■BRAKE CONTROL SYSTEM

1. General

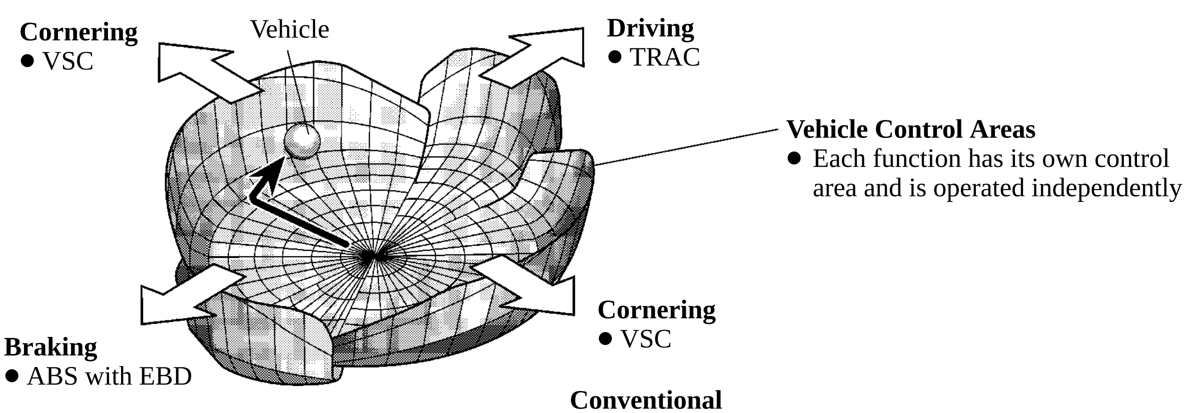
- A brake management function, VDIM (Vehicle Dynamics Integrated Management), which delivers comprehensive vehicle movement control, is used.
- An ECB (Electronically Controlled Brake System) is used.
- The brake control system is controlled by the skid control ECU.

2. VDIM (Vehicle Dynamics Integrated Management)

General

- The VDIM manages all functions, such as the ABS with EBD, the Brake Assist, the TRAC, and the VSC. And is operated by the ECB (Electronically Controlled Brake System), which regulates brake fluid pressure. In addition, the regenerative brake cooperative control and power steering cooperative control functions are also available, thus allowing the VDIM to perform the comprehensive management.
- Conventional brake control systems begin to control either the braking or motive force in order to stabilize the vehicle motion, when it becomes unstable due to loss of tire traction. In contrast, in order to maintain stable vehicle control, the VDIM commences controlling the brake, hybrid and steering systems in accordance with changes in balance before the vehicle becomes unstable. As a result, maintenance smooth vehicle control is achieved.
- Conventional brake control systems manage all related functions, such as the ABS with EBD, the Brake Assist, the TRAC and the VSC, independently, according to the vehicle dynamics. In contrast, the VDIM provides smooth control by seamlessly integrating all brake control related functions.

▶ Conceptual Diagram of Control Management ◀



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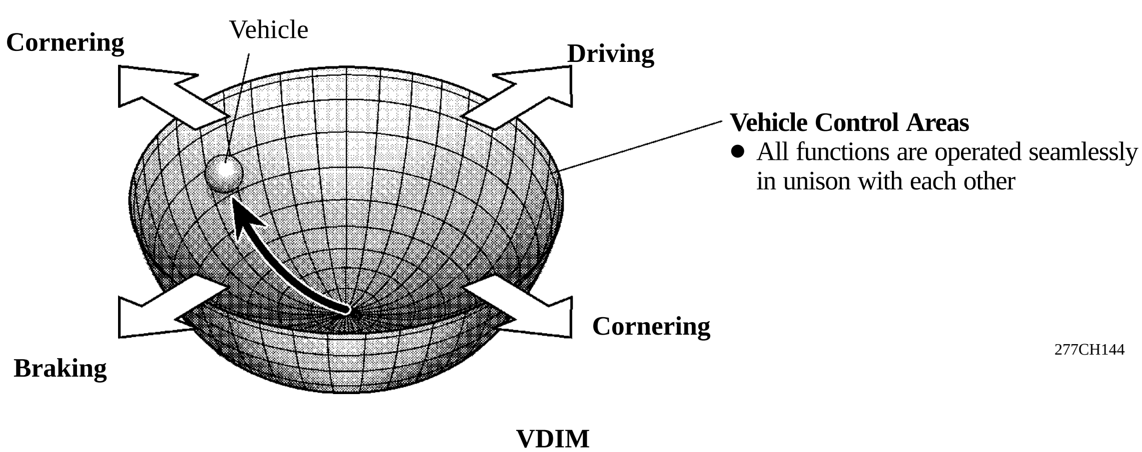

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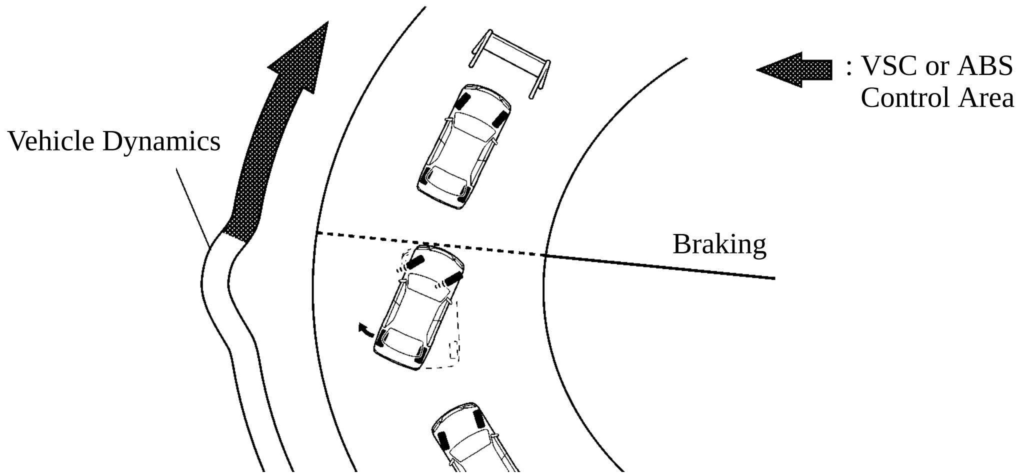
Examples of Control Operation

1) General

The difference in vehicle control during harsh braking situations while cornering, with the VDIM and conventional brake control systems, is as follows:

2) Conventional

Conventional brake control systems calculate vehicle motion based on signals transmitted by yaw rate and deceleration sensors, the speed sensors and the steering sensor, and activates VSC systems when vehicles are determined to be skidding. If the driver brakes suddenly, brake control systems perform assisting control to stabilize the vehicle dynamics, by activating the ABS system when a locked wheel is detected, or by affecting the VSC system when skidding is detected.



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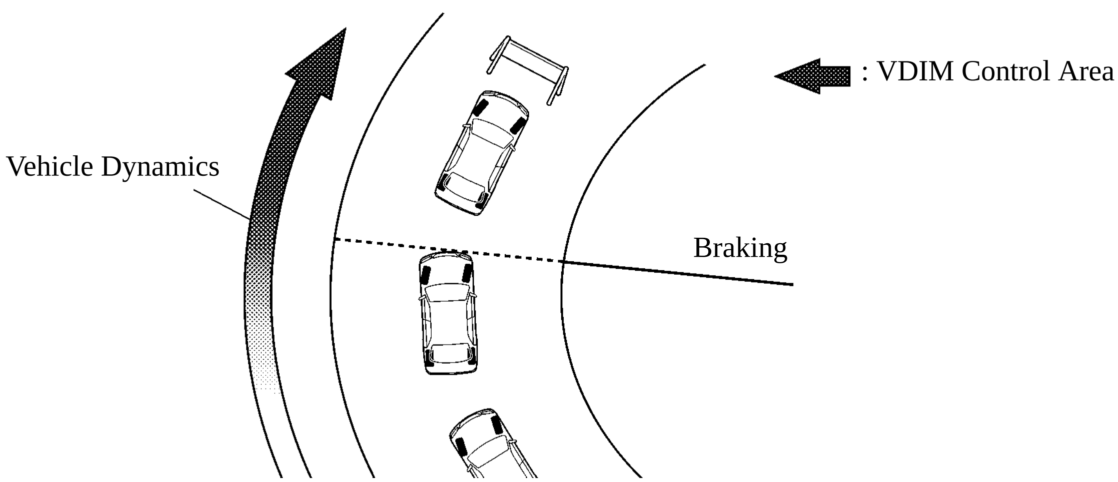
Harsh Braking

3) VDIM

The VDIM also calculates vehicle motion based on signals from the yaw rate and deceleration sensor, speed sensors and steering sensor. When the calculations indicate that the vehicle is likely to skid, the VDIM begins vehicle control with the VSC function. In addition, if the driver brakes suddenly, the VDIM reduces vehicle instability to a minimum and assists in achieving optimum driving stability by seamlessly delivering a suitable combination of the VSC and ABS functions.



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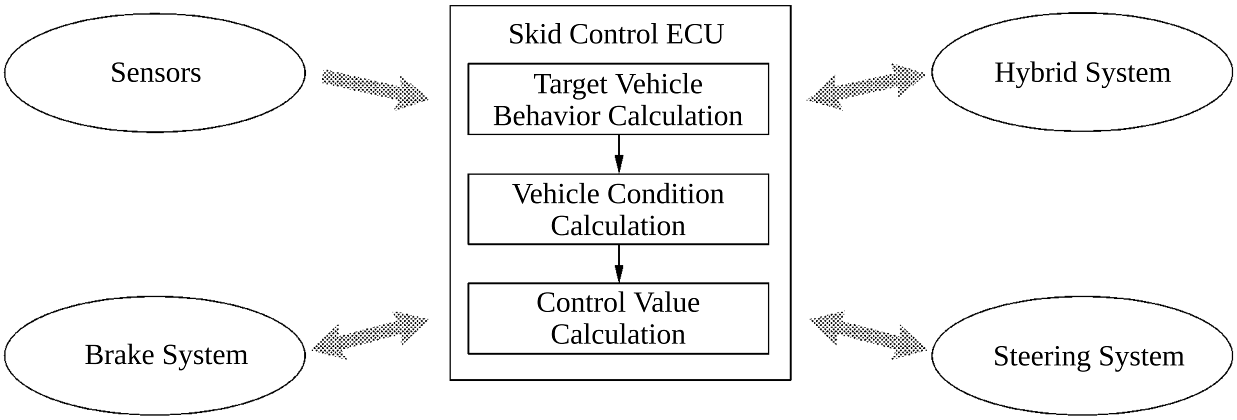
Harsh Braking

Control Configuration of VDIM



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Function

The brake control system of the ’07 Camry Hybrid model has a following function:

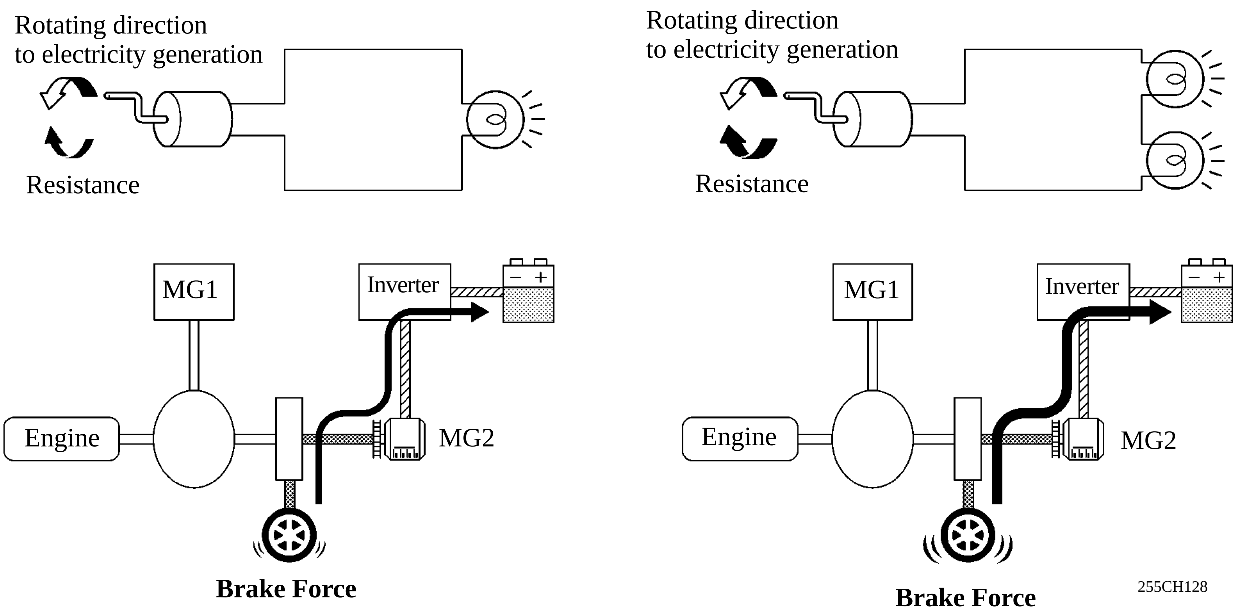
Brake Control System	Function		Outline
VDIM	Regenerative Brake Cooperative Control		Controls hydraulic braking in order to recover electrical energy by utilizing the regenerative brake of the THS II as much as possible.
	Power Steering Cooperative Control		Effects cooperative control with the EPS ECU in order to provide steering assist in accordance with the operating conditions of the vehicle.
	ECB*		● This system electrically detects the operation information for the brake pedal and generates an appropriate amount of hydraulic brake. ● Executes the hydraulic control of the brake control functions based on the VDIM.
		VSC (Vehicle Stability Control)	The VSC function helps prevent the vehicle from slipping sideways as a result of strong front wheel skid or strong rear wheel skid during cornering.
		TRAC (Traction Control)	The TRAC function helps prevent the drive wheels from slipping if the driver presses the accelerator pedal excessively when starting off or accelerating on a slippery surface.
		ABS (Anti-lock Brake System)	The ABS helps prevent the wheels from locking when the brakes are applied firmly or when braking on a slippery surface.
		EBD (Electronic Brake Force Distribution)	The EBD control utilizes ABS, realizing the proper brake force distribution between front and rear wheels in accordance with the driving conditions. In addition, during cornering braking, it also controls the brake forces of right and left wheels, helping 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 the vehicle’s brake performance.

*: ECB (Electronically Controlled Brake System)

Outline of Regenerative Brake Cooperative Control Function

1) General

- Regenerative brake consists of a resistance force that is generated at the rotational axle in the reverse direction of the rotation of the generator (MG2) that is generating electricity. The greater the generated amperage (battery charging amperage), the greater will be the resistance force.

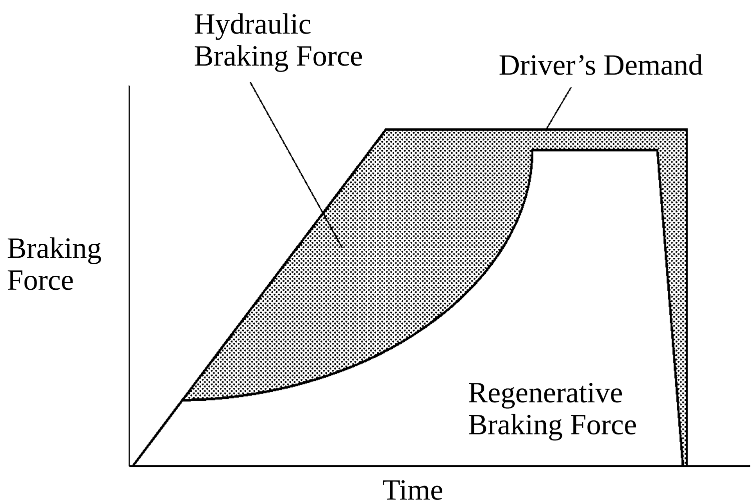


- The drive axle and MG2 are joined mechanically. When the drive wheels rotate MG2 and cause it to operate as a generator, a regenerative brake force of MG2 is transmitted to the drive wheels. This force is controlled by the THS II, which controls the generation of electricity.
  The regenerative brake cooperative control does not rely solely on the braking force of the hydraulic brake system to supply the brake force required by the driver. Instead, by effecting cooperative control with the THS II, this control provides a joint braking force provided by the regenerative brake and the hydraulic brake. As a result, this control minimizes the loss of the kinetic energy associated with the normal hydraulic brake, and recovers this energy by converting it into electrical energy.

2) Apportioning of the Brake Force

- The apportioning of the brake force between the hydraulic brake and the regenerative brake varies by the vehicle speed and time.
- The apportioning of the brake force between the hydraulic brake and the regenerative brake is accomplished by controlling the hydraulic brake so that the total brake force of the hydraulic brake and the regenerative brake matches the brake force required by the driver.
- If the regenerative brake becomes inoperative due to a malfunction in the THS II, the brake system effects control so that the entire brake force required by the driver is supplied with the hydraulic brake system.

▶ Imagery Drawing ◀



Changes in Braking Force Apportionment

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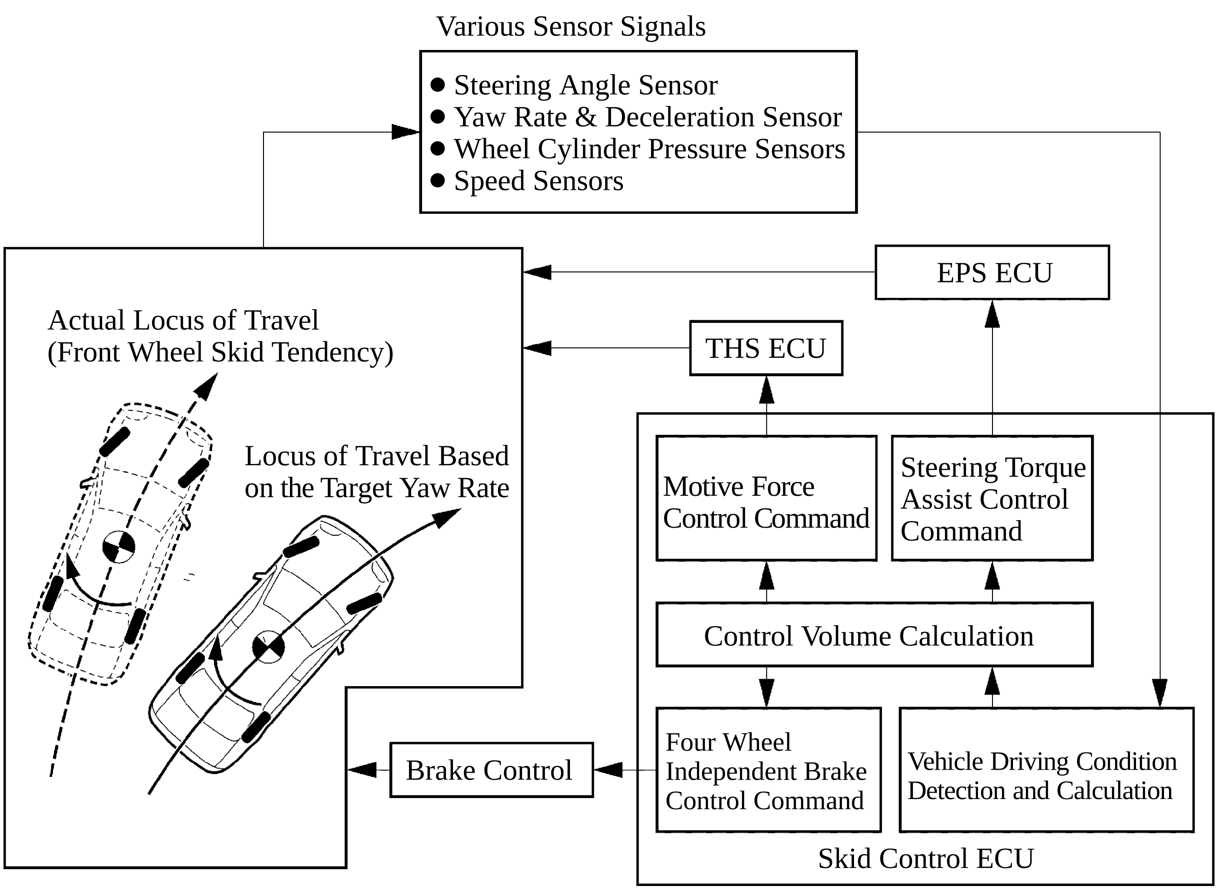
Outline of Power Steering Cooperative Control Function

1) General

- The VDIM effects coordinated control consisting of the ECB (Electronically Controlled Brake System) and EPS. By integrating these preventive safety functions, the VDIM ensures excellent driving stability and maneuverability of the vehicle.
- The VDIM coordinates the EPS and ECB (Electronically Controlled Brake System) to perform braking control on split friction roads and front and rear wheel skid tendency controls.
- If the vehicle loses stability due to wheel slippage, this function effects brake control by applying brake pressure to the wheels. At the same time, the EPS provides steering torque assist control to facilitate the driver's steering maneuver.



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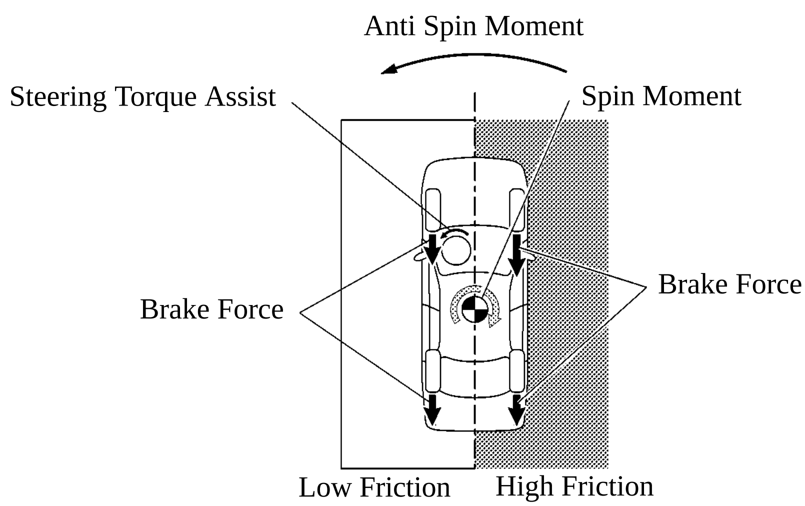
2) Operation in Braking on Split Friction Roads

When braking on a split friction road, the vehicle tends to deflect toward the higher friction side due to the difference between the braking forces on the left and right sides. In the VDIM, the EPS ECU receives command signals from the skid control ECU. Based on these signals, the EPS ECU operates the motor for the EPS to reduce the effect of the difference between the braking forces on the left and right sides, assisting steering operation. This enables the driver to operate the steering wheel to make steering corrections easily.



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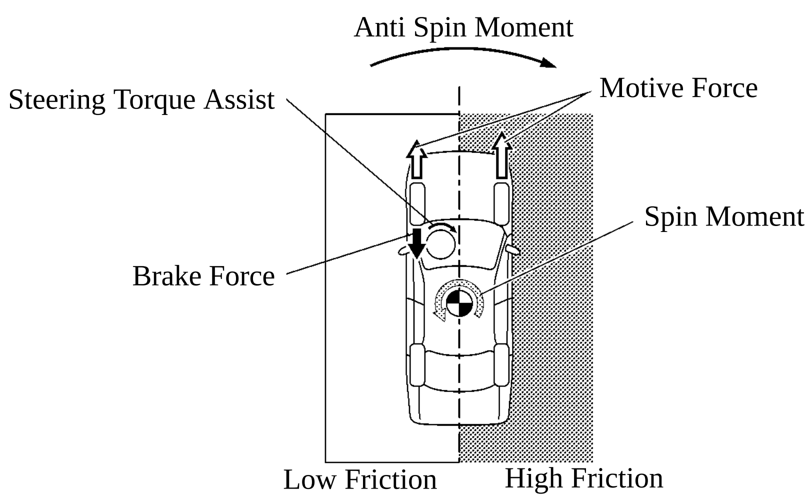
3) Operation in Accelerating on Split Friction Roads

When accelerating on a split friction road, the vehicle tends to deflect toward lower friction side due to the drive torque difference between the left and right sides. In the VDIM, the skid control ECU performs braking control of the drive wheel on the low friction side (TRAC function) and transmits command signals to the EPS ECU. Based on these signals, the EPS ECU operates the motor for the EPS to reduce the effect of the motive force difference between the left and right sides, assisting steering operation. As a result, the proper motive force and vehicle stability have been ensured.



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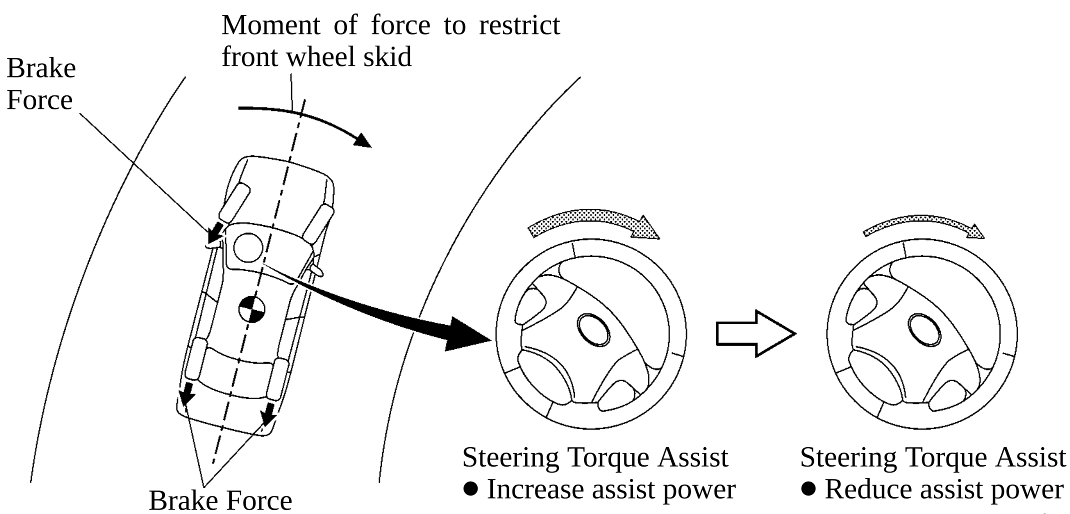
4) Operation in Front Wheel Skid Tendency Control

- When front wheel skidding is detected, motive force is limited and braking control is performed based on the amount of front wheel skid tendency. Accordingly, a moment of force is generated in the vehicle turning direction to limit front wheel skid tendency. (VSC function)
- In the case of a front wheel skid tendency, the steering torque will be light as a signal to the driver.
- With the VDIM, if the driver turns the steering wheel excessively, the EPS ECU will receive command signals from the skid control ECU. Based on these signals, the EPS ECU will operate to reduce the steering assist. This prevents the driver from increasing the front wheel skid tendency.



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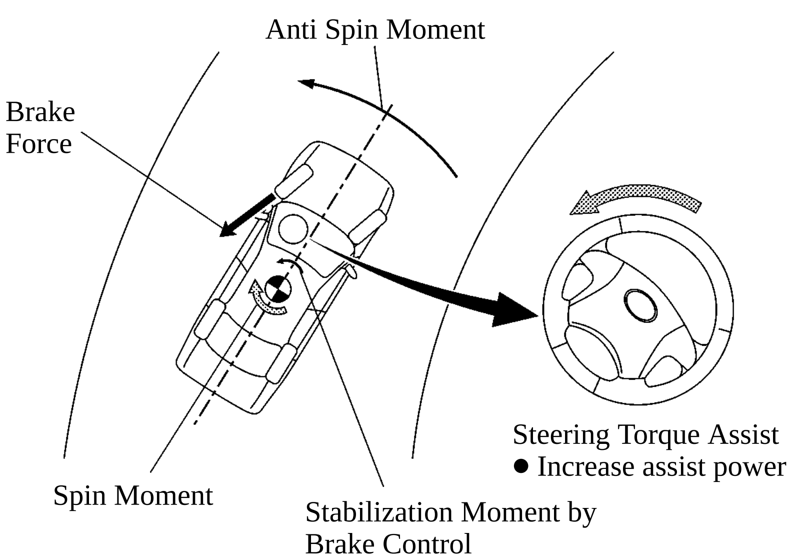
5) Operation in Rear Wheel Skid Tendency Control

- When rear wheel skidding is detected, motive force is limited and braking control is performed based on the amount of rear wheel skid tendency. Accordingly, an anti-spin moment is generated to limit the rear wheel skid tendency. (VSC function)
- With the VDIM, the EPS ECU receives command signals from the skid control ECU. Based on these signals, the EPS ECU operates the motor for the electric power steering to provide steering assist to help the driver compensate for the rear wheel skid tendency. This enables the driver to operate the steering wheel easily.



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