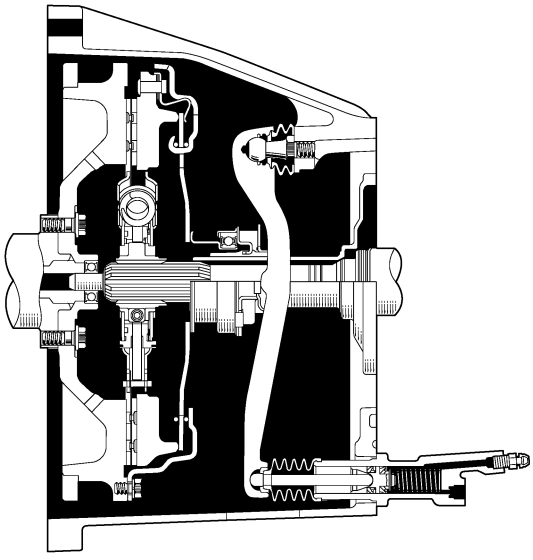
CHASSIS

CLUTCH

■ DESCRIPTION

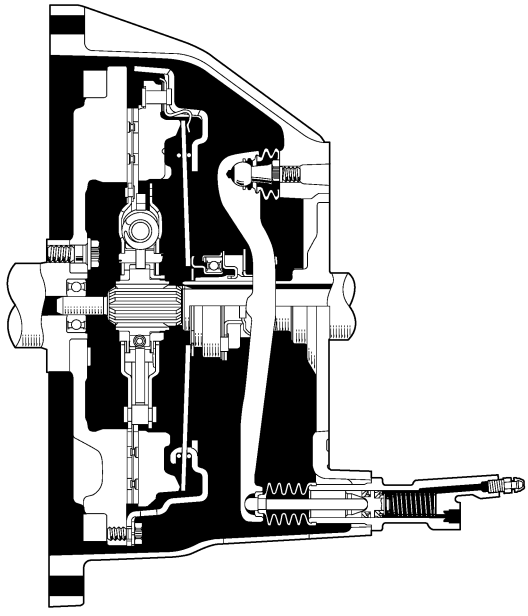
The new Land Cruiser (Station Wagon) has a clutch system with the following features.

- A dry type single plate clutch which is operated by hydraulic pressure is used.
- A clutch disc assembly that uses an organic solvent-free material is used to help protect the environment.
- A clutch accumulator assembly is used to reduce the noise and vibration that is transmitted to the clutch pedal.
- The clutch start system is used to help ensure safety.
- A turnover mechanism is used to reduce clutch pedal effort.



081CH01Y

1GR-FE Engine Models



081CH02Y

1VD-FTV Engine Models

▶ Specifications ◀

Engine Type			1GR-FE	1VD-FTV
Clutch	Type		Dry Type Single Plate Clutch Diaphragm Spring	←
	Operation		Hydraulic	←
Clutch Cover	Type		DST*1	←
	Size	mm (in.)	275 (10.83)	300 (11.81)
	Installed Load	N	8350	8340
Clutch Disc	Facing Size*2	mm (in.)	275 × 175 × 3.5 (10.83 × 6.89 × 0.14)	300 × 190 × 3.5 (11.81 × 7.48 × 0.14)
	Facing Area	cm^2 ($in.^2$)	353 (54.72)	423 (65.57)
Master Cylinder	Type		Conventional	←
	Cylinder Diameter	mm (in.)	19.05 (0.75)	←
Release Cylinder	Type		Non-adjustable	←
	Cylinder Diameter	mm (in.)	20.64 (0.813)	←
Clutch Accumulator Assembly			With	←
Clutch Start System			Standard	←
Clutch Pedal			Turnover	←

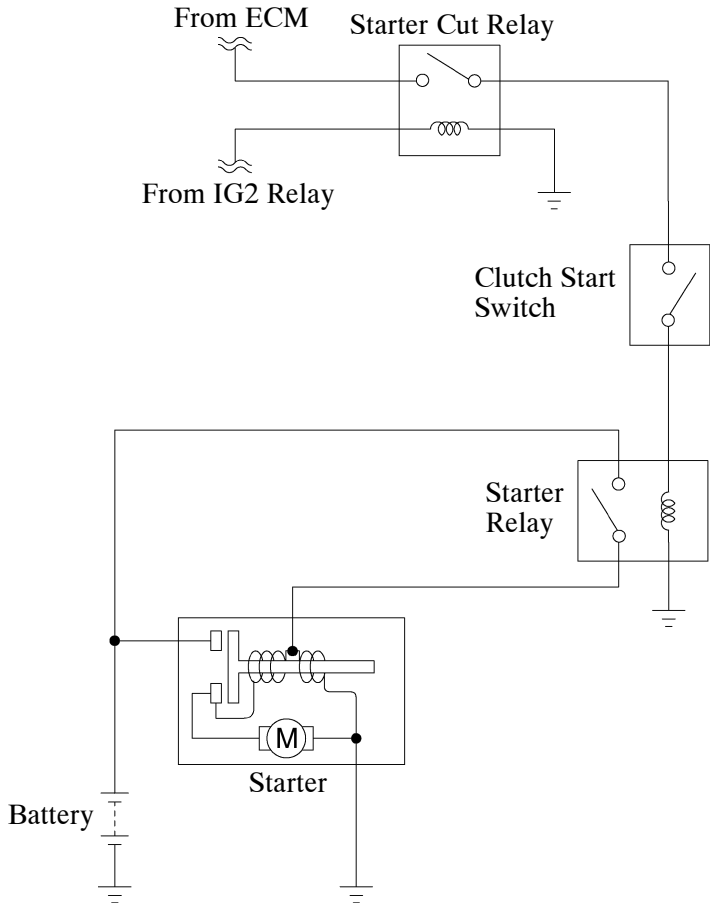
*1: DST (Diaphragm Spring Turnover)
*2: Outer Diameter × Inner Diameter × Thickness

■CLUTCH START SYSTEM

1. General

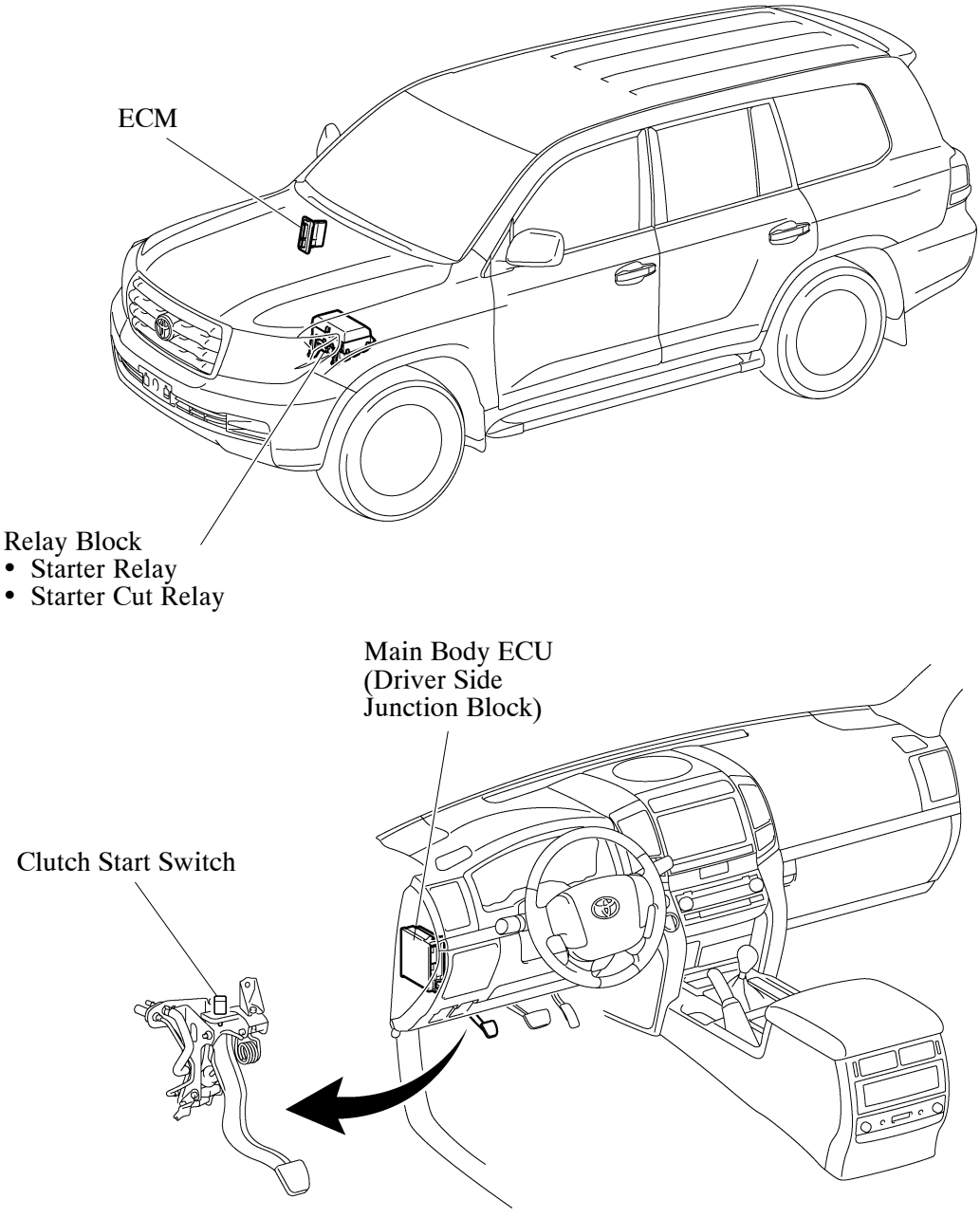
This system prevents the starter from cranking unless the clutch pedal is depressed. This prevents the engine from being started in gear, and ensures safety by preventing the vehicle from moving unintentionally.

2. Wiring Diagram



0140CH02C

3. Layout of Main Components



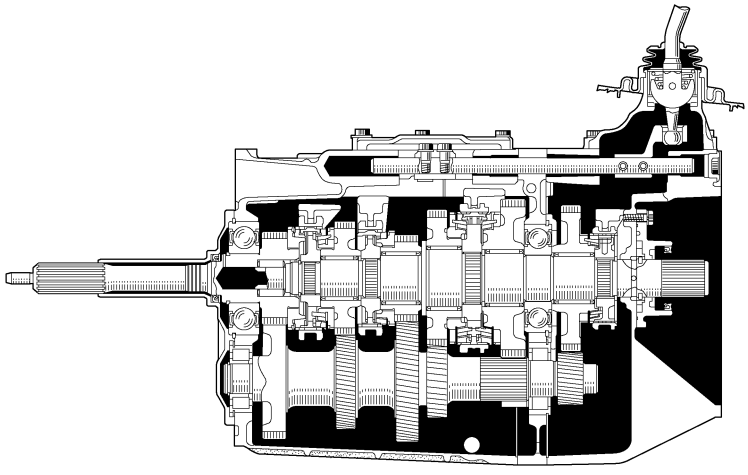
LHD Models

081CH03TE

H150F MANUAL TRANSMISSION

■ DESCRIPTION

- The H150F manual transmission is used on the 1GR-FE and 1VD-FTV engine models.
- The mounting position of the shift lever has been moved rearward so the shift lever is placed nearly vertical, which provides an excellent shift feeling.



081CH05Y

▶ Specifications ◀

Gear Ratio	1st	4.529
	2nd	2.464
	3rd	1.490
	4th	1.000
	5th	0.881
	Reverse	4.313
Oil Capacity	Liters (US qts, Imp. qts)	3.0 (3.2, 2.6)
Oil Viscosity		SAE 75W-90
Oil Grade		API GL-3
Weight (Reference)*	kg (lb)	69.2 (152.6)

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

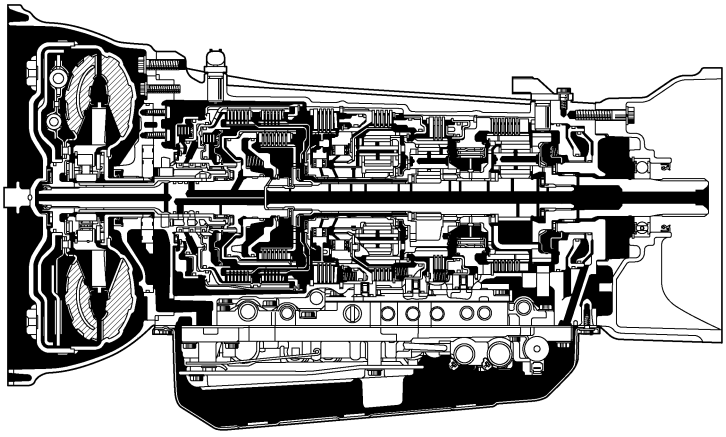
▶ Synchromesh Mechanism Specifications ◀

1st	Triple Cone
2nd	Triple Cone
3rd	Triple Cone
4th	Single Cone
5th	Single Cone
Reverse	Triple Cone

A750F AUTOMATIC TRANSMISSION

■ DESCRIPTION

The A750F 5-speed Super ECT (Electronic Controlled Transmission) is used on the 2UZ-FE and 1GR-FE engine models.

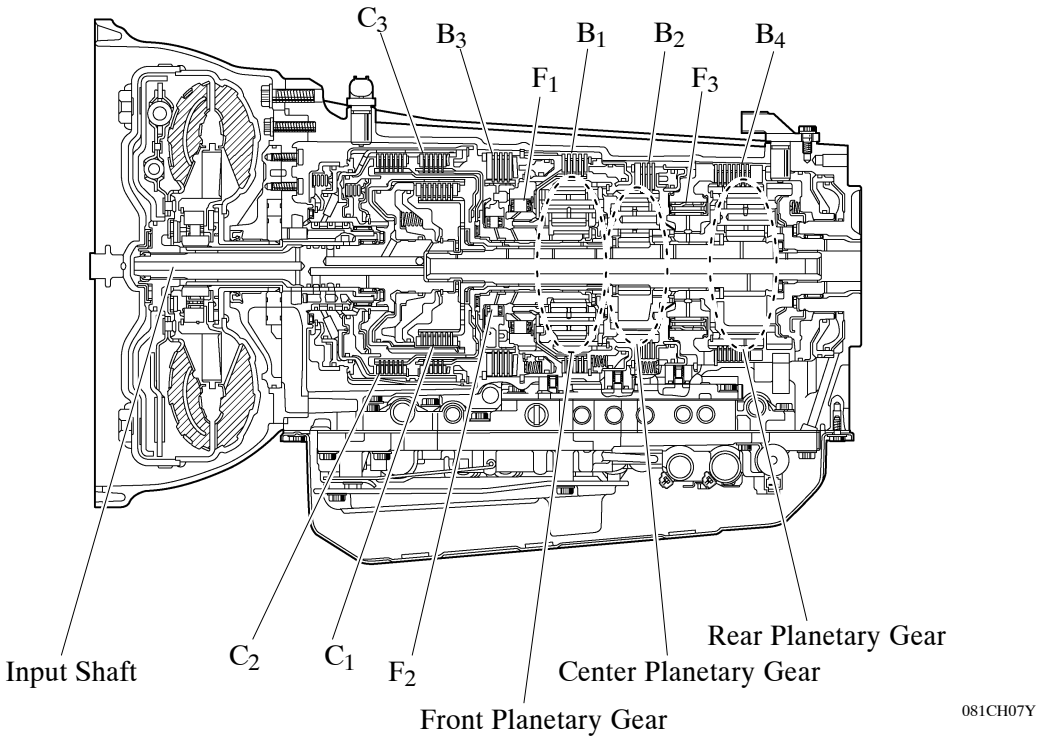


081CH06Y

▶ Specifications ◀

Engine Type		2UZ-FE	1GR-FE
Gear Ratio	1st	3.520	←
	2nd	2.042	←
	3rd	1.400	←
	4th	1.000	←
	5th	0.716	←
	Reverse	3.224	←
Fluid Type		Toyota Genuine ATF WS	←
Fluid Capacity Liters (US qts, Imp. qts)	with Water Cooled Oil Cooler + ATF Warmer	10.9 (11.5, 9.6)	←
	with Water Cooled Oil Cooler + Air cooled ATF Cooler	11.1 (11.7, 9.8)	←
Weight (Reference)* kg (lb)	with Water Cooled Oil Cooler + ATF Warmer	86.0 (189.6)	86.5 (190.7)
	with Water Cooled Oil Cooler + Air cooled ATF Cooler	86.1 (189.8)	86.7 (191.1)

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



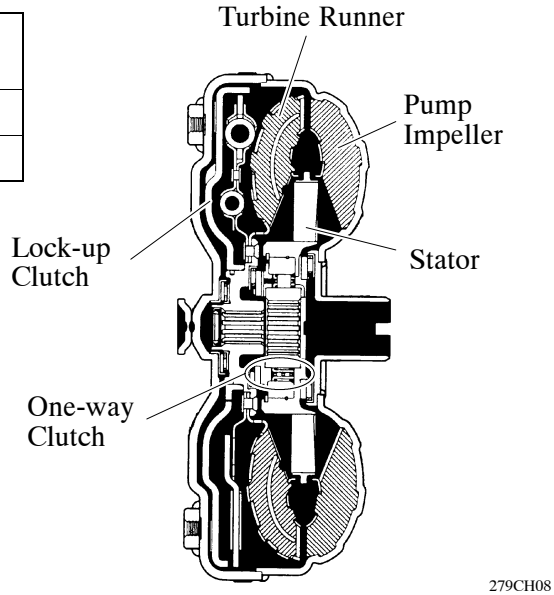
C_1	No.1 Clutch	The No. of Discs		7
C_2	No.2 Clutch			6
C_3	No.3 Clutch			5
B_1	No.1 Brake			4
B_2	No.2 Brake			3
B_3	No.3 Brake			4
B_4	No.4 Brake			8
F_1	No.1 One-way Clutch	The No. of Sprags		18
F_2	No.2 One-way Clutch			25
F_3	No.3 One-way Clutch			26
Front Planetary Gear		The No. of Sun Gear Teeth		40
		The No. of Pinion Gear Teeth	Inner	22
			Outer	21
		The No. of Ring Gear Teeth		91
Center Planetary Gear		The No. of Sun Gear Teeth		31
		The No. of Pinion Gear Teeth		23
		The No. of Ring Gear Teeth		77
Rear Planetary Gear		The No. of Sun Gear Teeth		25
		The No. of Pinion Gear Teeth		19
		The No. of Ring Gear Teeth		63

■TORQUE CONVERTER CLUTCH

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

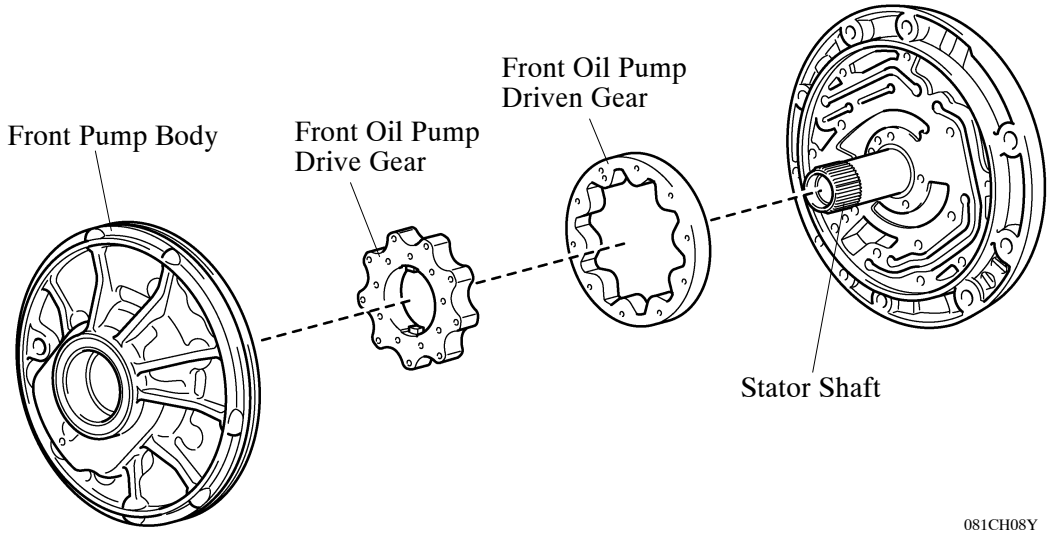
▶ Specifications ◀

Torque Converter Clutch Type		3-element, 1-step, 2-phase
Stall Torque Ratio	2UZ-FE	1.8
	1GR-FE	1.9



■OIL PUMP

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



CH

■ATF COOLING SYSTEM

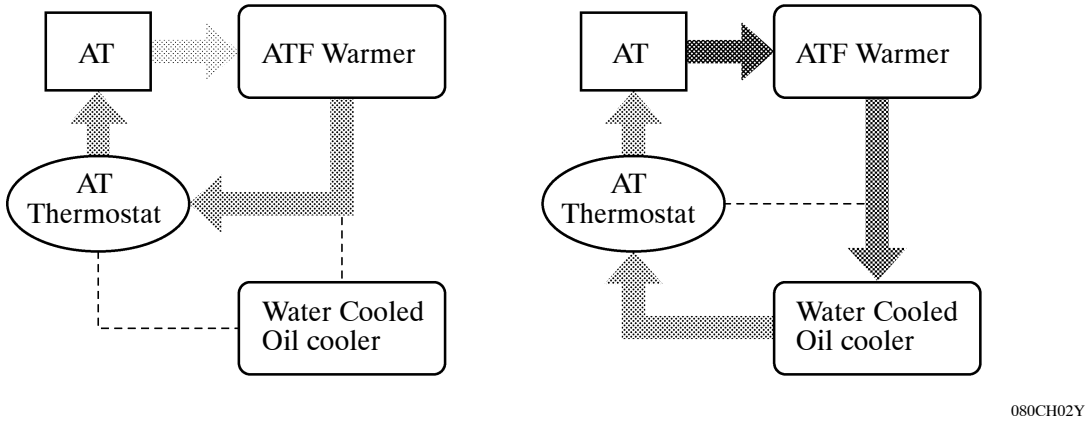
1. General

This automatic transmission uses an ATF warmer that accelerates a rise in the ATF temperature, and an ATF cooler that cools down ATF. The settings of an ATF warmer, water cooled oil cooler, and air cooled vary in accordance with the destinations.

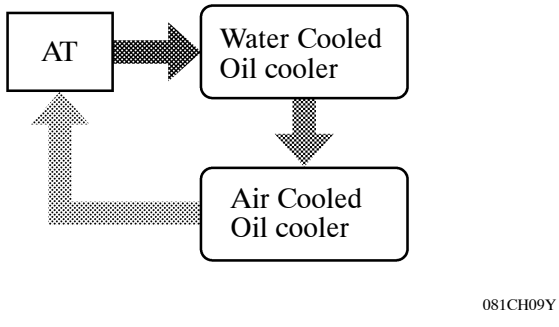
○: Standard —: Not available

Items		Europe	China	Australia	G.C.C. Countries	General Countries
ATF Warmer		○	○	—	—	—
Oil Cooler	Water Cooled	○	○	○	○	○
	Air Cooled	—	—	○	○	○

▶ Cooling Circuits ◀



ATF Warmer + Water Cooled Oil Cooler

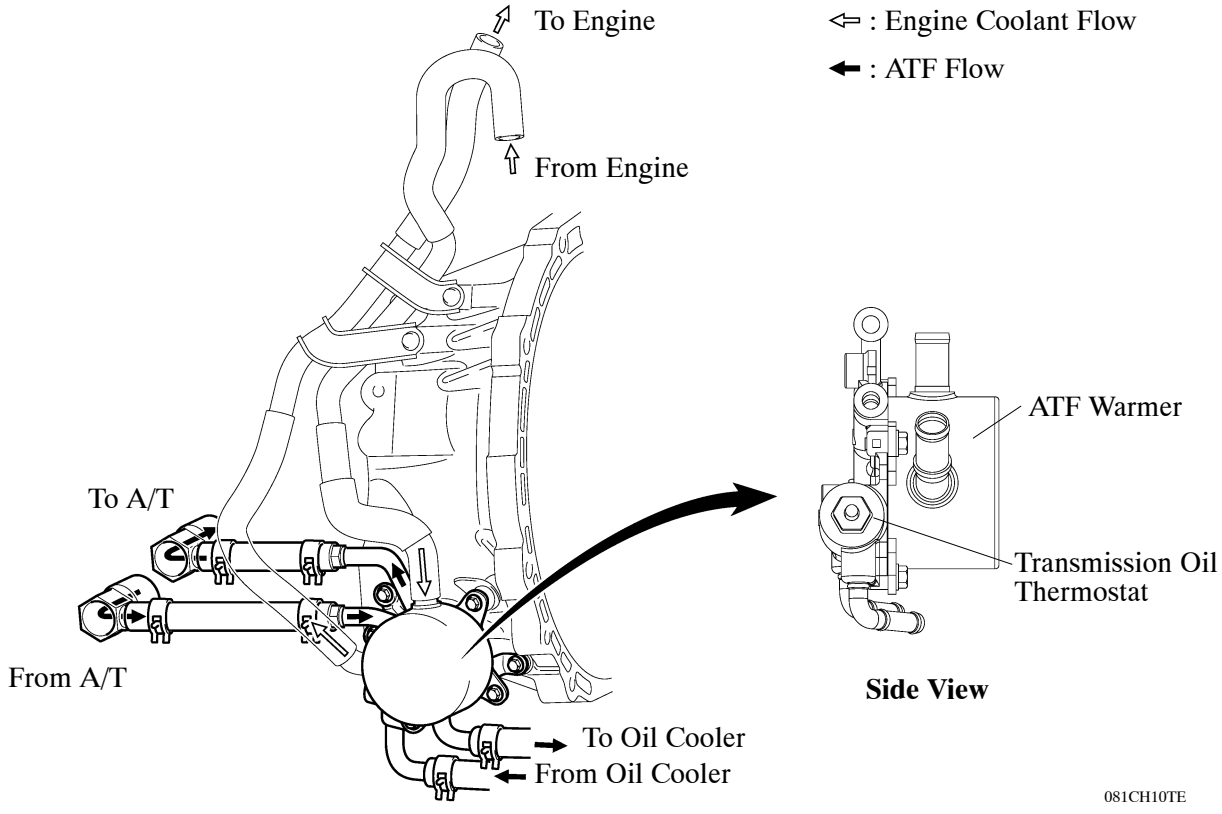


Water Cooled Oil Cooler +Air Cooled Oil Cooler

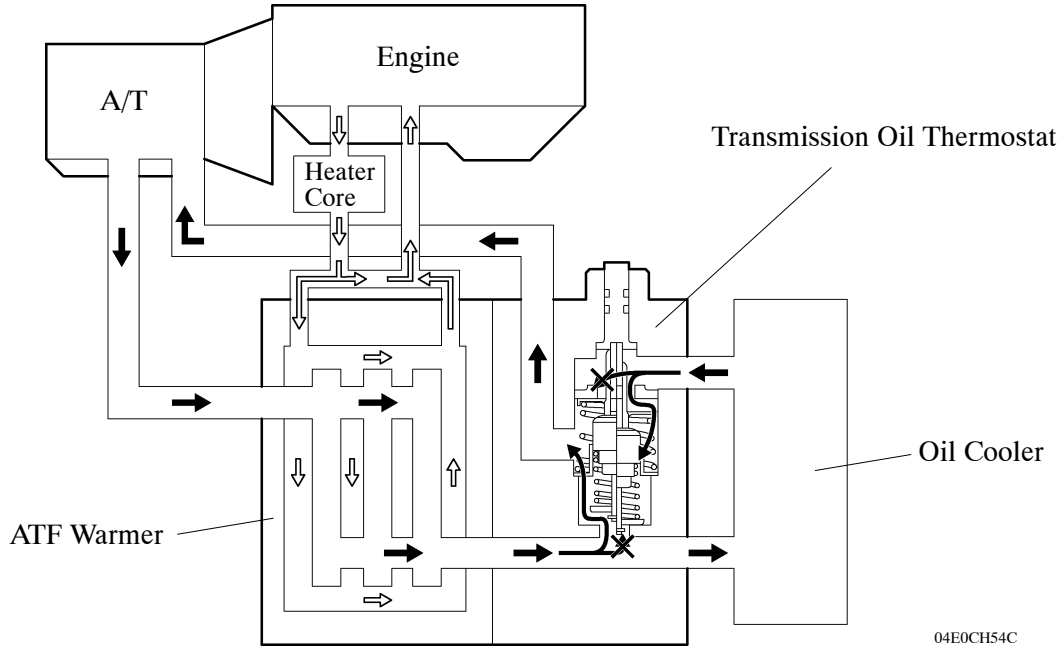
2. ATF WARMER

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 oil cooler.

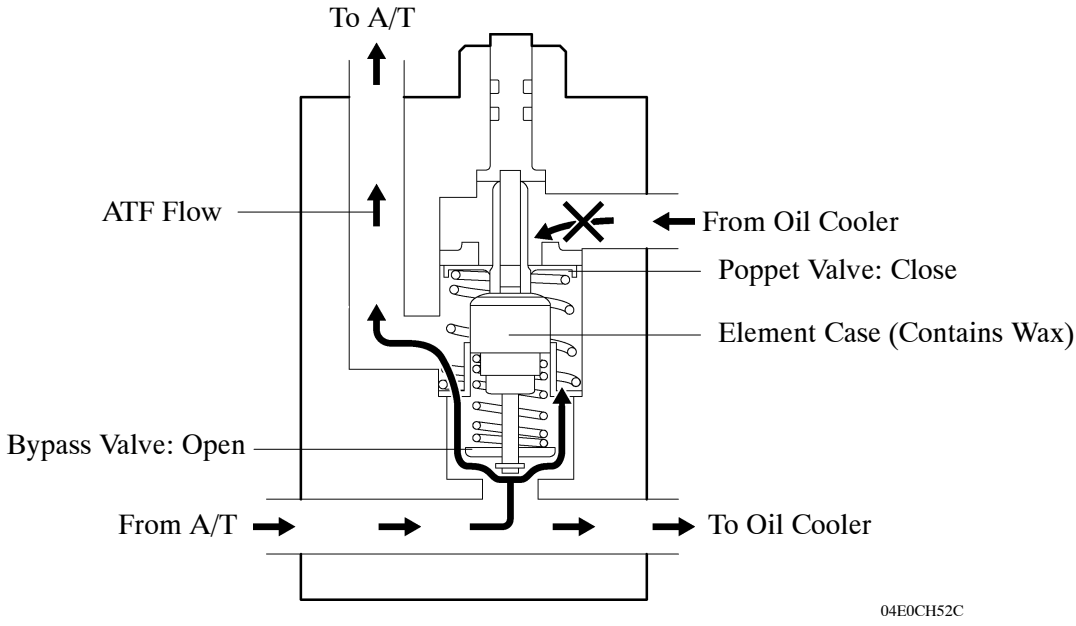


▶ System Diagram ◀

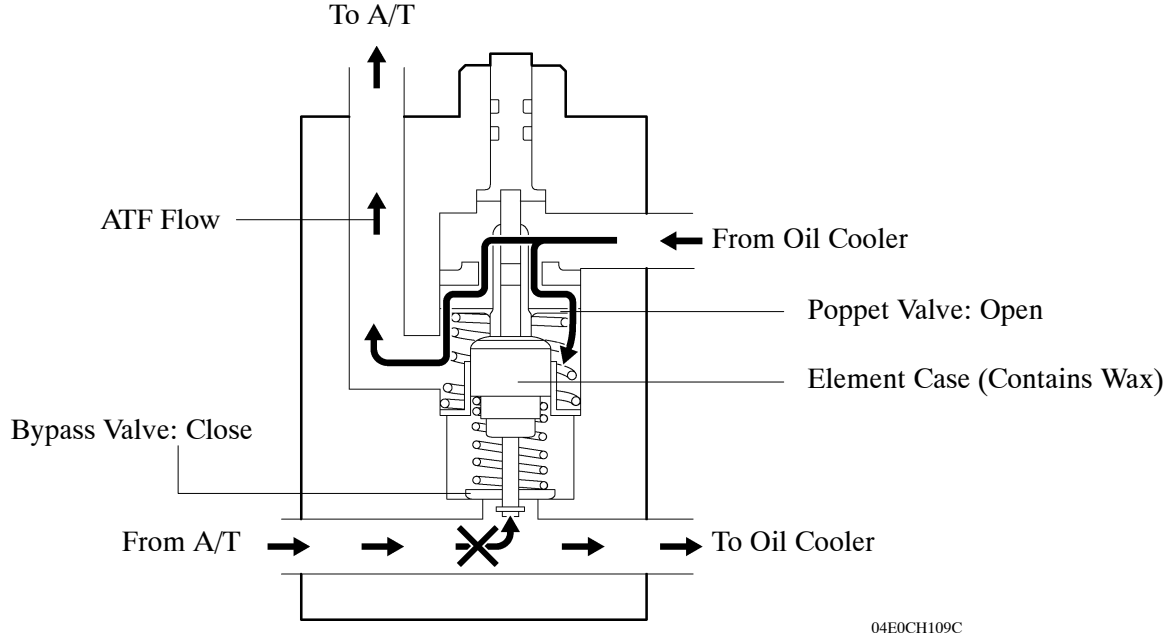


Transmission Oil Thermostat

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.



ATF Temperature: Low

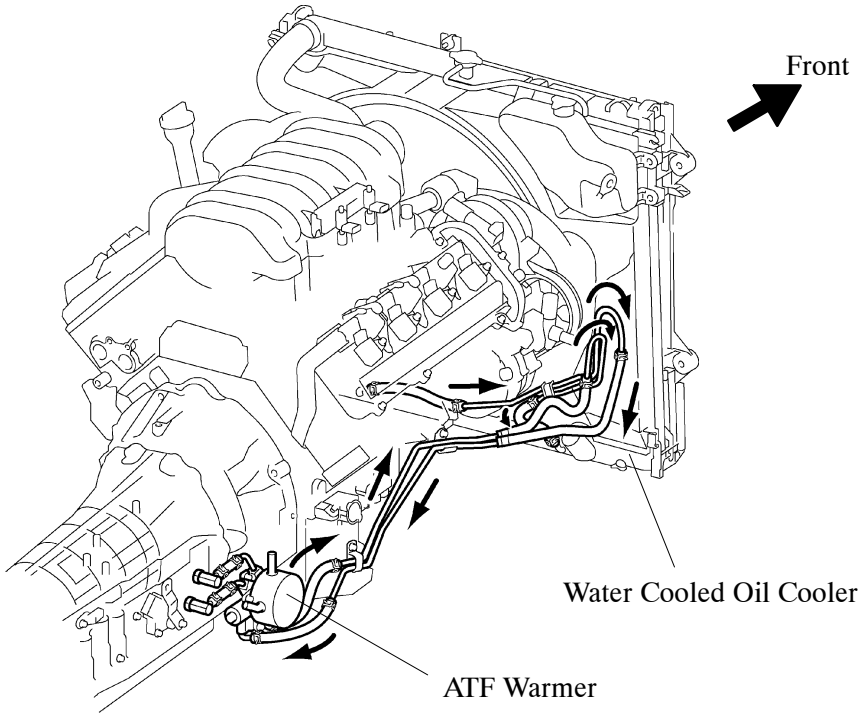


ATF Temperature: High

3. OIL COOLER

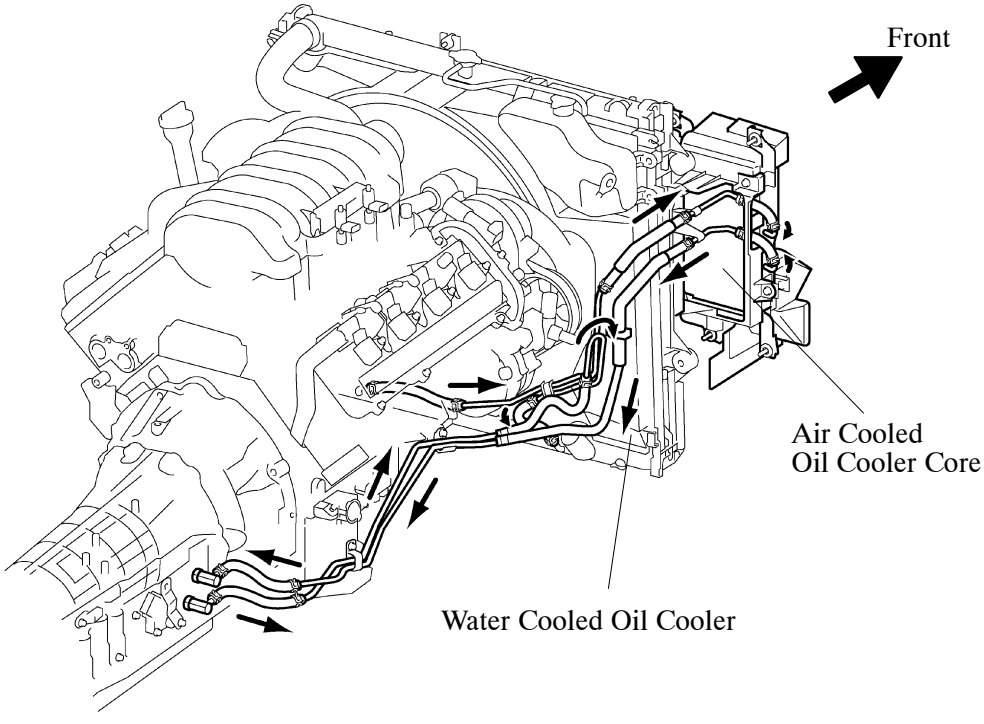
- The water cooled oil cooler cools down the ATF using the engine coolant, and is fitted on the lower of the radiator.
- The air cooled oil cooler cools down the ATF using the cooling fins which are provided on the cooler itself, and is fitted inside the radiator grille so that it can be exposed to the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

▶ Models ATF Warmer + Water Cooled Oil Cooler ◀



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▶ Models Water Cooled Oil Cooler + Air Cooled Oil Cooler ◀

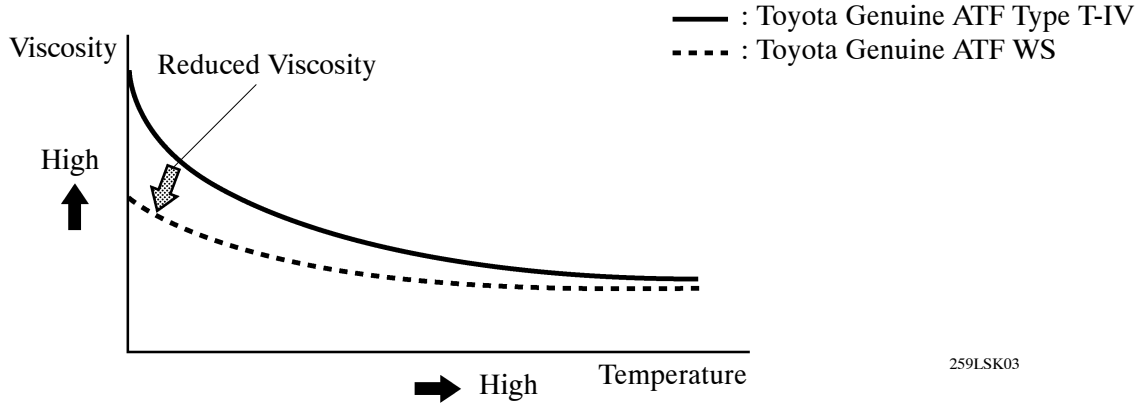


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■TOYOTA GENUINE ATF WS

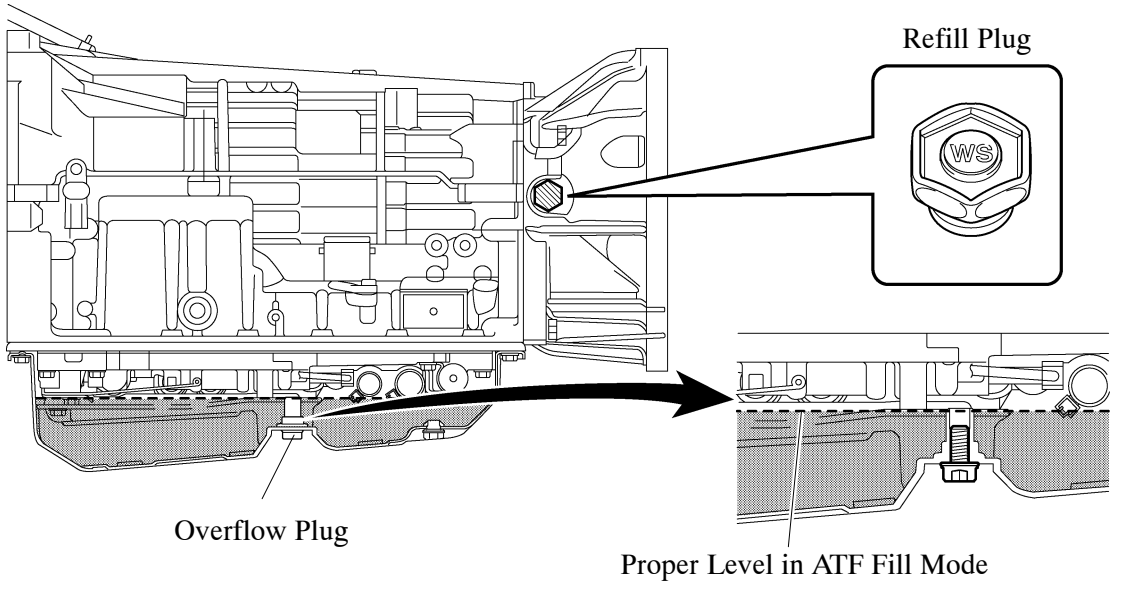
- Toyota Genuine ATF WS is used to reduce the resistance of the ATF and improve the fuel economy by reducing its viscosity in the practical operating temperature range. At higher ATF temperatures, the viscosity is the same as that of Toyota Genuine ATF type T-IV, which ensures the durability of the automatic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



■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 a refill plug, overflow plug, No.2.ATF temperature sensor and shift position indicator light “D”.



Service Tip

ATF Filling procedure using SST (09843-18040)

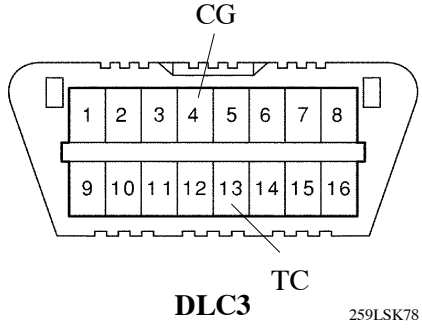
When a large amount of ATF needs to be filled (i.e. after removal and installation of oil pan or torque converter clutch), perform the procedure from step 1.
When a small amount of ATF is required (i.e. removal and installation of oil cooler tube, repair of a minor oil leak), perform the procedure from step 5.
Keep the vehicle level. Turn off the AHC height control switch before raising the vehicle.

1) Remove the refill plug and overflow plug.
2) Fill the transmission with WS type ATF through the refill plug hole until it overflows from the overflow plug hole.
   - ATF WS must be used to fill the transmission.
3) Reinstall the overflow plug.
4) Add the specified amount of ATF (specified amount is determined by the procedure that was performed) and reinstall the refill plug.

Example:

Procedure	Amount Liters (US qts, Imp.qts)
Removal and installation of an oil pan (including oil drainage)	1.7 (1.80, 1.50)
Removal and installation of a transmission valve body	4.3 (4.54, 3.78)
Replacement of a torque converter clutch	5.4 (5.71, 4.75)

5) Use the SST (09843-18040) to make shorts between the TC and CG terminals of the DLC3 connector:
6) Start the engine and allow it to idle.
   - A/C switch must be turned off.
7) Move the shift lever from the P position to the S mode position and slowly selects each gear S1 - S5. Then move the shift lever back to the P position.



DLC3 259LSK78

8) Move the shift lever to the D position, and then quickly move it back and forth between N and D (at least once every 1.5 seconds) for at least 6 seconds. This will activate oil temperature detection mode.
   Standard: The shift position indicator light "D" remains illuminated for 2 seconds and then goes off.
9) Return the shift lever to the P position and disconnect the TC terminal.
10) Idle the engine to raise the ATF temperature.
11) Immediately after the shift position indicator "D" light turns on, lift the vehicle up.
   - The shift position indicator light "D" will indicate the ATF temperature according to the following table.

ATF Temp.	Lower than Proper Temp.	Proper Temp.	Higher than Proper Temp.
Shift Position Indicator Light "D"	Turn OFF	Turn ON	Blinking

(Continued)

12) Remove the overflow plug and adjust the oil quantity.
- If the ATF overflows, go to step 15, and if the ATF does not overflow, go to step 13.

13) Remove the refill plug.
14) Add ATF through the refill plug hole until it flows out from the overflow plug hole.
15) When the ATF flow slows to a trickle, install the overflow plug and a new gasket.
16) Reinstall the refill plug (if the refill plug was removed).
17) Turn the engine switch OFF to stop the engine.

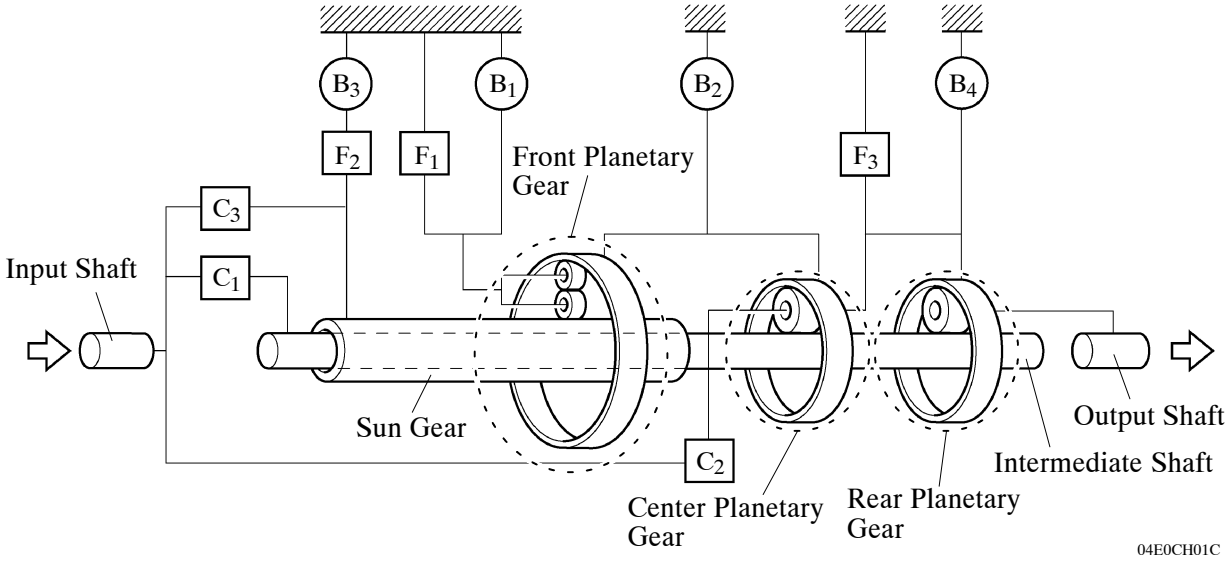
For details about the ATF Filling procedures, see the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

■PLANETARY GEAR UNIT

1. Construction

The planetary gear unit consists of three planetary gear units, three clutches, four brakes, and three one-way clutches.

- A centrifugal fluid pressure canceling mechanism is used in the C_1, C_2, and C_3 clutches that are applied when shifting from 2nd → 3rd, 3rd → 4th, and 4th → 5th. For details, see page CH-22.



2. Function of Components

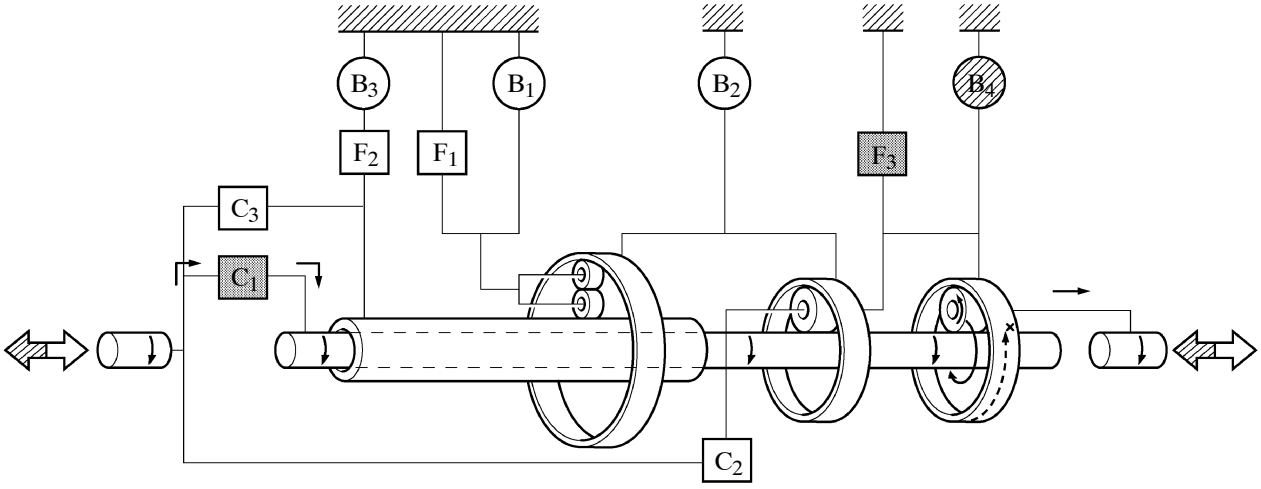
Components		Function
C_1	No.1 Clutch	Connects the input shaft and intermediate shaft.
C_2	No.2 Clutch	Connects the input shaft and center planetary carrier.
C_3	No.3 Clutch	Connects the input shaft and front sun gear.
B_1	No.1 Brake	Prevents the front planetary carrier from turning either clockwise or counterclockwise.
B_2	No.2 Brake	Prevents the front and center ring gear 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 rear 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, this one-way clutch prevents the front planetary sun gear from turning counterclockwise.
F_3	No.3 One-way Clutch	Prevents the center planetary carrier and rear ring gear from turning counterclockwise.
Planetary Gears		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 input and output speed.

3. Transmission Power Flow

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

○: Operates
●: Operates but is not related to power transmission
Δ: Operates during engine braking
*: with engine brake

1st Gear (D Position or S Mode)

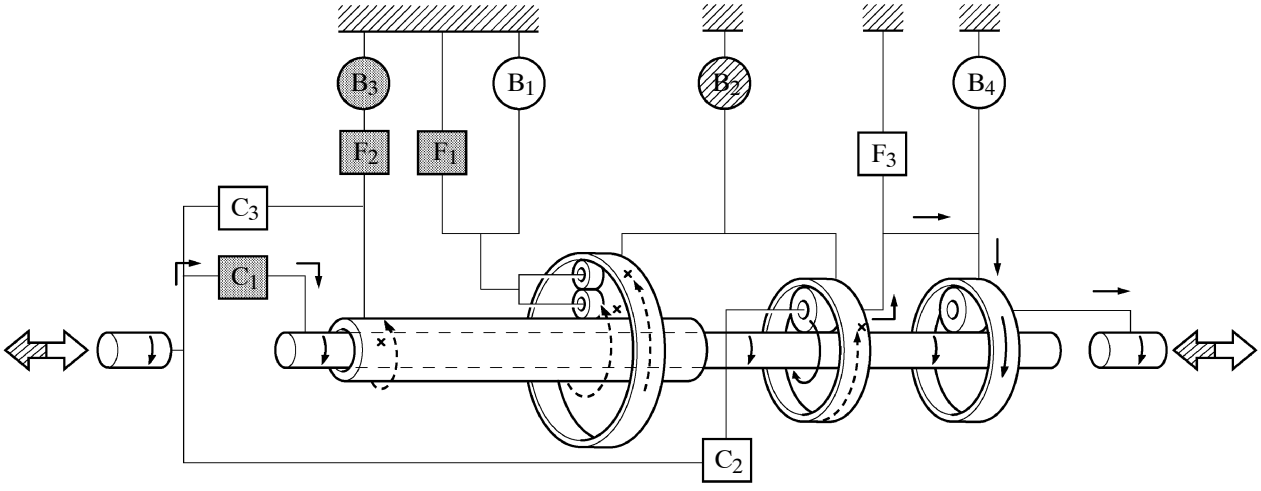


: Operates

: Operates only in the S1 range

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2nd Gear (D Position or S Mode)

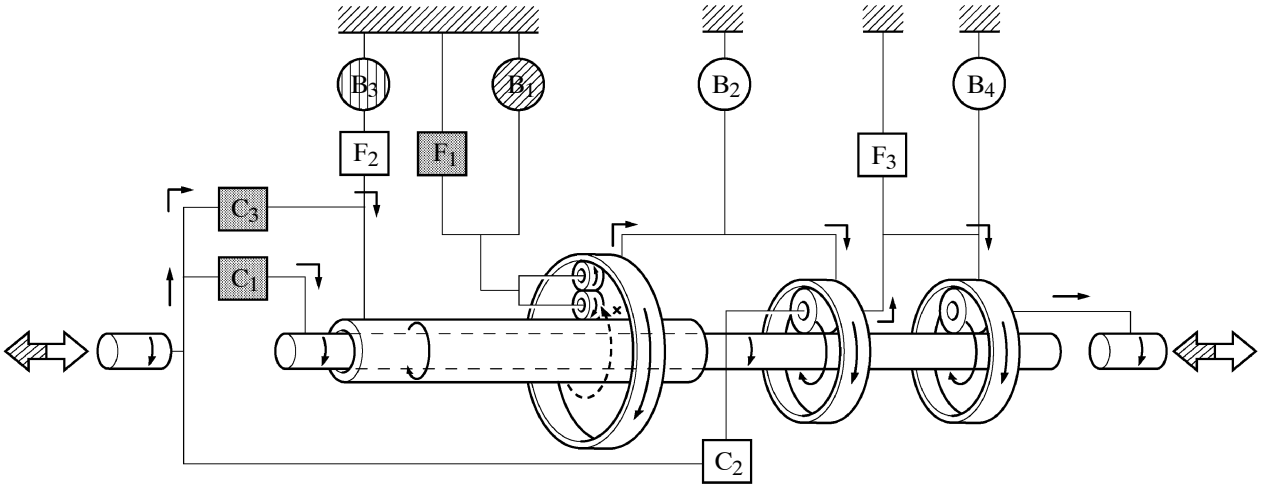


: Operates

: Operates only in the S2 range

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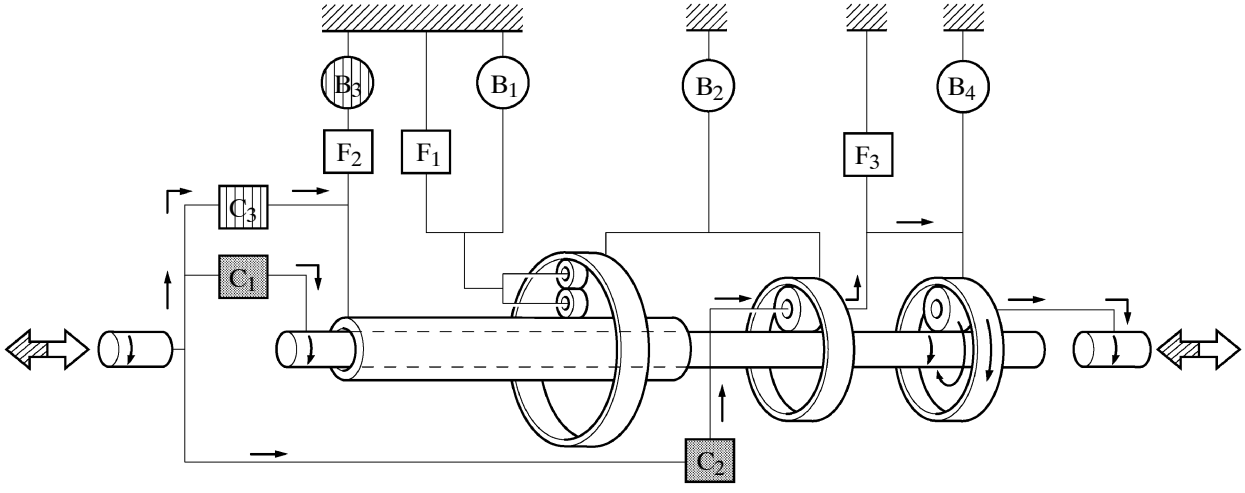
3rd Gear (D Position or S Mode)



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

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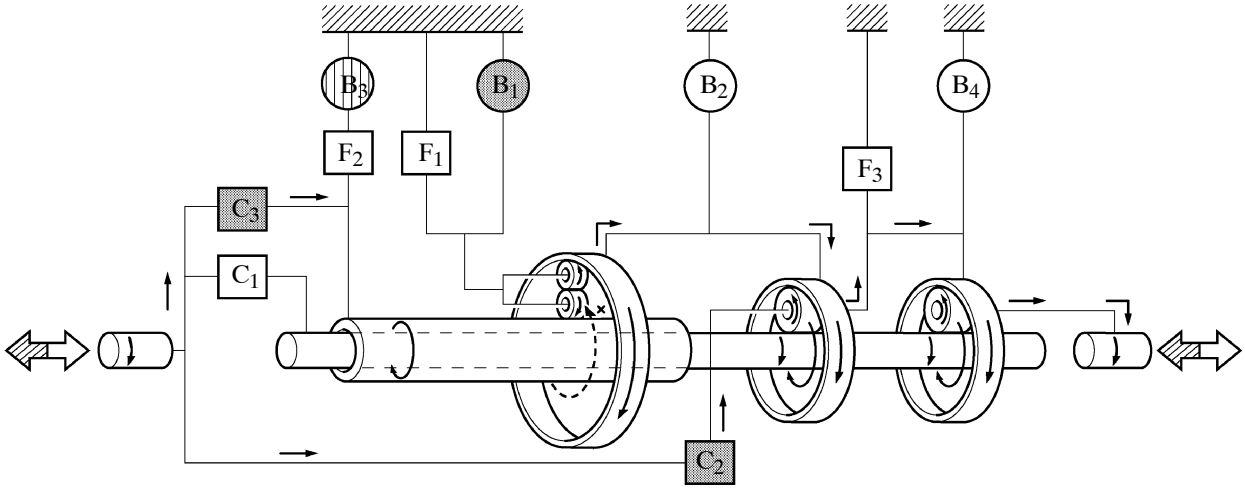
4th Gear (D Position or S mode)



: Operates
: Operates but is not related to power transmission

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5th Gear (D Position or S Mode)

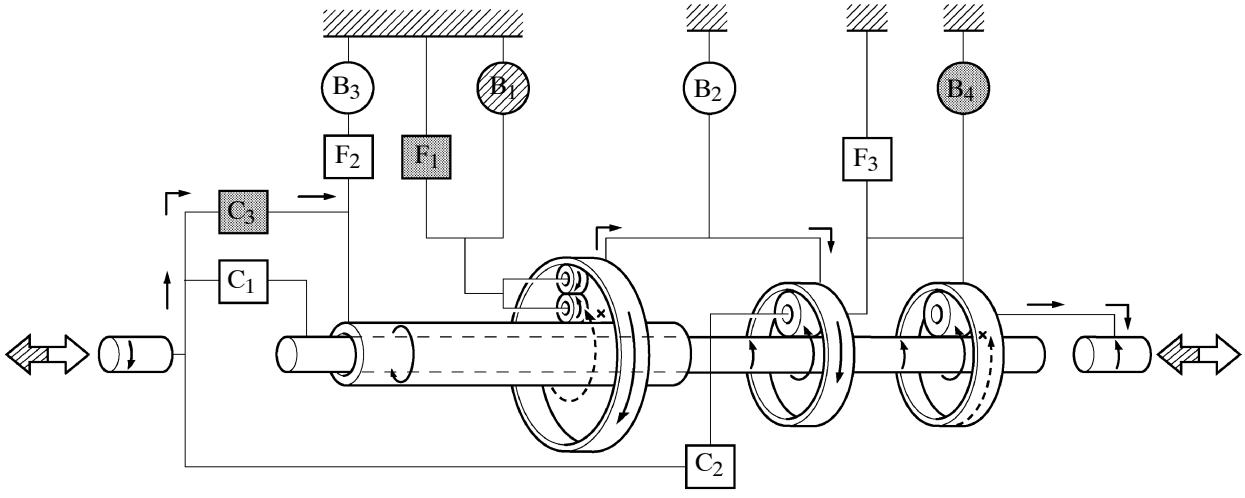


: Operates

: Operates but is not related to power transmission

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Reverse Gear (R Position)



: Operates

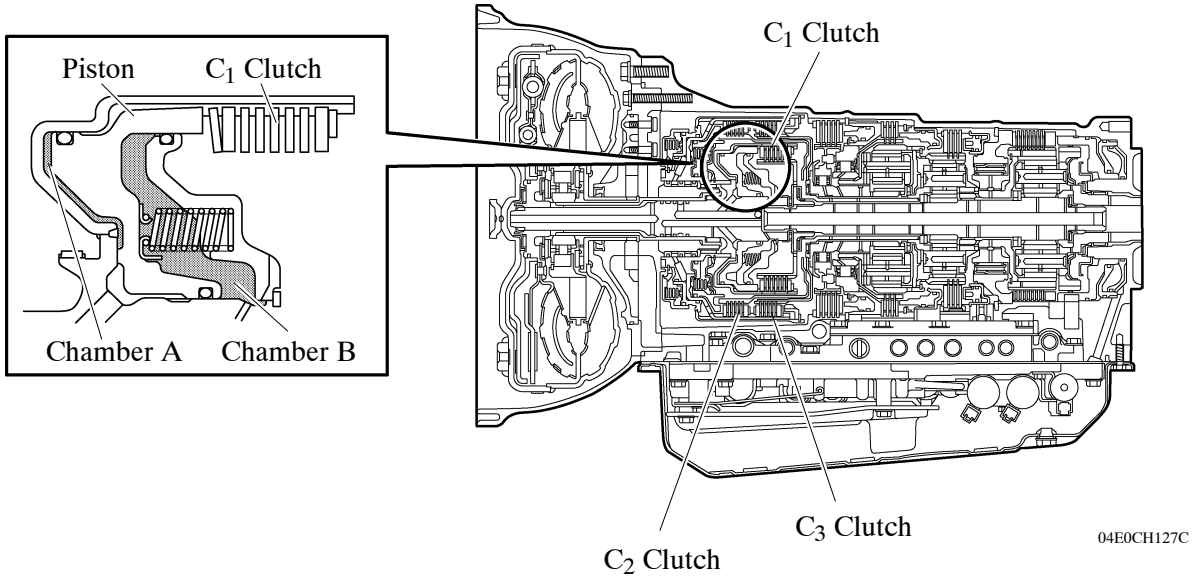
: Operates during engine braking

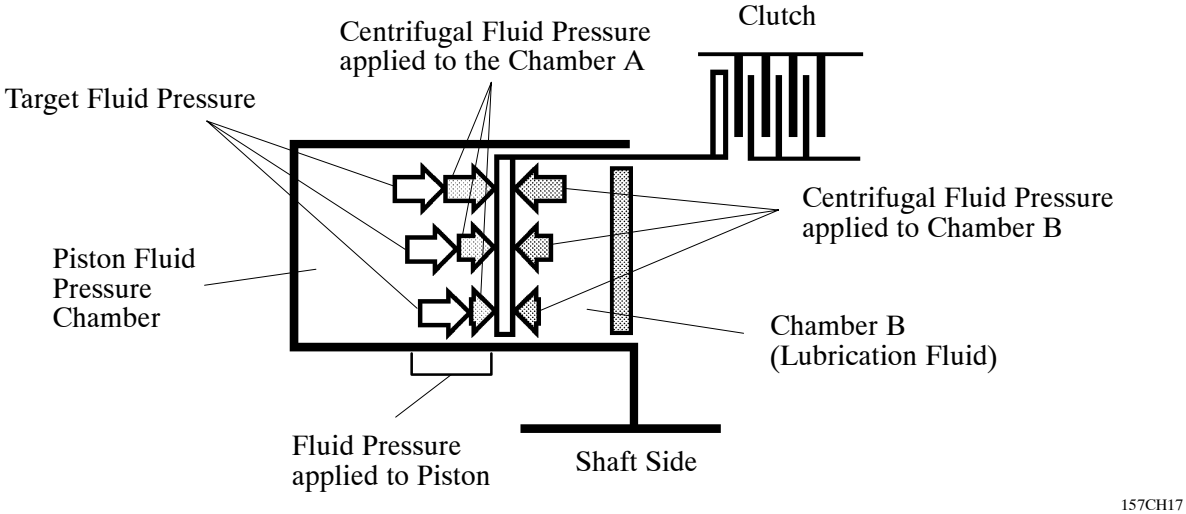
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4. Centrifugal Fluid Pressure Canceling Mechanism

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



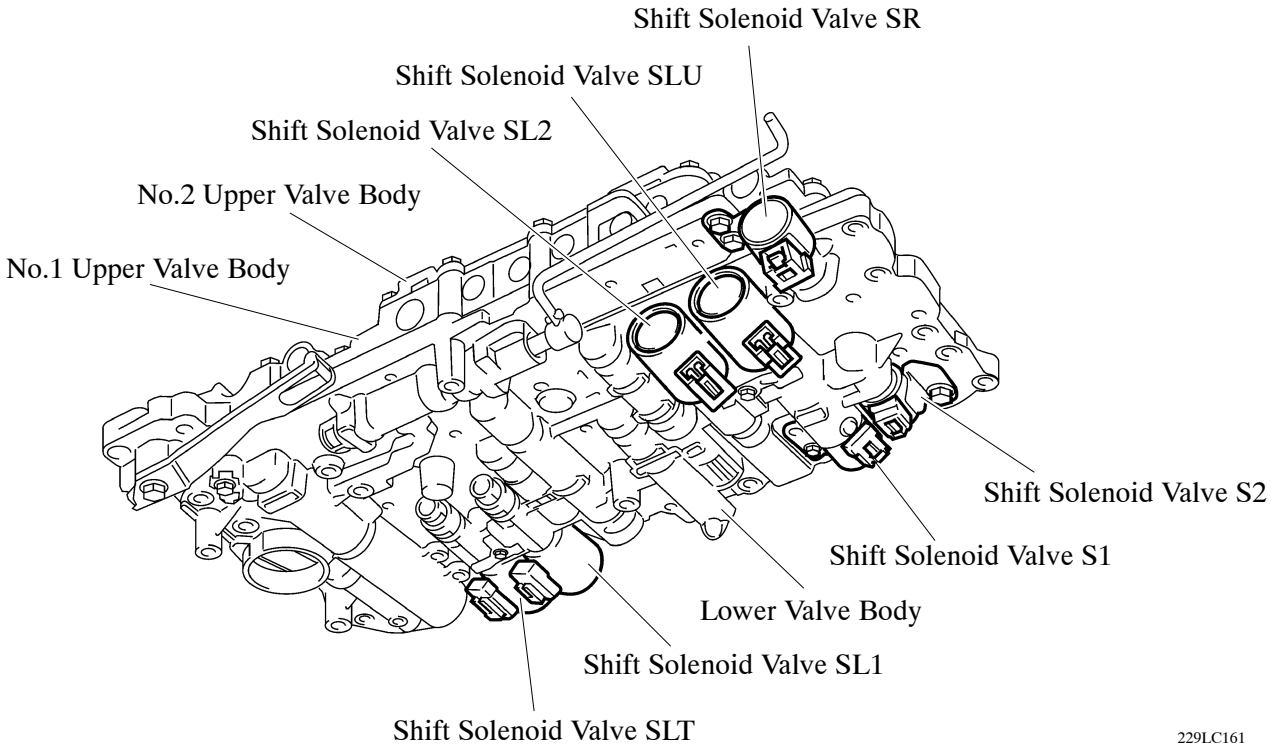


Fluid pressure applied to piston	—	Centrifugal fluid pressure applied to chamber B	=	Target fluid pressure (original clutch pressure)

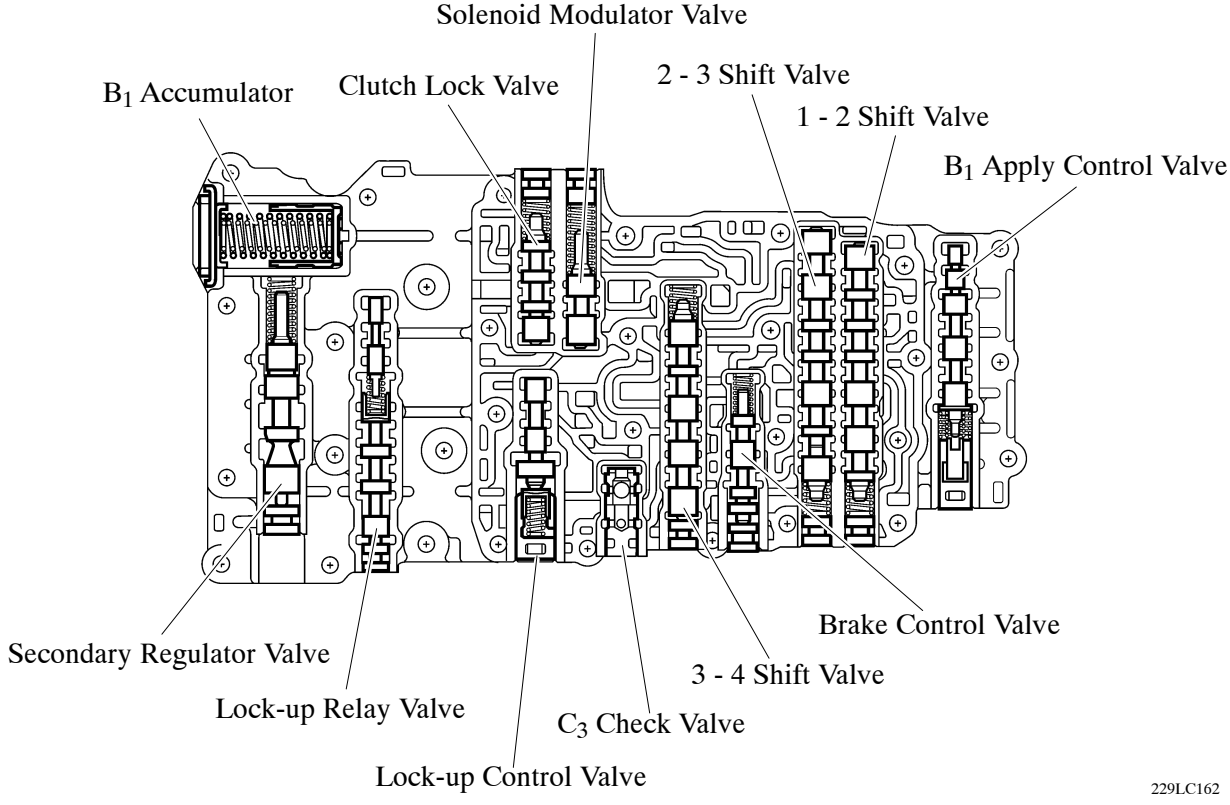
■VALVE BODY UNIT

1. General

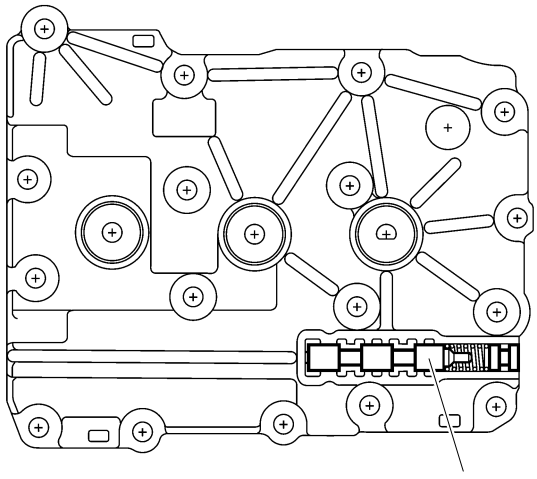
The valve body unit consists of the (No.1 and No.2) upper and lower valve bodies and 7 solenoid valves.



▶ No.1 Upper Valve Body ◀

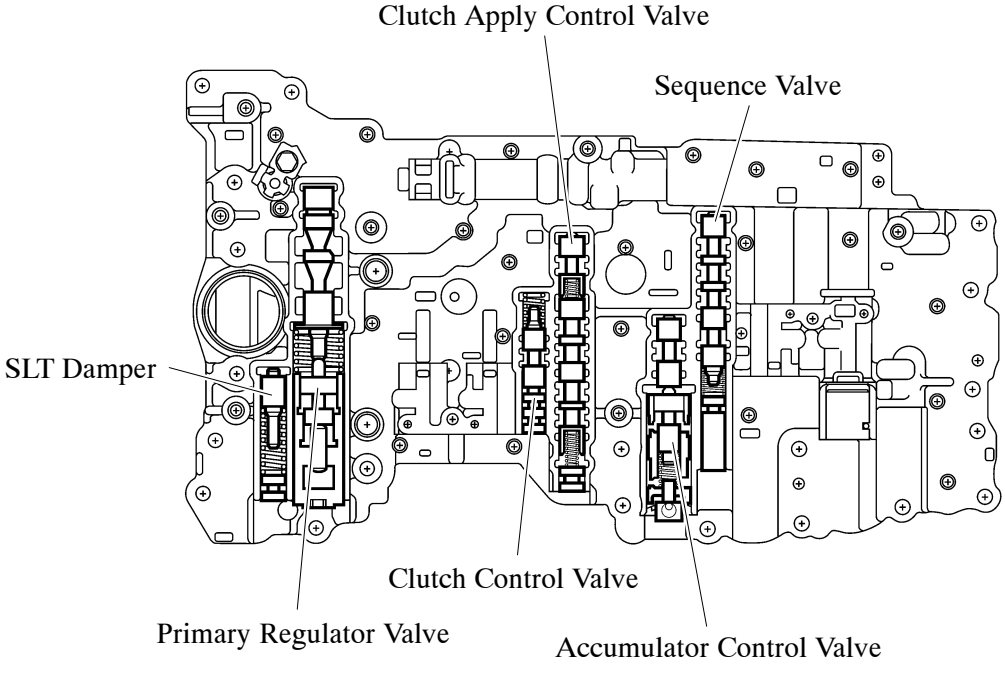


▶ No.2 Upper Valve Body ◀



229LC163

▶ Lower Valve Body ◀

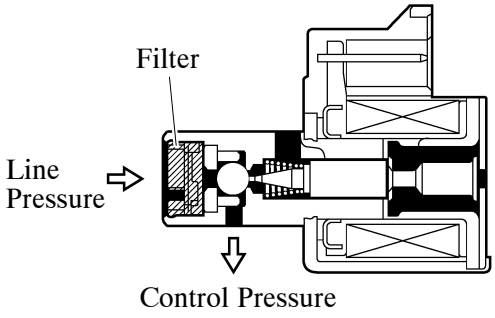


229LC164

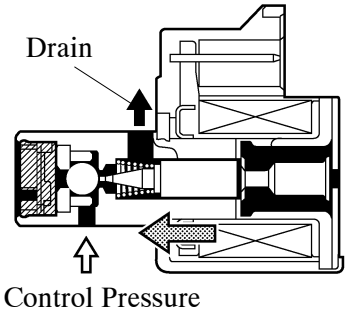
2. Shift Solenoid Valve

Shift Solenoid Valve S1, S2 and SR

- Solenoid valves S1 and SR use a 3-way solenoid valve.
- Solenoid valve S2 uses a 2-way solenoid valve.
- A filter is provided at the tip of each solenoid valve to further improve operational reliability.

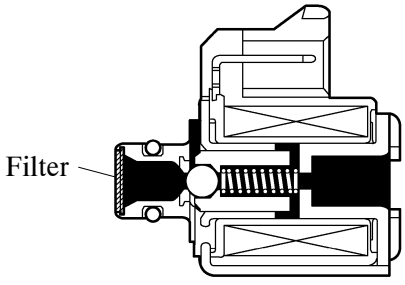


Shift Solenoid Valve S1 OFF

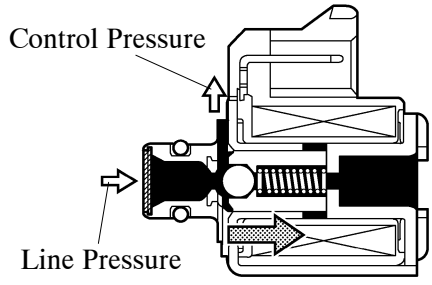


Shift Solenoid Valve S1 ON

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Shift Solenoid Valve S2 OFF



Shift Solenoid Valve S2

229LC166

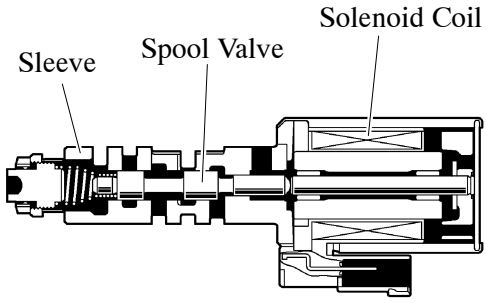
▶ Function of Shift Solenoid Valve S1, S2 and SR ◀

Shift Solenoid Valve	Type	Function
S1	3-way	Switches the 2 - 3 shift valve
S2	2-way	• Switches the 1 - 2 shift valve • Switches the 3 - 4 shift valve
SR	3-way	Switches the clutch apply control valve

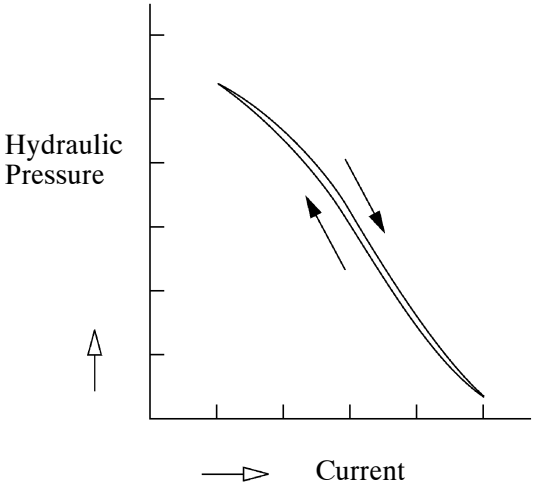
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Shift Solenoid Valve SL1, SL2, SLT and SLU

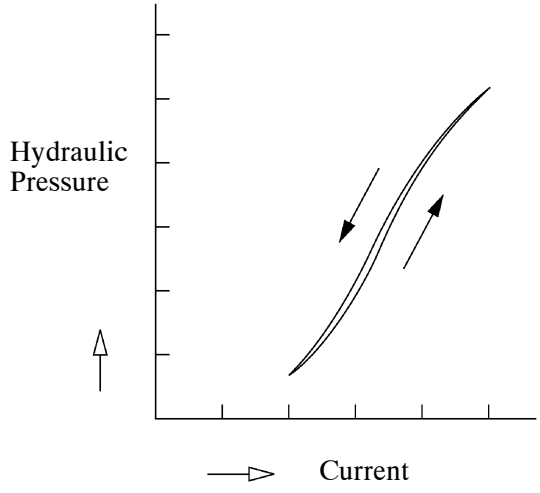
- SL1, SL2, SLT, and SLU are used by the ECM to control hydraulic pressures in a linear fashion based on the current that the ECM causes to flow through their solenoid coils. They control line, clutch, and brake engagement pressure based on the signals received from the ECM.
- The shift solenoid valves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



Shift Solenoid Valve SLT



Shift Solenoid Valve SL1, SL2, and SLT



Shift Solenoid Valve SLU

229LC181

▶ Function of Shift Solenoid Valve SL1, SL2, SLT and SLU ◀

Shift 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

■ELECTRONIC CONTROL SYSTEM

1. General

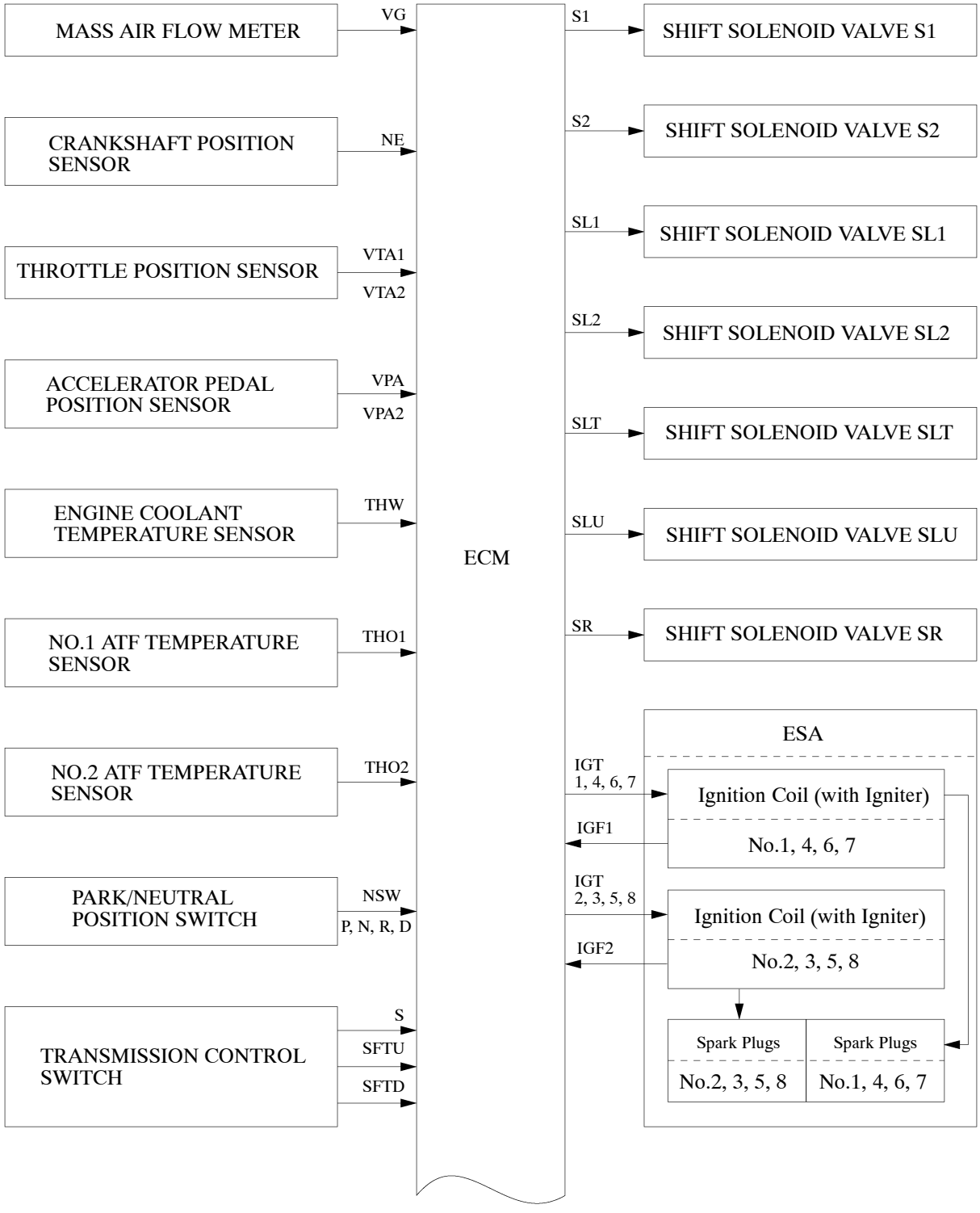
The electronic control system of the A750F automatic transmission consists of the control functions listed below.

System	Function
Shift Timing Control	The ECM sends current to shift solenoid valves S1, S2 or SR based on signals from various sensors in order to shift the gears.
Clutch Pressure Control (See Page CH-36)	• Controls the pressure that is applied directly to B_1 brake and C_1 clutch by actuating the shift solenoid valves SL1 and SL2 in accordance with the ECM signals. • The shift solenoid valve SLT and SL1 minutely controls the clutch pressure in accordance with the engine output and driving conditions.
Line Pressure Optimal Control (See Page CH-37)	Actuates the shift 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 up-shifts or downshifts occur.
Lock-up Timing Control	The ECM sends current to the shift 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-38)	Controls the shift 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.
“N” to “D” Squat Control	When the shift lever is shifted from “N” to “D” position, 2nd gear is temporarily engaged before 1st to reduce vehicle squat.
“R” to “D” Squat Control	When the shift lever is shifted from “R” to “D” position, 3rd gear is temporarily engaged before 1st to reduce vehicle squat.
2nd Start Control	Enabling the vehicle to take off in the 2nd gear and thus make it easy to take off snowy, sandy or muddy terrain.
AI (Artificial Intelligence) -SHIFT Control (See Page CH-39)	Based on the signals from various sensors, the ECM determines the road conditions and the intention of the driver. Thus, an appropriate shift pattern is automatically determined, thus improving drivability.
Multi-mode Automatic Transmission (See page CH-41)	The ECM appropriately controls the automatic transmission in accordance with the range position selected while the shift lever is in the S mode position.
Diagnosis (See Page CH-43)	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-43)	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

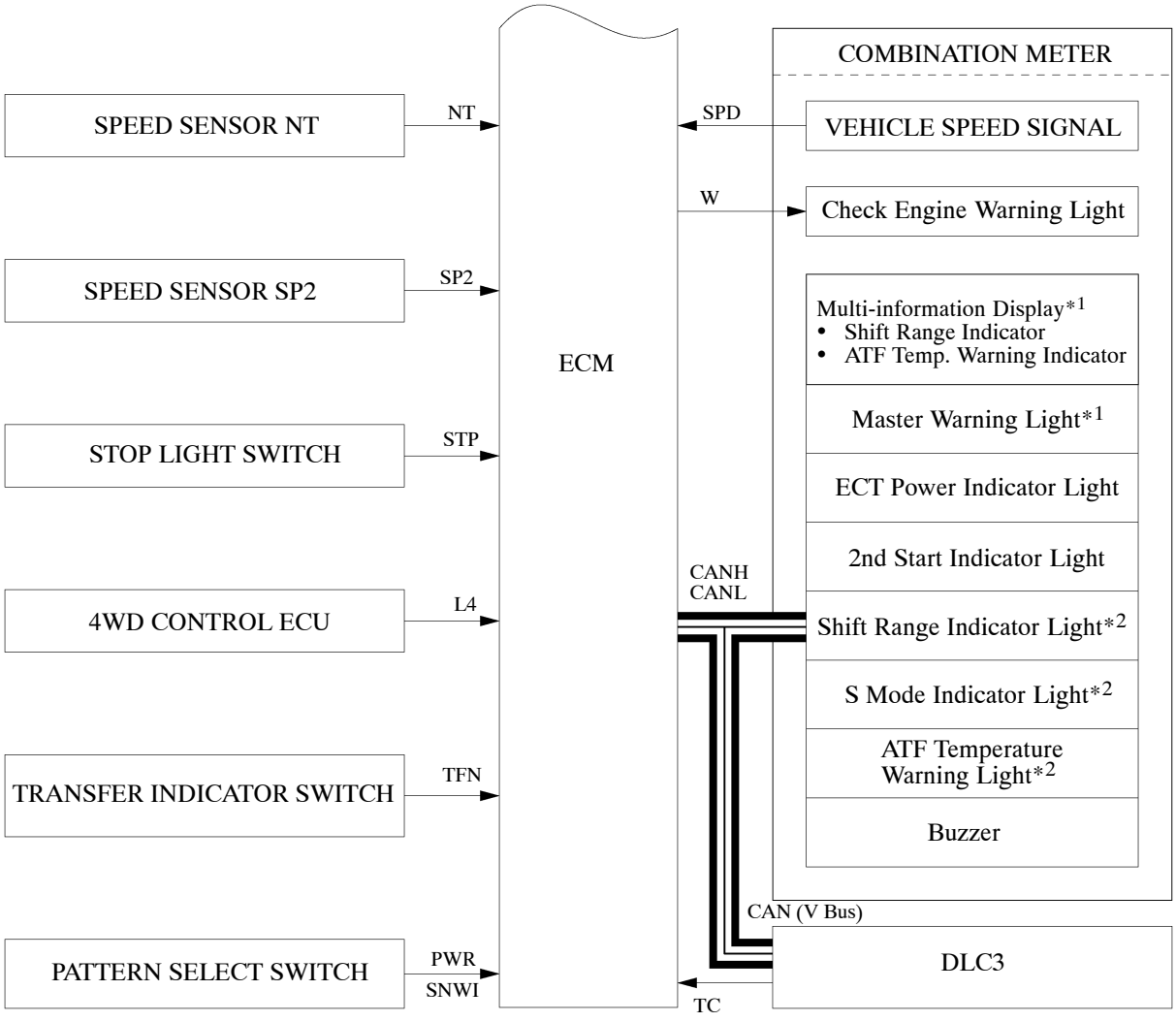
The configurations of the electronic control system for the A750F automatic transmission is as shown in the following chart.

▶ 2UZ-FE Engine Model ◀



(Continued)

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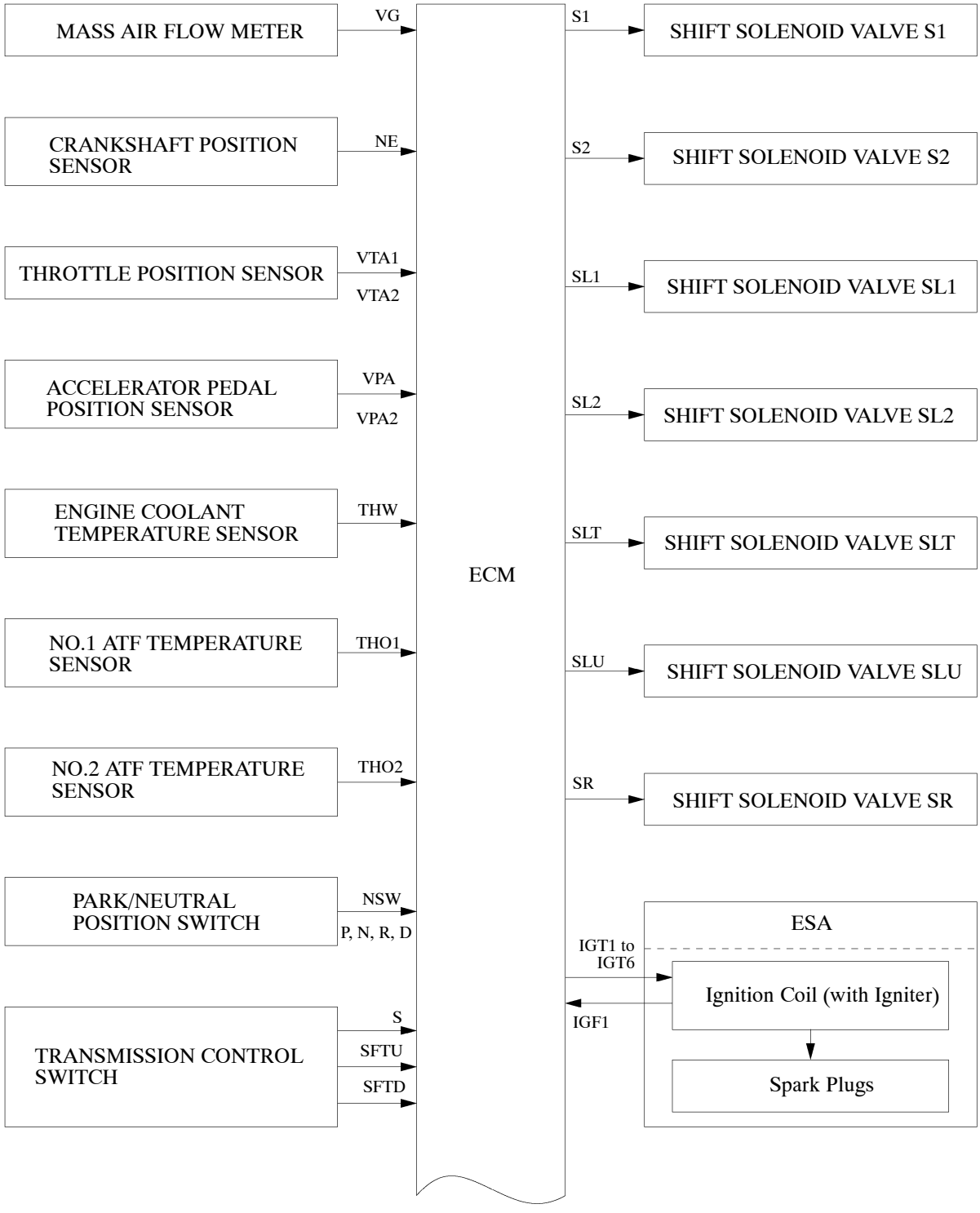


081CH63S

*1: Only for models with optitron type combination meter
*2: Only for models with analog type combination meter

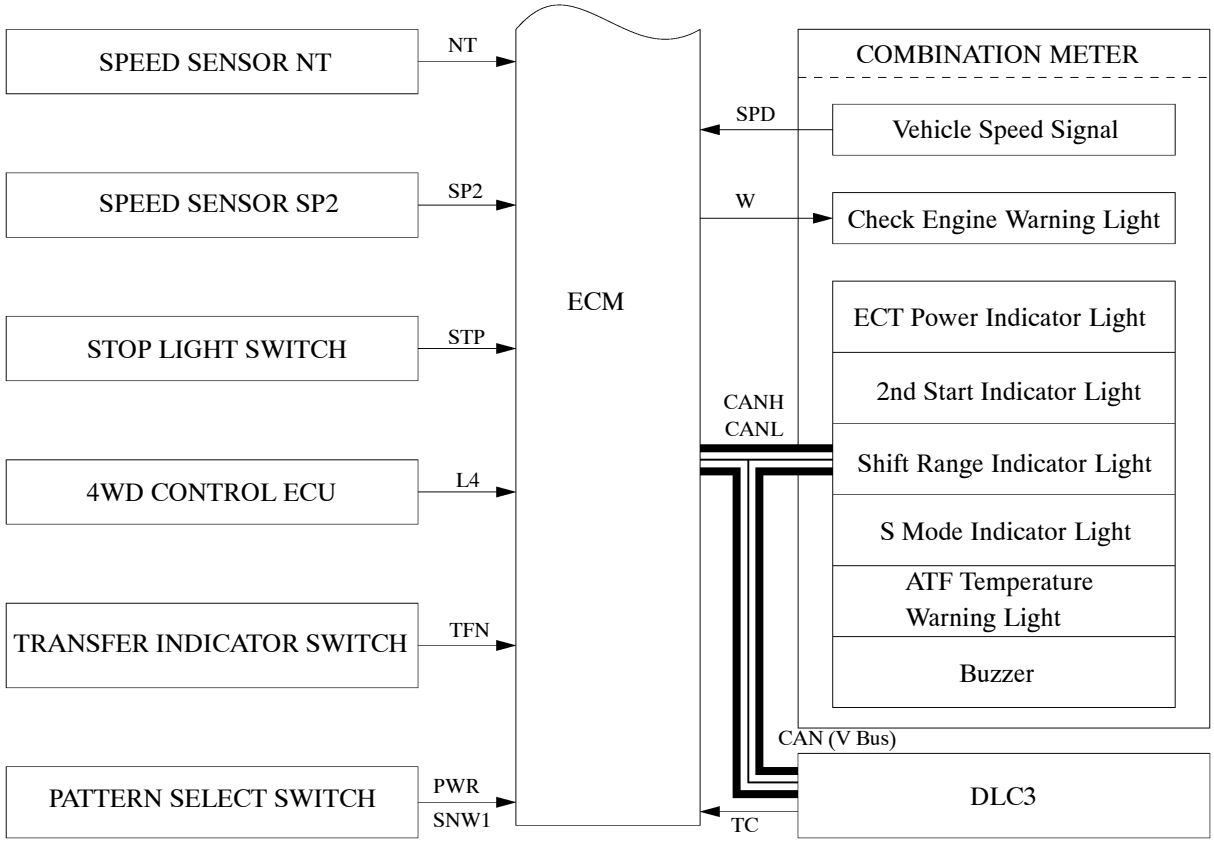
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▶ 1GR-FE Engine Model ◀



(Continued)

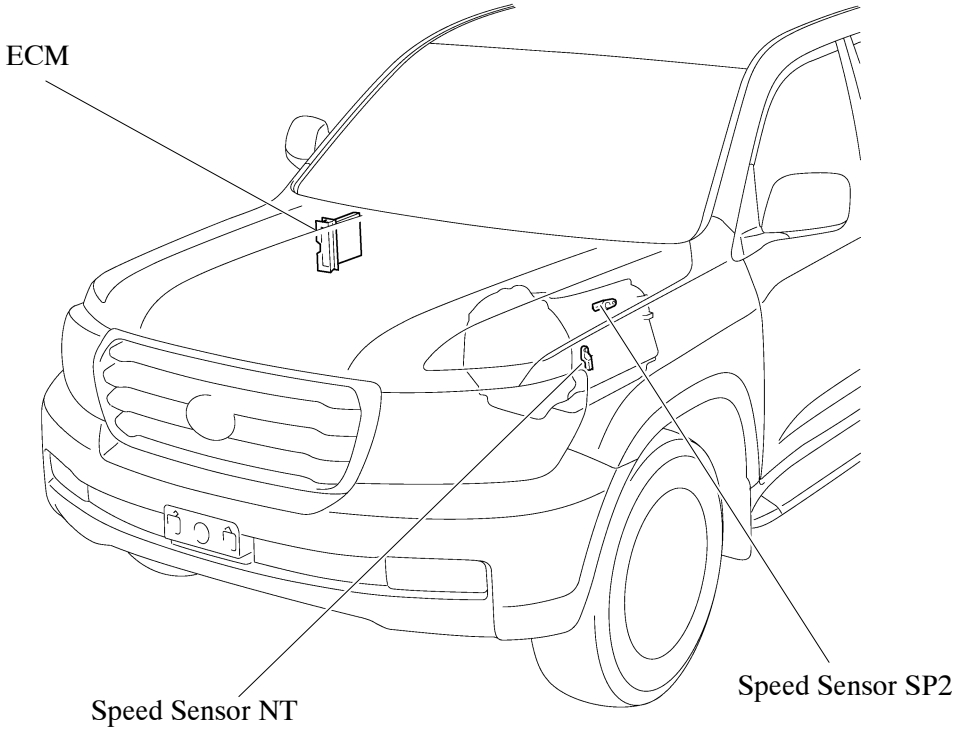
081CH15S

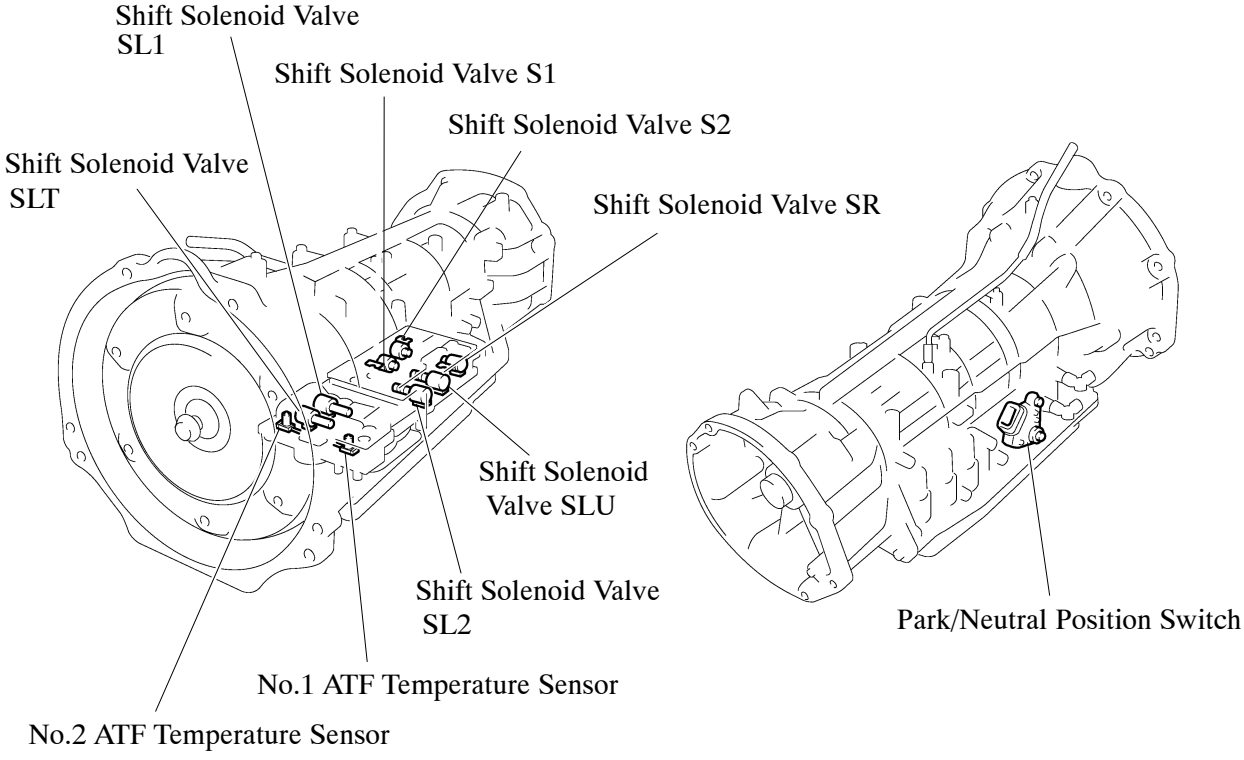

SPEED SENSOR NT
NT
SPEED SENSOR SP2
SP2
STOP LIGHT SWITCH
STP
4WD CONTROL ECU
L4
TRANSFER INDICATOR SWITCH
TFN
PATTERN SELECT SWITCH
PWR
SNW1
ECM
COMBINATION METER
SPD
Vehicle Speed Signal
W
Check Engine Warning Light
ECT Power Indicator Light
2nd Start Indicator Light
CANH
CANL
Shift Range Indicator Light
S Mode Indicator Light
ATF Temperature Warning Light
Buzzer
CAN (V Bus)
DLC3
TC

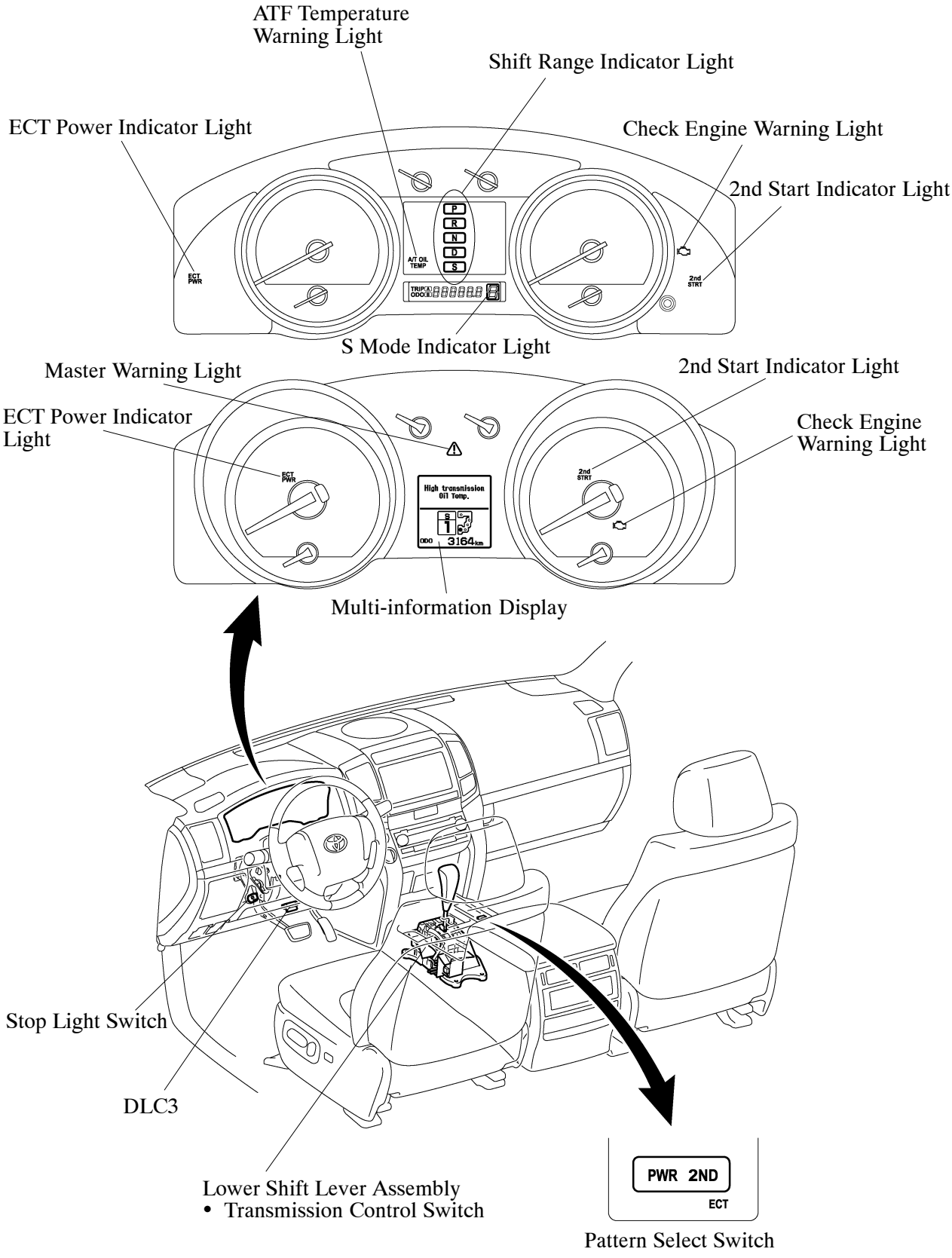
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3. Layout of Main Components







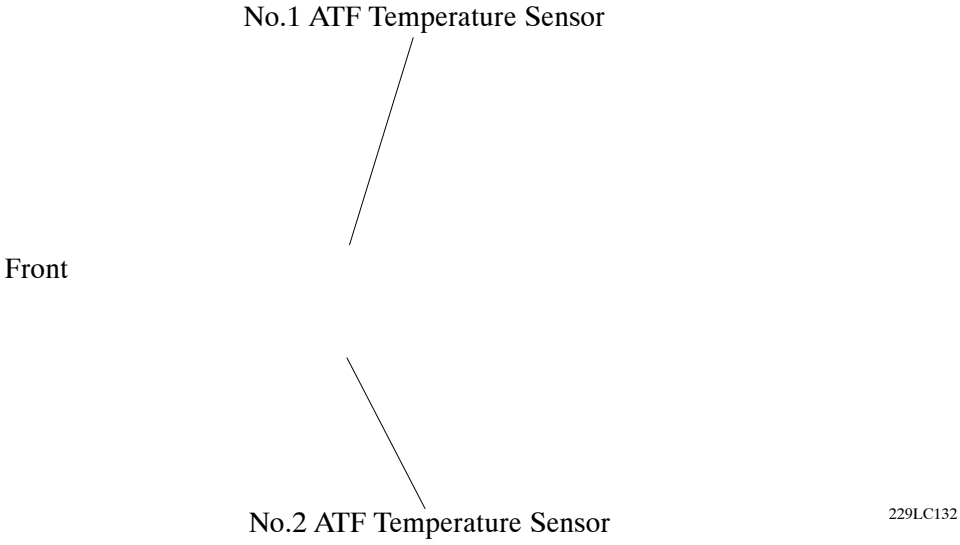
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4. Construction and Operation of Main Components

No.1 and No.2 ATF Temperature Sensor

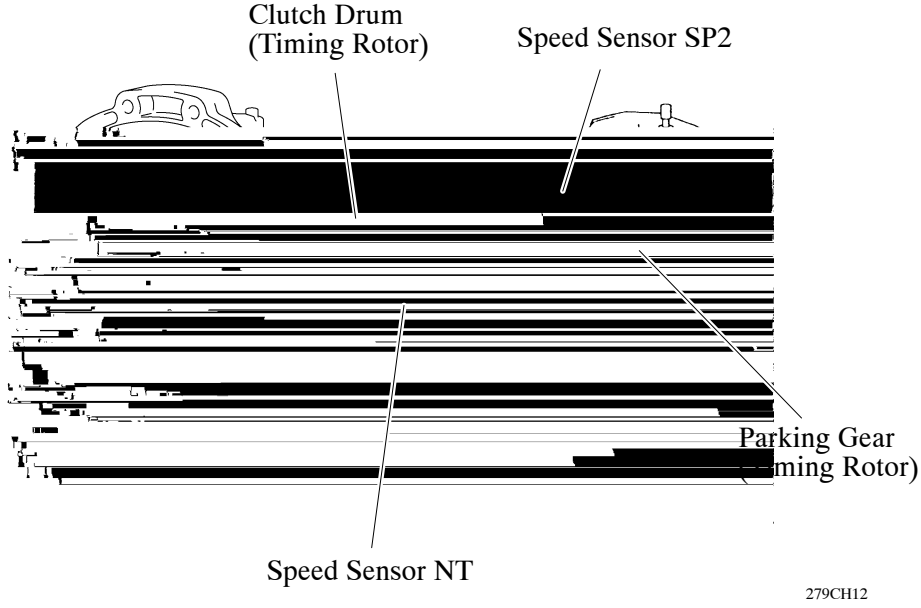
- No.1 ATF temperature sensor is used for hydraulic pressure control. This sensor is used for revision of the pressure that is used to apply clutches and brakes in the transmission. This helps to ensure smooth shift quality.
- No.2 ATF temperature sensor is used as a basis for modifying the ECT shift 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 A750F automatic transmission use a speed sensor NT (for NT signal) and speed sensor SP2 (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.

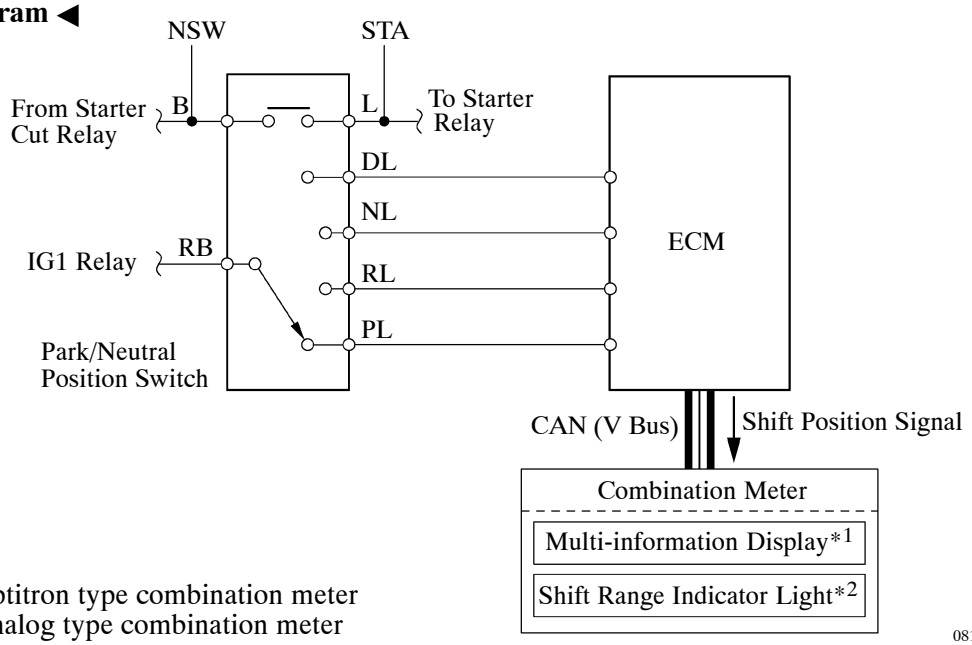
- The speed sensor NT detects the input speed of the transmission. The clutch drum is used as the timing rotor for this sensor.
- The speed sensor SP2 detects the speed of the output shaft. The parking gear on the rear planetary gear is used as the timing rotor for this sensor.



Park/Neutral Position Switch

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

▶ **Wiring Diagram** ◀



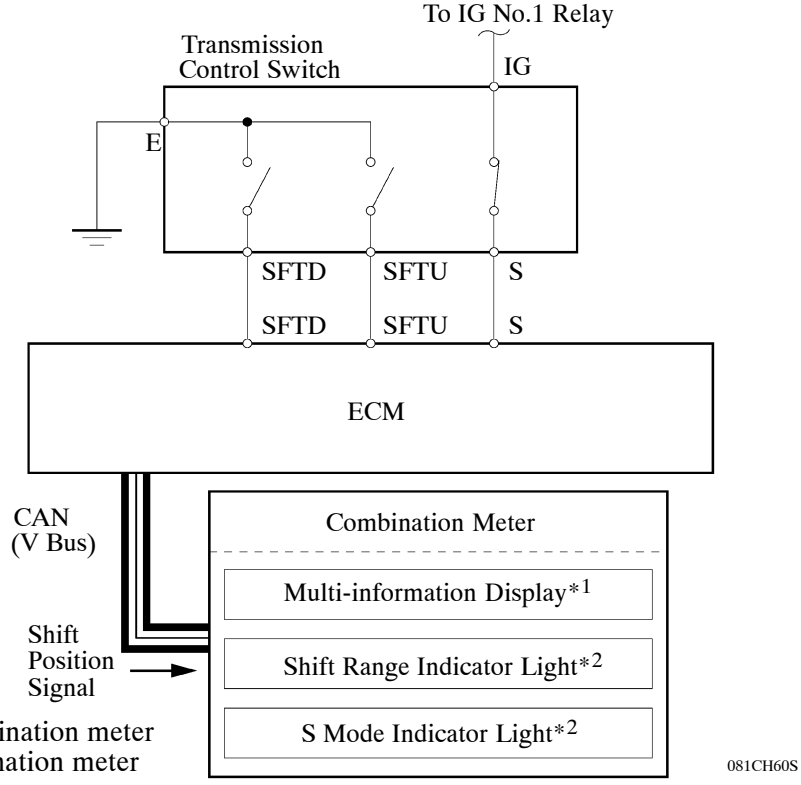
*1: Models with optitron type combination meter
*2: Models with analog type combination meter

081CH28S

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 indicator light and S mode indicator light.
- 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 range indicator light for the selected range.

▶ **Wiring Diagram** ◀



*1: Models with optitron type combination meter
*2: Models with analog type combination meter

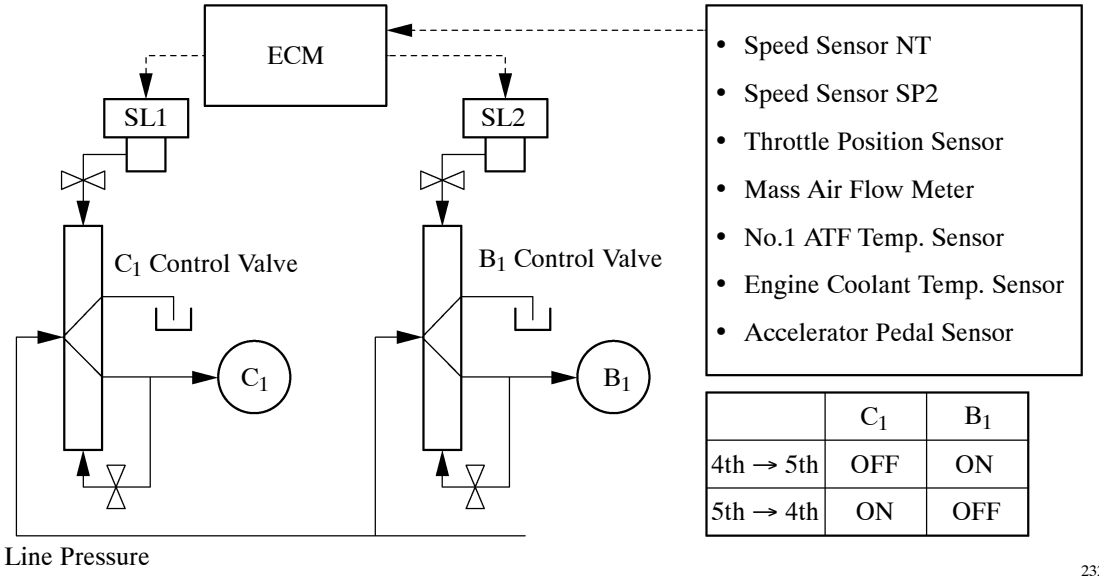
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5. Clutch Pressure Control

Clutch to Clutch Pressure Control

This control is used for shifting from 4th to 5th gear and from 5th to 4th gear.
The ECM actuates shift solenoid valves SL1 and SL2 in accordance with various signals. The output from these solenoid valves acts directly on control valves B_1 and C_1 in order to regulate the line pressure that acts on the B_1 brake and C_1 clutch.
As a result, high response and excellent shift characteristics have been realized.

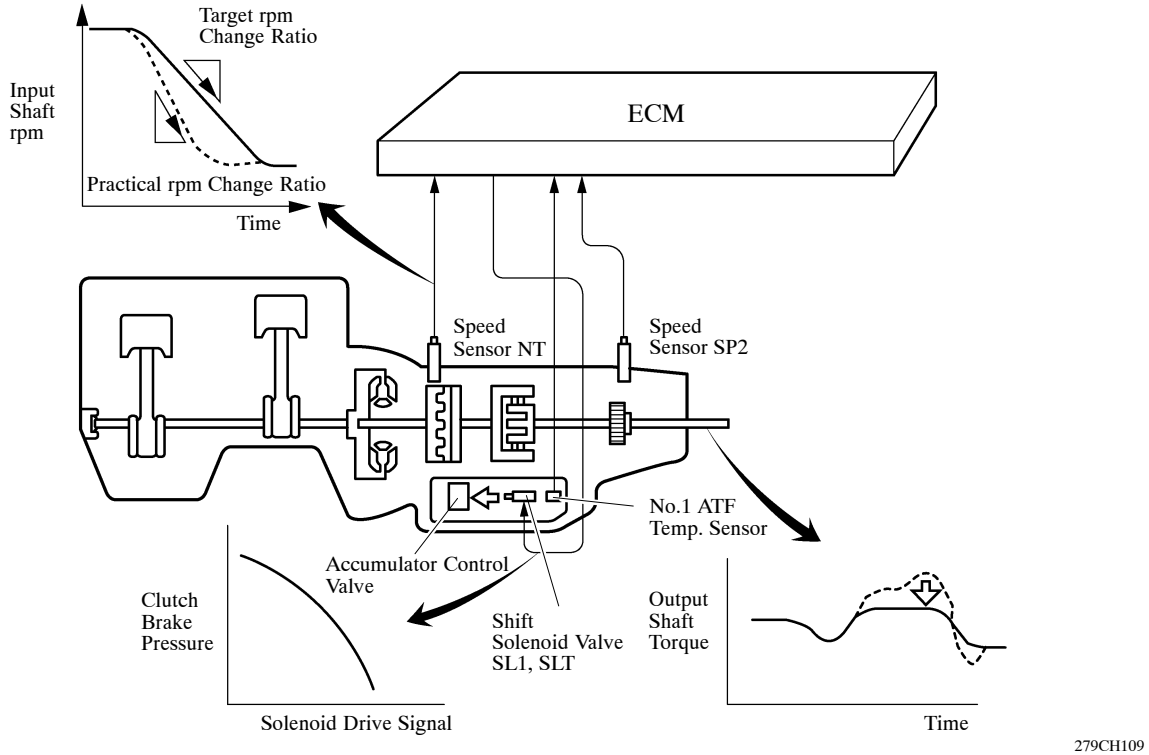


	C_1	B_1
4th → 5th	OFF	ON
5th → 4th	ON	OFF

232CH141

Clutch Pressure Optimal Control

The ECM monitors the signals from various types of sensors, such as the input speed sensor, allowing shift 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.

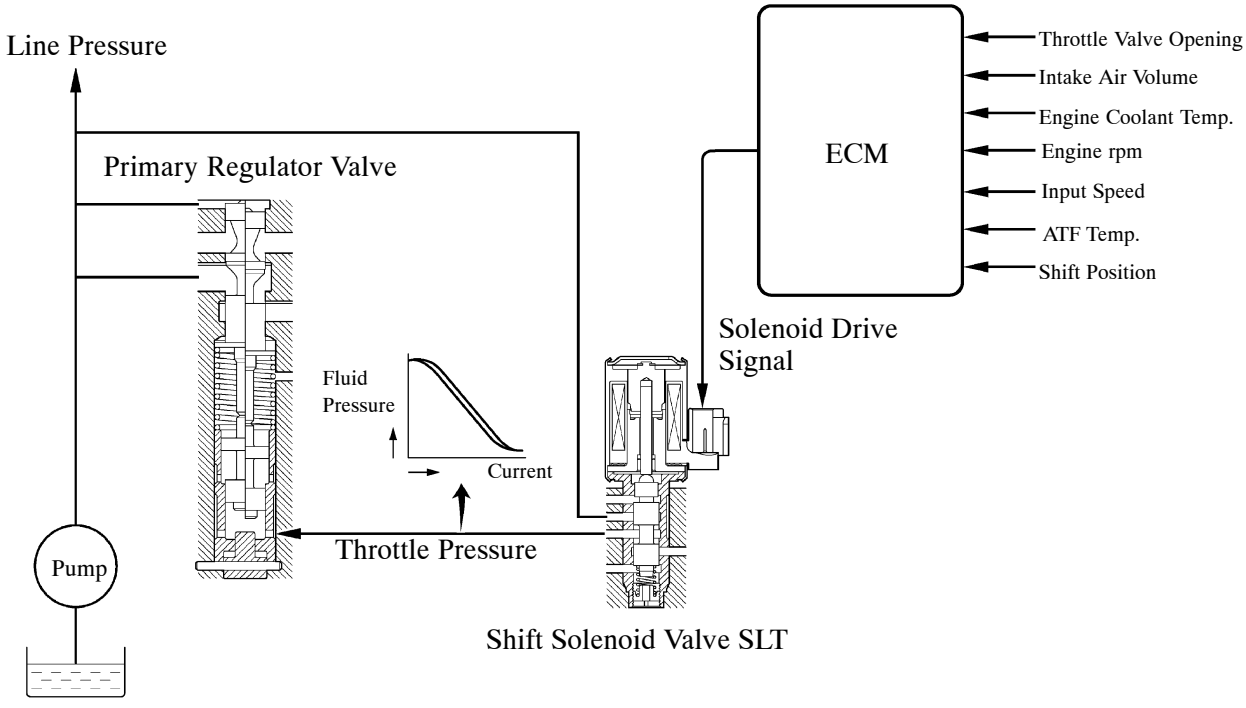


279CH109

6. Line Pressure Optimal Control

Through the use of the shift 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).

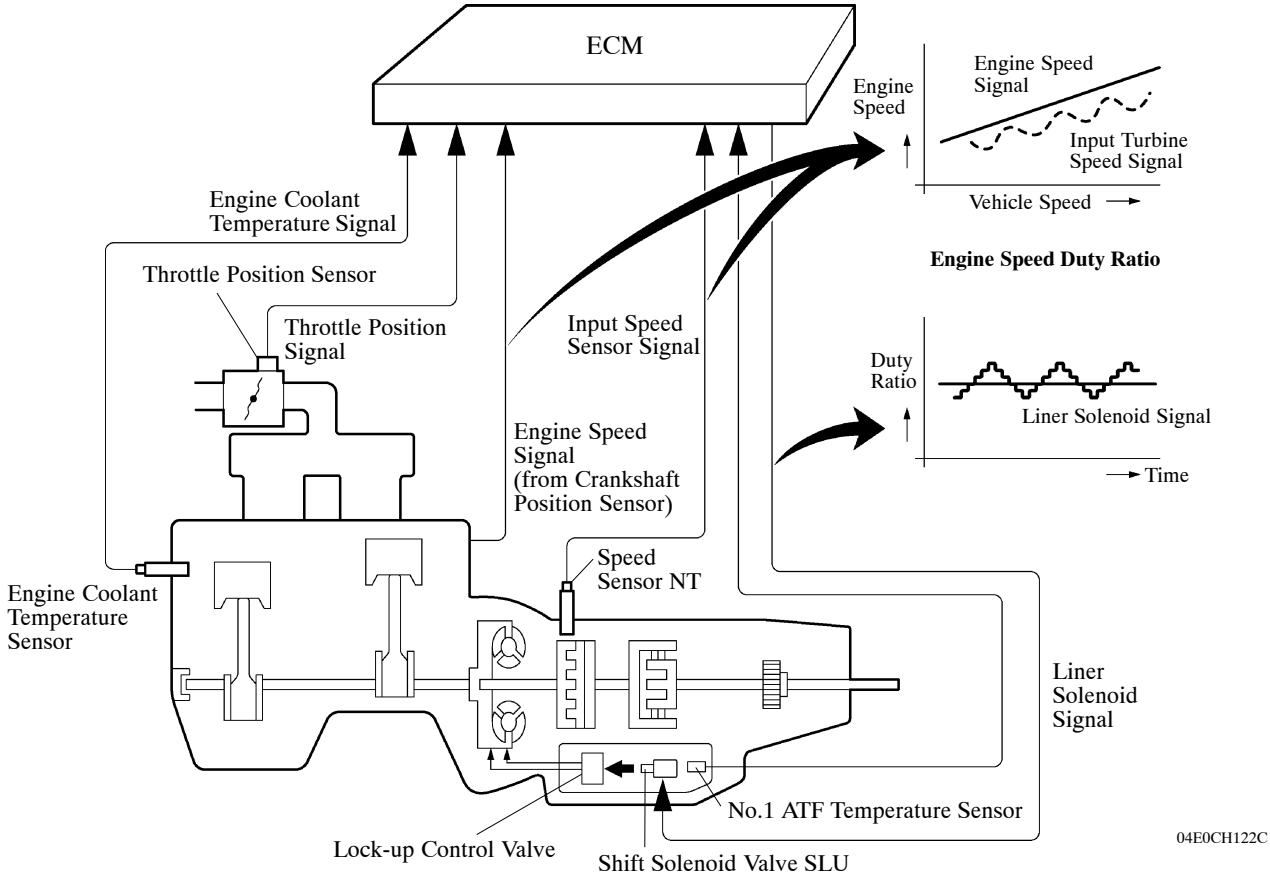


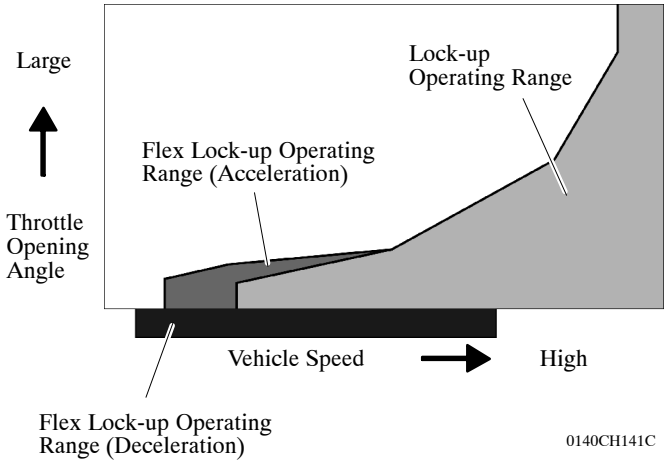
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7. Flex Lock-up Clutch Control

In the low-to-mid-speed range, this flex lock-up clutch control regulates the shift 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 and 5th gears in the D position and S5 range, 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 ◀

Range	Gear	Acceleration Flex Lock-up	Deceleration Flex Lock-up
D, S5	1st	×	×
	2nd	×	×
	3rd	○	×
	4th	○	○
	5th	○	○
S4	1st	×	×
	2nd	×	×
	3rd	×	×
	4th	×	○

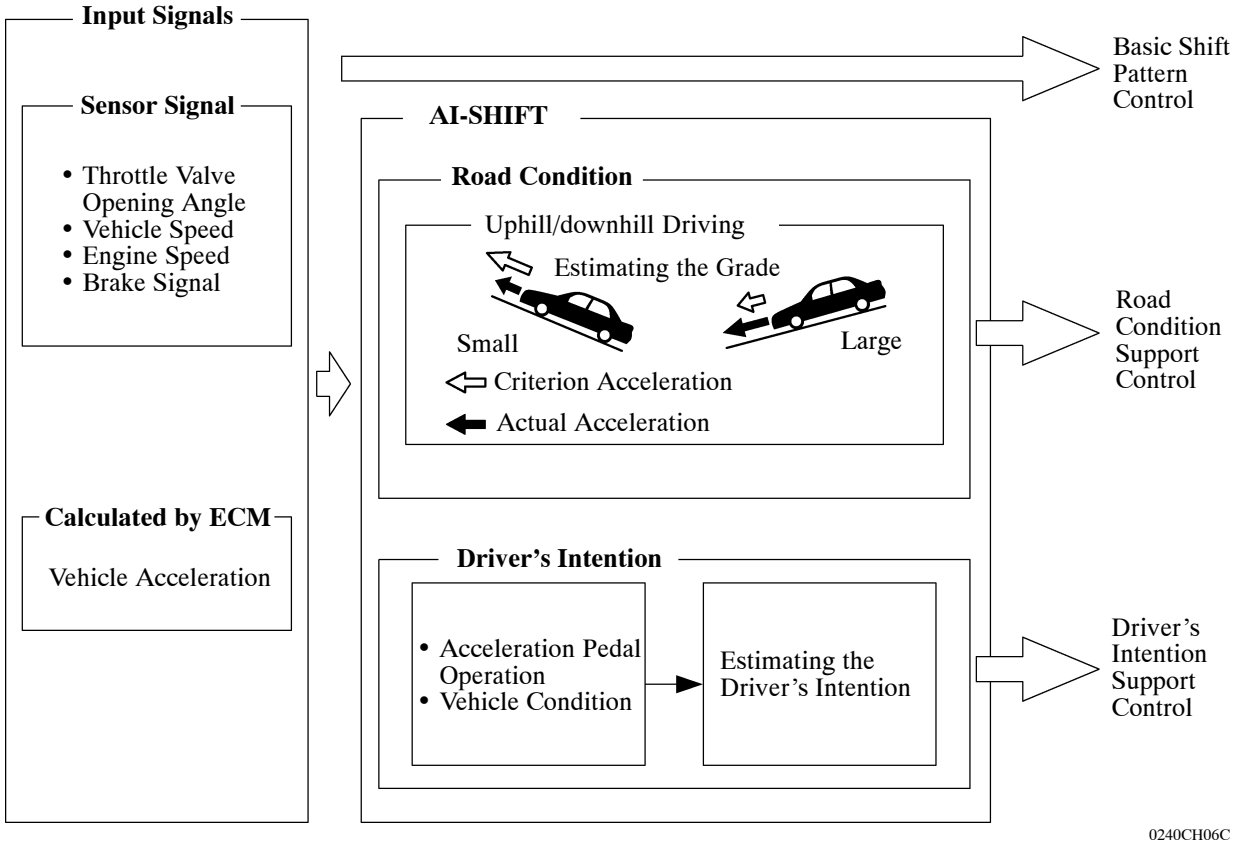
× = Off ○ = Operates

8. AI (Artificial Intelligence) - SHIFT Control

General

The AI-SHIFT control includes a road condition support control and a driver's intention support control. The AI-SHIFT control determines optimal transmission control based on input signals and automatically changes the shift pattern. As a result, a high caliber of transmission operation is achieved.

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

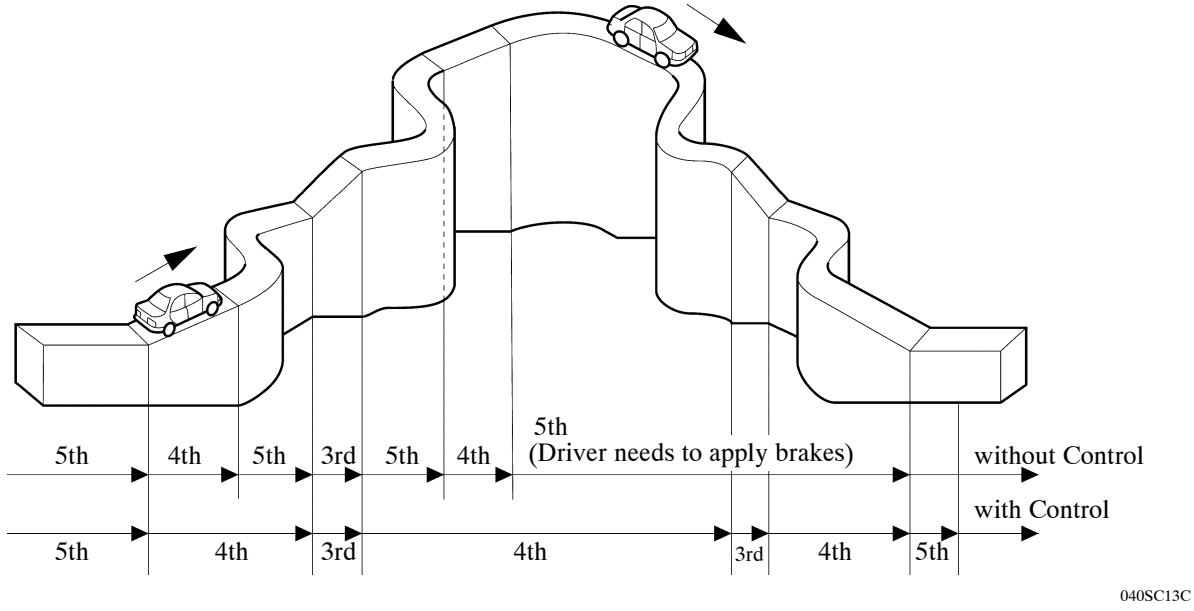


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Road Condition Support Control

Under road condition support control, the ECM identifies throttle valve opening angle and the vehicle speed to determine whether the vehicle is being driven uphill or downhill.

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



Driver's Intention Support Control

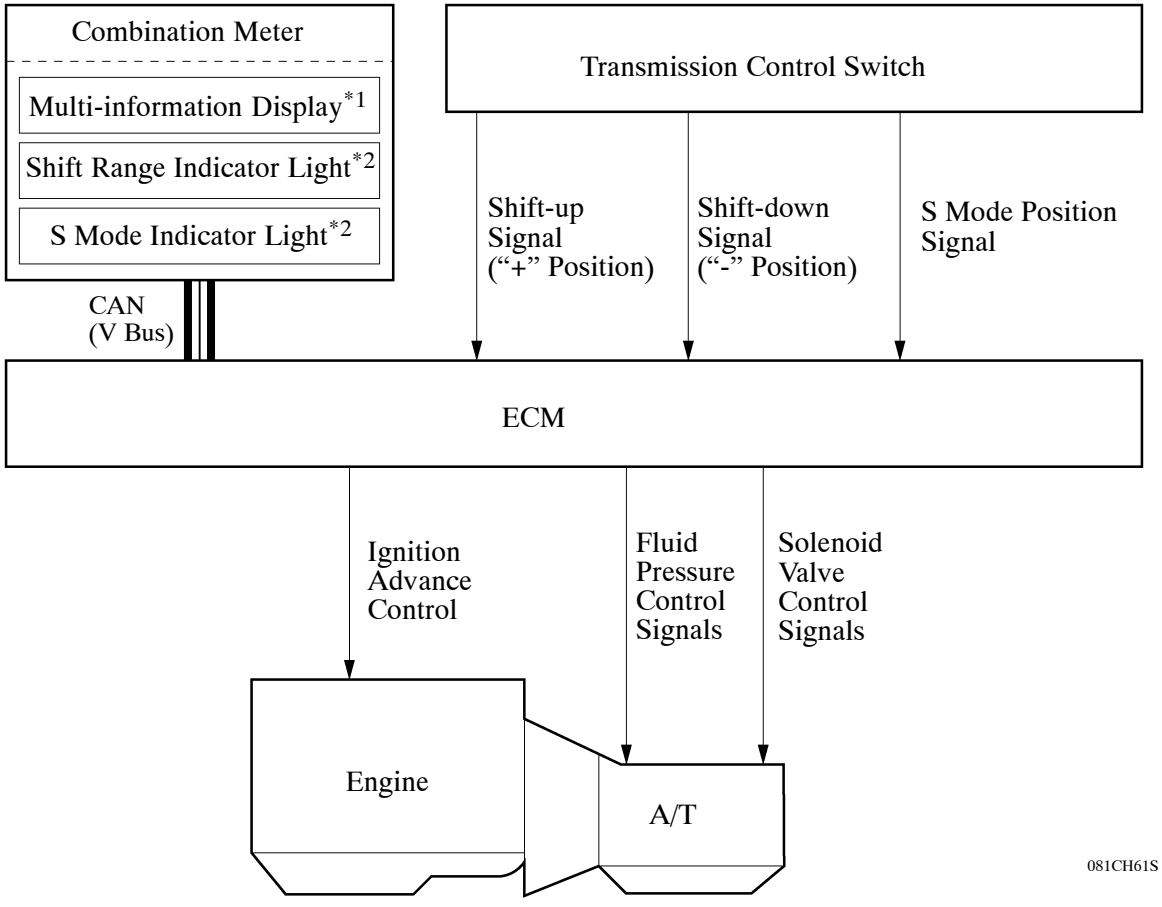
This control estimates the driver's intention based on the accelerator operation and vehicle condition and selects a shift pattern that is well-suited to each driver.

9. 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 shifting the shift lever to the S mode position and moving the shift lever to the "+" position or to the "-" position, the driver can select the desired shift range. Thus, the driver is able to shift gears with a manual-like feel.

▶ System Diagram ◀

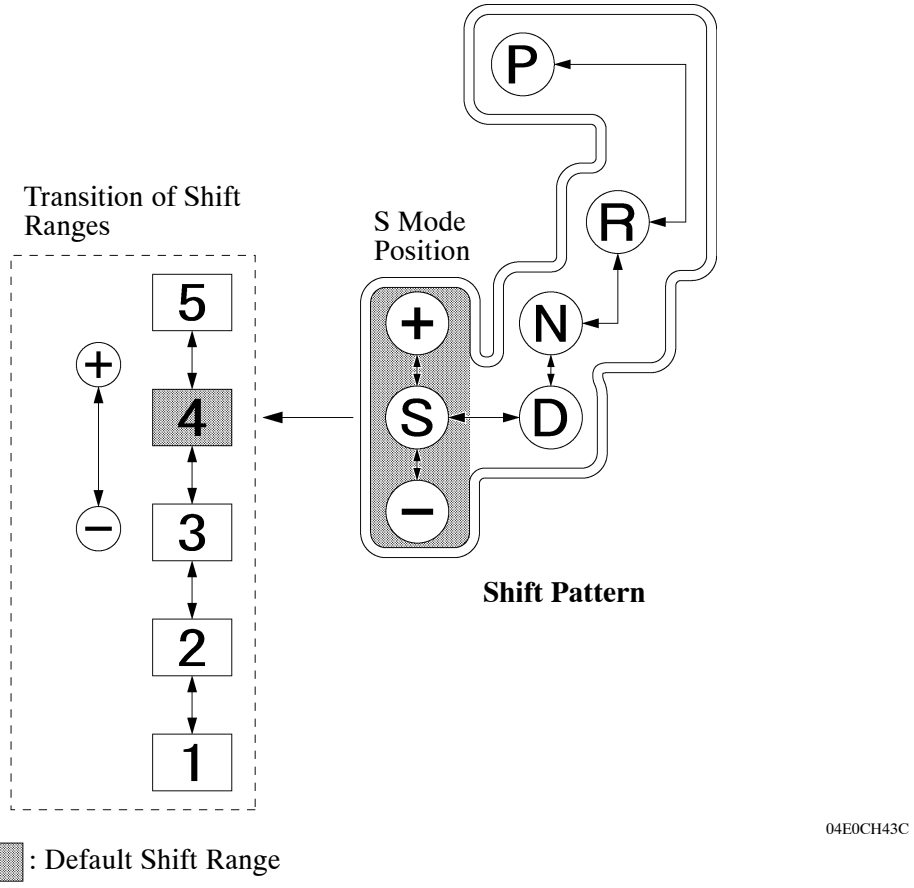


*1: Models with optitron type combination meter
*2: Models with analog type combination meter

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Operation

- The driver selects the S mode position by engaging the shift lever. At this time, the shift range position selects the 4th range. (During AI-SHIFT control, the shift range that has the currently controlled gear position as the maximum usable gear position will be displayed.) 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 5th range regardless of range position (1st to 4th).
- When the shift lever is in the S mode position, the S mode indicator light in the combination meter illuminates. The shift range indicator light indicates the state of the shift range position that the driver has selected.



▶ Usable Gear Chart ◀

Shift Range	Shift Range Indicator Light Indication	Usable Gear
5th	5	5th ↔ 4th ↔ 3rd ↔ 2nd ↔ 1st
4th	4	4th ↔ 3rd ↔ 2nd ↔ 1st
3rd	3	3rd ↔ 2nd ↔ 1st
2nd	2	2nd ↔ 1st
1st	1	1st

10. 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 an intelligent tester II to the DLC3.

For details, see the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

11. Fail-safe

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

▶ Fail-safe Control List ◀

Malfunction Part	Function
Speed Sensor NT	During a speed sensor NT malfunction, shift control is effected based on the speed sensor SP2 signal. During a speed sensor NT malfunction, up-shifts to 5th, AI-SHIFT and flex lock-up clutch control are prohibited.
Speed Sensor SP2	During a speed sensor SP2 malfunction, shift control is effected based on the speed sensor NT signal. During a speed sensor SP2 malfunction, up-shifts to 5th, AI-SHIFT and flex lock-up clutch control are prohibited.
No.1 ATF Temperature Sensor	During a No.1 ATF temperature sensor malfunction, up-shifts to 5th and flex lock-up clutch control are prohibited.
Shift Solenoid Valve S1, S2, and SR	When a shift solenoid valve listed at left malfunctions, current to the failed solenoid valve is cut off. Shift control is changed to a fail-safe mode to shift gears using the shift normal solenoid valves to allow continued driving. Refer to the table on the next page for operation example.
Shift Solenoid Valve SL1 and SL2	During a shift solenoid valve SL1 or SL2 malfunction, up-shifts to 5th and flex lock-up clutch control are prohibited.
Shift Solenoid Valve SLU	During a shift 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.
Shift Solenoid Valve SLT	During a shift solenoid valve SLT malfunction, the current to the solenoid valve is stopped. Because this stops line pressure optimal control, the shift shock will increase. However, shifting is effected based on normal clutch pressure control.

Position	Normal					
	Shift Solenoid Valve					Gear
	S1	S2	SR	SL1	SL2	
D, S5	ON	OFF	OFF	OFF	ON	1st
	ON	ON	OFF	OFF	ON	2nd
	OFF	ON	OFF	OFF	ON	3rd
	OFF	OFF	OFF	OFF	ON	4th
	OFF	OFF	ON	ON	OFF	5th
S4	ON	OFF	OFF	OFF	ON	1st
	ON	ON	OFF	OFF	ON	2nd
	OFF	ON	OFF	OFF	ON	3rd
	OFF	OFF	OFF	OFF	ON	4th
S3	ON	OFF	OFF	OFF	ON	1st
	ON	ON	OFF	OFF	ON	2nd
	OFF	ON	OFF	OFF	OFF	3rd (E/B)
S2	ON	OFF	OFF	OFF	ON	1st
	ON	ON	ON	OFF	OFF	2nd (E/B)
S1	ON	OFF	OFF	OFF	OFF	1st (E/B)

▶ Example ◀

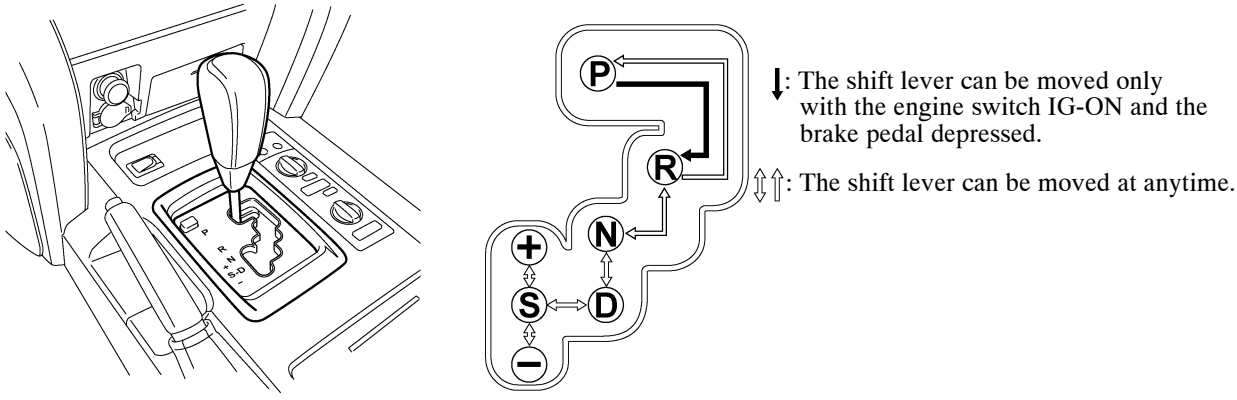
Position	Shift Solenoid Valve S1 Malfunction					
	Shift Solenoid Valve					Gear
	S1	S2	SR	SL1	SL2	
D, S5	×	OFF → ON	OFF	OFF	ON	4th → 3rd
	×	ON	OFF	OFF	ON	3rd
	×	ON	OFF	OFF	ON	3rd
	×	OFF	OFF	OFF	ON	4th
	×	OFF	ON	ON	OFF	5th
S4	×	OFF → ON	OFF	OFF	ON	4th → 3rd
	×	ON	OFF	OFF	ON	3rd
	×	ON	OFF	OFF	ON	3rd
	×	OFF	OFF	OFF	ON	4th
S3	×	OFF → ON	OFF	OFF	ON → OFF	3rd → 3rd (E/B)
	×	ON	OFF	OFF	ON → OFF	3rd → 3rd (E/B)
	×	ON	OFF	OFF	OFF	3rd (E/B)
S2	×	OFF	OFF	OFF	ON	1st
	×	ON	ON	OFF	OFF	3rd (E/B)
S1	×	OFF	OFF	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 on the side of the D position.
- A shift lock system is used.



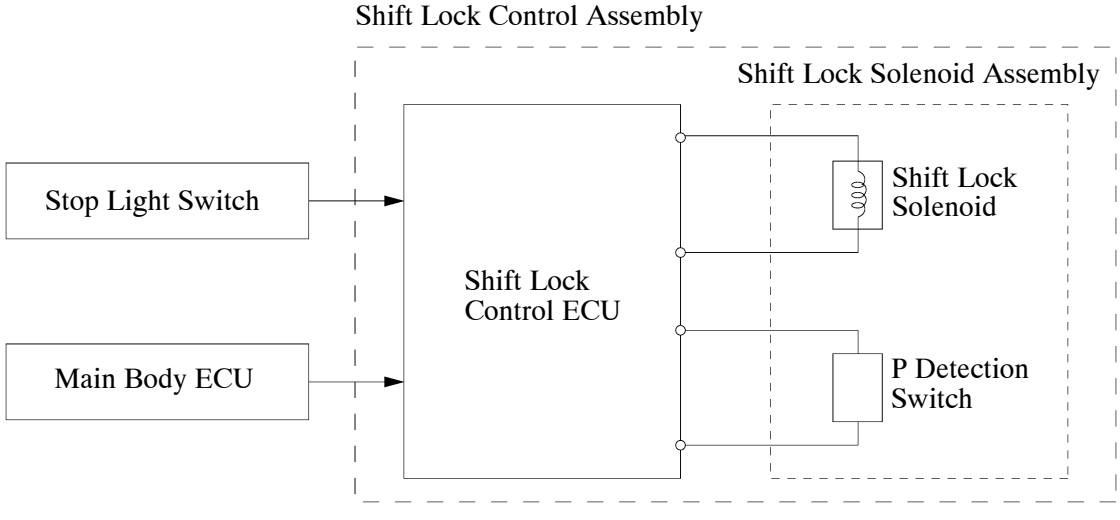
081CH27Y

2. Shift Lock System

General

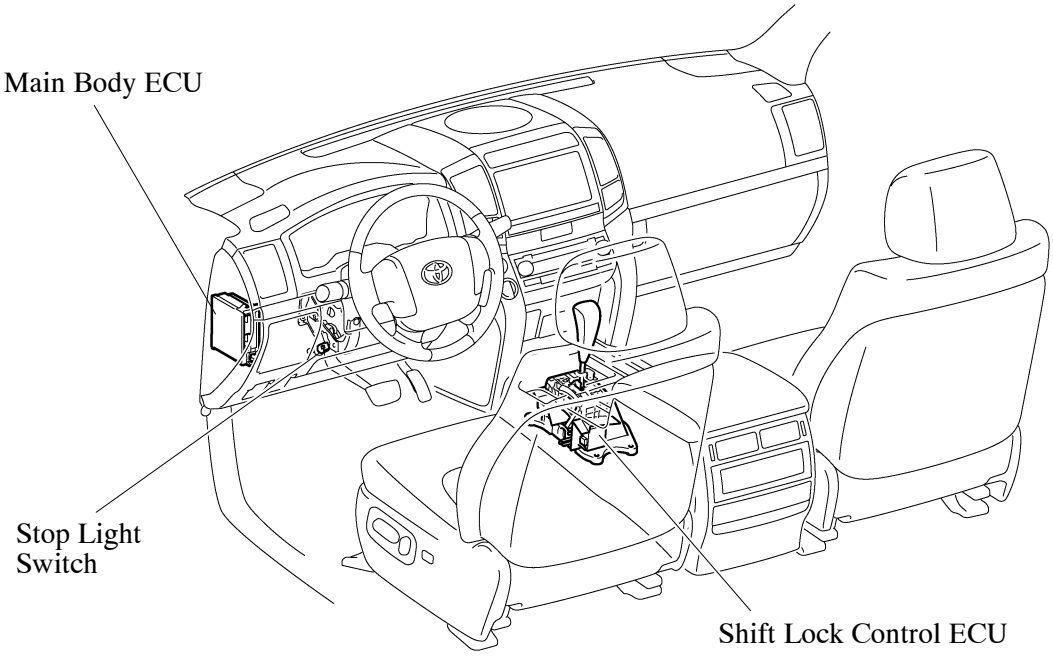
- The shift lock mechanism prevents the shift lever from being shifted to any position other than the P position, unless the IG-ON mode is selected, and the brake pedal is depressed. This mechanism helps to prevent unintentional acceleration.
- The shift lock system mainly consists of the shift lock control ECU, shift lock solenoid P detection switch and shift lock override button.

▶ System Diagram ◀



080CH89S

Layout of Main Components



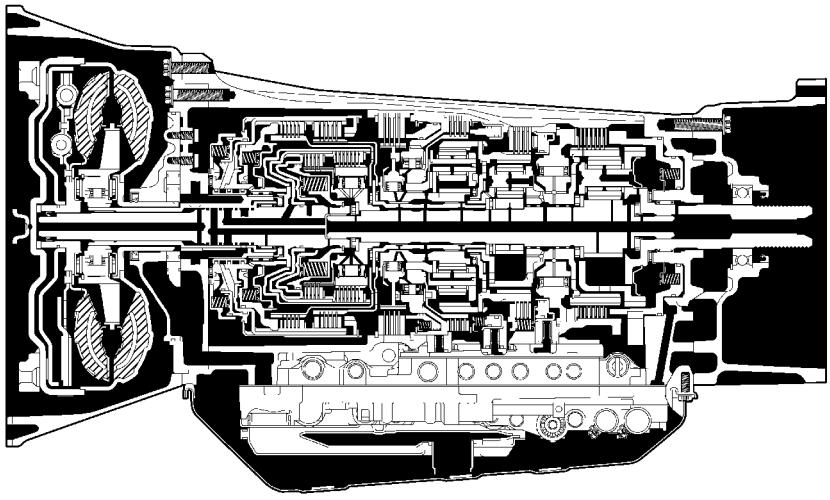
System Operation

- 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 override button, which manually overrides the shift lock mechanism, is used.

AB60F AUTOMATIC TRANSMISSION

■DESCRIPTION

- The AB60F 6-speed Super ECT (Electronic Controlled Transmission) is used on the 1VD-FTV engine models.
- As in the A750F automatic transmission, the ATF WS is used to reduce the resistance of the ATF and improve the fuel economy by lowering its viscosity in the practical operating temperature range. For details, see page CH-14.

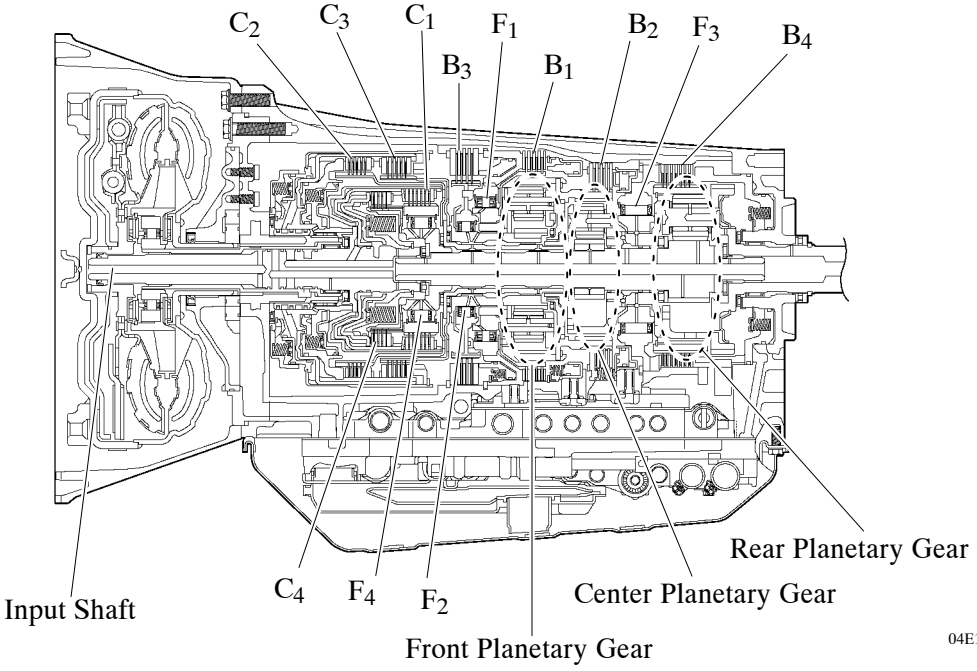


04E1CH02Z

▶ Specifications ◀

Gear Ratio	1st	3.333
	2nd	1.960
	3rd	1.353
	4th	1.000
	5th	0.728
	6th	0.588
	Reverse	3.061
Fluid Type		Toyota Genuine ATF WS
Fluid Capacity	Liters (US qts, Imp. qts)	11.8 (12.5, 10.4)
Weight (Reference)*	kg (lb)	110.5 (243.6)

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



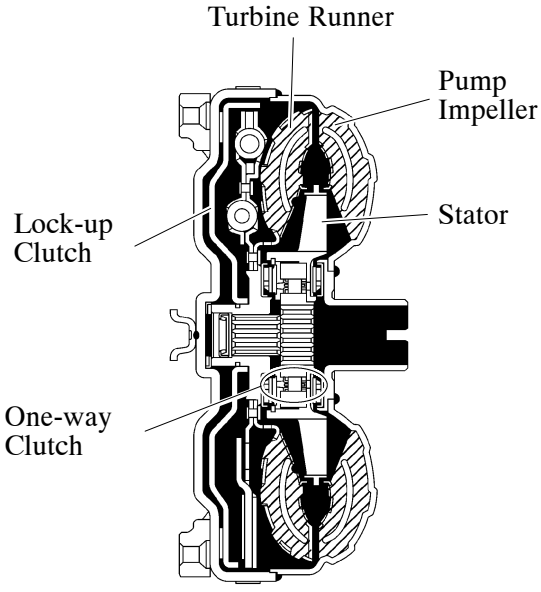
C_1	No.1 Clutch	The No. of Discs		6
C_2	No.2 Clutch			5
C_3	No.3 Clutch			5
C_4	No.4 Clutch			4
B_1	No.1 Brake			4
B_2	No.2 Brake			4
B_3	No.3 Brake			4
B_4	No.4 Brake			7
F_1	1-way Clutch	The No. of Sprags		30
F_2	No.2 1-way Clutch			25
F_3	No.3 1-way Clutch			33
F_4	No.4 1-way Clutch			28
Front Planetary 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 CLUTCH

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

▶ Specifications ◀

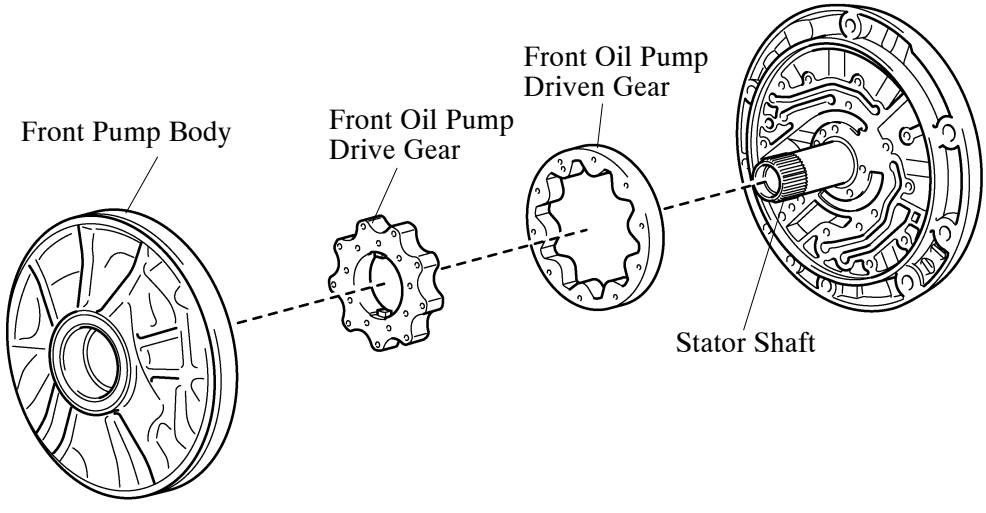
Torque Converter Clutch Type	3-element, 1-step, 2-phase
Stall Torque Ratio	1.8



04E1CH03Z

■OIL PUMP

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



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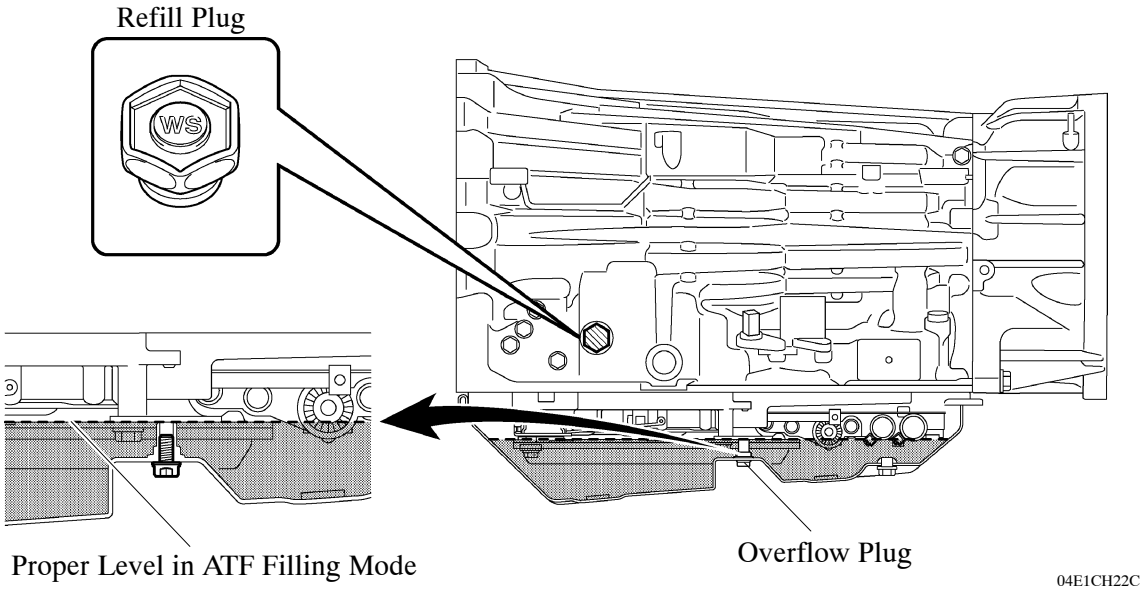
■ATF COOLING SYSTEM

- In order to cool down the ATF, both water cooled and air cooled oil coolers have been provided.
- The basic construction and operation are same as those of the A750F automatic transmission. For details, see page CH-10.

■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 a refill plug, overflow plug, No.2 ATF temperature sensor and shift position indicator light “D”.



Service Tip

ATF Filling procedure using SST (09843-18040)

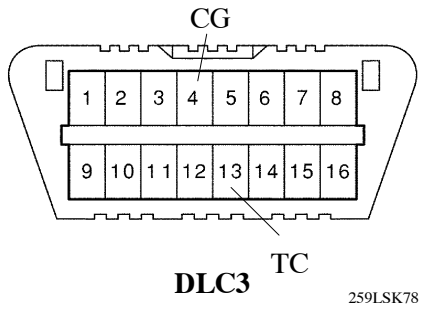
When a large amount of ATF needs to be filled (i.e. after removal and installation of oil pan or torque converter clutch), perform the procedure from step 1.
When a small amount of ATF is required (i.e. removal and installation of oil cooler tube, repair of a minor oil leak), perform the procedure from step 5.
Keep the vehicle level. Turn off the AHC height control switch before raising the vehicle.

1) Remove the refill plug and overflow plug.
2) Fill the transmission with WS type ATF through the refill plug hole until it overflows from the overflow plug hole.
   - ATF WS must be used to fill the transmission.
3) Reinstall the overflow plug.
4) Add the specified amount of ATF (specified amount is determined by the procedure that was performed) and reinstall the refill plug.

Example:

Procedure	Amount Liters (US qts, Imp.qts)
Removal and installation of an oil pan (including oil drainage)	2.1 (2.22, 1.85)
Removal and installation of a transmission valve body	4.7 (4.97, 4.14)
Replacement of a torque converter clutch	6.1 (6.45, 5.37)

(Continued)



DLC3 259LSK78

5) Use the SST (09843-18040) to make shorts between the TC and CG terminals of the DLC3 connector:
6) Start the engine and allow it to idle.
   - A/C switch must be turned off.
7) Move the shift lever from the P position to the S mode position and slowly selects each gear S1 - S6. Then move the shift lever back to the P position.
8) Move the shift lever to the D position, and then quickly move it back and forth between N and D (at least once every 1.5 seconds) for at least 6 seconds. This will activate oil temperature detection mode.
   Standard: The shift position indicator light "D" remains illuminated for 2 seconds and then goes off.
9) Return the shift lever to the P position and disconnect the TC terminal.
10) Idle the engine to raise the ATF temperature.
11) Immediately after the shift position indicator "D" light turns on, lift the vehicle up.
   - The shift position indicator light "D" will indicate the ATF temperature according to the following table.

ATF Temp.	Lower than Proper Temp.	Proper Temp.	Higher than Proper Temp.
Shift Position Indicator Light "D"	Turn OFF	Turn ON	Blinking

12) Remove the overflow plug and adjust the oil quantity.
   - If the ATF overflows, go to step 15, and if the ATF does not overflow, go to step 13.
13) Remove the refill plug.
14) Add ATF through the refill plug hole until it flows out from the overflow plug hole.
15) When the ATF flow slows to a trickle, install the overflow plug and a new gasket.
16) Reinstall the refill plug (if the refill plug was removed).
17) Turn the engine switch OFF to stop the engine.

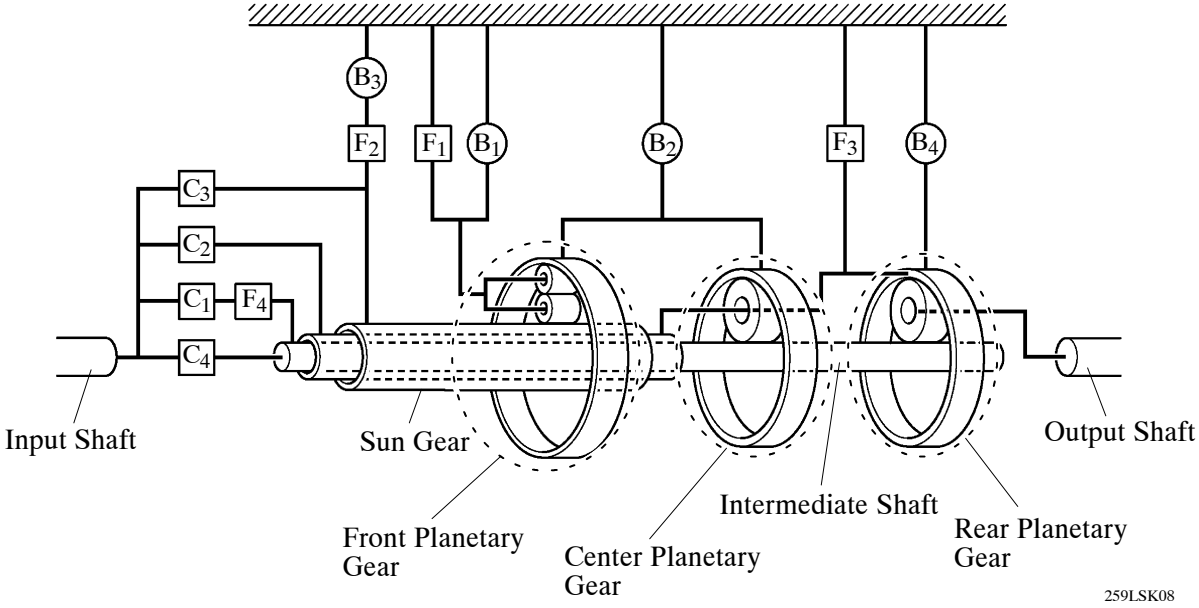
For details about the ATF Filling procedures, see the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

■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-58.



2. Function of Components

Components		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 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 the center ring gear from turning either clockwise or counterclockwise.
B_3	No.3 Brake	Prevents outer race of F_2 from turning either clockwise or counterclockwise.
B_4	No.4 Brake	Prevents center planetary carrier and the rear ring gear from turning either clockwise or counterclockwise.
F_1	1-Way Clutch	Prevents the front planetary carrier from turning counterclockwise.
F_2	No.2 1-Way Clutch	When B_3 is operating, the one-way clutch prevents the front sun gear from turning counterclockwise.
F_3	No.3 1-Way Clutch	Prevents the center planetary carrier and the rear ring gear from turning counterclockwise.
F_4	No.4 1-Way Clutch	Prevents the intermediate shaft from turning counterclockwise.
Planetary Gears		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.

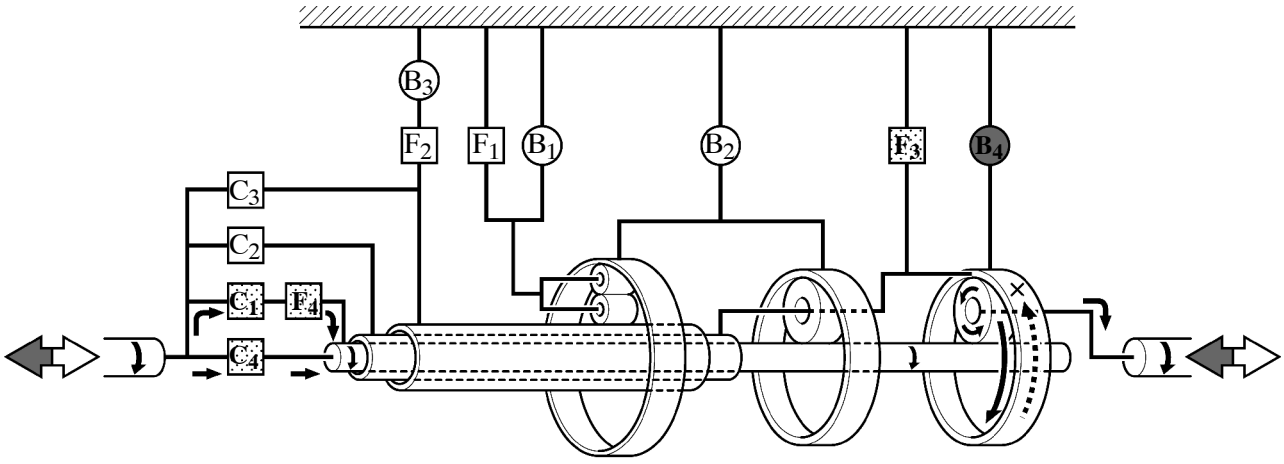
3. Transmission Power Flow

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													
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

CH

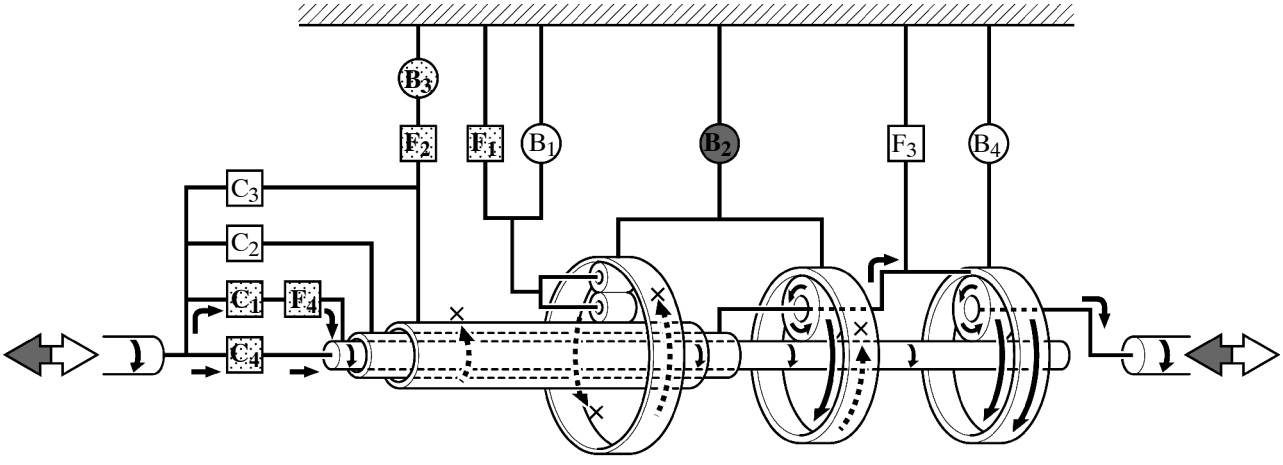
1st Gear (D Position or S Mode)



: Operates
: Operates only in the S1 range

040SC03C

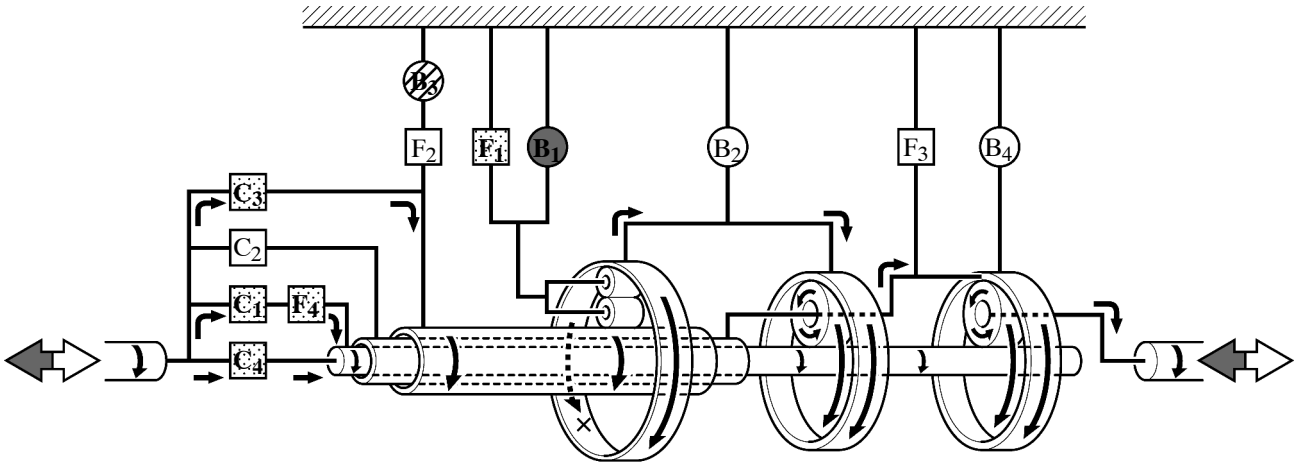
2nd Gear (D Position or S Mode)



: Operates
: Operates only in the S2 range

040SC04C

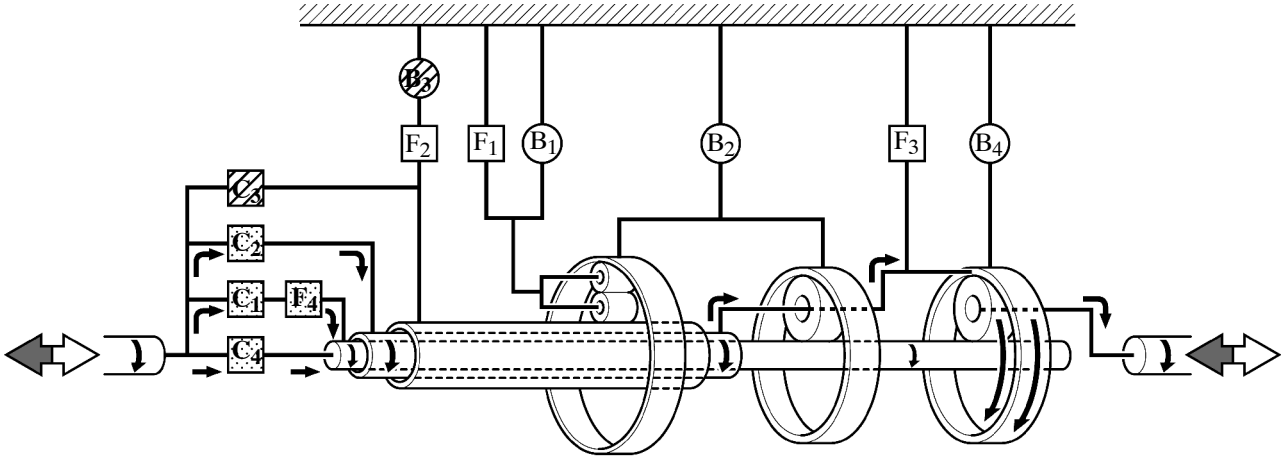
3rd Gear (D Position or S Mode)



: Operates
: Operates only in the S3 range
: Operates but is not related to power transmission.

040SC05C

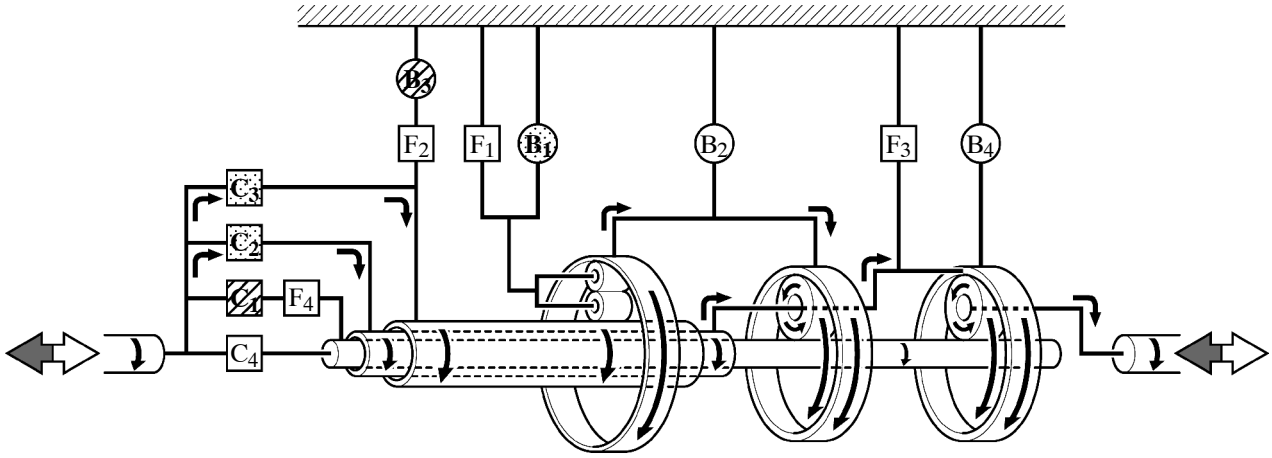
4th Gear (D Position or S Mode)



: Operates
: Operates but is not related to power transmission.

040SC06C

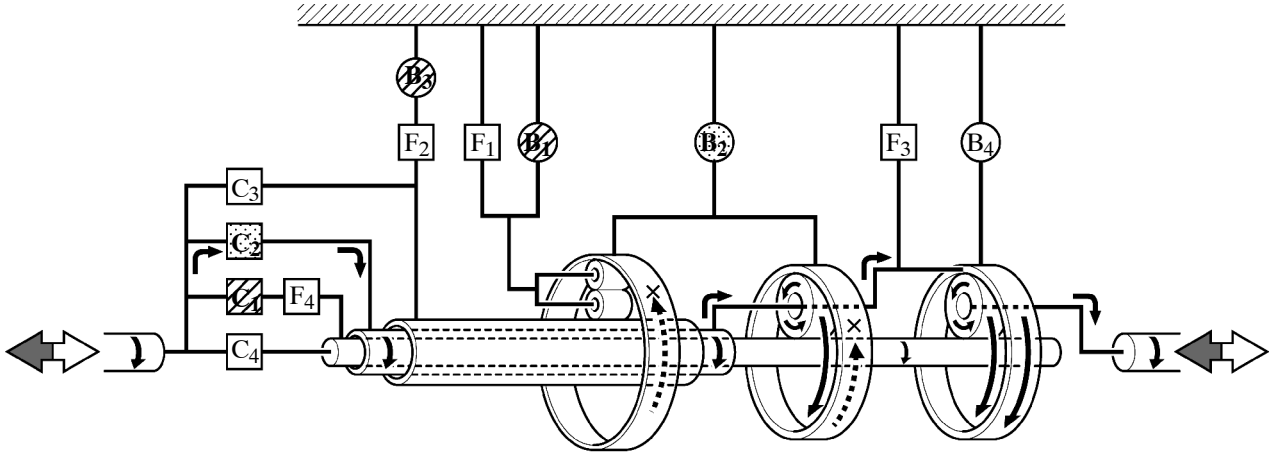
5th Gear (D Position or S Mode)



: Operates
: Operates but is not related to power transmission.

040SC07C

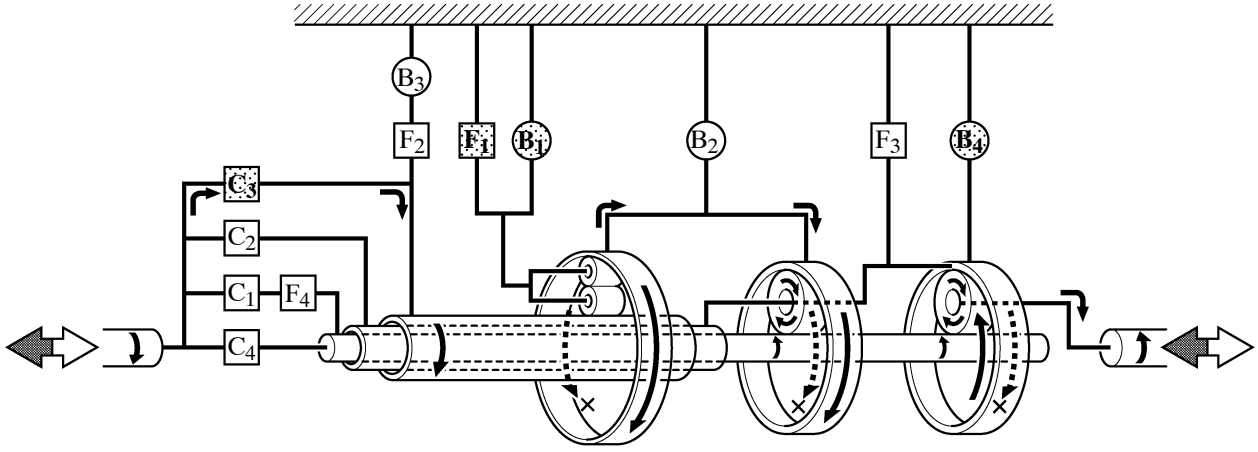
6th Gear (D Position or S Mode)



: Operates
: Operates but is not related to power transmission.

040SC08C

Reverse Gear (R Position)



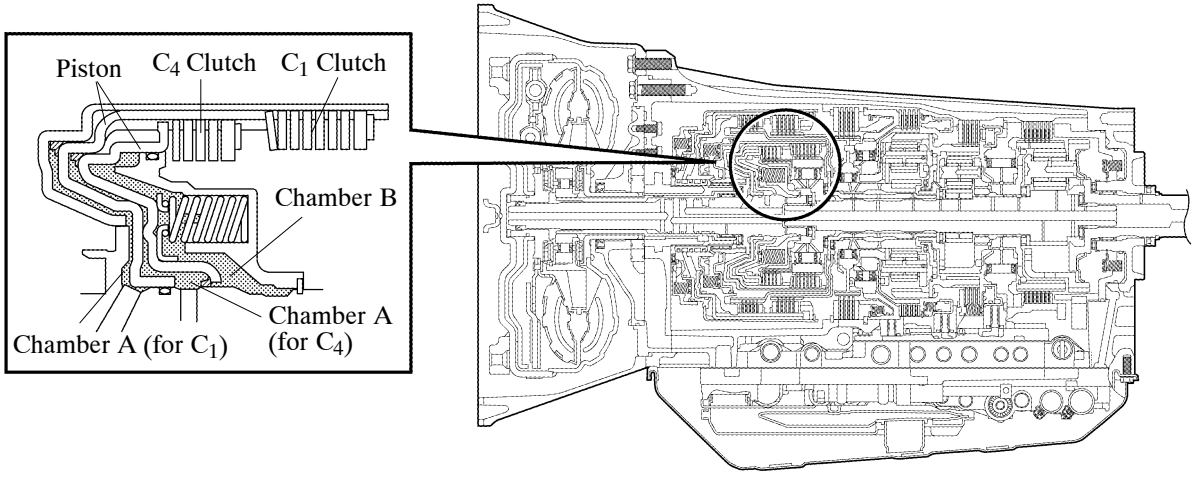
: Operates

0152CH11C

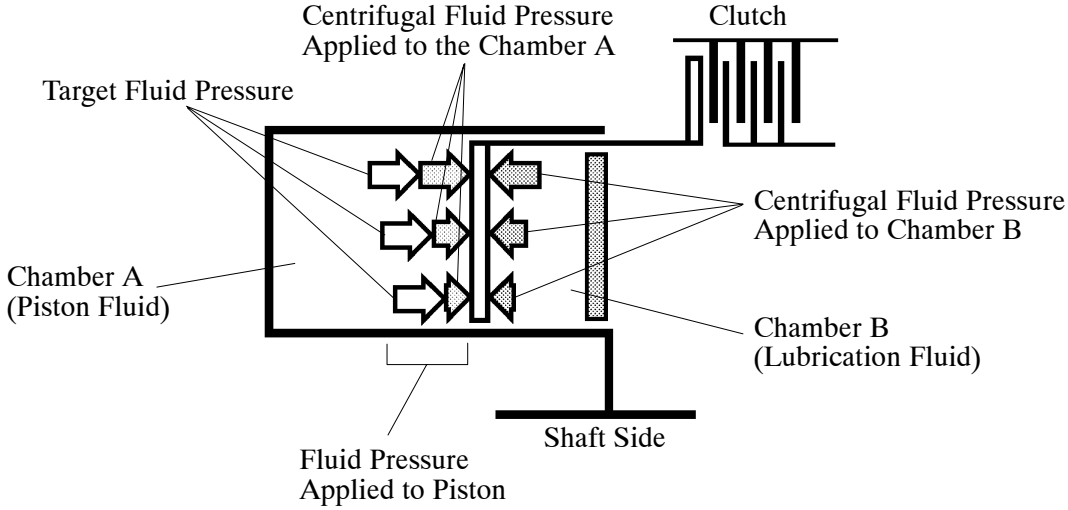
4. Centrifugal Fluid Pressure Canceling Mechanism

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.



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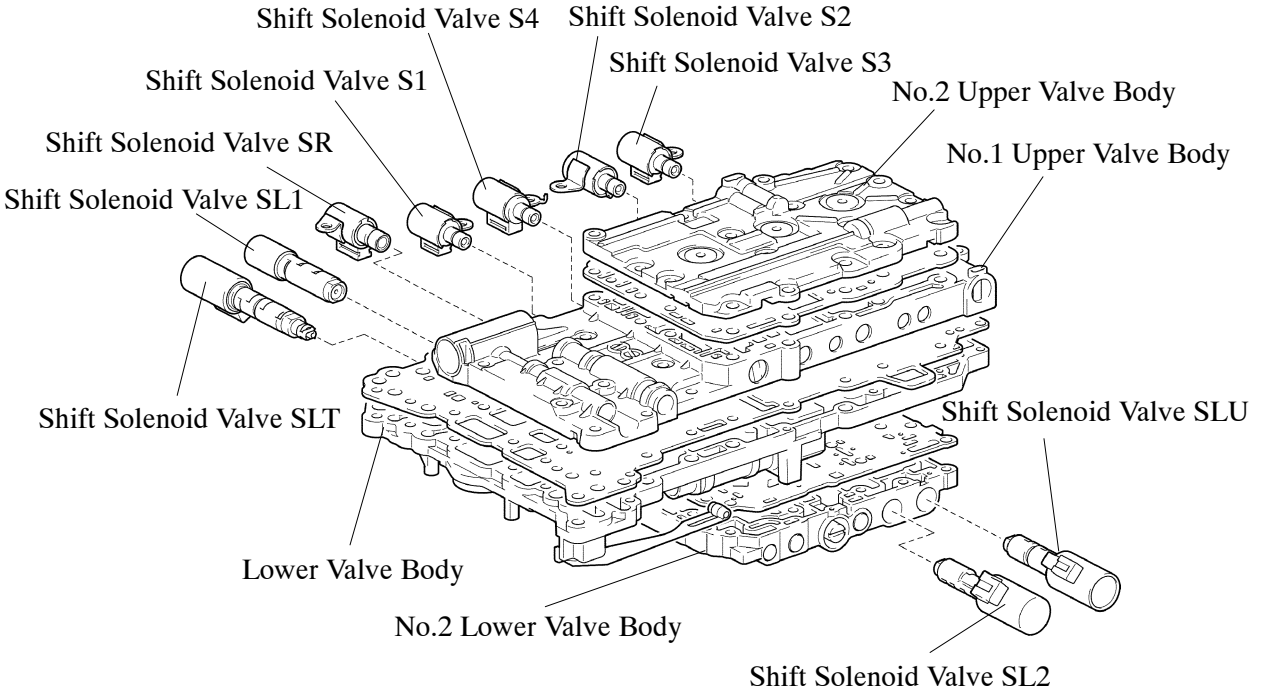
157CH17

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

■VALVE BODY UNIT

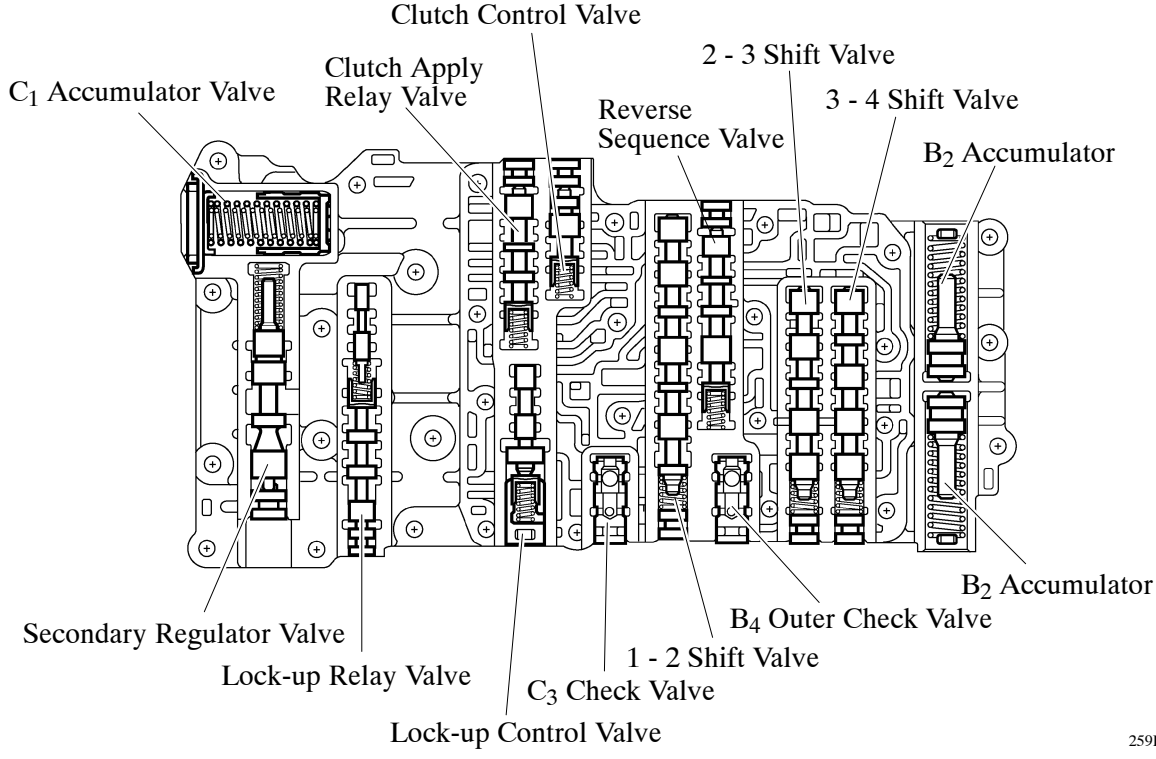
1. General

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



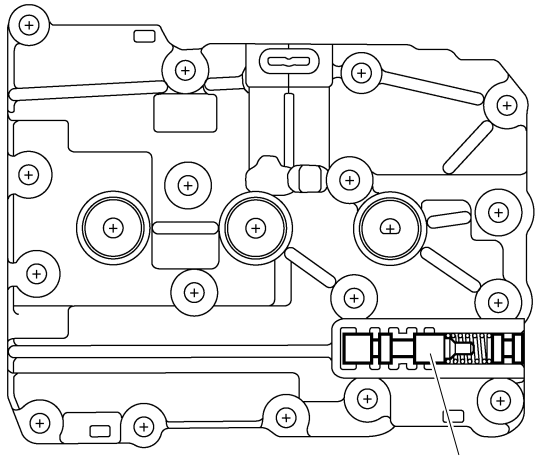
259LSK76

▶ No.1 Upper Valve Body ◀



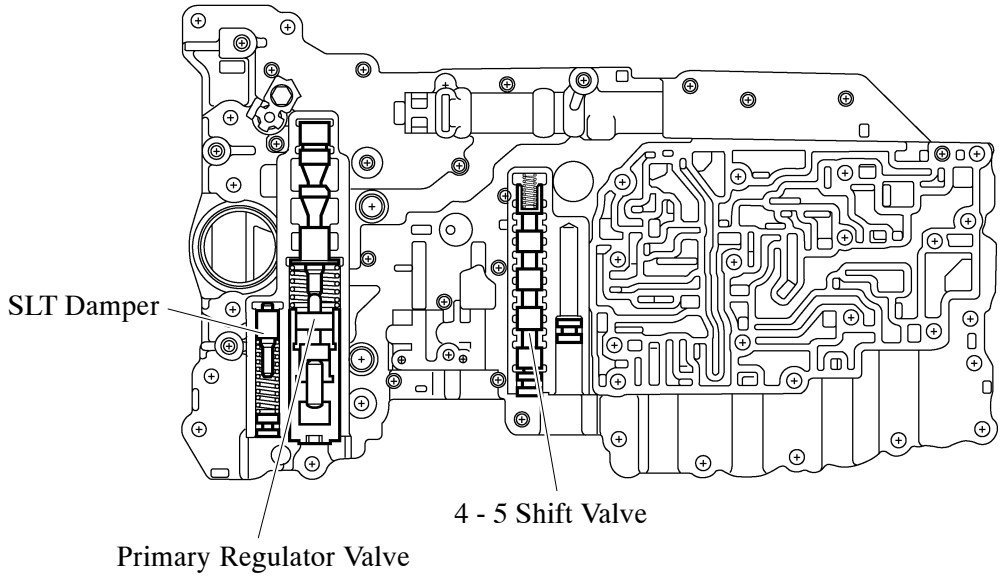
259LSK74

▶ No.2 Upper Valve Body ◀



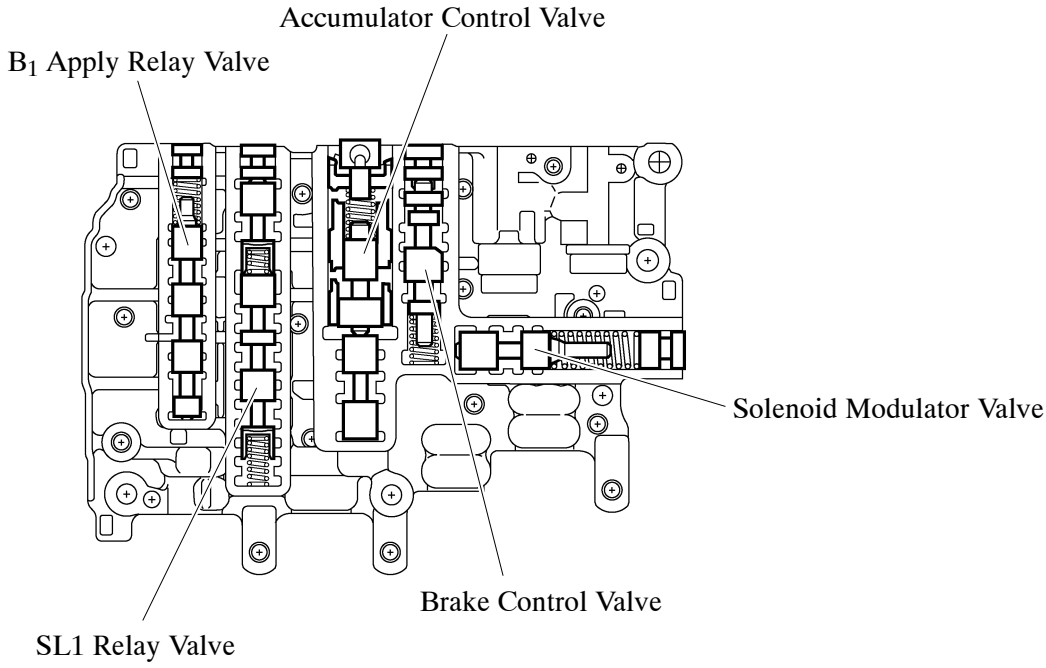
259LSK72

▶ Lower Valve Body ◀



259LSK73

▶ No.2 Lower Valve Body ◀

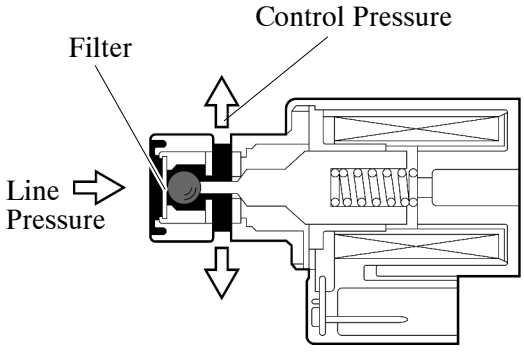


259LSK75

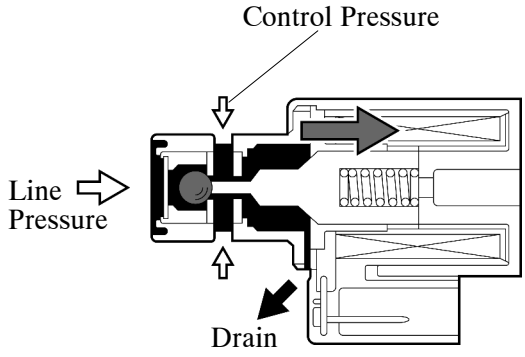
2. Shift Solenoid Valve

Shift Solenoid Valve 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.

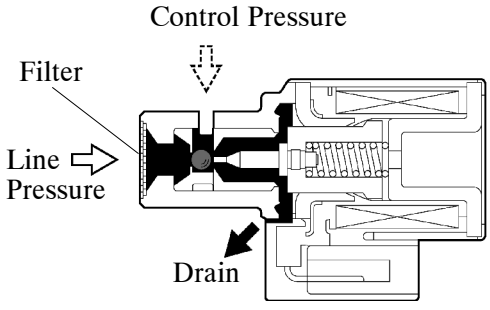


Shift Solenoid Valve S1 OFF

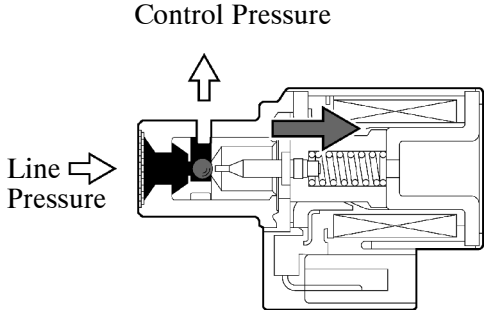


Shift Solenoid Valve S1 ON

040SC10C



Shift Solenoid Valve S4 OFF



Shift Solenoid Valve S4 ON

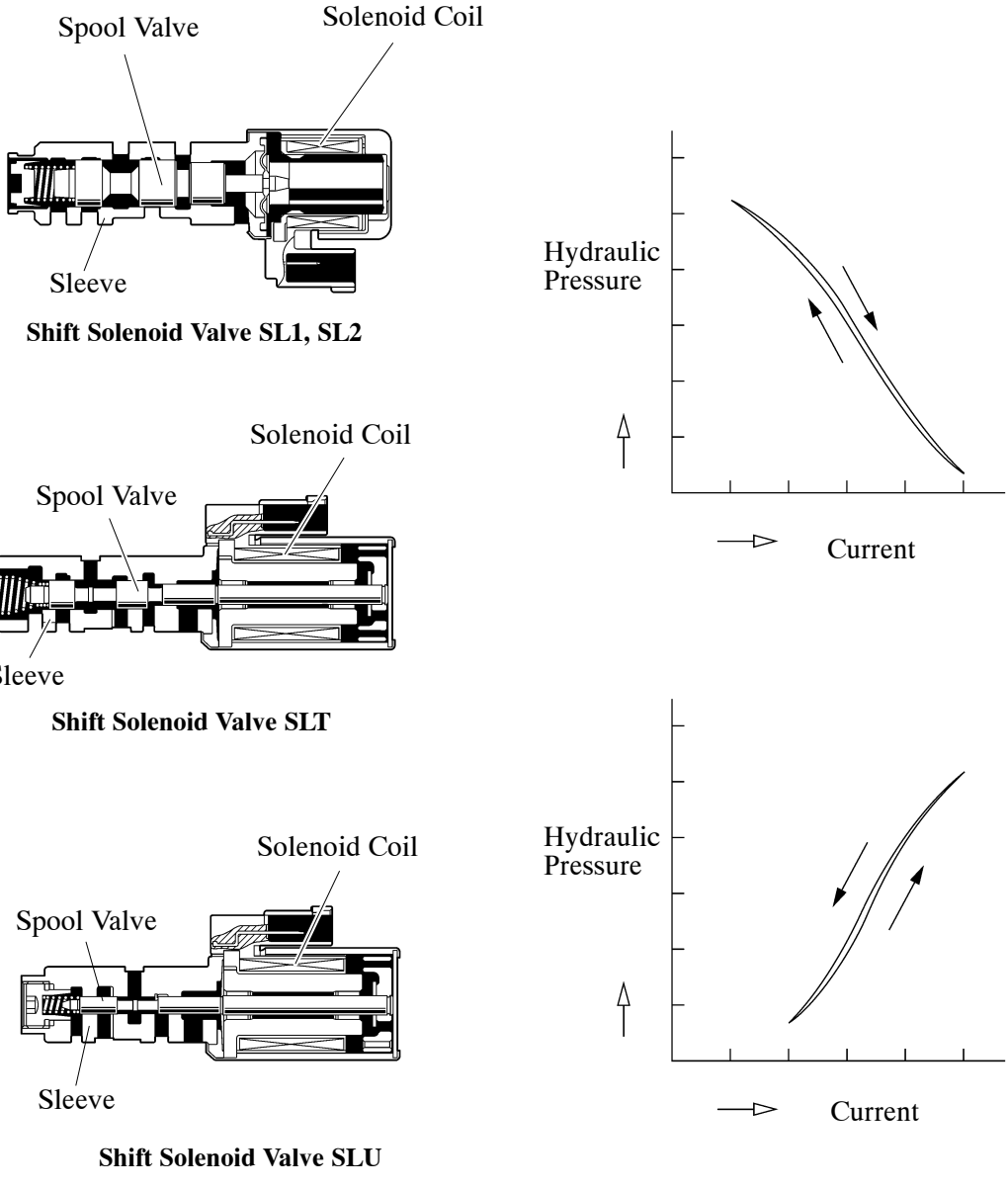
040SC11C

▶ Function of Shift Solenoid Valve S1, S2 and SR ◀

Shift Solenoid Valve	Function
S1	• Switches the 1 - 2 shift valve. • Switches the SL1 relay valve.
S2	• Switches the 2 - 3 shift valve • Switches the 5 - 6 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. • Switch the B_1 relay valve.

Shift Solenoid Valve 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 pressure based on the signals received from the ECM.



Shift Solenoid Valve SL1, SL2

Shift Solenoid Valve SLT

Shift Solenoid Valve SLU

04E1CH06Z

▶ Function of Shift Solenoid Valve SL1, SL2, SLT and SLU ◀

Shift 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

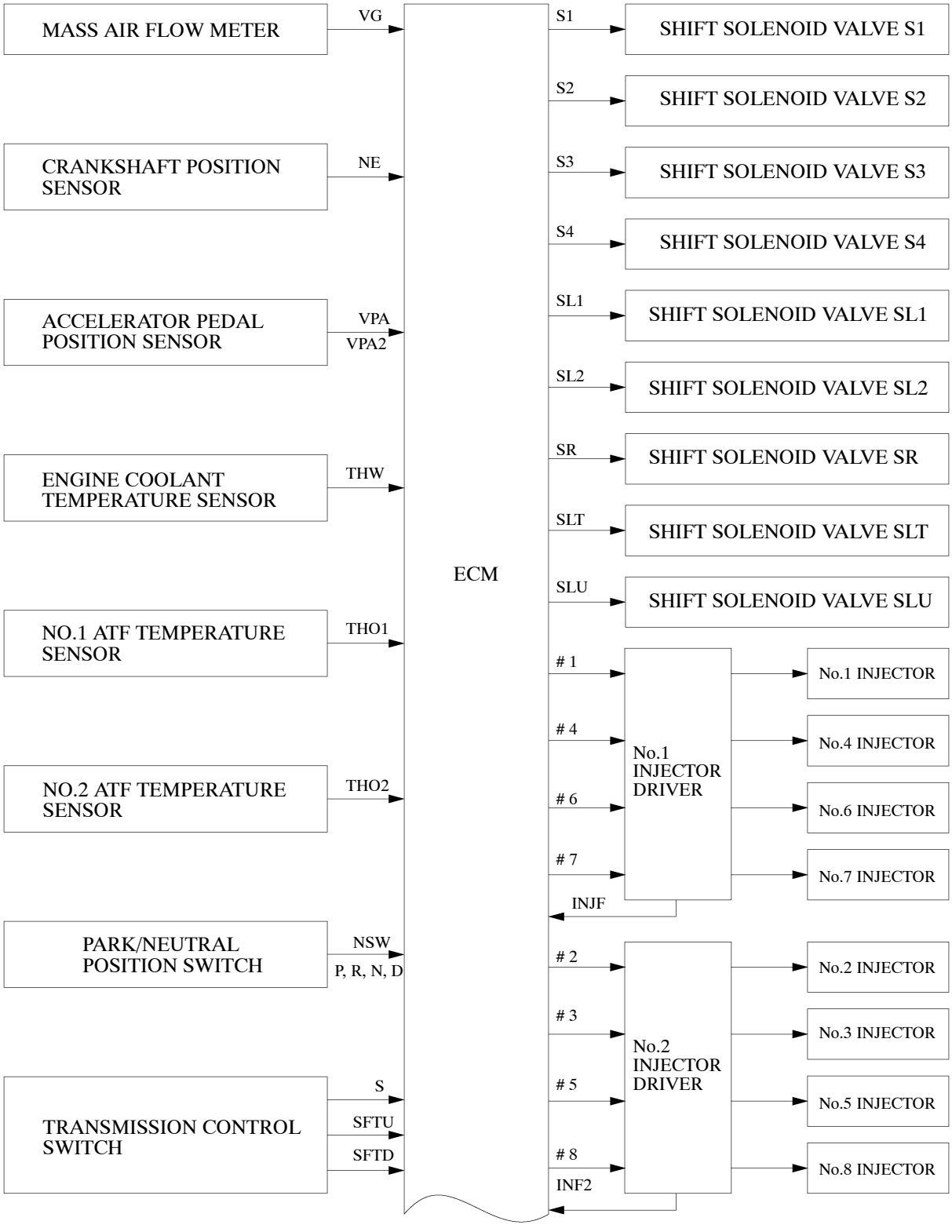
1. General

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 shift solenoid valves S1, S2, S3, S4 or SR based on signals from various sensors, in order to shift the gears.
Clutch Pressure Control (See page CH-71)	• 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 shift solenoid valve SLT and SL1 minutely controls the clutch pressure in accordance with the engine output and driving conditions.
Line Pressure Optimal Control (See page CH-72)	Actuates the shift 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	Reduces the injection quantity temporarily to improve shift feeling while upshifts or downshifts occur.
Lock-up Timing Control (See page CH-72)	The ECM sends current to the shift 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-73)	Controls the shift 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.
“N” to “D” Squat Control	When the shift lever is shifted from “N” to “D” position, 2nd gear is temporarily engaged before 1st to reduce vehicle squat.
“R” to “D” Squat Control	When the shift lever is shifted from “R” to “D” position, 3rd gear is temporarily engaged before 1st to reduce vehicle squat.
2nd Start Control	Enabling the vehicle to take off in the 2nd gear and thus make it easy to take off snowy, sandy or muddy terrain.
Coast Downshift Control (See page CH-74)	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-75)	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, thus improving drivability.
Multi-mode Automatic Transmission (See page CH-77)	The ECM appropriately controls the automatic transmission in accordance with the range position selected while the shift lever is in the S mode position.
Diagnosis (See page CH-79)	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-79)	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

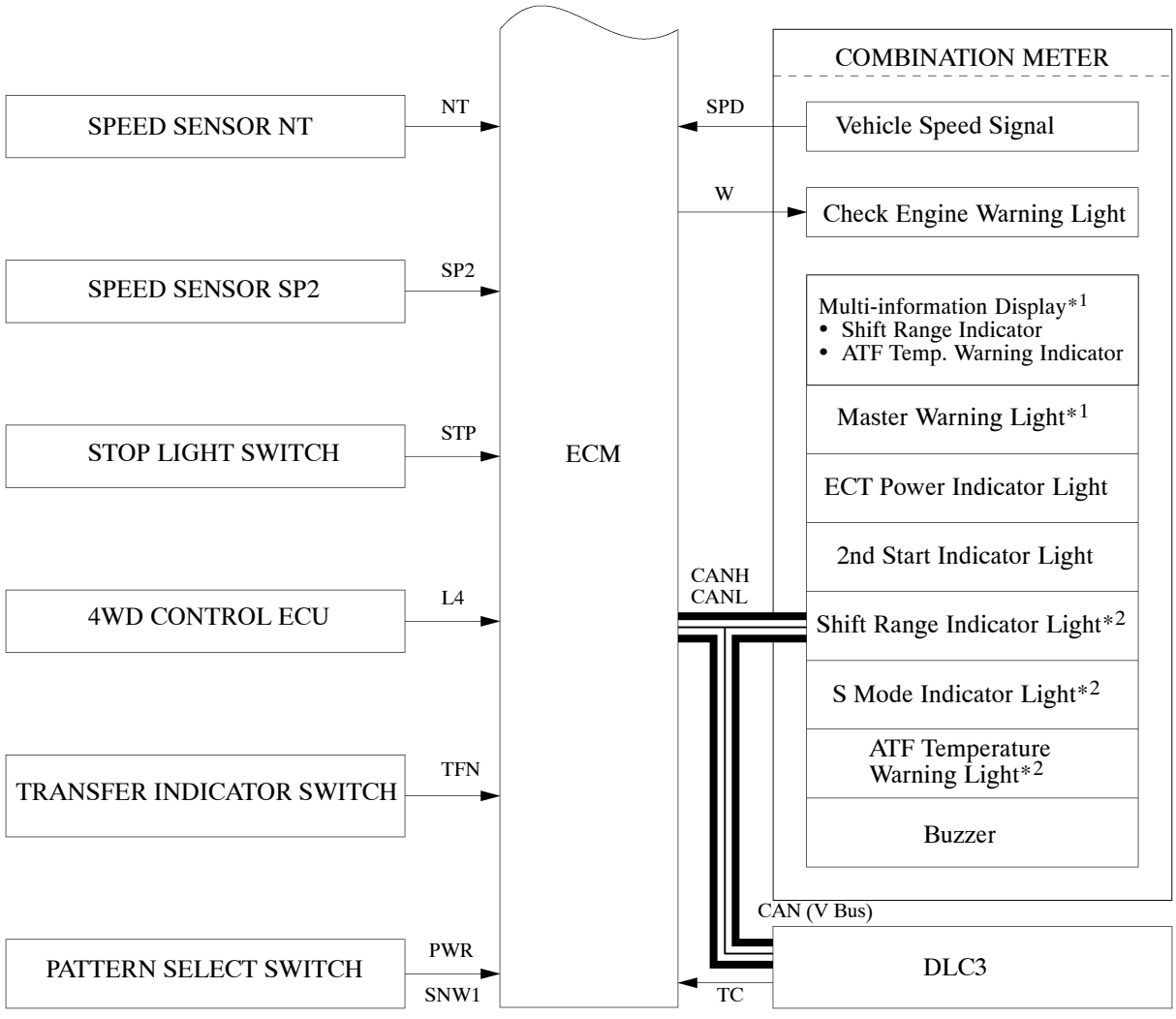
The configurations of the electronic control system for the AB60F automatic transmission is as shown in the following chart.



(Continued)

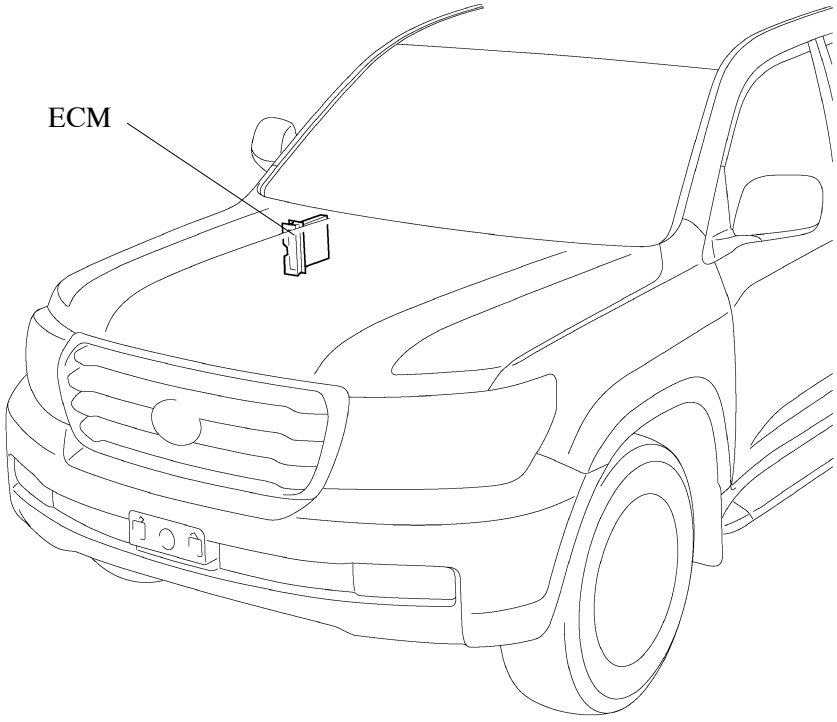
081CH41S

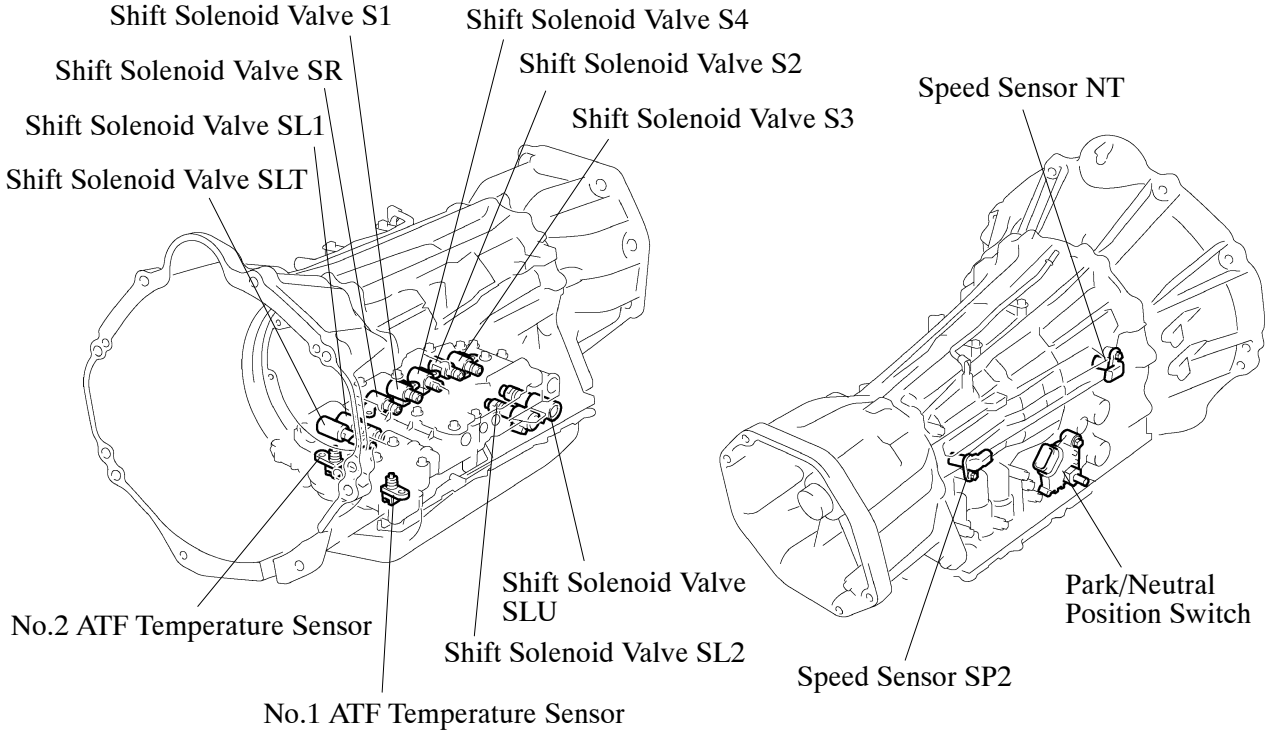
CH



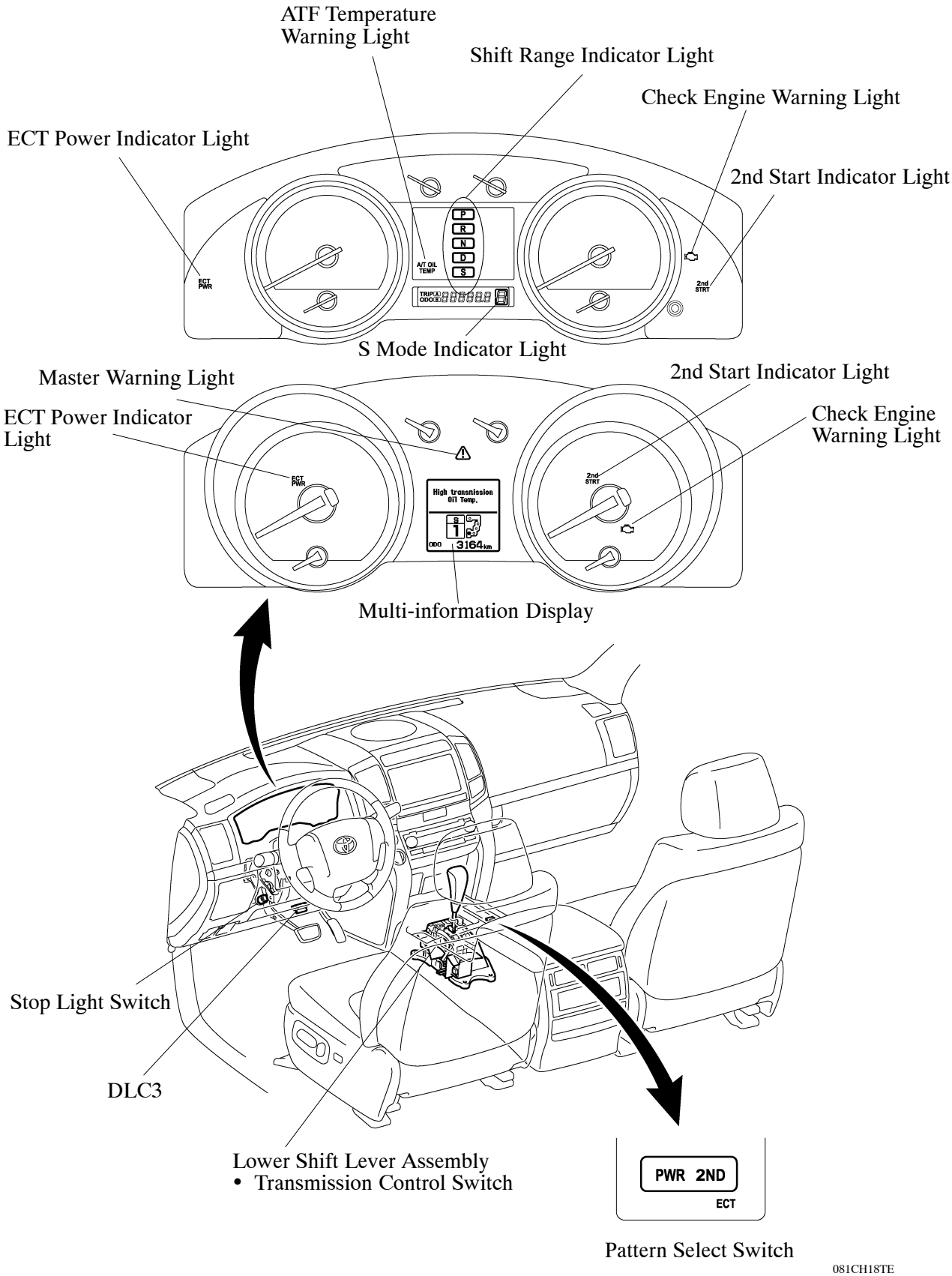
*1: Only for models with optitron type combination meter
*2: Only for models with analog type combination meter

3. Layout of Main Components





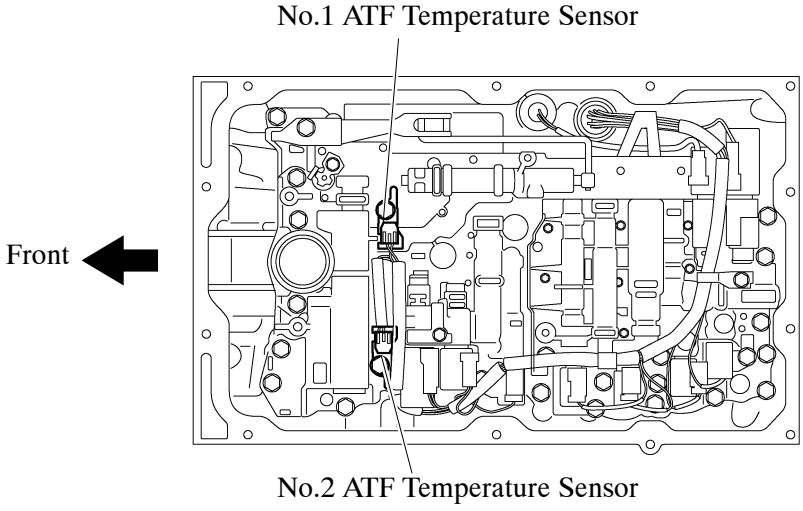
081CH19Z


ATF Temperature Warning Light
Shift Range Indicator Light
Check Engine Warning Light
ECT Power Indicator Light
2nd Start Indicator Light
S Mode Indicator Light
Master Warning Light
2nd Start Indicator Light
ECT Power Indicator Light
Check Engine Warning Light
Multi-information Display
Stop Light Switch
DLC3
Lower Shift Lever Assembly
• Transmission Control Switch
PWR 2ND
ECT
Pattern Select Switch
081CH18TE

4. Construction and Operation of Main Components

No.1 and No.2 ATF Temperature Sensor

- No.1 ATF temperature sensor 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.
- No.2 ATF temperature sensor 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.

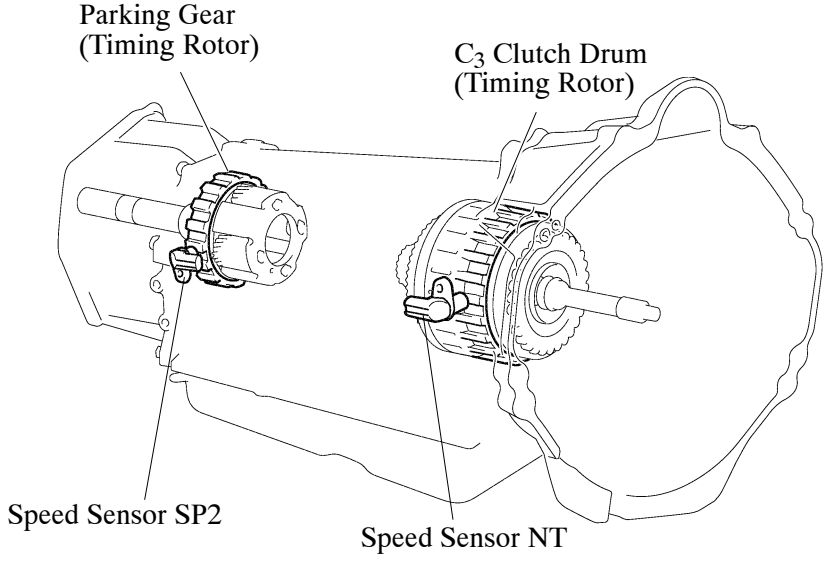


04E1CH17C

Input Speed Sensor and Output Speed Sensor

The AB60F automatic transmissions use a speed sensor NT (for NT signal) and speed sensor SP2 (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 speed sensor NT detects the input speed of the transmission. The clutch drum is used as the timing rotor for this sensor.
- The speed sensor SP2 detects the speed of the output shaft. The parking gear on the rear planetary gear is used as the timing rotor for this sensor.

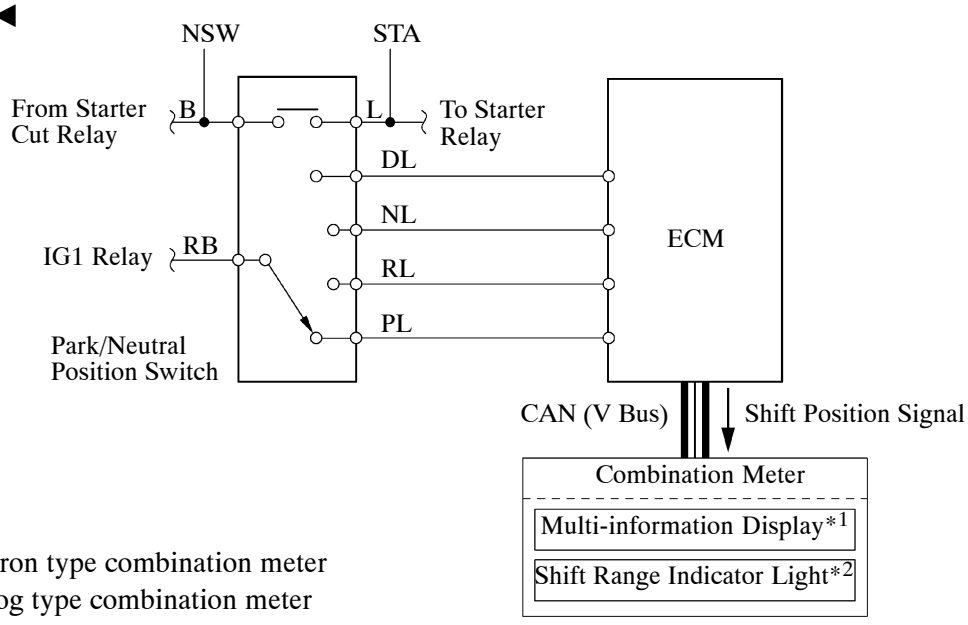


081CH42Z

Park/Neutral Position Switch

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

▶ Wiring Diagram ◀



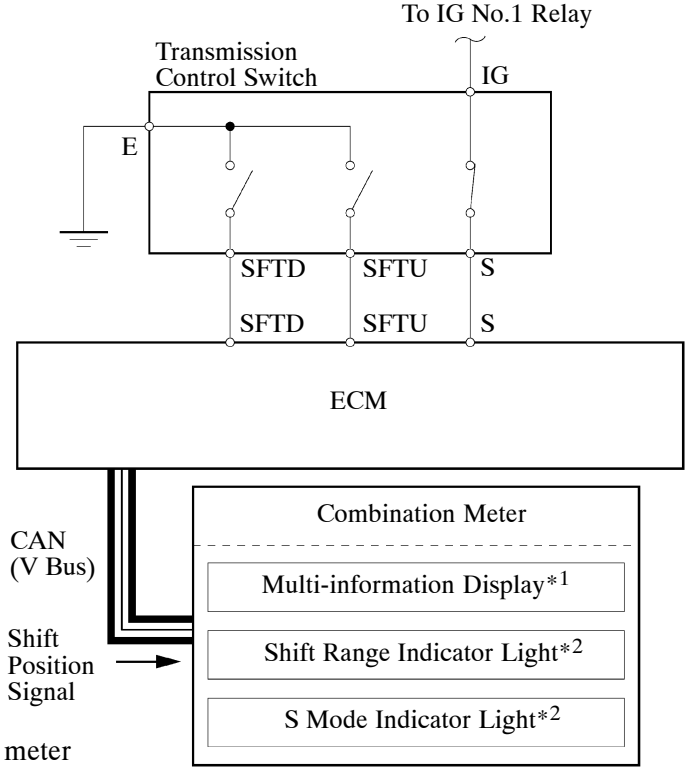
*1: Models with optitron type combination meter
*2: Models with analog type combination meter

081CH28S

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 indicator light and S mode indicator light.
- 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 range indicator light for the selected range.

▶ Wiring Diagram ◀



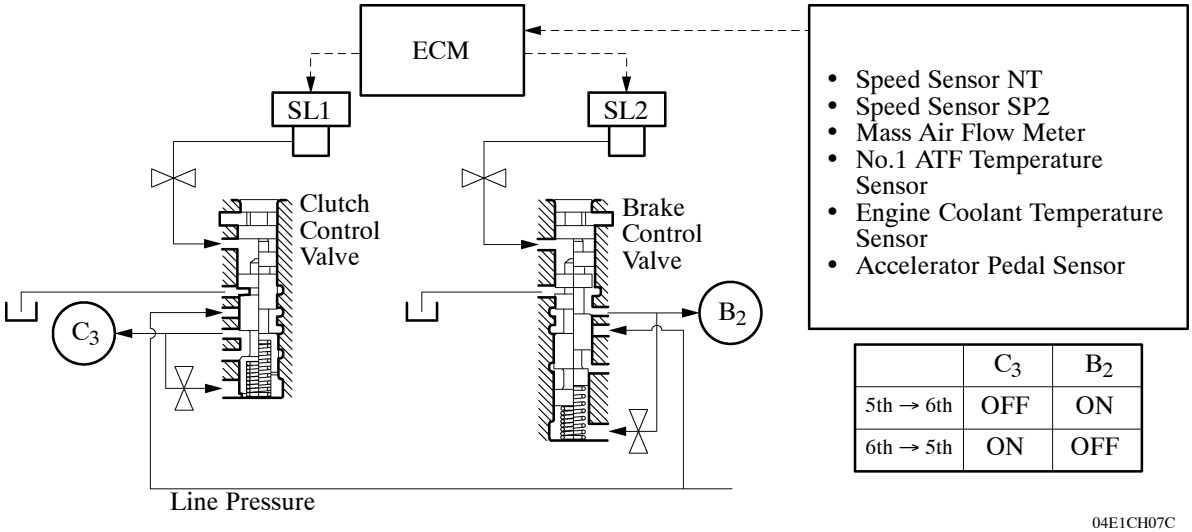
*1: Models with optitron type combination meter
*2: Models with analog type combination meter

081CH60S

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 shift 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.

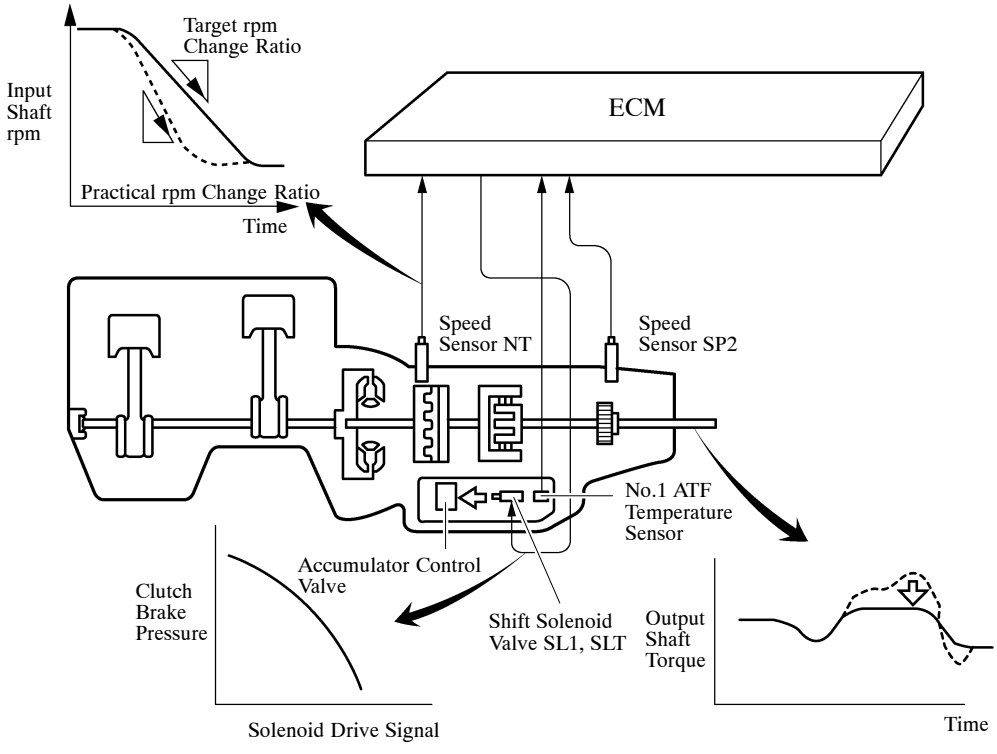


	C_3	B_2
5th → 6th	OFF	ON
6th → 5th	ON	OFF

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Clutch Pressure Optimal Control

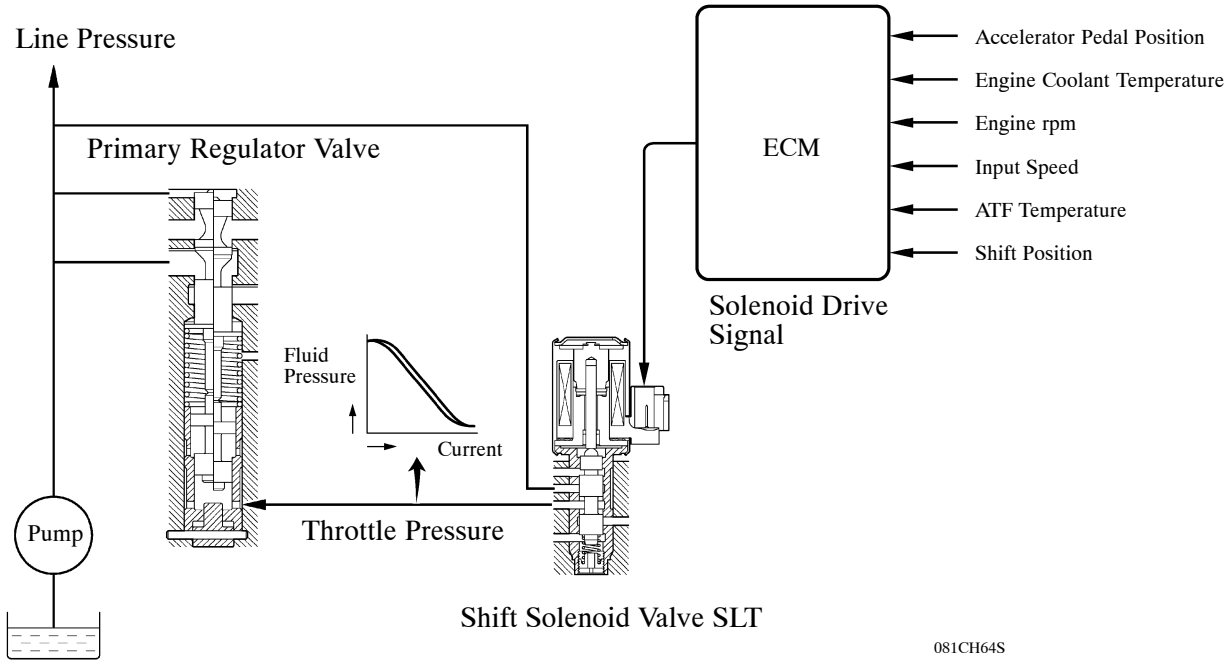
The ECM monitors the signals from various types of sensors, such as the input speed sensor, allowing shift solenoid valves SLT and SL1 to minutely control the clutch pressure in accordance with engine output and driving conditions. As a result, smooth shift characteristics are realized.



279CH109

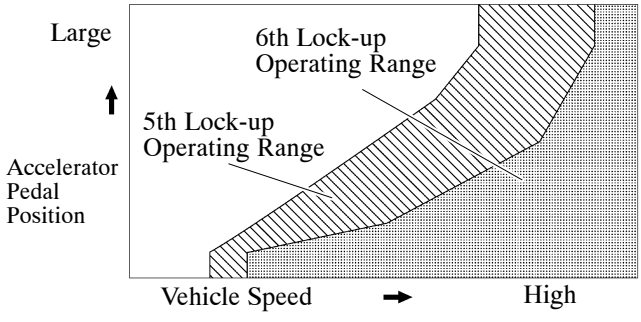
6. Line Pressure Optimal Control

Through the use of the shift 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 ◀

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

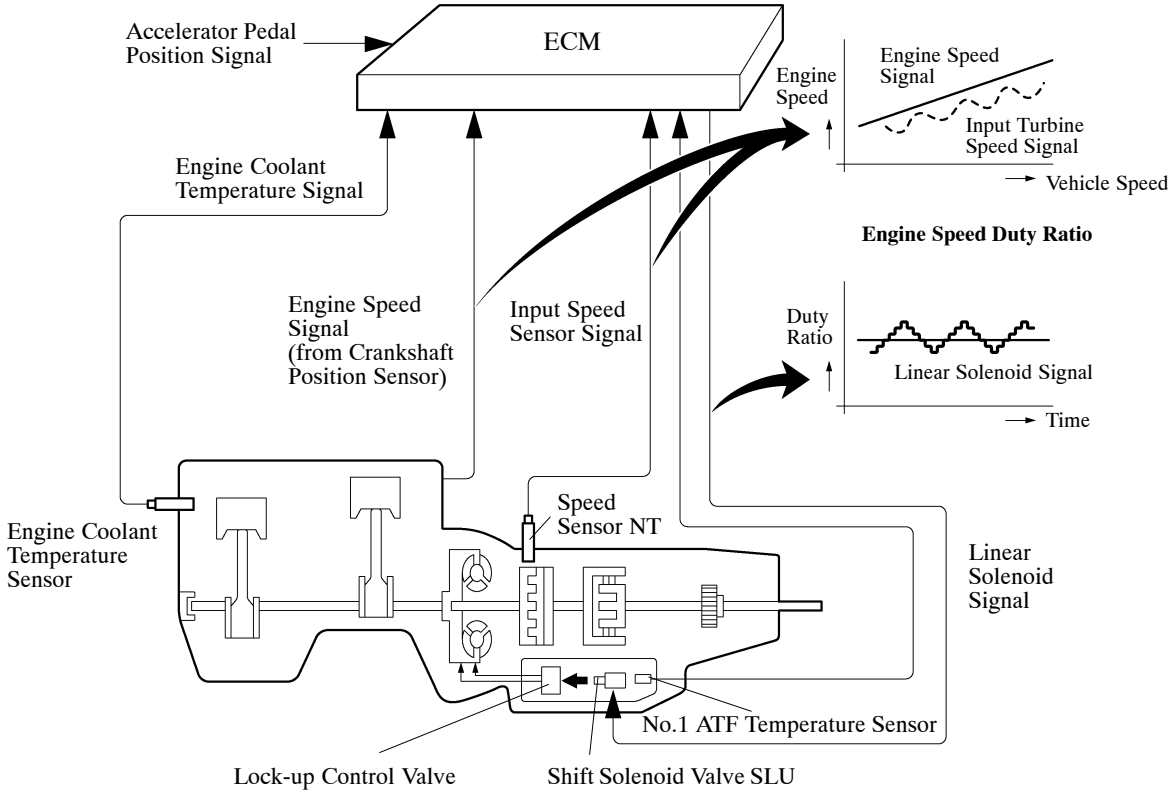
○: Available ×: Not available —: Not applicable

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

8. Flex Lock-up Clutch Control

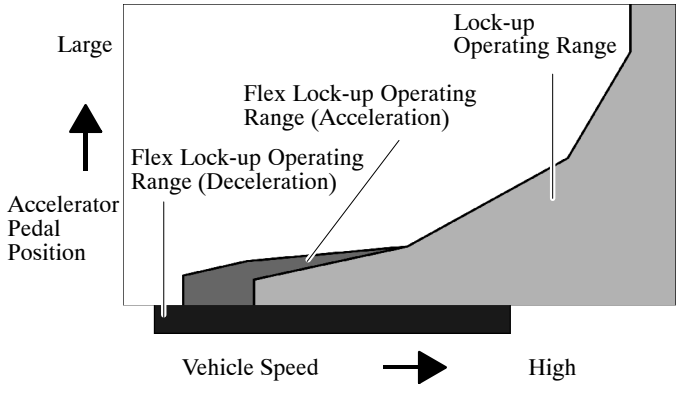
In the low-to-mid-speed range, this flex lock-up clutch control regulates the shift solenoid valve SLU to provide an intermediate mode between the ON/OFF operation of the lock-up clutch in order to improve the energy transmitting efficiency in this range.
As a result, the operating range of the lock-up 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 gear 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.



081CH65S

▶ Flex Lock-up Operation Gears in Each Range ◀



0140CH141C

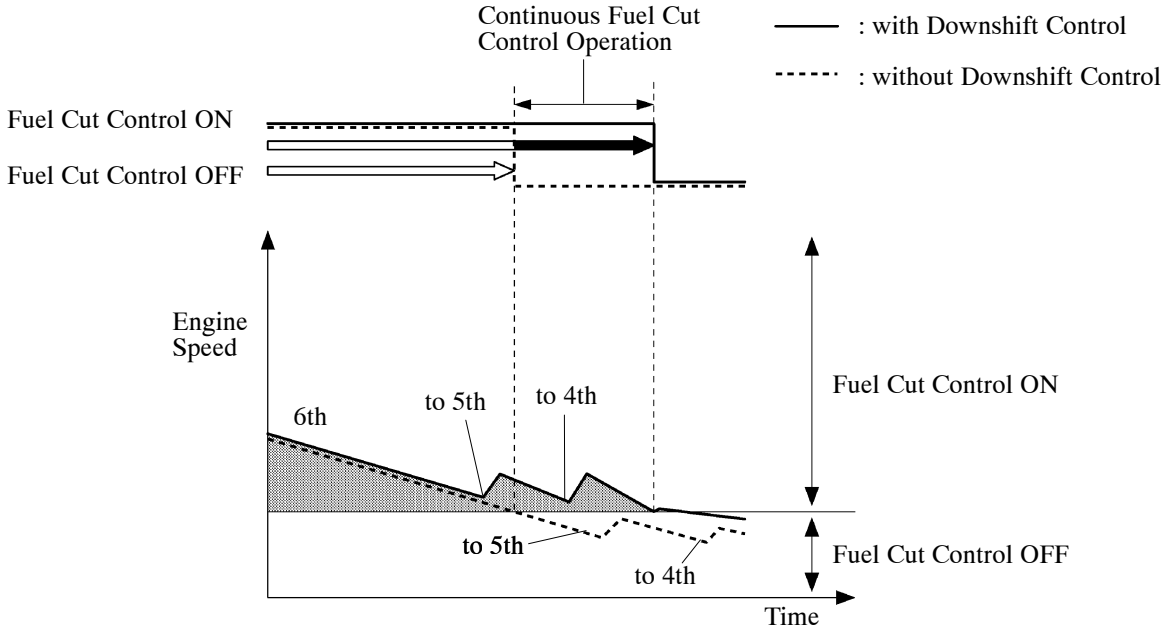
Gear \ Position or Range	D, S6	S5	S4
1st	×	×	×
2nd	×	×	×
3rd	○	○	○
4th	○*	○*	○*
5th	○*	○*	—
6th	○*	—	—

○: Available ×: Not available —: Not applicable
*: Flex Lock-up also operates, when the vehicle is decelerating.

9. 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.

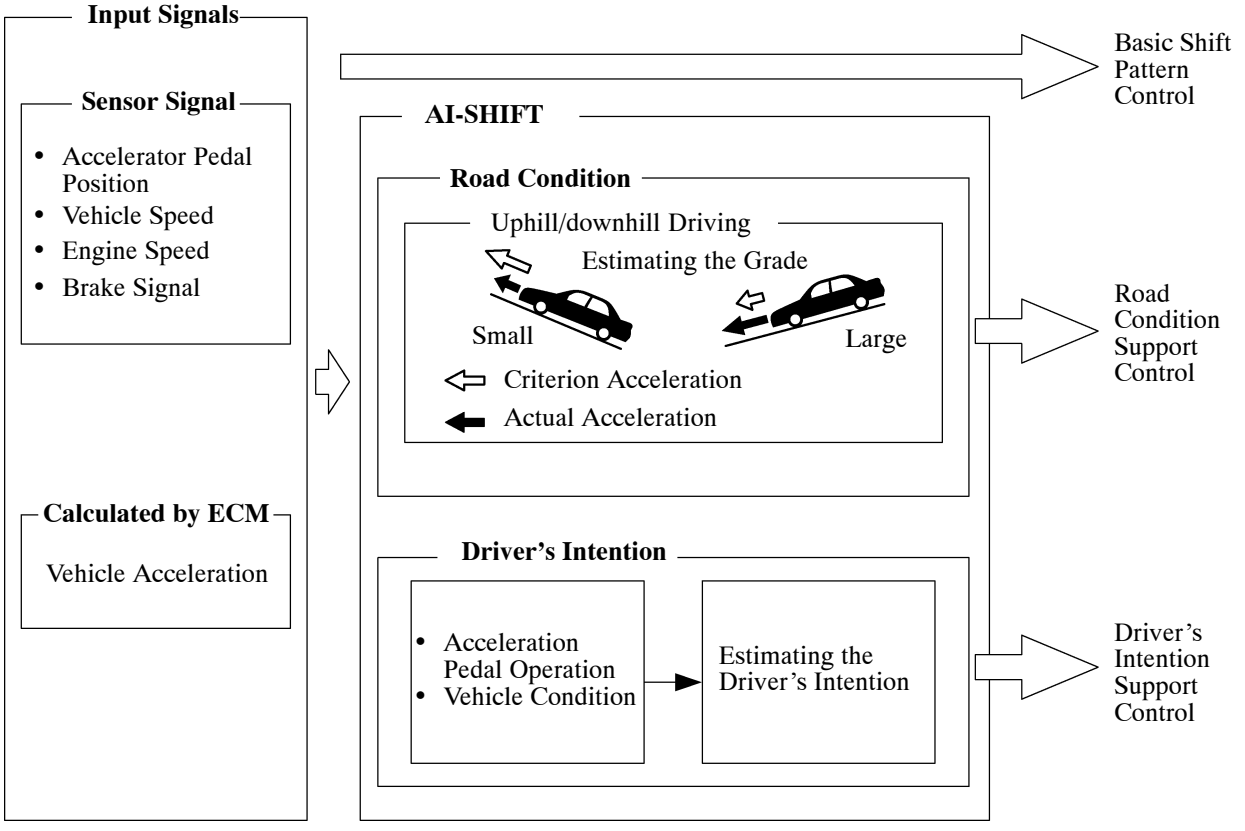


10. AI (Artificial Intelligence) - SHIFT Control

General

The AI-SHIFT control includes a road condition support control and a driver's intention support control. The AI-SHIFT control determines optimal transmission control based on input signals and automatically changes the shift pattern. As a result, a high caliber of transmission operation is achieved.

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



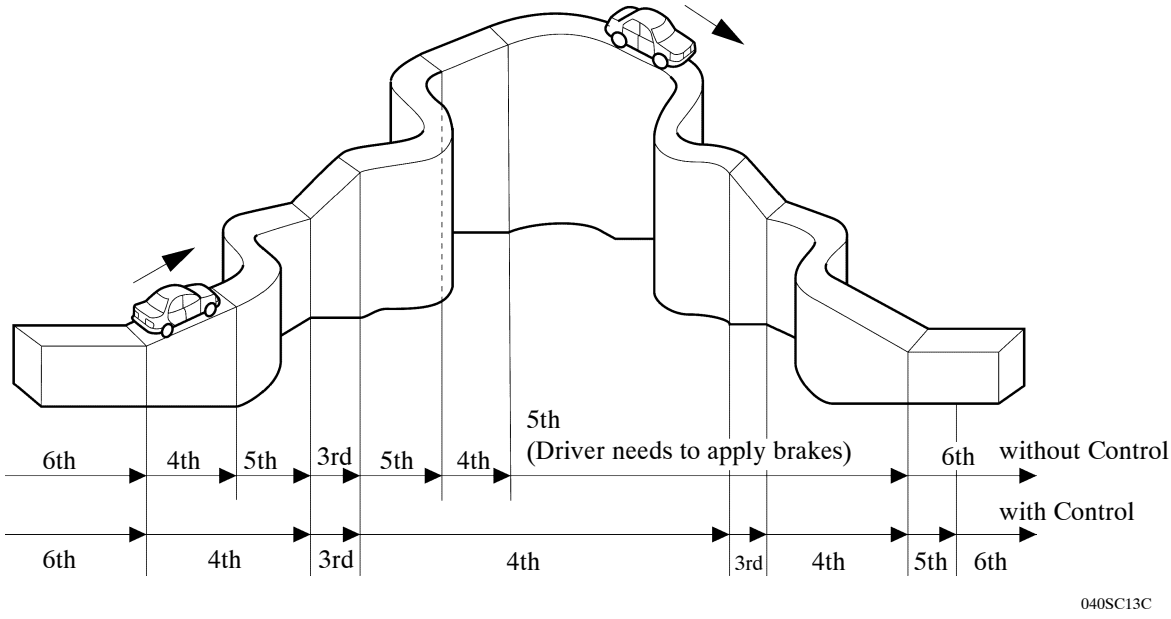
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Road Condition Support Control

Under road condition support control, the ECM determines accelerator pedal position and the vehicle speed whether the vehicle is being driven uphill or downhill.

- To achieve an optimal drive force while driving uphill, this control prevents the transmission from up-shifting 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 operation and vehicle condition and selects a shift pattern that is well-suited to each driver.

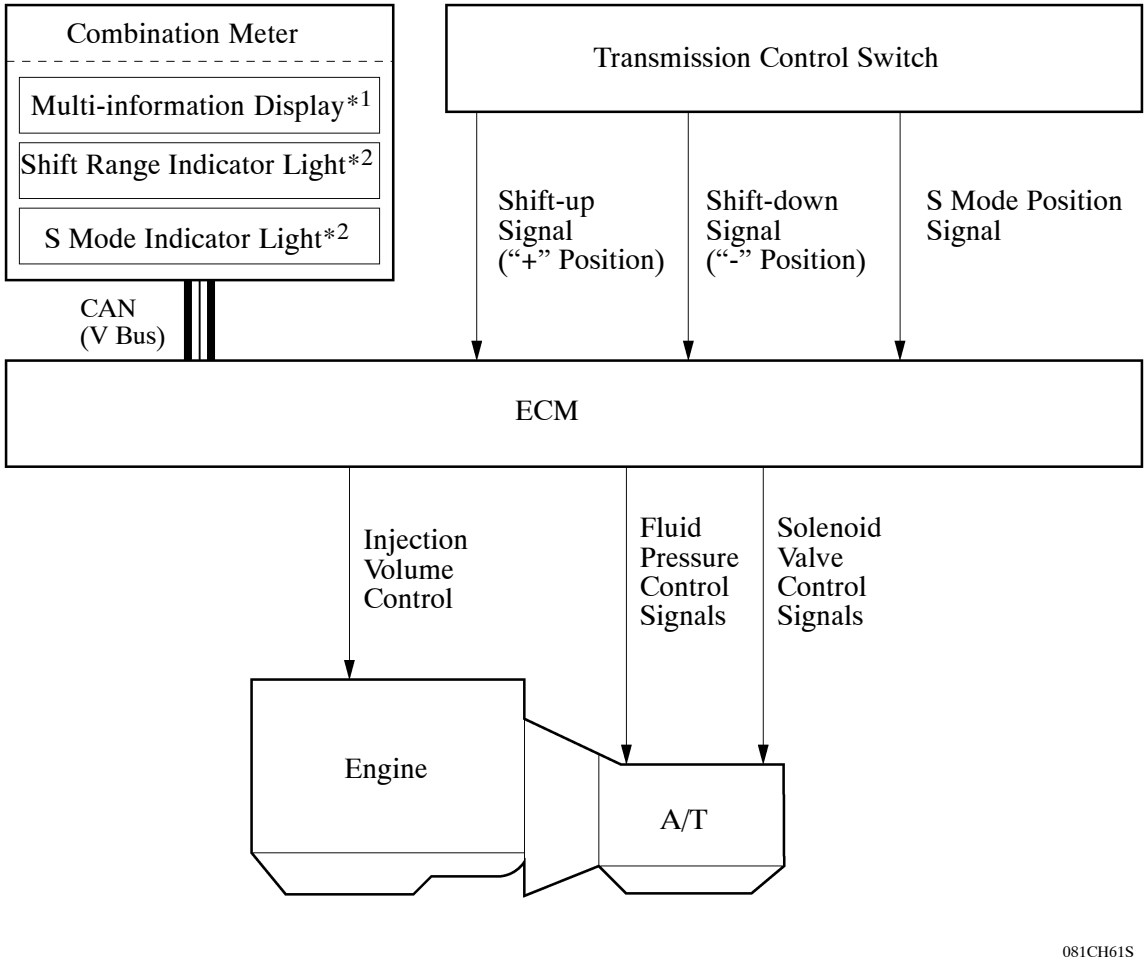
Control	Operation	Operate Gear	Pattern Select Switch
Sudden Accelerator Pedal Release Control	When the driver releases the accelerator quickly, this control makes it easy for the transmission to hold the gear, which improves engine braking force and re-acceleration response.	3rd to 5th	ECT POWER
Sudden 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	ECT POWER

11. 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 shifting the shift lever to the S mode position and moving the shift lever to the "+" position or to the "-" position, the driver can select the desired shift range. Thus, the driver is able to shift gears with a manual-like feel.

▶ System Diagram ◀

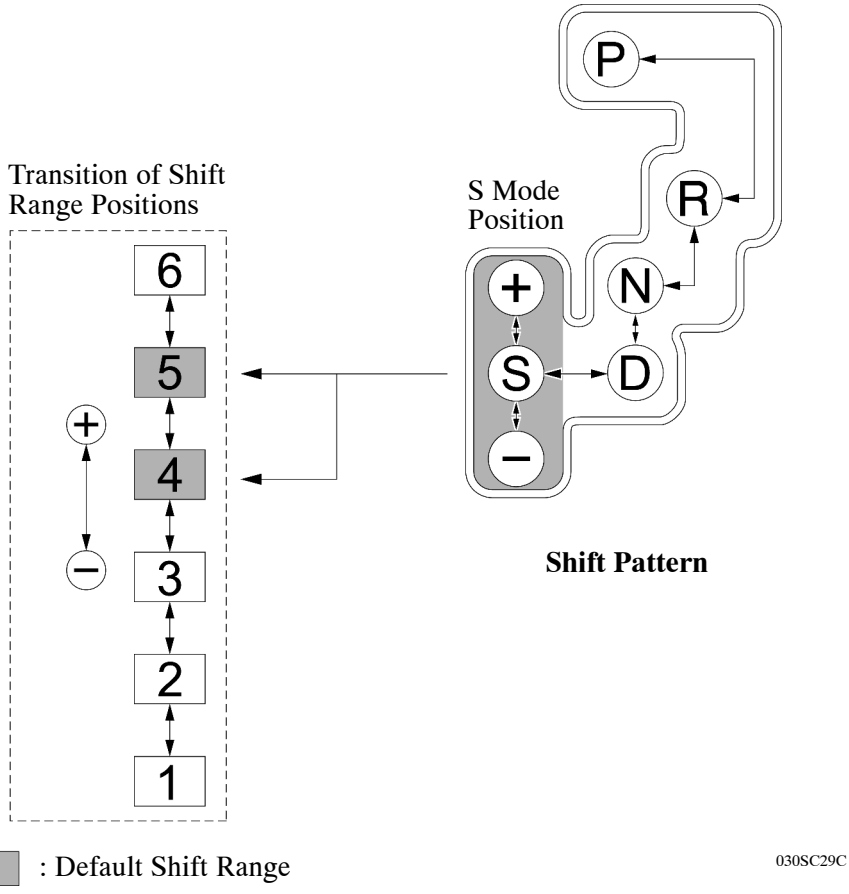


*1: Models with optitron type combination meter
*2: Models with analog type combination meter

CH

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 light in the combination meter illuminates. The shift range indicator light indicates the state of the shift range position that the driver has selected.



▶ Usable Gear Chart ◀

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

12. 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 an intelligent tester II to the DLC3.

For details, see the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

13. 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
Speed Sensor NT	When the speed sensor NT malfunctions, shift control is effected using the information from the speed sensor SP2 signal. During a speed sensor NT malfunction, up-shift to the 5th, 6th, AI-SHIFT and flex lock-up clutch control are prohibited.
Speed Sensor SP2	When the speed sensor SP2 malfunctions, shift control is effected using the information from the speed sensor NT signal. When the speed sensor SP2 malfunctions, up-shift to the 5th, 6th, AI-SHIFT and flex lock-up clutch control are prohibited.
No.1 ATF Temperature Sensor	When the No.1 ATF temperature sensor malfunctions, up-shift to the 5th, 6th and flex lock-up clutch control are prohibited.
Shift Solenoid Valve S1, S2, S3, S4 and SR	When a shift 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 shift solenoid valves to allow continued driving. Refer to the table on the next page for an operation example.
Shift Solenoid Valve SL1 and SL2	During a shift solenoid valve SL1 or SL2 malfunction, up-shift to the 5th and 6th and flex lock-up clutch control are prohibited.
Shift Solenoid Valve SLU	During a shift 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.
Shift Solenoid Valve SLT	During a shift 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.

Position	Normal							
	Shift Solenoid							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 ◀

Position	Shift Solenoid Valve S1 Malfunction							
	Shift Solenoid							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
	×	ON → 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	ON → OFF	OFF	OFF → ON	1st (E/B) → 2nd
S1	×	ON	ON	OFF	ON	OFF	OFF	1st (E/B)

E/B: Engine Braking

■ SHIFT CONTROL MECHANISM

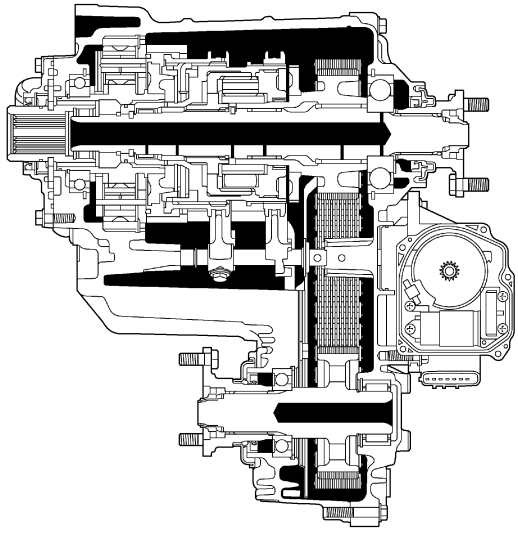
- A gate type shift lever is used.
- Shift pattern is provided with the S mode position on the side of the D position.
- A shift lock system is used, of which the basic construction and operation are the same as those of the A750F automatic transmission. For details, see page CH-45.

TRANSFER

■ DESCRIPTION

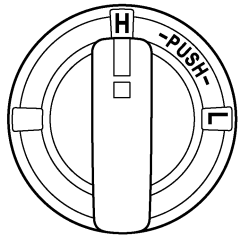
- The JF2A transfer has been newly developed. This transfer is a compact and lightweight full-time 2-speed transfer.
- The center differential uses a TORSEN LSD (Limited Slip Differential).
- A planetary gear train is used in the reduction mechanism and a silent chain is used to reduce noise for the front drive.
- This transfer switches the transfer gear ratio and center differential lock using two motor actuators. A dial type transfer position switch is used to change the transfer gear ratio, and a push button type center differential lock switch is used to change the center differential free-lock.

▶ JF2A Transfer ◀



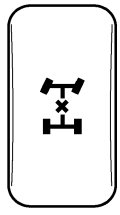
080CH30Y

▶ Transfer Position Switch ◀



080CH31Y

▶ Center Differential Lock Switch ◀



233CH28

▶ 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)

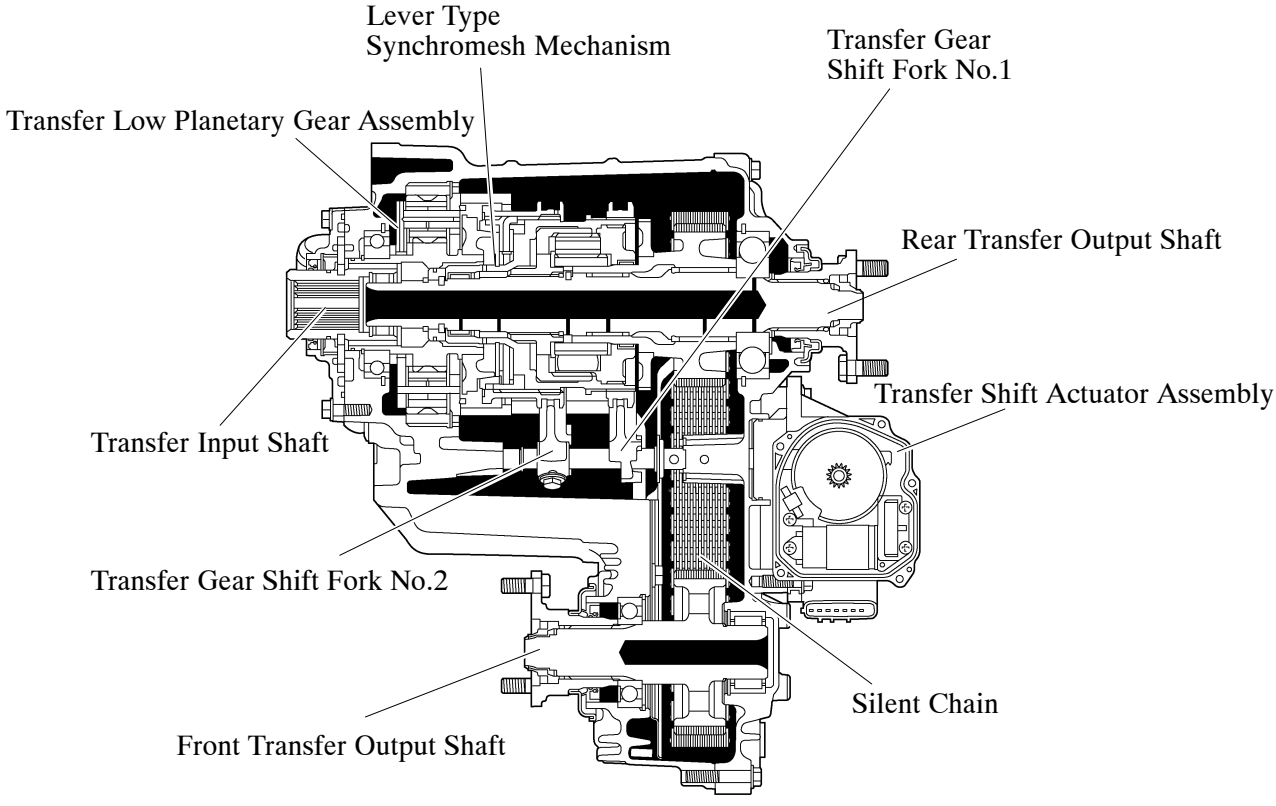
*: Weight shows the figure with the fluid fully filled.

■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.
- A lever type synchromesh mechanism is used for the H4-L4 switching section to eliminate gear clash when switching from H4-L4.
- For the JF2A transfer, a transfer shift actuator that has 2 built-in shift motors is used. As a result, switching from H4-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.



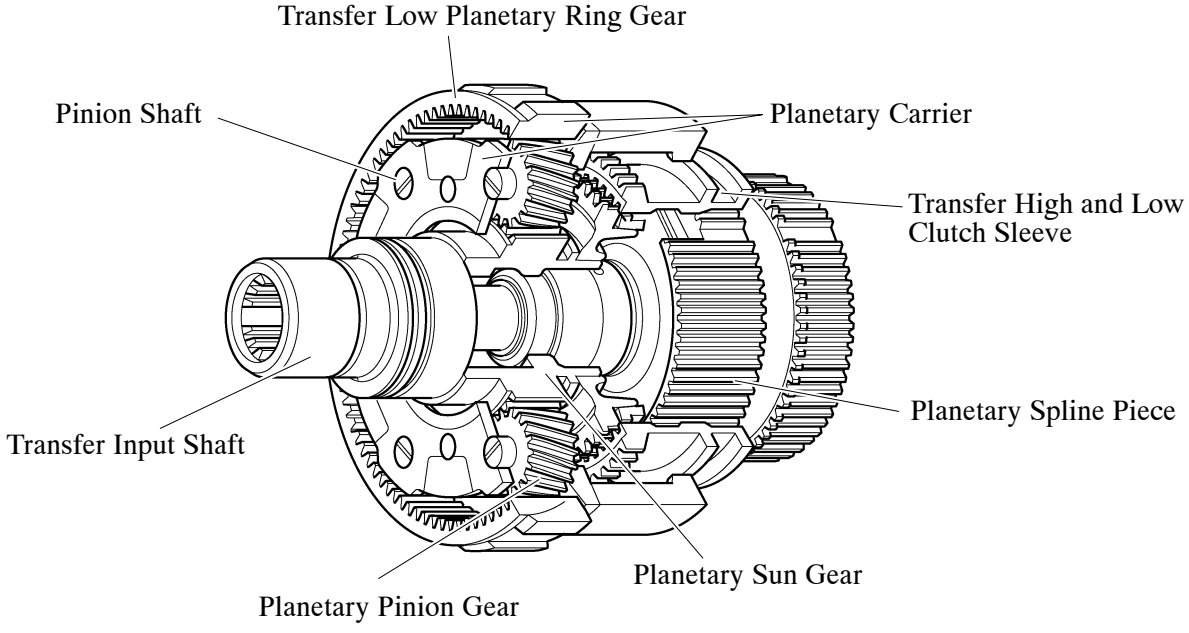
080CH30Y

2. Planetary Gear Unit

General

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

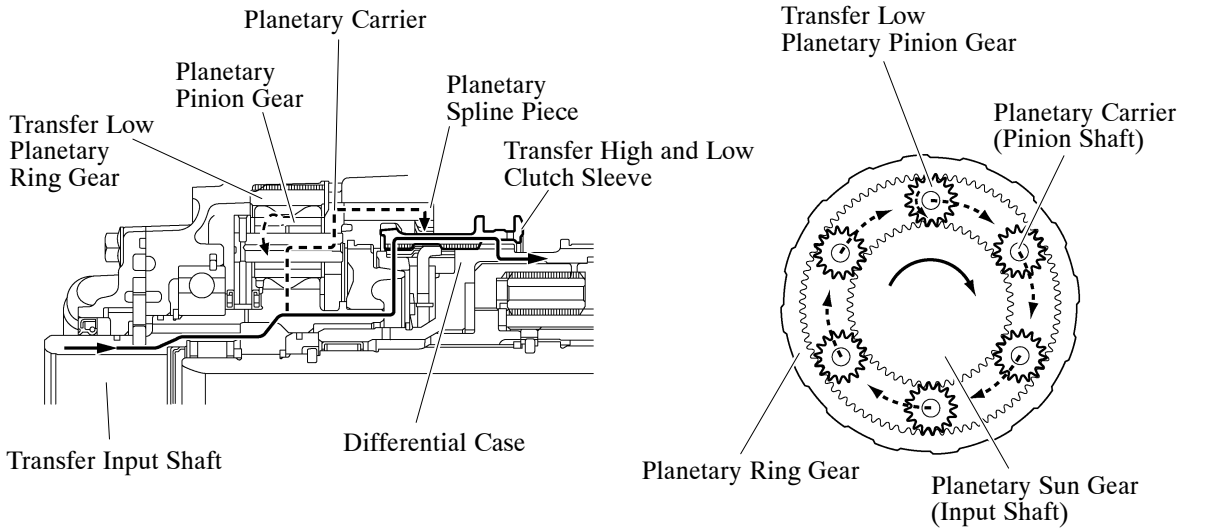
- The planetary sun gear is integrated with the transfer input shaft.
- 6 planetary pinion gears are fitted to the planetary carrier. Each pinion gear shaft is fixed to the planetary carrier. A planetary spline piece is fitted to the rear of the planetary carrier.
- The planetary ring gear is fixed to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



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H4 Position

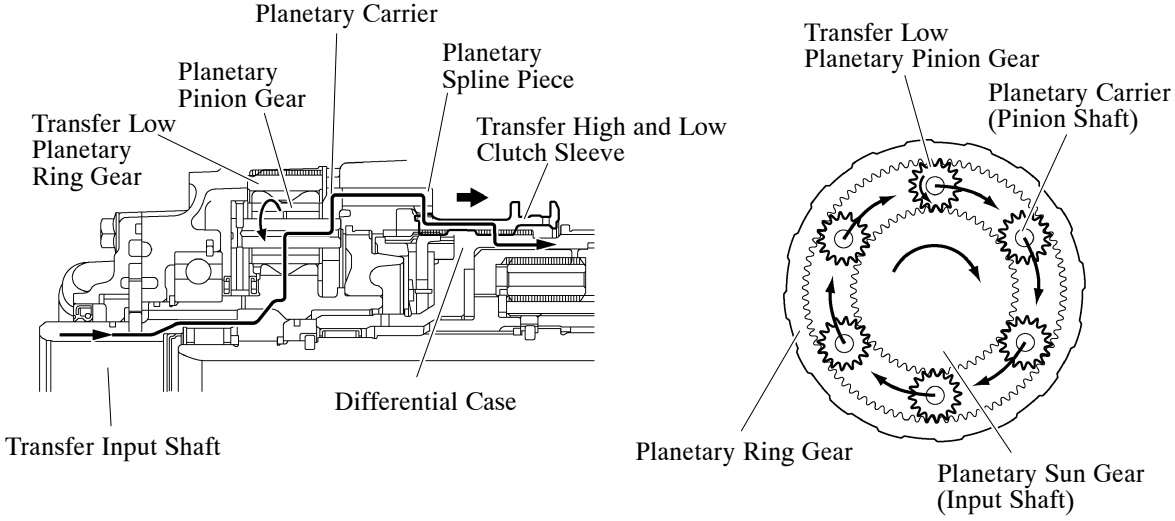
In the H (H4) position, the splines at the rear of the transfer input shaft mesh with the internal gear teeth of the high and low clutch sleeve.
Also, the transfer high and low clutch sleeve is meshed to the differential case. Thus, the rotation of the input shaft is transmitted to the transfer high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



080CH91Y

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 planetary sun gear, planetary pinion gear, planetary pinion gear shaft, planetary carrier, planetary spline piece, transfer high and low clutch sleeve, and differential case.



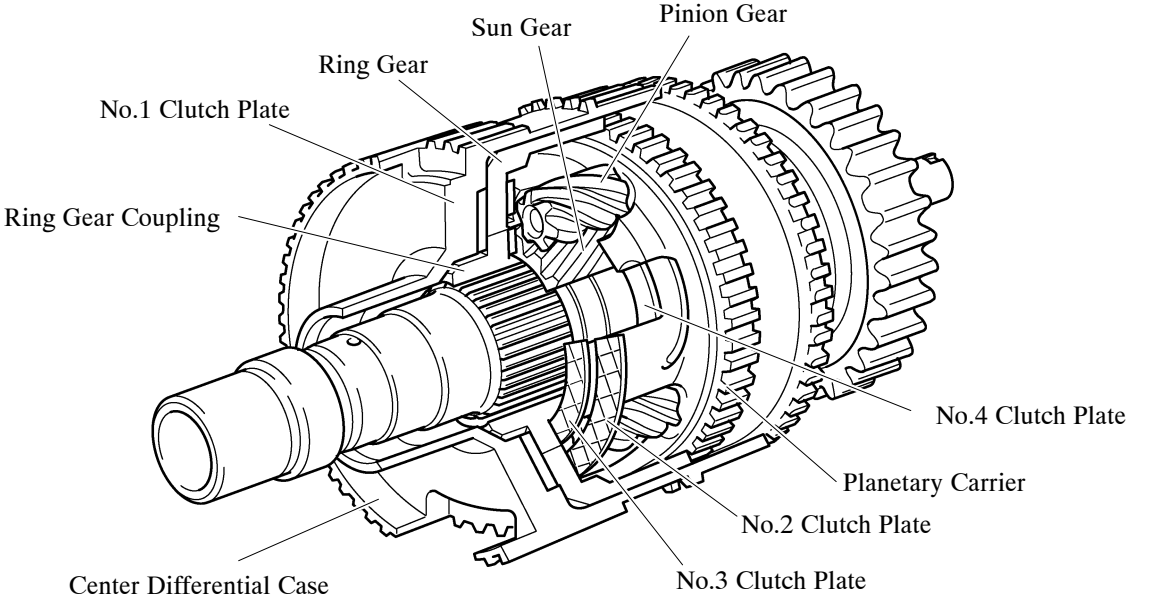
080CH92Y

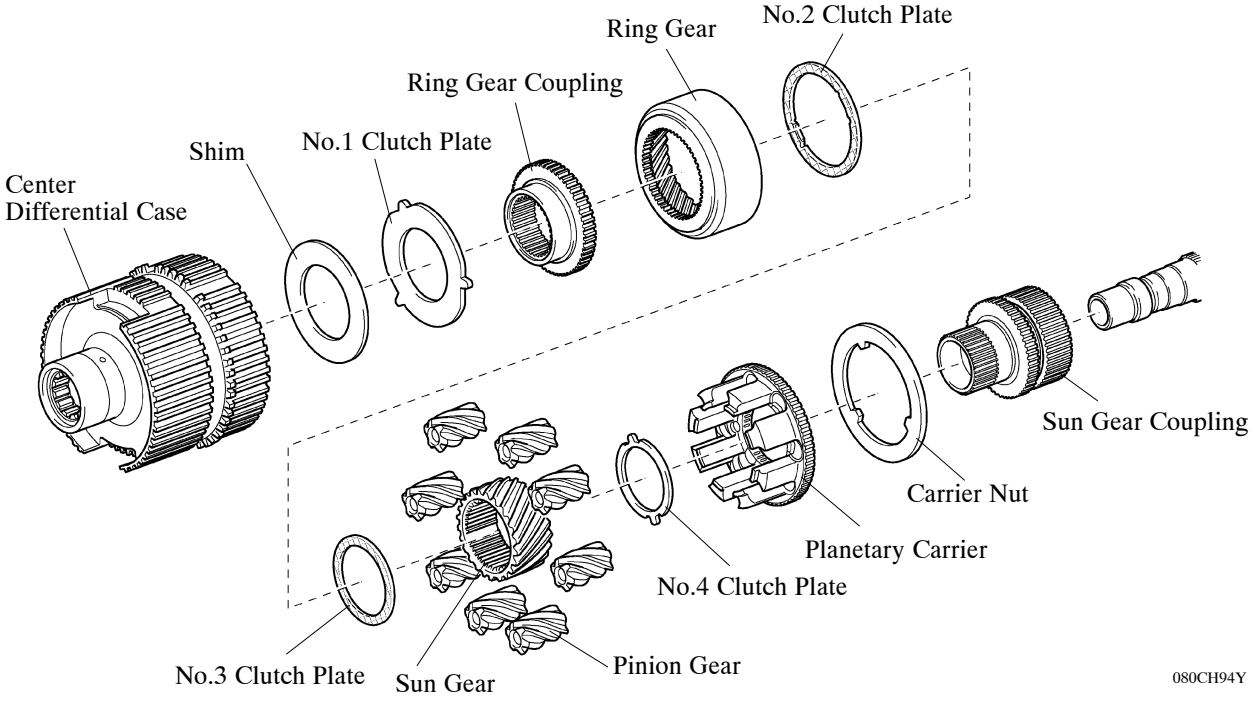
CH

3. Center Differential (TORSEN LSD)

General

- The center differential uses a TORSEN LSD (Limited Slip Differential).
- The TORSEN LSD is a 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 increases the rear wheels.
- This center differential consists of a center differential case, coupling, ring gear, 8 pinion gears, sun gear, and planetary carrier.



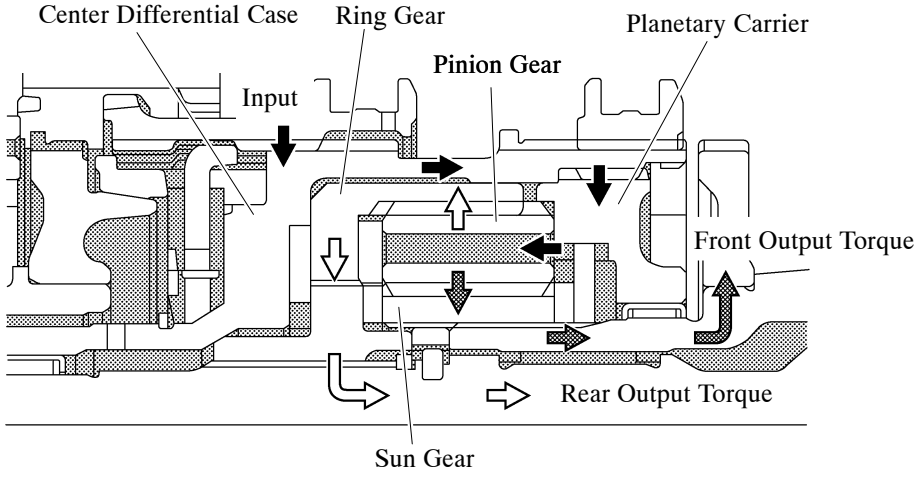


Service Tip

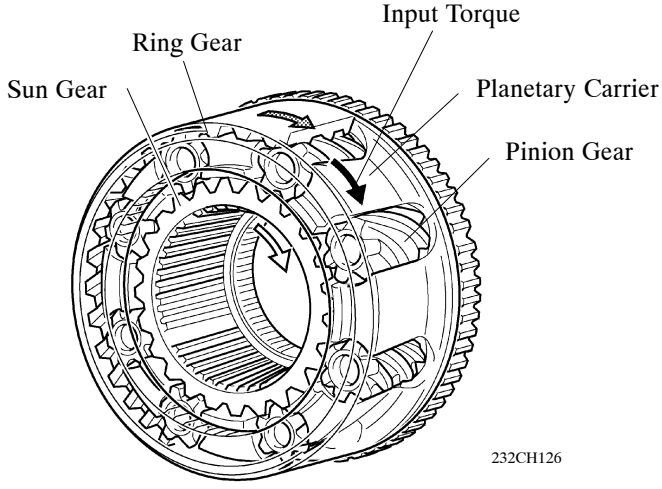
The TORSEN LSD cannot be disassembled, so it must be replaced as an assembly. For details, see the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

Normal Driving Operation

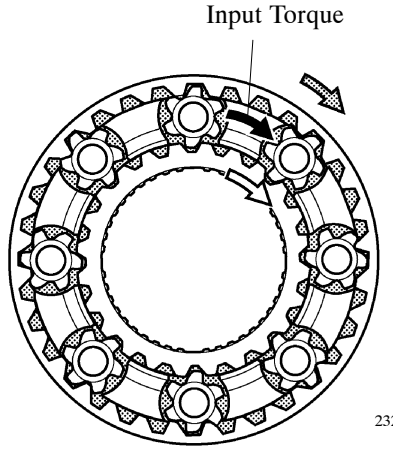
During normal driving (front wheel speed = rear wheel speed), the driving force that is input by the center differential case is transmitted (Front: 40/ Rear: 60) as shown below, without involving the LSD function.



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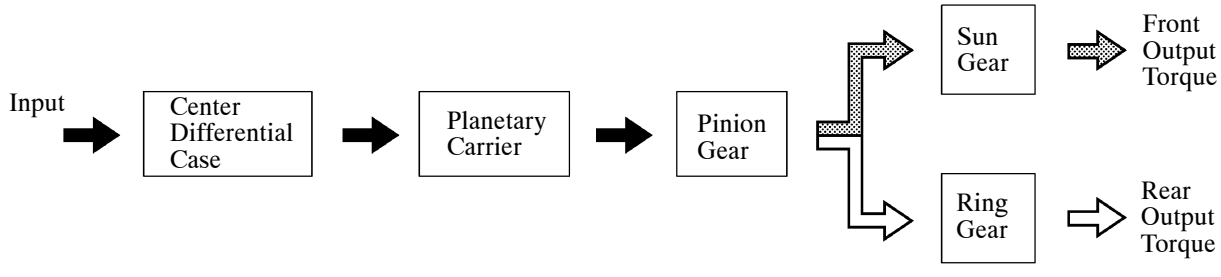


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▶ Torque Transmission Path ◀



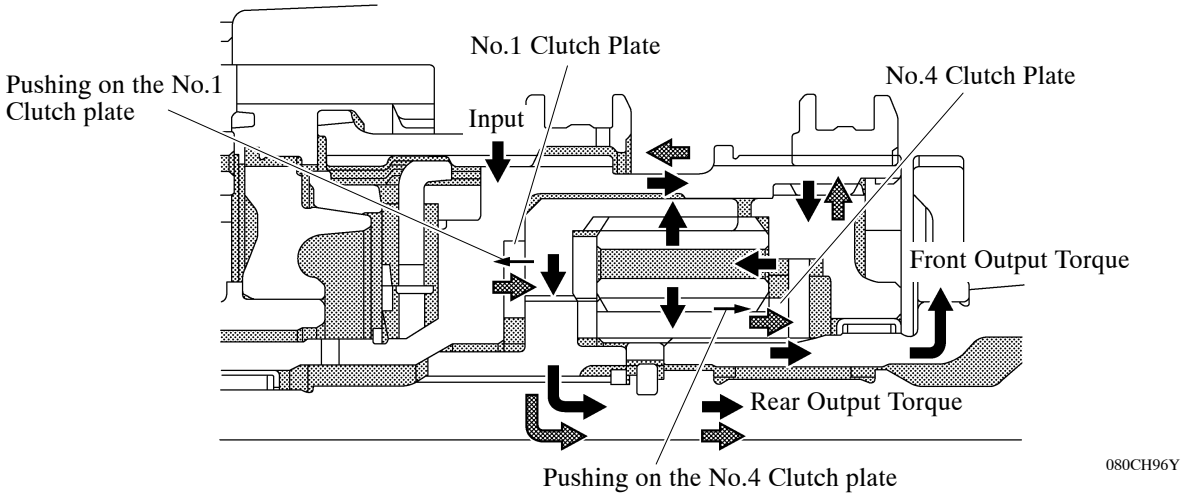
232CH60

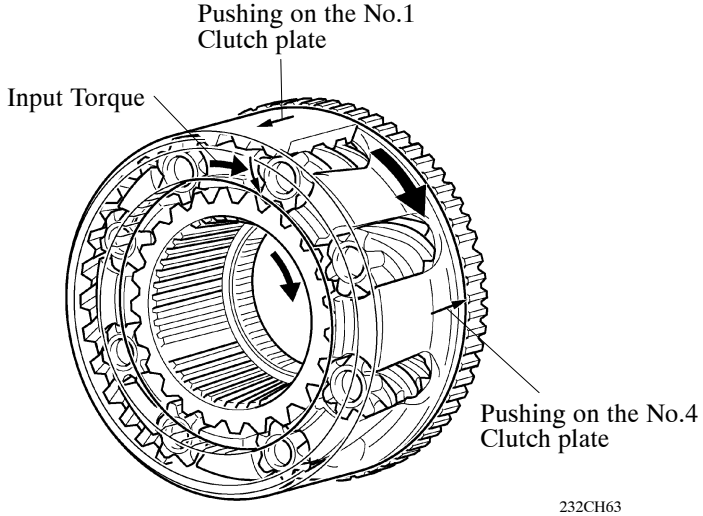
Front Wheel Skid Driving Operation

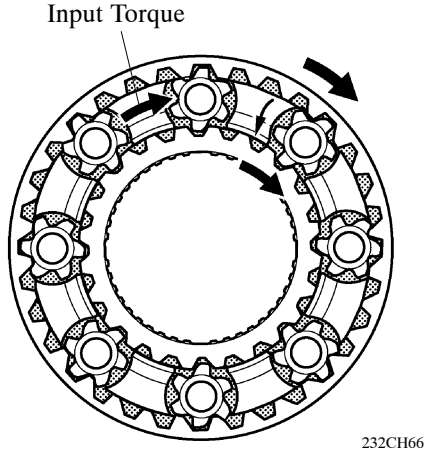
During front wheel skid driving (front wheel speed > rear wheel speed) when a rotational difference exists between the sun gear and the ring gear, the torque distribution of the driving force (torque) that is input by the differential case changes instantly before the torque is transmitted, as follows:

- 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 center differential case via the No.1. clutch plate.
- The ring gear outputs torque while pushing on the No.1. clutch plate.

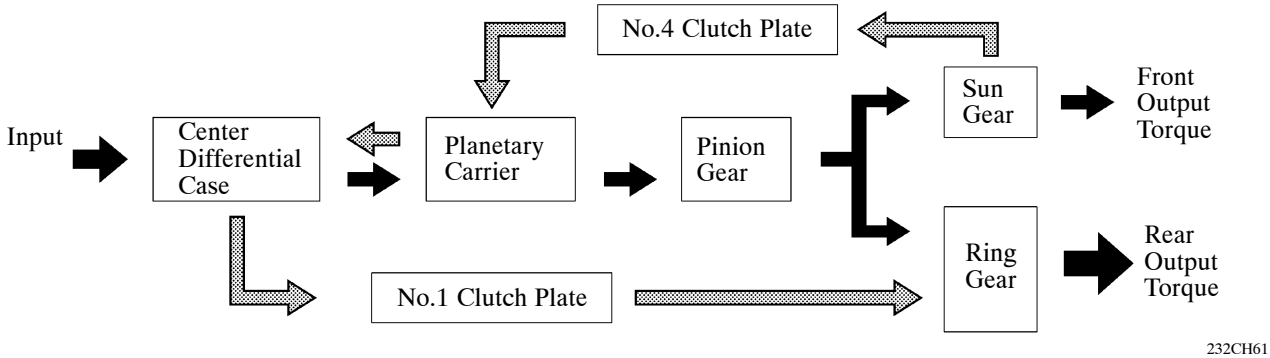
These LSD functions change the torque distribution.







▶ Torque Transmission Path ◀

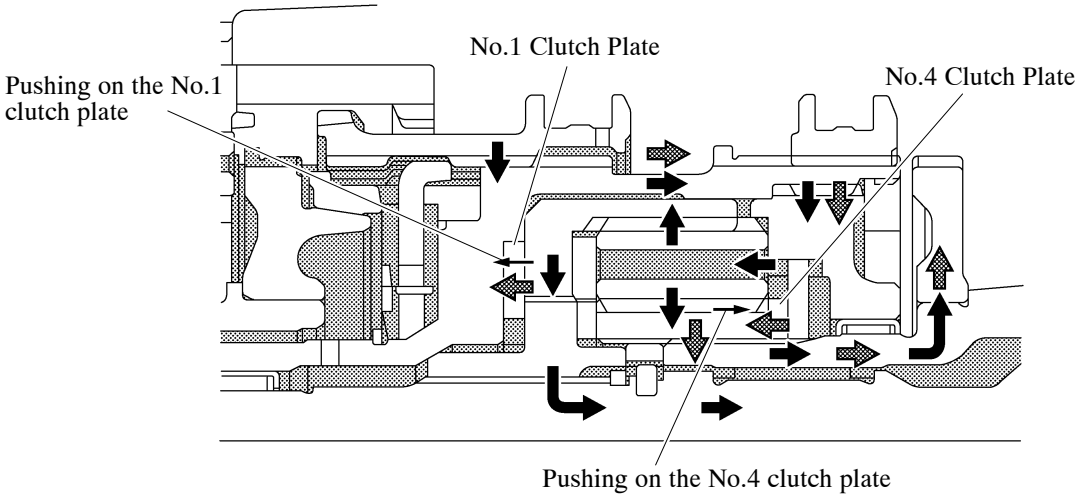


Rear Wheel Skid Driving Operation

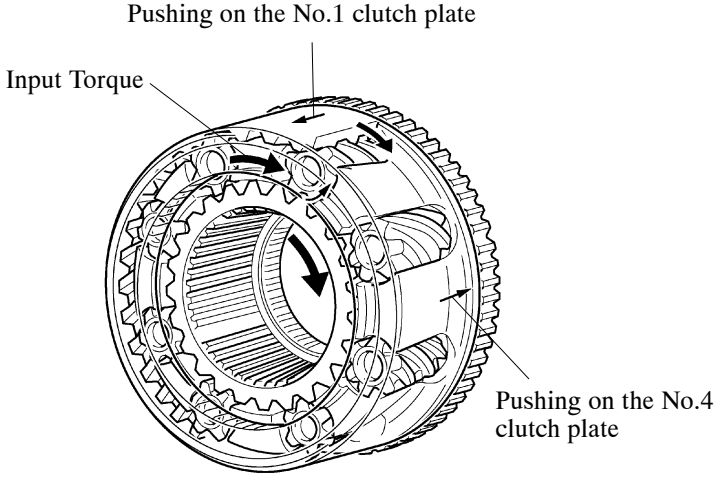
During rear wheel skid driving (front wheel speed < rear wheel speed), when a rotational difference exists between the sun gear and the ring gear, the torque distribution of the driving force (torque) that is input by the differential case changes instantly before the torque is transmitted, as follows:

- The ring gear transmits torque to the center 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.

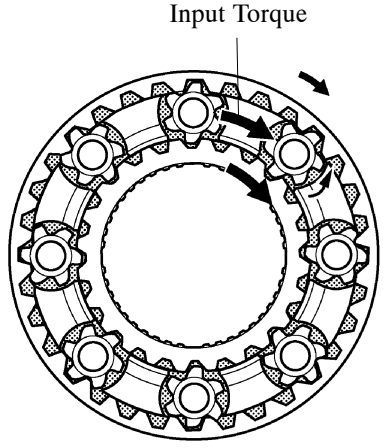
These LSD functions change the torque distribution.



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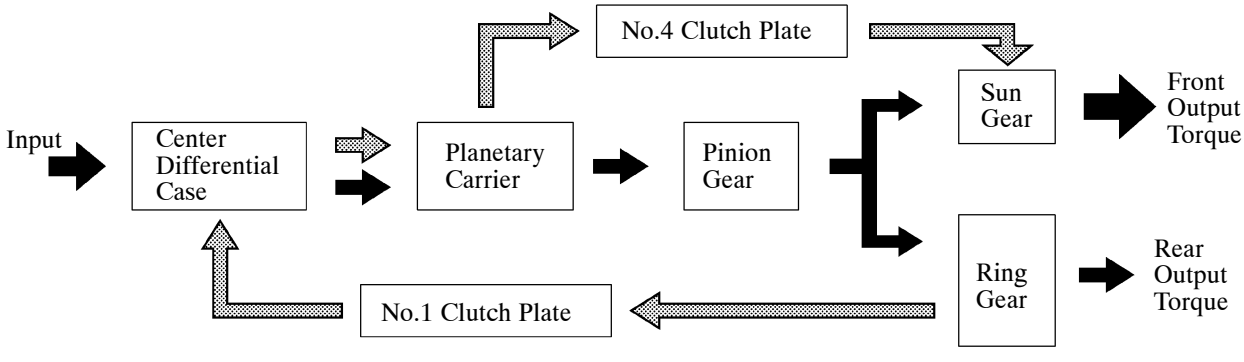


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▶ Torque Transmission Path ◀



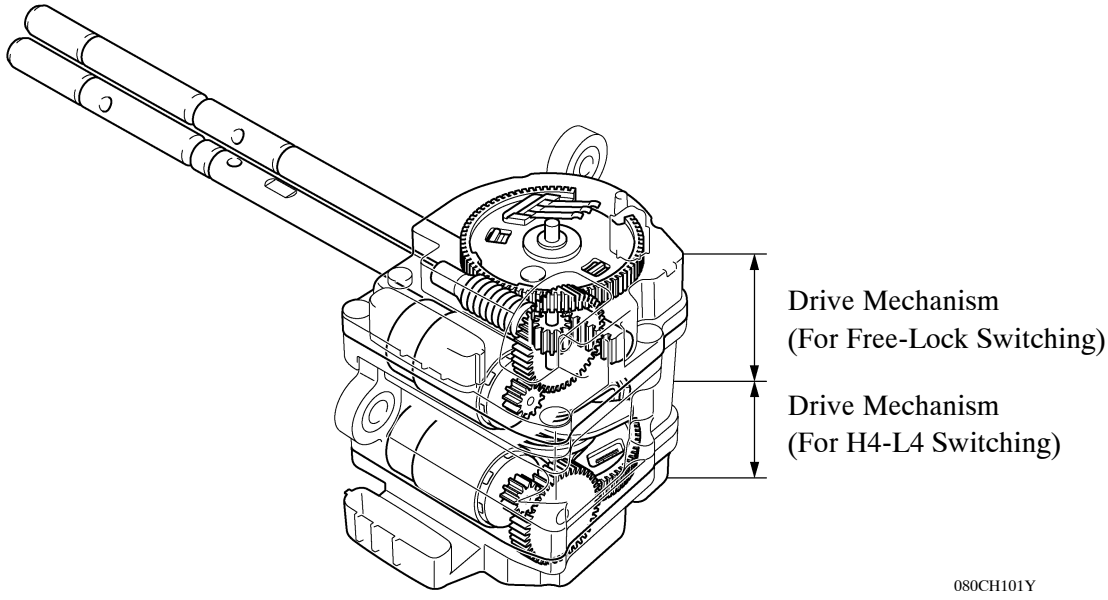
232CH64

4. Transfer Shift Actuator

General

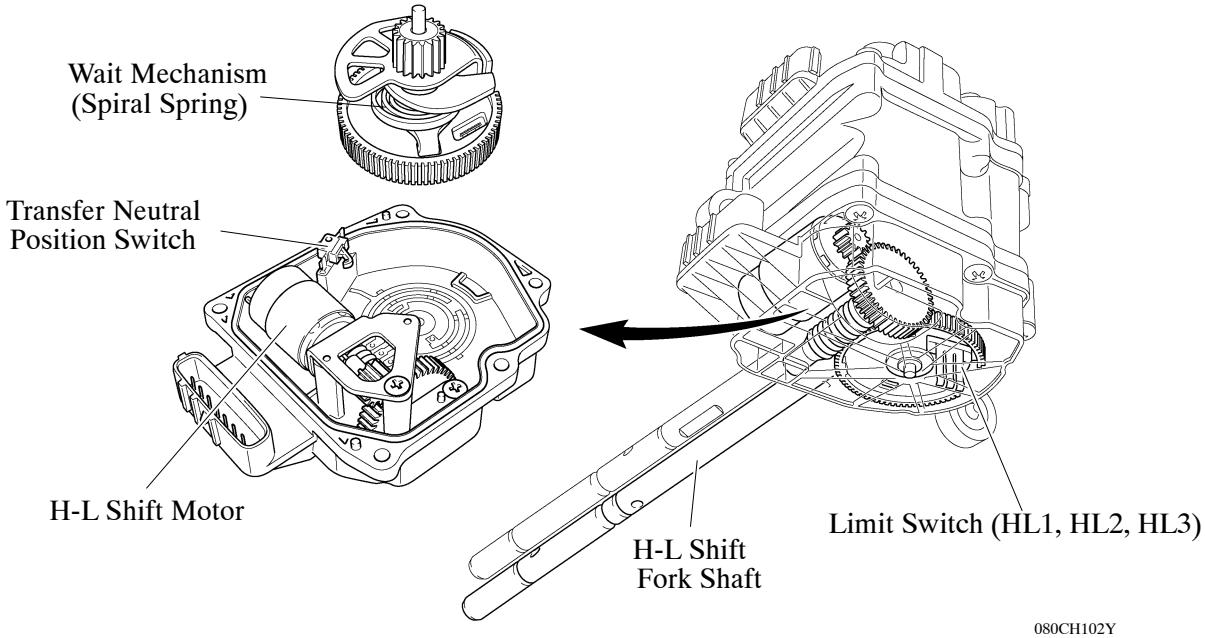
The transfer shift actuator assembly consists of the following two mechanisms.

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



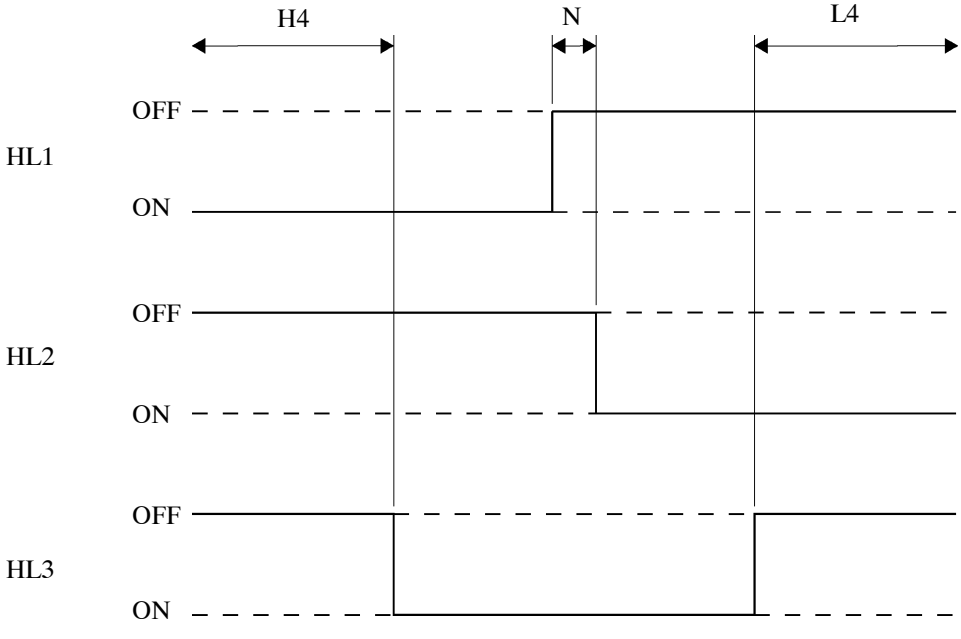
Drive Mechanism for H4-L4 Switching

- The drive mechanism for H4-L4 switching consists a H-L shift motor, limit switch, transfer neutral position switch, wait mechanism (spiral spring), and 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 shift fork shaft operations. If the operating resistance of the shift fork shaft is high, the shift rotation is partially stored in the spiral spring. Afterward, when the operating resistance is reduced, the spring force causes the shift fork to slide.



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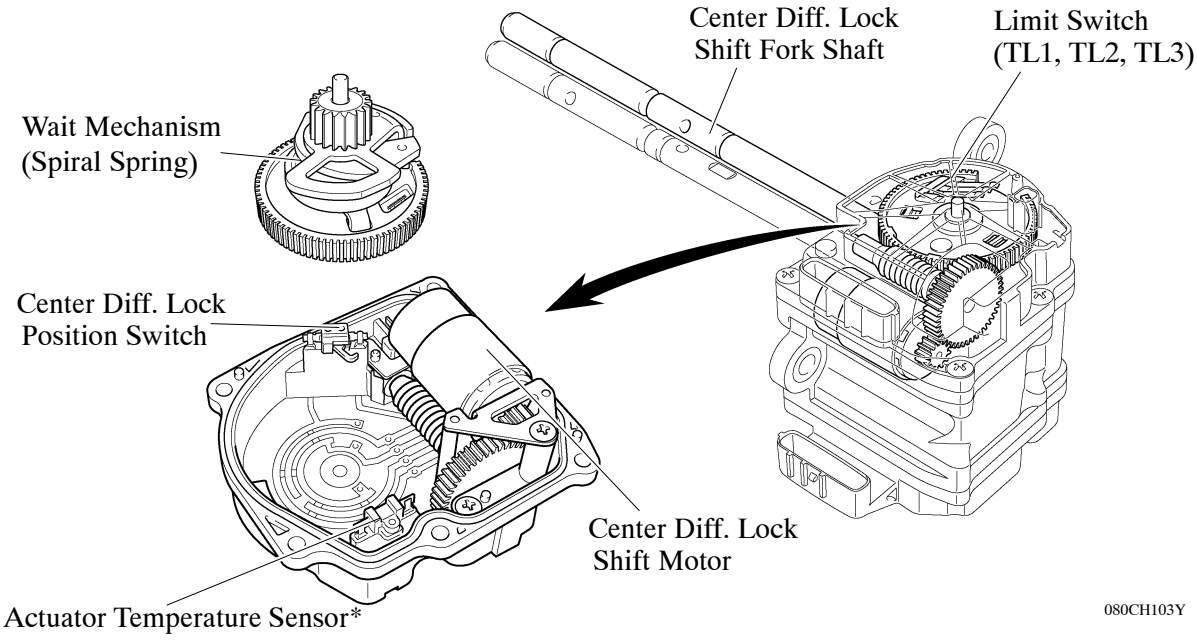
▶ Combination of 3 Contact Point Switches ◀



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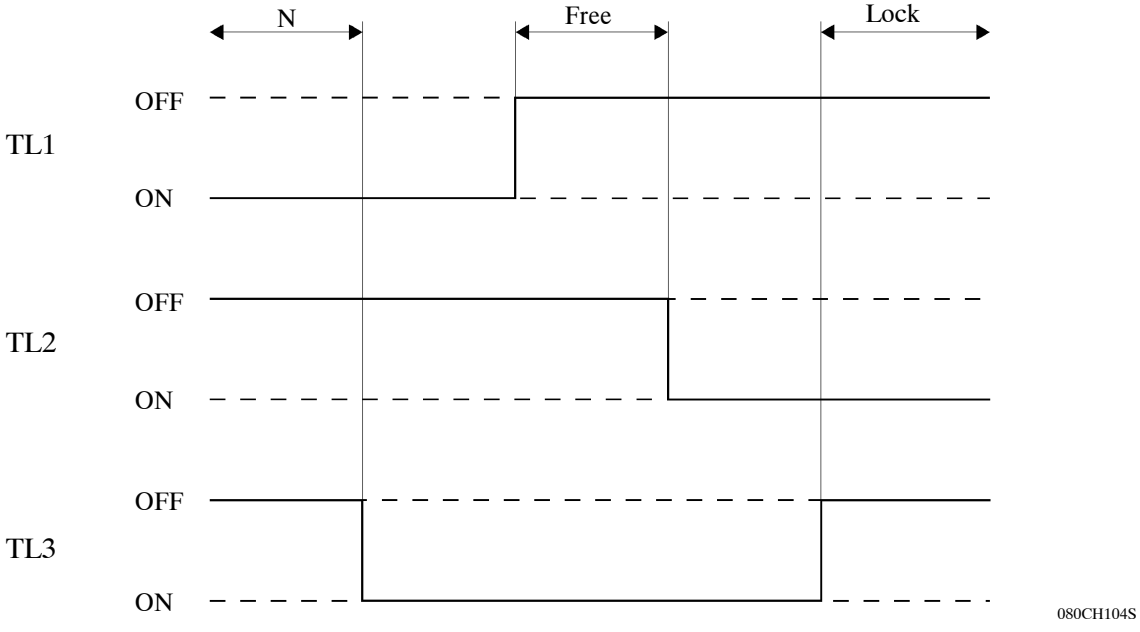
Drive Mechanism for Free-Lock Switching

- The drive mechanism for free-lock switching consists of a center differential lock shift motor, limit switch, center differential lock position switch, wait mechanism (spiral spring), center differential lock shift fork shaft, and 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 shift fork shaft operations. If the operating resistance of the shift fork shaft is high, the shift rotation is partially stored in the spiral spring. Afterward, when the operating resistance is reduced, the spring force causes the shift fork to slide.
- 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 on European models for the Russian package.

▶ Combination of 3 Contact Point Switches ◀

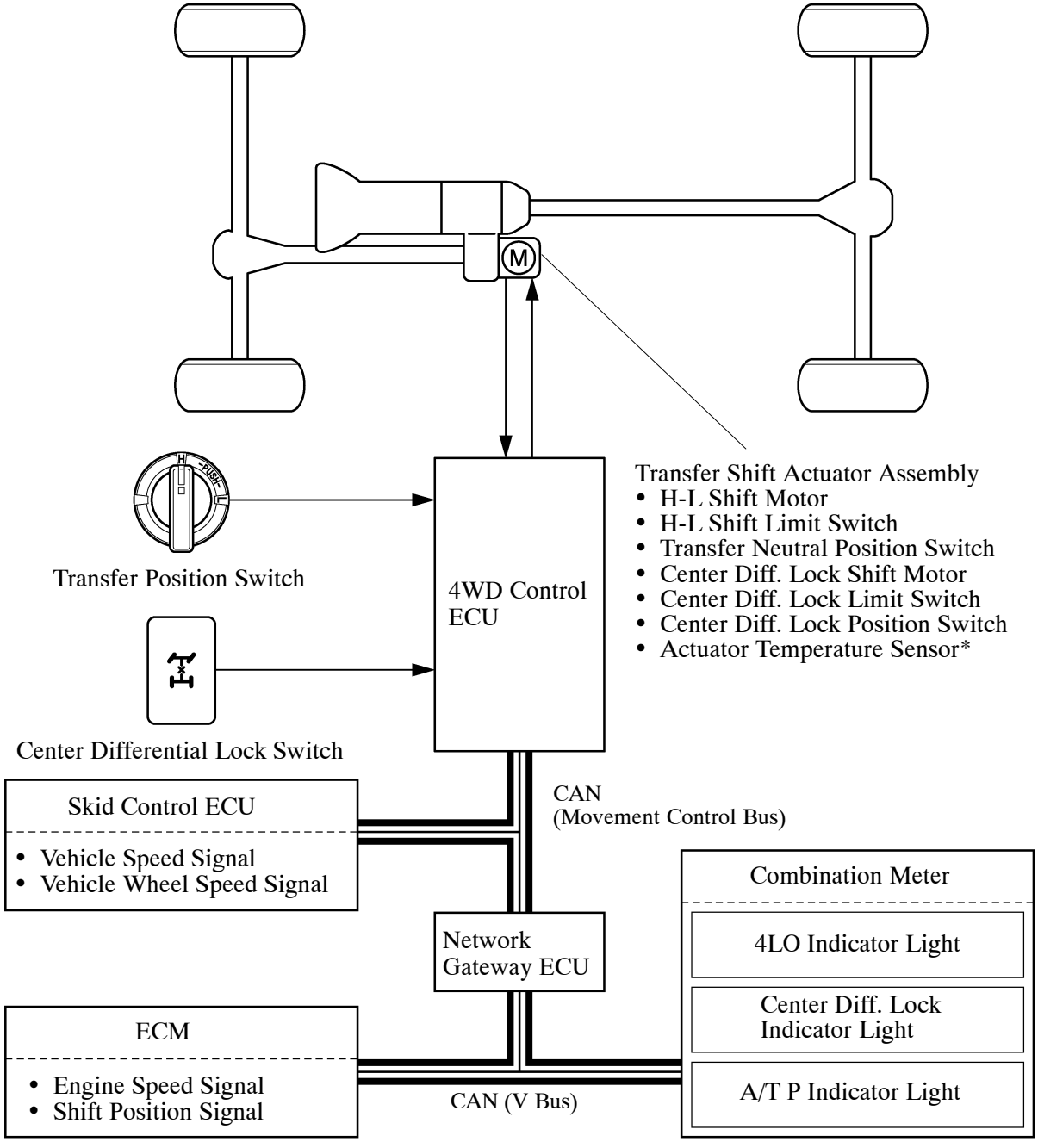


■4WD SYSTEM

1. General

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

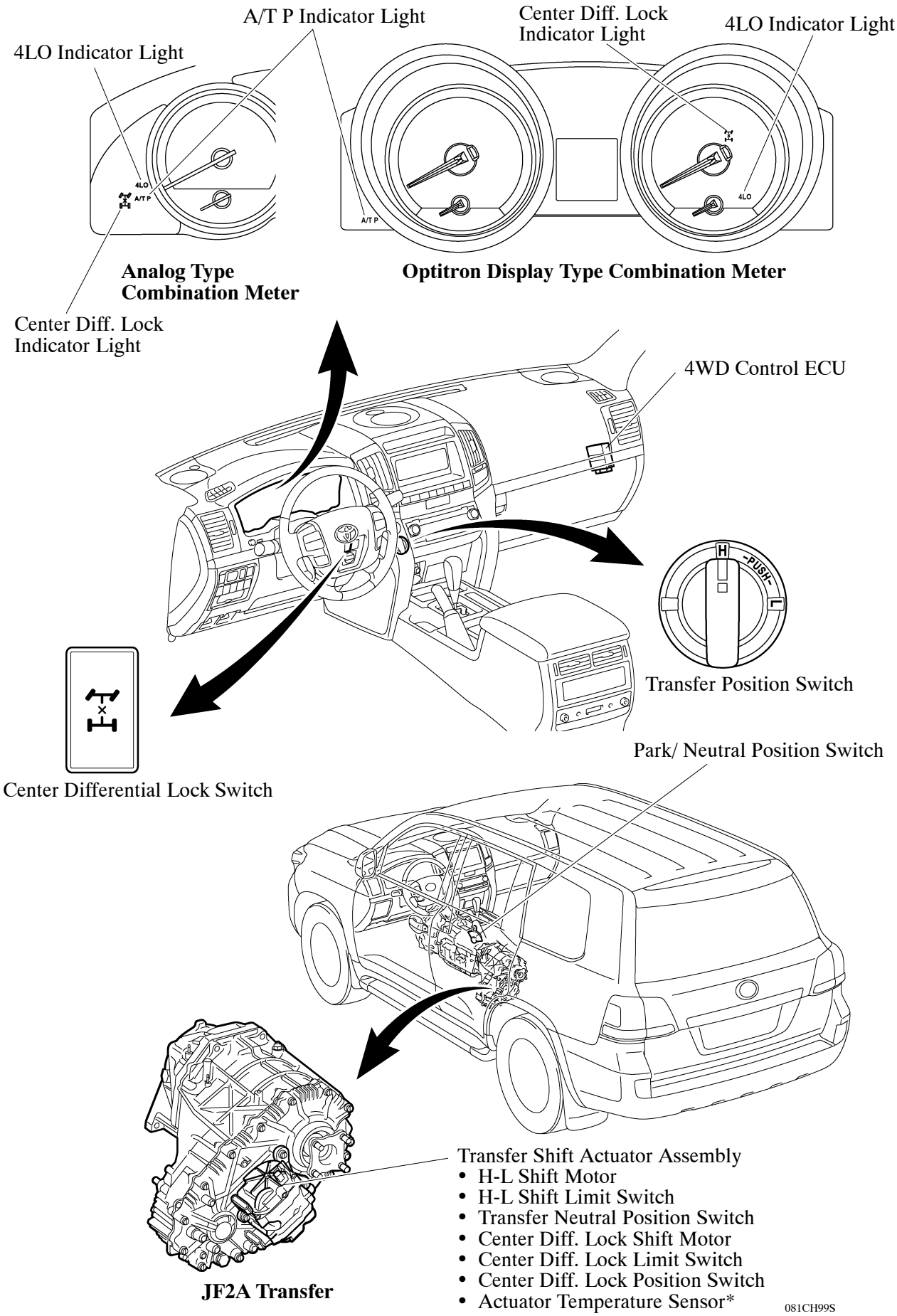
▶ System Diagram ◀



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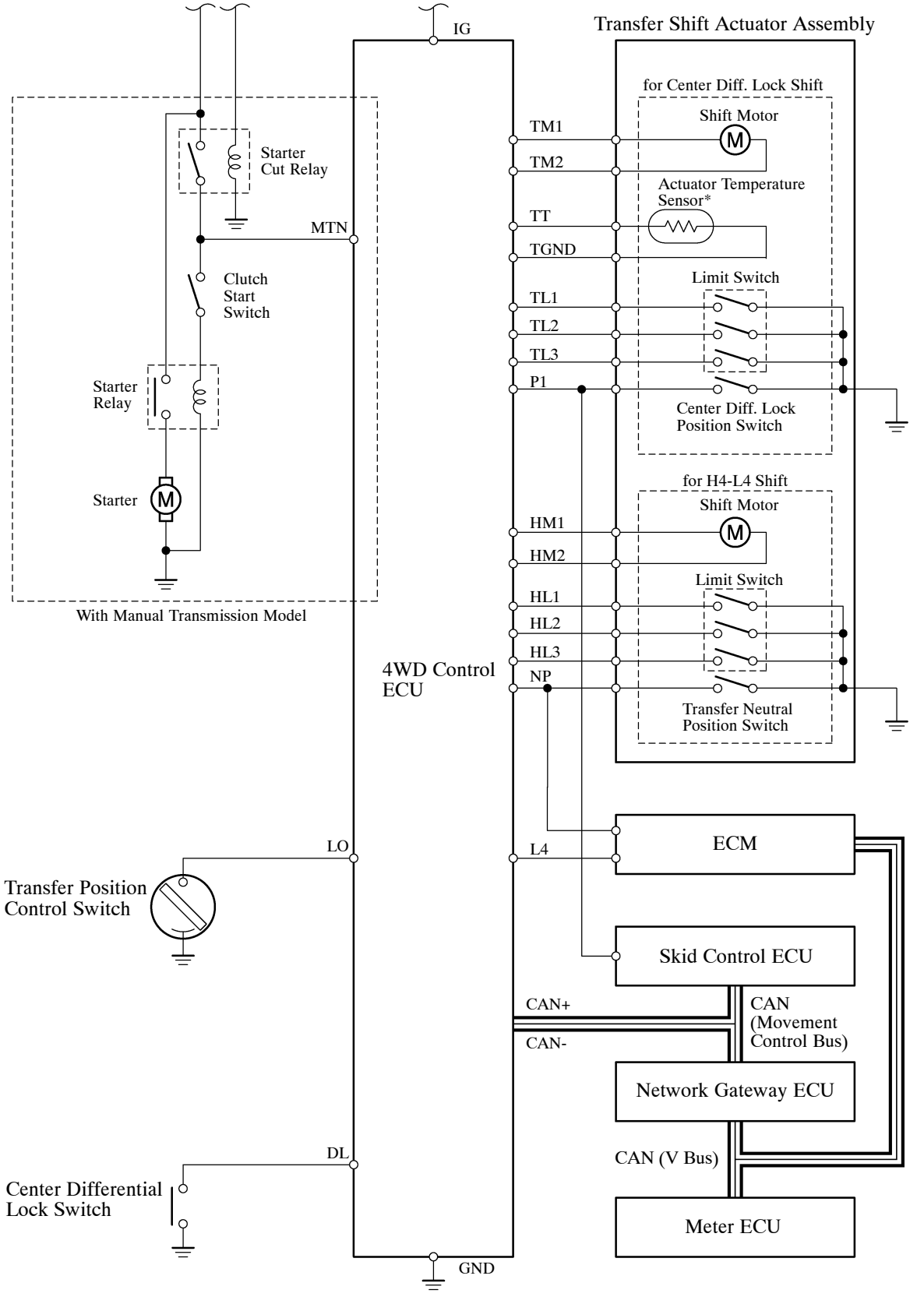
*: Only on European models for the Russian package.

2. Layout of Main Components



*: Only on European models for the Russian package.

3. Wiring Diagram



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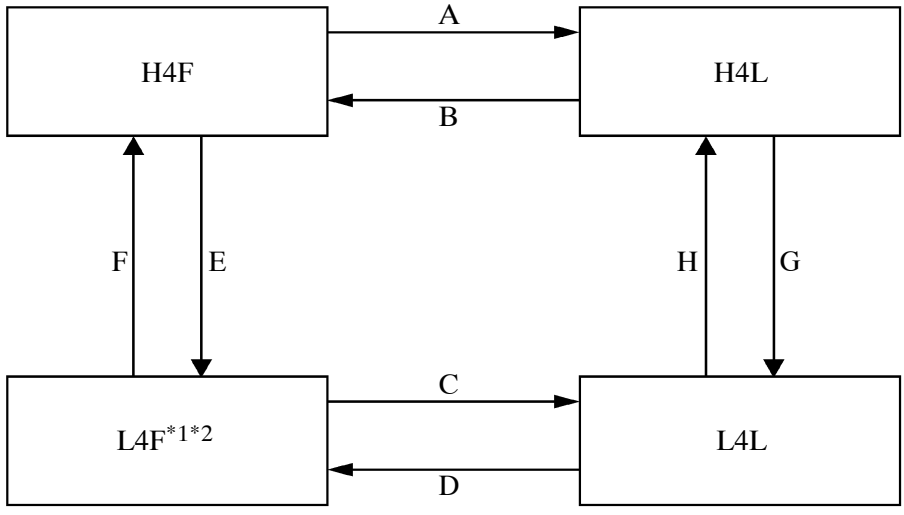
*: Only on European models for the Russian package.

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 100km/h (62mph), 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*.
  *: For models equipped with the manual transmission, when the vehicle is stationary and the clutch pedal is being depressed.

▶ 4WD Mode Switching Pattern ◀



080CH35S

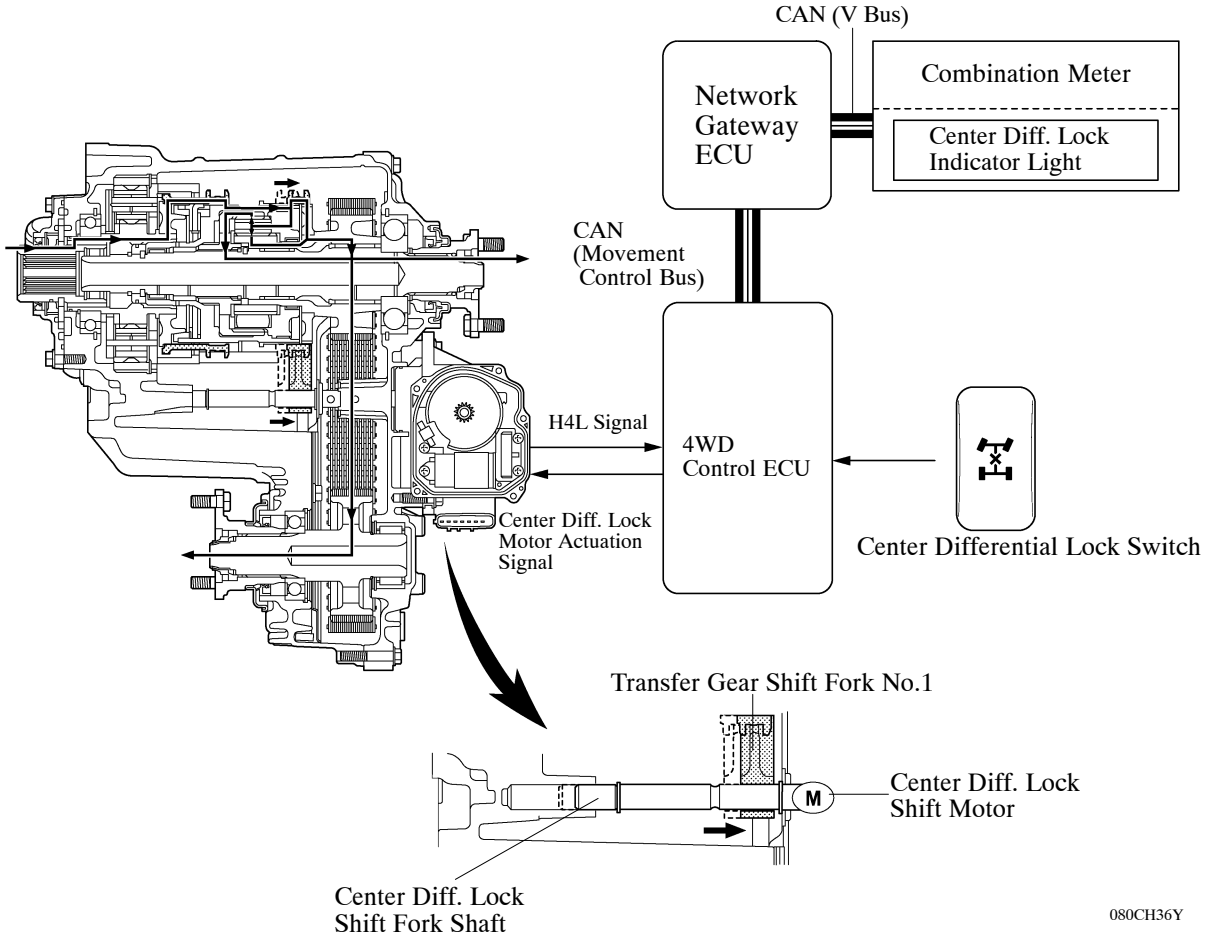
H4F: High Speed 4WD & Center Differential Free
H4L: High Speed 4WD & Center Differential Lock
L4F: Low Speed 4WD & Center Differential Free
L4L: Low Speed 4WD & Center Differential Lock

*1: For models without A-TRC, L4F is not available even when the transfer gear is switched from H to L in H4F mode. The mode changes from H4F to H4L, then to L4L. In addition, the center differential locks.

*2: For models without A-TRC, L4F is not available even when the center differential is switched from free to lock in L4L mode. The operation will be canceled.

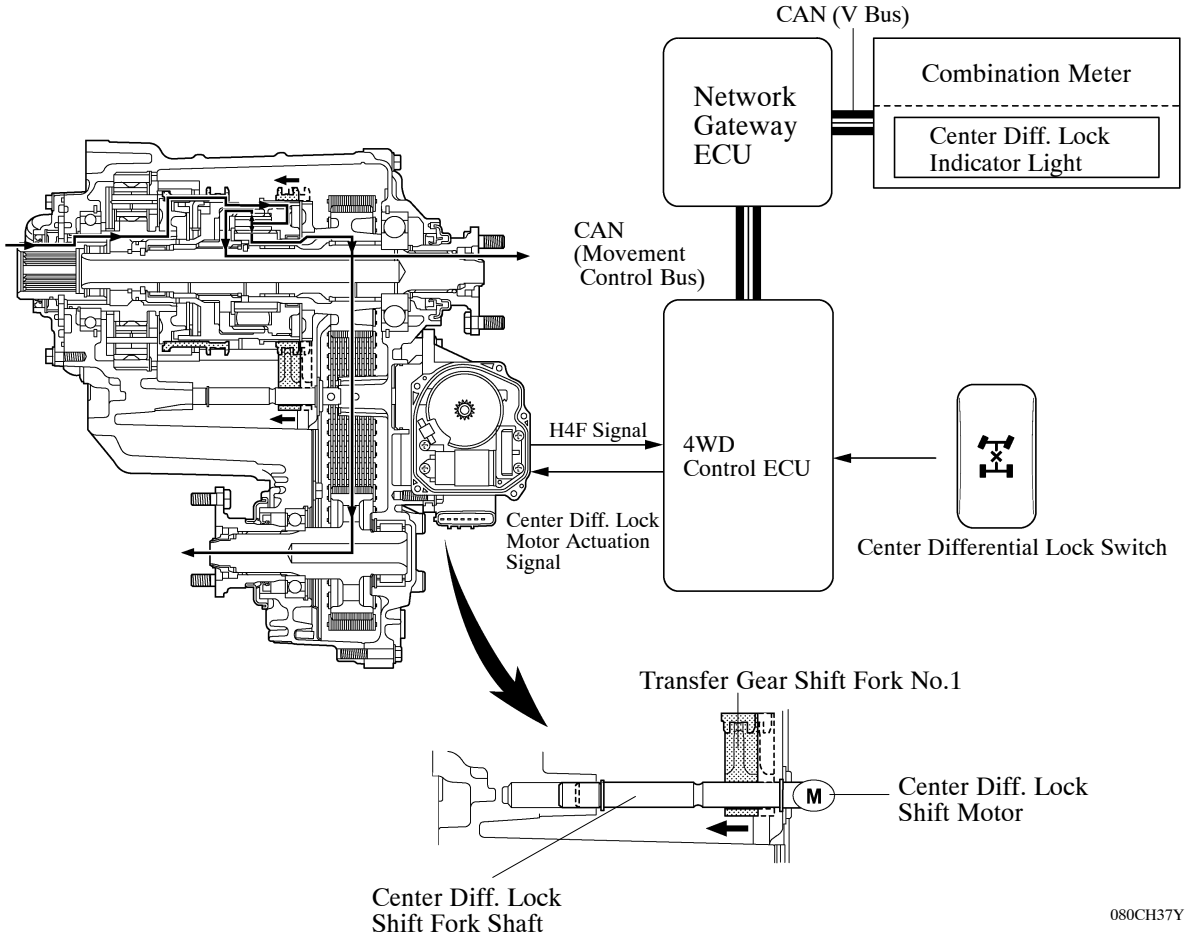
Switching Pattern : A (H4F → H4L)

- 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 right. Simultaneously, the shift fork moves right together with the fork shaft. As a result, the center differential lock sleeve engages the differential case and the drive sprocket hub, 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.



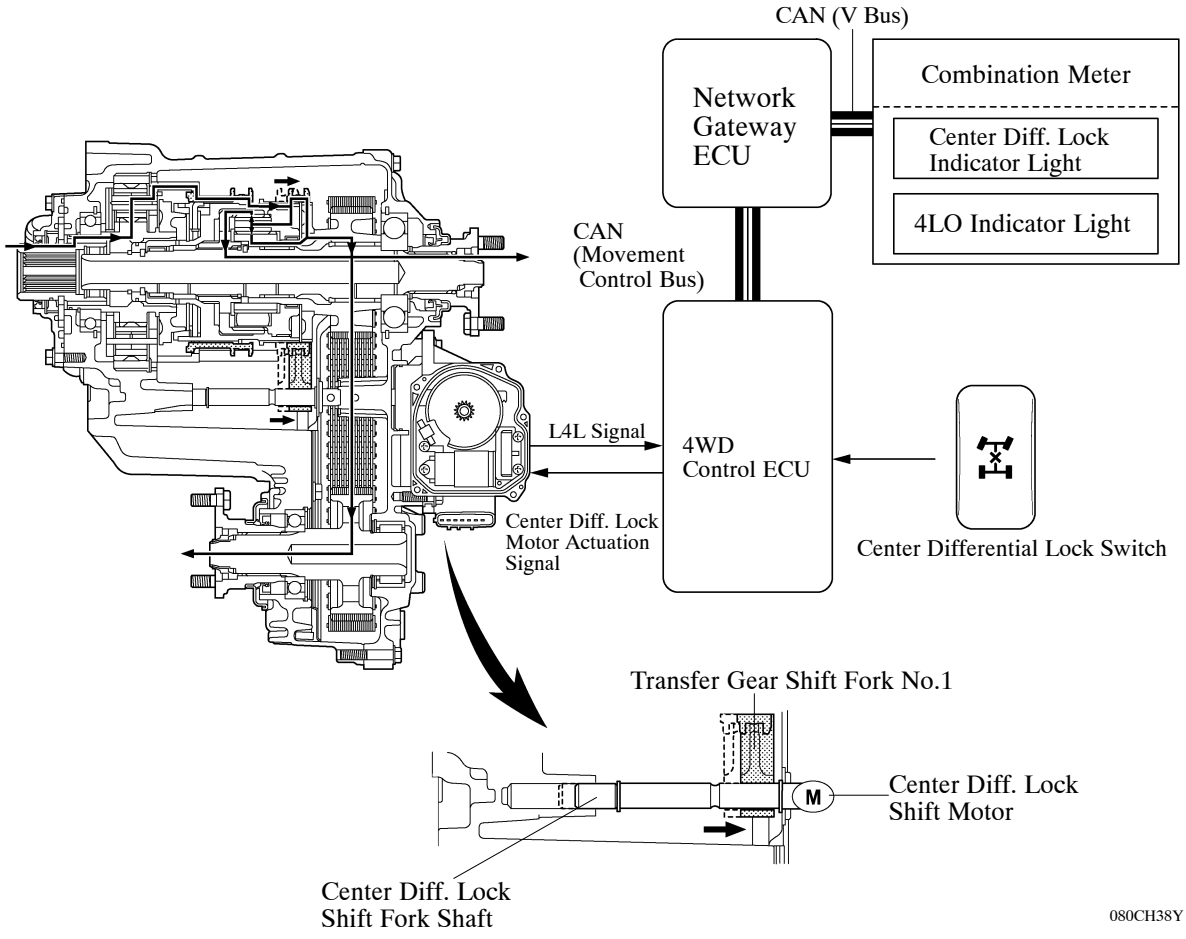
Switching Pattern : B (H4L → H4F)

- 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 left. Simultaneously, the shift fork moves left together with the fork shaft. As a result, the center differential lock sleeve disengages the differential case and the drive sprocket hub, 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.



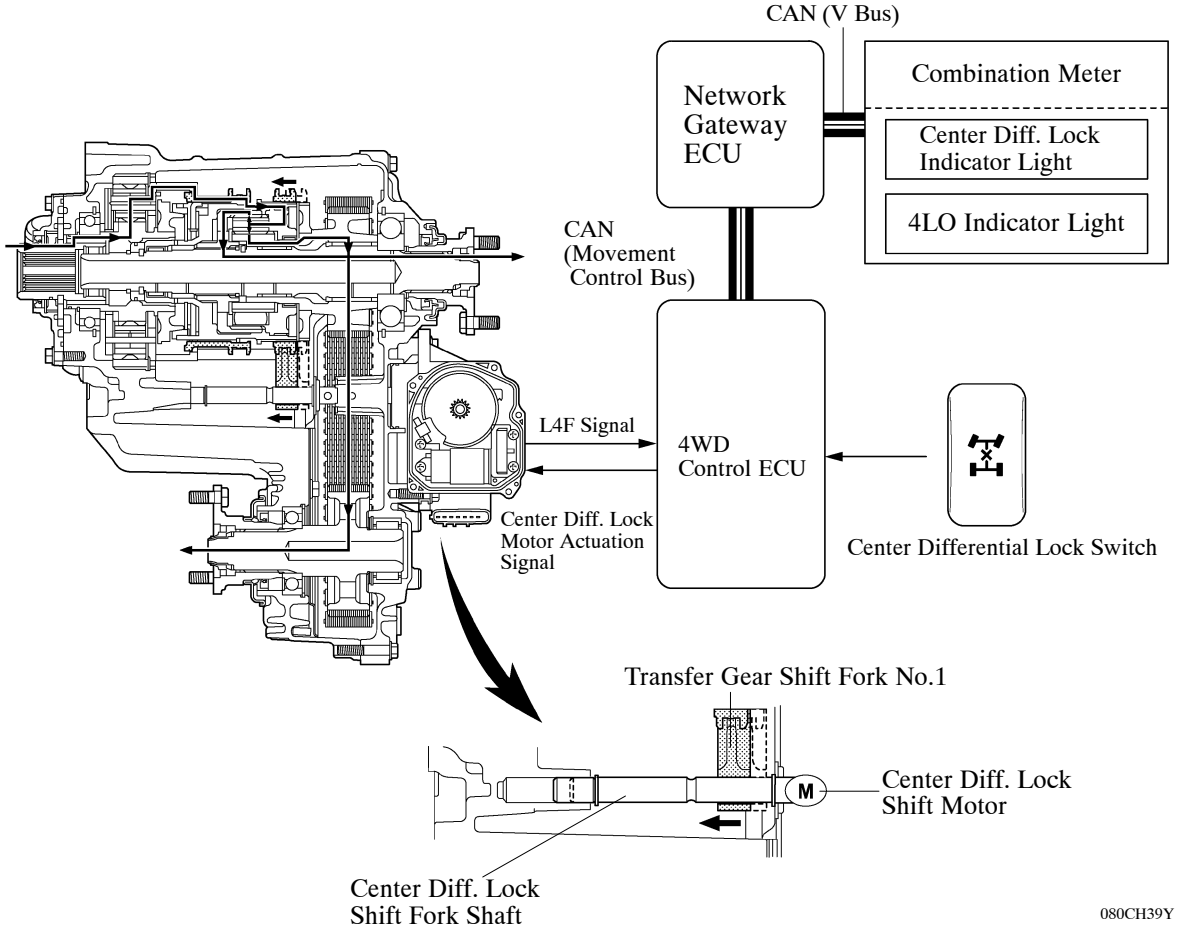
Switching Pattern : C (L4F → L4L)

- In L4F mode, when the center differential lock switch is turned on, the 4WD control ECU actuates the center differential shift motor to move the center differential lock shift fork shaft right. Simultaneously, the shift fork moves right together with the fork shaft. As a result, the center differential lock sleeve engages the center differential case and the drive sprocket hub, 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.



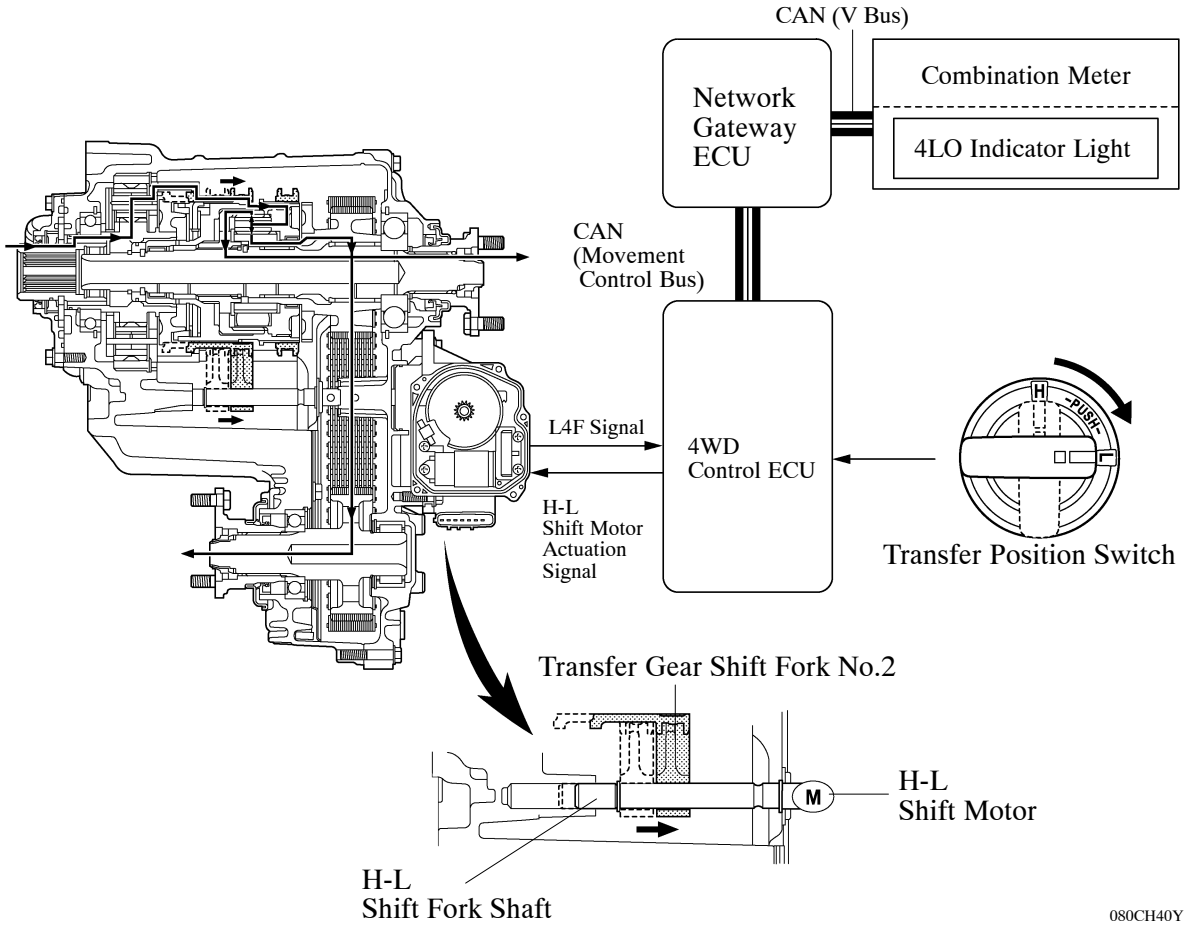
Switching Pattern : D (L4L → L4F)

- 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 left. Simultaneously, the shift fork moves left together with the fork shaft. As a result, the center differential lock sleeve disengages the differential case and the drive sprocket hub, 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)

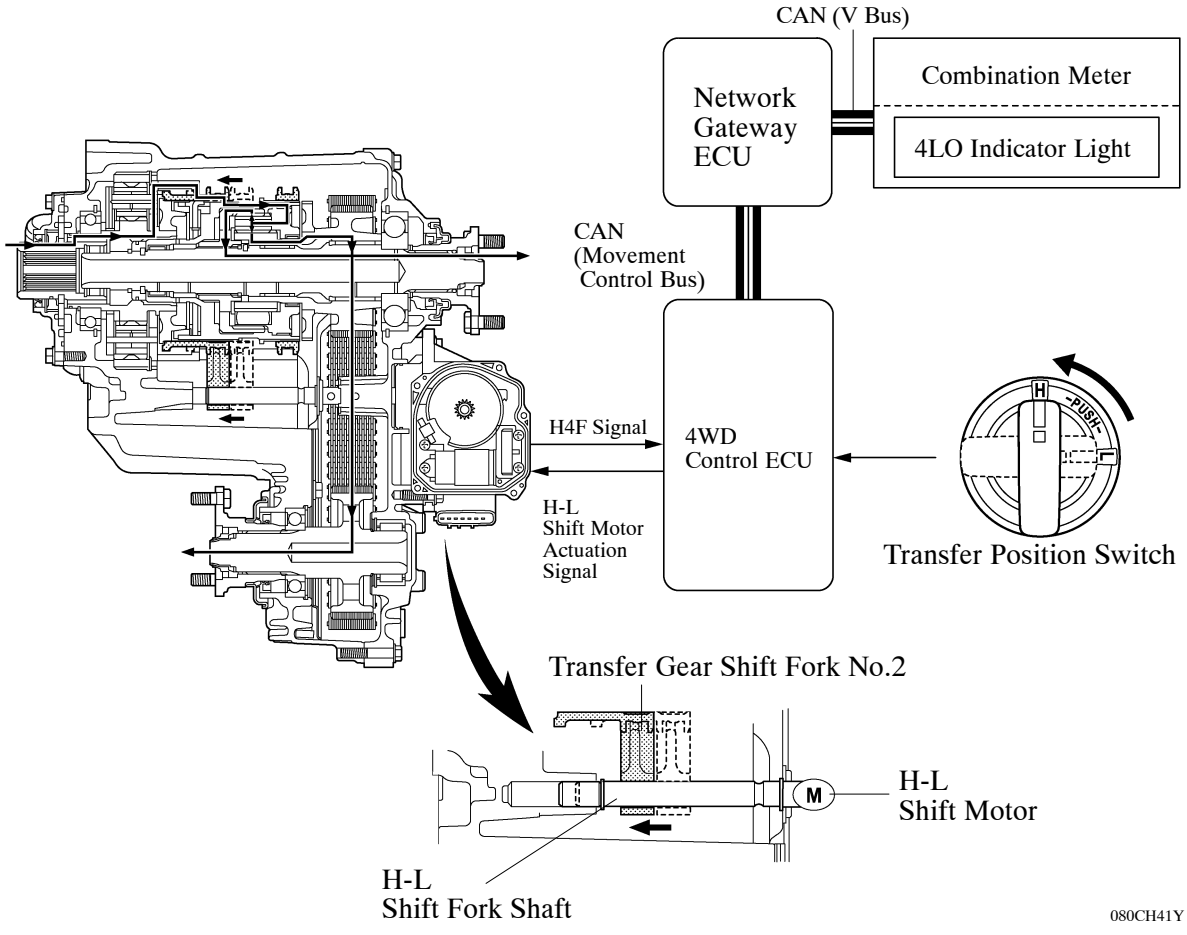
- In H4F mode, when the transfer position switch is turned to the 4L position, the 4WD control ECU actuates the H-L shift motor to move the H-L shift fork shaft right. Simultaneously, the shift fork moves right together with fork shaft. As a result, the high and low clutch sleeve of the planetary gear 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 the transfer to the L4F mode has been completed.



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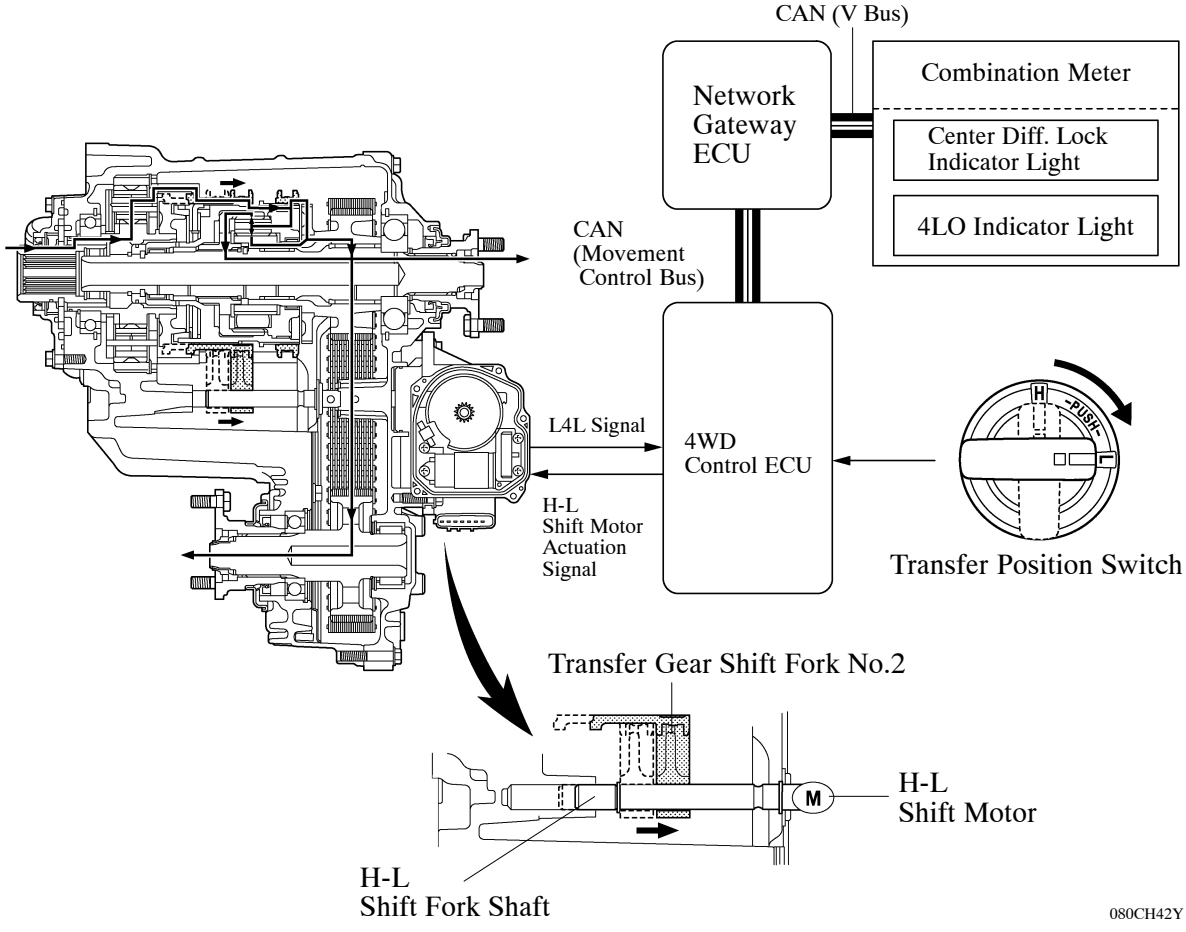
Switching Pattern : F (L4F → H4F)

- In L4F mode, when the transfer position switch is turned to the 4H position, the 4WD control ECU actuates the H-L shift motor to move the H-L shift fork shaft left. Simultaneously, shift fork moves left together with the fork shaft. As a result, the high and low clutch sleeve of the planetary gear unit engages with the 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 the transfer to the H4F mode has been completed.



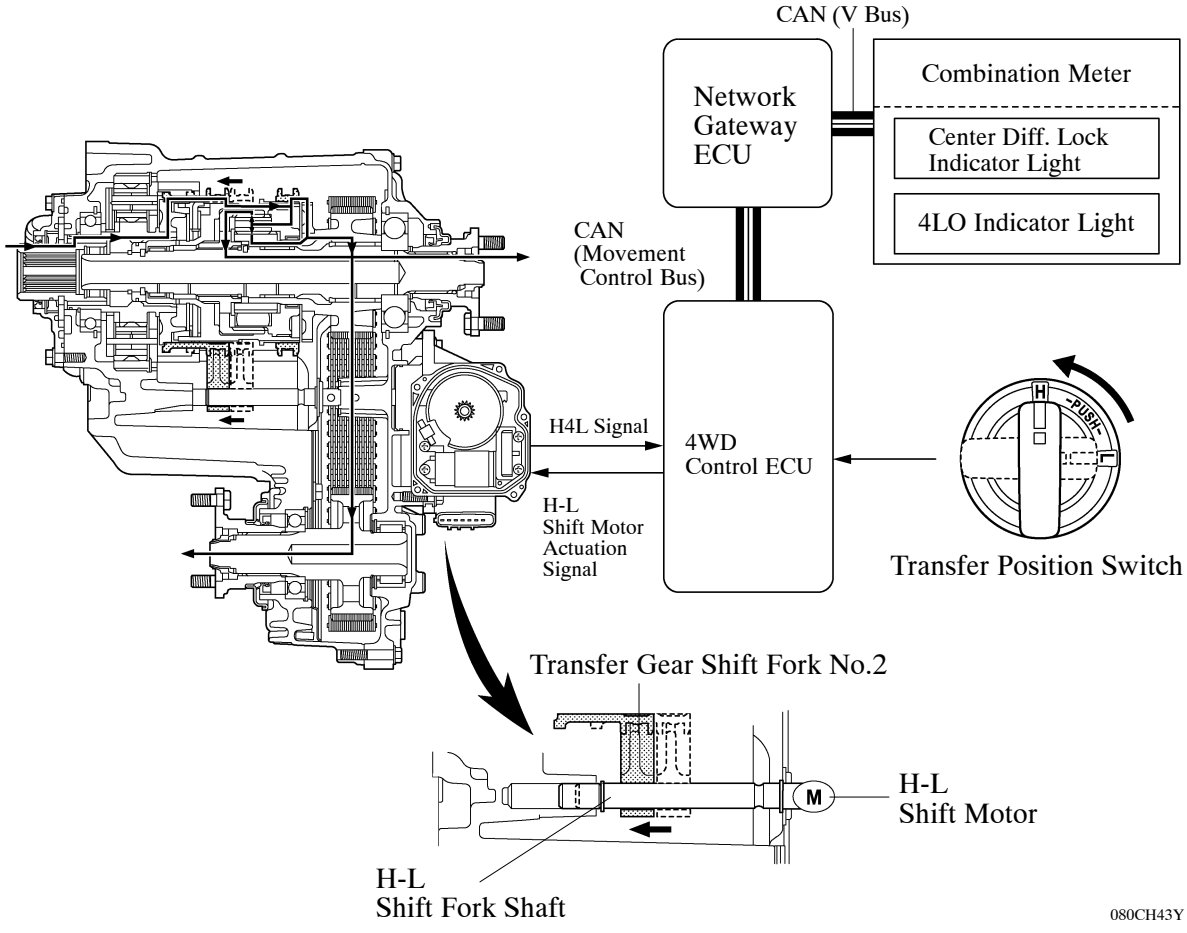
Switching Pattern : G (H4L → L4L)

- In H4L mode, when the transfer position switch is turned to the 4L position, the 4WD control ECU actuates the H-L shift motor to move the H-L shift fork shaft right. Simultaneously, the shift fork moves right together with the fork shaft. 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 the transfer to the L4L mode has been completed.



Switching Pattern : H (L4L → H4L)

- In L4L mode, the transfer position switch is turned to the 4H position, the 4WD control ECU actuates the H-L shift motor to move the H-L shift fork shaft left. Simultaneously, the shift fork moves left together with the fork shaft. As a result, the high and low clutch sleeve of the planetary gear unit engages with the 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 the transfer to the H4L mode has been completed.

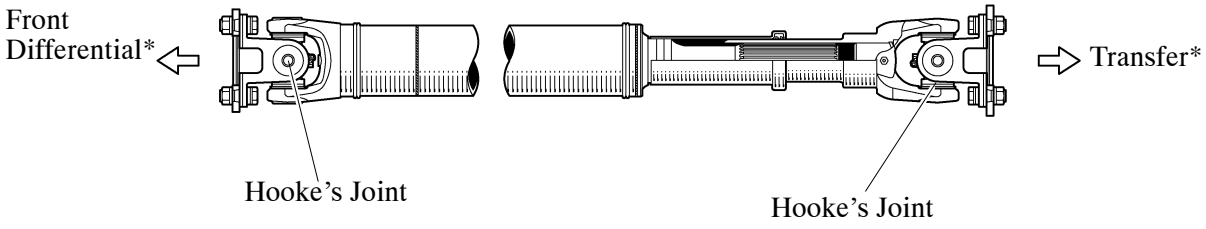


PROPELLER SHAFT

■ DESCRIPTION

2-joint type shafts are used for the front and rear propeller shaft assemblies.

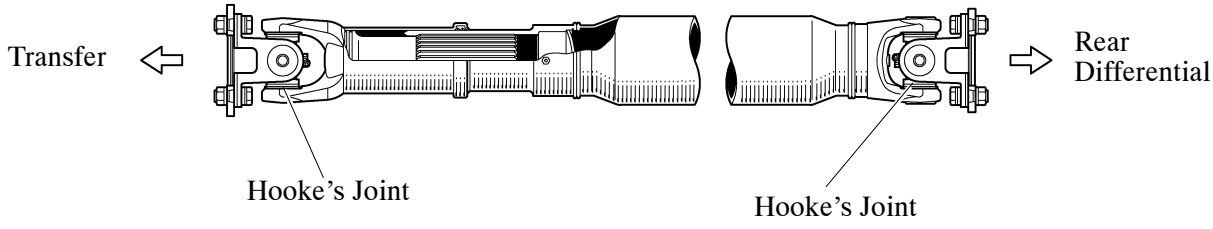
▶ Front Propeller Shaft Assembly ◀



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*: On 1VD-FTV engine models, the front and rear ends of the front propeller shaft are reversed.

▶ Rear Propeller Shaft Assembly ◀

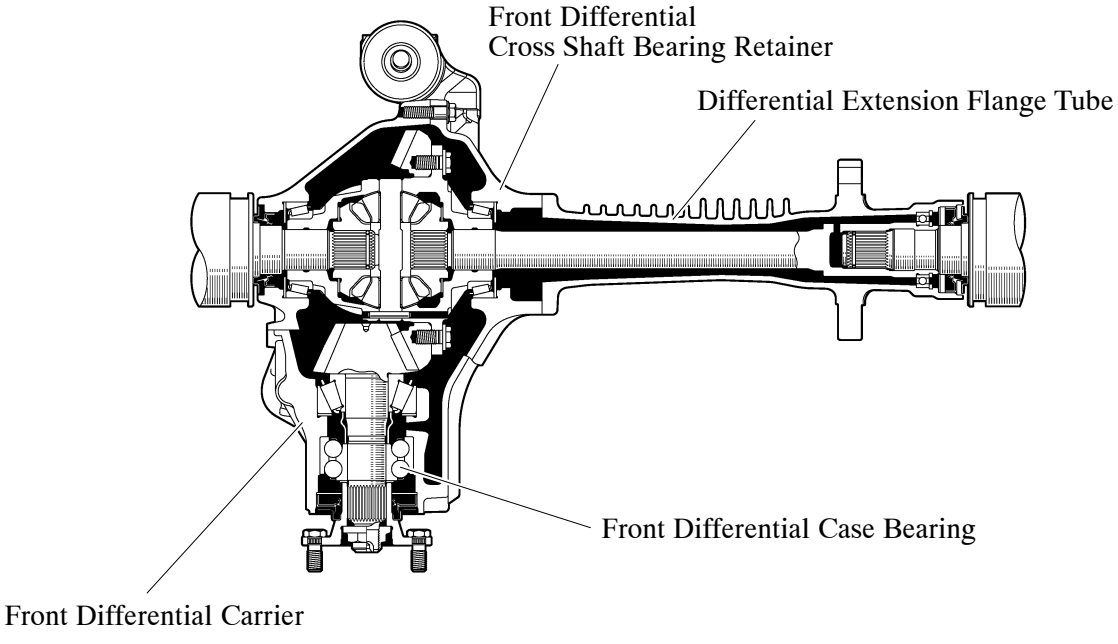


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DIFFERENTIAL

■ FRONT DIFFERENTIAL

- The front differential uses the SD22A type.
- The front differential carrier, front differential cross shaft bearing retainer and differential extension flange tube on the front differential are made of aluminum to reduce their weight.
- A double row bearing is used for the front differential case bearing to reduce friction loss, thus improving fuel consumption.
- Low viscosity oil is used for the front differential, thus lowering the fuel consumption.



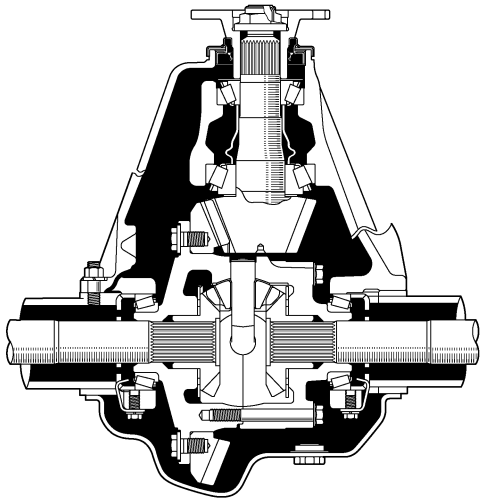
▶ Specifications ◀

Differential Type		SD22A	
Engine Type		2UZ-FE, 1GR-FE	1VD-FTV
Differential Gear Ratio		4.100	3.909
Ring Gear Size	mm (in.)	220 (8.7)	←
Oil Capacity	Liters (US qts, Imp.qts)	1.9 (2.0, 1.7)	←
Oil Viscosity		SAE 75W-85	←
Oil Grade		API GL-5	←
Weight (Reference) *	kg (lb)	33.7 (74.3)	←

*: Weight shows the figure with no fluids.

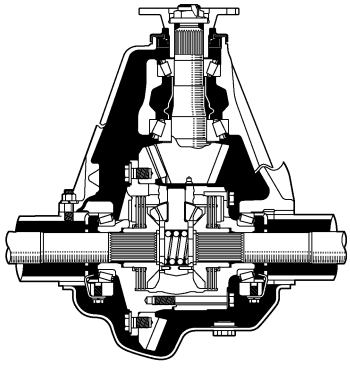
■REAR DIFFERENTIAL

- The rear differential uses the BD24A types.
- The limited slip differential and differential lock are available as options on all models except VX grade models.
- Low viscosity oil is used for the rear differential, thus lowering the fuel consumption.



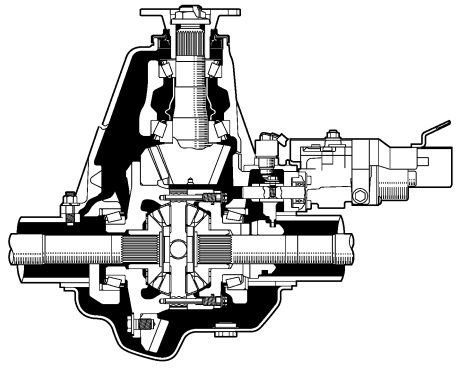
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Standard



081CH21Y

With Limited Slip Differential



081CH22Y

With Differential Lock

▶ Specifications ◀

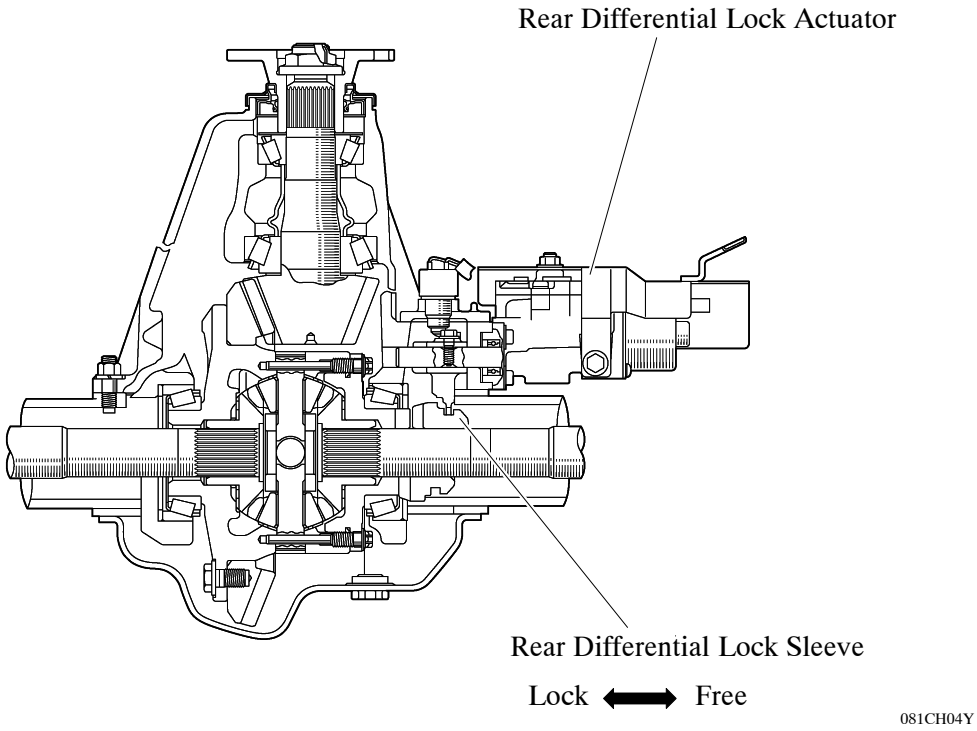
Differential Type		BD24A	
Engine Type		2UZ-FE, 1GR-FE	1VD-FTV
Differential Gear Ratio		4.100	3.909
Ring Gear Size	mm (in.)	241 (9.5)	←
Oil Capacity	Liters (US qts, Imp.qts)	4.2 (4.4, 3.7)	←
Oil Viscosity		SAE 75W-85	←
Oil Grade		API GL-5	←
Weight (Reference) *1	kg (lb)	38.0 (83.8), 39.6 (87.3) *2, 41.6 (91.7) *3	←

*1: Weight shows the figure with no fluids.
*2: with limited slip differential
*3: with differential lock

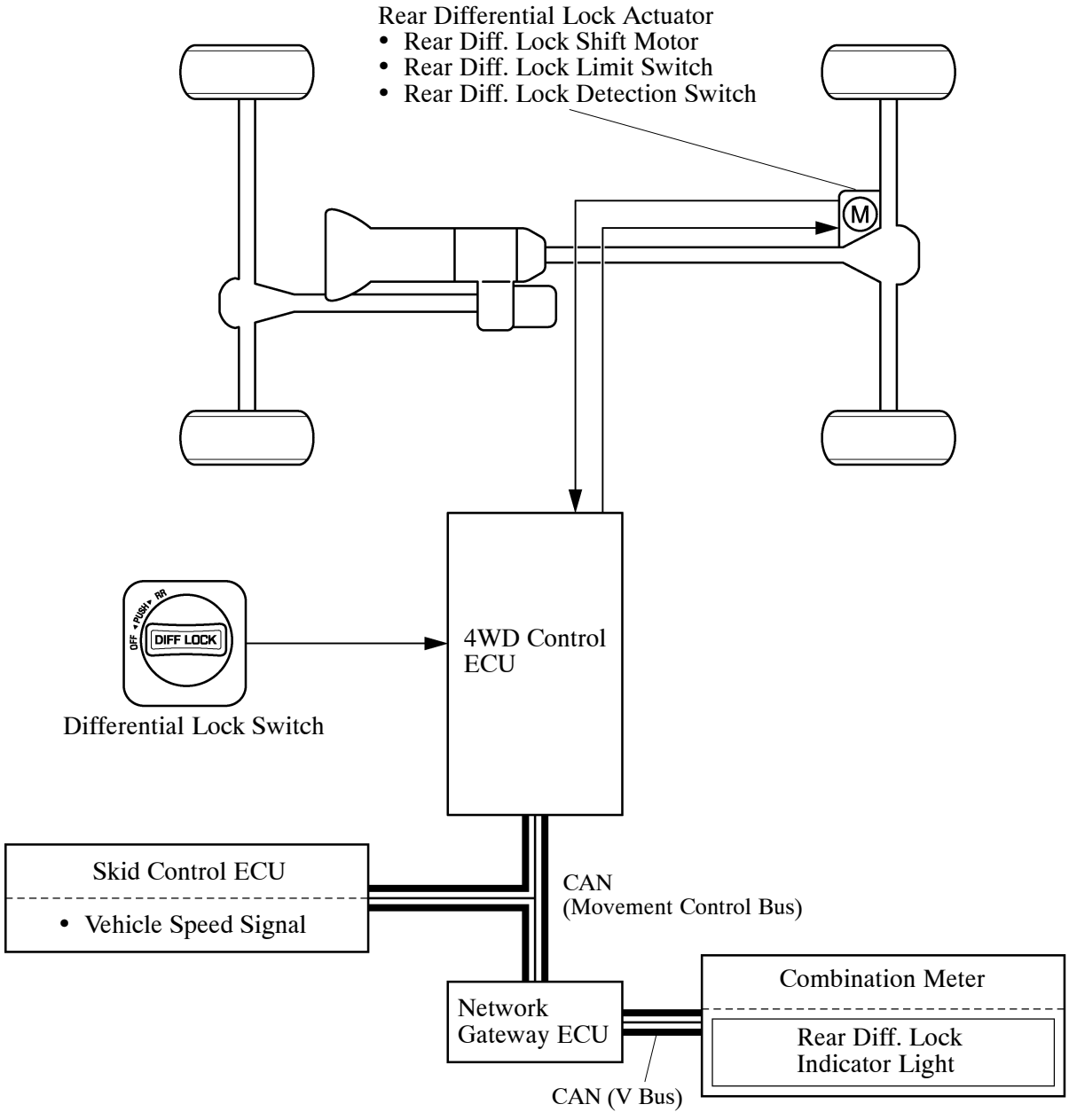
■ REAR DIFFERENTIAL LOCK SYSTEM

1. General

The sliding of the differential lock sleeve is accomplished by a rear differential lock actuator, which is controlled by the 4WD control ECU in conformity with the signals from the differential lock switch and from other signals.



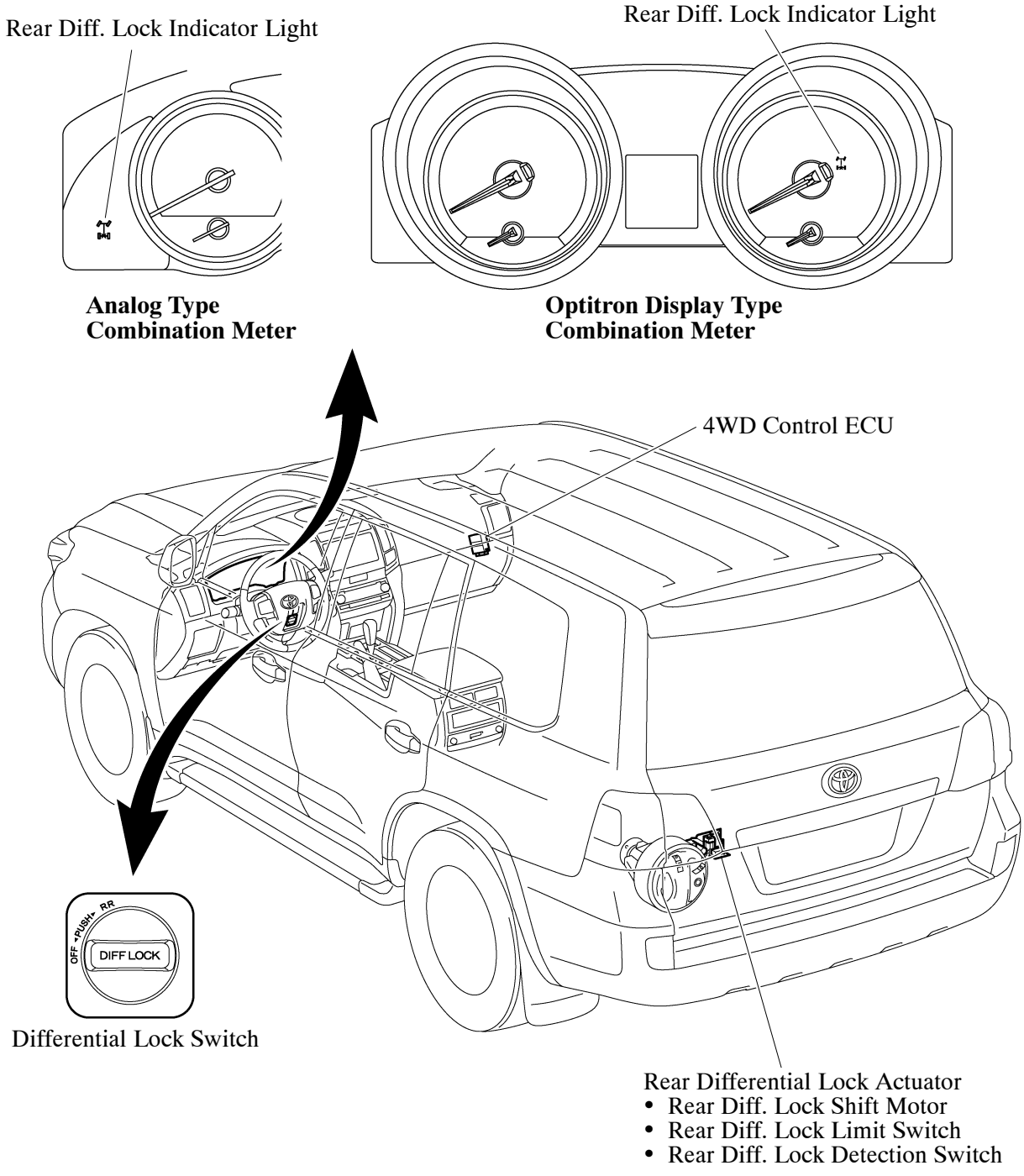
▶ System Diagram ◀



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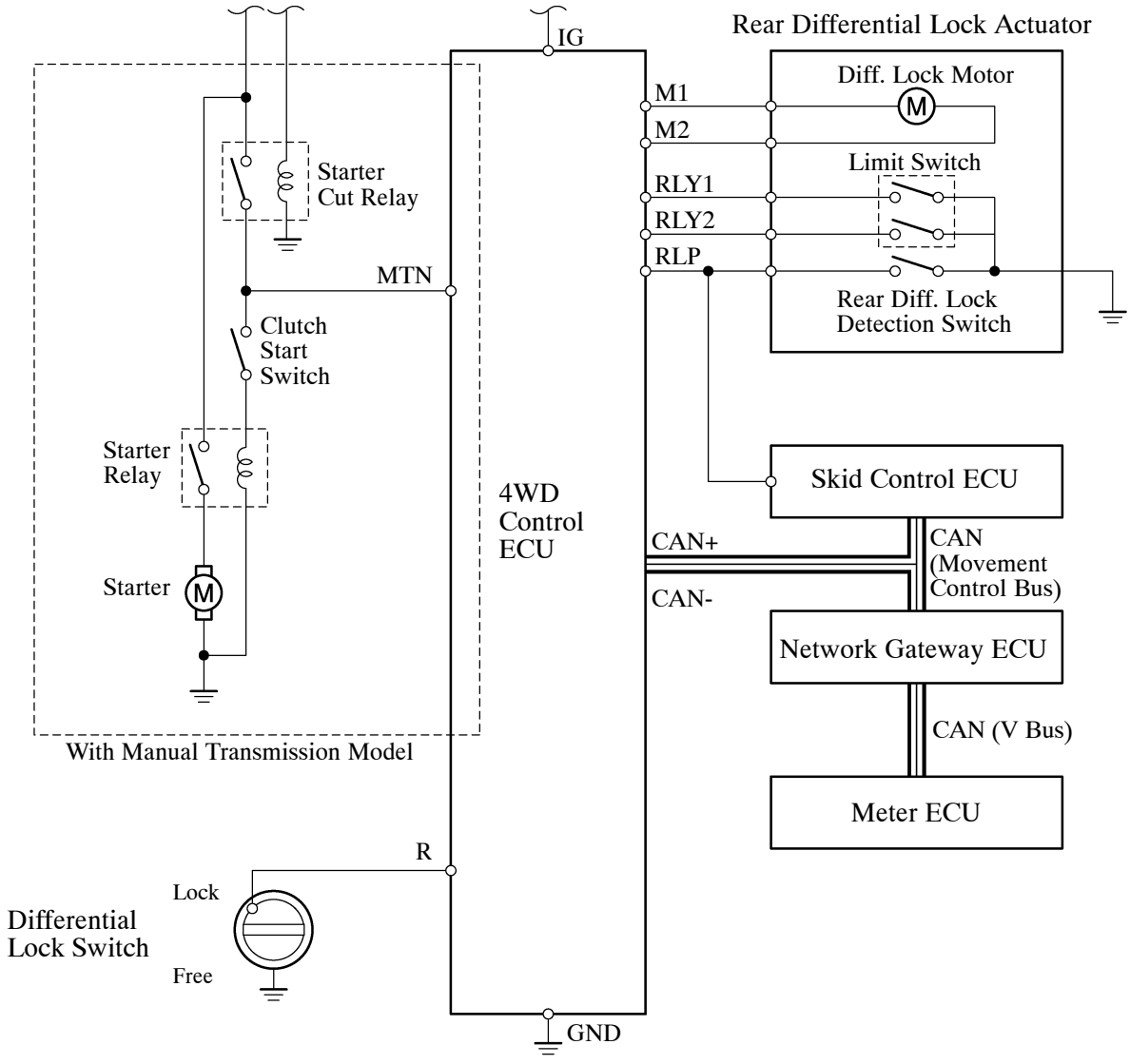
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2. Layout of Main Components



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3. Wiring Diagram



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4. System Operation

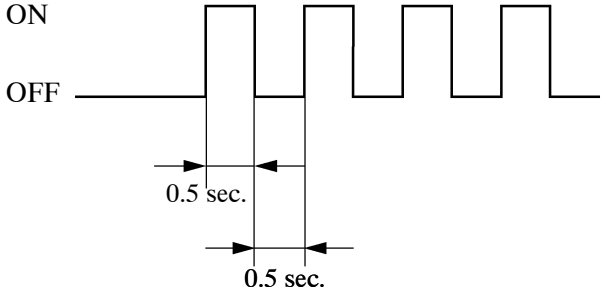
The table below shows how the 4WD control ECU controls the rear differential lock actuator and rear diff. lock indicator light based on the 4WD control ECU signals received from the switches and signals depending on the operation of the differential lock switch.

▶ Operation Condition ◀

Switches and Signal Condition					Rear Diff.	Rear Diff. Lock Indicator Light
Differential Lock Switch	L4 Position Switch	Center Differential Lock Switch	Vehicle Speed	Rear Diff. Lock Detection Switch		
OFF	OFF	OFF	Not input	OFF	Free	Turn OFF
ON	↑	↑	↑	↑	↑	Blinks 1
↑	ON	ON	8 km/h (5 mph) or higher	↑	↑	↑*1
↑	↑	↑	8 km/h (5 mph) or lower*2	↑	During shifting into LOCK mode	Blinks 2
↑	↑	↑	↑	ON	Lock	Turn ON

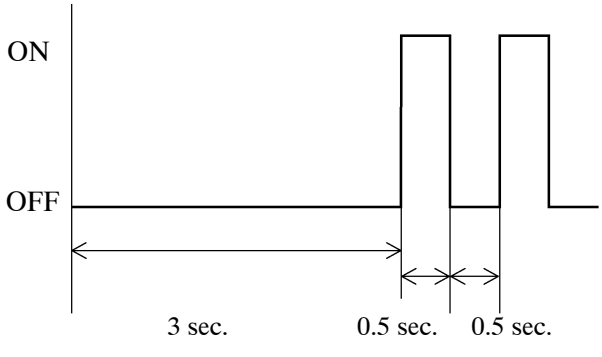
*1: When the vehicle speed is higher than approximately 8 km/h (5 mph), the 4WD control ECU prohibits shifting in the "LOCK" mode, and blinks the rear diff. lock indicator light.
*2: For models equipped with the manual transmission, when the clutch pedal is being depressed.

▶ Rear Diff. Lock Indicator Light Blinks Pattern ◀



Blinks 1

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Blinks 2

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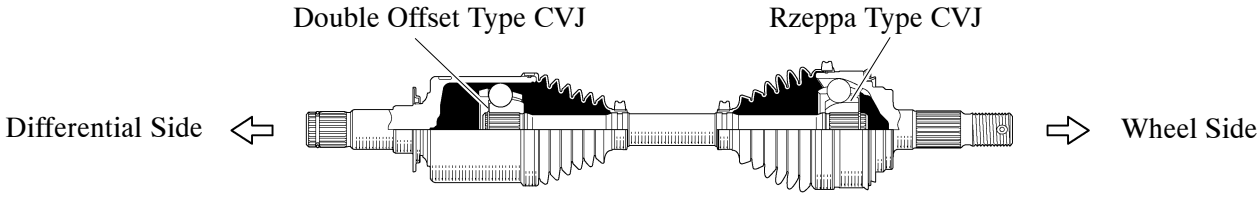
—Reference—

When the rear diff. lock is in operation, the skid control ECU stops the operation of the brake control (Multi-terrain ABS with EBD) and turns on the ABS warning light.

FRONT DRIVE SHAFT

■ DESCRIPTION

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



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SUSPENSION AND AXLE

■ SUSPENSION

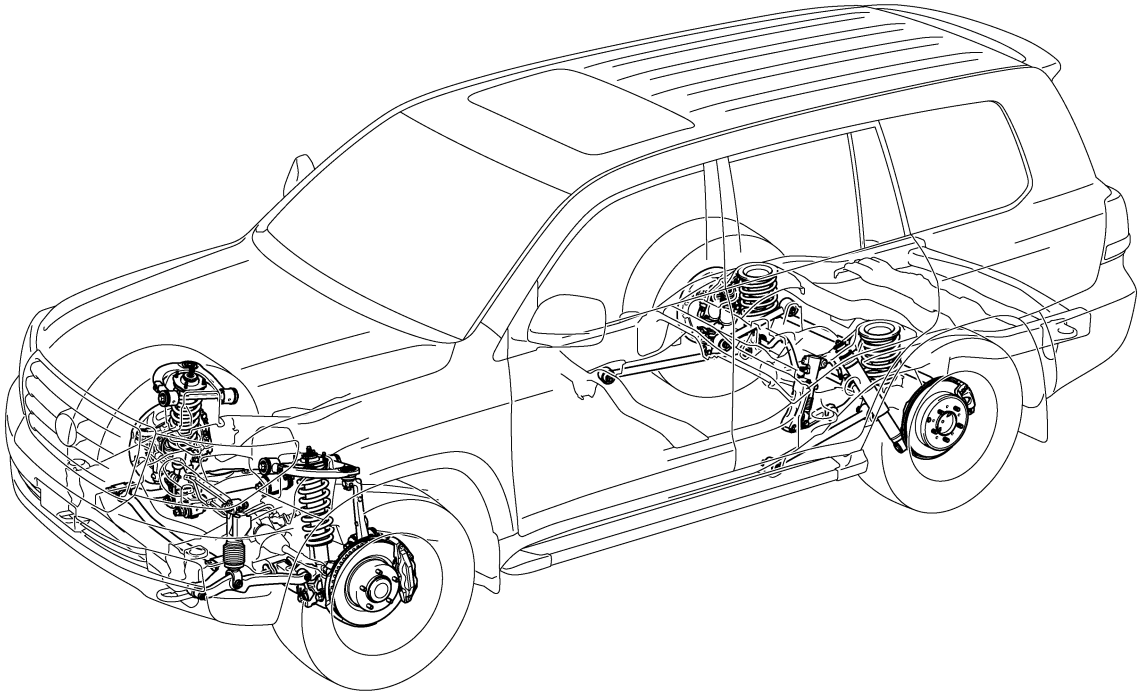
1. General

- The coil spring type double-wishbone independent suspension is used for the front, and the 4-link coil spring with lateral rod type suspension is used for the rear.
- A KDSS (Kinetic Dynamic Suspension System), which gives the vehicle both outstanding rolling rigidity and excellent performance in off-road driving, has been made available as standard or as an option depending on the model.
- A 4-wheel AHC (Active Height Control suspension) and AVS (Adaptive Variable Suspension) is optional equipment for European models.
- The new Land Cruiser (Station Wagon) has a suspension with the following equipment:

○: Standard OP: Option —: Not available

Destination		Europe	Australia		China	G.C.C. Countries		General Countries	
Grade		VX	VX	GX	VX	VX	GX	VX	GX
Suspension	Basic	—	○	←	—	—	○	←	○
	KDSS	○*1	○*2	OP	○	○	—	OP	—
	4-Wheel AHC & AVS	OP*1	—	—	—	—	—	—	—

*1: The KDSS is not available when 4-wheel AHC and AVS is used.
*2: Available as an option on 1VD-FTV engine models.



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Models with Kinetic Dynamic Suspension System

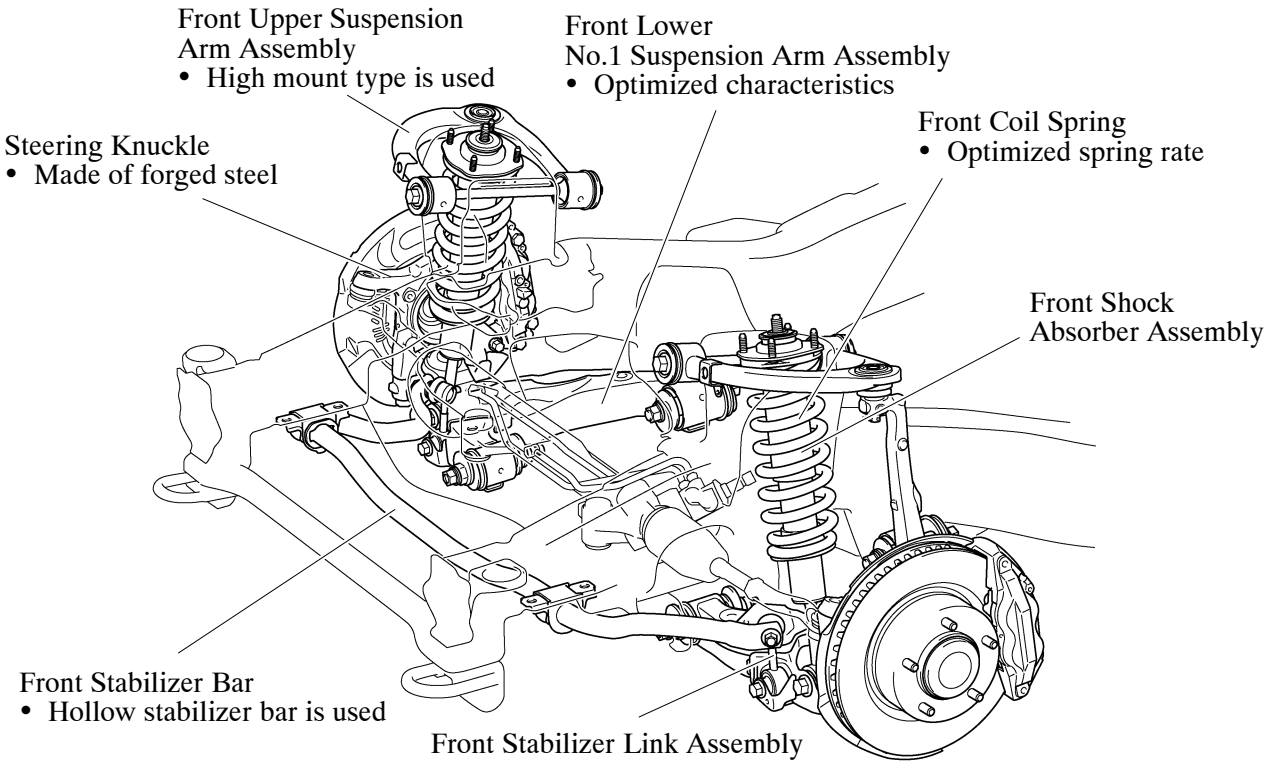
▶ Specifications ◀

Tire Size	Front Wheel Alignment*				Tread [mm (in.)]	
	Caster [degree]	Camber [degree]	Toe-In [mm (in.)]	King Pin Inclination [degree]	Front	Rear
245/75 R17	4°00’	0°00’	0 (0.00)	13°00’	1640 (64.6)	1635 (64.4)
285/65 R17	↑	↑	↑	↑	↑	↑
285/60 R18	↑	↑	↑	↑	↑	↑
285/50 R20	↑	↑	↑	↑	↑	↑

*: Standard Loaded Vehicle Condition

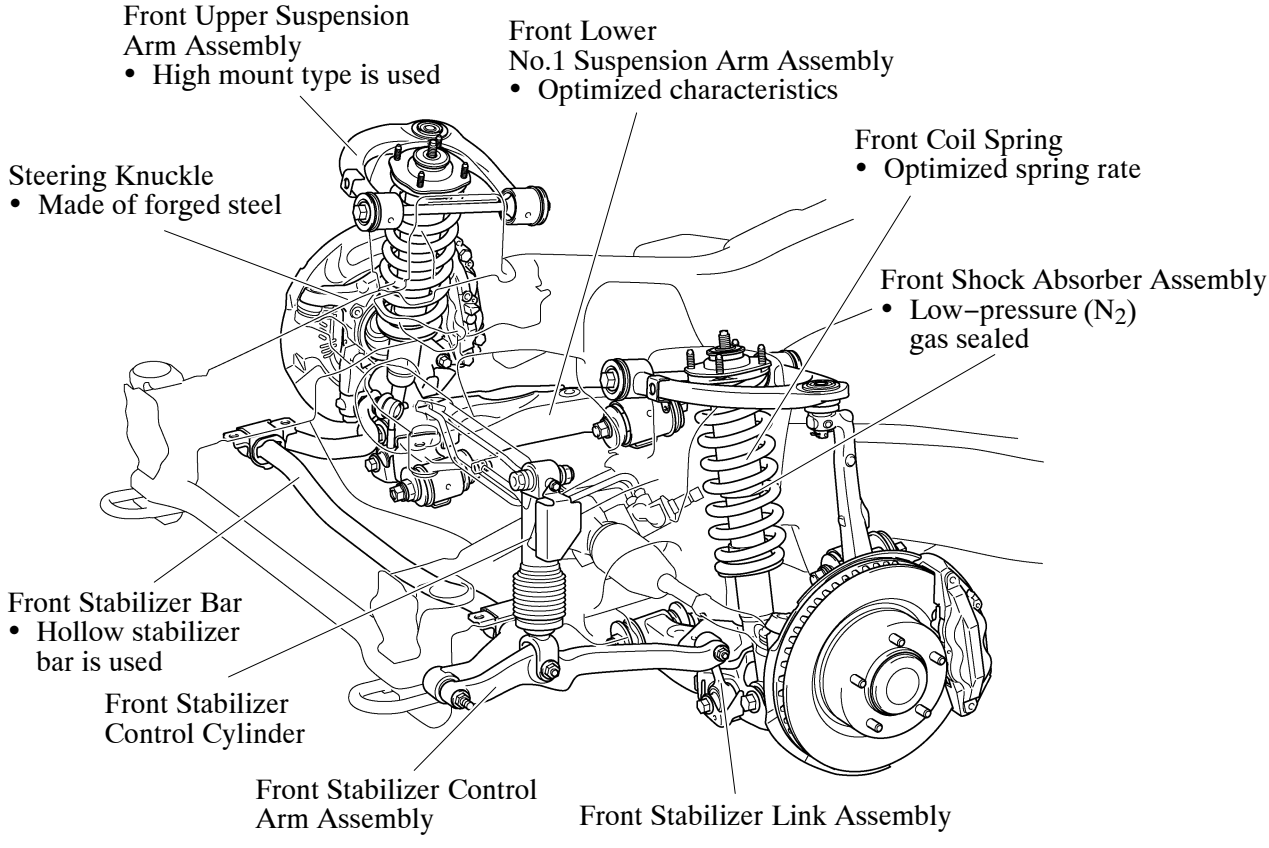
2. Front Suspension

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



Models with Active Height Control Suspension

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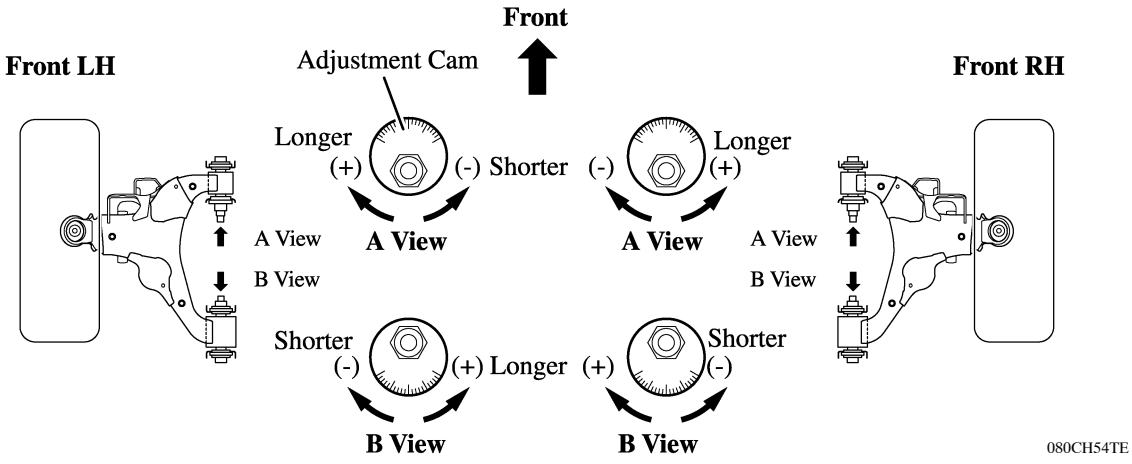
Models with KDSS

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Service Tip

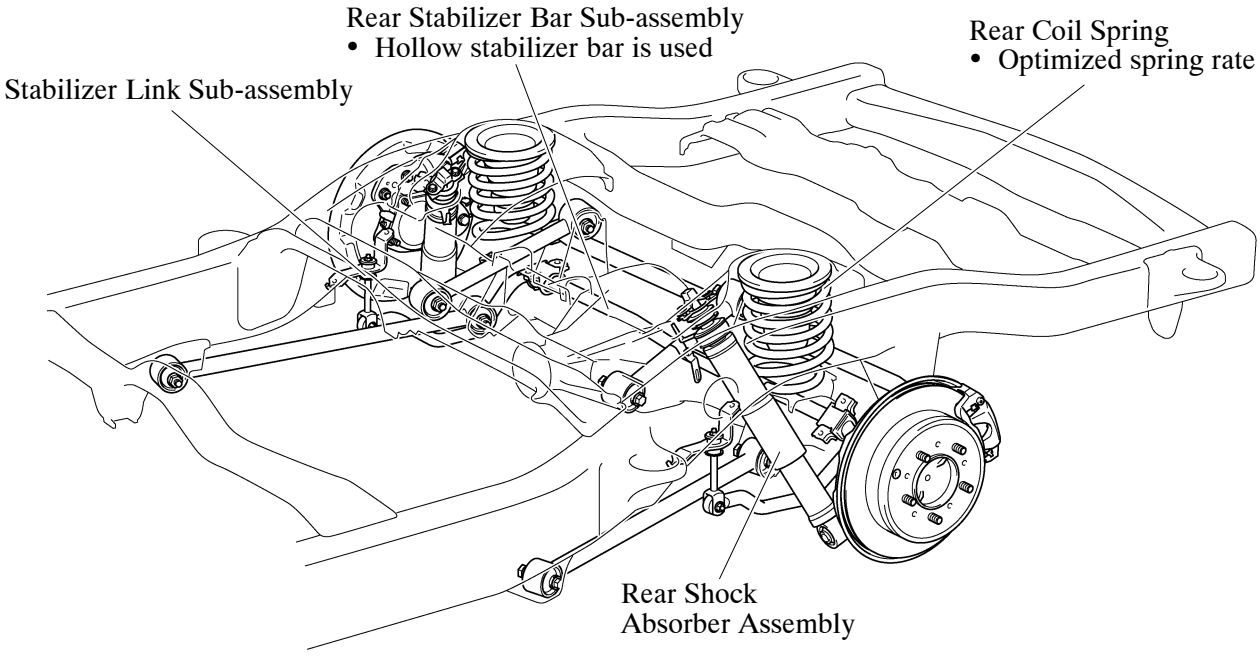
- To prevent hazardous conditions, make sure to empty the gas from the front shock absorber assembly before discarding a low-pressure (N_2) gas sealed front shock absorber assembly.
- The camber and caster of the front suspension can be adjusted using the adjustment cams of the lower arms.

For details, see the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

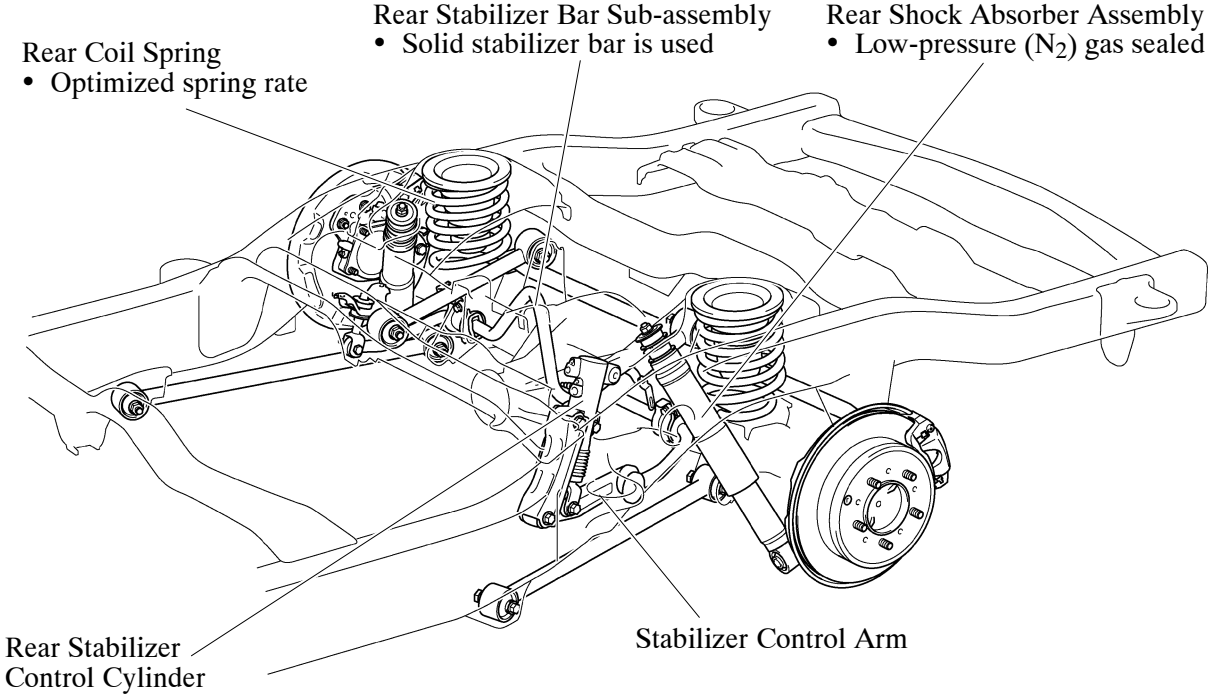


3. Rear Suspension

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



Models with Active Height Control Suspension 081CH49H



Models with KDSS 080CH57H

Service Tip

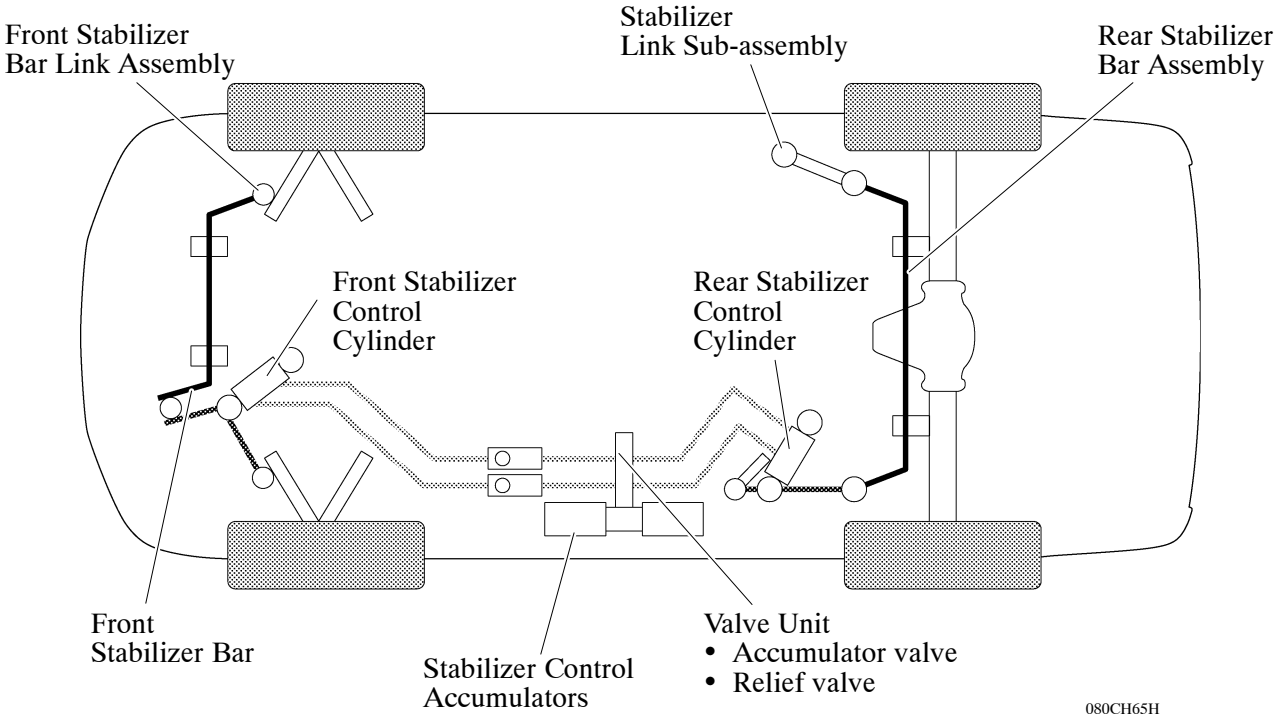
To prevent hazardous conditions, make sure to empty the gas from the shock absorber before discarding a low-pressure (N_2) gas sealed shock absorber. For details, see the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

4. Kinetic Dynamic Suspension System

General

- The KDSS (Kinetic Dynamic Suspension System) consists of a hollow stabilizer bar at the front and a sold stabilizer bar at the rear to realize the proper rolling rigidity of the vehicle, and two hydraulic stabilizer control cylinders to deliver excellent off-road driving performance.
- The two stabilizer control cylinders are piped via the valve unit.

▶ System Diagram ◀

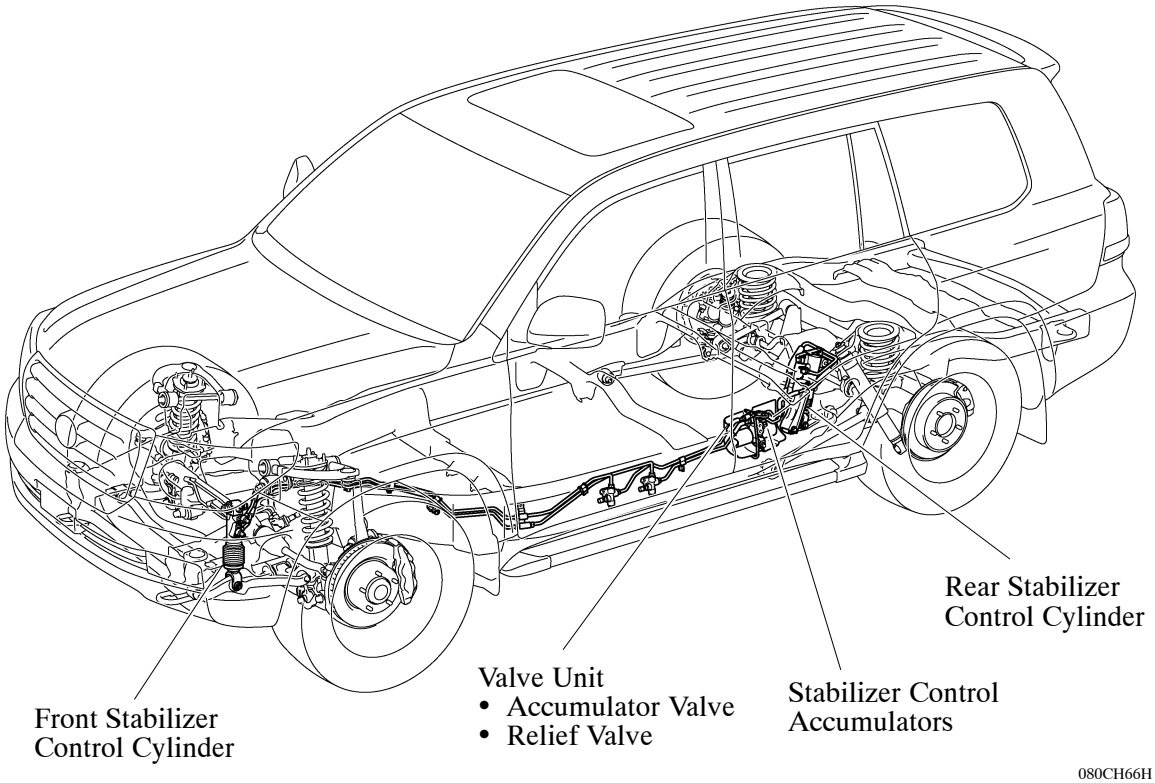


Service Tip

- This system uses the suspension fluid AHC (08886-01805).
- Before removing a stabilizer control cylinder, which contains high pressure, make sure to drain the fluid from the bleeder plugs for the upper and lower chambers.
- After installing a stabilizer control cylinder, make sure to use the SST (09760-60020) to bleed air from the system.

For details, see the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

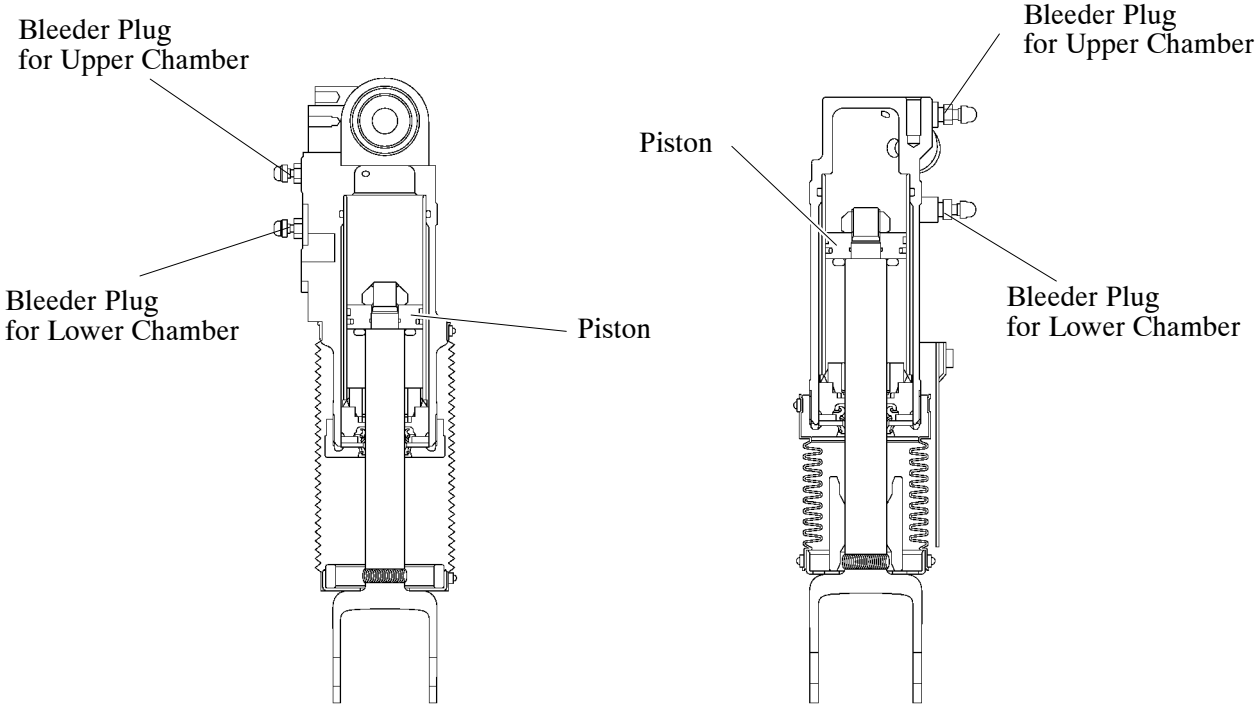
Layout of Main Components



Construction

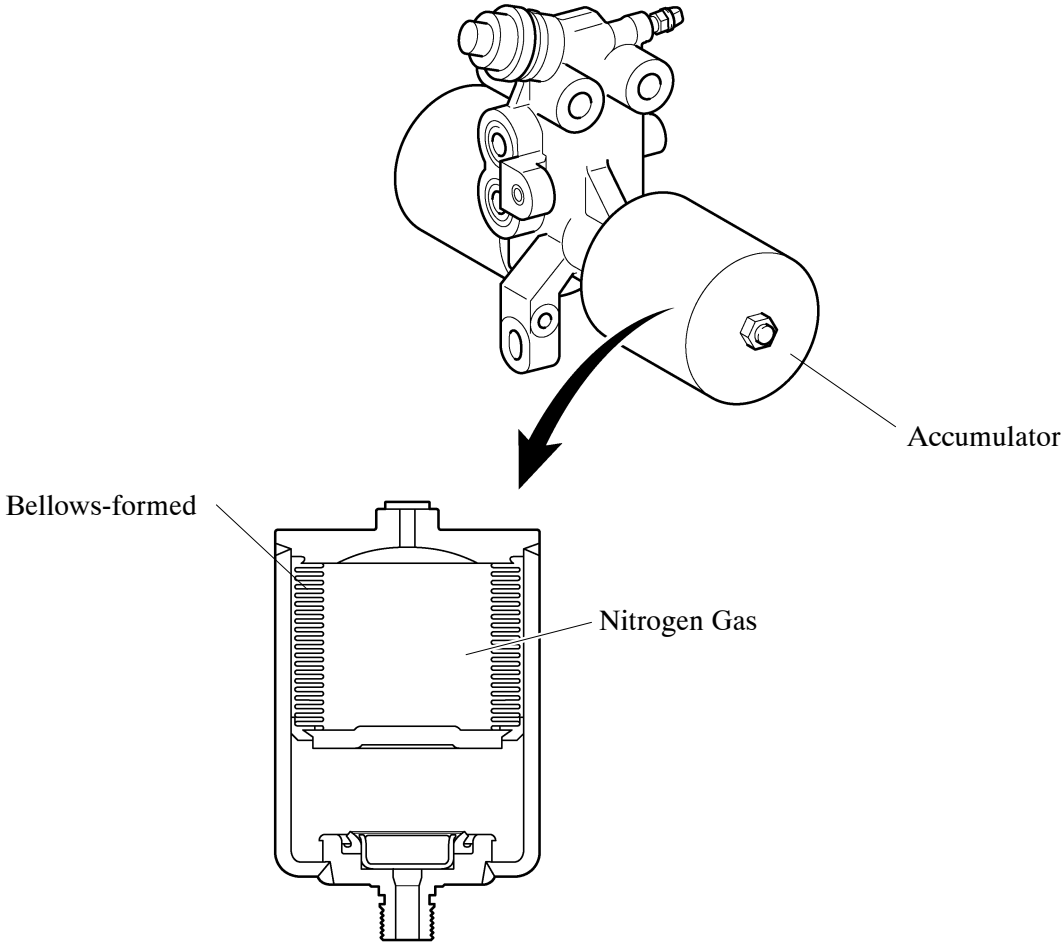
1) Stabilizer Control Cylinder

- Stabilizer control cylinder consists of the piston and upper and lower chambers. There is no connection between the upper and lower chambers. The front upper chamber is connected to the rear upper chamber, and the front lower chamber is connected to the rear lower chamber.
- A bleeder plug is provided for each chamber. To remove a stabilizer control cylinder, fluid must be drained from the bleeder plug.



2) Stabilizer Control Accumulator

- Inside the stabilizer control 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 stabilizer control accumulator.
- The nitrogen gas filled with the stabilizer control accumulator produces the initial pressure inside the system piping and absorbs the pressure from the stabilizer control cylinder, and the fluid volume also varies in accordance with the temperature, thus contributing to an increase in the riding comfort.



Cross Section

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Service Tip

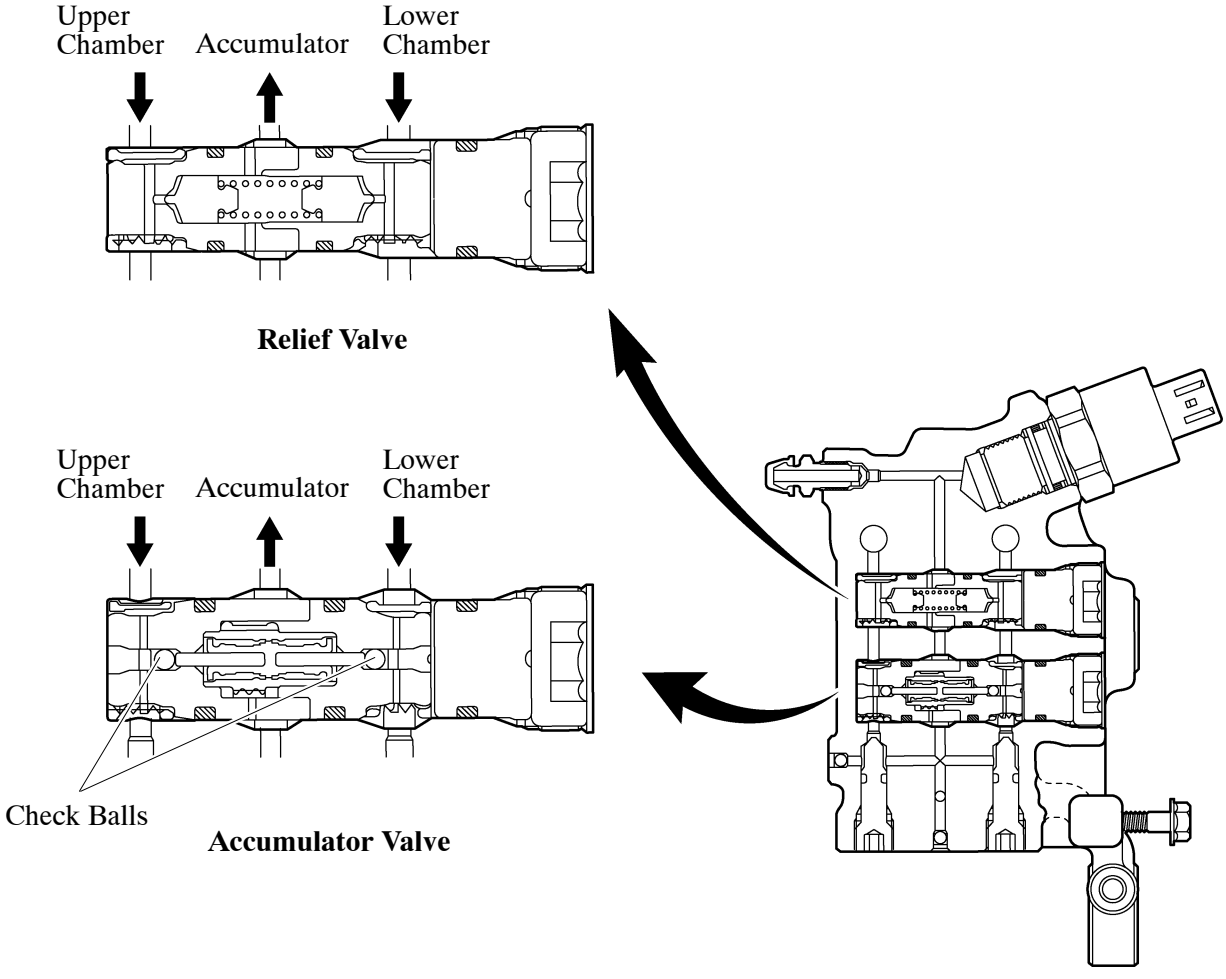
To prevent hazardous conditions, make sure to empty the gas from the accumulator before discarding a high-pressure (N_2) gas sealed stabilizer control accumulator. For details, see the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

3) Valve Unit

The valve unit consists of an accumulator valve and a relief valve.

- The accumulator valve is normally open, and opens and closes the fluid channel from the upper and lower chambers of the stabilizer control cylinder to the accumulator using the check ball.
- If the fluid pressure inside the upper chamber or lower camber rises above a specified value, the relief valve opens to let the fluid flow into the accumulator, preventing the system from being damaged.

▶ Simplified Diagram of Valve Unit ◀

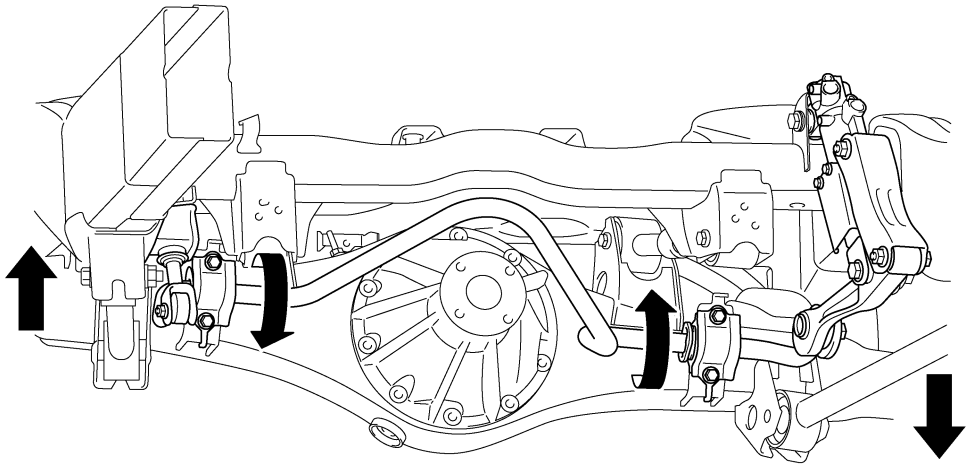


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Operation

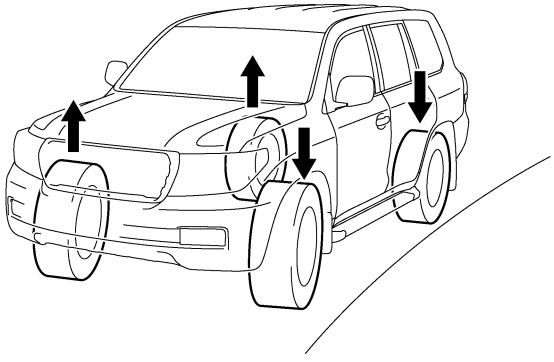
1) In a Roll Motion

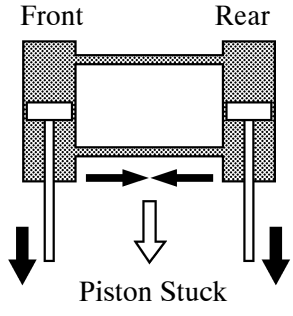
During a rolling motion, no stroking movement occurs in the stabilizer control cylinders. Instead, the stabilizer bars operate effectively. As a result, a high level of driving stability is ensured.



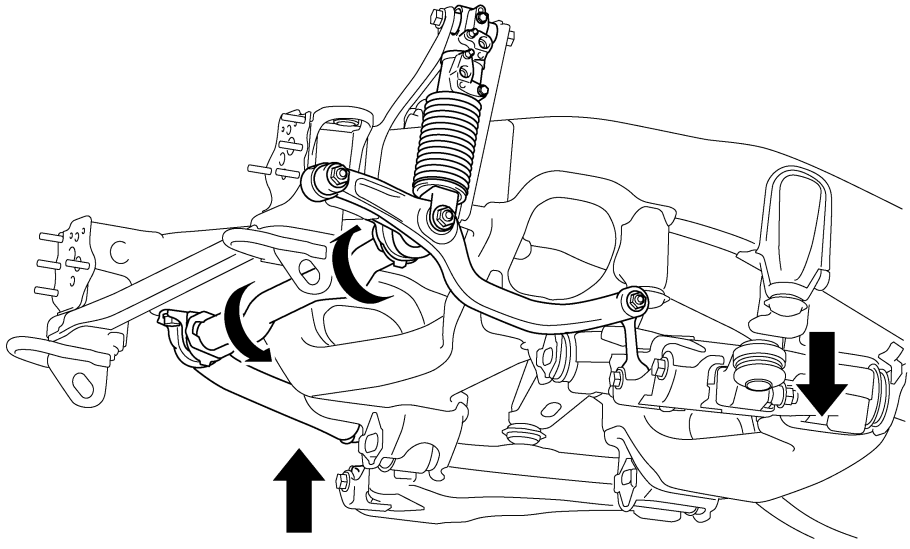
Rear

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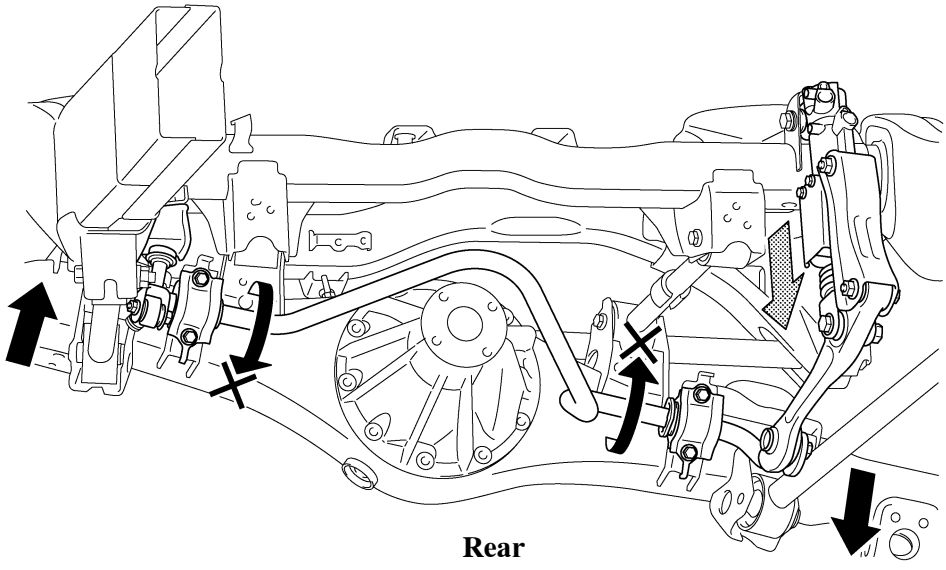


Front

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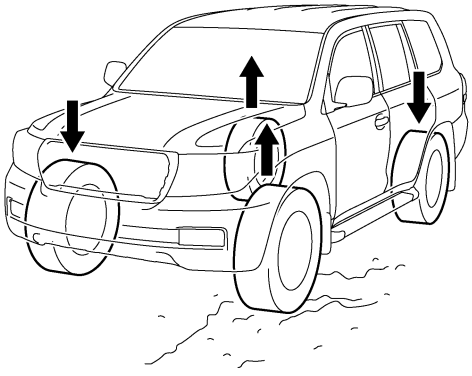
2) In Off-road Motion

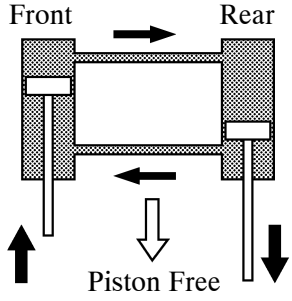
During an off-road motion, a stroking movement occurs in the stabilizer control cylinders, and the effectiveness of the stabilizer bars is reduced. Thus, the suspension moves easily, free of torsion. As a result, an excellent performance is realized on the off-road driving.



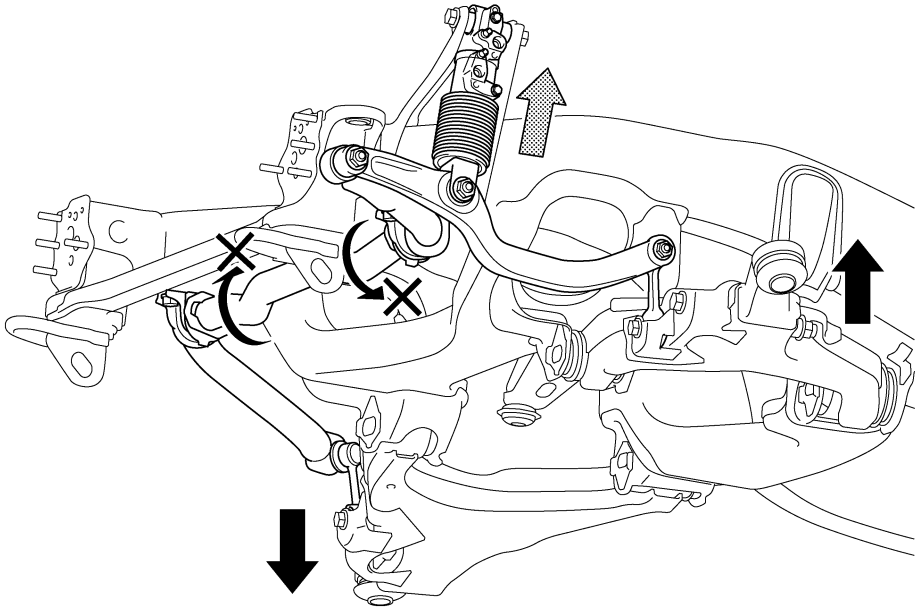
Rear

080CH71H





080CH72H



Front

080CH73H

5. 4-WHEEL AHC (ACTIVE HEIGHT CONTROL SUSPENSION) AND AVS (ADAPTIVE VARIABLE SUSPENSION)

General

In this active height control suspension, the height control, damping force control, spring rate control and 4-wheel related control are individually controlled by the coil spring, nitrogen gas springs and hydro-pneumatic suspension, thereby delivering high on-road and off-road driving performance.

▶ Control of Active Height Control Suspension ◀

Control	Outline
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, therefore, the vehicle height can be controlled within 5 levels: (Low, Normal 2, Normal, High and Extra-High).
Damping Force Control	• The optimum damping force can be obtained by controlling the damping force actuators arranged on each of the wheels in accordance with the manual switch operation and driving conditions. • The semi-active control of the damping force control has been changed from sky-hook control to non-linear H^{∞} control.
Spring Rate Control (for Front Suspension)	The spring rate (wheel 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 cylinder, therefore, the amount of hydraulic pressure for each of the shock absorbers can be individually adjusted via the center cylinder in accordance with the driving conditions.

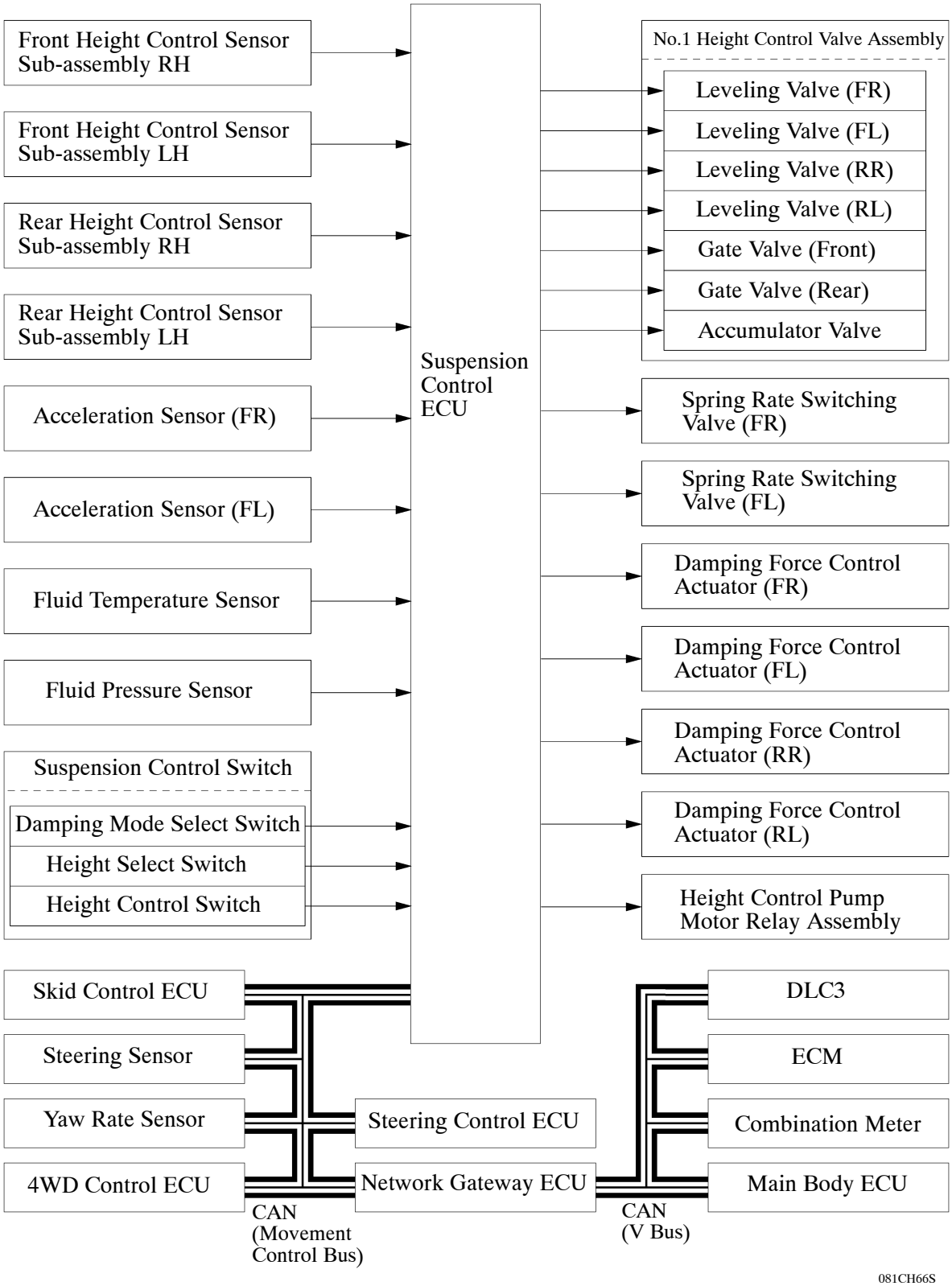
—REFERENCE—

- *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

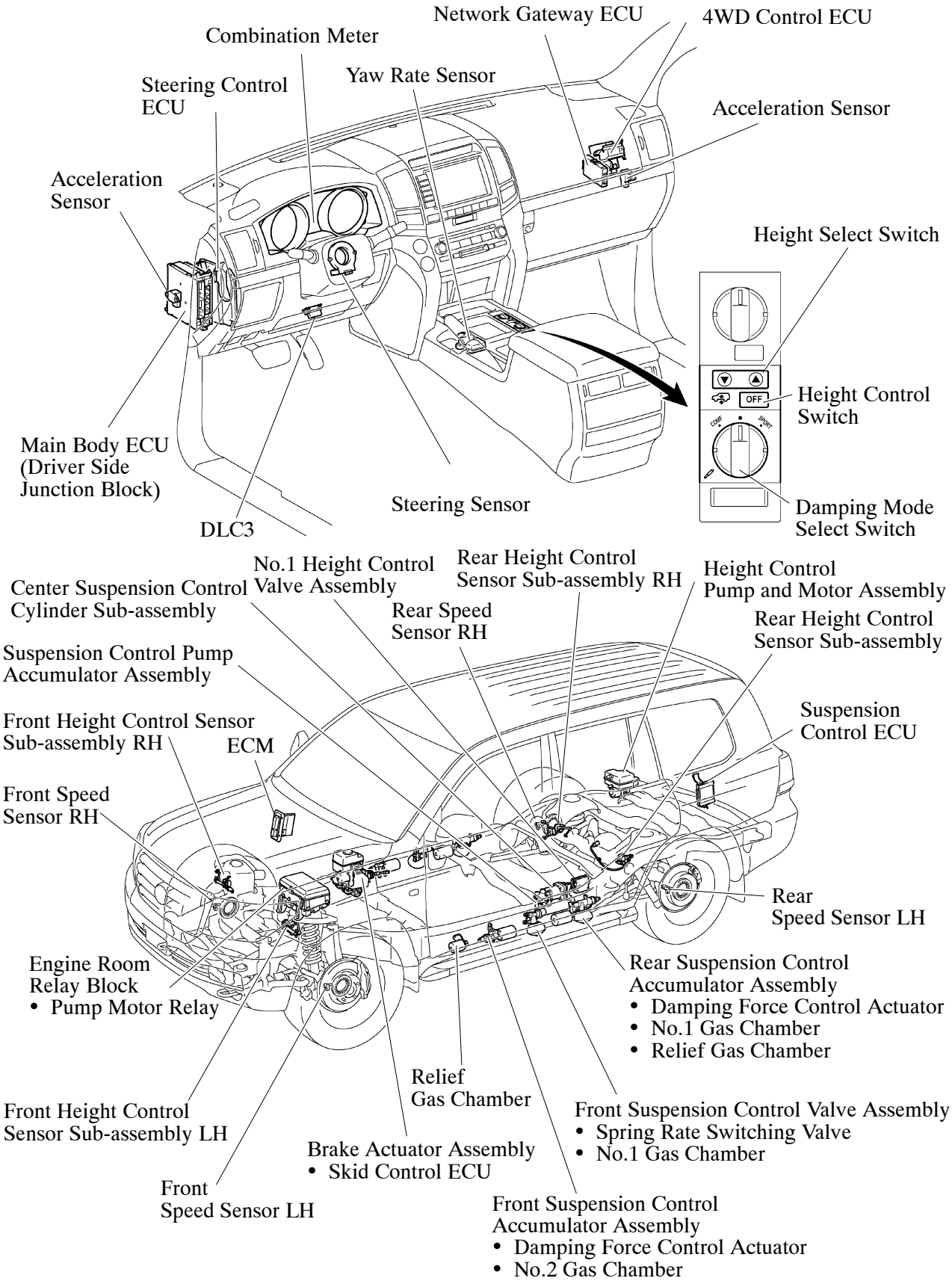
Before jacking the vehicle or raising it on a hoist, make sure that the engine switch is OFF.
If the vehicle must be lifted up when the engine switch is READY, turn the height control switch OFF and connect the OPA and CG terminals from the DLC3 using SST (09843-18040) to suspend vehicle height control operations of the suspension control ECU.
For details, see the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

System Diagram



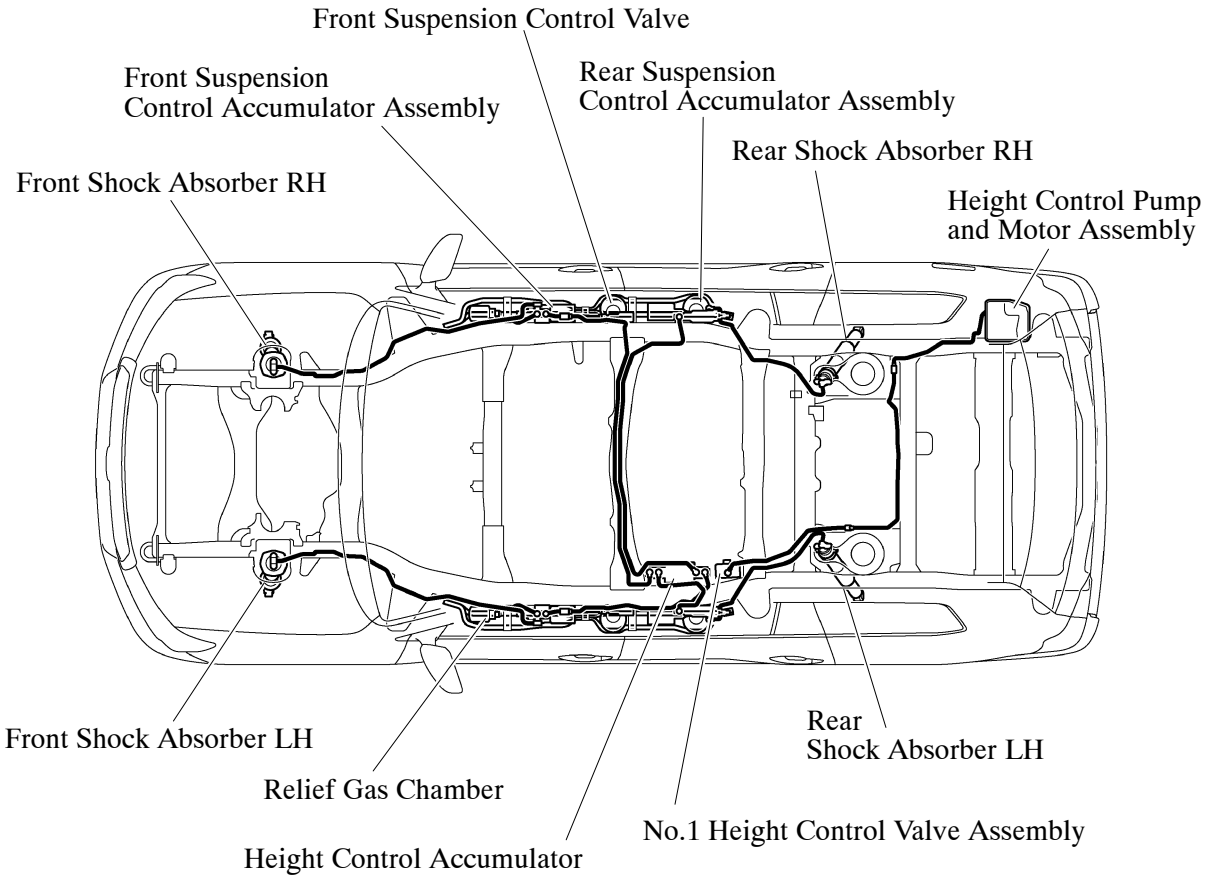
CH

Layout of Main Components

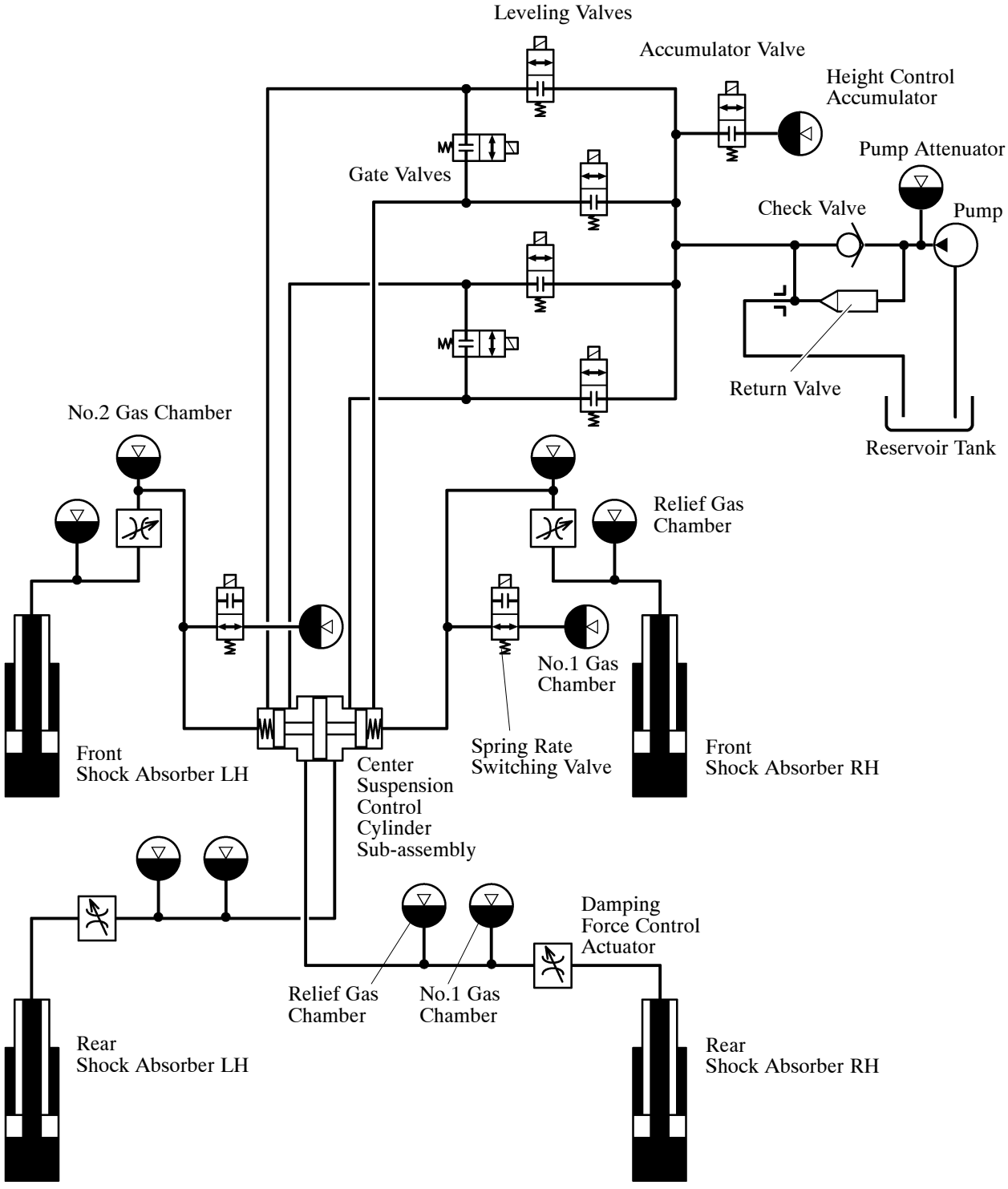


081CH52H

Suspension Tubing Location



Hydraulic Pressure Piping System Diagram



081CH67Y

Function of Main Components

Components		Function
Height Control Pump and Motor Assembly		Generates the high hydraulic pressure that is necessary for raising the vehicle height.
	Height Control Reservoir Assembly	Maintains the amount of fluid that is returned during the low vehicle height and the amount of fluid that is discharged during the high vehicle height.
	Return Valve	Opens and closes the fluid passage between the control valve assembly and the reservoir tank.
	Pressure Sensor	Detects the pump's discharge pressure.
	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 Assembly		Stores the hydraulic pressure to accelerate the speed in which the vehicle height is raised.
No.1 Height Control Valve Assembly	Leveling Valve	Open and close the fluid passage between the pump and the gas chamber on the wheel. This is individually provided on each of the wheels.
	Gate Valve	Open and close the fluid passage between the right and left shock absorbers. This is individually provided for both the front and rear shock absorbers.
	Accumulator Valve	Opens and closes the fluid passage to the height control accumulator.
Center Suspension Control Cylinder Sub-assembly		Mechanically operates in accordance with the pressure applied to the shock absorbers and optimally distributes the hydraulic pressure to each of the wheels.
Spring Rate Switching Valve		Opens and closes the fluid passage to the No.1 gas chamber.
No.1 Gas Chamber		Acts like a gas spring by partially utilizing coil spring force. This is provided on each of the wheels.
No.2 Gas Chamber		Acts like a gas spring by partially utilizing coil spring force. This is provided on both the left and right front wheels.
Relief Gas Chamber		Protects hydraulic systems by restricting increase in the hydraulic pressure inside the hydraulic tubes. This is provided on each of the wheels.
Damping Force Control Actuator		Switch the damping force.
Shock Absorber		• Generate 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.
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.

(Continued)

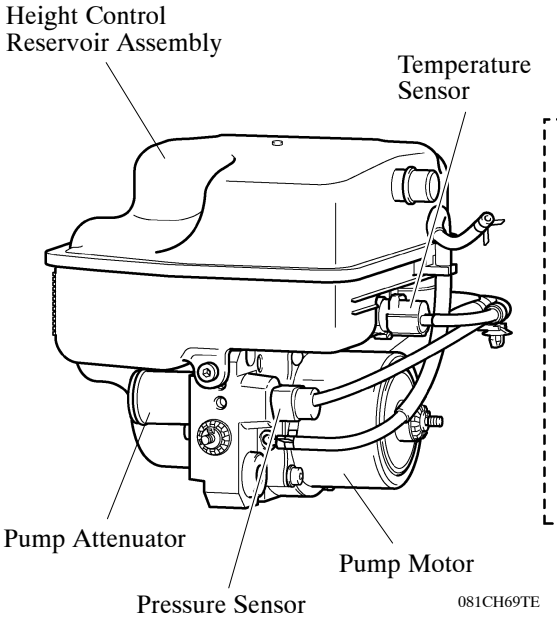
Components	Function
Height Select Switch	A seesaw type momentary switch has been adopted for the height select switch that is used for selecting a desired height. Pressing the up side of the switch once raises the vehicle height, and pressing the down side once lowers the vehicle height.
Height Control Switch	Pressing this switch prohibits the height control function. Pressing it again cancels the prohibition.
Damping Mode Select Switch	Damping mode select switch enables the driver to select a desired damping force from the 3 modes.
Height Control Sensors	Detect the vehicle height.
Steering Sensor	Detects the steering direction and angle of the steering wheel.
Yaw Rate Sensor	Detects the yaw rate and the longitudinal and lateral acceleration and deceleration of the vehicle body.
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. Thus, the acceleration sensors independently detect the vertical acceleration rate of the vehicle.
Pomp 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. • Sends the active height control status signal to ECM.
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 4WDl control ECU.
Main Body ECU	Sends the engine switch status signal and courtesy switch signal to the suspension control ECU.
Network Gateway ECU	Gateways signals between the V-bus and movement control bus.

Construction and Operation of Main Components

1) Height Control Pump and Motor

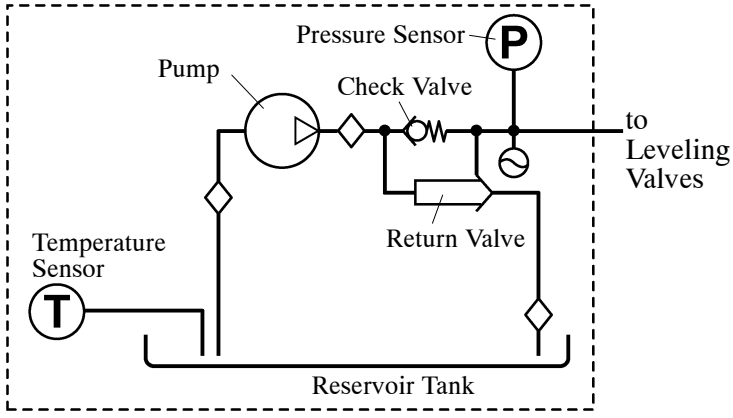
a. General

- A system in which the pump, pump motor, height control reservoir assembly, return valve, pump attenuator, pressure sensor, and temperature sensor are integrated is used.
- 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.
- A DC motor with 4-pole brushes is used to realize excellent durability and high torque.

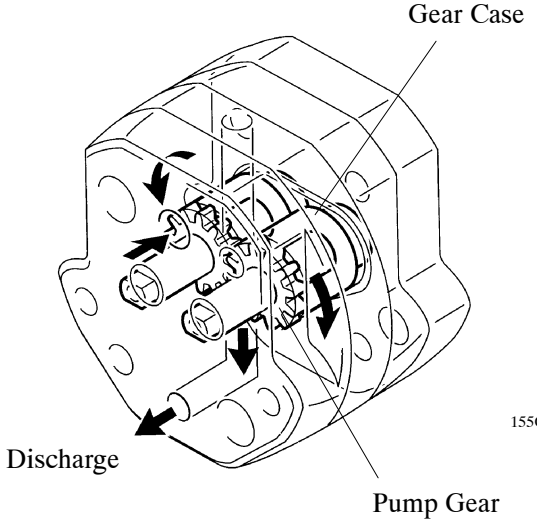


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Pump and Motor hydraulic diagram

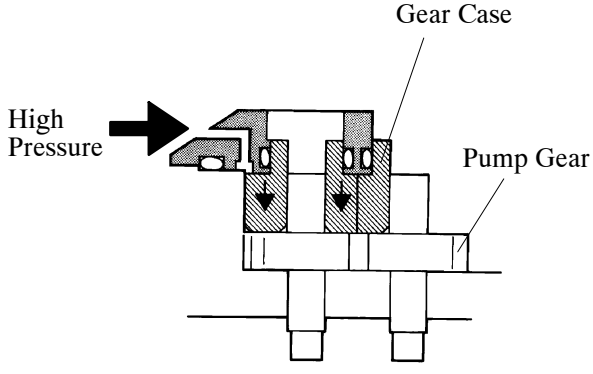


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155CH74

Pump

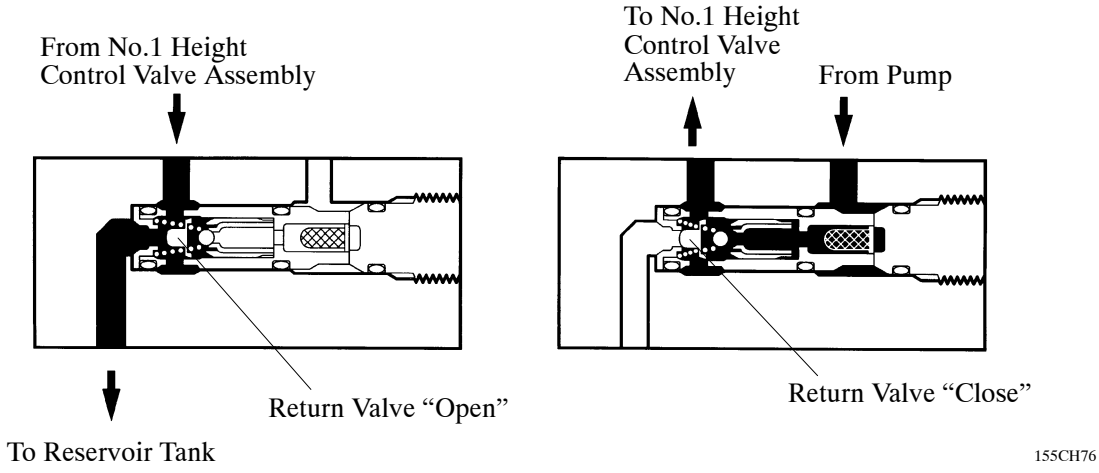


155CH75

Cross Section

b. Return Valve

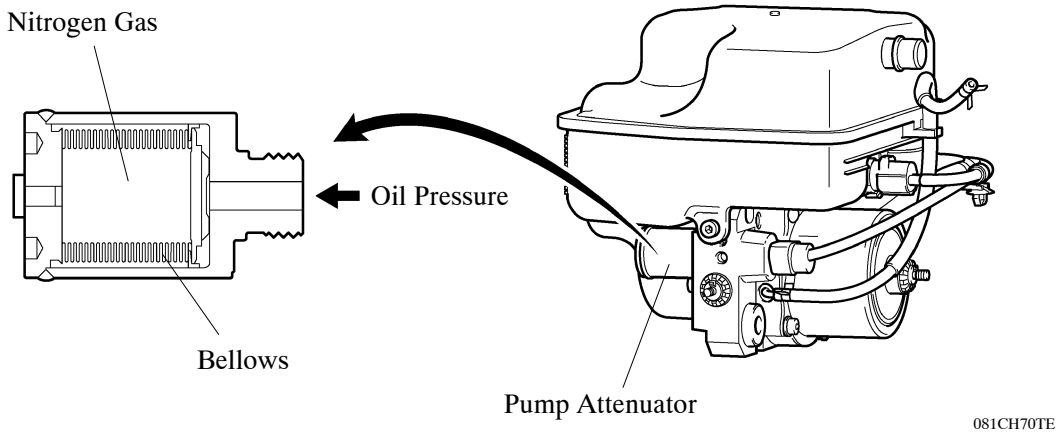
The return valve opens and closes the fluid passage between the No.1 height control valve assembly and the reservoir tank. The return valve has been simplified by adopting a construction in which the valve is closed by the flow of the discharged fluid.
Normally, a spring force is applied to the return valve to maintain the fluid passage between the No.1 height control valve assembly 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 No.1 height control valve assembly and the reservoir tank closes, and the fluid that is discharged from the pump flows towards the control valve assembly.



Normal Condition **Pump in Operation**

c. 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.

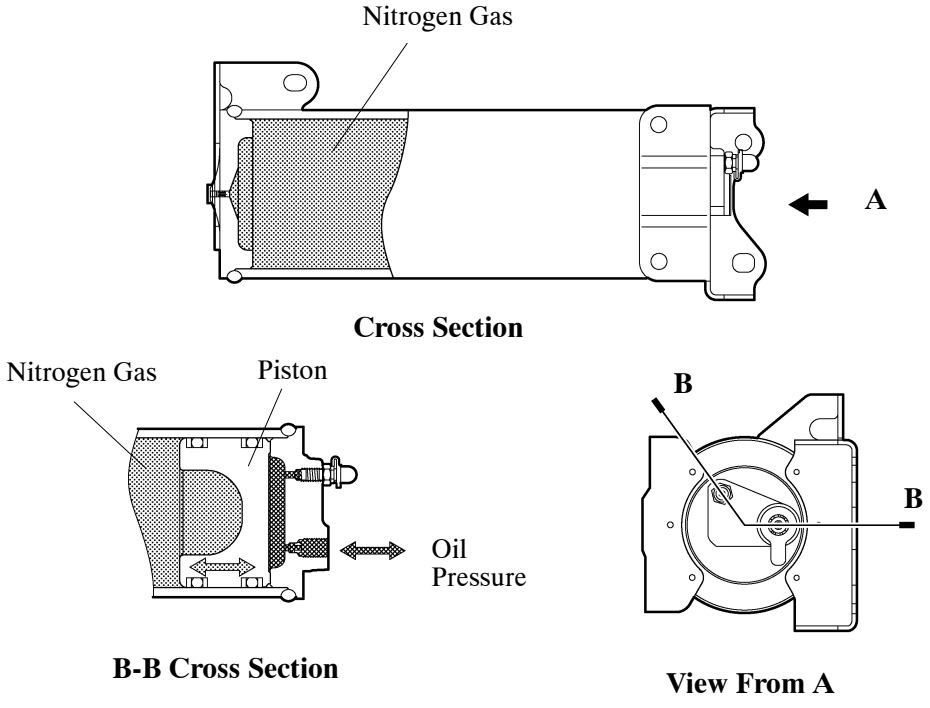


▶ Specifications ◀

Sealed Gas		Nitrogen Gas
Gas Chamber Volume	cc (cu in.)	1.75 (0.11)
Sealed Gas Pressure	MPa (kgf/cm^2, psi)	2 (20, 290)

2) 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 raising the vehicle height, the accumulator discharges the stored fluid to accelerate the raising speed.



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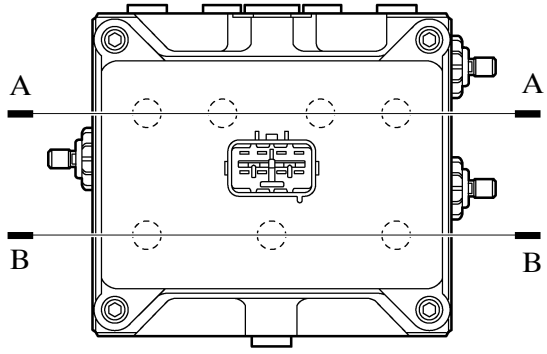
▶ Specifications ◀

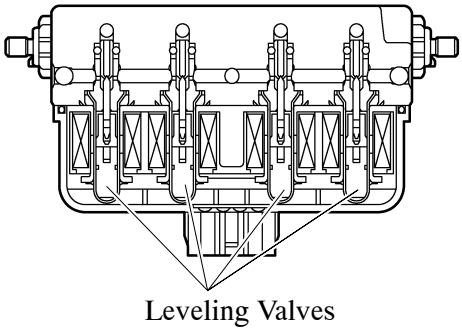
Sealed Gas		Nitrogen Gas
Gas Chamber Volume	cc (cu in.)	945 (57.7)
Sealed Gas Pressure	MPa (kgf/cm^2, psi)	5.9 (60, 856)

3) Height Control Valve

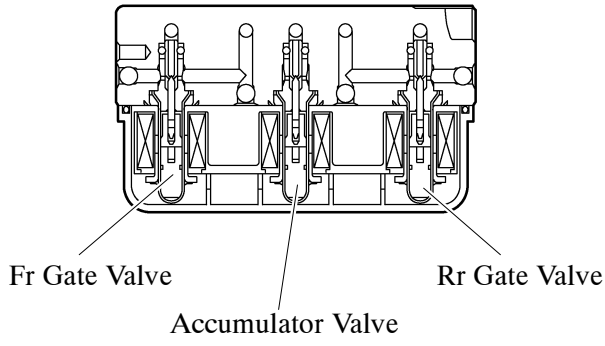
a. General

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





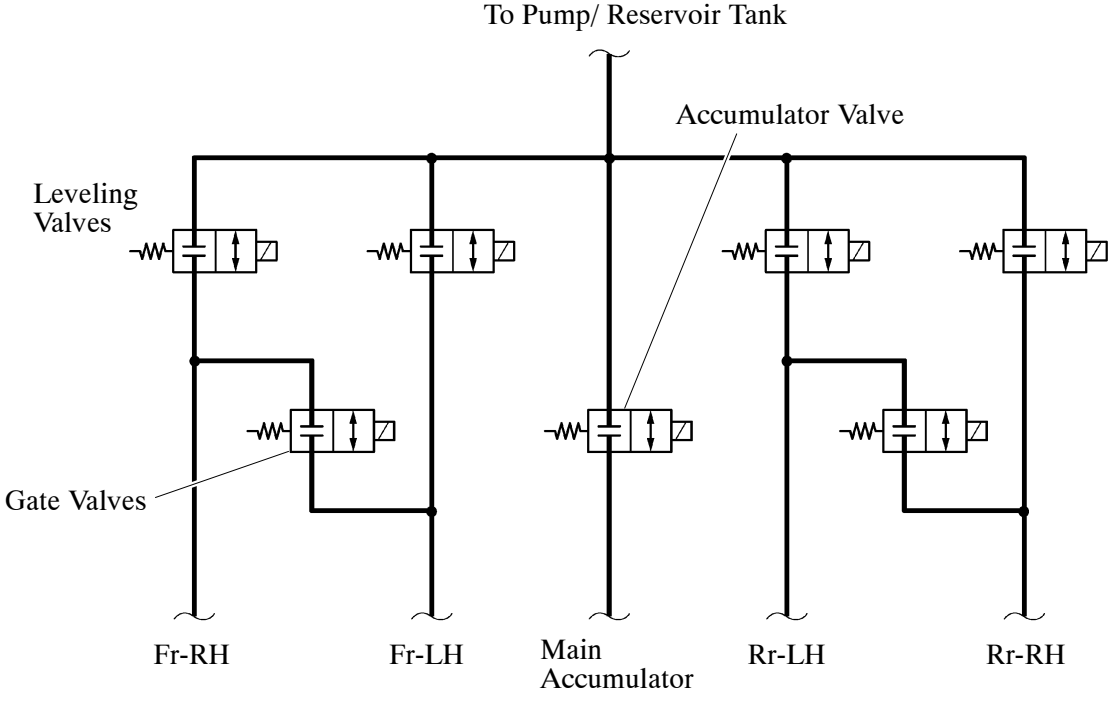
A-A Cross Section



B-B Cross Section

081CH72Y

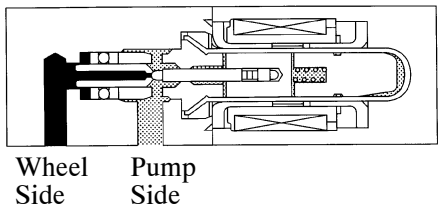
▶ Arrangement Layout of Hydraulic Tubes ◀



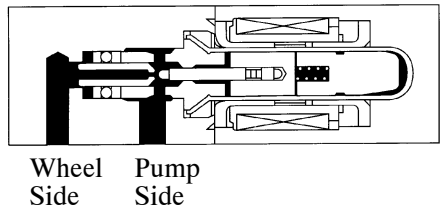
081CH73Y

b. 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, and during vehicle height control, the fluid passage opens in accordance with the signal received from the suspension control ECU.



Close



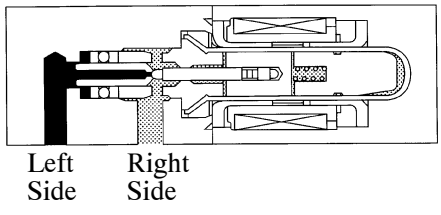
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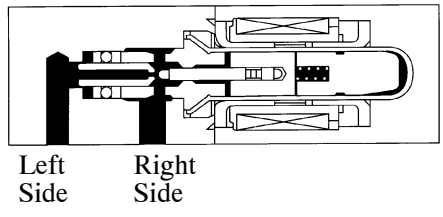
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c. Gate Valve

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. When the vehicle starts driving, the fluid passage opens in accordance with signals from the suspension control ECU, to balance the fluid pressure for both the left and right gas chambers.



Close

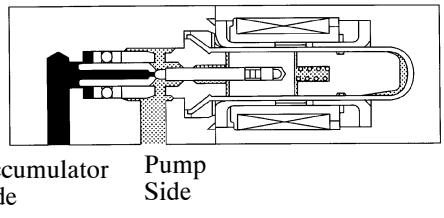


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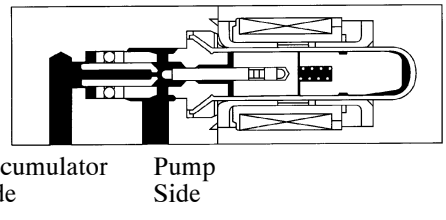
155CH80

d. Accumulator Valve

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



Close

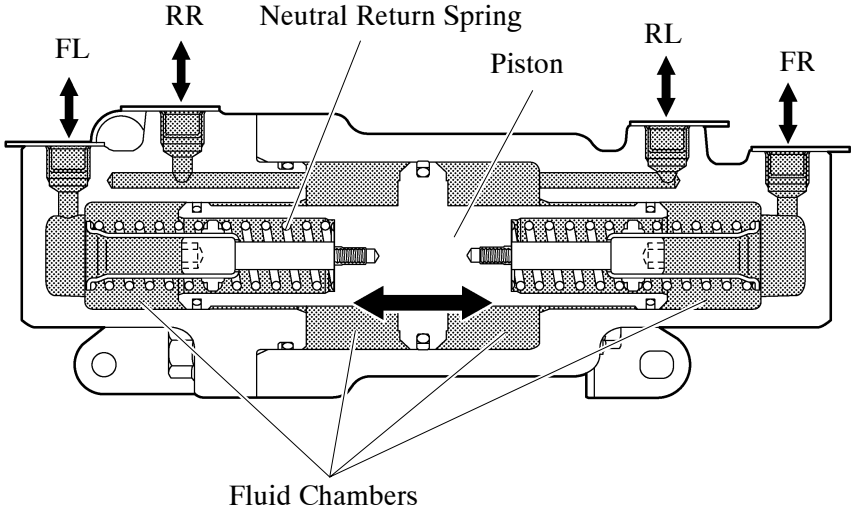


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4) Center Cylinder

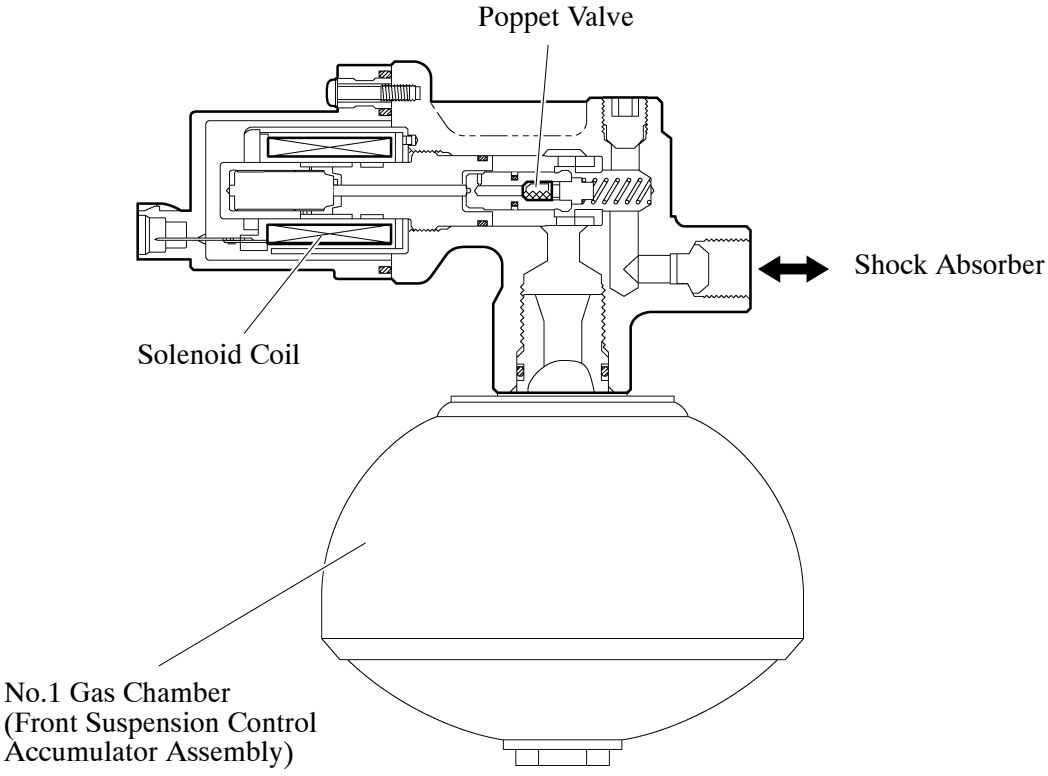
- The center suspension control cylinder sub-assembly is comprised of four fluid chambers and a piston.
- The fluid chambers are connected to each other via the hydraulic tubes from each of the shock absorbers. The center cylinder optimally distributes the hydraulic pressure for each of the wheels through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



081CH74Y

5) Spring Rate Switching Valve (Suspension Control Valve)

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

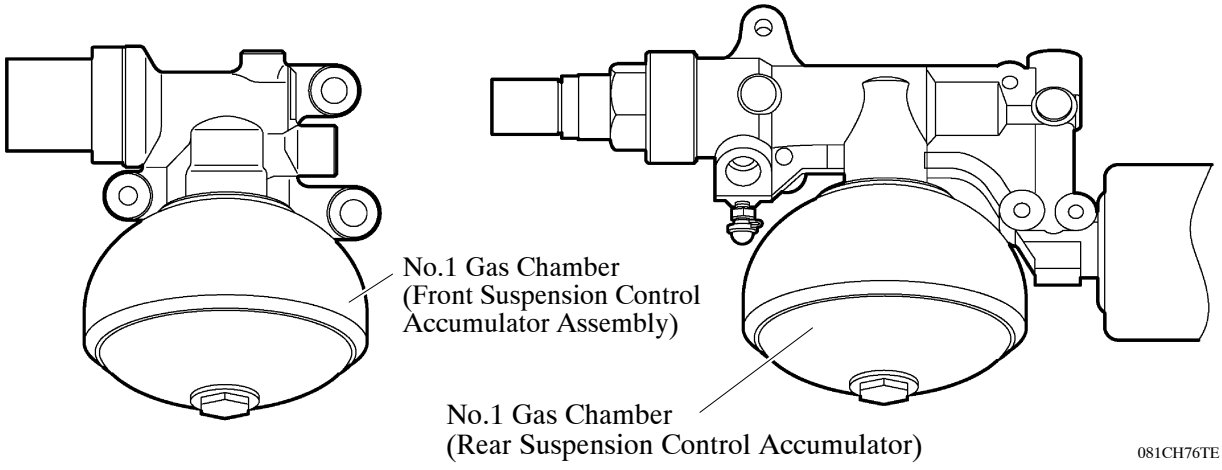


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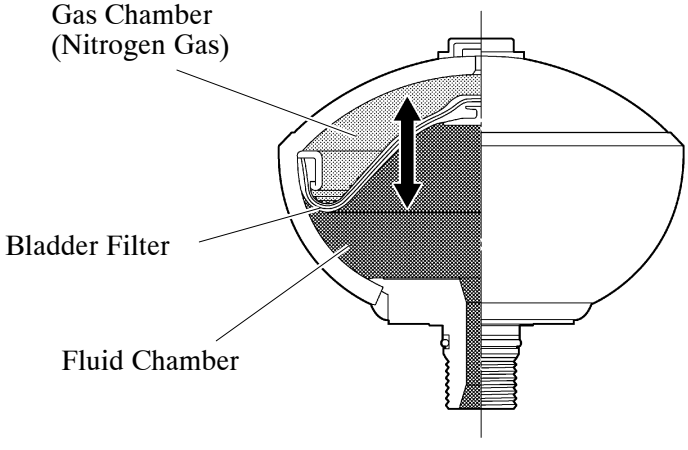
Suspension Control Valve

6) No.1 Gas Chamber

- A No.1 gas chamber is provided for each of the wheels. This acts like a gas spring and was designed with a very low compression rate utilizing a large-volume gas chamber.
- The front No.1 gas chamber is provided for the front suspension control valve.
- The rear No.1 gas chamber is provided for the rear shock absorber control valve.
- The No.1 gas chamber uses the bladder filter type hydropneumatic 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.



Front Suspension Control Valve Assembly **Rear Suspension Control Accumulator Assembly**



No.1 Gas Chamber

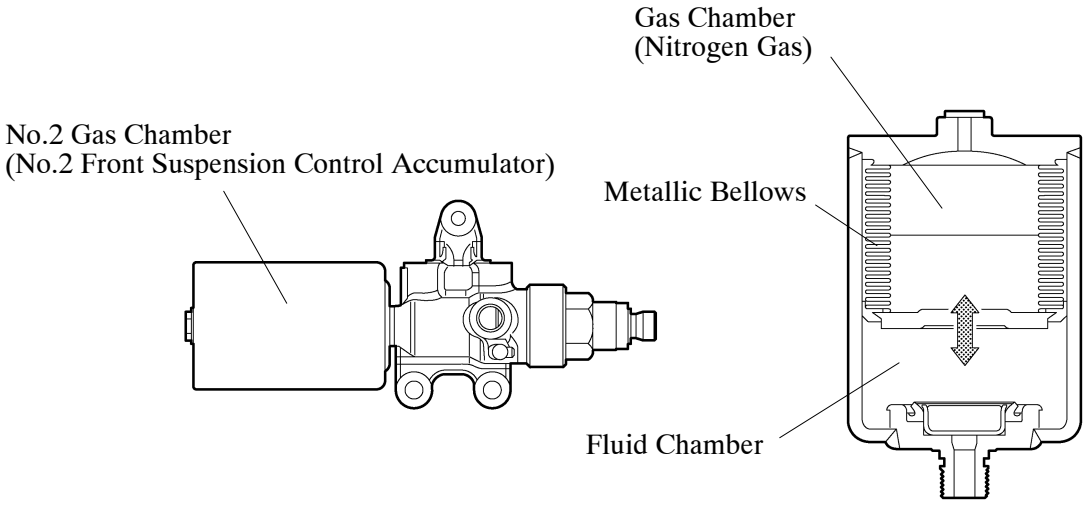
081CH91Y

▶ Specifications ◀

		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)

7) No.2 Gas Chamber

- A No.2 gas chamber is provided for the front shock absorber control valve. This acts like a gas spring and was designed with a very 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 in the gas chamber is varied by allowing the fluid to flow in and out of this gas chamber in accordance with the vehicle height adjustment and any impacts with the ground.



Front Suspension Control Accumulator Assembly **No.2 Gas Chamber**

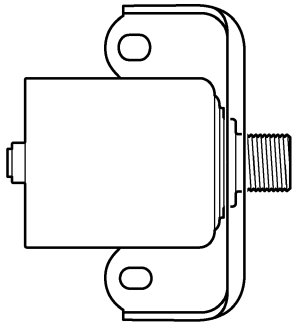
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▶ Specifications ◀

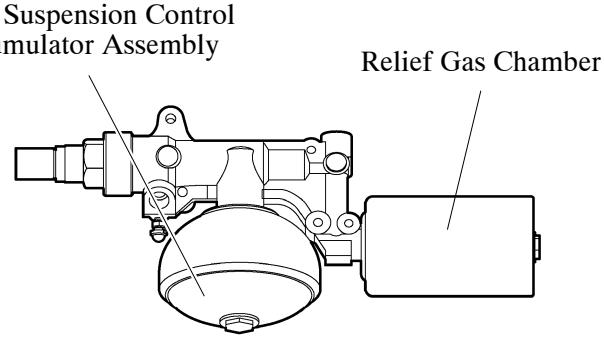
Sealed Gas		Nitrogen Gas
Gas Chamber Volume	cc (cu in.)	120 (7.3)
Sealed Gas Pressure	MPa (kgf/cm^2, psi)	1.8 (18, 261)

8) Relief Gas Chamber

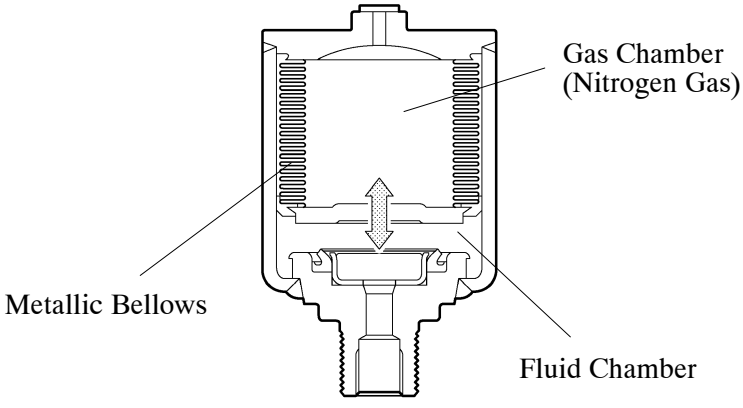
- A relief gas chamber is provided for each of the wheels. This protects the hydraulic system by reducing increases in the fluid pressure inside the hydraulic tubes for the active height control suspension.
- The front relief gas chamber is placed directly over the front hydraulic tubes.
- A rear relief gas chamber is provided for the rear shock absorber control valve.
- 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.



Front Relief Gas Chamber



Rear Suspension Control Accumulator Assembly



Relief Gas Chamber

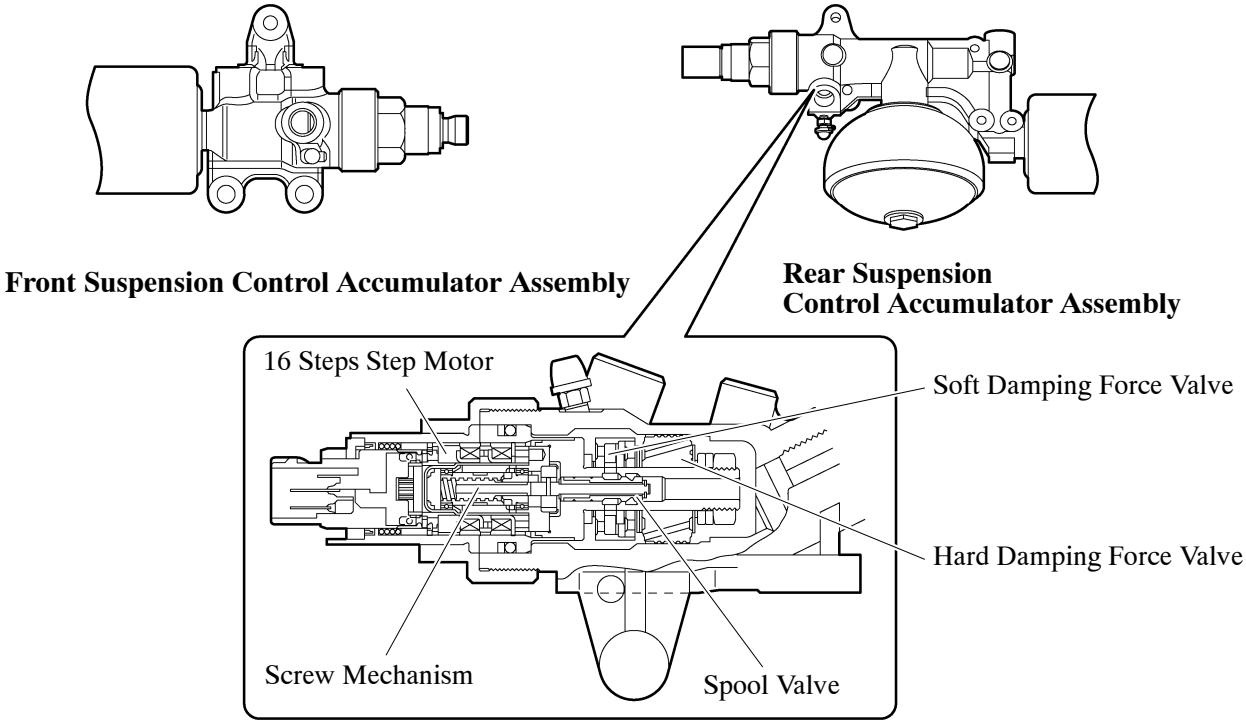
081CH78TE

▶ Specifications ◀

		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)

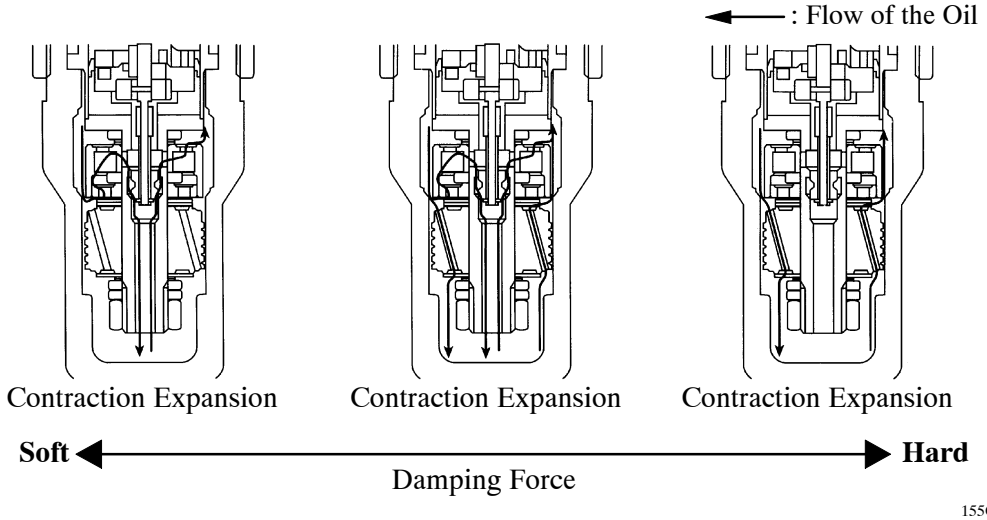
9) Damping Force Control Actuator

- A damping force control actuator is provided for each of the suspension control accumulator assemblies.
- This actuator consists of the 16 steps step motor, a screw mechanism (which converts the rotational movement to a linear movement), a spool valve, a soft damping force valve and 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.



081CH79TE

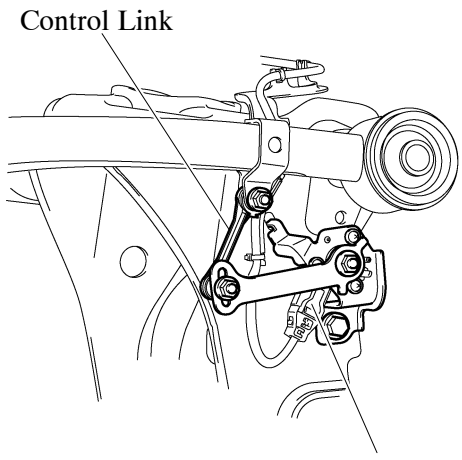
▶ Fluid flow in Damping Force Control Actuator ◀



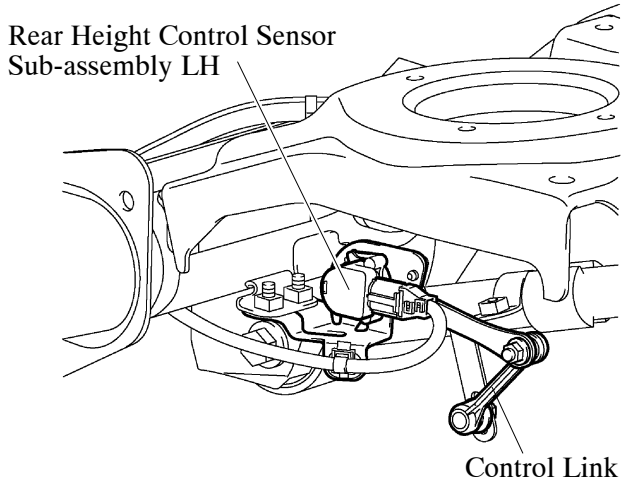
155CH84

10) Height Control Sensor

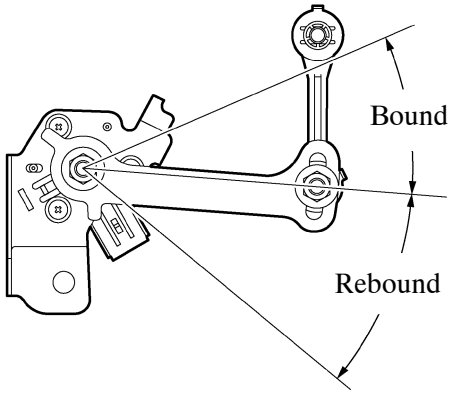
- Hall IC type height control sensors have been provided. The Hall IC converts the changes in the magnetic flux that occur at that time into electrical signals, and outputs them in the form of height control sensor effort to the suspension control ECU.
- There are two front height control sensors, one 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, for the right and left sides. 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.



081CH80TE

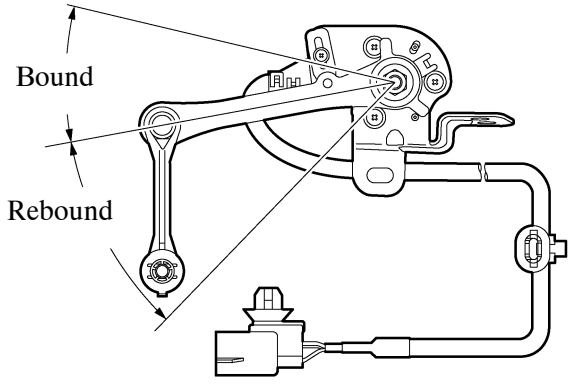


081CH92TE



Front

081CH93TE



Rear

081CH94TE

System Operation

1) Height Control

a. General

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

Function	Outline
Manual Operation (See Page CH-146)	The vehicle height will be automatically adjusted over 3 levels.
Automatic Leveling	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.
Extra-High	If the crawl control is activated or any of the tires are stuck when the transfer is set in the L4 range and the vehicle height is set to High, the vehicle height is raised up to the Extra-High position, 20mm higher than the position of High.
Vehicle Speed Sensing (See Page CH-150)	The vehicle height will be automatically adjusted in accordance with the vehicle speed and selected vehicle height.
Vehicle Height Adjustment Prohibition Control	When the vehicle is raised on a jack or is being towed with the engine turned OFF, the vehicle height adjustment can be prevented 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 vehicle height, or higher than approximately 30 km/h (19 mph) at the high or low vehicle height.

b. Manual Operation

i) General

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

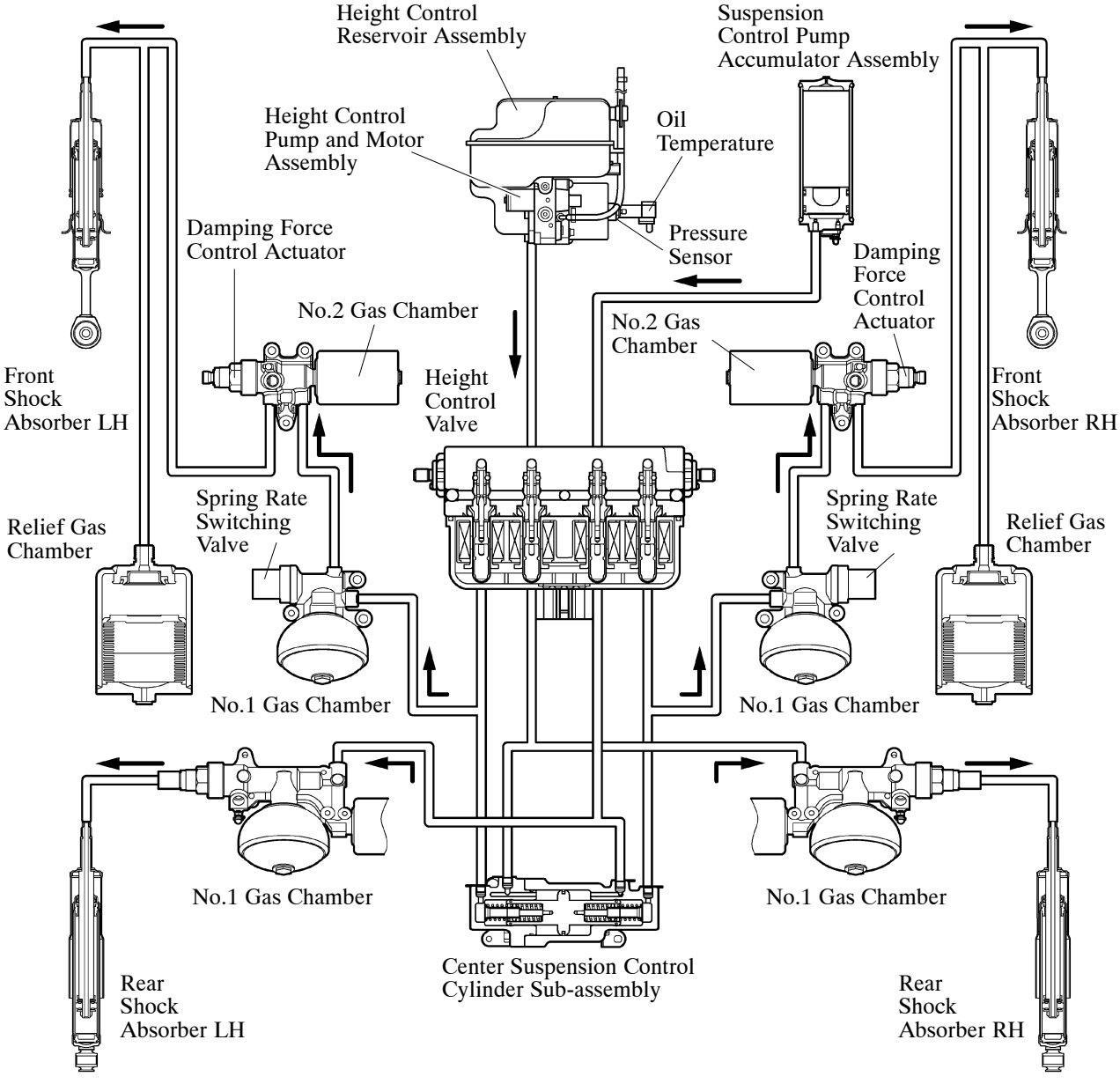
Selected Height Position		Lo	N	Hi
Vehicle Height	Front	Approximately -60mm (-2.4 in.)	Standard Vehicle Height	Approximately +50mm (+2.0 in.)
	Rear	Approximately -40mm (-1.6 in.)	Standard Vehicle Height	Approximately +60mm (+2.4 in.)
Vehicle Height Adjustment Speed	Up	Lo to N Approximately 11 to 16 seconds*1		
	Down	N to Lo Approximately 2 or 5 seconds*2		

*1: Vehicle height control speed differs depending on the loaded condition.
*2: The vehicle height adjustment speed varies depending on the shift positions:
- Approx. 2 seconds when the shift position is in the P range
- Approx. 5 seconds when the shift position is in the N range

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: 1460kg / Rear axle weight: 1800kg (3968 lb.)

ii) Raising the 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 No.1 height control valve assembly. This allows the fluid to flow from the pump into the shock absorber and gas chamber from the pump and results in an increase in the vehicle height. Simultaneously, the accumulator valve opens, guiding the fluid into them from the suspension control accumulator, thereby raising the vehicle height.

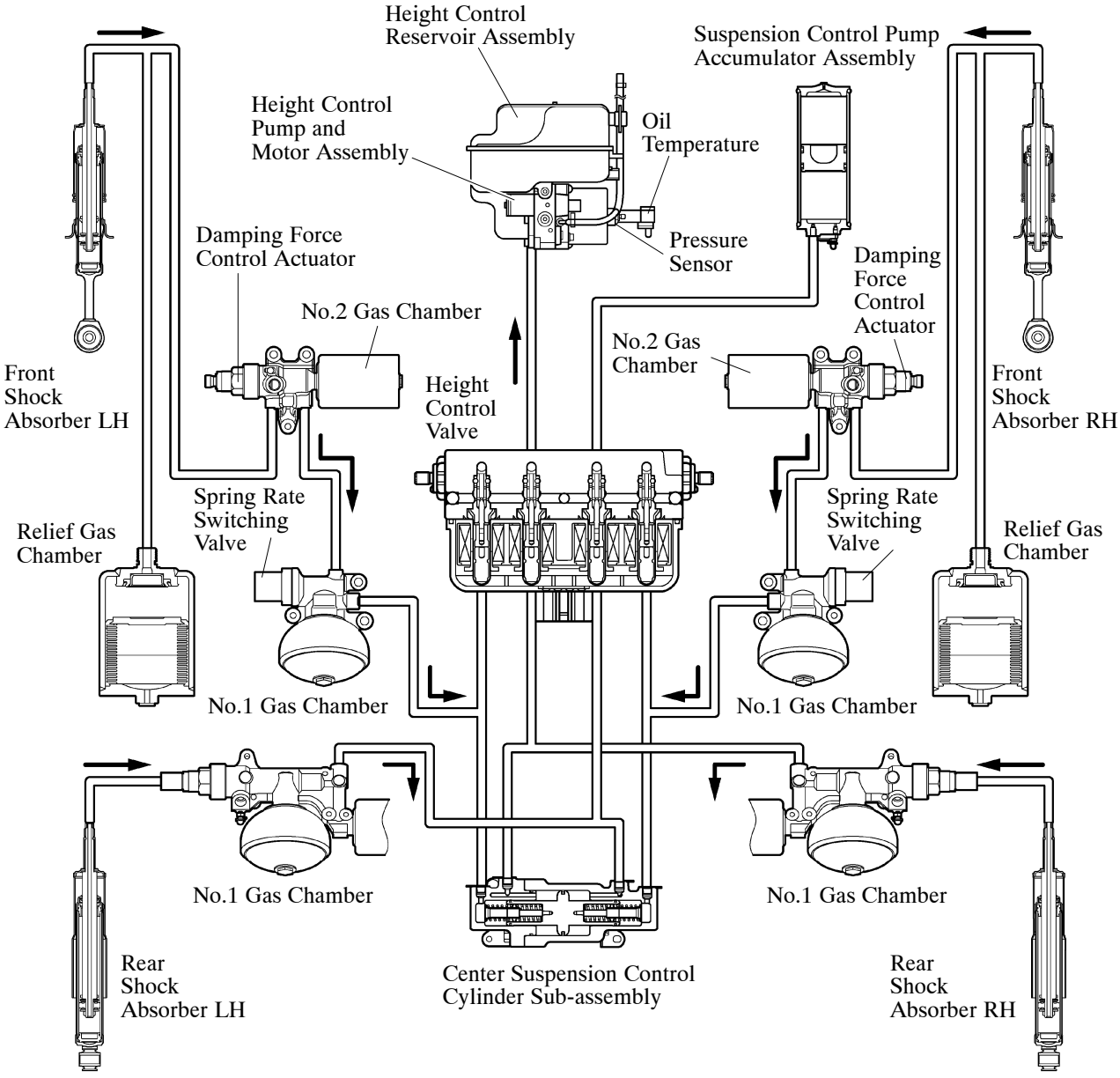


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iii) Lowering the Vehicle Height (Manual Operation)

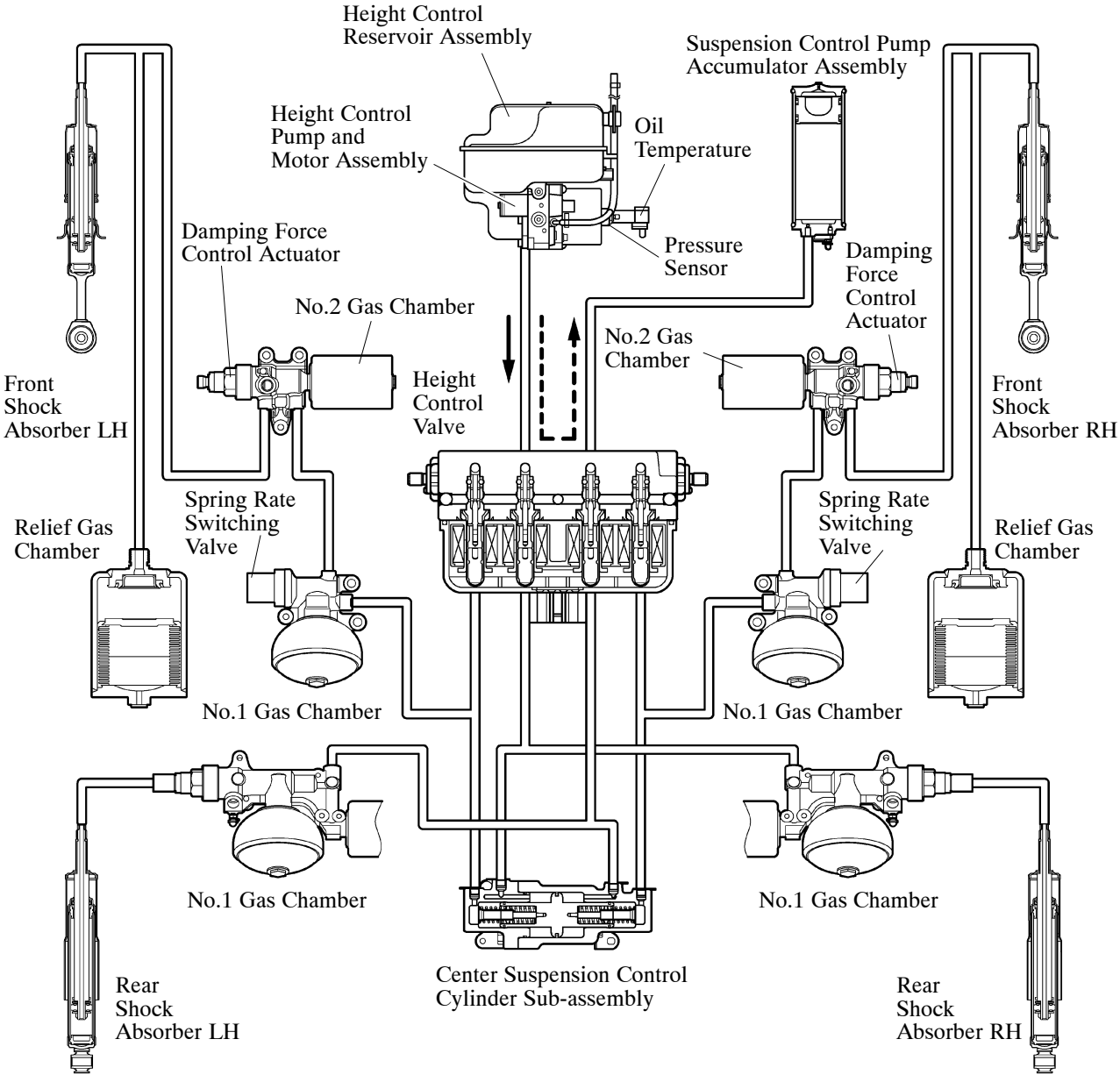
- When the height select switch is operated to lower the vehicle height from High to Normal, or from Normal to Low, the suspension control ECU opens the front and rear leveling valves simultaneously, allowing the fluid in the gas chambers and the shock absorbers arranged for each of the wheels to return into the height control reservoir assembly, 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.



081CH82TE

iv) Fluid Stored in Height Control Accumulator

Normally, the suspension control 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 low to normal, or from normal to high, it is necessary to replenish the fluid in the suspension control accumulator.
At this time, the pump motor is operated to rotate the pump, the leveling valves are closed, the accumulator valve of the suspension control accumulator is opened, and the fluid is stored in the suspension control accumulator.
When the vehicle height is raised while the fluid that is stored in the suspension control 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 accumulator.



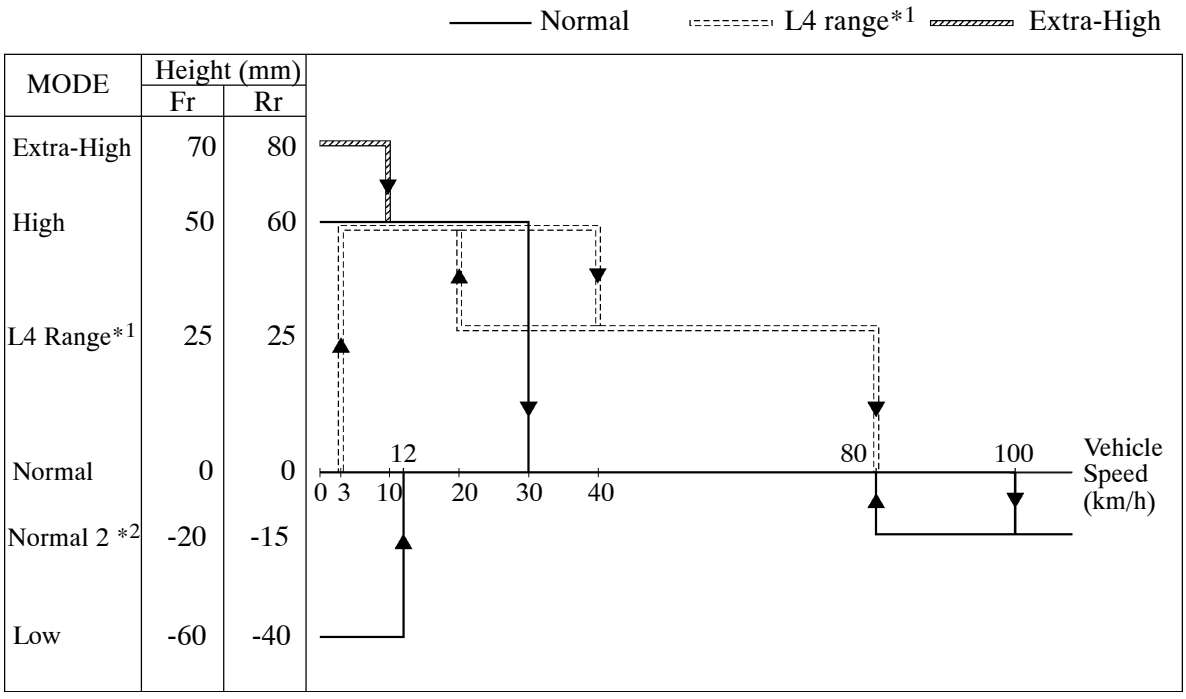
081CH83TE

c. Vehicle Speed Sensing Function

This function automatically adjusts the vehicle height in accordance with the vehicle speed in order to ensure stability and riding comfort while driving.

- If the vehicle speed exceeds approximately 12km/h (7mph) when the vehicle height is set to Low, the vehicle height will be automatically adjusted to Normal height.
- If the vehicle speed exceeds approximately 30km/h (19mph) when the vehicle height is set to High, the vehicle height will be automatically adjusted to Normal height.
- If the vehicle speed exceeds approximately 100km/h (62mph) when the vehicle height is set to Normal height, the vehicle height will be lowered to a position, approximately 20mm(front)/ 15 mm (rear) from the Normal height (Normal 2 mode). If the vehicle speed is decreased to approximately 80km/h (50mph) or less while this is in effect, the vehicle height is automatically adjusted to Normal height.
- If the vehicle speed exceeds approximately 3km/h (2mph) when the transfer is set in the L4 range and the vehicle height is set to Normal, and the suspension control ECU determines the vehicle is running on a rough road, the vehicle height is automatically adjusted to High. When the vehicle speed exceeds 40km/h (25mph), the vehicle height can be lowered, approximately 25 mm from the High height. When the vehicle speed is lowered to approximately 20km/h (12mph) or less, the vehicle height is automatically adjusted to High. On the other hand, when the vehicle speed exceeds approximately 80km/h (50mph), the vehicle height is automatically adjusted to Normal (L4 mode).
- If the vehicle speed exceeds approximately 10km/h (6mph) when the vehicle height is set to Extra-High, (approximately 20mm higher than the High height), the vehicle height is automatically adjusted to High.

▶ Height Control ◀



*1: When the transfer is in the L4 range.
*2: When the vehicle height is lowered during high-speed driving.

081CH84H

2) Damping Force Control

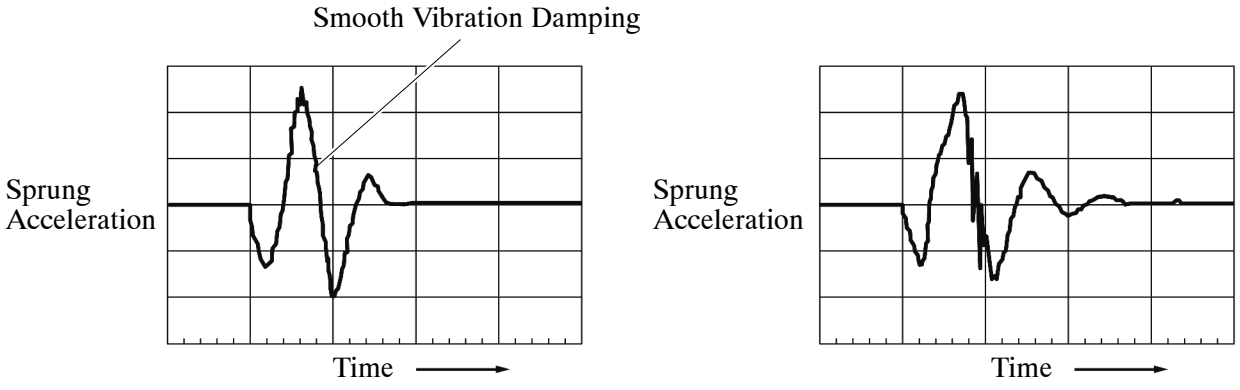
a. General

The damping force control has following functions:

Control	Function
Non-Linear H^{∞} Control (See Page CH-152)	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 ensuring a high level of vibration damping performance.
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-152)	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 at a softer variable range at low speeds, and at a firmer variable range at high speeds.
Absorber Control	The absorber control 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 3 or 8 steps, thereby ensuring riding comfort during off-road driving.

b. Non- Linear H^{∞} Control

This control uses 3 acceleration sensors to detect the sprung 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.

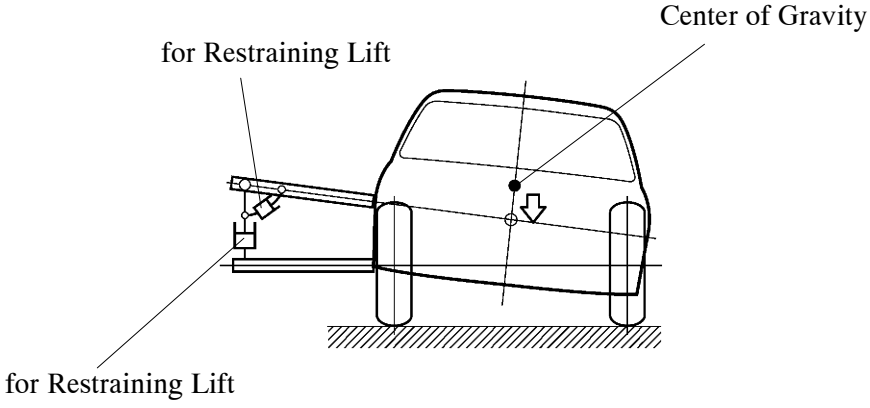


Non-linear H^{∞} Control **Linear Control**

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c. Roll Posture Control

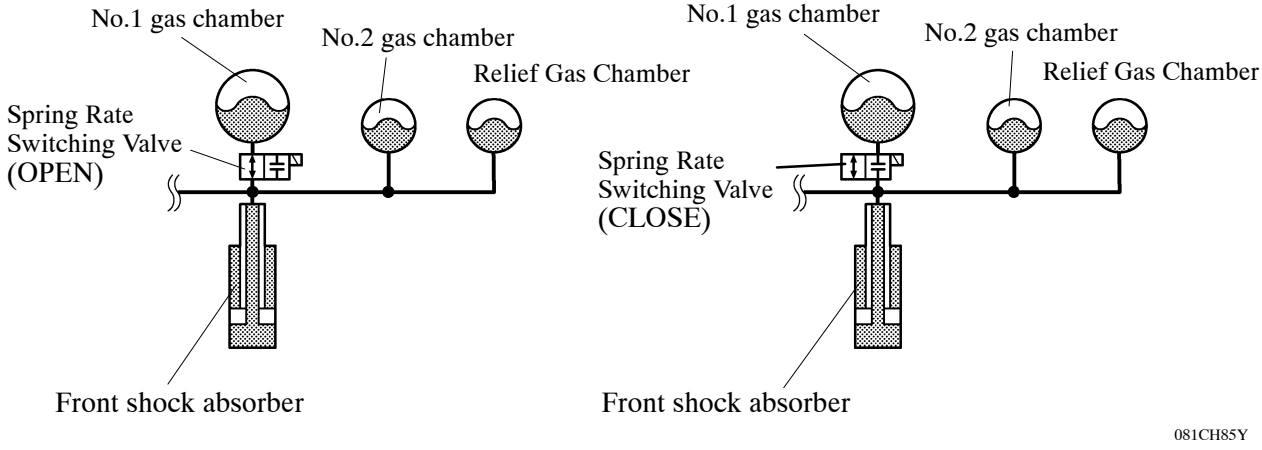
- Changes the damping force to control the vehicle posture during cornering. As a result, excellent stability and controllability have been realized during cornering. This control assumes that two types of shock absorbers (one for restraining roll and the other for restraining lift) are provided at an 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 sensor. Thus, the driving conditions of the vehicle are detected.



211CH54

3) 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 control 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 spring rate control closes the spring rate control 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.



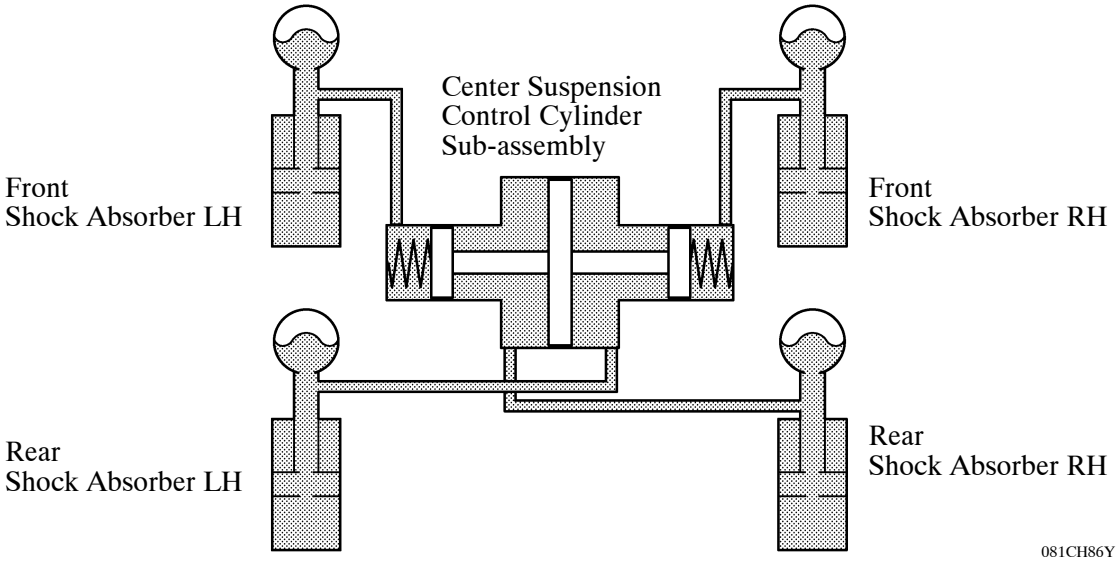
Under Normal Driving Conditions

When cornering or the brake pedal is being depressed

4) 4-wheel Related Control

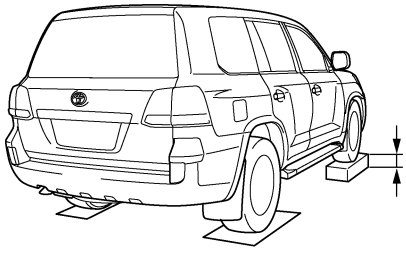
a. General

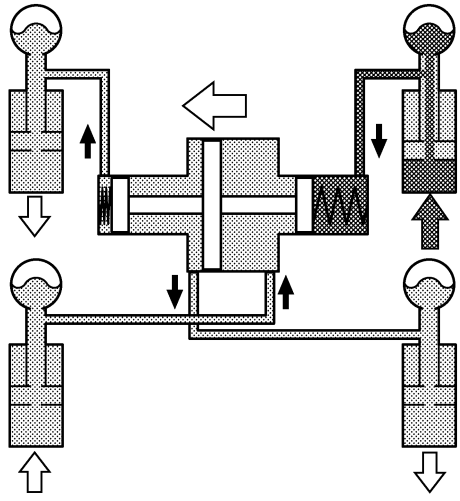
When a change in the hydraulic pressure for a shock absorber is required for the driving conditions, the 4-wheel related control adjusts the hydraulic pressure for the other shock absorbers through the center cylinder which is connected to all shock absorbers to stabilize the vehicle posture. Moreover, during cornering, braking and when driving on rough roads, the center cylinder operates differently depending on the center suspension control cylinder sub-assembly structure and shock absorber connection method, thereby achieving the optimum on-road and off-road driving performance.



b. 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 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.

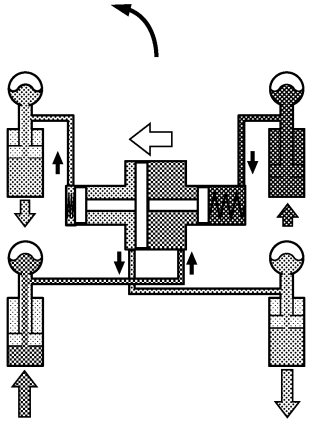




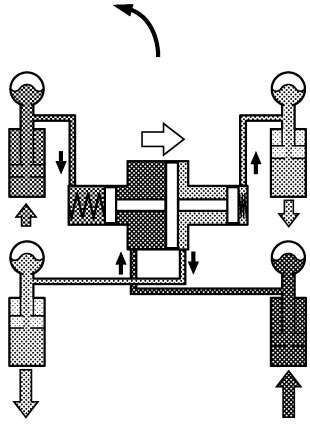
081CH87Y

c. 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, thus, the piston inside the center 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, thus, the piston inside the center cylinder moves to the right in accordance with changes in the hydraulic pressure balance for each of the wheels. As a result, the pressure is applied to the front right absorber, and the front suspension is caused to move in the opposite direction from that of the rear suspension. 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

5) Fail-safe

- If the suspension control ECU detects a malfunction in the active height control suspension, 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 height at a speed of 30 km/h (19mph) or more.

6) 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 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 and checking the “DIAG 4-WHEEL AHC” that appears on the multi-information display.

For details, see the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

7) Active Test

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

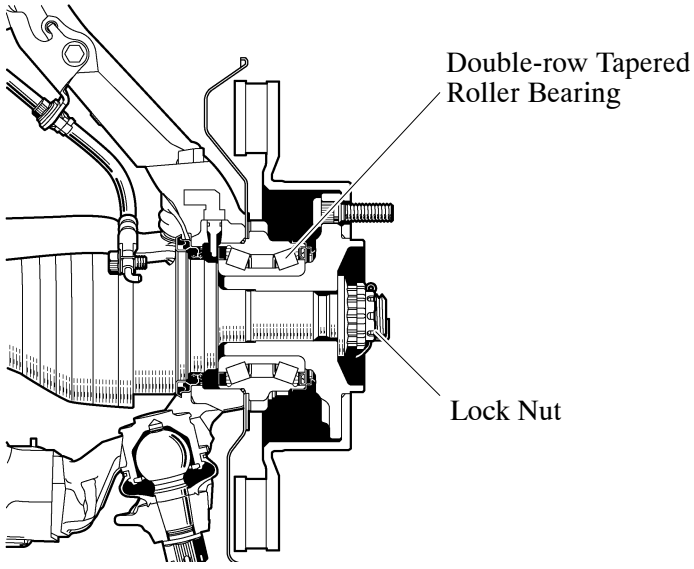
- Vehicle height and damping force of each wheel can be operated by connecting an intelligent tester II to the DLC3.
- Vehicle height of each wheel can be operated by connecting the terminals of the height control connector.

For details, see the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

■AXLE

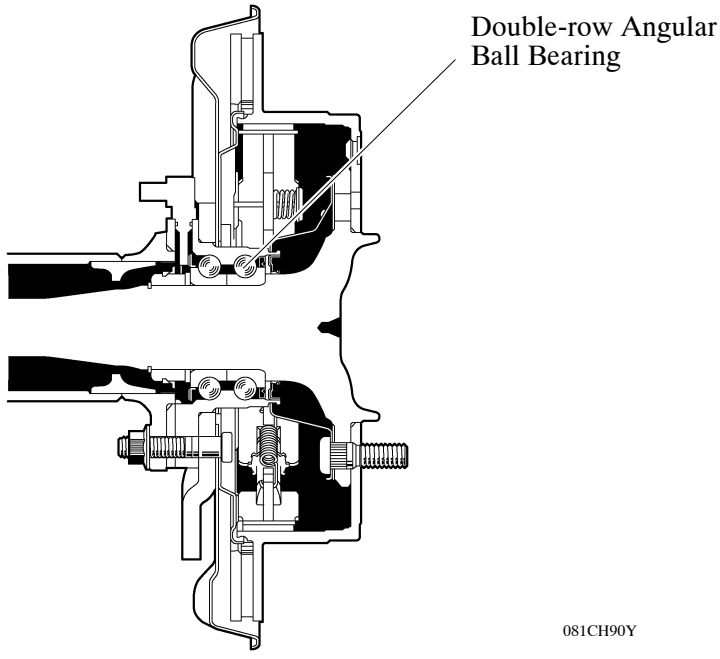
- Maintenance-free upper and lower ball joints and front axle hub bearings are used. The front axle hub bearings that are used are unit-type double-row tapered roller bearings.
- Unit-type double-row angular ball bearings are used for the rear axle shaft bearings.
- The speed sensor rotors have been 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).

▶ Front Axle ◀



081CH89Y

▶ Rear Axle ◀



081CH90Y

Service Tip

Speed Sensor Rotor Handling Precautions:

- Do not allow any iron particles, iron sand, dust, debris, or oil to come in contact with the surface of the speed sensor rotor.
- Do not place magnetized objects close to the surface of the speed sensor rotor.

BRAKE

■ DESCRIPTION

1. General

- The hydraulic brake booster assembly in which the brake actuator, brake booster, master cylinder are integrated is used.
- A double-link type variable lever ratio brake pedal is used.
- In addition to the conventional ABS, a Multi-terrain ABS, which automatically calculates 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 and brake pedal operation. (Only for 2UZ-FE engine models)
- The new Land Cruiser (Station Wagon) has a brake system with the following equipment and specifications:

▶ Equipment ◀

Front Brake Type		Ventilated Disc
Rear Brake Type		Ventilated Disc
Brake Control System	Multi-terrain ABS with EBD, Brake Assist	Standard
	Multi-terrain ABS with EBD, Brake Assist, A-TRC, VSC, Hill-start Assist Control and Downhill Assist Control*1	Standard or Option*3
	Multi-terrain ABS with EBD, Brake Assist, A-TRC, VSC, Hill-start Assist Control and CRAWL*2	Standard or Option*3
Parking Brake Operation Type		Lever Type

*1: Only for 1VD-FTV engine models.
*2: Only for 2UZ-FE engine models.
*3: Depending on the destinations and grades. For details, see page MO-33.

▶ Specifications ◀

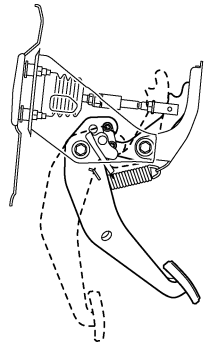
Master Cylinder	Type		Single (Double Piston)
	Diameter	mm (in.)	26.99 (1.06)
Brake Booster			Hydraulic
Front Brake	Caliper Type		17” S15WA
	Wheel Cylinder Diameter	mm (in.)	51.1 (2.01) × 2
	Rotor Size (D × T)*1	mm (in.)	340 × 32 (13.39 × 1.26)
	Pad Area	cm^2 ($in.^2$)	65.0 (10.08) × 2
	Pad Material		PV565H, T4146*2
Rear Brake	Caliper Type		17” FS13C
	Wheel Cylinder Diameter	mm (in.)	45.4 (1.79)
	Rotor Size (D × T)*1	mm (in.)	345 × 18 (13.59 × 0.71)
	Pad Area	cm^2 ($in.^2$)	36.7 (5.69) × 2
	Pad Material		PS558H
Parking Brake	Type		Duo Servo Drum
	Drum Inner Diameter	mm (in.)	240 (9.45)

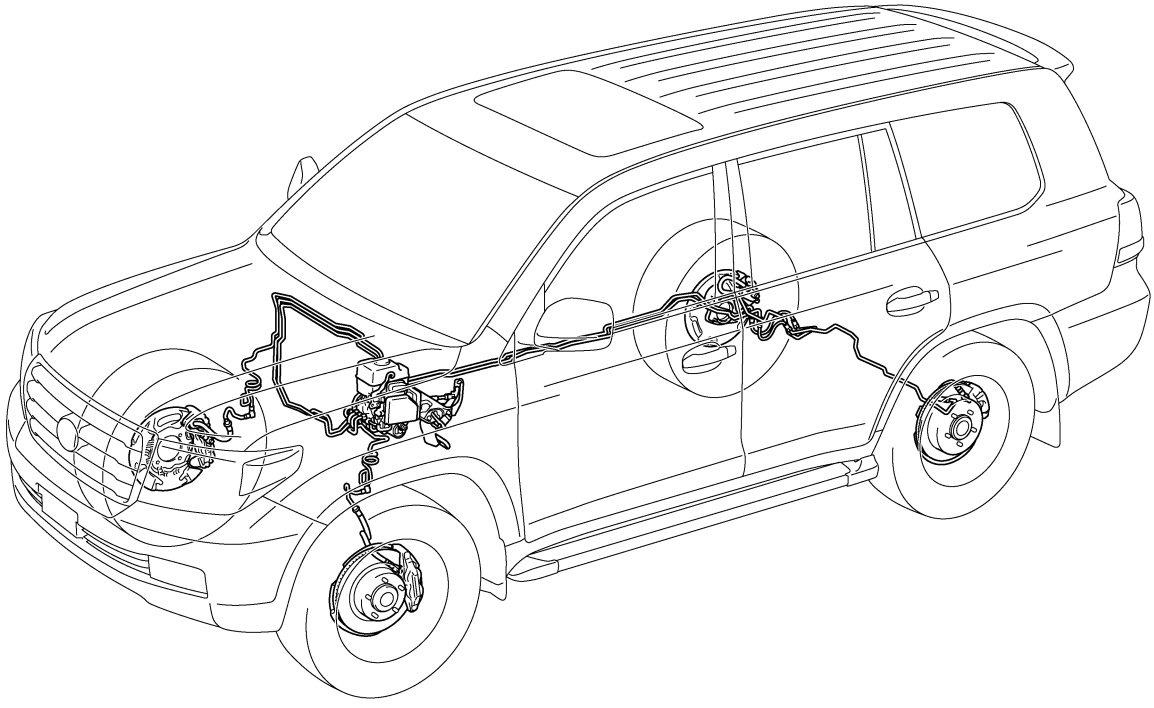
*1: D: Outer Diameter, T: Thickness

*2: Only on European models for the German package.

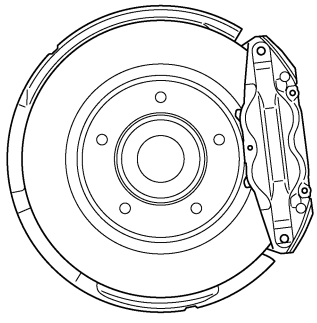
2. Components of Brake System

▶ **Brake Pedal (Double-Link Type)** ◀

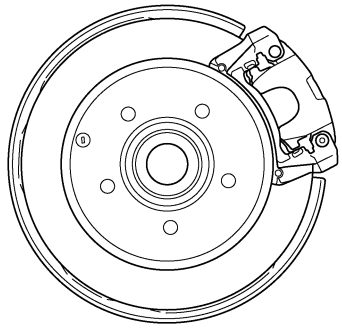




▶ **Front Brake** ◀



▶ **Rear Brake** ◀

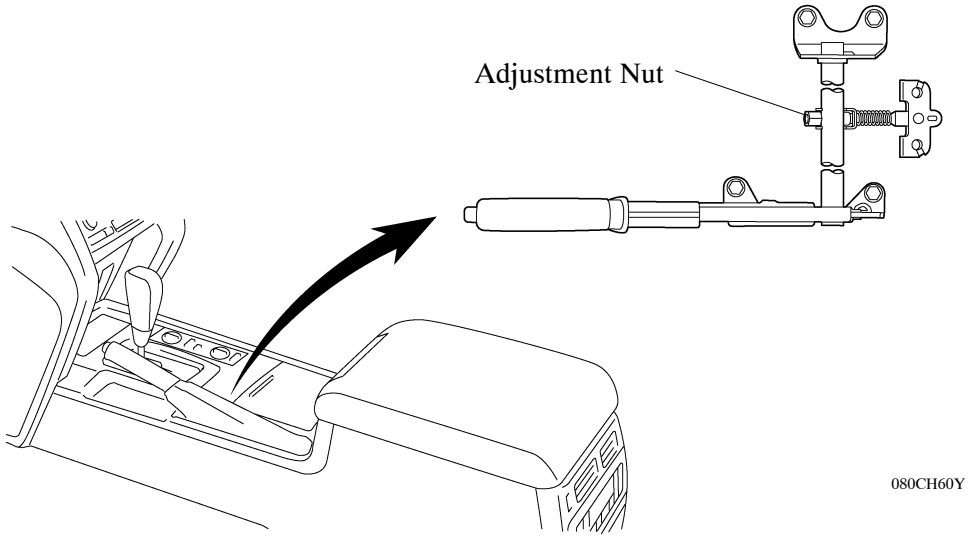


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■PARKING BRAKE

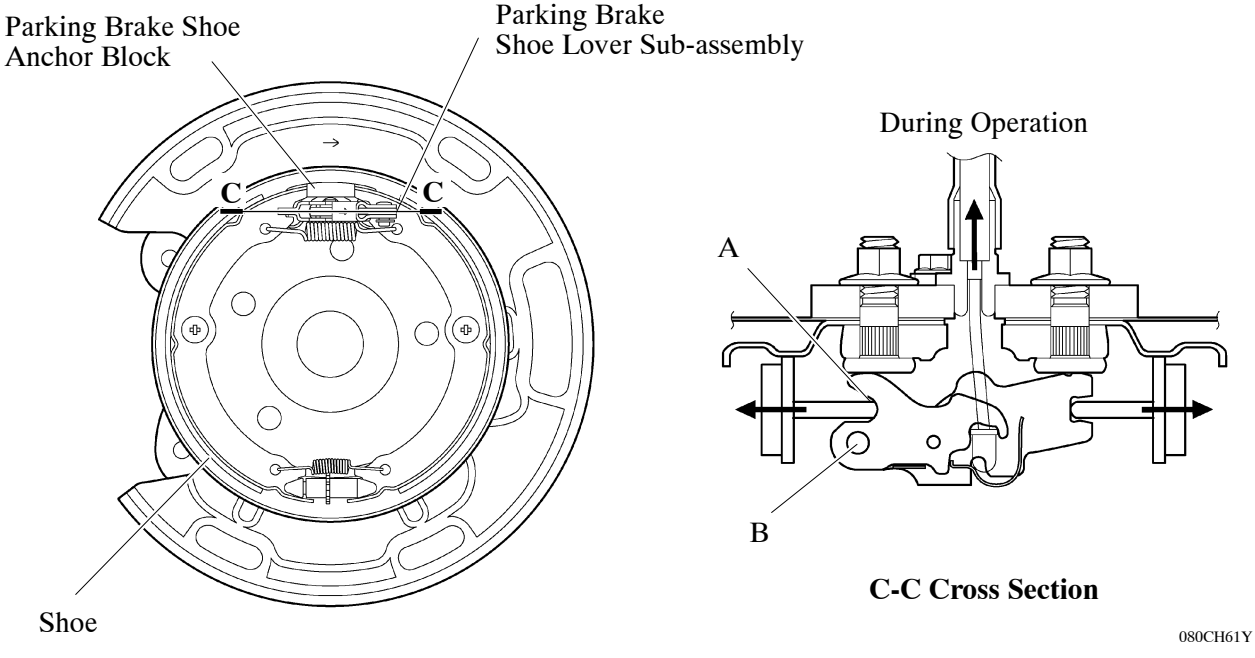
1. Offset Type Parking Brake Lever

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.



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 parking brake shoe lever sub-assembly, parking brake shoe anchor block, shoe. When the parking brake is operated, it pulls on the cable, and this causes the parking brake shoe lever to expand the shoes via fulcrums “A” and “B”.



■BRAKE CONTROL SYSTEM (Multi-terrain ABS with EBD and Brake Assist)

1. General

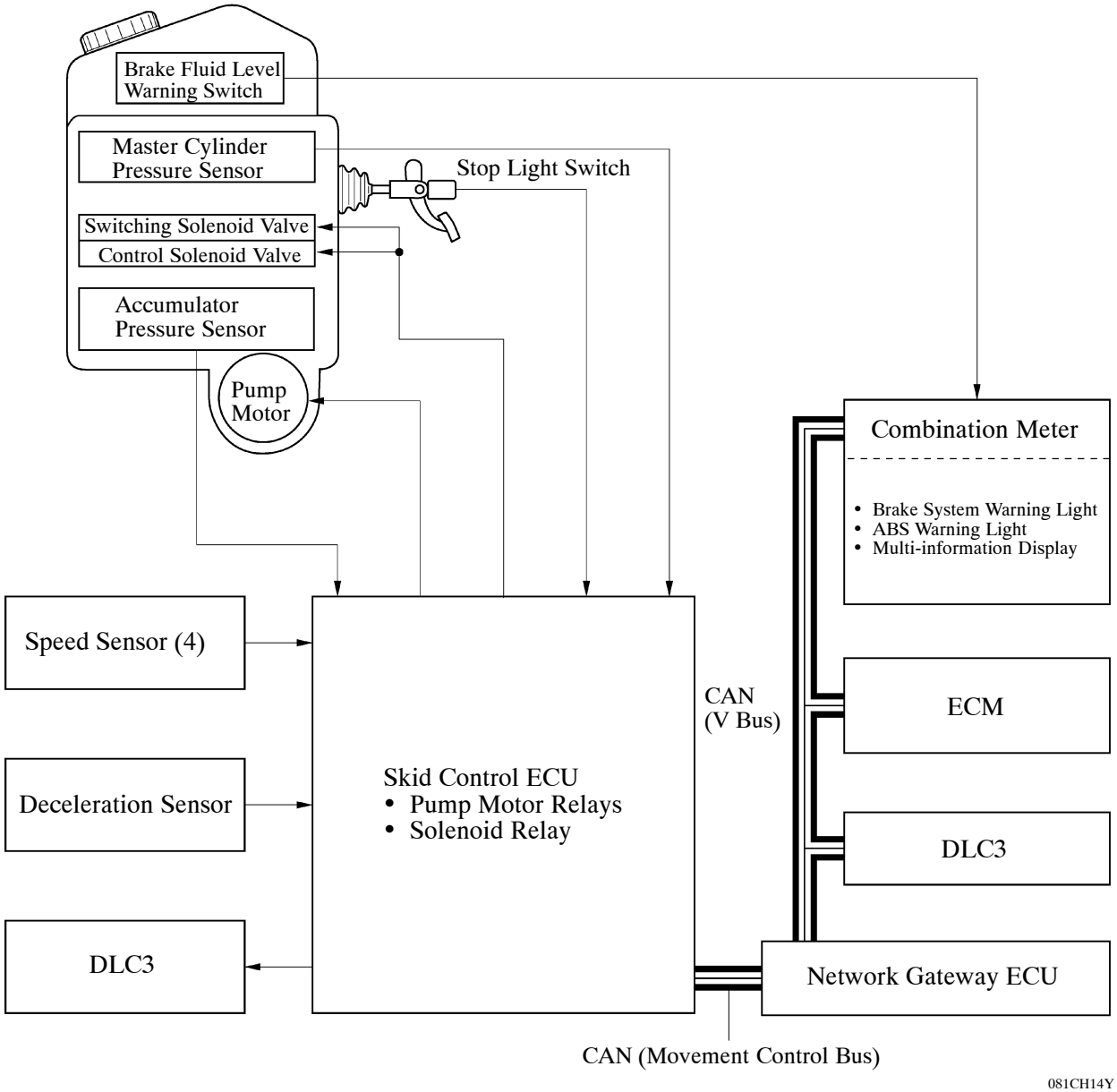
The brake control system (Multi-terrain ABS with EBD, brake assist) of new Land Cruiser (Station Wagon) has the following functions:

Function	Outline
Multi-terrain ABS (Anti-lock Brake System)	The ABS helps prevent the wheels from locking when the brakes are applied firmly or when braking on a slippery surface. In addition to the existing ABS function, the Multi-terrain ABS automatically calculates the optimum ABS control in accordance with the off-road situation such as a dirt or sandy road.
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.

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 a malfunction.

▶ System Diagram ◀



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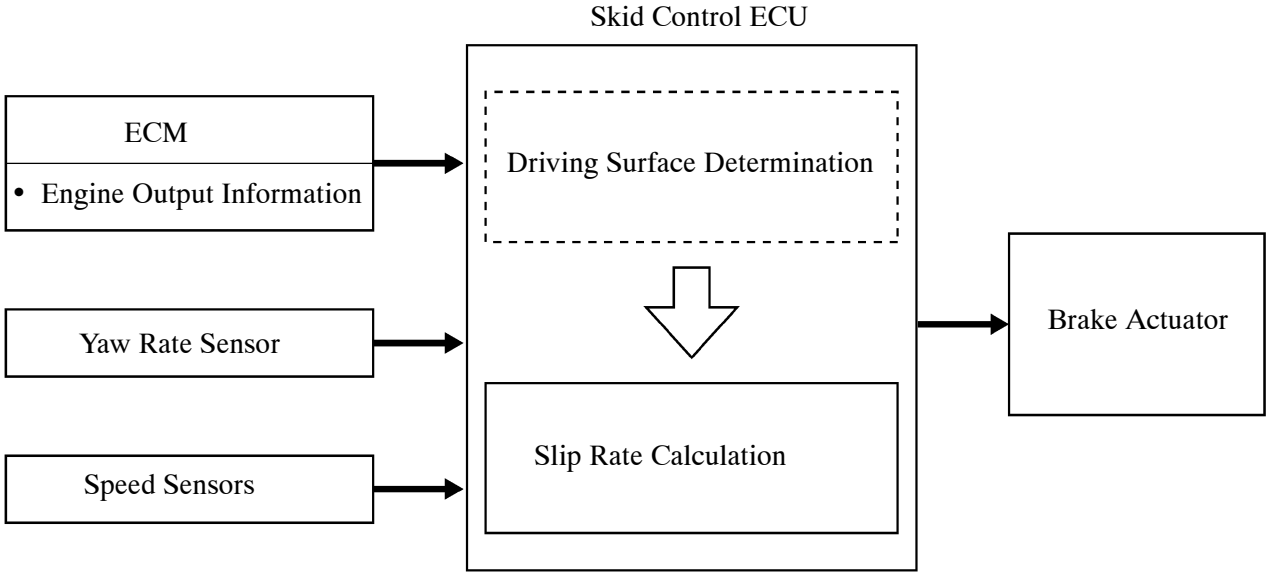
2. Outline of Multi-terrain ABS

General

The conventional ABS, by regulating the hydraulic brake pressure of all the wheels by monitoring the wheel speeds during braking, 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.

Effective 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, the deceleration rate has been increased.



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3. Outline of EBD

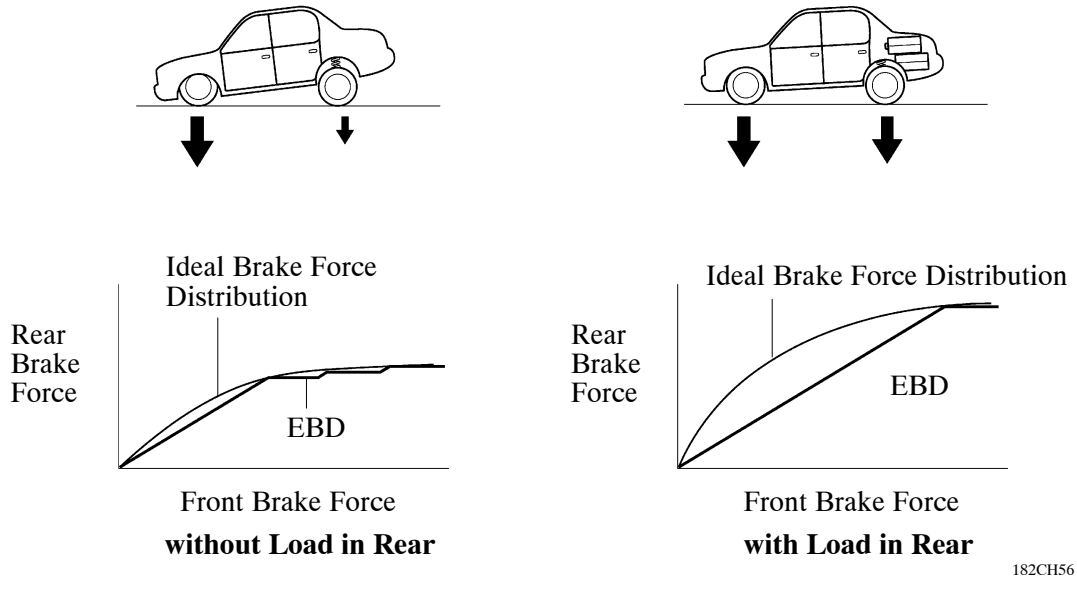
General

The distribution of the brake force, which was performed mechanically in the past, is now performed under electrical control of the skid control ECU, which precisely controls the braking force in accordance with the vehicle's driving conditions.

Front/ Rear Wheels Brake Force Distribution

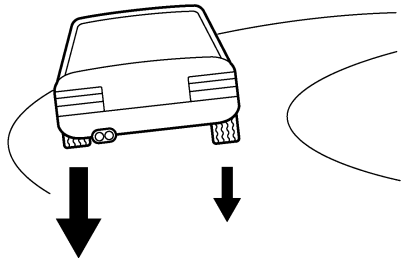
If the brakes are applied while the vehicle is moving straight forward, the transfer of the road reduces the load that is applied to the rear wheels. The skid control ECU determines this condition by way of the signals from the speed sensor, and the brake actuator regulates the distribution of the brake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

▶ EBD Concept ◀



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

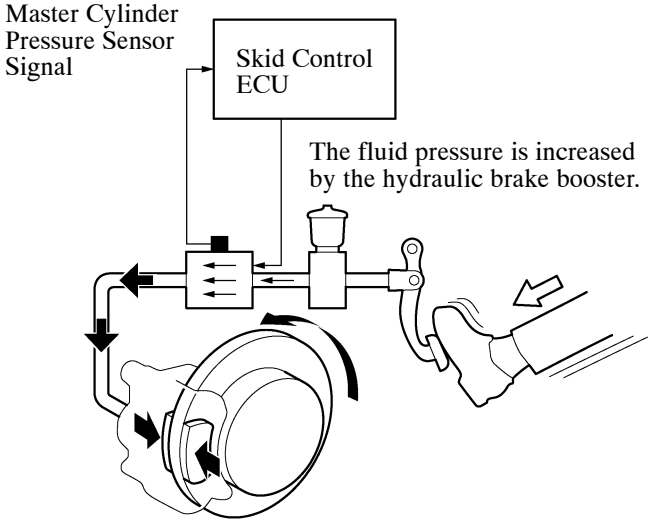
When the brakes are applied while the vehicle is cornering, the load that applied to the inner wheel decreases to the outer wheel increases.
The skid control ECU determines this condition by way of the signals from the speed sensor, and the brake actuator regulates the brake force in order to optimally control the distribution of the brake force to the inner wheel and outer wheel.



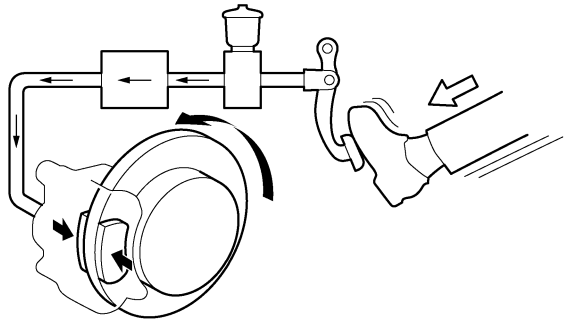
4. Outline of Brake Assist

- The brake assist in combination with ABS helping improves the vehicle's brake performance.
- The brake assist interprets a quick push of the brake pedal as emergency braking and supplements the brake power applied if the driver has not stepped hard enough on the brake pedal. In emergencies, driver, especially inexperienced ones, often panic and do not apply sufficient pressure on the brake pedal.
- A key feature of brake assist is that the timing and the degree of braking assistance are designed to ensure that the driver does not discern anything unusual about the braking operation.
  When the driver intentionally eases up on the brake pedal, the system reduces the amount of assistance it provides.
- Based on the signals from the master cylinder pressure sensor, the skid control ECU calculates the speed and the amount of the brake pedal application and then determines the intention of the driver to make an emergency braking. If the skid control ECU determines that the driver intends the emergency braking, the system activates the hydraulic brake booster to increase the brake fluid pressure, which increases the braking force.

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

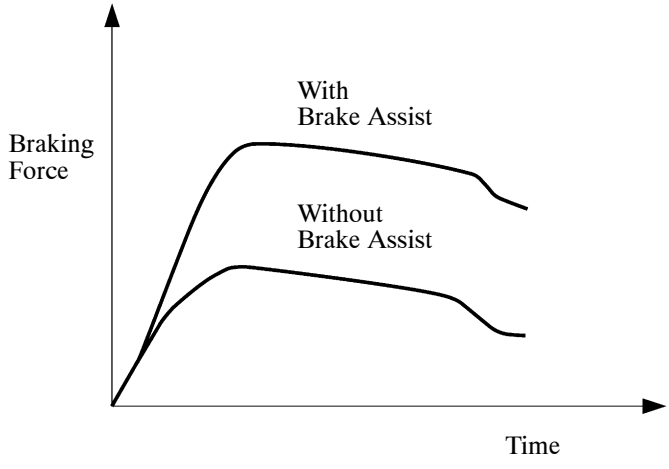


With Brake Assist

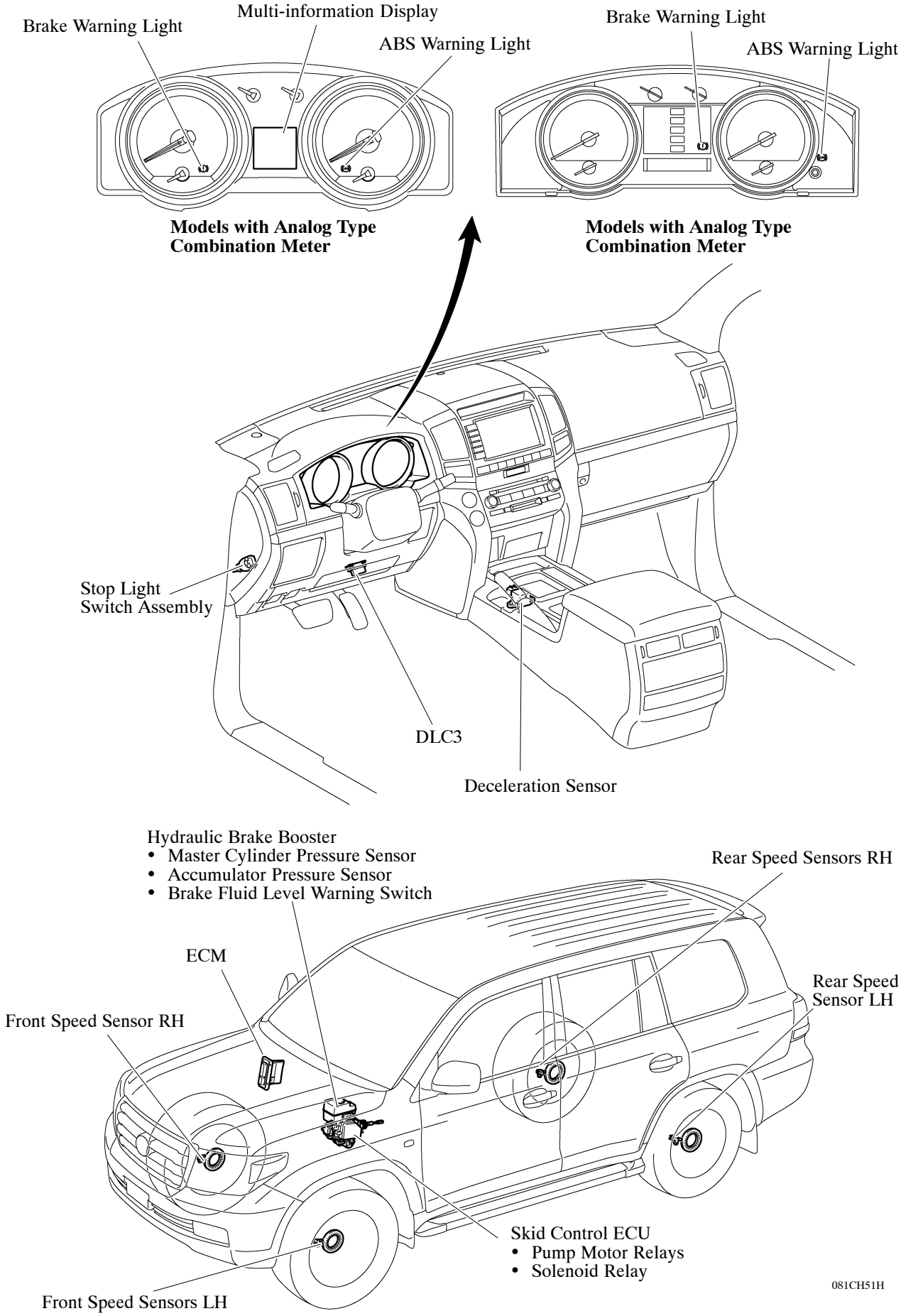


Without Brake Assist

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



5. Layout of Main Components



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6. Function of Main Components

Components		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 with EBD, brake assist in order to control the fluid pressure that is applied to the wheel cylinders.
	Master Cylinder Pressure Sensor	Detects the master cylinder pressure.
	Accumulator Pressure Sensor	Monitors the hydraulic pressure of the accumulator and detects the hydraulic pressure for the pump motor operation.
	Brake Fluid Level Warning Switch	Detects the brake fluid level.
Combination Meter	Brake 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, EBD, or brake assist.
Skid Control ECU		Judges the vehicle driving condition based on signals from each sensor, and sends brake control signals to the brake actuator.
	Pump Motor Relays	Controls the pump motor operation in the hydraulic brake booster.
	Solenoid Relay	Supplies or cuts off power to solenoid valves in the brake actuator.
Speed Sensor (4)		Detects the wheel speed and rotating direction of each of 4-wheel.
Deceleration Sensor		• Detects the vehicle's yaw rate. • Detects the vehicle's acceleration in the forward, rearward, and lateral.
Stop Light Switch		Detects the brake pedal depressing signal.
ECM		Transmits the engine output information to the skid control ECU.

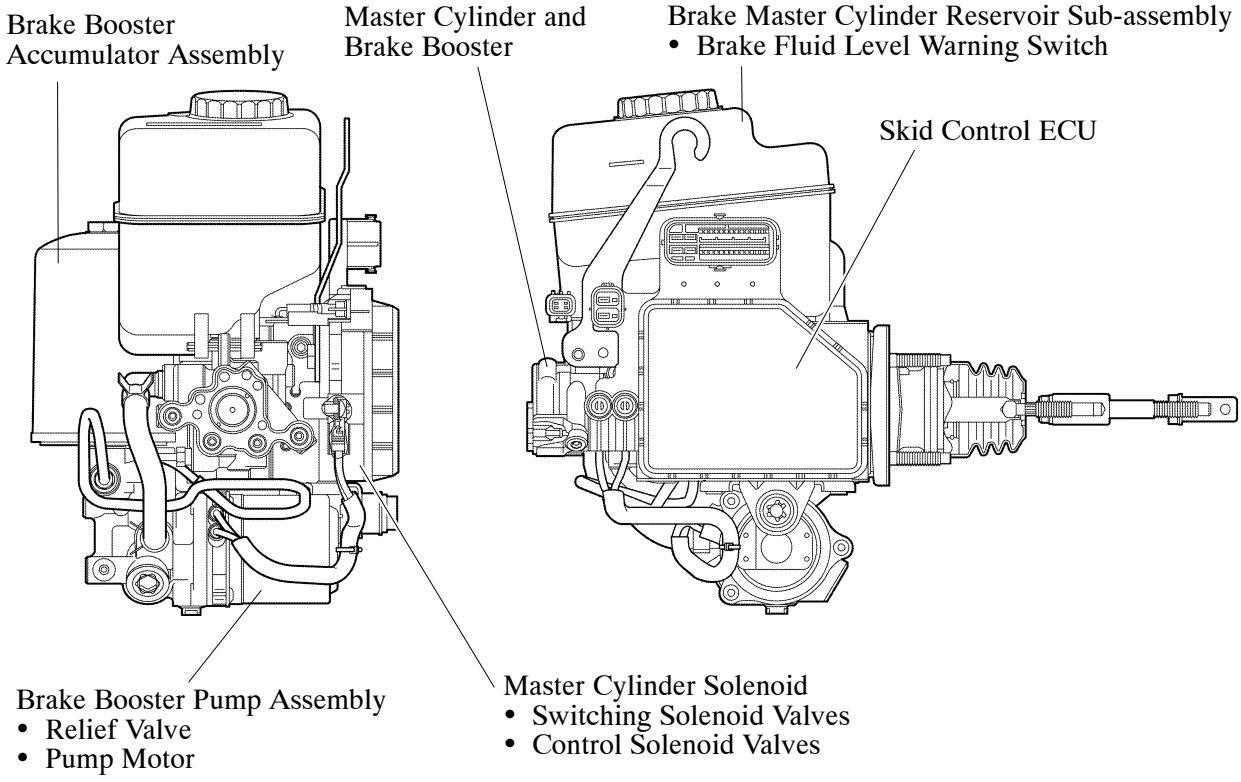
7. Construction of Main Components

Hydraulic Brake Booster

1) General

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

- The brake pressure generation portion is a master cylinder and brake booster and master cylinder pressure sensor.
- The power supply portion is a pump, pump motor, relief valve, reservoir tank, brake fluid level warning switch, accumulator and accumulator pressure sensor.
- The brake control portion is a skid control ECU, and brake actuator.



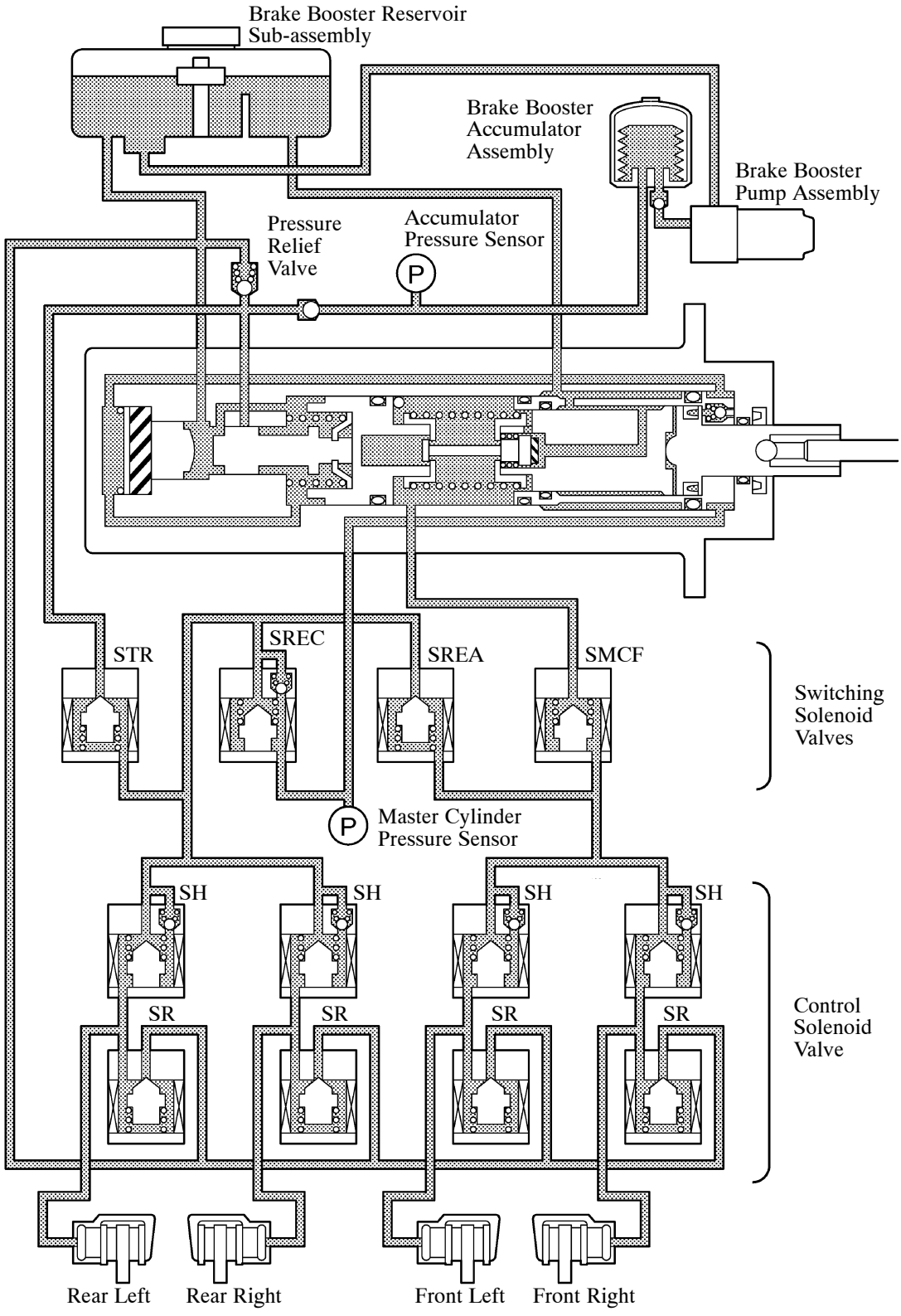
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The hydraulic brake booster consists of the following components:

Components			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	Brake Booster Pump Assembly		Draws up the brake fluid from the reservoir tank and provides high hydraulic pressure to the accumulator.
	Brake Booster Accumulator Assembly		Stores the hydraulic pressure that was generated by the brake booster pump assembly. The accumulator is filled with high-pressure nitrogen gas.
	Accumulator Pressure Sensor		Monitors the hydraulic pressure of the accumulator and detects the hydraulic pressure for the pump motor operation.
	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.
	Brake Master Cylinder Reservoir Sub-assembly		Stores the brake fluid.
	Brake Fluid Level Warning Switch		Detects the low brake fluid level.
Brake Control Portion	Master Cylinder Solenoid	Switching Solenoid Valves (4)	Switches the brake hydraulic path when the brake control system is activated.
		Control Solenoid Valves (8)	Controls the hydraulic pressure that is applied to the wheel cylinders during brake control.
	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, VSC, hill-start assist control, downhill assist control, and CRAWL. • Operates the brake booster pump assembly to control brake booster accumulator assembly pressure based on accumulator pressure sensor signal.

▶ 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

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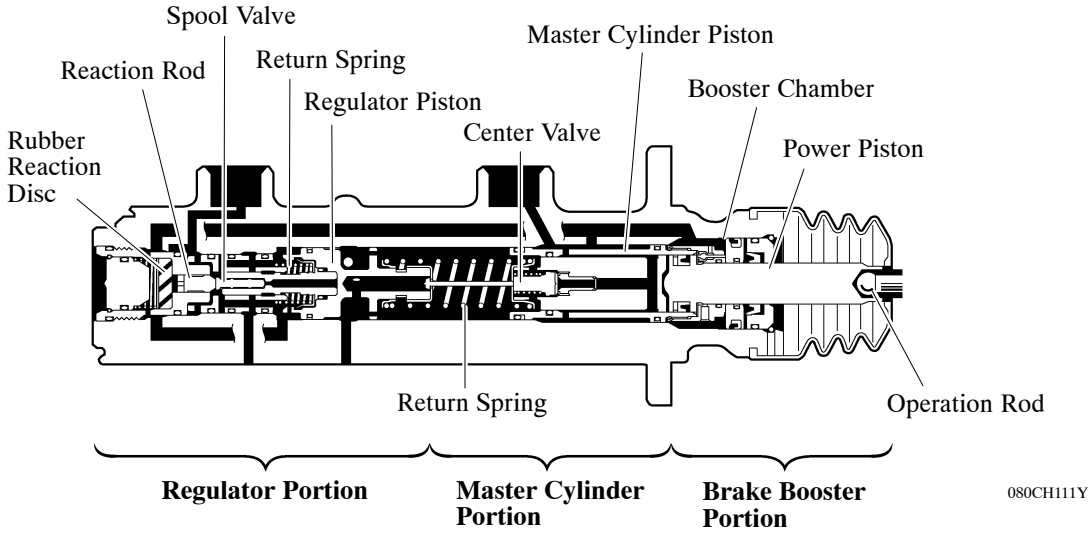
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2) Master Cylinder

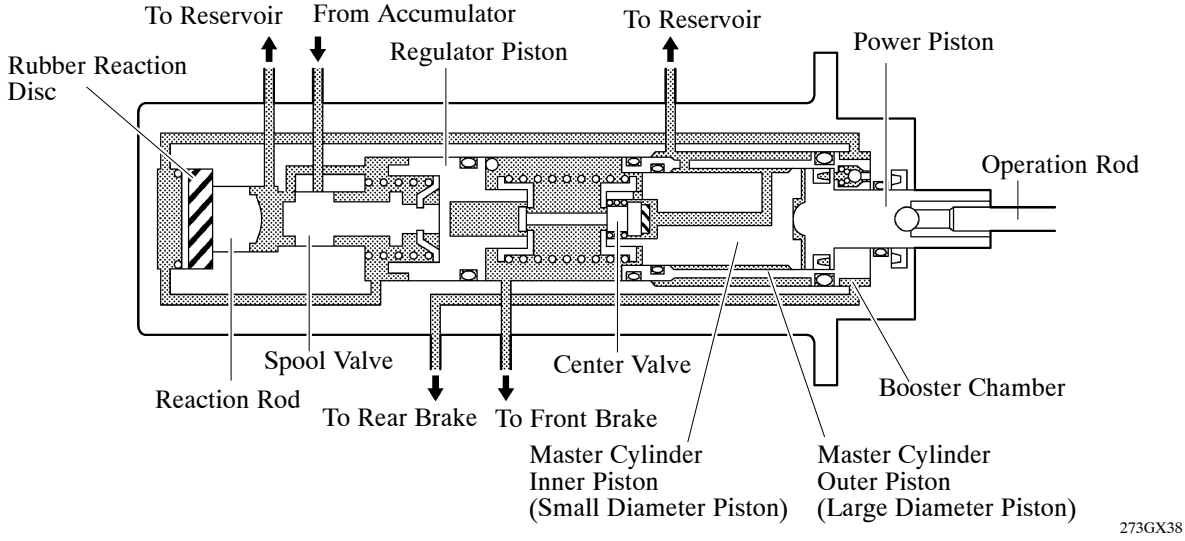
a. Construction

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



▶ Simplified Diagram ◀



Service Tip

The supply parts for the master cylinder and brake booster portion are provided as follows:

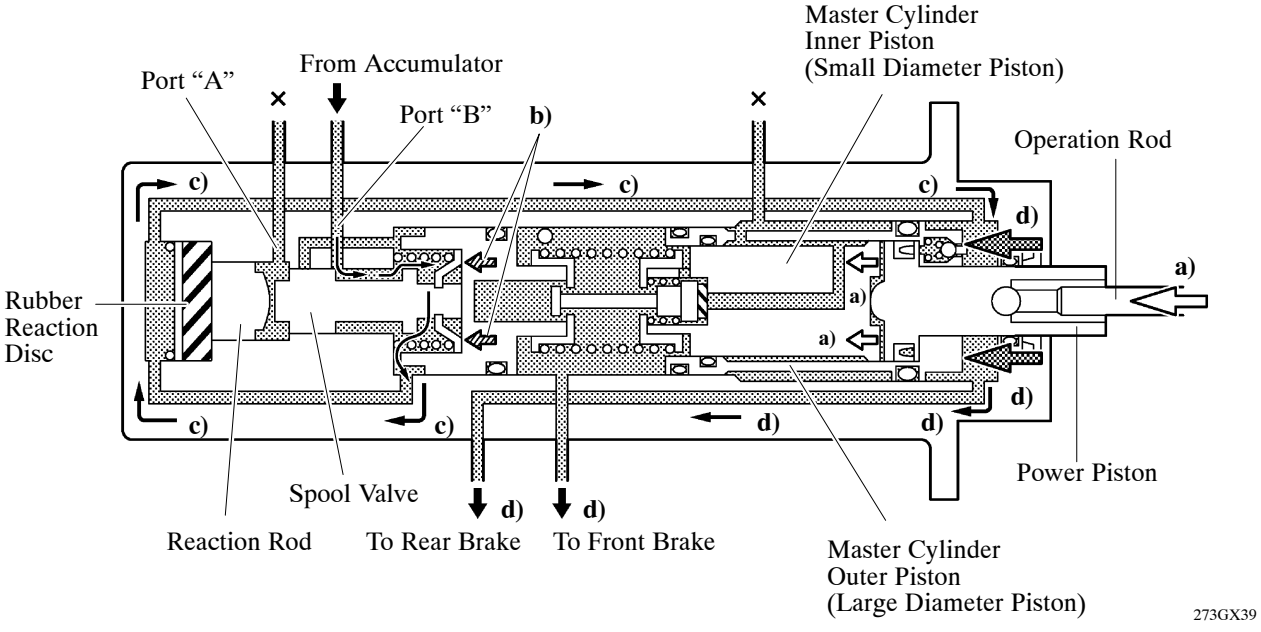
- The operation rod and the power piston, which are integrated, are supplied as the No.1 piston.
- The master cylinder piston is supplied as the No.2 piston.
- Other parts are not available as supply parts, so do not remove them.

For detailed removal procedure, see the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

b. Operation

i) Pressure Increase (Low Pressure)

a) The pedal operation force transmits 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, the regulator piston gets pushed before the volume 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 volume in the master cylinder to become compressed and increased the pressure that is applied to the front brakes. At the same, the pressure in the booster chamber increases the pressure that is applied to the rear brakes.

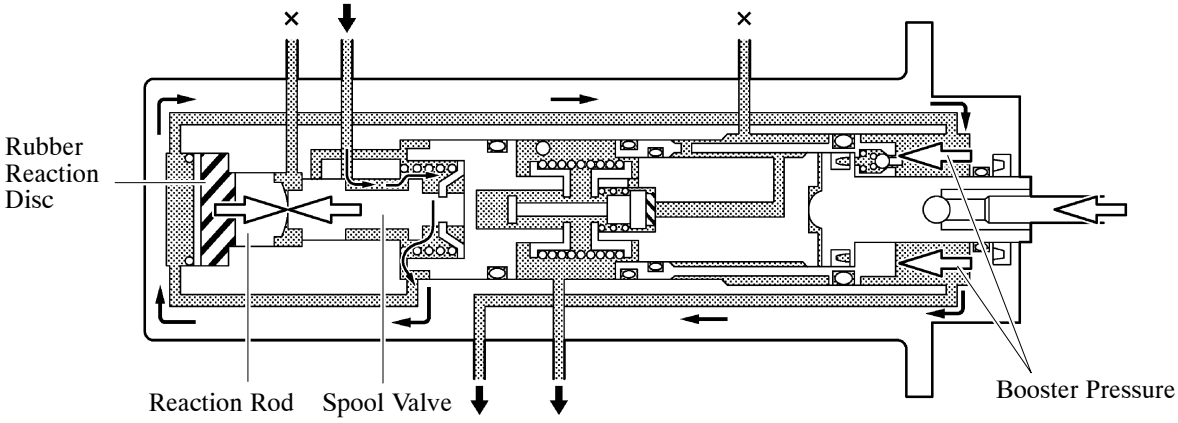


During the initial stage of the brake operation, the booster pressure that is applied to the rubber reaction disc is small. Therefore, a return force in the rightward direction does not apply to the spool valve via the reaction rod.

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.

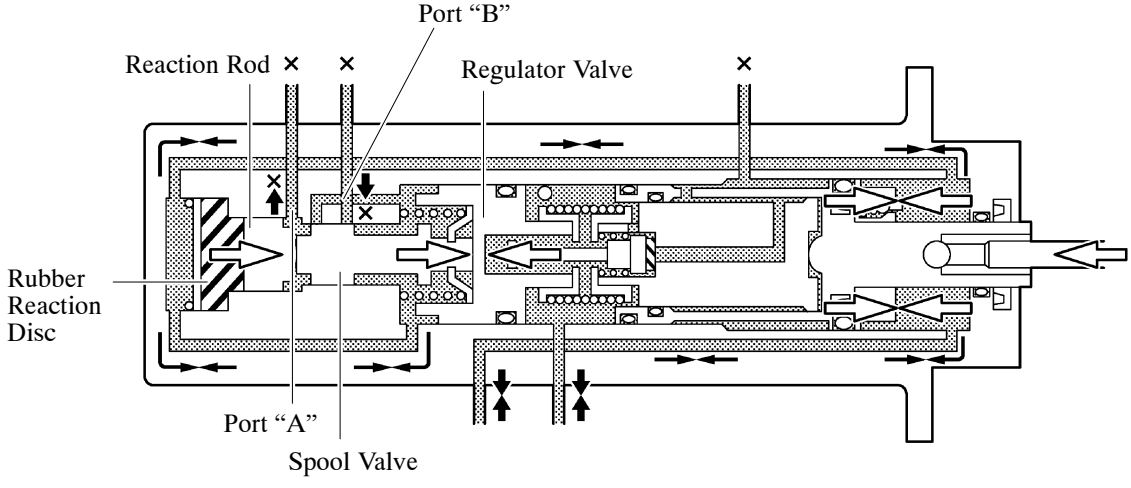


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iii) Holding

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 port “B” from the booster chamber to the accumulator and port “A” to the reservoir. As a result, the brake is in the holding state.

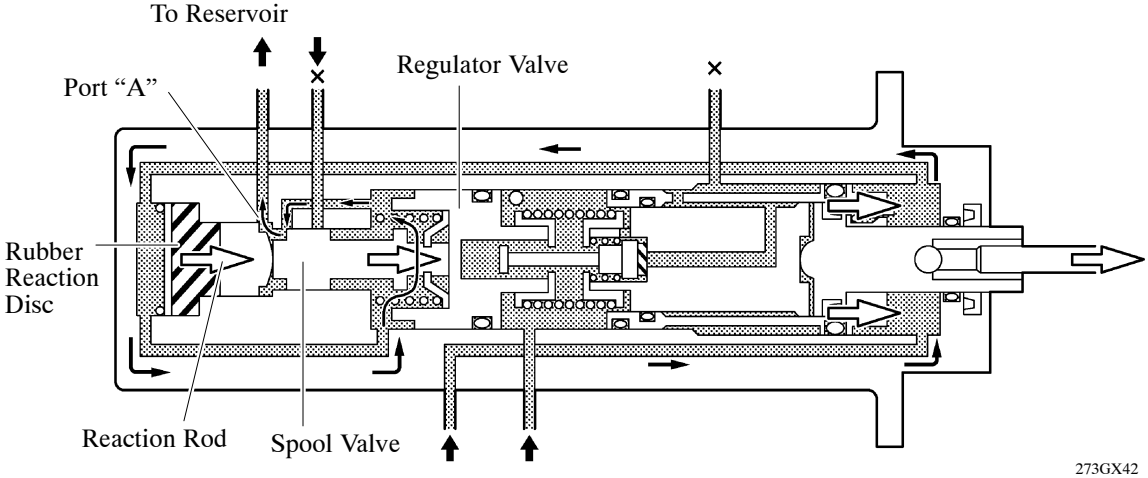


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iv) Pressure Reduce

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

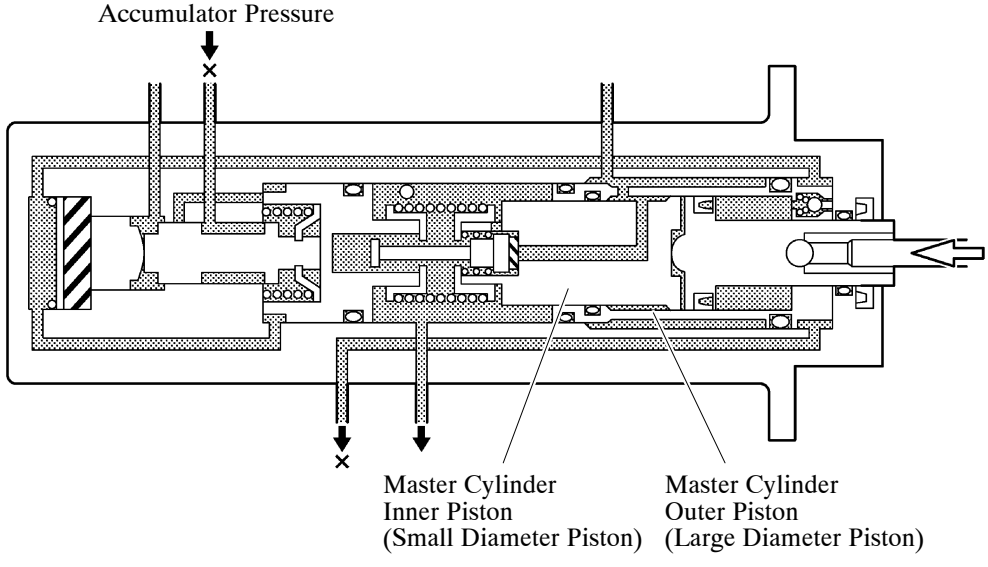
The booster pressure becomes reduced in this state, creating a balance that corresponds to the force that is newly applied via the brake pedal. This process is performed repetitively to reduce the booster pressure and the master cylinder pressure in accordance with the force that is applied via the brake pedal.



v) During Power Supply Malfunction

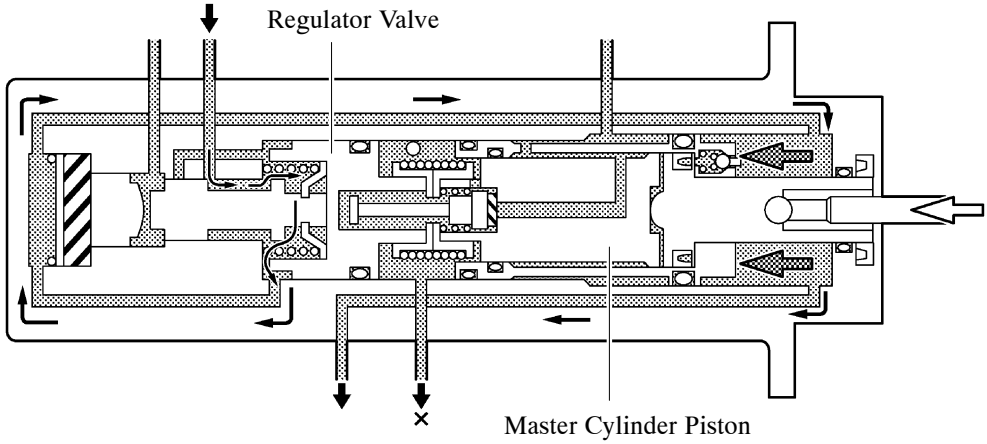
If the accumulator pressure is affected by any malfunction, no hydraulic pressure will be supplied to the booster chamber. For this reason, a power assist cannot be provided to the force that is applied via the brake pedal and the pressure to the rear brakes cannot be increased. Since there is no pressurized 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

In the front brake system, the master cylinder piston is moved by the booster chamber pressure but the hydraulic pressure does not increase. The piston moves until it hits the regulator piston while the brake fluid in the master cylinder is drained.
The rear brake system operates the same as in the normal operation.

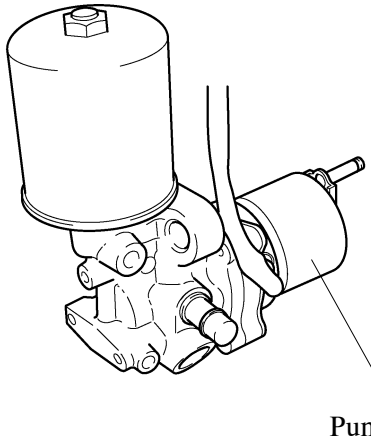


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3) Pump and Accumulator

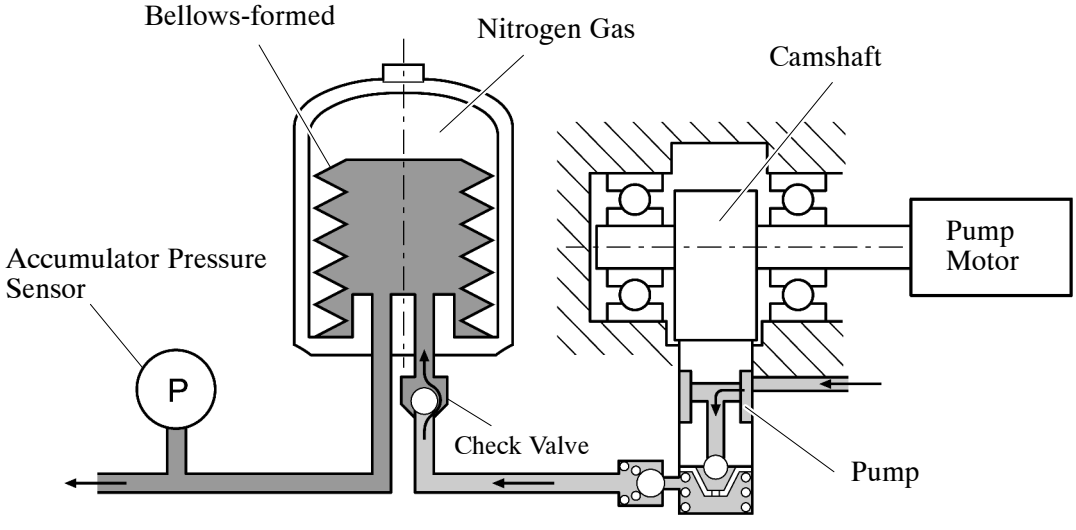
a. General

- 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 ◀

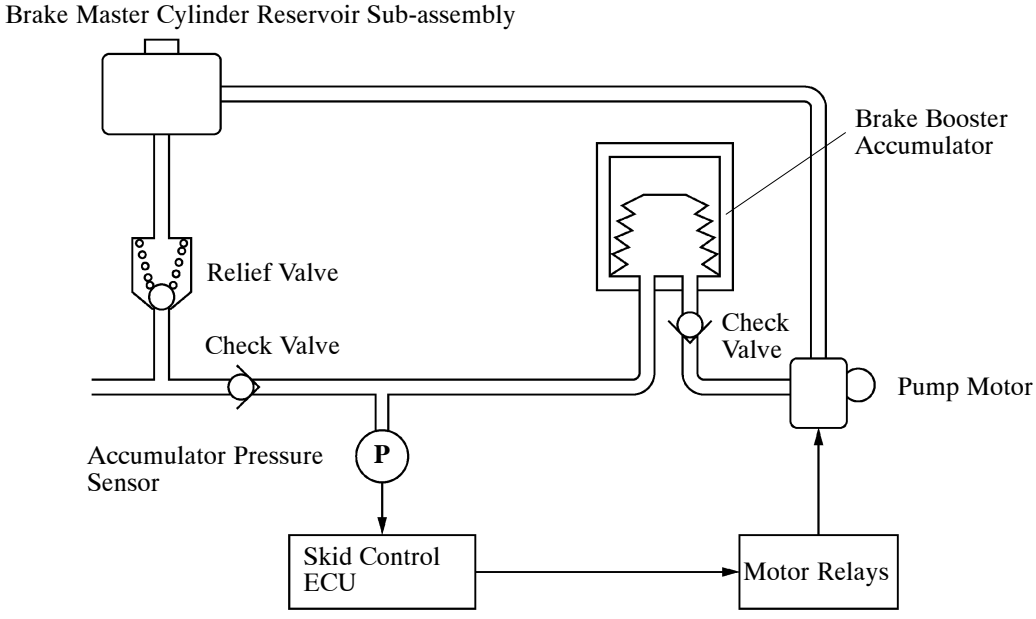


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b. Operation

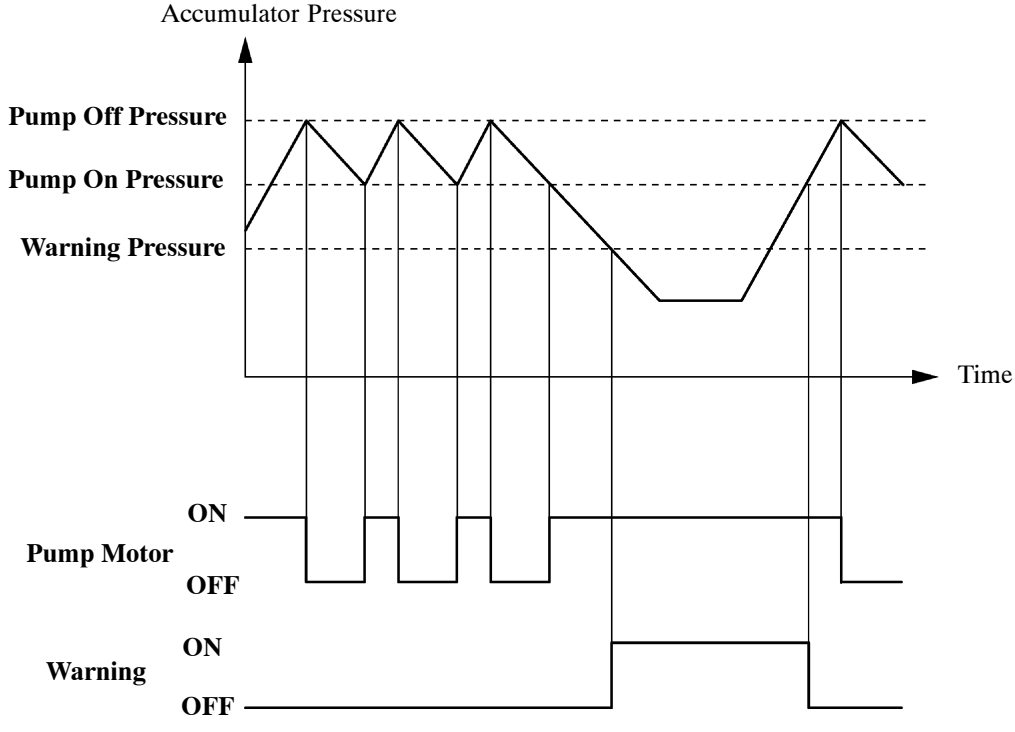
The power supply portion operates based on the accumulator pressure sensor signal as shown in the timing chart below.

- When the accumulator pressure drops to “pump ON pressure”, the skid control ECU operates the pump motor.
- When the accumulator pressure increases to “pump OFF pressure”, the skid control ECU stops the 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 DAC and CRAWL indicator lights, displays messages on the multi-information display, and sounds the skid control buzzer continuously.



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▶ Timing Chart ◀

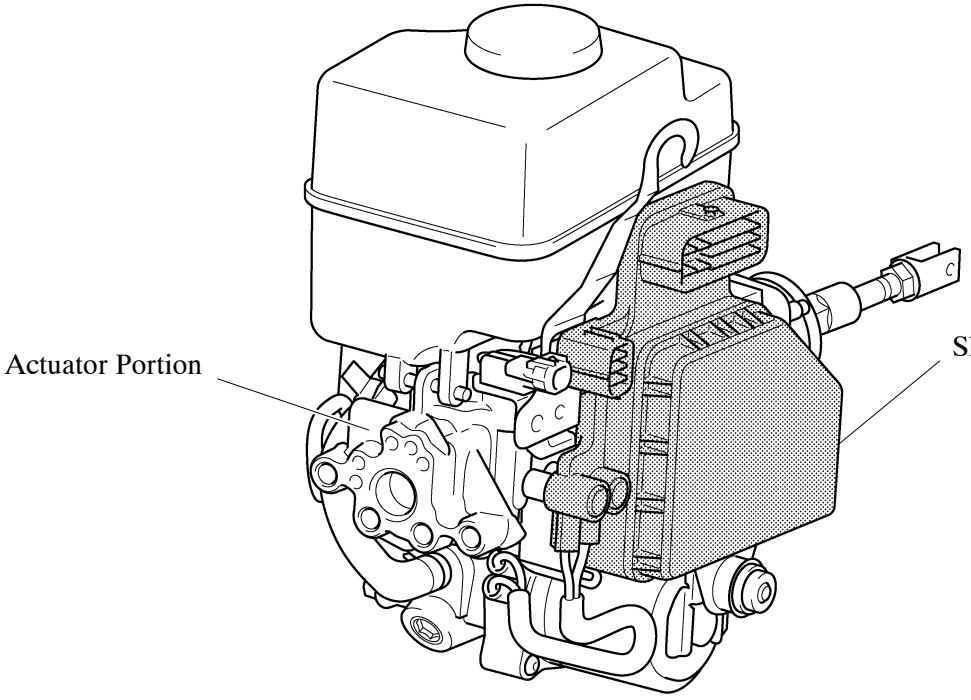


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4) Brake Actuator

a. General

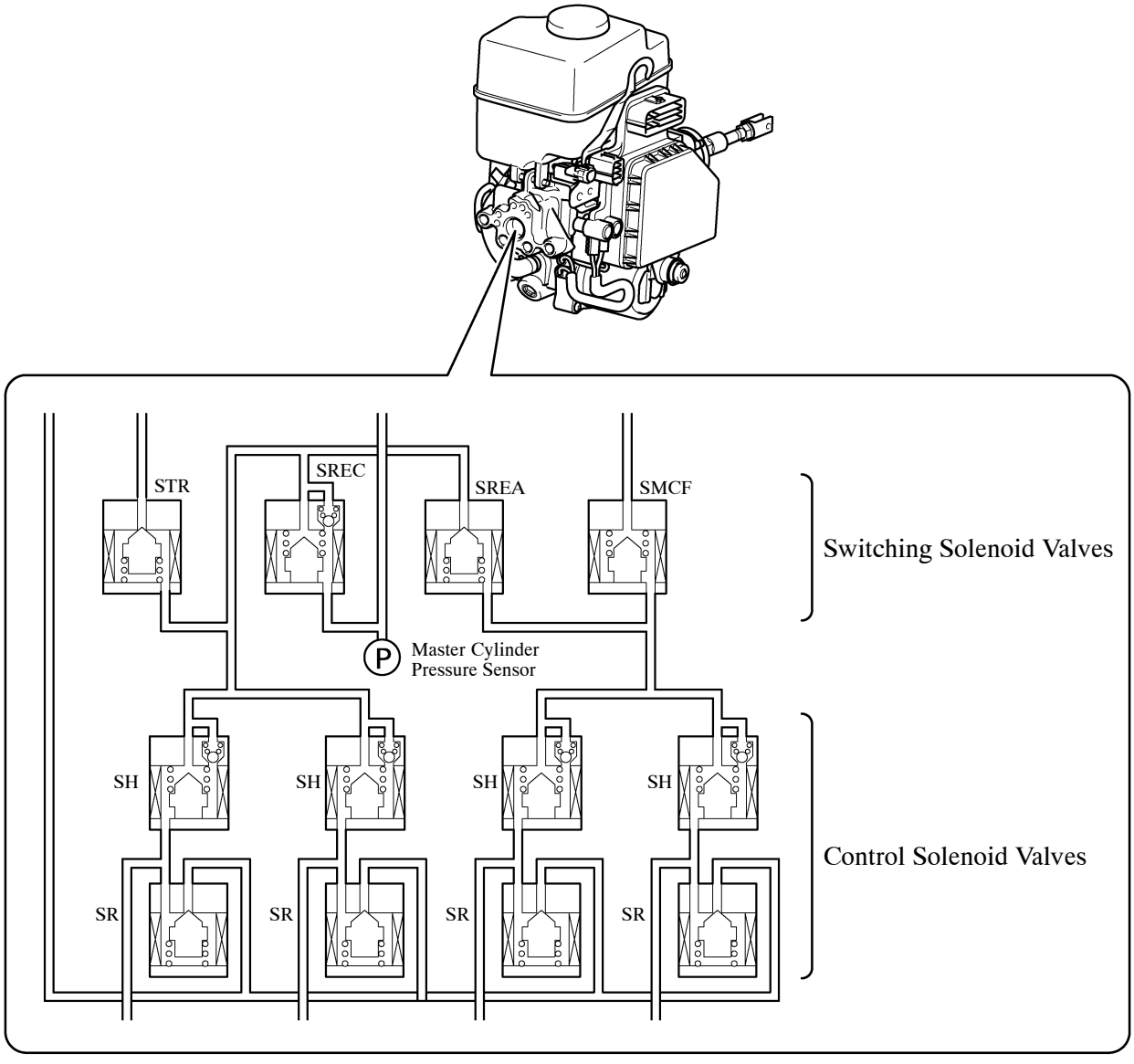
The brake actuator consists of actuator portion and skid control ECU.



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b. Solenoid Valve

- There are two types of solenoid valves: the switching solenoid valve and the control solenoid valve.
- 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-wheel (2 types per wheel: pressure holding solenoid and pressure reduction solenoid).
- 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.



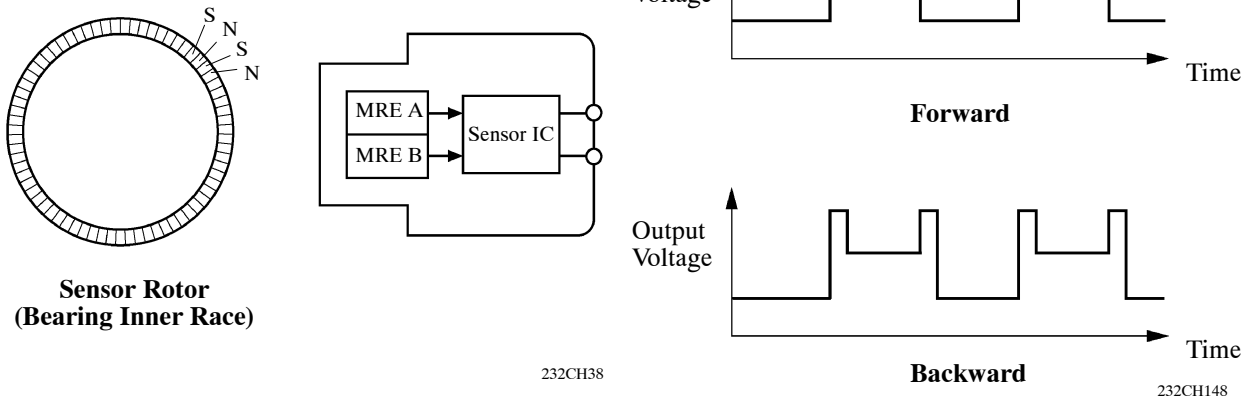
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Speed Sensor

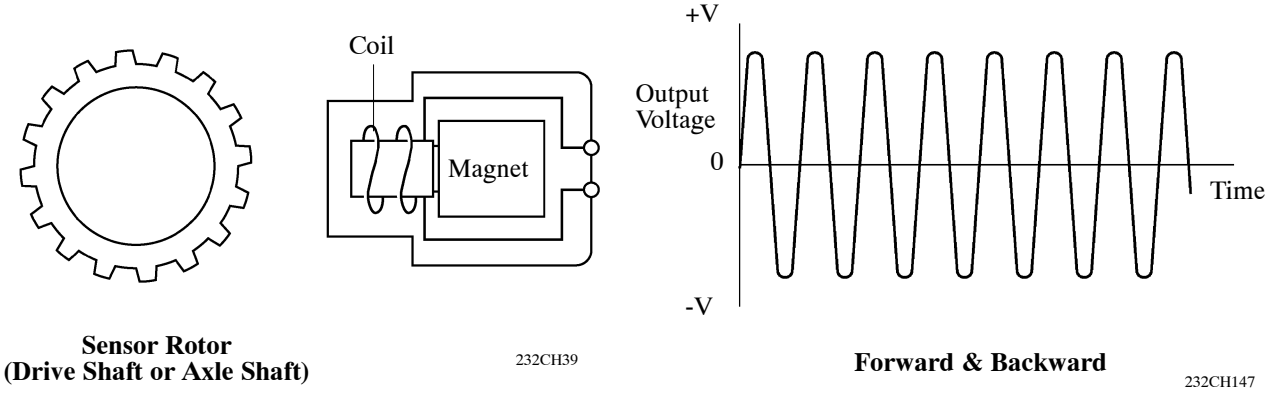
1) General

- 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 difference 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 ◀

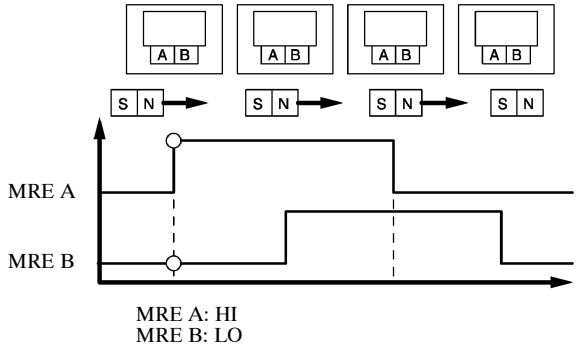


Type	Active	Passive
Direction Detection	Possible to judge both forward and backward	Impossible to judge the wheel rotation direction
Detection Speed	Approx. 0 km/h (0 mph)	3 km/h (5 mph) more than
Weight	Approx. 1/3 of passive type	—

2) Detection Method

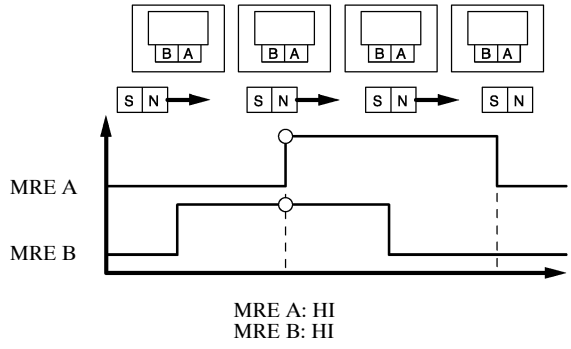
- To detect the rotation direction, the output waves are used to determine the relationship of the pulses that are generated by the 2 MREs.
- Upon receiving this signal, the sensor IC outputs a forward or backward wave.

▶ Forward ◀



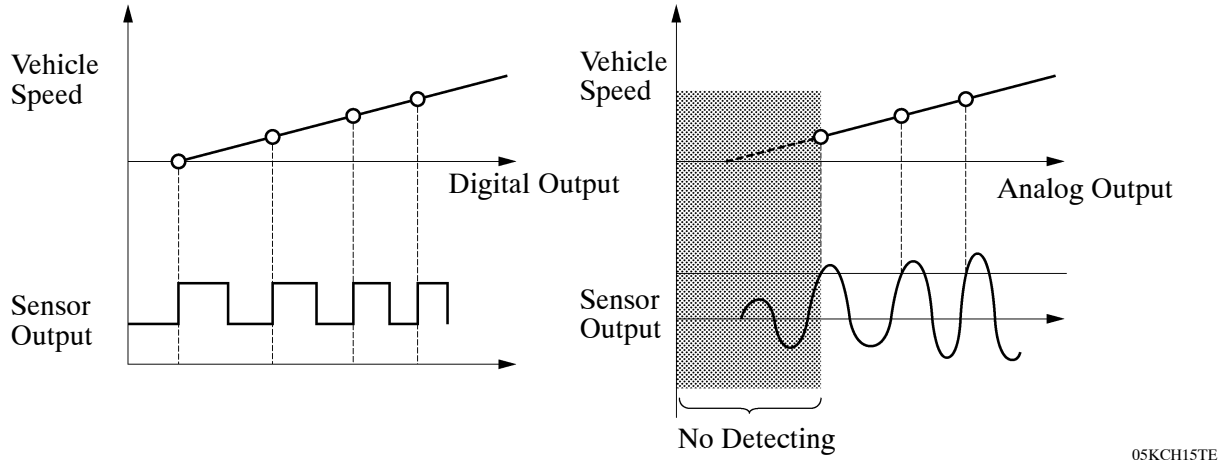
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▶ Backward ◀



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- 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).



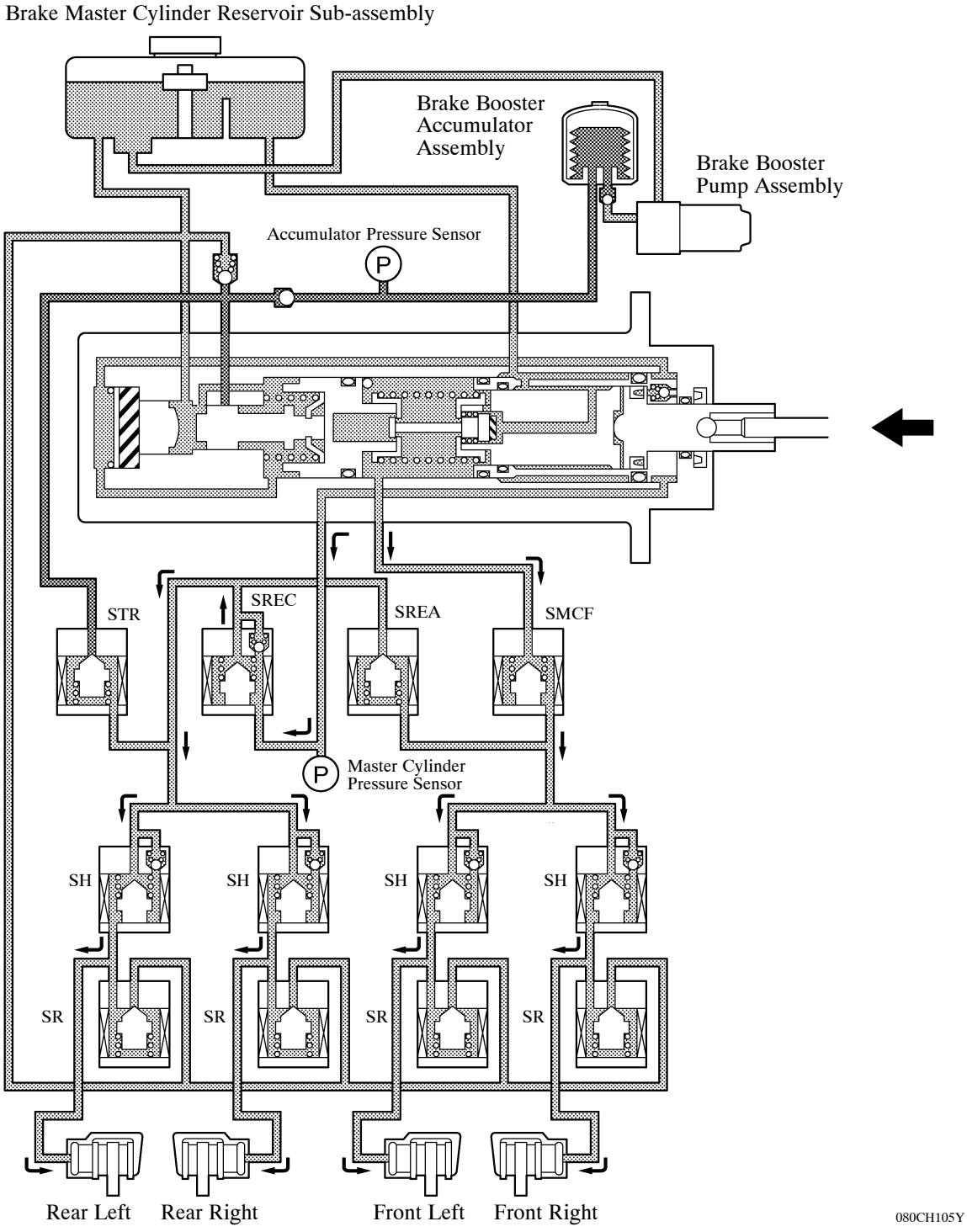
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Active Type **Passive Type**

8. System Operation

Normal Braking

During normal braking, all solenoid valves are turned OFF.



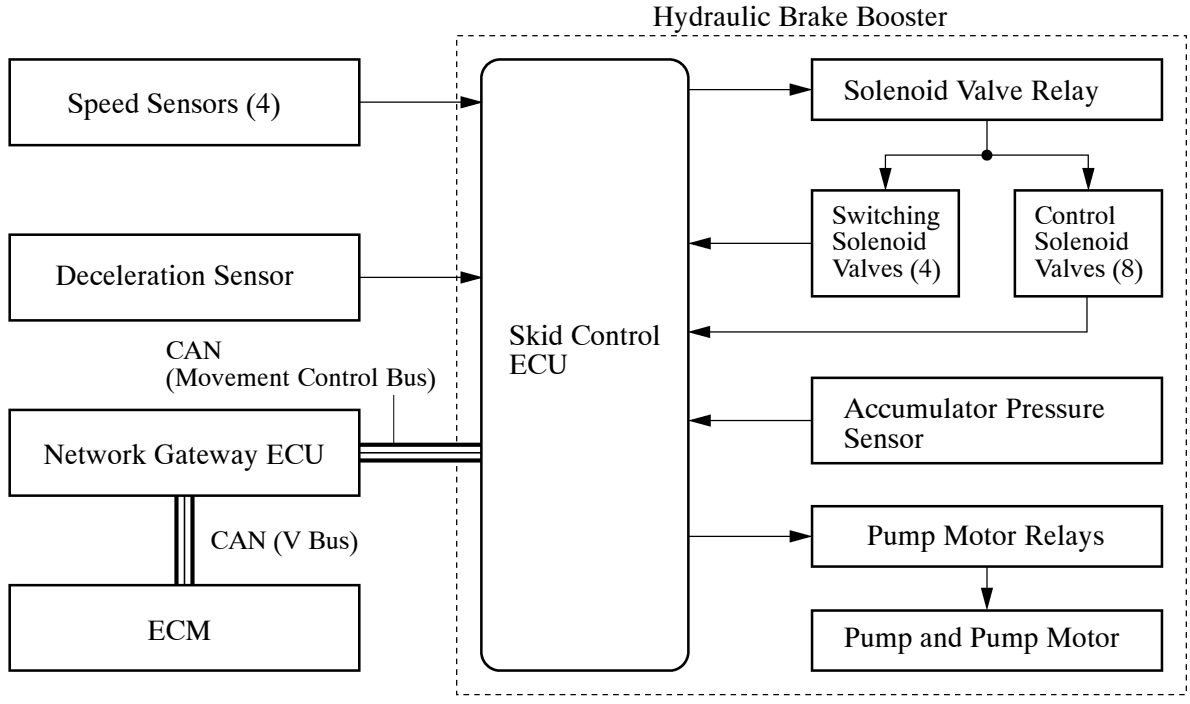
SMCF: Master Cut for Front Solenoid Valve
SREA: Regulator Apply for Front Solenoid Valve
SREC: Regulator Cut Solenoid Valve
STR: Traction Solenoid Valve (Accumulator Cut Solenoid Valve)
SH: Pressure Holding Solenoid Valve
SR: Pressure Reduction Solenoid Valve

Multi-terrain ABS with EBD Operation

The skid control ECU calculates the wheel speeds and deceleration rates, and checks the wheel slipping condition based on signals from the 4 wheel speed sensors and the yaw rate sensor as well as the engine output information transmitted from the ECM.

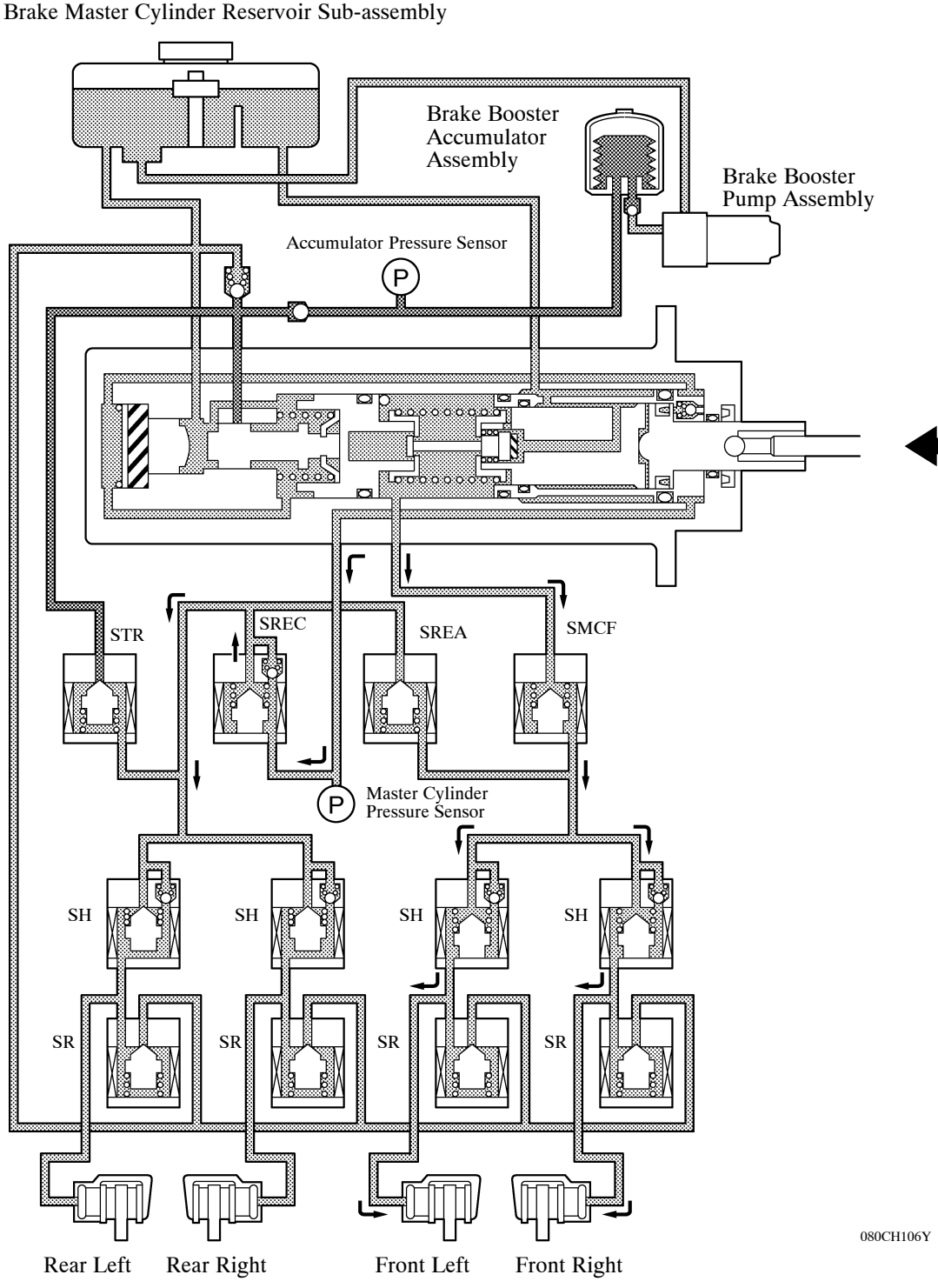
- The ECU compares the speed sensor signals of the front and rear, judges the slipping condition of the rear wheel, and operates the EBD.
- If the wheel is likely to be locked, the ECU controls the pressure holding solenoid valve and pressure reduction solenoid valve as Multi-terrain ABS operation in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

▶ System Diagram ◀



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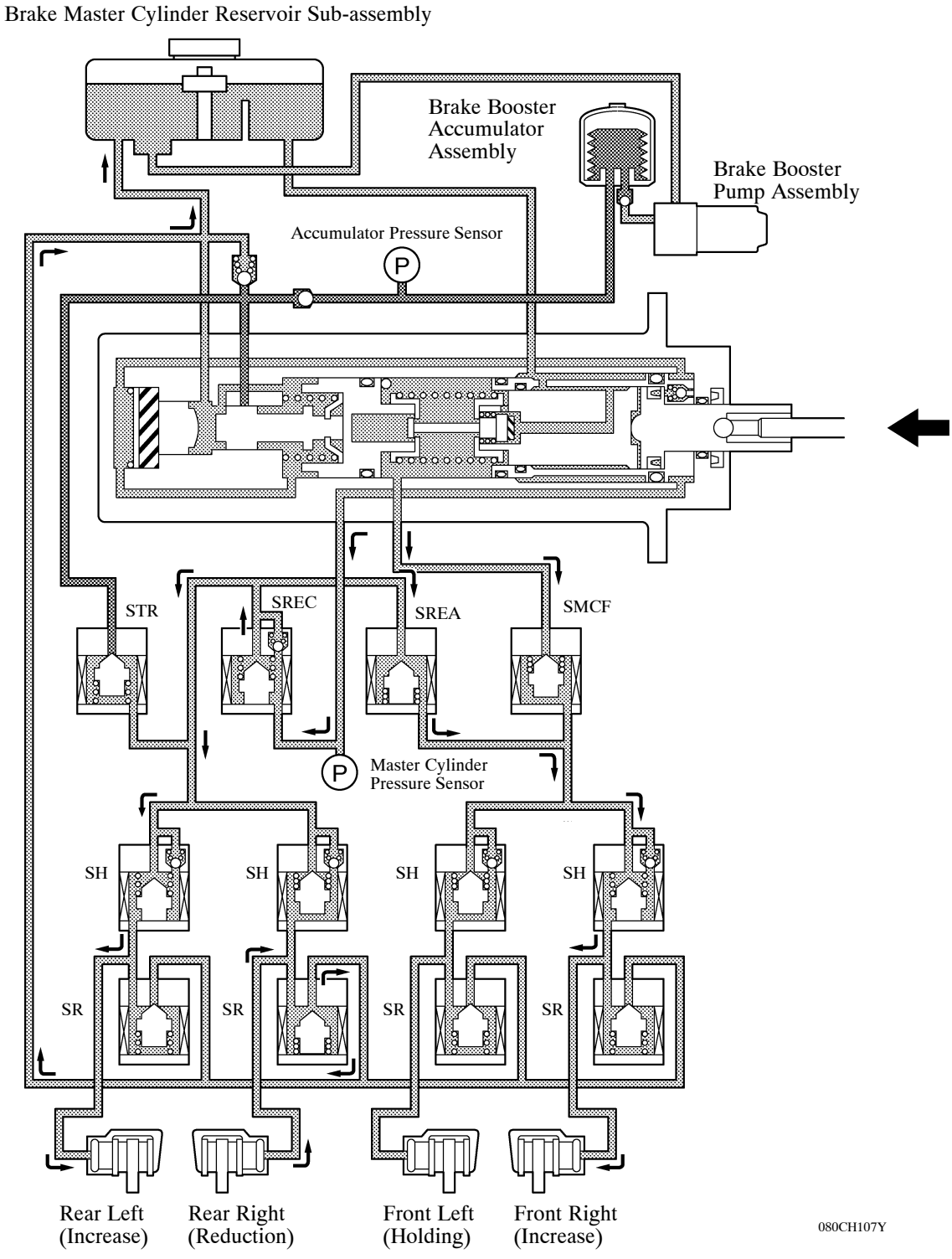
▶ EBD Operation ◀



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

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▶ 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

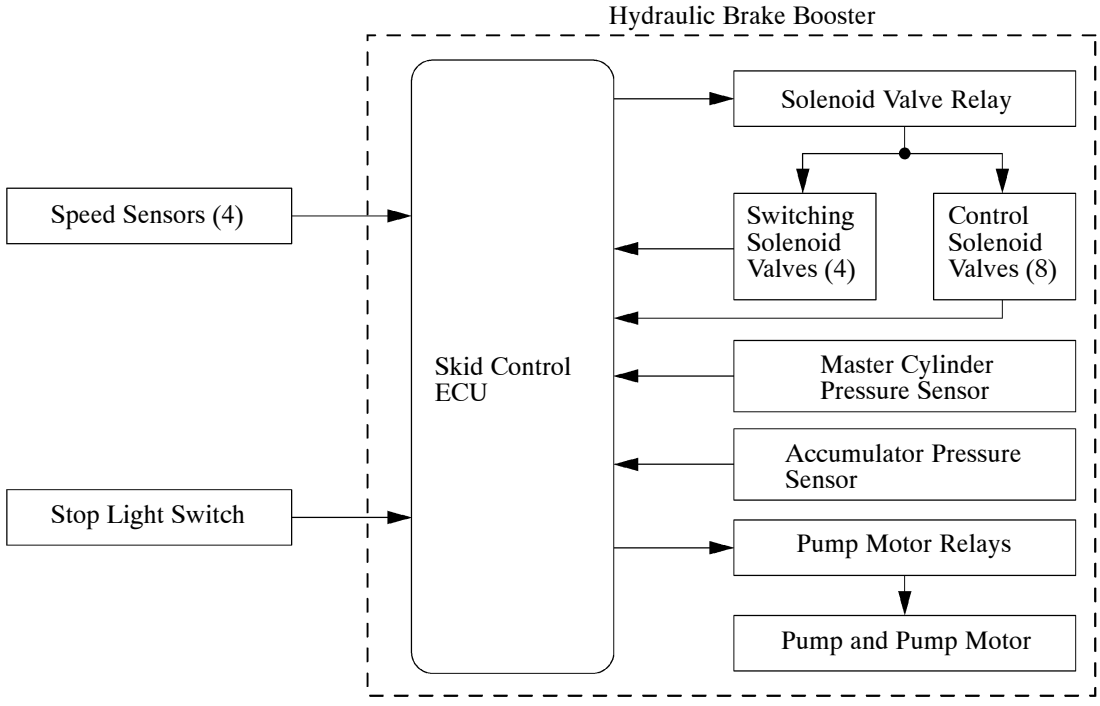
Item			Multi-terrain ABS with EBD not Activated	Multi-terrain ABS with EBD Activated		
				Mode		
				Increase	Holding	Reduction
Switching Solenoid Valve		SREC	OFF (Open)	←	←	←
		STR	OFF (Close)	←	←	←
	Front Brake	SMCF*1	OFF (Open)	ON (Close)	←	←
		SREA*1	OFF (Close)	ON (Open)	←	←
Control Switching Valve		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

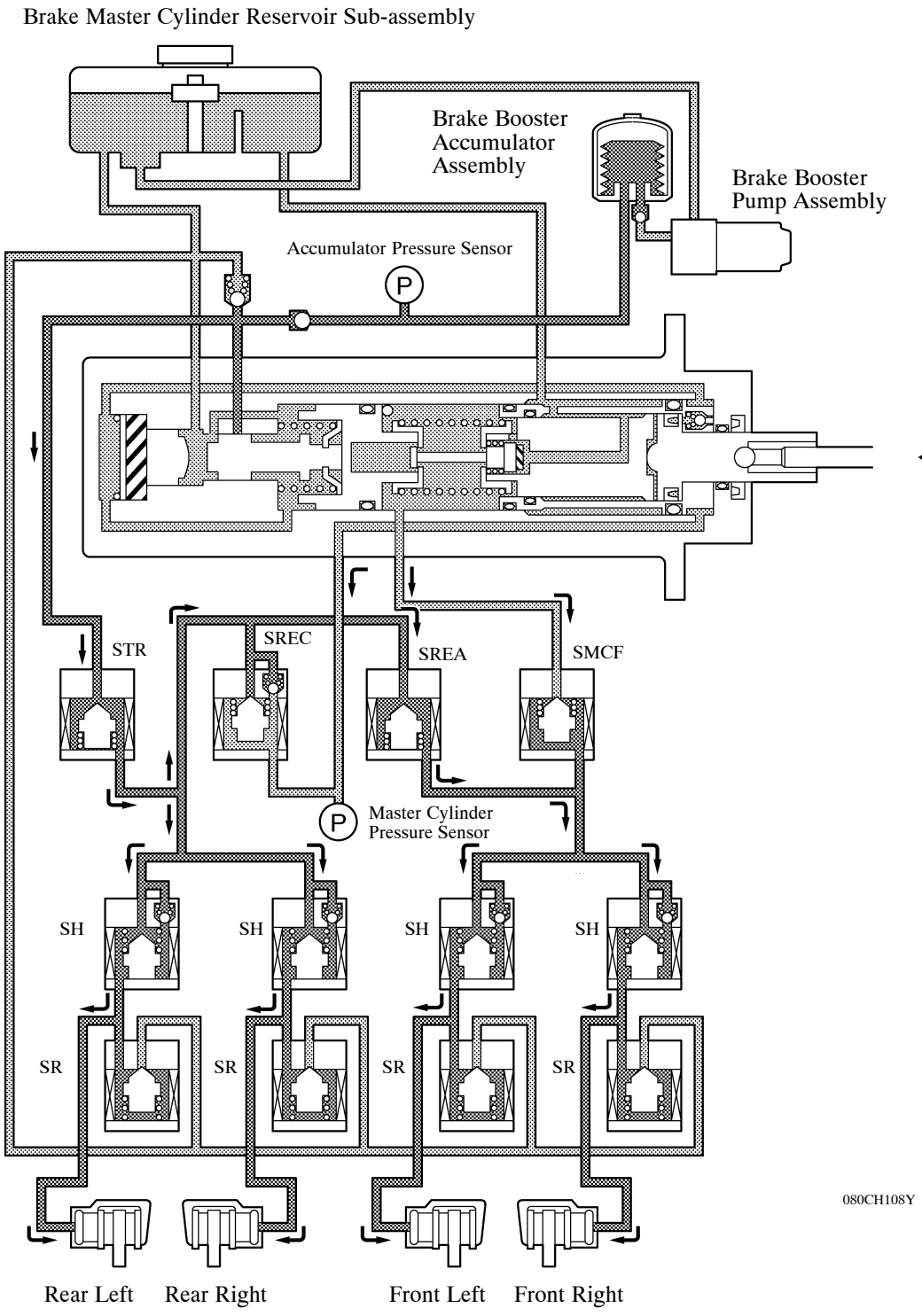
If an emergency braking situation has occurred, it is detected by the skid control ECU based on the vehicle speed signal from the speed sensor, the brake pedal application speed from the master cylinder pressure sensor, and the signal representing the amount of pedal effort. Then, the skid control ECU 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 ◀



273GX53

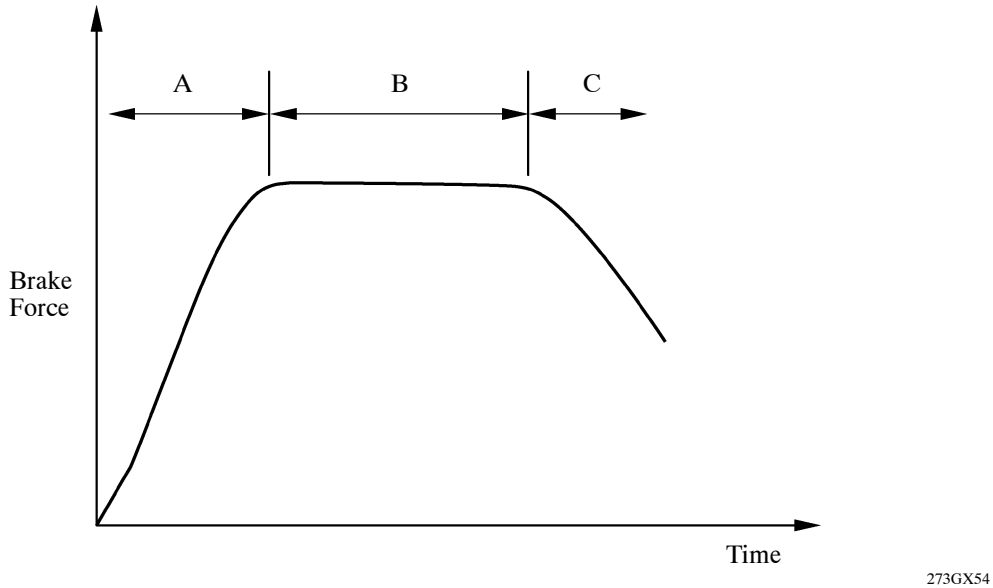
▶ Brake Assist Operation ◀



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

CH

▶ Brake Assist Timing ◀



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 (Close)
	Front Brake	SMCF	OFF (Open)	ON (Close)	←	←
		SREA	OFF (Close)	ON (Open)	←	←
Control Switching Valve		SH	OFF (Open)	←	ON (Close)	OFF (Open)
		SR	OFF (Close)	←	←	←
	Rear Brake	SH	OFF (Open)	←	ON (Close)	OFF (Open)
		SR	OFF (Close)	←	←	←
Wheel Cylinder Pressure			—	Increase	Hold	Reduce

Initial Check

Each time the engine switch is turned IG-ON, 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 in the hydraulic brake booster are checked in order.

9. Diagnosis

- If the skid control ECU detects a malfunction in the brake control system (Multi-terrain ABS with EBD, brake assist), then the ABS warning light, or brake warning light, illuminate either individually or as a group according to the function in which the malfunction has been detected, to alert the driver of the malfunction.
- At the same time, 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 an intelligent tester II to the DLC3.
  - The 2-digit DTC can be read from number of the blinking of 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.

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 Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

10. 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.

■BRAKE CONTROL SYSTEM (Multi-terrain ABS with EBD, Brake Assist, A-TRC, VSC, Hill-start Assist Control, Downhill Assist Control and CRAWL)

1. General

The brake control system (Multi-terrain ABS with EBD, brake assist, A-TRC, VSC, hill-start assist control, downhill assist control, CRAWL) of new Land Cruiser (Station Wagon) has the following functions:

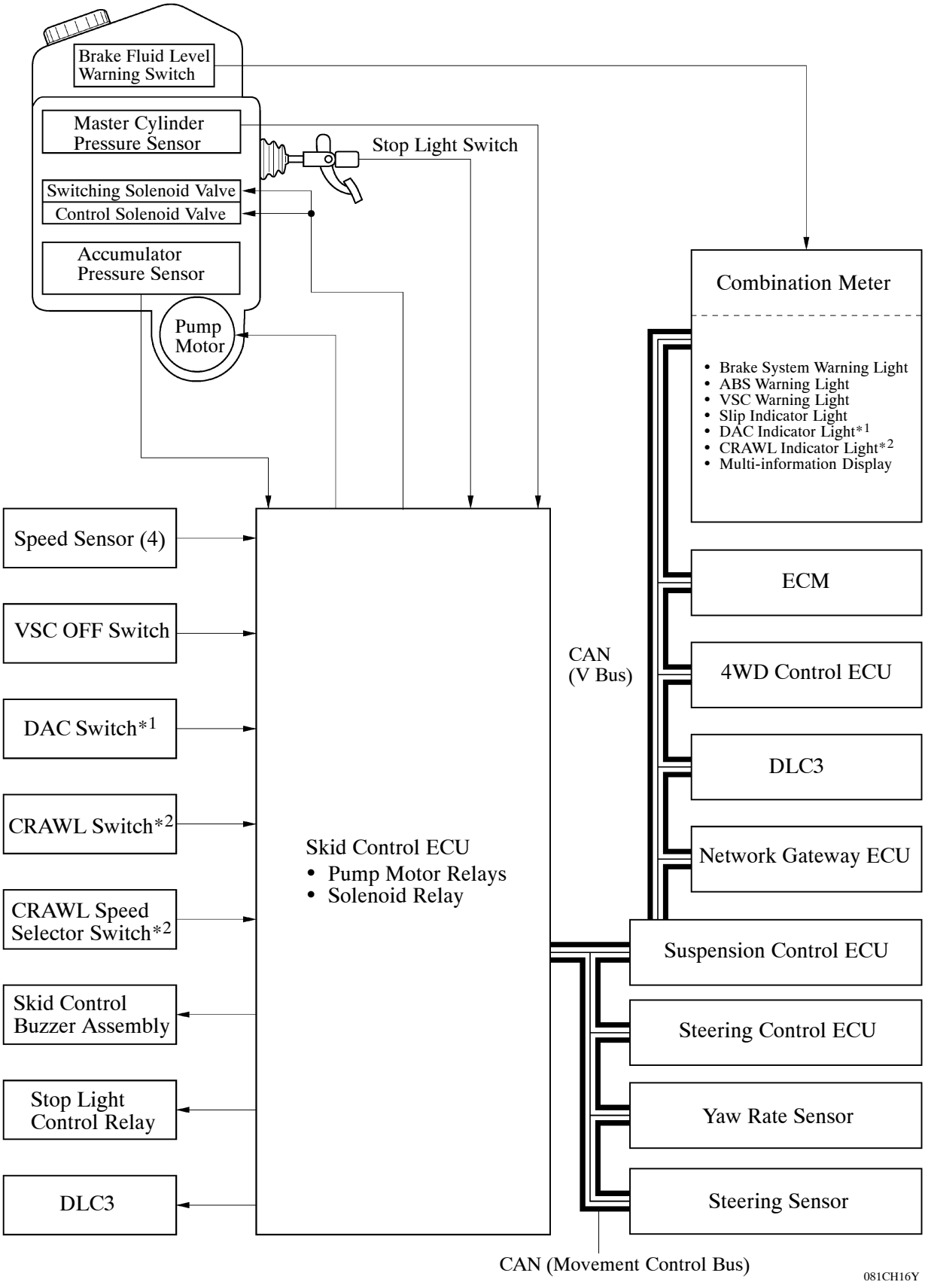
Function	Outline
Multi-terrain ABS (Anti-lock Brake System)	The ABS helps prevent the wheels from locking when the brakes are applied firmly or when braking on a slippery surface. In addition to the existing ABS function, the Multi-terrain ABS automatically calculates the optimum ABS control in accordance with the off-road situation such as a dirt or sandy road.
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 a LSD (Limited Slip Differential) effect. As a result, the vehicle's off-road drivability and ability to free itself from the mogul have been increased.
VSC (Vehicle Skid Control)	The VSC system helps prevent the vehicle from slipping sideways as a result of strong front wheel skid or strong rear wheel skid during cornering.
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.
Downhill Assist Control*1	When the DAC switch is pressed with transfer in low range and without accelerator and brake pedals operation, downhill assist control activates to effect 4-wheel hydraulic pressure control, in order to maintain a constant low vehicle speed without causing the wheels to become locked. Thus, the vehicle can descend a steep hill in a stable manner.
CRAWL*2	When the vehicle runs on extremely bumpy rough ground or a slippery road, by activating the CRAWL, the engine output and the hydraulic pressure of the 4 wheel are regulated by the CRAWL, allowing the driver to drive the vehicle at the desired speed and keep that speed with virtually no accelerator or brake pedal operation. This allows the driver to concentrate on steering and maintains vehicle stability.

*1: Only for 1VD-FTV engine models
*2: Only for 2UZ-FE engine models

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 a malfunction.

▶ System Diagram ◀



*1: Only for 1VD-FTV engine models
*2: Only for 2UZ-FE engine models

2. Outline of Multi-terrain ABS

The detailed outline is the same as that of brake control system (Multi-terrain ABS). For details, see page CH-164.

3. Outline of EBD

The detailed outline is the same as that of brake control system (EBD). For details, see page CH-165.

4. Outline of Brake Assist

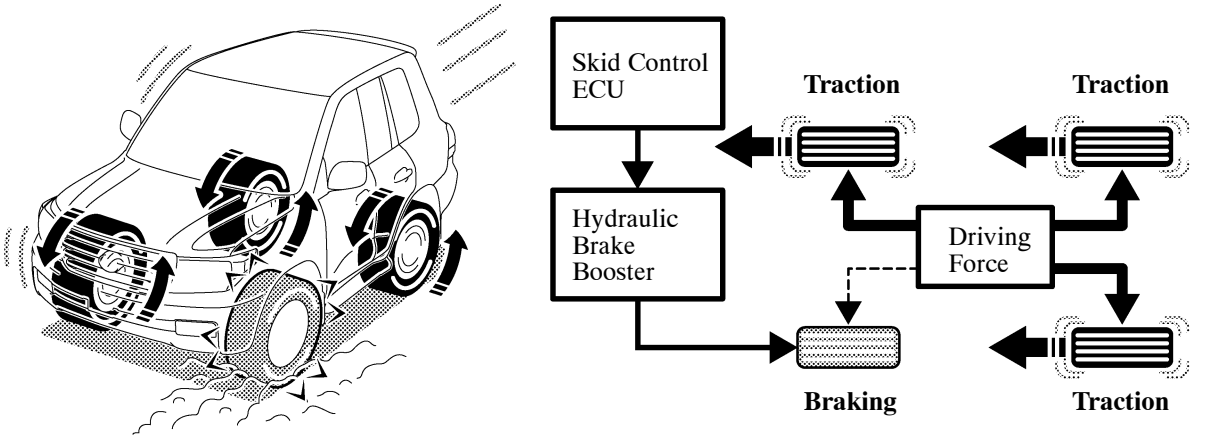
The detailed outline is the same as that of brake control system (brake assist). For details, see page CH-166.

5. Outline of A-TRC

General

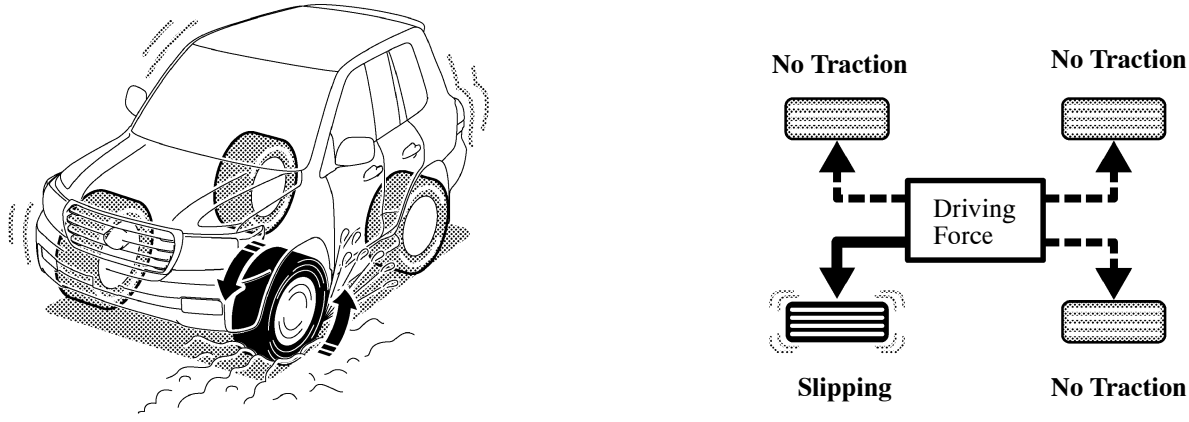
- If a tire slips while the vehicle is being driven on a snow-covered road or off-road, the function of the differential gear causes a large amount of drive force to be applied to the tire that is slipping.
- The A-TRC function helps restrain the slippage by controlling the engine output and brake fluid 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-wheel in accordance with the extent of the slippage at the wheels, as detected by the skid control ECU.

▶ with A-TRAC ◀



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▶ without A-TRAC ◀



080CH99TE

Effective 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 made the operation of the differential lock switches basically unnecessary to ensure the ease of driving.
- While realizing the off-road drivability that is equivalent to having the center and rear differentials locked, as compared to the differential gear in the locked state, the essential function of the differential gear itself ensures the ease of nimble steerability.

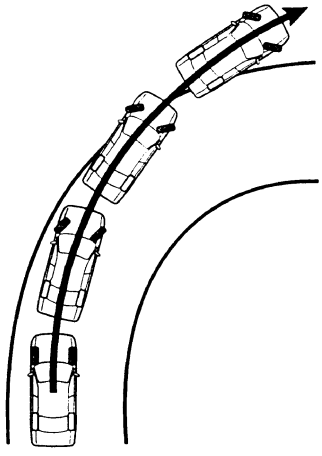
6. Outline of VSC

General

The followings are two examples that can be considered as circumstances in which the tires exceed their lateral grip limit.

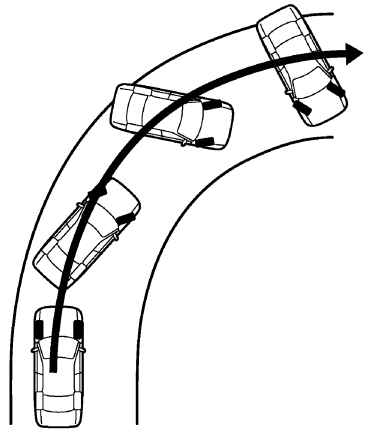
The VSC system is designed to help control the vehicle behavior by controlling the engine output and the brakes at each wheel when the vehicle is under one of the conditions indicated below.

- When the front wheels lose grip in relation to the rear wheels (front wheel skid tendency).
- When the rear wheels lose grip in relation to the front wheels (rear wheel skid tendency).



151CH17

Front Wheel Skid Tendency



189CH100

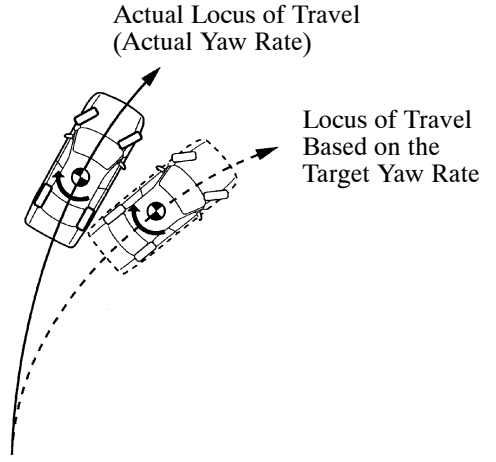
Rear Wheel Skid Tendency

Method for Determining the Vehicle Condition

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

1) Determining Front Wheel Skid

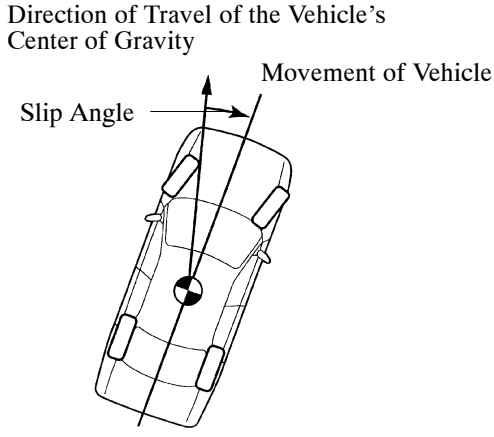
Whether or not the vehicle is in the state of front wheel skid is determined by the difference between the target yaw rate and the vehicle's actual yaw rate.
When the vehicle's actual yaw rate is smaller than the yaw rate (a target yaw rate that is determined by the vehicle speed and steering angle) that should be rightfully generated when the driver operates the steering wheel, it means the vehicle is making a turn at a greater angle than the locus of travel.
Thus, the skid control ECU determines that there is a large tendency to front wheel skid.



151CH19

2) Determining Rear Wheel Skid

Whether or not the vehicle is in the state of rear wheel skid is determined by the values of the vehicle's slip angle and the vehicle's slip angular velocity (time-dependent changes in the vehicle's slip angle). When the vehicle's slip angle is large, and the slip angular velocity is also large, the skid control ECU determines that the vehicle has a large rear wheel skid tendency.



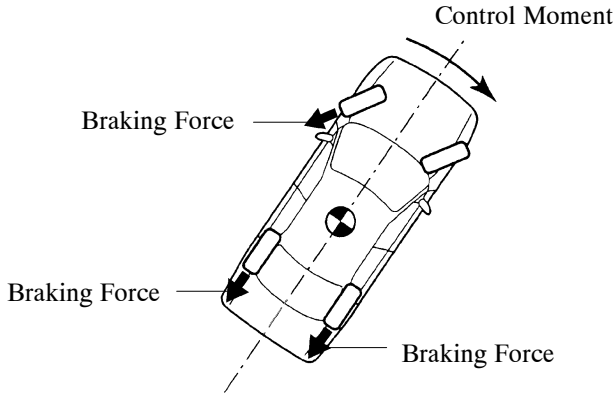
151CH18

Method for VSC Operation

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

1) Dampening a Front Wheel Skid

When the skid control ECU determines that there is a large front wheel skid tendency, it counteracts in accordance with the extent of that tendency. The skid control ECU controls the engine power output and applies the brakes of the front wheel of the outer circle in the turns and rear wheels in order to restrain the front wheel skid tendency.

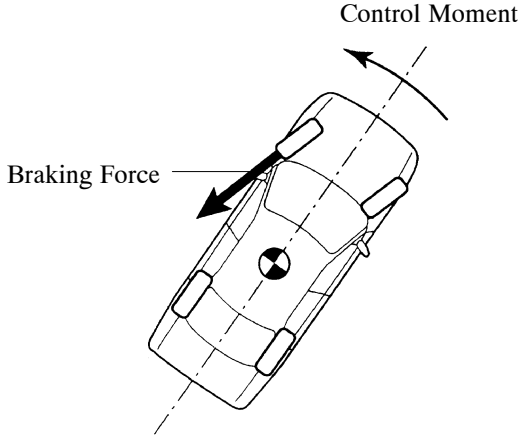


189CH101

Making a Right Turn

2) Dampening a Rear Wheel Skid

When the skid control ECU determines that there is a large rear wheel skid tendency, it counteracts in accordance with the extent of that tendency. It applies the brakes of the front wheel of the outer circle of the turn, and generates an outward moment of inertia in the vehicle, in order to restrain the rear wheel skid tendency. Along with the reduction in the vehicle speed caused by the braking force, the vehicle's stability is further improved.
In some cases, the skid control ECU applies the brake of the rear wheels, as necessary.



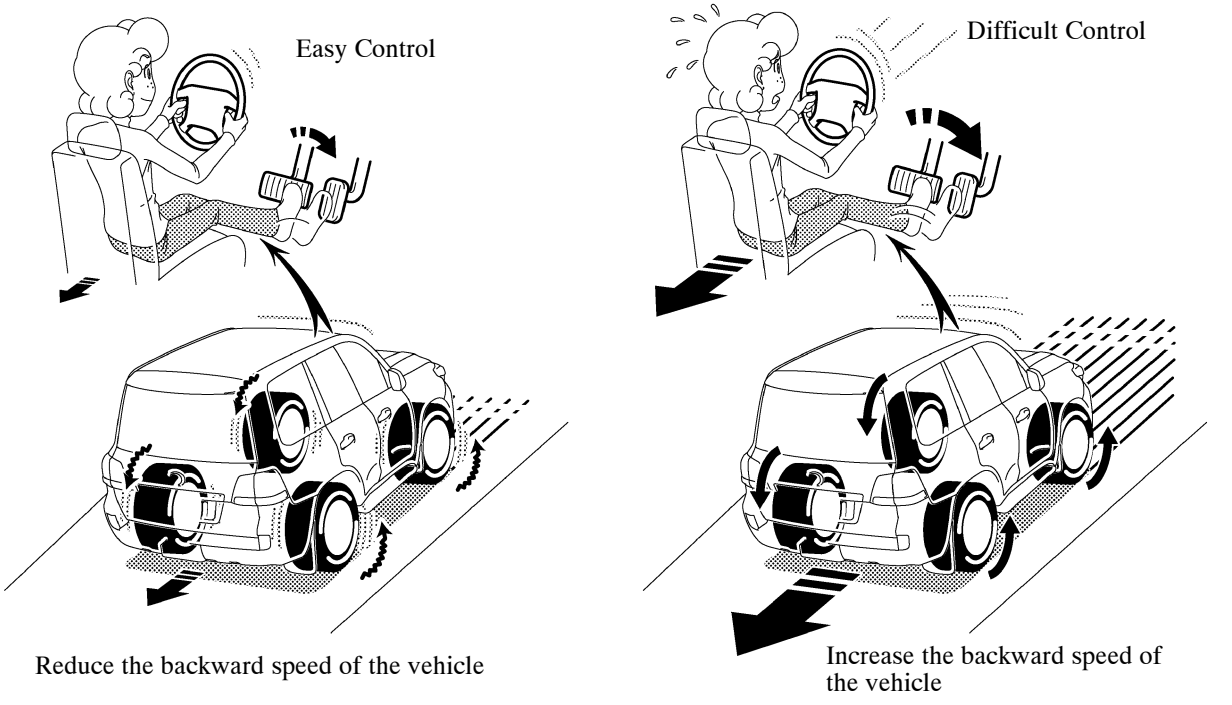
Making a Right Turn

204CH15

CH

7. Outline of 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-wheel 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.

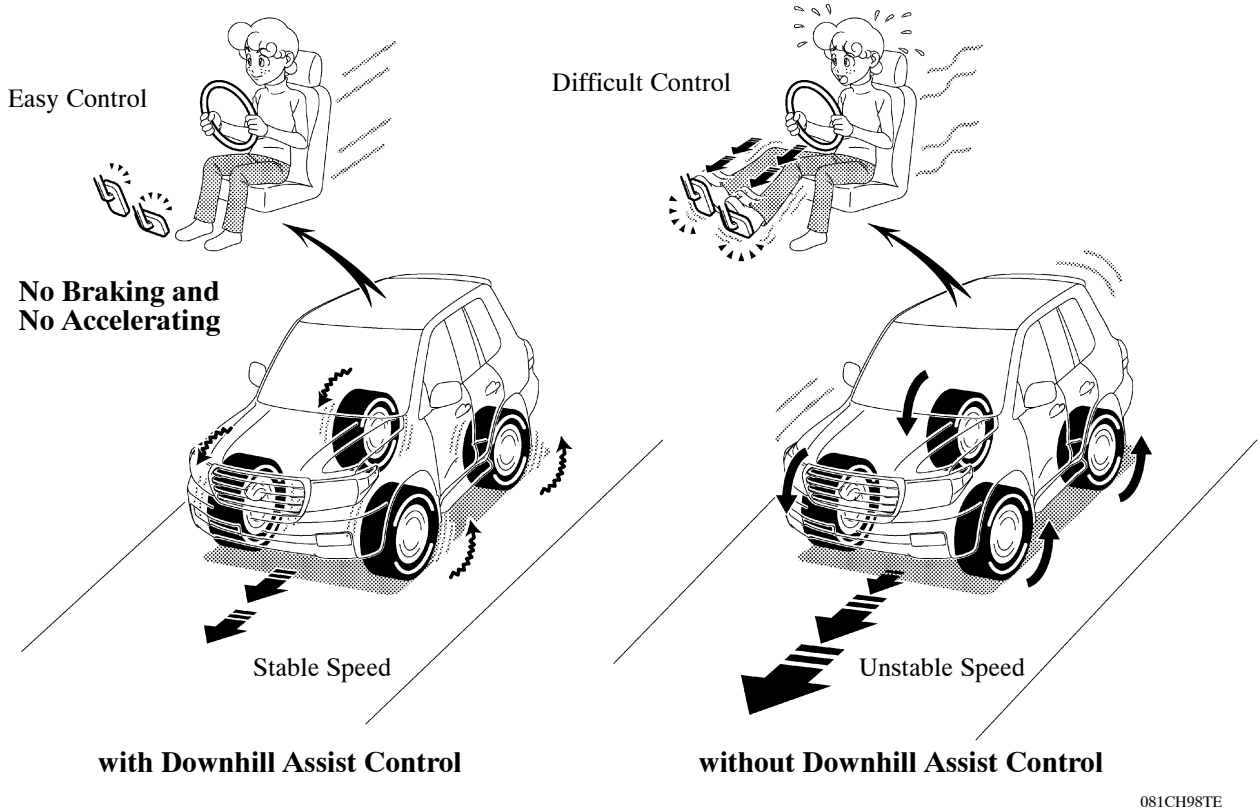


- Hill-start assist control operates when all of the following conditions have been met:

Hill-start Assist Control Operate Condition	• Shift lever position is 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.

8. Outline of Downhill Assist Control (Only for 1VD-FTV engine models)

- When the vehicle is descending a steep hill and the engine brake alone cannot provide a sufficient deceleration force while the transfer is in the L4 range, downhill assist control effects 4-wheel brake control to maintain a constant, low vehicle speed. Thus, the vehicle is able to descend in a stable manner without causing the wheels to become locked.
- When the vehicle descends a steep hill without downhill assist control, the driver must pay close attention to the brake and accelerator pedal maneuvers. However, with downhill assist control, the driver can concentrate on the steering operation, without accelerator and brake pedals operation.
- Downhill assist control enables the vehicle to maintain stability because it can descend a slippery hill at low speeds without causing the wheels to become locked.



with Downhill Assist Control **without Downhill Assist Control**

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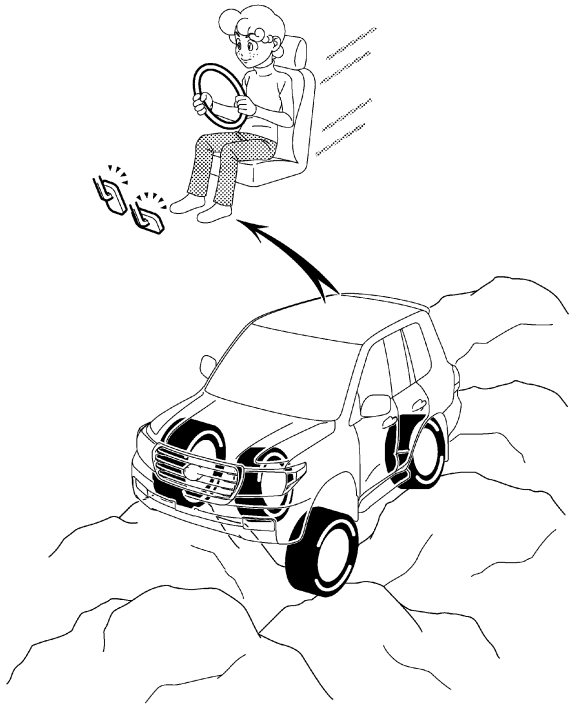
- Downhill assist control operates when all of the following conditions have been met:

Downhill Assist Control Operate Condition	• DAC switch ON • Transfer is L4 range. • Accelerator pedal and brake pedal are not pressed. • Descending a hill at a vehicle speed of 25 km/h (16 mph) or less.

9. Outline of CRAWL (Only for 2UZ-FE engine models)

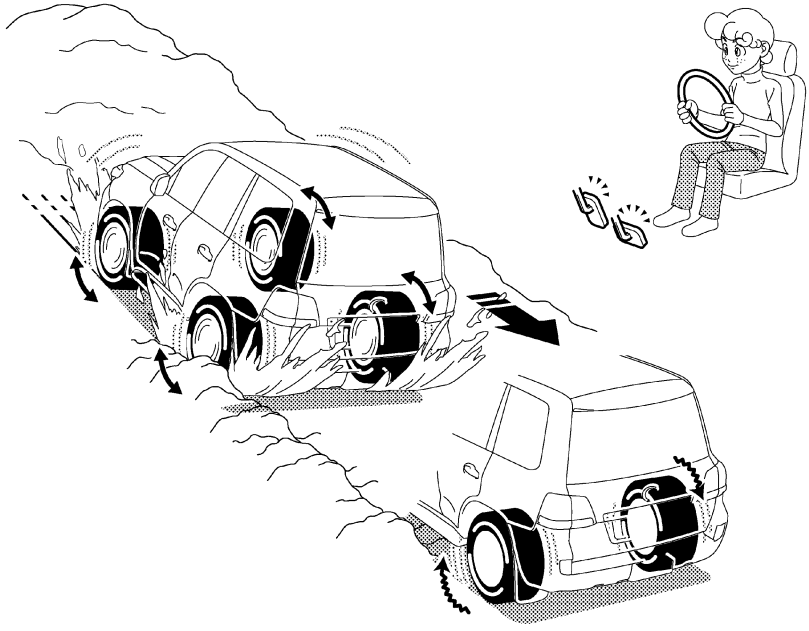
The CRAWL is a driving support system that regulates the engine output and the brake force, enabling the vehicle to be driven at a constant speed on rough ground or slippery roads.

- 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 or brake pedals.



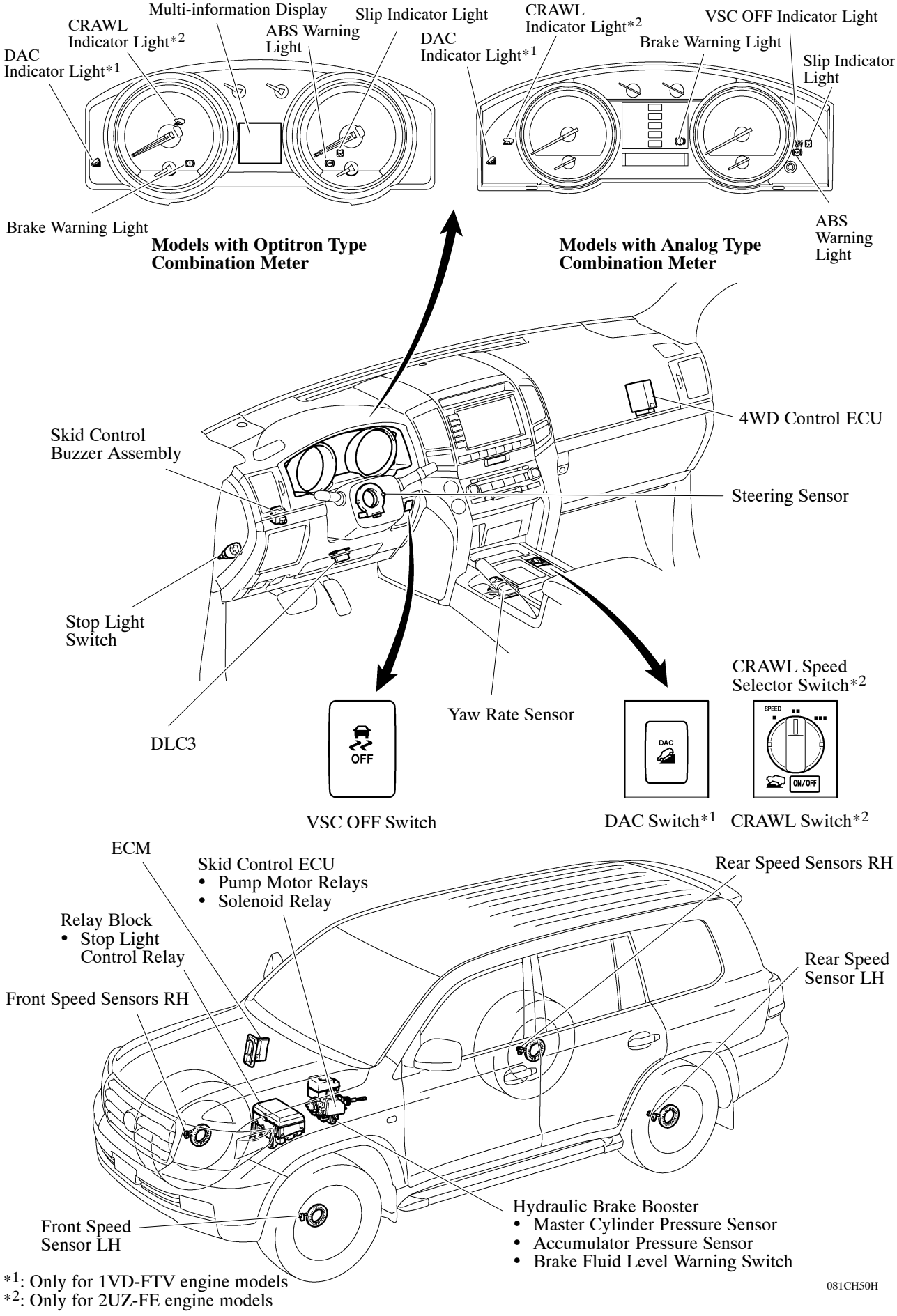
080CH05TE

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



080CH15TE

10. Layout of Main Components



*1: Only for 1VD-FTV engine models
*2: Only for 2UZ-FE engine models

081CH50H

CH

11. Function of Main Components

Components		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 with EBD, brake assist, A-TRC, VSC, hill-start assist control, downhill assist control, and CRAWL in order to control the fluid pressure that is applied to the wheel cylinders. • For details about the parts, see page CH-169.
Combination Meter	Multi-information Display*1	Informs the driver of the status of the brake control system. For the items displayed on the multi-information display, see page CH-205.
	Brake 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, EBD or brake assist system.
	VSC OFF Indicator Light	Informs the driver of the standstill status of the VSC.
	Slip Indicator Light	Blinks to inform the driver when the A-TRC, VSC, hill-start assist control, downhill assist control, or CRAWL is operated.
	DAC Indicator Light*2	Lights up to inform the driver when the DAC switch turned ON.
	CRAWL Indicator Light*3	Lights up to inform the driver when the CRAWL switch turned ON.
	Center Diff. Lock Indicator Light	Lights up to inform the driver when the center differential condition is locked.
Skid Control Buzzer Assembly		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, VSC, hill-start assist control, downhill 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 in malfunctioning.
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.
DAC Switch*2		Turns the downhill assist control ON and OFF.
CRAWL Switch*3		Turns the CRAWL ON and OFF.
CRAWL Speed Selector Switch*3		Used to select the target vehicle speed when the CRAWL is active.

(Continued)

Components		Function
Skid Control ECU		Judges the vehicle driving condition based on signals from each sensor, and sends brake control signals to the brake actuator.
	Pump Motor Relays	Control the pump motor operation in the hydraulic brake booster.
	Solenoid Relay	Supply or cut off power to solenoid valves in the brake actuator.
Speed Sensor (4)		Detects the wheel speed and rotating direction of each of 4-wheel.
Steering Sensor		Detects the steering direction and angle of the steering wheel.
Yaw Rate Sensor		• Detects the vehicle's yaw rate. • Detects the vehicle's acceleration in the forward, rearward, and lateral.
Stop Light Control Relay		Turn on the stop light during hill-start assist control, downhill assist control or CRAWL operation.
Stop Light Switch		Detects the brake pedal depressing signal.
Park/Neutral Position Switch		Detects the shift position.
ECM	for 2UZ-FE Engine	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.
	for 1VD-FTV Engine	Cutoff the fuel injection based on the signals receives from the skid control ECU, in order to control the engine output. Also, sends the accelerator pedal position signal, and engine speed signal to the skid control ECU.
Throttle Position Sensor (for 2UZ-FE engine)		Detects the opening of the throttle valve and inputs it into the ECM.
Throttle Control Motor (for 2UZ-FE engine)		Controls the opening of the throttle valve in accordance with the signals received from the ECM.
Accelerator Pedal Sensor (for 1VD-FTV engine)		Detects the depressing of the accelerator pedal and inputs it into the ECM.
EDU (for 1VD-FTV engine)		Controls the fuel injection in accordance with the signals received from the ECM.
Crankshaft Position Sensor		Detects the engine speed, and sends it via the ECM to the skid control ECU.
Transfer Shift Actuator	Center Diff. Lock Detection Switch	Detects the condition of the center differential lock.
4WD Control ECU		Detect the transfer condition shifted in the L4 and sends the L4 signal to the skid control ECU.

*1: Only on models equipped with the optitron type combination meter.
*2: Only for 1VD-FTV engine models.
*3: Only for 2UZ-FE engine models.

12. Construction of Main Components

Combination Meter

1) Warning and Indicator Lights and VSC Warning Buzzer

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

○: Illuminates (Continuous Sound) △: Blinks (Intermittent Sound) —: Not Available

Condition		Warning Light		Indicator Light				Buzzer
		BRAKE	ABS	VSC OFF*1	SLIP	DAC*2	CRAWL *3	
Initial Check		○	○	○	○	○	○	
During Operation	A-TRC				△			
	VSC				△			△
	Hill-start Assist Control				△			△
	Downhill Assist Control*2				△	○		
	CRAWL*3				△		○*4	
VSC OFF Switch	VSC OFF			○				
Driving Mode	Center Diff. Lock			○				
	Rear Diff. Lock		○	—	—	—	—	
During Actuator Protection					○	△	△	△
Cannot operate due to a malfunction	Multi-terrain ABS		○	○	○			
	EBD	○	○	○	○			
	Brake Assist		○	○	○			
	A-TRC			○	○			
	VSC			○	○			
	Hill-start Assist Control			○	○			
	Downhill Assist Control*2			○	○	△*5		
	CRAWL*3			○	○		△*6	
Others	Low Brake Fluid Level	○	○	○	○			
	ABS Malfunction		○	○	○	△*5	△*6	
	Low Accumulator Pressure	○	○	○	○			○
	Skid Control ECU Malfunction	○	○					

*1: Displayed on the multi-information display where equipped.
*2: Only for 1VD-FTV engine models.
*3: Only for 2UZ-FE engine models.
*4: When only the brake control of the CRAWL is operative, CRAWL indicator light blinks.
*5: Only when the DAC switch is pressed.
*6: If a malfunction occurs during the CRAWL operation, the CRAWL indicator light blinks and the CRAWL gradually stops operating. Then the CRAWL indicator light goes off. When the CRAWL is not operating, the indicator stays off.

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.

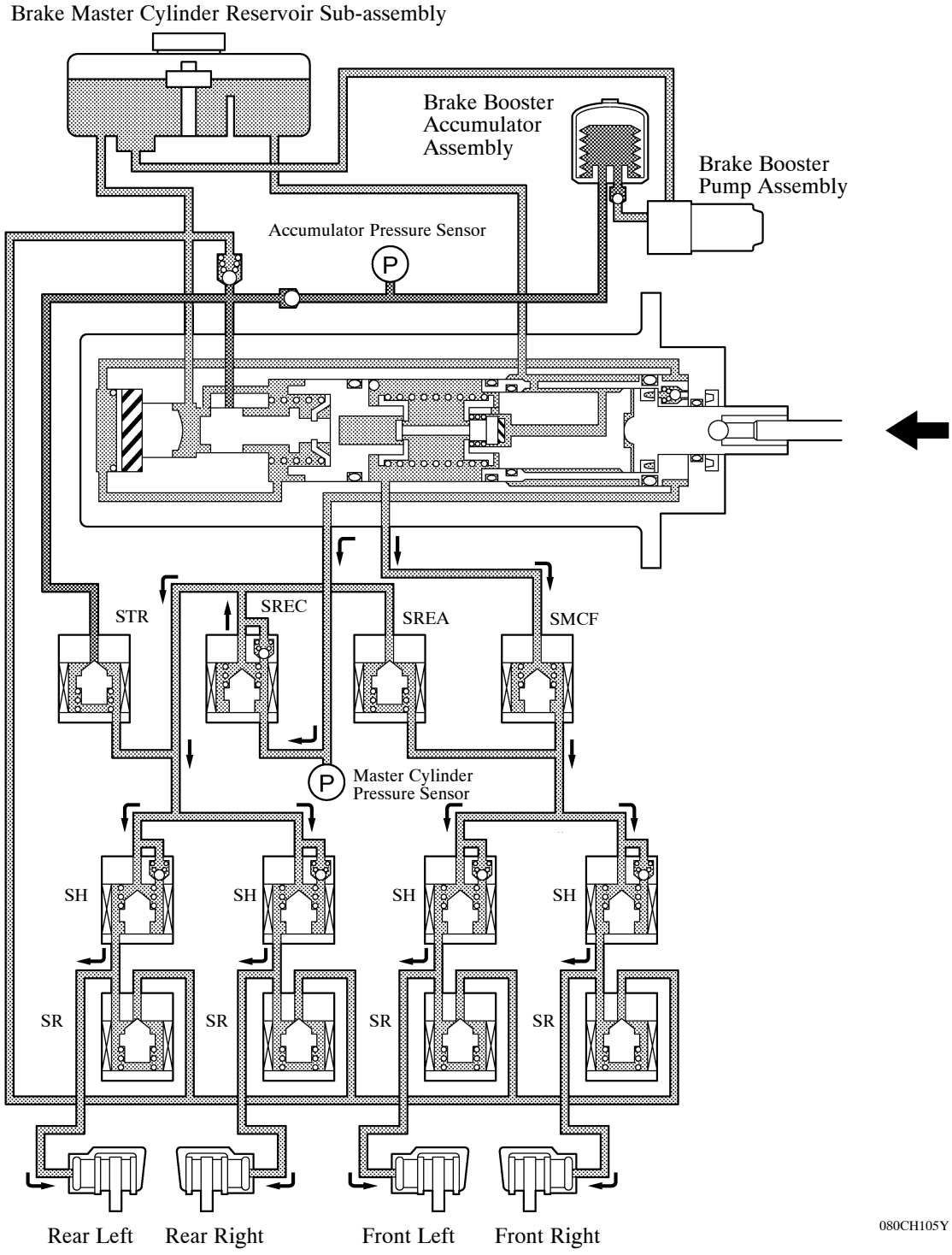
Display	Details
VSC OFF	Displayed when the A-TRC and VSC stop operating.
Check VSC	Displayed when a malfunction occurs in any one of the A-TRC, VSC, hill-start assist control, downhill assist control, or CRAWL. In addition, the master warning light and slip indicator light illuminate.
VSC Test Mode	Displayed when the VSC test mode is activated.
CRAWL is activated Speed: Lo Med Hi*	Displayed when the CRAWL switch is turned ON. Simultaneously, the target vehicle speed (Lo, Med or Hi), which is selected using the CRAWL speed selector switch, is displayed. In addition, the CRAWL indicator light illuminates and the slip indicator light blinks.
CRAWL has been deactivated*	Displayed when all the CRAWL controls stop operating. In addition, the CRAWL indicator light and the slip indicator light go off after blinking. If the CRAWL control is deactivated in any situation except when the CRAWL switch is turned OFF, the buzzer sounds for approximately 3 seconds.
	Displayed when only the CRAWL engine control stops operating. In addition, the slip indicator light goes off after blinking, and the buzzer sounds approximately. 3 seconds. The CRAWL indicator light blinks.
CRAWL not available Select L4 and shift to D or R position*	Displayed when the CRAWL switch is turned ON in either of the following situations: - Transfer is in H4 range - Shift position is in P or N range
CRAWL not available Check System operation conditions*	Displayed when the CRAWL switch is turned ON in any one of the following situations: - Vehicle is running - Engine is not running - Parking brake is being applied - Brake pedal is not being depressed - Driver's door is open - 2nd start switch is turned ON - Brake actuator temperature is too high - ATF temperature is too high - CRAWL is malfunctioning

*: Only for 2UZ-FE engine models

13. 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

Multi-terrain ABS with EBD Operation

The detailed operation is the same as that of brake control system (Multi-terrain ABS with EBD). For details, see page CH-184.

Brake Assist Operation

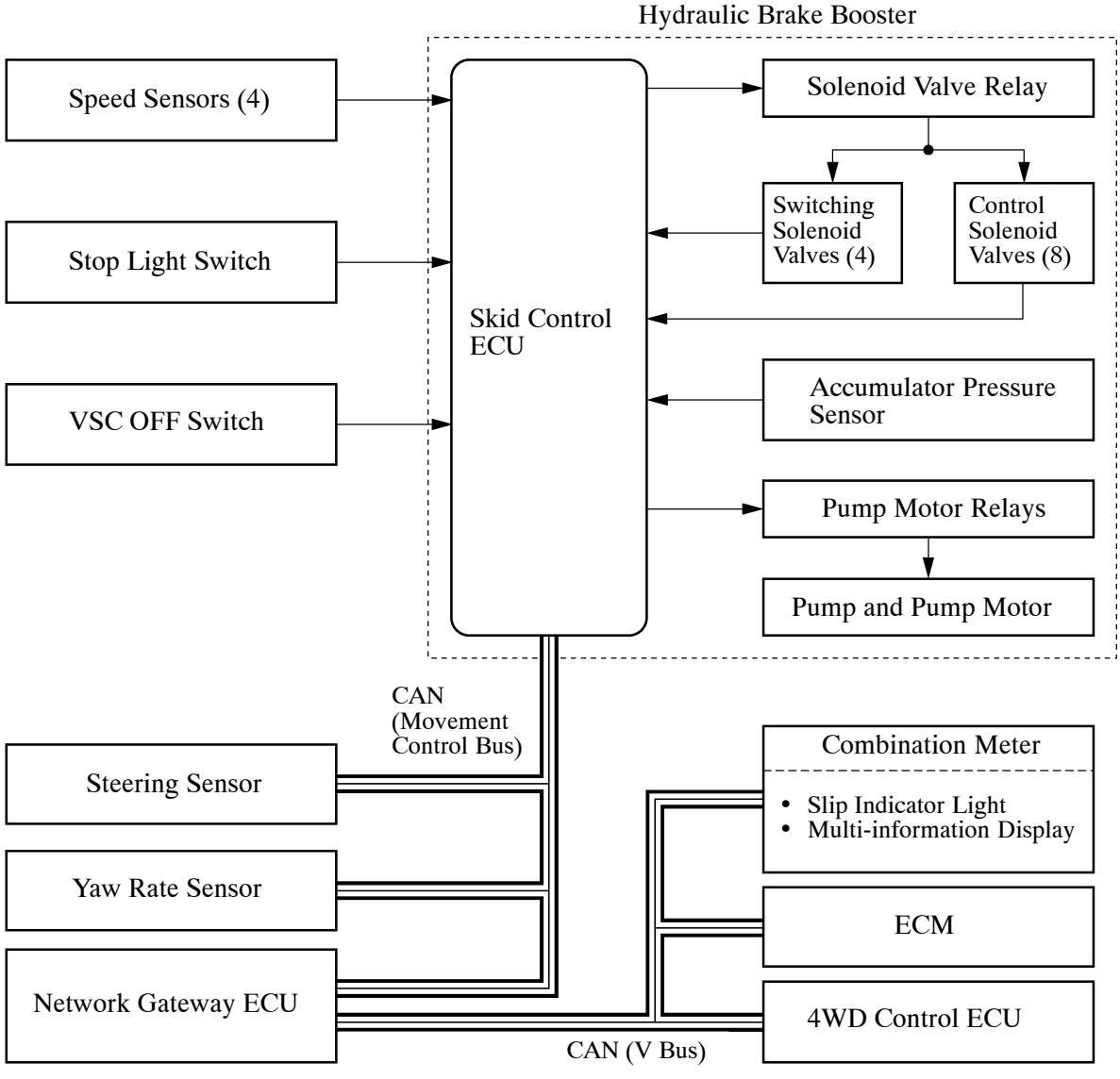
The detailed operation is the same as that of brake control system (brake assist). For details, see page CH-188.

A-TRC Operation

1) General

- Based on the vehicle speed that has been calculated from each speed sensor and signals of the yaw rate sensor, the skid control ECU computes the target control speed in accordance with the transfer range.
- The skid control ECU outputs an A-TRC operate signal to the ECM and the combination meter. Upon receiving this signal, the ECM effects throttle control to regulate the engine output. On 1VD-FTV engine models, the engine output is regulated via fuel injection. The combination meter causes the slip indicator light to blink.

▶ System Diagram ◀



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- 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.
- The skid control ECU compares the target control speed and the speeds of the wheels to determine whether or not a slippage exists. Upon detecting a 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 controlling the brake fluid pressure.
- 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	Contents	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	
Rocky or Off-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	
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 the release of the engine brake.
		Brake Control	Fluid pressure control to the front wheels	

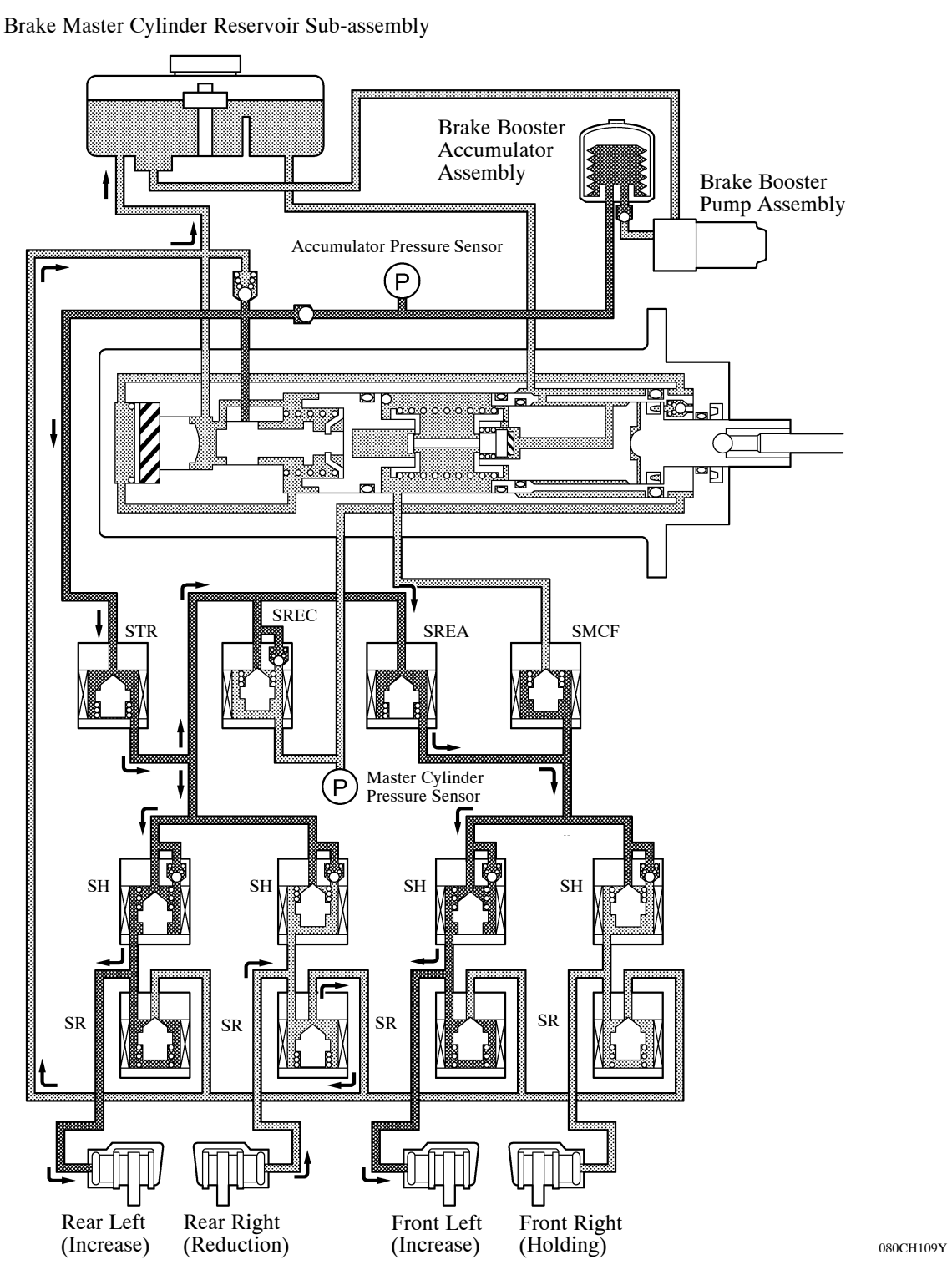
NOTICE

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 skid control 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.

2) A-TRC Operation

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.



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

Item			A-TRC not Activated	A-TRC Activated		
				Mode		
				Increase	Holding	Reduction
Switching Solenoid Valve		SREC	OFF (Open)	ON (Close)	←	←
		STR	OFF (Close)	ON (Open)	←	←
	Front Brake	SMCF	OFF (Open)	ON (Close)	←	←
		SREA	OFF (Close)	ON (Open)	←	←
Control Switching Valve		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

3) Cancel Operation

By pressing the VSC OFF switch, the A-TRC and VSC can be deactivated regardless of the status of the transfer gear and differential lock.
If the VSC or A-TRC is active when the vehicle attempts to escape from mud or snow, the engine output is limited despite the accelerator pedal being depressed, thus the escape will be difficult. The following switch operations enable the driver to deactivate or activate the VSC and A-TRC.

VSC OFF Switch Operation	Contents
Press the switch one time	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. These can be resumed by pressing the switch.

NOTE: 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 approximately 15km/h (9mph) may cause the A-TRC to be activated, however, this is not a malfunction.

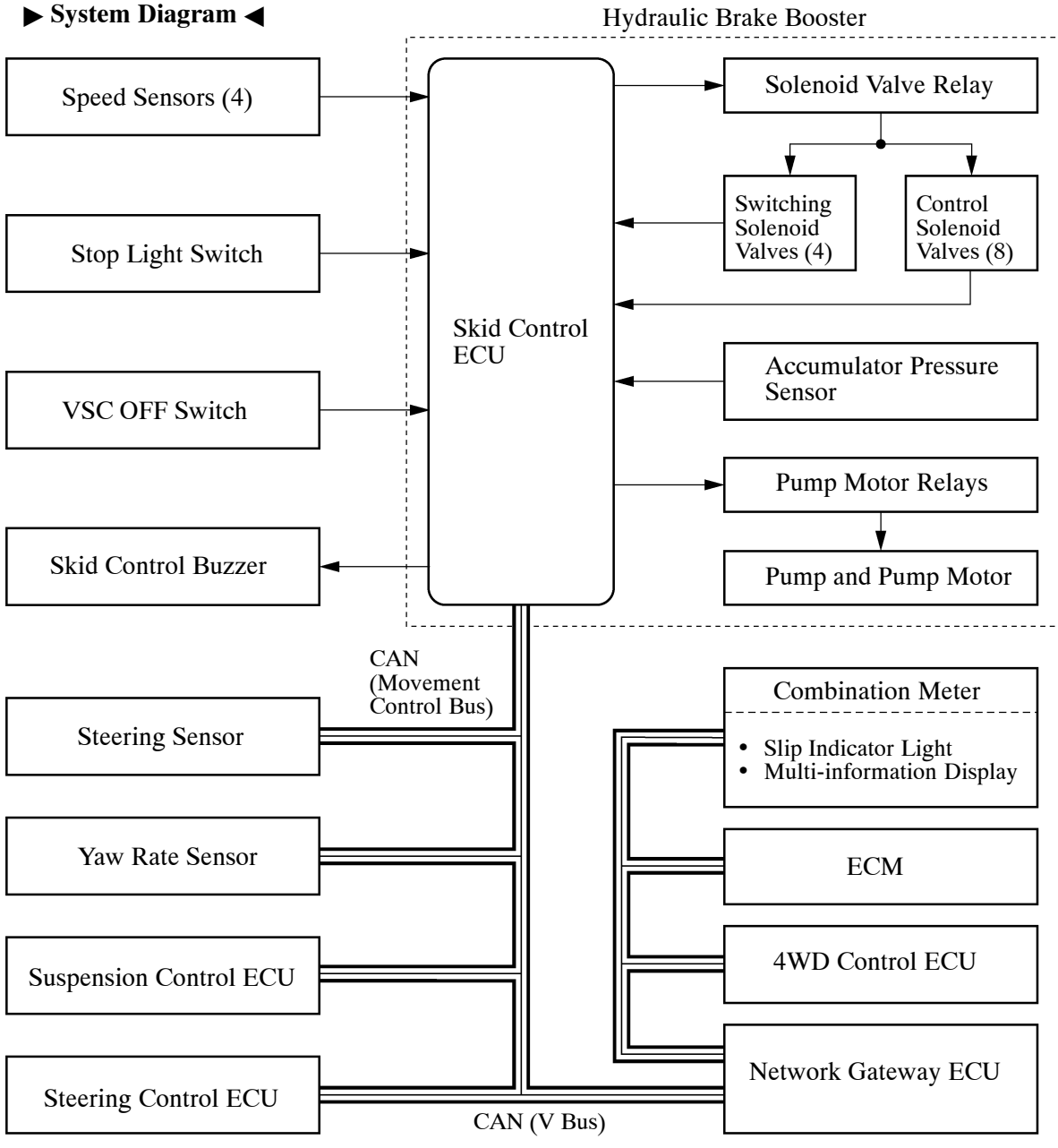
VSC Operation

1) General

- 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, the suspension control ECU and the combination meter cause the skid control buzzer to sound intermittently. Upon receiving the signal, the ECM regulates the engine output using fuel injection. The suspension control ECU regulates the suspension damping force. The combination meter causes the slip indicator light to blink.

NOTE: When the brake pedal is depressed while the VSC brake control 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.

▶ System Diagram ◀



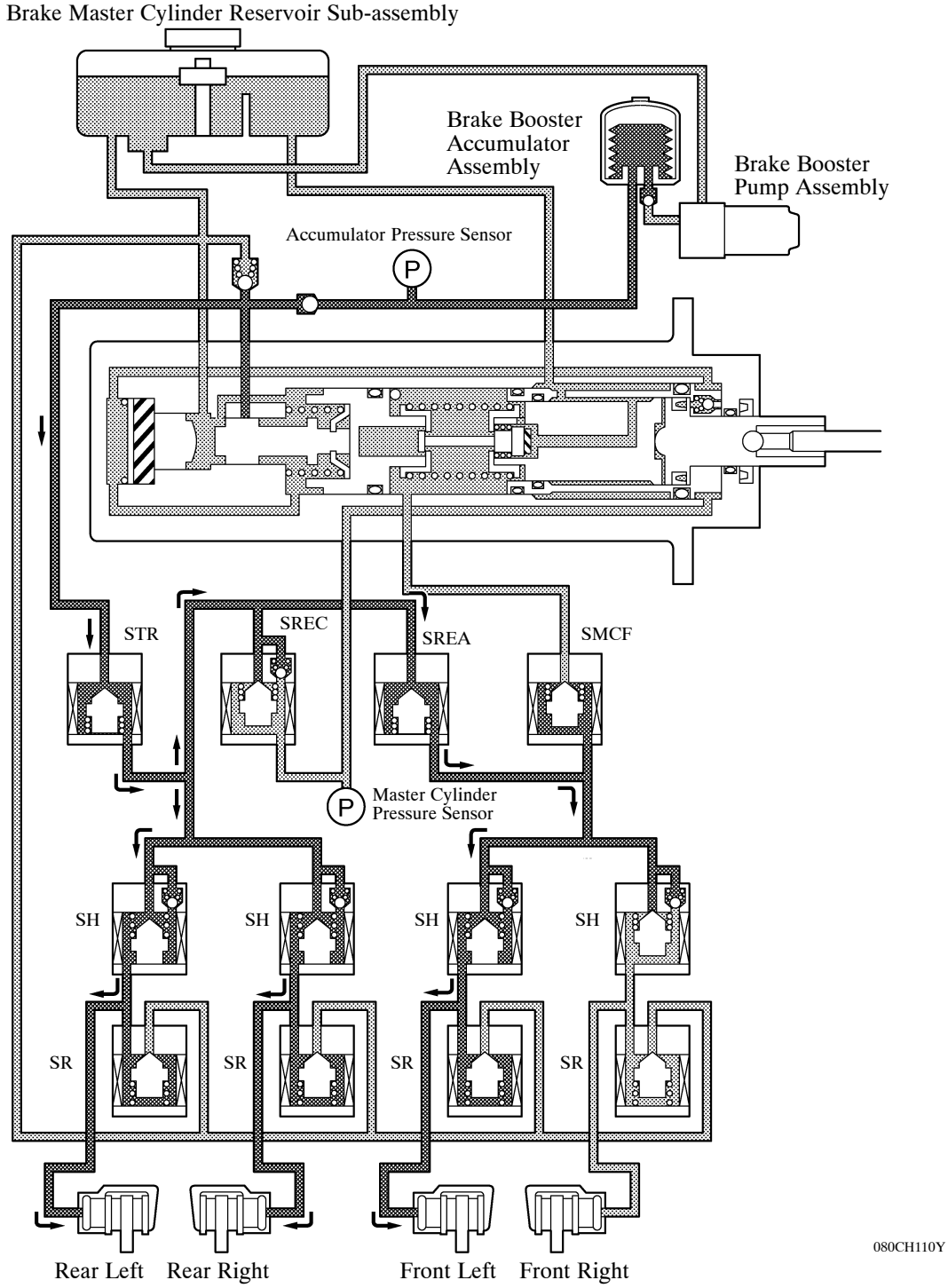
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2) Front Wheel Skid Restraining (Turning to the Right)

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

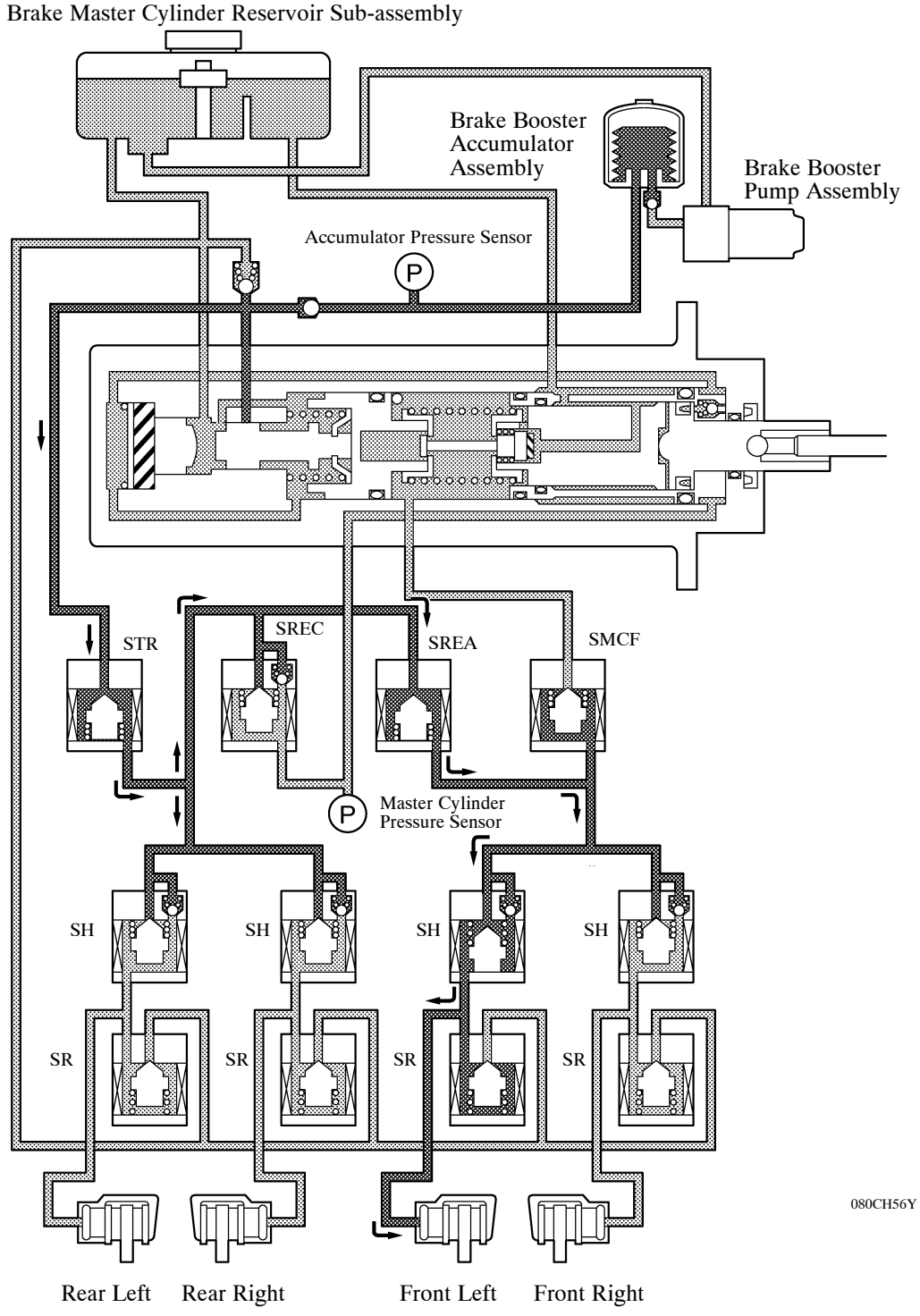
Item				VSC not Activated	VSC Activated		
					Mode		
					Increase	Holding	Reduction
Switching Solenoid Valve		SREC		OFF (Open)	ON (Close)	←	←
		STR		OFF (Close)	ON (Open)	←	←
	Front Brake	SMCF		OFF (Open)	ON (Close)	←	←
		SREA		OFF (Close)	ON (Open)	←	←
Control Switching Valve		SH	RH	OFF (Open)	ON (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

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3) 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

Item				VSC not Activated	VSC Activated		
					Mode		
					Increase	Holding	Reduction
Switching Solenoid Valve		SREC		OFF (Open)	ON (Close)	←	←
		STR		OFF (Close)	ON (Open)	←	←
	Front Brake	SMCF		OFF (Open)	ON (Close)	←	←
		SREA		OFF (Close)	ON (Open)	←	←
Control Switching Valve		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)	←	←	←
		Wheel Cylinder Pressure		—	—	—	—

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4) Cancel Operation

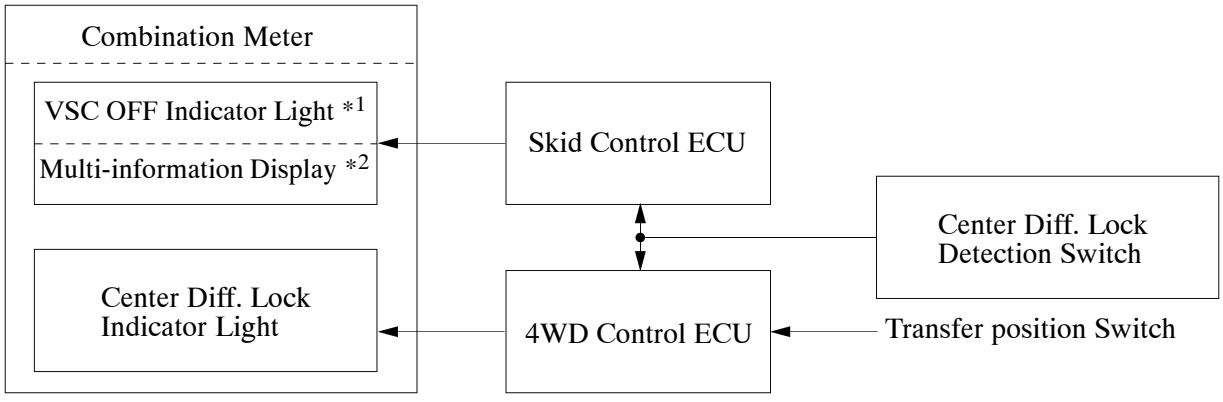
By pressing the VSC OFF switch, the A-TRC and VSC can be deactivated regardless of the status of the transfer gear and differential lock.
If the VSC or A-TRC is active when the vehicle attempts to escape from mud or snow, the engine output is limited despite the accelerator pedal being depressed, thus the escape will be difficult. The following switch operations enable the driver to deactivate or activate the VSC and A-TRC.

VSC OFF Switch Operation	Contents
Press the switch one time	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. These can be resumed by pressing the switch.

5) VSC Prohibit Control

When the center differential is locked, VSC is prohibited. At this time, the center differential indicator light and the VSC OFF indicator light* turn ON, or multi-information display shows VSC OFF. After the center differential is unlocked, the 2 indicator lights will turn OFF, and the VSC operation will turn ON.

▶ System Diagram ◀



*1: Only on models equipped with the analog type combination meter.
*2: Only on models equipped with the optitron type combination meter.

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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 park/ neutral position switch.
- This 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 sensor. Then, this 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, skid control ECU informs the driver by the slow and intermittent sound of the skid control buzzer. After that, this ECU alerts the driver by using the quick and intermittent sound of the skid control buzzer, and gradually releases the brake hydraulic pressure in order to end the hill-start assist control operation.

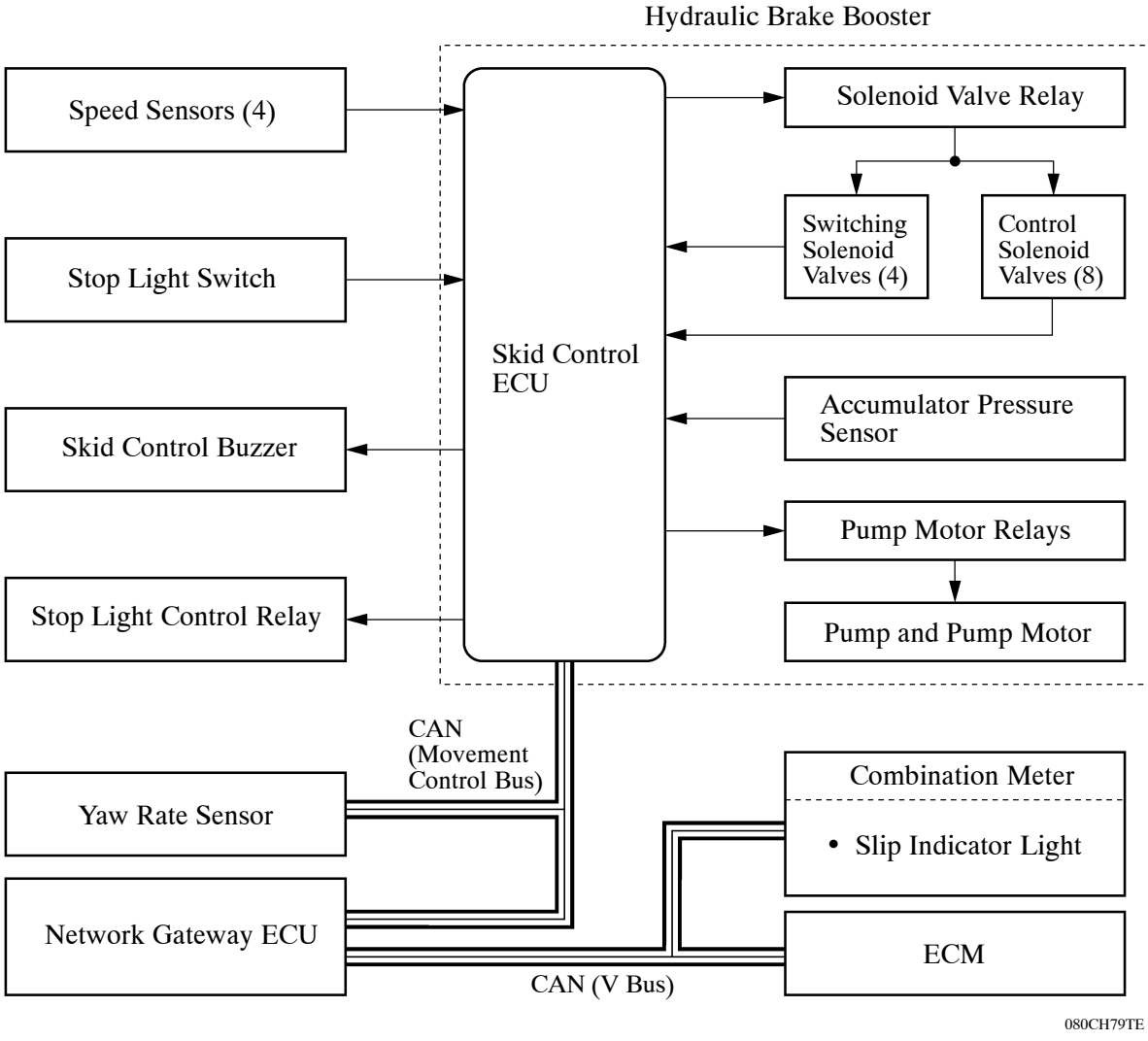
NOTICE

Precaution on Hill-start Assist Control Operation

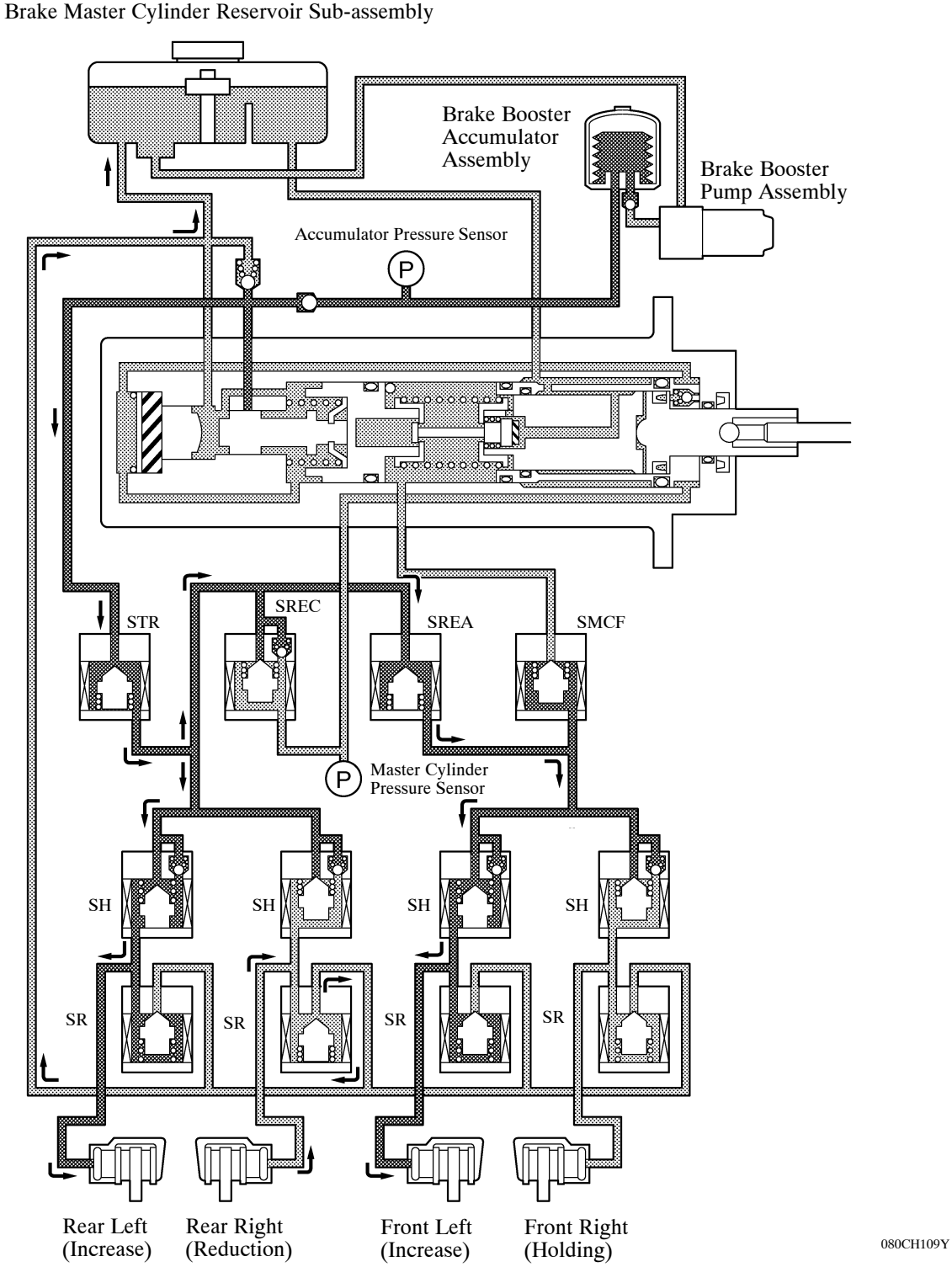
When the hill-start assist control is operating continuously while the vehicle is being driven on a slippery surface, the temperature of the actuator in the hydraulic brake booster increases. After a prescribed length of time elapses, the skid control ECU alerts the driver of this condition by causing 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.

▶ System Diagram ◀



▶ 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

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Item			Hill-start Assist Control not Activated	Hill-start Assist Control Activated		
				Mode		
				Increase	Holding	Reduction
Switching Solenoid Valve		SREC	OFF (Open)	ON (Close)	←	←
		STR	OFF (Close)	ON (Open)	←	←
	Front Brake	SMCF	OFF (Open)	ON (Close)	←	←
		SREA	OFF (Close)	ON (Open)	←	←
Control Switching Valve		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

Downhill Assist Control Operation (Only for 1VD-FTV engine models)

Based on the information provided by various sensors, switches, and the ECM, the skid control ECU determines the conditions that enable downhill assist control operation. 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 computes the vehicle speed, travel direction, and the gradient of the hill in accordance with the signals that are input by the speed sensor and the yaw rate sensor, and effects brake control to attain the target vehicle speed. The target vehicle speed is determined by the direction of the vehicle.

Travel Direction	Target Vehicle Speed
Forward	Approx. 4 to 9 km/h (2 to 6 mph)
Backward	Approx. 2 to 7 km/h (1 to 4 mph)

- During downhill assist control operation, the skid control ECU outputs signals to the stop light control relay to cause the stop light to turn ON and combination meter causing the slip indicator light to blink.
- The downhill assist control does not operate in the condition described below ever if the DAC switch is turned ON; In this case, the DAC indicator light blinks to alert the driver.
  - If the DAC switch is turned OFF during a downhill assist control operation, the hydraulic pressure decreases gradually to end the downhill assist control operation.
  - Transfer is H4 range.
  - Driving at a vehicle speed of 25 km/h (16 mph) or higher.

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NOTICE

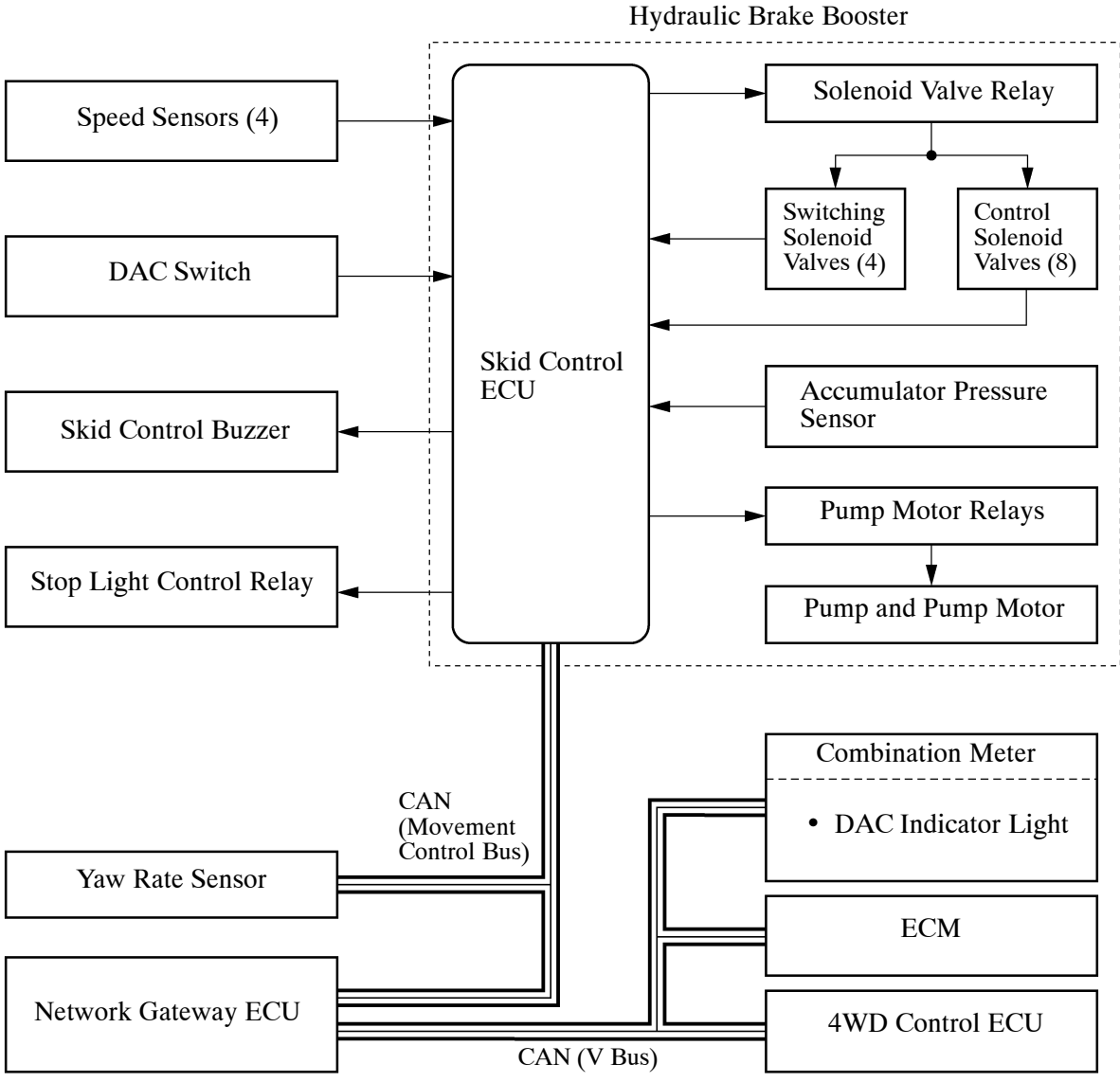
Precaution on Downhill Assist Control Operation

When driving on a steep downhill which causes the downhill assist control to be activated, select the L4 range and low gear, as well as use the engine brake. This enables the vehicle to run stably and reduce the load applied to the brake.

When the downhill assist control 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 skid control buzzer to sound intermittently for approximately three seconds, slip indicator light to illuminate, and the DAC indicator light to blink. Also, the downhill assist control operation is momentarily interrupted to protect the actuator.

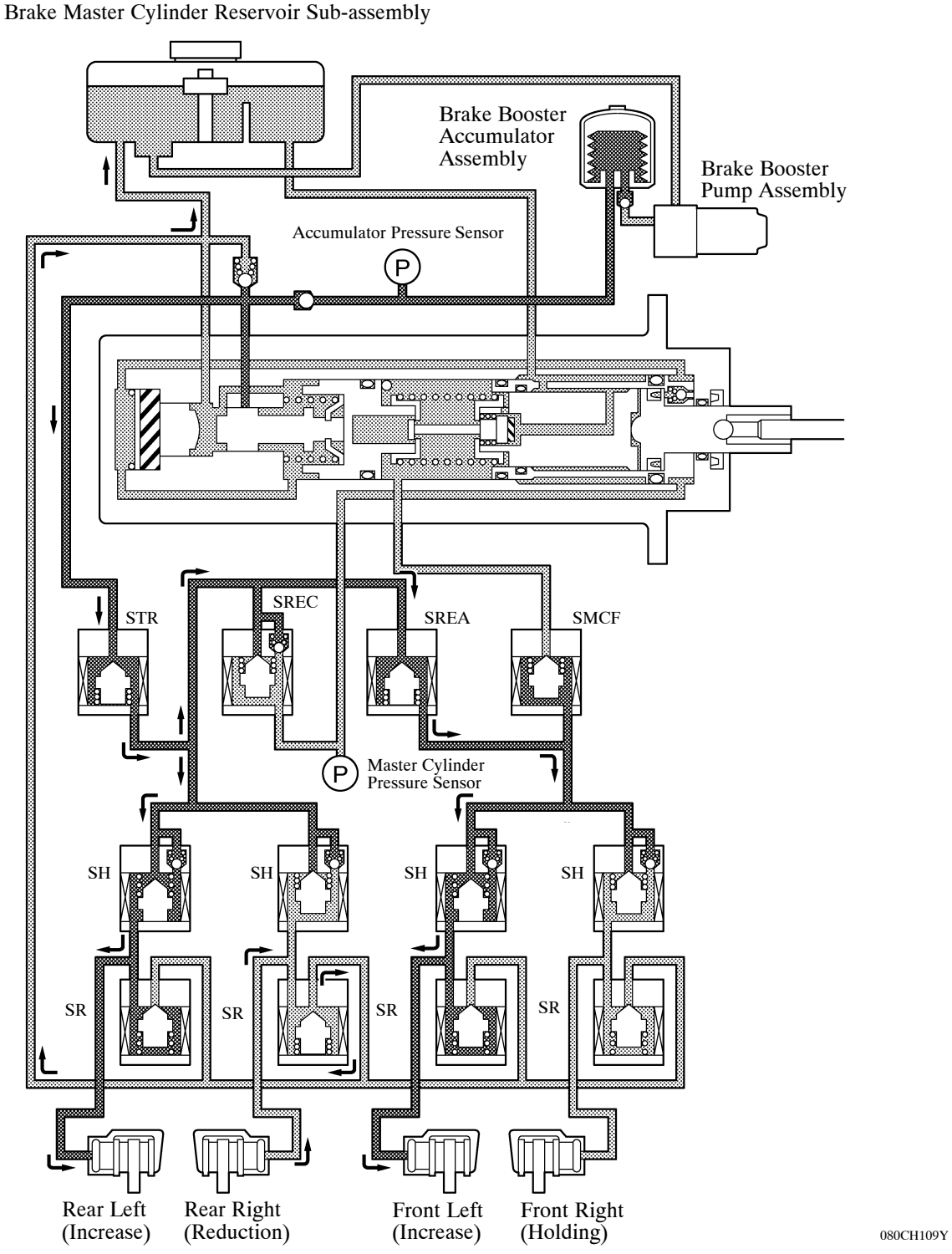
When the temperature of the actuator decreases, the slip indicator light turns OFF, and the downhill assist control is automatically restored to an operating state.

▶ System Diagram ◀



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▶ Downhill 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

CH

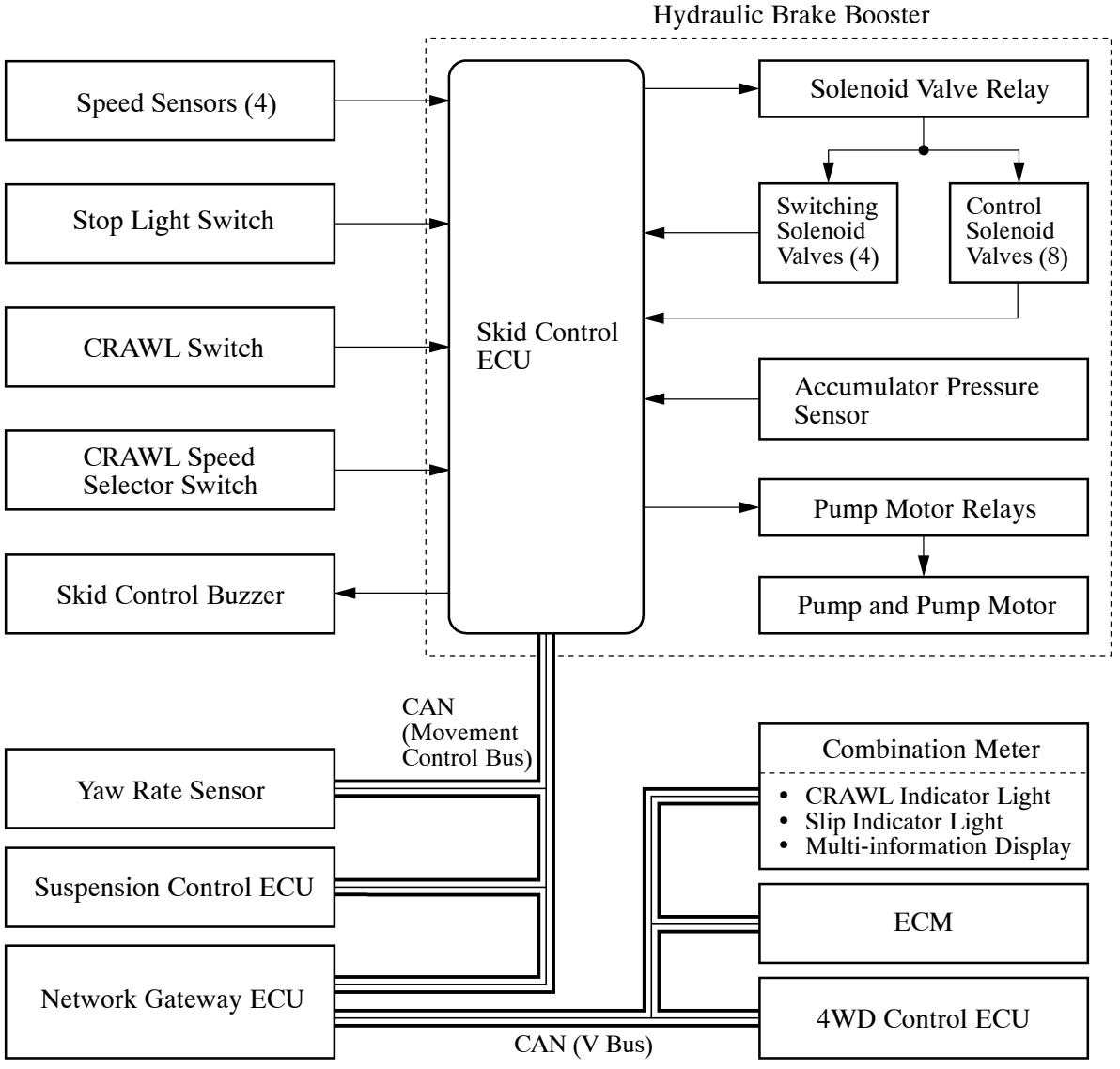
Item			Downhill Assist Control not Activated	Downhill Assist Control Activated		
				Mode		
				Increase	Holding	Reduction
Switching Solenoid Valve		SREC	OFF (Open)	ON (Close)	←	←
		STR	OFF (Close)	ON (Open)	←	←
	Front Brake	SMCF	OFF (Open)	ON (Close)	←	←
		SREA	OFF (Close)	ON (Open)	←	←
Control Switching Valve		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

CRAWL Operation (Only for 2UZ-FE engine models)

1) General

- 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 5km/h, 1 to 3mph) 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 exceeds the target speed, the engine output is reduced. When the wheel speeds exceed the target speeds, the hydraulic brake pressure on the wheels is increased.
- When the vehicle speed falls below the target speed, the engine output is increased. When the wheel speeds fall below the target speeds, the hydraulic brake pressure on the wheels is reduced.

▶ System Diagram ◀



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2) CRAWL Operation Condition

When the CRAWL 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.

- Transfer is L4.
- Shift position is in any position other than P or N.
- 2nd start switch is OFF.
- Vehicle speed is 0km/h (0mph).
- Brake pedal is being depressed.
- Parking brake is not applied.
- Driver's door is closed.
- Brake actuator temperature is too high.
- ATF temperature is too high.
- VSC system is operating normally.

3) 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. If the CRAWL control is deactivated in any situation except when the CRAWL switch is turned OFF, the buzzer sounds.

- CRAWL switch is turned OFF.
- Vehicle speed is above 25km/h (16mph).
- Transfer is changed to H4.
- Shift position is shifted into P.
- Brake actuator temperature is too high.
- VSC malfunctions. (If this happens, take appropriate actions such as stopping the vehicle.)

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.

- Shift position is N.
- 2nd start switch is turned ON.
- Vehicle speed is above 10km/h (6mph).
- Brake pedal is depressed firmly.
- Parking brake is applied.
- ATF temperature is too high.
- Driver's door is opened.
- Engine stalls.
- Target vehicle speed cannot be reached and the skid control ECU determines that the CRAWL control cannot operate.

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.

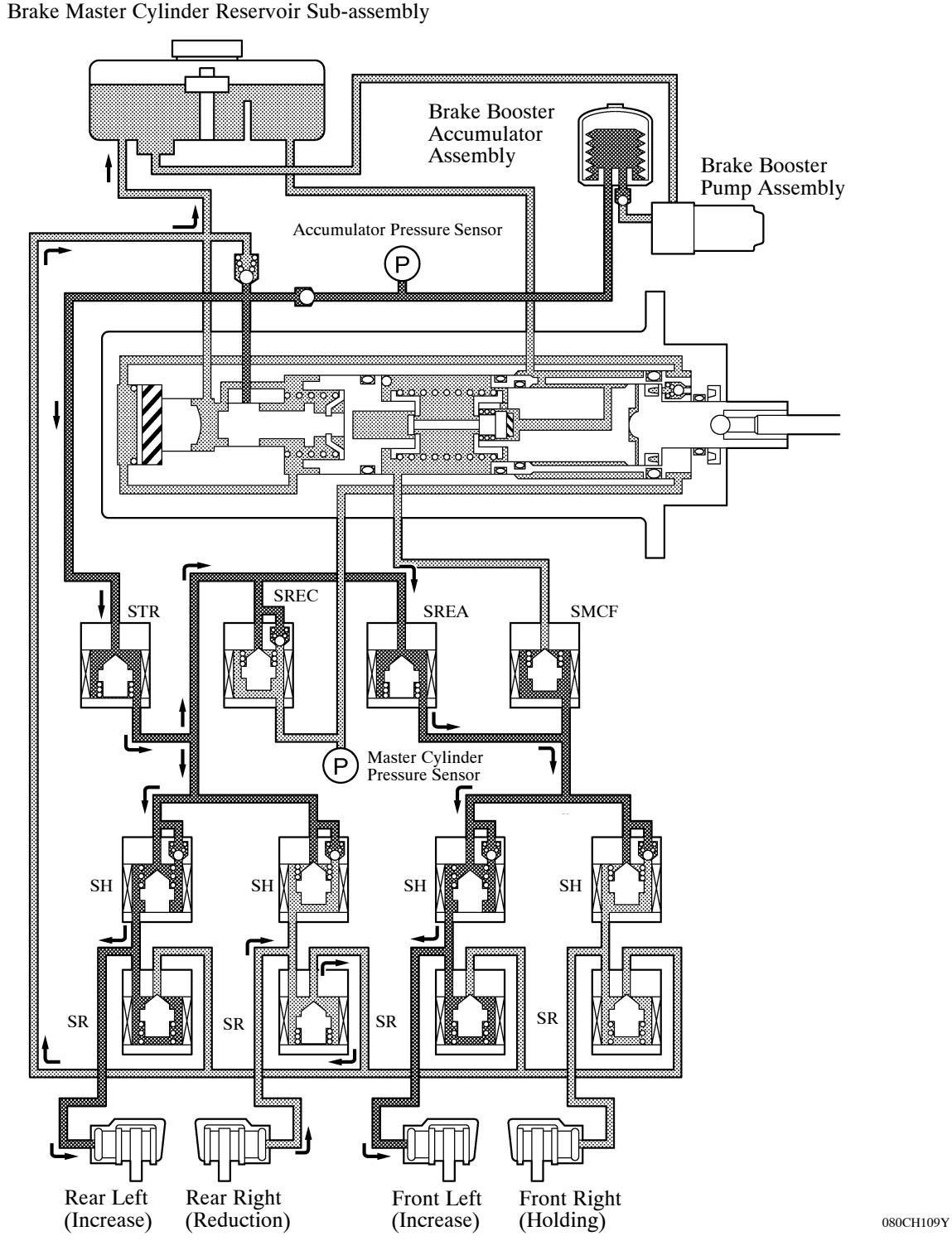
NOTICE

Precaution on CRAWL Operation

- 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 skid control 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 gradually deactivated to protect the actuator.
  When the temperature of the actuator decreases, the slip indicator light turns OFF, and the CRAWL becomes available.
- When the CRAWL continues operating, the ATF temperature may increase too much. If this happens, the ATF temperature warning light turns ON and the CRAWL operation stops operating to protect the automatic transmission. If the vehicle continues to be driven in this situation, ATF leakage or automatic transmission malfunctions may result. Therefore, immediately stop the vehicle in a safe area and select shift position P or N to let the ATF cool down enough.
  When the temperature of ATF decreases, the ATF temperature warning light turns OFF and the CRAWL becomes available.

4) 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.



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

Item			CRAWL not Activated	CRAWL Activated		
				Mode		
				Increase	Holding	Reduction
Switching Solenoid Valve		SREC	OFF (Open)	ON (Close)	←	←
		STR	OFF (Close)	ON (Open)	←	←
	Front Brake	SMCF	OFF (Open)	ON (Close)	←	←
		SREA	OFF (Close)	ON (Open)	←	←
Control Switching Valve		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

Engine Output Control

During a A-TRC, VSC, or CRAWL 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. On 1VD-FTV engine models, the engine output is regulated via fuel injection.

Initial Check

Each time the engine switch is turned IG-ON, 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 in the hydraulic brake booster are checked in order.

14. Diagnosis

- If the skid control ECU detects a malfunction in the brake control system (Multi-terrain ABS with EBD, brake assist, A-TRC, VSC, hill-start assist control, downhill assist control, CRAWL), then the ABS warning light, brake warning light, VSC OFF indicator light*, or slip indicator light illuminate either individually or as a group according to the function in which the malfunction has been detected, to alert the driver of the malfunction.
- At the same time, 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 an intelligent tester II to the DLC3.
  - The 2-digit DTC can be read from number of the blinking of 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.

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 Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

*: Displayed on the multi-information display where equipped.

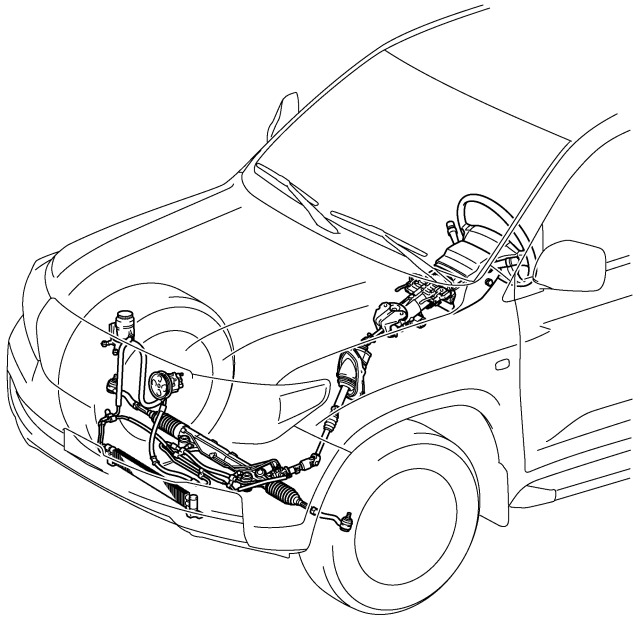
15. Fail-safe

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 and an engine revolution sensing type power steering are used on the all models.
- A variable gear ratio type steering rack is used.
- The VGRS (Variable Gear Ratio Steering) system is available as an option on European models. A VGRS system, which variably controls the steering angle in accordance with the vehicle speed, is used.
- A manual tilt and telescopic steering column is provided as standard on all models.
- In addition, a power tilt and power telescopic steering column is available as an option on VX grade models.
- The energy absorbing mechanism is used in the steering column.



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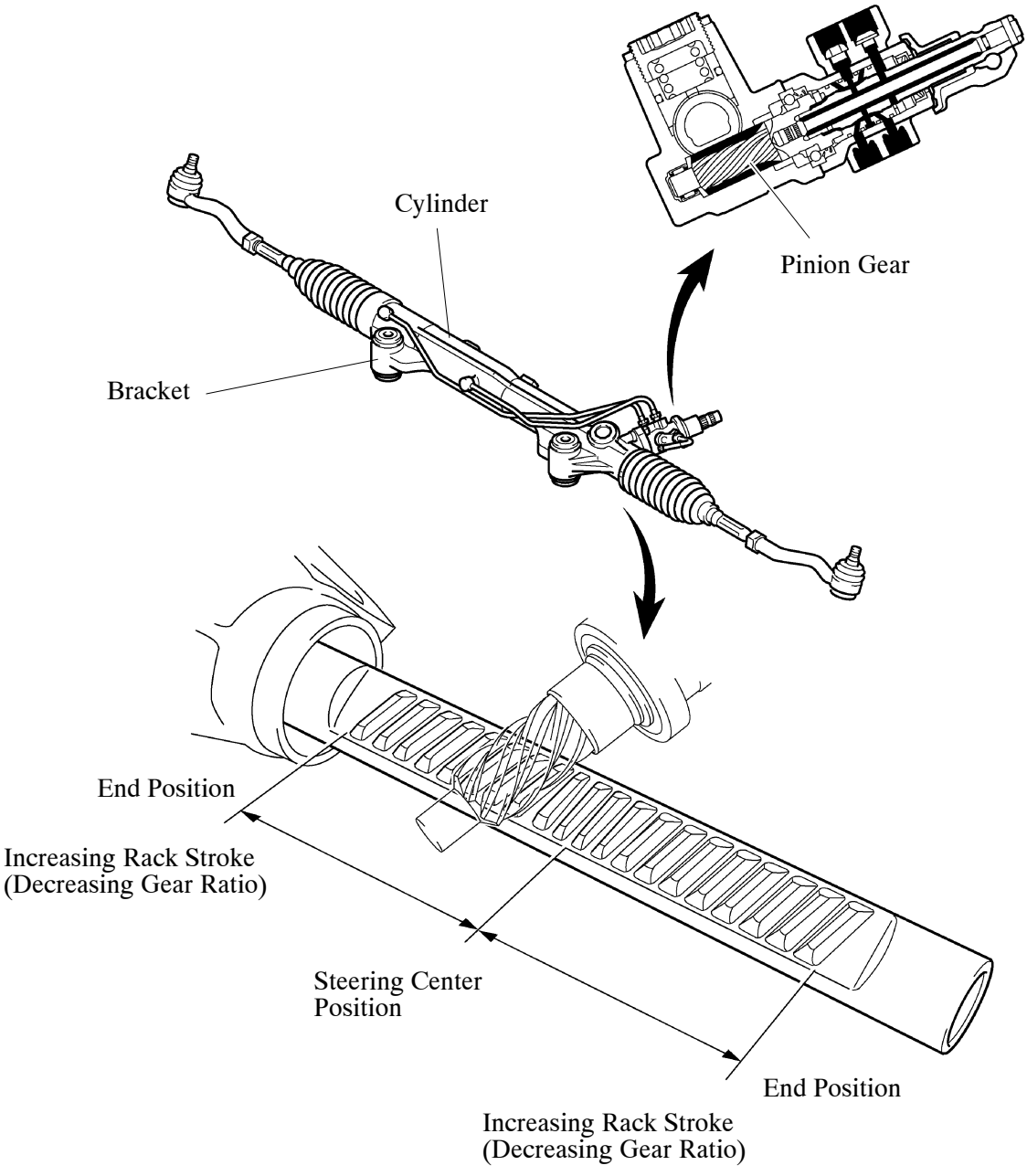
Models with VGRS System

▶ Specifications ◀

Items	Without VGRS System	With VGRS System
Gear Ratio (Overall)	16.7	14.2 to 17.6
No. of Turns Lock to Lock	3.14	2.66 to 3.30
Rack Stroke mm (in.)	175.0 (6.89)	←
Fluid Type	ATF Type DEXRON® II or III	←

■ STEERING GEAR

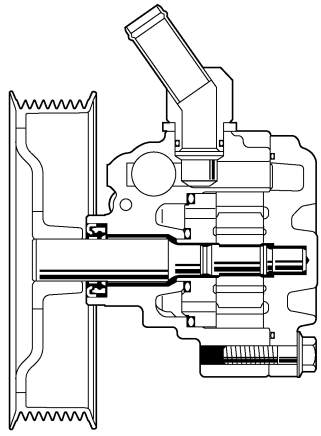
- For the purpose of weight reduction, an aluminum housing rack is used, which has the bracket and cylinder integrated.
- A variable gear ratio type steering rack is used. This steering rack changes the gear ratio gradually by changing the gear teeth form. The gear ratio is set larger around the steering center and smaller around the end position. And so, 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.



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■VANE PUMP

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



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Cross Section

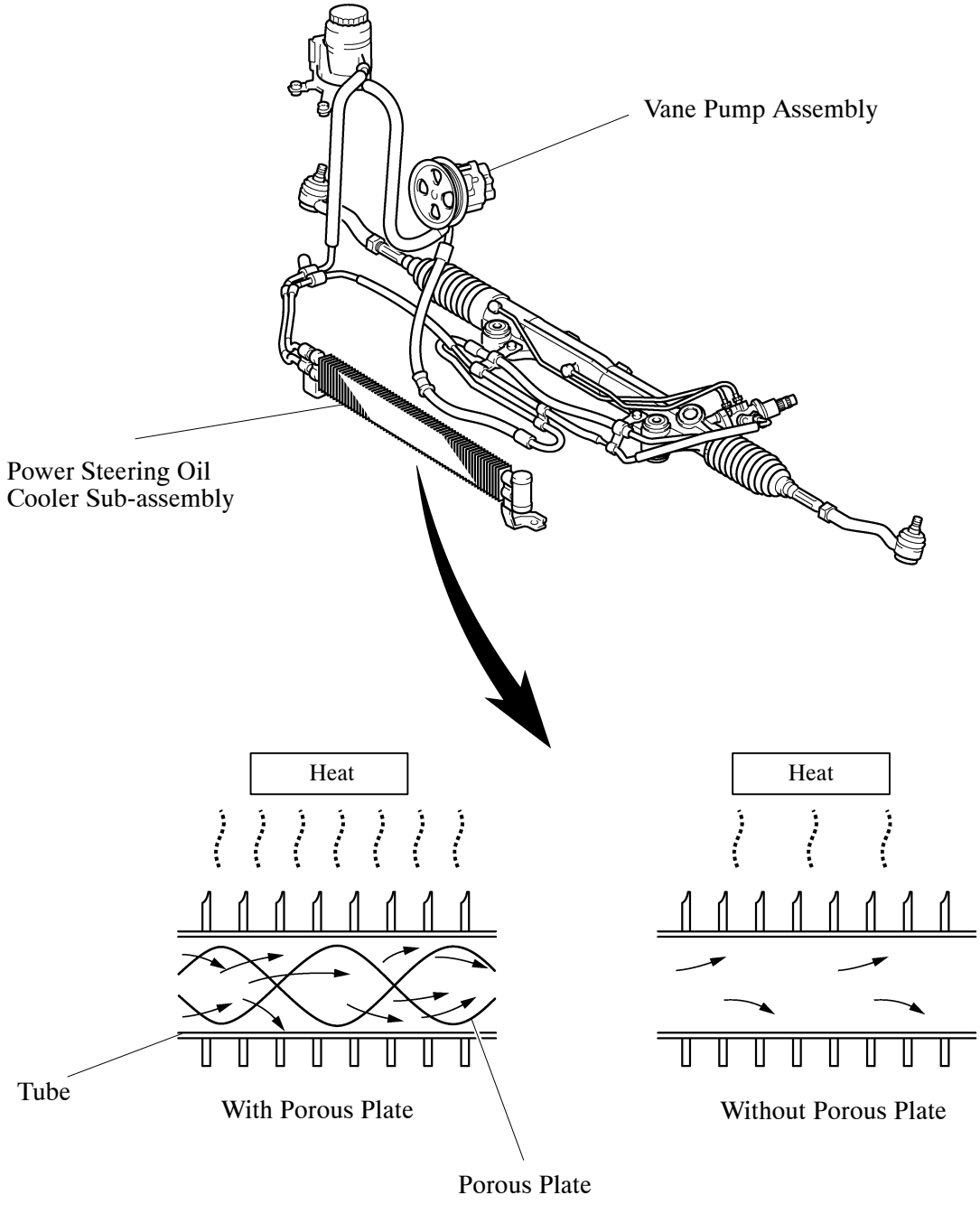
▶ Specifications ◀

Engine Type		2UZ-FE	1GR-FE		1VD-FTV	
Destination		All	Except G.C.C. Countries	G.C.C. Countries	Except G.C.C. Countries	G.C.C. Countries
Theoretical Discharge Rate	l/min	15	←	←	←	←
Relief valve mechanism		Incorporated into pump	←	Separated from pump	Incorporated into pump	Separated from pump
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 on 1GR-FE engine models for G.C.C. countries has a porous plate arranged in a spiral pattern in the tube. This plate diffuses fluid flow in the tube and helps improve fluid heat dissipation to ensure the cooling performance of the oil cooler.
- The installation position of the relief valve mechanism on 1GR-FE engine and 1VD-FTV engine models for G.C.C. countries has been changed from inside the power steering pump to between the power steering system piping.



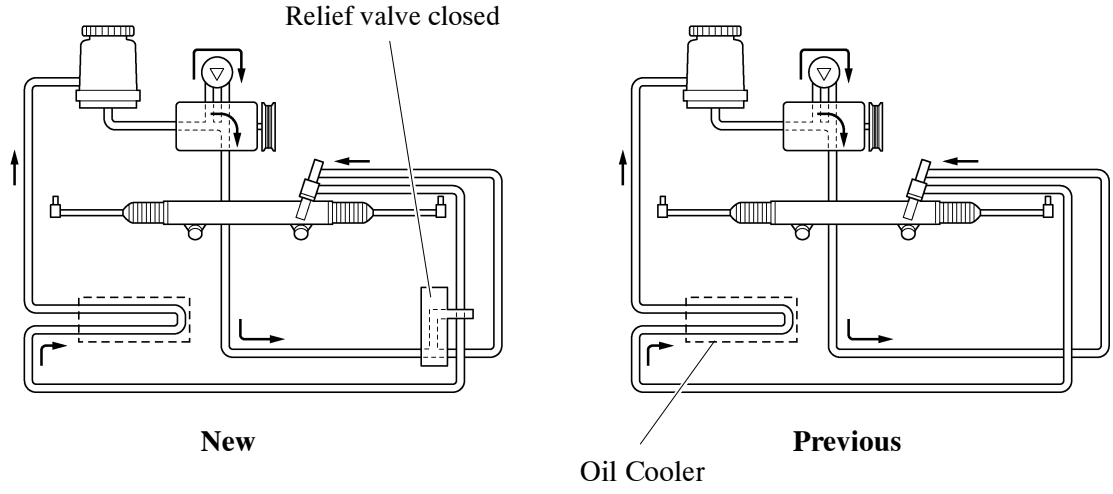
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2. Relief Valve Mounted Outside Pump (For G.C.C. Countries Models)

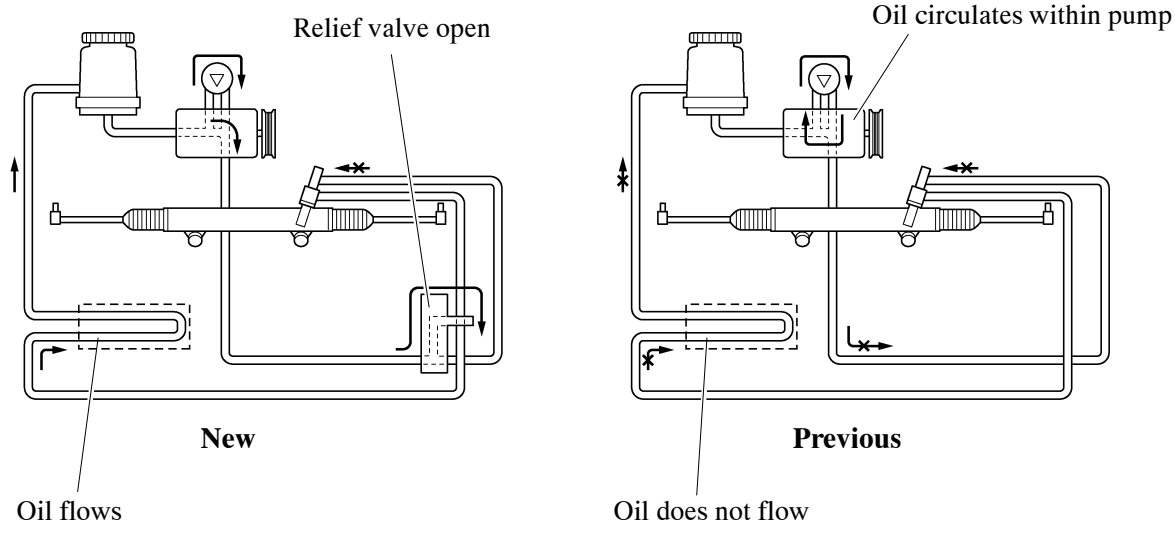
- When the steering wheel is not being turned, the relief valve is closed so oil flows through the pipes in the same manner as on a conventional model.
- If the relief valve is open while the steering wheel is being turned fully, the oil temperature tends to increase on the conventional model because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

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

- The controlled amount of oil flows.



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



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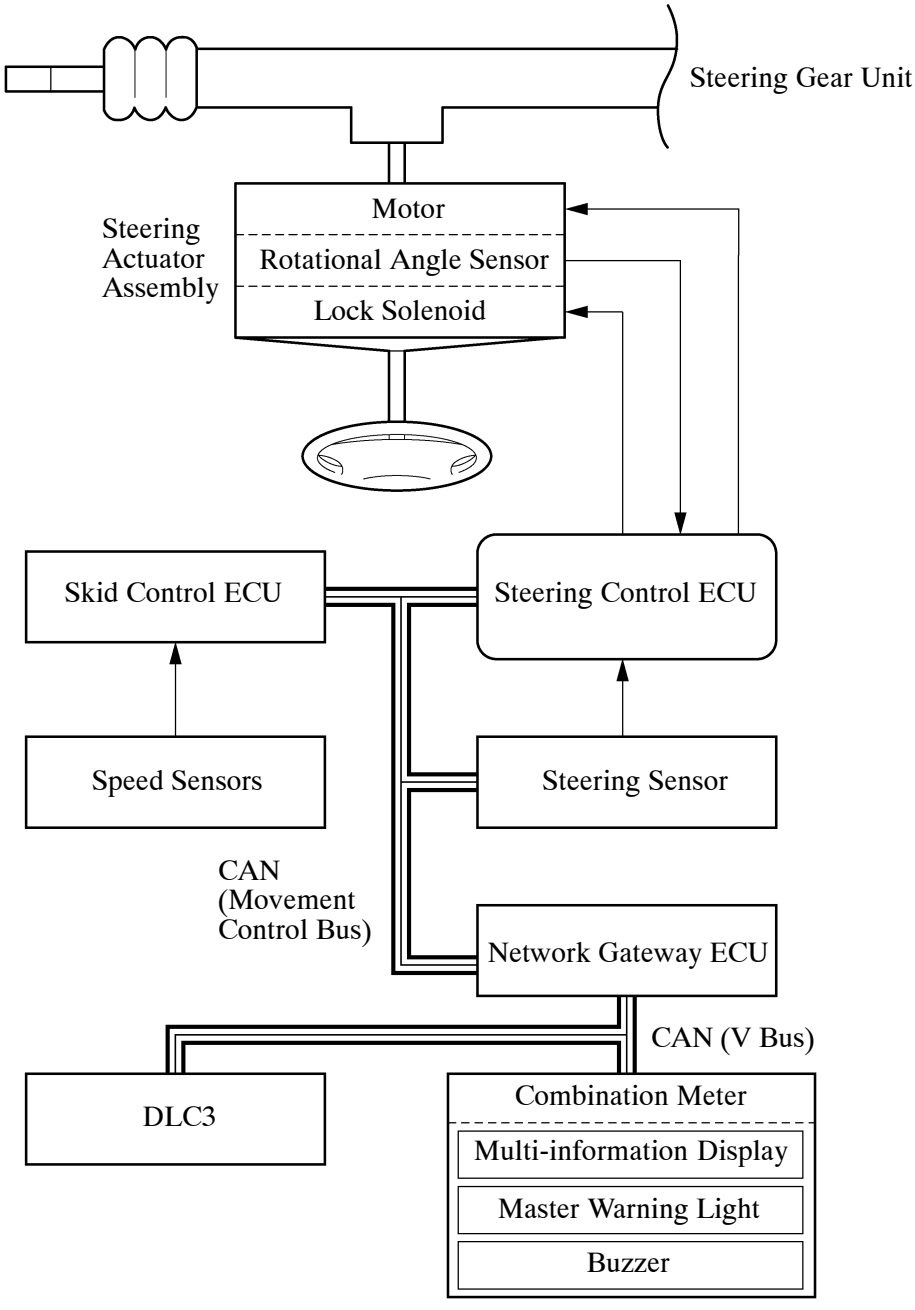
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■VGRS (VARIABLE GEAR RATIO STEERING) SYSTEM

1. General

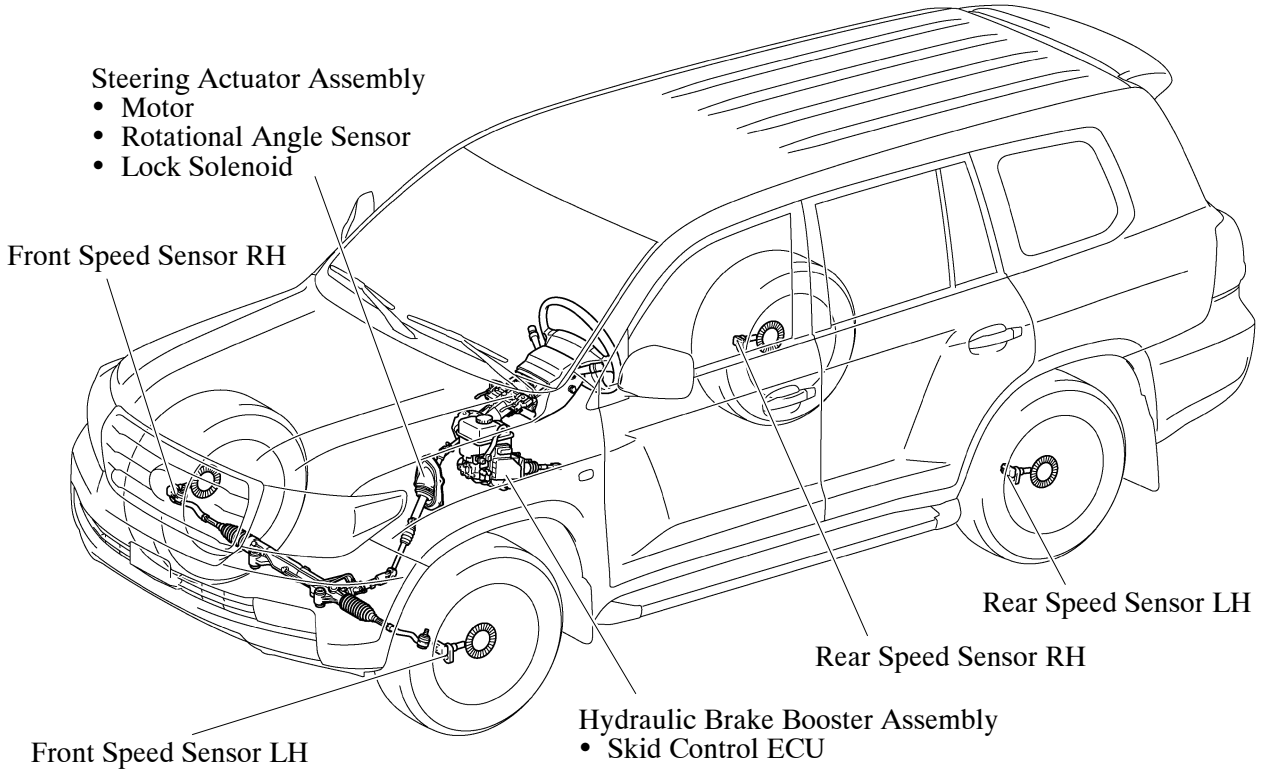
- A VGRS system is used to control the turning angle of the front wheels in accordance with the vehicle speed. As a result, excellent ease of steering operation and vehicle stability have been realized, from the low-speed to the high-speed range.
- This system is controlled by the steering control ECU,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

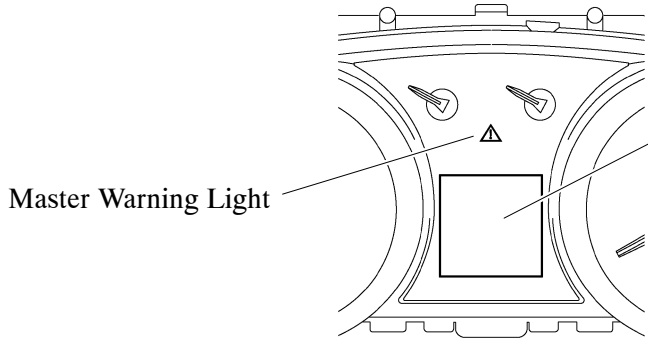
2. System Diagram



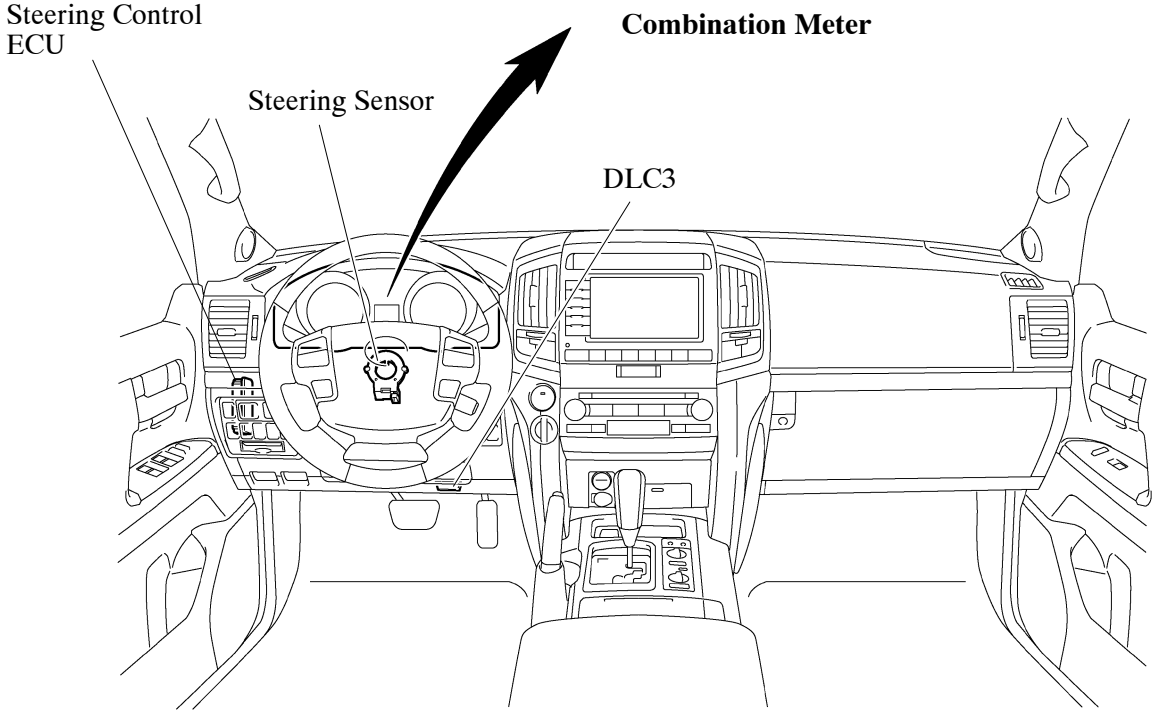
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3. Layout of Main Components





Combination Meter



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4. Function of Main Components

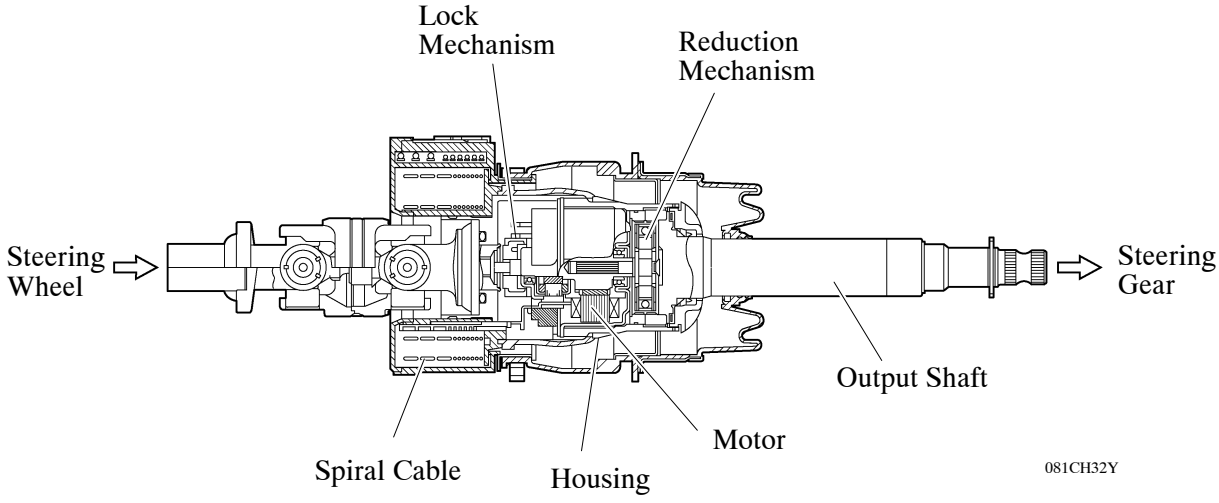
Components		Function
Steering Control ECU		Operates the motor by calculating the operating angle of the steering actuator based on the signals from the steering angle sensor and vehicle speed sensor.
Steering Actuator Assembly	Motor	Rotates to create the operating angle of the steering actuator upon 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 Sensor		Detects the steering angle of the steering wheel and transmits them to the steering control ECU.
Skid Control ECU		• Transmits the vehicle speed signal to the steering control ECU. • Transmits the power steering cooperative control signal to the steering control ECU.
Speed Sensors		Detects the wheel speed and outputs it to the skid control ECU.
Combination Meter	Multi-information Display	Indicates “Check VGRS” 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.

5. Construction and Operation

Steering Actuator

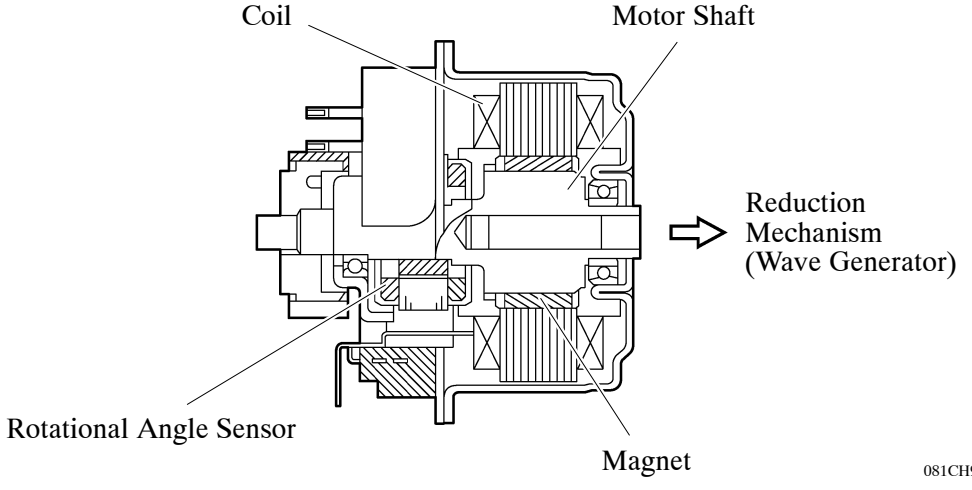
1) General

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



2) Motor

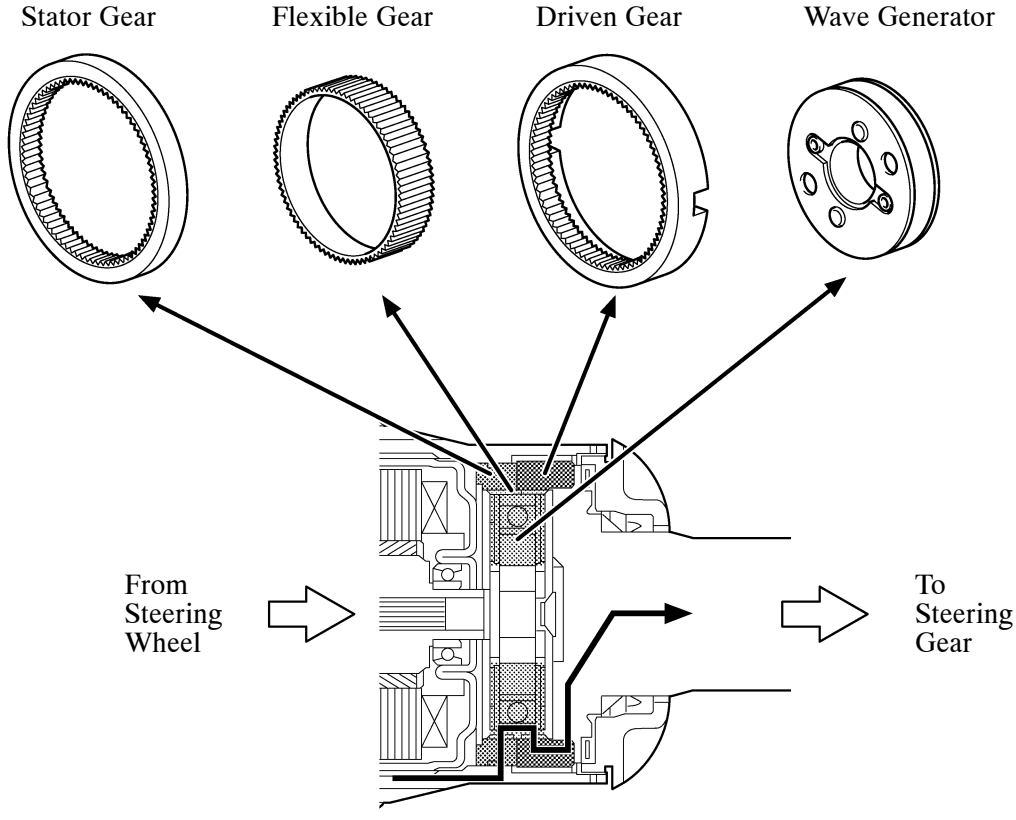
- A compact, high power output, and low noise brushless type motor is used. This motor is enclosed in the housing.
- This motor mainly consists of a magnet, coil, and motor shaft. The motor shaft is coupled to the wave generator of the reduction mechanism in order to transmit the rotational movement 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 rotating direction and rotation angle of the motor are detected by the rotational angle sensor.



3) Reduction Mechanism

a. General

- 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, stator gear, flexible gear, and wave generator.

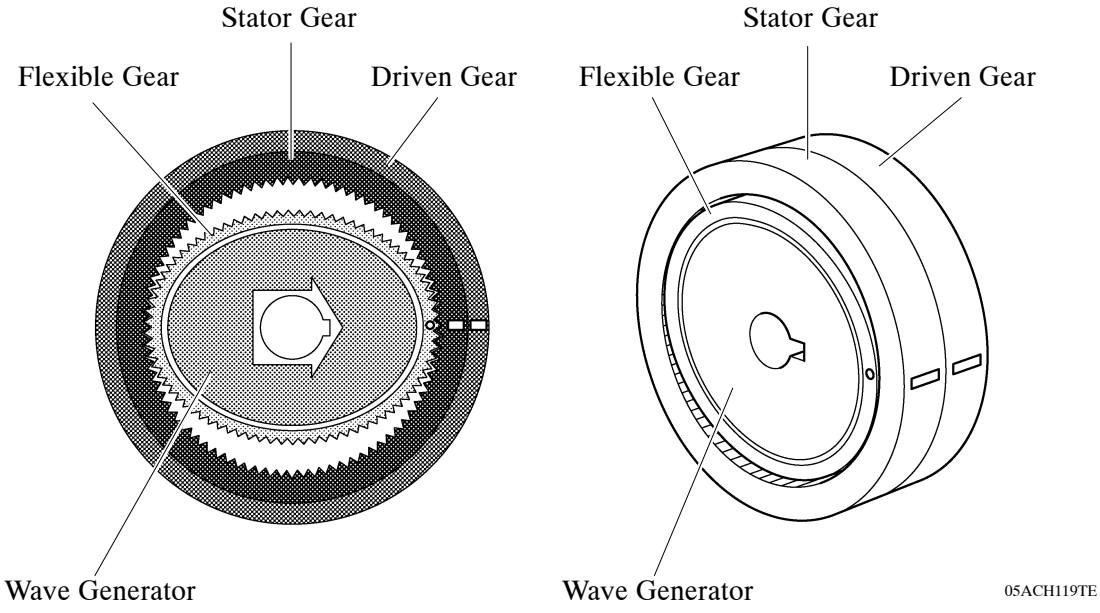


▶ Construction of Reduction Mechanism ◀

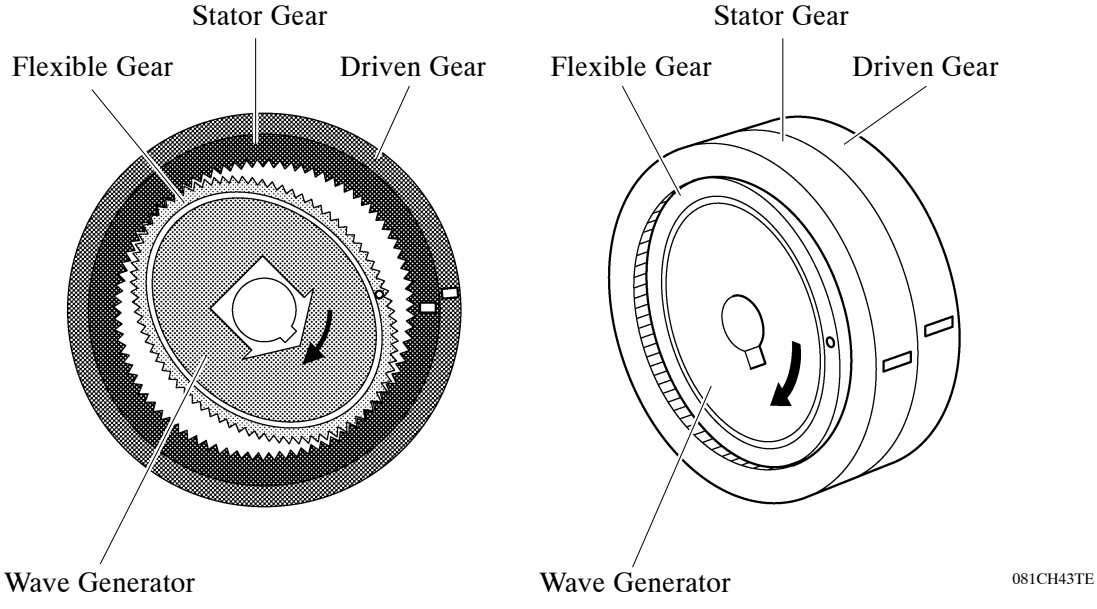
Item	Construction
Stator Gear (Input)	• Has a rigid body, a ring shape, and contains 102 teeth along the inner circumference. • Positioned parallel with the driven gear. • Coupled to the housing of the steering actuator.
Driven Gear (Output)	• Has a rigid body, a ring shape, and contains 100 teeth along the inner circumference. • Positioned parallel with the stator gear. • Coupled to the output shaft of the steering 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.

b. 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.

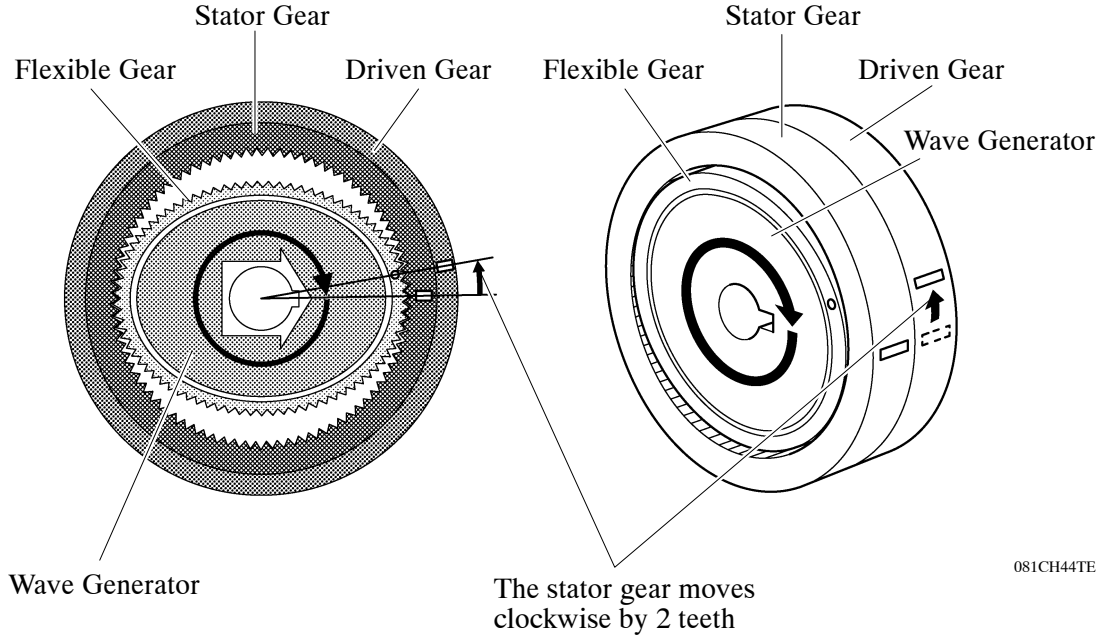


- When the stator gear is fixed and the wave generator rotates clockwise, the flexible gear undergoes an elastic deformation. This causes the meshed areas between the flexible gear, driven gear and stator gear to move consecutively.

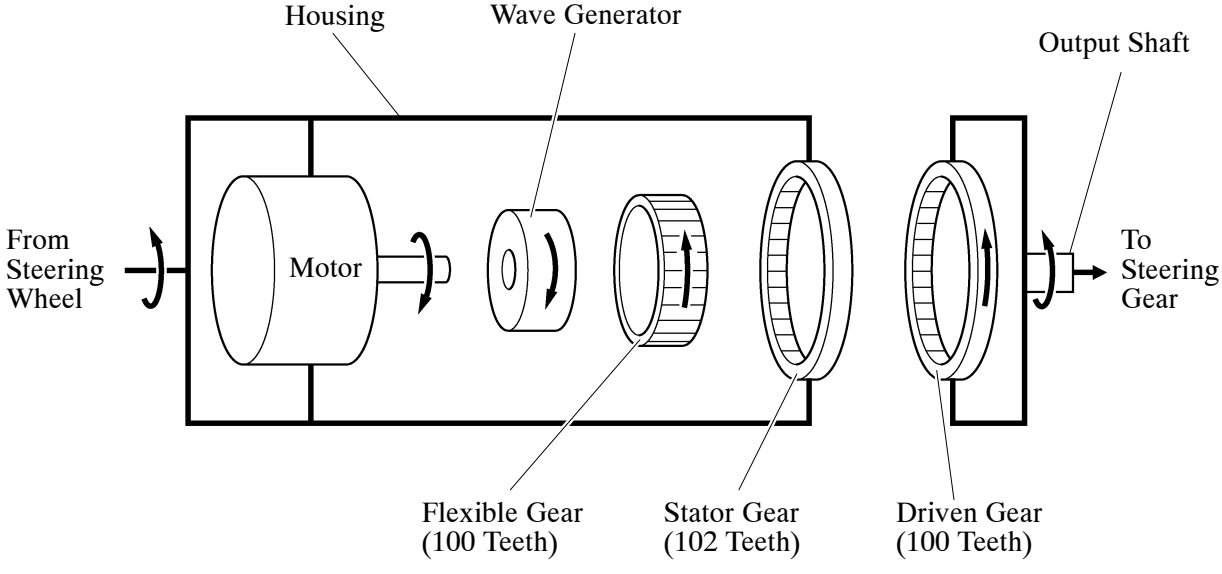


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- When the wave generator makes one rotation, the flexible gear moves counter clockwise by 2 teeth because the flexible gear has 2 fewer teeth than the stator gear. The driven gear and the flexible gear have the same number of teeth, so their rotational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

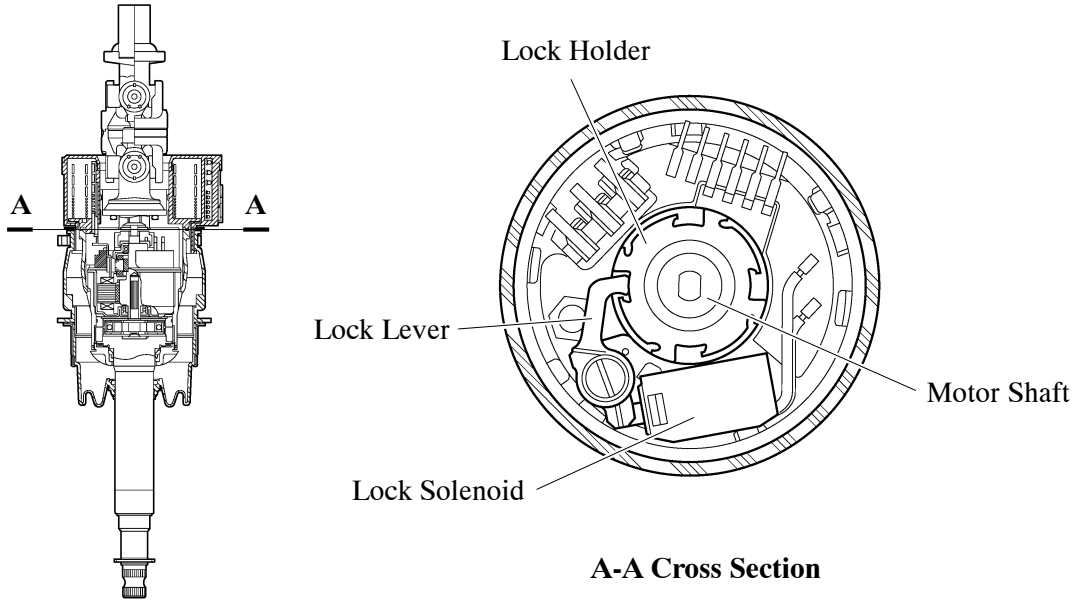


- Due to the aforementioned principle, when the motor rotates clockwise, the rotational movement that is input by the wave generator (which is coupled to the motor shaft) outputs to the driven gear (which is coupled to the output shaft). As a result, the output shaft rotates counter clockwise at the 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.



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. With this, the housing and the output shaft become united.
- 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.

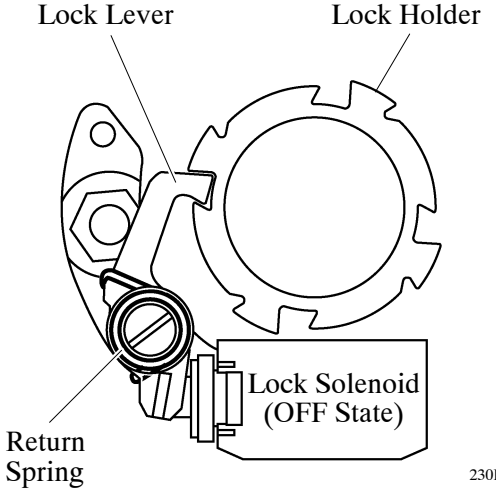


A-A Cross Section

VGRS Actuator Assembly

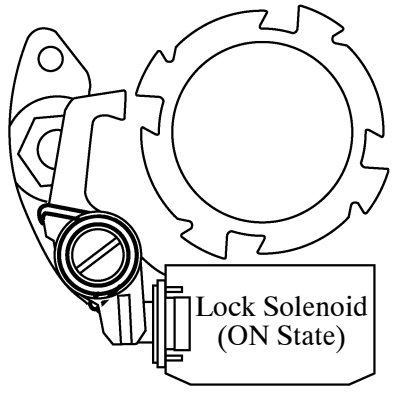
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- When the lock mechanism is activated, the steering control ECU turns OFF the current to the lock solenoid, and the return spring pushes the lock lever against the lock holder. Then, the lock lever meshes with the groove in the lock holder in order 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.



230LX37

Lock State



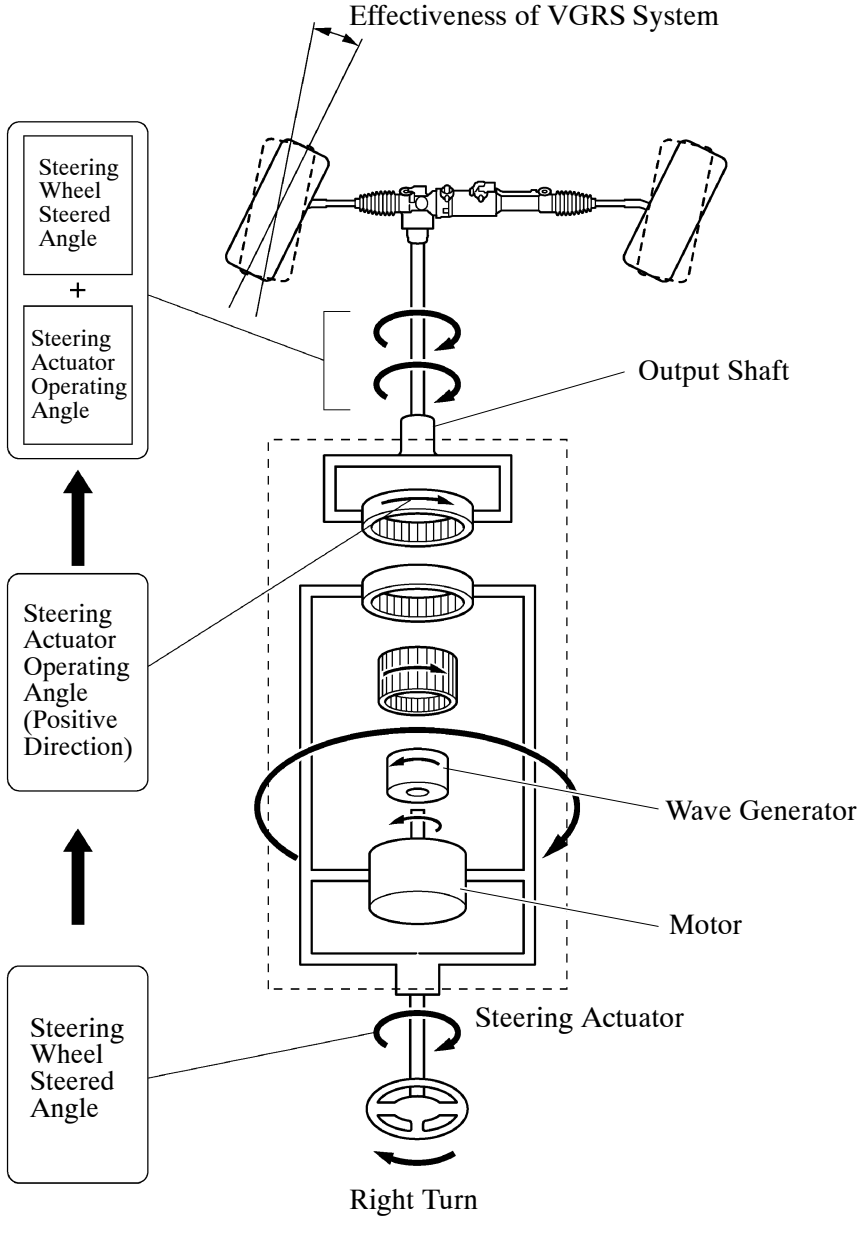
230LX38

Unlock State

5) Steering Torque Transmission

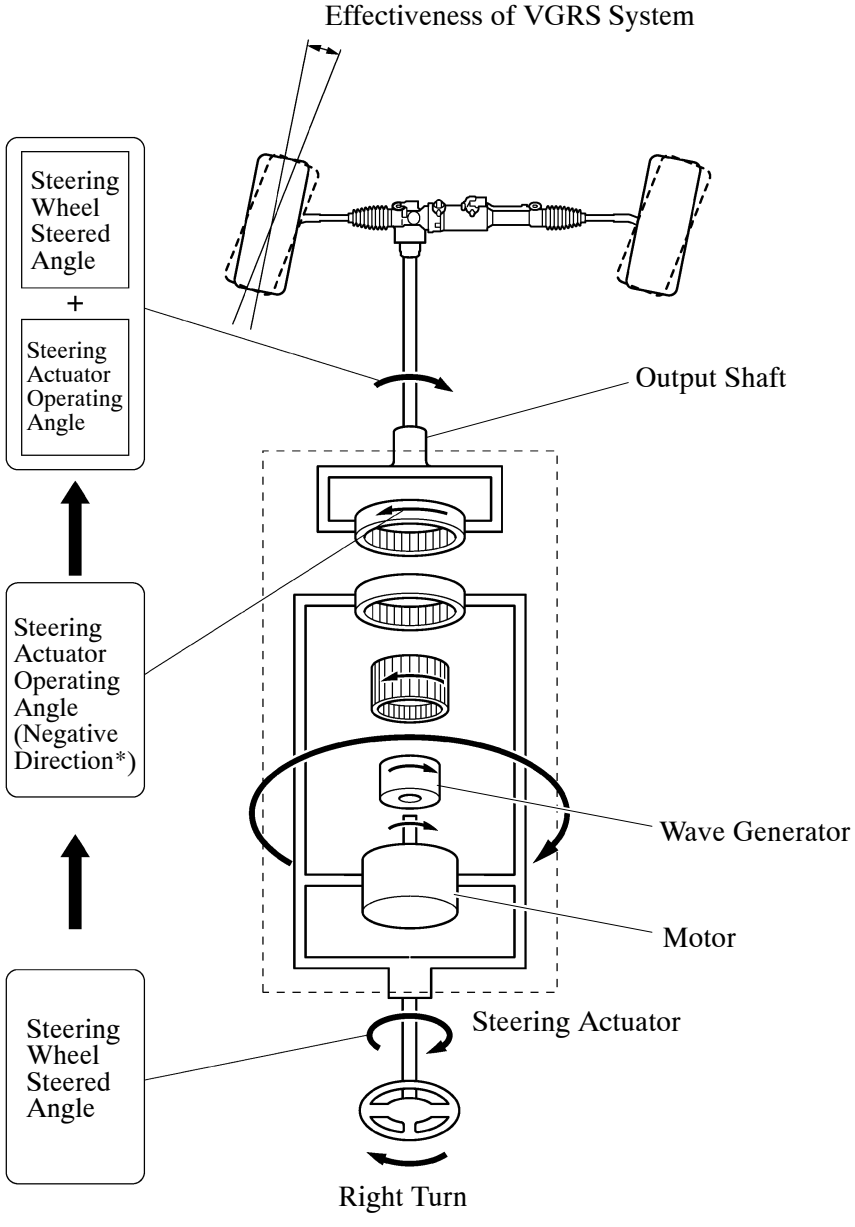
a. Low and Middle Speed Range

This system rotates the steering actuator in the positive direction in the low speed range (in which a reduction in the steering wheel operating effort is desired) or in the medium speed range (in which a more 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 steering actuator that has been determined by the steering control ECU, the motor in the steering actuator rotates counter 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 from the output shaft in the clockwise direction. This operating angle of the steering 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 steered angle of the steering wheel by the amount of the operating angle of the steering actuator. As a result, the front wheels turn more to the right.



b. High Speed Range

In the high speed range (in which an over-sensitive movement response of the vehicle is not desired), the steering 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 steering actuator that has been determined by the steering control ECU, the motor in the steering 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 steering 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 steered angle of the steering wheel by the amount of the operating angle of the steering actuator. As a result, the front wheels turn less to the right.

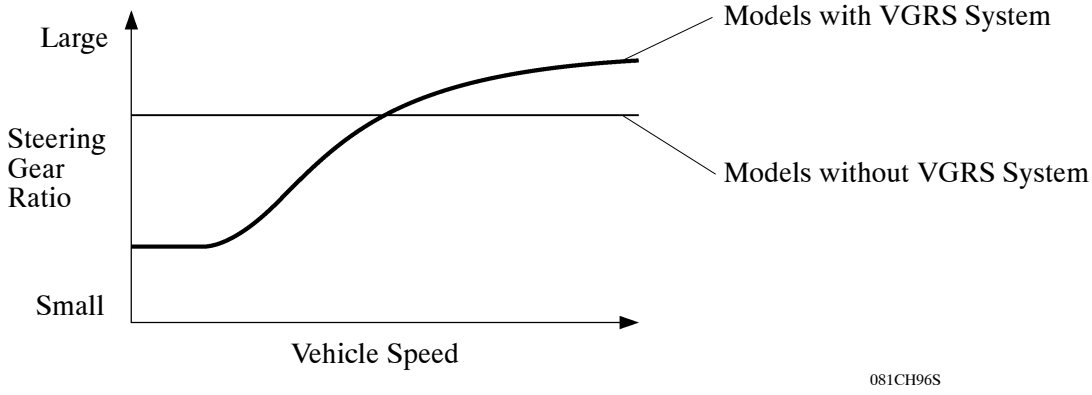


*: When the VGRS actuator rotates in the negative direction, it will not rotate in excess of the driver's steering angle.

Steering Control ECU

1) General

- The steering control ECU calculates the steering actuator target operating angle based upon 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 steering 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 steering 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 is achieved, regardless of the vehicle speed, from the low to high-speed ranges.



Steering Gear Ratio Control Image

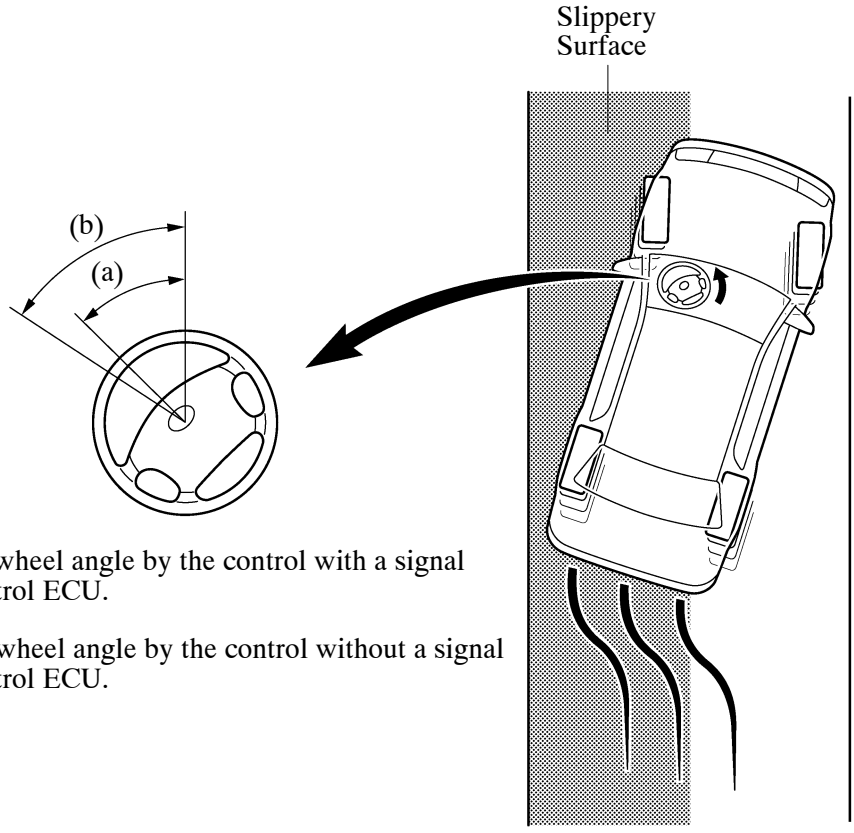
- The steering control ECU stores the neutral position of the steering actuator in its memory. Thus, the steering control ECU effects control by using this neutral position as a reference value. Furthermore, the steering control ECU constantly stores the operating angle of the steering actuator in its 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 steering actuator neutral position stored in the steering control ECU memory. For details, see the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

2) Control with a signal from the 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 steering 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 operation, thus reducing the driver's steering ability.



(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 steering 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"	Illuminate	Sound 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.	—	—	—
Steering 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 and checking the "DIAG VGRS" that appears on the multi-information display.

For details, see the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

▶ Display Example of Multi-information Display ◀



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System Check



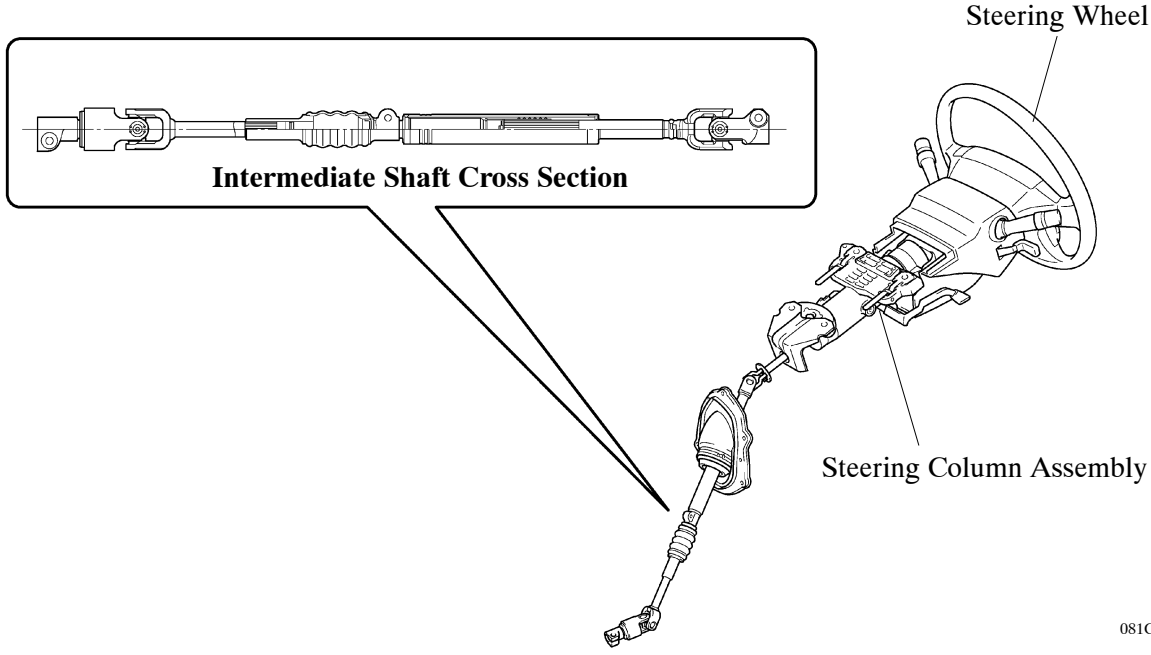
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Test Mode

■STEERING COLUMN

1. General

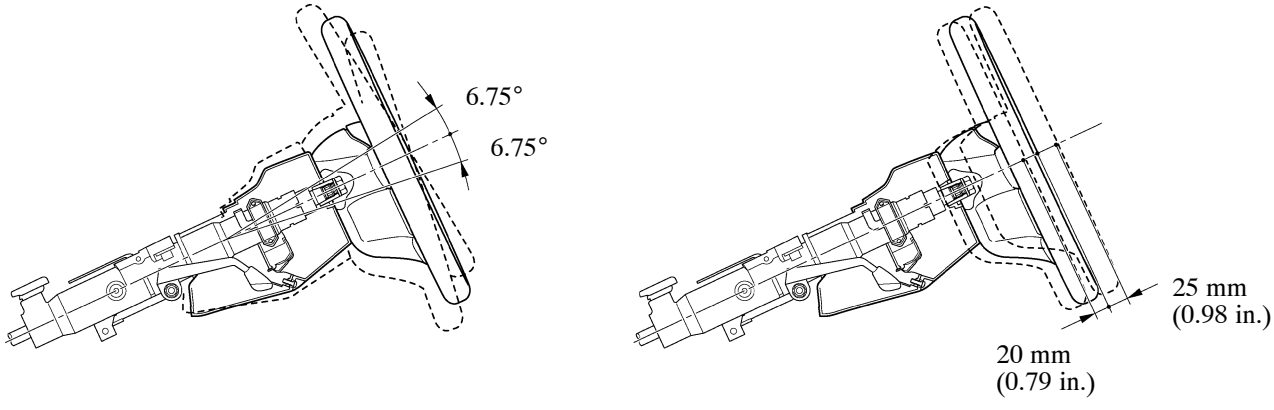
- A manual tilt and telescopic steering column is provided as standard on all models. In addition, a power tilt and power telescopic steering column is available as an option on VX grade models.
- The intermediate shaft is equipped with a mechanism capable of controlling the length of the shaft during driving so smooth steering can be attained.
- An energy absorbing mechanism and intermediate shaft contraction mechanism are used to ensure driver safety in the event of a collision.
- An electrical steering lock system is used. For details, see page BE-157.



2. Manual Tilt and Telescopic Steering Column

The manual tilt and telescopic mechanism allows adjustment of the steering wheel position in the vertical and longitudinal (extending and retracting) directions through lever operation. This provides the driver with the most comfortable driving position.

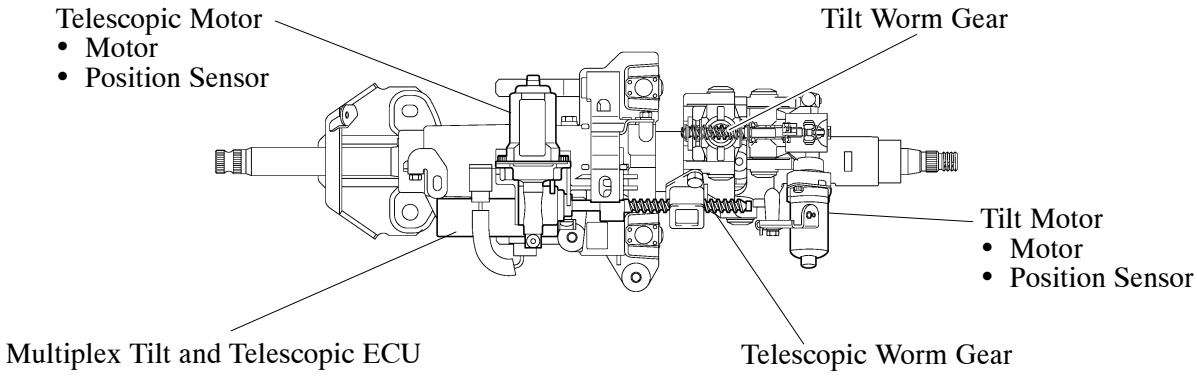
- The tilt and telescopic mechanism is locked using the tilt lever and telescopic lever.
- The tilt mechanism enables the steering column to be tilted up to 13.5° (2.25° × 6 steps), and the stepless telescopic mechanism enables the steering column to be moved up to 45 mm (1.77 in.).



3. Power Tilt and Power Telescopic Steering Column

General

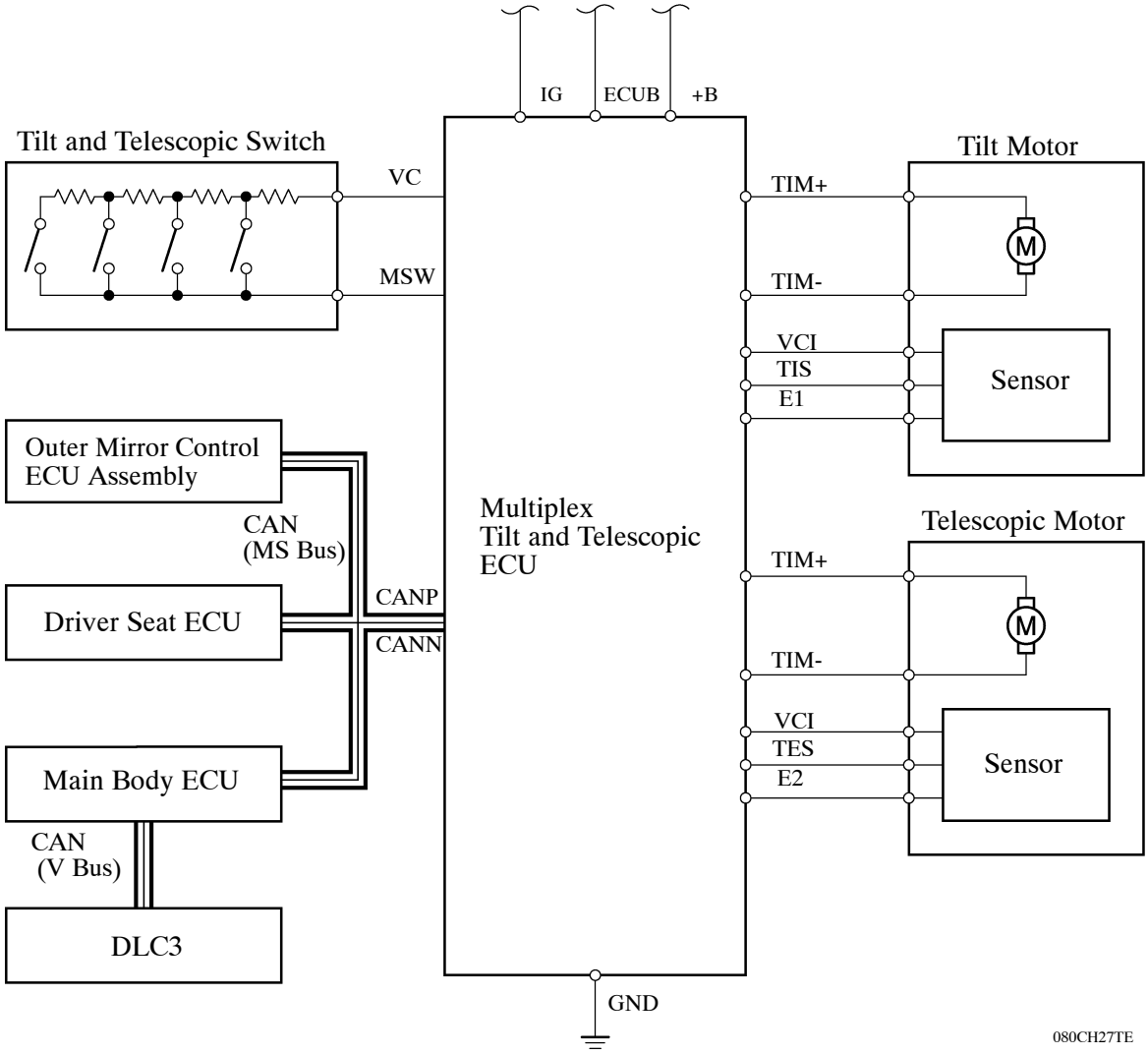
The power tilt and power telescopic steering column consists of the tilt and telescopic ECU, tilt motor, and telescopic motor.



Bottom View

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▶ System Diagram ◀

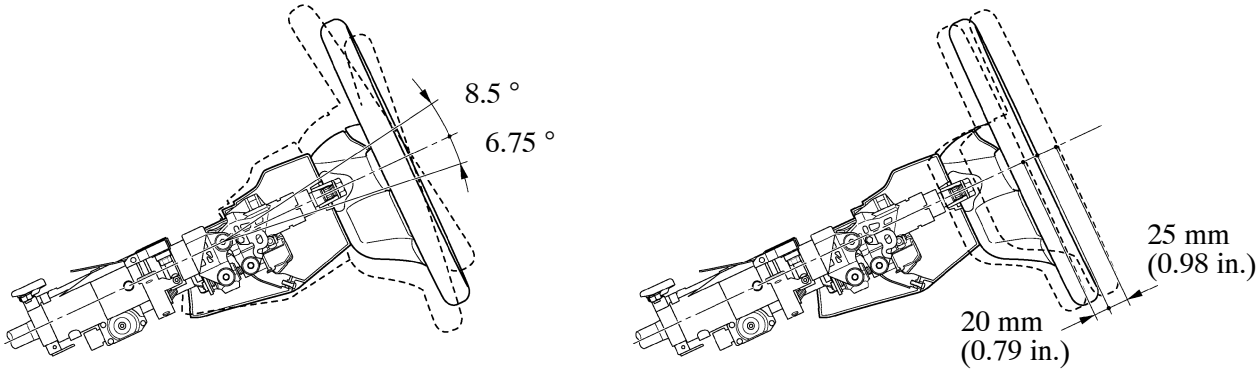


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Operation

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 ACC or IG-ON 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 ACC or IG-ON, the steering wheel automatically returns to the previous position which was set before the engine switch was turned OFF.

3) Memory Function (Only for Models with Memory System)

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 elements 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 multiplex 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	Mirror 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 is ACC or IG-ON while the signal from the main body ECU is interrupting.
- The operation is prohibited if the engine switch is OFF while the signal from the main body ECU is interrupting.

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

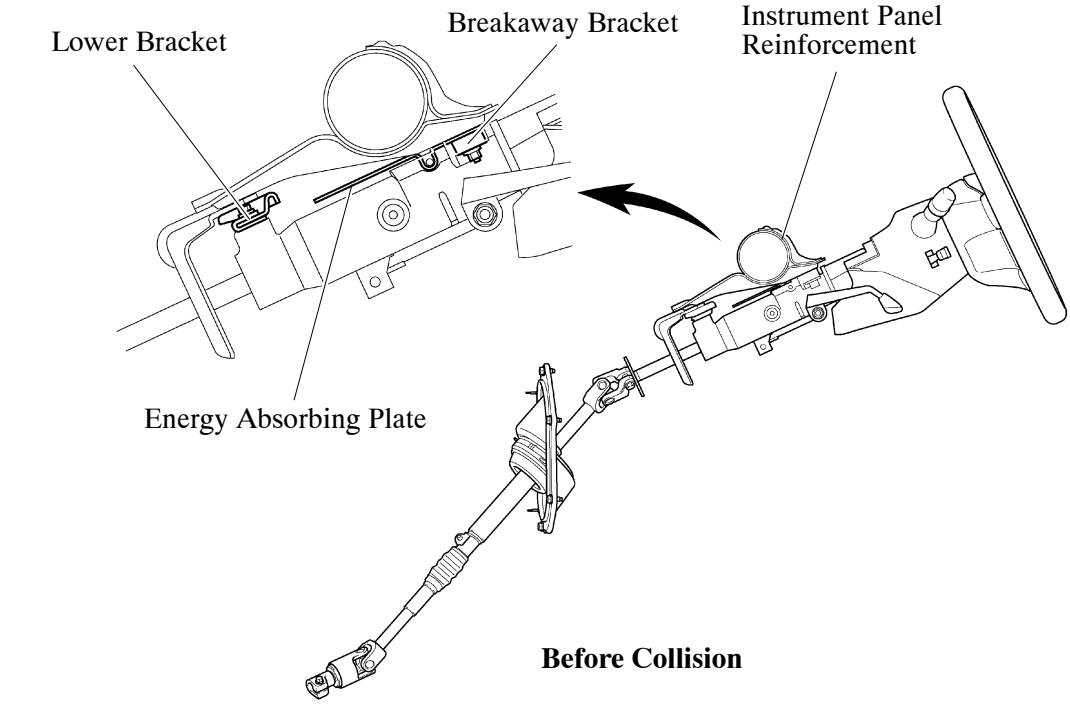
Diagnosis

If the multiplex 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 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 Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

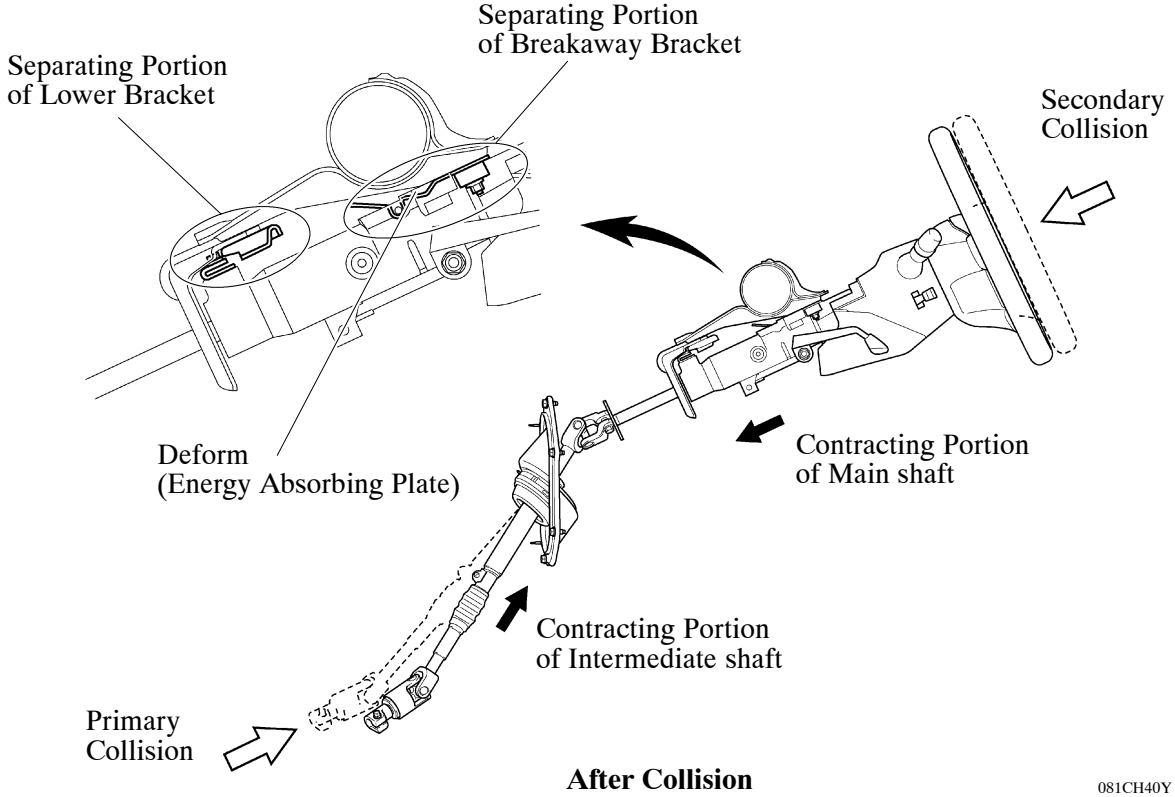
4. Energy Absorbing Mechanism

- 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



After Collision

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