■ ELECTRONIC CONTROL SYSTEM

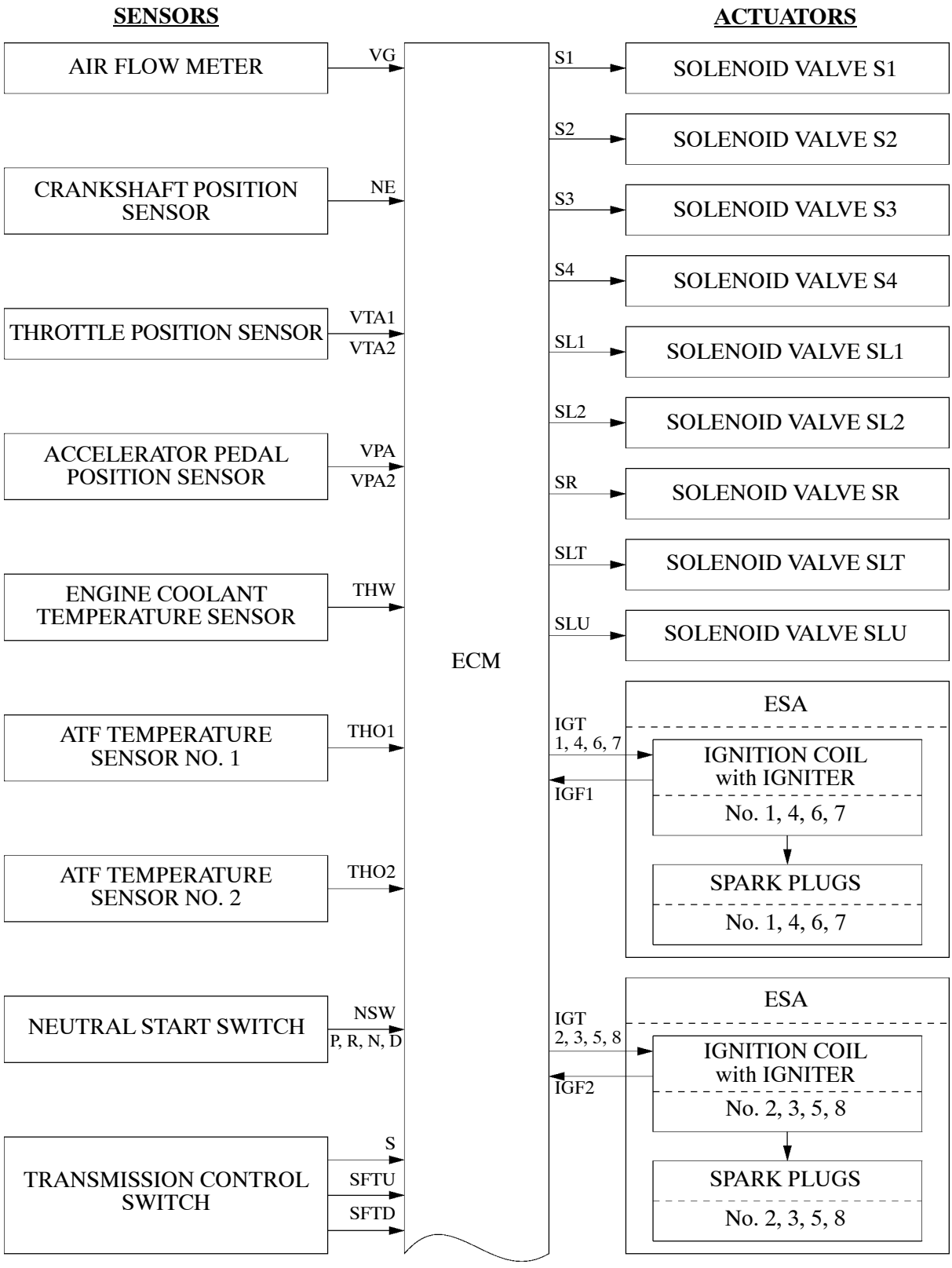
1. General

The electronic control system of the AB60E automatic transmission consists of the control functions listed below.

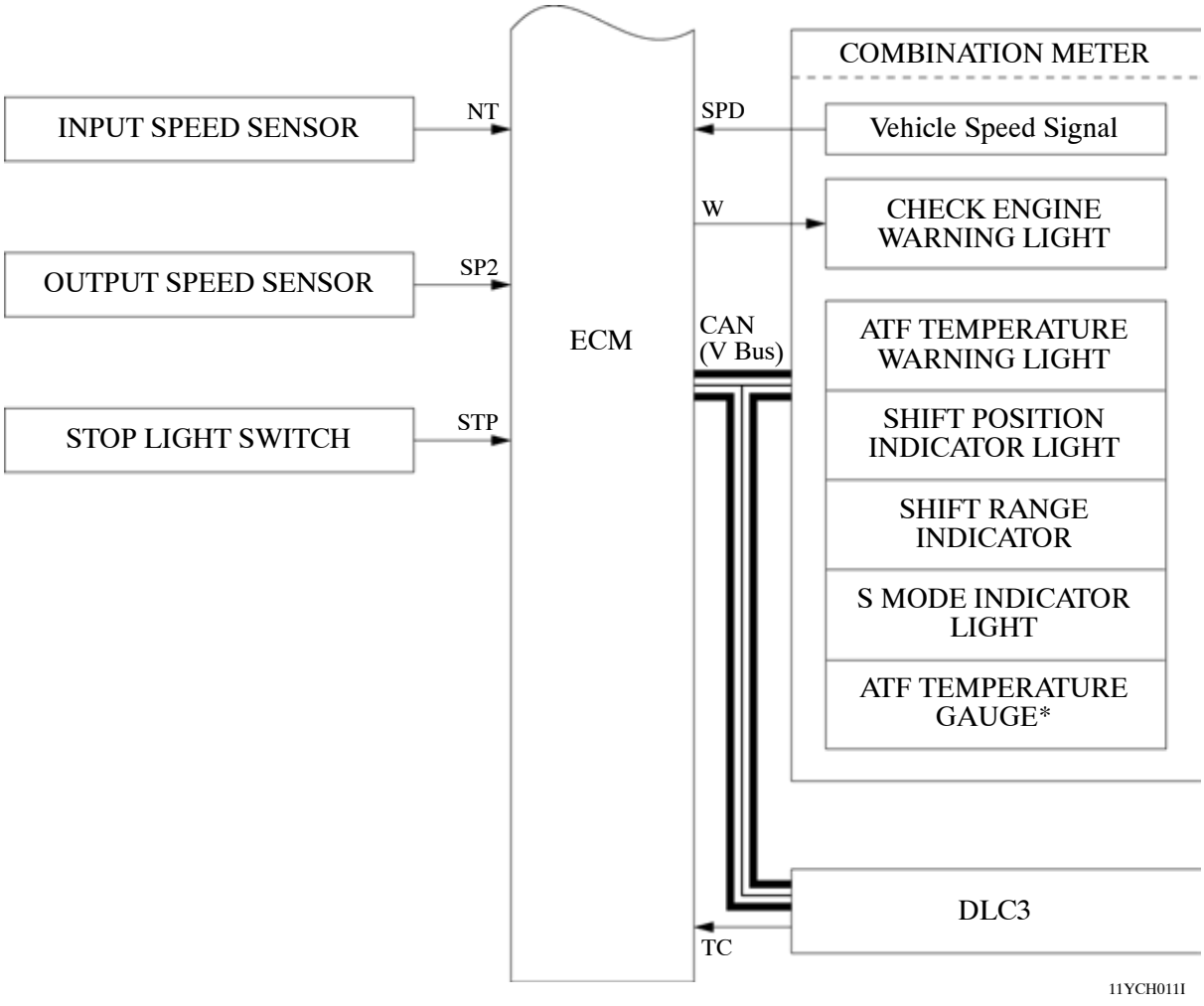
Control	Function
Shift Timing Control	The ECM sends current to solenoid valves SS1, SS2, SS3, SS4 and/or SR based on signals from various sensors, in order to shift the gears.
Clutch Pressure Control (See page CH-31)	● Controls the pressure that is applied directly to B_2 brake and C_3 clutch by actuating the solenoid valves SL1 and SL2 in accordance with the ECM signals. ● The solenoid valves SLT and SL1 minutely control the clutch pressure in accordance with the engine output and driving conditions.
Line Pressure Optimal Control (See page CH-32)	Actuates the solenoid valve SLT to control the line pressure in accordance with information from the ECM and the operating conditions of the transmission.
Engine Torque Control	Retards the engine ignition timing temporarily to improve shift feeling while upshifts or downshifts occur.
Lock-up Timing Control (See page CH-33)	The ECM sends current to the solenoid valve SLU based on signals from various sensors and engages or disengages the lock-up clutch.
Flex Lock-up Clutch Control (See page CH-34)	Controls the solenoid valve SLU, provides an intermediate mode for when the lock-up clutch is between on and off, and increases the operating range of the lock-up clutch to improve fuel economy.
Powertrain Cooperative Control (See page CH-36)	Controls both the shift control and engine output control in an integrated way, achieving excellent shift characteristics and drivability.
Coast Downshift Control (See page CH-37)	To prevent engine speed from decreasing and thereby maintain fuel cut, the ECM performs downshifts before fuel cut ends.
Artificial Intelligence-SHIFT (AI-SHIFT) Control (See page CH-38)	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-40)	The ECM appropriately controls the automatic transmission in accordance with the range position selected while the shift lever is in S mode.
R to D Squat Control	When the shift lever is shifted from “R” to “D”, the 3rd gear is temporarily engaged before the 1st gear to reduce vehicle squat.
N to D Squat Control	When the shift lever is shifted from “N” to “D”, the 2nd gear is temporarily engaged before the 1st gear to reduce vehicle squat.
Diagnosis (See page CH-42)	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-42)	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 AB60E automatic transmission is as shown in the following chart.



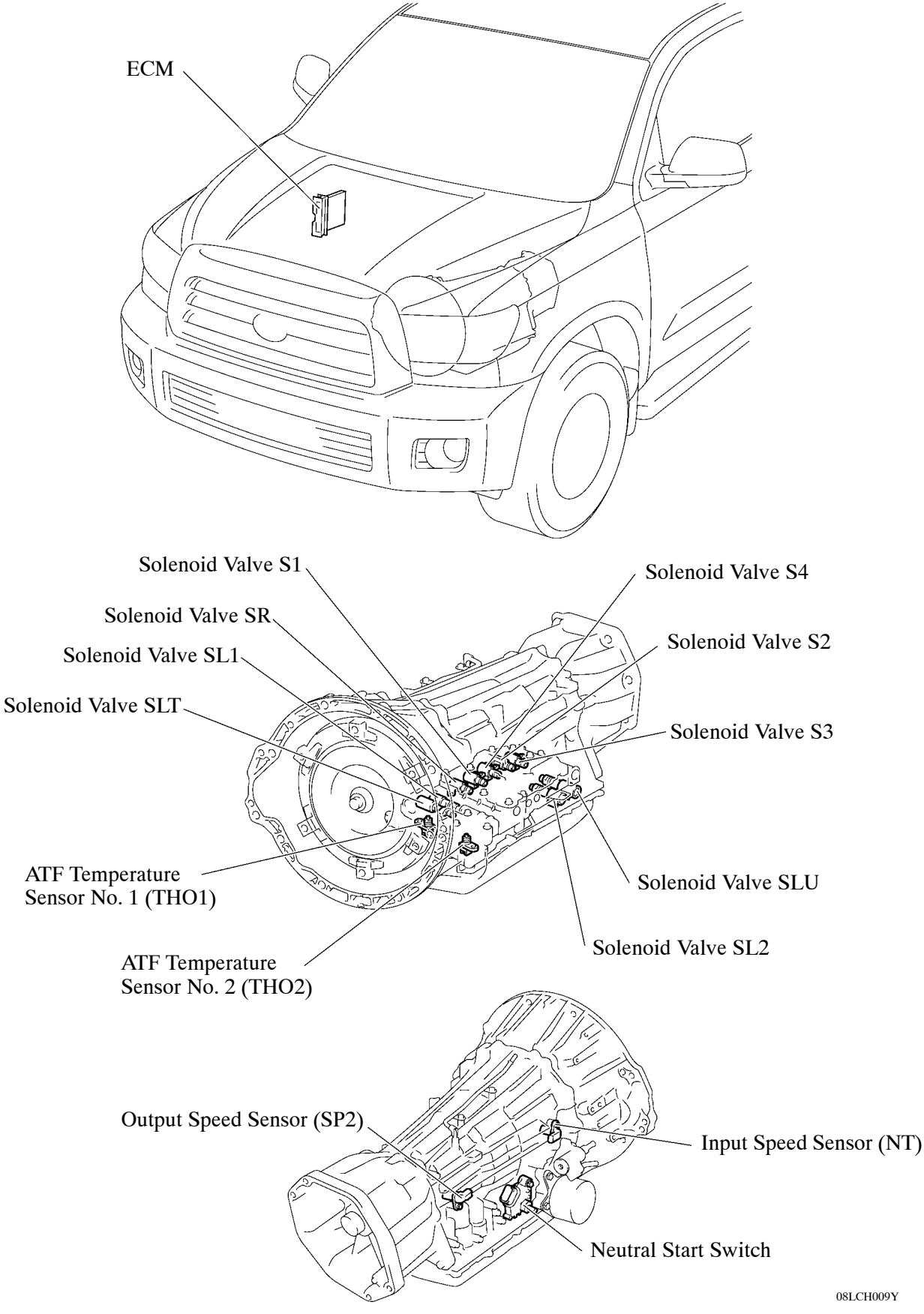
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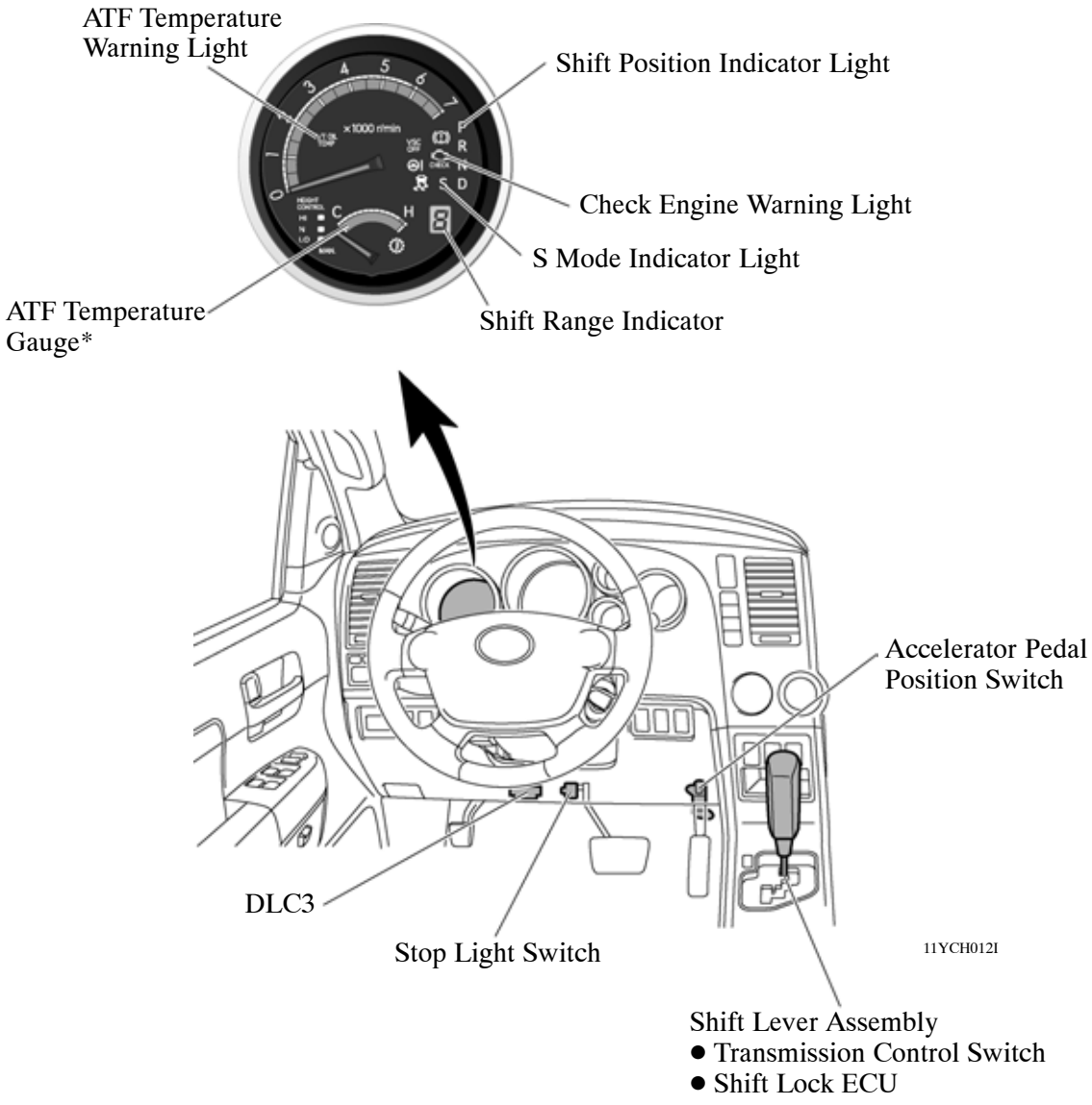


*: Models with Optitron display type combination meter

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3. Layout of Main Components





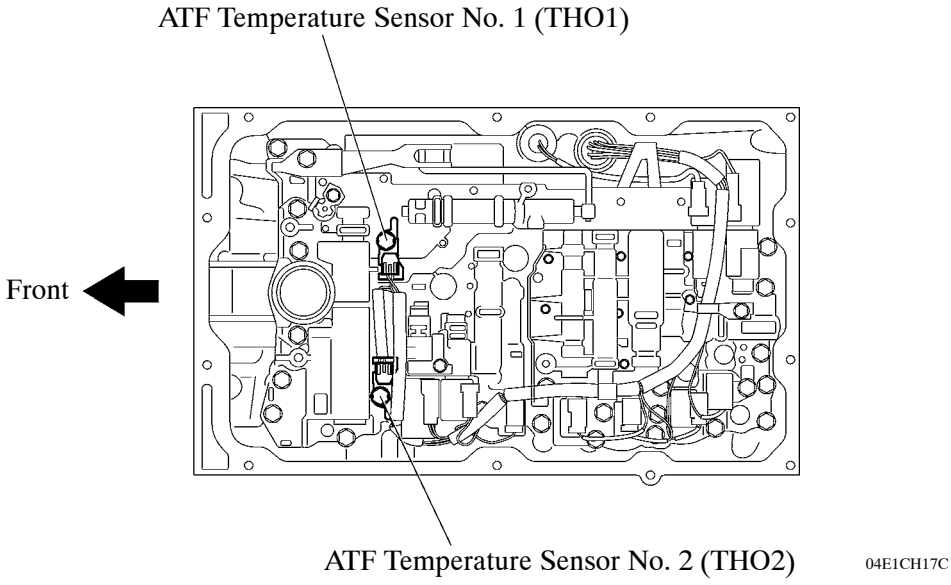
*: Models with Optitron display type combination meter

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4. Construction and Operation of Main Components

ATF Temperature Sensors No. 1 and No. 2

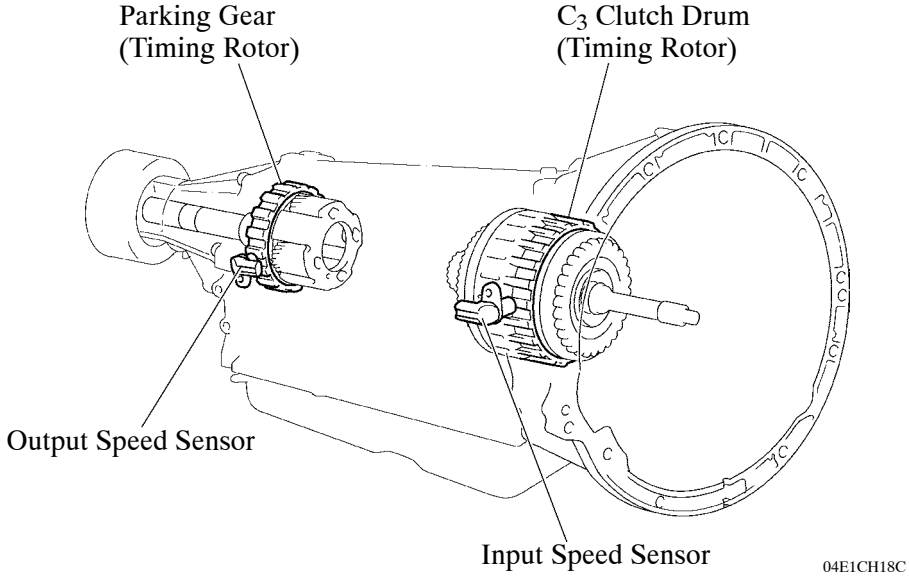
- The ATF temperature sensor No. 1 (THO1) is used for hydraulic pressure control. This sensor is used for revision of the pressure that is used to apply clutches and brakes in the transmission. This helps to ensure smooth shift quality.
- The ATF temperature sensor No. 2 (THO2) is used as a basis for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



Input Speed Sensor and Output Speed Sensor

The AB60E automatic transmission uses an input speed sensor (for NT signal) and an output speed sensor (for SP2 signal). Thus, the ECM can detect the timing of the shifting of the gears and appropriately control the engine torque and hydraulic pressure in response to various conditions.
These speed sensors are the pick-up coil type.

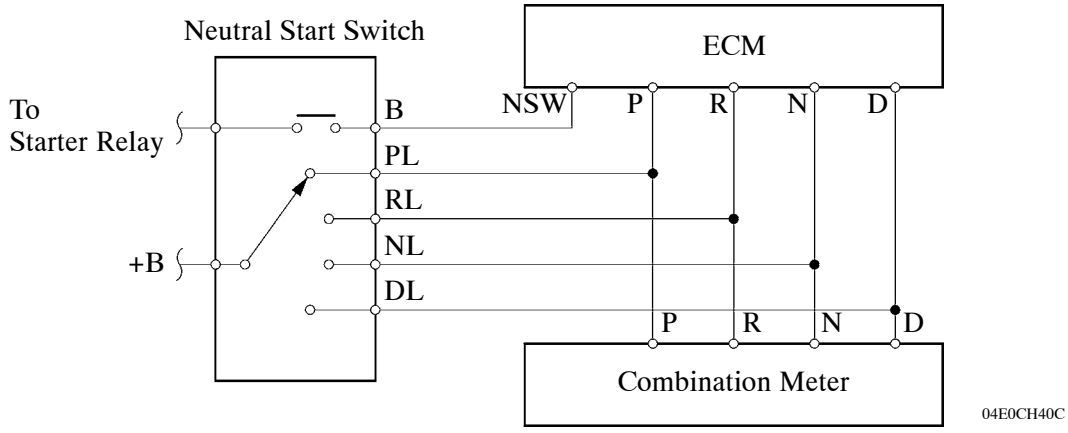
- The input speed sensor detects the input speed of the transmission. The clutch drum is used as the timing rotor for this sensor.
- The output speed sensor detects the speed of the output shaft. The parking gear on the rear planetary gear is used as the timing rotor for this sensor.



Neutral Start Switch

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

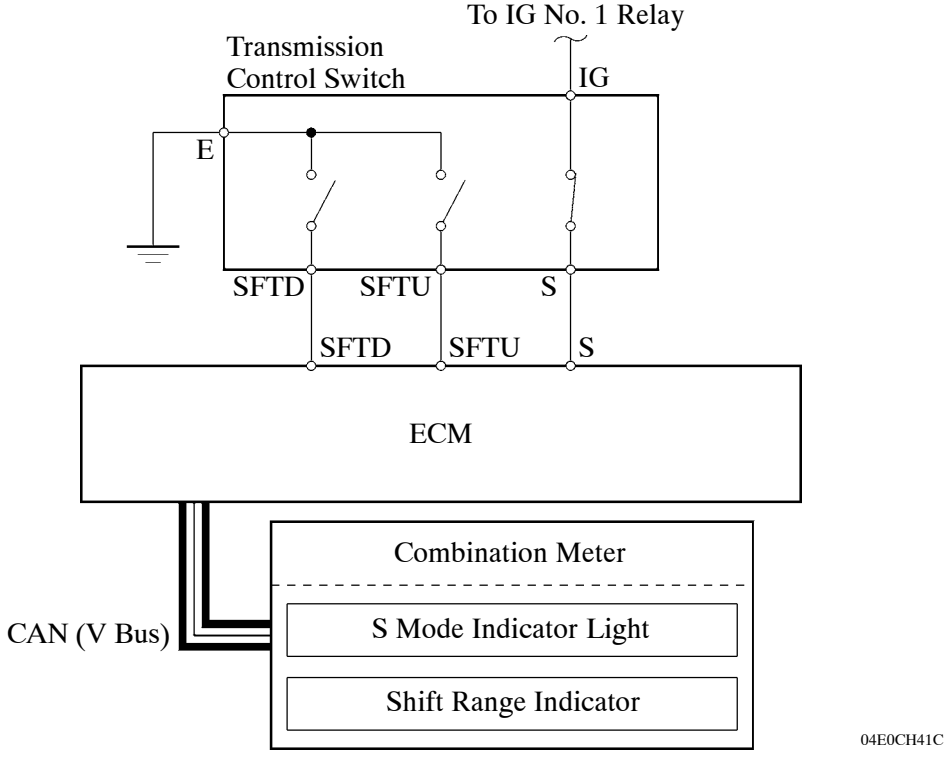
▶ Wiring Diagram ◀



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 D or in S, and detects the operating conditions of the shift lever (“+”or “–”) if the S mode is selected, and sends signals to the ECM. At this time, the ECM turns on the shift range indicator for the selected range.

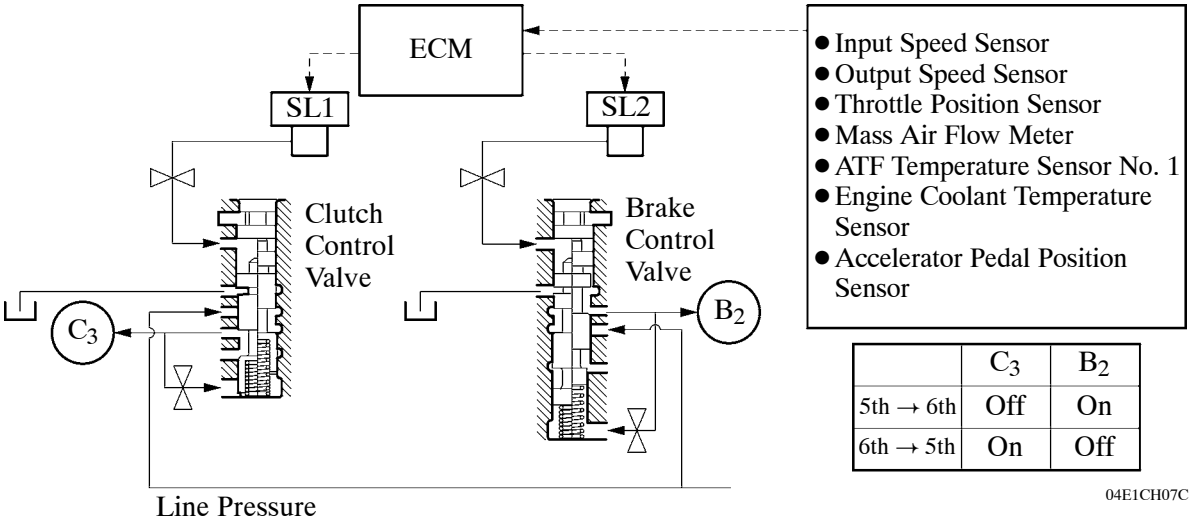
▶ Wiring Diagram ◀



5. Clutch Pressure Control

Clutch to Clutch Pressure Control

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

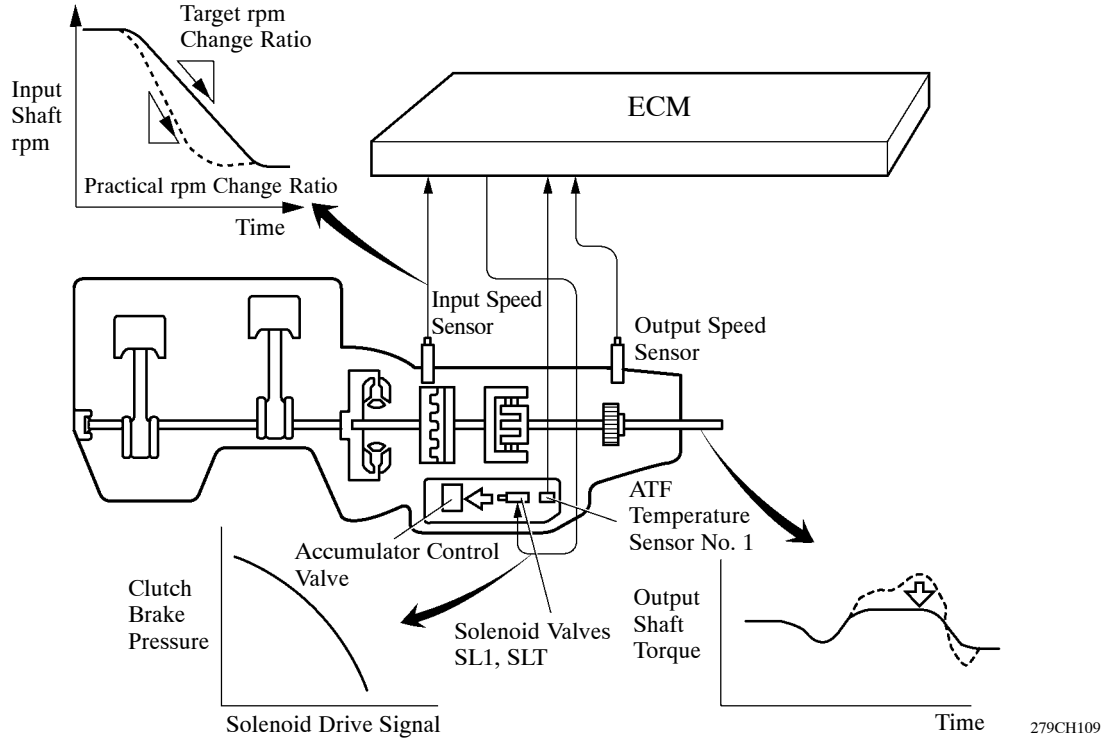


	C_3	B_2
5th → 6th	Off	On
6th → 5th	On	Off

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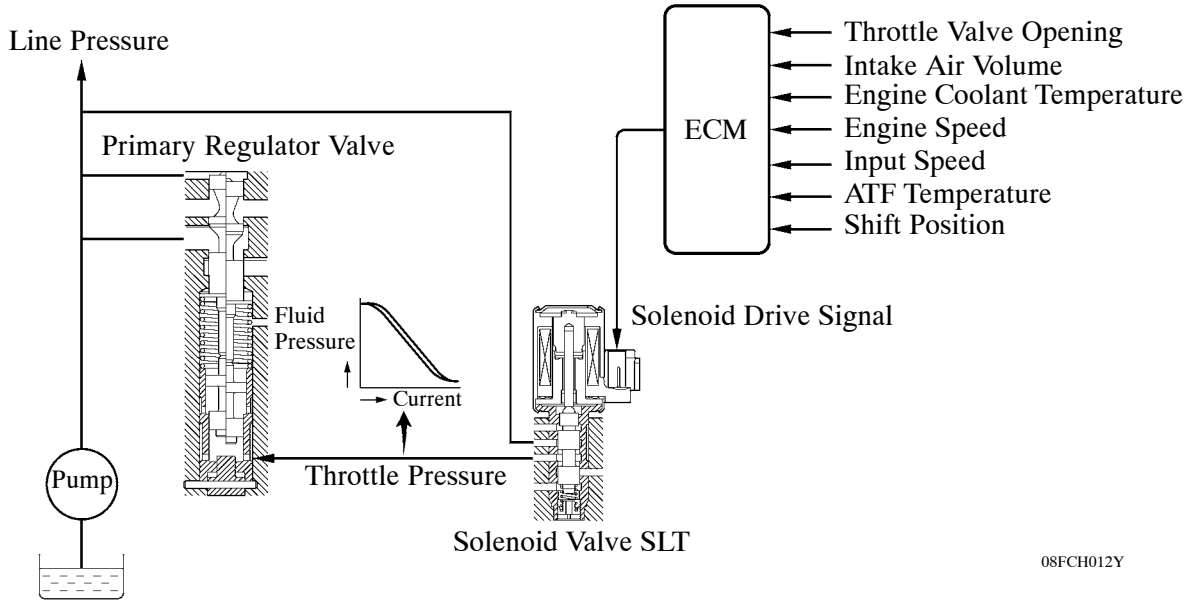
Clutch Pressure Optimal Control

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



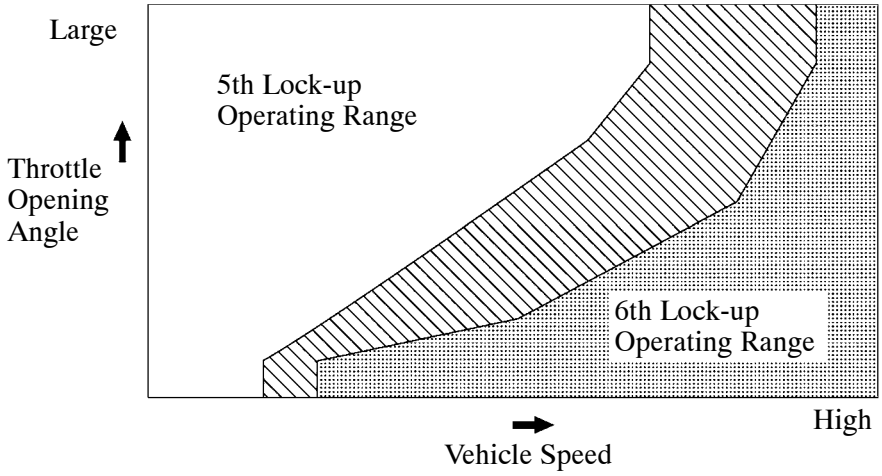
6. Line Pressure Optimal Control

Through the use of the solenoid valve SLT, the line pressure is optimally controlled in accordance with the engine torque information, as well as with the internal operating conditions of the torque converter clutch and the transmission.
Accordingly, the line pressure can be controlled minutely in accordance with the engine output, traveling condition, and ATF temperature, thus achieving 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.



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Lock-up Timing in D or S6 Range

▶ Lock-up Operation Gears in Each Range ◀

○: Available ×: Not available —: Not applicable

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

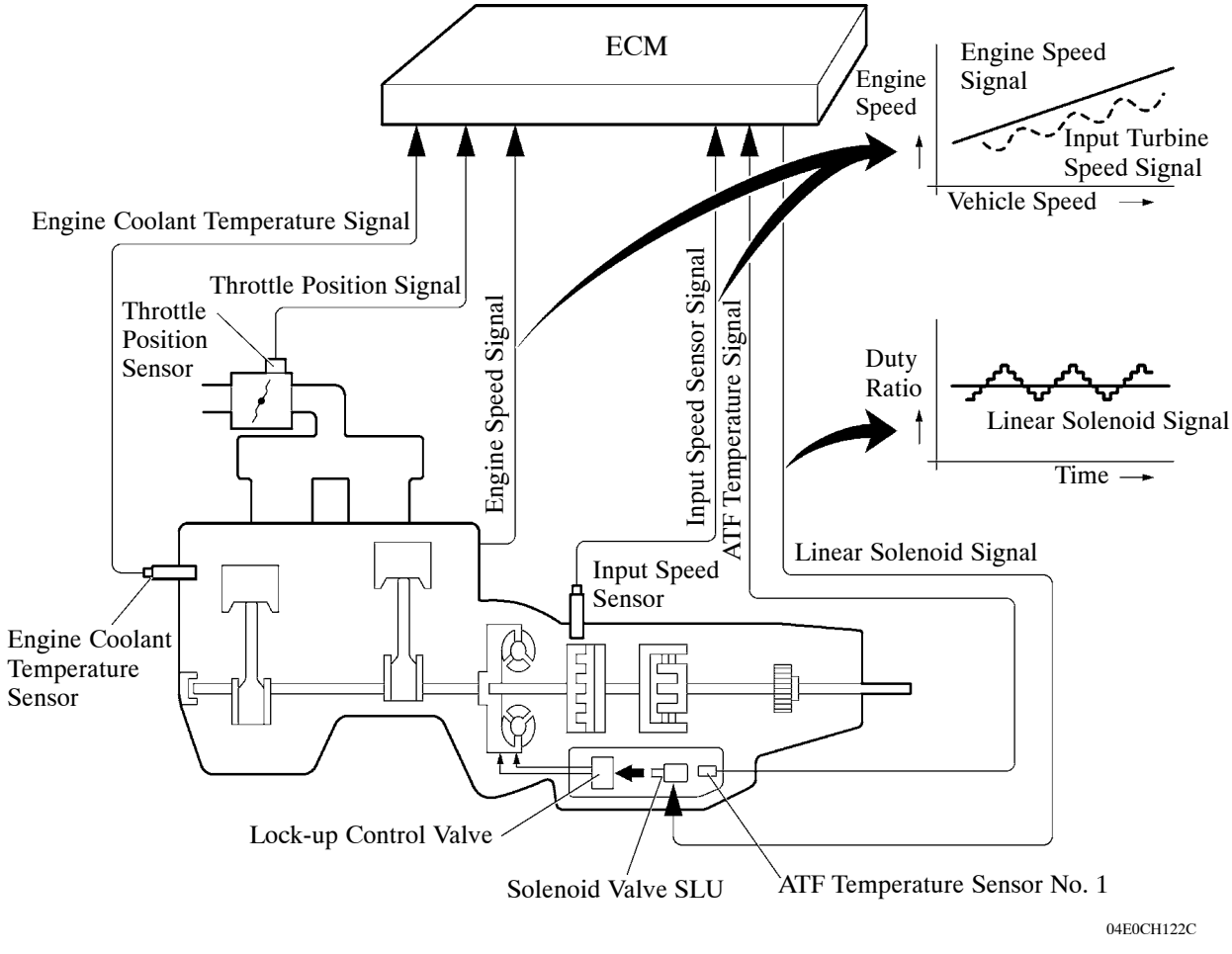
*: Lock-up operation is performed when the 4th gear is help during the AI-SHIFT control or the cruise control.

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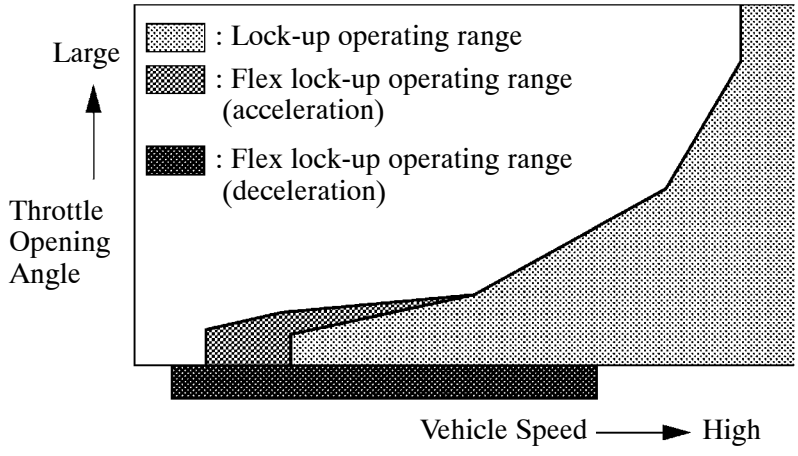
8. Flex Lock-up Clutch Control

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



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▶ Flex Lock-up Operation Gears in Each Range ◀

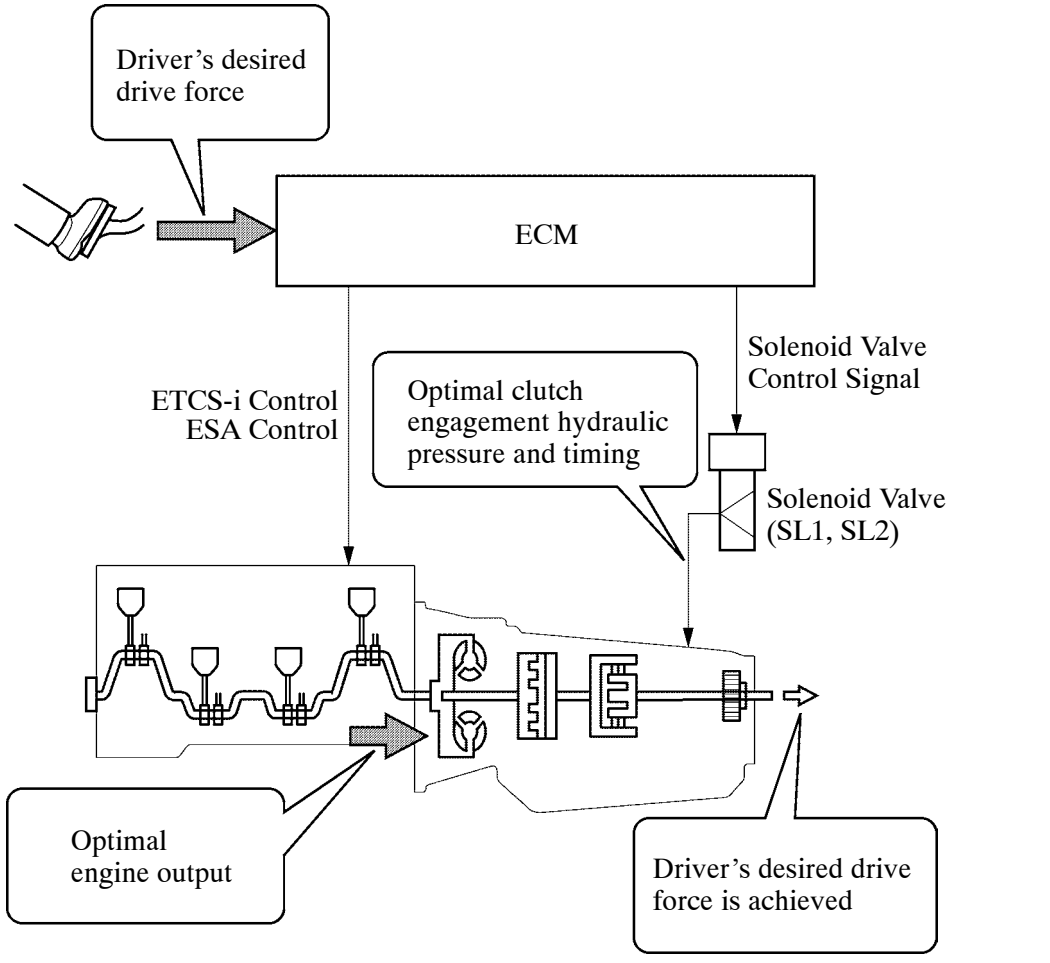
○: Available ×: Not available —: Not applicable

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

*1: Only flex lock-up operates when the vehicle is decelerating
*2: Only flex lock-up operates when the vehicle is accelerating

9. Powertrain Cooperative Control

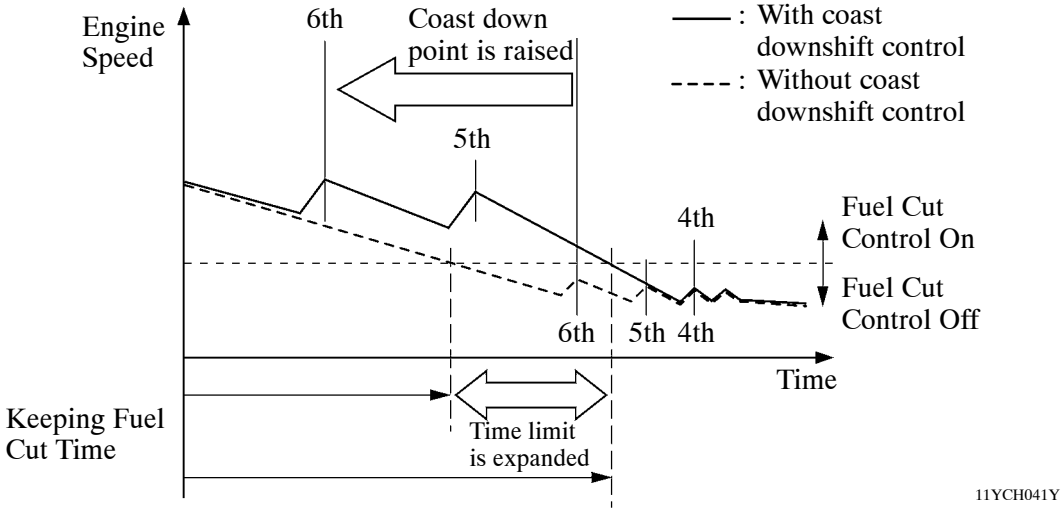
Through cooperative control with Electronic Throttle Control System-intelligent (ETCS-i) and Electronic Spark Advance (ESA), and electronic control of the engagement and release speed of the clutch and brake hydraulic pressures, excellent response and shift shock reduction have been achieved.



10. Coast Downshift Control

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

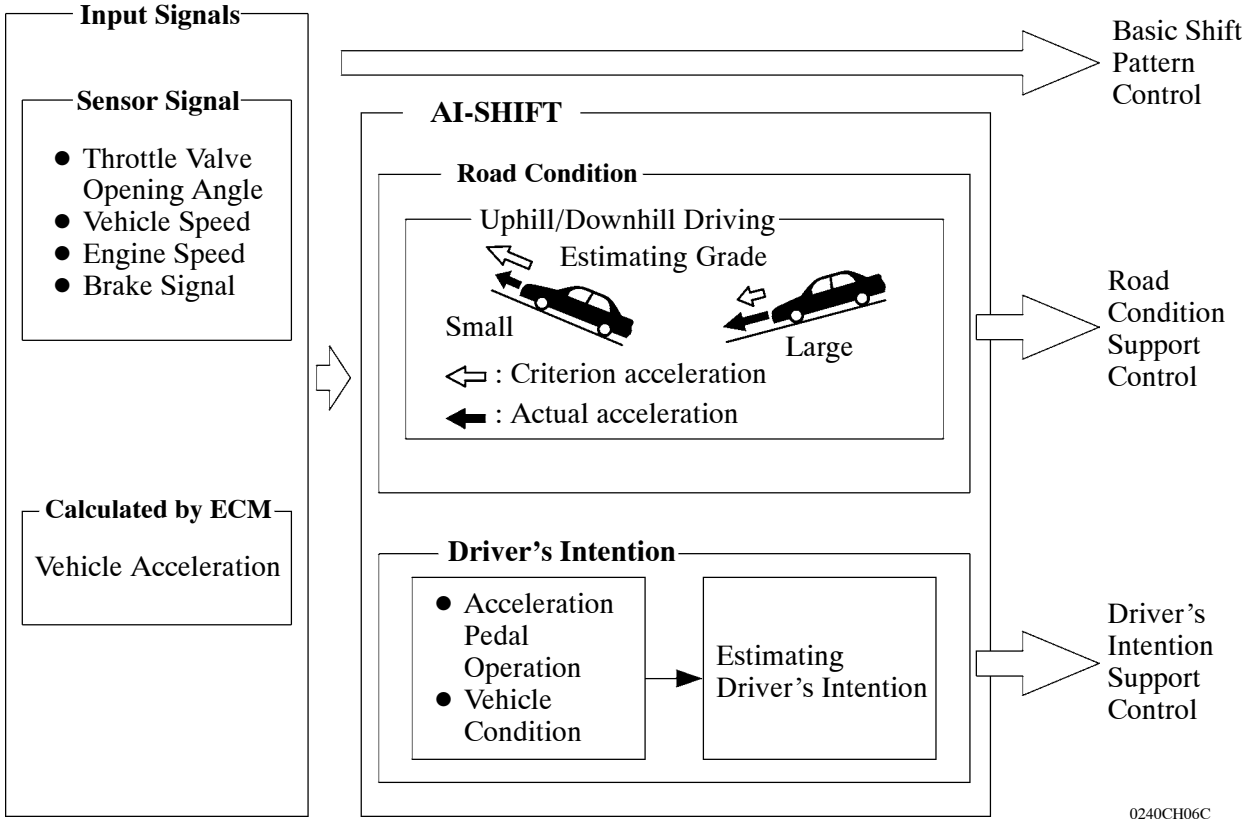
- In this control, the transmission downshifts from 6th to 5th and then 5th to 4th before fuel cut control ends when the vehicle is decelerated in the 6th gear, so that fuel cut control continues operating.



11. Artificial Intelligence-SHIFT (AI-SHIFT) Control

General

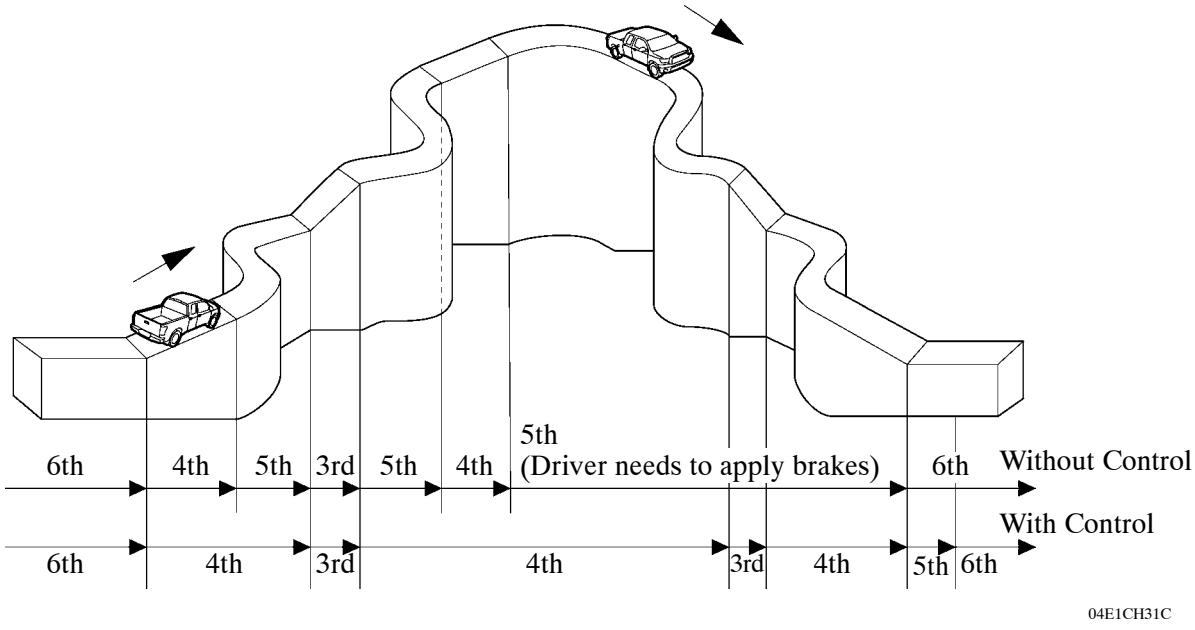
- The AI-SHIFT control determines optimal transmission control based on input signals and automatically changes the shift pattern. As a result, a high caliber of transmission operation is achieved.
- The AI-SHIFT control includes a road condition support control and a driver's intention support control.
- The AI-SHIFT control is effected only with the shift lever in D, based on the accelerator pedal and brake operation data. The AI-SHIFT control will be canceled when the driver selects the S mode.



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



Driver's Intention Support Control

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

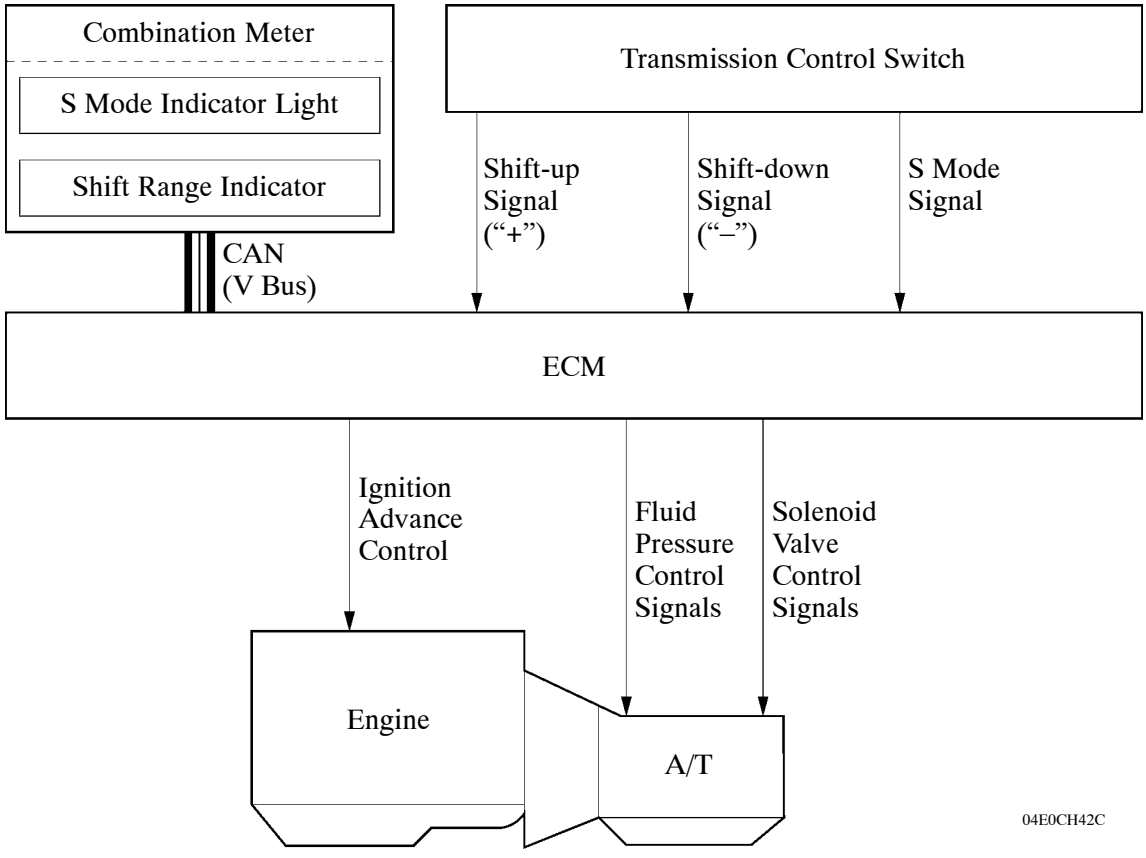
Control	Operation	Available for
Sudden Accelerator Pedal Depress Control	When the driver operates (presses) the accelerator pedal quickly, this control causes the transmission to downshift rapidly to improve acceleration response.	5th to 6th
Sudden Accelerator Pedal Release Control	When the driver releases 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
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

12. Multi-mode Automatic Transmission

General

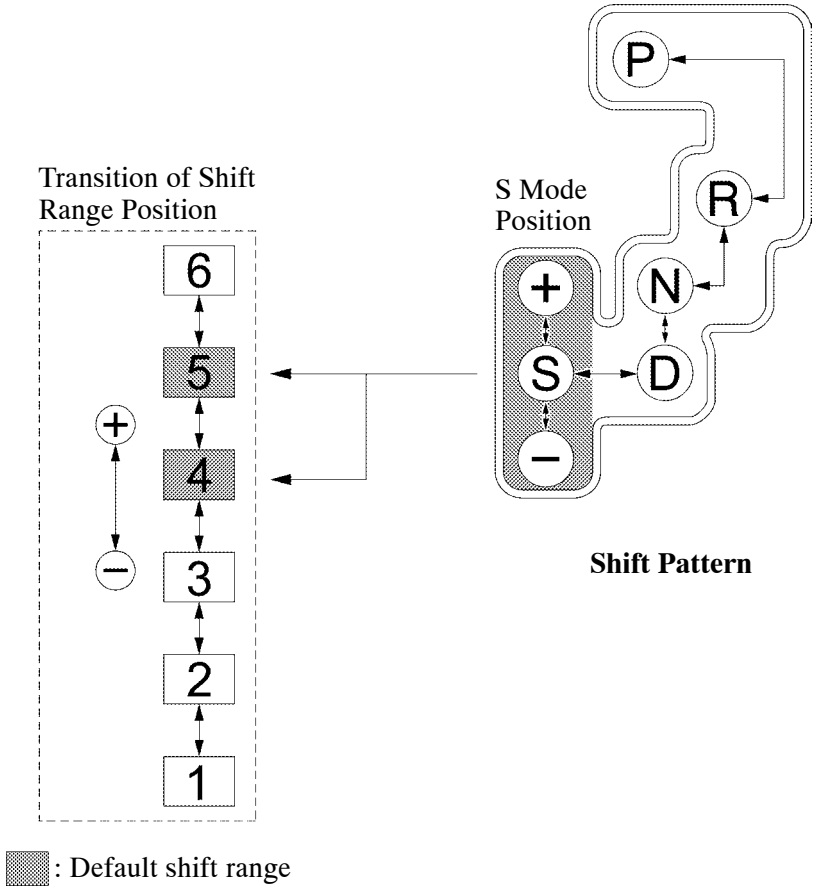
A multi-mode automatic transmission is designed to allow the driver to switch the gear ranges (a multi-mode transmission is not for manually selecting single gears). After moving the shift lever to S, the driver can select the desired shift range by moving the shift lever to the "+" or "–". Thus, the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

▶ System Diagram ◀



Operation

- The driver selects the S mode by engaging the shift lever. At this time, the S4 or S5 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 change one at a time, as the driver moves the shift lever to the front ("+") or to the rear ("–").
- 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 "+" with the shift lever in S will change the shift range to the S6 range regardless of range (S1 to S5).
- When the shift lever is in S, the S mode indicator light in the combination meter illuminates. The shift range indicator indicates the state of the shift range position that the driver has selected.



▶ Usable Gear Chart ◀

Shift Range	Shift Range Indicator Display	Usable Gears
S6	6	6th ↔ 5th ↔ 4th ↔ 3rd ↔ 2nd ↔ 1st
S5	5	5th ↔ 4th ↔ 3rd ↔ 2nd ↔ 1st
S4	4	4th ↔ 3rd ↔ 2nd ↔ 1st
S3	3	3rd ↔ 2nd ↔ 1st
S2	2	2nd ↔ 1st
S1	1	1st

13. Diagnosis

- When the ECM detects a malfunction, the ECM records the malfunction and memorizes the information related to the fault. Furthermore, the check engine warning light in the combination meter illuminates or blinks to inform the driver.
- The ECM will also store the Diagnostic Trouble Code (DTC) of the malfunctions. The DTC can be accessed using an intelligent tester II.

For details, refer to the SEQUOIA Repair Manual (Pub. No. RM11Y0E).

14. Fail-safe

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

▶ Fail-safe Control List ◀

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

▶ Normal Condition ◀

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

▶ Example (Solenoid Valve S1 Malfunction) ◀

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

E/B: Engine braking