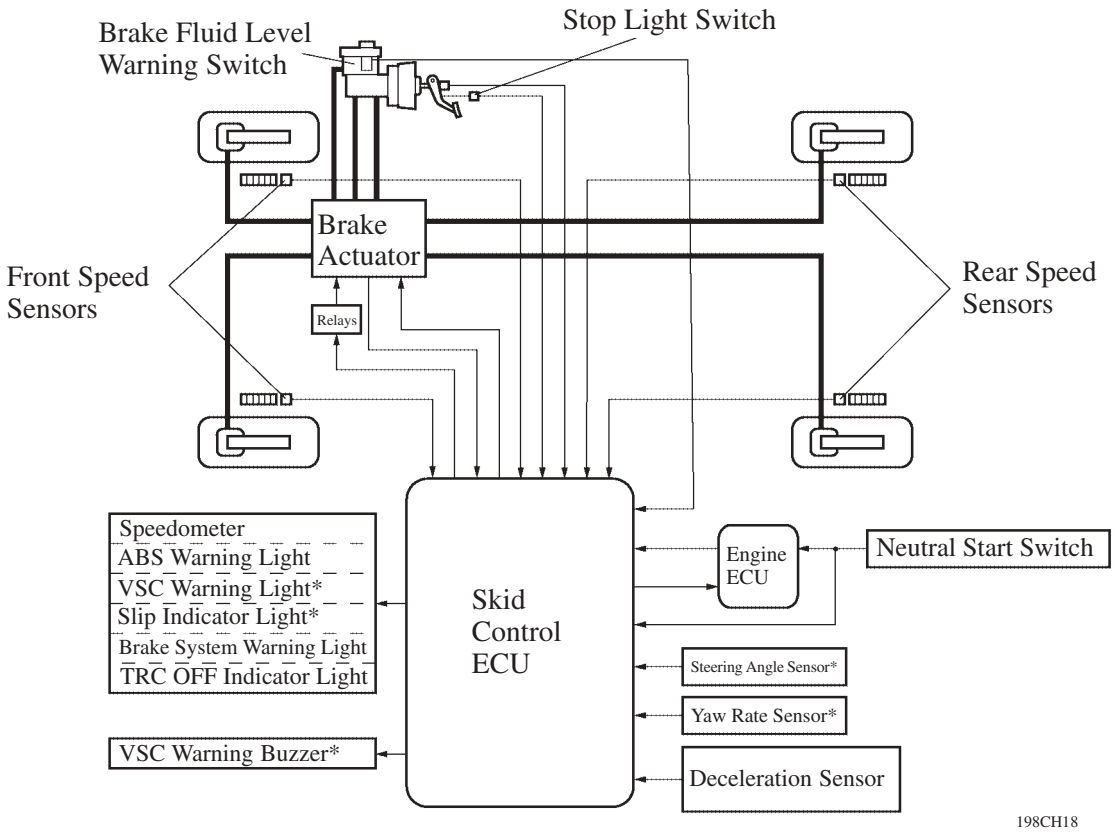
■ ABS with EBD & BRAKE ASSIST & TRC & VSC SYSTEM

1. General

- The ABS helps prevent the wheels from locking when the brakes are applied firmly or when braking on a slippery surface.
- 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.
- 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 TRC system helps prevent the drive wheels from slipping if the driver presses the accelerator pedal excessively when starting off or accelerating on a slippery surface.
- The VSC system helps prevent the vehicle from slipping sideways as a result of strong front wheel skid or rear wheel skid during cornering.

2. System Diagram



*: with VSC System

3. Outline of EBD Control

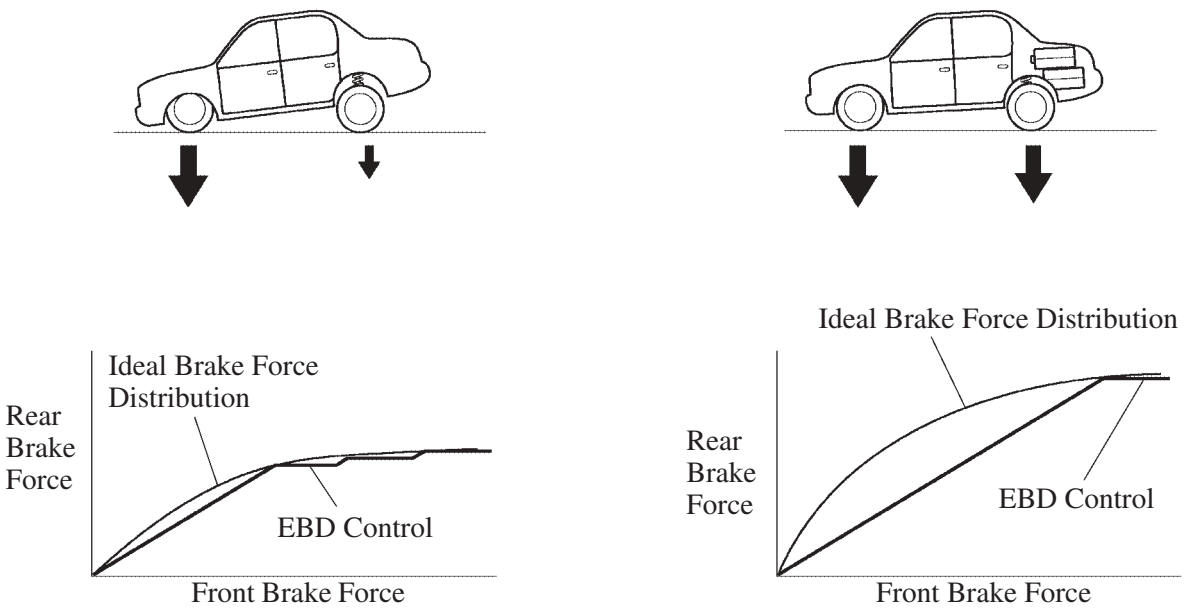
General

The distribution of the brake force, which was performed mechanically in the past, is now performed under electrical control of the skid control ECU, 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.

▶ EBD Control Concept ◀

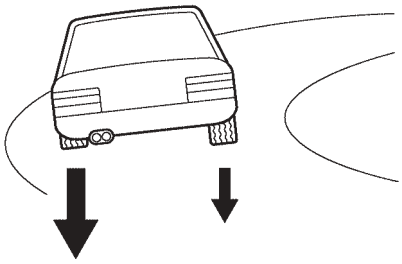


without Load in Rear **with Load in Rear**

182CH56

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

4. 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 –

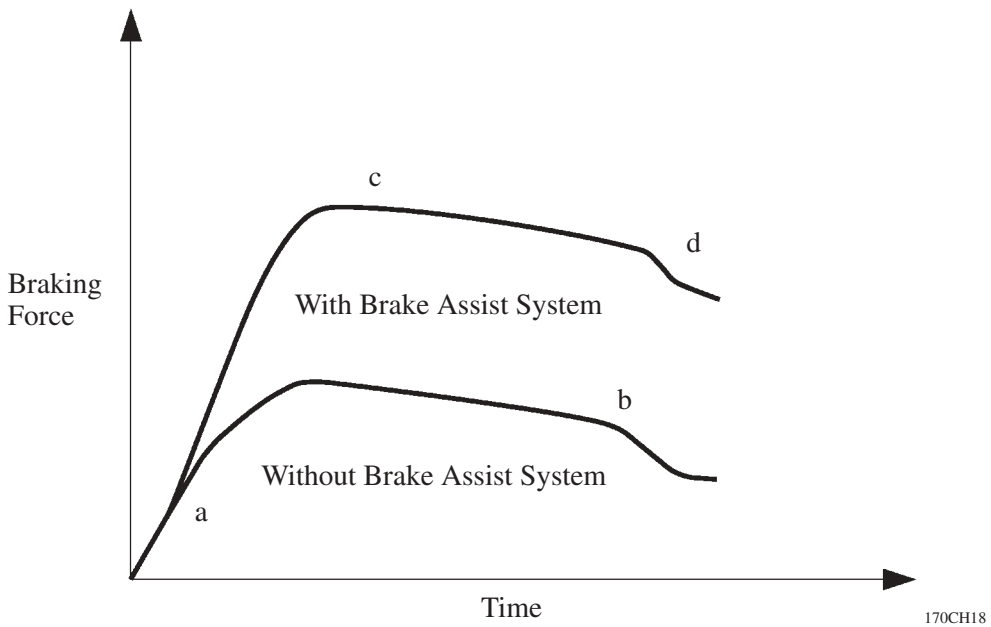
Effectiveness of the Brake Assist Operation 1:

a. 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.

b. The pedal effort of this type of driver might weaken as time passes, causing a reduction in the braking force.

c. 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.

d. 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

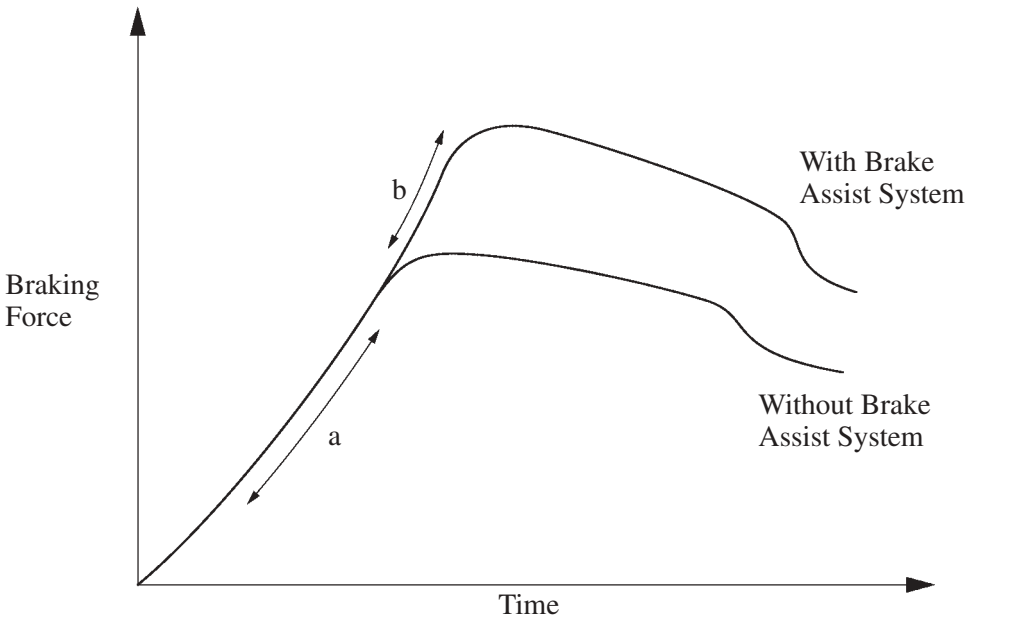
Service Tip

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.

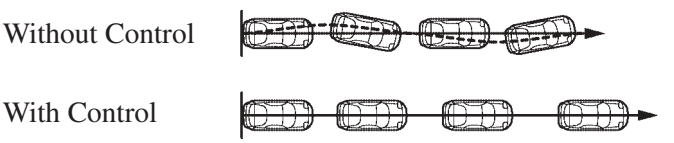
b. In such a case where stronger brake force is required, the Brake Assist system also increases brake force.



189CH70

5. Outline of TRC System

If the driver presses the accelerator pedal excessively when starting off or accelerating on a slippery surface, the drive wheel 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, the TRC system helps minimize the slippage of the drive wheels, thus generating the drive force that is appropriate for the road surface conditions.



Straightline Start-Off Control

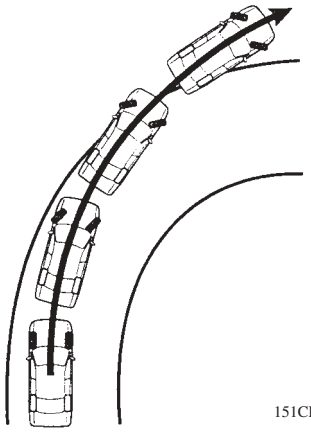
199CH41

6. Outline of VSC System

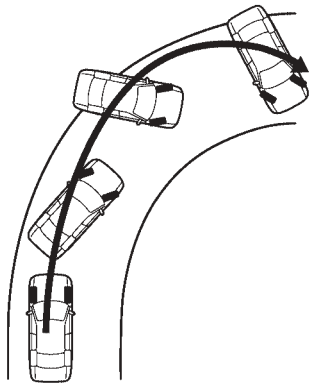
General

The followings are two examples that can be considered as circumstances in which the tires overcome their lateral grip limit.
VSC system is to help control the vehicle position by applying the engine output control and brake control when the vehicle is under the condition indicated below.

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



Strong Front Wheel Skid Tendency



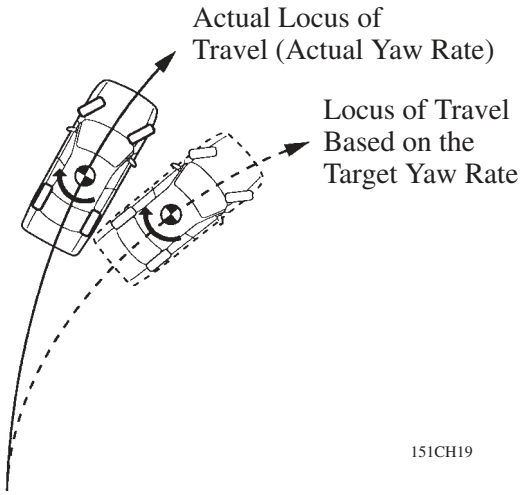
Strong Rear Wheel Skid Tendency

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.

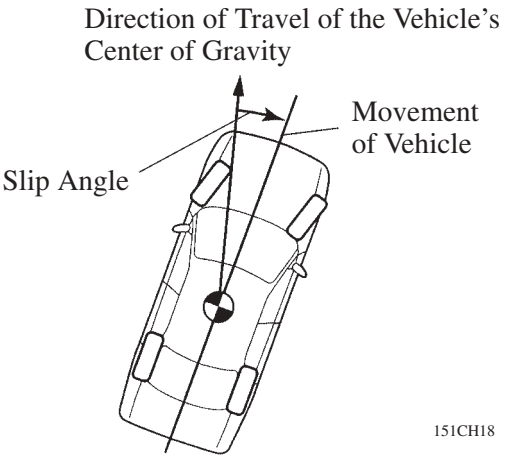
1) Determining Front Wheel Skid

Whether or not the vehicle is in the state of 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 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 front wheel skid.



2) Determining Rear Wheel Skid

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

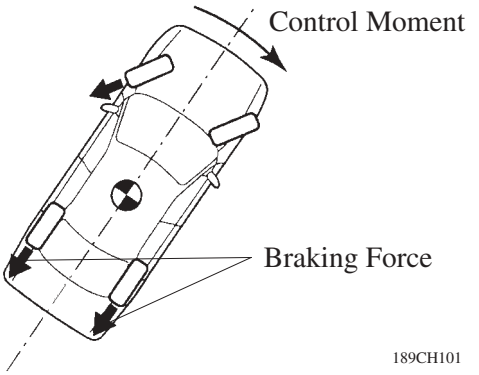


Method of VSC Operation

When the skid control ECU determines that the vehicle exhibits a tendency to front wheel skid or rear wheel skid, it decreases the engine output and applies the brake of a 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

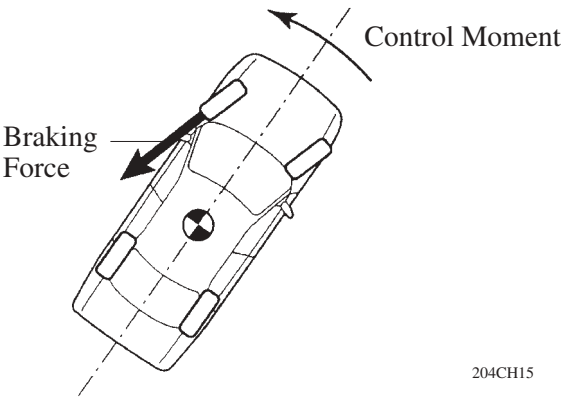
When the skid control ECU determines that there is a large front wheel skid tendency, it counteracts in accordance with the extent of that tendency. The skid control ECU controls the engine power output and applies the brakes of the rear wheels in order to restrain the front wheel skid tendency.



Making a Right Turn

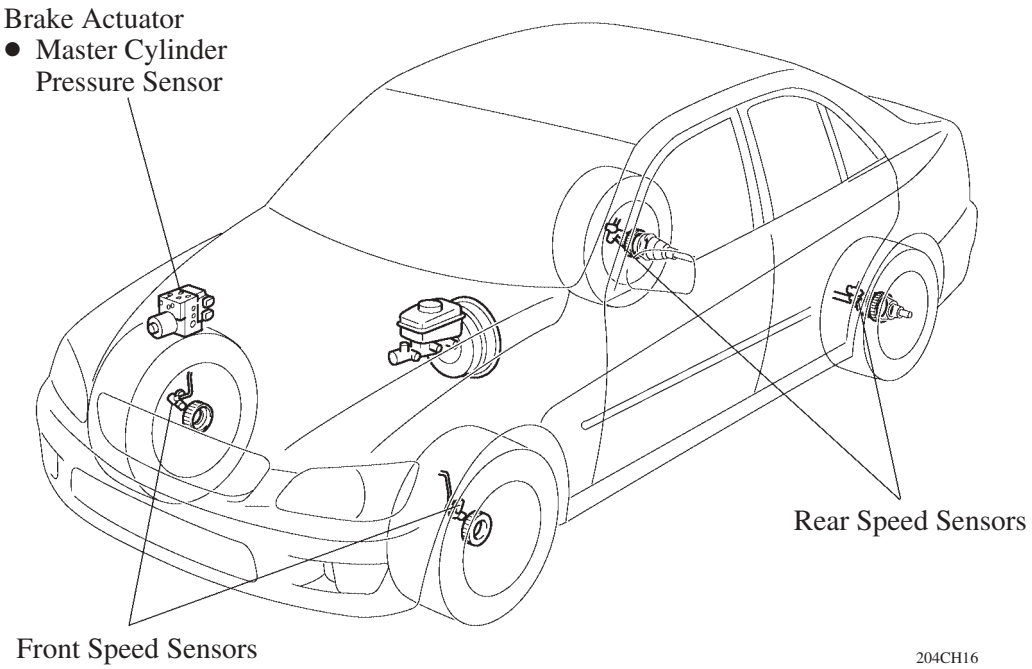
2) Dampening a Rear Wheel Skid

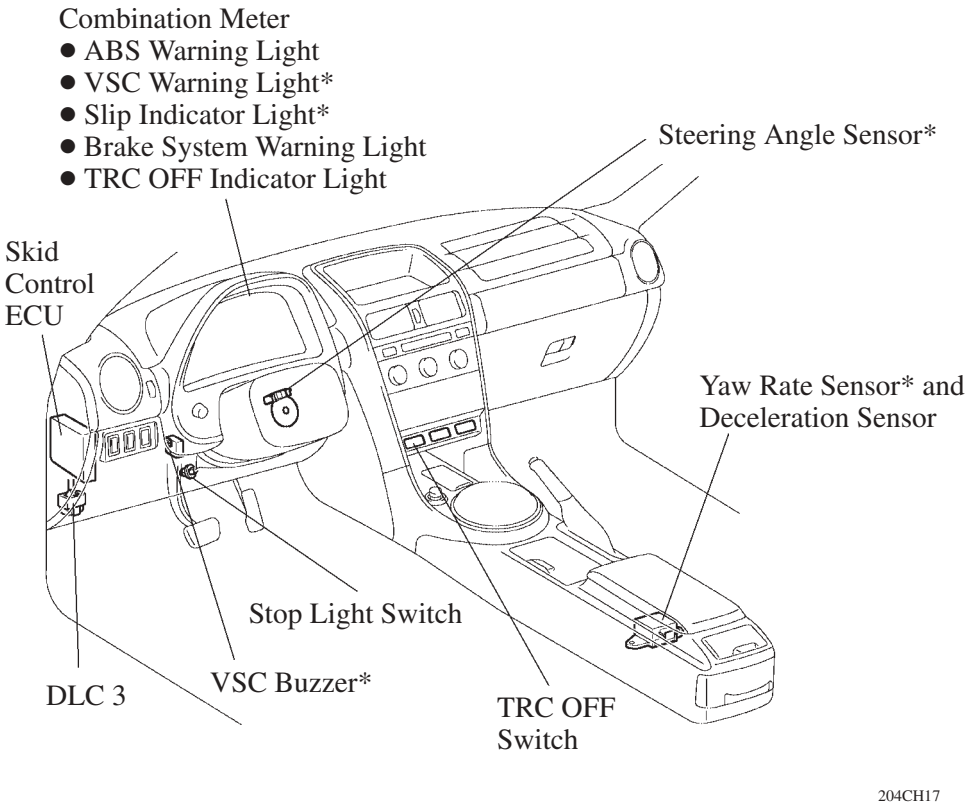
When the skid control ECU determines that there is a large rear wheel skid tendency, it counteracts in accordance with the extent of that tendency. It applies the brakes of the front wheel of the outer circle of the turn, and generates an outward moment of inertia in the vehicle, in order to restrain the rear wheel skid tendency. Along with the reduction in the vehicle speed caused by the braking force, the vehicle's stability is further improved.
In some cases, the skid control ECU applies the brakes of the rear wheels, as necessary.



Making a Right Turn

7. Layout of Components





LHD Model

*: with VSC System

8. Function of Components

Components		Function
Warning Light and Indicator Light	ABS Warning Light	Lights up to alert the driver when the skid control ECU detects the malfunction in the ABS or Brake Assist System.
	VSC Warning Light*	Lights up to alert the driver when the skid control ECU detects the malfunction in the VSC system.
	Slip Indicator Light*	Blinks to inform the driver when the TRC system or the VSC system is operated.
	Brake System Warning Light	Lights up together with the ABS warning light to alert the driver when the skid control ECU detects the malfunction not only in the ABS but also in the EBD control.
	TRC OFF Indicator Light	Lights up to inform the driver when the TRC system is turned OFF by the TRC OFF switch. Light up to alert the driver when the skid control ECU detects the malfunction in the TRC system.
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		Detect 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 cylinders.
	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.
Brake Fluid Level Warning Switch		Detects the brake fluid level.
VSC Warning Buzzer*		Emits an intermittent sound to inform the driver that the skid control ECU detects the strong front wheel skid tendency or strong rear wheel skid tendency.
Stop Light Switch		Detects the brake depressing signal.
Yaw Rate Sensor*		Detects the vehicle's yaw rate.
Deceleration Sensor*		Detects the vehicle's acceleration in the forward and rearward directions.
Steering Angle Sensor*		Detects the steering direction and angle of the steering wheel.
TRC OFF Switch		Turn the TRC system inoperative.

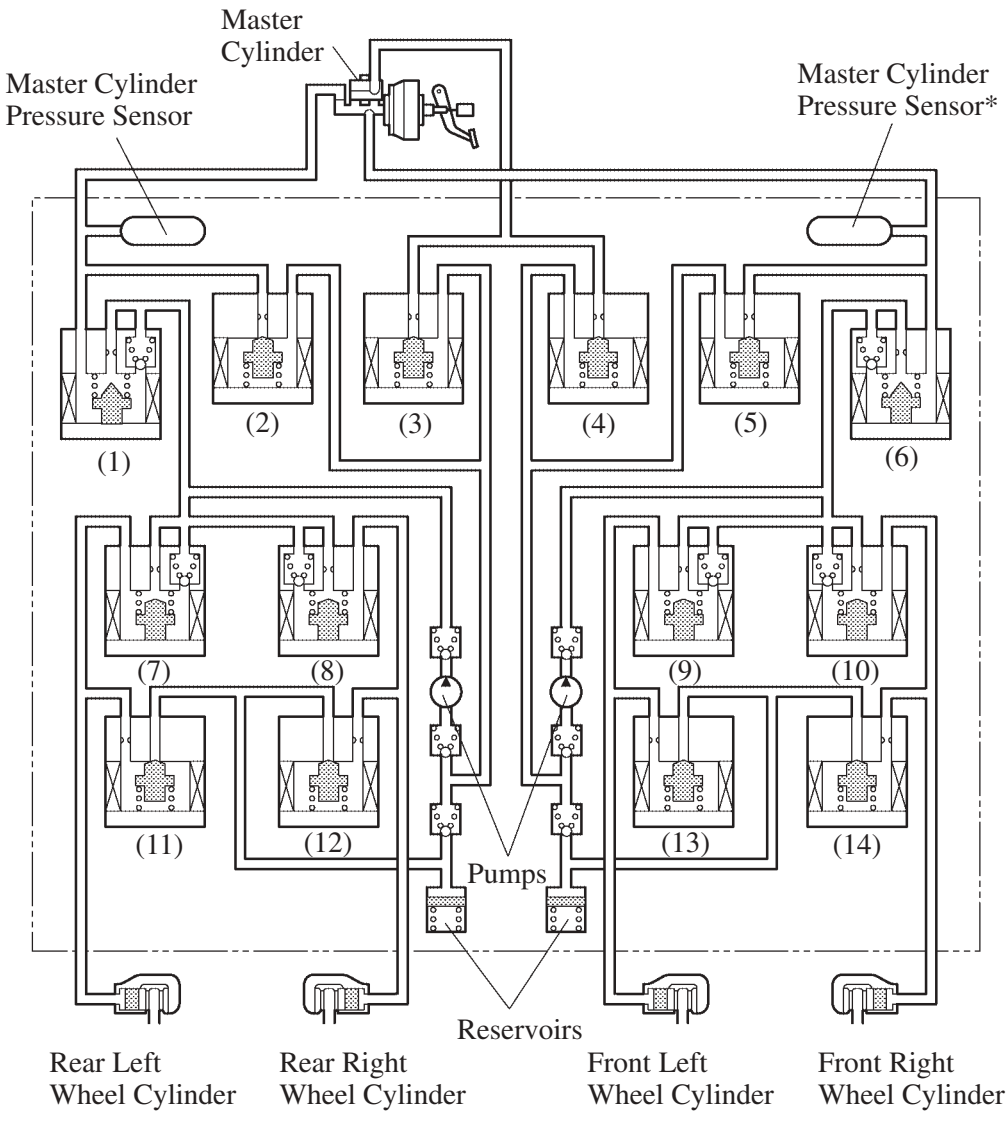
*: with VSC System

9. Brake Actuator

Construction

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

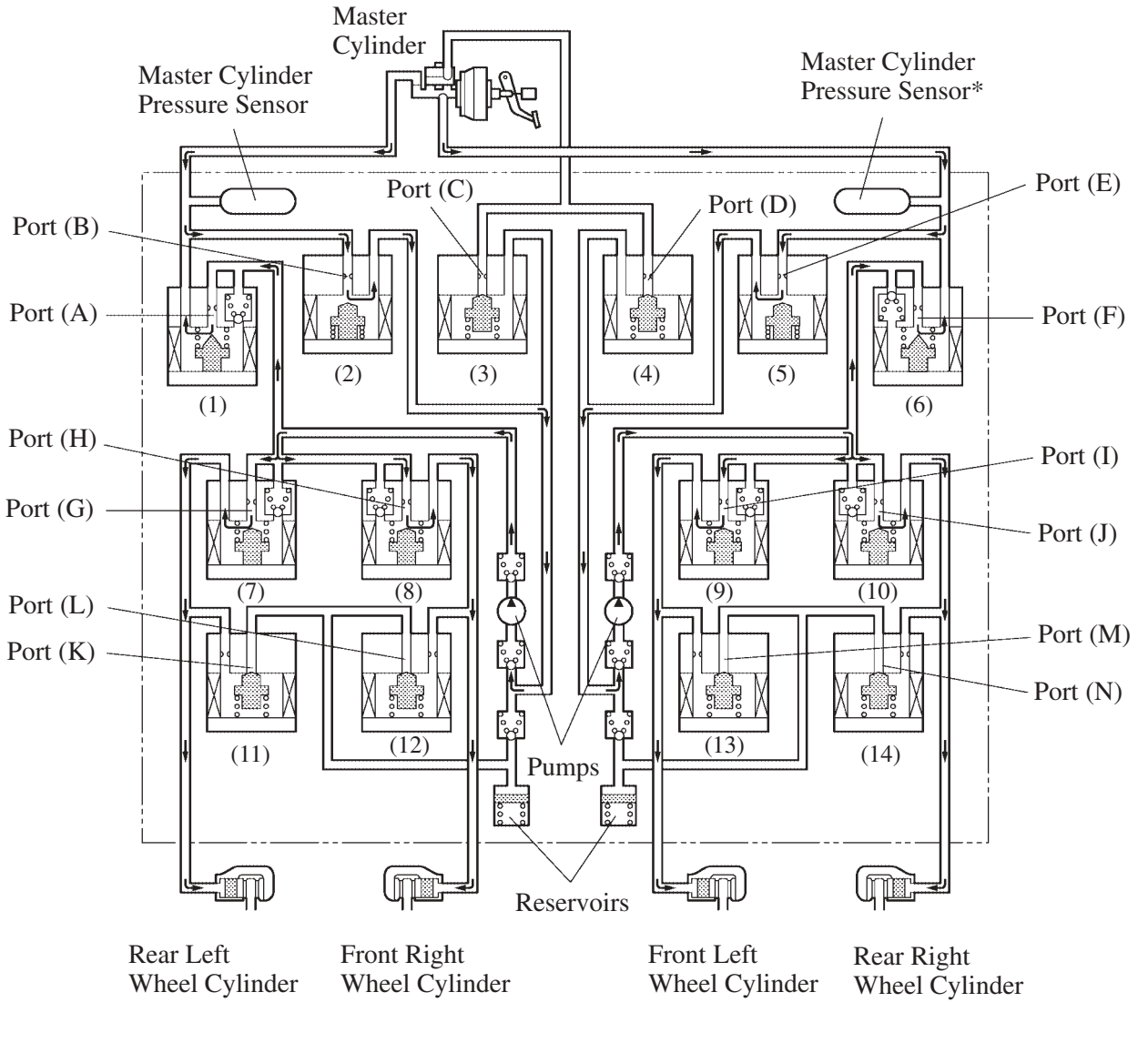


204CH18

*: with VSC System

Brake Assist Operation

If an emergency braking situation has occurred, it is detected by the skid control ECU based on the vehicle speed signal from the speed sensor, and the brake pedal application speed from the master cylinder pressure sensor. Then, the skid control ECU actuates the switching solenoid valves. As a result, the fluid pressure 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.



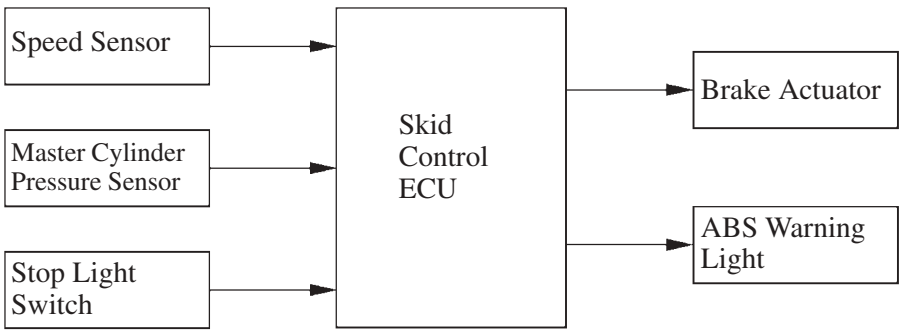
240CH19

*: with VSC System

Item		Brake Assist Not Activated	Brake Assist Activated
(1)	Master Cylinder Cut Solenoid Valve (Front, Rear)	OFF	ON*
(6)	Port: (A), (F)	(Open)	
(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.

▶ System Diagram ◀



204CH20

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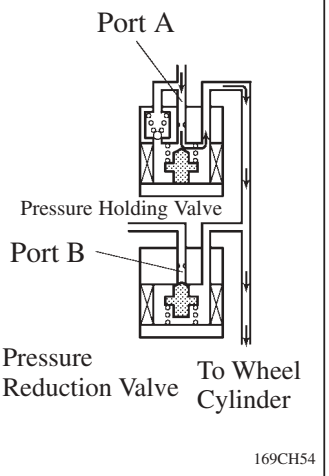
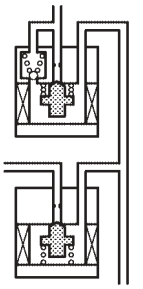
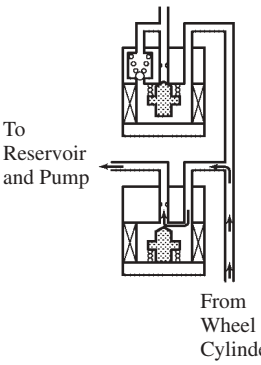
ABS with EBD Operation

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.

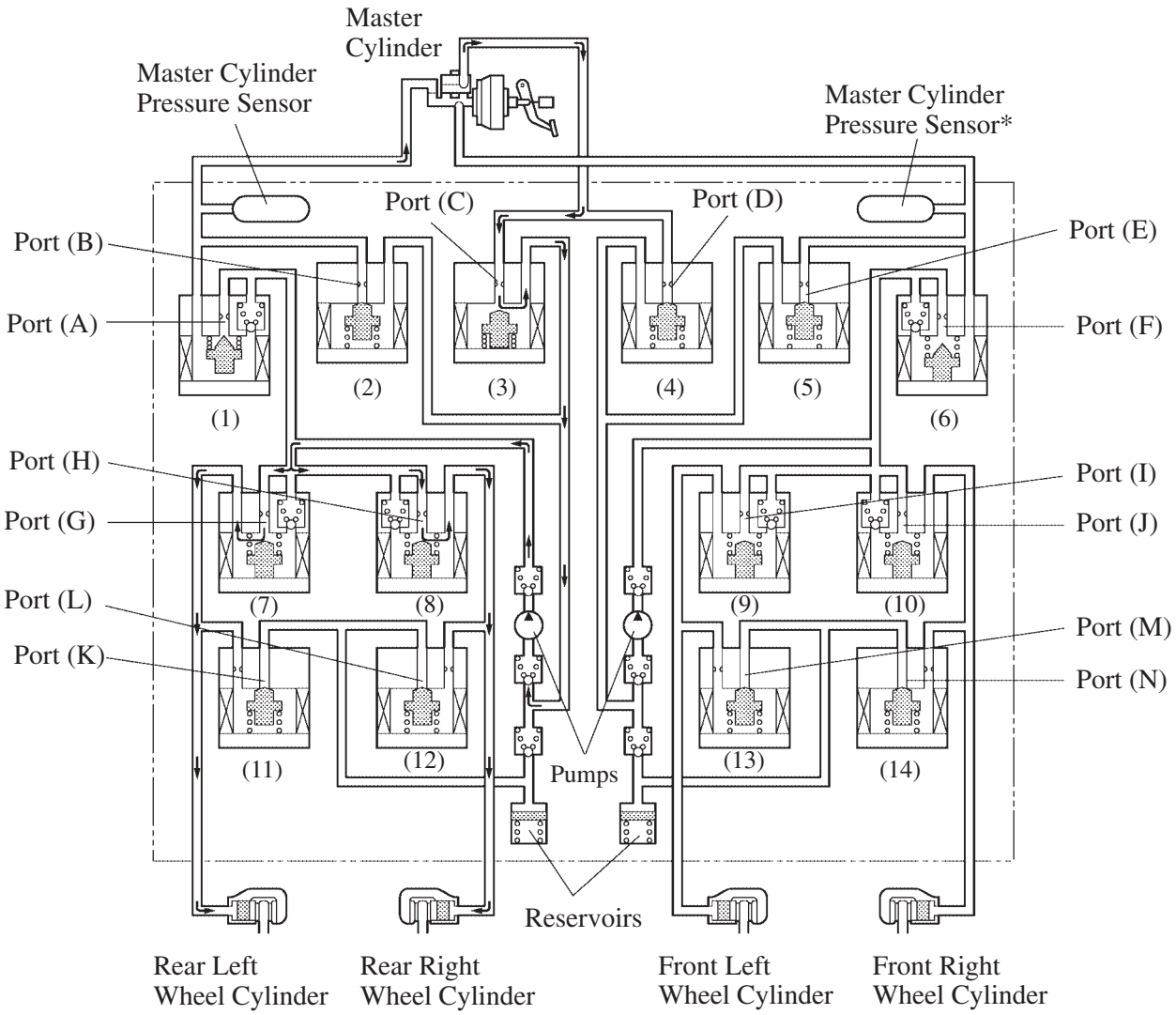
Not Activated	Normal Braking	—	—
Activated	Pressure Increase Mode	Pressure Holding Mode	Pressure Reduction Mode
Hydraulic Circuit			
Pressure Holding Valve (Port A)	OFF (Open)	ON (Close)	ON (Close)
Pressure Reduction Valve (Port B)	OFF (Close)	OFF (Close)	ON (Open)
Wheel Cylinder Pressure	Increase	Hold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



Increase Mode

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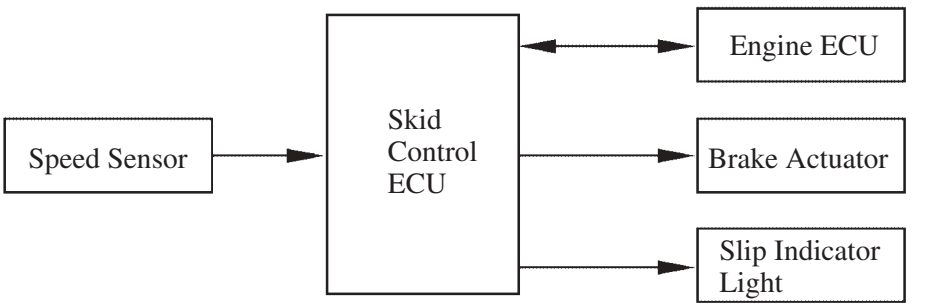
*: with VSC System

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)	(Close)	(Close)	(Close)	(Close)
	(9)	Pressure Holding Valve	OFF	OFF	OFF	OFF
	(10)	Port: (I), (J)	(Open)	(Open)	(Open)	(Open)
	(13)	Pressure Reduction Valve	OFF	OFF	OFF	OFF
	(14)	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)			
	(3)	Reservoir Cut Solenoid Valve	OFF	ON	OFF	OFF
		Port: (C)	(Close)	(Open)	(Close)	(Close)
	(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		—	Increase	Hold	Reduction

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

▶ System Diagram ◀

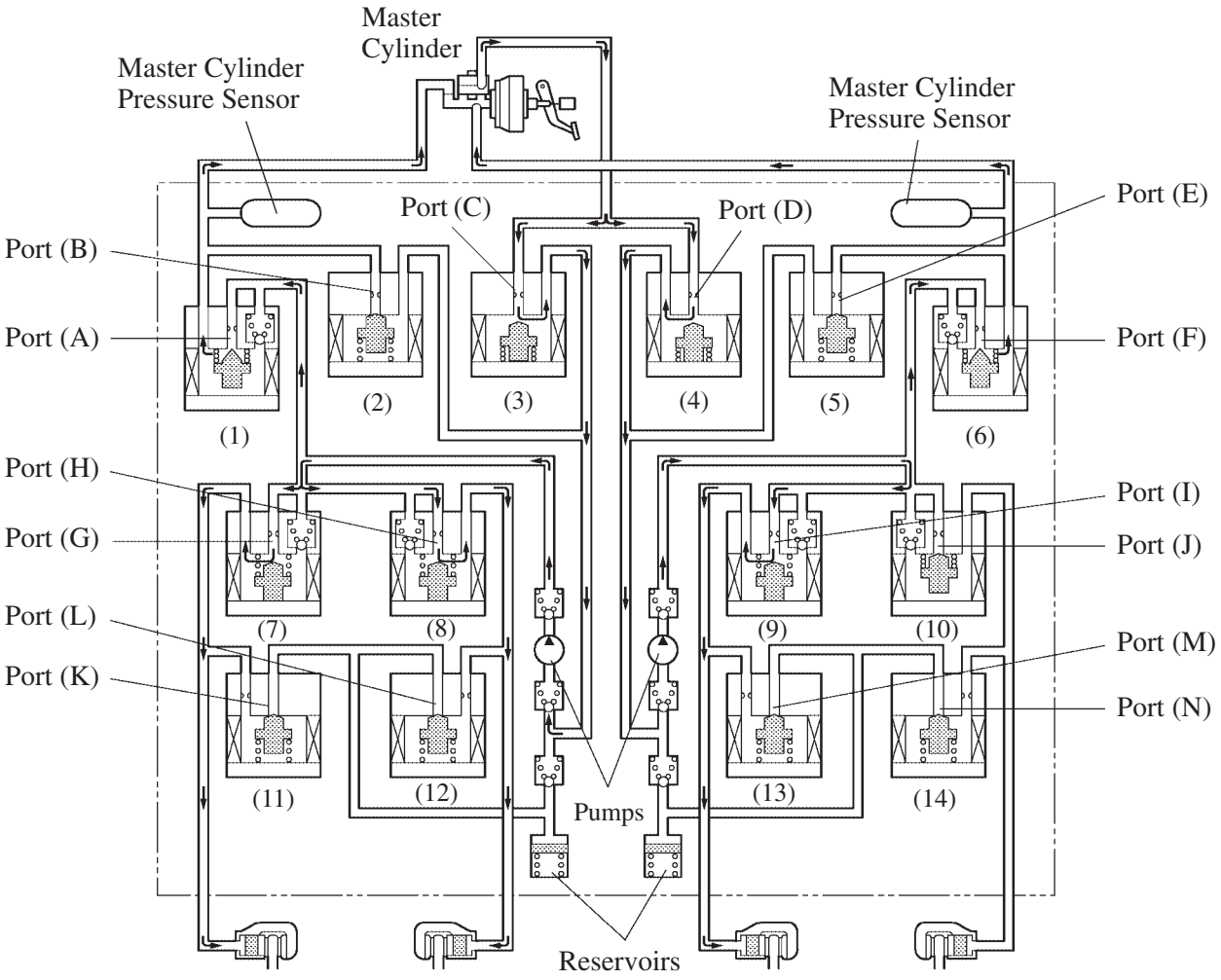


187CH41

VSC Operation

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.

The diagram below shows the hydraulic circuit in the pressure increase mode when the VSC system is effecting rear wheel skid restraining control while the vehicle is making a right turn.



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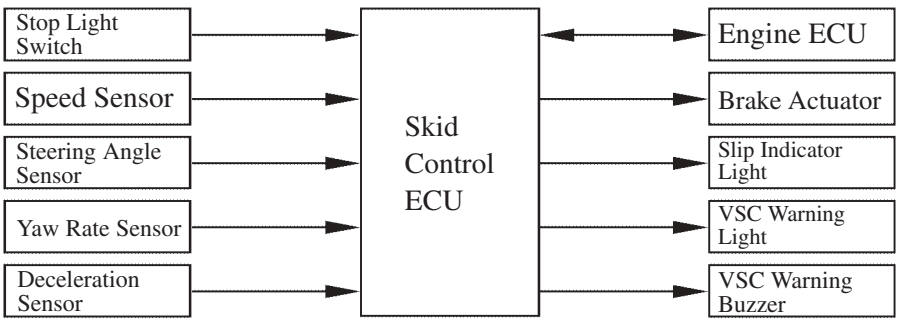
Increase Mode

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

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

▶ System Diagram ◀

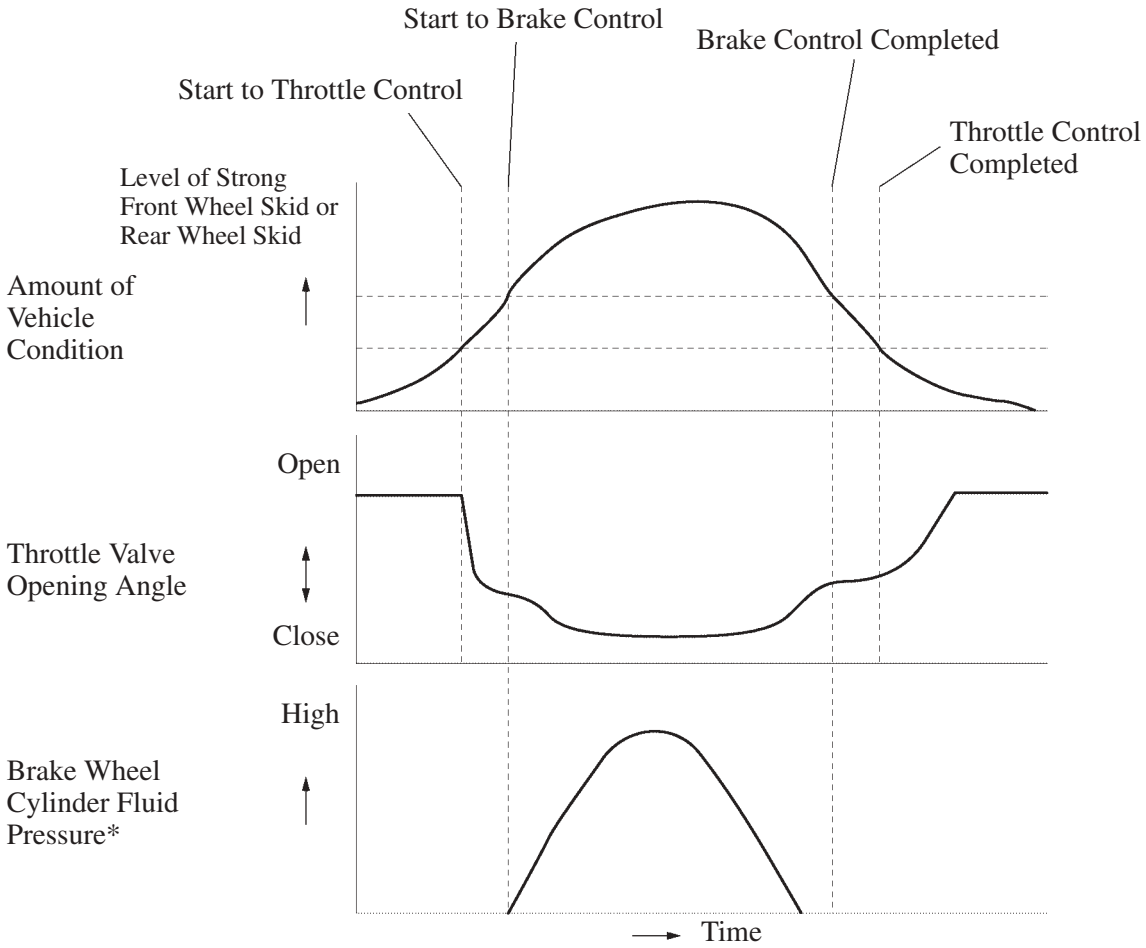


204CH23

10. Skid Control ECU

Vehicle Stability 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 front wheel skid or rear wheel skid 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.



*: 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 ABS with EBD, Brake Assist, TRC and VSC system, 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.

○: Light ON —: Light OFF

Item	ABS	EBD	Brake Assist	TRC	VSC*	Skid Control ECU
VSC Warning Light*1	○	—	—	○	○	○*1
TRC OFF Indicator Light*2	○	—	—	○	○	○
ABS Warning Light	○	○	○	—	—	○
Brake System Warning Light	—	○	—	—	—	—

- If the skid control ECU detects a malfunction in this system, it illuminates the warning light or indicator light to alert the driver. At the same time, the DTCs (Diagnostic Trouble Codes) are stored in memory. The DTCs can be read by connecting the SST (09843-18040) between the Tc and E_1 terminals of DLC3 and observing the blinking of the ABS warning light, TRC OFF indicator light and VSC warning light*, or by connecting a hand-held tester.
  For Details, see the LEXUS IS300/200 Repair Manual Supplement (Pub. No. RM870E).

*1: with VSC System
*2: without pushing "TRC OFF" switch

– Changes (from previous IS200) –

The DTCs listed below have been added.

▶ Output by Blinking ABS Warning Light ◀

DTC No.	Detection Item
C1246/46	Malfunction in master cylinder pressure sensor

▶ Output by Blinking VSC Warning Light ◀

DTC No.	Detection Item	DTC No.	Detection Item
C1231/31	Malfunction in steering angle sensor.	C1235/35	Open circuit in steering angle sensor.
C1232/32	Malfunction in deceleration sensor (constant output).	C1236/36	Zero point calibration of yaw rate sensor undone.
C1233/33	Open or short circuit in yaw rate sensor circuit.	C1336/39	Zero point calibration of deceleration sensor undone.
C1234/34	Malfunction in yaw rate sensor.	C1360/61	Malfunction in master cylinder pressure sensor.

Fail-Safe

In the event of a malfunction in the skid control ECU turns on the ABS warning light, TRC OFF indicator light and VSC warning light*, and prohibits the ABS with EBD, Brake Assist, TRC and VSC system. 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.

*: with VSC System