■ELECTRONIC CONTROL SYSTEM

1. General

The electronic control system of the A960E automatic transmissions consist of the control functions listed below.

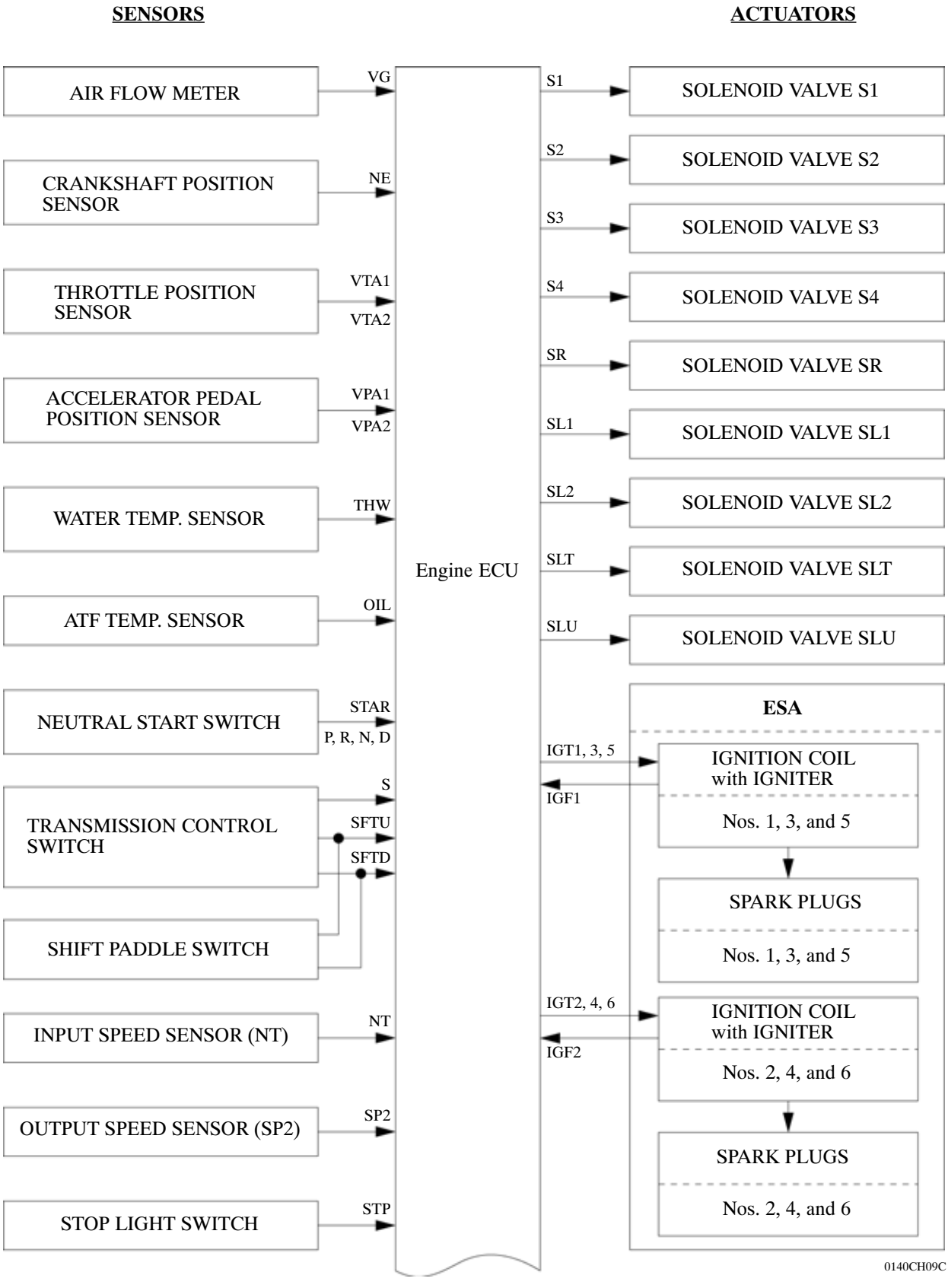
System	Function
Shift Timing Control	The Engine ECU sends current to solenoid valves S1, S2, S3, S4 and/or SR based on signals from various sensors, in order to shift the gears.
Clutch Pressure Control (See page CH-37)	• Controls the pressure that is applied directly to B_2 brake and C_3 clutch by actuating the linear solenoid valves SL1 and SL2 in accordance with the Engine ECU signals. • The solenoid valve SLT and SL1 minutely control the clutch pressure in accordance with the engine output and driving conditions.
Line Pressure Control (See page CH-38)	Based on the throttle opening angle and various signals, the Engine ECU sends a signal to solenoid valve SLT to generate line pressure that varies according to the engine output and to allow smooth gear changes.
Engine Torque Control	Retards the engine ignition timing temporarily to improve shift feeling while upshifts or downshifts occur.
High Response Shift Control	Though cooperative control with ETCS-i (Electronic Throttle Control System-intelligent), and the electronic control of application and release speed of the clutch and brake hydraulic pressures, excellent response has been realized.
Lock-up Timing Control (See page CH-38)	While in 5th or 6th gear when the shift lever is in the D position or S6 range, the Engine ECU sends current to the shift solenoid valve SLU based on the signals from the sensors and engages or disengages the lock-up clutch. This control also applies for 5th gear when the shift lever is in the S5 range and in the 4th gear when the shift lever is in the S4 range.
Flex Lock-up Clutch Control (See page CH-39)	• Controls the solenoid valve SLU, provides an intermediate mode between the ON/OFF operation of the lock-up clutch, and increases the operating range of the lock-up clutch to improve fuel economy. • The flex lock-up clutch control operates in the 3rd, 4th, 5th and 6th gears in both D position and S6 range, 3rd, 4th and 5th gears in the S5 range and 3rd and 4th gears in the S4 range.
AI (Artificial Intelligence) -SHIFT (See page CH-40)	Based on the signals from various sensors, the Engine ECU determines the road condition 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.
Orifice Switching Control (See page CH-42)	The orifice switching control prevents the oil pump from drawing air during extremely low temperatures while in 1st gear.
Multi-Mode Automatic Transmission (See page CH-43)	The Engine ECU appropriately controls the automatic transmission in accordance with the range position selected while the shift lever is in the S mode position.
Vehicle lift Control	To restrain the upward movement of the vehicle when the shift lever is moved from the D position to N, the clutch release speed has been optimized.
Shift Down Control	In order to ensure a smooth shift feel during downshifting to accelerate the vehicle, the hydraulic passages and control have been optimized.

(Continued)

System	Function
Diagnosis (See page CH-46)	When the Engine ECU detects a malfunction, the Engine ECU makes a diagnosis and memorizes the information that relates to the fault.
Fail-safe (See page CH-46)	If a malfunction is detected in the sensors or solenoids, the Engine ECU effects fail-safe control to prevent the vehicle's drivability from being affected significantly.

2. Construction

The configuration of the electronic control system in the A960E is as shown in the following chart.



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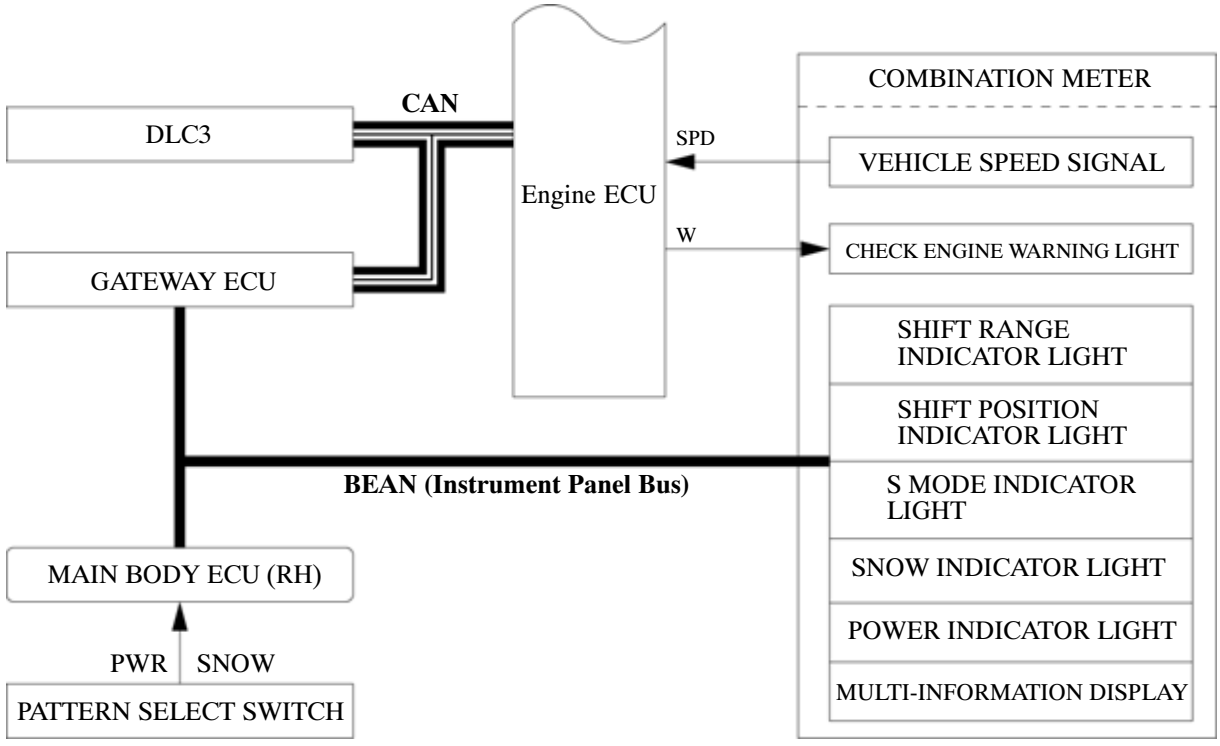
CAN
DLC3
GATEWAY ECU
Engine ECU
SPD
W
COMBINATION METER
VEHICLE SPEED SIGNAL
CHECK ENGINE WARNING LIGHT
SHIFT RANGE INDICATOR LIGHT
SHIFT POSITION INDICATOR LIGHT
S MODE INDICATOR LIGHT
SNOW INDICATOR LIGHT
POWER INDICATOR LIGHT
MULTI-INFORMATION DISPLAY
BEAN (Instrument Panel Bus)
MAIN BODY ECU (RH)
PWR
SNOW
PATTERN SELECT SWITCH

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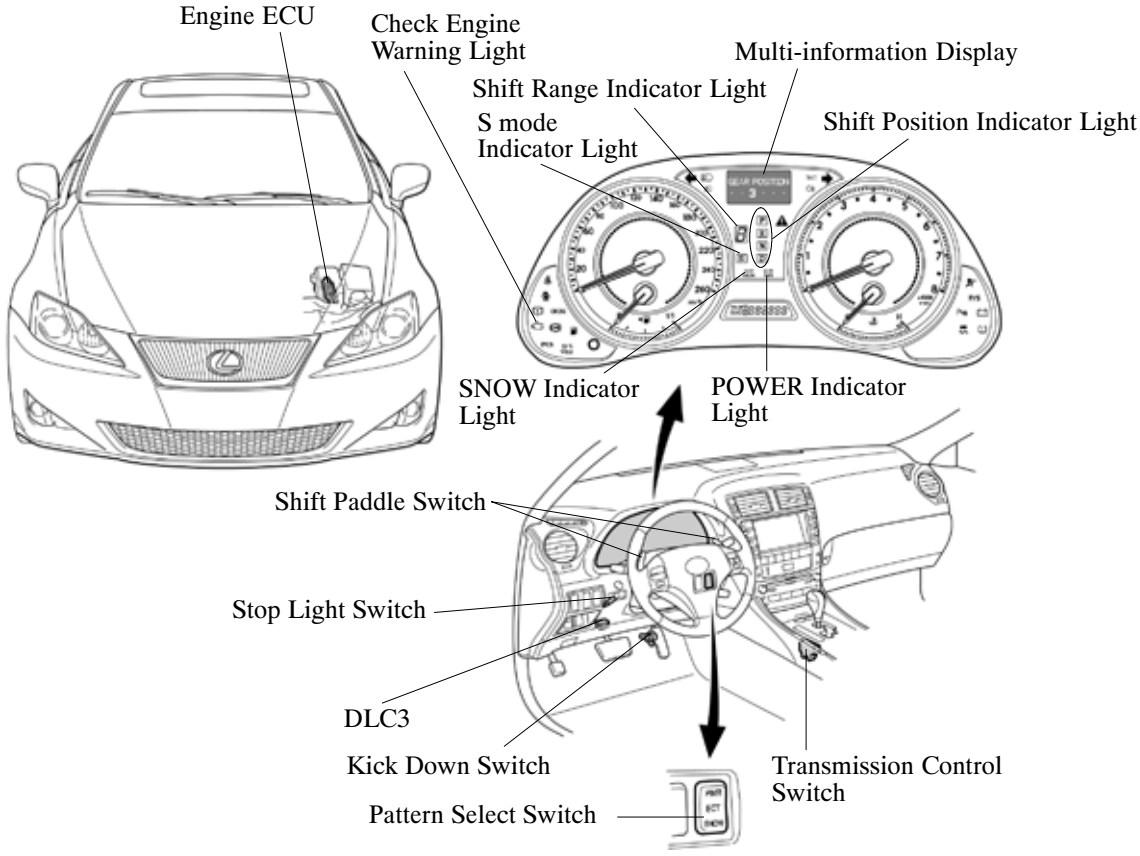
3. Layout of Main Component



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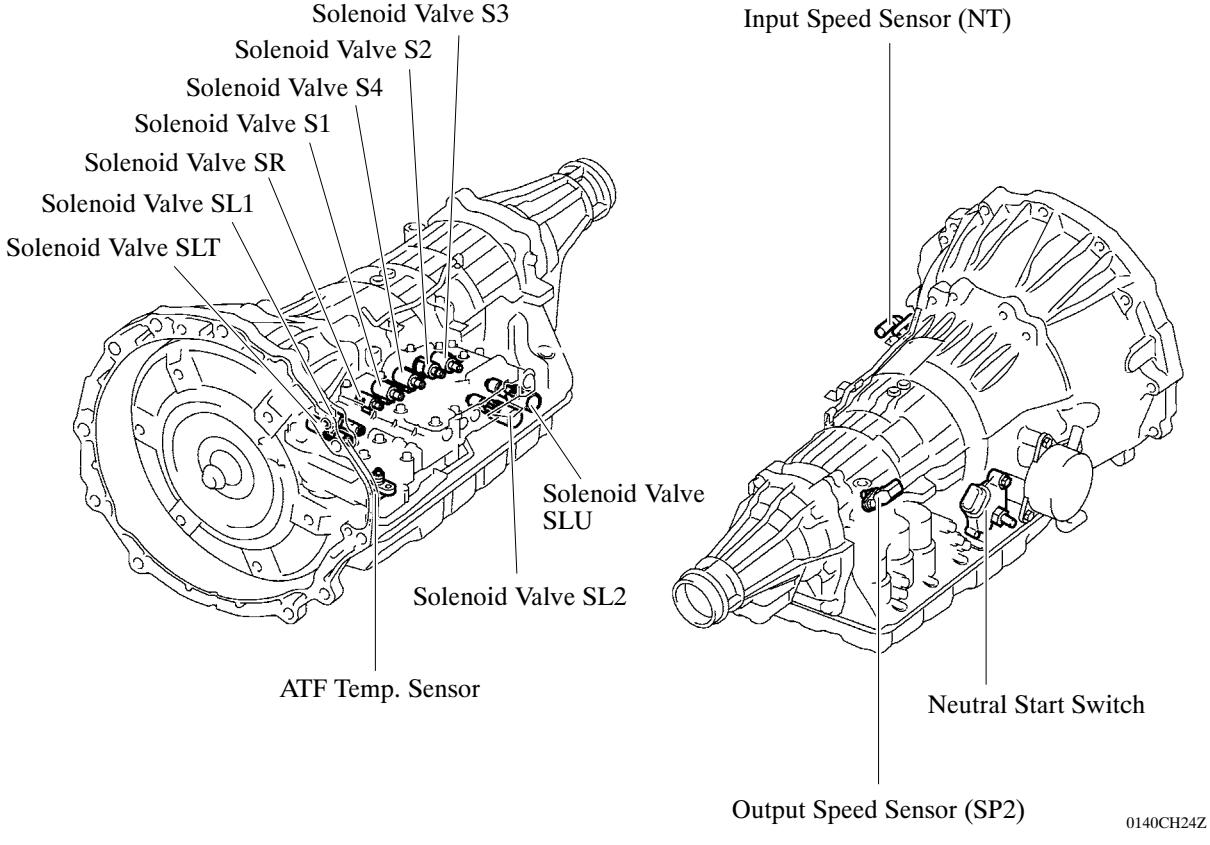

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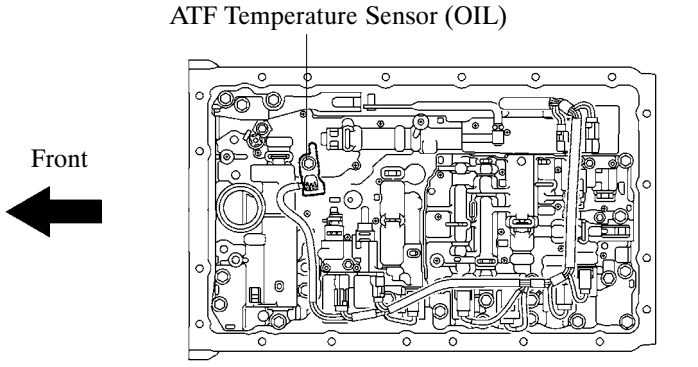
4. Construction and Operation of Main Component

ATF Temperature Sensor

The ATF temperature sensor (OIL) is used as an input for hydraulic pressure control. This sensor is used to assist in determining the clutch and brake pressures necessary to maintain smooth shift qualities with varying temperatures of transmission fluid.

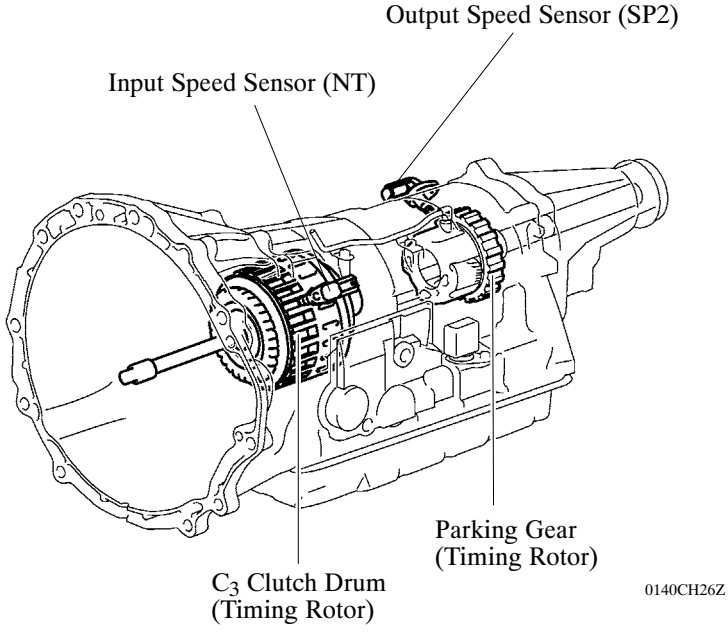


0140CH25Z

Input Speed Sensor and Output Speed Sensor

The A960E automatic transmission uses an input speed sensor (for NT signal) and output speed sensor (for SP2 signal). Thus, the Engine ECU can detect the timing of the shifting of the gears and appropriately control the engine torque and hydraulic pressure in response to the various conditions.
These speed sensors are a pick-up coil type.

- The input speed sensor detects the input speed of the transmission. The C_3 clutch drum is used as the timing rotor for this sensor.
- The output speed sensor detects the speed of the output shaft. The parking gear on the rear planetary gear is used as the timing rotor for this sensor.

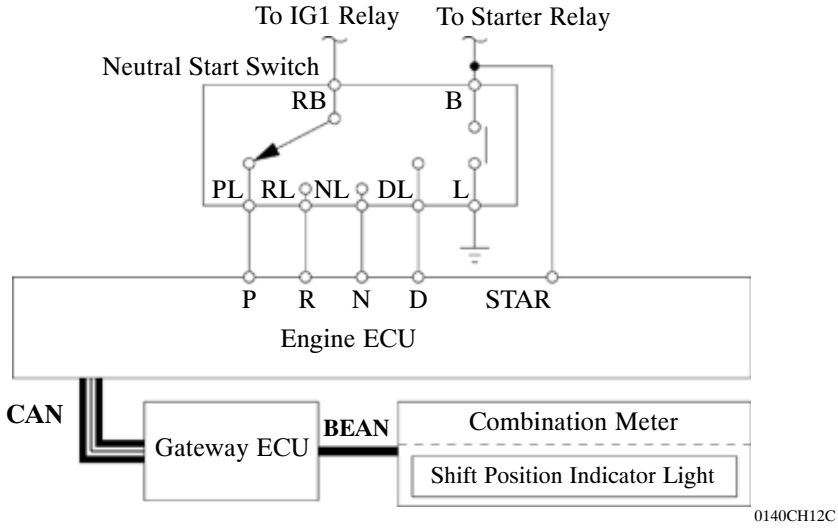


0140CH26Z

Neutral Start Switch

The neutral start switch sends the P, R, N, D and STAR position signals to the Engine ECU. It also sends signals for the shift position indicator light (P, R, N, and D).

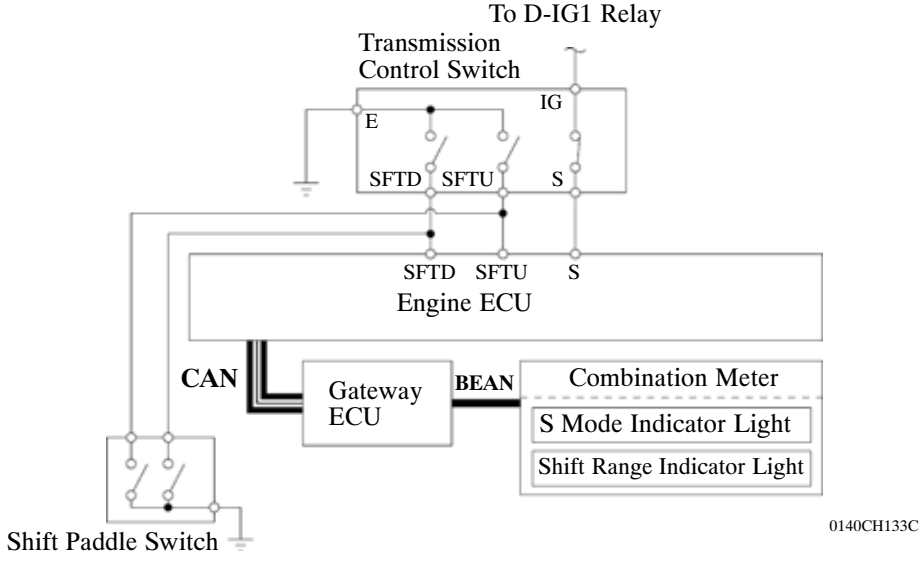
▶ Wiring Diagram ◀



Transmission Control Switch and Shift Paddle Switch

- The transmission control switch is installed inside the shift lever assembly to detect the shift lever position and to inform the Engine ECU. The Engine ECU 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 (front [+ position] or rear [- position]) if the S mode is selected, and sends signals to the Engine ECU. At this time, the Engine ECU turns on the shift range indicator light for the selected range.
- The shift paddle switch is installed steering wheel assembly. The Engine ECU detects the operating conditions of the shift paddle switches (right [+ position] or left [- position]) when the shift lever is in the S mode. At this time, the Engine ECU turns on the shift range indicator light for the selected range.

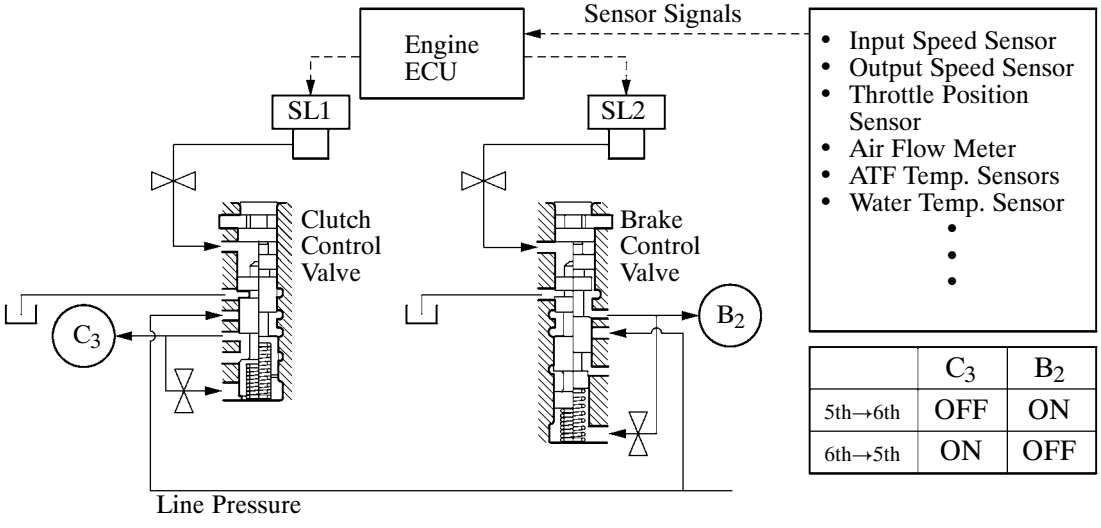
▶ Wiring Diagram ◀



5. Clutch Pressure Control

Clutch to Clutch Pressure Control

This control is adopted for shifting from the 5th to 6th gear and from the 6th to 5th gear.
Solenoid valves SL1 and SL2 are actuated in accordance with the signals from the Engine ECU, and guides this output pressure directly to the control valves B_2 and C_3 in order to regulate the line pressure that acts on the B_2 brake and C_3 clutches.
As a result, high response and excellent shift characteristics are realized.

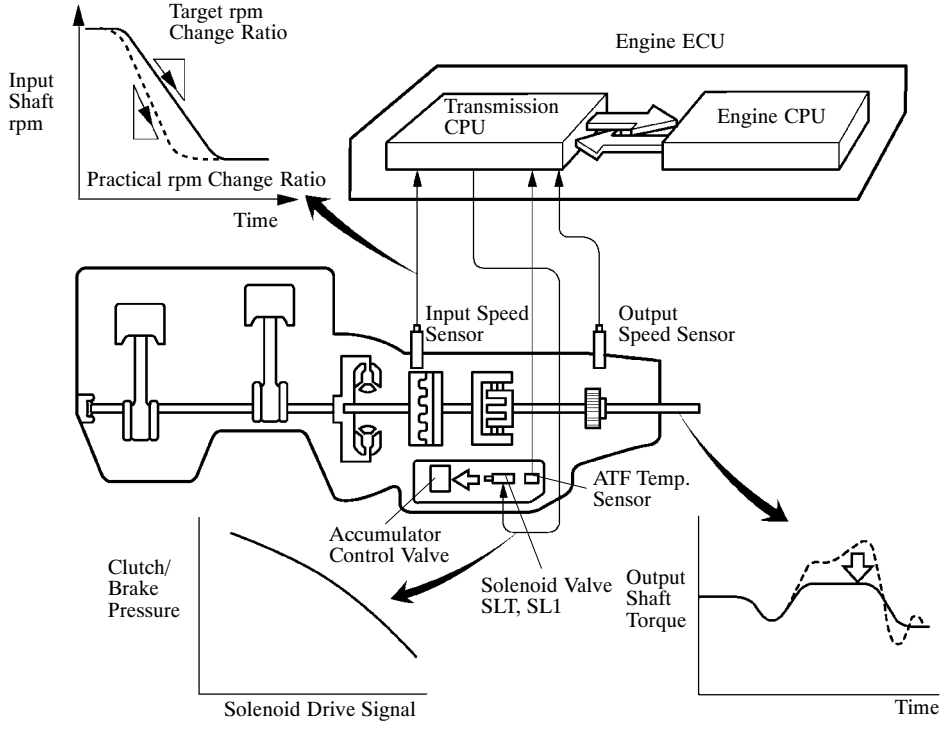


	C_3	B_2
5th→6th	OFF	ON
6th→5th	ON	OFF

259LSK69

Clutch Pressure Optimal Control

The Engine ECU 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 have been realized.



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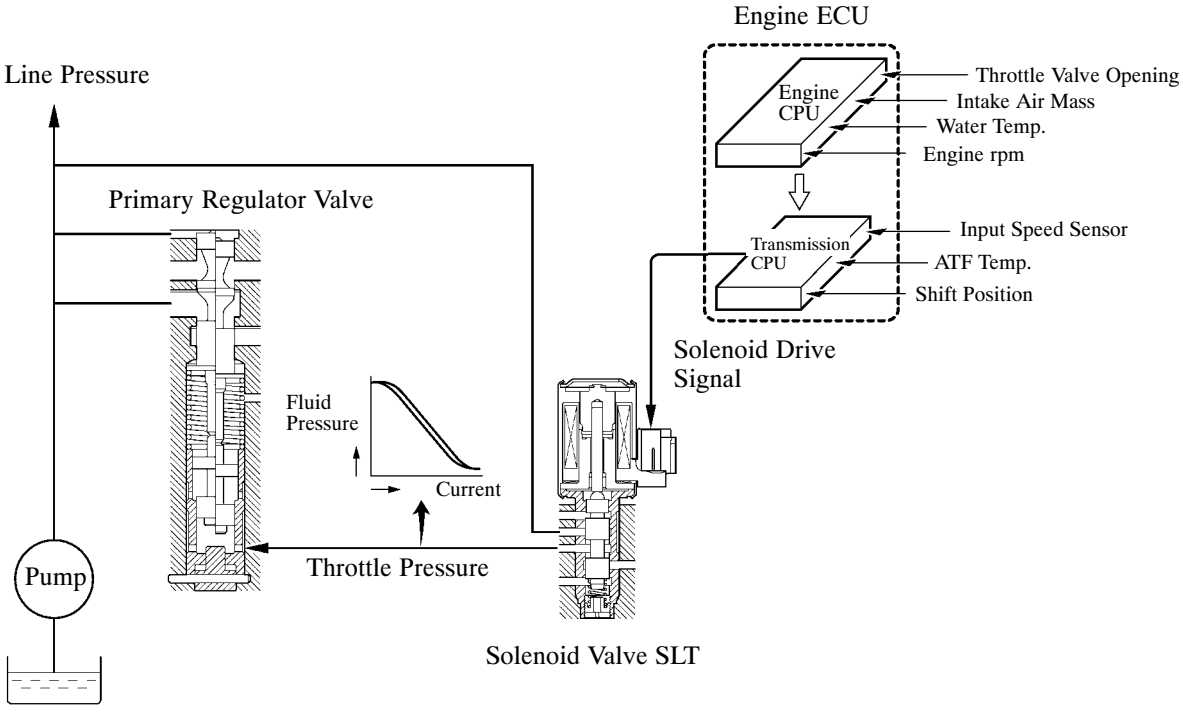
6. Line Pressure Optimal Control

Through the use of the solenoid valve SLT, the line pressure is optimally controlled in accordance with the engine torque information, as well as with the internal operating conditions of the torque converter and the transmission.

Accordingly, the line pressure can be controlled minutely in accordance with the engine output, traveling condition, and the ATF temperature, thus realizing smooth shift characteristics and optimizing the workload of the oil pump (reducing unnecessary parasitic losses).



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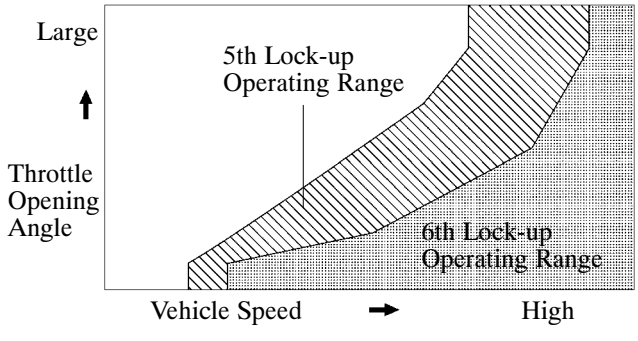
7. Lock-up Timing Control

The Engine ECU 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

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▶ 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

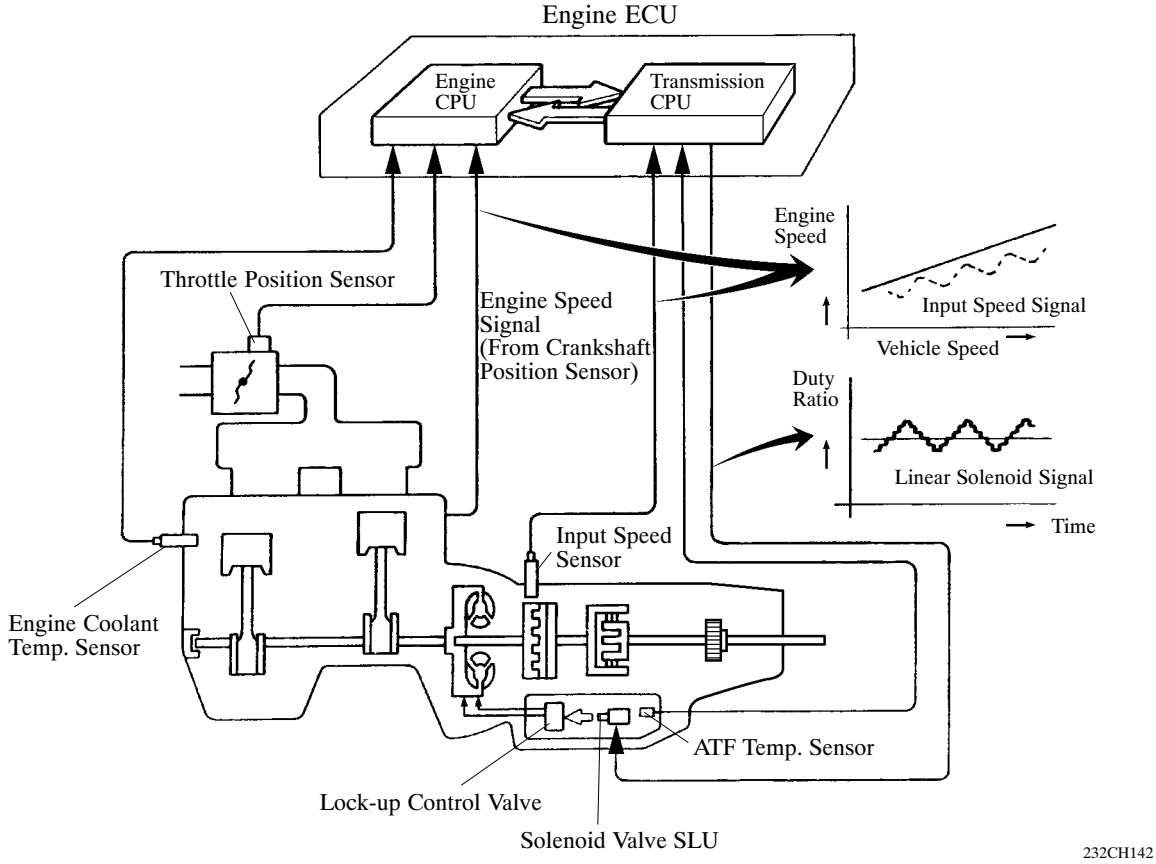
*: Lock up operation is performed when the 4th gear is hold during the AI-SHIFT control.

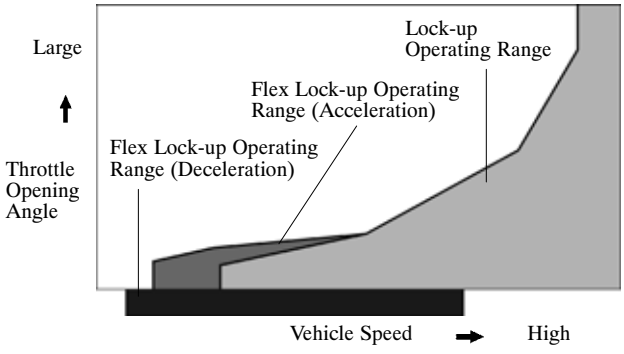
8. Flex Lock-up Clutch Control

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

As a result, the operating range of the lock-up clutch is increased and fuel economy is improved. The flex lock-up clutch control operates in the 3rd, 4th, 5th and 6th gears in both D position and S6 range, 3rd, 4th and 5th gears in the S5 range and 3rd and 4th gears in the S4 range.

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





Flex Lock-Up Timing in 6th Gear

▶ Flex 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

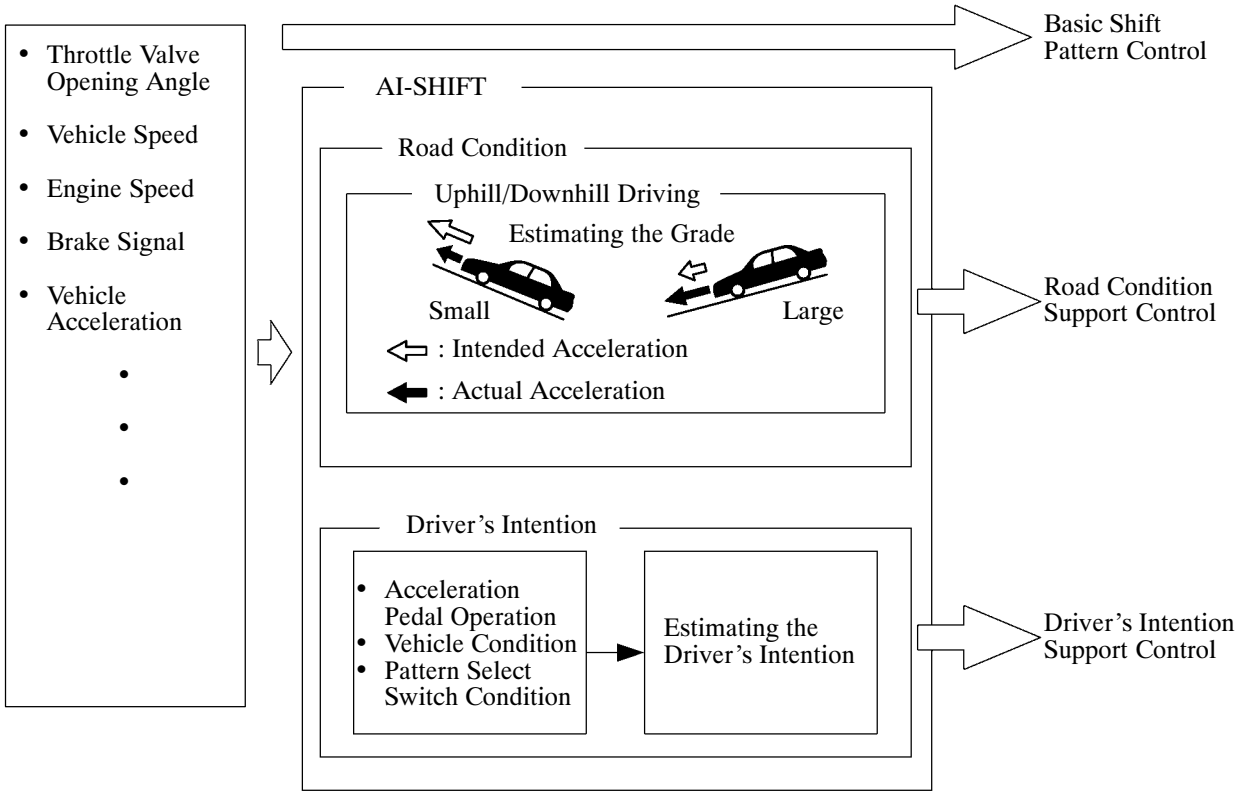
*: Flex Lock-up also operates, when the vehicle is decelerating

9. AI (Artificial Intelligence)- SHIFT Control

General

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

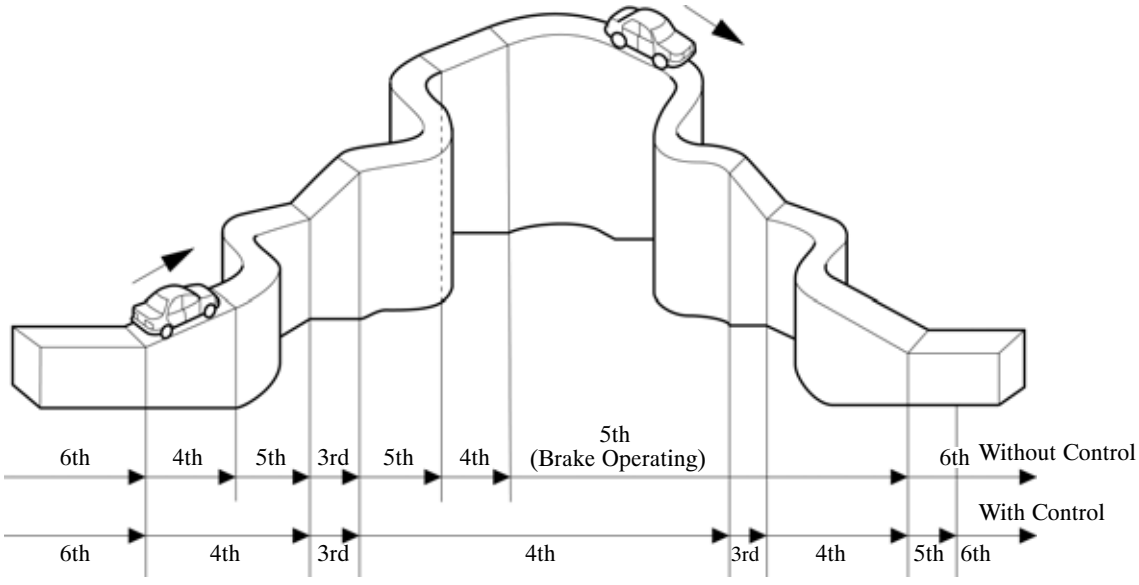
- AI-SHIFT control is effect only with the shift lever in the D position, based on the accelerator and brake operation data. AI-SHIFT control will be canceled when the driver selects the S mode.



232CH143

Road Condition Support Control

Under road condition support control, the Engine ECU determines throttle valve opening angle 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 the 4th or 5th or 6th gear. To achieve an optimal engine brake effect while driving downhill, this control automatically downshifts the transmission to the 5th or 4th or 3rd gear.



Driver's Intention Support Control

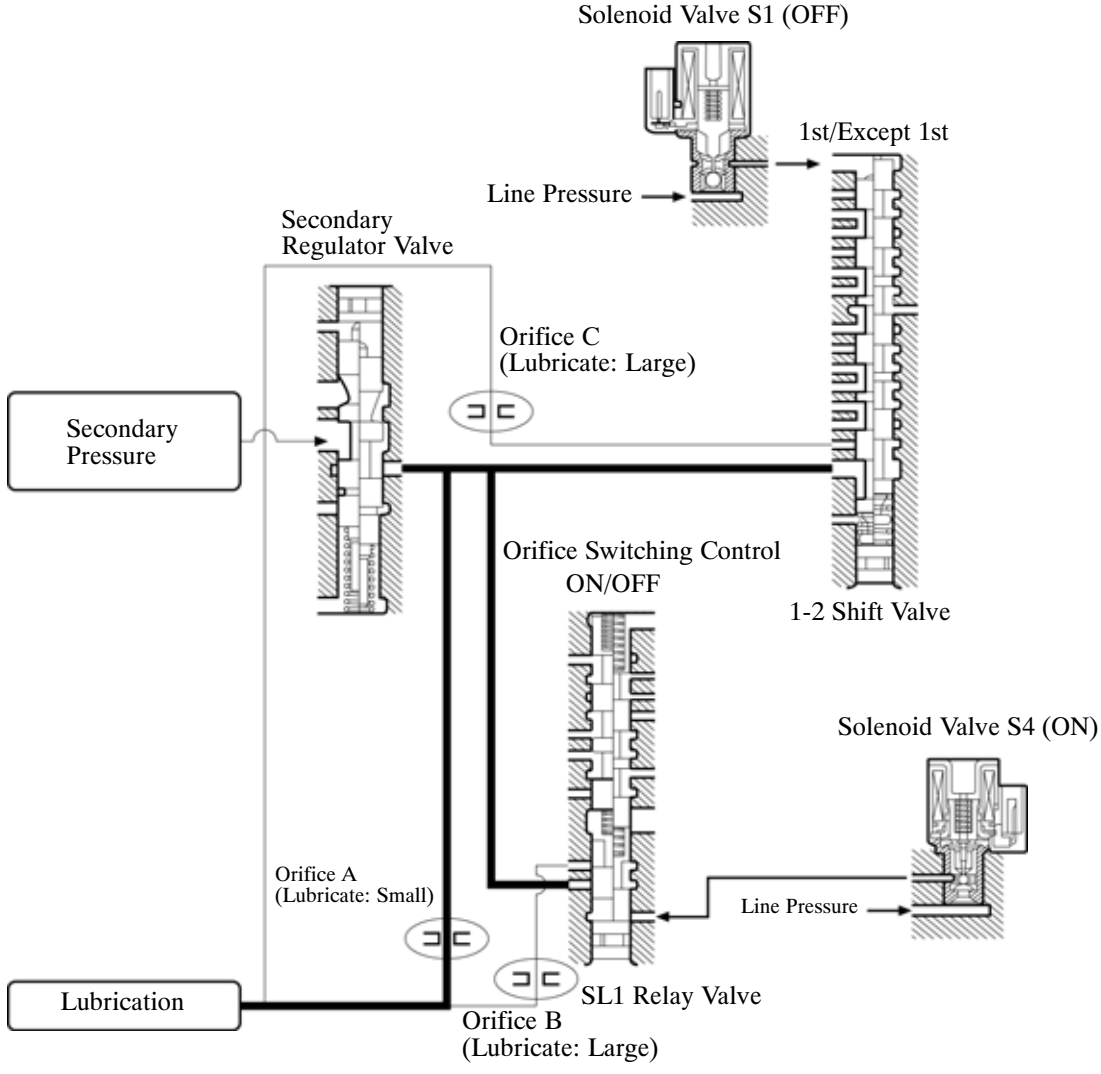
The driver's intention support control achieves sport driving based on the driver's intention according to the accelerator pedal operation, vehicle condition, and pattern select switch condition.

Control	Operation	Operate Gear	Pattern Select Switch
Sudden Accelerator Pedal Depress Control	When the driver operates (presses) the accelerator pedal quickly, this control causes the transmission to downshift rapidly to improve acceleration response.	4th, 5th, 6th	POWER
Sudden Accelerator Pedal Release Control	When the driver releases the accelerator quickly, this control makes it easy for the transmission to hold the gear, which improves engine braking force and re-acceleration response.	2nd to 5th	POWER
Sudden Deceleration Downshift Control	When the driver decelerates the vehicle suddenly, this control downshifts rapidly, which improves engine braking force and re-acceleration response.	4th, 5th, 6th	POWER

10. Orifice Switching Control

At extremely low temperatures, the ATF viscosity increases (becomes thick), making the oil pump susceptible to cavitation. For this reason, the orifice switching control reduces the volume of the oil in the transmission and increases the volume of oil drawn by the oil pump, in order to prevent the oil pump from cavitating.

- While stopped in 1st, the Engine ECU turns OFF the solenoid valve S1 and turns ON (normally OFF) the solenoid valve S4 in order to apply the line pressure to the 1-2 shift valve and the SL1 relay valve. The 1-2 shift valve and the SL1 relay valve close the oil passage for the secondary pressure from the secondary regulator valve, thus causing the secondary pressure to pass through orifice "A". As a result, the volume of oil in the transmission decreases.
- While stopped in a gear other than 1st, the secondary pressure from the secondary regulator valve travels through either or both of the 1-2 shift valve and SL1 relay valve, and passes through orifice "B" and "C", in order to lubricate the inside of the transmission. As a result, the volume of the oil in the transmission does not decrease.



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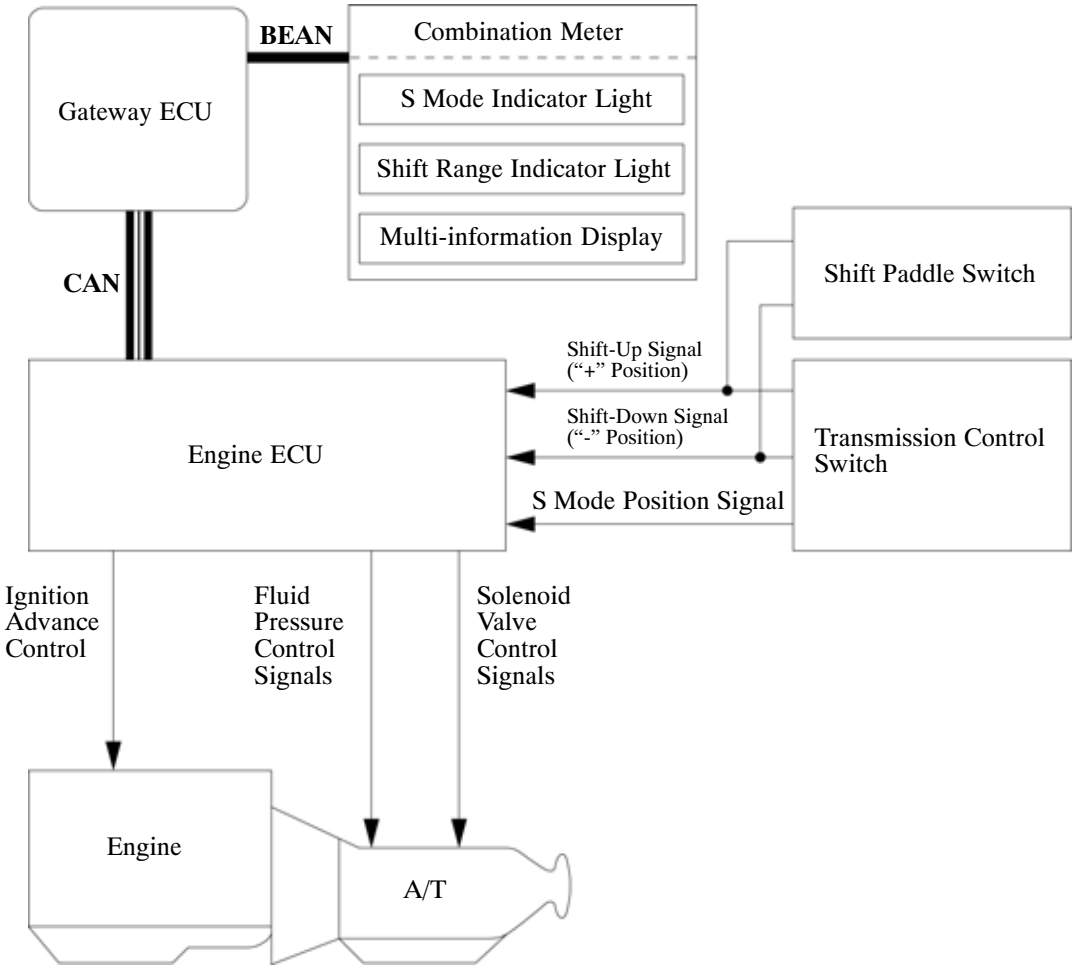
11. Multi-Mode Automatic Transmission

General

By moving the shift lever to the front ("+" position) or to the rear ("-" position), the driver can select the desired shift range position. Also, the shift paddle switch is adopted, which enables changing the shift ranges while the driver is holding the steering wheel. Thus, the driver is able to shift gears with a manual-like feel.

- This Multi-mode automatic transmission is designed to allow the driver to switch the gear ranges; not for manually selecting single gears.
- An S mode indicator light which illuminates when the S mode position is selected and a shift range indicator light, which indicates the range position, have been provided in the combination meter.

▶ System Diagram ◀



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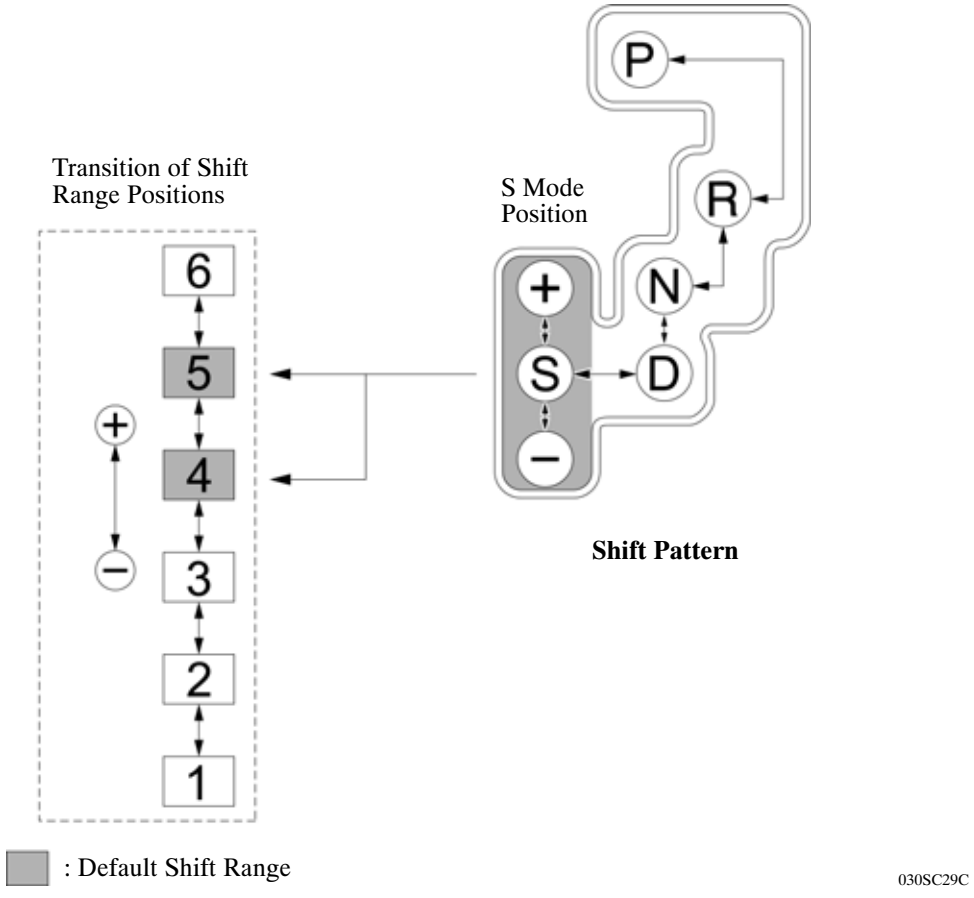
Operation

1) Shift Lever

- The driver selects the S mode position by engaging the shift lever. At this time, the shift range position selects the 4th or 5th range according to the vehicle speed. (During AI-Shift control, the shift range that has the currently controlled gear position as the maximum usable gear position will be desplayd.) 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 Engine ECU 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.
- 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.

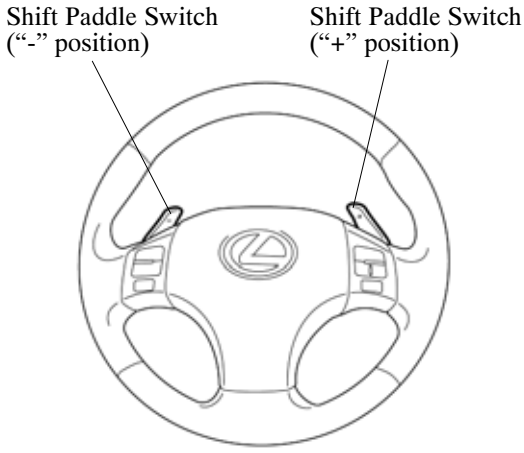


▶ Usable Gear Chart ◀

Shift Range	Shift Range Indicator Light Indication	Usable Gear
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

2) Shift Paddle Switch

- When the shift lever is in the S mode position, the shift ranges can be selected by using the shift paddle switches located behind the steering wheel. Then, the shift range positions change one at a time, as the driver pulls the right shift paddle switch (“+” position) or to the left one (“-” position).
- The usable gears in the shift range selected using the shift paddle switches are the same as those that can be selected by operating the shift lever.



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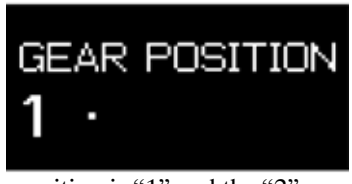
3) Gear Position Indicator

The gear position indicator is added to the menus of the multi-information display. The gear position indicator indicates the usable gears in the current shift range by using “•”, and the current gear position with the numerical number. Accordingly, both the shift range and the current gear position are clearly indicated to contribute to a sporty driving in the S mode.

Current gear position is “3” and the shift lever is in “D” or the 6th range is selected.



Current gear position is “1” and the “2” range is selected.

The shift lever is in any position other than “D” or “S”.

Gear position indicator display examples

0140CH15C

12. Diagnosis

- When the Engine ECU detects a malfunction, the Engine ECU makes a diagnosis 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 (Diagnosis Trouble Codes) are stored in memory. The DTC can be read by connecting an intelligent tester II to DLC3.

Service Tip

Because the Engine ECU of the new IS250 effects diagnosis communication through CAN (Control Area Network) protocol, an intelligent tester II is required in order to obtain diagnostic information. For details, see the LEXUS IS250 Repair Manual (Pub. No. RM0150E).

13. Fail Safe

This function minimizes the loss of operability when an abnormality occurs with a sensor or solenoid.

▶ Fail-Safe Control List ◀

Malfunction Part	Function
Input Speed Sensor (NT)	When the input speed sensor malfunctions, shift control is effected using the information from the output speed sensor signal (SP2). During an input speed sensor malfunction, up-shift to the 5th, 6th, AI-SHIFT and flex lock-up clutch control are prohibited.
Output Speed Sensor (SP2)	When the output speed sensor malfunctions, shift control is effected using the information from the input speed sensor signal (NT). When the output speed sensor malfunctions, up-shift to the 5th, 6th, AI-SHIFT and flex lock-up clutch control are prohibited.
ATF Temp. Sensor	When the ATF temperature sensor malfunctions, up-shift to the 5th, 6th and flex lock-up clutch control are prohibited.
Solenoid Valve S1, S2, S3, S4 and SR	When a solenoid valve listed at left fails, the current to the failed solenoid valve is cut off. Shift control is changed to a fail-safe mode to shift gears using the normal solenoid valves to allow continued driving. Refer to the table on the next page for an operation example.
Solenoid Valve SL1 and SL2	During a solenoid valve SL1 or SL2 malfunction, up-shift to the 5th and 6th and flex lock-up clutch control are prohibited.
Solenoid Valve SLU	During a solenoid valve SLU malfunction, the current to the solenoid valve is stopped. Because this stops lock-up control and flex lock-up control, fuel economy decreases.
Solenoid Valve SLT	During a solenoid valve SLT malfunction, the current to the solenoid valve is stopped. Because this stops line pressure optimal control, the shift shock increases. However, shifting is effected through normal clutch pressure control.

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 (E/B)
S2	OFF	ON	ON	OFF	ON	OFF	ON	1st
	ON	ON	ON	ON	OFF	OFF	OFF	2nd (E/B)
S1	OFF	ON	ON	OFF	ON	OFF	OFF	1st (E/B)

▶ 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→OFF	ON	OFF	OFF→ON	1st (E/B)→4th
S1	×	ON	ON	OFF	ON	OFF	OFF	1st (E/B)

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