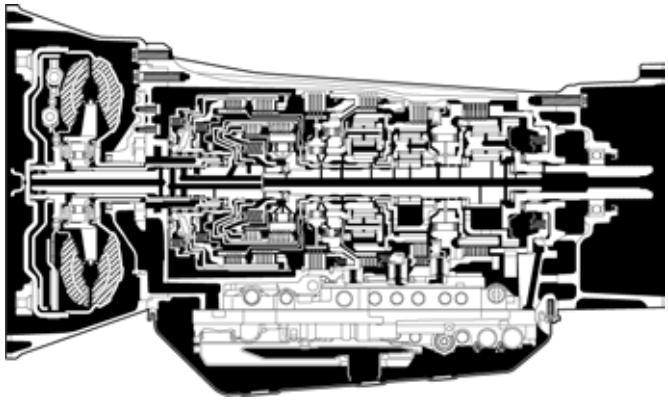
CHASSIS

AB60F AUTOMATIC TRANSMISSION

■ DESCRIPTION

The AB60F automatic transmission is used. This automatic transmission is a compact, lightweight and high-capacity 6-speed Super ECT (Electronically Controlled Transmission).

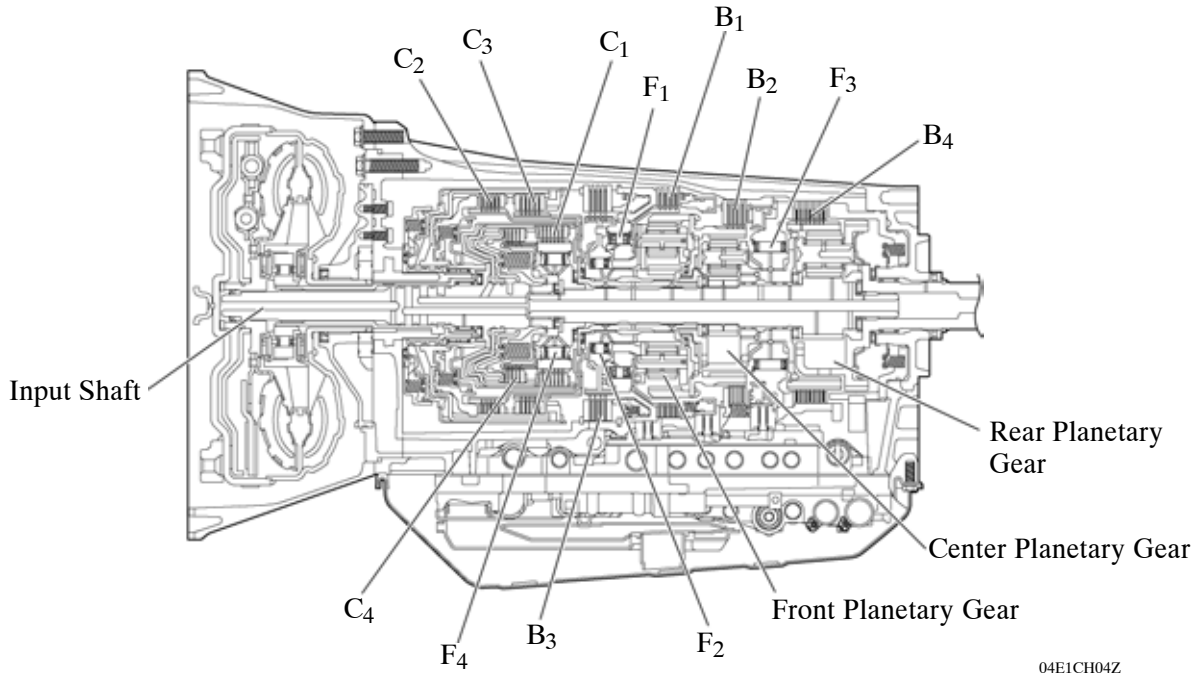


04E1CH02Z

▶ Specifications ◀

Transmission Type		AB60F
Engine Type		3UR-FE
Fluid Type		Toyota Genuine ATF WS
Gear Ratio	1st	3.333
	2nd	1.960
	3rd	1.353
	4th	1.000
	5th	0.728
	6th	0.588
	Reverse	3.061
Fluid Capacity Liters (US qts, Imp. qts)	With Air-cooled Type ATF Cooler	11.8 (12.5, 10.4)
	With ATF Warmer	11.6 (12.3, 10.2)
Weight (Reference)* kg (lb)	With Air-cooled Type ATF Cooler	107.9 (237.9)
	With ATF Warmer	108.7 (239.6)

*: The figure shown is the weight of the part including the fluid.

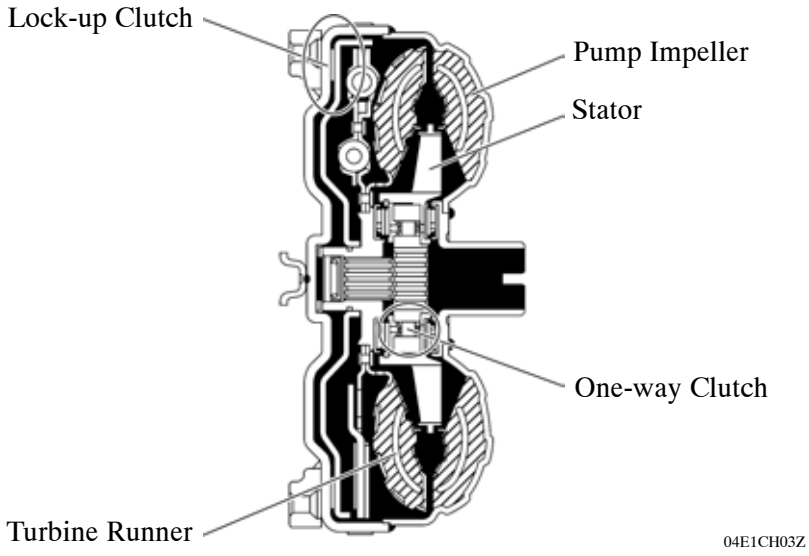


▶ Specifications ◀

C_1	No. 1 Clutch	The No. of Discs		6
C_2	No. 2 Clutch			5
C_3	No. 3 Clutch			5
C_4	No. 4 Clutch			4
B_1	No. 1 Brake			4
B_2	No. 2 Brake			4
B_3	No. 3 Brake			4
B_4	No. 4 Brake			7
F_1	No. 1 One-way Clutch	The No. of Sprags		30
F_2	No. 2 One-way Clutch			25
F_3	No. 3 One-way Clutch			33
F_4	No. 4 One-way Clutch			28
Front Planetary Gear		The No. of Sun Gear Teeth		42
		The No. of Pinion Gear Teeth	Inner	19
			Outer	18
		The No. of Ring Gear Teeth		90
Center Planetary Gear		The No. of Sun Gear Teeth		30
		The No. of Pinion Gear Teeth		20
		The No. of Ring Gear Teeth		70
Rear Planetary Gear		The No. of Sun Gear Teeth		30
		The No. of Pinion Gear Teeth		20
		The No. of Ring Gear Teeth		70

■TORQUE CONVERTER

A compact, lightweight and high-capacity torque converter is used. The torque converter supports flex lock-up clutch control, thus allowing for improved fuel economy.

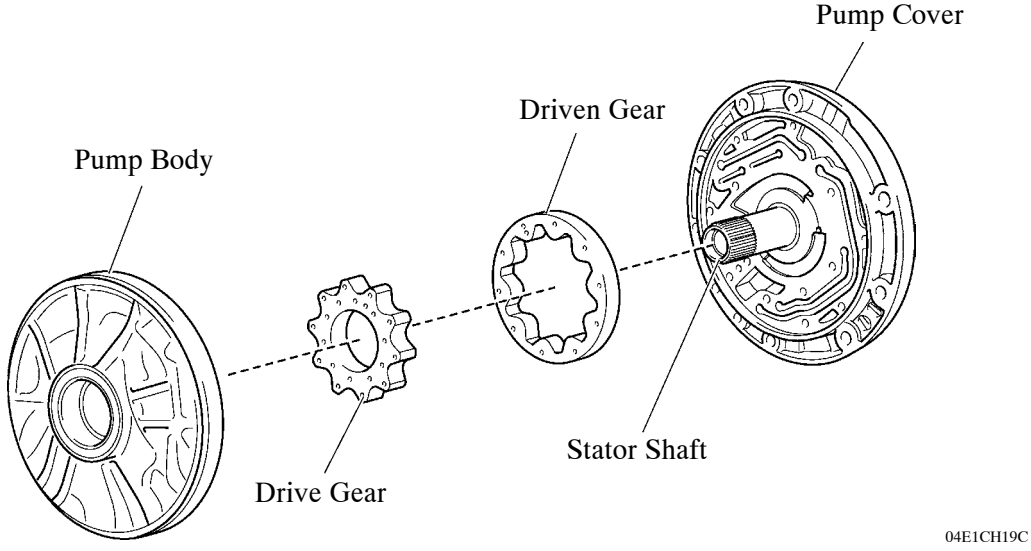


▶ Specifications ◀

Torque Converter Type	3-element, 1-step, 2-phase
Stall Torque Ratio	1.80

■OIL PUMP

The oil pump is driven by the torque converter. It lubricates the planetary gear and supplies operating fluid pressure for hydraulic control.



■ATF COOLING SYSTEM

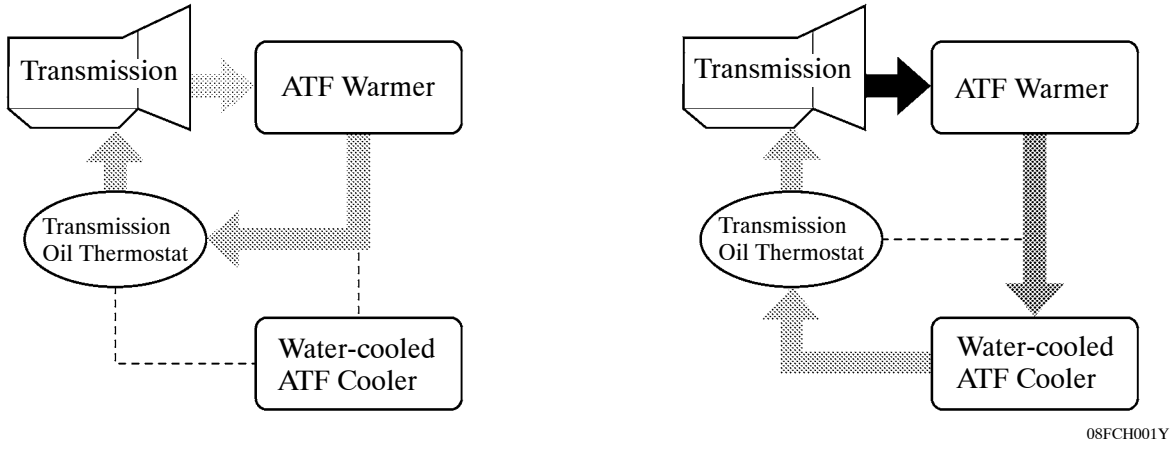
1. General

In addition to the water-cooled type ATF cooler, either of an air-cooled type ATF cooler or an ATF warmer is provided to this automatic transmission. The ATF warmer is used to warm up ATF quickly and to set an ATF temperature higher. The ATF cooling system for each destination is set as follows:

○: Standard —: Not available

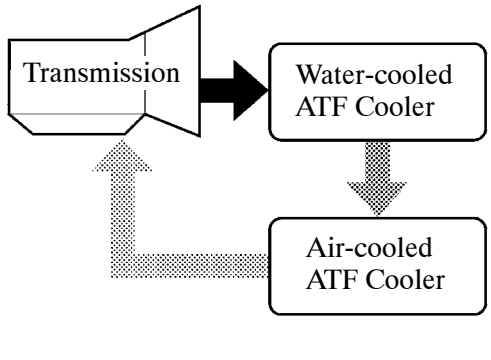
Item		Destination			
		Europe	Australia	G.C.C. Countries	China
ATF Warmer		○	—	—	○
ATF Cooler	Water-cooled Type	○	○	○	○
	Air-cooled Type	—	○	○	—

▶ Cooling Circuits (ATF Warmer and Water-cooled Type ATF Cooler) ◀



ATF Temperature: Low **ATF Temperature: High**

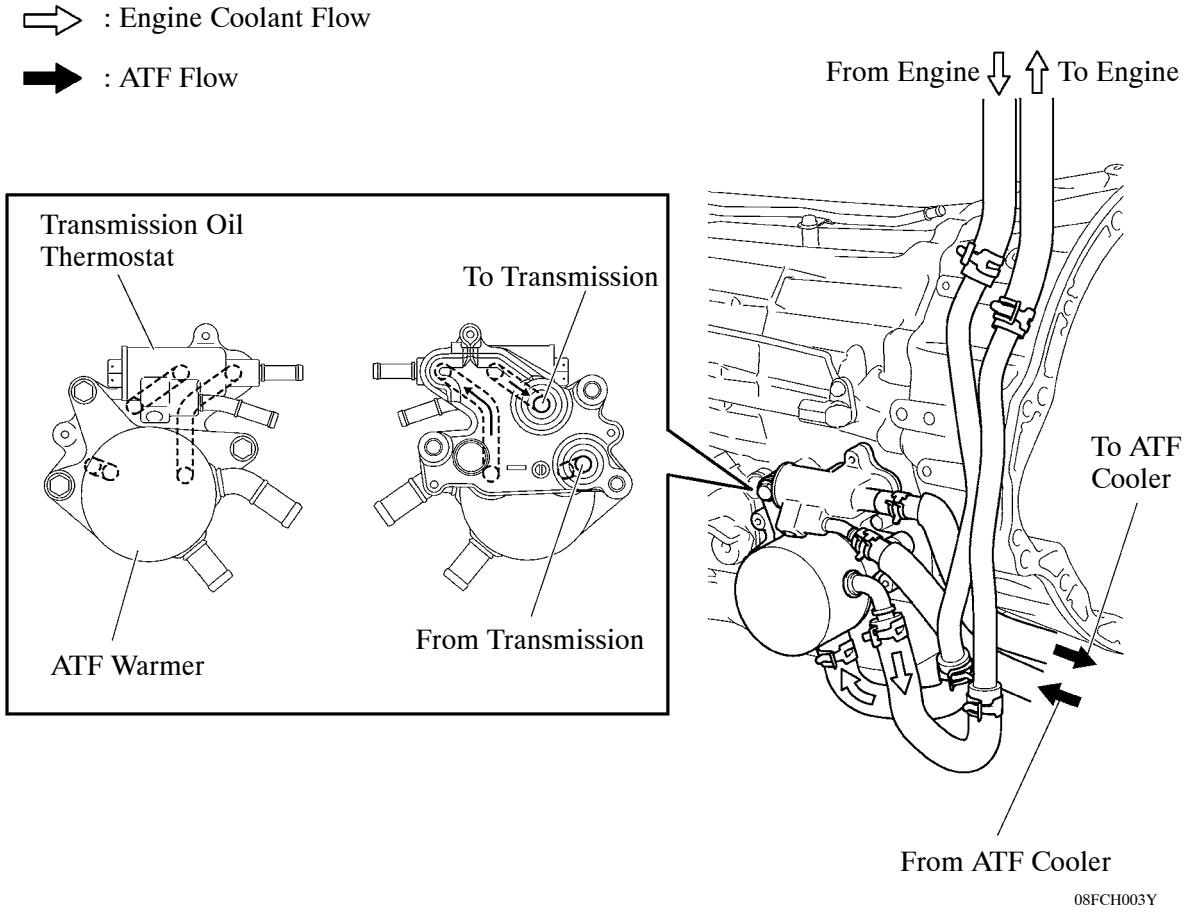
▶ Cooling Circuits (Water-cooled Type ATF Cooler and Air-cooled Type ATF Cooler) ◀



2. ATF Warmer

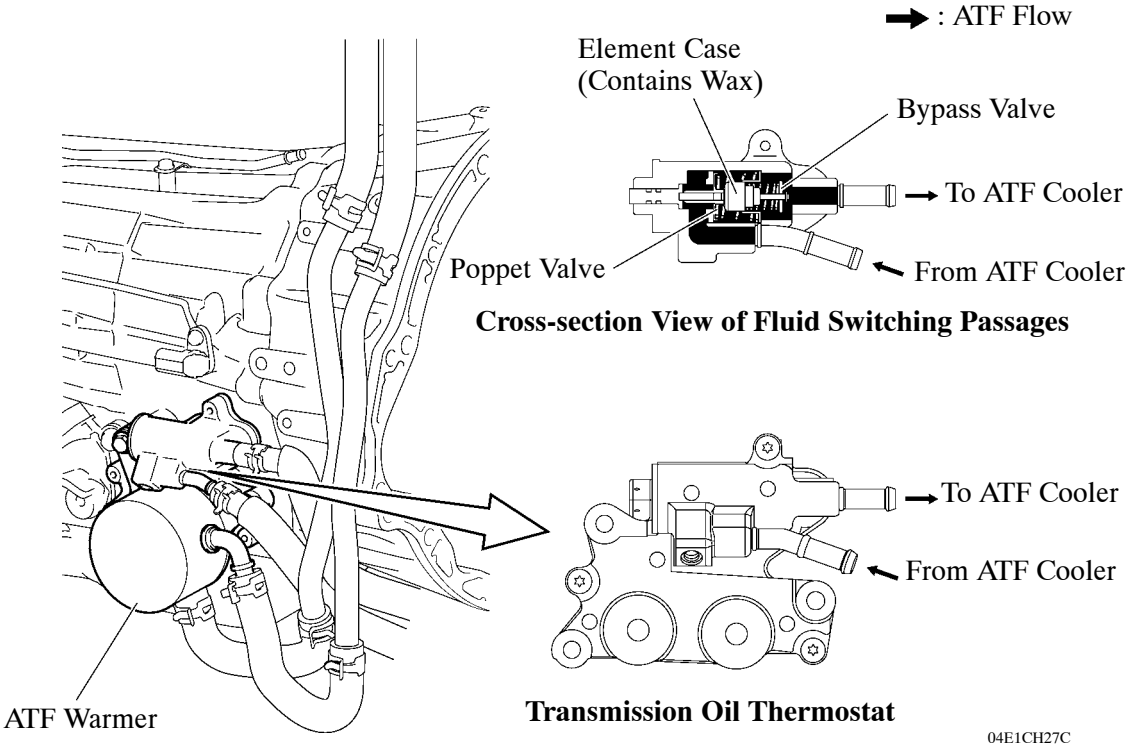
General

- The ATF warmer uses engine coolant to warm up the ATF quickly and keep the ATF temperature higher (within limits). Consequently, the friction losses of the automatic transmission are quickly reduced, thus improving fuel economy.
- The ATF warmer has a transmission oil thermostat that changes the route through which the ATF flows. When the ATF temperature is low, it is heated by the ATF warmer using the engine coolant, and when the temperature is high, it is cooled down by the ATF warmer and ATF cooler.



Transmission Oil Thermostat

The transmission oil thermostat consists of the poppet valve, bypass valve and element case (contains wax). When the ATF temperature changes from low to high, the wax will expand to start to open the poppet valve and close the bypass valve, thus switching the ATF passages.

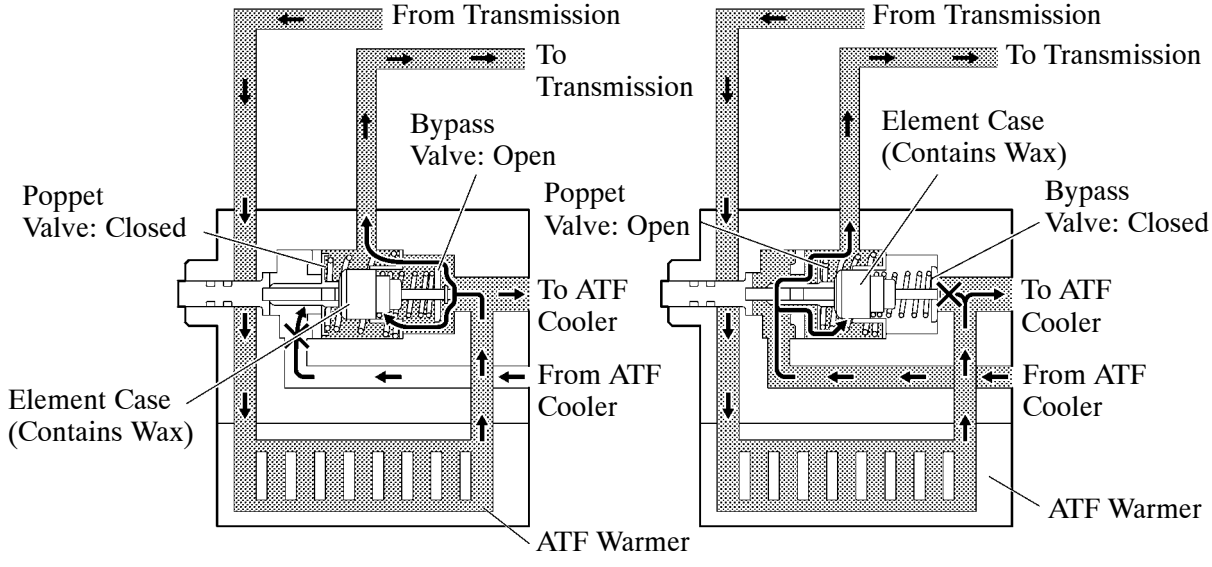


Cross-section View of Fluid Switching Passages

Transmission Oil Thermostat

04E1CH27C

▶ Operation of Transmission Oil Thermostat ◀

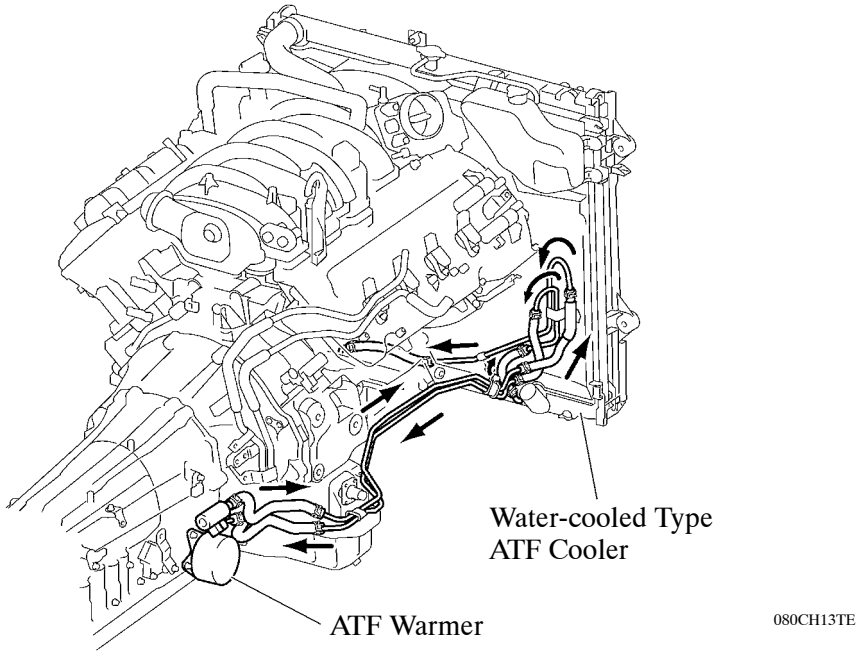


ATF Temperature: Low **ATF Temperature: High**

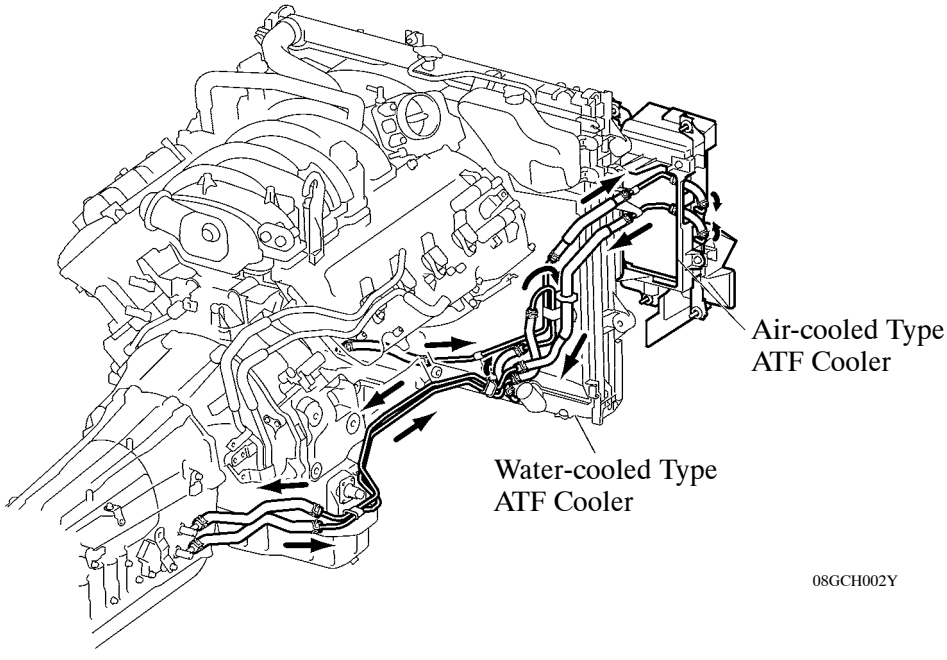
08FCH004Y

3. ATF Cooler

- The water-cooled type ATF cooler cools down the ATF using the engine coolant, and is fitted on the lower of the radiator.
- The air-cooled type ATF cooler cools down the ATF using the cooling fins which are provided on the cooler itself, and is fitted inside the radiator grille so that it can be exposed to the air directly while the vehicle is running.



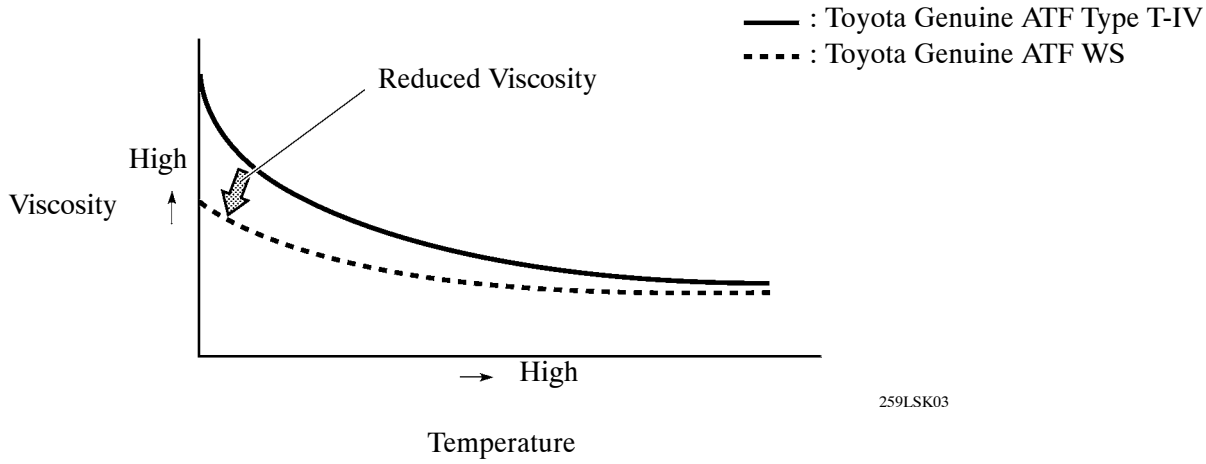
Models with ATF Warmer and Water-cooled Type ATF Cooler



Models with Water-cooled Type and Air-cooled Type ATF Coolers

■TOYOTA GENUINE ATF WS

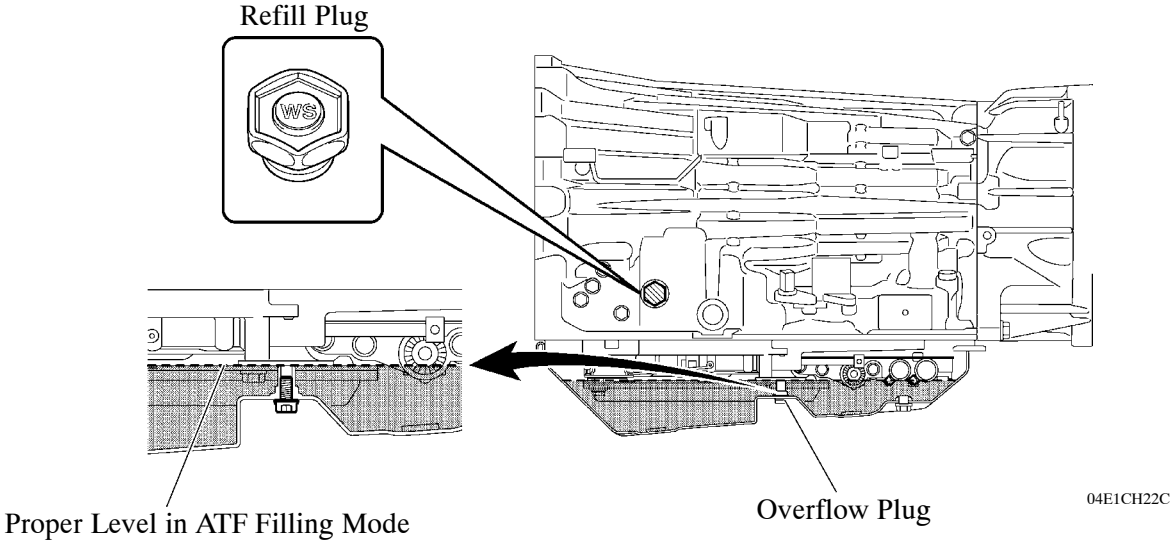
- Toyota genuine ATF WS is used to reduce the resistance of the ATF and improve fuel economy by reducing its viscosity in the practical operating temperature range. At higher-fluid temperatures, the viscosity is the same as that of Toyota genuine ATF Type T-IV, to ensure the durability of the automatic transmission.
- There is no interchangeability between the Toyota genuine ATF WS and other types of ATF (Toyota Genuine ATF Type T-IV, D-II).



■ATF FILLING PROCEDURE

An ATF filling procedure is used in order to improve the accuracy of the ATF level when the transmission is being repaired or replaced. As a result, the oil filler tube and the oil level gauge used in the conventional automatic transmission have been discontinued, eliminating the need to inspect the fluid level as a part of routine maintenance.

- This filling procedure uses the refill plug, overflow plug, ATF temperature sensor No. 2, and shift position indicator “D”.
- ATF filling procedures are different between the models with an ATF cooler and the models without an ATF cooler.



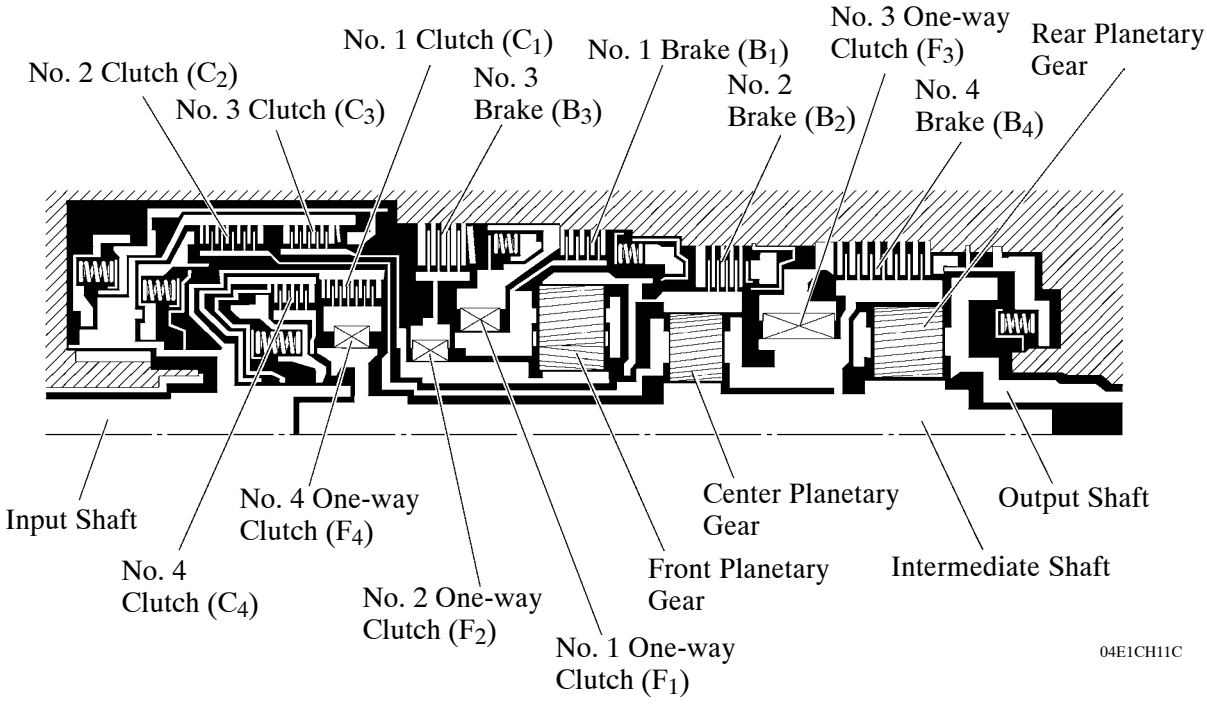
Service Tip

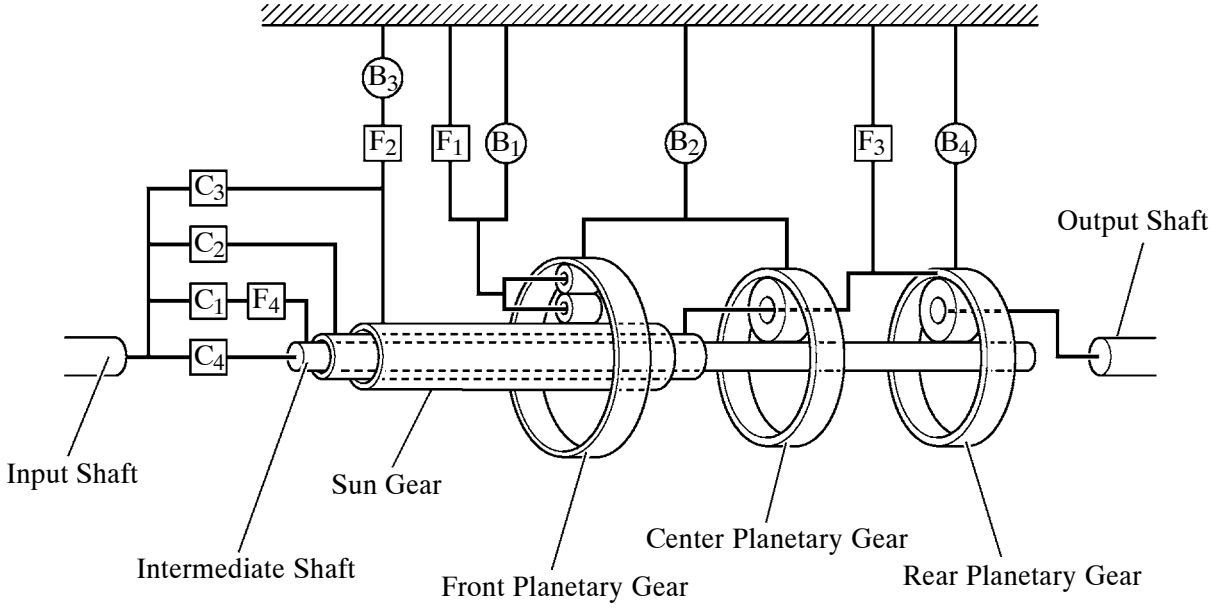
For details about the ATF filling procedures, see the LEXUS LX 570 Repair Manual (Pub. No. RM08G0E).

■ PLANETARY GEAR UNIT

1. Construction

- The planetary gear unit consists of three planetary gear units, four clutches, four brakes, and four one-way clutches.
- A centrifugal fluid pressure canceling mechanism is used in the C_1, C_2, C_3, and C_4 clutches that are applied when shifting 2nd → 3rd, 3rd → 4th, 4th → 5th, and 5th → 6th. For details, see page CH-17.





2. Function of Components

Component		Function
C_1	No. 1 Clutch	Connects the input shaft, F_4 and intermediate shaft.
C_2	No. 2 Clutch	Connects the input shaft and center planetary carrier.
C_3	No. 3 Clutch	Connects the input shaft and front planetary sun gear.
C_4	No. 4 Clutch	Connects the input shaft and intermediate shaft.
B_1	No. 1 Brake	Prevents the front planetary carrier from turning either clockwise or counterclockwise.
B_2	No. 2 Brake	Prevents the front and center planetary ring gears from turning either clockwise or counterclockwise.
B_3	No. 3 Brake	Prevents the outer race of F_2 from turning either clockwise or counterclockwise.
B_4	No. 4 Brake	Prevents the center planetary carrier and the rear planetary ring gear from turning either clockwise or counterclockwise.
F_1	No. 1 One-way Clutch	Prevents the front planetary carrier from turning counterclockwise.
F_2	No. 2 One-way Clutch	When B_3 is operating, the one-way clutch prevents the sun gear from turning counterclockwise.
F_3	No. 3 One-way Clutch	Prevents the center planetary carrier and rear planetary ring gear from turning counterclockwise.
F_4	No. 4 One-way Clutch	Prevents the intermediate shaft from turning counterclockwise.
Planetary Gear		These gears change the route through which driving force is transmitted, in accordance with the operation of each clutch and brake, in order to increase or reduce the output shaft speed.

3. Transmission Power Flow

General

Shift Lever Position		Solenoid Valve								Clutch				Brake				One-way Clutch			
		S1	S2	S3	S4	SR	SL1	SL2	SLU	C_1	C_2	C_3	C_4	B_1	B_2	B_3	B_4	F_1	F_2	F_3	F_4
P			ON	ON		ON		ON													
R			ON	ON		ON		ON				○		○			○	○			
N			ON	ON		ON	ON	ON													
D, S6	1st		ON	ON		ON		ON		○			○							○	○
	2nd	ON	ON	ON		ON		ON	ON	○			○			○		○	○		○
	3rd	ON		ON		ON		ON	ON	○		○	○			●		○			○
	4th*	ON				ON		ON	ON	○	○	●	○			●					○
	5th*	ON			ON		ON		ON	●	○	○		○		●					
	6th*	ON	ON		ON		ON		ON	●	○			●	○	●					
S5	1st		ON	ON		ON		ON		○			○							○	○
	2nd	ON	ON	ON		ON		ON	ON	○			○			○		○	○		○
	3rd	ON		ON		ON		ON	ON	○		○	○			●		○			○
	4th*	ON				ON		ON	ON	○	○	●	○			●					○
	5th*	ON			ON		ON		ON	●	○	○		○		●					
S4	1st		ON	ON		ON		ON		○			○							○	○
	2nd	ON	ON	ON		ON		ON	ON	○			○			○		○	○		○
	3rd	ON		ON		ON		ON	ON	○		○	○			●		○			○
	4th*	ON				ON		ON	ON	○	○	●	○			●					○
S3	1st		ON	ON		ON		ON		○			○							○	○
	2nd	ON	ON	ON		ON		ON	ON	○			○			○		○	○		○
	3rd*	ON		ON		ON			ON	○		○	○	△		●		○			○
S2	1st		ON	ON		ON		ON		○			○							○	○
	2nd*	ON	ON	ON	ON	ON			ON	○			○		△	○		○	○		○
S1	1st*		ON	ON		ON				○			○				△			○	○

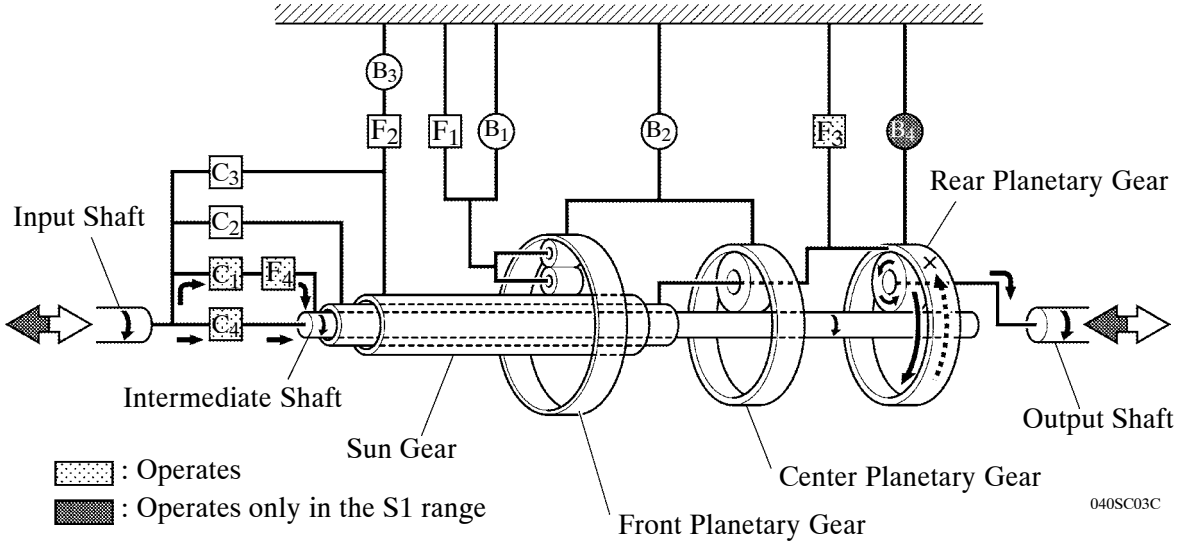
○: Operates

●: Operates but is not related to power transmission

△: Operates during engine braking

*: With engine brake

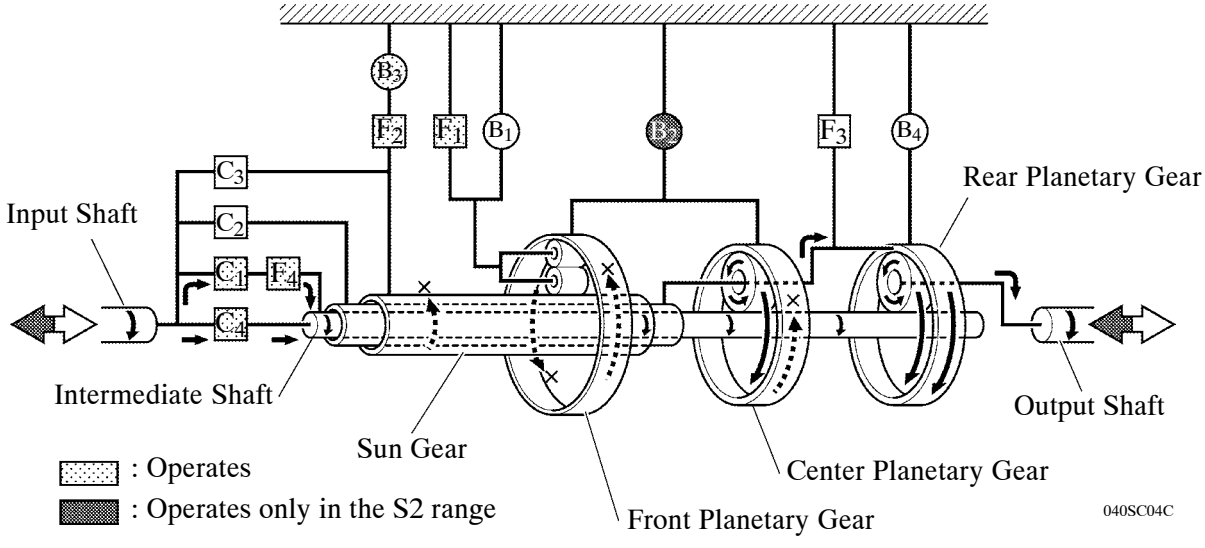
1st Gear (D Position or S Mode)



C_1	C_2	C_3	C_4	B_1	B_2	B_3	B_4	F_1	F_2	F_3	F_4
○			○				△			○	○

○: Operates △: Operates only in the S1 range

2nd Gear (D Position or S Mode)

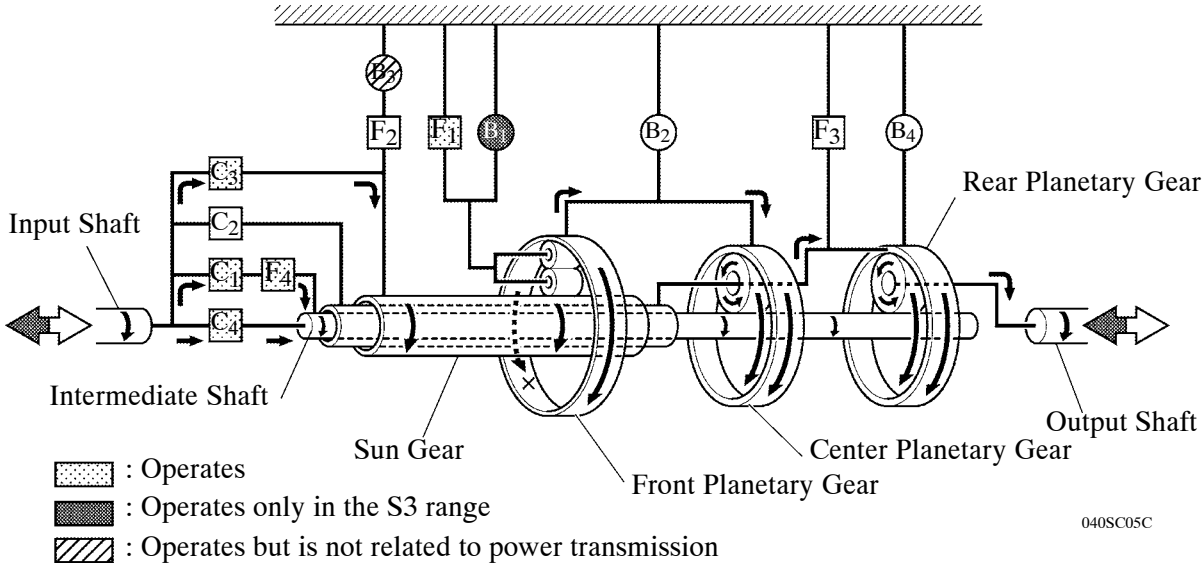


C_1	C_2	C_3	C_4	B_1	B_2	B_3	B_4	F_1	F_2	F_3	F_4
○			○		△	○		○	○		○

○: Operates △: Operates only in the S2 range

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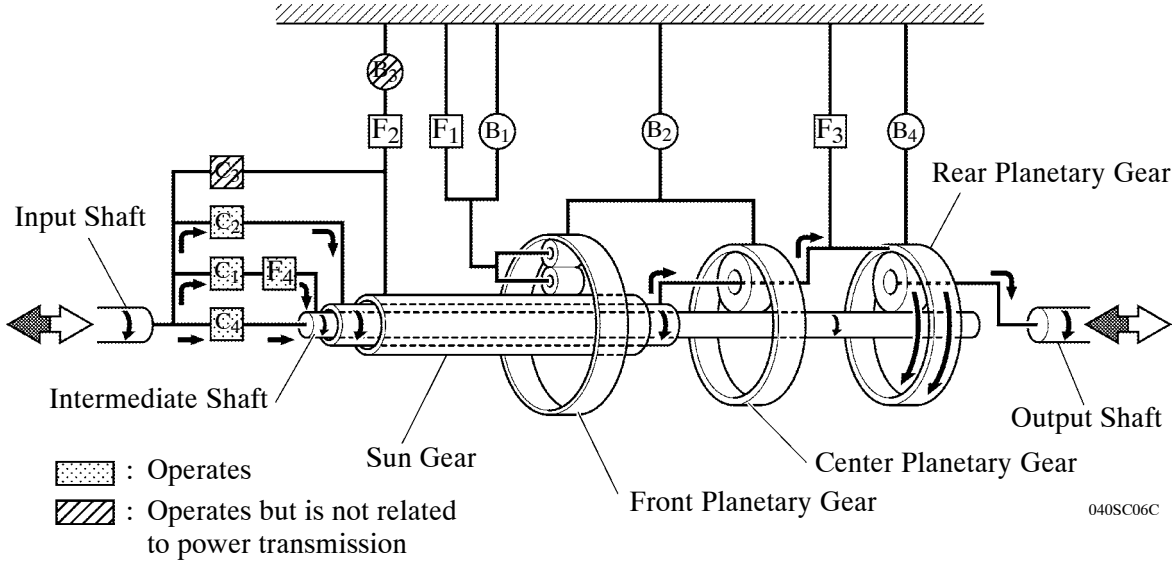
3rd Gear (D Position or S Mode)



C_1	C_2	C_3	C_4	B_1	B_2	B_3	B_4	F_1	F_2	F_3	F_4
○		○	○	△		●		○			○

○: Operates △: Operates only in the S3 range ●: Operates but is not related to power transmission

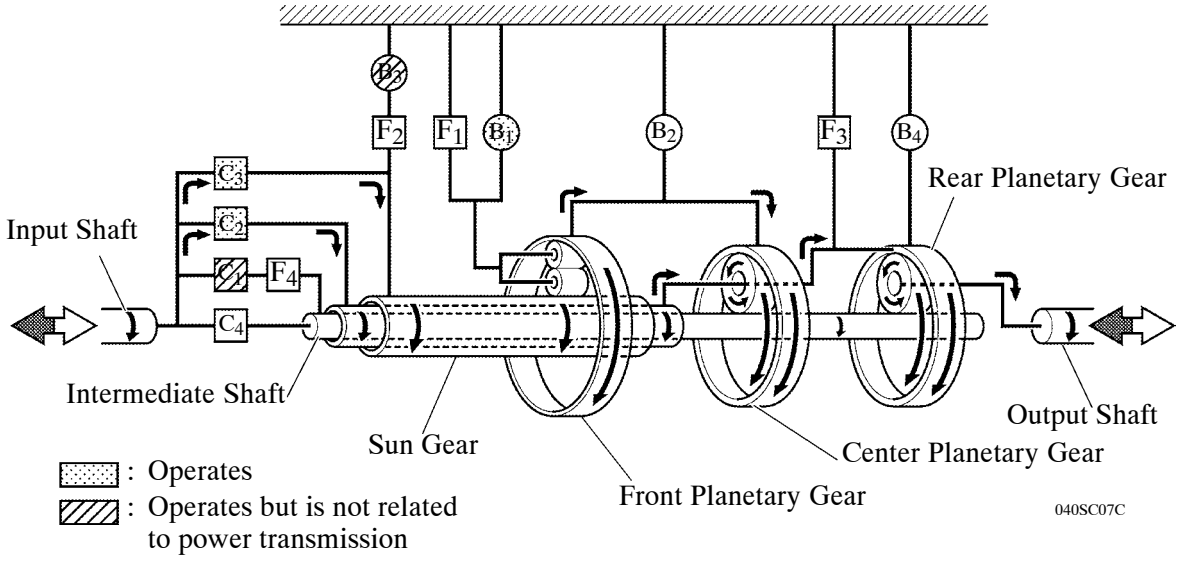
4th Gear (D Position or S Mode)



C_1	C_2	C_3	C_4	B_1	B_2	B_3	B_4	F_1	F_2	F_3	F_4
○	○	●	○			●					○

○: Operates ●: Operates but is not related to power transmission

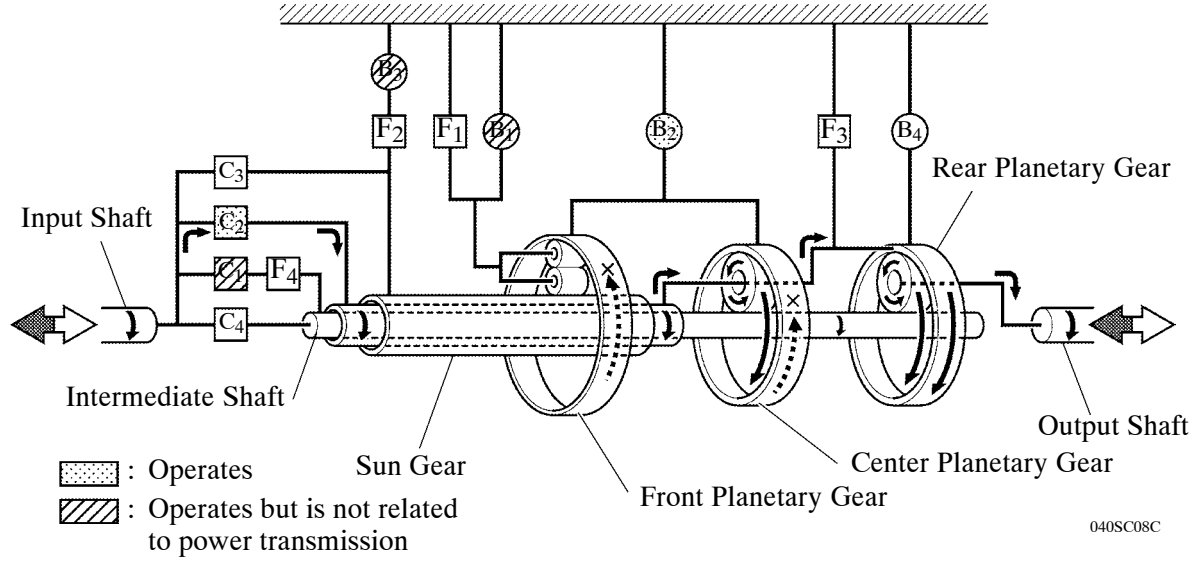
5th Gear (D Position or S Mode)



C_1	C_2	C_3	C_4	B_1	B_2	B_3	B_4	F_1	F_2	F_3	F_4
●	○	○		○		●					

○: Operates ●: Operates but is not related to power transmission

6th Gear (D Position or S Mode)

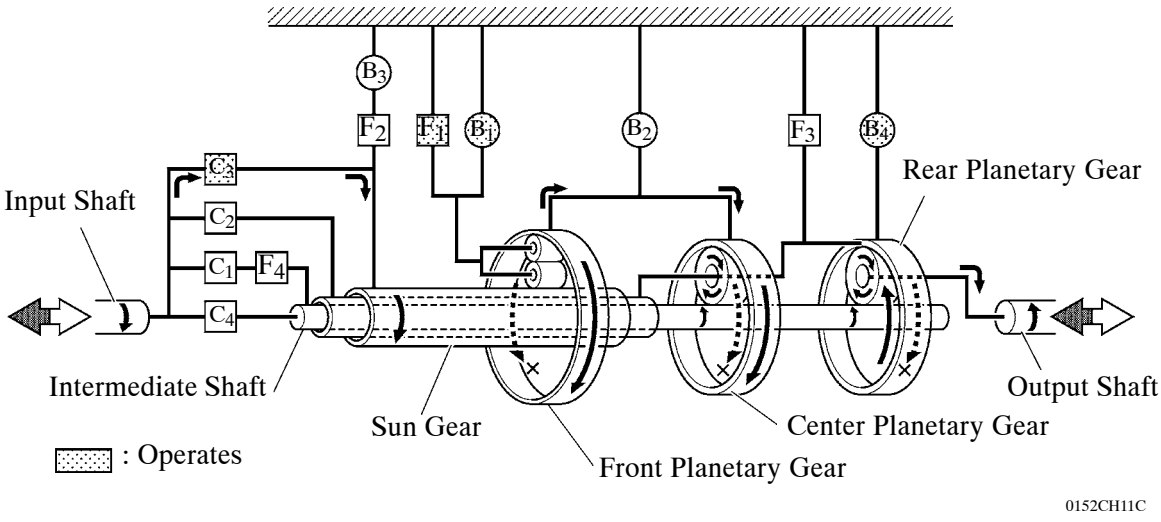


C_1	C_2	C_3	C_4	B_1	B_2	B_3	B_4	F_1	F_2	F_3	F_4
●	○			●	○	●					

○: Operates ●: Operates but is not related to power transmission

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Reverse Gear (R Position)



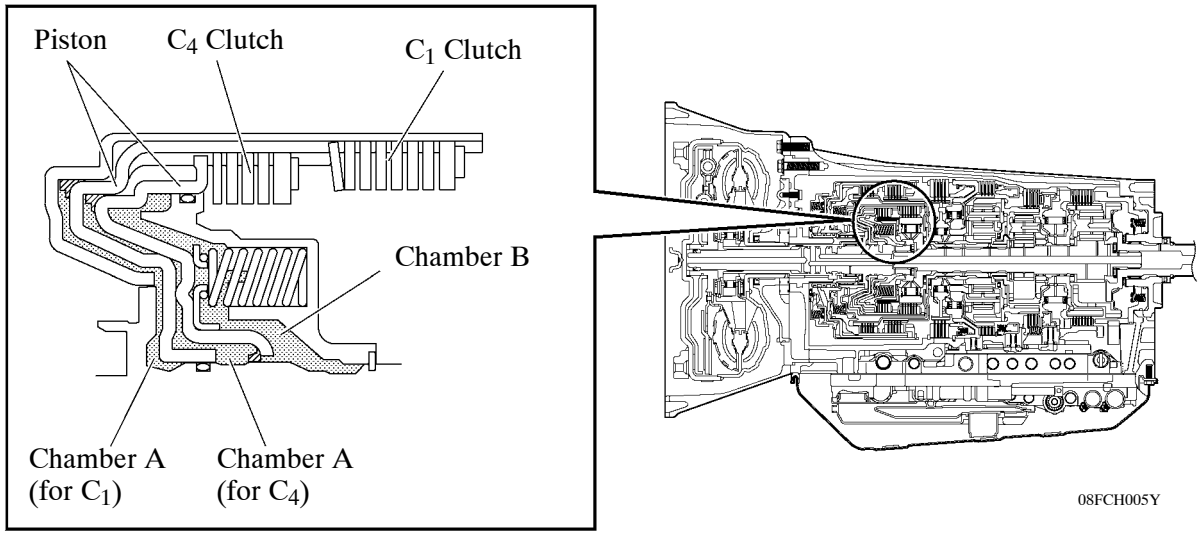
C_1	C_2	C_3	C_4	B_1	B_2	B_3	B_4	F_1	F_2	F_3	F_4
		○		○			○	○			

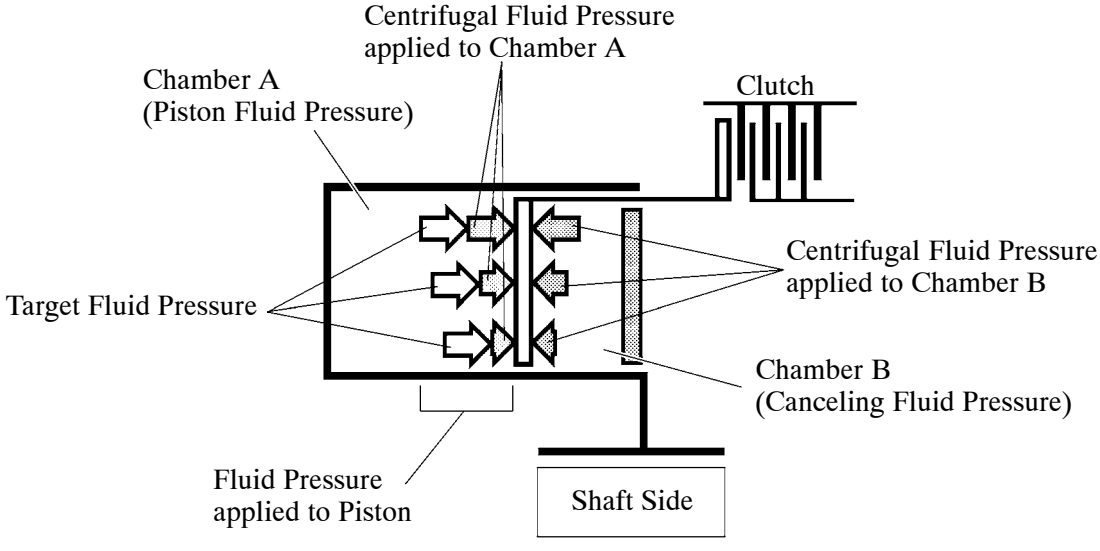
○: Operates

4. Centrifugal Fluid Pressure Canceling Mechanism

For the following reason, the centrifugal fluid pressure canceling mechanism is used on the C_1, C_2, C_3, and C_4 clutches.

- Clutch shifting operation is affected not only by the valve body controlling fluid pressure but also by centrifugal fluid pressure that is present due to fluid in the clutch piston oil pressure chamber. The centrifugal fluid pressure canceling mechanism has chamber B to reduce this affect applied to the chamber A. As a result, smooth shifting with excellent response has been achieved.



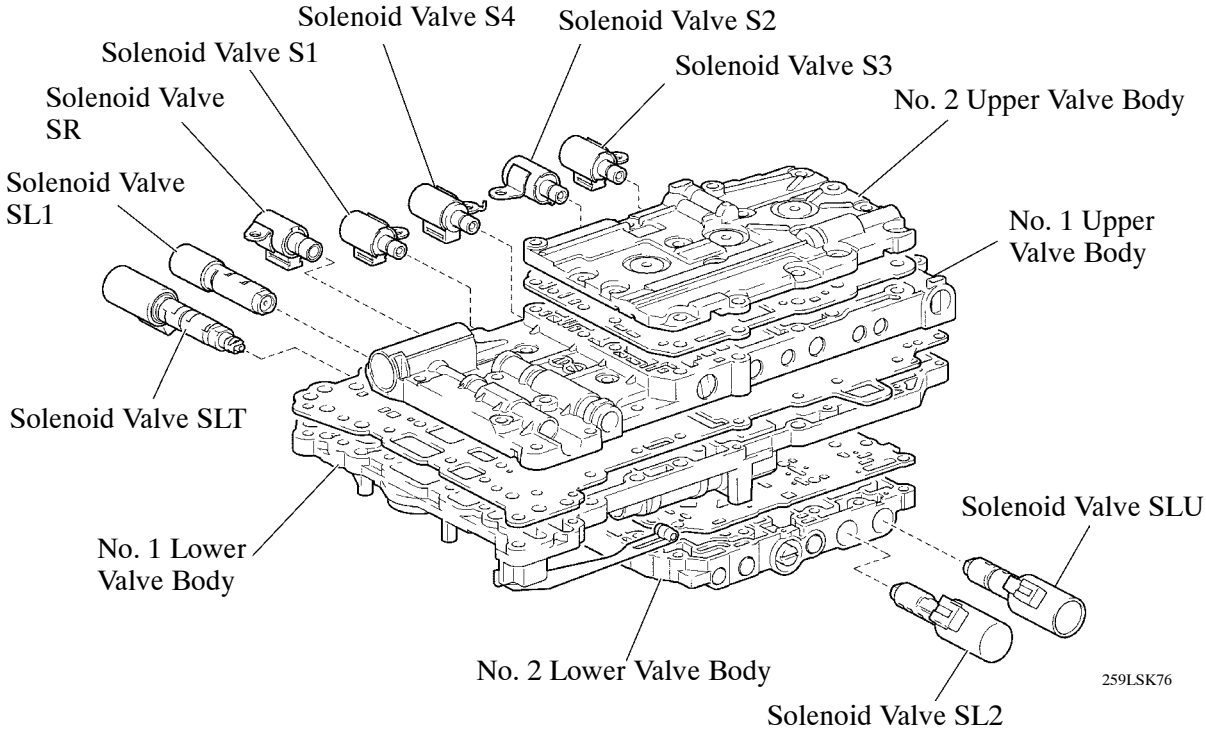


Fluid pressure applied to piston	–	Centrifugal fluid pressure applied to chamber B	=	Target fluid pressure (original clutch pressure)

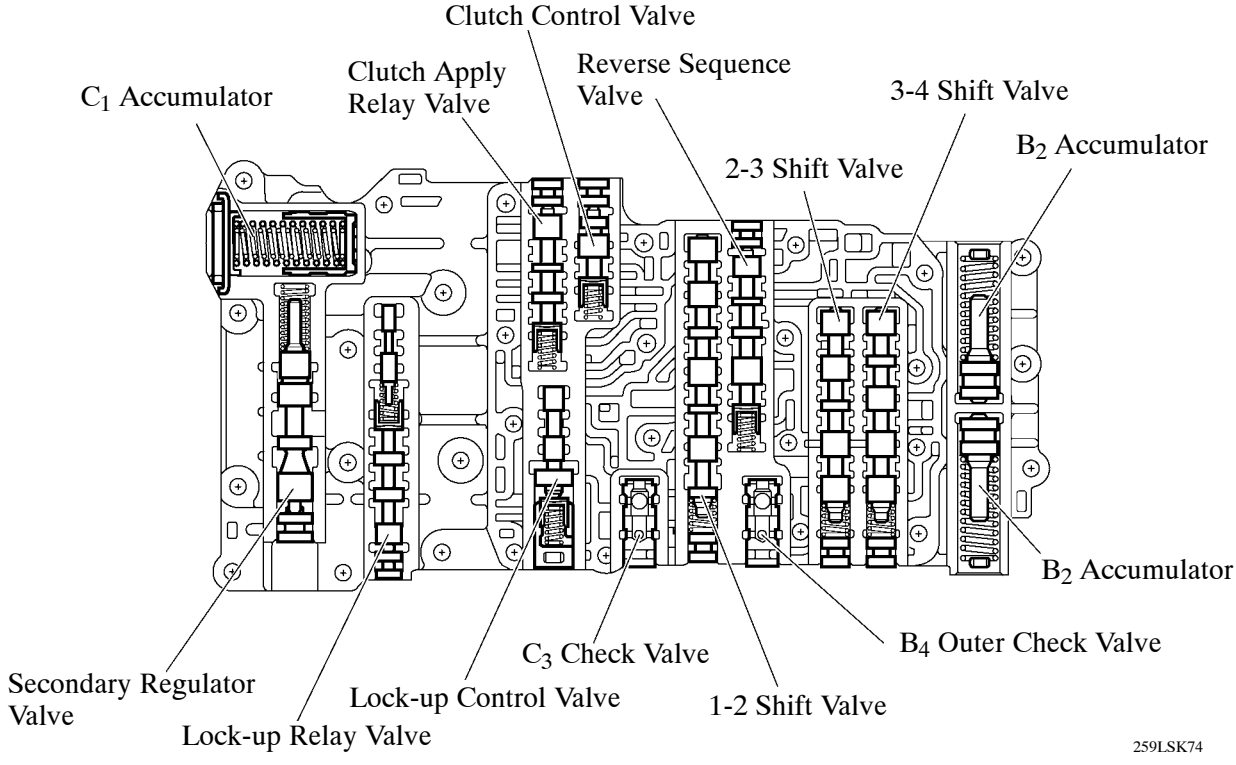
■VALVE BODY UNIT

1. General

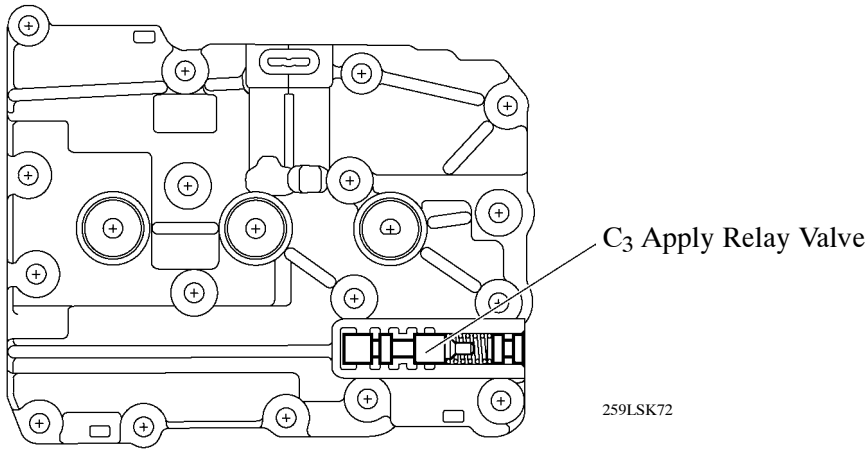
The valve body consists of the upper (No. 1 and No. 2) and lower (No. 1 and No. 2) valve bodies and 9 solenoid valves.



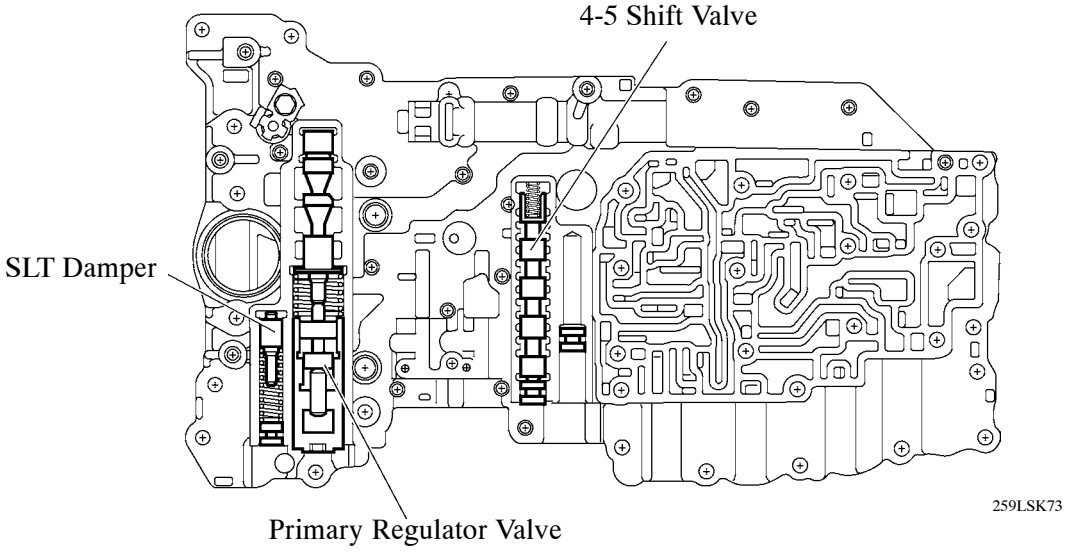
▶ No. 1 Upper Valve Body ◀



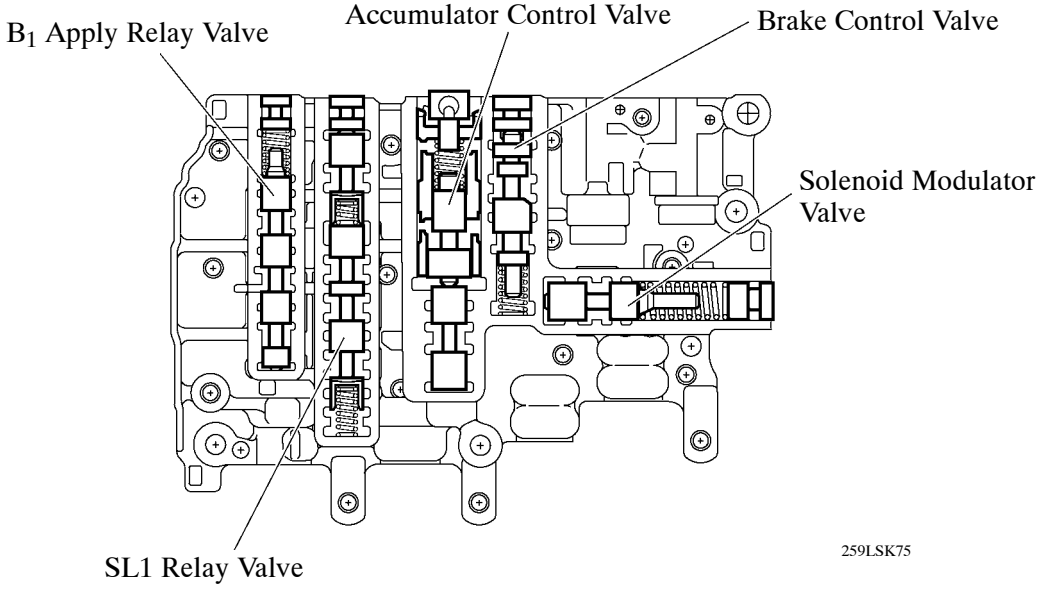
▶ No. 2 Upper Valve Body ◀



▶ Lower Valve Body ◀



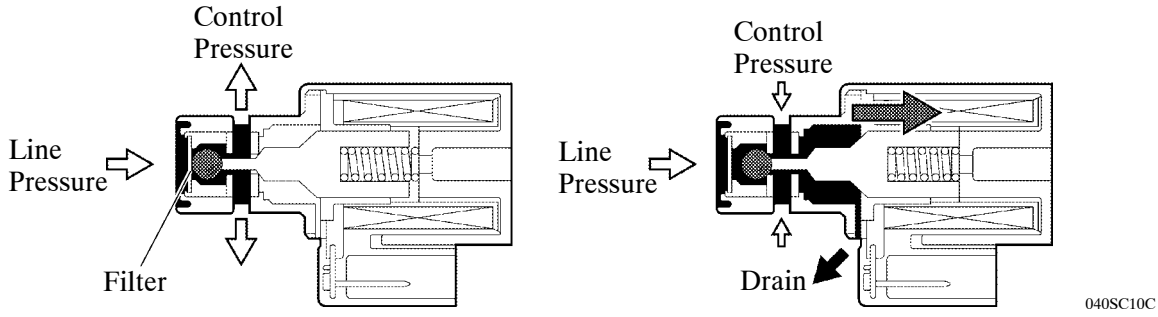
▶ No. 2 Lower Valve Body ◀



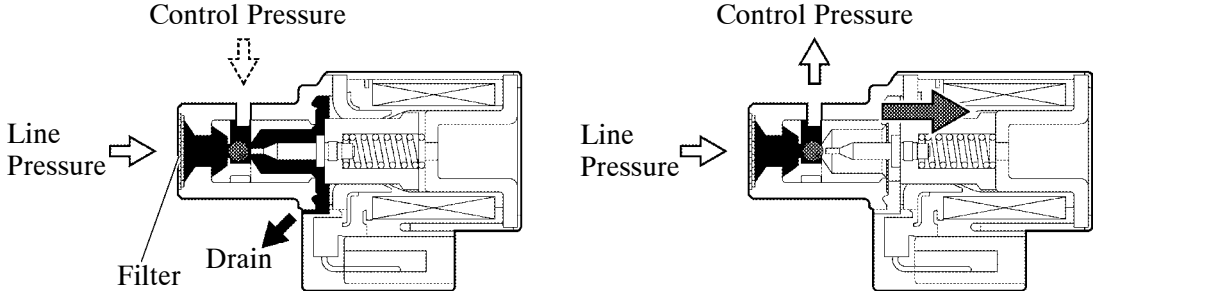
2. Solenoid Valve

Solenoid Valves S1, S2, S3, S4 and SR

These solenoid valves are 3-way solenoid valves. A filter is provided at the tip of the solenoid valve to further improve operational reliability.



Solenoid Valve S1 OFF **Solenoid Valve S1 ON**



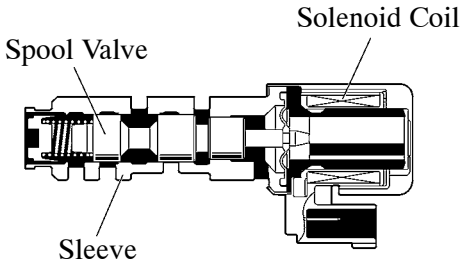
Solenoid Valve S4 OFF **Solenoid Valve S4 ON**

▶ Function of Solenoid Valves S1, S2, S3, S4 and SR ◀

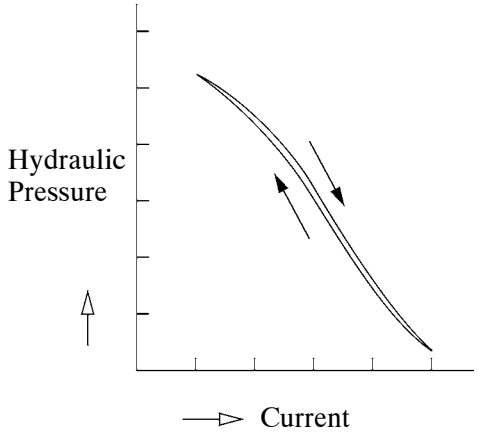
Solenoid Valve	Function
S1	● Switches the 1 – 2 shift valve. ● Switches the SL1 relay valve.
S2	● Switches the 2 – 3 and 5 – 6 shift valve. ● Switches the 1 – 2 shift valve.
S3	Switches the 3 – 4 shift valve.
S4	● Switches the 4 – 5 shift valve. ● Switches the SL1 relay valve. ● Switches the reverse sequence valve.
SR	● Switches the clutch apply relay valve. ● Switches the B_1 relay valve.

Solenoid Valves SL1, SL2, SLT and SLU

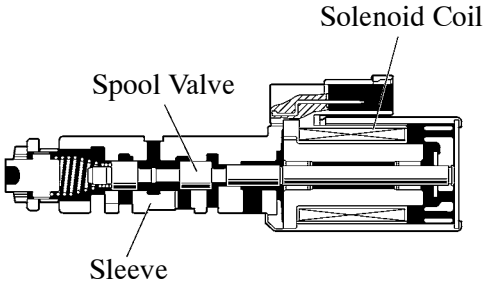
SL1, SL2, SLT, and SLU are used by the ECM to control hydraulic pressures in a linear fashion based on the current that the ECM causes to flow through their solenoid coils. They control line, clutch, and brake engagement pressures based on the signals received from the ECM.



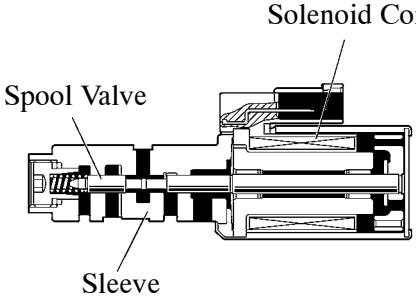
Solenoid Valves SL1, SL2



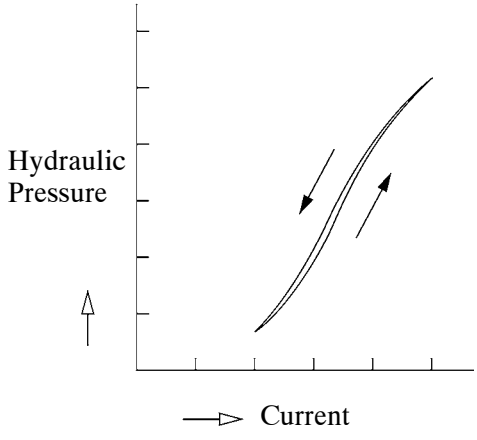
Output Characteristics of SL1, SL2 and SLT



Solenoid Valve SLT



Solenoid Valve SLU



Output Characteristics of SLU

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▶ Function of Solenoid Valves SL1, SL2, SLT and SLU ◀

Solenoid Valve	Function
SL1	● Clutch pressure control ● Accumulator back pressure control
SL2	Brake pressure control
SLT	● Line pressure control ● Accumulator back pressure control
SLU	Lock-up clutch pressure control

CH

■ELECTRONIC CONTROL SYSTEM

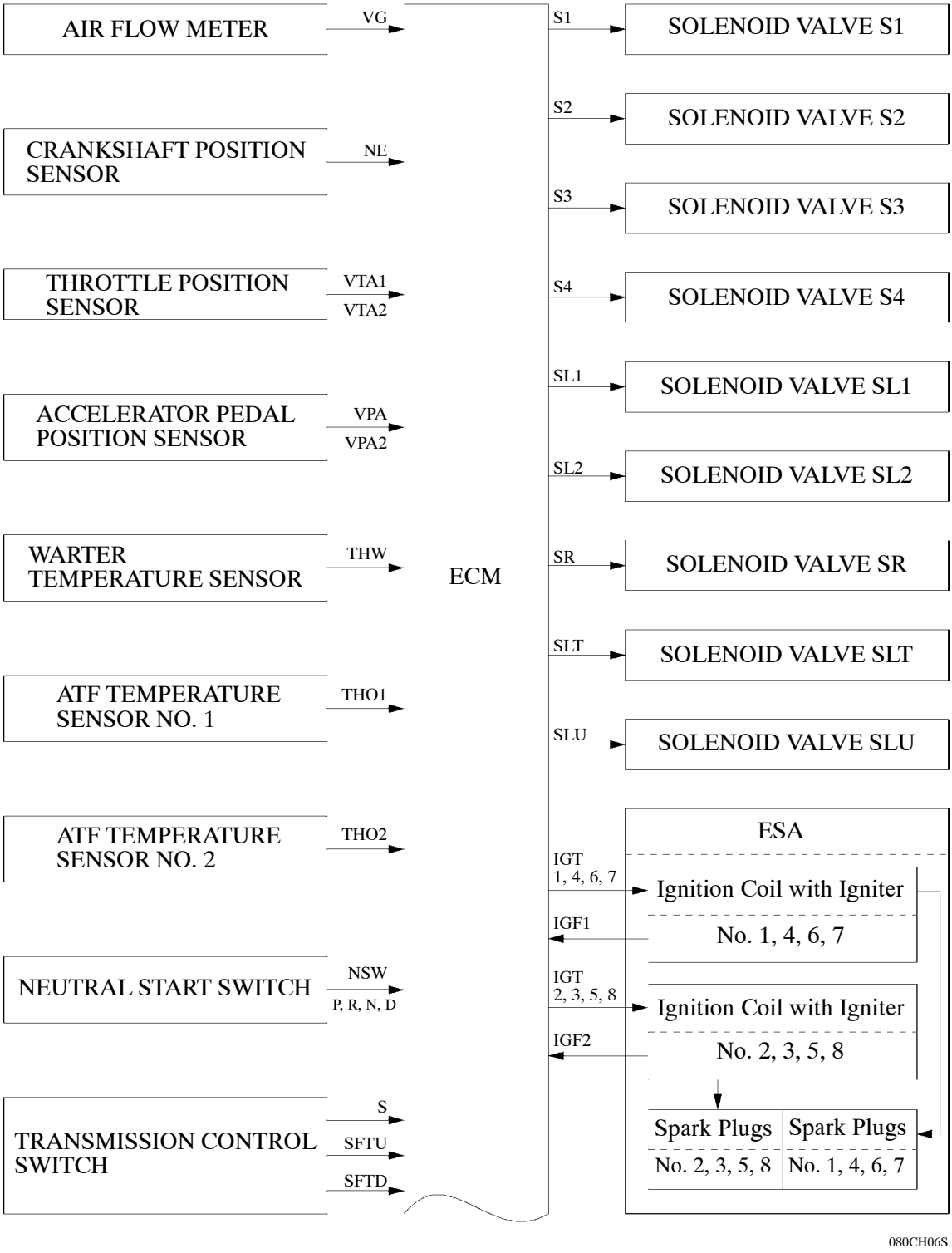
1. General

The electronic control system of the AB60F automatic transmissions consists of the control functions listed below.

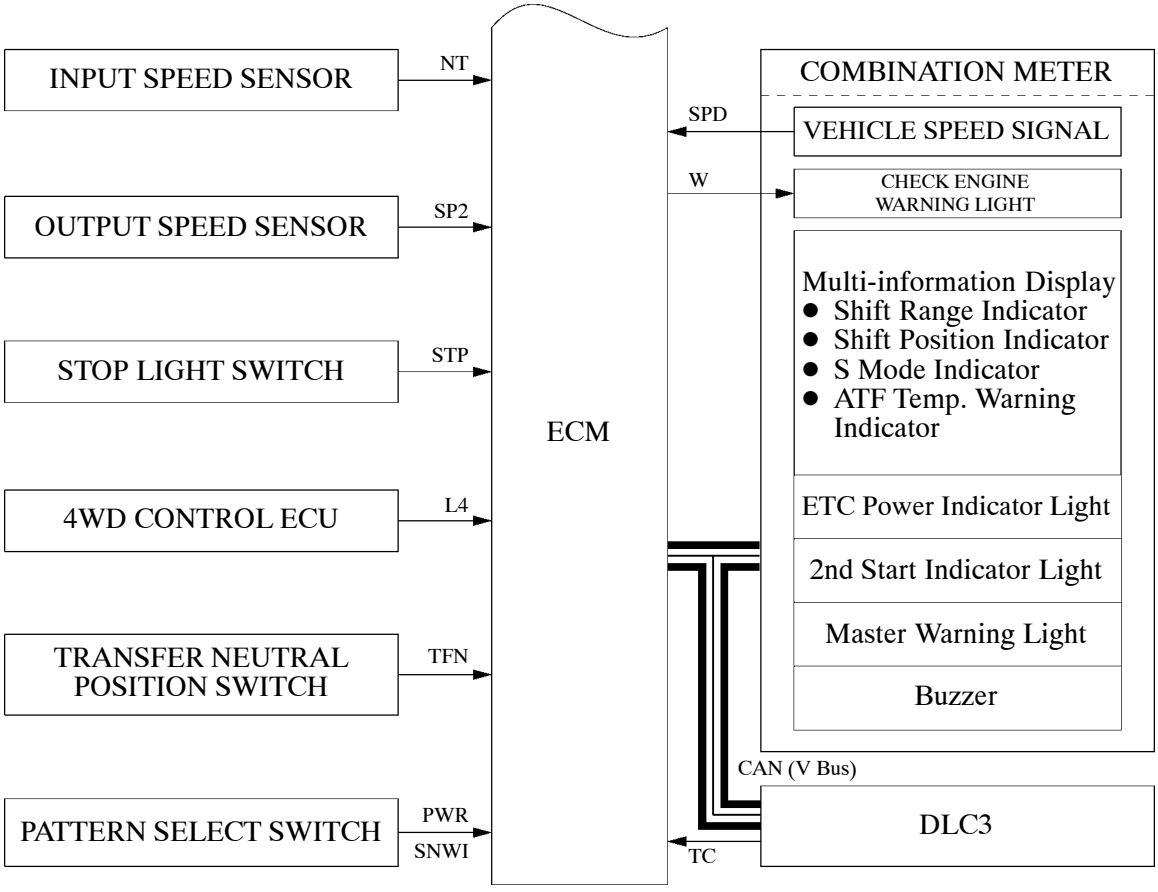
System	Function
Shift Timing Control	The ECM sends current to solenoid valves S1, S2, S3, S4 and/or SR based on signals from various sensors, in order to shift the gears.
Clutch Pressure Control (See Page CH-30)	● Controls the pressure that is applied directly to B_2 brake and C_3 clutch by actuating the linear solenoid valves SL1 and SL2 in accordance with the ECM signals. ● The solenoid valves SLT and SL1 minutely control the clutch pressure in accordance with the engine output and driving conditions.
Line Pressure Optimal Control (See Page CH-31)	Actuates the solenoid valve SLT to control the line pressure in accordance with information from the ECM and the operating conditions of the transmission.
Engine Torque Control	Retards the engine ignition timing temporarily to improve shift feeling while upshifts or downshifts occur.
Lock-up Timing Control (See Page CH-32)	The ECM sends current to the solenoid valve SLU based on signals from various sensors and engages or disengages the lock-up clutch.
Flex Lock-up Clutch Control (See Page CH-33)	Controls the solenoid valve SLU, provides an intermediate mode for when the lock-up clutch is between ON and OFF, increasing the operating range of the lock-up clutch to improve fuel economy.
Powertrain Cooperative Control (See Page CH-34)	Controls both the shift control and engine output control in an integrated way, achieving excellent shift characteristics and drivability.
Coast Downshift Control (See Page CH-35)	To prevent engine speed from decreasing and thereby maintain fuel cut, the ECM performs downshifts before fuel cut ends.
AI (Artificial Intelligence)-SHIFT Control (See Page CH-36)	Based on the signals from various sensors, the ECM determines the road conditions and the intention of the driver. While the pattern select switch is in POWER, the shift pattern is biased toward sporty driving. Thus, an appropriate shift pattern is automatically determined, improving drivability.
Multi-mode Automatic Transmission (See Page CH-38)	The ECM appropriately controls the automatic transmission in accordance with the range position selected while the shift lever is in the S mode position.
R to D Squat Control	When the shift lever is shifted from R to D position, the 3rd gear is temporarily engaged before the 1st gear to reduce vehicle squat.
N to D Squat Control	When the shift lever is shifted from N to D position, the 2nd gear is temporarily engaged before the 1st gear to reduce vehicle squat.
2nd Start Control	Enabling the vehicle to start off in the 2nd gear and thus make it easy to start off snowy, sandy or muddy terrain.
Diagnosis (See Page CH-40)	When the ECM detects a malfunction, the ECM records the malfunction and memorizes the information that relates to the fault.
Fail-safe (See Page CH-40)	If a malfunction is detected in the sensors or solenoids, the ECM effects fail-safe control to prevent the vehicle's drivability from being affected significantly.

2. Construction

The configuration of the electronic control system for the AB60F automatic transmission is as shown in the following chart.

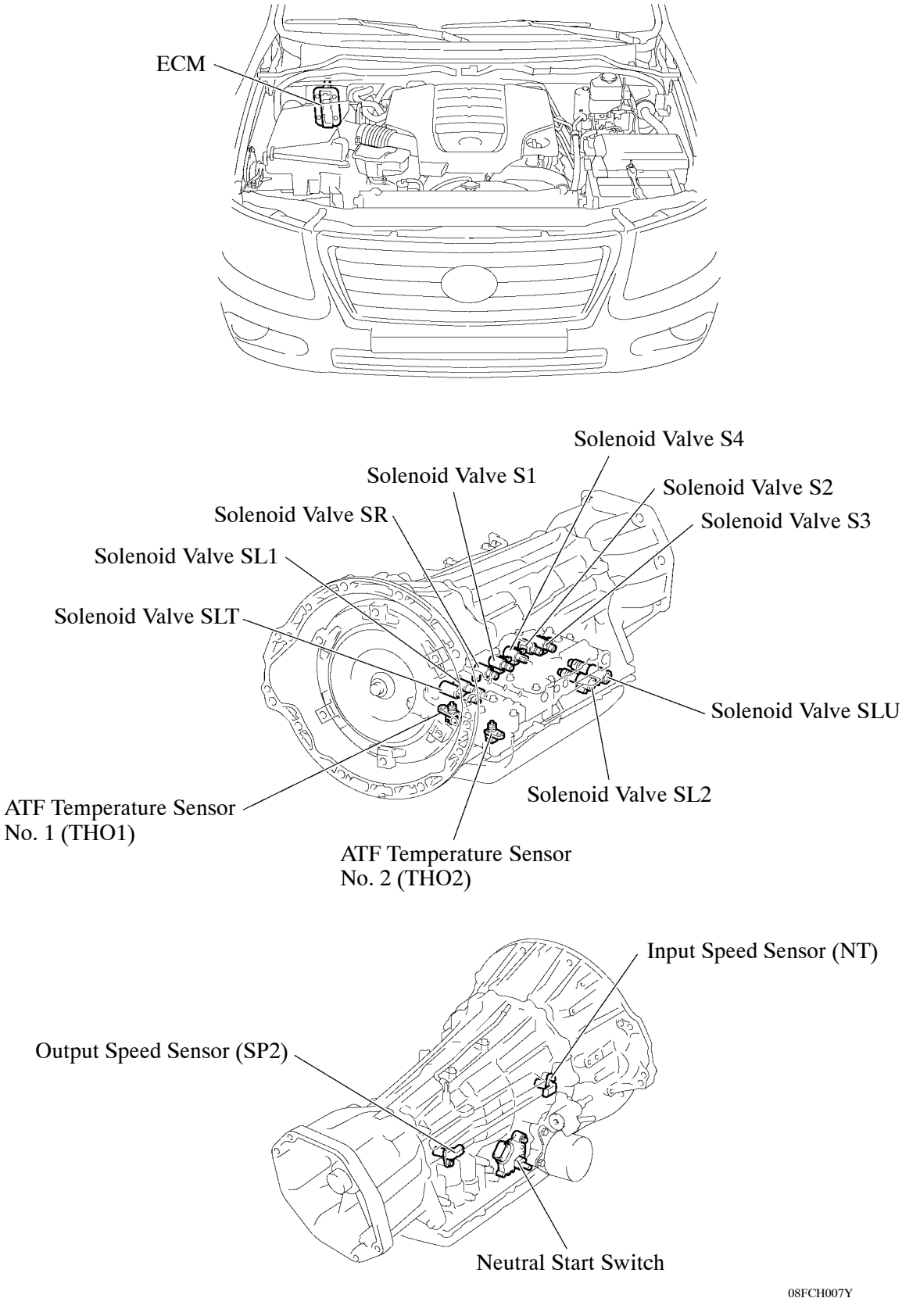


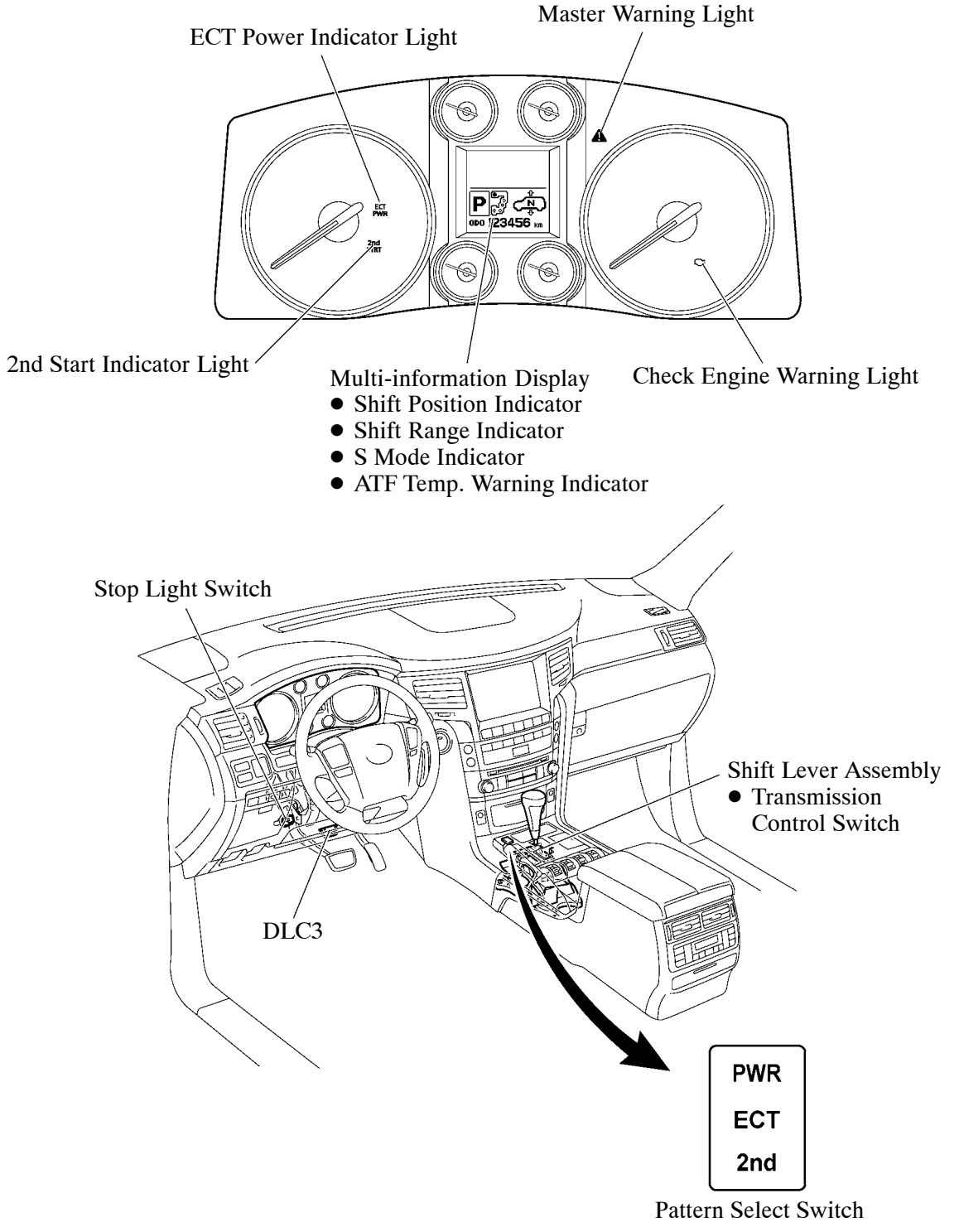
(Continued)


INPUT SPEED SENSOR
NT
OUTPUT SPEED SENSOR
SP2
STOP LIGHT SWITCH
STP
4WD CONTROL ECU
L4
TRANSFER NEUTRAL POSITION SWITCH
TFN
PATTERN SELECT SWITCH
PWR
SNWI
ECM
SPD
W
TC
COMBINATION METER
VEHICLE SPEED SIGNAL
CHECK ENGINE WARNING LIGHT
Multi-information Display
Shift Range Indicator
Shift Position Indicator
S Mode Indicator
ATF Temp. Warning Indicator
ETC Power Indicator Light
2nd Start Indicator Light
Master Warning Light
Buzzer
CAN (V Bus)
DLC3

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3. Layout of Main Components





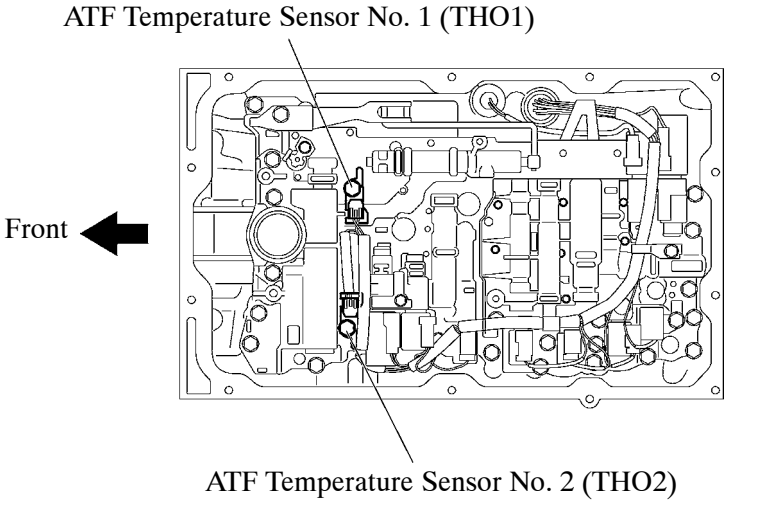
LHD Model

08GCH014I

4. Construction and Operation of Main Components

ATF Temperature Sensors No. 1 and No. 2

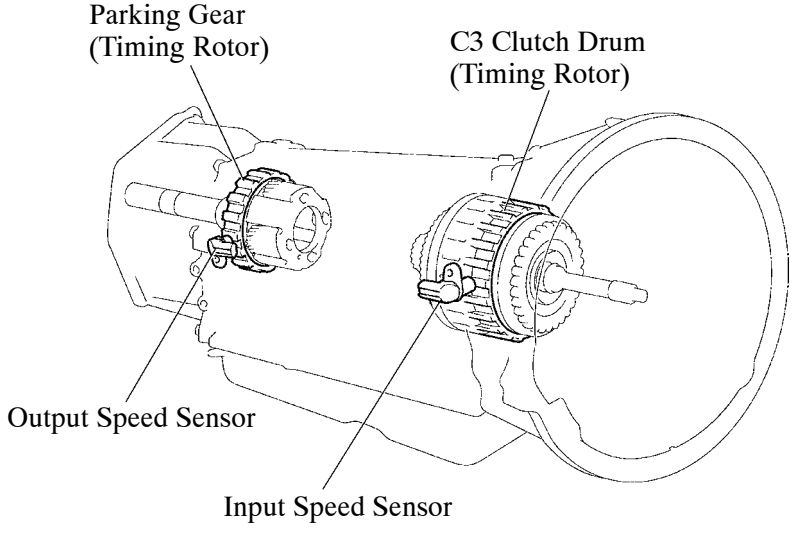
- The ATF temperature sensor No. 1 (THO1) is used for hydraulic pressure control. This sensor is used for revision of the pressure that is used to apply clutches and brakes in the transmission. This helps to ensure smooth shift quality.
- The ATF temperature sensor No. 2 (THO2) is used as a basis for modifying the ECT shift timing control when the ATF temperature is high. It is also used for the ATF temperature warning light.



Input Speed Sensor and Output Speed Sensor

The AB60F automatic transmissions use an input speed sensor (for NT signal) and an output speed sensor (for SP2 signal). Thus, the ECM can detect the timing of the shifting of the gears and appropriately control the engine torque and hydraulic pressure in response to various conditions. These speed sensors are the pick-up coil type.

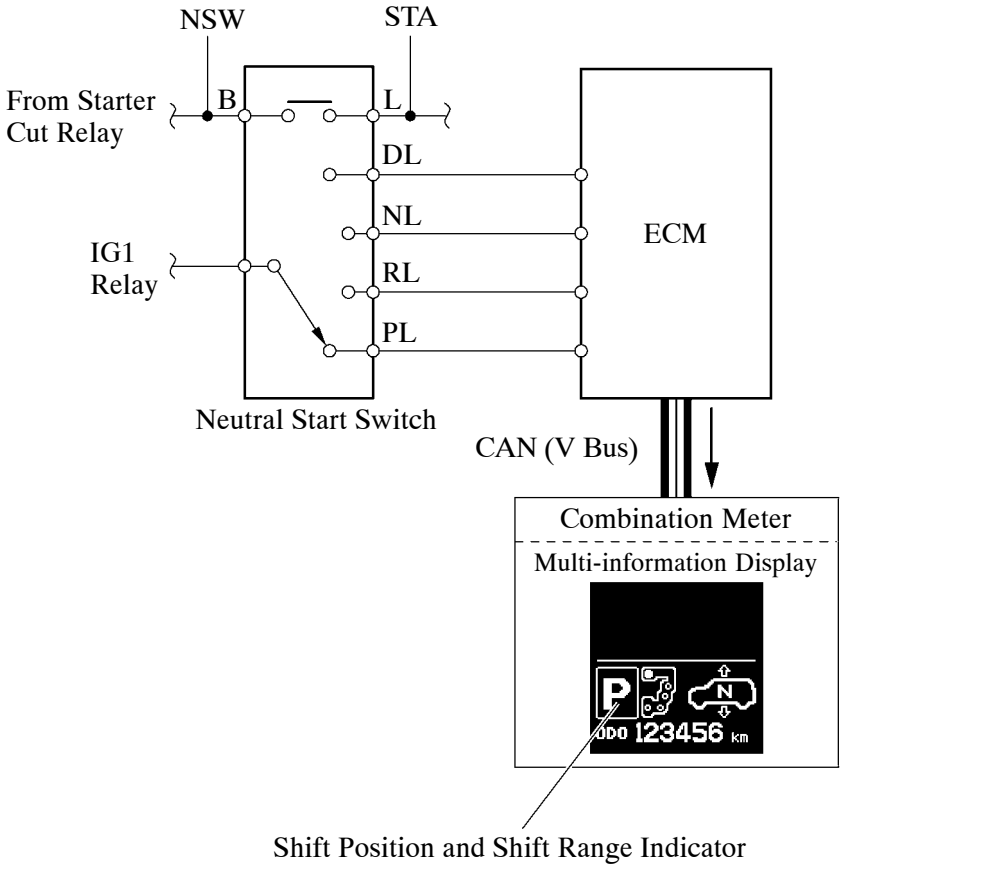
- The input speed sensor detects the input speed of the transmission. The clutch drum is used as the timing rotor for this sensor.
- The output speed sensor detects the speed of the output shaft. The parking gear on the rear planetary gear is used as the timing rotor for this sensor.



Neutral Start Switch

The neutral start switch sends the P, R, N, D and NSW position signals to the ECM. It also sends signals for the shift position and shift range indicator (P, R, N, and D).

▶ Wiring Diagram ◀

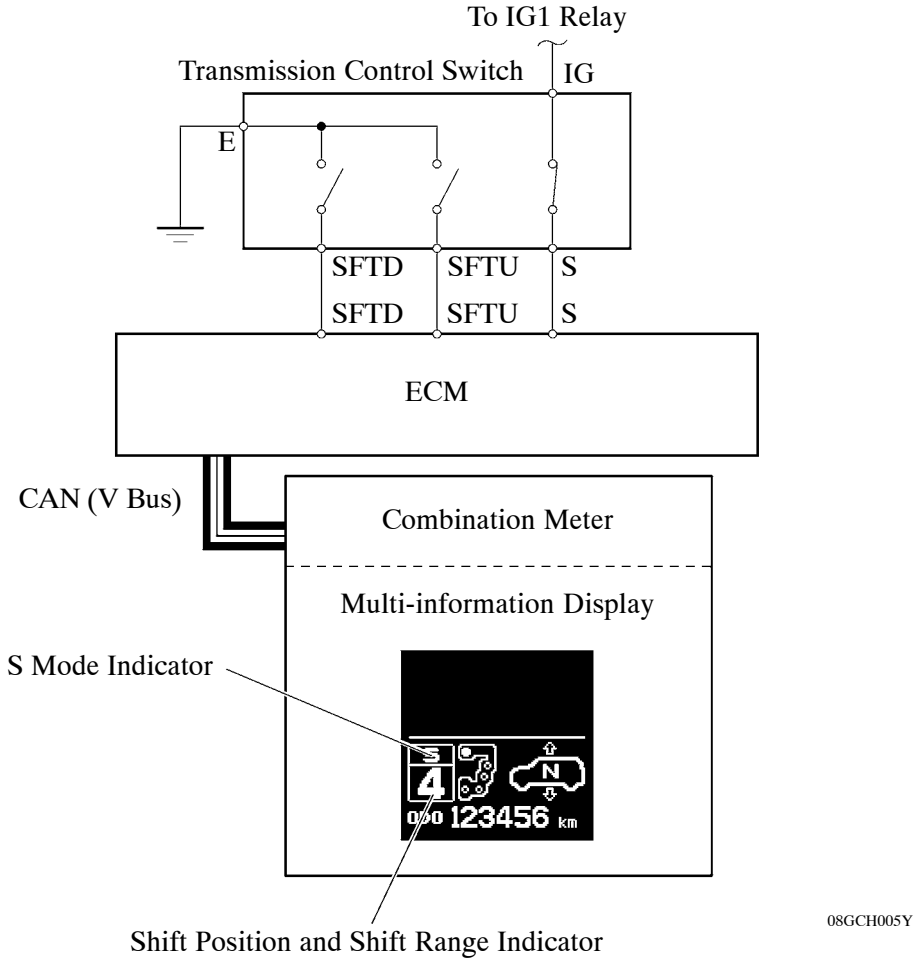


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Transmission Control Switch

- The transmission control switch is installed inside the shift lever assembly to detect the shift lever position and to inform the ECM. The ECM turns on the shift position and shift range indicator and S mode indicator.
- The transmission control switch detects whether the shift lever is in the D position or in the S mode position, and detects the operating conditions of the shift lever ("+" position or "–" position) if the S mode is selected, and sends signals to the ECM. At this time, the ECM turns on the shift position and shift range indicator for the selected range.

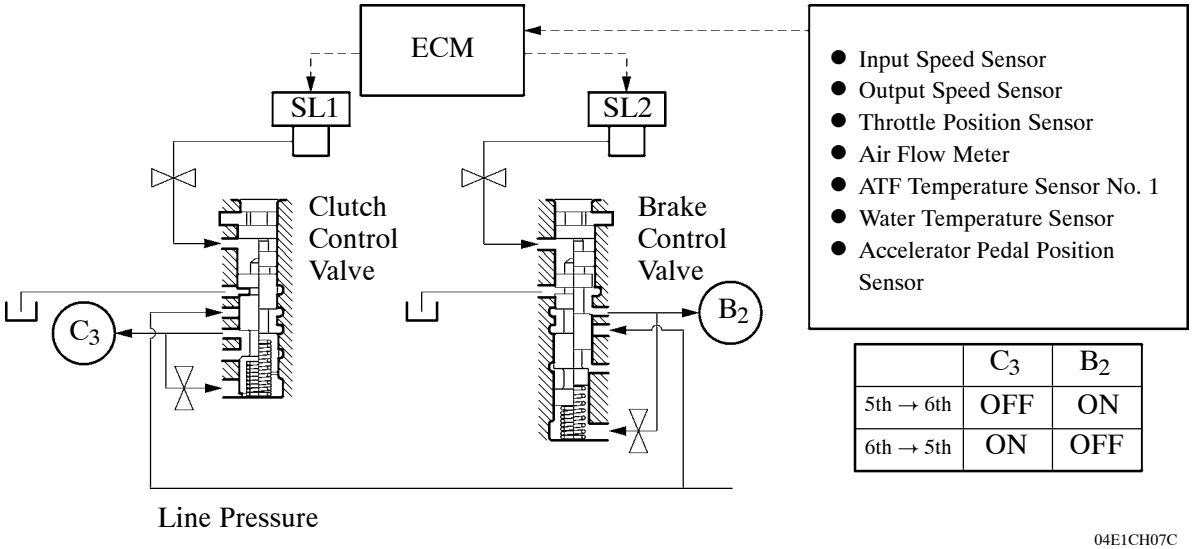
▶ Wiring Diagram ◀



5. Clutch Pressure Control

Clutch to Clutch Pressure Control

- This control is used for shifting from 5th to 6th gear and from 6th to 5th gear.
- The ECM actuates solenoid valves SL1 and SL2 in accordance with various signals. The output from these solenoid valves acts directly on control valves B_2 and C_3 in order to regulate the line pressure that acts on the B_2 brake and C_3 clutch. As a result, high response and excellent shift characteristics have been realized.

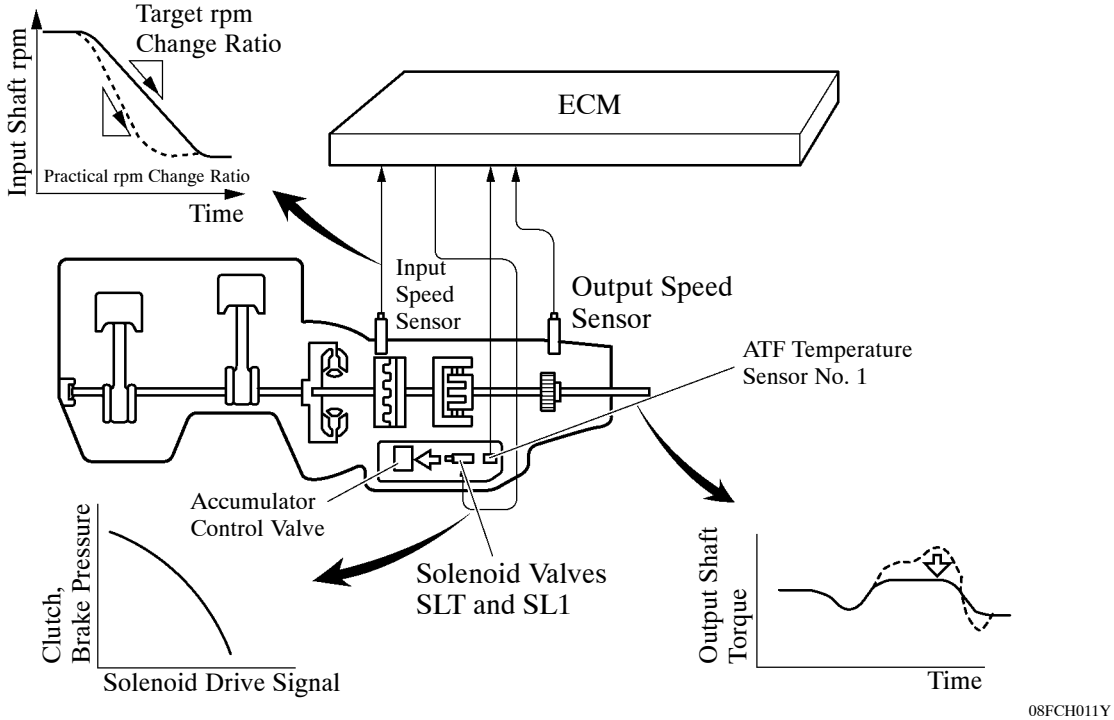


	C_3	B_2
5th → 6th	OFF	ON
6th → 5th	ON	OFF

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Clutch Pressure Optimal Control

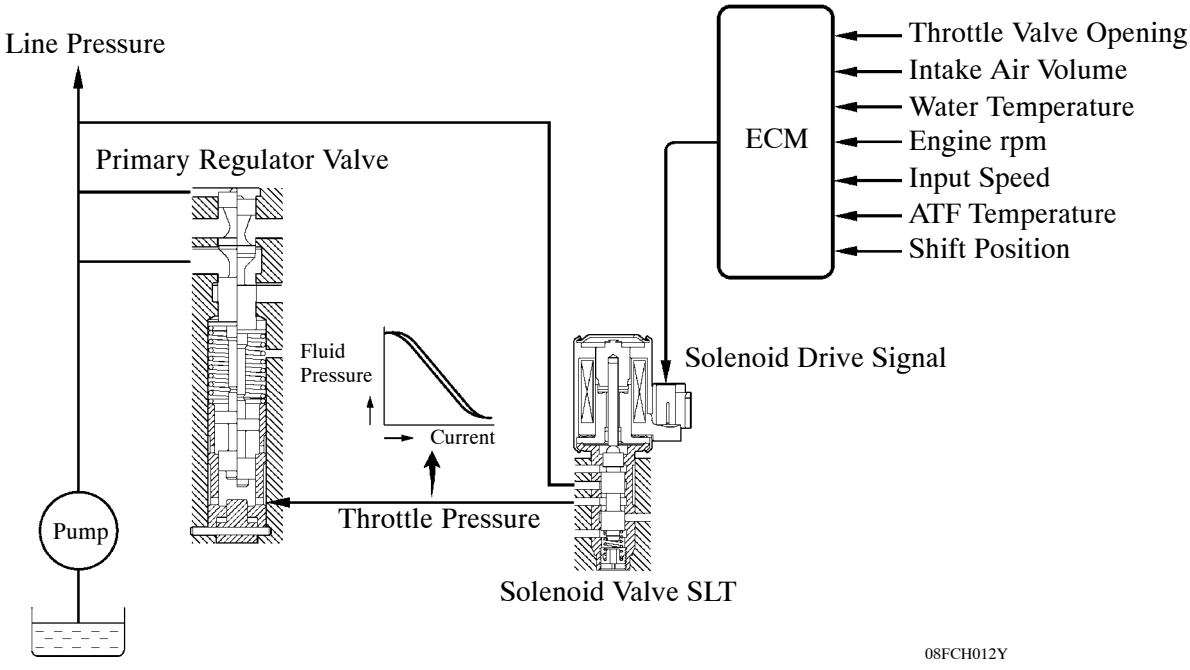
The ECM monitors the signals from various types of sensors, such as the input speed sensor, allowing solenoid valves SLT and SL1 to minutely control the clutch pressure in accordance with engine output and driving conditions. As a result, smooth shift characteristics are realized.



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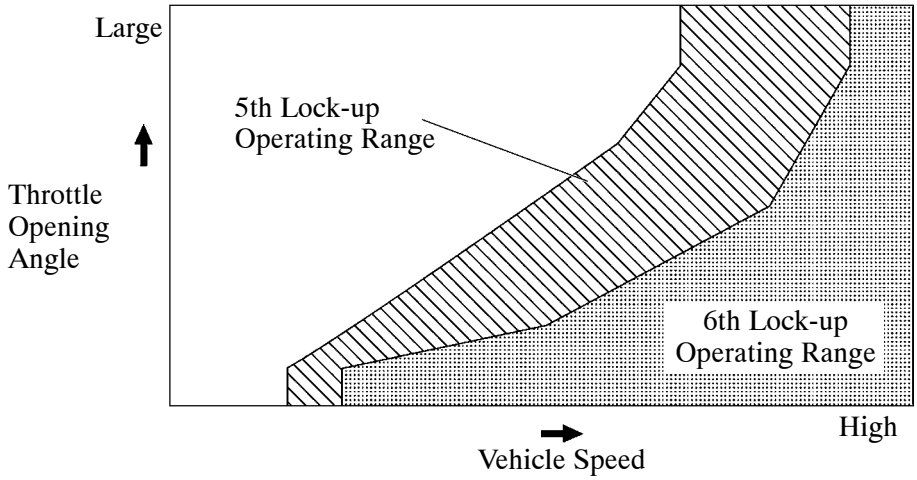
6. Line Pressure Optimal Control

Through the use of the solenoid valve SLT, the line pressure is optimally controlled in accordance with the engine torque information, as well as with the internal operating conditions of the torque converter clutch and the transmission.
Accordingly, the line pressure can be controlled minutely in accordance with the engine output, traveling condition, and ATF temperature, thus realizing smooth shift characteristics and optimizing the workload of the oil pump (reducing unnecessary parasitic losses).



7. Lock-up Timing Control

The ECM operates the lock-up timing control in order to improve the fuel consumption performance while in top gear with the shift lever in the S4 or S5 range, and in 5th or 6th gear with the shift lever in the S6 range or D position.



Lock-up Timing in D Position or S6 Range 259LSK19

▶ Lock-up Operation Gears in Each Range ◀

○: Available ×: Not available —: Not applicable

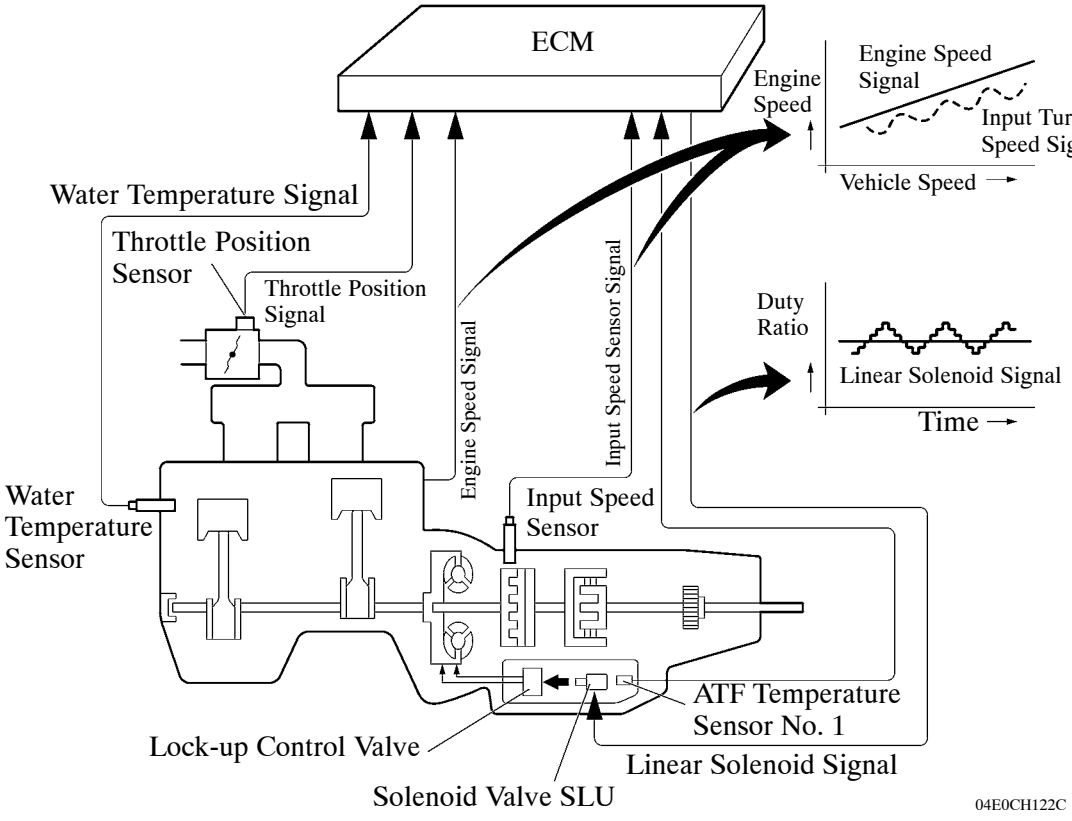
Shift Position or Shift Range		D, S6	S5	S4
Gear	1st	×	×	×
	2nd	×	×	×
	3rd	×	×	×
	4th	×*	×*	○
	5th	○	○	—
	6th	○	—	—

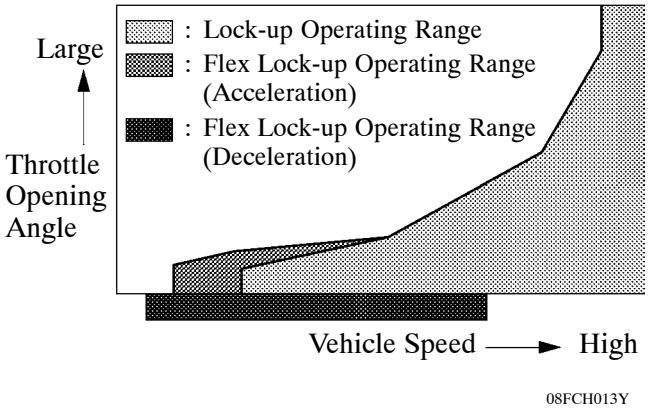
*: Lock-up operation is performed when the 4th gear is help during the AI-SHIFT control or the cruise control.

8. Flex Lock-up Clutch Control

In the low-to-mid-speed range, this flex lock-up clutch control regulates the solenoid valve SLU to provide an intermediate mode between the ON/OFF operation of the lock-up clutch in order to improve the energy transmitting efficiency in this range.
As a result, the operating range of the lock-up clutch has been increased and fuel economy has been improved.
The flex lock-up clutch control operates in the 3rd, 4th, 5th and 6th gears in the D position and S6 range, 3rd, 4th and 5th gears in the S5 range, 3rd and 4th gears in the S4 range.

- Even when the vehicle is decelerating (the accelerator pedal is released), the flex lock-up clutch control operates. Therefore, fuel-cut area of the engine has been expanded and fuel-economy has been improved.





▶ Flex Lock-up Operation Gears in Each Range ◀

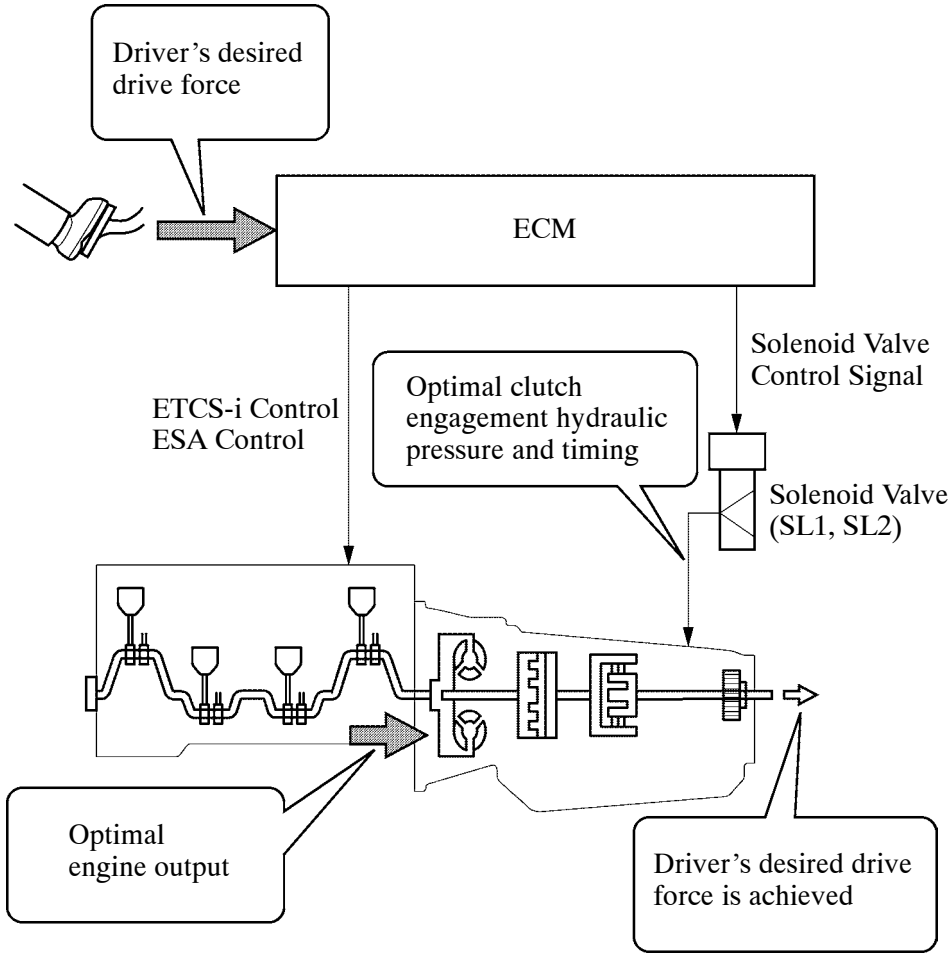
○: Available ×: Not available —: Not applicable

Shift Position or Shift Range		D, S6	S5	S4
Gear	1st	×	×	×
	2nd	×	×	×
	3rd	○	○	○
	4th	○*	○*	○*
	5th	○*	○*	—
	6th	○*	—	—

*: Flex Lock-up also operates when the vehicle is decelerating.

9. Powertrain Cooperative Control

Through cooperative control with ETCS-i (Electronic Throttle Control System-intelligent) and ESA (Electronic Spark Advance), and optimally controlled hydraulic pressure to the clutch and brake, excellent response and shift shock reduction have been achieved.

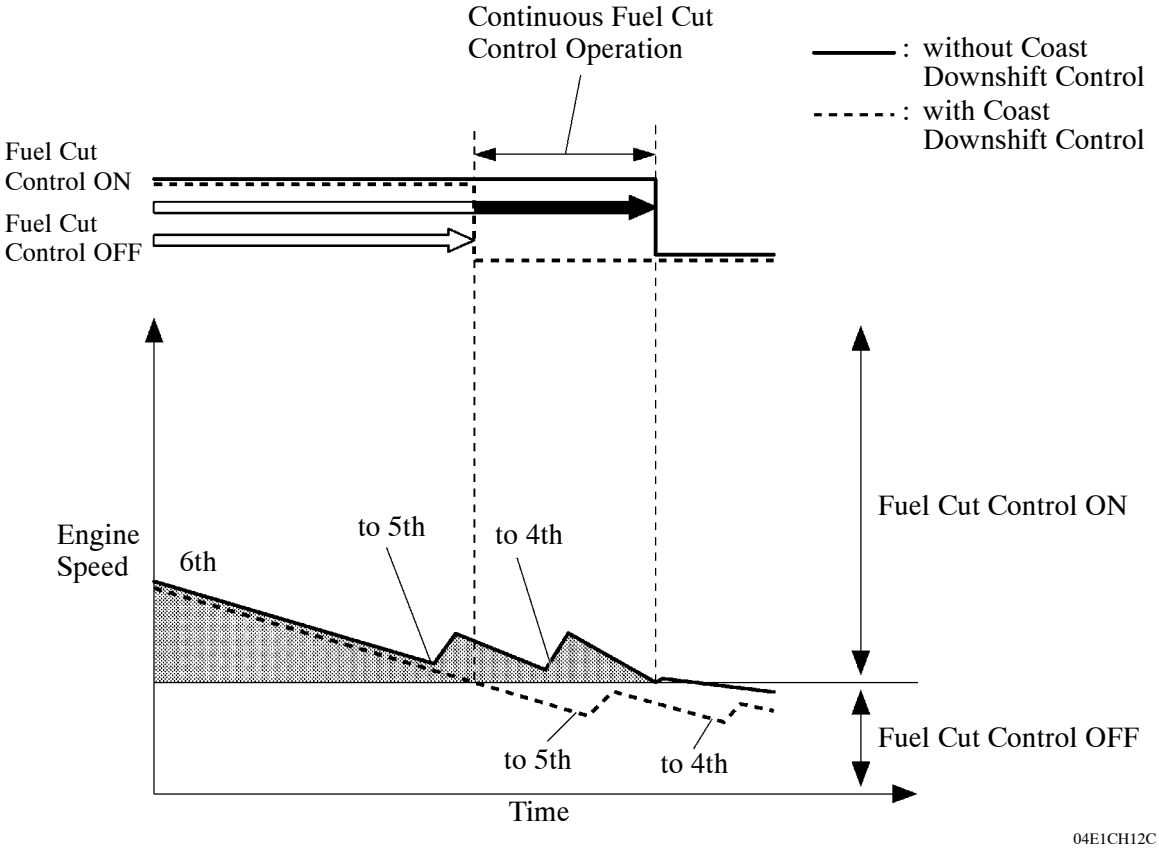


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10. Coast Downshift Control

As a result of coast downshift control, downshifts are performed to maintain sufficient engine speed to avoid ending fuel cut control. Thus, fuel cut time is extended and fuel economy is achieved.

- In this control, the transmission downshifts from 6th to 5th and then 5th to 4th before fuel cut control ends when the vehicle is decelerated in the 6th gear, so that fuel cut control continues operating.



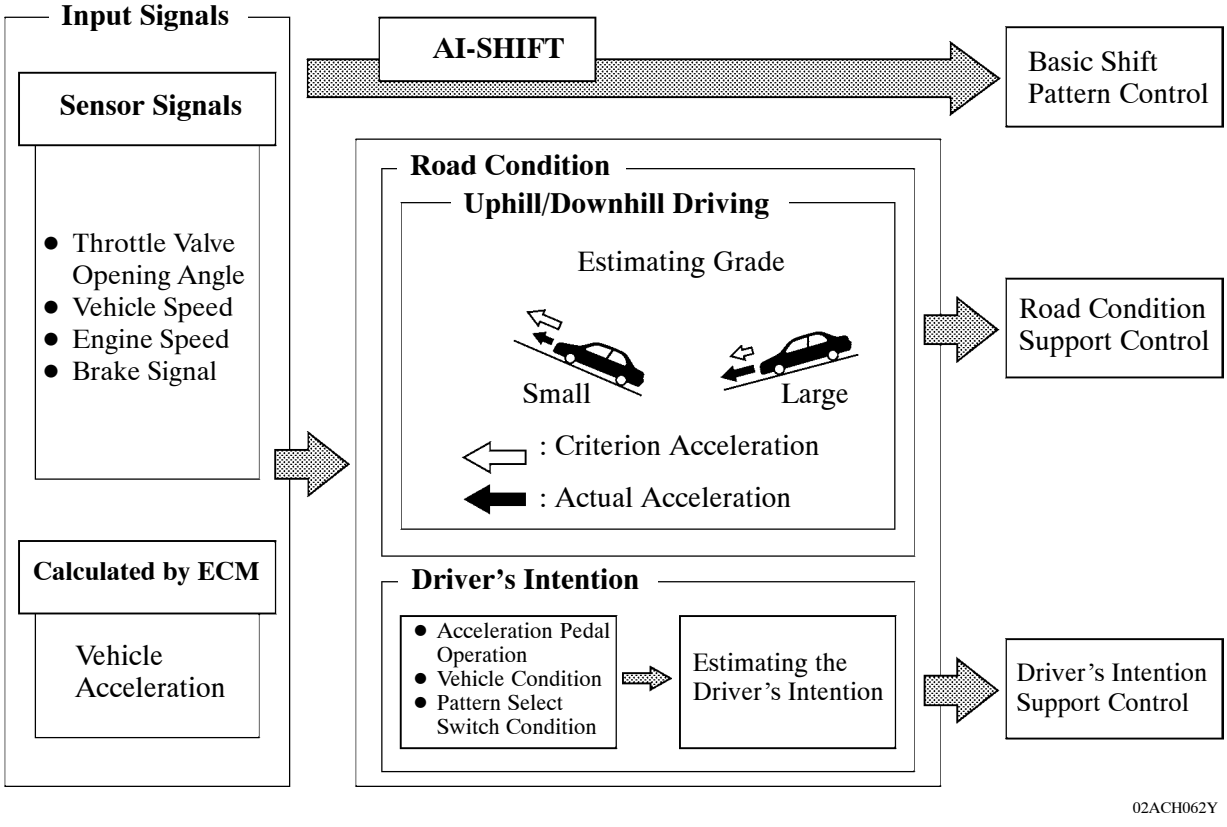
CH

11. AI (Artificial Intelligence)-SHIFT Control

General

In addition to changing the shift pattern through the pattern select switch, the AI-SHIFT control enables the ECM to estimate the road condition, the driver's intention, and the pattern select switch condition in order to automatically select the optimal shift pattern. As a result, a comfortable ride is realized.

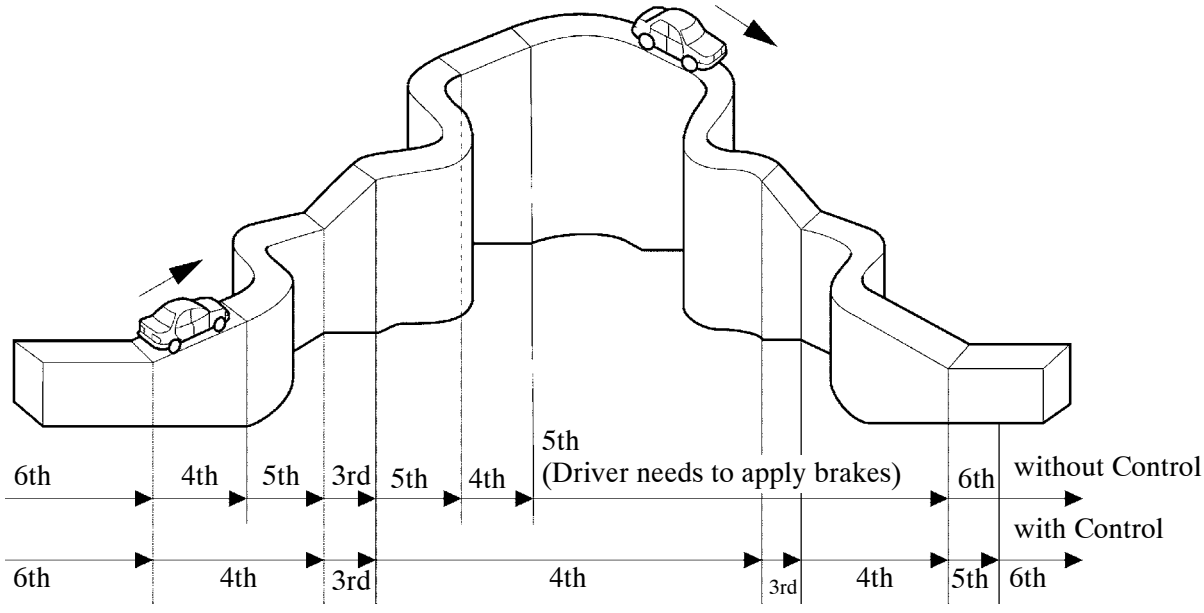
- AI-SHIFT control is effect only with the shift lever in the D position, based on the accelerator pedal and brake operation data. AI-SHIFT control will be canceled when the driver selects the S mode.



Road Condition Support Control

Under road condition support control, the ECM determines whether the vehicle is being driven uphill or downhill based on the throttle valve opening angle and the vehicle speed.

- To achieve an optimal drive force while driving uphill, this control prevents the transmission from upshifting to 4th, 5th or 6th gear.
- To achieve an optimal engine braking effect while driving downhill, this control automatically downshifts the transmission to 5th, 4th or 3rd gear.



Driver's Intention Support Control

Driver's intention support control estimates the driver's intention based on the accelerator pedal operation and vehicle condition and selects a shift pattern that is well-suited to each driver.

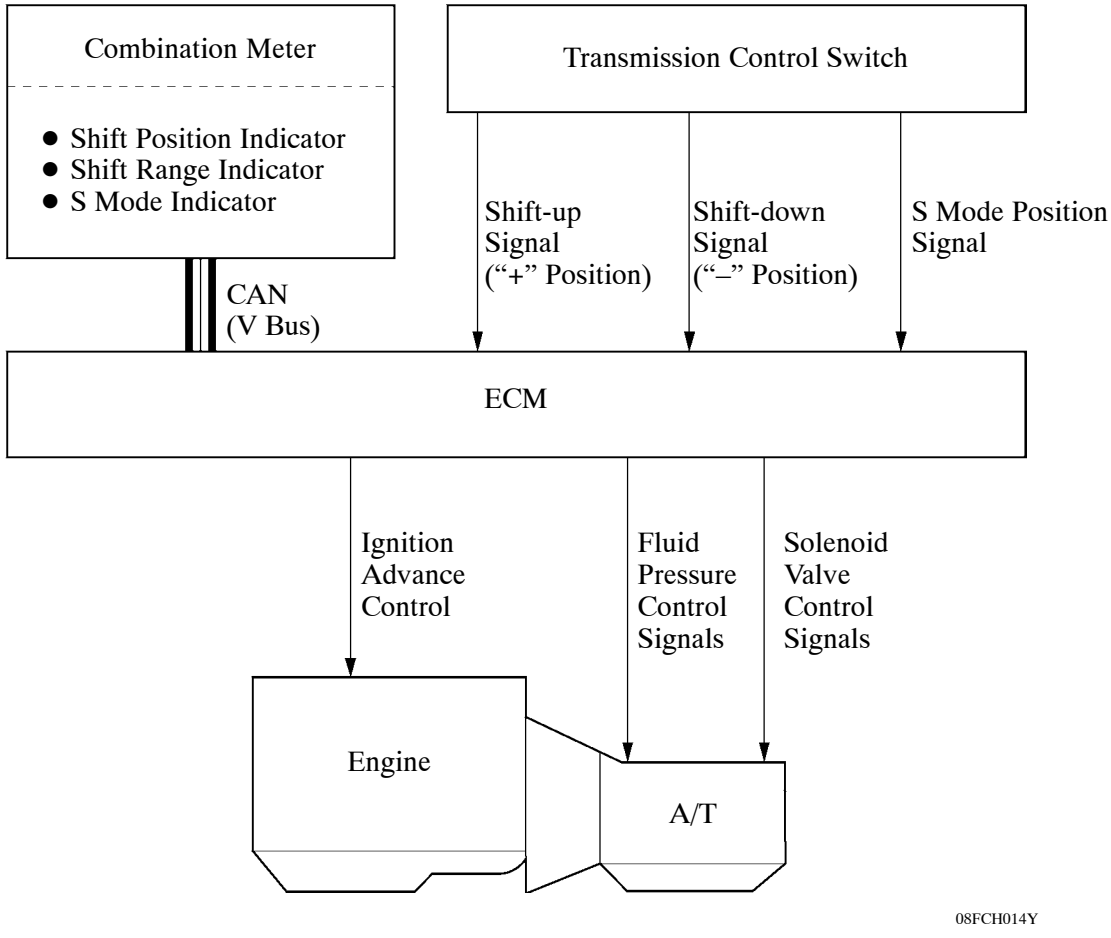
Control	Operation	Operate Gear	Pattern Select Switch
Sudden Accelerator Pedal Depress Control	When the driver operates (presses) the accelerator pedal quickly, this control causes the transmission to downshift rapidly to improve acceleration response.	5th to 6th	POWER
Sudden Accelerator Pedal Release Control	When the driver releases the accelerator quickly, this control makes it easy for the transmission to hold the gear, which improves engine braking force and re-acceleration response.	3rd to 5th	POWER
Sudden Deceleration Downshift Control	When the driver decelerates the vehicle suddenly, this control downshifts rapidly, which improves engine braking force and re-acceleration response.	4th to 6th	POWER

12. Multi-mode Automatic Transmission

General

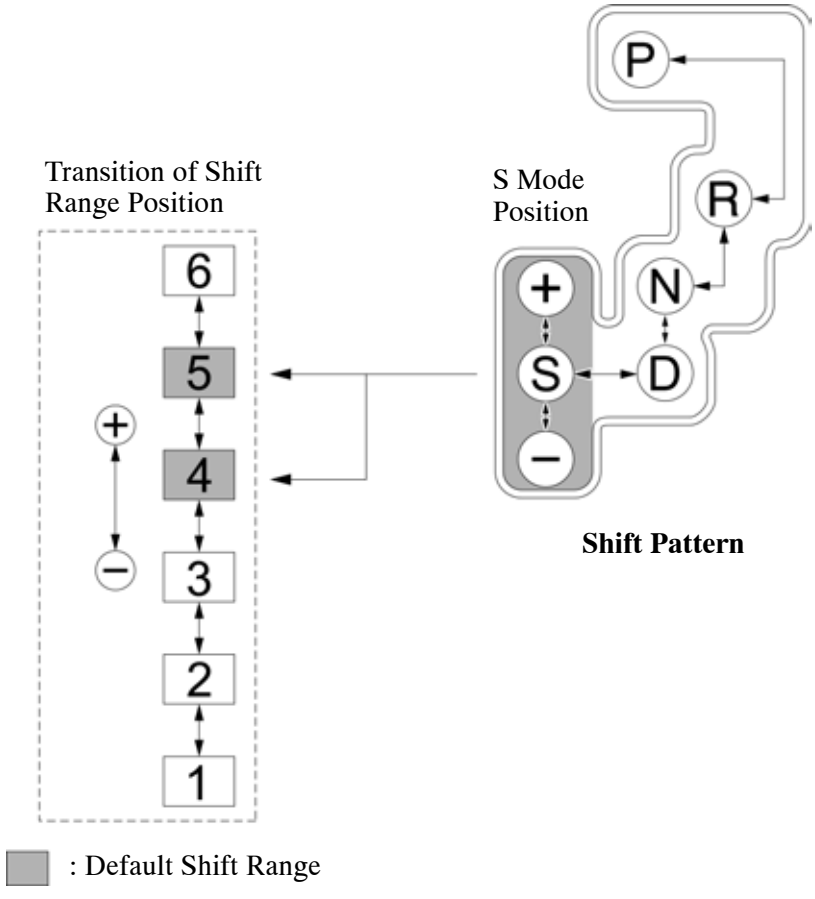
A multi-mode automatic transmission is designed to allow the driver to switch the gear ranges (a multi-mode transmission is not for manually selecting single gears). After moving the shift lever to the S mode position, the driver can select the desired shift range by moving the shift lever to the "+" or "–" position. Thus, the driver is able to shift gears with a manual-like feel.

▶ System Diagram ◀



Operation

- The driver selects the S mode position by engaging the shift lever. At this time, the 4th or 5th range is selected according to the vehicle speed. (When the driver selects the S mode during AI-SHIFT control, the current gear will be selected as the shift range.) Then, the shift range positions change one at a time, as the driver moves the shift lever to the front ("+" position) or to the rear ("–" position).
- Under this control, the ECM effects optimal shift control within the usable gear range that the driver has selected. As with an ordinary automatic transmission, it shifts to the 1st gear when the vehicle is stopped.
- Holding the transmission control switch in the "+" position with the shift lever in the S mode position will change the shift range to the 6th range regardless of range position (1st to 5th).
- When the shift lever is in the S mode position, the S mode indicator in the multi-information display indicates that. The shift range indicator indicates the state of the shift range position that the driver has selected.



Shift Pattern

▶ Usable Gear Chart ◀

Shift Range Indicator Display	Shift Range	Usable Gears
6	6	6th ↔ 5th ↔ 4th ↔ 3rd ↔ 2nd ↔ 1st
5	5	5th ↔ 4th ↔ 3rd ↔ 2nd ↔ 1st
4	4	4th ↔ 3rd ↔ 2nd ↔ 1st
3	3	3rd ↔ 2nd ↔ 1st
2	2	2nd ↔ 1st
1	1	1st

13. Diagnosis

- When the ECM detects a malfunction, the ECM records the malfunction and memorizes the information related to the fault. Furthermore, the check engine warning light in the combination meter illuminates or blinks to inform the driver.
- At the same time, the DTC (Diagnostic Trouble Code) is stored in memory. The DTC can be read by connecting a intelligent tester II to the DLC3.

For details, see the LEXUS LX 570 Repair Manual (Pub. No. RM08G0E).

14. Fail-safe

The fail-safe function minimizes the loss of operability when an abnormality occurs in a sensor or solenoid.

▶ Fail-safe Control List ◀

Malfunction Part	Function
Input Speed Sensor (NT)	When the input speed sensor malfunctions, shift control is effected using the information from the output speed sensor signal (SP2). During an input speed sensor malfunction, upshifting to the 5th and 6th, AI-SHIFT and flex lock-up clutch control are prohibited.
Output Speed Sensor (SP2)	When the output speed sensor malfunctions, shift control is effected using the information from the input speed sensor signal (NT). When the output speed sensor malfunctions, upshifting to the 5th and 6th, AI-SHIFT and flex lock-up clutch control are prohibited.
ATF Temperature Sensor No. 1 (THO1)	When the ATF temperature sensor No. 1 malfunctions, upshifting to the 5th and 6th and flex lock-up clutch control are prohibited.
Solenoid Valves S1, S2, S3, S4 and SR	When a solenoid valve listed at left fails, the current to the failed solenoid valve is cut off. Shift control is changed to a fail-safe mode to shift gears using the normal solenoid valves to allow continued driving. Refer to the table on the next page for an operation example.
Solenoid Valves SL1 and SL2	During a solenoid valve SL1 or SL2 malfunction, upshifting to the 5th and 6th and flex lock-up clutch control are prohibited.
Solenoid Valve SLU	During a solenoid valve SLU malfunction, the current to the solenoid valve is stopped. Because this stops lock-up control and flex lock-up control, fuel economy decreases.
Solenoid Valve SLT	During a solenoid valve SLT malfunction, the current to the solenoid valve is stopped. Because this stops line pressure optimal control, the shift shock increases. However, shifting is effected through normal clutch pressure control.

▶ Normal Condition ◀

Shift Lever or Gear Range Position	Solenoid Valve							Gear
	S1	S2	S3	S4	SR	SL1	SL2	
D, S6	OFF	ON	ON	OFF	ON	OFF	ON	1st
	ON	ON	ON	OFF	ON	OFF	ON	2nd
	ON	OFF	ON	OFF	ON	OFF	ON	3rd
	ON	OFF	OFF	OFF	ON	OFF	ON	4th
	ON	OFF	OFF	ON	OFF	ON	OFF	5th
	ON	ON	OFF	ON	OFF	ON	OFF	6th
S5	OFF	ON	ON	OFF	ON	OFF	ON	1st
	ON	ON	ON	OFF	ON	OFF	ON	2nd
	ON	OFF	ON	OFF	ON	OFF	ON	3rd
	ON	OFF	OFF	OFF	ON	OFF	ON	4th
	ON	OFF	OFF	ON	OFF	ON	OFF	5th
S4	OFF	ON	ON	OFF	ON	OFF	ON	1st
	ON	ON	ON	OFF	ON	OFF	ON	2nd
	ON	OFF	ON	OFF	ON	OFF	ON	3rd
	ON	OFF	OFF	OFF	ON	OFF	ON	4th
S3	OFF	ON	ON	OFF	ON	OFF	ON	1st
	ON	ON	ON	OFF	ON	OFF	ON	2nd
	ON	OFF	ON	OFF	ON	OFF	OFF	3rd
S2	OFF	ON	ON	OFF	ON	OFF	ON	1st
	ON	ON	ON	ON	ON	OFF	OFF	2nd
S1	OFF	ON	ON	OFF	ON	OFF	OFF	1st

▶ Example (Solenoid Valve S1 Malfunction) ◀

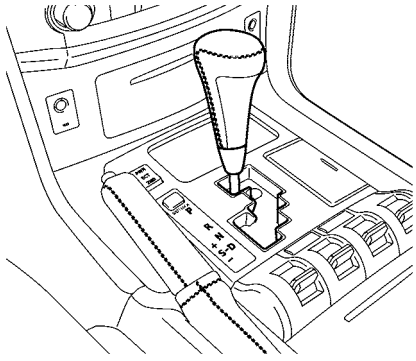
Shift Lever or Gear Range Position	Solenoid Valve							Gear
	S1	S2	S3	S4	SR	SL1	SL2	
D, S6	×	ON	ON	OFF	ON	OFF	ON	1st
	×	ON ↓ OFF	ON ↓ OFF	OFF	ON	OFF	ON	1st ↓ 4th
	×	OFF	ON ↓ OFF	OFF	ON	OFF	ON	3rd ↓ 4th
	×	OFF	OFF	OFF	ON	OFF	ON	4th
	×	OFF	OFF	ON	OFF	ON	OFF	5th
	×	ON ↓ OFF	OFF	ON	OFF	ON	OFF	N ↓ 5th
S5	×	ON	ON	OFF	ON	OFF	ON	1st
	×	ON ↓ OFF	ON ↓ OFF	OFF	ON	OFF	ON	1st ↓ 4th
	×	OFF	ON ↓ OFF	OFF	ON	OFF	ON	3rd ↓ 4th
	×	OFF	OFF	OFF	ON	OFF	ON	4th
	×	OFF	OFF	ON	OFF	ON	OFF	5th
S4	×	ON	ON	OFF	ON	OFF	ON	1st
	×	ON ↓ OFF	ON ↓ OFF	OFF	ON	OFF	ON	1st ↓ 4th
	×	OFF	ON ↓ OFF	OFF	ON	OFF	ON	3rd ↓ 4th
	×	OFF	OFF	OFF	ON	OFF	ON	4th
S3	×	ON	ON	OFF	ON	OFF	ON	1st
	×	ON ↓ OFF	ON ↓ OFF	OFF	ON	OFF	ON	1st ↓ 4th
	×	OFF	ON ↓ OFF	OFF	ON	OFF	OFF ↓ ON	3rd (E/B) ↓ 4th
S2	×	ON	ON	OFF	ON	OFF	ON	1st
	×	ON ↓ OFF	ON ↓ OFF	ON ↓ OFF	ON	OFF	OFF ↓ ON	2nd (E/B) ↓ 4th
S1	×	ON	ON	OFF	ON	OFF	OFF	1st (E/B)

E/B: Engine Braking

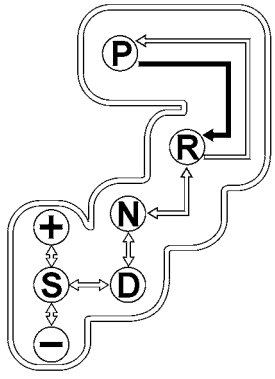
■SHIFT CONTROL MECHANISM

1. General

- A gate type shift lever is used.
- Shift pattern is provided with the S mode position next to the D position.
- A shift lock system is used.



LHD Model



: The shift lever can be moved only with the engine switch ON (IG) and the brake pedal depressed.

⇕ : The shift lever can be moved at anytime.

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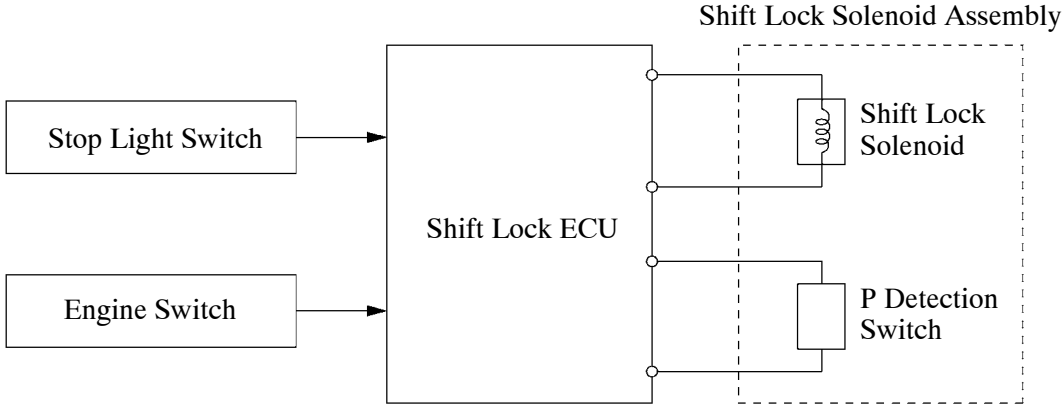
CH

2. Shift Lock System

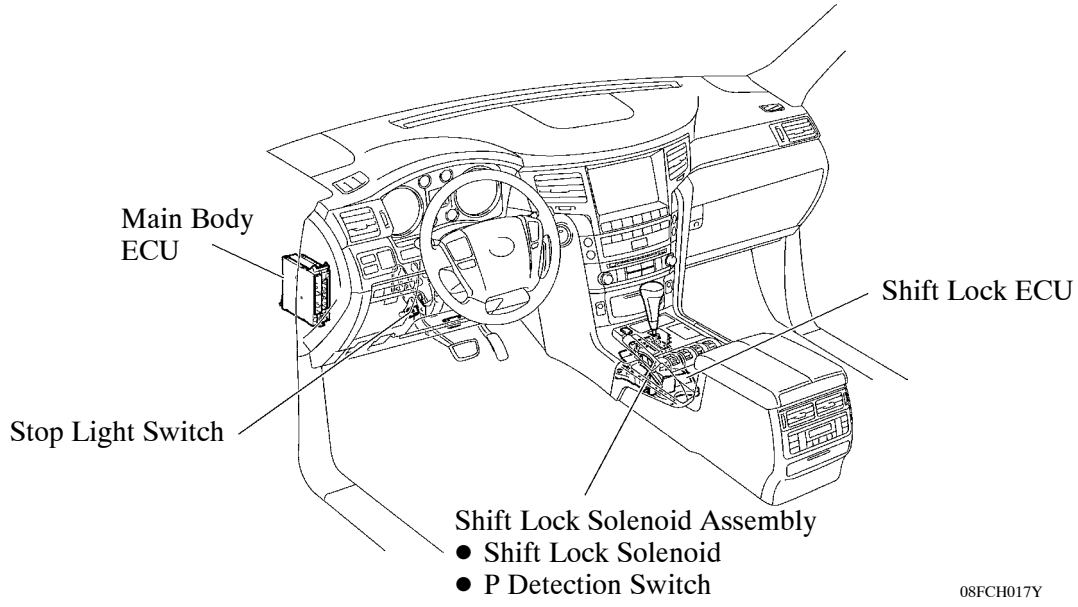
General

- The shift lock mechanism prevents the shift lever from being moved to any position other than the P position, unless the engine switch is turned ON (IG) and the brake pedal is depressed. This mechanism helps to prevent unintentional acceleration.
- The shift lock system mainly consists of the shift lock ECU, shift lock solenoid, P detection switch and shift lock release button.

▶ System Diagram ◀



Layout of Main Components



LHD Model

System Operation

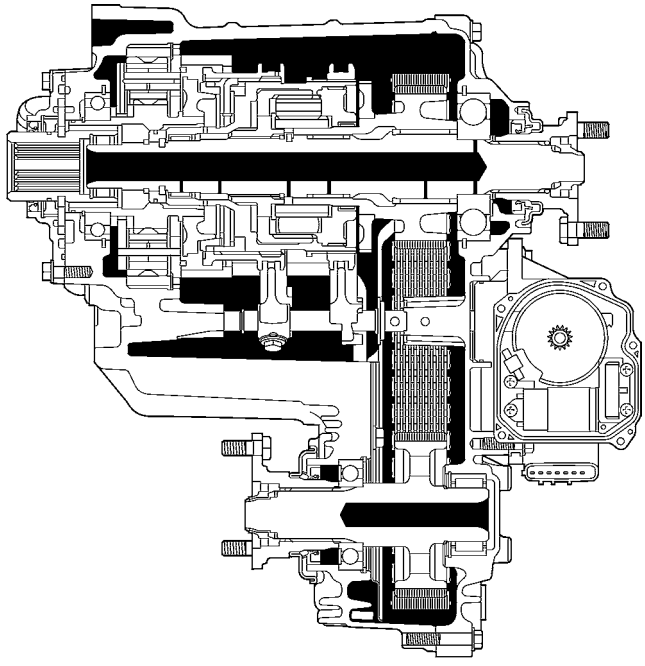
- The shift lock ECU uses the P detection switch to detect the shift lever position, and receives inputs from the stop light switch and the main body ECU. Upon receiving these signals, the shift lock ECU turns ON the shift lock solenoid in order to release the shift lock.
- A shift lock release button, which manually overrides the shift lock mechanism, is used.

TRANSFER

■ DESCRIPTION

- The JF2A transfer has been newly developed. This transfer is a compact and lightweight full-time 2-speed transfer.
- The center differential uses a TORSEN* LSD (Limited Slip Differential).
- A planetary gear train is used in the reduction mechanism and a silent chain is used to reduce noise for the front drive. The 4WD control switch is used to change the transfer gear ratio, and the center differential lock switch is used to change the center differential between free and lock.

*: TORSEN is JTEKT CORPORATION's registered trademark.



JF2A Transfer 080CH30Y

▶ Specifications ◀

Transfer Type		JF2A
Drive Type		Full-time
Gear Ratio	H4	1.000
	L4	2.618
Reduction Gear Type		Single Pinion Planetary
Center Differential Gear Type		TORSEN LSD
Oil Capacity	Liters (US qts, Imp. qts)	1.45 (1.53, 1.28)
Oil Viscosity		SAE 75W-90
Oil Grade		API GL-5
Weight (Reference)*	kg (lb)	50.0 (110.2)

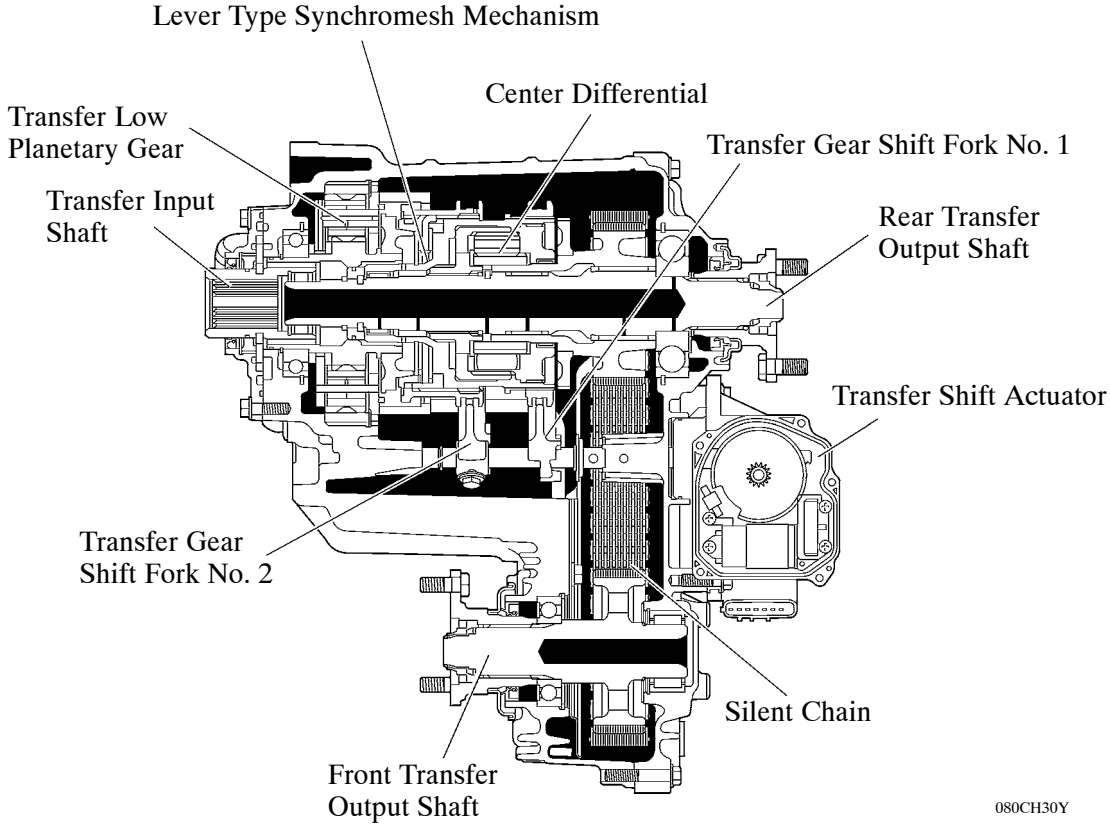
*: Weight shows the figure with the fluid fully filled.

■ CONSTRUCTION

1. General

The construction of the JF2A transfer is shown below.

- A planetary gear unit is used in the reduction mechanism and a silent chain is used to reduce front drive noise.
- The center differential uses a TORSEN LSD (Limited Slip Differential). As a result, this LSD ensures the proper torque distribution during acceleration and high-speed driving.
- A lever type synchromesh mechanism is used for the H4-L4 switching section to eliminate gear clash when switching between H4 and L4.
- For the JF2A transfer, a transfer shift actuator that has 2 built-in shift motors is used. As a result, switching between H4 and L4 can be performed independently using the shift motors, achieving a simple shift actuation mechanism. This enhances efficiency of power transfer and durability of the shift mechanism.

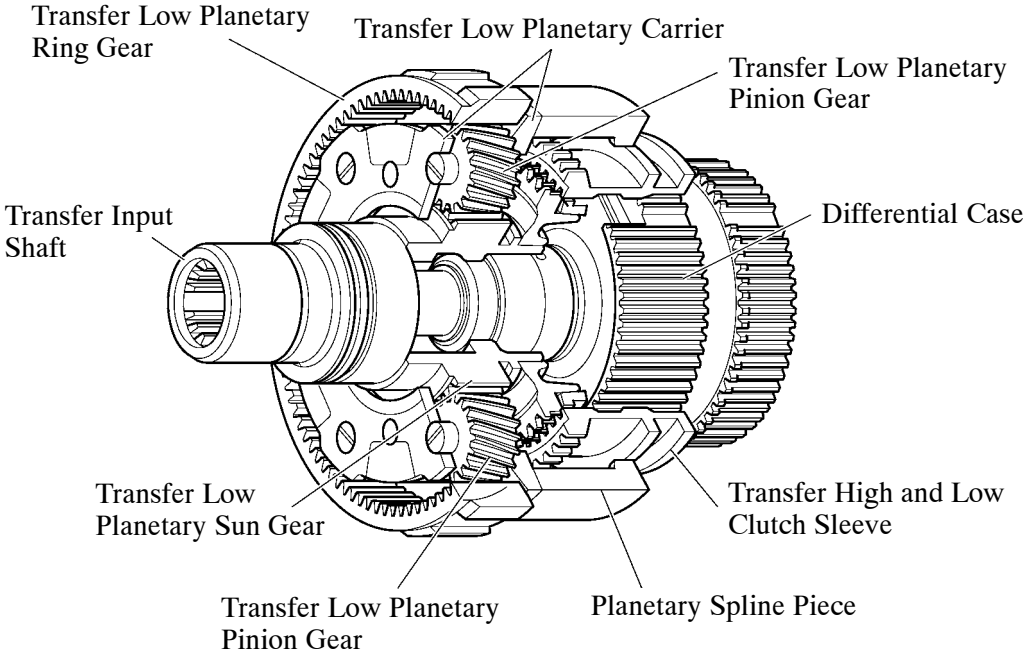


2. Planetary Gear Unit

General

The transfer low planetary gear unit consists of a transfer low planetary sun gear, 6 transfer low planetary pinion gears, a transfer low planetary ring gear, and a transfer low planetary carrier.

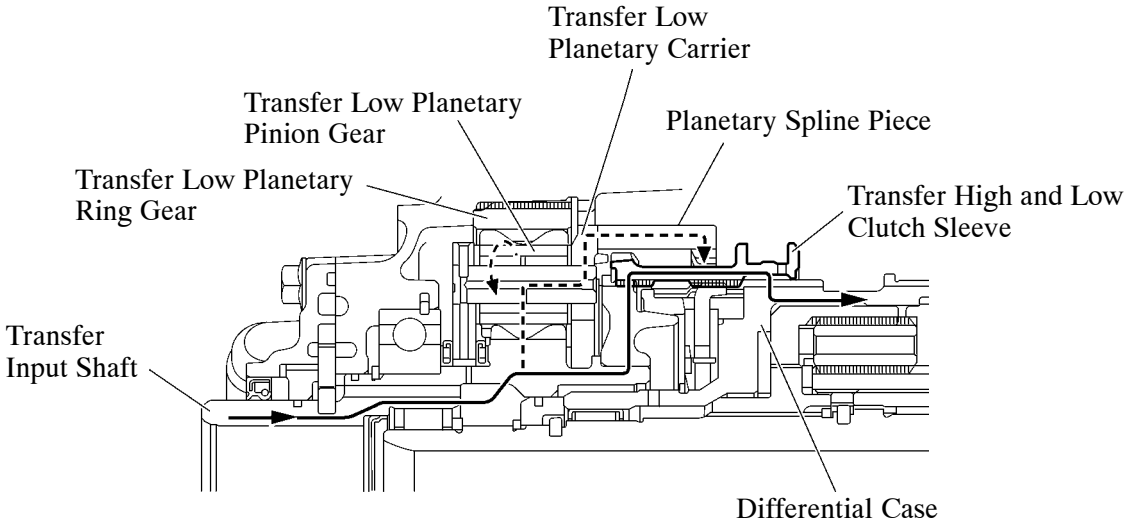
- The transfer low planetary sun gear is integrated with the transfer input shaft.
- The 6 transfer low planetary pinion gears are fitted to the transfer low planetary carrier. Each transfer low pinion gear shaft is fixed to the transfer low planetary carrier. A planetary spline piece is fitted to the rear of the transfer low planetary carrier.
- The transfer low planetary ring gear is fixed to the transfer case and its internal teeth mesh with the transfer low planetary pinion gears.
- In this planetary gear unit, the drive torque transmission route is switched in accordance with the movement of the transfer high and low clutch sleeve. The drive torque from the transfer input shaft is transmitted to the differential case via the transfer high and low clutch sleeve.

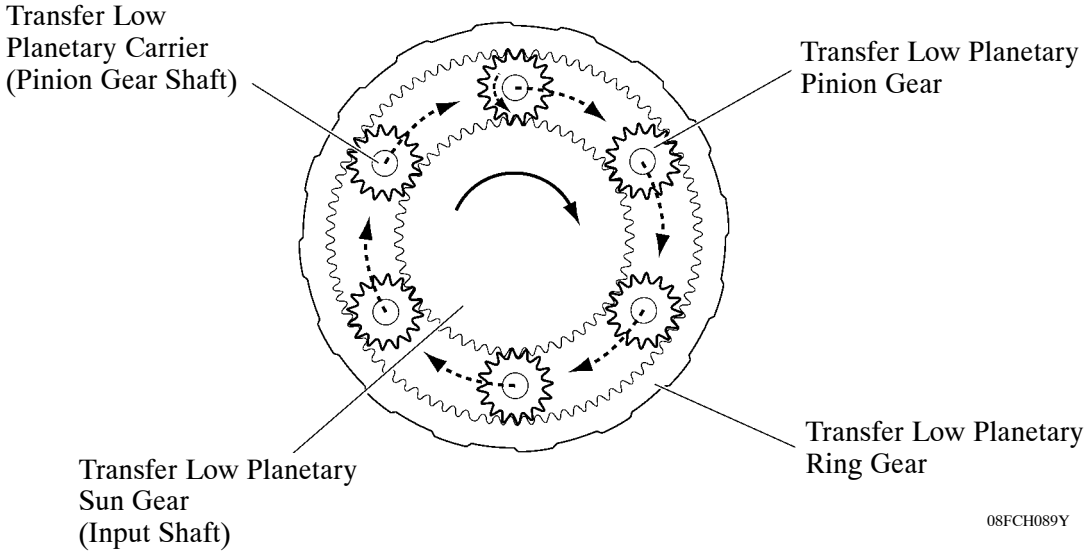


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H4 Position

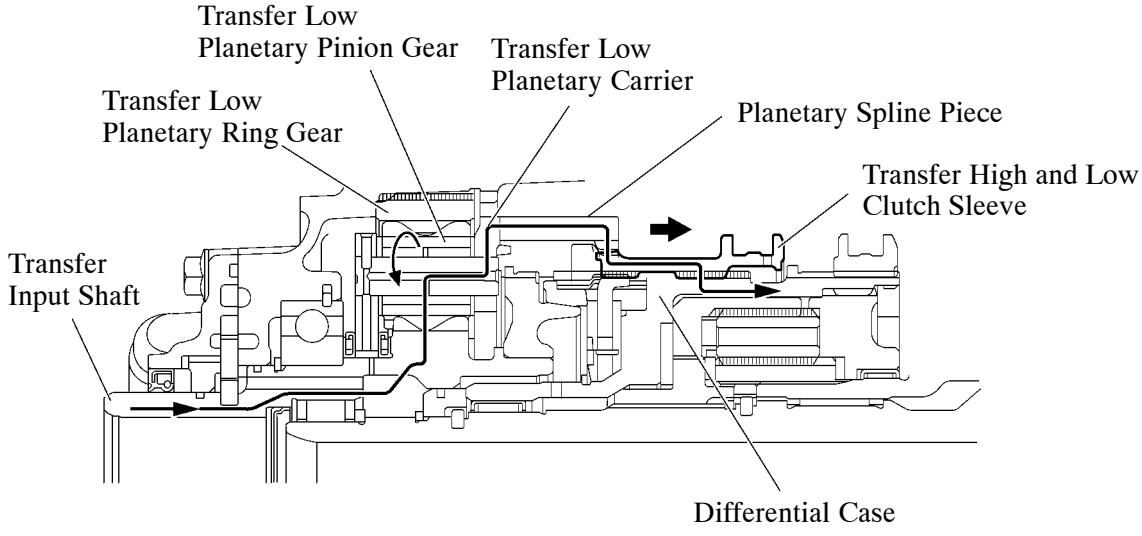
In the H (H4) position, the splines at the rear of the transfer input shaft mesh with the internal gear teeth of the transfer high and low clutch sleeve.
Also, the transfer high and low clutch sleeve is meshed to the differential case. Thus, the rotation of the input shaft is transmitted to the transfer high and low clutch sleeve, and then to the differential case.

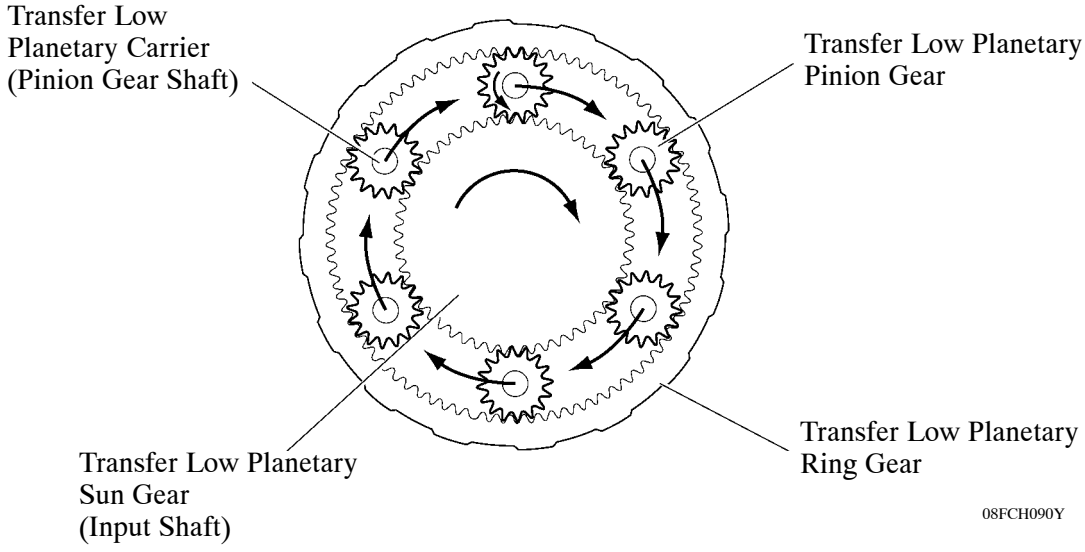




L4 Position

In the L (L4) position, the external teeth of the transfer high and low clutch sleeve are meshed with the planetary spline piece.
Thus, the rotation of the transfer input shaft is transmitted in a reduced form to the transfer low planetary sun gear, transfer low planetary pinion gears, transfer low planetary pinion gear shafts, transfer low planetary carrier, planetary spline piece, transfer high and low clutch sleeve, and differential case.

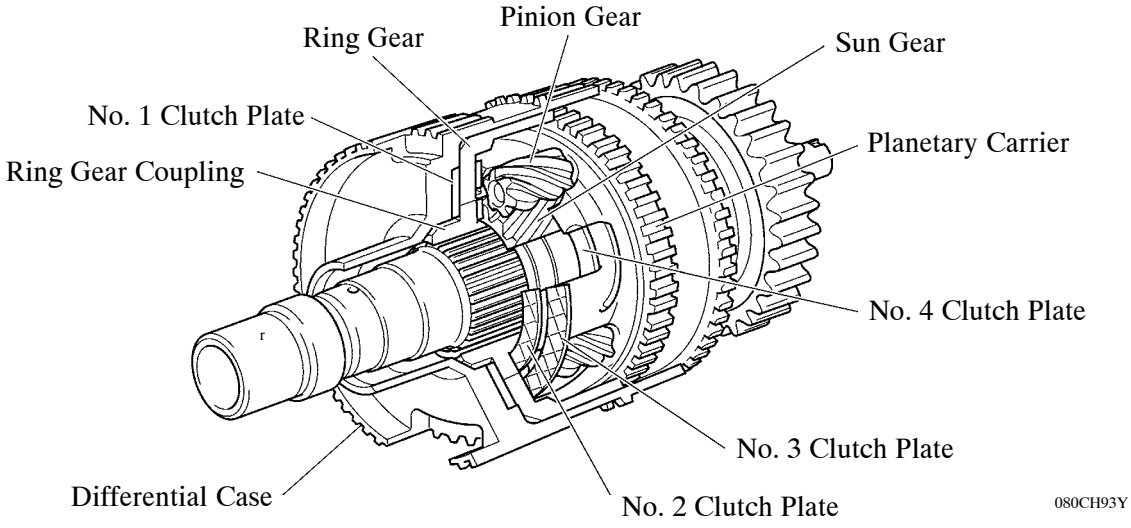


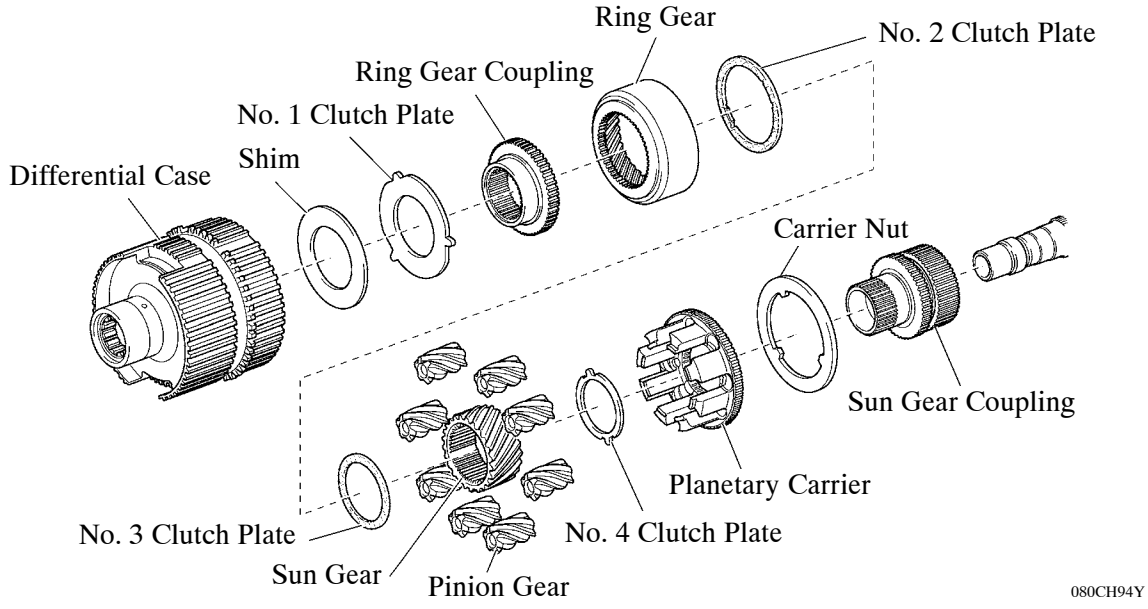


3. Center Differential (TORSEN LSD)

General

- The center differential uses a TORSEN LSD (Limited Slip Differential).
- The TORSEN LSD is torque-sensing LSD. It generates a limited-differential torque in proportion to the drive torque, and instantly changes the front and rear torque distribution.
- The torque distribution during straightline driving is 40/60 (front/rear), which is helpful for an appropriate steering response during the initial stage of a turn. During the acceleration stage of a turn, the torque distribution to the rear wheels increases.
- This center differential consists of a differential case, a ring gear coupling, a ring gear, 8 pinion gears, a sun gear, a planetary carrier, and clutch plates.



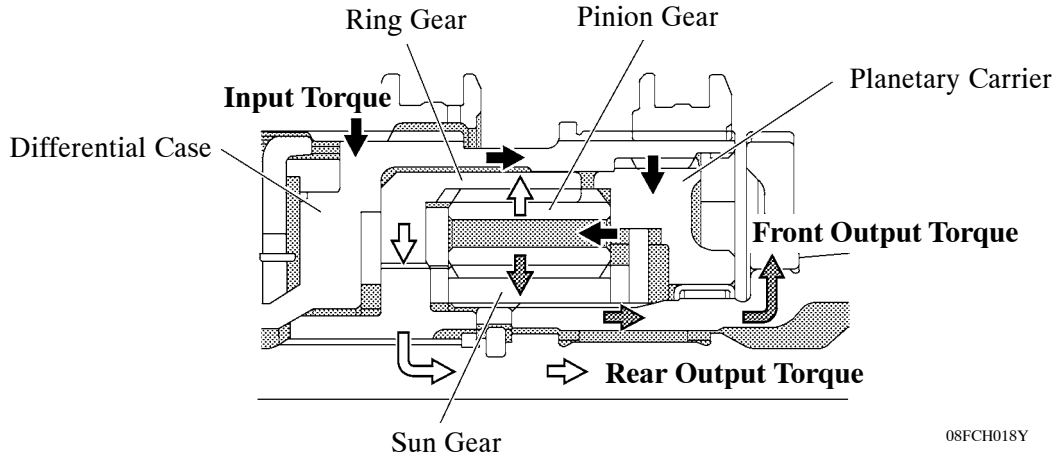


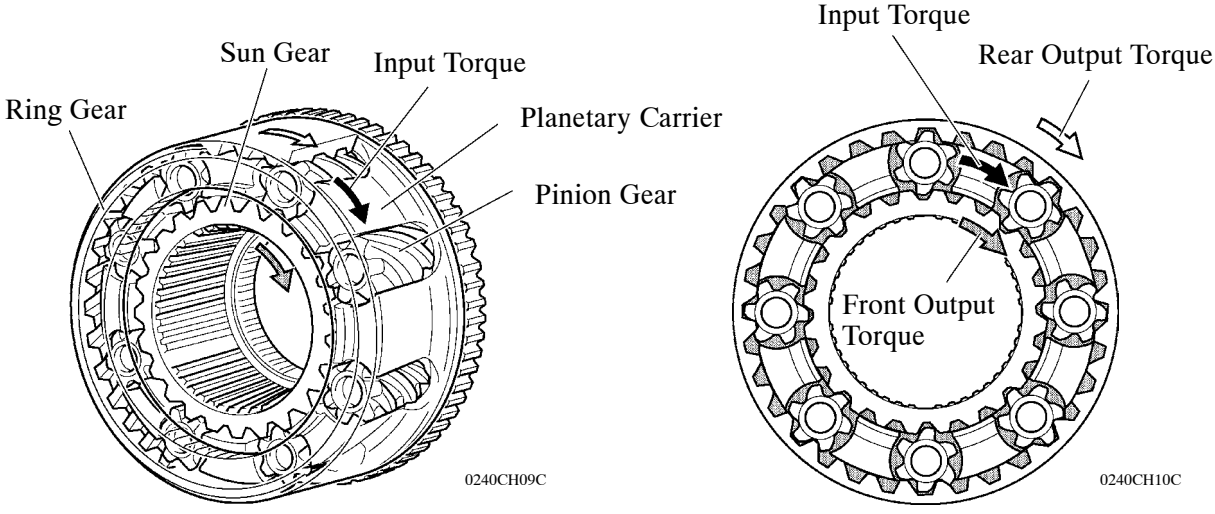
Service Tip

The TORSEN LSD cannot be disassembled, so it must be replaced as an assembly.
For details, see the LEXUS LX 570 Repair Manual (Pub. No. RM08G0E).

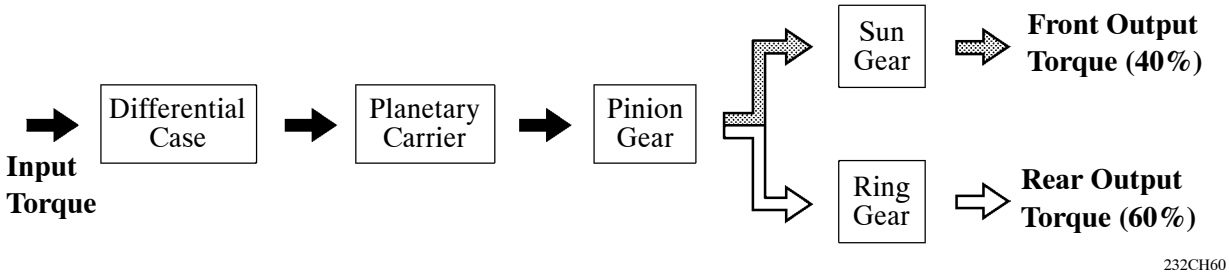
Normal Driving Operation

During normal driving (front wheel speed = rear wheel speed), the drive torque that is input by the differential case is transmitted (front: 40/rear: 60) as shown below, without involving the LSD function.





▶ Power Flow ◀



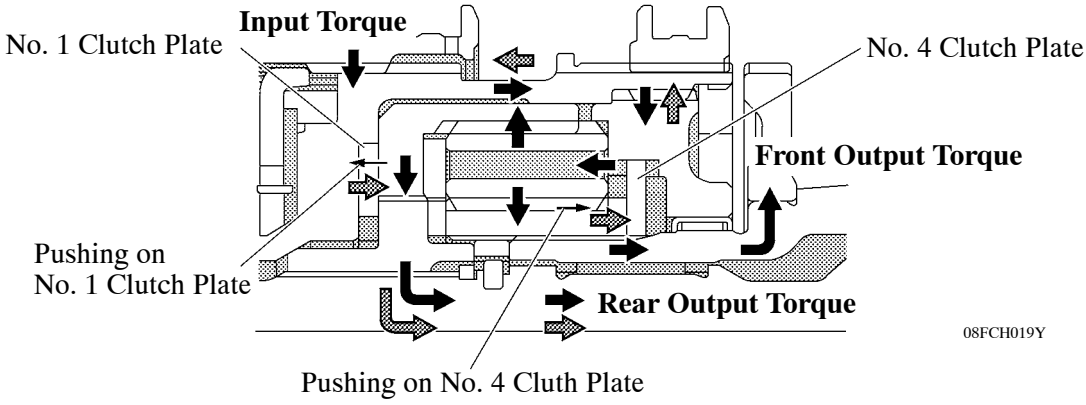
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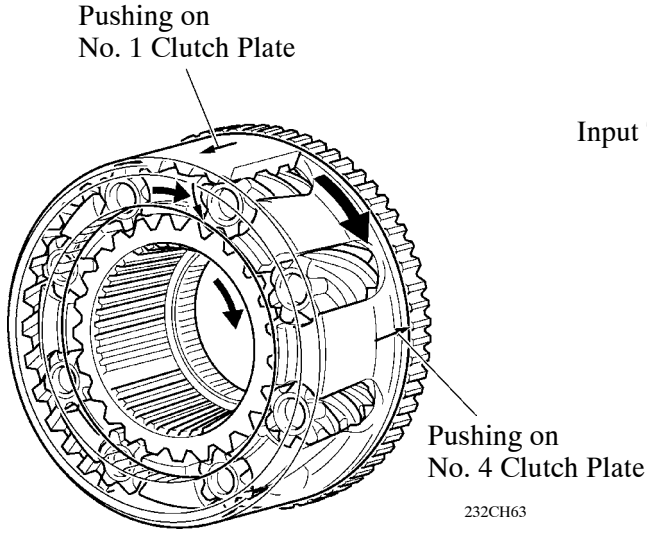
Front Wheel Skid Driving Operation

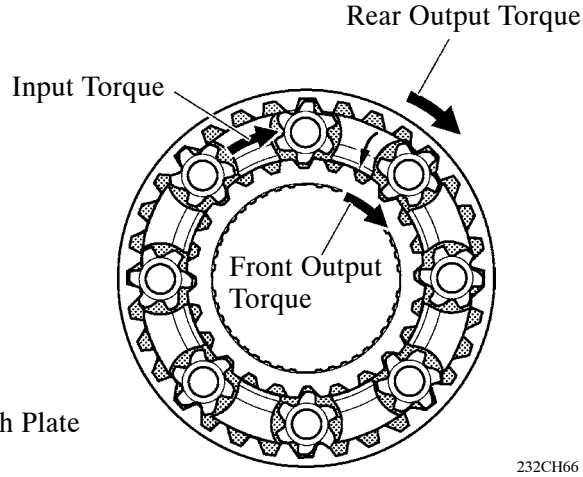
During front wheel skid driving (front wheel speed > rear wheel speed) when a rotational difference exists between the sun gear and the ring gear, the distribution of the drive torque that is input by the differential case changes instantly before the torque is transmitted, as follows:

- The sun gear transmits torque to the planetary carrier while pushing on the No. 4 clutch plate. The planetary carrier transmits this torque to the ring gear from the differential case via the No. 1 clutch plate.
- The ring gear outputs torque while pushing on the No. 1 clutch plate.

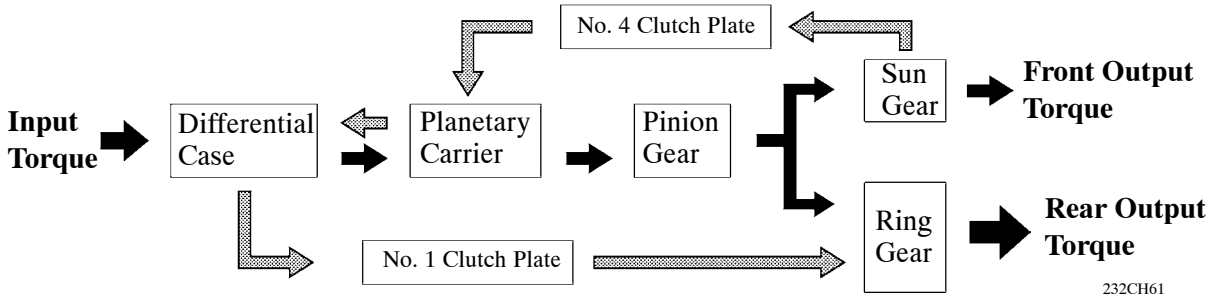
These LSD functions change the torque distribution.







▶ Power Flow ◀

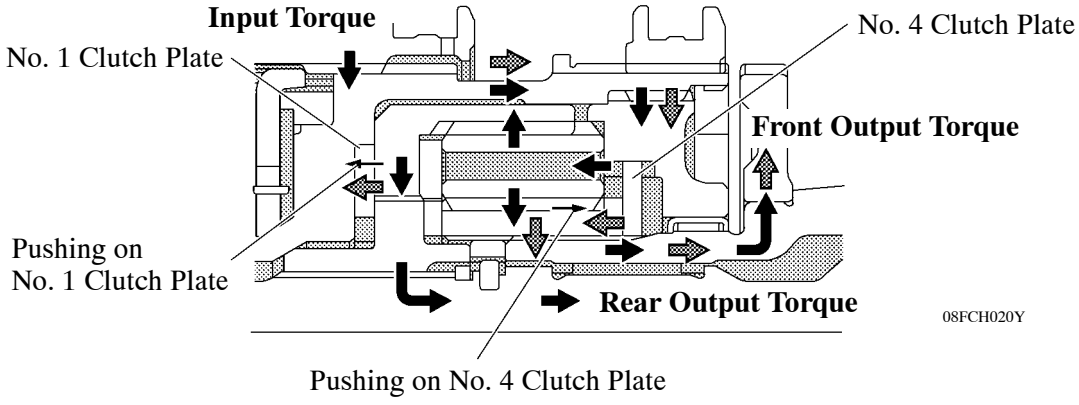


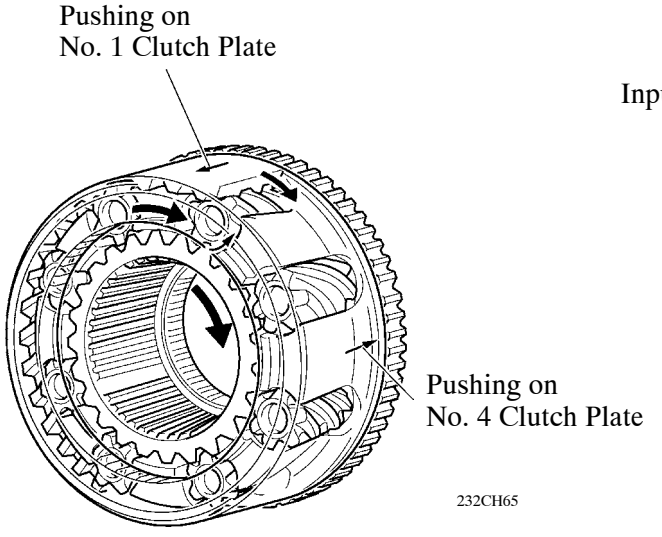
Rear Wheel Skid Driving Operation

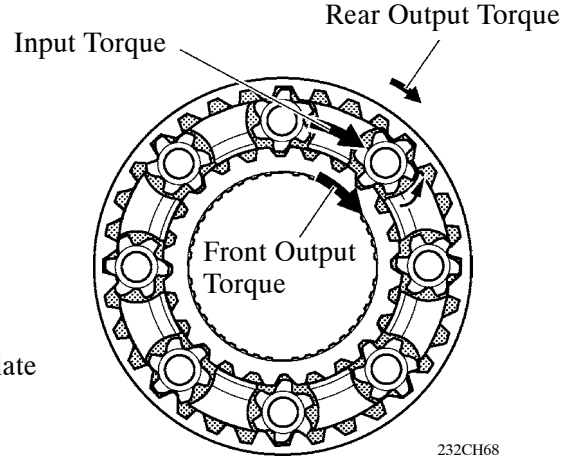
During rear wheel skid driving (front wheel speed < rear wheel speed), when a rotational difference exists between the sun gear and the ring gear, the distribution of the drive torque that is input by the differential case changes instantly before the torque is transmitted, as follows:

- The ring gear transmits torque to the differential case while pushing the No. 1 clutch plate. The differential case transmits this torque from the planetary carrier to the sun gear via the No. 4 clutch plate.
- The sun gear outputs torque while pushing on the No. 4 clutch plate.

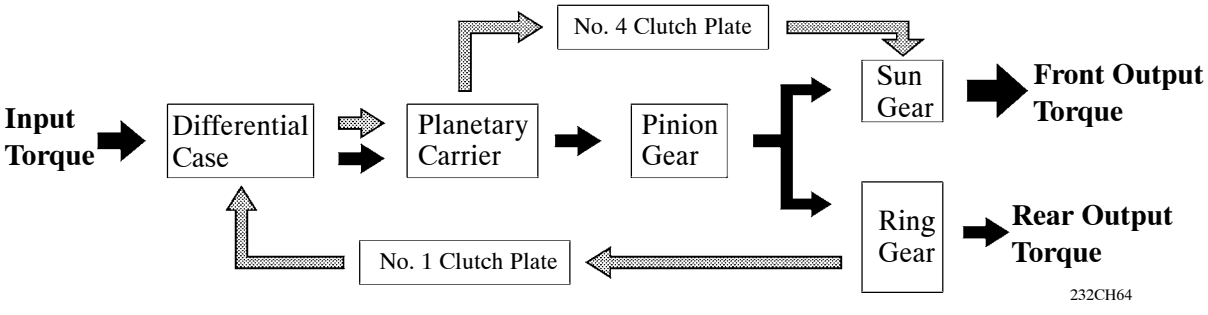
These LSD functions change the torque distribution.







▶ Power Flow ◀

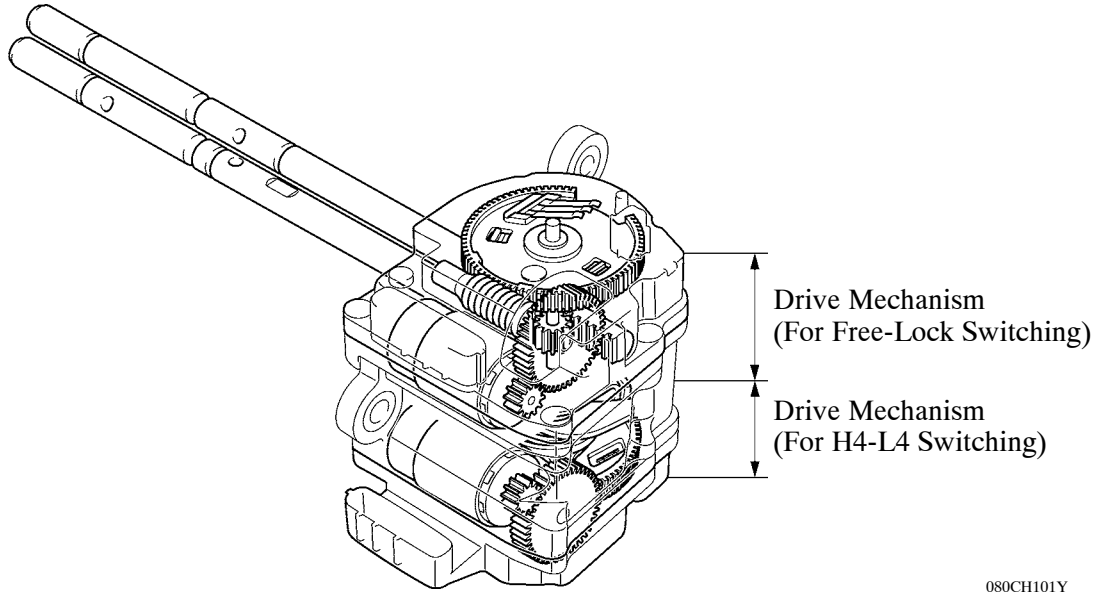


4. Transfer Shift Actuator

General

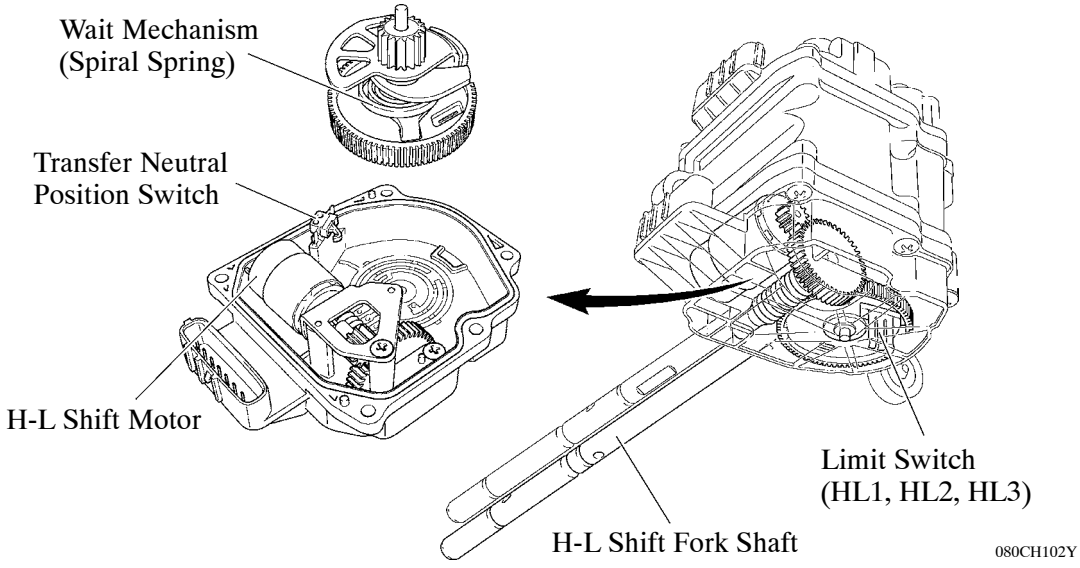
The transfer shift actuator consists of the following two mechanisms.

- H4-L4 switching (to switch the transfer gear ratio).
- Free-lock switching (to switch the center differential lock).

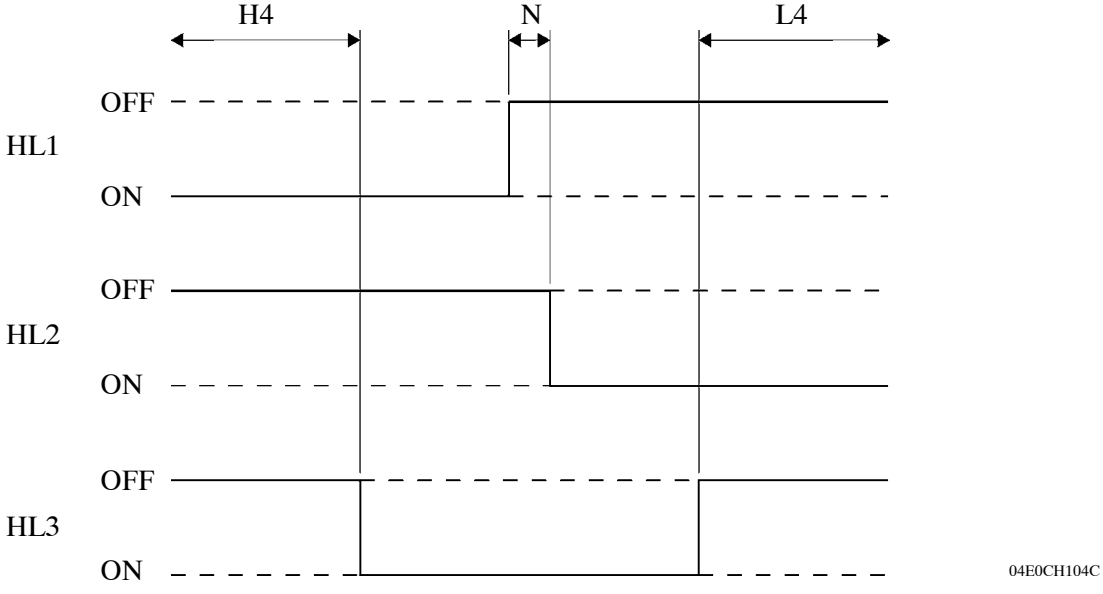


Drive Mechanism for H4-L4 Switching

- The drive mechanism for H4-L4 switching consists of an H-L shift motor, a limit switch, a transfer neutral position switch, a wait mechanism (spiral spring), and an H-L shift fork shaft. This drive mechanism cannot be disassembled.
- The limit switch has three contact points and detects the shift motor position.
- The wait mechanism (spiral spring) is used for H-L shift fork shaft operations. If the operating resistance of the H-L shift fork shaft is high, the rotation of the H-L shift motor is partially stored in the spiral spring. Afterward, when the operating resistance is reduced, the spring force causes the H-L shift fork shaft to slide.

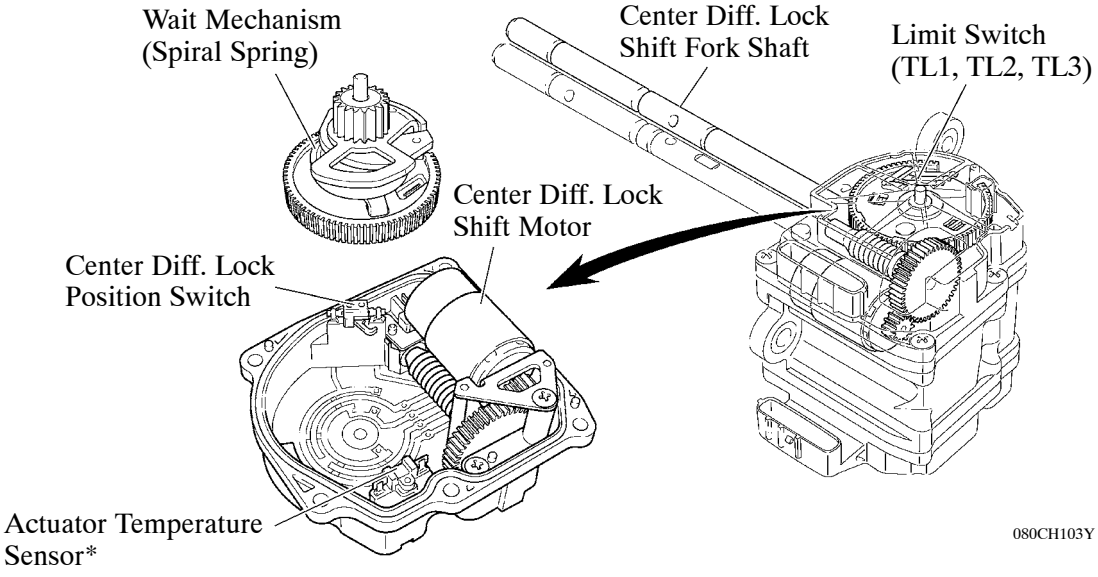


▶ Combination of 3 Contact Point Switches ◀



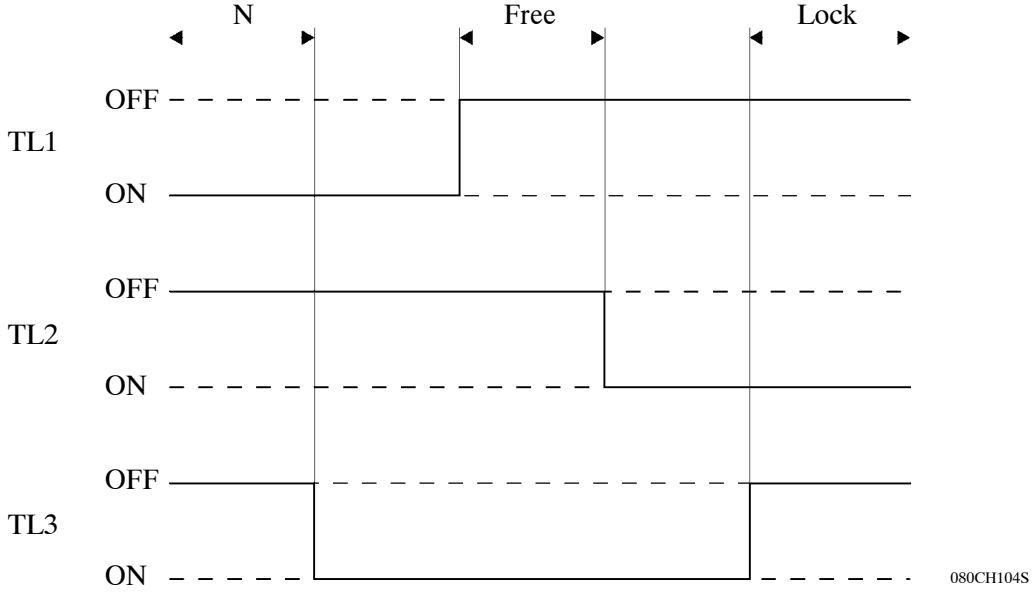
Drive Mechanism for Free-Lock Switching

- The drive mechanism for free-lock switching consists of a center differential lock shift motor, a limit switch, a center differential lock position switch, a wait mechanism (spiral spring), a center differential lock shift fork shaft, and an actuator temperature sensor*. This drive mechanism cannot be disassembled.
- The limit switch has three contact points and detects the shift motor position.
- The wait mechanism (spiral spring) is used for center differential lock shift fork shaft operations. If the operating resistance of the center differential lock shift fork shaft is high, the rotation of the center differential lock shift motor is partially stored in the spiral spring. Afterward, when the operating resistance is reduced, the spring force causes the center differential lock shift fork shaft to slide.
- On the Europe and China models, an actuator temperature sensor is provided on the shift actuator in order to allow an increase of the amount of current applied to the shift motors, and improves switching performance at low temperatures.



*: Only for Europe and China Models

▶ Combination of 3 Contact Point Switches ◀

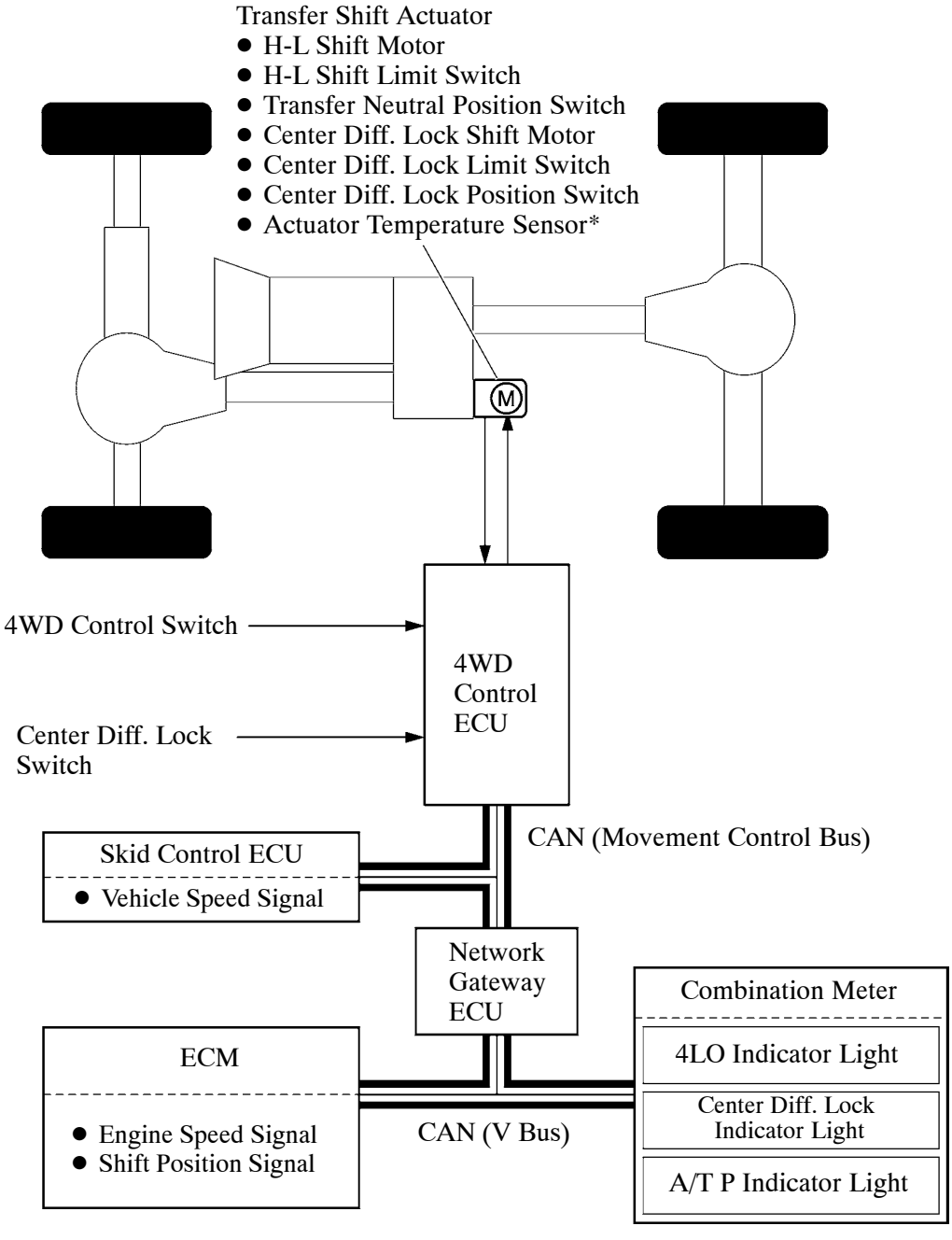


■4WD SYSTEM

1. General

- The 4WD system used on the new LX 570 allows the driver to select the appropriate mode from among the four drive modes by utilizing the 4WD control switch and center differential lock switch.
- Through these switch signals, the 4WD control ECU actuates the 2 shift motors in the transfer shift actuator.

▶ System Diagram ◀

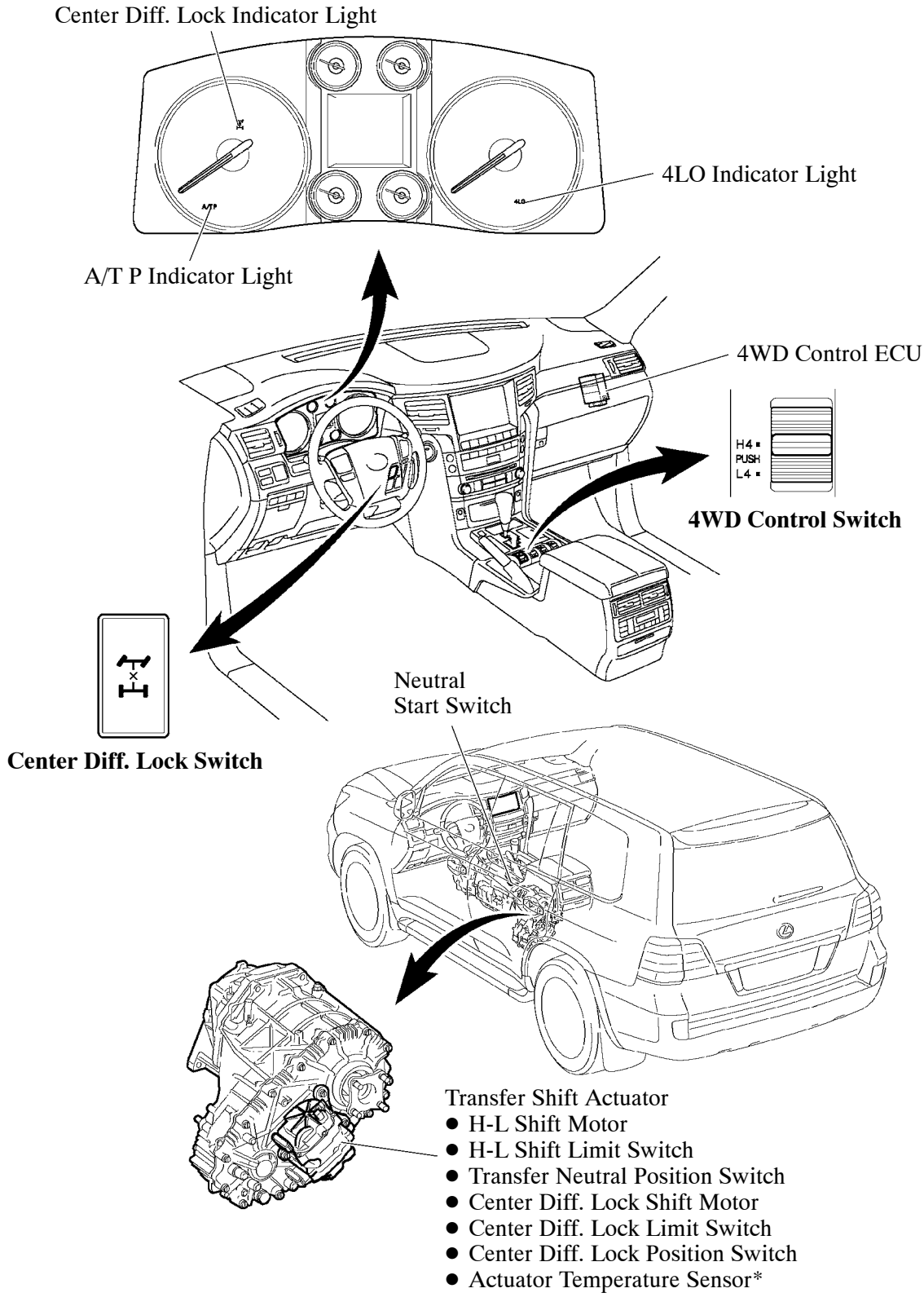


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*: Only for Europe and China Models

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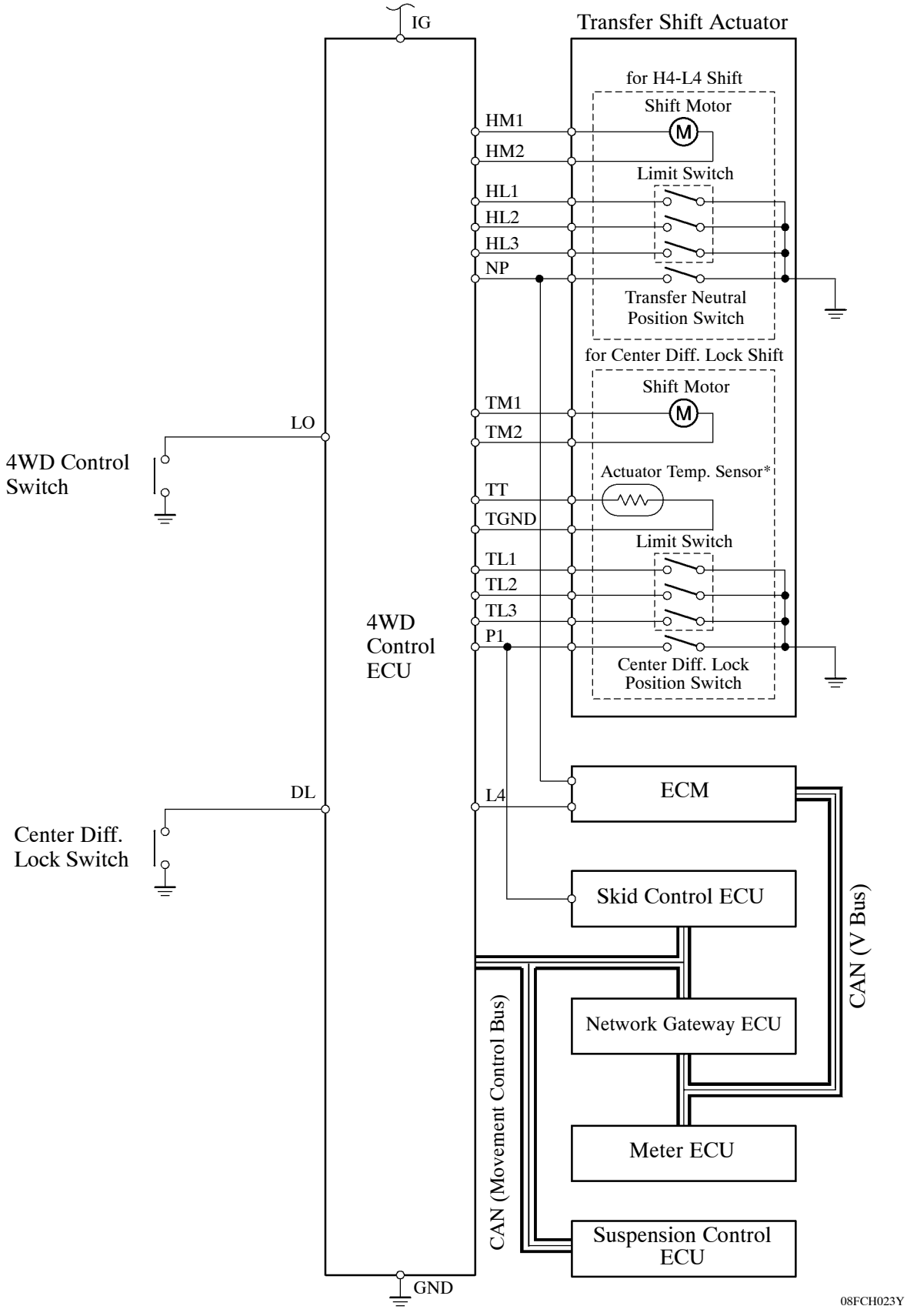
2. Layout of Main Components



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*: Only for Europe and China Model

3. Wiring Diagram



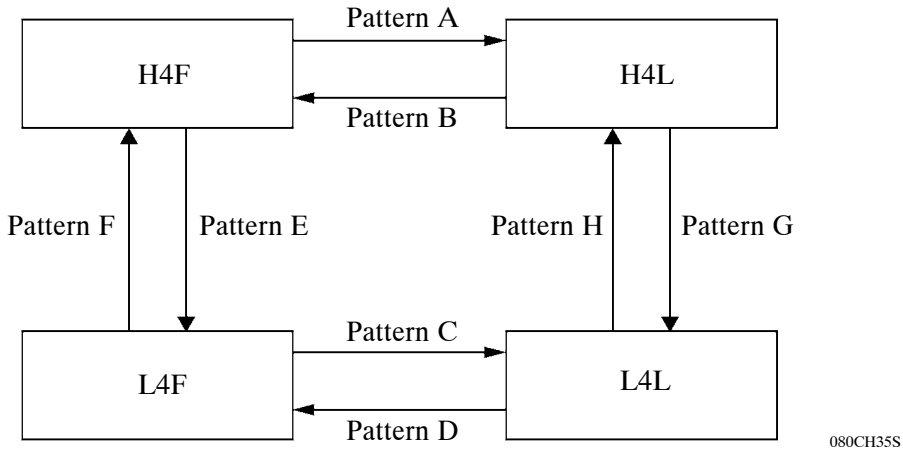
*: Only for Europe and China Model

4. System Operation

General

- The 4WD mode switching pattern of this system is as shown in the illustration below. The system operation of each switching pattern is explained from the next page.
- When the vehicle speed is below approximately 100 km/h (62 mph), free-lock switching of the center differential lock (switching patterns A to D) is available while the vehicle is running.
- The H4-L4 switching of the transfer gear ratio (switching patterns E to H) is available only when the vehicle is stationary and the shift position is N.

▶ 4WD Mode Switching Pattern ◀



H4F: High Speed 4WD & Center Differential Free
H4L: High Speed 4WD & Center Differential Lock
L4F: Low Speed 4WD & Center Differential Free
L4L: Low Speed 4WD & Center Differential Lock

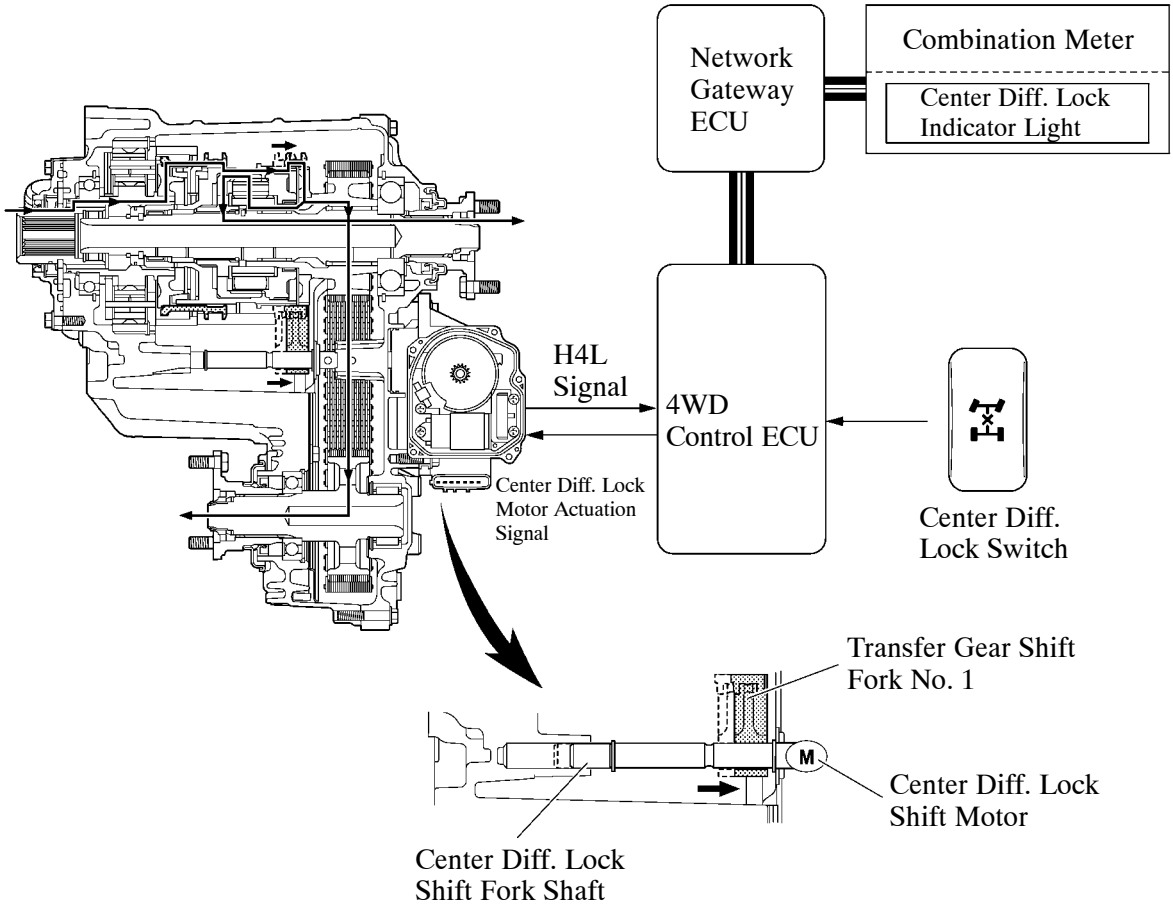
Service Tip

The neutral position is provided between H4 and L4. Switch to the neutral position or release the neutral position with the vehicle at standstill.

- The procedures to switch to the neutral position are as follows:
  1) Switch the transfer position to H4F.
  2) Move the shift lever to the P position.
  3) Depress the brake pedal three times, and then keep it depressed.
  4) Move the shift lever to the N position.
  5) Depress the brake pedal three times.
  6) Turn the 4WD control switch from H4 to L4, then to H4.
  7) The 4LO indicator light blinks.
  8) Move the shift lever to the P position.
  9) The A/T P indicator light turns ON, and the neutral position is selected.
- The procedures to release the neutral position are as follows:
  1) Move the shift lever to the N position.
  2) Turn the 4WD control switch from H4 to L4, then to H4.
  3) The 4LO indicator light turns OFF.
  4) The transfer position is switched to H4F, and the neutral position is released.

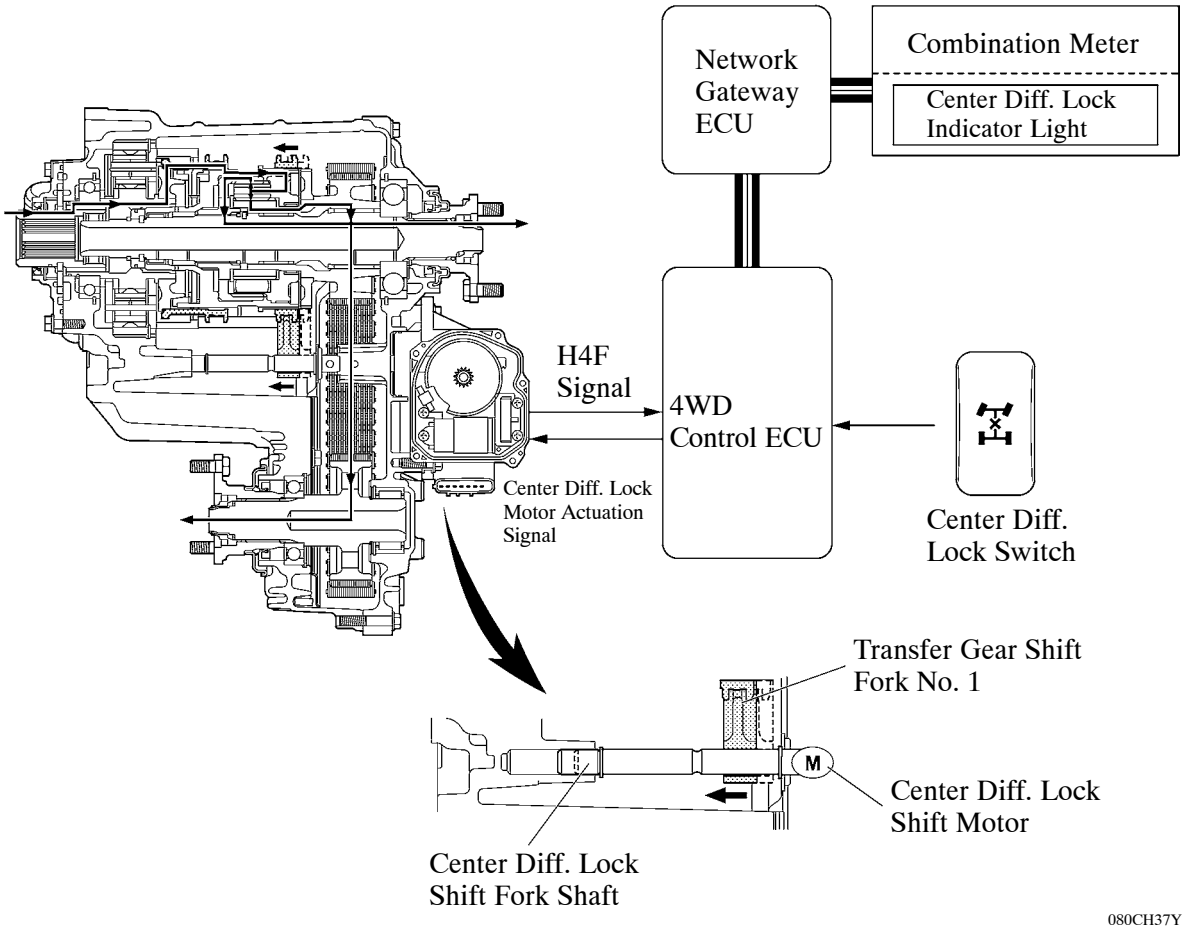
Switching Pattern A (H4F → H4L)

- In H4F mode, when the center differential lock switch is turned ON, the 4WD control ECU actuates the center differential lock shift motor to move the center differential lock shift fork shaft to the right. Simultaneously, the center differential lock shift fork shaft moves to the right together with the transfer gear shift fork No. 1. As a result, the center differential lock sleeve engages the differential case and the drive sprocket piece, and the mode changes to H4L.
- The 4WD control ECU detects the state of the center differential through the limit switch and center differential lock position switch. The 4WD control ECU causes the center differential lock indicator light to turn ON when the center differential is locked.



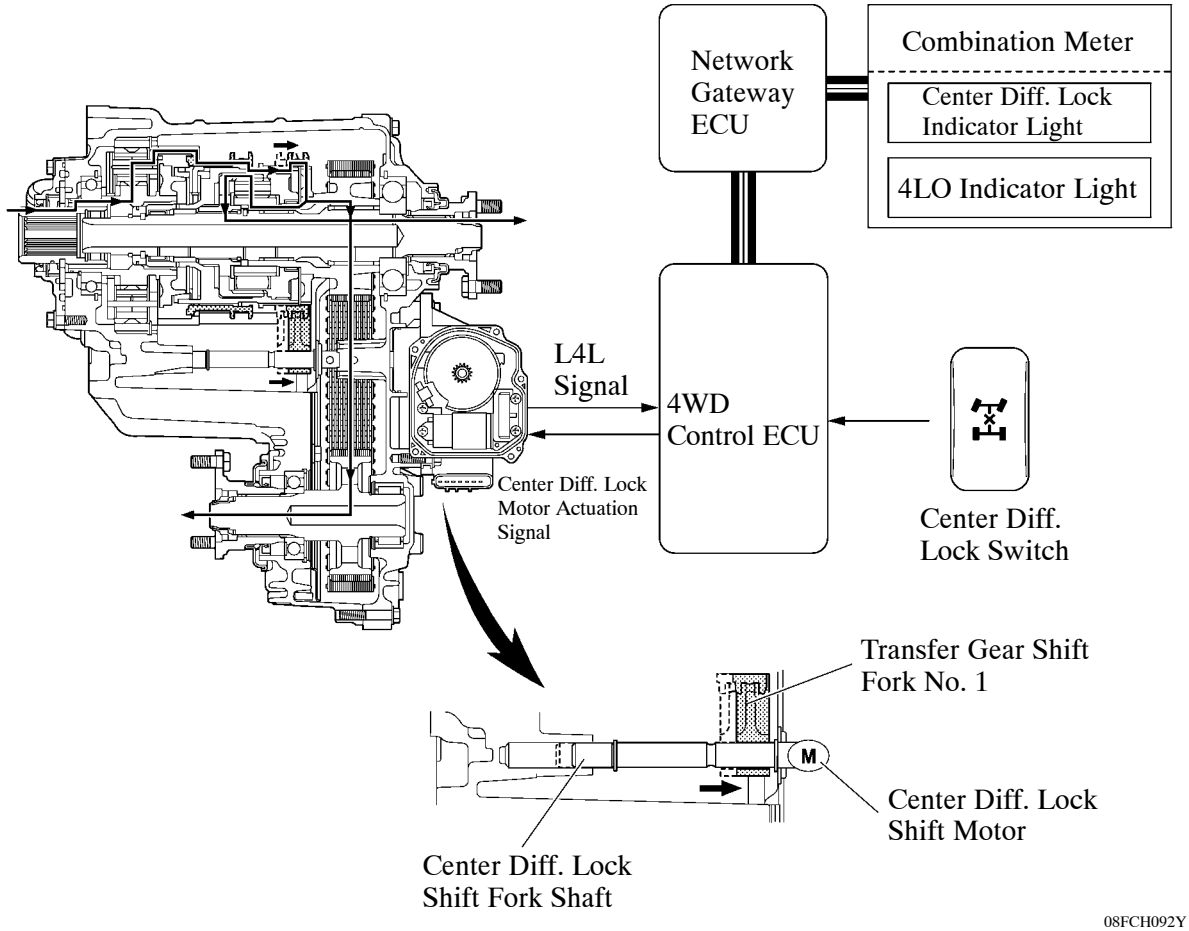
Switching Pattern B (H4L → H4F)

- In H4L mode, when the center differential lock switch is turned OFF, the 4WD control ECU actuates the center differential lock shift motor to move the center differential lock shift fork shaft to the left. Simultaneously, the center differential lock shift fork shaft moves to the left together with the transfer gear shift fork No. 1. As a result, the center differential lock sleeve disengages the differential case and the drive sprocket piece, and the mode changes to H4F.
- The 4WD control ECU detects the state of the center differential through the limit switch and center differential lock position switch. The 4WD control ECU causes the center differential lock indicator light to turn OFF when the center differential is unlocked.



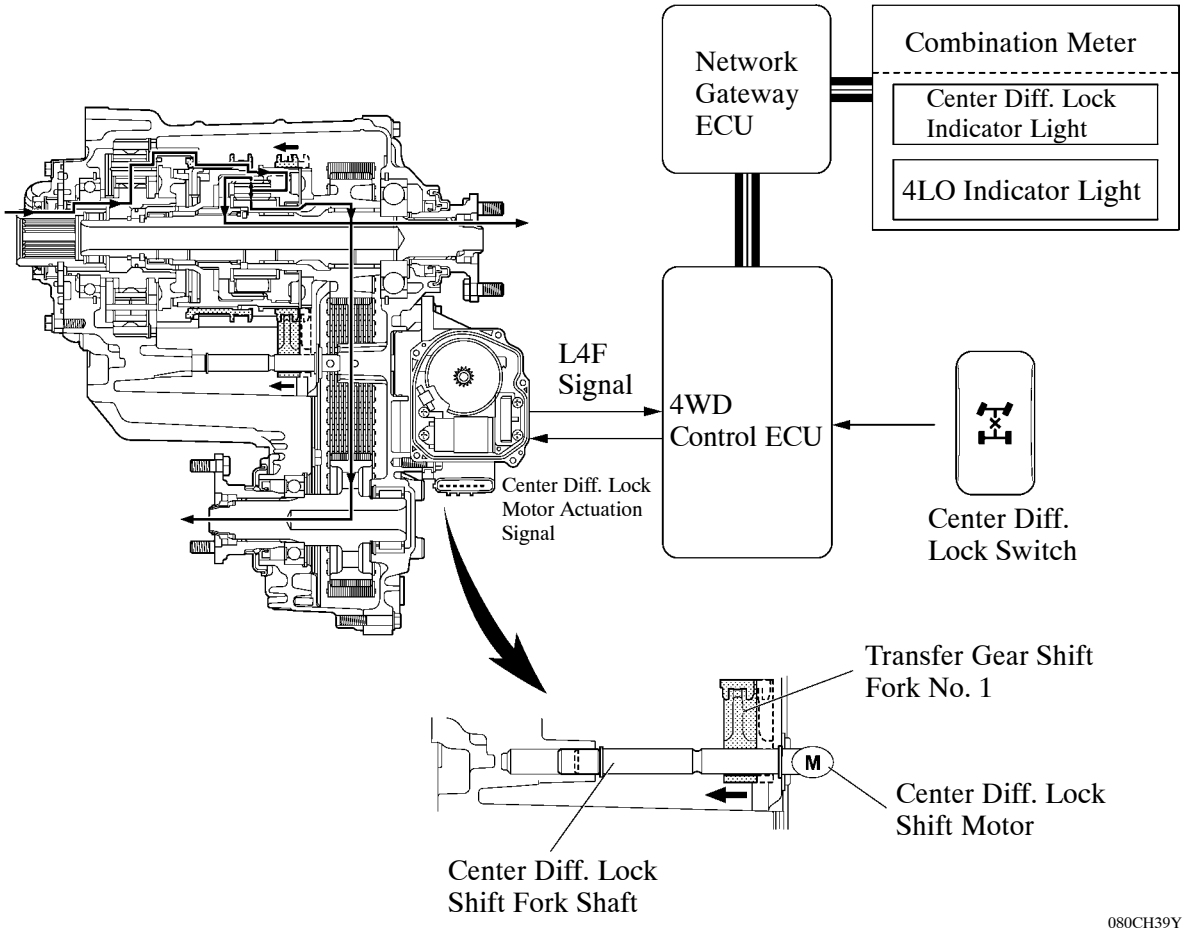
Switching Pattern C (L4F → L4L)

- In L4F mode, when the center differential lock switch is turned ON, the 4WD control ECU actuates the center differential lock shift motor to move the center differential lock shift fork shaft to the right. Simultaneously, the center differential lock shift fork shaft moves to the right together with the transfer gear shift fork No. 1. As a result, the center differential lock sleeve engages the differential case and the drive sprocket piece, and the mode changes to L4L.
- The 4WD control ECU detects the state of the center differential through the limit switch and center differential lock position switch. The 4WD control ECU causes the center differential lock indicator light to turn ON when the center differential is locked.



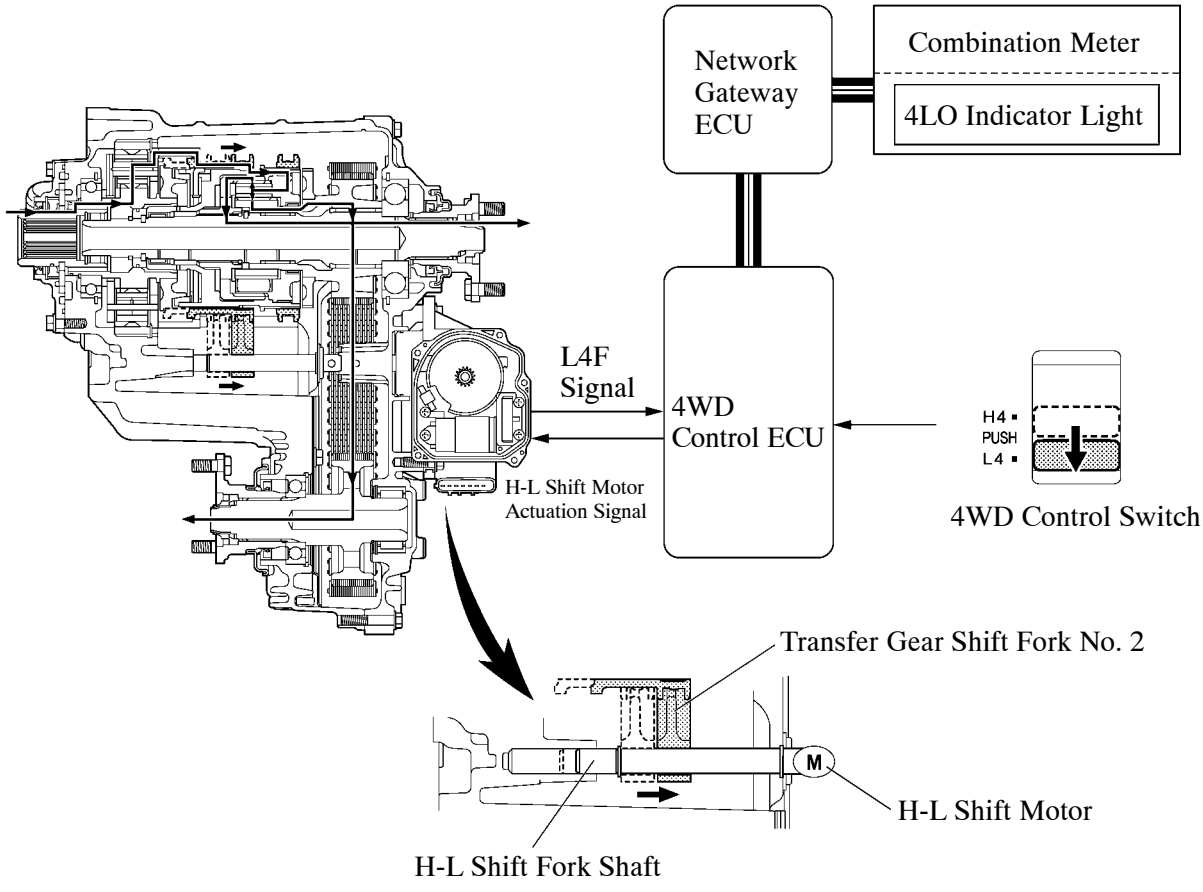
Switching Pattern D (L4L → L4F)

- In L4L mode, when the center differential lock switch is turned OFF, the 4WD control ECU actuates the center differential lock shift motor to move the center differential lock shift fork shaft to the left. Simultaneously, the center differential lock shift fork shaft moves to the left together with the transfer gear shift fork No. 1. As a result, the center differential lock sleeve disengages the differential case and the drive sprocket piece, and the mode changes to L4F.
- The 4WD control ECU detects the state of the center differential through the limit switch and center differential lock position switch. The 4WD control ECU causes the center differential lock indicator light to turn OFF when the center differential is unlocked.



Switching Pattern E (H4F → L4F)

- In H4F mode, when the 4WD control switch is turned to the L4 position, the 4WD control ECU actuates the H-L shift motor to move the H-L shift fork shaft to the right. Simultaneously, the H-L shift fork shaft moves to the right together with the transfer gear shift fork No. 2. As a result, the high and low clutch sleeve of the planetary gear unit engages with the planetary carrier, and the mode changes to L4F.
- The 4WD control ECU detects the state of the H-L position through the limit switch and transfer neutral position switch. The 4WD control ECU causes the 4LO indicator light to turn ON when switching to the L4F mode has been completed.

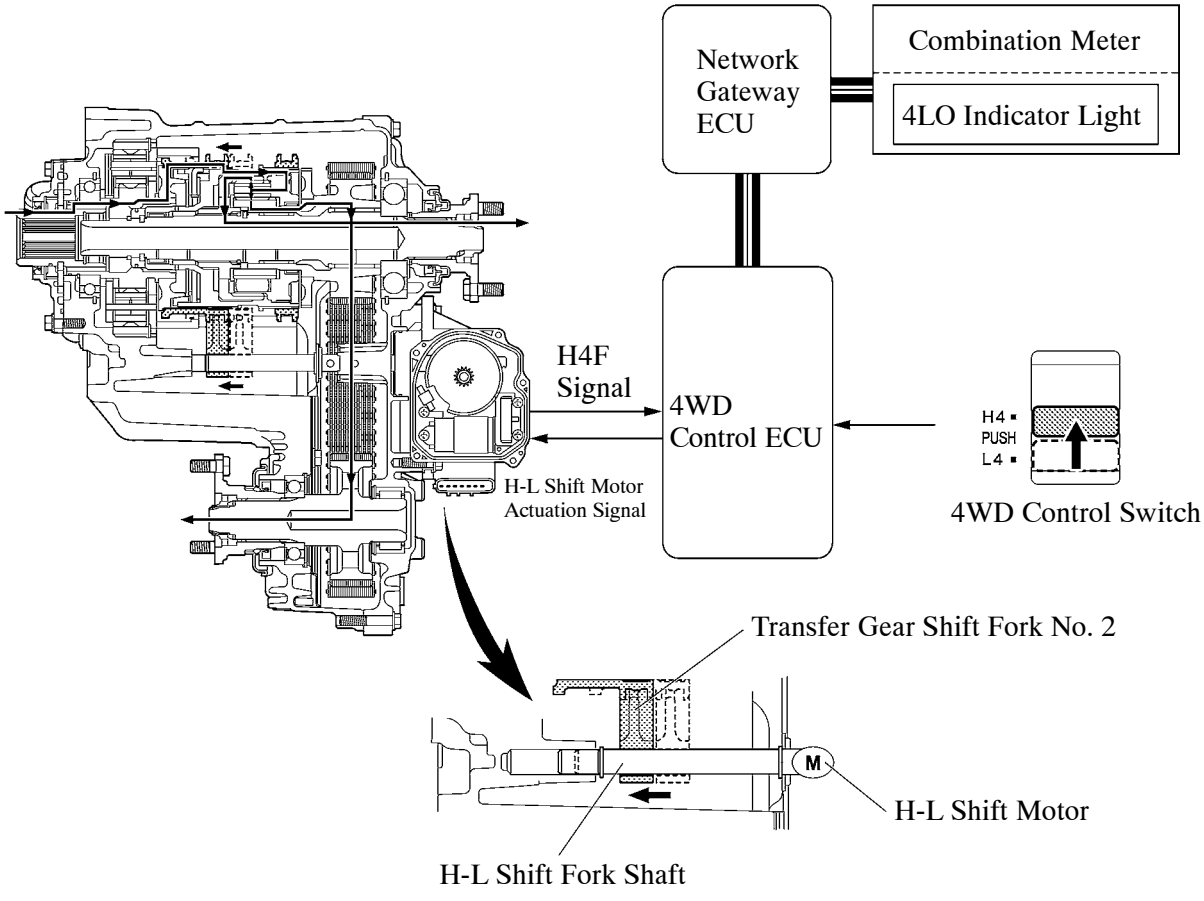


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Switching Pattern F (L4F → H4F)

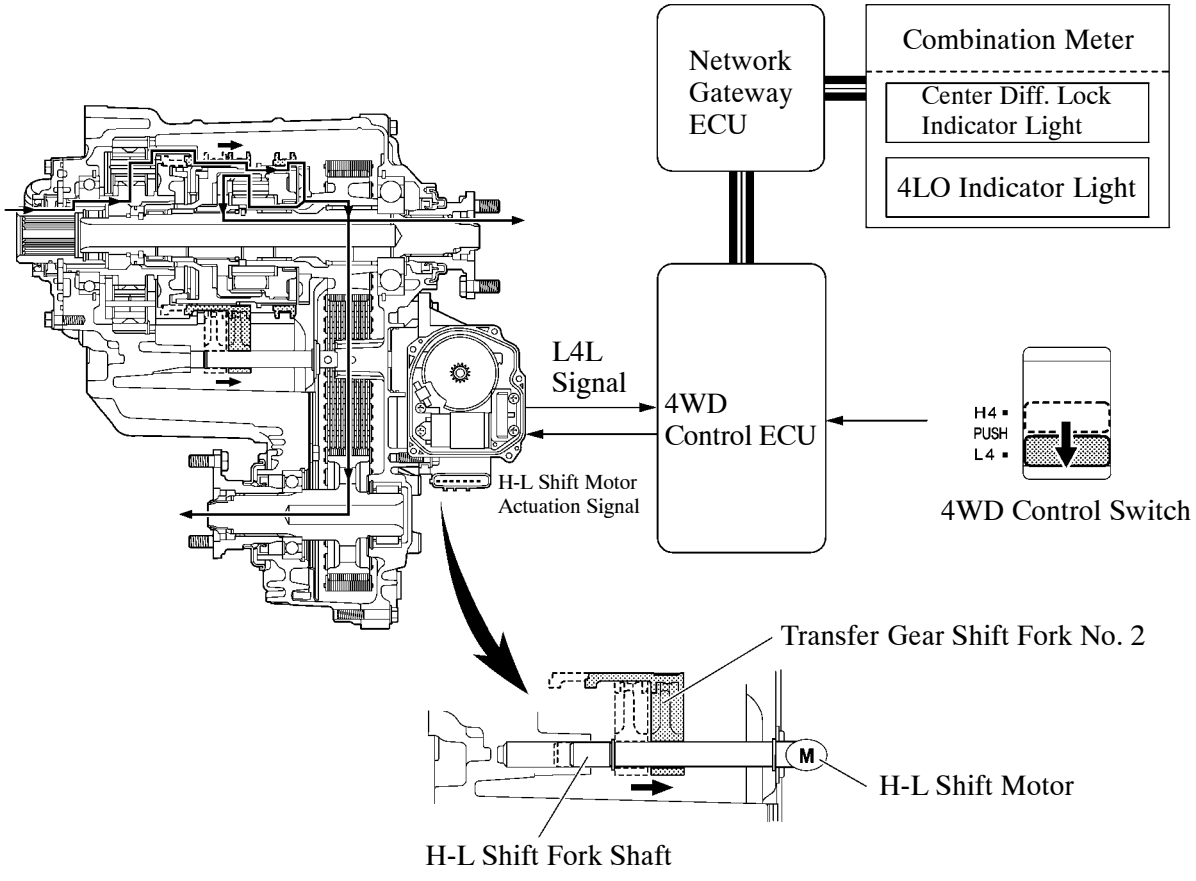
- In L4F mode, when the 4WD control switch is turned to the H4 position, the 4WD control ECU actuates the H-L shift motor to move the H-L shift fork shaft to the left. Simultaneously, the H-L shift fork shaft moves to the left together with the transfer gear shift fork No. 2. As a result, the high and low clutch sleeve of the planetary gear unit engages with the rear of the transfer input shaft, and the mode changes to H4F.
- The 4WD control ECU detects the state of the H-L position through the limit switch and transfer neutral position switch. The 4WD control ECU causes the 4LO indicator light to turn OFF when switching to the H4F mode has been completed.



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Switching Pattern G (H4L → L4L)

- In H4L mode, when the 4WD control Switch is turned to the L4 position, the 4WD control ECU actuates the H-L shift motor to move the H-L shift fork shaft to the right. Simultaneously, the H-L shift fork shaft moves to the right together with the transfer gear shift fork No. 2. As a result, the high and low clutch sleeve of the planetary gear unit engages with the planetary carrier, and the mode changes to L4L.
- The 4WD control ECU detects the state of the H-L position through the limit switch and transfer neutral position switch. The 4WD control ECU causes the 4LO indicator light to turn ON when switching to the L4L mode has been completed.

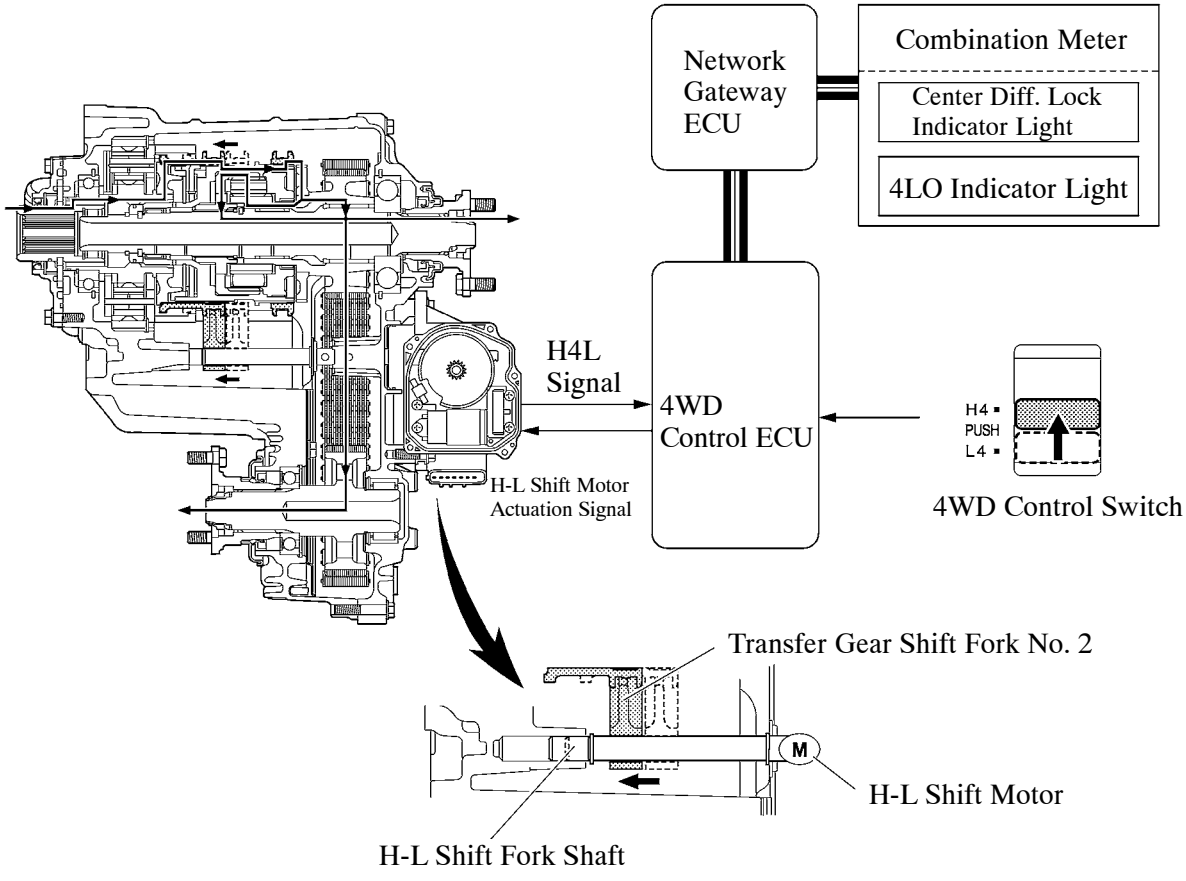


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Switching Pattern H (L4L → H4L)

- In L4L mode, when the 4WD control switch is turned to the H4 position, the 4WD control ECU actuates the H-L shift motor to move the H-L shift fork shaft to the left. Simultaneously, the H-L shift fork shaft moves to the left together with the transfer gear shift fork No. 2. As a result, the high and low clutch sleeve of the planetary gear unit engages with the rear of transfer input shaft, and the mode changes to H4L.
- The 4WD control ECU detects the state of the H-L position through the limit switch and transfer neutral position switch. The 4WD control ECU causes the 4LO indicator light to turn OFF when switching to the H4L mode has been completed.

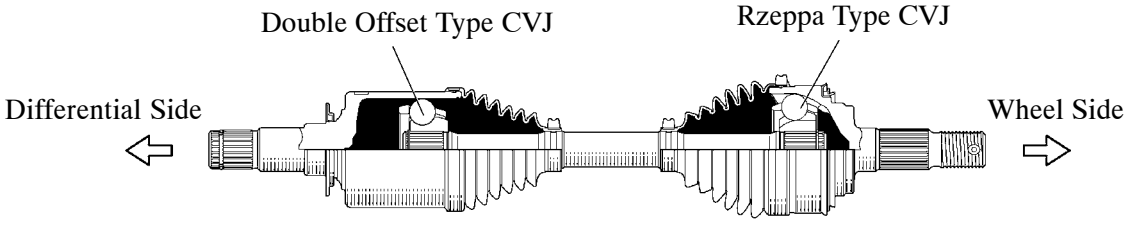


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FRONT DRIVE SHAFT

■ DESCRIPTION

The front drive shaft uses the double offset type CVJ (Constant-Velocity Joint) on the differential side, and the Rzeppa type CVJ on the wheel side.

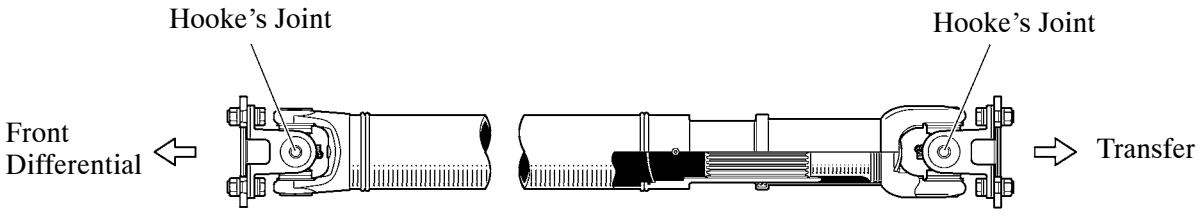


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PROPELLER SHAFT

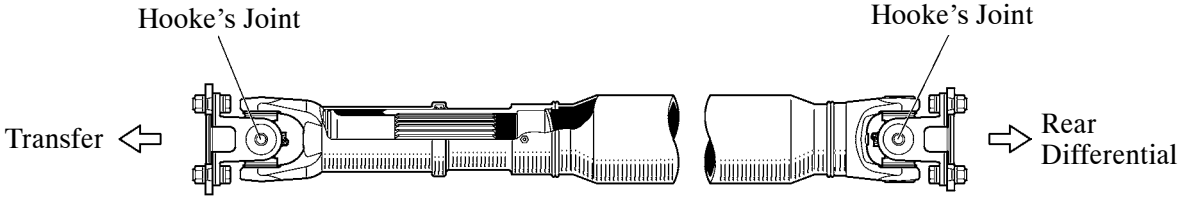
■ DESCRIPTION

The 2-joint type propeller shaft is used for the front and rear propeller shafts.



Front Propeller Shaft

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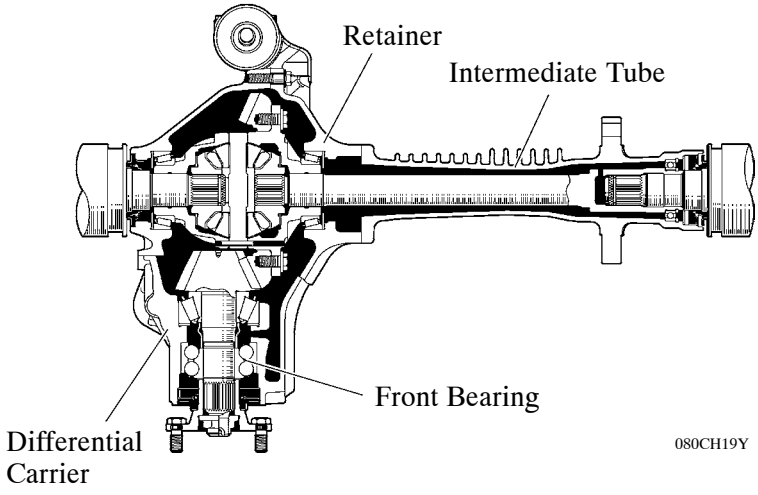
Rear Propeller Shaft

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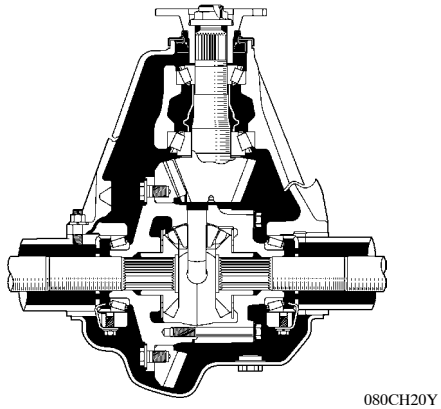
DIFFERENTIAL

■ DESCRIPTION

- The front differential uses the SD22A type.
- The rear differential uses the BD24A type.
- The differential carrier, differential retainer and intermediate tube on the front differential are made of aluminum to reduce their weight.
- A double-row angular ball bearing is used for the front bearing on the front differential to reduce friction loss, thus improving fuel consumption.
- Low viscosity oil is used for front and rear differentials, also improving fuel consumption.



Front Differential



Rear Differential

▶ Specifications ◀

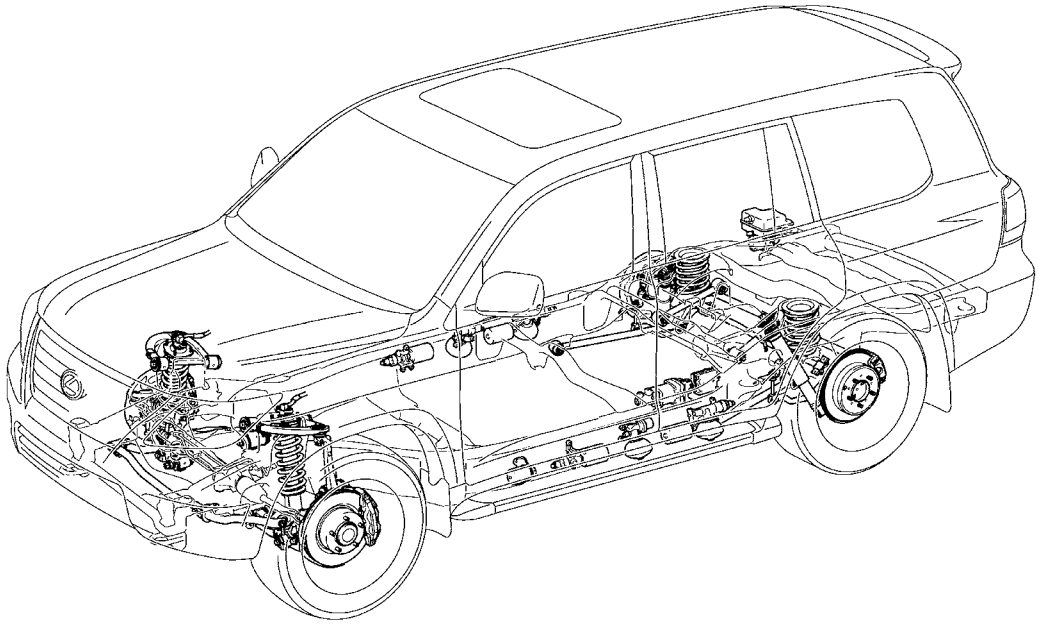
Differential Type		Front	Rear
		SD22A	BD24A
Differential Gear Ratio		3.909	3.909
Ring Gear Size	mm (in.)	220 (8.7)	241 (9.5)
Oil Capacity	Liters (US qts, Imp. qts)	1.9 (2.0, 1.7)	4.2 (4.4, 3.7)
Oil Viscosity		SAE 75W-85	←
Oil Grade		API GL-5	←
Weight (Reference)*	kg (lb)	33.7 (74.3)	38.0 (83.8)

*: Weight shows the figure with no fluids.

SUSPENSION AND AXLE

■ DESCRIPTION

- The coil spring type double-wishbone independent suspension is used for the front suspension, and the 4-link coil spring with lateral rod type suspension is used for the rear suspension.
- A 4-wheel active height control suspension and an adaptive variable suspension are used.



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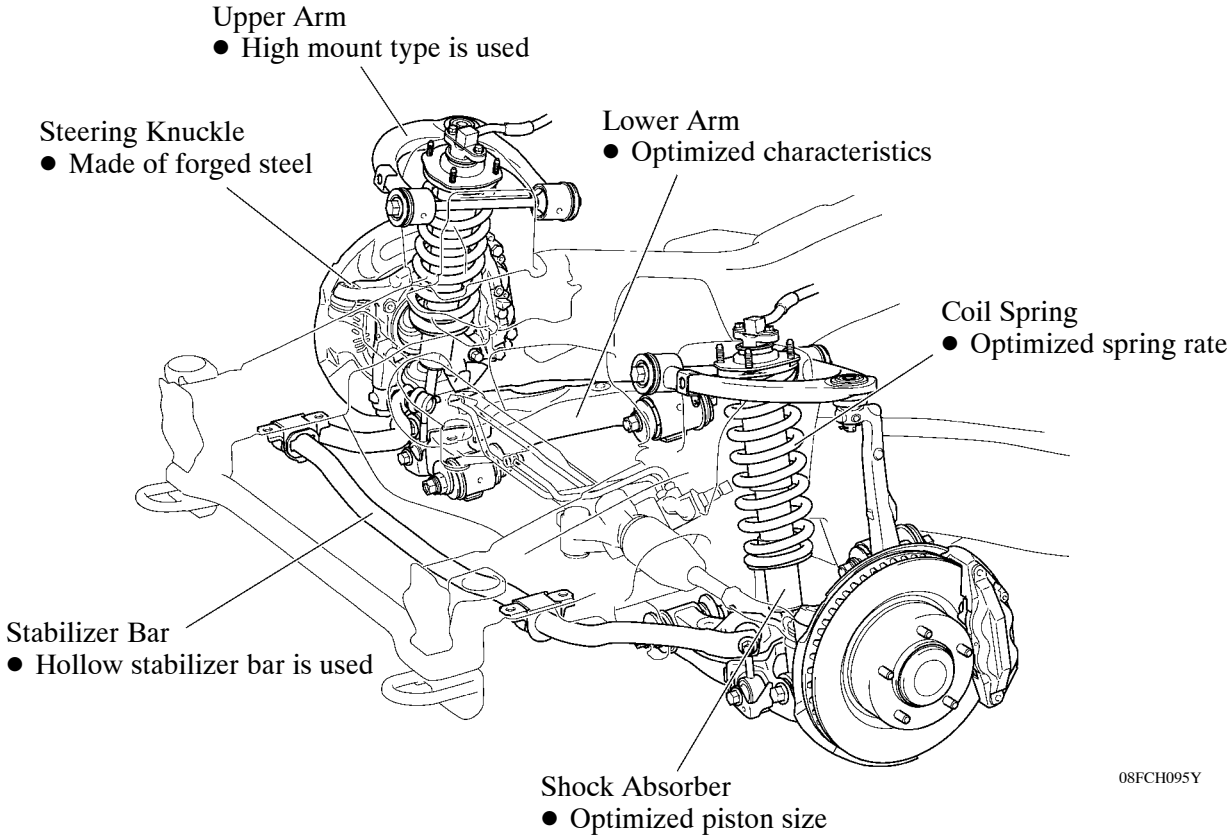
▶ Specifications ◀

Tire Size			285/60 R18
Tread*	Front	mm (in.)	1640 (64.6)
	Rear	mm (in.)	1635 (64.4)
Front Wheel Alignment*	Caster	degrees	3°23’
	Camber	degrees	0°00’
	Toe-in	mm (in.)	0 (0.0)
	King Pin Inclination	degrees	13°00’

*: Unloaded Vehicle Condition

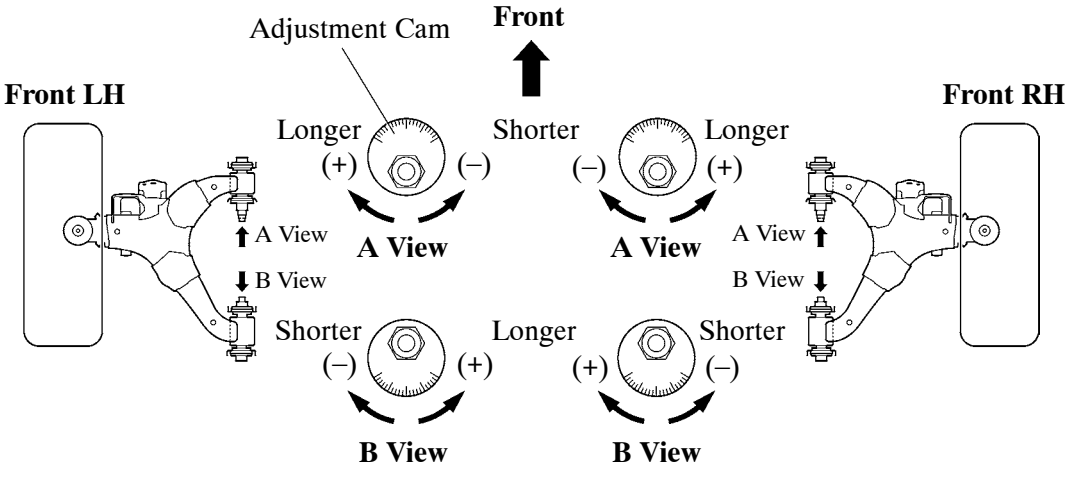
■FRONT SUSPENSION

Through the optimal allocation of components, the front suspension realizes excellent riding comfort, controllability, and off-road drivability.



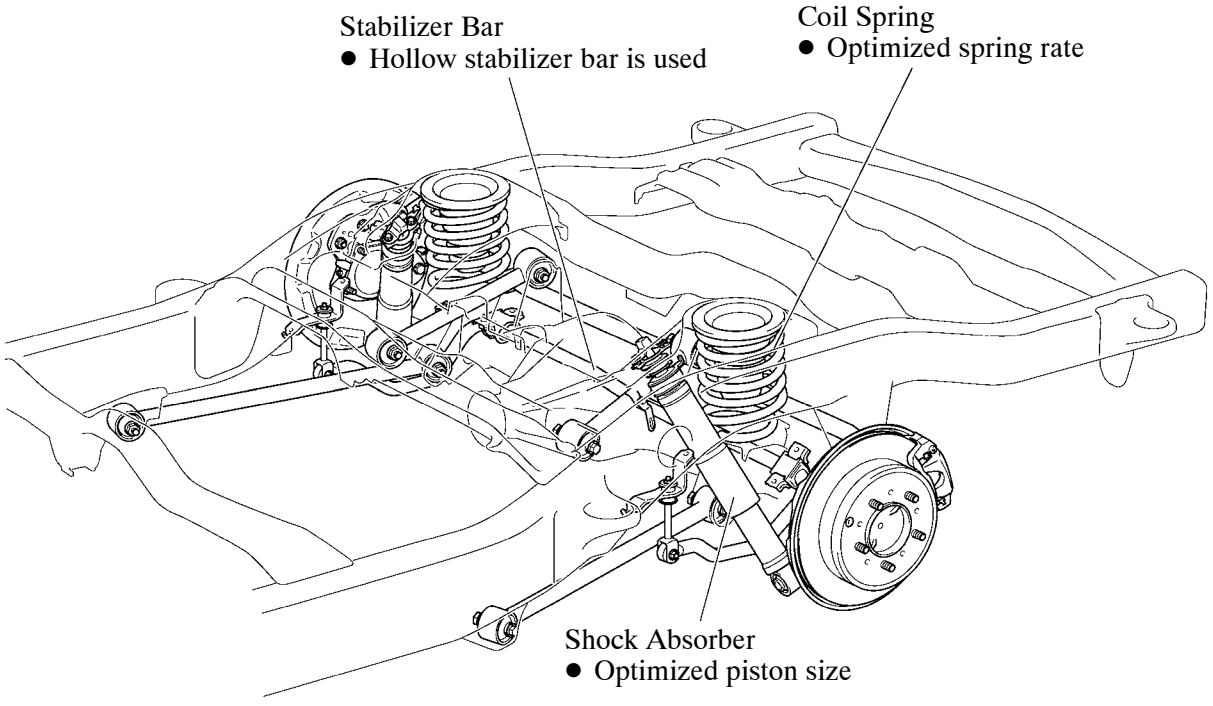
Service Tip

The camber and caster of the front suspension can be adjusted using the adjustment cams of the lower arms. For details, see the LEXUS LX 570 Repair Manual (Pub. No. RM08G0E)



■ REAR SUSPENSION

Through the optimal allocation of components, the rear suspension realizes excellent riding comfort, controllability, and off-road drivability.



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■4-WHEEL ACTIVE HEIGHT CONTROL SUSPENSION AND ADAPTIVE VARIABLE SUSPENSION

1. General

The suspension system, which consists of 4-wheel active height control suspension and adaptive variable suspension, offers both comfort and convenience to achieve high driving performance for on-road and off-road driving.

- The front suspension uses spring rate control to improve driving performance during on-road driving.
- 4-wheel related control is used to improve driving performance during on-road and off-road driving.
- The vehicle height control is provided with an easy access control function for improved convenience.
- The damping force control uses non-linear H∞ control.

Control	Outline	LX 570	LX 470
Vehicle Height Control	The amount of fluid to be sent through the height control valve into the shock absorbers for each of the wheels is regulated in accordance with the manual switch operation and driving conditions.	○	○
Damping Force Control	The optimum damping force can be obtained by controlling the damping force control actuators arranged on each of the wheels in accordance with the manual switch operation and driving conditions.	○	○
Spring Rate Control (for Front Suspension)	The spring rate can be controlled by switching the fluid passage to the gas chambers arranged on both the left and right front shock absorbers.	○	—
4-wheel Related Control	The hydraulic tubes for the shock absorbers are channeled through the center suspension control cylinder, therefore, the amount of hydraulic pressure for each of the shock absorbers can be individually adjusted via the center suspension control cylinder in accordance with the driving conditions.	○	—

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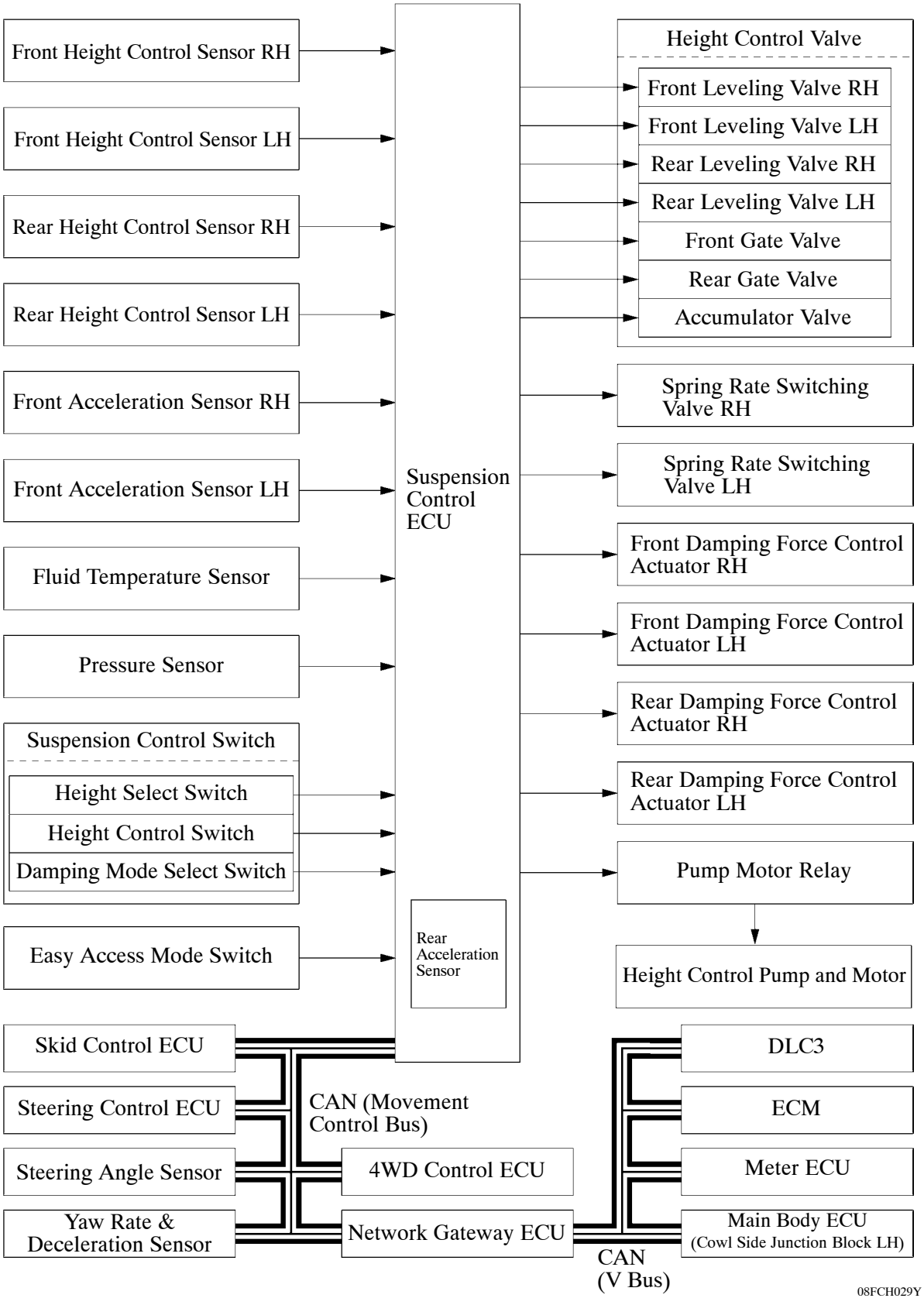
— REFERENCE —

- *To summarize, H^{∞} control is a theory for designing a controller that meets the control specifications that are represented by the H^{∞} norm (a unit of measurement of the transfer function of the system). When this is expanded into a non-linear system, it is called "non-linear H^{∞} control".*
- *The "H" is the initial letter of the mathematician named Hardy (who studied the stability of control systems) who advocated the mathematical space that is handled by this control logic. The "∞" represents the ∞ norm, which is one of the mathematical units used for measuring the size of the signals.*

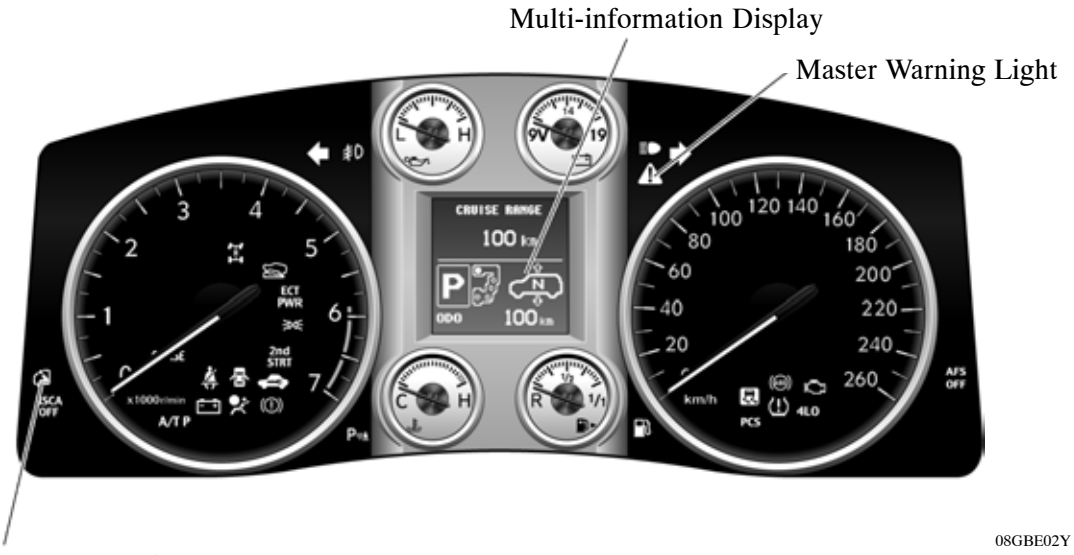
Service Tip

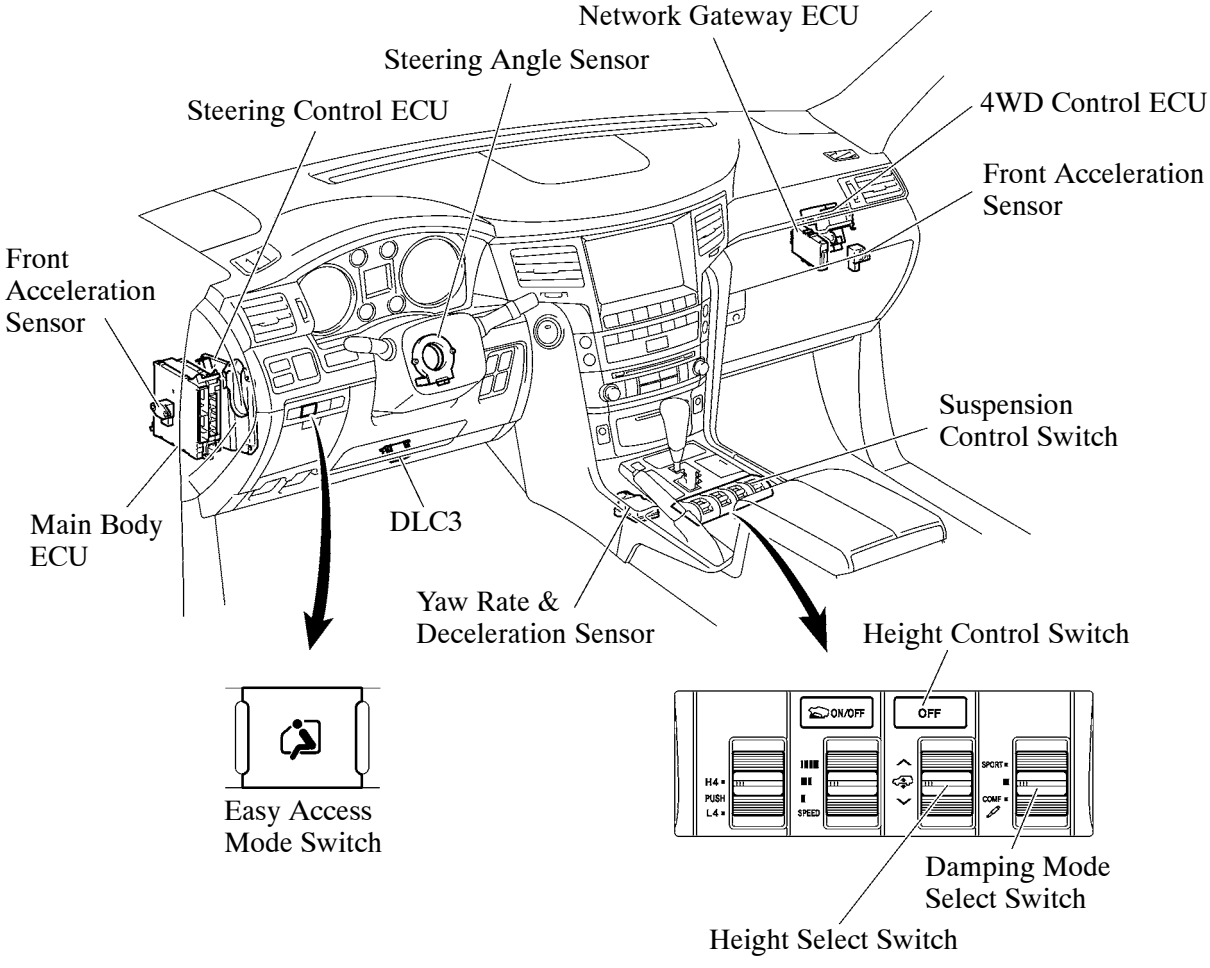
Before jacking the vehicle or raising it on a hoist, make sure that the engine switch is OFF.
If the vehicle must be lifted up when the engine switch is ON (IG), turn the height control OFF switch OFF and connect the OPA and CG terminals of the DLC3 using SST (09843-18040) to suspend vehicle height control operations in the suspension control ECU.
For derails, see the LEXUS LX 570 Repair Manual (Pub. No. RM08G0E).

2. System Diagram

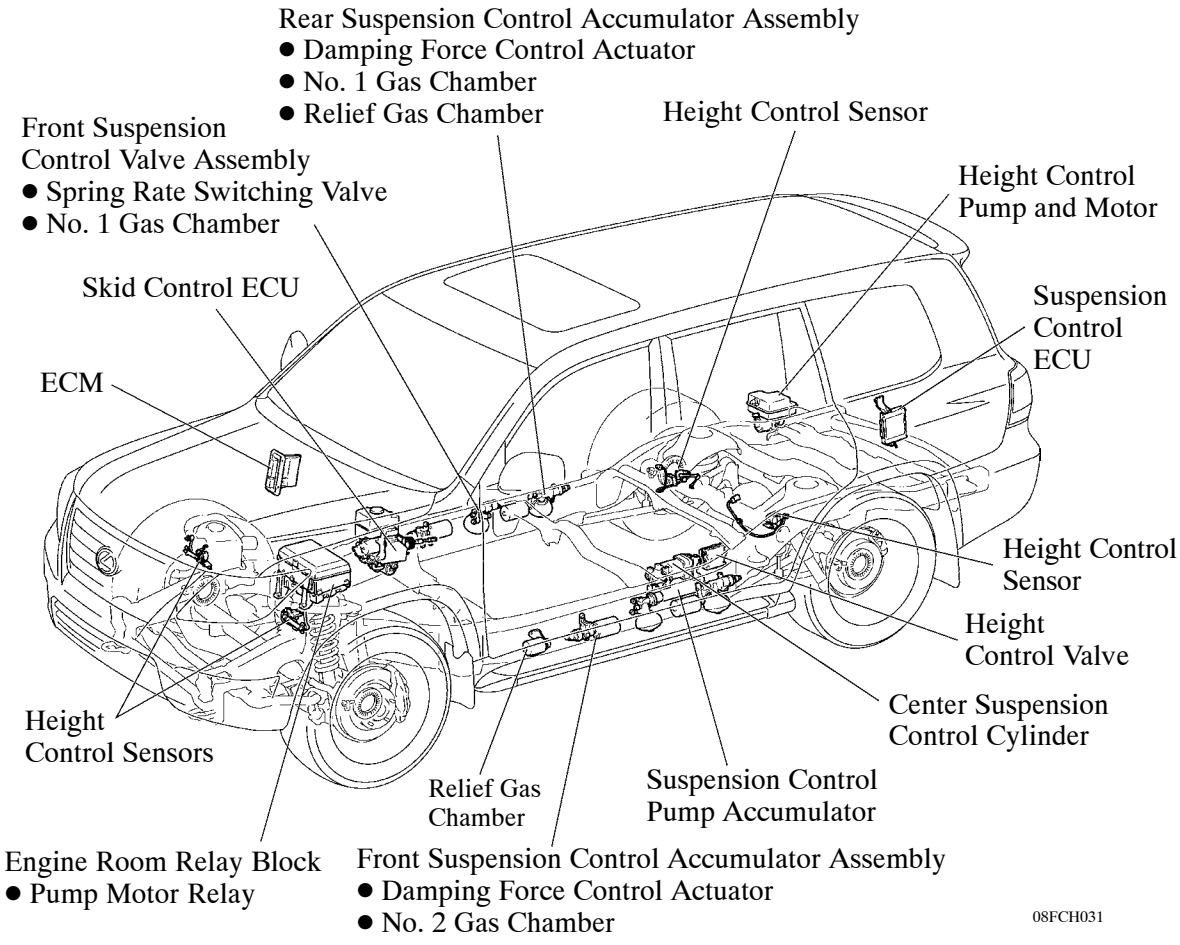


3. Layout of Main Components

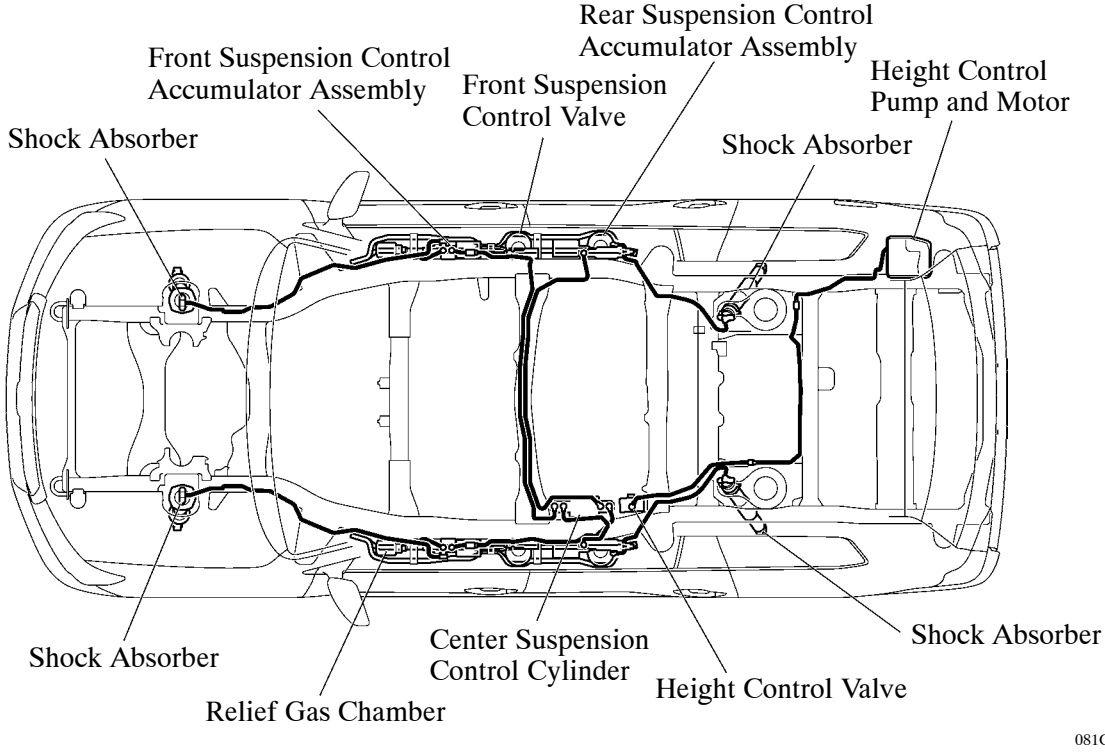




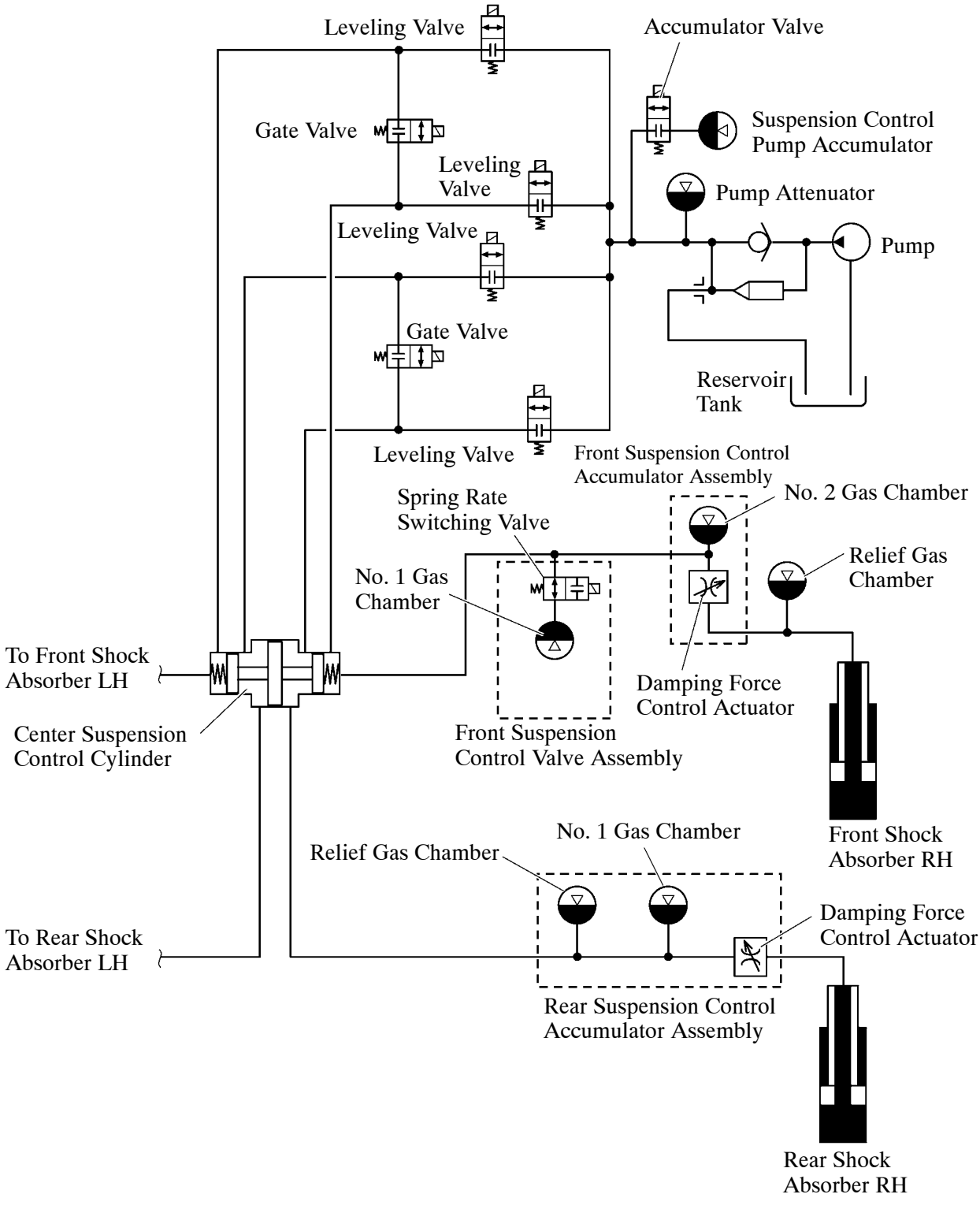
LHD Model



4. Suspension Tubing Diagram



5. Hydraulic Circuit



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6. Function of Main Components

Component		Function
Height Control Pump and Motor		Generates the high hydraulic pressure that is necessary for raising the vehicle height.
	Reservoir Tank	Maintains the amount of fluid that is returned during the LO position and the amount of fluid that is discharged during the HI position.
	Return Valve	Opens and closes the fluid passage between the height control valve and the reservoir tank.
	Pressure Sensor	Detects the pump's discharge pressure.
	Fluid Temperature Sensor	Detects the fluid temperature.
	Pump Attenuator	Dampens the hydraulic pulsation of the fluid that is discharged by the pump.
Suspension Control Pump Accumulator		Stores the hydraulic pressure to accelerate the speed in which the vehicle height is raised.
Height Control Valve	Leveling Valve	Opens and closes the fluid passage between the pump and the gas chamber on the wheel.
	Gate Valve	Opens and closes the fluid passage between the right and left shock absorbers.
	Accumulator Valve	Opens and closes the fluid passage to the suspension control pump accumulator.
Center Suspension Control Cylinder		Mechanically operates in accordance with the pressure applied to the shock absorbers and optimally distributes the hydraulic pressure to each of the wheels.
Front Suspension Control Valve Assembly	Spring Rate Switching Valve	Opens and closes the fluid passage to the No. 1 gas chamber.
	No. 1 Gas Chamber (Low spring rate)	Acts like a gas spring by partially utilizing coil spring force. This is provided on the front wheels.
Front Suspension Control Accumulator Assembly	No. 2 Gas Chamber (High spring rate)	Acts like a gas spring by partially utilizing coil spring force. This is provided on the front wheels.
	Damping Force Control Actuato	Switches the damping force.
Relief Gas Chamber (for Front Suspension)		Protects hydraulic systems by restricting increase in the hydraulic pressure inside the hydraulic tubes.
Rear Suspension Control Accumulator Assembly	No. 1 Gas Chamber	Acts like a gas spring by partially utilizing coil spring force. This is provided on the rear wheels.
	Relief Gas Chamber	Protects hydraulic systems by restricting increase in the hydraulic pressure inside the hydraulic tubes.
	Damping Force Control Actuator	Switches the damping force.
Shock Absorber		● Generates a damping force similar to the conventional shock absorber. ● Includes a high-pressure main seal and high-pressure oil seal for friction reduction and further improvement of the sealing performance.

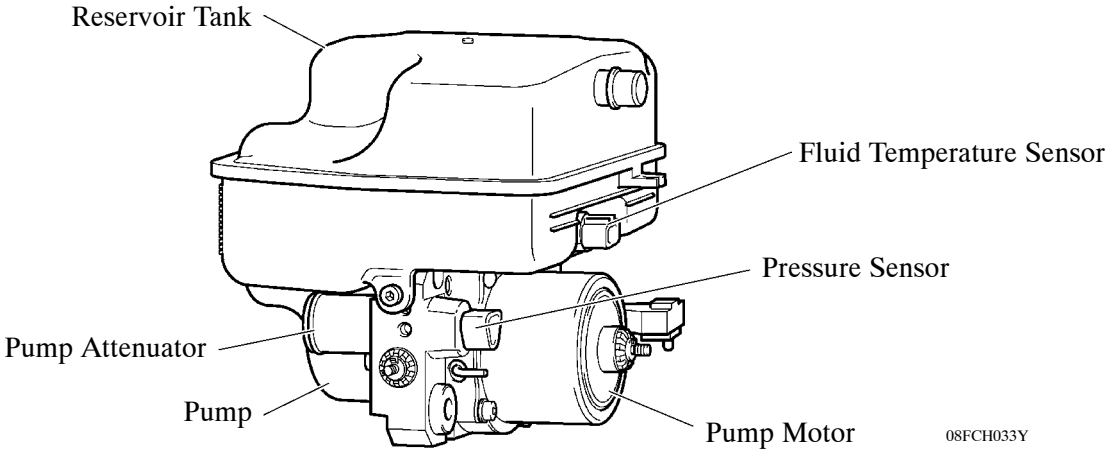
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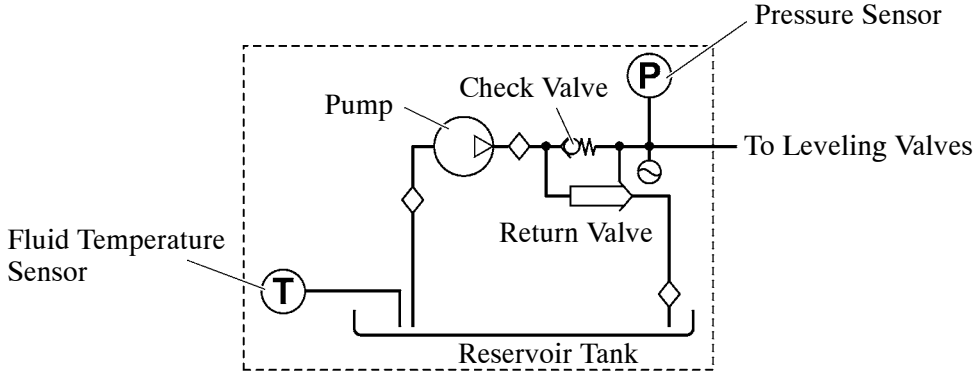
Component		Function
Combination Meter	Multi-information Display	● Displays the vehicle height and control conditions. ● Displays a warning message when a system malfunction occurs.
	Master Warning Light	Illuminates when the warning message is displayed.
	Buzzer	Sounds when the warning message is displayed.
	Easy Access Mode Indicator Light	● Illuminates when the easy access mode switch is turned ON. ● Blinks while the easy access control is operating.
Suspension Control Switch	Height Select Switch	Selects the target vehicle height.
	Height Control Switch	Prohibits the vehicle height control.
	Damping Mode Select Switch	Selects a damping force control mode.
Easy Access Mode Switch		Switches the easy access control between ON and OFF.
Height Control Sensor		Detects the vehicle height.
Steering Angle Sensor		Detects the steering 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.
Acceleration Sensor		3 acceleration sensors are provided in total. The two of them are provided in the front of the vehicle and one is built into the suspension control ECU located in the rear of the vehicle. Thus, the acceleration sensors independently detect the vertical acceleration rate of the vehicle.
Pump Motor Relay		Controls the pump motor operation.
Suspension Control ECU		Controls the entire system by performing the calculations for height control, damping force control and spring rate control based on the signals received from the sensors and switches.
Steering Control ECU		Sends the VGRS control status signal to the suspension control ECU.
Skid Control ECU		Sends the speed sensor signal and brake control status signal to the suspension control ECU.
4WD Control ECU		Sends the 4WD control status signal to the suspension control ECU.
ECM		Sends the engine speed signal to the suspension control ECU.
Main Body ECU (Cowl Side Junction Block LH)		Sends the engine switch status signal, door courtesy switch signal and suspension control switch signal to the suspension control ECU.

7. Construction and Operation of Main Components

Height Control Pump and Motor

A system in which the pump, pump motor, reservoir tank, return valve, pump attenuator, pressure sensor, and fluid temperature sensor are integrated is used.

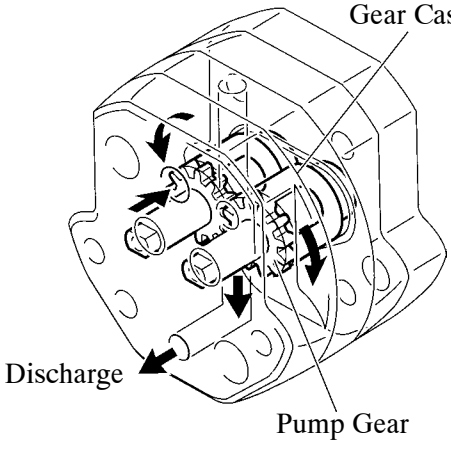


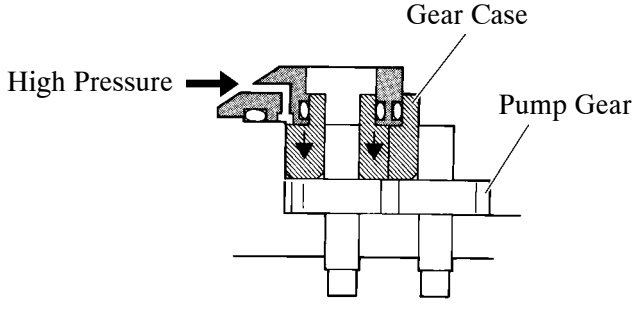


Pump and Motor Hydraulic Diagram 081CH68Y

1) Pump

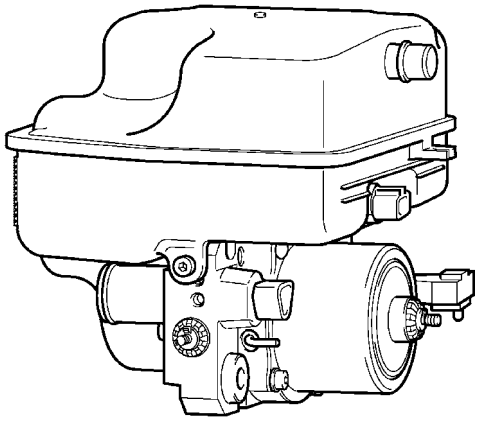
An external gear pump that contains less parts and excels in durability is used. Also, the pump is a pressure-loading type in which the discharge pressure of the pump itself is utilized and routed via the gear case to push on the side of the pump gear in order to reduce the internal leakage, thus making high-pressure discharge possible.



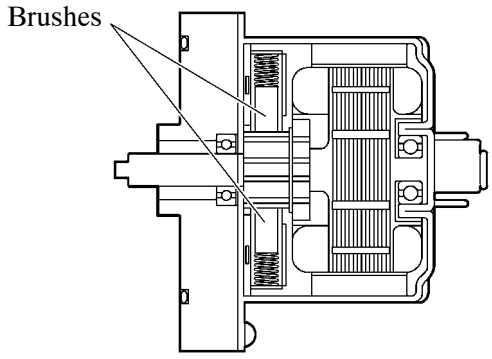


2) Motor

A DC motor with 4-pole brushes is used to realize excellent durability and high torque.



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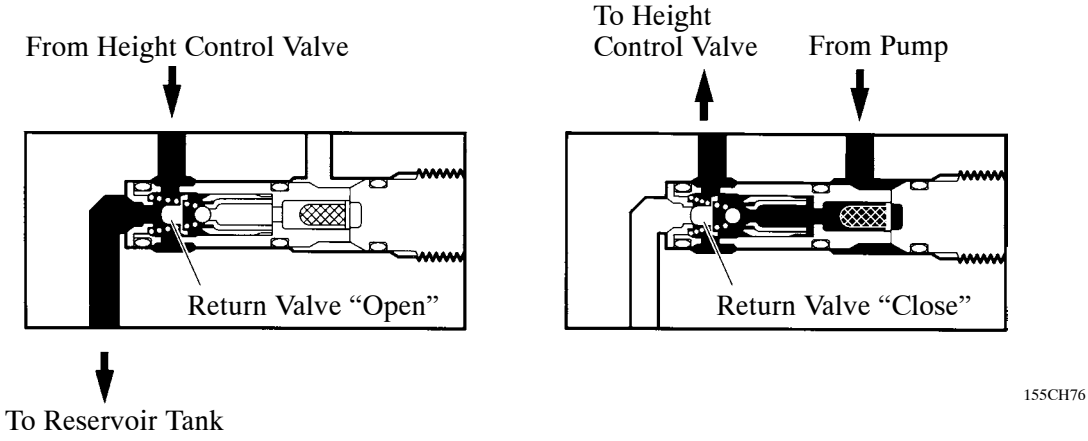


Cross Section

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3) Return Valve

The return valve opens and closes the fluid passage between the height control valve and the reservoir tank. The return valve has been simplified by adopting a construction in which the valve is closed by the flow of the discharged fluid.
Normally, a spring force is applied to the return valve to maintain the fluid passage between the height control valve and the reservoir tank open.
When the pump operates in order to raise the vehicle height, the pressure of the fluid that is discharged by the pump causes the return valve to move to the left of the diagram as illustrated.
Accordingly, the fluid passage between the height control valve and the reservoir tank closes, and the fluid that is discharged from the pump flows towards the height control valve.

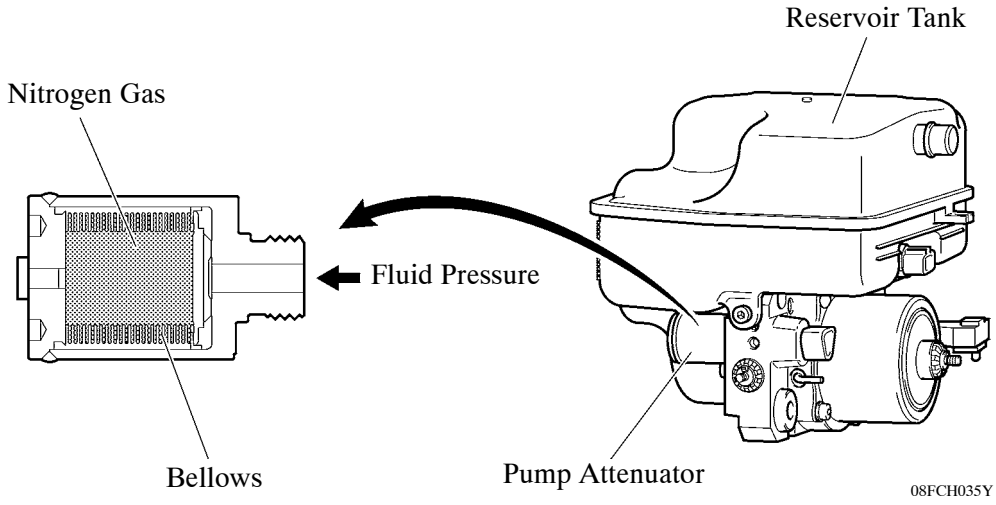


155CH76

Normal Condition **Pump in Operation**

4) Pump Attenuator

The pump attenuator dampens the hydraulic pulsation of the fluid that is discharged by the pump. A bellows type accumulator that is made of stainless steel, which offers excellent gas penetration resistance and good pulsation absorption performance, is used.

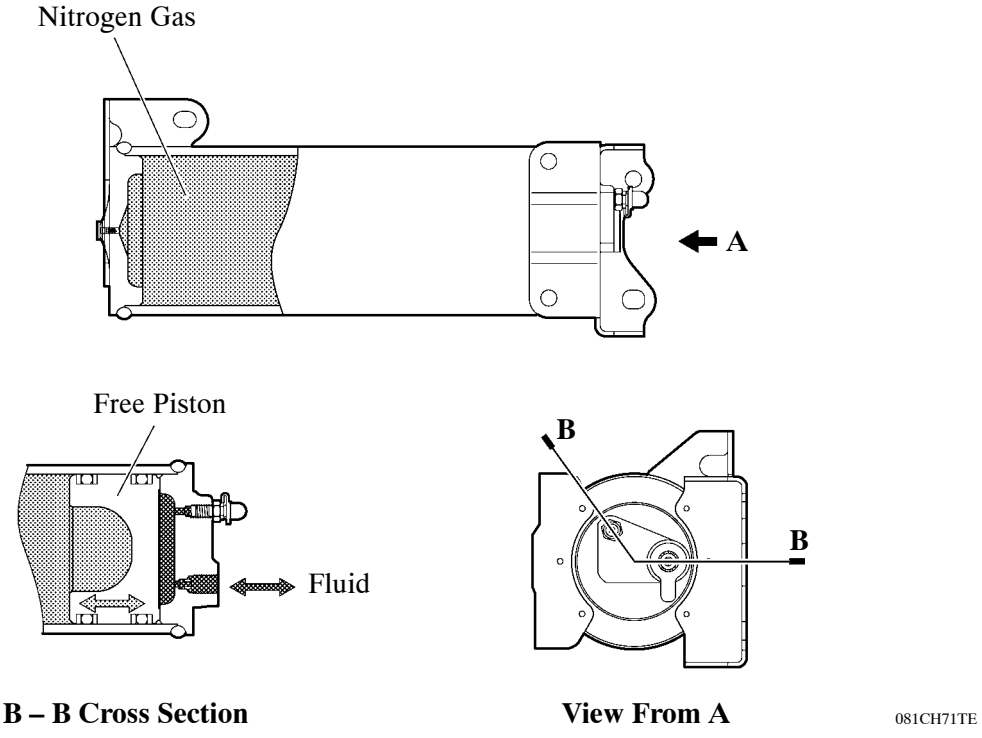


▶ Specifications ◀

Sealed Gas		Nitrogen Gas
Gas Chamber Volume	cc (cu in.)	1.75 (0.11)
Sealed Gas Pressure	MPa (kgf/cm^2, psi)	2.0 (20.4, 290.1)

Suspension Control Pump Accumulator

A free piston type accumulator, which provides a large gas chamber capacity, is used for the suspension control pump accumulator.
When the vehicle height is being raised, the accumulator discharges the stored fluid to accelerate the raising speed.



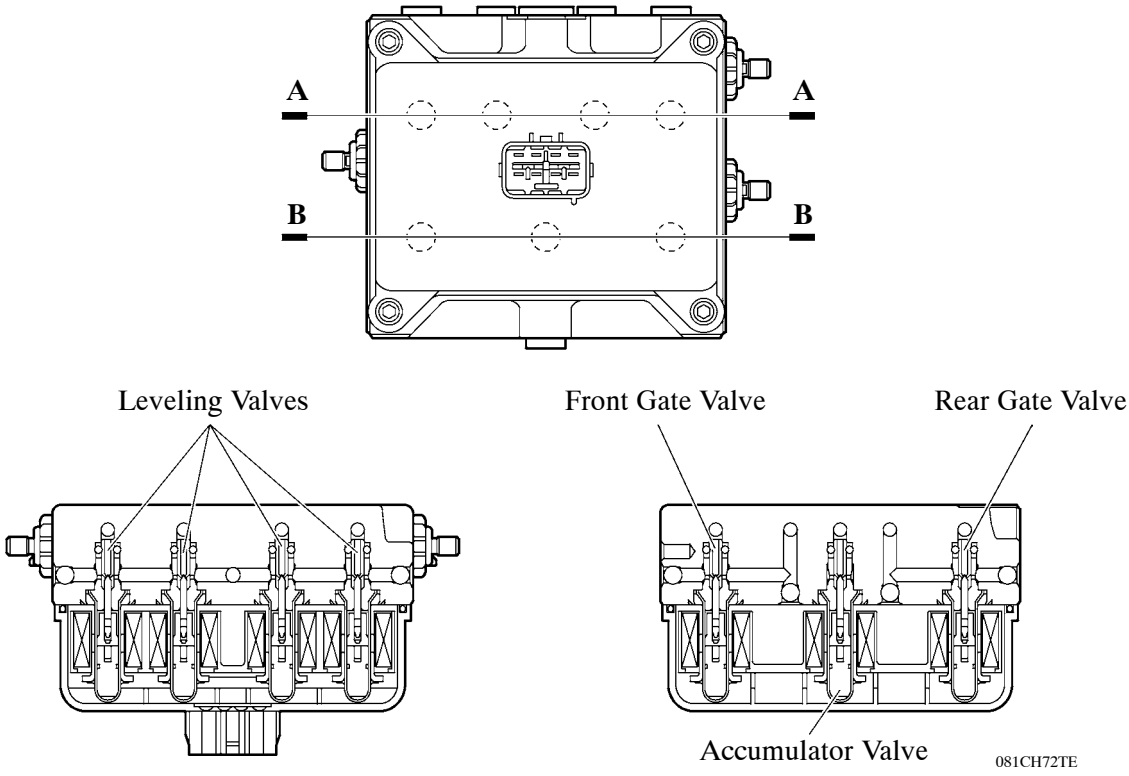
B – B Cross Section **View From A** 081CH71TE

▶ Specifications ◀

Sealed Gas		Nitrogen Gas
Gas Chamber Volume	cc (cu in.)	945 (57.7)
Sealed Gas Pressure	MPa (kgf/cm^2, psi)	5.9 (60, 856)

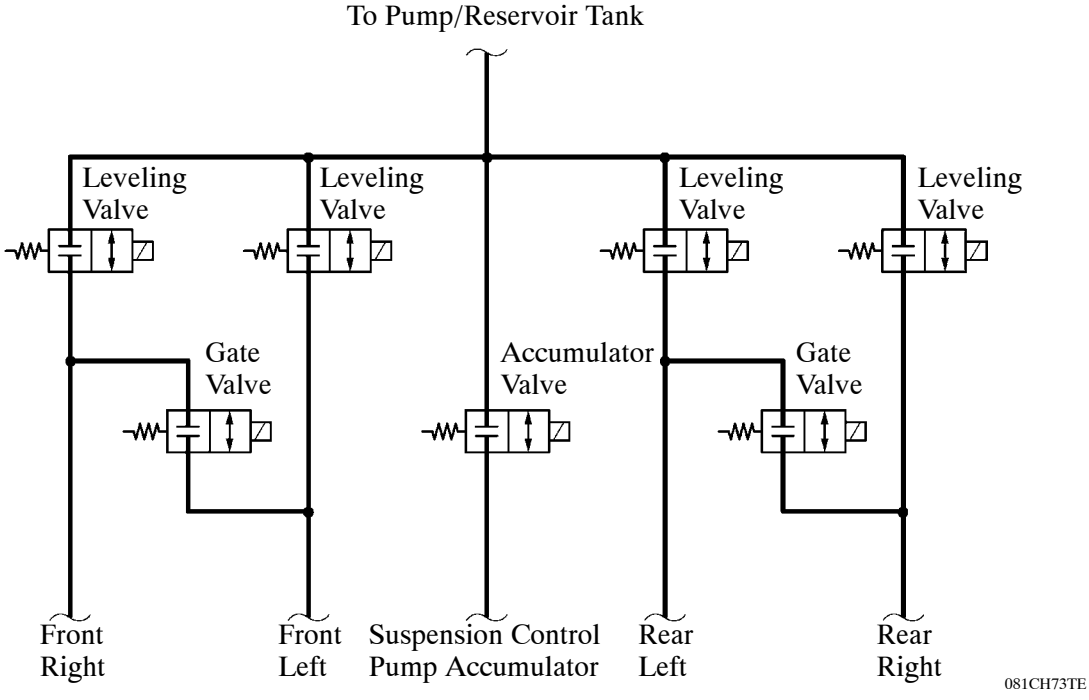
Height Control Valve

The height control valve is comprised of four leveling valves, two gate valves and an accumulator valve.



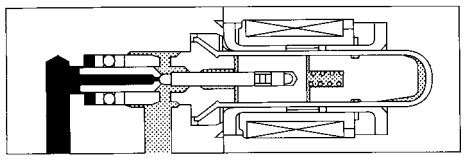
A – A Cross Section **B – B Cross Section**

▶ Arrangement Layout of Hydraulic Tubes ◀

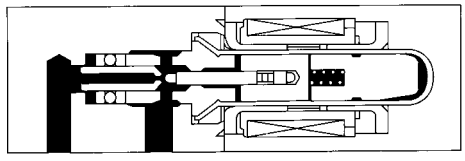


1) Leveling Valve

This valve opens and closes the fluid passage between the pump and the gas chamber located at each wheel. Normally, the fluid passage remains closed. During vehicle height control, the fluid passage opens in accordance with the signal received from the suspension control ECU.



Close

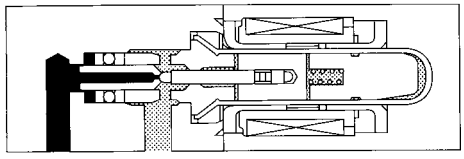


Open

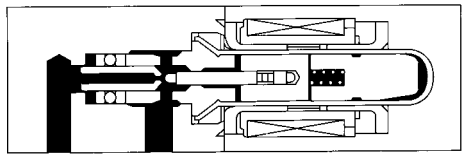
155CH80

2) Gate Valve

This valve is provided for both the front and rear sides. This valve opens and closes the fluid passage to both the left and right leveling valves. Normally, the fluid passage is closed. The fluid passage opens in accordance with signals from the suspension control ECU, thereby balancing the fluid pressure for both the left and right gas chambers.



Close

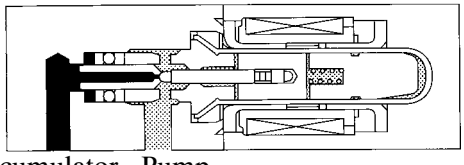


Open

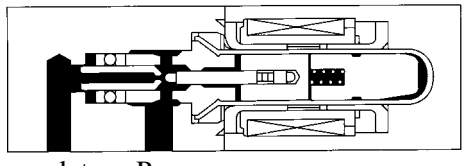
155CH80

3) Accumulator Valve

This valve opens and closes the fluid passage between the pump and the suspension control pump accumulator. Normally, the fluid passage remains closed. When the vehicle height is being raised or the fluid is being stored in the suspension control pump accumulator, the solenoid valve opens in accordance with the signal received from the suspension control ECU.



Close

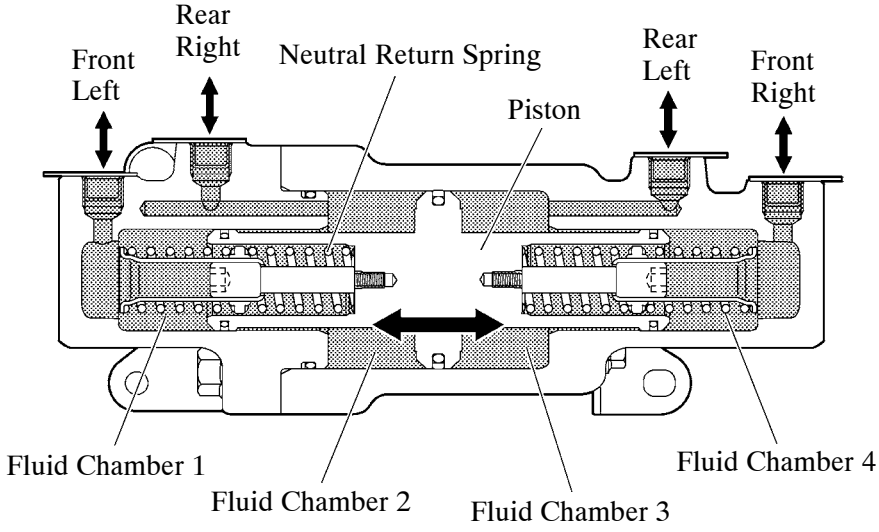


Open

155CH80

Center Suspension Control Cylinder

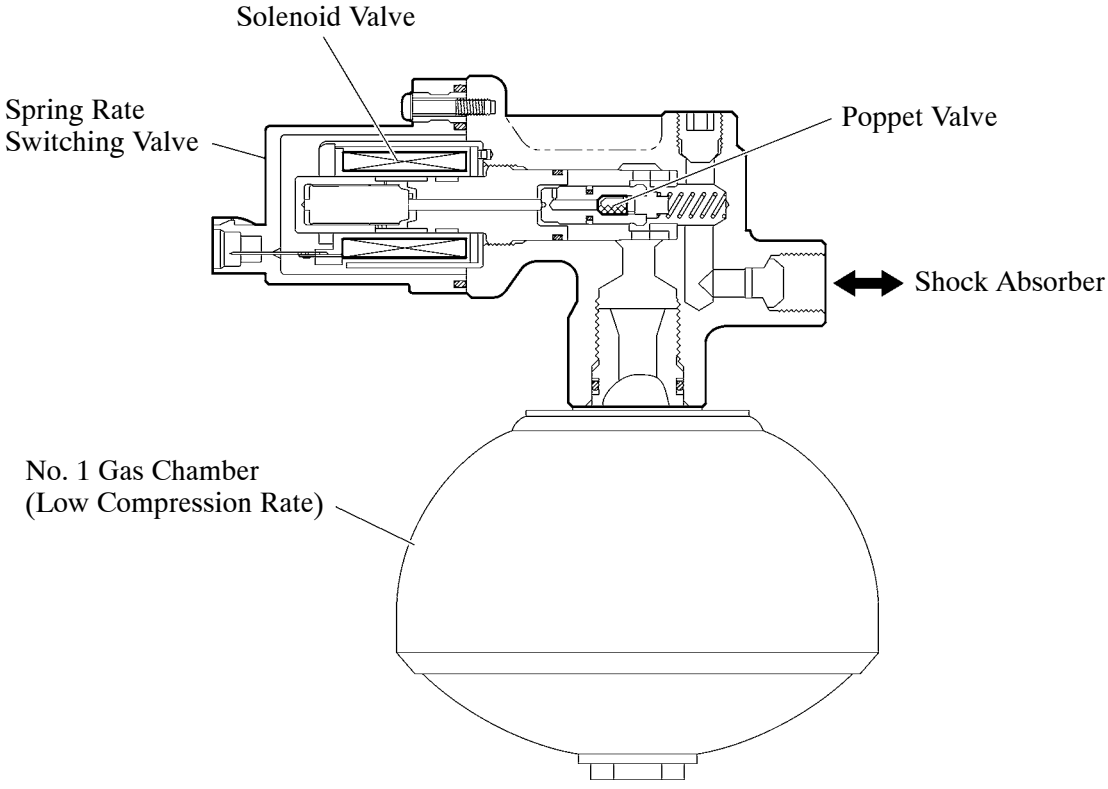
- The center suspension control cylinder is comprised of four fluid chambers and a piston.
- The fluid chambers are connected to each other via the hydraulic tubes from each of the shock absorbers. The center suspension control cylinder optimally distributes the hydraulic pressure for each of the wheels through the piston which operates in accordance with the input hydraulic pressure.



081CH74Y

Spring Rate Switching Valve

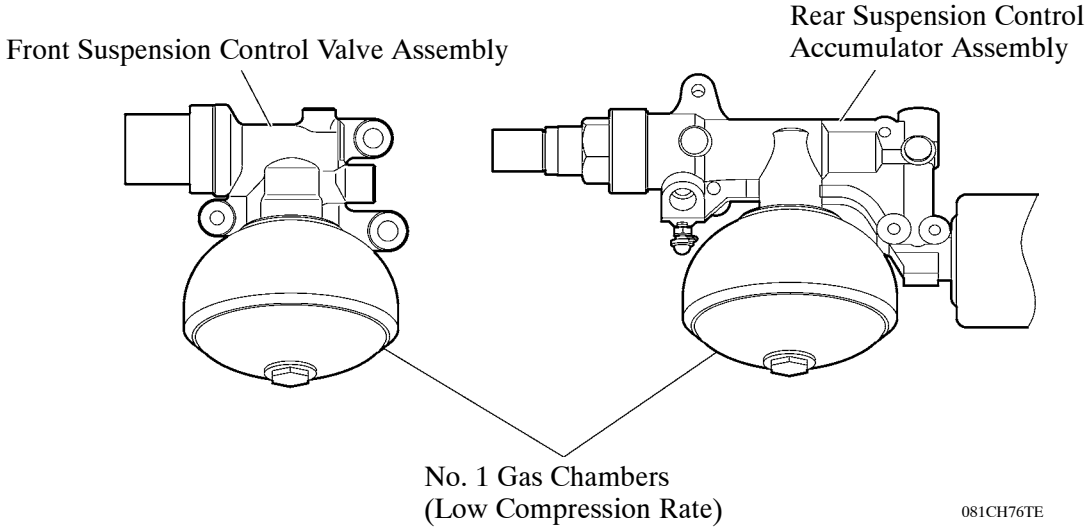
- This valve is provided in the front suspension control valve assembly, and it opens and closes the fluid passage to the No. 1 gas chamber to perform spring rate control.
- Normally, the fluid passage remains opened. During spring rate control, the fluid passage closes is accordance with the signal received from the suspension control ECU.

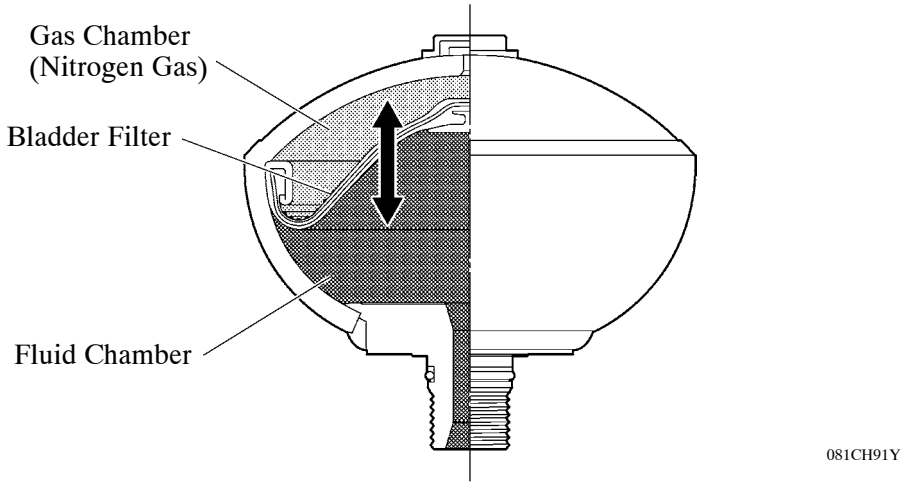


Front Suspension Control Valve Assembly 081CH75TI

No. 1 Gas Chamber

- The No. 1 gas chamber is provided for each of the wheels. This gas chamber is designed with a low compression rate utilizing a large-volume gas chamber.
- The front No. 1 gas chamber is provided for the front suspension control valve assembly.
- The rear No. 1 gas chamber is provided for the rear suspension control accumulator assembly.
- The No. 1 gas chamber uses the bladder filter type hydro-pneumatic accumulator. A resin membrane is sandwiched between rubber layers to realize excellent gas penetration resistance.
- The internal pressure of the gas chamber is varied by allowing the fluid to flow in and out of this gas chamber in order to raise or lower the vehicle height.





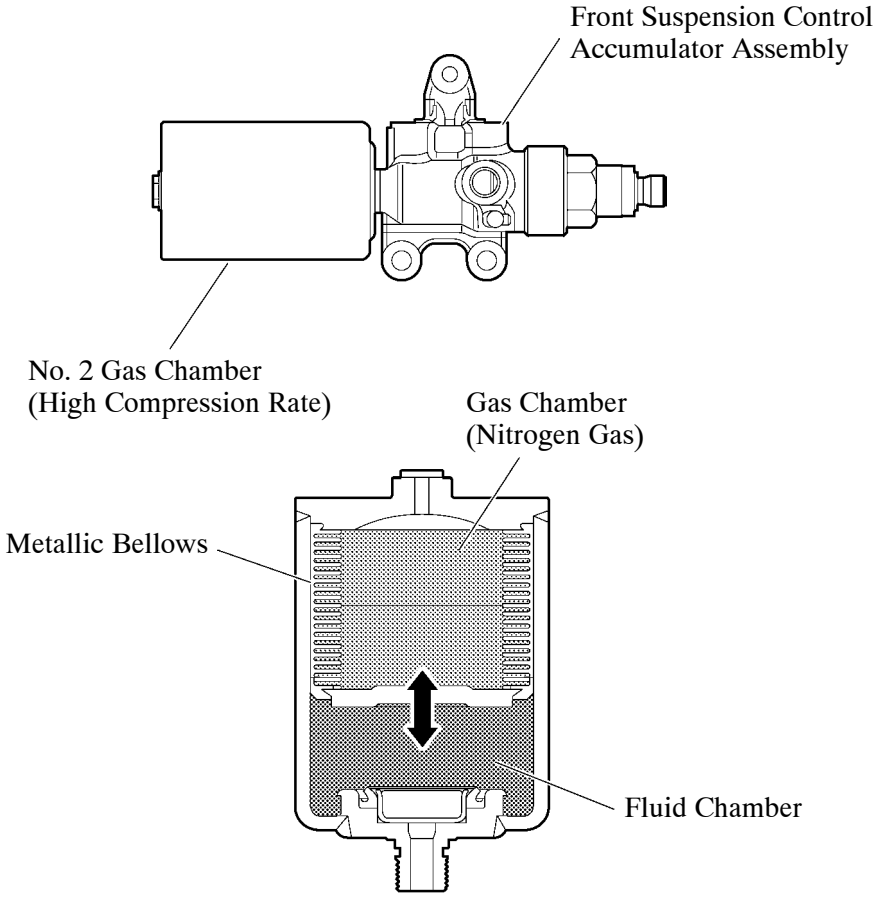
No. 1 Gas Chamber

▶ Specifications ◀

No. 1 Gas Chamber		Front	Rear
Sealed Gas		Nitrogen Gas	←
Gas Chamber Volume	cc (cu in.)	400 (24.4)	←
Sealed Gas Pressure	MPa (kgf/cm^2, psi)	2.26 (23, 328)	1.90 (19, 276)

No. 2 Gas Chamber

- A No. 2 gas chamber is provided for the front suspension control accumulator assembly. This gas chamber is designed with a high compression rate utilizing a small-volume gas chamber.
- The No. 2 gas chamber uses a metallic bellows type hydro-pneumatic accumulator, to prevent gas leakage.
- The internal pressure of the gas chamber is varied by allowing the fluid to flow in and out of this gas chamber in order to raise or lower the vehicle height.



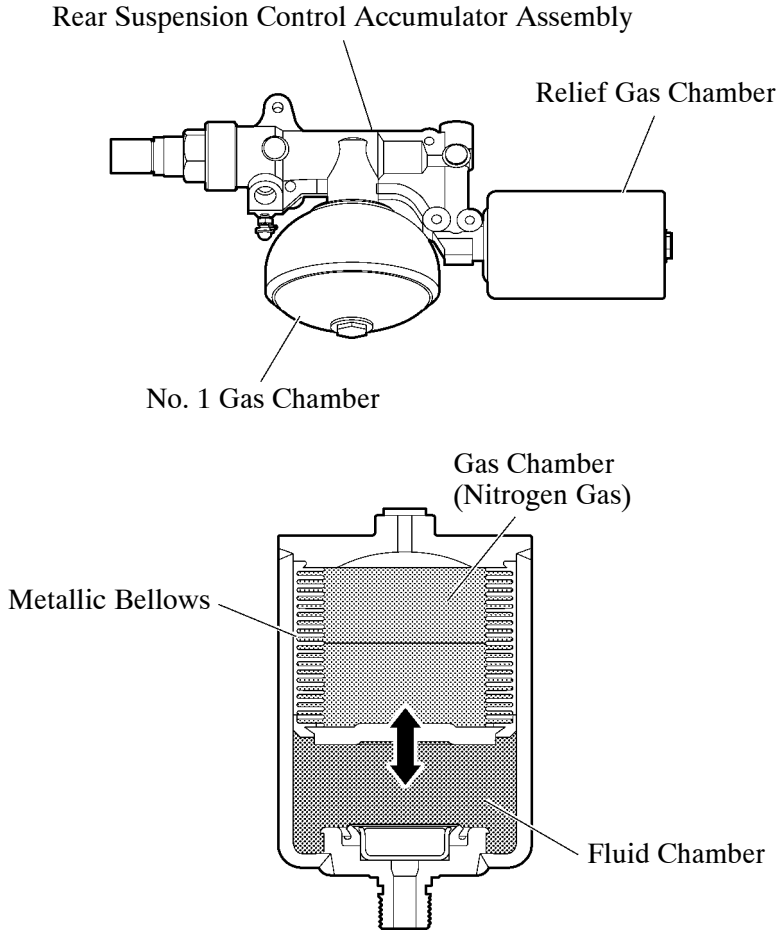
No. 2 Gas Chamber 08FCH036Y

▶ Specifications ◀

Sealed Gas		Nitrogen Gas
Gas Chamber Volume	cc (cu in.)	120 (7.3)
Sealed Gas Pressure	MPa (kgf/cm^2, psi)	1.8 (18, 261)

Relief Gas Chamber

- A relief gas chamber is provided for each of the wheels. This protects the hydraulic system by reducing increases in the fluid pressure inside the hydraulic tubes for the 4-wheel active height control suspension.
- The front relief gas chamber is placed directly over the front hydraulic tubes.
- The rear relief gas chamber is provided for the rear suspension control accumulator assembly.
- The relief gas chamber uses a metallic bellows type hydro-pneumatic accumulator likewise with the No. 2 gas chamber.
- The fluid inside the hydraulic tubes is allowed to flow into the relief gas chamber when the fluid pressure inside the hydraulic tubes exceeds the pressure of the nitrogen gas sealed in the relief gas chamber. Thus, fluid pressure increases inside the hydraulic tubes can be reduced.



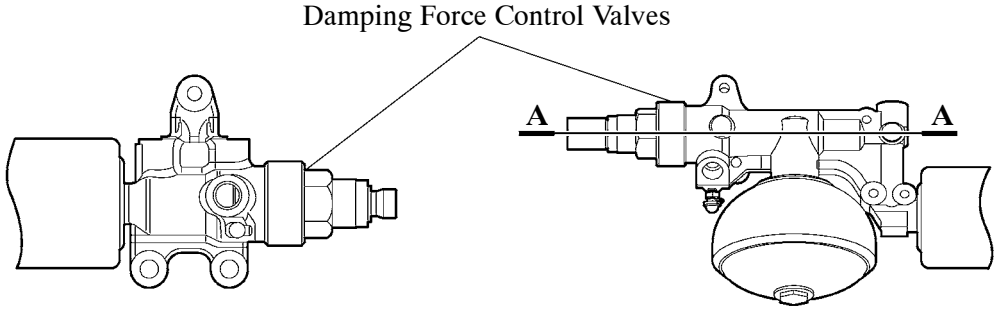
Relief Gas Chamber 08FCH037Y

▶ Specifications ◀

Relief Gas Chamber		Front	Rear
Sealed Gas		Nitrogen Gas	←
Gas Chamber Volume	cc (cu in.)	120 (7.3)	150 (9.2)
Sealed Gas Pressure	MPa (kgf/cm^2, psi)	13.5 (138, 1958)	10 (102, 1450)

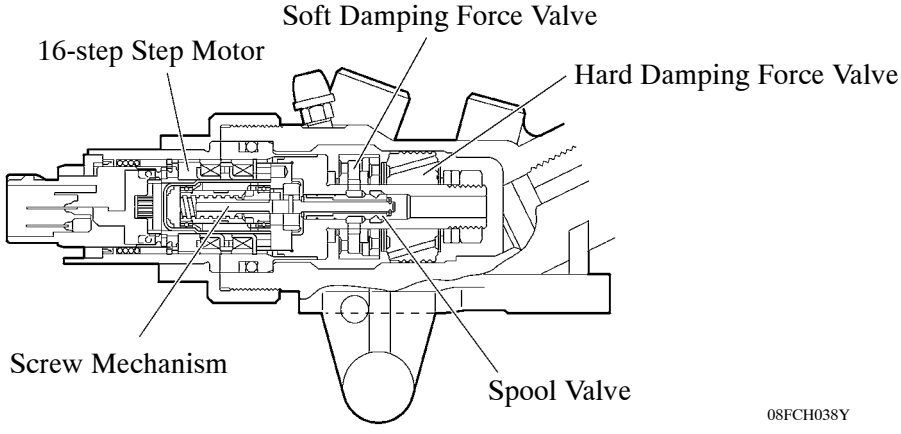
Damping Force Control Actuator

- The damping force control actuator is provided for each of the suspension control accumulator assemblies.
- This actuator consists of the 16-step step motor, a screw mechanism (which converts the rotational movement to a linear movement), a spool valve, a soft damping force valve and a hard damping force valve.
- Signals from the suspension control ECU activate the actuator, causing the spool valve to switch the fluid passage. Thus, the volume of fluid that passes through each valve is varied in order to control the damping force in 16 steps.

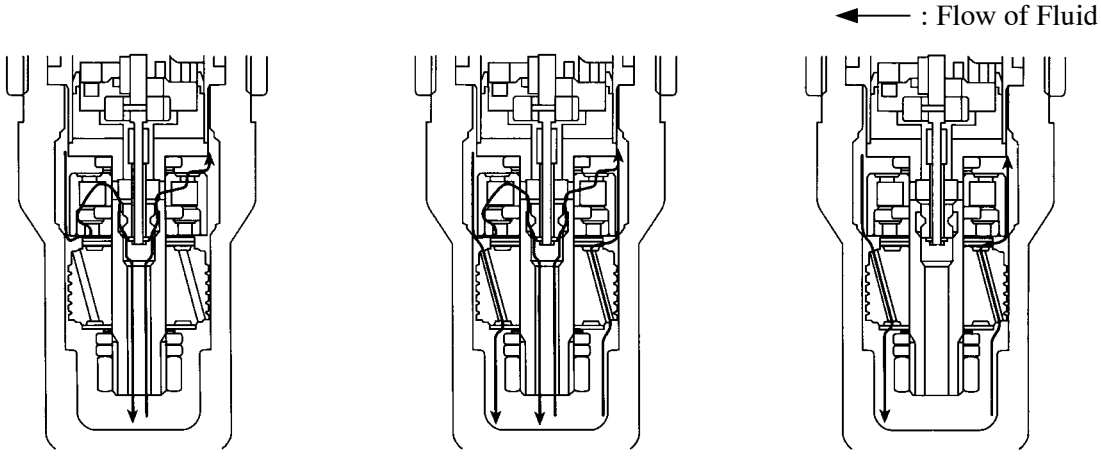


Front Suspension Control Accumulator Assembly

Rear Suspension Control Accumulator Assembly



A – A Cross Section



Damping Force (Soft)

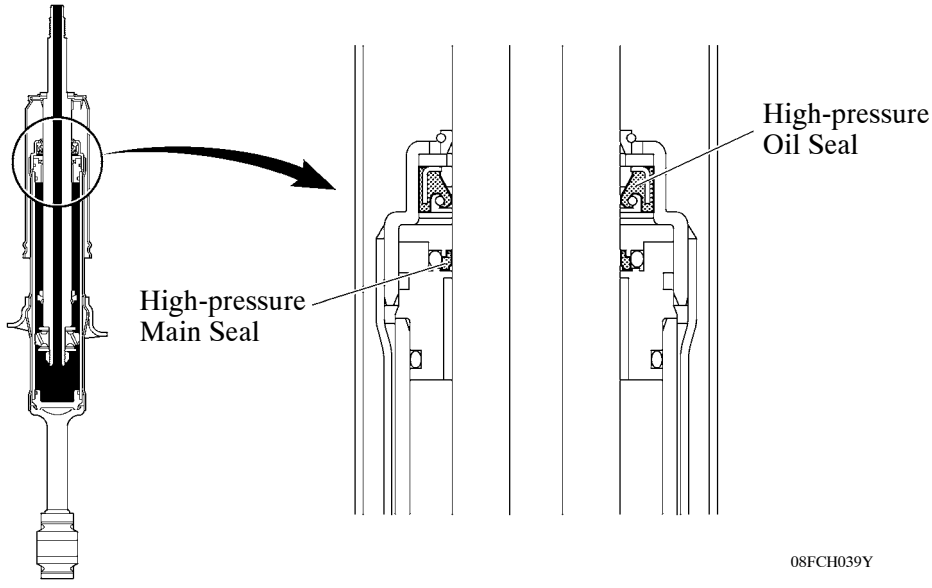
Damping Force (Medium)

Damping Force (Hard)

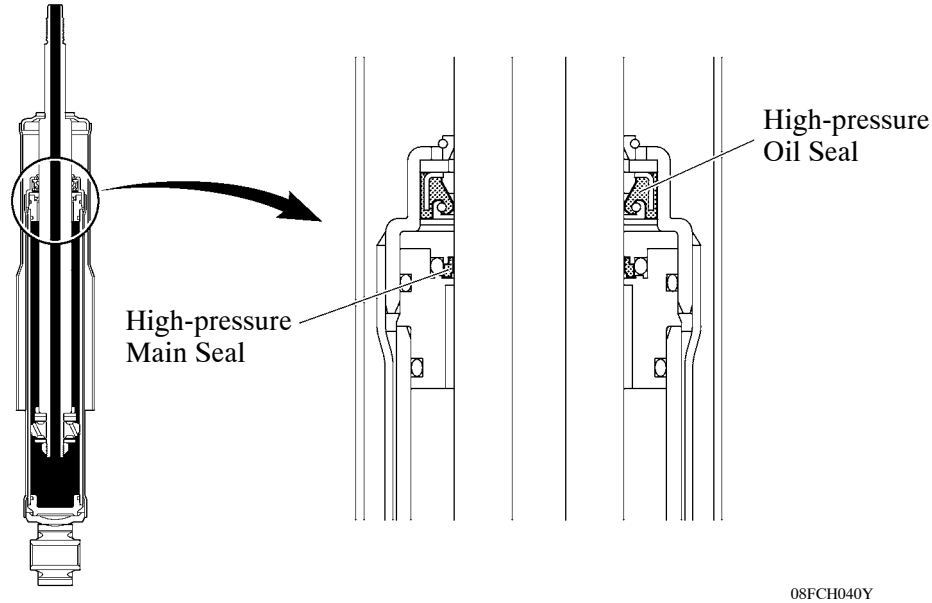
155CH84

Shock Absorber

- The shock absorber has a dual construction using a high-pressure main seal made of fluoroethylene resin and a high-pressure oil seal made of nitrile rubber and provided with a backup ring in order to ensure sealing performance and reduce friction.
- The piston size has been increased to improve response, drivability, and ride comfort.



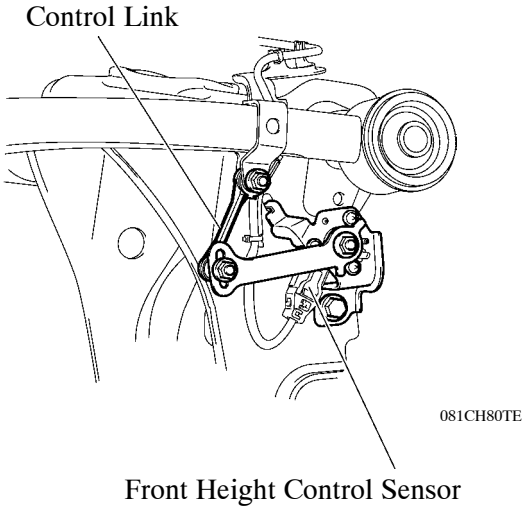
Front Shock Absorber

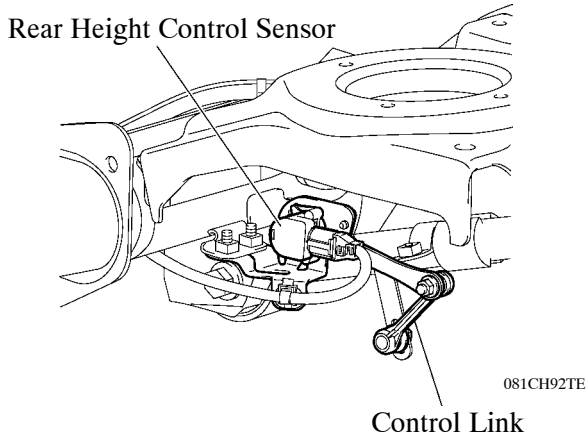


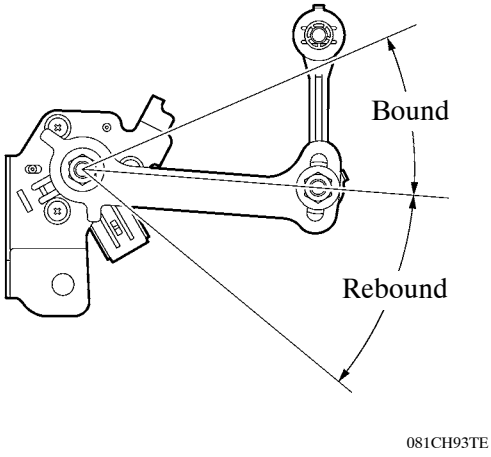
Rear Shock Absorber

Height Control Sensor

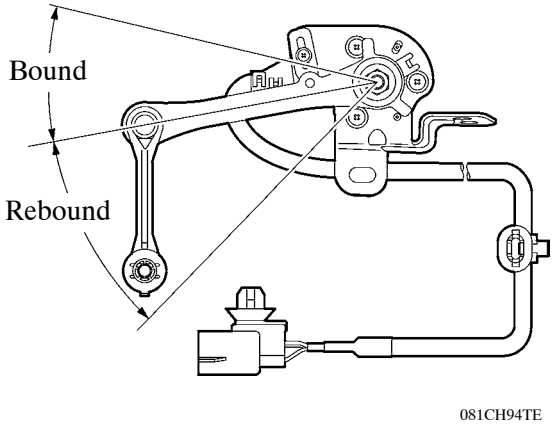
- Hall IC type height control sensors have been provided. The Hall IC converts the changes in the magnetic flux that occur at that time into electrical signals, and outputs them in the form of height control sensor effort to the suspension control ECU.
- There are two front height control sensors, one for the right, and the other for the left. They are mounted via the control links to the upper arms of the front suspension and to the body.
- There are also two rear height control sensors, one for the right, and the other for the left. They are mounted via the control links to the upper control arms of the rear suspension and to the body.
- Through the use of a height control sensor link and shaft, each height control sensor converts the rectilinear movement of the control link into a rotational movement, and the result is detected in the form of a rotational angle.







Front Height Control Sensor

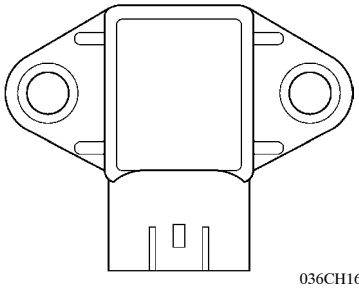


Rear Height Control Sensor

Acceleration Sensor

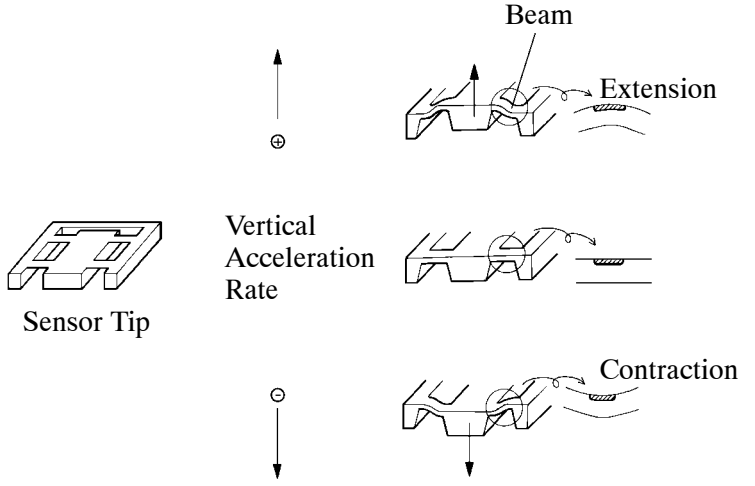
- The acceleration sensors detect the vertical movement above the body.
- The front acceleration sensors are placed on the right and left sides of the instrument panel and the rear acceleration sensor is placed inside the suspension control ECU. Thus, the acceleration sensors independently detect the vertical acceleration rate of the vehicle.

▶ Method for Detecting Vertical Acceleration ◀



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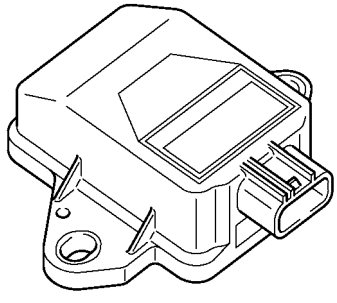
Front Acceleration Sensor



02DCH103Y

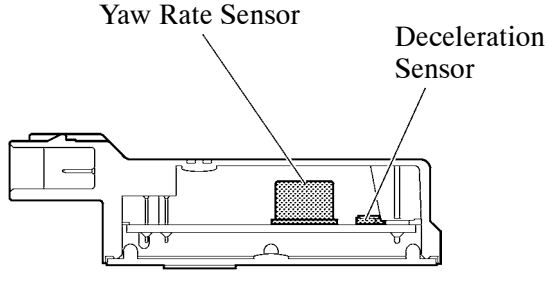
Yaw Rate and Deceleration Sensor

- A deceleration sensor is built into the yaw rate sensor.
- This sensor detects the yaw rate and lateral and longitudinal acceleration and deceleration, and sends this signal to the suspension control ECU.



255CH141

Yaw Rate and Deceleration Sensor

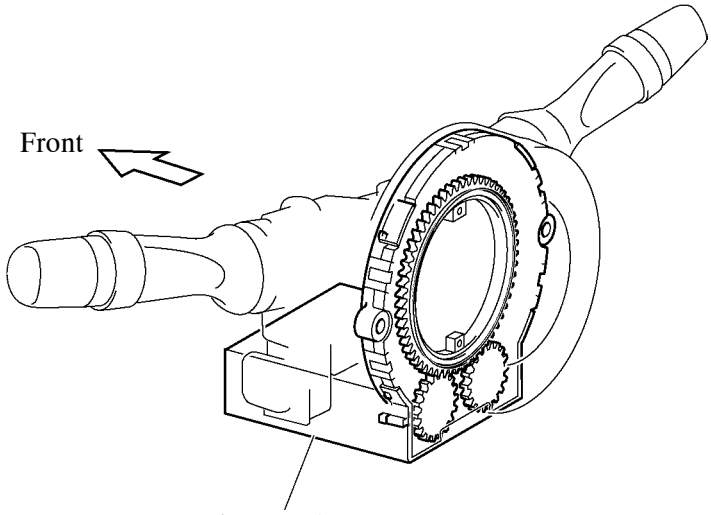


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Cross Section

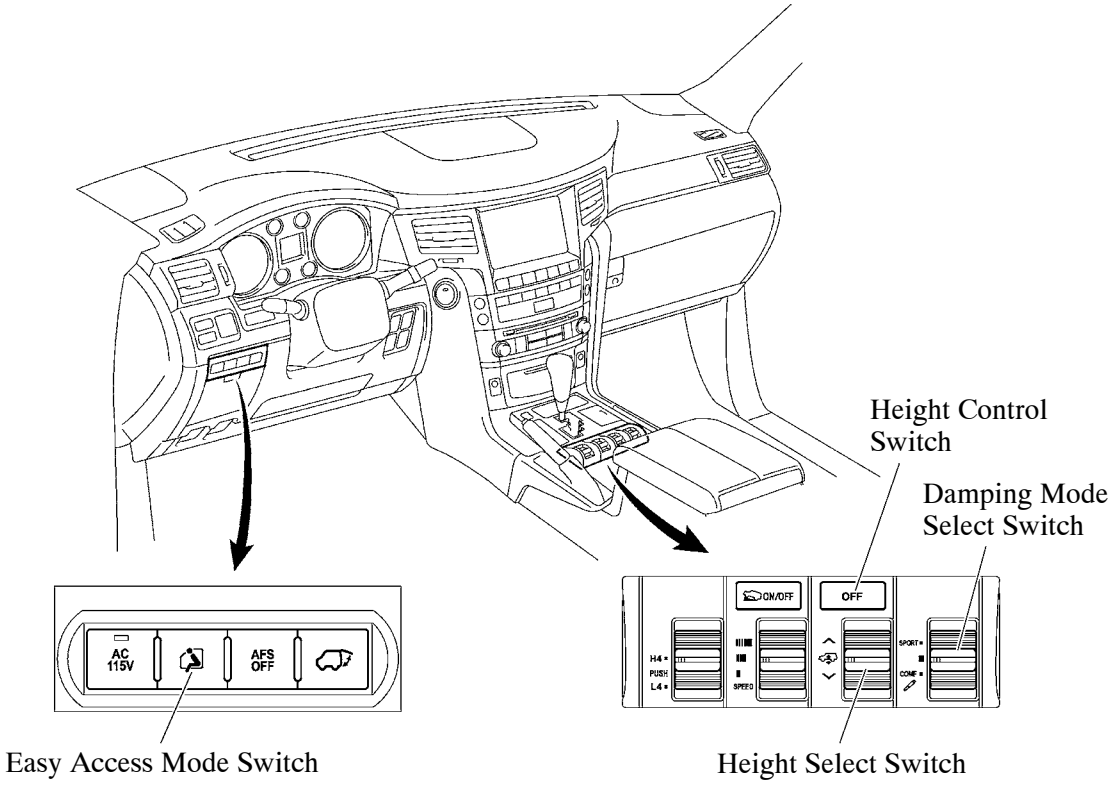
Steering Angle Sensor

- A steering angle sensor is provided in the combination switch area. This sensor detects the amount of steering effort and the direction of steering wheel.
- The sensor assembly contains two 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.



Suspension Control Switch and Easy Access Mode Switch

- The suspension control switch (the height select switch, height control switch, and damping mode select switch) is placed on the center console.
- The easy access mode switch is placed on the left side of the instrument panel (for LHD models).
- The easy access mode switch is placed on the right side of the instrument panel (for RHD models).



LHD Model

Switch		Function
Suspension Control Switch	Height Select Switch	Selects vehicle height between three levels by operating this switch. When the height control switch is ON, vehicle height cannot be changed.
	Height Control Switch	Prohibits the vehicle height control by operating this switch.
	Damping Mode Select Switch	Selects damping force between three levels by operating this switch.
Easy Access Mode Switch		Switches the easy access control between ON and OFF by operating this switch.

8. System Operation

Vehicle Height Control

- The vehicle height control controls the vehicle height over 5 levels in accordance with the manual switch operation or the driving conditions.
- The vehicle height control has the following functions:

Function	Outline
Vehicle Height Selection Function (See Page CH-100)	Enables the selection of 3 levels of vehicle height by operating a switch.
Automatic Leveling Function	This function maintains the vehicle height constant regardless of the load conditions such as the number of occupants or the weight of the cargo under the prescribed loading condition. It effects constant control so that the vehicle height is maintained at a prescribed value when the Normal position is selected.
Extra HI Mode	● While driving on an unpaved road with the transfer shifted in the L4 range and the vehicle height set to the HI position, if one of the wheels freewheels, the vehicle is raised up to the Extra HI position, 20 mm (0.8 in.) higher than the HI position. ● When the CRAWL function of the brake control system is in operation and the vehicle height adjustment request signal for switching to the Extra HI position is input from the skid control ECU to the suspension control ECU, the vehicle is raised up to the Extra HI position.
Vehicle Speed Sensing Function (See Page CH-104)	The vehicle height will be automatically adjusted in accordance with the vehicle speed and selected vehicle height.
Easy Access Control (See Page CH-106)	For convenient in-and-out access, this function effects vehicle height control in conjunction with the engine switch when the easy access mode is set to ON.
Vehicle Height Adjustment Prohibition Control	When the vehicle is raised on a jack or is being towed, the vehicle adjustment can be prohibited by operating the height control switch*. However, the prohibition control cancels automatically when the vehicle speed becomes higher than approximately 80 km/h (50 mph) at the Normal position, or higher than approximately 30 km/h (19 mph) at the HI or LO position.

*: This control is available only when the vehicle is stopped [the vehicle speed is 5 km/h (3.1 mph) or less].

1) Vehicle Height Selection Function

The following three types of vehicle heights can be selected by operating the switch: normal vehicle height (Normal), low vehicle height (LO), and high vehicle height (HI).

Selected Height Position		LO	Normal	HI
Vehicle Height	Front	Approximately –60 mm (–2.4 in.)	Standard Vehicle Height	Approximately +50 mm (+2.0 in.)
	Rear	Approximately –40 mm (–1.6 in.)	Standard Vehicle Height	Approximately +60 mm (+2.4 in.)
Vehicle Height Adjustment Speed*1	Up	LO to Normal Approximately 11 to 16 seconds		
	Down	Normal to LO Approximately 2 seconds*2		

*1: Vehicle height control speed differs depending on the loaded condition.
*2: Approximately 5 seconds when the shift lever is in N.

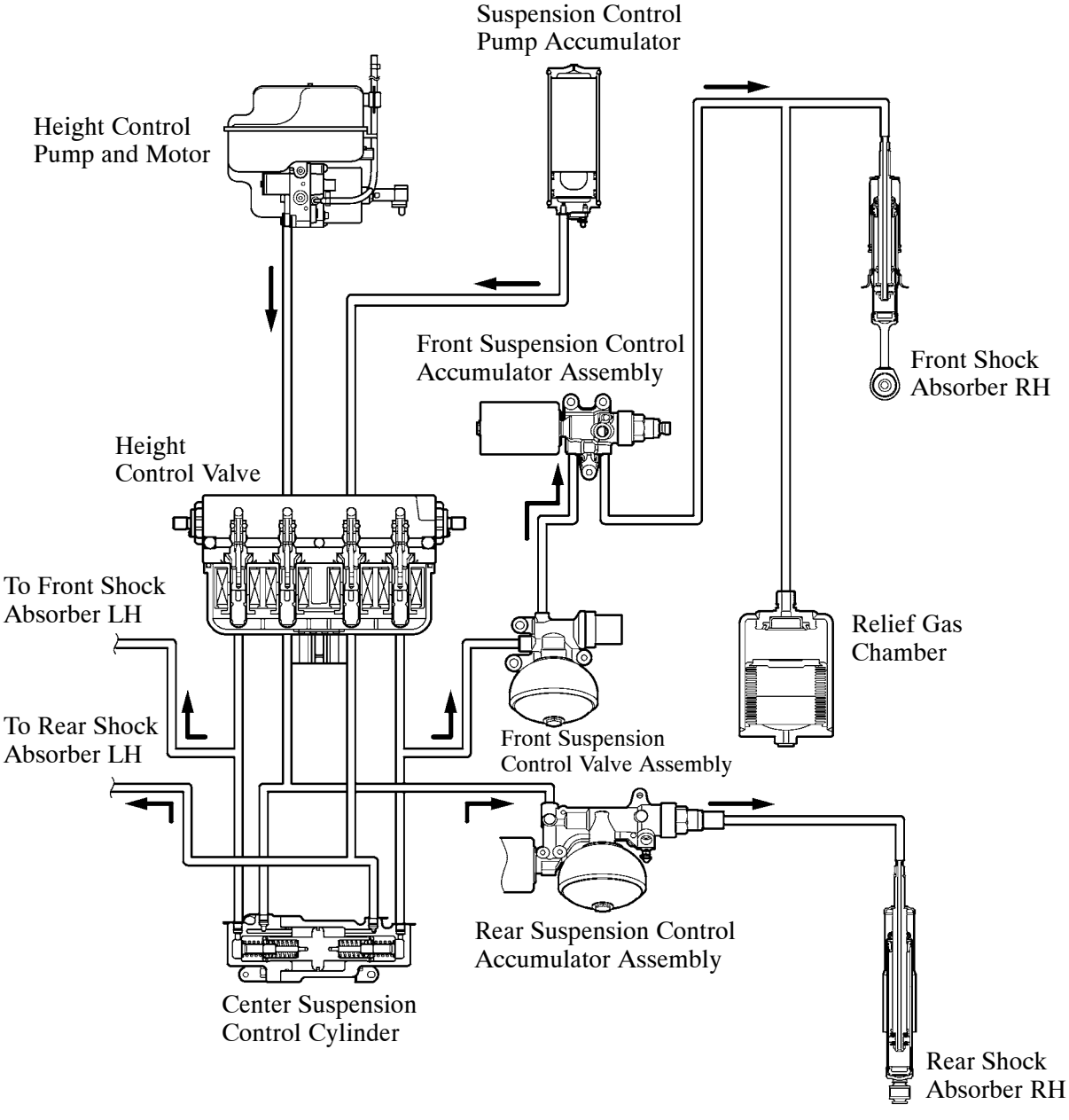
NOTE

When a load exceeding the following axle weight limitations is applied to the vehicle, it causes the vehicle not to stay at the Normal height. At times like this, it might not be possible to raise the vehicle height even by operating the switch.

- In Normal mode: Front axle weight: 1460 kg (3212 lb)/Rear axle weight: 1800 kg (3960 lb)

a. Raising Vehicle Height (Manual Operation)

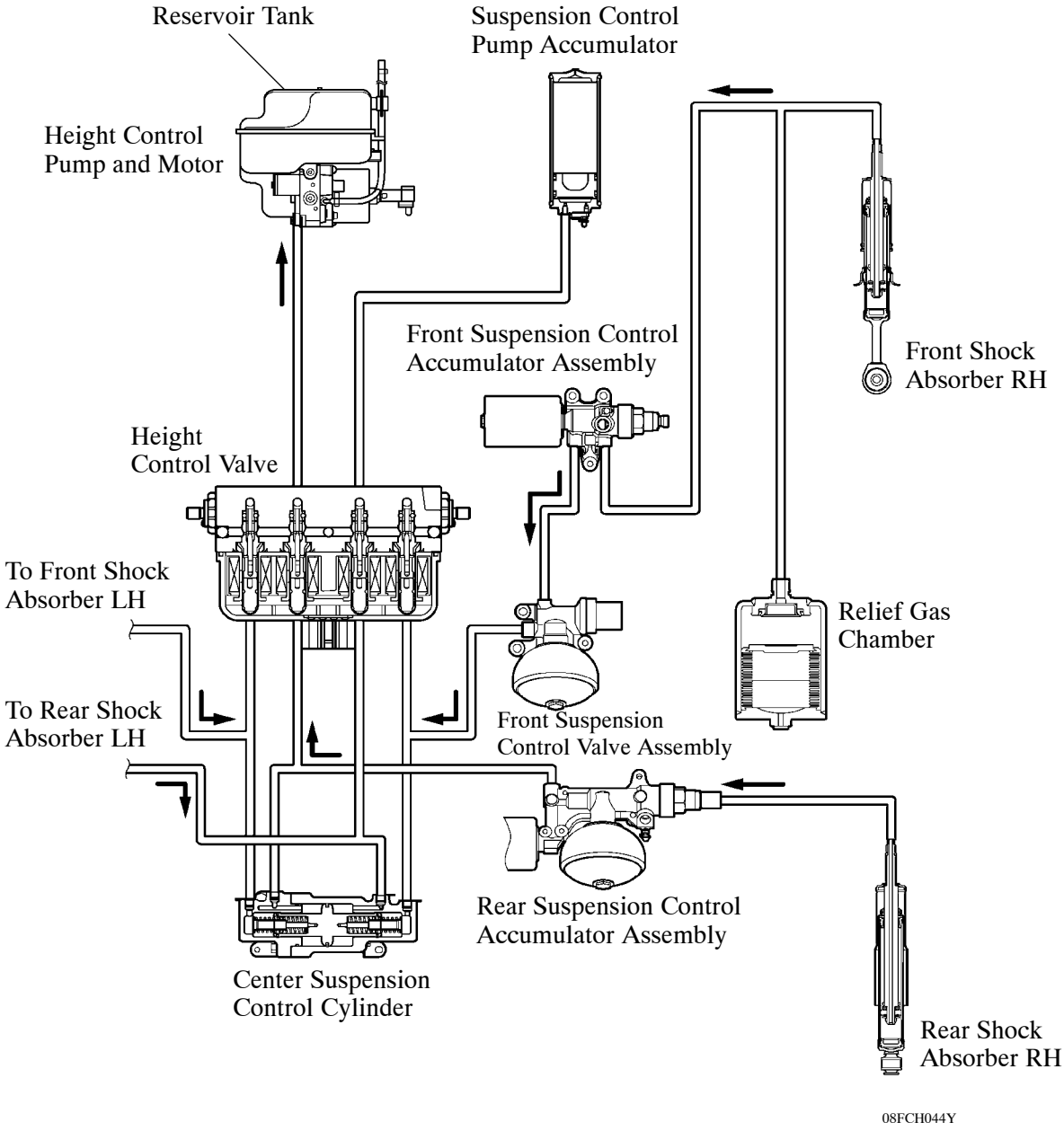
When the height select switch is operated to raise the vehicle height, the suspension control ECU opens the leveling valves for each of the wheels arranged inside the height control valve. This allows the fluid to flow from the pump into the shock absorber and gas chamber and results in an increase in the vehicle height. Simultaneously, the accumulator valve opens, guiding the fluid into them from the suspension control pump accumulator, thereby raising the vehicle height.



CH

b. Lowering Vehicle Height (Manual Operation)

When the height select switch is operated to lower the vehicle height from the HI to the Normal position, or from the Normal to the LO position, the suspension control ECU opens the front and rear leveling valves. As a result, the fluid in the gas chambers and the shock absorbers arranged for each of the wheels returns into the reservoir tank, thereby lowering the height of the suspension. However, if the rear side is expected to become lower more quickly due to the load condition, and the difference between the lowering of the front side and the rear side becomes greater than a prescribed value, the rear leveling valve closes once, allowing only the vehicle height to become lowered at the front side. This feature prevents the headlights from being aimed upward.

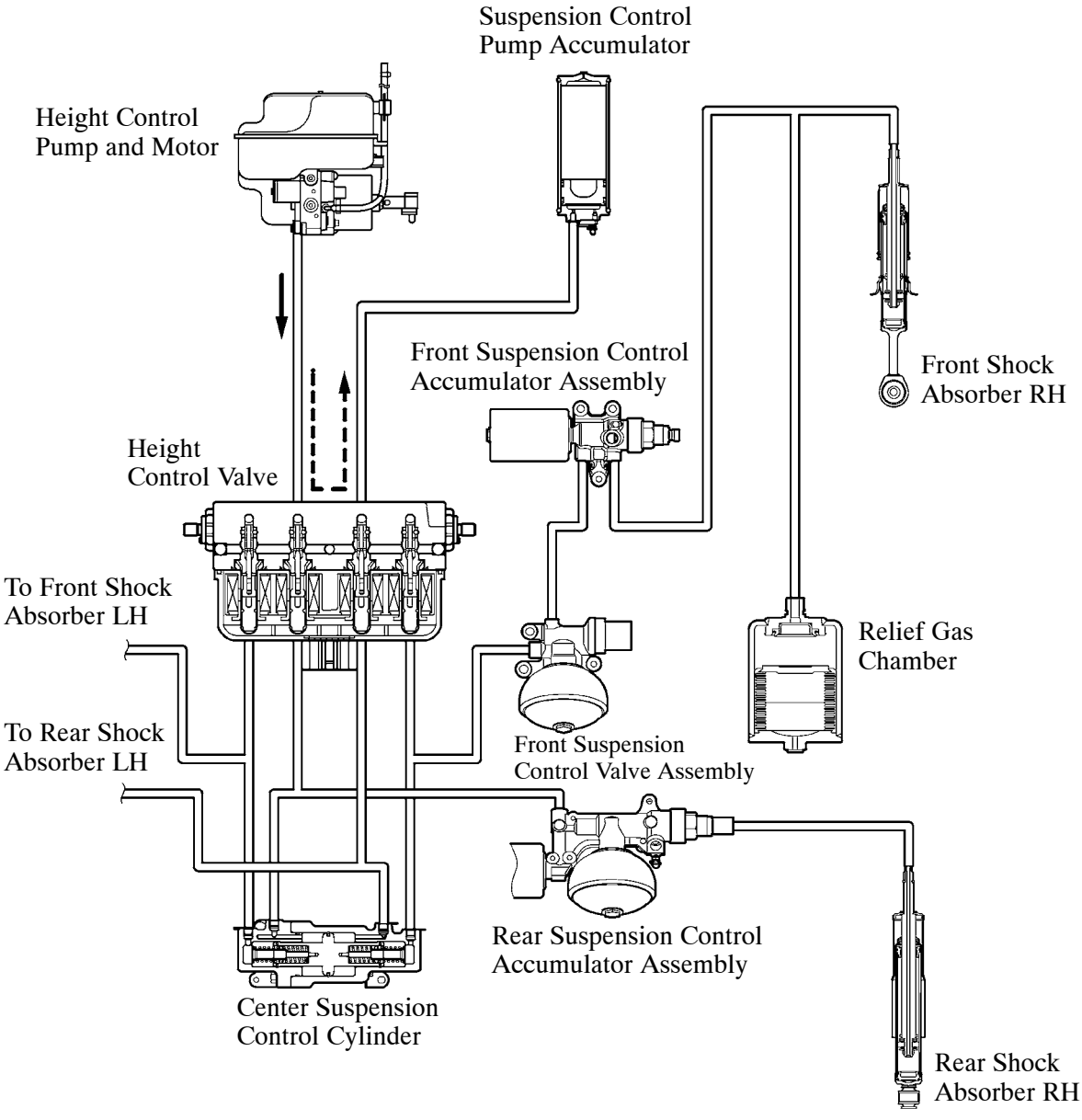


c. Fluid Stored in Height Control Accumulator

Normally, the suspension control pump accumulator stores only the amount of fluid that is equivalent that used in raising the vehicle height once. Therefore, after the vehicle has been raised from the LO position to the Normal position, or from the Normal position to the HI position, it is necessary to replenish the fluid in the suspension control pump accumulator.

At this time, the pump motor is operated to rotate the pump, the leveling valves are closed, the accumulator valve of the height control valve is opened, and the fluid is stored in the suspension control pump accumulator.

When the vehicle height is raised while the fluid that is stored in the suspension control pump accumulator has not reached a prescribed pressure, only the fluid that is discharged by the pump is used for raising the vehicle height, without using the fluid in the suspension control pump accumulator.



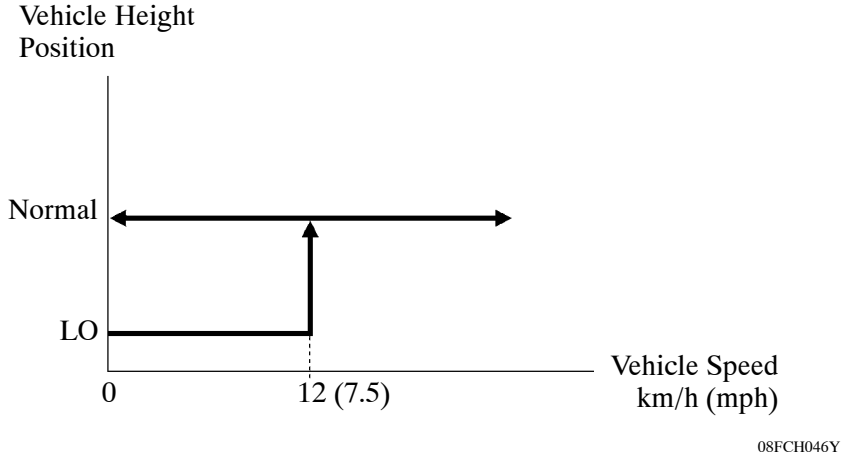
CH

2) Vehicle Speed Sensing Function

This function automatically adjusts the vehicle to any of the six levels of the height positions depending on vehicle speeds and vehicle conditions. The values of each height position are as follows:

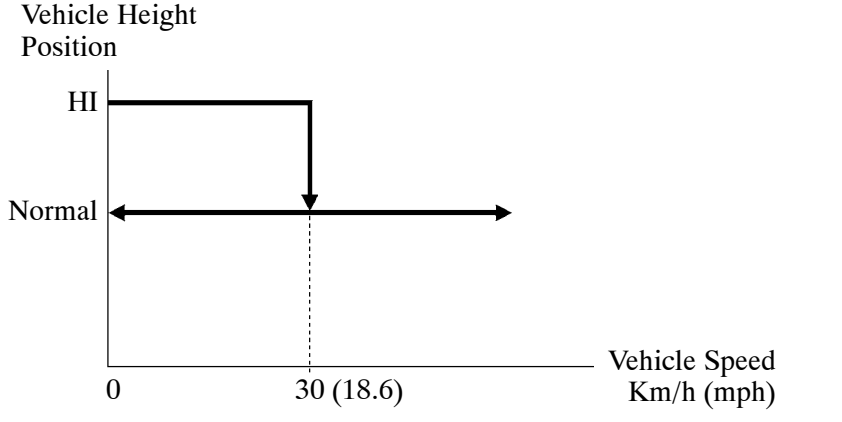
Height Position	Front Suspension Adjustment Value	Rear Suspension Adjustment Value
Extra HI	70 mm (2.8 in.)	80 mm (3.1 in.)
HI	50 mm (2.0 in.)	60 mm (2.4 in.)
L4 Range HI	25 mm (1.0 in.)	25 mm (1.0 in.)
Normal	0 mm (0 in.)	0 mm (0 in.)
High Speed LO	–20 mm (–0.8 in.)	–15 mm (–0.6 in.)
LO	–60 mm (–2.4 in.)	–40 mm (–1.6 in.)

- If the vehicle speed exceeds approximately 12 km/h (7.5 mph) when the vehicle height is set to the LO position, the vehicle height will be automatically adjusted to the Normal position.



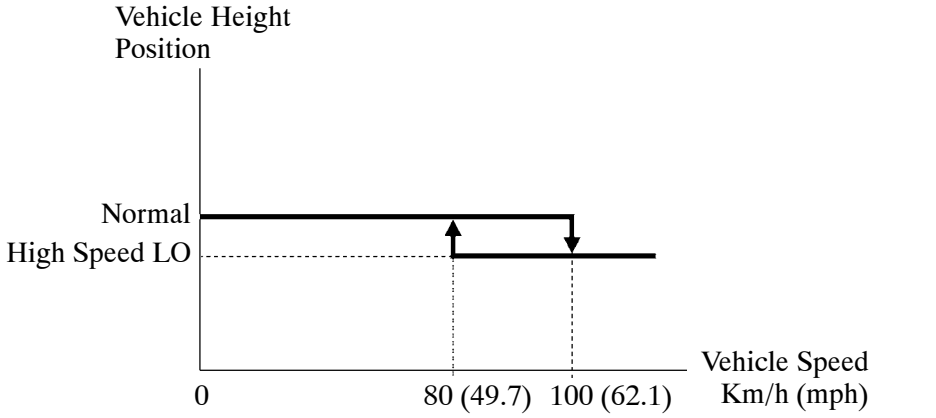
08FCH046Y

- If the vehicle speed exceeds approximately 30 km/h (18.6 mph) when the vehicle height is set to the HI position, the vehicle height will be automatically adjusted to the Normal position.



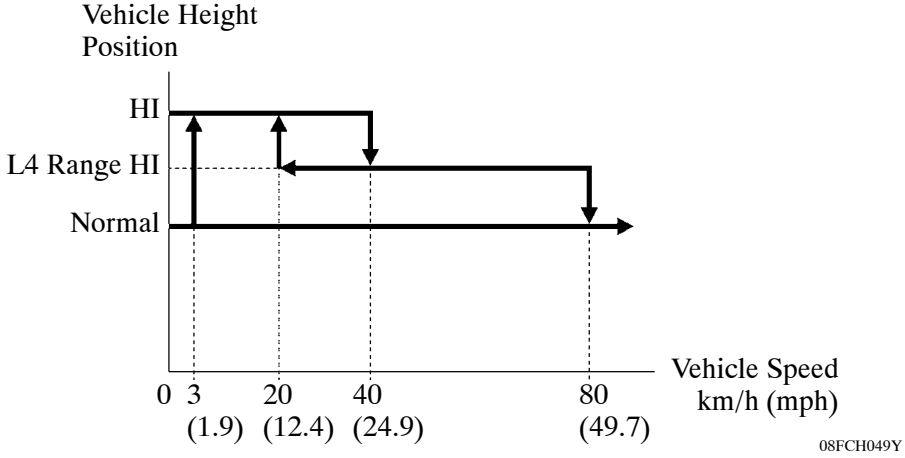
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- If the vehicle speed exceeds approximately 100 km/h (62.1 mph) when the vehicle height is set to the Normal position, the vehicle height will be adjusted to the High Speed LO position. If the vehicle speed is decreased to approximately 80 km/h (49.7 mph) or less while this is in effect, the vehicle height will be automatically adjusted to the Normal position.



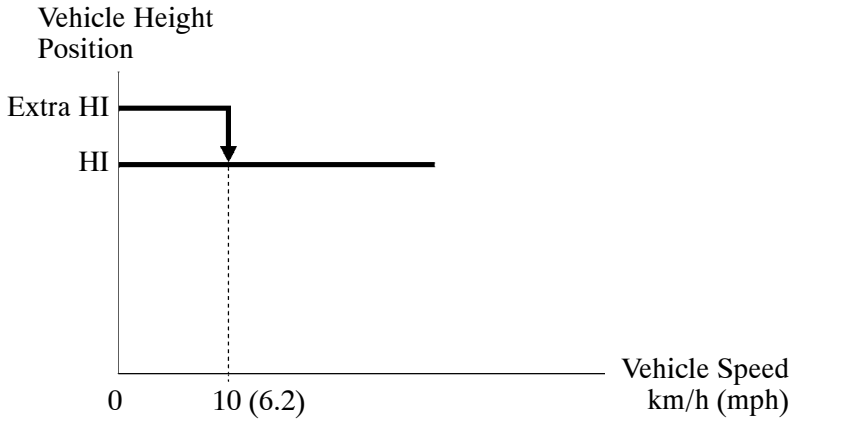
08FCH048Y

- When the transfer is set in the L4 range, the following control is performed.
  - If the vehicle speed exceeds approximately 3 km/h (1.9 mph) when the vehicle height is set to the Normal or LO position and a rough road condition is detected, the vehicle height will be automatically adjusted to the HI position.
  - When the vehicle speed exceeds 40 km/h (24.9 mph), the vehicle height will be adjusted to the L4 Range HI position. If the vehicle further accelerates in this condition and the vehicle speed exceeds 80 km/h (49.7 mph), the vehicle height will be automatically adjusted to the Normal position. On the other hand, if the vehicle decelerates and the vehicle speed is decreased to 20 km/h (12.4 mph) or less, the vehicle height will be automatically adjusted to the HI position.



08FCH049Y

- If the vehicle speed exceeds approximately 10 km/h (6.2 mph) when the vehicle height is set to Extra HI position, the vehicle height will be automatically adjusted to the HI position.



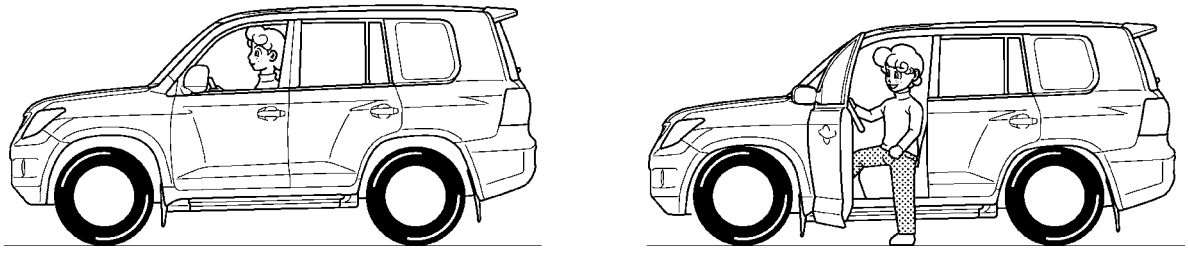
08FCH050Y

3) Easy Access Control

This function effects vehicle height control in conjunction with the engine switch when all of the following conditions have been met.

Condition	Function
● Easy access mode switch is ON ● Vehicle height is Normal ● Shift lever is in P position ● Vehicle speed is 0 km/h (0 mph) ● Engine switch is turned OFF ● Vehicle is on flat road	● The vehicle height is changed from the Normal position to the LO position. ● The wireless door lock buzzer sounds*1. ● The hazard light flashes*2. ● The easy access mode indicator light is changed from illuminating condition to blinking condition.
● Easy access mode switch is ON ● Engine switch is turned ON (IG) ● Vehicle speed is 12 km/h (7.5 mph) or more	● The vehicle height is changed from the LO position to the Normal position.

*1: Except China Models
*2: For China Models



Normal Position **LO Position**

08FCH051Y

Damping Force Control

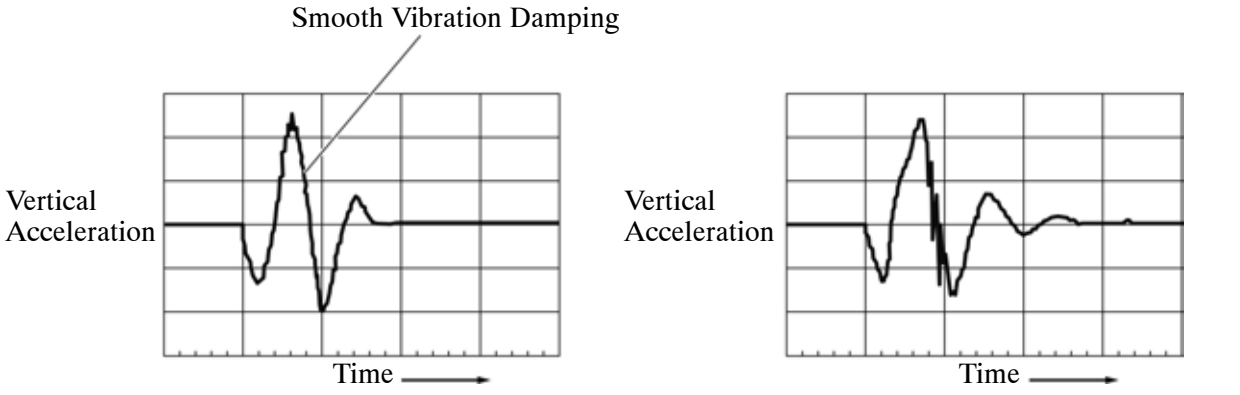
The damping force control has following functions:

Control	Function
Non-linear H^{∞} Control (See Page CH-108)	Smoothly changes the damping force to a target value in accordance with the changes in the road surface or driving conditions. Thus, excellent ride comfort has been realized while a high level of vibration damping performance is ensured.
Thumping Sensitive Control	Controls the shock absorbers so that the damping force for the shock absorbers will not increase while driving on a rough road.
Large-amplitude Control	When the suspension control ECU detects any large fluctuation in the wheel stroke when driving at low speeds, the damping force is adjusted to a firmer variable range for a predetermined time, to decrease the spring vibration.
Roll Posture Control (See Page CH-108)	Changes the damping force to control the vehicle posture during cornering. As a result, excellent stability and controllability have been realized during cornering.
Anti-dive Control	During braking, this function makes the damping force firmer to restrain the body dive, thus ensuring excellent stability and controllability.
Anti-squat Control	During acceleration, this function makes the damping force firmer to minimize the changes in the vehicle body posture.
High Speed Control	This function varies the variable range of the damping force according to vehicle speed in order to realize a soft and comfortable ride and a stable driving condition. The damping force is controlled in a softer variable range at low speeds, and in a firmer variable range at high speeds.
Absorber Control	The damping mode select switch enables the driver to select a desired damping force from the 3 modes.
L4 Range Control	The damping force is normally controlled in 16 steps. However, when the transfer is set in the L4 range, it is controlled in the intermediate 8 steps*, thereby ensuring riding comfort during off-road driving.

*: It is controlled in 3 steps when the vehicle speed is 55 km/h (34.2 mph) or less, and 8 steps when the vehicle speed is more than 55 km/h (34.2 mph).

1) Non-linear H^{∞} Control

This control uses 3 acceleration sensors to detect the vertical acceleration rate that corresponds to the bumps on the road surface and applies the non-linear H^{∞} control to calculate the target damping force. Unlike linear control which linearly changes the damping force proportional to the sprung acceleration rate, non-linear H^{∞} control achieves a higher level of vibration damping performance. As a result, superior riding comfort is ensured on any road surface or under any driving conditions.

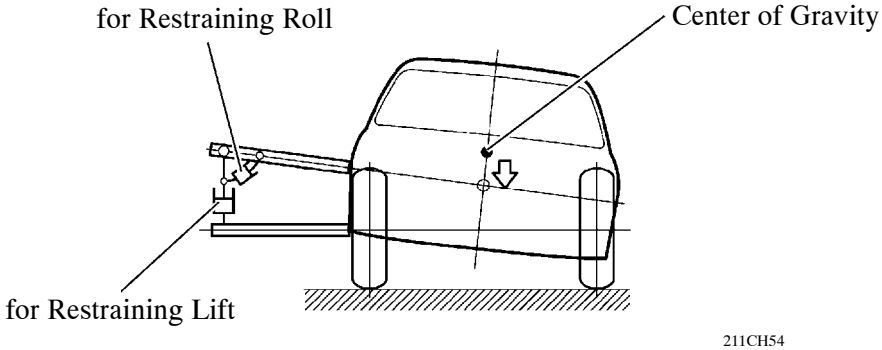


Non-linear H^{∞} Control **Linear Control**

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2) Roll Posture Control

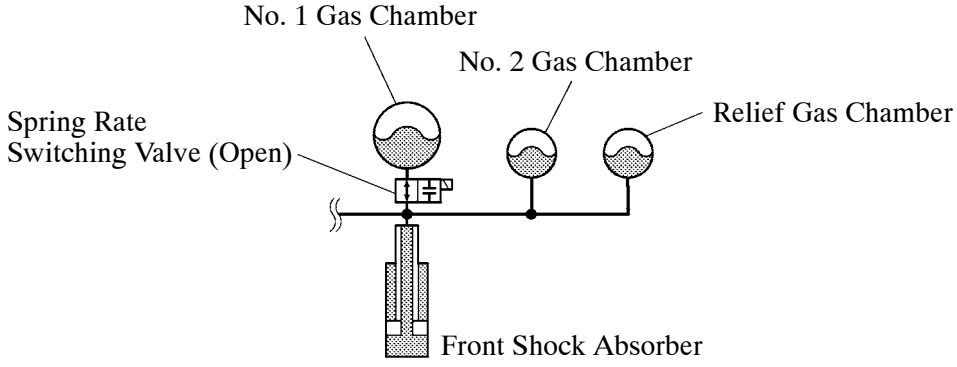
- This control changes the damping force to control the vehicle posture during cornering. As a result, excellent stability and controllability have been realized during cornering. This control assumes that two types of shock absorbers (one for restraining roll and the other for restraining lift) are provided at an imaginary point on the inside of the turn of the vehicle. The function of these shock absorbers is to prevent the center of gravity of the vehicle from rising. The damping force of the front and rear shock absorbers is controlled in order to control the vehicle's posture as in this imaginary condition.
- To effect this control, the suspension stroke information is calculated based on the information from the 3 acceleration sensors and a steering angle sensor. Thus, the driving conditions of the vehicle are detected.



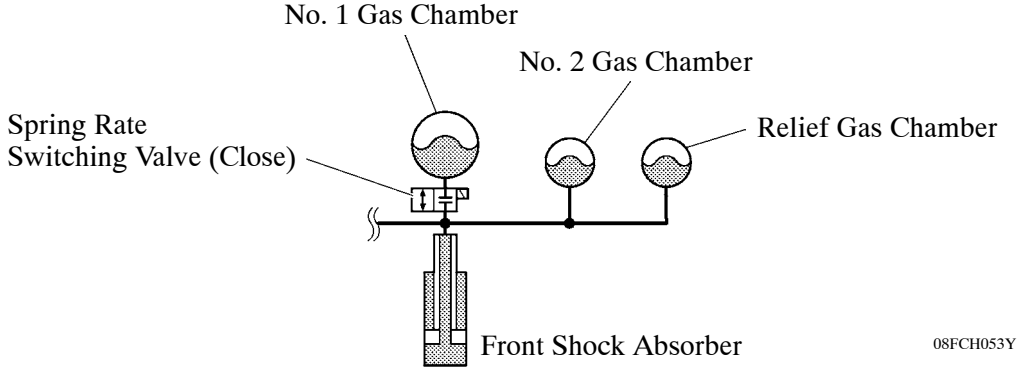
211CH54

Spring Rate Control

- The front shock absorber includes No. 1 and No. 2 gas chambers. These gas chambers are automatically selected in accordance with the driving conditions, and this ensures both driving comfort and steering stability.
- Under normal driving conditions, the suspension control ECU opens the spring rate switching valve and allows the gas chambers to operate, thereby reducing the spring rate and ensuring ride comfort.
- If the vehicle speed exceeds a predetermined speed while cornering or when the brake pedal is depressed, the suspension control ECU closes the spring rate switching valve and allows only the No. 2 gas chamber to operate, thereby increasing the spring rate to control the vehicle posture and improve the steering stability.



Normal Driving Condition

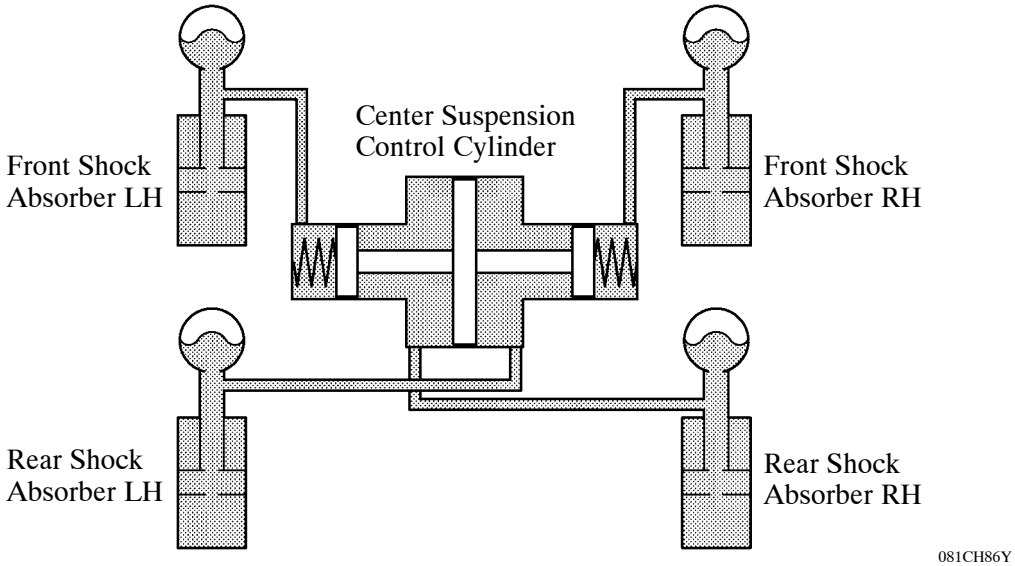


During Cornering or while Brake Pedal is being Depressed

4-wheel Related Control

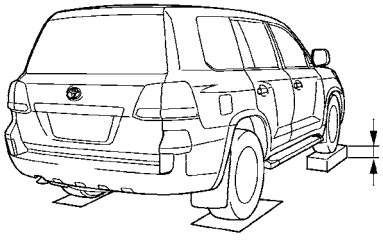
1) General

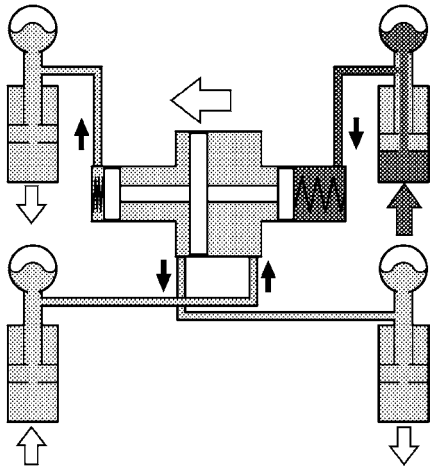
When a hydraulic pressure of one of the shock absorbers has changed because of changes in driving conditions, the 4-wheel related control adjusts the hydraulic pressure for the other shock absorbers through the center suspension control cylinder which is connected to all shock absorbers to stabilize the vehicle posture. When the vehicle is cornering, braking or driving on rough roads, the center suspension control cylinder operates differently through the center suspension control cylinder structure and shock absorber connection method, thereby achieving the optimum on-road and off-road driving performance.



2) Driving under Rough Road Conditions (When an impact force is applied to only one wheel)

When an impact is only applied to the front right wheel during on-road driving, the piston placed inside the center suspension control cylinder moves to the left in accordance with increase in the wheel pressure. This movement prompts the other shock absorbers to expand or contract as shown in the illustration, thereby improving the grounding performance.



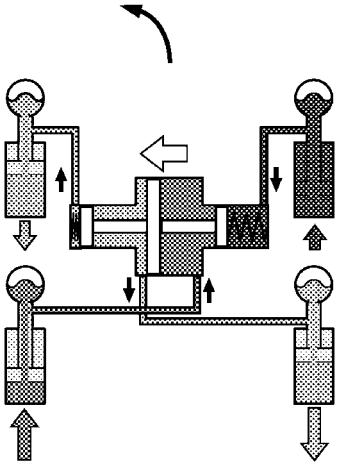


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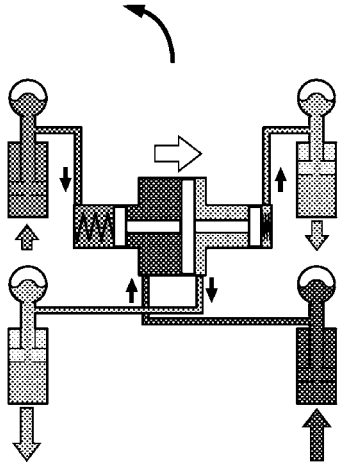
3) While Cornering

As shown in the illustration, when a small load is applied to the rear of the vehicle and the rolling stiffness of the suspension for the front wheels is high, the hydraulic pressure of the front right absorber is high. Then, the piston inside the center suspension control cylinder moves to the left in accordance with changes in the hydraulic pressure balance for each of the wheels. As a result, the pressure is applied to the rear right absorber, and the rear suspension is caused to move in the opposite direction from that of the front suspension.

On the other hand, when a large load is applied to the rear of the vehicle and the rolling stiffness of the suspension for the rear wheels is high, the hydraulic pressure of the rear right absorber is high. Then, the piston inside the center suspension control cylinder moves to the right in accordance with changes in the hydraulic pressure balance for each of the wheels. This optimizes the rolling stiffness distribution regardless of load quantity and improves the steering stability.



When Cornering Left
(Front wheel rolling stiffness is high)



When Cornering Left
(Rear wheel rolling stiffness is high)

081CH88Y

9. Fail-safe

- If the suspension control ECU detects a malfunction in the active height control suspension system, the ECU illuminates the master warning light, indicates the warning message “Check 4-WHEEL AHC System” on the multi-information display, and sounds the buzzer to inform the driver of the malfunction.
- When a vehicle can still be driven even if a system malfunction occurs, the vehicle height is automatically returned to the Normal position at a speed of 30 km/h or more.

10. Diagnosis

If a system malfunction occurs, DTC (Diagnostic Trouble Code) is stored in memory of the suspension control ECU. This DTC can be read by the following two methods.

- The 5-digit DTC can be read by connecting a intelligent tester II to the DLC3.
- The 2-digit DTC can be read by connecting the SST (09843-18040) between the TC and CG terminals of the DLC3.

For details, see the LEXUS LX 570 Repair Manual (Pub. No. RM08G0E).

11. Active Test

Vehicle height control and damping force control operation in the suspension system can be checked through either of the following two methods:

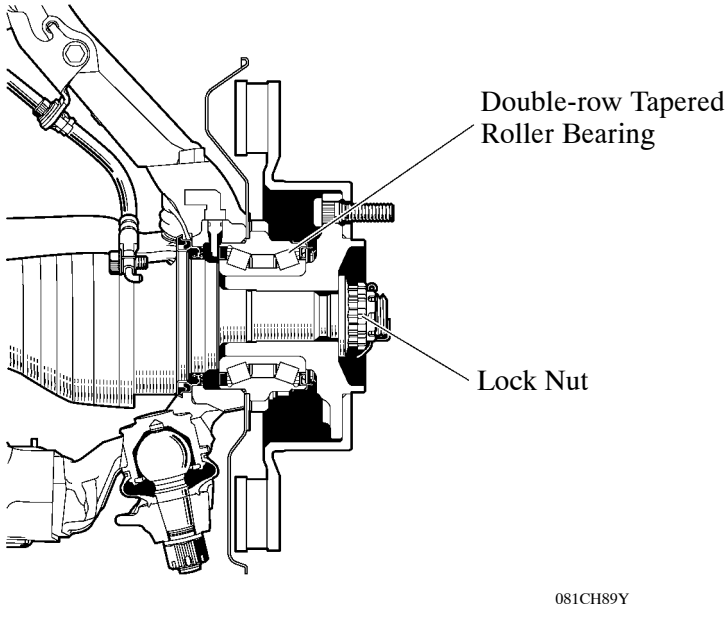
- Vehicle height and damping force of each wheel can be operated by connecting an intelligent tester II to the DLC3.
- Vehicle height of each wheel can be operated by connecting the terminals of the height control connector.

For details, see the LEXUS LX 570 Repair Manual (Pub. No. RM08G0E).

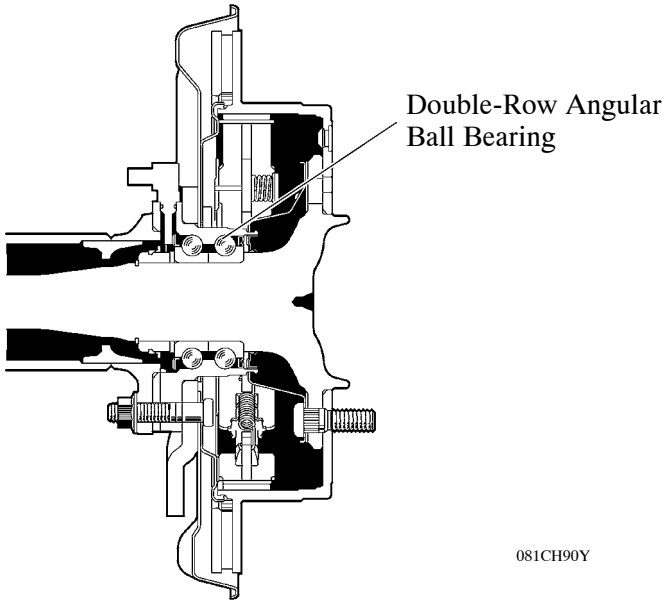
■AXLE

1. General

- Maintenance-free upper and lower ball joints and front axle hub bearings are used. The front axle hub bearings that are used are unit-type double-row tapered roller bearings.
- Unit-type double-row angular ball bearings are used for the rear axle shaft bearings.
- The speed sensor rotors have been integrated in the inner races of the front and rear wheel bearings due to the adoption of active type speed sensors (for the brake control system).



081CH89Y



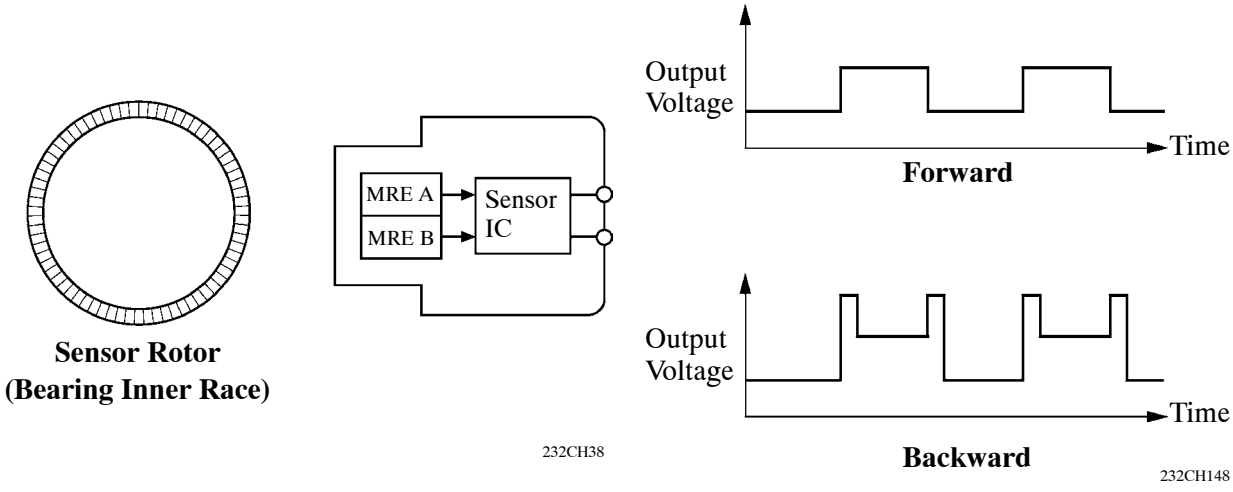
081CH90Y

2. Speed Sensor

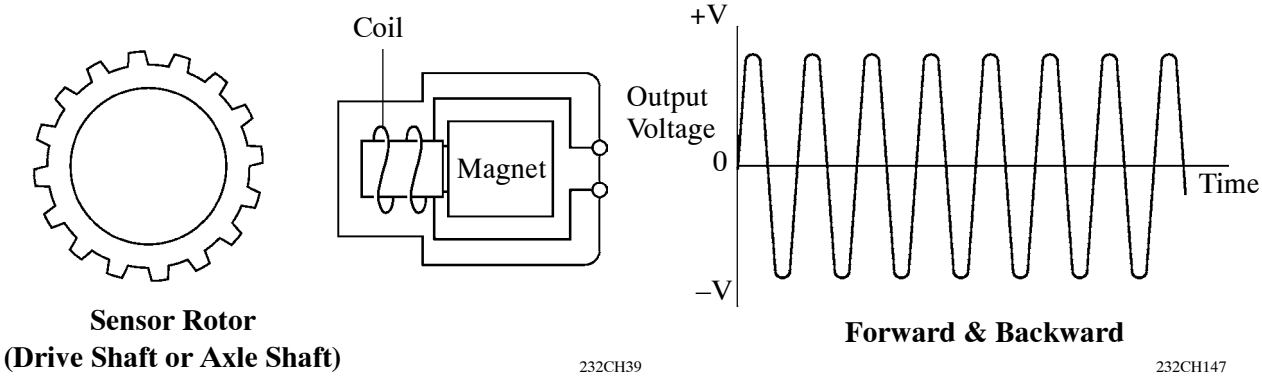
General

- Active type speed sensors, which can detect the rotational direction of the wheel, have been provided. 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 inner race of the hub bearing.
- The differences between the passive type speed sensor (containing a pick-up coil to detect speeds) and the active type speed sensors are described below.

▶ Active Type Speed Sensor ◀



▶ Passive Type Speed Sensor ◀

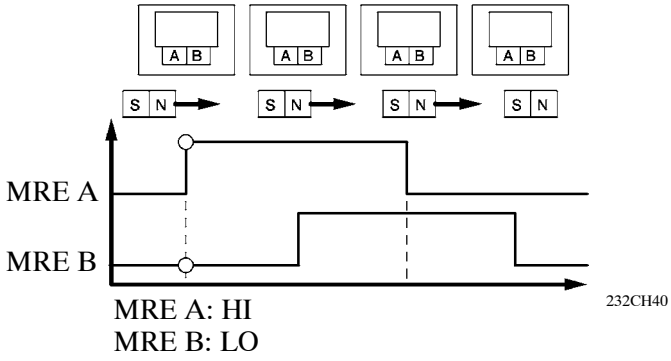


Type	Active	Passive
Direction Detection	Possible to judge both forward and backward	Impossible to judge the wheel rotation direction
Detection Speed	Approx. 0 km/h (0 mph)	5 km/h (3 mph) or more
Weight	Approx. 1/3 of passive type	—

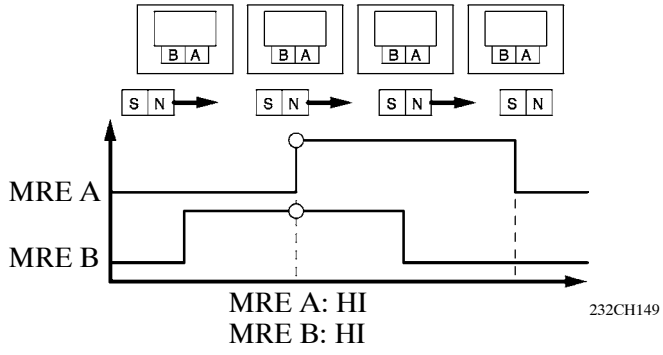
Detection Method

- To detect the rotation direction, the output waves are used to determine the relationship of the pulses that are generated by the 2 MREs.
- Upon receiving this signal, the sensor IC outputs a forward or backward wave.

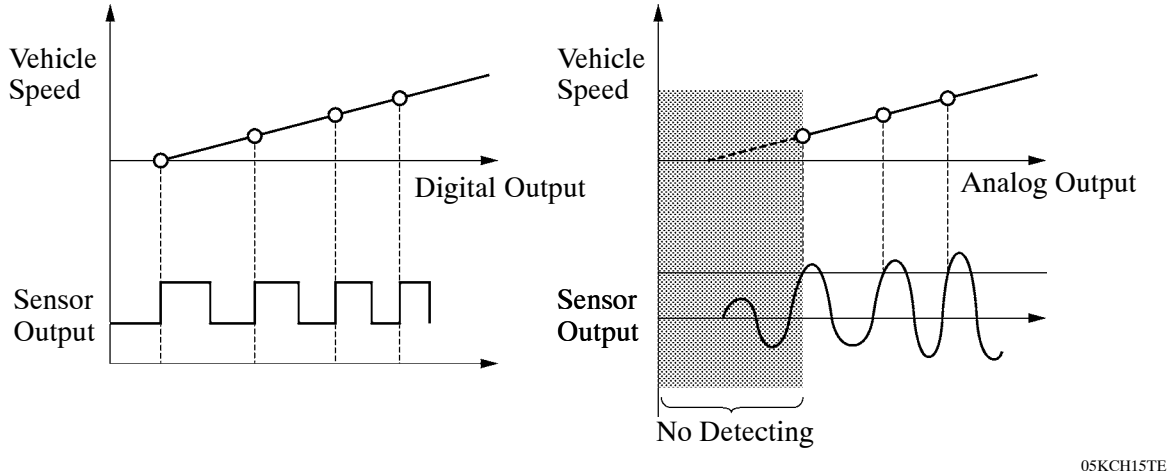
▶ Forward ◀



▶ Backward ◀



- To detect the vehicle speed, the duration of the output pulses is used. Because the active type sensor outputs digital pulses, it can detect vehicle speeds even at approximately 0 km/h (0 mph).



Active Type **Passive Type**

CH

BRAKE

■ DESCRIPTION

1. General

- The hydraulic brake booster in which the brake actuator, brake booster, master cylinder are integrated is used.
- In addition to the conventional ABS, a multi-terrain ABS, which automatically selects the optimum ABS control in accordance with the off-road terrain such as dirt, sand, or gravel, is newly provided. The braking feel in off-road situations has been enhanced.
- The CRAWL, a driving support system which aids the driver when the vehicle is driven on very bumpy or slippery roads, has been newly added. When the CRAWL is active, the engine output and the brake force are automatically regulated, thus enabling the vehicle to run at a constant speed. As a result, the driver is allowed to concentrate on maneuvering the steering wheel with less accelerator pedal and brake pedal operation.

The new LX 570 has a brake system with the following specifications:

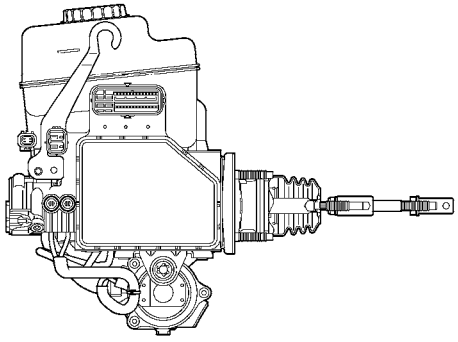
Front Brake		Ventilated Disc
Rear Brake		Ventilated Disc
Brake Control System	Multi-terrain ABS (Anti-lock Brake System), EBD (Electronic Brake force Distribution), Brake Assist, A-TRC (Active Traction Control), VSC (Vehicle Stability Control), Hill-start Assist Control, CRAWL	Standard
Parking Brake Operation Type		Lever Type

▶ Specifications ◀

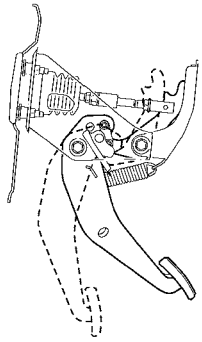
Brake Booster			Hydraulic
Master Cylinder	Type		Dual Piston Diameter
	Diameter	mm (in.)	Large: 26.99 (1.06) Small: 20.00 (0.79)
Front Brake	Caliper Type		S15WA
	Wheel Cylinder Diameter	mm (in.)	51.1 (2.01) × 2
	Rotor Size (D × T)*	mm (in.)	340 × 32 (13.39 × 1.26)
	Pad Area	cm^2 ($in.^2$)	65.0 (10.08) × 2
Rear Brake	Caliper Type		FS13C
	Wheel Cylinder Diameter	mm (in.)	45.4 (1.79)
	Rotor Size (D × T)*	mm (in.)	345 × 18 (13.58 × 0.71)
	Pad Area	cm^2 ($in.^2$)	36.7 (5.69) × 2
Parking Brake	Type		Toggle Lever Type Duo Servo Drum
	Drum Inner Diameter	mm (in.)	240 (9.45)

*: (Diameter × Thickness)

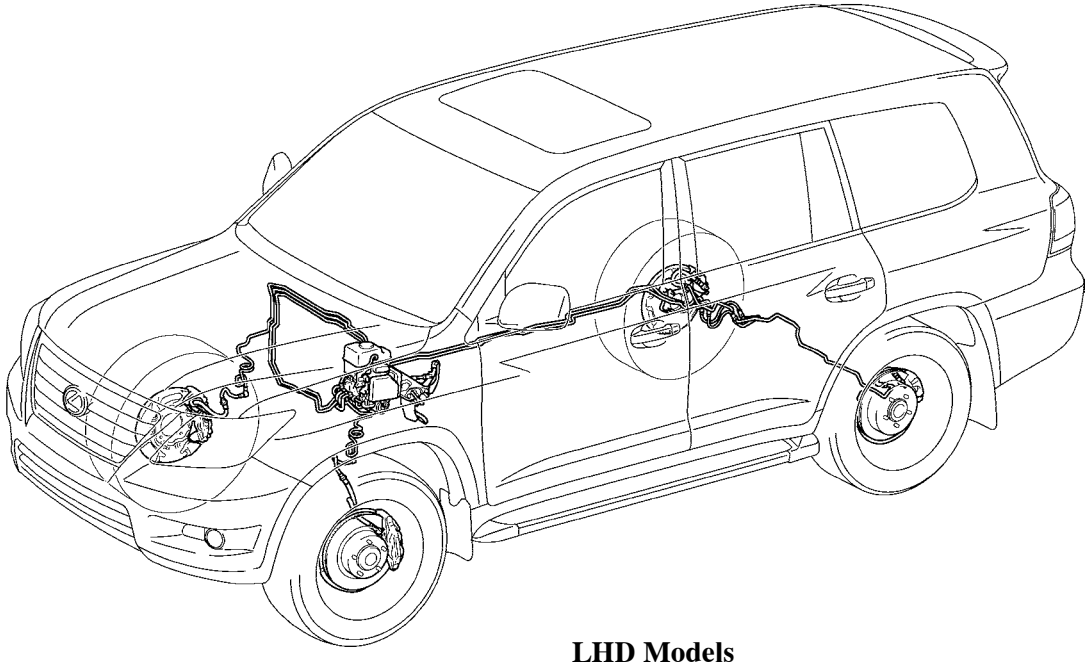
2. Components of Brake System



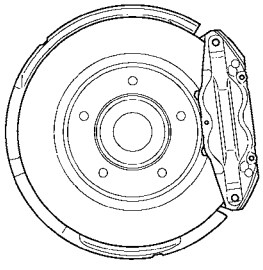
Hydraulic Brake Booster



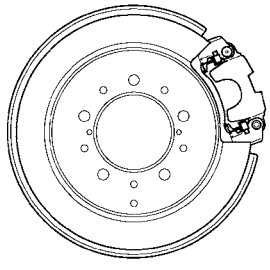
Brake Pedal



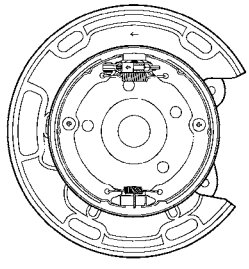
LHD Models



Front Brake



Rear Brake



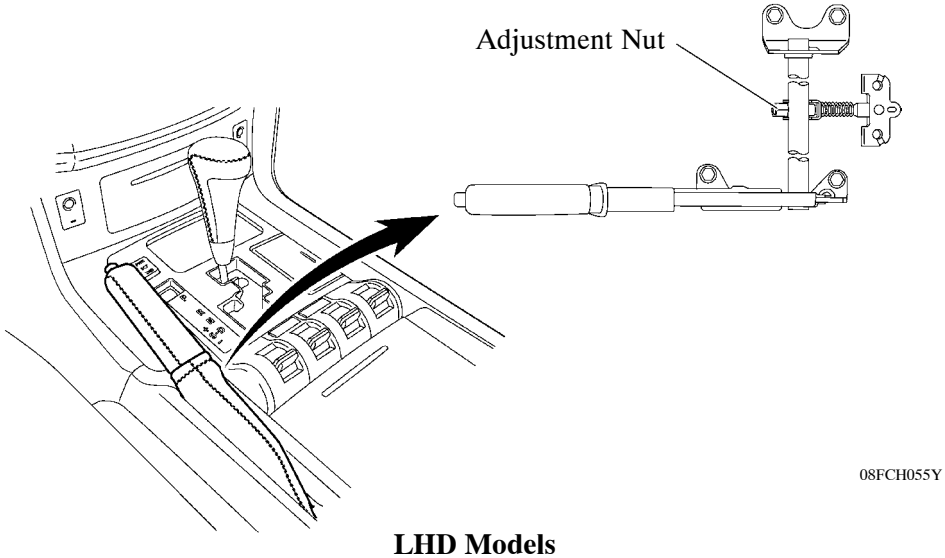
Parking Brake

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■ PARKING BRAKE

1. Offset Type Parking Brake Lever

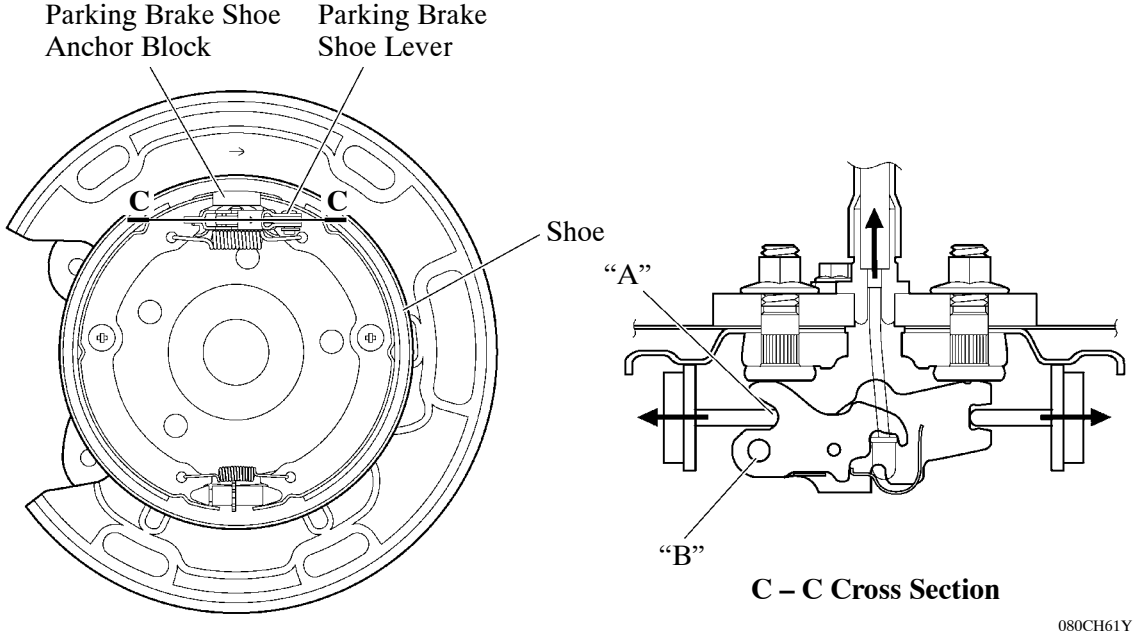
An offset type parking brake lever is used to ensure a space on the console box. In consideration of serviceability, the double nuts for parking brake cable adjustment have been discontinued and replaced by an adjustment nut.



LHD Models

2. Toggle Lever Type Parking Brake

- A toggle lever type duo-servo brake mechanism is used for the parking brake to simplify the constituent parts and to achieve weight reduction.
- This parking brake mainly consists of a parking brake shoe lever, a parking brake shoe anchor block, and a shoe. When the parking brake lever is operated, it pulls on the cable, and this causes the parking brake shoe lever to expand the shoes via fulcrums “A” and “B”.



C – C Cross Section

■ BRAKE CONTROL SYSTEM

1. General

The brake control system (multi-terrain ABS, EBD, brake assist, A-TRC, VSC, Hill-start Assist Control, CRAWL) of new LX 570 has the following functions:

Function	Outline
Multi-terrain ABS (Anti-lock Brake System)	The ABS helps prevent the wheels from locking when the brakes are applied firmly or on a slippery surface. In addition to the existing ABS function, the multi-terrain ABS automatically selects the optimum ABS control for the off-road situation such as a dirt road or a sandy road, providing the most suitable brake force for the ground surface.
EBD (Electronic Brake force Distribution)	The EBD utilizes multi-terrain 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 draw the vehicle's brake performance.
A-TRC (Active Traction Control)	During rugged off-road 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 an LSD (Limited Slip Differential) effect. As a result, the vehicle's off-road drivability and ability to free itself from bumping have been increased.
VSC (Vehicle Stability 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.
Hill-start Assist Control	When the vehicle starts off on a steep or a slippery hill, Hill-start Assist Control detects the backward descent of the vehicle and effects 4-wheel hydraulic pressure control to reduce the backward speed of the vehicle. As a result, the vehicle can be started off on a hill more easily.
CRAWL	When the vehicle runs on extremely bumpy rough ground or a slippery road, the CRAWL is activated to regulate the engine output and the hydraulic pressure of the 4 wheels, allowing the driver to drive the vehicle at the desired speed and keep that speed with virtually no accelerator or brake pedal operation. As a result, the off-road ground covering performance has been more improved.

Service Tip

When the 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. Outline of Brake Control Functions

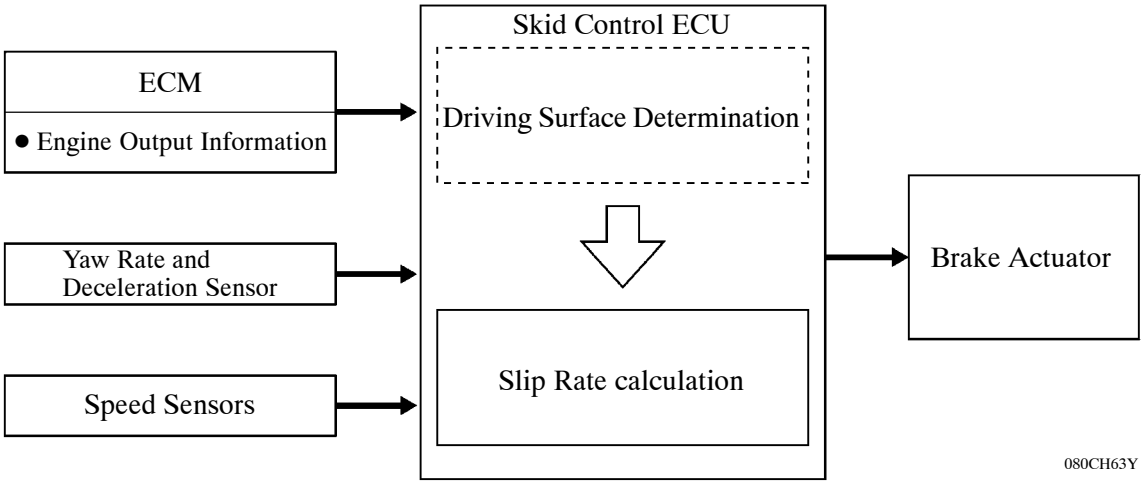
Multi-terrain ABS (Anti-lock Brake System)

1) General

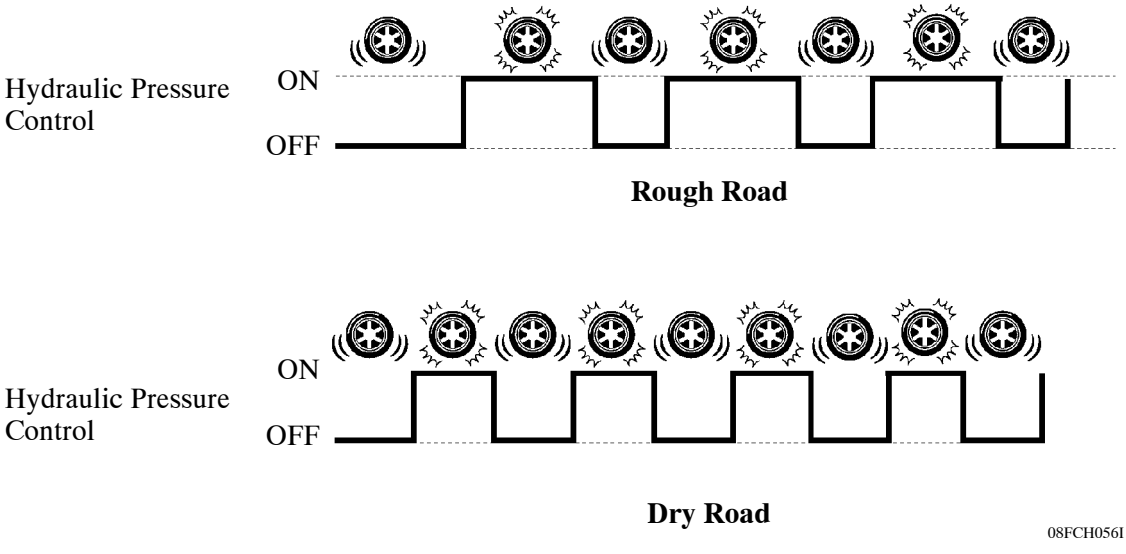
The conventional ABS regulates the hydraulic brake pressure of all the wheels by monitoring the wheel speeds during braking, and prevents the wheels from locking when braking to ensure the vehicle stability and the steering maneuverability. The newly provided multi-terrain ABS has a function that detects the off-road ground conditions such as sand, mud, or gravel via information such as the engine output, vehicle acceleration rate, and wheel speeds, and then selects the optimum ABS control in accordance with the situation. As a result, the braking feel in off-road driving has been enhanced.

2) Effectiveness of Multi-terrain ABS

Through the addition of the engine output information to the existing control information, the accuracy of determining the road surface conditions has been more improved. By changing the slip rate in accordance with the road surface, it secures superior braking performance on the off-road surface.



▶ Hydraulic Pressure Control Image of Multi-terrain ABS ◀



EBD (Electronic Brake force Distribution)

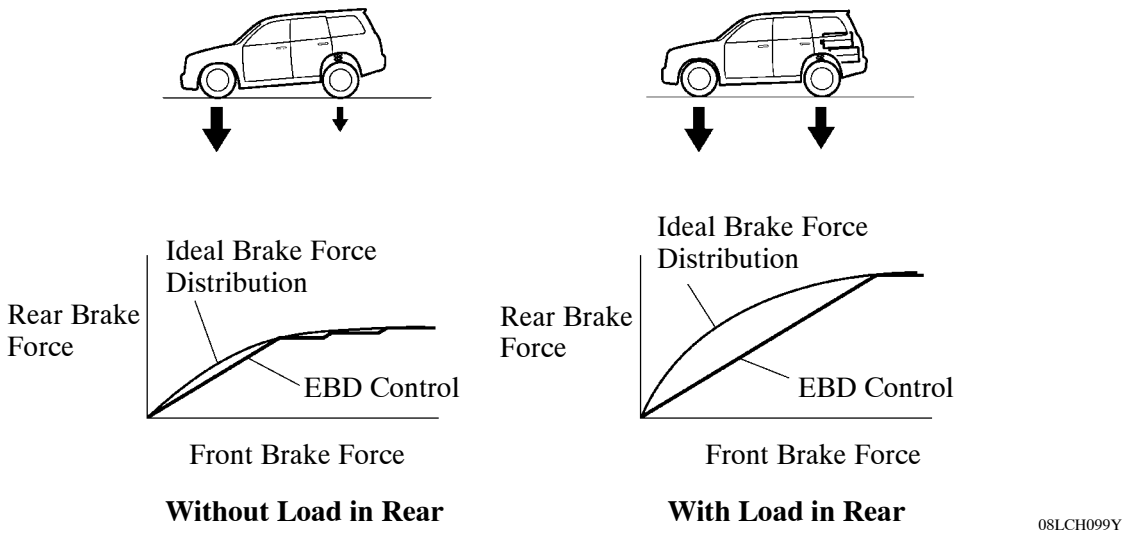
1) General

The EBD control utilizes the multi-terrain 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.

2) Front/Rear Wheels Brake Force Distribution

This function controls the brake force that acts on the rear wheels in accordance with the changes in the vehicle conditions such as load factors or deceleration, in order to ensure excellent braking performance.

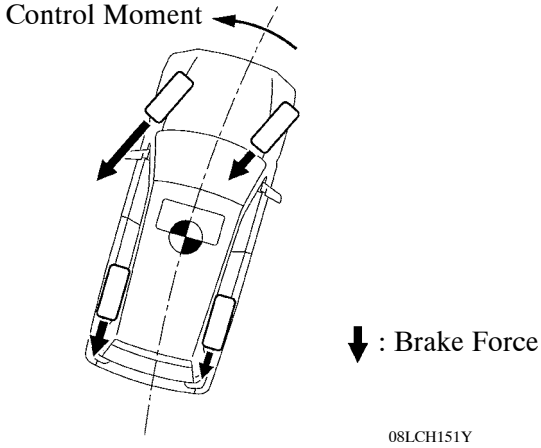
▶ EBD Control Concept ◀



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

During cornering braking, this function controls the brake force that acts on the left and right wheels in accordance with the vehicle conditions at that time. This ensures vehicle stability and excellent braking performance.

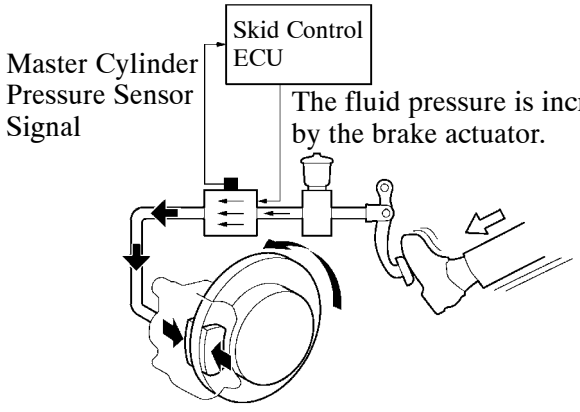


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Brake Assist

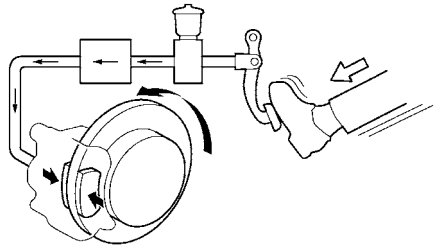
- The primary purpose of the brake assist is to provide an auxiliary brake force to assist the driver who cannot generate a large brake force during emergency braking, thus helping draw the vehicle's brake performance.
- Based on the signals from the master cylinder pressure sensor, the skid control 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, this function 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 applying emergency braking ◀



With Brake Assist

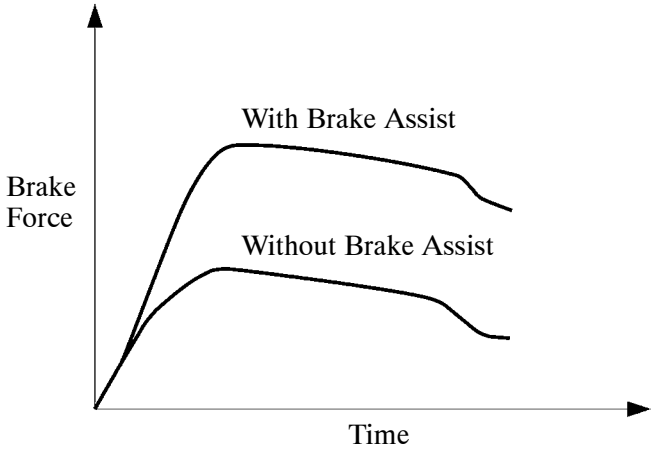
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Without Brake Assist

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



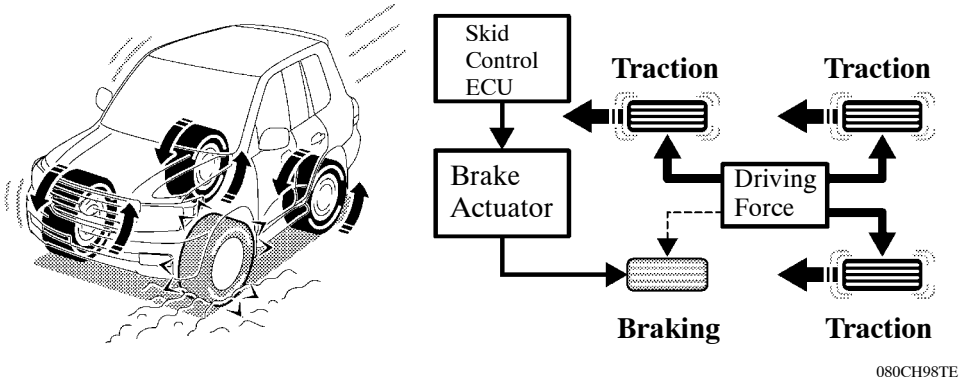
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A-TRC (Active Traction Control)

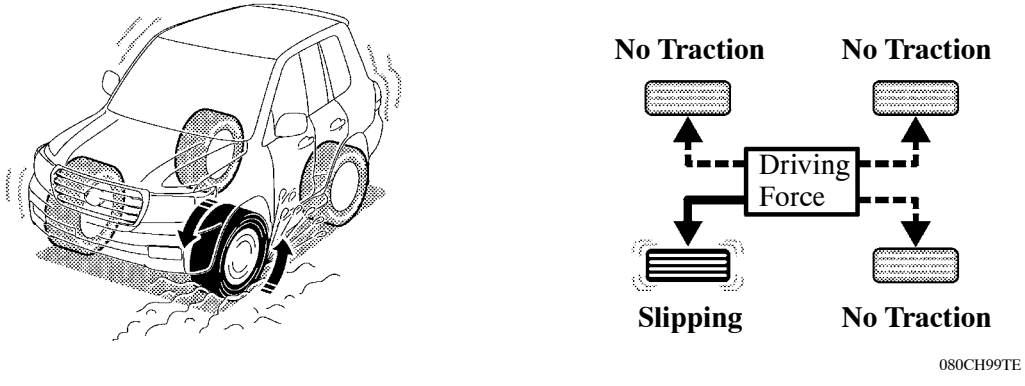
1) General

- If a tire slips while the vehicle is being driven on a snow-covered road or a rough 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-TRC 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 4 wheels in accordance with the extent of the slippage at the wheels, as detected by the skid control ECU.

▶ With A-TRC ◀



▶ Without A-TRC ◀



2) Effectiveness of A-TRC

The effectiveness of the A-TRC is as follows:

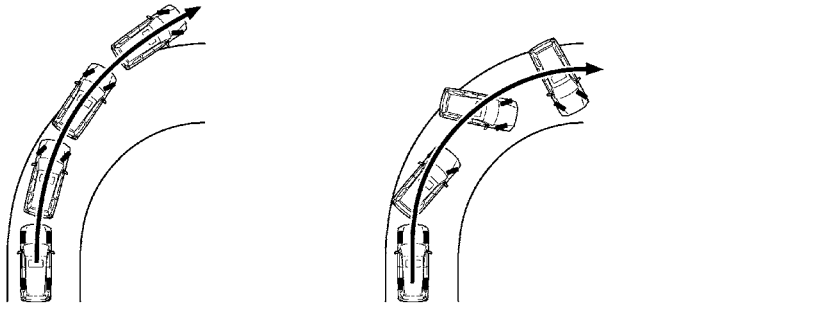
- Off-road drivability that is equivalent to having the center differential locked and limited slip differential on both front and rear differentials has been realized.
- This function makes the operation of the differential lock switches basically unnecessary to ensure the ease of driving.
- While realizing 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 prevention of tight corner braking phenomenon ensures the ease of nimble steerability.

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VSC (Vehicle Stability Control)

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** 08LCH153Y

1) Method for Determining Vehicle Condition

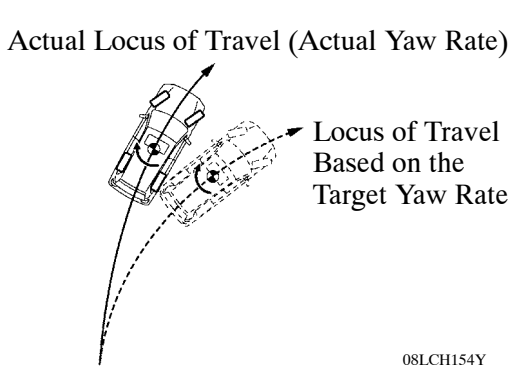
To determine the condition of the vehicle, sensors detect the steering angle, vehicle speed, vehicle's yaw rate, and vehicle's lateral acceleration, which are then calculated by the skid control ECU.

a. Determining Front Wheel Skid

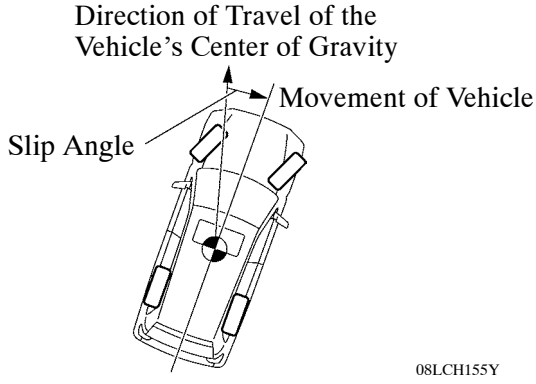
Whether the vehicle is in the state of the front wheel skid or not is determined by the difference between the target yaw rate and the vehicle's actual yaw rate. When the vehicle's actual yaw rate is smaller than the yaw rate (a target yaw rate that is determined by the vehicle speed and steering angle)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



Determining Front Wheel Skid



Determining Rear Wheel Skid

2) Method for VSC Operation

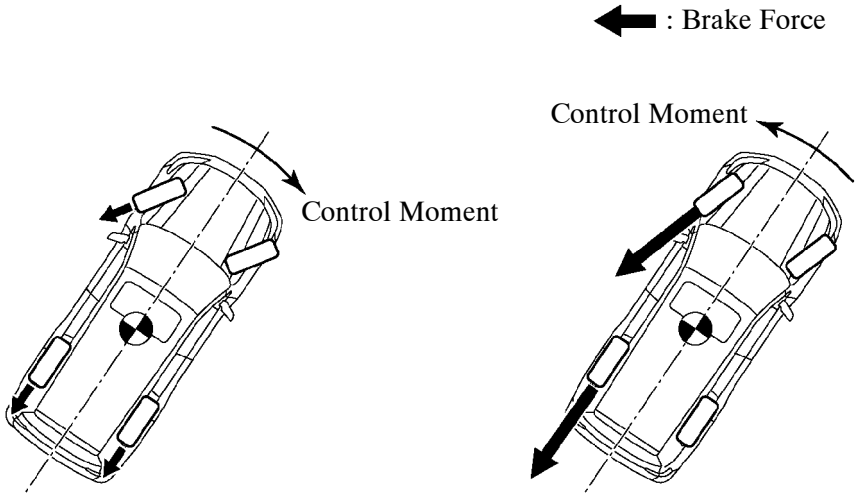
When the skid control ECU determines that the vehicle has a tendency to front wheel skid or rear wheel skid, it decreases the engine output and applies the brake of a front or rear wheel to control the vehicle's yaw moment.
The basic operation of the VSC is described below. However, the control method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

a. Dampening 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 brake of the front wheel of the outer circle in the turns and rear wheels in order to restrain the front wheel skid tendency.

b. Dampening 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 and rear wheels 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.



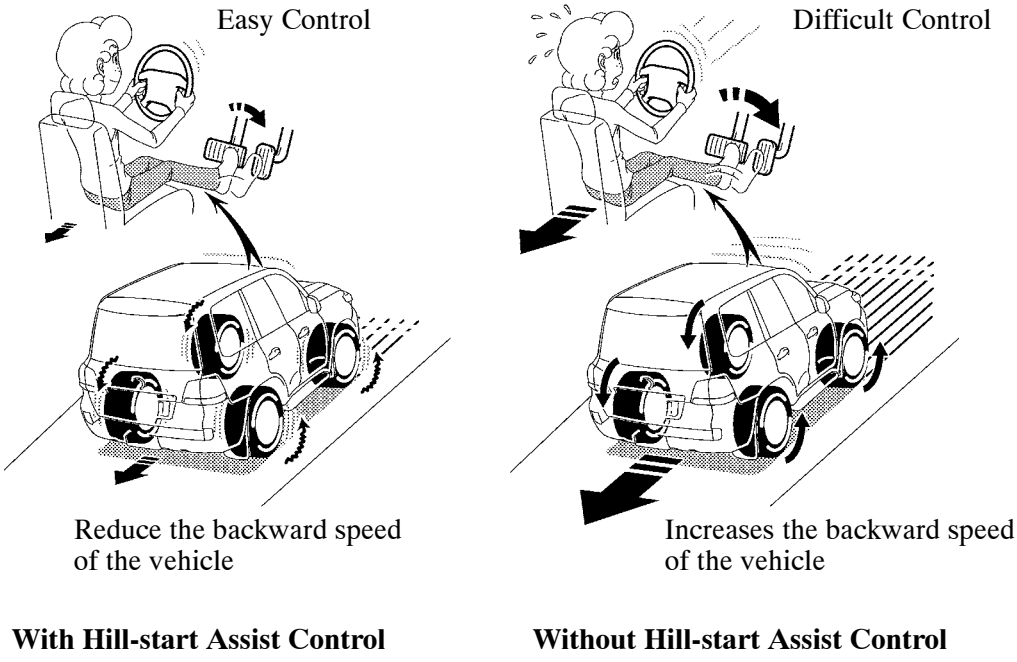
Dampening a Front Wheel Skid (Marking a Right Turn)

Dampening a Rear Wheel Skid (Marking a Right Turn)

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Hill-start Assist Control

- 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, Hill-start Assist Control 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 Hill-start Assist Control, the driver must quickly and precisely switch from the brake pedal to the accelerator pedal. With Hill-start Assist Control, however, the driver can start off easily and operate the pedal in a relaxed manner because Hill-start Assist Control reduces the backward speed of the vehicle.



- Hill-start Assist Control operates when all of the following conditions have been met:

Hill-start Assist Control Operate Condition	● The shift lever is in the D or S 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.

CRAWL

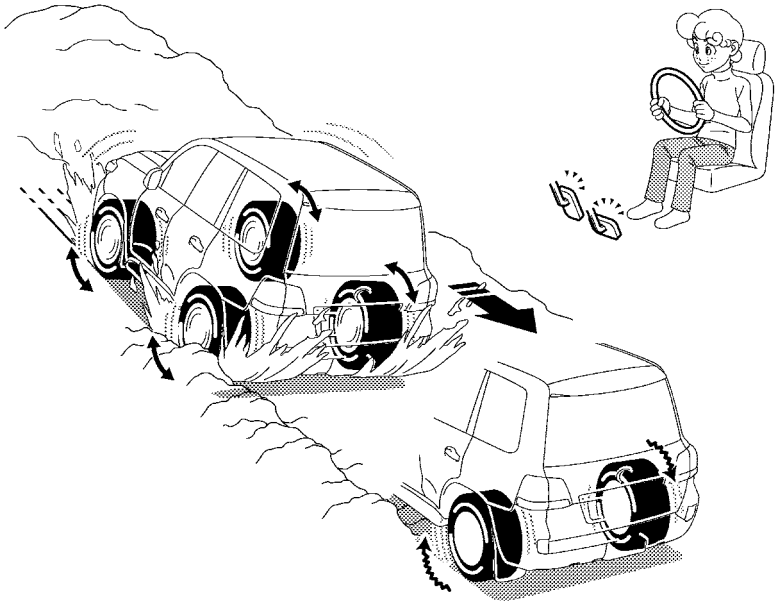
The CRAWL is a driving support system that regulates the engine output and the brake force, enabling the vehicle to be driven at a constant speed on rough ground or slippery roads.

- When the vehicle drives across rough grounds such as extremely bumpy rough roads, the driver needs to pay attention to the steering, braking and acceleration operations. However, with the CRAWL, the driver can concentrate on steering, without worrying about the accelerator pedal or brake pedal.



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- The CRAWL ensures good vehicle stability in situations such as when the vehicle is running on a slippery or steep road because the chances of the wheels spinning or locking are minimized by regulating the engine output and the brake force.



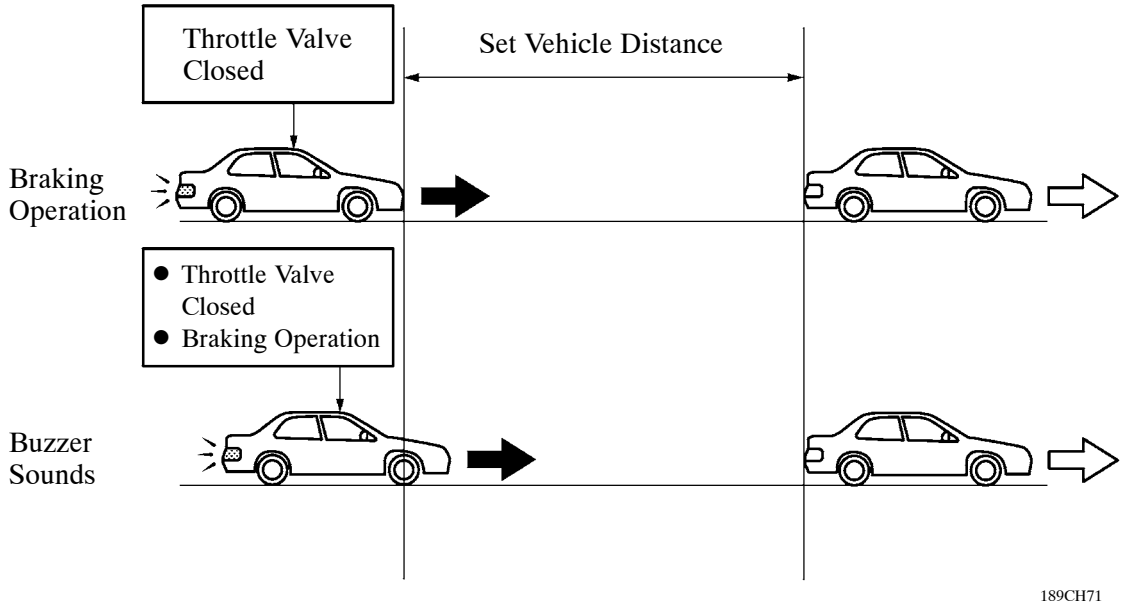
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Other Functions

The following brake control functions are provided on the vehicles with the dynamic radar cruise control system and the pre-crash safety system.

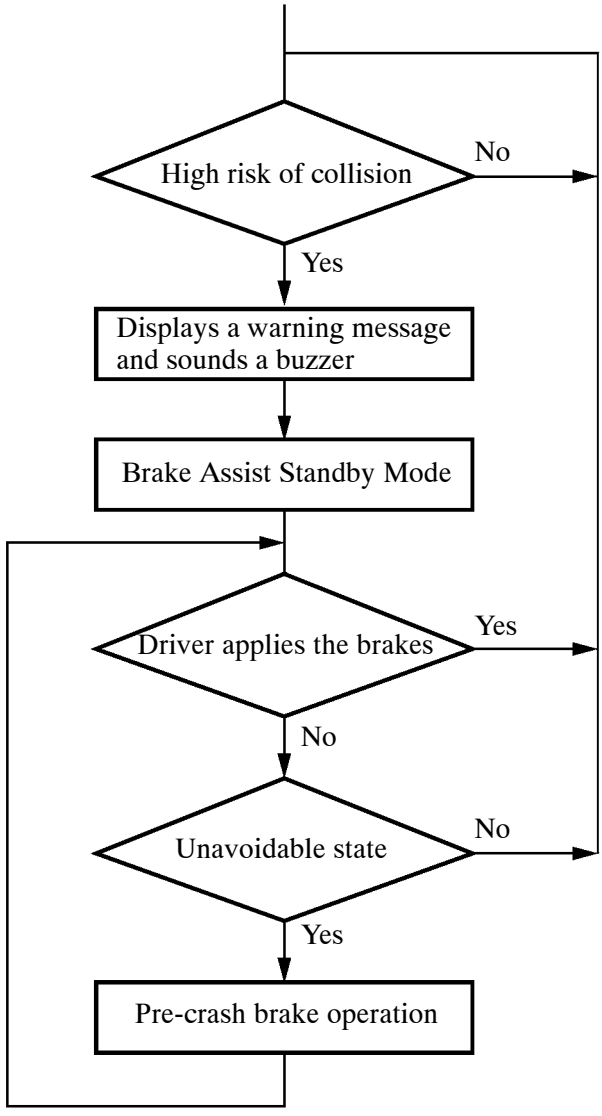
1) Brake Control Function during Dynamic Radar Cruise Control System Operation

During dynamic radar type cruise control system operation, if the distance to the vehicle being driven ahead is reduced and a sufficient deceleration cannot be attained by fully closing the throttle valve, the skid control ECU activates the brake actuator to apply the brakes according to the distance control ECU's request. As a result, the stop lights illuminate. If further deceleration is required, the system sounds a VSC warning buzzer to alert the driver to apply the brakes.



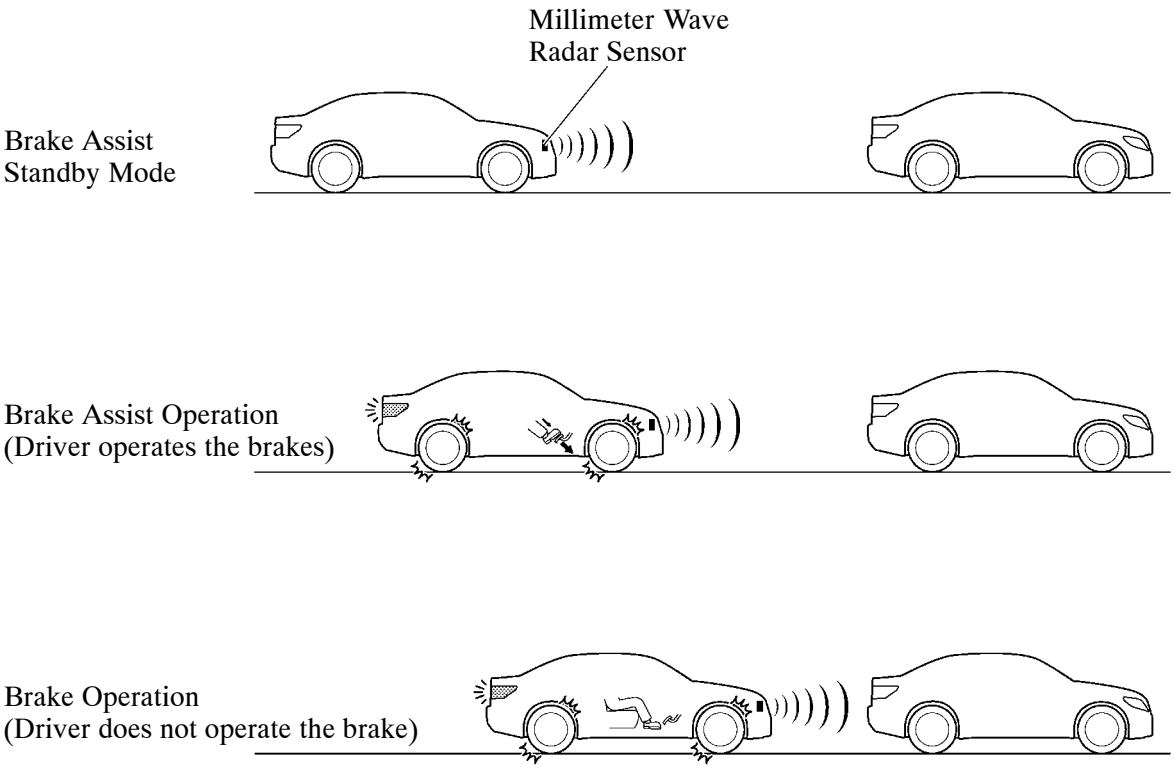
2) Brake Control Function during Pre-crash Safety System Operation

If the distance control ECU determines that the risk of the vehicle being involved in a collision is high, it sends a pre-crash brake assist control signal to the skid control ECU. This signal takes into account the conditions of the vehicle and the intention of the driver to apply the brakes. Upon receiving the signal, the skid control ECU effects system control to help avoid a vehicle collision as shown in the flowchart below. Thus, the system helps to avoid vehicle collisions.



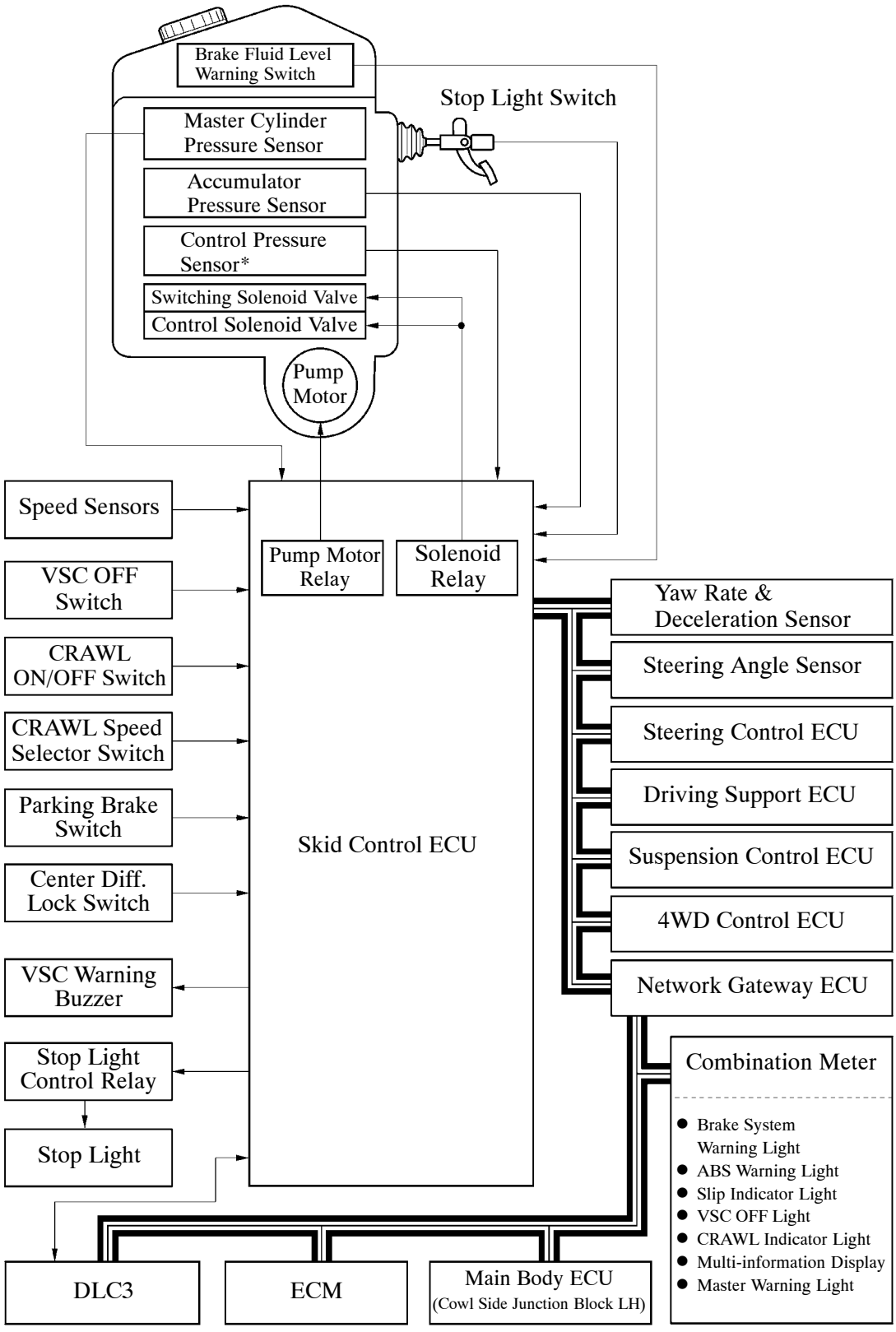
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▶ Brake Operation ◀



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3. System Diagram

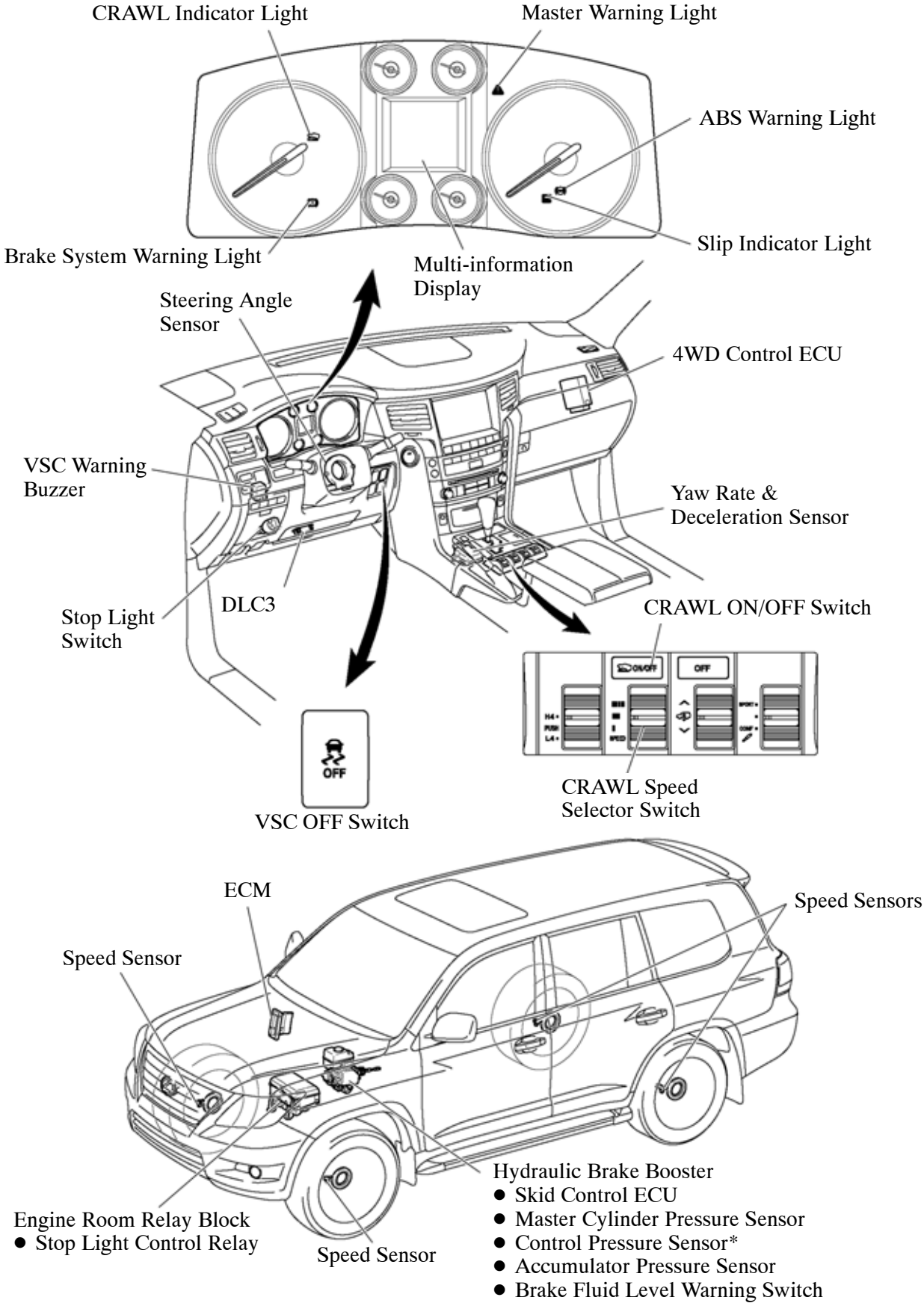


*: Only for Models with Pre-crash Safety System

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4. Layout of Main Components



*: Only for Models with Pre-crash Safety System

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5. Function of Main Components

Component			Function
Hydraulic Brake Booster (Including Brake Actuator)			● Assists with the brake pedal effort applied to the brake pedal. ● Changes the brake fluid path based on the signals from the skid control ECU during the operations of the multi-terrain ABS, EBD, brake assist, A-TRC, VSC, Hill-start Assist Control, and CRAWL in order to control the hydraulic pressure that is applied to the wheel cylinders.
	Master Cylinder Pressure Sensor		Detects the master cylinder pressure.
	Accumulator Pressure Sensor		Detects the accumulator pressure.
	Control Pressure Sensor*		Detects the control hydraulic pressure output by the accumulator.
	Brake Fluid Level Warning Switch		Detects the brake fluid level.
	Skid Control ECU		Judges the vehicle driving condition based on signals from each sensor, and sends brake control signals to the brake actuator.
		Solenoid Relay	Supplies or cuts off power to control solenoid valves and switching solenoid valves in the brake actuator.
		Pump Motor Relay	Supplies or cuts off power to pump motor.
Combination Meter		Brake System Warning Light	● Lights up to alert the driver when a malfunction occurs in the EBD or skid control ECU. ● Lights up to alert the driver that the hydraulic pressure of the accumulator in the hydraulic brake booster has decreased. ● Lights up to alert the driver when the brake fluid in the reservoir tank reaches the low level.
		ABS Warning Light	Lights up to alert the driver when the skid control ECU detects a malfunction in the multi-terrain ABS or Brake Assist system.
		CRAWL Indicator Light	Lights up to inform the driver when the CRAWL ON/OFF switch turned ON.
		Slip Indicator Light	Blinks to inform the driver when the A-TRC, VSC, Hill-start Assist Control, or CRAWL is operated.
		Multi-information Display	Informs the driver of the status of the brake control system.
		Master Warning Light	Informs the driver of the status of the brake control system.
VSC warning Buzzer			This buzzer has 3 types of sounds. ● This buzzer sounds intermittently to inform the driver that the VSC and Hill-start Assist Control are actives. ● This buzzer sounds intermittently to inform the driver if the temperature of the brake actuator has increased excessively due to the continuous operation of the A-TRC, Hill-start Assist Control, and CRAWL. ● This buzzer sounds continuously to alert the driver that the hydraulic pressure of the accumulator in the hydraulic brake booster has decreased, and that the power supply system has a malfunction.

(Continued)

*: Only for Models with Pre-crash Safety System

Component	Function
VSC OFF Switch	● By pressing the switch, only the A-TRC engine control is brought to a halt. ● By pressing the switch for more than 3 seconds, both the A-TRC and VSC stop operating.
CRAWL ON/OFF Switch	Turns the CRAWL ON and OFF.
CRAWL Speed Selector Switch	Used to select the target vehicle speed when the CRAWL is active.
Speed Sensor	Detects the wheel speed and rotating direction of each of 4 wheels.
Steering Angle Sensor	Detects the steering direction and angle of the steering wheel.
Yaw Rate & Deceleration Sensor	● Detects the vehicle's yaw rate. ● Detects the vehicle's acceleration and deceleration in the forward, rearward, and lateral directions.
Stop Light Control Relay	Turns on the stop light during Hill-start Assist Control, or CRAWL, or dynamic radar cruise control, or Pre-crash brake operation.
Stop Light Switch	Detects the brake pedal depressing signal.
Parking Brake Switch	Detects that the parking brake lever is pulled up.
ECM	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.
4WD Control ECU	Detects the transfer condition shifted in the L4 and sends the L4 signal to the skid control ECU.

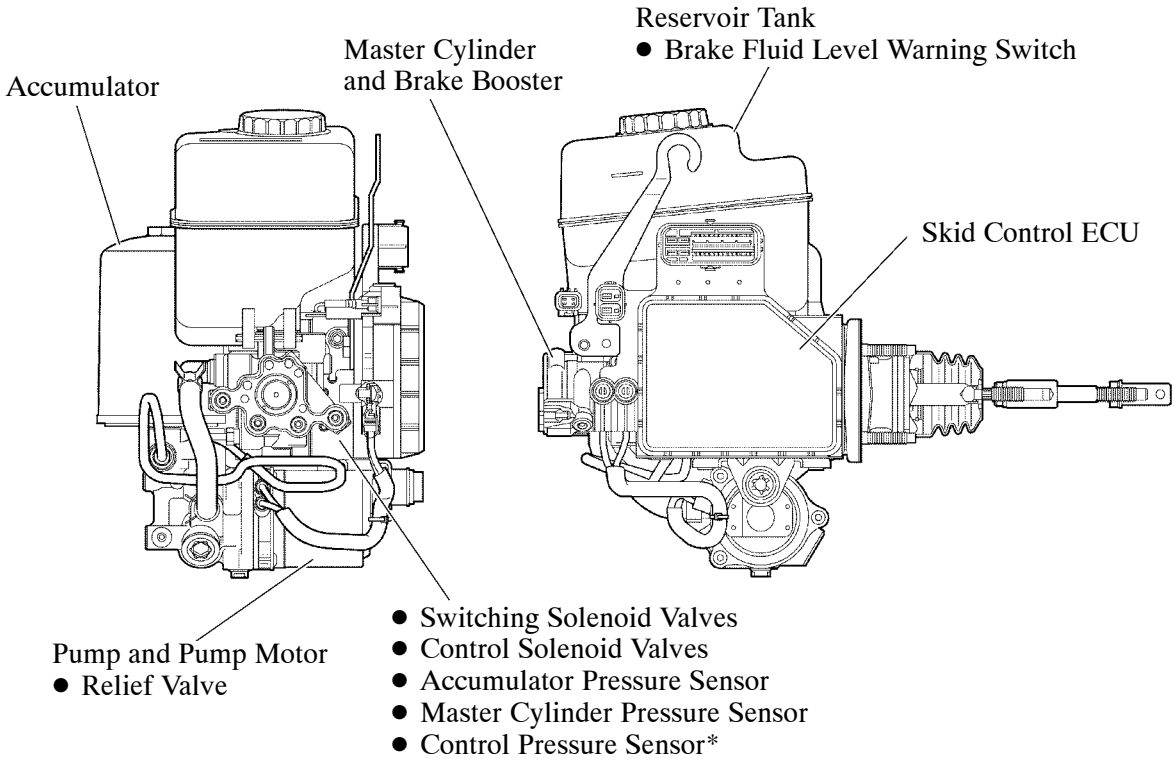
6. Construction of Main Components

Hydraulic Brake Booster

1) General

The hydraulic brake booster consists of the brake pressure generation portion, power supply portion, and brake control portion.

- The brake pressure generation portion consists of a master cylinder and brake booster and a master cylinder pressure sensor.
- The power supply portion consists of a pump and pump motor, a relief valve, a reservoir tank, a brake fluid level warning switch, an accumulator and an accumulator pressure sensor.
- The brake control portion consists of a skid control ECU, four switching solenoid valves, and eight control solenoid valves.



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*: Only for Models with Pre-crash Safety System

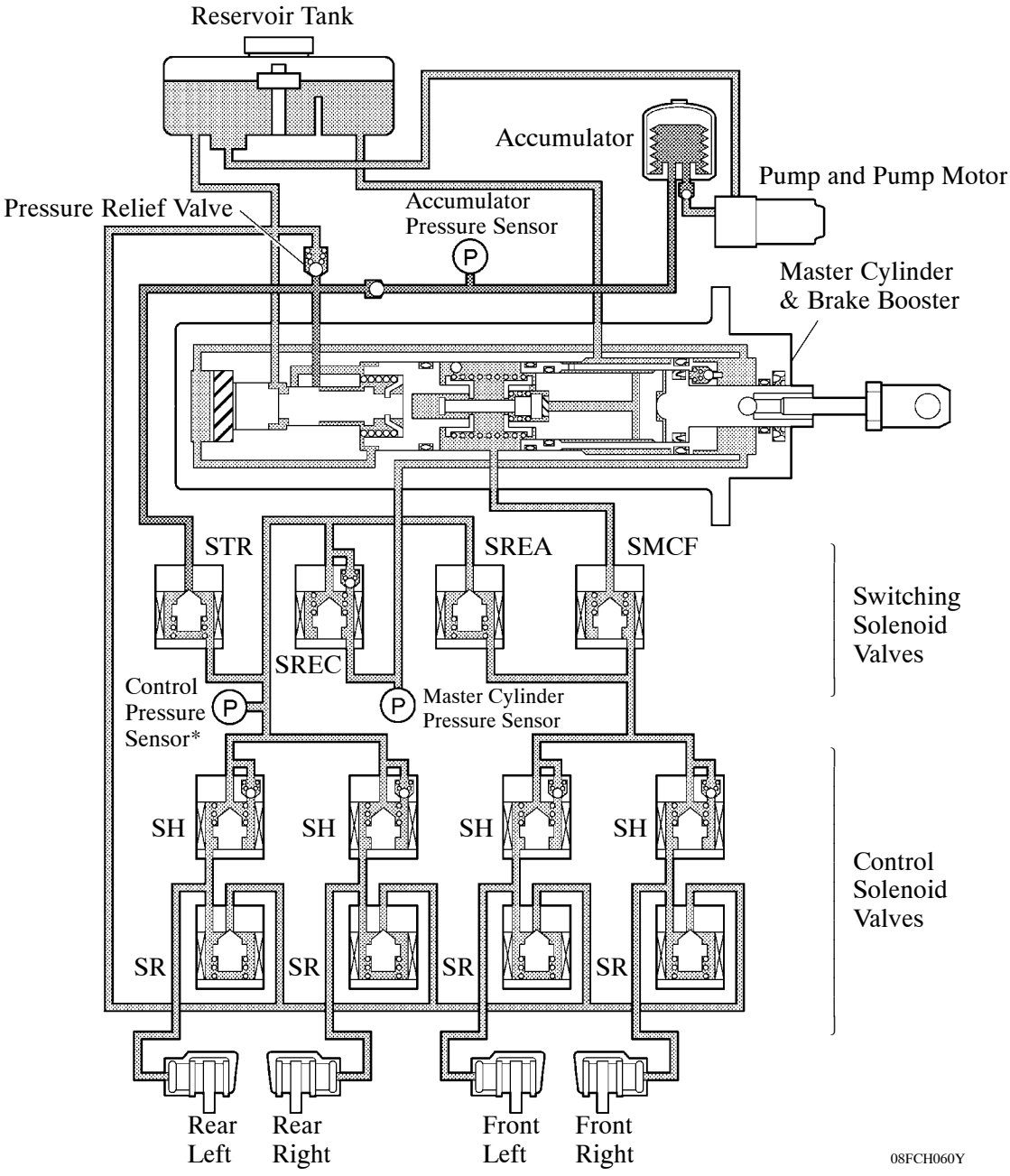
2) Components of Hydraulic Brake Booster

The hydraulic brake booster consists of the following components:

Component		Function
Brake Pressure Generation Portion	Master Cylinder and Brake Booster	● Generates the hydraulic pressure that is provided to the wheel cylinders during normal brake. ● Regulates the accumulator pressure in accordance with the pedal effort that is applied to the brake pedal and introduce this pressure to the booster chamber in order to provide a power assist to the brakes.
	Master Cylinder Pressure Sensor	Detects the master cylinder pressure and outputs this signal to the skid control ECU.
Power Supply Portion	Pump and Pump Motor	Draws up the brake fluid from the reservoir tank and provides high hydraulic pressure to the accumulator.
	Accumulator	Stores the hydraulic pressure that was generated by the pump. The accumulator is filled with high-pressure nitrogen gas.
	Accumulator Pressure Sensor	Monitors the hydraulic pressure of the accumulator and outputs this signals for the pump motor control.
	Relief Valve	Returns the brake fluid to the reservoir tank to prevent excessive pressure if the pump operates continuously due to a malfunction of the pressure sensor.
	Reservoir Tank	Stores the brake fluid.
	Brake Fluid Level Warning Switch	Detects the low brake fluid level.
Brake Control Portion	Switching Solenoid Valve	Switches the brake hydraulic path when the brake control system is activated.
	Control Solenoid Valve	Controls the hydraulic pressure that is applied to the wheel cylinders during brake control.
	Control Pressure Sensor*	In the brake control of the pre-crash safety system, hydraulic pressure is applied from the accumulator to each wheel cylinder, generating braking force automatically. The control pressure sensor detects the control hydraulic pressure at that time.
	Skid Control ECU	● Judges the vehicle driving condition based on signals from each sensor, and controls multi-terrain ABS with EBD, brake assist, A-TRC, Hill-start Assist Control, and CRAWL. ● Operates the pump and pump motor to control accumulator pressure based on accumulator pressure sensor signal.

*: Only for Models with Pre-crash Safety System

3) Hydraulic Circuit



SMCF: Master Cut for Front Solenoid Valve
SREA: Regulator Apply for Front Solenoid Valve
SREC: Regulator Cut Solenoid Valve
STR: Traction Solenoid Valve (Accumulator Cut Solenoid Valve)
SH: Pressure Holding Solenoid Valve
SR: Pressure Reduction Solenoid Valve

*: Only for Models with Pre-crash Safety System

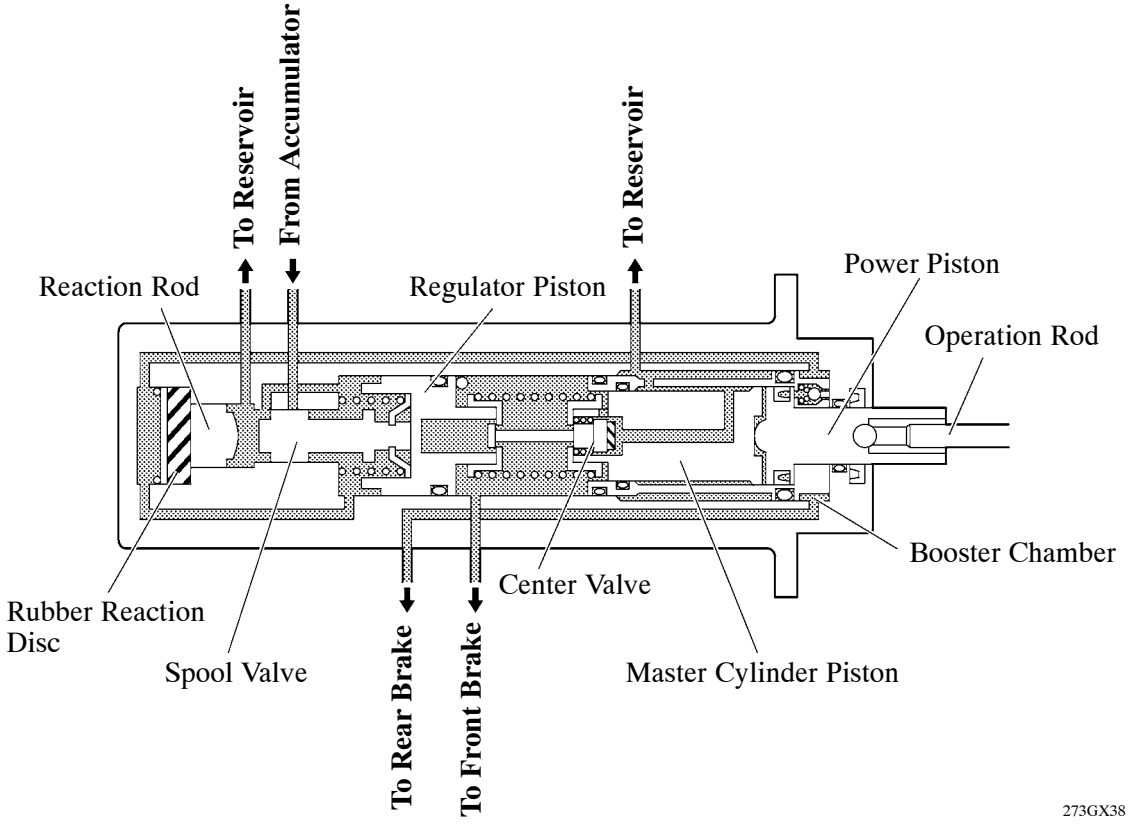
4) Master Cylinder and Brake Booster

a. Construction

The master cylinder and brake booster consists of the brake booster portion, master cylinder portion, and regulator portion. These are positioned coaxially to achieve a simple and compact construction.

- The brake booster portion consists of an operation rod, a power piston and a booster chamber.
- The master cylinder portion consists of a master cylinder piston (large diameter piston and small diameter piston), a return spring and a center valve.
- The regulator portion consists of a regulator piston, a return spring, a spool valve, a reaction rod, and a rubber reaction disc.

▶ Simplified Diagram ◀



b. Operation

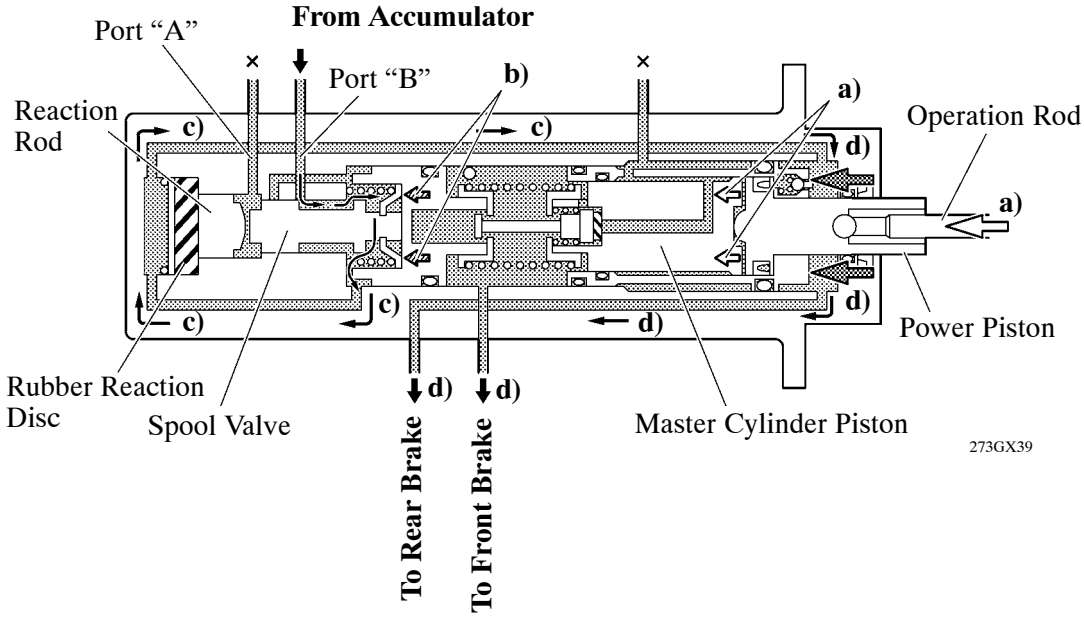
i) Pressure Increase (Low Pressure)

a) The pedal operation force is transmitted as follows: operation rod → power piston → master cylinder piston (small diameter piston)

b) The load setting of the master cylinder's return spring is higher than that of the regulator piston's return spring. Therefore, the regulator piston gets pushed before the fluid in the master cylinder becomes compressed.

c) The spool valve closes the port "A" (between the reservoir tank and booster chamber) and opens the port "B" (between the reservoir tank and accumulator). Then, the pressurized brake fluid is introduced into the booster chamber to provide a power assist to the pedal effort. The pressure of the pressurized brake fluid is transmitted to the large diameter master cylinder piston.

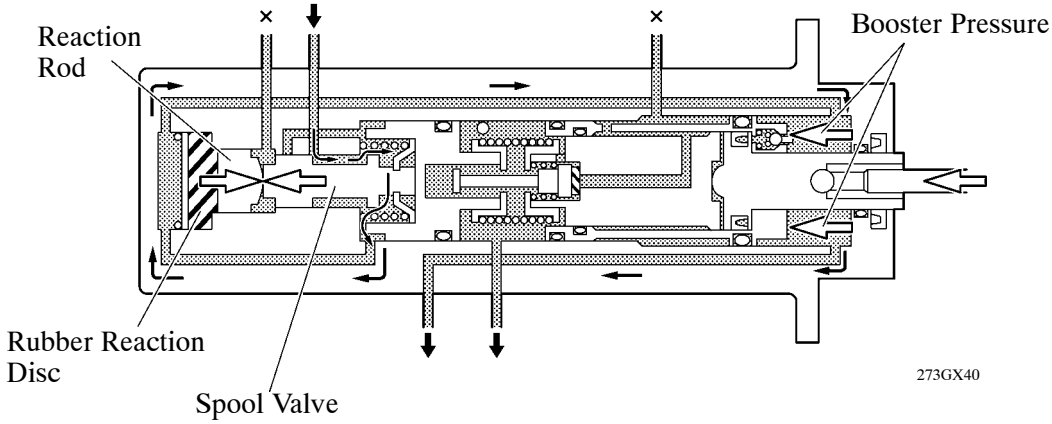
d) This time, the power assist overcomes the force of the master cylinder's return spring. This causes the fluid in the master cylinder to become compressed and increased the pressure that is applied to the front brakes. At the same time, the pressure in the booster chamber increases the pressure that is applied to the rear brakes.



During the initial stage of the brake operation, the booster pressure that is applied to the rubber reaction disc is small. Therefore, a return force in the rightward direction is not applied to the spool valve via the reaction rod.

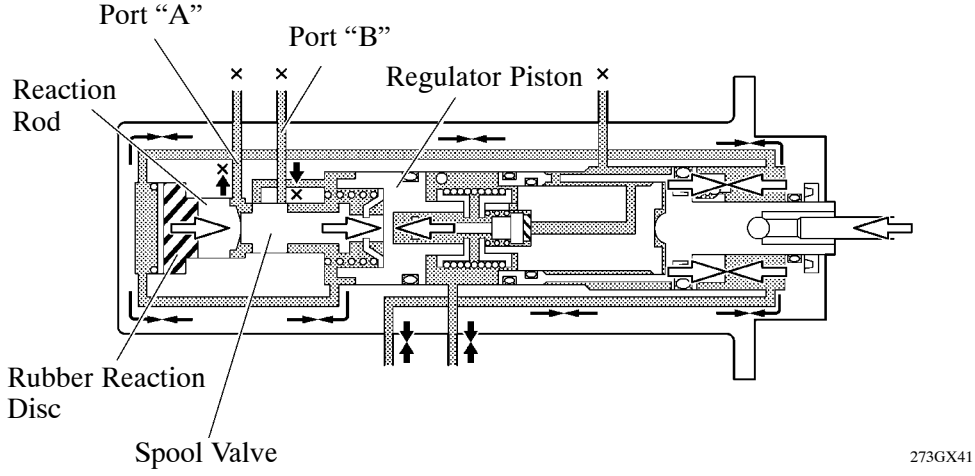
ii) Pressure Increase (High Pressure)

In contrast to the time when the pressure is low, when the pressure is high, the booster pressure that is applied to the rubber reaction disc increases. Accordingly, the rubber reaction disc deforms and causes a return force in the rightward direction to be applied to the spool valve via the reaction rod. Therefore, in contrast to the time when the pressure is low, a greater reaction force is transmitted to the brake pedal.
As a result, a variable servo mechanism is realized, in which the servo ratio is lower during high pressure than during low pressure.



iii) Holding

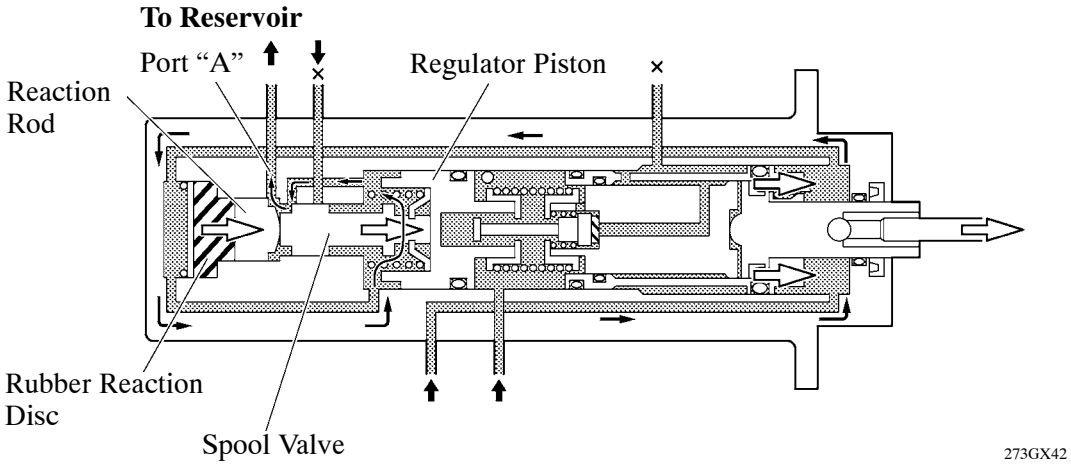
This is a state in which the force that is applied via the brake pedal and the master cylinder pressure are in balance.
The forces that are applied to the front and the rear of the regulator piston, in other words, forces that are generated by the master cylinder pressure and the regulator pressure become balanced. This causes the spool valve to close both the port "B" (between the reservoir tank and the accumulator) and the port "A" (between the booster chamber and reservoir tank). As a result, the brake is in the holding state.



iv) Pressure Reduction

When the pressure that is applied to the brake pedal is released, the master cylinder pressure decreases. Then, the regulator piston's return (rightward) force becomes relatively greater, causing the regulator piston and the spool valve to retract. As a result, the port "A" between the reservoir tank and the booster chamber opens.

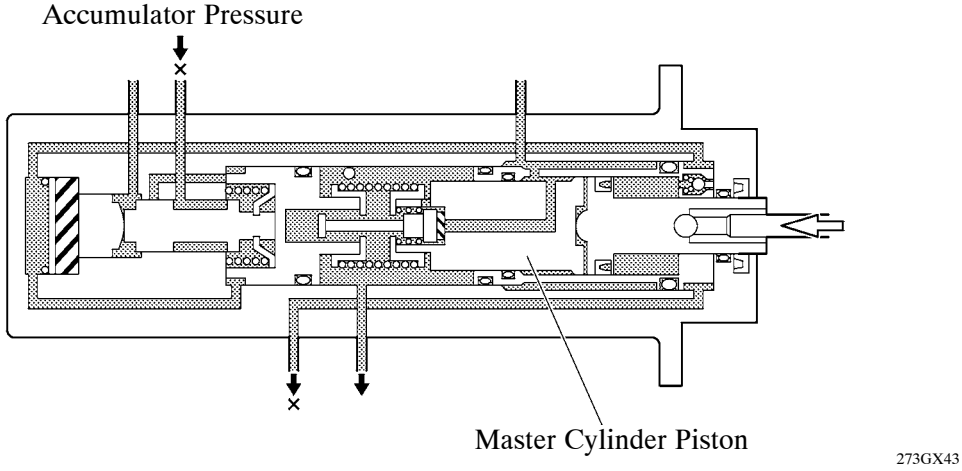
The booster pressure becomes reduced in this state, creating a balance that corresponds to the change of brake pedal application force. This process occurs constantly to reduce the booster pressure and the master cylinder pressure in accordance with the force that is applied via the brake pedal.



v) During Brake Pressure Supply Malfunction

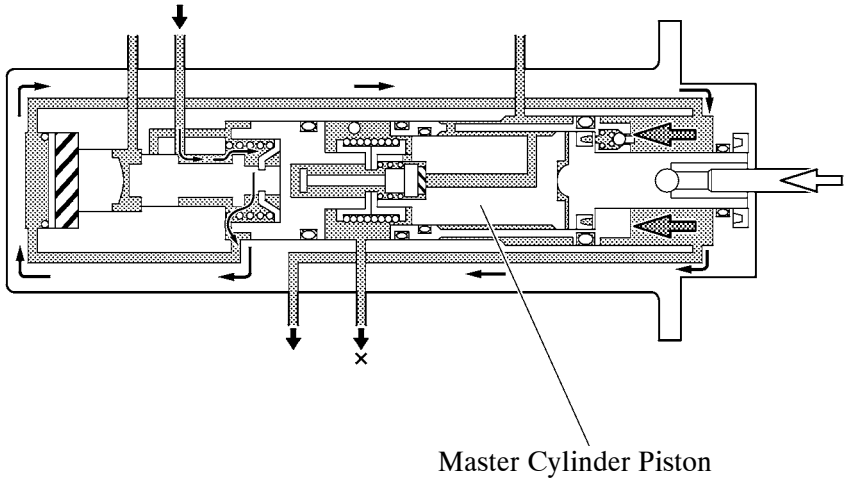
If the accumulator pressure is affected by any malfunction, no hydraulic pressure will be supplied to the booster chamber. For this reason, a power assist cannot be provided to the force that is applied via the brake pedal and the pressure to the rear brakes cannot be increased. Since there is no pressurized brake fluid in the large diameter master cylinder piston at this time, the piston does not move from the original position.

However, the pressure to the front brakes will be increased at the small diameter master cylinder piston in accordance with the pedal effort applied to the brake pedal.



vi) Front Brake System Malfunction

If the front brake system malfunctions, the master cylinder piston is moved by the booster chamber pressure but the hydraulic pressure does not increase.
The rear brake system operates the same as in the normal operation.

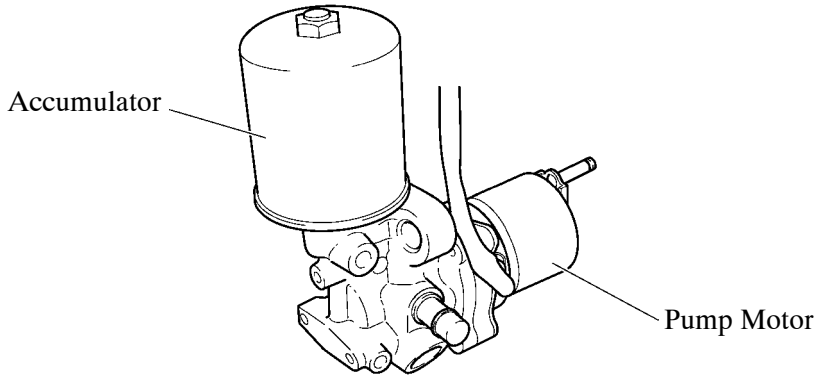


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5) Pump and Accumulator

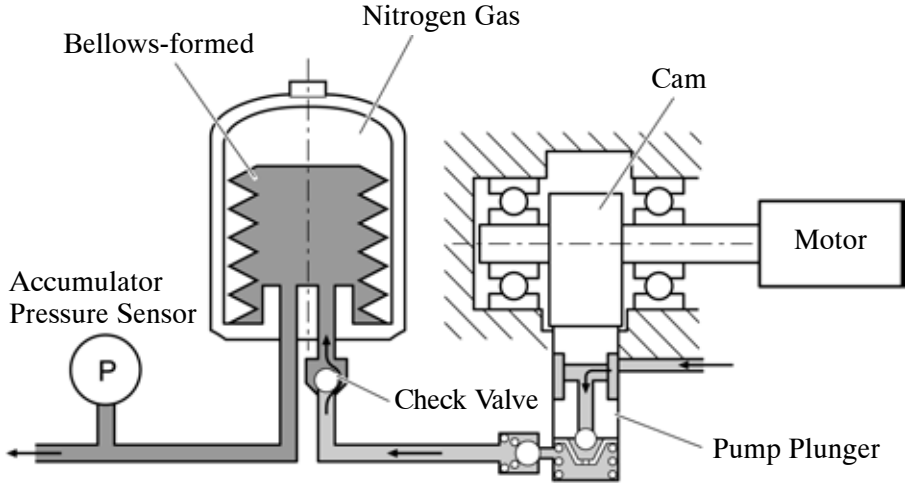
General

- A plunger type pump is used. This pump is driven by the pump motor, and generates high hydraulic pressure, and then supplies the hydraulic pressure to the accumulator.
- Inside the accumulator, the high-pressurized nitrogen gas is charged and sealed. In addition, metallic bellows-formed tube is used, in order to enhance the gastight performance of the accumulator.



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▶ Simplified Diagram ◀



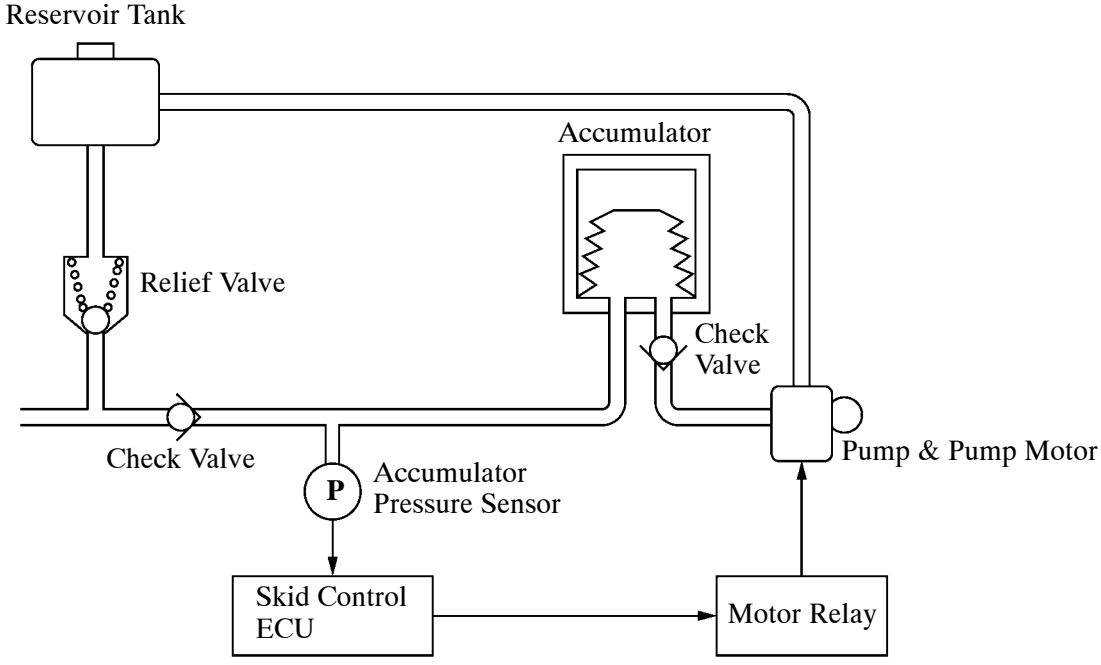
080CH85Z

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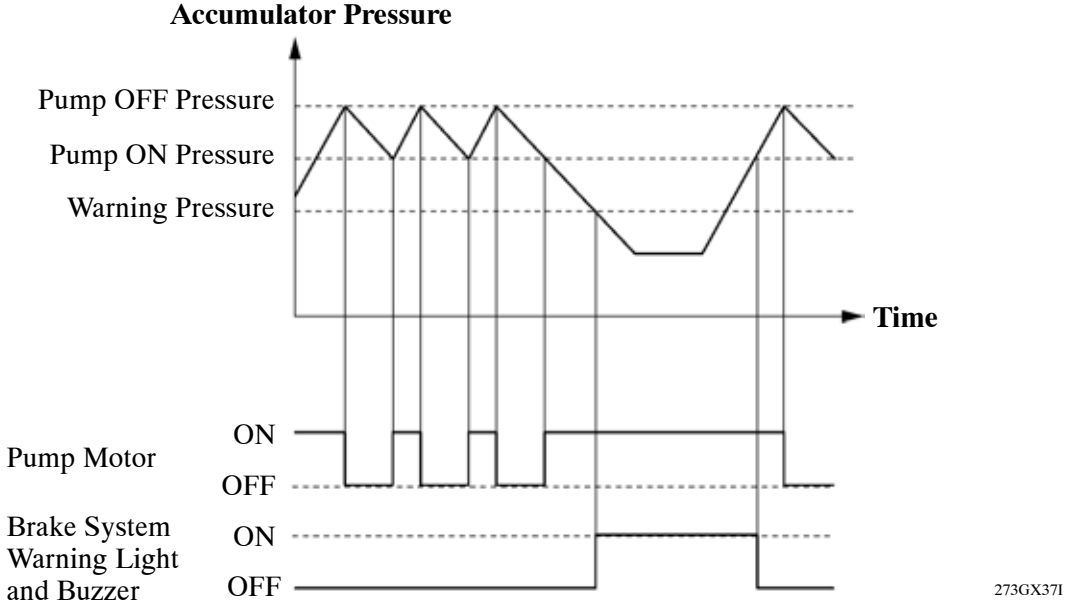
Operation

The power supply portion operates based on the accumulator pressure sensor signal as shown in the timing chart below.

- When the accumulator pressure drops to “pump ON pressure”, the skid control ECU operates the pump and pump motor.
- When the accumulator pressure increases to “pump OFF pressure”, the skid control ECU stops the pump and pump motor.
- When the accumulator pressure drops below the “warning pressure” level, the skid control ECU illuminates all warning and indicator lights other than the CRAWL indicator light, displays messages on the multi-information display, and sounds the VSC brake warning buzzer continuously.



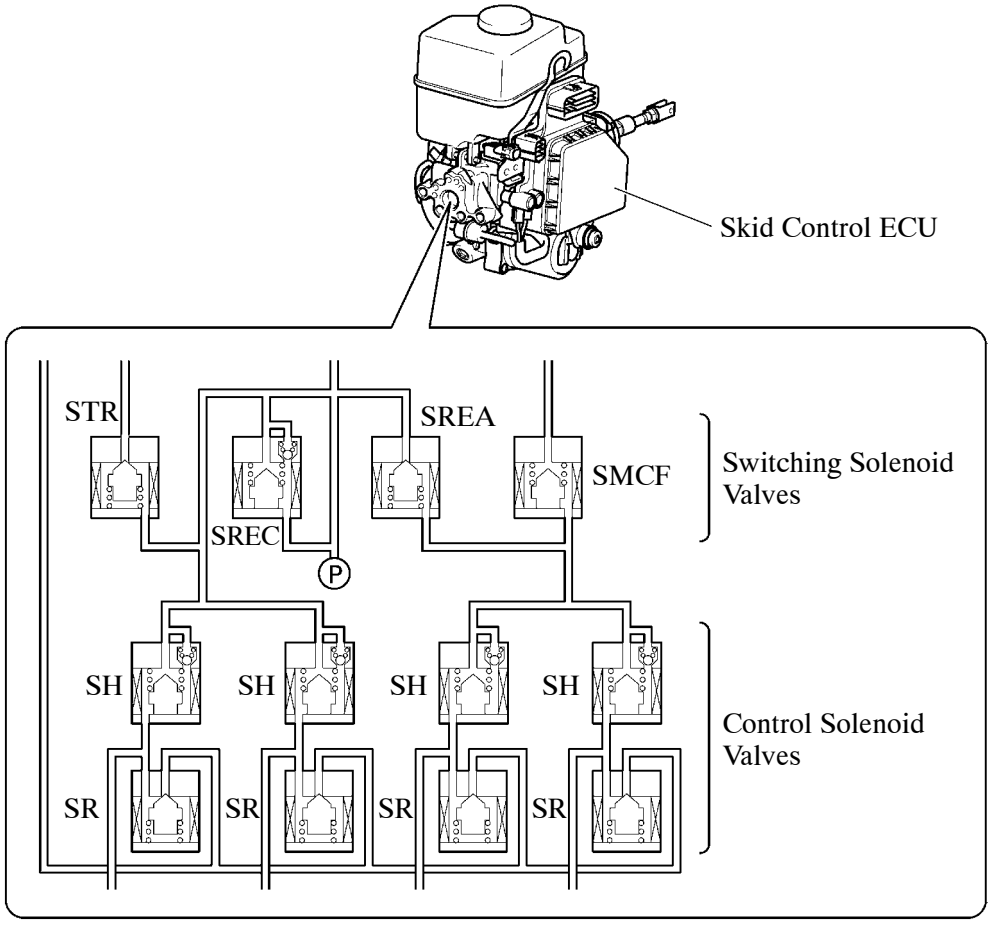
▶ Timing Chart ◀



6) Brake Control Portion

General

The brake control portion consists of switching solenoid valves, control solenoid valves and skid control ECU.



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Solenoid Valve

There are two types of solenoid valves: the switching solenoid valve and the control solenoid valve. The pressure increase mode, the pressure holding mode, and the pressure reduction mode are effected based on the combination of these valves that are turned ON and OFF, in order to control the hydraulic pressure that is applied to each of the wheel cylinders.

- A total of 4 switching solenoid valves are used: 2 (SMCF, SREA) in the front brake fluid path, 1 (SREC) in the rear brake fluid path, and 1 (STR) in the accumulator fluid path. The switching valves open and close in accordance with the control signals from the skid control ECU in order to switch the respective brake fluid paths.
- A total of 8 control solenoid valves are used for the 4 wheels (2 types per wheel: pressure holding solenoid and pressure reduction solenoid).

Combination Meter

1) Warning Light, Indicator Light and VSC Warning Buzzer

The warning and indicator lights and VSC warning buzzer operate as follows:

○: Illuminates (Continuous Sound) △: Blinks (Intermittent Sound)

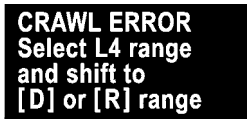
Condition		Warning Light		Indicator Light		Buzzer
		BRAKE	ABS	SLIP	CRAWL	
Initial Check		○	○	○	○	
During Operation	A-TRC			△		
	VSC			△		△
	Hill-start Assist Control			△		△
	CRAWL			△	○*1	△*2
During Actuator Protection				○	△	
Cannot operate due to a malfunction	Multi-terrain ABS		○			
	EBD	○	○			
	Brake Assist		○			
	A-TRC			○		
	VSC			○		
	Hill-start Assist Control			○		
	CRAWL			○		
Others	Low Brake Fluid Level	○		○		
	Low Accumulator Pressure	○	○	○		○

*1: When only the brake control of the CRAWL is operating, the CRAWL indicator light blinks.
*2: When the control of the CRAWL is finished, buzzer sounds intermittently for 3 seconds.

2) Multi-information Display

The skid control ECU displays the status of the brake control system or system malfunctions on the multi-information display to inform the driver of the system status or malfunctions.

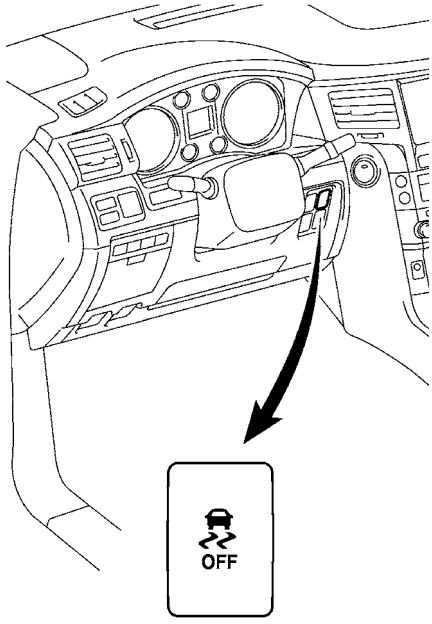
○: Illuminates (Continuous Sound)

Display	Details	Master Warning Light	Buzzer
 08FCH061Y	Displayed when a malfunction occurs in any one of the A-TRC, VSC, Hill-start Assist Control, or CRAWL.	○	○
 08FCH062Y	VSC test mode is activated.		
 08FCH063Y	Displayed when the A-TRC and VSC stop operating.	○	○
 08FCH064Y	Displayed when all the CRAWL controls stop operating.		
 08FCH065Y	Displayed when the CRAWL ON/OFF switch is turned ON. Simultaneously, the target vehicle speed (Lo, Mid or Hi), which is selected using the CRAWL speed selector switch, is displayed.		
 08FCH066Y	Displayed when the CRAWL ON/OFF switch is turned ON in either of the following situations: ● Transfer is in H4 range ● Shift position is in P or N		
 08FCH067Y	Displayed when the CRAWL ON/OFF switch is turned ON in any one of the following situations: ● Vehicle is running ● Parking brake is being applied ● Brake pedal is not being depressed ● Driver's door is open ● CRAWL is malfunctioning ● ECT mode is 2nd start mode		

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VSC OFF Switch

- The VSC OFF switch has been provided.
- The VSC OFF switch can stop the engine control of the VSC function and A-TRC function regardless of the position of the transfer range or the condition of the center differential switch.



VSC OFF Switch

08FCH068Y

▶ Cancel Operation ◀

VSC OFF Switch Operation	Contents
Press the switch once	● The A-TRC engine control stops operating. ● The control can be resumed by pressing the switch again or when the vehicle speed increases.
Press and hold the switch for more than 3 seconds when the vehicle is stationary.	● The A-TRC and VSC stop operating. ● The A-TRC and VSC can be resumed by pressing the switch.

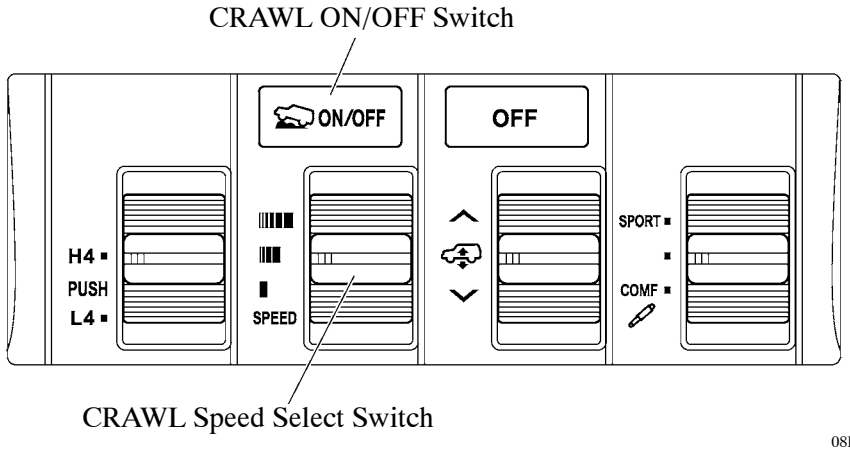
NOTE

- The A-TRAC and VSC functions control brake hydraulic pressure and engine output to ensure vehicle stability. Therefore, operate the VSC OFF switch (stop the operation of the A-TRC and VSC functions) only when it is necessary.
- When the transfer is in the L4 range and the center differential is not locked, even when both the A-TRC and VSC are not operating, vehicle speeds less than 15 km/h (9 mph) may cause the A-TRC to be activated, however, this is not a malfunction.

CRAWL ON/OFF Switch and CRAWL Speed Select Switch

The CRAWL ON/OFF switch and the CRAWL speed select switch are placed on the center console.

- The CRAWL control is switched between ON and OFF by operating the CRAWL ON/OFF switch.
- The CRAWL control vehicle speed is changed by operating the CRAWL speed select switch.

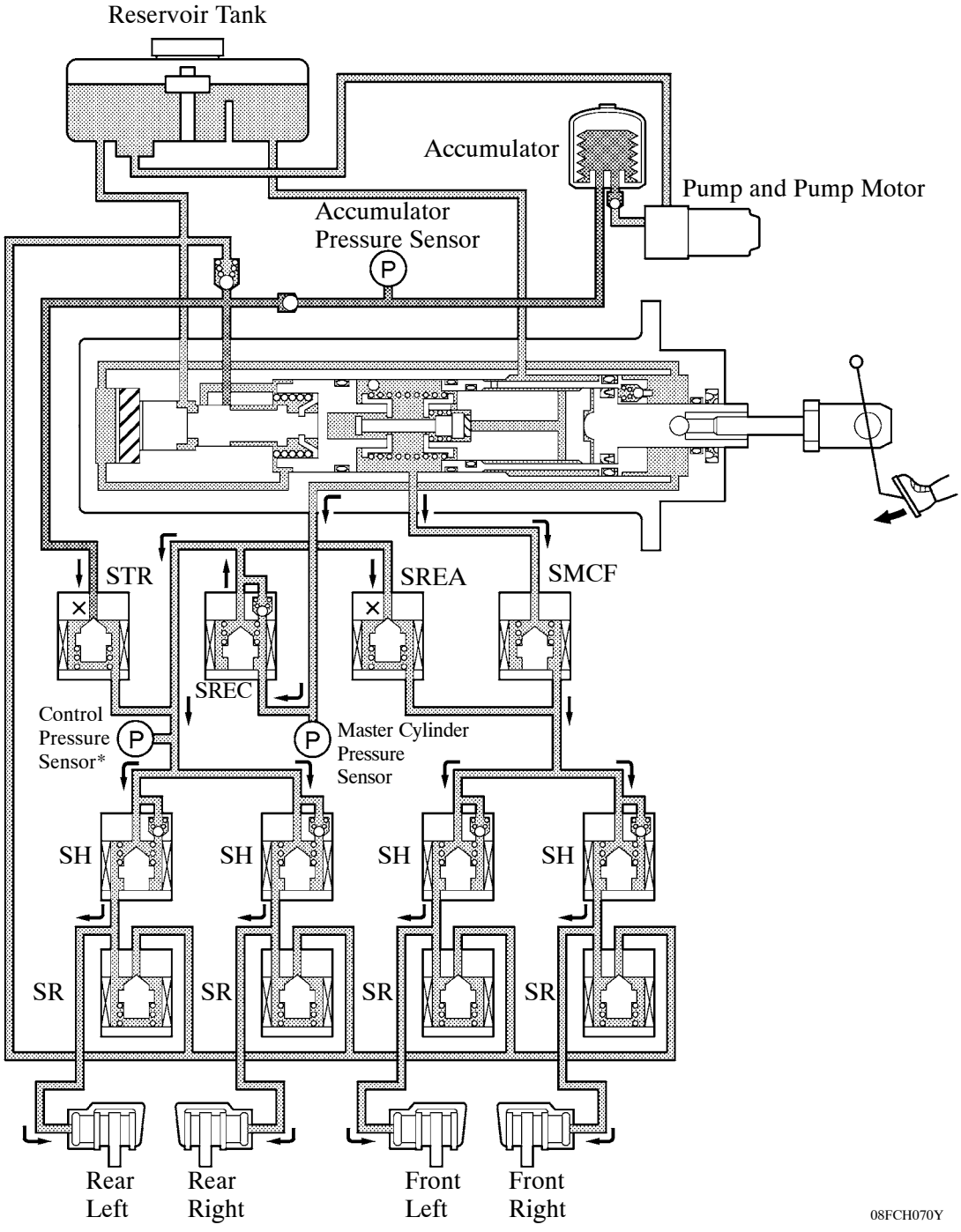


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7. System Operation

Normal Braking

During normal braking, all solenoid valves are turned OFF.



SMCF: Master Cut for Front Solenoid Valve
SREA: Regulator Apply for Front Solenoid Valve
SREC: Regulator Cut Solenoid Valve
STR: Traction Solenoid Valve (Accumulator Cut Solenoid Valve)
SH: Pressure Holding Solenoid Valve
SR: Pressure Reduction Solenoid Valve

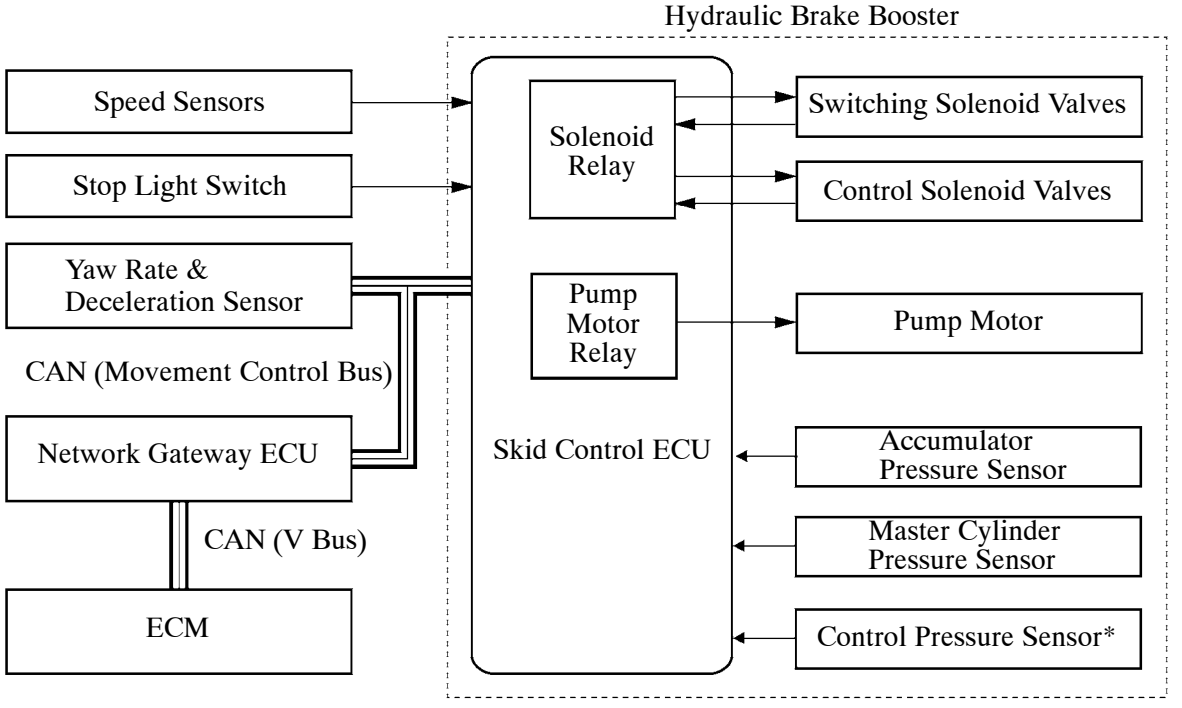
*: Only for Models with Pre-crash Safety System

Multi-terrain ABS and EBD Operation

During braking, the load moves in the longitudinal direction of the vehicle. This reduces the ground load of the rear wheels, making them more susceptible to slipping than the front wheels.
The skid control ECU calculates speed and deceleration of each wheel, and checks wheel slipping condition based on signals from the 4 wheel speed sensors and yaw rate & deceleration sensor as well as the engine output information transmitted from the ECM.

- The skid control ECU compares the speed sensor signals of the front and rear, judges the slipping condition of the rear wheel, and operates the EBD.
- If the wheel is likely to be locked, the skid control ECU controls the pressure holding solenoid valve and pressure reduction solenoid valve as multi-terrain ABS operation in the following three modes: increase, hold, and reduce.

▶ System Diagram ◀

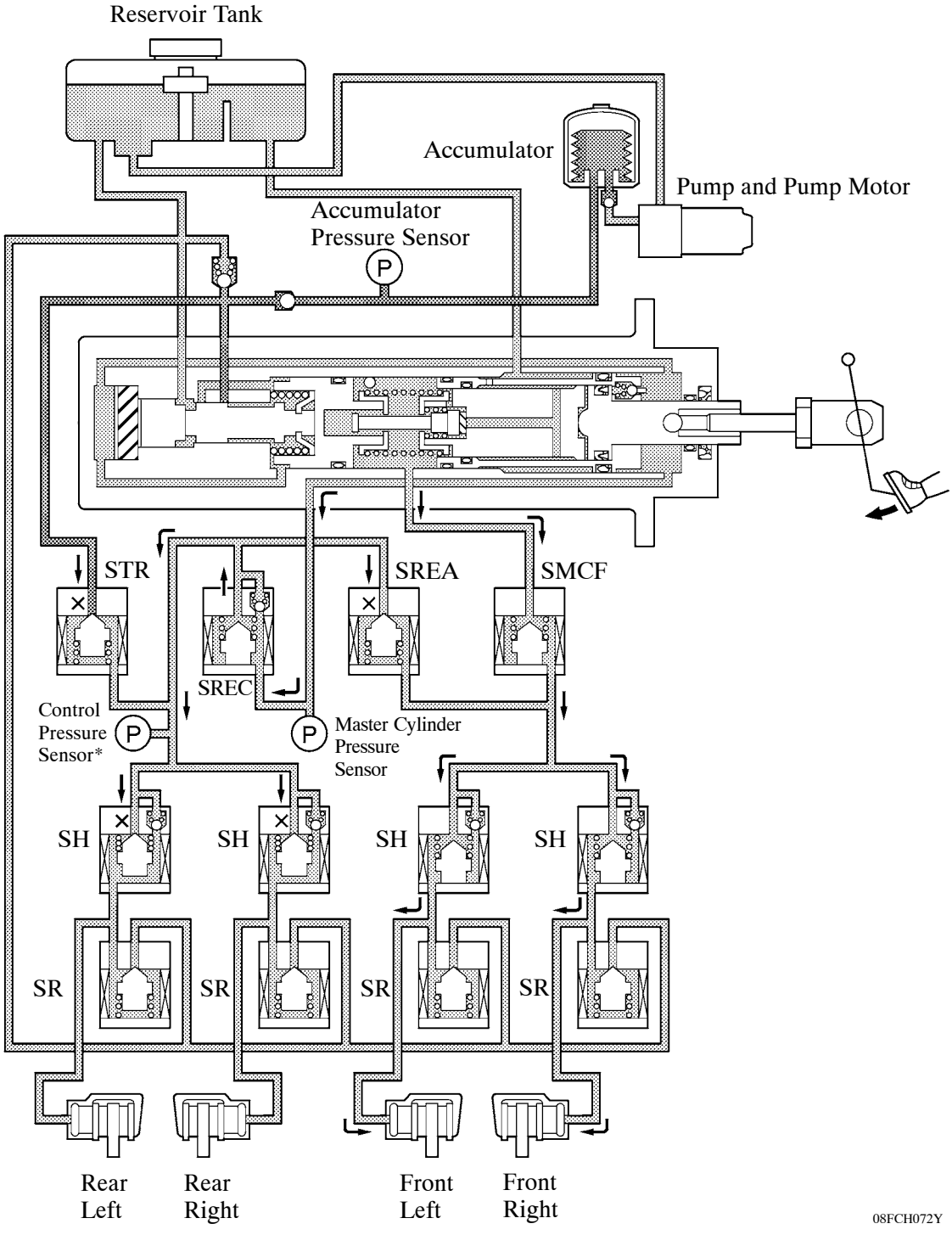


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*: Only for Models with Pre-crash Safety System

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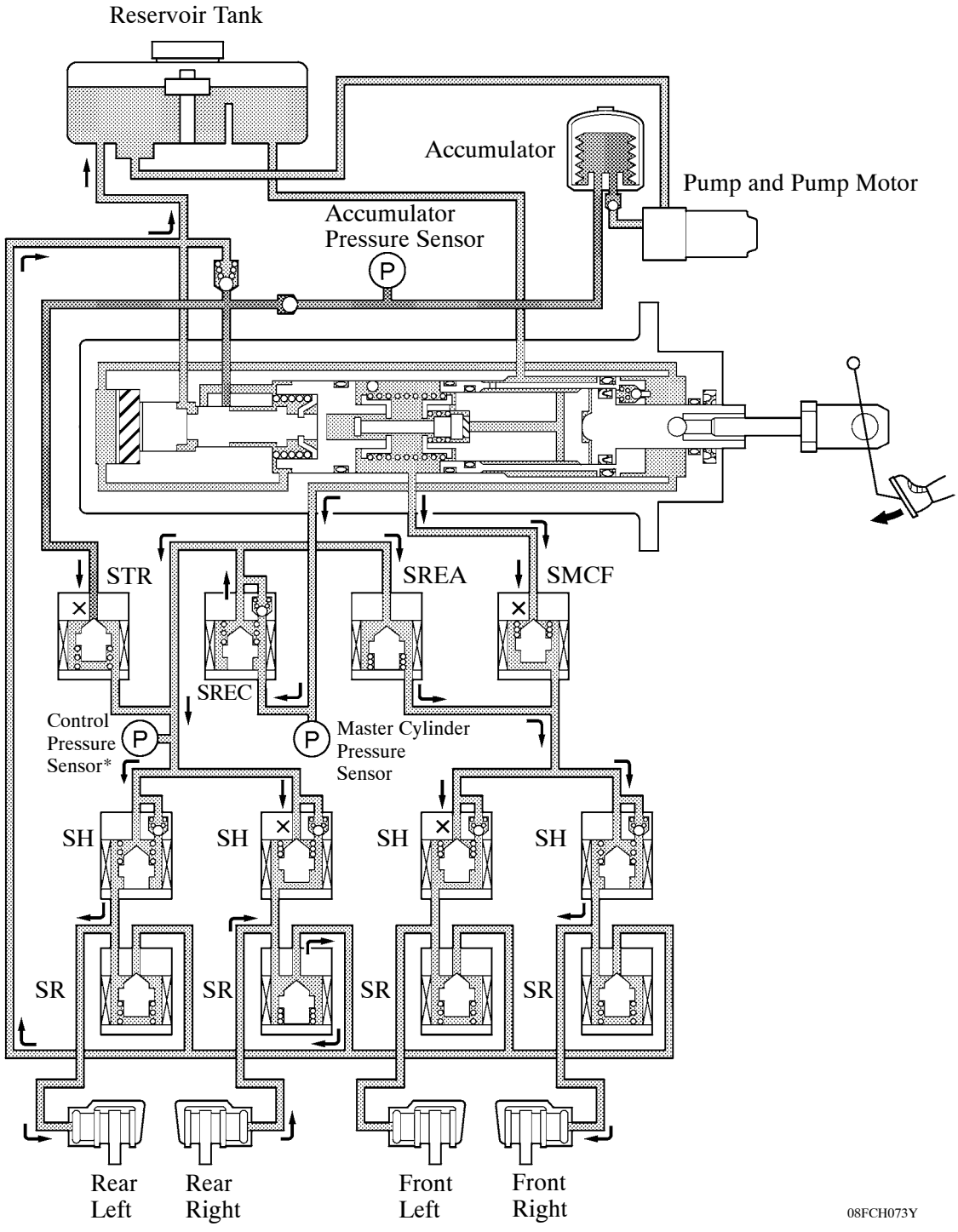
▶ EBD Operation ◀



SMCF: Master Cut for Front Solenoid Valve
SREA: Regulator Apply for Front Solenoid Valve
SREC: Regulator Cut Solenoid Valve
STR: Traction Solenoid Valve (Accumulator Cut Solenoid Valve)
SH: Pressure Holding Solenoid Valve
SR: Pressure Reduction Solenoid Valve

*: Only for Models with Pre-crash Safety System

▶ Multi-terrain ABS Operation ◀



SMCF: Master Cut for Front Solenoid Valve
SREA: Regulator Apply for Front Solenoid Valve
SREC: Regulator Cut Solenoid Valve
STR: Traction Solenoid Valve (Accumulator Cut Solenoid Valve)
SH: Pressure Holding Solenoid Valve
SR: Pressure Reduction Solenoid Valve

*: Only for Models with Pre-crash Safety System

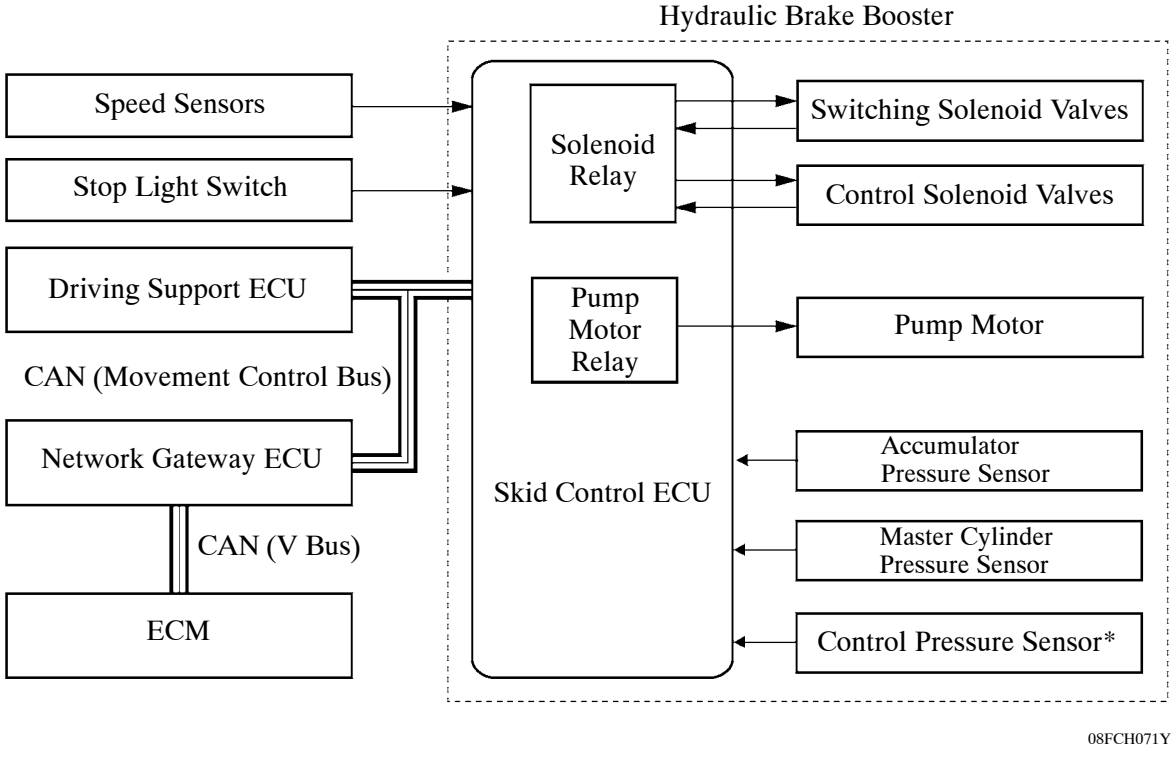
Item			Multi-terrain ABS, EBD Not Activated	Multi-terrain ABS, EBD Activated		
				Increase Mode	Holding Mode	Reduction Mode
Switching Solenoid Valve		SREC	OFF (Open)	←	←	←
		STR	OFF (Close)	←	←	←
		SMCF*1	OFF (Open)	ON (Close)	←	←
		SREA*1	OFF (Close)	ON (Open)	←	←
Control Solenoid Valve	Front Brake	SH	OFF (Open)	←	ON (Close)	←
		SR	OFF (Close)	←	←	ON (Open)
		Wheel Cylinder Pressure	—	Increase	Hold	Reduce
	Rear Brake	SH*2	OFF (Open)	←	ON (Close)	←
		SR	OFF (Close)	←	←	ON (Open)
		Wheel Cylinder Pressure	—	Increase	Hold	Reduce

*1: While the front wheels are in multi-terrain ABS operation, SMCF and SREA are ON.
While only rear wheels are in multi-terrain ABS operation, SMCF and SREA are OFF.
*2: During EBD operation, only SH for both rear wheels is ON (close).

Brake Assist Operation

If an emergency braking situation has occurred, it is detected by the skid control ECU based on the vehicle speed signal from the speed sensor, the brake pedal application speed from the master cylinder pressure sensor, and the signal representing the amount of pedal effort. Then, the skid control ECU actuates each solenoid valve. As a result, the pressure from the accumulator is applied to the wheel cylinders. The accumulator pressure that is applied to the wheel cylinders generates a higher pressure than the master cylinder.

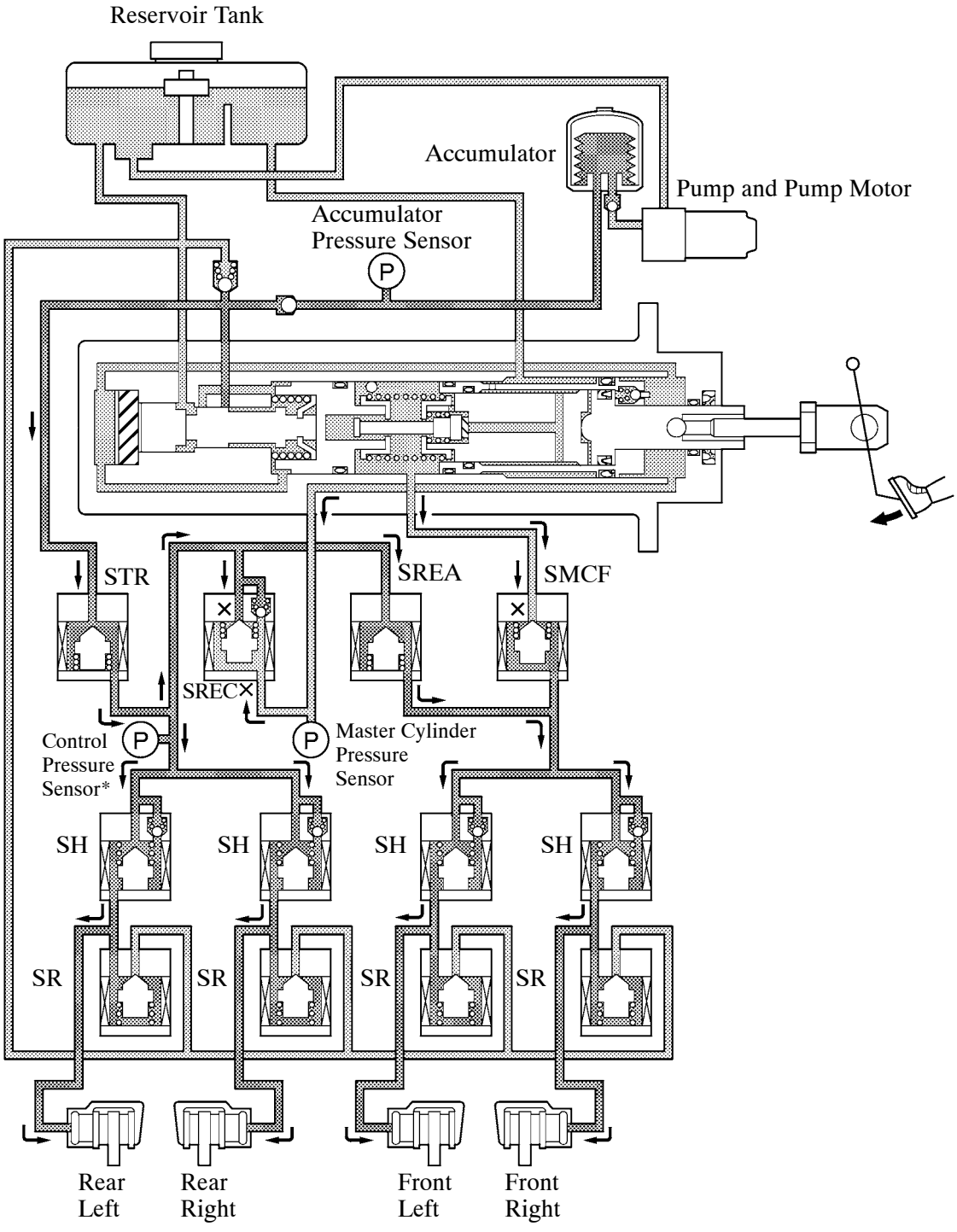
▶ System Diagram ◀



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*: Only for Models with Pre-crash Safety System

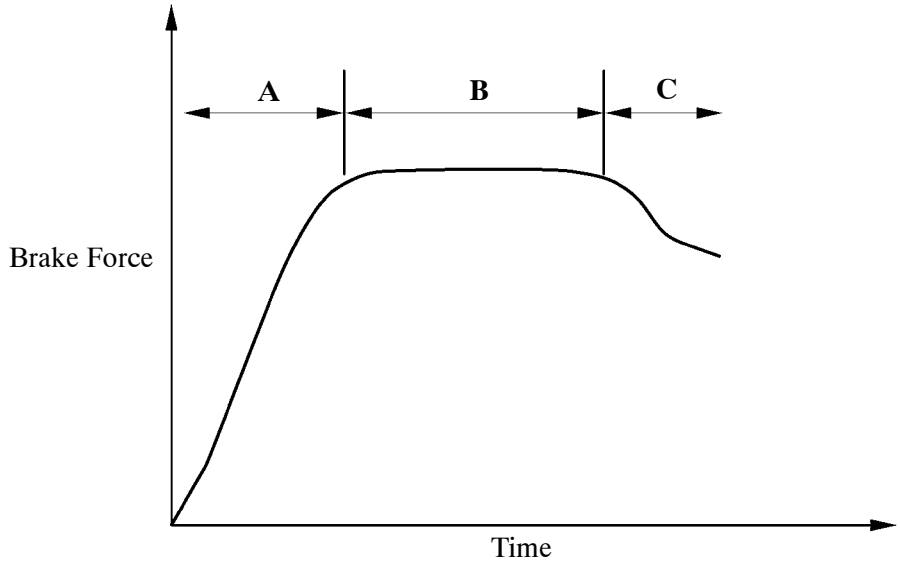
▶ Brake Assist Operation ◀



SMCF: Master Cut for Front Solenoid Valve
SREA: Regulator Apply for Front Solenoid Valve
SREC: Regulator Cut Solenoid Valve
STR: Traction Solenoid Valve (Accumulator Cut Solenoid Valve)
SH: Pressure Holding Solenoid Valve
SR: Pressure Reduction Solenoid Valve

*: Only for Models with Pre-crash Safety System

▶ Brake Assist Timing ◀



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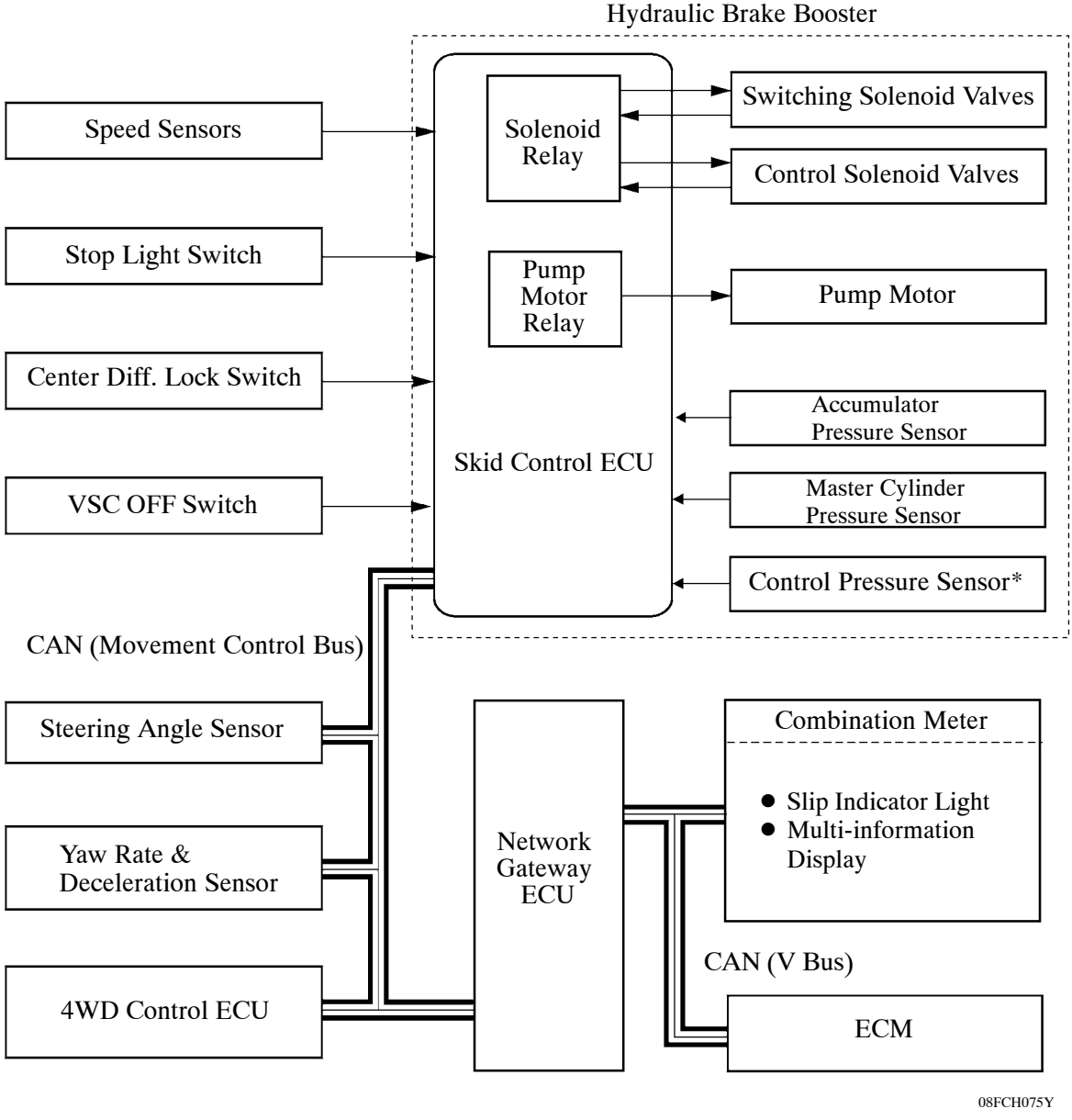
Item			Brake Assist Not Activated	Brake Assist Activated		
				A	B	C
Switching Solenoid Valve		SREC	OFF (Open)	ON (Close)	←	OFF (Open)
		STR	OFF (Close)	ON (Open)	←	OFF (Open)
		SMCF	OFF (Open)	ON (Close)	←	←
		SREA	OFF (Close)	ON (Open)	←	←
Control Solenoid Valve	Front Brake	SH	OFF (Open)	←	ON (Close)	OFF (Open)
		SR	OFF (Close)	←	←	←
		Wheel Cylinder Pressure	—	Increase	Hold	Reduce
	Rear Brake	SH	OFF (Open)	←	ON (Close)	OFF (Open)
		SR	OFF (Close)	←	←	←
		Wheel Cylinder Pressure	—	Increase	Hold	Reduce

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A-TRC Operation

- Based on the vehicle speed that has been calculated from each speed sensor and signals of the yaw rate and deceleration sensor, the skid control ECU computes the target control speed in accordance with the transfer range. The skid control ECU compares the target control speed and the speed of the wheels to determine whether or not slippage exists. Upon detecting slippage, the skid control ECU controls the solenoid valve of the hydraulic brake booster to control the brake fluid pressure that is applied to the slipping wheel. When the wheel speed becomes lower than the target control speed, the skid control ECU stops increasing the brake fluid pressure.

▶ System Diagram ◀



*: Only for Models with Pre-crash Safety System

- The engine output control of the A-TRC function varies in accordance with the range in which the transfer is engaged. When the transfer is engaged in the H4 range, this function effects engine output control that varies between stability-priority and drivability-priority in accordance with the amount of pedal effort applied to the accelerator pedal. When the transfer is engaged in the L4 range, it affects engine output control on a drivability-priority basis.
- As shown in the table below, the target control speed and the brake fluid pressure control vary in accordance with the transfer range.

Road Condition	Transfer Range	Control		Outline
Ordinary Road	H4	Target Control Speed	Vehicle Speed + Slip Rate (H range set value)	Control designed to ensure the ease of driving on low-friction roads, dirt roads, and general roads.
		Brake Control	Gradual Fluid Pressure Control	
		Engine Output Control	Effects control only when center differential lock switch is OFF	
Rocky or Rough Road	L4	Target Control Speed	Vehicle Speed + Slip Rate (L range set value)	Control designed for rugged off-road driving.
		Brake Control	Sudden Fluid Pressure Control	
		Engine Output Control	Not Control	
Downhill	L4 + 1st gear	Target Control Speed	Vehicle speed when deceleration slippage has been determined during downhill driving.	Designed for rugged, off-road downhill driving with the engine brake applied. It prevents the acceleration of the vehicle that could be caused by releasing the engine brake.
		Brake Control	Fluid pressure control to each wheel	

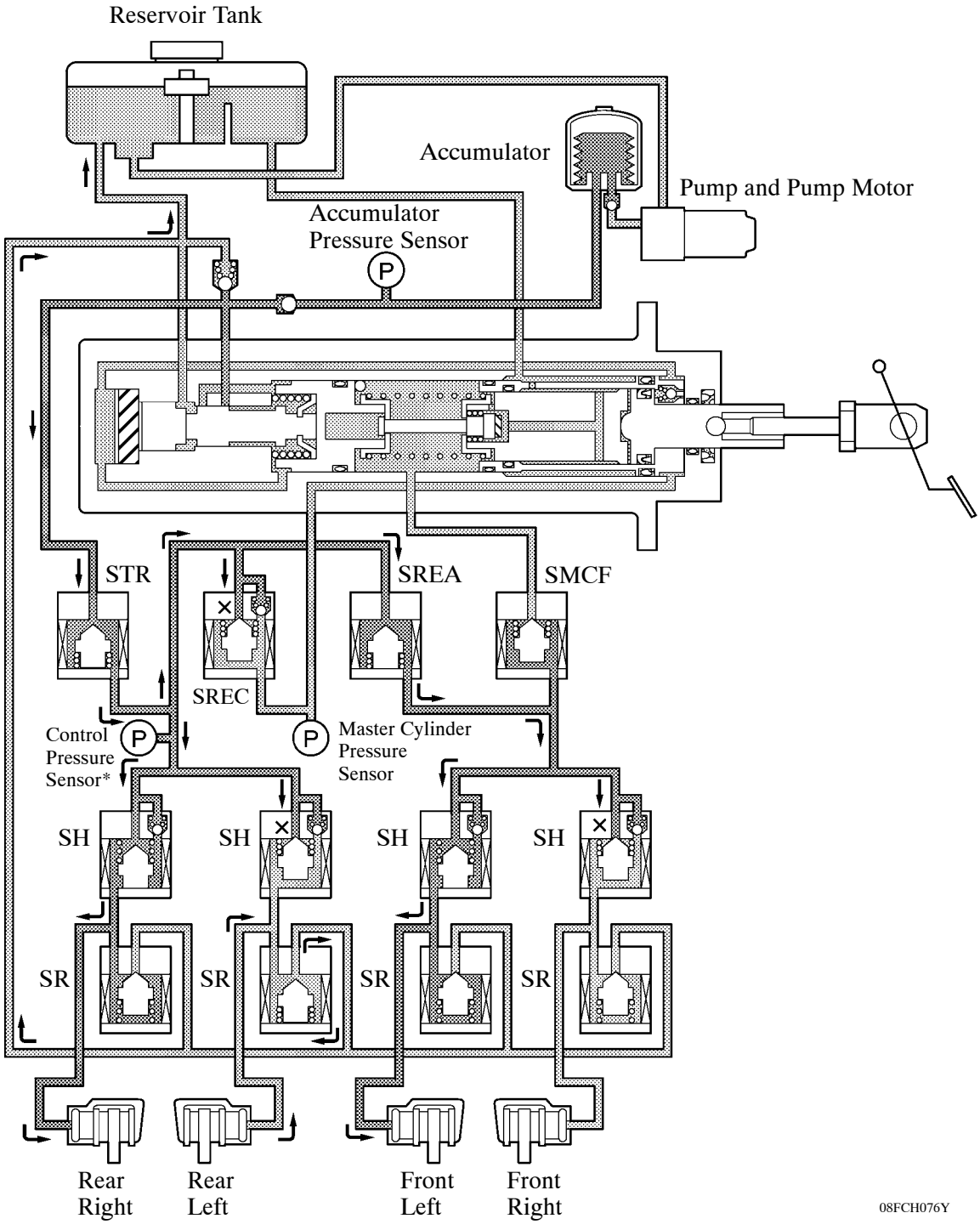
NOTICE

Precaution on A-TRC Operation

When the A-TRC is operating continuously while the vehicle is being driven on a slippery surface, the temperature of the actuator in the hydraulic brake booster increases. After a prescribed length of time elapses, the skid control ECU alerts the driver of this condition by causing the VSC warning buzzer to sound intermittently for approximately three seconds, and the slip indicator warning light to illuminate. Also, the A-TRC operation is momentarily interrupted to protect the actuator.
When the temperature of the actuator decreases, the slip indicator light turns OFF, and the A-TRC is automatically restored to an operating state.

- The fluid pressure control of the A-TRC independently controls the brake of each wheel by operating the individual solenoid valves in accordance with the signals received from the skid control ECU. The brake of each wheel is controlled in the following three modes: pressure reduction, pressure hold, and pressure increase modes.

▶ A-TRC Operation ◀



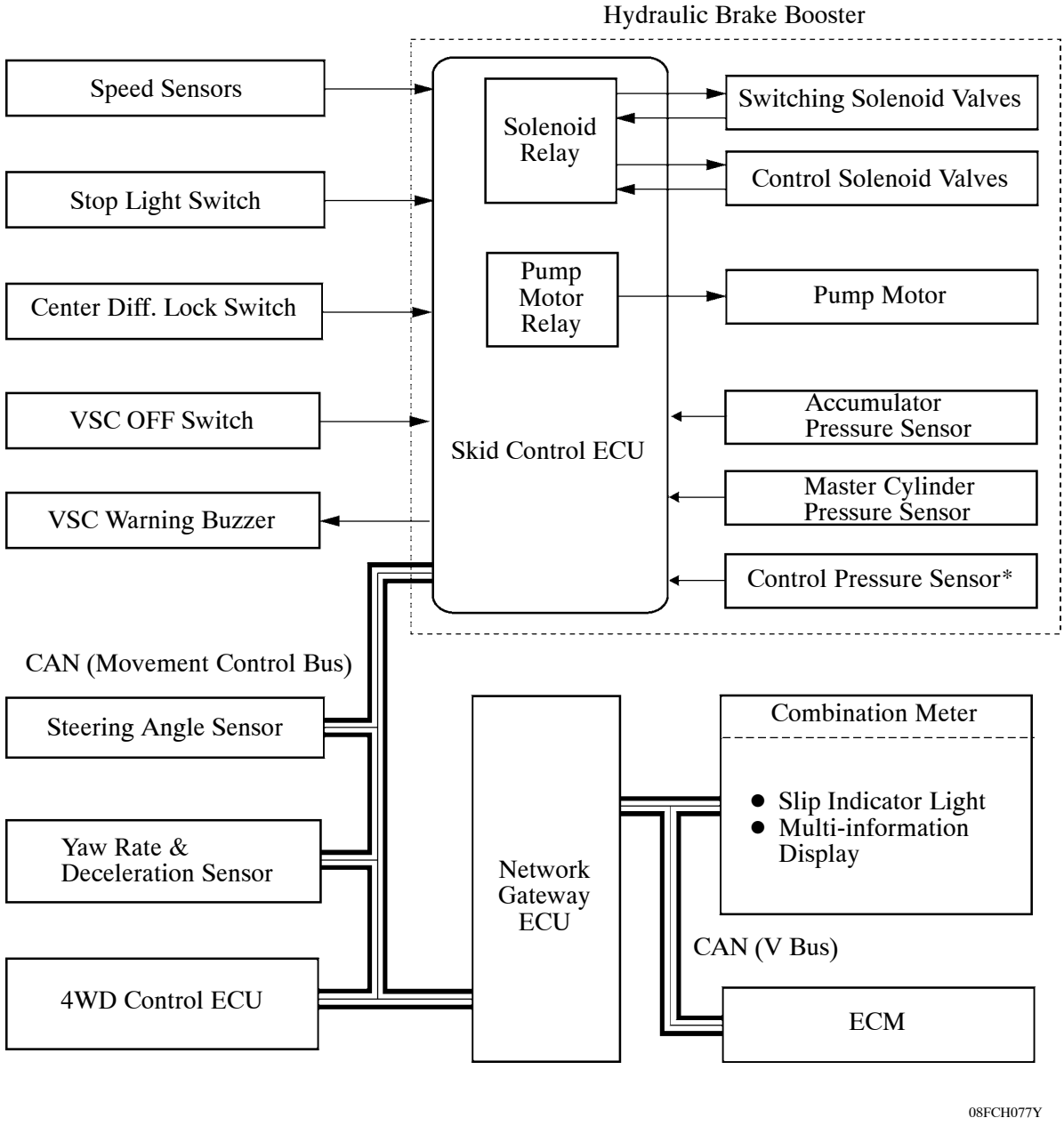
SMCF: Master Cut for Front Solenoid Valve
SREA: Regulator Apply for Front Solenoid Valve
SREC: Regulator Cut Solenoid Valve
STR: Traction Solenoid Valve (Accumulator Cut Solenoid Valve)
SH: Pressure Holding Solenoid Valve
SR: Pressure Reduction Solenoid Valve
*: Only for Models with Pre-crash Safety System

Item			A-TRC Not Activated	A-TRC Activated		
				Increase Mode	Holding Mode	Reduction Mode
Switching Solenoid Valve		SREC	OFF (Open)	ON (Close)	←	←
		STR	OFF (Close)	ON (Open)	←	←
		SMCF	OFF (Open)	ON (Close)	←	←
		SREA	OFF (Close)	ON (Open)	←	←
Control Solenoid Valve	Front Brake	SH	OFF (Open)	←	ON (Close)	←
		SR	OFF (Close)	←	←	ON (Open)
		Wheel Cylinder Pressure	—	Increase	Hold	Reduce
	Rear Brake	SH	OFF (Open)	←	ON (Close)	←
		SR	OFF (Close)	←	←	ON (Open)
		Wheel Cylinder Pressure	—	Increase	Hold	Reduce

VSC Operation

- Based on the information provided by various sensors, switches, and the ECM, the skid control ECU determines the vehicle's yaw moment. Then, the skid control ECU controls the fluid pressure that is generated by the pump and pump motor and applies it by way of the solenoid valves to the brake wheel cylinder of each wheel in the following three modes: pressure reduction, pressure hold, and pressure increase modes. As a result, the tendency of the front wheels or the rear wheels to skid is restrained.
- At this time, the skid control ECU outputs a VSC operation signal to the ECM and the combination meter and causes the VSC warning buzzer to sound intermittently. Upon receiving this signal, the ECM controls the engine output. The slip indicator light will blink in the combination meter.

▶ System Diagram ◀

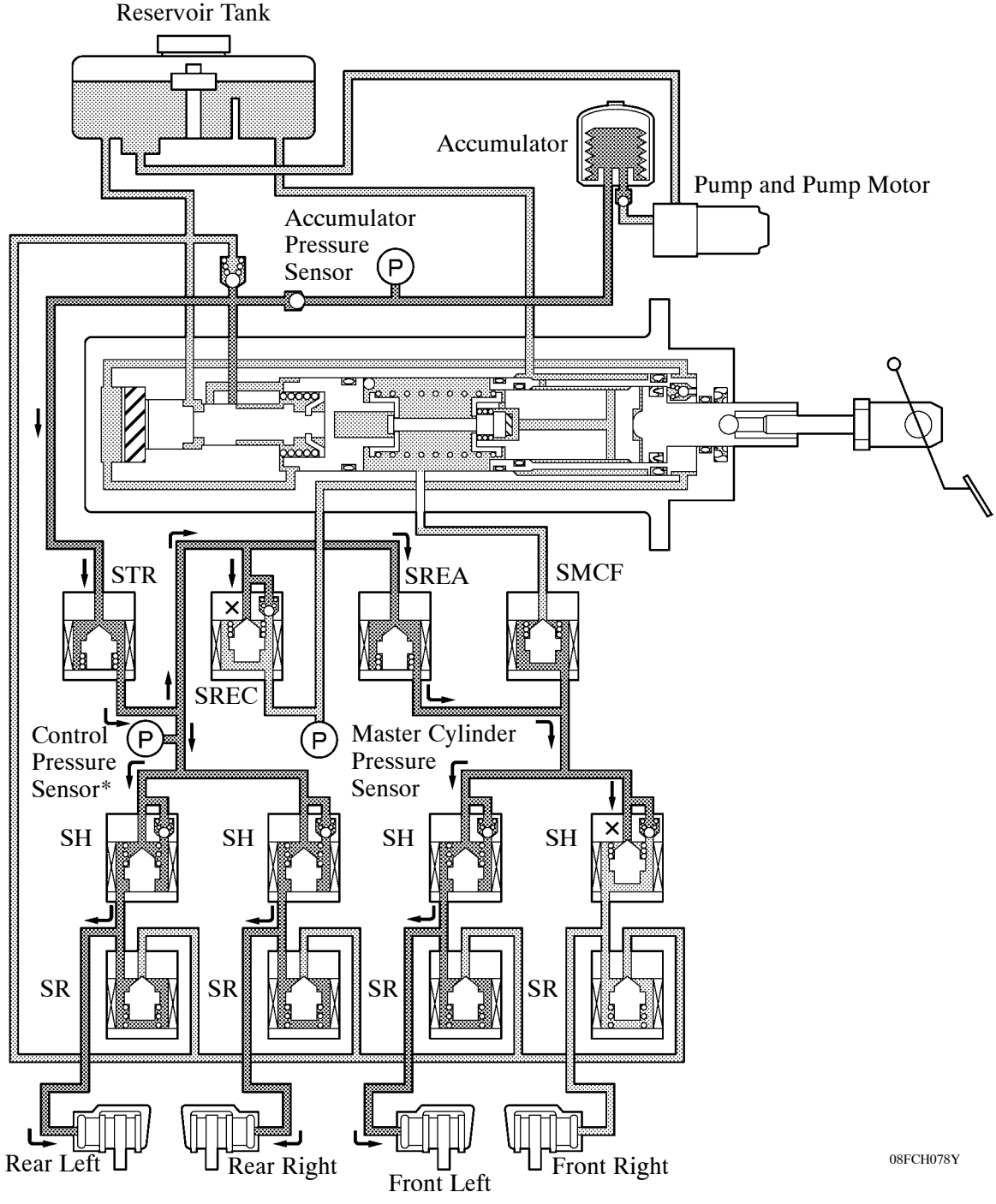


*: Only for Models with Pre-crash Safety System

1) Front Wheel Skid Restraining (Turning to the Right)

In front wheel skid restraining control, the brakes of the rear wheels and front wheel of the outer side 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 below shows the hydraulic circuit in the pressure increase mode, as it restrains a front wheel skid condition while the vehicle makes a right turn.
In other operating modes, the pressure holding valve and the pressure reduction valve are turned ON/OFF according to the multi-terrain ABS with EBD operation pattern.

▶ VSC Operation (Front Wheel Skid Restraining) ◀



SMCF: Master Cut for Front Solenoid Valve
SREA: Regulator Apply for Front Solenoid Valve
SREC: Regulator Cut Solenoid Valve
STR: Traction Solenoid Valve (Accumulator Cut Solenoid Valve)
SH: Pressure Holding Solenoid Valve
SR: Pressure Reduction Solenoid Valve
*: Only for Models with Pre-crash Safety System

Item				VSC Not Activated	VSC Activated		
					Increase Mode	Holding Mode	Reduction Mode
Switching Solenoid Valve		SREC		OFF (Open)	ON (Close)	←	←
		STR		OFF (Close)	ON (Open)	←	←
		SMCF		OFF (Open)	ON (Close)	←	←
		SREA		OFF (Close)	ON (Open)	←	←
Control Solenoid Valve	Front Brake	SH	RH	OFF (Open)	ON (Close)	←	←
			LH	OFF (Open)	←	ON (Close)	←
		SR	RH	OFF (Close)	←	←	←
			LH	OFF (Close)	←	←	ON (Open)
		Wheel Cylinder Pressure	RH	—	—	—	—
			LH	—	Increase	Hold	Reduce
	Rear Brake	SH		OFF (Open)	←	ON (Close)	←
		SR		OFF (Close)	←	←	ON (Open)
		Wheel Cylinder Pressure		—	Increase	Hold	Reduce

NOTICE

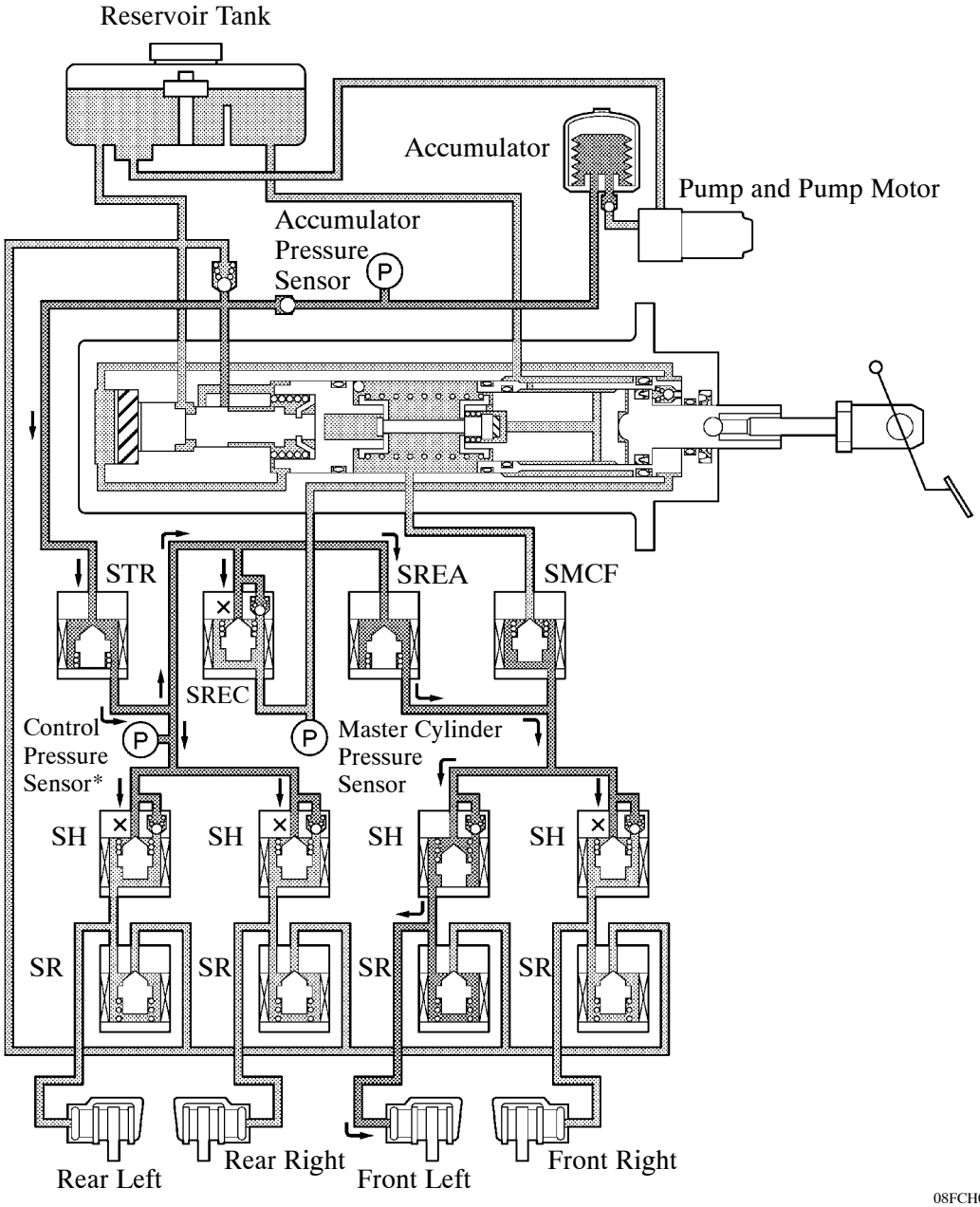
Precaution on VSC Operation

- When the brake pedal is depressed while the VSC is in operation, the brake pedal becomes more difficult to depress than it used to be, however, this is not a malfunction.
  By continuing to depress the brake pedal further, the appropriate brake force can be obtained.
- When the center differential is locked, the VSC is prohibited from operating. At this time, the center differential indicator light turns ON and the multi information display shows VSC OFF. When the center differential is unlocked, the indicator light and the VSC OFF indicator go OFF, and the VSC turns ON.

2) Rear Wheel Skid Restraining Control (Turning to the Right)

In rear wheel skid restraining control, the front wheel brake of the outer side 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 be applied to the rear brake of the outer side the turn. The diagram below shows the hydraulic circuit in the pressure increase mode, as it restrains a rear wheel skid condition while the vehicle makes a right turn.
In other operating modes, the pressure holding valve and the pressure reduction valve are turned ON/OFF according to the multi-terrain ABS with EBD operation pattern.

▶ VSC Operation (Rear Wheel Skid Restraining) ◀



SMCF: Master Cut for Front Solenoid Valve
SREA: Regulator Apply for Front Solenoid Valve
SREC: Regulator Cut Solenoid Valve
STR: Traction Solenoid Valve (Accumulator Cut Solenoid Valve)
SH: Pressure Holding Solenoid Valve
SR: Pressure Reduction Solenoid Valve
*: Only for Models with Pre-crash Safety System

Item				VSC Not Activated	VSC Activated		
					Increase Mode	Holding Mode	Reduction Mode
Switching Solenoid Valve		SREC		OFF (Open)	ON (Close)	←	←
		STR		OFF (Close)	ON (Open)	←	←
		SMCF		OFF (Open)	ON (Close)	←	←
		SREA		OFF (Close)	ON (Open)	←	←
Control Solenoid Valve	Front Brake	SH	RH	OFF (Open)	ON (Close)	←	←
			LH	OFF (Open)	←	ON (Close)	←
		SR	RH	OFF (Close)	←	←	←
			LH	OFF (Close)	←	←	ON (Open)
		Wheel Cylinder Pressure	RH	—	—	—	—
			LH	—	Increase	Hold	Reduce
	Rear Brake	SH		OFF (Open)	←	←	←
		SR		OFF (Close)	←	←	ON (Open)
		Wheel Cylinder Pressure		—	—	—	—

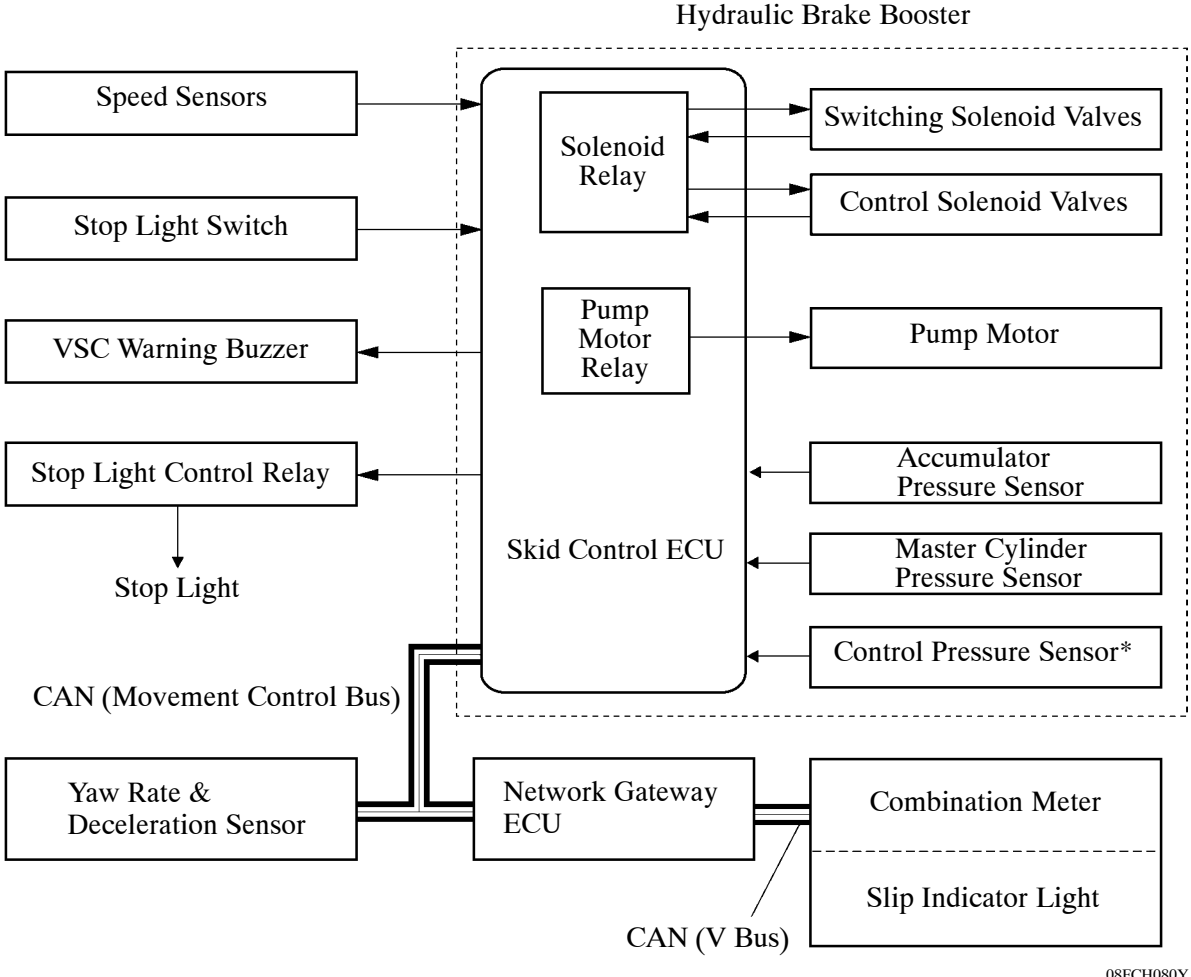
Hill-start Assist Control Operation

Based on the information provided by various sensors, switches, and the ECM, the skid control ECU computes the backward movement of the vehicle that occurs when the vehicle starts off on a hill. Then, the skid control ECU controls the fluid pressure that is generated by the pump and pump motor and applies it by way of the solenoid valves to the brake wheel cylinder of each wheel in the following three modes: pressure reduction, pressure hold, and pressure increase modes.

- The skid control ECU determines the state of the backward movement of the vehicle while the driver is attempting to drive uphill, based on the speed sensors and the neutral start switch.
- The skid control ECU determines the gradient of the hill, the acceleration state of the vehicle, the locked state and the direction of rotation of each wheel through the speed sensors and the yaw rate & deceleration sensor. Then, the skid ECU computes the amount of brake control that prevents the wheels from locking.
- During this operation, the skid control ECU outputs a Hill-start Assist Control operation signal to the combination meter. This causes the slip indicator light to blink, outputs signals to the stop light control relay which turns ON the stop light.
- The Hill-start Assist Control operates for approximately five seconds. At this time, the skid control ECU informs the driver by the slow and intermittent sound of the VSC warning buzzer. After that, the skid control ECU alerts the driver by using the quick and intermittent sound of the VSC warning buzzer, and gradually releases the brake hydraulic pressure in order to end the Hill-start Assist Control operation.

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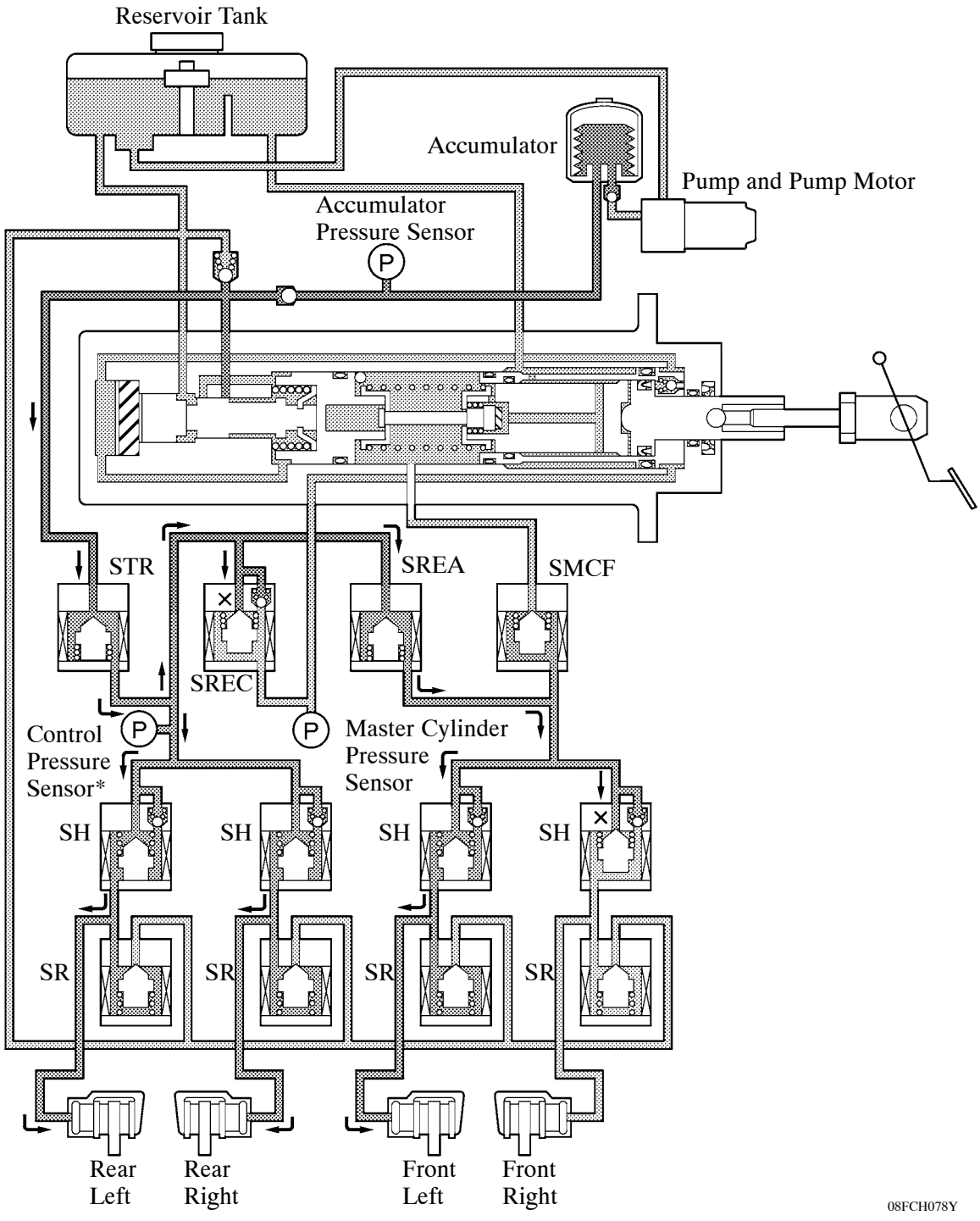
▶ System Diagram ◀



08FCH080Y

*: Only for Models with Pre-crash Safety System

▶ Hill-start Assist Control Operation ◀



SMCF: Master Cut for Front Solenoid Valve
SREA: Regulator Apply for Front Solenoid Valve
SREC: Regulator Cut Solenoid Valve
STR: Traction Solenoid Valve (Accumulator Cut Solenoid Valve)
SH: Pressure Holding Solenoid Valve
SR: Pressure Reduction Solenoid Valve

*: Only for Models with Pre-crash Safety System

Item			Hill-start Assist Control Not Activated	Hill-start Assist Control Activated		
				Increase Mode	Holding Mode	Reduction Mode
Switching Solenoid Valve		SREC	OFF (Open)	ON (Close)	←	←
		STR	OFF (Close)	ON (Open)	←	←
		SMCF	OFF (Open)	ON (Close)	←	←
		SREA	OFF (Close)	ON (Open)	←	←
Control Solenoid Valve	Front Brake	SH	OFF (Open)	←	ON (Close)	←
		SR	OFF (Close)	←	←	ON (Open)
		Wheel Cylinder Pressure	—	Increase	Hold	Reduce
	Rear Brake	SH	OFF (Open)	←	ON (Close)	←
		SR	OFF (Close)	←	←	ON (Open)
		Wheel Cylinder Pressure	—	Increase	Hold	Reduce

NOTICE

Precaution on Hill-start Assist Control Operation

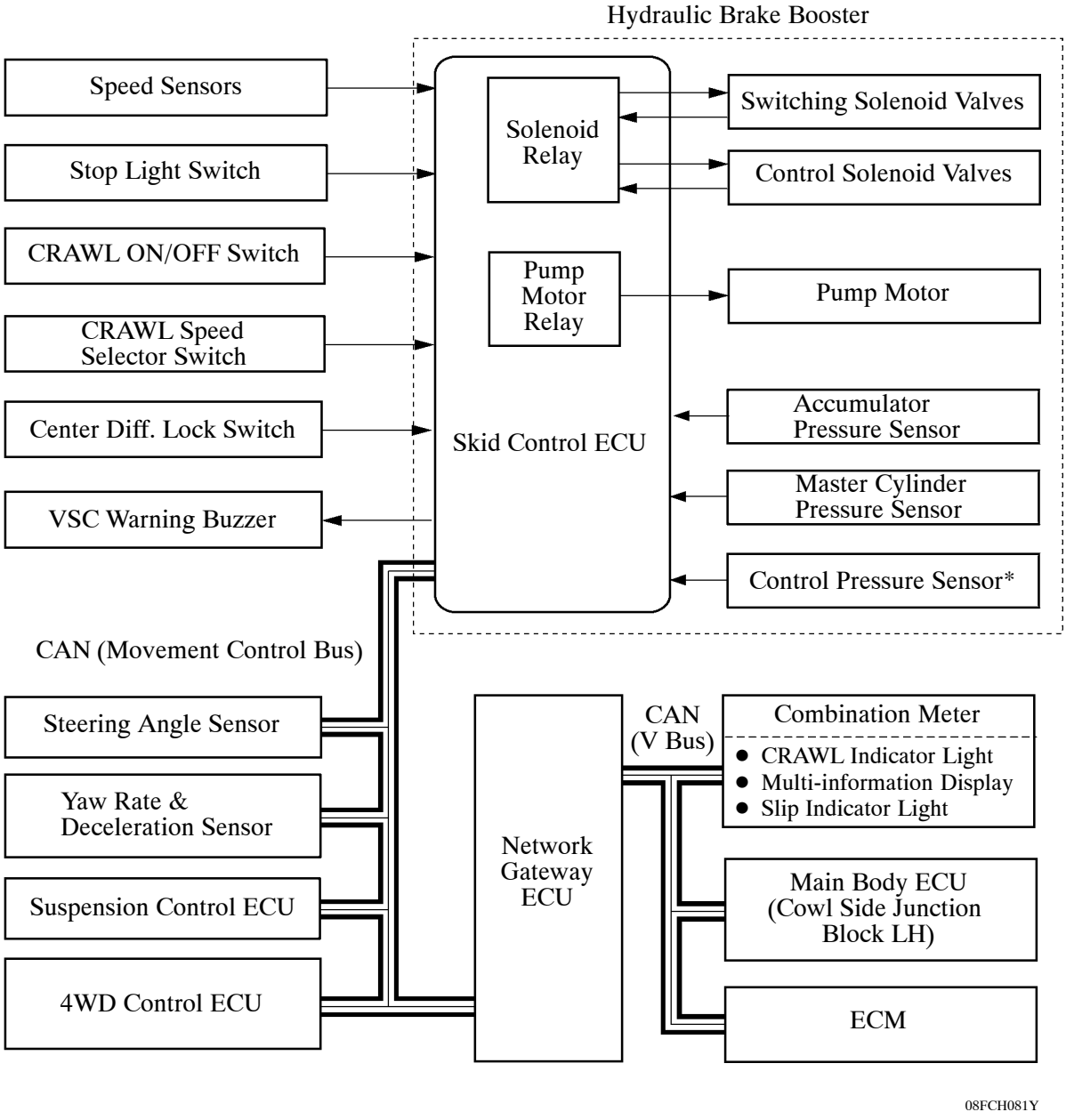
When the Hill-start Assist Control is operating continuously while the vehicle is being driven on a slippery surface, the temperature of the actuator in the hydraulic brake booster increases. After a prescribed length of time elapses, the skid control ECU alerts the driver of this condition by causing the slip indicator light to illuminate. Also, the Hill-start Assist Control operation is momentarily interrupted to protect the actuator.

When the temperature of the actuator decreases, the slip indicator light turns OFF, and the Hill-start Assist Control is automatically restored to an operating state.

CRAWL Operation

- Based on the information provided by various sensors, switches, and the ECM, the skid control ECU determines the conditions that enable the CRAWL to operate. The skid control ECU computes the target vehicle speed (approximately 1 to 5 km/h, 1 to 3 mph) to control the vehicle speed, and the target wheel speeds to control the wheel slipping. The target vehicle speed can be changed using the speed selector switch.
- When the vehicle speed differs from the target speed, the engine output is regulated. When the wheel speeds differ from the target speeds, the hydraulic brake pressure of the wheels is regulated.

▶ System Diagram ◀



*: Only for Models with Pre-crash Safety System

1) CRAWL Operation Condition

When the CRAWL ON/OFF switch is pressed with all of the following conditions met, the CRAWL control starts operating. The activation of the control causes the CRAWL indicator light to illuminate and the slip indicator light to blink. The operating conditions of CRAWL control and the selected speed will appear on the multi-information display.

CRAWL Operation Condition	● Transfer is L4. ● Shift position is in any position other than P or N. ● 2nd start switch is OFF. ● Vehicle speed is 0 km/h (0 mph). ● Brake pedal is being depressed. ● Parking brake is not applied. ● Driver's door is closed.

2) CRAWL Operation Ending Condition

- When any of the following conditions is met, the CRAWL control stops operating. The deactivation of the control causes the indicator light to go OFF. A message will appear on the multi-information display for a few seconds, indicating that the CRAWL control has ended.

CRAWL Operation Ending Condition	● CRAWL ON/OFF switch is turned OFF. ● Transfer is changed to H4. ● Shift position is shifted into P. ● CRAWL malfunctions. ● Vehicle speed is above 25 km/h (15.5 mph).

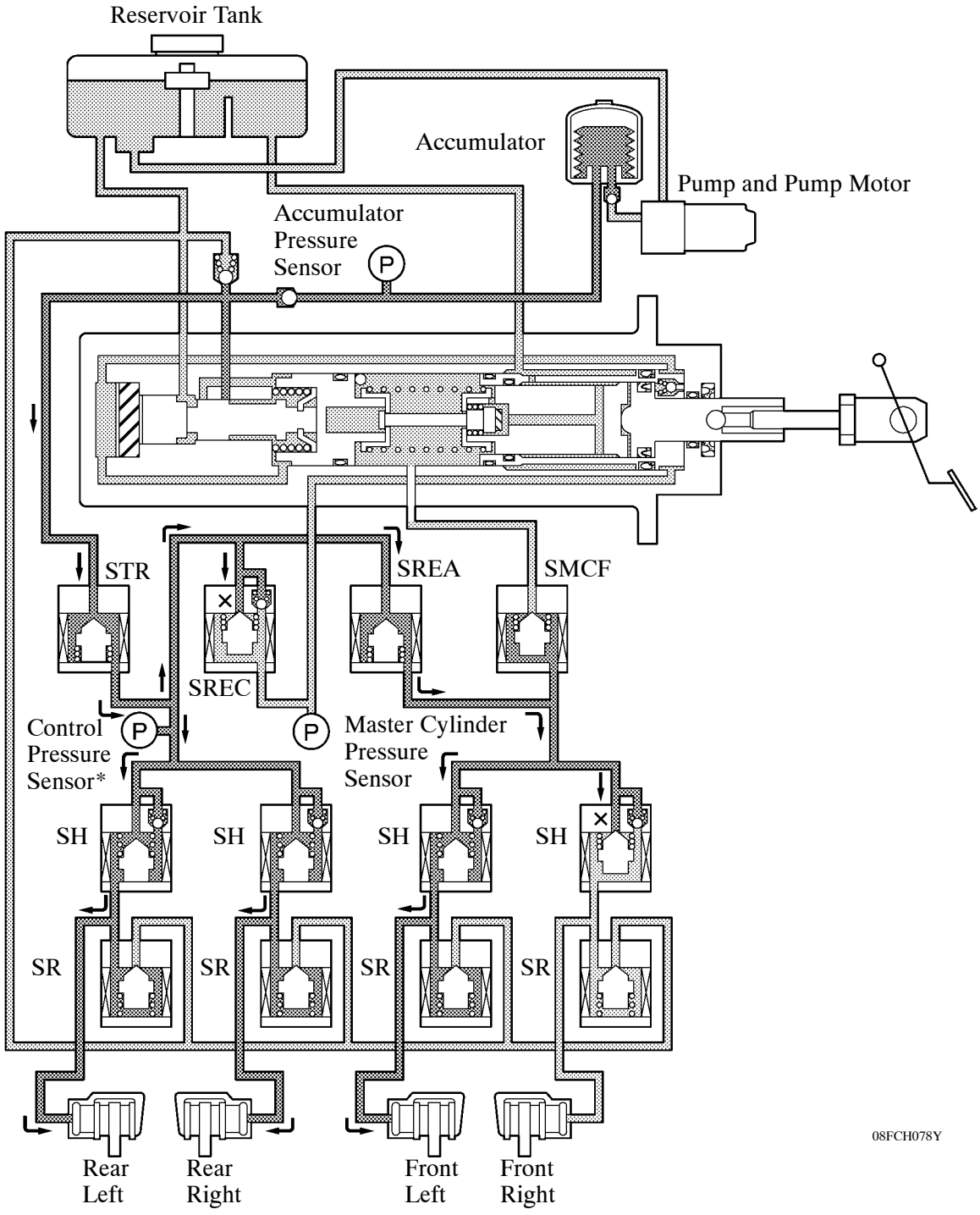
- When any of the following conditions is met, only the CRAWL engine control is deactivated. Under this situation, only the CRAWL brake control continues to be active. When the CRAWL engine control is deactivated, the buzzer sounds intermittently and the CRAWL indicator light switches from illuminating to blinking. If this happens, take appropriate actions such as stopping the vehicle. When the CRAWL control stops operating completely, the indicator light goes OFF.

CRAWL Operation Condition	● Shift position is N. ● 2nd start switch is turned ON. ● Vehicle speed is above 10 km/h (6 mph). ● Brake pedal is depressed firmly. ● Parking brake is applied. ● Driver's door is opened.

3) CRAWL Operation

The skid control ECU controls the fluid pressure that is generated by the pump and pump motor and applies it by way of the solenoid valves to the brake wheel cylinder of each wheel in the following three modes: pressure reduction, pressure hold, and pressure increase modes.

▶ CRAWL Operation ◀



SMCF: Master Cut for Front Solenoid Valve
SREA: Regulator Apply for Front Solenoid Valve
SREC: Regulator Cut Solenoid Valve
STR: Traction Solenoid Valve (Accumulator Cut Solenoid Valve)
SH: Pressure Holding Solenoid Valve
SR: Pressure Reduction Solenoid Valve

*: Only for Models with Pre-crash Safety System

Item			CRAWL Control Not Activated	CRAWL Control Activated		
				Increase Mode	Holding Mode	Reduction Mode
Switching Solenoid Valve		SREC	OFF (Open)	ON (Close)	←	←
		STR	OFF (Close)	ON (Open)	←	←
		SMCF	OFF (Open)	ON (Close)	←	←
		SREA	OFF (Close)	ON (Open)	←	←
Control Solenoid Valve	Front Brake	SH	OFF (Open)	←	ON (Close)	←
		SR	OFF (Close)	←	←	ON (Open)
		Wheel Cylinder Pressure	—	Increase	Hold	Reduce
	Rear Brake	SH	OFF (Open)	←	ON (Close)	←
		SR	OFF (Close)	←	←	ON (Open)
		Wheel Cylinder Pressure	—	Increase	Hold	Reduce

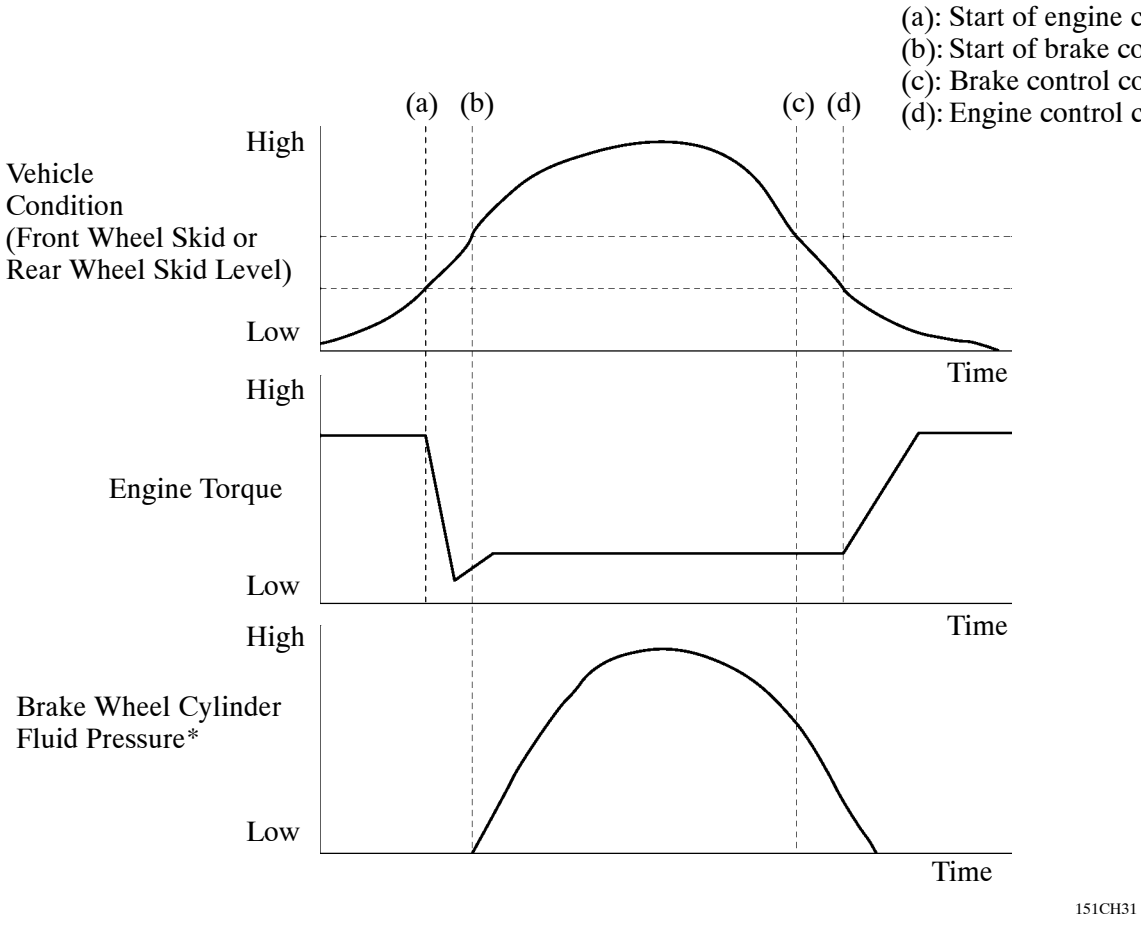
NOTICE

Precaution on CRAWL Operation

- Prior to starting off, check the CRAWL indicator light. If the indicator light is blinking, the CRAWL brake control will work but the CRAWL engine control will not.
- When the CRAWL is operating continuously, the temperature of the actuator in the hydraulic brake booster increases. After a prescribed length of time elapses, the skid control ECU alerts the driver of this condition by causing the VSC warning buzzer to sound intermittently for approximately three seconds, slip indicator light to illuminate, and the CRAWL indicator light to blink. Also, the CRAWL operation is momentarily interrupted to protect the actuator.
  When the temperature of the actuator decreases, the slip indicator light turns OFF, and the CRAWL is automatically restored to an operating state.
- When the CRAWL continues operating, the ATF temperature may increase too much. If this happens, the ATF temperature warning indicator in the multi-information display turns ON and the CRAWL operation is momentarily interrupted to protect the automatic transmission. If the vehicle continues to be driven in this situation, ATF leakage or automatic transmission malfunctions may result. Therefore, the driver should immediately stop the vehicle in a safe area and select shift position P or N to let the ATF cool down enough.
  When the ATF temperature decreases, the ATF temperature warning indicator turns OFF. Then, the CRAWL becomes available.

8. Engine Output Control

During a VSC operation, the skid control ECU outputs a brake control operation signal to the ECM. Upon receiving this signal, the ECM effects throttle control to regulate the engine output.



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

9. Initial Check

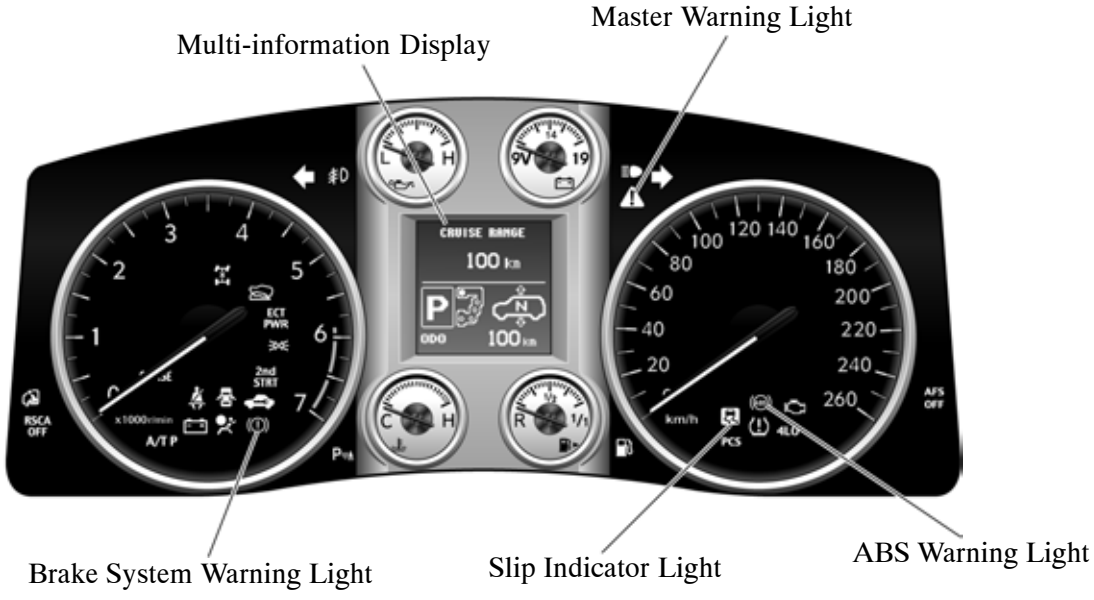
Each time the engine switch is turned ON (IG), and the vehicle reaches approximately speed of 6 km/h (4 mph) or more, the skid control ECU performs the initial check.
The functions of each solenoid valve, pump and pump motor in the hydraulic brake booster are checked in order.

10. Diagnosis

- If a failure occurs in one of the sensors or hydraulic brake booster in the brake system, the skid control ECU informs the driver of the failure in the brake system by illuminating the brake warning light, ABS warning light, or slip indicator light in the combination meter, or displaying a VSC warning message/“Check VSC System” (on the multi-information display).
- At the same time, DTC (Diagnostic Trouble Code) is stored in memory of the skid control ECU. This DTC can be read by the following two methods.
  - The 5-digit DTC can be read by connecting a an intelligent tester II to the DLC3.
  - The 2-digit DTC can be read from the number of the blinking of the ABS warning light by connecting the SST (90843-18040) 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 an intelligent tester II or 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.

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For details on the DTC that are stored in skid control ECU memory and the DTC that are output through the sensor signal check function, see the LEXUS LX 570 Repair Manual (Pub. No. RM08G0E).



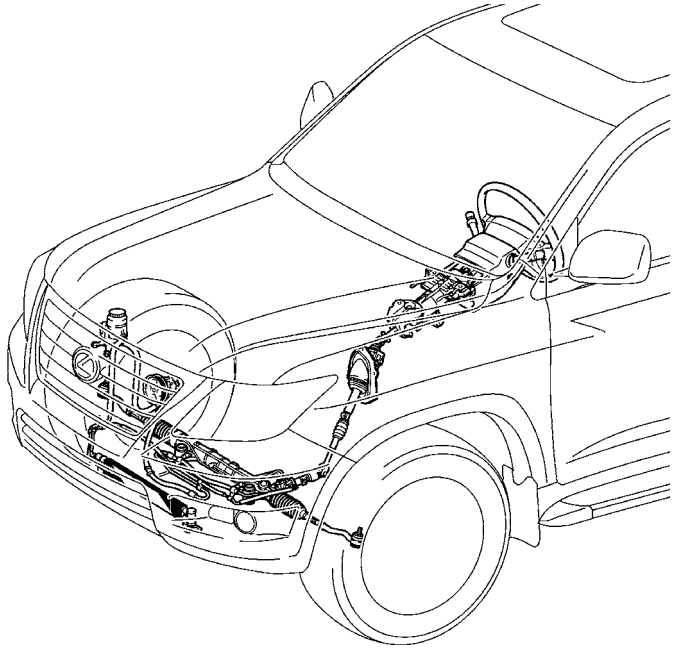
11. Fail-safe

If a failure occurs in the skid control ECU, sensors, or brake actuators, the system continues effecting brake control by excluding the failed area and using only the areas that are operating normally.

STEERING

■ DESCRIPTION

- A rack and pinion type steering gear with an engine speed sensing type power steering is used.
- A variable gear ratio type steering rack is used.
- A VGRS (Variable Gear Ratio Steering) system, which variably controls the steering angle in accordance with the vehicle speed, is used.
- The power tilt and power telescopic mechanism with memory function is used.
- The steering column uses an energy absorbing mechanism.



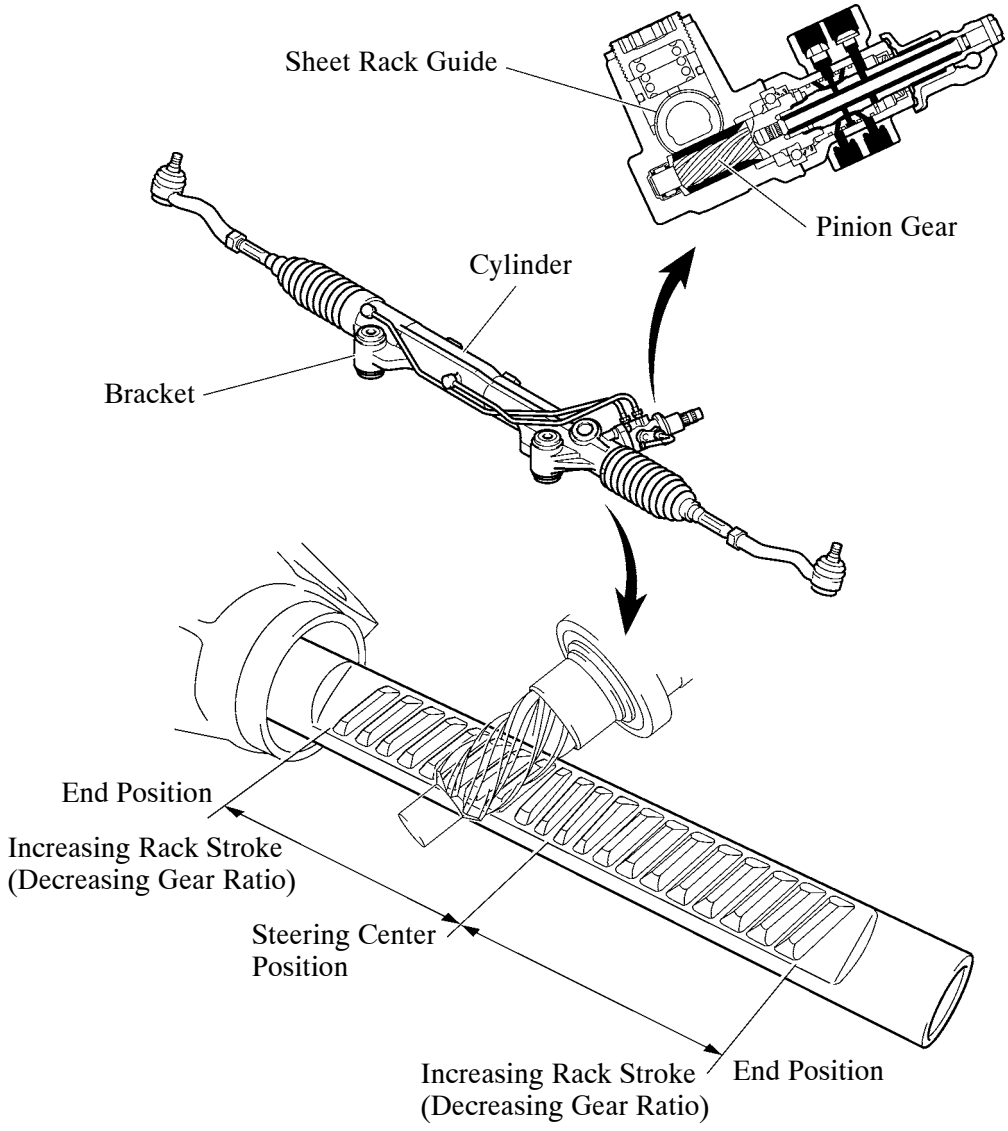
LHD Model 08FCH084Y

▶ Specifications ◀

Gear Ratio (Overall)		14.2 to 17.6
No. of Turns Lock to Lock		3.14
Rack Stroke	mm (in.)	175.0 (6.89)
Fluid Type		ATF Type DEXRON® II or III

■ STEERING GEAR

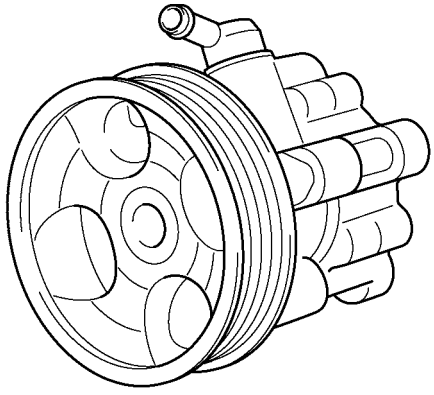
- For the purpose of weight reduction, an aluminum housing rack is used, which has the bracket and cylinder integrated.
- A variable gear ratio type steering rack is used. This steering rack changes the gear ratio gradually by changing the gear teeth form. The gear ratio is set larger around the steering center and smaller around the end position. Thus, rack stroke around the end position is larger to reduce the steering operation while ensuring the moderate response around the steering center.
- The rack guide structure has been optimized to improve the steering operation feeling.

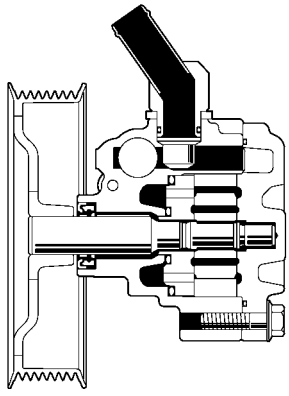


LHD Model

■VANE PUMP

A compact and lightweight vane pump, which uses die-cast aluminum as the material for its front and rear housings, is used. By optimizing its internal construction, this vane pump realizes low-friction operation, which leads to low fuel consumption.





Cross Section

08FCH085Y

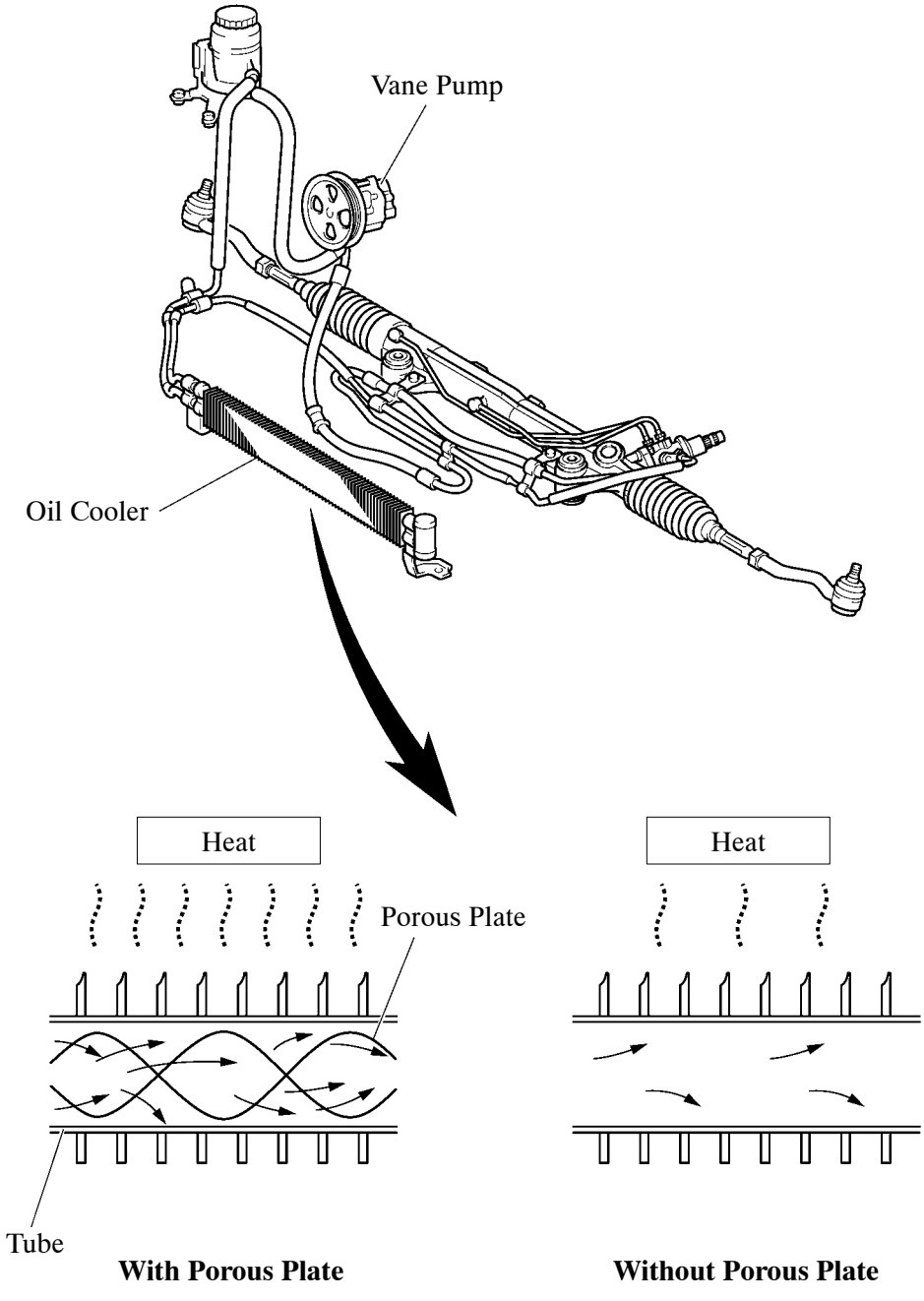
▶ Specifications ◀

Theoretical Discharge Rate	l/min	15
Relief Pressure	MPa (kgf/cm^2, psi)	10 (102, 1450)

■ POWER STEERING PIPING

1. General

- The power steering piping has been optimized to reduce hydraulic pulsation and thus improve quietness.
- The power steering piping has an oil cooler provided with cooling fins.
- The oil cooler for all models except the G.C.C. countries models has porous plates arranged in a spiral pattern in the tube. These plates diffuse the fluid flow in the tube and help improve heat dissipation from the fluid to improve the cooling performance of the oil cooler.
- On the G.C.C. countries models, the relief valve is installed on the power steering piping.

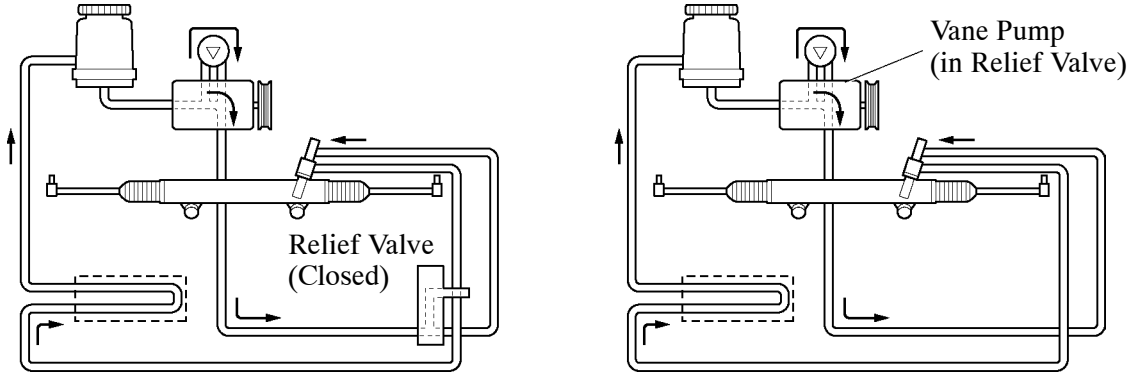


LHD Model

2. Relief Valve (For G.C.C. Countries Models)

- When the steering wheel is not being turned, the relief valve is closed so fluid flows through the pipes in the same manner as on a conventional model.
- If the relief valve is open while the steering wheel is being turned fully, the fluid temperature tends to increase on the conventional model because the fluid only circulates within the pump. On the other hand, the fluid circulates through the piping system on the new model, which reduces the fluid temperature increase.

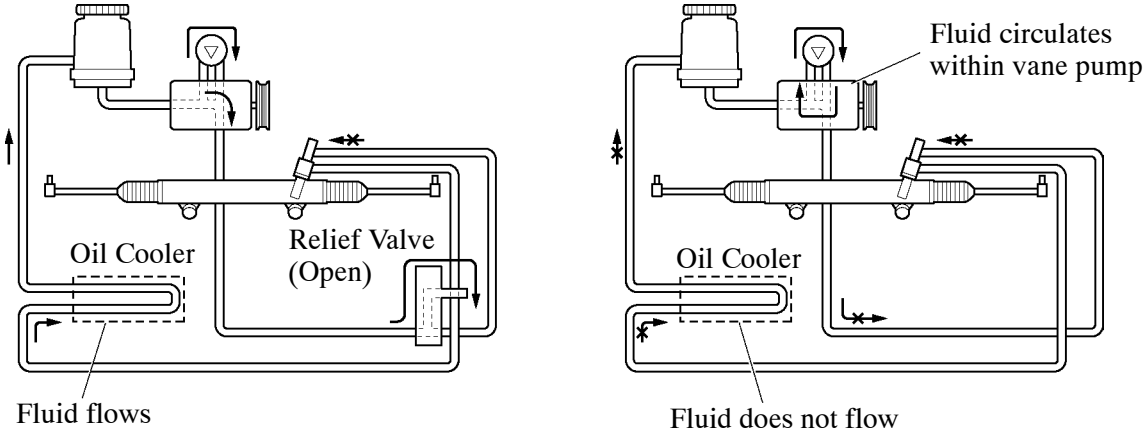
▶ When relief valve is not activated (steering wheel is not being turned) ◀



New Model **Conventional Model**

08GCH010I

▶ When relief valve is activated (steering wheel is turned fully) ◀



New Model **Conventional Model**

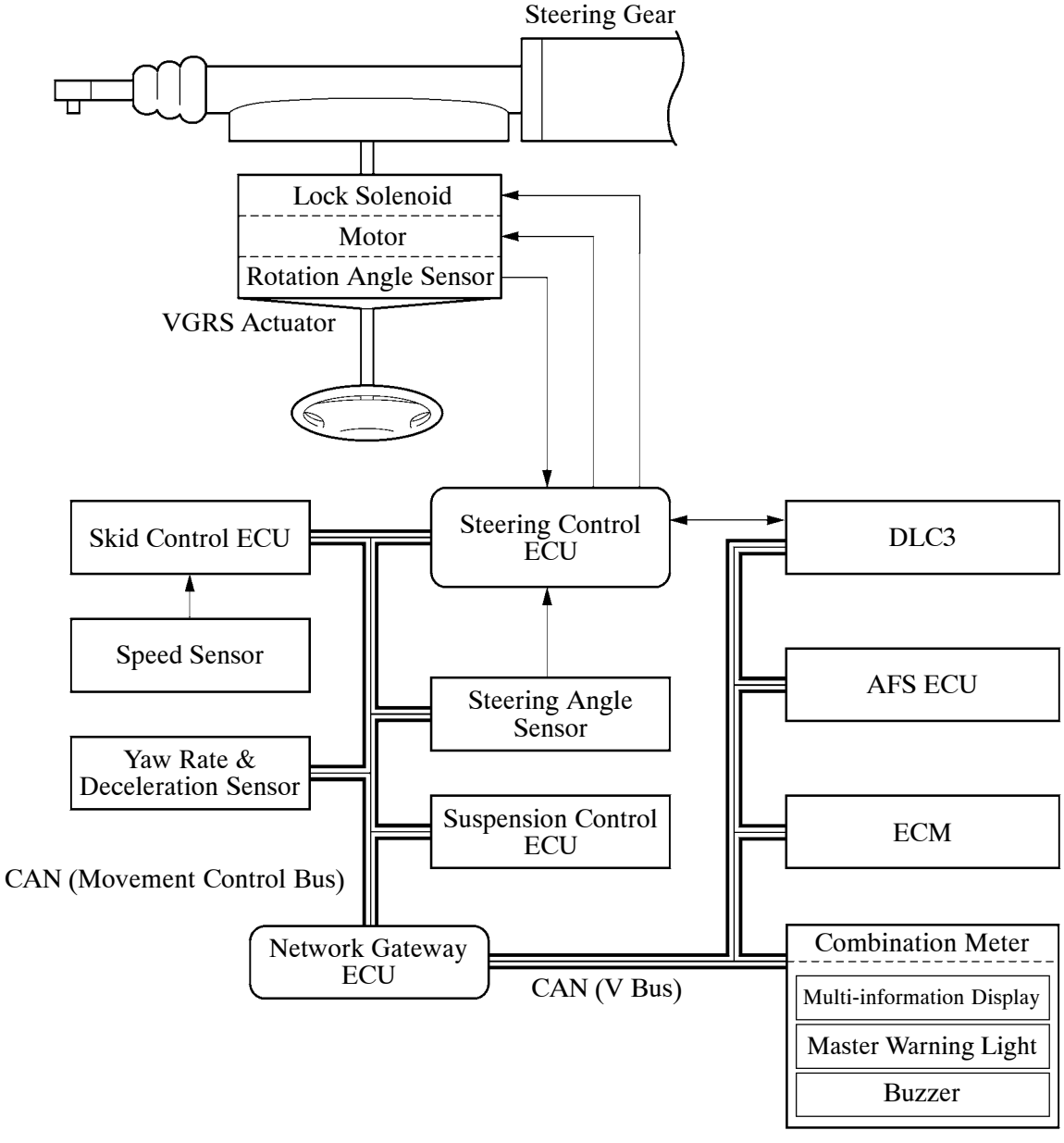
08GCH011I

■VGRS (VARIABLE GEAR RATIO STEERING) SYSTEM

1. General

- A VGRS system is used to control the turning angle of the front wheels in accordance with the vehicle speed. As a result, excellent ease of steering operation and vehicle stability have been realized, from the low-speed to the high-speed range.
- This system is controlled by the steering control ECU, which operates the VGRS actuator that is mounted on the steering intermediate shaft. The steering control ECU calculates the desired steering angle and controls the VGRS actuator operating angle based on the current steering angle detected by the steering angle sensor and vehicle speed.

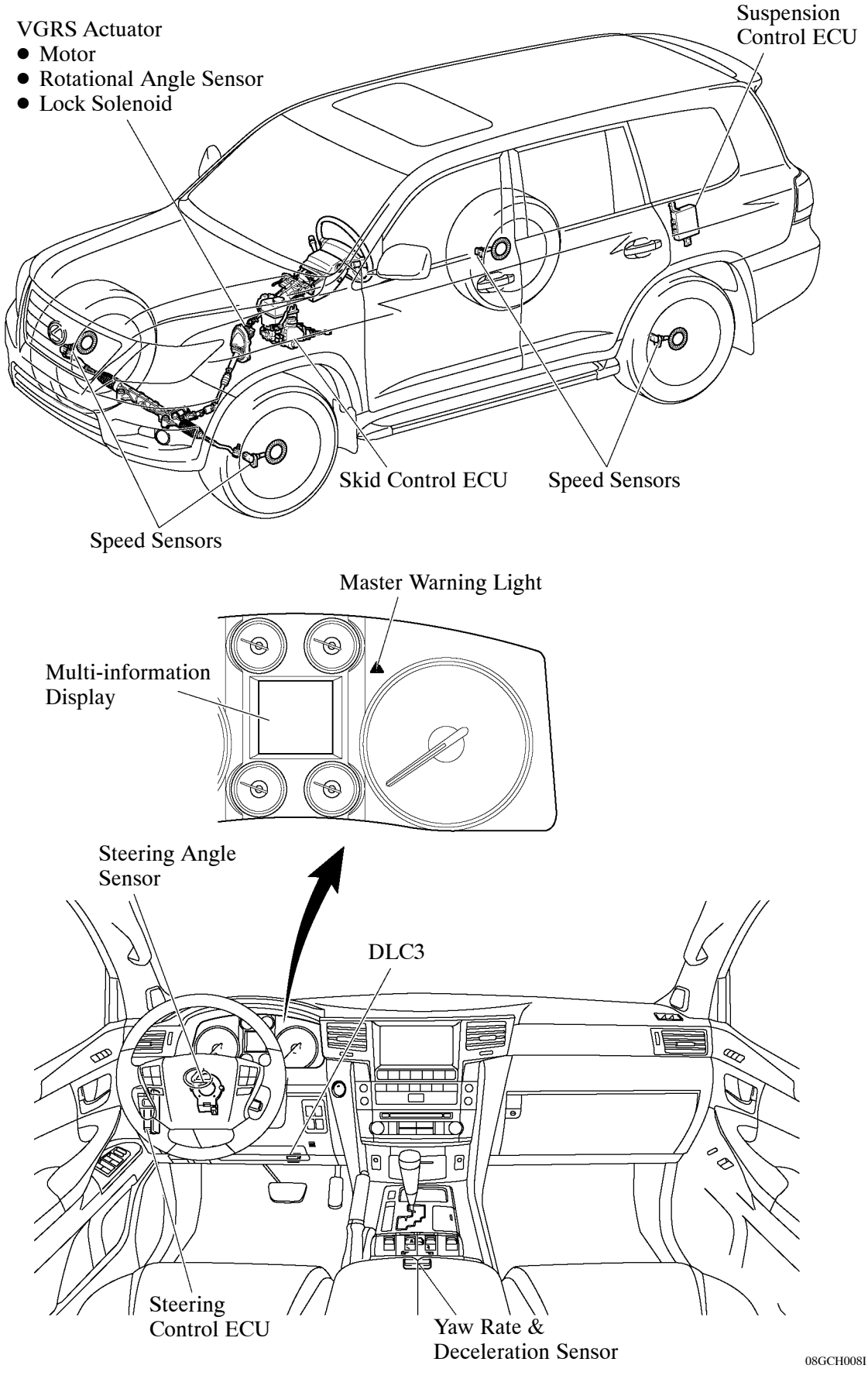
▶ System Diagram ◀



08FCH086Y

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2. Layout of Main Components



LHD Model

3. Function of Main Components

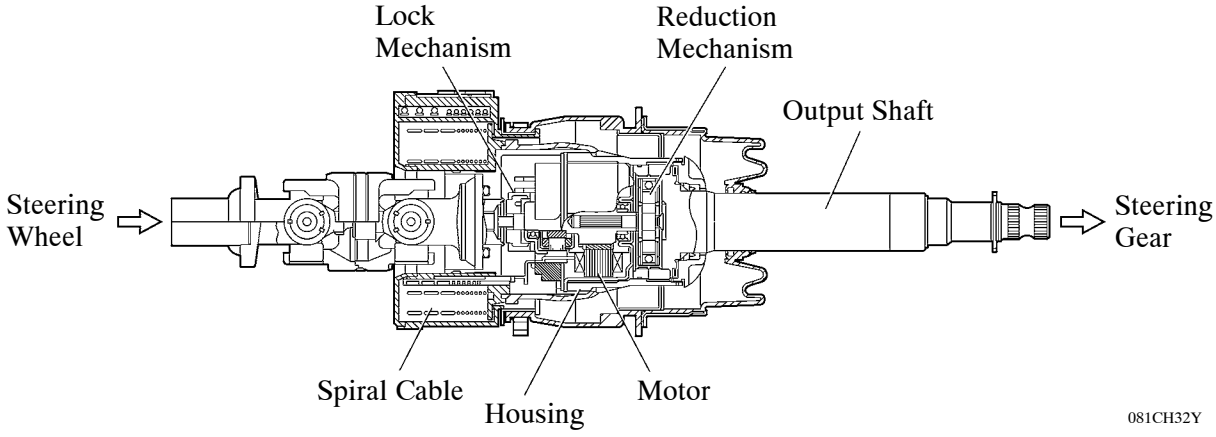
Component		Function
Steering Control ECU		Operates the motor by calculating the operating angle of the VGRS actuator based on the signals from the steering angle sensor and vehicle speed sensor.
VGRS Actuator	Motor	Rotates to create the operating angle of the VGRS actuator upon receiving the signals from the steering control ECU.
	Rotational Angle Sensor	Outputs the rotational angle of the motor to the steering control ECU.
	Lock Solenoid	Locks the motor shaft so that the motor will not rotate in case of a system malfunction.
Steering Angle Sensor		Detects the angle of the steering wheel and transmits them to the steering control ECU.
Yaw Rate & Deceleration Sensor		Detects the yaw rate and the longitudinal and lateral acceleration and deceleration of the vehicle body and transmits them to the steering control ECU.
Speed Sensor		Detects the wheel speed and outputs it to the skid control ECU.
Skid Control ECU		Transmits the vehicle speed signal to the steering control ECU.
Combination Meter	Multi-information Display	Indicates “Check VGRS System” to inform the driver of a malfunction in the system.
	Master Warning Light	Illuminates to warn the driver of a malfunction in the system.
	Buzzer	Sounds to warn the driver of a malfunction in the system.

4. Construction and Operation

VGRS Actuator

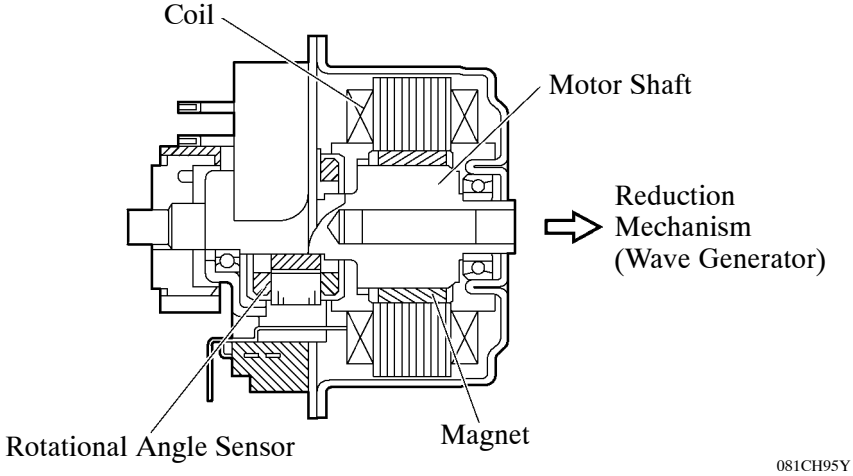
1) General

The VGRS actuator consists of a housing, a motor, a reduction mechanism, an input shaft, an output shaft, and a lock mechanism.



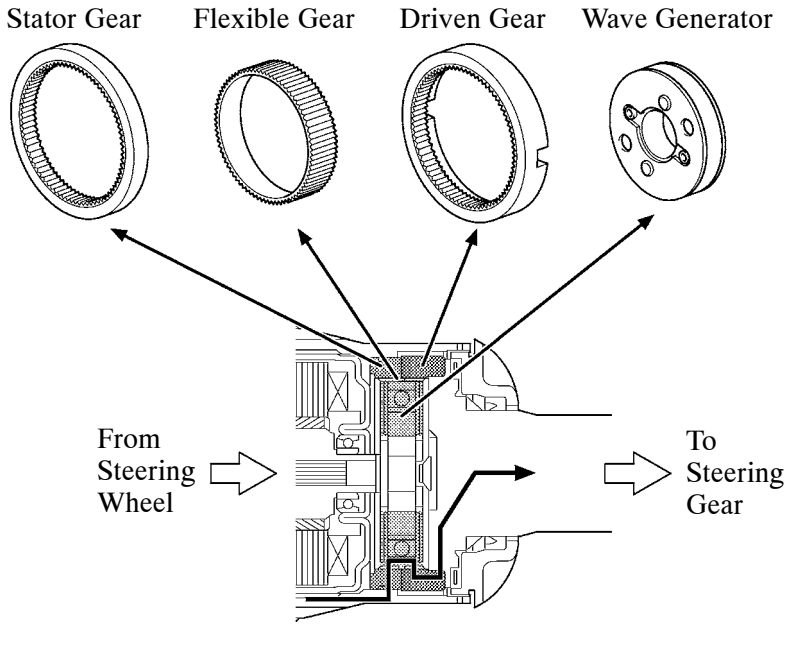
2) Motor

- A compact, high power output, and low noise brushless type motor is used. This motor is enclosed in the housing.
- This motor mainly consists of a magnet, a coil, and a motor shaft. The motor shaft is coupled to the wave generator of the reduction mechanism in order to transmit the rotational movement of the motor to the reduction mechanism.
- This motor, which is controlled by the signal from the steering control ECU, rotates either clockwise or counterclockwise, depending on the steered direction of the steering wheel.
- The rotational direction and rotational angle of the motor are detected by the rotational angle sensor.



3) Reduction Mechanism

- The reduction mechanism uses strain wave gearing, which is compact and highly accurate, and creates a large reduction gear ratio (1:50) using a small number of components.
- This reduction mechanism consists of a driven gear, a stator gear, a flexible gear, and a wave generator.



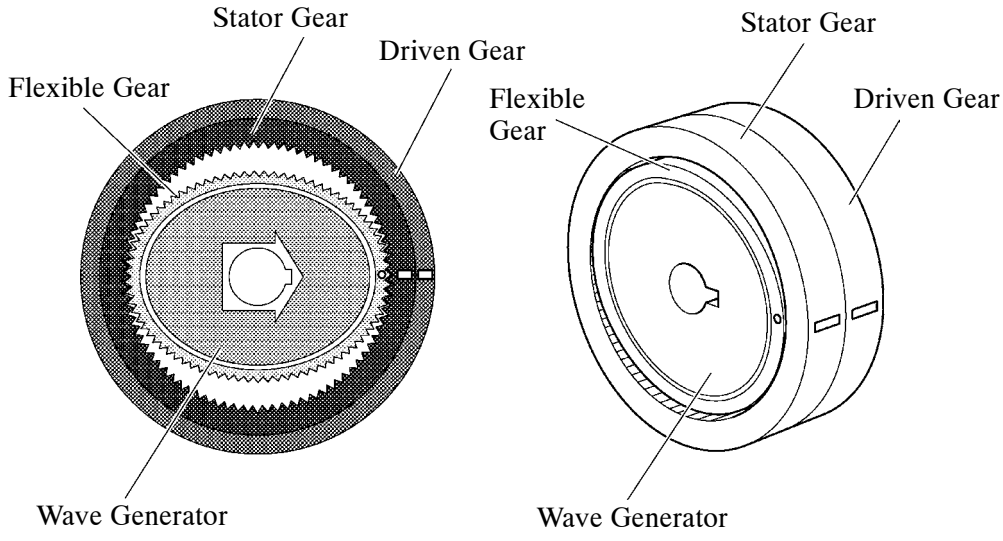
▶ Construction of Reduction Mechanism ◀

Item	Construction
Stator Gear (Input)	● Has a rigid body, a ring shape, and contains 102 teeth along the inner circumference. ● Positioned parallel with the driven gear. ● Coupled to the housing of the VGRS actuator.
Driven Gear (Output)	● Has a rigid body, a ring shape, and contains 100 teeth along the inner circumference. ● Positioned parallel with the stator gear. ● Coupled to the output shaft of the VGRS actuator.
Flexible Gear	● Has a flexible metal body that forms a belt shape and contains 100 teeth along the outer circumference. ● Located outside of the wave generator, and positioned in a way that its gear teeth are meshed with the inside of both stator gear and driven gear.
Wave Generator	● Consists of an oval-shaped cam and a ball bearing that is fitted around the cam. ● Coupled to the motor shaft of the motor, rotates inside the flexible gear while pushing the flexible gear against the stator gear and the driven gear.

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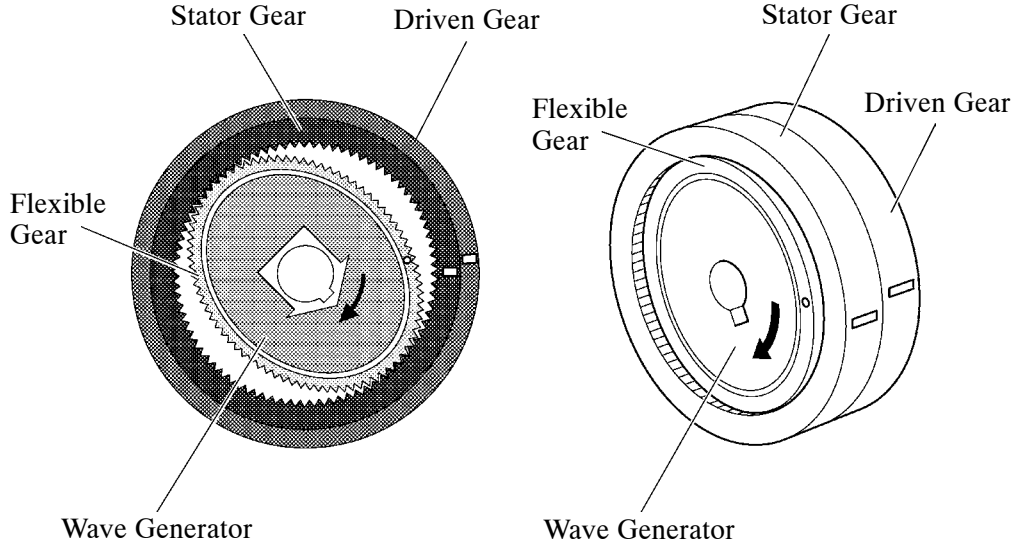
Operating Principle of Reduction Mechanism

- The flexible gear is fitted inside the driven gear and stator gear as illustrated. Furthermore, the wave generator is fitted inside the flexible gear. The rotational movement of the wave generator causes the flexible gear to become deformed into an oval shape. The teeth at the major axis of the oval shape meshes with the teeth of the driven gear and stator gear, and the teeth at the minor axis are disengaged.



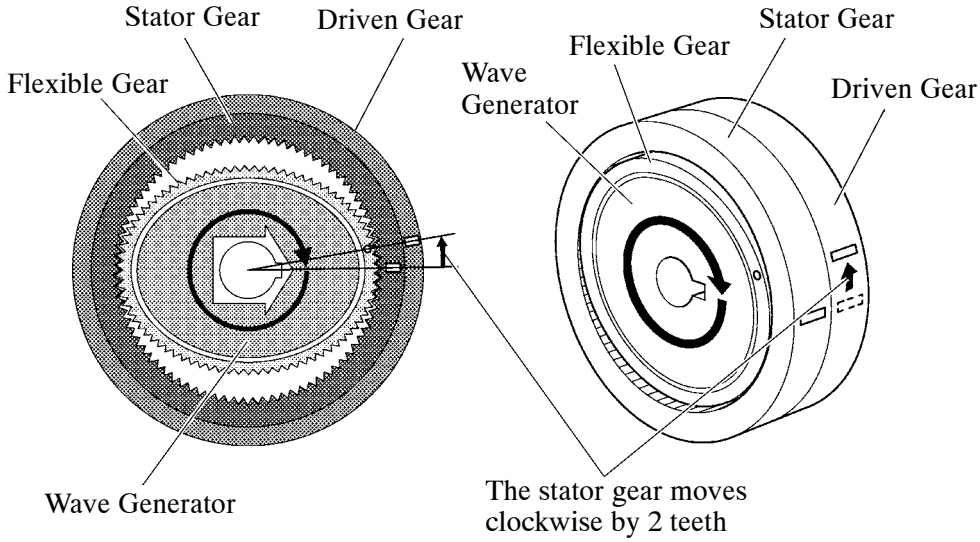
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- When the stator gear is fixed and the wave generator rotates clockwise, the flexible gear undergoes an elastic deformation. This causes the meshed areas between the flexible gear, driven gear and stator gear to move consecutively.

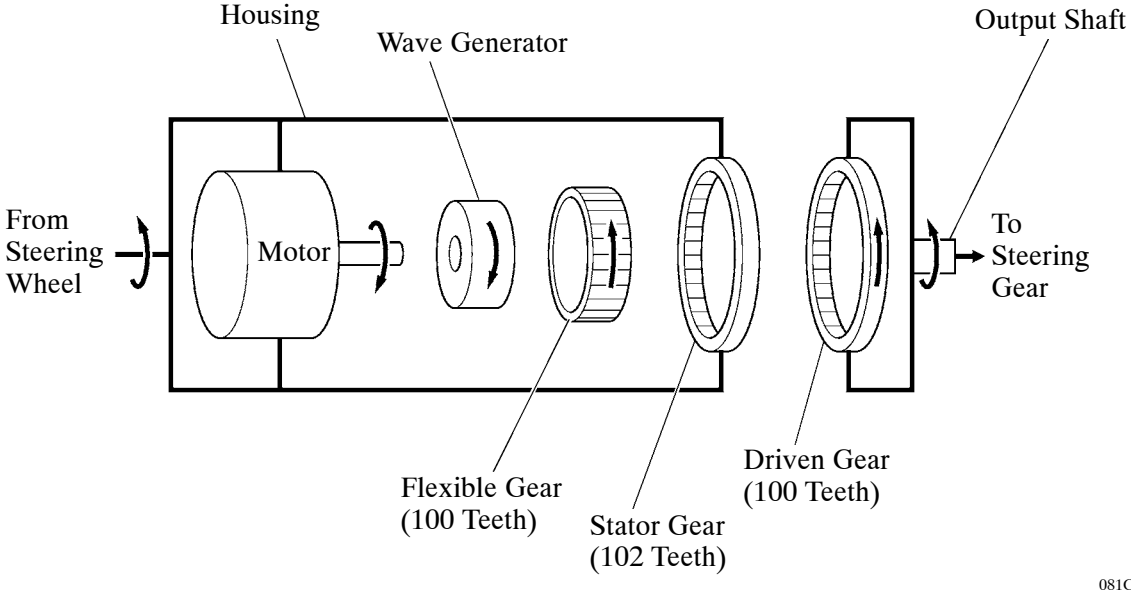


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- When the wave generator makes one rotation, the flexible gear moves counterclockwise by 2 teeth because the flexible gear has 2 fewer teeth than the stator gear. The driven gear and the flexible gear have the same number of teeth, so their rotational movements are identical. Therefore, the driven gear (output) moves by 2 teeth.



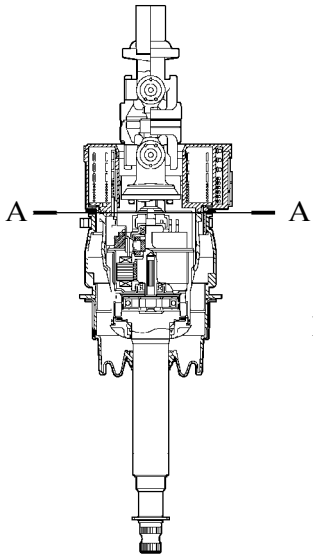
- Due to the aforementioned principle, when the motor rotates clockwise, the rotational movement that is input by the wave generator (which is coupled to the motor shaft) is output to the driven gear (which is coupled to the output shaft). As a result, the output shaft rotates counterclockwise at the 1:50 gear ratio. This rotational angle is added to the actual steered angle of the steering wheel, thus changing the turning angle of the front wheels.



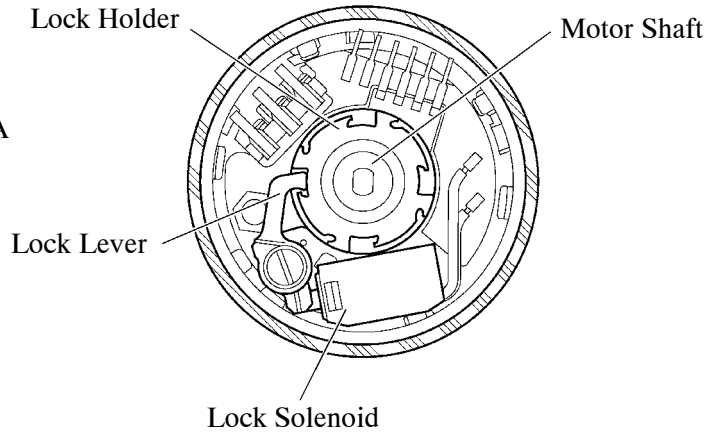
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4) Lock Mechanism

- This system contains a lock mechanism that mechanically locks the motor so that the motor will not rotate if a malfunction occurs. Along with this, the housing and the output shaft are integrated.
- The lock mechanism is mounted on the motor. It consists primarily of a lock holder that is secured to the motor shaft, a lock lever that is mounted on the housing, and a lock solenoid that operates the lock lever.



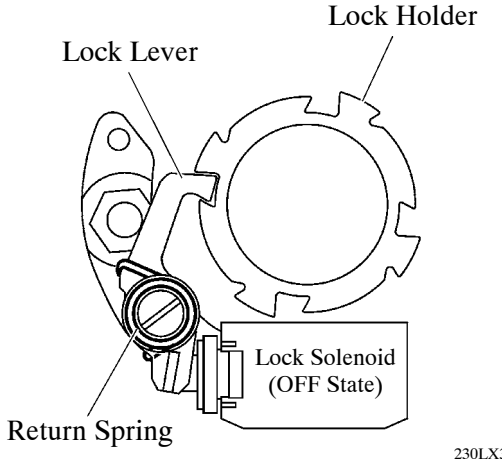
VGRS Actuator Assembly



A – A Cross Section

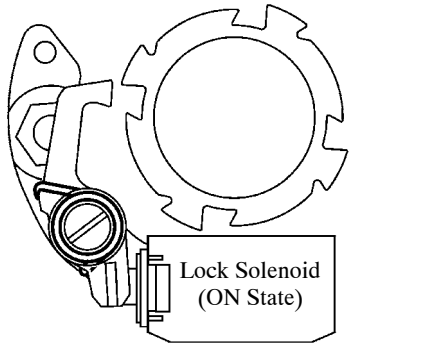
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- When the lock mechanism is activated, the steering control ECU turns OFF the current to the lock solenoid, and the return spring pushes the lock lever against the lock holder. Then, the lock lever meshes with the groove in the lock holder in order to mechanically lock the movement of the motor. When the lock is disengaged, the steering control ECU turns ON the current to the lock solenoid, thus disengaging the lock lever and the lock holder and freeing the movement of the motor.



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Lock State



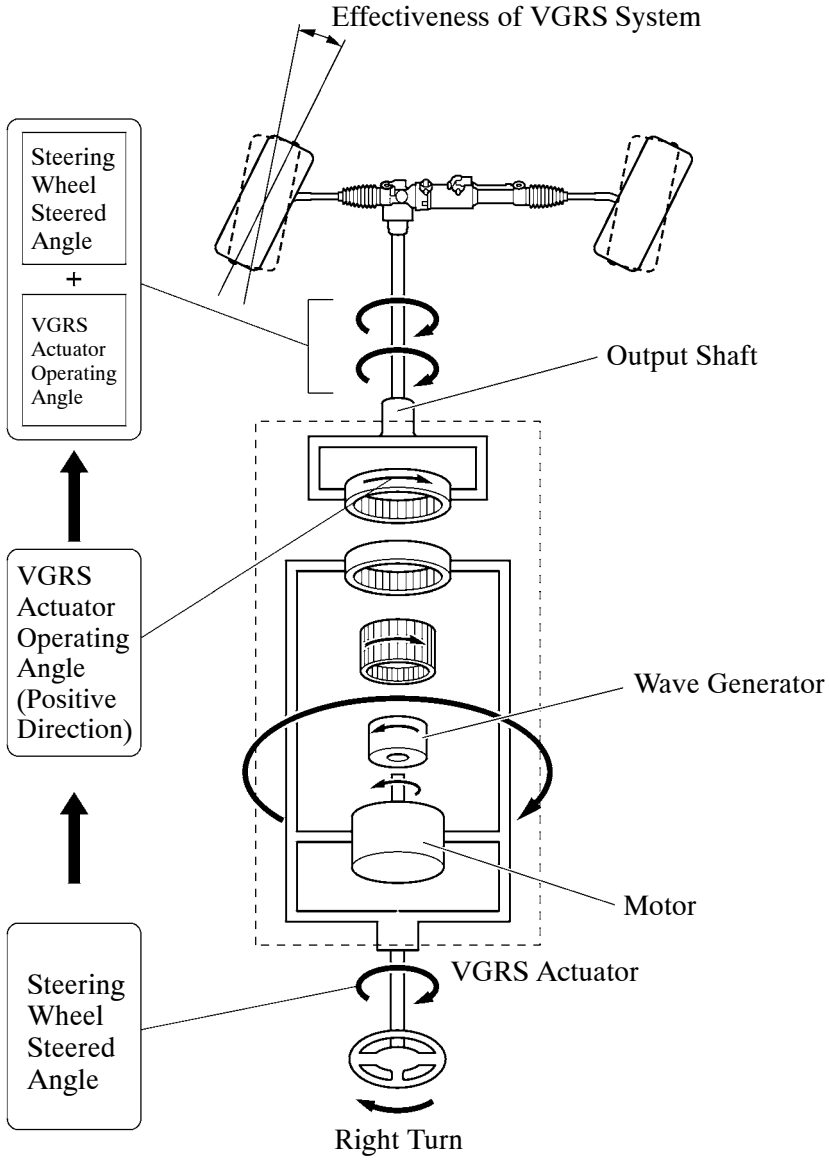
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Unlock State

5) Steering Torque Transmission

a. Low and Middle Speed Range

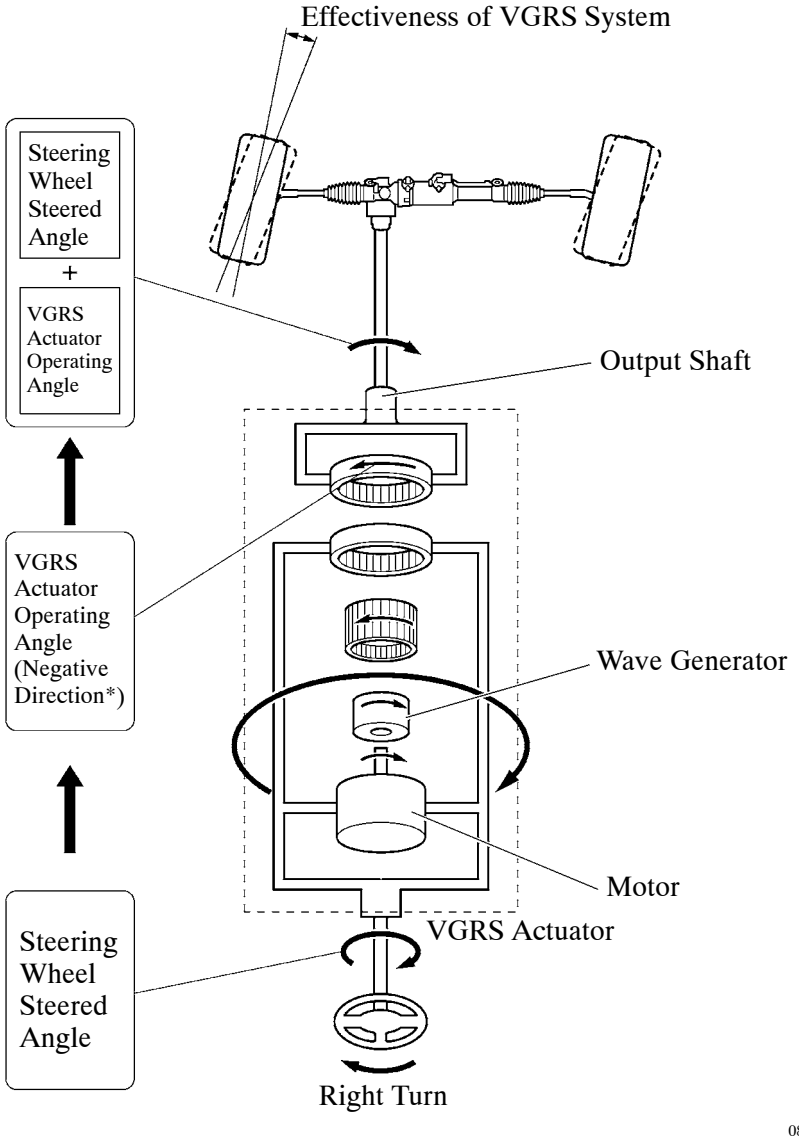
This system rotates the VGRS actuator in the positive direction in the low speed range (in which a reduction in the steering wheel operating angle is desired) or in the medium speed range (in which an agile vehicle response is desired).
For example, if the driver turns the steering wheel clockwise, the torque is transmitted as illustrated below.
In order to create the target operating angle for the VGRS actuator that has been determined by the steering control ECU, the motor in the VGRS actuator rotates counterclockwise. Then, the rotational movement of the motor is input into the reduction mechanism by way of the wave generator. The rotational movement is reduced to a 1:50 gear ratio, and is output from the output shaft in the clockwise direction. This operating angle of the VGRS actuator is then added to the angle in which the steering wheel is steered by the driver. Thus, the output shaft rotates more clockwise than the actual steered angle of the steering wheel by the operation of the VGRS actuator. As a result, the front wheels turn more to the right.



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b. High Speed Range

In the high speed range (in which an over-sensitive movement response of the vehicle is not desired), the VGRS actuator of this system rotates slightly in the negative direction.
For example, if the driver turns the steering wheel clockwise, the torque is transmitted as illustrated below.
In order to create the target operating angle for the VGRS actuator that has been determined by the steering control ECU, the motor in the VGRS actuator rotates clockwise. Then, the rotational movement of the motor is input into the reduction mechanism by way of the wave generator. The rotational movement is reduced to a 1:50 gear ratio, and is output a little from the output shaft in the counterclockwise direction. This operating angle of the VGRS actuator is then subtracted from the angle in which the steering wheel is steered by the driver. Thus, the output shaft rotates less clockwise than the actual steered angle of the steering wheel by the operation of the VGRS actuator. As a result, the front wheels turn less to the right.

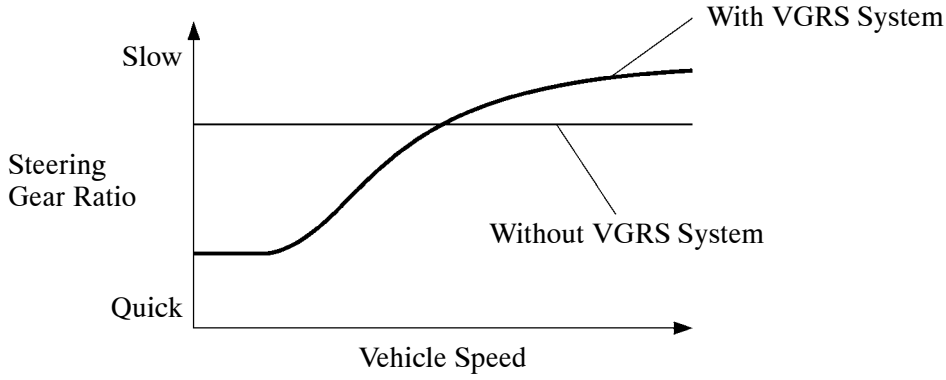


*: When the VGRS actuator rotates in the negative direction, it will not rotate in excess of the driver's steering angle.

Steering Control ECU

1) General

- The steering control ECU calculates the VGRS actuator target operating angle according to the steering angle sensor signal which is based on the steering wheel turning status and the vehicle speed signal which is transmitted from the skid control ECU. The steering control ECU operates the VGRS actuator until it reaches the target operating angle. The steering control ECU controls the turning angles of the front wheels by adding the operating angle of the VGRS actuator to the angle in which the steering wheel is steered by the driver. As a result, the steering gear ratio fluctuates depending on the driving conditions. Thus, excellent steering feel and vehicle stability are achieved, regardless of the vehicle speed, from the low- to high-speed ranges.



Steering Gear Ratio Control Image 081CH96S

- The steering control ECU stores the neutral position of the VGRS actuator in its memory. Thus, the steering control ECU effects control by using this neutral position as a reference value. Furthermore, the steering control ECU constantly stores the operating angle of the VGRS actuator in its memory. These data that have been stored in memory will not be erased even if the battery terminals are disconnected.

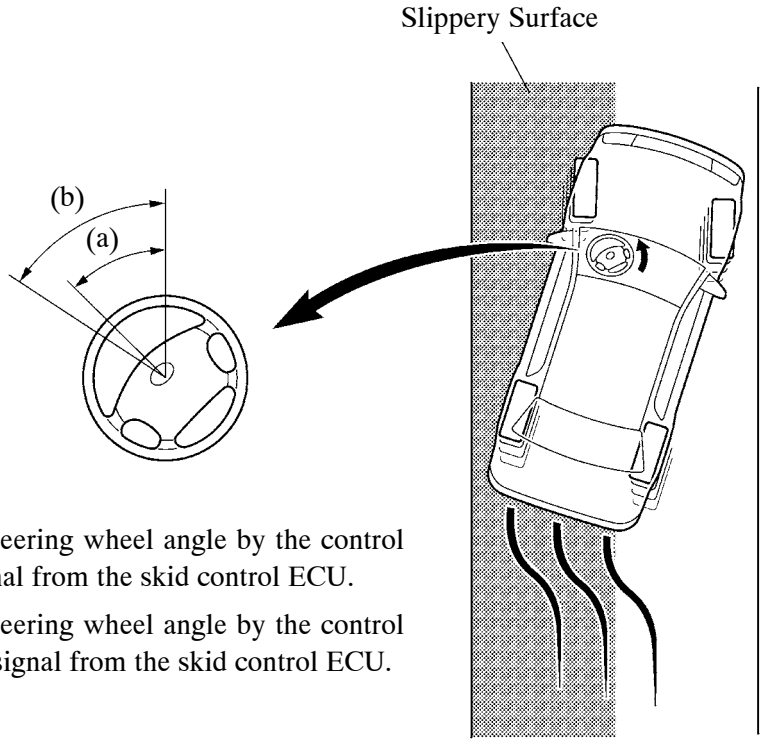
Service Tip

When the steering control ECU is replaced or when any parts between the steering wheel and tires are removed, replaced or adjusted, initialize the VGRS actuator neutral position stored in the steering control ECU memory. For details, see the LEXUS LX 570 Repair Manual (Pub. No. RM08G0E).

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2) Control with Signal from Skid Control ECU

If a vehicle that driven straight ahead over a road surface with different friction coefficients brakes suddenly and causes the VSC to activate, the vehicle posture becomes disrupted, thus requiring the driver to operate the steering wheel. When this occurs, the skid control ECU transmits signals to the steering control ECU. When the steering control ECU receives these signals, it calculates the target operating angle for the VGRS actuator based on the driver's steering angle and direction (which are obtained from the steering angle sensor signals) and the vehicle speed signal (which is obtained from the skid control ECU). Then, the VGRS system operates, reducing the driver's steering effort.



(a): Driver's steering wheel angle by the control with a signal from the skid control ECU.

(b): Driver's steering wheel angle by the control without a signal from the skid control ECU.

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3) Fail-safe

- If the steering control ECU detects a malfunction in the VGRS system, the ECU illuminates the master warning light, indicates the warning message "Check VGRS System" on the multi-information display, sounds the buzzer to inform the driver, and stops the system control.
- If a system malfunction occurs, it turns off the lock solenoid of the lock mechanism and locks the VGRS actuator motor.
- Fail-safe operation modes are as follows:

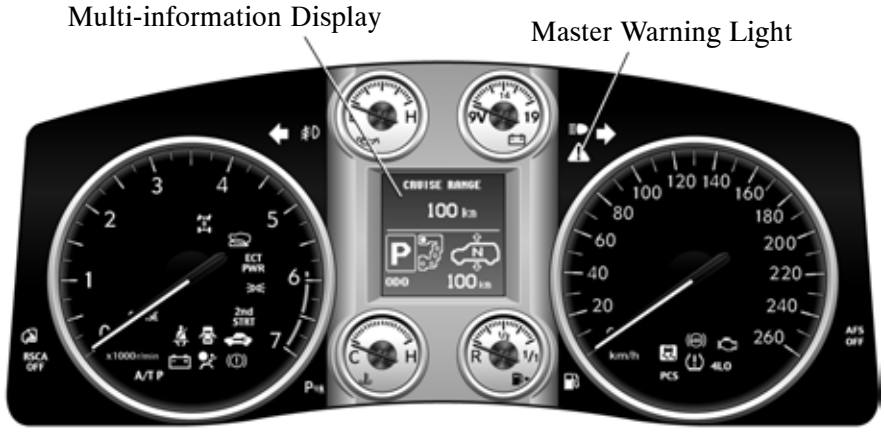
Malfunction Item	Description of Control	Multi-information Display Indication	Master Warning Light	Buzzer
Steering Angle Sensor Malfunction	Stops the control.	"Check VGRS"	Illuminates	Sounds Once
Motor Malfunction	↑	↑	↑	↑
Motor Circuit Malfunction	↑	↑	↑	↑
Lock Mechanism Malfunction	↑	↑	↑	↑
Steering Control ECU Malfunction	↑	↑	↑	↑
Vehicle Speed Signal Malfunction	↑	↑	↑	↑
Skid Control ECU Communication Signal Malfunction	↑	↑	↑	↑
Motor Overheating (Detected by monitoring the motor operating voltage)	First, the control is stopped; then, the control resumes after the system returns to the normal condition.	—	—	—
VGRS Actuator Malfunction	↑	—	—	—
Steering Control ECU Overheating (Internal Temperature Sensor)	↑	—	—	—
PIG Power Source Voltage Drop	↑	—	—	—

4) Diagnosis

If a system malfunction occurs, DTC (Diagnostic Trouble Code) is stored in memory of the steering control ECU. This DTC can be read by the following two methods.

- The 5-digit DTC can be read by connecting an intelligent tester II to the DLC3.
- The 2-digit DTC can be read by connecting the SST (09843-18040) between the TC and CG terminals of the DLC3.

For details, see the LEXUS LX 570 Repair Manual (Pub. No. RM08G0E).

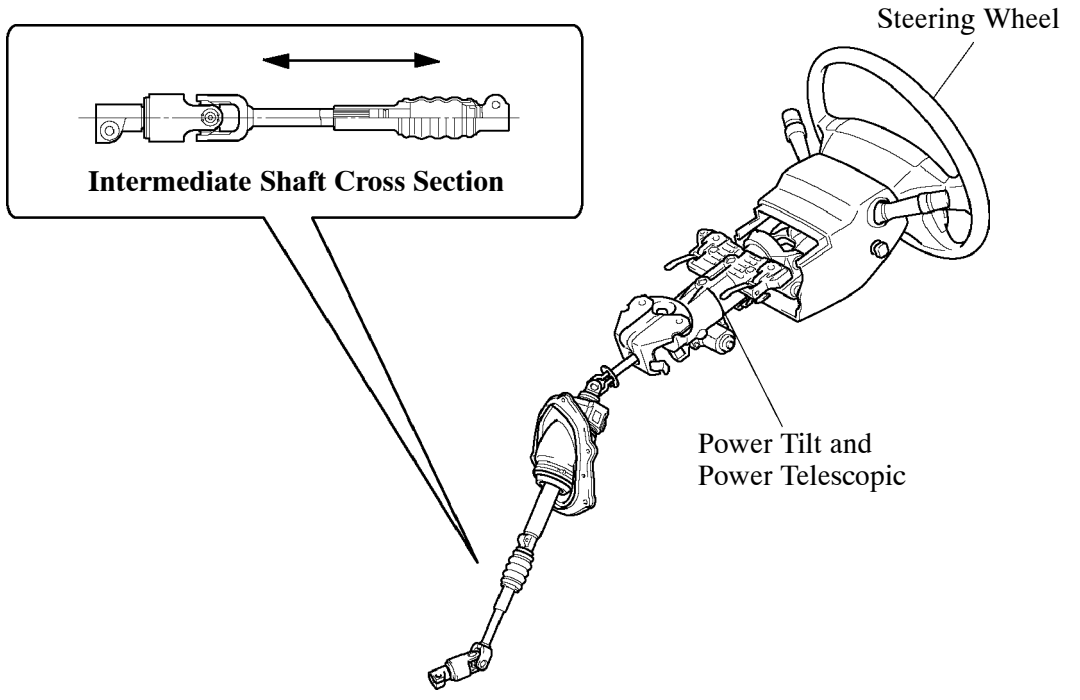


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■STEERING COLUMN

1. General

- A power tilt and power telescopic steering column is used.
- The intermediate shaft is equipped with a mechanism capable of controlling the length of the shaft during driving so that smooth steering can be attained.
- An energy absorbing mechanism and an intermediate shaft contraction mechanism are used to help ensure driver safety in the event of a collision.
- An electrical steering lock system is used. For details, see page BE-182.

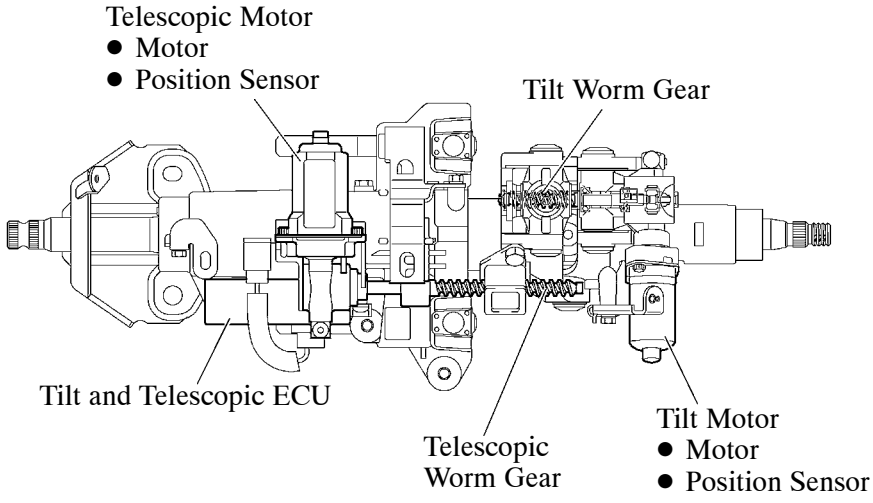


LHD Model

2. Power Tilt and Power Telescopic Steering Column

General

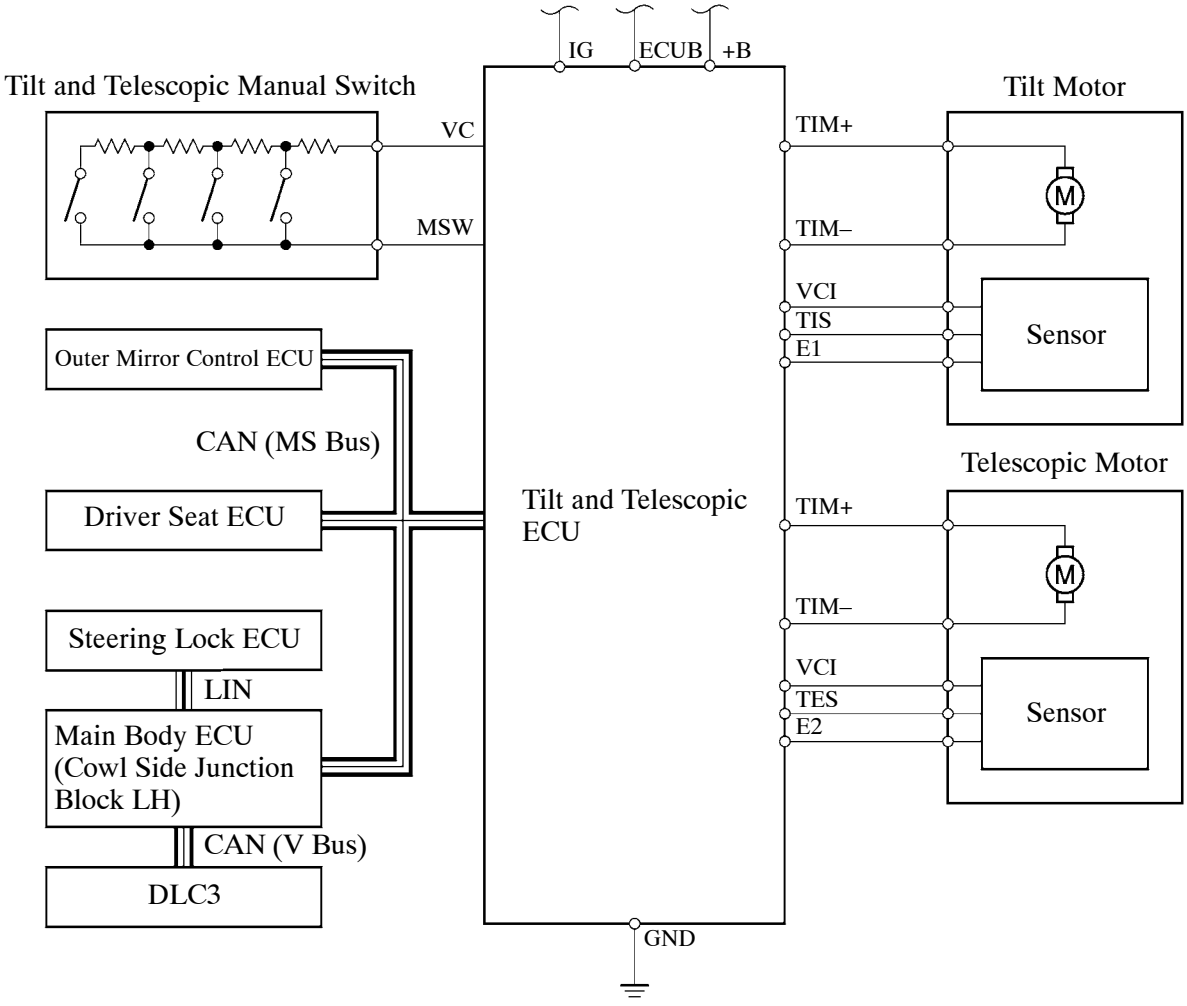
- The power tilt and power telescopic steering column consists of the tilt and telescopic ECU, tilt motor, and telescopic motor.
- This steering column contains a driving position memory function, which operates in unison with the driver's seat and the outer rear view mirror. This function memorizes three driving positions. For details on the memory system, see page BE-303.



Bottom View

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▶ System Diagram ◀



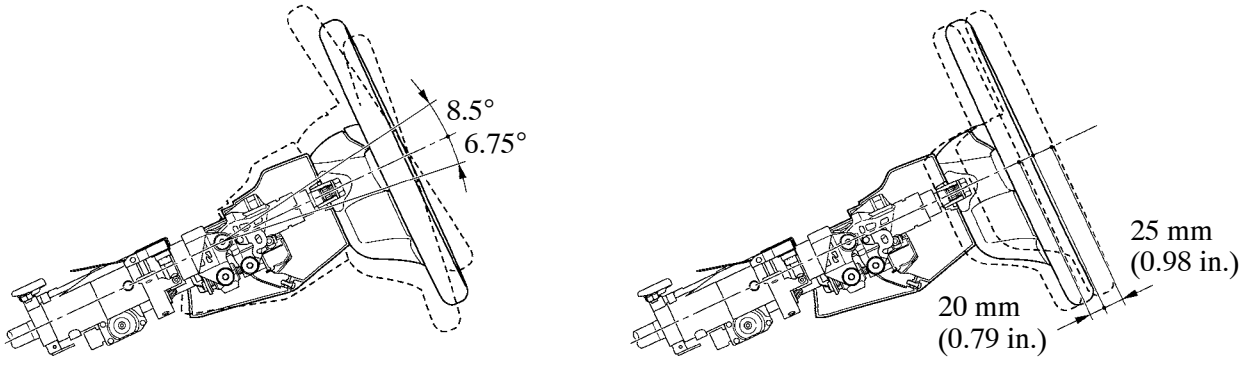
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Operation

1) Manual Operation

A stepless adjustment enables the tilt mechanism to be tilted 15.25° vertically, and the telescopic mechanism to be moved 45 mm (1.77 in.) longitudinally.



Tilt **Telescopic**

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2) Automatic Set Function

Function	Outline
Auto Away	When the engine switch is turned from ON (ACC) or ON (IG) to OFF, the steering wheel automatically tilts up and retracts all the way for easy exit and entry.
Auto Return	When the engine switch is turned from OFF to ON (ACC) or ON (IG), the steering wheel automatically returns to the previous position which was set before the engine switch was turned OFF.

3) Memory Function

Three steering wheel positions can be memorized, allowing different positions to be restored by the memory system.

4) Position Detection

To detect the position of the tilt and telescopic steering column, position sensors that utilize Hall ICs are located in the tilt and telescopic motors and are used to detect the changes in the magnetic field of the magnets, which are attached to the shafts of the motors.

Fail-safe

- If the tilt and telescopic ECU detects a malfunction in the power tilt and power telescopic steering column system, the ECU changes the control mode to a fail-safe mode as follows:

Detection Item	Fail-safe
Key Code Confirm Signal Malfunction	Auto away or auto return stops.
Tilt Position Sensor or Tilt Motor Circuit Malfunction	Tilt operation is suspended.
Telescopic Position Sensor or Telescopic Motor Circuit Malfunction	Telescopic operation is suspended.
ECU Power Source Circuit Malfunction	Tilt and Telescopic operations are suspended.

- If a communication problem has occurred in any ECU related to the tilt and telescopic ECU and the power tilt and power telescopic steering column system, the power tilt and power telescopic steering column system allows the following controls to continue:

Control	ECU in which Communication is Lost			
	Main Body ECU	Outer Mirror Control ECU	Driver Seat ECU	Related All ECU
Manual	×*1	○	○	×*1
Auto Away	×	×	○	×
Auto Return	×*2	×*2	○	×*2
Memory	×	×	×	×

*1: The operation is permitted if the engine switch mode is ON (ACC) or ON (IG) while the signal from the main body ECU is interrupted.
The operation is prohibited if the engine switch is OFF while the signal from the main body ECU is interrupted.

*2: In case that the signal from main body ECU is interrupted after the operation has started, the operation will be continued if the engine switch is ON (ACC) or ON (IG).
The operation is prohibited if the engine switch is OFF while the signal from main body ECU is interrupted.

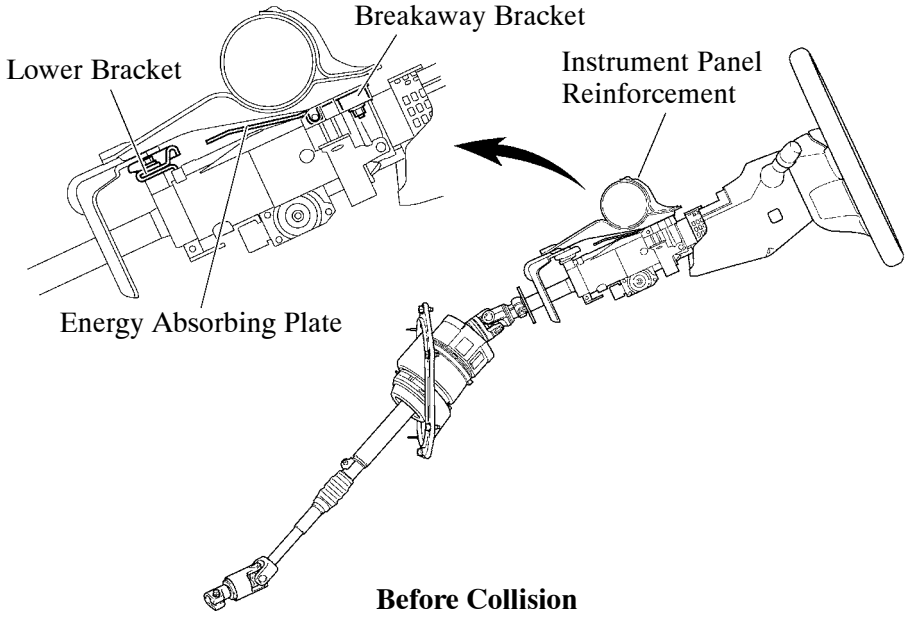
Diagnosis

If the tilt and telescopic ECU detects a malfunction in the power tilt and power telescopic steering column system, the ECU stores the DTC (Diagnostic Trouble Code) in memory. Then, by connecting an intelligent tester II to the DLC3, the DTC can be read and an active test can be performed to test the operation of the tilt motor and the telescopic motor. For details, see the LEXUS LX 570 Repair Manual (Pub. No. RM08G0E).

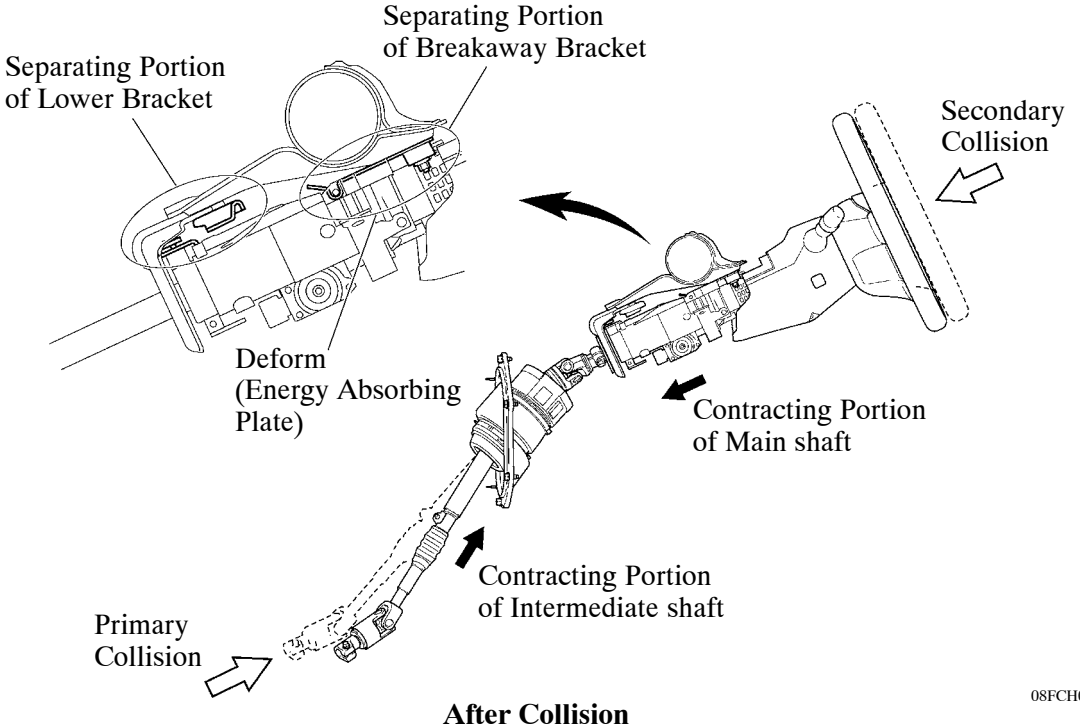
3. Energy Absorbing Mechanism

- The energy absorbing mechanism mainly consists of a breakaway bracket, energy absorbing plate, lower bracket, main shaft, and intermediate shaft.
- When an impact is transmitted to the steering wheel in a collision (secondary collision), the steering wheel and the steering wheel pad help absorb the impact. In addition, the breakaway bracket and the lower bracket separate, causing the entire steering column to move forward.
  At this time, the energy absorbing plate becomes deformed to help absorb the impact of the secondary collision.

▶ Energy Absorbing Mechanism ◀



Before Collision



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After Collision