■ENGINE CONTROL SYSTEM

1. General

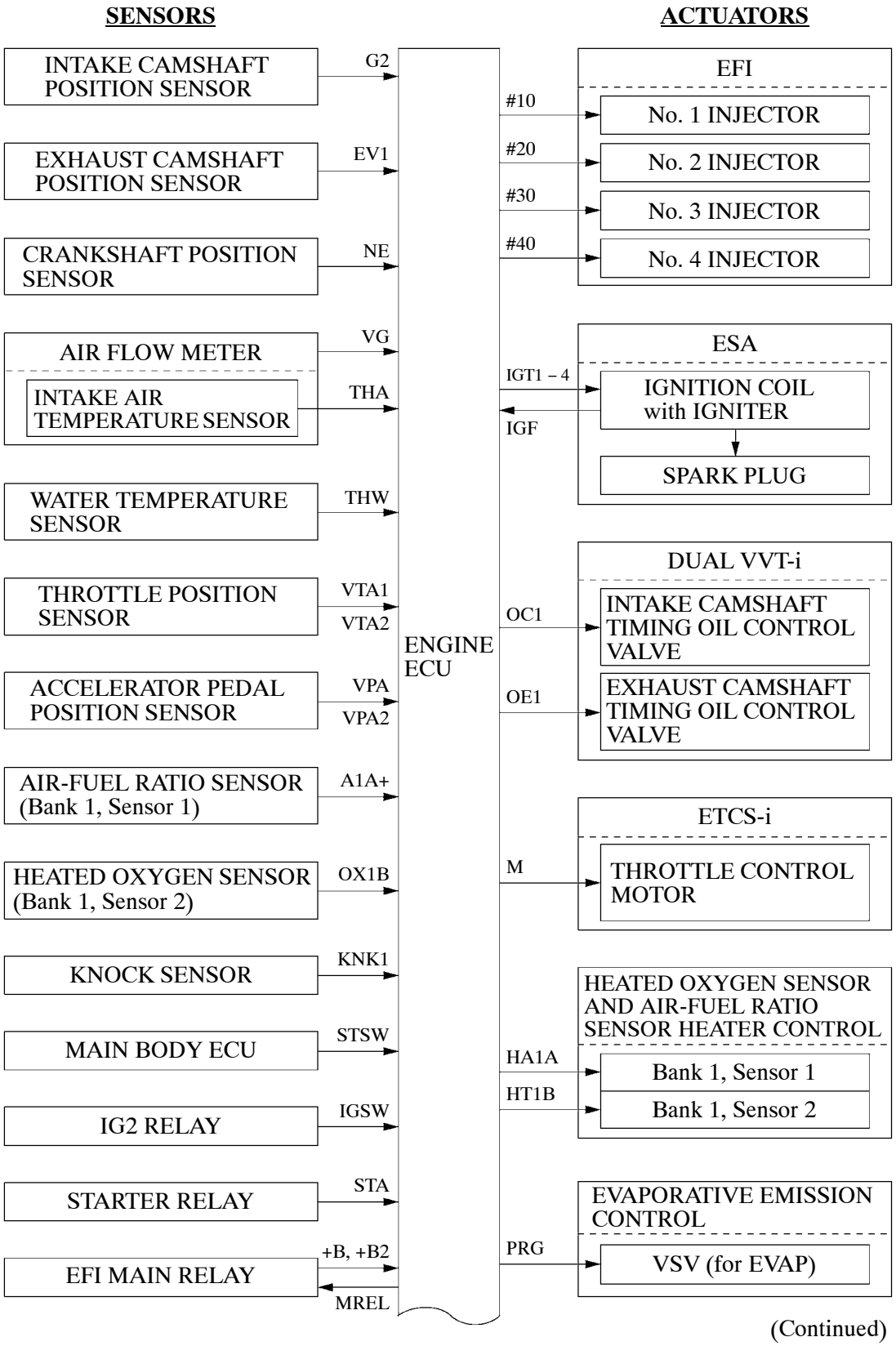
The engine control system for the 2ZR-FE engine has following systems.

System	Outline
EFI (Electronic Fuel Injection) [See page 59]	● 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.
ETCS-i (Electronic Throttle Control System-intelligent) [See page 60]	Optimally controls the throttle valve opening in accordance with the amount of accelerator pedal effort, the throttle valve opening control request from the engine ECU, and the condition of the engine and the vehicle.
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.
Dual VVT-i (Variable Valve Timing-intelligent) [See page 65]	Regulates operation of the intake and exhaust camshafts to ensure an optimal valve timing in accordance with the engine condition.
Fuel Pump Control [See page 71]	● Fuel pump operation is controlled by signals from the engine ECU. ● The fuel pump is stopped, when the SRS airbag is deployed in a front or side collision.
Heated Oxygen Sensor and Air-fuel Ratio Sensor Heater Control	Maintains the temperature of the heated oxygen sensor and air-fuel ratio sensor at an appropriate level to increase accuracy of detection of the oxygen concentration in the exhaust gas.
Evaporative Emission	The engine ECU controls the purge flow of evaporative emissions (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 key.
Air Conditioner Cut-off Control*	By turning the air conditioner compressor ON or OFF in accordance with the engine condition, drivability is maintained.
Cooling Fan Control [See page 72]	Cooling fan operation is controlled by signals from the engine ECU based on the water temperature sensor signal.
Starter Control (Cranking Hold Function) [See page 73]	● 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.
Diagnosis [See page 77]	When the engine ECU detects a malfunction, the engine ECU diagnoses and memorizes the failed section.
Fail-safe [See page 77]	When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the data already stored in memory.

*: Models with Air Conditioner

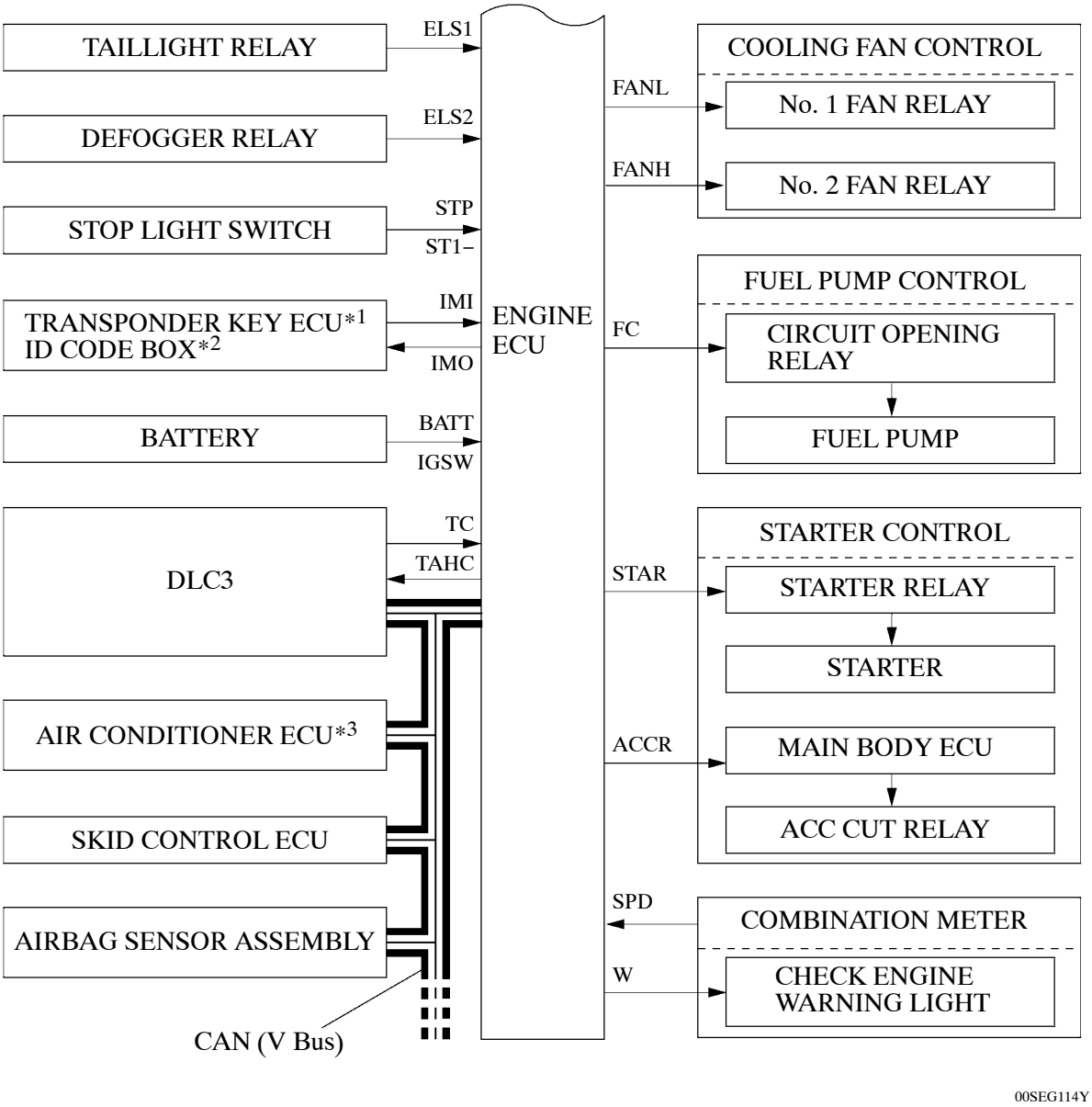
2. Construction

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



(Continued)

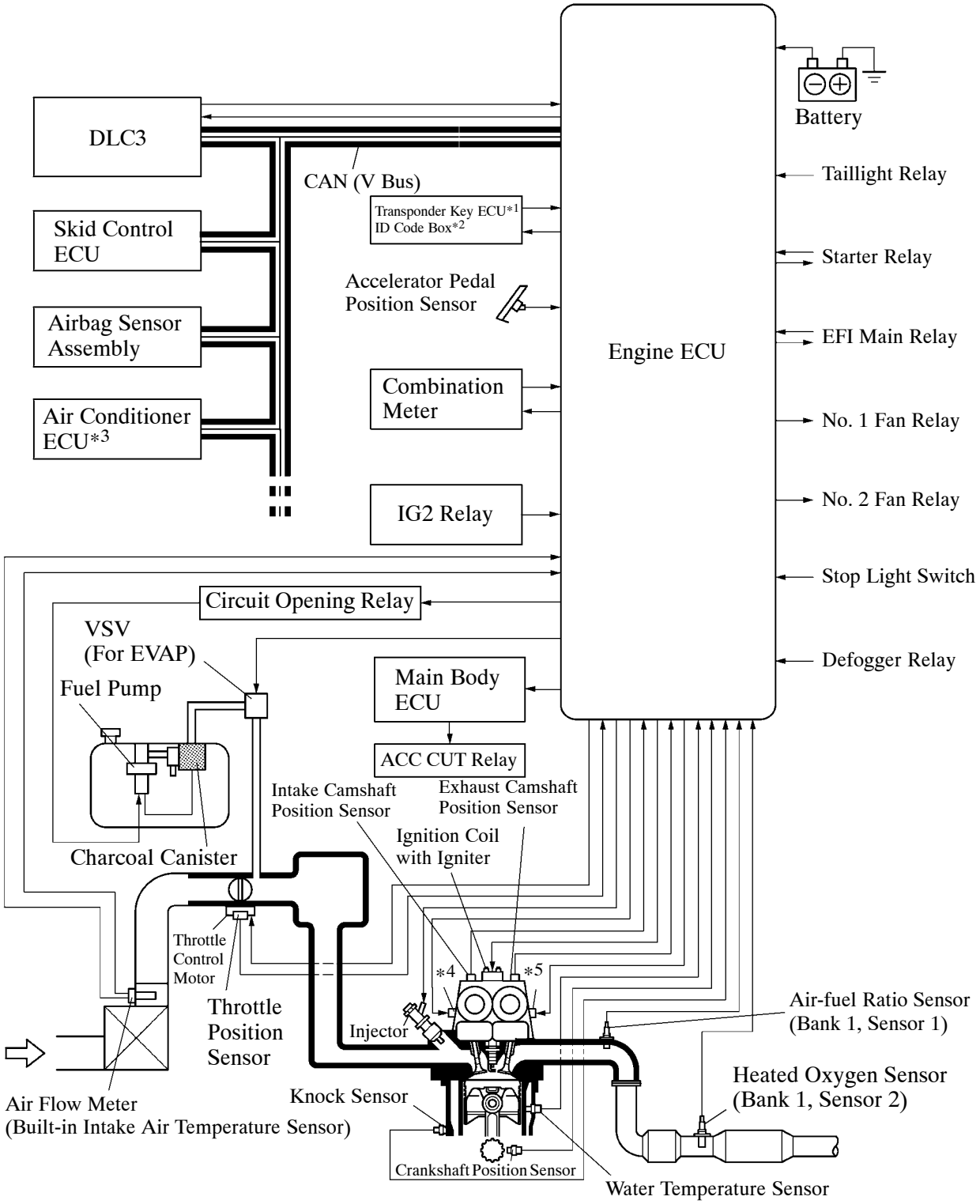
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*1: Models without Smart Entry & Start System
*2: Models with Smart Entry & Start System
*3: Models with Air Conditioner

3. Engine Control System Diagram

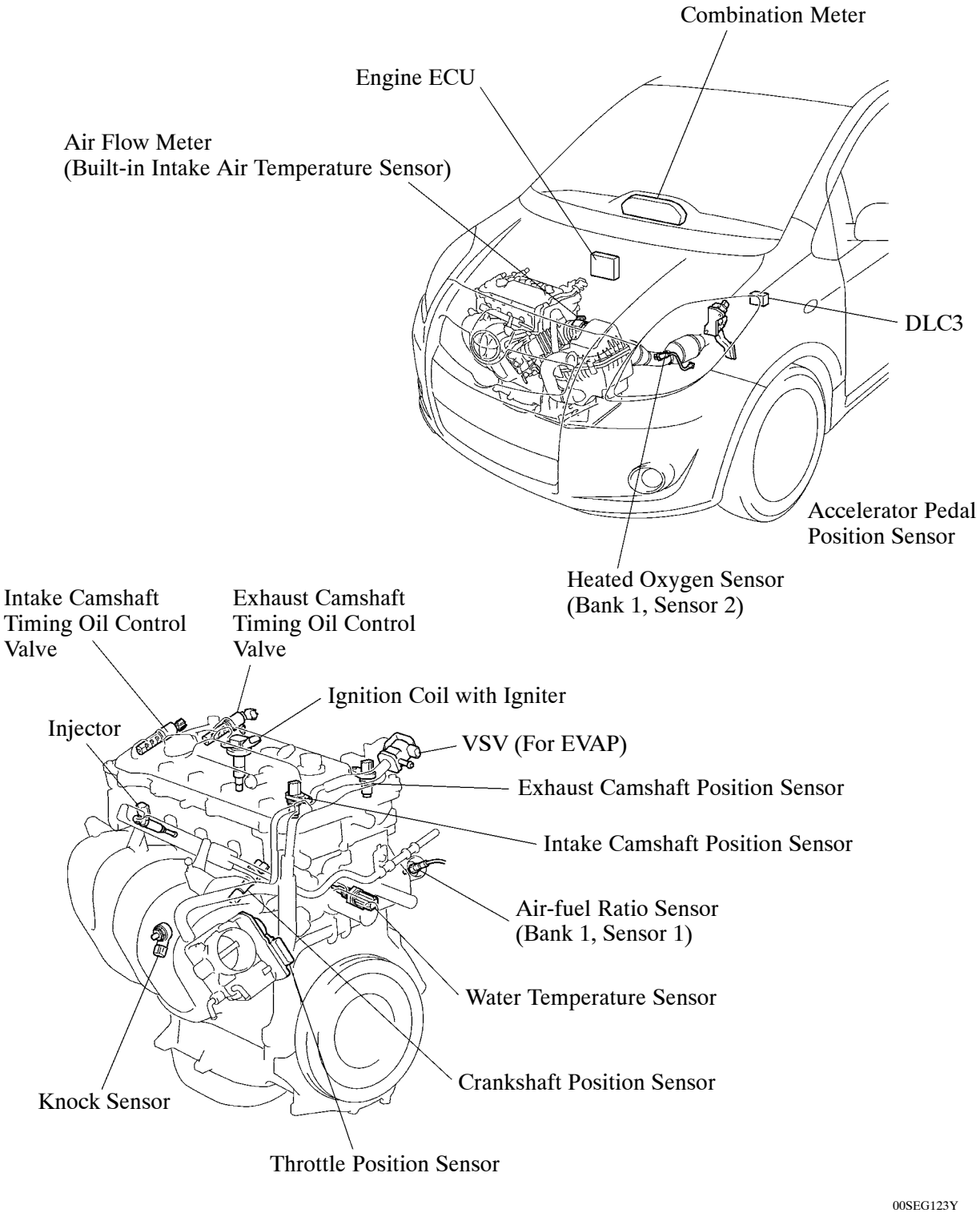


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*1: Models without Smart Entry & Start System
*2: Models with Smart Entry & Start System
*3: Models with Air Conditioner
*4: Intake Camshaft Timing Oil Control Valve
*5: Exhaust Camshaft Timing Oil Control Valve

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4. Layout of Main Components



5. Main Components of Engine Control System

General

The main components of the 2ZR-FE engine control systems are as follows:

Components	Outline	Quantity	Function
Engine ECU	32-bit	1	The engine ECU optimally controls the EFI, ESA, and ISC to suit the operating conditions of the engine in accordance with the signals provided by the sensors.
Heated Oxygen Sensor (Bank 1, Sensor 2)	Type with Heater (Cup Type)	1	This sensor detects the oxygen concentration in the exhaust emission by measuring the electromotive force which is generated in the sensor itself.
Air-fuel Ratio Sensor (Bank 1, Sensor 1)	Type with Heater (Planar Type)	1	As with the heated oxygen sensor, this sensor detects the oxygen concentration in the exhaust emission. However, it detects the oxygen concentration in the exhaust emission linearly.
Air Flow Meter	Hot-wire Type	1	This sensor has a built-in hot-wire to directly detect the intake air mass.
Crankshaft Position Sensor (Rotor Teeth)	Pick-up Coil Type (36-2)	1	This sensor detects the engine speed and performs the cylinder identification.
Camshaft Position Sensor (Rotor Teeth)	MRE (Magnetic Resistance Element) Type (3)	2	This sensor performs the cylinder identification.
Throttle Position Sensor	Non-contact Type	1	This sensor detects the throttle valve opening angle.
Accelerator Pedal Position Sensor	Non-contact Type	1	This sensor detects the amount of pedal effort applied to the accelerator pedal.
Knock Sensor	Built-in Piezoelectric Element 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.
Injector	12-hole Type	4	The injector is an electromagnetically-operated nozzle which injects fuel in accordance with the signals from the engine ECU.

Engine ECU

The 32-bit CPU of the engine ECU is used.

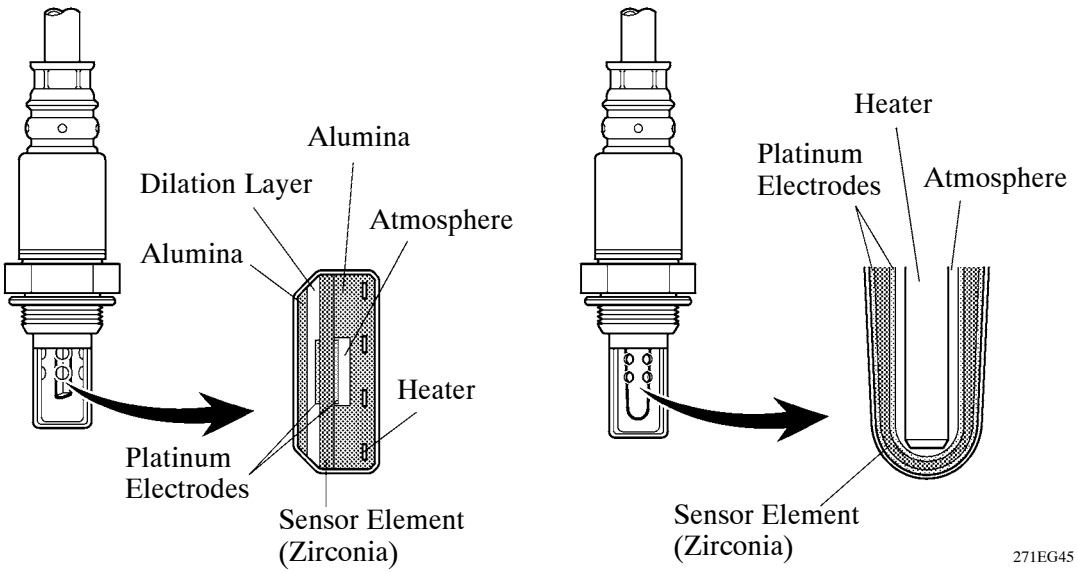
Heated Oxygen Sensor and Air-fuel Ratio Sensor

1) General

Planar type air-fuel ratio sensor and cup type heated oxygen sensor are used.

2) Construction

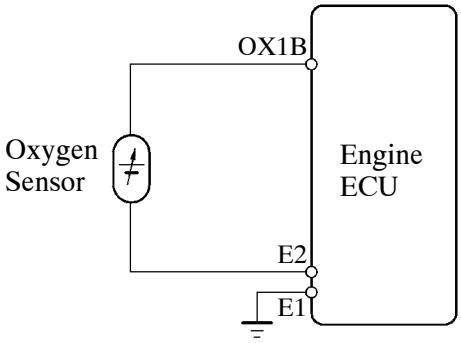
- The basic construction of the heated oxygen sensor and the air-fuel ratio sensor is the same. However, they are divided into the cup type and the planar type, according to the types of heater construction that are used.
- The cup type sensor contains a sensor element that surrounds a heater.
- The planer 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.



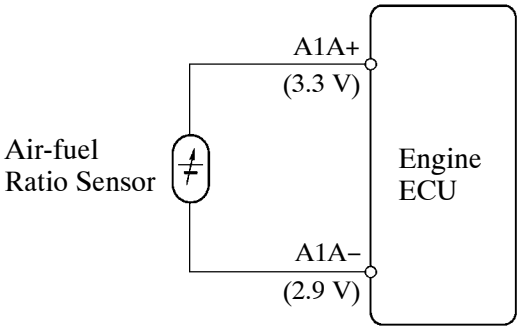
Planer Type Air-fuel Ratio Sensor **Cup Type Heated Oxygen Sensor**

3) Characteristics

- The heated oxygen sensor and the air-fuel ratio sensor differ in 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.
- Approximately 0.4 V is constantly applied to the air-fuel ratio sensor. The air-fuel ratio sensor converts the oxygen density to the current and sends it to the engine ECU. The engine ECU converts the changes in the output amperage into voltage in order to linearly detect the present air-fuel ratio.
  The air-fuel ratio sensor data is approximately proportionate to the existing air-fuel ratio. As a result, the detection precision of the air-fuel ratio has been improved. The air-fuel ratio sensor data is read out by an intelligent tester II.

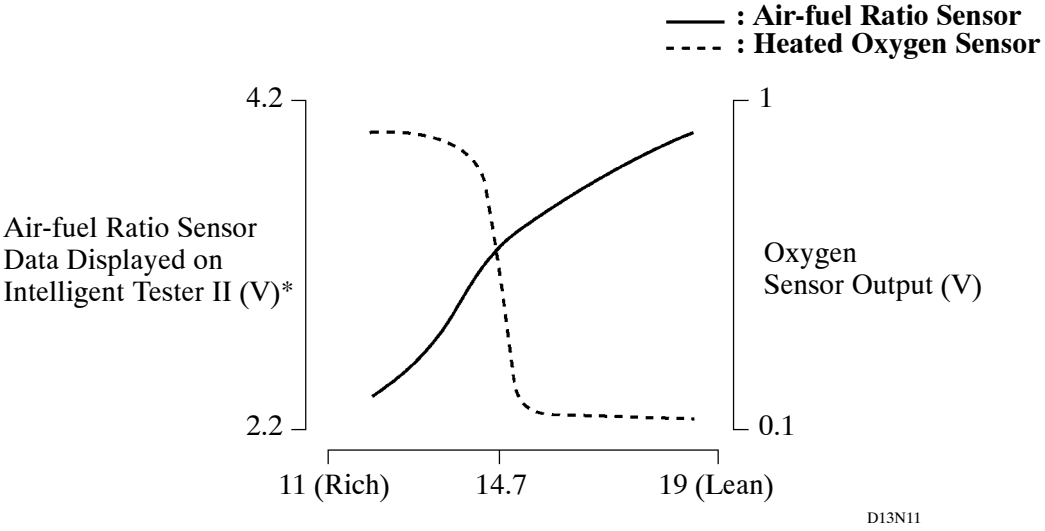


Heated Oxygen Sensor Circuit



Air-fuel Ratio Sensor Circuit

276PD57



D13N11

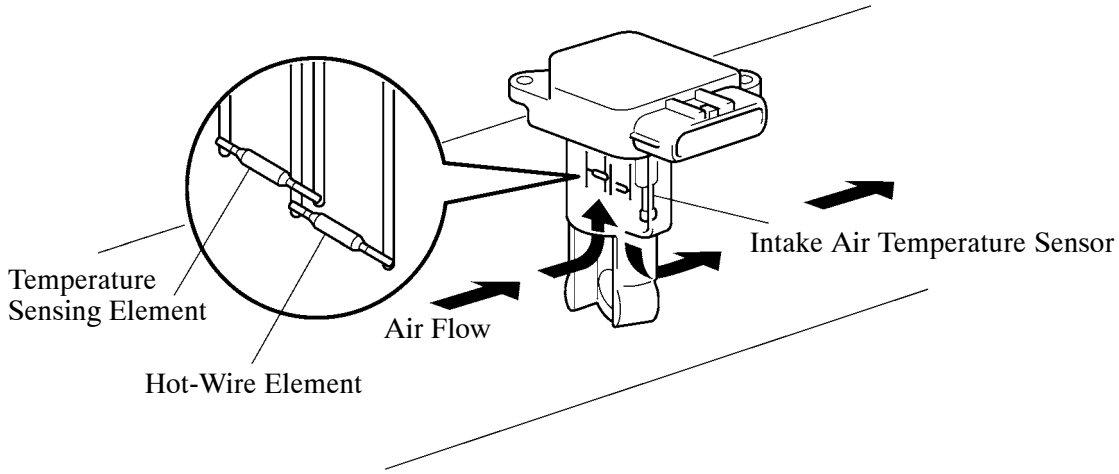
*: This data is used internally in the engine ECU, and is not an engine ECU terminal voltage.

▶ Warm-up Specification ◀

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

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 air flow meter has a built-in intake air temperature sensor.

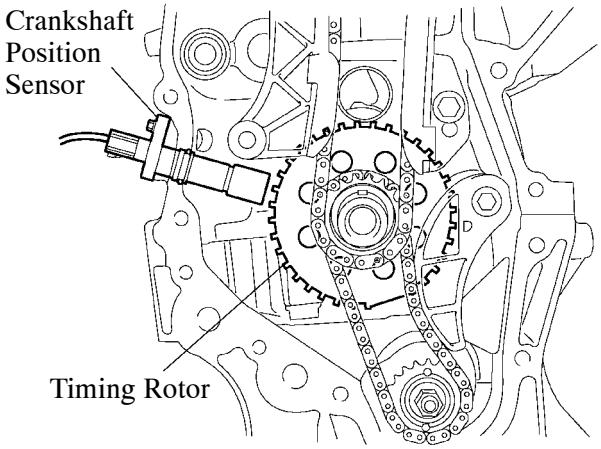


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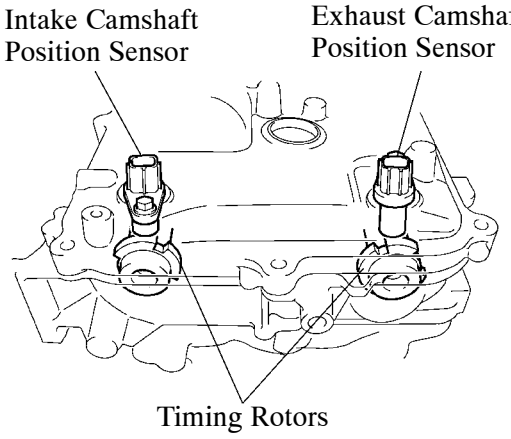
Crankshaft and Camshaft Position Sensors

1) General

- The pick-up coil type crankshaft position sensor is used. 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.
- The MRE (Magnetic Resistance Element) type intake and exhaust camshaft position sensors are used. To detect the camshaft position, each timing rotor on the intake and exhaust camshafts is used to generate 3 (3 Hi Output, 3 Lo Output) pulses for every 2 revolutions of the crankshaft.

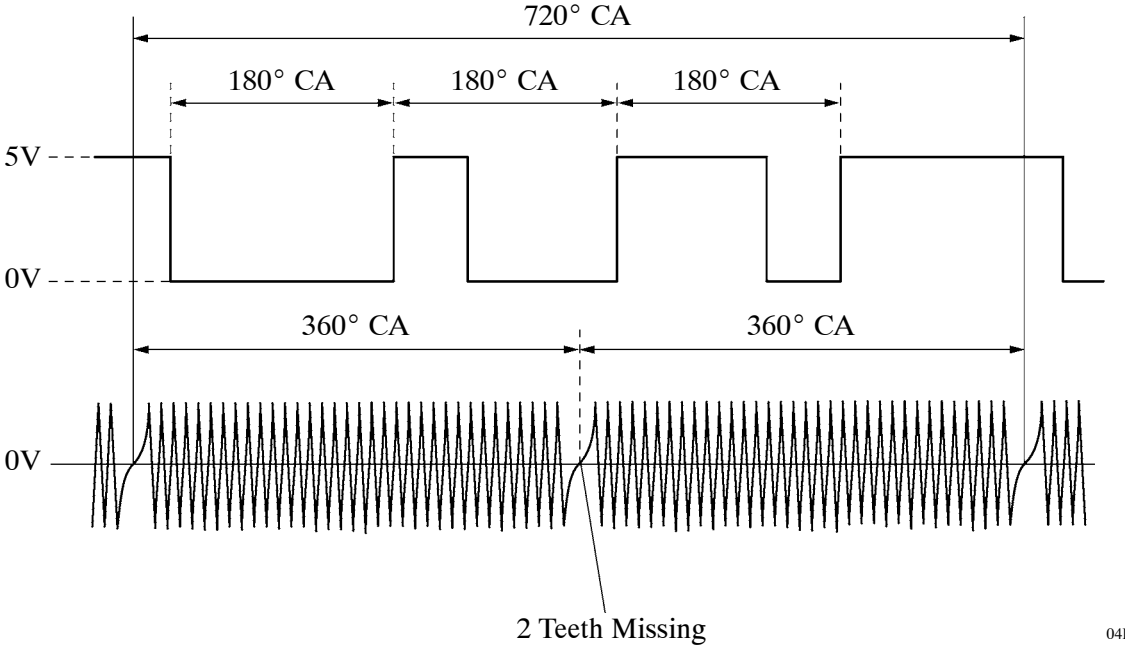


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▶ Sensor Output Waveforms ◀



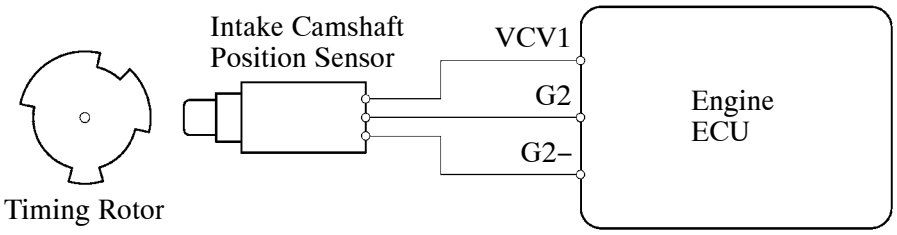
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2) MRE Type Camshaft Position Sensor

- The MRE type camshaft position sensor consists of an MRE, a magnet and a sensor. The direction of the magnetic field changes due to the different shapes (protruded and non-protruded portions) of the timing rotor, which passes by the sensor. As a result, the resistance of the MRE changes, and the output voltage to the engine ECU changes to Hi or Lo. The engine ECU detects the camshaft position based on this output voltage.
- The differences between the MRE type camshaft position sensor and the pick-up coil camshaft position sensor used on the conventional model are as follows.

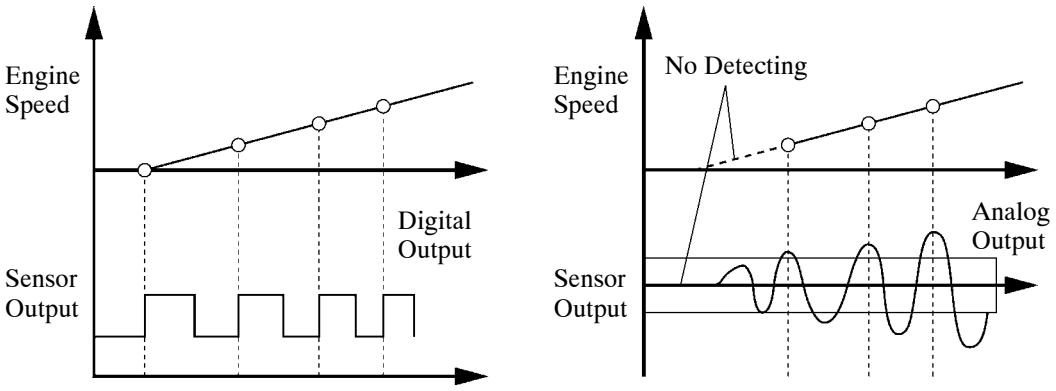
Item	Sensor Type	
	MRE	Pick-up Coil
Signal Output	Constant digital output starts from low engine speeds.	Analog output changes with the engine speed.
Camshaft Position Detection	Detection is made by comparing the NE signals with the Hi/Lo output switch timing due to the protruded/non-protruded portions of the timing rotor, or made based on the number of the input NE signals during Hi/Lo outputs.	Detection is made by comparing the NE signals with the change of waveform that is output when the protruded portion of the timing rotor passes.

▶ Wiring Diagram ◀



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▶ MRE Type and Pick-up Coil Type Output Waveform Image Comparison ◀



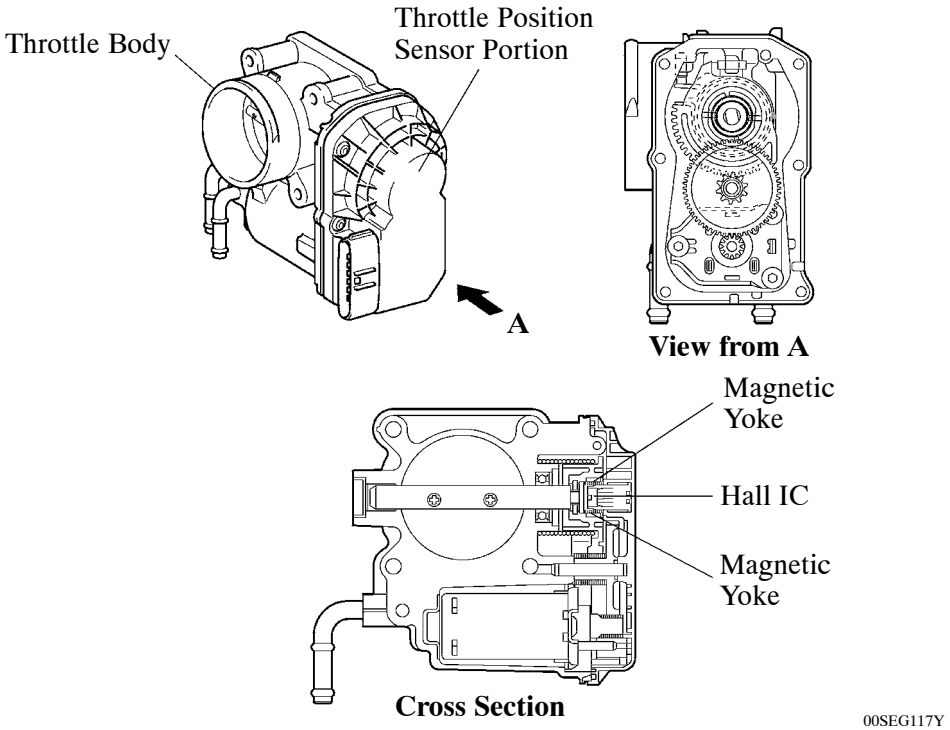
MRE Type **Pick-up Coil Type**

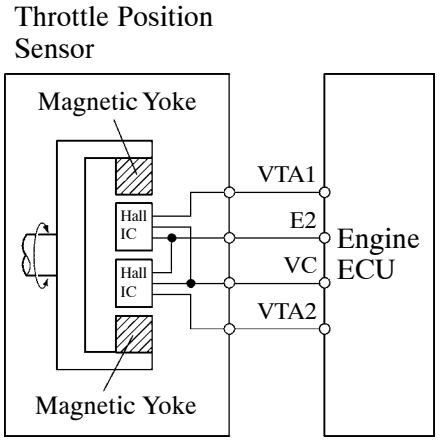
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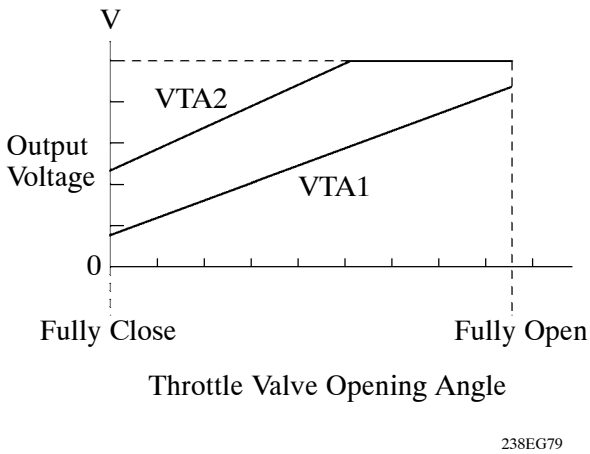
Throttle Position Sensor

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.







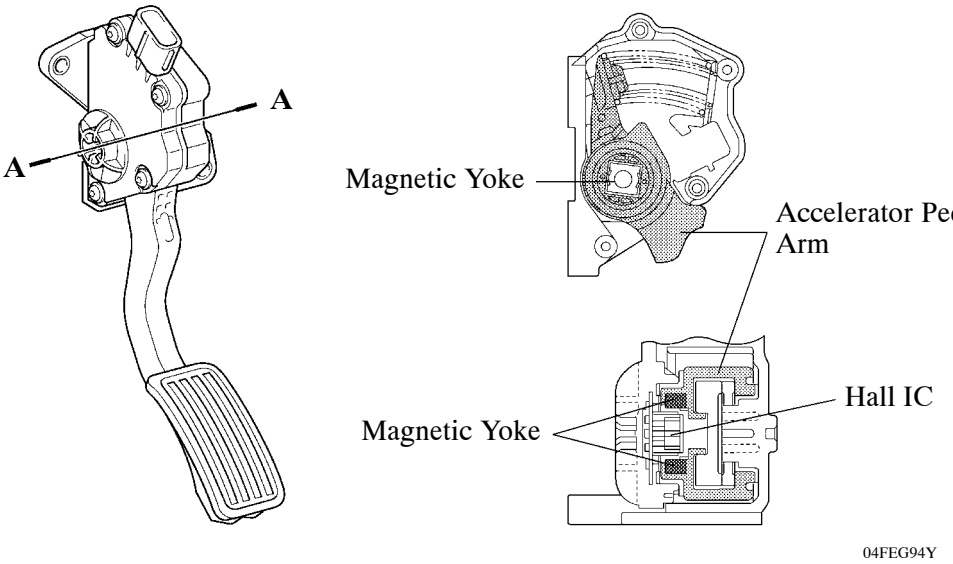
Service Tip

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 Supplement (Pub. No. RM00S3E).

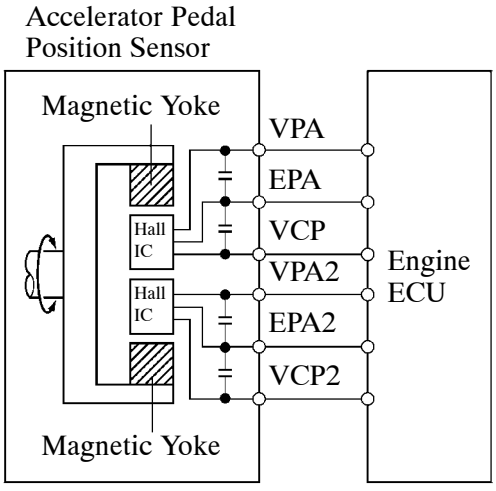
Accelerator Pedal Position Sensor

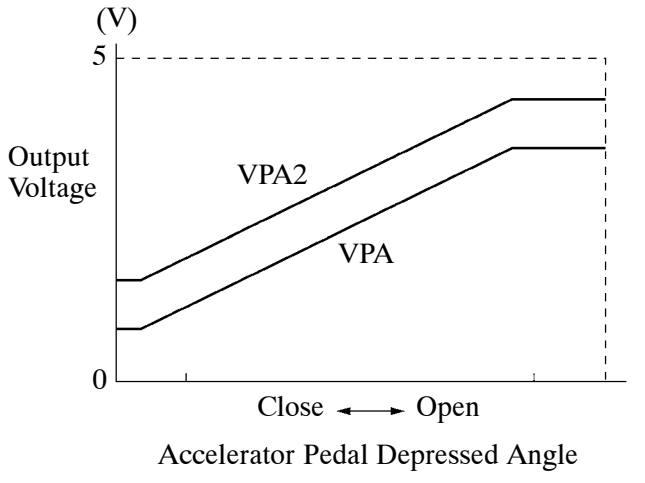
The non-contact type accelerator pedal position sensor uses a Hall IC.

- The magnetic yoke that is mounted at the accelerator pedal arm rotates around the Hall IC in accordance with the amount of effort that is applied to the accelerator pedal. The Hall IC converts the changes in the magnetic flux that occur at that time into electrical signals, and outputs them as accelerator pedal effort to the engine ECU.
- The Hall IC contains circuits for the main and sub signals. It converts the accelerator pedal depressed angles into electric signals with two differing characteristics and outputs them to the engine ECU.



A – A Cross Section





Service Tip

The inspection method differs from the conventional contact type accelerator pedal position sensor because this non-contact type sensor uses a Hall IC.
For details, refer to the Yaris Repair Manual Supplement (Pub. No. RM00S3E).

Knock Sensor (Flat Type)

1) General

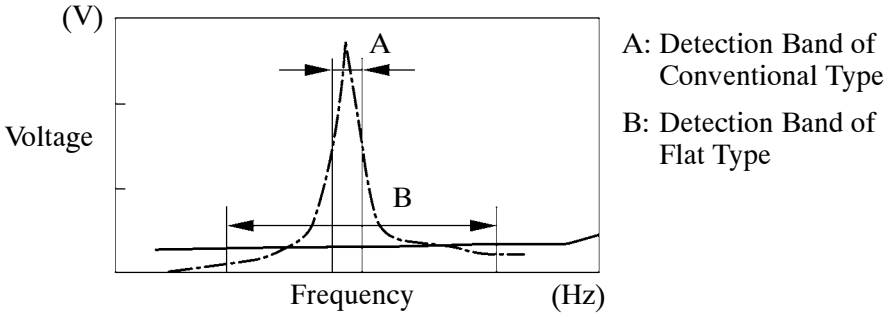
In the conventional type knock sensor (resonant type), a vibration plate which has the same resonance point as the knocking frequency of the engine is built in and can detect the vibration in this frequency band.

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 more precise ignition timing control is possible.

—·— : Conventional Type

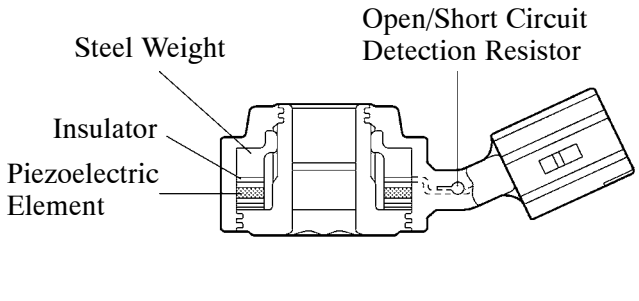
——— : Flat Type



Characteristic of Knock Sensor 214CE04

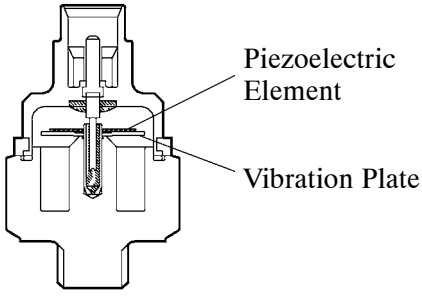
2) Construction

- 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 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.



214CE01

Flat Type Knock Sensor (Non-resonant Type)

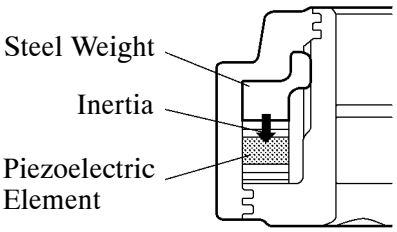


214CE02

Conventional Type Knock Sensor (Resonant Type)

3) Operation

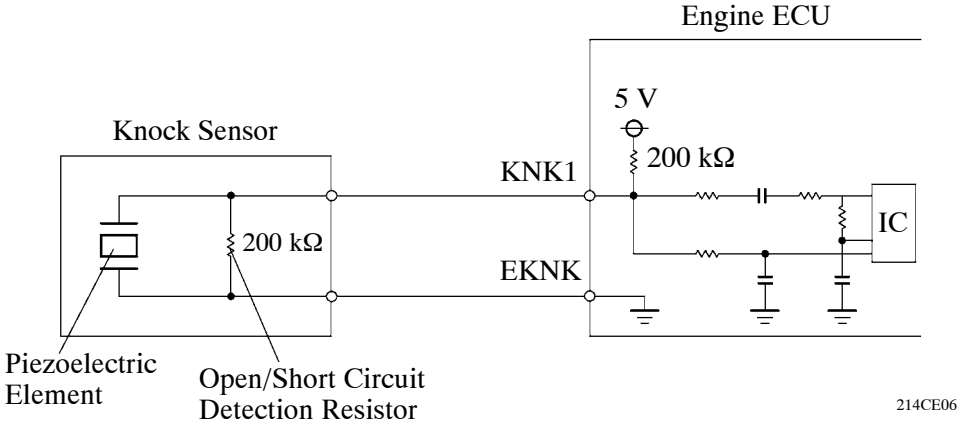
The knocking vibration is transmitted to the steel weight and its inertia applies pressure to the piezoelectric element. The action generates electromotive force.



214CE08

4) Open/Short Circuit Detection Resistor

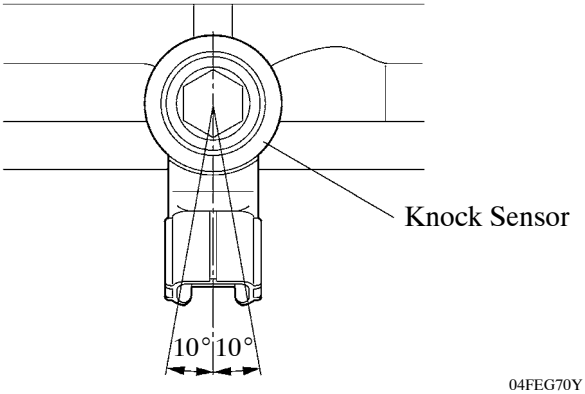
While the ignition is ON, the open/short circuit detection resistor in the knock sensor and the resistor in the engine ECU keep constant the voltage at the terminal KNK1 of engine.
An IC (Integrated Circuit) in the engine ECU is always monitoring the voltage of the terminal KNK1. If the open/short circuit 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).



214CE06

Service Tip

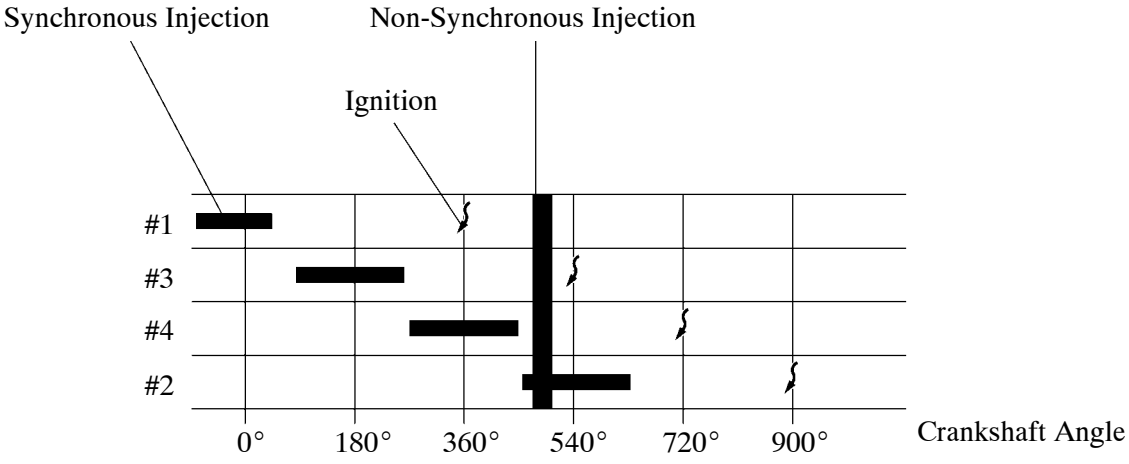
- In accordance with the adoption of an open/short circuit detection resistor, the inspection method for the sensor has been changed. For details, refer to the Yaris Repair Manual Supplement (Pub. No. RM00S3E).
- To prevent the water accumulation in the connecter, make sure to install the flat type knock sensor in the position as shown in the following illustration.



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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.
- There are two types of injections (synchronous and non-synchronous):
  a) The synchronous injection, in which corrections based on the signals from the sensors are added to the basic injection time, so that injection always occurs at the same position.
  b) The non-synchronous injection, in which injection is effected by detecting the requests from the signals of the sensors regardless of the crankshaft angle.
- This system performs group injection when the water temperature is extremely low and the engine speed is low.



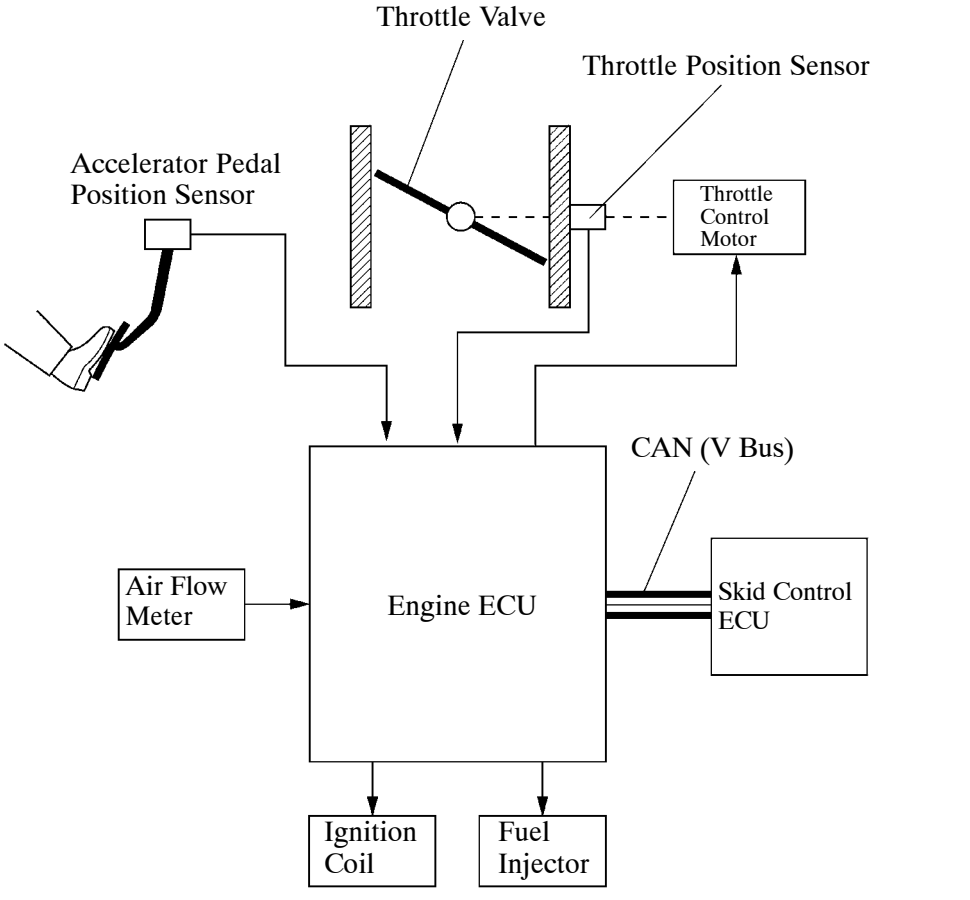
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7. ETCS-i (Electronic Throttle Control System-intelligent)

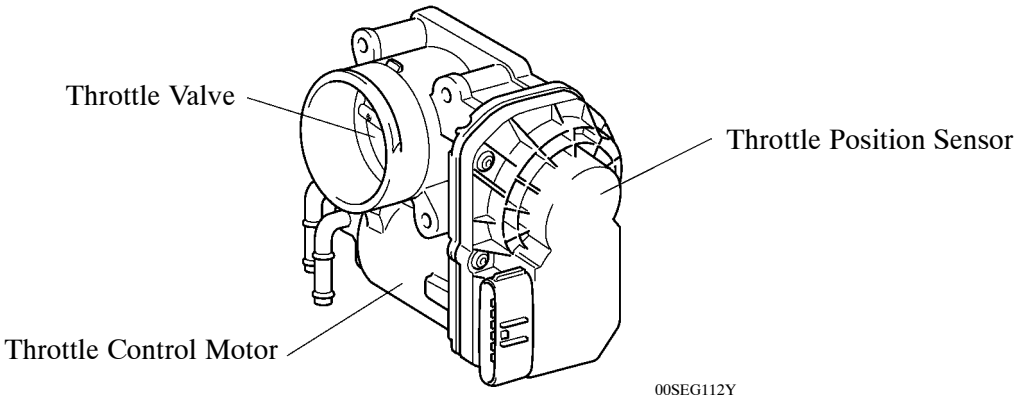
General

- 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 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 ETCS-i controls the ISC (Idle Speed Control) system, the TRC (Traction Control) and VSC (Vehicle Stability Control) system.
- In case of an abnormal condition, this system switches to the limp mode.

▶ System Diagram ◀



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 of the throttle valve.

Operation

1) General

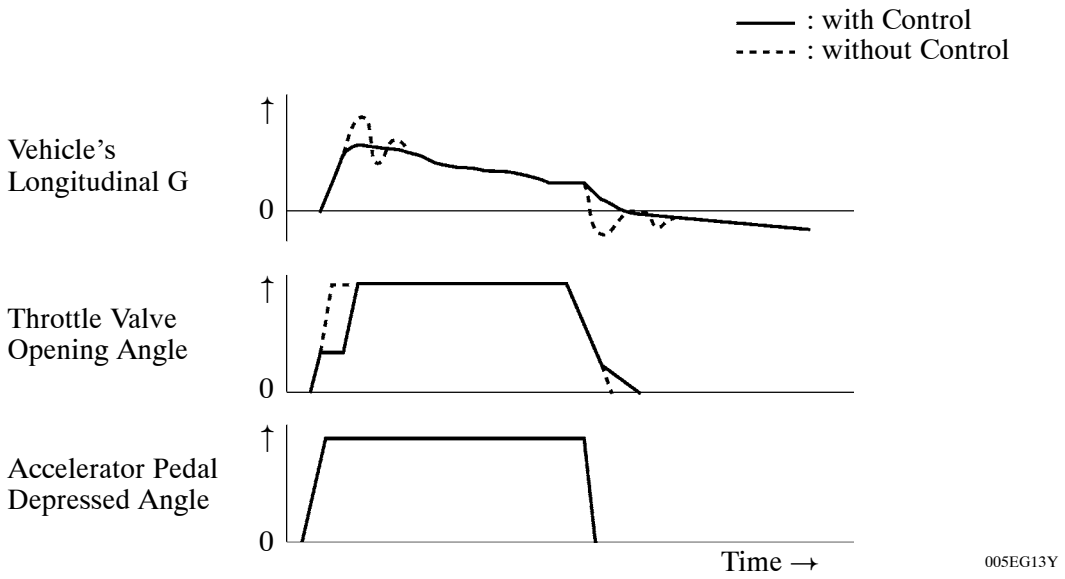
The engine ECU drives the throttle control motor by determining the target throttle valve opening in accordance with the respective operating condition.

- Non-Linear Control
- Idle Speed Control
- TRC Throttle Control
- VSC Coordination Control

2) Non-Linear Control

The engine ECU 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 ◀



3) Idle Speed Control

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

4) TRC Throttle Control

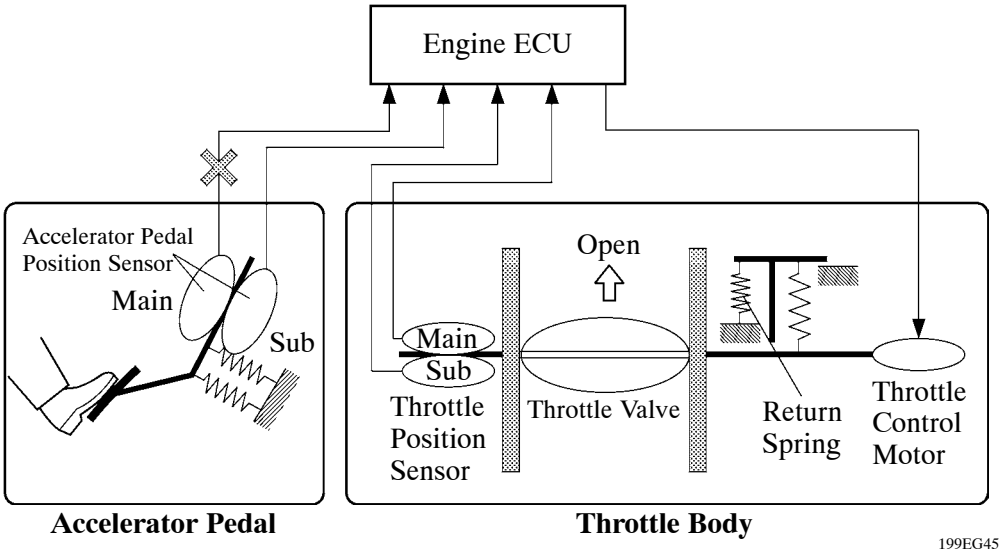
As part of TRC system, the throttle valve is closed by a request signal from the skid control ECU if an excessive amount of slippage is created at a driving wheel, thus it facilitates the vehicle in ensuring stability and driving force.

5) VSC Coordination Control

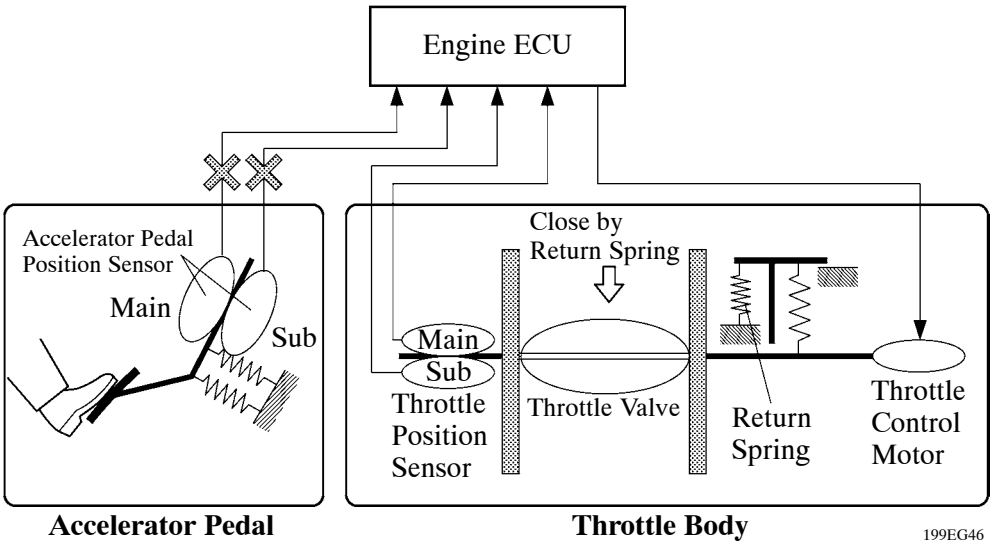
In order to bring the effectiveness of the VSC system control into full play, the throttle valve opening angle is controlled by effecting a coordination control with the skid control ECU.

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 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.

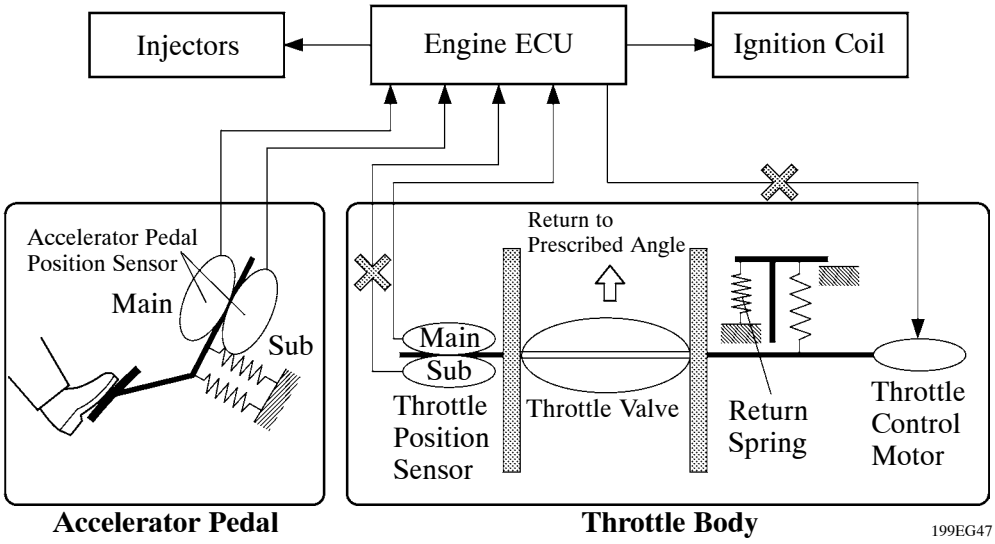


- If both circuits have a malfunction, the engine ECU detects the abnormal signal voltage from these two sensor circuits and discontinues the throttle control. At this time, the vehicle can be driven within its idling range.



Fail-safe of Throttle Position Sensor

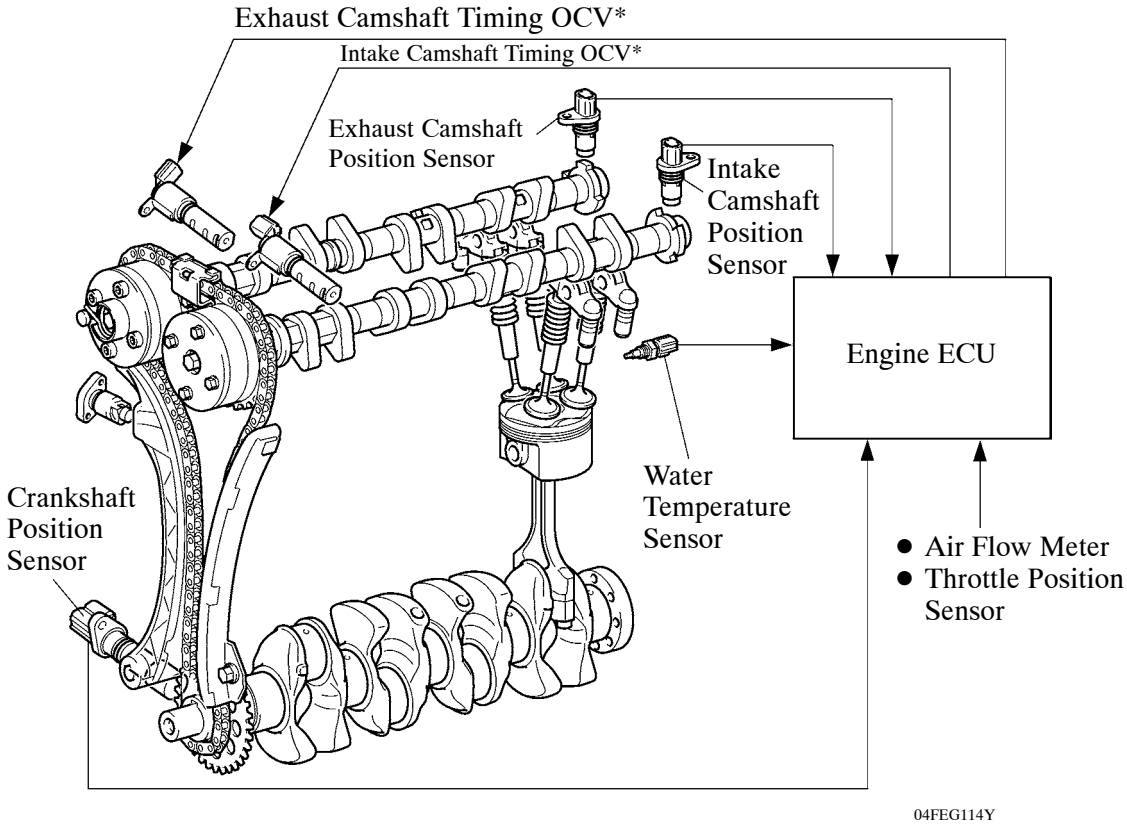
- The throttle position sensor is comprised of two (main, sub) sensor circuits. If a malfunction occurs in either one or both of the sensor circuits, the engine ECU detects the abnormal signal voltage difference between these two sensor circuits, cuts off the current to the throttle control motor, and 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. Dual VVT-i (Variable Valve Timing-intelligent) System

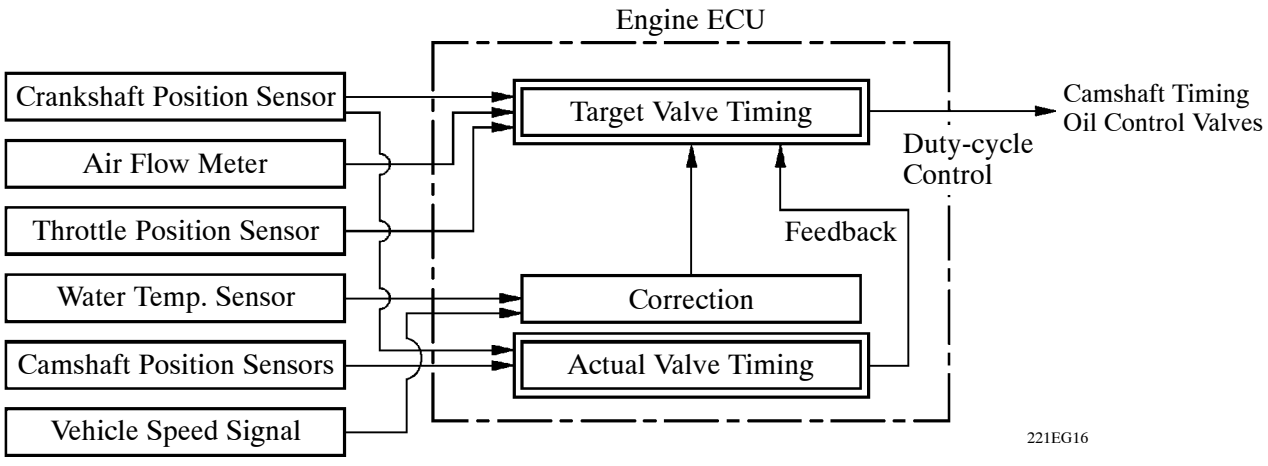
General

- The Dual VVT-i system is designed to control the intake and exhaust camshafts within a range of 55° and 40° respectively (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.

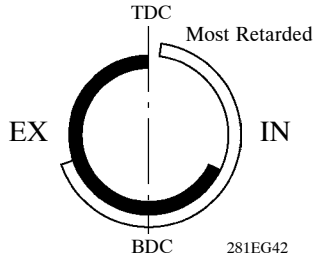
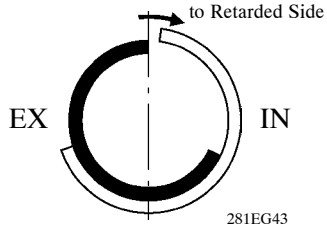
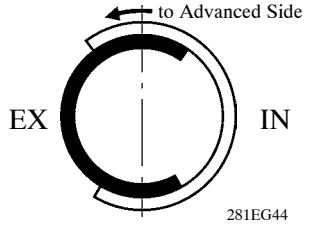
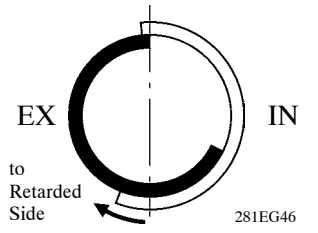
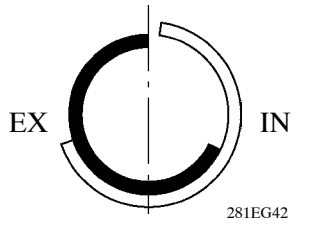
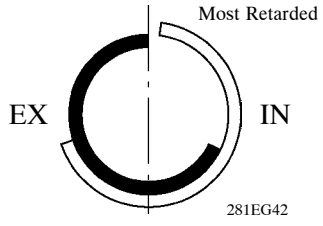


*: Oil Control Valve

- Using the engine speed, intake air mass, 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.



Effectiveness of the Dual VVT-i System

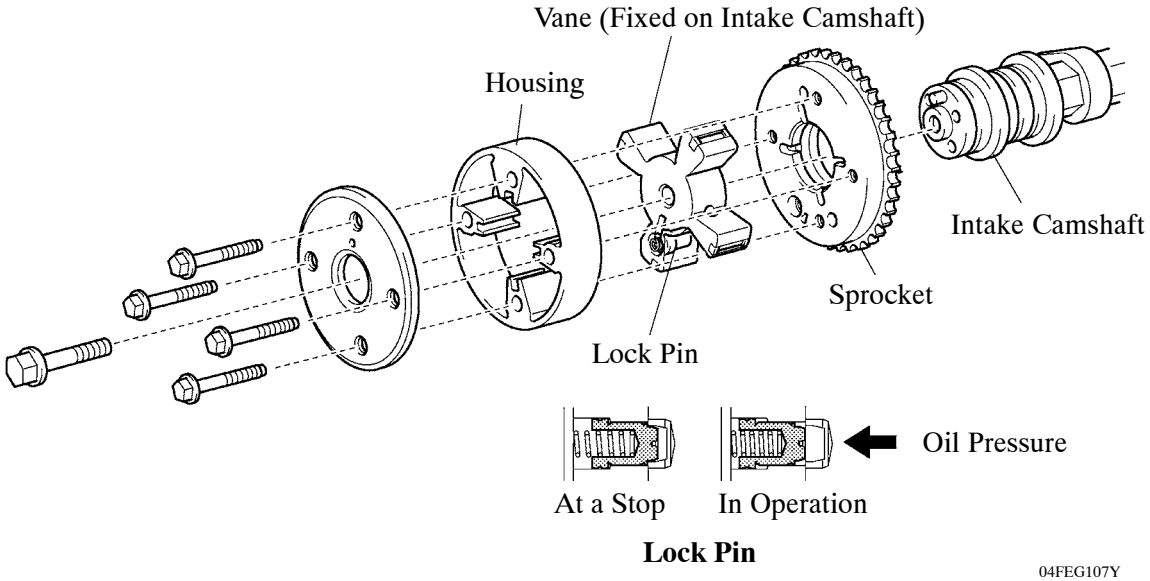
Operation State	Objective	Effect
During Idling	 Eliminating overlap to reduce blow back to the intake side	● Stabilized idling rpm ● Better fuel economy
At Light Load	 Eliminating overlap to reduce blow back to the intake side	Ensured engine stability
At Medium Load	 Increasing overlap to increase internal EGR to reduce pumping loss	● Better fuel economy ● Improved emission control
In Low to Medium Speed Range with Heavy Load	 Advancing the intake valve close timing for volumetric efficiency improvement	Improved torque in low to medium speed range
In High Speed Range with Heavy Load	 Retarding the intake valve close timing for volumetric efficiency improvement	Improved output
At Low Temperatures	 Eliminating overlap to reduce blow back to the intake side leads to the lean burning condition, and stabilizes the idling speed at fast idle	● Stabilized fast idle rpm ● Better fuel economy
● Upon Starting ● Stopping the Engine	 Eliminating overlap to minimize blow back to the intake side	Improved startability

Construction

1) VVT-i Controller

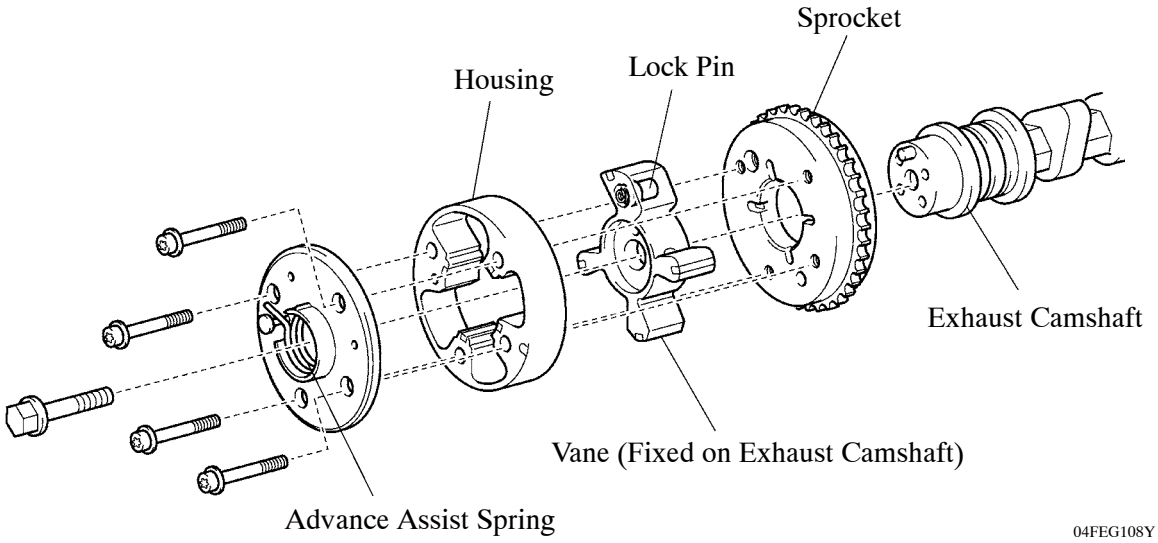
- Each controller consists of the housing driven from the timing chain and the vane coupled with the intake or exhaust camshaft.
- Both the intake and exhaust sides have a four-blade vane.
- The oil pressure sent from the advanced or retarded side path at the intake and exhaust camshafts causes rotation in the VVT-i controller vane circumferential direction to vary the intake and exhaust valve timing continuously.
- When the engine is stopped, a lock pin locks the intake camshaft at the most retarded end and the exhaust camshaft at the most advanced end, to ensure that the engine starts properly.
- An advance assist spring is provided on the exhaust side VVT-i controller. This spring applies torque in the advance direction when the engine is stopped, thus ensuring the engagement of the lock pin.

▶ Intake Side VVT-i Controller ◀



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▶ Exhaust Side VVT-i Controller ◀

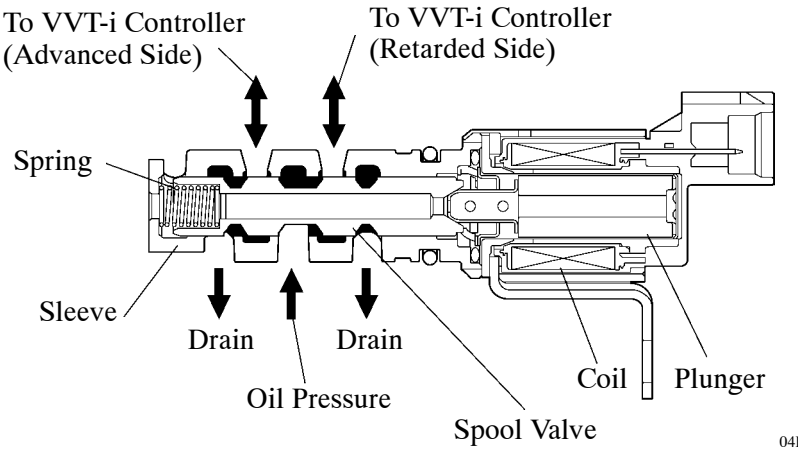


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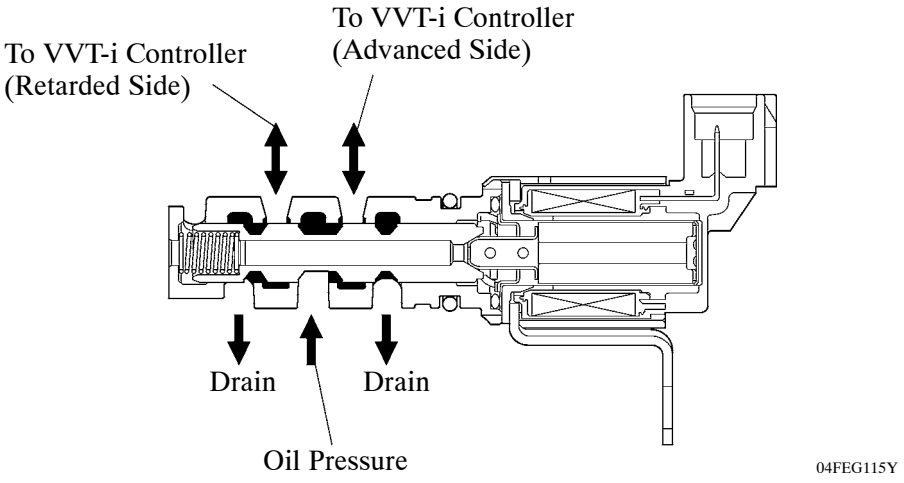
2) Camshaft Timing Oil Control Valve

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 advanced or retarded side. When the engine is stopped, the camshaft timing oil control valve is in the most retarded position.

▶ Intake Camshaft Timing Oil Control Valve ◀



▶ Exhaust Camshaft Timing Oil Control Valve ◀

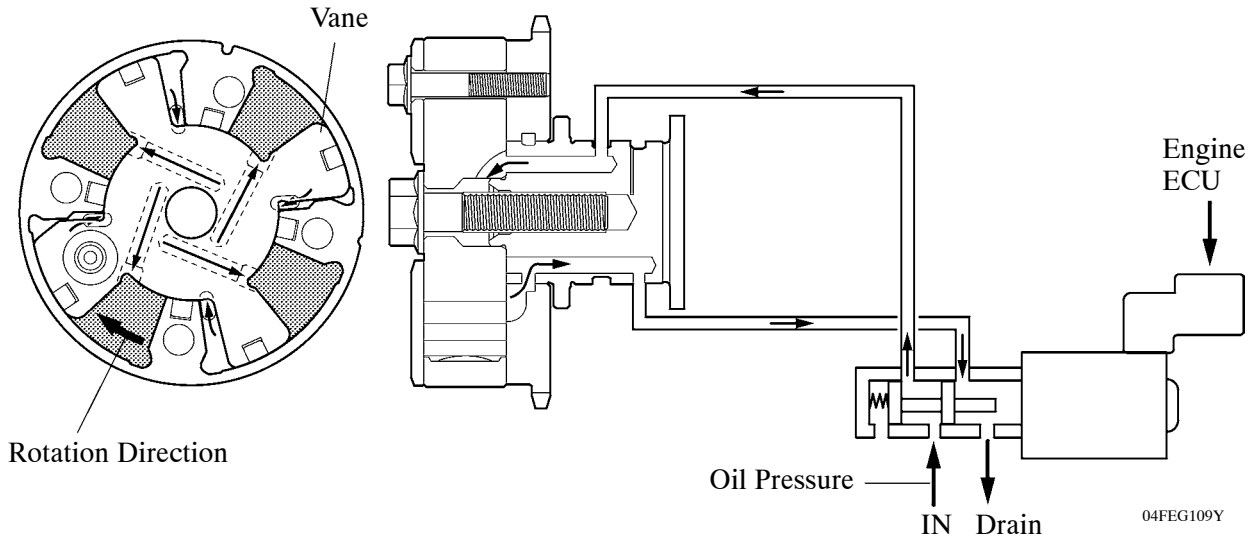


Operation

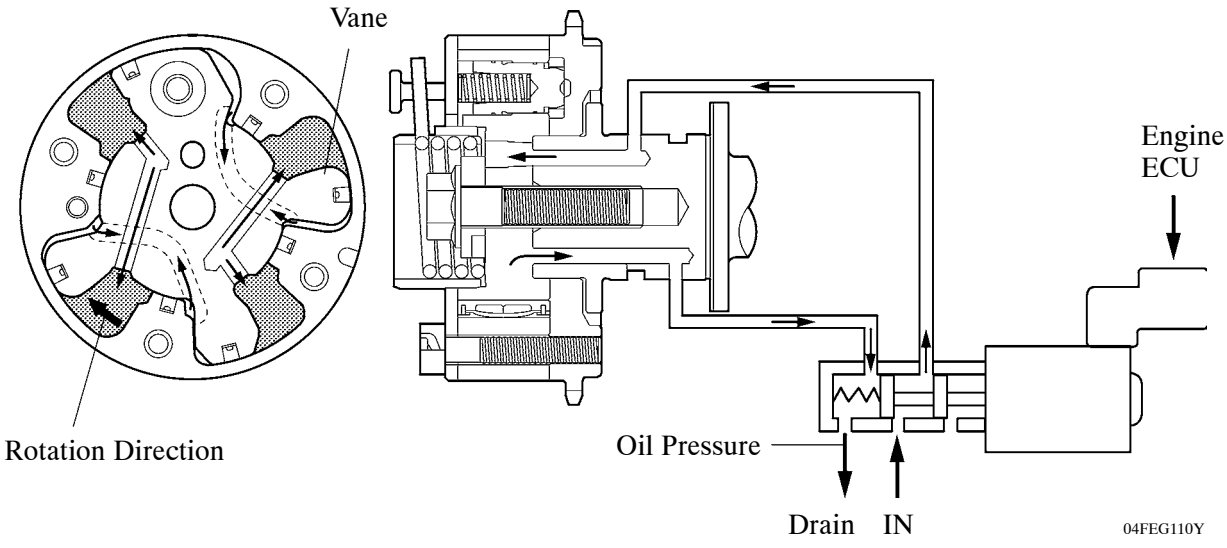
1) Advance

When the camshaft timing oil control valve is positioned as illustrated below by the advance signals 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.

▶ Intake Side ◀



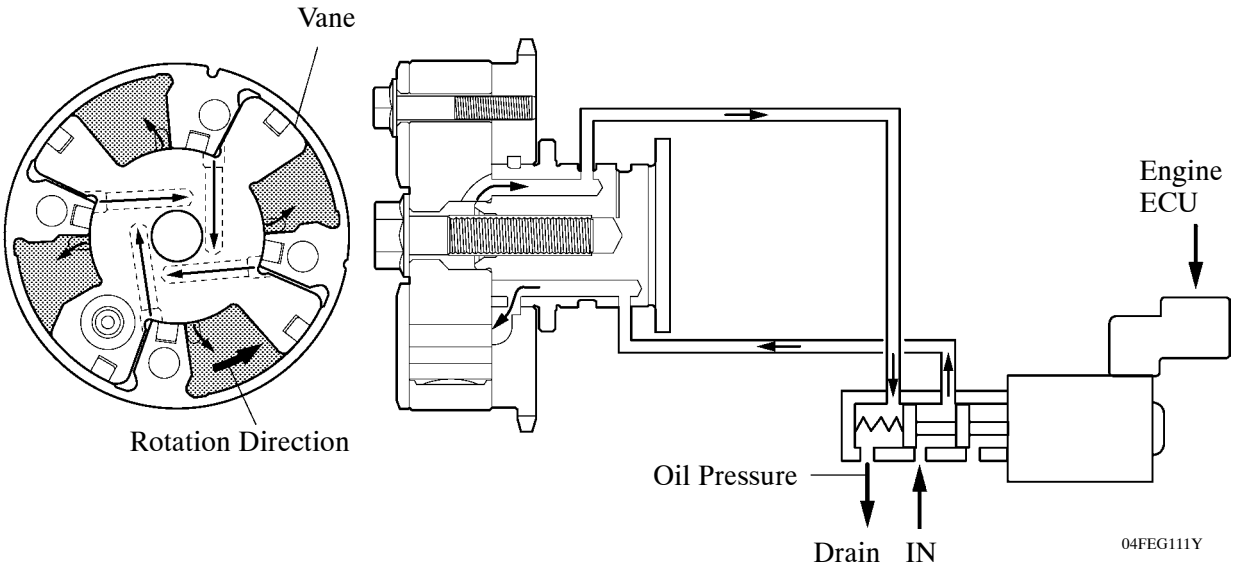
▶ Exhaust Side ◀



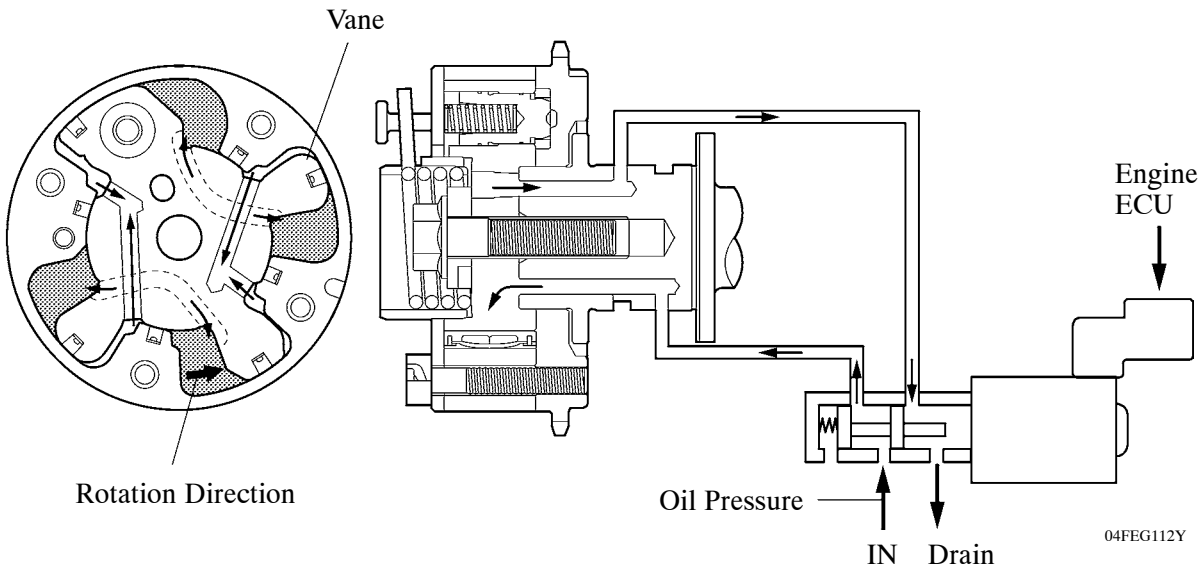
2) Retard

When the camshaft timing oil control valve is positioned as illustrated below by the retard signals 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.

▶ Intake Side ◀



▶ Exhaust Side ◀



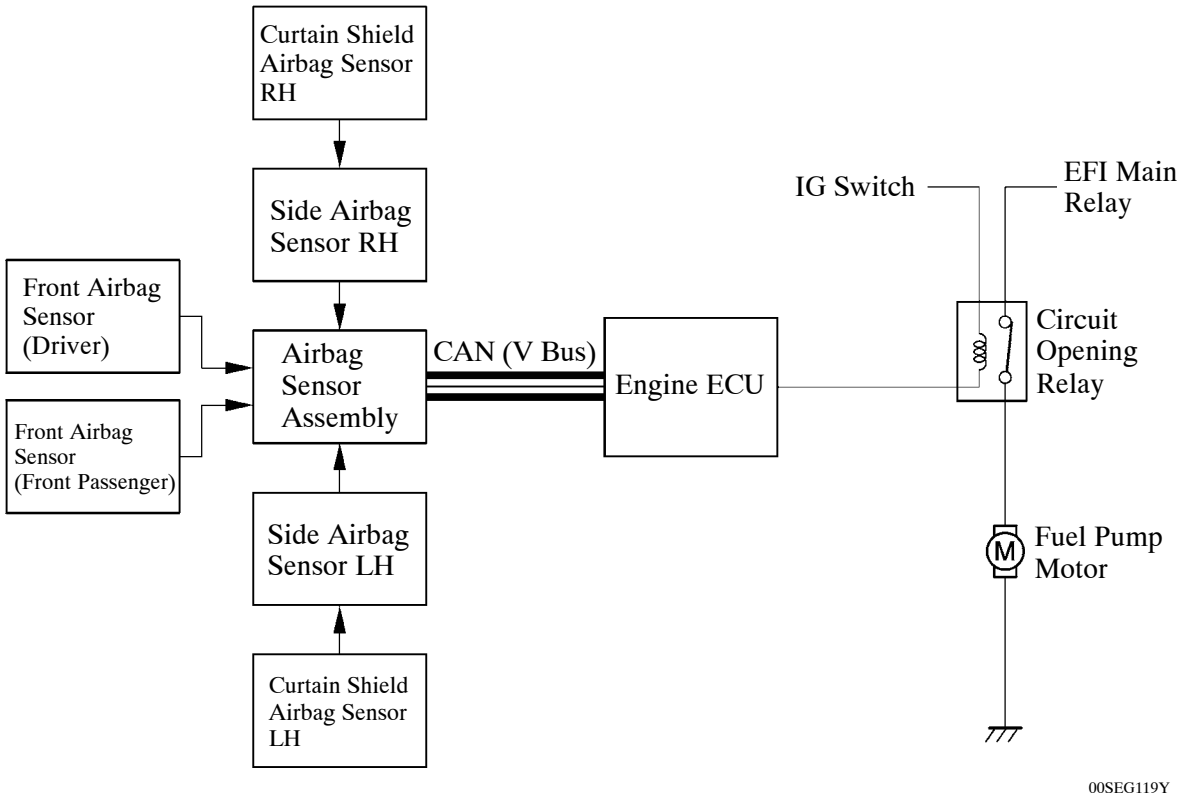
3) Hold

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. Fuel Pump Control

- A fuel cut control is used to stop the fuel pump once when the SRS airbags are deployed in a front or side collision.
- In this system, the airbag deployment signal from the airbag assembly is detected by the engine ECU, and it turns OFF the circuit opening relay. After the fuel cut control has been activated, turning the ignition switch (engine switch*) from OFF to ON (IG) cancels the fuel cut control, and the engine can be restarted.

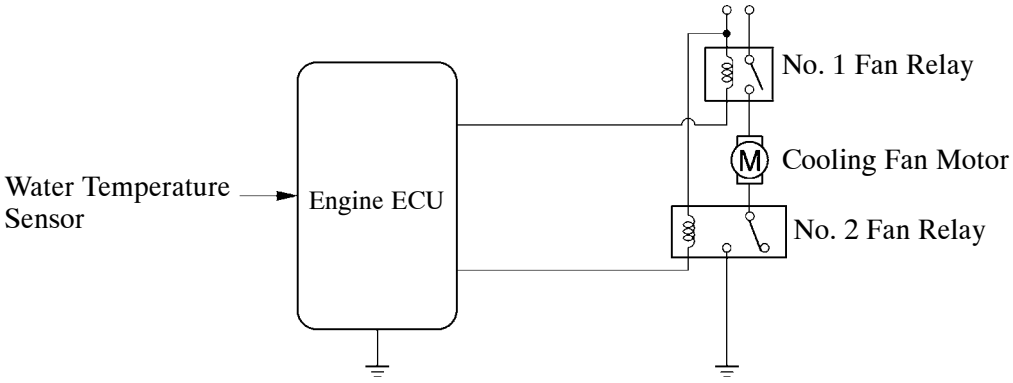
*: Models with Smart Entry & Start System



10. Cooling Fan Control

- On the models without air conditioner, the engine ECU controls the operation of the cooling fan based on the water temperature sensor signal.

▶ Wiring Diagram ◀

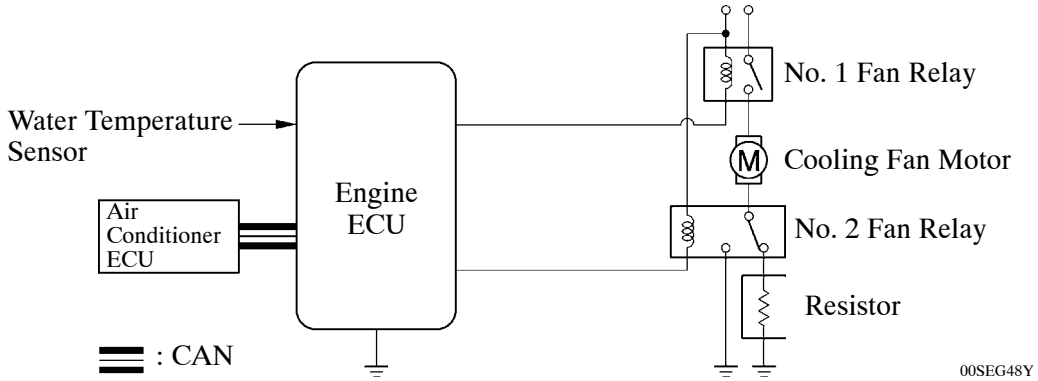


▶ Cooling Fan Operation ◀

Water Temperature*1	Low	High
Cooling Fan Operation	OFF	ON

- On the models with air conditioner, the engine ECU controls the operation of the cooling fan in two speeds (low and high) based on the water temperature sensor signal and the air conditioner ECU signal. The low speed operation is accomplished by applying the current through a resistor, which reduces the speed of the cooling fan.

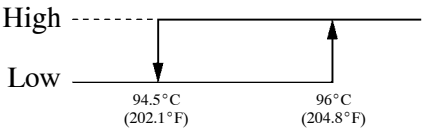
▶ Wiring Diagram ◀



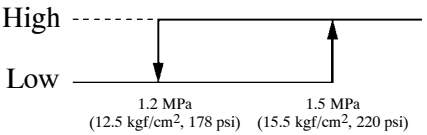
▶ Cooling Fan Operation ◀

Water Temperature*1	Air Conditioner Condition		Cooling Fan Operation
	A/C Switch	Refrigerant Pressure*2	
Low	OFF	Low	OFF
	ON	Low	Low
	ON	High	High
High	OFF	Low	High
	ON	Low	High
	ON	High	High

*1: Judgmental standard of water temperature



*2: Judgmental standard of refrigerant pressure



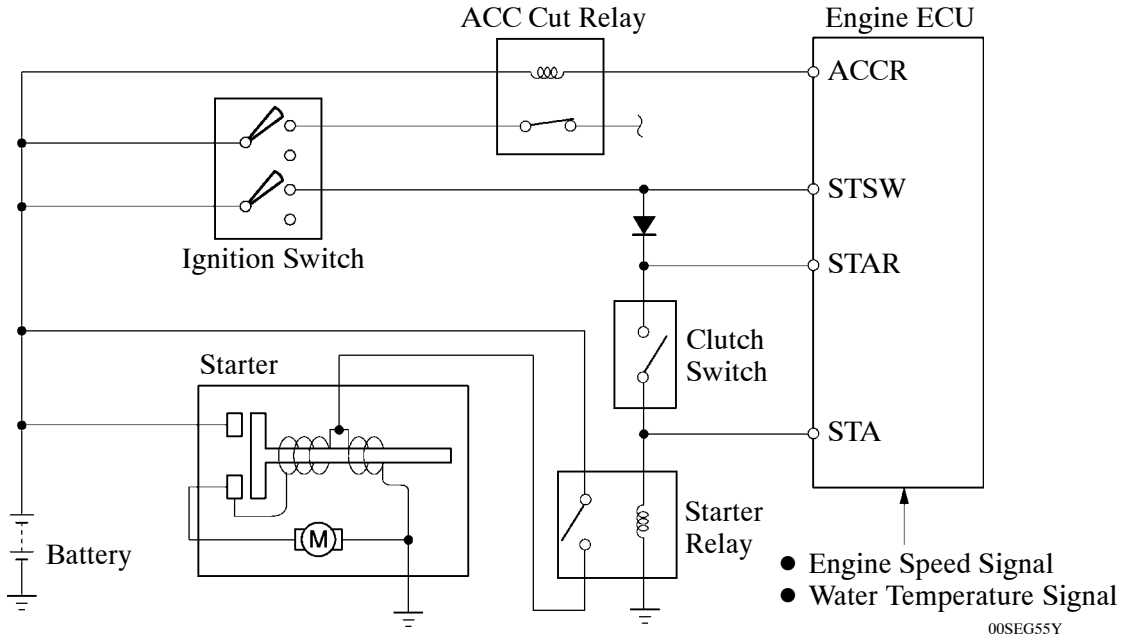
11. Starter Control (Cranking Hold Function)

General

1) For 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 starts, without having to hold the ignition switch in the START position. This prevents starting failures.
- When the engine ECU detects a start signal from the ignition switch, this system monitors the engine speed (NE) signal and continues to operate the starter until it determines that the engine has started.

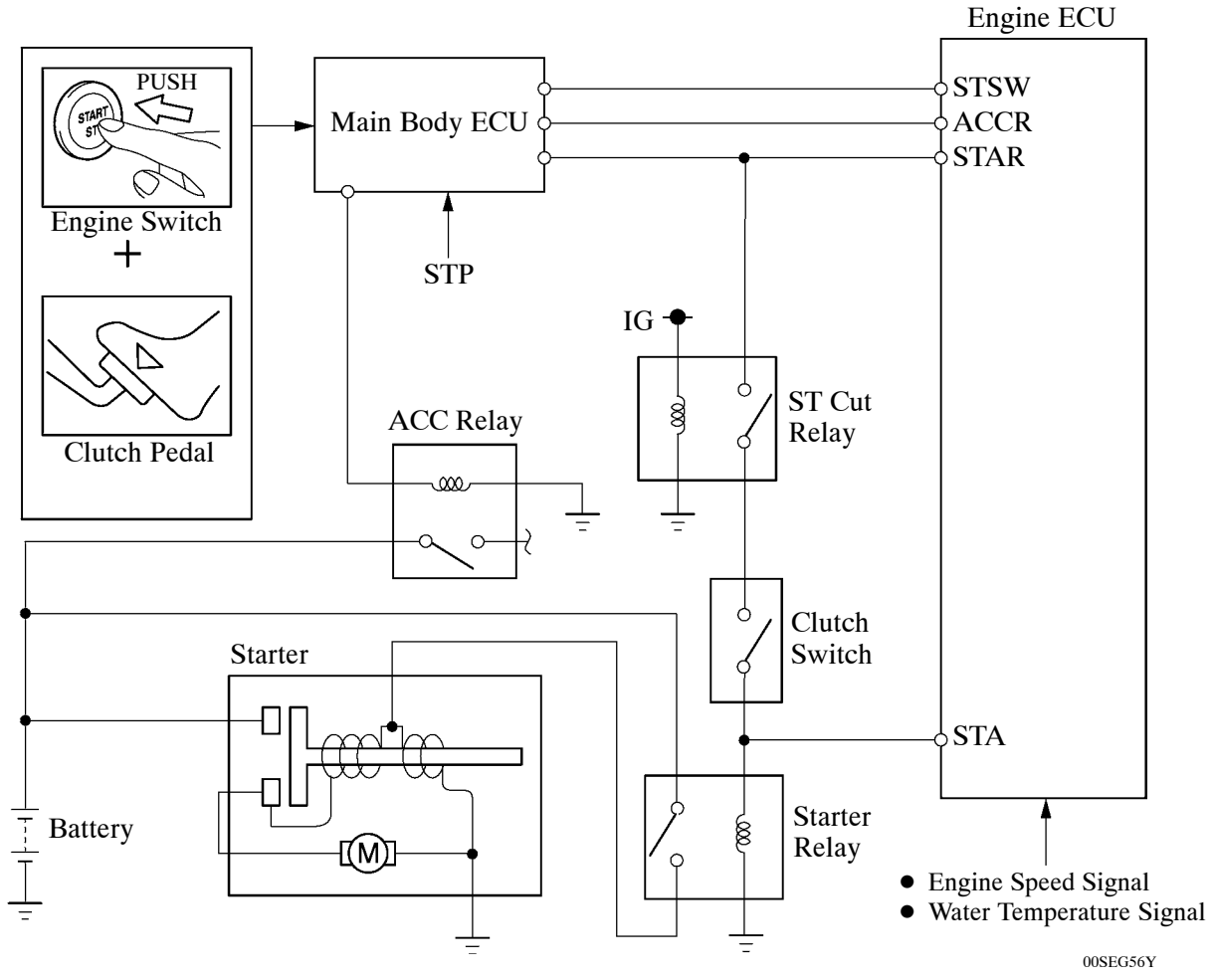
▶ System Diagram ◀



2) For Models with Smart Entry & Start System

- Once the engine switch is pushed, this function continues to operate the starter until the engine starts, provided that the clutch pedal is pressed. This prevents starting failures and the engine from being cranked after the engine has started.
- When the engine ECU detects a start signal from the main body ECU, this system monitors the engine speed (NE) signal and continues to operate the starter until it determines that the engine has started. Furthermore, even if the engine ECU detects a start signal from the main body ECU, this system will not operate the starter if the engine ECU has determined that the engine has already started.

▶ System Diagram ◀

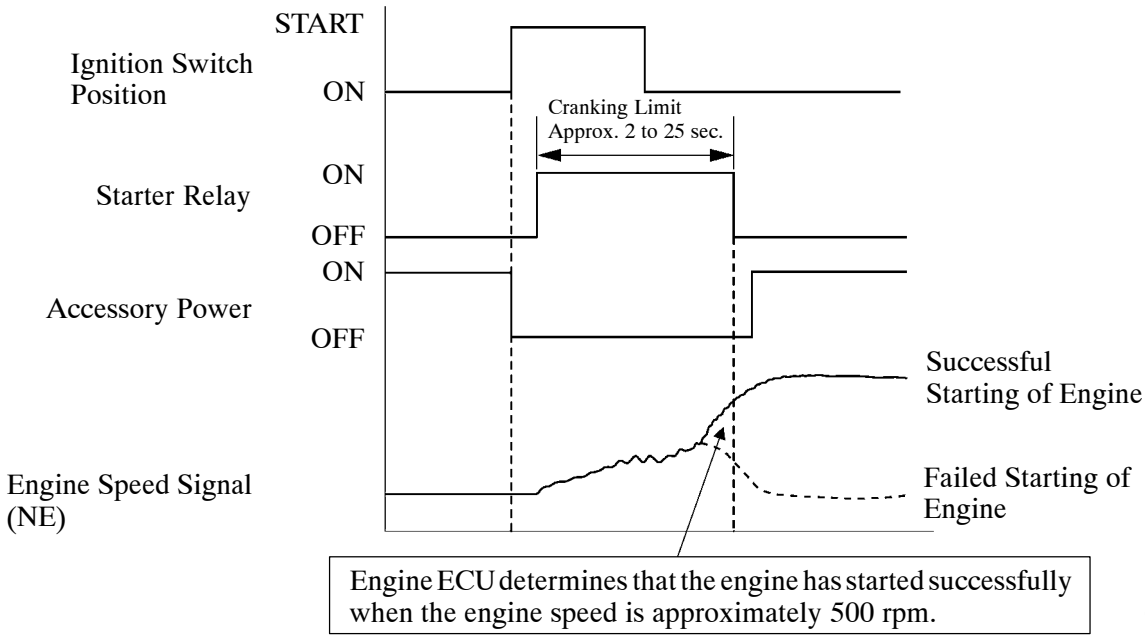


Operation

3) For Models without Smart Entry & Start System

- As indicated in the following timing chart, when the engine ECU detects a start signal from the ignition switch, it energizes the starter relay to operate the starter. If the engine is already running, the engine ECU will not energize the starter relay.
- After the starter operates and the engine speed becomes higher than approximately 500 rpm, the engine ECU determines that the engine has started and stops the operation of the starter.
- If the engine has any failure and does not work, the starter operates as long as its maximum continuous operation time and stops automatically. The maximum continuous operation time is approximately 2 seconds through 25 seconds depending on the water temperature condition. When the water temperature is extremely low, it is approximately 25 seconds and when the engine is warmed up sufficiently, it is approximately 2 seconds.
- This system cuts off the current that powers the accessories while the engine is cranking to prevent the accessory illumination from operating intermittently due to the unstable voltage that is associated with the cranking of the engine.
- This system has the following protections.
  - While the engine is running normally, even if turning the ignition switch to START position, the starter will not operate.
  - In case that the driver keeps holding the ignition switch in START position and the engine successfully started, the engine ECU will stop the starter operation when the engine speed has become approximately 1,200 rpm or more.
  - In case that the driver keeps holding the ignition switch in START position and the engine will not start, the engine ECU will stop the starter operation when approximately 30 seconds have been passed.
  - In case that the starter begins to operate, but cannot detect the engine speed signal, the engine ECU will stop the starter operation immediately.

▶ Timing Chart ◀



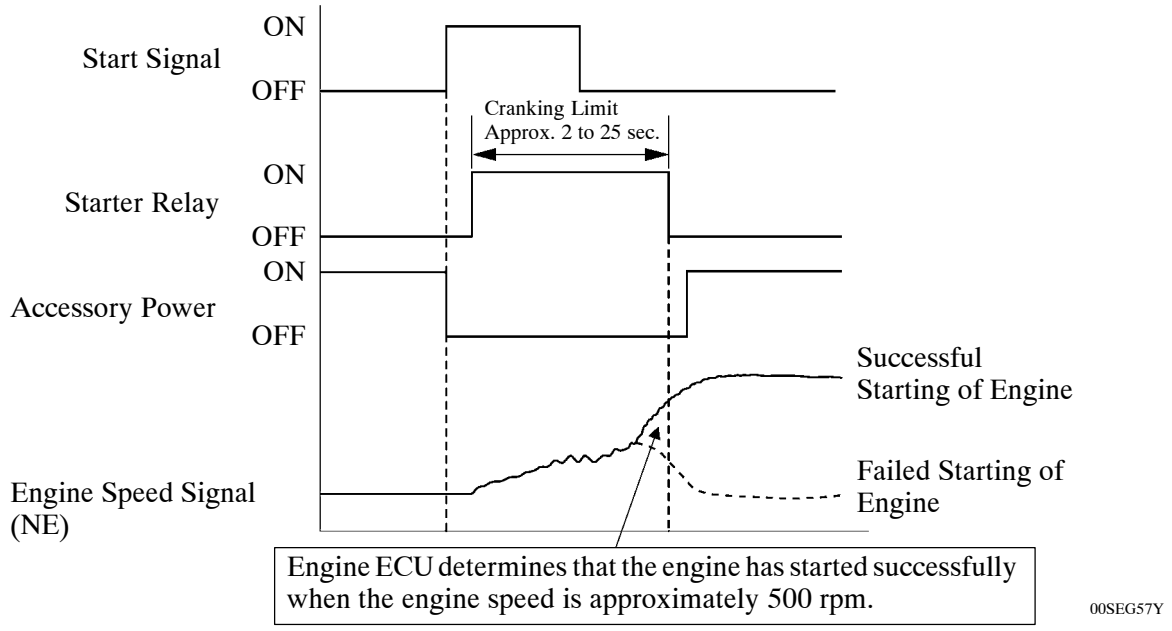
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4) For Models with Smart Entry & Start System

- As indicated in the following timing chart, when the engine ECU detects a start signal (STSW) from the main body ECU, the engine ECU outputs the STAR and ACCR signals to the main body ECU. Upon detecting the STAR and ACCR signals from the engine ECU, the main body ECU energizes the starter relay to operate the starter. If the engine is already running, the engine ECU stops the output of the STAR and ACCR signals to the main body ECU. Thus, the main body ECU will not energize the starter relay.
- After the starter operates and the engine speed becomes higher than approximately 500 rpm, the engine ECU determines that the engine has started and stops the output of the STAR and ACCR signals to the main body ECU. Thus, the main body ECU will stop the operation of the starter.
- If the engine has any failure and does not work, the starter operates as long as its maximum continuous operation time and stops automatically. The maximum continuous operation time is approximately 2 seconds through 25 seconds depending on the water temperature condition. When the water temperature is extremely low, it is approximately 25 seconds and when the engine is warmed up sufficiently, it is approximately 2 seconds.
- This system cuts off the current that powers the accessories while the engine is cranking to prevent the accessory illumination from operating intermittently due to the unstable voltage that is associated with the cranking of the engine.
- This system has the following protections.
  - While the engine is running normally, the starter does not operate.
  - In case the driver keeps pressing the engine switch and the engine successfully started, the engine ECU stops the output of the STAR and ACCR signals when the engine speed becomes higher than 1,200 rpm. Thus, the main body ECU will stop the operation of the starter.
  - In case the driver keeps pressing the engine switch and the engine does not start, the engine ECU stops the output of the STAR and ACCR signals after 30 seconds have elapsed. Thus, the main body ECU will stop the operation of the starter.
  - In case the engine ECU cannot detect an engine speed signal while the starter is operating, the engine ECU will immediately stop the output of the STAR and ACCR signals. Thus, the main body ECU will stop the operation of the starter.

▶ Timing Chart ◀



12. Diagnosis

- 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.
- The engine ECU will also store the DTCs (Diagnostic Trouble Codes) of the malfunctions.
- The DTCs can be accessed by the use of the intelligent tester II.
- 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 Yaris Repair Manual Supplement (Pub. No. RM00S3E).

Service Tip

To clear the DTC that is stored in the engine ECU, use an intelligent tester II or disconnect the battery terminal or remove the EFI fuse for 1 minute or longer.

13. Fail-safe

When a malfunction is detected by any of the sensors, there is a possibility of an engine or another 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 Supplement (Pub. No. RM00S3E).