

■ BRAKE CONTROL SYSTEM

1. General

The brake control system has the following functions:

Function	Outline	Model	
		2WD	4WD
ABS (Anti-lock Brake System)	The ABS helps prevent the wheels from locking when the brakes are applied firmly or on a slippery surface.	○	○
EBD (Electronic Brake force Distribution)	The EBD utilizes the 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 maintain the vehicle behavior.	○	○
Brake Assist	<ul style="list-style-type: none"> 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. 	○	○
TRAC (Traction Control)	TRAC helps prevent the drive wheels from slipping if the driver presses the accelerator pedal excessively when starting off or accelerating on a slippery surface.	○	○*
A-TRAC (Active Traction Control)	When the vehicle drive mode is H4 or L4, the A-TRAC operates. A-TRAC controls the brake hydraulic pressure that is applied to the slipping wheel, and distributes the drive force that would have been lost through the slippage to the remaining wheels in order to achieve an LSD effect.	—	○
Auto LSD (Limited Slip Differential)	Briefly pressing the VSC OFF switch in normal mode enters TRAC OFF mode, allowing the Auto LSD to operate. The Auto LSD achieves a function equivalent to that of an LSD system through the use of the TRAC. The Auto LSD applies brake hydraulic pressure to a slipping wheel to reduce the difference in rotation speed between the left and right drive wheels. This causes driving torque to be transmitted to the wheel opposite the slipping wheel.	○	○*
VSC (Vehicle Stability Control)	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].	○	○

*: For 4WD models, these functions operate while in 2WD mode.

2. Drive Modes

The brake control functions vary by the drive mode as shown in the following table:

► 2WD Models ◀

○: Operates

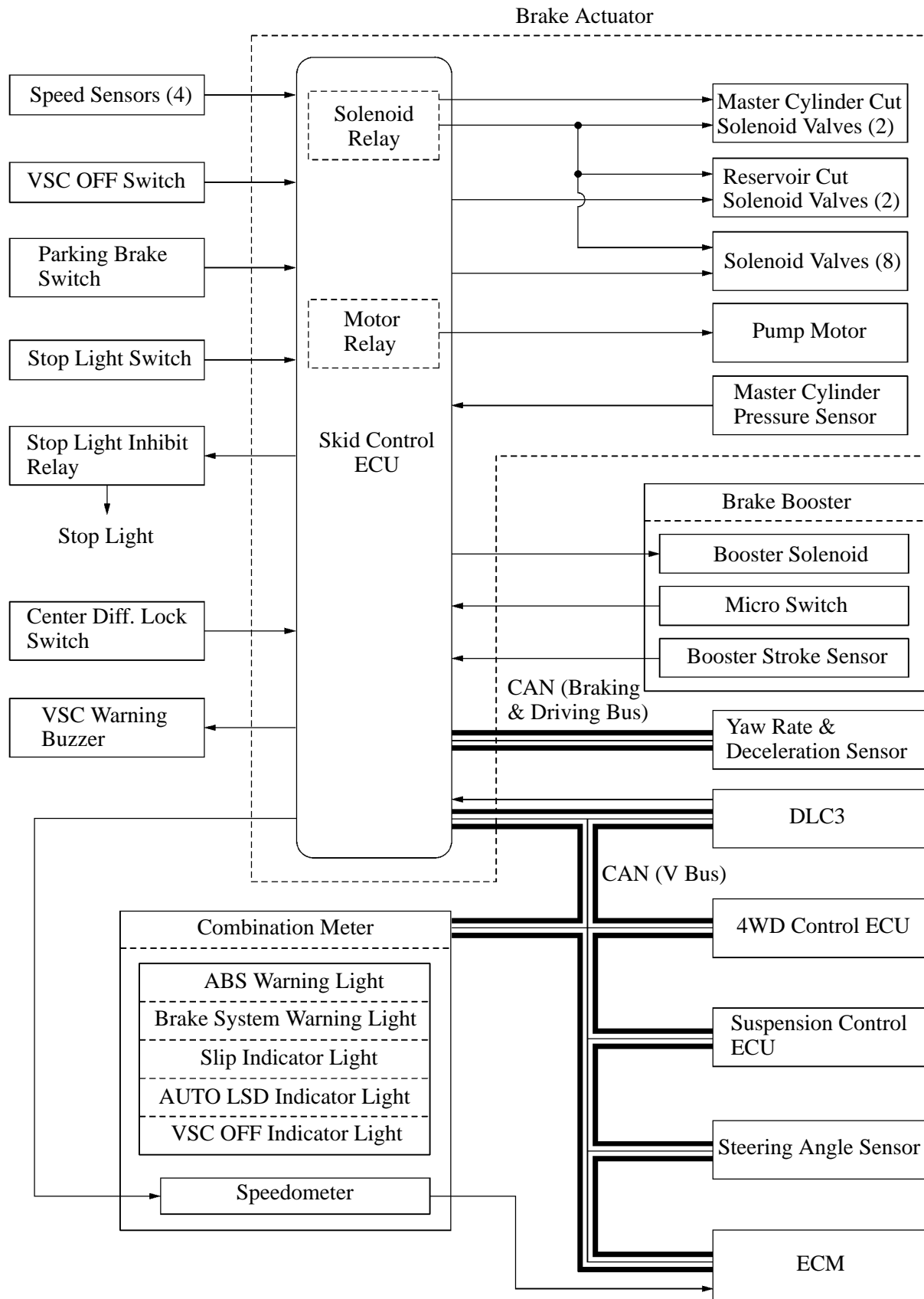
Drive Mode	VSC OFF Switch	Brake Control Function					
		ABS	EBD	Brake Assist	TRAC	Auto LSD	VSC
2WD	Normal Mode	○	○	○	○	—	○
	TRAC OFF Mode	○	○	○	—	○	○
	Auto LSD Mode	○	○	○	—	○	—
	VSC OFF Mode	○	○	○	—	—	—

► 4WD Models ◀

○: Operates

Drive Mode		VSC OFF Switch	Brake Control Function						
			ABS	EBD	Brake Assist	TRAC	A-TAC	Auto LSD	VSC
2WD		Normal Mode	○	○	○	○	—	—	○
		TRAC OFF Mode	○	○	○	—	—	○	○
		Auto LSD Mode	○	○	○	—	—	○	—
		VSC OFF Mode	○	○	○	—	—	—	—
4WD	H4F	Normal Mode	○	○	○	—	○	—	○
		TRAC OFF Mode	○	○	○	—	○	—	○
		VSC OFF Mode	○	○	○	—	—	—	—
	L4F	Normal Mode	○	○	○	—	○	—	○
		VSC OFF Mode	○	○	○	—	—	—	—
	H4L L4L	Normal Mode	○	○	○	—	○	—	—
		VSC OFF Mode	○	○	○	—	—	—	—

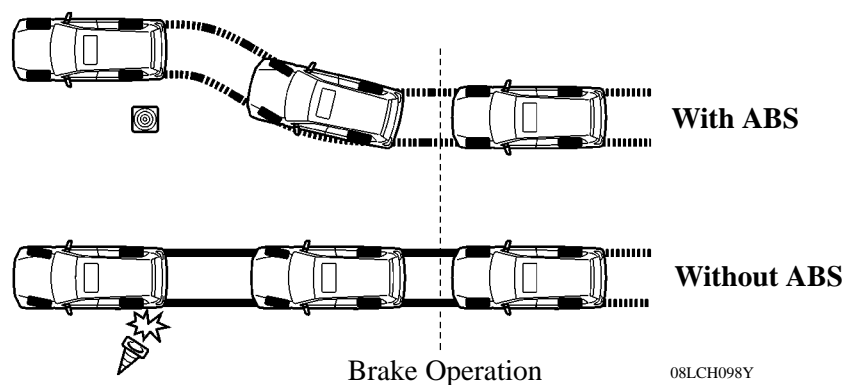
3. System Diagram



4. Outline of Brake Control Function

ABS (Anti-lock Brake System)

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.



◆: The illustration provides a conceptual image.

EBD (Electronic Brake force Distribution)

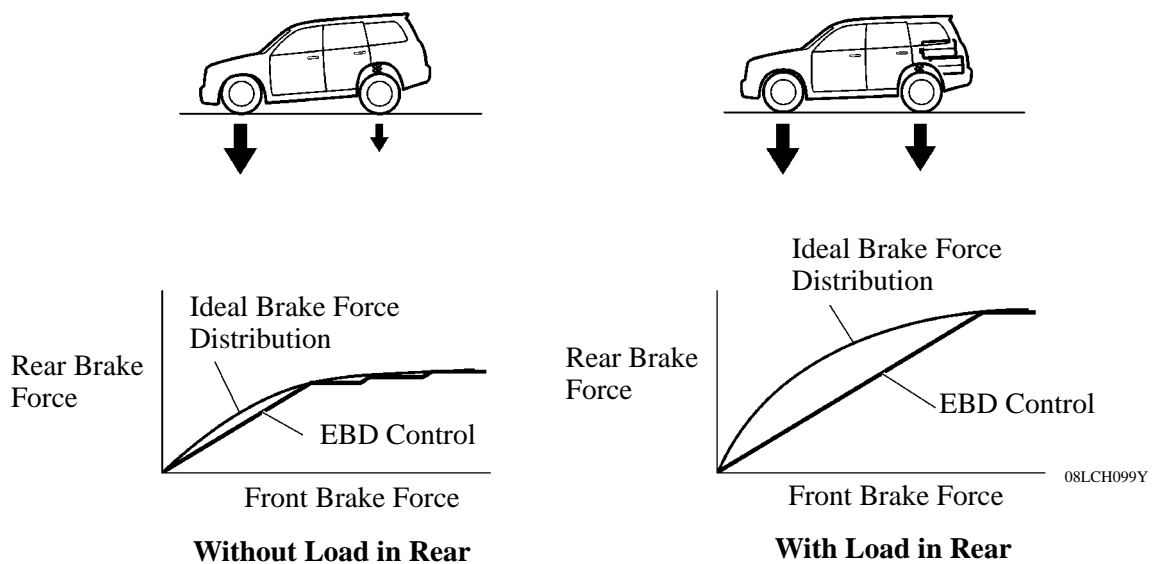
1) General

The EBD control utilizes the ABS, realizing 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

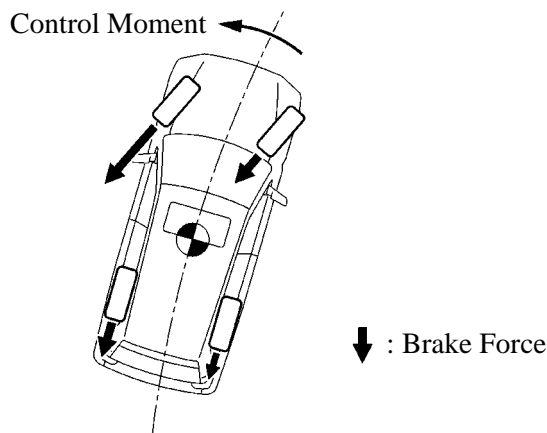
This function controls the brake force that acts on the rear wheels in accordance with the changes in the vehicle conditions such as load factors or deceleration, in order to ensure excellent braking performance.

► EBD Control Concept ◀



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

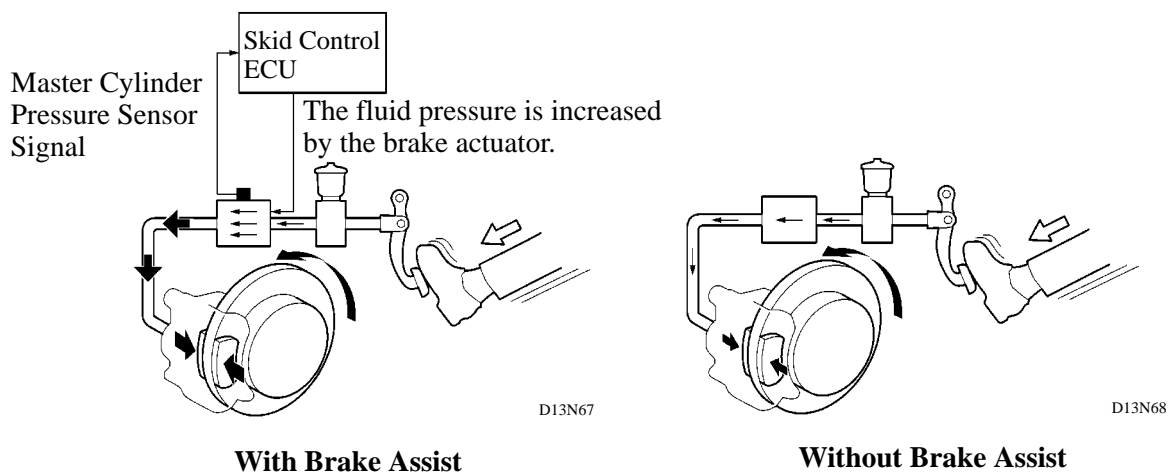
During cornering braking, this function controls the brake force that acts on the left and right wheels in accordance with the vehicle conditions at that time. This ensures vehicle stability and excellent braking performance.



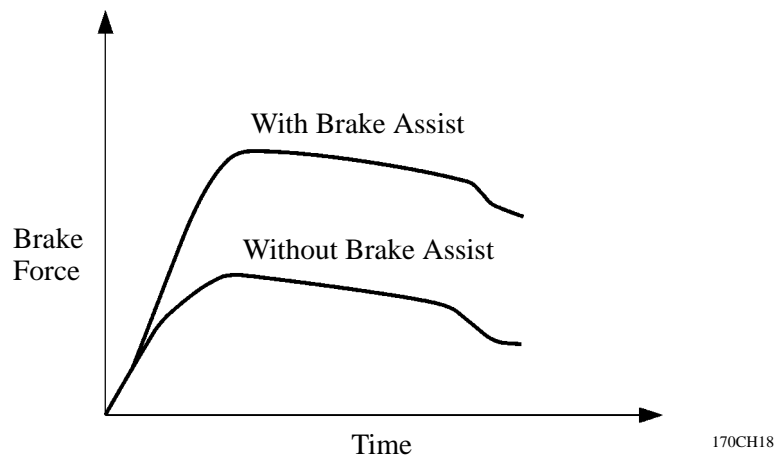
Brake Assist

- 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 the driver's depressing force is small when applying emergency braking ◀



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

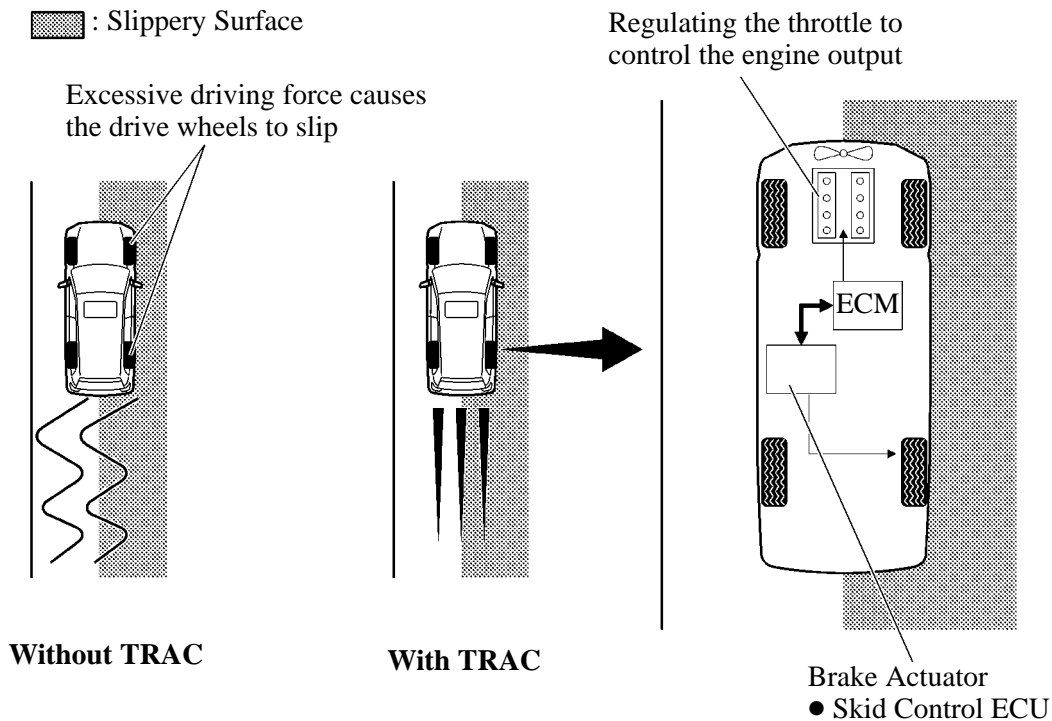


TRAC (Traction Control)

- 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, TRAC 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 two vehicles, one with TRAC 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 TRAC, 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, TRAC can constantly help the driver to maintain stability while accelerating.

◆: On the 4WD models, this function operates only when the vehicle is driving in 2WD mode.

► Driving condition on road with different surface friction characteristics ◀



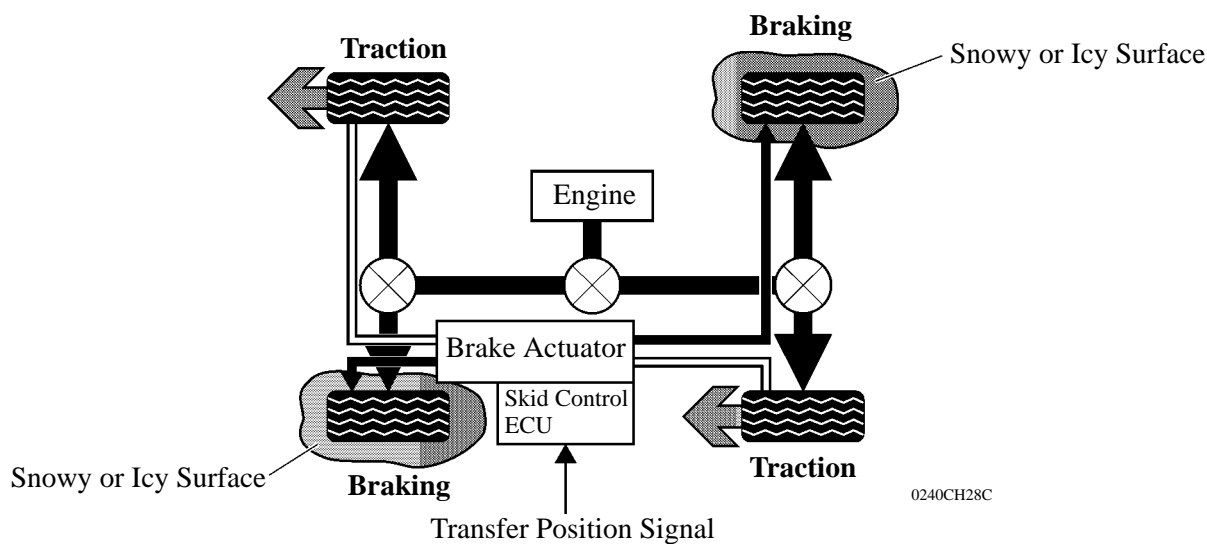
A-TRAC (Active Traction Control)

1) General

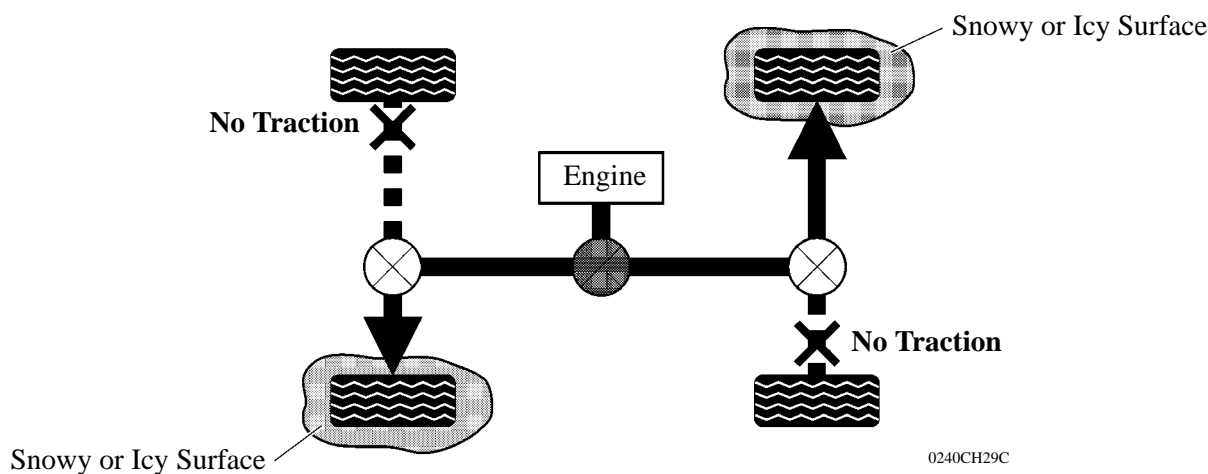
When the vehicle drive mode is H4 or L4, the A-TRAC helps restrain wheelspin by controlling the brake fluid pressure that is applied to the spinning wheels, and distributes the drive force that would have been lost through the slippage to the remaining wheels in order to achieve an effect that is similar to LSD.

- It independently controls the brake fluid pressure to the four wheels in accordance with the extent of the slippage at the wheels, as detected by the skid control ECU.

► With A-TRAC ◀



► Without A-TRAC ◀



2) Effectiveness of A-TRAC

The effectiveness of A-TRAC is as follows:

- Off-road drivability that is equivalent to having the center differential locked and limited slip differentials on both front and rear has been realized.
- This function makes the operation of the differential lock switches basically unnecessary to ensure the ease of driving.
- While realizing the off-road drivability that is equivalent to having the center and rear differentials locked, as compared to the differential gear in the locked state, the prevention of tight corner braking phenomenon ensures the ease of nimble steerability.

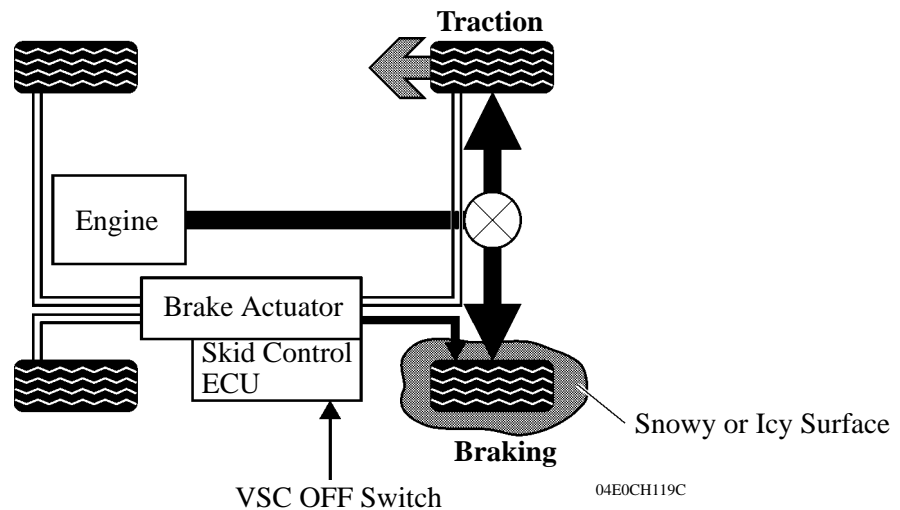
Auto LSD

Briefly pressing the VSC OFF switch in normal mode allows the Auto LSD to operate (TRAC OFF mode is selected). The Auto LSD achieves the LSD effect by regulating the hydraulic pressure that acts on the drive wheels.

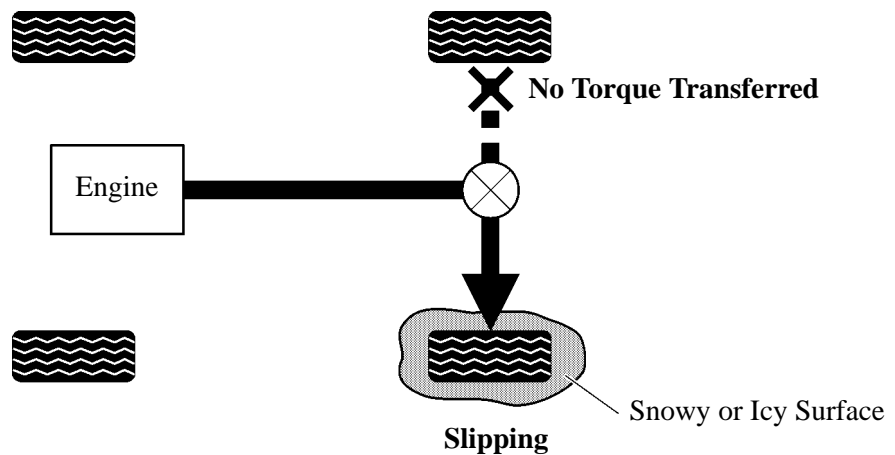
- TRAC enhances the start-off performance of the vehicle during low-grip surface conditions, such as snow or mud, by restricting the acceleration effort during a start-off, in order to help prevent the wheels from spinning.
- The Auto LSD enhances the acceleration effort, in order to apply greater drive torque to the wheel that has grip. Thus, this function enables the vehicle to get unstuck if a wheel loses its grip, and enhances the vehicle's start-off performance when high-resistance surface conditions exist, such as loose gravel or sand.

◆: On the 4WD models, this function operates only when the vehicle is driving in 2WD mode.

► With Auto LSD ◀



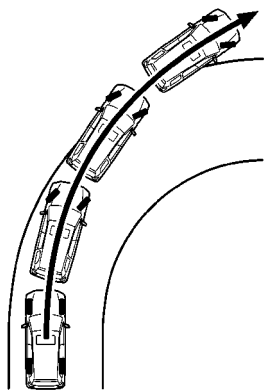
► Without Auto LSD ◀



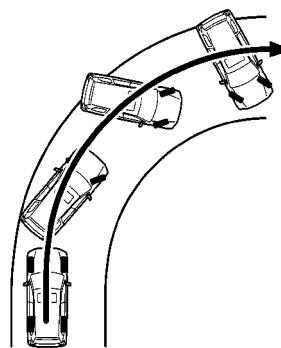
VSC (Vehicle Stability Control)

The followings are two 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

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1) Method for Determining Vehicle Condition

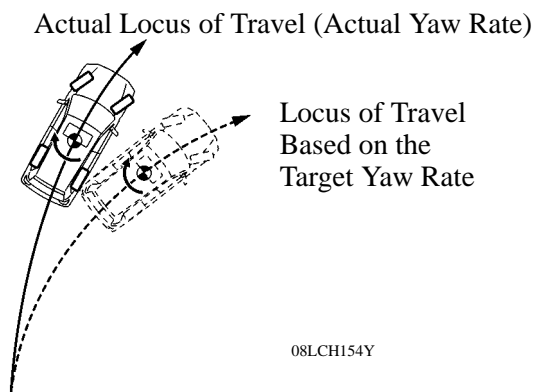
To determine the condition of the vehicle, sensors detect the steering angle, vehicle speed, vehicle's yaw rate, and vehicle's lateral acceleration, which are then calculated by the skid control ECU.

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.

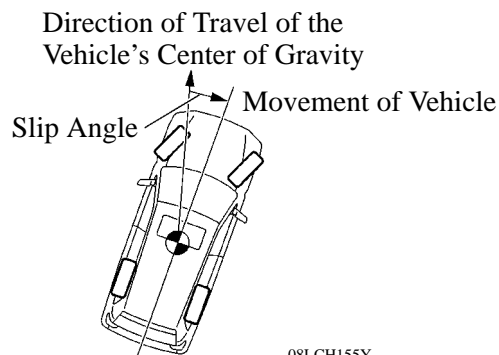
b. Determining Rear Wheel Skid

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.



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Determining Front Wheel Skid



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Determining Rear Wheel Skid

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.

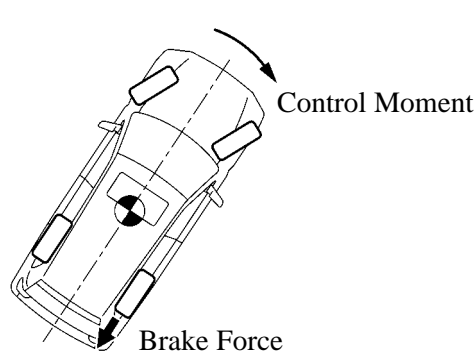
a. Dampening Front Wheel Skid

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.

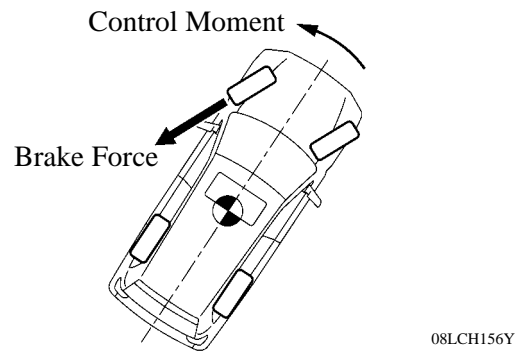
b. Dampening Rear Wheel Skid

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.

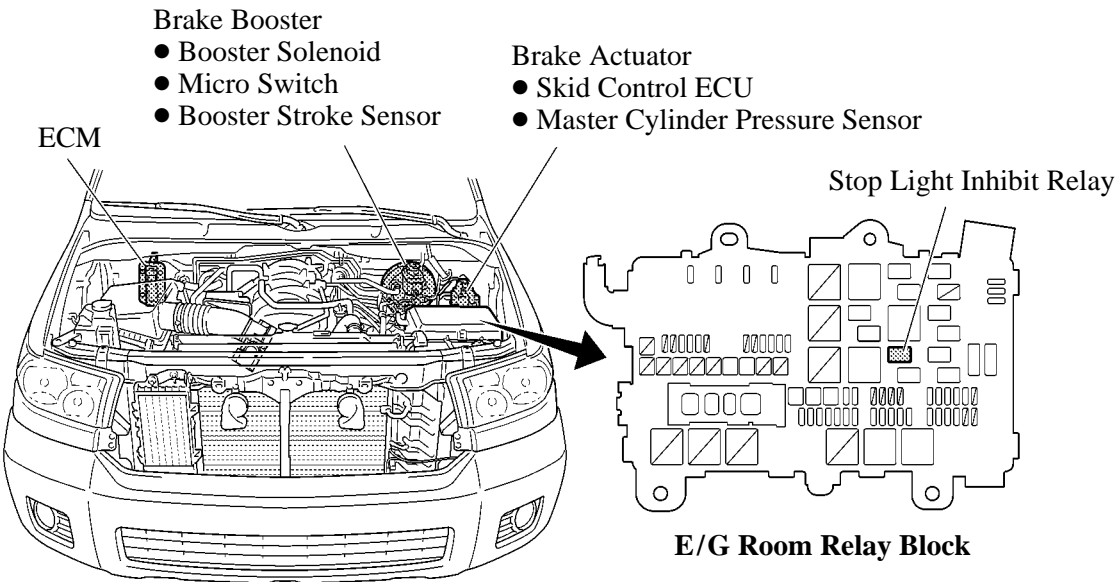
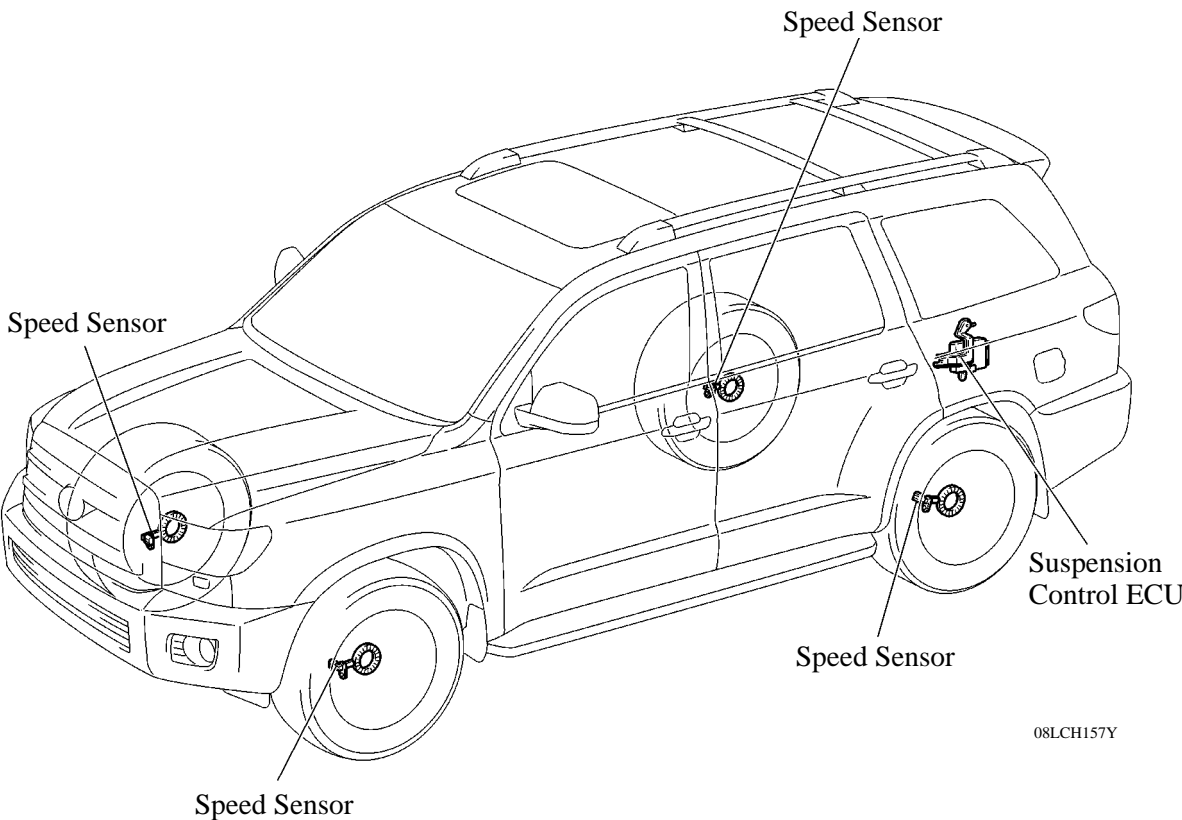


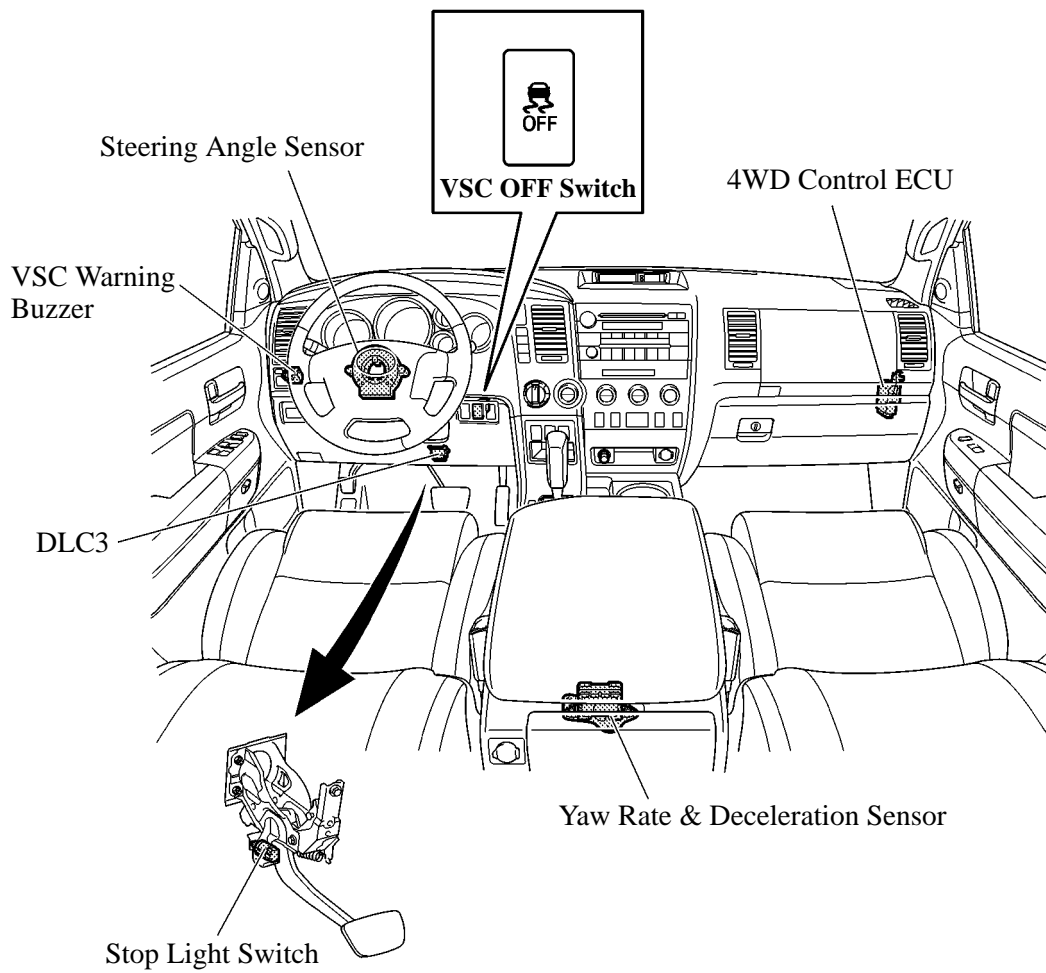
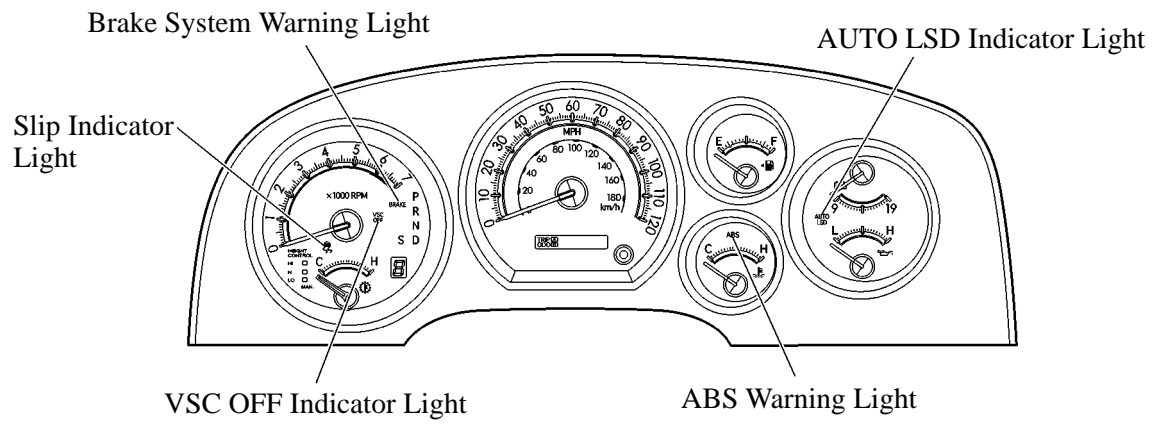
**Dampening a Front Wheel Skid
(Marking a Right Turn)**



**Dampening a Rear Wheel Skid
(Marking a Right Turn)**

5. Layout of Main Components





6. 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	<ul style="list-style-type: none"> ● 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	<ul style="list-style-type: none"> ● Blinks to inform the driver that the TRAC, A-TRAC, Auto LSD or VSC is operated. ● Lights up to alert the driver that the skid control ECU detects a malfunction in the TRAC, A-TRAC, Auto LSD or VSC. ● Lights up to inform the driver that the TRAC OFF mode or VSC OFF mode is entered using the VSC OFF switch.
	VSC OFF Indicator Light	<ul style="list-style-type: none"> ● Lights up to inform the driver that the VSC OFF mode is selected using the VSC OFF switch. ● When the skid control ECU detects a malfunction and determines that the TRAC, A-TRAC, Auto LSD, or VSC is not available, the VSC OFF indicator light blinks to alert the driver.
	AUTO LSD Indicator Light	<ul style="list-style-type: none"> ● Lights up to inform the driver that the TRAC OFF mode (Auto LSD ON) is selected using the VSC OFF switch.
VSC Warning Buzzer		<p>The VSC warning buzzer has two types of sounds.</p> <ul style="list-style-type: none"> ● The buzzer sounds intermittently to inform the driver that the VSC is active. ● The buzzer sounds intermittently to inform the driver if the temperature of the brake pads has increased excessively due to the continuous operation of the TRAC, A-TRAC or Auto LSD.
Brake Actuator	Changes the fluid path based on the signals from the skid control ECU during the operation of the ABS, EBD, brake assist, TRAC, A-TRAC, Auto LSD 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	<ul style="list-style-type: none"> ● 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.
	Solenoid Relay	Controls power supplied to the solenoid valves.
	Motor Relay	Supplies power to the pump motor in the brake actuator.

(Continued)

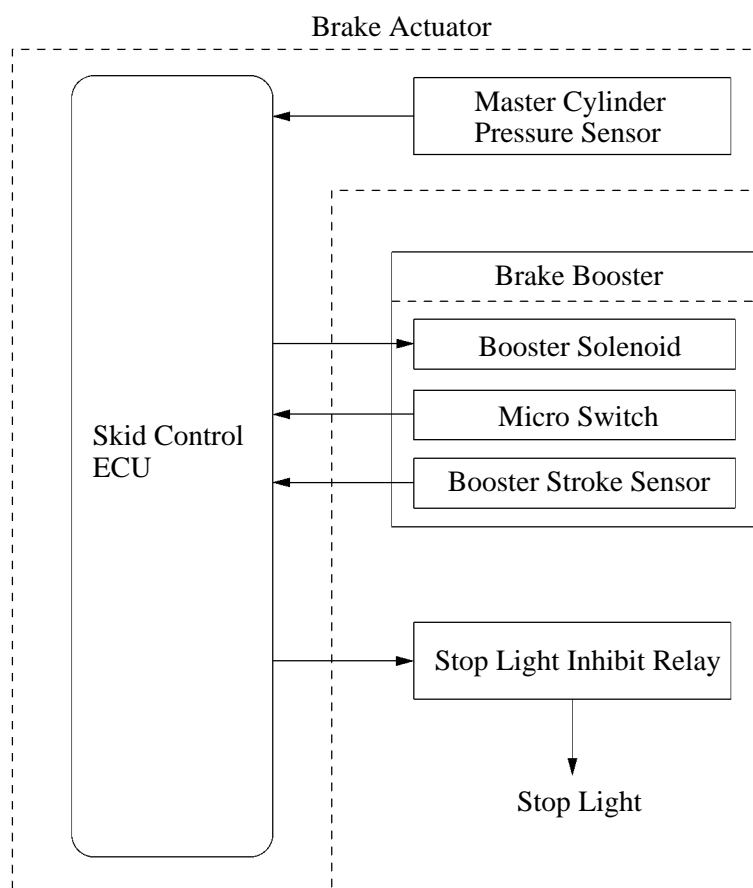
Component		Function
Brake Booster	Booster Solenoid	When the VSC is activated, this solenoid operates in accordance with the signals from the skid control ECU to boost the hydraulic pressure to the wheel cylinders.
	Micro Switch	Detects that the brake pedal is depressed.
	Booster Stroke Sensor	Detects the brake pedal stroke distance.
Speed Sensor		Detects the wheel speed of each of the four wheels.
Yaw Rate & Deceleration Sensor		<ul style="list-style-type: none"> • Detects the vehicle's yaw rate. • Detects the vehicle's lateral acceleration (2WD models). • Detects the vehicle's longitudinal and lateral acceleration (4WD models).
Steering Angle Sensor		Detects the steering direction and angle of the steering wheel.
VSC OFF Switch		<ul style="list-style-type: none"> • Cancels the TRAC or VSC. • Selects the 4 modes (Normal mode, TRAC-OFF mode, Auto LSD mode, VSC-OFF mode).
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 though the driver is not depressing the brake pedal, this relay prevents the stop light from turning ON.
4WD Control ECU (Only for 4WD models)		Detects the transfer shift position (H4 or L4) and sends the information to the skid control ECU.
ECM		<ul style="list-style-type: none"> • 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.

7. 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 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.

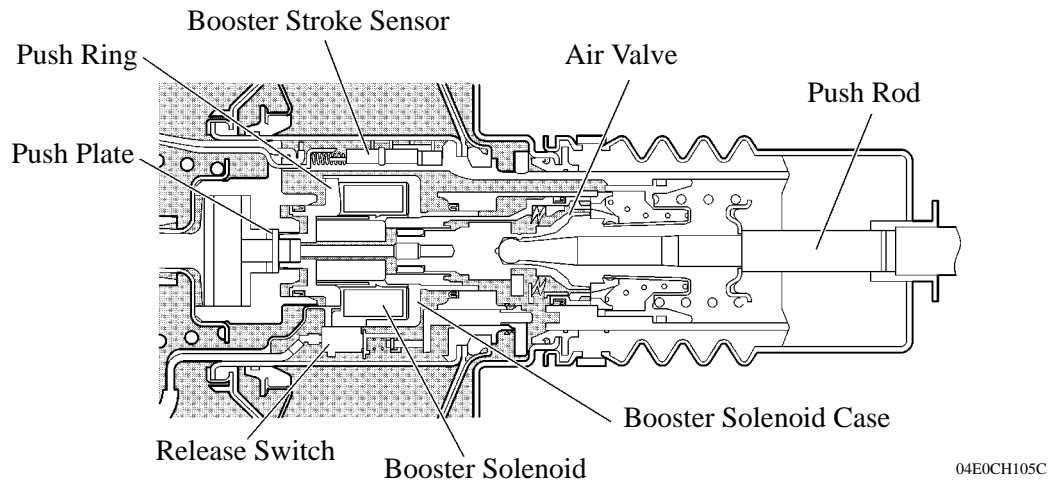
► System Diagram ◀



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Construction

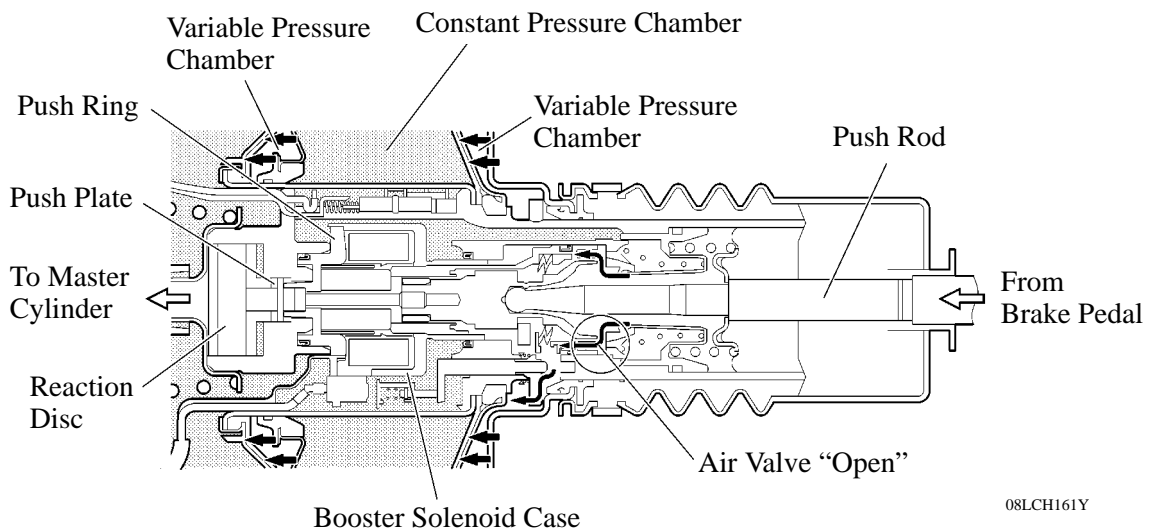
The brake booster mainly consists of the push rod, air valve, booster solenoid, booster solenoid case, release switch, push ring, push plate and booster stroke sensor.



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.

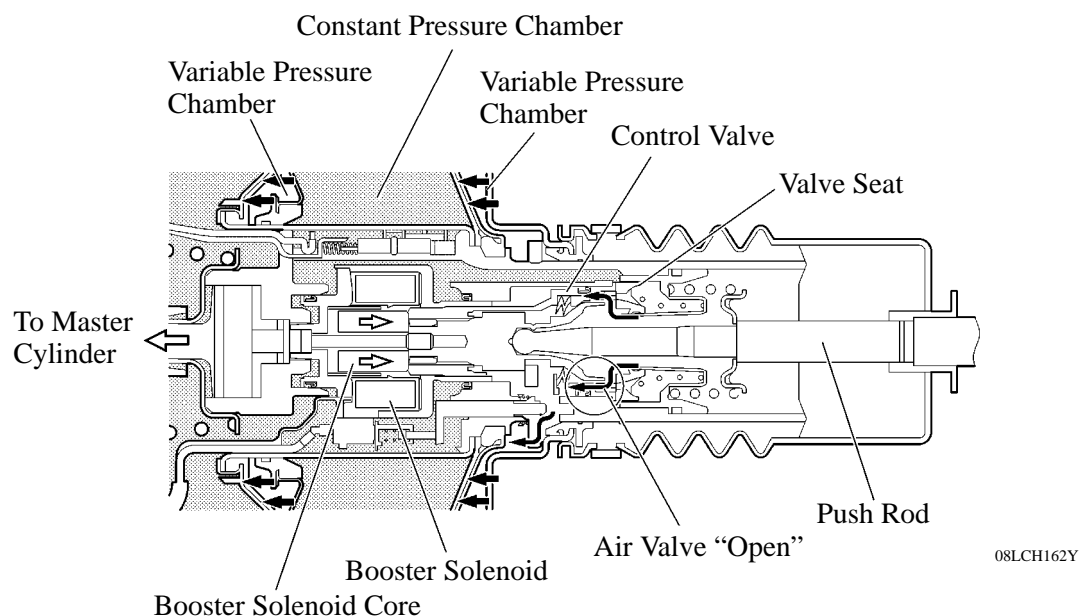


2) VSC Operation

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.

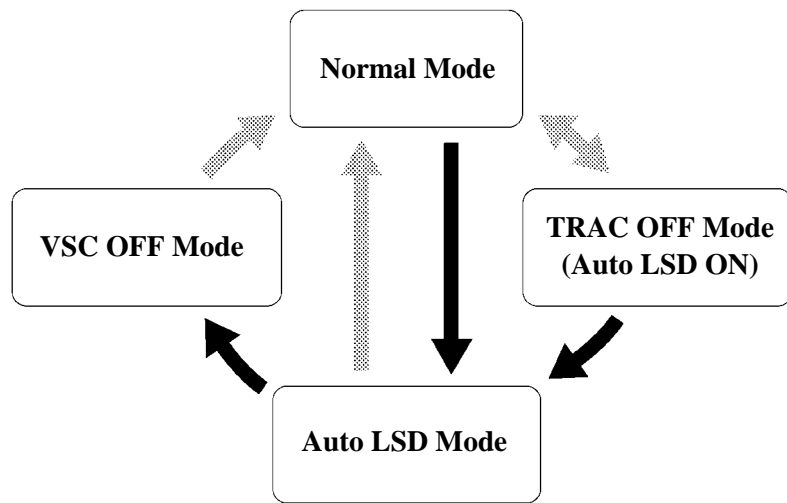



8. VSC OFF Switch


4WD Models (in 2WD Mode) and 2WD Models

The VSC OFF switch can select the 4 modes (Normal mode, TRAC OFF mode, Auto LSD mode, VSC OFF mode).

- Briefly pressing the VSC OFF switch in Normal mode selects the TRAC OFF mode, turning the Auto LSD ON (standby).
- Pressing and holding the VSC OFF switch for 3 seconds or more with the vehicle stopped selects the Auto LSD mode, disabling the TRAC and VSC functions.
- In the Auto LSD mode, pressing and holding the VSC OFF switch for 3 seconds or more with the vehicle stopped selects the VSC OFF mode, disabling all functions.
- After the ignition switch is turned OFF in the TRAC OFF mode, Auto LSD mode or VSC OFF mode, turning the ignition switch ON again selects the Normal mode.




 : VSC OFF Switch Operation (Briefly press)

 : VSC OFF Switch Operation
(Press and hold for 3 seconds or more)

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- The operation of the brake control functions and the illumination state of the respective indicator lights in each mode are as follows:

○: Controlled —: Not Controlled

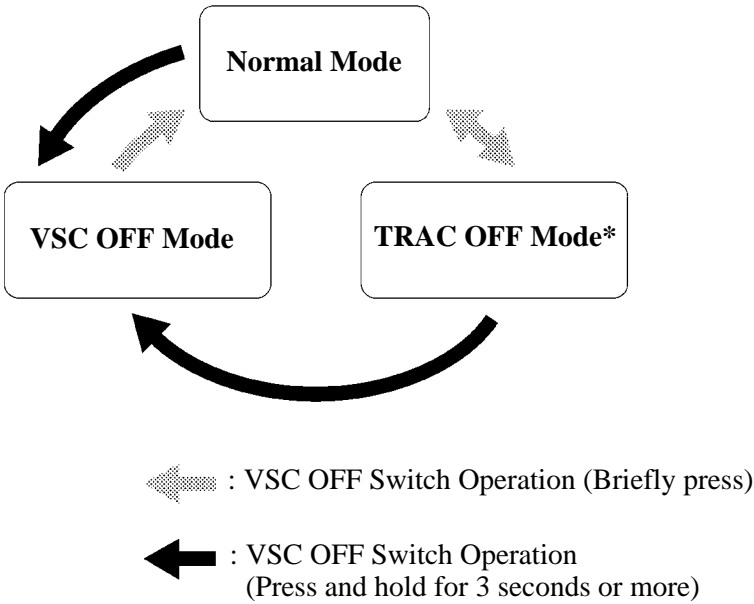
Item	Brake Control Function			AUTO LSD Indicator Light	Slip Indicator Light	VSC OFF Indicator Light
	TRAC	VSC	Auto LSD	AUTO LSD 03NCH004Y	 03NCH005Y	VSC OFF 03NCH006Y
Normal Mode	○	○	—	—	—	—
TRAC OFF Mode	—	○	○	Light ON	Light ON	—
Auto LSD Mode	—	—	○	Light ON	Light ON	Light ON
VSC OFF Mode	—	—*	—	—	Light ON	Light ON

*: When the vehicle is braking or the yaw rate is large, the VSC will operate even in the VSC OFF mode.

4WD Models (in 4WD Mode)

The VSC OFF switch can select the 3 modes (Normal mode, TRAC OFF mode*, VSC OFF mode).

- Briefly pressing the VSC OFF switch in Normal mode selects the TRAC OFF mode*.
- Pressing and holding the VSC OFF switch for 3 seconds or more with the vehicle stopped selects the VSC OFF mode, disabling the TRAC and VSC functions.
- Briefly pressing the VSC OFF switch in the TRAC OFF mode* or VSC OFF mode or turning the ignition switch OFF returns to the Normal mode.




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*: The driver can't choose the TRAC OFF mode when the transfer is in the H4L, L4F and L4L mode.

- The operation of the brake control functions and the illumination state of the respective indicator lights in each mode are as follows:

○: Controlled —: Not Controlled

Item		Brake Control Function		Slip Indicator Light	VSC OFF Indicator Light
		A-TRAC	VSC	 03NCH005Y	VSC OFF 03NCH006Y
H4F	Normal Mode	○	○	—	—
	TRAC OFF Mode* ¹	○	○	Light ON	—
	VSC OFF Mode	—	—* ²	Light ON	Light ON
L4F	Normal Mode	○	○	—	—
	VSC OFF Mode	—	—	Light ON	Light ON
H4L	Normal Mode	○	—	—	Light ON
L4L	VSC OFF Mode	—	—	Light ON	Light ON


*¹: The driver can't choose the TRAC OFF mode when the transfer is in the H4L, L4F and L4L mode.

*²: When the vehicle is braking or the yaw rate is large, the VSC will operate even in the VSC OFF mode.

9. Warning Light, Indicator Light and VSC Warning Buzzer

The warning and indicator lights and VSC warning buzzer operate as follows:

○: Illuminates Δ: Blinks

Condition		Warning Light		Indicator Light			VSC Warning Buzzer
		BRAKE 08LCH16SI	ABS 03NCH008Y	VSC OFF 03NCH006Y	 03NCH005Y	AUTO LSD 03NCH004Y	
Initial Check		○	○	○	○	○	
During Operation	TRAC/A-TRAC*1				Δ		
	Auto LSD				Δ	○	
	TRAC OFF Mode				Δ	○	
	Auto LSD Mode			○	Δ	○	
VSC					Δ		Intermittent Sound
Drive Mode*1	H4L, L4L			○			
Brake Actuator Protection					○*2		Intermittent Sound*2
Cannot operate due to a malfunction	ABS, Brake Assist		○	Δ	○*3		
	EBD	○	○	Δ	○*3		
	TRAC/A-TRAC*1			Δ	○		
	Auto LSD			Δ	○		
	VSC			Δ	○		
Other	Low Brake Fluid Level	○					
	Zero point calibration of yaw rate and deceleration sensor not done		○	Δ	○		

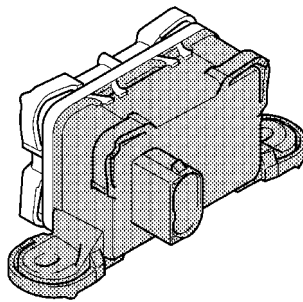
*1: Only for 4WD Models

*2: An extreme rise in the temperature of the brake pads causes the VSC warning buzzer to sound. Further rise in the temperature causes the VSC warning buzzer to sound (continuously for 3 seconds) and the slip indicator light to come ON.

*3: Failure in the ABS, EBD and brake assist prohibits operation of the TRAC, A-TRAC, Auto LSD and VSC. Accordingly, the VSC OFF indicator light will be blinked and slip indicator light will be illuminated.

10. Yaw Rate & Deceleration Sensor

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



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*: Only for 4WD Models

Service Tip

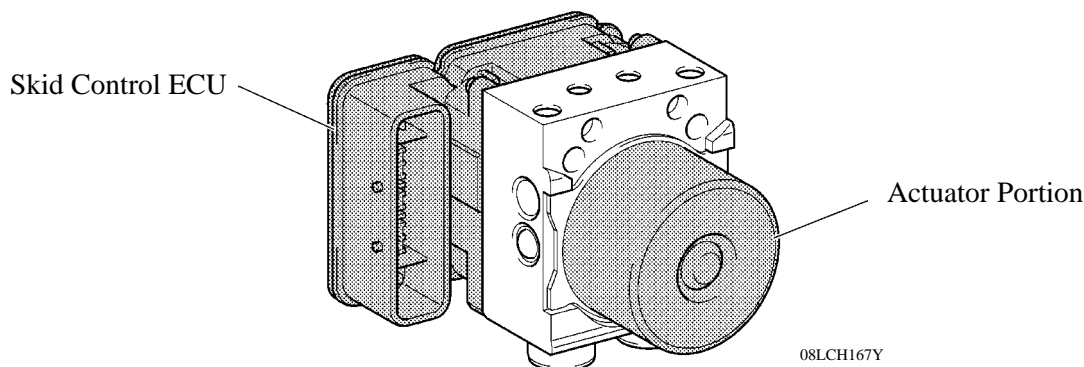
After replacing the yaw rate and deceleration sensor or the skid control ECU, initialization of the yaw rate and deceleration sensor is required.

For details, refer to the 2008 Sequoia Repair Manual (Pub. No. RM08L0U).

11. Brake Actuator

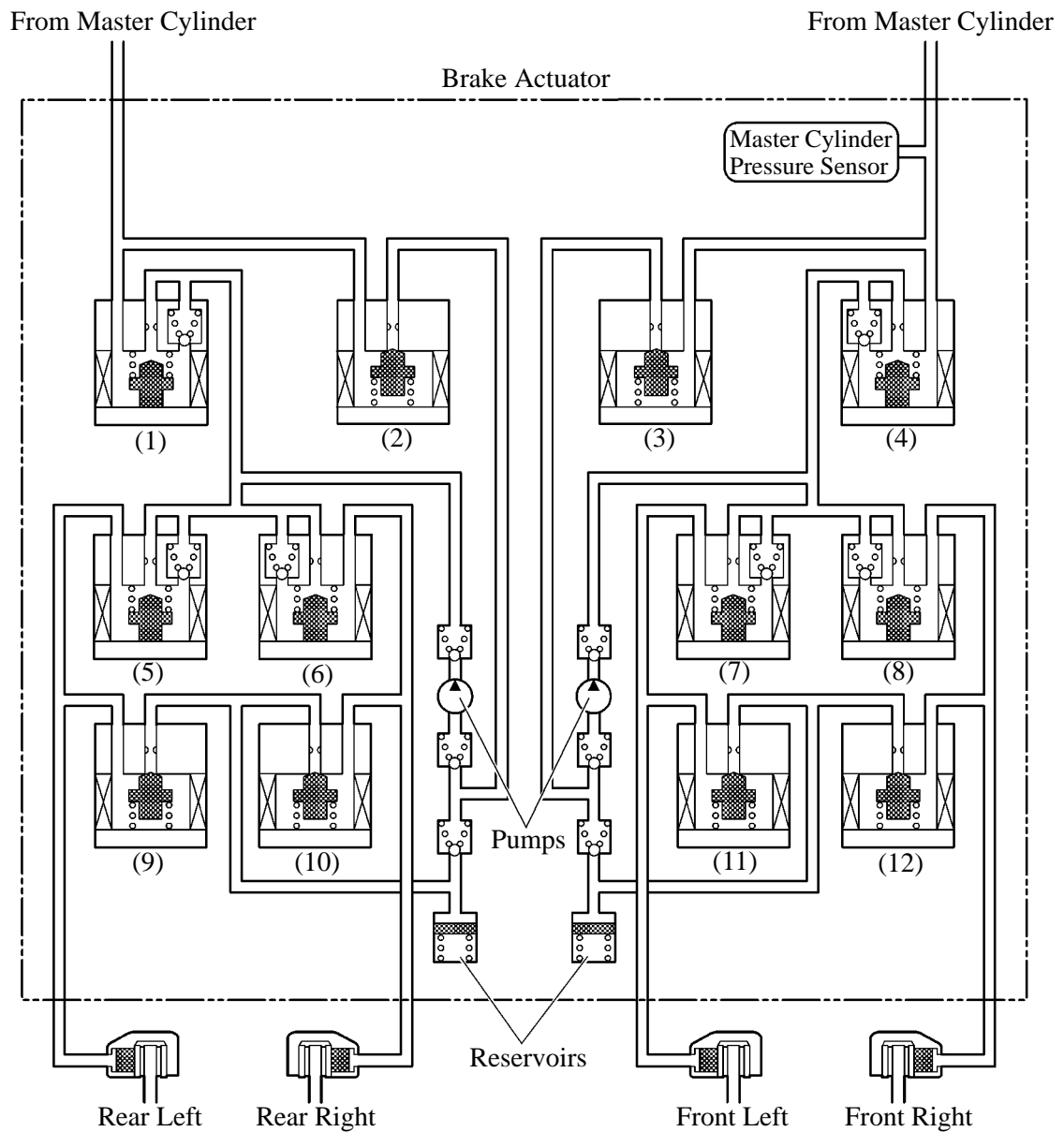
The brake actuator consists of the actuator portion and skid control ECU.

- 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)].



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► Hydraulic Circuit ◀



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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