■BRAKE CONTROL SYSTEM (ABS with EBD, BRAKE ASSIST, TRAC/ A-TRAC, VSC, DAC, and HAC)

1. General

The brake control system of ’03 4Runner has a following function:

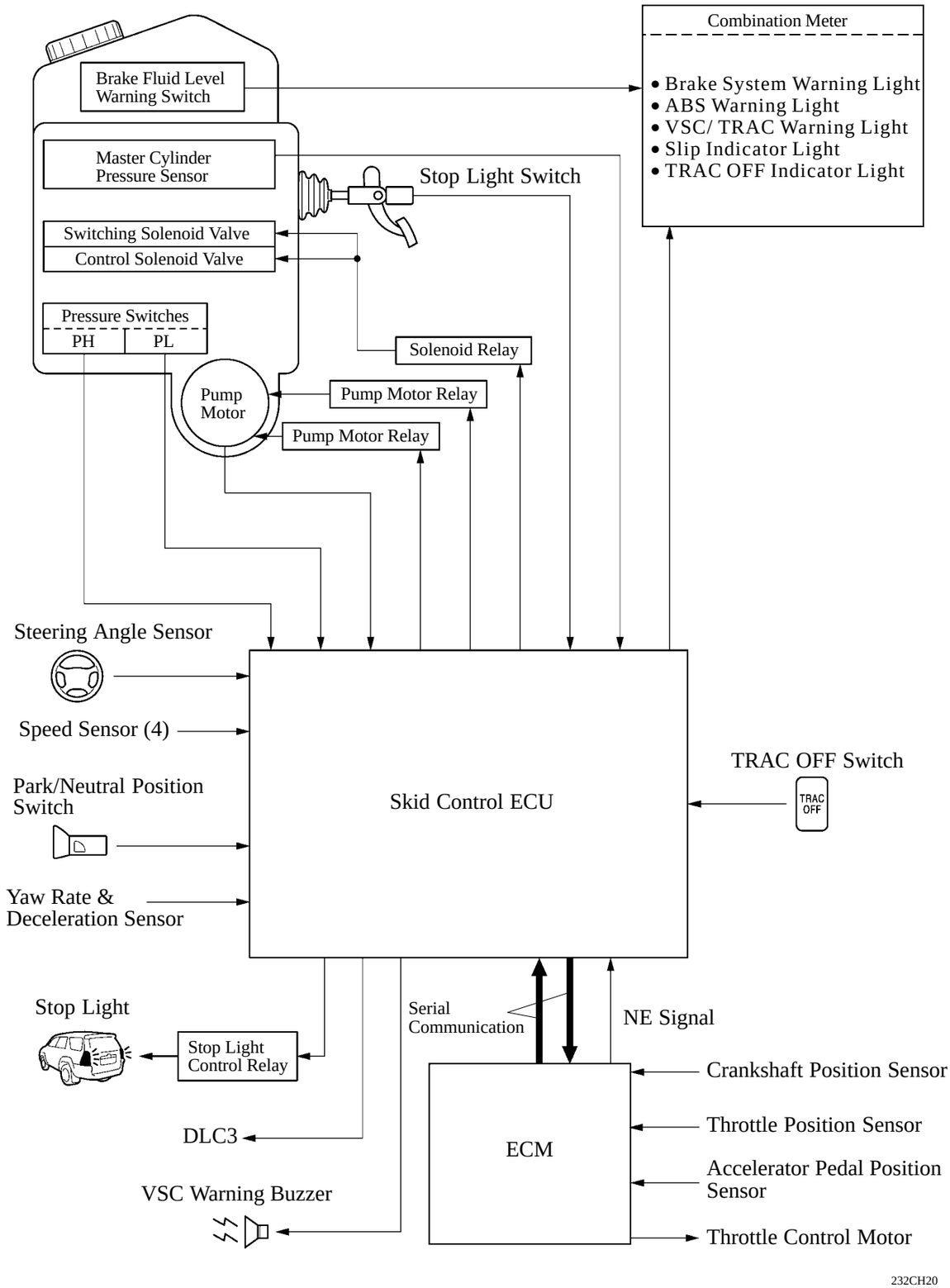
□: New

Function	Outline	Model	
		2WD	4WD
ABS (Anti-lock Brake System)	The ABS helps prevent the wheels from locking when the brakes are applied firmly or when braking on a slippery surface.	○	○
EBD (Electronic Brake force Distribution)	The EBD control utilizes 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 system 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 system helps prevent the drive wheels from slipping if the driver presses the accelerator pedal excessively when starting off or accelerating on a slippery surface.	○	○
A-TRAC (Active Traction Control)	During rugged offroad driving, this function controls the engine output and the brake fluid pressure that is applied to the slipping wheel, and distributes the drive force that would have been lost through the slippage to the remaining wheels in order to achieve a LSD (Limited Slip Differential) effect. As a result, the vehicle’s offroad drivability and ability to free itself from the mogul have been increased.	—	○
VSC (Vehicle Skid Control)	The VSC system helps prevent the vehicle from slipping sideways as a result of strong front wheel skid or strong rear wheel skid during cornering.	○	○
DAC (Downhill Assist Control)	When the DAC switch is pressed with transfer in low range and without accelerator and brake pedals operation, DAC activates to effect 4-wheel hydraulic pressure control, in order to maintain a constant low vehicle speed without causing the wheels to become locked. Thus, the vehicle can descend a steep hill in a stable manner.	—	○
HAC (Hill-start Assist Control)	When the vehicle starts off on a steep or a slippery hill, HAC detects the backward descent of the vehicle and effects 4-wheel hydraulic pressure control to reduce the backward speed of the vehicle.	○	○

Service Tip

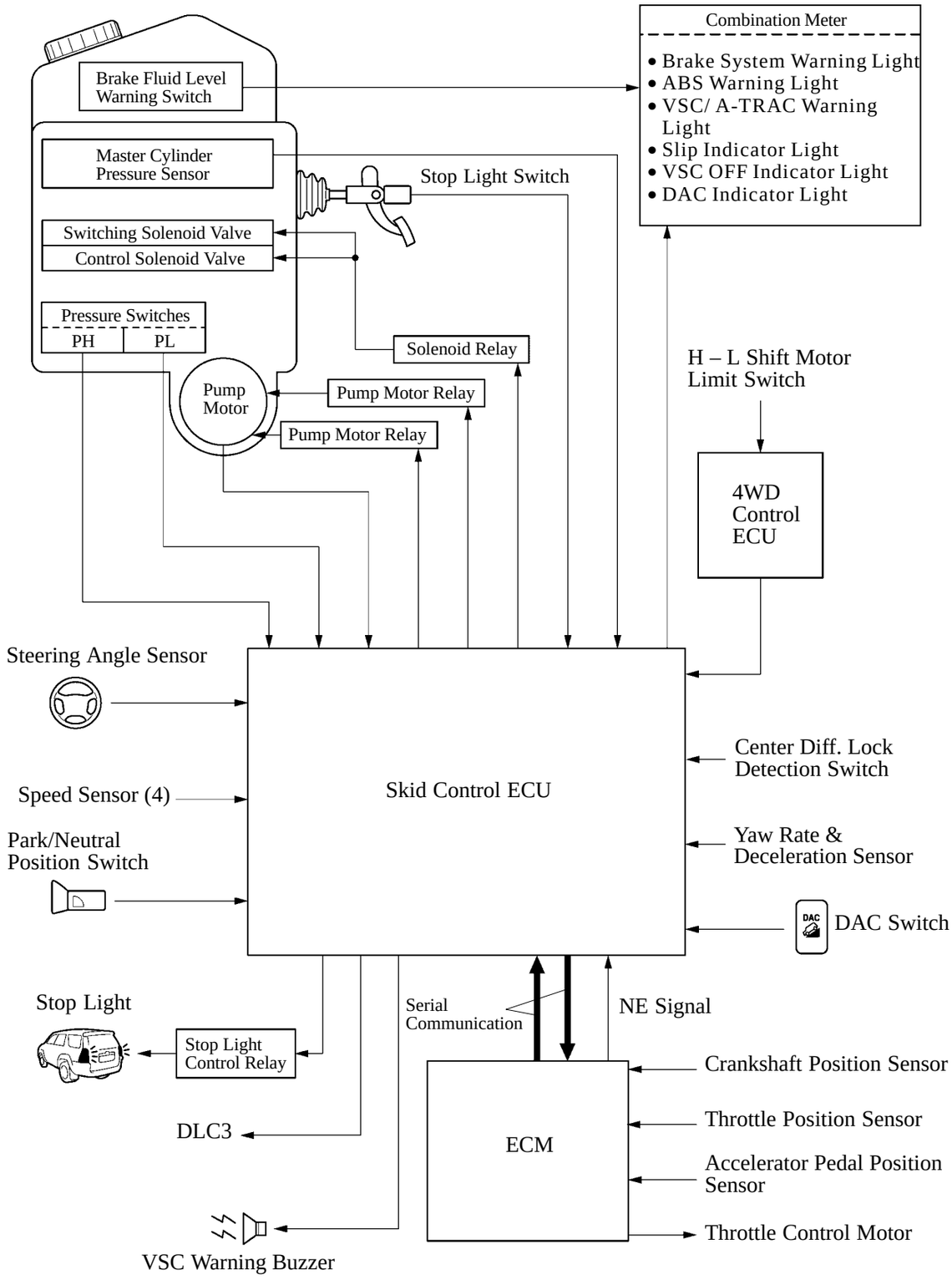
When brake control system is activated, the brake pedal could shudder, which is a normal occurrence of the system in operation and should not be considered a malfunction.

▶ System Diagram (for 2WD Model) ◀



232CH20

▶ System Diagram (for 4WD Model) ◀



232CH21

2. Major Difference

- Similar to the ’02 4Runner, this system uses a hydraulic brake booster.
- The following chart describes the changes from the brake control system on the ’02 4Runner to the brake control system on the ’03 4Runner.

Item	Outline	Model	
		2WD	4WD
Brake Control Function	Adoption of the HAC.	○	○
	• Adoption of the DAC. • The consecutive operation time of A-TRAC has increased.	—	○
Speed Sensor	Changed of the type. (Passive Type → Active Type)	○	○
Hydraulic Brake Booster	Solenoid coil has been changed to increase heat resistance.	○	○
Stop Light Control Relay	Adoption of the stop light control relay.	○	○
Yaw Rate Sensor	Integrated of the deceleration sensor.	○	○
Deceleration Sensor	Integrated in the yaw rate sensor.	○	○
Combination Meter	Added of the DAC indicator light.	—	○
DAC switch	Added of the DAC switch.	—	○
Skid Control ECU	• In accordance with the each change, changed of the soft logic in the skid control ECU. • Added of the DTC.	○	○
Others	Configuration and structure are the same as brake control system on the ’02 4Runner.		

3. Outline of EBD Control

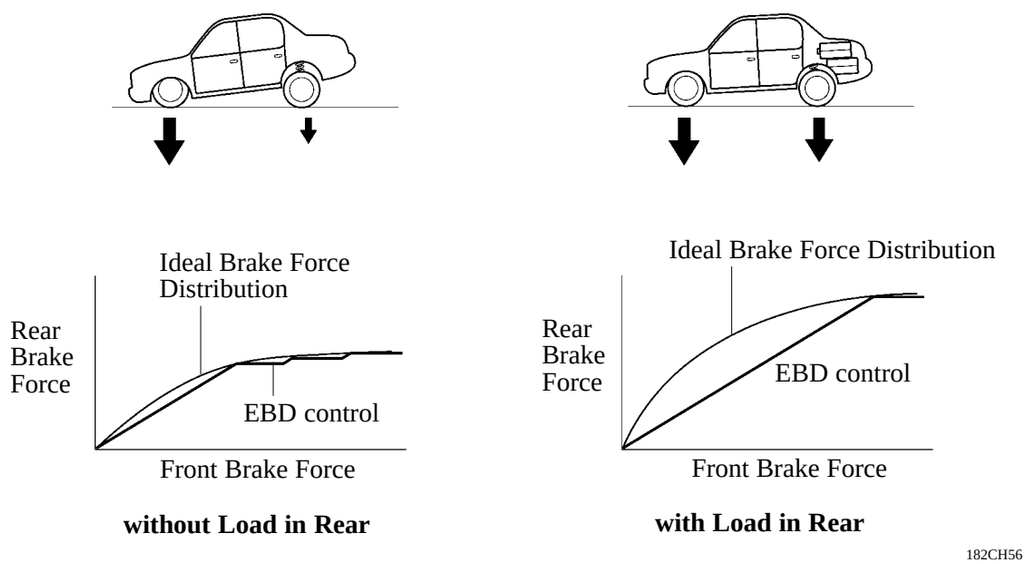
General

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 precisely controls the braking force in accordance with the vehicle's driving conditions.

Front/ Rear Wheels Brake Force Distribution

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

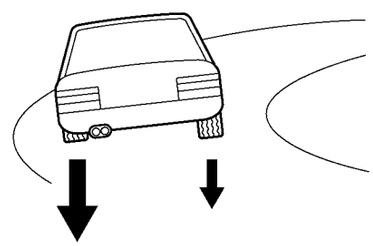
▶ EBD Control Concept ◀



182CH56

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

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

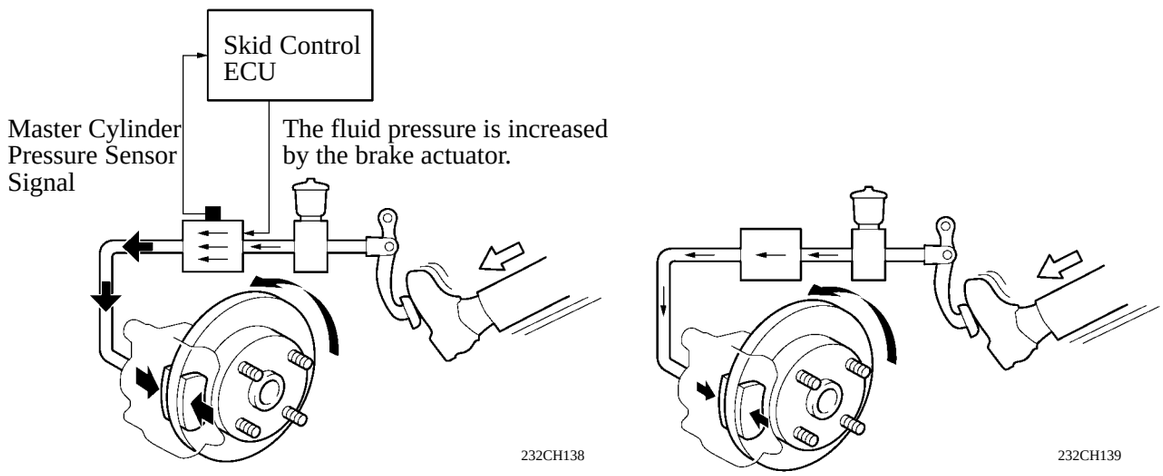


181CH56

4. Outline of Brake Assist System

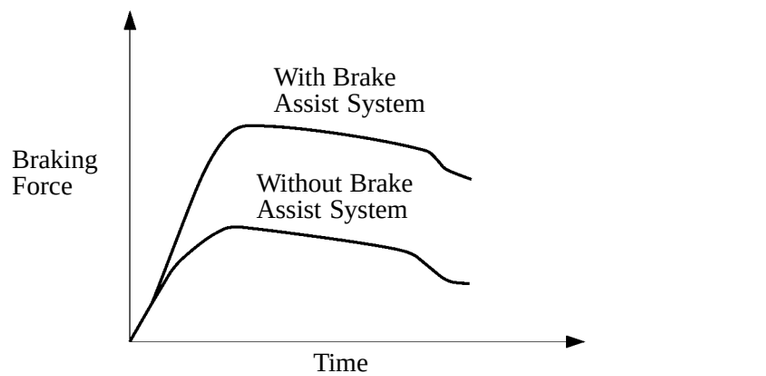
- The Brake Assist system in combination with ABS helping improves the vehicle's brake performance.
- The Brake Assist system interprets a quick push of the brake pedal as emergency braking and supplements the brake power applied if the driver has not stepped hard enough on the brake pedal. In emergencies, driver, especially inexperienced ones, often panic and do not apply sufficient pressure on the brake pedal.
- A key feature of Brake Assist system is that the timing and the degree of braking assistance are designed to 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 braking force.

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



with Brake Assist System **without Brake Assist System***

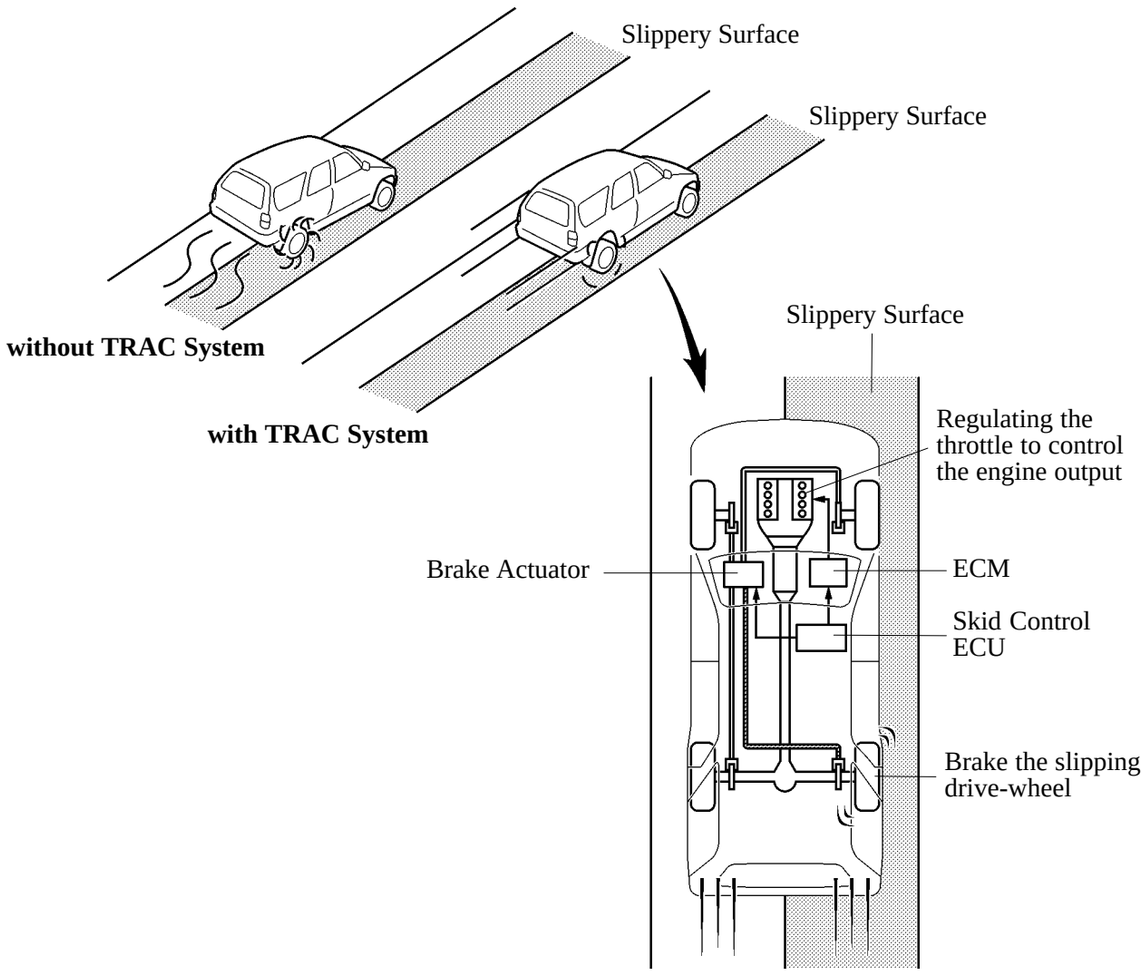
*: The basic performance of the brake is the same as of the model with the brake assist system.



5. Outline of TRAC System (for 2WD Model)

- If the driver presses the accelerator pedal aggressively when starting off or accelerating on a slippery surface, the drive wheel could slip due to the excessive amount of torque that is generated. By applying hydraulic brake control to the drive wheels and regulating the throttle to control the engine output, the TRAC system 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 system 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 TRAC system, the skid control ECU instantly determines the state of the vehicle and operates the brake actuator in order to apply the brake of the slipping drive wheel. Furthermore, the ECM receives the signals from the skid control ECU and regulates the throttle in order to control the engine output. Thus, the system can constantly maintain a stable vehicle posture.

▶ Driving condition on road with different surface friction characteristics ◀



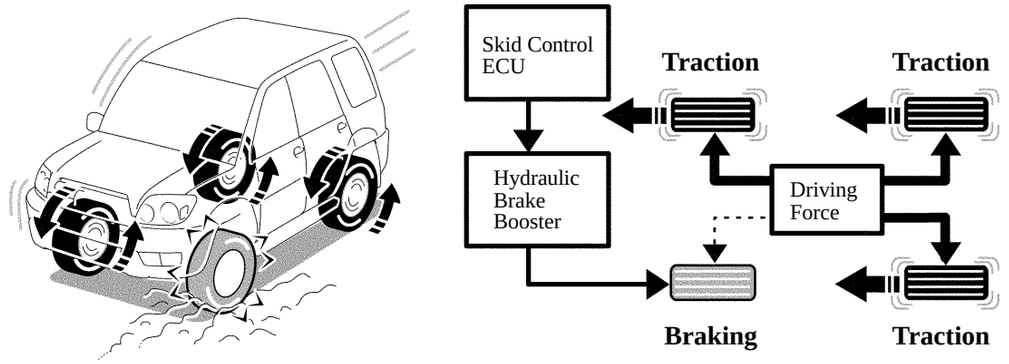
232CH22

6. Outline of A-TRAC System (for 4WD Model)

General

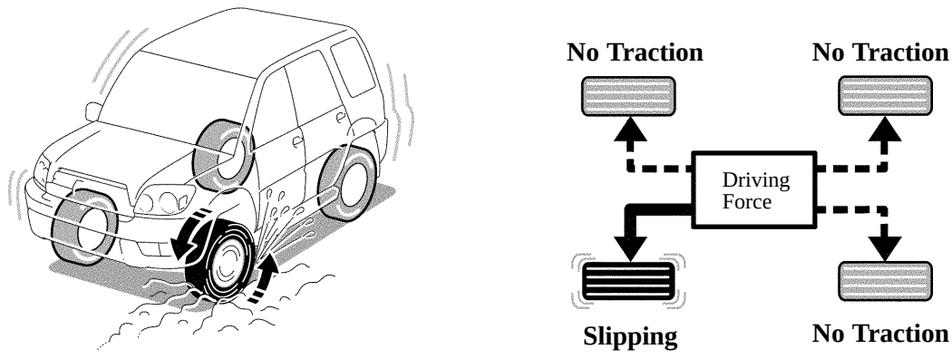
- If a tire slips while the vehicle is being driven on a snow-covered road or off-road, the function of the differential gear causes a large amount of drive force to be applied to the tire that is slipping.
- The A-TRAC function helps restrain the slippage by controlling the engine output and brake fluid pressure that is applied to the slipping wheel, and distributes the drive force that would have been lost through the slippage to the remaining wheels in order to achieve an effect that is similar to the LSD (Limited Slip Differential).
- It independently controls the brake hydraulic pressure to the four wheels in accordance with the extent of the slippage at the wheels, as detected by the skid control ECU.

▶ with A-TRAC ◀



232CH24

▶ without A-TRAC ◀



232CH23

Effective of A-TRAC

The effectiveness of the A-TRAC is as follows:

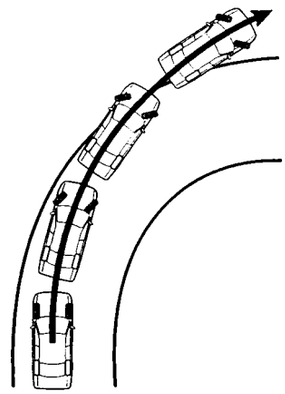
- Off-road drivability that is equivalent to having the center differential locked and limited slip differential on both front and rear differentials has been realized.
- This function made the operation of the differential lock switches basically unnecessary to ensure the ease of driving.
- While realizing the off-road drivability that is equivalent to having the center and rear differentials locked, as compared to the differential gear in the locked state, the essential function of the differential gear itself ensures the ease of nimble steerability.

7. Outline of VSC System

General

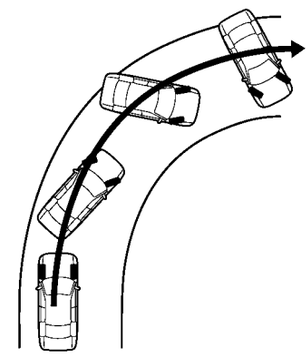
The followings are two examples that can be considered as circumstances in which the tires exceed their lateral grip limit.
The VSC system is designed to help control the vehicle behavior by controlling the engine output and the brakes at each wheel when the vehicle is under one of the conditions indicated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



189CH100

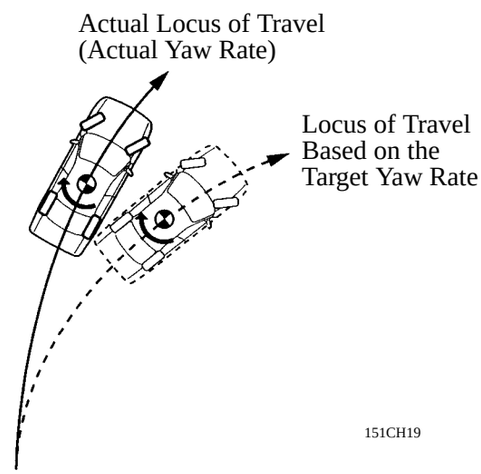
Rear Wheel Skid Tendency

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 the vehicle's lateral acceleration, which are then calculated by the skid control ECU.

1) Determining Front Wheel Skid

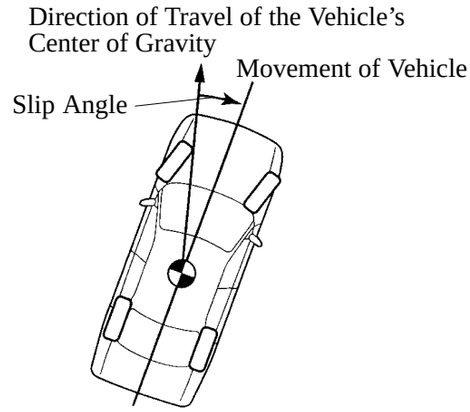
Whether or not the vehicle is in the state of front wheel skid is determined by the difference between the target yaw rate and the vehicle's actual yaw rate.
When the vehicle's actual yaw rate is smaller than the yaw rate (a target yaw rate that is determined by the vehicle speed and steering angle) 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 or not the vehicle is in the state of rear wheel skid is determined by the values of the vehicle's slip angle and the vehicle's slip angular velocity (time-dependent changes in the vehicle's slip angle). When the vehicle's slip angle is large, and the slip angular velocity is also large, the skid control ECU determines that the vehicle has a large rear wheel skid tendency.



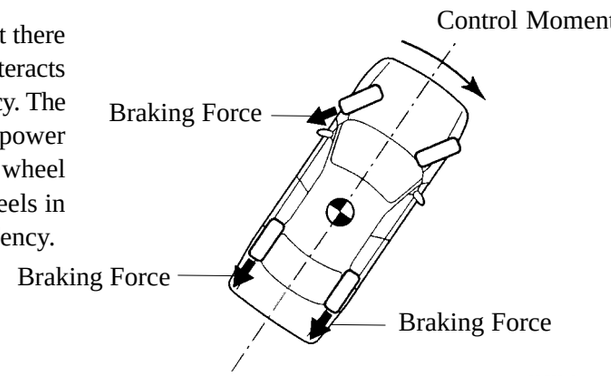
151CH18

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 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 power output and applies the brakes of the front wheel of the outer circle in the turns and rear wheels in order to restrain the front wheel skid tendency.

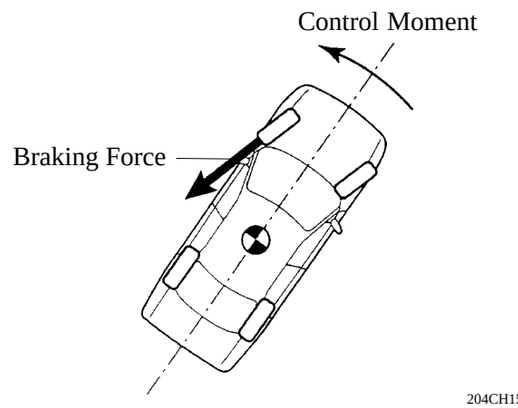


189CH101

Making a Right Turn

2) 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 restrain the rear wheel skid tendency. Along with the reduction in the vehicle speed caused by the braking force, the vehicle's stability is further improved.
In some cases, the skid control ECU applies the brake of the rear wheels, as necessary.

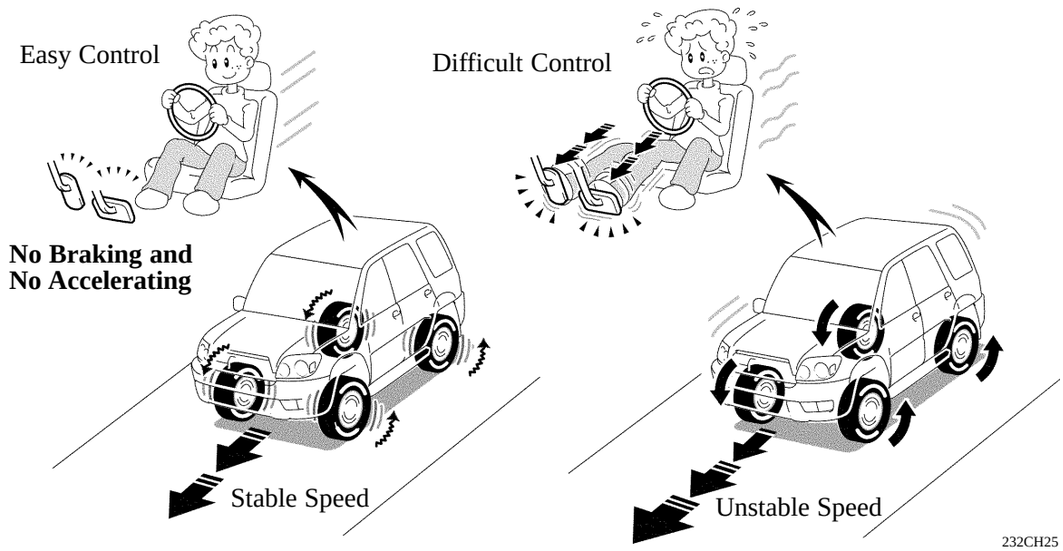


204CH15

Making a Right Turn

8. Outline of DAC System (for 4WD Model)

- When the vehicle is descending a steep hill and the engine brake alone cannot provide a sufficient deceleration force while the transfer is in the L4 range, 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 DAC, the driver must pay close attention to the brake and accelerator pedal maneuvers. However, with DAC, the driver can concentrate on the steering operation, without accelerator and brake pedals operation.
- 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.



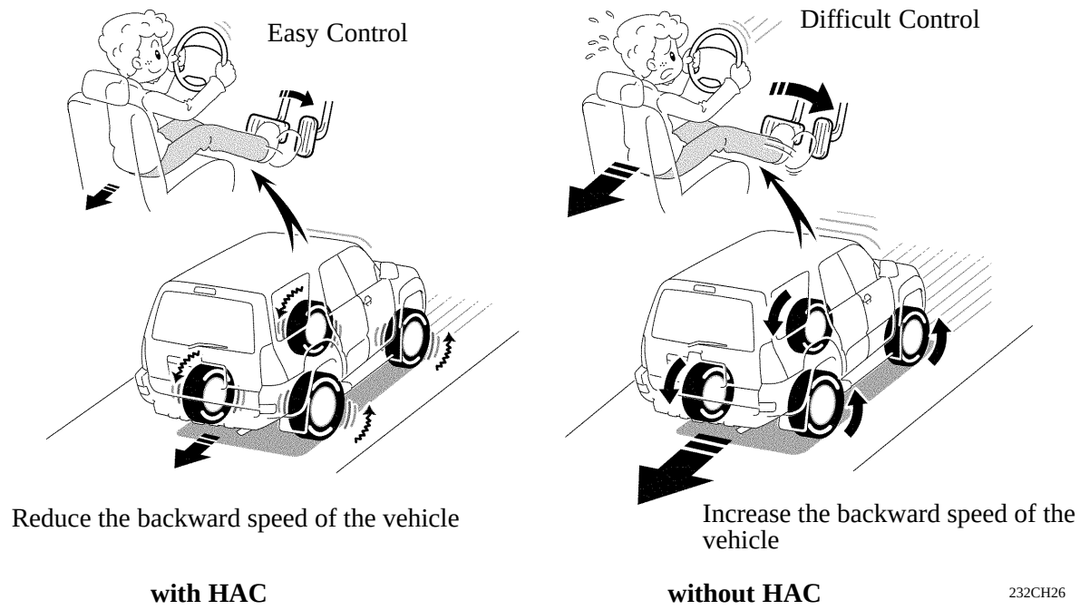
with DAC **without DAC**

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

DAC Operate Condition	• DAC switch ON • Transfer is L range. • Accelerator pedal and brake pedal are not pressed. • Descending a hill at a vehicle speed of 25 km/h (16 mph) or less.

9. Outline of HAC System

- When the vehicle starts off on a steep or slippery hill, the vehicle could descend backward while the driver switches from the pedal brake to the accelerator pedal, thus making it difficult for the vehicle to start off. To prevent this from occurring, HAC temporarily (approximately 5 seconds at the maximum) applies the brakes to the 4 wheels in order to reduce the backward speed of the vehicle.
- Without HAC, the driver must quickly and precisely switch from the brake pedal to the accelerator pedal. With HAC however, the driver can start off easily and operate the pedal in a relaxed manner because HAC reduces the backward speed of the vehicle.



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

HAC Operate Condition	• Shift lever position is D, 4, 3, 2, or L positions. • The brake pedal is not pressed. • The skid control ECU has detected the backward movement of the vehicle when the driver is starting off on a hill.