■ENGINE CONTROL SYSTEM

1. General

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

System	Outline
SFI (Sequential Multiport Fuel Injection)	• An L-type SFI system detects the intake air mass with a hot-wire type mass air flow meter. • The fuel injection system is a sequential multiport fuel injection system.
ETCS-i (Electronic Throttle Control System-intelligent) [See page EG-44]	Optimally controls the throttle valve opening in accordance with the amount of accelerator pedal effort, the throttle valve opening control request from the ECM, and the condition of the engine and the vehicle.
	• A linkless-type is used, without an accelerator cable. • An accelerator pedal position sensor is provided on the accelerator pedal. • The non-contact type throttle position sensor and accelerator pedal position sensor are used.
ESA (Electronic Spark Advance)	Ignition timing is determined by the ECM based on signals from various sensors. The ECM corrects ignition timing in response to engine knocking.
Dual VVT-i (Variable Valve Timing-intelligent) [See page EG-49]	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 EG-55]	• Fuel pump operation is controlled by signals from the ECM. • 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 Control [See page EG-56]	The ECM controls the purge flow of evaporative emissions (HC) in the canister in accordance with engine conditions.
	Approximately five hours after the ignition switch has been turned OFF, the ECM operates the canister pump module to detect any evaporative emission leakage occurring in the EVAP (evaporative emission) control system through changes in the 0.02 in. leak pressure.
Engine Immobilizer	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid key.
Air Conditioning Cut-off Control*	By turning the air conditioning compressor ON or OFF in accordance with the engine condition, drivability is maintained.

(Continued)

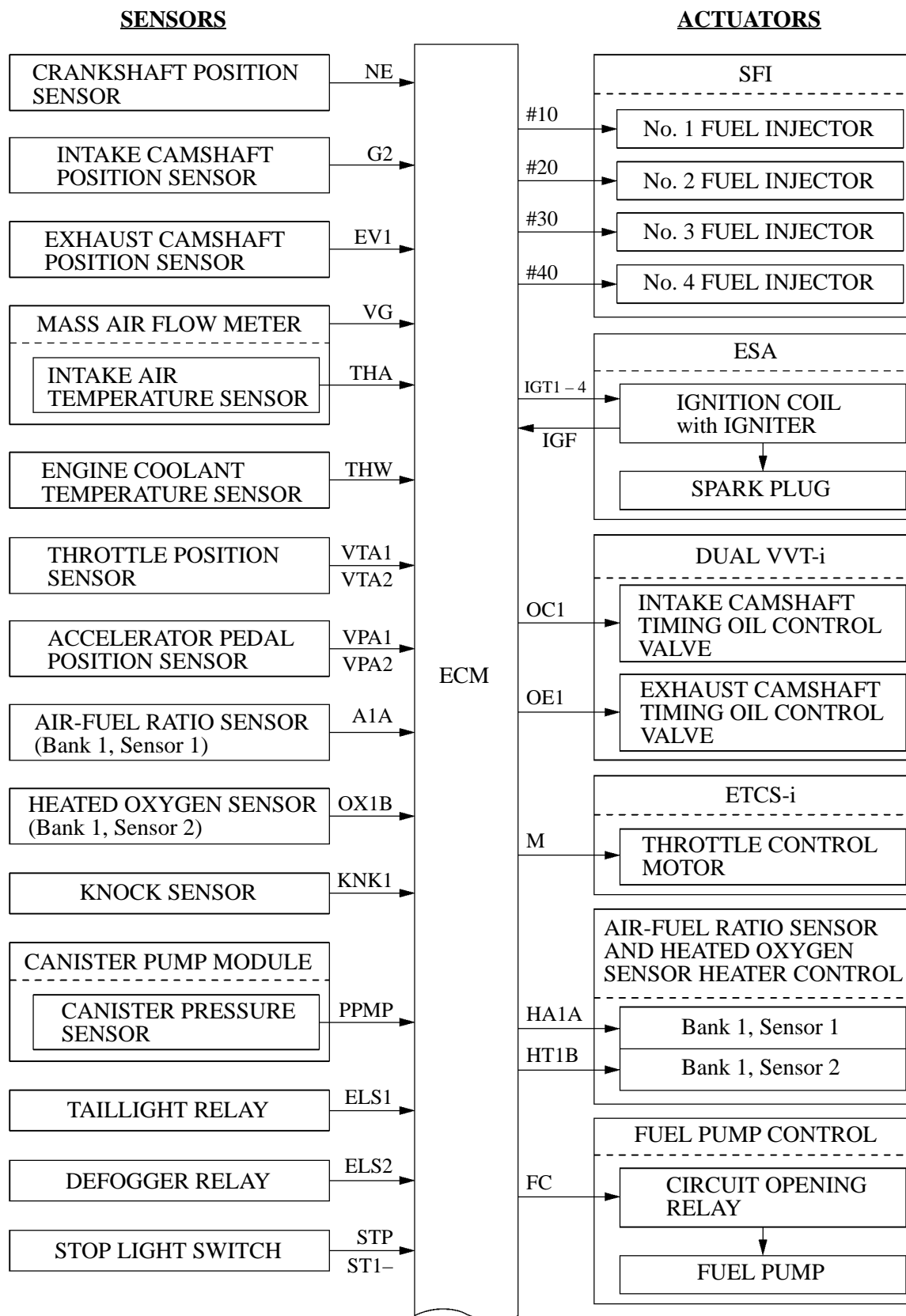*: Models with Air Conditioning System

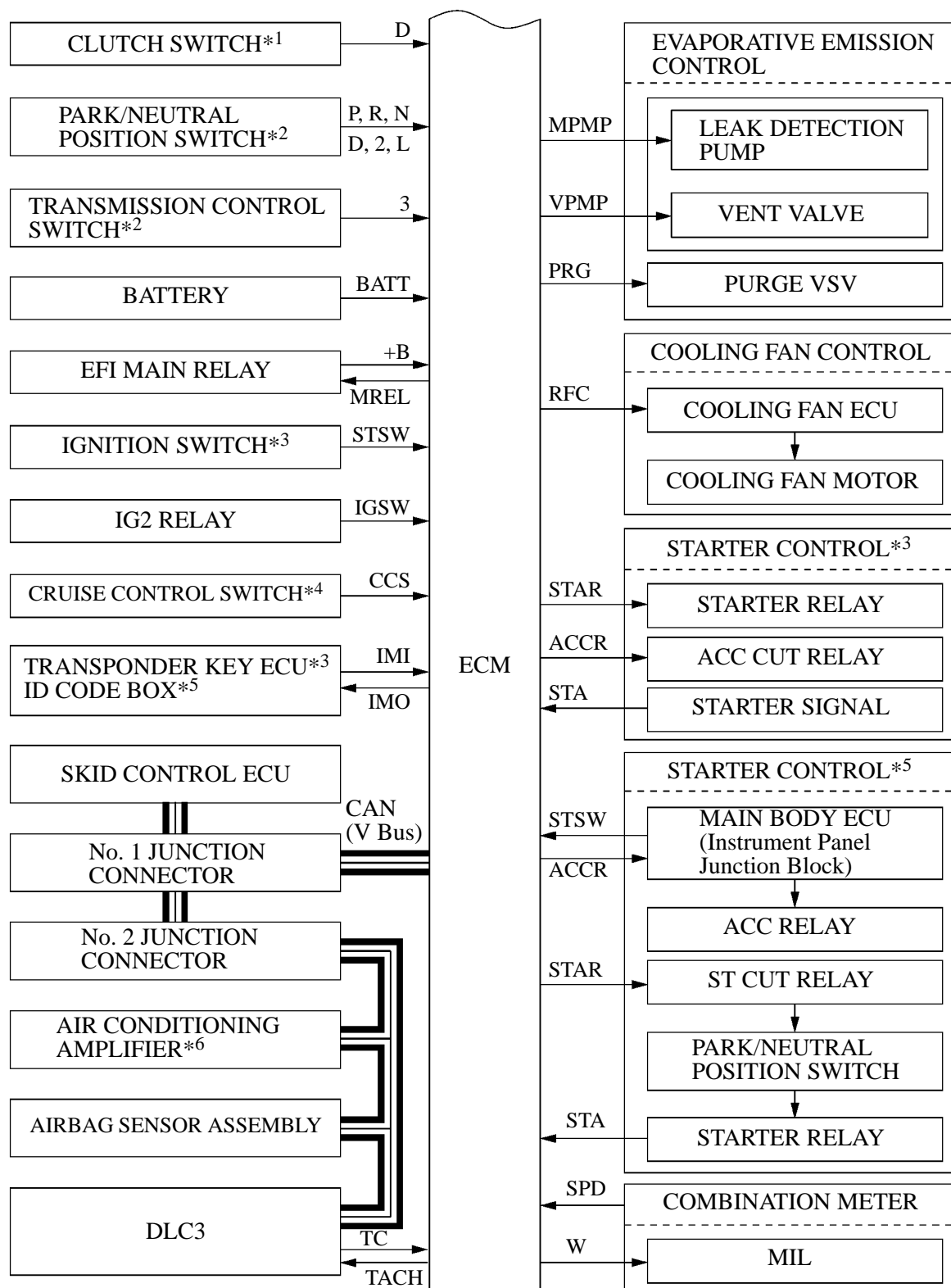| System	Outline
Cooling Fan Control [See page EG-68]	The cooling fan ECU steplessly controls the speed of the fans in accordance with the engine coolant temperature, vehicle speed, engine speed, and air conditioning operating conditions. As a result, the cooling performance is improved.
Starter Control (Cranking Hold Function) [See page EG-70]	• Once the ignition switch is turned to the START position, this control continues to operate the starter until the engine is started.*[1] • Once the engine switch is pushed, this control continues to operate the starter until the engine is started.*[2]
Diagnosis [See page EG-74]	When the ECM detects a malfunction, the ECM diagnoses and memorizes the failed section.
Fail-safe [See page EG-74]	When the ECM detects a malfunction, the ECM stops or controls the engine according to the data already stored in memory.

*[1]: Models without Smart Key System

*[2]: Models with Smart Key System

2. Construction

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

SENSORS		ACTUATORS

SENSORS

CRANKSHAFT POSITION SENSOR	NE
INTAKE CAMSHAFT POSITION SENSOR	G2
EXHAUST CAMSHAFT POSITION SENSOR	EV1
MASS AIR FLOW METER	VG
INTAKE AIR TEMPERATURE SENSOR	THA
ENGINE COOLANT TEMPERATURE SENSOR	THW
THROTTLE POSITION SENSOR	VTA1 / VTA2
ACCELERATOR PEDAL POSITION SENSOR	VPA1 / VPA2
AIR-FUEL RATIO SENSOR (Bank 1, Sensor 1)	A1A
HEATED OXYGEN SENSOR (Bank 1, Sensor 2)	OX1B
KNOCK SENSOR	KNK1
CANISTER PUMP MODULE	
CANISTER PRESSURE SENSOR	PPMP
TAILLIGHT RELAY	ELS1
DEFOGGER RELAY	ELS2
STOP LIGHT SWITCH	STP / ST1–

ECM

ACTUATORS

SFI
- #10 → No. 1 FUEL INJECTOR
- #20 → No. 2 FUEL INJECTOR
- #30 → No. 3 FUEL INJECTOR
- #40 → No. 4 FUEL INJECTOR

ESA
- IGT1 – 4 → IGNITION COIL with IGNITER
- IGF
- SPARK PLUG

DUAL VVT-i
- OC1 → INTAKE CAMSHAFT TIMING OIL CONTROL VALVE
- OE1 → EXHAUST CAMSHAFT TIMING OIL CONTROL VALVE

ETCS-i
- M → THROTTLE CONTROL MOTOR

AIR-FUEL RATIO SENSOR AND HEATED OXYGEN SENSOR HEATER CONTROL
- HA1A → Bank 1, Sensor 1
- HT1B → Bank 1, Sensor 2

FUEL PUMP CONTROL
- FC → CIRCUIT OPENING RELAY
- FUEL PUMP

(Continued)

08MEG04Y

CLUTCH SWITCH*1	D →	
PARK/NEUTRAL POSITION SWITCH*2	P, R, N → / D, 2, L →	
TRANSMISSION CONTROL SWITCH*2	3 →	
BATTERY	BATT →	
EFI MAIN RELAY	+B → / MREL ←	
IGNITION SWITCH*3	STSW →	
IG2 RELAY	IGSW →	
CRUISE CONTROL SWITCH*4	CCS →	
TRANSPONDER KEY ECU*3 ID CODE BOX*5	IMI → / IMO ←	
SKID CONTROL ECU		
No. 1 JUNCTION CONNECTOR	CAN (V Bus)	
No. 2 JUNCTION CONNECTOR		
AIR CONDITIONING AMPLIFIER*6		
AIRBAG SENSOR ASSEMBLY		
DLC3	TC / TACH	

ECM

EVAPORATIVE EMISSION CONTROL
- MPMP → LEAK DETECTION PUMP
- VPMP → VENT VALVE
- PRG → PURGE VSV

COOLING FAN CONTROL
- RFC → COOLING FAN ECU → COOLING FAN MOTOR

STARTER CONTROL*3
- STAR → STARTER RELAY
- ACCR → ACC CUT RELAY
- STA ← STARTER SIGNAL

STARTER CONTROL*5
- STSW → MAIN BODY ECU (Instrument Panel Junction Block)
- ACCR →
- ACC RELAY
- STAR → ST CUT RELAY
- PARK/NEUTRAL POSITION SWITCH
- STA ← STARTER RELAY

COMBINATION METER
- SPD ← COMBINATION METER
- W → MIL

*1: Manual Transaxle Models
*2: Automatic Transaxle Models
*3: Models without Smart Key System
*4: Models with Cruise Control System
*5: Models with Smart Key System
*6: Models with Air Conditioning System

08MEG05Y

3. Engine Control System Diagram
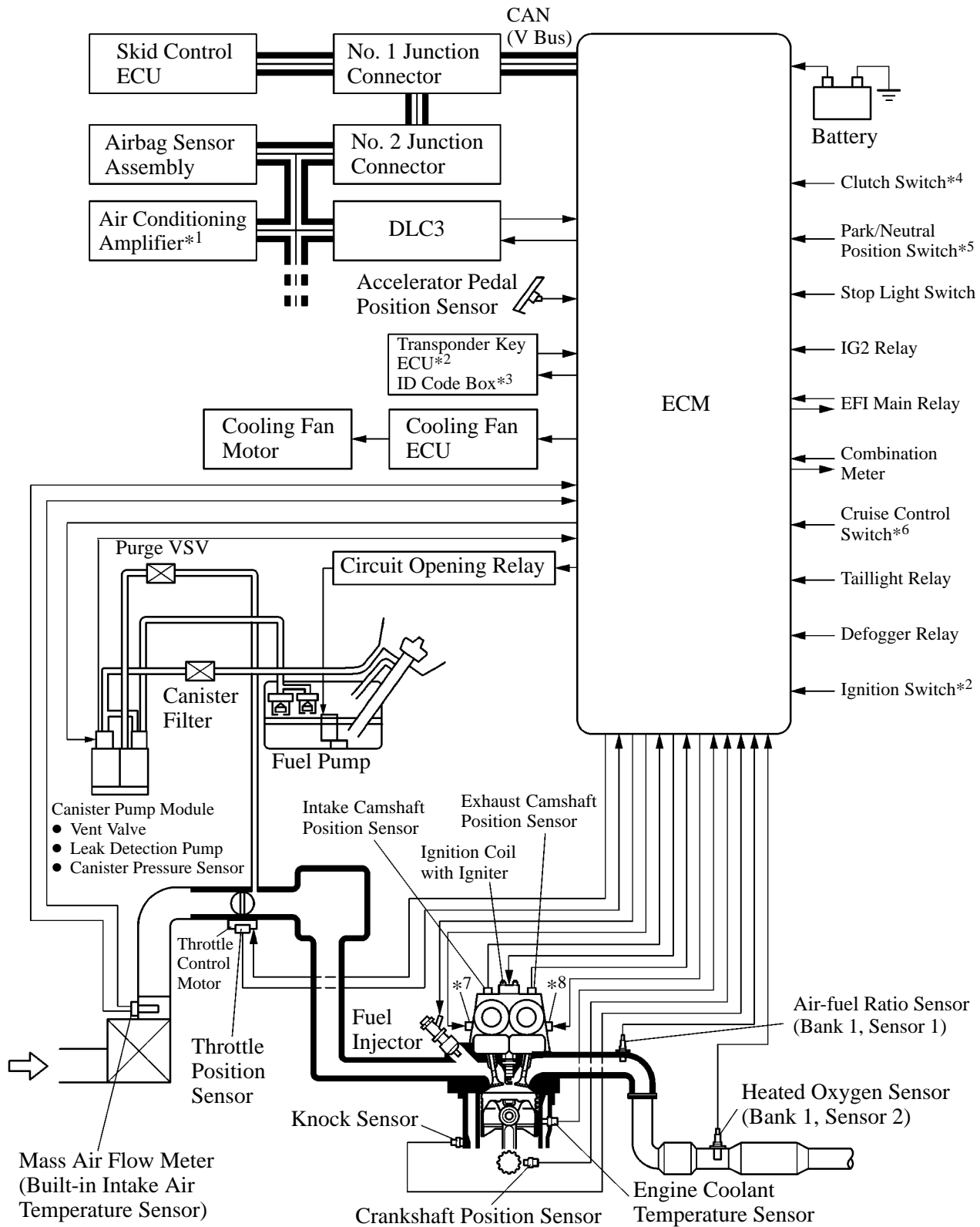
08SEG08Y

*1: Models with Air Conditioning System
*3: Models with Smart Key System
*5: Automatic Transaxle Models
*7: Intake Camshaft Timing Oil Control Valve

*2: Models without Smart Key System
*4: Manual Transaxle Models
*6: Models with Cruise Control System
*8: Exhaust Camshaft Timing Oil Control Valve

4. Layout of Main Components

Canister Pump Module
- Vent Valve
- Leak Detection Pump
- Canister Pressure Sensor

Accelerator Pedal Position Sensor

ECM

Mass Air Flow Meter
(Built-in Intake Air
Temperature Sensor)

Fuel Pump Assembly

DLC3

Heated Oxygen Sensor
(Bank 1, Sensor 2)

Intake Camshaft Timing
Oil Control Valve

Exhaust Camshaft Timing
Oil Control Valve

Ignition Coil with Igniter

Fuel Injector

Purge VSV

Exhaust Camshaft Position Sensor

Intake Camshaft Position Sensor

Crankshaft Position
Sensor

Air-fuel Ratio Sensor
(Bank 1, Sensor 1)

Engine Coolant
Temperature Sensor

Knock Sensor

Throttle Position Sensor

08MEG13Y

5. Main Components of Engine Control System

General

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

Components	Outline	Quantity	Function
ECM	32-bit	1	The ECM optimally controls the SFI, ESA, and ISC to suit the operating conditions of the engine in accordance with the signals provided by the sensors.
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.
Engine Coolant Temperature Sensor	Thermistor Type	1	This sensor detects the engine coolant temperature by means of an internal thermistor.
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.
Mass 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.
Fuel Injector	12-hole Type	4	The fuel injector is an electromagnetically-operated nozzle which injects fuel in accordance with the signals from the ECM.

Air-fuel Ratio Sensor and Heated Oxygen Sensor

1) General

- The air-fuel ratio sensor and heated oxygen sensor differ in output characteristics.

- Approximately 0.4V is constantly applied to the air-fuel ratio sensor, which outputs an amperage that varies in accordance with the oxygen concentration in the exhaust emission. The ECM 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 read out by the Techstream.

- The output voltage of the heated oxygen sensor changes in accordance with the oxygen concentration in the exhaust emission. The ECM uses this output voltage to determine whether the present air-fuel ratio is richer or leaner than the stoichiometric air-fuel ratio.

A1A+
(3.3 V)

Air-fuel
Ratio Sensor

ECM

A1A−
(2.9 V)

OX1B

Heated
Oxygen
Sensor

ECM

EX1B
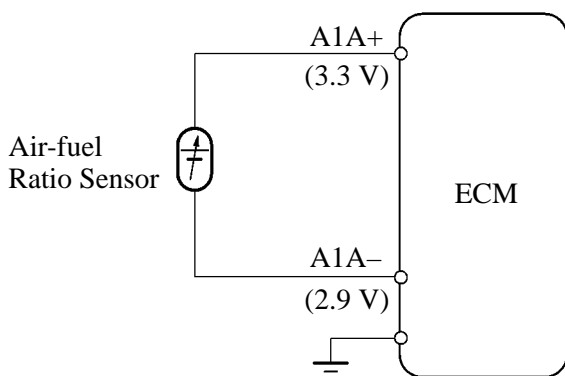
00REG21Y

Air-fuel Ratio Sensor Circuit

Heated Oxygen Sensor

——— **: Air-fuel Ratio Sensor**

- - - - **: Heated Oxygen Sensor**

4.2

1

Air-fuel Ratio Sensor Data
Displayed on Techstream

Heated Oxygen
Sensor Output (V)

2.2

0.1

11(Rich)   14.7   19 (Lean)
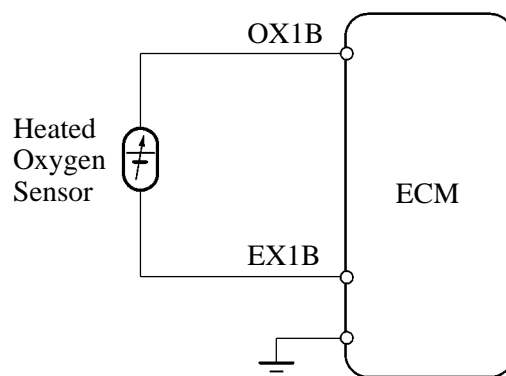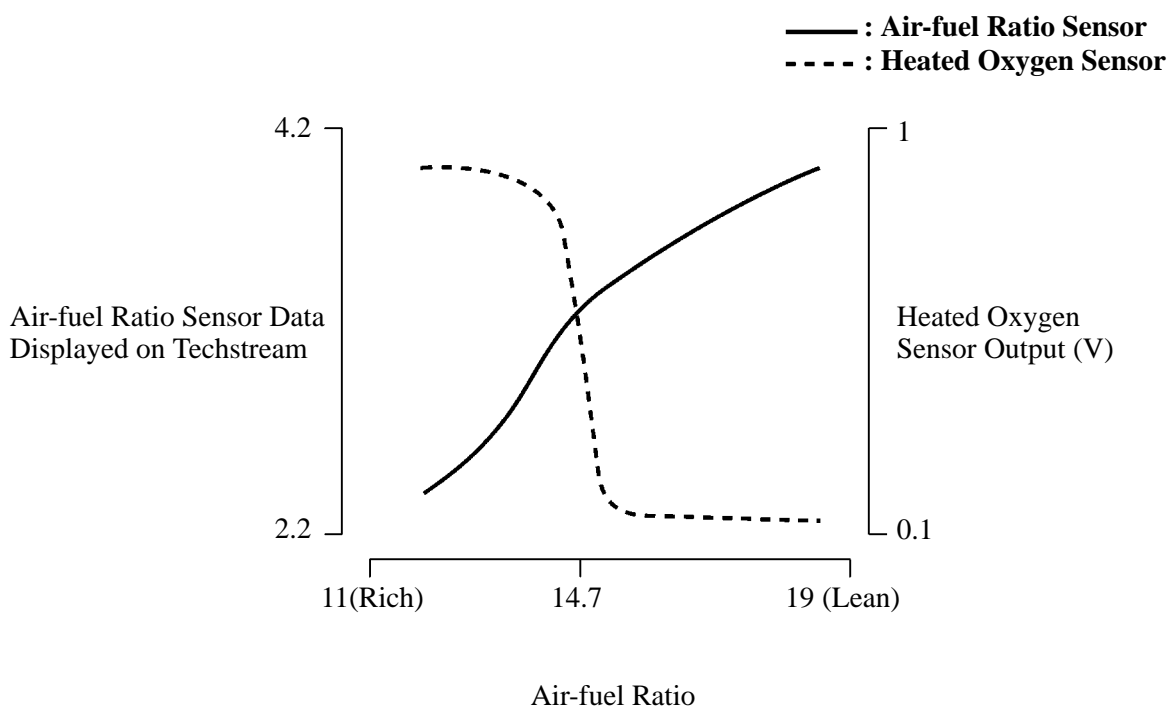
Air-fuel Ratio

D13N11

2) Construction

- The basic construction of the air-fuel ratio sensor and heated oxygen sensor is the same. However, they are divided into the cup type and the planar type, according to the different types of heater construction that are used.
- 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 realizing the excellent warm-up performance of the sensor.
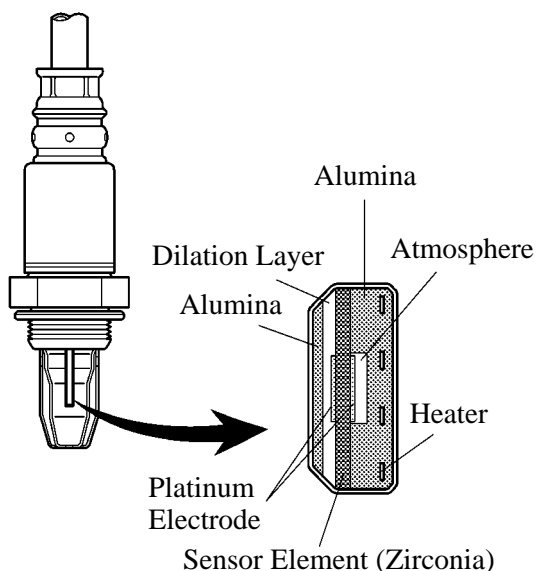
Planar Type Air-fuel Ratio Sensor   **Cup Type Heated Oxygen Sensor**
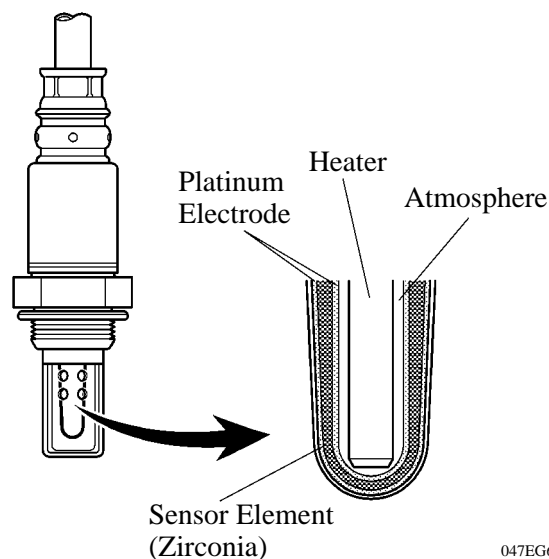
▶ **Warm-up Specification** ◀

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

Mass Air Flow Meter

- This compact and lightweight mass 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.
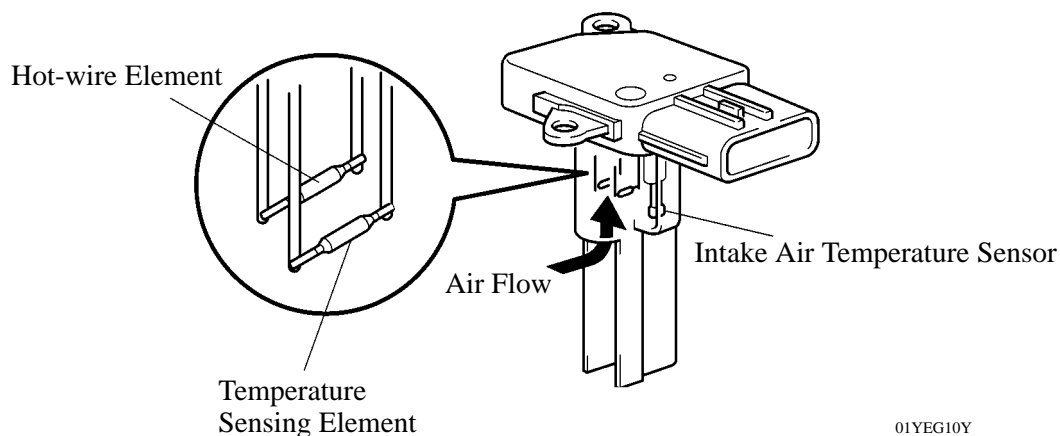
Crankshaft and Camshaft Position Sensors

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.

Crankshaft Position Sensor

Timing Rotor

Intake Camshaft Position Sensor

Exhaust Camshaft Position Sensor

Timing Rotors
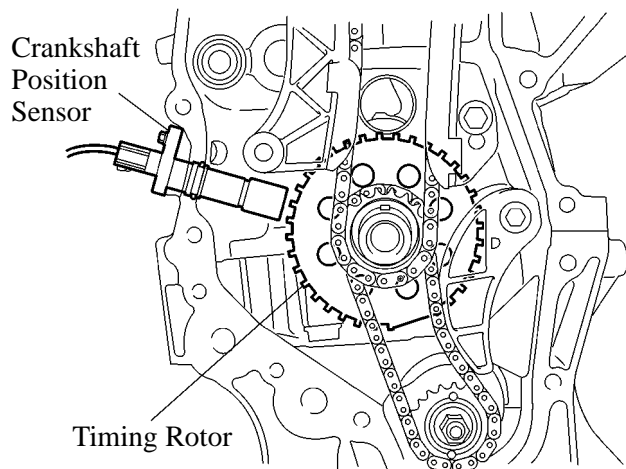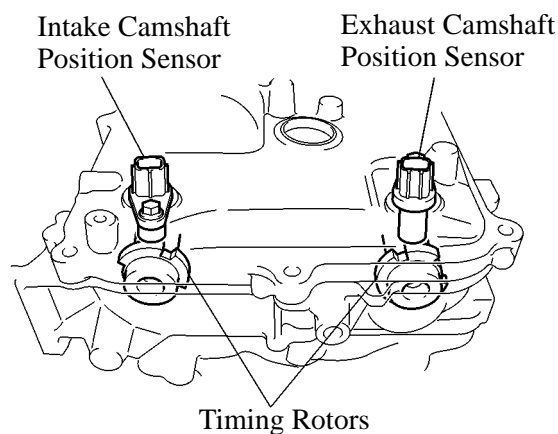
04FEG63Y   04FEG64Y

▶ **Sensor Output Waveforms** ◀

720° CA

180° CA   180° CA   180° CA

5 V

0 V

360° CA   360° CA

0 V

2 Teeth Missing
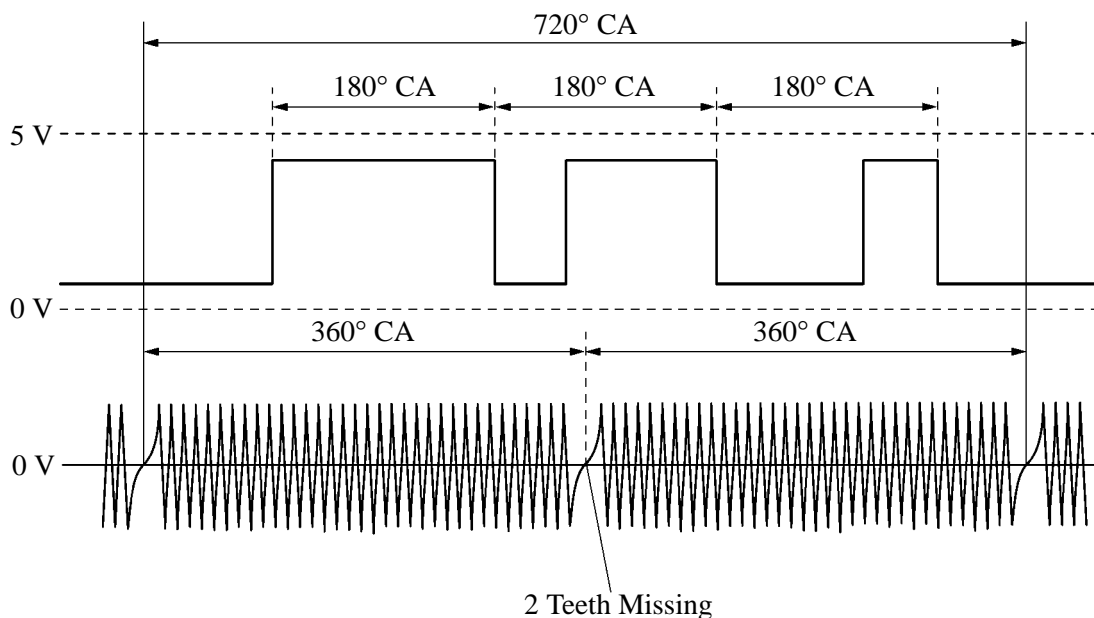
08MEG14Y

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 ECM changes to Hi or Lo. The ECM 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** ◀
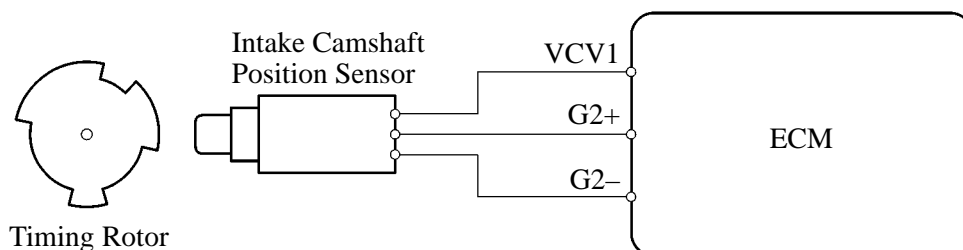
04FEG96Y

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

MRE Type   **Pick-up Coil Type**
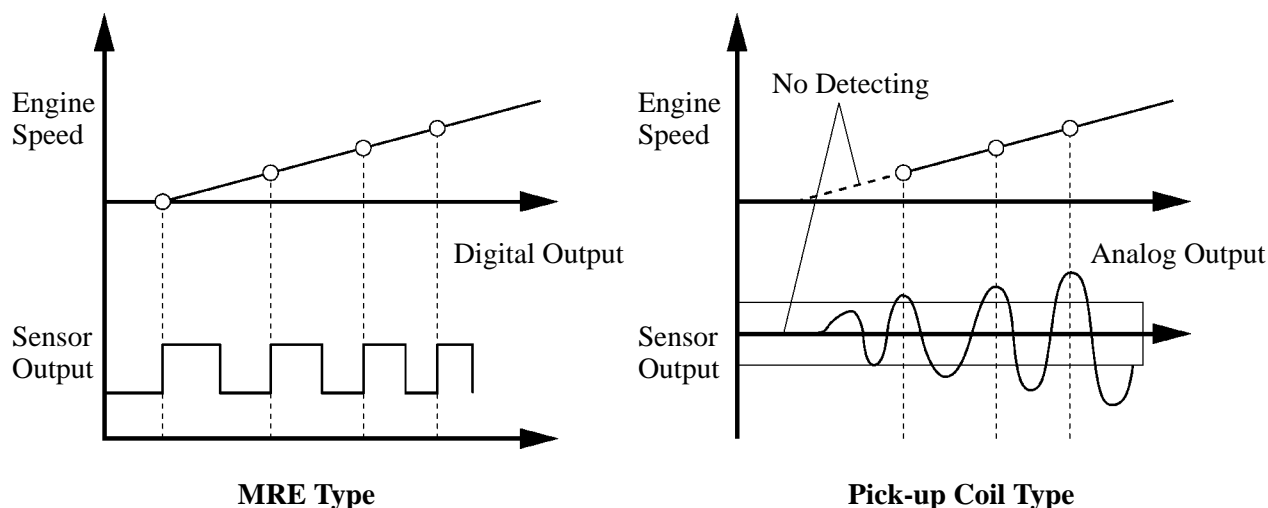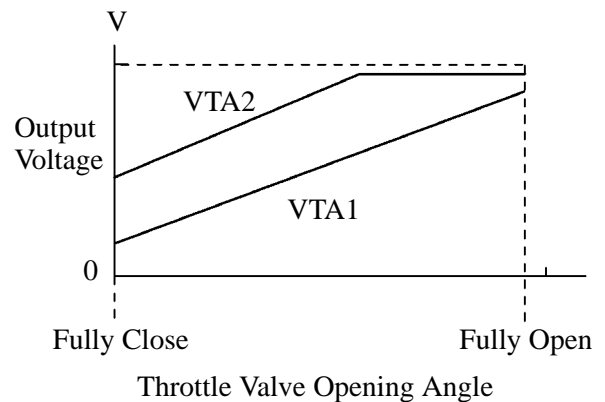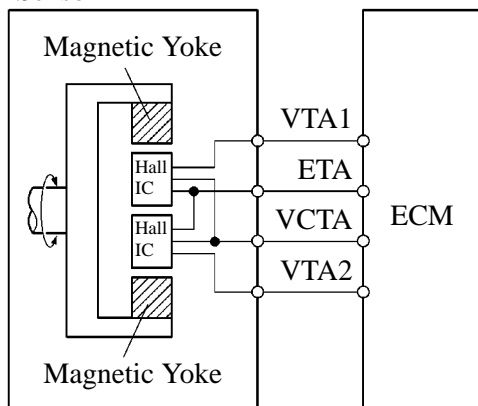
232CH41

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 it as a throttle valve effort to the ECM.

- 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 ECM.

Throttle Body   Throttle Position
                       Sensor Portion

A   **View from A**

Magnetic Yoke

Hall IC

Magnetic Yoke
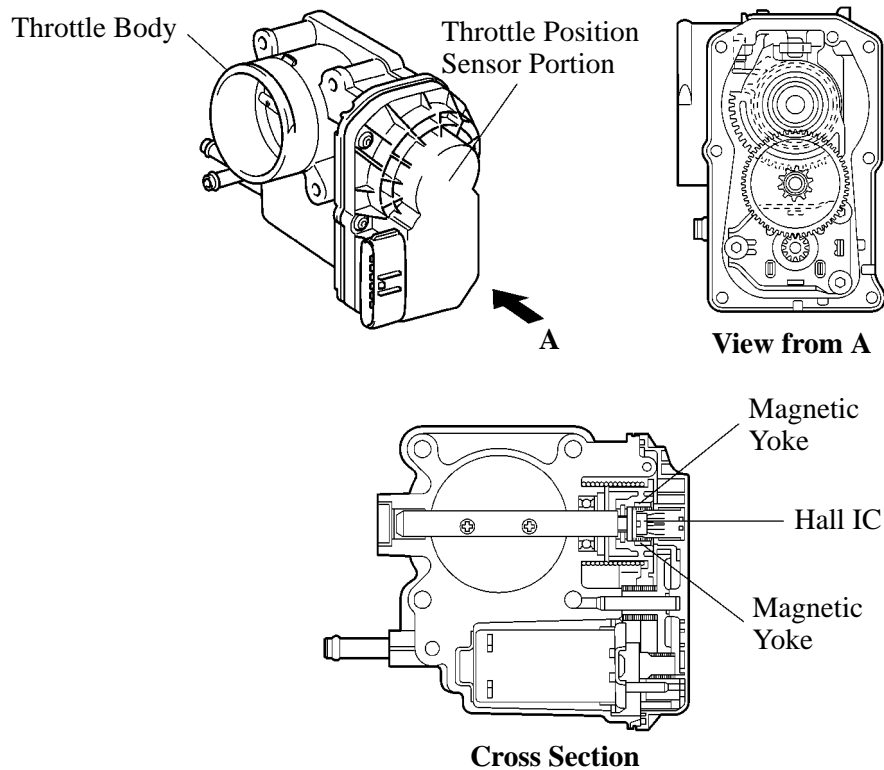
Cross Section   04FEG78Y

Throttle Position
Sensor

Magnetic Yoke

VTA1
ETA
VCTA   ECM
VTA2

Magnetic Yoke

230LX12

Output Voltage

VTA2

VTA1

Fully Close   Fully Open

Throttle Valve Opening Angle

082EG14Y

> **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 2009 Corolla Repair Manual (Pub. No. RM08M0U).

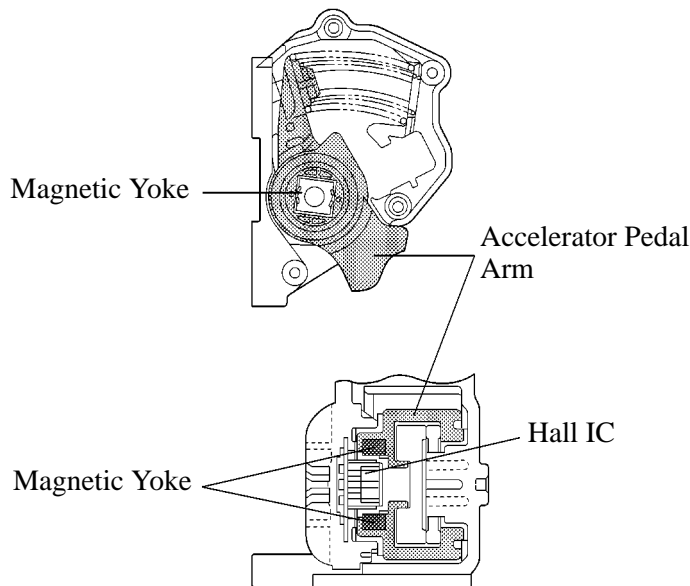## Accelerator Pedal Position Sensor

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 ECM.
- 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 ECM.

▶ **TMC Models** ◀

Internal Construction

Magnetic Yoke

Accelerator Pedal Arm

Magnetic Yoke

Hall IC
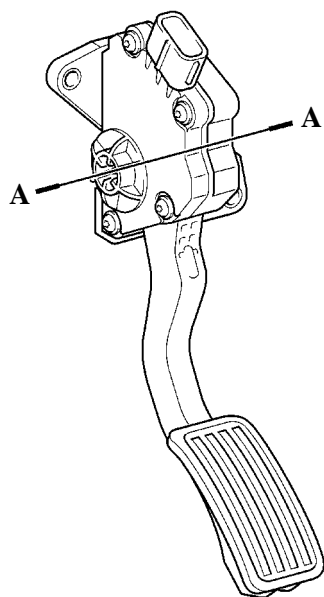
A – A Cross Section

04FEG94Y

Accelerator Pedal Position Sensor

Magnetic Yoke

Hall IC

Hall IC

Magnetic Yoke

VPA
EPA
VCPA
VPA2
EPA2
VCP2

ECM

V

5

Output Voltage

VPA2

VPA

0

Fully Close

Fully Open
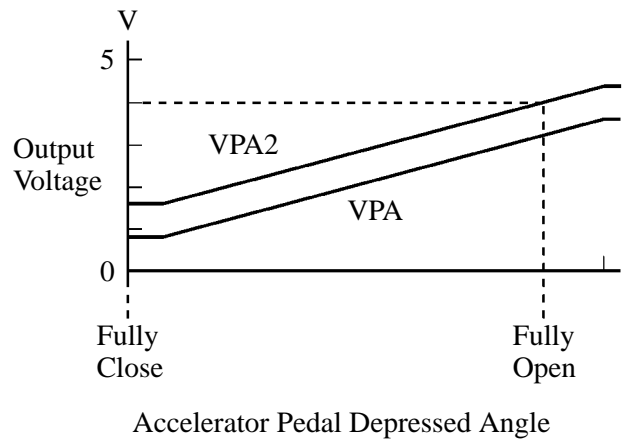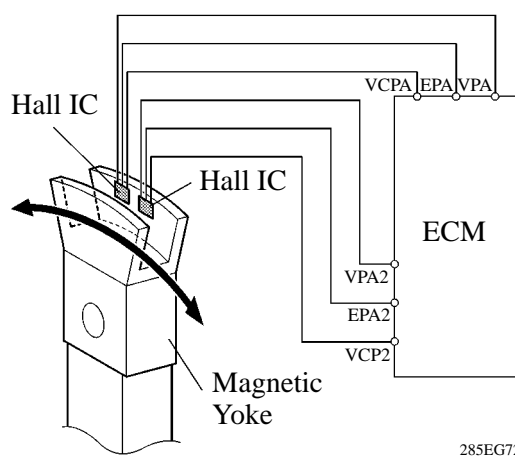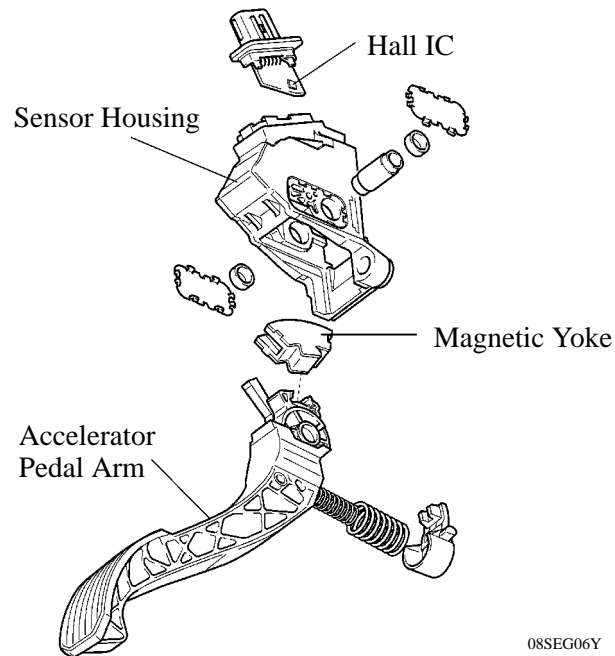
Accelerator Pedal Depressed Angle

228TU24

082EG12Y

> **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 2009 Corolla Repair Manual (Pub. No. RM08M0U).

▶ TMMC & NUMMI Models ◀

Hall IC

Sensor Housing

Magnetic Yoke

Accelerator
Pedal Arm

08SEG06Y

Hall IC

Hall IC

Magnetic
Yoke

VCPA EPA VPA

VPA2

EPA2

VCP2

ECM

285EG72

V

5

Output
Voltage

VPA2

VPA

0

Fully
Close

Fully
Open

Accelerator Pedal Depressed Angle

082EG12Y

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 2009 Corolla Repair Manual (Pub. No. RM08M0U).

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.
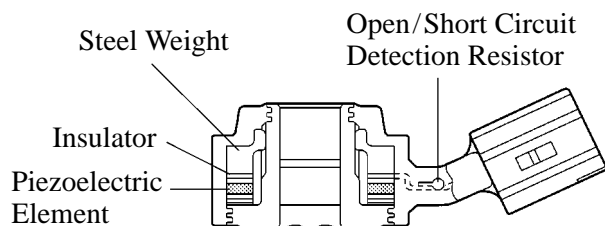
— · — : Conventional Type

———— : Flat Type

A: Detection Band of Conventional Type

B: Detection Band of Flat Type
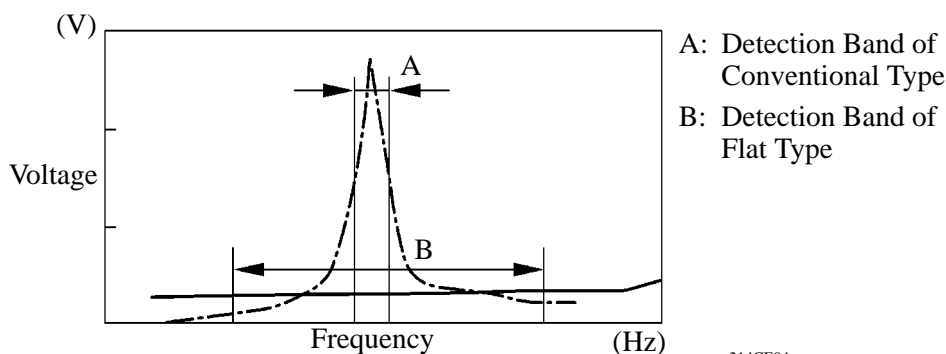
214CE04

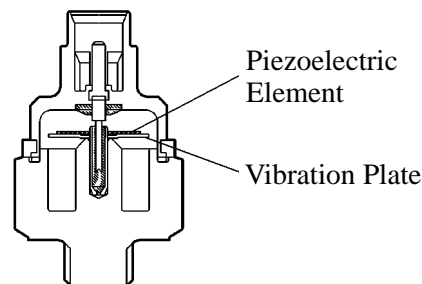**Characteristic of Knock Sensor**

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.

Flat Type Knock Sensor   214CE01
(Non-resonant Type)
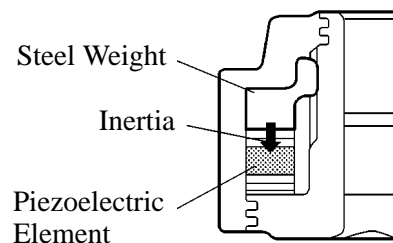
Conventional Type Knock Sensor   214CE02
(Resonant Type)

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.

Steel Weight

Inertia

Piezoelectric Element

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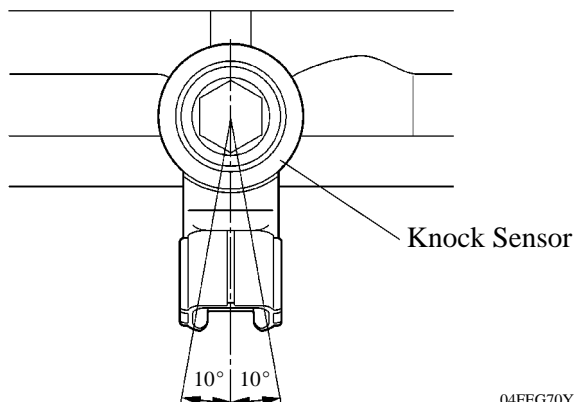An IC (Integrated Circuit) in the ECM is always monitoring the voltage of the terminal KNK1. If the open/short circuit occurs between the knock sensor and the ECM, the voltage of the terminal KNK1 will change and the ECM detects the open/short circuit and stores DTC (Diagnostic Trouble Code).

ECM

Knock Sensor

5 V

150 kΩ

KNK1

200 kΩ

IC

EKNK

Piezoelectric Element

Open/Short Circuit Detection Resistor
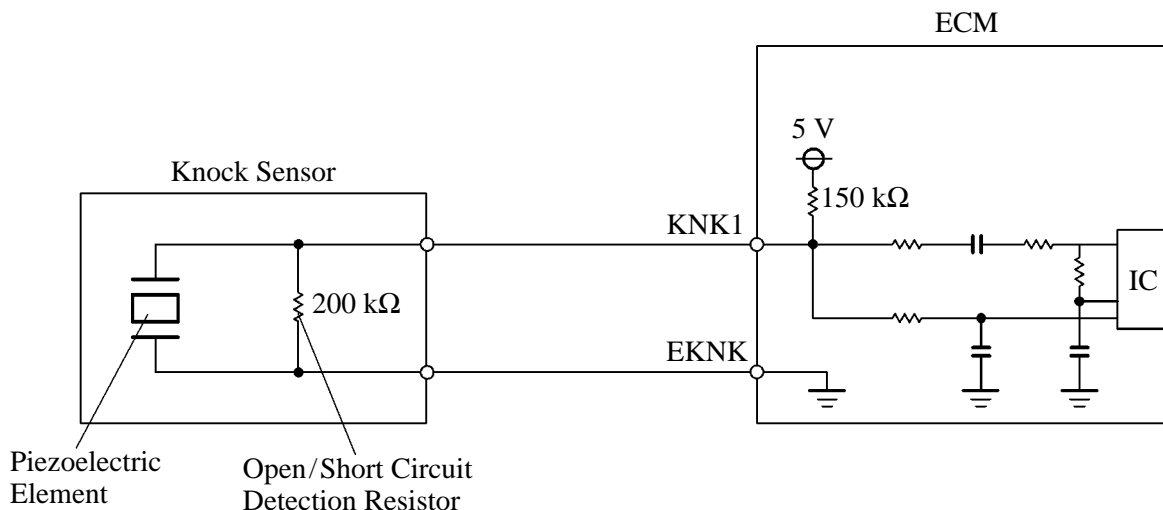
214CE06

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 2009 Corolla Repair Manual (Pub. No. RM08M0U).
- 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.

Knock Sensor

10° | 10°

04FEG70Y