6. Engine Control System

General

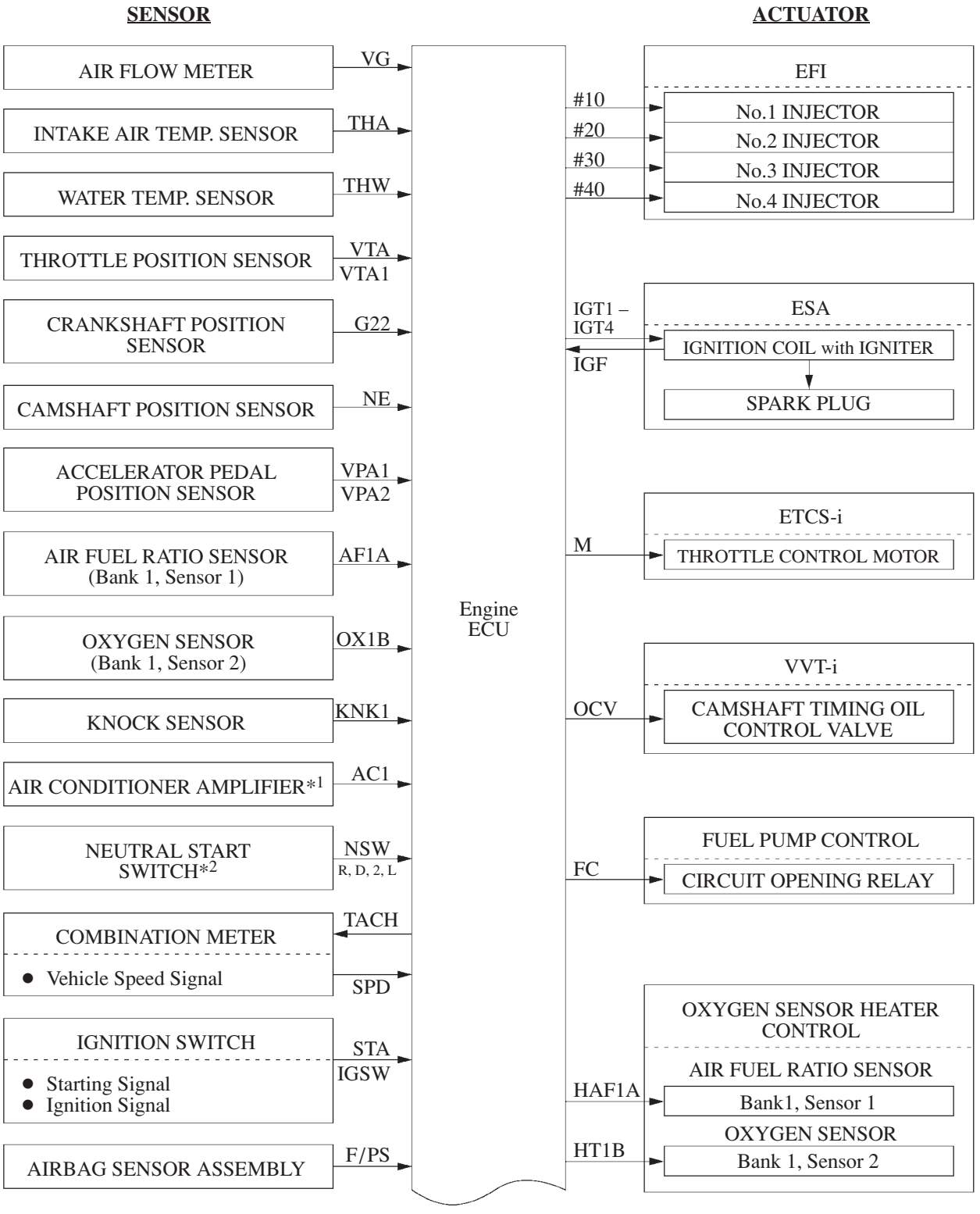
The engine control system of the 1AZ-FE engine on the new RAV4 has following system.

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 438)	● Optimally controls the throttle valve opening in accordance with the amount of accelerator pedal effort and the condition of the engine and the vehicle. ● A link-less type is used, without an accelerator cable. ● An accelerator pedal position sensor is provided on the accelerator pedal. ● A no-contact type throttle position sensor and accelerator pedal position sensor are used. ● Controls the fast idle and idle speed.	○	—
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*1	By turning the air conditioner 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*2	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.	○	○

*1: With Air Conditioner Models
*2: With Engine Immobilizer Model

Construction

The configuration of the engine control system in the 1AZ-FE in the new RAV4 is as shown in the following chart.

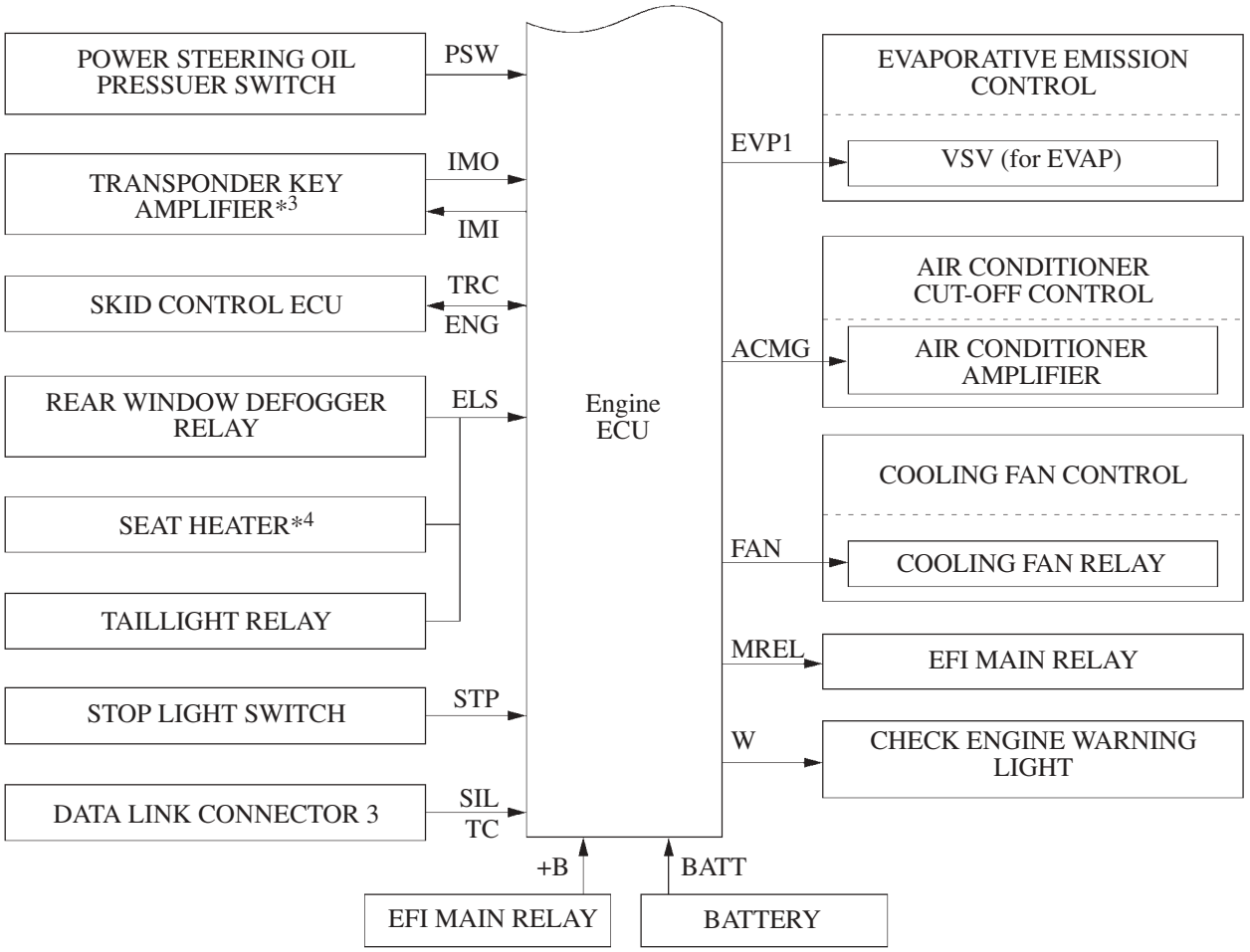


(Continued)

258RV38

*1: With Air Conditioner

*2: Only for Automatic Transaxle



258RV39

*3: With Engine Immobilizer
*4: With Seat Heater

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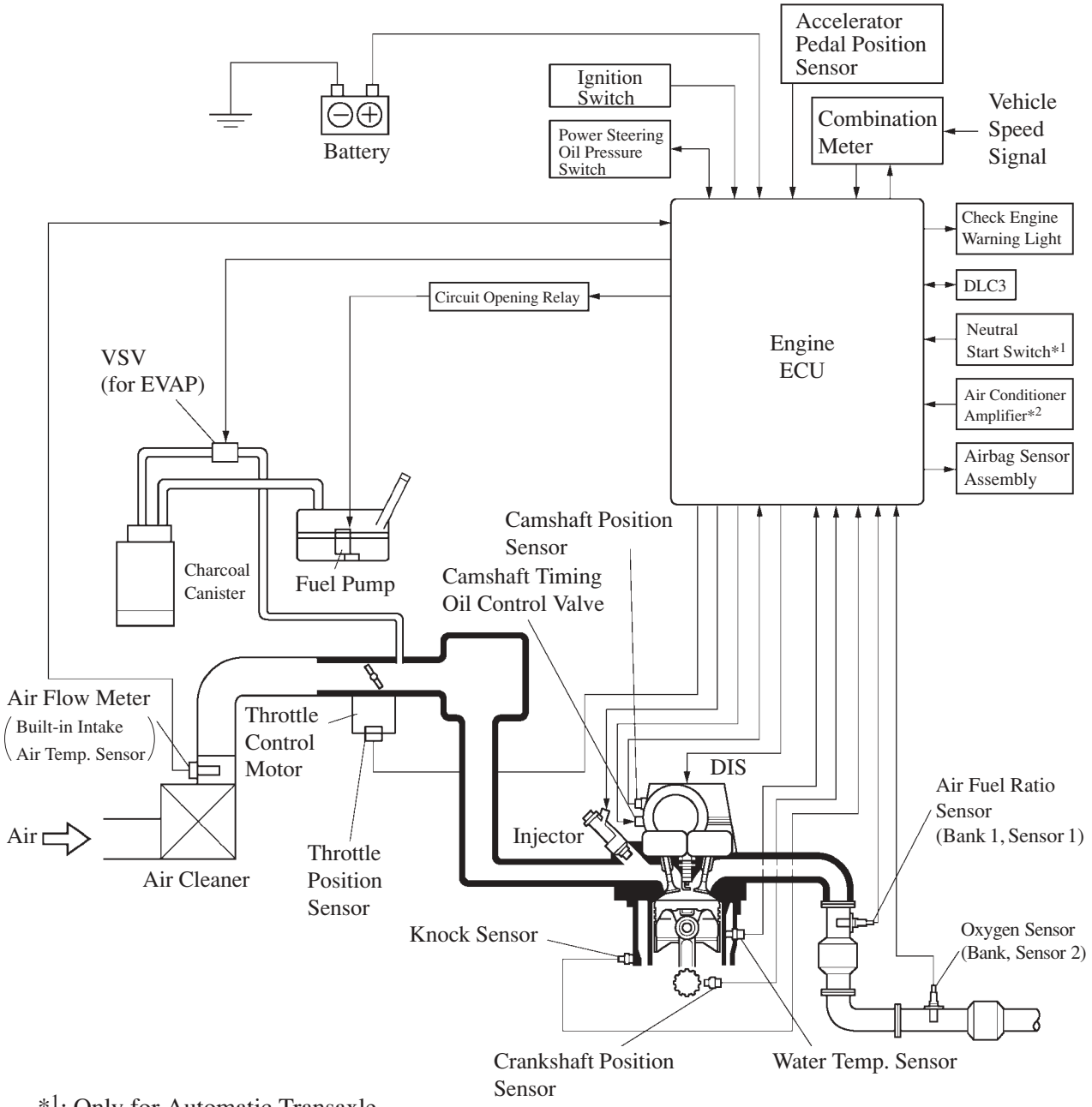
Engine Control System Diagram



*1: Only for Automatic Transaxle
*2: With Air Conditioner

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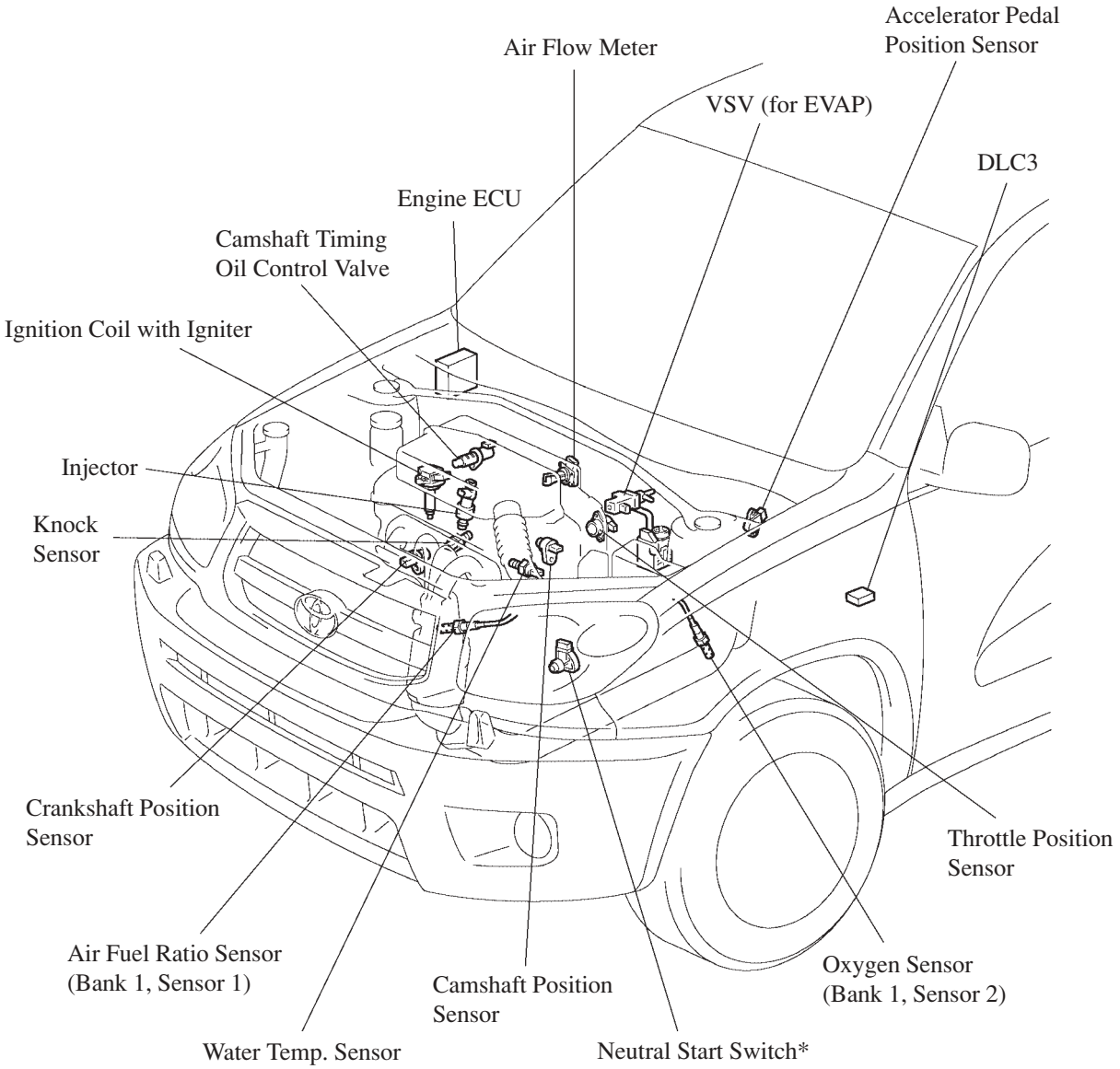
Layout of Main Components



*: Only for Automatic Transaxle

Main Components of Engine Control System

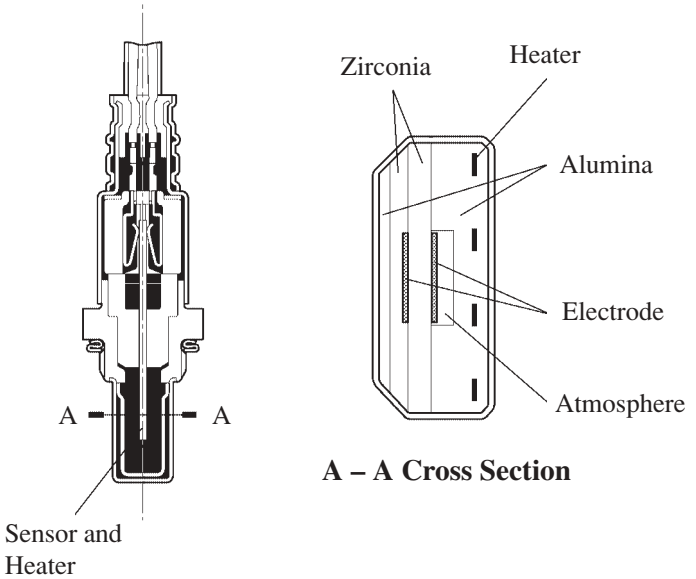
1) General

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	Linear Type	1	—	
Throttle Position Sensor	No-contact Type	1	Linear Type	1

2) Air Fuel Ratio Sensor (Planar Type)

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



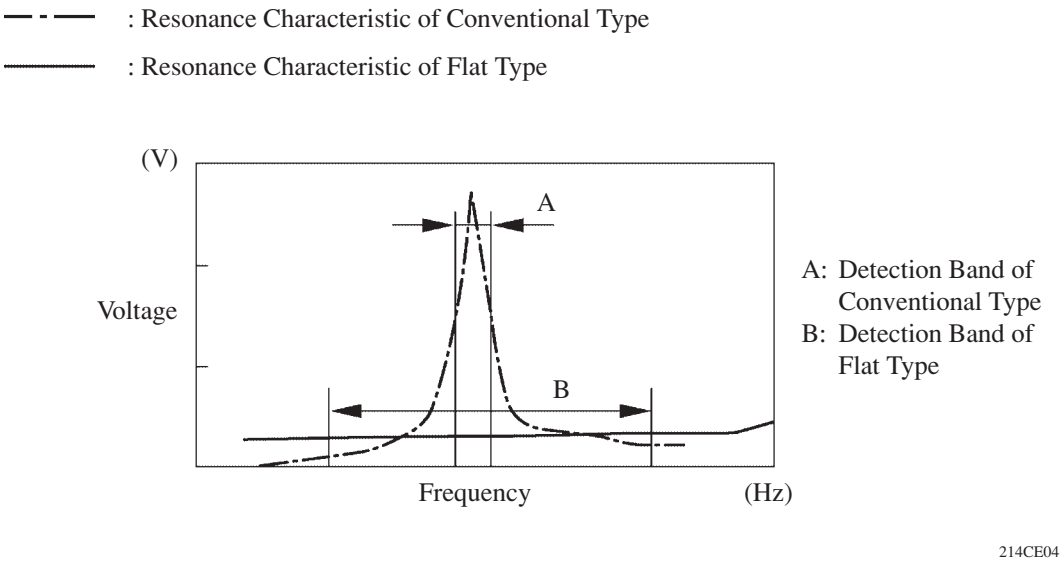
3) Knock Sensor (Flat Type)

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.

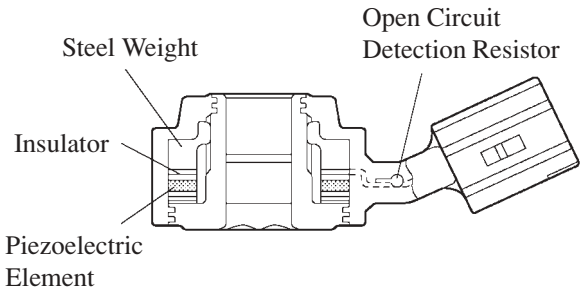
- The engine knocking frequency will change a bit depending on the engine speed. The flat type knock sensor can detect the vibration even when the engine knocking frequency is changed. Thus the vibration detection ability is increased compared to the conventional type knock sensor, and a more precise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



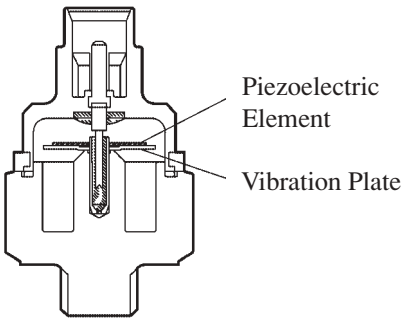
Characteristic of Knock Sensor

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.



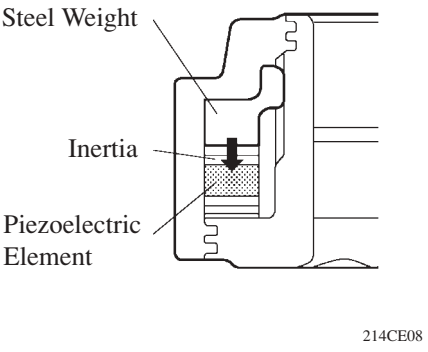
Flat Type Knock Sensor (Non-Resonant Type)



Conventional Type Knock Sensor (Resonant Type)

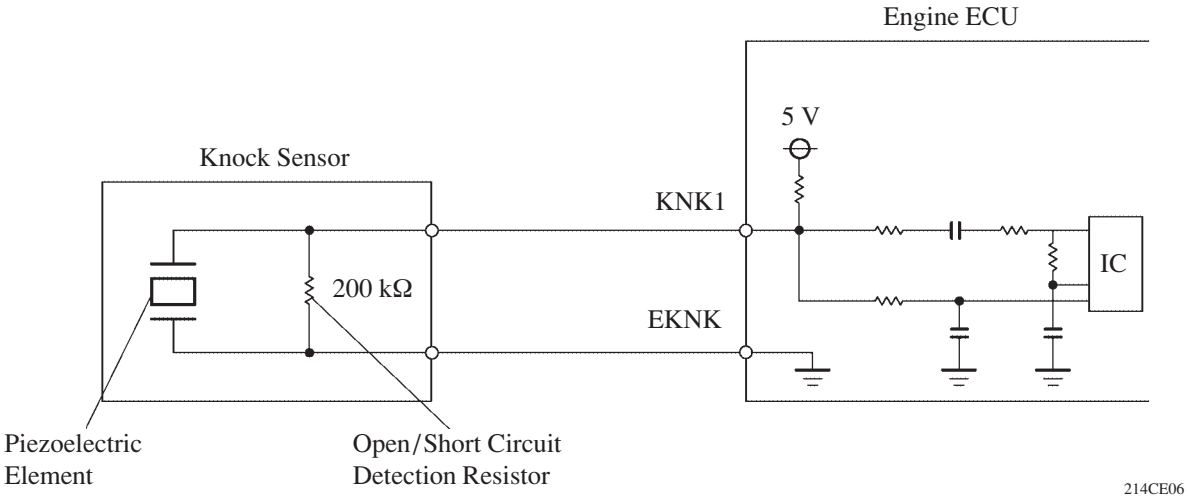
c. Operation

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



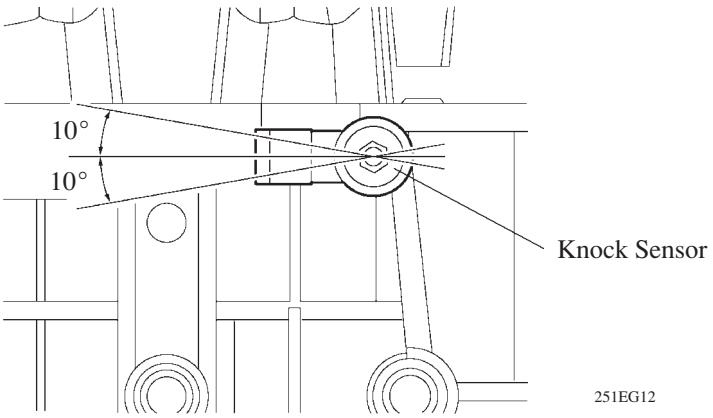
d. Open/Short Circuit Detection Resistor

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. For details, refer to the 1AZ-FE engine Repair Manual Supplement (Pub. No. RM1079E).
- To prevent the water accumulation in the connector, make sure to install the flat type knock sensor in the position as shown in the following illustration.



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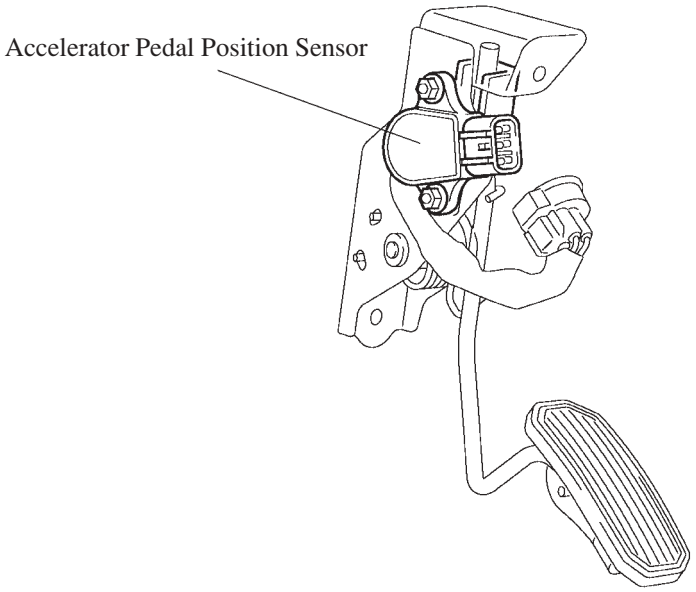
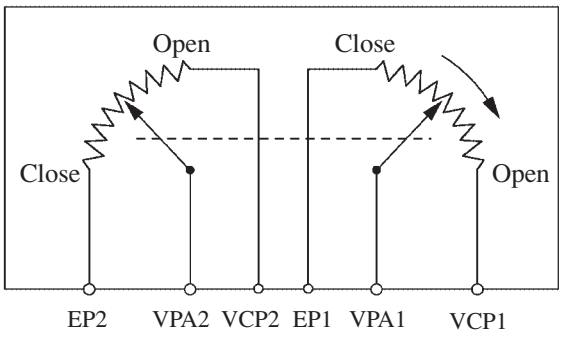
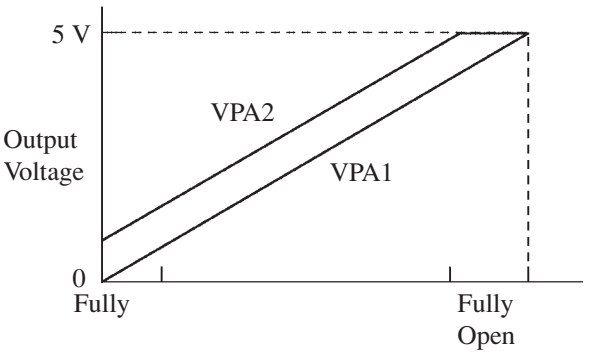
4) Accelerator pedal position sensor

This sensor converts the accelerator pedal depressed angles into electric signals with two different 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.





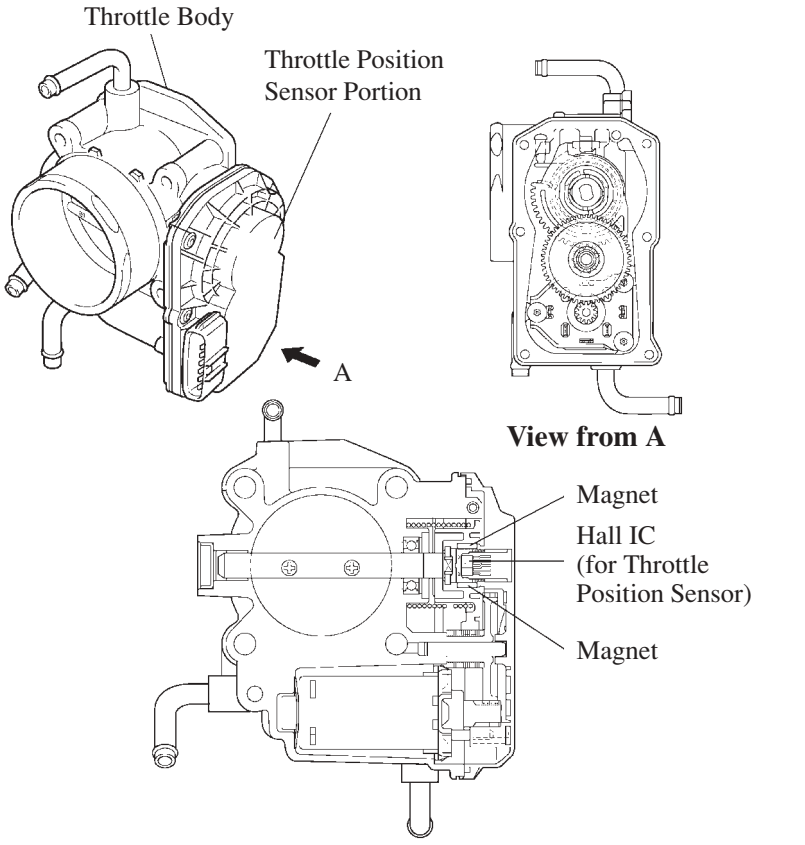
Accelerator Pedal Position Sensor

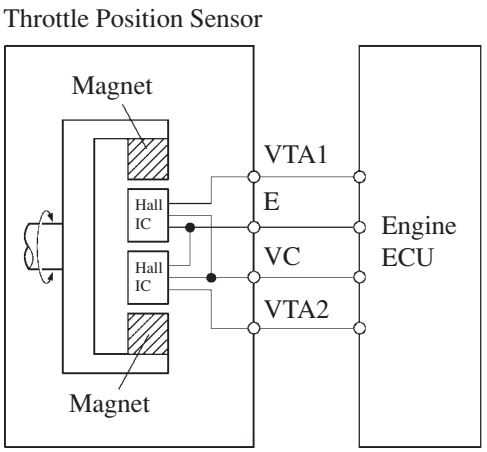


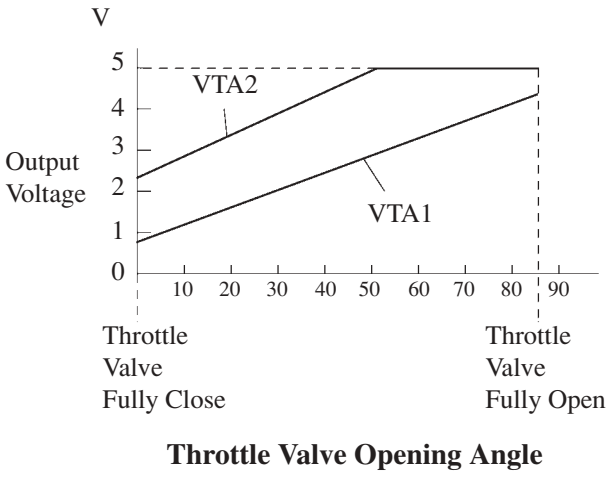
Accelerator Pedal Depressed Angle 251EG13

5) Throttle position sensor (no-contact 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.







Service Tip

The inspection method differs from the conventional throttle position sensor because this sensor uses a Hall IC. For details, refer to the 1AZ-FE engine Repair Manual Supplement (Pub. No. RM1079E).

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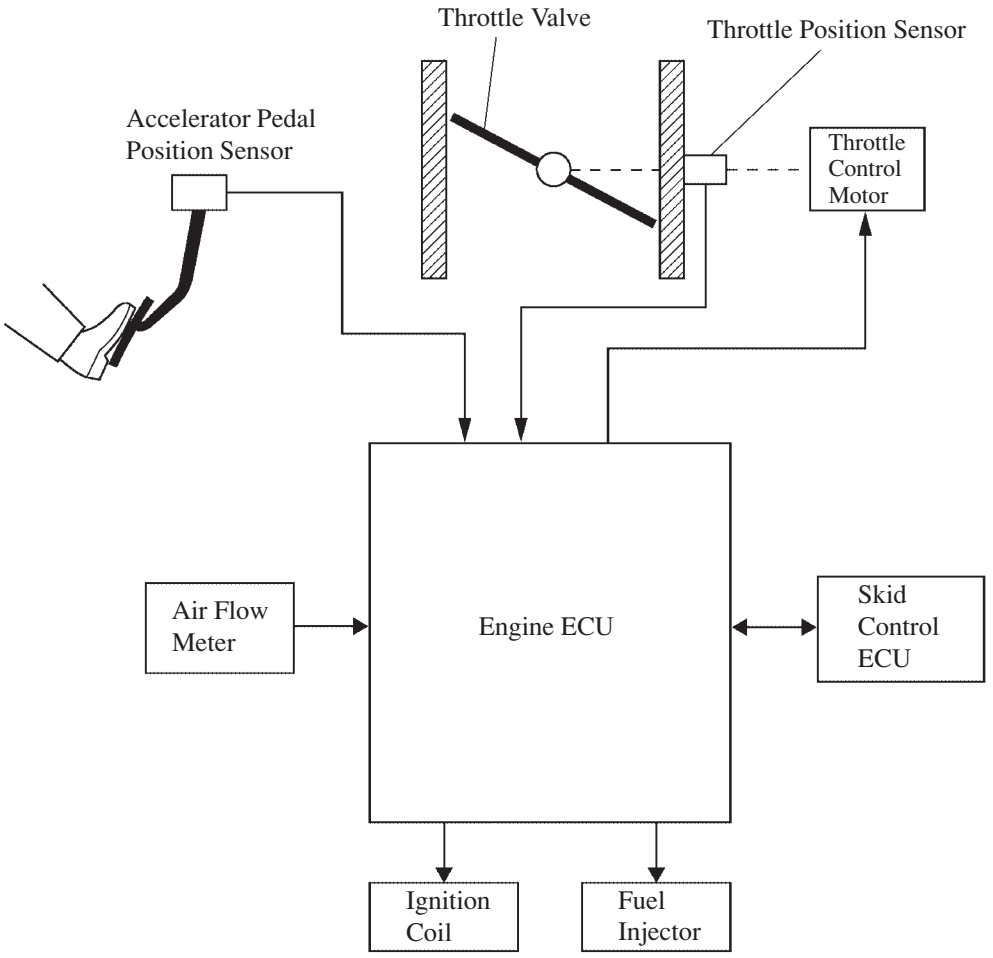
ETCS-i (Electronic Throttle Control System-intelligent)

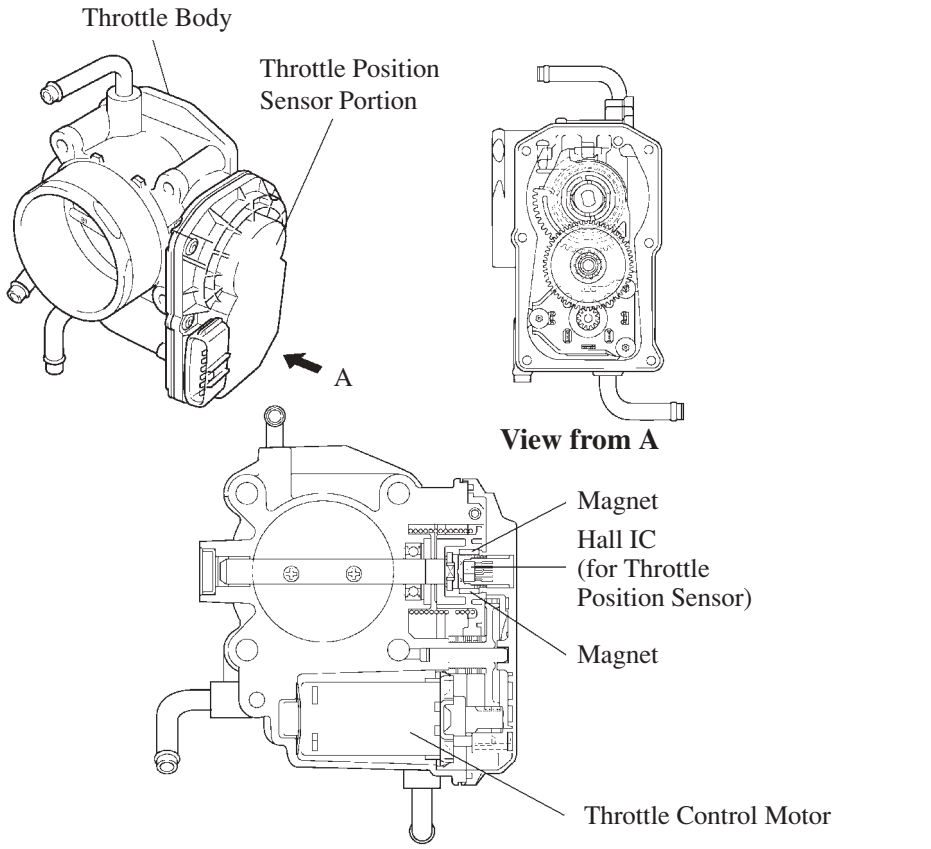
- The ETCS-i is used, providing excellent throttle control in all the operating ranges.
- In the conventional throttle body, the throttle valve opening in determined invariably by the amount of the accelerator pedal effort. In contrast, the ETCS-i uses the engine ECU to calculate the optimal throttle valve opening that is appropriate for the respective driving condition and uses a throttle control motor to control the opening.
- The linear type accelerator pedal position sensor has been adopted.
- 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 ◀



208EG44

1) Construction



Cross Section

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 437.

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

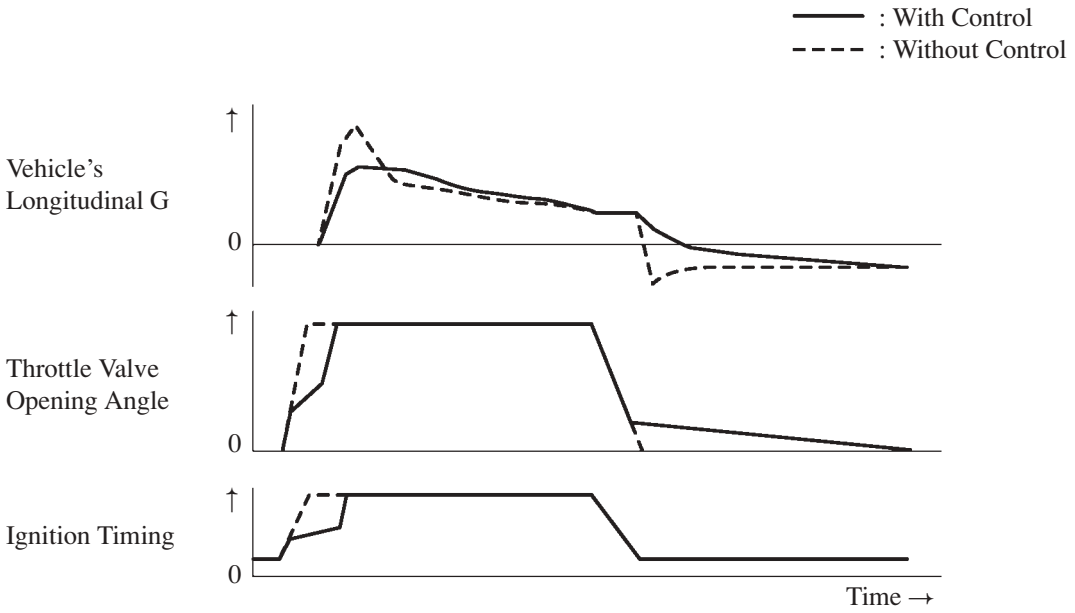
4) VSC Coordination Control

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 excellent throttle control and comfort in all operating ranges.

▶ Control Examples During Acceleration and Deceleration ◀



150EG37

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

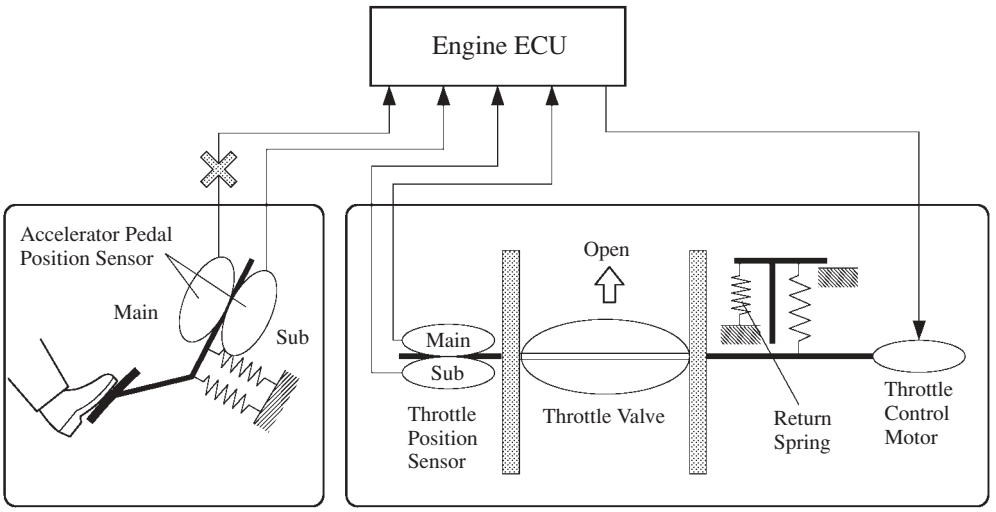
In order to bring the effectiveness of the VSC system control into full play, the throttle valve opening angle is controlled by effecting a coordination control with the skid control ECU.

f. Cruise Control

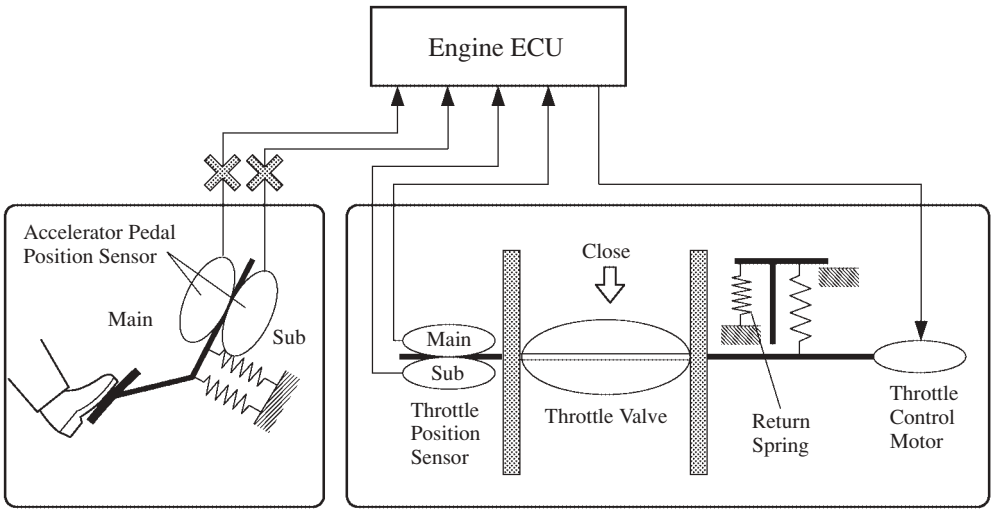
An engine ECU with an integrated cruise control ECU directly actuates the throttle valve for operation of the cruise control.

3) Fail-Safe of Accelerator Pedal Position Sensor

- The accelerator pedal position sensor comprises two (main and 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 circuit 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.

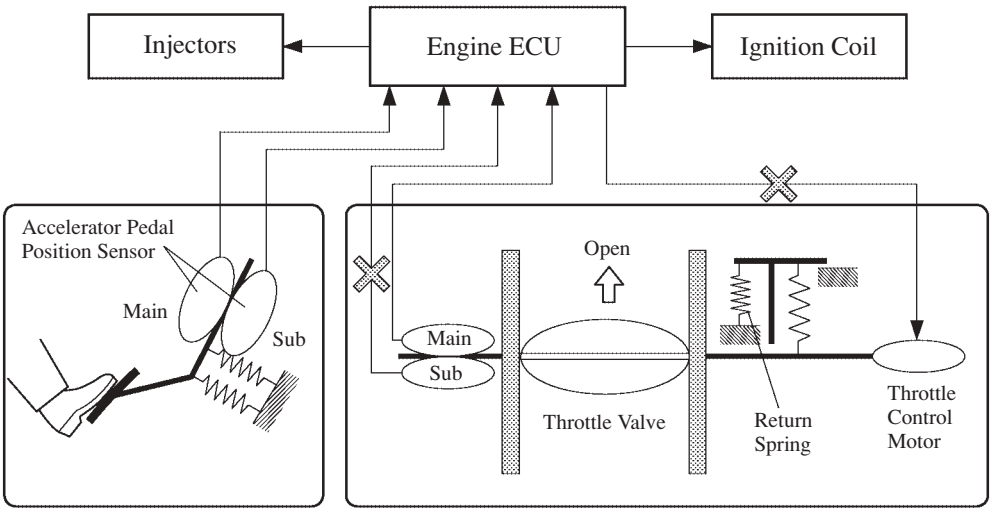


- If both circuits malfunction, the engine ECU detects the abnormal signal voltage from these two sensor circuits and discontinues the throttle control. At this time, the vehicle can be driven within its idling range.



4) Fail-Safe of Throttle Position Sensor

- The throttle position sensor comprises two (main and 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.

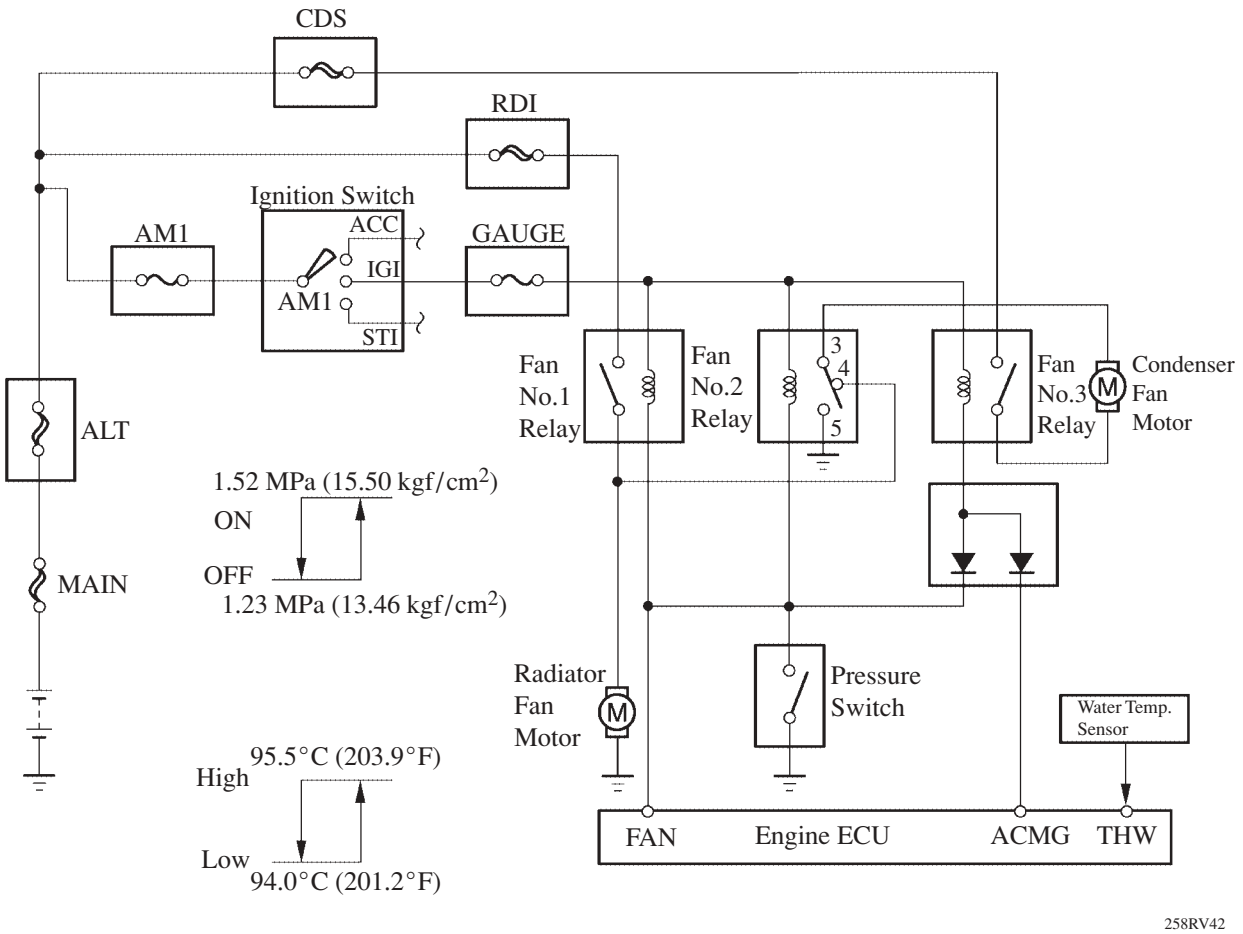


Cooling Fan Control

The cooling fan system, on the models for Europe and the G. C. C. countries, which was controlled by the water temperature switch, has been changed to engine ECU control.

- A cooling fan system in which the engine ECU controls the cooling fan speed in accordance with the signals from the water temperature sensor, etc. has been newly adopted. As a result, the water temperature switch of the previous model has been discontinued in order to simplify the system.
- The engine ECU controls the cooling fan speeds in accordance with the water temperature and the operating conditions of the A/C compressor and A/C pressure switch. This control is accomplished by operating the 2 fan motors in 2 stages through low speed (series connection) and high speed (parallel connection).

▶ Wiring Diagram ◀



▶ Cooling Fan Operation ◀

A/C Compressor	A/C Pressure Switch	Water Temperature	Relay Operation			Cooling Fan Motor Connection	Cooling Fan Operation
			No.1	No.2	No.3		
OFF	OFF	Low	OFF	3 to 4	OFF	OFF	OFF
	OFF	High	ON	3 to 5	ON	Parallel	High
ON	OFF	Low	OFF	3 to 4	ON	Series	Low
	ON	Low	ON	3 to 5	ON	Parallel	High
	OFF	High	ON	3 to 5	ON	Parallel	High
	ON	High	ON	3 to 5	ON	Parallel	High

Purge VSV

Purge flow rate of the models for Europe has been changed from 40 liters per minute to 60 liters per minute.

Diagnosis

The ETCS-i has been adopted and some of the DTCs have been further divided into smaller detection areas than in the past. As a result, multiple DTCs (Diagnostic Trouble Codes) have been added.
The items that appear in the chart below indicate the DTCs that have been newly added.
For details, refer to the 1AZ-FE engine Repair Manual Supplement (Pub. No. RM1079E).
As a result of the adoption of the SAE controlled codes, the DTCs have been changed as described below.

▶ Diagnostic Trouble Code ◀

DTC No.	Detection Item	DTC No.	Detection Item
P0010	Camshaft Position "A" Actuator Circuit (Bank 1)	P0123	Throttle/Pedal Position Sensor/Switch "A" Circuit High Input
P0011	Camshaft position "A" – Timing Over-Advanced or System performance (Bank 1)	P0220	Throttle/Pedal Position Sensor/Switch "B" Circuit
P0012	Camshaft Position "A" – Timing Over-Retarded (Bank 1)	P0222	Throttle/Pedal Position Sensor/Switch "B" Circuit Low Input
P0016	Camshaft Position – Camshaft Position Correlation (Bank 1 Sensor A)	P0223	Throttle/Pedal Position Sensor/Switch "B" Circuit High Input
P0031	Oxygen Sensor Heater Control Circuit Low (Bank 1 Sensor 1) *	P0327	Knock Sensor 1 Circuit Low Input (Bank 1 or Single Sensor)
P0032	Oxygen Sensor Heater Control Circuit High (Bank 1 Sensor 1) *	P0328	Knock Sensor 1 Circuit High Input (Bank 1 or Single Sensor)
P0037	Oxygen Sensor Heater Control Circuit Low (Bank 1 Sensor 2)	P0339	Crankshaft Position Sensor "A" Circuit Intermittent
P0038	Oxygen Sensor Heater Control Circuit High (Bank 1 Sensor 2)	P0341	Camshaft Position Sensor "A" Circuit Range/performance (Bank 1 or Single Sensor)
P0102	Mass or Volume Air Flow Circuit Low Input	P0351	Ignition Coil "A" Primary/Secondary Circuit
P0103	Mass or Volume Air Flow Circuit High Input	P0352	Ignition Coil "B" Primary/Secondary Circuit
P0112	Intake Air Temperature Circuit Low Input	P0353	Ignition Coil "C" Primary/Secondary Circuit
P0113	Intake Air Temperature Circuit High Input	P0354	Ignition Coil "D" Primary/Secondary Circuit
P0117	Water Temperature Circuit low Input	P0443	Evaporative Emission Control System Purge Control Valve Circuit
P0118	Water Temperature Circuit High Input	P0504	Brake Switch "A"/"B" correlation
P0122	Throttle/Pedal Position Sensor/Switch "A" Circuit Low Input	P0560	System Voltage
P0604	Internal Control Module Random Access Memory (RAM) Error	P2125	Throttle/Pedal Position Sensor/Switch "E" Circuit
P0606	ECU/PCM Processor	P2127	Throttle/Pedal Position Sensor/Switch "E" Circuit Low Input
P0607	Control Module Performance	P2128	Throttle/Pedal Position Sensor/Switch "E" Circuit High Input
P0617	Starter Relay Circuit High	P2135	Throttle/Pedal Position Sensor/Switch "A"/"B" Voltage Correlation

(Continued)

*: Although the title(DTC description) says "oxygen sensor", this DTC is related to the "air fuel ratio sensor".

DTC No.	Detection Item	DTC No.	Detection Item
P0657	Actuator Supply Voltage Circuit/Open	P2138	Throttle Pedal Position Sensor/Switch "D"/"E" Voltage Correlation
P2102	Throttle Actuator Control Motor Circuit Low	P2195	Oxygen Sensor Signal Stuck Lean (Bank 1 Sensor 1) *
P2103	Throttle Actuator Control Motor Circuit High	P2196	Oxygen Sensor Signal Stuck Rich (Bank 1 Sensor 1) *
P2111	Throttle Actuator Control System – Stuck Open	P2237	Oxygen Sensor Pumping current Circuit/Open (for A/F sensor) (Bank 1 Sensor 1)
P2112	Throttle Actuator Control System – Stuck Closed	P2238	Oxygen Sensor Pumping current Circuit/Low (for A/F sensor) (Bank 1 Sensor 1)
P2118	Throttle Actuator Control Motor Current Range/Performance	P2239	Oxygen Sensor Pumping current Circuit/High (for A/F sensor) (Bank 1 Sensor 1)
P2119	Throttle Actuator Control Throttle Body Range/Performance	P2251	Oxygen Sensor Reference Ground Circuit/Open (for A/F sensor) (Bank 1 Sensor 1)
P2120	Throttle/Pedal Position Sensor/Switch "D" Circuit	P2252	Oxygen Sensor Reference Ground Circuit Low (for A/F sensor) (Bank 1 Sensor 1)
P2121	Throttle/Pedal Position Sensor/Switch "D" Circuit Range/Performance	P2253	Oxygen Sensor Reference Ground Circuit High (for A/F sensor) (Bank 1 Sensor 1)
P2122	Throttle/Pedal Position Sensor/Switch "D" Circuit Low Input	P2A00	Air Fuel Ratio Sensor Circuit Slow Response (Bank 1 Sensor 1)
P2123	Throttle/Pedal Position Sensor/Switch "D" Circuit High Input	B2799	Engine Immobilizer System Malfunction

*: Although the title (DTC description) says "oxygen sensor", this DTC is related to the "air fuel ratio sensor".

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 Control List ◀

Location on Malfunction	Description Control
Air Flow Meter	In case of a single malfunction, the engine could operate poorly or the catalyst could overheat if the engine continues to be controlled with the signals from the sensors. Therefore, the engine ECU effects control by using the values in the engine ECU or stops the engine.
Accelerator Pedal Position Sensor (For details, see page 436)	In a case of a signal malfunction, the engine ECU calculates the accelerator pedal opening angle that is limited by the dual system sensor value and continues effecting throttle valve control. If both system malfunction, the engine ECU considers that the accelerator pedal is fully closed.
Throttle Position Sensor (For details, see page 437)	In a case of signal malfunction, the engine ECU cuts off the current to the throttle control motor. The throttle valve returns to the prescribed opening by the force of the return spring. The engine ECU then adjusts the engine output by controlling the fuel injection and ignition timing in accordance with the accelerator pedal opening angle to enable the vehicle to continue driving.
Water Temp. Sensor and Intake Air Temp. Sensor	In a case of signal malfunction, the use of the values from the sensors will make the air-fuel ratio become too rich or too lean, which could causes the engine to stall or to run poorly during cold operation. Therefore, the engine ECU fixes the air-fuel ratio to the stoichiometric ratio and uses the constant values of 80°C water temperature and 20°C intake air temperature to perform the calculation.
Knock Sensor	In a case of signal malfunction in the knock sensor or in the knocking signal system (open or short circuit), the engine could become damaged if the timing is advanced despite the presence of knocking. Therefore, if a malfunction is detected in the knock sensor system, the engine ECU turns the timing retard correction of the knock sensor into the maximum retard value.
Ignition Coil (with Igniter)	In a case of signal malfunction in the ignition system, such as an open circuit in the ignition coil, the catalyst could become overheated due to engine misfire. Therefore, if the (IGf) ignition signal is not input twice or more in a row, the engine ECU determines that a malfunction occurred in the ignition system and stops only the injection of fuel into the cylinder with the malfunction.
Camshaft Position Sensor	In case of a signal malfunction (open or short circuit) or a mechanical malfunction, the engine ECU stops the VVT-i control.