ENGINE CONTROL SYSTEM

1. General

The engine control system of the 2UR-GSE engine has the following features.

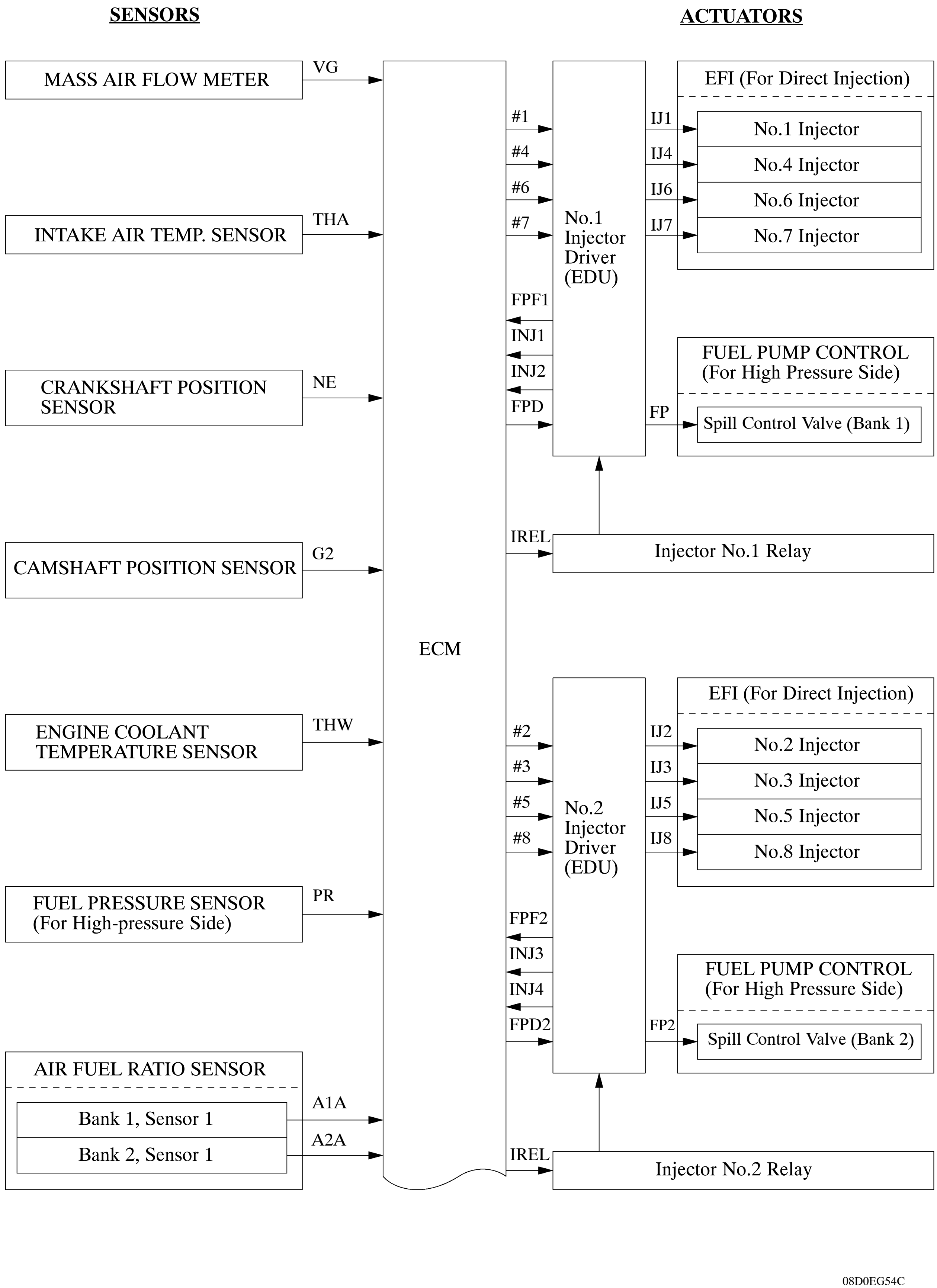
System		Outline
D-4S EFI (Electronic Fuel Injection) [See page EG-85]		• A D-4S EFI system directly detects the intake air mass with a hot-wire type mass air flow meters. • The D-4S (Direct injection 4-stroke gasoline engine Superior version) system is a fuel injection system which combines fuel injector assemblies (for direct injection) and fuel injector assemblies (for port injection). • Based on signals from various sensors, the ECM controls the injection volume and timing of each type of fuel injector (direct and port injection types) according to the engine speed and the engine load in order to optimize combustion conditions.
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. • This system selects the optimal ignition timing in accordance with the signals received from the sensors and sends the ignition signals (IGT) to the igniters.
ETCS-i (Electronic Throttle Control System-intelligent) [See page EG-88]		Optimally controls the throttle valve opening in accordance with the amount of accelerator pedal effort and the conditions of the engine and the vehicle.
Dual VVT-i (Variable Valve Timing-intelligent) [See page EG-91]		• Controls the intake and exhaust camshafts to an optimal valve timing in accordance with the engine conditions. • VVT-iE is used for the intake camshafts. VVT-iE uses electric motors to control the valve timing. VVT-i is used for the exhaust camshafts, engine oil pressure is used to control the valve timing.
Air Intake Control System [See page EG-104]		The ECM selects between using one, or using both intake air ducts, in order to choose the option that provides the most appropriate balance of noise reduction and airflow for the engine operating conditions.
Fuel Pump Control	For High-pressure Side	Regulates the fuel pressure within a range of 4 to 13 MPa in accordance with the driving conditions.
	For Low-pressure Side [See page EG-106]	• Fuel pump operation is controlled by signals from the ECM. • The fuel pump is stopped, when the SRS airbags deploy in a frontal, side, or rear side collision.
Air Fuel Ratio Sensor and Heated Oxygen Sensor Heater Control		Maintains the temperature of the air fuel ratio sensors and heated oxygen sensors at an appropriate level to increase accuracy of detection of the oxygen concentration in the exhaust gas.
Air Conditioning Cut-off Control		By turning the air conditioning compressor on or off in accordance with the engine operating conditions, drivability is maintained.
Cooling Fan Control [See page EG-107]		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-109]		Once the engine switch is pushed, while the brake pedal is depressed, this control continues to operate the starter until the engine starts.

(Continued)

System	Outline
Evaporative Emission Control	The ECM controls the purge flow of evaporative emission (HC) in the canister in accordance with the engine conditions.
Engine Immobilizer	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid key.
Diagnosis [See page EG-111]	When the ECM detects a malfunction, the ECM memorizes information related to the fault.
Fail-safe [See page EG-111]	When the ECM detects a malfunction, the ECM stops or controls the engine according to data already stored in memory.

2. Construction

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



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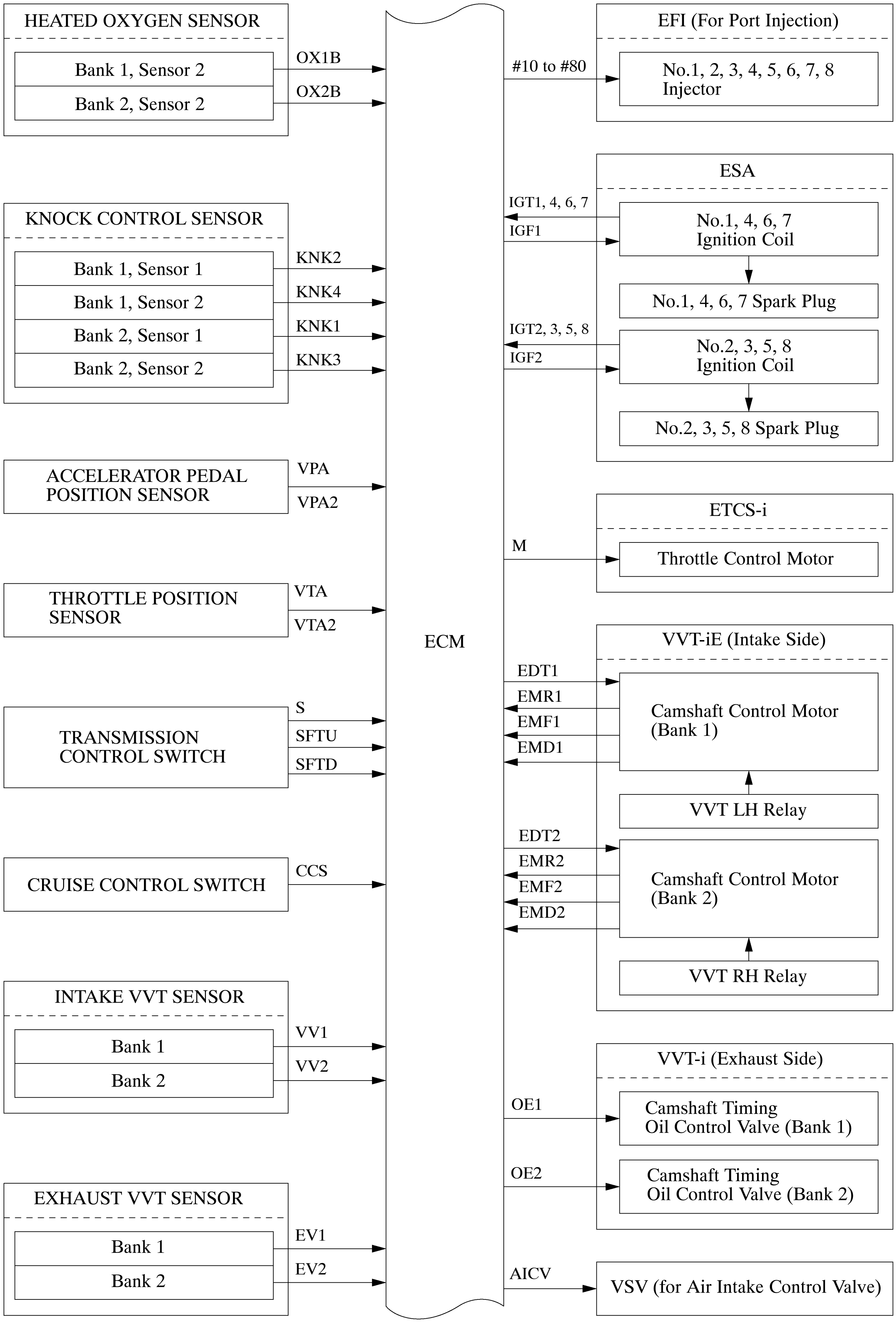
EG


HEATED OXYGEN SENSOR
Bank 1, Sensor 2
Bank 2, Sensor 2
OX1B
OX2B
KNOCK CONTROL SENSOR
Bank 1, Sensor 1
Bank 1, Sensor 2
Bank 2, Sensor 1
Bank 2, Sensor 2
KNK2
KNK4
KNK1
KNK3
ACCELERATOR PEDAL POSITION SENSOR
VPA
VPA2
THROTTLE POSITION SENSOR
VTA
VTA2
TRANSMISSION CONTROL SWITCH
S
SFTU
SFTD
CRUISE CONTROL SWITCH
CCS
INTAKE VVT SENSOR
Bank 1
Bank 2
VV1
VV2
EXHAUST VVT SENSOR
Bank 1
Bank 2
EV1
EV2
ECM
EFI (For Port Injection)
#10 to #80
No.1, 2, 3, 4, 5, 6, 7, 8 Injector
ESA
IGT1, 4, 6, 7
IGF1
No.1, 4, 6, 7 Ignition Coil
No.1, 4, 6, 7 Spark Plug
IGT2, 3, 5, 8
IGF2
No.2, 3, 5, 8 Ignition Coil
No.2, 3, 5, 8 Spark Plug
ETCS-i
M
Throttle Control Motor
VVT-iE (Intake Side)
EDT1
EMR1
EMF1
EMD1
Camshaft Control Motor (Bank 1)
VVT LH Relay
EDT2
EMR2
EMF2
EMD2
Camshaft Control Motor (Bank 2)
VVT RH Relay
VVT-i (Exhaust Side)
OE1
Camshaft Timing Oil Control Valve (Bank 1)
OE2
Camshaft Timing Oil Control Valve (Bank 2)
AICV
VSV (for Air Intake Control Valve)
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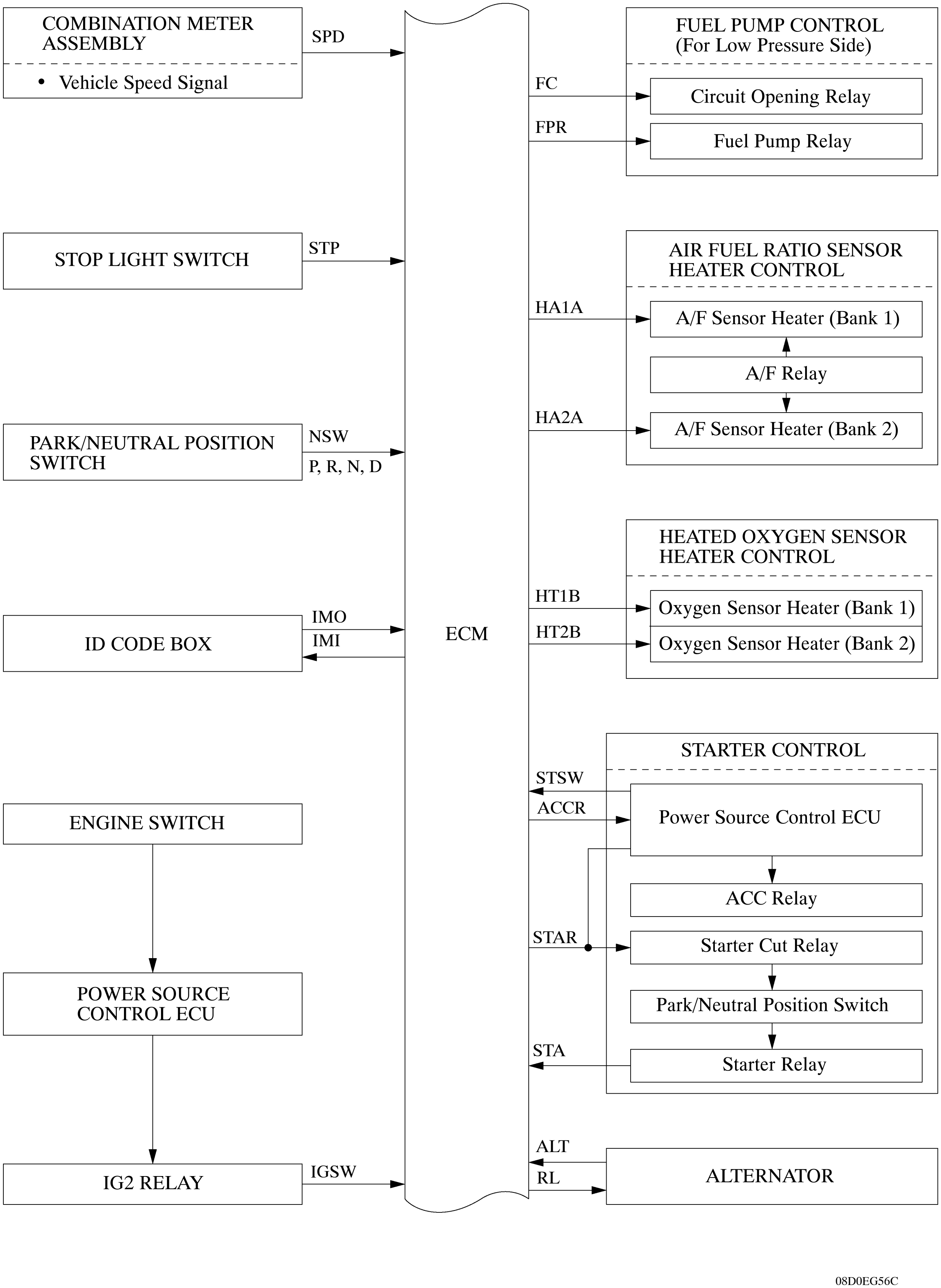
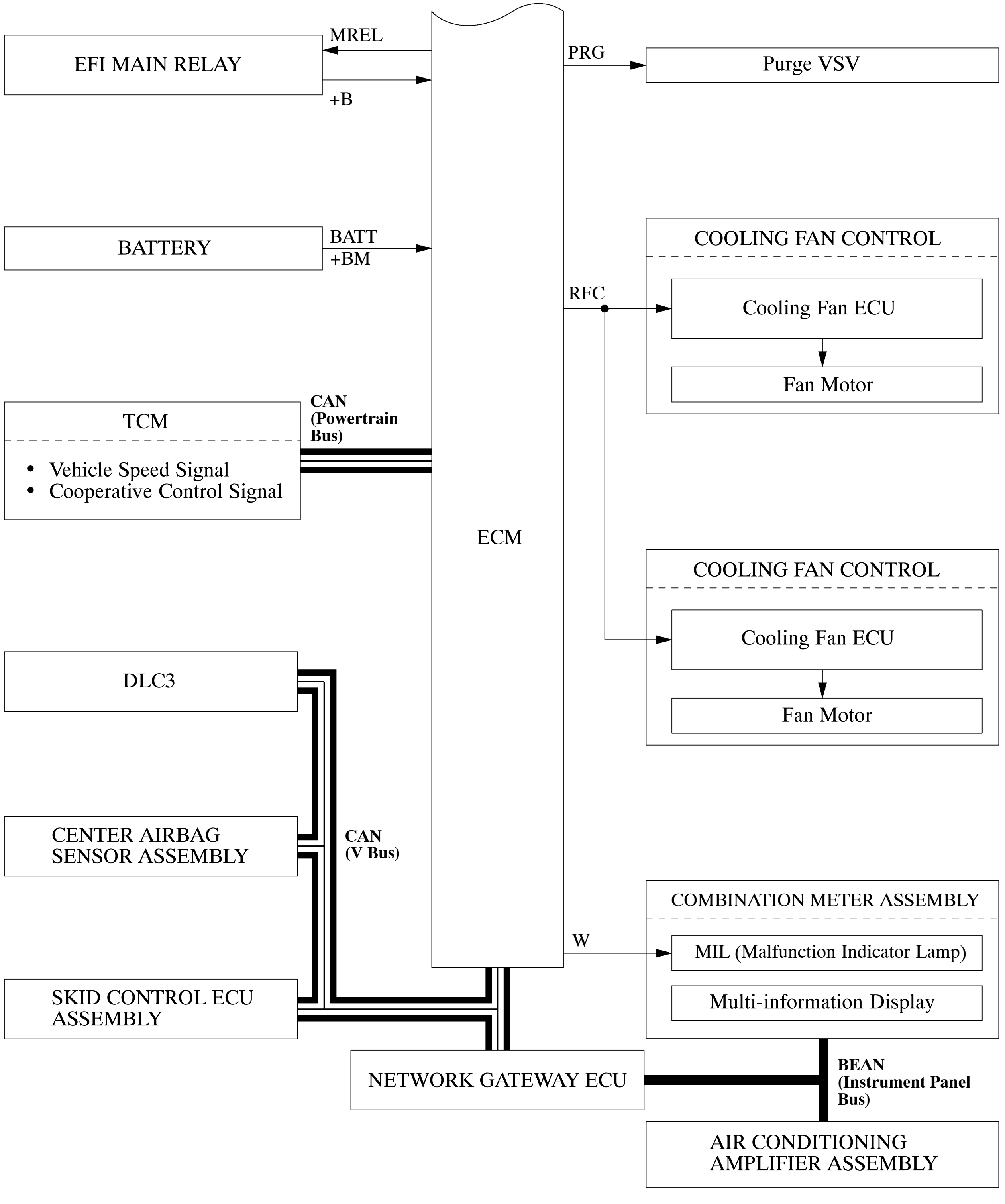
(Continued)


COMBINATION METER ASSEMBLY
• Vehicle Speed Signal
SPD
STOP LIGHT SWITCH
STP
PARK/NEUTRAL POSITION SWITCH
NSW
P, R, N, D
ID CODE BOX
IMO
IMI
ENGINE SWITCH
POWER SOURCE CONTROL ECU
IG2 RELAY
IGSW
ECM
FUEL PUMP CONTROL (For Low Pressure Side)
FC
Circuit Opening Relay
FPR
Fuel Pump Relay
AIR FUEL RATIO SENSOR HEATER CONTROL
HA1A
A/F Sensor Heater (Bank 1)
A/F Relay
HA2A
A/F Sensor Heater (Bank 2)
HEATED OXYGEN SENSOR HEATER CONTROL
HT1B
Oxygen Sensor Heater (Bank 1)
HT2B
Oxygen Sensor Heater (Bank 2)
STARTER CONTROL
STSW
ACCR
Power Source Control ECU
ACC Relay
STAR
Starter Cut Relay
Park/Neutral Position Switch
STA
Starter Relay
ALT
RL
ALTERNATOR
08D0EG56C

(Continued)


EFI MAIN RELAY
MREL
+B
BATTERY
BATT
+BM
TCM
• Vehicle Speed Signal
• Cooperative Control Signal
CAN
(Powertrain
Bus)
DLC3
CENTER AIRBAG
SENSOR ASSEMBLY
CAN
(V Bus)
SKID CONTROL ECU
ASSEMBLY
ECM
NETWORK GATEWAY ECU
PRG
Purge VSV
COOLING FAN CONTROL
RFC
Cooling Fan ECU
Fan Motor
COOLING FAN CONTROL
Cooling Fan ECU
Fan Motor
COMBINATION METER ASSEMBLY
W
MIL (Malfunction Indicator Lamp)
Multi-information Display
BEAN
(Instrument Panel
Bus)
AIR CONDITIONING
AMPLIFIER ASSEMBLY

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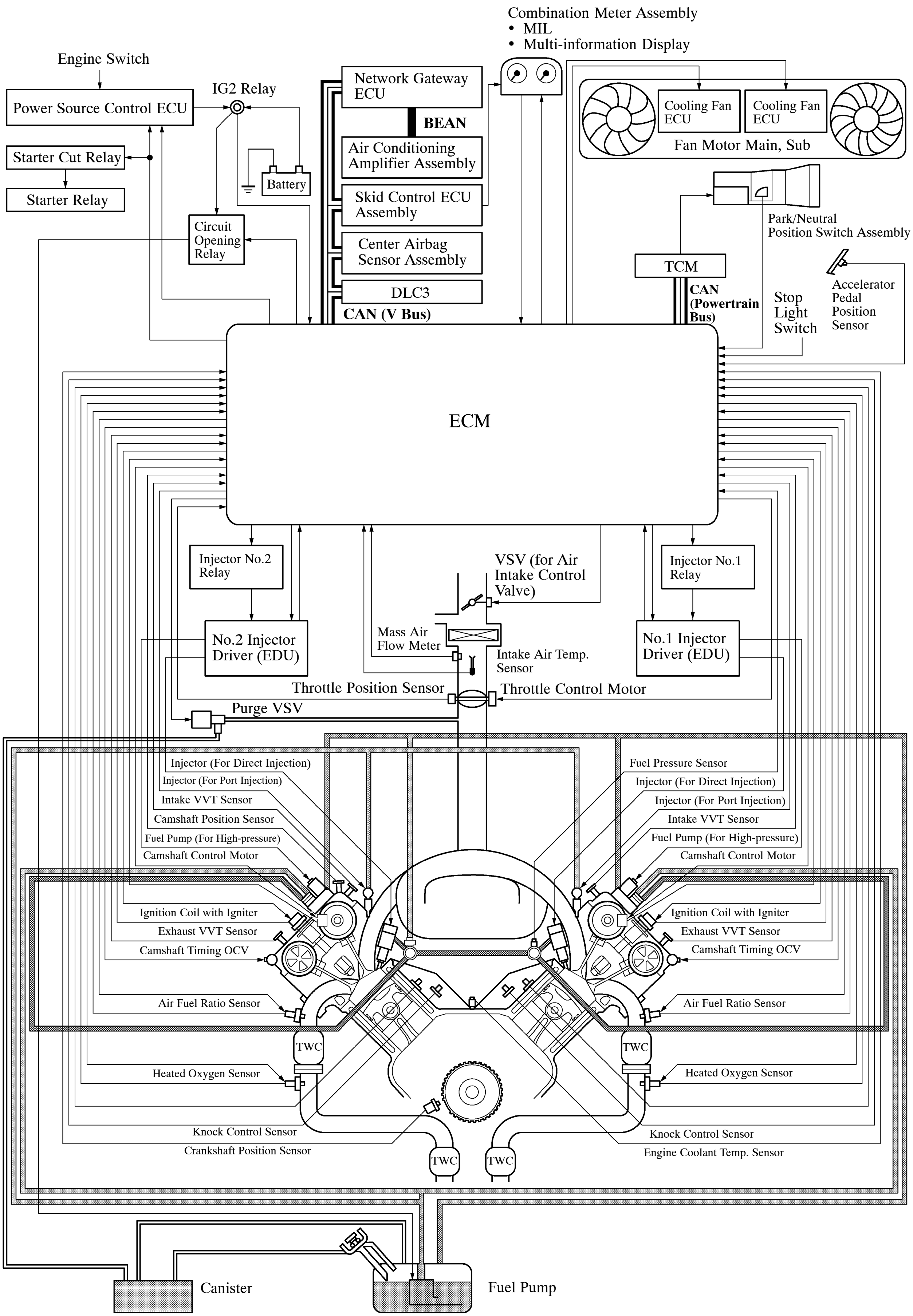
3. Engine Control System Diagram



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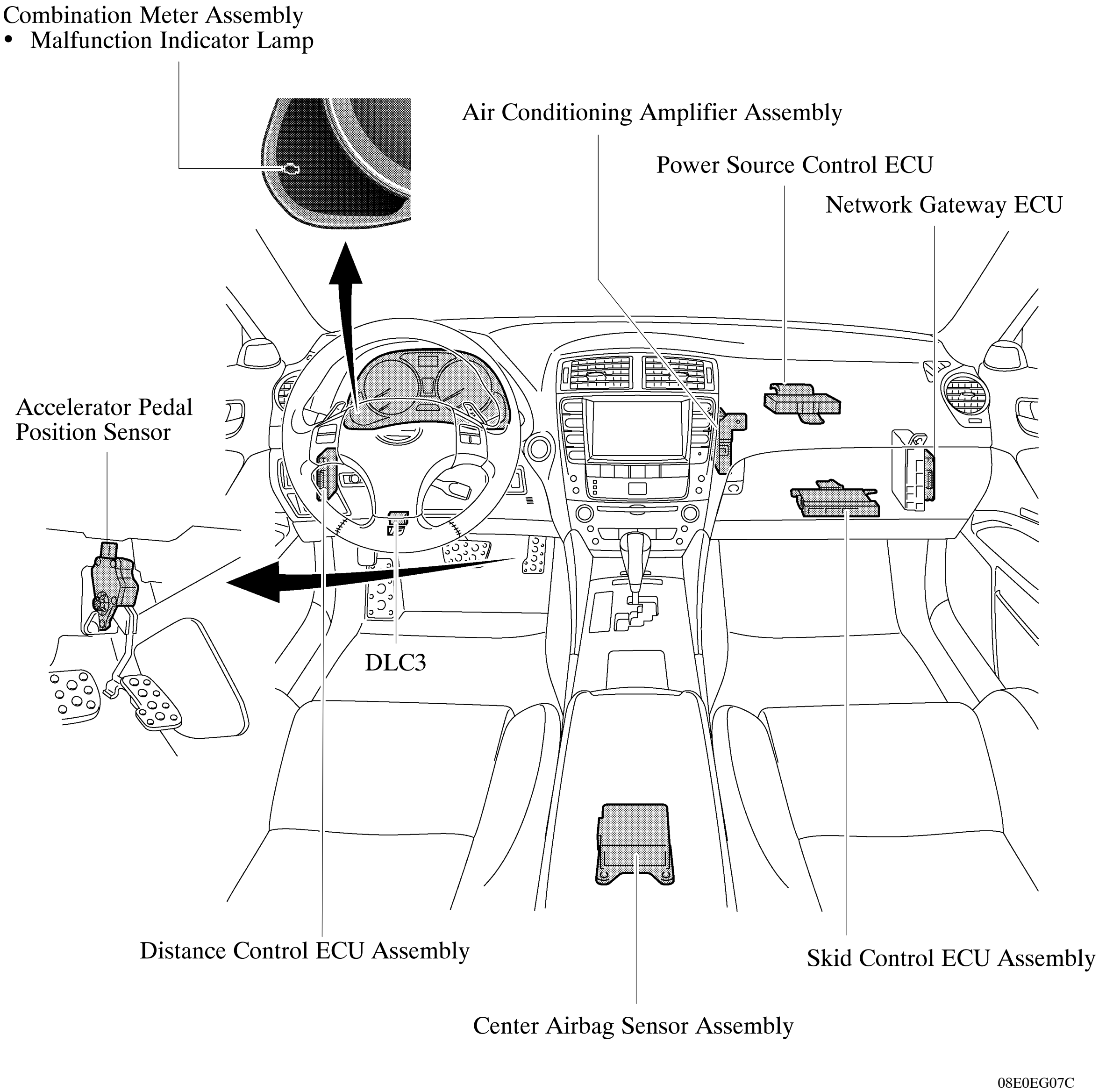
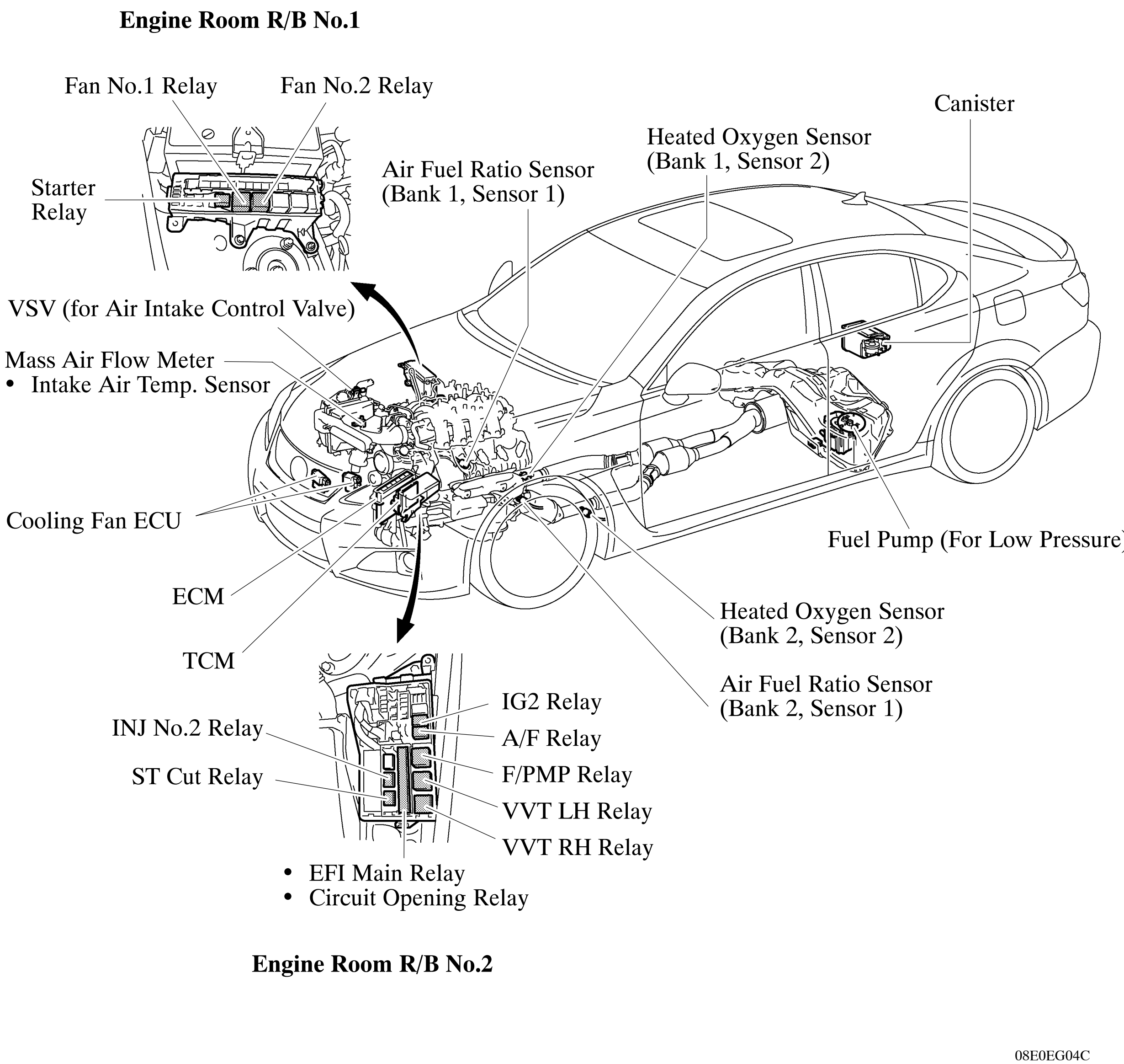
4. Layout of Main Components




Engine Room R/B No.1
Fan No.1 Relay
Fan No.2 Relay
Starter Relay
Canister
Heated Oxygen Sensor (Bank 1, Sensor 2)
Air Fuel Ratio Sensor (Bank 1, Sensor 1)
VSV (for Air Intake Control Valve)
Mass Air Flow Meter
• Intake Air Temp. Sensor
Cooling Fan ECU
Fuel Pump (For Low Pressure)
ECM
Heated Oxygen Sensor (Bank 2, Sensor 2)
TCM
Air Fuel Ratio Sensor (Bank 2, Sensor 1)
IG2 Relay
INJ No.2 Relay
A/F Relay
ST Cut Relay
F/PMP Relay
VVT LH Relay
VVT RH Relay
• EFI Main Relay
• Circuit Opening Relay
Engine Room R/B No.2
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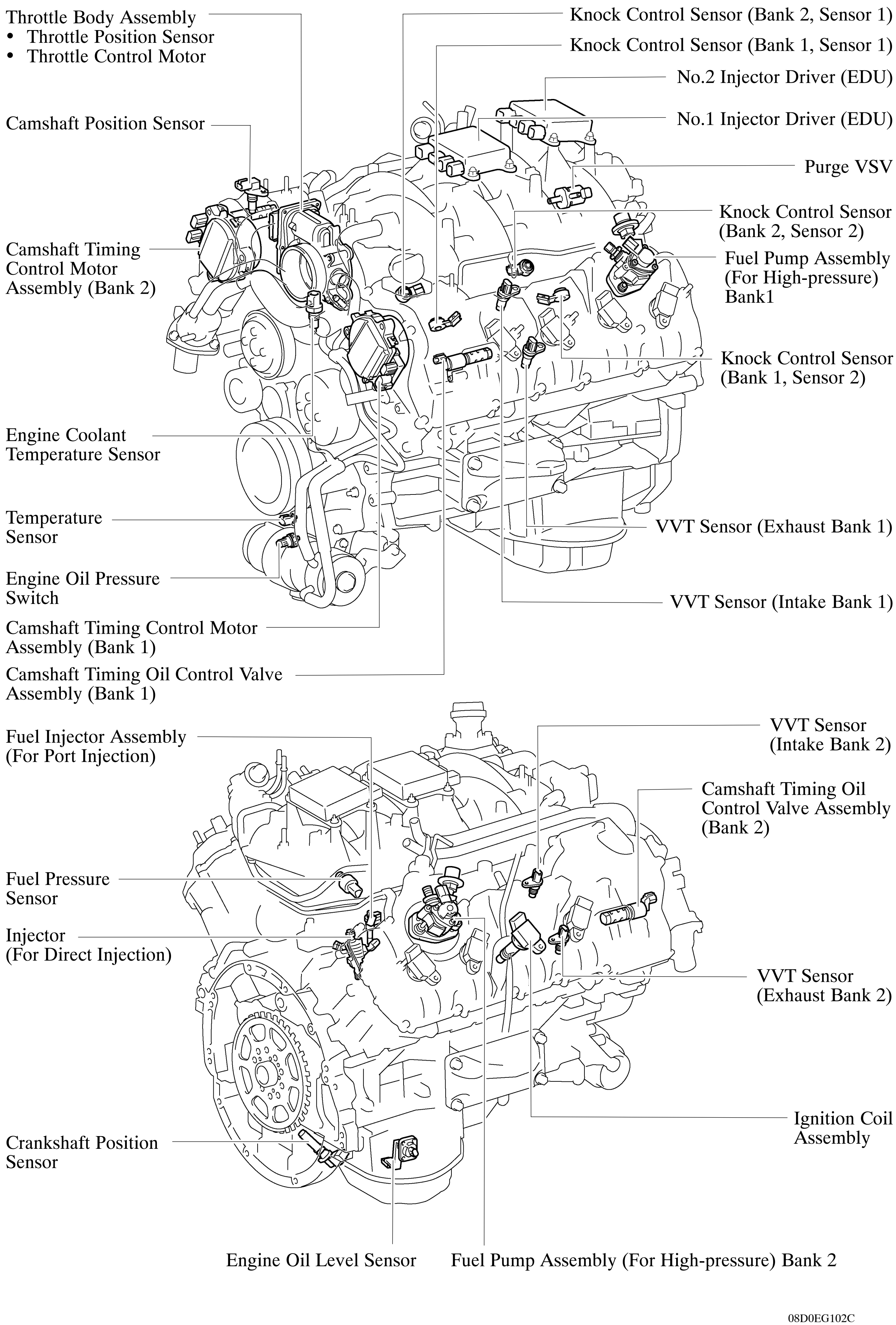
Throttle Body Assembly
• Throttle Position Sensor
• Throttle Control Motor
Camshaft Position Sensor
Camshaft Timing Control Motor Assembly (Bank 2)
Engine Coolant Temperature Sensor
Temperature Sensor
Engine Oil Pressure Switch
Camshaft Timing Control Motor Assembly (Bank 1)
Camshaft Timing Oil Control Valve Assembly (Bank 1)
Knock Control Sensor (Bank 2, Sensor 1)
Knock Control Sensor (Bank 1, Sensor 1)
No.2 Injector Driver (EDU)
No.1 Injector Driver (EDU)
Purge VSV
Knock Control Sensor (Bank 2, Sensor 2)
Fuel Pump Assembly (For High-pressure) Bank1
Knock Control Sensor (Bank 1, Sensor 2)
VVT Sensor (Exhaust Bank 1)
VVT Sensor (Intake Bank 1)
Fuel Injector Assembly (For Port Injection)
Fuel Pressure Sensor
Injector (For Direct Injection)
Crankshaft Position Sensor
VVT Sensor (Intake Bank 2)
Camshaft Timing Oil Control Valve Assembly (Bank 2)
VVT Sensor (Exhaust Bank 2)
Ignition Coil Assembly
Engine Oil Level Sensor
Fuel Pump Assembly (For High-pressure) Bank 2
08D0EG102C

5. Main Components of Engine Control System

General

The main components of the 2UR-GSE engine control system are as follows:

Components	Outline	Quantity	Function
ECM	32-bit CPU	1	The ECM optimally controls the EFI, ESA and ISC to suit the operating conditions of the engine in accordance with the signals provided by the sensors.
Mass Air Flow Meter [See page EG-75]	Hot-wire Type	1	This sensor has a built-in hot-wire to directly detect the intake air mass.
Intake Air Temperature Sensor [See page EG-75]	Thermistor Type	1	This sensor detects the intake air temperature by means of an internal thermistor (built into the mass airflow meter).
Crankshaft Position Sensor [See page EG-76]	MRE Type (Rotor Teeth/36-2)	1	This sensor detects the engine speed and the crankshaft position.
Camshaft Position Sensor [See page EG-76]	MRE Type (Rotor Teeth/3)	1	This sensor detects the camshaft position and is used for cylinder identification.
VVT Sensor (Intake) [See page EG-76]	MRE Type (Rotor Teeth/3)	1 each bank	This sensor detects the actual valve timing.
VVT Sensor (Exhaust) [See page EG-76]	MRE Type (Rotor Teeth/3)	1 each bank	This sensor detects the actual valve timing.
Accelerator Pedal Position Sensor [See page EG-79]	Hall IC Type (No-contact Type)	1	This sensor detects the amount the accelerator pedal is depressed.
Throttle Position Sensor [See page EG-80]	Hall IC Type (Non-contact Type)	1	This sensor detects the throttle valve opening angle.
Knock Control Sensor [See page EG-81]	Built-in Piezoelectric Element (Flat Type)	2 each bank	This sensor detects an occurrence of the engine knocking indirectly from the vibration of the cylinder block caused by the occurrence of engine knocking.
Heated Oxygen Sensor [See page EG-83]	Cup Type with Heater	1 each bank	This sensor detects the oxygen concentration in the exhaust by voltage which is generated in the sensor itself.
Air Fuel Ratio Sensor [See page EG-83]	Planar Type with Heater	1 each bank	As with the oxygen sensor, this sensor detects the oxygen concentration in the exhaust emission. However, using a different method, it detects the oxygen concentration in the exhaust emission in a linear manner.
Engine Coolant Temperature Sensor	Thermistor Type	1	This sensor detects the engine coolant temperature by means of an internal thermistor.
Fuel Injector Assembly (For Port Injection) [See page EG-49]	12-hole Type	8	This fuel injector assembly (for port injection) contains an electro-magnetically operated nozzle to inject fuel into the intake port.

(Continued)

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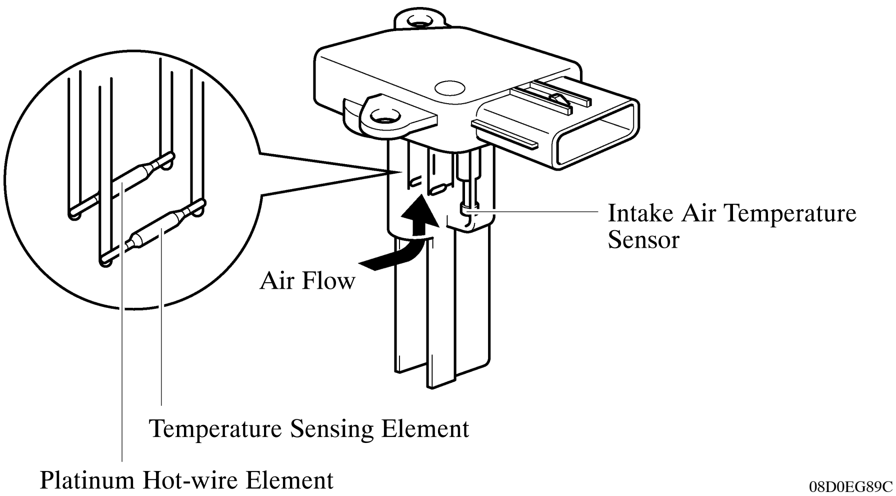
Components	Outline	Quantity	Function
Fuel Injector Assembly (For Direct Injection) [See page EG-50]	High-pressure Double Slit Nozzle Type	8	This fuel injector assembly (for direct injection) contains a high-pressure electro-magnetically operated nozzle to inject fuel directly into the cylinder.
Injector Driver (EDU) [See page EG-50]	Built-in DC/DC Converter	2	The injector driver converts the signals from the ECM into high-voltage, high-amperage current in order to drive the fuel injector assemblies (for direct injection).
Camshaft Timing Control Motor Assembly [See page EG-95]	EDU-integrated (Brushless Type DC Motor)	1 each bank	The rotational movement of the camshaft timing control motor assembly changes the intake valve timing by operating the camshaft timing gear assembly in accordance with the signals received from the ECM.
Camshaft Timing Oil Control Valve Assembly [See page EG-102]	Electro-magnetic Coil Type	1 each bank	The camshaft timing oil control valve assembly changes the exhaust valve timing by switching the oil passage that acts on the camshaft timing exhaust gear in accordance with the signals received from the ECM.

Mass Air Flow Meter

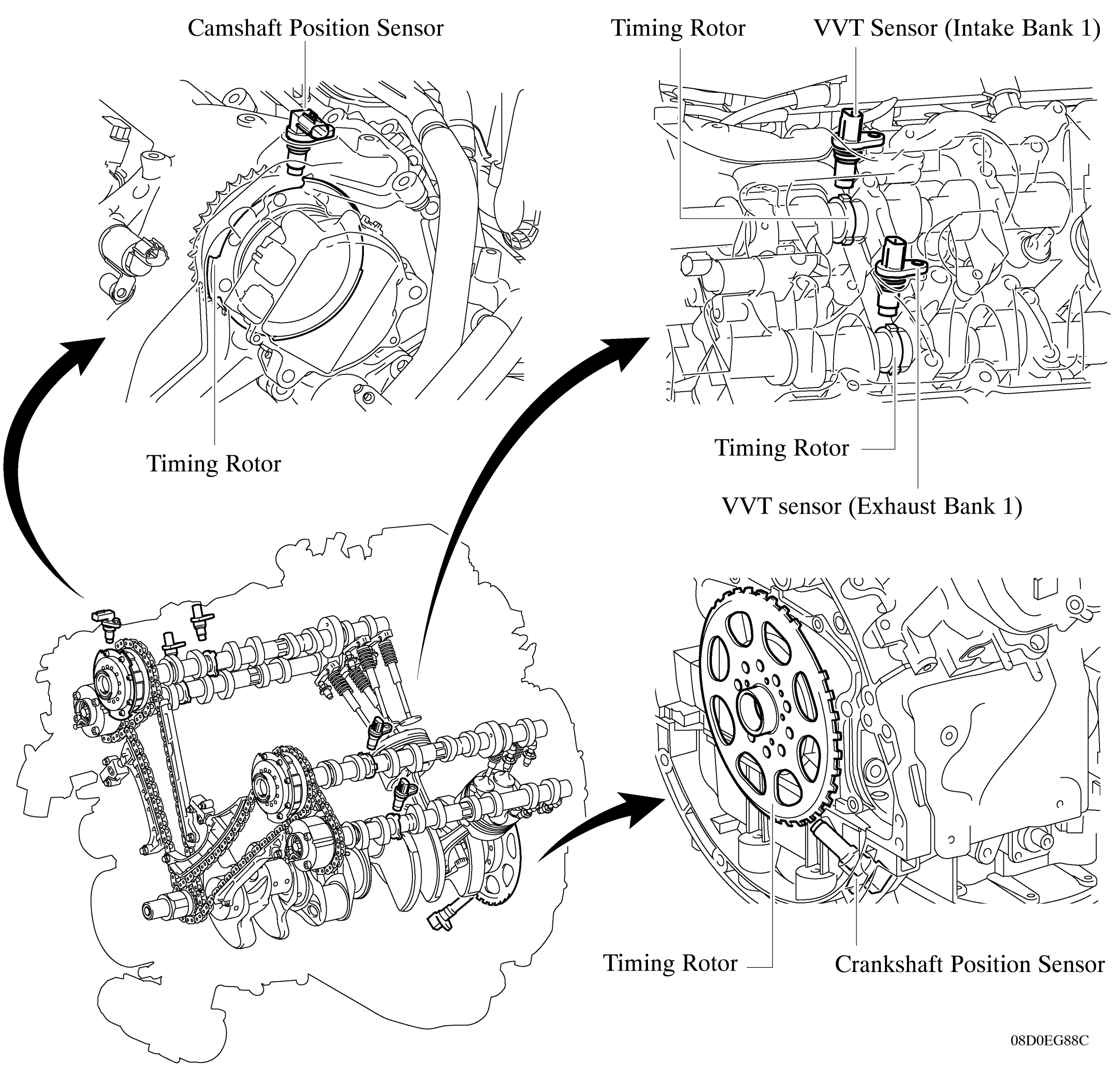
- This mass air flow meter, which is a plug-in type, allows a portion of the intake air to flow through the detection area. By directly measuring the mass and the flow rate of the intake air, the detection precision is improved and the intake air resistance is reduced.
- This mass air flow meter has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



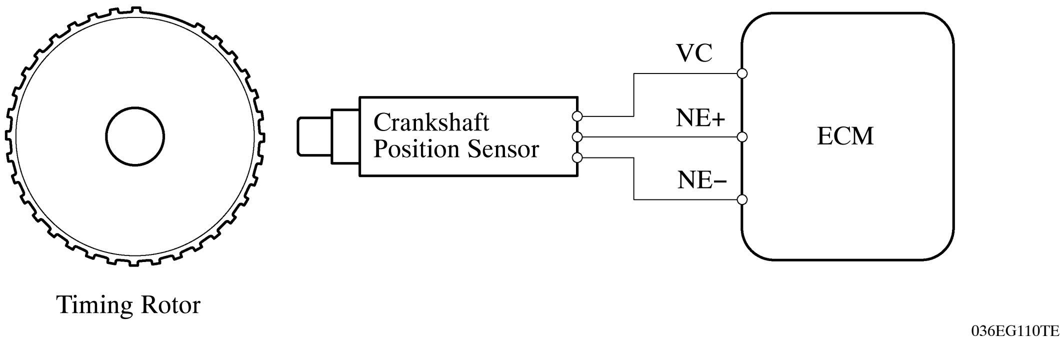
Crankshaft Position and Camshaft Position and VVT Sensors

1) General

- MRE (Magnetic Resistance Element) sensors are used for the crankshaft position, camshaft position, and VVT sensors.
- The timing rotor for the crankshaft position sensor is installed on the back end of the crankshaft. The timing rotor has 34 teeth, with 2 teeth missing, at 10_ intervals. Based on these teeth, the crankshaft position sensor transmits crankshaft position signals (NE signal) consisting of 33 high/low output pulses every 10_ per revolution of the crankshaft, and 1 high/low output pulse every 30_. The ECM uses the NE signal for detecting the crankshaft position as well as for detecting the engine speed. It uses the missing teeth signal for determining the top-dead-center.
- The camshaft position sensor uses a timing rotor that is installed on the front end of the intake camshaft sprocket of the right bank. Based on the timing rotor, the sensor outputs camshaft position signals (G2 signal) consisting of 6 (3 high output, 3 low output) pulses for every 2 revolutions of the crankshaft. The ECM compares the G2 and NE signals to detect the camshaft position and identify the cylinder.
- The intake and exhaust VVT sensors use timing rotors that are installed on the intake and exhaust camshafts of each bank. Based on the timing rotors, the sensors output VVT position signals consisting of 6 (3 high output, 3 low output) pulses for every 2 revolutions of the crankshaft. The ECM compares these VVT position signals to the NE signal to detect the actual valve timing.

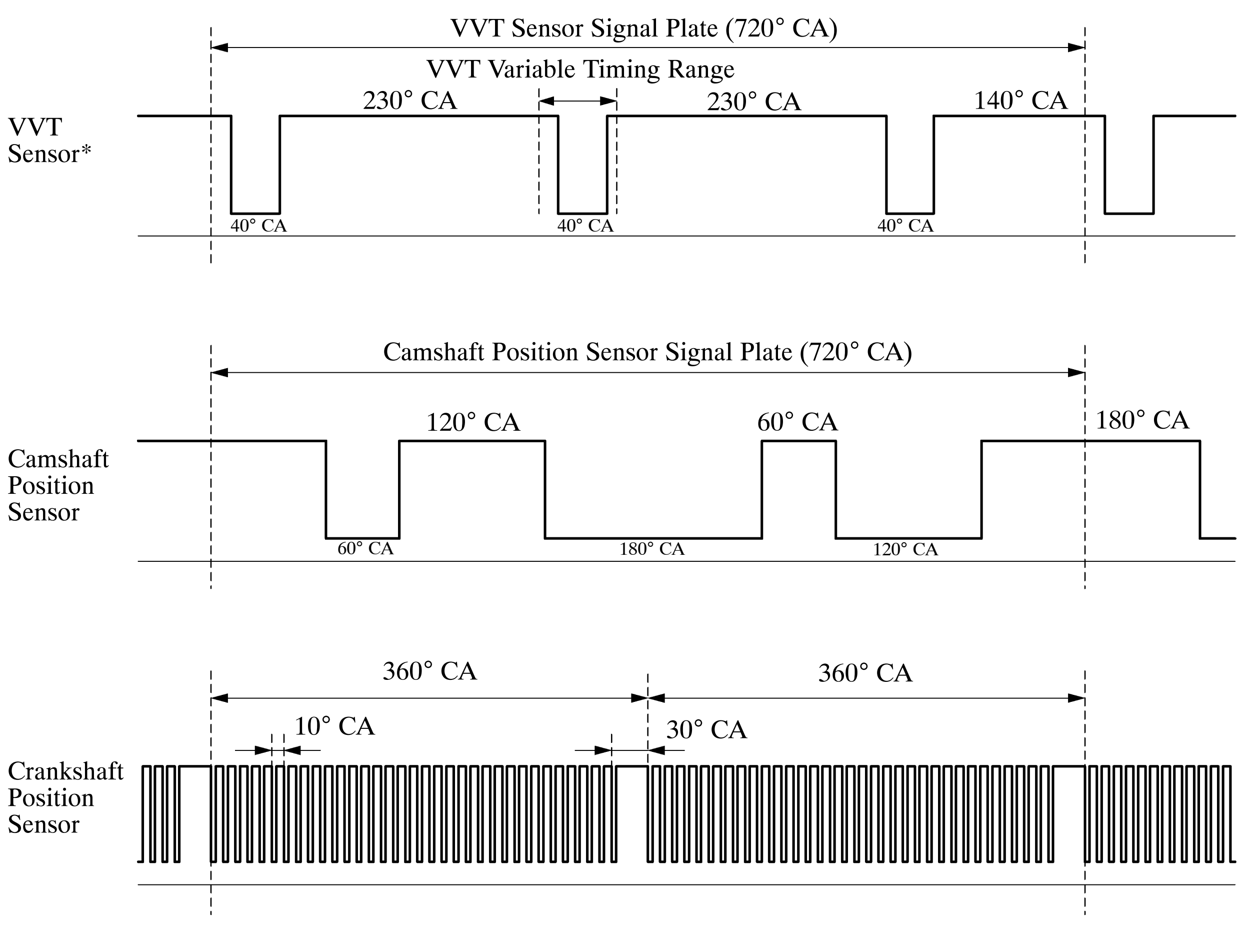


▶ Wiring Diagram ◀



Crankshaft Position Sensor Circuit

▶ Sensor Output Waveforms ◀

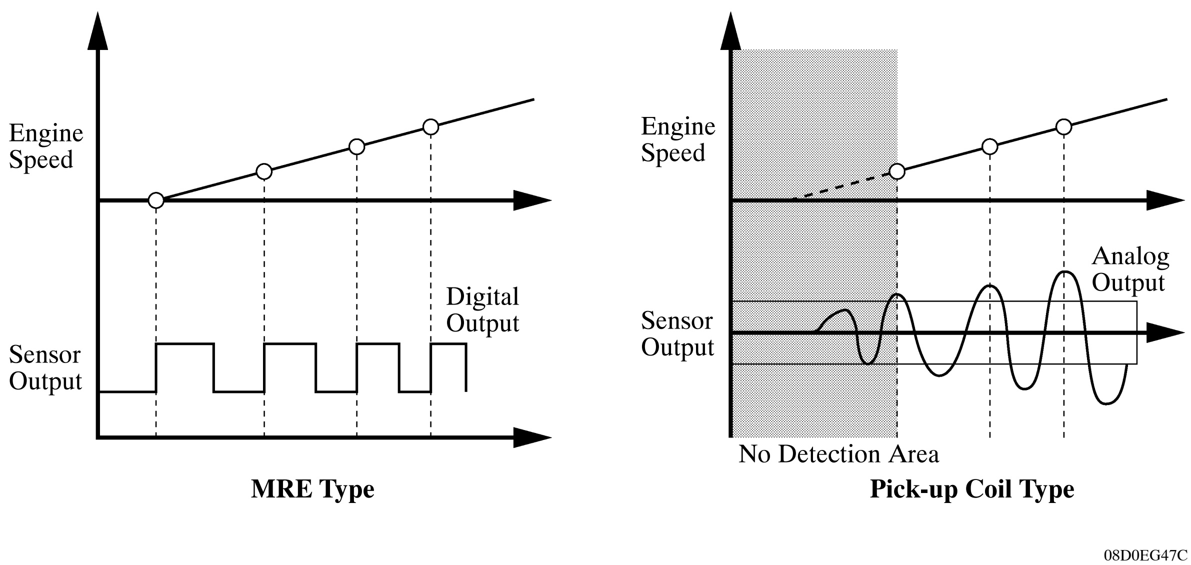


*: This is an example of an output waveform of the intake VVT sensor (bank 2).

2) MRE Type Sensor

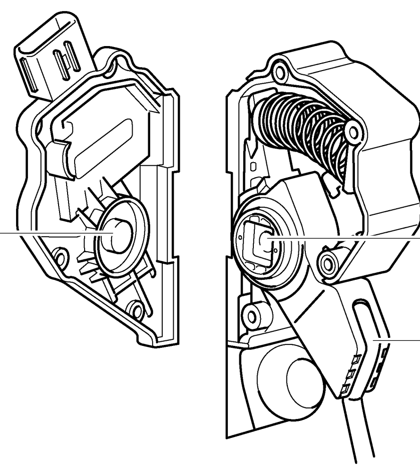
- An MRE type sensor consists of an MRE, a magnet and a sensor.
- The direction of the magnetic field changes due to the different shapes (protruded and non-protruded portions) of the timing rotor, which passes by the sensor. As a result, the resistance of the MRE changes, and the output voltage to the ECM changes to high or low. Based on the switching timing of the high/low output voltage, the ECM detects the positions of the crankshaft and camshaft.
- The differences between the MRE type sensor and the pick-up coil type sensor used on a conventional model are as follows.
  - An MRE type sensor outputs a constant level of high/low digital signals regardless of the engine speed. Therefore, an MRE type sensor can detect the positions of the crankshaft and camshaft at an early stage of cranking.
  - A pickup coil type sensor outputs analog signals with levels that change with engine speed.

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



Accelerator Pedal Position Sensor

- This non-contact type accelerator pedal position sensor uses a Hall IC, which is mounted on the accelerator pedal arm.
- A magnetic yoke is mounted at the base of the accelerator pedal arm. This yoke rotates around the Hall IC in accordance with the position of the accelerator pedal. The Hall IC converts the changes that occur in the magnetic flux into electrical signals, and outputs these accelerator pedal position signals to the ECM.
- The Hall IC contains two circuits, one for the main signal, and one for the sub signal. It converts the accelerator pedal position (angle) into electric signals that have differing characteristics and outputs them to the ECM.



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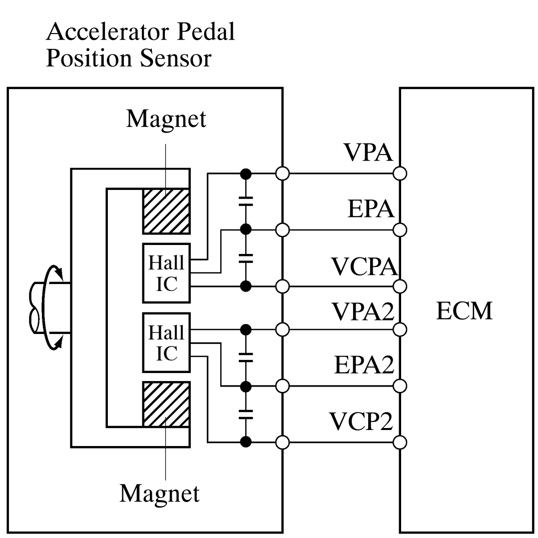
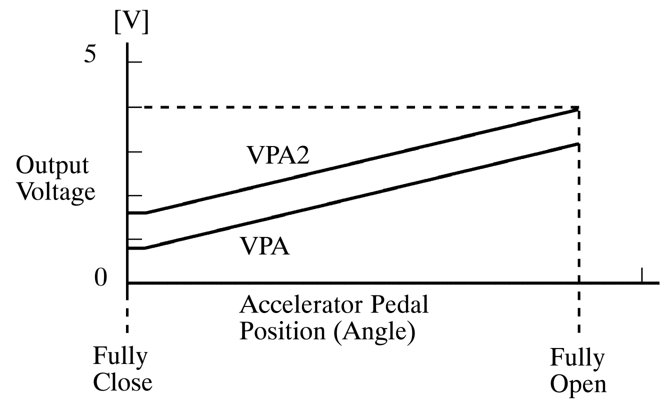


228TU24



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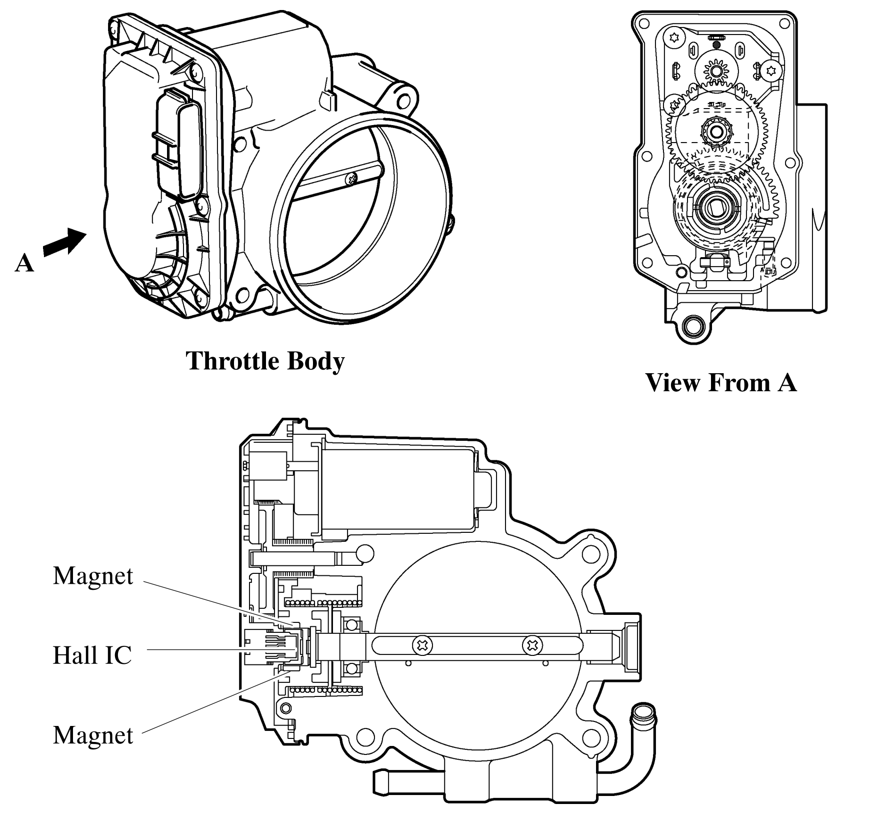
Service Tip

The inspection method differs from a potentiometer type accelerator pedal position sensor because this sensor uses a Hall IC. For details, refer to the LEXUS IS F Repair Manual (Pub. No. RM08E0E).

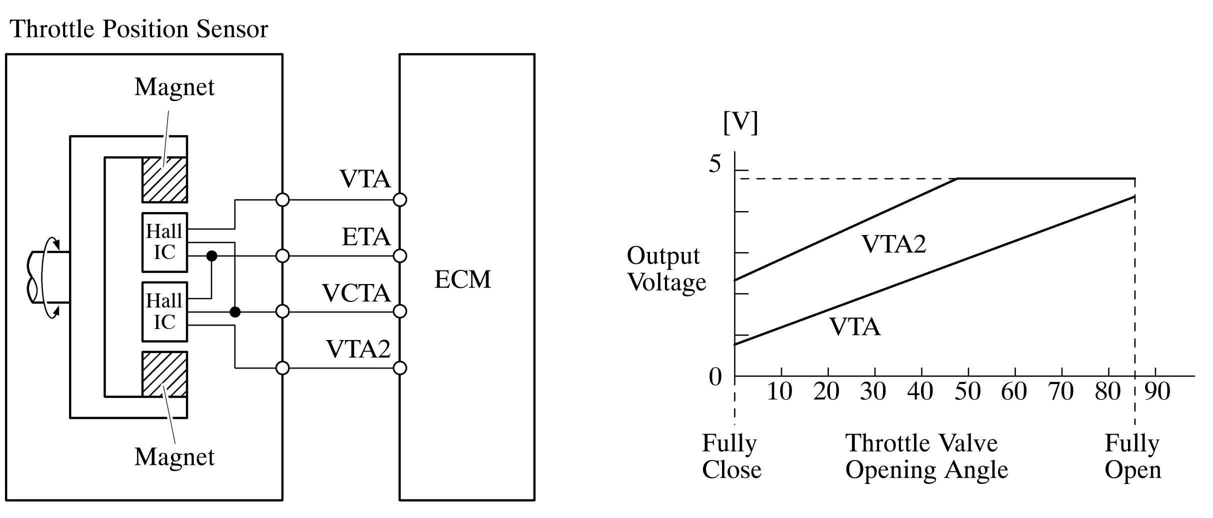
Throttle Position Sensor

- This non-contact type throttle position 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 when the throttle shaft rotates into electrical signals and outputs them to the ECM.
- The Hall IC contains circuits for a main and a sub signals. It converts the throttle valve opening angles into two electrical signals with differing characteristics and outputs them to the ECM.



Throttle Body **View From A**

Cross Section



Service Tip

The inspection method differs from a potentiometer type throttle position sensor because this sensor uses a Hall IC. For details, refer to the LEXUS IS F Repair Manual (Pub. No. RM08E0E).

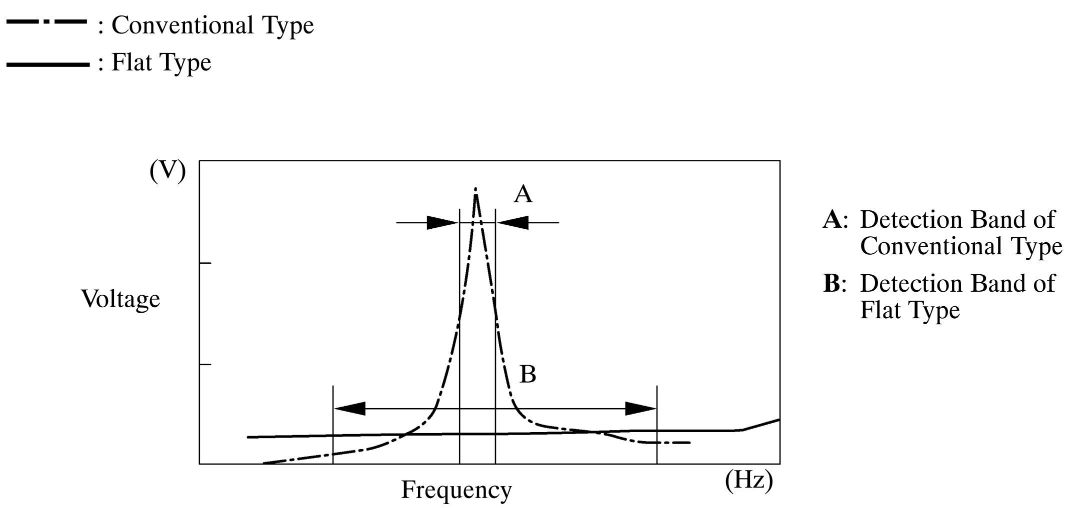
Knock Control Sensor (Flat Type)

1) General

In the conventional type knock control 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 control 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 control sensor can detect vibration even when the engine knocking frequency changes. Thus the vibration detection ability is increased compared to a conventional type knock control sensor, and more precise ignition timing control is possible.



Characteristic of Knock Control Sensor

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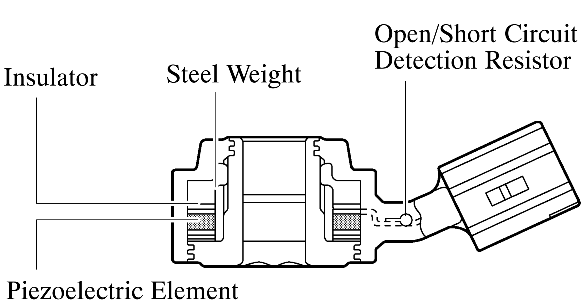
2) Construction

- The flat type knock control 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 located 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.
- An open/short circuit detection resistor is integrated.



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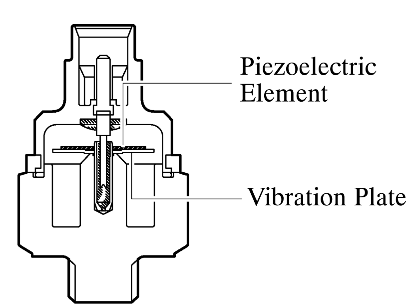
Flat Type Knock Control Sensor (Non-Resonant Type)



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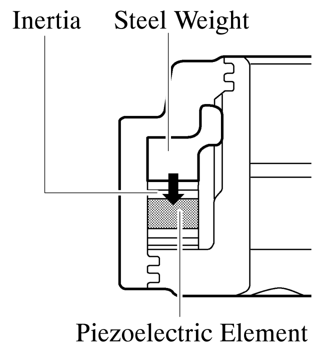
Conventional Type Knock Control Sensor (Resonant Type)

3) Operation

Knocking vibration is transmitted to the steel weight and the inertia of the plate applies pressure to the piezoelectric element. This action generates electromotive force.



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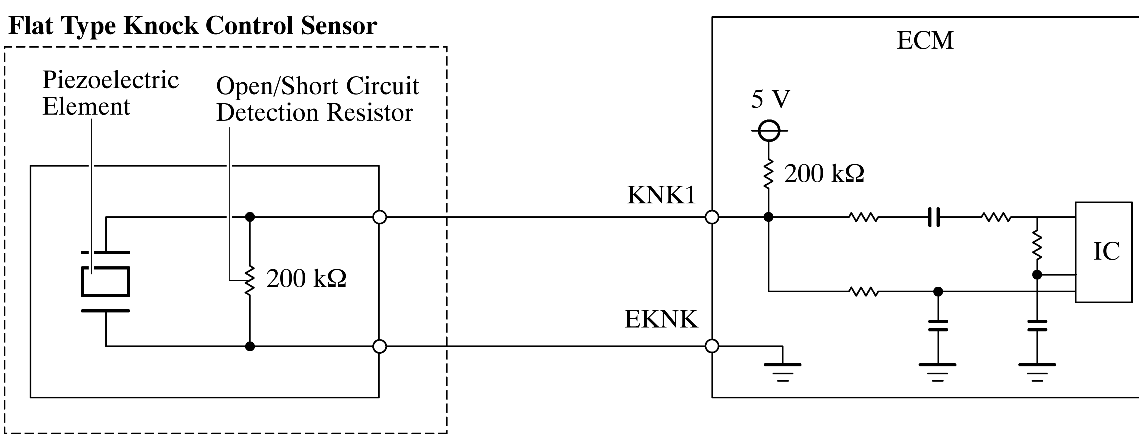
4) Open/Short Circuit Detection Resistor

When the engine switch is on (IG), the open/short circuit detection resistor in the knock control sensor and the resistor in the ECM keep the voltage at the terminal KNK1 of engine constant.
An IC (Integrated Circuit) in the ECM is always monitoring the voltage of the terminal KNK1. If a open or short circuit occurs between the knock control sensor and the ECM, the voltage of terminal KNK1 will change and the ECM will detects the open or short circuit and store a DTC (Diagnostic Trouble Code).



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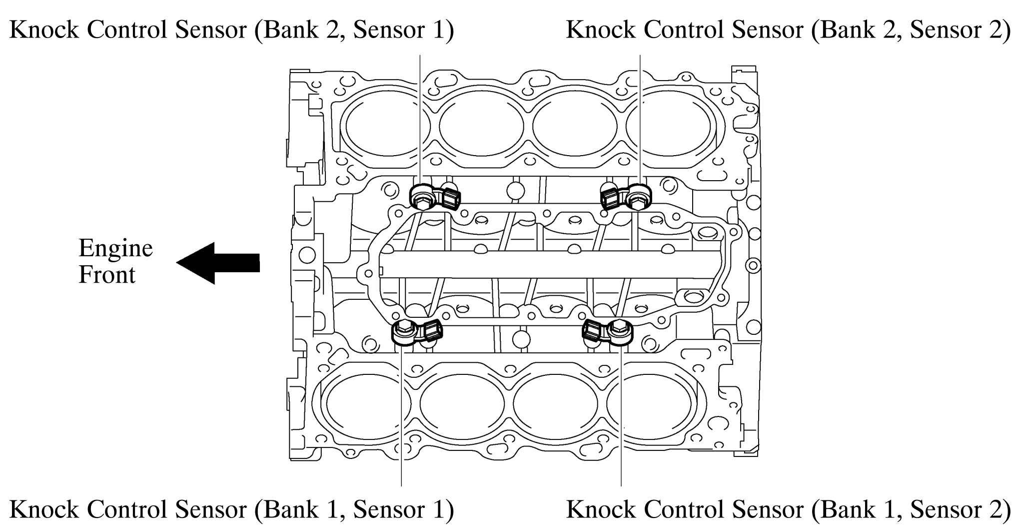
Service Tip

These knock control sensors are mounted in the specific directions and angles as illustrated. For details, refer to the LEXUS IS F Repair Manual (Pub. No. RM08E0E).



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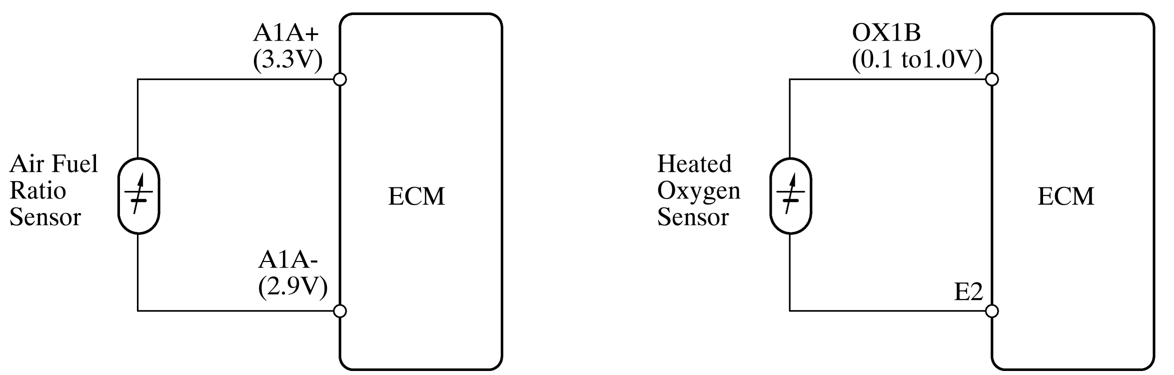
Air Fuel Ratio Sensor and Heated Oxygen Sensor

1) General

- Heated oxygen sensors and air fuel ratio sensors have different output characteristics.
- The output voltage of the heated oxygen sensor changes in accordance with the oxygen concentration in the exhaust gas. The ECM 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 outputs an amperage that varies in accordance with the oxygen concentration in the exhaust gas. The ECM converts the changes in the output amperage into voltage in order to determine the present air fuel ratio in a linear manner.



Air Fuel Ratio Sensor Circuit **Heated Oxygen Sensor Circuit**

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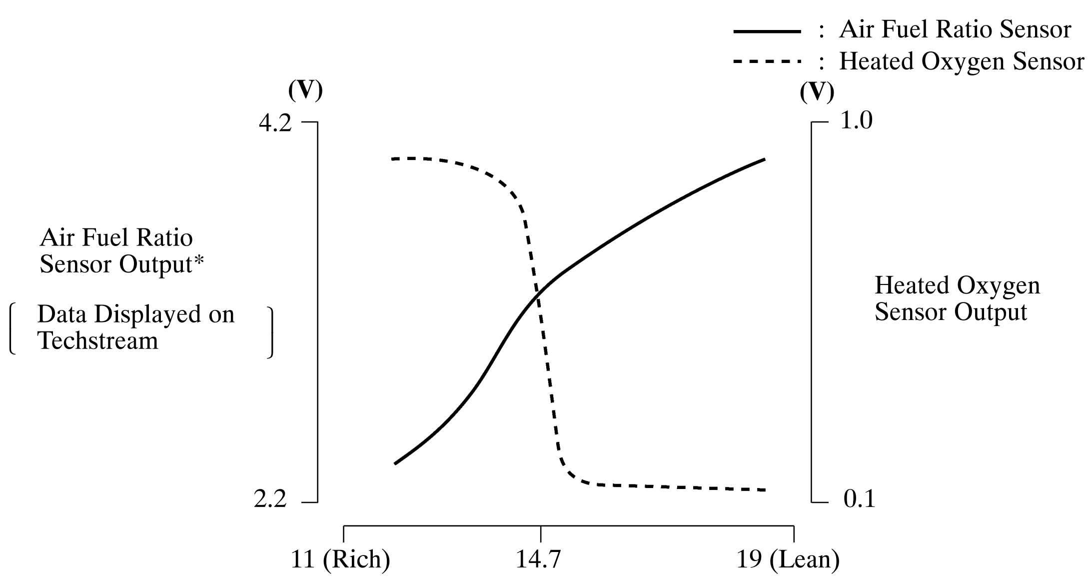


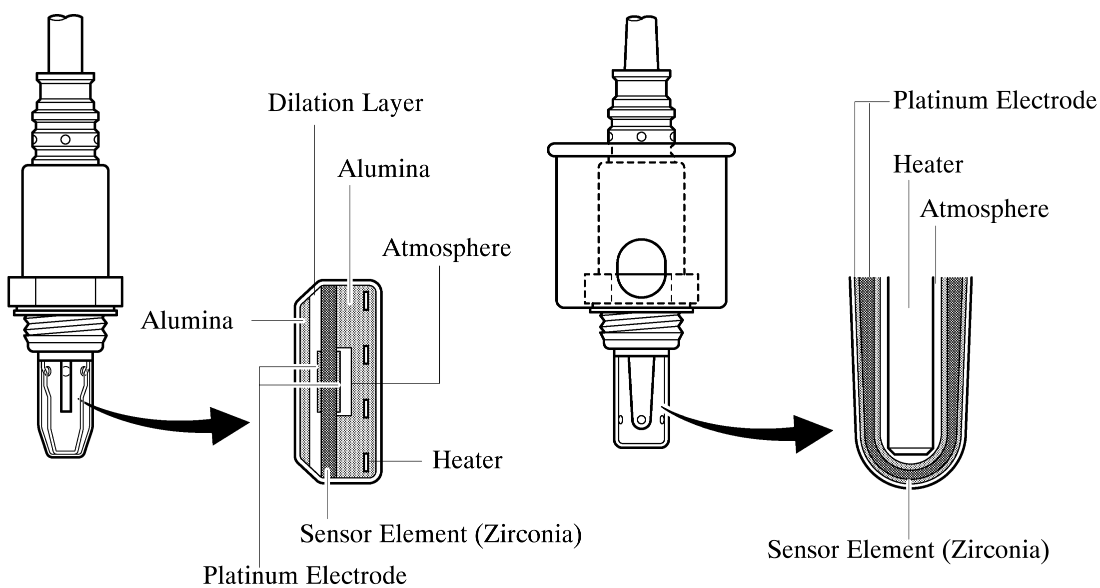
Air Fuel Ratio

08D0EG53C

*: This value is calculated internally in the ECM, and is not an ECM terminal voltage.

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 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 electrical insulation, to integrate a sensor element with a heater, thus improving the warm up performance of the sensor.

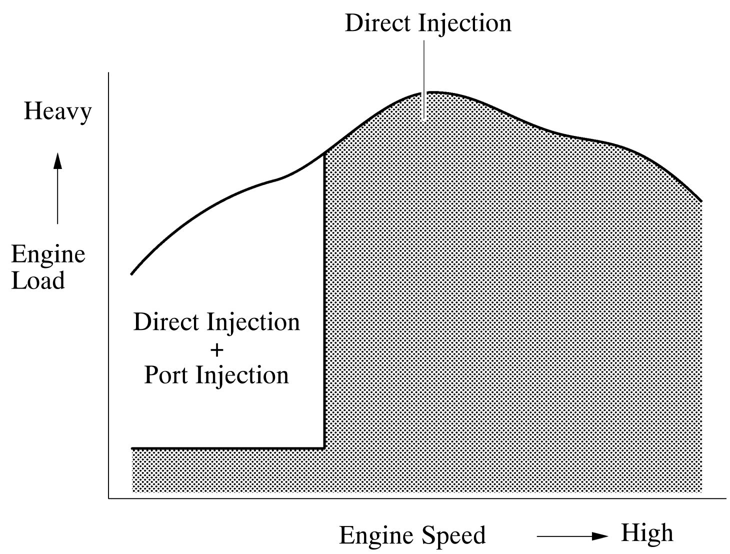


Planar Type Air Fuel Ratio Sensor **Cup Type Heated Oxygen Sensor**

6. D-4S EFI (Electronic Fuel Injection) System

General

- The D-4S (Direct injection 4-stroke gasoline engine Superior version) EFI system directly detects the intake air mass with a hot-wire type mass air flow meter.
- The D-4S system is a fuel injection system which combines fuel injector assemblies (for direct injection) and fuel injector assemblies (for port injection).
- Based on signals from each sensor, the ECM controls the injection volume and timing of each type of fuel injector (direct and port injection types) according to engine load and engine speed in order to optimize combustion conditions.
- To promote warm up of the catalyst after a cold engine start, this system uses a stratified air-fuel mixture, that results in an area near the spark plug that is richer than the rest of the air-fuel mixture. This allows a retarded ignition timing to be used so the exhaust gas temperature can be increased. This results in more rapid heating of the catalytic converters, reducing exhaust emissions.



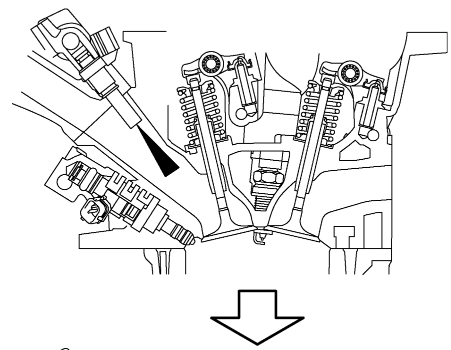
Fuel Injection System Activation Ranges 036EG166TE

Stratified Combustion

Immediately after a cold engine start, fuel is injected into the intake port from the fuel injector assembly (for port injection) during the exhaust stroke. Fuel is also injected from the fuel injector assembly (for direct injection) near the end of the compression stroke. This results in an air-fuel mixture that is stratified, the area near the spark plug is richer than the rest of the air-fuel mixture. This allows a retarded ignition timing to be used, raising the exhaust gas temperature. The increased exhaust gas temperatures promote rapid warm up of the catalysts, and significantly improve exhaust emission performance.

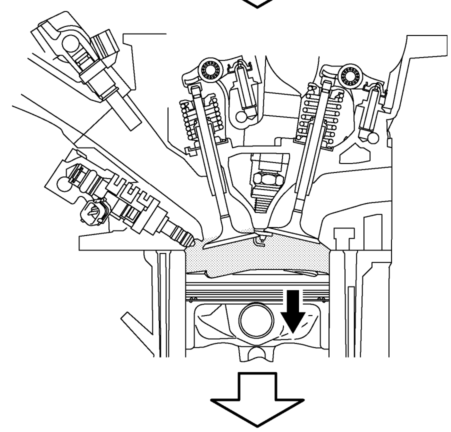
1) Exhaust Stroke

Fuel is injected into the intake port from the fuel injector assembly (for port injection) before the intake valves open.



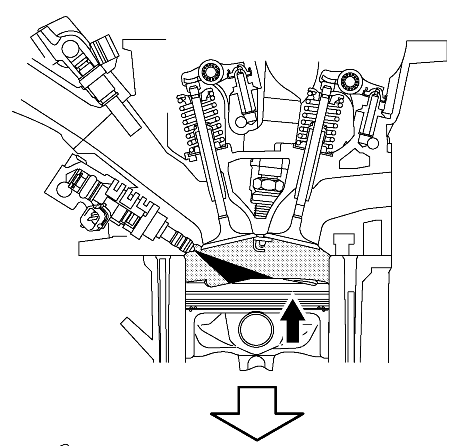
2) Intake Stroke

The intake valves open and a homogeneous air-fuel mixture is drawn into the combustion chamber.



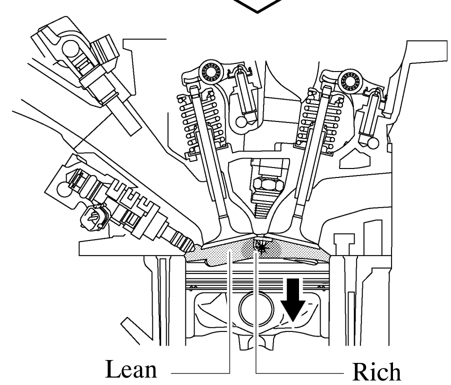
3) Compression Stroke

Fuel is injected into the combustion chamber from the fuel injector assembly (for direct injection) near the end of compression stroke.



4) Ignition to combustion Stroke

Injected fuel is directed along the piston contour to the area near the spark plug. This produces a combustible area of a rich air-fuel mixture that allows for easy ignition. This allows combustion of a lean air-fuel mixture to occur.



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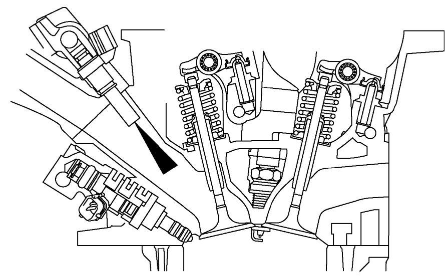
Homogeneous Combustion

To optimize combustion conditions, the ECM controls injection volume and timing of the fuel injector assemblies (for port injection) which inject fuel into the intake ports during the expansion, exhaust, and intake strokes. The ECM also controls the injection volume and timing of the furl injector assemblies (for direct injection) which inject fuel during the first half of the intake stroke. The homogeneous air-fuel mixture is created by either combined or individual use of the two different types of injectors. This allows utilization of the heat of evaporation of the injected fuel to cool the compressed air, it also allows an increase of charging efficiency and power output.

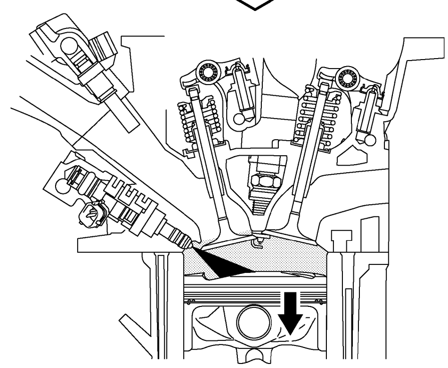
1) Exhaust Stroke

Fuel is injected into the intake port from the fuel injector assembly (for port injection) before the intake valves open.



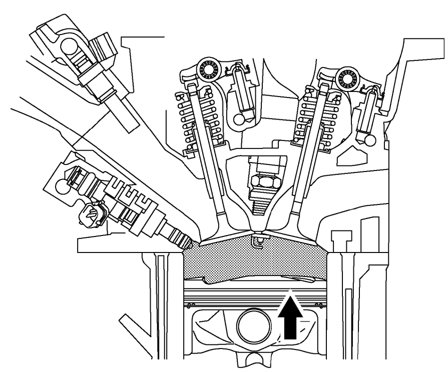
2) Intake Stroke

The intake valves open to allow the homogeneous air-fuel mixture into the combustion chamber, and fuel is injected into the combustion chamber from the fuel injector assembly (for direct injection) during the first half of the intake stroke. The injected fuel and air are evenly mixed by intake air force.



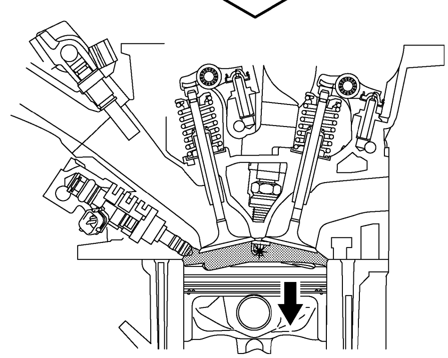
3) Compression Stroke

The homogeneous air-fuel mixture is compressed.



4) Ignition to combustion Stroke

The spark plug ignites the homogeneous air-fuel mixture.



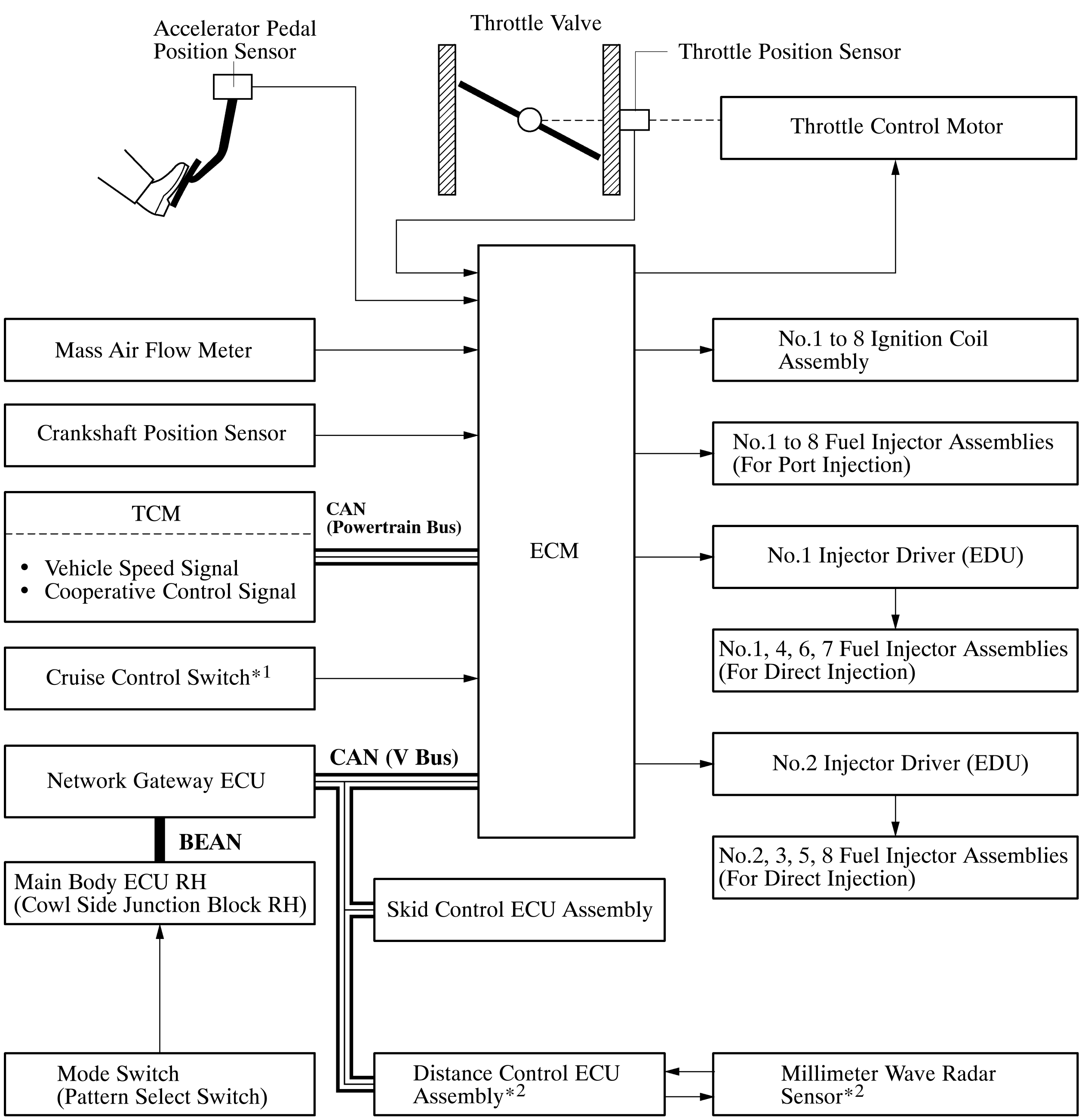
08D0EG78C

7. ETCS-i

General

- For a cable operated throttle body assembly, the throttle valve angle is determined invariably by the amount of the accelerator pedal effort. In contrast, ETCS-i (Electronic Throttle Control System-intelligent) uses the ECM to calculate the optimal throttle valve angle that is appropriate for the respective driving condition and uses a throttle control motor to control the angle.
- In case of a malfunction, this system enters fail-safe mode.

▶ System Diagram ◀



*1: Without Dynamic Radar Cruise Control system
*2: With Dynamic Radar Cruise Control system

Control

1) General

The ETCS-i consists of the following functions:

- Normal Throttle Control (Non-linear Control)
- ISC (Idle Speed Control)
- Powertrain Cooperative Control
- TRC (Traction Control)
- VSC (Vehicle Stability Control)
- Cruise Control
- Dynamic Radar Cruise Control*

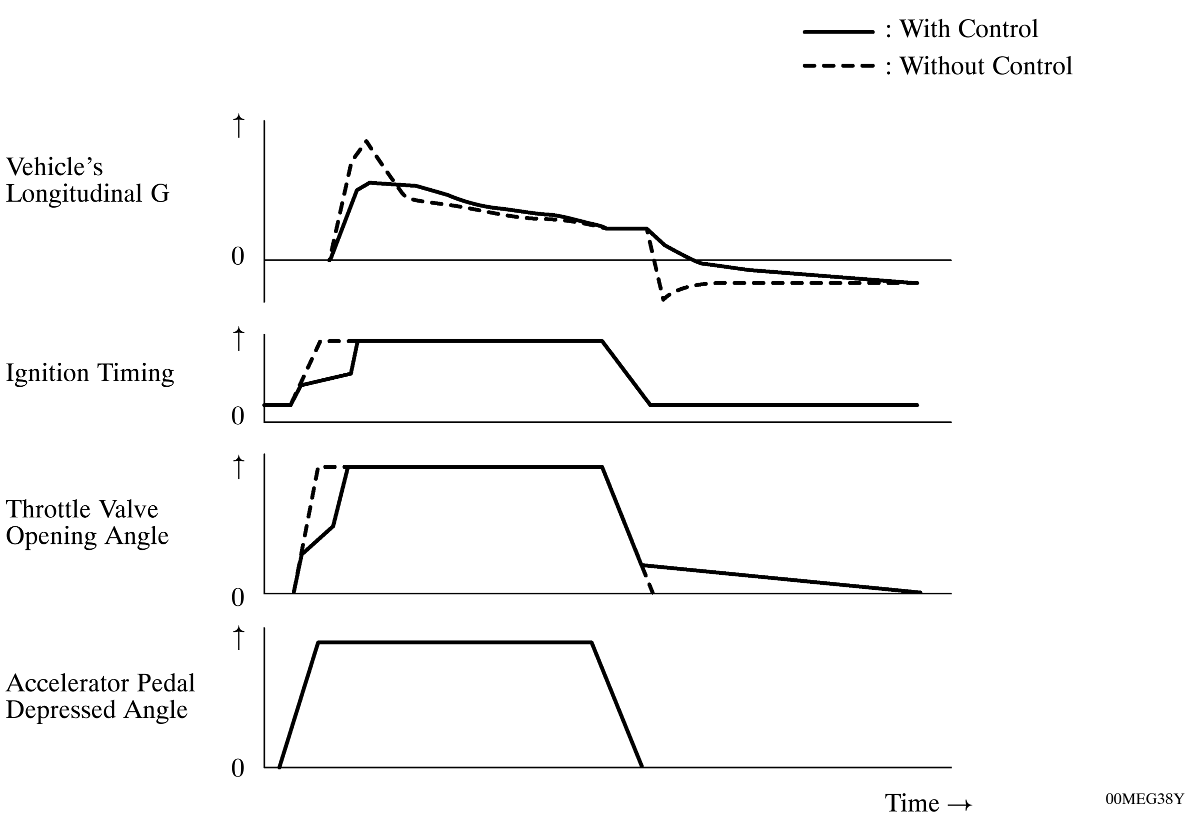
*: With Dynamic Radar Cruise Control system

2) Normal Throttle Control (Non-linear Control)

a. Normal-mode Control

Controls the throttle to an optimal throttle valve 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.

▶ Conceptual Diagrams of Engine Control During Acceleration and Deceleration ◀



b. Snow-mode Control

In situations in which low-μ (low friction) road surface conditions can be anticipated, such as when driving in the snow, the rate of throttle valve opening can be controlled to help vehicle stability while driving on the slippery surface. This is accomplished by turning on SNOW mode. Pressing the SNOW side of the mode switch (pattern select switch) activates this mode. This mode modifies the relationship and reaction of the throttle to the accelerator pedal, and assists the driver by reducing the engine output from that of a normal level.

3) Idle Speed Control

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

4) Powertrain Cooperative Control

The ECM effects cooperative control with the TCM in order to control the throttle valve at a position that is optimal for the driving conditions. Thus, it ensures a quick response to the driver's accelerator pedal effort and reduces shift shock.

5) TRC Throttle Control

As part of the TRC function, the throttle valve is closed by a demand signal from the skid control ECU if an excessive amount of slippage is created at a drive wheel, thus facilitating the vehicle in ensuring excellent vehicle stability and driving force.

6) VSC Coordination Control

In order to bring the effectiveness of the VSC function control into full play, the throttle valve angle is controlled by performing coordinated control with the skid control ECU assembly.

7) Cruise Control

The ECM has an integrated cruise control ECU and the ECM directly actuates the throttle valve for operation of the cruise control.

8) Dynamic Radar Cruise Control

The dynamic radar cruise control uses a millimeter wave radar sensor and the distance control ECU assembly to determine the distance of the vehicle driven ahead, its direction, and relative speed. Thus, the system can perform deceleration cruising control, follow up cruising control, cruising at a fixed speed control, and acceleration cruising control. To make these controls possible, the ECM controls the throttle valve.

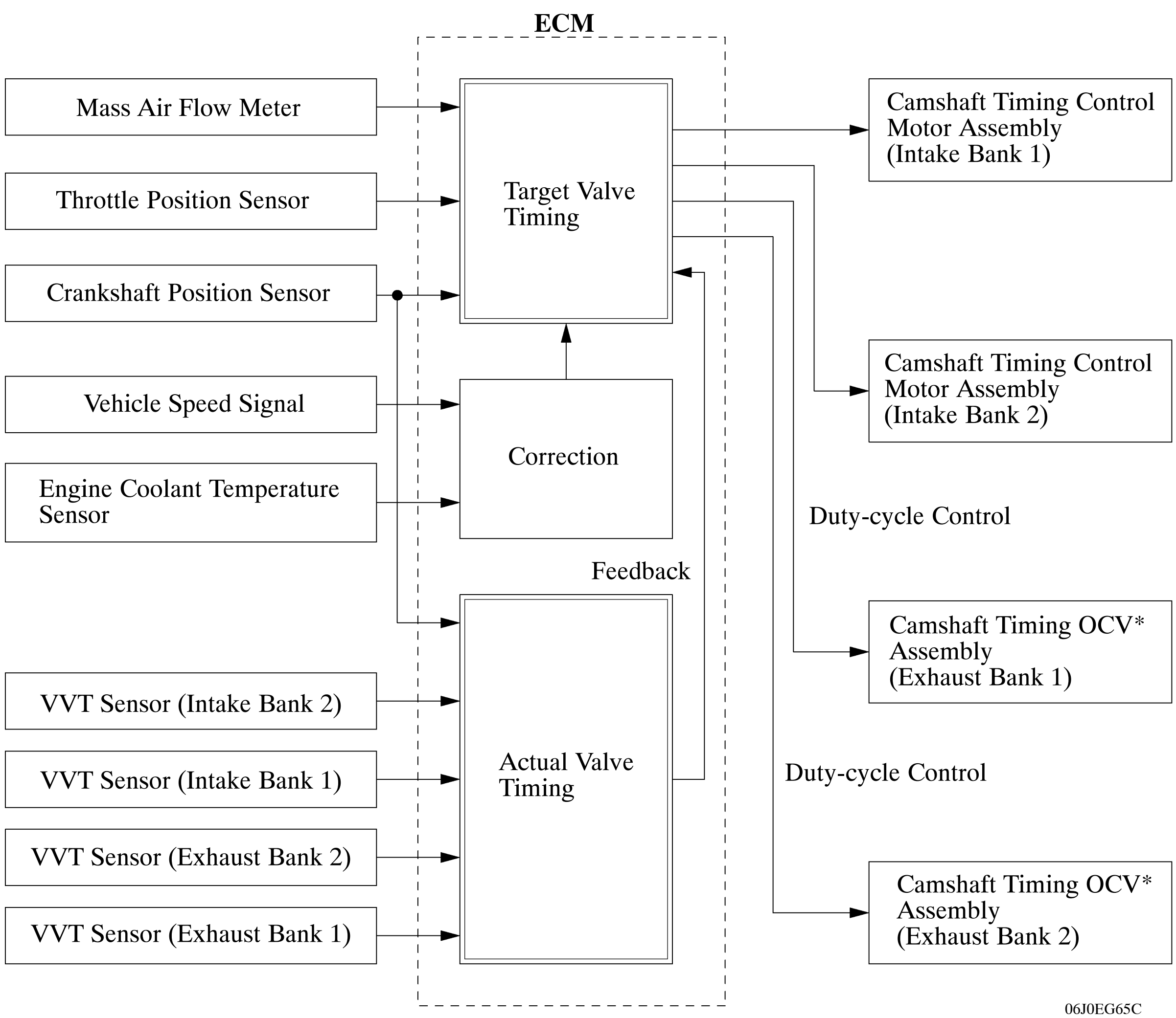
8. Dual VVT-i (Variable Valve Timing-intelligent) System

General

- The dual VVT-i system is designed to control the intake and exhaust camshafts within a range of 40_ and 35_ respectively (of crankshaft angle) to provide valve timing that is optimally suited to engine operating conditions. This improves torque in all engine speed ranges as well as increasing fuel economy, and reducing exhaust emissions.
- For the intake valves, VVT-iE uses electric motors to control the valve timing. Because VVT-iE is actuated by electric motors, it can perform optimal valve timing control even when the engine oil pressure is low, such as when the engine oil temperature or the engine speed is low. For conventional VVT-i, the most retarded valve timing adjustment possible is determined by the cam timing needed when starting the engine. Because this system can control the valve timing from the time the engine is started, it is possible to set the most retarded timing position to be more retarded than the engine starting valve timing.
- The exhaust side has VVT-i that uses engine oil pressure to control the valve timing.
- Based on engine speed, intake air volume, throttle position and engine coolant temperature, the ECM calculates optimal valve timing for all driving conditions. The ECM uses the results of these calculations to control the camshaft timing oil control valve assemblies and the camshaft control motors. Furthermore, the ECM uses signals from the camshaft position sensors and the crankshaft position sensors to detect the actual valve timing, thus providing feedback control to achieve the target valve timing.

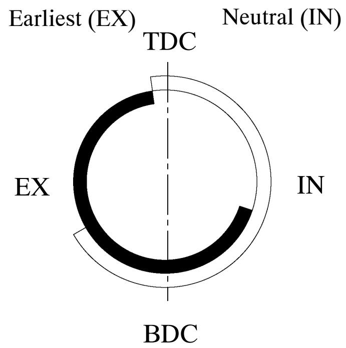
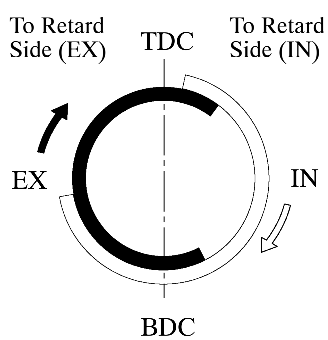
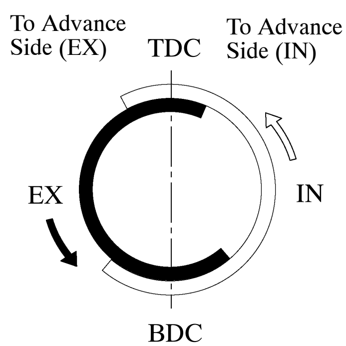
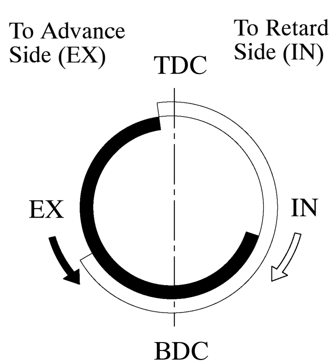
EG

▶ System Diagram ◀

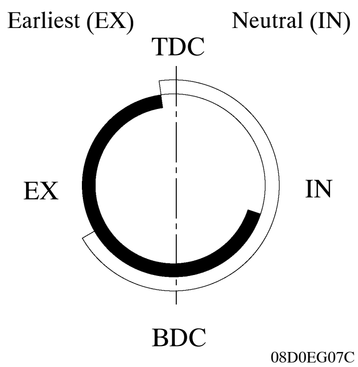
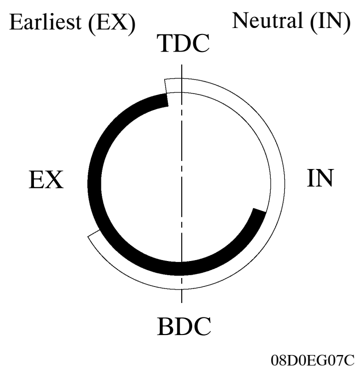


*: Oil Control Valve

Effectiveness of the Dual VVT-i System

Operation State	Objective	Effect
During Idling	 08D0EG07C Eliminating overlap reduces blow back to the intake side.	• Stabilized idling rpm • Better fuel economy
In Low Speed Range with Light to Medium Load	 08D0EG08C • Retarding the intake valve close timing to reduce pumping losses. • Increasing overlap to increase internal EGR.	• Better fuel economy • Improved emission control
In Low to Medium Speed Range with Heavy Load	 08D0EG09C Advancing the intake valve closing timing improves volumetric efficiency.	Improved torque in low to medium speed range
In High Speed Range with Heavy Load	 08D0EG10C Retarding the intake valve closing timing improves volumetric efficiency.	Improved output

(Continued)

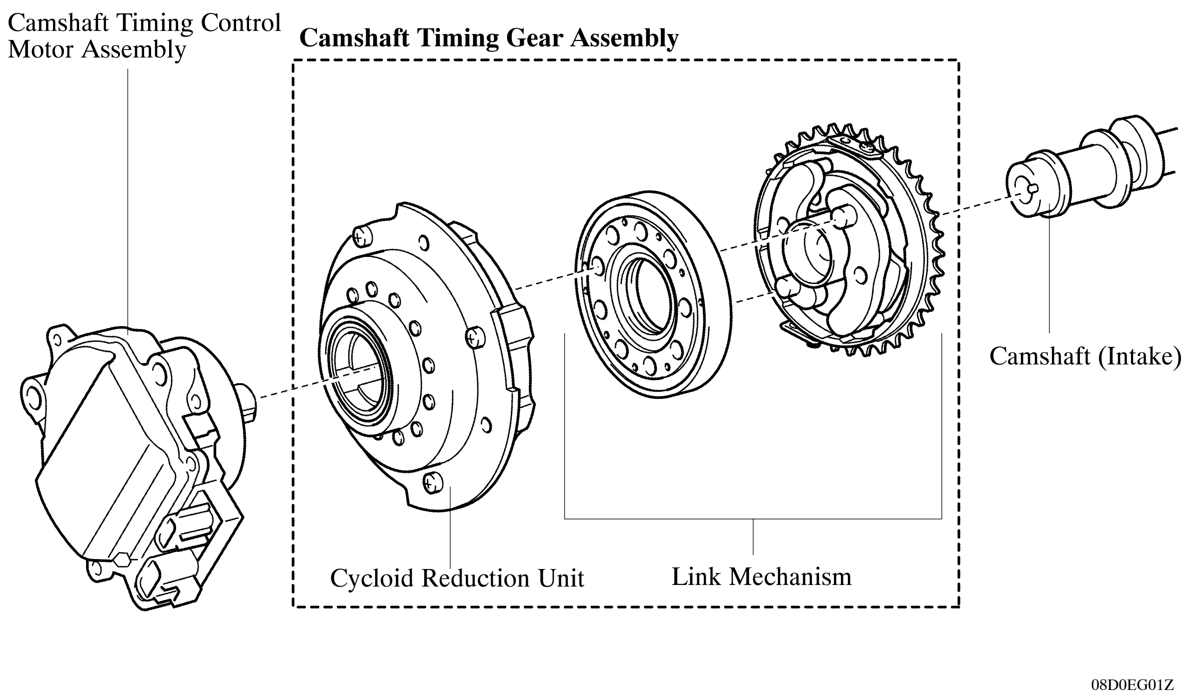
Operation State	Objective	Effect
At Low Temperatures	 Eliminating overlap to reduce blow back to the intake side stabilizes the idle at fast idle.	• Stabilized fast idle rpm • Better fuel economy
• Upon Starting • Stopping the Engine	 Eliminating overlap minimizes blow back to the intake side.	Improved startability

VVT-iE

1) General

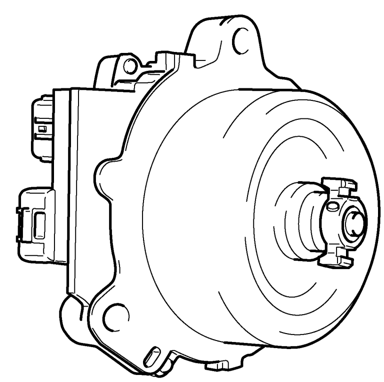
VVT-iE consists of camshaft timing control motor assembly and camshaft timing gear assembly.

- The camshaft timing control motor assembly operates a camshaft timing gear assembly in accordance with the signals received from the ECM.
- The camshaft timing gear assembly consists of a cycloid reduction unit and link mechanism.
- The camshaft timing gear assembly rotates the camshaft via a link mechanism.

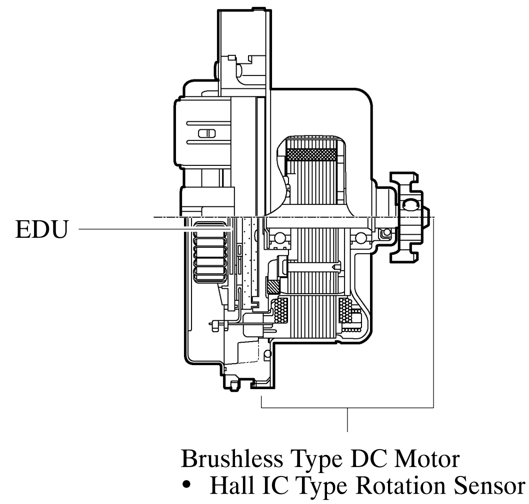


2) Camshaft Timing Control Motor Assembly

- The camshaft timing control motor assembly consists of a motor that operates the camshaft timing gear assembly in the advance or retard direction, an EDU that controls the rotational condition of the motor, and a Hall IC type rotation sensor that detects the rotational condition of the motor.
- The motor is a brushless type DC motor that is installed in the timing chain cover forward of the camshaft timing gear assembly. It rotates coaxially with the intake camshaft.
- In accordance with the target valve timing, the ECM transmits the motor speed instruction signals and the motor rotation direction instruction signals to the EDU. Based on those signals, the EDU drives the motor to rotate the intake camshaft in the advance or retard direction.
- The EDU always monitors the motor operating condition, and transmits the actual motor speed signals, the actual motor rotation direction signals, and the operating state signals to the ECM. The ECM uses these signals to diagnose malfunctions.



Camshaft Timing Control Motor Assembly



Cross Section

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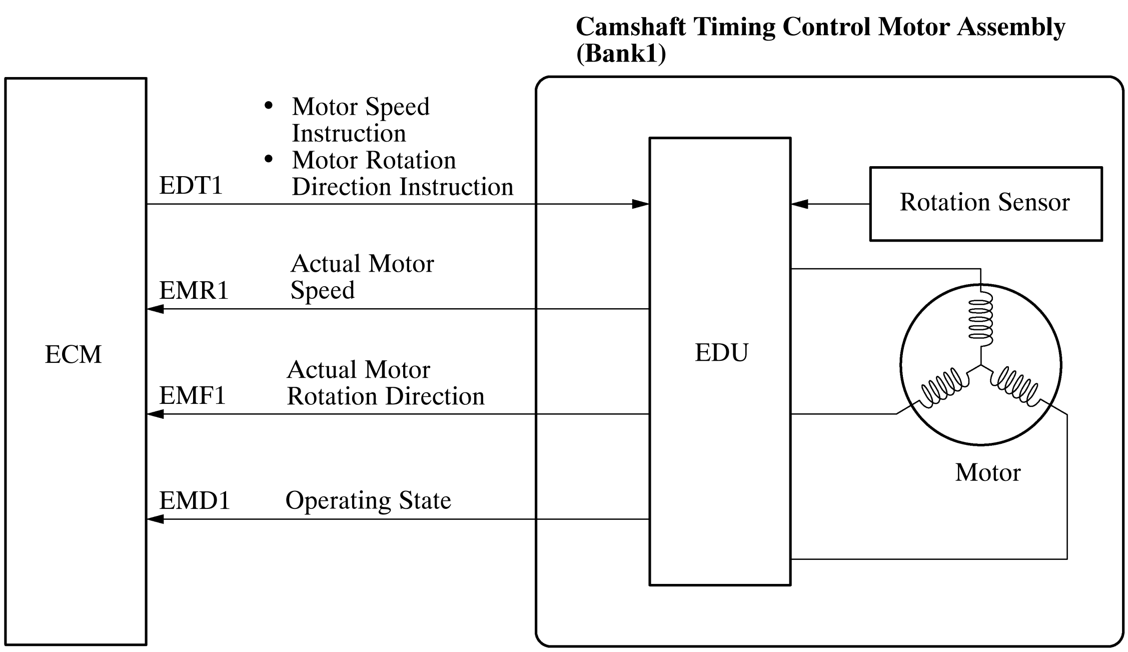
▶ System Diagram ◀



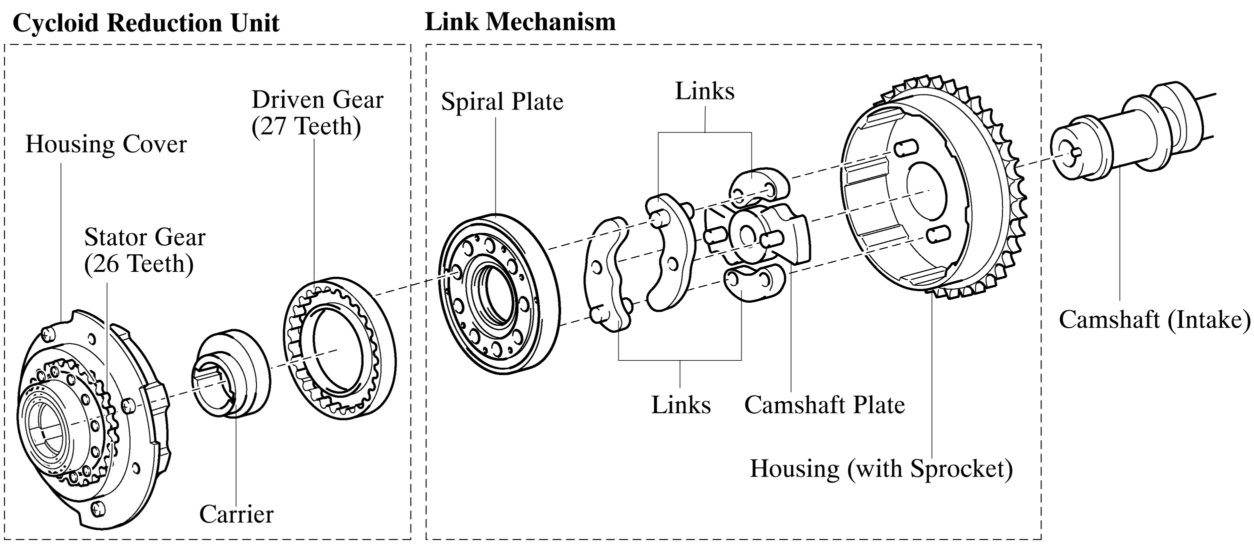
036EG156TE

3) Camshaft Timing Gear Assembly

a. General

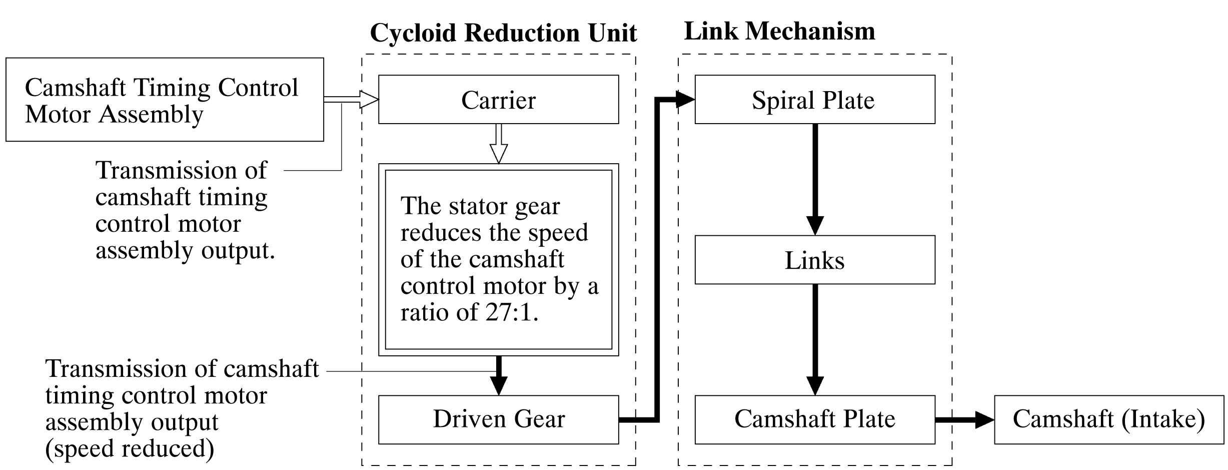
The camshaft timing gear assembly consists of a cycloid reduction unit to reduce the speed of the motor output and a link mechanism that rotates the intake camshaft to the advance or retard side.

- The cycloid reduction unit consists of a housing cover fitted with a stator gear, a carrier, and a driven gear. It reduces the speed of the camshaft timing control motor assembly by a ratio of 27:1.
- The link mechanism consists of a spiral plate, links, a camshaft plate and housing (with sprocket).



08D0EG02C

▶ Camshaft Control Drive Transmission ◀

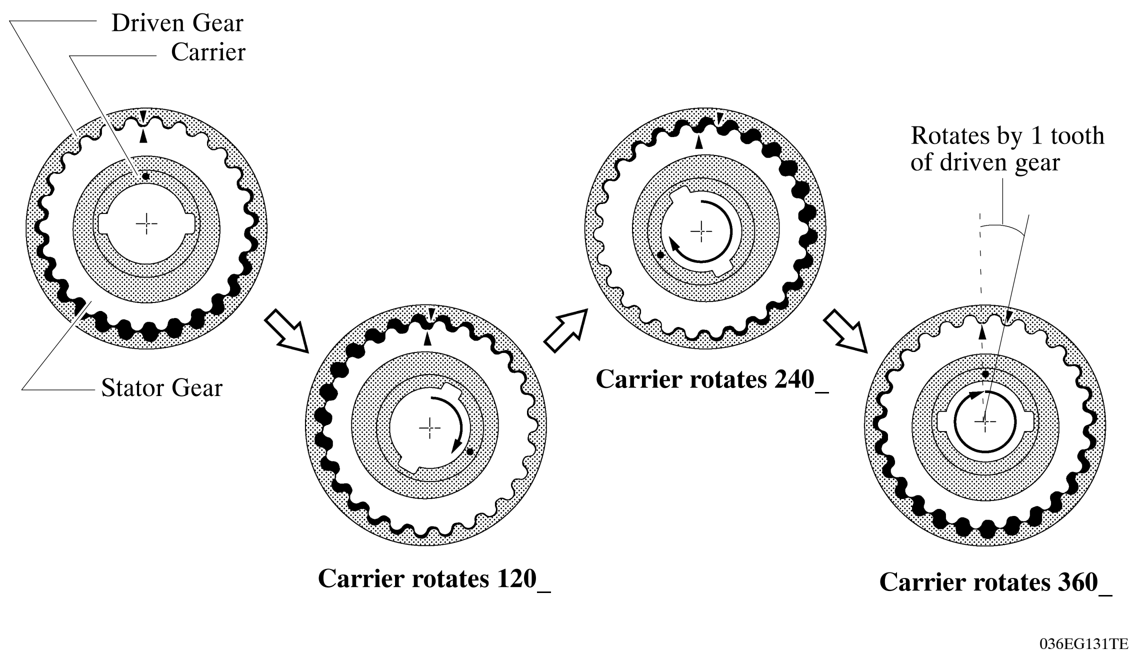


08D0EG03C

b. Cycloid Reduction Unit

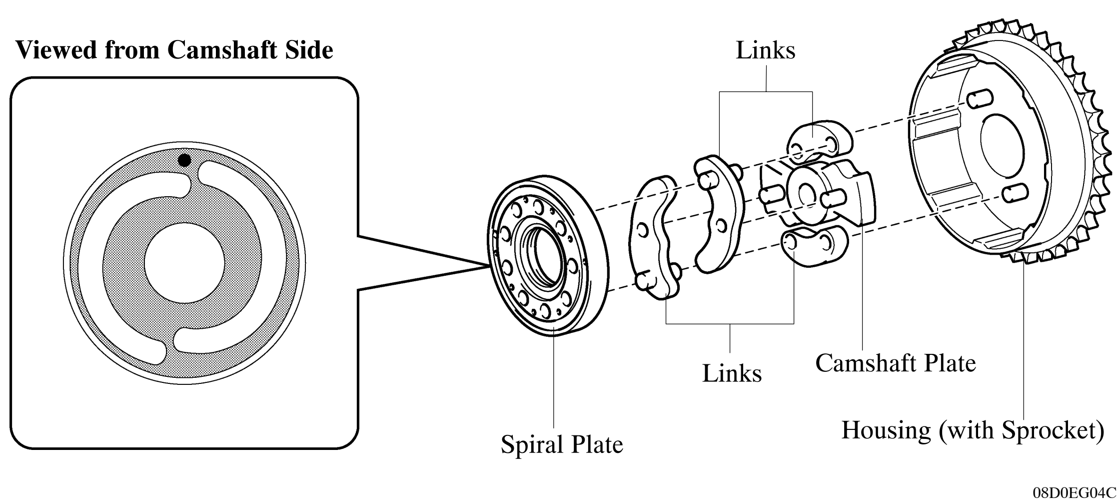
- The carrier is an eccentric cam and is engaged to the camshaft timing control motor assembly.
- The stator gear is fixed inside the housing in order to reduce the speed of the camshaft timing control motor assembly.
- The driven gear is interlinked with the stator gear and rotates through the eccentric motion of the carrier.
- The illustration shows the mechanism of the cycloid reduction unit. When the motor rotates the carrier by 1 revolution, the driven gear moves in the same direction by only 1 tooth.

▶ Mechanism of Cycloid Reduction Unit ◀



c. Link Mechanism

- The links engage with the spiral plate and housing, transferring the advance or retard action to the camshaft plate.
- The camshaft plate is fixed to the intake camshaft.



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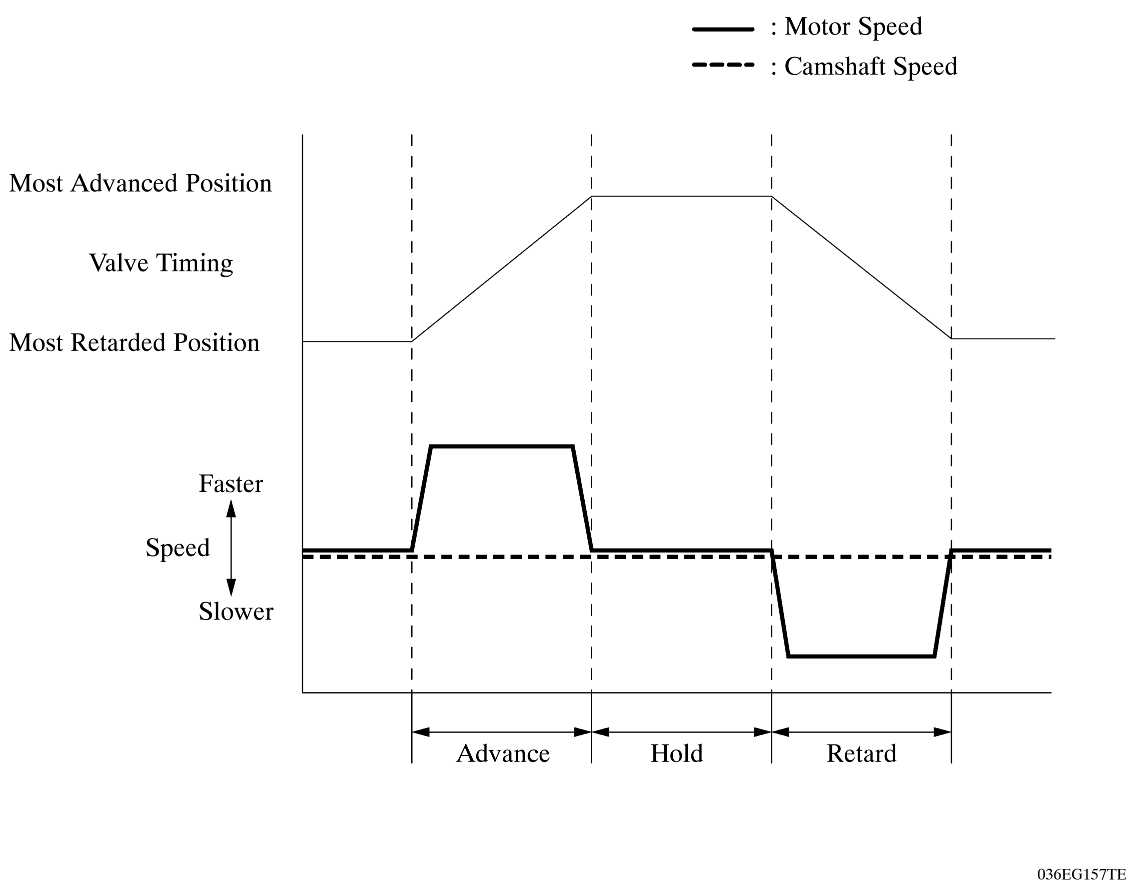
4) Operation

a. General

The ECM controls the advance and retard operation by way of the speed difference between the motor and the camshaft. The ECM maintains the valve timing by rotating the motor at the same speed as the camshaft.

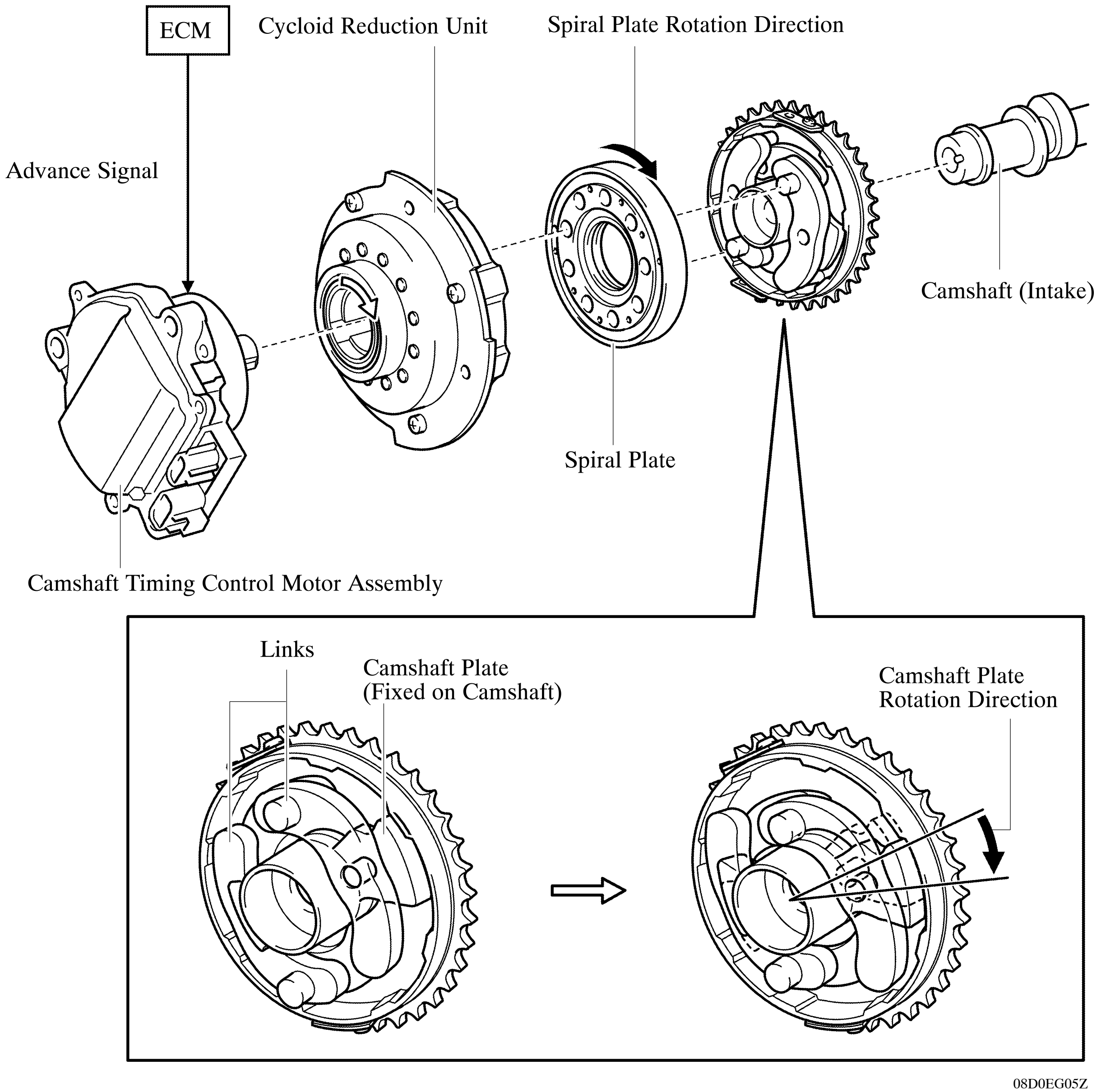
- To advance the cam timing, the motor speed becomes faster than the camshaft rotational speed.
- To retard the cam timing, the motor speed becomes slower than the camshaft rotational speed. (Depending on the camshaft speed, the motor may rotate counterclockwise.)

▶ Relationship Between Motor Rotational Speed and Advancing and Retarding Timing ◀



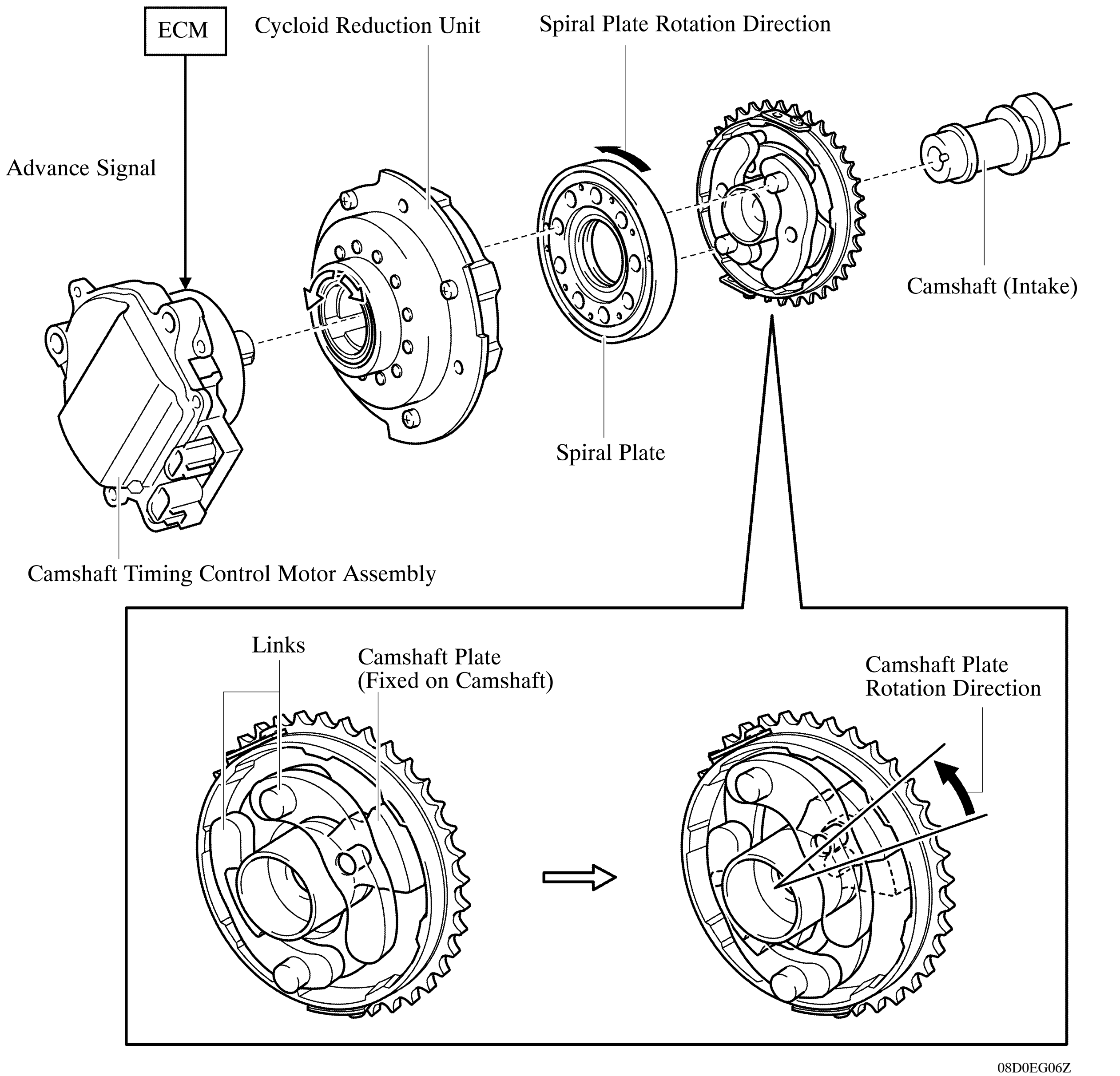
b. Advance

- As the advance signals from the ECM cause the camshaft timing control motor assembly to rotate faster than the camshaft, the spiral plate rotates clockwise via the cycloid reduction unit.
- The rotational movement of the spiral plate moves the links towards the center of rotation of the camshaft. As a result, the links rotate the camshaft plate, which is fixed to the intake camshaft, in the advance direction.



c. Retard

- As the retard signals from the ECM cause the camshaft timing control motor assembly to rotate slower than the camshaft, the spiral plate rotates counterclockwise via the reduction unit.
- The rotational movement of the spiral plate moves the links away from the center of rotation of the camshaft. As a result, the links rotate the camshaft plate, which is fixed to the intake camshaft, in the retard direction.



d. Hold

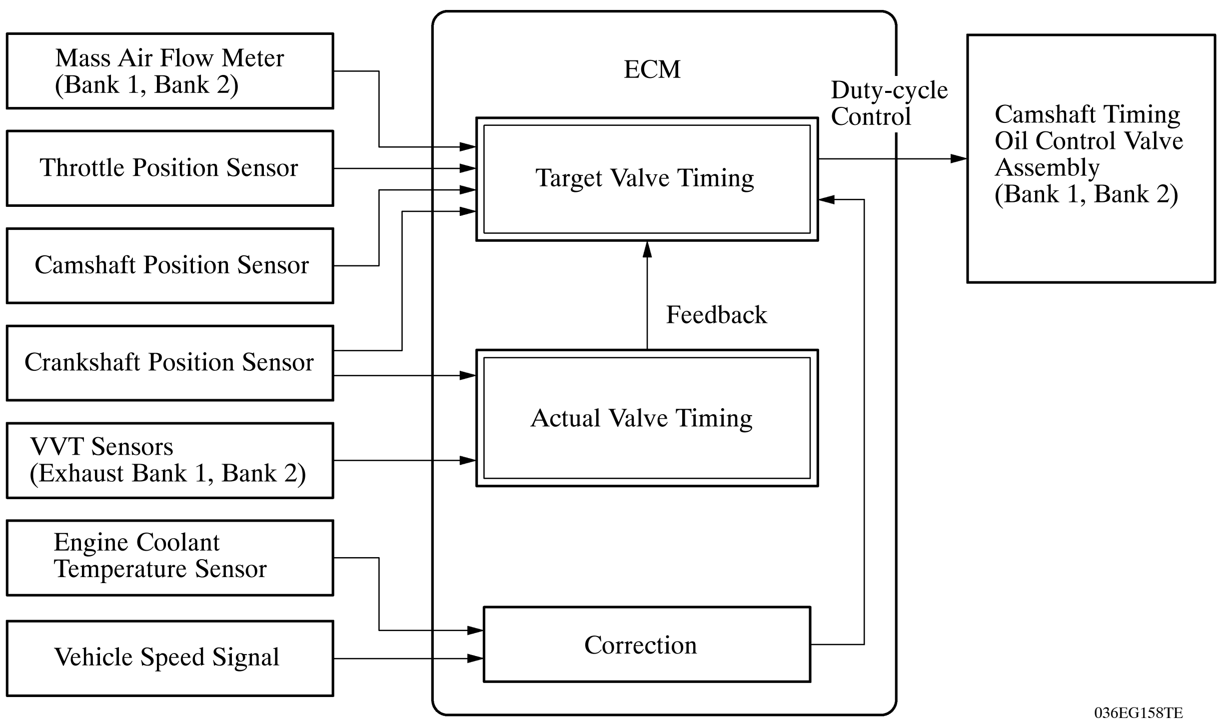
After the target valve timing has been reached, the ECM rotates the motor at the same speed as the camshaft. As a result, the link mechanism of the camshaft timing gear assembly becomes locked, thus holding the camshaft at the valve timing.

VVT-i

1) General

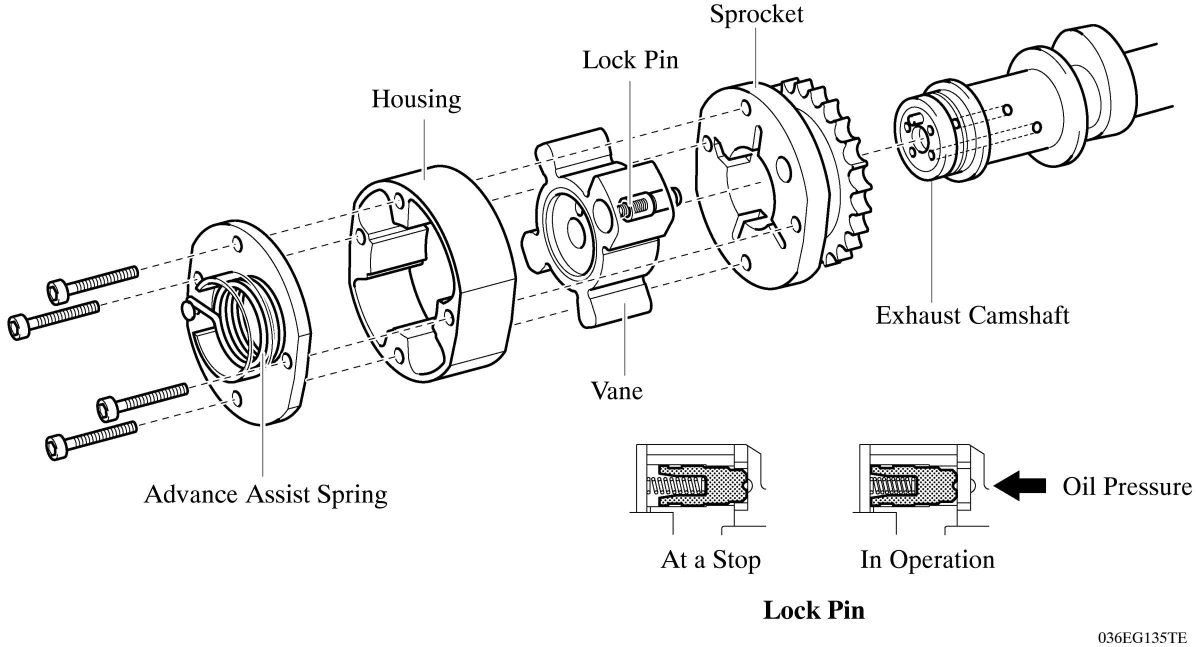
- VVT-i consists of camshaft timing exhaust gears that operate by engine oil pressure and the camshaft timing oil control valve assemblies that switch the engine oil pressure passages in accordance with the signals from the ECM.
- Based on engine speed, intake air mass, throttle position, vehicle speed, and engine coolant temperature, the ECM calculates optimal valve timing for all driving conditions. The ECM uses the calculated valve timing as the target valve timing to control the camshaft timing oil control valve assemblies. In addition, the ECM uses signals from the VVT sensors (exhaust) and the crankshaft position sensor to detect the actual valve timing, thus providing feedback control to achieve the target valve timing.

▶ System Diagram ◀



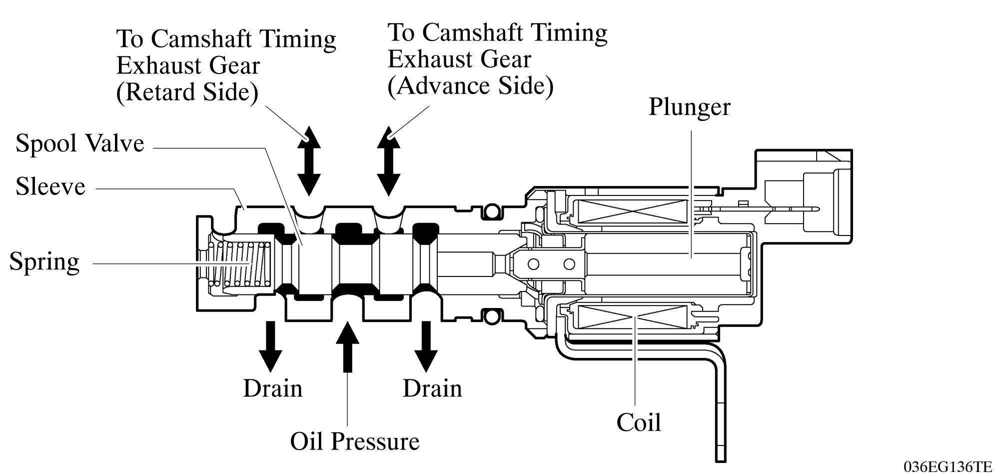
2) Camshaft Timing Exhaust Gear

- The camshaft timing exhaust gear consists of a sprocket driven by the timing chain, a housing coupled with the sprocket, and a vane coupled with the exhaust camshaft.
- The engine oil pressure sent from the advance or retard side path of the exhaust camshaft causes rotation in the camshaft timing exhaust gear vane circumferential direction to vary the exhaust valve timing continuously.
- As the engine stops, the advance assist spring moves the camshaft timing exhaust gear to the most advanced position. Then, a lock pin locks the vane to the sprocket, in order to ensure engine startability. After the engine is started, engine oil pressure acts on the hole in which the lock pin is engaged, to release the lock.



3) Camshaft Timing Oil Control Valve Assembly

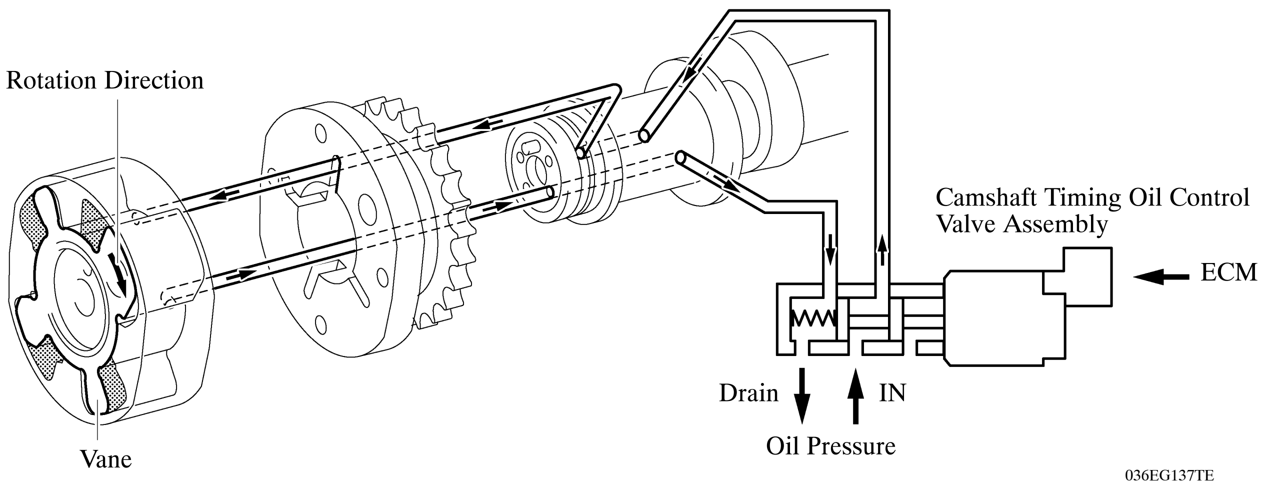
This camshaft timing oil control valve assembly controls the spool valve using duty cycle control from the ECM. This allows engine oil pressure to be applied to the camshaft timing exhaust gear advance or retard side. When the engine is stopped, the camshaft timing oil control valve assembly is in the most advanced position.



4) Operation

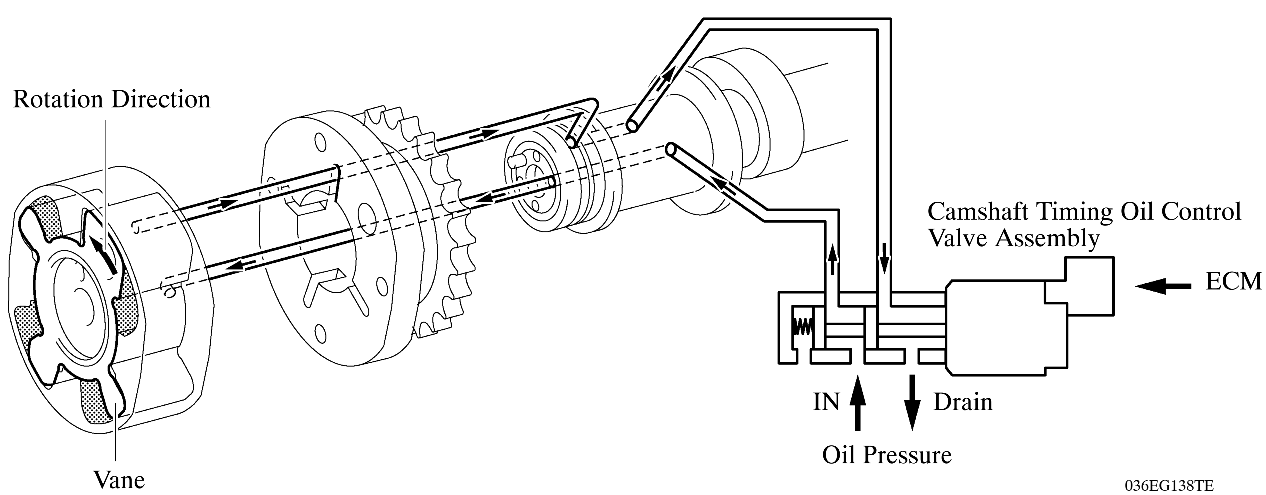
a. Advance

When the camshaft timing oil control valve assembly is positioned as illustrated below by a duty cycle provided by the ECM, the resultant oil pressure is applied to the timing advance side vane chamber to rotate the camshaft in the timing advance direction.



b. Retard

When the camshaft timing oil control valve assembly is positioned as illustrated below by a duty cycle provided by the ECM, the resultant oil pressure is applied to the timing retard side vane chamber to rotate the camshaft in the timing retard direction.



c. Hold

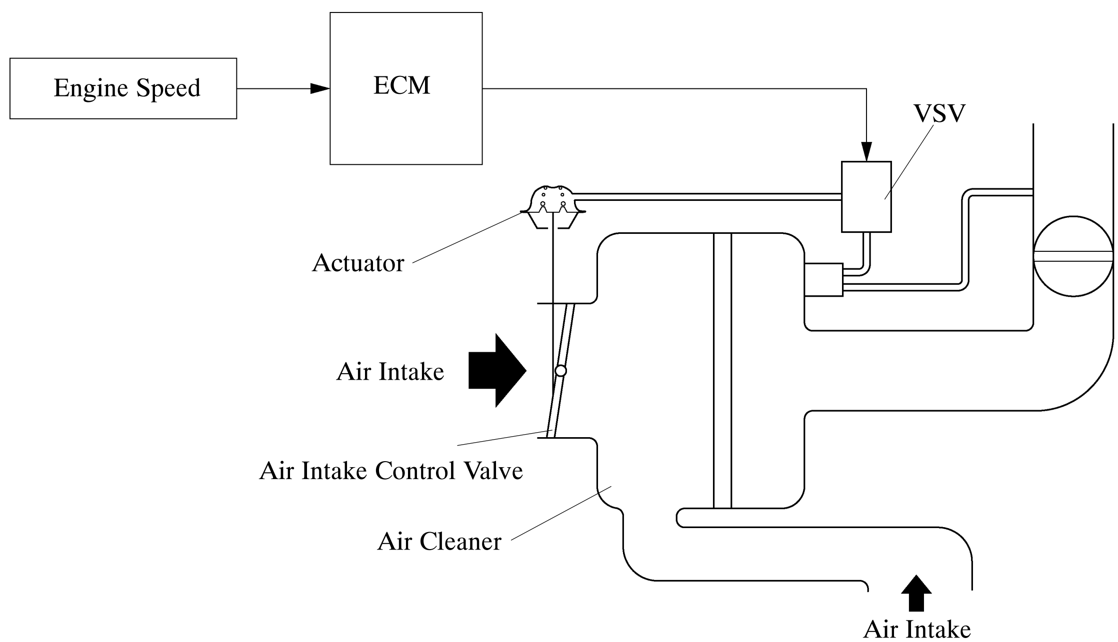
After reaching the target timing, the engine valve timing is maintained by keeping the camshaft timing oil control valve assembly in the neutral position unless the engine operating conditions change.
This maintains the valve timing at the desired target position and prevents the engine oil from running out of the oil control valve.

9. Air Intake Control System

General

- The system has a dual path design in the intake for the air cleaner box. An air intake control valve and actuator control the choice of air flow path. As a result, a reduction of intake noise in the low-speed range and an increase in the power output in the high-speed range is realized.
- The ECM controls the operation of the air intake control valve by switching the VSV according to engine conditions.

▶ Layout of Components ◀



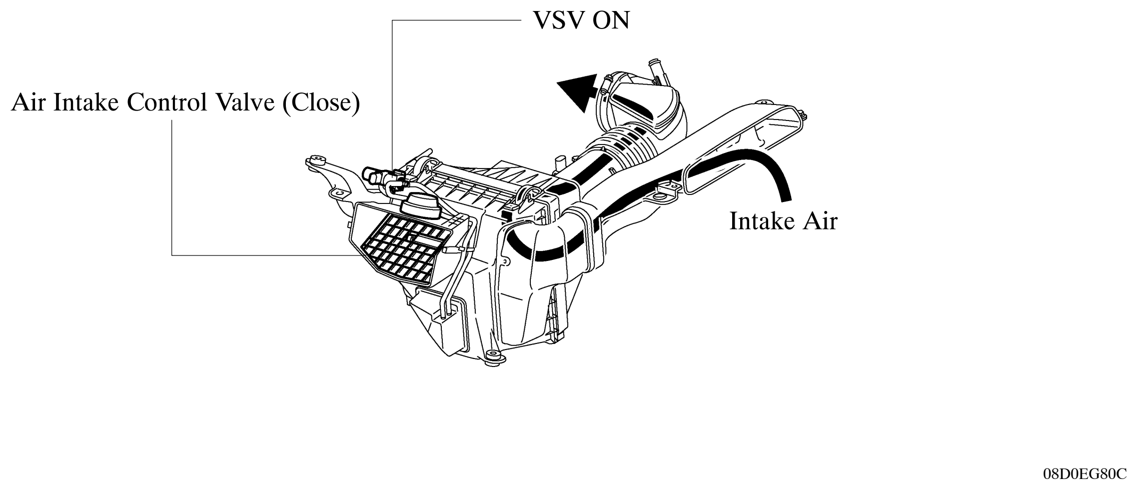
08D0EG79C

Operation

1) When the Air Intake Control Valve Closes

When the engine is operating in the low- speed, this control operates the air intake control valve to close one part of the air cleaner inlet. As a result, the air enters the air filter box via the smaller port, allowing the resonator to help to reduce the intake noise.

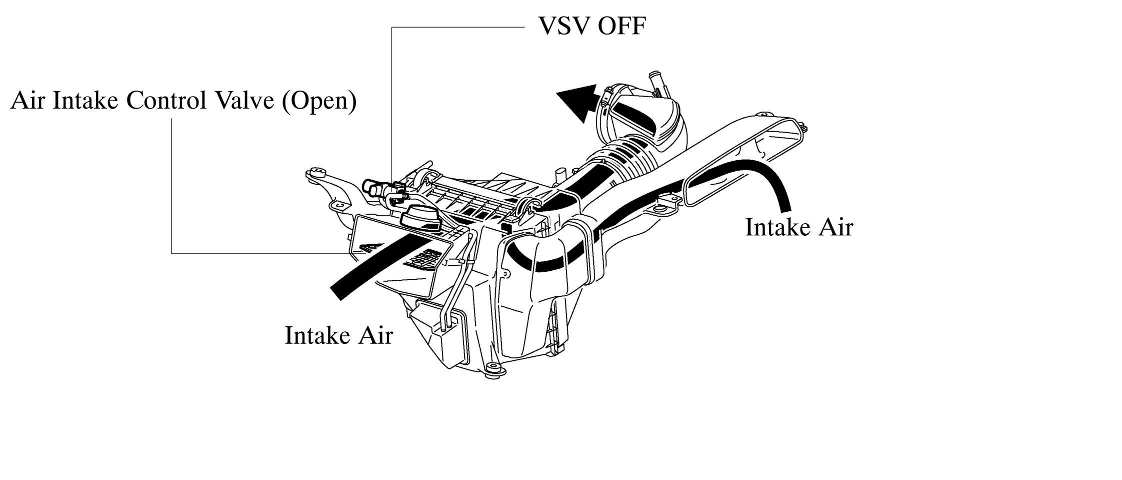
Engine Speed: Less than 3600 rpm



2) When the Air Intake Control Valve Open

When the engine is operating in the mid-speed range to high-speed range, this control operates the air intake control valve to open both sides of the air cleaner inlet. As a result, the intake area is maximized and the intake efficiency is improved.

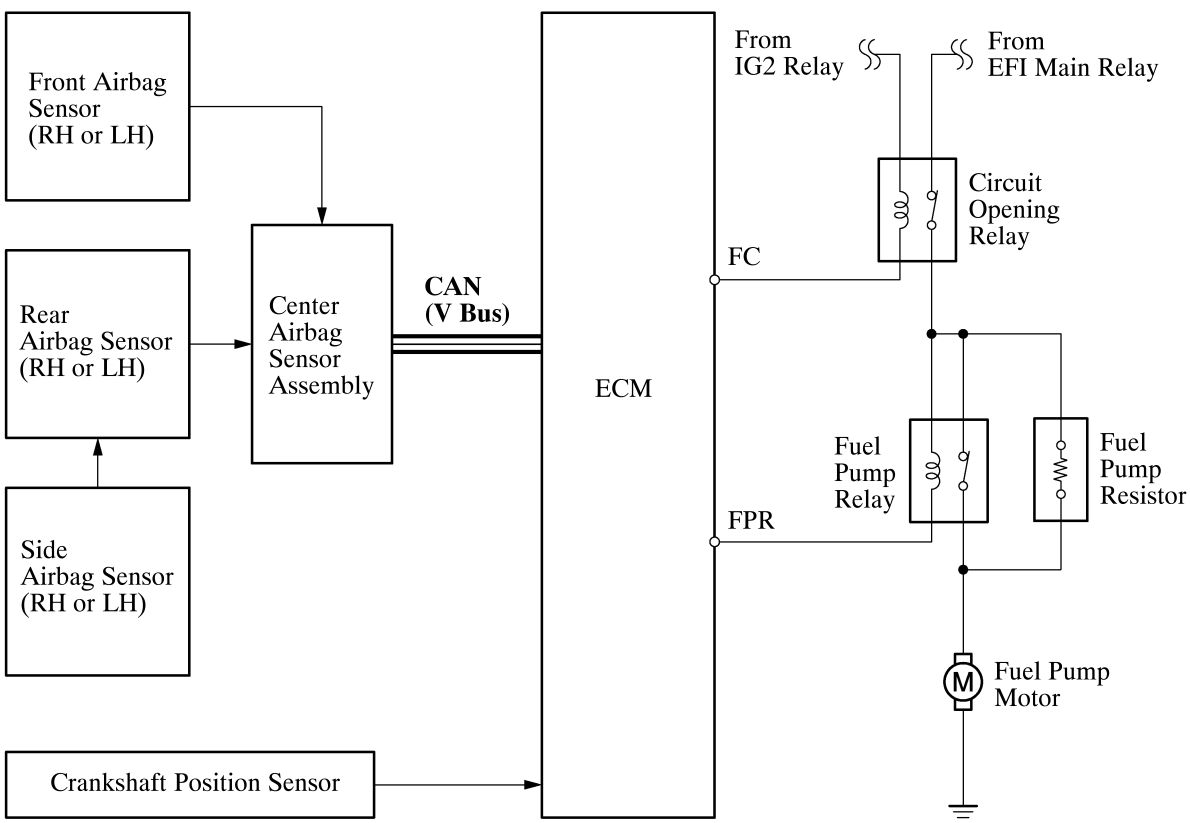
Engine Speed: More than 3600 rpm



10. Fuel Pump Control (For Low-pressure Side)

- A fuel cut function is used to stop the fuel pump once when any of the SRS airbags have deployed. In this system, the airbag deployment signal from the airbag sensor assembly is detected by the ECM, and the ECM turns the circuit opening relay off. After the fuel cut function has been activated, turning the engine switch off and then back to on (IG) cancels the fuel cut function, and the engine can be restarted.
- The ECM uses the fuel pump relay and the fuel pump resistor to control the fuel pump speed in accordance with driving conditions.

▶ System Diagram ◀



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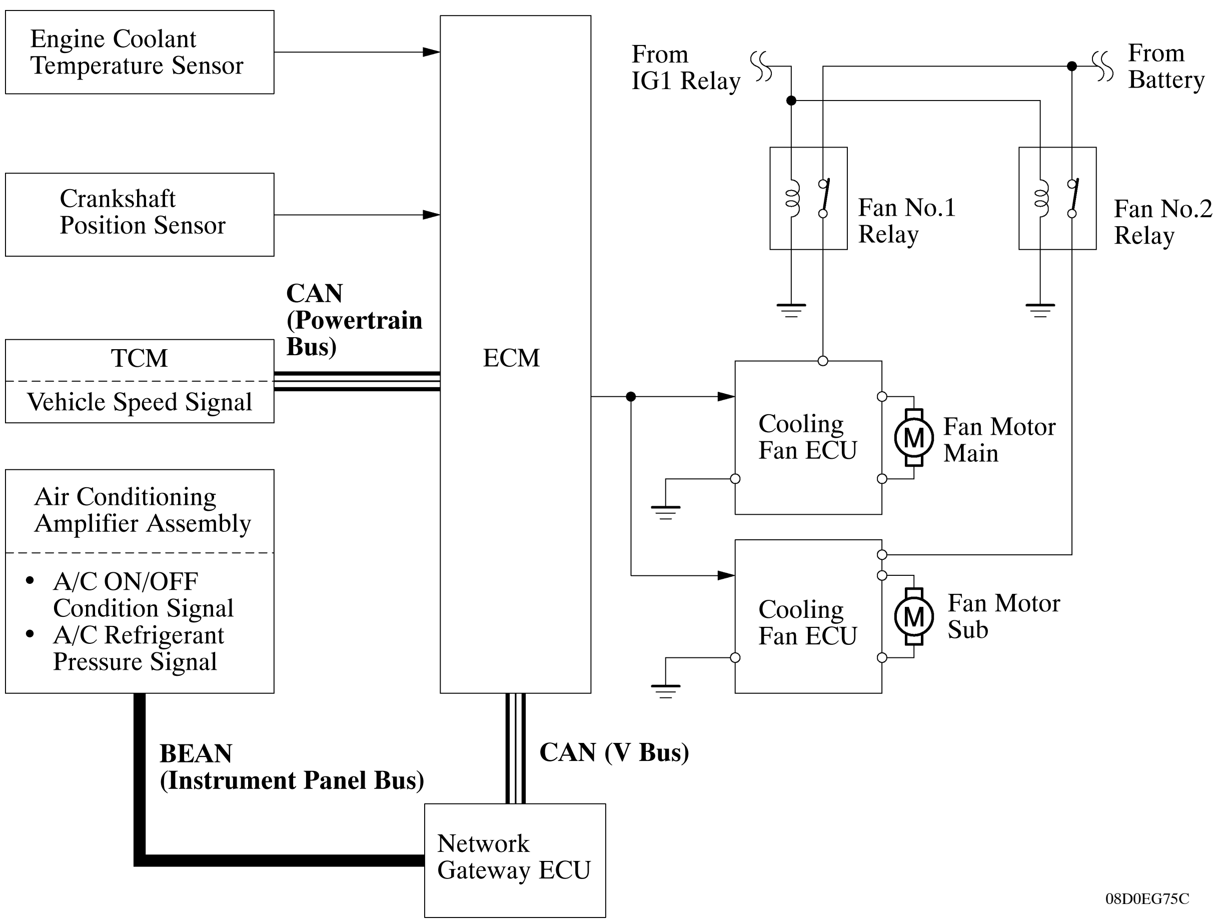
11. Cooling Fan Control System

General

A cooling fan control system is used. To achieve an optimal fan speed in accordance with the engine coolant temperature, engine speed, vehicle speed, and air conditioning operating conditions, the ECM calculates an appropriate fan speed and sends signals to the cooling fan ECU. Upon receiving the signals from the ECM, the cooling fan ECU actuates the fan motors.

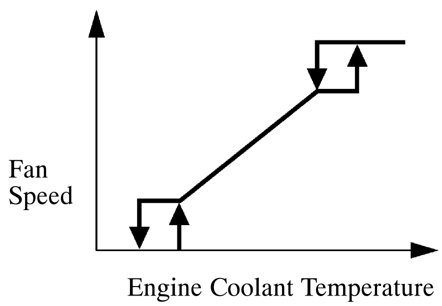
▶ System Diagram ◀



Operation

As illustrated below, the ECM determines the required fan speed by selecting the fastest fan speed from among the following:

(A) Fan speed required by the engine coolant temperature
(B) Fan speed required by the air conditioning refrigerant pressure
(C) Fan speed required by the engine speed
(D) Fan speed required by the vehicle speed



(A) Fan speed required by engine coolant temperature

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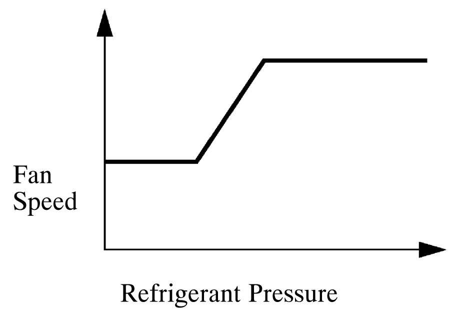

(B) Fan speed required by air conditioning refrigerant pressure

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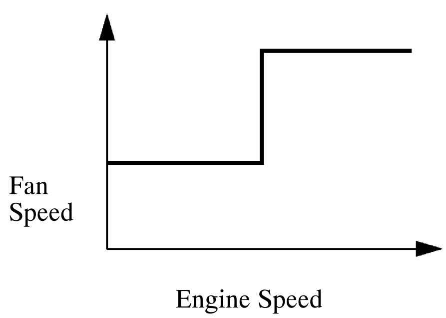
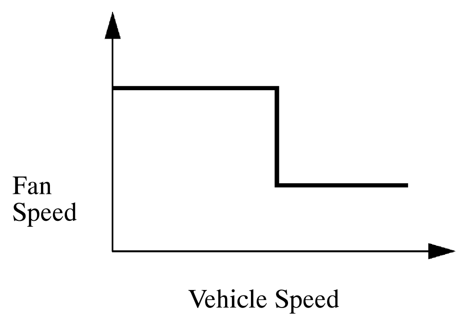


(C) Fan speed required by engine speed

189EG15



(D) Fan speed required by vehicle speed

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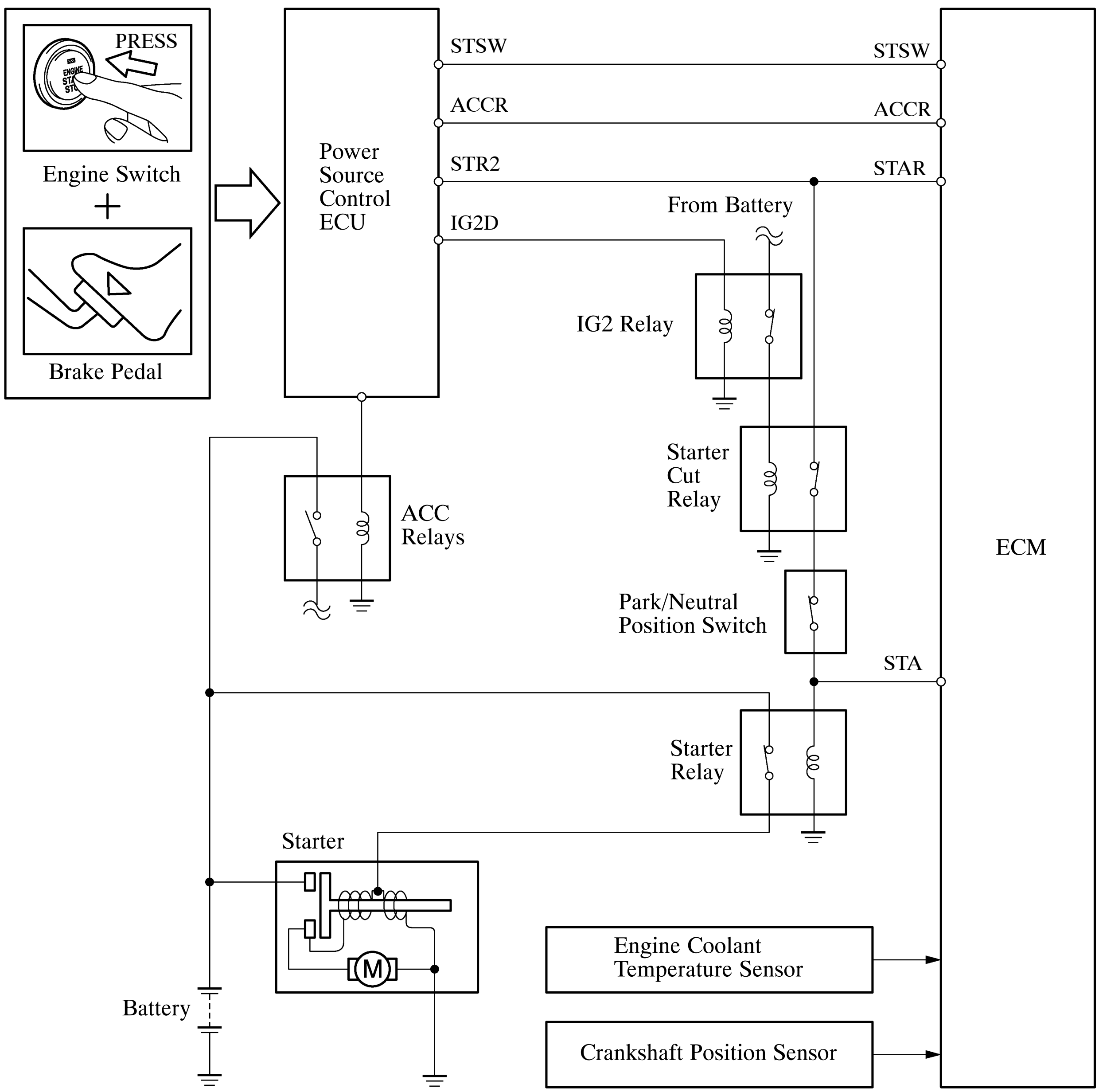
12. Cranking Hold Function

General

- Once the engine switch is pressed, this function continues to operate the starter until the engine has started, provided that the brake pedal is depressed. This prevents starting failure and prevents the engine from being cranked after it has started.
- When the ECM detects a start signal from the power source control ECU, this system monitors the engine speed (NE signal) and continues to operate the starter until it has determined that the engine has started. Furthermore, even if the ECM detects a start signal from the power source control ECU, this system will not operate the starter if the ECM has determined that the engine has already started.

▶ System Diagram ◀



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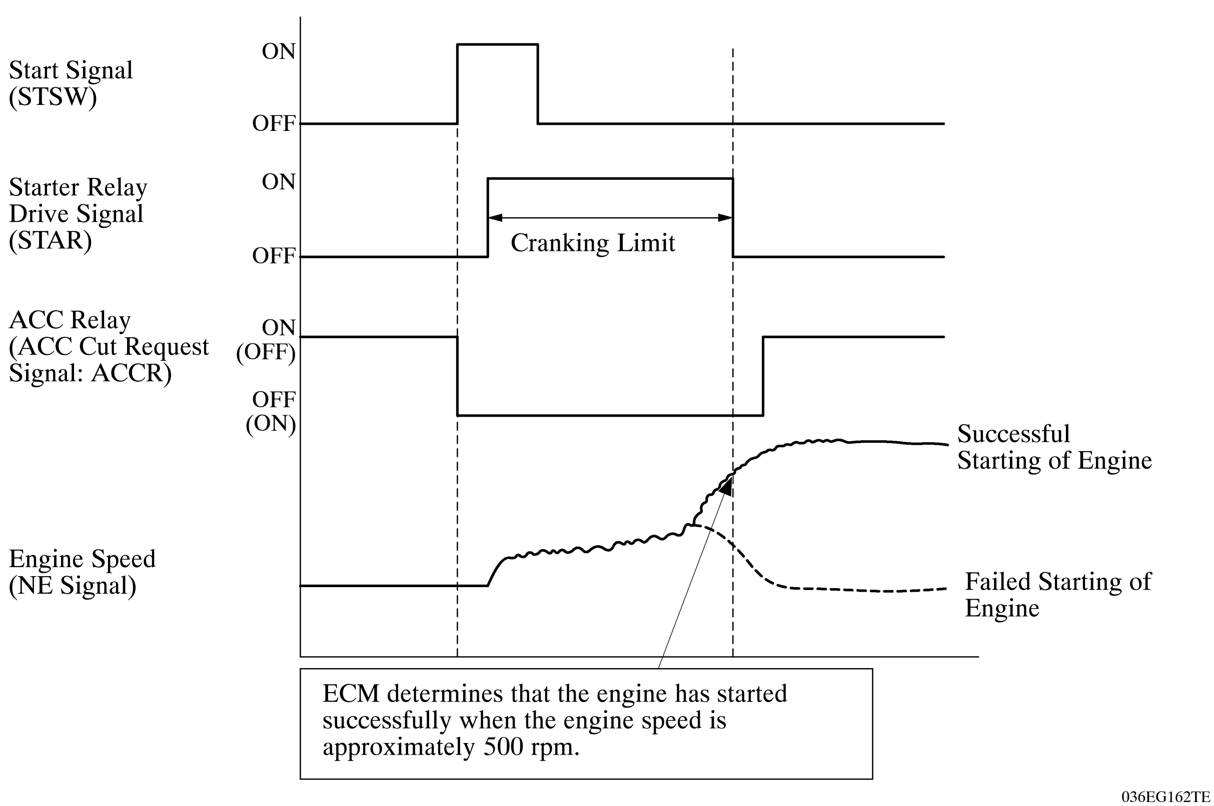
Operation

- As indicated in the following timing chart, when the ECM detects a STSW signal (start signal) from the power source control ECU, the ECM outputs STAR signal (starter relay drive signal) through the starter cut relay to the starter relay and actuates the starter. The ECM also outputs ACCR signal (ACC cut request signal) to the power source control ECU. Thus, the power source control ECU will not energize the ACC relay.
- After the starter operates and the engine speed becomes higher than approximately 500 rpm, the ECM determines that the engine has started and stops the output of the STAR signal to the starter relay and the output of ACCR signal to the power source control ECU. Thus, the starter operation stops and the power source control ECU energizes the ACC relay.
- If the engine has a problem and does not start, the starter operates as long as its maximum continuous operation time and stops automatically. The maximum continuous operation time varies depending on the engine coolant temperature. When the engine coolant temperature is extremely low, the cranking limit will be long and when the engine is warmed up sufficiently, it will be short.
- 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 following protection features:
  - While the engine is running normally, the starter does not operate.
  - Even if the driver keeps pressing the engine switch, the ECM stops the output of the STAR and ACCR signals when the engine speed becomes higher than 1200 rpm. Thus, the starter operation will stop and the power source control ECU will energize the ACC relay.
  - In case the driver keeps pressing the engine switch and the engine does not start, the ECM stops the output of the STAR and ACCR signals after 30 seconds have elapsed. Thus, the starter operation will stop and the power source control ECU will energize the ACC relay.
  - In case the ECM cannot detect an engine speed signal while the starter is operating, the ECM will immediately stop the output of the STAR and ACCR signals. Thus, the starter operation will stop and the power source control ECU will energize the ACC relay.

▶ Timing Chart ◀



13. Diagnosis

- When the ECM detects a malfunction, the ECM records information related to the fault. Furthermore, the MIL (Malfunction Indicator Lamp) in the combination meter illuminates or blinks to inform the driver.
- The ECM will also store a DTC (Diagnostic Trouble Code) for the malfunction. The DTC can be accessed using the intelligent tester.
- For details, refer to the LEXUS IS F Repair Manual (Pub. No. RM08E0E).

Service Tip

- The ECM uses the CAN protocol for diagnostic communication. For details, refer to the LEXUS IS F Repair Manual (Pub. No. RM08E0E).
- To clear DTCs that are stored in the ECM, use the intelligent tester, disconnect the battery terminal or remove the EFI fuse and ETCS fuse for 1 minute or longer.

14. Fail-safe

When a sensor malfunction is detected, there is a possibility of an engine or other malfunction occurring if the ECM were to continue to control the engine control system in the normal way. To prevent such a problem, the fail-safe function of the ECM 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 LEXUS IS F Repair Manual (Pub. No. RM08E0E).