■ ENGINE CONTROL SYSTEM

1. General

- The engine is controlled by the THS ECU. The THS ECU determines the motive force required by the driver in accordance with the pedal effort applied by the driver on the accelerator. Then, the THS ECU determines the driving conditions of the vehicle in accordance with the vehicle speed, vehicle load, and various sensor signals. Furthermore, the THS ECU starts and stops the engine in accordance with the motive force required by the driver, regardless of the driving conditions, and generates the required engine motive force.
- The engine control system of the 3MZ-FE engine on the RX400h has following system.

System	Outline	RX400h THS ECU	RX330 ECM
EFI (Electronic Fuel Injection)	• An L-type EFI system directly detects the intake air mass with a hot wire type air flow meter. • The fuel injection system is a sequential multiport fuel injection system. • Fuel injection takes two forms: Synchronous injection, which always takes place with the same timing in accordance with the basic injection duration and an additional correction based on the signals provided by the sensors. Non-synchronous injection, which takes place at the time an injection request based on the signals provided by the sensors is detected, regardless of the crankshaft position. • Synchronous injection is further divided into group injection during a cold start, and independent injection after the engine is started.	○	○
ESA (Electronic Spark Advance)	• Ignition timing is determined by the THS ECU/ECM based on signals from various sensors. The THS ECU/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 (IGT) ignition signal to the igniter.	○	○
ETCS-i (Electronic Throttle Control System-intelligent) (See page EG-46)	• Optimally controls the throttle valve opening in accordance with the amount of accelerator pedal effort and the condition of the engine and the vehicle. • A link-less type is used, without an accelerator cable. • An accelerator pedal position sensor is provided on the accelerator pedal. • A no-contact type throttle position sensor and accelerator pedal position sensor are used.	○	○
VVT-i (Variable Valve Timing-intelligent) (See page EG-49)	• Controls the intake camshaft to an optimal valve timing in accordance with the engine conditions and the control request received from the THS ECU/ECM.	○	○
	• The maximum retard closing timing of the intake valve has been changed from 64° to 92° ABDC (After Bottom-Dead-Center). As a result, the cold-starting performance of the engine has been improved.	○	-
Air Fuel Ratio Sensor, Oxygen Sensor Heater Control	Maintains the temperature of the air fuel ratio sensor or oxygen sensor at an appropriate level to increase accuracy of detection of the oxygen concentration in the exhaust gas.	○	○

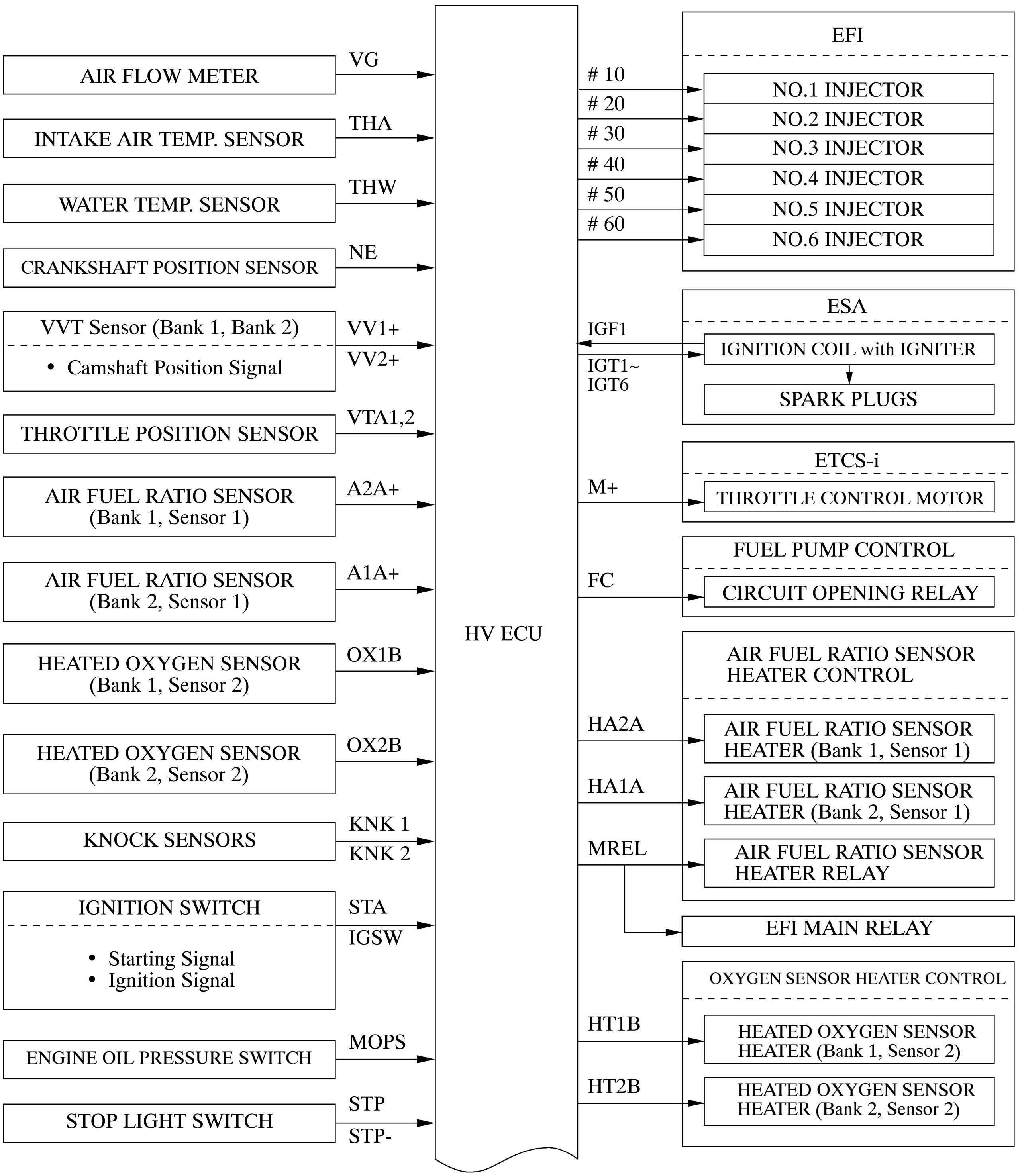
(Continued)

System	Outline	RX400h THS ECU	RX330 ECM
Cooling Fan Control (See page EG-53)	The THS ECU/ECM 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 has been improved.	○	○
Fuel Pump Control	• Fuel pump operation is controlled by signal from the THS ECU/ECM. • A fuel cut control is used to stop the fuel pump when the airbag is deployed during front or side collision.	○	○
Evaporative Emission Control	The THS ECU controls the purge flow of evaporative emission (HC) in the charcoal canister in accordance with engine conditions.	○	○
THS Immobilizer	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid ignition key.	○	-
Diagnosis (See page EG-55)	• When the THS ECU/ECM detects a malfunction, the THS ECU/ECM diagnoses and memorizes the failed section. • All the DTCs (Diagnostic Trouble Codes) have been made to correspond to the SAE controlled codes.	○	○
Fail-Safe (See page EG-55)	When the THS ECU/ECM detects a malfunction, the THS ECU/ECM stops or controls the engine according to the data already stored in the memory.	○	○

EG

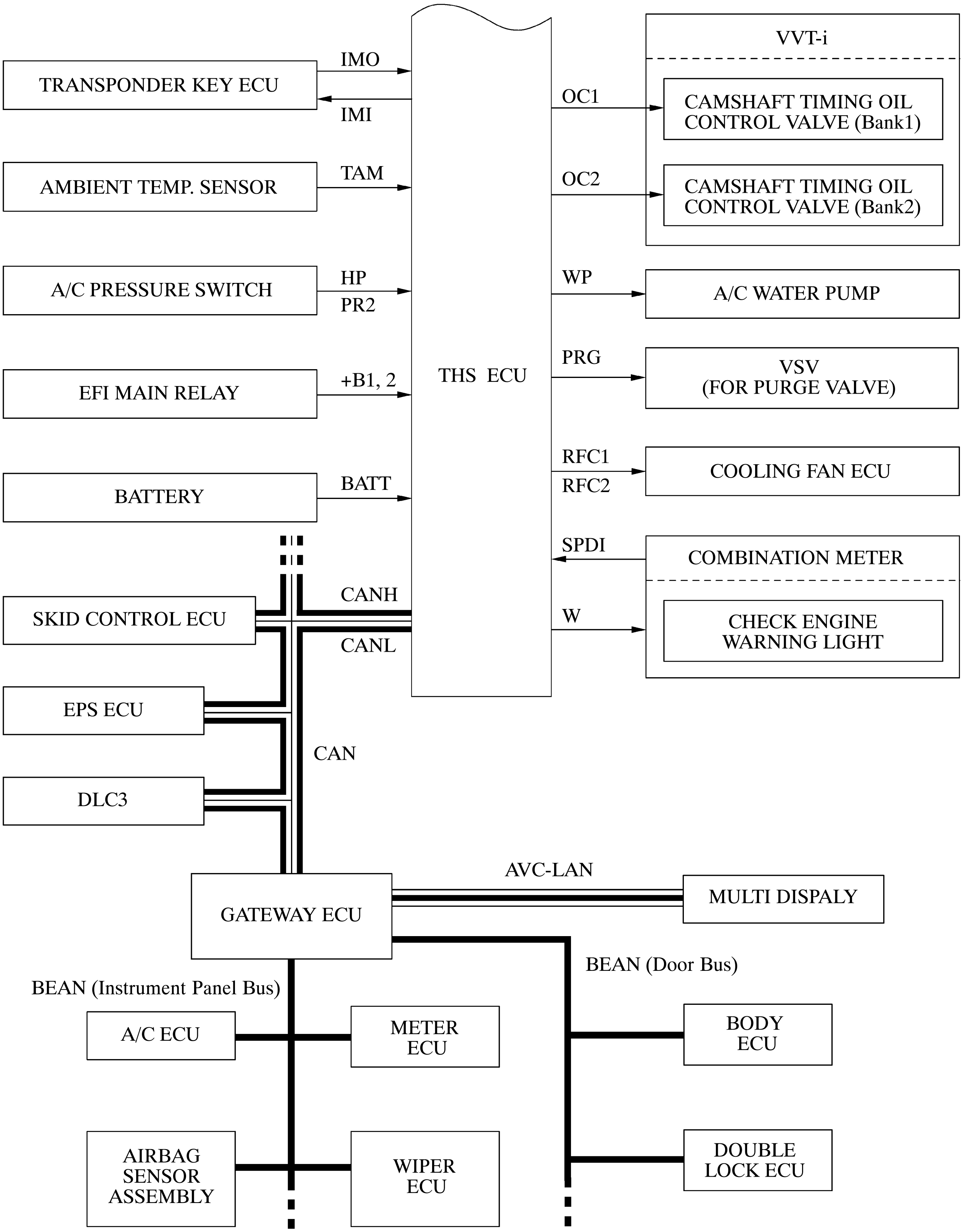
2. Construction

The configuration of the engine control system in the 3MZ-FE engine on the RX400h is as shown in the following chart.



(Continued)

278EG03

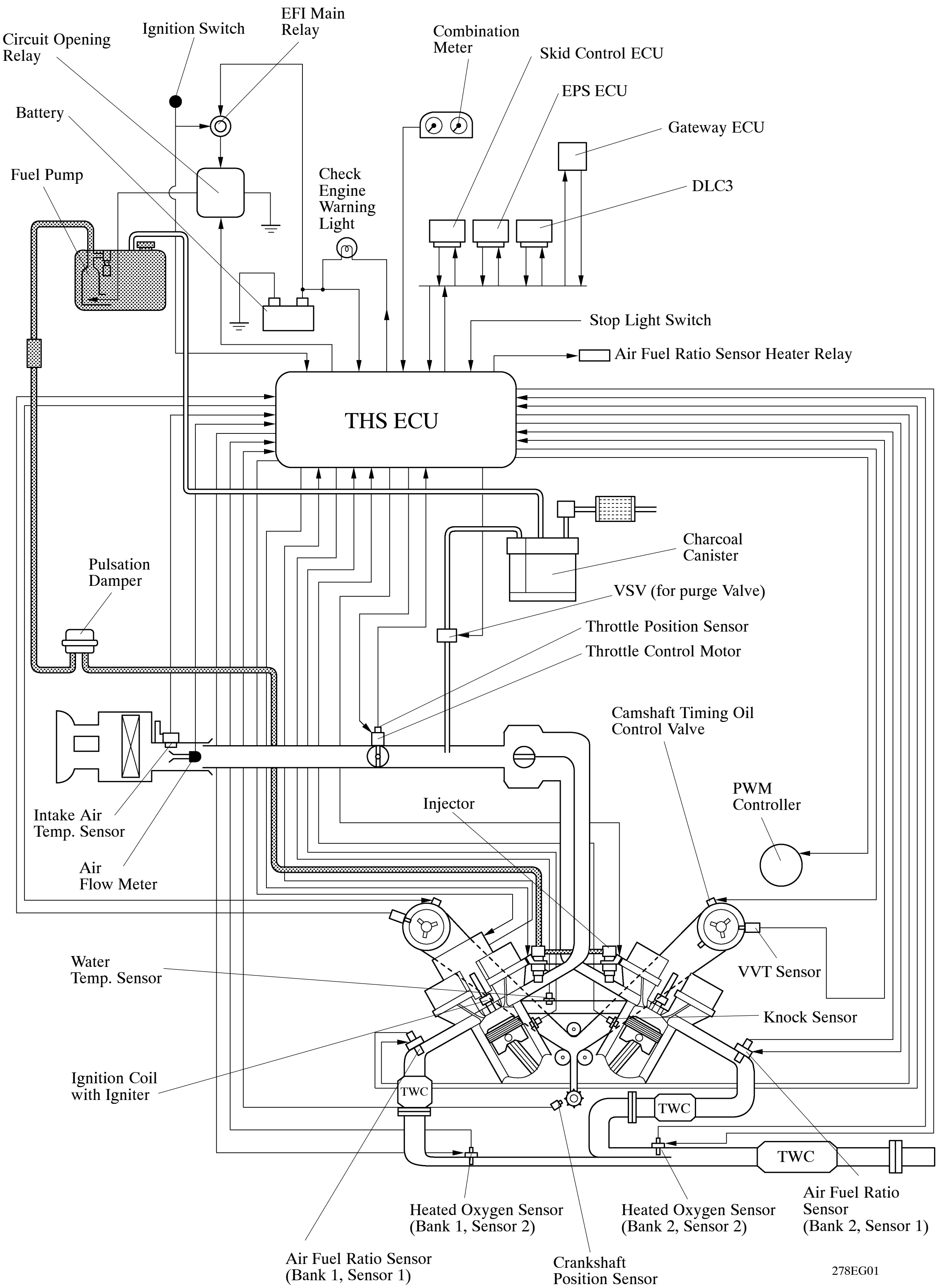

TRANSPONDER KEY ECU
IMO
IMI
AMBIENT TEMP. SENSOR
TAM
A/C PRESSURE SWITCH
HP
PR2
EFI MAIN RELAY
+B1, 2
BATTERY
BATT
THS ECU
VVT-i
OC1
CAMSHAFT TIMING OIL CONTROL VALVE (Bank1)
OC2
CAMSHAFT TIMING OIL CONTROL VALVE (Bank2)
WP
A/C WATER PUMP
PRG
VSV (FOR PURGE VALVE)
RFC1
RFC2
COOLING FAN ECU
SPDI
COMBINATION METER
W
CHECK ENGINE WARNING LIGHT
SKID CONTROL ECU
CANH
CANL
EPS ECU
CAN
DLC3
GATEWAY ECU
AVC-LAN
MULTI DISPALY
BEAN (Door Bus)
BEAN (Instrument Panel Bus)
A/C ECU
METER ECU
BODY ECU
AIRBAG SENSOR ASSEMBLY
WIPER ECU
DOUBLE LOCK ECU

278EG04

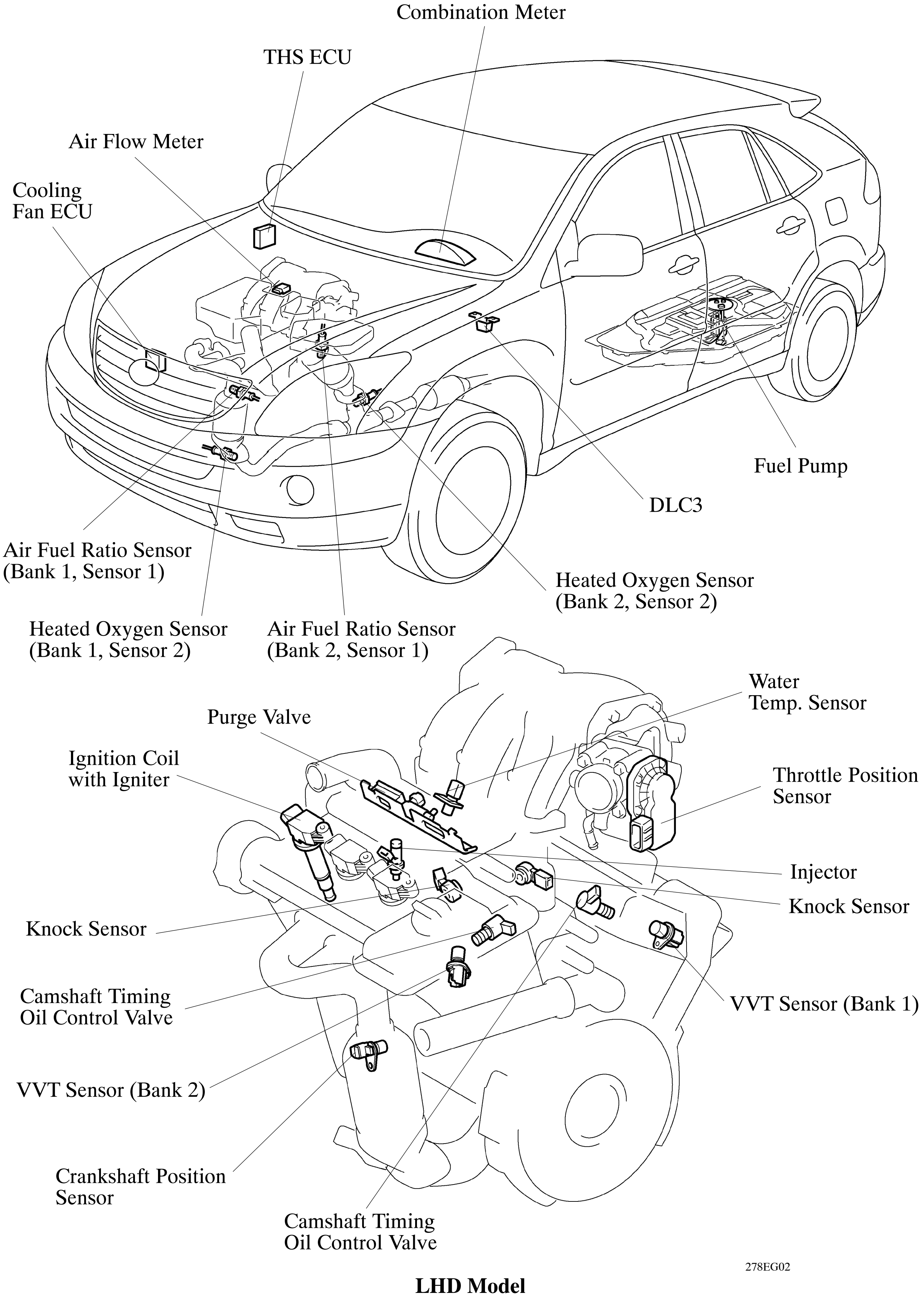
▶ MPX Communication ◀

Type	ECU	Signals Exchanged with ECU	
		Transmission Signals	Reception Signals
CAN	Skid Control ECU	—	• Engine speed • Ambient Temp. sensor
	EPS ECU	—	• Test mode • Engine speed
BEAN (Instrument Panel Bus)	A/C ECU	—	• Water Temp. sensor • Engine speed • Ambient Temp. sensor
	Airbag Sensor Assembly	—	• Test mode • Engine speed
	Wiper ECU	—	• Engine speed
	Meter ECU	Fuel Sender Gauge Level	• Water Temp. sensor • Engine speed • Fuel injection volume • Engine oil pressure switch • Test mode • Fuel lid sensor
BEAN (Door Bus)	Double Lock ECU	—	• Engine speed • Test mode
	Body ECU	—	• Engine speed • Test mode
AVC-LAN	Multi Display	—	• Water Temp. sensor • Engine oil pressure switch • Test mode

3. Engine Control System Diagram



4. Layout of Main Components



LHD Model

5. Main Components of Engine Control System

General

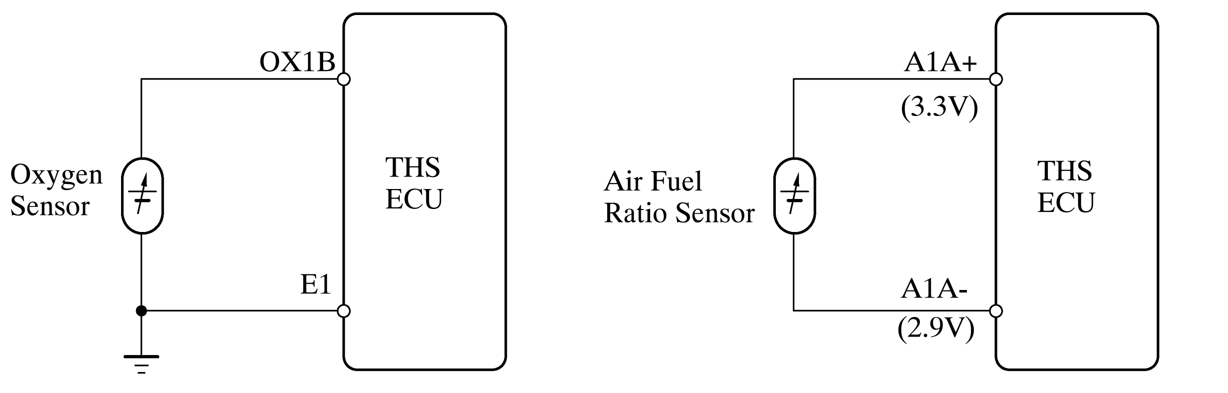
The main components of the 3MZ-FE engine control system are as follows:

Components	Outline	Quantity	Function	RX400h	RX330
THS ECU	32-bit CPU	1	The THS ECU optimally controls the EFI and ESA to suit the operating conditions of the engine in accordance with the signals provided by the sensors.	○	-
Oxygen Sensor (Bank 1, Sensor 2) (Bank 2, Sensor 2)	with Heater Type (Cup Type)	2	This sensor detects the oxygen concentration in the exhaust emission by measuring the electromotive force which is generated in the sensor itself.	○	○
Air Fuel Ratio Sensor (Bank 1, Sensor 1) (Bank 2, Sensor 1)	with Heater Type (Planar Type)	2	As with the oxygen sensor, this sensor detects the oxygen concentration in the exhaust emission. However, it detects the oxygen concentration in the exhaust emission linearly.	○	○
Air Flow Meter	Hot-wire Type	1	This sensor has a built-in hot-wire to directly detect the intake air volume.	○	○
Crankshaft Position Sensor (Rotor Teeth)	Pick-up Coil Type (36-2)	1	This sensor detects the engine speed and performs the cylinder identification.	○	○
VVT Sensor LH, RH (Rotor Teeth)	Pick-up Coil Type (3)	2	This sensor performs the cylinder identification.	○	○
Water Temperature Sensor	Thermistor Type	1	This sensor detects the water temperature by means of an internal thermistor.	○	○
Intake Air Temperature Sensor	Thermistor Type	1	This sensor detects the intake air temperature by means of an internal thermistor.	○	○
Knock Sensor 1,2	Built-in Piezoelectric Type (Flat Type)	2	This sensor detects an occurrence of the engine knocking indirectly from the vibration of the cylinder block caused by the occurrence of engine knocking.	○	○
Throttle Position Sensor	No-contact Type	1	This sensor detects the throttle valve opening angle.	○	○
Injector	12-Hole Type	6	The injector is an electromagnetically-operated nozzle which injects fuel in accordance with signals from the THS ECU.	○	○

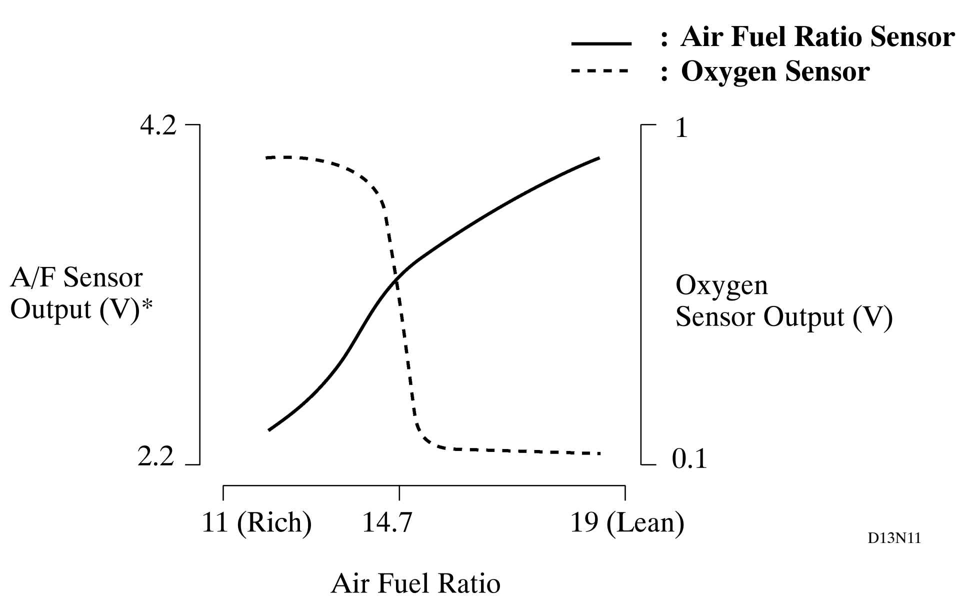
Oxygen Sensor and Air Fuel Ratio Sensor

1) General

- The oxygen sensor and the air fuel ratio sensor differ in output characteristics.
- The output voltage of the oxygen sensor changes in accordance with the oxygen concentration in the exhaust emission. The THS ECU uses this output voltage to determine whether the present air-fuel ratio is richer or leaner than the stoichiometric air-fuel ratio.
- Approximately 0.4V 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 THS ECU converts the changes in the output amperage into voltage in order to linearly detect the present air-fuel ratio.



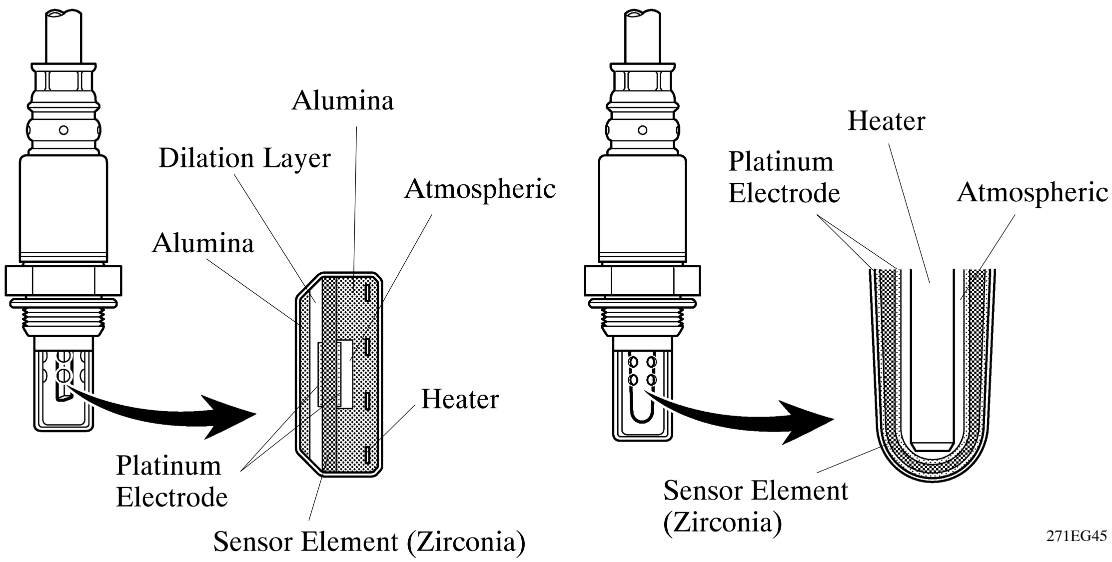
Oxygen Sensor Circuit **Air Fuel Ratio Sensor Circuit**



*: This calculation value is used internally in the THS ECU, and is not a THS ECU terminal voltage.

2) **Construction**

- The basic construction of the 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 planer type sensor uses alumina, which excels in heat conductivity and insulation, to integrate a sensor element with a heater, thus improving the warm-up performance of the sensor.



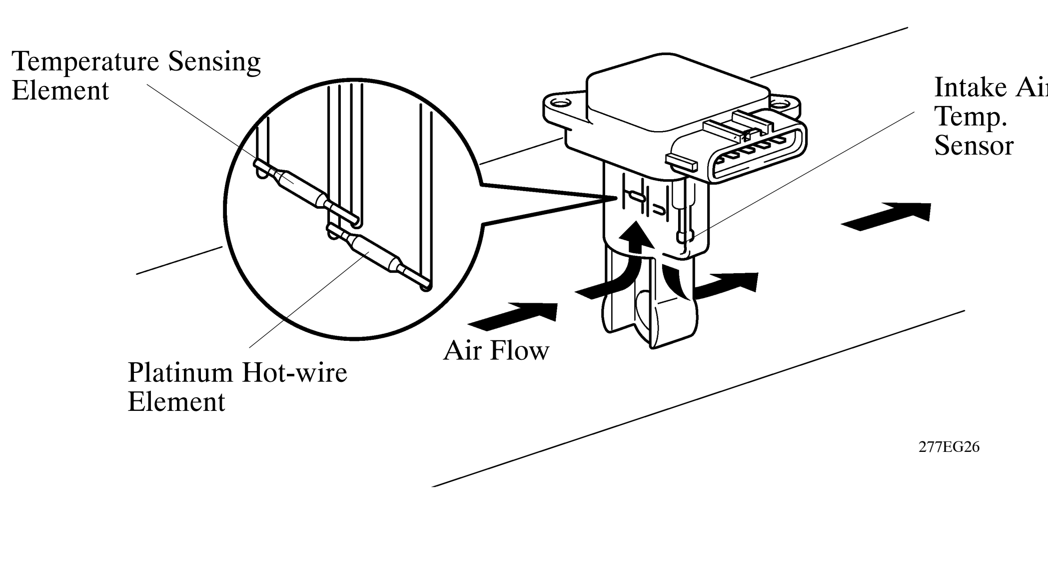
Planer Type Air Fuel Ratio Sensor **Cup Type Oxygen Sensor**

▶ **Warm-up Specification** ◀

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

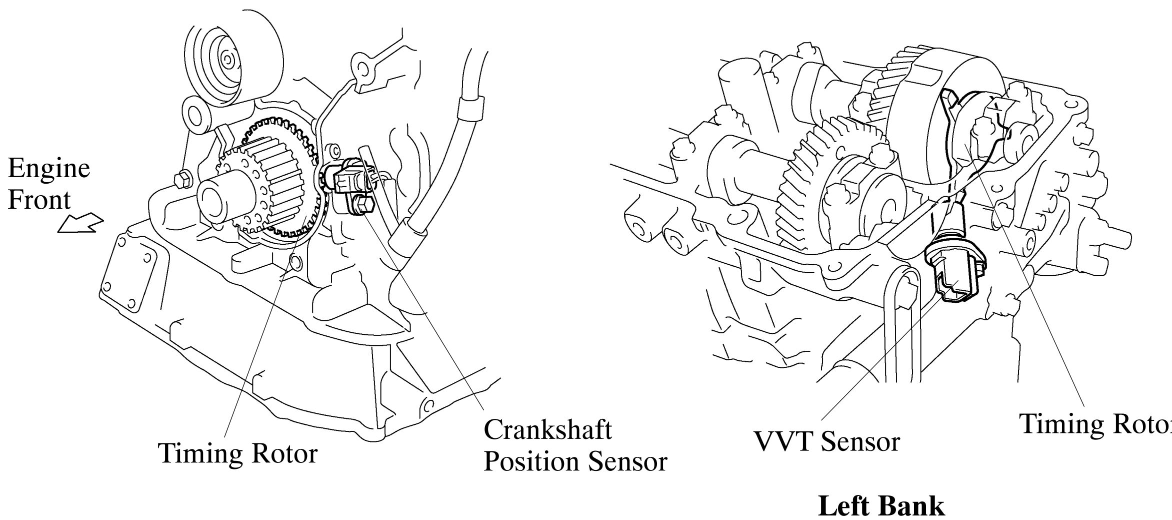
Air Flow Meter

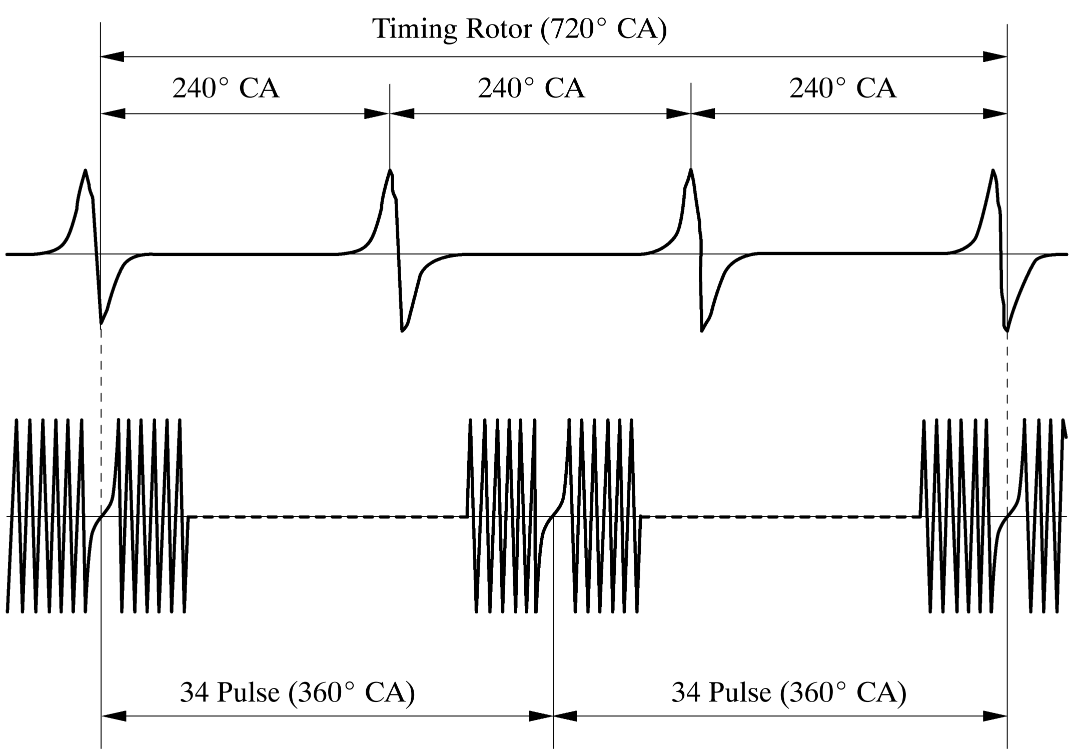
- This air flow meter, which is a plug-in type, allows a portion of the intake air to flow through the detection area. By directly measuring the mass and the flow rate of the intake air, the detection precision has been improved and the intake air resistance has been reduced.
- This air flow meter has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



Crankshaft Position and VVT Sensor

- The timing rotor of the crankshaft consists of 34 teeth, with 2 teeth missing. The crankshaft position sensor outputs the crankshaft rotation signals every 10°, and the missing teeth are used to determine the top-dead-center.
- The VVT sensors are mounted on the right and left banks of the cylinder heads. To detect the camshaft position, these sensors pick up the protrusion of the timing rotor that is secured to the camshaft in front of the VVT controller. In addition, each sensor generates 3 pulses for every 2 revolutions of the crankshaft.



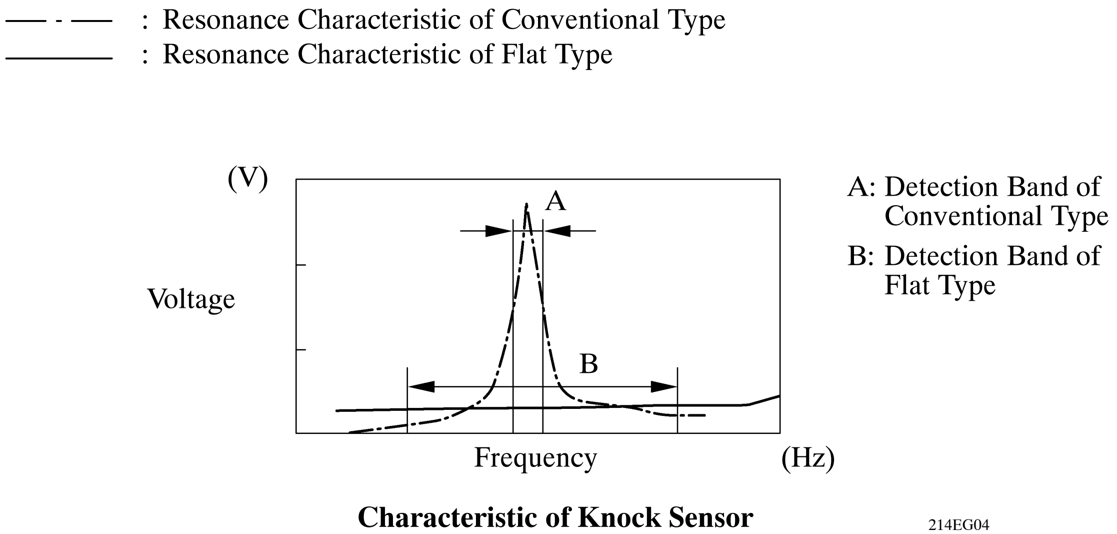


277EG24

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.

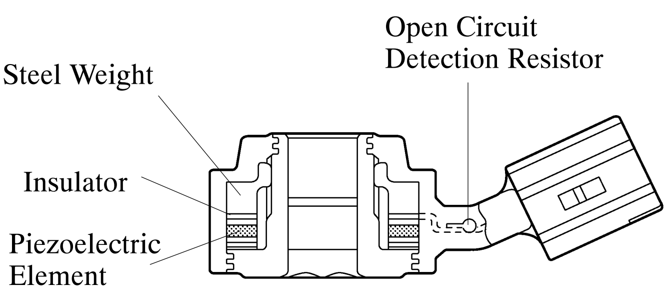


Characteristic of Knock Sensor

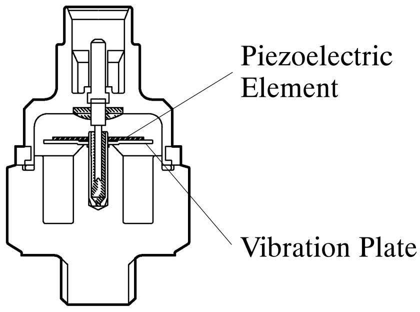
EG

2) Construction

- The flat type knock sensor is installed on the engine through the stud bolt installed on the cylinder block. For this reason, a hole for the stud bolt is running through in the center of the sensor.
- Inside of the sensor, a steel weight is located on the upper portion and a piezoelectric element is located under the weight through the insulator.
- The open/short circuit detection resistor is integrated.



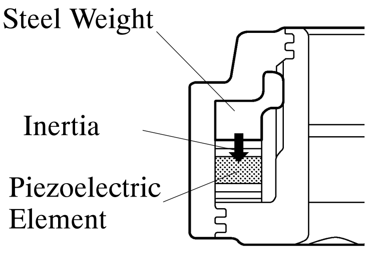
Flat Type Knock Sensor (Non-Resonant Type)



Conventional Type Knock Sensor (Resonant Type)

3) Operation

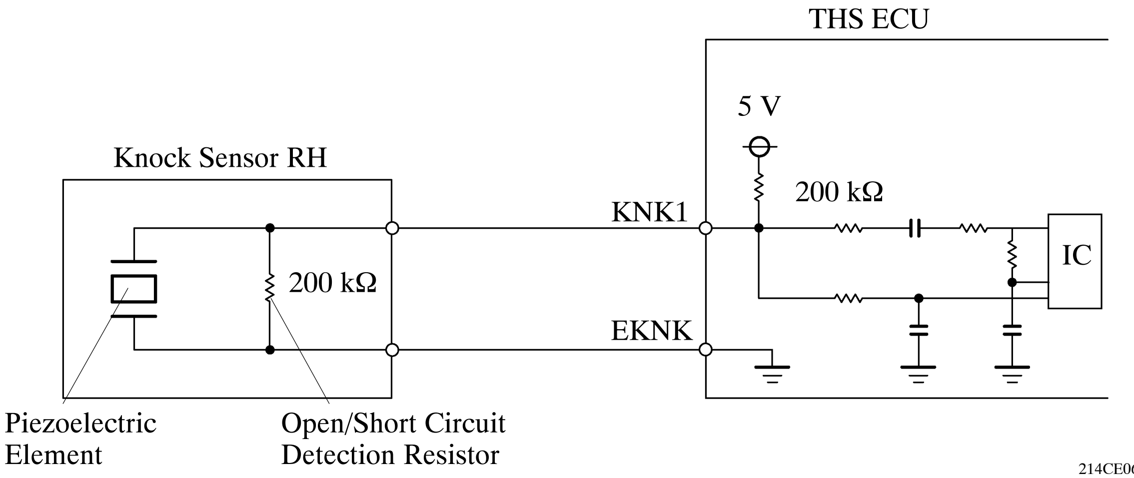
The knocking vibration is transmitted to the steel weight and its inertia applies pressure to the piezoelectric element. The action generates electromotive force.



214CE08

4) Open/Short Circuit Detection Resistor

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



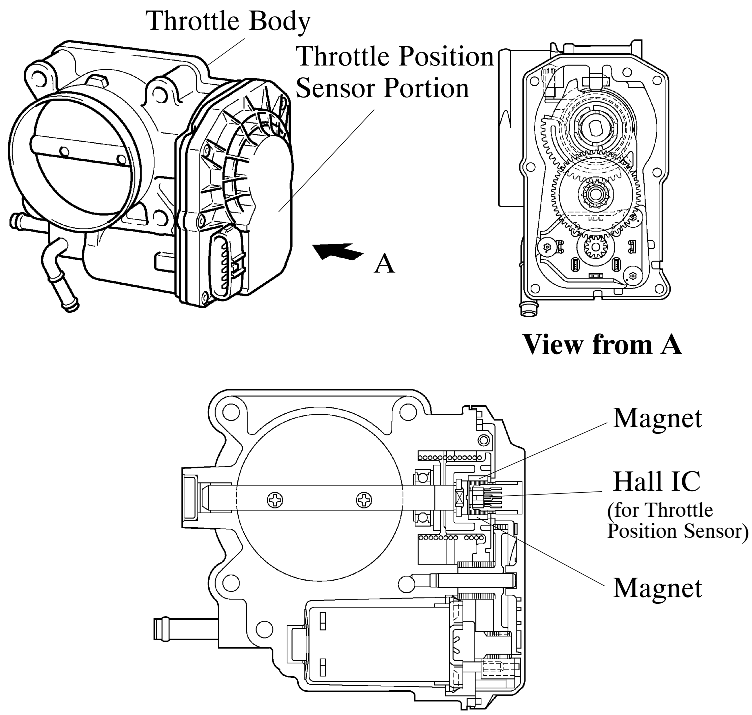
214CE06

Service Tip

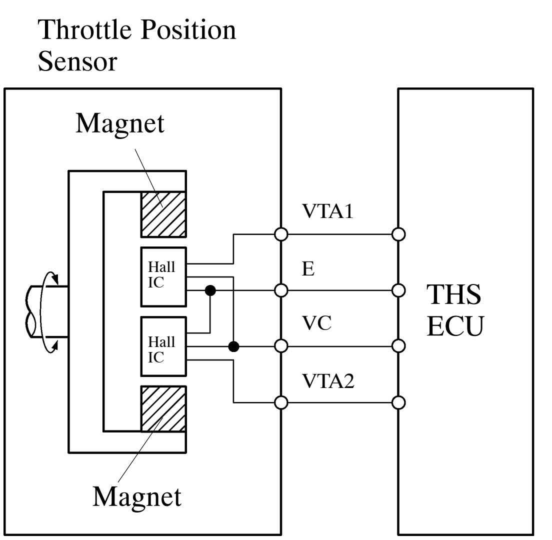
In accordance with the use of open/short circuit detection resistor, the inspection method for the sensor has been changed. For details, refer to LEXUS RX400h Repair Manual (Pub. No. RM1139E).

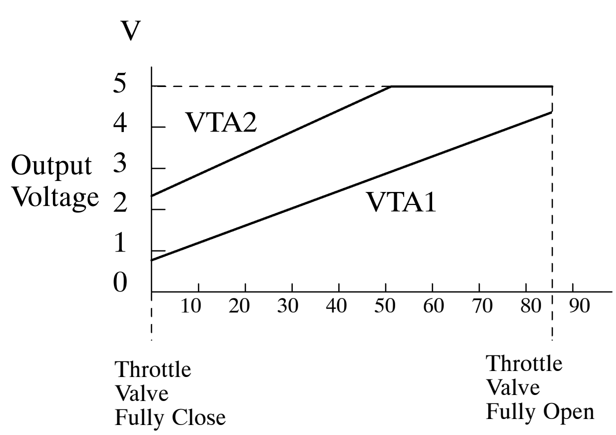
Throttle Position Sensor

The throttle position sensor is mounted on the throttle body, to detect the opening angle of the throttle valve, the throttle position sensor converts the magnetic flux density that changes when the magnetic yoke (located on the same axis as the throttle shaft) rotates around the Hall IC into electric signals to operate the throttle control motor.



Cross Section





Throttle Valve Opening Angle

238EG79

Service Tip

The inspection method differs from the conventional throttle position sensor because this sensor uses a Hall IC. For details, refer to the LEXUS RX400h Repair Manual (Pub. No. RM1139E.)

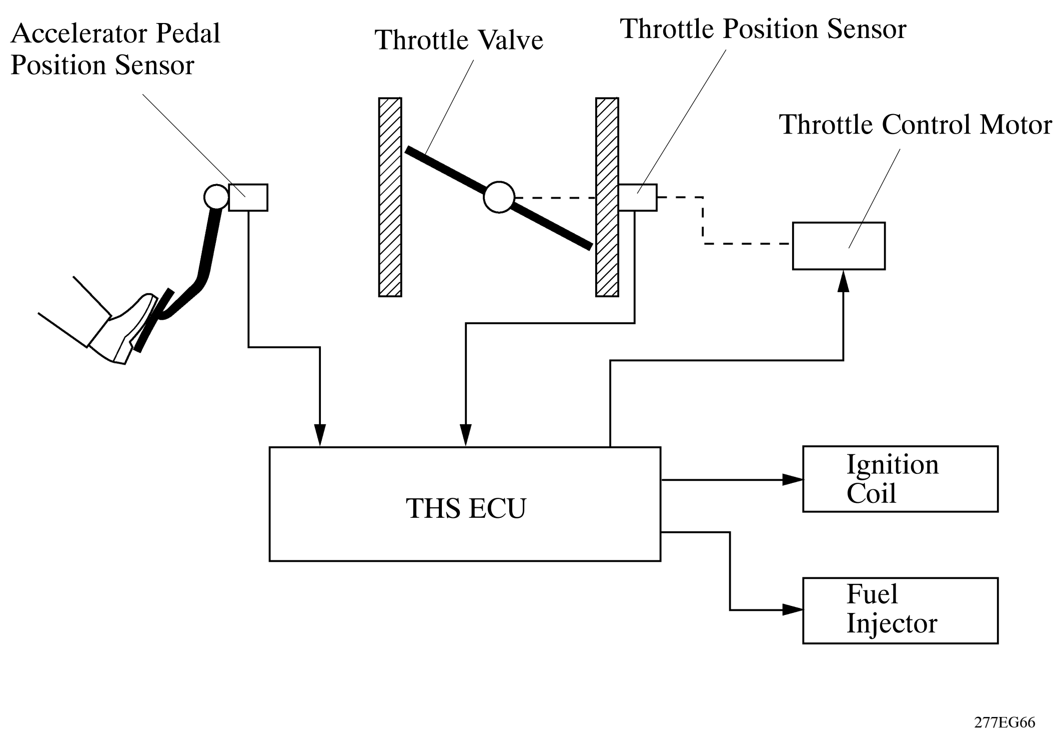
EG

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

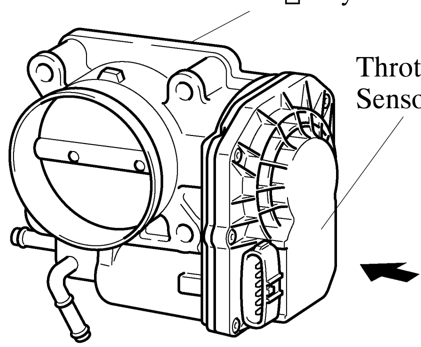
General

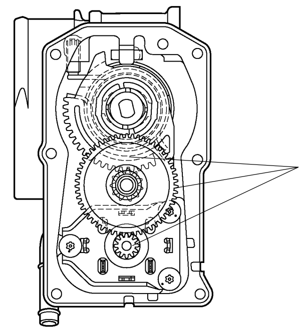
- The ETCS-i is used, providing excellent throttle control in all the operating ranges.
- In the conventional throttle body, the throttle valve opening is determined by the amount of the accelerator pedal effort. In contrast, the ETCS-i uses the THS ECU to calculate the optimal throttle valve opening that is appropriate for the respective driving condition and uses a throttle control motor to control the opening.
- In case of an abnormal condition, this system transfers to the limp mode.

▶ System Diagram ◀

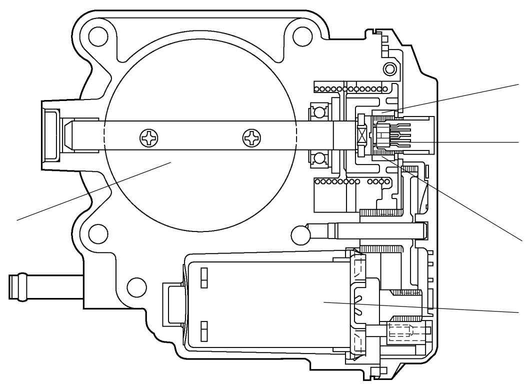


Construction





View from A



Cross Section

241EG28

1) Throttle Position Sensor

The throttle position sensor is mounted on the throttle body, to detect the opening angle of the throttle valve. For details, refer to Main Components of Engine Control System on page 45.

2) Throttle Control Motor

A DC motor with excellent response and minimal power consumption is used for the throttle control motor. The THS ECU performs the duty ratio control of the direction and the amperage of the current that flows to the throttle control motor in order to regulate the opening of the throttle valve.

Operation

1) General

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

a) Idle Speed Control
b) VSC Coordination Control and TRC Throttle Control
c) Cruise Control

a) Idle Speed Control

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

b) VSC Coordination Control and TRC Throttle Control

The effectiveness of VSC Coordination Control and TRC Throttle Control, are controlled by the throttle valve opening angle and the skid control ECU.

c) Cruise Control

A THS ECU with an integrated cruise control ECU directly actuates the throttle valve operation of the cruise Control.

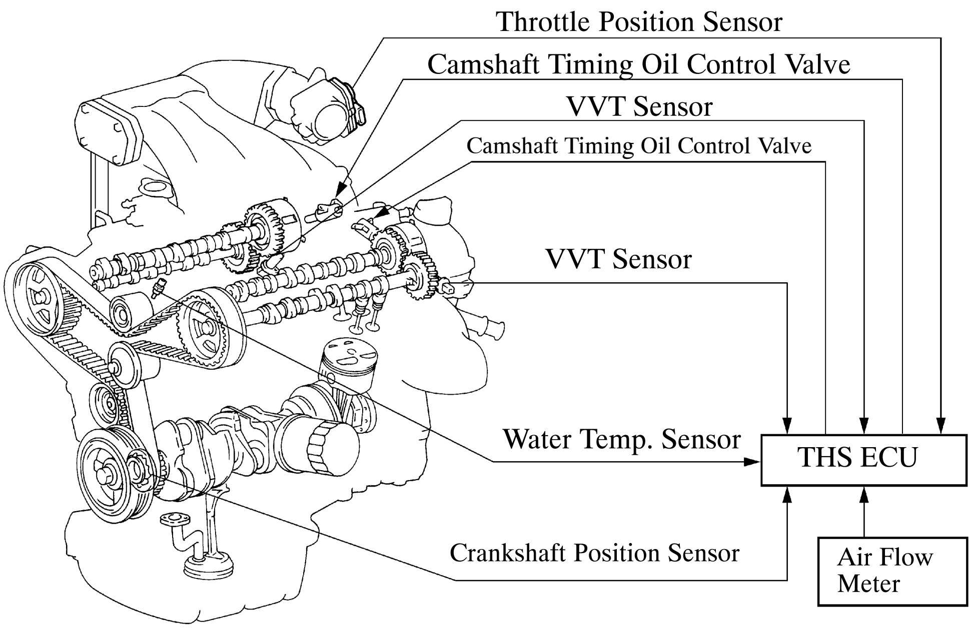
7. VVT-i (Variable Valve Timing-intelligent) System

General

The VVT-i system is designed to control the intake camshaft within a range of 60° (of Crankshaft Angle) to provide valve timing that is optimally suited to the engine condition. This improves torque in all the speed ranges as well as increasing fuel economy, and reducing exhaust emissions.

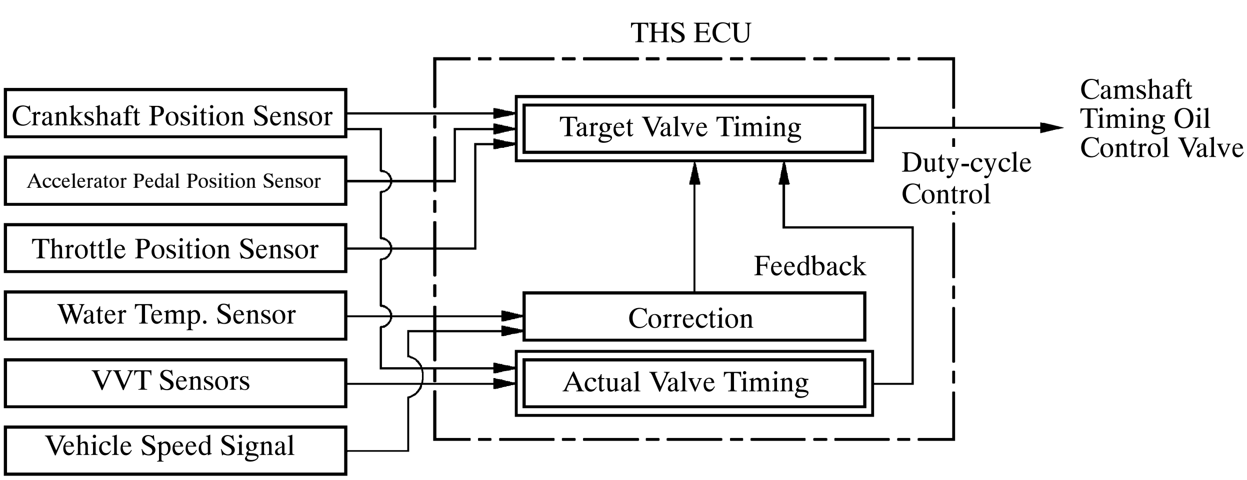
— Main Changes from Current RX330 —

The maximum closing timing of the intake valve has been retarded from 64° to 92° ABDC (After Bottom-Dead-Center). This reduces the effective cylinder capacity and temporarily lowers the combustion pressure, thus reducing the vibrations created during the start of the engine.



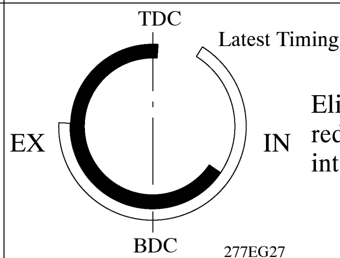
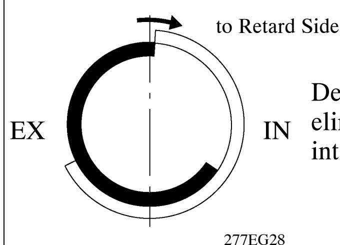
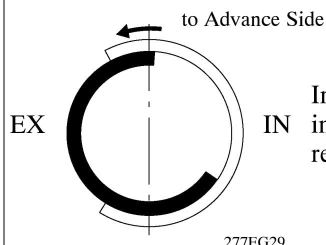
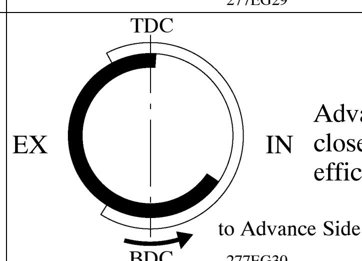
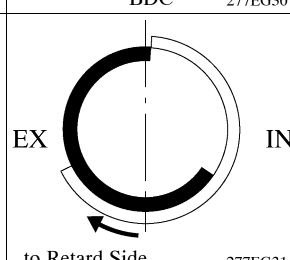
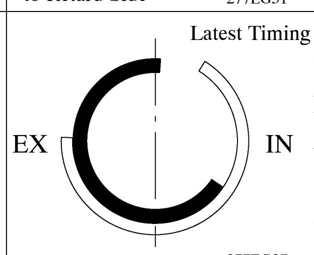
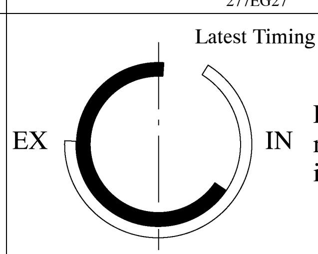
277EG33

- Using the engine speed, intake air volume, throttle position and water temperature, the THS ECU can calculate optimal valve timing for each driving condition and controls the camshaft timing oil control valve. In addition, the THS ECU uses signals from the camshaft position sensor and the crankshaft position sensor to detect the actual valve timing, thus providing feedback control to achieve the target valve timing.



221EG16

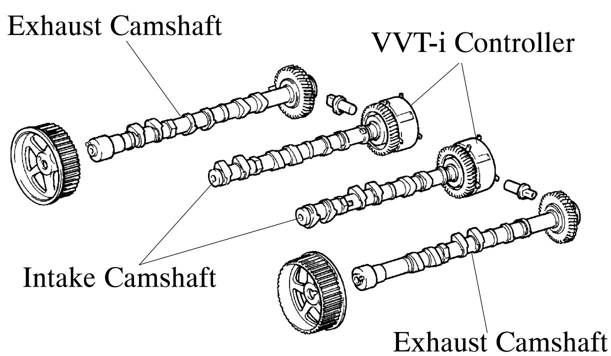
Effectiveness of the VVT-i System

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

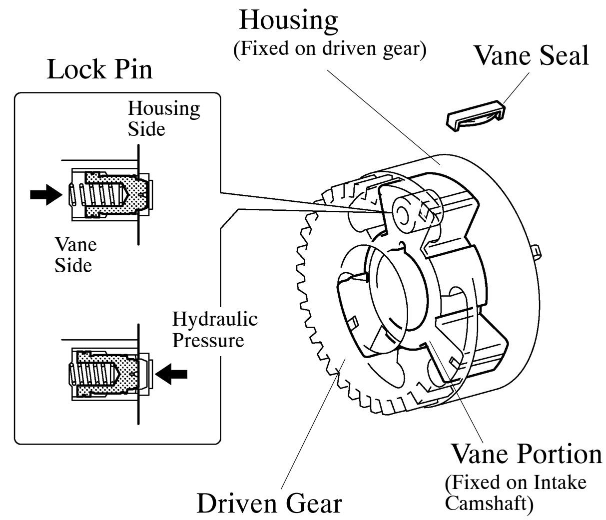
Construction

1) VVT-i Controller

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



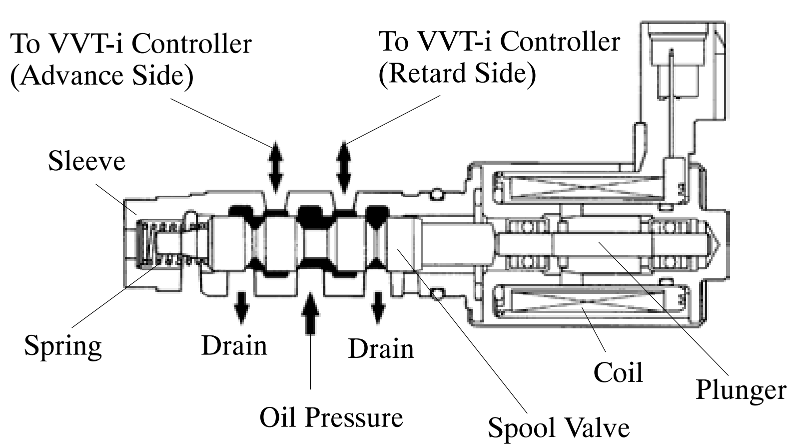
157EG24



170EG05

2) Camshaft Timing Oil Control Valve

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

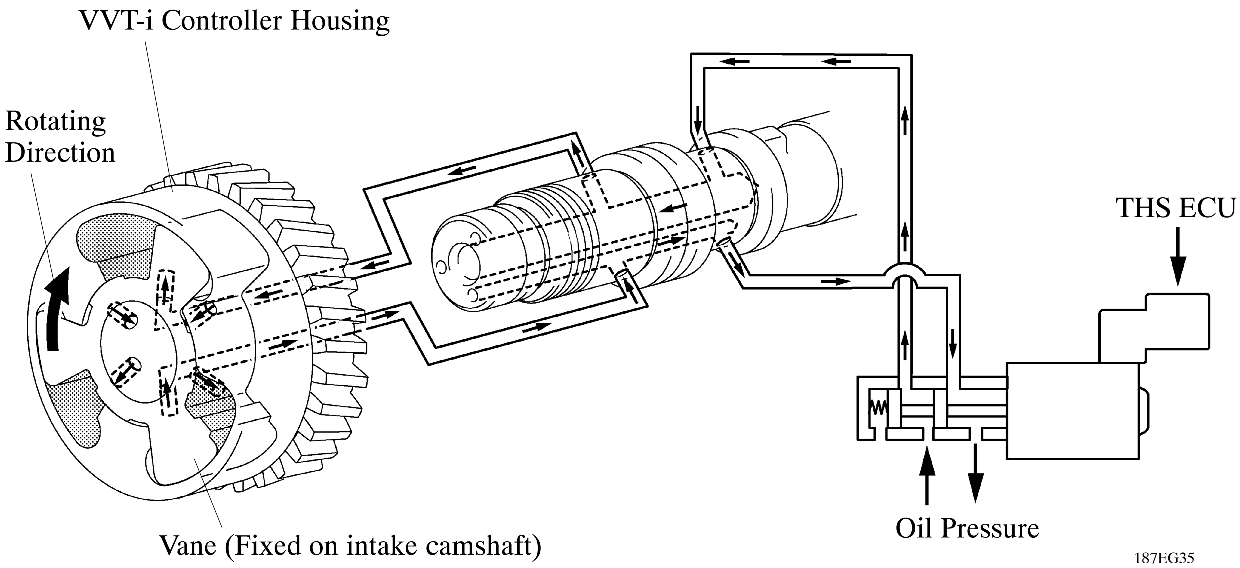


170EG06

Operation

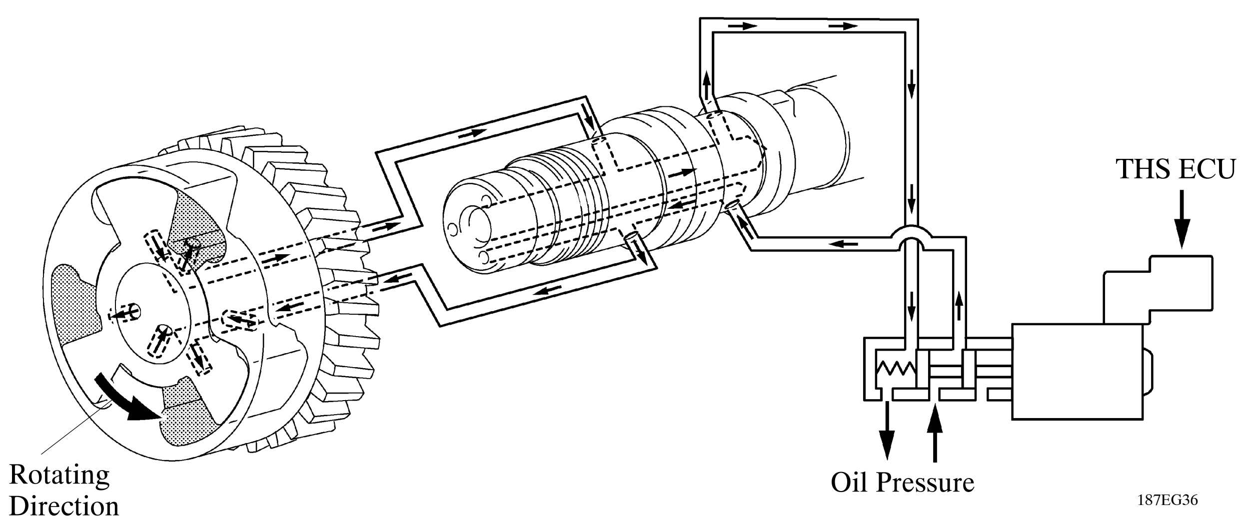
1) Advance

When the camshaft timing oil control valve is positioned as illustrated below by the advance signals from the THS ECU, the resultant oil pressure is applied to the vane chamber of advance side to rotate the camshaft in the timing advance direction.



2) Retard

When the camshaft timing oil control valve is positioned as illustrated below by the retard signals from the THS ECU, the resultant oil pressure is applied to the vane chamber of retard side to rotate the camshaft in the timing retard direction.



3) Hold

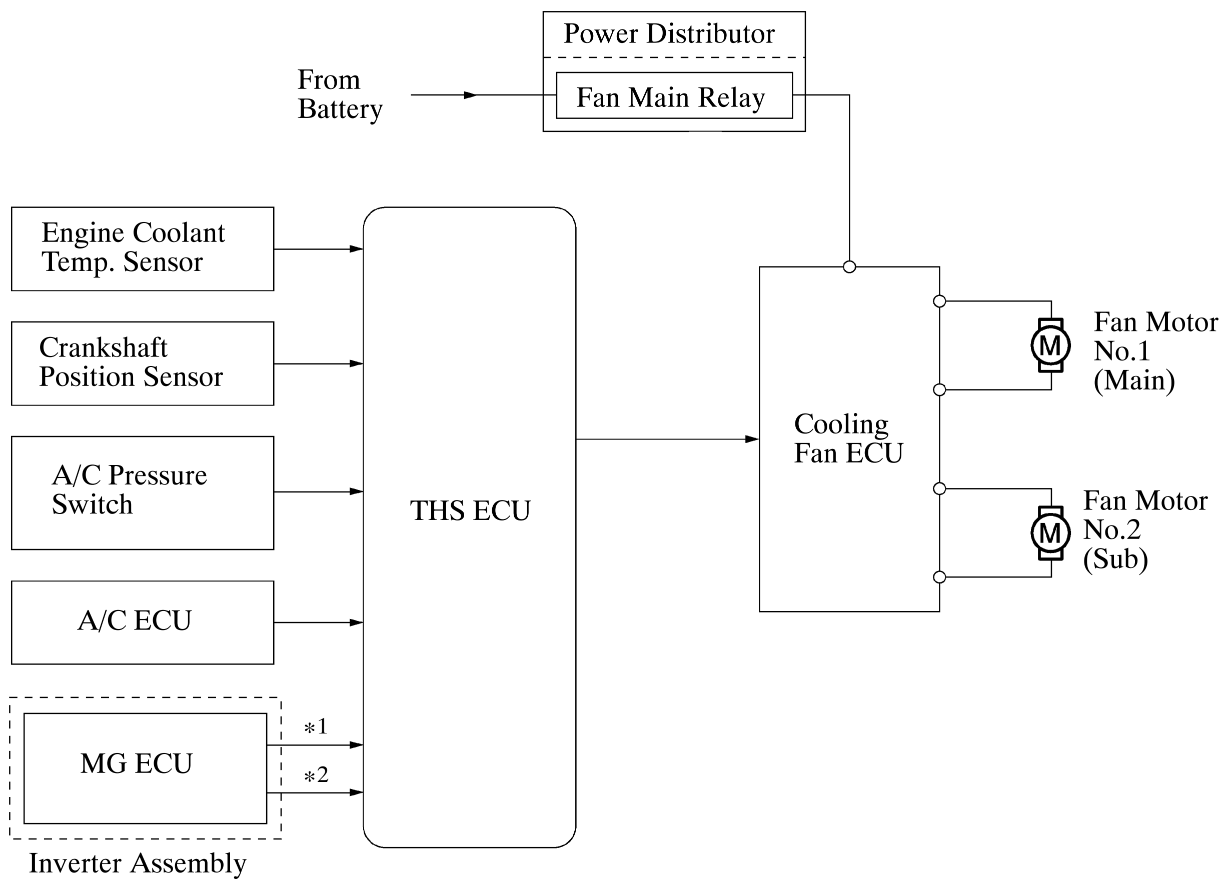
After reaching the target timing, the valve timing is held by keeping the camshaft timing oil control valve in the neutral position unless the traveling state changes.
This adjusts the valve timing at the desired target position and prevents the engine oil from running out when it is unnecessary.

8. Cooling Fan Control System

General

A cooling fan control system is used on the 3MZ-FE engine of the RX400h. To achieve an optimal fan speed in accordance with the engine coolant temperature, vehicle speed, engine speed, and air conditioning operating conditions, the THS ECU calculates the proper fan speed and sends the signals to the cooling fan ECU. Upon receiving the signals from the THS ECU, the cooling fan ECU actuates the fan motors. Also, the fan speed is controlled by the THS ECU using a stepless control.

▶ System Diagram ◀

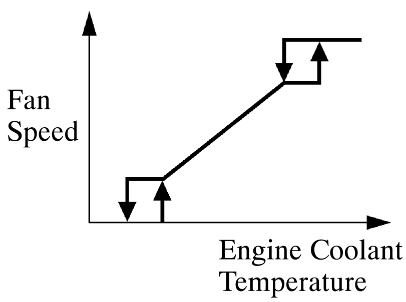


*1: Inverter Water Temperature
*2: Inverter Temperature

277EG67

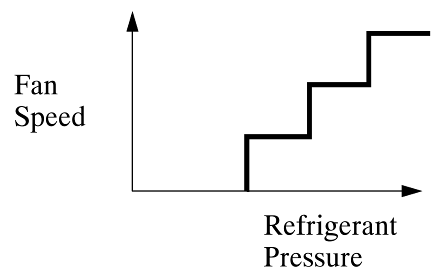
Operation

As illustrated below, the THS ECU determines the required fan speed by selecting the fastest fan speed from among the following:
(A) The fan speed required by the engine coolant temperature, (B) the fan speed required by the air conditioning refrigerant pressure, (C) the fan speed required by the inverter temperature and inverter water temperature.



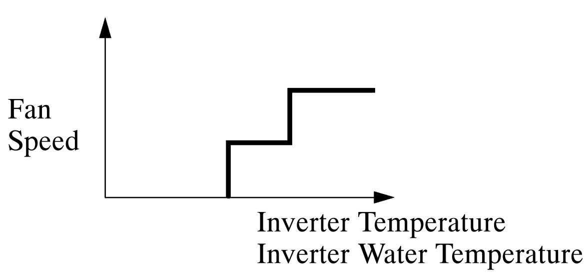
(A) Fan speed required by Engine coolant temperature

189EG13



(B) Fan speed required by air conditioning refrigerant pressure

277EG79



(C) Fan speed required by Inverter temperature and Inverter water temperature

277EG80

9. Diagnosis

- When the THS ECU detects a malfunction, the THS ECU makes a diagnosis and memorizes the failed section.
  Furthermore, the check engine warning light in the combination meter illuminates or blinks to inform the driver.
- The THS ECU will also store the DTCs of the malfunctions.
- The diagnosis communication has been changed from serial communication (ISO9141) to CAN communication. Accordingly, a newly adopted Intelligent Tester II is required for reading the DTCs of the engine ECU. For details, refer to the LEXUS RX400h Repair Manual (Pub. No. RM1139E).
- All the DTCs (Diagnostic Trouble Codes) have been made to correspond to the SAE controlled codes. Some of the DTCs have been further divided into smaller detection areas than in the past, and new DTCs have been assigned to them. For details, refer to the LEXUS RX400h Repair Manual (Pub. No. RM1139E).

Service Tip

To clear the DTC that is stored in the HV ECU, use a Intelligent Tester II or disconnect the battery terminal or remove the EFI fuse for 1 minute or longer.

10. Fail-Safe

When a malfunction is detected by any of the sensors, there is a possibility of an engine or other malfunction occurring if the ECU were to continue to control the engine control system in the normal way. To prevent such a problem, the fail-safe function of the ECU either relies on the data stored in memory to allow the engine control system to continue operating, or stops the engine if a hazard is anticipated. For details, refer to the LEXUS RX400h Repair Manual (Pub. No. RM1139E).