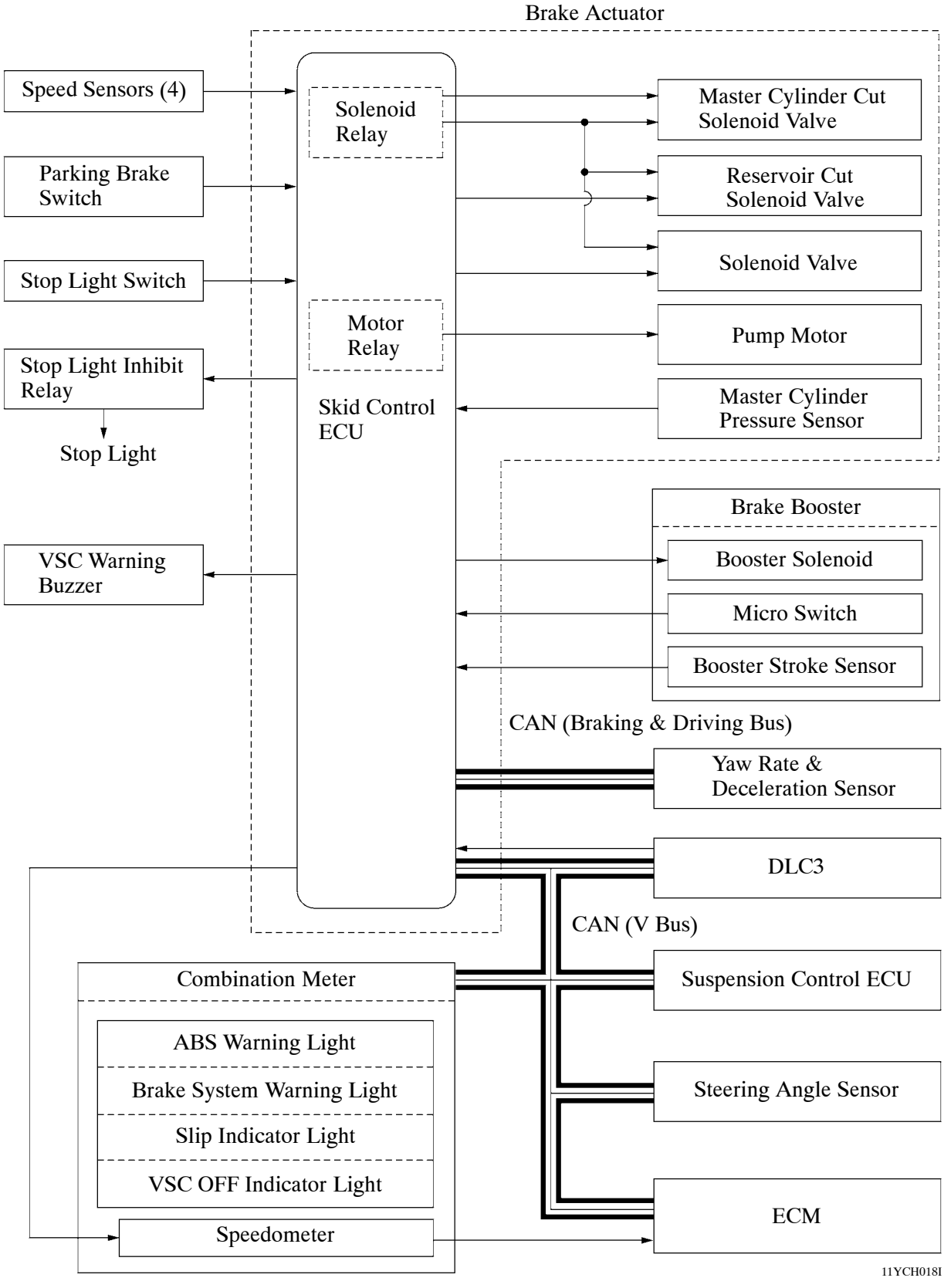
■ BRAKE CONTROL SYSTEM

1. General

The brake control system has the following functions:

Function	Outline
Anti-lock Brake System (ABS)	The ABS helps prevent the wheels from locking when the brakes are applied firmly or on a slippery surface.
Electronic Brake force Distribution (EBD)	The EBD utilizes the ABS, achieving 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 maintain the vehicle behavior.
Brake Assist	● The primary purpose of brake assist is to provide a supplemental braking force to assist a driver who cannot generate a large brake force during emergency braking, thus helping improve the vehicle's braking performance. ● If the brake booster malfunctions and the skid control ECU judges that the brake pedal force applied by the driver is not sufficient to ensure adequate braking force, brake assist is used to enhance the braking force.
Traction Control (TRC)	TRC helps prevent the drive wheels from slipping if the driver presses the accelerator pedal excessively when starting off or accelerating on a slippery surface.
Vehicle Stability Control (VSC)	VSC helps prevent the vehicle from slipping sideways as a result of strong front wheel skid or strong rear wheel skid during unstable situation [VSC operates when the vehicle speed is 15 km/h (9.3 mph) or more].

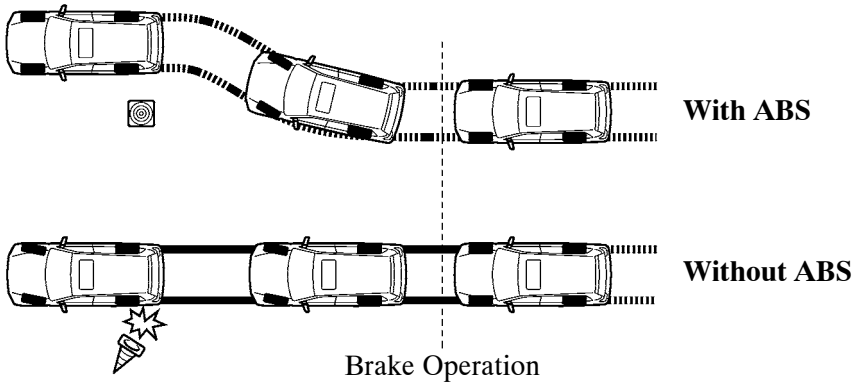
2. System Diagram



3. Outline of Brake Control Function

Anti-lock Brake System (ABS)

The ABS prevents the wheels from locking during sudden braking or braking on a slippery surface. This provides the proper braking force when the vehicle slips, thus ensuring vehicle stability and excellent braking performance.



08LCH098Y

◆: The illustration provides a conceptual image.

Electronic Brake force Distribution (EBD)

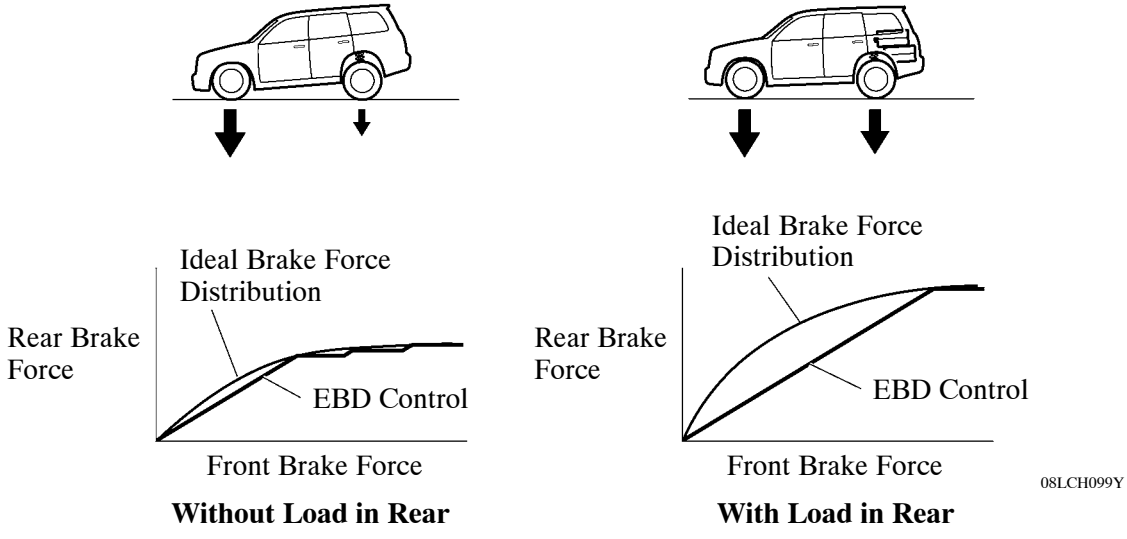
1) General

The EBD control utilizes the ABS, achieving the proper brake force distribution between the front and rear wheels in accordance with the driving conditions. In addition, during cornering braking, it also controls the brake forces of the right and left wheels, helping to maintain the vehicle behavior.

2) Front/Rear Wheels Brake Force Distribution

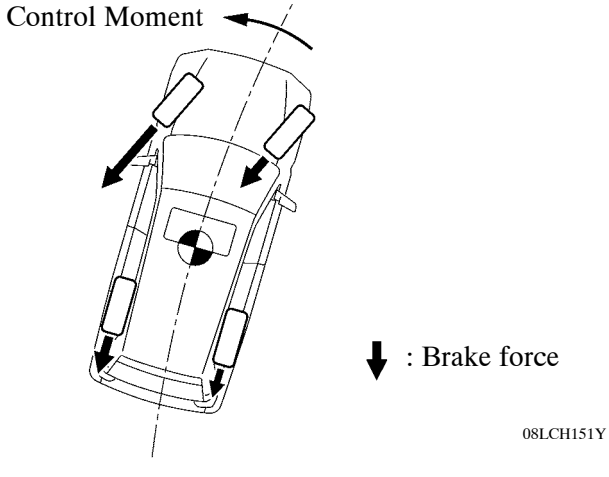
This function controls the brake force that acts on the rear wheels in accordance with the changes in the vehicle conditions such as load factors or deceleration, in order to ensure excellent braking performance.

▶ EBD Control Concept ◀



3) Right/Left Wheels Brake Force Distribution (During Cornering Braking)

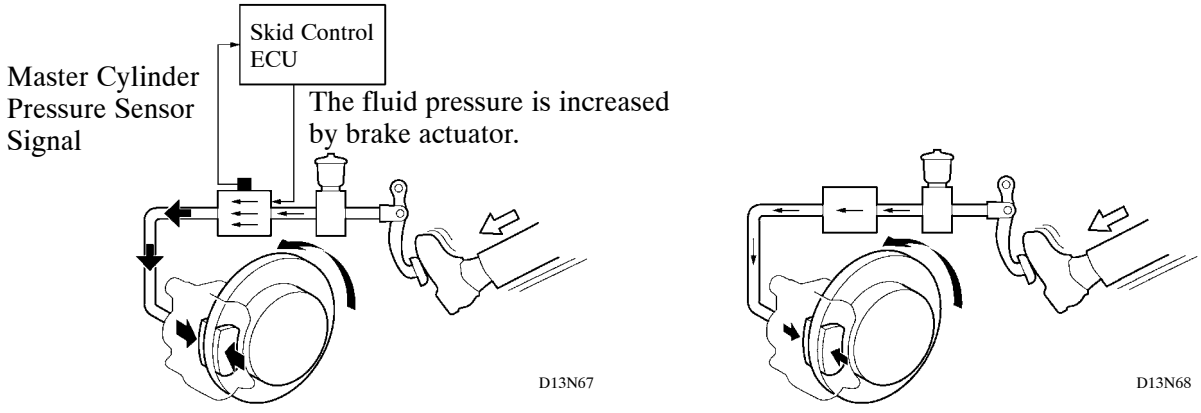
During cornering braking, this function controls the brake force that acts on the left and right wheels in accordance with the vehicle conditions at that time. This ensures vehicle stability and excellent braking performance.



Brake Assist

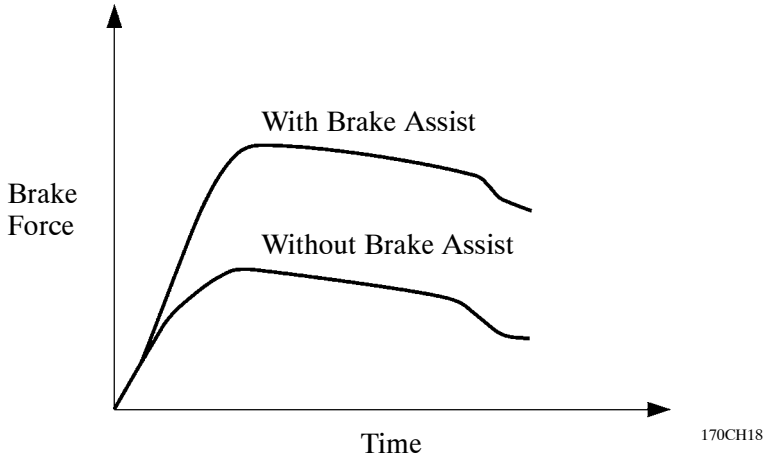
- The primary purpose of the brake assist is to provide an auxiliary brake force to assist the driver who cannot generate a large brake force during emergency braking, thus helping draw the vehicle's brake performance.
- Based on the signals from the master cylinder pressure sensor, the skid control ECU calculates the speed and the amount of the brake pedal application and then determines the intention of the driver to make an emergency braking. If the skid control ECU determines that the driver intends the emergency braking, this function activates the brake actuator to increase the brake fluid pressure, which increases the brake force.

▶ In case that driver's depressing force is small when applying emergency braking ◀



With Brake Assist **Without Brake Assist**

◆: There is no difference of the maximum brake performance between the vehicles with and without brake assist.

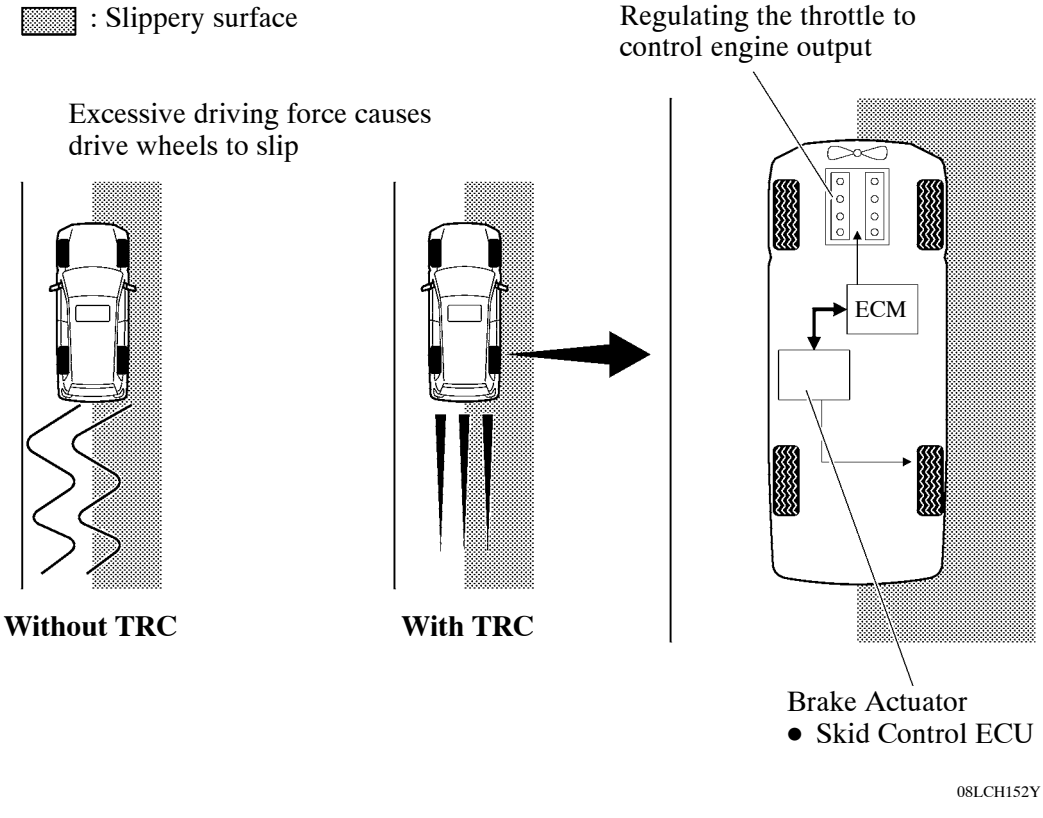


CH

Traction Control (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 helping to apply the drive force that is appropriate for the road surface conditions.
- For example, a comparison may be made between 2 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 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 and regulates the throttle in order to control the engine output. Thus, TRC can constantly help the driver to maintain stability while accelerating.

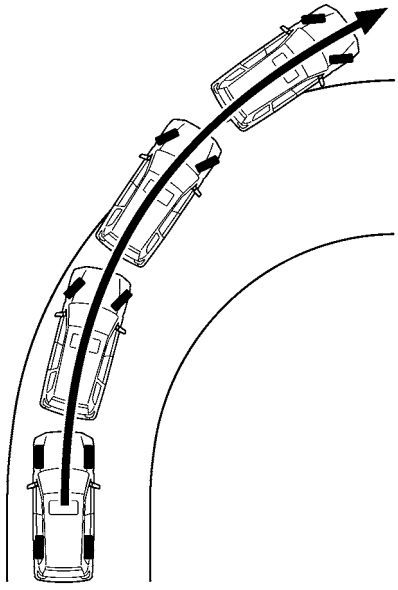
▶ Driving condition on road with different surface friction characteristics ◀



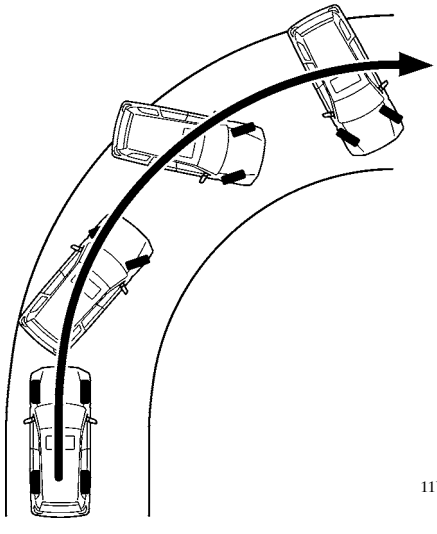
Vehicle Stability Control (VSC)

The followings are 2 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 is under one of the conditions indicated below.

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



Front Wheel Skid Tendency



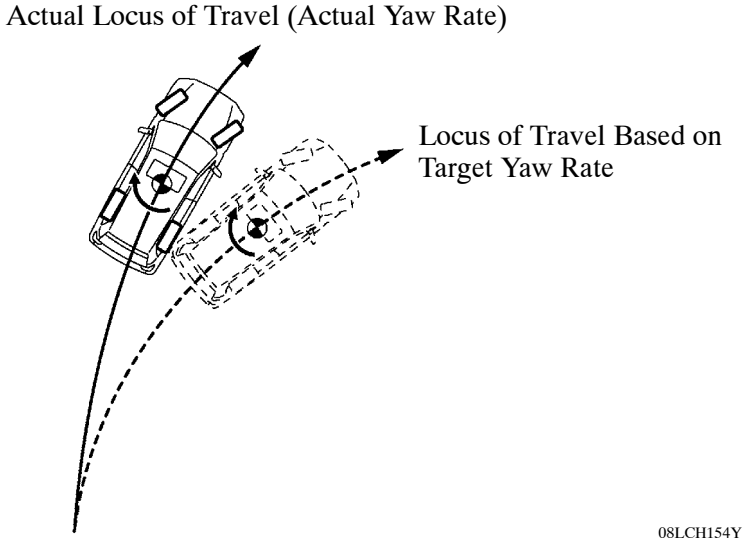
Rear Wheel Skid Tendency

1) Method for Determining Vehicle Condition

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

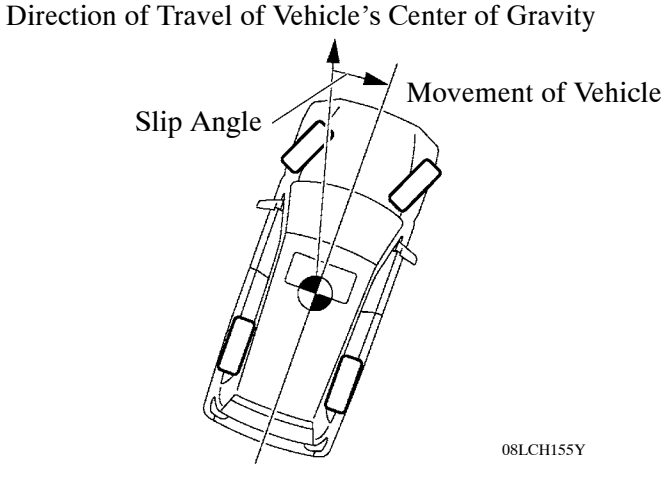
a. Determining Front Wheel Skid

Whether the vehicle is in the state of the front wheel skid or not 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 locus of travel. Thus, the skid control ECU determines that there is a large tendency to front wheel skid.



b. Determining Rear Wheel Skid

Whether the vehicle is in the state of the rear wheel skid or not 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 and the slip angular velocity are large, the skid control ECU determines that the vehicle has a large rear wheel skid tendency.

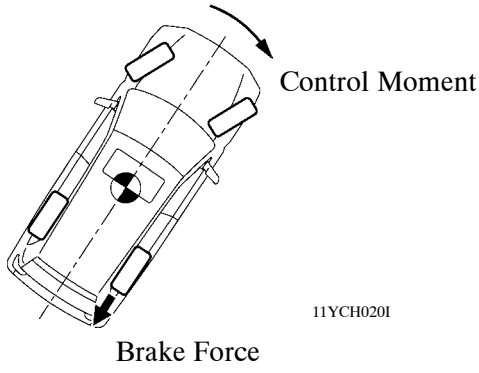


2) Method for VSC Operation

When the skid control ECU determines that the vehicle has a tendency to front wheel skid or rear wheel skid, 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.

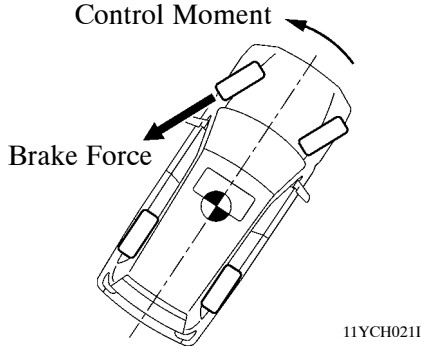
a. Dampening Front Wheel Skid

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 output and applies the brake to the rear wheel of the inner circle of the turn in order to help restrain the front wheel skid tendency.

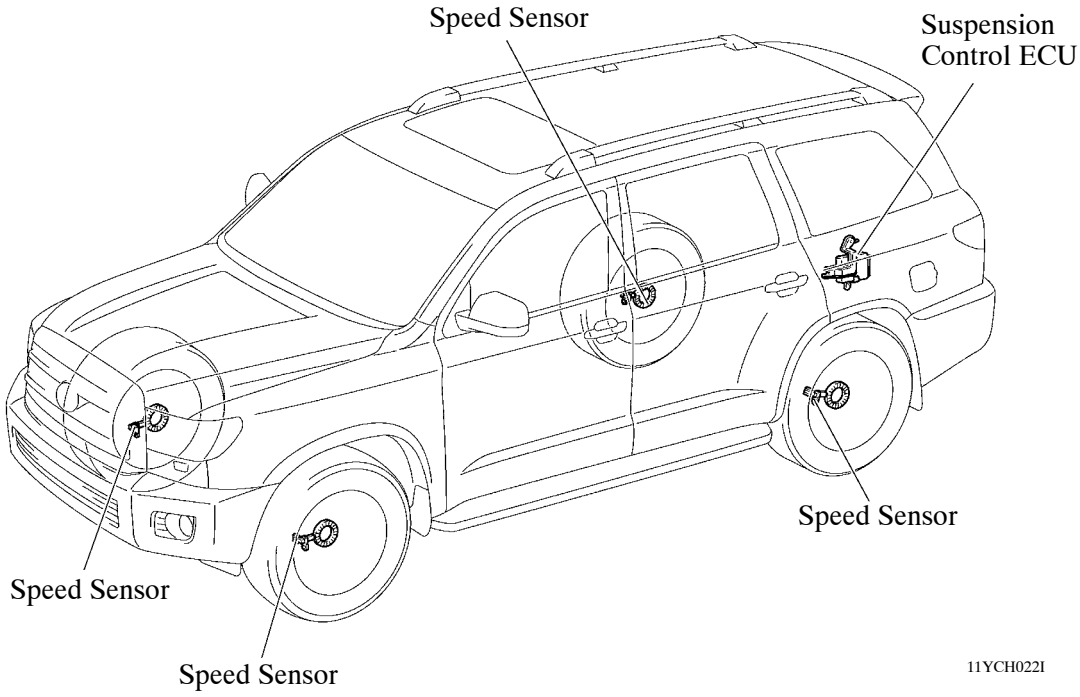


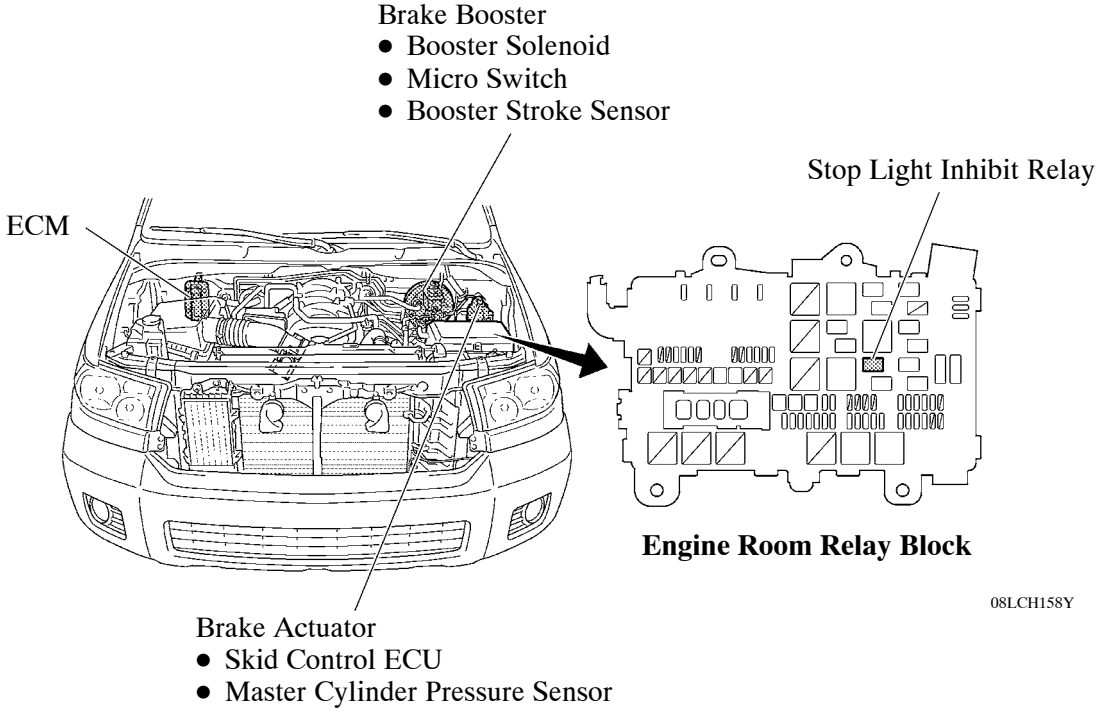
b. Dampening Rear Wheel Skid

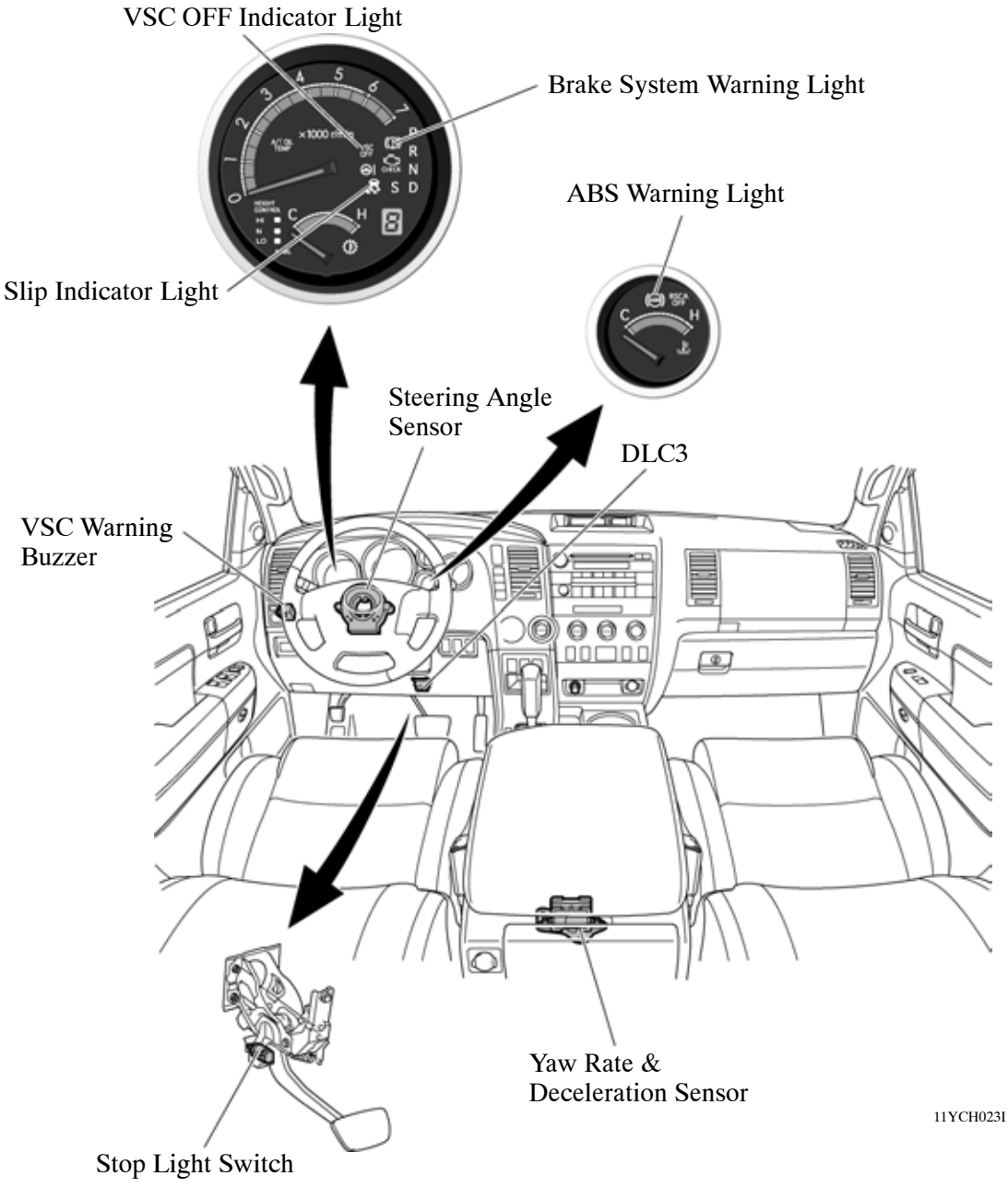
When the skid control ECU determines that there is a large rear wheel skid tendency, it counteracts in accordance with the extent of that tendency. It applies the brakes of the front wheel of the outer circle of the turn, and generates an outward moment of inertia in the vehicle, in order to help restrain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



4. Layout of Main Components






VSC OFF Indicator Light
Brake System Warning Light
ABS Warning Light
Slip Indicator Light
Steering Angle Sensor
DLC3
VSC Warning Buzzer
Yaw Rate & Deceleration Sensor
Stop Light Switch
11YCH023I

5. Function of Main Components

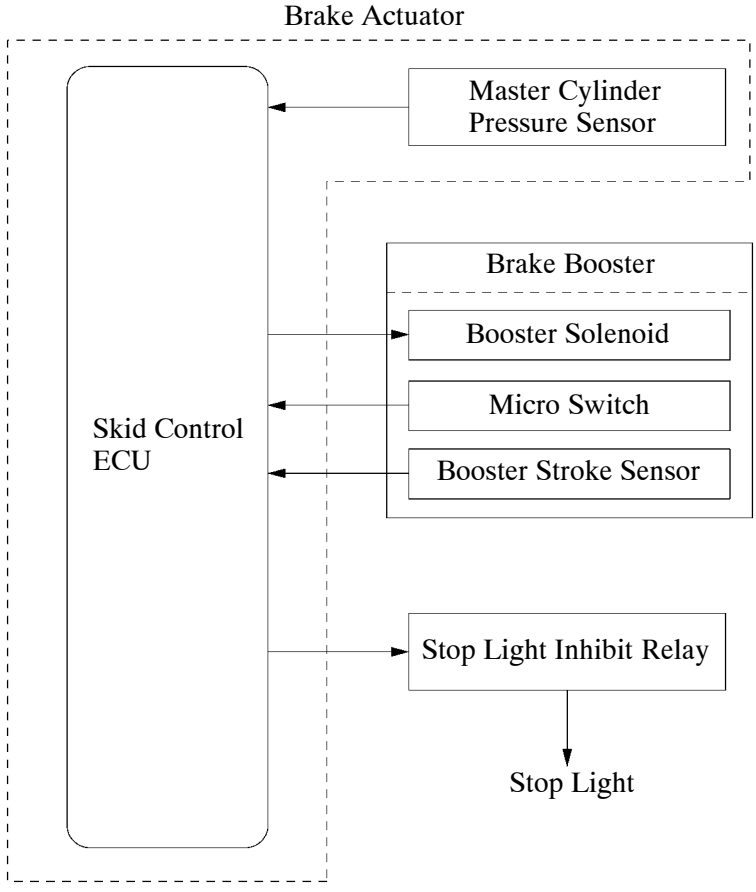
Component		Function
Combination Meter	ABS Warning Light	Lights up to alert the driver that the skid control ECU detects a malfunction in the ABS, EBD or brake assist system.
	Brake System Warning Light	● Lights up together with the ABS warning light to alert the driver that the skid control ECU detects a malfunction in the EBD or when a malfunction occurs in the brake booster. ● Lights up to alert the driver that the brake fluid level is low. ● Lights up to alert the driver that the parking brake is applied.
	Slip Indicator Light	● Blinks to inform the driver that the TRC or VSC is operated. ● Lights up to alert the driver that the skid control ECU detects a malfunction in the TRC or VSC.
	VSC OFF Indicator Light	When the skid control ECU detects a malfunction and determines that the VSC is not available, the VSC OFF indicator light blinks to alert the driver.
VSC Warning Buzzer		The buzzer sounds intermittently to inform the driver that the VSC is active.
Brake Actuator		Changes the fluid path based on the signals from the skid control ECU during the operation of the ABS, EBD, brake assist, TRC and VSC, in order to control the fluid pressure that is applied to the brakes for the different wheels.
	Master Cylinder Pressure Sensor	Detects the master cylinder pressure.
	Skid Control ECU	● Judges the vehicle driving conditions based on signals from each sensor, and sends brake control signals to the brake actuator. ● Judges the vehicle driving conditions based on signals from each sensor, and calculates the amount of engine output adjustment required. The skid control ECU transmits command signals to the ECM.
Brake Booster	Booster Solenoid	When the VSC is activated, this solenoid operates in accordance with the signals from the skid control ECU to boost the hydraulic pressure to the wheel cylinders.
	Micro Switch	Detects that the brake pedal is depressed.
	Booster Stroke Sensor	Detects the brake pedal stroke distance.
Speed Sensor		Detects the wheel speed of each of the 4 wheels.
Yaw Rate & Deceleration Sensor		● Detects the vehicle's yaw rate. ● Detects the vehicle's lateral acceleration.
Steering Angle Sensor		Detects the steering direction and angle of the steering wheel.
Parking Brake Switch		Detects parking brake application.
Stop Light Switch		Detects brake pedal application.
Stop Light Inhibit Relay		Because the brake pedal could move down when the VSC is activated (booster solenoid is turned on) even thought the driver is not depressing the brake pedal, this relay prevents the stop light from turning on.
ECM		● Sends the throttle valve angle signal, accelerator pedal position signal, engine speed signal, and intake air temperature signal to the skid control ECU. ● Receives an engine output adjustment command signals from the skid control ECU. Based on these signals, the ECM operates the throttle valve to control engine output.

6. Brake Booster

General

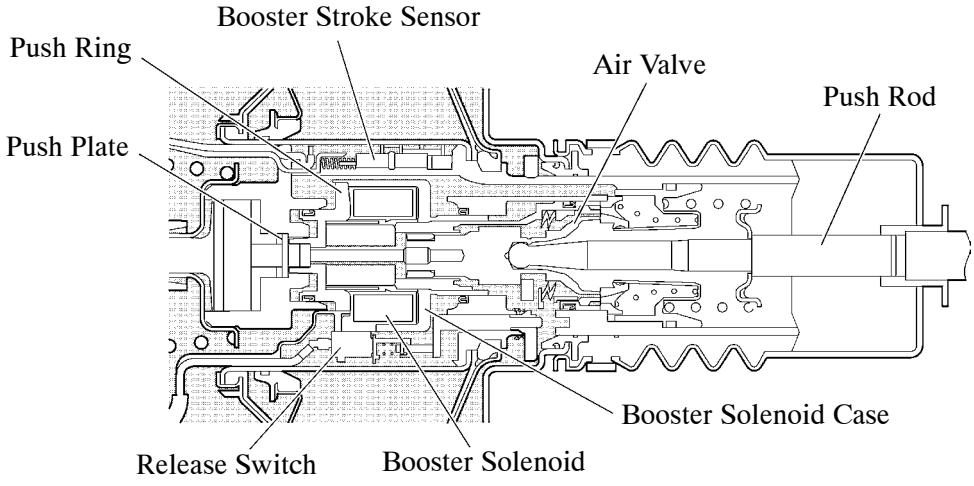
- When the VSC is activated, the booster solenoid that is enclosed in the brake booster moves the air valve to regulate the amount of pressure applied by the master cylinder.
  At this time, the skid control ECU controls the booster solenoid in accordance with the signals from the master cylinder pressure sensor. Thus, the brake fluid pressure is supplemented when the VSC is activated, resulting in excellent brake control.
- Because the brake pedal could move down with the activation of the VSC, the fact that the driver is depressing the brake pedal is determined by the release switch that is enclosed in the brake booster.
- The booster stroke sensor is used to detect a malfunction of the active brake booster. If the booster malfunctions, the brake assist system will be activated to assist the braking force.

▶ System Diagram ◀



Construction

The brake booster mainly consists of the push rod, air valve, booster solenoid, booster solenoid case, release switch, push ring, push plate and booster stroke sensor.

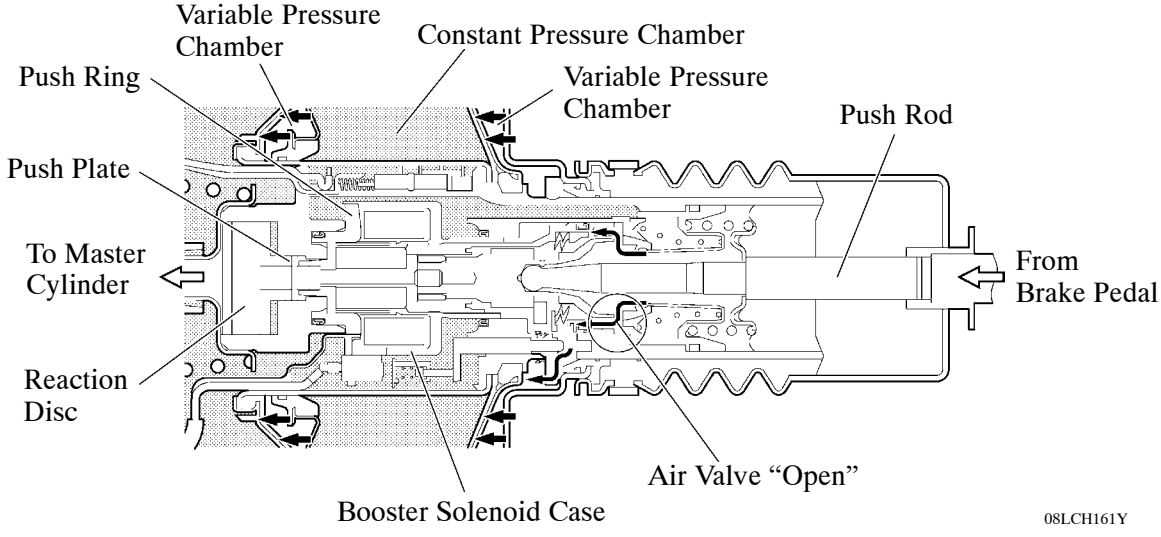


04E0CH105C

Operation

1) Normal Braking

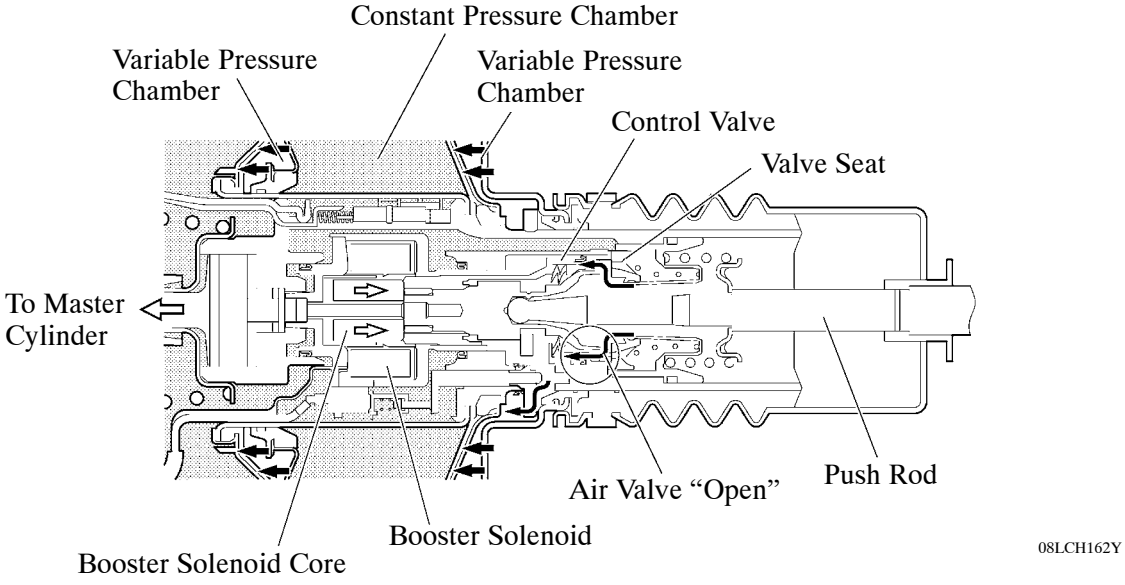
During normal braking, the input load from the brake pedal is transmitted to the push rod, air valve, booster solenoid case, push ring, push plate, and reaction disc, and then output to the master cylinder. At this time, the air valve moves, and air flows into the variable pressure chamber. This creates a pressure difference between the constant pressure chamber and the variable pressure chamber, and the input load from the brake pedal is amplified and output to the master cylinder.



08LCH161Y

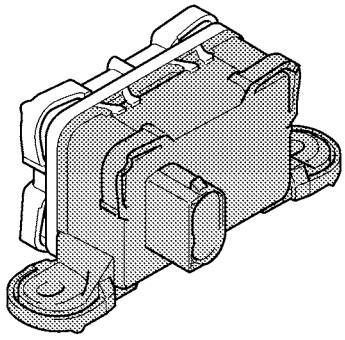
2) VSC Operation

When the VSC is activated, current flows to the booster solenoid in accordance with the signals from the skid control ECU. The booster solenoid core and the control valve then move toward the brake pedal, thus moving the valve seat toward the brake pedal.
As a result, the air valve opens and air flows into the variable pressure chamber. This creates a pressure difference between the constant pressure chamber and the variable pressure chamber. The pressure difference causes the brake booster to activate and output to the master cylinder.
VSC operation may cause the brake pedal to move downward. A stop light inhibit relay is provided to prevent undesired operation of the stop lights due to operation of VSC.



7. Yaw Rate & Deceleration Sensor

- A deceleration sensor is built into the yaw rate sensor.
- This sensor detects the yaw rate and lateral acceleration and deceleration.



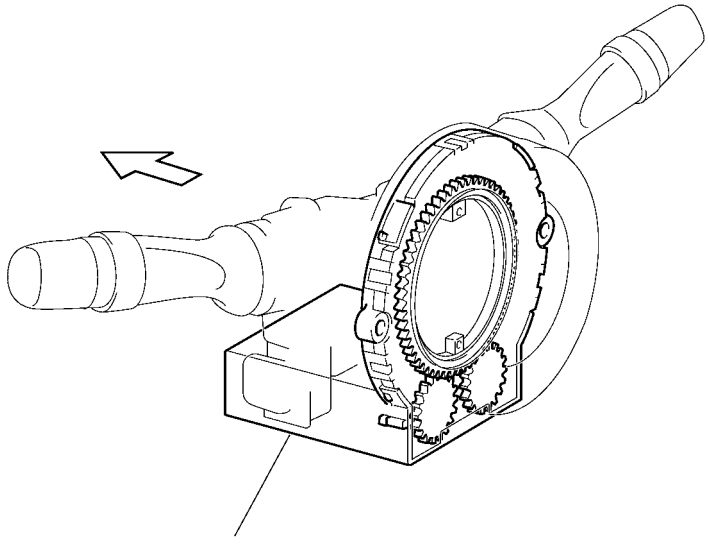
08LCH166Y

Service Tip

After replacing the yaw rate and deceleration sensor or the skid control ECU, initialization of the yaw rate and deceleration sensor is required.
For details, refer to the SEQUOIA Repair Manual (Pub. No. RM11Y0E).

8. Steering Angle Sensor

- A steering angle sensor is provided in the combination switch area. This sensor detects the amount of steering effort and the direction of steering wheel.
- The sensor assembly contains 2 sets of magnetic reluctance elements that detect the rotational movement of a magnet that is built into the detection gear. Thus, the sensor detects the changes that occur in the magnetic reluctance elements along with the rotational movement of the detection gear, in order to detect the rotational movement of the steering wheel.



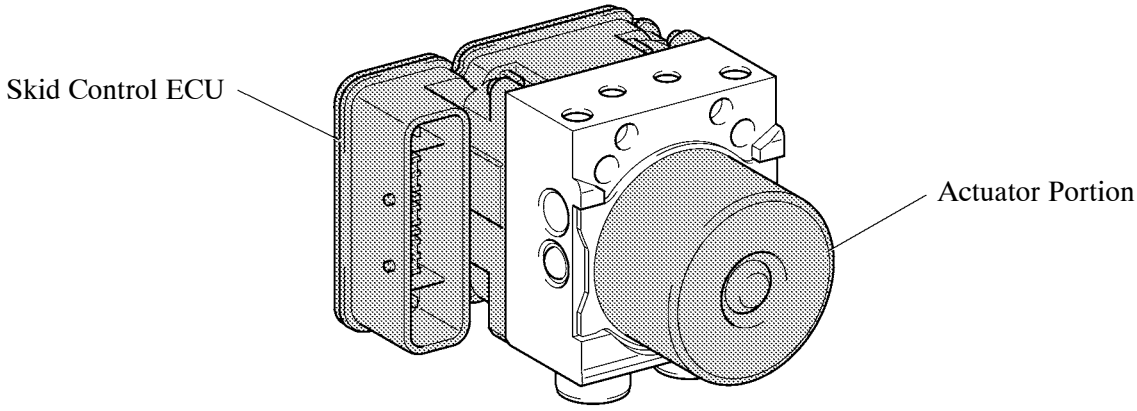
08LCH074Y

Steering Angle Sensor

9. Brake Actuator

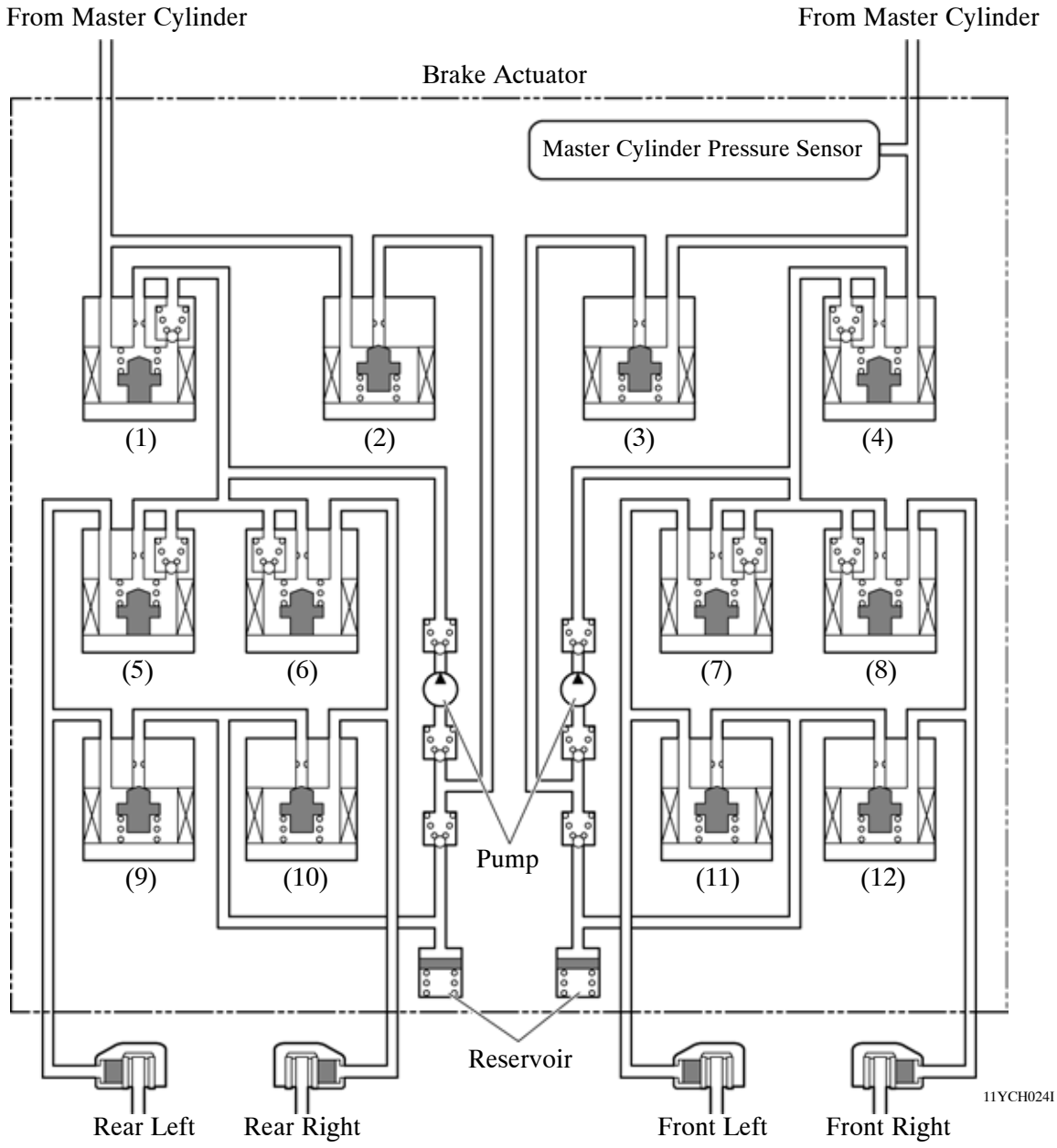
The brake actuator consists of the actuator portion and skid control ECU.

- The actuator portion consists of 12 solenoid valves, pump motor, 2 pumps, 2 reservoirs, and master cylinder pressure sensor.
- The 12 solenoid valves consists of 2 master cylinder cut solenoid valves [(1), (4)], 2 reservoir cut solenoid valves [(2), (3)], 4 pressure holding solenoid valves [(5), (6), (7), (8)], and 4 pressure reduction solenoid valves [(9), (10), (11), (12)].



08LCH167Y

▶ Hydraulic Circuit ◀

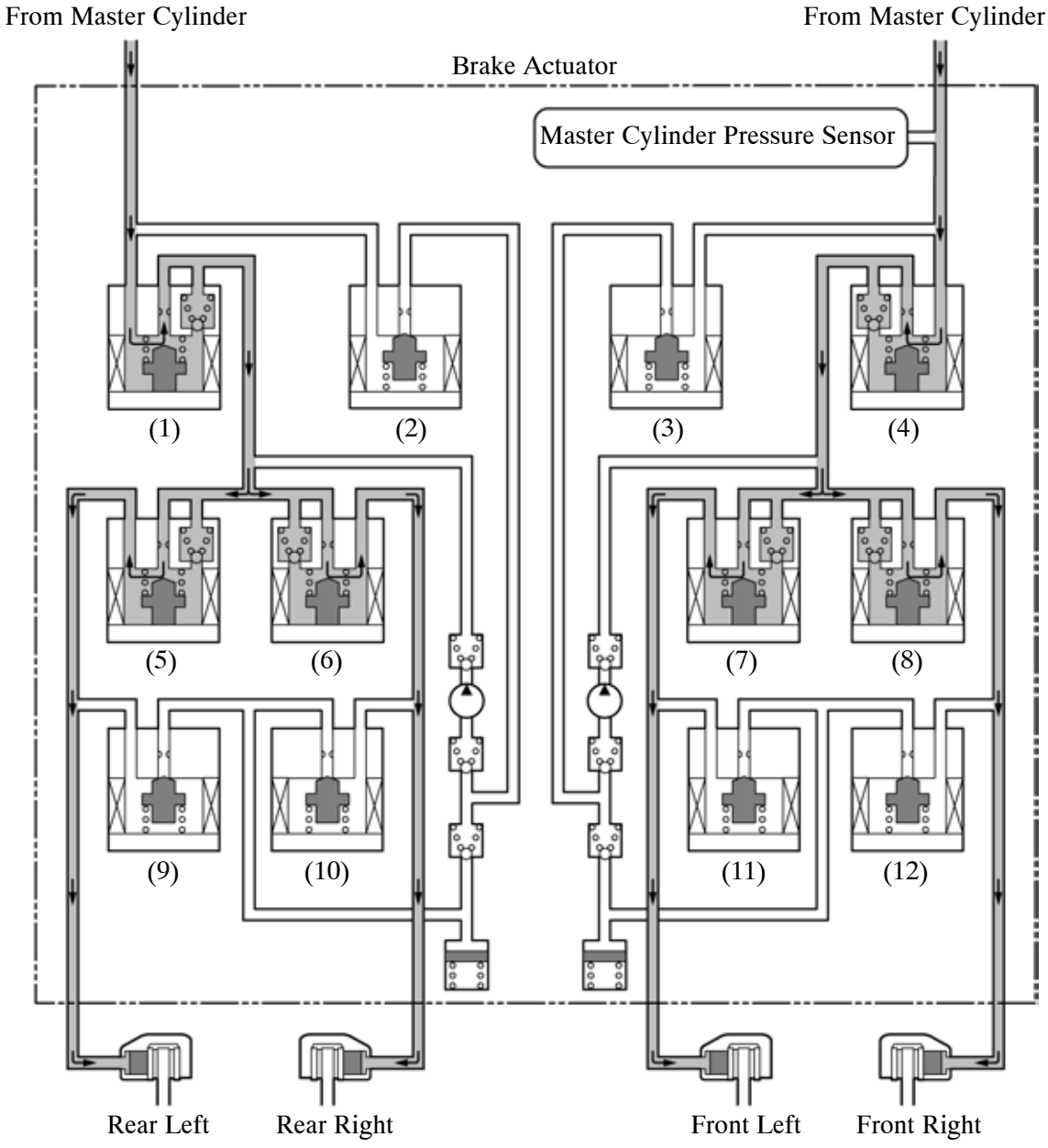


Item	
(1), (4)	Master Cylinder Cut Solenoid Valve
(2), (3)	Reservoir Cut Solenoid Valve
(5), (6), (7), (8)	Pressure Holding Solenoid Valve
(9), (10), (11), (12)	Pressure Reduction Solenoid Valve

10. System Operation

Normal Braking

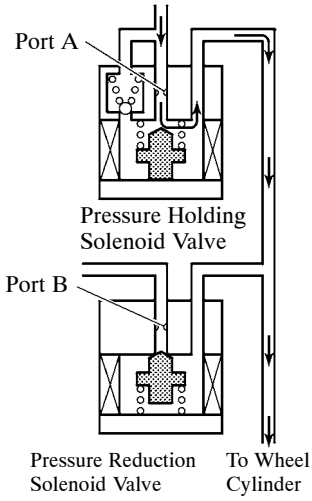
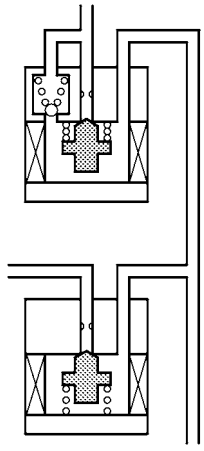
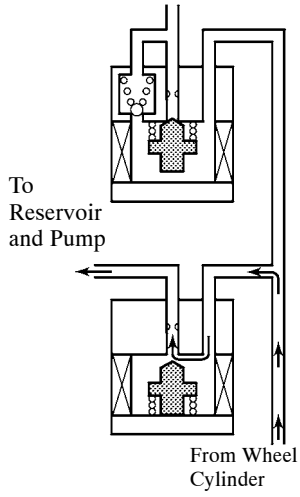
During normal braking, all solenoid valves are turned off.



11YCH025I

ABS and EBD Operation

Based on the signals received from the 4 wheel speed sensors and yaw rate & deceleration sensor, the skid control ECU 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 skid control 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 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 Solenoid Valve (Port A)	Off/Open	On/Closed	On/Closed
Pressure Reduction Solenoid Valve (Port B)	Off/Closed	Off/Closed	On/Open
Pressure	Increase	Hold	Reduce

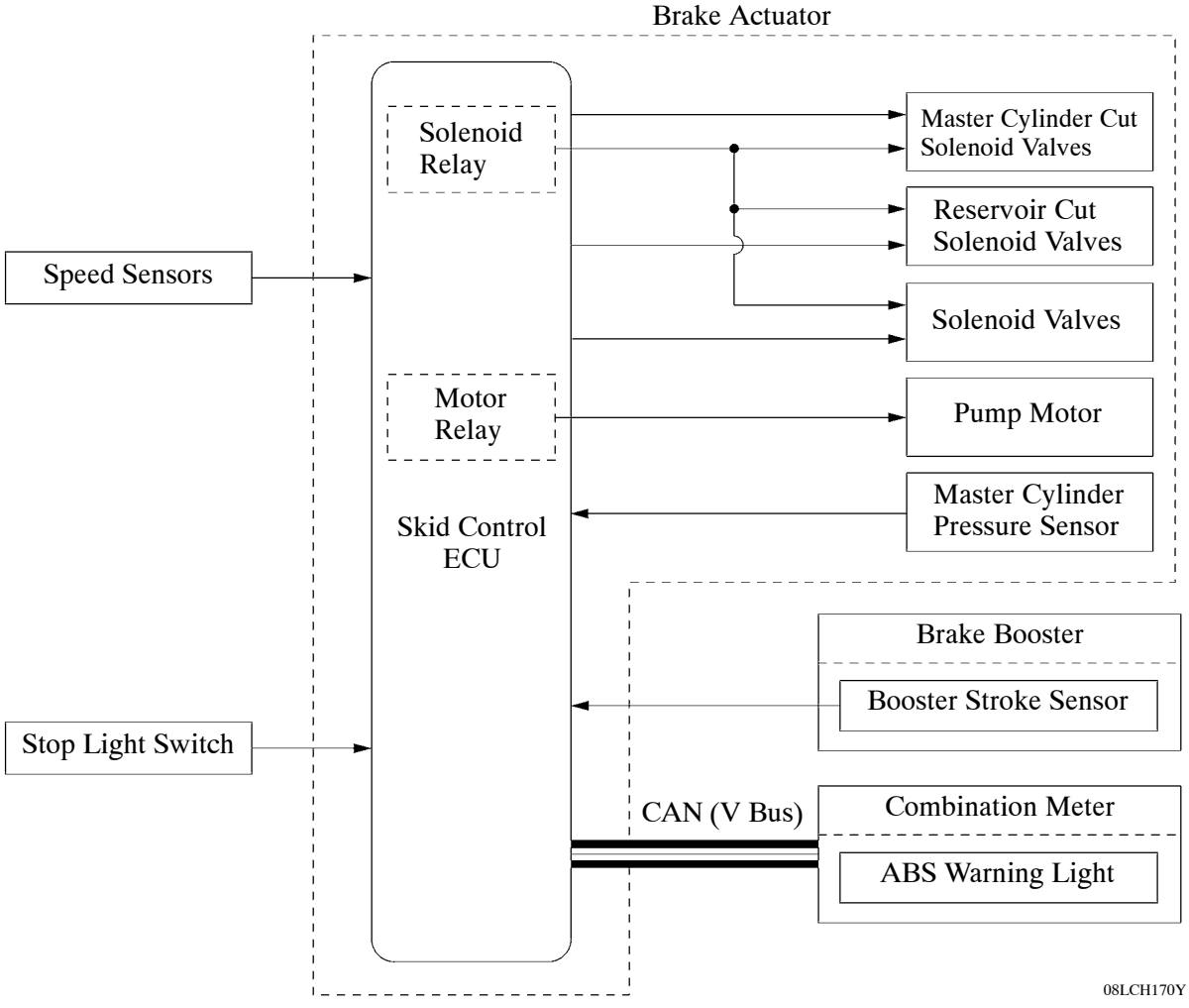
Brake Assist Operation

In the event of emergency braking, the skid control ECU detects the driver's intention based on the speed of the pressure increase in the master cylinder determined by the master cylinder pressure sensor signals. If the skid control 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 the master cylinder. Also, in the following case, the skid control ECU provides brake assist.

- In the event of a brake booster failure, the skid control ECU judges the failure using the booster stroke sensor in the brake booster and master cylinder pressure sensor signals.

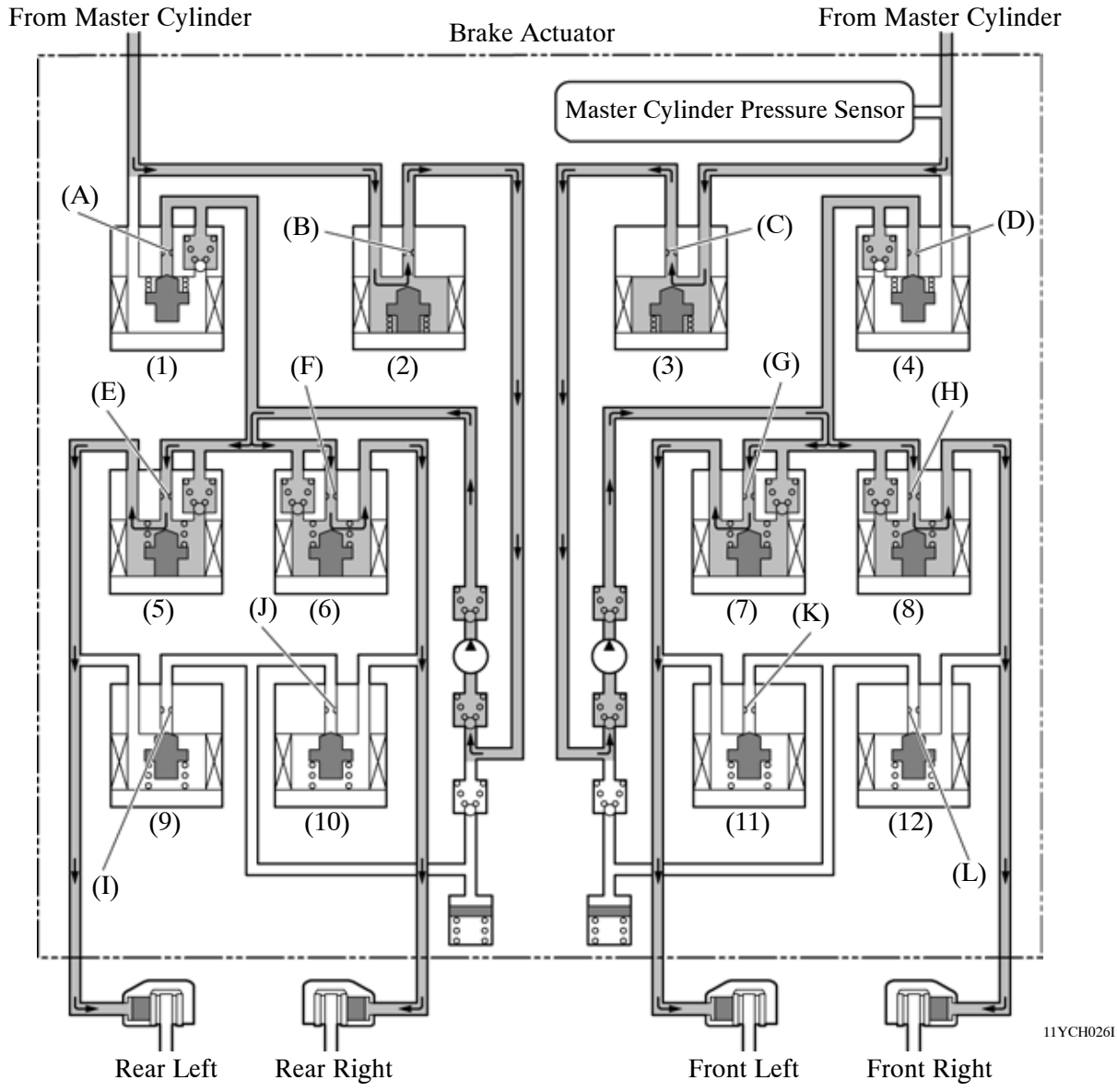
When the brake assist is activated, each solenoid valve operates as shown in the table on the next page.

▶ System Diagram ◀



CH

▶ Brake Assist Operation ◀

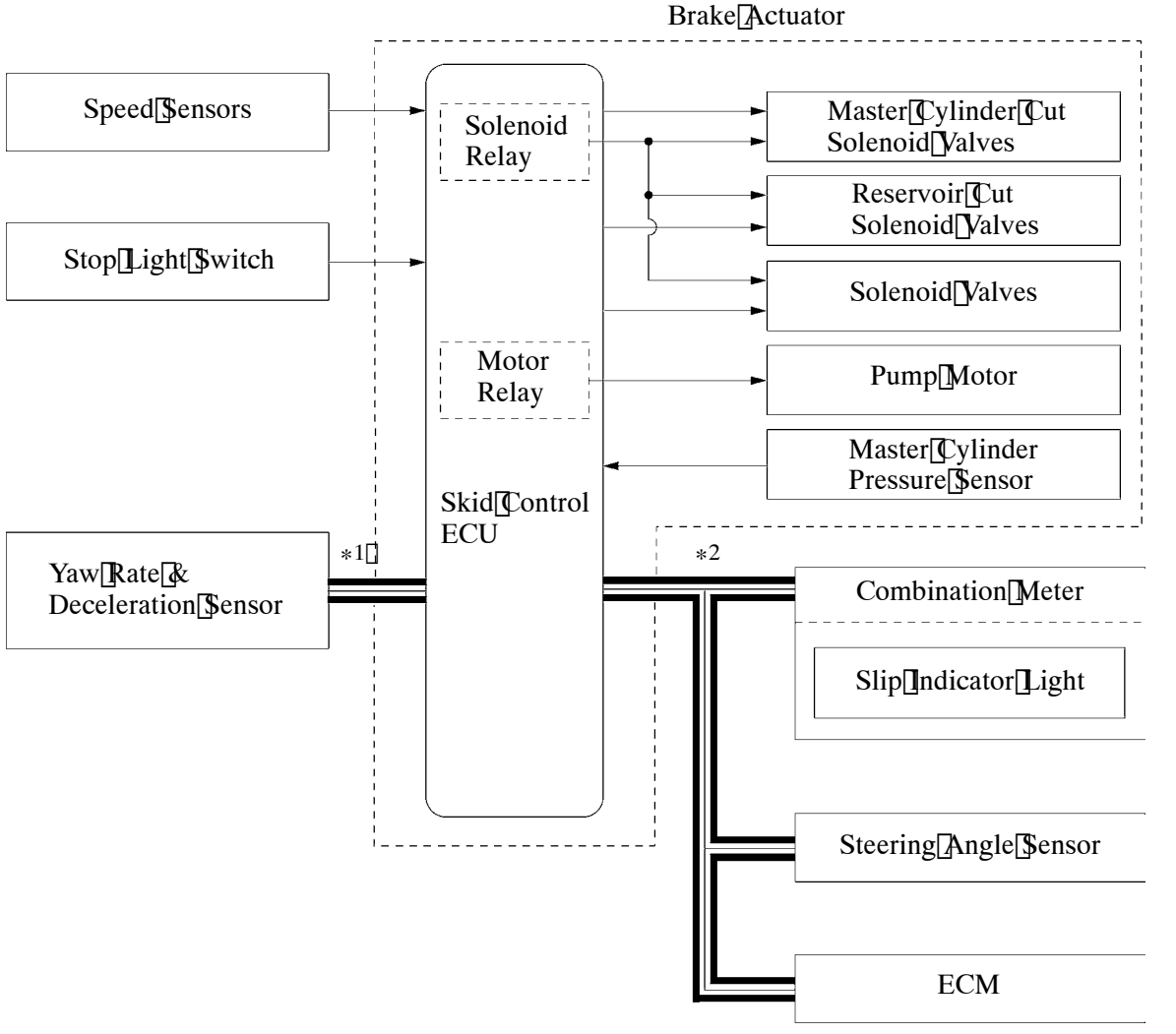


Item			Brake Assist Not Activated	Brake Assist Activated
Pumpt			Off	On
Master Cylinder Cut Solenoid Valve	(1)	Port (A)	Off/Open	On/Closed
	(4)	Port (D)		
Reservoir Cut Solenoid Valve	(2)	Port (B)	Off/Closed	On/Open
	(3)	Port (C)		
Pressure Holding Solenoid Valve	(5)	Port (E)	Off/Open	←
	(6)	Port (F)		
	(7)	Port (G)		
	(8)	Port (H)		
Pressure Reduction Solenoid Valve	(9)	Port (I)	Off/Closed	←
	(10)	Port (J)		
	(11)	Port (K)		
	(12)	Port (L)		

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 control the slippage of the drive wheels.
The diagram on the next page shows the hydraulic circuit in the pressure increase mode when the TRC is activated. The pressure holding solenoid valve and the pressure reduction solenoid valve are turned on/off according to the ABS and EBD operation pattern described on page CH-108. When the TRC is activated, each solenoid valve operates as shown in the table on page CH-113.

▶ System Diagram ◀

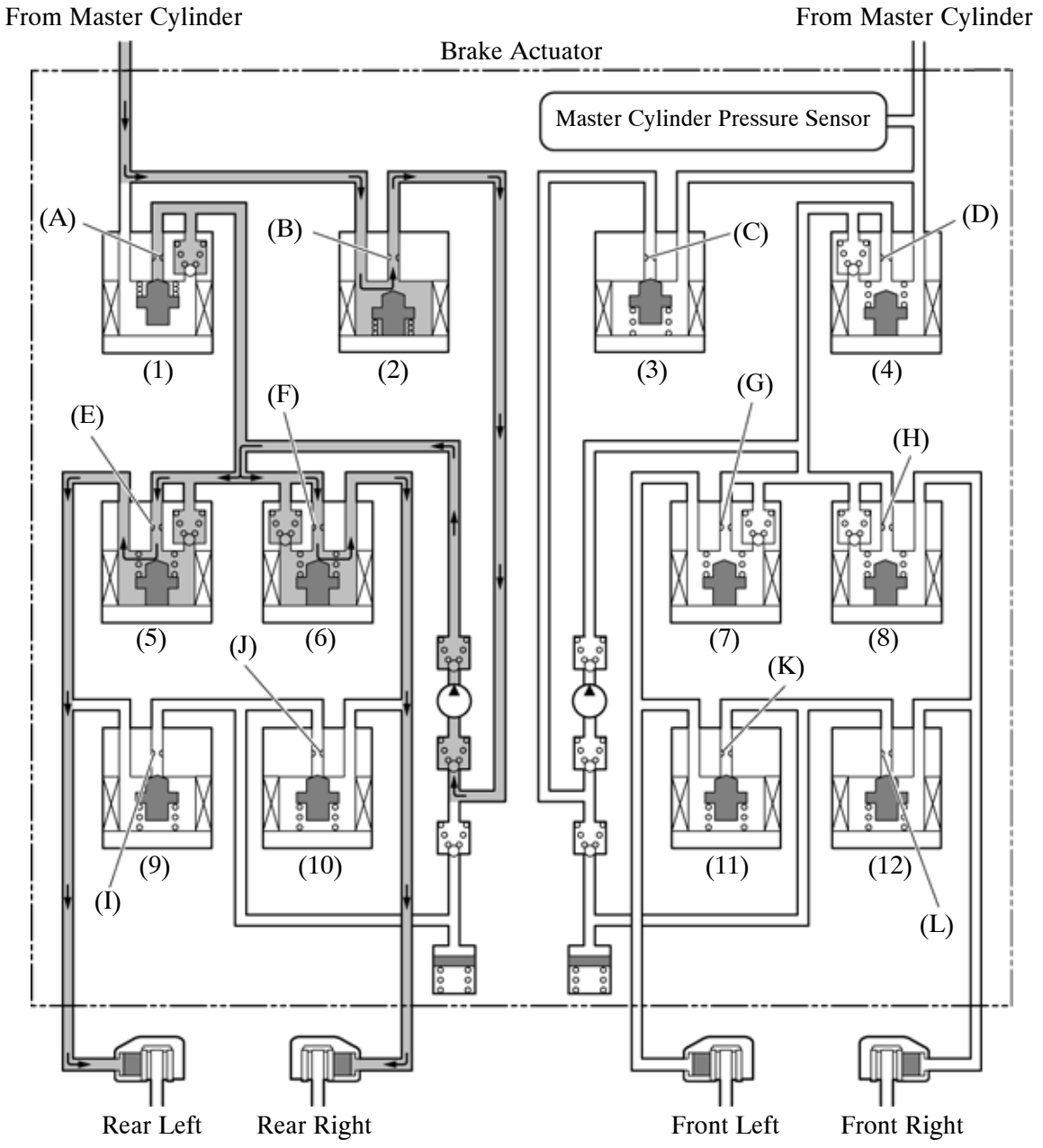


*1: CAN (braking & driving bus)
*2: CAN (V bus)

11YCH027I

CH

▶ TRC Operation ◀



Item				TRC Operation			
				Not Activated	Pressure Increase Mode	Pressure Holding Mode	Pressure Reduction Mode
Pump				Off	On	←	←
Master Cylinder Cut Solenoid Valve		(1)	Port (A)	Off/Open	On/Closed	←	Off/Open
		(4)	Port (D)	Off/Open	←	←	←
Reservoir Cut Solenoid Valve		(2)	Port (B)	Off/Closed	On/Open	←	Off/Closed
		(3)	Port (C)	Off/Closed	←	←	←
Front Brake	Pressure Holding Solenoid Valve	(7)	Port (G)	Off/Open	Off/Open	←	←
		(8)	Port (H)				
	Pressure Reduction Solenoid Valve	(11)	Port (K)	Off/Closed	←	←	←
		(12)	Port (L)				
	Wheel Cylinder Pressure	Right		—	—	—	—
		Left					
Rear Brake	Pressure Holding Solenoid Valve	(5)	Port (E)	Off/Open	←	On/Closed	Off/Open
		(6)	Port (F)				
	Pressure Reduction Solenoid Valve	(9)	Port (I)	Off/Closed	←	←	←
		(10)	Port (J)				
	Wheel Cylinder Pressure	Right		—	Increase	Hold	Reduce
		Left					

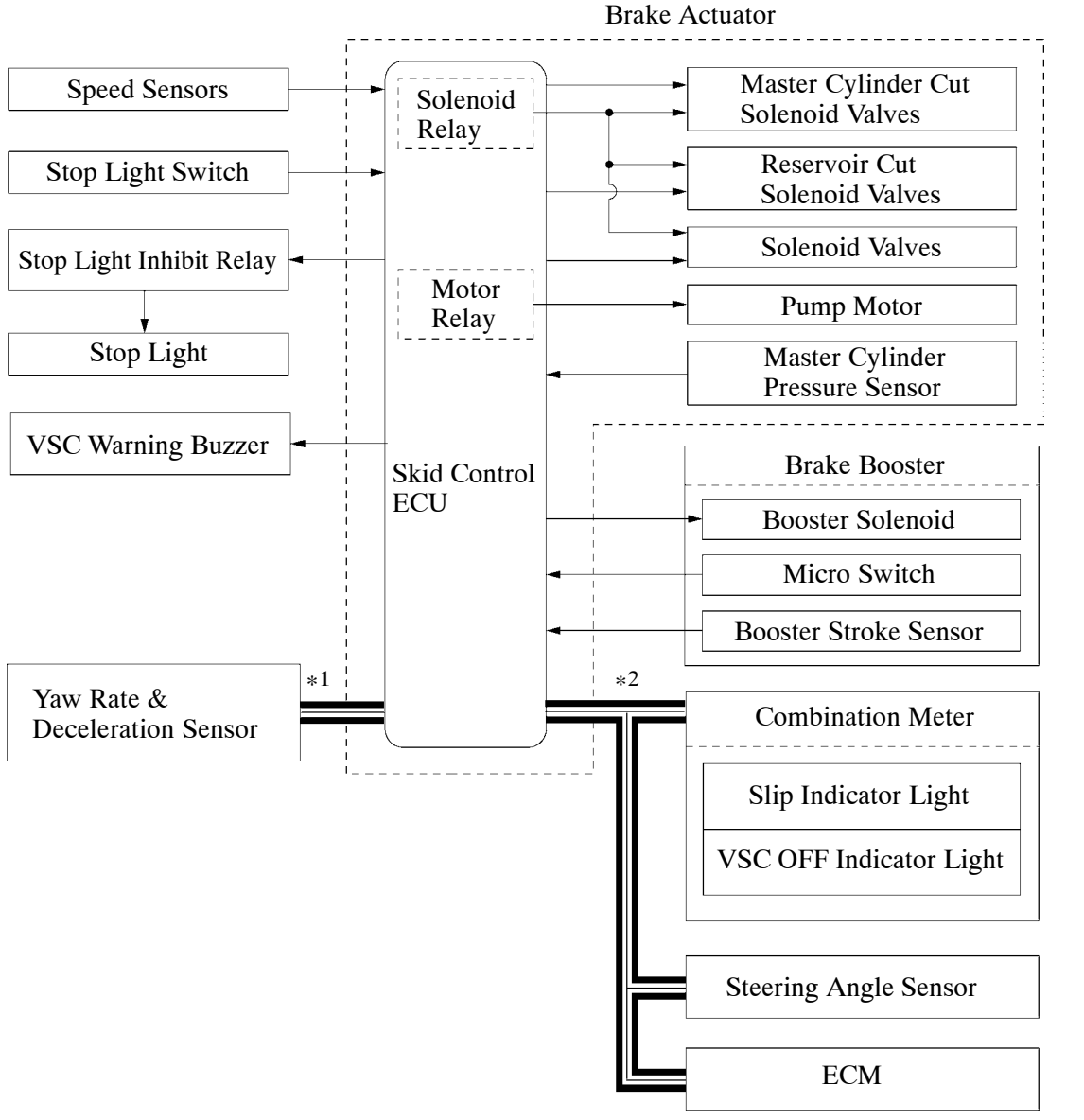
CH

VSC Operation

1) General

- Based on the information provided by various sensors, switches, and the ECM, the skid control ECU determines the vehicle's yaw moment. Then, the skid control ECU controls the fluid pressure that is generated by the pump & pump motor and applies it by way of the solenoid valves to the brake wheel cylinder of each wheel in the following three modes: pressure reduction, pressure hold, and pressure increase modes. As a result, the tendency of the vehicle to experience a front wheel skid or rear wheel skid is restrained.
- At this time, the skid control ECU outputs a VSC operation signal to the ECM and the combination meter and causes the VSC warning buzzer to sound. Upon receiving this signal, the ECM controls the throttle to regulate the engine output. The slip indicator light will blink in the combination meter.

▶ System Diagram ◀



*1: CAN (braking & driving bus)
*2: CAN (V bus)

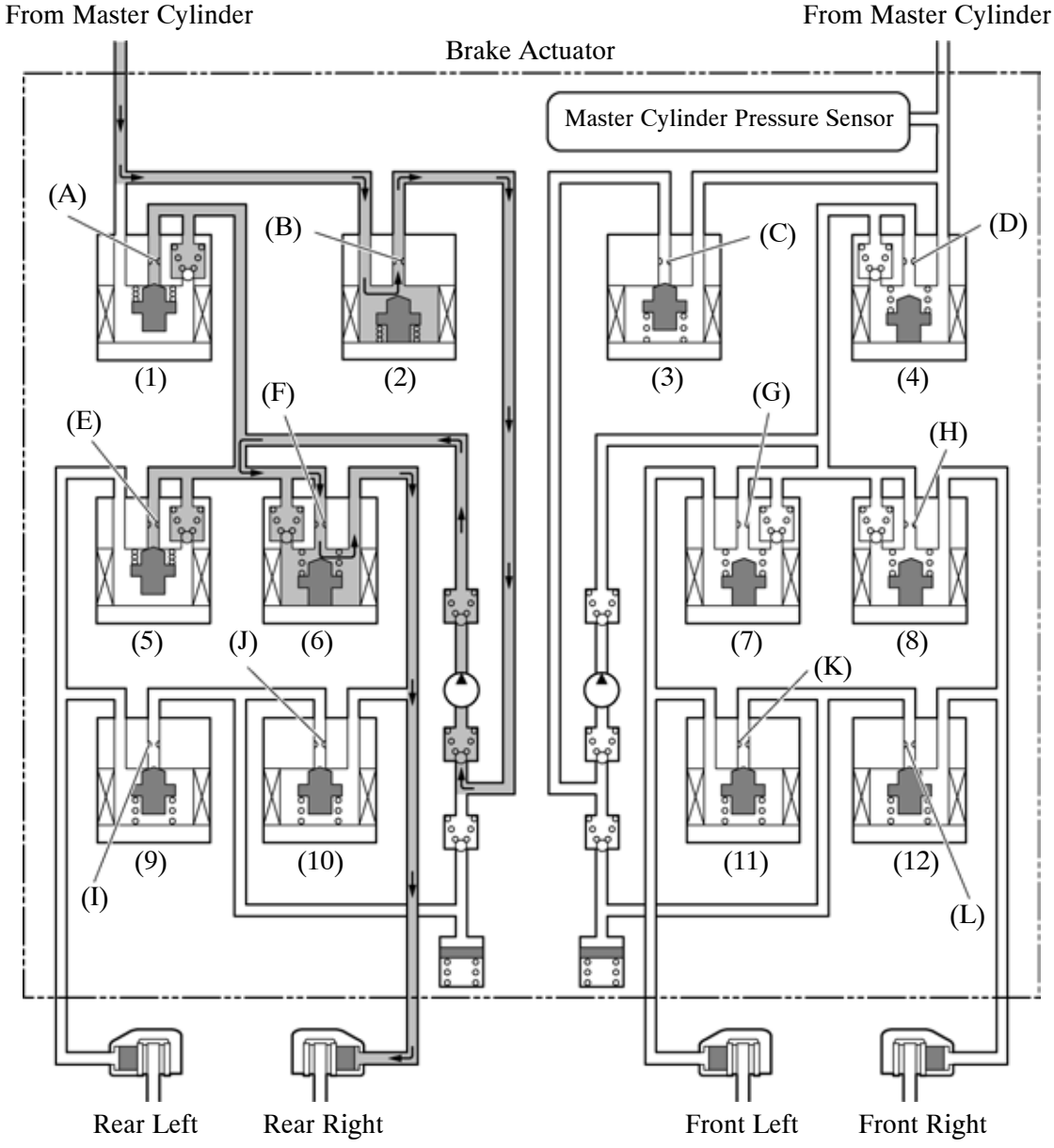
11YCH029I

2) Front Wheel Skid Restraining (Turning to Right)

In front wheel skid restraining control, the brakes of the 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 controls the front wheel skid condition while the vehicle makes a right turn.
- In other operating modes, the pressure holding valves and the pressure reduction valves are turned on/off according to a pattern that suits the ABS and EBD operation.
- When the VSC is activated, each solenoid valve operates as shown in the table on the next page.

▶ VSC Operation (Front Wheel Skid Restraining) ◀



11YCH030I

CH

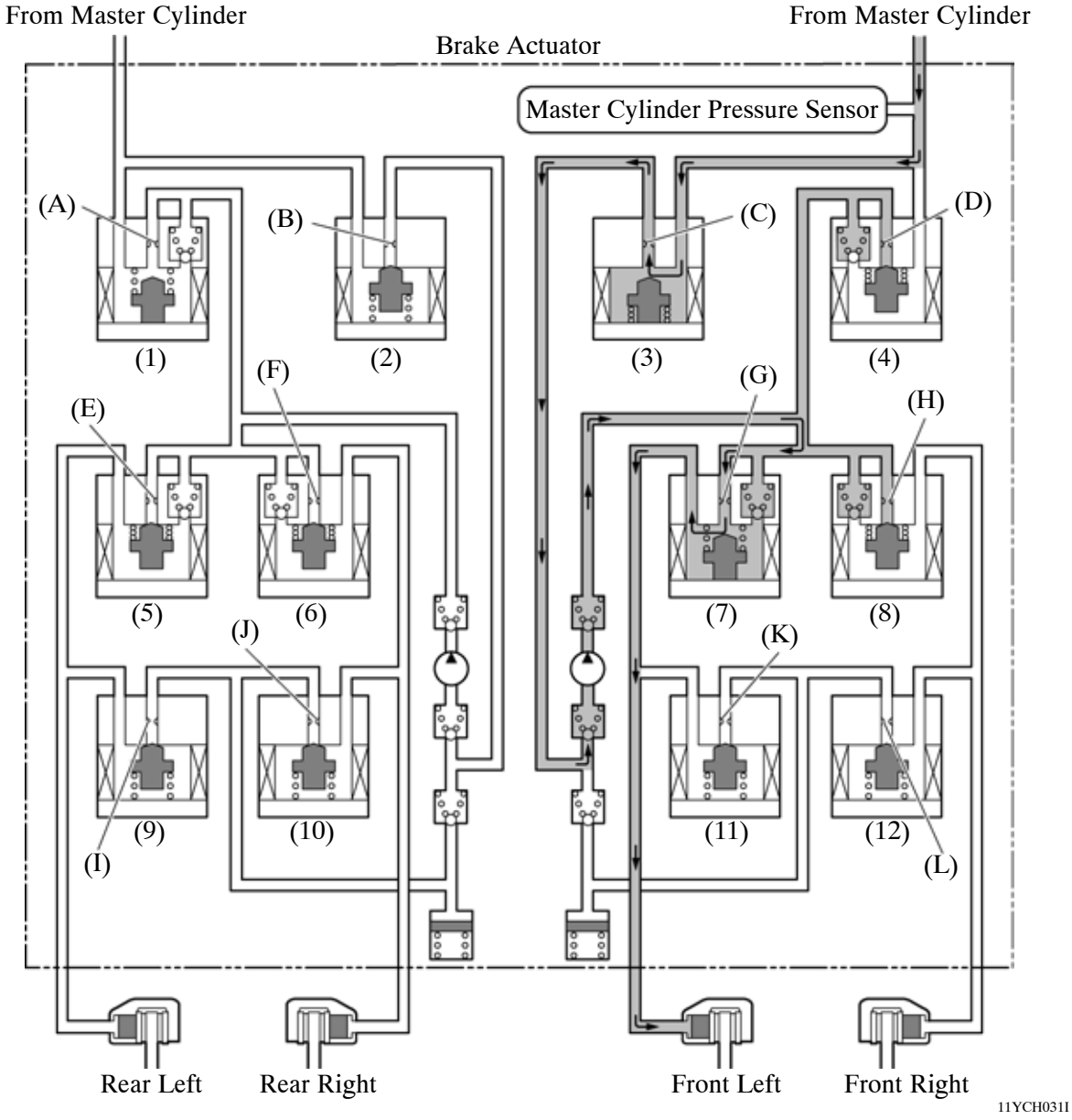
Item				VSC Operation			
				Not Activated	Pressure Increase Mode	Pressure Holding Mode	Pressure Reduction Mode
Pump				Off	On	←	←
Master Cylinder Cut Solenoid Valve		(1)	Port (A)	Off/Open	On/Closed	←	Off/Open
		(4)	Port (D)	Off/Open	←	←	←
Reservoir Cut Solenoid Valve		(2)	Port (B)	Off/Closed	On/Open	Off/Closed	←
		(3)	Port (C)	Off/Closed	←	←	←
Front Brake	Pressure Holding Solenoid Valve	(7)	Port (G)	Off/Open	←	←	←
		(8)	Port (H)				
	Pressure Reduction Solenoid Valve	(11)	Port (K)	Off/Closed	←	←	←
		(12)	Port (L)				
	Wheel Cylinder Pressure	Right		—	—	—	—
		Left		—	—	—	—
Rear Brake	Pressure Holding Solenoid Valve	(5)	Port (E)	Off/Open	On/Closed	←	←
		(6)	Port (F)	Off/Open	←	←	←
	Pressure Reduction Solenoid Valve	(9)	Port (I)	Off/Closed	←	←	←
		(10)	Port (J)	Off/Closed	←	←	←
	Wheel Cylinder Pressure	Right		—	Increase	Hold	Reduce
		Left		—	—	—	—

3) Rear Wheel Skid Restraining (Turning to Right)

In rear wheel skid restraining control, the brake of the front wheel of the outer 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 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 and EBD operation pattern.
- When the VSC is activated, each solenoid valve operates as shown in the table on the next page.

▶ VSC Operation (Rear Wheel Skid Restraining) ◀



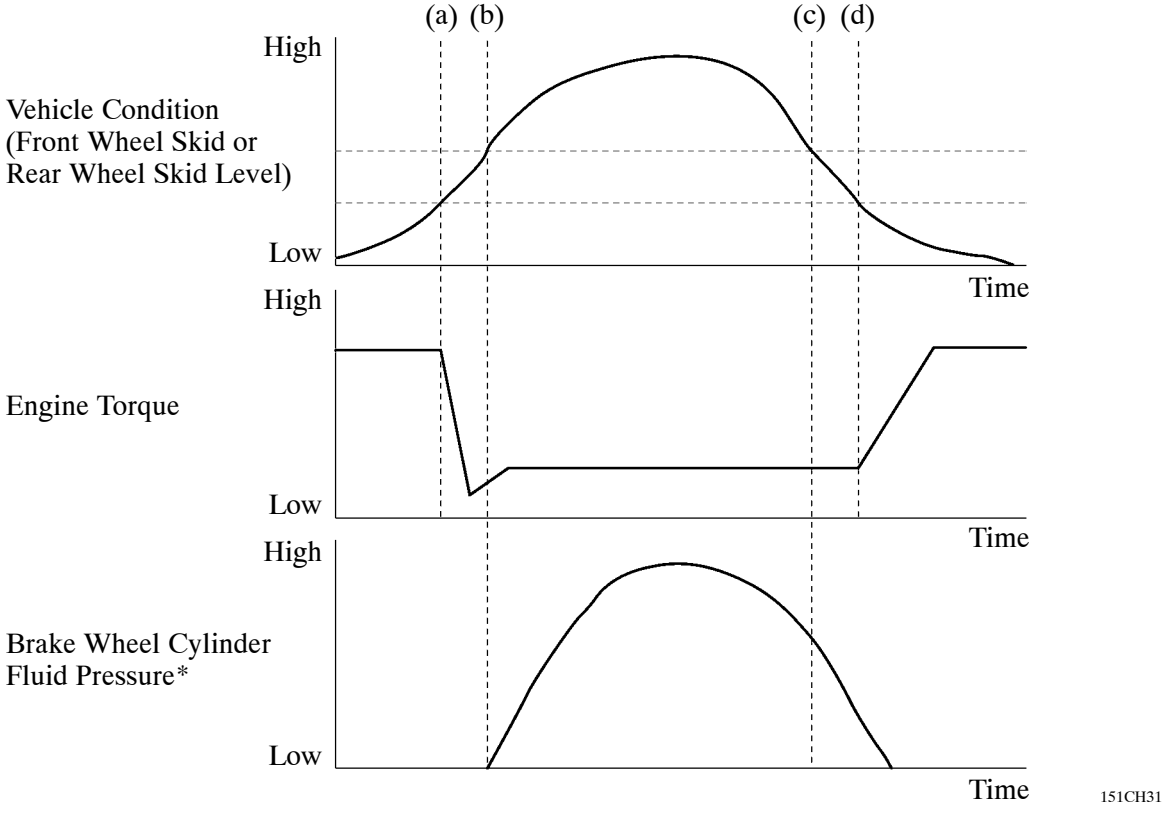
CH

Item				VSC Operation			
				Not Activated	Pressure Increase Mode	Pressure Holding Mode	Pressure Reduction Mode
Pump				Off	On	←	←
Master Cylinder Cut Solenoid Valve		(1)	Port (A)	Off/Open	←	←	←
		(4)	Port (D)	Off/Open	On/Closed	←	Off/Open
Reservoir Cut Solenoid Valve		(2)	Port (B)	Off/Closed	←	←	←
		(3)	Port (C)	Off/Closed	On/Open	←	Off/Closed
Front Brake	Pressure Holding Solenoid Valve	(7)	Port (G)	Off/Open	←	On/Closed	Off/Open
		(8)	Port (H)	Off/Open	On/Closed	←	←
	Pressure Reduction Solenoid Valve	(11)	Port (K)	Off/Closed	←	←	←
		(12)	Port (L)	Off/Closed	←	←	←
	Wheel Cylinder Pressure	Right		—	—	—	—
		Left		—	Increase	Hold	Reduce
Rear Brake	Pressure Holding Solenoid Valve	(5)	Port (E)	Off/Open	On/Closed	←	←
		(6)	Port (F)				
	Pressure Reduction Solenoid Valve	(9)	Port (I)	Off/Closed	←	←	←
		(10)	Port (J)				
	Wheel Cylinder Pressure	Right		—	—	—	—
		Left		—	—	—	—

11. Engine Output Control

During the VSC and TRC operation, the skid control ECU outputs an engine output control request signal to the ECM. Upon receiving this signal, the ECM effects throttle control to regulate the engine output.

(a): Start of engine control
(b): Start of brake control
(c): Brake control completed
(d): Engine control completed



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

12. Initial Check

Each time the ignition switch is turned ON, and the vehicle reaches approximately speed of 23 km/h (14.3 mph) or more, the skid control ECU performs an initial check.
The functions of each solenoid valve and pump motor in the brake actuator are checked in sequence.

13. Diagnosis

- If the skid control ECU detects a malfunction in the brake control system (ABS, EBD, brake assist, TRC, or VSC), the warning lights or indicator lights illuminate to alert the driver of the malfunction. At the same time, the skid control ECU stores the Diagnostic Trouble Code (DTC) in memory. This DTC can be read by the following 2 methods.
  - The 5-digit DTC can be read by connecting an intelligent tester II to the DLC3.
  - The 2-digit DTC can be read from the number of the blinking of the ABS warning light by connecting the SST (09843-18040) to the TC and CG terminals of the DLC3.
- This system has a sensor signal check (test mode) function. This function is activated by connecting an intelligent tester II or by connecting the SST (09843-18040) to the TS and CG terminals of the DLC3. If the skid control ECU detects a malfunction during a sensor signal check (test mode), it stores the DTC in its memory.

For details on the DTC that are stored in skid control ECU memory and the DTC that are output through the sensor signal check function, refer to the SEQUOIA Repair Manual (Pub. No. RM11Y0E).

14. Fail-safe

- In the event of a malfunction in the ABS and/or brake assist, the skid control ECU prohibits ABS, brake assist, TRC, and VSC operation.
- In the event of a malfunction in the EBD control, the skid control ECU prohibits EBD operation. In this case, normal (non electronically assisted) braking performance will be available. Functions of the brake control system (ABS, EBD, brake assist, TRC, and VSC) will not be available.
- In the event of a malfunction in the TRC and/or VSC, the skid control ECU prohibits TRC and VSC operations.
- If a communication malfunction occurs between the skid control ECU and the steering angle sensor or the yaw rate & deceleration sensor, the skid control ECU stops TRC and VSC operation.
- When the ECM detects a DTC in the engine control system, it will disable the TRC and VSC operations.