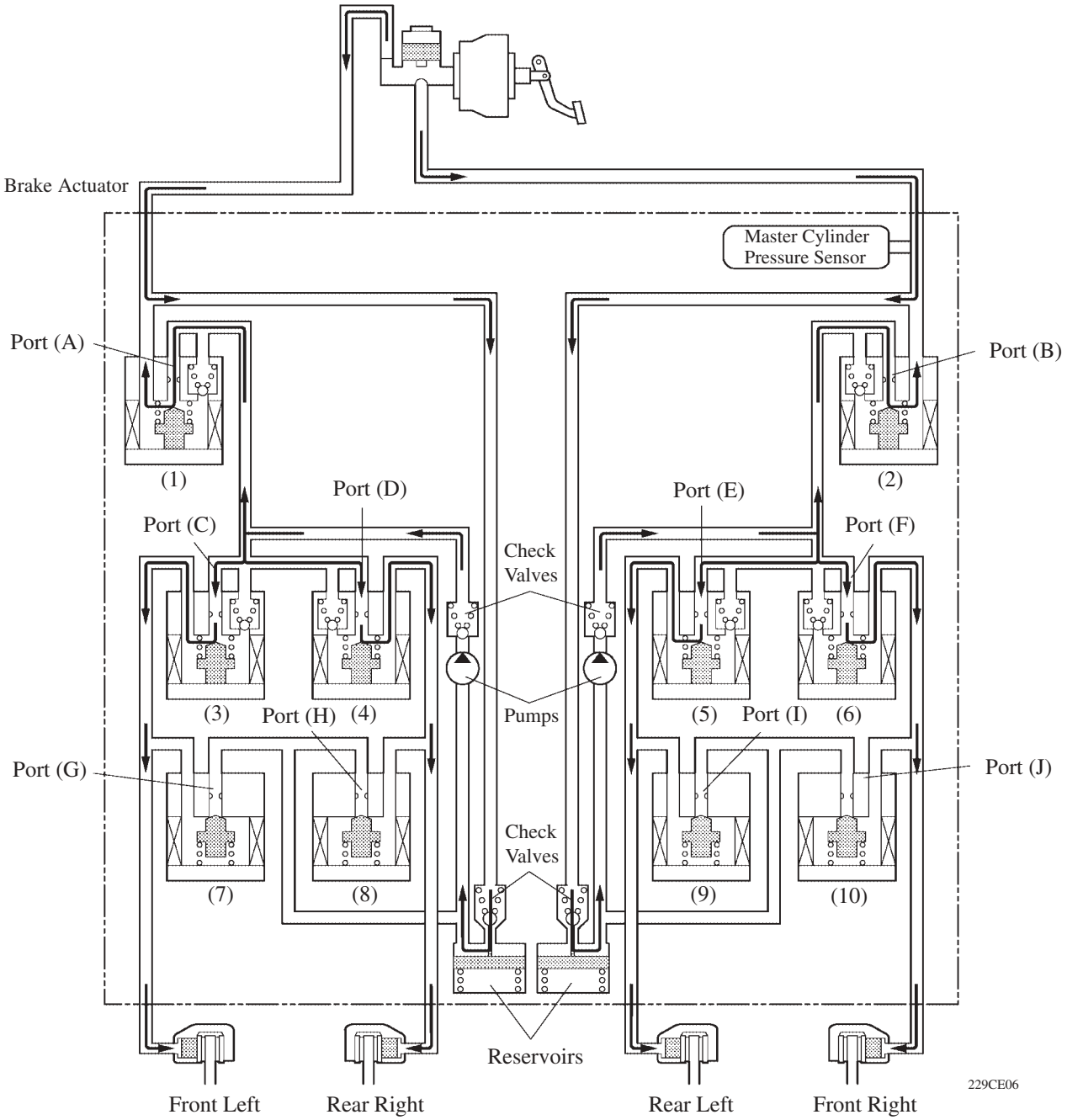
Not Activated	Normal Braking	—	—
Activated	Increase Mode	Hold Mode	Reduction Mode
Hydraulic Circuit			
Pressure Holding Valve (Port A)	OFF (Open)	ON (Close)	ON (Close)
Pressure Reduction Valve (Port B)	OFF (Close)	OFF (Close)	ON (Open)
Wheel Cylinder Pressure	Increase	Hold	Reduction

Brake Assist Operation

The fluid pressure that has been generated by the pump in the brake actuator is directed to the wheel cylinders. By applying a greater fluid pressure than the master cylinder, a greater braking force is achieved.

▶ System Diagram ◀





Brake Assist Activated

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

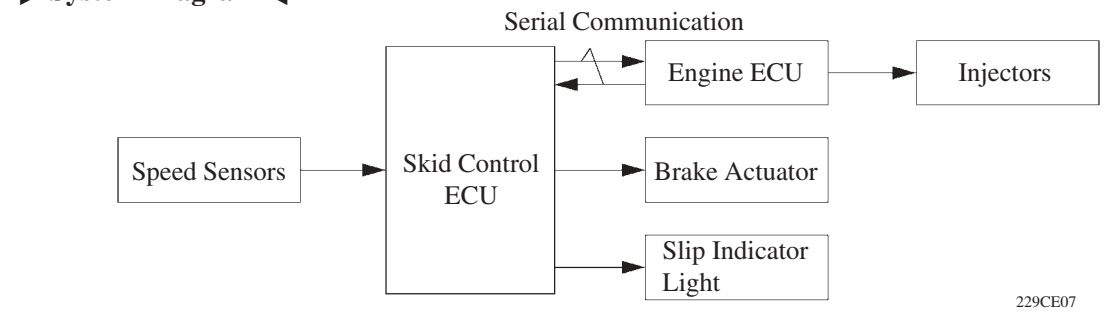
*: The solenoid valve controls the hydraulic pressure between “open” through “close” according to the operating condition by adjusting continually.

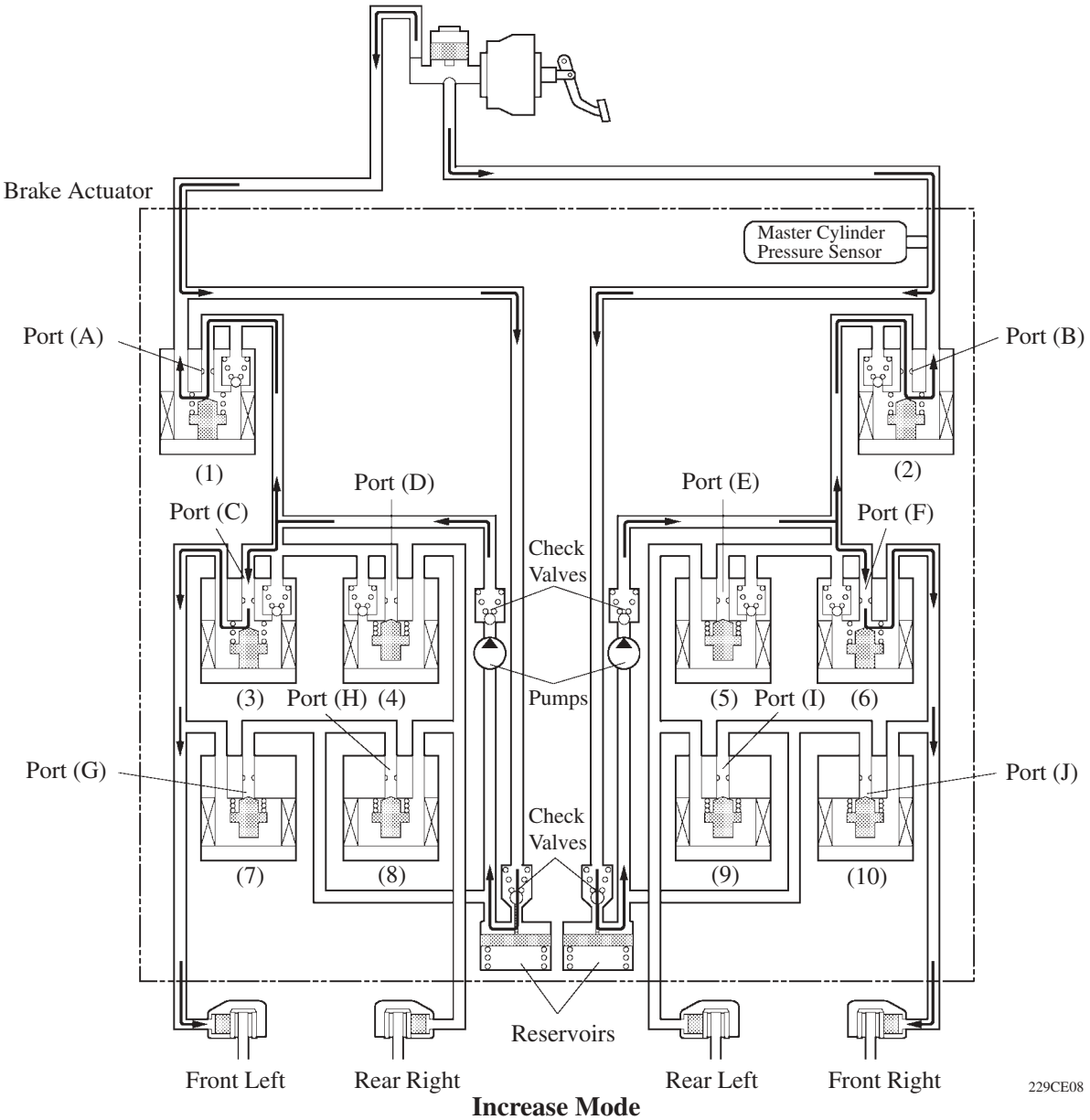
TRC Operation

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

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

▶ System Diagram ◀





Increase Mode

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

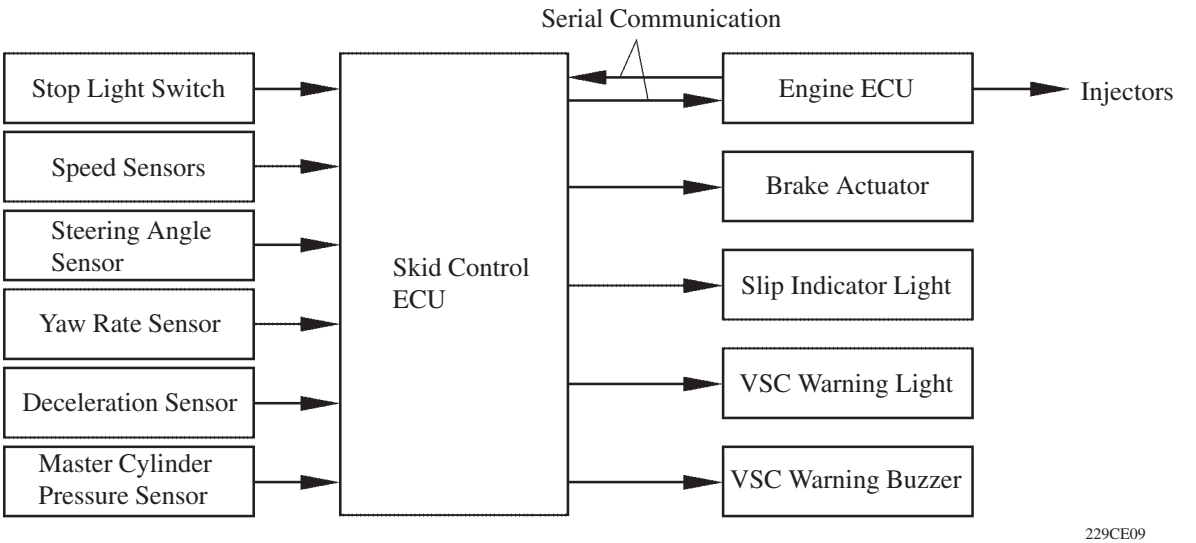
*: The solenoid valve controls the hydraulic pressure between “open” through “close” according to the operating condition by adjusting continually.

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 each wheel in the following 3 modes: pressure reduction, pressure holding, and pressure increase modes. As a result, the tendency to front wheel skid or rear wheel skid is restrained.

▶ System Diagram ◀



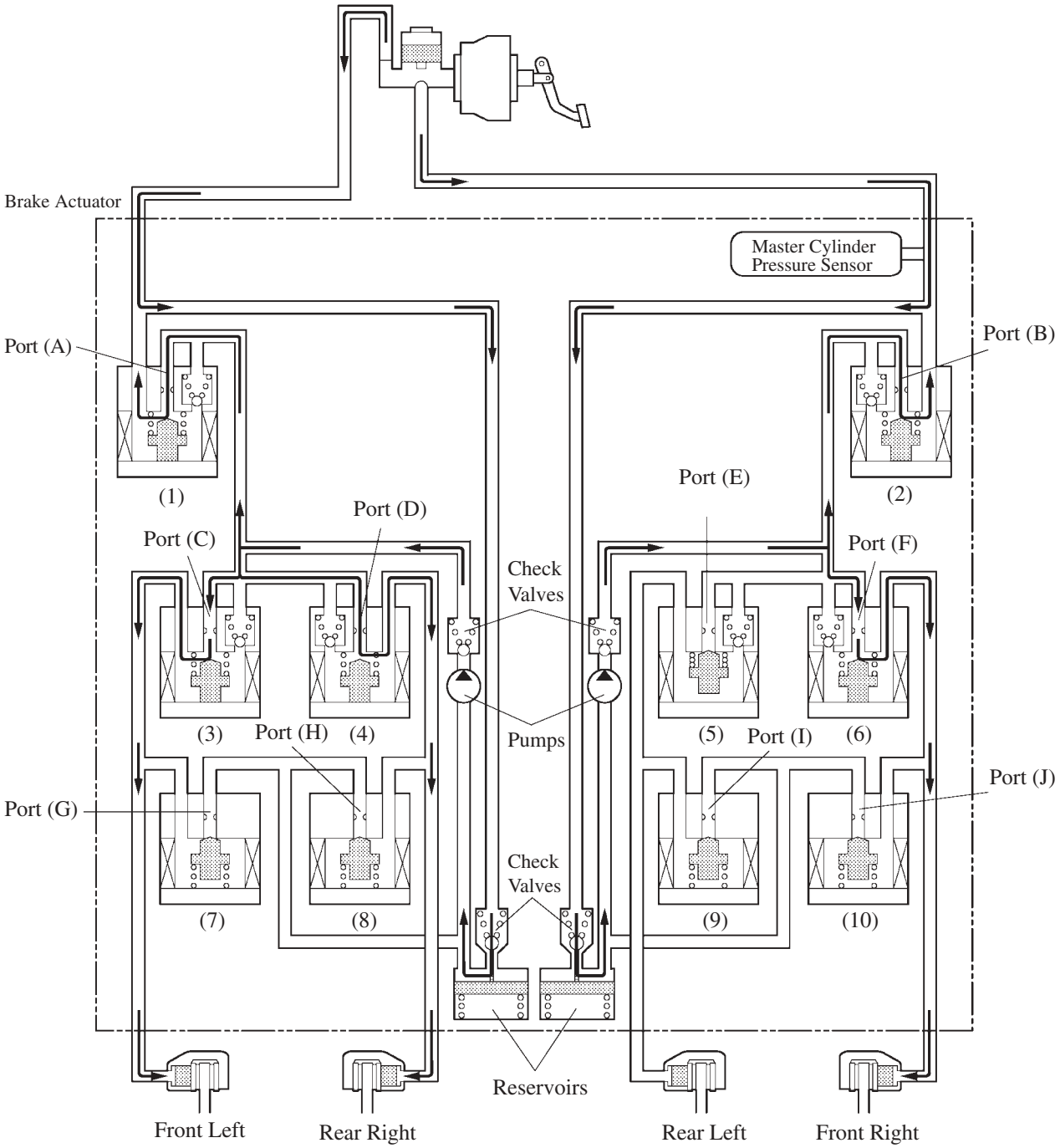
2) Front Wheel Skid Restrain (Turn to the Right)

In the front wheel skid control, the brakes of the front wheels and the rear wheel 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 brake might not be applied to the wheels even if those wheels are targeted for braking.

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

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



Increase Mode

229CE10

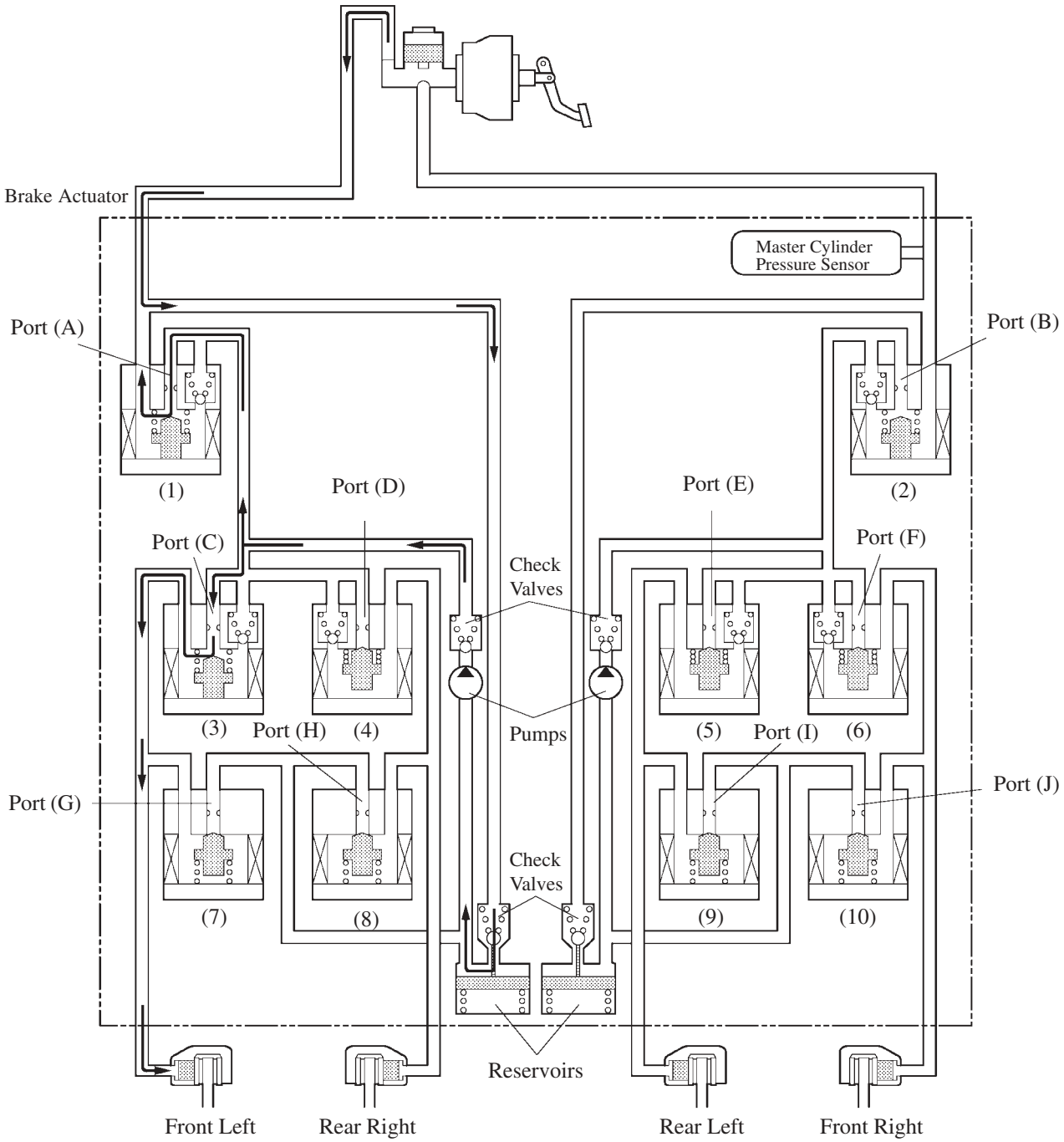
Item			VSC not Activated	VSC Activated		
				Increase Mode	Hold Mode	Reduction Mode
(1), (2)	Master Cylinder Cut Solenoid Valve		OFF (Open)	ON*	ON*	ON*
	Port: (A), (B)					
Front Brake	(3), (6)	Pressure Holding Valve	OFF (Open)	OFF (Open)	ON (Close)	ON (Close)
		Port: (C), (F)				
	(7), (10)	Pressure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

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

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

In rear wheel skid restrain, the brake of the front wheel of the outer circle of the turn is applied. As an example, the diagram below shows the hydraulic circuit in the pressure increase mode, as it restrains the rear wheel skid condition while the vehicle make a right turn.

As in front wheel skid restrain the pressure holding valve and the pressure reduction valve are turned ON/OFF according to the ABS operating pattern.



Increase Mode

229CE11

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

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