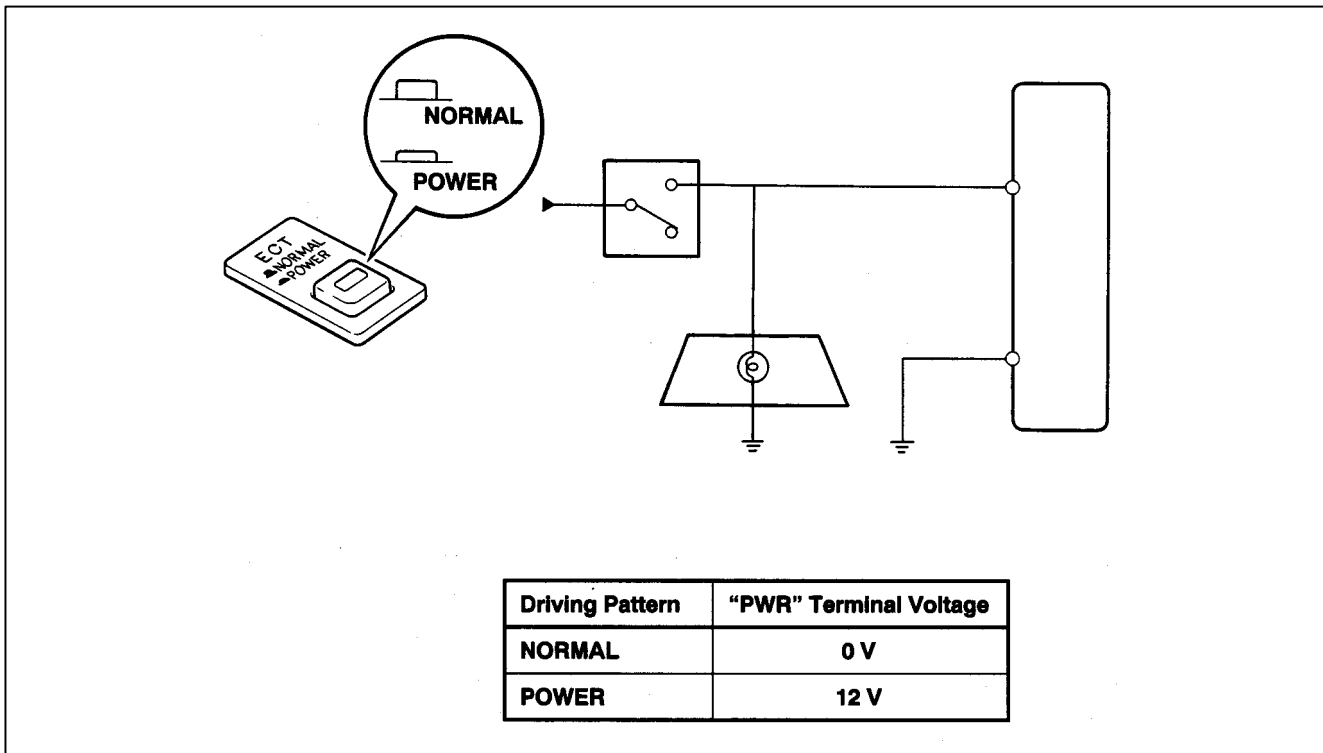


# ELECTRICAL CONTROL



- Lesson Objectives:**
1. Describe the operation of the OD Main Switch and its control of fourth gear.
  2. List the three items which control overdrive in a Non-ECT transmission.
  3. Describe the effect of the OD solenoid on the torque converter lock-up control for Non-ECT transmissions.
  4. Describe the effect of the pattern select switch on the upshift pattern.
  5. Explain the effect of the neutral start switch in maintaining manual select positions in ECT transmissions.
  6. Given the solenoid back-up function chart, describe the ECU control of the remaining solenoid to allow the vehicle to operate.

## Non-ECT Transmission

Electrical control in a non-ECT transmission consists of overdrive and torque converter lock-up operation.

### Overdrive Control System

Overdrive enables the output rpm of the transmission to be greater than the input rpm, so the vehicle can maintain a certain road speed with lower engine rpm. The control system provides line pressure at the top of the 3-4 shift valve to hold it in the third gear position. It also provides a solenoid to open and close a drain for this line pressure to control the shift valve position.

In a hydraulic-controlled transmission, the hydraulic circuit is controlled by the No. 3 solenoid, sometimes called the OD solenoid. The solenoid controls the drain on the hydraulic circuit at the top of the 3-4 shift valve which will counteract governor pressure when the drain is closed.

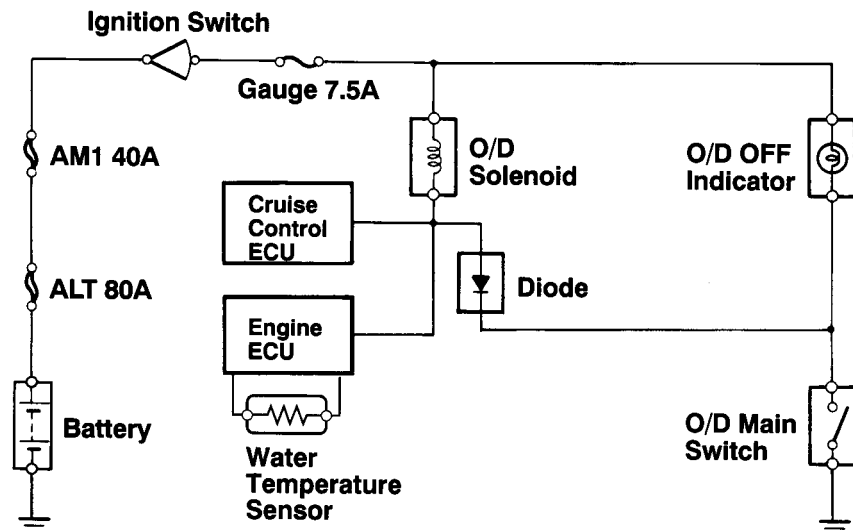
The components which make up this system include:

- OD main switch
- OD off indicator light
- Water temperature sensor
- OD solenoid valve

### OD Wiring Diagram

OD Solenoid can be grounded by:

- Cruise Control ECU
- Water Temperature Sensor
- OD Main Switch



**OD Main Switch** The OD main switch is located on the gear selector. Generally we think of a switch as closed when it is on and open when it is off. However, the OD main switch is just the opposite. When the OD switch is in the ON position, the switch contacts are open and the overdrive system is working. When the OD switch is in the OFF position, the switch contacts are closed and the overdrive system is not working. This enables the system to be in overdrive without having the solenoid energized.

**OD Main Switch**

The operation of the switch is the opposite of its description

CONTACTS OF OD SWITCH	OD SWITCH	
	ON	OFF
CONTACTS OF OD SWITCH	Open	Closed
UPSHIFTING	Enabled	Disabled
OD "OFF" INDICATOR	Off	On

**OD MAIN SWITCH ON**

**OD MAIN SWITCH OFF**

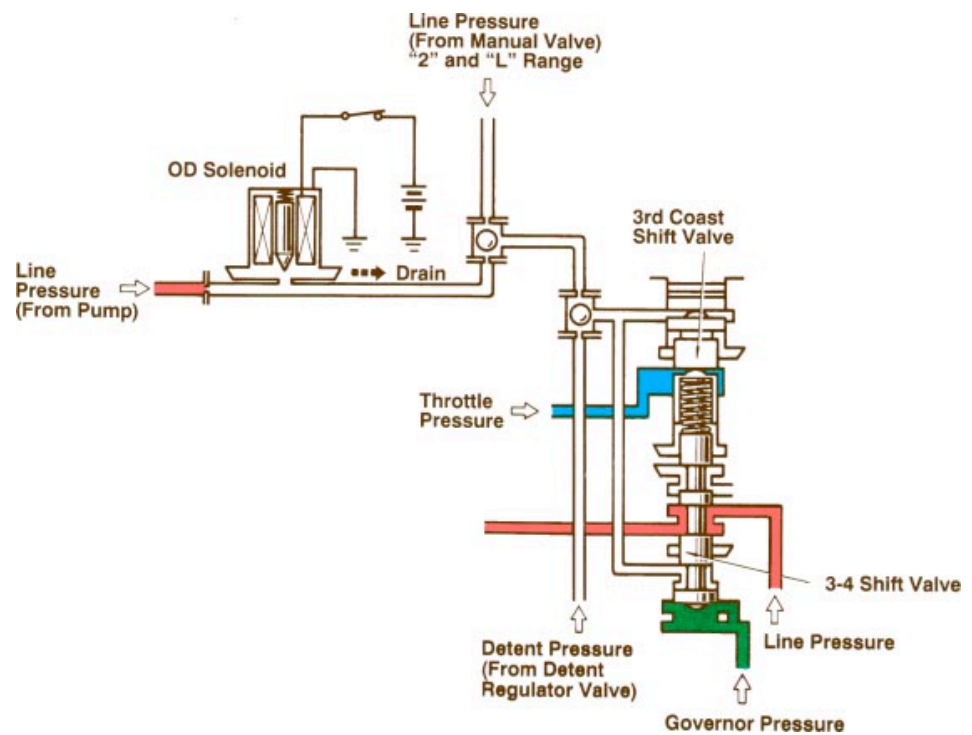
**OD Off Indicator Light** This indicator light remains on as long as the overdrive main switch is off (OD switch contacts closed). It is located in the combination meter.

**Water Temperature Sensor** The water temperature sensor monitors the temperature of the engine coolant and is connected to the engine ECU. The engine ECU grounds the circuit through the ECT terminal. It prevents the transmission from shifting into overdrive until the engine coolant is greater than 122°F. This threshold temperature may vary depending on the vehicle model. While the engine temperature is below the threshold temperature, the lock-up solenoid circuit will be open, preventing movement of the 3-4 shift valve. On some earlier models, this sensor function was accomplished by a water thermo switch. The outcome is the same; however, the thermo switch controls the circuit without the engine ECU.

**OD Solenoid Valve** The OD solenoid valve is a normally closed solenoid; that is, the valve is spring loaded in the closed position. When the solenoid is energized, the valve opens a drain in the hydraulic circuit to the top of the 3-4 shift valve. This allows governor pressure to overcome spring tension and throttle pressure to allow an upshift to overdrive. The OD main switch can manually disable this system as described previously.

### Overdrive Solenoid Operation

OD solenoid is a normally closed solenoid

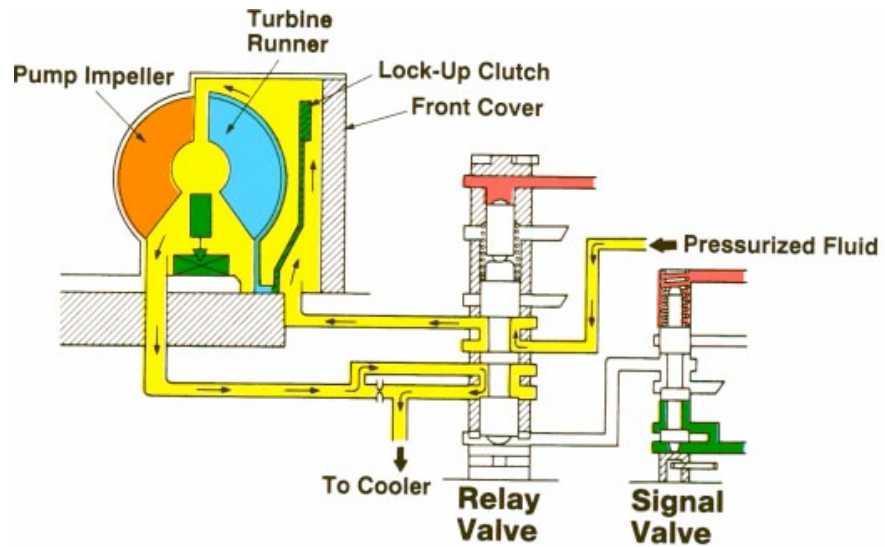


**OD Main Relay** An overdrive main relay is used in Truck and Van systems where the transmission is hydraulically controlled as opposed to electronically (ECT) controlled. The relay is controlled by either the OD main switch, the water temperature sensor (in some cases through the engine ECU) or the cruise control ECU grounding the circuit.

**Converter Lock-Up** Lock-up in a non-ECT transmission is controlled hydraulically by governor pressure and line pressure. Lock-up occurs only in the top gear position. For example: in an A130L series transmission, lock-up occurs only in third gear; in an A140L or A240L series transmission, lock-up occurs only in fourth gear.

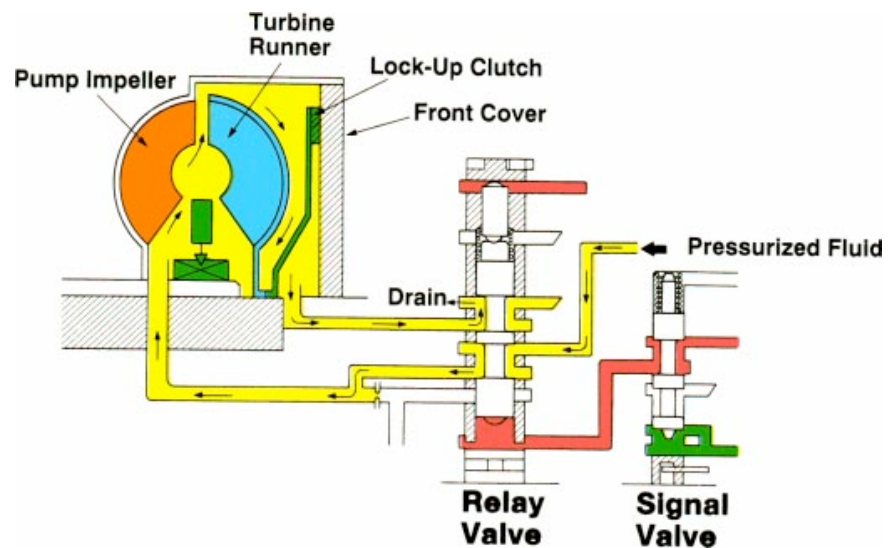
***Lock-Up Clutch — Disengaged***

When overdrive is disabled through solenoid No. 3, the lock-up clutch is also disabled



Two valves control the operation of the lock-up converter. The lock-up relay valve controls the distribution of converter/lubrication pressure to the torque converter. Line pressure and spring tension hold the relay valve in its normal down position. The signal valve blocks line pressure from the 3-4 shift valve. Governor pressure increases with vehicle speed to overcome spring tension at the top of the signal valve. When the signal valve moves up, line pressure flows through the valve to the base of the relay valve. The relay valve has a larger surface area at the base than at the top, and it moves upward, changing the flow of converter pressure to the converter and opening a drain to the front of the lock-up clutch, engaging the clutch with the converter housing.

***Lock-Up Clutch –  
Engaged***



## Electronic Control Transmission

The Electronic Control Transmission is an automatic transmission which uses modern electronic control technologies to control the transmission. The transmission itself, except for the valve body and speed sensor, is virtually the same as a full hydraulically controlled transmission, but it also consists of electronic parts, sensors, an electronic control unit and actuators.

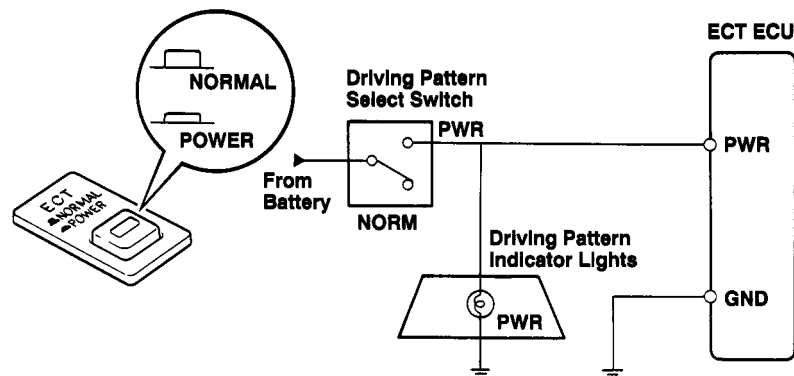
The electronic sensors monitor the speed of the vehicle, gear position selection and throttle opening, sending this information to the ECU. The ECU then controls the operation of the clutches and brakes based on this data and controls the timing of shift points and torque converter lock-up.

## Driving Pattern Select Switch

The pattern select switch is controlled by the driver to select the desired driving mode, either "Normal" or "Power." Based on the position of the switch, the ECT ECU selects the shift pattern and lock-up accordingly. The upshift in the power mode will occur later, at a higher speed depending on the throttle opening. For example, an upshift to third gear at 50% throttle will occur at about 37 mph in normal mode and about 47 mph in power mode.

### Drive Pattern Select Switch

When the ECU does not receive 12 volts at the PWR terminal, it determines that normal has been selected.

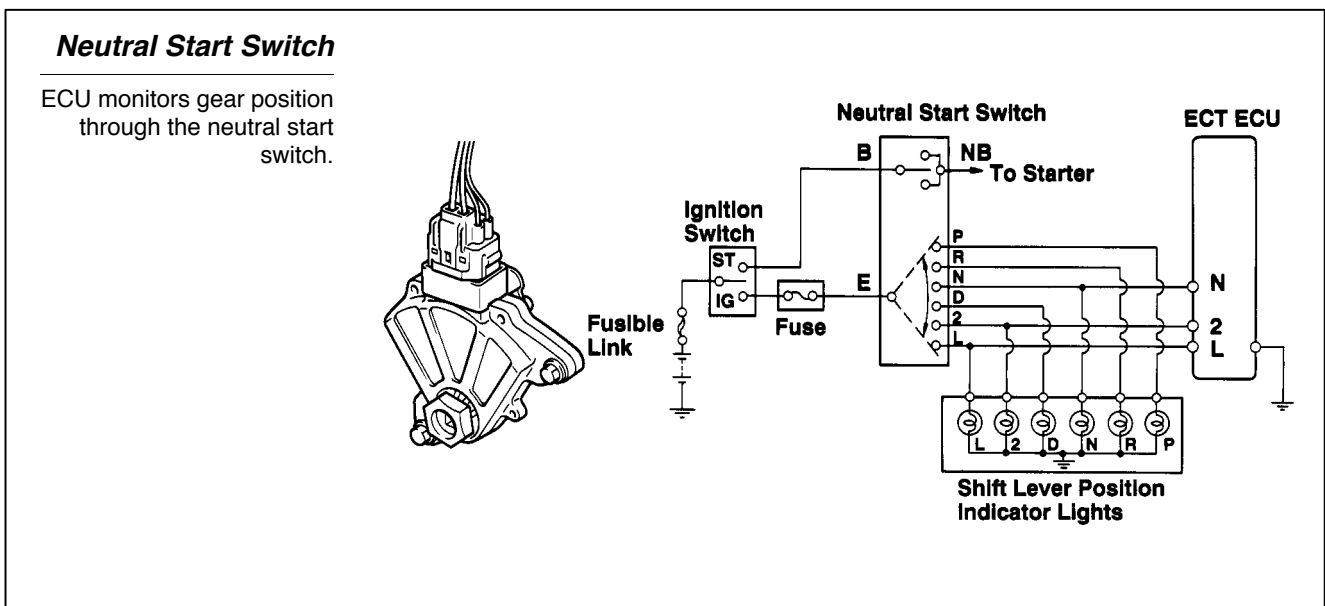


Driving Pattern	"PWR" Terminal Voltage
NORMAL	0 V
POWER	12 V

The ECU has a "PWR" terminal but does not have a "Normal" terminal. When "Power" is selected, 12 volts are applied to the "PWR" terminal of the ECU and the power light illuminates. When "Normal" is selected, the voltage at "PWR" is 0 volts. When the ECU senses 0 volts at the terminal, it recognizes that "Normal" has been selected.

Beginning with the 1990 MR2 and Celica and the 1991 Previa, the pattern select switch was discontinued. In the Celica and Previa systems, several shift patterns are stored in the ECU memory. Utilizing sensory inputs, the ECU selects the appropriate shift pattern and operates the shift solenoids accordingly. The MR2 and 1993 Corolla have only one shift pattern stored in the ECU memory.

**Neutral Start Switch** The ECT ECU receives information on the gear range into which the transmission has been shifted from the shift position sensor, located in the neutral start switch, and determines the appropriate shift pattern. The neutral start switch is actuated by the manual valve shaft in response to gear selector movement.



The ECT ECU only monitors positions "2" and "L." If either of these terminals provides a 12-volt signal to the ECU, it determines that the transmission is in neutral, second gear or first gear. If the ECU does not receive a 12-volt signal at terminals "2" or "1," the ECU determines that the transmission is in the "D" range.

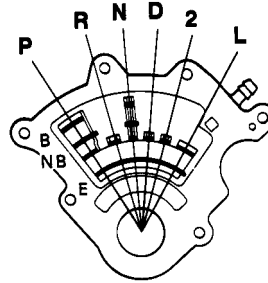
Some neutral start switches have contacts for all gear ranges. Each contact is attached to the gear position indicator lights if the vehicle is so equipped.



In addition to sensing gear positions, the neutral switch prevents the starter from cranking the engine unless it is in the park or neutral position. In the park and neutral position, continuity is established between terminals "B" and "NB" of the neutral start switch illustrated below.

**Starter Control**

In Park and Neutral positions, continuity exists between terminals "B" and "NB".



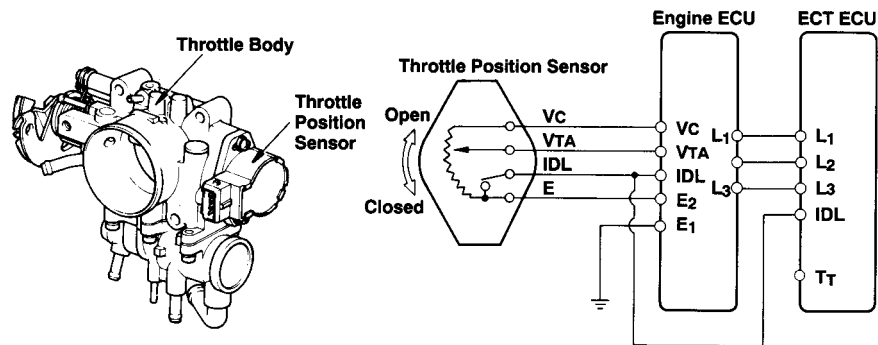
**Throttle Position Sensor**

This sensor is mounted on the throttle body and electronically senses how far the throttle is open and then sends this data to the ECU. The throttle position sensor takes the place of throttle pressure in a fully hydraulic control transmission. By relaying the throttle position, it gives the ECU an indication of engine load to control the shifting and lock-up timing of the transmission.

There are two types of throttle sensors associated with ECT transmissions. The type is related to how they connect to the ECT ECU. The first is the indirect type because it is connected directly to the engine ECU, and the engine ECU then relays throttle position information to the ECT ECU. The second type is the direct type which is connected directly to the ECT ECU.

**Throttle Position Sensor—Indirect Type**

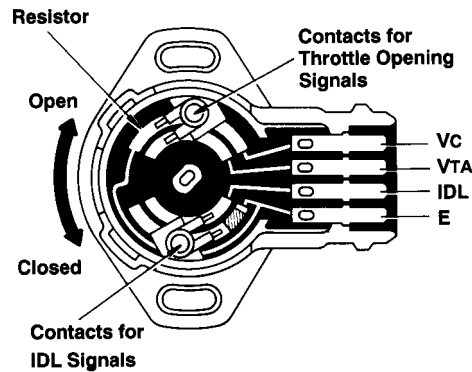
Throttle sensor signals converted in Engine ECU are relayed to the ECT ECU.



**Indirect Type** This throttle position sensor converts the throttle valve opening angle into voltage signals. It has four terminals: Vc, VTA, IDL and E. A constant 5 volts is applied to terminal VC from the engine ECU. As the contact point slides along the resistor with throttle opening, voltage is applied to the VTA terminal. This voltage increases linearly from 0 volts at closed throttle to 5 volts at wide-open throttle.

### Throttle Position Sensor

A linear voltage signal indicates throttle opening position and idle contacts indicate when the throttle is closed.

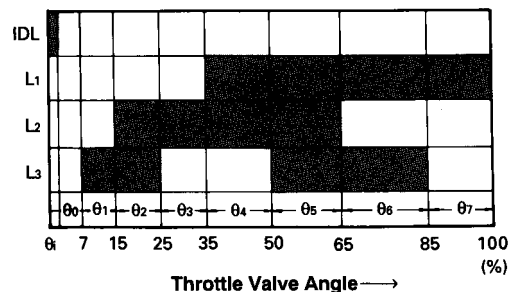


The engine ECU converts the VTA voltage into one of eight different throttle opening angle signals to inform the ECT ECU of the throttle opening. These signals consist of various combinations of high and low voltages at ECT ECU terminals as shown in the chart below. The shaded areas of the chart represent low voltage (about 0 volts). The white areas represent high voltage (L1, L2, L3: about 5 volts; IDL: about 12 volts).

### Throttle Valve Angle Signal Chart

Shaded area = low voltage (about 0 v).

Clear area = high voltage (about 5 v).



When the throttle valve is completely closed, the contact points for the IDL signal connect the IDL and E terminals, sending an IDL signal to the ECT ECU to inform it that the throttle is fully closed.

As the ECT ECU receives the LI, L2 and L3 signals, it provides an output voltage from 1 to 8 volts at the TT or ECT terminal of the diagnostic check connector. The voltage signal varies depending on the throttle opening angle and informs the technician whether or not the throttle opening signal is being input properly.

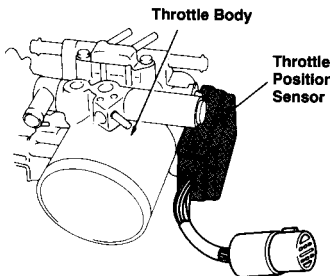
**Direct Type** With this type of throttle sensor, signals are input directly to the ECT ECU from the throttle position sensor. Three movable contact points rotate with the throttle valve, causing contacts LI, L2, L3 and IDL to make and break the circuit with 'contact E (ground). The grid which the contact points slide across is laid out in such a way as to provide signals to the ECT ECU depicted in the chart below. The voltage signals provided to the ECT ECU indicate throttle position just as they did in the indirect type of sensor.

If the idle contact or its circuit on either throttle sensor malfunctions, certain symptoms occur. If it is shorted to ground, lock-up of the torque converter will not occur. If the circuit is open, neutral to drive squat control does not occur and a harsh engagement may be the result. If the LI, L2, L3 signals are abnormal, shift timing will be incorrect.

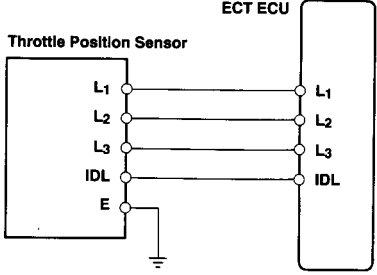
Refer to the ECT Diagnostic Information chart in the appendix of this book to determine which throttle position sensor is used in each model.

### Throttle Position Sensor—Direct Type

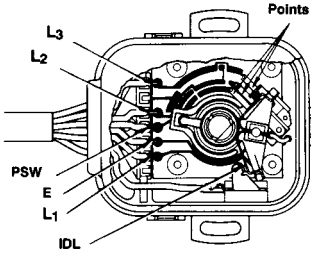
Throttle sensor printed circuit board and contract points provide the ECT ECU with the same signal pattern for throttle opening as the indirect type of throttle sensor.



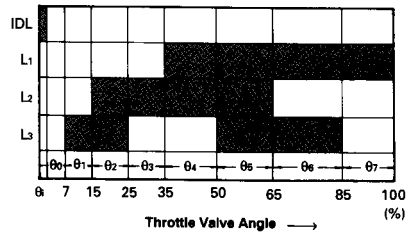
Throttle Body  
Throttle Position Sensor



ECT ECU  
Throttle Position Sensor



Points  
L3  
L2  
PSW  
E  
L1  
IDL



IDL  
L1  
L2  
L3

00 01 02 03 04 05 06 07  
0 7 15 25 35 50 65 85 100 (%)

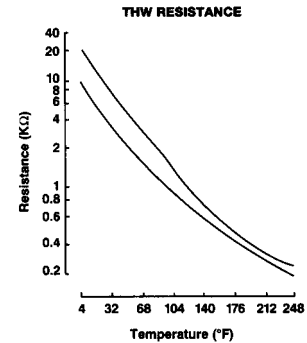
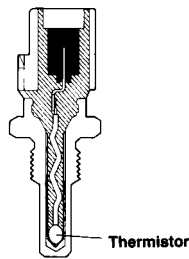
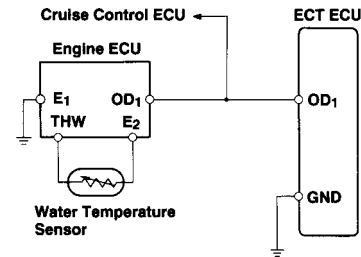
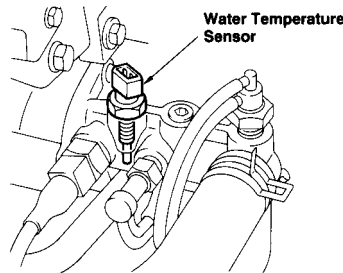
Throttle Valve Angle →

## Water Temperature Sensor

The water temperature sensor monitors engine coolant temperature and is typically located near the cylinder head water outlet. A thermistor is mounted within the temperature sensor, and its resistance value decreases as the temperature increases. Therefore, when the engine temperature is low, resistance will be high.

### Water Temperature Sensor

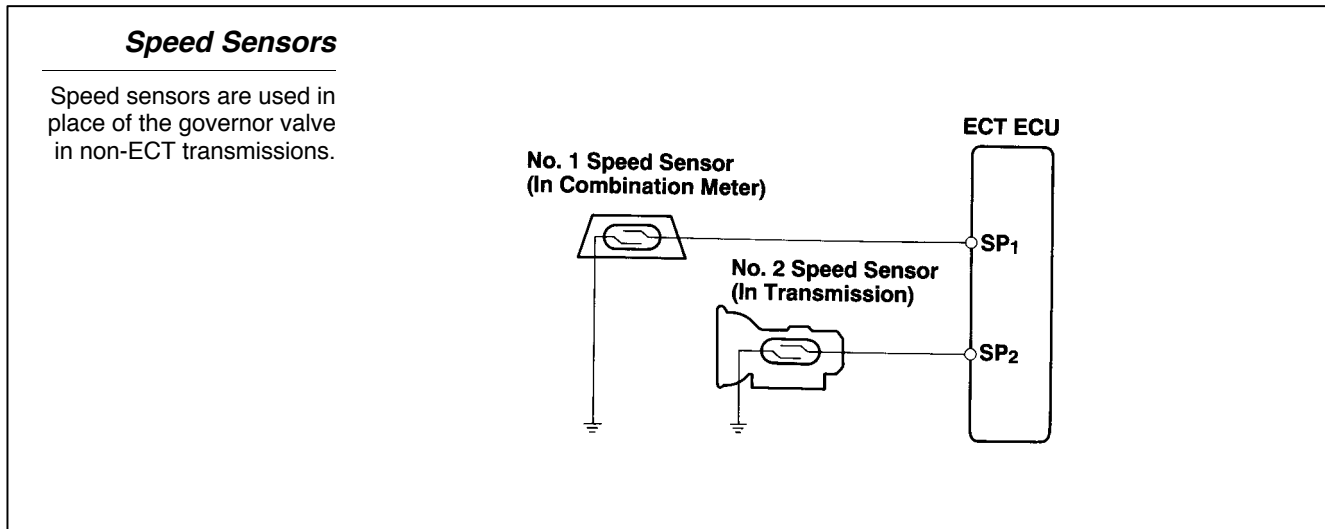
Coolant temperature is monitored by the engine ECU which controls the signal to OD1 of the ECT ECU to cancel overdrive.



When the engine coolant is below a predetermined temperature, the engine performance and the vehicle's drivability would suffer if the transmission were shifted into overdrive or the converter clutch were locked-up. The engine ECU monitors coolant temperature and sends a signal to terminal GDI of the ECT ECU. The ECU prevents the transmission from upshifting into overdrive and lock-up until the coolant has reached a predetermined temperature. This temperature will vary from 122°F to 162°F depending on the transmission and vehicle model. For specific temperatures, refer to the ECT Diagnostic Information chart in the appendix of this book.

Some models, depending on the model year, cancel upshifts to third gear at lower temperatures. This information is found in the appendix and is indicated in the heading of the OD Cancel Temp column of the ECT Diagnostic Information chart by listing in parenthesis the temperature for restricting third gear.

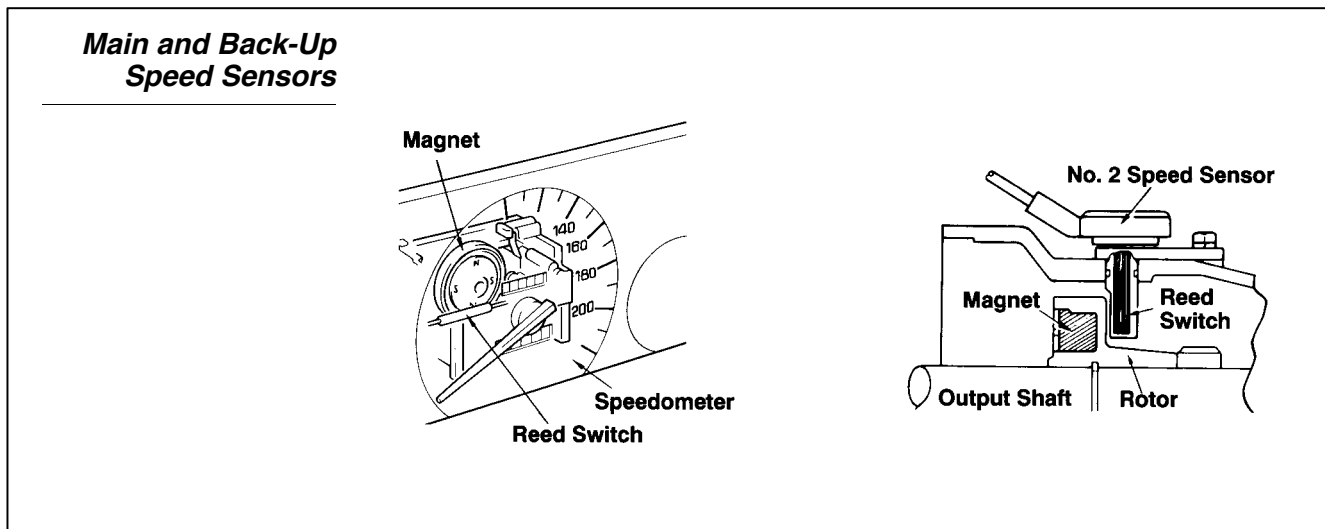
**Speed Sensors** To ensure that the ECT ECU is kept informed of the correct vehicle speed at all times, vehicle speed signals are input into it by two speed sensors. For further accuracy, the ECT ECU constantly compares these two signals to see whether they are the same. The speed sensor is used in place of governor pressure in the conventional hydraulically controlled transmission.



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

The main speed sensor is located in the transmission housing. A rotor with built-in magnet is mounted on the drive pinion shaft or output shaft. Every time the shaft makes one complete revolution, the magnet activates the reed switch, causing it to generate a signal. This signal is sent to the ECU, which uses it in controlling the shift point and the operation of the lock-up clutch. This sensor outputs one pulse for every one revolution of the output shaft.

Beginning with the 1993 Corolla A245E, the No. 2 speed sensor has been discontinued and only the No. 1 speed sensor is monitored for shift timing.



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

The back-up speed sensor is built into the combination meter assembly and is operated by the speedometer cable. The sensor consists of an electrical reed switch and a multiple pole permanent magnet assembly. As the speedometer cable turns, the permanent magnet rotates past the reed switch. The magnetic flux lines between the poles of the magnet cause the contacts to open and close as they pass. The sensor outputs four pulses for every one revolution of the speedometer cable.

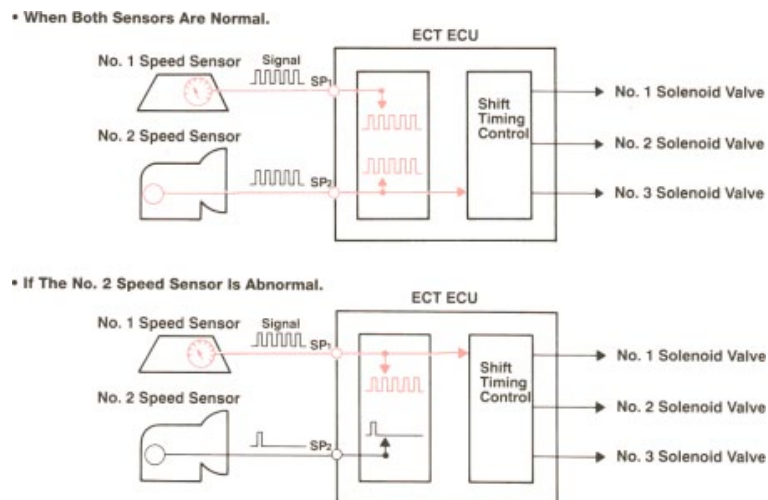
The sensor can also be a photocoupler type which uses a photo transistor and light-emitting diode (LED). The LED is aimed at the phototransistor and separated by a slotted wheel. The slotted wheel is driven by the speedometer cable. As the slotted wheel rotates between the LED and photo diode, it generates 20 light pulses for each rotation. This signal is converted within the phototransistor to four pulses sent to the ECU.

### Speed Sensor Failsafe

If both vehicle speed signals are correct, the signal from the main speed sensor is used in shift timing control after comparison with the output of the back-up speed sensor. If the signals from the main speed sensor fail, the ECU immediately discontinues use of this signal and uses the signals from the back-up speed sensor for shift timing.

#### Speed Sensor—Failsafe

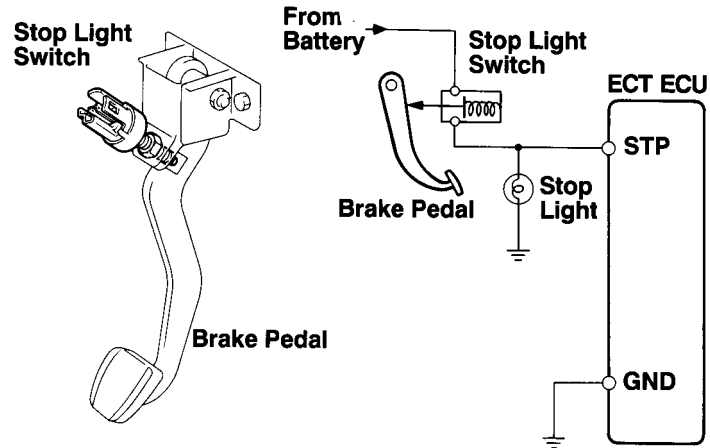
ECT ECU compares the back-up speed sensor with the main speed sensor for shift timing control.



**Stop Light Switch** The stop light switch is mounted on the brake pedal bracket. When the brake pedal is depressed, it sends a signal to the STP terminal of the ECT ECU, informing it that the brakes have been applied.

**Stop Light Switch**

The ECU cancels torque converter lock-up and Neutral to Drive squat control based on the stop light switch.



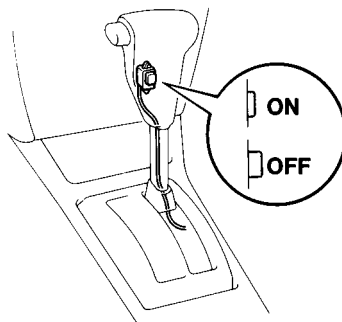
Brake Pedal	STP Terminal Voltage
Depressed	12 V
Released	0 V

The ECU cancels torque converter lock-up when the brake pedal is depressed, and it cancels "N" to "D" squat control when the brake pedal is not depressed and the gear selector is shifted from neutral to drive.

**Overdrive Main Switch** The overdrive main switch is located on the gear selector. It allows the driver to manually control overdrive. When it is turned on, the ECT can shift into overdrive. When it is turned off, the ECT is prevented from shifting into overdrive.

**Overdrive Main Switch**

Allows driver to manually control overdrive.

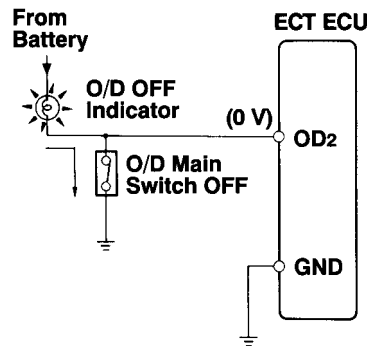


	O/D Main Switch	
	ON	OFF
Contacts of O/D Main Switch	Open	Closed
O/D Gear	Enabled	Disabled
O/D OFF Indicator Light	Off	On

**O/D Main Switch ON** When the O/D switch is in the ON position, the electrical contacts are actually open and current from the battery flows to the OD2 terminal of the ECT ECU as shown below.

### **Overdrive (O/D) Main Switch—ON**

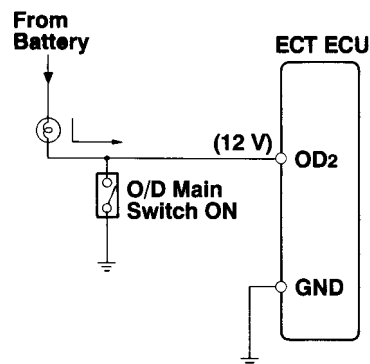
When O/D main switch is on, OD<sub>2</sub> terminal has 12 v.



**O/D main Switch OFF** When the O/D switch is in the OFF position, the electrical contacts are actually closed and current from the battery flows to ground and 0 volts is present at the OD2 terminal as shown below. At the same time, the O/D OFF indicator is illuminated.

### **Overdrive (O/D) Main Switch—OFF**

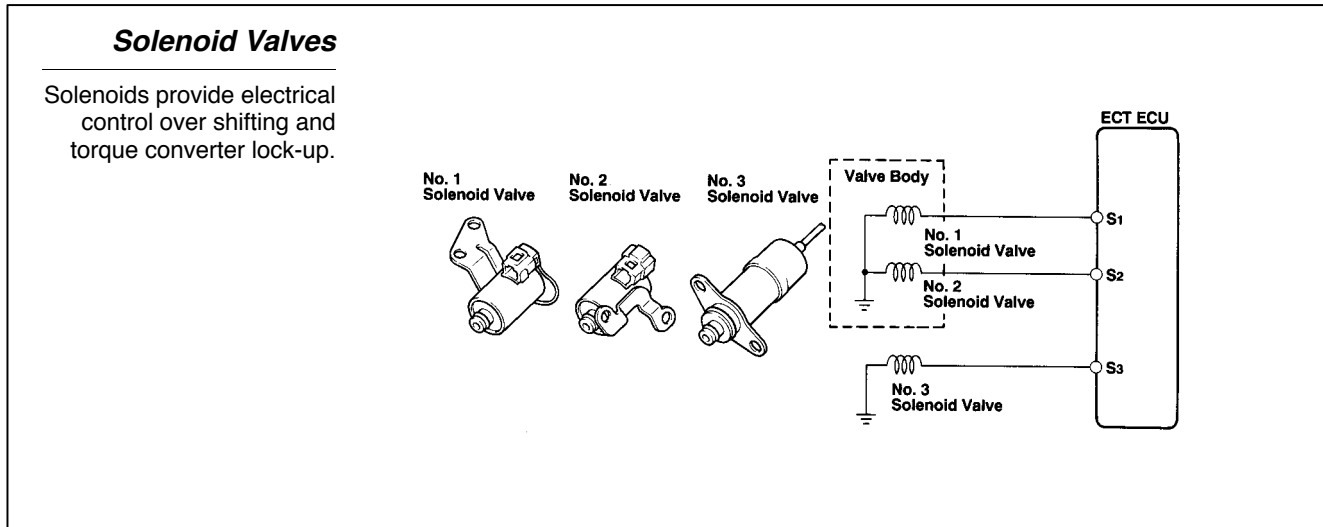
When O/D main switch is on, OD<sub>2</sub> terminal has 0 v.



**Solenoid Valves** Solenoid valves are electro-mechanical devices which control hydraulic circuits by opening a drain for pressurized hydraulic fluid. Of the solenoid valves, No. 1 and No. 2 control gear shifting while No. 3 controls torque converter lock-up.



**No. 1 and No. 2 Solenoid Valves** These solenoid valves are mounted on the valve body and are turned on and off by electrical signals from the ECU, causing various hydraulic circuits to be switched as necessary. By controlling the two solenoids' on and off sequences, we are able to provide four forward gears as well as prevent upshifts into third or fourth gear.



The No. 1 and No. 2 solenoids are normally closed. The plunger is spring-loaded to the closed position, and when energized, the plunger is pulled up, allowing line pressure fluid to drain. The operation of these solenoids by the ECT ECU is described on pages 123 - 126 of this book.

**No. 3 Solenoid Valve** This solenoid valve is mounted on the transmission exterior or valve body. It controls line pressure which affects the operation of the torque converter lock-up system. This solenoid is either a normally open or normally closed solenoid. The A340E, A340H, A540E and A540H transmissions use the normally open solenoid.

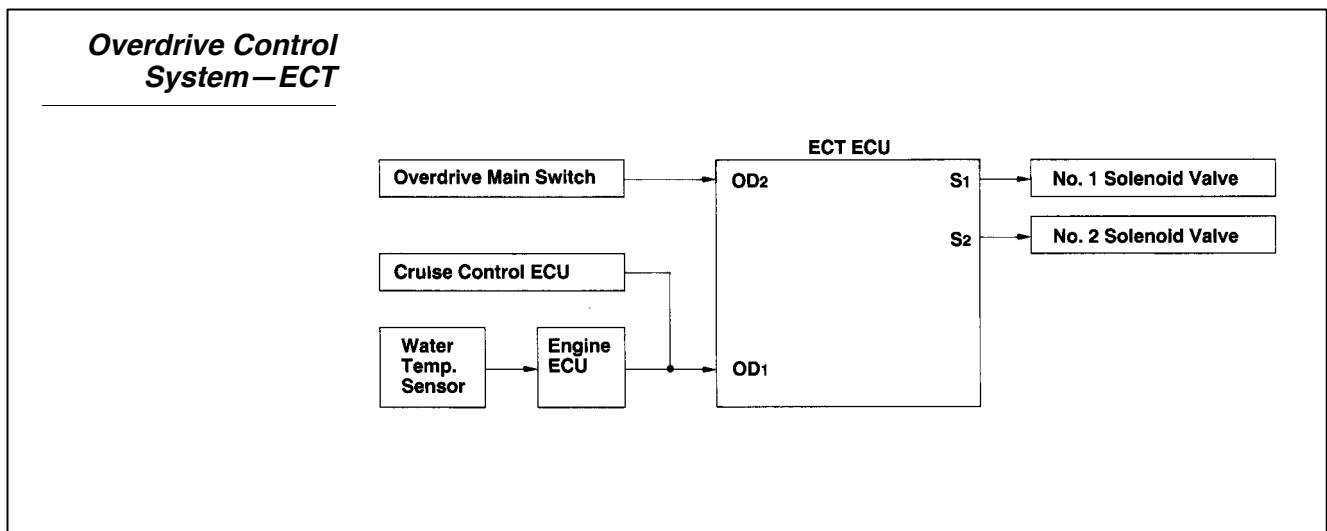
**No. 4 Solenoid Valve** This solenoid is found exclusively on the A340H transfer unit described on page 152 of this book. This solenoid is a normally closed solenoid which controls the shift to low 4-wheel drive. It is controlled by the ECT ECU when low 4-wheel drive has been selected at vehicle speeds below 18 mph with light throttle opening.

## Functions of ECT ECU

### Control of Shift Timing

The components which make up this system include:

- OD main switch
- OD Off indicator light
- ECT ECU
- Water temperature sensor
- Cruise control ECU
- No. 1 and No. 2 solenoid valves (shift solenoids)



The ECU controls No. 1 and No. 2 solenoid valves based on vehicle speed, throttle opening angle and mode select switch position.

The ECT ECU prevents an upshift to overdrive under the following conditions:

- Water temperature is below 122°F to 146°F\*.
- Cruise control speed is 6 mph below set speed.
- OD main switch is off (contacts closed).

In addition to preventing the OD from engaging below a specific engine temperature, upshift to third gear is also prevented in the Supra and Cressida below 96°F and the V6 Camry below 100°F.

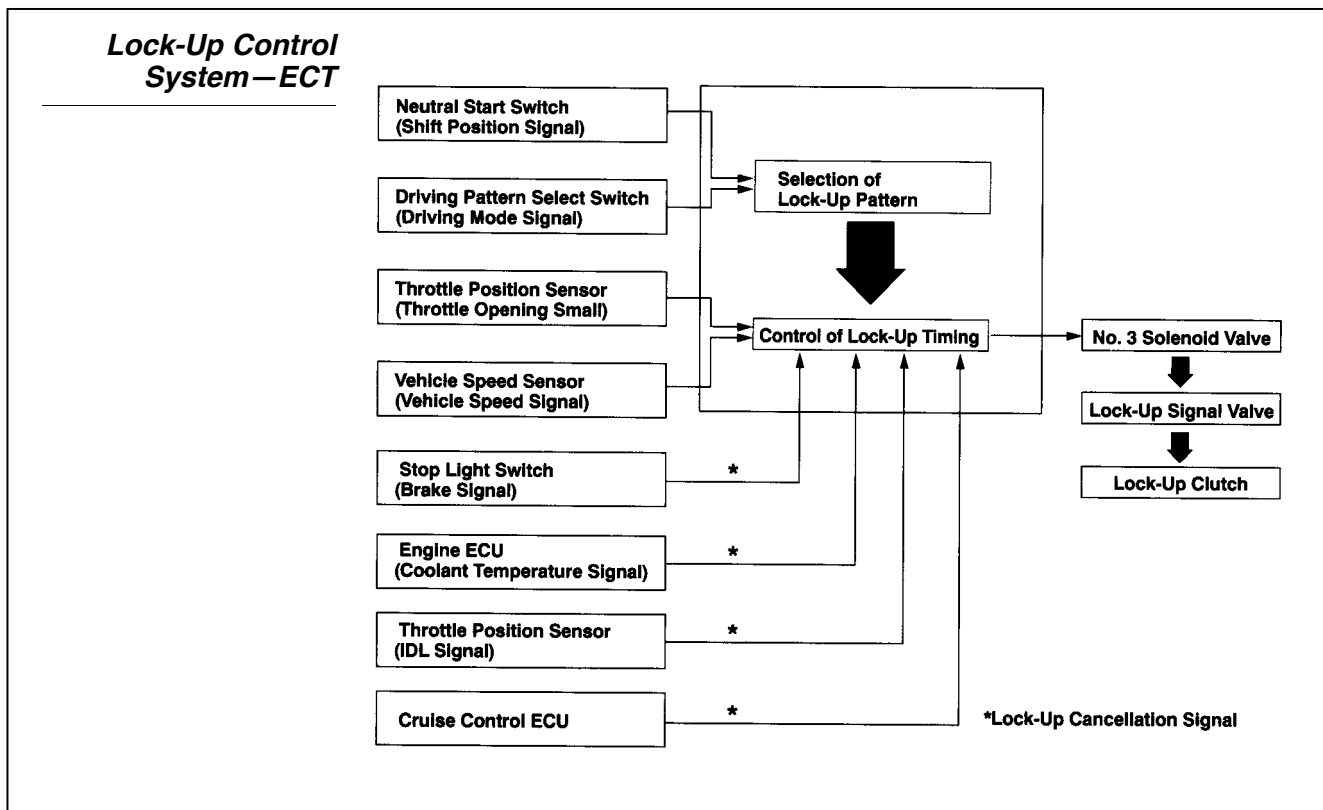
- \* Consult the specific repair manual or the ECT Diagnostic Information Technician Reference Card for the specific temperature at which overdrive is enabled.

**Control of Lock-Up** The ECT ECU has lock-up clutch operation pattern for each driving mode (Normal and Power) programmed in its memory. The ECU turns the No. 3 solenoid valve on or off according to vehicle speed and throttle opening signals. The lock-up control valve changes the fluid passages for the converter pressure acting on the torque converter piston to engage or disengage the lock-up clutch.

In order to turn on solenoid valve No. 3 to operate the lock-up system, the following three conditions must exist simultaneously:

- The vehicle is traveling in second, third, or overdrive ("D" range).
- Vehicle speed is at or above the specified speed and the throttle opening is at or above the specified value.
- The ECU has received no mandatory lock-up system cancellation signal.

The ECU controls lock-up timing in order to reduce shift shock. If the transmission up-shifts or down-shifts while the lock-up is in operation, the ECU deactivates the lock-up clutch.



The ECU will cancel lock-up if any of the following conditions occur:

- The stop light switch comes on.
- The coolant temperature is below 122°F to 145°F depending on the model. Consult the vehicle repair manual or the ECT Diagnostic Information Technician Reference Card.
- The IDL contact points of the throttle position sensor close.

The vehicle speed drops about 6 mph or more below the set speed while the cruise control system is operating.

The stop light switch and IDL contacts are monitored in order to prevent the engine from stalling in the event that the rear wheels lock up during braking. Coolant temperature is monitored to enhance drivability and transmission warm-up. The cruise control monitoring allows the engine to run at higher rpm and gain torque multiplication through the torque converter.

**Neutral to Drive  
Squat Control**

When the transmission is shifted from the neutral to the drive range, the ECU prevents it from shifting directly into first gear by causing it to shift into second or third gear before it shifts to first gear. It does this in order to reduce shift shock and squatting of the vehicle.

**Engine Torque  
Control**

To prevent shifting shock on some models, the ignition timing is retarded temporarily during gear shifting in order to reduce the engine's torque. The TCCS and ECT ECU monitors engine speed signals (Ne) and transmission output shaft speed (No. 2 speed sensor) then determines how much to retard the ignition timing based on shift pattern selection and throttle opening angle.

**Fail-Safe Operation**

The ECT ECU has several fail-safe functions to allow the vehicle to continue operating even if a malfunction occurs in the electrical system during driving. The speed sensor fail-safe has already been discussed on page 169 of this book.

**Solenoid Valve Back-Up Function**

In the event that the shift solenoids malfunction, the ECU can still control the transmission by operating the remaining solenoid to put the transmission in a gear that will allow the vehicle to continue to run.

The chart below identifies the gear position the ECU places the transmission if a given solenoid should fail. Notice that if the ECU was not equipped with fail-safe, the items in parenthesis would be the normal operation. But because the ECU senses the failure, it modifies the shift pattern so the driver can still drive the vehicle. For example, if No. 1 solenoid failed, the transmission would normally go to overdrive in drive range first gear. But instead, No. 2 solenoid turned it on to give 3rd gear.

**Solenoid Valve Back-Up Function Chart**

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 lever is manually operated
	NO. 1	NO. 2		NO. 1	NO. 2		NO. 1	NO. 2		
"D"	ON	OFF	1st	x	ON (OFF)	3rd (O/D)	ON	x	1st	O/D
	ON	ON	2nd	x	ON	3rd	OFF (ON)	x	O/D (1st)	O/D
	OFF	ON	3rd	x	ON	3rd	OFF	x	O/D	O/D
	OFF	OFF	O/D	x	OFF	O/D	OFF	x	O/D	O/D
"2"	ON	OFF	1st	x	ON (OFF)	3rd (O/D)	ON	x	1st	3rd*
	ON	ON	2nd	x	ON	3rd	OFF (ON)	x	3rd* (1st)	3rd*
	OFF	ON	3rd	x	ON	3rd	OFF	x	3rd*	3rd*
"L"	ON	OFF	1st	x	OFF	1st	ON	x	1st	1st
	ON	ON	2nd	x	ON	2nd	ON	x	1st	1st

( ): If no fail-safe function were provided x: Malfunctions

\*O/D in the A540E, A540H

Should both solenoids malfunction, the driver can still safely drive the vehicle by operating the shift lever manually.