■ BRAKE CONTROL SYSTEM (ABS with EBD, Brake Assist, TRC and VSC)

1. General

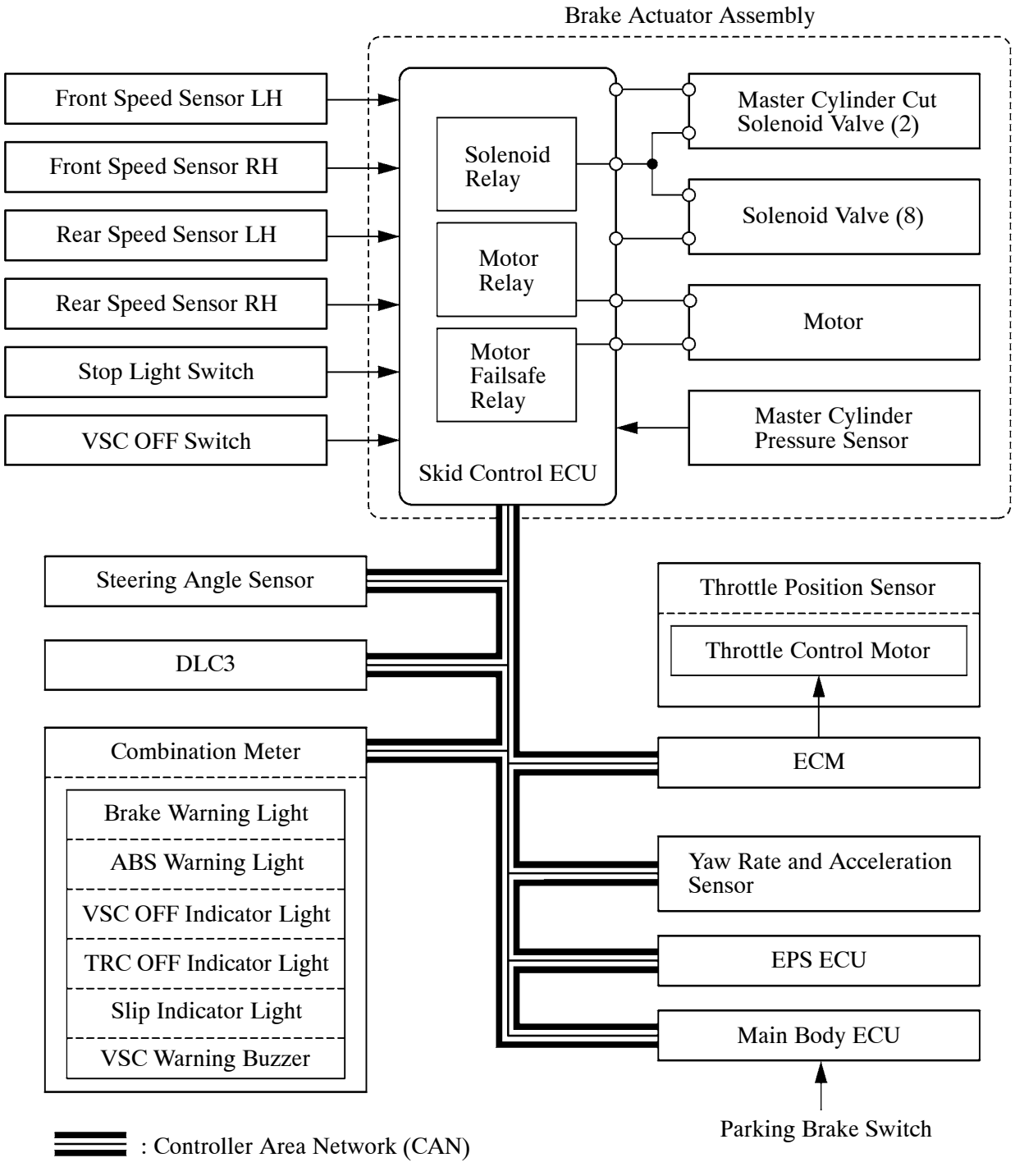
The brake control system (ABS with EBD, Brake Assist, TRC and VSC) of new model has the following functions:

Function	Outline
ABS	The ABS helps prevent the wheels from locking when the brake is applied firmly or applied on a slippery surface.
EBD	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.
TRC	The TRC 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	The VSC helps prevent the vehicle from slipping sideways as a result of strong front wheel skid or strong rear wheel skid during cornering.

Service Tip

When brake control system is activated, the brake pedal could shudder, which is a normal occurrence of the system in operation and should not be considered as a malfunction.

2. System Diagram



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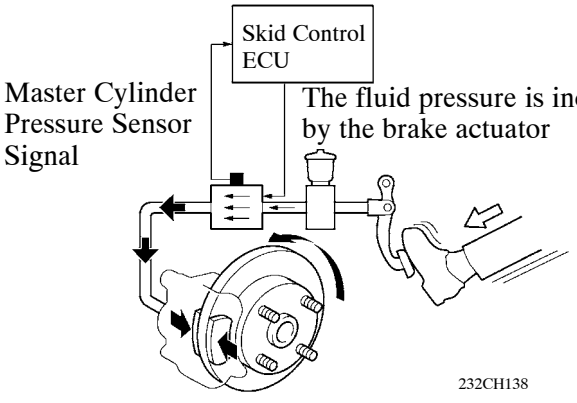
3. Outline of EBD

The detailed outline is the same as that of the brake control system (ABS with EBD).

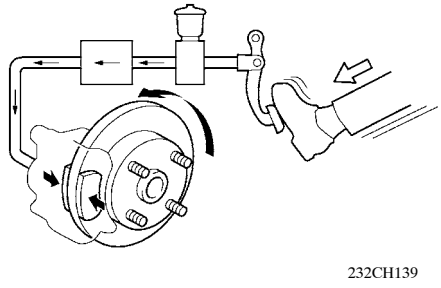
4. Outline of Brake Assist

- 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, driver, 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 dose 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 braking force.

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

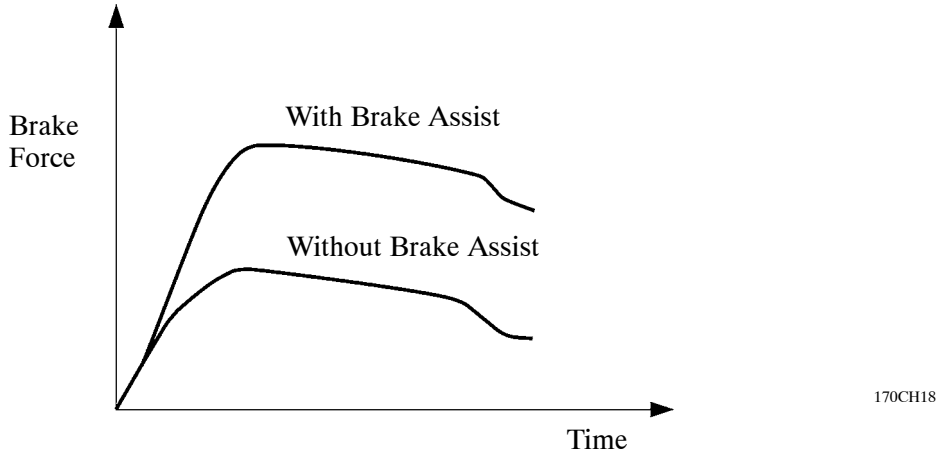


With Brake Assist



Without Brake Assist*

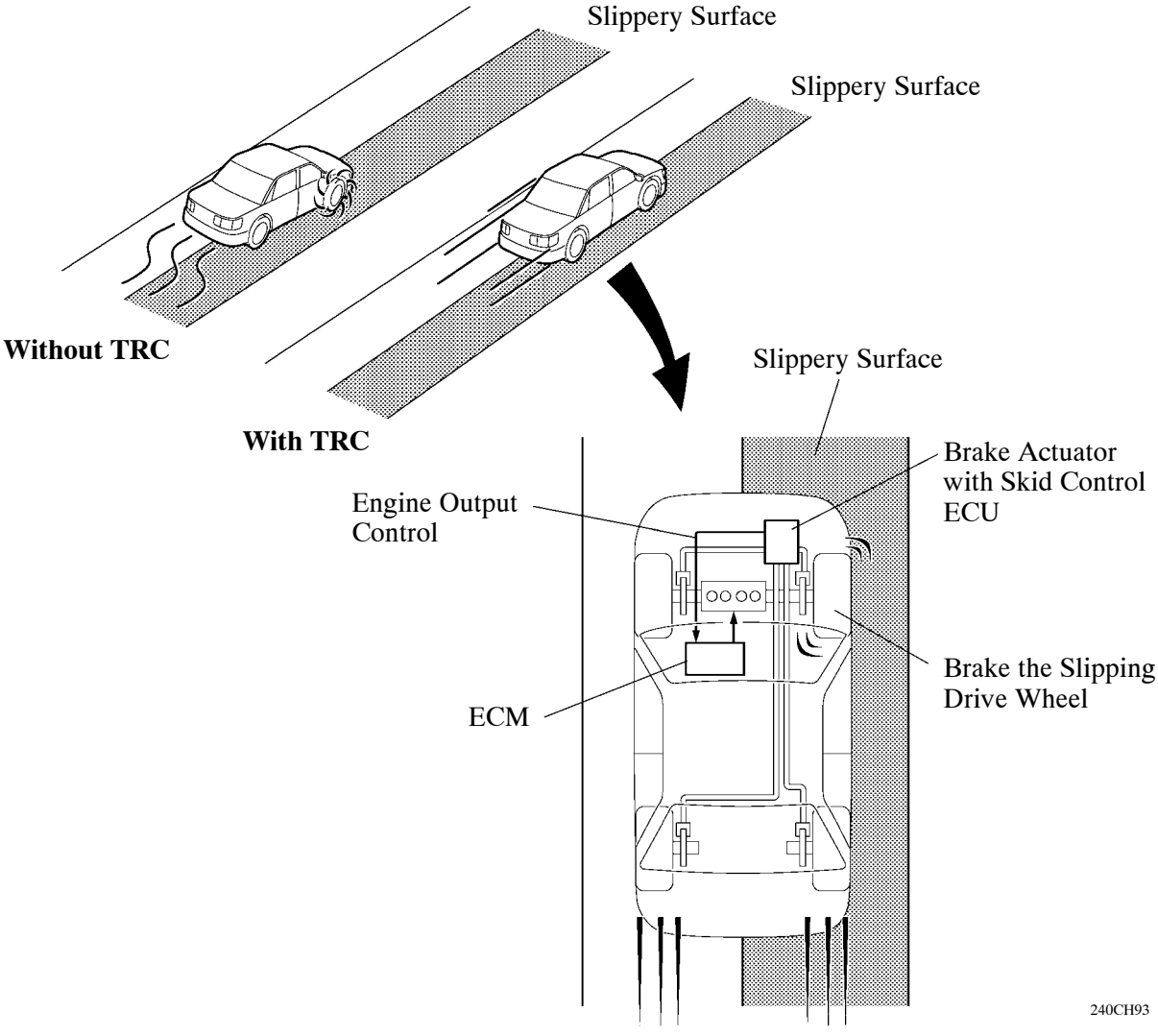
*: The basic performance of the brake is the same as of the models with the brake assist system



5. Outline of TRC

- 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 TRC 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 TRC and the other without. If the driver of each vehicle operates the accelerator pedal in a rough manner while driving over a surface with different surface friction characteristics, the drive wheel on the slippery surface could slip as illustrated. As a result, the vehicle could become unstable.
  However, when the vehicle is equipped with the TRC, 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 to control the engine output. Thus, the system can constantly maintain a stable vehicle posture.

▶ Driving condition on road with different surface friction characteristics ◀

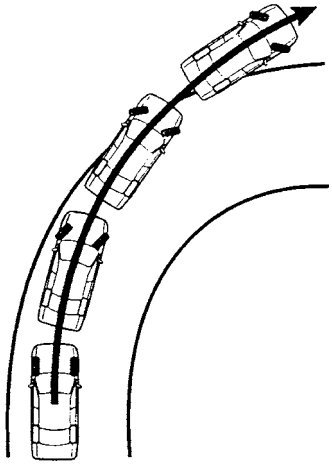


6. Outline of VSC

General

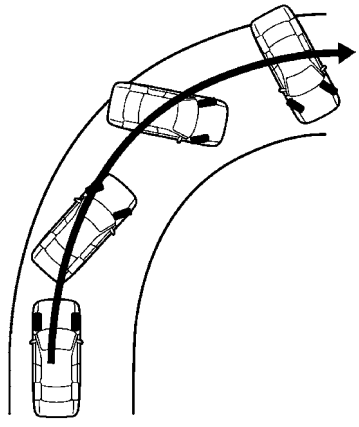
The followings are two examples that can be considered as circumstances in which the tires exceed their lateral grip limit.
The VSC is designed to help control the vehicle behavior by controlling the engine output and the brakes at each wheel when the vehicle is under one of the conditions indicated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



151CH17

Front Wheel Skid Tendency



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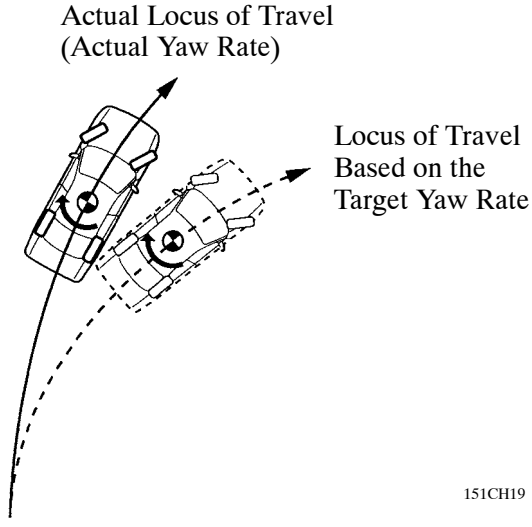
Rear Wheel Skid Tendency

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.

1) Determining Front Wheel Skid

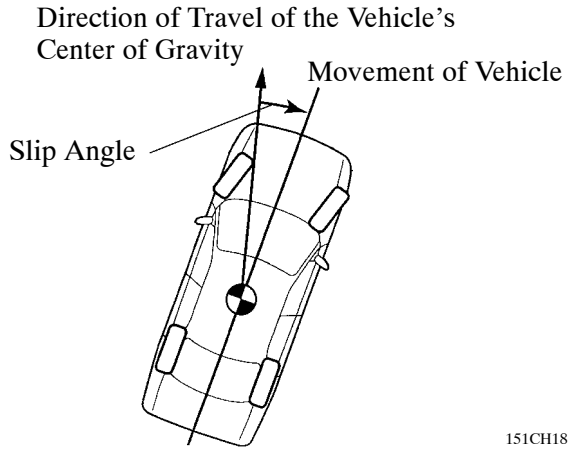
Whether the vehicle is in the state of the front wheel skid or not is determined by the difference between the target yaw rate and the vehicle's actual yaw rate.
When the vehicle's actual yaw rate is smaller than the yaw rate (a target yaw rate that is determined by the vehicle speed and steering angle) 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.



151CH19

2) 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 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.

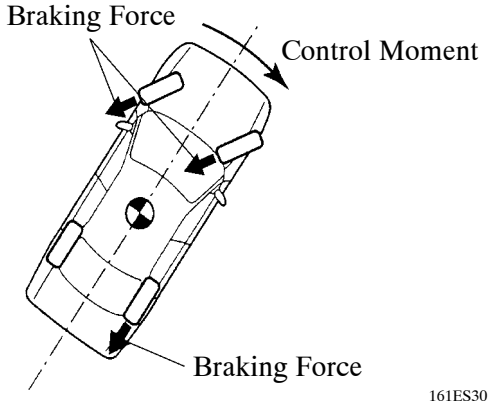


Method for VSC Operation

When the skid control ECU determines that the vehicle exhibits 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.

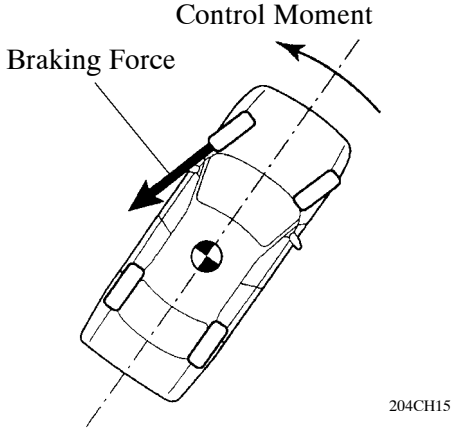
1) Dampening a Strong Front Wheel Skid

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.

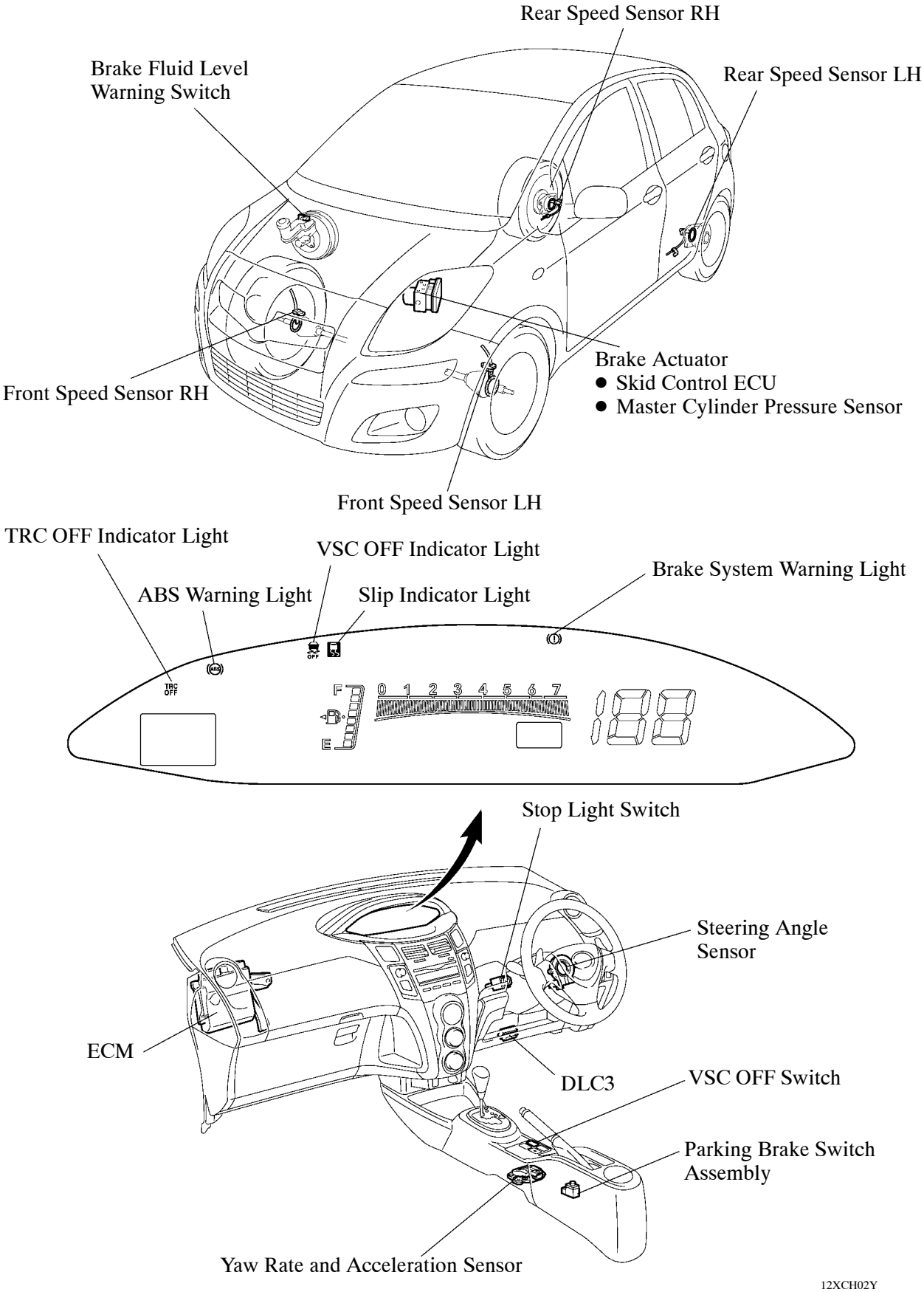


2) Dampening a Strong Rear Wheel Skid

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 braking force, the excellent vehicle's stability is ensured.
In some cases, the skid control ECU applies the brake of the rear wheels as necessary.



7. Layout of Main Components

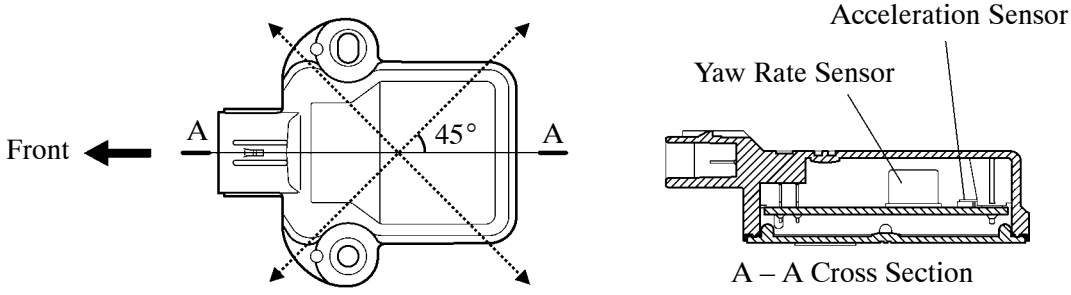


8. Function of Main Components

Component		Function
Combination Meter	ABS Warning Light	Lights up to alert the driver when the skid control ECU detects the malfunction in the ABS, EBD or Brake Assist system.
	VSC OFF Indicator Light	Illuminates to inform the driver of "VSC-off mode" being selected.
	TRC OFF Indicator Light	Illuminates to inform the driver of "TRC-off mode" being selected.
	Slip Indicator Light	Blinks to inform the driver when the TRC or the VSC is operated.
	Brake System Warning Light	● Lights up together with the ABS warning light to alert the driver when the skid control ECU detects the malfunction in the EBD. ● Lights up to alert the driver when the brake fluid level is low. ● Lights up to inform the driver when the parking brake lever is pulled up.
VSC Warning Buzzer		Emits an intermittent sound to inform the driver that the skid control ECU detects a strong front wheel skid tendency or strong rear wheel skid tendency.
Brake Fluid Level Warning Switch		Detects the brake fluid level.
Stop Light Switch		Detects the brake pedal depressing signal.
Parking Brake Switch		Detects when the parking brake lever is pulled up.
VSC OFF Switch		Enables the driver to select the "normal mode", "TRC-off mode", or "VSC-off mode".
Speed Sensor (4)		Detects the wheel speed of each 4 wheels.
Yaw Rate and Acceleration 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 Actuator	Skid Control ECU	Judges the vehicle driving conditions based on the signals from each sensor and sends brake control signals to the brake actuator and engine output control signals to the ECM.
	Solenoid Valve (10)	Changes the fluid path based on the signals from the skid control ECU during the operation of the ABS with EBD, Brake Assist, TRC and VSC in order to control the fluid pressure that is applied to the wheel cylinders.
	Motor	Drives the pumps inside the brake actuator.
	Solenoid Relay	Supply power to the solenoid valves.
	Motor Relay	Supplies the power to the motor.
	Motor Failsafe Relay	Cuts the power to the motor when the motor relay malfunctions.
	Master Cylinder Pressure Sensor	Assembled in the brake actuator and detects the master cylinder pressure.
ECM		● Based on the signals receives from the skid control ECU, controls the engine output. ● Also, sends the accelerator pedal position signal and the engine speed signal to the skid control ECU.

9. Yaw Rate and Acceleration Sensor

- The yaw rate sensor is built into the acceleration sensor.
- The yaw rate sensor detects acceleration in the horizontal forward-backward and left-right directions using the signals from 2 acceleration sensors, which are fitted at an angle of 45° to the front and back directions of the vehicle body and transmits signals to the skid control ECU.

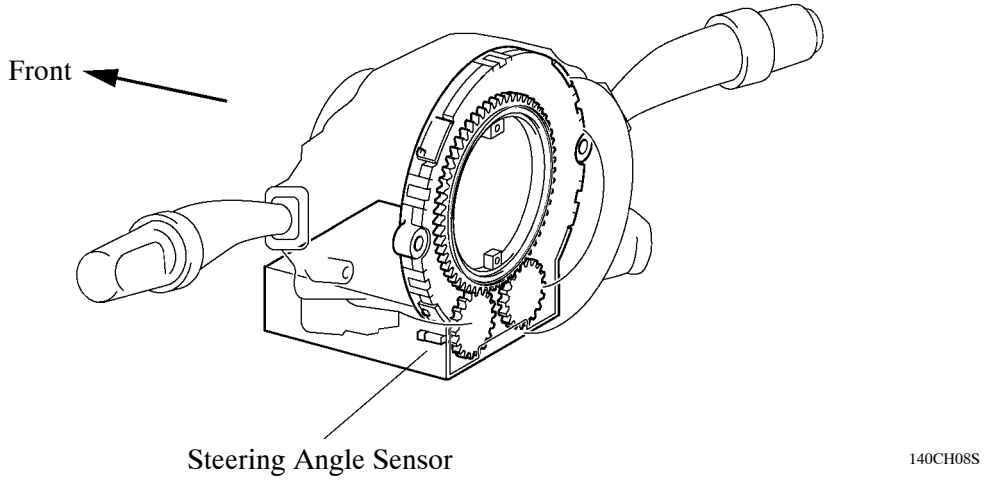


Service Tip

After replacing the yaw rate sensor or the skid control ECU, initialization of the yaw rate sensor is required. For the actual procedure, refer to the Yaris Repair Manual (Pub. No. RM00S8E).

10. Steering Angle Sensor

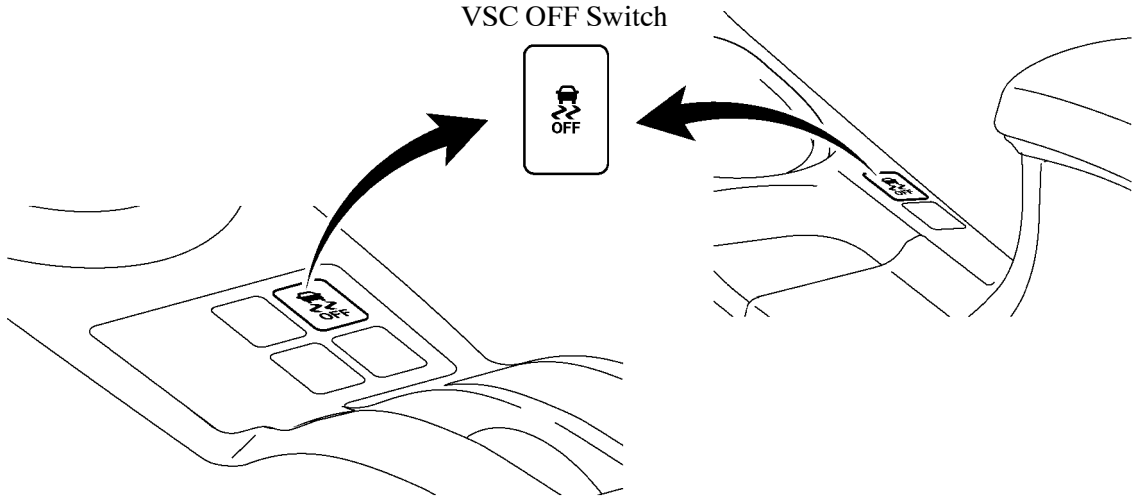
- The steering angle sensor detects the steering direction and angle of the steering wheel and transmits this signal to the skid control ECU.
- The sensor assembly contains 2 sets of magnetic reluctance elements that detect the rotational movement of a magnet that is built into the detection gear. Thus, the sensor detects the changes that occur in the magnetic reluctance elements along with the rotational movement of the detection gear, in order to detect the rotational movement of the steering wheel.



11. VSC OFF Switch

General

The control of the TRC and VSC can be stopped by the VSC OFF switch. While the vehicle is running off the shoulder of the road or running on the dirt road, the engine output control is stopped to maintain drive force.



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Operation of VSC OFF Switch

- The VSC OFF switch can be used to select the “TRC-off mode” or “TRC and VSC-off mode”.
- The TRC-off mode can be selected by pressing the VSC OFF switch. To select the TRC and VSC-off mode, the switch need to be pressed and held for 3 seconds or more while the vehicle is stationary.
- Both modes can be canceled either by operating the VSC OFF switch or turning the ignition switch off. In addition, the TRC-off mode is automatically canceled if the vehicle speed exceeds a predetermined speed.
- A selected mode is indicated by the indicator light illumination in the combination meter as shown in the table below.

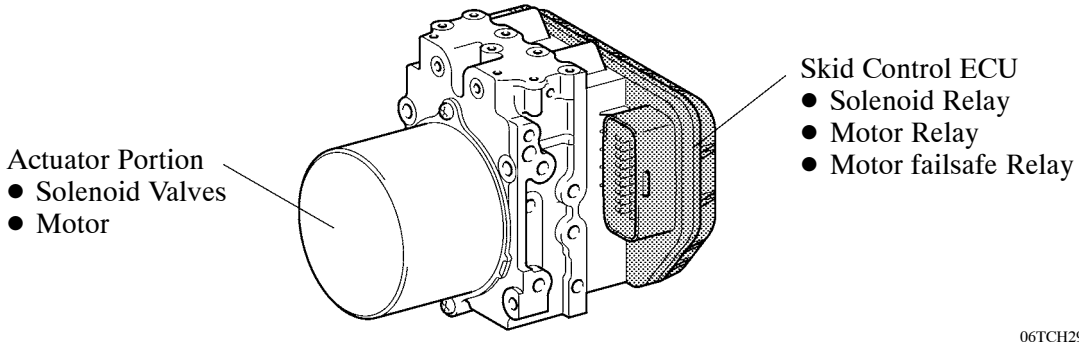
○: Illuminate

Item	VSC OFF Indicator Light	TRC OFF Indicator Light
TRC-off Mode	—	○
TRC and VSC-off Mode	○	○

12. Brake Actuator

General

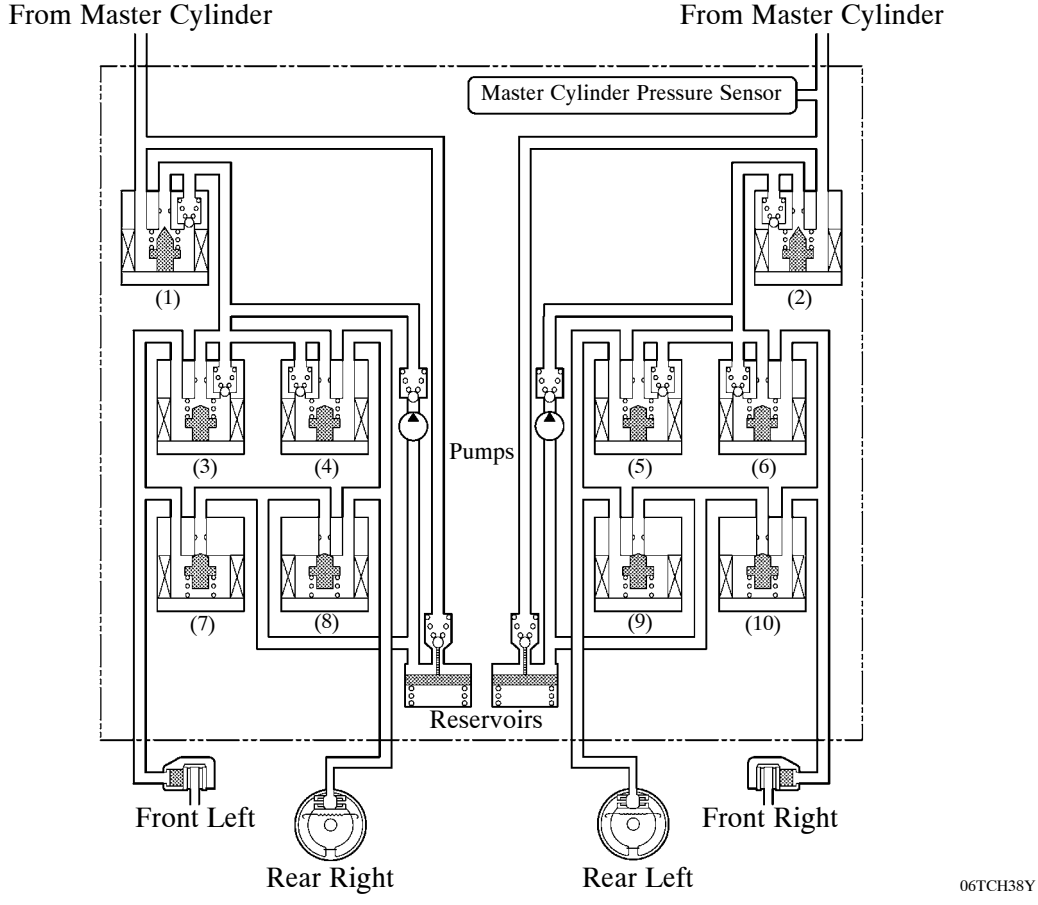
- The brake actuator consists of the actuator portion (solenoid valves and motor) and skid control ECU.
- The 3 relays (solenoid relay, motor relay and motor failsafe relay) are built into the skid control ECU.



Actuator Portion

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

▶ Hydraulic Circuit ◀



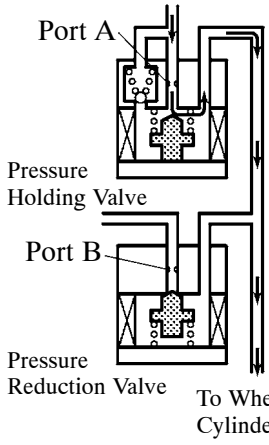
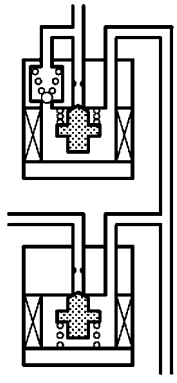
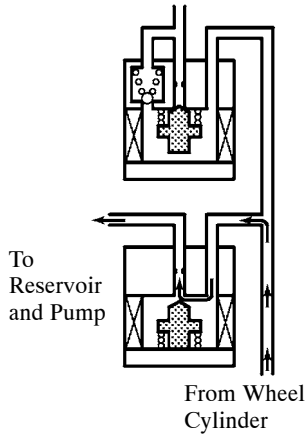
13. System Operation

Normal Braking Operation

During normal braking, all solenoid valves are remained OFF.

ABS with EBD Operation

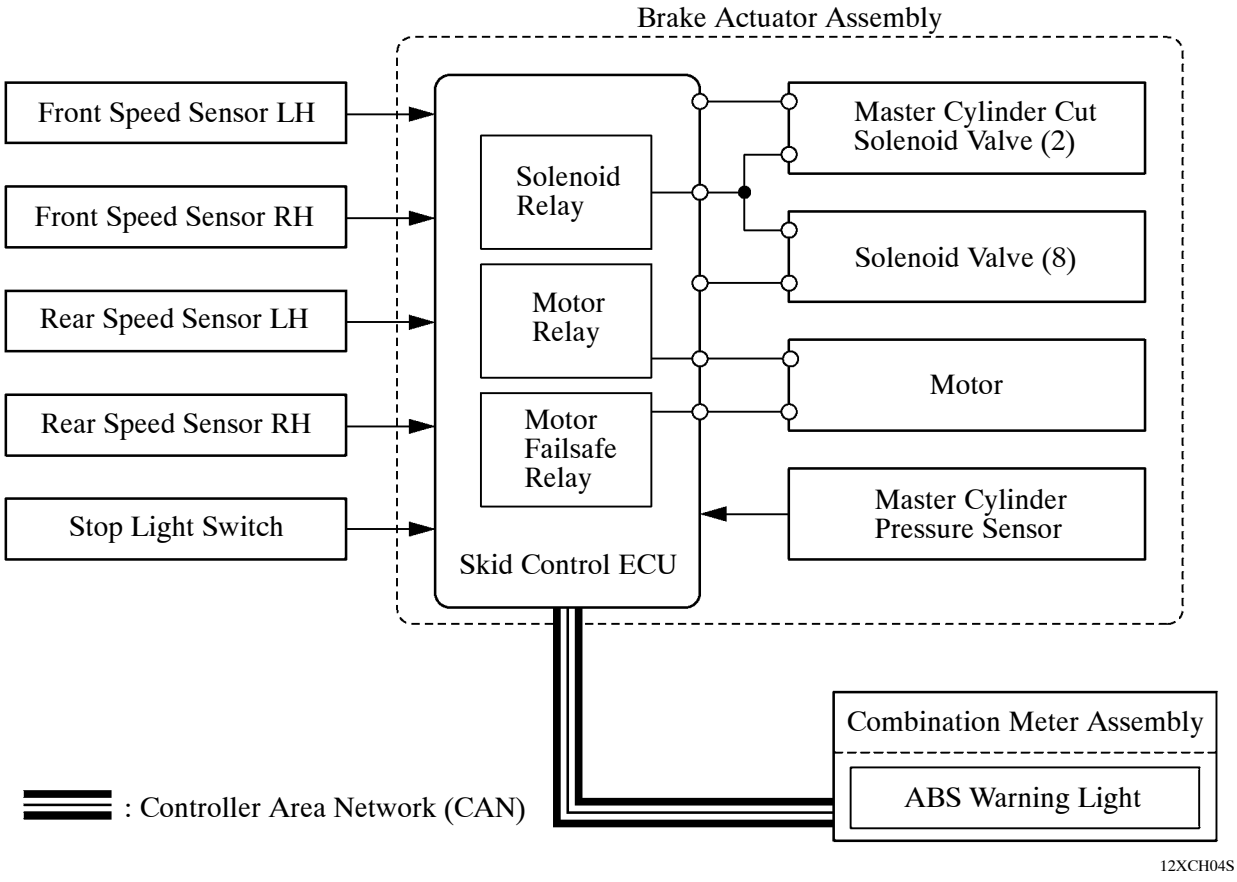
Based on the signals received from the 4 speed sensors, the skid control ECU calculates each wheel speed and deceleration and checks wheel slipping condition.
According to the slipping condition, the ECU controls the pressure holding solenoid valve and pressure reduction solenoid valve in order to adjust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

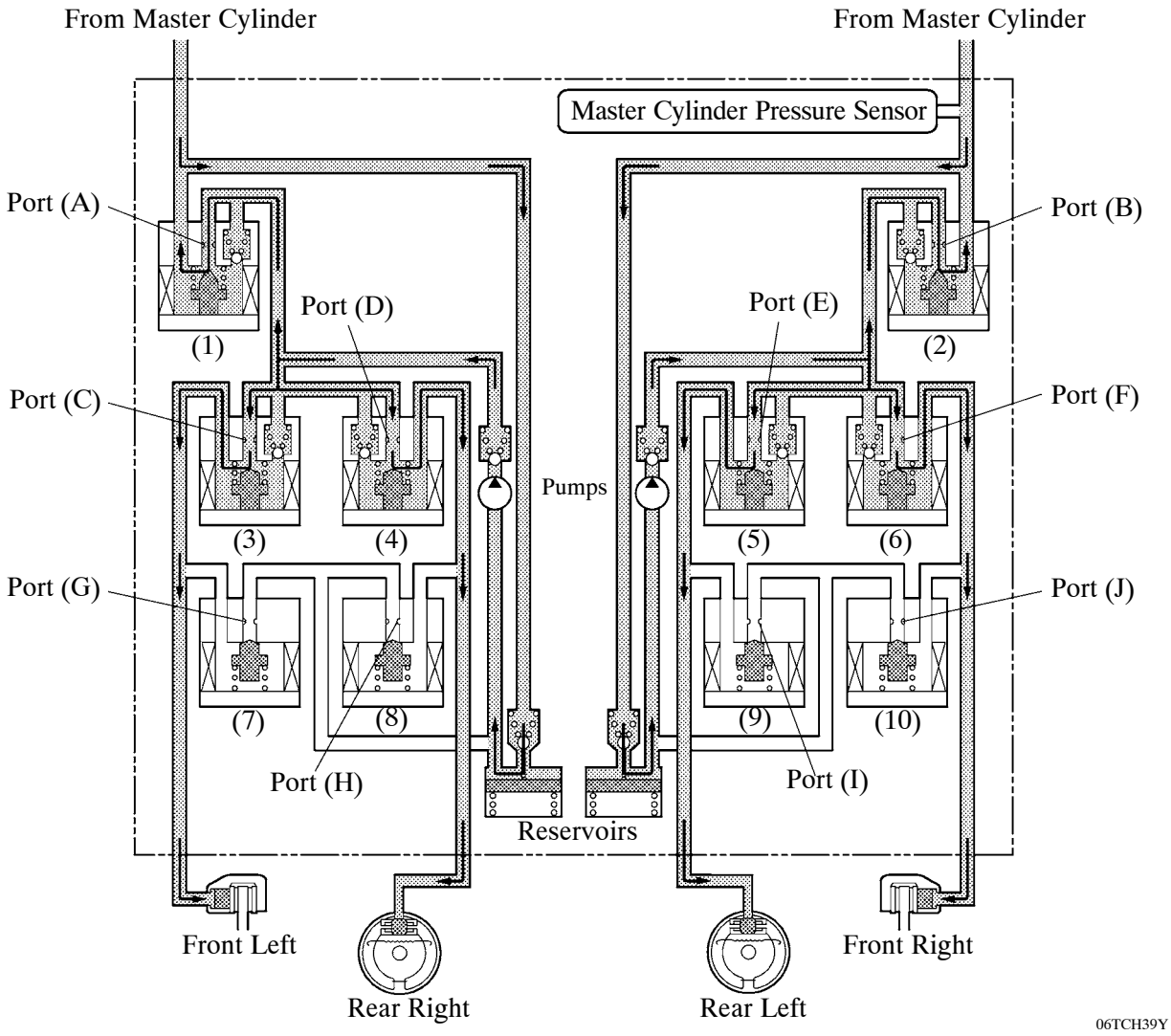
Brake Assist Operation

- 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, the fluid 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.
- When the Brake Assist is activated, each solenoid valve operates as shown in the table on the next page.

▶ System Diagram ◀



▶ Brake Assist Operation ◀



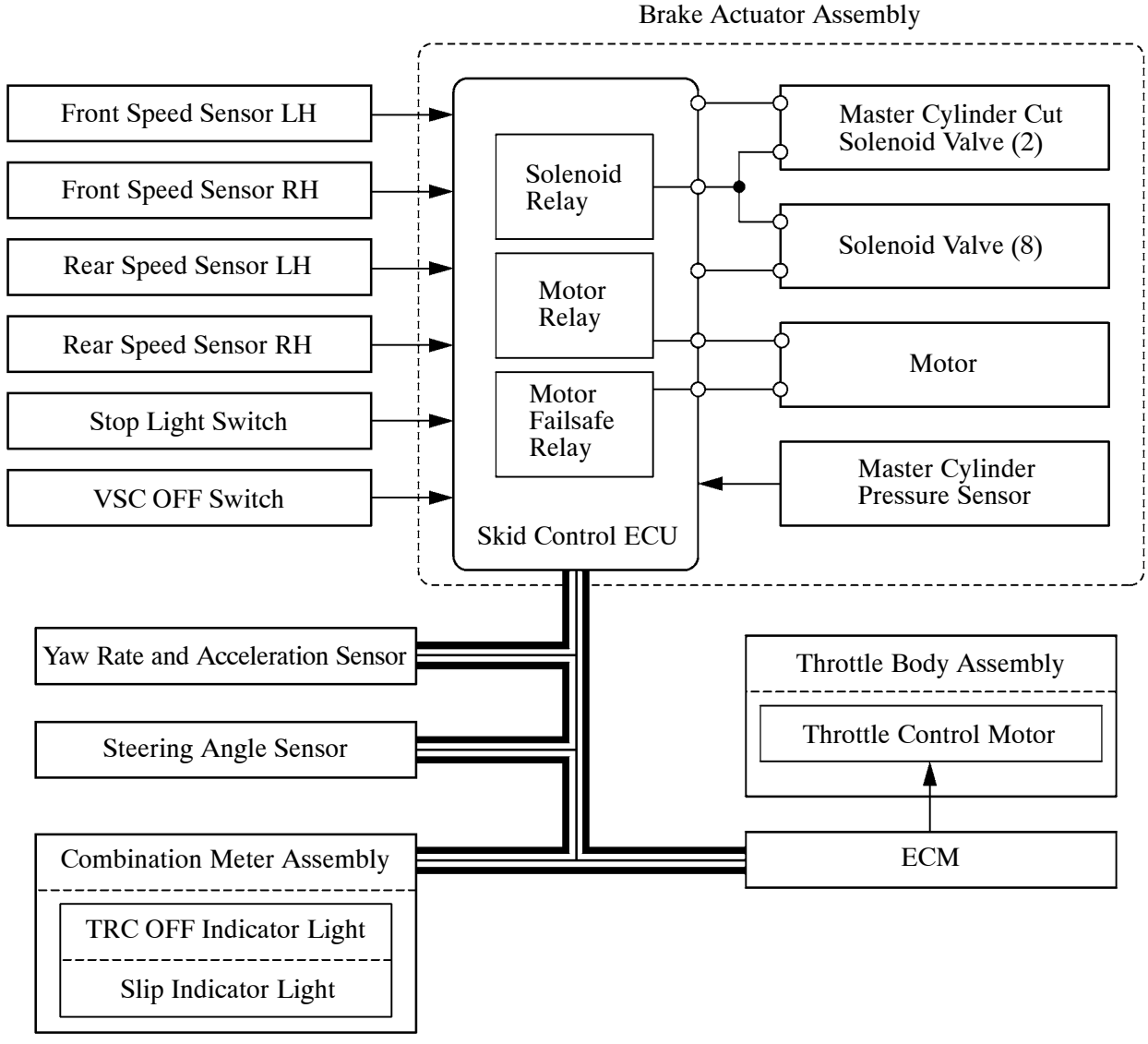
Item		Port	Brake Assist Not Activated	Brake Assist Activated
(1) (2)	Master Cylinder Cut Solenoid Valve	(A) (B)	OFF (Open)	ON*
(3) (4) (5) (6)	Pressure Holding Solenoid Valve	(C) (D) (E) (F)	OFF (Open)	←
(7) (8) (9) (10)	Pressure Reduction Solenoid Valve	(G) (H) (I) (J)	OFF (Close)	←
Pump			OFF	ON

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

TRC Operation

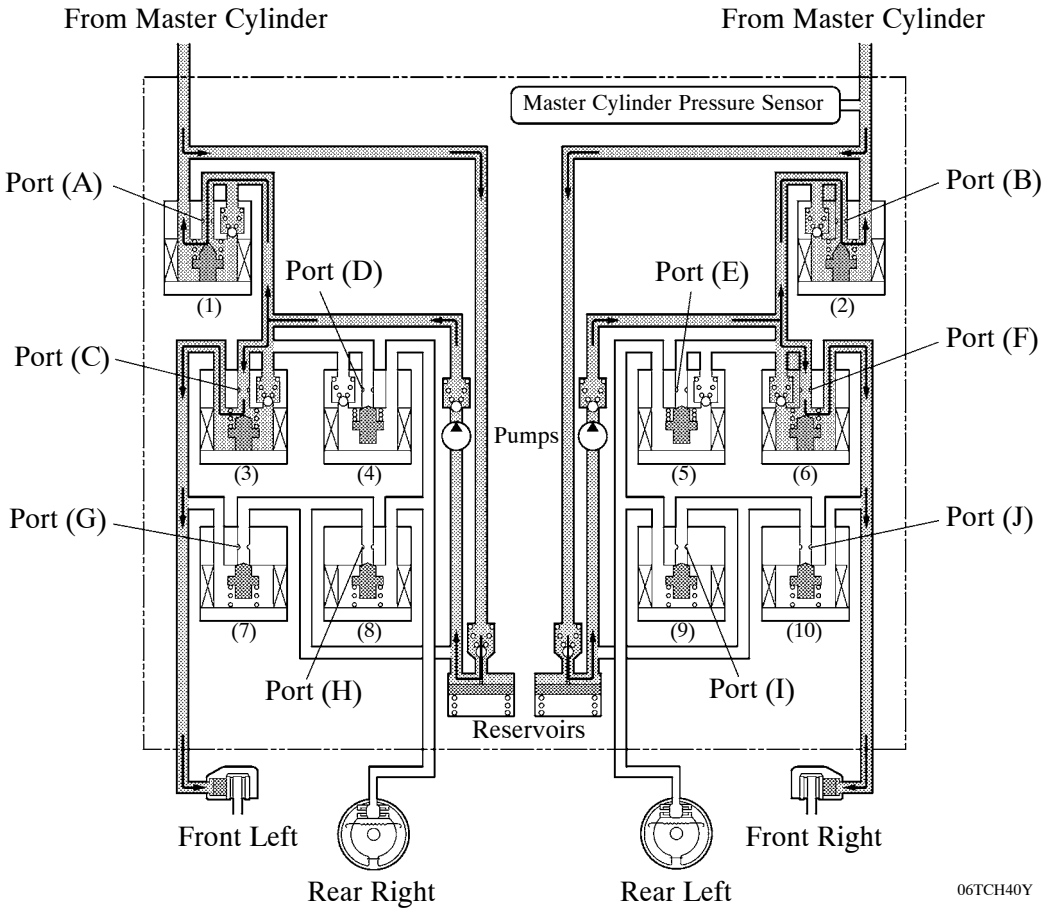
- The fluid pressure generated by the pump is regulated by the master cylinder cut solenoid valve to the required pressure. Thus, the wheel cylinders of the drive wheels are controlled in the following 3 modes: pressure reduction, pressure holding and pressure increase modes, to control the slippage of the drive wheels.
- The hydraulic circuit on the next page shows the hydraulic circuit in the pressure increase mode when the TRC is activated.
- In other operating modes, the pressure holding solenoid valve and the pressure reduction solenoid valve are turned on/off according to the ABS operation pattern described on the previous page.
- When the TRC is activated, each solenoid valve operates as shown in the table on the next page.

▶ System Diagram ◀



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▶ TRC Operation (Pressure Increase Mode) ◀



Item			Port	TRC Not Activated	TRC 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)	←	←	←
	Wheel Cylinder Pressure	Right	—	—	—	—	—
		Left	—	—	—	—	—
Pump				OFF	ON	←	←

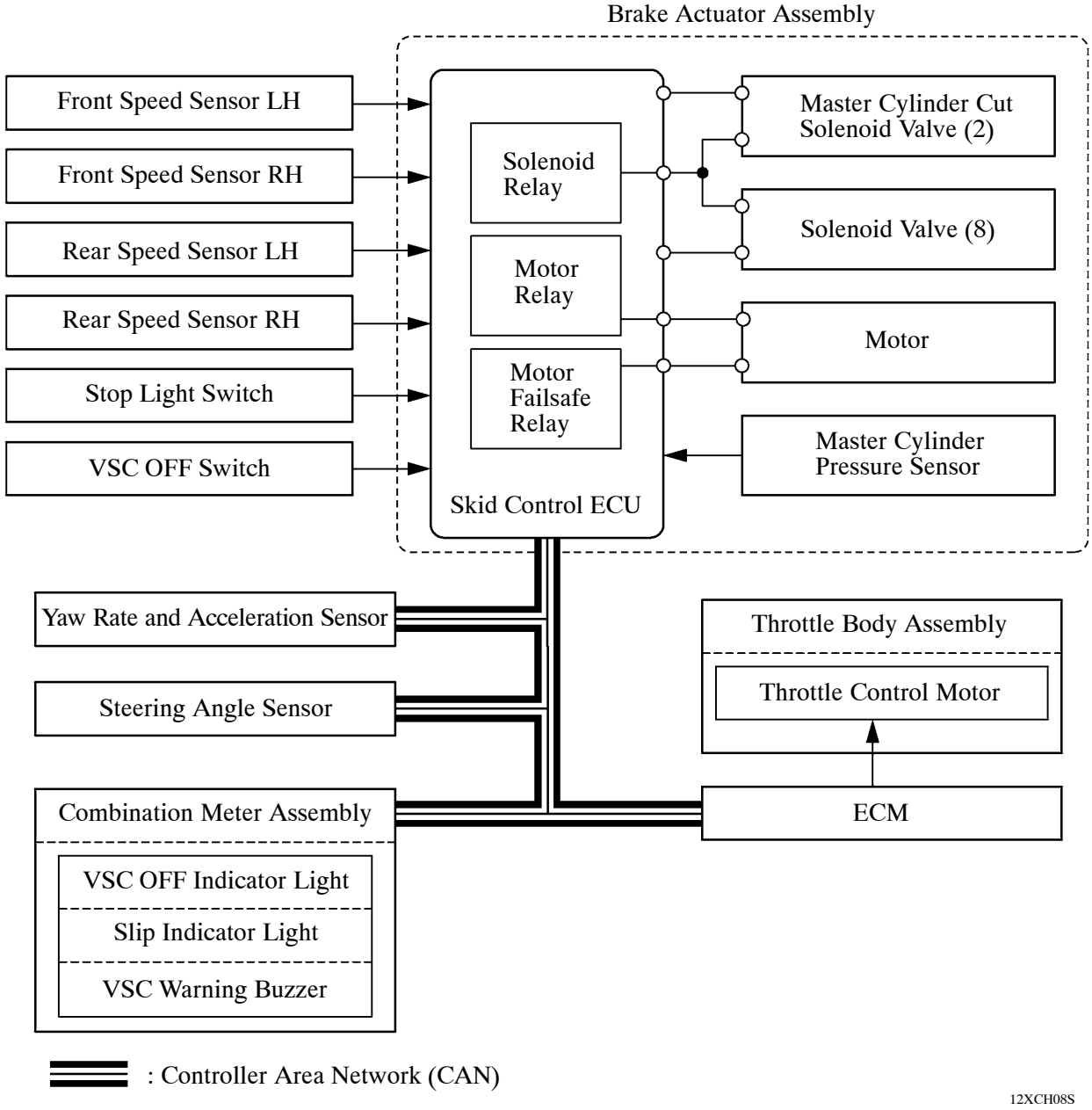
*: The solenoid valve controls the hydraulic pressure between “open” and “close” according to the operating condition by adjusting continually.

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 to front wheel skid or rear wheel skid is controlled.

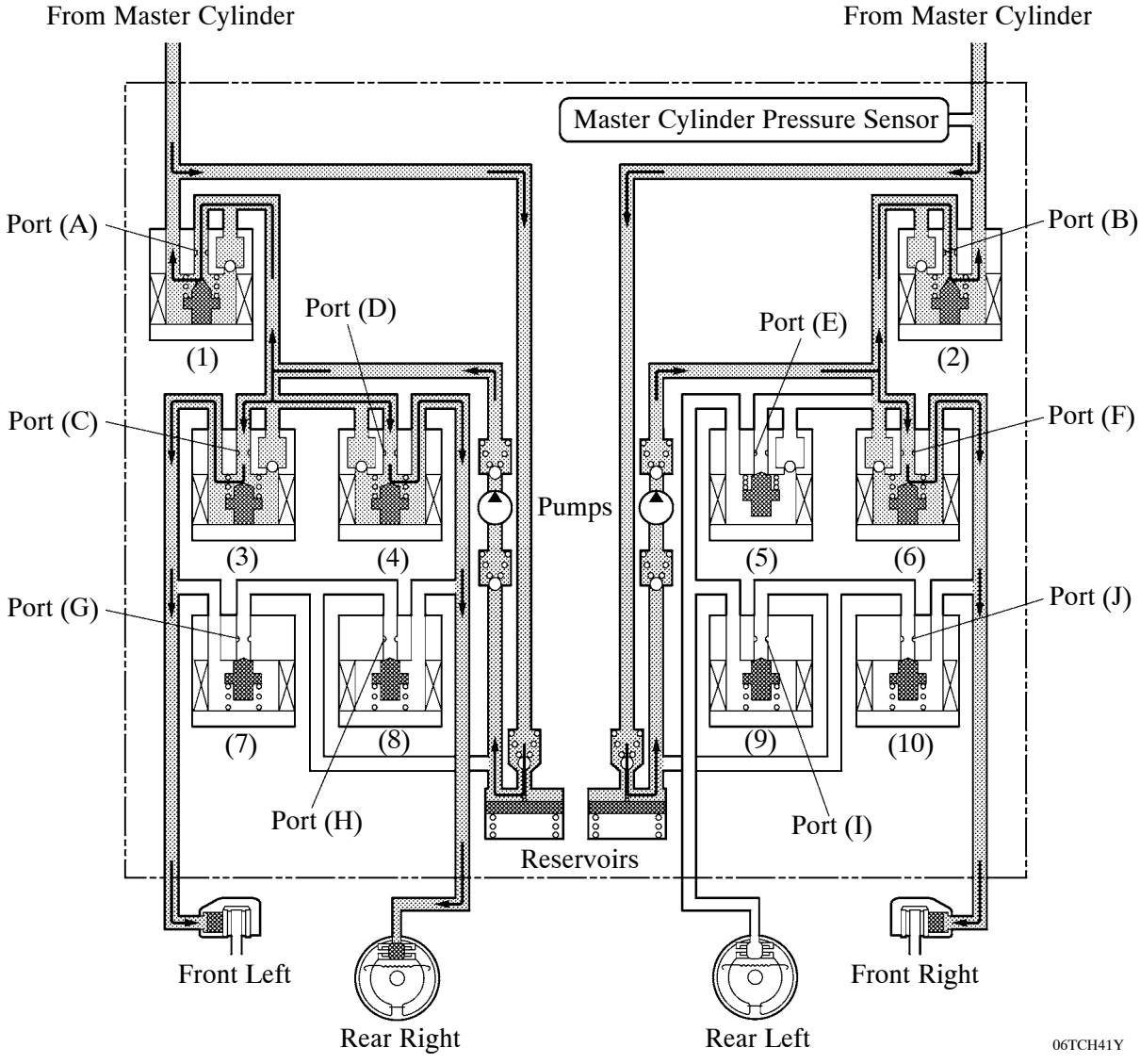
▶ System Diagram ◀



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

- In the front wheel skid restraining control, the brake 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 hydraulic circuit 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 solenoid valve and the pressure reduction solenoid valve are turned on/off according to the ABS operation pattern described on the previous page.
- When the front wheel skid restraining control is activated, each solenoid valve operates as show in the table on the next page.

▶ Pressure Increase Mode ◀



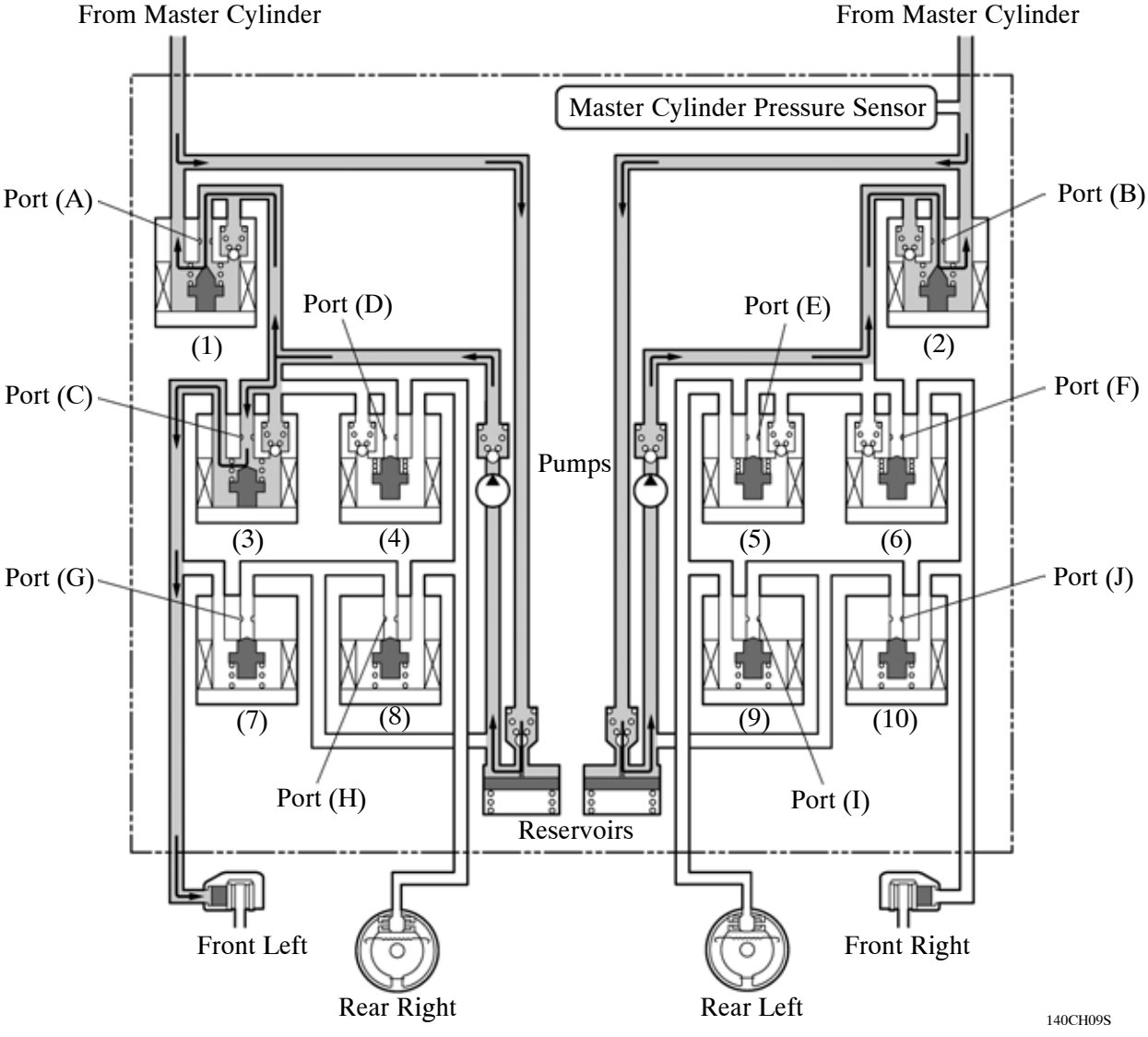
Item			Port	VSC Not Activated	VSC Activated		
					Increase Mode	Holding Mode	Reduction Mode
(1) (2)		Master Cylinder Cut Solenoid Valve	(A) (B)	OFF (Open)	ON*	←	←
Front Brake	(3)	Pressure Holding Solenoid Valve	(C)	OFF (Open)	←	ON (Close)	←
	(6)		(F)	OFF (Open)	←	ON (Close)	←
	(7)	Pressure Reduction 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.

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

- In the rear wheel skid restraining control, the brakes 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 wheel even if the wheel is targeted for braking.
- The hydraulic circuit 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 solenoid valve and the pressure reduction solenoid valve are turned on/off according to the ABS operation pattern described on the previous page.
- When the rear wheel skid restraining control is activated, each solenoid valve operates as shown in the table on the next page.

▶ Pressure Increase Mode ◀

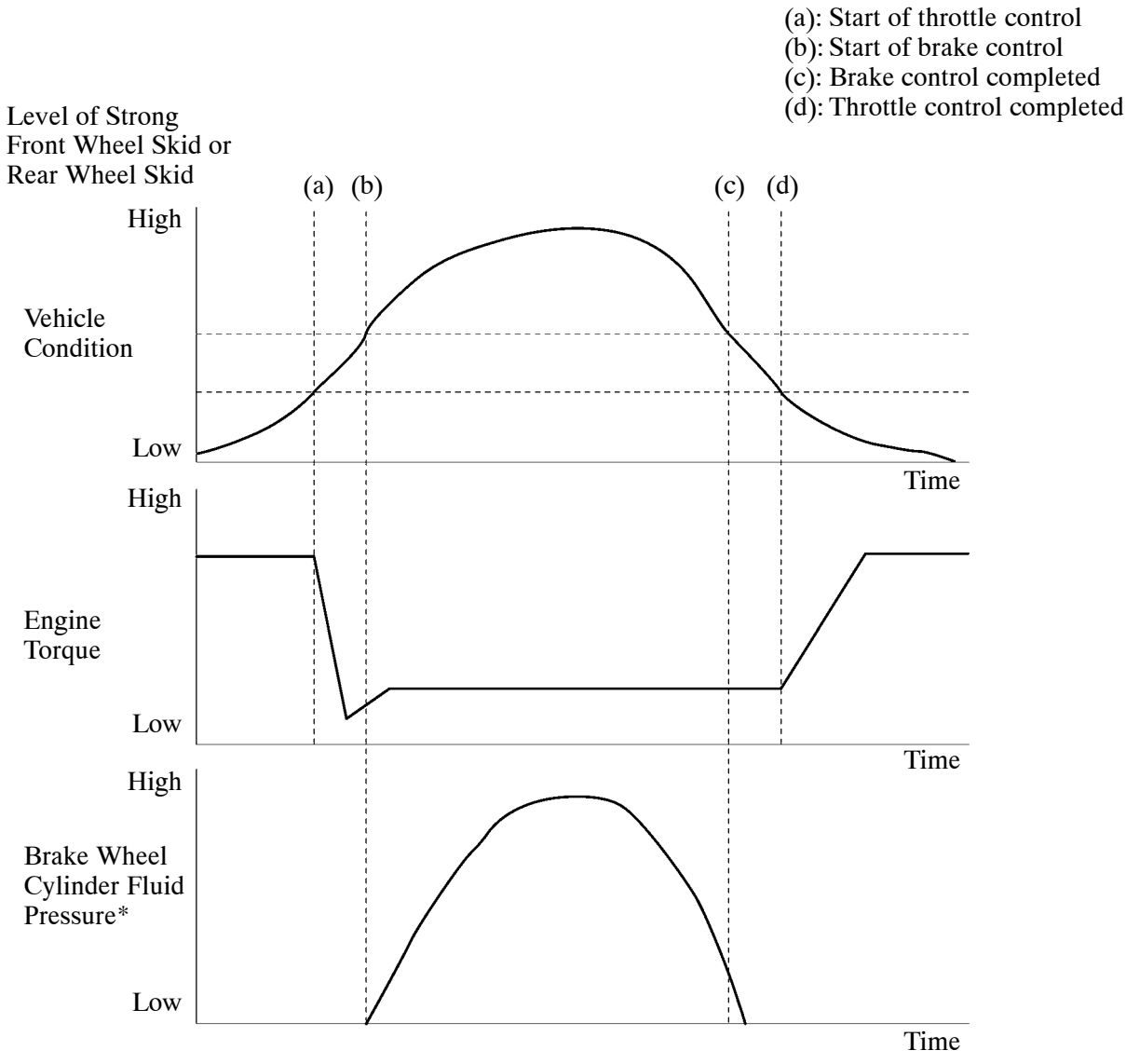


Item			Port	VSC Not Activated	VSC Activated		
					Increase Mode	Holding Mode	Reduction Mode
(1)		Master Cylinder Cut Solenoid Valve	(A)	OFF (Open)	ON*	←	←
(2)			(B)	OFF (Open)	←	←	←
Front Brake	(3)	Pressure Holding Solenoid Valve	(C)	OFF (Open)	←	ON (Close)	←
	(6)		(F)	OFF (Open)	ON (Close)	←	←
	(7)	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.

Engine Output Control

During the TRC or VSC operation, the skid control ECU outputs the engine output control signal to the ECM. Upon receiving this signal, the ECM uses throttle control to regulate the engine output.



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

Initial Check

After the ignition switch is turned on and the vehicle attains an approximate speed of 6 km/h (4 mph) or more only at first time, 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.

14. Diagnosis

- If the skid control ECU detects a malfunction in the brake control system (ABS with EBD, Brake Assist, TRC and VSC), then the ABS warning light, brake warning light, or slip indicator light illuminate either individually or as a group according to the function in which the malfunction has been detected, to alert the driver of the malfunction.
- At the same time, Diagnostic Trouble Code (DTC) is stored in memory of the skid control ECU. This DTC can be read by the following method.
  - The 2-digit DTC can be read from number of the blinking of 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 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, refer to the Yaris Repair Manual (Pub. No. RM00S8E).

15. Fail-safe

- In the event of a malfunction in the ABS or Brake Assist, the skid control ECU prohibits the ABS, Brake Assist, TRC and VSC operations.
- In the event of a malfunction in the EBD, the skid control ECU prohibits the EBD operation. Thus, the brake will be operated in the same condition as the brake system without the brake control system (ABS with EBD, Brake Assist, TRC and VSC)
- In the event of a malfunction in the TRC or VSC, the skid control ECU prohibits the TRC and VSC operations.
- When the ECM detects the DTC, it will disable the engine output control for the TRC and VSC.