

## 6. Engine Control System

### General

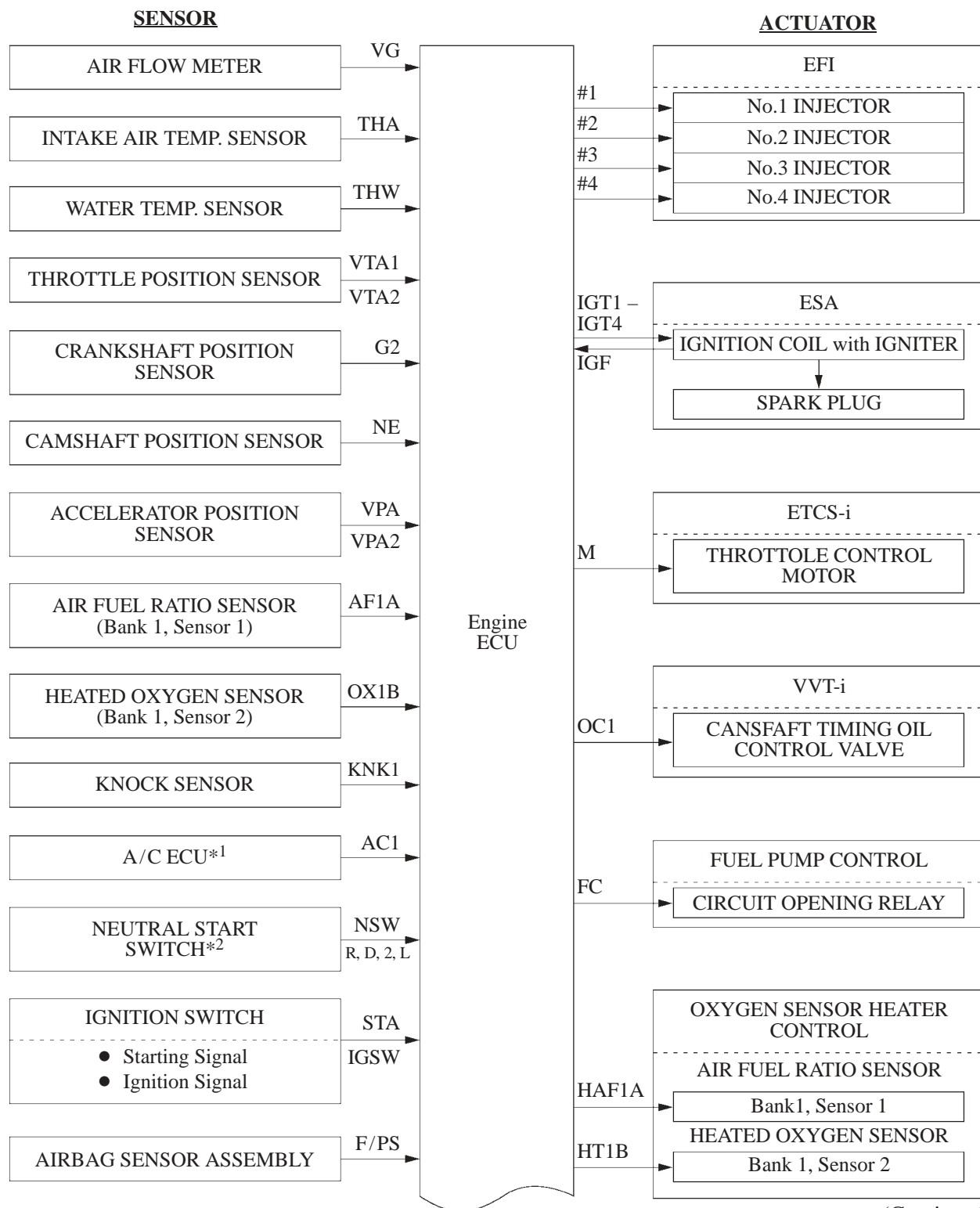
The engine control system of the 1AZ-FE engine of the new Avensis Verso has following system.

System	Outline	New	Previous
EFI ( Electronic Fuel Injection )	An L-type EFI system directly detects the intake air mass with a hot wire type mass air flow meter.	○	○
ESA ( Electronic Spark Advance )	Ignition timing is determined by the engine ECU based on signals from various sensors. The engine ECU corrects ignition timing in response to engine knocking.	○	○
ETCS-i ( Electronic Throttle Control System-intelligent ) (See page 174)	<ul style="list-style-type: none"> <li>● Optimally controls the throttle valve opening in accordance with the amount of accelerator pedal effort and the condition of the engine and the vehicle.</li> <li>● A link-less type is used, without an accelerator cable.</li> <li>● A contact type accelerator pedal position sensor is provided on the accelerator pedal.</li> <li>● A no-contact type throttle position sensor and accelerator pedal position sensor are used.</li> <li>● Controls the fast idle and idle speed.</li> </ul>	○	—
VVT-i ( Variable Valve Timing-intelligent )	Controls the intake camshaft to an optimal valve timing in accordance with the engine condition.	○	○
Air Fuel Ratio Sensor, Oxygen Sensor Heater Control	Maintains the temperature of the air fuel ratio sensor or oxygen sensor at an appropriate level to increase accuracy of detection of the oxygen concentration in the exhaust gas.	○	○
Air Conditioner Cut-off Control*	By turning the air conditioning compressor ON or OFF in accordance with the engine condition, drivability is maintained.	○	○
Cooling Fan Control System	Radiator cooling fan operation is controlled by water temperature sensor signal (THW) and the condition of the air conditioner operation.	○	○
Fuel Pump Control	Fuel pump operation is controlled by signal from the engine ECU.	○	○
	A fuel cut control is adopted to stop the fuel pump when the airbag is deployed during front or side collision.	○	○
Evaporative Emission Control	The engine ECU controls the purge flow of evaporative emission (HC) in the charcoal canister in accordance with engine conditions.	○	○
Engine Immobilizer	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid ignition key.	○	○
	The ID code stored in the transponder key ECU is compared with that of the transponder tip in the ignition key.	○	—
Diagnosis	When the engine ECU detects a malfunction, the engine ECU diagnoses and memorizes the failed section.	○	○
	All the DTCs (Diagnostic Trouble Codes) have been made to correspond to the SAE controlled codes.	○	—
Fail-Safe	When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the data already stored in the memory.	○	○

\*: With Air Conditioner Models.

## Construction

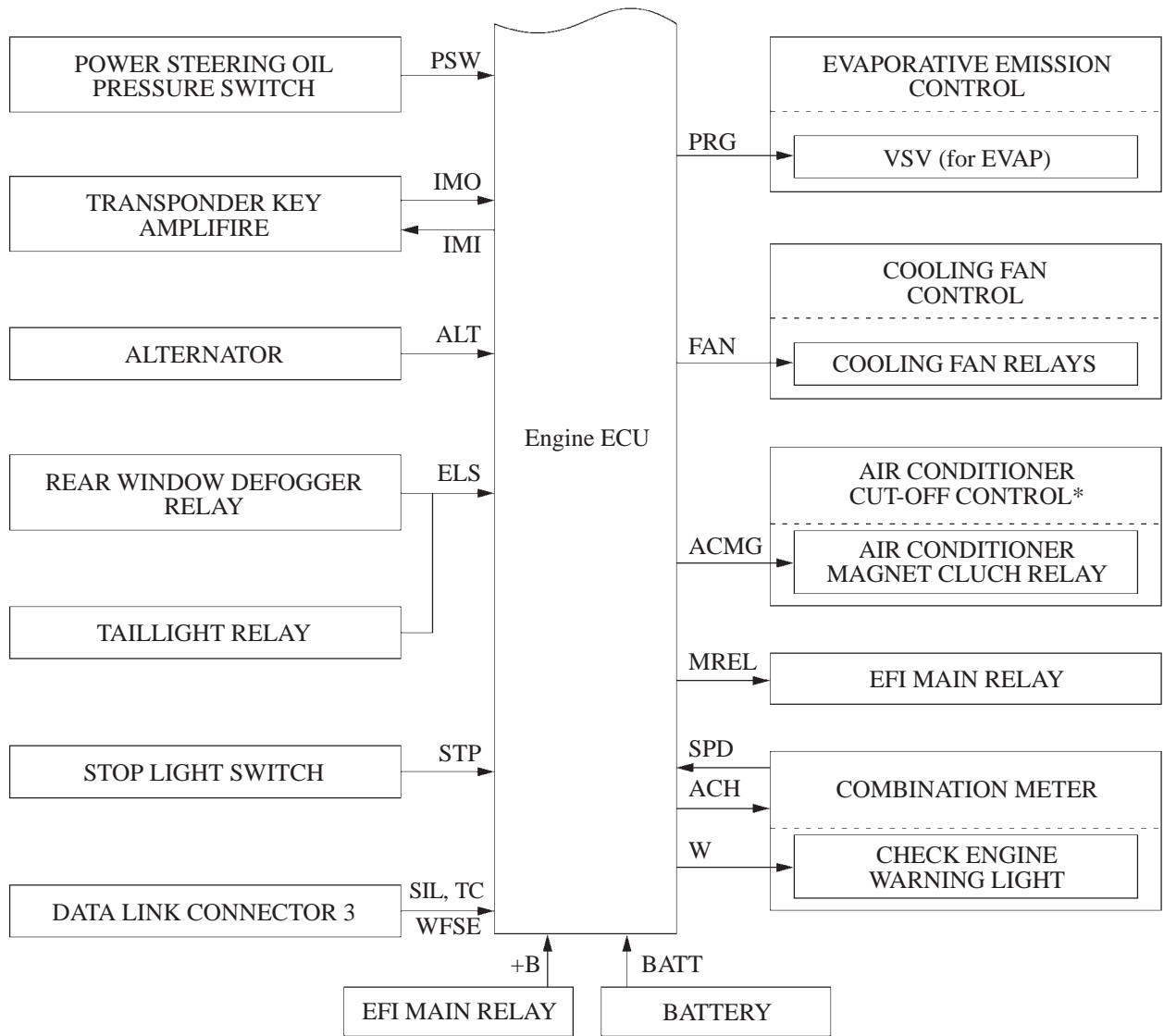
The configuration of the engine control system in the 1AZ-FE of the new Avensis Verso is as shown in the following chart.



(Continued)

\*1: With Air Conditioner

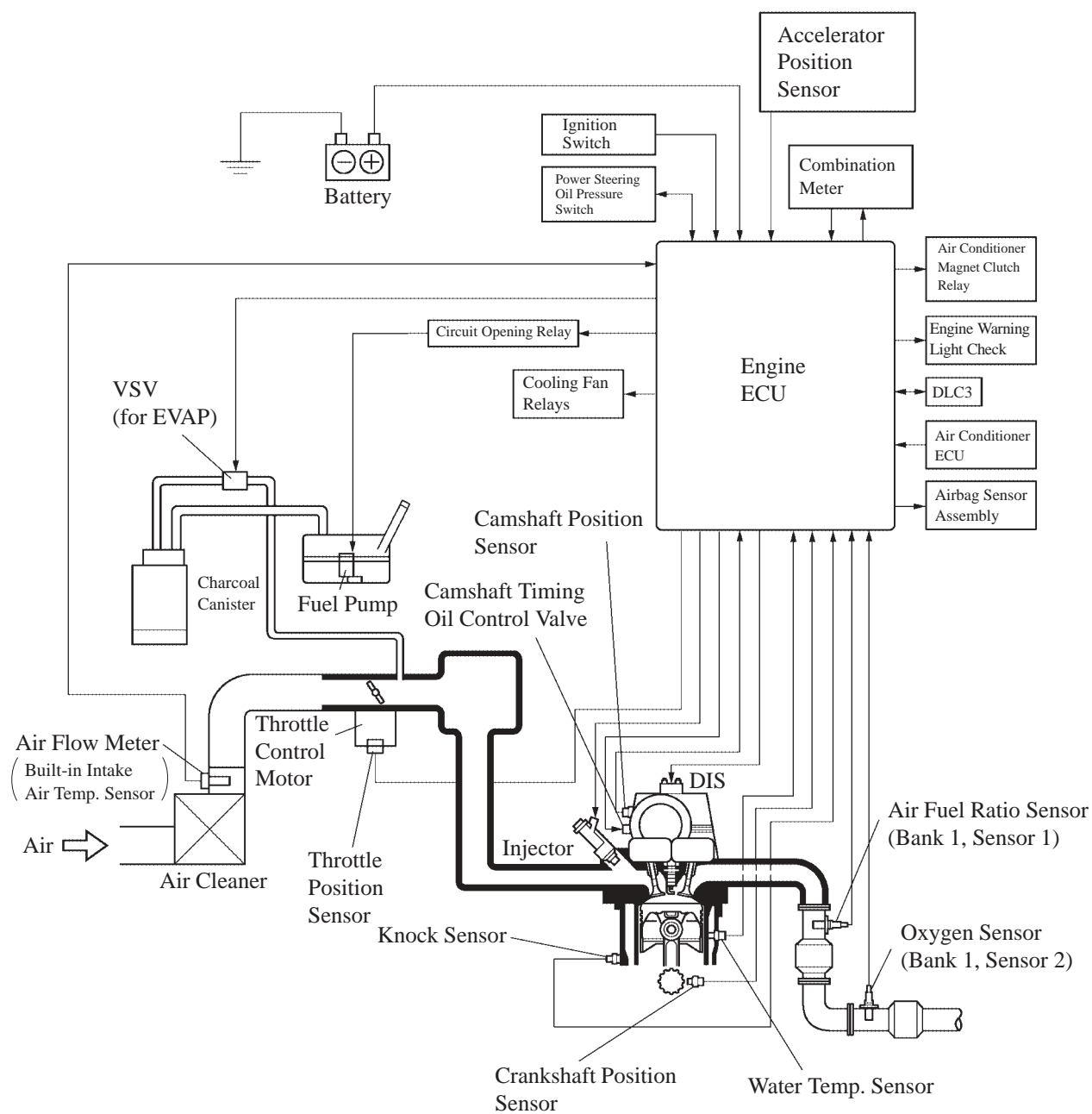
\*2: Only for Automatic Transaxle



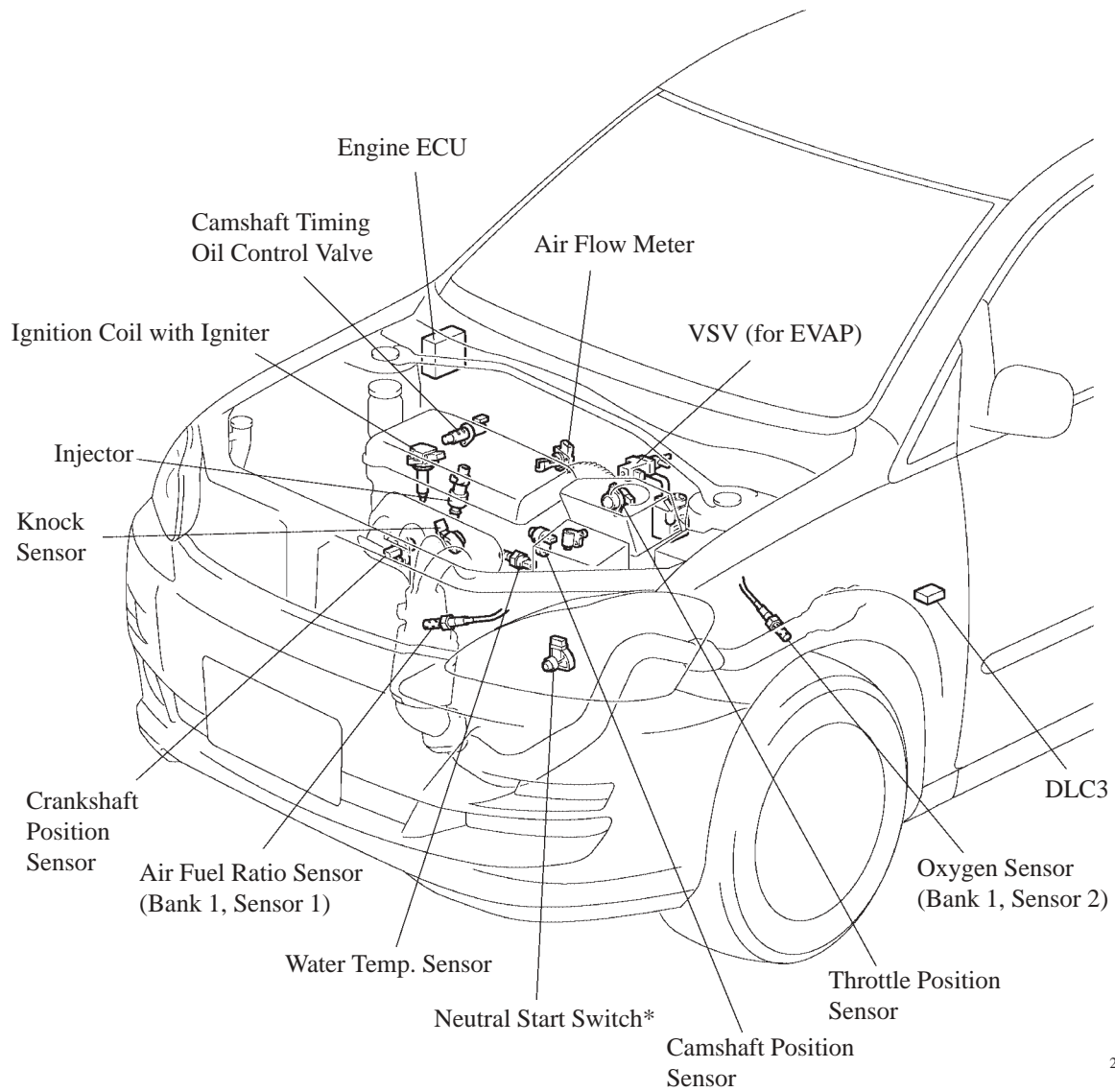
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\*: With Air Conditioner

## Engine Control System Diagram



## Layout of Main Components



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## Main Components of Engine Control System

### 1) General

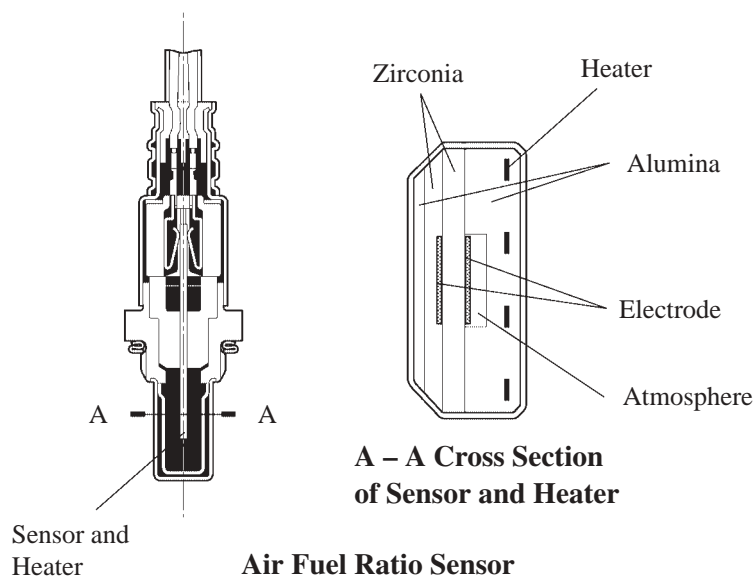
The following table compares the main components for new and previous 1AZ-FE engine.

Components	New		Previous	
	Outline	Quantity	Outline	Quantity
Engine ECU	32-bit CPU	1	←	1
Air Fuel Ratio Sensor (Bank 1, Sensor 1)	with Heater Type (Planar Type)	1	with Heater Type (Cup Type)	2
Oxygen Sensor (Bank 1, Sensor 2)	with Heater Type (Cup Type)	1	←	2
Air Flow Meter	Hot-wire Type	1	←	
Crankshaft Position Sensor (Rotor Teeth)	Pick-up Coil Type (36-2)	1	←	
Camshaft Position Sensor (Rotor Teeth)	Pick-up Coil Type (3)	1	←	
Knock Sensor	Built-in Piezoelectric Element Type (Flat Type)	1	Built-in Piezoelectric Element Type (Resonant Type)	1
Accelerator Pedal Position Sensor	Contact Type	1	—	
Throttle Position Sensor	No-contact Type	1	Contact Type	1

### 2) Air Fuel Ratio Sensor ( Planar Type)

The planar type of air fuel ratio sensor has been adopted.

Compared to the conventional type, the sensor and heater portions of the planar type are narrower overall. Because the heat of the heater acts directly on the alumina and zirconia (of the sensor portion) it accelerates the activation of the sensor.



### 3) Knock Sensor (Flat Type)

#### a. General

In the conventional type knock sensor (resonant type), a vibration plate which has the same resonance point as the knocking frequency of the engine is built in and can detect the vibration in this frequency band.

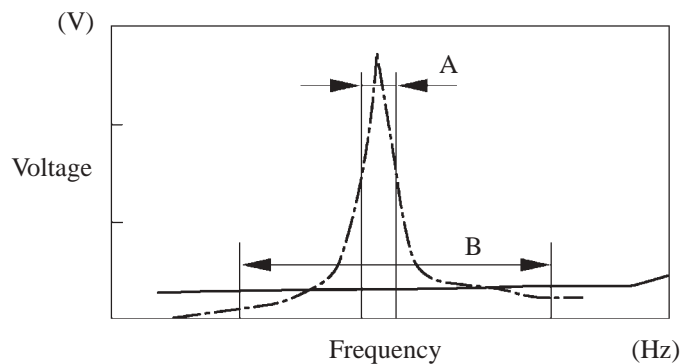
On the other hand, a flat type knock sensor (non-resonant type) has the ability to detect vibration in a wider frequency band from about 6 kHz to 15 kHz, and has the following features.

- The engine knocking frequency will change a bit depending on the engine speed. The flat type knock sensor can detect the vibration even when the engine knocking frequency is changed. Thus the vibration detection ability is increased compared to the conventional type knock sensor, and a more precise ignition timing control is possible.

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— - — : Resonance Characteristic of Conventional Type

———— : Resonance Characteristic of Flat Type



A: Detection Band of Conventional Type

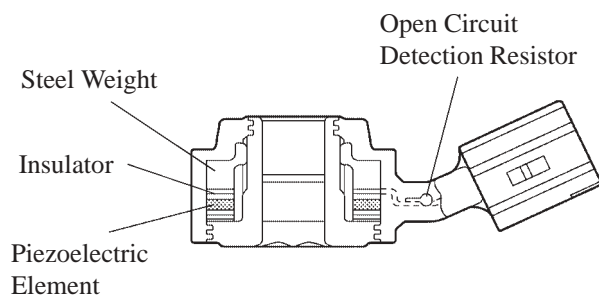
B: Detection Band of Flat Type

**Characteristic of Knock Sensor**

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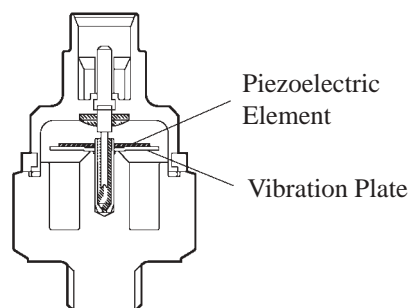
### b. Construction

- The flat type knock sensor is installed on the engine through the stud bolt installed on the cylinder block. For this reason, a hole for the stud bolt is running through in the center of the sensor.
- Inside of the sensor, a steel weight is located on the upper portion and a piezoelectric element is located under the weight through the insulator.
- The open/short circuit detection resistor is integrated.



**Flat Type Knock Sensor  
(Non-Resonant Type)**

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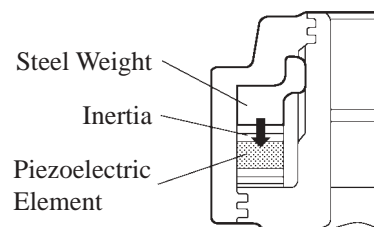


**Conventional Type Knock Sensor  
(Resonant Type)**

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### c. Operation

The knocking vibration is transmitted to the steel weight and its inertia applies pressure to the piezoelectric element. The action generates electromotive force.



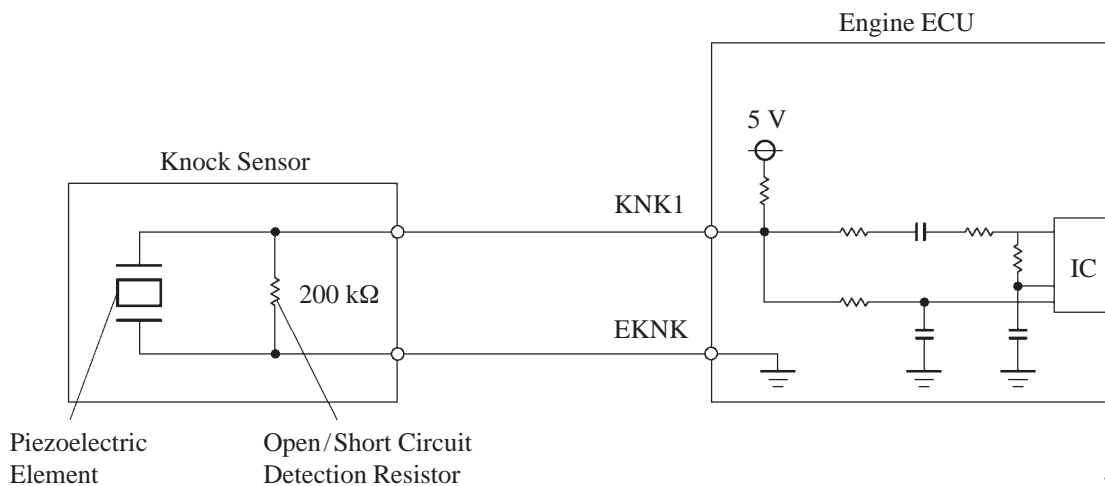
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#### d. Open/Short Circuit Detection Resistor

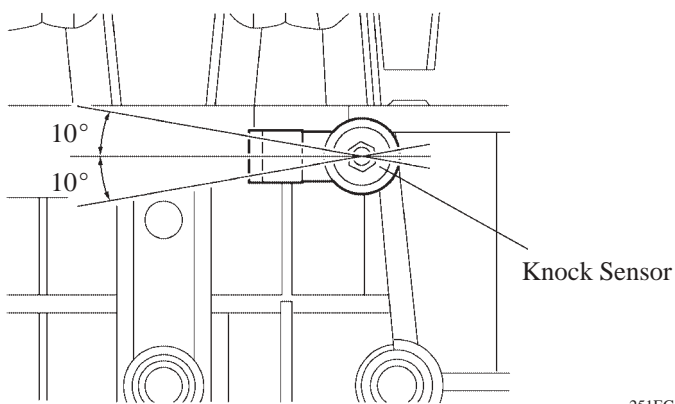
During the ignition is ON, the open/short circuit detection resistor in the knock sensor and the resistor in the engine ECU keep the voltage at the terminal KNK1 of engine constant.

An IC (Integrated Circuit) in the engine ECU is always monitoring the voltage of the terminal KNK1. If the open/short circuit occurs between the knock sensor and the engine ECU, the voltage of the terminal KNK1 will change and the engine ECU detects the open/short circuit and stores DTC (Diagnostic Trouble Code).



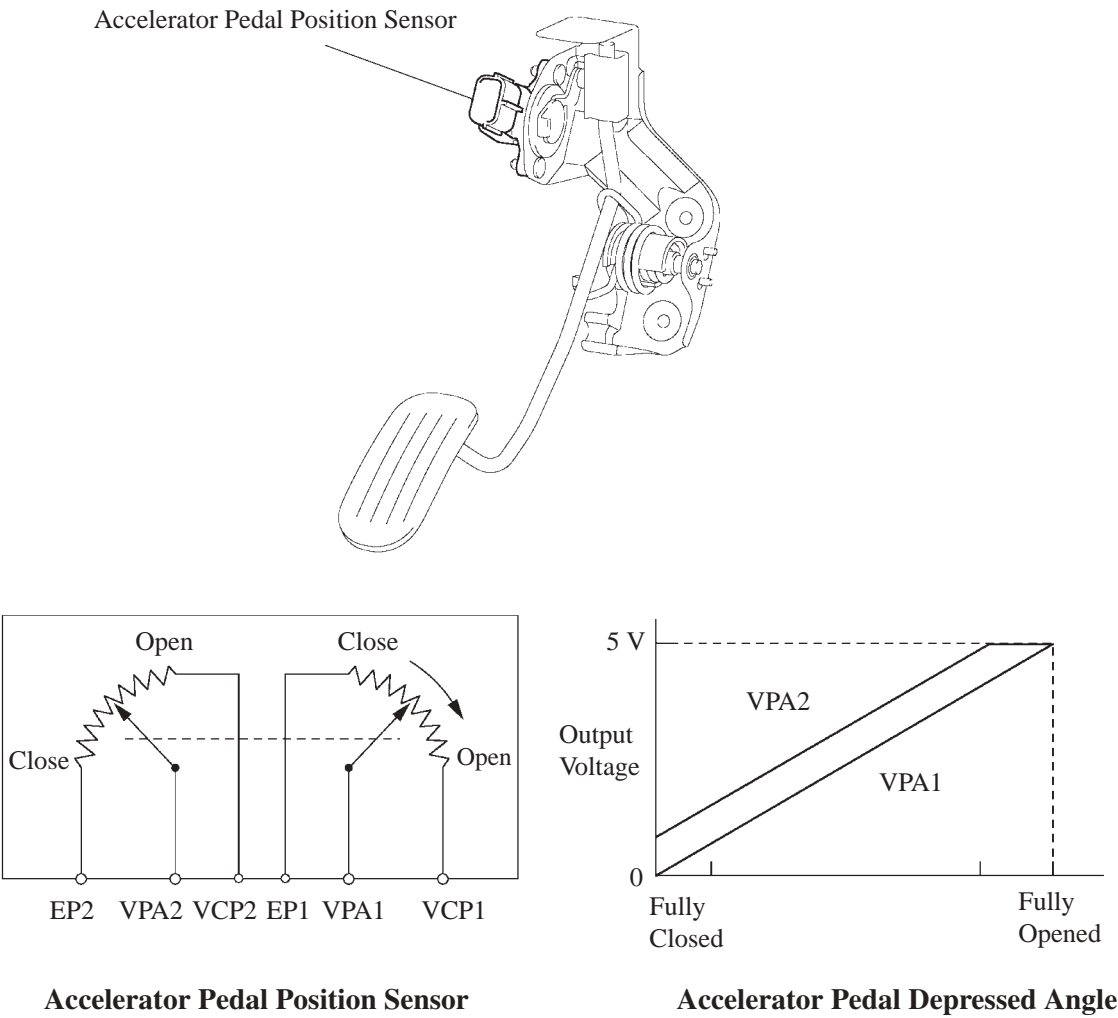
#### Service Tip

- In accordance with the adoption of open/short circuit detection resistor, the inspection method for the sensor has been changed.
- To prevent the water accumulation in the connector, make sure to install the flat type knock sensor in the position as illustration.



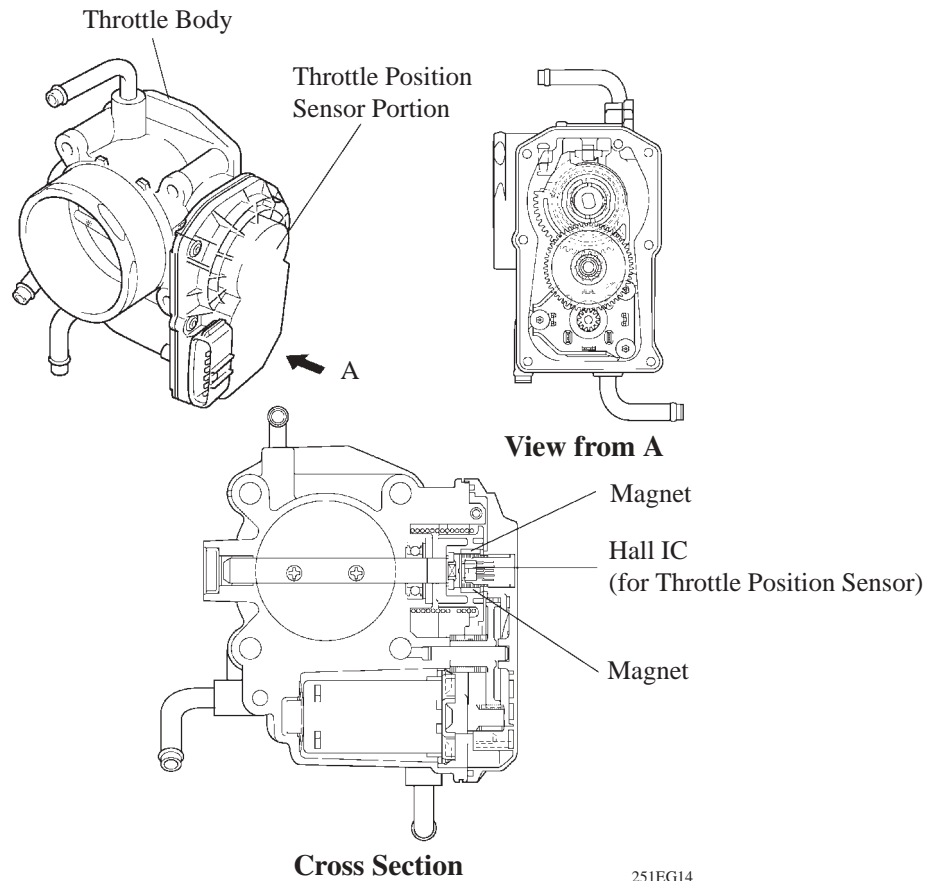
4) Accelerator Pedal Position Sensor

This sensor converts the accelerator pedal depressed angles into electric signals with two differing characteristics and outputs them to the engine ECU. One is the VPA1 signal that linearly outputs the voltage along the entire range of the accelerator pedal depressed angle. The other is the VPA2 signal that outputs on offset voltage.



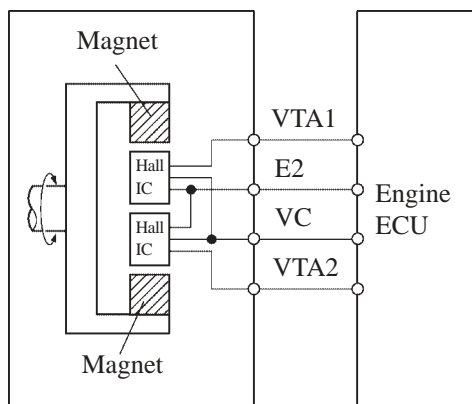
### 5) Throttle Position Sensor (Hall IC Type)

The throttle position sensor is mounted on the throttle body, to detect the opening angle of the throttle valve. The throttle position sensor converts the magnetic flux density that changes when the magnetic yoke (located on the same axis as the throttle shaft) rotates around the Hall IC into electric signals to operate the throttle control motor.

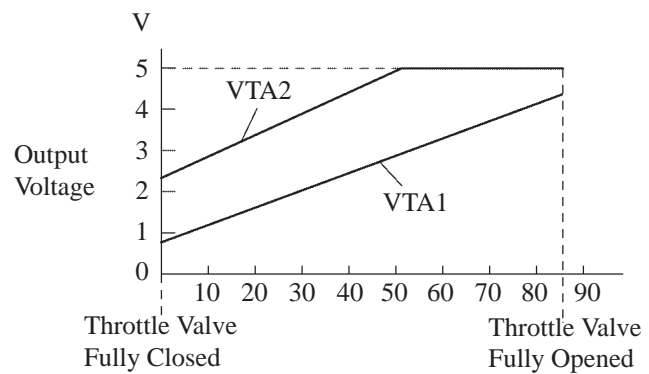


251EG14

Throttle Position Sensor



230LX12



Throttle Valve Opening Angle

238EG79

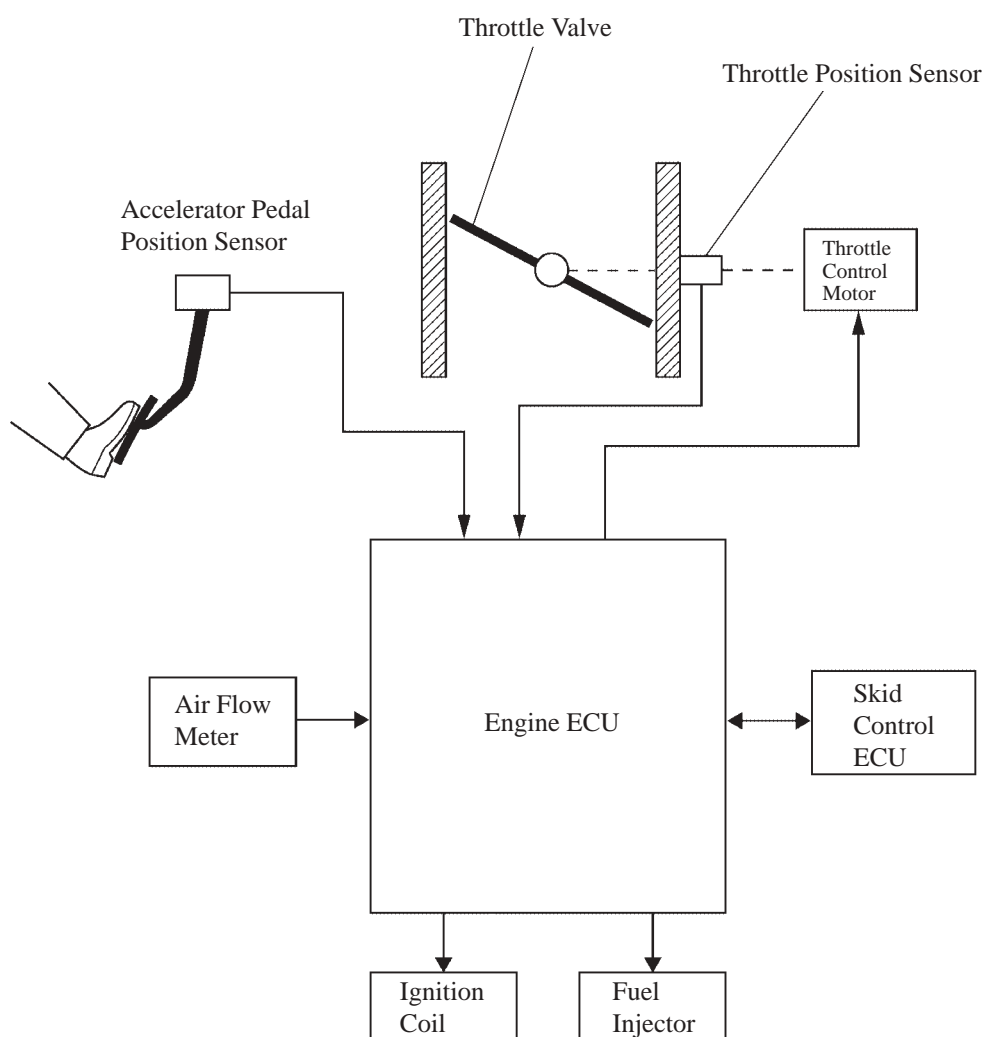
#### Service Tip

The inspection method differs from the conventional throttle position sensor because this sensor uses a Hall IC.

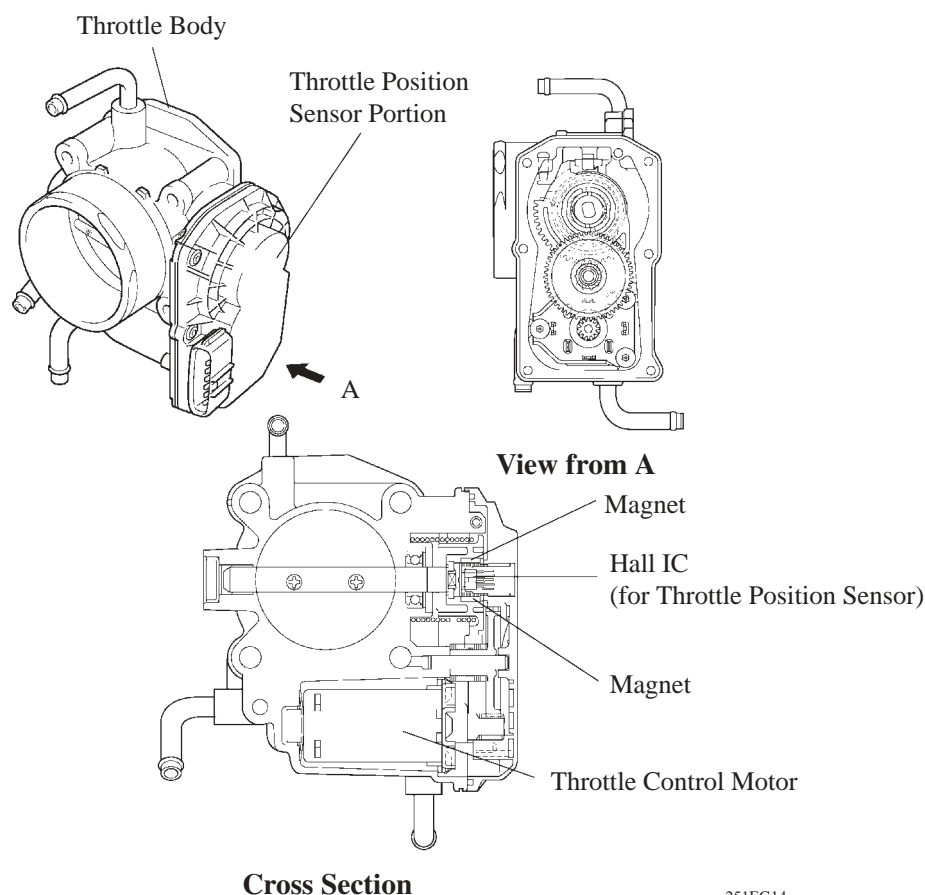
### ETCS-i (Electronic Throttle Control System-intelligent)

- The ETCS-i is used, providing excellent throttle control in all the operating ranges.
- 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 engine ECU 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 contact type accelerator pedal position sensor has been adopted.
- The no-contact type throttle position sensor has been adopted.
- The ETCS-i controls the ISC (Idle Speed Control) system, the TRC (Traction Control) and the VSC (Vehicle Stability Control) system.
- In case of an abnormal condition, this system transfers to the limp mode.

#### ► System Diagram ◀



## 1) Construction



### a. Throttle Position Sensor

The throttle position sensor is mounted on the throttle body to detect the opening angle of the throttle valve. For details, refer to Main Components of Engine Control System section on [page 173](#).

### b. Throttle Control Motor

A DC motor with excellent response and minimal power consumption is used for the throttle control motor. The engine ECU 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.

## 2) Operation

### a. General

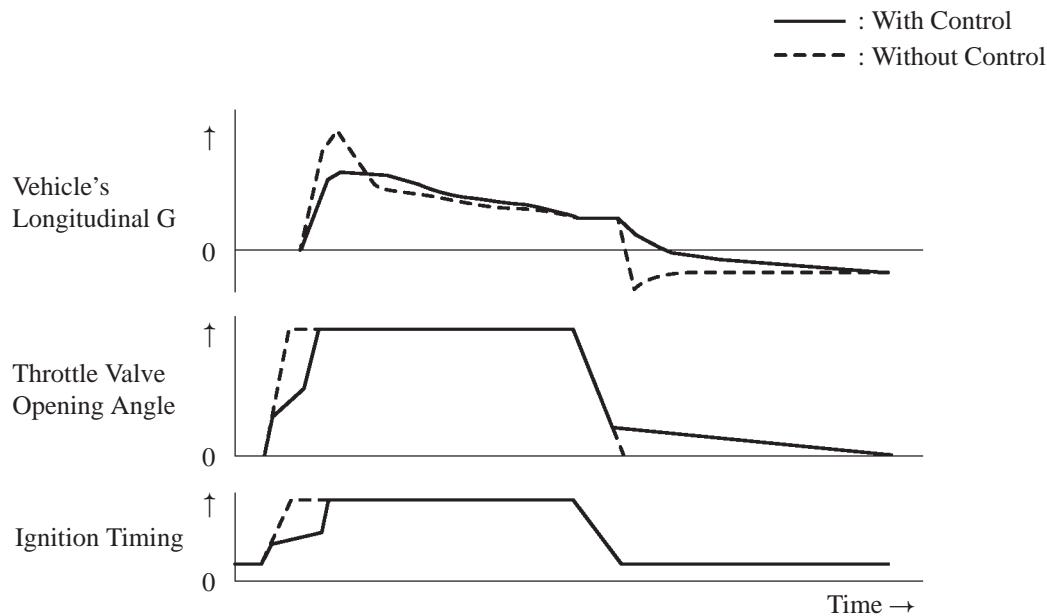
The engine ECU drives the throttle control motor by determining the target throttle valve opening in accordance with the respective operating condition.

- 1) Non-Linear Control
- 2) Idle Speed Control
- 3) TRC Throttle Control
- 4) VSC Coordination Control
- 5) Cruise Control

### b. 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 speed in order to realize an excellent throttle control and comfort in all operating ranges.

#### ► Control Examples During Acceleration and Deceleration ◀



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### c. Idle Speed Control

The engine ECU controls the throttle valve in order to constantly maintain an ideal idle speed.

### d. TRC Throttle Control

As part of the TRC system, the throttle valve is closed by a demand signal from the skid control ECU if an excessive amount of slippage is created at a driving wheel, thus facilitating the vehicle in providing excellent stability and driving force.

### e. VSC Coordination Control

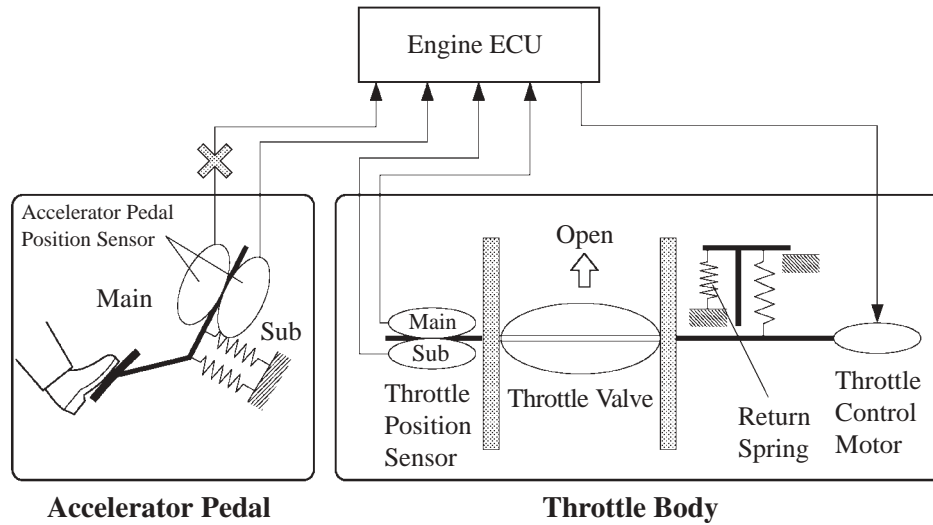
In order to bring the effectiveness of the VSC system control into full play, the throttle valve opening angle is controlled by effecting a coordination control with the skid control ECU.

### f. Cruise Control

An engine ECU with an integrated cruise control ECU directly actuates the throttle valve for operation of the cruise control.

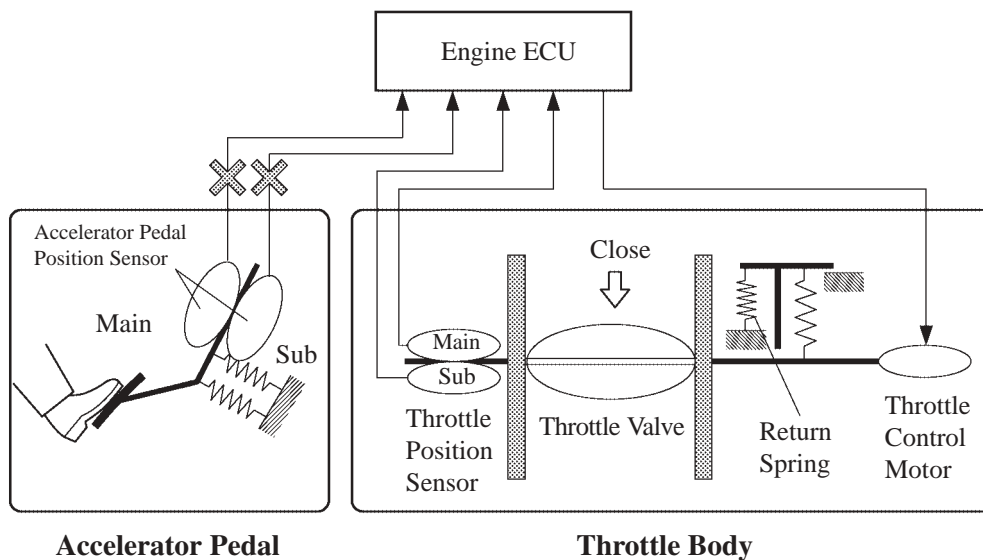
## Fail-Safe of Accelerator Pedal Position Sensor

- The accelerator pedal position sensor comprises two (main, sub) sensor circuits. If a malfunction occurs in either one of the sensor circuits, the engine ECU detects the abnormal signal voltage difference between these two sensor circuits, and switches to the limp mode. In the limp mode, the remaining circuit is used to calculate the accelerator pedal opening, in order to operate the vehicle under limp mode control.



199EG45

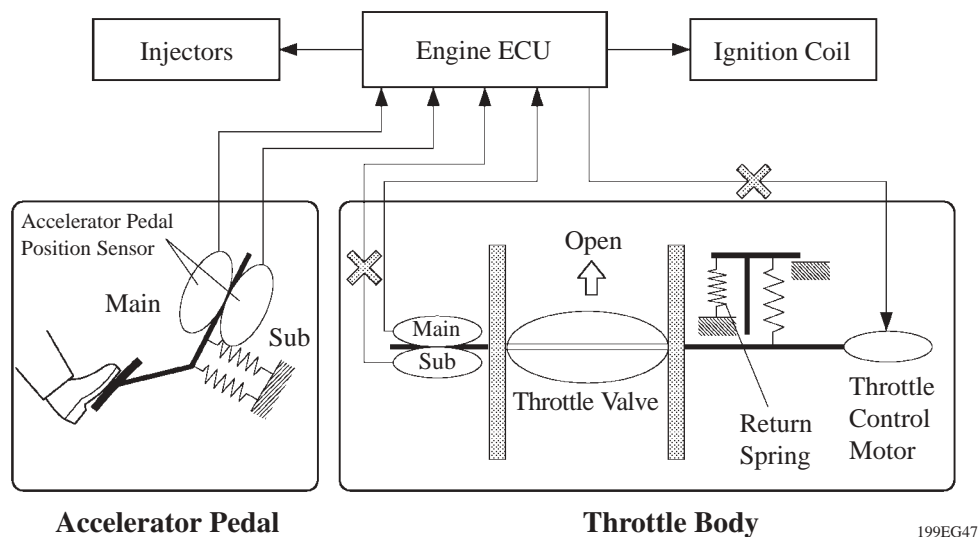
- When both circuits malfunction, the engine ECU detects the abnormal signal voltage from these two sensor circuits, and discontinues the throttle control. At this time, the vehicle can be driven within its idling range.



199EG46

### Fail-Safe of Throttle Position Sensor

- The throttle position sensor comprises two (main, sub) sensor circuits. If a malfunction occurs in either one of the sensor circuits, the engine ECU detects the abnormal signal voltage difference between these two sensor circuits, cuts off the current to the throttle control motor, and switches to the limp mode. Then, the force of the return spring causes the throttle valve to return and stay at the prescribed opening. At this time, the vehicle can be driven in the limp mode while the engine output is regulated through the control of the fuel injection and ignition timing in accordance with the accelerator opening.
- The same control as above is effected if the engine ECU detects a malfunction in the throttle control motor system.





## Diagnosis

- When the engine ECU detects a malfunction, the engine ECU makes a diagnosis and memorizes the failed section.  
Furthermore, the engine warning light in the combination meter illuminates or blinks to inform the driver.
- The engine ECU will also store the DTCs (Diagnostic Trouble Codes) of the malfunctions.
- The DTCs can be accessed the use of the hand-held tester.
- All the DTCs have been made to correspond to the SAE controlled codes. Some of the DTCs have been further divided into smaller detection areas than in the past, and new DTCs have been assigned to them. For details, refer to the Avensis Verso Repair Manual (Pub. No. RM1032E).

### Service Tip

To clear the DTC that is stored in the engine ECU, use a hand-held tester or disconnect the battery terminal or remove the EFI fuse for 1 minute or longer.

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## Fail-Safe

When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the data already stored in the memory.

### ► Fail-Safe Chart ◀

DTC No.	Fail-Safe Operation	Fail-Safe Deactivation Conditions
P0031, P0032, P0037, P0038,	The heater circuit in which the abnormality is detected is turned off.	Ignition switch OFF.
P0100, P0102, P0103	Ignition timing is calculated from engine speed and a throttle angle.	Return to normal condition.
P0110, P0112, P0113	Intake air temp. is fixed at 20°C (68°F).	Return to normal condition.
P0115, P0117, P0118	Water temp. is fixed at 80°C (176°F).	Return to normal condition.
P0120, P0122, P0123, P0220, P0222, P0223, P2135	Fuel cut intermittently when idle.	Return to normal condition and ignition switch OFF.
P0325, P0327, P0328	Max. timing retardation.	Ignition switch OFF.
P0351, P0352, P0353, P0354	Fuel cut.	Return to normal condition.
P0604, P0606, P0607, P0657	Fuel cut intermittently when idle.	Return to normal condition and ignition switch OFF.
P2102, P2103	Fuel cut intermittently when idle.	Return to normal condition and ignition switch OFF.
P2111, P2112	Fuel cut intermittently when idle.	Return to normal condition and ignition switch OFF.
P2118, P2119	Fuel cut intermittently when idle.	Return to normal condition and ignition switch OFF.