■ENGINE CONTROL SYSTEM

1. General

The engine control system for the 2SZ-FE engine in the new model and previous model are compared below.

System	Outline	New	Previous
EFI (Electronic Fuel Injection) [See page EG-94]	● An L-type EFI system detects the intake air mass with a hot-wire type air flow meter. ● The fuel injection system is a sequential multiport fuel injection system.	○	○
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 EG-95]	Optimally controls the throttle valve opening angle in accordance with the amount of accelerator pedal effort and the condition of the engine and the vehicle.	○	—
ISC (Idle Speed Control)	A rotary solenoid type ISC valve controls the fast idle and idle speeds.	—	○
VVT-i Variable Valve Timing-intelligent [See page EG-101]	Controls the intake camshaft to an optimal valve timing in accordance with the engine condition.	○	○
Cooling Fan Control [For details, see page EG-54 in 1KR-FE engine section.]	Cooling fan operation is controlled by signals from the engine ECU based on the water temperature sensor signal and the condition of the air conditioner operation.	○	○
Fuel Pump Control [For details, see page EG-55 in 1KR-FE engine section.]	Fuel pump operation is controlled by signals from the engine ECU.	○	○
	The fuel pump is stopped when the SRS airbags are deployed in a front or side collision.	○	○
Heated Oxygen Sensor Heater Control	Maintains the temperature of the heated oxygen sensors 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.	○	○

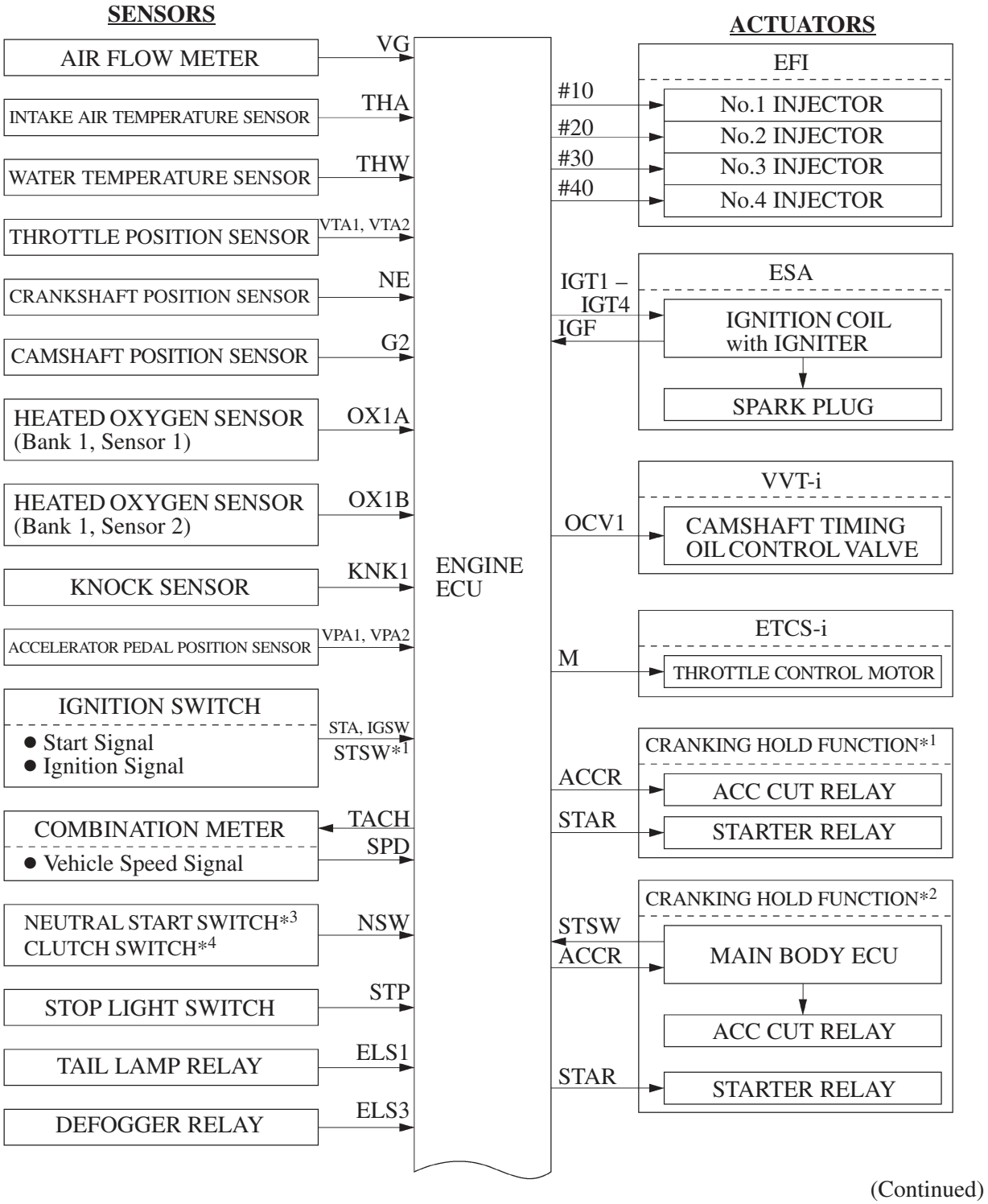
*: Models with Air Conditioner

(Continued)

System	Outline	New	Previous
Starter Control (Cranking Hold Function) [For details, see page EG-56 in 1KR-FE engine section.]	● On the models without smart entry & start system, once the ignition switch is turned to the START position, this control continues to operate the starter until the engine is started. ● On the models with smart entry & start system, once the engine switch is pushed, this control continues to operate the starter until the engine is started.	○	—
Engine Immobilizer	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid key.	○	○
Diagnosis [See page EG-104]	When the engine ECU detects a malfunction, the engine ECU diagnoses and memorizes the failed section.	○	○
Fail-safe [See page EG-104]	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

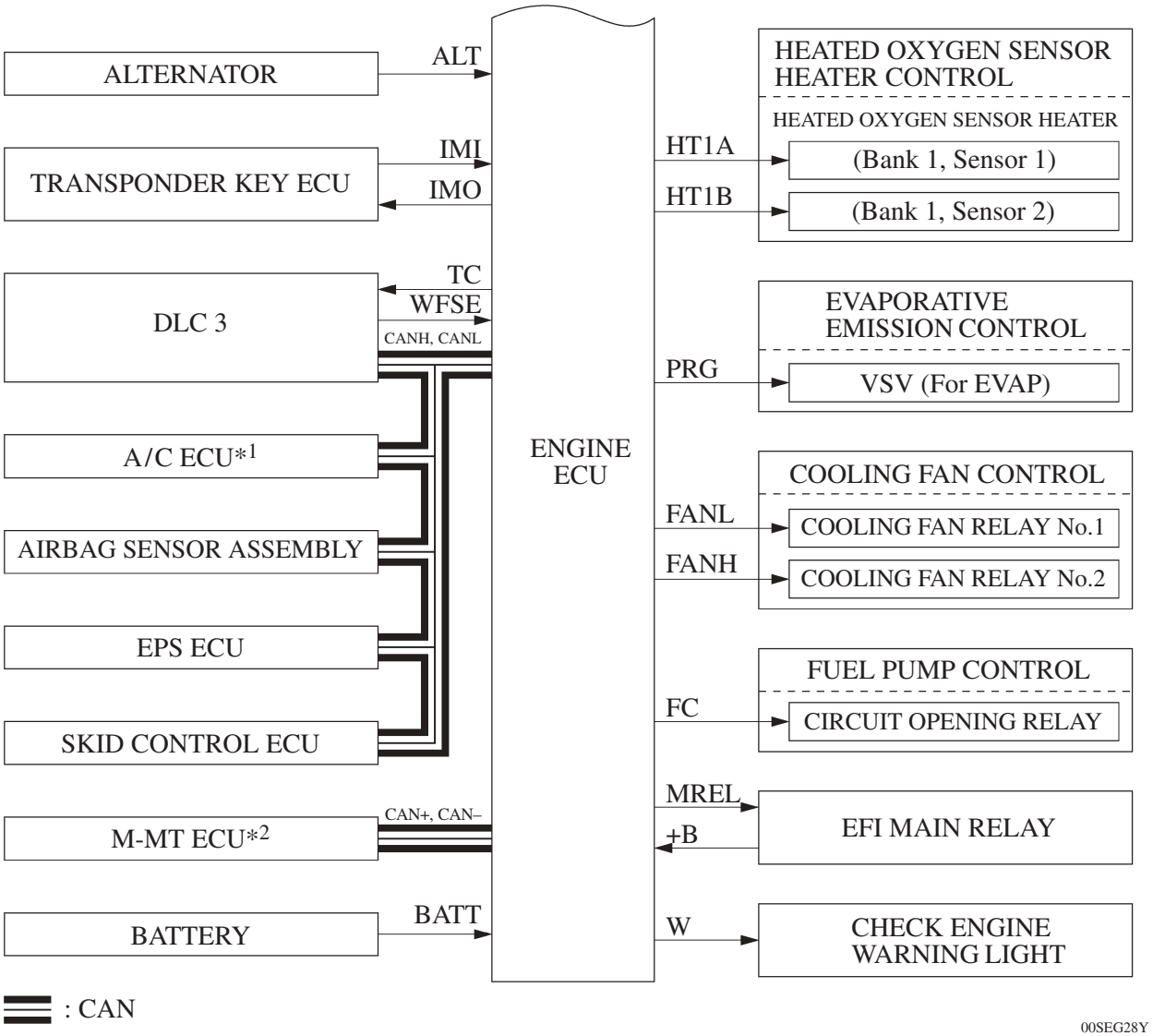
The configuration of the engine control system in the 2SZ-FE engine is as shown in the following chart.



(Continued)

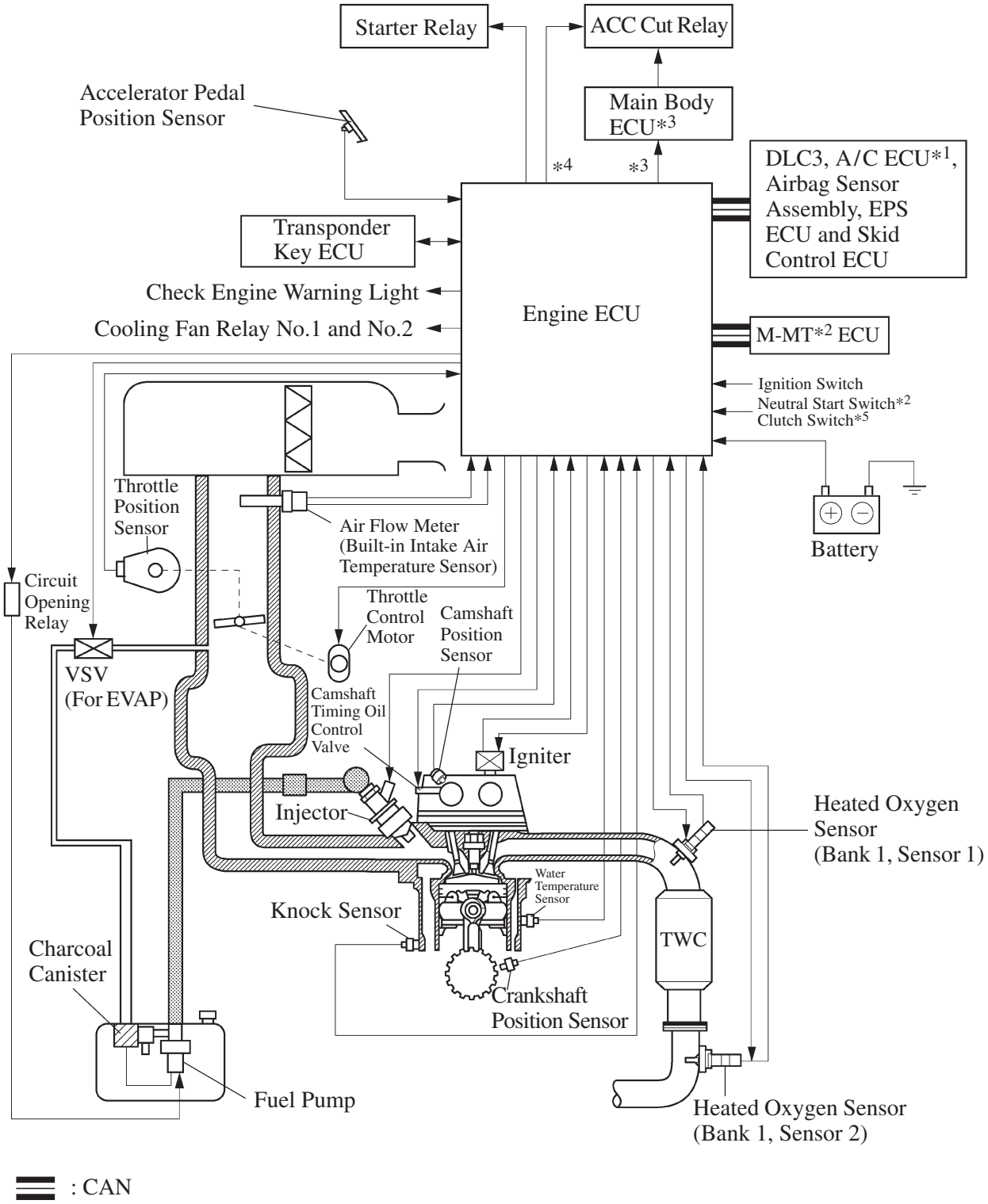
00SEG27Y

*1: Models without Smart Entry & Start System
*2: Models with Smart Entry & Start System
*3: M-MT Models
*4: M/T Models



*1: Models with Air Conditioner
*2: M-MT Models

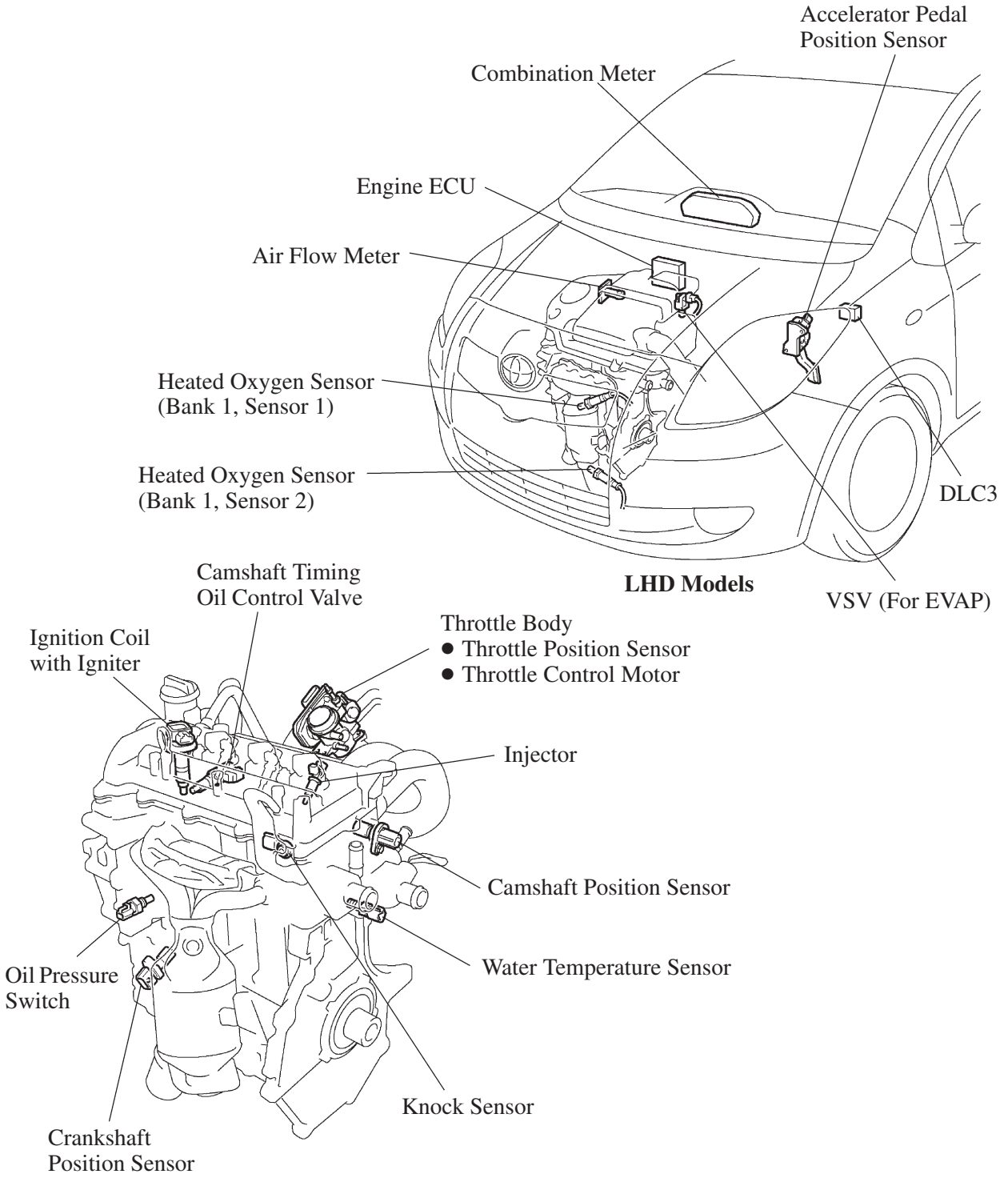
3. Engine Control System Diagram



00SEG82Y

*1: Models with Air Conditioner
*2: Multi-mode Manual Transmission Models
*3: Models with Smart Entry & Start System
*4: Models without Smart Entry & Start System
*5: M/T Models

4. Layout of Main Components



00SEG83Y

5. Main Components of Engine Control System

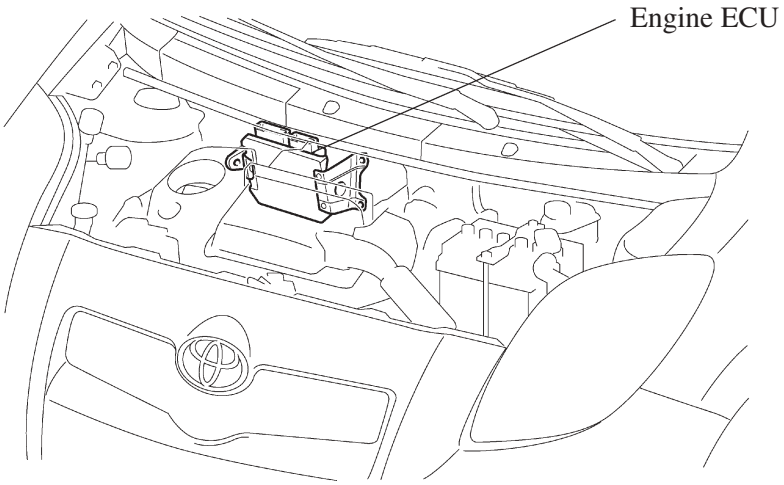
General

The main components of the 2SZ-FE engine control system are as follows:

Component	Outline	Quantity	Function
Engine ECU	32-bit CPU	1	The engine ECU optimally controls the EFI, ESA, and ETCS-i to suit the operating conditions of the engine in accordance with the signals provided by the sensors.
Heated Oxygen Sensor (Bank 1, Sensor 1)	Planar Type with Heater	1	This sensor detects the oxygen concentration in the exhaust emission by measuring the electromotive force which is generated in the sensor itself.
Heated Oxygen Sensor (Bank 1, Sensor 2)	Cup Type with Heater	1	
Air Flow Meter	Hot-wire Type	1	This sensor has a built-in hot-wire to directly detect the intake air mass.
Intake Air Temperature Sensor	Thermistor Type	1	This sensor detects the intake air temperature by means of an internal thermistor.
Crankshaft Position Sensor (Rotor Teeth)	Pickup Coil Type (36 - 2)	1	This sensor detects the engine speed and performs the cylinder identification.
Camshaft Position Sensor (Rotor Teeth)	Pickup Coil Type (3)	1	This sensor performs the cylinder identification.
Water Temperature Sensor	Thermistor Type	1	This sensor detects the water temperature by means of an internal thermistor.
Knock Sensor	Built-in Piezoelectric Type (Flat Type)	1	This sensor detects an occurrence of the engine knocking indirectly from the vibration of the cylinder block caused by the occurrence of engine knocking.
Accelerator Pedal Position Sensor	Non-contact Type	1	This sensor detects the amount of pedal effort applied to the accelerator pedal.
Throttle Position Sensor	Non-contact Type	1	This sensor detects the throttle valve opening angle.
Injector	10-hole Type	4	The injector is an electromagnetically-operated nozzle which injects fuel in accordance with the signals from the engine ECU.

Engine ECU

- A 32-bit CPU is used in the engine ECU.
- The engine ECU is installed in the engine compartment. As a result, the wiring harness has been shortened, thus realizing weight reduction.



LHD Models

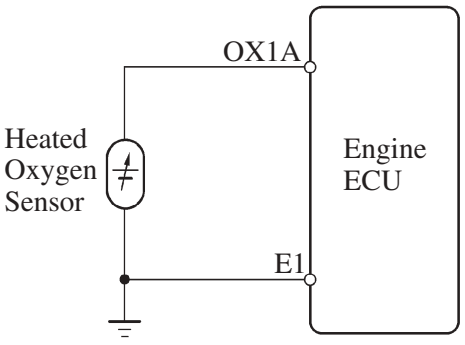
00SEG63Y

Heated Oxygen Sensor

1) General

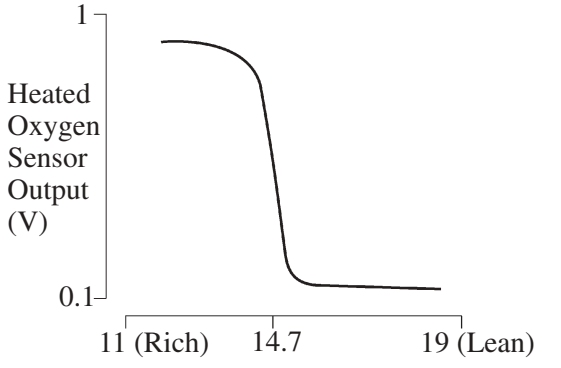
- A planar type oxygen sensor is used on the front side (bank 1, sensor 1), and a cup type heated oxygen sensor is used on the rear side (bank 1, sensor 2).
- Both types have the same functions and output characteristics.
- The output voltage of the heated oxygen sensor changes in accordance with the oxygen concentration in the exhaust emission. The engine ECU uses this output voltage to determine whether the present air-fuel ratio is richer or leaner than the stoichiometric air-fuel ratio.

▶ Sensor Circuit ◀



00SEG30Y

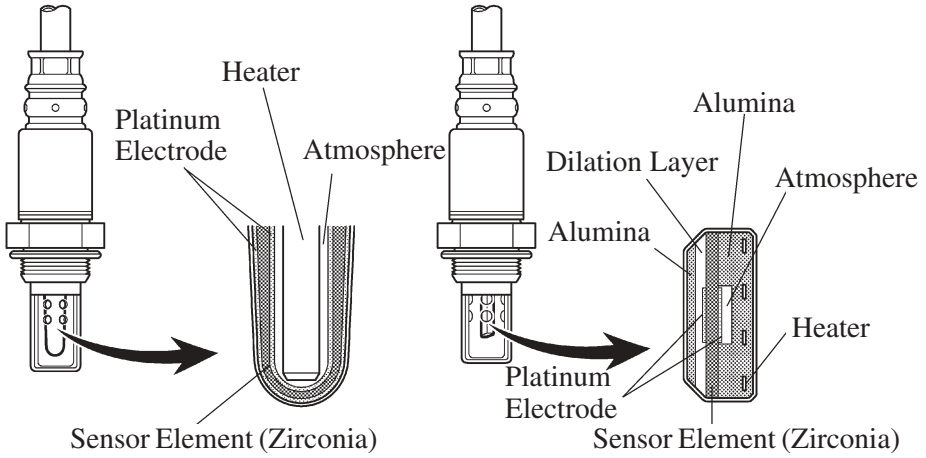
▶ Sensor Output Voltage ◀



00SEG31Y

2) Construction

- The basic composition is the same for the cup type and the planar type. The cup type and planar type are differentiated by the composition of their heaters.
- The cup type sensor contains a sensor element that surrounds a heater.
- The planar type sensor uses alumina, which excels in heat conductivity and insulation, to integrate a sensor element with a heater, thus improving the warm-up performance of the sensor.

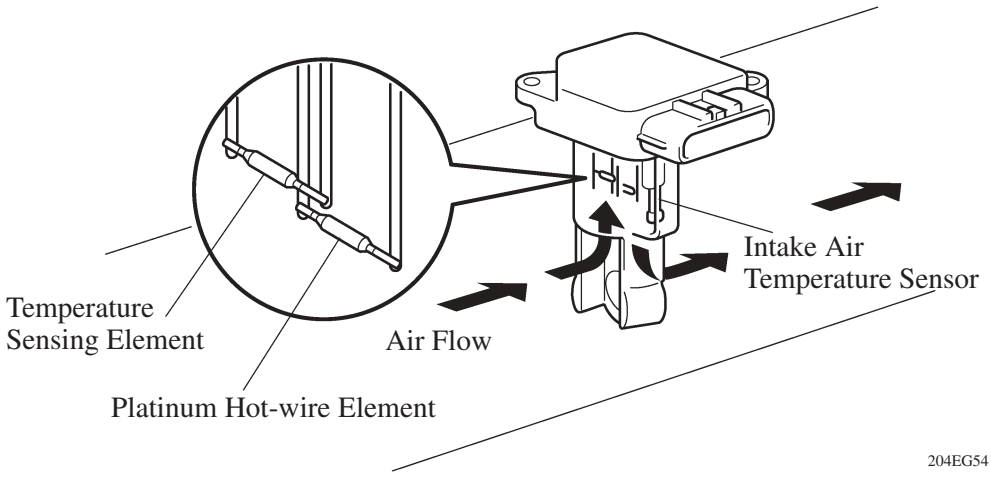


▶ Warm-up Specification ◀

Sensor Type	Planar Type	Cup Type
Warm-up Time	Approx. 10 sec.	Approx. 30 sec.

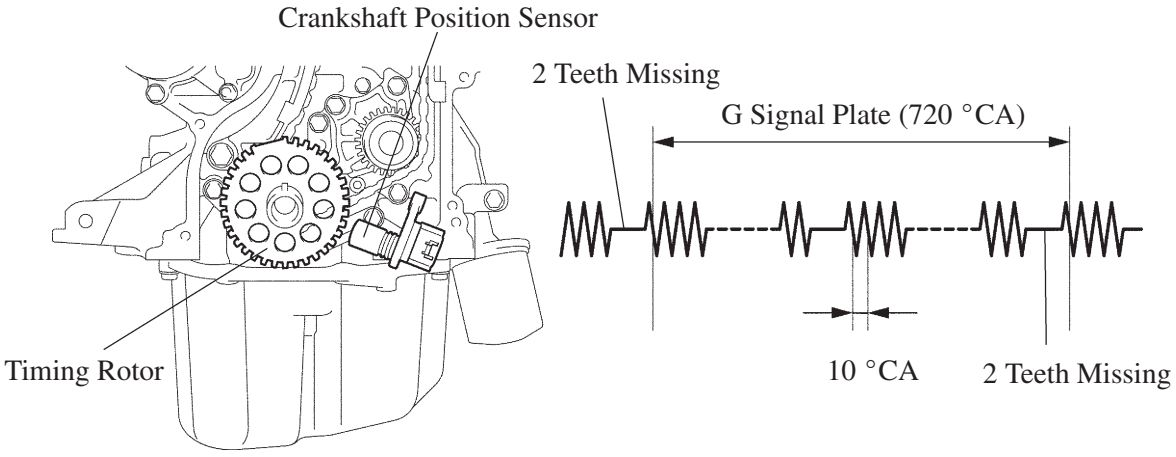
Air Flow Meter

- This compact and lightweight air flow meter is a plug-in type and 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 high detection precision is achieved and the intake air resistance is reduced.
- This air flow meter has a built-in intake air temperature sensor.



Crankshaft Position Sensor

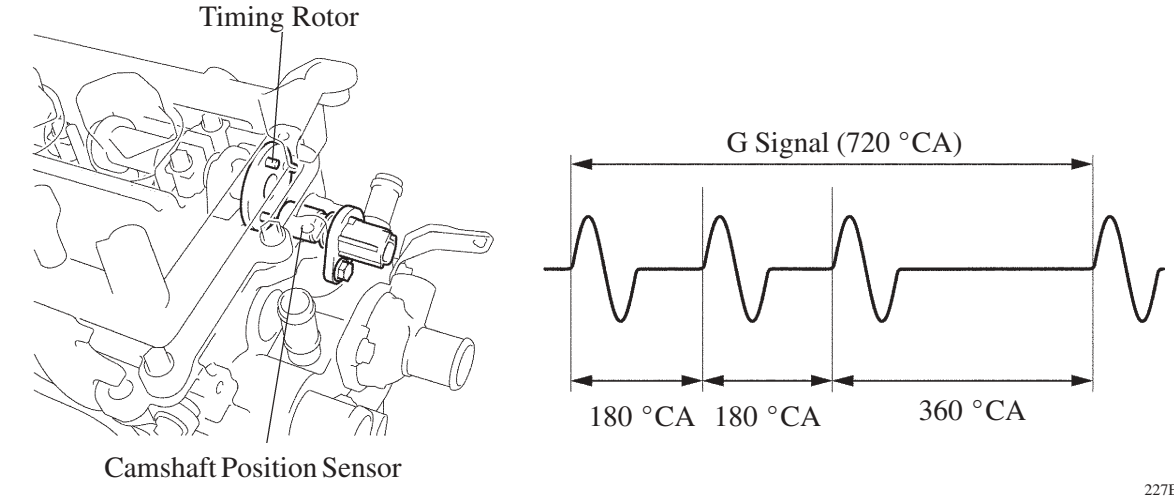
The timing rotor of the crankshaft consists of 34 teeth, with 2 teeth missing. The crankshaft position sensor outputs the crankshaft rotation signals every 10°, and the missing teeth are used to determine the top-dead-center.



227EG30

Camshaft Position Sensor

To detect the camshaft position, a timing rotor on the intake camshaft is used to generate 3 pulses for every 2 revolutions of the crankshaft.



227EG31

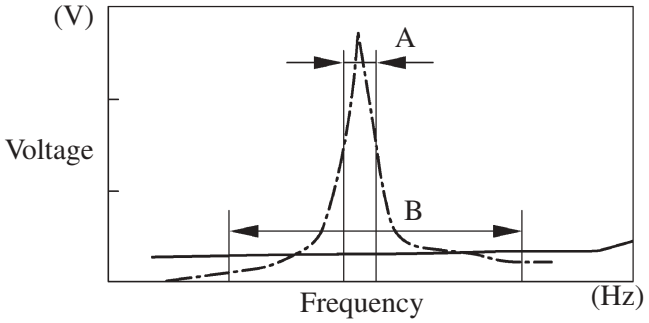
Knock Sensor (Flat Type)

1) 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 precise ignition timing control is possible.

—·— : Resonance Characteristic of Conventional Type
——— : Resonance Characteristic of Flat Type

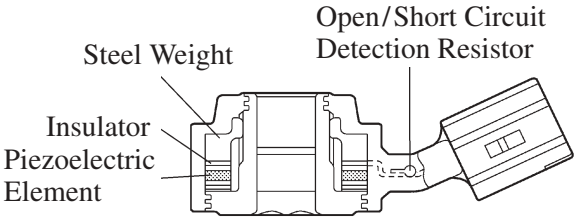


Characteristic of Knock Sensor

214CE04

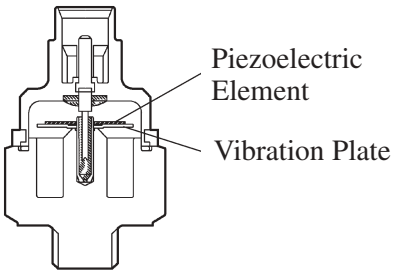
2) Construction

- 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)

214CE01

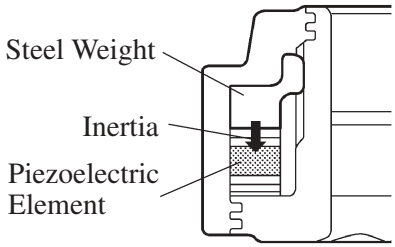


Conventional Type Knock Sensor (Resonant Type)

214CE02

3) Operation

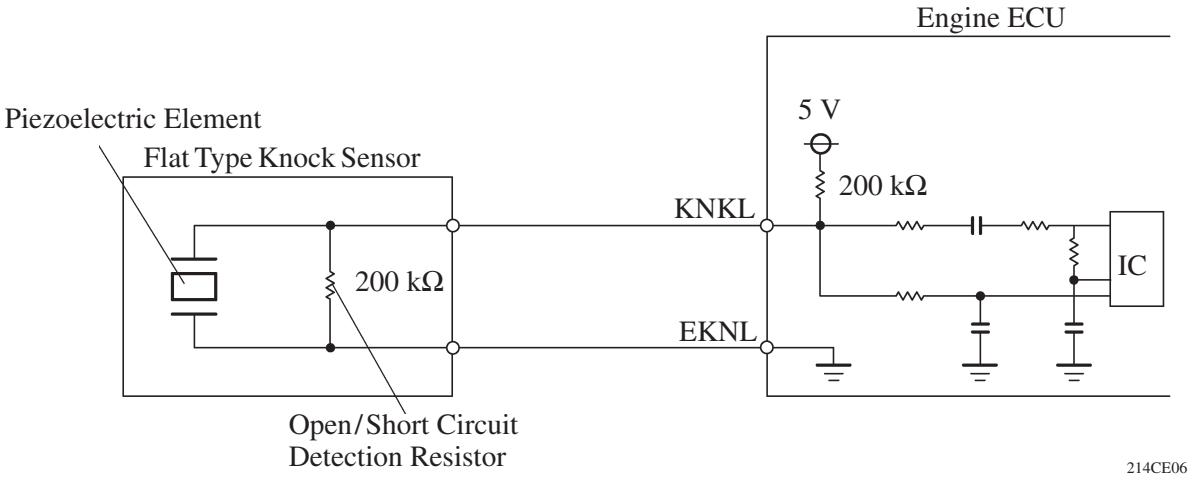
The knocking vibration is transmitted to the steel weight and its inertia applies pressure to the piezoelectric element. The action generates electromotive force.



214CE08

4) Open/Short Circuit Detection Resistor

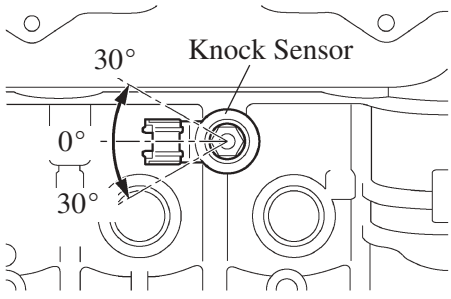
During the ignition is ON, the open/short circuit detection resistor in the knock sensor and the resistor in the engine ECU keep the voltage at the terminal KNKL of engine ECU constant.
An IC (Integrated Circuit) in the engine ECU is always monitoring the voltage of the terminal KNKL. If the open/short circuit occurs between the knock sensor and the engine ECU, the voltage of the terminal KNKL will change and the engine ECU will detect the open/short circuit and store DTC (Diagnostic Trouble Code).



214CE06

Service Tip

- In accordance with the adoption of an open/short circuit detection resistor, the inspection method for the sensor has been changed. For details, refer to the Yaris Repair Manual (Pub. No. RM00S1E).
- Because of the wire harness arrangement, make sure to install the flat type knock sensor in the position as shown in the following illustration.



00SEG32

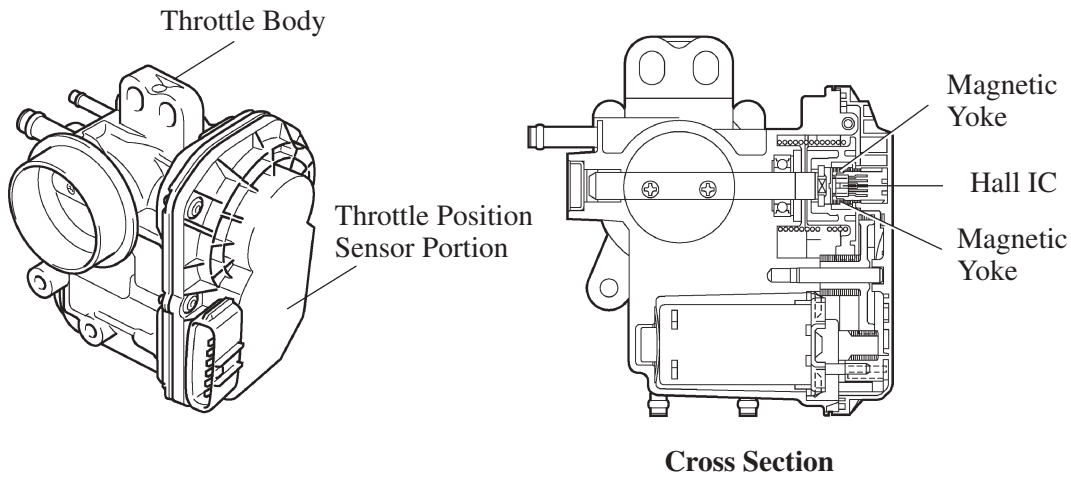
Accelerator Pedal Position Sensor

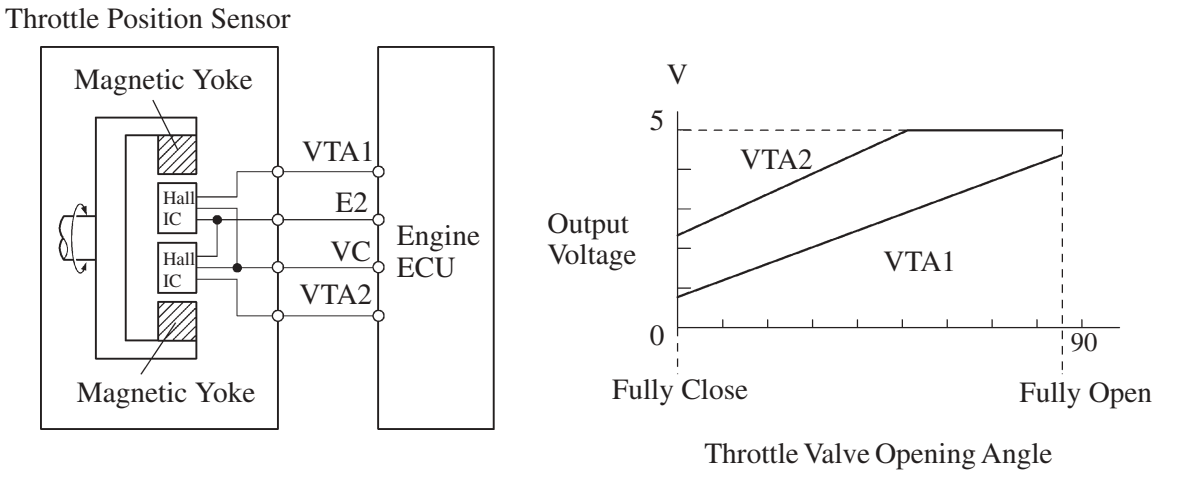
The same accelerator pedal position sensor as 1KR-FE engine models is used. For details, see page EG-42 in 1KR-FE engine section.

Throttle Position Sensor

The non-contact type throttle position sensor is used. This sensor uses a Hall IC, which is mounted on the throttle body.

- The Hall IC is surrounded by a magnetic yoke. The Hall IC converts the changes that occur in the magnetic flux at that time into electrical signals and outputs in as a throttle valve effort to the engine ECU.
- The Hall IC contains circuits for the main and sub signals. It converts the throttle valve opening angles into electric signals with two differing characteristics and outputs them to the engine ECU.





Service Tip

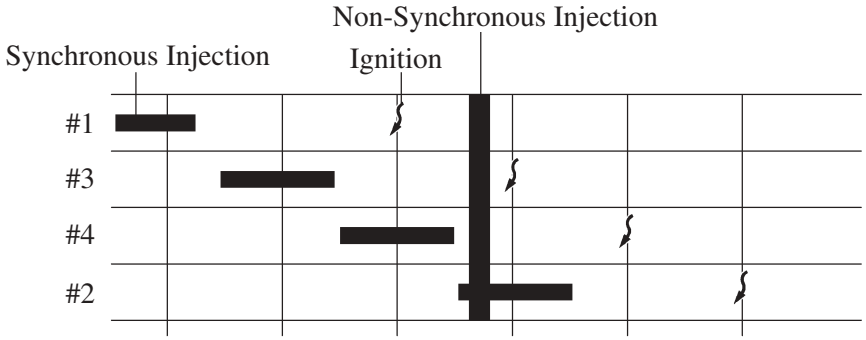
The inspection method differs from the conventional contact type throttle position sensor because this non-contact type sensor uses a Hall IC. For details, refer to the Yaris Repair Manual (Pub. No. RM00S1E).

6. EFI (Electronic Fuel Injection) System

- An L-type EFI system directly detects the intake air mass with a hot wire type air flow meter.
- An independent injection system (in which fuel is injected once into each cylinder for each two revolutions of the crankshaft) is used.
- Fuel injection occurs in two modes (synchronous and non-synchronous):

  a) One is the synchronous injection in which corrections based on the signals from the sensors are added to the basic injection time so that injection occurs always at the same position.

  b) The other is the non-synchronous injection in which injection is effected by detecting the requests from the signals of the sensors regardless of the crankshaft angle.



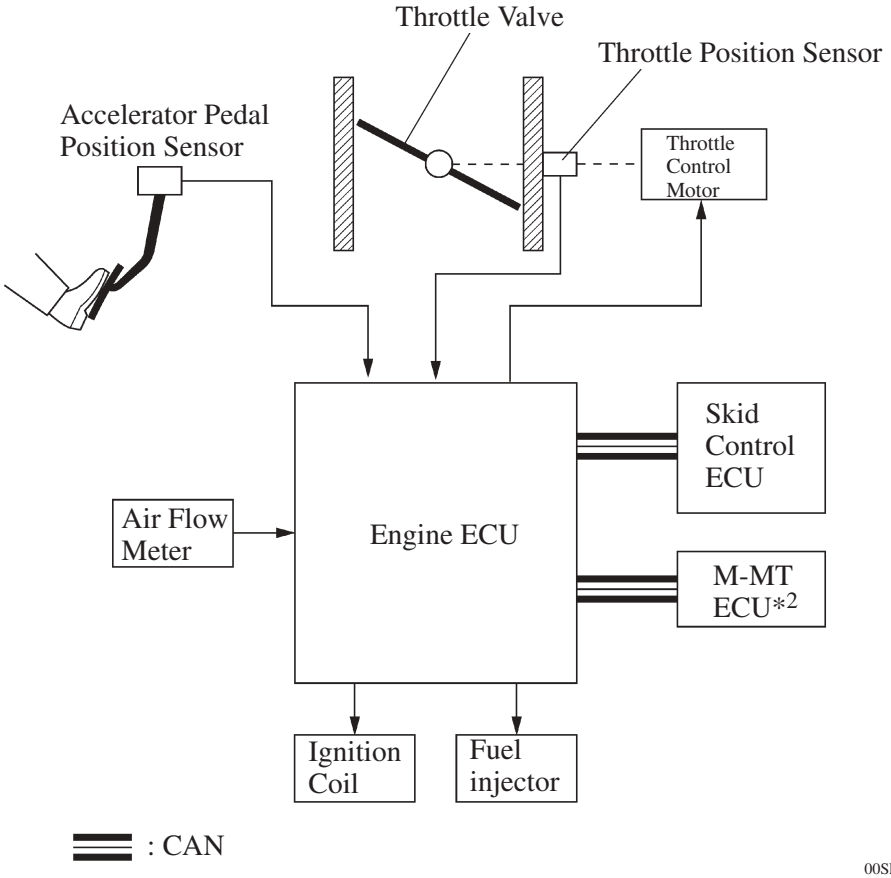
227EG48

7. ETCS-i (Electronic Throttle Control System-intelligent)

General

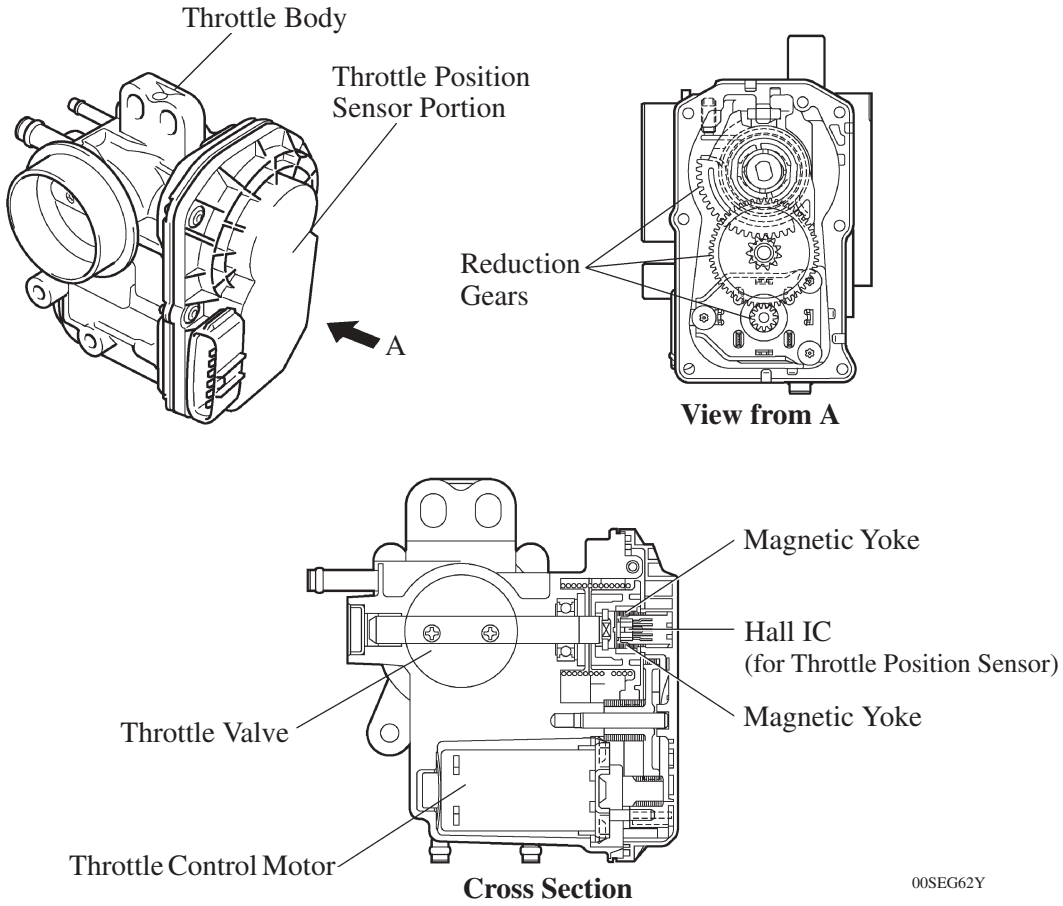
- The ETCS-i is used, providing excellent throttle control in all the operating ranges.
  The accelerator cable has been discontinued, and an accelerator pedal position sensor has been provided on the accelerator pedal.
- In the conventional throttle body, the throttle valve opening angle is determined 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 angle that is appropriate for the respective driving condition and uses a throttle control motor to control the opening angle.
- The ETCS-i controls the ISC (Idle Speed Control), TRC*1 (Traction Control), and VSC*1 (Vehicle Stability Control) systems.
- In case of an abnormal condition, this system switches to the limp mode.
- On the M-MT (Multi-mode Manual Transmission) models, the engine ECU and the M-MT ECU maintain communication via the CAN (Controller Area Network). Thus, the engine ECU is able to effect ETCS-i control to suit the M-MT system control in order to optimize the system control of the M-MT ECU.

▶ System Diagram ◀



*1: Optional Equipment
*2: Multi-mode Manual Transmission Models Only

Construction



1) Throttle Position Sensor

The throttle position sensor is mounted on the throttle body to detect the opening angle of the throttle valve.

2) 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 angle of the throttle valve.

Operation

1) General

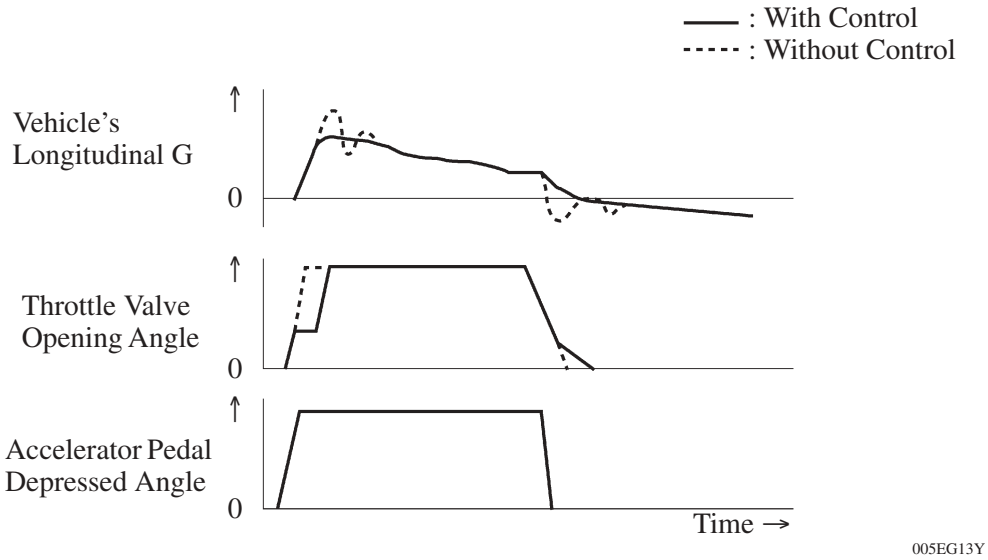
The engine ECU drives the throttle control motor by determining the target throttle valve opening angle in accordance with the respective operating condition.

- Non-linear Control
- Idle Speed Control
- TRC Throttle Control*1
- VSC Coordination Control*1
- M-MT System Control*2

2) Non-linear Control

The engine ECU controls the throttle valve to an optimal opening angle 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 ◀



005EG13Y

3) Idle Speed Control

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

4) TRC Throttle Control*1

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

*1: Models with VSC and TRC Systems
*2: M-MT Models

5) VSC Coordination Control*1

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.

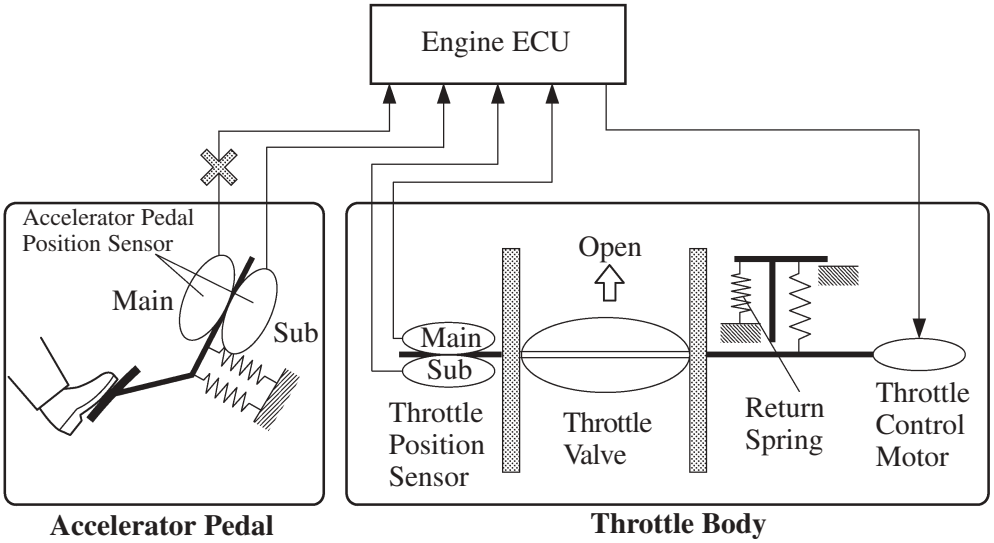
6) M-MT System Control*2

As part of the M-MT system, the throttle valve opening angle is controlled by a request signal from the M-MT ECU.

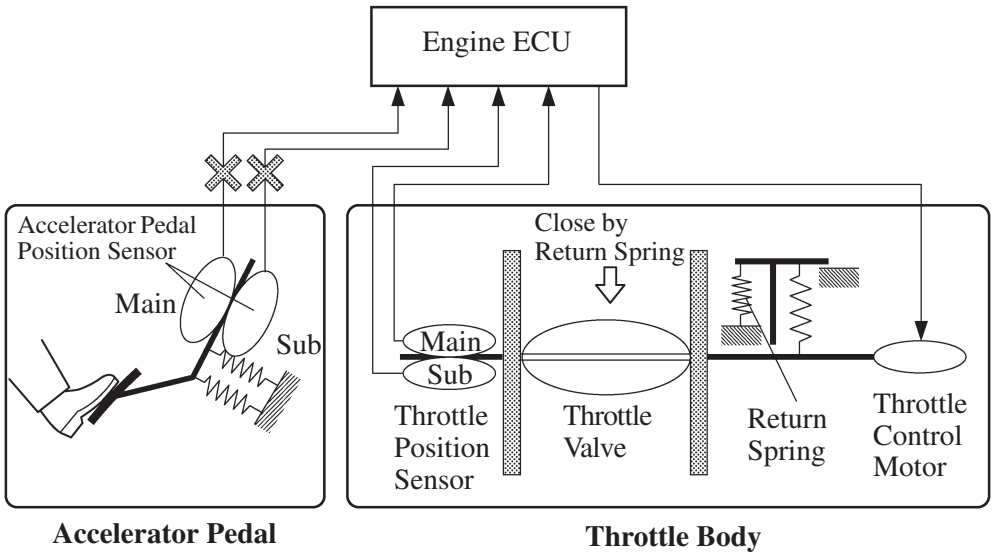
*1: Models with VSC and TRC Systems
*2: M-MT Models

Fail-safe of Accelerator Pedal Position Sensor

- The accelerator pedal position sensor is comprised of two (main, sub) sensor circuits. If a malfunction occurs in either one of the sensor circuits, the engine ECU detects the abnormal signal by 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 depressed angle, in order to operate the vehicle under limp mode control.

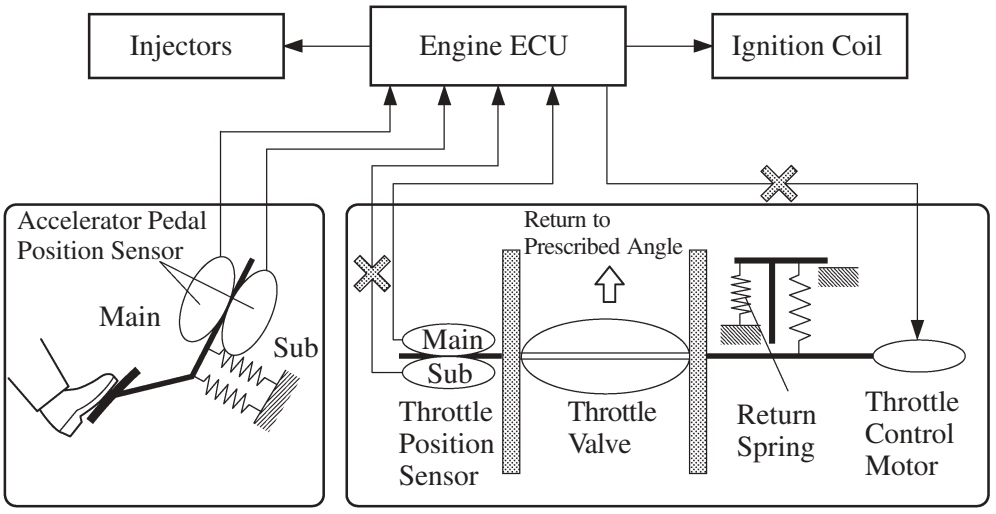


- If both circuits have a malfunction, the engine ECU detects the abnormal signal by voltage from these two sensor circuits and discontinues the throttle control. At this time, the vehicle can be driven within its idling range.



Fail-safe of Throttle Position Sensor

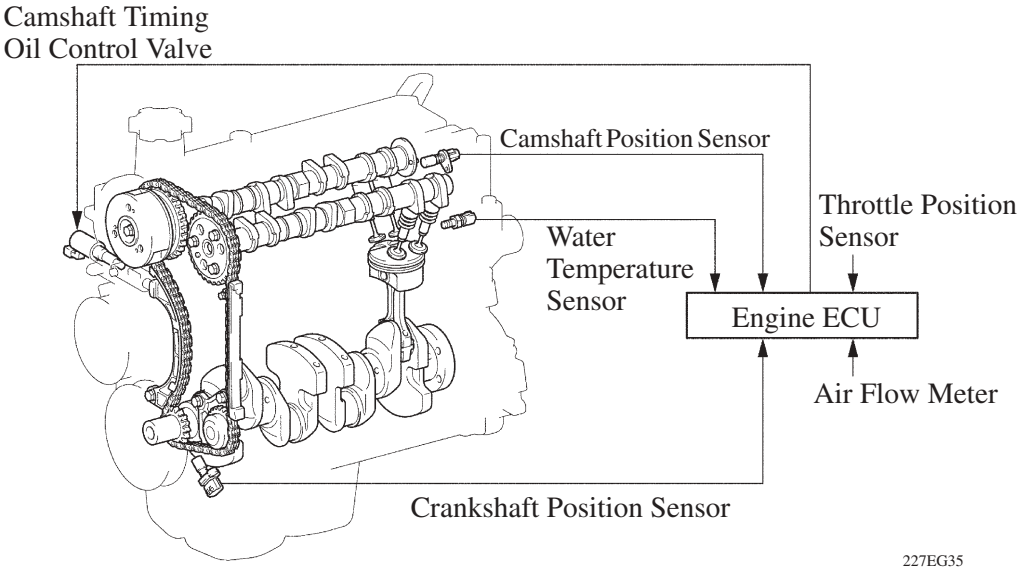
- The throttle position sensor is comprised of two (main, sub) sensor circuits. If a malfunction occurs in either one or both of the sensor circuits, the engine ECU detects the abnormal signal by voltage difference between these two sensor circuits, cuts off the current to the throttle control motor, 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 angle. 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 (intermittent fuel-cut) 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.



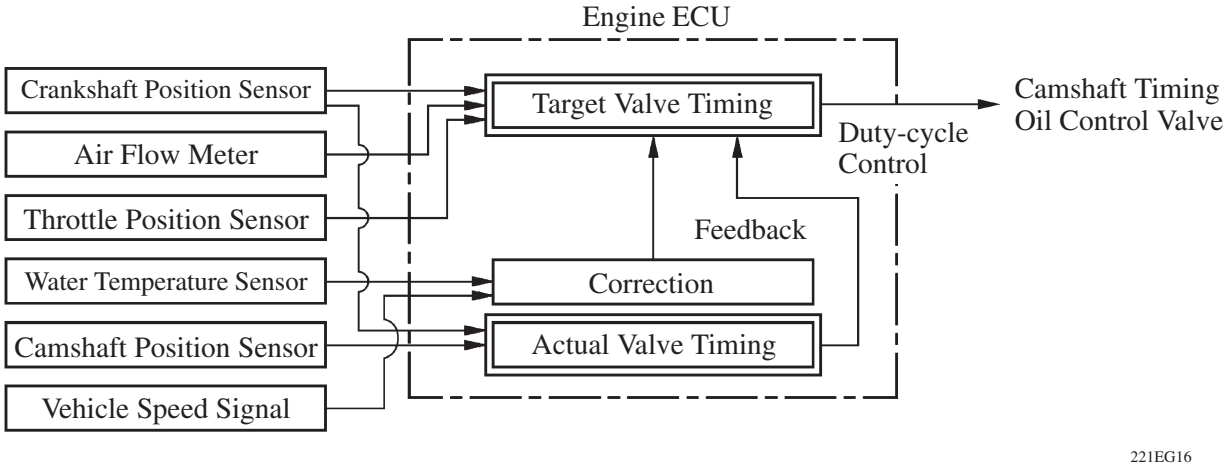
8. VVT-i (Variable Valve Timing-intelligent) System

General

- The VVT-i system is designed to control the intake camshaft within a range of 42° (of Crankshaft Angle) to provide valve timing that is optimally suited to the engine condition. This improves torque in all the speed ranges as well as increasing fuel economy, and reducing exhaust emissions.



- Using the engine speed signal, vehicle speed signal, and the signals from air flow meter, throttle position sensor and water temperature sensor, 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.



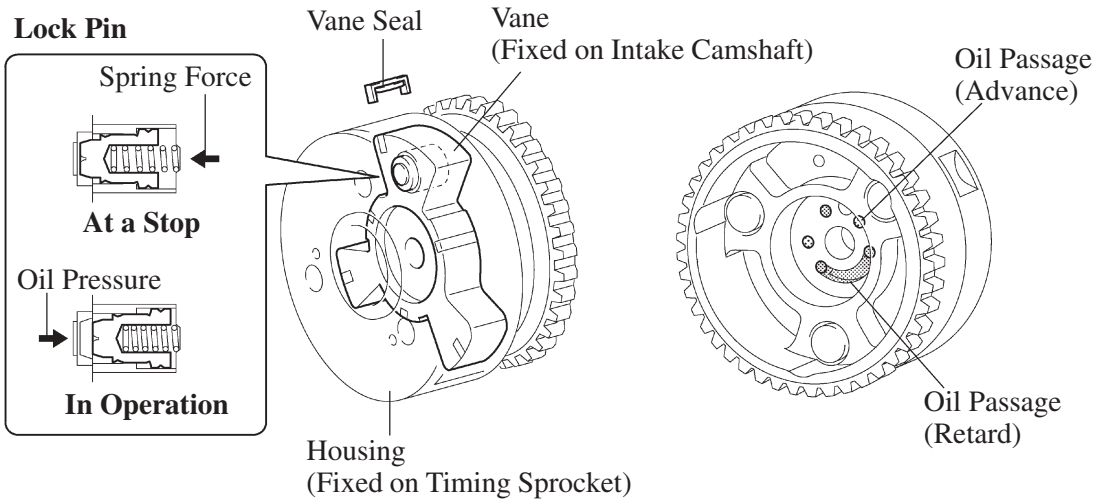
Effectiveness of the VVT-i System

For details, see page EG-51 in 1KR-FE engine section.

Construction

1) VVT-i Controller

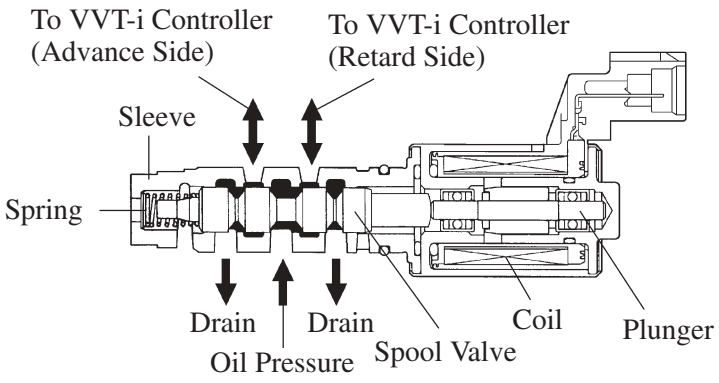
This controller consists of the housing driven from the timing chain and the vane coupled with the intake camshaft.
The oil pressure sent from the advance or retard side path at the intake camshaft causes rotation in the VVT-i controller vane circumferential direction to vary the intake valve timing continuously.
When the engine is stopped, the intake camshaft will be in the most retarded state to ensure startability.
When hydraulic pressure is not applied to the VVT-i controller immediately after the engine has been started, the lock pin locks the movement of the VVT-i controller to prevent a knocking noise.



227EG46

2) Camshaft Timing Oil Control Valve

This camshaft timing oil control valve controls the spool valve using duty-cycle control from the engine ECU. This allows hydraulic pressure to be applied to the VVT-i controller advance or retard side. When the engine is stopped, the camshaft timing oil control valve is in the most retarded position.

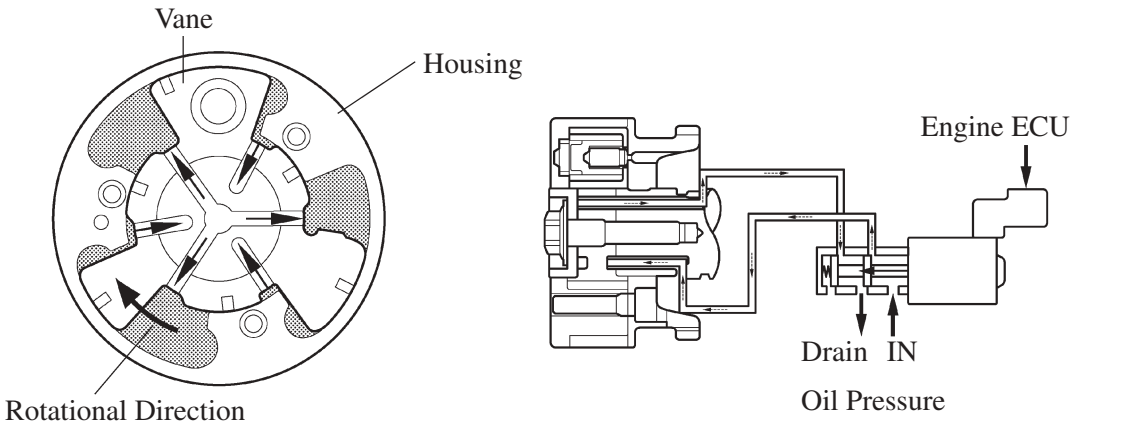


221EG17

Operation

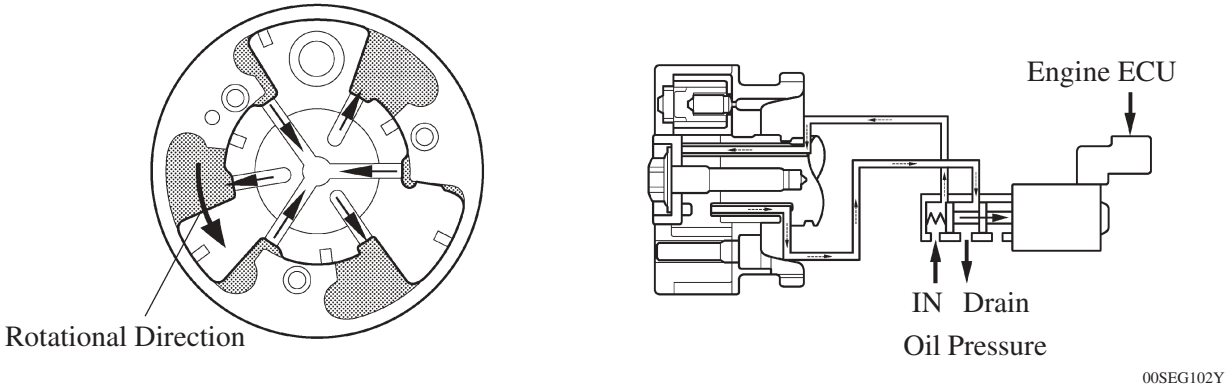
1) Advance

When the camshaft timing oil control valve is operated as illustrated below by the advance signal from the engine ECU, the resultant oil pressure is applied to the timing advance side vane chamber to rotate the camshaft in the timing advance direction.



2) Retard

When the camshaft timing oil control valve is operated as illustrated below by the retard signal from the engine ECU, the resultant oil pressure is applied to the timing retard side vane chamber to rotate the camshaft in the timing retard direction.



3) Hold

After reaching the target timing, the valve timing is held by keeping the camshaft timing oil control valve in the neutral position unless the traveling state changes.
This adjusts the valve timing at the desired target position and prevents the engine oil from running out when it is unnecessary.

9. Diagnosis

- The diagnosis system of the 2SZ-FE 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 intelligent tester II.
- For details, refer to the Yaris Repair Manual (Pub. No. RM00S1E).

10. Fail-safe

When a malfunction is detected by any of the sensors, there is a possibility of an engine or other malfunction occurring if the engine ECU were to continue to control the engine control system in the normal way. To prevent such a problem, the fail-safe function of the engine ECU either relies on the data stored in memory to allow the engine control system to continue operating, or stops the engine if a hazard is anticipated. For details, refer to the Yaris Repair Manual (Pub. No. RM00S1E).