■BRAKE CONTROL SYSTEM (ABS with EBD, Brake Assist, TRAC, A-TRAC, AUTO LSD and VSC)

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 when braking on a slippery surface.	○	○
EBD (Electronic Brake force Distribution)	The EBD control utilizes the ABS, realizing the proper brake force distribution between front and rear wheels in accordance with the driving conditions. In addition, during braking while cornering, 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 supplementary 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.	○	○*1
A-TRAC*2 (Active Traction Control)	When the vehicle drive mode is 4H or 4L, 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 system to operate. The AUTO LSD system 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.	○	○*1
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 or more).	○	○*1

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

*2: This function only uses brakes to perform traction control.

2. Drive Modes

Drive Modes and Each Function

The functions of the various drive modes are shown in the following table:

▶ 2WD Models ◀

○: Operates

Drive Mode	VSC OFF Switch	Brake Control					
		ABS	EBD	Brake Assist	TRAC	AUTO LSD	VSC
2WD	Normal Mode	○	○	○	○	-	○
	TRAC OFF Mode	○	○	○	-	○	○
	VSC OFF Mode	○	○	○	-	-	-

▶ 4WD Models ◀

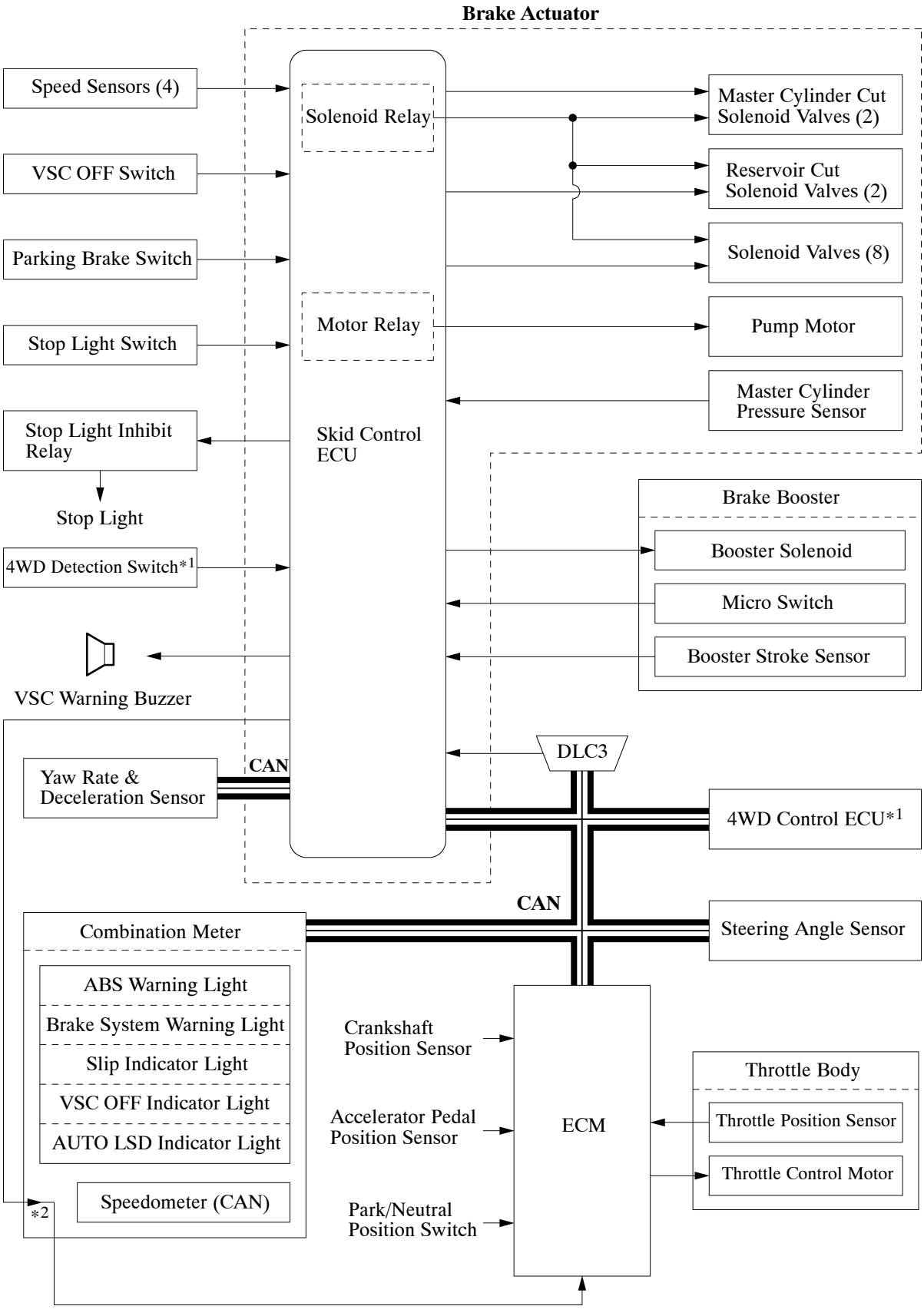
○: Operates

Drive Mode		VSC OFF Switch	Brake Control						
			ABS	EBD	Brake Assist	TRAC	A-TRAC	AUTO LSD	VSC
2WD		Normal Mode	○	○	○	○	-	-	○
		TRAC OFF Mode	○	○	○	-	-	○	○
		VSC OFF Mode	○	○	○	-	-	-	-
4WD	4H	Normal Mode	○	○	○	-	○	-	-
		VSC OFF Mode	○	○	○	-	-	-	-
	4L	Normal Mode	○	○	○	-	○	-	-
		VSC OFF Mode	○	○	○	-	-	-	-

4H or 4L Mode (Only for 4WD Models)

When the 4WD control switch is in the 4H or 4L position, VSC and AUTO LSD operation is disabled and the VSC OFF indicator light turns ON.

3. System Diagram



04E0CH56C

*1: Only for 4WD Models
*2: The vehicle speed signal for the ECM passes through the combination meter. The speedometer operates using a vehicle speed signal from the CAN.

4. Outline of EBD Control

General

The EBD control distributes the braking force in accordance with the vehicle's driving conditions. The Skid Control ECU electrically controls the control solenoid valves to distribute the braking force.

- Braking force distribution is divided into two main categories: one is to the front and rear wheels, and the other is to the right to left sides (braking while cornering).

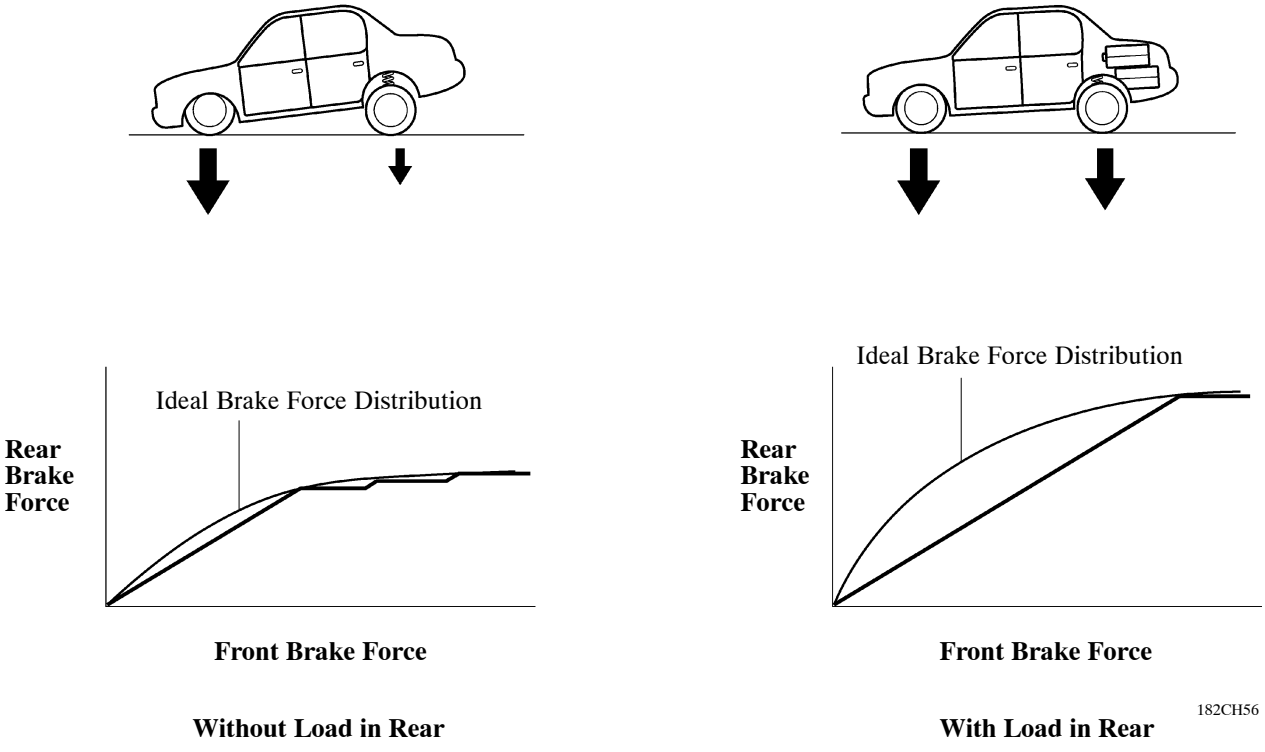
Front/Rear Wheel Brake Force Distribution

If the brakes are applied while the vehicle is moving straight forward, the transfer of the load reduces the weight that is applied to the rear wheels. The Skid Control ECU determines this condition by way of the signals from the speed sensors, and the brake actuator regulates the distribution of the brake force of the rear wheels to optimally control braking operation.

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

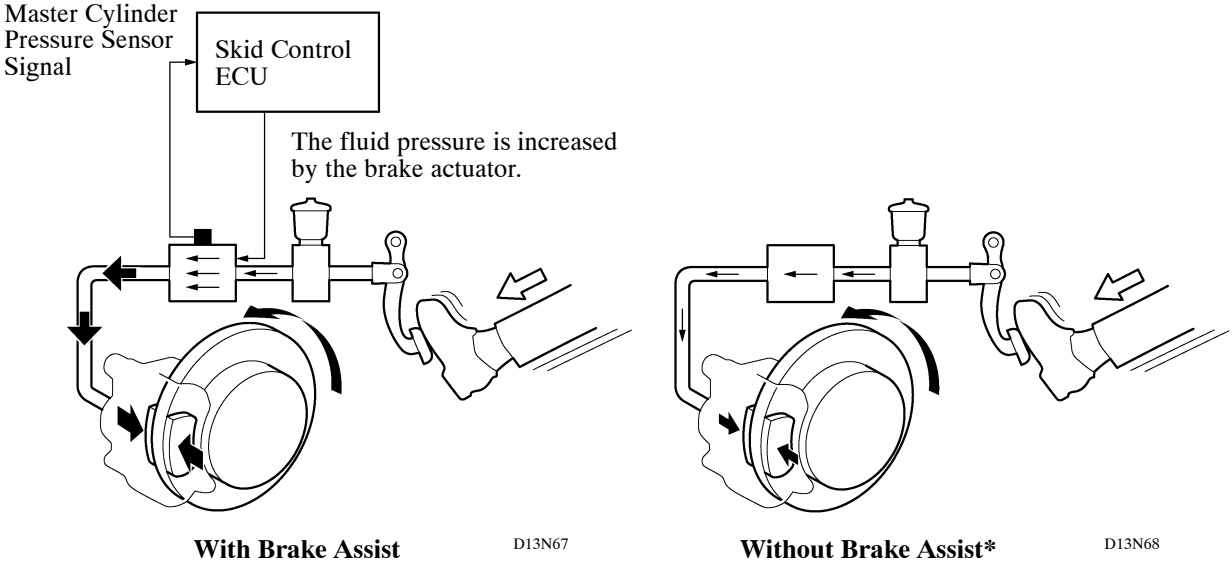
▶ EBD Control Concept ◀



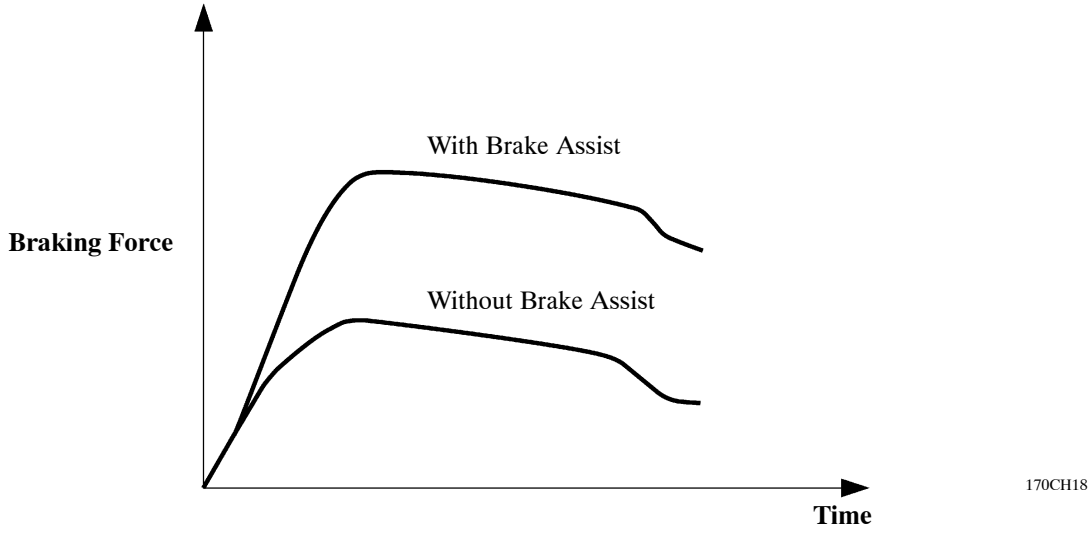
5. Outline of Brake Assist

- The Brake Assist, in combination with ABS, helps improve the vehicle's braking performance.
- The Brake Assist interprets a quick push of the brake pedal as emergency braking. It supplements the brake 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 to the brake pedal.
- A key feature of Brake Assist is that the timing and the degree of braking assistance are designed to help ensure that the driver does not discern anything unusual about the braking operation. When the driver intentionally eases up on the brake pedal, the Brake Assist reduces the amount of assistance it provides.
- 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 perform emergency braking. If the Skid Control ECU determines that the driver intends emergency braking, the system activates the brake actuator to increase the brake fluid pressure, which increases the braking force.
- When the vehicle is fully loaded, stronger brake force may be required, even if the brakes are not applied quickly. In such a case where stronger brake force is required, the Brake Assist also increases brake force.

▶ In case that the driver's pedal application force is small when applying emergency braking ◀



*: The fundamental ability of the brakes is the same as that of a model with Brake Assist.

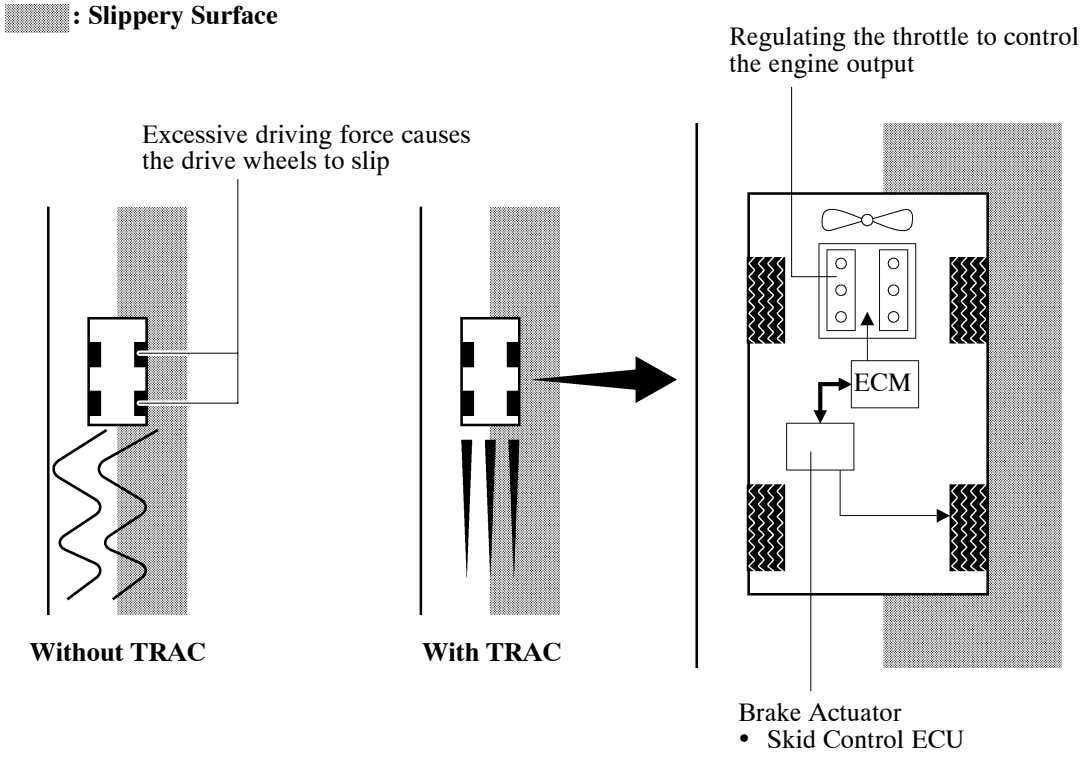


6. Outline of TRAC*

- 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 model, the system operates only when the vehicle is driving in 2WD mode.

▶ Driving condition on road with different surface friction characteristics ◀



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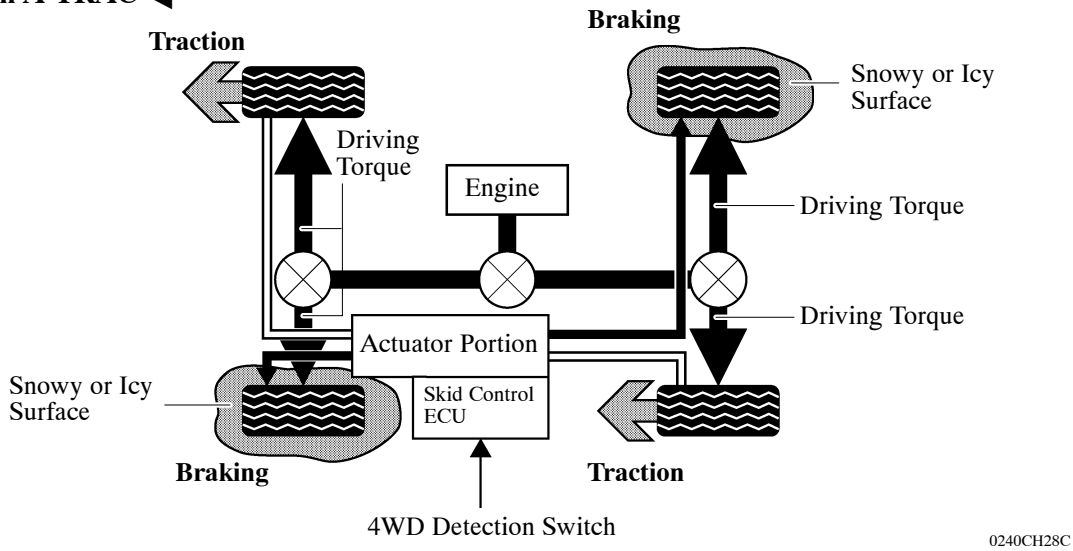
7. Outline of A-TRAC (Only for 4WD models)

General

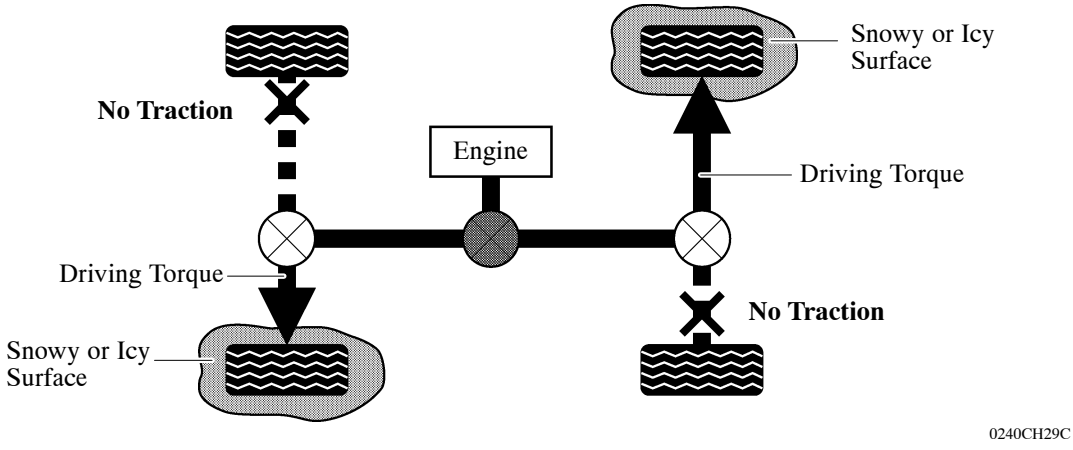
When the vehicle drive mode is 4H or 4L, the A-TRAC helps restrain wheelspin by controlling the brake fluid pressure that is applied to the spinning wheels, and distributes the drive force that would have been lost through the slippage to the remaining wheels in order to achieve an effect that is similar to LSD.

- It independently controls the brake hydraulic 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 ◀



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.
- A-TRAC allows for drivability benefits similar to those of locked differentials, while still allowing for the vehicle to be steered at low speeds, without the binding that would normally be associated with locked differentials.

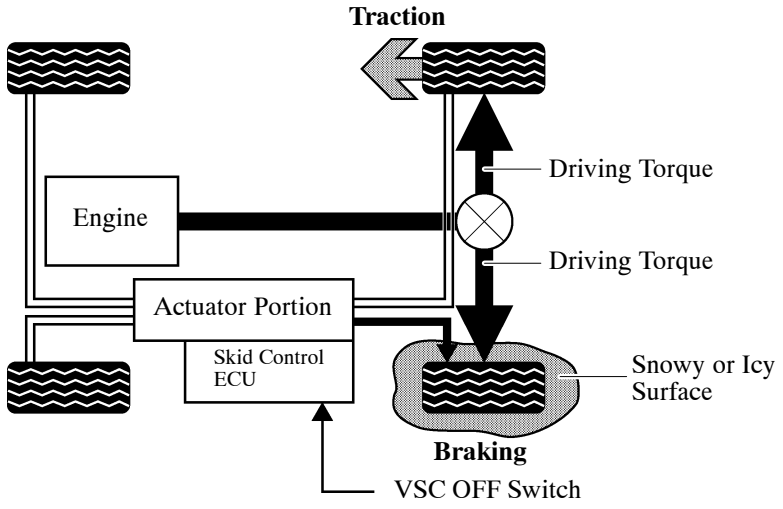
8. Outline of AUTO LSD*

Briefly pressing the VSC OFF switch in normal mode allows the AUTO LSD to operate (TRAC OFF mode is entered). 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.
- AUTO LSD tends to enhance the acceleration effort somewhat, 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.

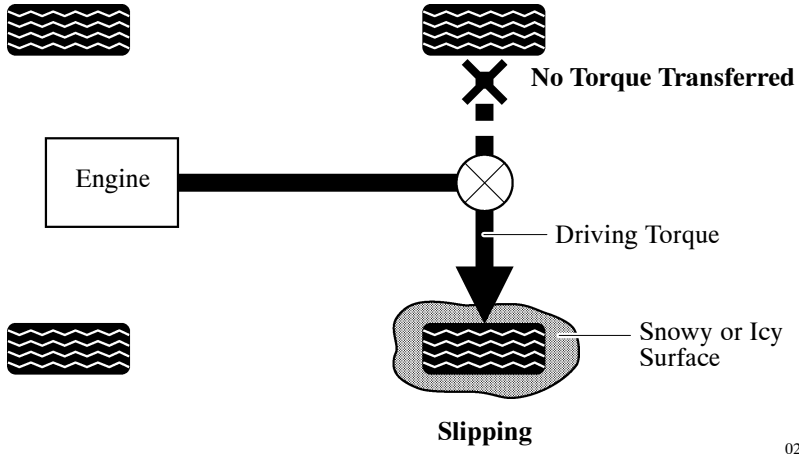
*: On the 4WD model, the system operates only when the vehicle is driving in 2WD mode.

▶ With AUTO LSD ◀



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▶ Without AUTO LSD ◀



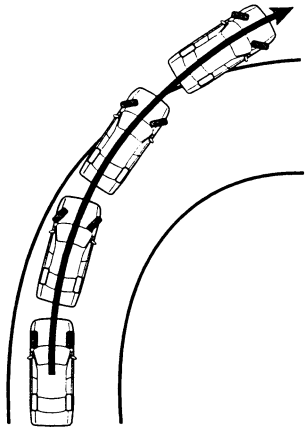
0240CH31C

9. Outline of VSC

General

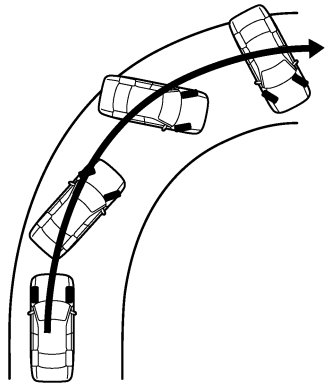
The following are two examples that can be considered as circumstances in which the tires exceed their lateral grip limit.
The VSC is designed to help control the vehicle behavior by controlling the engine output and the brakes at each wheel when the vehicle experiences one of the conditions indicated below.

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



151CH17

Front Wheel Skid Tendency



189CH100

Rear Wheel Skid Tendency

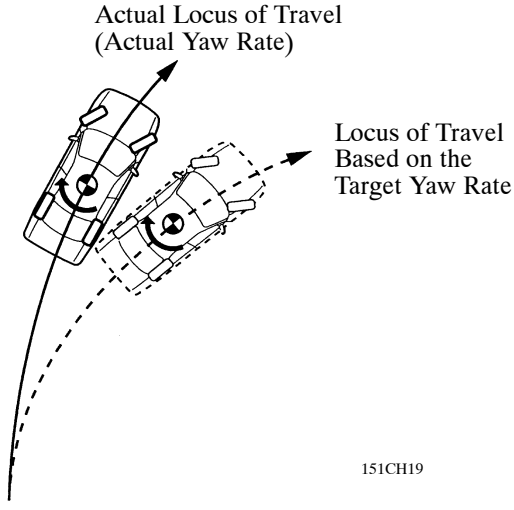
Method for Determining the Vehicle Condition

1) General

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 used by the Skid Control ECU for calculations.

2) Determining a Front Wheel Skid

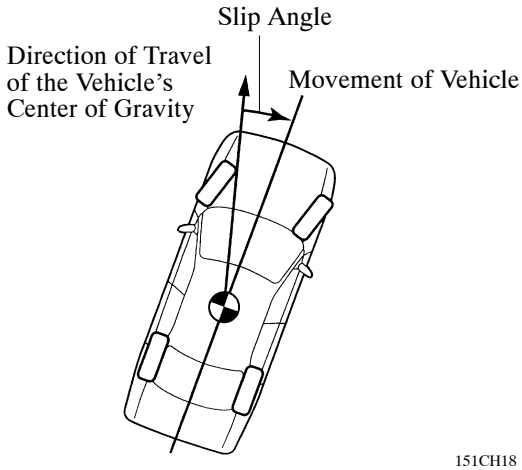
Whether or not the vehicle is experiencing a front wheel skid is determined by the difference between the target yaw rate and the vehicle's actual yaw rate.
When the vehicle's actual yaw rate is smaller than the target yaw rate (a target yaw rate is determined based on the vehicle speed and steering 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 target locus of travel.
Thus, the Skid Control ECU determines that there is a large front wheel skid tendency.



151CH19

3) Determining a Rear Wheel Skid

Whether or not the vehicle is experiencing a 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 Skid Control ECU determines that the vehicle has a large rear wheel skid tendency.



151CH18

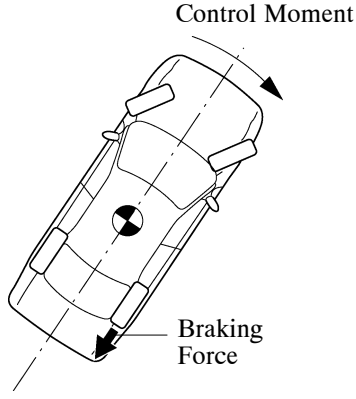
VSC Operation Methods

1) General

When the Skid Control ECU determines that the vehicle exhibits a tendency to front wheel skid or rear wheel skid, it decreases engine output and applies the brake to 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 may differ depending on the vehicle's characteristics and driving conditions.

2) Dampening a Strong Front Wheel Skid

When the Skid Control ECU determines that there is a large front wheel skid tendency, it attempts to counteract the tendency based on the extent of that tendency. The Skid Control ECU controls the engine power output and applies the brakes of the rear inside wheel (the inside of the turn).

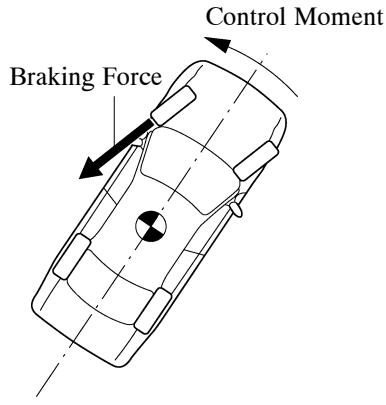


Making a Right Turn

04E0CH120C

3) Dampening a Strong Rear Wheel Skid

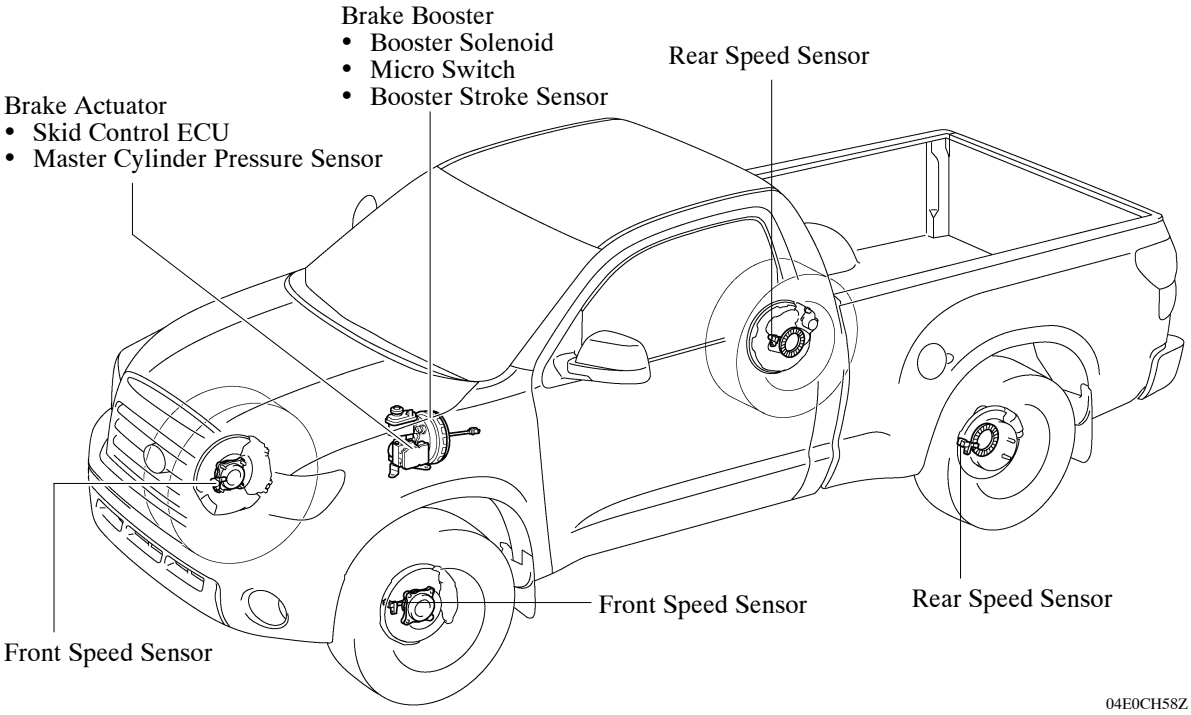
When the Skid Control ECU determines that there is a large rear wheel skid tendency, it attempts to counteract the tendency based on the extent of that tendency. It applies the brakes of the front outer wheels (the outside of the turn), and generates an outward moment of inertia in the vehicle, in order to restrain the rear wheel skid tendency. Along with the reduction in the vehicle speed caused by the braking force, excellent vehicle stability is ensured.
In some cases, the Skid Control ECU applies the rear brakes, as necessary.



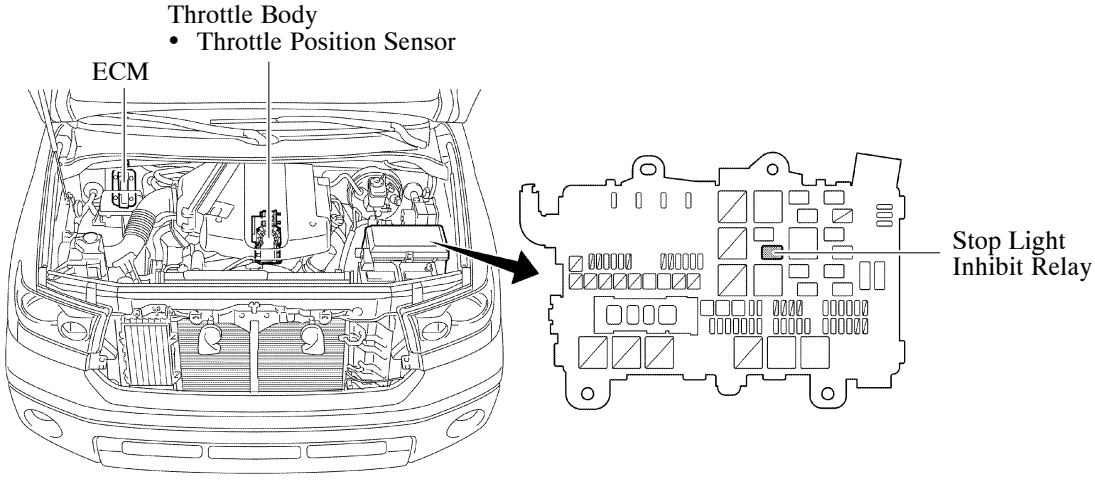
Making a Right Turn

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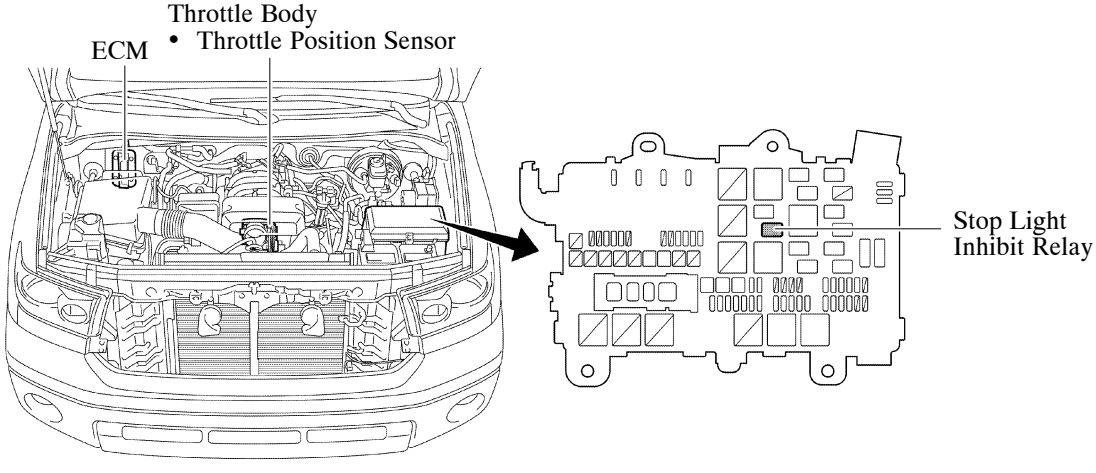
10. Layout of Main Components



04E0CH58Z



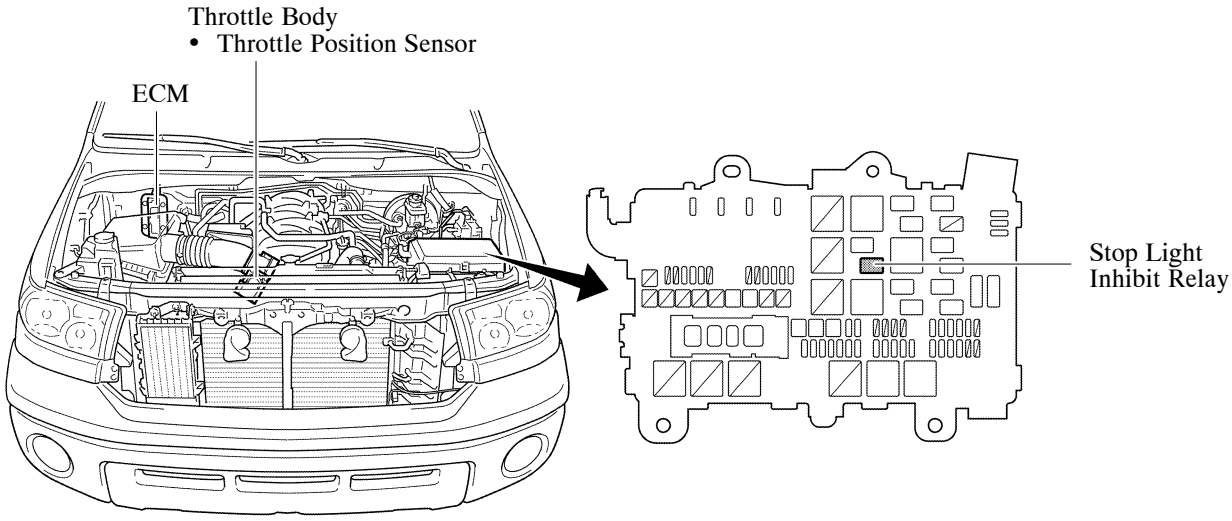
Models for 1GR-FE Engine



Models for 2UZ-FE Engine

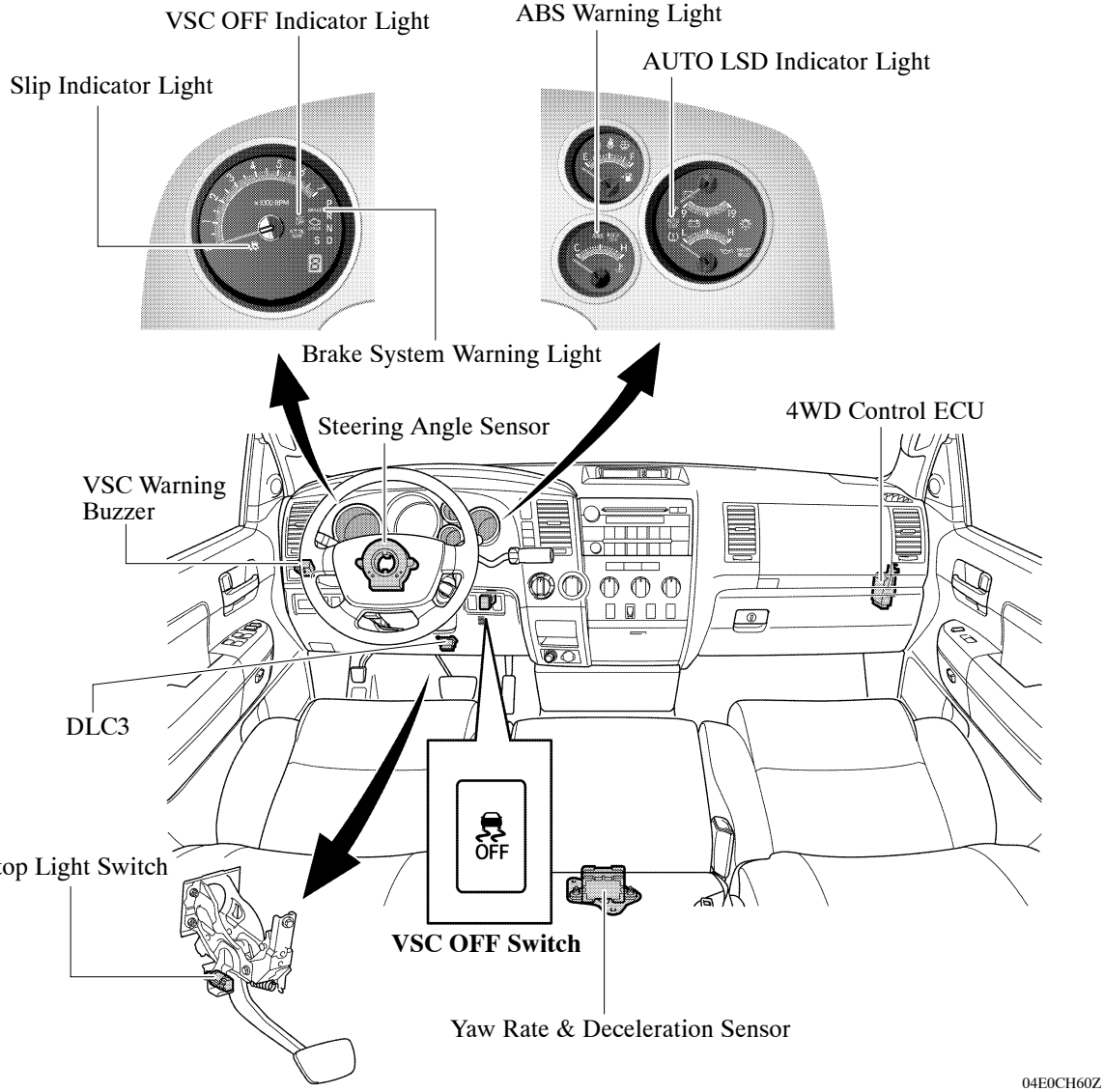
04E1CH40Z

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Models for 3UR-FE Engine

04E1CH38Z



04E0CH60Z

11. Function of Main Components

Component			Function
Combination Meter	ABS Warning Light		Lights up to alert the driver when 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 when the Skid Control ECU detects a malfunction in the EBD control or when a malfunction occurs in the brake booster. • Lights up to alert the driver when the brake fluid level is low. • Lights up to alert the driver when the parking brake is application.
	Slip Indicator Light		• Blinks to inform the driver when the VSC is operated. • Lights up to inform the driver when the TRAC OFF mode or VSC OFF mode is entered using the VSC OFF switch.
	VSC OFF Indicator Light		• Lights up to inform the driver when the VSC OFF mode is entered using the VSC OFF switch. • When the 4WD control switch is 4H or 4L position (4WD detection switch ON) the VSC OFF indicator light lights up to alert the driver. • 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 comes on to alert the driver (Only while in VSC OFF mode, this indicator light will blink if an abnormality is detected).
	AUTO LSD Indicator Light		• Lights up to inform the driver when the TRAC OFF mode (AUTO LSD ON) is entered using the VSC OFF switch.
Speed Sensors (4)			Detects the wheel speed of each of the four wheels.
Yaw Rate & Deceleration Sensor			• 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 Warning Buzzer			The VSC warning buzzer has two types of sounds. • 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 have 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 with 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		• 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.
Brake Booster	Booster Solenoid		When the VSC system 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.

(Continued)

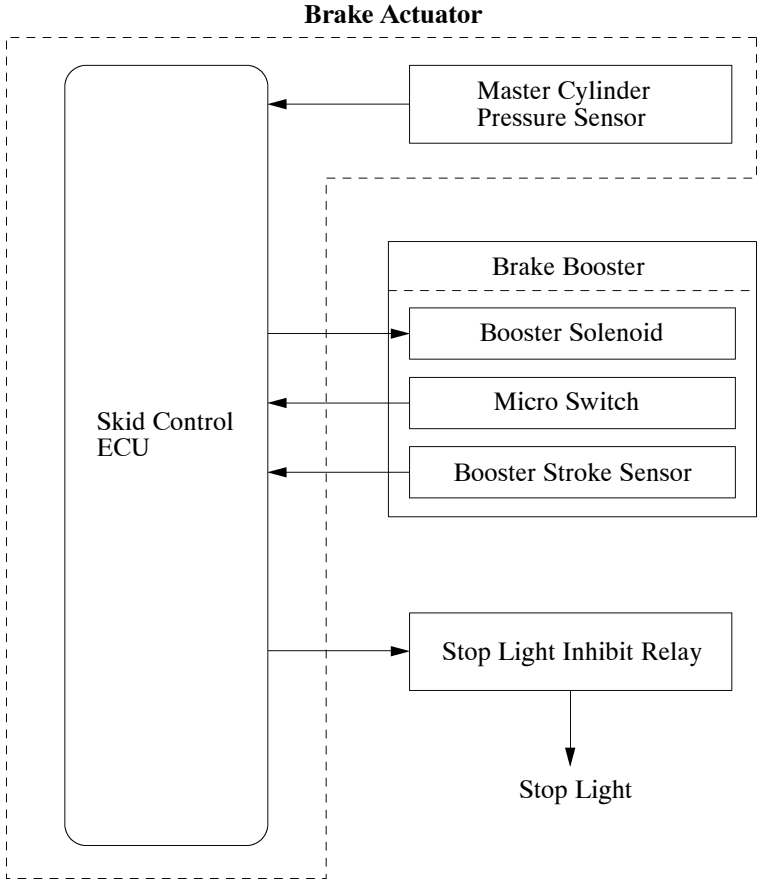
Component	Function
VSC OFF Switch	• Cancels the TRAC or VSC system. • Selects the 3 modes (Normal mode, TRAC-OFF mode, VSC-OFF mode).
4WD Detection Switch (Only for 4WD models)	Detects the condition of the transfer (2WD or 4WD).
Parking Brake Switch	Detects parking brake application.
Stop Light Switch	Detects brake pedal application.
Stop Light Inhibit Relay	Because the brake pedal could move down when the VSC system 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.
4WD Control ECU (Only for 4WD models)	Detects the transfer shift position (4H or 4L) and sends the information to the skid control ECU.
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.

12. Brake Booster

General

- When the VSC system 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.
  As at this time the Skid Control ECU controls the solenoid in accordance with the signals from the master cylinder pressure sensor, thus supplementing the brake fluid pressure when the VSC system is activated, resulting in excellent brake control.
- Because the brake pedal could move down with the activation of the VSC system, 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.

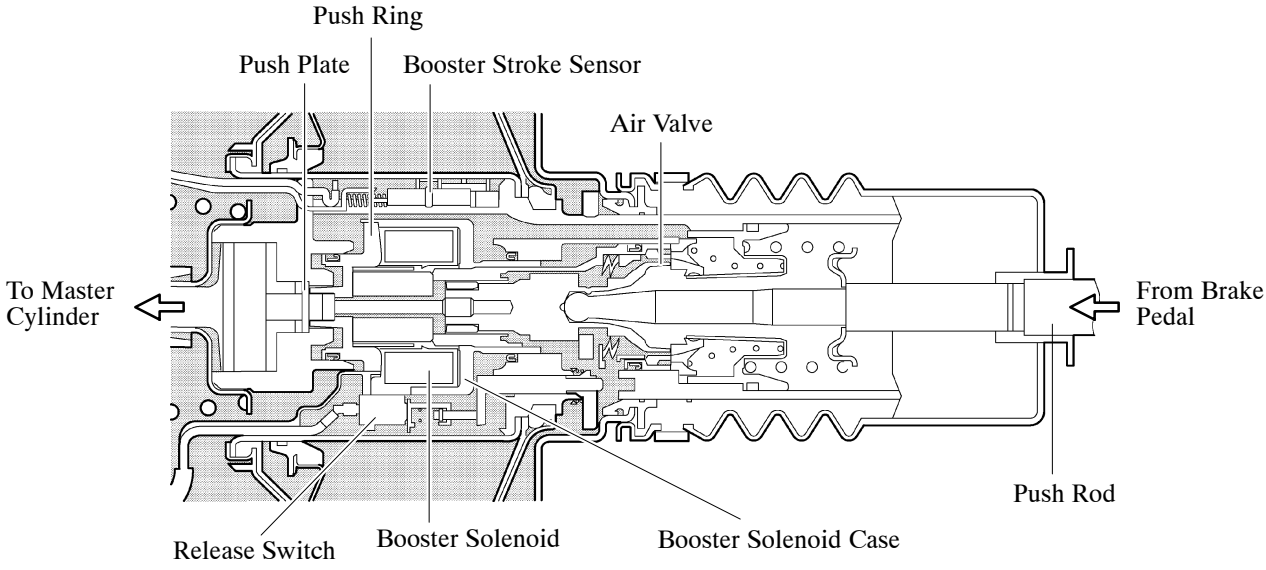
▶ System Diagram ◀



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Construction

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

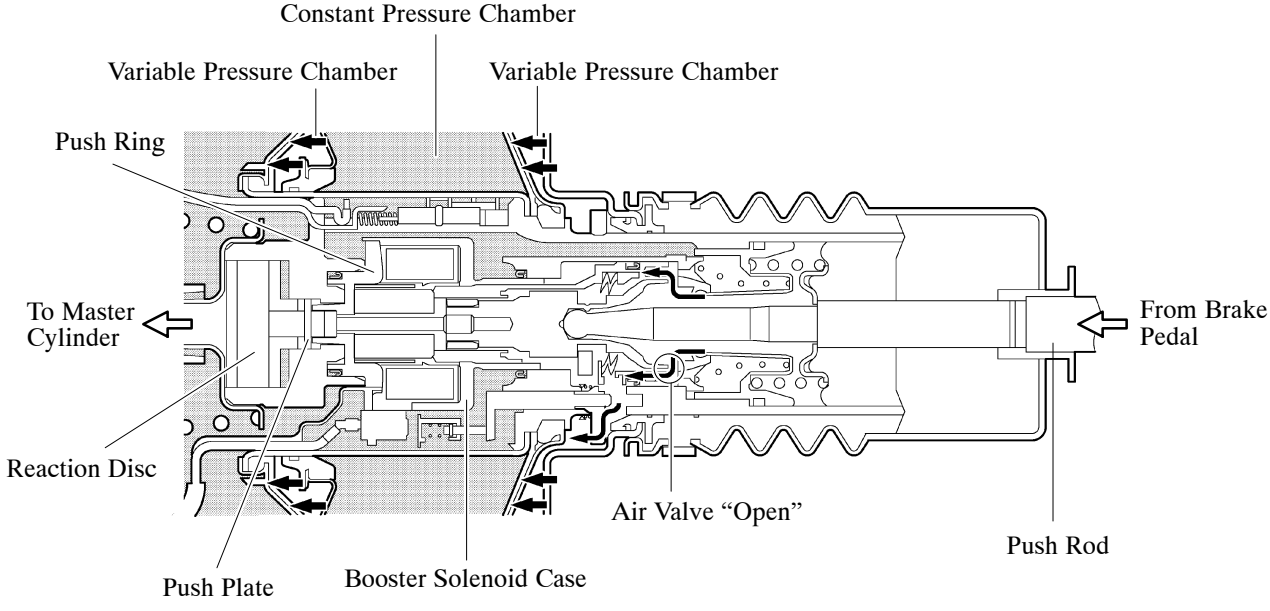


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Operation

1) Normal Braking

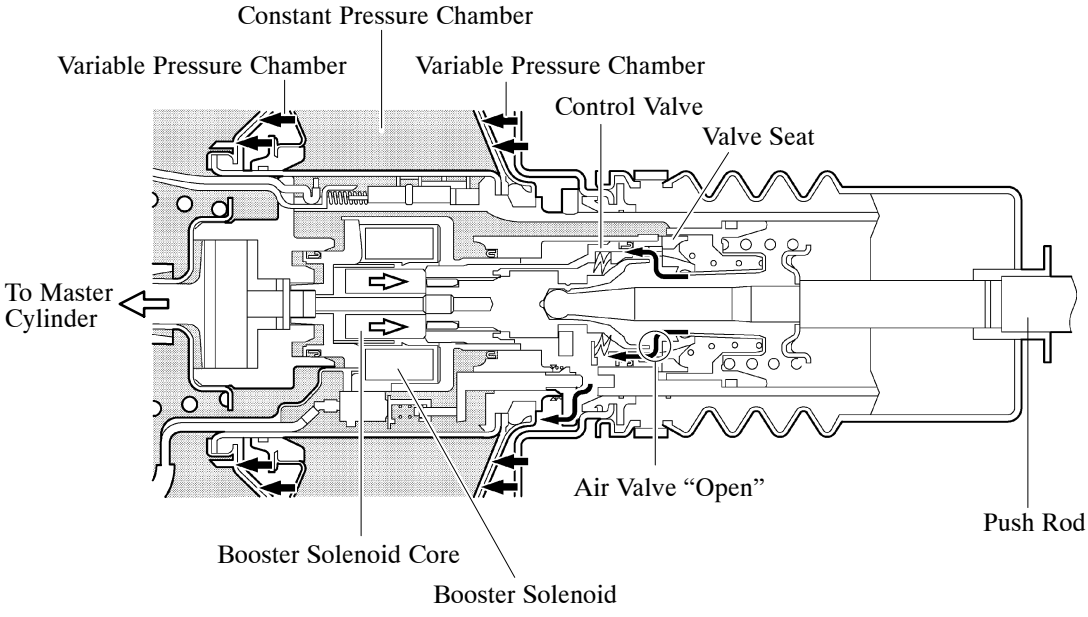
During normal braking, the input load from the brake pedal is transmitted to the push rod, air valve, booster solenoid case, push ring, push plate, and reaction disc, and is output to the master cylinder.
At this time, the air valve moves, and air flows into the variable pressure chamber. This creates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



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2) VSC System Operation

When the VSC system 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.

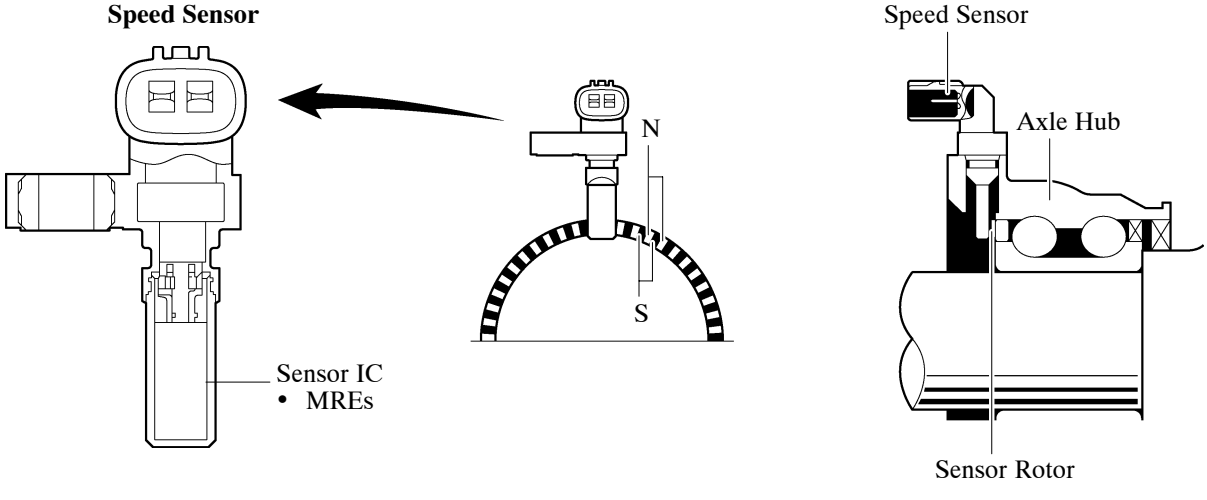


04E0CH107C

13. Speed Sensor

General

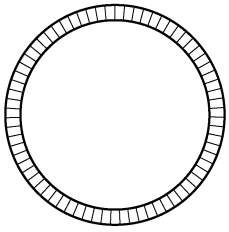
- Active type speed sensors can detect the wheel rotation. This sensor contains a sensor IC, which consists of the MREs (Magnetic Resistance Elements).
- The sensor rotor, which consists of N and S poles that are arranged in a circle, is integrated with the inner race of the hub bearing.



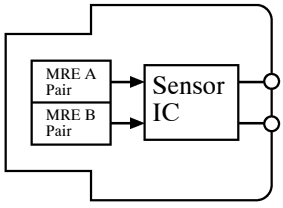
0240CH33C

Detection Method

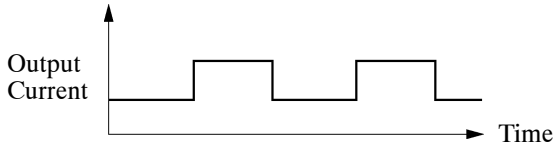
- An active type speed sensor uses a sensor IC to detect magnetic field changes caused when the sensor rotor rotates, and the sensor outputs the detected information to the skid control ECU as digital pulses (vehicle speed signal).



Sensor Rotor (Bearing Inner Race)



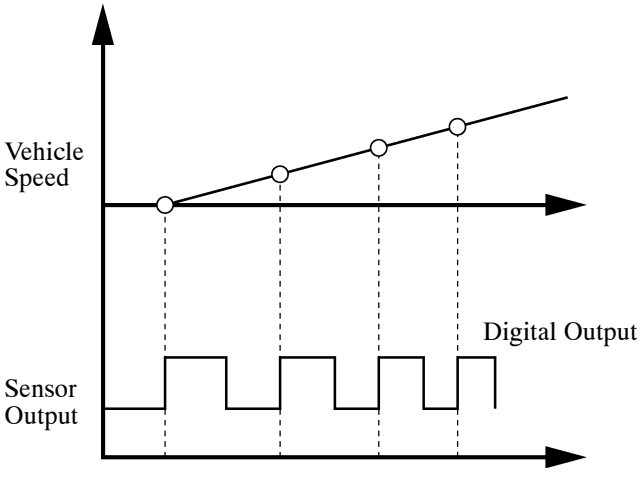
232CH38



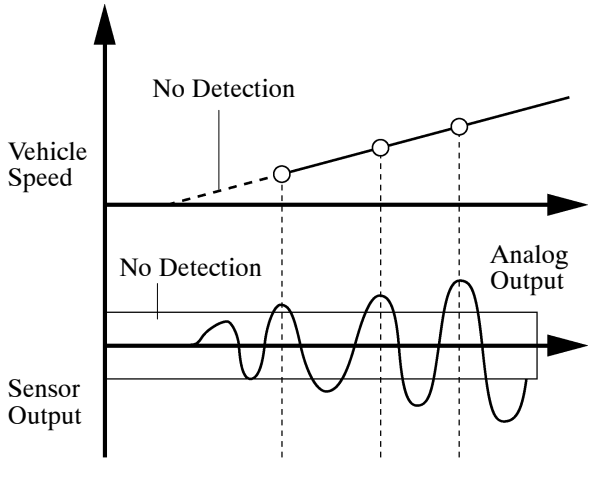
04E0CH123C

Detection Speed	Direction Detection
From 0.5 km/h	Wheel rotation direction is not judged.

- To detect the vehicle speed, the frequency of the output pulses is used. Because the active type sensor outputs digital pulses, it can detect vehicle speeds even when the vehicle is nearly stationary.



Active Type



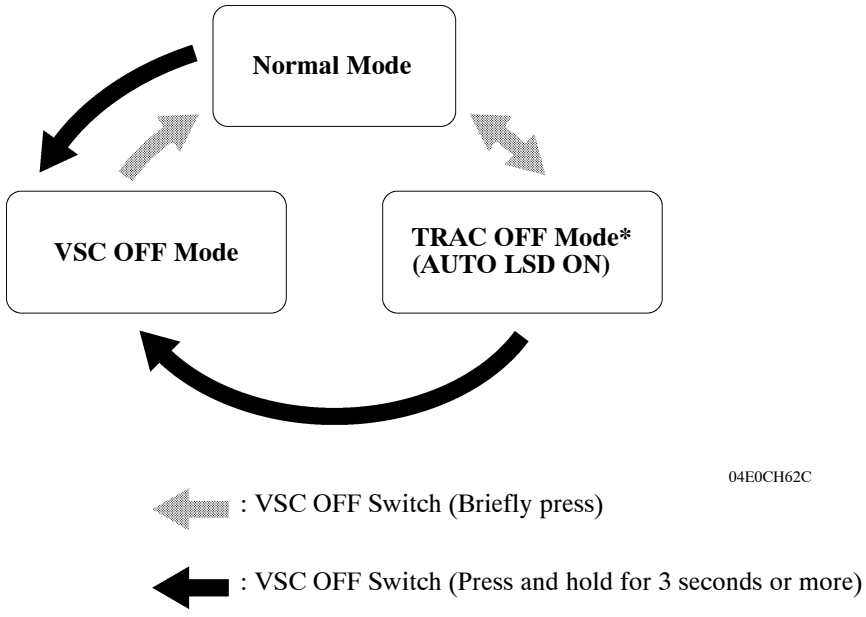
Passive Type

232CH41

14. VSC OFF Switch

The operation of the VSC and TRAC functions can be stopped by the VSC OFF switch. This switch can select the 3 modes (Normal mode, TRAC-OFF mode*, VSC-OFF mode).

- Briefly pressing the VSC OFF switch in normal mode enters TRAC OFF mode*, turning the AUTO LSD ON.
- Pressing and holding the VSC OFF switch for 3 seconds or more with the vehicle stopped enters VSC OFF mode, disabling TRAC, auto LSD and VSC functions.
- Briefly pressing the VSC OFF switch in TRAC OFF* or VSC OFF mode or turning the ignition switch off returns to normal mode.



*: On the 4WD models, the driver can't choose the TRAC OFF mode when the vehicle is driving in 4WD 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			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*1	-	○	○	Light ON	Light ON	-
VSC OFF Mode	-	-*2	-	-	Light ON	Light ON

*1: On the 4WD models, the driver can't choose the TRAC OFF mode when the vehicle is driving in 4WD mode.

*2: In case the yaw rate is large during braking, the VSC will operate even in VSC OFF mode.

15. Warning and Indicator Lights and VSC Warning Buzzer

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

		Warning Light		Indicator Light			VSC Warning Buzzer
		BRAKE	ABS	VSC OFF		AUTO LSD	
Initial Check		○	○	○	○	○	
During Operation	TRAC/A-TRAC*1				Blinks		
	AUTO LSD (TRAC OFF Mode)				Blinks	○*2	
	VSC				Blinks		Intermittent Sound
TRAC OFF Mode (AUTO LSD ON)					○	○	
VSC OFF Mode				○	○		
Drive Mode*1	4H, 4L			○			
Brake Actuator Protection					○*3		Intermittent Sound*3
Cannot operate due to a malfunction	ABS & Brake Assist		○	○*4, 5	○*4		
	EBD	○	○	○*4, 5	○*4		
	TRAC/A-TRAC*1			○*5	○		
	AUTO LSD			○*5	○		
	VSC			○*5	○		
Others	Low Brake Fluid Level	○					
	ABS Malfunction		○	○	○		
	Zero point calibration of yaw rate or deceleration sensor not done		○*1	○	○		
	Skid Control ECU Malfunction	○	○	○			

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*1: Only for 4WD Models

*2: This indicator light turns on when the AUTO LSD is operational (standby state) with the TRAC OFF mode.

*3: 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 buzzer to sound (continuously for 3 seconds) and the slip indicator light to come on.

*4: Failure in the ABS, EBD, and Brake Assist systems prohibits operation of the TRAC, A-TRAC, AUTO LSD and VSC systems. Accordingly, the VSC OFF indicator light and slip indicator lights will be illuminated.

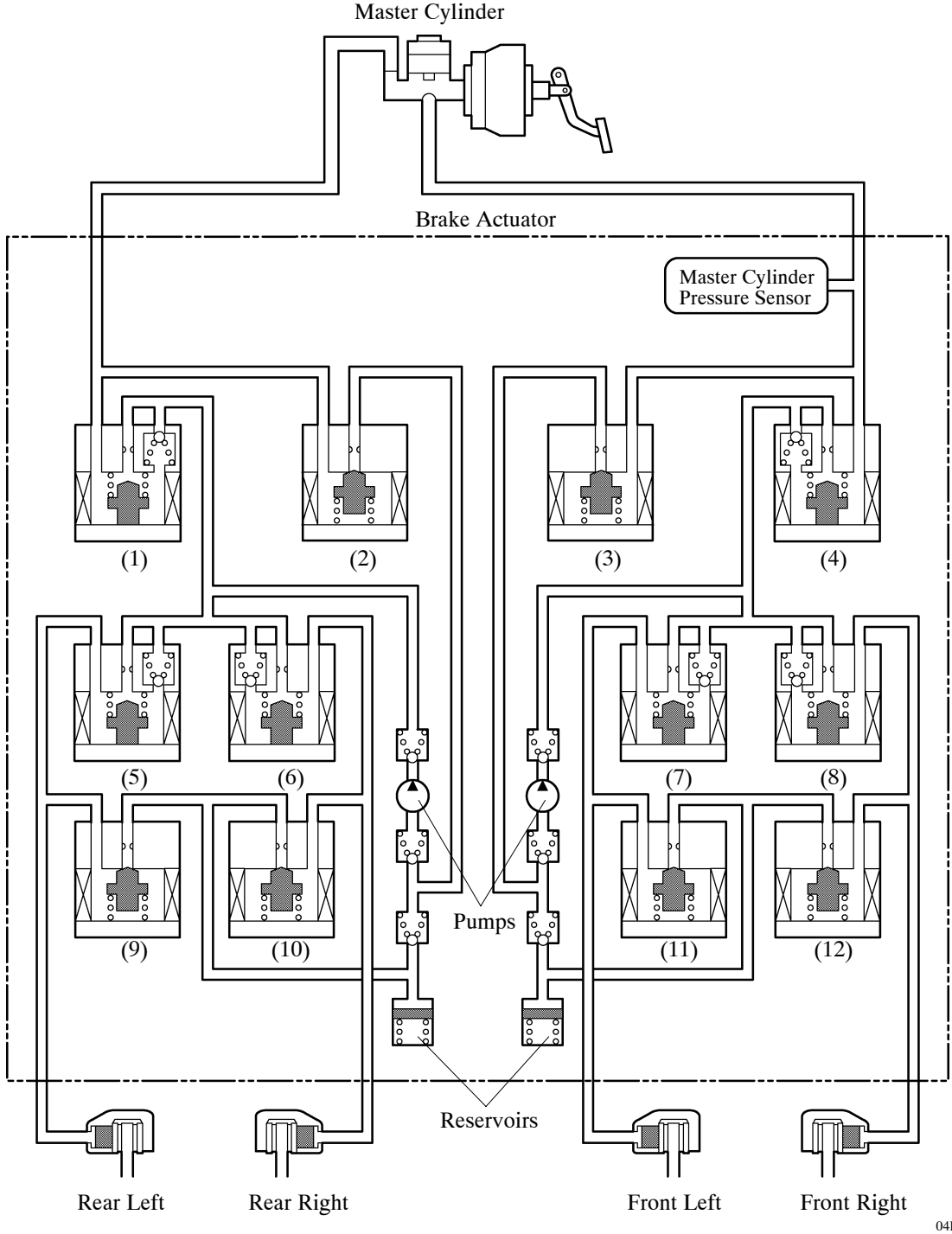
*5: Only while in VSC OFF mode, this indicator light will blink if an abnormality is detected.

16. Brake Actuator

The brake actuator consists of the actuator portion, Skid Control ECU, solenoid relay, motor relay, pump motor, and master cylinder pressure sensor.

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

▶ Hydraulic Circuit ◀

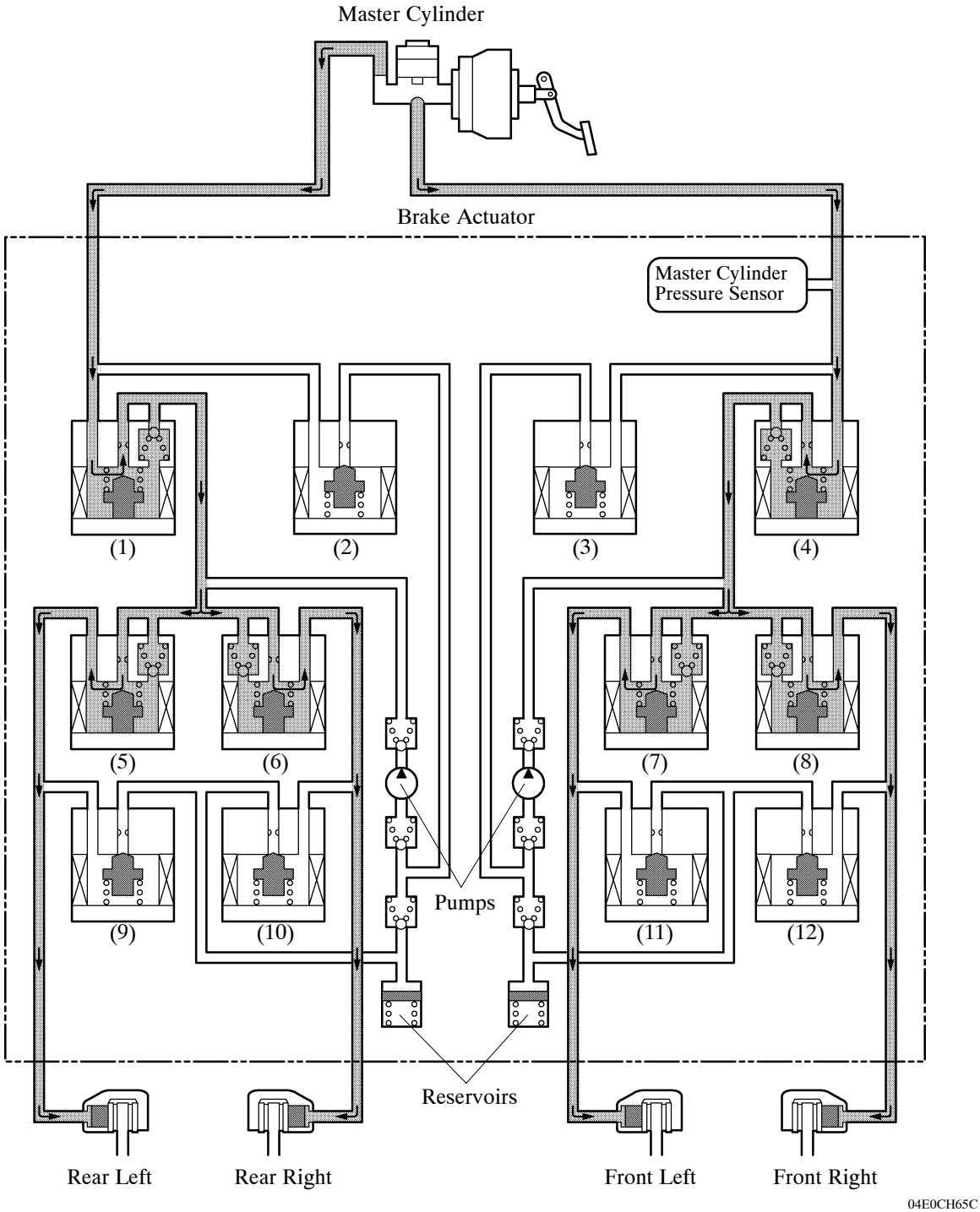


CH

17. System Operation

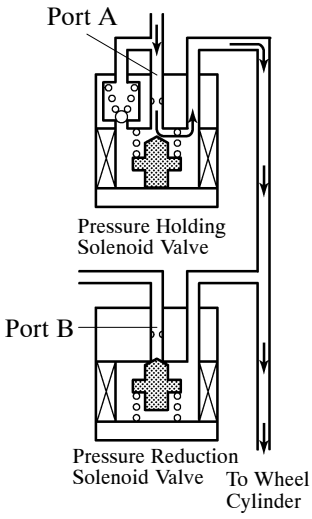
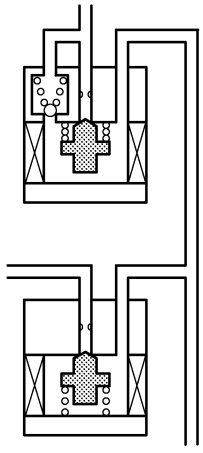
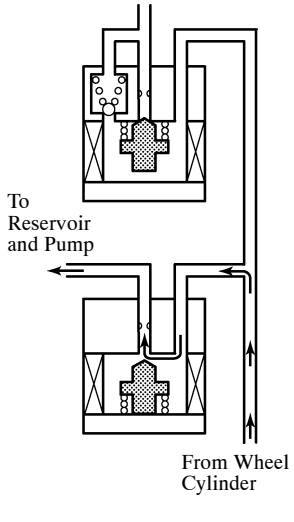
Normal Braking

During normal braking, all solenoid valves are turned OFF.



ABS with EBD Operation

Based on the signals received from the four 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 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 three modes: pressure reduction, pressure holding, and pressure increase modes.

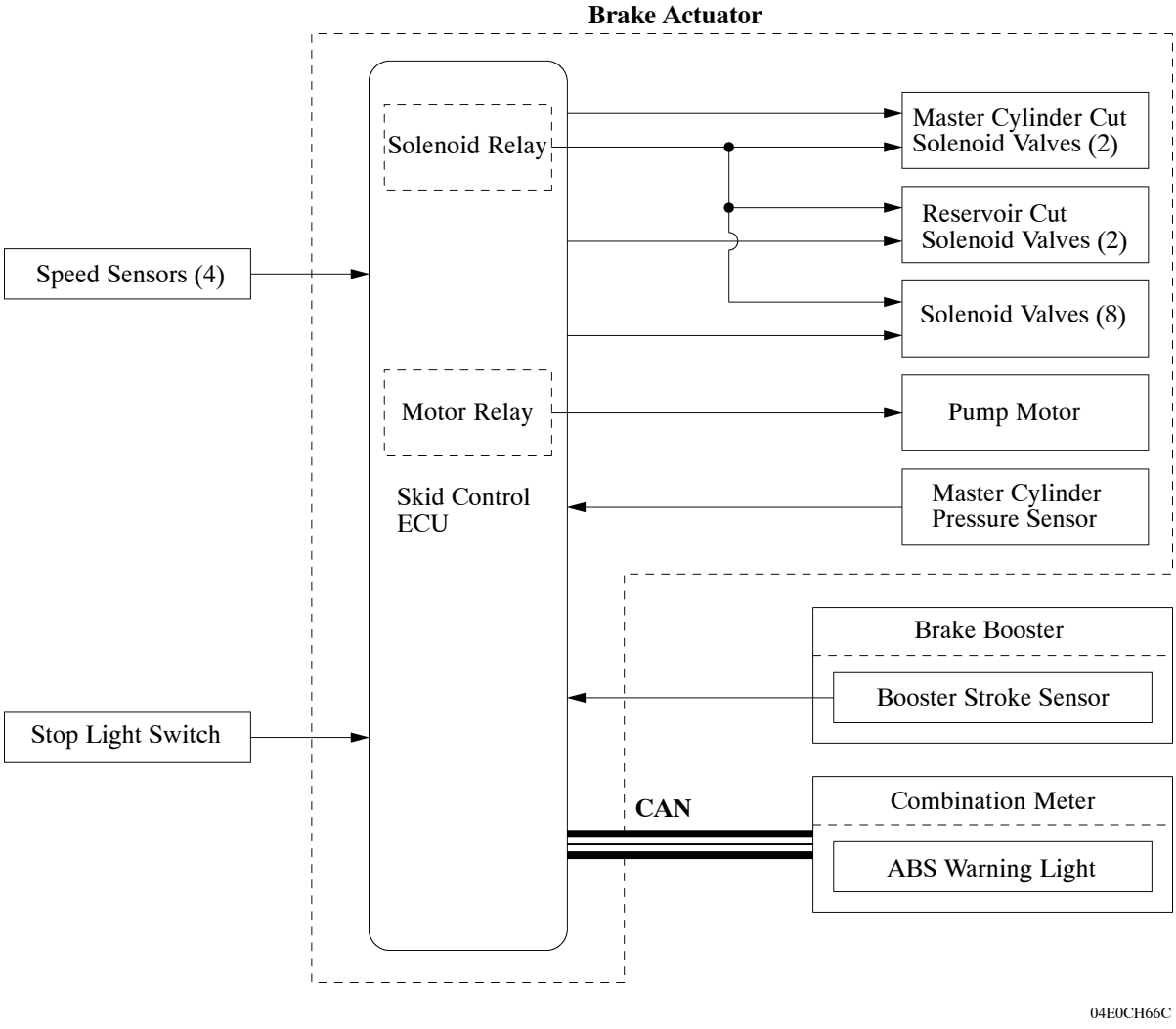
Not Activated	Normal Braking	—	—
Activated	Pressure Increase Mode	Pressure Holding Mode	Pressure Reduction Mode
Hydraulic Circuit			
Pressure Holding Valve (Port A)	OFF/Open	ON/Closed	ON/Closed
Pressure Reduction Valve (Port B)	OFF/Closed	OFF/Closed	ON/Open
Pressure	Increase	Hold	Reduce

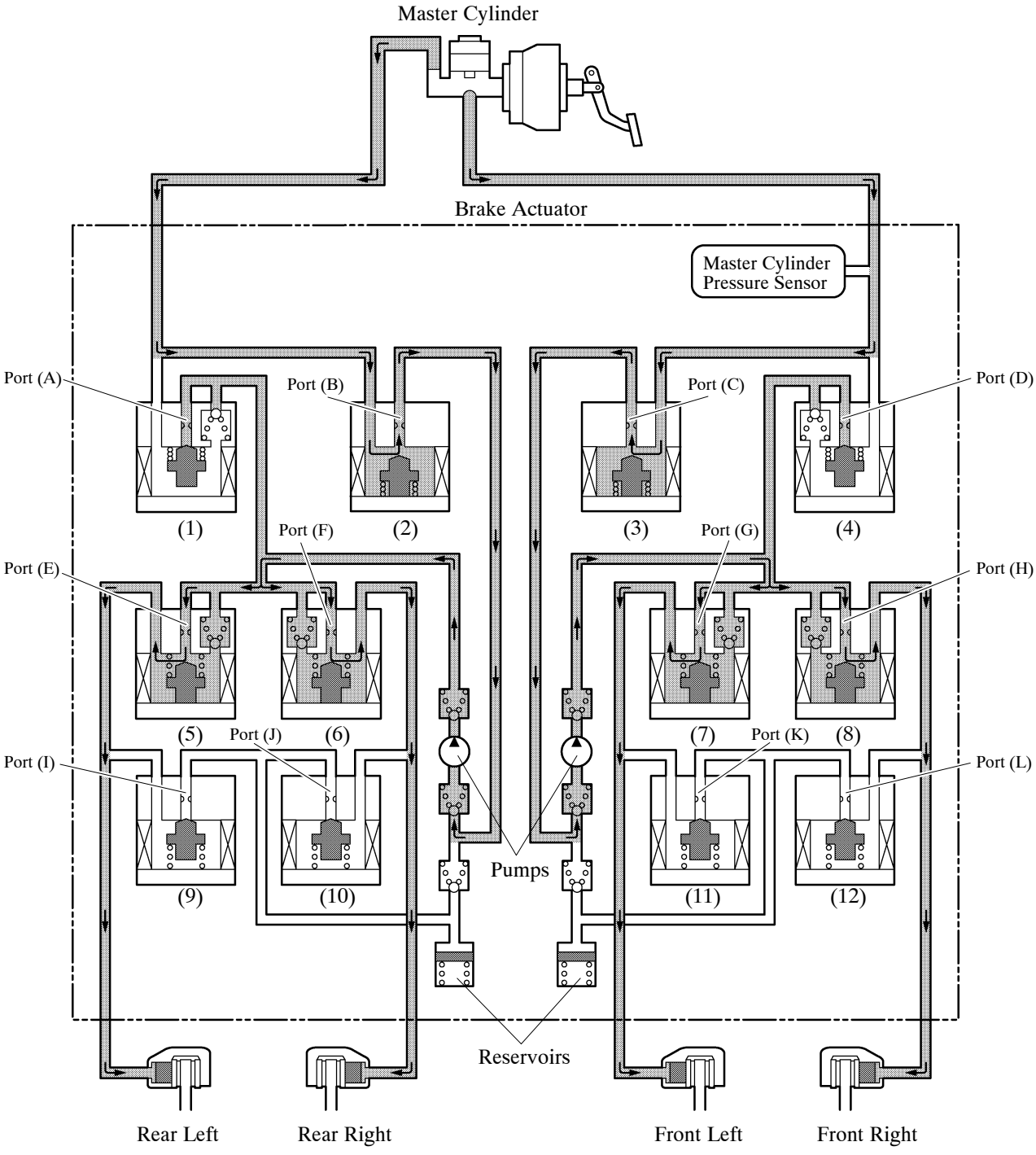
Brake Assist Operation

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, which is based on the master cylinder pressure sensor signals. If the 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 is present in the master cylinder. Also, in the following cases, the system provides Brake Assist.

- When greater braking force is needed than normal, the Skid Control ECU judges the need for Brake Assist using the master cylinder pressure sensor.
- 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.
- The diagram on the next page shows the hydraulic circuit when the Brake Assist is activated.
- The brake assist system is activated, each solenoid operates as shown in the table on page CH-148.

▶ System Diagram ◀





Brake Assist Activated

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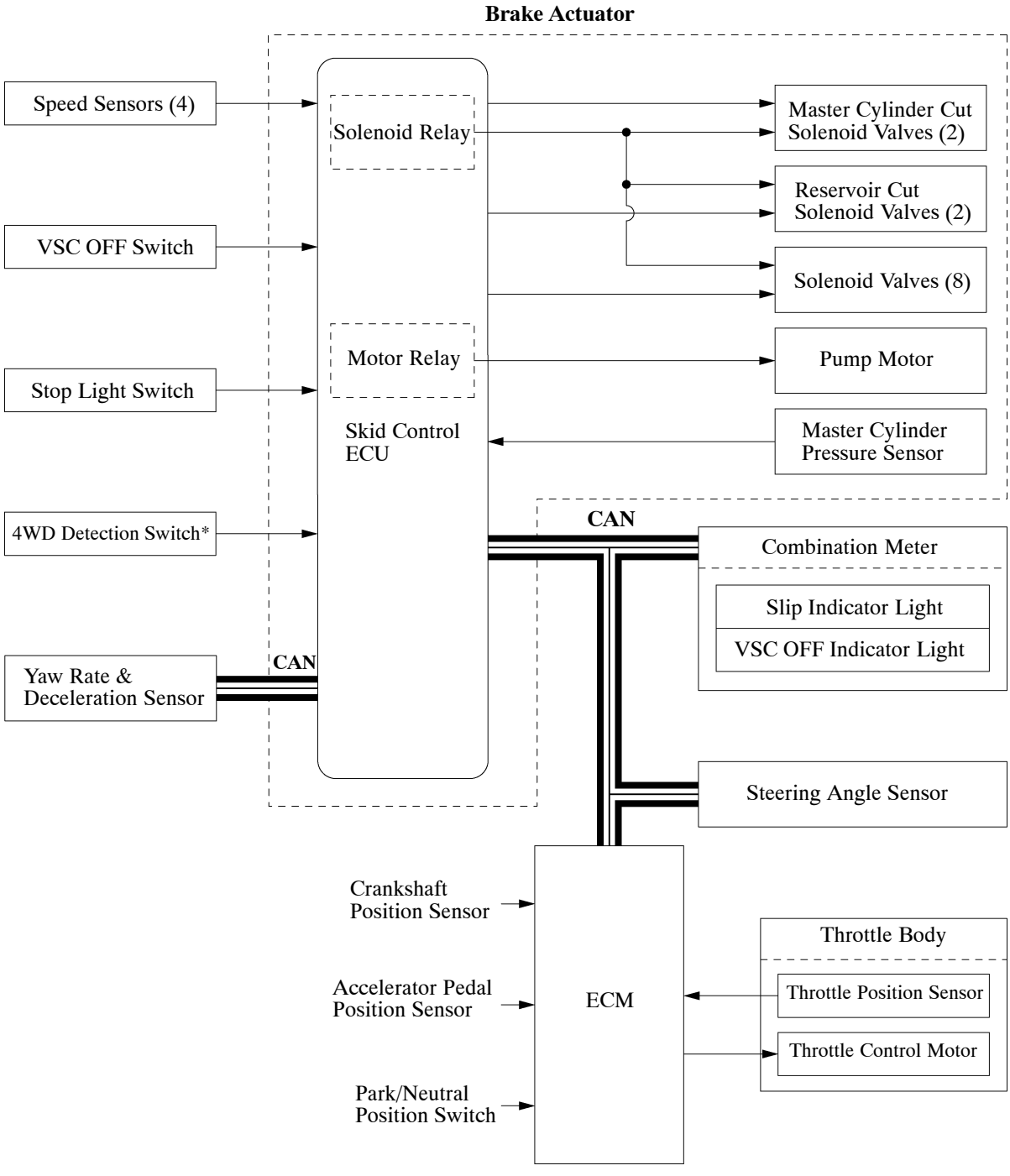
Item		Brake Assist Not Activated	Brake Assist Activated
(1), (4)	Master Cylinder Cut Solenoid Valve	OFF/Open	ON/Closed
	Port: (A), (D)		
(2), (3)	Reservoir Cut Solenoid Valve	OFF/Closed	ON/Open
	Port: (B), (C)		
(5), (6), (7), (8)	Pressure Holding Solenoid Valve	OFF/Open	←
	Port: (E), (F), (G), (H)	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

TRAC Operation

The fluid pressure generated by the pump is regulated by the master cylinder cut solenoid valve to achieve the required pressure. Thus, the brakes for the drive wheels are controlled in the following 3 modes: pressure reduction, pressure holding, and pressure increase modes, to control slippage of the drive wheels.

- The diagram on the next page shows the hydraulic circuit in the pressure increase mode when the TRAC is activated.
- The pressure holding solenoid valve and the pressure reduction solenoid valve are turned ON/OFF according to the ABS with EBD operation pattern described on the previous page.
- The TRAC is activated, each solenoid operates as shown in the table on page CH-151.

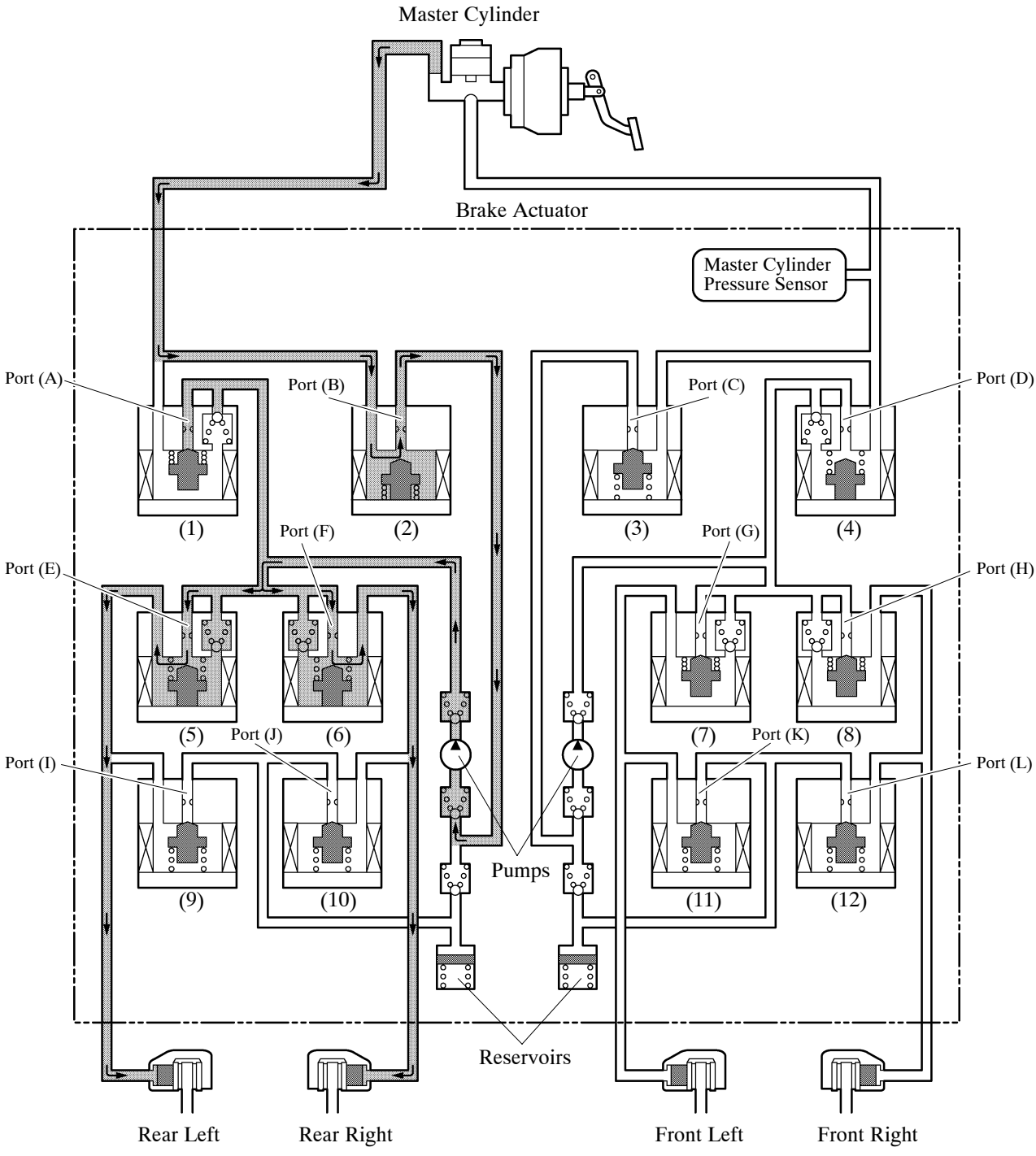
▶ System Diagram ◀



*: Only for 4WD Models

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Pressure Increase Mode

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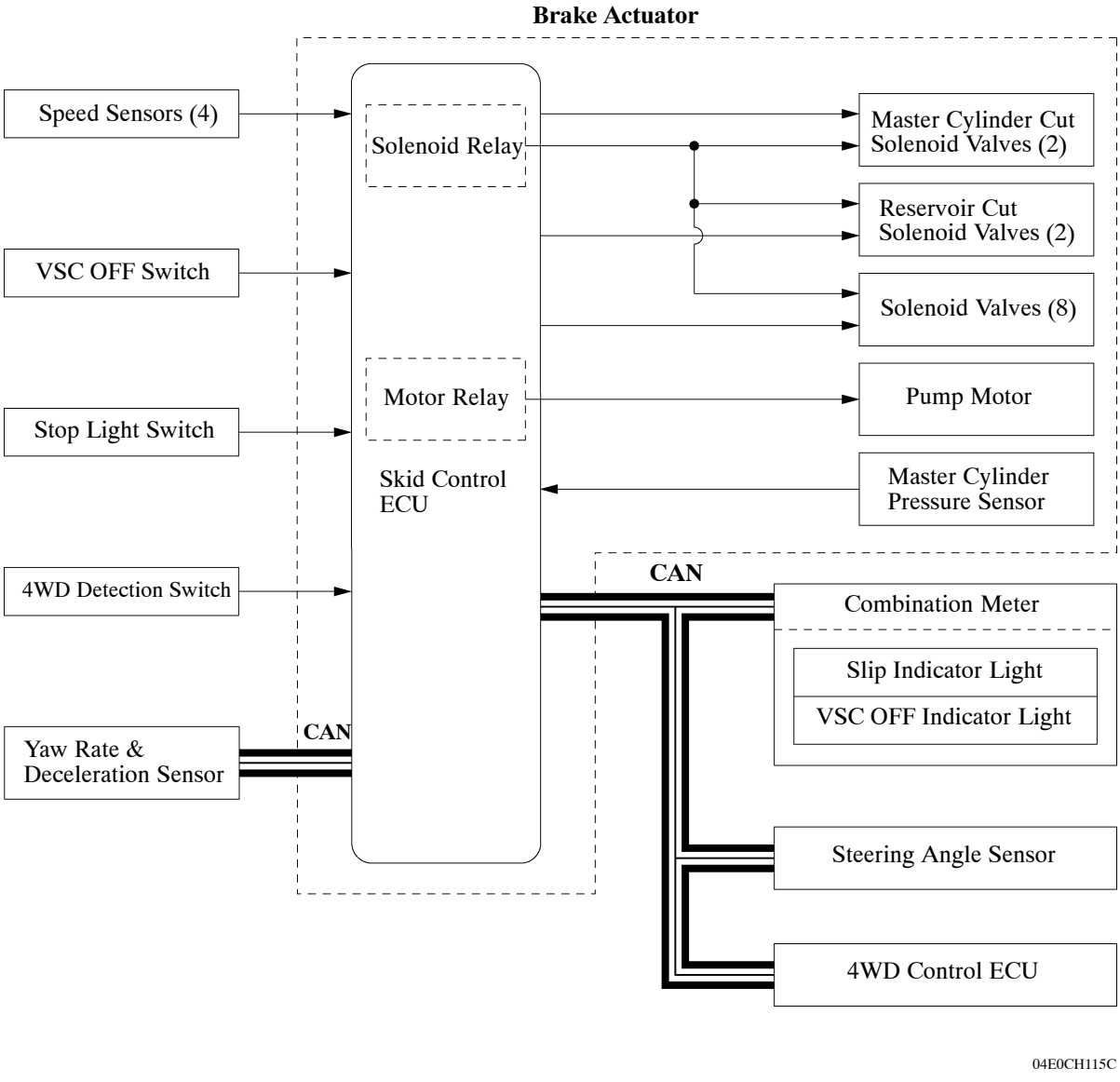
Item			TRAC Not Activated	TRAC Activated		
				Pressure Increase Mode	Pressure Holding Mode	Pressure Reduction Mode
(1)	Master Cylinder Cut Solenoid Valve		OFF/Open	ON/Closed	←	OFF/Open
	Port: (A)					
(4)	Master Cylinder Cut Solenoid Valve		OFF/Open	←	←	←
	Port: (D)					
(2)	Reservoir Cut Solenoid Valve		OFF/Closed	ON/Open	←	OFF/Closed
	Port: (B)					
(3)	Reservoir Cut Solenoid Valve		OFF/Closed	←	←	←
	Port: (C)					
Front Brake	(7), (8)	Pressure Holding Valve	OFF/Open	ON/Closed	←	←
		Port: (G), (H)				
	(11), (12)	Pressure Reduction Valve	OFF/Closed	←	←	←
		Port: (K), (L)				
	Wheel Cylinder Pressure		—	—	—	—
Rear Brake	(5), (6)	Pressure Holding Valve	OFF/Open	←	ON/Closed	OFF/Open
		Port: (E), (F)				
	(9), (10)	Pressure Reduction Valve	OFF/Closed	←	←	←
		Port: (I), (J)				
	Wheel Cylinder Pressure		—	Increase	Holding	Reduce

A-TRAC Operation

Based on the vehicle speed that has been calculated from the wheel speed sensors, and the signals of the yaw rate & deceleration sensor, the Skid Control ECU computes the target control speed.

- The Skid Control ECU compares the target control speed and the speeds of the wheels to determine whether or not slippage exists. Upon detecting slippage, the Skid Control ECU controls the solenoid valves of the brake actuator to control the brake fluid pressure that is applied to the slipping wheel. When the wheel speed becomes lower than the target control speed, the Skid Control ECU stops increasing the brake fluid pressure.
- The diagram on page CH-154 shows the hydraulic circuit in the pressure increase mode when the A-TRAC is activated.
- The A-TRAC is activated, each solenoid operates as shown in the table on page CH-155.

▶ System Diagram ◀



04E0CH115C

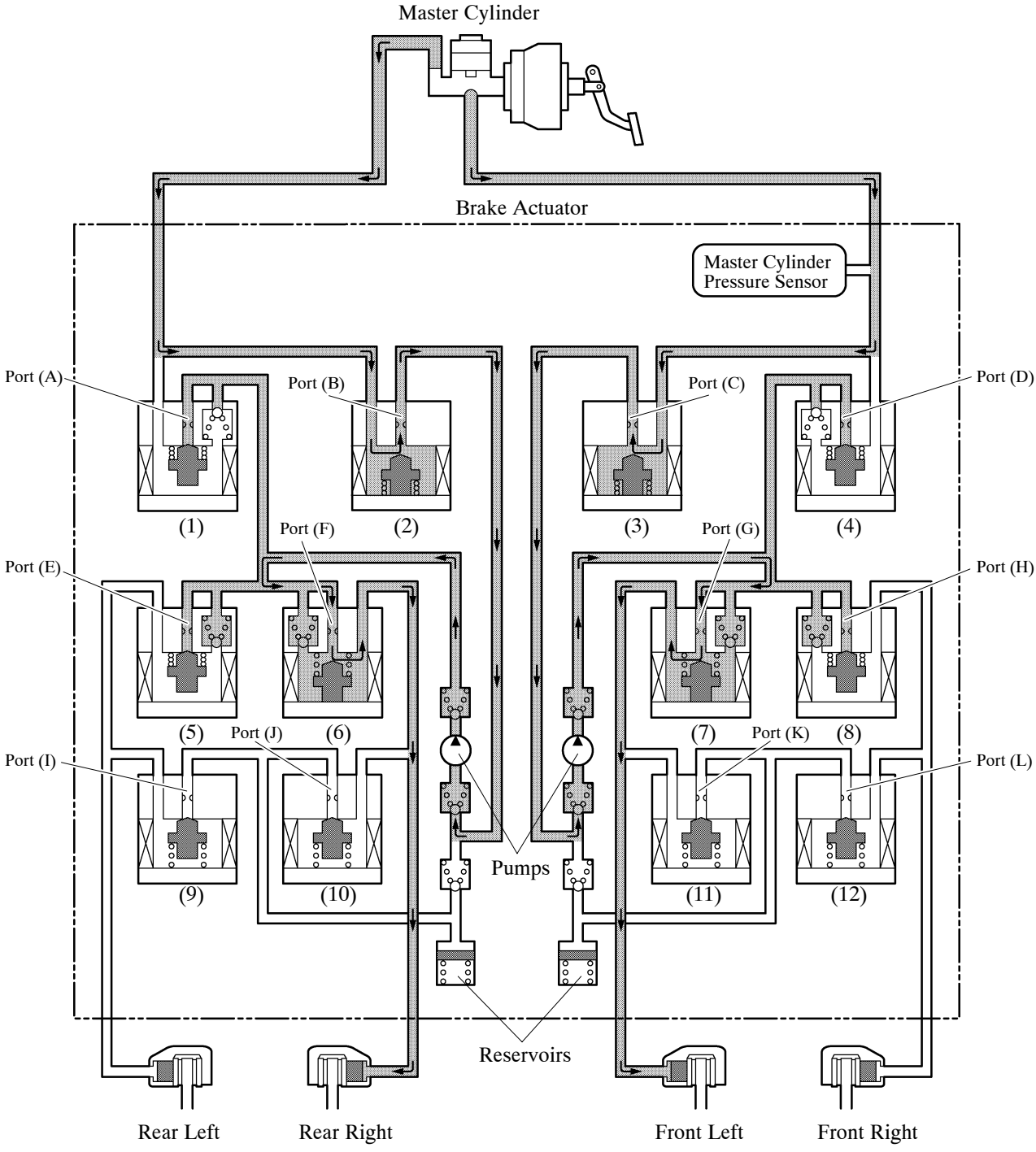
- As shown in the table below, the target control speed and the brake fluid pressure control.

Road Condition	Transfer Range	Control		Outline
Ordinary	4H	Target Control Speed	Vehicle Speed + Slip Rate (4H range set value)	Control designed to ensure the ease of driving on low-friction roads, dirt roads, and general roads.
		Brake Control	Gradual fluid Pressure Control	
Rocky or Offroad	4L	Target Control Speed	Vehicle Speed + Slip Rate (4L range set value)	Control designed for rugged offroad driving conditions.
		Brake Control	Sudden fluid Pressure Control	

A-TRAC Operation Precaution

When the A-TRAC is operating continuously while the vehicle is being driven on a slippery surface, the temperature of the brake pads increases. After a set length of time elapses, the Skid Control ECU alerts the driver of this condition by causing the VSC warning buzzer to sound, and the slip indicator warning light to illuminate. Also, the A-TRAC operation is temporarily interrupted to protect the pads. When the temperature of the pads decreases, the slip indicator light turns OFF, and the A-TRAC is automatically restored to an operating state.

▶ A-TRAC Operation (When wheelspin of the front left wheel and rear right wheel occurs) ◀



Pressure Increase Mode

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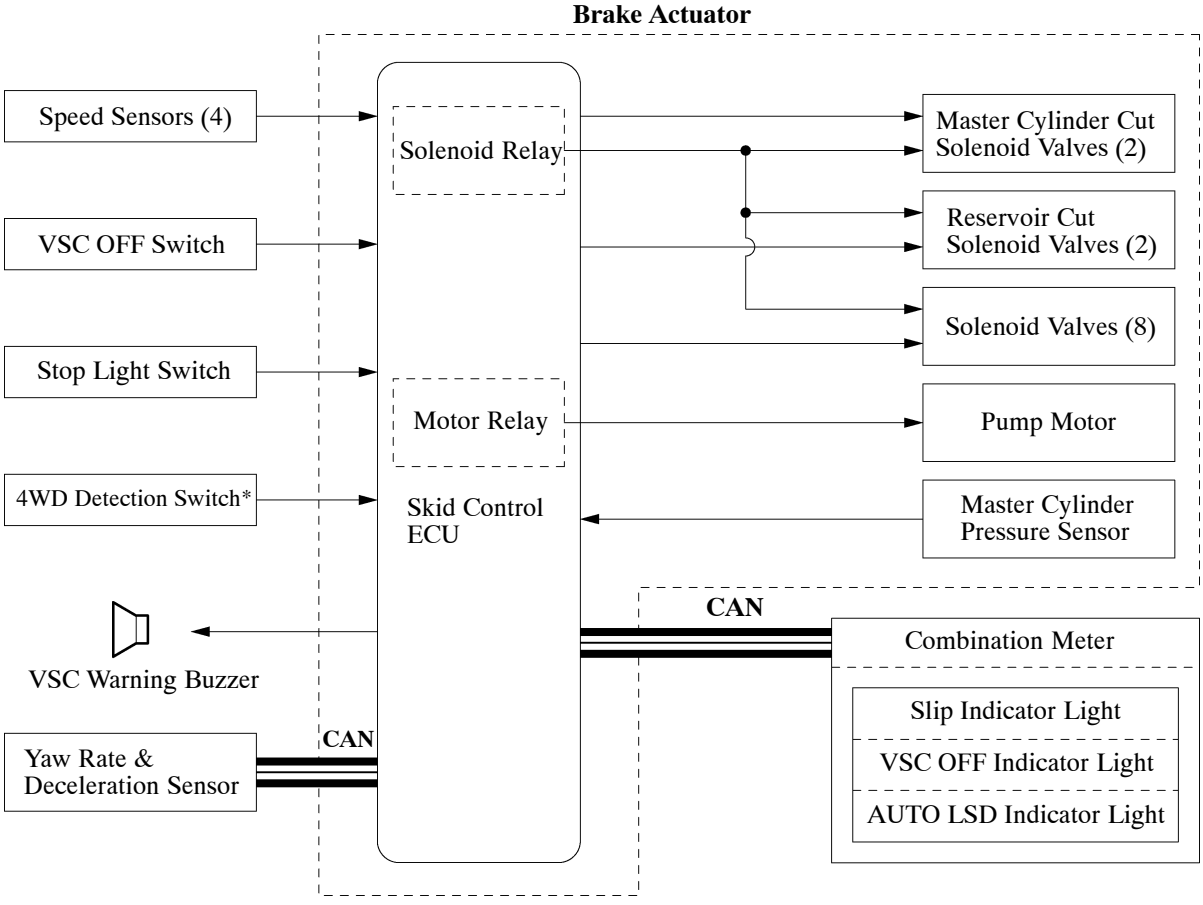
Item			A-TRAC Not Activated	A-TRAC Activated		
				Pressure Increase Mode	Pressure Holding Mode	Pressure Reduction Mode
(1), (4)	Master Cylinder Cut Solenoid Valve		OFF/Open	ON/Closed	←	OFF/Open
	Port: (A), (D)					
(2), (3)	Reservoir Cut Solenoid Valve		OFF/Closed	ON/Open	←	OFF/Closed
	Port: (B), (C)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

AUTO LSD Operation

1) General

- AUTO LSD is a function that has effects similar to a mechanical type LSD. AUTO LSD employs TRAC to control brake hydraulic pressure.
- The Skid Control ECU detects slippage that occurs as a result of a rotational speed difference between the wheel with grip and the wheel without grip. Via the TRAC, the AUTO LSD detects the wheel slip that occurs (the wheel that is rotating faster), based on the rotational difference of the right and left drive wheels, and creates the AUTO LSD effect.
- The operation of the brake actuator while AUTO LSD is working is the same as that of TRAC.
- The diagram on page CH-158 shows the hydraulic circuit in the pressure increase mode when the AUTO LSD is activated.
- The AUTO LSD is activated, each solenoid operates as shown in the table on page CH-159.

▶ System Diagram ◀



*: Only for 4WD Models

04E0CH71C

2) AUTO LSD Operation Condition

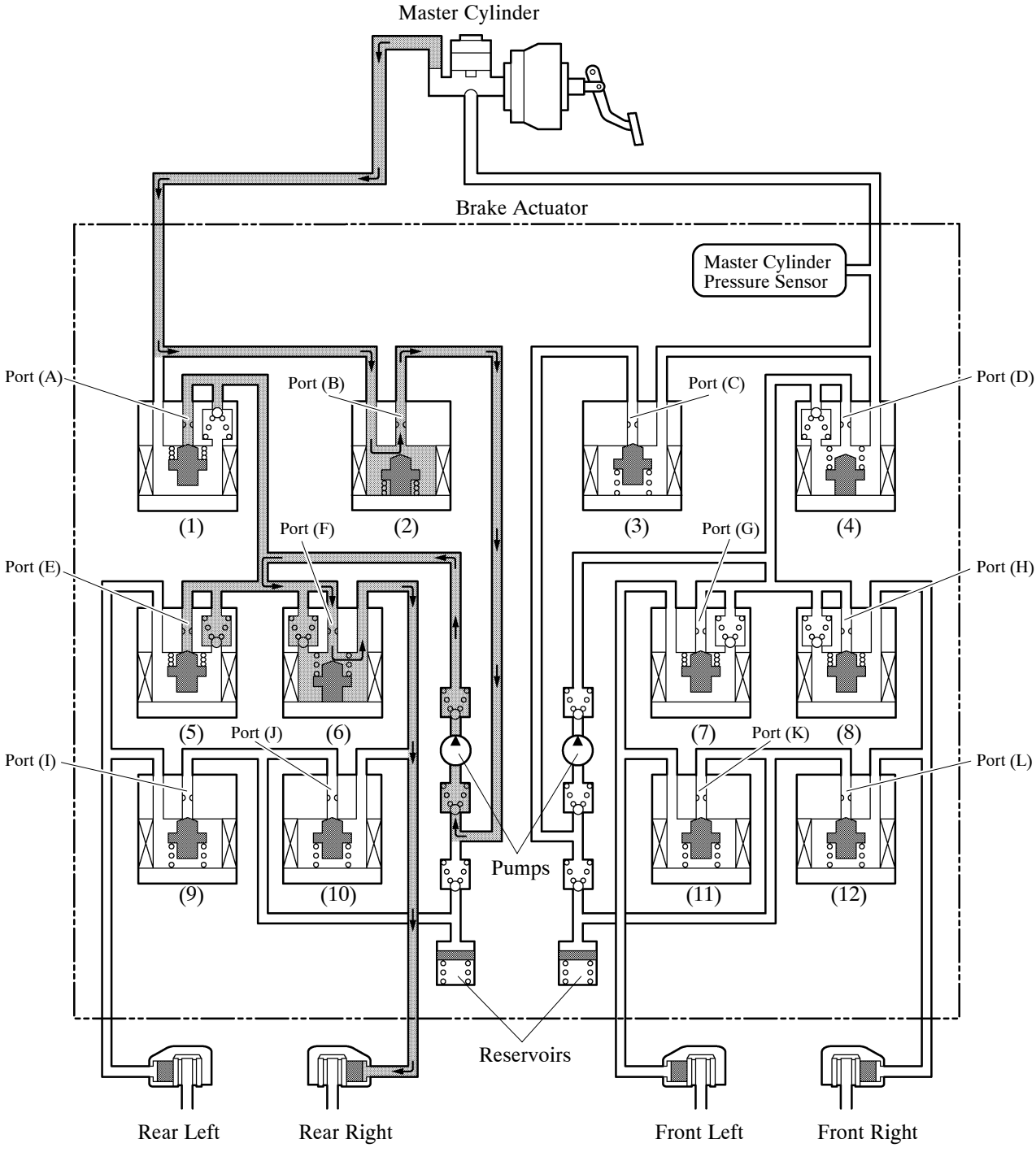
The following conditions must be met to enable operation of AUTO LSD. The AUTO LSD indicator light turns on when the operation is enabled.

Operating Condition	Content
Select the 2WD mode	AUTO LSD is operational only in the 2WD mode.
TRAC OFF mode	Briefly pressing the VSC OFF switch in normal mode enters TRAC OFF mode, turning the AUTO LSD ON.
Accelerator Pedal ON	AUTO LSD does not operate when the brake pedal is being operated. This ensures that AUTO LSD does not interfere with the driver's attempt to reduce vehicle speed.
Vehicle Speed	Driving at a speed under 50km/h (31mph).

AUTO LSD Operation Precautions

- Operate the AUTO LSD control only when the wheels are susceptible to spinning, such as when driving on a grooved, slippery, or rough surface.
- Make sure the vehicle is stopped before turning ON the AUTO LSD.
- To prevent instability, do not continue driving the vehicle with the AUTO LSD turned ON.
- The slip indicator light will blink when the AUTO LSD is operating.
- If the brake control of the AUTO LSD is operated continuously, the temperature of the brake pads will rise.
  The Skid Control ECU, which monitors* the temperature of the brake pads, alerts the driver by sounding the VSC warning buzzer if the brake pads becomes overheated. In this case, the AUTO LSD will temporarily stop operating in order to protect the system.
  *: The Skid Control ECU calculates the temperature of the brake pads based on its operating time.
- The AUTO LSD applies the brakes to the drive wheel with the higher speed and controls the extent of the brake application in order to achieve the function of an LSD. However, it might not be able to achieve this function on a steep incline or on an extremely slippery surface, such as a frozen or snowy surface.

▶ AUTO LSD Operation (When wheelspin of the rear right wheel occurs) ◀



Pressure Increase Mode

04E0CH72C

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

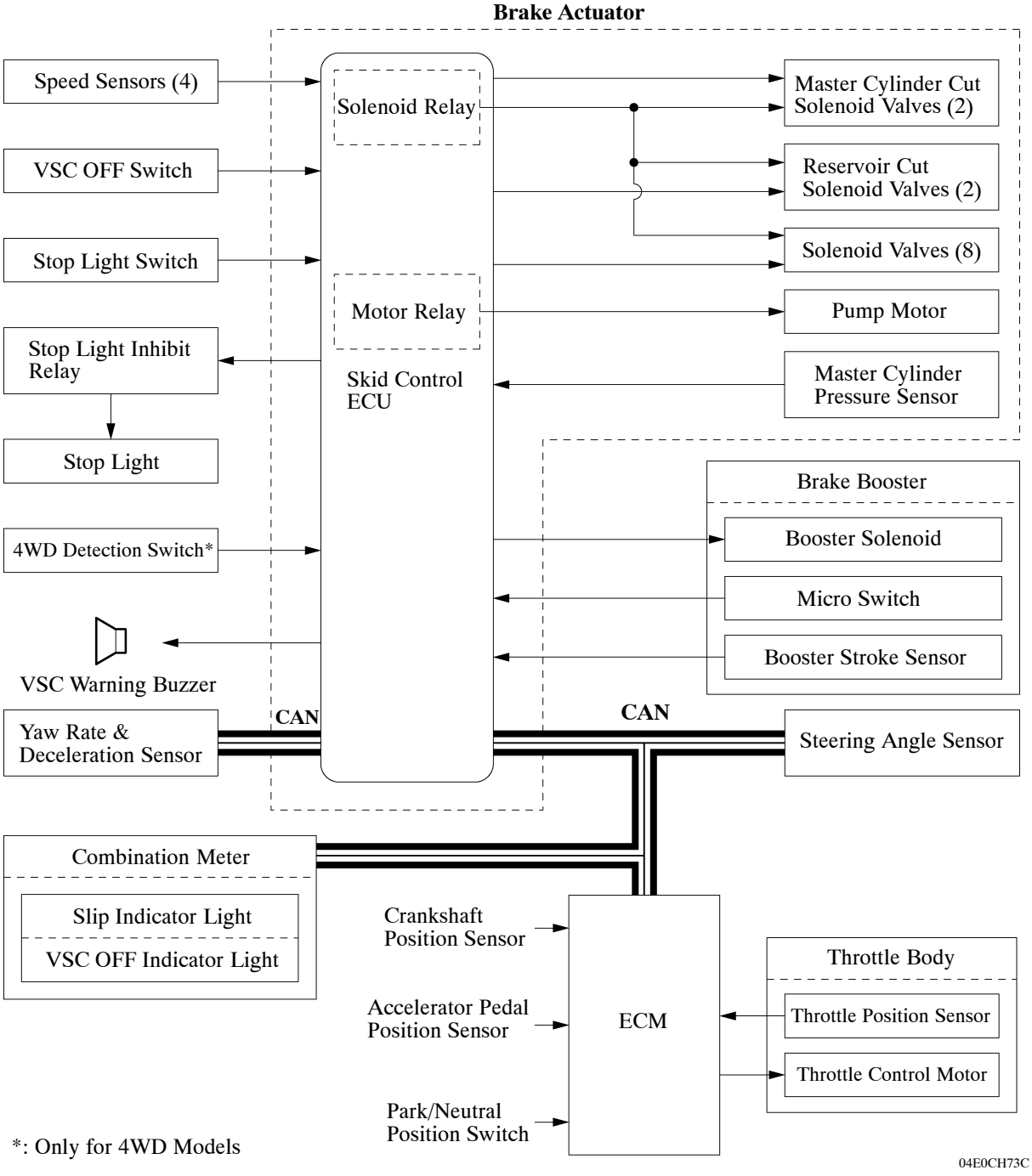
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VSC Operation

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 controlled.
- 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 ◀



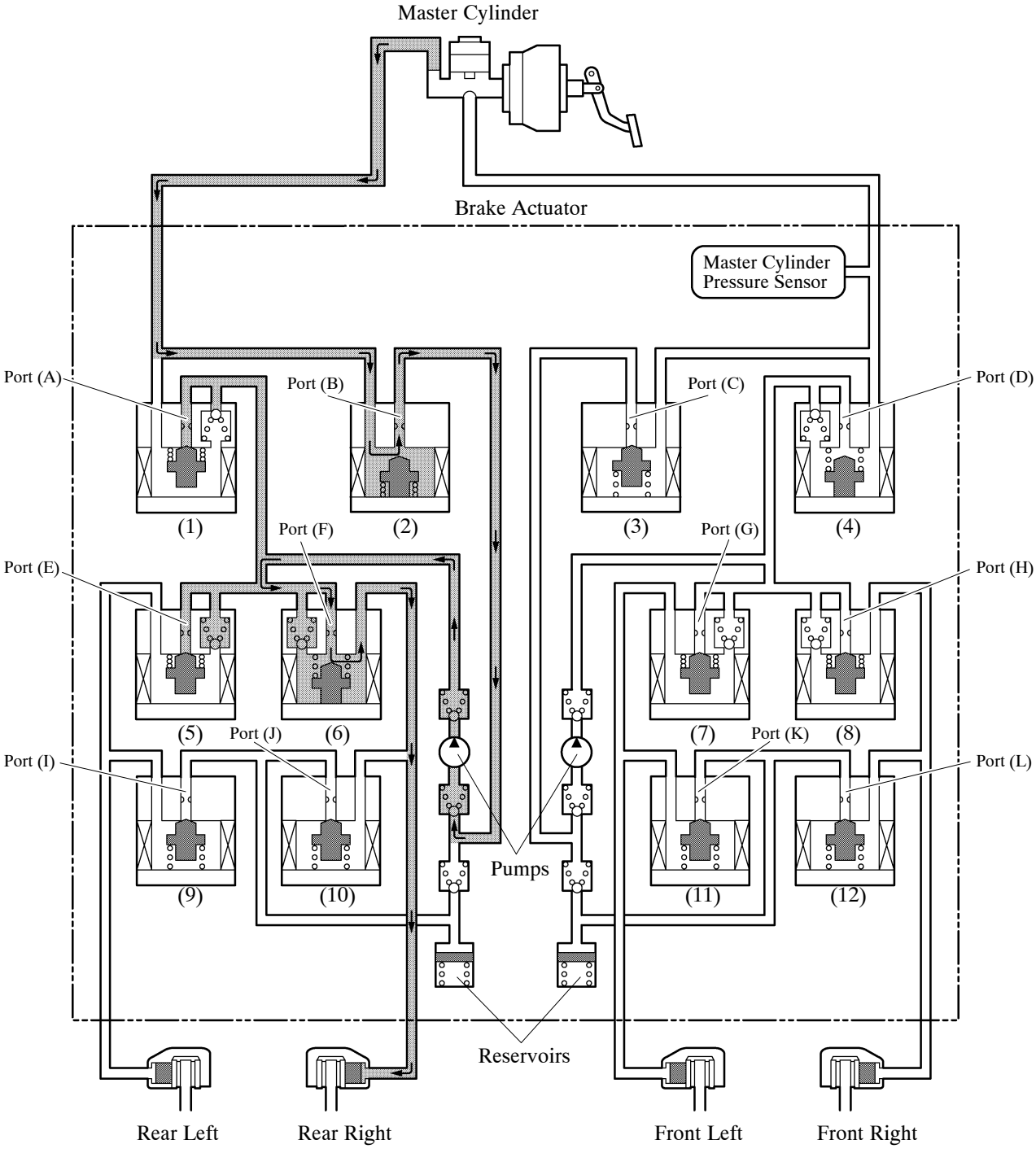
*: Only for 4WD Models

04E0CH73C

2) Front Wheel Skid Restraining Control (Right Turn)

For 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 ABS with EBD operation.
- The VSC is activated, each solenoid operates as shown in the table on page CH-162.



Pressure Increase Mode

04E0CH72C

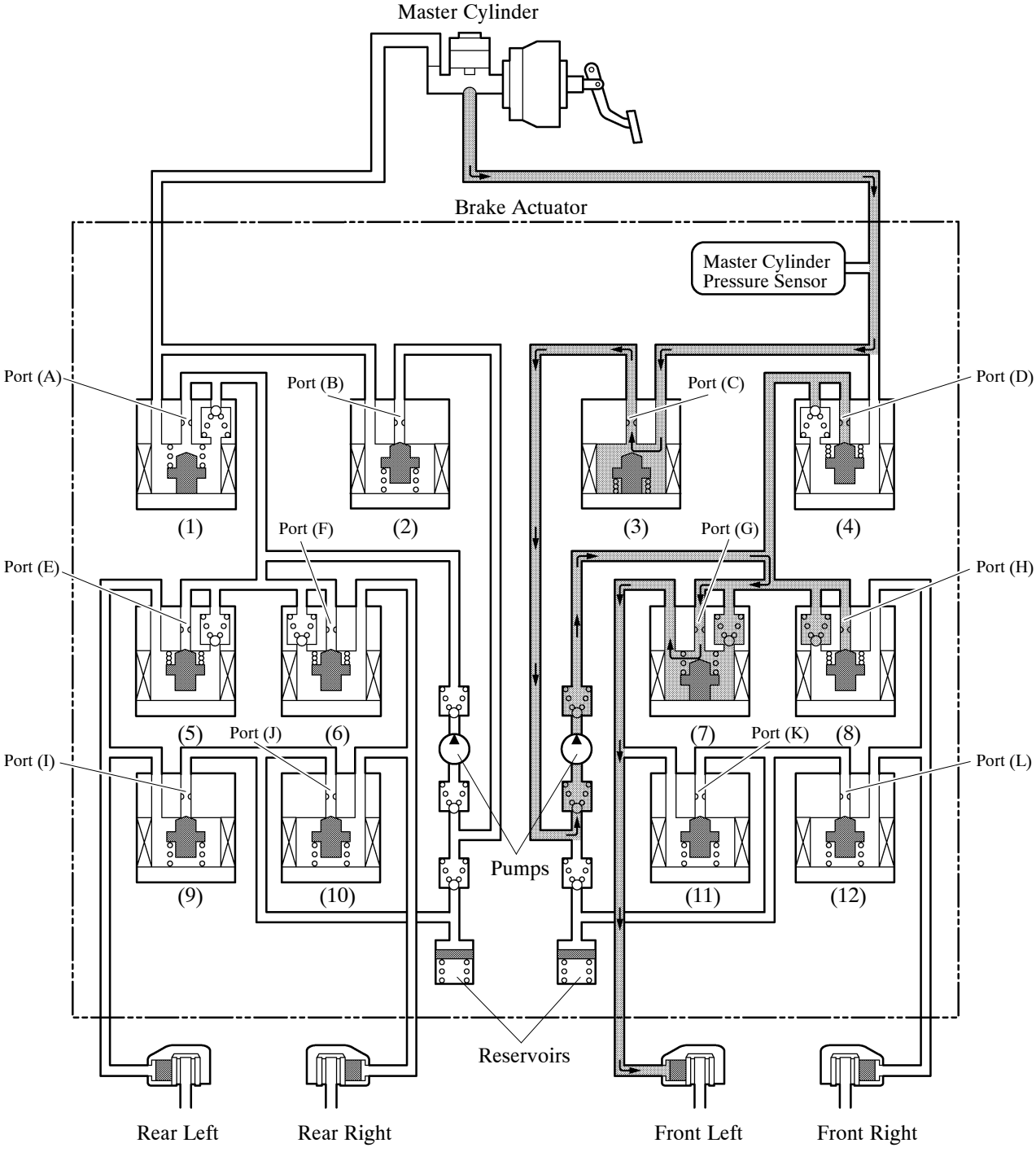
CH

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

3) Rear Wheel Skid Restraining Control (Right Turn)

For 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 with EBD operation pattern.
- The VSC is activated, each solenoid operates as shown in the table on page CH-164.



Pressure Increase Mode

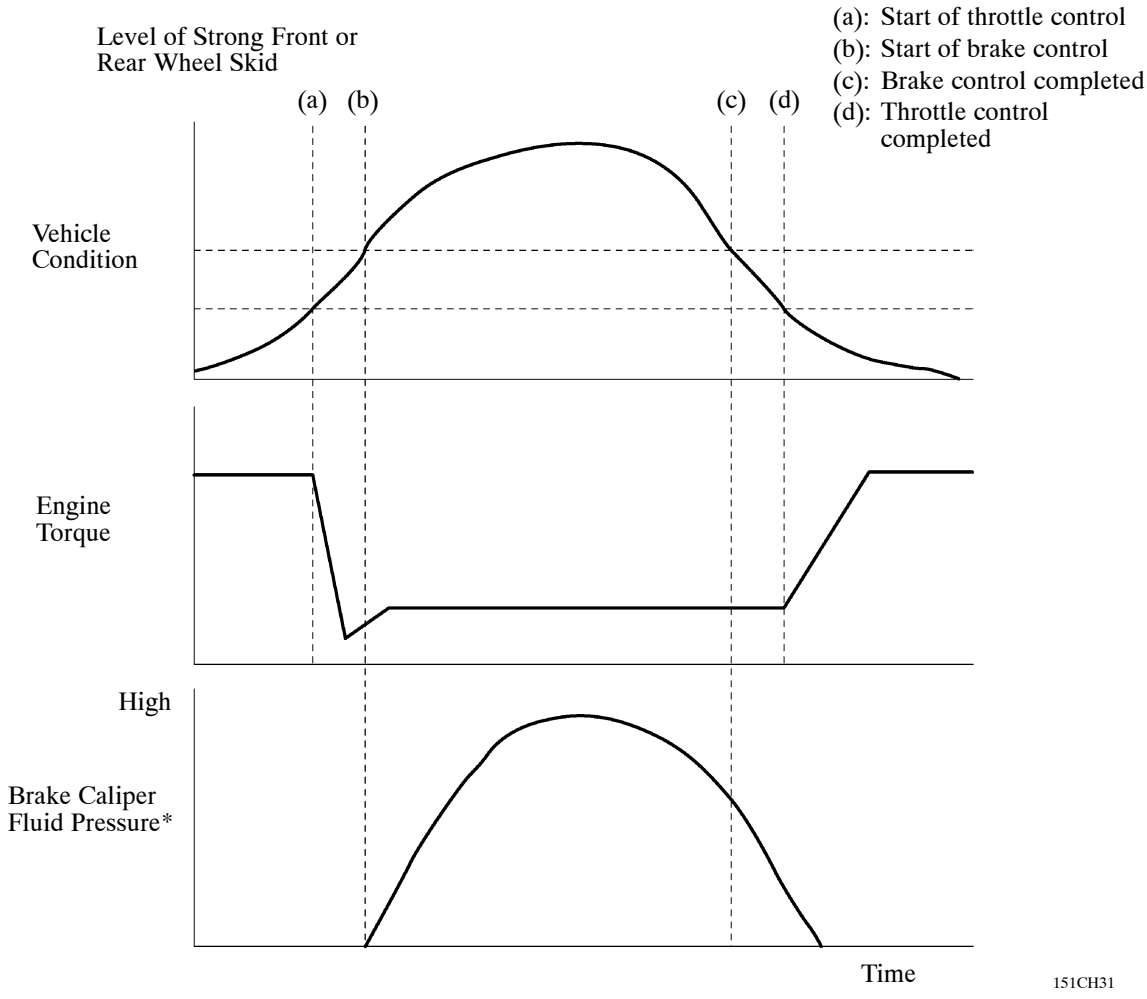
04E0CH75C

CH

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

Engine Output Control

During a VSC 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.



*: The caliper that activates varies depending on the driving conditions experienced by the vehicle.

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.

18. CAN (Controller Area Network)

CAN communication is used among the Skid Control ECU, steering angle sensor, 4WD Control ECU, ECM and DLC3. For details, see page BE-8.

19. Self-Diagnosis

If the Skid Control ECU detects a malfunction in the brake control system (ABS with EBD, Brake Assist, TRAC, A-TRAC, AUTO LSD, or VSC), the warning light or indicator light lights up to alert the driver of the malfunction, as indicated in the table below. At the same time, Skid Control ECU stores the DTC (Diagnostic Trouble Code) in memory.

○: Light ON -: Light OFF

	Brake Control						
Warning or Indicator Light	**ABS**	**EBD**	**Brake Assist**	**TRAC**	**A-TRAC**	**AUTO LSD**	**VSC**
ABS Warning Light	○	○	○	-	-	-	-
Brake System Warning Light	-	○	-	-	-	-	-
VSC OFF Indicator Light	○*1	○*1	○*1	○	○	○	○
Slip Indicator Light	○*1	○*1	○*1	○	○	○	○

There are 2-digit DTCs and 5-digit DTCs.

- 2-digit DTCs can be read by connecting the SST (09843-18040) to Tc and CG terminals of DLC3, and observing the blinking of the ABS warning light or the VSC OFF indicator light.
- 5-digit DTCs can be read by connecting a hand-held tester or Techstream*2 to DLC3.
  The self-diagnosis has a sensor signal check (test mode) function.
- This function is activated by connecting the SST (09843-18040) between the Ts and CG terminal of the DLC3 or by connecting a hand-held tester or Techstream*2.
- If the Skid Control ECU detects malfunctions during a sensor check, it stores the DTCs in its memory.
- These DTCs can be read during a sensor check operation by connecting the SST (09843-18040) to the Tc and CG terminals of the DLC3 and observing the blinking of the ABS warning light or the VSC OFF indicator light. These DTCs can also be read by connecting a hand-held tester or Techstream*2.

Service Tip

The Skid Control ECU uses the CAN protocol for diagnostic communication. Therefore, a hand-held tester and a dedicated adapter [CAN VIM (Vehicle Interface Module)] or Techstream*2 are required for accessing diagnostic data. For details, see the 2007 TOYOTA TUNDRA Repair Manual (Pub. No. RM04E2U).

*1: A failure in the ABS, EBD, and Brake Assist systems prohibits operation of the TRAC, A-TRAC, AUTO LSD and VSC systems. Accordingly, the VSC OFF indicator light and slip indicator lights will be illuminated.

*2: Techstream is the name for the diagnostic tester in North America, but other countries will continue to use the hand-held tester.

20. Fail-Safe

- In the event of a malfunction in the ABS and/or Brake Assist controls, the Skid Control ECU prohibits ABS, Brake Assist, TRAC, A-TRAC, AUTO LSD, 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 with EBD, Brake Assist, TRAC, A-TRAC, AUTO LSD, and VSC) will not be available.
- In the event of a malfunction in the TRAC, A-TRAC, AUTO LSD, and/or VSC, the Skid Control ECU prohibits TRAC, A-TRAC, AUTO LSD, 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 TRAC, A-TRAC, AUTO LSD, and VSC operation.
- When the ECM detects an engine control DTC, it will disable the TRAC, A-TRAC, AUTO LSD, and VSC operations.