13. Engine Control System

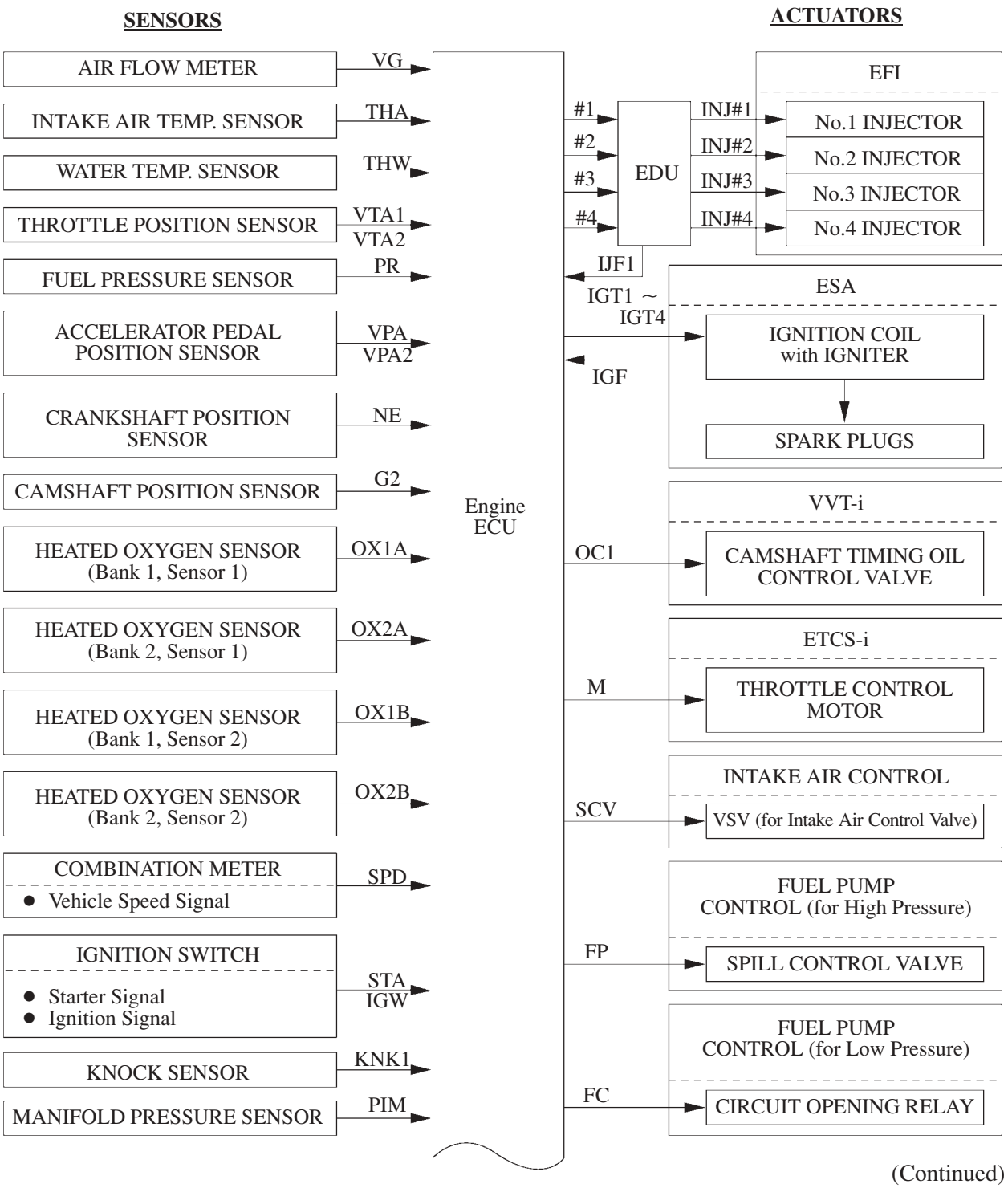
1) General

The engine control system for the 2AZ-FSE engine has following features.

System		Outline	2AZ-FSE	1AZ-FSE
D-4 EFI Electronic Fuel Injection [See page 56]		● An L-type EFI system detects the intake air volume with a hot-wire type air flow meter. ● In contrast to the conventional EFI, D-4 EFI conducts the injection volume control and injection timing control simultaneously. ● The fuel injection system is a sequential multiport fuel injection system.	○	○
ESA Electronic Spark Advance		Ignition timing determined by the engine ECU based on signals from various sensors. The engine ECU corrects ignition timing in response to engine knocking.	○	○
VVT-i Variable Valve Timing-intelligent [See page 57]		Controls the intake camshaft to an optimal valve timing in accordance with the engine condition.	○	○
ETCS-i Electronic Throttle Control System-intelligent [See page 58]		Optimally controls the throttle valve opening in accordance with the amount of accelerator pedal effort and the condition of the engine and the vehicle. In addition, comprehensively controls the ISC, VSC system, and TRC systems.	○	○
Intake Air Control [See page 62]		The engine ECU controls the intake air control valve via the VSV and the diaphragm in accordance with the engine conditioning signals (air flow meter, manifold pressure sensor, crankshaft position sensor, water temp. sensor, and throttle position sensor).	○	○
Fuel Pump Control	For High Pressure Side	Regulates the fuel pressure within a range of 8 to 13 MPa in accordance with driving conditions.	○	○
	For Low Pressure Side	● Fuel pump operation is controlled by signal from the engine ECU. ● To stop the fuel pump when the airbag is deployed at the front or side collision.	○	○
Oxygen Sensor Heater Control		Maintains the temperature of the air fuel ratio sensor and oxygen sensor at an appropriate level to increase accuracy of detection of the oxygen concentration in the exhaust gas.	○	○
Evaporative Emission Control		The engine ECU controls the purge flow of evaporative emissions (HC) in the charcoal canister in accordance with engine conditions.	○	○
Air Conditioner Cut-off Control		By turning the air conditioner compressor ON or OFF in accordance with the engine condition, drivability is maintained.	○	○
TWC Warm-Up Control [See page 63]		Significantly retards the ignition timing in order to quickly warm-up the TWC.	○	○
Engine Immobilizer		Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid ignition key.	○	○
Diagnosis [See page 64]		When the engine ECU detects a malfunction, the engine ECU diagnoses and memorizes the failed section.	○	○
Fail-Safe [See page 64]		When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the data already stored in memory.	○	○

2) Construction

The configuration of the engine control system is as shown in the following chart.



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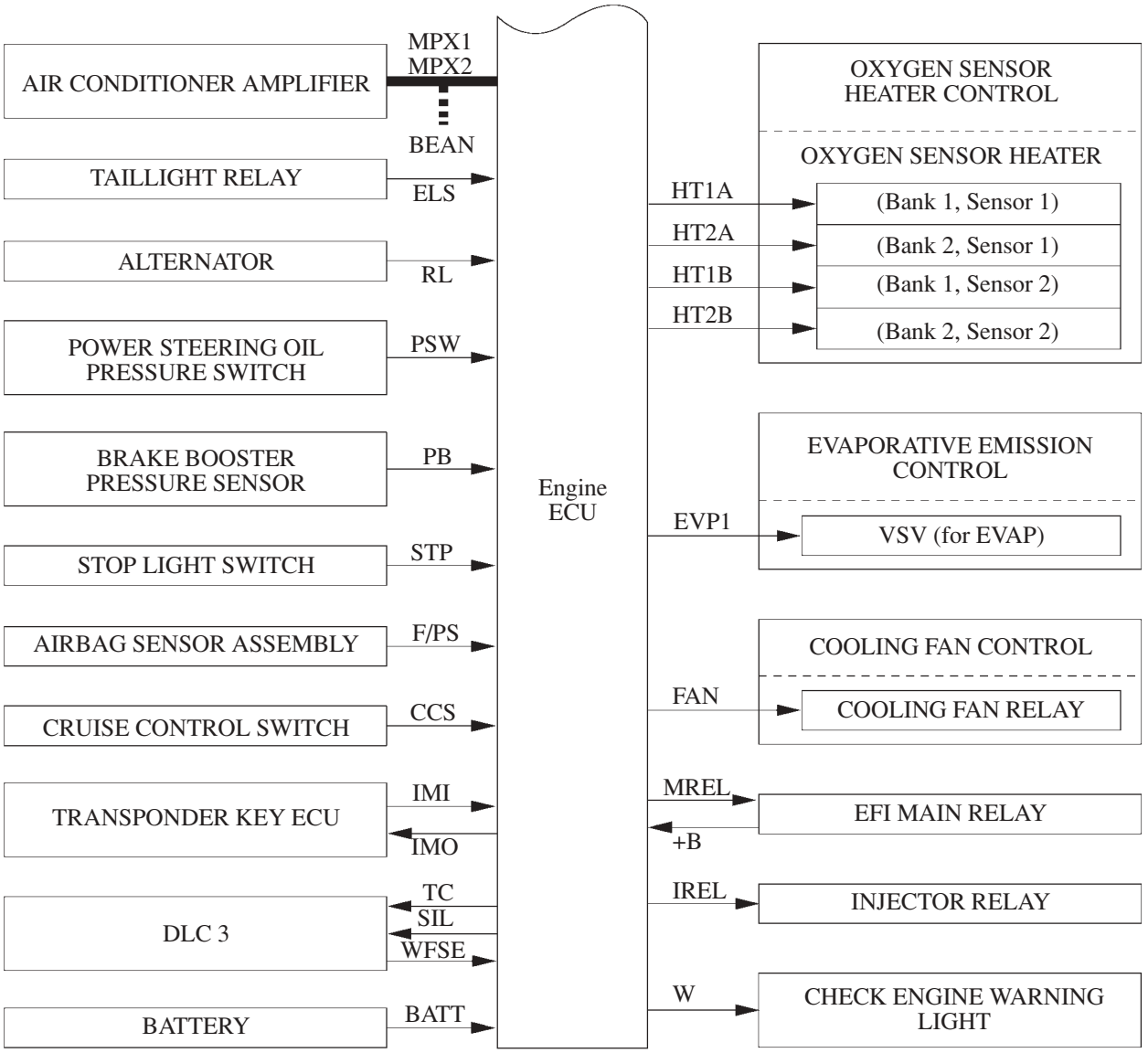
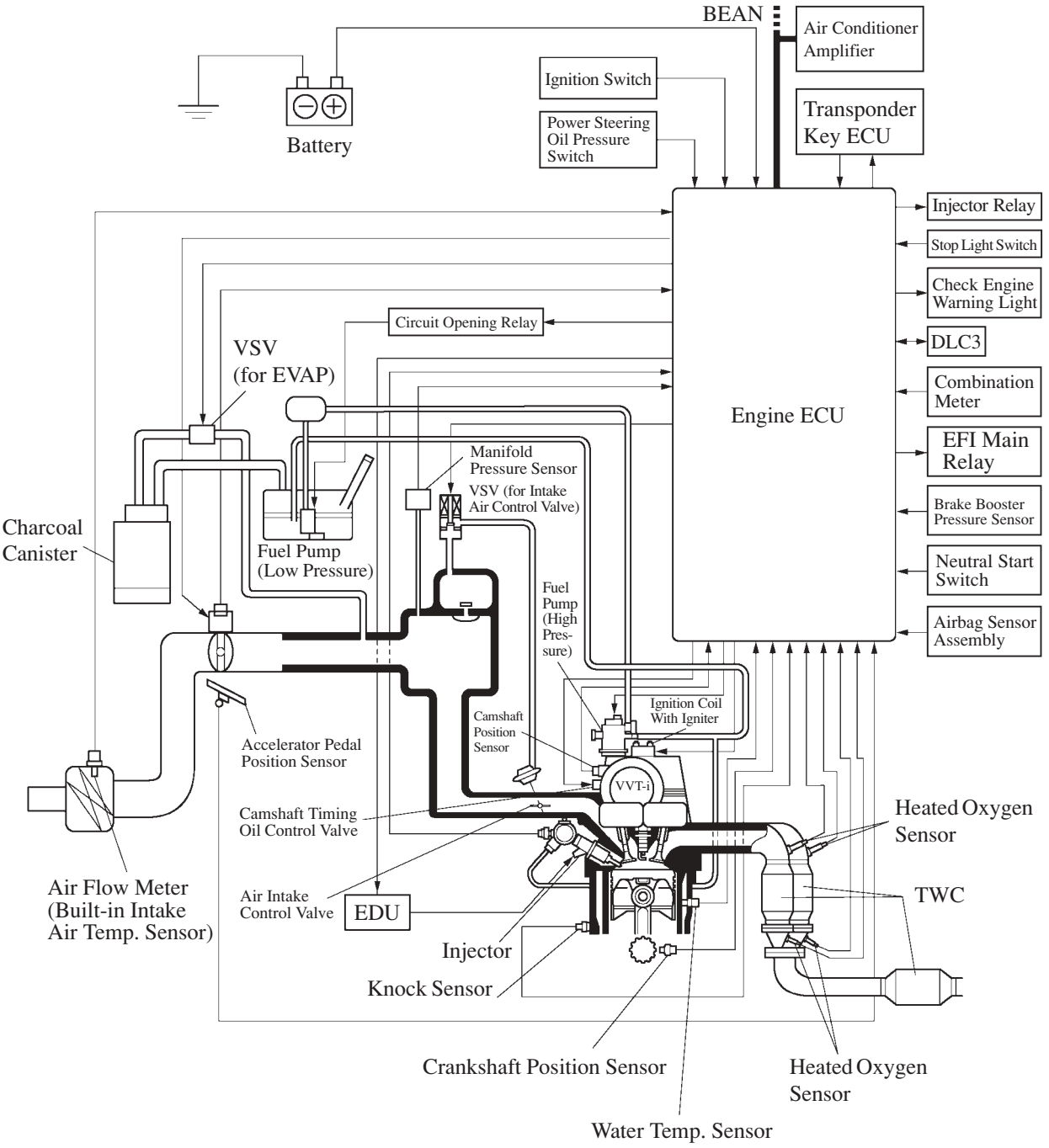

AIR CONDITIONER AMPLIFIER
MPX1
MPX2
BEAN
TAILLIGHT RELAY
ELS
ALTERNATOR
RL
POWER STEERING OIL PRESSURE SWITCH
PSW
BRAKE BOOSTER PRESSURE SENSOR
PB
STOP LIGHT SWITCH
STP
AIRBAG SENSOR ASSEMBLY
F/PS
CRUISE CONTROL SWITCH
CCS
TRANSPONDER KEY ECU
IMI
IMO
DLC 3
TC
SIL
WFSE
BATTERY
BATT
Engine ECU
OXYGEN SENSOR HEATER CONTROL
OXYGEN SENSOR HEATER
HT1A
HT2A
HT1B
HT2B
(Bank 1, Sensor 1)
(Bank 2, Sensor 1)
(Bank 1, Sensor 2)
(Bank 2, Sensor 2)
EVAPORATIVE EMISSION CONTROL
EVP1
VSV (for EVAP)
COOLING FAN CONTROL
FAN
COOLING FAN RELAY
MREL
+B
EFI MAIN RELAY
IREL
INJECTOR RELAY
W
CHECK ENGINE WARNING LIGHT

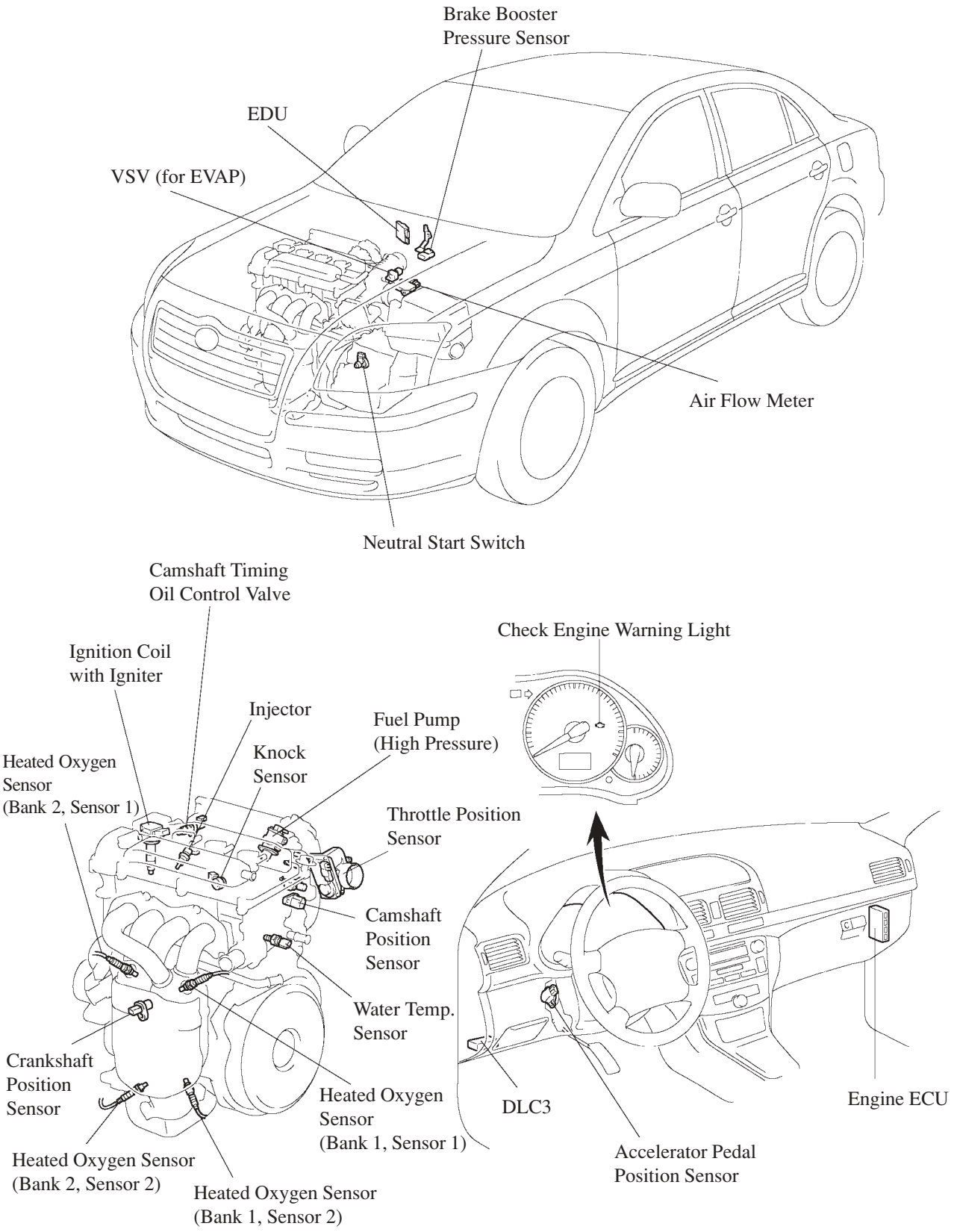
258AE117

3) Engine Control System Diagram



258AE122

4) Layout of Main Components



258AE116

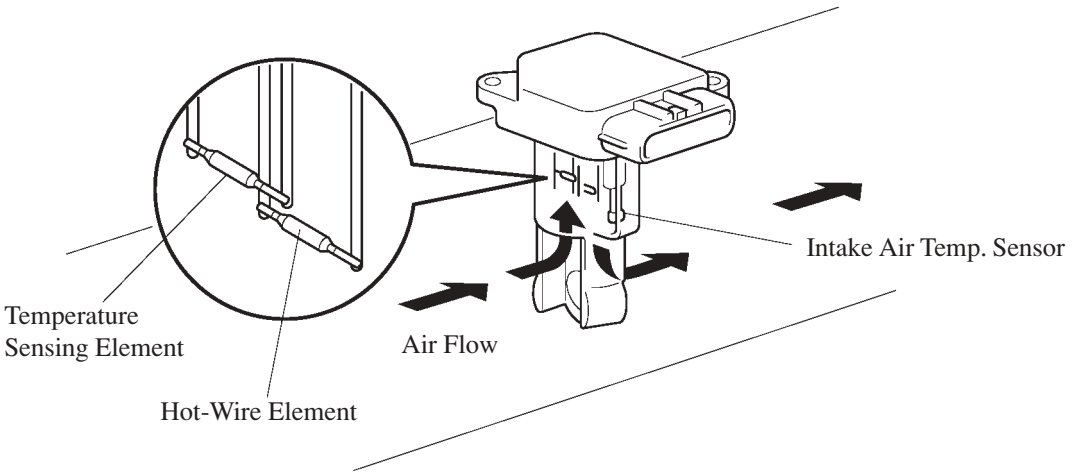
5) Main Components of Engine Control System

The main components of the 2AZ-FSE engine control system are as follows:

Components	Outline	Quantity	
		2AZ-FSE	1AZ-FSE
Engine ECU	32-bit	1	1
Air Flow Meter	Hot-Wire Type	1	1
Manifold Pressure Sensor	Semiconductor Type	1	1
Fuel Pressure Sensor	Semiconductor Strain Gauge Type	1	1
Crankshaft Position Sensor (Rotor Teeth)	Pick-Up Coil Type (36 – 2)	1	1
Camshaft Position Sensor (Rotor Teeth)	Pick-Up Coil Type (3)	1	1
Throttle Position Sensor	No-contact Type	1	1
Accelerator Pedal Position Sensor	Linear Type	1	1
Knock Sensor	Built-in Piezoelectric Element Type (Flat Type)	1	1
Oxygen Sensor (Bank 1, Sensor 1) (Bank 2, Sensor 1) (Bank 1, Sensor 2) (Bank 2, Sensor 2)	Type with Heater	4	4
Injector	High Pressure Slit Nozzle Type	4	4
Brake Booster Pressure Sensor	Semiconductor Type	1	1
EDU (Electronic Driver Unit)	Built-in DC/DC Converter	1	1

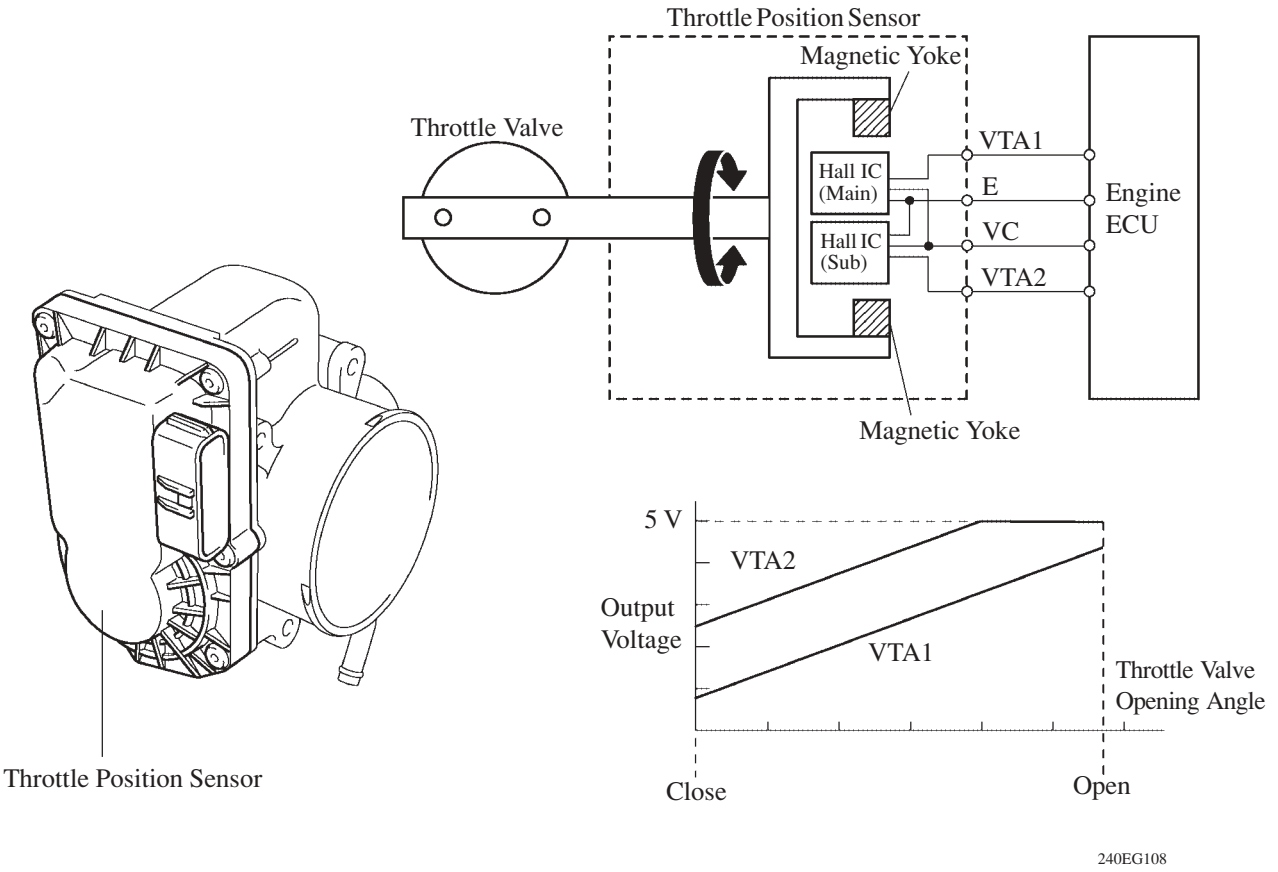
6) Air Flow Meter

- This compact and lightweight air flow meter, which is a plug-in type, allows a portion of the intake air to flow through the detection area. By directly measuring the mass and the flow rate of the intake air, the detection precision is improved and the intake air resistance has been reduced.
- This mass air flow meter has a built-in intake air temperature sensor.



7) Throttle Position Sensor

- The throttle position sensor uses 2 Hall ICs. This sensor detects the throttle valve opening angle by converting into electrical signals the changes in magnetic flux density created when the 2 magnetic yoke revolves around the 2 Hall ICs.
- This sensor converts the throttle valve opening angles into electronic signals with two differing characteristics and outputs them to the engine ECU. One is the VTA1 (main) signal that linearly outputs the voltage along the ensure range of the throttle valve opening angle. The other is the VTA2 (sub) signal that outputs an offset voltage.

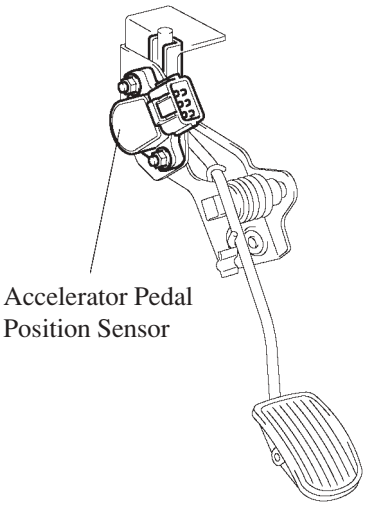


Service Tip

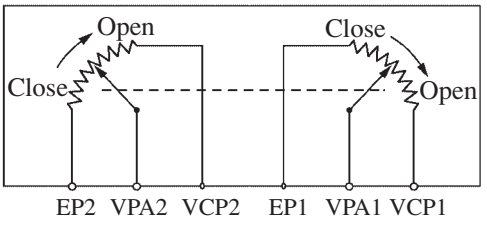
This sensor uses a Hall IC, so the inspection method differs from that of a conventional throttle position sensor.
For details, refer to the Avensis Repair Manual Supplement (Pub. No. RM1045E).

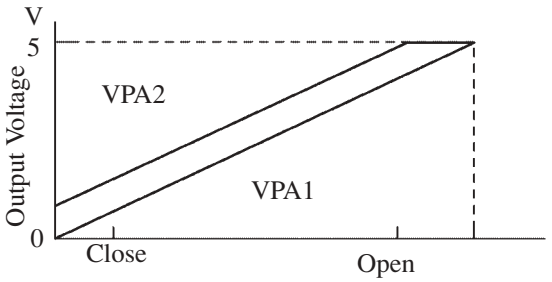
8) Accelerator Pedal Position Sensor

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.



206EG37

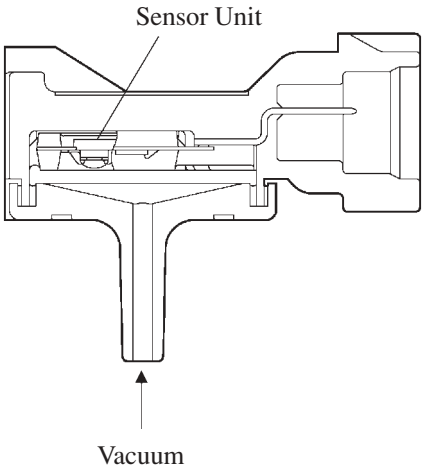




199EG40

9) Brake Booster Pressure Sensor

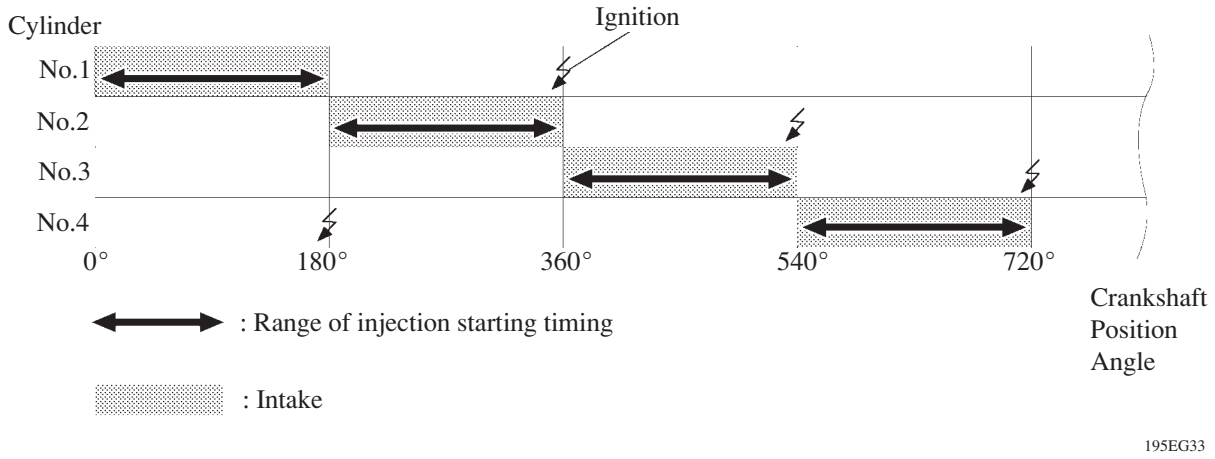
The brake booster pressure sensor consists of a semiconductor, which utilizes the characteristic of a silicon chip that changes its electrical resistance when pressure is applied to it. The sensor converts the pressure into an electrical signal, and sends it to the engine ECU in an amplified form.



210EG57

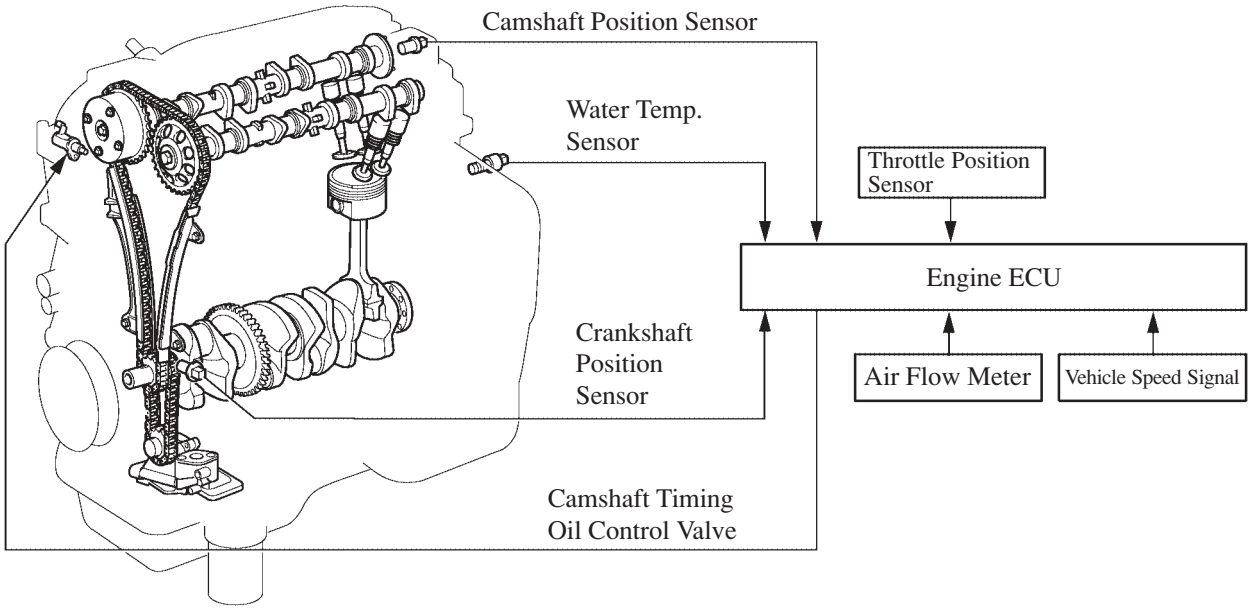
10) D-4 EFI (Electronic Fuel Injection) System

- In contrast to the conventional EFI (Electronic Fuel Injection), the D-4 (Direct Injection 4-Stroke Gasoline Engine) EFI conducts the injection volume control and injection timing control simultaneously.
- The injection volume is determined by the engine ECU, based on the signals from the air flow meter, to which corrections from various sensors are added. The engine ECU achieves optimal injection volume by controlling the fuel pressure and the opening time of the injector nozzle.
- A sequential multiport fuel injection system is used. The engine ECU calculates the optimal injection timing independently into each cylinder in accordance with the driving conditions.



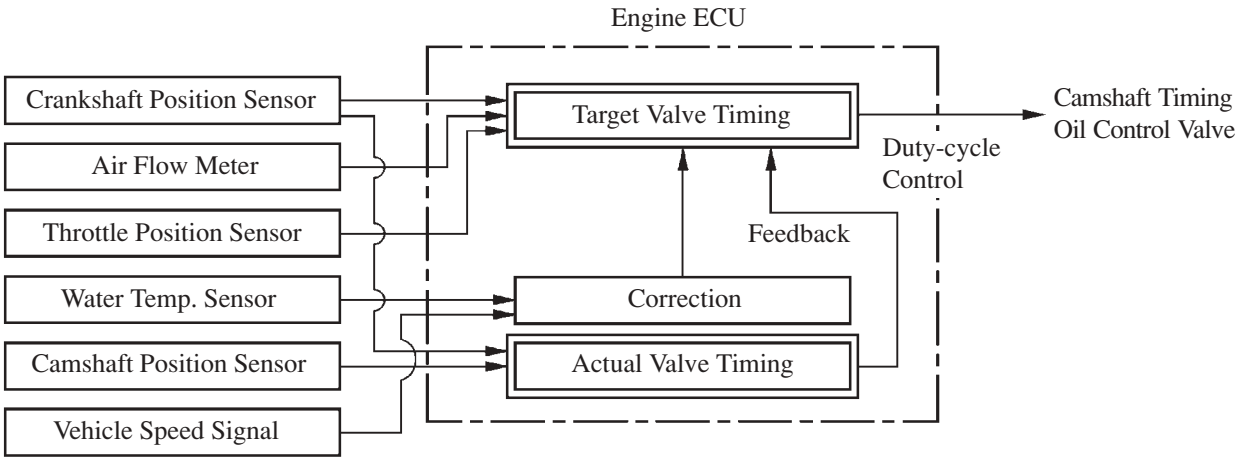
11) VVT-i (Variable Valve Timing-intelligent) System

- The VVT-i system is designed to control the intake camshaft within a range of 45° (of Crankshaft Angle) to provide valve timing that is optimally suited to the engine conditions. This improves torque in all the speed ranges as well as increasing fuel economy, and reducing exhaust emissions.



198EG19

- Using the engine speed, intake air volume, throttle position, and water temperature, the engine ECU can calculate optimal valve timing for each driving condition and controls the camshaft timing oil control valve. In addition, the engine ECU uses signals from the camshaft position sensor and the crankshaft position sensor to detect the actual valve timing, thus providing feedback control to achieve the target valve timing.

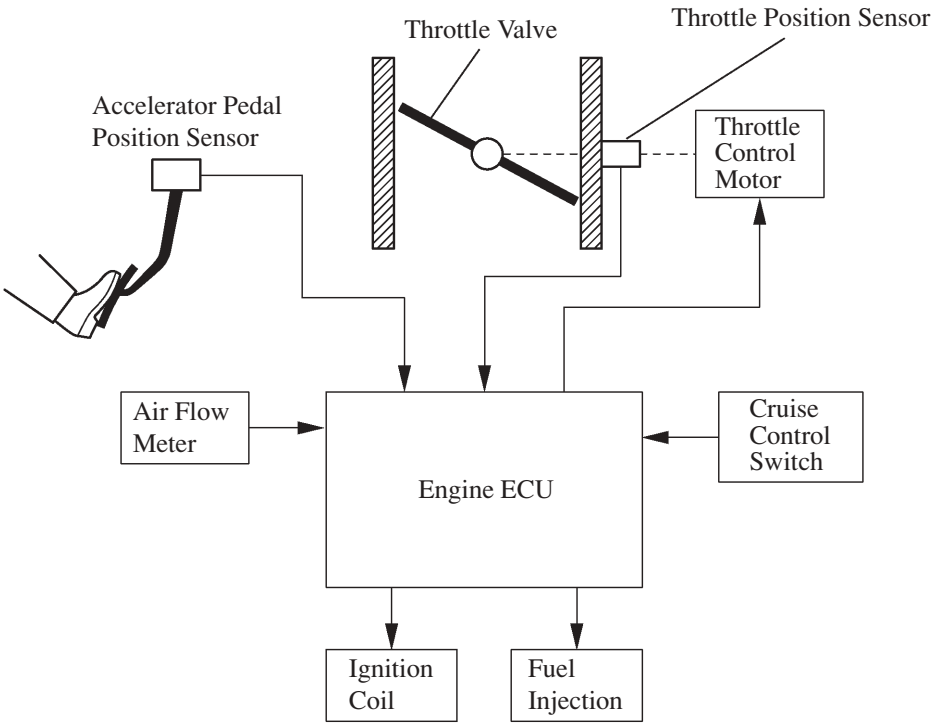


221EG16

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

a. General

- The ETCS-i system, which realizes excellent throttle control in all the operating ranges, is used.
- 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 ETCS-i controls the ISC (Idle Speed Control) system, the TRC (Traction Control) system, the VSC (Vehicle Stability Control) system, and the cruise control.



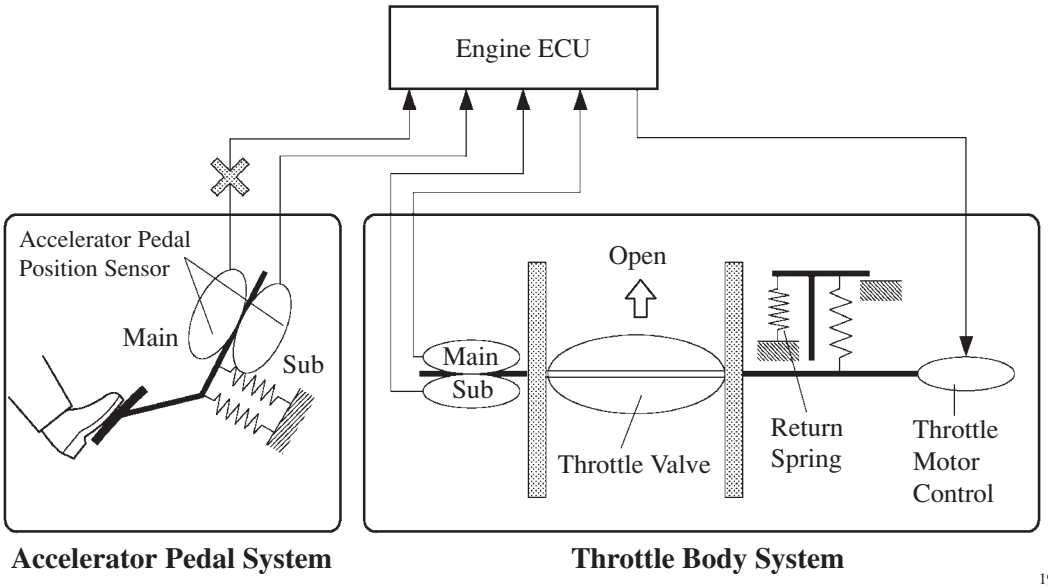
b. Operation

The engine ECU drives the throttle control motor by determining the target throttle valve opening in accordance with the respective operating condition. The 2AZ-FSE engine mainly has the following ETCS-i controls.

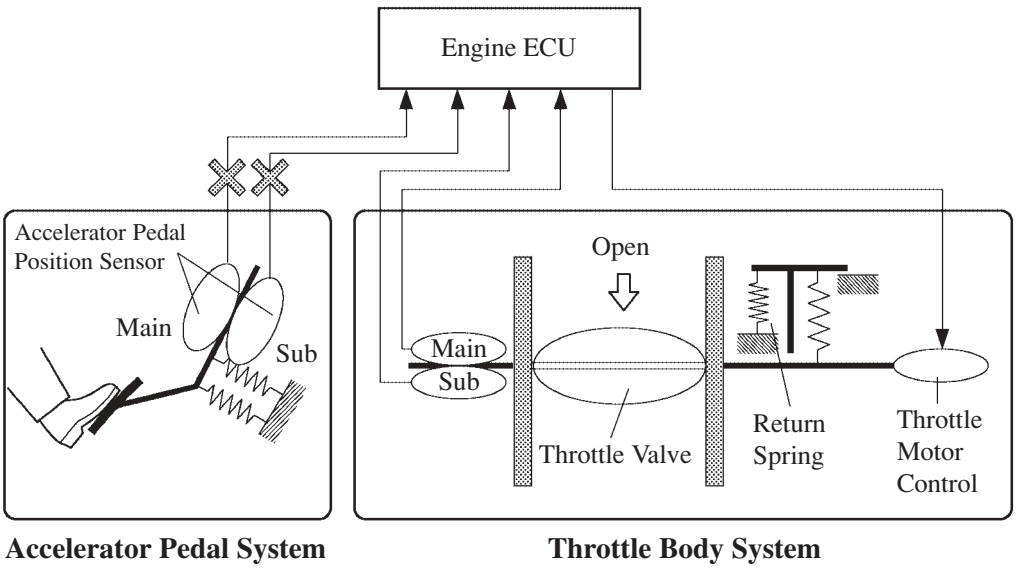
Control	Outline
Idle Speed	Controls the engine ECU and the throttle valve in order to constantly effect ideal idle speed control.
TRC Throttle	As part of the TRC system, the throttle valve is closed by a demand signal from the skid control ECU if an excessive amount of slippage is created at a driving wheel, thus facilitating the vehicle in ensuring stability and driving force.
VSC Coordination	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.
Maximum Vehicle Speed	When the vehicle speed is exceeded the target speed, the engine ECU operates the throttle valve to the closing side and controls the maximum vehicle speed.
Power Train Protect	At the time of multiple shifting down when accelerating, the throttle valve opening is gradually controlled soon after the shift down in order to smooth the driving force change and to protect the driving system parts.
Wheel Locking Protect	On the low μ surface road, when the driver down-shifted manually to decelerate, ECT (Electronically Controlled Transaxle) controls the opening of the throttle valve gradually in order to protect the driving wheels from locking soon after the deceleration.
Cruise Control System	An engine ECU with an integrated cruise control ECU directly actuates the throttle valve to effect the operation of the cruise control.

c. 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 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.

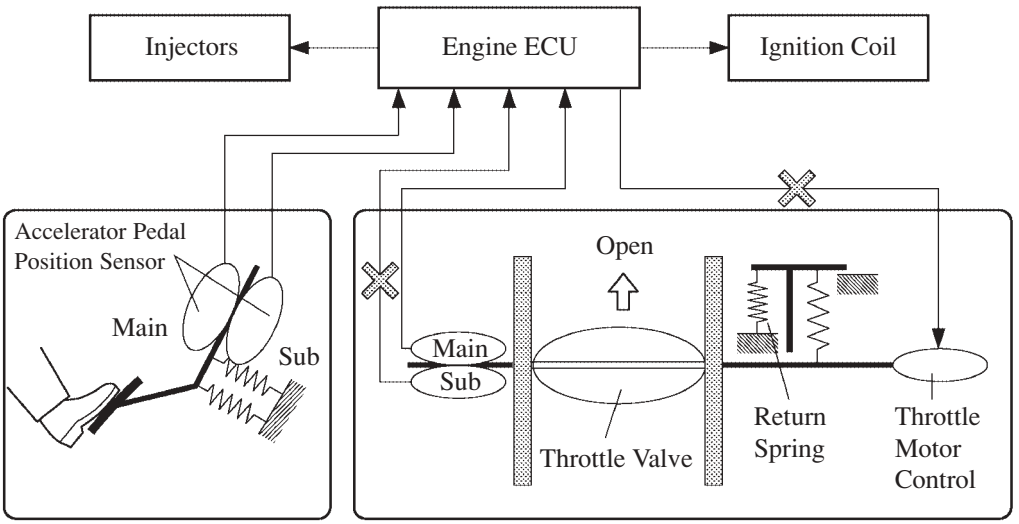


- If both circuits malfunction, the engine ECU detects the abnormal signal voltage from these two sensor circuits and discontinues the throttle control. At this time, the vehicle can be driven within its idling range.



d. 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, cut off the current to the throttle 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.

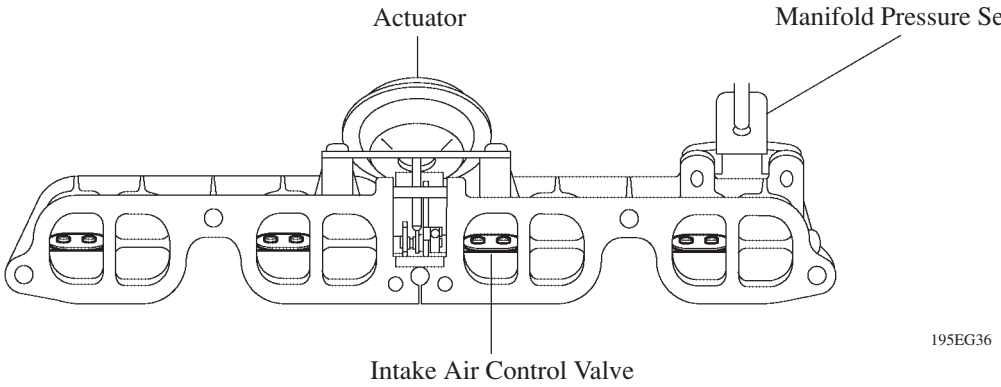


Accelerator Pedal System **Throttle Body System**

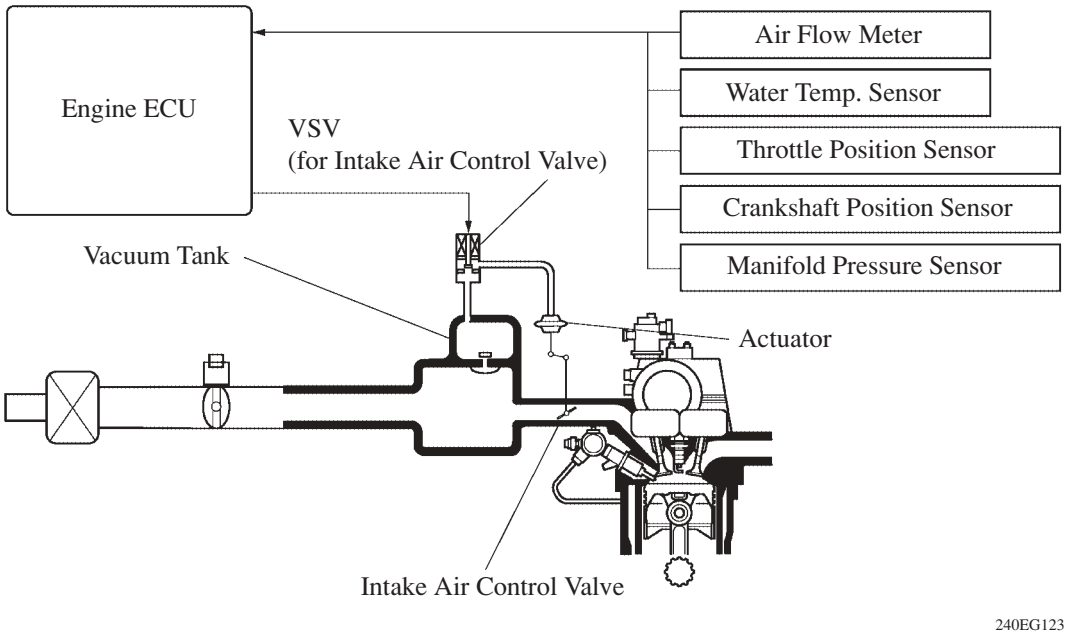
199EG47

13) Intake Air Control System

- An aluminum die-cast intake air control valve has been provided between the intake manifold and the cylinder head.
- A valve is provided on one of the two intake ports that are provided for each cylinder, and this valve is closed when the engine is operating at low speeds. Thus, increasing the intake air flow velocity and improving the volumetric efficiency. The valve is also closed when the water temperature is low to promote the atomization of fuel by strengthening the swirl in the combustion chamber. As a result, combustion is stabilized.
- According to the operating conditions of the engine, the engine ECU actuates the VSV (for intake air control valve) to turn the intake air control valve ON/OFF by regulating the vacuum that is applied to the actuator. This uses the vacuum that is stored in the vacuum tank, which is integrated in the intake manifold.
- The engine ECU monitors the operating condition (Open/Close) of intake air control valve by the signal from manifold pressure sensor.



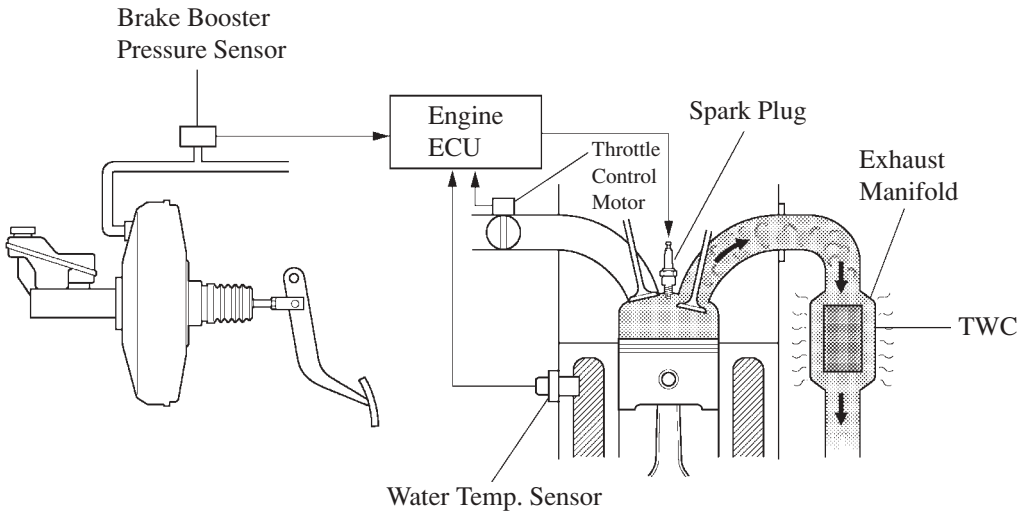
▶ System Diagram ◀



14) TWC Warm-up Control

While a cold engine is being started, this control regulates the ignition timing and the throttle valve in order to improve the warm-up performance of the TWC (Three-Way Catalytic Converter).
The engine ECU effects this control based on the signals from the water temperature sensor and the brake booster pressure sensor.

- When the water temperature is below a predetermined value, the engine ECU retards the ignition timing to the maximum level in order to raise the exhaust gas temperature. Consequently, the high-temperature exhaust gas, which is in the middle of combustion, flows into the exhaust manifold, in order to warm up the TWC at an early stage.
- Retarding the ignition timing to the maximum level will reduce combustion efficiency. Therefore, the engine ECU opens the throttle valve in order to prevent the engine output from decreasing. The intake manifold vacuum pressure decreases at this time. Therefore, the engine ECU monitors the brake booster pressure, and if this pressure is too low, the ECU reduces the amount of retard of the ignition timing and shortens the control duration in order to prevent the vacuum pressure from dropping.



15) Diagnosis

- The diagnosis system of the 2AZ-FSE engine uses the EURO-OBD (Europe On-Board Diagnosis) that complies with European regulations.
- When the engine ECU detects a malfunction, the engine ECU makes a diagnosis and memorizes the failed section. Furthermore, the check engine warning light in the combination meter illuminates or blinks to inform the driver.
- At the same time, the DTCs (Diagnostic Trouble Codes) are stored in memory. The DTCs can be read by connecting a hand-held tester.
- The DTCs have been further divided to correspond to SAE codes.
- For details, see the Avensis Repair Manual Supplement (Pub. No. RM1045E).

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.

16) 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 as the following conditions.

▶ Fail-Safe Control List ◀

DTC	Fail-safe Operation	Fail-safe Deactivation Conditions
P0031, P0032, P0037, P0038, P0051, P0052, P0057, P0058	Faulty heater circuit is turned off.	Ignition switch OFF
P0100, P0102, P0103	Ignition timing is calculated based on an engine speed and a throttle opening angle.	"Pass" detection has occurred. Upon this occurrence, the engine ECU will return to normal mode.
P0105, P0107, P0108	● Intake air pressure is controlled with a calculated value in proportion to the throttle opening angle and the engine speed. ● Limit the engine speed to 3,000 rpm or less.	"Pass" detection has occurred. Upon this occurrence, the engine ECU will return to normal mode.
P0110, P0112, P0113	Intake air temperature is fixed at 20°C (68°F).	"Pass" detection has occurred. Upon this occurrence, the engine ECU will return to normal mode.
P0115, P0117, P0118	Water temperature is fixed at 80°C (176°F).	"Pass" detection has occurred. Upon this occurrence, the engine ECU will return to normal mode.
P0120, P0121, P0122, P0123, P0220, P0222, P0223, P2135	Turn off the power for the throttle motor, return the throttle valve in position using the return spring, and fuel cut intermittent.	Repeat the following conditions at least 2 seconds or more with the throttle position switch closed: ● 0.1 V less than VTA less than 0.95 V ● Engine speed is 0 km/h
P0190, P0191	● Stop the high-pressure pump operation. ● Limit the engine speed to 2,000 rpm or less.	After it is returned to normal condition, turn the ignition switch ON.

(Continue)

DTC	Fail-safe Operation	Fail-safe Deactivation Conditions
P0200	Turn off the INJ relay and cut the power for the EDU.	After it is returned to normal condition, turn the ignition switch ON.
P0201, P0202, P0203, P0204	● Stop fuel injection for an abnormal cylinder and related other cylinders. ● Limit the engine speed to 3,000 rpm or less.	
P0325, P0327, P0328	Maximum timing retardation	Ignition switch OFF
P0351, P0352, P0353, P0354	Stop fuel injection for all the cylinders.	"Pass" detection has occurred. Upon this occurrence, the engine ECU will return to normal mode.
P0604, P0606, P0607, P0657	Turn off the power for the throttle motor, return the throttle valve in position using the return spring, and fuel cut intermittent.	After it is returned to normal condition, turn the ignition switch ON.
P1235	● Stop the high-pressure pump operation. ● Limit the engine speed to 2,000 rpm or less.	After it is returned to normal condition, turn the ignition switch ON.
P2008	Force IACV to close.	After it is returned to normal condition, turn the ignition switch ON.
P2102, P2103, P2111, P2112, P2118, P2119	Turn off the power for the throttle motor, return the throttle valve in position using the return spring, and fuel cut intermittent.	After it is returned to normal condition, turn the ignition switch ON.