## ■ ELECTRONIC CONTROL SYSTEM

### 1. General

The 441E automatic transmission is an ECT (Electronically Controlled Transmission) in which the gear shift timing and lock-up timing are controlled accurately by an ECU according to the vehicle driving conditions and engine operating conditions as detected by various sensors. In order to maintain good driveability, optimal control of the transmission system by the ECU supresses vehicle shifting shock. In addition, the A441E automatic transmission has a self-diagnosis function which diagnoses and warns when a malfunction occurs in the electronically controlled components, and a fail-safe which enables continuous vehicle running even when a malfunction has occurred. The electronic control system for the A441E automatic transmission has the following functions:

#### Shift Timing Control

Current flows to the No.1 and/or No.2 (shift control) solenoid valve(s) according to the vehicle speed and throttle valve opening angle, to control gear shift timing.

#### Lock-Up Timing Control

Current flows to the No.3 (lock-up control) solenoid valve according to the vehicle speed and throttle valve opening angle, to control lock-up timing. When the gear is shifted up or down while the lock-up clutch is engaged, the lock-up clutch is disengaged momentarily. It is re-engaged when up or down gear shifting is completed to enable smooth gear shifting.

#### "N" to "D" Squat Control

When the signals from the various switches and sensors satisfy the predetermined conditions, the ECU does not shift directly to 1st gear when the transmission is shifted from the "N" to the "D" range. The transmission is first shifted momentarily to 4th gear, then to 1st gear, reducing vehicle squat.

#### Self-Diagnosis

The O/D (overdrive) OFF indicator light blinks to inform the driver (when the O/D OFF indicator light is off) if a short or open wire occurs in the following areas.

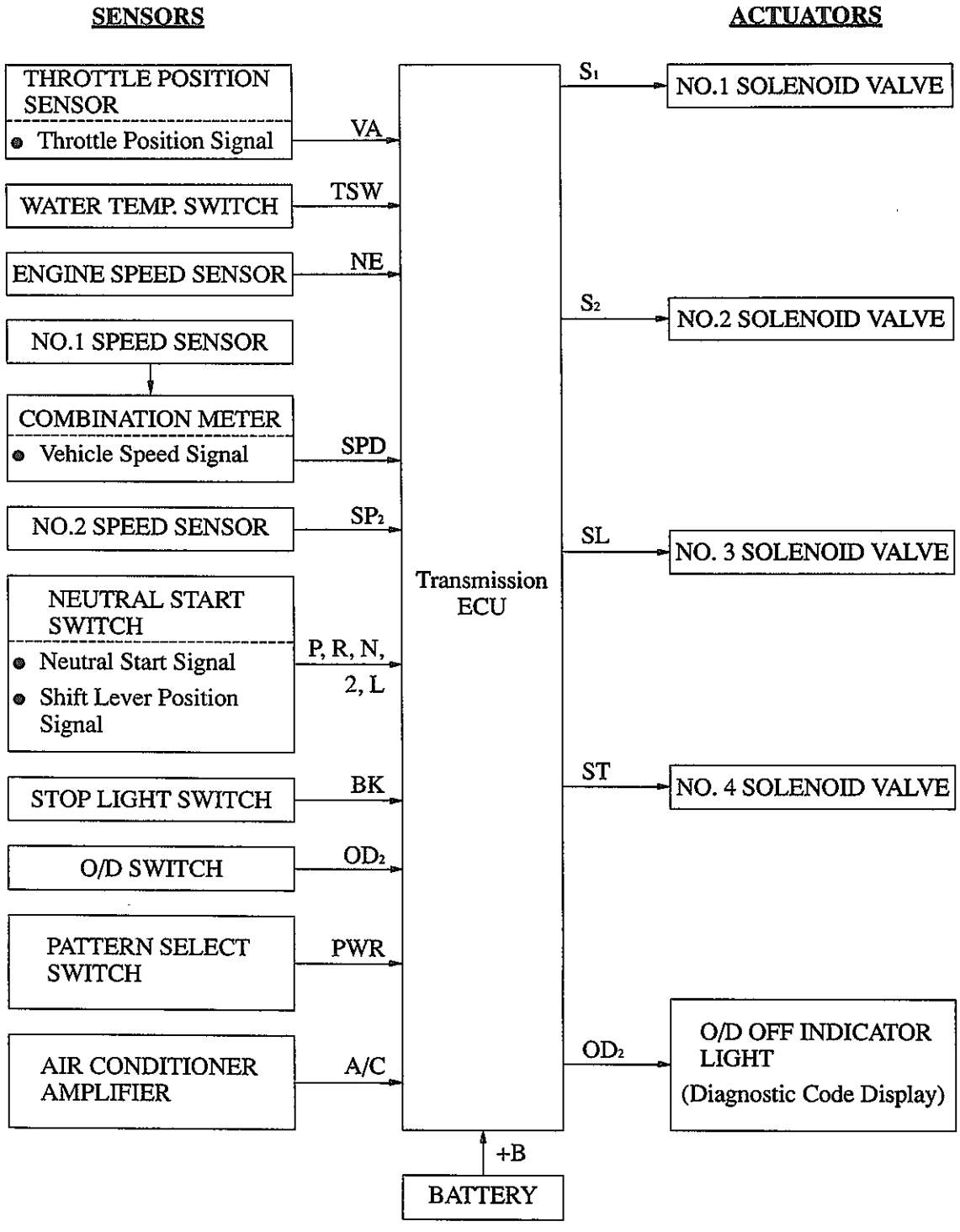
- No.1 and No.2 solenoid valves
- No.1 and No.2 speed sensors
- Throttle Position Sensor
- Engine Speed Sensor

#### Fail-Safe

A solenoid valve back-up function, speed sensor back-up function and manual operation function make driving possible even when the electrical circuit is malfunctioning.

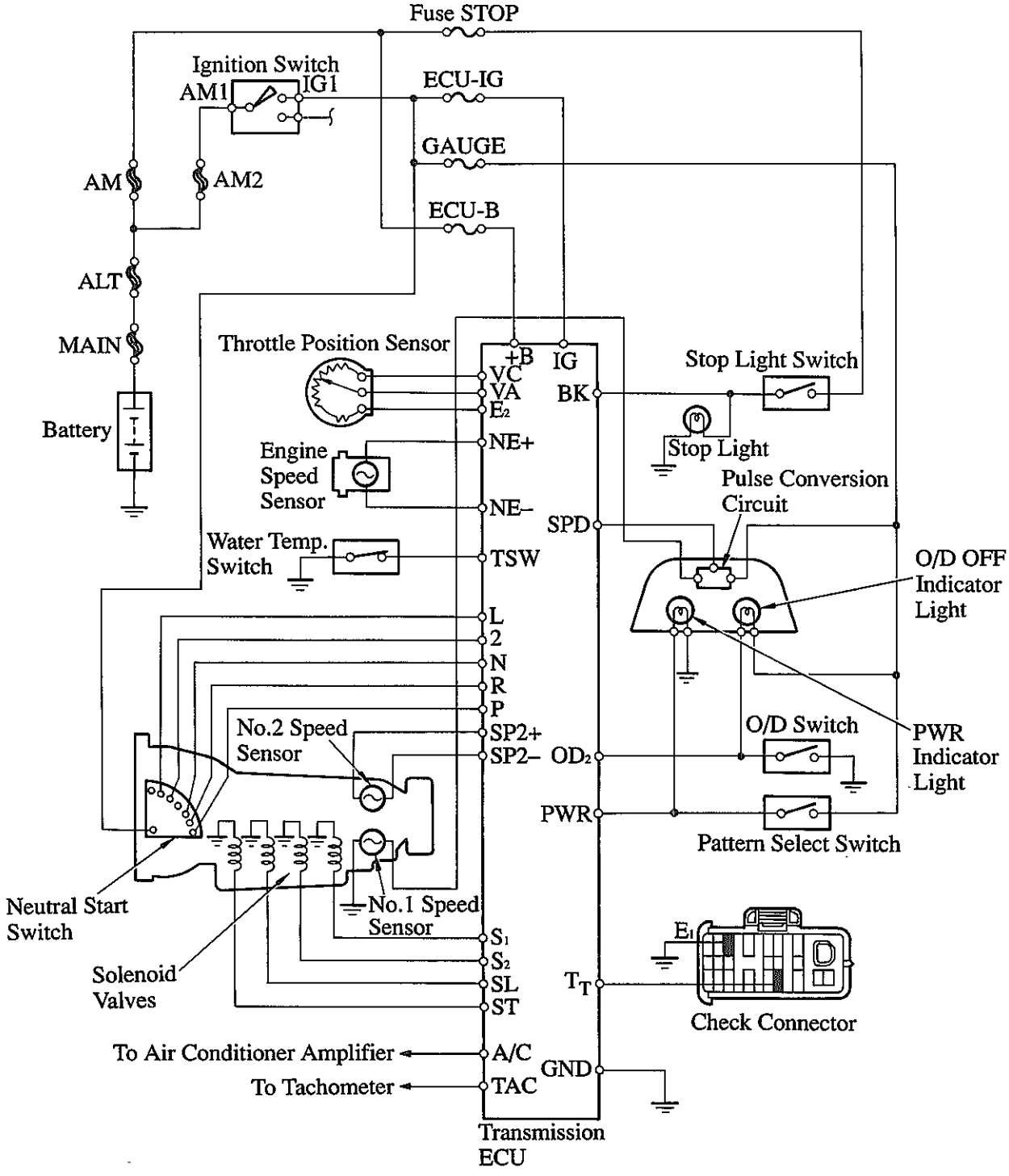
## 2. Construction

The electronic control system can be broadly divided into three groups; the sensors, ECU and actuators.

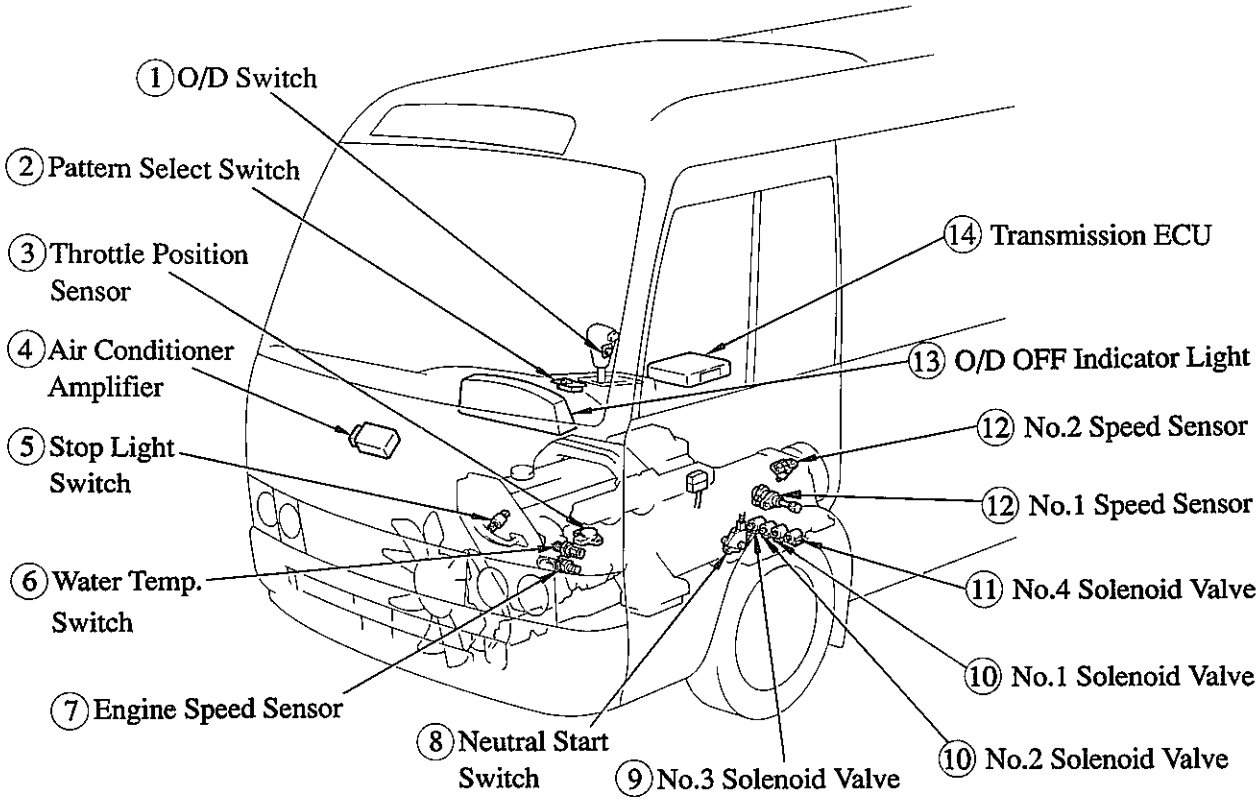



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## 3. System Diagram



## 4. Layout of Components



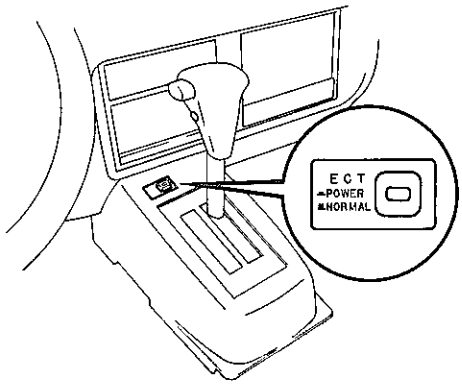

## 5. Function of Components

| No. | Components | Function |
|---|---|---|
| ① | O/D Switch | Prevents upshifting into OD if the O/D switch is off. |
| ② | Pattern Select Switch | Selects the shifting and lock-up timing by the normal mode or power mode. |
| ③ | Throttle Position Sensor | Detects the throttle valve opening angle. |
| ④ | Air Conditioner Amplifier | Detects the operation signal of the air conditioner. |
| ⑤ | Stop Light Swtich | Detects the brake pedal depression. |
| ⑥ | Water Temp. Switch | Detects the engine coolant temperature. |
| ⑦ | Engine Speed Sensor | Detects the engine speed and sends signals to the transmission ECU. |
| ⑧ | Neutral Start Switch | Detects the shift lever position. |
| ⑨ | No.3 Solenoid Valve | Controls the hydraulic pressure applied to the rear of the lock-up clutch for lock-up timing, in conformity with ECU signals. |
| ⑩ | No.1 and No.2 Solenoid Valves | Controls the hydraulic pressure applied to each shift valve, for gear shifting, in conformity with ECU signals. |
| ⑪ | No.4 Solenoid Valve | Controls the hydraulic pressure applied to each valve by way of ECU signals to regulate gear shift timing. |
| ⑫ | No.1 and No.2 Speed Sensors | Detects the vehicle speed. The No.2 speed sensor signal is ordinarily used by ECU, while the No.1 speed sensor remains as a back-up. |
| ⑬ | O/D OFF Indicator Light | Alerts the driver of a malfunction in the electronic control circuit, while the O/D indicator light is off. |
| ⑭ | Transmission ECU | Controls the transmission actuators in conformity with the signals from various sensors. |

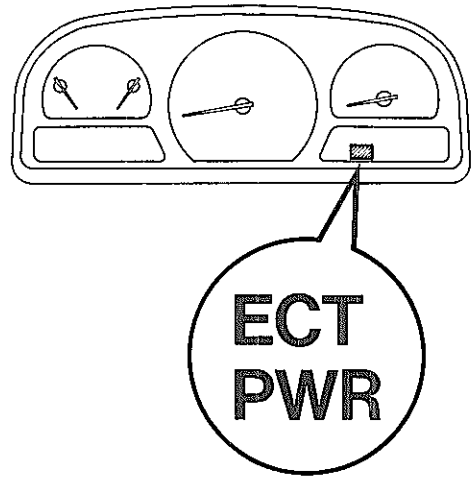
## 6. Construction and Operation of Main Components

### Driving Pattern Select Switch and Indicator Light

Two shift modes (NORMAL and POWER) are programmed in the ECU and one of these modes is selected according to a signal selected by the driving pattern select switch. The switch is located in the shift lever console. When the POWER mode is selected, an indicator light goes on inside the combination meter.



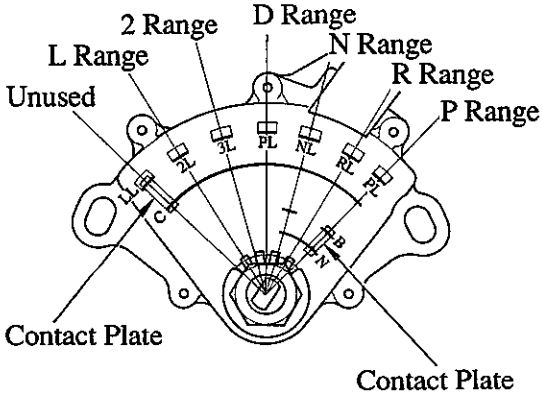

**Pattern Select Switch**




**Indicator Light**

### Neutral Start Switch

The neutral start switch outputs transmission shift lever position signals to the ECU. If one of terminals RL, NL, 3L, or 2L completes its circuit with terminal C, the ECU determines that the transmission is in the "R", "N", "2", or "L" position. When the shift lever is placed in the "P" or "N" position, terminals B and N close, and input the N signal to the ECU. If none of the terminals RL, NL, 3L, or 2L completes its circuit with the terminal C, and terminals B and N are not closed, then the ECU determines that the transmission is in the "D" position. The LL terminal is not being used for this application.



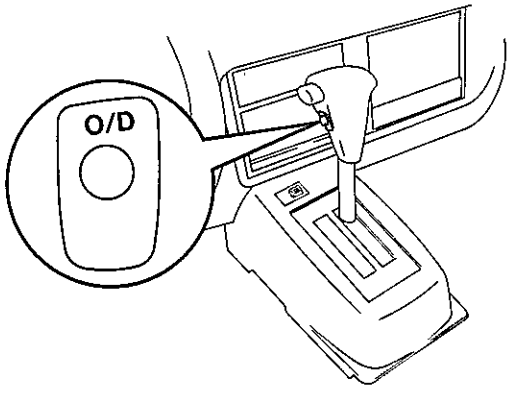

**▶ Connection of Each Contact ◀**

| Terminal / Shift Position | For Neutral Starting | | For Detection of Shift Lever Position | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | B | N | C | PL | RL | NL | DL | 3L | 2L | LL |
| P | ○—○ | | ○—○ | | | | | | | |
| R | | | ○—○ | | | | | | | |
| N | ○—○ | | ○—○ | | | | | | | |
| D | | | ○—○ | | | | | | | |
| 2 | | | ○—○ | | | | | | | |
| L | | | ○—○ | | | | | | | |
| | | | ○—○ | | | | | | | |

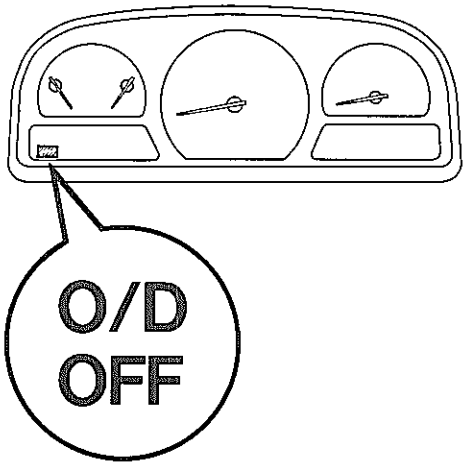
○—○ Indicates that terminals are electrically connected

## O/D (Overdrive) Switch and Indicator

The O/D switch is built into the shift lever knob. Pressing this switch causes shifting to the OD gear. Pressing it again (pushed out) prohibits shifting to the OD gear and turns on the O/D OFF indicator light on the combination meter.
The O/D OFF indicator light blinks to warn when a malfunction is detected by self-diagnosis. See page 73 for details.




O/D Switch

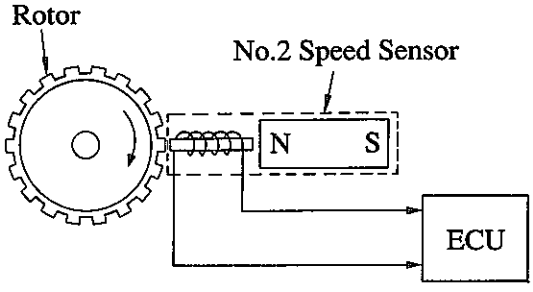


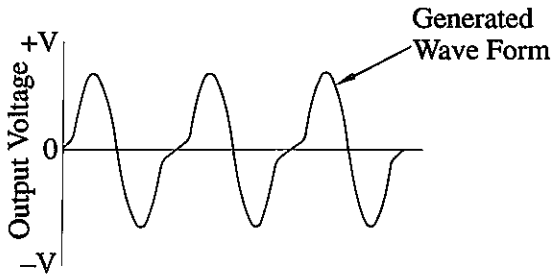

Indicator Light

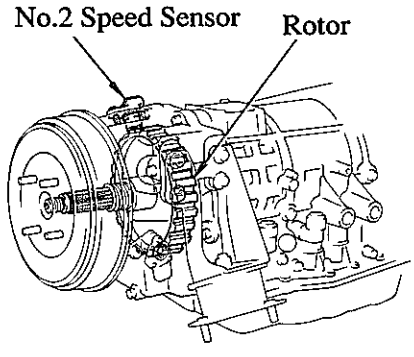


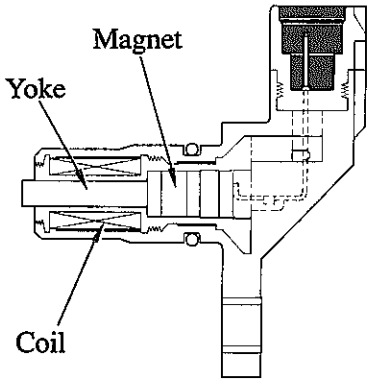
## No.2 Speed Sensor (Main Speed Sensor)

The No.2 speed sensor mounted in the transmission extension housing detects the speed of the transmission output shaft rotation. It consists of a permanent magnet, coil, and yoke. A rotor, which has eighteen teeth is attached directly onto the transmission output shaft and rotates as a unit.
While the output shaft rotates, the teeth on the rotor causes a fluctuation in the distance between the rotor and the yoke, or the front-end of the sensor. This causes the number of lines of magnetic force passing through the yoke to fluctuate also, generating AC voltage in the coil. The frequency of this AC voltage, which is proportional to the speed of the rotor, is used in calculating the vehicle speed.



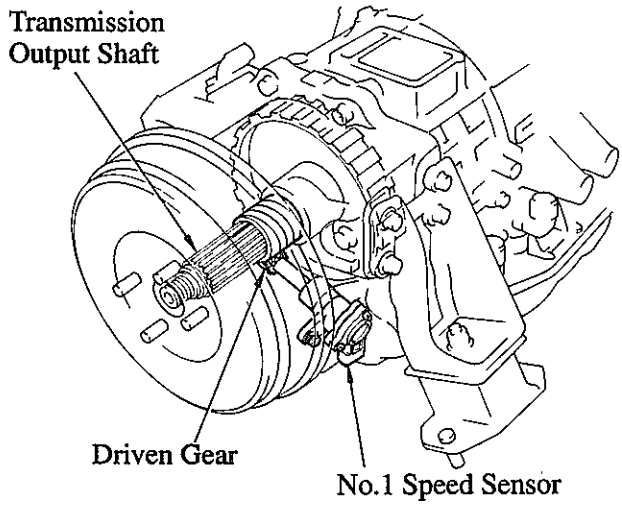



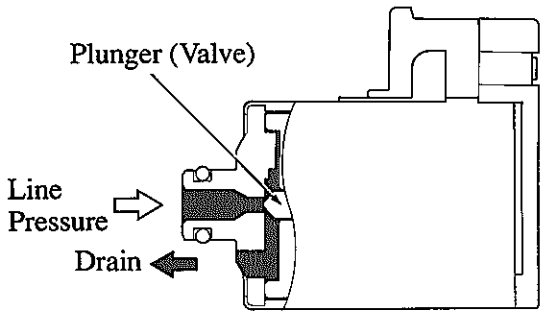
## No.1 Speed Sensor (Back-Up Sensor)

The No.1 speed sensor generates four signals per one rotation of the rotor shaft which is driven by the transmission output shaft via the driven gear. In the ECT, this sensor is used as a back-up sensor in case of malfunction of the No.2 speed sensor. For more details about this sensor, refer to the speedometer section on page 111.




## No.1 and No.2 Solenoid Valves (For Shift Control)

Nos.1 and 2 solenoid valves are fitted to the transmission valve body. The ECU controls ON-OFF combinations of these valves to control transmission gear shifting. The valve ON-OFF combination for each gear shift is shown in the table below. When the plunger is pulled to the right in the drawing below, this opens the valve and allows line pressure to drain.

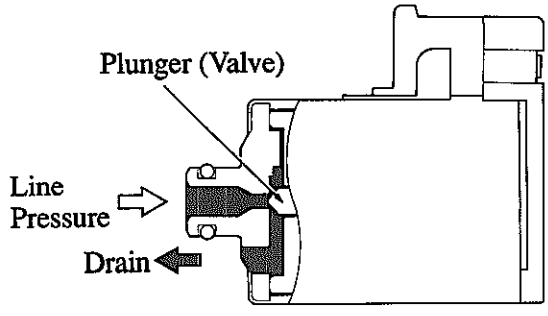



| No.1 Solenoid / No.2 Solenoid / Shift Position | | | | | |
|---|---|---|---|---|---|
| | | ON | ON | OFF | OFF |
| | | OFF | ON | ON | OFF |
| P | | Park | Park | Park | Park |
| R | | (Reverse)* | Neutral | Reverse | Reverse |
| N | | Neutral | Neutral | Neutral | Neutral |
| D | | 1st | 2nd | 3rd | OD |
| 2 | | 1st | 2nd | 3rd | (3rd)* |
| L | No.4 Solenoid OFF | 1st | 2nd | (2nd)* | (1st)* |
| | No.4 Solenoid ON | 1st | 2nd | 3rd | (3rd)* |

* When a malfunction has occured in the solenoid valve(s).

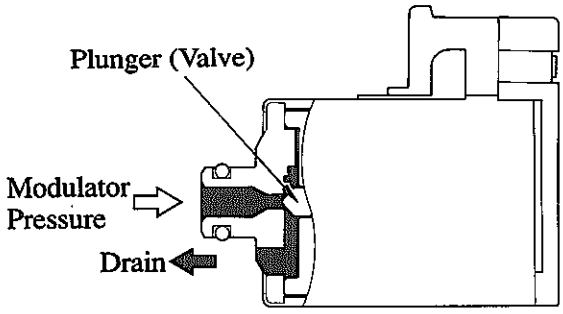
## NO.3 Solenoid Valve (For Lock-Up Control)

The No.3 solenoid valve is also mounted on the valve body, the same as the No.1 and No.2 solenoid valves.
However, the No.3 solenoid valve operates differently to the No.1 and No.2 solenoid valves; when continuity is established the port is opened and when continuity ceases the port is closed. Signals from the ECU turn this valve on and off, controlling the lock-up clutch.



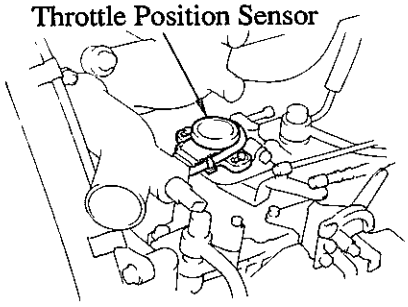
## No.4 Solenoid Valve

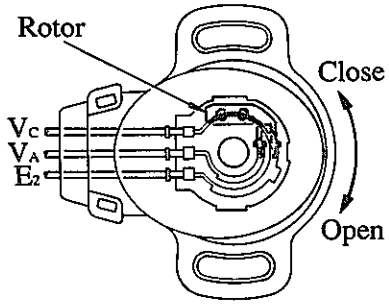
The No.4 solenoid valve is located in the valve body. It receives the on-off signals from the ECU to control the modulator pressure applied to the 2-3 shift timing valve, low inhibit valve, orifice control valve, and low coast modulator valve. Its internal construction is identical to that of the No.1 , No.2, and No.3 solenoid valves.

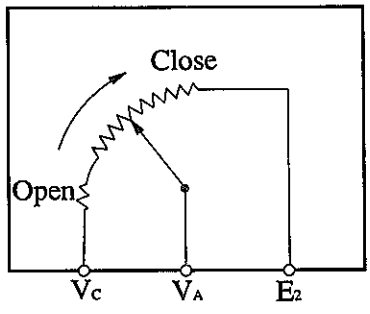


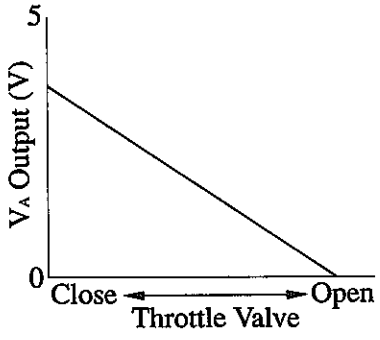

## Throttle Position Sensor

The throttle position sensor is mounted on the injection pump. This sensor converts the throttle opening angle into a voltage and sends it to the ECU as the throttle position signal.
A constant 5V is applied to the Vc terminal from the ECU. As the contact slides along the resistor in accordance with the throttle valve opening angle, a voltage is applied to the $V_A$ terminal in proportion to this angle.



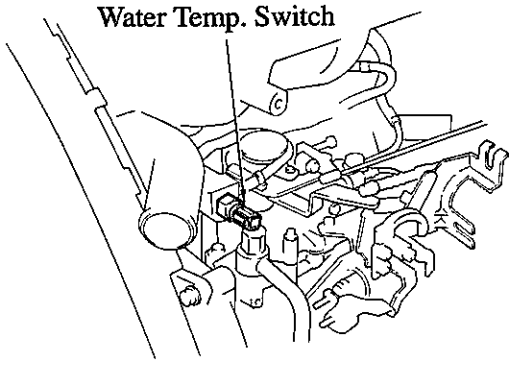



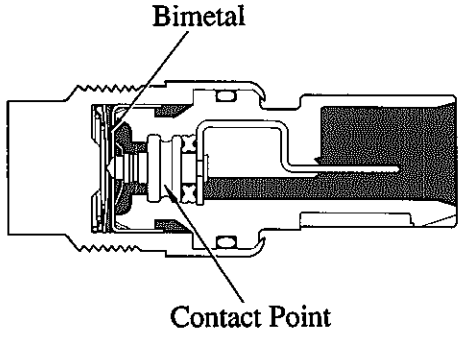




## Water Temp. Switch

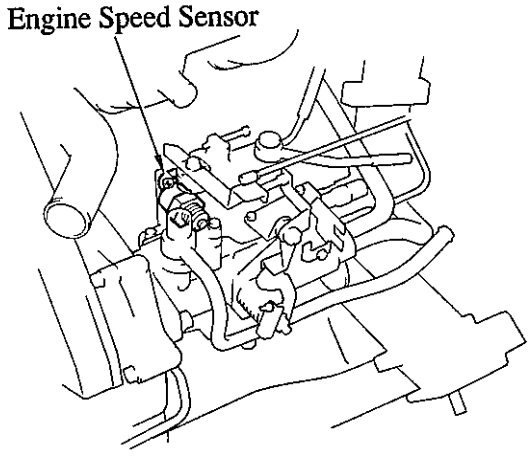
The water temperature switch detects coolant temperature and is fitted to the water outlet housing of the engine. This switch has a bimetal and a contact point inside. The contact point closes when the coolant temperature is below 50°C (122°F) and opens above that level.

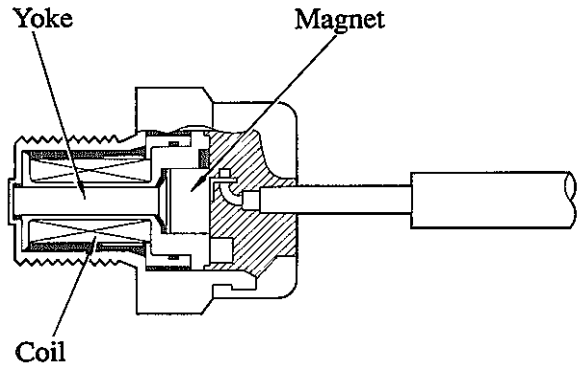


### Engine Speed Sensor

The engine speed sensor is mounted onto the injection pump. It outputs the rotation speed signals of the injection pump drive shaft to the ECU. Its basic construction and operation are the same as those of the No.2 speed sensor. See page 69 for further details.




## 7. Function of ECU

The ECU receives signals from various sensors and determines the proper shift and lock-up timings accordingly. In addition, the ECU controls "N" to "D" squat control to maintain drivability.
It also has a self-diagnostic function and fail-safe function.

### Shift and Lock-Up Timing Control

Optimum transmission shift and lock-up patterns are stored in the ECU memory, and are accessible by the pattern select switch and the transmission shift lever. To implement shift control, the ECU turns the No.1 and No.2 shift control solenoid valves on or off in accordance with the throttle position sensor and the No.2 (or No.1) speed sensor signals received. The ECU effects up-shifting or down-shifting by operating each shift valve in this manner, causing the fluid passages to the clutches and brakes to open or close.

To implement lock-up clutch control, the ECU operates the lock-up control solenoid valve in accordance with the throttle position, vehicle speed, and gear shift position signals received. This operation of the solenoid valve causes the lock-up signal valve and lock-up control valve to change the fluid passages of the converter pressure applied to the torque converter, in order to engage or disengage the lock-up clutch.

### "N" to "D" Squat Control

When the transmission is shifted from "N" range to "D" range, the squat control function prevents it from shifting directly into 1st gear, by causing it to shift into 4th gear first, and then into 1st gear, in order to reduce shifting shock and squatting of the vehicle.

## Self-Diagnosis

### 1) Outline

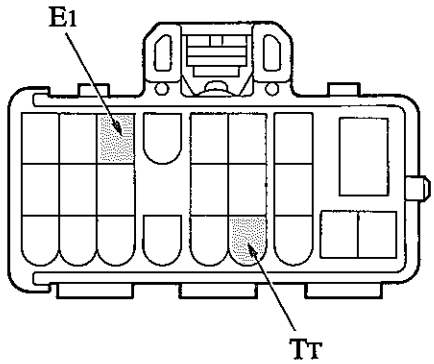
The ECU constantly monitors sensors, actuators and the ECU itself, and detects and warns that a malfunction has occurred. When a malfunction in the system has occurred, the ECU blinks the O/D OFF indicator light on the combination meter and displays the section of the malfunction by code number/s.

### 2) Diagnosis

When the ECU detects an open or short circuit in the speed sensors or solenoid valve circuits, it blinks the O/D OFF indicator light to alert the driver. At the same time, the ECU stores the malfunction in the form of a code number in its memory. The ECU memory is maintained by a back-up power supply.
The malfunction codes will be displayed through the O/D OFF indicator light by turning the ignition switch ON and connecting the $T_T$ and $E_1$ terminals of the check connector.

**NOTE:** When the O/D switch is OFF, the O/D OFF indicator light does not blink. The O/D switch must be in the ON position.





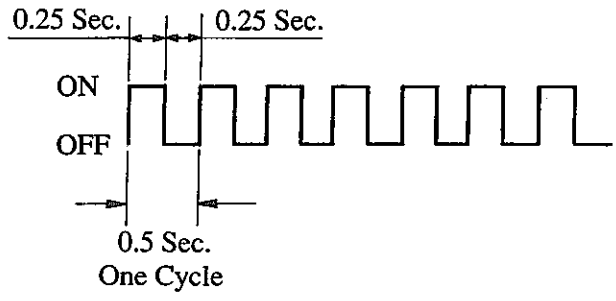

**Check Connector**

### 3) Diagnostic Result

A diagnostic result is indicated by the blinking of the O/D OFF indicator light shown below.

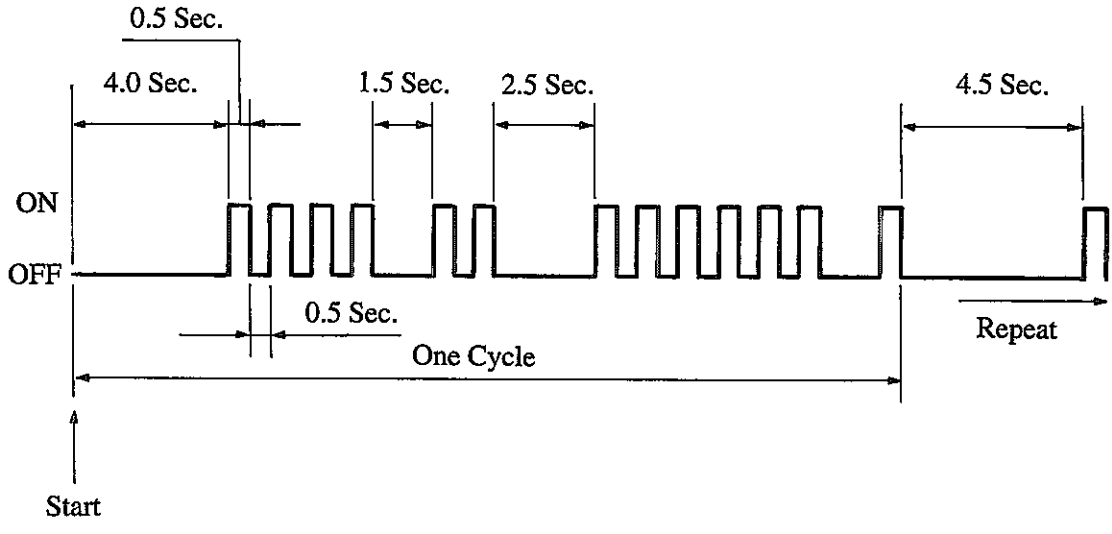
- Normal

The light will flash 2 times per second as shown below.



- **Malfunction Indication**

The appropriate diagnostic code(s) will be indicated by the light as shown below. In this case, codes 42 and 61 are indicated.
If two or more malfunctions are indicated at the same time, the lowest-numbered diagnostic code will be displayed first.




**▶Diagnostic Codes◀**

| Code No. | Diagnostic |
|---|---|
| 41 | Throttle position sensor signal malfunction. |
| 42 | No.1 speed sensor signal malfunction. |
| 61 | No.2 speed sensor signal malfunction. |
| 62 | Open or short circuit in No.1 shift control solenoid valve. |
| 63 | Open or short circuit in No.2 shift control solenoid valve. |
| 64 | Open or short circuit in lock-up control solenoid valve. |
| 65 | Open of short circuit in timing control solenoid valve. |
| 86 | Engine speed sensor signal malfunction. |

**NOTE:** In order for the indicator light to stop blinking and to turn off, the malfunction must return to normal and terminals $T_T$ and $E_1$ be disconnected. The malfunction code No(s), however, is stored in the memory until it is cleared by removing the ECU-B fuse for 10 seconds or longer. The fuse then must be re-installed.

## Fail-Safe

The fail-safe function allows the vehicle to be driven even with malfunctions in the sensors or solenoid valves.

### 1) Shift Control Solenoid Valve Malfunction

The ECU can control the transmission even if either No.1 or No.2 solenoid valve malfunctions. This is accomplished by operating the remaining solenoid to shift the transmission into a gear which will allow the vehicle to be operated.
If, for example, the No.1 solenoid valve fails while the vehicle is being driven in 1st gear, and the shift lever is in the "D" position, the fail-safe function shifts the transmission automatically into 3rd gear.
Further, if both solenoid valves fail, the driver can safety drive the vehicle by manually shifting the transmission.

| Range | Normal | | | | No.1 Solenoid Malfunctioning | | | No.2 Solenoid Malfunctioning | | | Both Solenoids Malfunctioning |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Solenoid Valve | | | Gear | Solenoid Valve | | Gear | Solenoid Valve | | Gear | Gear when shift selector is manually operated |
| | No.1 | No.2 | No. 4 | | No.1 | No.2 | | No.1 | No.2 | | |
| D | ON | OFF | – | 1st | × | ON | 3rd | ON | × | 1st | OD |
| | ON | ON | – | 2nd | × | ON | 3rd | OFF | × | OD | OD |
| | OFF | ON | – | 3rd | × | ON | 3rd | OFF | × | OD | OD |
| | OFF | OFF | – | OD | × | OFF | OD | OFF | × | OD | OD |
| 2 | ON | OFF | – | 1st | × | ON | 3rd | ON | × | 1st | 3rd |
| | ON | ON | – | 2nd | × | ON | 3rd | OFF | × | 3rd | 3rd |
| | OFF | ON | – | 3rd | × | ON | 3rd | OFF | × | 3rd | 3rd |
| L | ON | OFF | OFF | 1st | × | OFF | 1st | ON | × | 1st | 1st |
| | | | ON | 1st | × | OFF | 3rd | ON | × | 1st | 3rd |
| | ON | ON | OFF | 2nd | × | ON | 2nd | OFF | × | 1st | 1st |
| | | | ON | 2nd | × | ON | 3rd | OFF | × | 3rd | 3rd |
| | OFF | ON | OFF | – | × | ON | 2nd | OFF | × | 1st | 1st |
| | | | ON | 3rd | × | ON | 3rd | OFF | × | 3rd | 3rd |

×: Malfunctions

### 2) Vehicle Speed Sensor Malfunction

There are two vehicle speed sensors: the main sensor (No.2), and the back-up sensor (No.1). In the event the main sensor fails, the ECU is capable of operating normally through the input of the back-up sensor signals. If, however, both sensors No.1 and No.2 fail, and no speed signals are input to the ECU, the ECU will interpret this condition to be that of the vehicle speed of 0 km/h (0 mph), and instructs the transmission to shift into 1st gear only.