■ELECTRONIC CONTROL SYSTEM

1. General

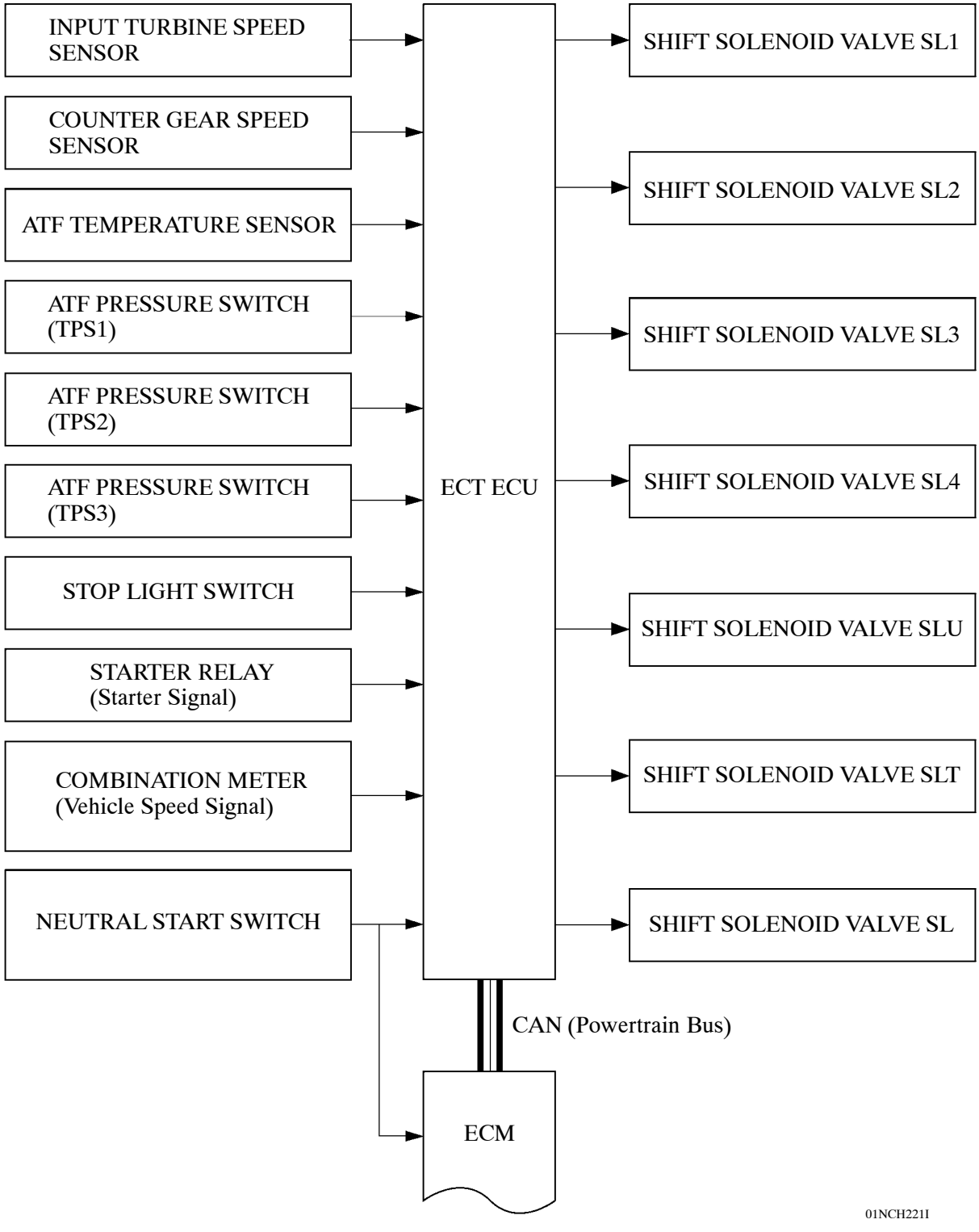
The electronic control system of the U660F automatic transaxle consists of the controls listed below:

Control	Function	
Shift Timing Control	The ECT ECU sends current to shift solenoid valves SL1, SL2, SL3, SL4, SL and/or SLU based on signals from various sensors, in order to shift the gears.	
Clutch to Clutch Pressure Control (See page 43)	Controls the pressure applied directly to the No. 1 clutch (C_1), No. 2 clutch (C_2), No. 1 brake (B_1) and No. 3 brake (B_3) by actuating the shift solenoid valves (SL1, SL2, SL3 and SL4) in accordance with ECT ECU signals.	
Line Pressure Optimal Control (See page 44)	Actuates shift solenoid valve SLT to control the line pressure in accordance with information from the ECT ECU and the operating conditions of the transaxle.	
Powertrain Cooperative Control (See page 45)	Controls both shift control and engine output control in an integrated way, achieving excellent shift characteristics and driveability.	
Artificial Intelligence Shift (AI-shift) Control (See page 47)	Based on the signals from various sensors, the ECT ECU determines the road conditions and the intention of the driver. Thus, an appropriate shift pattern is automatically determined, improving driveability.	
Coast Downshift Control (See page 49)	To prevent engine speed from decreasing and thereby maintain the fuel cut, the ECT ECU performs downshifts before the fuel cut ends.	
Lock-up Timing Control (See page 50)	The ECT ECU sends current to shift solenoid valves SL and SLU based on signals from various sensors to engage or disengage the lock-up clutch.	
Flex Lock-up Clutch Control (See page 51)	Controls shift solenoid valve SLU, provides an intermediate mode between the on and off states of the lock-up clutch, and increases the operating range of the lock-up clutch to improve fuel economy.	
Multi-mode Automatic Transmission (with Transmission Shift Switch) (See page 53)	• The ECT ECU appropriately controls the automatic transaxle in accordance with the gear range selected using the shift lever or transmission shift switch while the shift lever is in M. • When the shift lever is in D, the driver can select a desired gear range using the transmission shift switch.	
	Gear Hold Control	Holds the gear range selected by the driver, unless the vehicle is decelerated and the shift lever or transmission shift switch is operated.
	Complete Lock-up Control	In 2nd gear and higher, this control transmits engine output directly to the transaxle using the torque converter lock-up clutch. However, even in 2nd gear and higher, when engine speed is low, the control is not operated.
	High Response Upshift Control	Achieves crisp and high response upshift using the clutch to clutch pressure control and powertrain cooperative control.
	Blipping Downshift Control	Achieves smooth and quick downshift using the clutch to clutch pressure control and powertrain cooperative control.
Diagnosis (See page 56)	When the ECT ECU detects a malfunction, the ECT ECU makes a diagnosis and memorizes the information related to the fault.	
Fail-safe (See page 56)	If a malfunction is detected in the sensors or shift solenoid valves, the ECT ECU performs fail-safe control to prevent the vehicle's driveability from being significantly affected.	

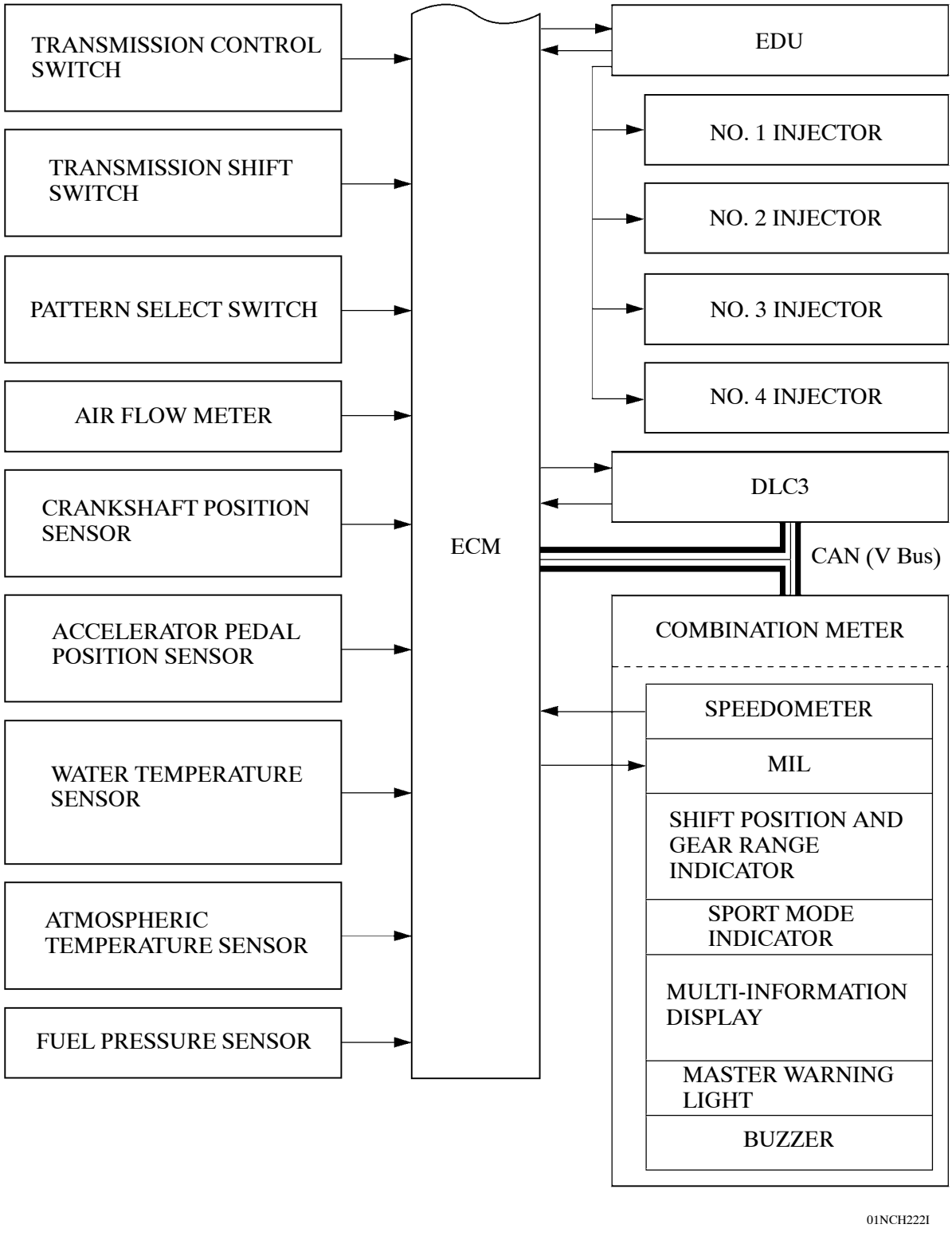
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2. Construction

The configuration of the electronic control system in the U660F automatic transaxle is as shown in the following chart:

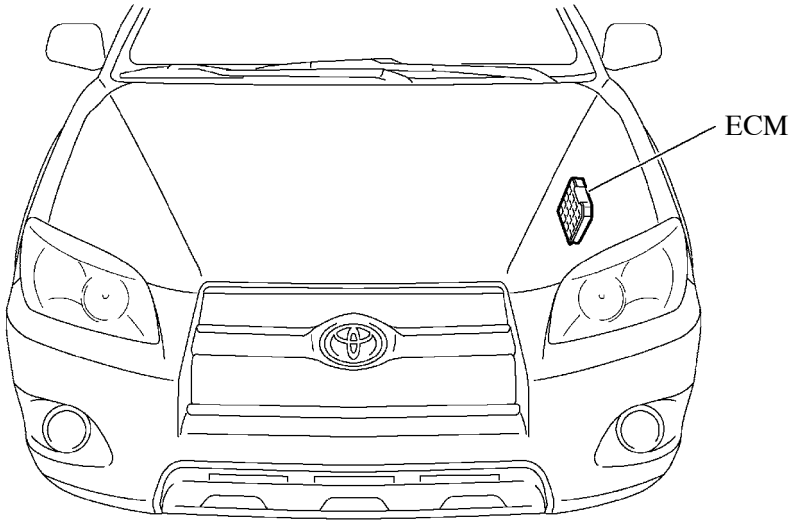


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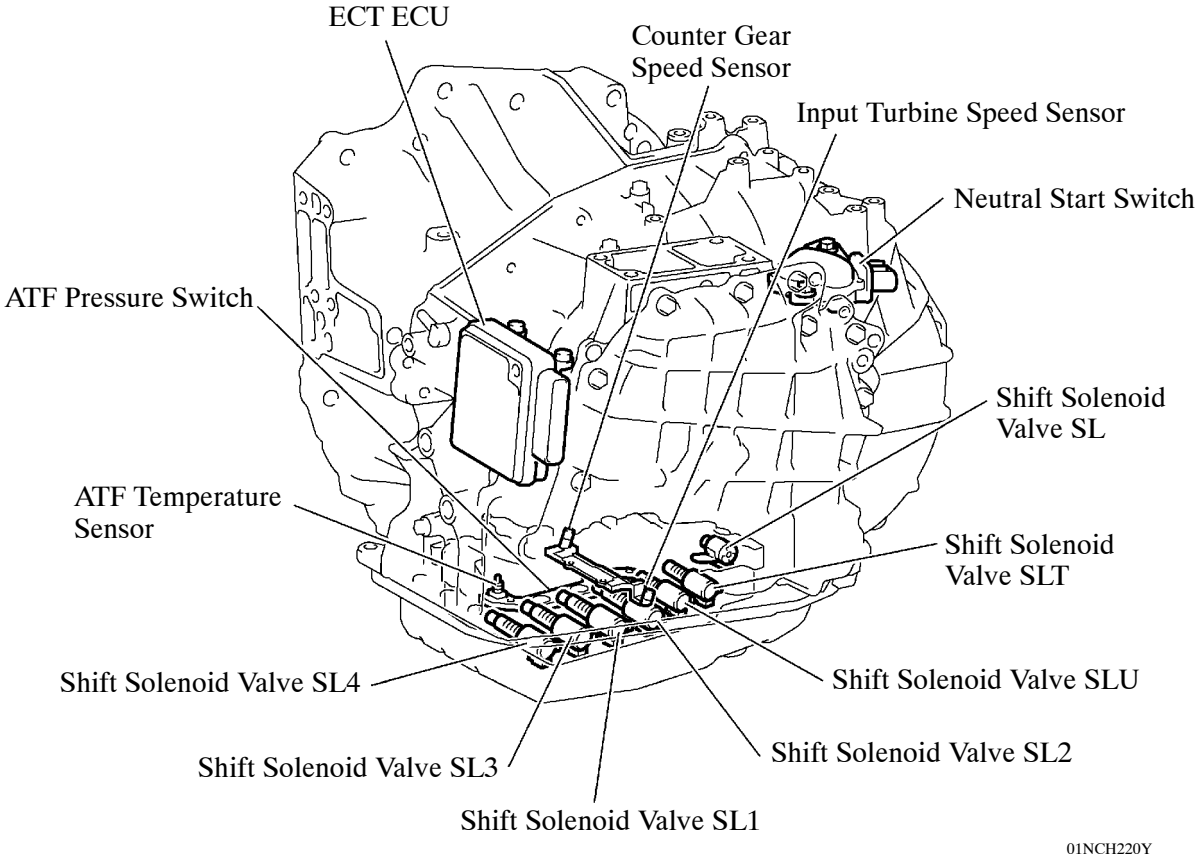

TRANSMISSION CONTROL SWITCH
TRANSMISSION SHIFT SWITCH
PATTERN SELECT SWITCH
AIR FLOW METER
CRANKSHAFT POSITION SENSOR
ACCELERATOR PEDAL POSITION SENSOR
WATER TEMPERATURE SENSOR
ATMOSPHERIC TEMPERATURE SENSOR
FUEL PRESSURE SENSOR
ECM
EDU
NO. 1 INJECTOR
NO. 2 INJECTOR
NO. 3 INJECTOR
NO. 4 INJECTOR
DLC3
CAN (V Bus)
COMBINATION METER
SPEEDOMETER
MIL
SHIFT POSITION AND GEAR RANGE INDICATOR
SPORT MODE INDICATOR
MULTI-INFORMATION DISPLAY
MASTER WARNING LIGHT
BUZZER
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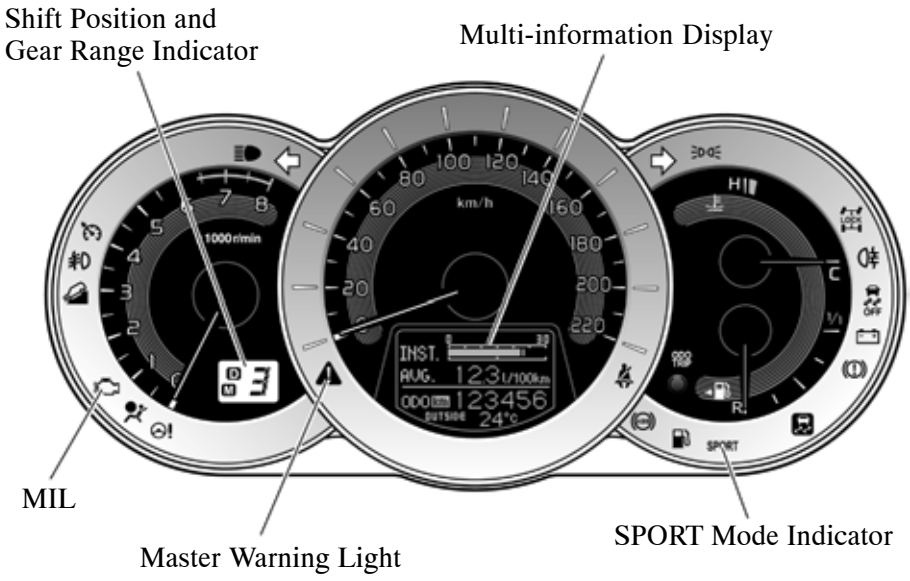
3. Layout of Main Components



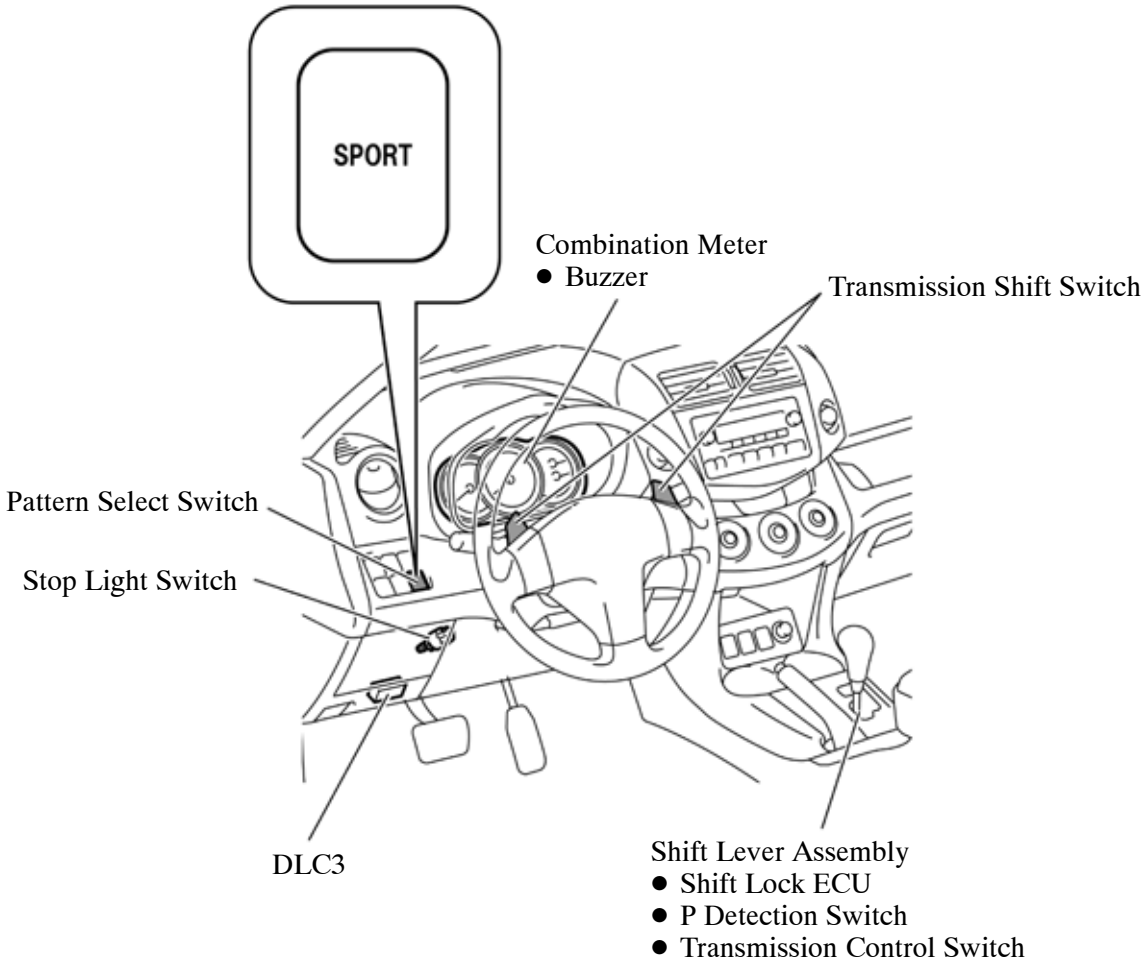
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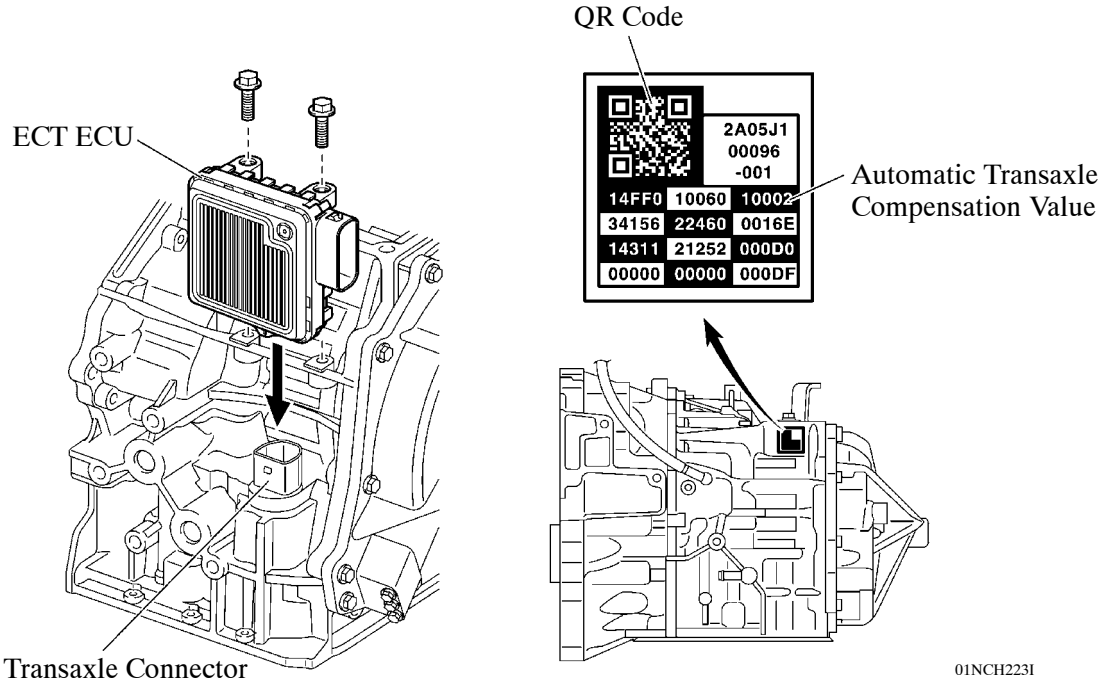


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4. Construction and Operation of Main Components

ECT ECU

- The ECT ECU has been isolated from the ECM and directly fitted to the transaxle. Because of this, the wiring harness has been shortened, allowing weight to be reduced. All the solenoid valves and sensors used for automatic transaxle control are directly connected to the ECT ECU through the connector located in front of the automatic transaxle.
- The ECT ECU maintains communication with the ECM through the Controller Area Network (CAN). Thus, engine control can be performed in coordination with ECT control.
- A label, on which the automatic transaxle compensation values and Quick Response (QR) code are printed, is attached on the top of the automatic transaxle. The label contains encoded information about the characteristics of the automatic transaxle. When the automatic transaxle is replaced, allow the ECT ECU to learn the characteristics of the automatic transaxle by inputting the automatic transaxle compensation values into the ECT ECU using the intelligent tester II. In this way, the shift control performance is improved immediately after replacement of the automatic transaxle. For details, refer to the TOYOTA RAV4 Repair Manual.
- The QR code, which requires a special tool to read, is used at the vehicle assembly plant.



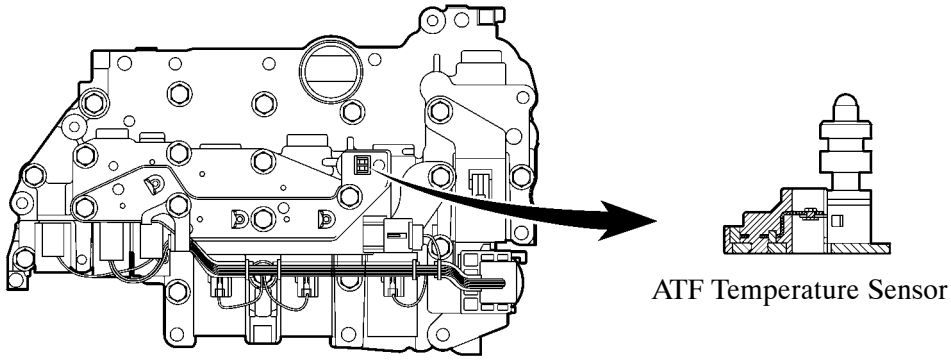
— REFERENCE —

What are QR Codes?

- *QR code, a matrix symbology consisting of an array of nominally square cells, allows omni-directional, high-speed reading of large amounts of data.*
- *QR codes encode many types of data such as numeric, alphanumeric, kanji, kana and binary codes. A maximum of 7089 characters (numeric) can be encoded.*
- *QR codes (2D code) contain information in the vertical and horizontal directions, whereas bar codes only contain data in one direction. QR codes (2D code) hold considerably greater volumes of information than bar codes.*

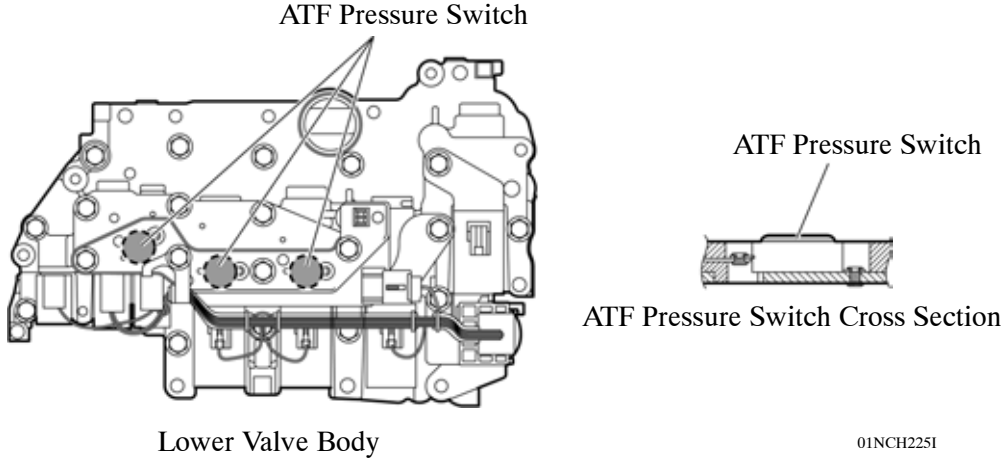
ATF Temperature Sensor

- The ATF temperature sensor is installed in the valve body assembly for direct detection of the fluid temperature.
- The ATF temperature sensor is used for hydraulic pressure control. This sensor is used for fine-tuning the pressure used to apply clutches and brakes in the transaxle. This helps to ensure smooth shift quality.



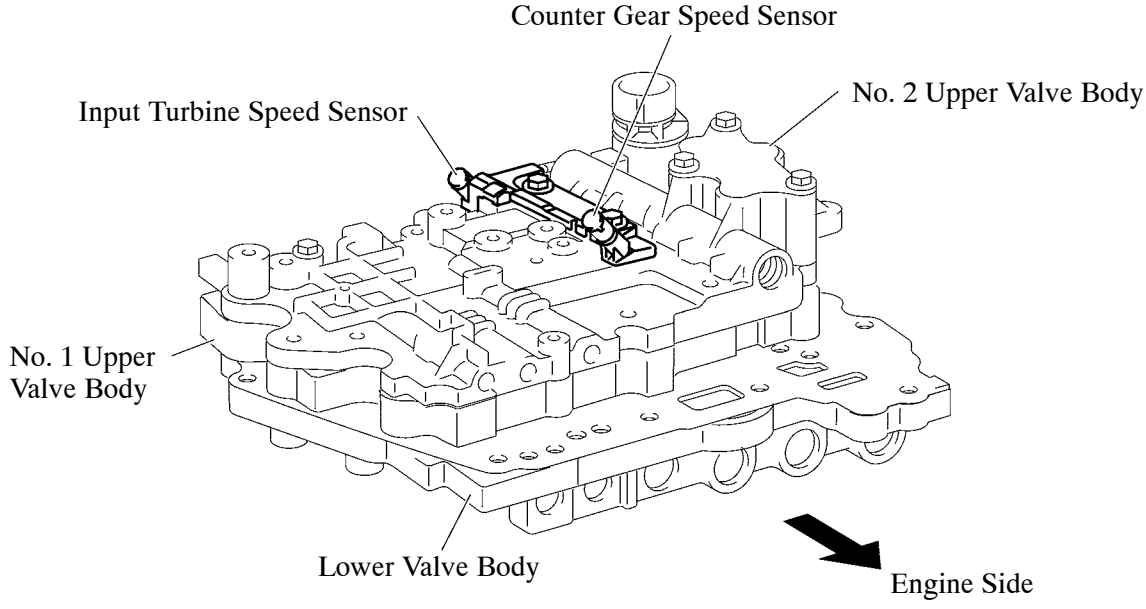
ATF Pressure Switch

- The ATF pressure switches are located in the output fluid passages of shift solenoid valves SL1, SL2 and SLU, and they turn on and off in accordance with the output fluid pressure of shift solenoid valves SL1, SL2 and SLU.
- The ECT ECU detects malfunctions in shift solenoid valves SLU and SL used in lock-up control in accordance with the on or off signals from ATF pressure switch 3 located in the SLU output fluid passage.
- When any shift solenoid valve from SL1 to SL4 malfunctions, the ECT ECU determines the appropriate fail-safe operation in accordance with the on or off signals from ATF pressure switches 1 and 2 located in the SL1 and SL2 output fluid passages.



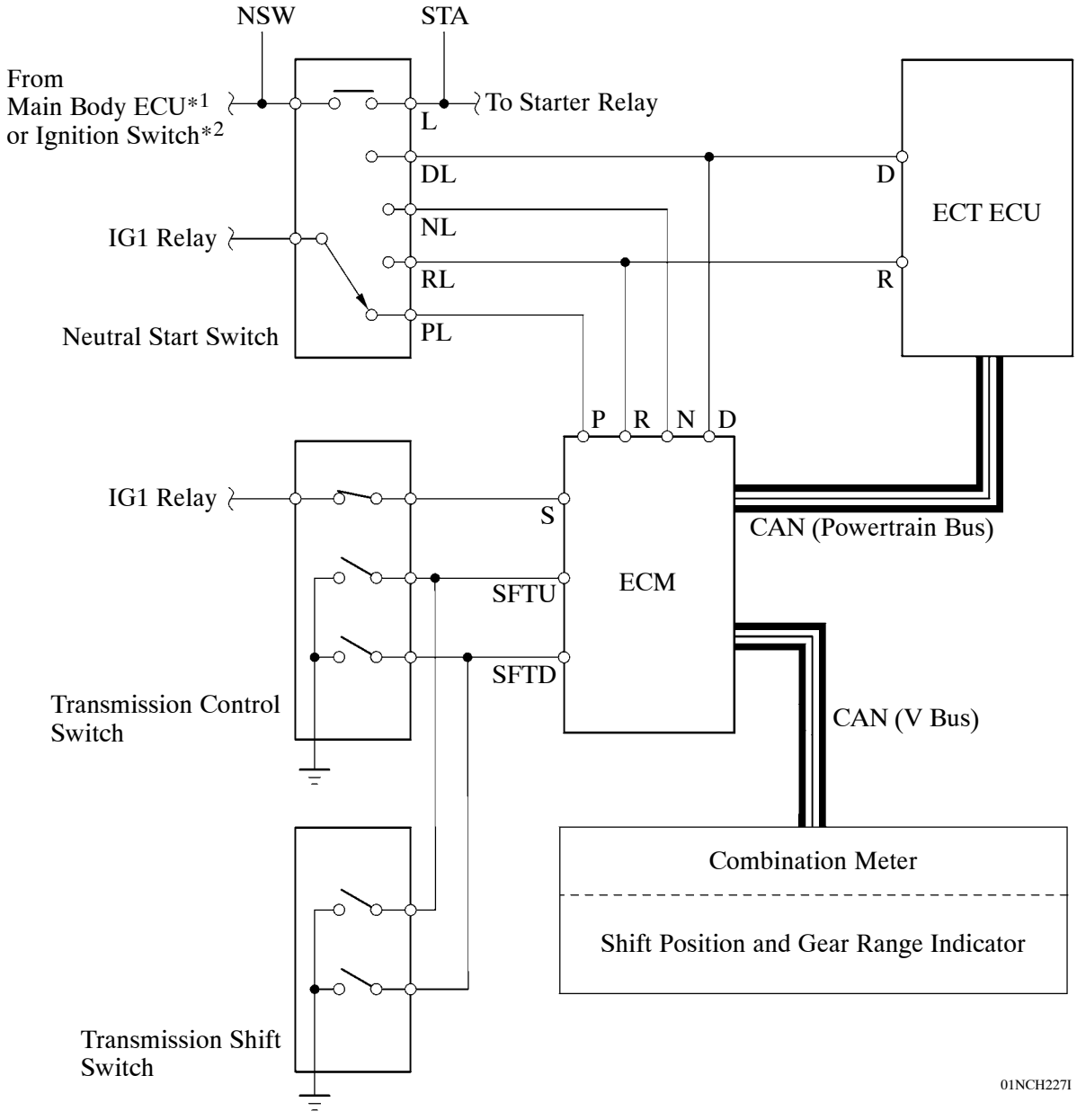
Speed Sensors

- The U660F automatic transaxle uses an input turbine speed sensor (for the NT signal) and a counter gear speed sensor (for the NC signal). Using these, the ECT ECU can determine the timing of the shifting of the gears and appropriately control the engine torque and hydraulic pressure in response to the various conditions.
- The input turbine speed sensor detects the input speed of the transaxle. The No. 2 clutch piston is used as the timing rotor for this sensor.
- The counter gear speed sensor detects the speed of the counter gear. The counter drive gear is used as the timing rotor for this sensor.
- A Hall type speed sensor consists of a magnet and a Hall IC. The Hall IC converts the changes in the magnetic flux density that occur through the rotation of the timing rotor into an electric signal, and outputs the signal to the ECT ECU.



Neutral Start Switch, Transmission Control Switch and Transmission Shift Switch

- The ECT ECU and ECM use the neutral start switch and transmission control switch to detect the shift lever position.
- The neutral start switch sends R and D signals to both the ECT ECU and ECM, and sends P and N signals to the ECM only.
- The transmission control switch is installed inside the shift lever assembly to inform the ECM of the shift lever position.
- The transmission shift switch is installed in the steering wheel. The ECM detects the operation of the transmission shift switches "+" (upshift) or "–" (downshift) when the shift lever is in D or M.

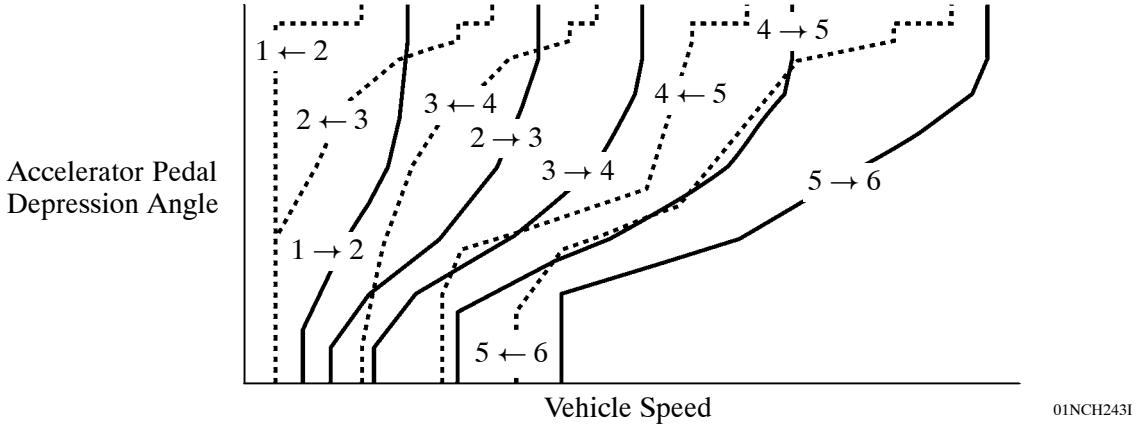


*1: Models with entry and start system
*2: Models without entry and start system

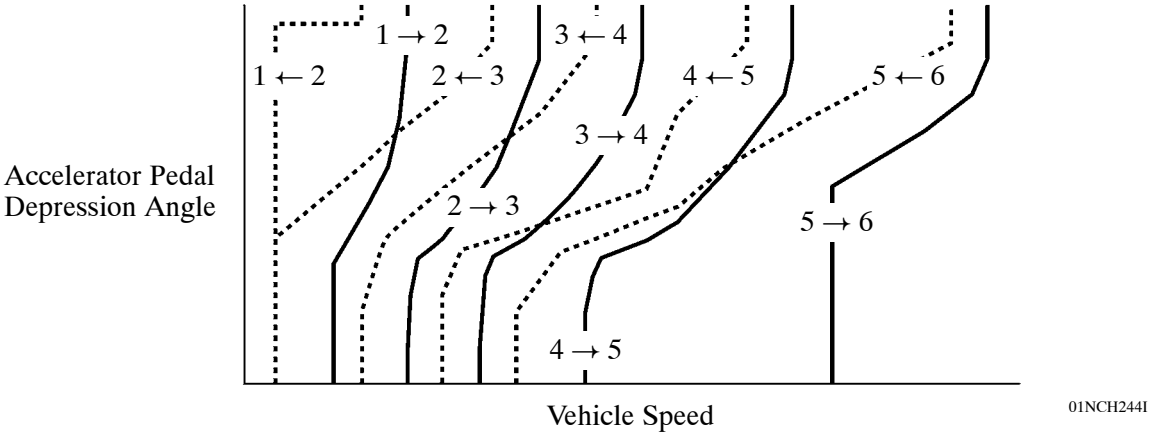
Pattern Select Switch

- The driver can select 2 different settings for shift schedule and AI-shift control.
- When the pattern select switch is on (SPORT mode), a more aggressive shift schedule and AI-shift tuning is selected for sporty driving.

▶ Normal Mode Shift Pattern ◀

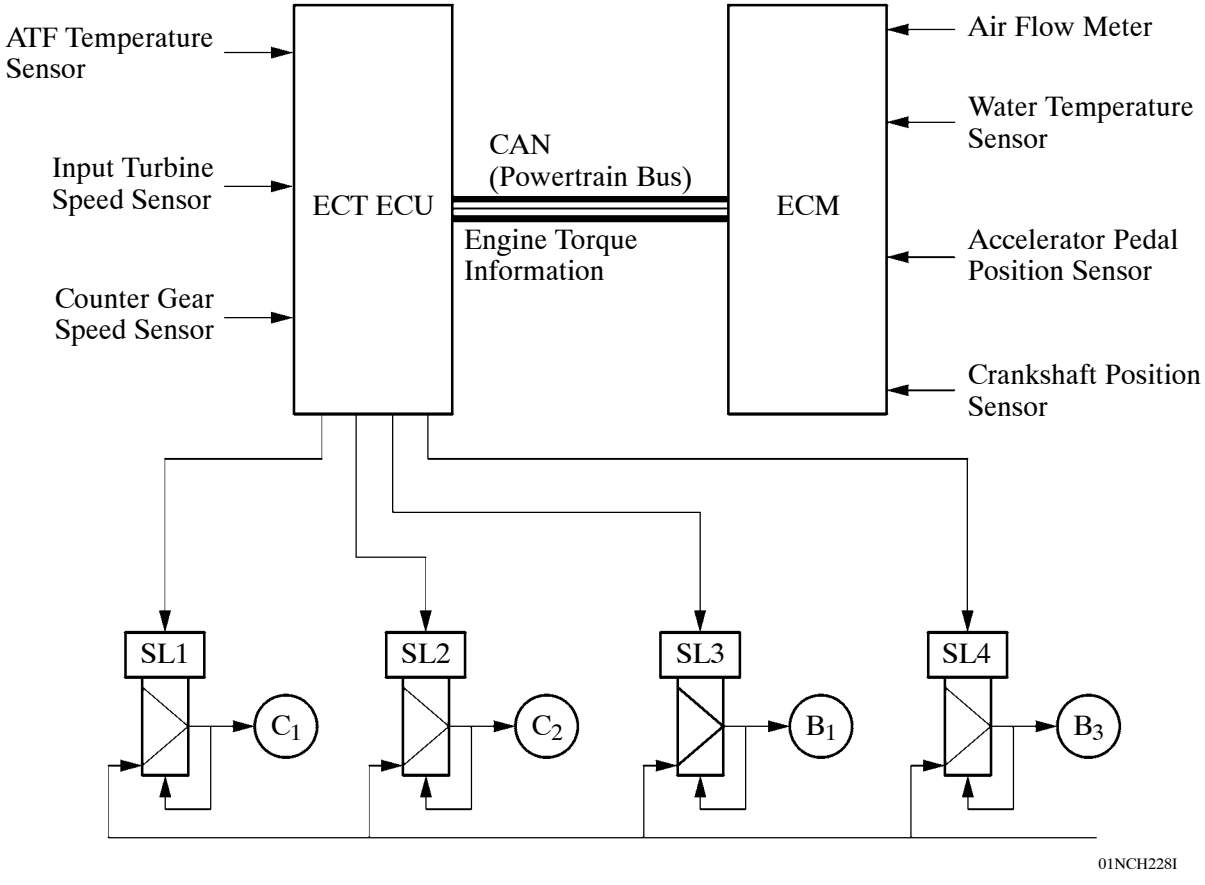


▶ SPORT Mode Shift Pattern ◀



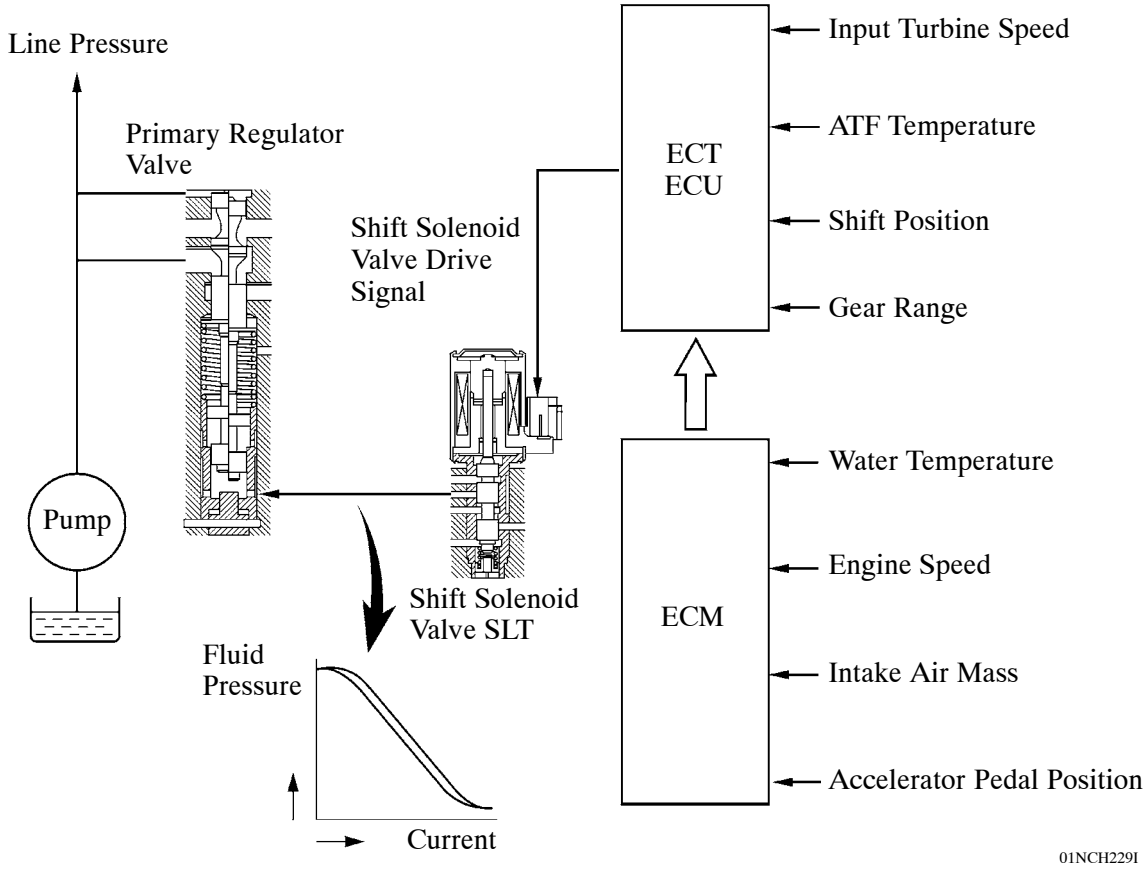
5. Clutch to Clutch Pressure Control

- The clutch to clutch pressure control is used for shift control. As a result, shift control in 2nd gear or above can be performed without using a 1-way clutch, making the automatic transaxle lightweight and compact.
- Based on the information about transaxle input and output speed, engine torque and other items, the ECT ECU controls each clutch and brake in accordance with the optimum fluid pressure and timing, in order to shift the gears. The ECT ECU changes gears using fluid pressure circuits which enable the No. 1 clutch (C_1), No. 2 clutch (C_2), No. 1 brake (B_1) and No. 3 brake (B_3) to be controlled independently, and using high flow SL1, SL2, SL3 and SL4 shift solenoid valves which directly control the line pressure. As a result, highly responsive and excellent shift characteristics have been achieved.



6. Line Pressure Optimal Control

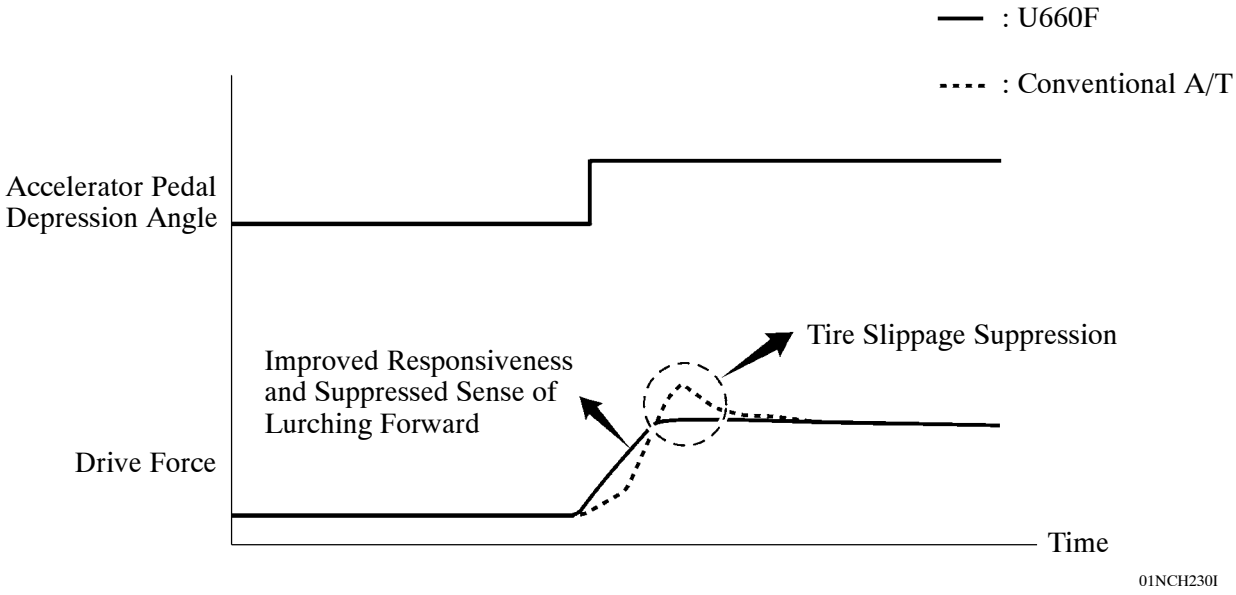
- The line pressure is controlled using shift solenoid valve SLT.
- Through the use of shift solenoid valve SLT, the line pressure is optimally controlled in accordance with the engine torque information, as well as with the internal operating conditions of the torque converter and the transaxle.
- Accordingly, the line pressure can be accurately controlled 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. Powertrain Cooperative Control

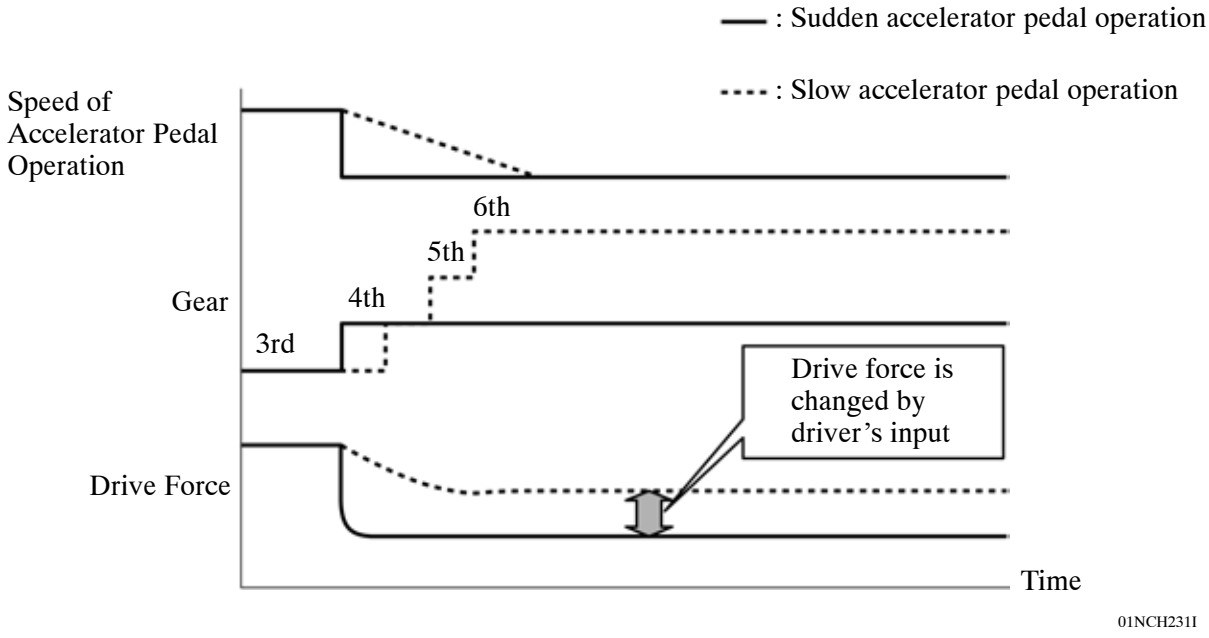
Throttle Control at Starting

The engine output is optimally controlled using the fuel injection volume control in real time and in accordance with the transient force from the torque converter when the vehicle is launched. This achieves a suppressed sense of lurching forward, tire slippage suppression and improved responsiveness, ensuring excellent launch performance.



Deceleration Force Control

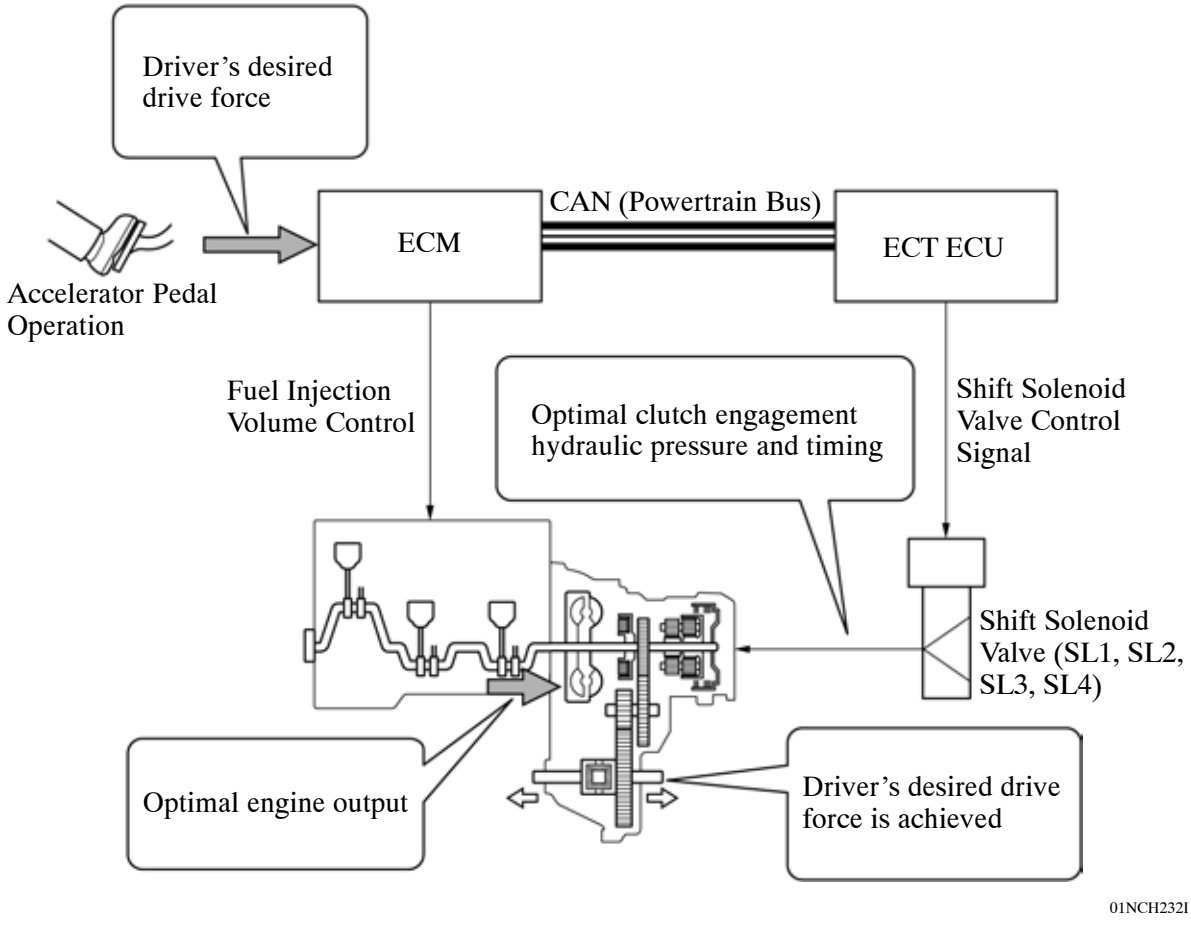
The ECT ECU determines the gear that is to be selected when the accelerator pedal is released (released completely) in accordance with the way the accelerator pedal is released (suddenly or slowly) during deceleration. In this way, unnecessary upshifts are prevented during deceleration, matching the driver's intentions. In addition, unintended downshifts are prevented when accelerating the vehicle again, achieving smooth acceleration.



Transient Shifting Control

Quick response and shift shock reduction have been achieved through a cooperative control with the following controls:

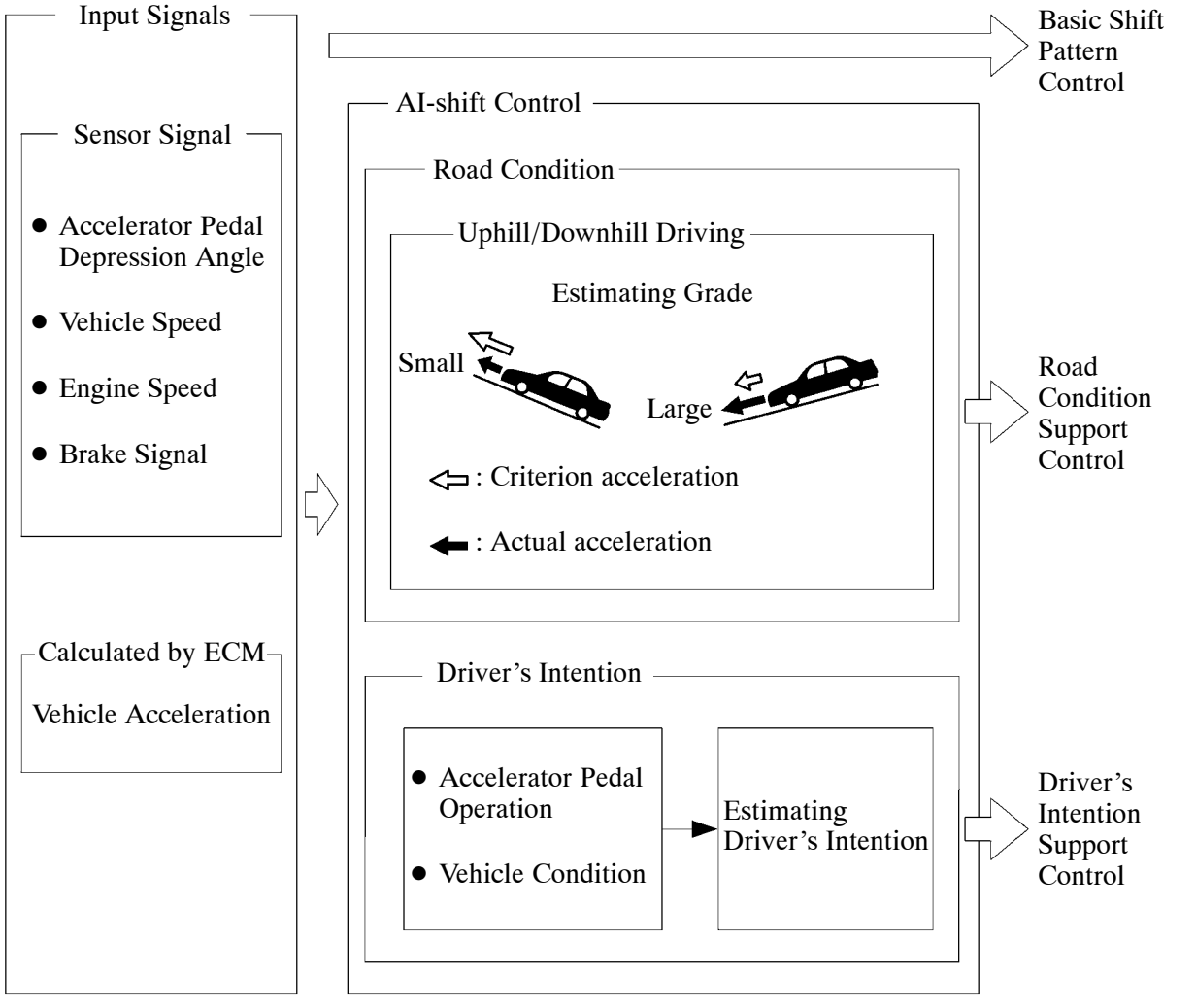
- Fuel injection volume control
- Electronic control of the engagement and release speed of the clutch and brake hydraulic pressures



8. Artificial Intelligence Shift Control (AI-shift Control)

General

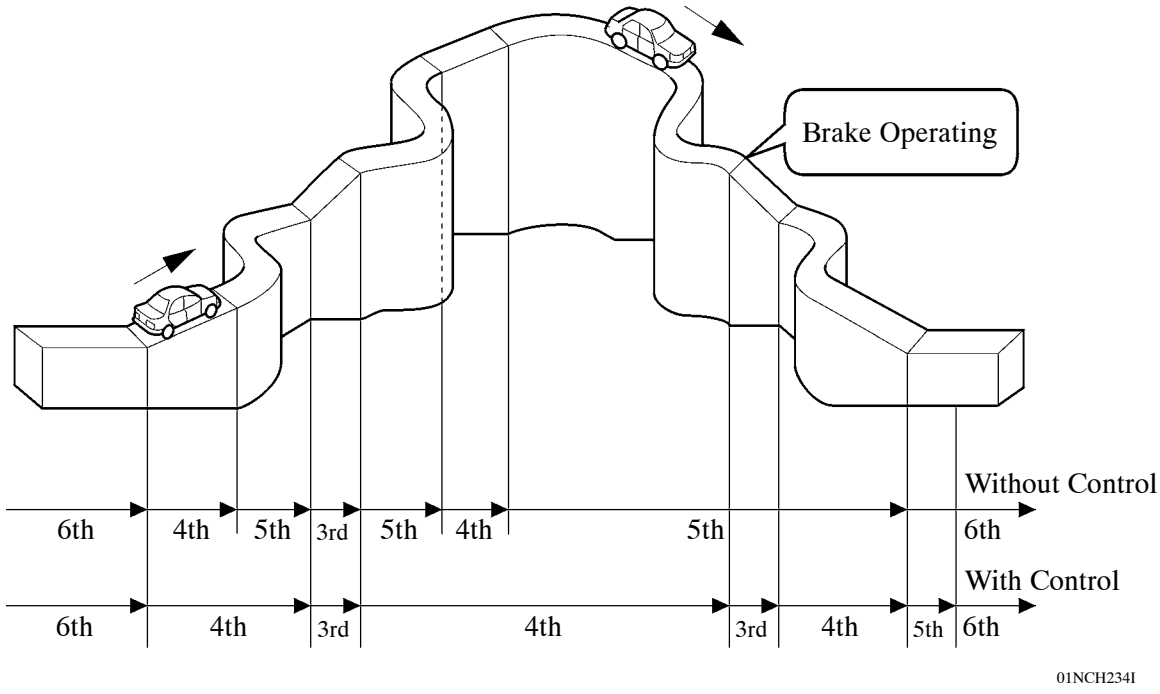
- The automatic transaxle gear is determined by the shift pattern, which uses the vehicle speed and acceleration pedal depression angle.
- Additionally, AI-shift control enables the ECT ECU to estimate the road conditions and the driver's intention in order to automatically control the shift pattern in the optimal manner. As a result, a comfortable ride has been achieved.
- The AI-shift control includes road condition support control and driver's intention support control.
- The AI-shift control determines optimal transaxle control based on input signals and automatically changes the shift pattern.



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Road Condition Support Control

Under road condition support control, the ECT ECU determines from the accelerator pedal depressing angle and the vehicle speed whether the vehicle is being driven uphill or downhill. To achieve the optimal drive force while driving uphill, this control prevents unnecessary upshifts. To achieve the optimal engine brake effect while driving downhill, this control automatically performs downshifts.

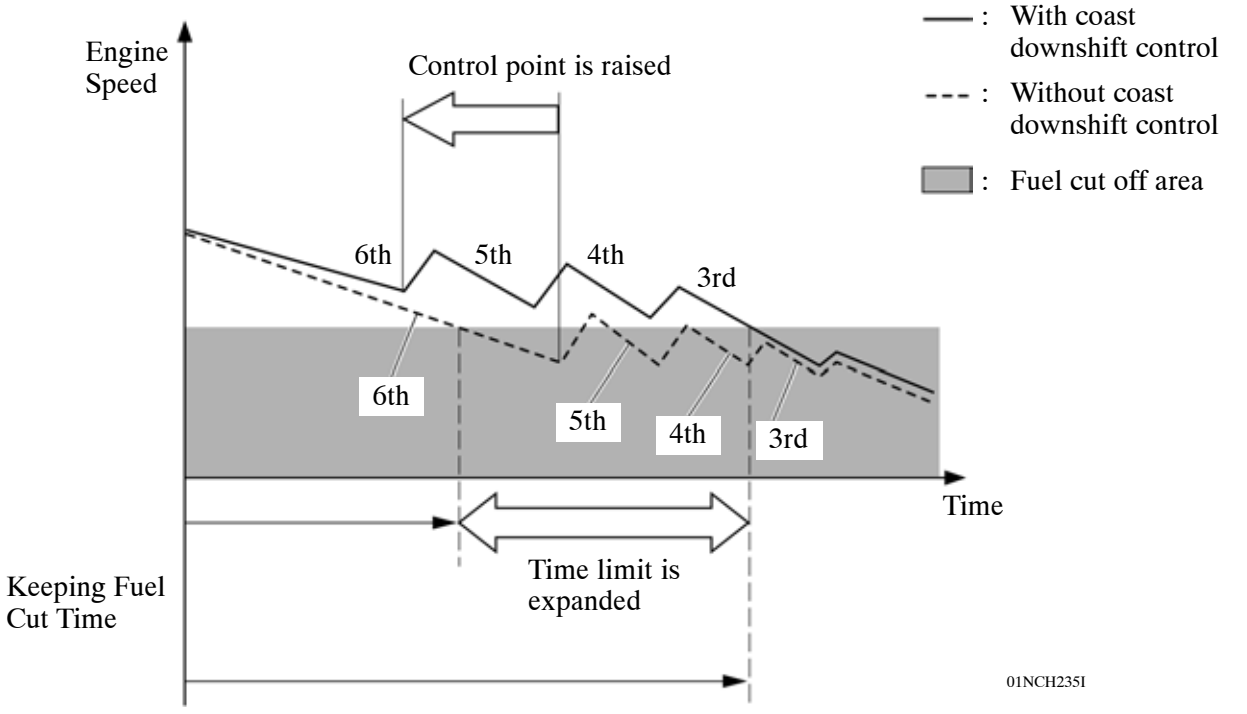


Driver's Intention Support Control

The driver's intention is estimated based on the accelerator pedal depressing angle and vehicle condition to switch to a shift pattern that is well-suited to the driver.

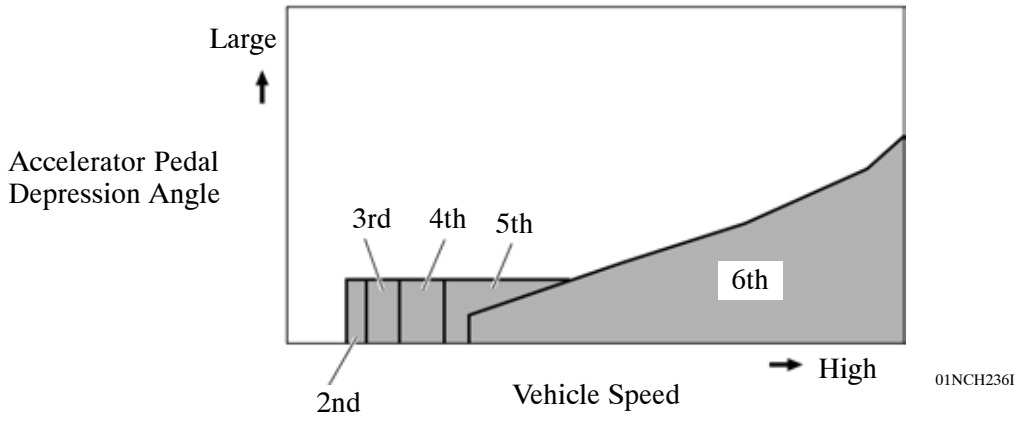
9. Coast Downshift Control

- The ECT ECU performs downshift control to help prevent the engine speed from decreasing, thus keeping fuel cut control operating for as long as possible. In this way, fuel economy is improved.
- For this control, when the vehicle is in 6th gear and starts decelerating, the transaxle downshifts from 6th to 5th, 5th to 4th and 4th to 3rd before fuel cut control ends so that the fuel cut control can continue operating.



10. Lock-up Timing Control

The ECT ECU uses lock-up timing control in order to improve the fuel consumption performance in 2nd or higher when the shift lever is in D or M, or when D6, D5, D4, D3 or D2 range has been selected.



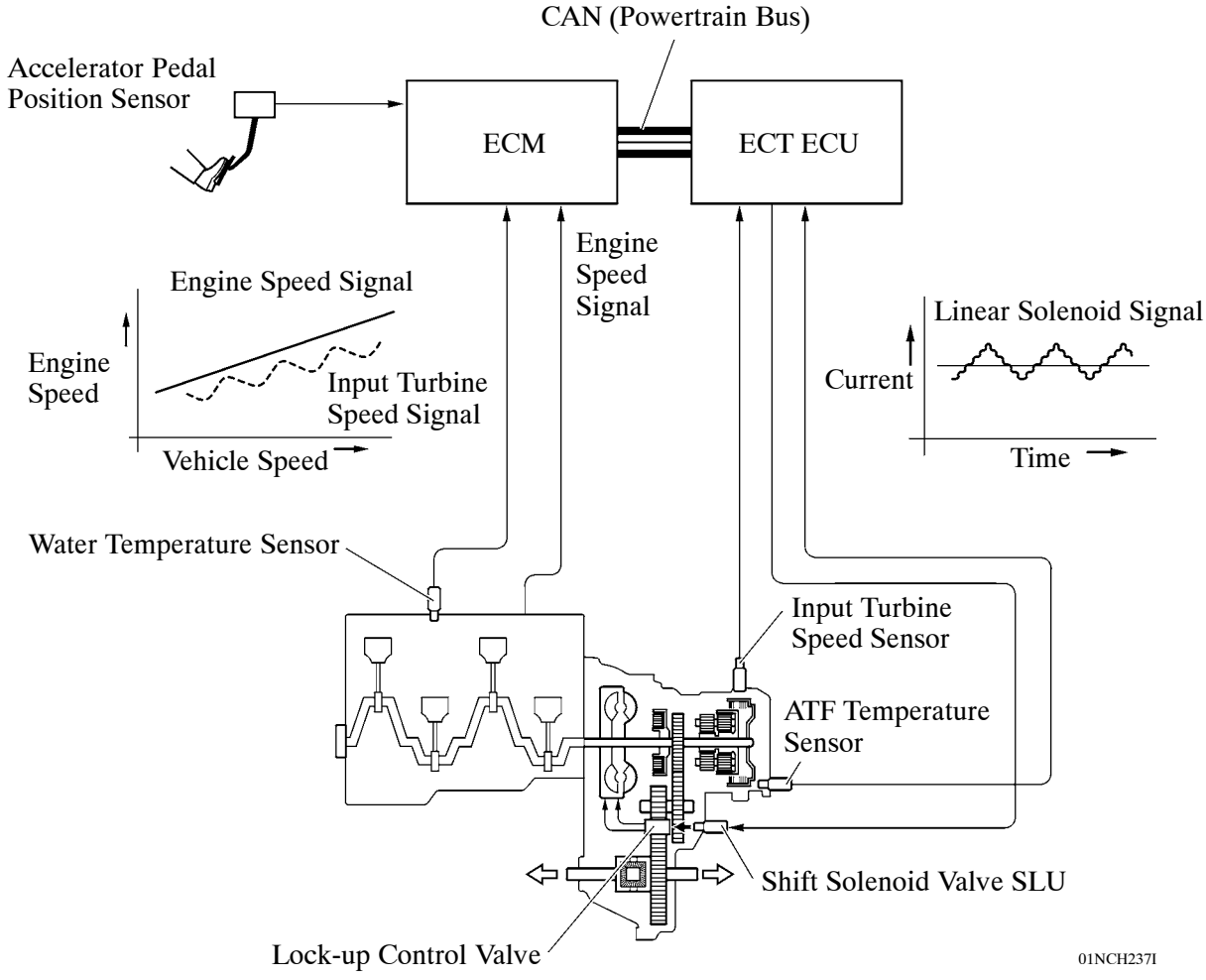
▶ Lock-up Timing Control Operation ◀

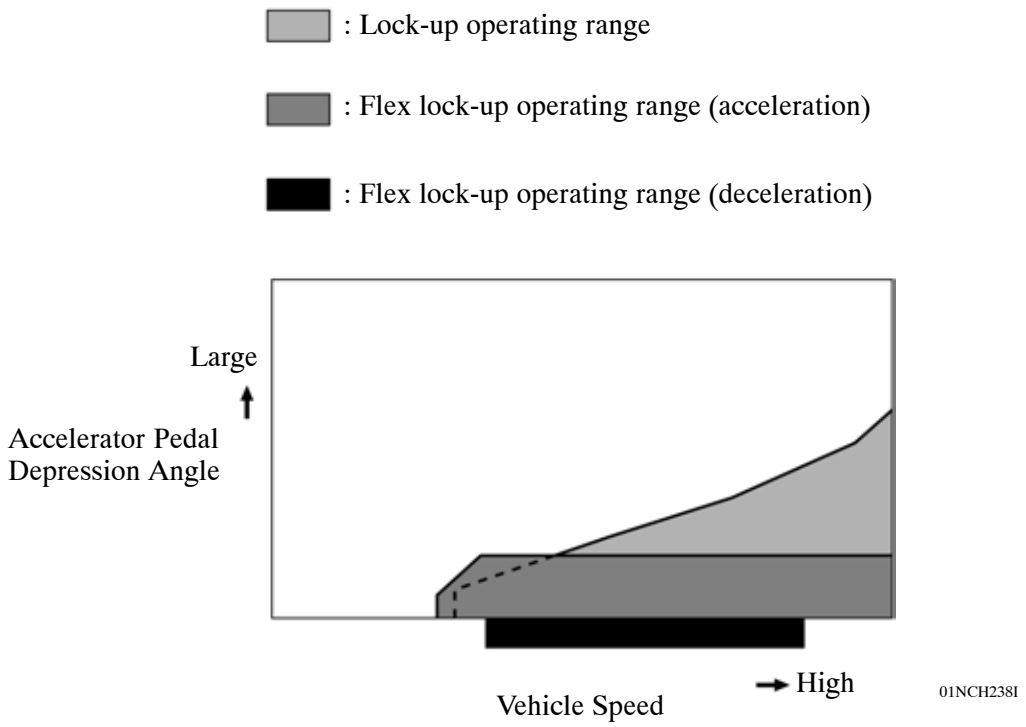
○: Available ×: Not available

Gear	Shift Lever Position						
	D	D (Transmission Shift Switch Operation)					M
		D6	D5	D4	D3	D2	
1st	×	×	×	×	×	×	×
2nd	○	○	○	○	○	○	○
3rd	○	○	○	○	○	—	○
4th	○	○	○	○	—	—	○
5th	○	○	○	—	—	—	○
6th	○	○	—	—	—	—	○

11. Flex Lock-up Clutch Control

- During acceleration, the partial control of the power transmission between the lock-up clutch and torque converter greatly boosts the transmission efficiency in accordance with the driving conditions, improving the fuel economy.
- Even when the vehicle is decelerating (the accelerator pedal is released), flex lock-up clutch control operates. Therefore, the fuel cut area has been expanded and fuel economy has been improved.
- By allowing flex lock-up clutch control to continue operating during gearshifts, smooth torque transmission is achieved. As a result, fuel economy and driveability have been improved.
- For flex lock-up control, H infinity (H∞) control theory is used to achieve a high level of system stability and response to various characteristic changes.





▶ Flex Lock-up Clutch Control Operation ◀

○: Available ×: Not available

Gear	Shift Lever Position					
	D	D (Transmission Shift Switch Operation)				
		D6	D5	D4	D3	D2
1st	×	×	×	×	×	×
2nd	○	○	○	○	○	○
3rd	○*1	○*1	○*1	○*1	○	—
4th	○*2	○*2	○*2	○*2	—	—
5th	○*2	○*2	○*2	—	—	—
6th	○*2	○*2	—	—	—	—

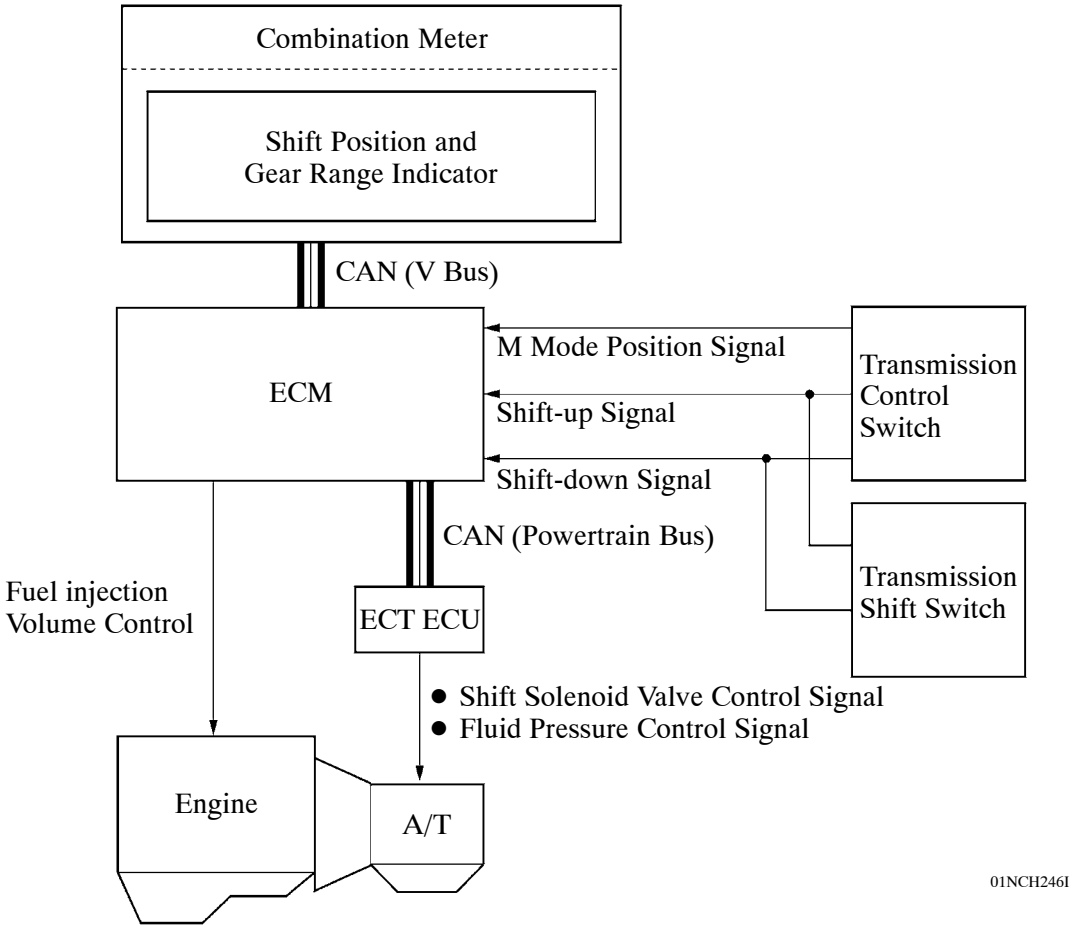
*1: Flex lock-up clutch control operates during deceleration only by coast downshift from 4th gear with deceleration flex lock-up.

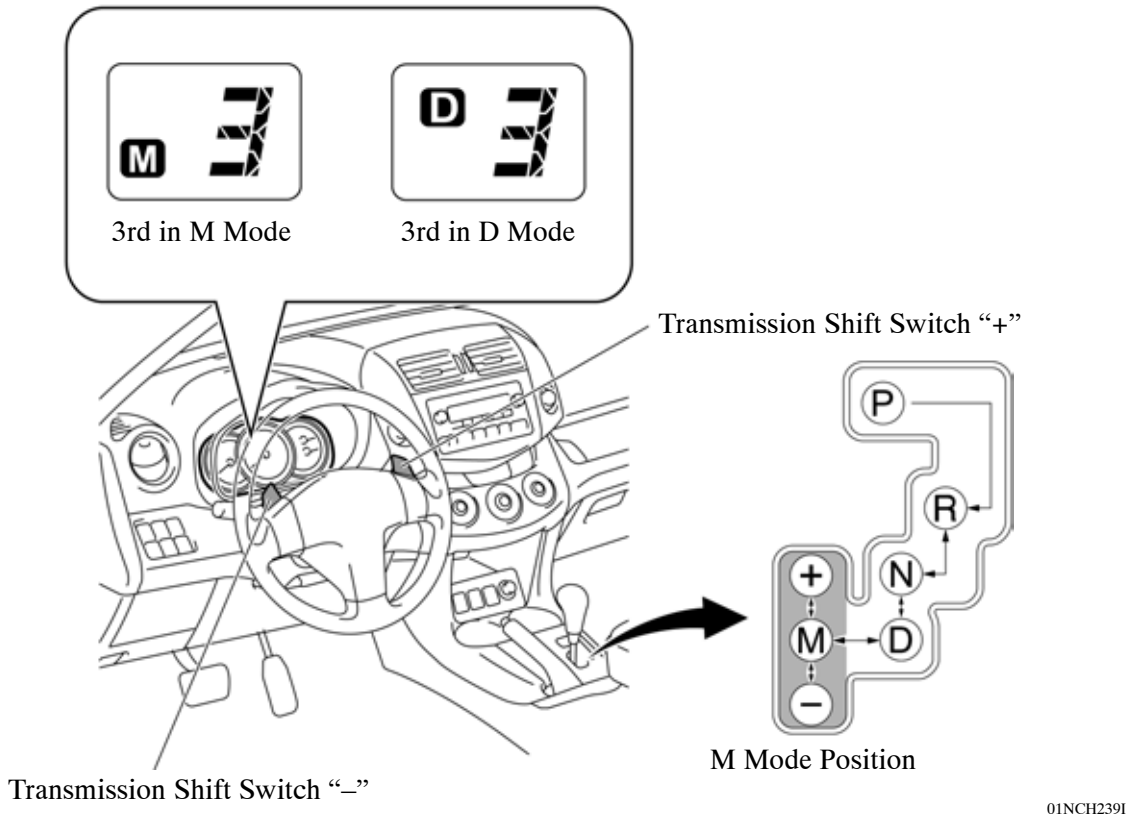
*2: Flex lock-up clutch control also operates during deceleration.

12. Multi-mode Automatic Transmission (with Transmission Shift Switch)

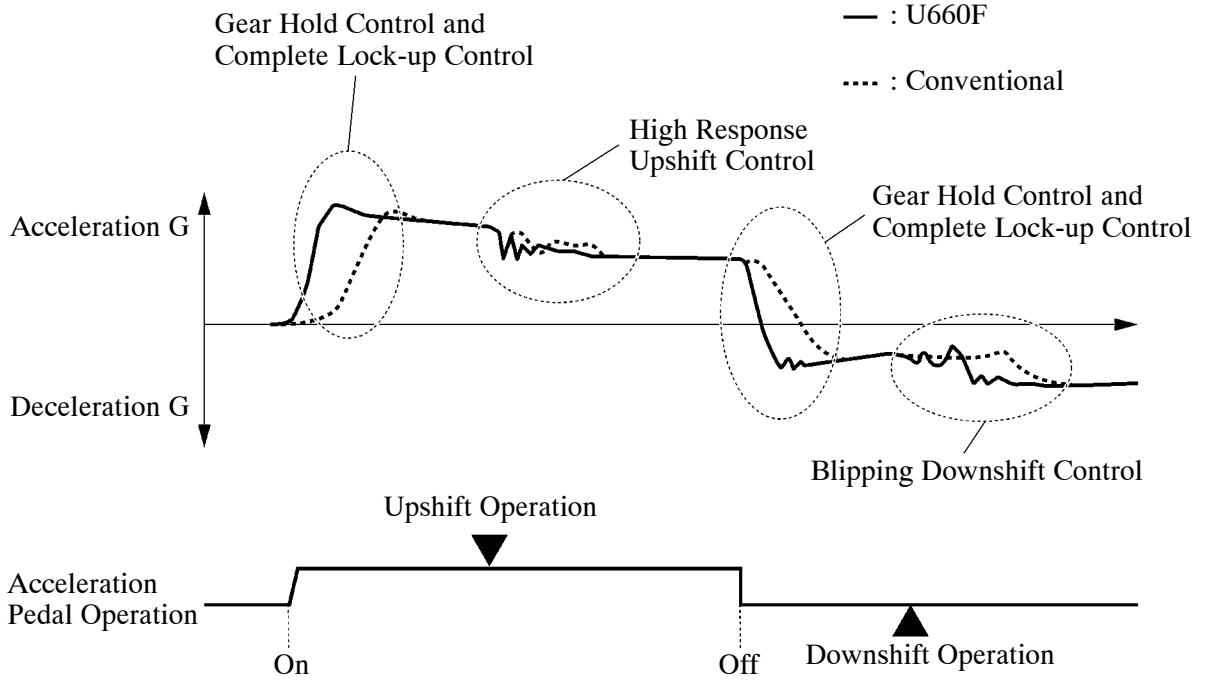
- The driver can select the desired gear range by moving the shift lever to "+" (forwards) or to "–" (backwards) while the shift lever is in M (M mode). Also, the transmission shift switch can be used to change the gear range while the driver is holding the steering wheel. Thus, the driver is able to shift gears with a manual-like feel.
- When the shift lever is in D (D mode), the driver can momentarily select a desired gear range by operating the transmission shift switch. Automatic shifting (D mode) will be reinstated under the following conditions:
  - The vehicle has stopped.
  - The driver continues to push the transmission shift switch in the "+" direction longer than 1 second.
  - The driver depresses the accelerator pedal longer than a predetermined length of time.
- When the vehicle is being driven at a speed that is higher than the maximum safe speed for a downshift, any attempt to shift to a lower range by operating the shift lever will not be performed. This is done in order to protect the automatic transaxle. In this case, the ECM sounds the buzzer in the combination meter twice to alert the driver.

▶ System Diagram ◀





- In M mode, the gear hold control, complete lock-up control, high response upshift control and blipping downshift control are used in order to improve response in accordance with the driver's operation of the accelerator pedal, shift lever, or transmission shift switch, and to improve gear shift feeling.

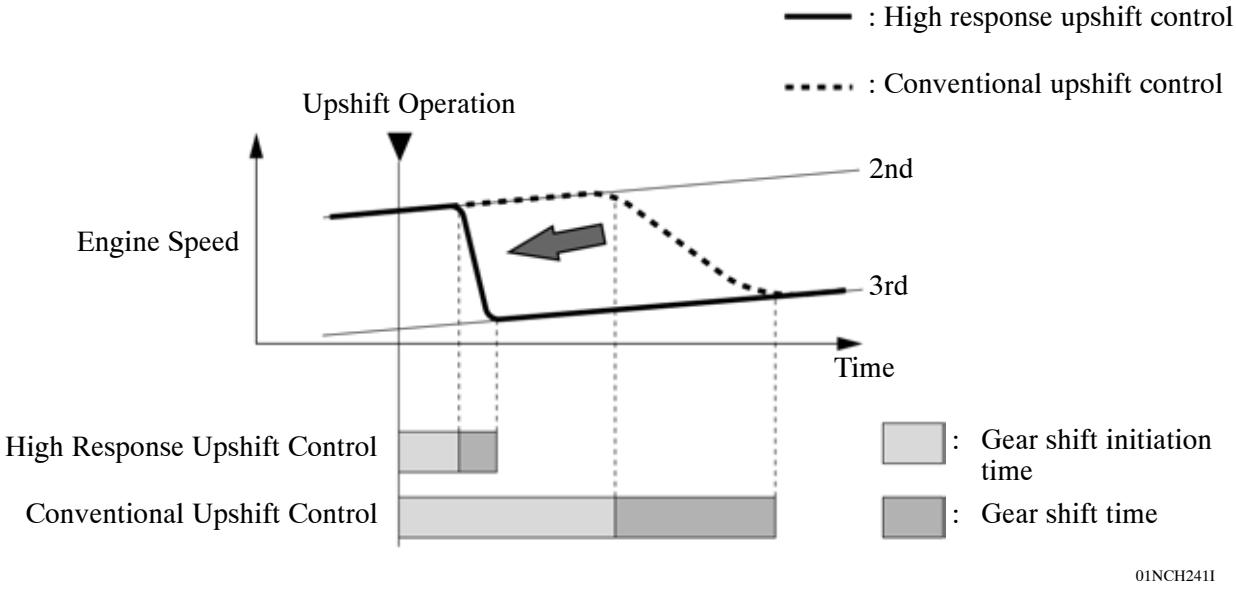


Gear Hold Control

The gear shifting will not be performed under gear hold control as long as the shift lever or transmission shift switch is not operated. This makes it possible to make efficient use of highest engine speeds. However, if the vehicle speed is drops, a downshift will be performed from the current gear to a gear appropriate for that speed. Also, when the ATF temperature is extremely high, upshift will be performed automatically.

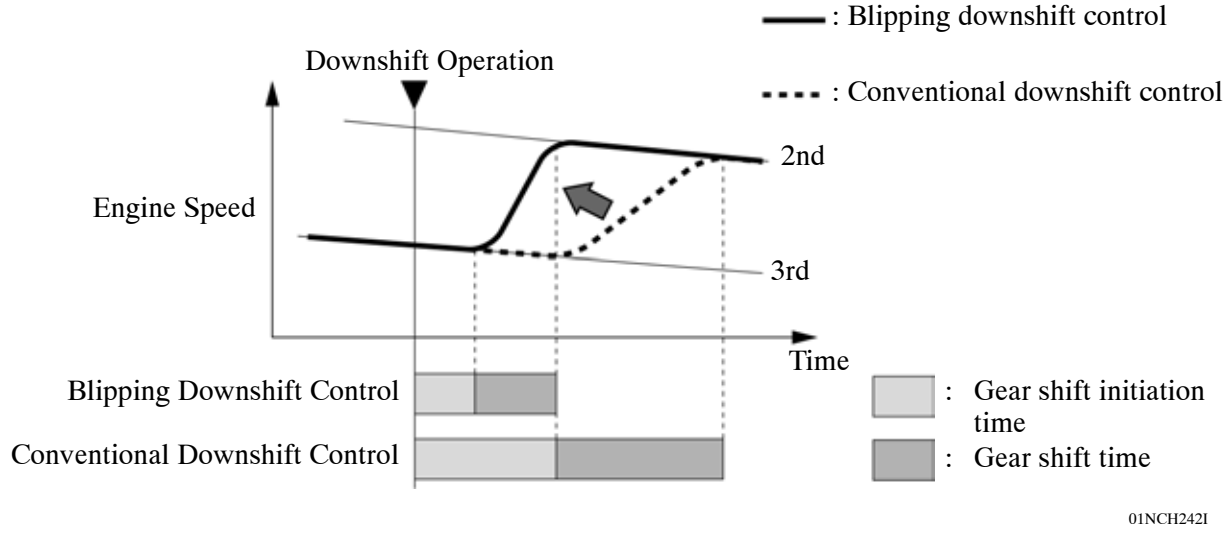
High Response Upshift Control

The high response upshift control achieves highly responsive upshift operation using the clutch to clutch pressure control, which regulates each clutch and brake quickly and precisely, and by the powertrain cooperative control, which optimally regulates engine torque during shifting.



Blipping Downshift Control

The blipping downshift control regulates each clutch and brake using the clutch to clutch pressure control, allowing them to be engaged smoothly and disengaged quickly. In addition, fuel injection volume is increased and engine speed is boosted by the powertrain cooperative control, thus ensuring engine brake force. In this way, a smooth and quick downshift is achieved.



13. Diagnosis

- When the ECT ECU detects a malfunction, the ECT ECU makes a diagnosis and memorizes the information related to the fault. Furthermore, the MIL in the combination meter illuminates or blinks to inform the driver.
- The ECT ECU will also store the Diagnostic Trouble Codes (DTCs) of the malfunctions. The DTCs can be read by connecting the intelligent tester II.
- For details, refer to the TOYOTA RAV4 Repair Manual.

14. Fail-safe

- The fail-safe function minimizes the loss of operability when any abnormality occurs in a sensor or a shift solenoid valve.
- For details, refer to the TOYOTA RAV4 Repair Manual.