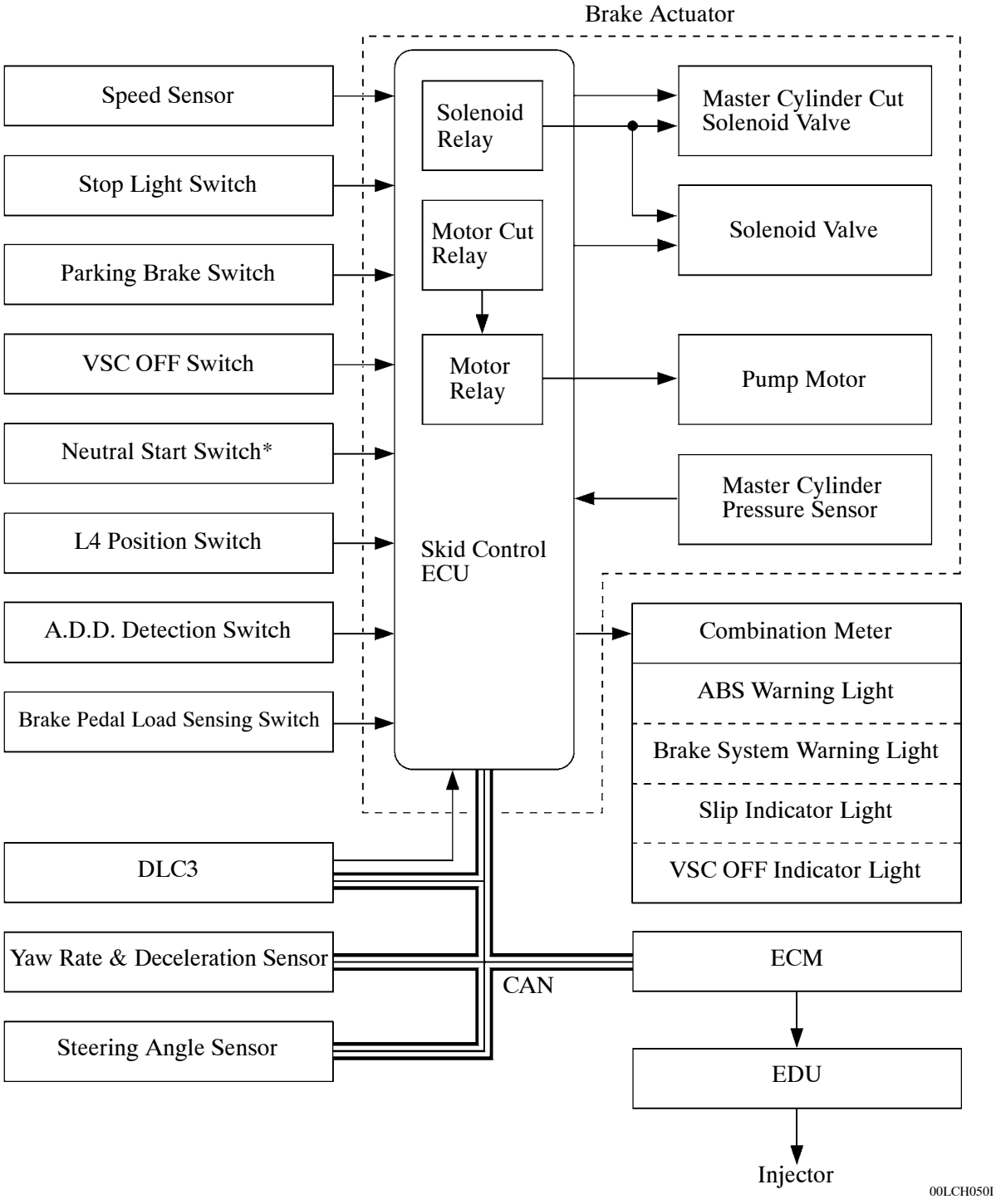
■ BRAKE CONTROL SYSTEM (ABS, EBD, BRAKE ASSIST, TRC and VSC)

1. General

The brake control system (ABS, EBD, brake assist, TRC, VSC) of the new Hilux has following functions:

Function	Outline
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 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 the 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.
TRC (Traction Control)	The 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.
VSC (Vehicle Stability Control)	The VSC helps prevent the vehicle from slipping sideways as a result of strong front wheel skid or strong rear wheel skid during cornering.

2. System Diagram



*: Models with automatic transmission

3. Outline of EBD

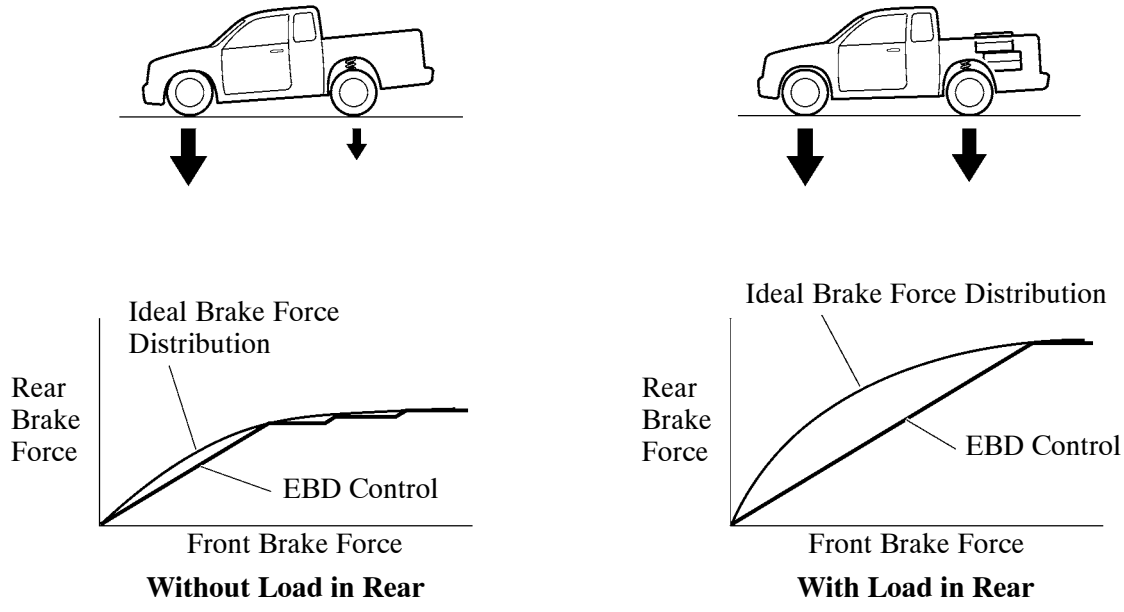
General

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.

Front/Rear Wheels Brake Force Distribution

If the brakes are applied while the vehicle is moving straight forward, the transfer of the load reduces the weight applied to the rear wheels. The skid control ECU determines this condition by way of the signals from the speed sensor, and the brake actuator regulates the distribution of the brake force of the rear wheels to optimally control them.
For example, the amount of brake force applied to the rear wheels during braking varies depending on whether the vehicle is carrying load or not. The amount of the brake force 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 wheels is optimally controlled in order to effectively utilize the brake force of the rear wheels under these conditions.

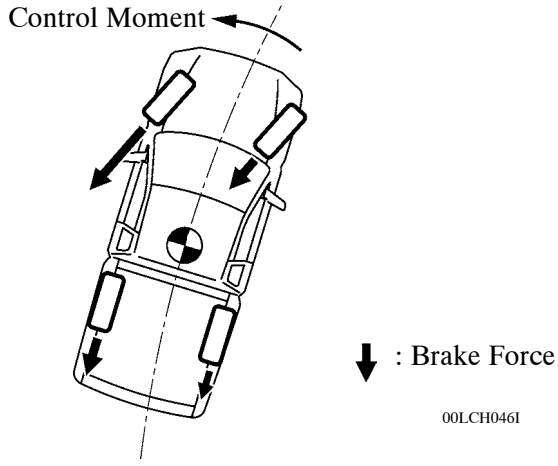
▶ EBD Control Concept ◀



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

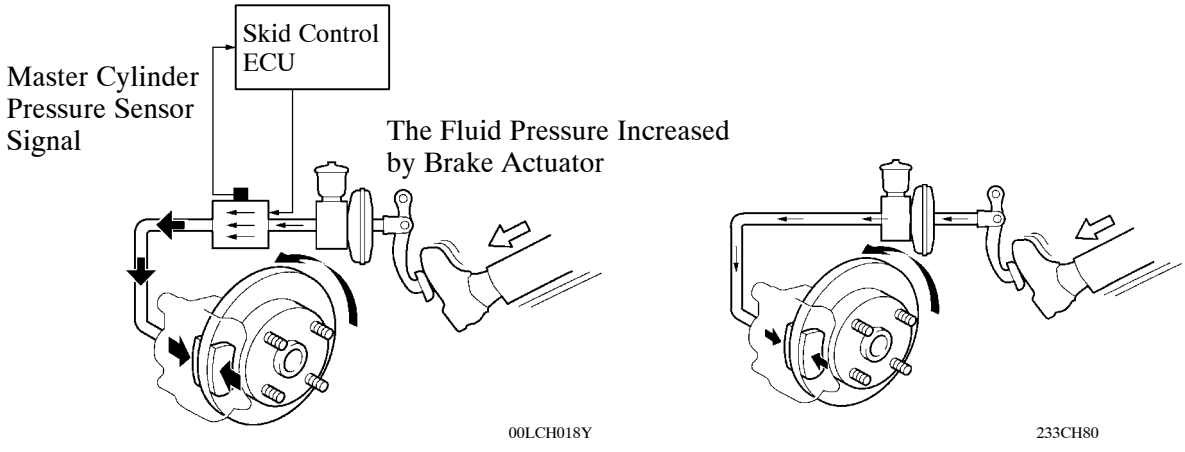
When the brake is applied while the vehicle is cornering, the load applied to the inner wheels decreases as the load to the outer wheels increases.
The skid control ECU determines this condition by way of the signals from the speed sensor, and the brake actuator regulates the brake force in order to optimally control the distribution of the brake force to the inner wheels and outer wheels.



4. Outline of Brake Assist

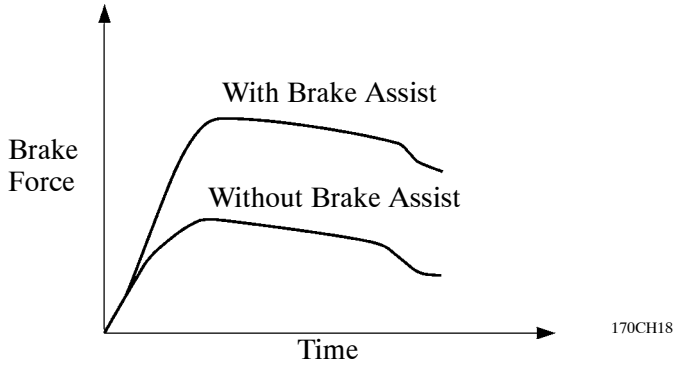
- The brake assist in combination with the ABS helps ensure the vehicle's brake performance.
- The brake assist interprets a quick push of the brake pedal as emergency braking and supplements the brake force applied if the driver has not depressed hard enough the brake pedal. In emergencies, drivers, 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 system 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 make an emergency braking. If the skid control ECU determines that the driver intends to make an emergency braking, this function activates the brake actuator to increase the brake fluid pressure, which increases the brake force.

▶ If the Driver's Depressing Force is Small when Emergency Braking is Applied ◀



With Brake Assist **Without Brake Assist***

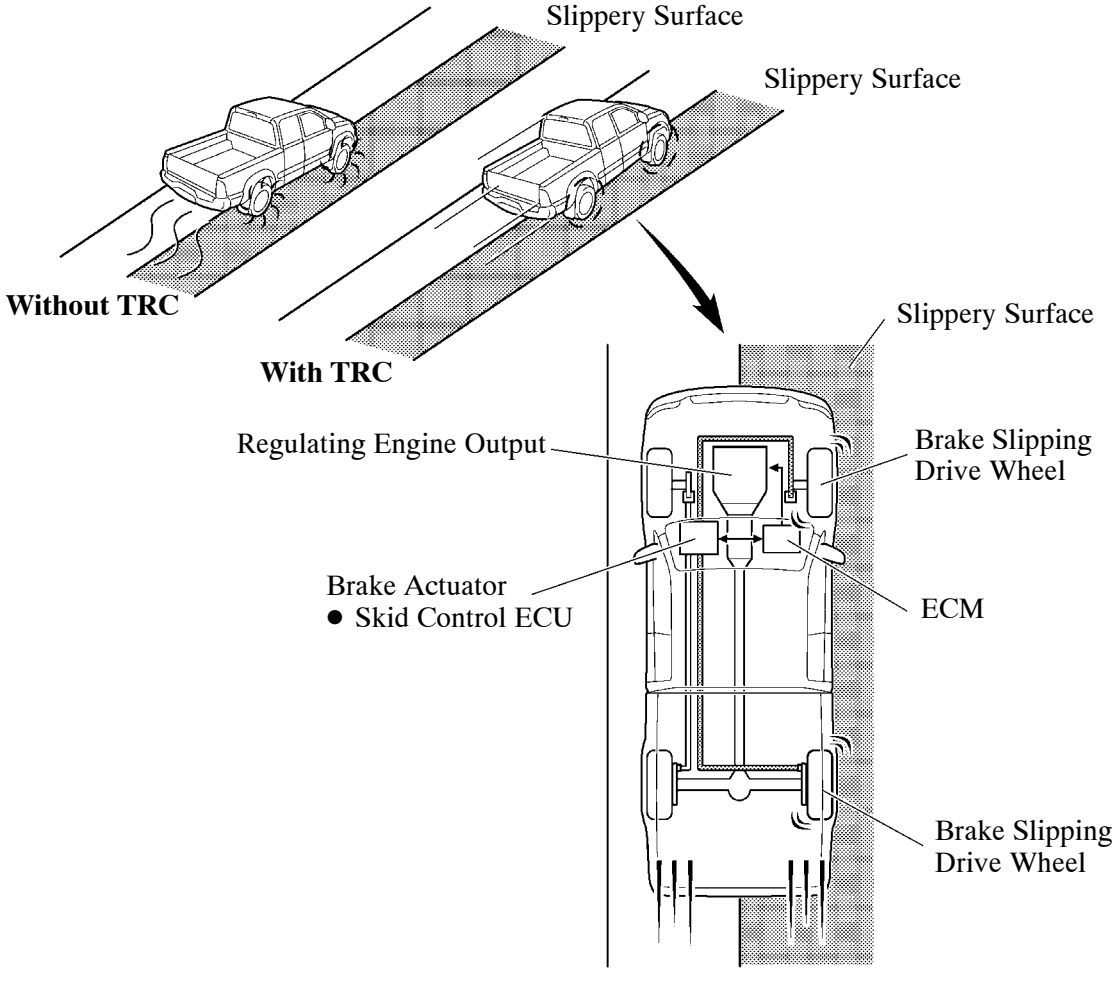
*: The basic performance of the brake is the same as that of the models with the brake assist



5. Outline of TRC

- If the driver presses the accelerator pedal aggressively when initially accelerating or when accelerating on a slippery surface, the drive wheels may slip due to the excessive amount of torque that is generated. By applying hydraulic brake control to the drive wheels and regulating 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 is made below between two vehicles, one with TRC and the other without it as illustrated. If the driver of each vehicle operates the accelerator pedal in a rough manner while driving over a surface with differing surface friction characteristics, the drive wheel on the slippery surface may slip. As a result, the vehicle without TRC can not start accelerating smoothly.
  However, on the vehicle 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 engine output. Thus, TRC can constantly help the driver to maintain stability during acceleration.

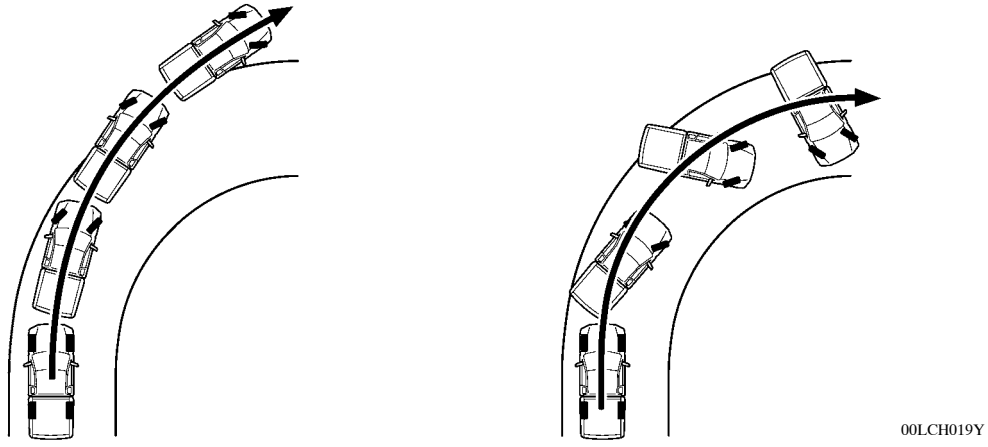
▶ Driving Condition on Road with Different Surface Friction Characteristics ◀



6. Outline of VSC

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 is in one of the situations described 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).



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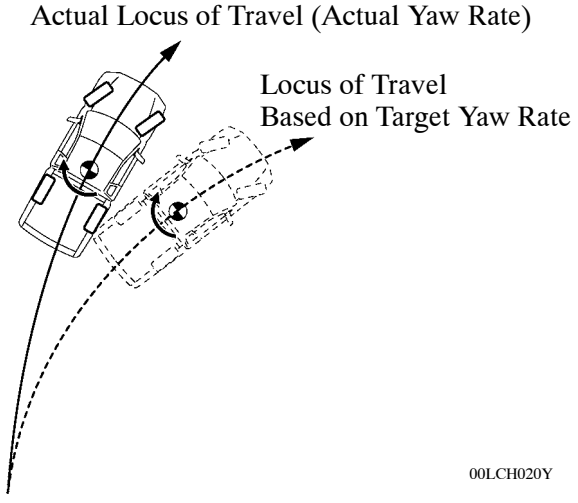
Front Wheel Skid Tendency **Rear Wheel Skid Tendency**

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.

1) Determining Front Wheel Skid

Whether the vehicle is in a state of 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 possibility of front wheel skid.

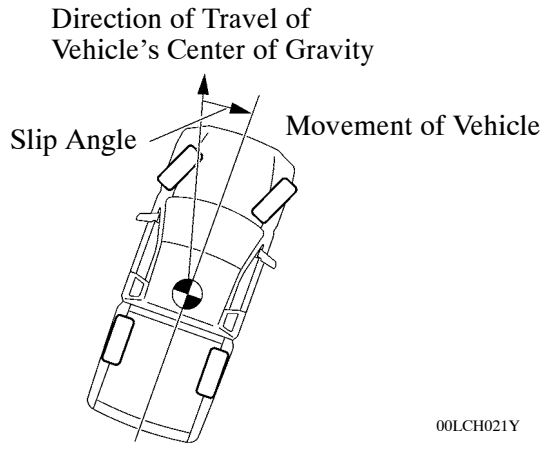


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Determining Front Wheel Skid

2) Determining Rear Wheel Skid

Whether the vehicle is in a state of 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.



Determining Rear Wheel Skid

Method for VSC Operation

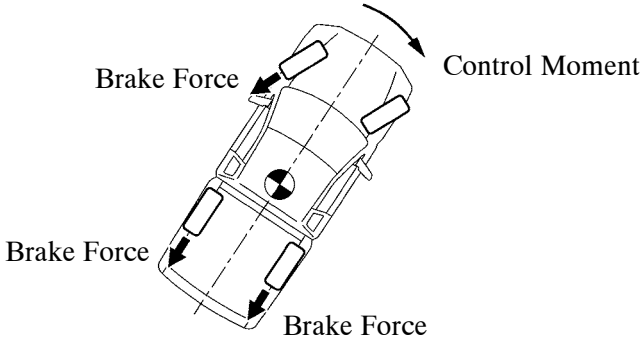
When the skid control ECU determines that the vehicle has a tendency to front wheel skid or rear wheel skid, it decreases the engine output and applies the brake of the front or rear wheels to control the vehicle's yaw moment.
The basic operation of the VSC is described below. However, the control method differs depending on the vehicle's characteristics and driving conditions.

1) Dampening Front Wheel Skid

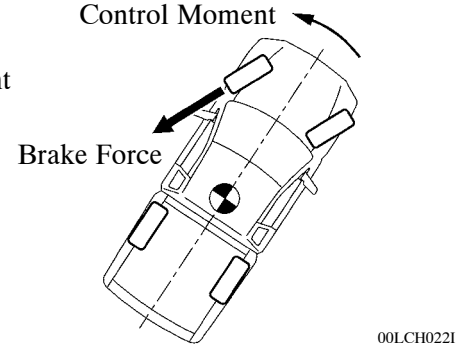
When the skid control ECU determines that there is a large front wheel skid tendency, it counteracts in accordance with the extent of that tendency. The skid control ECU controls the engine output and applies the brakes of the front outside wheel (the outside of the turn) and rear wheels in order to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

2) 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 brake 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, excellent vehicle stability is ensured.
In some cases, the skid control ECU applies the brake of the rear wheels as necessary.

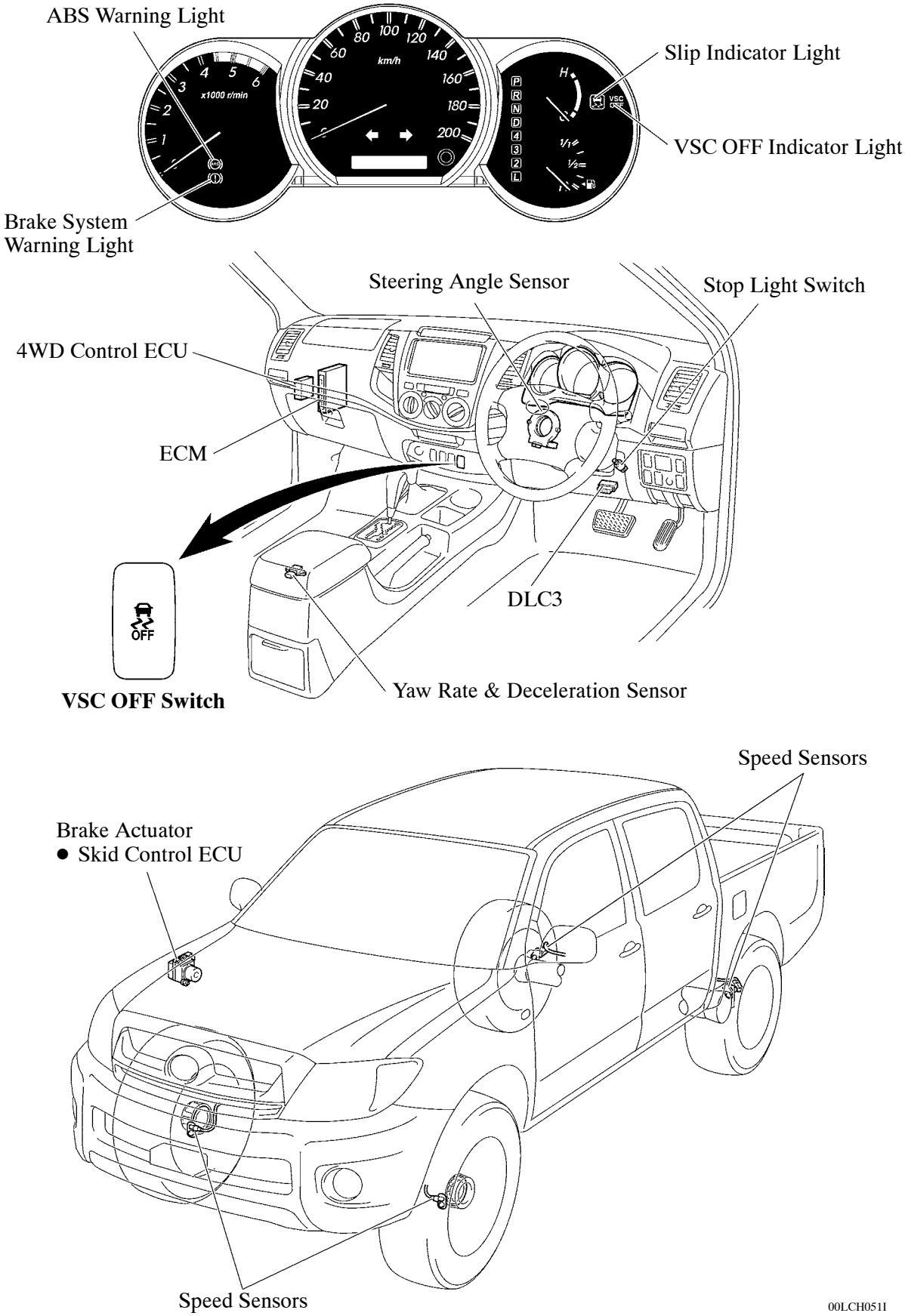


Dampening Front Wheel Skid (Making Right Turn)



Dampening Rear Wheel Skid (Making Right Turn)

7. Layout of Main Components



8. 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.
	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 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. ● Lights up to inform the driver that the TRC OFF mode or VSC OFF mode is entered using the VSC OFF switch.
	VSC OFF Indicator Light	● 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 TRC or VSC is not available, the VSC OFF indicator light blinks to alert the driver.
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.
	Solenoid Relay	Controls power supplied to the solenoid valves.
	Motor Relay	Supplies power to the pump motor in the brake actuator.
	Motor Cut Relay	Cuts the power to the pump motor in the brake actuator.
Speed Sensor		Detects the wheel speed of each of the four wheels.
Yaw Rate & Deceleration Sensor		● Detects the vehicle's yaw rate. ● Detects the vehicle's longitudinal and lateral acceleration.
Steering Angle Sensor		Detects the steering direction and angle of the steering wheel.
Brake Pedal Load Sensing Switch		Detects the brake pedal depressing force.
Stop Light Switch		Detects brake pedal application.
Parking Brake Switch		Detects parking brake application.

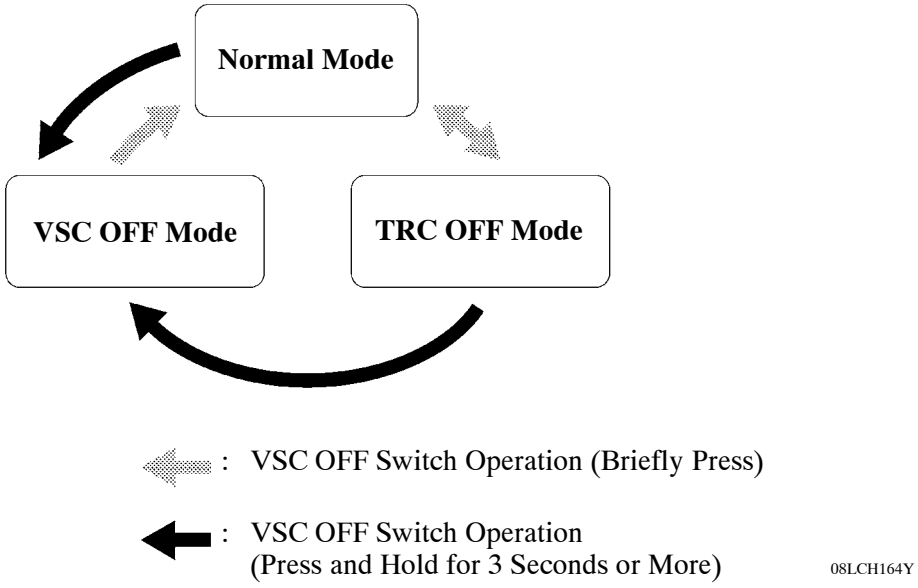
(Continued)

Component	Function
VSC OFF Switch	● Cancels the TRC or VSC. ● Selects the 3 modes (Normal mode, TRC OFF mode, and VSC OFF mode).
Neutral Start Switch*	Detects the shift lever position.
L4 Position Switch	Detects the L4 position condition.
A.D.D. Detection Switch	Detects the A.D.D. shift actuator operating condition.
ECM	● Sends the accelerator pedal position signal and engine speed signal to the skid control ECU. ● Receives an engine output adjustment command signals from the skid control ECU. Based on these signals, the ECM regulates the engine output.

*: Models with automatic transmission

9. VSC OFF Switch

- The VSC OFF switch can select the 3 modes (Normal mode, TRC OFF mode, and VSC OFF mode).
- Briefly pressing the VSC OFF switch in Normal mode selects the TRC 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 TRC and VSC functions.
- Briefly pressing the VSC OFF switch in the TRC OFF mode or VSC OFF mode or turning the ignition switch OFF returns to the Normal 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
		TRC	VSC	 03NCH005Y	VSC OFF 03NCH006Y
H2	Normal Mode	○	○	—	—
	TRC OFF Mode	×*1	○	Light ON	—
	VSC OFF Mode	×	×*2	Light ON	Light ON
H4	Normal Mode	○	○	—	—
	TRC OFF Mode	×*1	○	Light ON	—
	VSC OFF Mode	×	×*2	Light ON	Light ON
L4	Normal Mode	○	×	—	Light ON
	VSC OFF Mode	×	×	Light ON	Light ON

*1: When the vehicle exceeds a determined speed [approximately 50 km/h (31 mph)], Normal mode will operate.

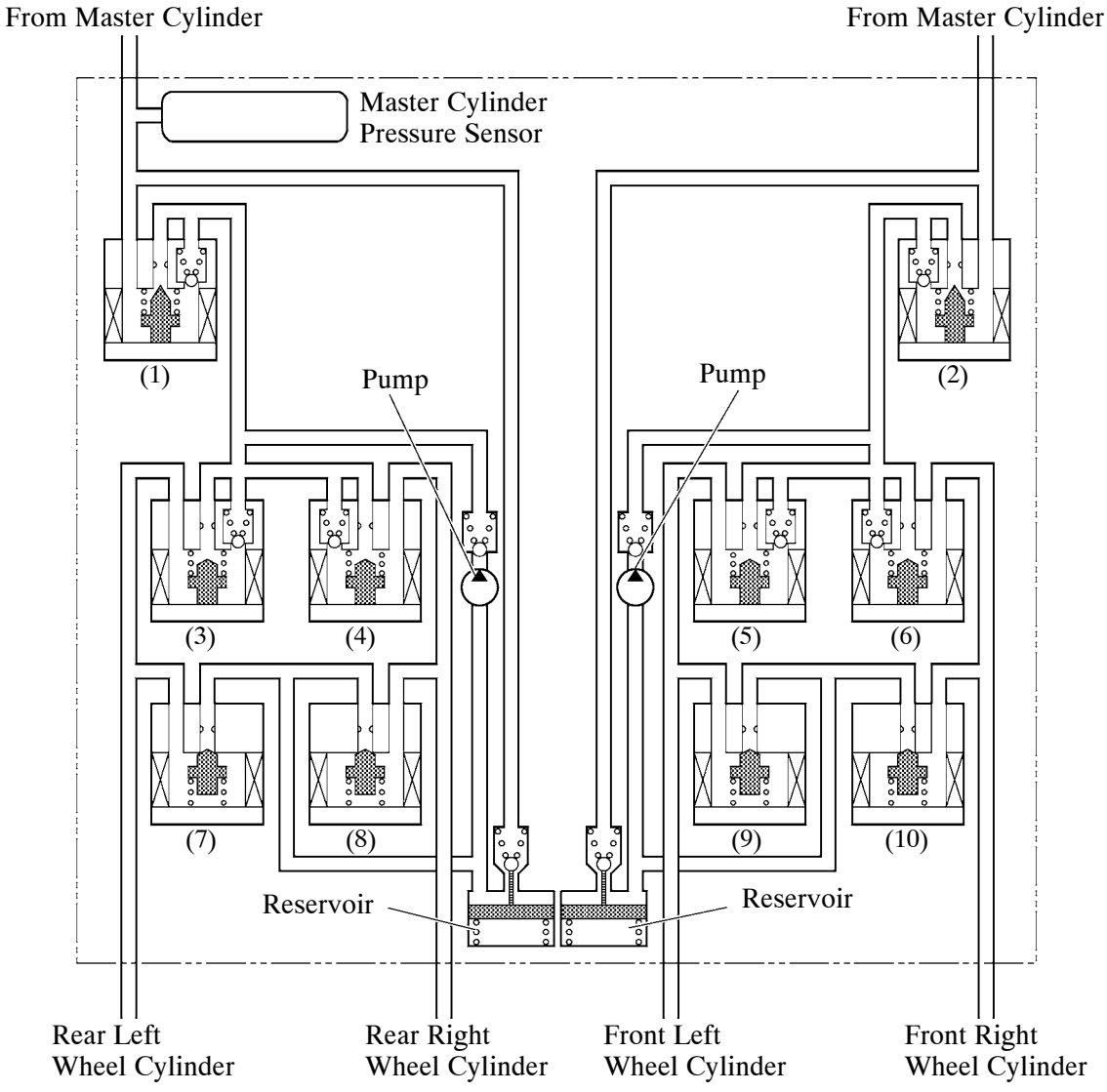
*2: When the vehicle is braking or the yaw rate is large, the VSC will operate even in the VSC OFF mode.(In this case, the engine output is not controlled.)

10. Brake Actuator

The brake actuator consists of an actuator portion, a pump motor and a skid control ECU.

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

▶ Hydraulic Circuit ◀



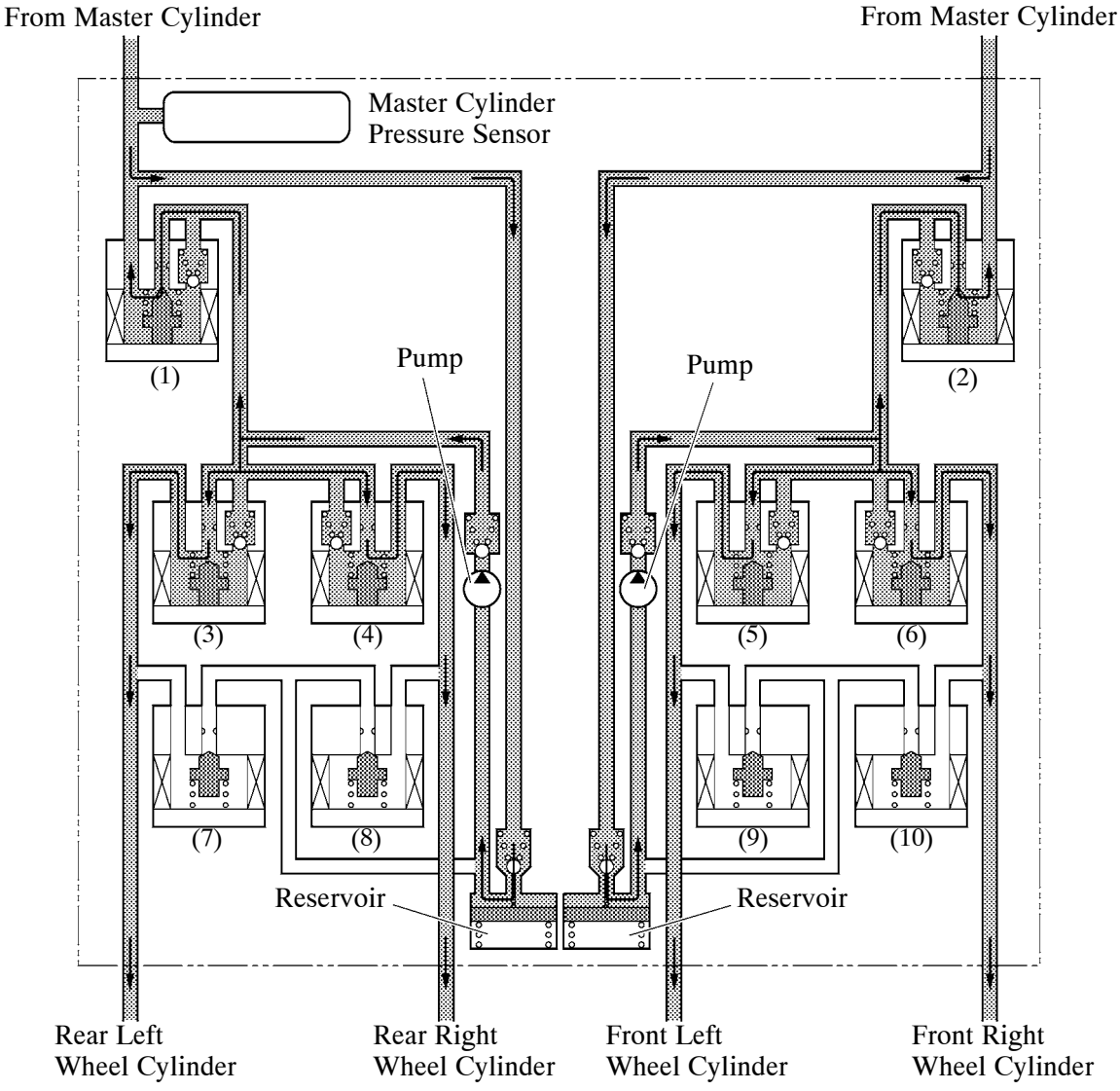
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11. System Operation

Normal Braking Operation

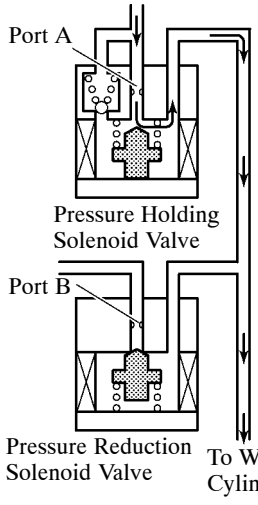
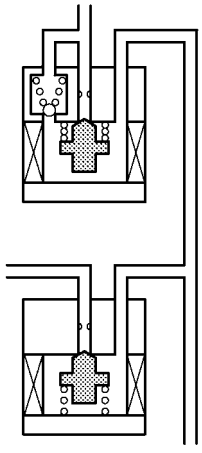
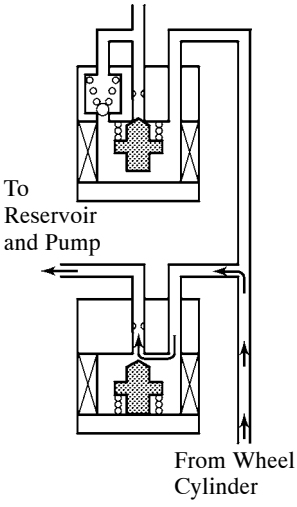
During normal braking, all solenoid valves are turned OFF.



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ABS and 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 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 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 Solenoid Valve (Port A)	OFF/Open	ON/Closed	ON/Closed
Pressure Reduction Solenoid Valve (Port B)	OFF/Closed	OFF/Closed	ON/Open
Pressure	Increases	Holds	Reduces

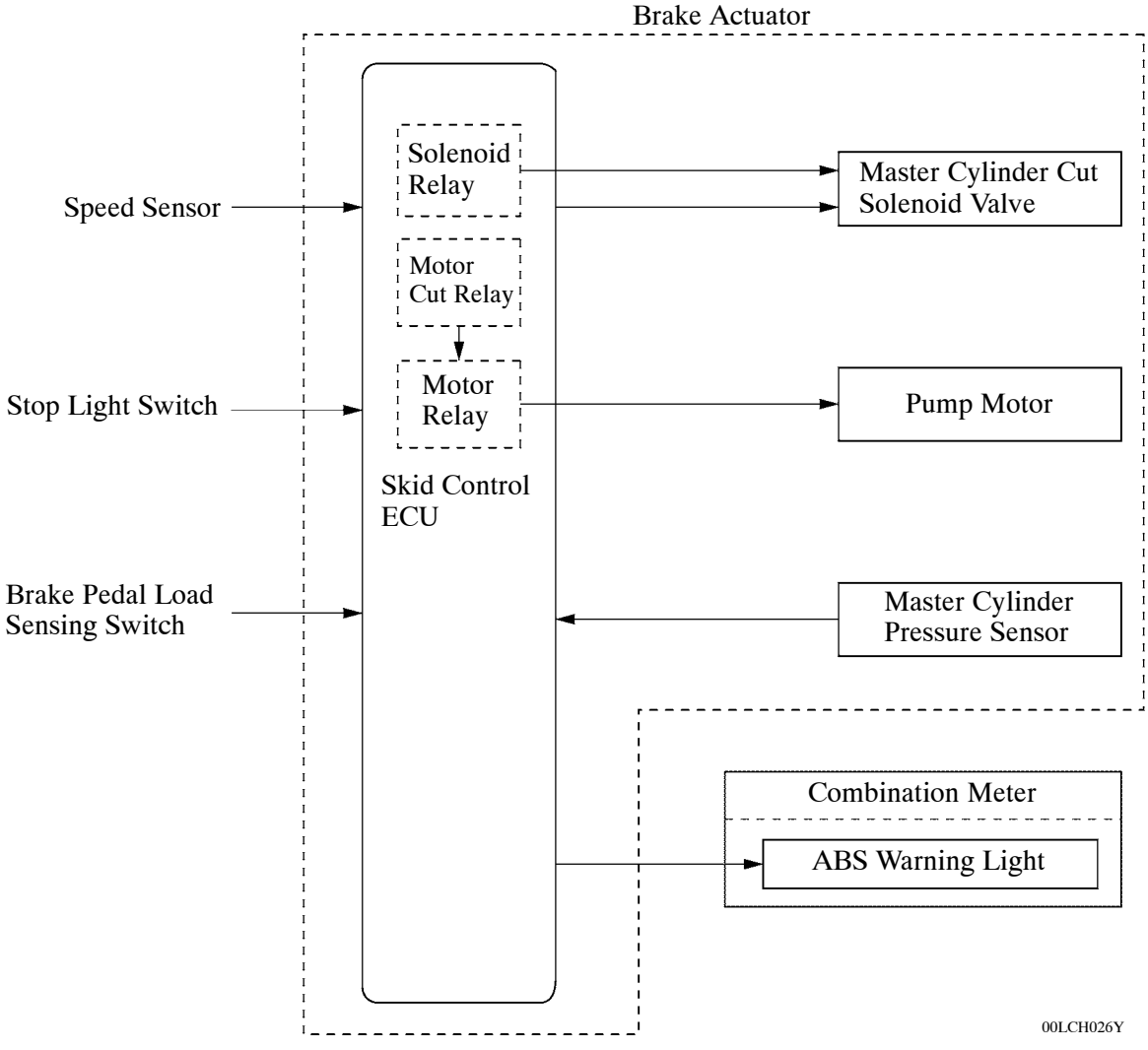
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Brake Assist Operation

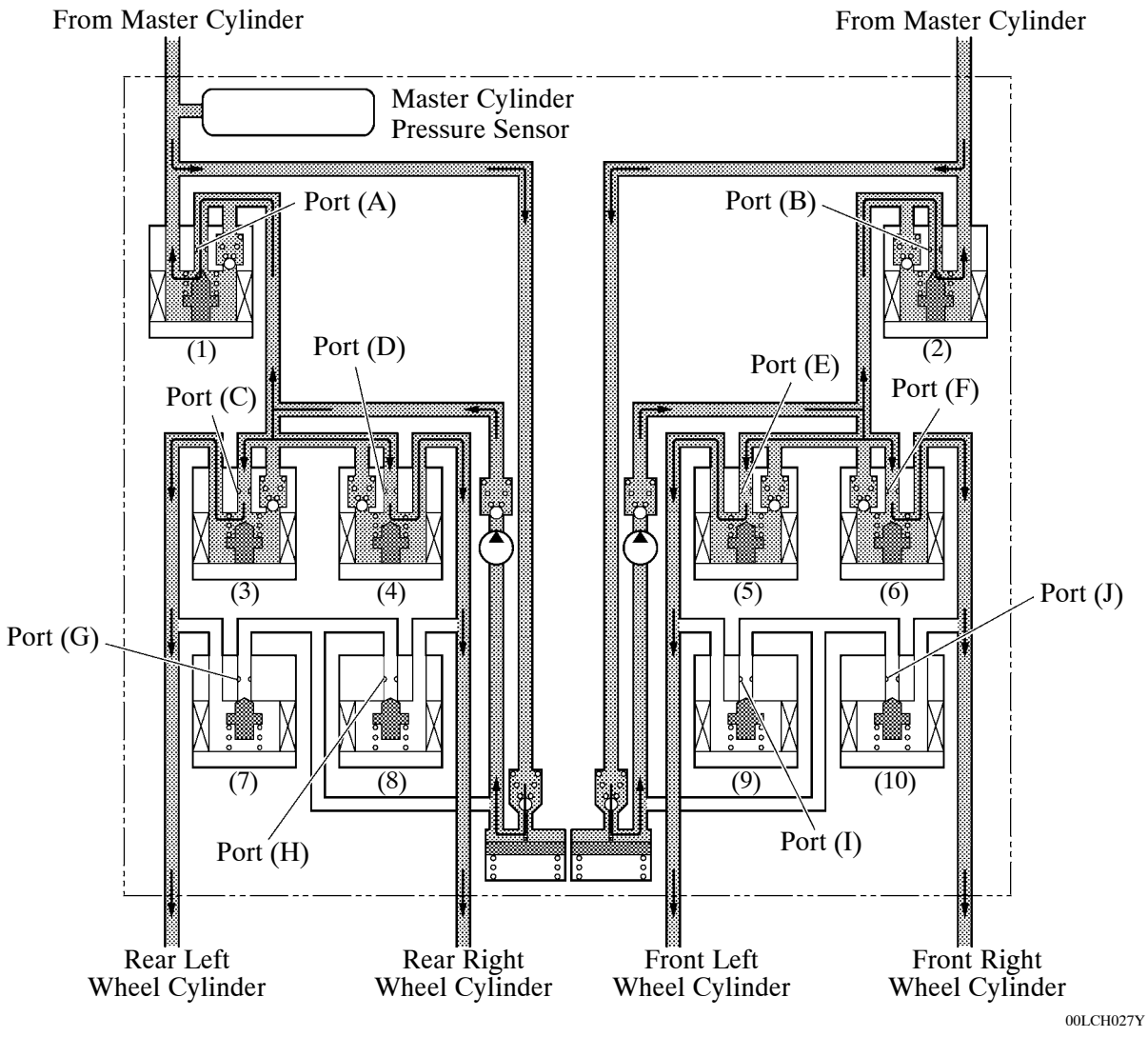
In the event of emergency braking, the skid control ECU detects the driver's intention based on the speed of the pressure increase in the master cylinder determined by the master cylinder pressure sensor signals. If the skid control ECU judges the need for additional brake assist, pressure is generated 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 brake load sensing switch and master cylinder pressure sensor signals.

▶ System Diagram ◀



▶ Brake Assist Operation ◀



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

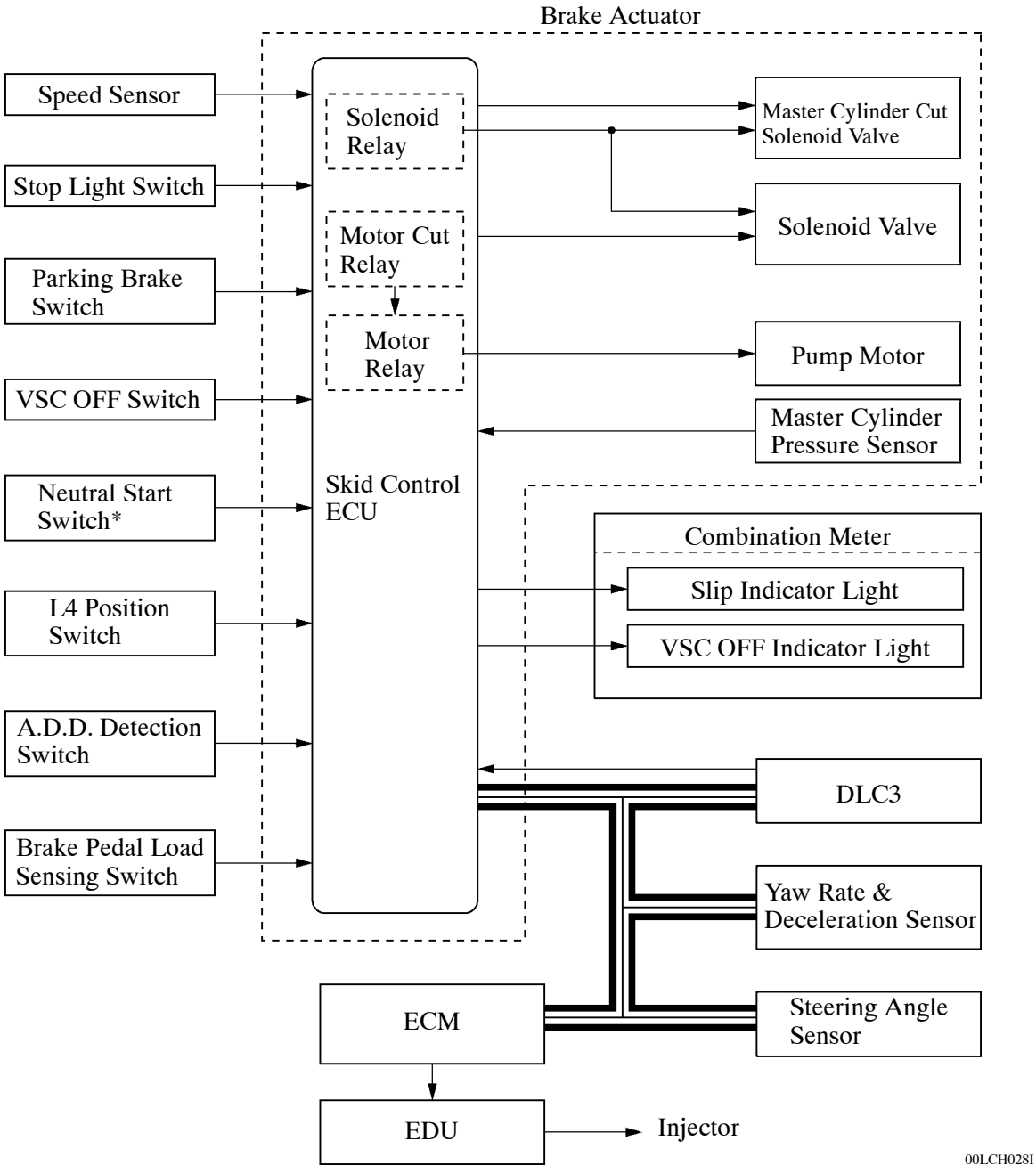
*: The solenoid valve controls the hydraulic pressure by cycling continually between “open” and “closed” according to the operating conditions.

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.

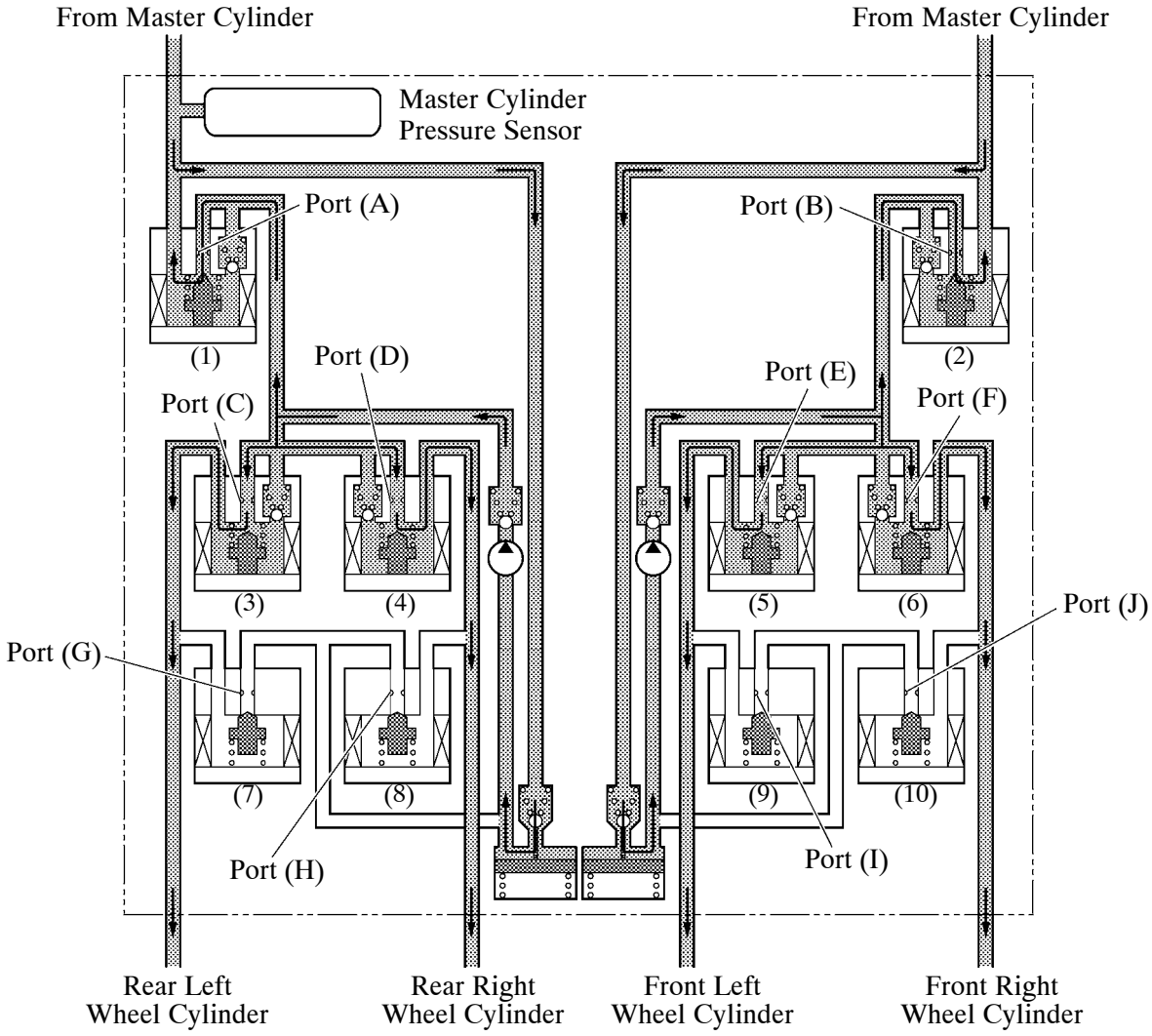
The diagram on the next page shows the hydraulic circuit in the pressure increase mode when the TRC is activated. The pressure holding solenoid valve and the pressure reduction solenoid valve are turned ON/OFF according to the ABS and EBD operation patterns described on page CH-129. When the TRC is activated, each solenoid valve operates as shown in the table on page CH-134.

▶ System Diagram ◀



*: Models with automatic transmission

▶ TRC Operation ◀



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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*	←	←
		(2)	Port (B)	OFF/Open	ON*	←	←
Front Brake	Pressure Holding Solenoid Valve	(5)	Port (E)	OFF/Open	←	ON/Closed	←
		(6)	Port (F)				
	Pressure Reduction Solenoid Valve	(9)	Port (I)	OFF/Closed	←	←	ON/Open
		(10)	Port (J)				
	Wheel Cylinder Pressure	Right		—	Increases	Holds	Reduces
		Left					
Rear Brake	Pressure Holding Solenoid Valve	(3)	Port (C)	OFF/Open	←	ON/Closed	←
		(4)	Port (D)				
	Pressure Reduction Solenoid Valve	(7)	Port (G)	OFF/Closed	←	←	ON/Open
		(8)	Port (H)				
	Wheel Cylinder Pressure	Right		—	Increases	Holds	Reduces
		Left					

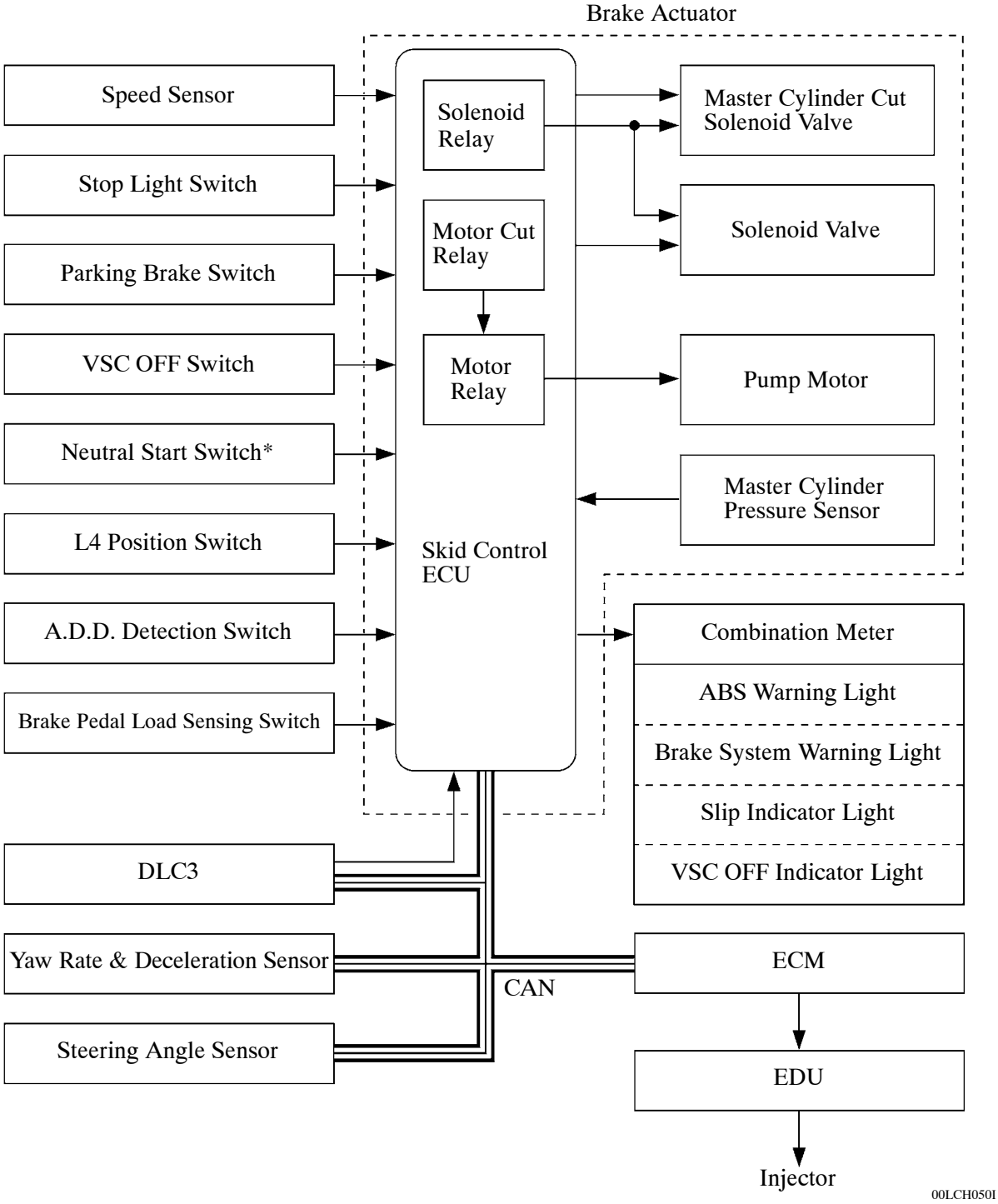
*: The solenoid valve controls the hydraulic pressure by cycling continually between “open” and “closed” according to the operating conditions.

VSC Operation

1) General

The VSC, by way of solenoid valves, controls the fluid pressure that is generated by the pump and applies it to the brake wheel cylinder of each wheel in the following 3 modes: pressure reduction, pressure holding, and pressure increase modes. As a result, the tendency of the vehicle to experience a front wheel skid or rear wheel skid is controlled.

▶ System Diagram ◀



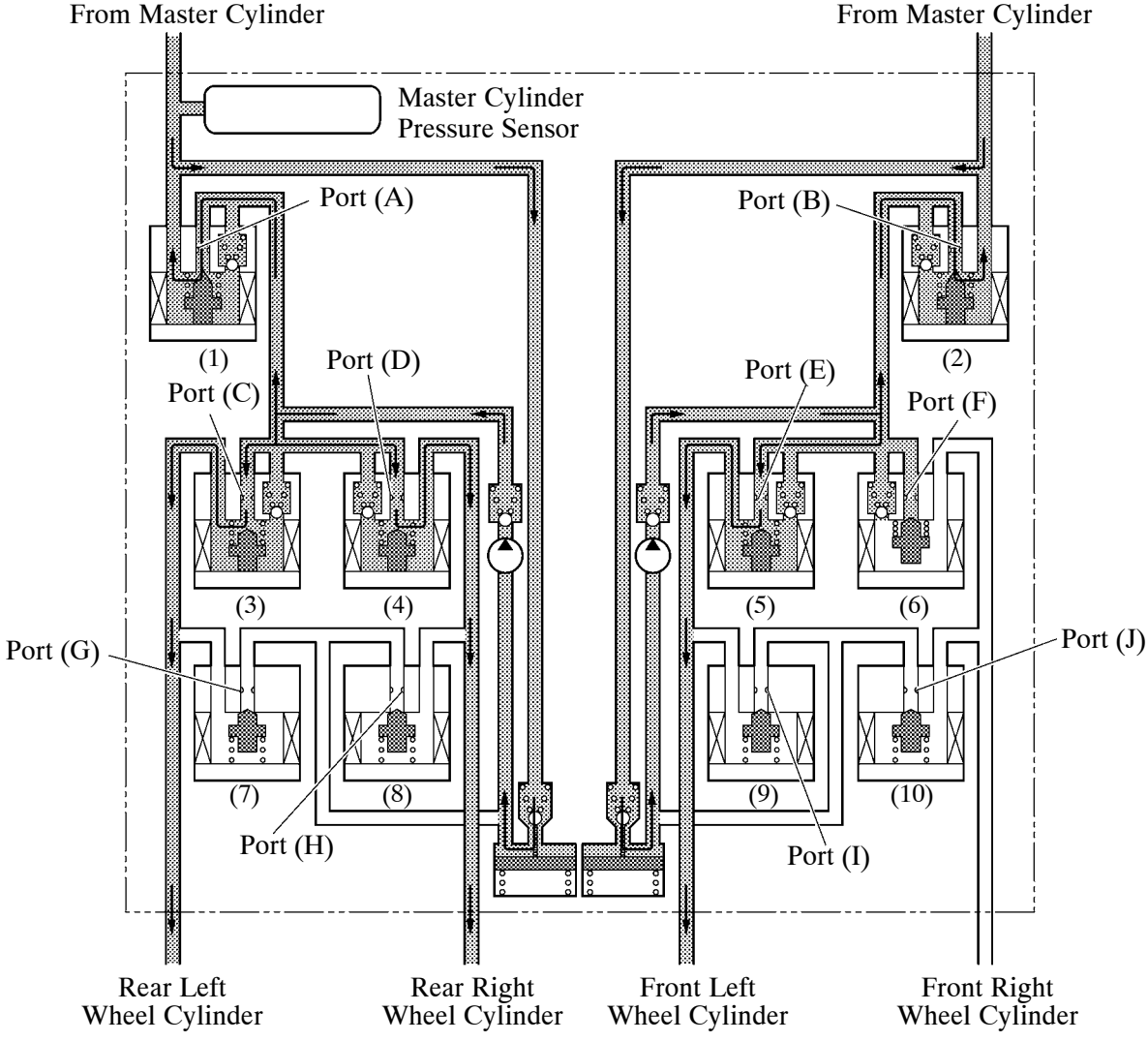
*: Models with automatic transmission

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2) Front Wheel Skid Restraining (Turning to the Right)

For front wheel skid restraining control, the brakes of the front wheel of the outer side of the turn and the rear wheels are 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 valve and the pressure reduction valve are turned ON/OFF according to the ABS with EBD operation pattern.



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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*	←	←
		(2)	Port (B)	OFF/Open	ON*	←	←
Front Brake	Pressure Holding Solenoid Valve	(5)	Port (E)	OFF/Open	←	ON/Closed	←
		(6)	Port (F)	OFF/Open	ON/Closed	←	←
	Pressure Reduction Solenoid Valve	(9)	Port (I)	OFF /Closed	←	←	ON/Open
		(10)	Port (J)	OFF /Closed	←	←	←
	Wheel Cylinder Pressure	Right		—	—	—	—
		Left		—	Increases	Holds	Reduces
Rear Brake	Pressure Holding Solenoid Valve	(3)	Port (C)	OFF/Open	←	ON/Closed	←
		(4)	Port (D)	OFF/Open	←	ON/Closed	←
	Pressure Reduction Solenoid Valve	(7)	Port (G)	OFF /Closed	←	←	ON/Open
		(8)	Port (H)	OFF /Closed	←	←	ON/Open
	Wheel Cylinder Pressure	Right		—	Increases	Holds	Reduces
		Left		—	Increases	Holds	Reduces

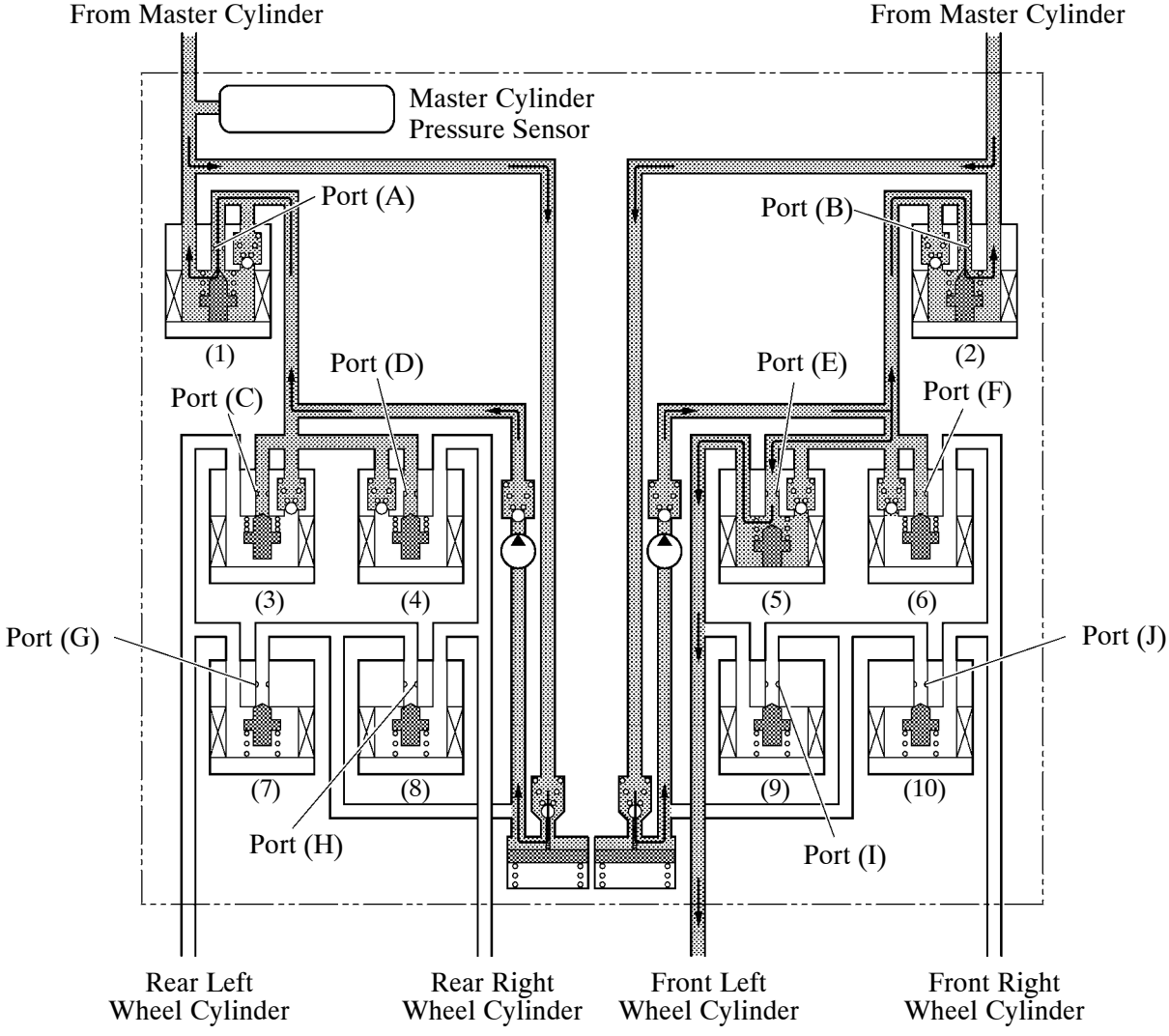
*: The solenoid valve controls the hydraulic pressure by cycling continually between “open” and “closed” according to the operating conditions.

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3) Rear Wheel Skid Restraining (Turning to the 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 patterns.



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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*	←	←
		(2)	Port (B)	OFF/Open	ON*	←	←
Front Brake	Pressure Holding Solenoid Valve	(5)	Port (E)	OFF/Open	←	ON/Closed	←
		(6)	Port (F)	OFF/Open	ON/Closed	←	←
	Pressure Reduction Solenoid Valve	(9)	Port (I)	OFF /Closed	←	←	ON/Open
		(10)	Port (J)	OFF /Closed	←	←	←
	Wheel Cylinder Pressure	Right		—	—	—	—
		Left		—	Increases	Holds	Reduces
Rear Brake	Pressure Holding Solenoid Valve	(3)	Port (C)	OFF/Open	ON/Closed	←	←
		(4)	Port (D)	OFF/Open	ON/Closed	←	←
	Pressure Reduction Solenoid Valve	(7)	Port (G)	OFF /Closed	←	←	←
		(8)	Port (H)	OFF /Closed	←	←	←
	Wheel Cylinder Pressure	Right		—	—	—	—
		Left		—	—	—	—

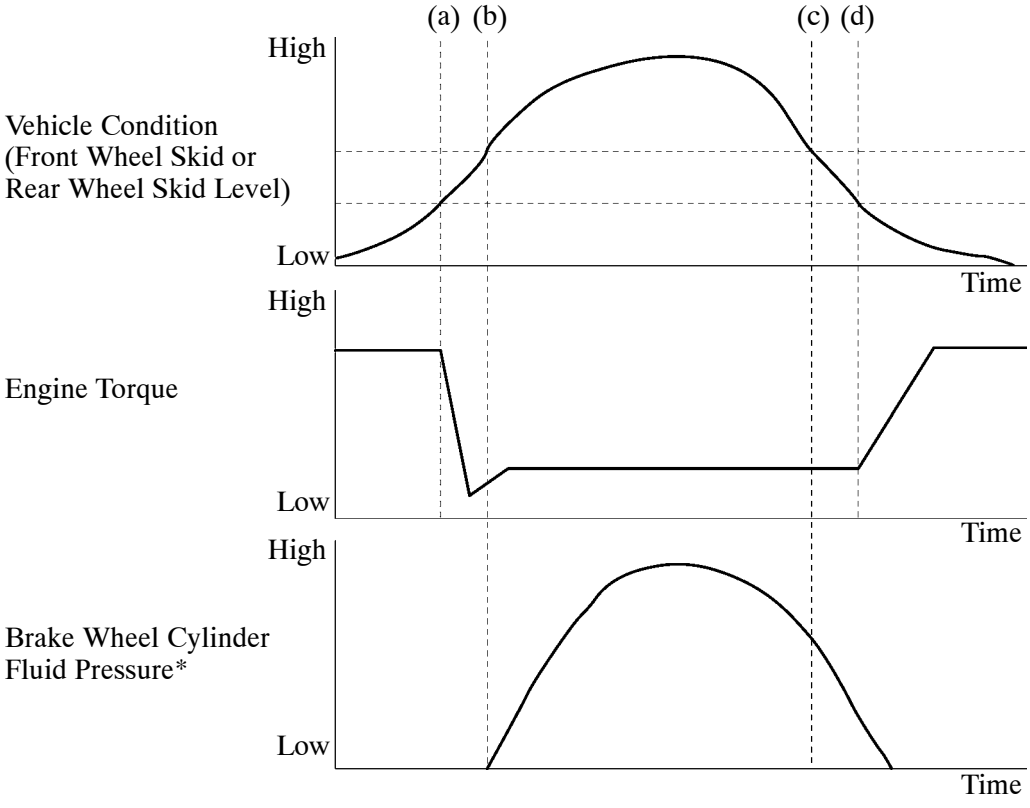
*: The solenoid valve controls the hydraulic pressure by cycling continually between “open” and “closed” according to the operating conditions.

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12. 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 regulates the engine output.

(a): Start of Engine Control
(b): Start of Brake Control
(c): Brake Control Completed
(d): Engine Control Completed



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

13. Initial Check

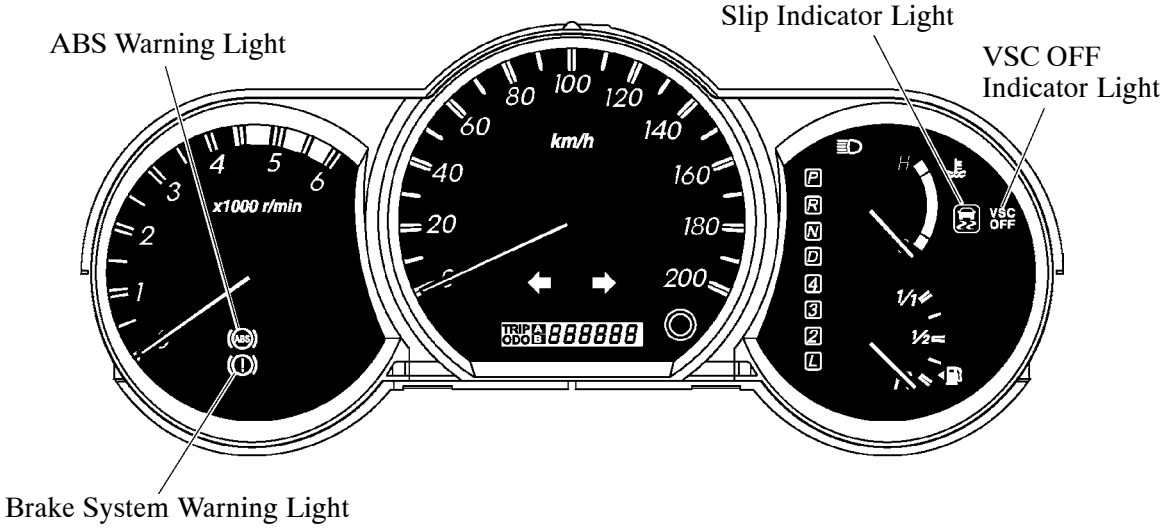
Each time the ignition switch is turned ON, and the vehicle reaches a speed of approximately 6 km/h (4 mph) or more, the skid control ECU performs an initial check. The functions of each solenoid valve and pump motor in the brake actuator are checked in sequence.

14. 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 DTC (Diagnostic Trouble Code) in memory. This DTC can be read by the following two 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 Hilux Repair Manual.

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15. 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, the brake system is operated as long as possible even if the ABS is prohibited. If EBD control becomes impossible, the ABS and brake system warning lights illuminate to inform the driver of this.
- 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.