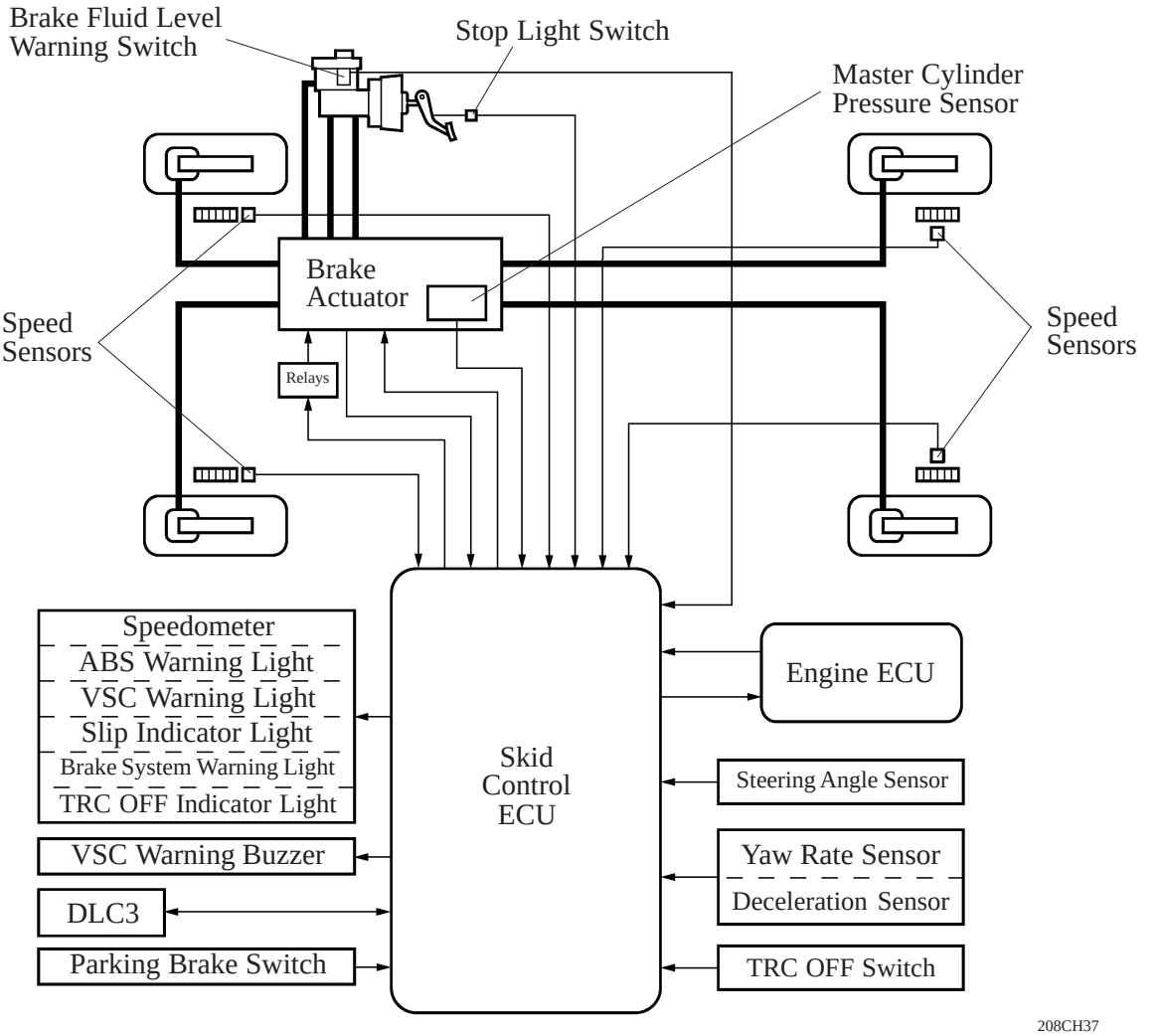
■ABS with EBD & BRAKE ASSIST & TRC & VSC SYSTEM

1. General

- The primary purpose of the ABS and TRC system has been to help the vehicle's behavior during braking and acceleration.
  In contrast, the purpose of the VSC system is to help maintain the vehicle's behavior during cornering.
- The TRC system controls driving wheels, therefore, it controls the front wheels.
  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 maintain vehicle behavior.
- 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.
- 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 behavior.

2. System Diagram



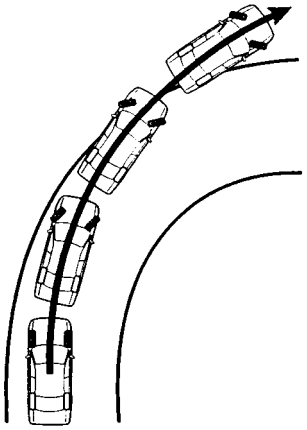
208CH37

3. Outline of VSC System

General

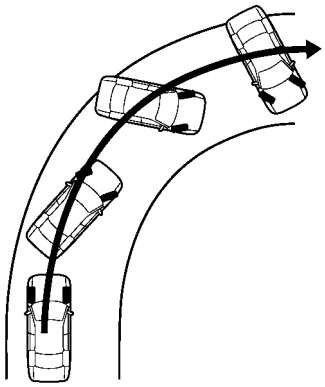
The followings are two examples that can be considered as circumstances in which the tires over their lateral grip limit.
VSC system is to help control the vehicle behavior by applying the engine output control and each wheels brake control when the vehicle is under the condition indicated below.

- 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 overstee tendency).



Strong Understeer Tendency

151CH17



Strong Oversteer Tendency

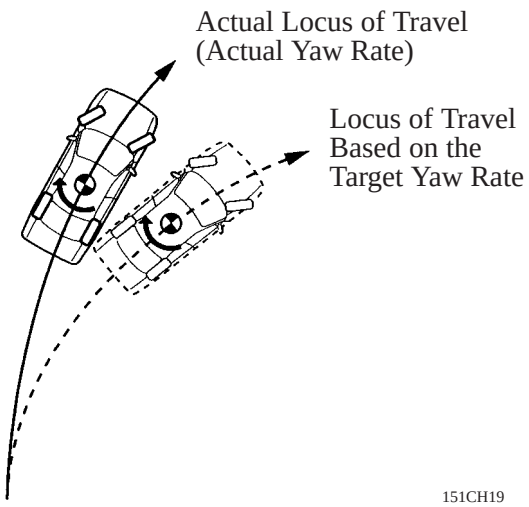
189CH100

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

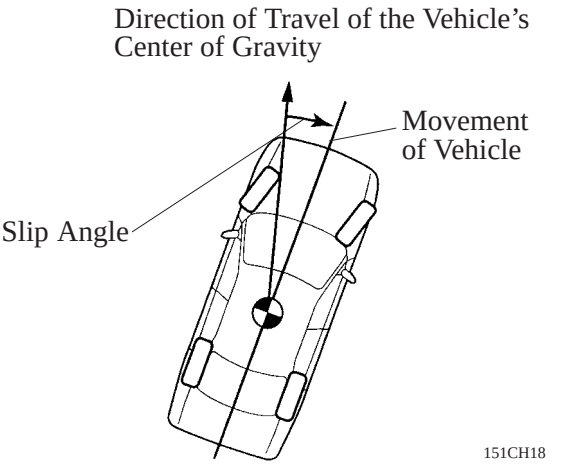
Whether or not the vehicle is in the state of understeer is determined by the difference between the target yaw rate and the vehicle's actual yaw rate. When the vehicle's actual yaw rate is smaller than the yaw rate (a target yaw rate that is determined by the vehicle speed and steering angle) that should 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 vehcle'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

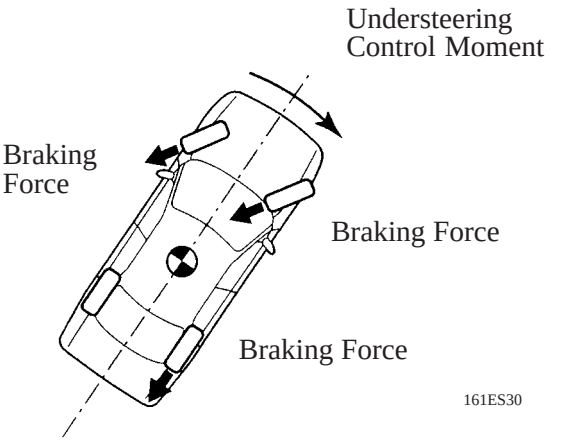
When the skid control ECU determines that the vehicle exhibits a tendency to understeer or oversteer, it decreases the engine output and applies the brake of a front or rear wheel to control the vehicle's yaw moment.

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 Understeer

When the skid control ECU determines that the vehicle exhibits a strong tendency to understeer, depending on the extent of that tendency, it decreases 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.

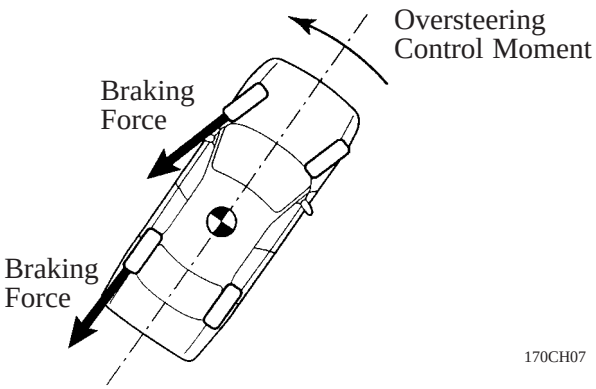
Also, depending on whether the brakes are ON or OFF and the condition of the vehicle, there are circumstances in which the brakes might not be applied to the wheels even if those wheels are targeted for braking.



Making a Right Turn

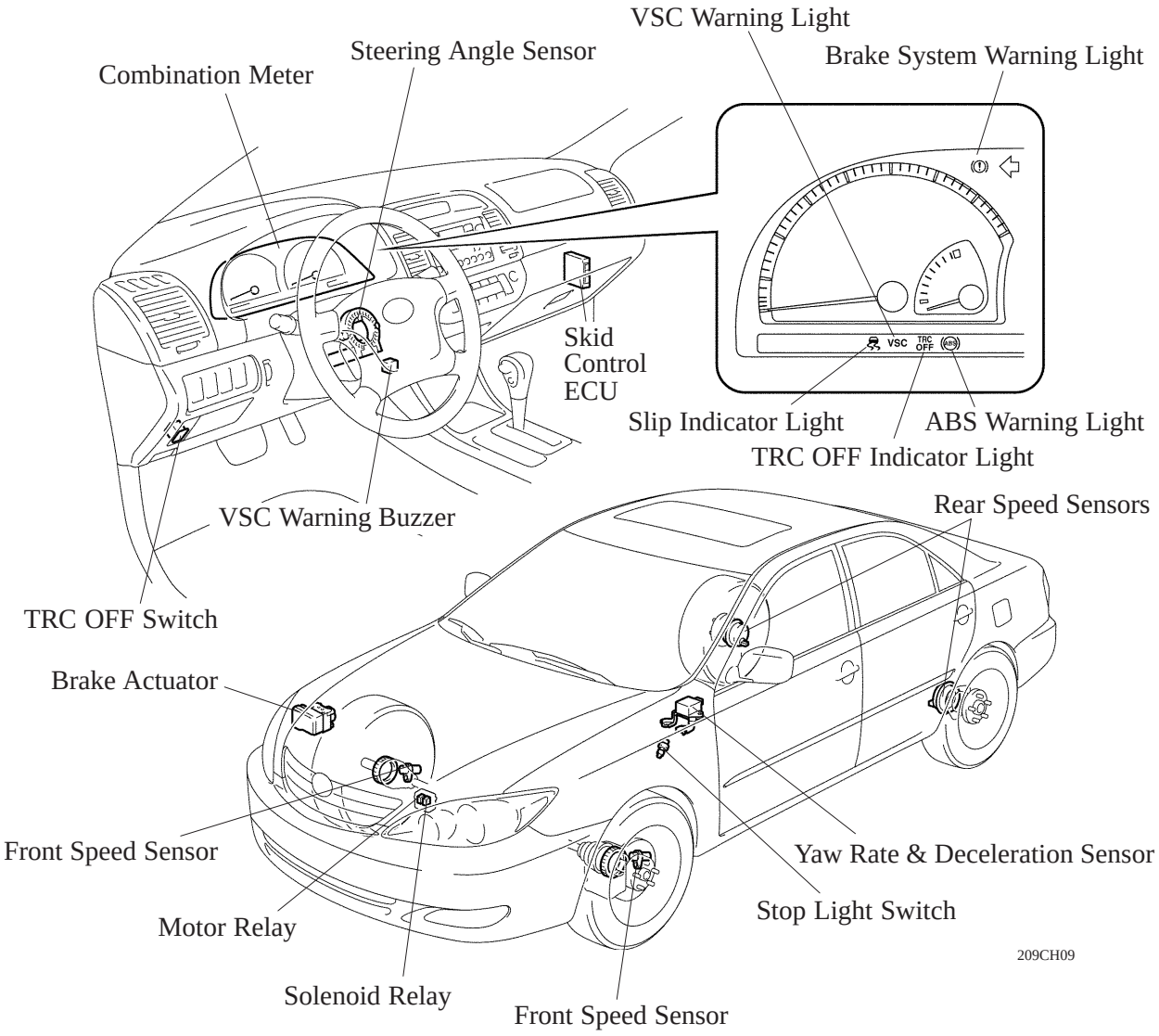
2) Dampening a Strong Oversteer

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.



Making a Right Turn

4. Layout of Components



5. Function of Component

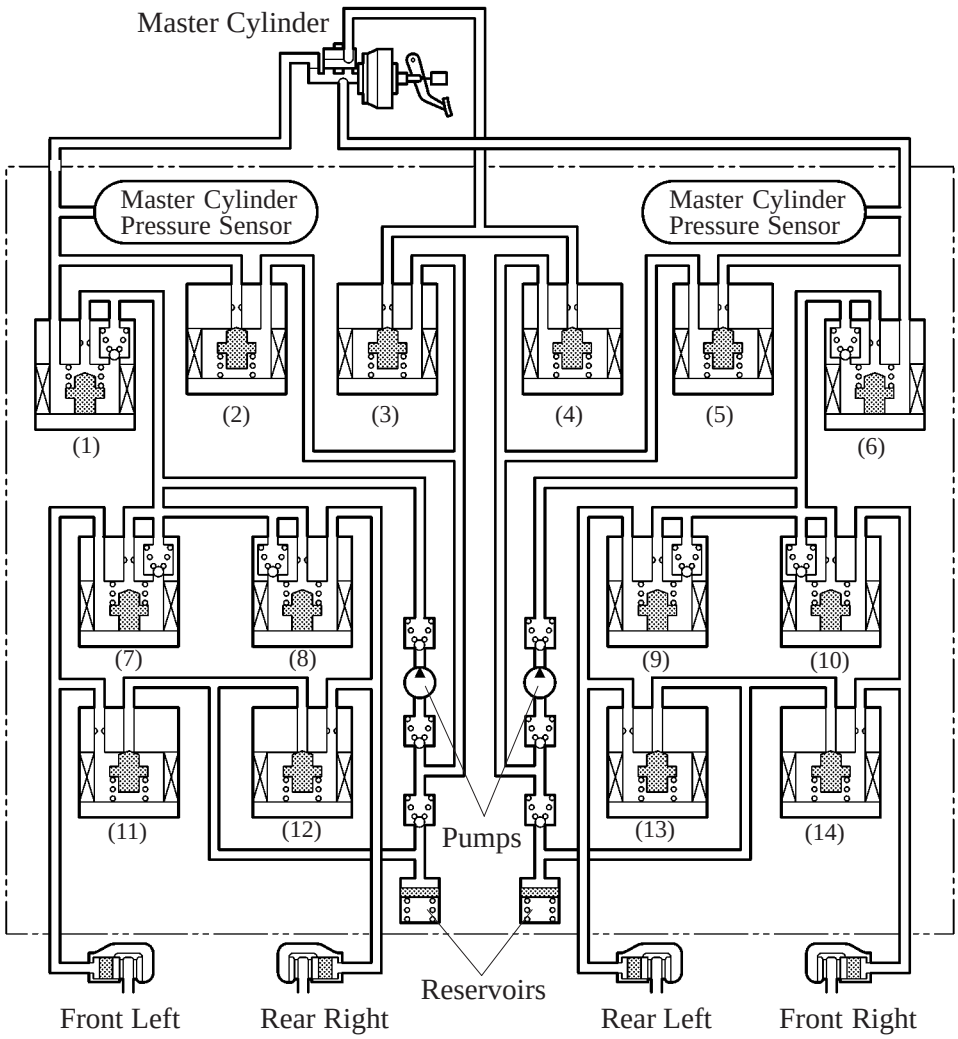
Component		Function
Combination Meter	ABS Warning Light	Lights up to alert the driver when the skid control ECU detects the malfunction in the ABS or Brake Assist system.
	VSC Warning Light	Lights up to alert the driver when the skid control ECU detects the malfunction in the VSC system.
	Slip Indicator Light	Blinks to inform the driver when the TRC system or the VSC system is operated.
	TRC OFF Indicator Light	Lights up to inform the driver when the TRC system is turned OFF by the TRC OFF switch.
	Brake System Warning Light	Lights up together with the ABS warning light to alert the driver when the skid control ECU detects the malfunction in the EBD control.
Engine ECU		• Sends the throttle valve opening angle signal, crankshaft position sensor, intake air temp. sensor, etc., to the skid control ECU. • Receive the signal of throttle valve opening request from the skid control ECU.
Speed Sensors		Detects the wheel speed of each four wheels.
Brake Actuator		Charges 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.
Skid Control ECU		Judges the vehicle driving condition based on signals from each sensor, and sends brake control signal to the brake actuator.
Brake Fluid Level Warning Switch		Detects the brake fluid level.
Stop Light Switch		Detects the brake pedal depressing signal.
TRC OFF Switch		Turns the TRC system inoperative.
VSC Warning Buzzer		Emits an intermittent sound to inform the driver that the skid control ECU detects the strong understeer tendency or strong oversteer tendency.
Yaw Rate & Deceleration Sensor		• Detects the vehicle's yaw rate. • Detects the vehicle's acceleration in the forward, rearward, lateral and all directions.
Steering Angle Sensor		Detects the steering direction and angle of the steering wheel.
Motor Relay		Supply power to the pump motor in the brake actuator.
Solenoid Relay		Supply power to the solenoid valves in the brake actuator.

6. Brake Actuator

Construction

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



208CH28

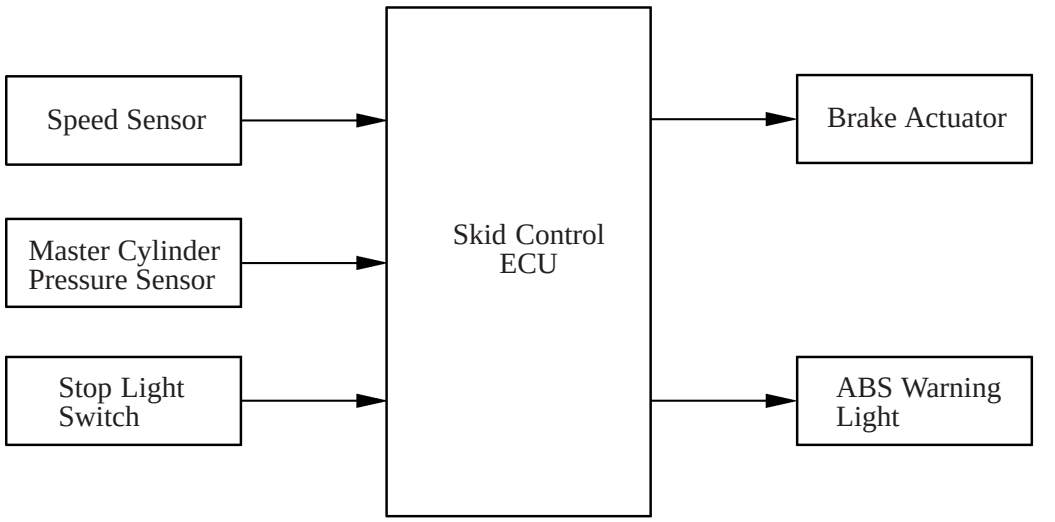
ABS with EBD Operation

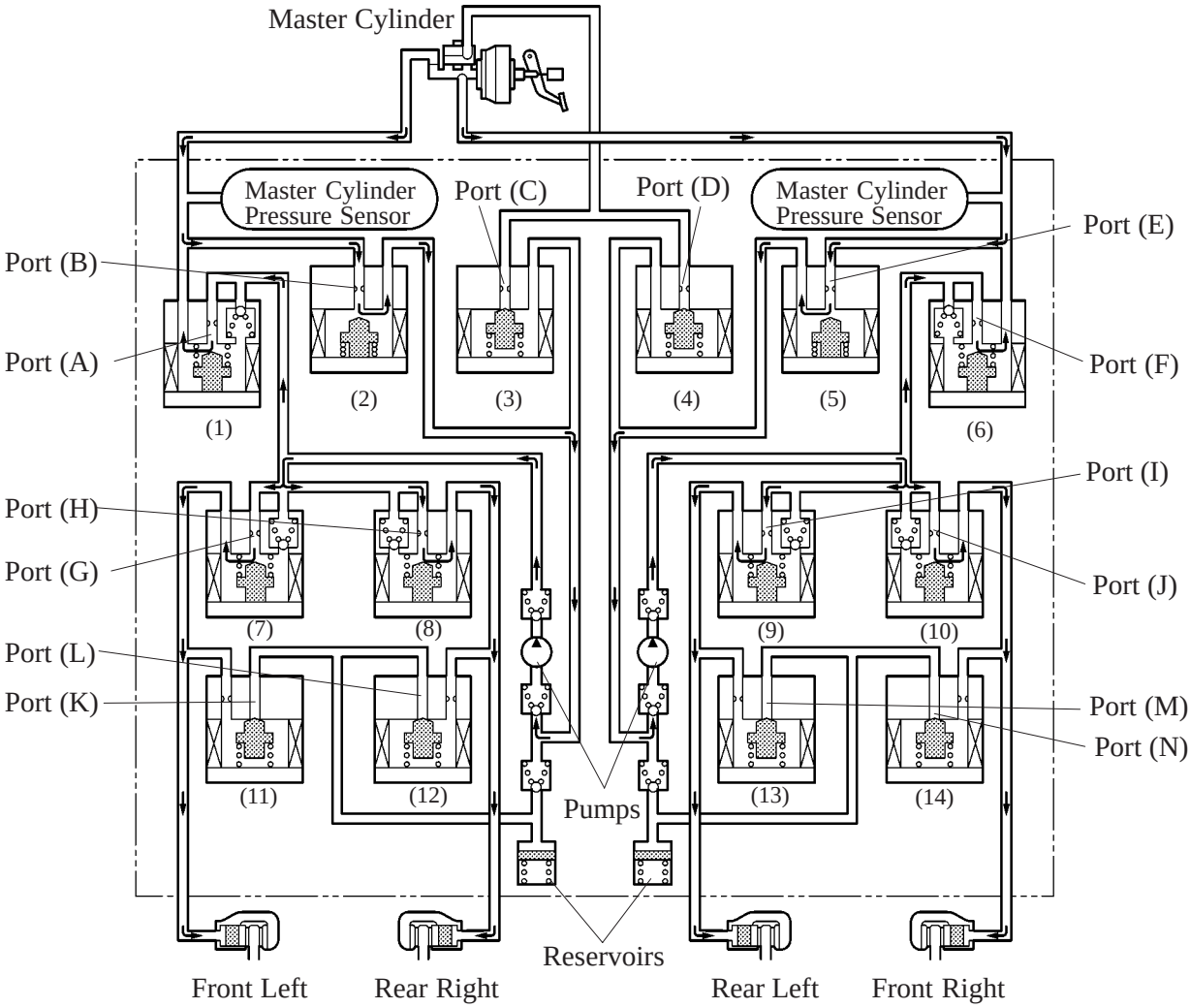
The ABS with EBD operation is the same as the operation of the ABS with EBD system. Refer to that system for details.

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 ◀





208CH29

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

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

CH

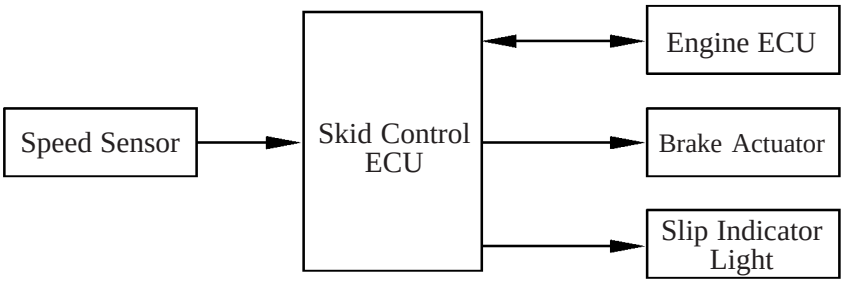
TRC Operation

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 are controlled in the following 3 modes: pressure reduction, pressure holding, and pressure increase modes, to restrain the slippage of the drive wheels.

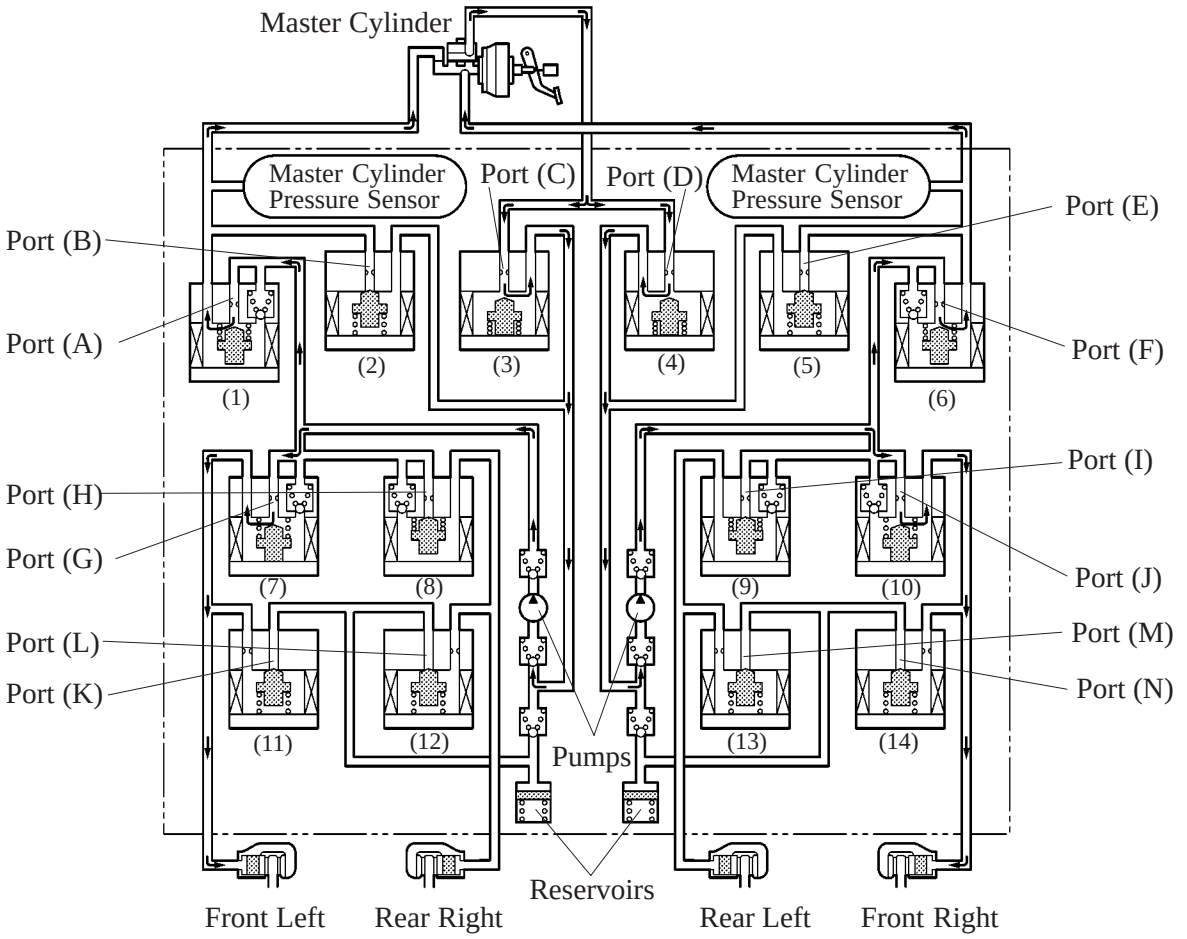
The diagram below shows the hydraulic circuit in the pressure increase mode when the TRC system is activated.

In other, 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 ◀



187CH41



208CH31

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

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

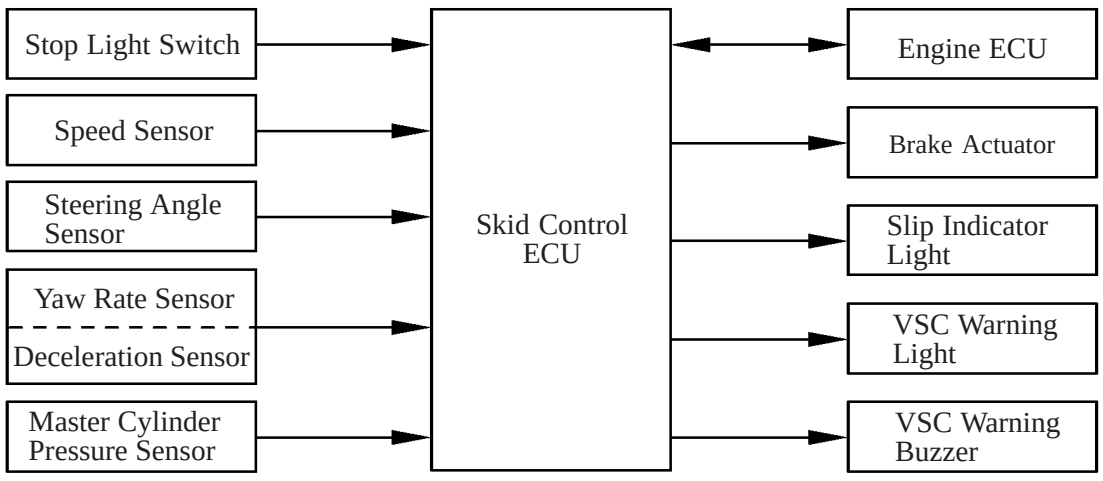
CH

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.

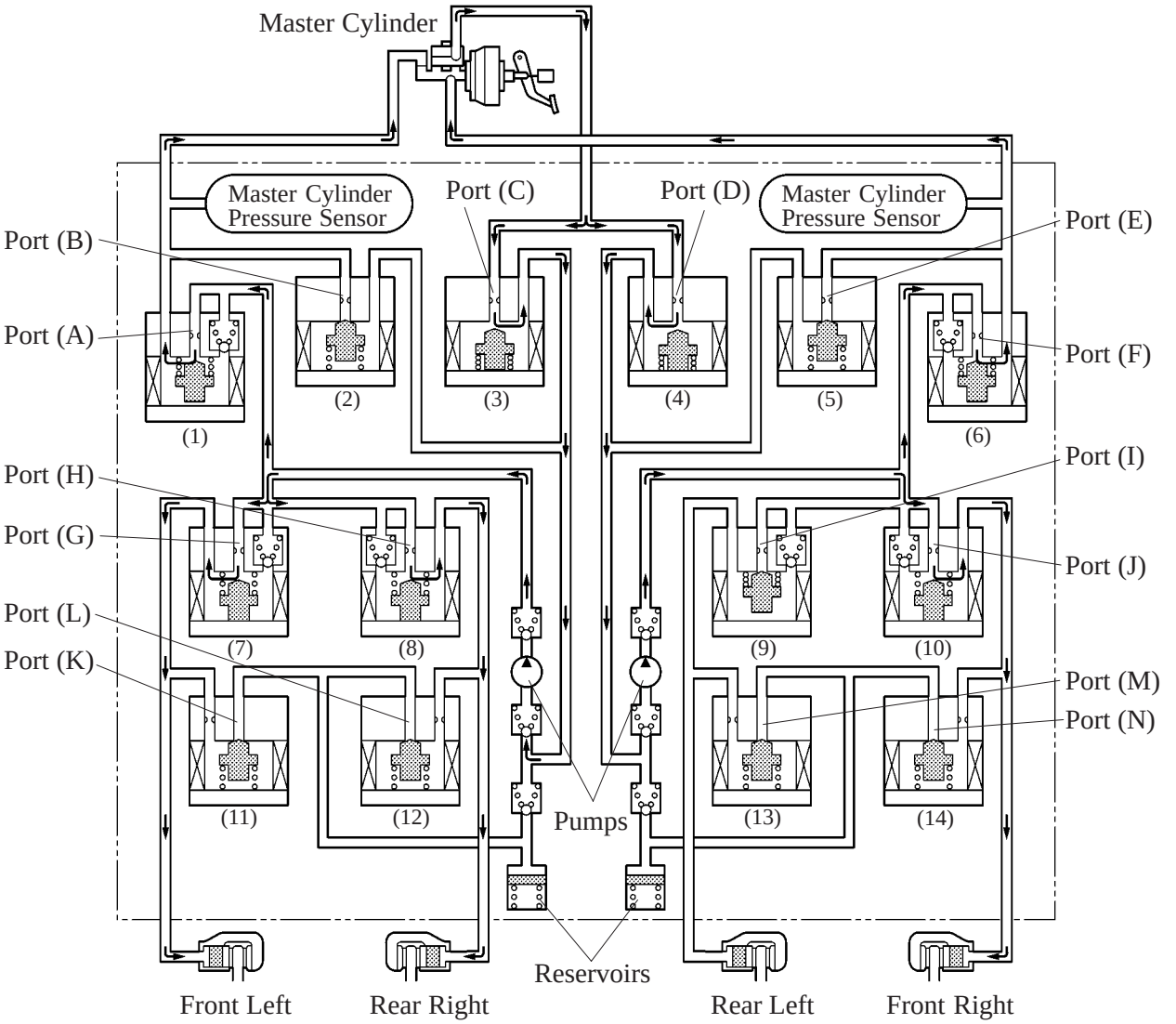
▶ System Diagram ◀



208CH32

2) Understeer Restraining Control (Turning to the Right)

In understeer restraining control, the brake of the front wheels and rear wheel of the inner side of the turn 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, the pressure holding valve and the pressure reduction valve are turned ON/OFF according to the ABS operation pattern.



Increase Mode

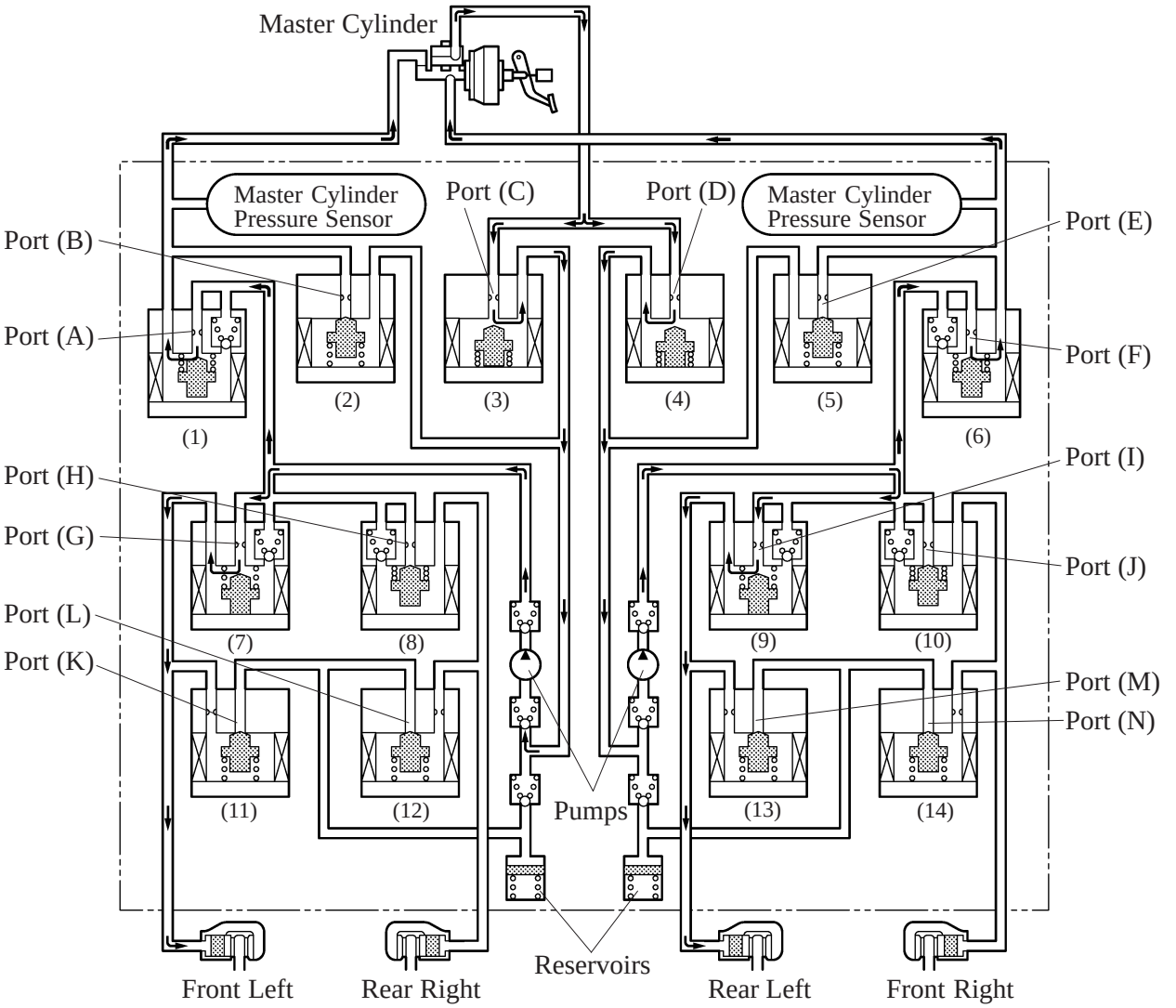
208CH33

Item				VSC not Activated	VSC Activated		
					Increase Mode	Holding Mode	Reduction Mode
(1), (6)		Master Cylinder Cut Solenoid Valve		OFF (Open)	ON*	ON*	ON*
		Port: (A), (F)					
(3), (4)		Reservoir Cut Solenoid Valve		OFF (Close)	ON (Open)	ON (Open)	ON (Open)
		Port: (C), (D)					
(2), (5)		Suction Solenoid Valve		OFF (Close)	OFF (Close)	OFF (Close)	OFF (Close)
		Port: (B), (E)					
Front Brake	(7), (10)	Pressure Holding Valve		OFF (Open)	OFF (Open)	ON (Close)	ON (Close)
		Port: (G), (J)					
	(11), (14)	Pressure Reduction Valve		OFF (Close)	OFF (Close)	OFF (Close)	ON (Open)
		Port: (K), (N)					
	Wheel Cylinder Pressure			—	Increase	Hold	Reduction
Rear Brake	(8)	Pressure Holding Valve (Rear Right)		OFF (Open)	OFF (Open)	ON (Close)	ON (Close)
		Port: (H)					
	(9)	Pressure Holding Valve (Rear Left)		OFF (Open)	ON (Close)	ON (Close)	ON (Close)
		Port: (I)					
	(12)	Pressure Reduction Valve (Rear Right)		OFF (Close)	OFF (Close)	OFF (Close)	ON (Open)
		Port: (L)					
	(13)	Pressure Reduction Valve (Rear Left)		OFF (Close)	OFF (Close)	OFF (Close)	OFF (Close)
		Port: (M)					
	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) 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 make a right turn.
As in understeer restraining control, in other, the pressure holding valve and the pressure reduction valve are turned ON/OFF according to the ABS operating 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

208CH34

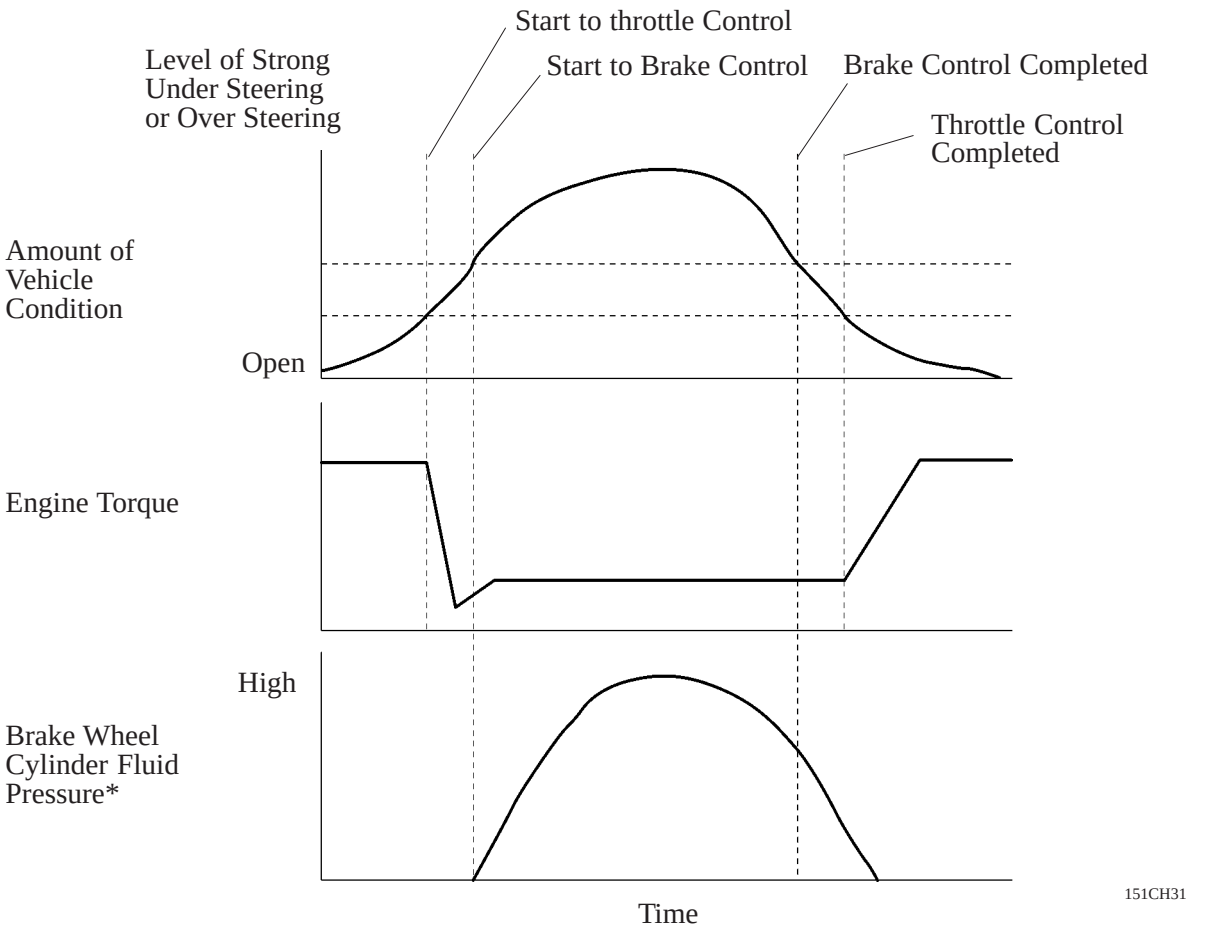
Item				VSC not Activated	VSC Activated		
					Increase Mode	Holding Mode	Reduction Mode
(1), (6)		Master Cylinder Cut Solenoid Valve		OFF (Open)	ON*	ON*	ON*
		Port: (A), (F)					
(3), (4)		Reservoir Cut Solenoid Valve		OFF (Close)	ON (Open)	ON (Open)	ON (Open)
		Port: (C), (D)					
(2), (5)		Suction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

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

7. Skid Control ECU

VSC

Based on the 4 type of sensor signals received from the speed sensors, yaw rate sensor, deceleration sensor and steering 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 engine torque through throttle 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 the initial check.
The functions of each solenoid valve and pump motor in the brake 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 systems, the ABS, brake system, VSC warning lights and TRC OFF 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
ABS Warning Light	○	○	○	—	—	○
Brake System Warning Light	—	○	—	—	—	○
TRC OFF Indicator Light	○	○	○	○	○	○
VSC Warning Light	○	○	○	○	○	○

- At the same time, the DTCs (Diagnosis Trouble Codes) are stored in memory. The DTCs can be read by connecting the SST (09843-18040) between the Tc and CG terminals DLC3 and observing the blinking of the ABS warning light and VSC warning light, or by connecting a hand-held tester.
- This system has a sensor signal check function. The DTCs can be read by connecting the SST (09843-18040) between the Ts and CG terminals of DLC3 and observing the blinking of the ABS warning light and VSC warning light, or by connecting a hand-held tester.
- The check connector has been discontinued.
- The following DTCs have been added to the TRC system of the previous model:

CH

▶ Output by blinking ABS warning light ◀

DTC No.	Detection Item	DTC No.	Detection Item
C1235/35	Foreign matter is attached on the tip of the right front sensor	C1243/43	Malfunction in deceleration sensor (abnormal constant output)
C1236/36	Foreign matter is attached on the tip of the left front sensor	C1244/44	Open or short circuit of deceleration sensor circuit
C1238/38	Foreign matter is attached on the tip of the right rear sensor	C1245/45	Malfunction in deceleration sensor circuit
C1239/39	Foreign matter is attached on the tip of the left rear sensor	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	C1223/43	Malfunction in ABS control system
C1232/32	Malfunction in deceleration sensor	C1224/44	Open or short circuit in NE signal circuit
C1233/33	Open or short circuit of yaw rate sensor circuit	C1201/51	Engine ECU system malfunction
C1234/34	Malfunction in yaw rate sensor	C1202/52	• Brake fluid level low • Open circuit of brake fluid level warning switch circuit
C1335/35	Malfunction in steering angle sensor communication circuit	C1203/53	Engine ECU communication circuit malfunction
C1210/36	Zero point calibration of yaw rate sensor undone	C1261/61	Malfunction in master cylinder pressure sensor
C1336/39	Zero point calibration of deceleration sensor undone	—	—

- The C1228/28 (Open or short circuit in SRC2 circuit) DTC have been discontinued to the TRC system of the previous model.

For details on the DTCs that are stored in skid control ECU memory and the DTCs that are output through the sensor check function, see the Camry Chassis & Body Repair Manual (Pub. No. RM915E).

Fail-Safe

- In the event of a malfunction in the TRC and/or VSC, the skid control ECU prohibits the TRAC and VSC control.
- In the event of a malfunction in the ABS and/or Brake Assist, the skid control ECU prohibits the ABS, TRC, and VSC control and Brake Assist.
- In the event of a malfunction in the EBD control, skid control ECU prohibits the EBD control. Thus, brake and throttle valve opening angle control will be opened in the same condition as in the condition without the ABS, TRC, VSC control and Brake Assist.