■BRAKE CONTROL SYSTEM (ABS with EBD and BRAKE ASSIST)

1. General

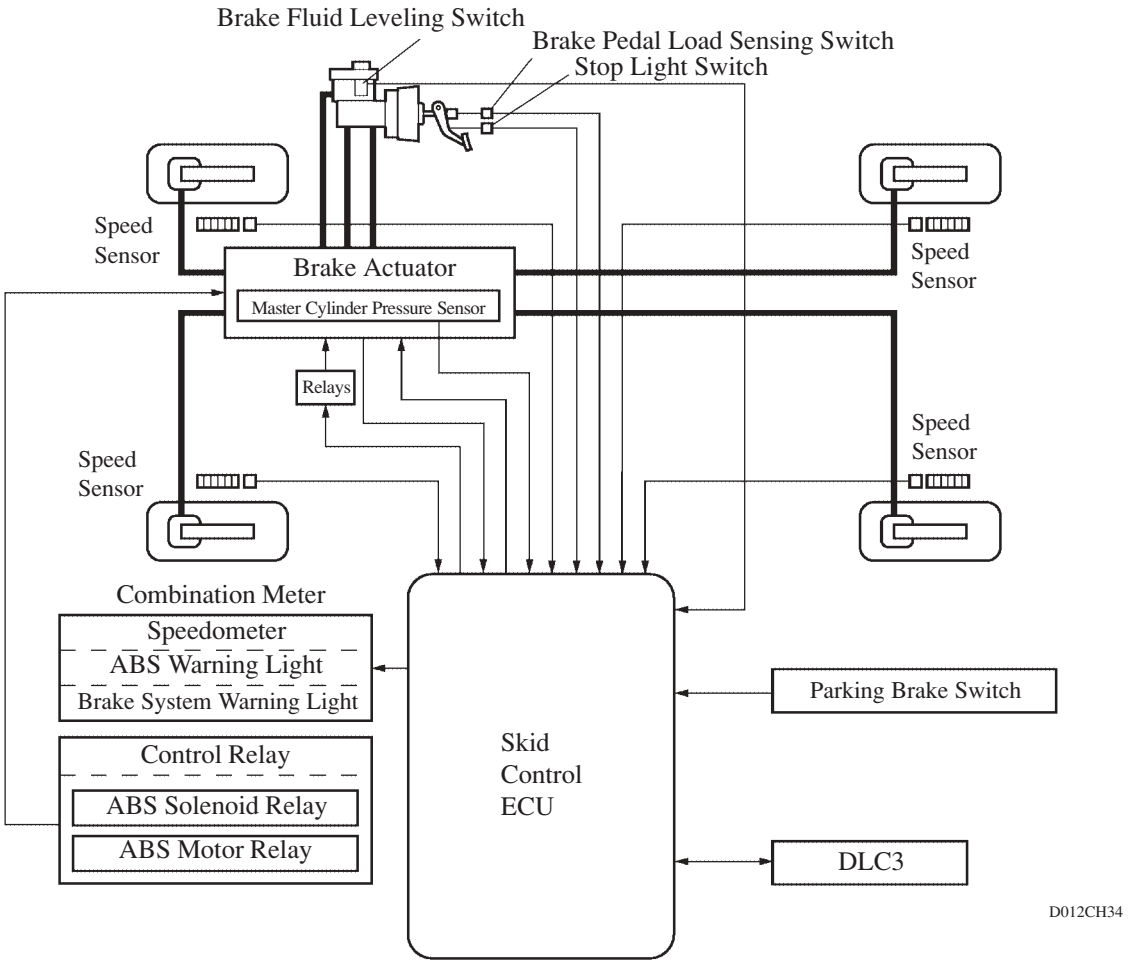
- The brake control system (ABS with EBD and Brake Assist) of new Kluger has a following function:

Function	Outline
ABS (Anti-lock Brake System)	The ABS helps prevent the wheels from locking when the brakes are applied firmly or when braking on a slippery surface.
EBD (Electronic Brake force Distribution)	The EBD 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 Brake Assist has three functions: ● To increase the braking force if the brake pedal operation is not sufficient when urgent braking is needed. ● To increase the braking force if stronger brake force is required. ● To increase the braking force if the brake booster is in failure.

Service Tip

When brake control system (ABS with EBD) 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 ◀



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2. Outline of EBD Control

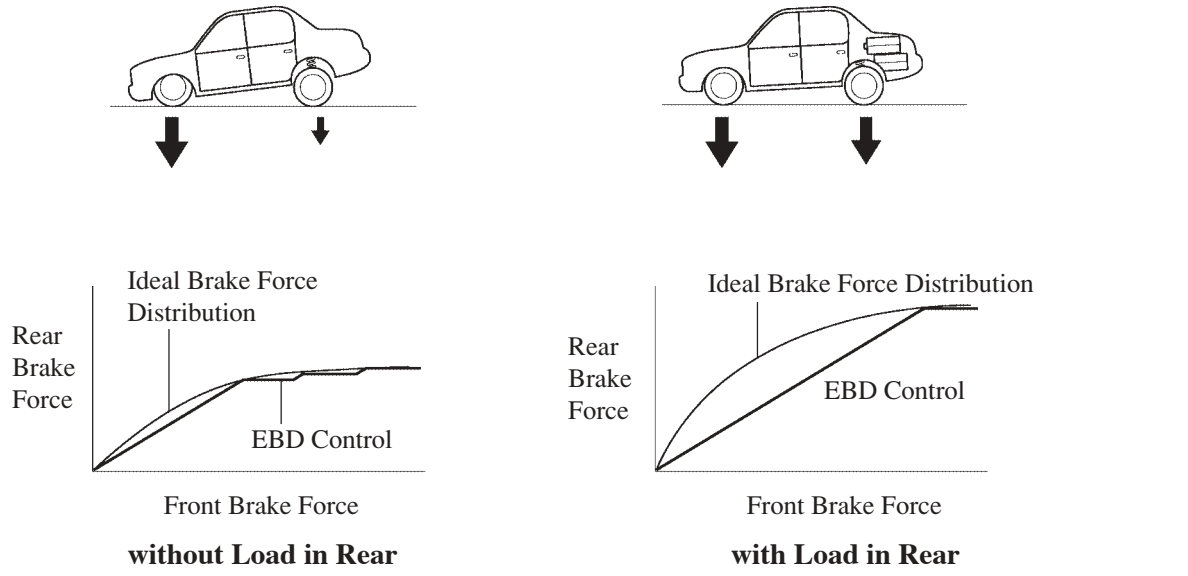
General

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.

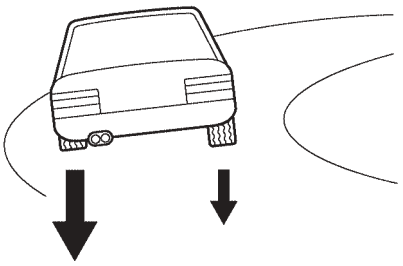
▶ EBD Control Concept ◀



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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.

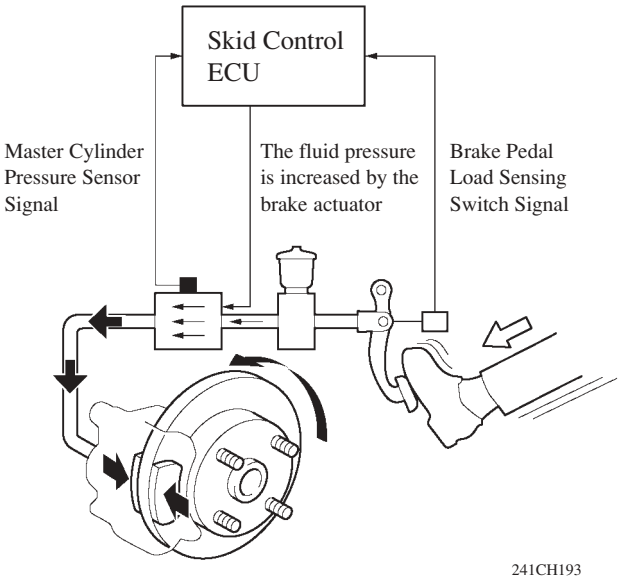


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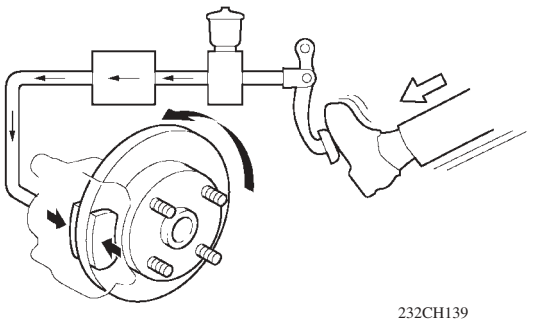
3. Outline of Brake Assist System

- The Brake Assist System interprets a quick push of the brake pedal as emergency braking and supplements the braking power applied if the driver has not stepped hard enough on the brake pedal. In emergencies, drivers, especially inexperienced ones, often panic and do not apply sufficient pressure on the brake pedal. 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 emergency braking, the system activates the brake actuator to increase the brake fluid pressure.
  The Brake Assist System in combination with ABS helps ensure the vehicle's brake performance.
  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.
- For example, in case that the vehicle is fully loaded, stronger brake force may be required even if the brakes are not applied quickly. Then, the brake assist system also operates to increase brake force.
- If the brake booster should fail, the skid control ECU detects the failure of the brake booster based on the signals from the brake pedal load sensing switch and the master cylinder pressure sensor and actuates the brake actuator to increase the brake fluid pressure to meet the requirements for braking.

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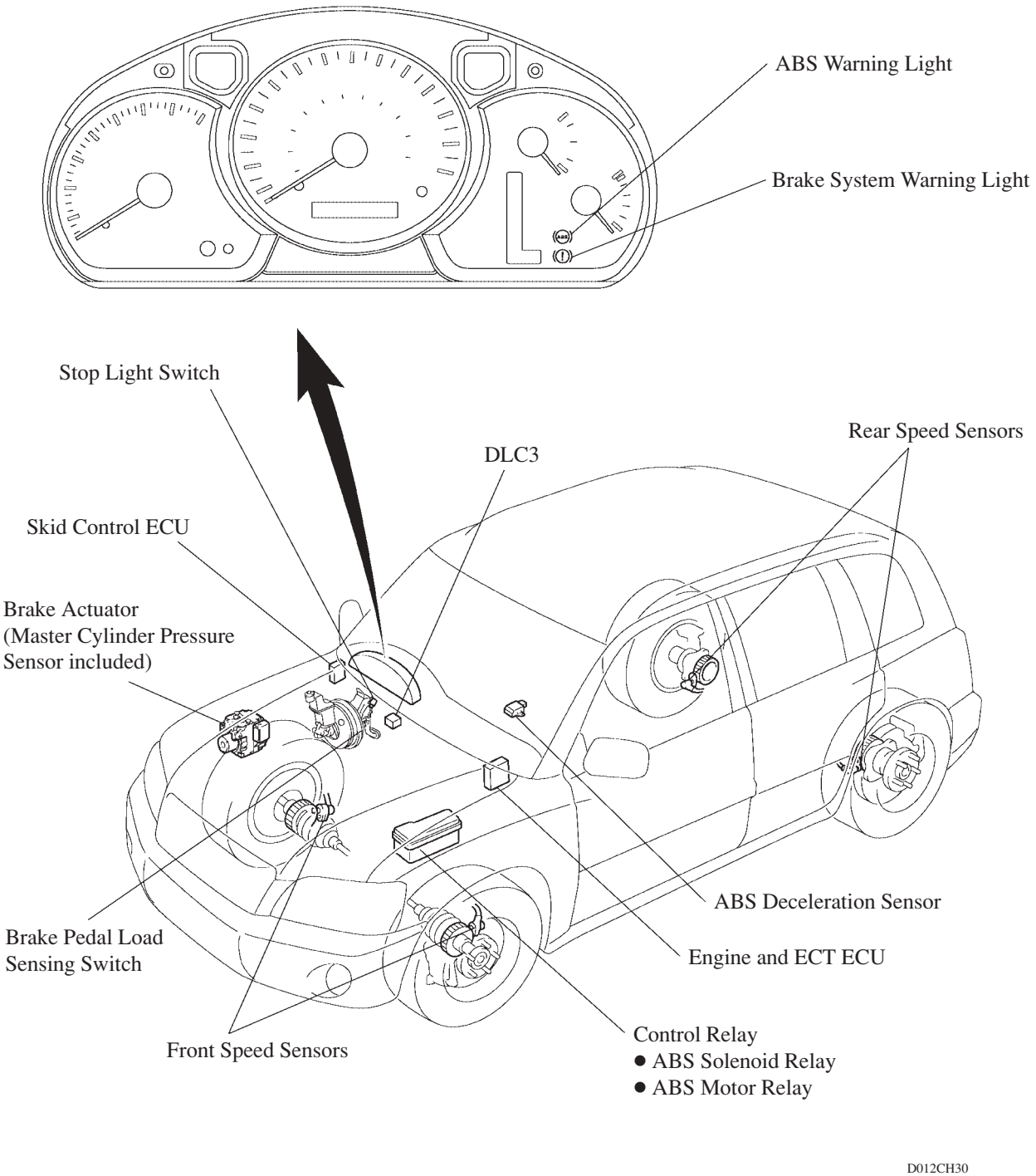
with Brake Assist System



without Brake Assist System

◆: There is no difference of the maximum brake performance between the vehicles with and without brake assist system.

4. Layout of Main Components



5. Function of Main Components

Components		Function
Brake Actuator		Changes the fluid path based on the signals from the skid control ECU during the operation of the ABS with EBD and Brake Assist system, in order to control the fluid pressure that is applied to the wheel cylinders.
	Master Cylinder Pressure Sensor	Assembled in the brake actuator and detects the master cylinder pressure.
Skid Control ECU		Judges the vehicle driving condition based on signals from each sensor, and sends brake control signals to the brake actuator.
Combination Meter	Brake System Warning Light	● Lights up to alert the driver when a malfunction occurs in the brake system. ● Lights up to alert the driver when the skid control ECU detects a malfunction in the EBD control. ● Light up to inform the driver when the parking brake pedal depressed. ● Light up to alert the driver when the brake fluid level decreased.
	ABS Warning Light	Lights up to alert the driver when the skid control ECU detects a malfunction in the ABS, EBD, or Brake Assist system.
Speed Sensor (FL, FR, RL, RR)		Detects the wheel speed of each wheels.
ABS Deceleration Sensor		Detects the vehicle's acceleration in the forward, rearward, and lateral.
Control Relay	ABS Motor Relay	Supply power to the pump motor in the brake actuator.
	ABS Solenoid Relay	Supply power to the solenoid valves in the brake actuator.
Stop Light Switch		Detects the brake pedal depressing signal.
Engine and ECT ECU		Controls the throttle valve opening angle based on the signals receives from the skid control ECU, in order to control the engine output. Also, sends the throttle valve opening angle signal, accelerator pedal position signal, and engine speed signal to the skid control ECU.
Brake Pedal Load Sensing Switch		● This switch turns ON when the brake pedal load is reached to the specific load. ● Detects the brake booster failure by using information of the switch and the master cylinder pressure sensor.

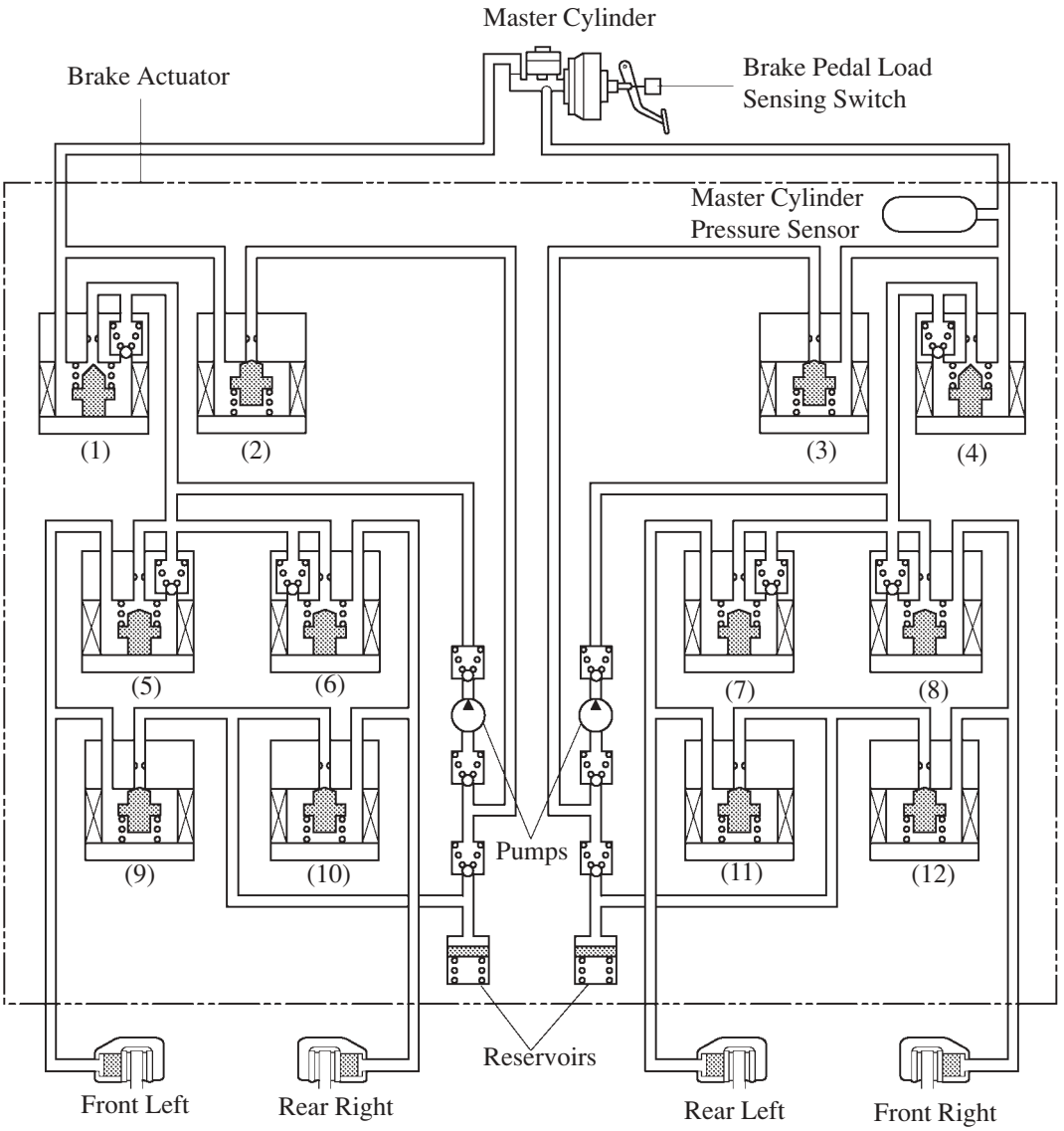
6. Construction and Operation of Main Components

Brake Actuator

1) General

- The brake actuator consists of 12 two-position solenoid valves, 1 motor, 2 pumps, 2 reservoirs, and master cylinder pressure sensor.
  The 12 two-position solenoid valves consists of the following:
  – 2 master cylinder cut solenoid valves [(1), (4)]
  – 2 suction solenoid valves [(2), (3)]
  – 4 pressure holding solenoid valves [(5), (6), (7), (8)]
  – 4 pressure reduction solenoid valves [(9), (10), (11), (12)]

▶ Hydraulic Circuit ◀



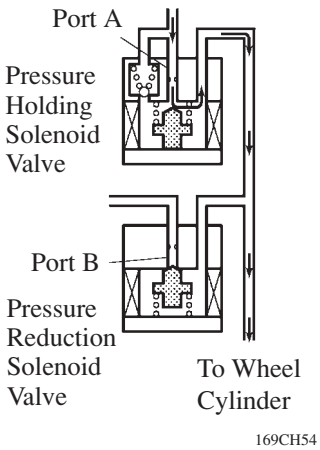
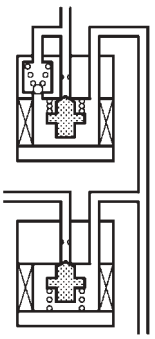
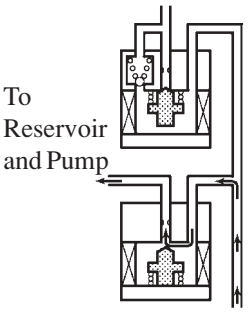
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▶ Function of Main Components ◀

Component		Function
(1), (4)	Master Cylinder Cut Solenoid Valve (Linear Type)	To effect the respective brake controls of the Brake Assist system, a combination of the ON/OFF conditions of the master cylinder cut solenoid valve and suction solenoid valve are used to appropriately vary the fluid pressure.
(2), (3)	Suction Solenoid Valves	
(5), (6), (7), (8)	Pressure Holding Valve	Each wheel cylinder contains a pressure holding solenoid valve and a pressure reduction solenoid valve. A combination of the ON/OFF conditions of the respective valves is used in order to change the increase mode, holding mode, or the reduction mode during the operation of the ABS system.
(9), (10), (11), (12)	Pressure Reduction Valve	
Master Cylinder Pressure Sensor		The master cylinder pressure sensor converts the brake fluid pressure that the master cylinder applies to the brake actuator into an electrical signal and sends it to the skid control ECU. The skid control ECU can thus monitor the brake fluid pressure that is applied to the brake actuator in accordance with this signal.
Reservoir		While effecting the reduction mode during the operation of the ABS system, the reservoir stores the brake fluid that has returned from the wheel cylinders. It also functions as an accumulator.
Pump		Pumps the brake fluid that is stored in the reservoir and returns it to the master cylinder. While effecting the increase mode during the operating of the Brake Assist system, the pump operates in order to apply brake fluid pressure to the wheel cylinders.

ABS with EBD Operation

Based on the signals received from the 4 wheel speed sensors and yaw rate & deceleration sensor, 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 3 modes: pressure reduction, pressure holding and pressure increase modes.

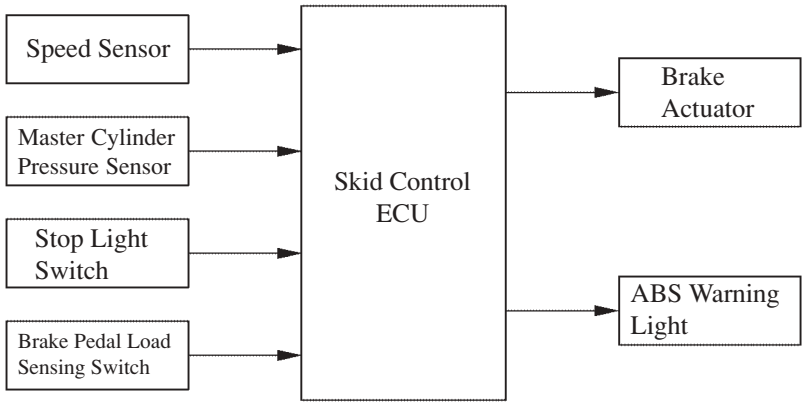
Not Activated	Normal Braking	—	—
Activated	Pressure Increase Mode	Pressure Holding Mode	Pressure Reduction Mode
Hydraulic Circuit	 169CH54	 169CH55	 169CH56
Pressure Holding Valve (Port A)	OFF (Open)	ON (Close)	ON (Close)
Pressure Reduction Valve (Port B)	OFF (Close)	OFF (Close)	ON (Open)
Wheel Cylinder Pressure	Increase	Hold	Reduction

Brake Assist Operation

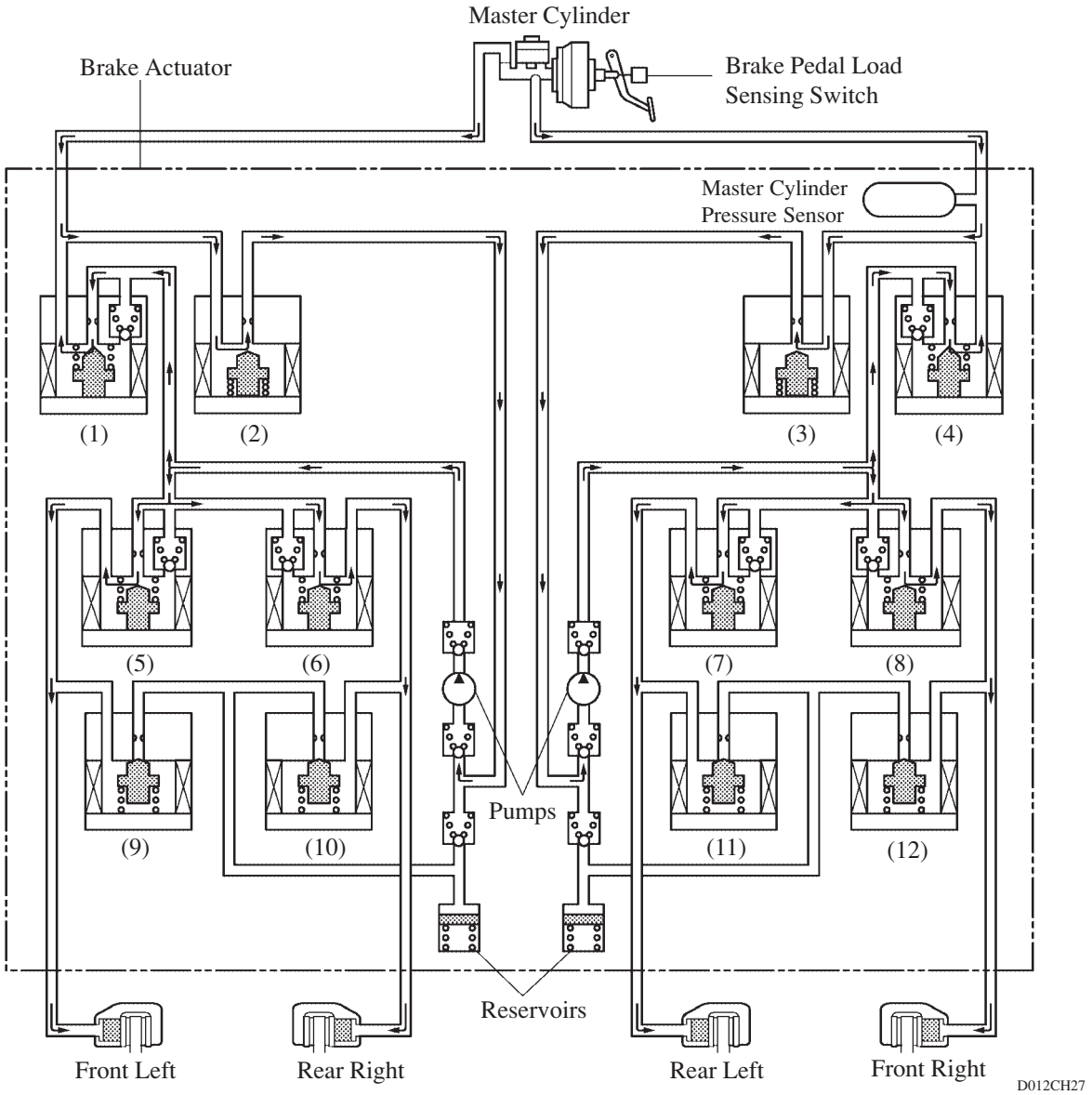
In the event of emergency braking, the skid control ECU detects the driver's intention based on the speed of the pressure increase in the master cylinder determined by the pressure sensor signal. If the ECU judges the need for the additional brake assist, the fluid pressure is generated by the pump in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

- When greater braking force is needed than normal, such as when the vehicle is fully loaded and downhill driving, etc., the skid control ECU judges the need for brake assist using the master cylinder pressure sensor.
- In the event of a brake booster failure, the skid control ECU judges the failure using the brake load sensing switch and master cylinder pressure sensor signals.

▶ System Diagram ◀



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Item			Brake Assist Not Activated	Brake Assist Activated
Master Cylinder Cut Solenoid Valve 1		(4)	OFF (Open)	ON*
Suction Solenoid Valves 1		(3)	OFF (Close)	ON (Open)
Master Cylinder Cut Solenoid Valve 2		(1)	OFF (Open)	ON*
Suction Solenoid Valves 2		(2)	OFF (Close)	ON (Open)
Front Wheel	Pressure Holding Solenoid Valve	(5), (8)	OFF (Open)	OFF (Open)
	Pressure Reduction Valve	(9), (12)	OFF (Close)	OFF (Close)
	Wheel Cylinder Pressure		—	Pressure increases above master cylinder pressure
Rear Wheel	Pressure Holding Solenoid Valve	(6), (7)	OFF (Open)	OFF (Open)
	Pressure Reduction Valve	(10), (11)	OFF (Close)	OFF (Close)
	Wheel Cylinder Pressure		—	Pressure increases above master cylinder pressure

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

Self-Diagnosis

- If the skid control ECU detects a malfunction in the ABS with EBD system, the ABS and brake system warning lights that corresponds to the function in which the malfunction has been detected indicates or lights up, indicated in the table below, to alert the driver of the malfunction.

○: Light ON —: Light OFF

Item	ABS	EBD	Brake Assist
ABS Warning Light	○	○	○
Brake System Warning Light	—	○	—

- At the same time, the DTCs (Diagnostic Trouble Codes) are stored in memory. The DTCs can be read by connecting the SST (09843-18040) between the Tc and CG terminals of DLC3 and observing the blinks of the ABS warning light, or by connecting a hand-held tester.
- This system has a sensor signal check (test mode) function. This function is activated by connecting the SST (09843-18040) the between Ts and CG terminals of the DLC3 or by connecting a hand-held tester.
- If the skid control ECU detects a malfunction during a sensor check, it stores the DTCs in its memory. These DTCs can be read during a sensor check operation by connecting the Tc and CG terminals of the DLC3 and observing the blinking of the ABS warning light or on a hand-held tester.

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For details, on the DTCs that are stored in skid control ECU memory and the DTCs that are output through the sensor signal check (test mode) functions, see the Kluger Repair Manual (Pub. No. RM1087E).

▶ DTC Chart (blinking ABS Warning Light) ◀

DTC No.		Detection Item	DTC No.		Detection Item
2-digit	5-digit	Detection Item	2-digit	5-digit	Detection Item
11	C0278	Open or short circuit in ABS solenoid relay circuit	34	C0215	Left rear wheel speed sensor signal malfunction
12	C0279	Short circuit in ABS solenoid relay circuit	35	C1330	Open circuit in the right front speed sensor
13	C0273	Open or short circuit in ABS motor relay circuit	36	C1331	Open circuit in the left front speed sensor
14	C0274	Short circuit in ABS motor relay circuit	38	C1332	Open circuit in the right rear speed sensor
21	C0226	Open or short circuit in 2-position solenoid circuit for right front wheel	41	C1241	Low battery voltage or abnormally high battery voltage
22	C0236	Open or short circuit in 2-position solenoid circuit for left front wheel	43	C1243	Malfunction in deceleration sensor (constant output)
23	C0246	Open or short circuit in 2-position solenoid circuit for right rear wheel	44	C1244	Malfunction in deceleration sensor
24	C0256	Open or short circuit in 2-position solenoid circuit for left rear wheel	45	C1245	Malfunction in deceleration sensor
25	C1225	Open or short circuit of brake actuator solenoid circuit (SM circuit)	46	C1246	Malfunction in master cylinder pressure sensor
26	C1226	Open or short circuit of brake actuator solenoid circuit (SM circuit)	49	C1249	Open circuit in stop light switch circuit
31	C0200	Right front wheel speed sensor signal malfunction	51	C1350	Pump motor is locked or opencircuit in pump motor ground
32	C0205	Left front wheel speed sensor signal malfunction	58	C1249	Open circuit in stop light switch circuit
33	C0210	Right rear wheel speed sensor signal malfunction	67	C1267	Malfunction in brake pedal load sensing switch

▶ DTC Chart of sensor check (blinking ABS warning light) ◀

DTC No.		Detection Item	DTC No.		Detection Item
2-digit	5-digit		2-digit	5-digit	
71	C1271	Low output voltage of right front speed sensor	75	C1275	Abnormal change in output voltage of right front speed sensor
72	C1272	Low output voltage of left front speed sensor	76	C1276	Abnormal change in output voltage of left front speed sensor
73	C1273	Low output voltage of right rear speed sensor	77	C1277	Abnormal change in output voltage of right rear speed sensor
74	C1274	Low output voltage of left rear speed sensor	78	C1278	Abnormal change in output voltage of left rear speed sensor

Fail-Safe

- In the event of a malfunction in the ABS, the skid control ECU prohibits the ABS operation.
- In the event of a malfunction in EBD control, skid control ECU prohibits the EBD control. Thus, the brake will be operated in the same condition as in the condition without the ABS with EBD.