■BRAKE CONTROL SYSTEM

1. General

The ’06 RAV4 brake control system (ABS with EBD, Brake Assist, TRAC, VSC, Auto LSD, Hill-start Assist Control and DAC) has the following functions:

Function	Outline	Drive Type	
		2WD	4WD
ABS (Anti-lock Brake System)	The ABS helps prevent the wheels from locking when the brake is applied firmly or applied on a slippery surface.	○	○
EBD (Electronic Brake force Distribution)	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.	○	○
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.	○	○
TRAC (Traction Control)	The TRAC helps prevent the drive wheels from slipping if the driver depresses 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.	○	○
Cooperative Control with EPS	Effects cooperative control with the EPS ECU in order to provide steering assist in accordance with the operating conditions of the vehicle.	○	○
Cooperative Control with 4WD System	Effects cooperative control with the 4WD ECU in order to control the drive torque of the front and rear wheels in accordance with the operating conditions of the vehicle.	—	○
Auto LSD*1 (Limited Slip Differential)	Auto LSD uses a TRAC to achieve LSD capability. It allows for greater traction control than the TRAC, ensuring startability and traction on sand or other road surfaces that present high degrees of drive resistance.	○	—
Hill-start Assist Control*2,3	When starting uphill, this control maintains the brake hydraulic pressure to the four wheels, in order to momentarily prevent the vehicle from descending backward.	○	○
DAC*2,3 (Downhill Assist Control)	This control is used when driving downhill on a sharp slope on which the engine brake alone will not adequately decelerate the vehicle. The driver can operate the DAC switch while the shift lever is in the L or R position, in order to automatically control the brake hydraulic pressure to the four wheels.	○	○

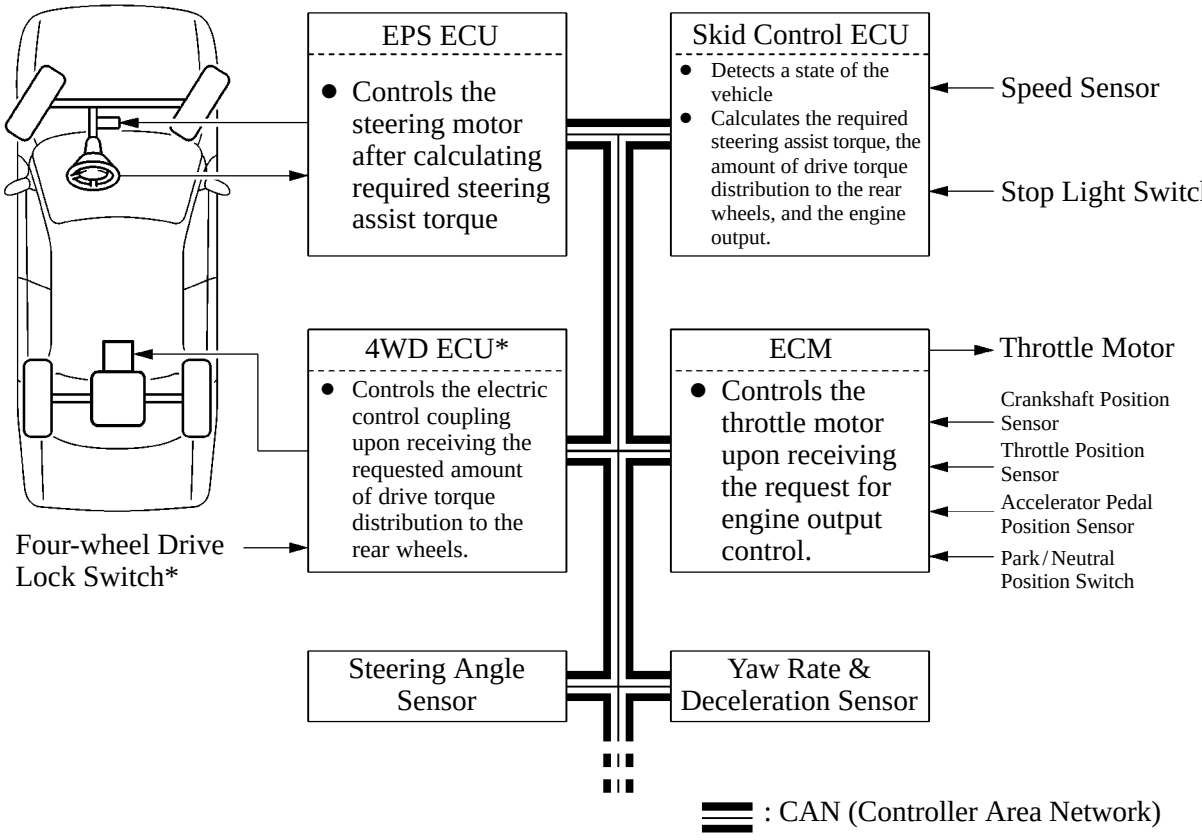
*1: Only for 2WD Models

*2: Standard Equipment on 2GR-FE Engine Models

*3: Optional Equipment on Standard and Limited Grades for 2AZ-FE Engine Models with Rear No. 2 Seat

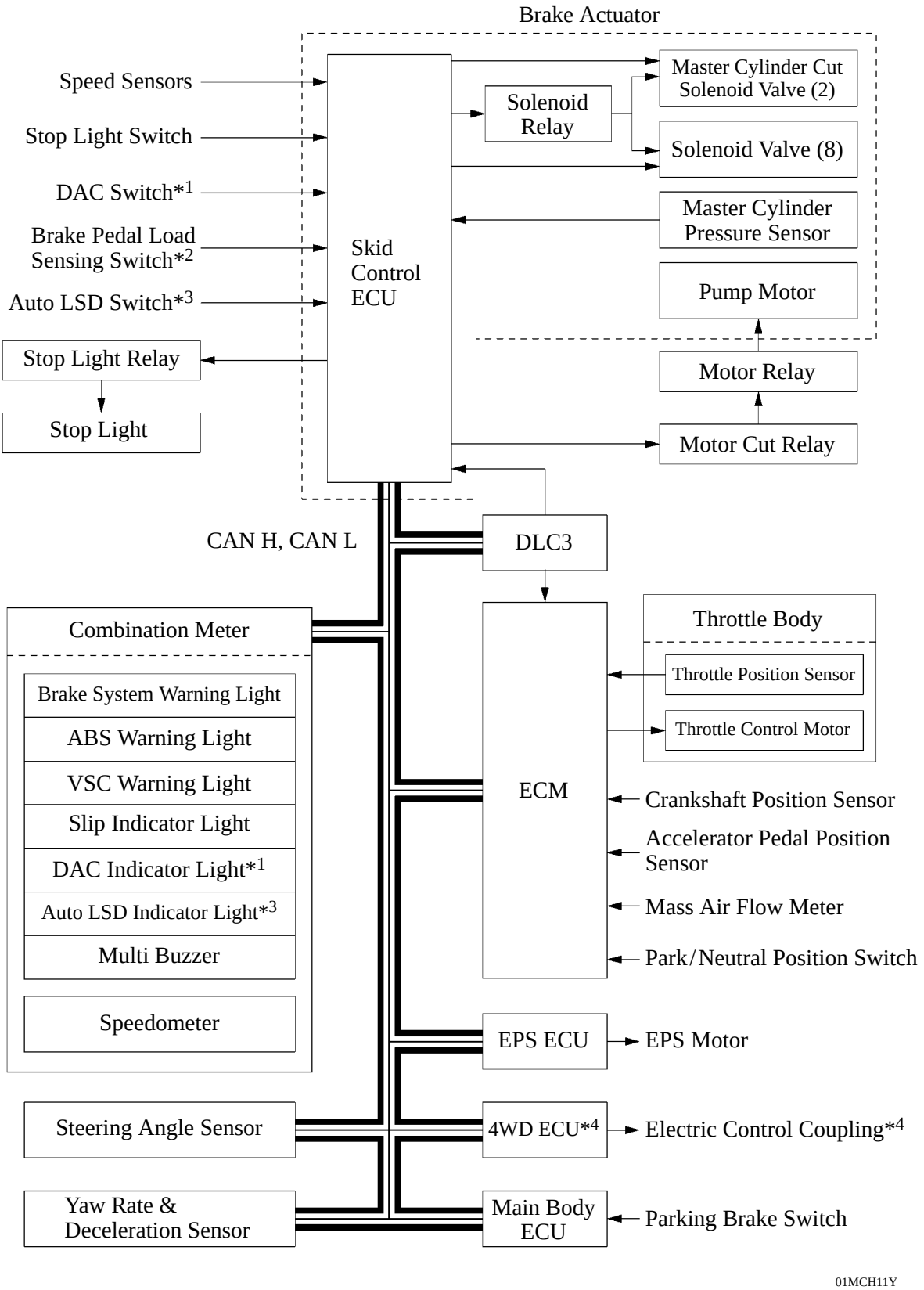
2. Enhanced VSC System

In the past, the brake control system (ABS, TRAC, VSC) and the EPS were controlled individually. In contrast, the ’06 RAV4 uses a new Enhanced VSC system. This system uses a cooperative control function that effects integrated control of the brake control system and the EPS in accordance with driving conditions. Thus, it improves the dynamic performance of the vehicle to “run, turn, and stop” and ensures excellent driving stability and drivability. On the 4WD models, this system effects cooperative control with the 4WD system to improve acceleration performance during cornering.



*: Only for 4WD Models

3. System Diagram



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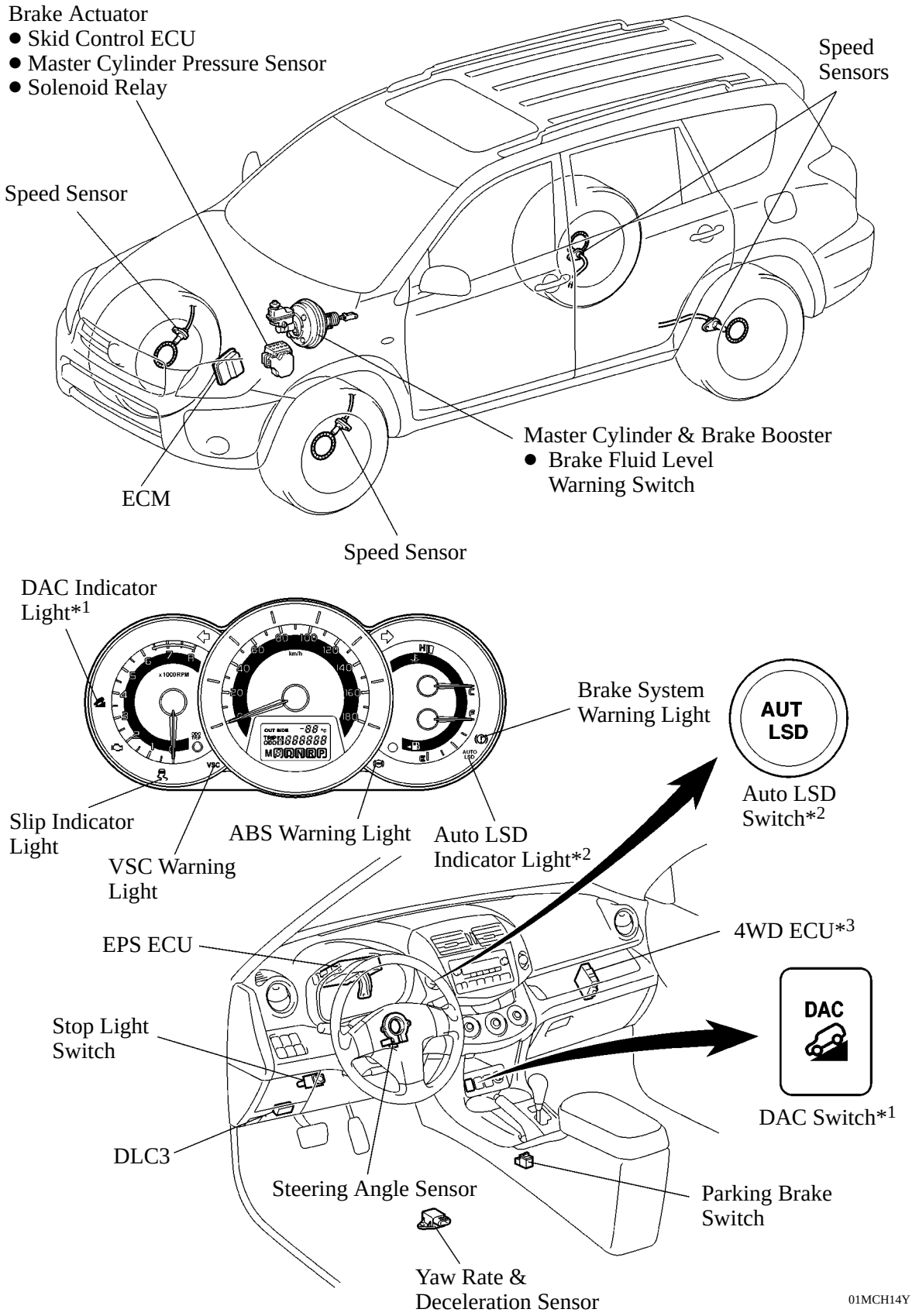
*1: Only for Models with DAC Function
*2: Only for Models with 16 in. Ventilated Disc
*3: Only for 2WD Models
*4: Only for 4WD Models

4. Layout of Main Components



*1: Only for Models with DAC Function *2: Only for 2WD Models *3: Only for 4WD Models

5. 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 function.
	VSC Warning Light	Lights up to alert the driver when the skid control ECU detects the malfunction in the TRAC, VSC, Hill-start Assist Control or DAC function.
	Brake System Warning Light	● Lights up together with ABS warning light to alert the driver when the skid control ECU detects the malfunction not only in the ABS but also in the EBD. ● Lights up to inform the driver when the parking brake lever is pulled up. ● Lights up to alert the driver when the brake fluid level is low.
	Slip Indicator Light	Blinks to inform the driver when the TRAC, VSC, Auto LSD Hill-start Assist Control or DAC is operated.
	DAC Indicator Light*1	Lights up to inform the driver when DAC operation is possible.
	Auto LSD Indicator Light*2	Lights up to inform the driver when Auto LSD operation is possible.
	Multi Buzzer	Located in the combination meter, the buzzer emits a warning sound to inform the driver during VSC operation, Hill-start Assist Control operation starting, etc.
Brake Actuator		Changes the fluid path based on the signals from the skid control ECU during the operation of the brake control system functions, in order to control the fluid pressure that is applied to the wheel cylinders.
	Master Cylinder Pressure Sensor	Assembled in the brake actuator, detects the master cylinder pressure.
	Solenoid Relay	Supply power to the solenoid valves.
	Skid Control ECU	Judges the vehicle driving condition based on the signals from each sensor, and sends the brake control signals to the brake actuator.
Stop Light Switch		Detects the brake pedal depressing signal.
DAC Switch*1		Allows the driver to turn DAC ON and OFF.
Auto LSD Switch*2		Allows the driver to turn Auto LSD ON and OFF.
Brake Pedal Load Sensing Switch*3		Detects the brake pedal load.
Parking Brake Switch		Detects when the parking brake lever is pulled up.
Brake Fluid Level Warning Switch		Detects the brake fluid level.
Speed Sensor		Detect the wheel speed of each of 4 wheels.

*1: Only for Models with DAC Function
*2: Only for 2WD Models
*3: Only for Models with 16 in. Ventilated Disc

(Continued)

Steering Angle Sensor	Detects the direction and angle of the steering wheel.
Yaw Rate & Deceleration Sensor	● Detects the vehicle's yaw rate. ● Detects the vehicle's longitudinal and lateral acceleration and deceleration.
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.
ECM	● Sends the throttle position signal, accelerator pedal position signal, engine speed signal, etc., to the skid control ECU. ● Based on the signals receives from the skid control ECU, controls the engine output.
EPS ECU	Operates cooperatively with the skid control ECU to control the steering assist torque.
4WD ECU*1	Operates cooperatively with the skid control ECU to control the torque distribution between the front and rear wheels.

*1: Only for 4WD Models

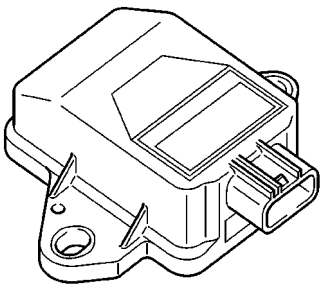
Yaw Rate & Deceleration Sensor

1) Yaw Rate Sensor

A yaw rate sensor has been provided under the driver seat. This sensor detects the vehicle's yaw rate.

2) Deceleration Sensor

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



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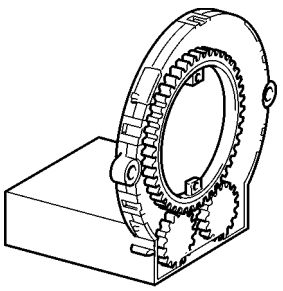
Steering Angle Sensor

This steering angle sensor detects the steering direction and angle, and sends this signal to the skid control ECU.



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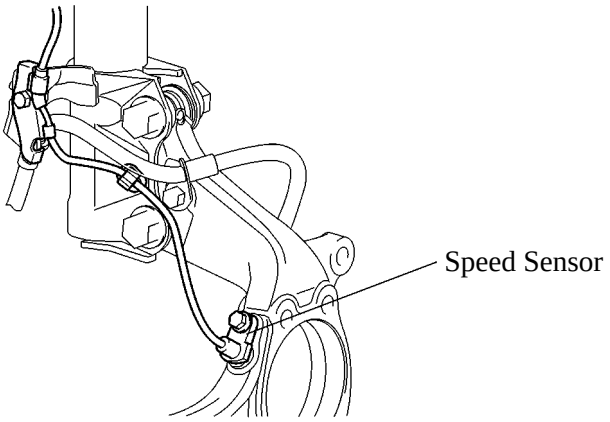
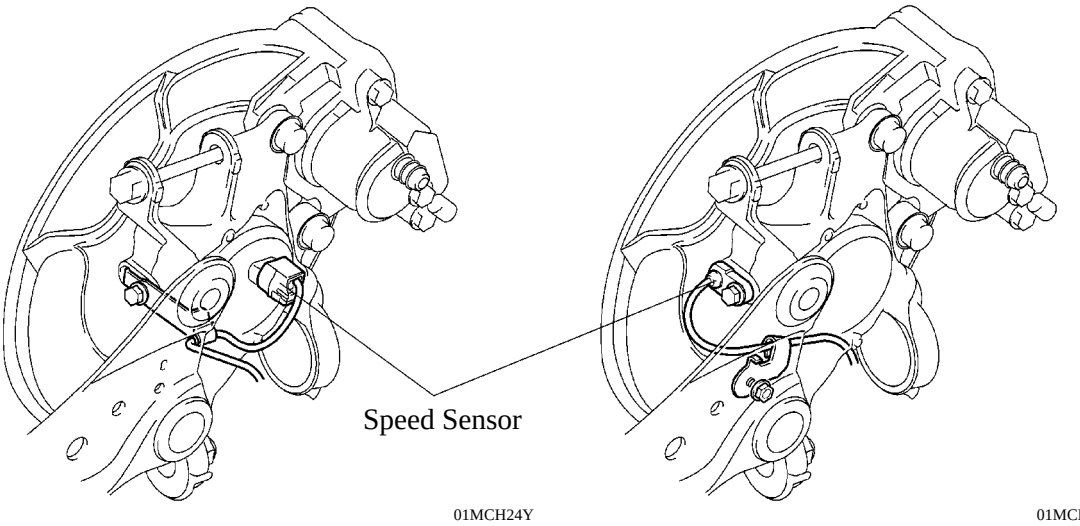
Speed Sensor

1) General

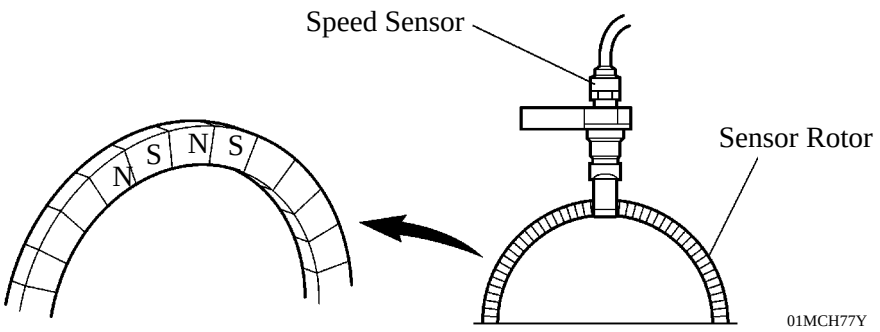
- An active type speed sensor is used. This sensor contains a sensor IC, which consists of two MREs (Magnetic Resistance Elements).
- The sensor rotor, which consists of N and S poles that are arranged in a circle, is integrated with the hub bearing inner race.



Front Axle



Rear Axle (2WD Model) **Rear Axle (4WD Model)**

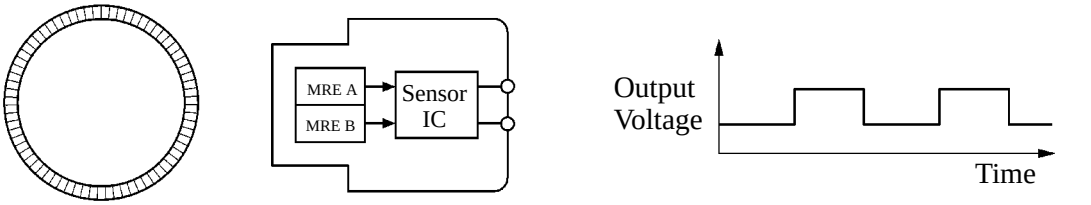


N and S Poles Arrangement

2) Operation

- Along with the rotational movement of the magnetic rotor, the N and S poles of the magnetic rotor pass alternately near the sensing portion of the speed sensor. This speed sensor outputs magnetic flux as a current value. The skid control ECU detects the changes in the output current to determine the wheel speed.
- Unlike the passive type speed sensors used on conventional models that output analog pulses, the active type speed sensor outputs digital pulses. Therefore, it can start detecting vehicle speeds at approximately 0 km/h.

▶ Active Type Speed Sensor ◀



Sensor Rotor (Hub Bearing Inner Race)

Forward and Backward

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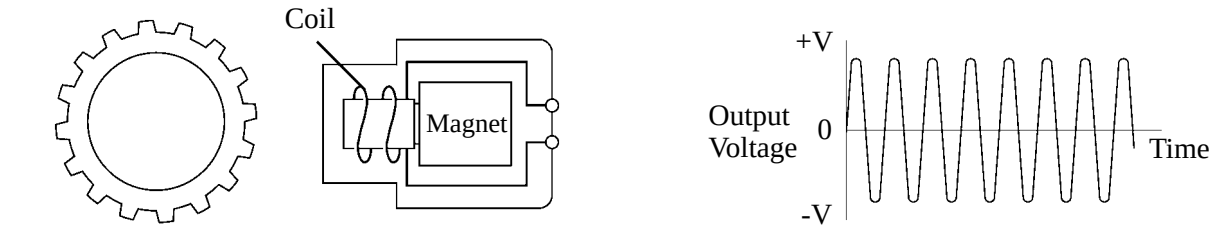
▶ Passive Type Speed Sensor ◀



Sensor Rotor (Drive Shaft or Axle Shaft)

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Forward and Backward

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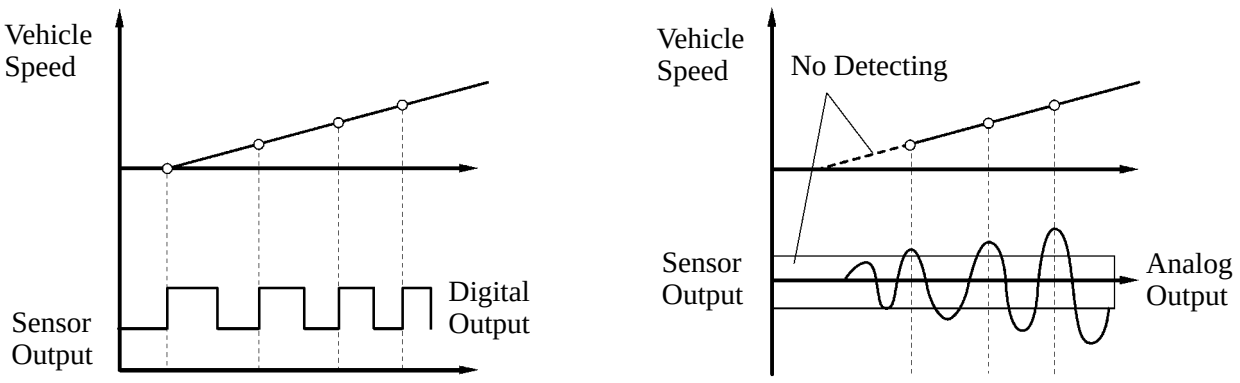
▶ Comparison between Active Type and Passive Type Output Waveform Image ◀



Active Type

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Passive Type

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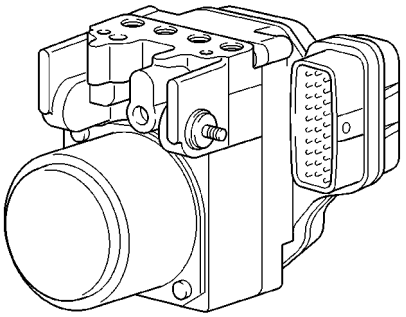
Brake Actuator

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

- The actuator portion consists of 10 solenoid valves, 2 pumps, 2 reservoirs, and 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)].



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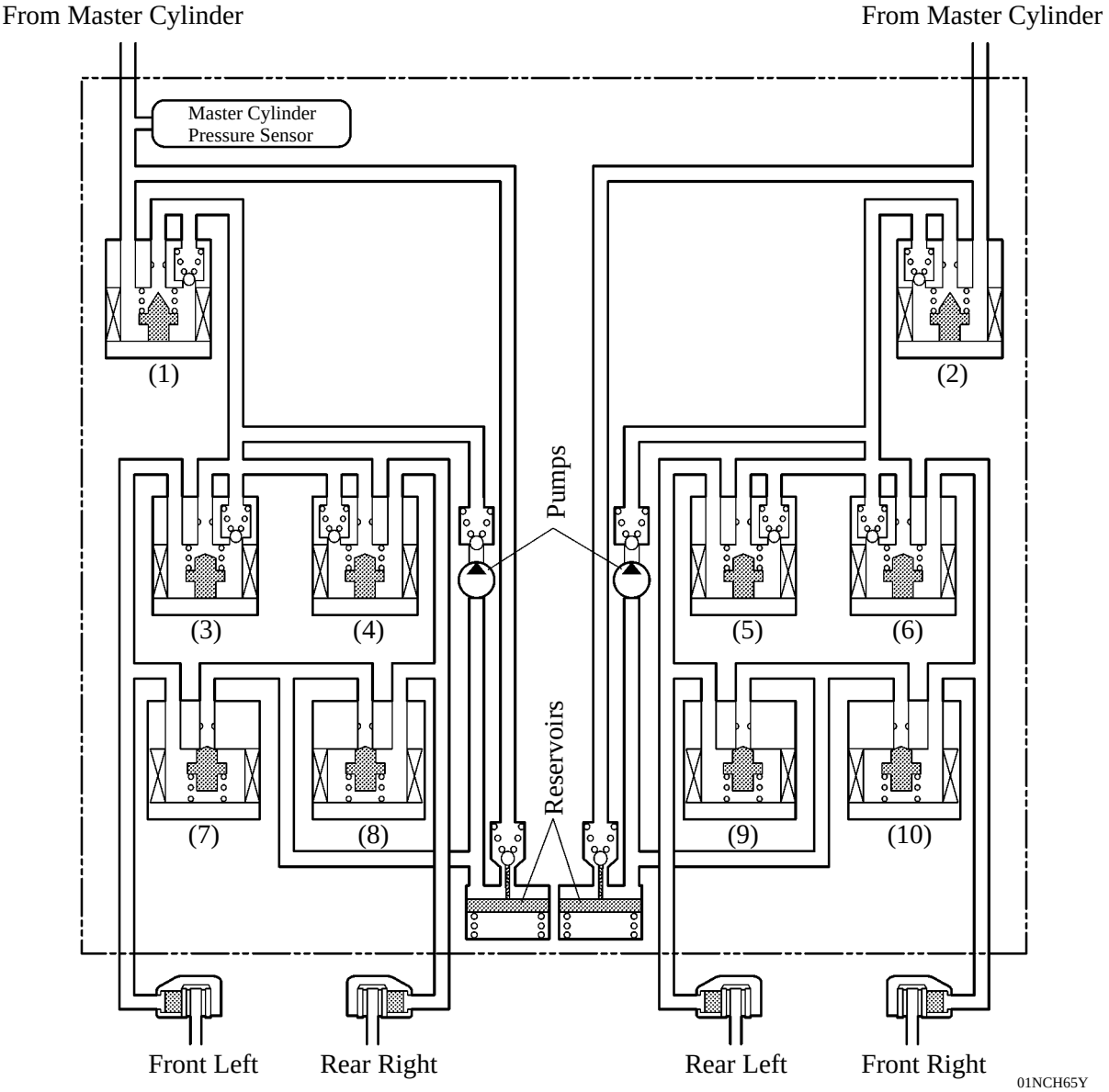
▶ Hydraulic Circuit ◀



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6. ABS with EBD Function

Outline of EBD

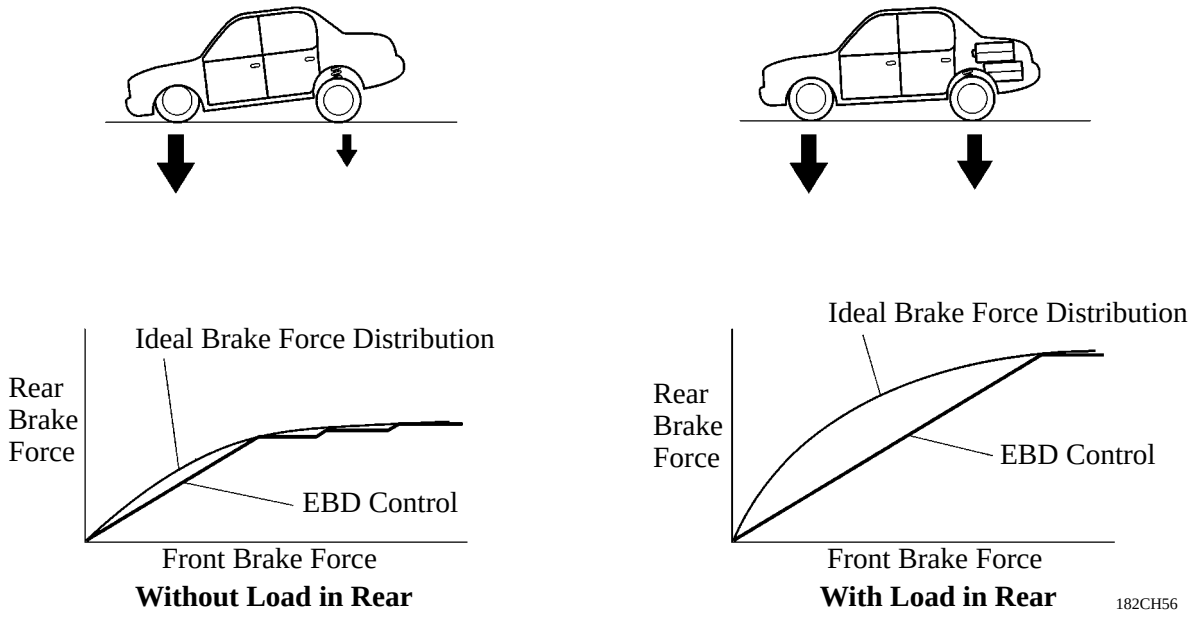
1) General

The distribution of the brake force, which was performed mechanically in the past, is now performed under electrical control of the skid control ECU, which controls the brake force in accordance with the vehicle's driving conditions.

2) Front/Rear Wheels Brake Force Distribution

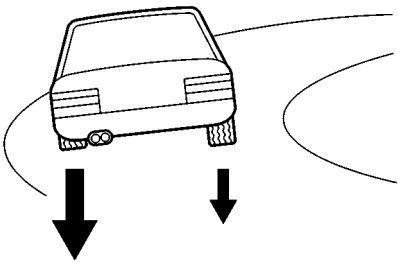
If the brakes are applied while the vehicle is moving straight forward, the transfer of the load reduces the weight that is applied to the rear wheels. The skid control ECU determines this condition by way of the signals from the yaw rate & deceleration sensor, and the brake actuator regulates the distribution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

▶ EBD Control Concept ◀



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

When the brakes are applied while the vehicle is cornering, the load that is applied to the inner wheel decreases as the load to the outer wheel 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 wheel and outer wheel.

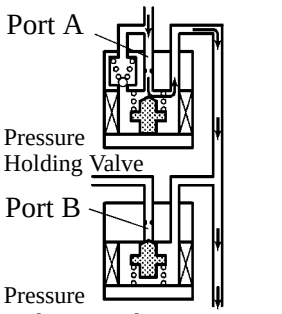
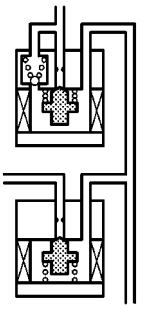
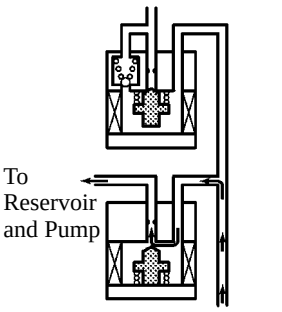


Normal Braking Operation

During normal braking, all solenoid valves are remained OFF.

ABS with EBD Operation

Based on the signals received from the 4 speed sensors, the skid control ECU calculates each wheel speed and deceleration, and checks wheel slipping conditions. According to the slipping condition, the skid control ECU controls the pressure holding valve and pressure reduction valve in order to adjust the fluid pressure of the each wheel cylinder in the following 3 modes: pressure reduction, pressure holding, and pressure increase modes.

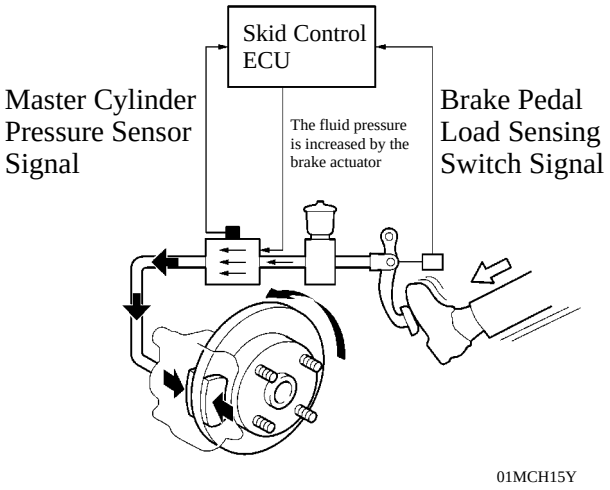
Not Activated	Normal Braking	—	—
Activated	Increase Mode	Holding Mode	Reduction Mode
Hydraulic Circuit			
Pressure Holding Valve (Port A)	OFF (Open)	ON (Close)	←
Pressure Reduction Valve (Port B)	OFF (Close)	←	ON (Open)
Wheel Cylinder Pressure	Increase	Hold	Reduce

7. Brake Assist Function

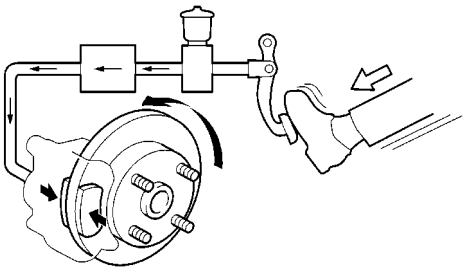
Outline of Brake Assist

- 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 on 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 the emergency braking, the system 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 emergency braking is applied ◀

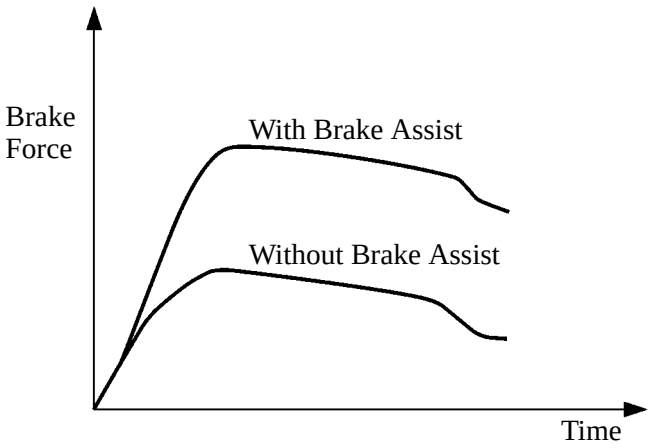


With Brake Assist



Without Brake Assist*

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



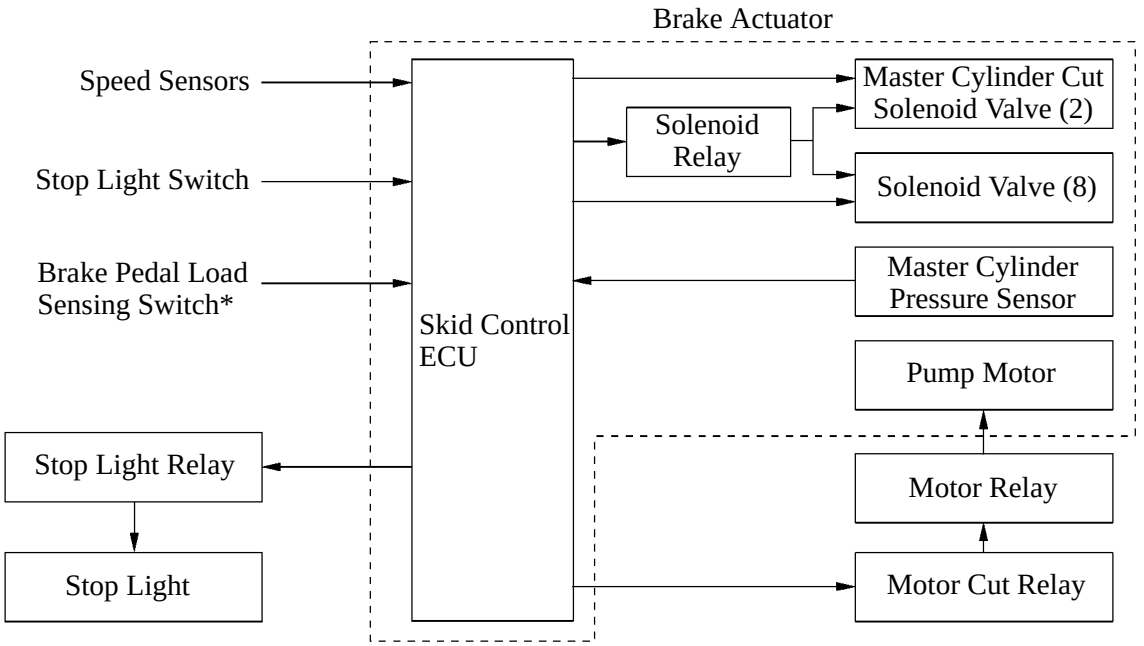
Brake Assist Operation

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 signal. 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 wheel cylinder to apply a greater fluid pressure than the master cylinder. Also in the following cases, the skid control ECU provides brake assist.

- In the event of a brake booster failure, the skid control ECU detects the failure based on the data from the brake load sensing switch and master cylinder pressure sensor.

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

▶ System Diagram ◀



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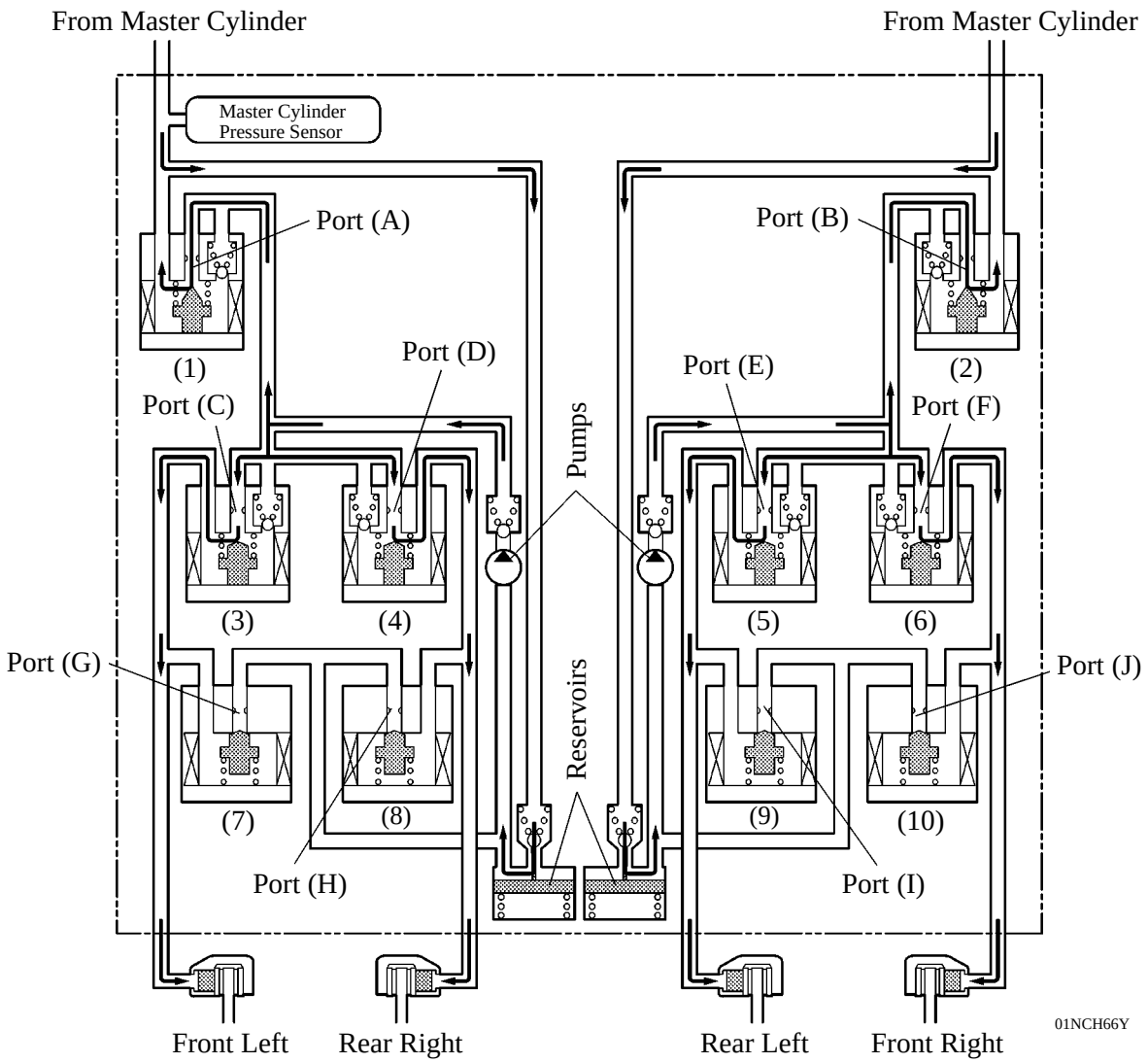
*: Only for Models with 16 in. Ventilated Disc

▶ Brake Assist Operation ◀



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

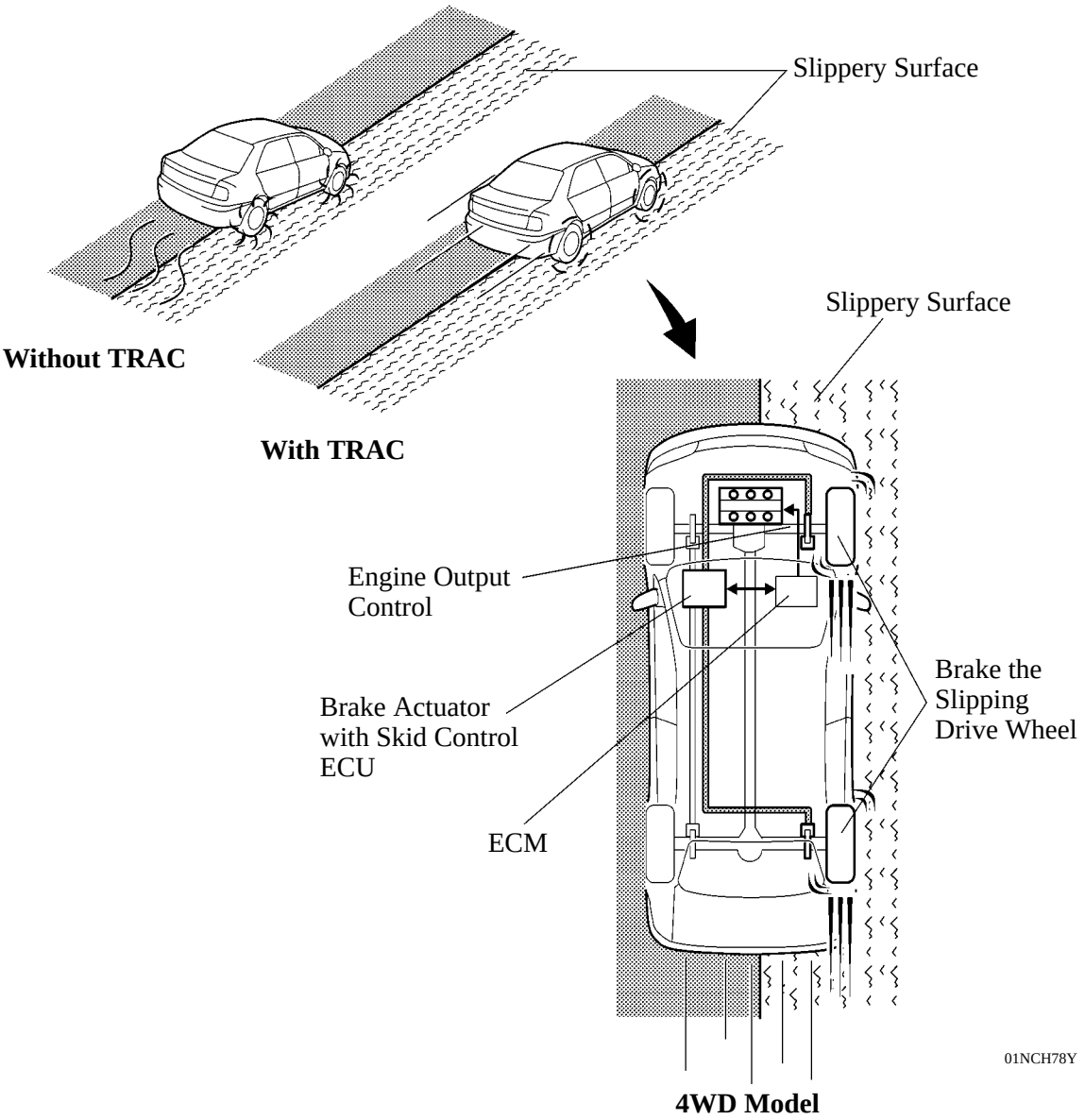
*: The solenoid valve controls the hydraulic pressure between “open” and “close” according to the operating condition by adjusting continually.

8. TRAC Function

Outline of TRAC

- If the driver depresses the accelerator pedal aggressively when starting off or 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 engine output control, the TRAC helps minimize the slippage of the drive wheels, thus generating the drive force that is appropriate for the road surface conditions.
- For example, a comparison may be made between two vehicles, one with the TRAC and the other without. In the vehicle without the TRAC, if the accelerator pedal is operated 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 could become unstable.
  However, in the vehicle with the TRAC, the skid control ECU instantly determines the state of the vehicle and operates the brake actuator in order to apply to the slipping drive wheel. Furthermore, the ECM receives the signals from the skid control ECU and regulates the engine output. Thus, the function can constantly maintain a stable vehicle posture.

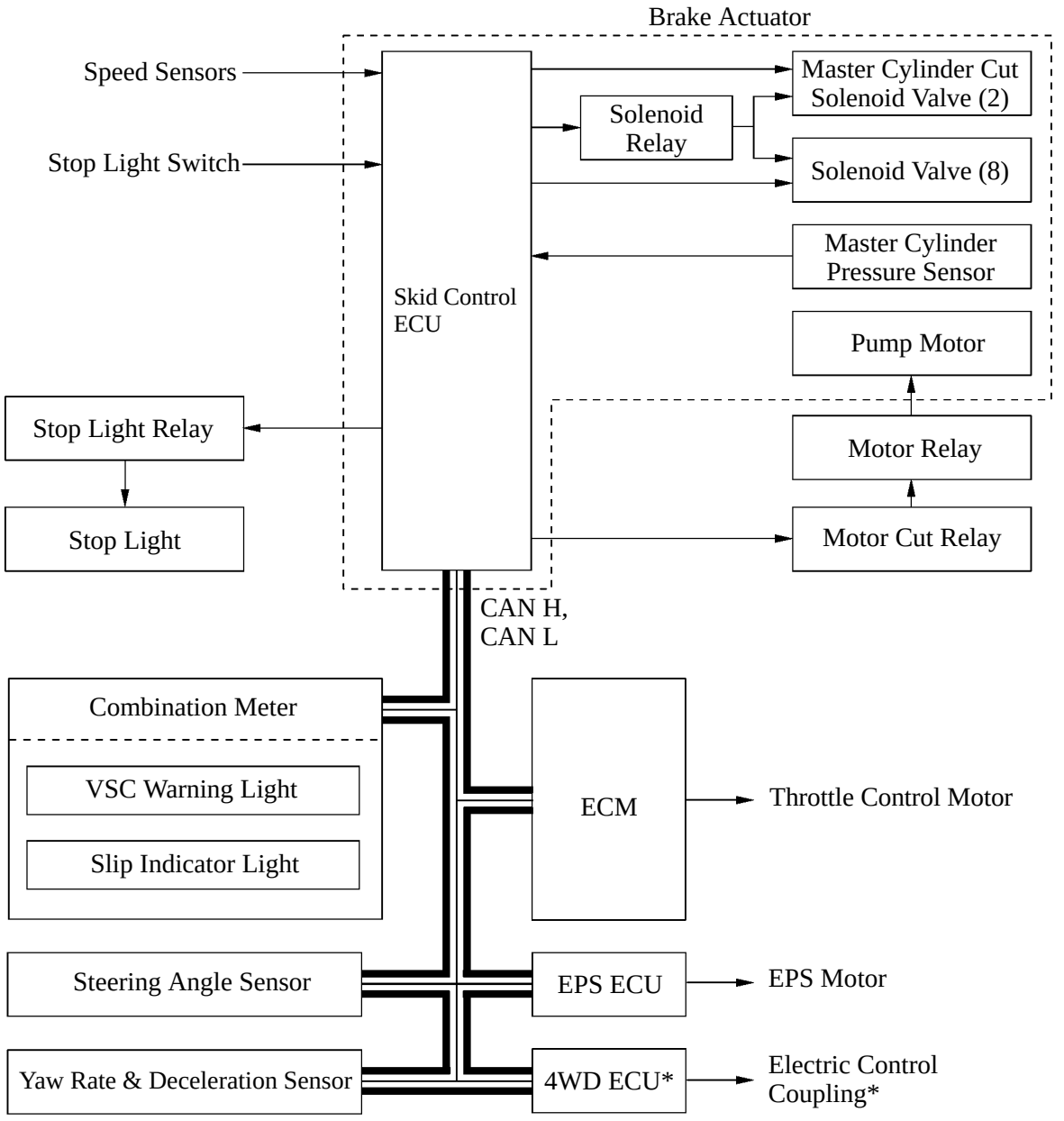
▶ Driving condition on road with different surface friction characteristics ◀



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

▶ System Diagram ◀



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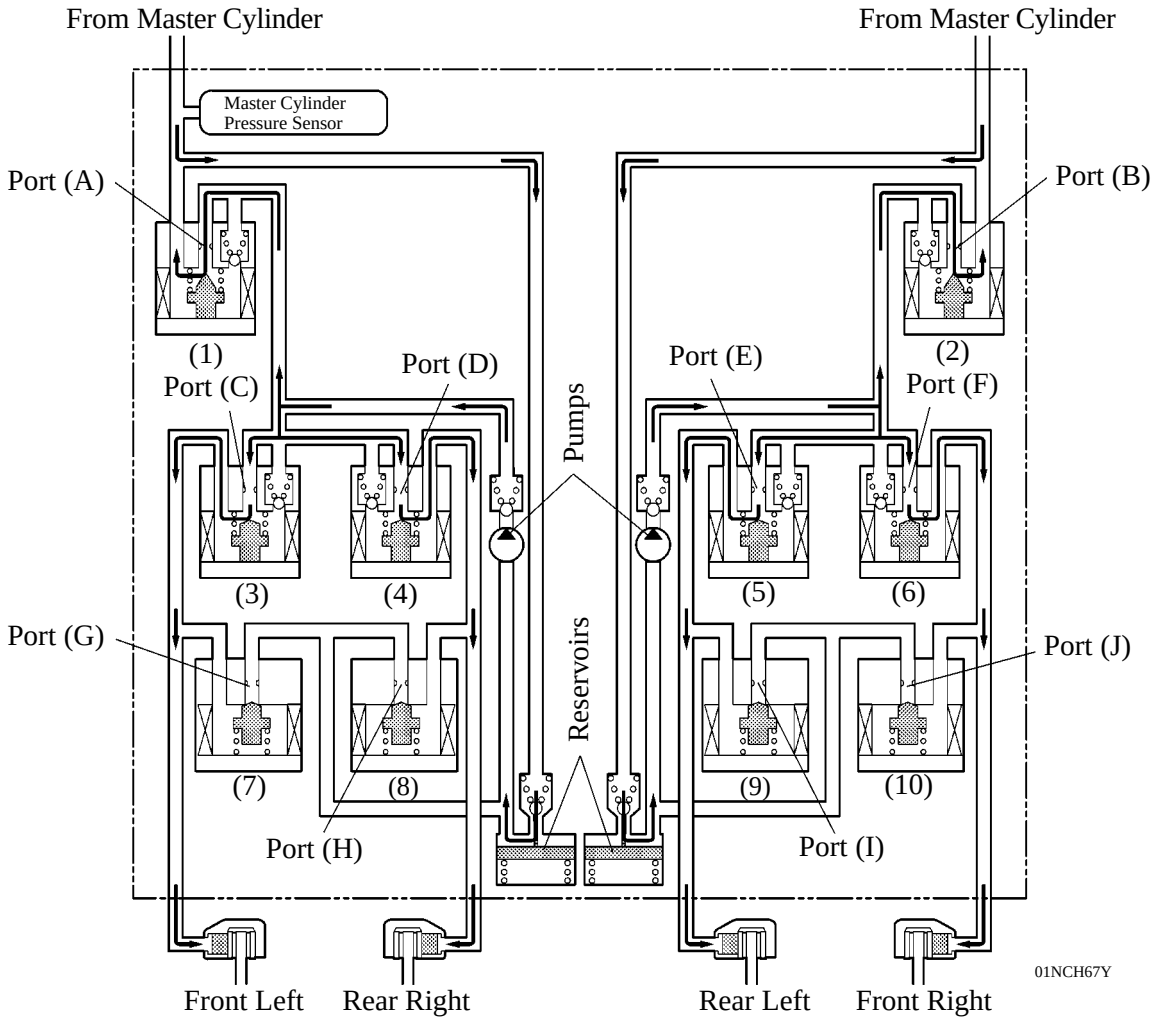
*: Only for 4WD Models

▶ TRAC Operation (4WD Model) ◀



Item			Port	TRAC Not Activated	TRAC Activated		
					Increase Mode	Holding Mode	Reduction Mode
(1) (2)		Master Cylinder Cut Solenoid Valve	(A) (B)	OFF (Open)	ON*	←	←
Front Brake	(3) (6)	Pressure Holding Solenoid Valve	(C) (F)	OFF (Open)	←	ON (Close)	←
	(7) (10)	Pressure Reduction Solenoid Valve	(G) (J)	OFF (Close)	←	←	ON (Open)
	Wheel Cylinder Pressure	Right	—	—	Increase	Hold	Reduce
		Left	—	—	Increase	Hold	Reduce
Rear Brake	(4) (5)	Pressure Holding Solenoid Valve	(D) (E)	OFF (Open)	←	ON (Close)	←
	(8) (9)	Pressure Reduction Solenoid Valve	(H) (I)	OFF (Close)	←	←	ON (Open)
	Wheel Cylinder Pressure	Right	—	—	Increase	Hold	Reduce
		Left	—	—	Increase	Hold	Reduce
Pump				OFF	ON	←	←

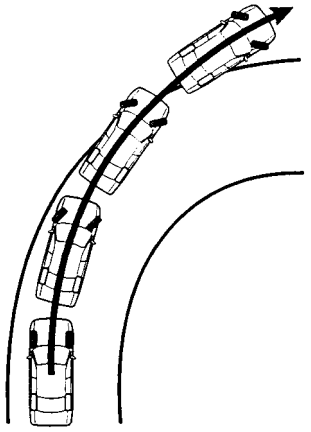
*: The solenoid valve controls the hydraulic pressure between “open” and “close” according to the operating condition by adjusting continually.

9. VSC Function

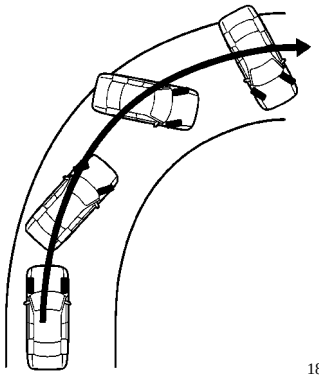
Outline of VSC

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



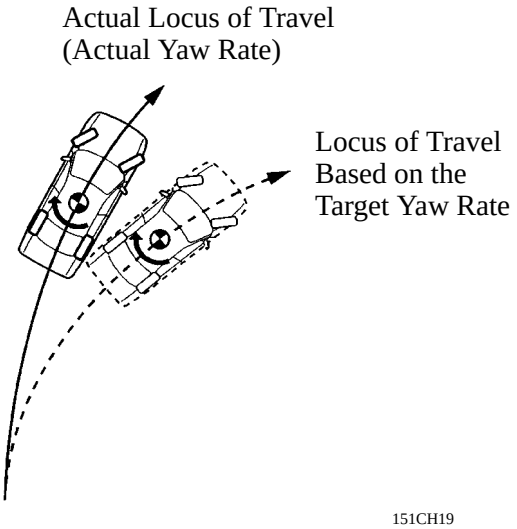
Rear Wheel Skid Tendency

1) Method for Determining the Vehicle Condition

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

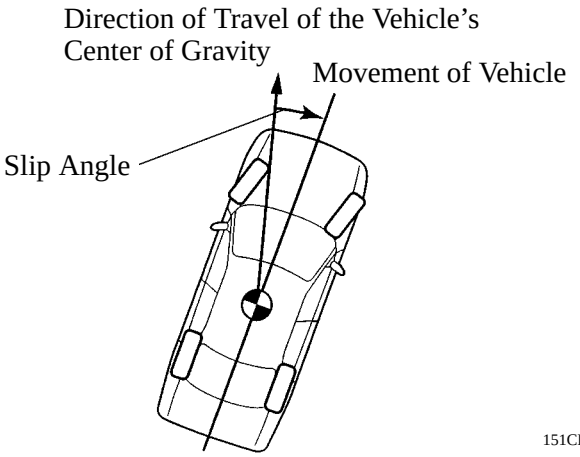
a. Determining Front Wheel Skid

Whether the vehicle is in the state of the front wheel skid or not is determined by the difference between the target yaw rate and the vehicle's actual yaw rate.
When the vehicle's actual yaw rate is smaller than the yaw rate (a target yaw rate that is determined by the vehicle speed and steering angle) that should be rightfully generated when the driver operates the steering wheel, it means the vehicle is making a turn at a greater angle than the locus of travel.
Thus, the skid control ECU determines that there is a large tendency to front wheel skid.



b. Determining Rear Wheel Skid

Whether the vehicle is in the state of the rear wheel skid or not is determined by the values of the vehicle's slip angle and the vehicle's slip angular velocity (time-dependent changes in the vehicle's slip angle). When the vehicle's slip angle and the slip angular velocity are large, the skid control ECU determines that the vehicle has a large rear wheel skid tendency.

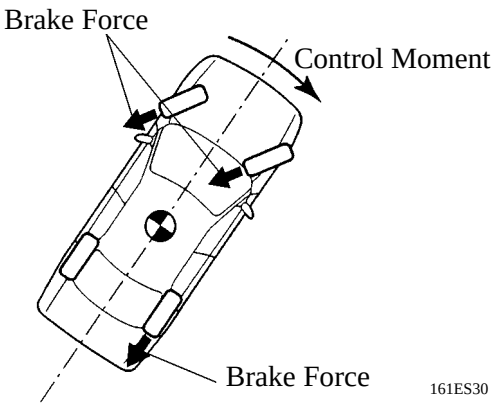


2) Method for VSC Operation

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

a. Dampening a Front Wheel Skid

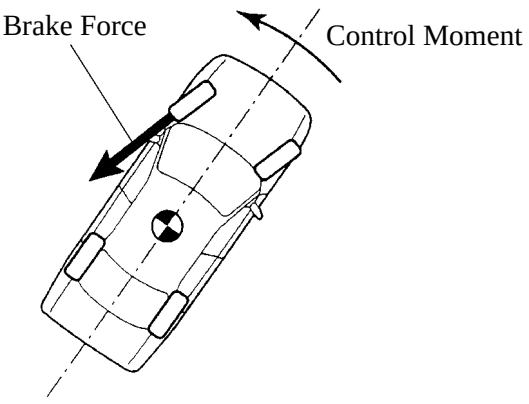
When the skid control ECU determines that there is a large front wheel skid tendency, it counteracts in accordance with the extent of that tendency. The skid control ECU controls the engine output and applies the brakes of the front wheels and rear wheel of the inner circle of the turn in order to help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



Marking a Right Turn

b. Dampening a 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.

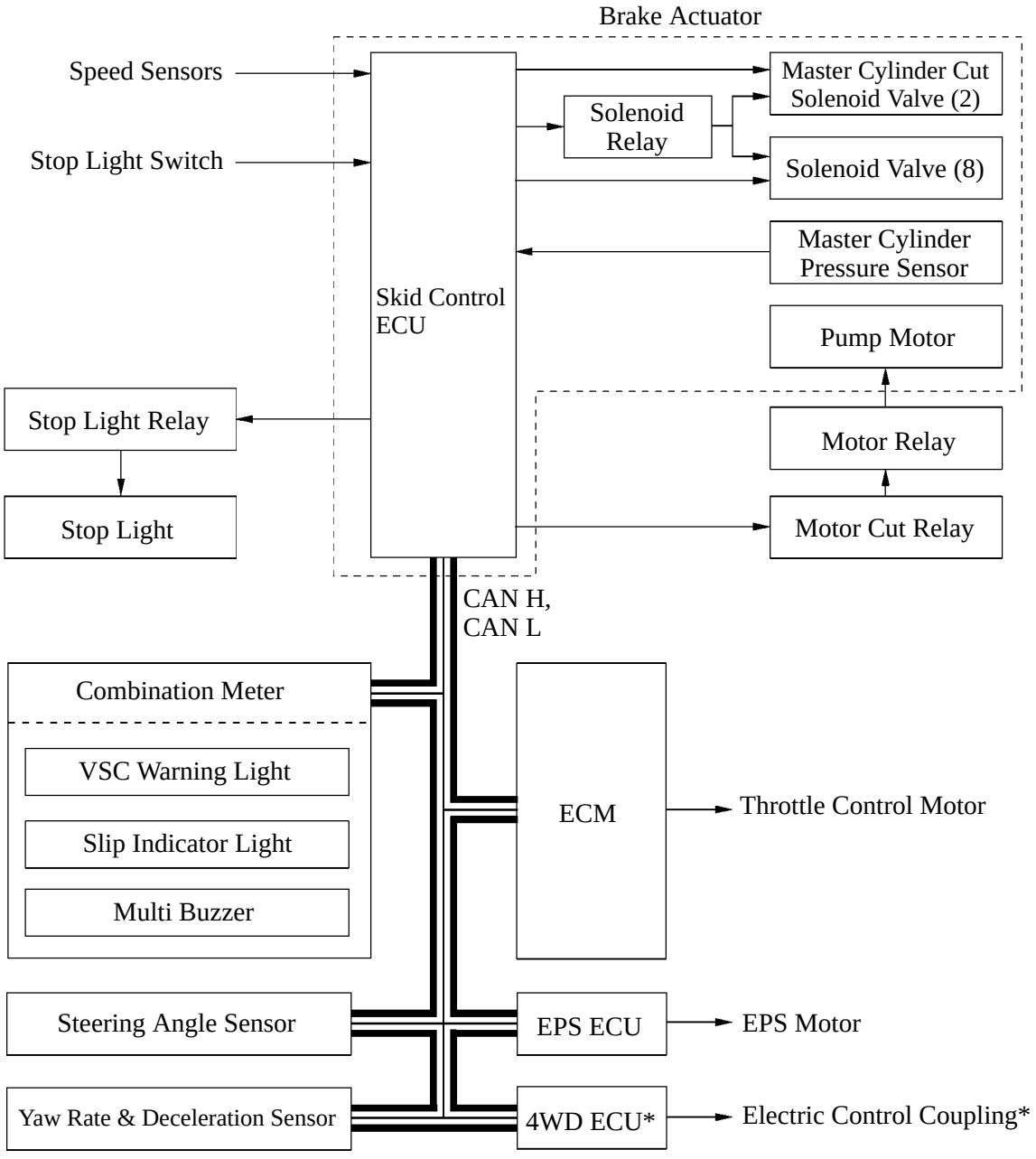


Marking a Right Turn

VSC Operation

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 to front wheel skid or rear wheel skid is controlled.

▶ System Diagram ◀



*: Only for 4WD Models

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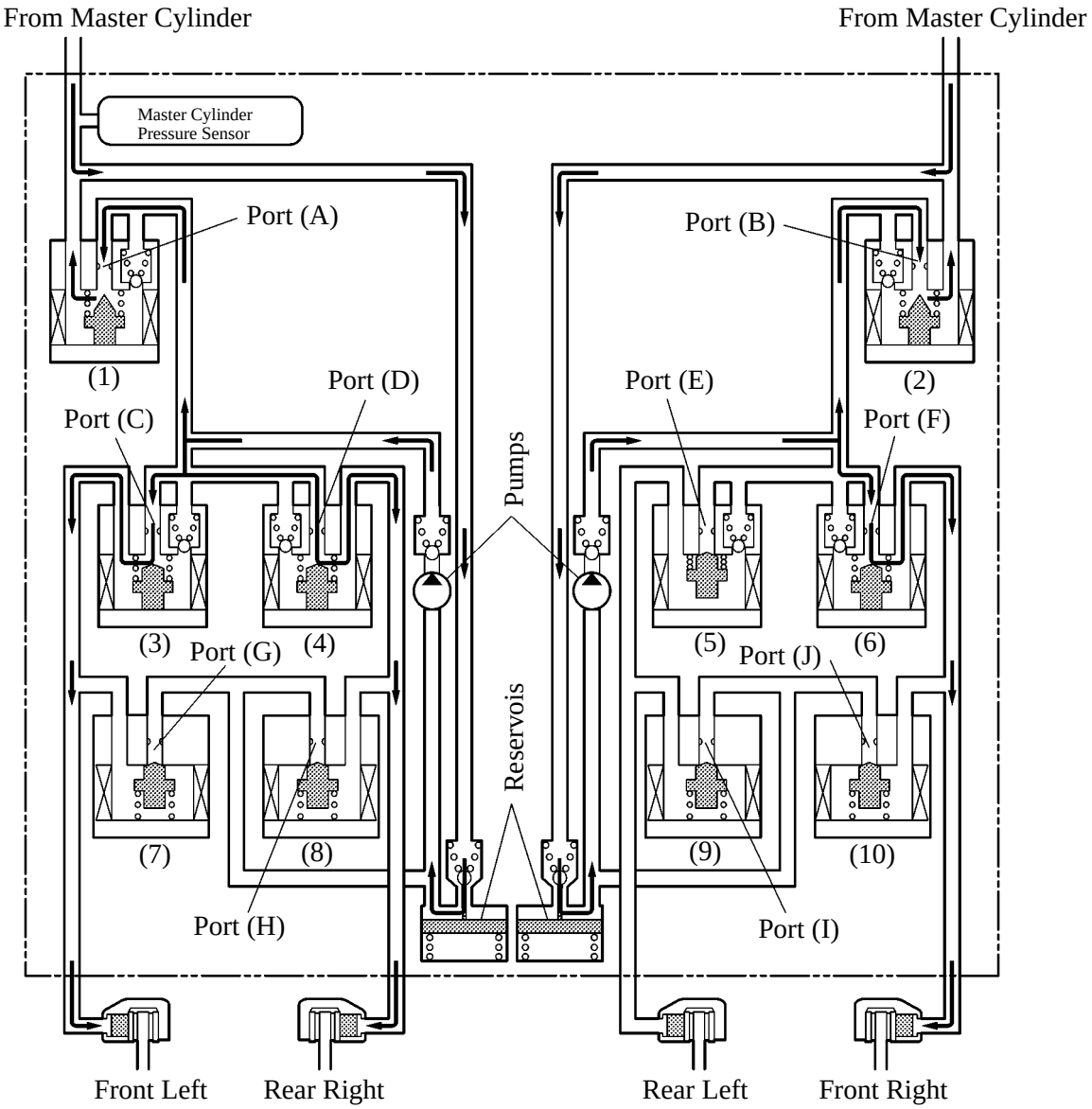
1) Front Wheel Skid Restraining Control (Making a Right Turn)

In the front wheel skid restraining control, the brakes of the front wheels and the rear wheel of the inner circle of the turn 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 mode, the pressure holding valve and the pressure reduction valve are turned ON/OFF according to the ABS operation pattern.
When the front wheel skid restraining control is activated, each solenoid valve operates as show in the table on the next page.

▶ VSC Operation (Front Wheel Skid Restraining) ◀



01NCH68Y

Item			Port	VSC Not Activated	VSC Activated		
					Increase Mode	Holding Mode	Reduction Mode
(1) (2)		Master Cylinder Cut Solenoid Valve	(A) (B)	OFF (Open)	ON*	←	←
Front Brake	(3)	Pressure Holding Solenoid Valve	(C)	OFF (Open)	←	ON (Close)	←
	(6)		(F)	OFF (Open)	←	ON (Close)	←
	(7)	Pressure Reduction Solenoid Valve	(G)	OFF (Close)	←	←	ON (Open)
	(10)		(J)	OFF (Close)	←	←	ON (Open)
	Wheel Cylinder Pressure	Right	—	—	Increase	Hold	Reduce
		Left	—	—	Increase	Hold	Reduce
Rear Brake	(4)	Pressure Holding Solenoid Valve	(D)	OFF (Open)	←	ON (Close)	←
	(5)		(E)	OFF (Open)	ON (Close)	←	←
	(8)	Pressure Reduction Solenoid Valve	(H)	OFF (Close)	←	←	ON (Open)
	(9)		(I)	OFF (Close)	←	←	←
	Wheel Cylinder Pressure	Right	—	—	Increase	Hold	Reduce
		Left	—	—	—	—	—
Pump				OFF	ON	←	←

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

2) Rear Wheel Skid Restraining Control (Making a Right Turn)

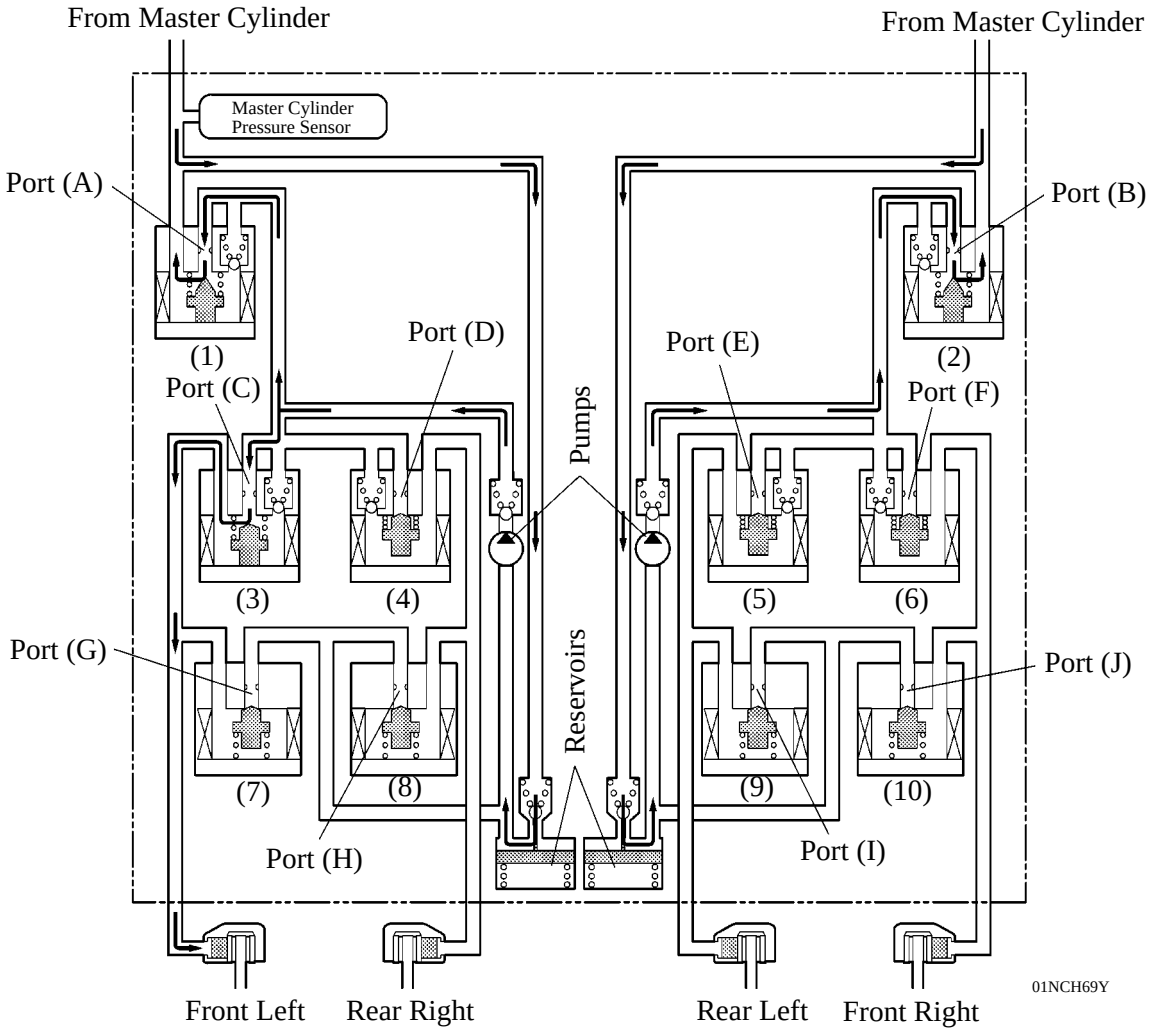
In the rear wheel skid restraining control, the brake of the front wheel of the outer circle of the turn is applied. Also, depending on whether the brake is ON or OFF and the condition of the vehicle, there are circumstances in which the brake might not be applied to the wheels even if those wheels are targeted for braking.

The diagram on the next page 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 mode, the pressure holding valve and the pressure reduction valve are turned ON/OFF according to the ABS operation pattern.

When the rear wheel skid restraining control is activated, each solenoid valve operates as shown in the table on the next page.

▶ VSC Operation (Rear Wheel Skid Restraining) ◀



Item			Port	VSC Not Activated	VSC Activated		
					Increase Mode	Holding Mode	Reduction Mode
(1) (2)		Master Cylinder Cut Solenoid Valve	(A)	OFF (Open)	ON*	←	←
			(B)	OFF (Open)	←	←	←
Front Brake	(3)	Pressure Holding Solenoid Valve	(C)	OFF (Open)	←	ON (Close)	←
	(6)		(F)	OFF (Open)	ON (Close)	←	←
	(7)	Pressure Reduction Solenoid Valve	(G)	OFF (Close)	←	←	ON (Open)
	(10)		(J)	OFF (Close)	←	←	←
	Wheel Cylinder Pressure	Right	—	—	—	—	—
		Left	—	—	Increase	Hold	Reduce
Rear Brake	(4)	Pressure Holding Solenoid Valve	(D)	OFF (Open)	ON (Close)	←	←
	(5)		(E)	OFF (Open)	ON (Close)	←	←
	(8)	Pressure Reduction Solenoid Valve	(H)	OFF (Close)	←	←	←
	(9)		(I)	OFF (Close)	←	←	←
	Wheel Cylinder Pressure	Right	—	—	—	—	—
		Left	—	—	—	—	—
Pump				OFF	ON	←	←

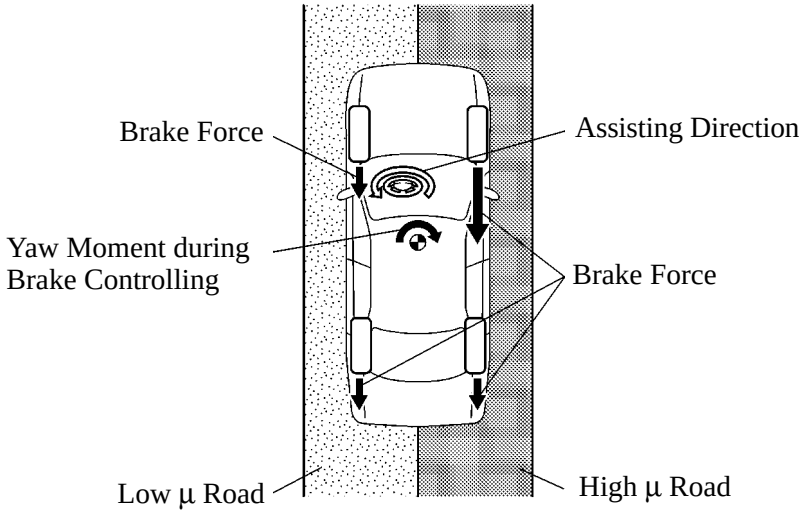
*: The solenoid valve controls the hydraulic pressure between “open” and “close” according to the operating condition by adjusting continually.

10. Cooperative Control Function

Outline of Cooperative Control

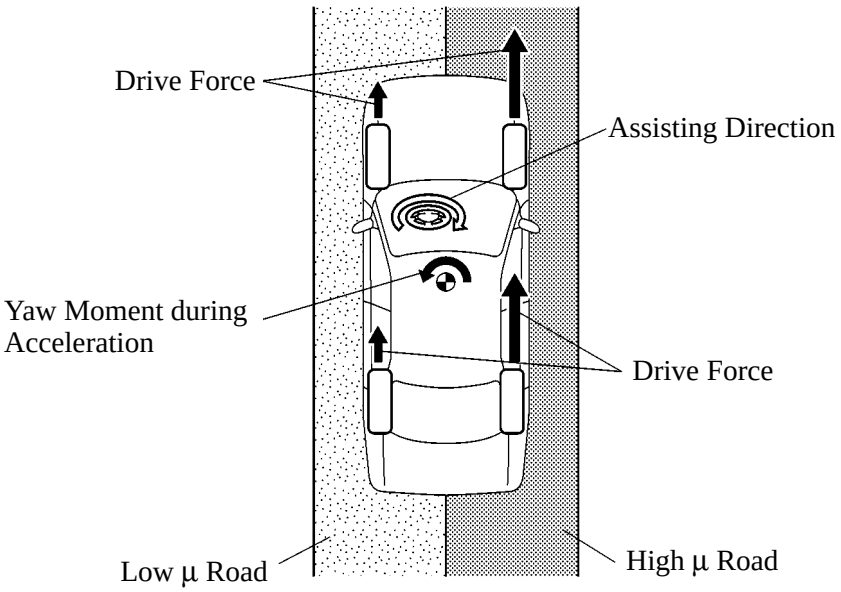
1) Braking when Surface Resistance Differs between Both Sides of Wheels

If the driver suddenly applies the brakes on a road surface with a considerable difference in friction coefficient between the right and left wheels, the difference in the brake force between the right and left wheels will cause the vehicle posture to become unstable and create a yaw moment. In this state, the skid control ECU controls the VSC to stabilize the vehicle posture. At the same time, it effects cooperative control with the EPS to provide steering torque assist, which facilitates the driver's steering maneuvers to stabilize the vehicle posture.



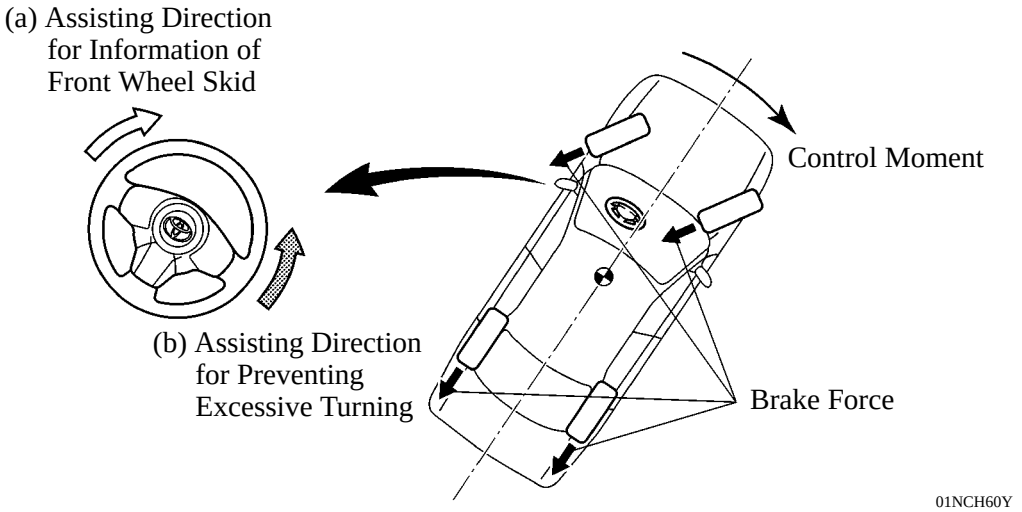
2) Accelerating when Surface Resistance Differs between Both Sides of Wheels

If the driver suddenly starts off or accelerates on a road surface with a considerable difference in friction coefficient between the right and left wheels, the slippage of a drive wheel will cause the vehicle posture to become unstable and negatively affect its acceleration performance. In this state, the skid control ECU causes the TRAC to control the hydraulic brake of the slipping drive wheel, and requests the ECM to effect engine output control. At the same time, it effects cooperative control with the EPS to provide steering torque assist, which facilitates the driver's steering maneuvers to stabilize the vehicle posture.



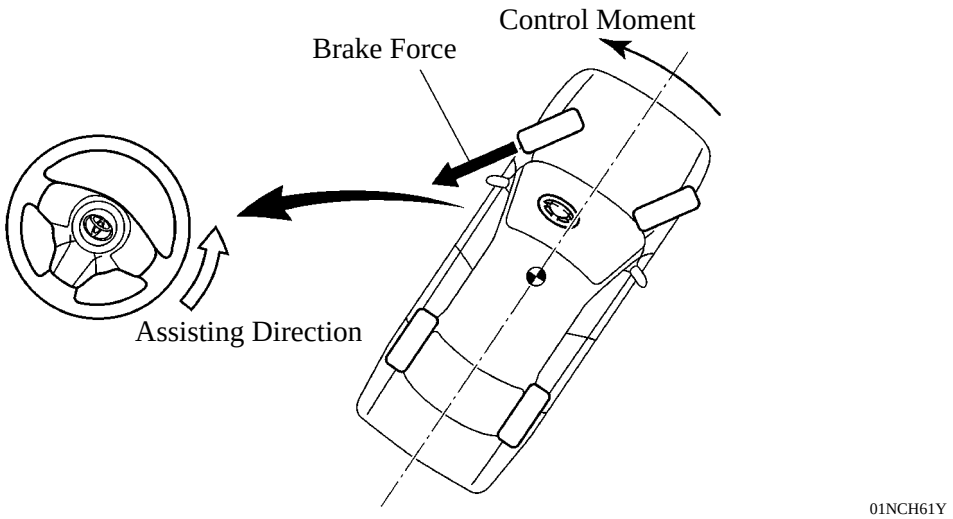
3) Front Wheel Skid Tendency

When the skid control ECU determines a front wheel skid tendency (see page CH-108), it controls the VSC to dampen the front wheel skid (see page CH-109). At the same time, it effects the cooperative control with the EPS to provide steering torque assists, which controls the driver's steering maneuvers to stabilize the vehicle posture. Steering torque assists are provided to inform the driver of the front wheel skid (a), and to prevent the driver's excessive turning of the steering wheel (b). In the assist for preventing excessive turning (b), it increases the resistance to counter the driver's steering effort, if the driver turns the steering wheel excessively.



4) Rear Wheel Skid Tendency

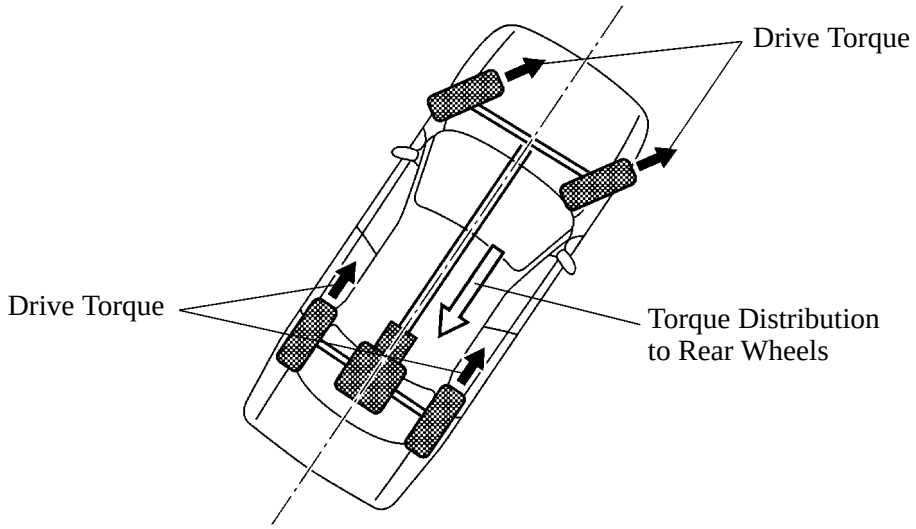
When the skid control ECU determines a rear wheel skid tendency (see page CH-109), it controls the VSC to dampen the rear wheel skid (see page CH-109). At the same time, it effects cooperative control with the EPS to provide steering torque assist, which facilitates the driver's steering maneuvers in the direction to correct the rear wheel skid.



5) Acceleration During Cornering (Only for 4WD Models)

A sudden acceleration of the vehicle during cornering may cause a drive wheel to freewheel, which could cause the front wheels or rear wheels to skid. If the skid control ECU determines the freewheeling of a drive wheel, a front wheel skid tendency, or a rear wheel skid tendency, it effects cooperative control with the 4WD system to optimally control the drive torque distribution to the front and rear wheels. Furthermore, it controls the TRAC and the VSC as needed to ensure driving stability and acceleration performance.

▶ Front Wheel Skid Tendency ◀



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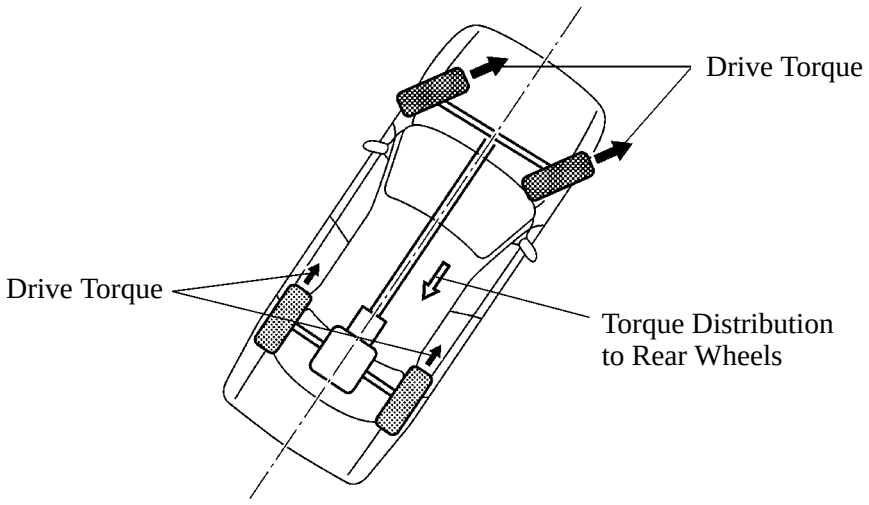
▶ Rear Wheel Skid Tendency ◀



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Cooperative Control Operation

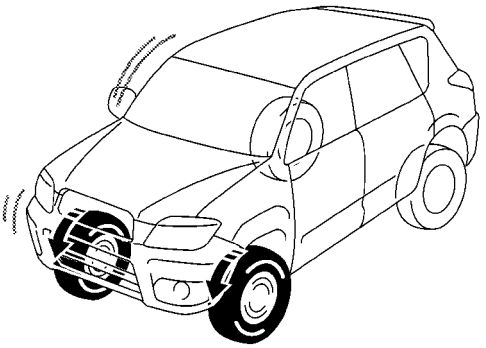
The operation of the solenoid valves under the cooperative control is the same as the TRAC or VSC operation.

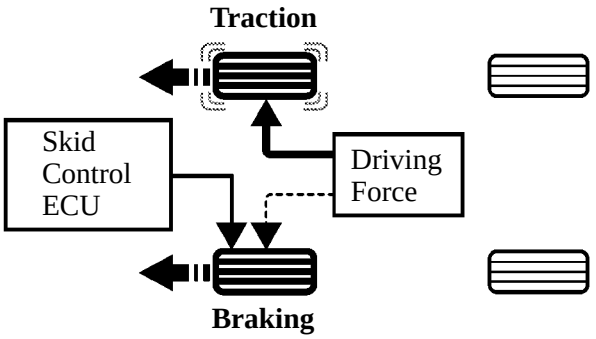
11. Auto LSD Function (Only for 2WD models)

Outline of Auto LSD

- The Auto LSD achieves the equivalent functions of an LSD (Limited Slip Differential) through the use of a traction control function. For this reason, the contents of brake control are the same between Auto LSD and TRAC. When the driver presses the Auto LSD switch, this function achieves the LSD effect by regulating the hydraulic pressure that acts on the drive wheels and controlling the engine output in accordance with the amount of pedal effort applied on the accelerator.
- TRAC enhances the start off performance of the vehicle during low-resistance surface conditions, such as snow or mud, by restricting the acceleration effort during a start off in order to prevent the wheels from spinning.
- On the other hand, the Auto LSD tends to enhance the acceleration effort somewhat in order to apply greater drive torque to the wheel that is making contact with the ground. Thus, this function helps the vehicle get unstuck if a wheel loses its grip, and enhances the vehicle's start off performance on high-resistance surface conditions such as gravel roads.

▶ With Auto LSD Function ◀





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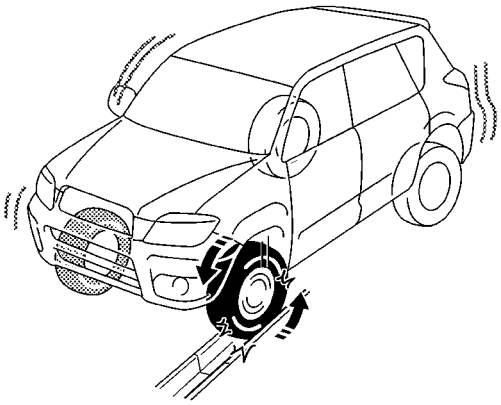
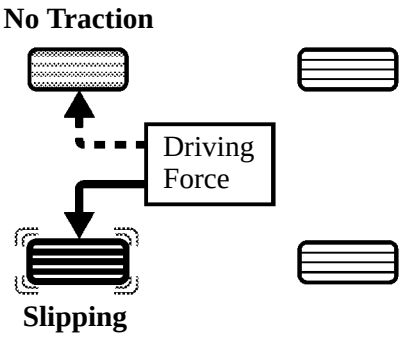
▶ Without Auto LSD Function ◀





01MCH20Y

- The following conditions are required for operating the Auto LSD function.

Auto LSD Switch	ON
Accelerator Pedal	ON

Auto LSD Operation

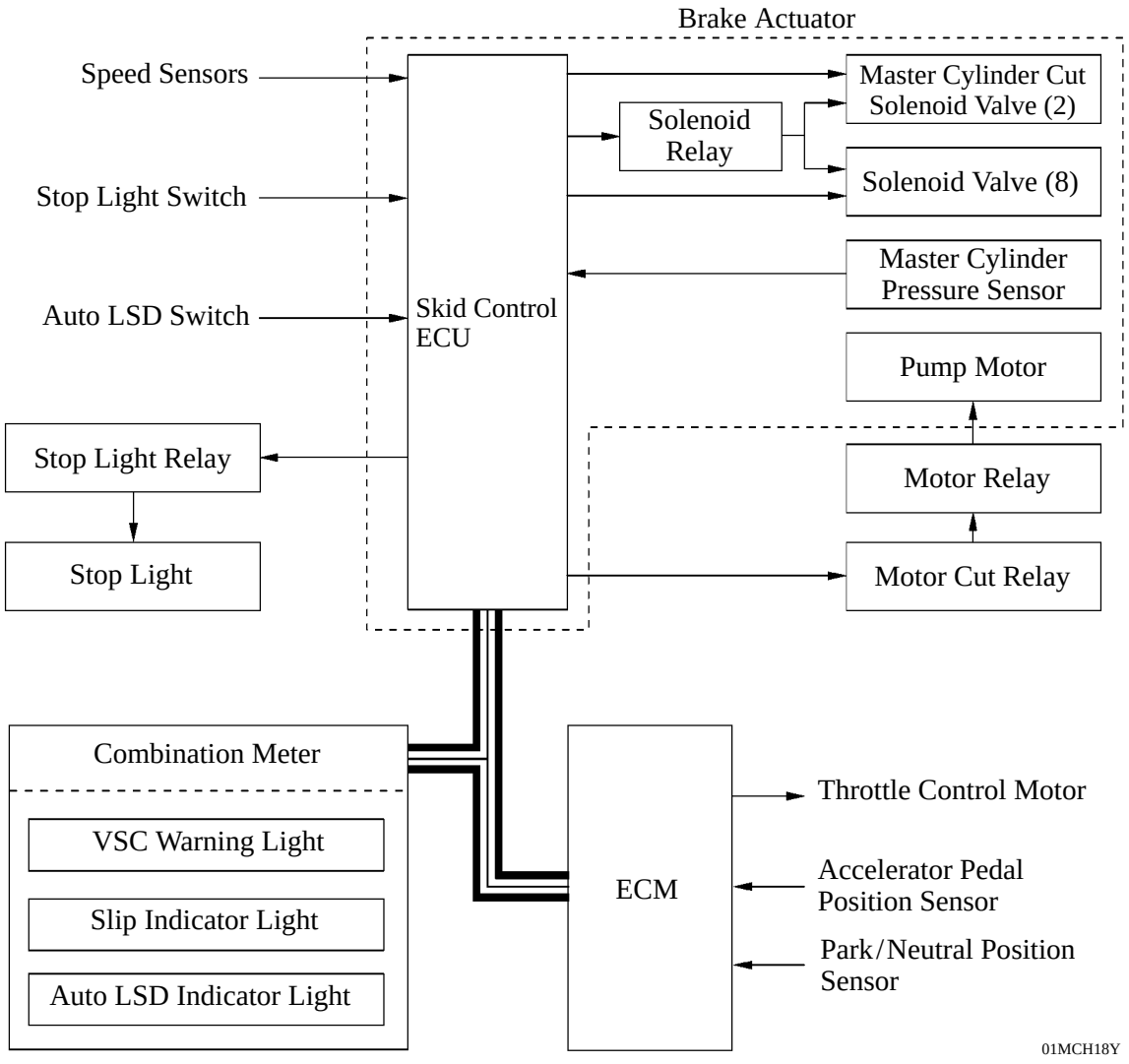
- The skid control ECU determines that the vehicle is in a state in which the Auto LSD can operate, by using various sensors and switches to detect the operating conditions of the Auto LSD switch, shift position, accelerator pedal, and brake pedal.
- When the vehicle is in a state in which the Auto LSD can operate, the skid control ECU effects hydraulic pressure control of the wheel cylinder at the wheel with the faster wheel speed so that the wheel speeds of the right and left drive wheels will become equal.
- The Auto LSD indicator light illuminates when the vehicle is in a state in which the Auto LSD can operate, and the slip indicator light flashes during Auto LSD control.

If the Auto LSD function operates due to the slippage of the left drive wheel, see the next page for the operation of the solenoid valves.

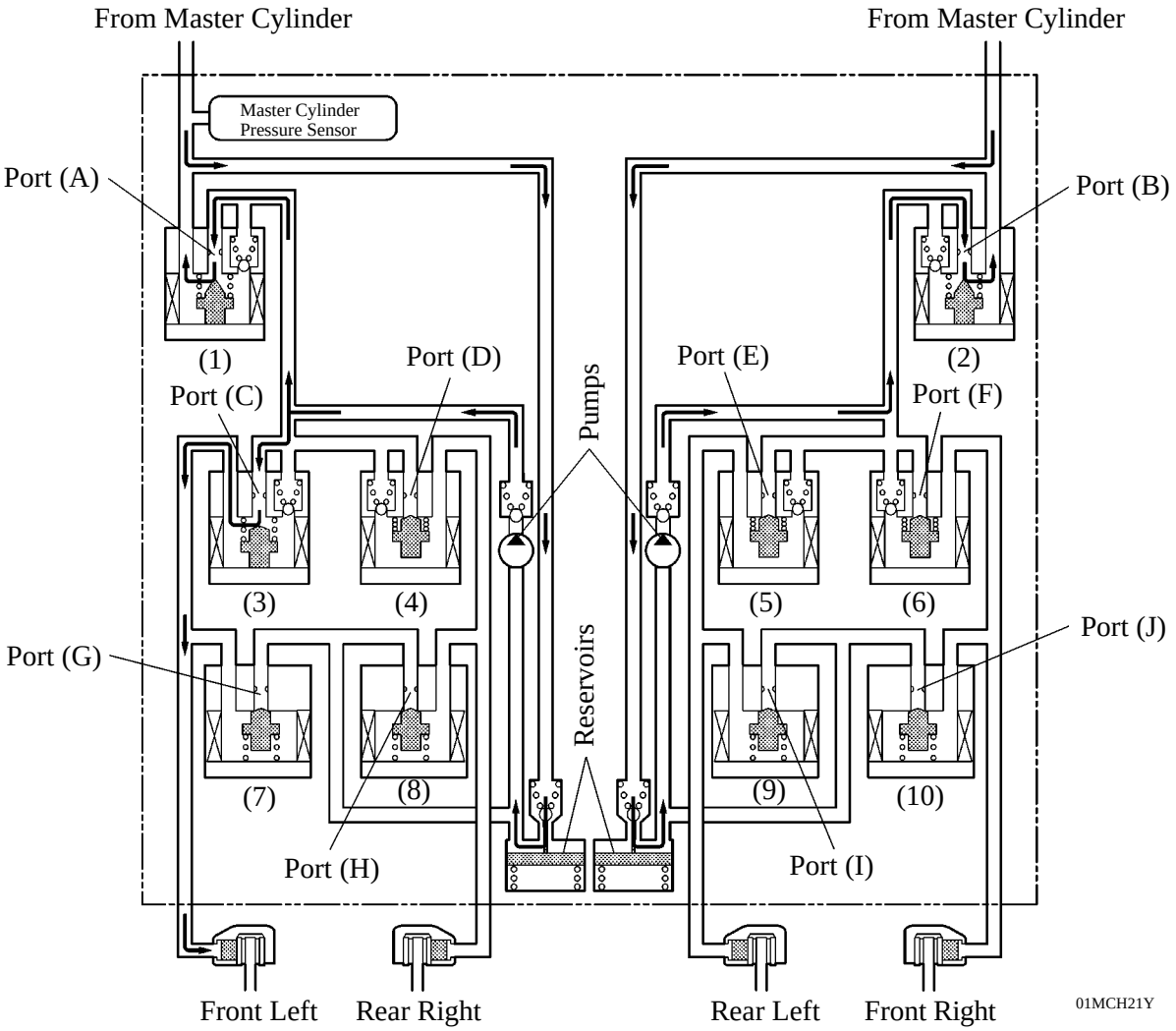
NOTICE

- Use the Auto LSD only if a wheel comes off or while driving on a road surface with high driving resistance such as sand or mud. Do not use it for normal driving. After using the Auto LSD, make sure the Auto LSD indicator light is off before resuming driving.
- To operate the Auto LSD switch, make sure the wheels are not spinning.

▶ System Diagram ◀



▶ Auto LSD Operation (Front Left Drive Wheel Slipping) ◀



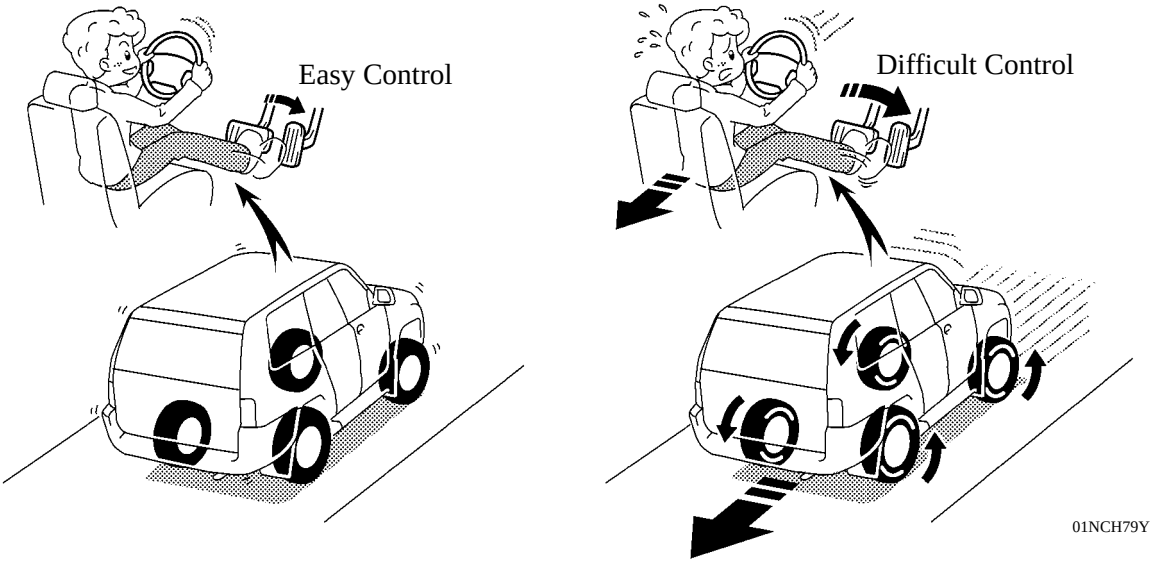
Item			Port	Auto LSD Not Activated	Auto LSD Activated		
					Increase Mode	Holding Mode	Reduction Mode
(1)		Master Cylinder Cut Solenoid Valve	(A)	OFF (Open)	ON*	←	←
(2)			(B)	OFF (Open)	←	←	←
Front Brake	(3)	Pressure Holding Solenoid Valve	(C)	OFF (Open)	←	ON (Close)	←
	(6)		(F)	OFF (Open)	ON (Close)	←	←
	(7)	Pressure Reduction Solenoid Valve	(G)	OFF (Close)	←	←	ON (Open)
	(10)		(J)	OFF (Close)	←	←	←
	Wheel Cylinder Pressure	Right	—	—	—	—	—
		Left	—	—	Increase	Hold	Reduce
Rear Brake	(4)	Pressure Holding Solenoid Valve	(D)	OFF (Open)	ON (Close)	←	←
	(5)		(E)	OFF (Open)	ON (Close)	←	←
	(8)	Pressure Reduction Solenoid Valve	(H)	OFF (Close)	←	←	←
	(9)		(I)	OFF (Close)	←	←	←
	Wheel Cylinder Pressure	Right	—	—	—	—	—
		Left	—	—	—	—	—
Pump				OFF	ON	←	←

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

12. Hill-start Assist Control Function

Outline of Hill-start Assist Control

- When the vehicle starts off a steep or slippery hill, the vehicle could descend backward while the driver switches from the brake pedal to the accelerator pedal, thus making it difficult for the vehicle to start off. To prevent this from occurring, the Hill-start Assist Control temporarily (approximately 2 seconds at the maximum) applies the brakes to the 4 wheels in order to prevent the vehicle from descending backward.
- Without the Hill-start Assist Control, the driver must quickly and precisely switch from the brake pedal to the accelerator pedal. With the Hill-start Assist Control, however, the driver can start off easily and operate the pedal in a relaxed manner because the Hill-start Assist Control prevents the vehicle from descending backward.



Prevents the vehicle from descending backward — **With Hill-start Assist Control**

Increases the backward speed of the vehicle — **Without Hill-start Assist Control**

- Provided that all the conditions listed below have been met, and the driver depresses the brake pedal further while the vehicle is stopped, the system starts the Hill-start Assist Control.

Hill-start Assist Control Operation Condition	● Shift lever is in the position other than P. ● The accelerator pedal is not depressed. ● The vehicle is at standstill. ● The parking brake is not pulled up.

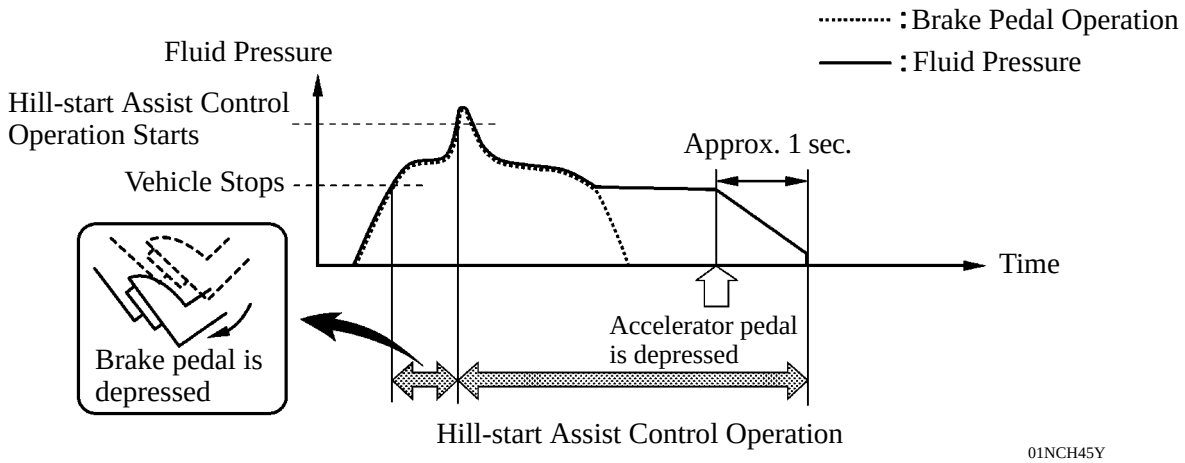
Hill-start Assist Control Operation

The skid control ECU determines the starting of the Hill-start Assist Control operation in accordance with information provided by various sensors, switches, and the ECM. At this time, the skid control ECU controls the fluid pressure that is generated by the pump and applies it by way of the solenoid valves to the brake wheel cylinder of each wheel in the following 2 modes: pressure reduction and pressure holding modes.

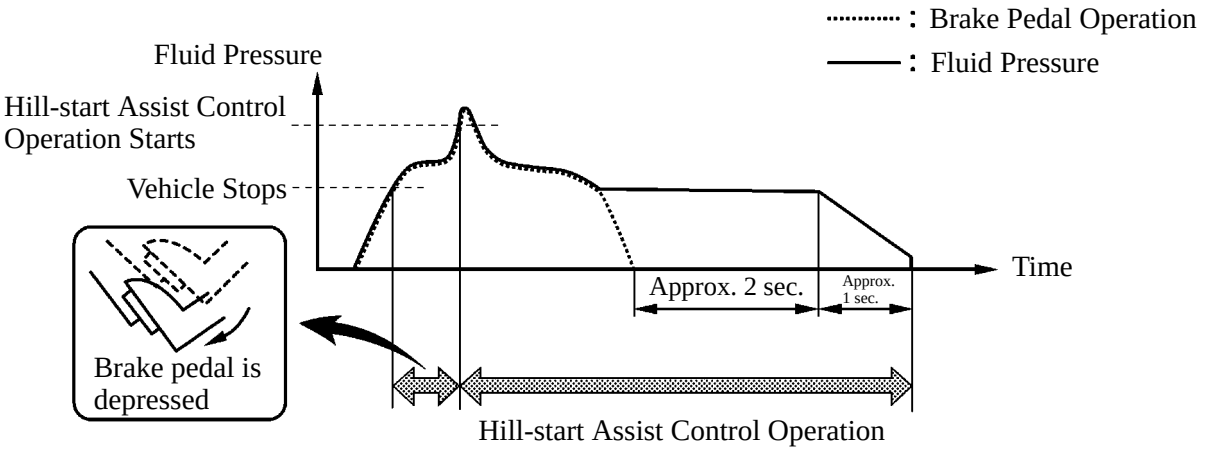
- The skid control ECU computes that the vehicle is in a state in which the Hill-start Assist Control can start operating in accordance with the signals provided by the speed sensor, yaw rate & deceleration sensor, park/neutral position switch, stop light switch, accelerator pedal position sensor, and parking brake switch. In this state, if the driver depresses the brake pedal further, causing the master cylinder pressure sensor signal to be input into the skid control ECU, the skid control ECU starts the Hill-start Assist Control operation.
- During the Hill-start Assist Control operation, the skid control ECU outputs signals to the stop light relay to cause the stop light to turn ON, to the combination meter to cause the slip indicator light to blink, and to sound the multi buzzer in the combination meter once.
- If a signal indicating one of the conditions listed below has been input into the skid control ECU, the skid control ECU turns OFF the slip indicator light, sounds the multi buzzer twice, and cancels the Hill-start Assist Control operation.
  - The driver takes no action for 2 seconds or longer after the Hill-start Assist Control operation has started.
  - The driver has moved the shift lever to the P position.
  - The driver has depressed the accelerator pedal*.
  - The driver has pulled up the parking brake lever.
  - The driver has depressed the brake pedal.

*: This will not cause the multi buzzer to sound.

▶ After the Hill-start Assist Control operation, the driver depresses the accelerator pedal to start off the vehicle ◀



▶ After the Hill-start Assist Control operation, the driver takes no action ◀



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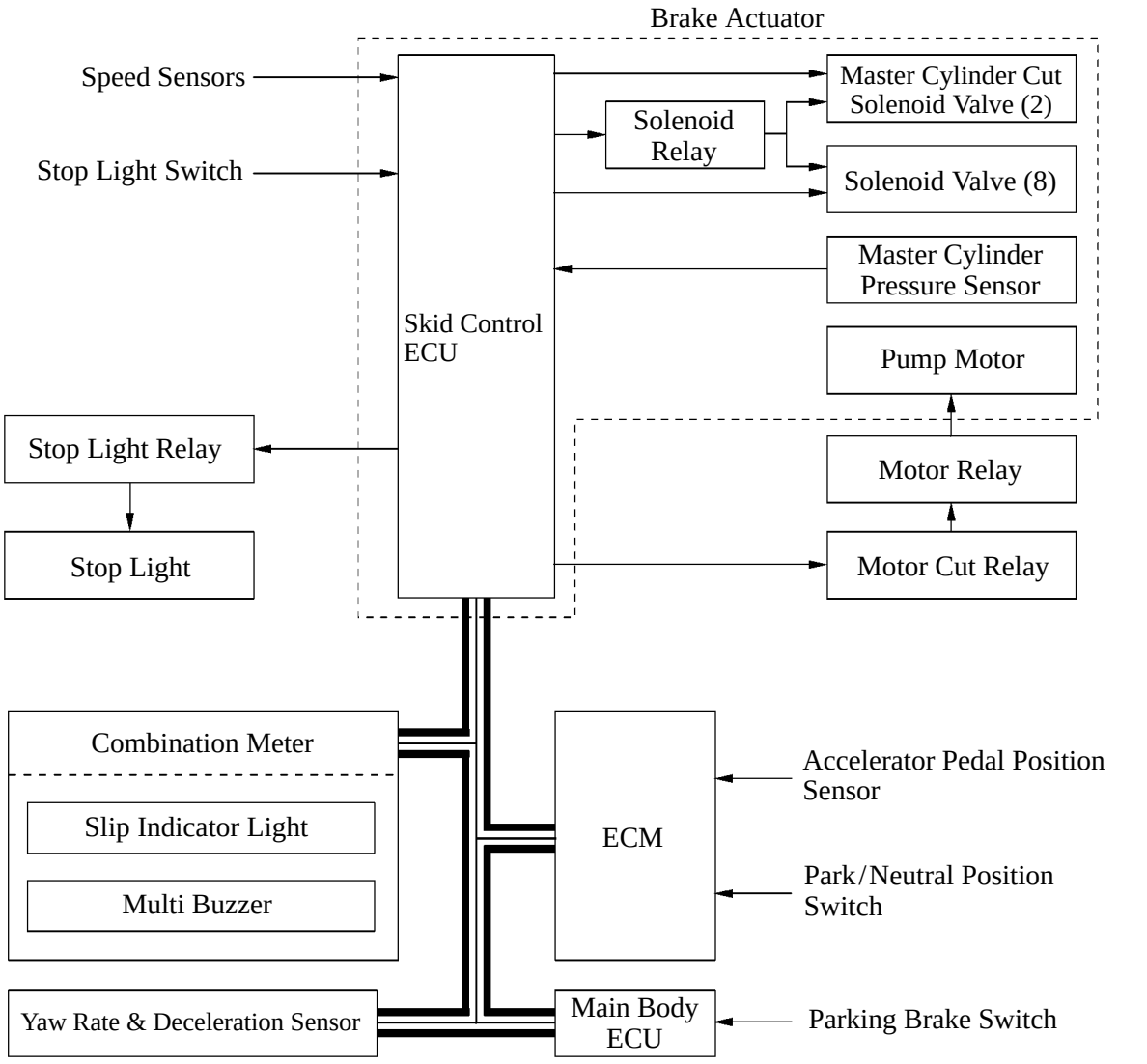
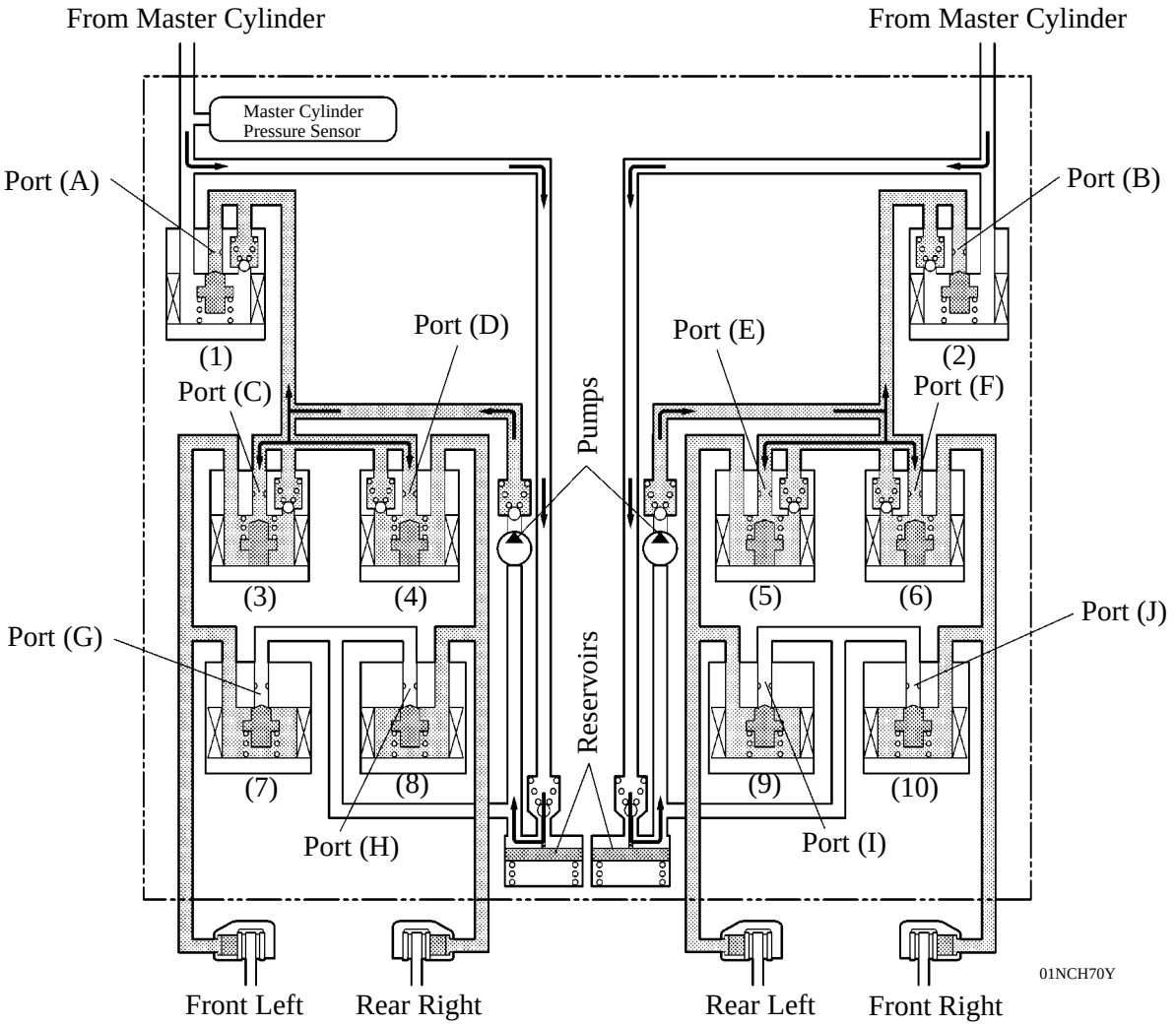
▶ System Diagram ◀



01NCH47Y

▶ Hill-start Assist Control Operation ◀

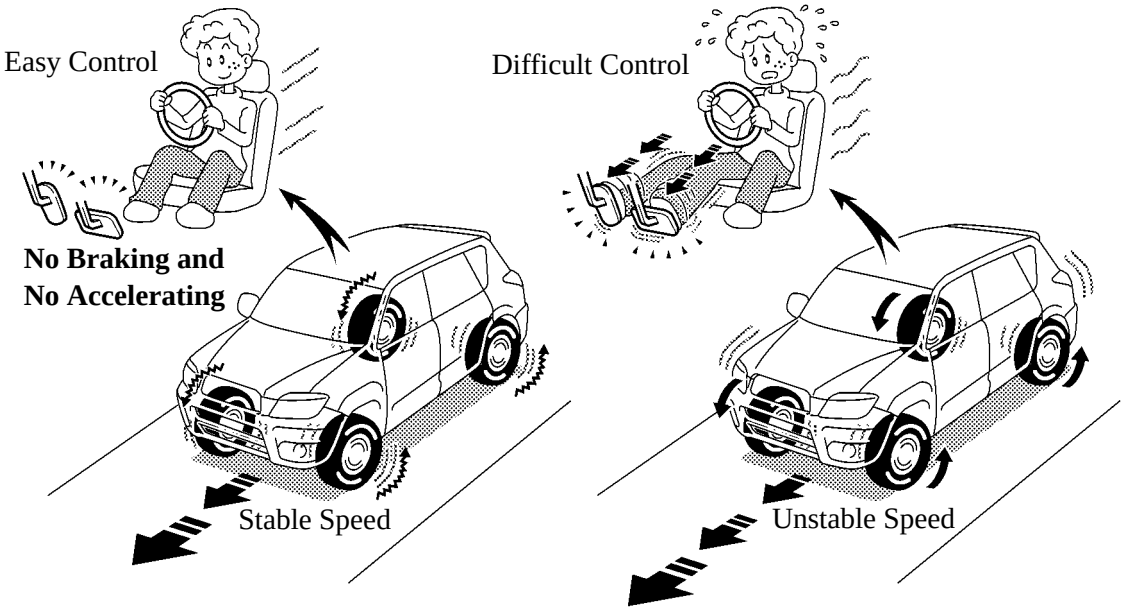


Item			Port	Hill-start Assist Control Not Activated	Hill-stars Assist Contorl Activated	
					Holding Mode	Reduction Mode
(1)		Master Cylinder Cut Solenoid Valve	(A)	OFF (Open)	ON	OFF (Open)
(2)			(B)	OFF (Open)	ON	OFF (Open)
Front Brake	(3)	Pressure Holding Solenoid Valve	(C)	OFF (Open)	←	←
	(6)		(F)	OFF (Open)	←	←
	(7)	Pressure Reduction Solenoid Valve	(G)	OFF (Close)	←	←
	(10)		(J)	OFF (Close)	←	←
	Wheel Cylinder Pressure	Right	—	—	Hold	Reduce
		Left	—	—	Hold	Reduce
Rear Brake	(4)	Pressure Holding Solenoid Valve	(D)	OFF (Open)	←	←
	(5)		(E)	OFF (Open)	←	←
	(8)	Pressure Reduction Solenoid Valve	(H)	OFF (Close)	←	←
	(9)		(I)	OFF (Close)	←	←
	Wheel Cylinder Pressure	Right	—	—	Hold	Reduce
		Left	—	—	Hold	Reduce
Pump				OFF	←	←

13. DAC Function

Outline of DAC

- When the vehicle is descending a steep hill and engine brake alone cannot provide a sufficient deceleration force while the transaxle is in the L or R range, the DAC effects 4-wheel brake control to maintain a constant, low vehicle speed. Thus, the vehicle is able to descend in a stable manner without causing the wheels to become locked.
- When the vehicle descends a steep hill without the DAC, the driver must pay close attention to the brake and accelerator pedals operation. However, with the DAC, the driver can concentrate on the steering operation, without accelerator and brake pedals operation.
- The DAC enables the vehicle to realize a high level of stability because it can descend a slippery hill at low speeds without causing the wheels to become locked.



With DAC **Without DAC**

01NCH80Y

- The DAC operates when all of the following conditions have been met:

DAC Operation Condition	● DAC switch is ON.
	● Shift lever is in the L or R position.
	● Accelerator pedal and brake pedal are not depressed.
	● Descending a hill at a vehicle speed of 25 km/h (16 mph) or less.

DAC Operation

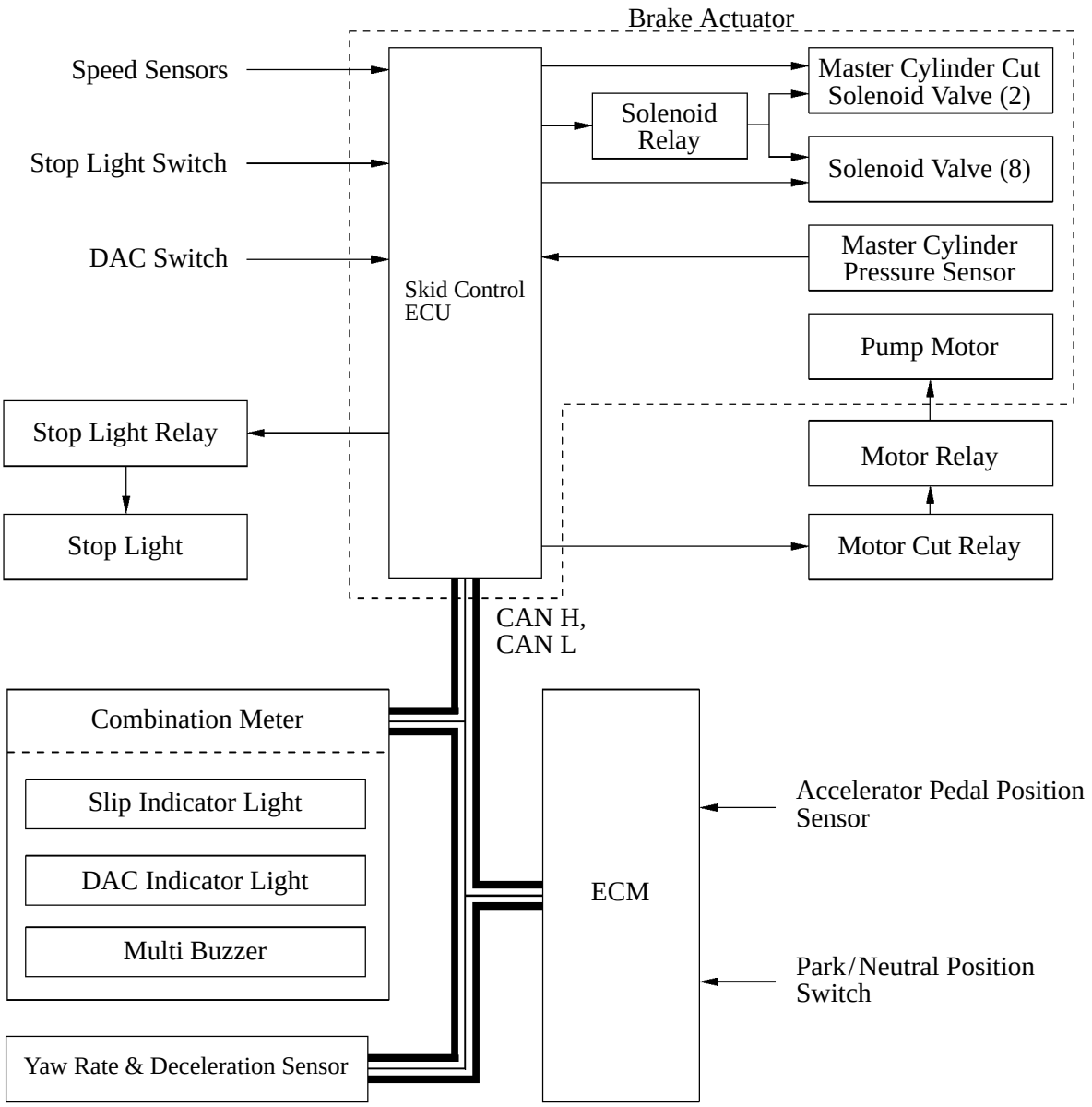
Based on the information provided by various sensors, switches, and ECM, the skid control ECU determines the conditions that enable the DAC operation. Then, the skid control ECU controls the fluid pressure that is generated by the pump and applies it by way of the solenoid valve to the brake wheel cylinder of each wheel in the following 3 modes: pressure reduction, pressure holding and pressure increase modes.

- The skid control ECU computes the vehicle speed, travel direction, and the gradient of the hill in accordance with the signals that are input by the speed sensor and the yaw rate & deceleration sensor, and effects brake control to attain the target vehicle speed. The target vehicle speed is determined by the direction of the vehicle.

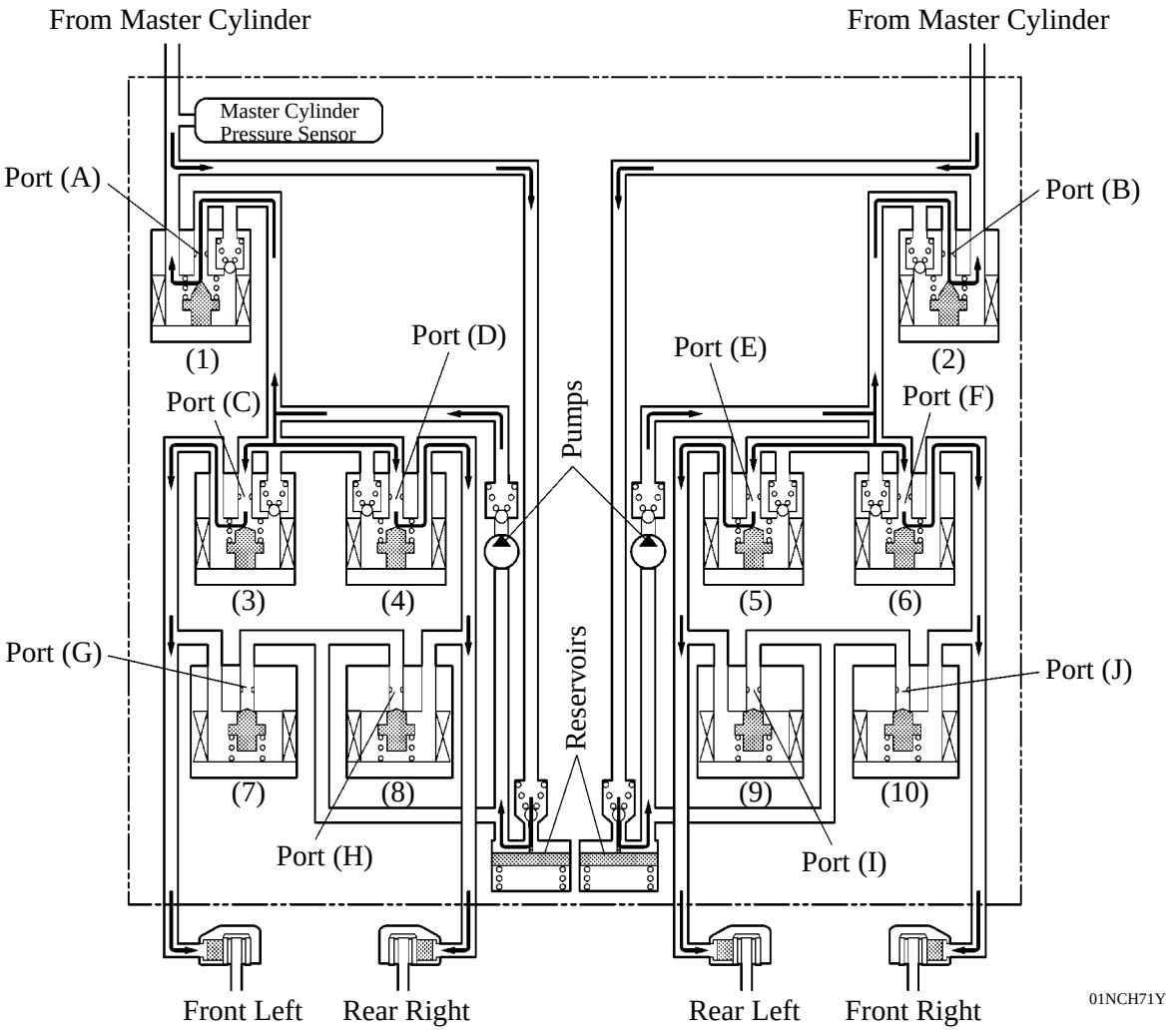
Travel Direction	Target Vehicle Speed
Forward	5 - 7 km/h (3 - 4 mph)
Backward	3 - 5 km/h (2 - 3 mph)

- During the DAC operation, the skid control ECU outputs signals to the stop light relay to cause the stop light to turn ON, and to the combination meter to cause the slip indicator light to blink.
- The DAC dose not operate under the condition described below even if the DAC switch is turned ON; In this case, the DAC indicator light blinks to alert the driver.
  - The shift lever is in a position other than L or R.
  - In the event of malfunction in the DAC system.
  - The temperature of the brake actuator rises, causing the DAC operation to stop.
- Under the conditions described below, the DAC operates. However, the DAC indicator light blinks to alert the driver.
  - If the DAC switch is turned OFF during the DAC operation, the hydraulic pressure decreases gradually to stop the DAC operation.

▶ System Diagram ◀



▶ Pressure Increase Mode ◀

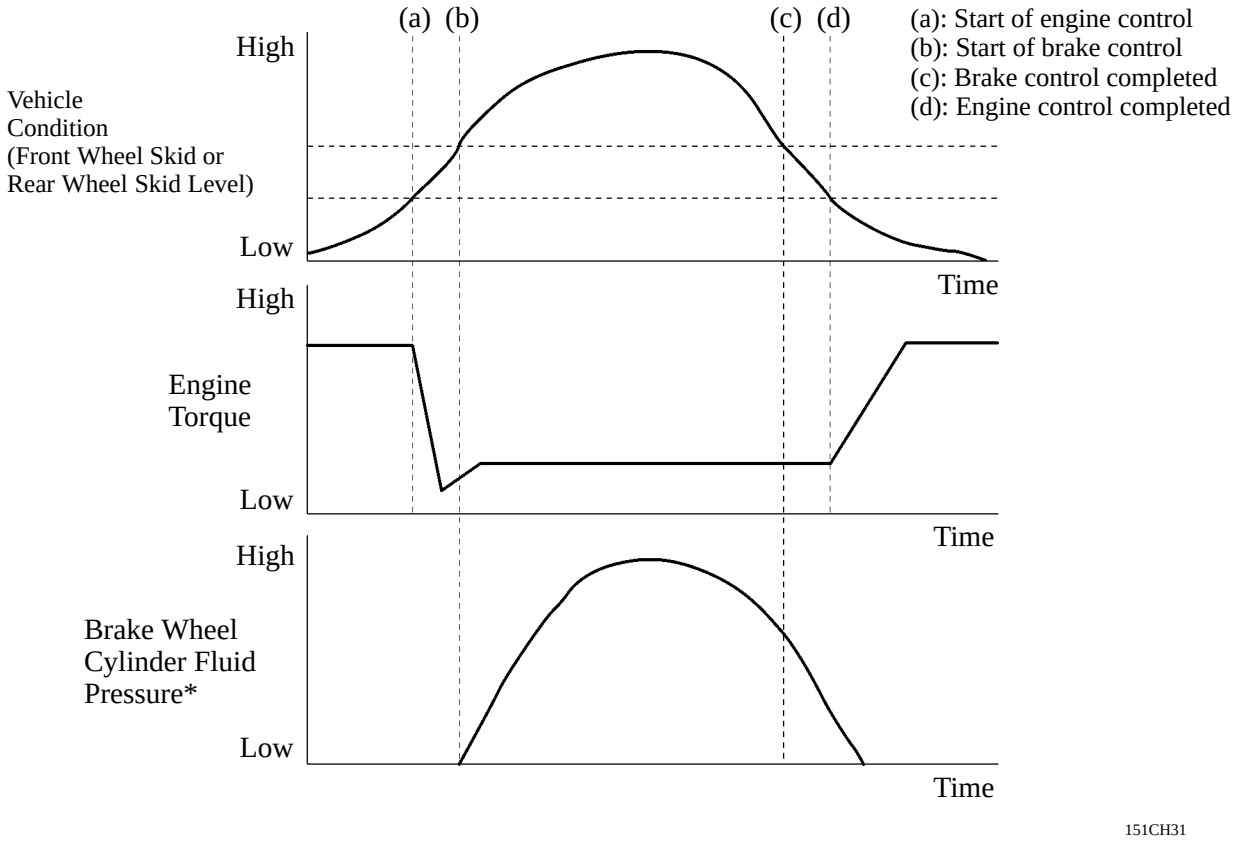


Item			Port	DAC Not Activated	DAC Activated		
					Increase Mode	Holding Mode	Reduction Mode
(1)		Master Cylinder Cut	(A)	OFF (Open)	ON*	z	←
(2)		Solenoid Valve	(B)	OFF (Open)	ON*	←	←
Front Brake	(3)	Pressure Holding Solenoid Valve	(C)	OFF (Open)	←	ON (Close)	←
	(6)		(F)	OFF (Open)	←	ON (Close)	←
	(7)	Pressure Reduction Solenoid Valve	(G)	OFF (Close)	←	←	ON (Open)
	(10)		(J)	OFF (Close)	←	←	ON (Open)
	Wheel Cylinder Pressure	Right	—	—	Increase	Hold	Reduce
		Left	—	—	Increase	Hold	Reduce
Rear Brake	(4)	Pressure Holding Solenoid Valve	(D)	OFF (Open)	←	ON (Close)	←
	(5)		(E)	OFF (Open)	←	ON (Close)	←
	(8)	Pressure Reduction Solenoid Valve	(H)	OFF (Close)	←	←	ON (Open)
	(9)		(I)	OFF (Close)	←	←	ON (Open)
	Wheel Cylinder Pressure	Right	—	—	Increase	Hold	Reduce
		Left	—	—	Increase	Hold	Reduce
Pump				OFF	ON	←	←

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

14. Engine Output Control

During a TRAC, Auto LSD or VSC operation, the skid control ECU outputs a engine output control signal to the ECM. Upon receiving this signal, the ECM affects throttle control to regulate the engine output.



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

15. Initial Check

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

16. Self-diagnosis

General

- If the skid control ECU detects a malfunction in the brake control system (ABS with EBD, Brake Assist, TRAC, Auto LSD, VSC, Hill-start Assist Control and DAC), the ABS, brake system, VSC warning lights or slip indicator light that corresponds to the function in which the malfunction has been detected indicates or lights up as indicated in the table below to alert the driver of the malfunction.

○: Light ON —: Light OFF

Item	ABS	EBD	Brake Assist	TRAC	VSC	Auto LSD*1	Hill-start Assist Control*2	DAC*3
ABS Warning Light	○	○	○	—	—	—	—	—
Brake System Warning Light	—	○	○*4	—	—	—	—	—
VSC Warning Light	○	○	○	○	○	○	○	○
Slip Indicator Light	○	○	○	○	○	○	○	○

*1: Only for 2WD Models
*2: Only for Models with Hill-start Assist Control Function
*3: Only for Models with DAC Function
*4: Only for Models with 16 in. Ventilated Disc

- At the same time, the DTCs (Diagnostic Trouble Codes) are stored in memory. The DTCs can be read by connecting a hand-held tester, or by connecting the SST (09843-18040) to the TC and CG terminals of the DLC3, and observing the blinking of the ABS warning light and VSC warning light.
- This system has a sensor signal check (test mode) function. This function is activated by connecting a hand-held tester, or by connecting the SST (09843-18040) to the TS and CG terminal of the DLC3. This check function performs yaw rate sensor zero point calibration, deceleration sensor zero point calibration, yaw rate sensor check, master cylinder pressure sensor check, steering angle sensor check, and speed sensor check.
- If the skid control ECU detects a malfunction during a sensor signal check, it stores the DTCs in its memory. These DTCs can be read during a sensor check operation by connecting a hand-held tester or 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 warning light.
- If the CAN has a communication error at ECUs or sensors, multiple DTCs are output simultaneously to indicate the malfunction location.

For details of the DTCs that are stored in skid control ECU memory and the DTCs that are output through the sensor signal check functions, see the 2006 RAV4 Repair Manual (Pub. No. RM01M1U).

Fail-safe

- In the event of a malfunction in the ABS and/or Brake Assist controls, the skid control ECU prohibits the ABS, Brake Assist, TRAC, VSC, Auto LSD, Hill-start Assist Control and DAC operations.
- In the event of a malfunction in the TRAC, Auto LSD and/or VSC, the skid control ECU prohibits the TRAC, Auto LSD and VSC operation.
- In the event of a malfunction in the EBD control, the brake system is operated as long as possible even if the ABS control is prohibited. If the EBD control becomes impossible, the brake system warning light illuminates to inform the driver of that. In this case, the brake system is operated in the same condition as the brake system without the brake control system (ABS with EBD, Brake Assist, TRAC, Auto LSD, VSC, Hill-start Assist Control and DAC).
- If a communication malfunction occurs between the skid control ECU and the steering angle sensor, the yaw rate & deceleration sensor or ECM, the skid control ECU stops the TRAC, Auto LSD, VSC, Hill-start Assist Control and DAC.
- When the ECM detects the DTC, it will disable the TRAC, Auto LSD, VSC, Hill-start Assist Control and DAC control.