

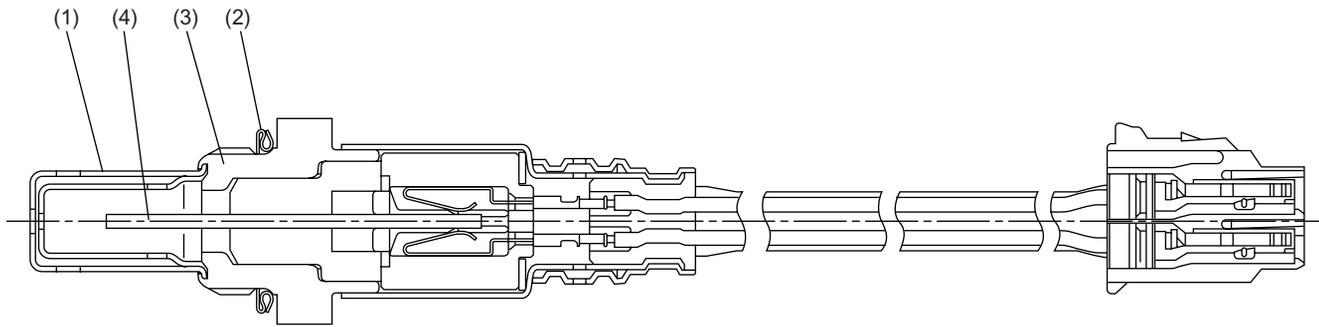
SENSORS AND SWITCHES

FUEL INJECTION (FUEL SYSTEM)

4. Sensors and Switches

A: FRONT OXYGEN (A/F) SENSOR

- The front oxygen sensor uses zirconium oxide (ZrO_2) which is a solid electrolyte, at portions exposed to exhaust gas.
- The zirconium oxide has the property of generating electromotive force when its both sides are exposed to oxygen ions of different concentration and the magnitude of this electromotive force depends on how much the difference is.
The front oxygen (A/F) sensor detects the amount of oxygen in exhaust gases by making use of this property of the zirconium oxide material.
- The zirconium oxide material is formed into a closed end tube and its external surface is exposed to exhaust gases with smaller oxygen ion concentration, whereas its internal surface is exposed to atmospheric air. The external surface has a porous platinum coating. The sensor housing is grounded to the exhaust pipe and the inside is connected to the ECM through the harness to be able to use the current output from the sensor.
- The sensor incorporates a ceramic heater to improve its performance at low temperatures.



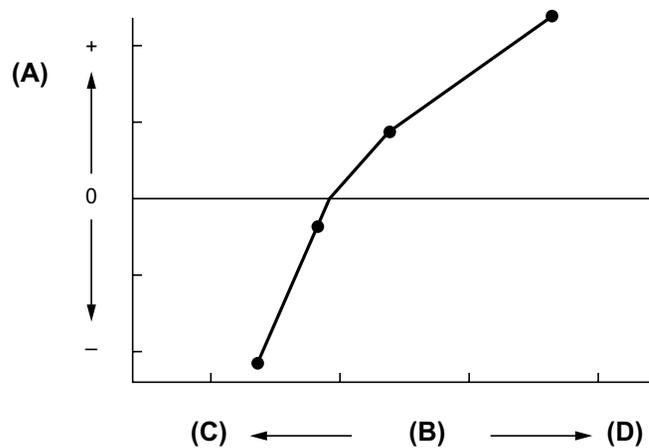
FU-02163

- (1) Protection tube
- (2) Gasket
- (3) Sensor housing
- (4) Ceramic heater

SENSORS AND SWITCHES

FUEL INJECTION (FUEL SYSTEM)

- When rich air-fuel mixture is burnt in the cylinder, the oxygen in the exhaust gases is almost completely used in the catalytic reaction by the platinum coating on the external surface of the zirconia tube. This results in a very large difference in the oxygen ion concentration between the inside and outside of the tube, and the electromotive force generated is large.
- When a lean air-fuel mixture is burnt in the cylinder, relatively large amount of oxygen remains in the exhaust gases even after the catalytic action, and this results in a small difference in the oxygen ion concentration between the tube's internal and external surfaces. The electromotive force in this case is very small.
- The difference in oxygen concentration changes drastically in the vicinity of the stoichiometric air-fuel ratio, and hence the change in the electromotive force is also large. By using this information, the ECM can determine the air-fuel ratio of the supplied mixture easily. The front oxygen (A/F) sensor does not generate much electromotive force when the temperature is low. The output characteristics of the sensor stabilize at a temperature of approximately 700°C (1,292°F).



FU-02015

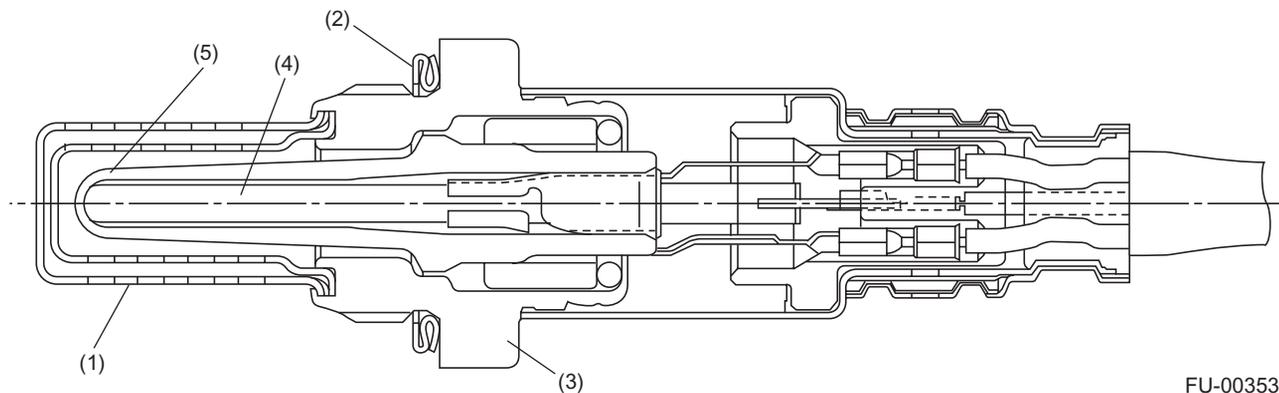
- (A) Current
- (B) Air/fuel ratio
- (C) Rich
- (D) Lean

SENSORS AND SWITCHES

FUEL INJECTION (FUEL SYSTEM)

B: REAR OXYGEN SENSOR

- The rear oxygen sensor is used to sense oxygen concentration in the exhaust gas. If the air-fuel ratio is leaner than the stoichiometric ratio in the mixture (i.e., excessive amount of air), the exhaust gas contains more oxygen. To the contrary, if the fuel ratio is richer than the stoichiometric ratio, the exhaust gas contains almost no oxygen.
- By detecting the oxygen concentration in the exhaust gas using the oxygen sensor makes it possible to determine whether the air-fuel ratio is leaner or richer than the stoichiometric ratio.
- The rear oxygen sensor has a zirconia tube (ceramic) which generates voltage if there is a difference in oxygen ion concentration between the inside and outside of the tube. Platinum is coated on the inside and outside of the zirconia tube as a catalysis and electrode material. The sensor housing is grounded to the exhaust pipe and the inside is connected to the ECM through the harness.
- A ceramic heater is employed to improve performance at low temperatures.



FU-00353

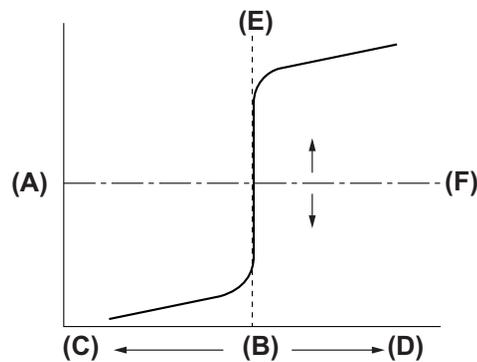
- (1) Protection tube
- (2) Gasket
- (3) Sensor housing

- (4) Ceramic heater
- (5) Zirconia tube

SENSORS AND SWITCHES

FUEL INJECTION (FUEL SYSTEM)

- When rich air-fuel mixture is burnt in the cylinder, the oxygen in the exhaust gases is almost completely used in the catalytic reaction by the platinum coating on the external surface of the zirconia tube. This results in a very large difference in the oxygen ion concentration between the inside and outside of the tube, and the electromotive force generated is large.
- When a lean air-fuel mixture is burnt in the cylinder, relatively large amount of oxygen remains in the exhaust gases even after the catalytic action, and this results in a small difference in the oxygen ion concentration between the tube's internal and external surfaces. The electromotive force in this case is very small.
- The difference in oxygen concentration changes drastically in the vicinity of the stoichiometric air-fuel ratio, and hence the change in the electromotive force is also large. By using this information, the ECM can determine the air-fuel ratio of the supplied mixture easily. The rear oxygen sensor does not generate much electromotive force when the temperature is low. The output characteristics of the sensor stabilize at a temperature of approximately 300 to 400°C (572 to 752°F).



FU-02016

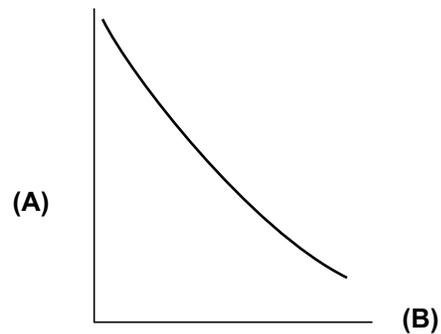
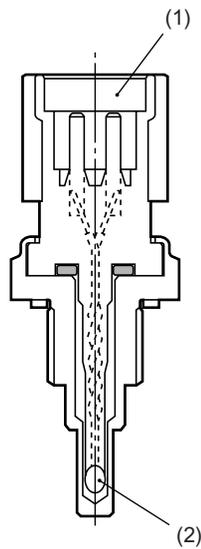
- (A) Electromotive force
- (B) Air/fuel ratio
- (C) Lean
- (D) Rich
- (E) Stoichiometric ratio
- (F) Comparison voltage

SENSORS AND SWITCHES

FUEL INJECTION (FUEL SYSTEM)

C: ENGINE COOLANT TEMPERATURE SENSOR

The engine coolant temperature sensor is located on the engine coolant pipe. The sensor uses a thermistor whose resistance changes inversely with temperature. Resistance signals as engine coolant temperature information are transmitted to the ECM to make fuel injection, ignition timing, purge control solenoid valve and other controls.



FU-02017

- (1) Connector
- (2) Thermistor element

- (A) Resistance (k Ω)
- (B) Temperature °C (°F)

D: EXHAUST GAS TEMPERATURE SENSOR

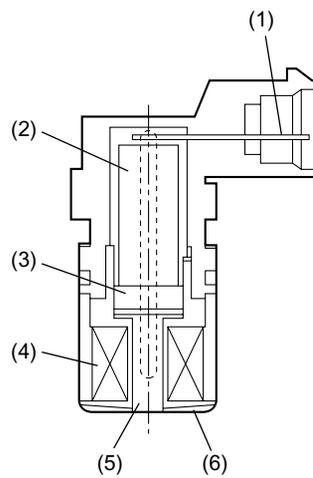
The exhaust gas temperature sensor is located on the joint pipe and used to monitor the condition of the pre-catalytic converter.

SENSORS AND SWITCHES

FUEL INJECTION (FUEL SYSTEM)

E: CRANKSHAFT POSITION SENSOR

- The crankshaft position sensor is installed on the oil pump which is located in the front center portion of the cylinder block. The sensor generates a pulse when one of the teeth on the perimeter of the crankshaft sprocket (rotating together with the crankshaft) passes in front of it. The ECM determines the crankshaft angular position by counting the number of pulses.
- The crankshaft position sensor is a magnet pickup type and is molded with components such as a magnet, core, coil, and terminal, etc.



FU-00234

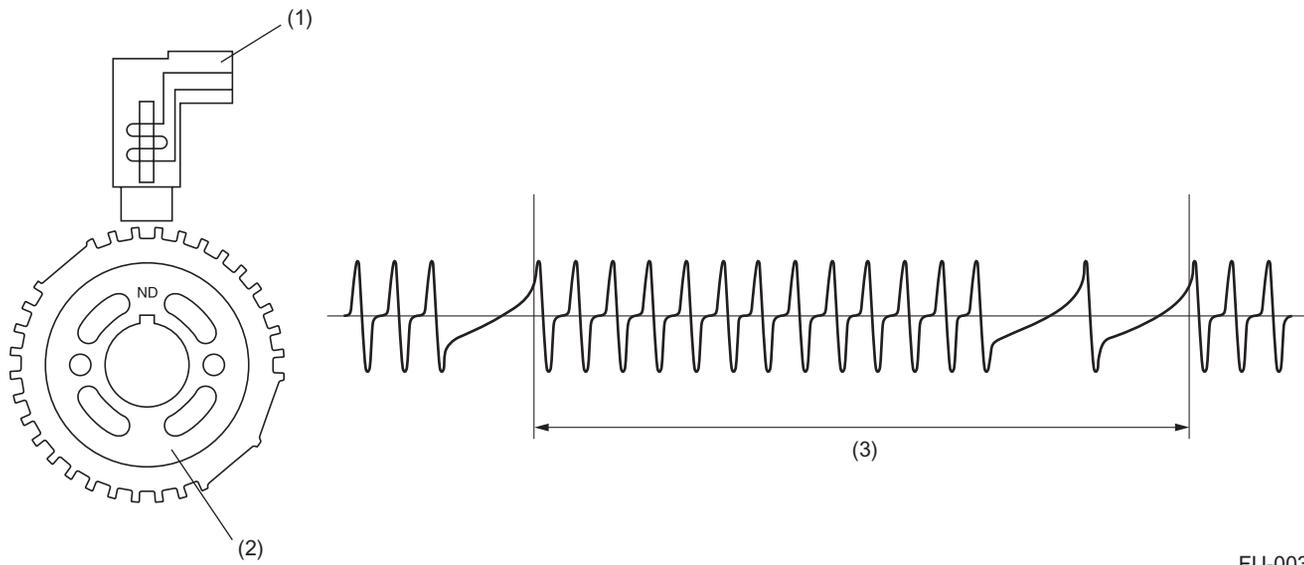
- (1) Terminal
- (2) Yoke core
- (3) Magnet

- (4) Coil
- (5) Core
- (6) Cover

SENSORS AND SWITCHES

FUEL INJECTION (FUEL SYSTEM)

- As the crankshaft rotates, each tooth aligns with the crankshaft position sensor. At that time, the magnetic flux in the sensor's coil changes since the air gap between the sensor pickup and the sprocket changes. This change in magnetic flux induces a voltage pulse in the sensor and the pulse is transmitted to the ECM.



FU-00354

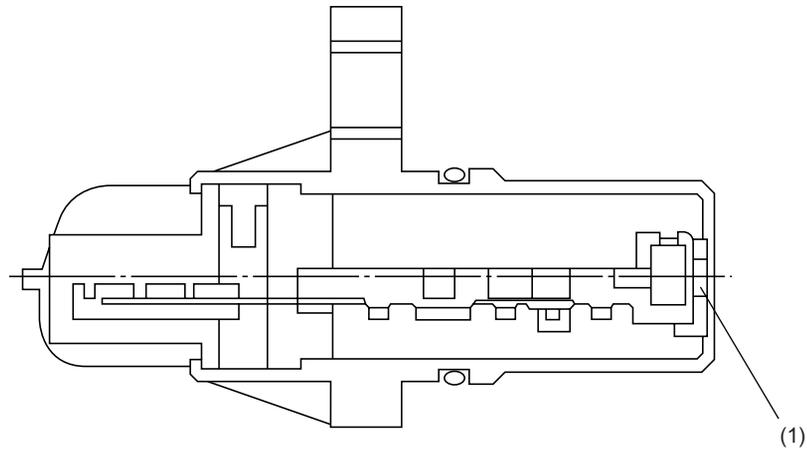
- (1) Crankshaft position sensor
- (2) Crankshaft sprocket
- (3) Crankshaft half rotation

SENSORS AND SWITCHES

FUEL INJECTION (FUEL SYSTEM)

F: CAMSHAFT POSITION SENSOR

- The camshaft position sensor is located on the cylinder head.
- A hall element is used in this sensor and its construction is as shown below.



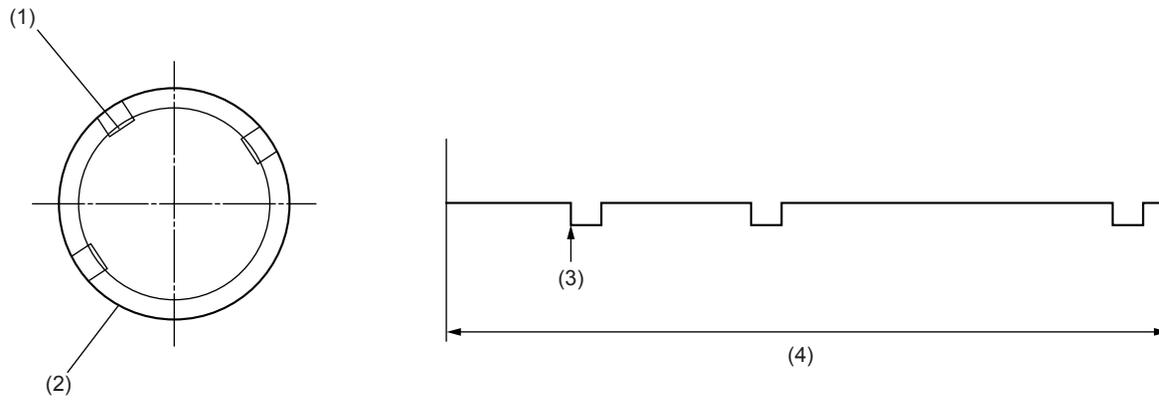
FU-02029

(1) Hall element

SENSORS AND SWITCHES

FUEL INJECTION (FUEL SYSTEM)

- The sensor generates a pulse when one of the slots in the camshaft passes in front of the sensor. The ECM detects the camshaft position by measuring the pulse. Three slots are provided on the camshaft as shown below.



FU-01151

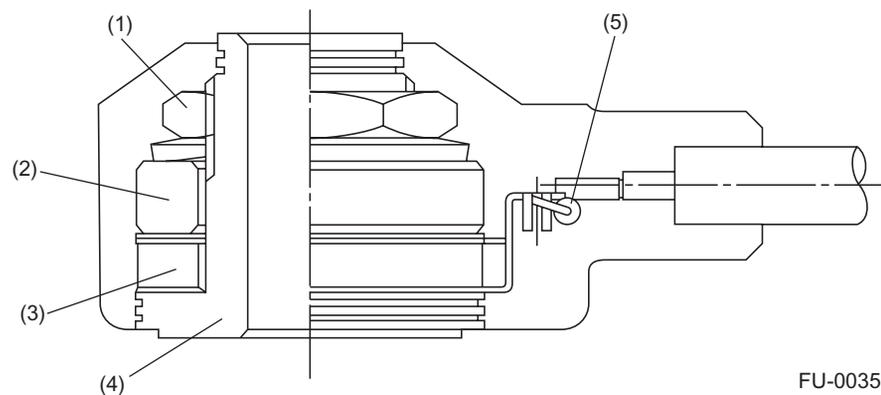
- (1) Slot
- (2) Camshaft
- (3) Detection point
- (4) Camshaft one rotation (crankshaft two rotations)

SENSORS AND SWITCHES

FUEL INJECTION (FUEL SYSTEM)

G: KNOCK SENSOR

- The knock sensor is installed on the cylinder block, and senses knocking that occurs in the engine.
- The sensor is a piezo-electric type which converts vibration resulting from knocking into electric signals.
- In addition to a piezo-electric element, the sensor has a weight and case as its components. If knocking occurs in the engine, the weight in the case moves causing the piezo-electric element to generate a voltage.
- The knock sensor harness is connected to the engine harness.



- (1) Nut
- (2) Weight
- (3) Piezo-electric element
- (4) Housing
- (5) Resistance

H: VEHICLE SPEED SENSOR

Vehicle speed signals are sent from the vehicle speed sensor to the ABS and VDC control modules. The signals are sent to the ECM via CAN communication. For details, refer to the LAN section. <Ref. to LAN section.>