## 9. Engine Control System

### General

The engine control system has been changed from that of the ’97 LS400 in the areas described below.

- The VVT-i, ETCS-i, and ACIS systems have been adopted.
- The cruise control system and the engine immobiliser system have been integrated with the ECM.
- A function to communicate with the multiplex communication system has been added.

The engine control system of the 1UZ-FE engine in the ’98 LS400 and ’97 LS400 are compared below.

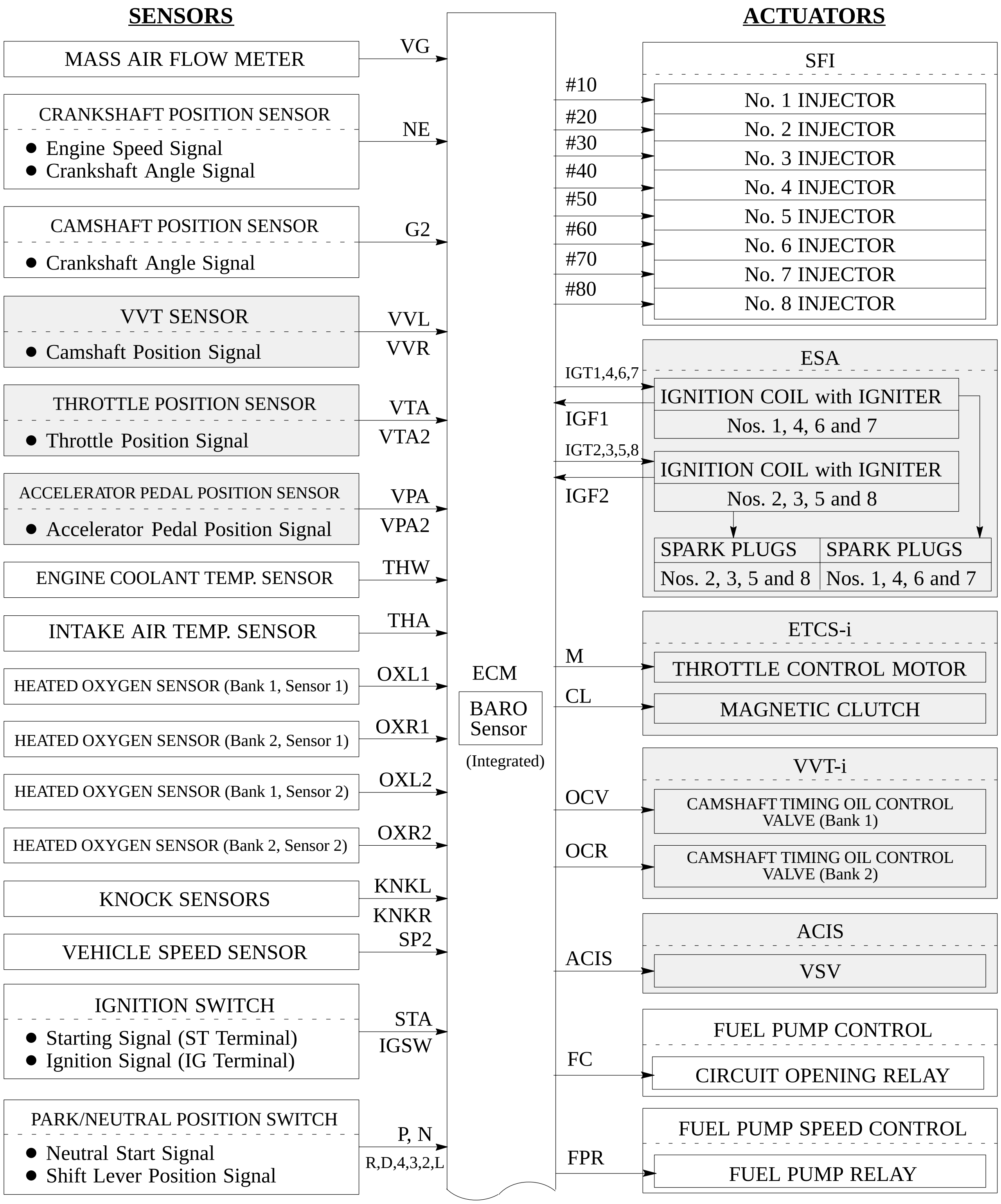
| System | Outline | ’98 LS400 | ’97 LS400 |
|---|---|---|---|
| SFI (Sequential Multiport Fuel Injection) | A L-type SFI system directly detects the intake air volume with a hot-wire type mass air flow meter. | ○ | ○ |
| | The fuel injection system is a sequential multiport fuel injection system. | ○ | ○ |
| ESA (Electronic Spark Advance) | Ignition timing is determined by the ECM based on signals from various sensors. Corrects ignition timing in response to engine knocking. | ○ | ○ |
| | The torque control correction during gear shifting has been used to minimize the shift shock. | ○ | ○ |
| | 2 knock sensors are used to further improve knock detection. | ○ | ○ |
| IAC (Idle Air Control) | A step motor type IAC system controls the fast idle and idle speeds. | — | ○ |
| VVT-i (Valiable Valve Timing-intelligent) | Controls the intake camshaft to an optimal valve timing in accordance with the engine condition. | ○ | — |
| ETCS-i (Electronic Throttle Control System-intelligent) | Optimally controls the throttle valve opening in accordance with the amount of the accelerator pedal effort, and the conditions of the engine and the vehicle, and comprehensively controls the ISC, cruise control, and the VSC system. | ○ | — |
| ACIS (Acoustic Control Induction System) | The intake air passages are switched according to the engine speed and throttle valve opening angle to provide high performance in all speed ranges. | ○ | — |
| Fuel Pump Control | Under light engine loads, pump speed is low to reduce electric power loss. | ○ | ○ |
| Fuel Pressure Control | In hot engine condition, the fuel pressure is increased to improve restartability. | — | ○ |
| Oxygen Sensor Heater Control | Maintains the temperature of the oxygen sensor at an appropriate level to increase accuracy of detection of the oxygen concentration in the exhaust gas. | ○ | ○ |
| Air Conditioning Cut-Off Control | By controlling the air conditioning compressor ON or OFF in accordance with the engine condition, drivability is maintained. | ○ | ○ |
| EGR Control | Drives the EGR valve with step motor, controlling the EGR volume in accordance with the engine conditions. | — | ○ |

(Continued)

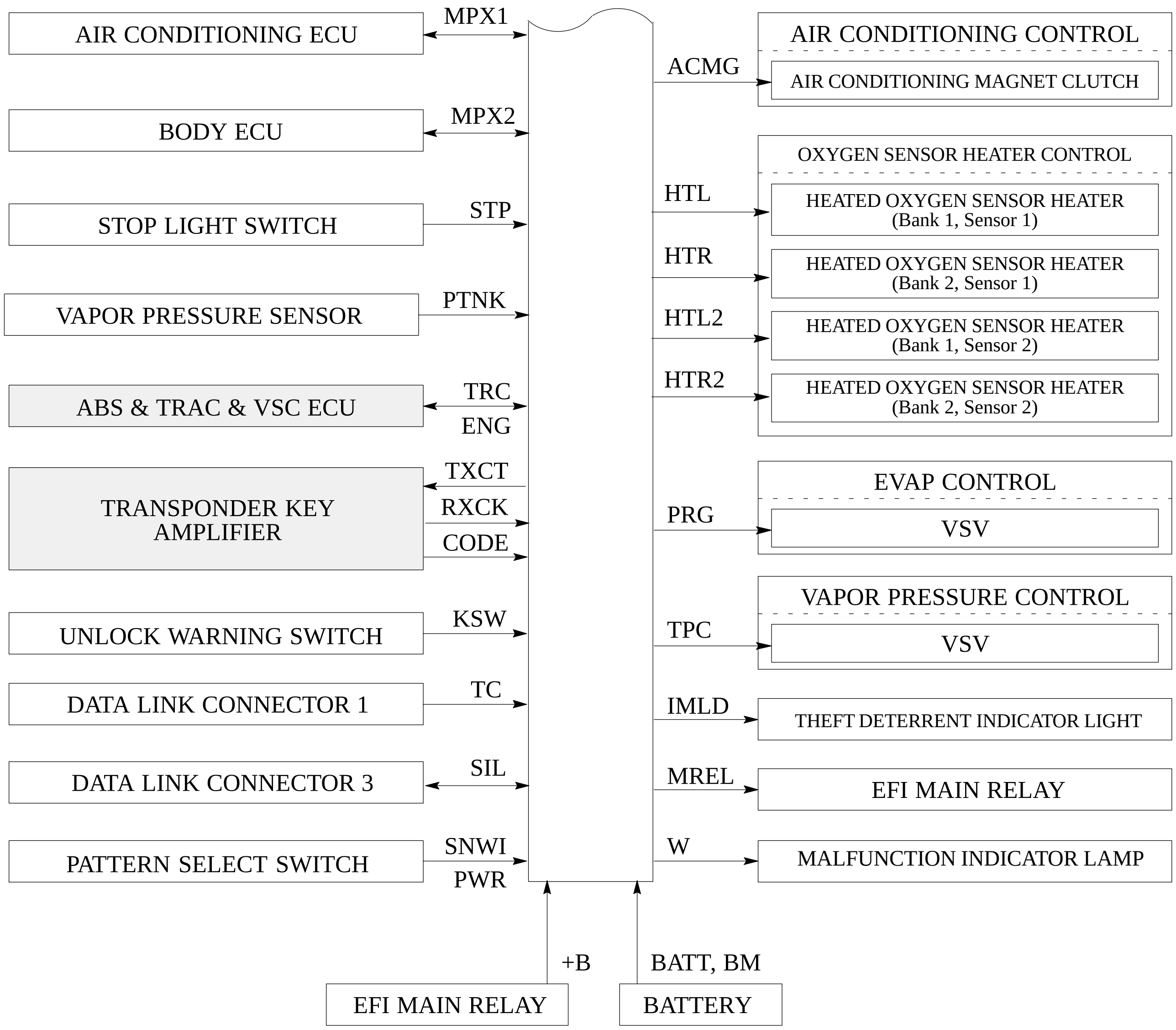
| System | Outline | ’98 LS400 | ’97 LS400 |
|---|---|---|---|
| Evaporative Emission Control | The ECM controls the purge flow of evaporative emissions (HC) in the charcoal canister in accordance with engine conditions. | ○ | ○ |
| Engine Immobiliser | Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid ignition key. | ○ | ○ |
| Function to communicate with multiplex communication system | Communicates with the body ECU, A/C ECU, etc., on the body side, to input/output necessary signals. | ○ | — |
| Diagnosis | When the ECM detects a malfunction, the ECM diagnoses and memorizes the failed section. | ○ | ○ |
| | The diagnosis system includes a function that detects a malfunction in the evaporative emission control system. | ○ | ○ |
| Fail-Safe | When the ECM detects a malfunction, the ECM stops or controls the engine according to the data already stored in the memory. | ○ | ○ |

## Construction

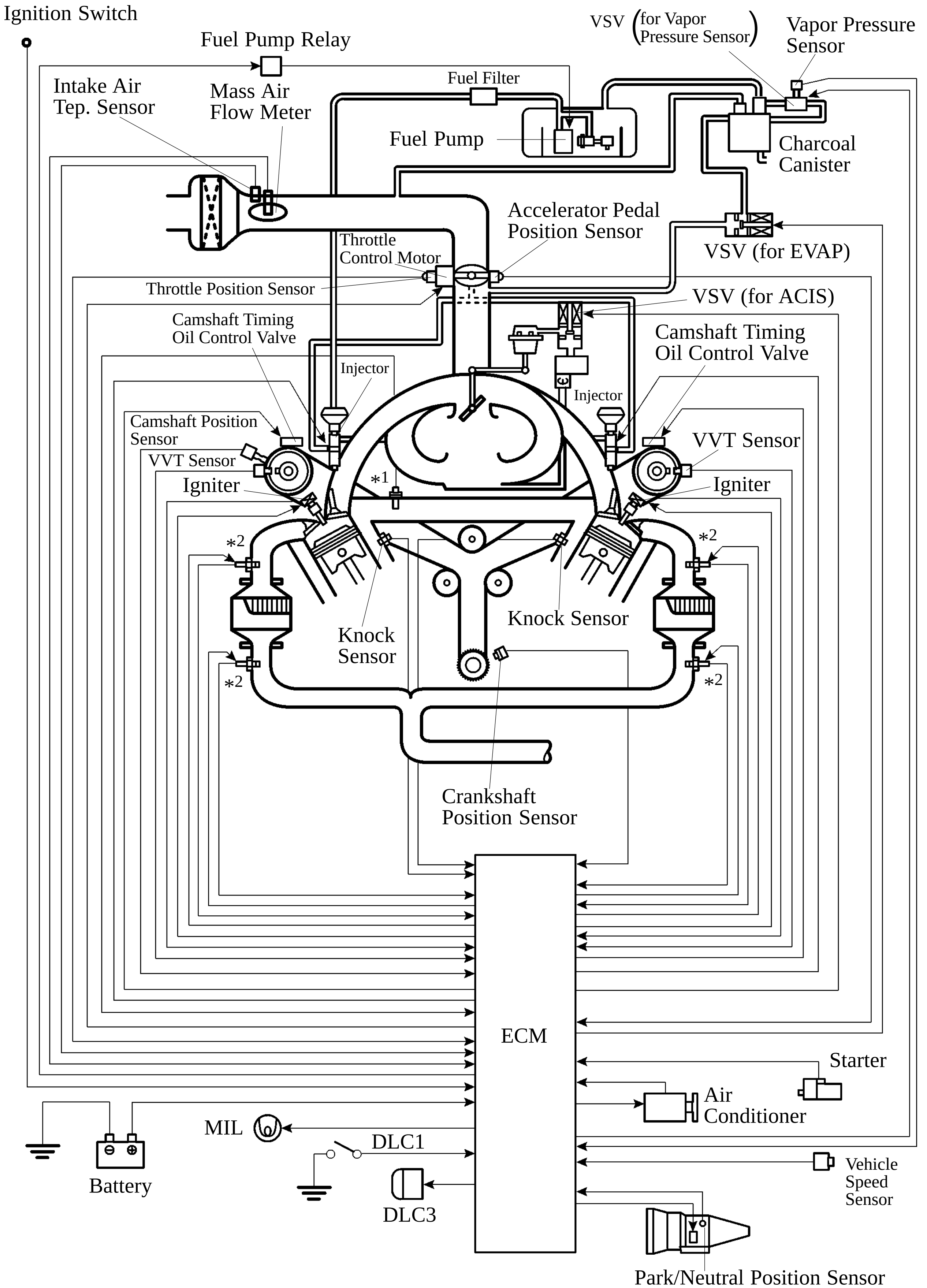
The configuration of the engine control system in the 1UZ-FE engine of the '98 LS400 is as shown in the following chart. Shaded portions [ ] differ from the 1UZ-FE engine of the '97 LS400.




(Continued)


AIR CONDITIONING ECU
MPX1
BODY ECU
MPX2
STOP LIGHT SWITCH
STP
VAPOR PRESSURE SENSOR
PTNK
ABS & TRAC & VSC ECU
TRC
ENG
TRANSPONDER KEY AMPLIFIER
TXCT
RXCK
CODE
UNLOCK WARNING SWITCH
KSW
DATA LINK CONNECTOR 1
TC
DATA LINK CONNECTOR 3
SIL
PATTERN SELECT SWITCH
SNWI
PWR
ACMG
AIR CONDITIONING CONTROL
AIR CONDITIONING MAGNET CLUTCH
OXYGEN SENSOR HEATER CONTROL
HTL
HEATED OXYGEN SENSOR HEATER (Bank 1, Sensor 1)
HTR
HEATED OXYGEN SENSOR HEATER (Bank 2, Sensor 1)
HTL2
HEATED OXYGEN SENSOR HEATER (Bank 1, Sensor 2)
HTR2
HEATED OXYGEN SENSOR HEATER (Bank 2, Sensor 2)
EVAP CONTROL
PRG
VSV
VAPOR PRESSURE CONTROL
TPC
VSV
IMLD
THEFT DETERRENT INDICATOR LIGHT
MREL
EFI MAIN RELAY
W
MALFUNCTION INDICATOR LAMP
+B
EFI MAIN RELAY
BATT, BM
BATTERY

### Engine Control System Diagram




*1: Engine Coolant Temp. Sensor
*2: Heated Oxygen Sensor

151EG06

## Main Components of Engine Control System

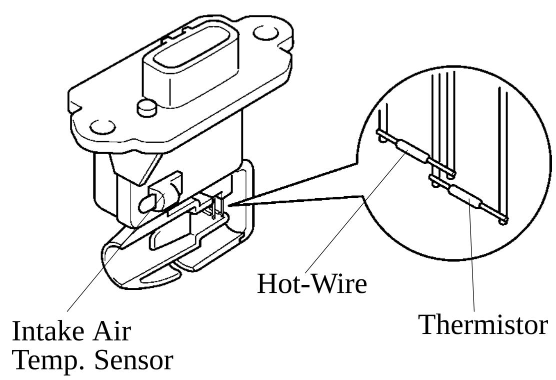
### 1) General

The following table compares the main components of the 1UZ-FE engine in the ’98 LS400 and ’97 LS400.

| 1UZ-FE Engine / Components | ’98 LS400 | ’97 LS400 |
|---|---|---|
| Mass Air Flow Meter | Hot-Wire Type | ← |
| Crankshaft Position Sensor | Pick-Up Coil Type, 1 | ← |
| Camshaft Position Sensor | Pick-Up Coil Type, 1 | Pick-Up Coil Type, 2 |
| VVT Sensor | Pick-Up Coil Type, 2 | — |
| Throttle Position Sensor | Linear Type, 2 | Linear Type, 1 |
| Accelerator Pedal Position Sensor | Linear Type, 2 | — |
| Knock Sensor | Built-In Piezoelectric Type, 2 | ← |
| Oxygen Sensor | Heated Oxygen Sensor (Bank 1, Sensor 1) (Bank 2, Sensor 1) (Bank 1, Sensor 2) (Bank 2, Sensor 2) | ← |
| Injector | 4-Hole Type with Air Assist | 2-Hole Type without Air Assist |
| IAC Valve | — | Step Motor Type |

### 2) Mass Air Flow Meter

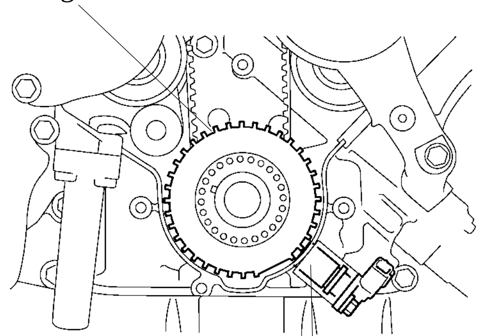
The hot wire type mass air flow meter has been changed to the plug-in type. Its basic operation is the same as that of the previous type.




150EG29

**3) Crankshaft Position Sensor**

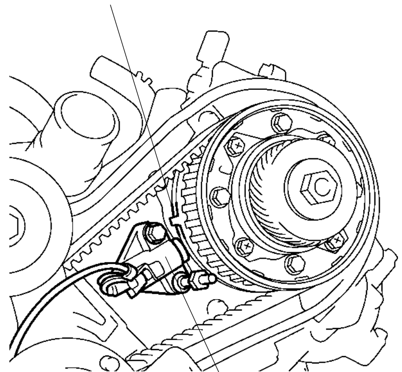
The timing rotor of the crankshaft position sensor has been changed from the previous 12 teeth to 34 teeth, with 2 teeth missing. It detects the crankshaft angle at 10° intervals.




151EG18

**4) Camshaft Position Sensor**

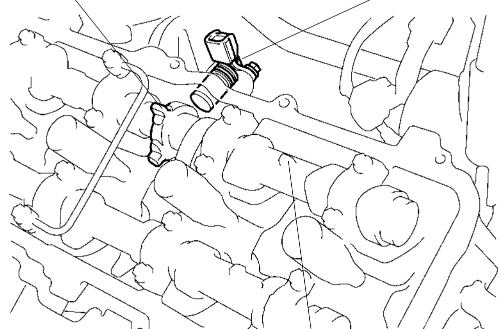
The camshaft position sensor is mounted on the left bank cylinder head. To detect the camshaft position, a protrusion that is provided on the timing pulley is used to generate 1 pulse for every 2 revolutions of the crankshaft.




151EG19

**5) VVT Sensor**

A VVT sensor is mounted on the intake side of each cylinder head. To detect the camshaft position, a timing rotor that is provided on the intake camshaft is used to generate 3 pulses for every 2 revolutions of the crankshaft.

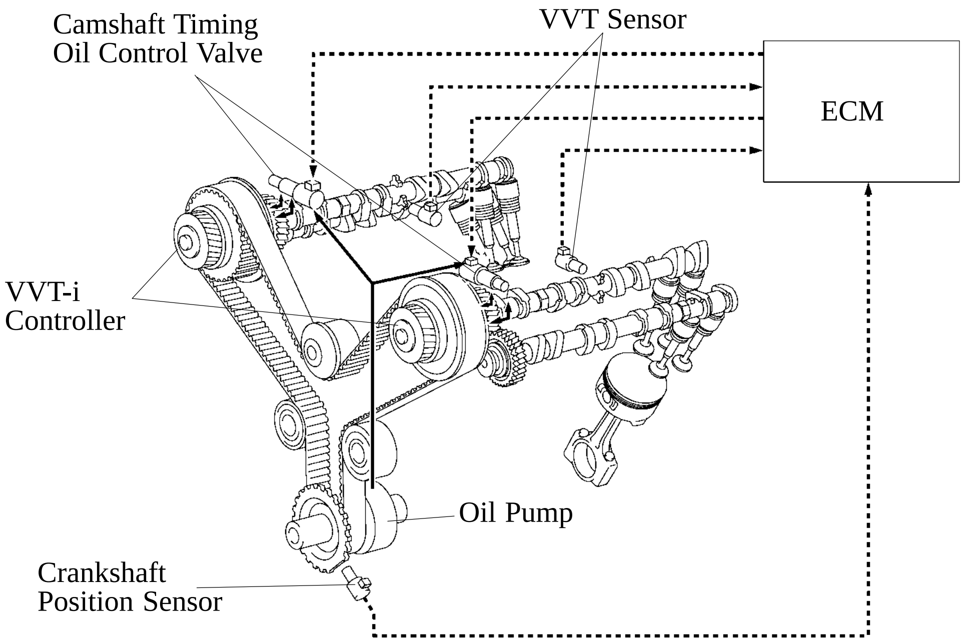



151EG20

## VVT-i (Valiable Valve Timing-intelligent) System

### 1) General

The VVT-i system is designed to control the intake camshaft within a wide range of 50° (of crankshaft angle) to provide a valve timing that is optimally suited to the engine condition, thus realizing improved torque in all the speed ranges and fuel economy, and exhust emissions.

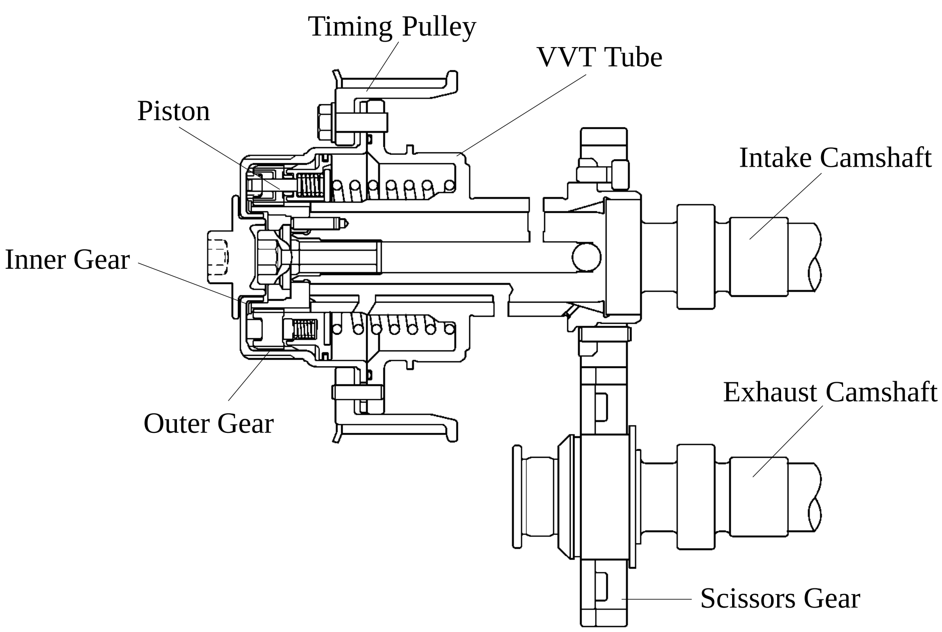



151EG27

### 2) Construction and Operation

#### a. VVT-i Controller

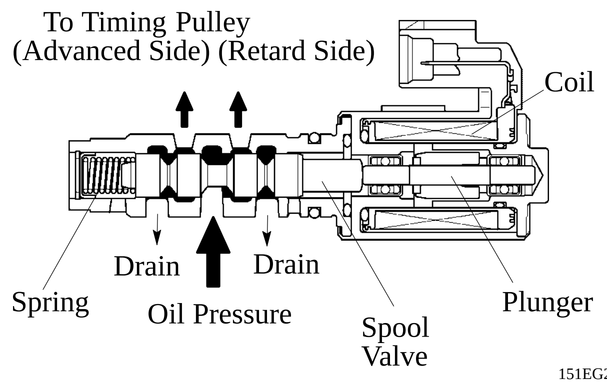
The VVT-i Controller comprises the outer gear that is driven by the timing belt, the inner gear that is affixed to the camshaft and a movable piston that is placed between the outer gear and inner gear. Having helical splines (twisted, vertical grooves) on its inner and outer periphery, the piston moves in the axial direction to shift the phase of the outer gear and inner gear, thus causing the valve timing to change continuously.
The VVT tube drives the exhaust camshaft via the scissors gear that is installed on the back.




151EG29

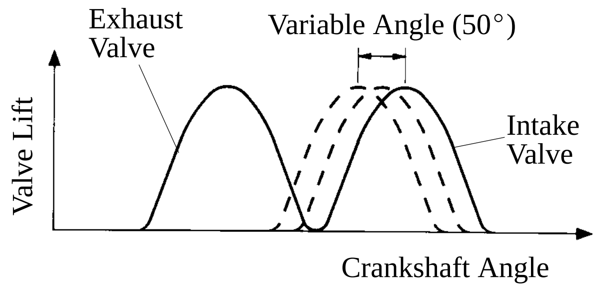
**b. Camshaft Timing Oil Control Valve**

- The camshaft timing oil control valve controls the spool valve position in accordance with the command of the ECM thus allocating the hydraulic pressure that is applied to the intake camshaft timing pulley to the advance and the retard side. When the engine is stopped, the camshaft timing oil control valve is in the most retarded state.




151EG28

- By the command of the ECM, when the camshaft timing oil control valve is in the position given in Fig. 1, hydraulic pressure is applied from the left side of the piston, which causes the piston to move to the right. Because of the twist in the helical splines that are cut out in the piston, the intake camshaft rotates in the advance direction in relation to the camshaft timing pulley. When the camshaft timing oil control valve is in the position given in Fig. 2, the piston moves to the left and rotates in the retard direction. Furthermore, the camshaft timing oil control valve shuts off the oil passages to maintain the hydraulic pressure at both sides of the piston, thus maintaining the phase at that position. This enables the phase to be set to a desired position.




Valve Timing

150EG31

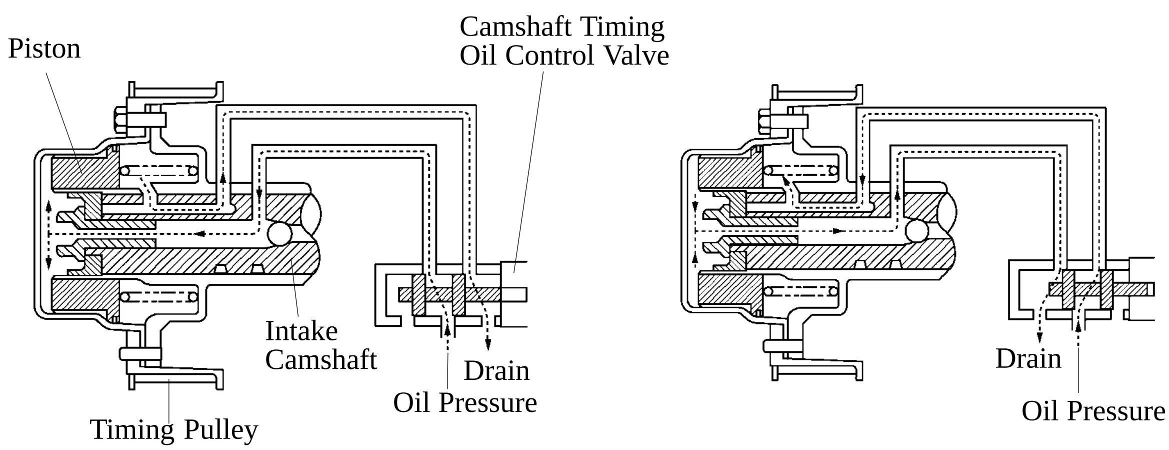


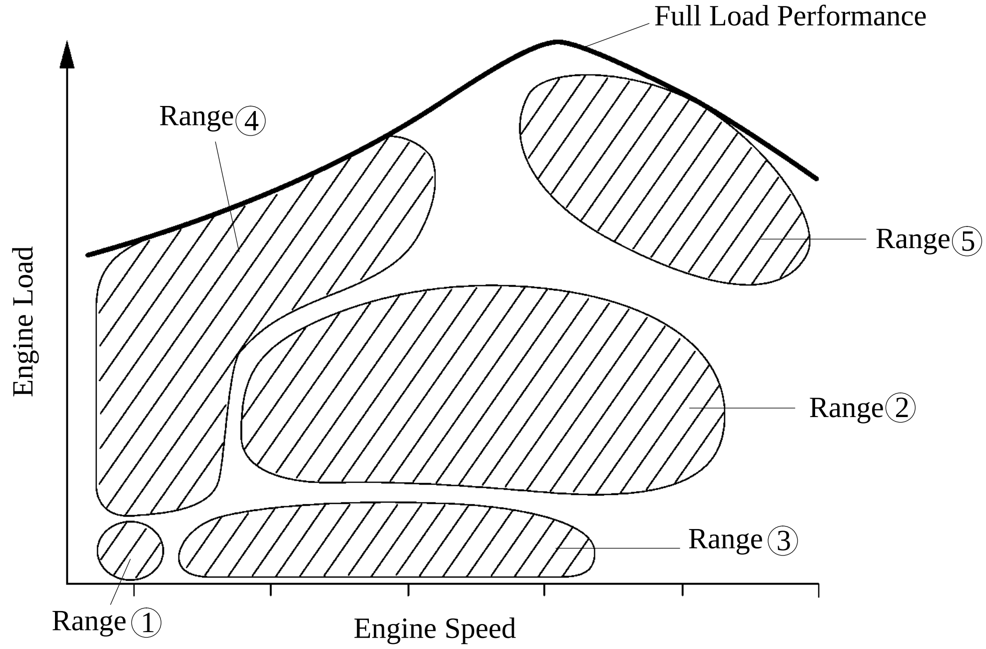

**Fig. 1** **Fig. 2**

151EG08 151EG09

### c. ECM

In proportion to the engine speed, intake air volume, throttle position and coolant temperature, the ECM searches an optimal valve timing under each driving condition and control the camshaft timing oil control valve. In addition, the ECM uses signal from the VVT sensors and the crankshaft position sensor to detect the actual valve timing, thus performing feedback control to achieve the target valve timing.

**▶ Operation During Various Driving Conditions ◀**



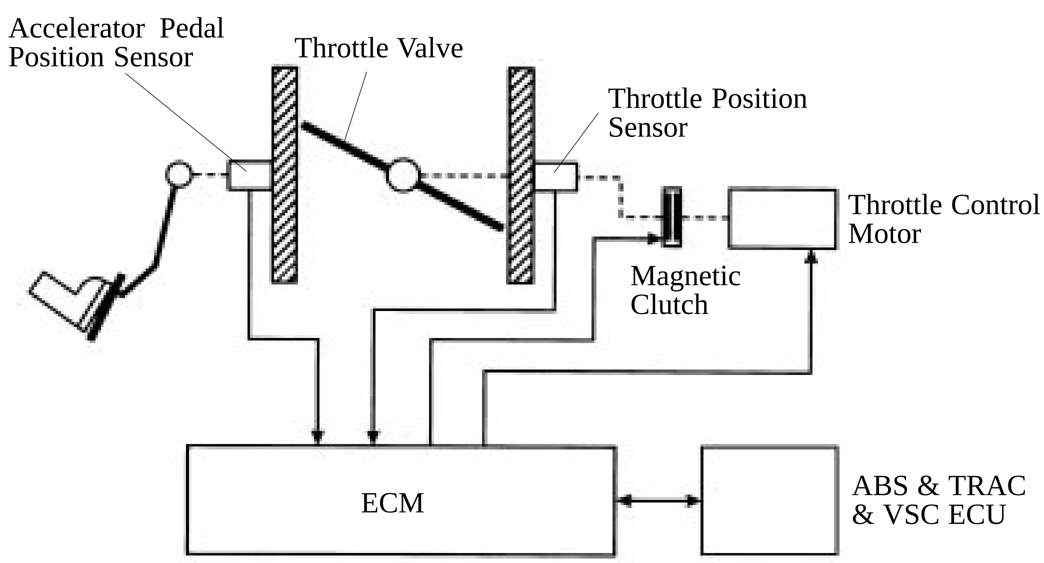

150EG74

| Range | Conditions | Operation |
|---|---|---|
| ① | Idle Operation | The valve timing is set to the advance angle 0° (most retarded angle), and because of the lack of overlap, the idle rpm is stabilized. |
| ② | Medium load range | The valve timing is advanced to increase the amount valve overlap. Thus, the internal EGR rate is increased and the pumping loss is decreased resulting in improved fuel economy. |
| ③ | Low load range | The valve timing is retarded to decrease the amount of valve overlap, thus ensuring the engine's stability. |
| ④ | High load, low-to medium-speed range | The valve timing is advanced to advance the timing of the closing of the intake valve. The volumetric efficiency is thus improved resulting in improved low-to medium-speed range torque. |
| ⑤ | High load, high speed range | The valve timing is retarded to retard the timing of the closing of the intake valve resulting in improved volumetric in the high-speed range. |
| — | Engine started and stopped | When the engine is started and stopped, the valve timing is at the most retarded state. |
| — | High load at low temperature | The valve timing is fixed to the advanced side to quicken the timing of the intake valve closure, thus improving the volumetric efficiency and torque. |

## ETCS-i (Electronic Throttle Control System-intelligent)

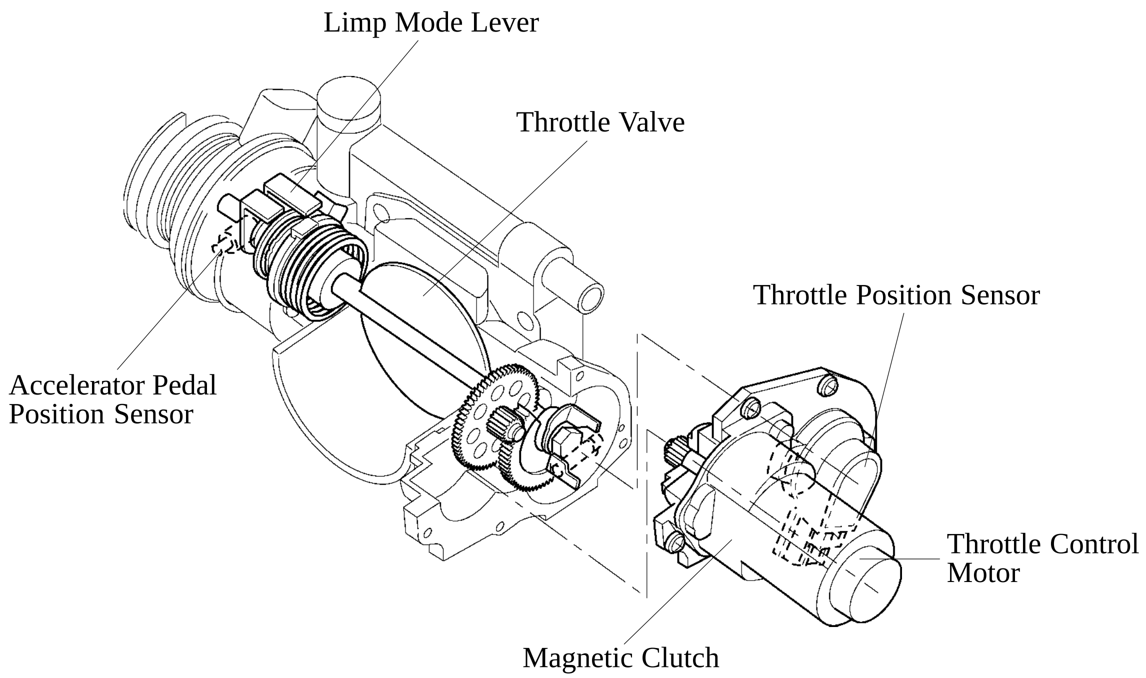
### 1) General

- The ETCS-i system, which realizes excellent throttle control in all the operating ranges, has been adopted.
- In the conventional throttle body, the throttle valve opening is determined invariably by the amount of the accelerator pedal effort. In contrast, the ETCS-i uses the ECM to calculate the optimal throttle valve opening that is appropriate for the respective driving condition and uses a throttle control motor to control the opening.
- The ETCS-i controls the ISC (Idle Speed Control) system, the cruise control system, and the VSC (Vehicle Skid Control).
- A duplicate system is provided to ensure a high level of reliability, and the system shuts off in case of an abnormal condition. Even when the system is shut off, the accelerator pedal can be used to operate the vehicle in the limp mode.




150EG41

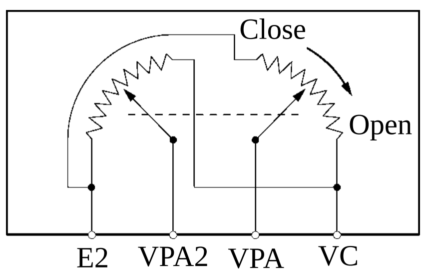
**2) Construction**



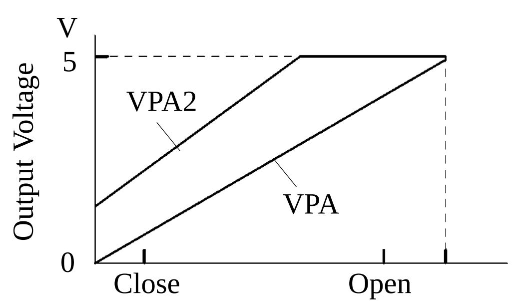

151EG01

**a. Accelerator Pedal Position Sensor**

The accelerator pedal position sensor, which is mounted on the throttle body, is integrated with the throttle lever, which is connected to the cable that extends from the accelerator pedal.
The accelerator pedal position sensor converts the amount of accelerator pedal effort into two types of electrical signals with distinct output characteristics. The signals are then input into the ECM.




150EG40




150EG39

Accelerator Pedal Depressed Angle

**b. Throttle Position Sensor**

The throttle position sensor converts the throttle valve opening into an electrical signal and inputs into the ECM. The output characteristics are the same as those of the accelerator position pedal sensor.

**c. Throttle Control Motor**

A DC motor with excellent response and minimal power consumption is used for the throttle control motor. The ECM performs the duty ratio control of the direction and the amperage of the current that flows to the throttle control motor in order to regulate the opening of the throttle valve.

**d. Magnetic Clutch**

Ordinarily, the magnetic clutch engages the clutch to enable the throttle control motor to open and close the throttle valve. In case that a malfunction occurs in the system, this clutch is disengaged to prevent the throttle control motor to open and close the throttle valve.

**3) Operation**

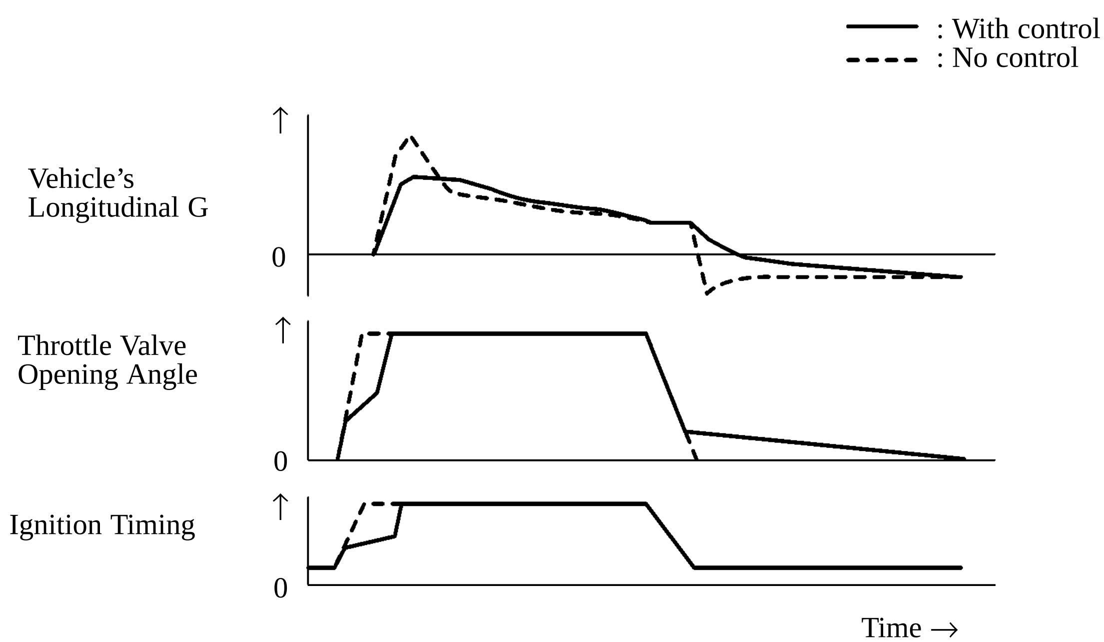
The ECM drives the throttle control motor by determining the target throttle valve opening in accordance with the respective operating condition.

a. Non-linear Control
b. Idle Speed Control
c. Shift Shock Reduction Control
d. TRAC Throttle Control
e. VSC Coordination Control
f. Cruise Control

**a. Non-linear Control**

- Controls the throttle to an optimal throttle valve opening that is appropriate for the driving condition such as the amount of the accelerator pedal effort and the engine rpm in order to realize excellent throttle control and comfort in all operating ranges.

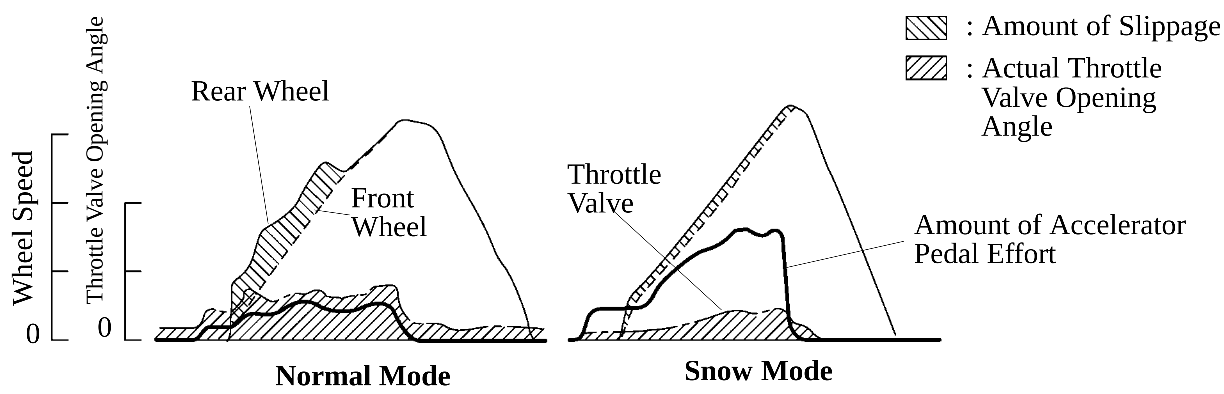
**▶ Control Examples During Acceleration and Deceleration ◀**




150EG37

- In situations in which low-μ surface conditions can be anticipated, such as when driving in the snow, the throttle valve can be controlled to help vehicle stability while driving over the slippery surface. This is accomplished by turning ON the SNOW switch, which, in response to the amount of the accelerator pedal effort that is applied, reduces the engine output from that of the normal driving level.

**▶ Control Example During Startoff Acceleration in 1st Gear on Packed Snow Surface (TRAC OFF) ◀**




151EG40

**b. Shift Shock Reduction Control**

The throttle control is synchronized to the ECT (Electronically Controlled Transmission) control during the shifting of the transmission in order to reduce the shift shock.

**c. Idle Speed Control**

Previously, a step motor type IAC valve was used to perform idle speed control such as fast idle during cold operating conditions and idle-up. In conjunction with the adoption of the ETCS-i, idle speed control is now performed by the throttle control motor, which controls the throttle valve opening.

**d. TRAC Throttle Control**

As part of the TRAC system, the throttle valve is closed by a demand signal from the ABS & TRAC & VSC ECU if an excessive amount of slippage is created at a driving wheel, thus facilitating the vehicle in ensuring stability and driving force.

**e. VSC Coordination Control**

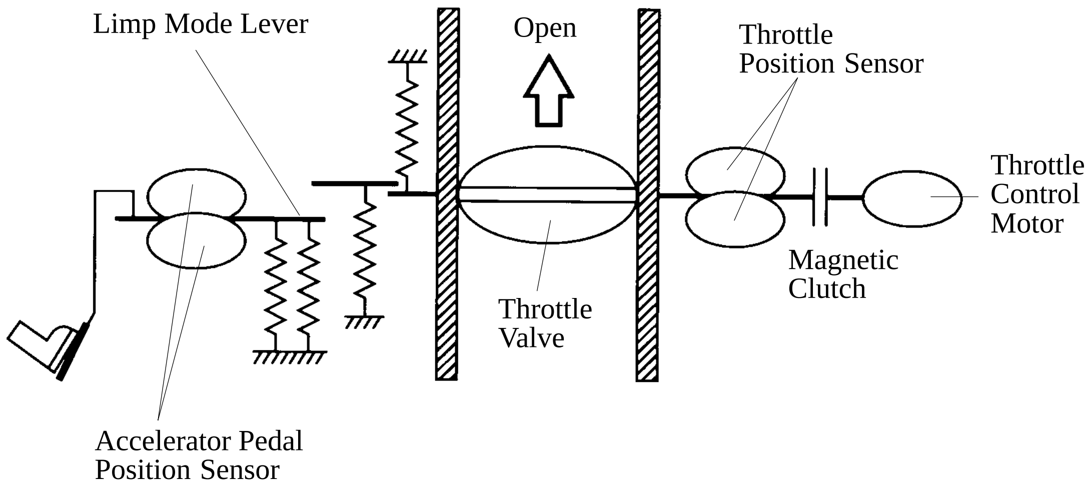
In order to bring the effectiveness of the VSC system control into full play, the throttle valve opening angle is controlled by effecting a coordination control with the ABS & TRAC & VSC ECU.

**f. Cruise Control**

Previously, the vehicle speed was controlled by the cruise control actuator, which opened and closed the throttle valve. Along with the adoption of the ETCS-i, the vehicle speed is now controlled by the throttle control motor, which controls the throttle valve.

#### 4) Fail-Safe

If an abnormal condition occurs with the ETCS-i, the MIL illuminates to alert the driver. At the same time, the current to the throttle control motor and magnetic clutch are cut off in order not to operate the ETCS-i. This enables the return spring to close the throttle valve.
Even in this situation, the accelerator pedal can be used to operate the limp mode lever, which operates the throttle valve to enable the vehicle to be driven in the limp mode.




150EG42

#### 5) Diagnosis

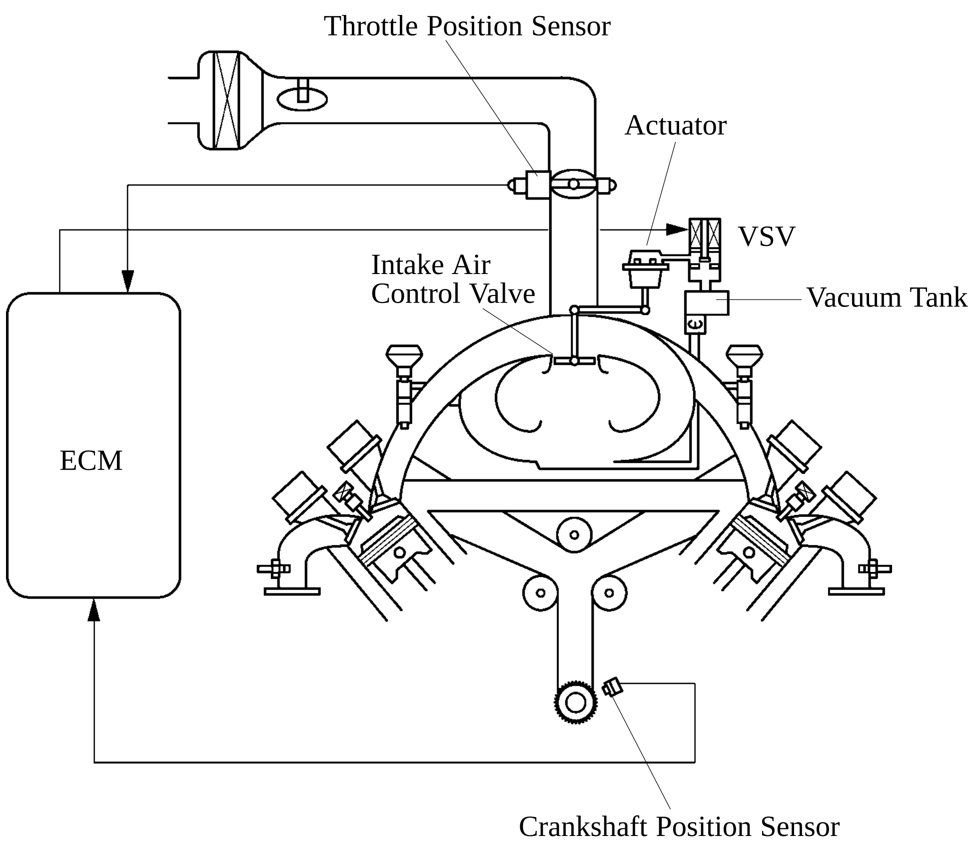
The diagnostic trouble codes can be output via DLC3 to an OBD-II scan tool or a hand-held tool. For details, refer to the ’98 LS400 Repair Manual (Pub. No. RM578U).

## ACIS (Acoustic Control Induction System)

### 1) General

The ACIS (Acoustic Control Induction System) is realized by using a bulkhead to divide the intake manifold into 2 stages, with an intake air control valve in the bulkhead being opened and closed to vary the effective length of the intake manifold in accordance with the engine speed and throttle valve opening angle. This increases the power output in all ranges from low to high speed.

**▶ System Diagram ◀**

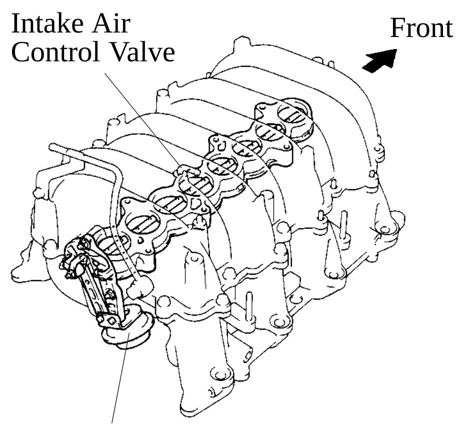



151EG13

### 2) Construction

#### a. Intake Air Control Valve

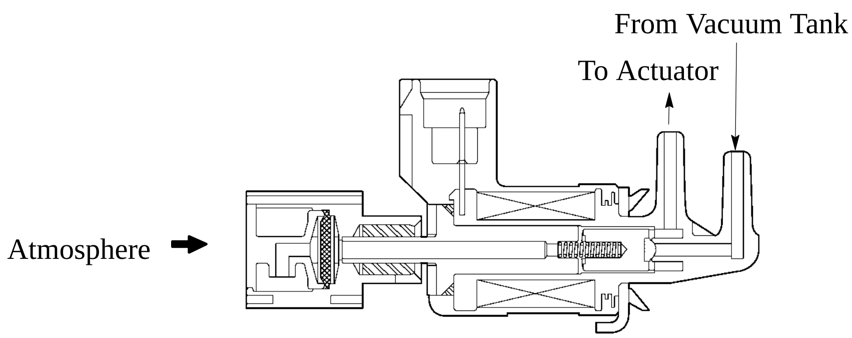
The intake air control valve, which is provided in the middle of the intake manifold in the intake air chamber, opens and closes to change the effective length of the intake manifold in two stages.




151EG11

#### b. VSV (Vacuum Switching Valve)

Controls the vacuum that is applied to the actuator by way of the signal (ACIS) that is output by the ECM.




151EG42

#### c. Vacuum Tank

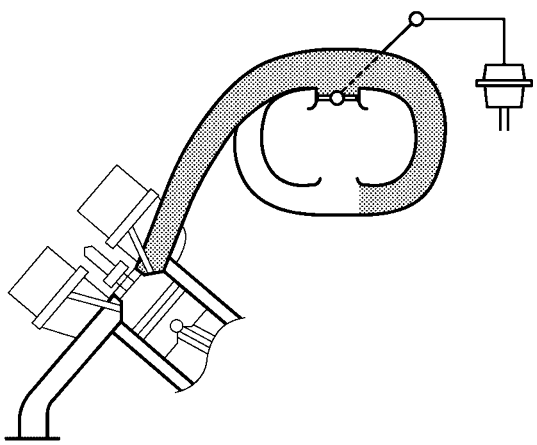
Equipped with an internal check valve, the vacuum tank stores the vacuum that is applied to the actuator in order to maintain the intake air control valve fully closed even during low-vacuum conditions.

### 3) Operation

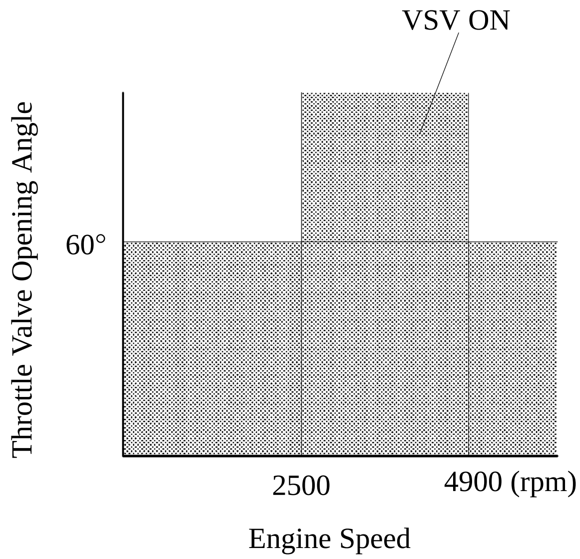
#### a. When the Intake Control Valve Closes (VSV ON)

The ECM activates the VSV to match the longer pulsation cycle so that the negative pressure acts on the diaphragm chamber of the actuator. This closes the control valve. As a result, the effective length of the intake manifold is lengthened and the intake efficiency in the low-to-medium speed range is improved due to the dynamic effect of the intake air, thereby increasing the power output.

: Effective Intake Manifold Length



151EG14

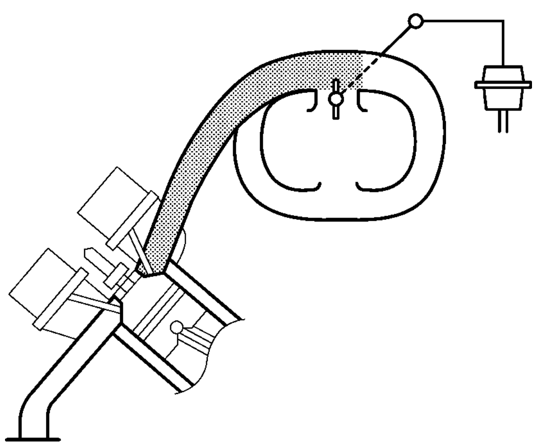



151EG16

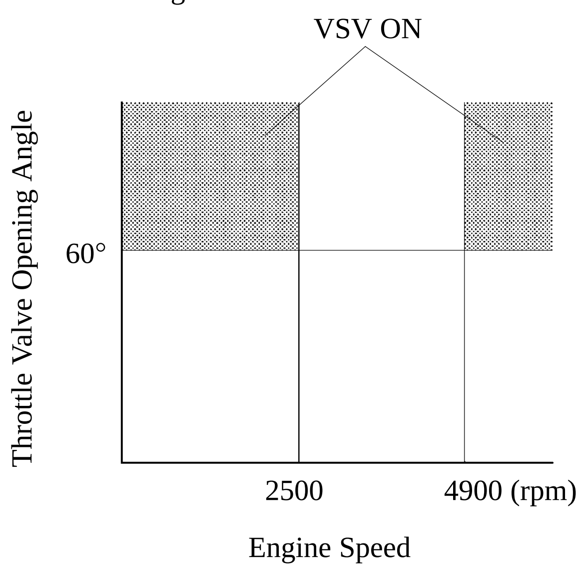
#### b. When the Intake Control Valve Open (VSV OFF)

The ECM deactivates the VSV to match the shorter pulsation cycle so that the atmospheric air is led into the diaphragm chamber of the actuator and opens the control valve. When the control valve is open, the effective length of the intake air chamber is shortened and the peak intake efficiency is shifted to the high engine speed range, thus providing greater output at high engine speeds.

: Effective Intake Manifold Length



151EG15




151EG17

### Function to Communicate with Multiplex Communication System

The ECM communicates with the meter ECU, air conditioning ECU, body ECU, etc., of the multiplex communication system.

The main output signals from the ECM are as follows:

- Signals from the Indicator Lights in the Speedometer (Oil Pressure Signal, Oil Level Signal and Generator L Terninal Signal)
- Engine Coolant Temp. Signal
- Engine Speed Signal
- Signals related to the Air Conditioning System (Refrigerant Pressure Signal and Compressor Speed Signal)

The main input signals to the ECM are as follows:

- Air Conditioning Signal
- Electrical Load Signal (Taillight and Rear Window Defogger System)

### Engine Immobiliser System

The transponder key computer, which was previously separate, is now enclosed in the ECM. For details, see page 167.