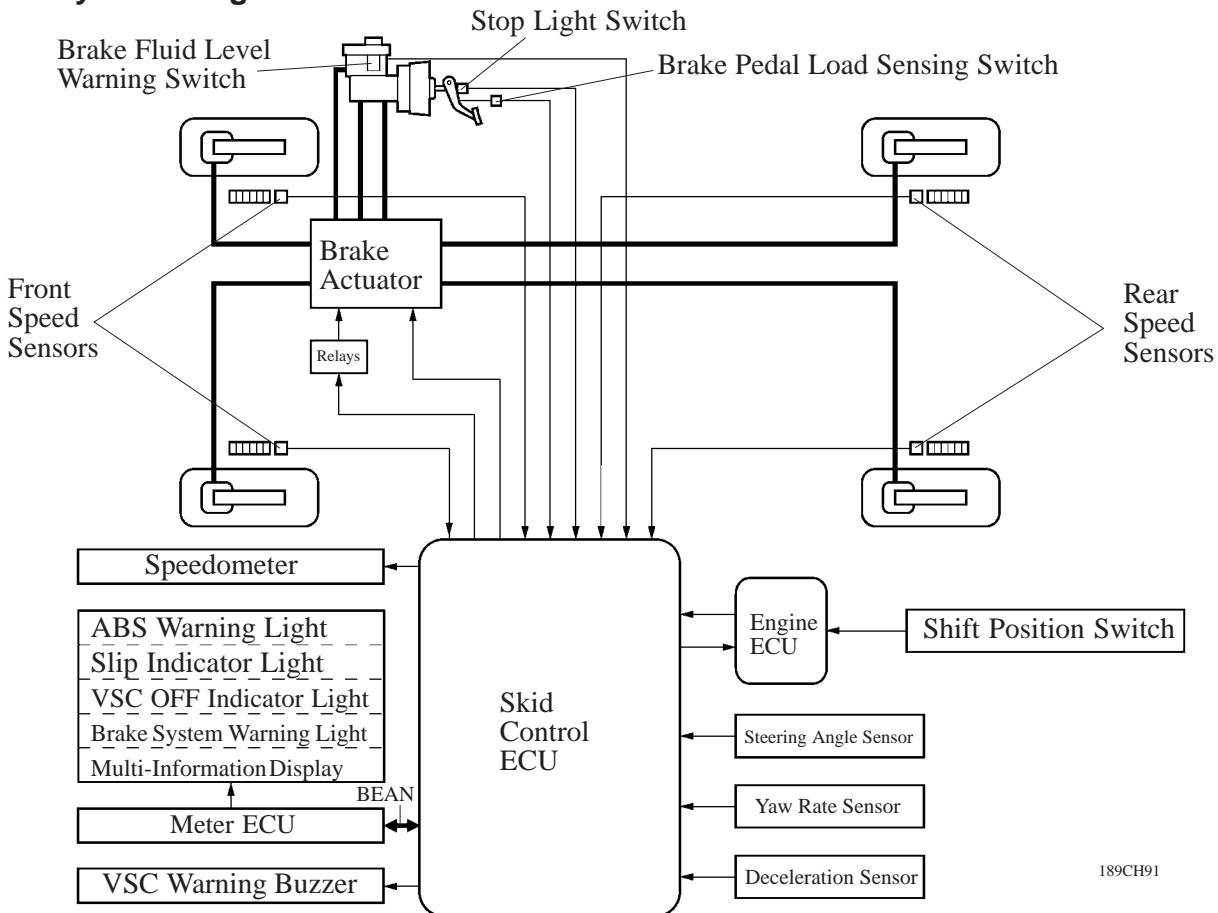


■ ABS WITH EBD & BRAKE ASSIST & TRC & VSC SYSTEM

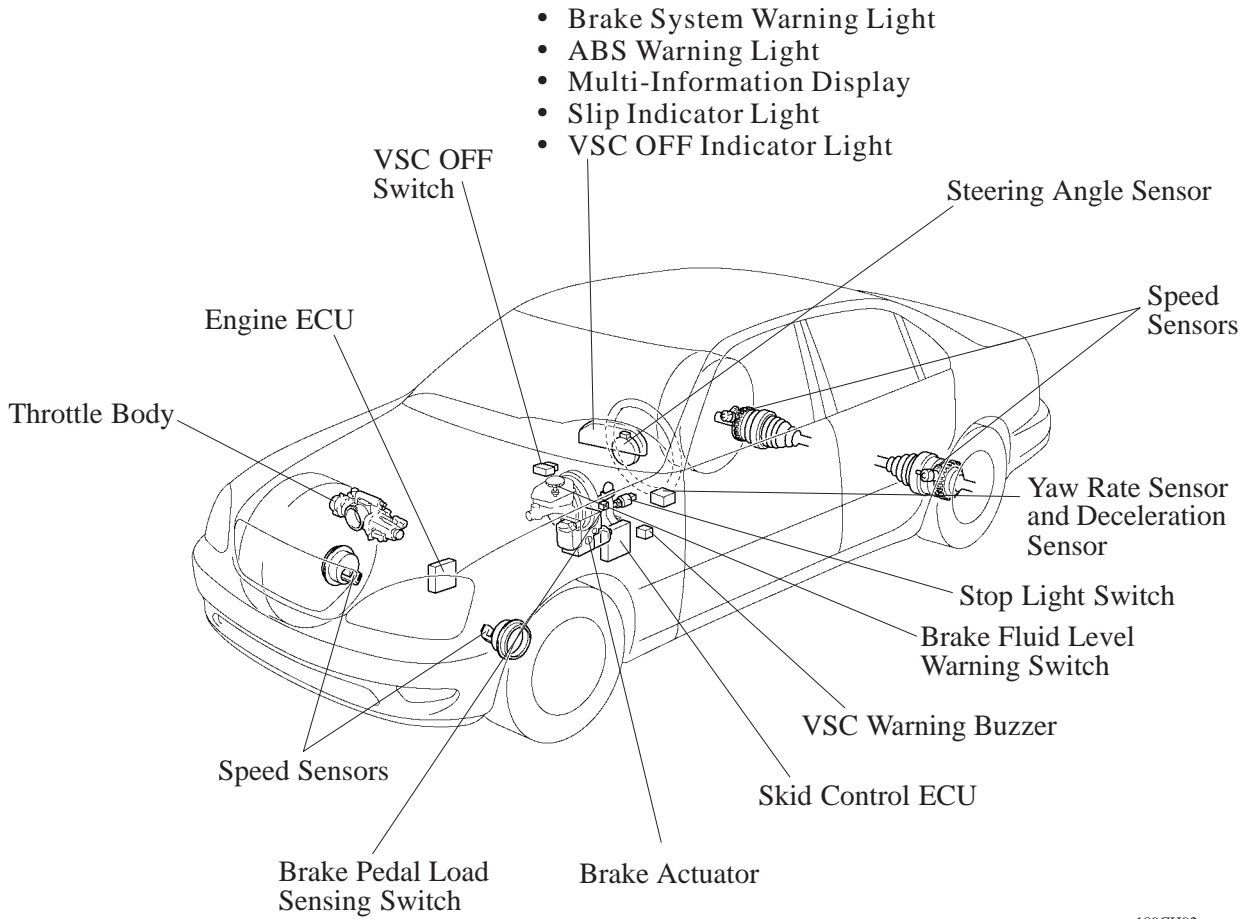
1. General

- The ABS with EBD & Brake Assist & TRC & VSC system is provided as standard equipment on the new LS430.
- The primary purpose of the ABS and TRC system has been to help the vehicle’s stability during braking and acceleration. In contrast, the purpose of the VSC system is to help the vehicle’s stability during cornering.
- Ordinarily, the vehicle corners in a stable manner in accordance with the steering operation. However, depending on the unexpected situations or external elements such as the ground surface conditions, vehicle speed, and emergency avoidance maneuvers, the vehicle may exhibit strong understeer or oversteer tendencies. In such situations, the VSC system dampens the strong understeer or oversteer to help vehicle stability.
- The primary purpose of the Brake Assist system is to provide an auxiliary brake force assist to the driver who cannot generate a large brake force during emergency braking, thus maximizing the vehicle’s brake performance.
- The EBD control utilizes ABS, realizing the proper brake force distribution between front and rear wheels in accordance with the driving conditions.  
In addition, during cornering braking, it also controls the brake forces of right and left wheels, helping to maintain the vehicle stability.

2. System Diagram



3. Layout of Components



CH

189CH92

LHD Model

#### 4. Function of Components

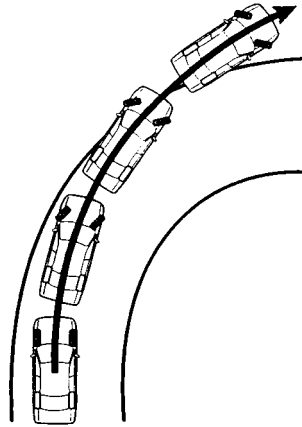
Components		Function
Warning Light and Indicator Light	ABS Warning Light	Lights up to alert the driver when the ECU detects the malfunction in the ABS or Brake Assist system.
	Slip Indicator Light	Blinks to inform the driver when the TRC system or the VSC system is operated.
	VSC OFF Indicator Light	Lights up to inform the driver when the TRC and VSC system is turned OFF by the VSC OFF switch.
	Brake System Warning Light	Lights up together with the ABS warning light to alert the driver when the ECU detects the malfunction not only in the ABS but also in the EBD control.
Multi-Information Display (Warning Message “CHECK VSC”)		Alert the driver when the ECU detects the malfunction in the TRC and VSC system in the multi-information display.
Engine ECU		Sends the throttle valve opening angle signal, shift position signal, etc., to the skid control ECU.
Skid Control ECU		Judges the vehicle driving condition based on signals from each sensor, and sends brake control signal to the brake actuator. Also transmits the control information to the engine ECU.
Speed Sensors		Detects the wheel speed of each of four wheels.
Brake Actuator		Changes the fluid path based on the signals from the skid control ECU during the operation of the ABS with EBD & Brake Assist & TRC & VSC system, in order to control the fluid pressure that is applied to the wheel cylinder.
	Master Cylinder Pressure Sensor	Assembled in the brake actuator and detects the master cylinder pressure.
Control Relay	Pump Motor Relay	Supply power to the pump motor in the actuator.
	Solenoid Relay	Supply power to the solenoid valves in the actuator.
VSC OFF Switch		Turns the TRC and VSC system inoperative.
Brake Fluid Level Warning Switch		Detects the brake fluid level.
VSC Warning Buzzer		Emits an intermittent sound to inform the driver that the ECU detects the strong understeer tendency or strong oversteer tendency.
Stop Light Switch		Detects the brake depressing signal.
Brake Pedal Load Sensing Switch		Detects the brake pedal load.
Yaw Rate Sensor		Detects the vehicle’s yaw rate.
Deceleration Sensor		Detects the vehicle’s acceleration in the lateral directions.
Steering Angle Sensor		Detects the steering direction and angle of the steering wheel.

## 5. Outline of VSC System

### General

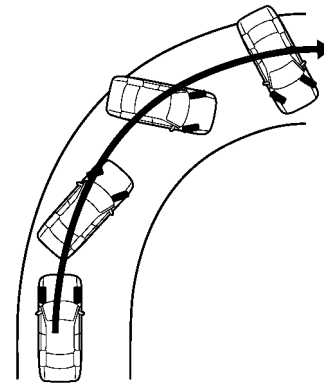
The followings are two examples that can be considered as circumstances in which the tires overcome their lateral grip limit.

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



151CH17

**Strong Understeer Tendency**



189CH100

**Strong Oversteer Tendency**

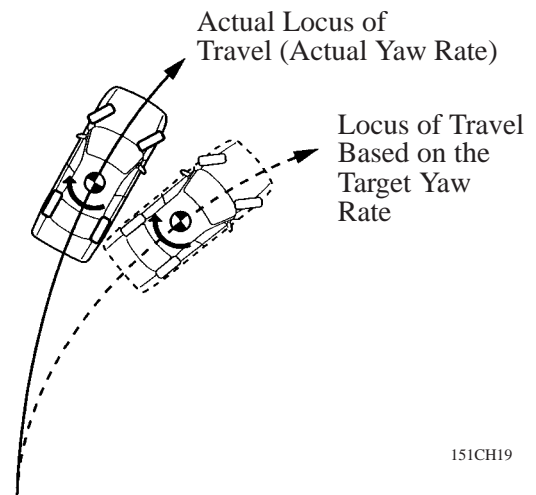
CH

### 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 Understeer

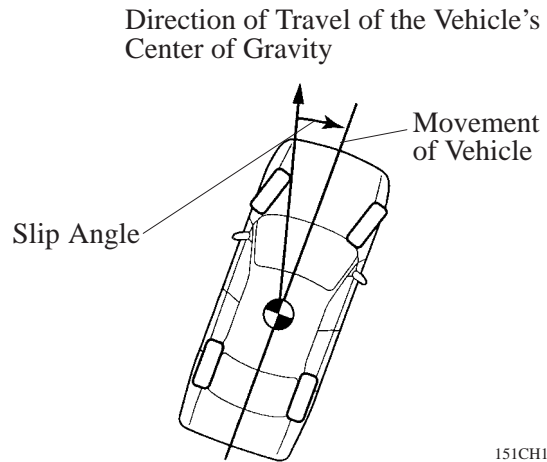
Whether or not the vehicle is in the state of understeer is determined by the difference between the target yaw rate and the vehicle's actual yaw rate. When the vehicle's actual yaw rate is smaller than the target yaw rate (a target yaw rate that is determined by the vehicle speed and steering angle) 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 loss of travel. Thus, the ECU determines that there is a large tendency to understeer.



151CH19

## 2) Determining Oversteer

Whether or not the vehicle is in the state of oversteer 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 ECU determines that the vehicle has a large oversteer tendency.

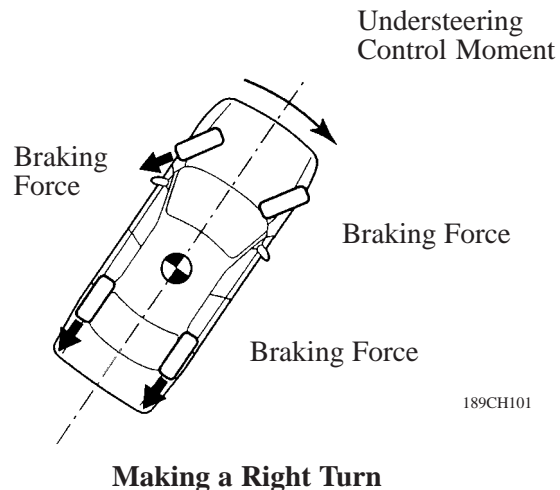


## Method of VSC Operation

When the skid control ECU determines that the vehicle exhibits a tendency to understeer or oversteer, it decreases the engine output and applies the brake of a front or rear wheel to control the vehicle's yaw moment.

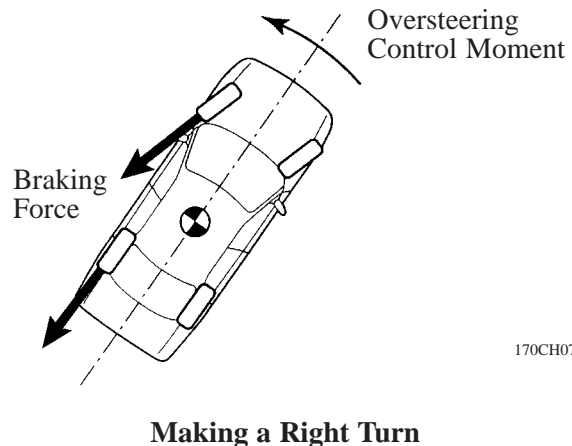
### 1) Dampening a Strong Understeer

When the skid control ECU determines that the vehicle exhibits a strong tendency to understeer, depending on the extent of that tendency, it controls the engine output and applies the brakes of the front wheels and inside rear wheel, thus providing the vehicle with an understeer control moment, which helps dampen its tendency to understeer. Also, depending on whether the brakes are ON or OFF and the condition of the vehicle, there are circumstances in which the brakes might not be applied to the wheels even if those wheels are targeted for braking.



### 2) Dampening a Strong Oversteer

When the skid control ECU determines that the vehicle exhibits a strong tendency to oversteer, depending on the extent of that tendency, it controls the engine output and applies the brakes of the front and rear wheels of the outside of the turn, thus generating an inertial moment in the vehicle's outward direction, which helps dampen its tendency to oversteer.



## 6. Outline of Brake Assist System

Brake Assist interprets a quick push of the brake pedal as emergency braking and supplements the braking power applied if the driver has not stepped hard enough on the brake pedal.

In emergencies, drivers, especially inexperienced ones, often panic and do not apply sufficient pressure on the brake pedal.

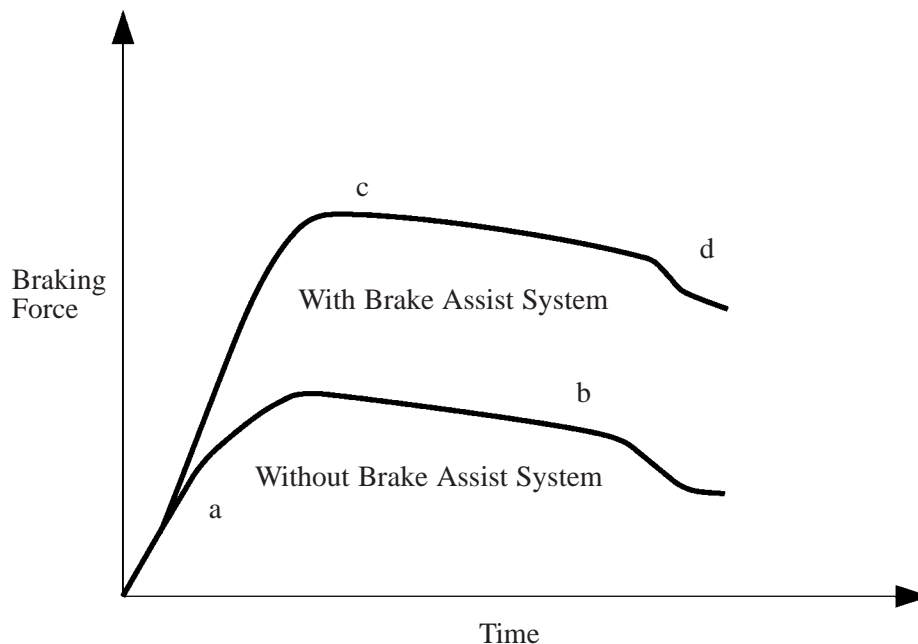
Brake Assist system measures the speed and force with which the brake pedal is pushed to determine whether the driver is attempting to brake rapidly, and applies additional pressure to maximize braking performance of both conventional brakes and ABS equipped brakes.

A key feature of Brake Assist is that the timing and the degree of braking assistance are designed to ensure that the driver does not discern anything unusual about the braking operation. When the driver intentionally eases up on the brake pedal, the system reduce the amount of assistance it provides.

### — REFERENCE —

Effectiveness of the Brake Assist Operation 1:

- During emergency braking, an inexperienced driver, or a driver in a state of panic might not be able to firmly depress the brake pedal, although driver can depress it quickly. As a result, only a small amount of brake force is generated.
- The pedal effort of this type of driver might weaken as time passes, causing a reduction in the braking force.
- Based on how quickly the brake pedal is depressed, the Brake Assist operation assesses the intention of the driver to apply emergency braking and increases the brake force.
- After the Brake Assist operation, if the driver intentionally releases the brake pedal, the assist operation reduces the amount of Brake Assist in order to reduce the feeling of uneasiness.



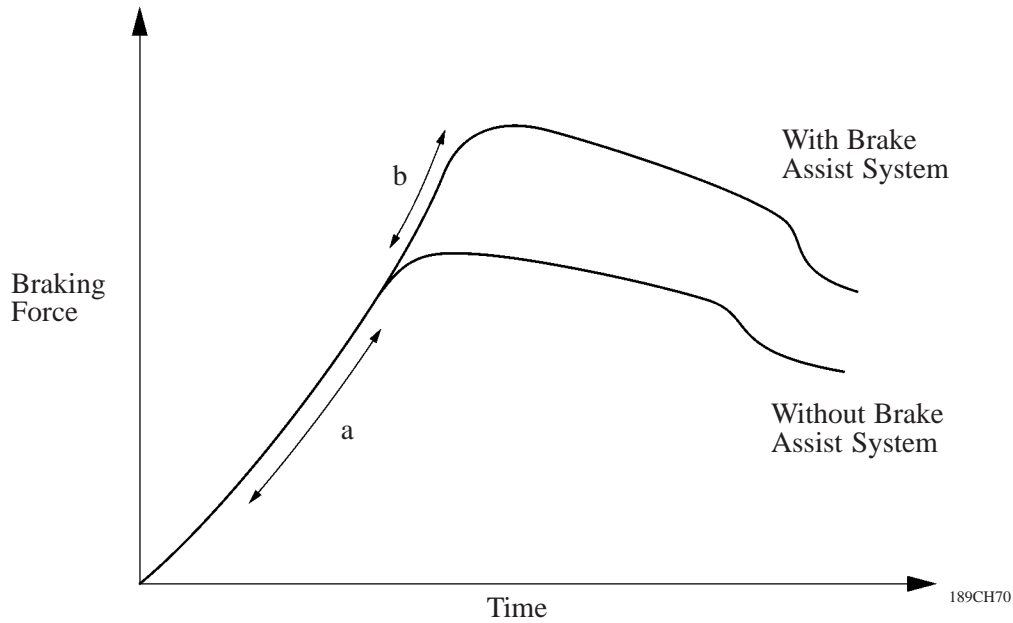
170CH18

### Service Tip

When this system is activated, the brake pedal could shudder, which is a normal occurrence of the system in operation and should not be considered a malfunction.

Effectiveness of the Brake Assist Operation 2:

- a. And, for example, when the vehicle is fully loaded, stronger brake force may be required, even if the brakes are not applied quickly.
- b. In such a case where stronger brake force is required, the Brake Assist system also increases brake force.



## 7. Outline of EBD Control

### General

The EBD control utilizes ABS, realizing the proper brake force distribution between front and rear wheels in accordance with the driving conditions.

In addition, during cornering braking, it also controls the brake forces of right and left wheels, helping to maintain the vehicle stability.

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

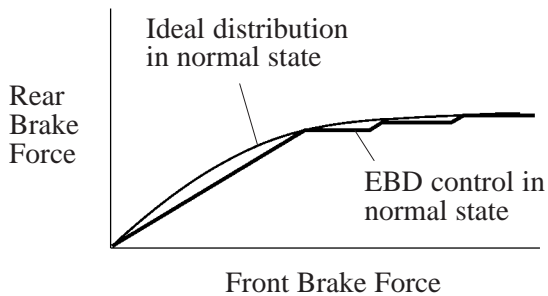
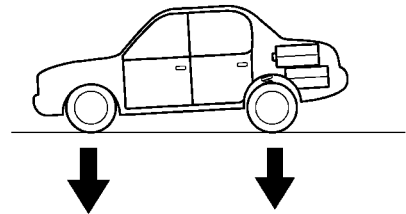
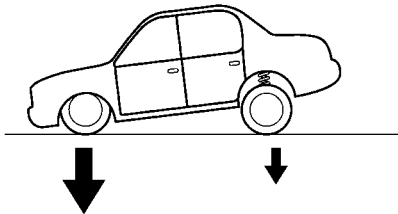
### Front/Rear Wheels Brake Force Distribution

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

For example, the amount of the load that is applied to the rear wheels during braking varies whether or not the vehicle is carrying a load. The amount of the load 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.

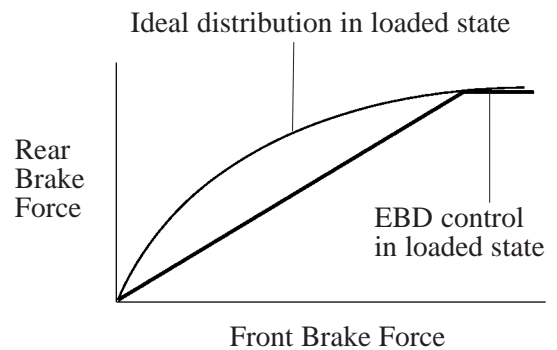
CH

#### ► EBD Control Concept ◀



Front Brake Force

Normal State



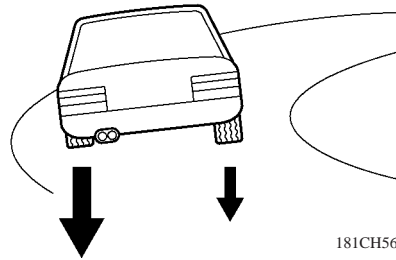
Front Brake Force

Load State



### Right/Left Wheels 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. The skid control ECU determines this condition by way of the signals from the speed sensor, and regulates the brake actuator in order to optimally control the distribution of the brake force to the inner wheel.



181CH56

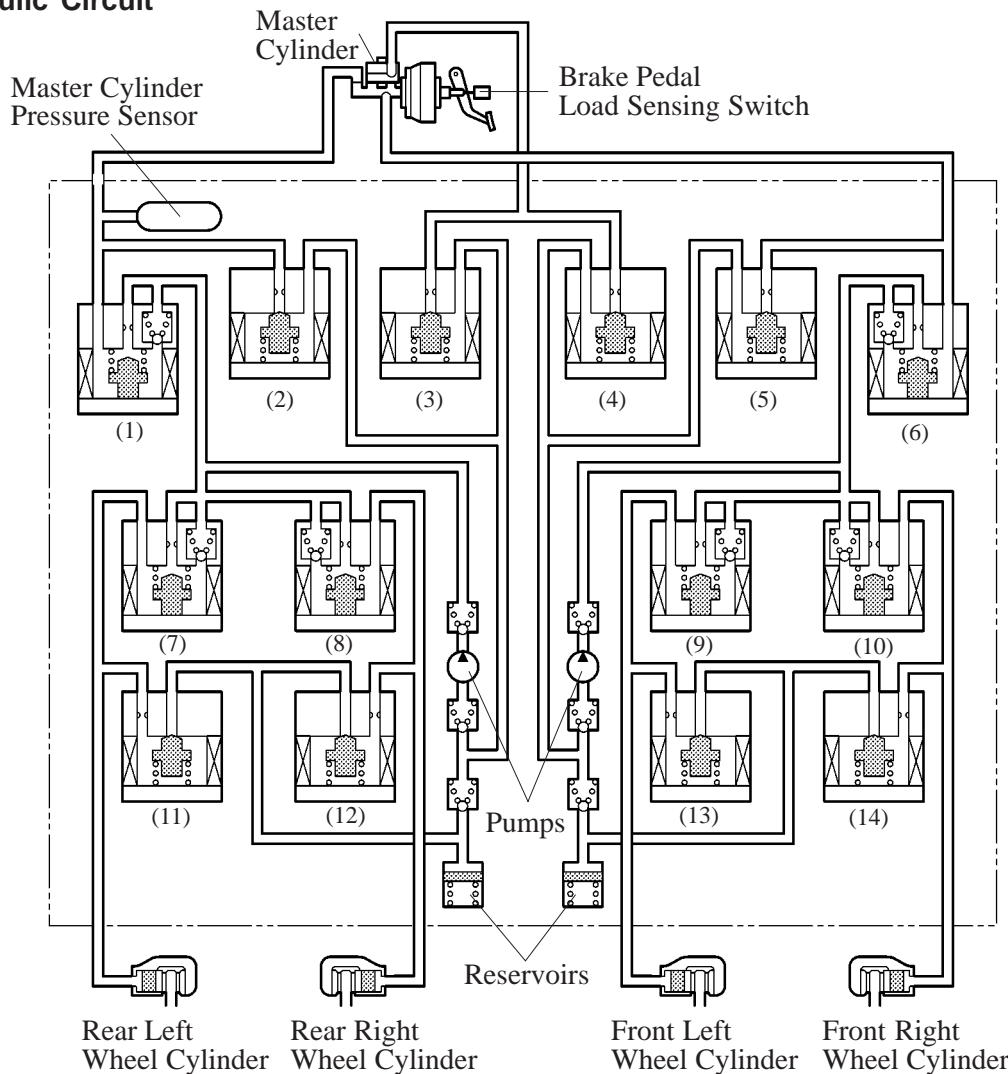
## 8. Brake Actuator

### Construction

The brake actuator consists of 14 two-position solenoid valves, 1 motor 2 pumps, 2 reservoirs, and master cylinder pressure sensor.

The 14 two-position solenoid valves consist of 2 master cylinder cut solenoid valve [(1), (6)], 2 suction solenoid valves [(2), (5)], 2 reservoir cut solenoid valves [(3), (4)], 4 pressure holding valves [(7), (8), (9), (10)], and 4 pressure reduction valves [(11), (12), (13), (14)].

### Hydraulic Circuit



189CH72

**ABS with EBD Operation**

Based on the signals received from the 4 wheel speed sensors and deceleration sensor, 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 holding valve and pressure reduction valve in order to adjust the fluid pressure of each wheel cylinder in the following 3 modes: pressure reduction, pressure holding, and pressure increase modes.

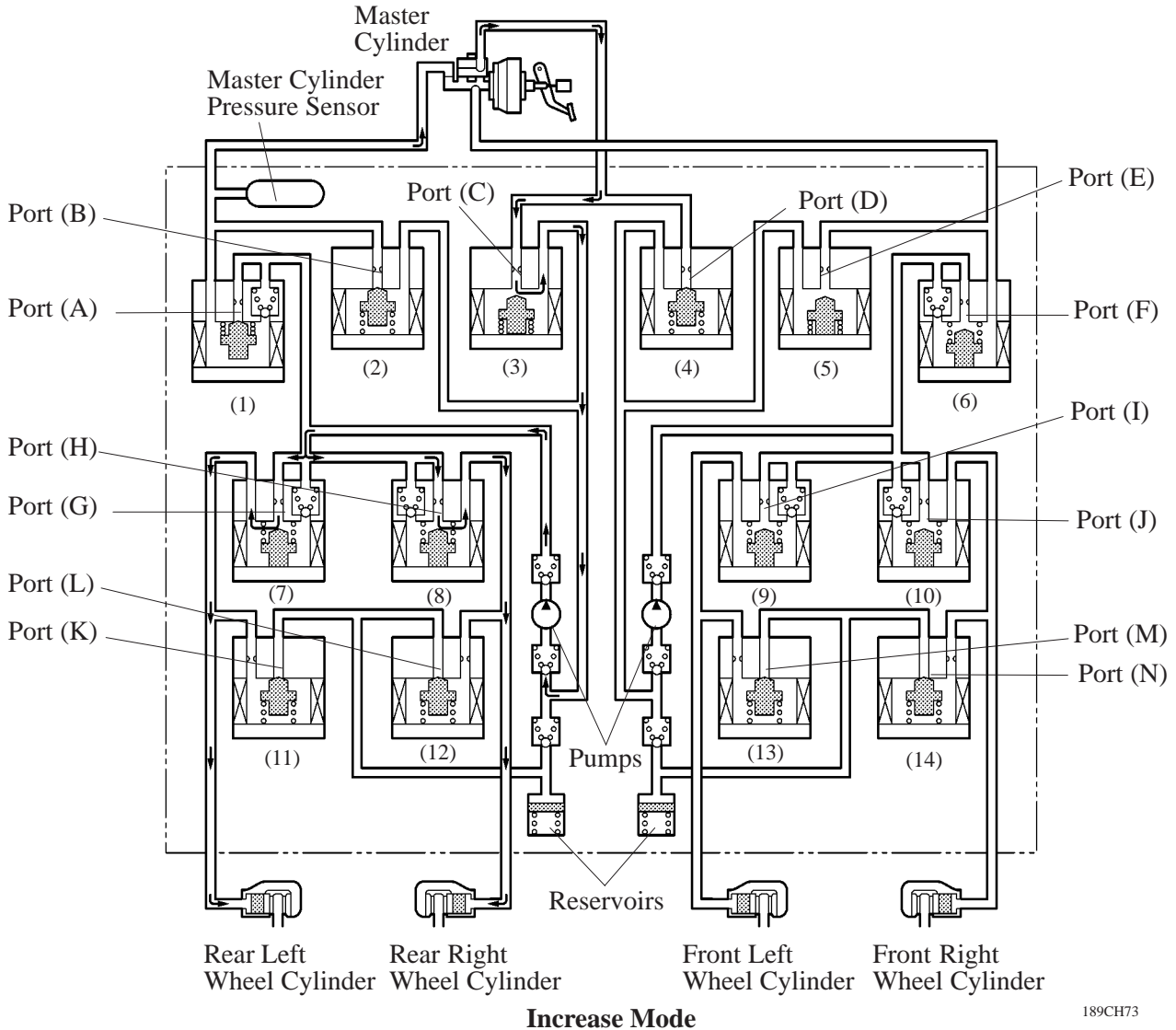
Not Activated	Normal Braking	—	—
Activated	Pressure Increase Mode	Pressure Holding Mode	Pressure Reduction Mode
Hydraulic Circuit	<p>Port A</p> <p>Pressure Holding Valve</p> <p>Port B</p> <p>Pressure Reduction Valve</p> <p>To Wheel Cylinder</p> <p>169CH54</p>	<p>169CH55</p>	<p>To Reservoir and Pump</p> <p>From Wheel Cylinder</p> <p>169CH56</p>
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

**TRC Operation**

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

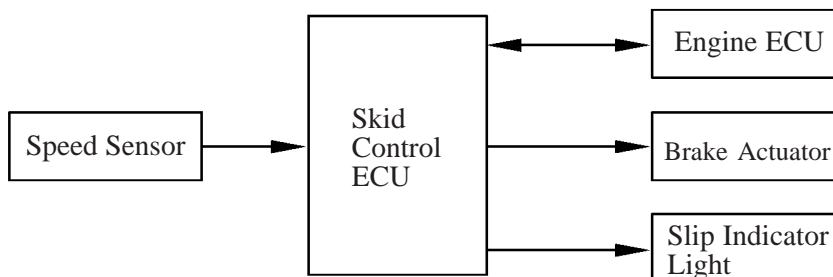
The diagram below shows the hydraulic circuit in the pressure increase mode when the TRC system is activated.

In other operating modes, the pressure holding valve and the pressure reduction valve are turned ON/OFF according to the ABS operation pattern described on the previous page.



189CH73

► **System Diagram** ◀



187CH41

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

\*: This solenoid valve adjusts the pressure depending on the condition.

**CH**

### VSC Operation

#### 1) General

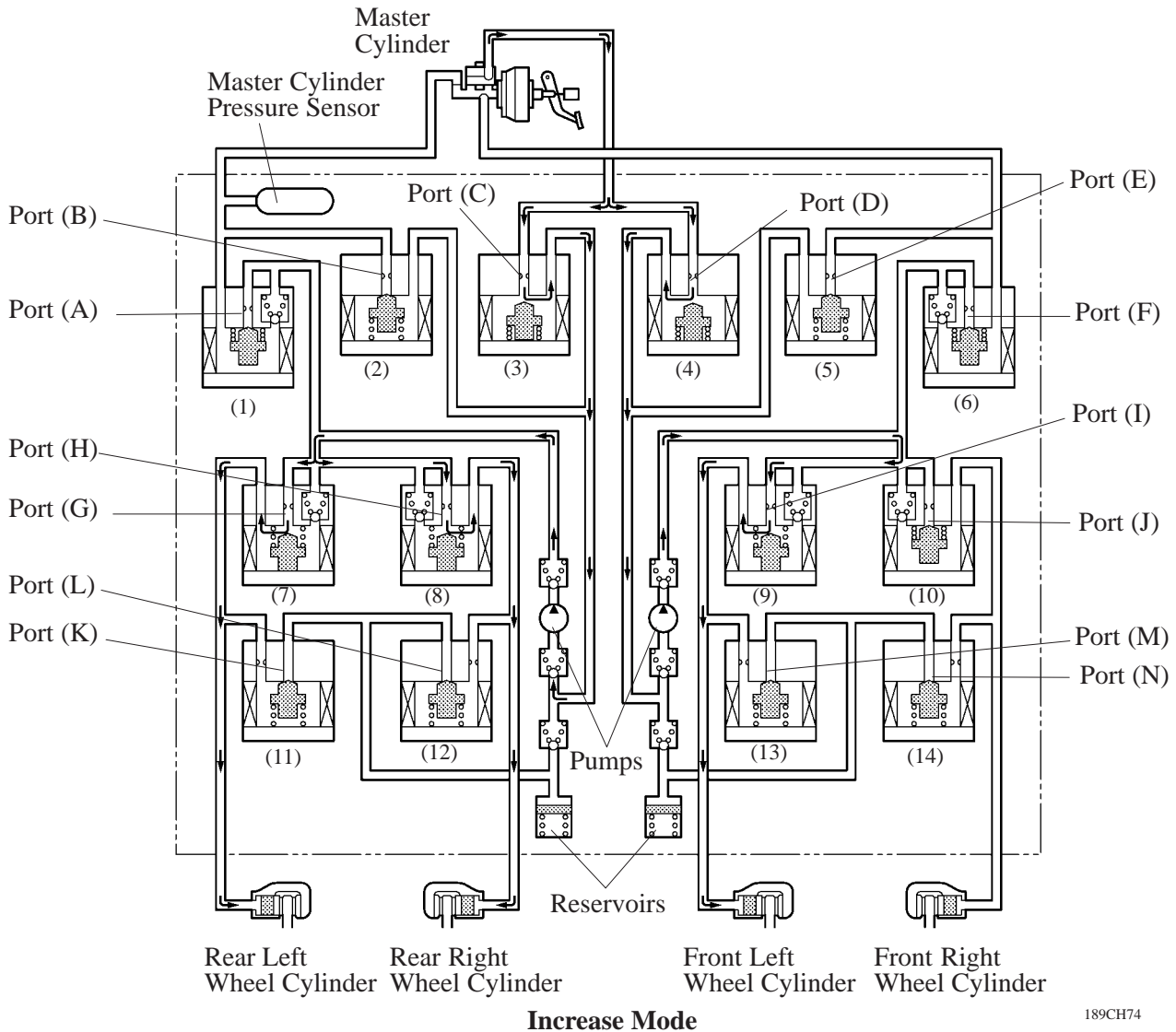
The VSC system, by way of solenoid valves, controls the fluid pressure that is generated by the pump and applies it to the brake wheel cylinder of each wheel in the following 3 modes: pressure reduction, pressure holding, and pressure increase modes. As a result, the tendency to understeer or oversteer is restrained.

#### 2) Understeer Restraining Control (Turning to the Right)

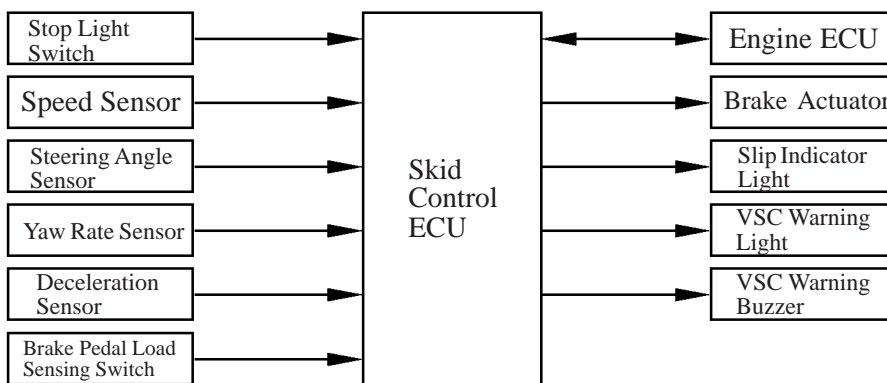
In understeer restraining control, the brakes of the front wheel of the outer side of the turn and rear wheels is applied.

Also, depending on whether the brake is ON or OFF and the condition of the vehicle, there are circumstances in which the brake might not be applied to the wheels even if those wheels are targeted for braking. The diagram below shows the hydraulic circuit in the pressure increase mode, as it restrains an understeer 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 operation pattern.



► System Diagram ◀



189CH102

Item		VSC Not Activated	VSC Activated			
			Pressure Increase Mode	Pressure Holding Mode	Pressure Reduction Mode	
Front Brake	(6)	Master Cylinder Cut Solenoid Valve	OFF	ON	ON	ON
		Port: (F)	(Open)	(Close)	(Close)	(Close)
	(4)	Reservoir Cut Solenoid Valve	OFF	ON	ON	ON
		Port: (D)	(Close)	(Open)	(Open)	(Open)
	(5)	Suction Solenoid Valve	OFF	OFF	OFF	OFF
		Port: (E)	(Close)	(Close)	(Close)	(Close)
	(9)	Pressure Holding Valve (Front Left)	OFF	OFF	ON	ON
		Port: (I)	(Open)	(Open)	(Close)	(Close)
	(10)	Pressure Holding Valve (Front Right)	OFF	ON	ON	ON
		Port: (J)	(Open)	(Close)	(Close)	(Close)
(13)	Pressure Reduction Valve (Front Left)	OFF	OFF	OFF	ON	
	Port: (M)	(Close)	(Close)	(Close)	(Open)	
(14)	Pressure Reduction Valve (Front Right)	OFF	OFF	OFF	OFF	
	Port: (N)	(Close)	(Close)	(Close)	(Close)	
Wheel Cylinder Pressure						
		Front Right	—	—	—	—
		Front Left	—	Increase	Hold	Reduction
Rear Brake	(1)	Master Cylinder Cut Solenoid Valve	OFF	ON	ON	ON
		Port: (A)	(Open)	(Close)	(Close)	(Close)
	(3)	Reservoir Cut Solenoid Valve	OFF	ON	ON	ON
		Port: (C)	(Close)	(Open)	(Open)	(Open)
	(2)	Suction Solenoid Valve	OFF	OFF	OFF	OFF
		Port: (B)	(Close)	(Close)	(Close)	(Close)
	(7)	Pressure Holding Valve	OFF	OFF	ON	ON
	(8)	Port: (G), (H)	(Open)	(Open)	(Close)	(Close)
	(11)	Pressure Reduction Valve	OFF	OFF	OFF	ON
	(12)	Port: (K), (L)	(Close)	(Close)	(Close)	(Open)
Wheel Cylinder Pressure						
		Rear Right	—	Increase	Hold	Reduction
		Rear Left	—	Increase	Hold	Reduction

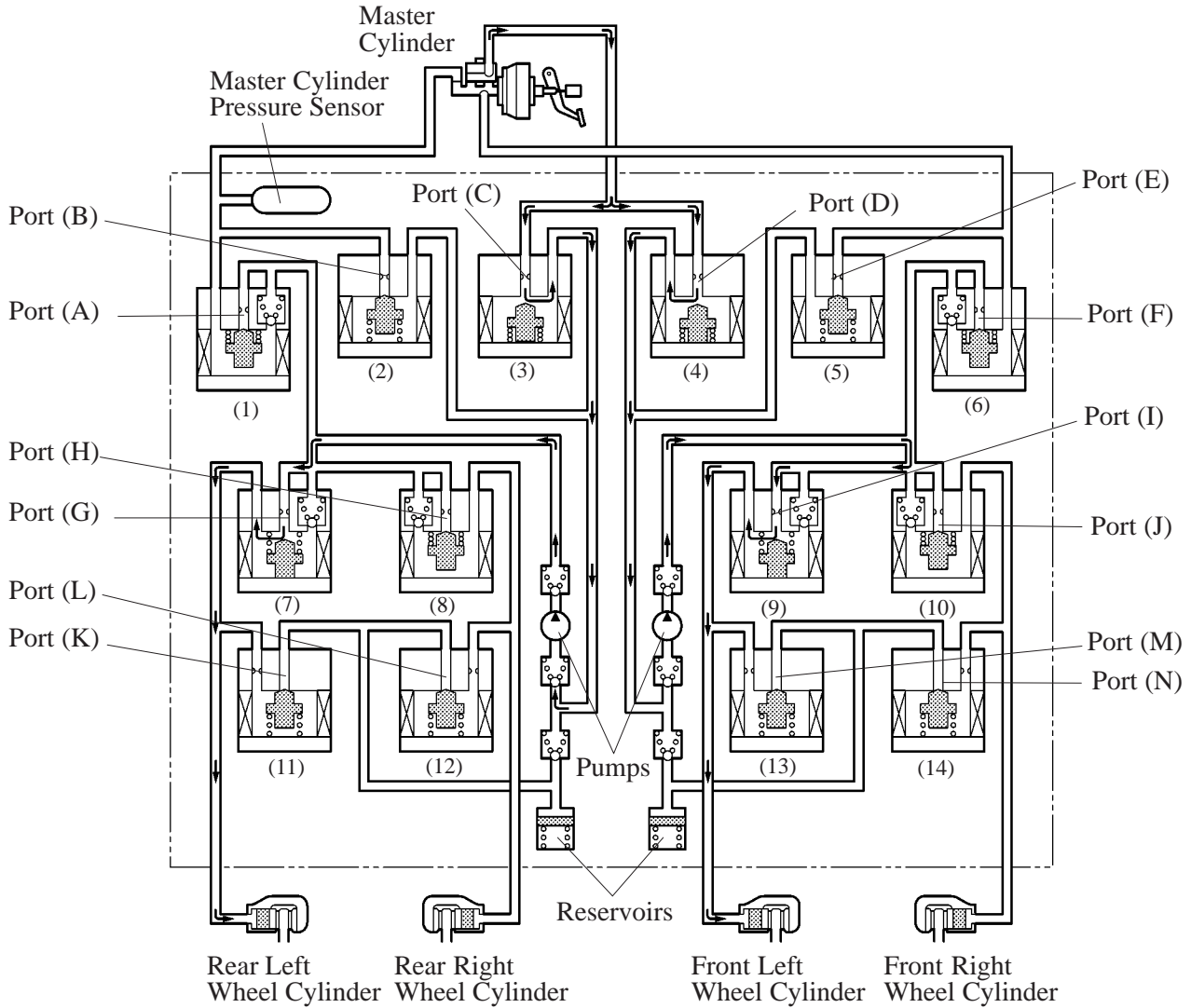
CH

3) Oversteer Restraining Control (Turning to the Right)

In oversteer restraining control, the brake of the front and rear wheels of the outer side of the turn is applied. As an example, the diagram below shows the hydraulic circuit in the pressure increase mode, as it restrains an oversteer condition while the vehicle makes a right turn.

As in understeer restraining control, in other operating modes, the pressure holding valve and the pressure reduction valve are turned ON/OFF according to the ABS operation pattern.

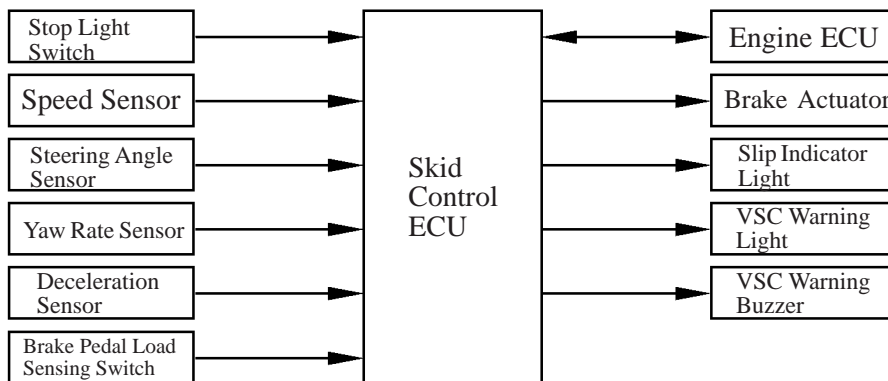
However, in oversteer control, the pressure holding valve is turned ON and blocks the hydraulic passage to the front inner wheel in order to prevent applying the brake to the front inner wheel.



Increase Mode

189CH75

► System Diagram ◀



189CH102

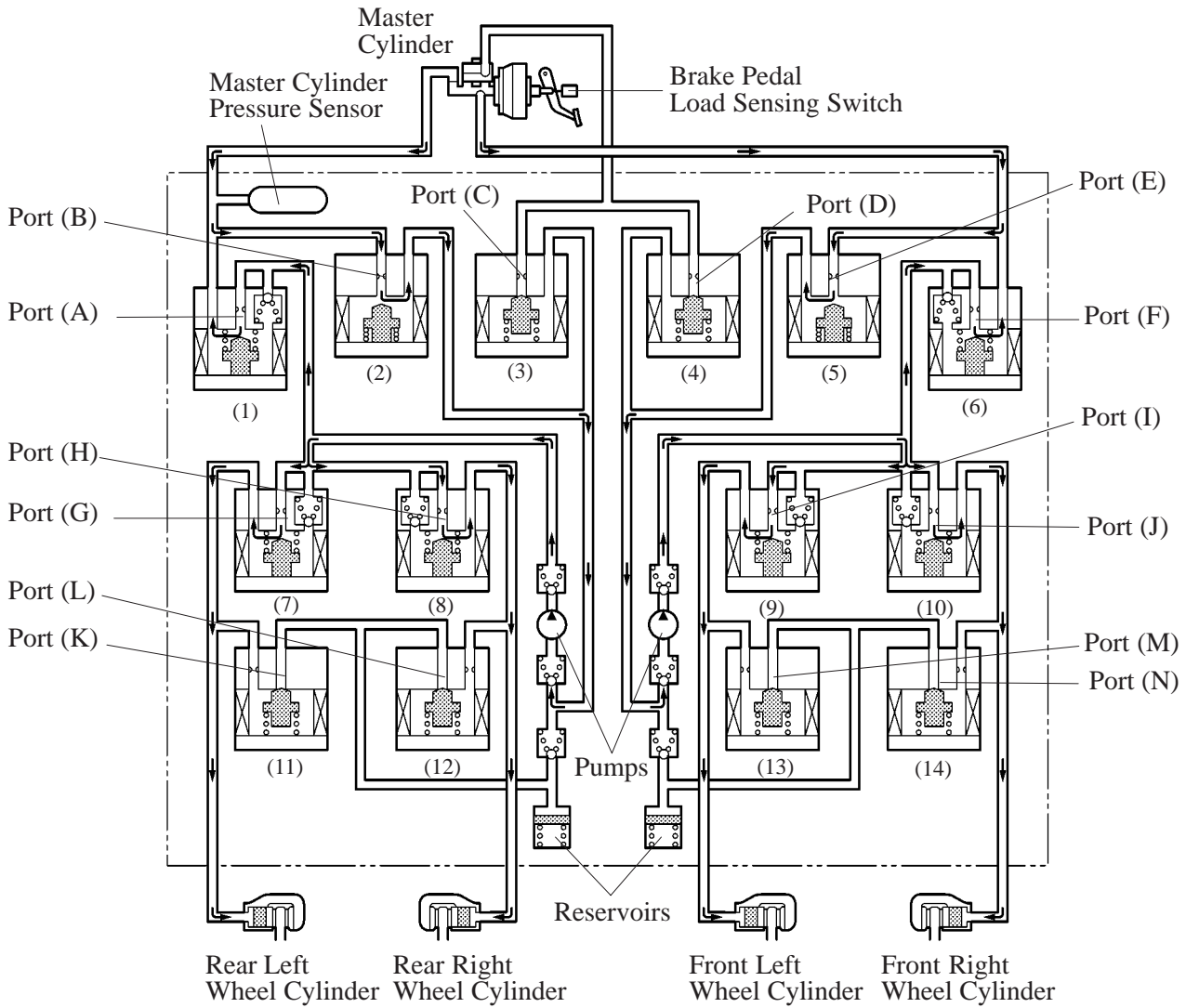
Item		VSC Not Activated	VSC Activated			
			Pressure Increase Mode	Pressure Holding Mode	Pressure Reduction Mode	
Front Brake	(6)	Master Cylinder Cut Solenoid Valve	OFF	ON	ON	ON
		Port: (F)	(Open)	(Close)	(Close)	(Close)
	(4)	Reservoir Cut Solenoid Valve	OFF	ON	ON	ON
		Port: (D)	(Close)	(Open)	(Open)	(Open)
	(5)	Suction Solenoid Valve	OFF	OFF	OFF	OFF
		Port: (E)	(Close)	(Close)	(Close)	(Close)
	(9)	Pressure Holding Valve (Front Left)	OFF	OFF	ON	ON
		Port: (I)	(Open)	(Open)	(Close)	(Close)
	(10)	Pressure Holding Valve (Front Right)	OFF	ON	ON	ON
		Port: (J)	(Open)	(Close)	(Close)	(Close)
(13)	Pressure Reduction Valve (Front Left)	OFF	OFF	OFF	ON	
	Port: (M)	(Close)	(Close)	(Close)	(Open)	
(14)	Pressure Reduction Valve (Rear Right)	OFF	OFF	OFF	OFF	
	Port: (N)	(Close)	(Close)	(Close)	(Close)	
Wheel Cylinder Pressure		Front Right	—	—	—	—
		Front Left	—	Increase	Hold	Reduction
Rear Brake	(1)	Master Cylinder Cut Solenoid Valve	OFF	ON	ON	ON
		Port: (A)	(Open)	(Close)	(Close)	(Close)
	(3)	Reservoir Cut Solenoid Valve	OFF	ON	ON	ON
		Port: (C)	(Close)	(Open)	(Open)	(Open)
	(2)	Suction Solenoid Valve	OFF	OFF	OFF	OFF
		Port: (B)	(Close)	(Close)	(Close)	(Close)
	(7)	Pressure Holding Valve (Rear Left)	OFF	OFF	ON	ON
		Port: (G)	(Open)	(Open)	(Close)	(Close)
	(8)	Pressure Holding Valve (Rear Right)	OFF	ON	ON	ON
		Port: (H)	(Open)	(Close)	(Close)	(Close)
(11)	Pressure Reduction Valve (Rear Left)	OFF	OFF	OFF	ON	
	Port: (K)	(Close)	(Close)	(Close)	(Open)	
(12)	Pressure Reduction Valve (Rear Right)	OFF	OFF	OFF	OFF	
	Port: (L)	(Close)	(Close)	(Close)	(Close)	
Wheel Cylinder Pressure		Rear Right	—	—	—	—
		Rear Left	—	Increase	Hold	Reduction

CH



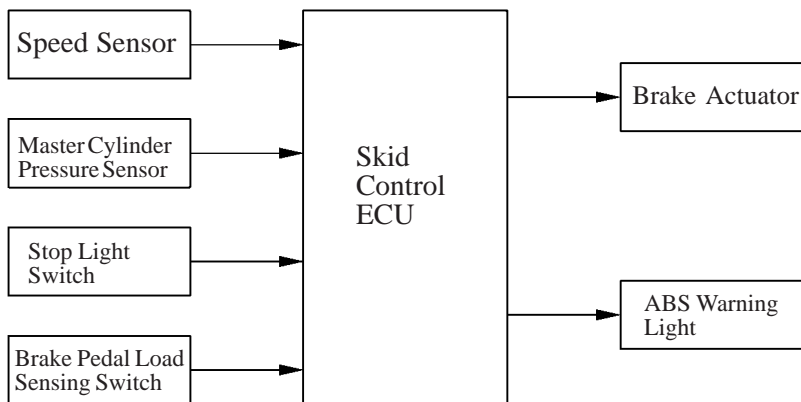
**Brake Assist Operation**

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.



189CH76

► **System Diagram** ◀



189CH94

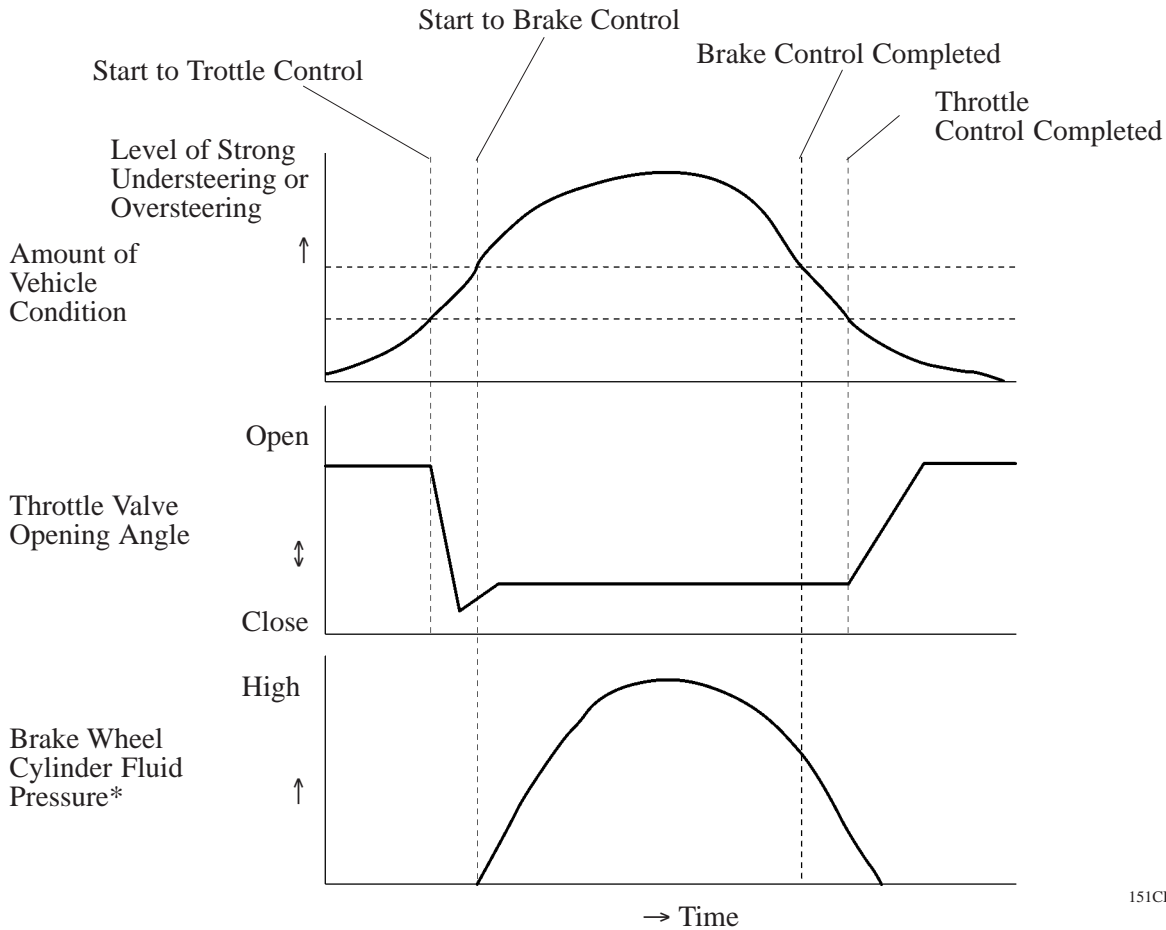
Item		Brake Assist Not Activated	Brake Assist Activated
(1)	Master Cylinder Cut Solenoid Valve (Front, Rear)	OFF	ON*
(6)	Port: (A), (F)	(Open)	(Close)
(3)	Reservoir Cut Solenoid Valve (Front, Rear)	OFF	OFF
(4)	Port: (C), (D)	(Close)	(Close)
(2)	Suction Solenoid Valve (Front, Rear)	OFF	ON
(5)	Port: (B), (E)	(Close)	(Open)
(7), (8)	Pressure Holding Valve (Front, Rear)	OFF	OFF
(9), (10)	Port: (G), (H), (I), (J)	(Open)	(Open)
(11), (12)	Pressure Reduction Valve (Front, Rear)	OFF	OFF
(13), (14)	Port: (K), (L), (M), (N)	(Close)	(Close)

\*: This solenoid valve adjusts the pressure depending on the condition.

## 9. Skid Control ECU

### Vehicle Skid Control

Based on the 4 types of sensor signals received from the speed sensors, yaw rate sensor, deceleration sensor, and steering angle sensor, the skid control ECU calculates the amount of vehicle condition. If a strong understeer or oversteer tendency is created during an emergency avoidance maneuver or cornering, and the skid control ECU determines that the amount of vehicle condition exceeds a prescribed value, it controls the throttle valve opening angle and the brake fluid pressure according to the amount of the vehicle condition.



151CH31

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

### Initial Check

After the ignition is turned ON, and the vehicle attains an approximate speed of 6 km/h (4 mph) or more only at first time, the skid control ECU performs an initial check.

The functions of each solenoid valve and pump motor in the actuator are checked in order.

## Self-Diagnosis

If the skid control ECU detects a malfunction in the VSC system, the warning message, the warning light, or the indicator light that corresponds to the function in which the malfunction has been detected indicates or lights up, as indicated in the table below, to alert the driver of the malfunction. The ECU will also store the codes of the malfunctions.

The DTCs (Diagnostic Trouble Codes) can be accessed through the blinking of the ABS warning light and the multi-information display or the use of the hand-held tester.

For details, see the LEXUS LS430 Repair Manual (Pub. No. RM792E).

Item	ABS	TRC	VSC	EBD	Brake Assist
ABS Warning Light	○	—	—	○	○
Brake System Warning Light	—	—	—	○	—
Warning Message “CHECK VSC”	—	○	○	—	—
VSC OFF Indicator Light	—	○	○	—	—

## Fail-Safe

In the event of a malfunction in the skid control ECU turns on the ABS warning light and VSC warning light and prohibits the ABS, TRC, VSC, and Brake Assist. In the case of the malfunction that the EBD control can not be carried out, the ECU also turns on the brake system warning light and prohibits the EBD control.