■ ENGINE CONTROL SYSTEM

1. General

The 1GR-FE engine control systems of the new models and previous models have the following differences:

System	Outline	New	Previous
Electronic Fuel Injection (EFI)	An L-type EFI system detects the intake air mass with a hot-wire type intake mass air flow meter sub-assembly.	○	○
Electronic Spark Advance (ESA)	● This ECM determines the optimal ignition timing in accordance with the signals received from the sensors and sends an ignition signal (IGT) to the igniter. ● The ECM corrects ignition timing in response to engine knocking.	○	○
Electronic Throttle Control System-intelligent (ETCS-i)	Optimally controls the opening angle of the throttle valve in accordance with the accelerator pedal input and the engine and vehicle conditions.	○	○
Dual Variable Valve Timing-intelligent (Dual VVT-i)	Controls the intake and exhaust camshafts to optimal valve timing in accordance with the engine operating conditions.	○	—
Variable Valve Timing-intelligent (VVT-i)	Controls the intake camshaft to optimal valve timing in accordance with the engine operating conditions.	—	○
Acoustic Control Induction System (ACIS)	The intake air passages are switched based on engine speed and throttle valve opening angle to provide high performance in all engine speed ranges.	—	○
Fuel Pump Control	Based on signals from the ECM, the fuel pump control ECU controls the fuel pump in 3 stages.	—	○
	Based on signals from the ECM, the fuel pump control ECU controls the fuel pump in linear control.	○	—
	The fuel pump is stopped when the SRS airbag is deployed.	○	○
Air Fuel Ratio Sensor and Oxygen Sensor Heater Control	Maintains the temperature of the air fuel ratio sensors or oxygen sensors at an appropriate level to increase the detection accuracy of the exhaust gas oxygen concentration.	○	○
Air Injection Control	The ECM controls the air injection time based on the signals from the crank position sensor, engine coolant temperature sensor, intake mass air flow meter sub-assembly and air pressure sensor.	○*	—
Evaporative Emission Control	The ECM controls the purge flow of evaporative emission (HC) in the charcoal canister in accordance with the engine conditions.	○	○

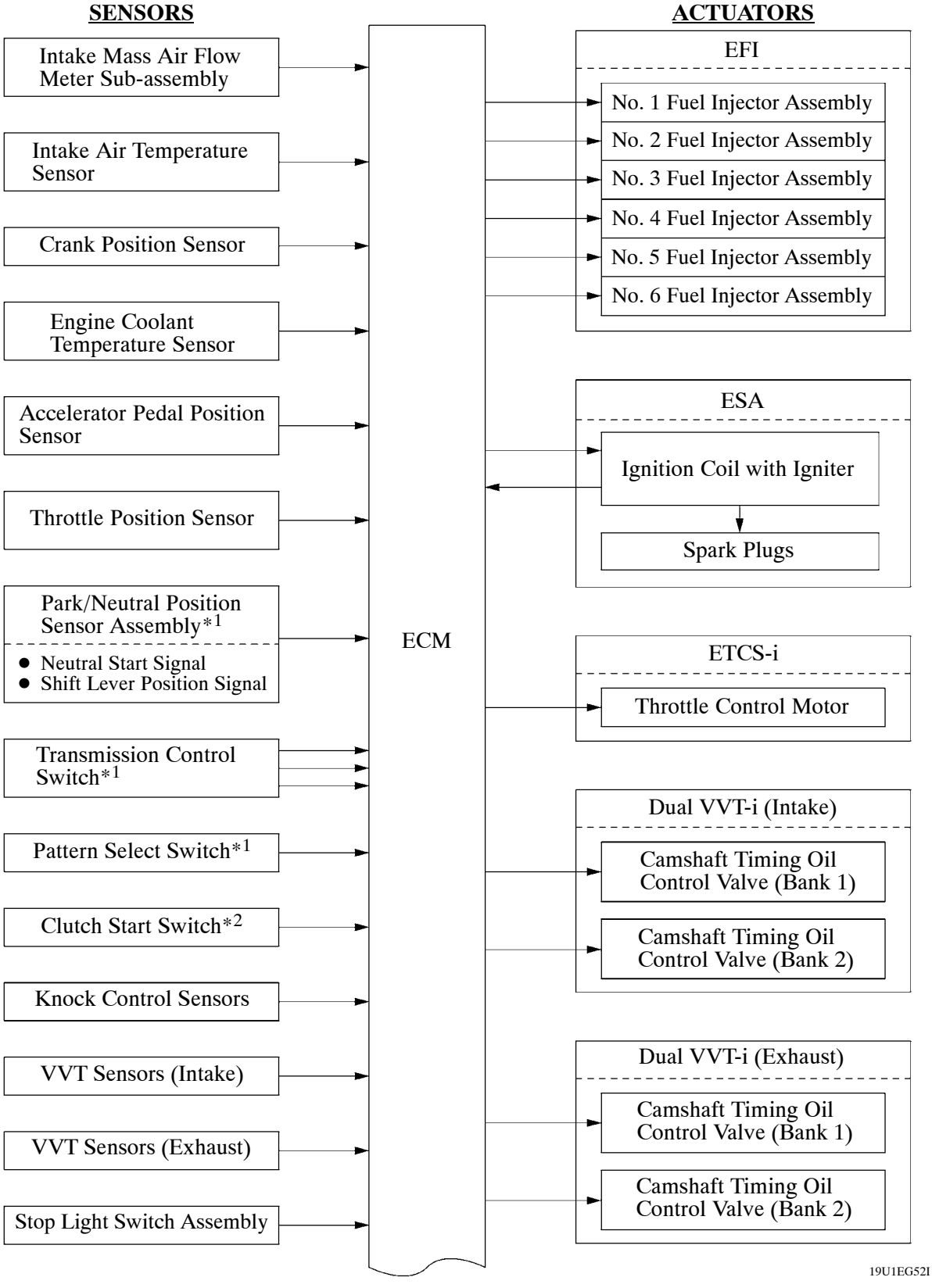
*: Models compliant with EURO 5 emission regulations

(Continued)

System	Outline	New	Previous
Air Conditioning Cut-off Control	By turning the air conditioning compressor on or off in accordance with the engine condition, driveability is maintained.	○	○
Engine Immobiliser	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid key.	○	○
Brake Override System	Restricts the driving torque when the brake pedal is depressed while the accelerator pedal is depressed. (For the Activation Conditions and Inspection Method, refer to the Repair Manual.)	○	—
Diagnosis	When the ECM detects a malfunction, it records the malfunction and memorizes information related to the fault.	○	○
Fail-safe	When the ECM detects a malfunction, it stops or controls the engine in accordance with the data already stored in the memory.	○	○

2. Construction

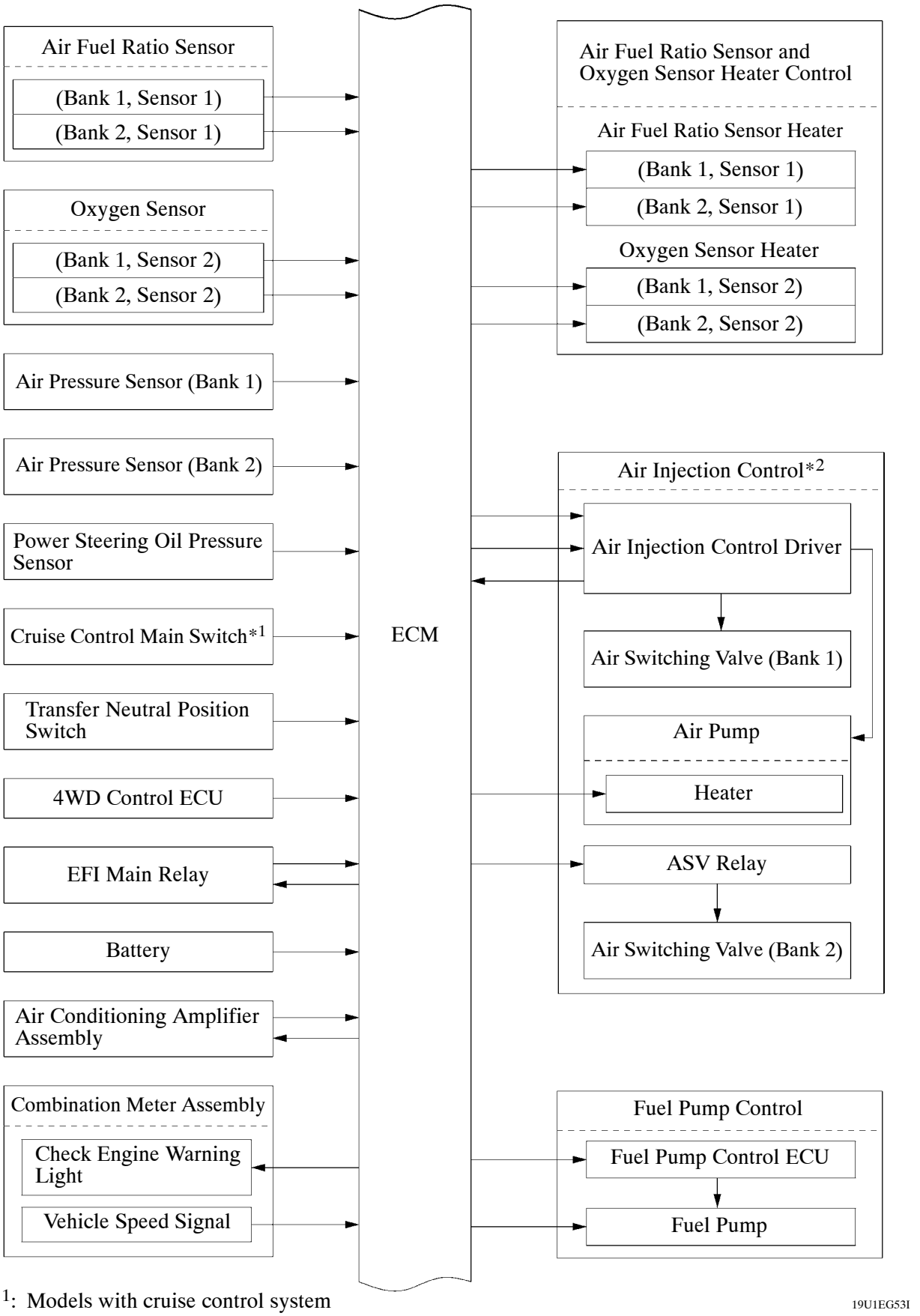
The configuration of the engine control system is as shown in the following chart:



*1: Models with automatic transmission
*2: Models with manual transmission

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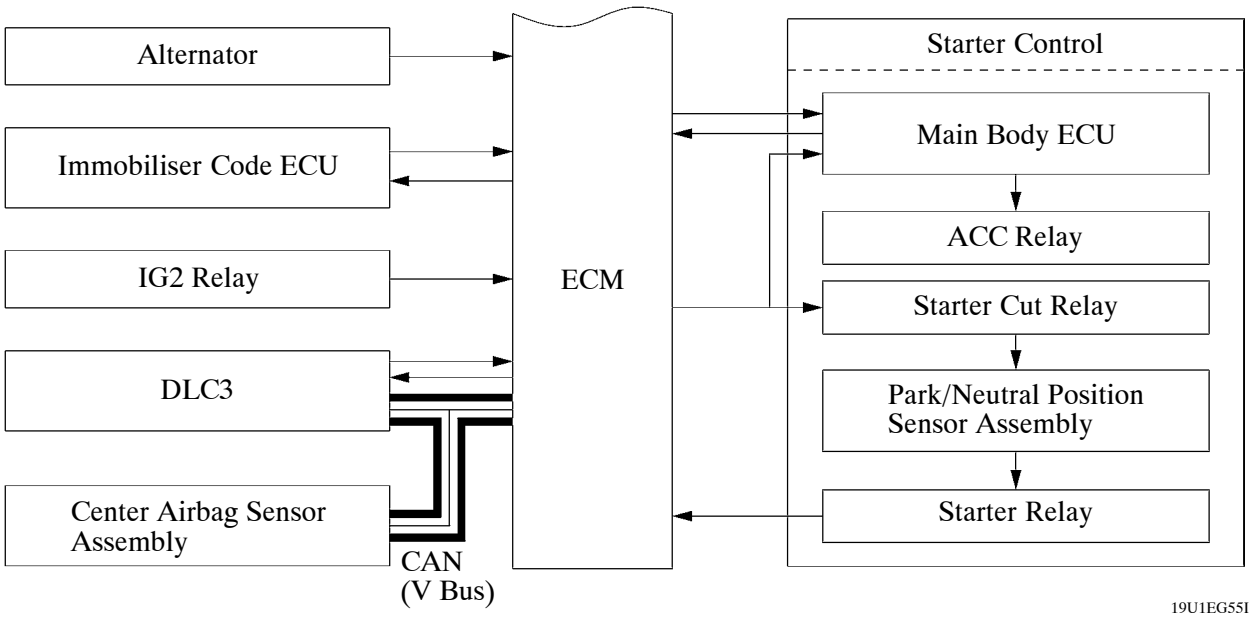


*1: Models with cruise control system

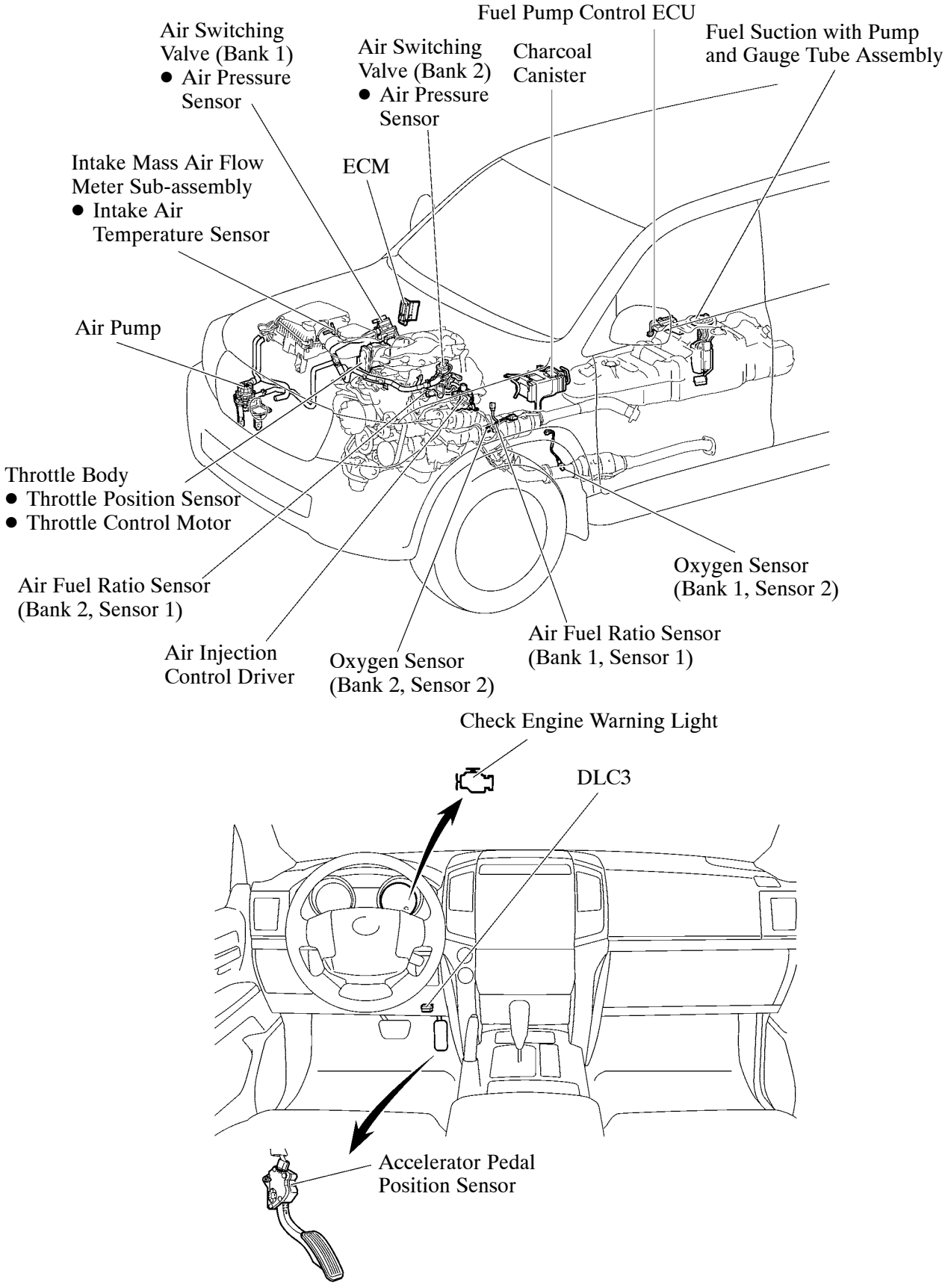
*2: Models compliant with EURO 5 emission regulations

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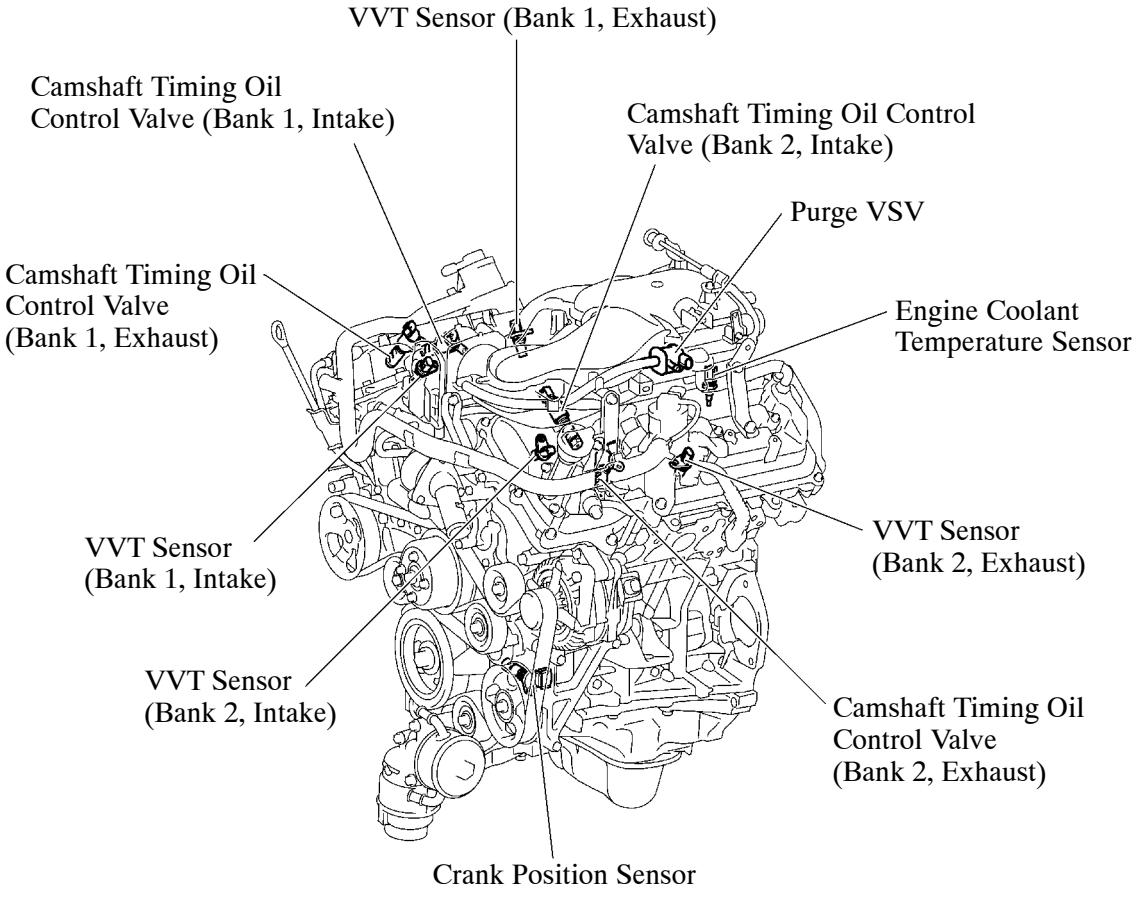

Alternator
Immobiliser Code ECU
IG2 Relay
DLC3
Center Airbag Sensor Assembly
CAN (V Bus)
ECM
Starter Control
Main Body ECU
ACC Relay
Starter Cut Relay
Park/Neutral Position Sensor Assembly
Starter Relay
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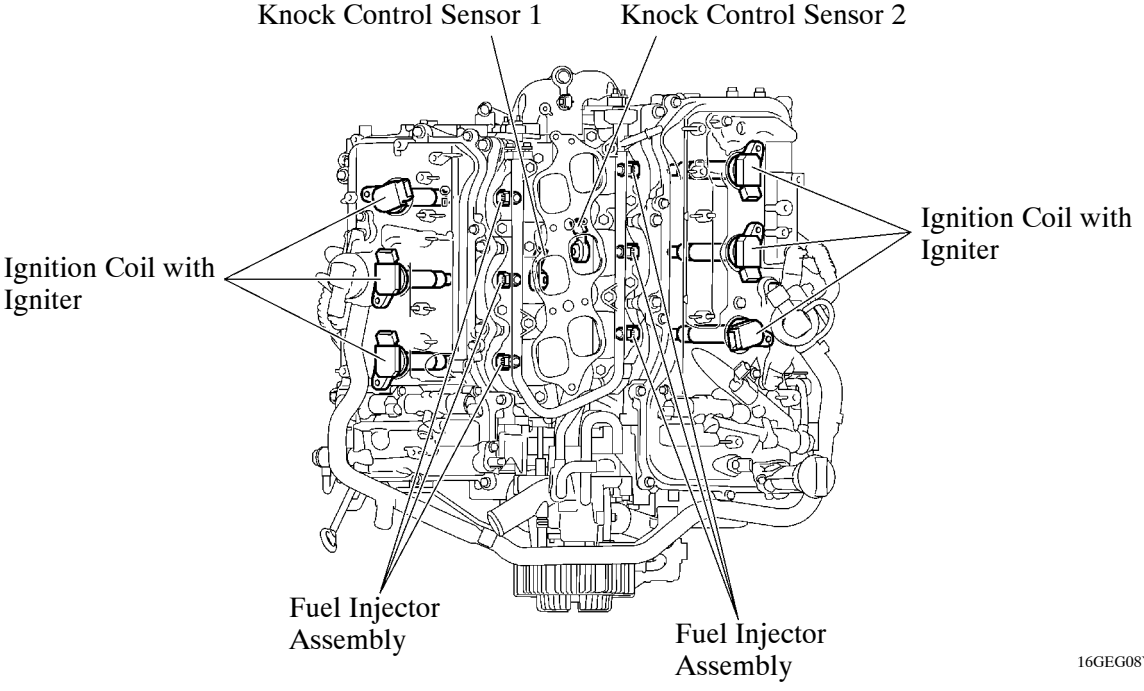
3. Layout of Main Components



LHD Models

19U1EG61Y


VVT Sensor (Bank 1, Exhaust)
Camshaft Timing Oil Control Valve (Bank 1, Intake)
Camshaft Timing Oil Control Valve (Bank 2, Intake)
Purge VSV
Camshaft Timing Oil Control Valve (Bank 1, Exhaust)
Engine Coolant Temperature Sensor
VVT Sensor (Bank 1, Intake)
VVT Sensor (Bank 2, Exhaust)
VVT Sensor (Bank 2, Intake)
Camshaft Timing Oil Control Valve (Bank 2, Exhaust)
Crank Position Sensor


Knock Control Sensor 1
Knock Control Sensor 2
Ignition Coil with Igniter
Ignition Coil with Igniter
Fuel Injector Assembly
Fuel Injector Assembly
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4. Main Components of Engine Control System

General

The 1GR-FE engine control system has the following main components:

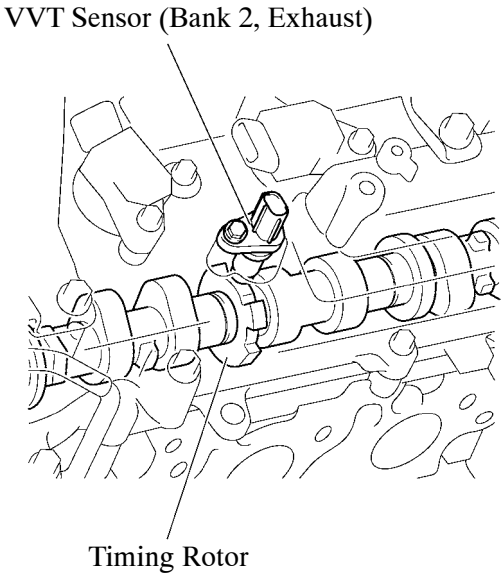
Components	Outline	Quantity	Function	New	Previous
ECM	32-bit CPU	1	The ECM optimally controls the EFI, ESA, and ISC to suit the operating conditions of the engine in accordance with the signals provided by the sensors.	○	○
Intake Mass Air Flow Meter Sub-assembly	Hot-wire Type	1	This sensor has a built-in hot-wire to directly detect the intake air mass and flow rate.	○	○
Intake Air Temperature Sensor	Thermistor Type	1	This sensor detects the intake air temperature by means of an internal thermistor.	○	○
Crank Position Sensor	Pick-up Coil Type (Rotor Teeth/36-2)	1	This sensor detects the engine speed and crank angle.	○	○
VVT Sensors (Intake)	MRE Type (Rotor Teeth/3)	2 (1 Each Bank)	These sensors perform the cylinder identification and detect VVT angle.	○	○
VVT Sensors (Exhaust)	MRE Type (Rotor Teeth/3)	2 (1 Each Bank)	These sensors detect VVT angle.	○	—
Accelerator Pedal Position Sensor	Hall IC Type (Non-contact Type)	1	This sensor detects the amount of pedal effort applied to the accelerator pedal.	○	○
Throttle Position Sensor	Hall IC Type (Non-contact Type)	1	This sensor detects the throttle valve opening angle.	○	○
Knock Control Sensors	Built-in Piezoelectric Type (Flat Type)	2 (1 Each Bank)	These sensors detect an occurrence of the engine knocking indirectly from the vibration of the cylinder block caused by the occurrence of engine knocking.	○	○
Oxygen Sensors (Bank 1, Sensor 2) (Bank 2, Sensor 2)	Cup Type with Heater	2 (1 Each Bank)	These sensors detect the oxygen concentration in the exhaust emission by measuring the electromotive force which is generated in the sensor itself.	○	○
Air Fuel Ratio Sensors (Bank 1, Sensor 1) (Bank 2, Sensor 1)	Planar Type with Heater	2 (1 Each Bank)	As with the oxygen sensor, these sensors detect the oxygen concentration in the exhaust emissions. However, they detect the oxygen concentration in the exhaust emissions linearly.	○	○
Engine Coolant Temperature Sensor	Thermistor Type	1	This sensor detects the engine coolant temperature by means of an internal thermistor.	○	○

(Continued)

Components	Outline	Quantity	Function	New	Previous
Fuel Injector Assemblies	12-hole Type	6	These assemblies contain an electro-magnetically operated nozzle to inject fuel into the intake port.	○	○
Camshaft Timing Oil Control Valves	Electro-magnetic Coil Type	4 (2 Each Bank)	These valves change the valve timing by switching the oil passage that acts on the camshaft timing gear assembly in accordance with the signals received from the ECM.	○	○

VVT Sensor (Exhaust)

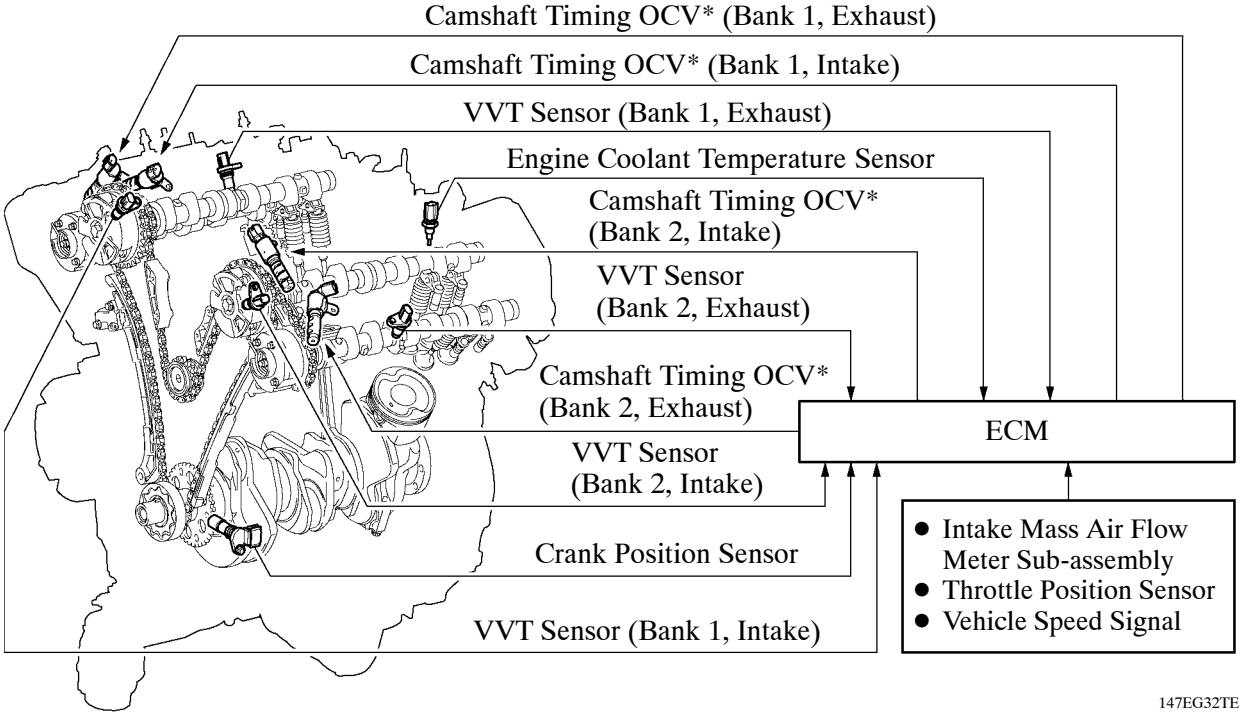
The Magnetic Resistance Element (MRE) type VVT sensor has been added to each bank on the exhaust side, the same as on the intake side. The installation location has been set on the cylinder head cover.



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

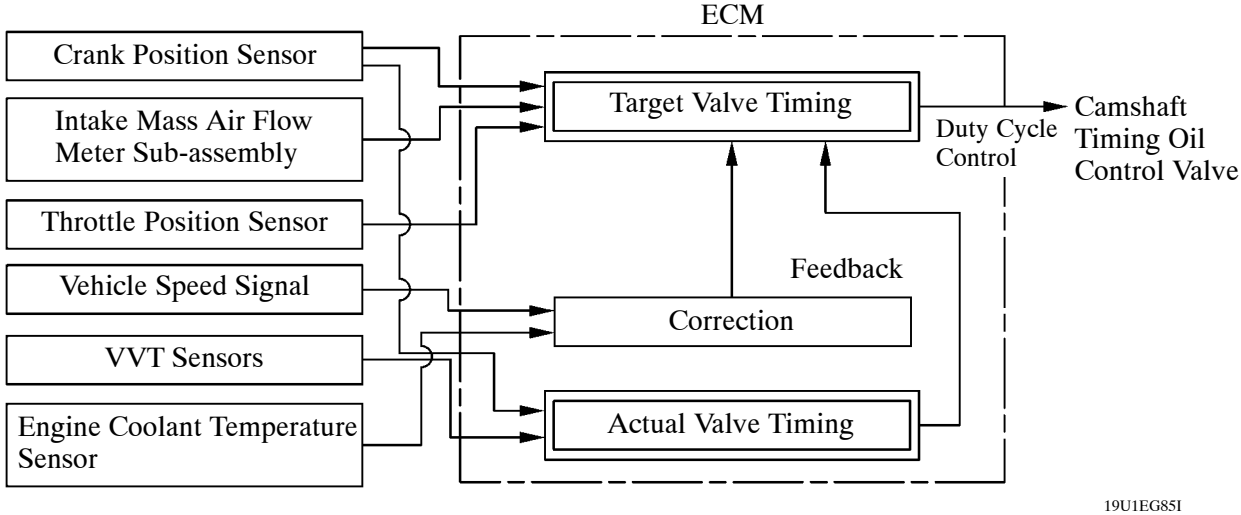
General

- 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 the engine condition. This improves torque in all the speed ranges as well as increasing fuel economy, and reducing exhaust emissions.

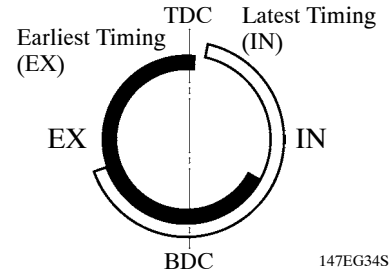
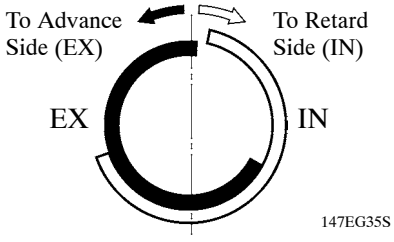
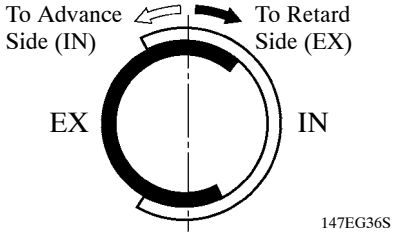
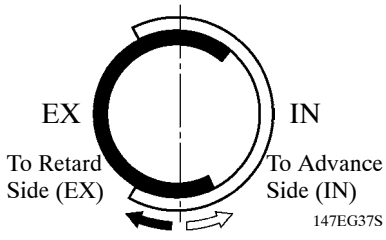
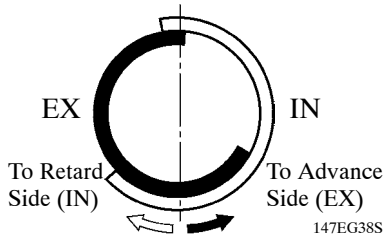
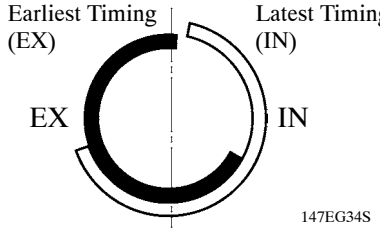
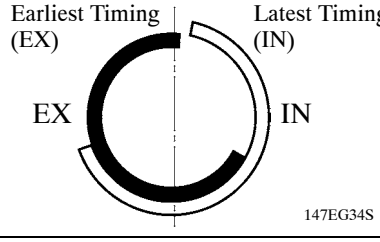


*: Oil Control Valve

- By using the engine speed, intake air mass, throttle position and engine coolant temperature, the ECM calculates optimal valve timing for each driving condition and controls the camshaft timing oil control valve. In addition, the ECM uses signals from the intake and exhaust VVT sensors for each bank and the crank position sensor to detect the actual valve timing, thus providing feedback control to achieve the target valve timing.



Effectiveness of Dual VVT-i System

Operation State	Objective		Effect
During Idling		Eliminating overlap to reduce blowback to the intake side.	● Stabilized idling speed ● Better fuel economy
At Light Load		Eliminating overlap to reduce blowback to the intake side.	Ensured engine stability
At Medium Load		Increasing overlap increases internal EGR, reducing pumping loss.	● Better fuel economy ● Improved emission control
In Low to Medium Speed Range with Heavy Load		Advancing the intake valve closing timing for volumetric efficiency improvement.	Improved torque in low to medium speed range
In High Speed Range with Heavy Load		Retarding the intake valve closing timing for volumetric efficiency improvement.	Improved output
At Low Temperatures		Eliminating overlap to reduce blowback to the intake side.	● Stabilized fast idle speed ● Better fuel economy
● Upon Starting ● Stopping the Engine		Eliminating overlap to minimize blowback to the intake side.	Improved startability

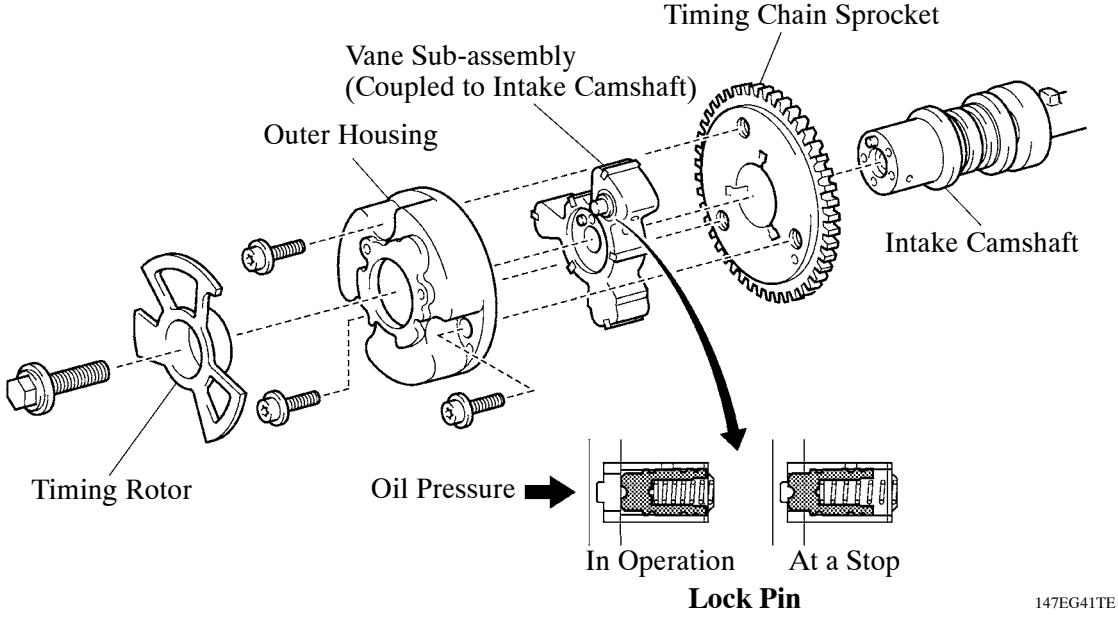
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Construction

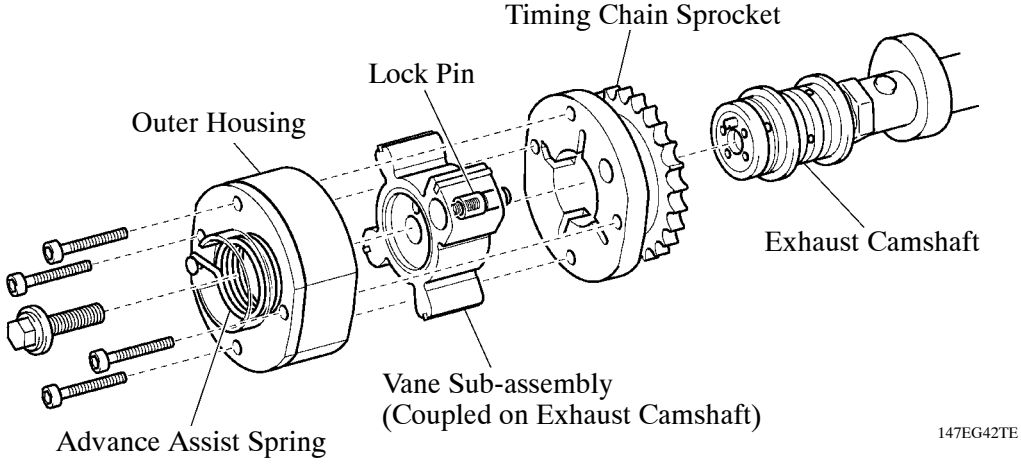
1) Camshaft Timing Gear Assembly

- The camshaft timing gear assembly consists of an outer housing that is driven by the timing chain sprocket, and a vane sub-assembly that is coupled to each camshaft.
- The intake side uses a camshaft timing gear assembly with 3 vanes, and the exhaust side uses one with 4 vanes.
- When the engine stops, the camshaft timing gear assembly (intake) is locked at the most retarded angle by its lock pin, and the camshaft timing gear assembly (exhaust) is locked at the most advanced angle. This ensures excellent engine startability.
- The oil pressure sent from the advance or retard side passages of the intake and exhaust camshafts causes rotation of the vane sub-assembly relative to the timing chain sprocket, to vary the valve timing continuously.
- An advance assist spring is provided on the camshaft timing gear assembly (exhaust). This helps to apply torque in the advanced angle direction so that the vane lock pin securely engages with the housing when the engine stops.

▶ Intake Side ◀



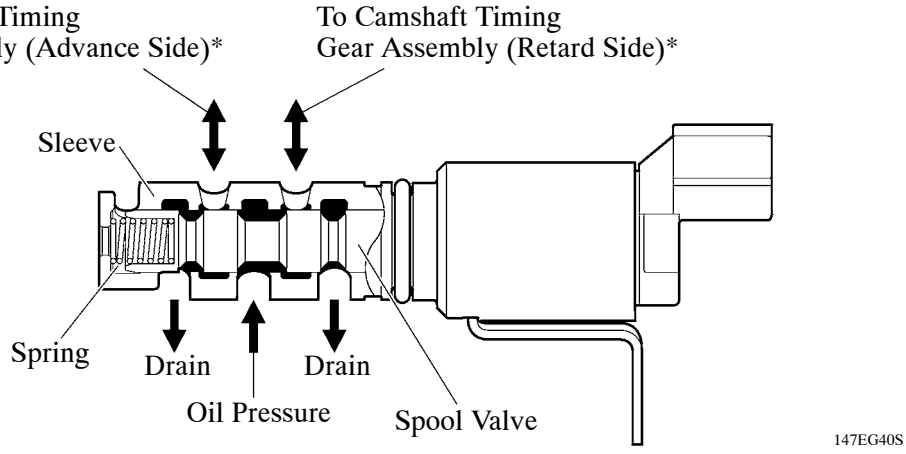
▶ Exhaust Side ◀



Camshaft Timing Oil Control Valve

This camshaft timing oil control valve controls the spool valve using duty-cycle control from the ECM. This allows hydraulic pressure to be applied to the camshaft timing gear assembly advance or retard side. When the engine is stopped, the camshaft timing oil control valve (intake) will move to the retard position, and the camshaft timing oil control valve (exhaust) will move to the advance position.

▶ Exhaust Side ◀



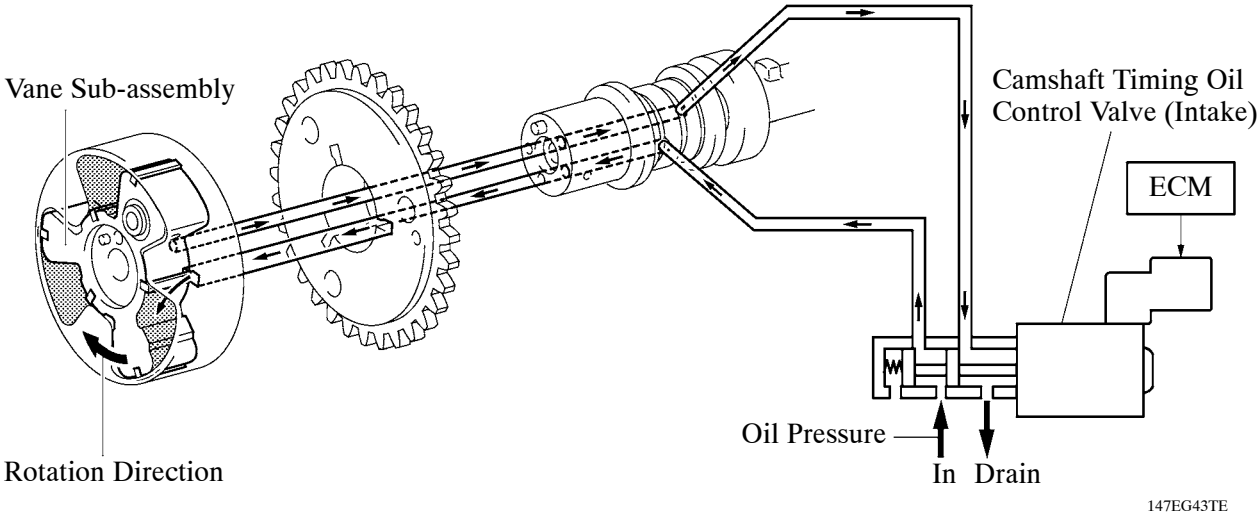
*: The advance and retard sides of the intake side oil control valve are the reverse of the exhaust side.

Operation

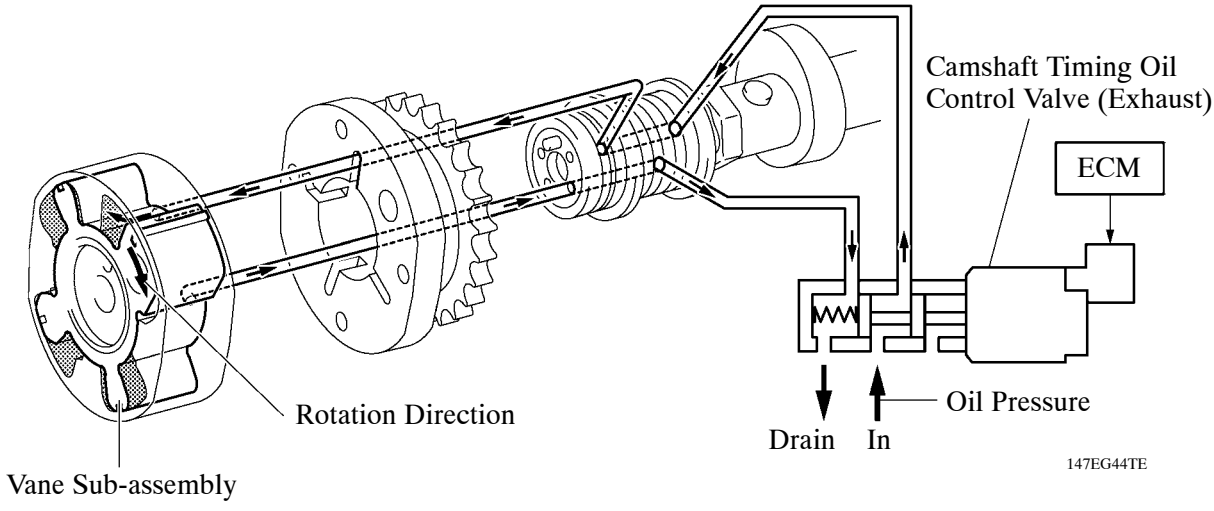
1) Advance

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

▶ Intake Side ◀



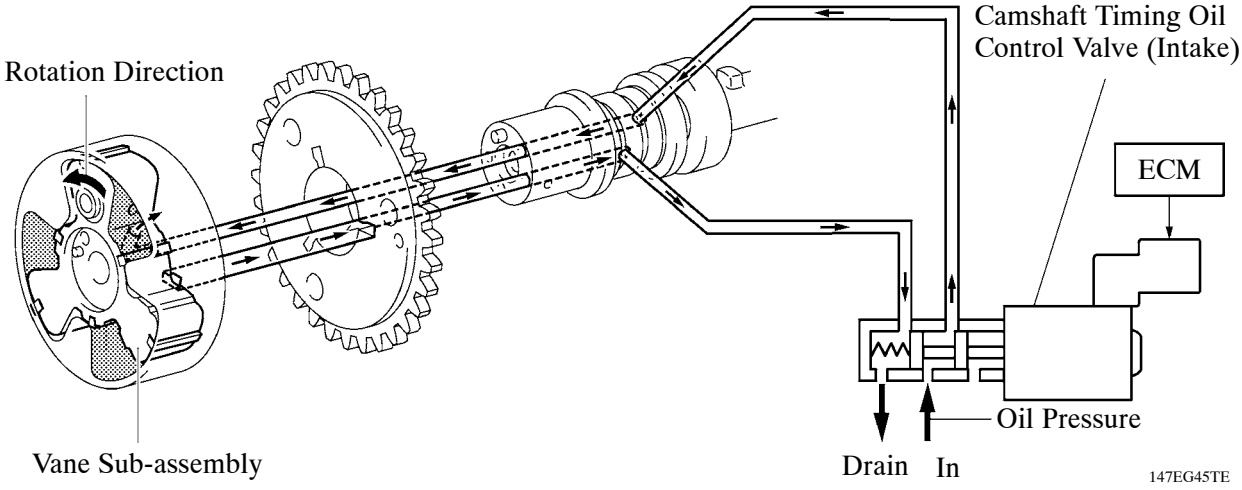
▶ Exhaust Side ◀



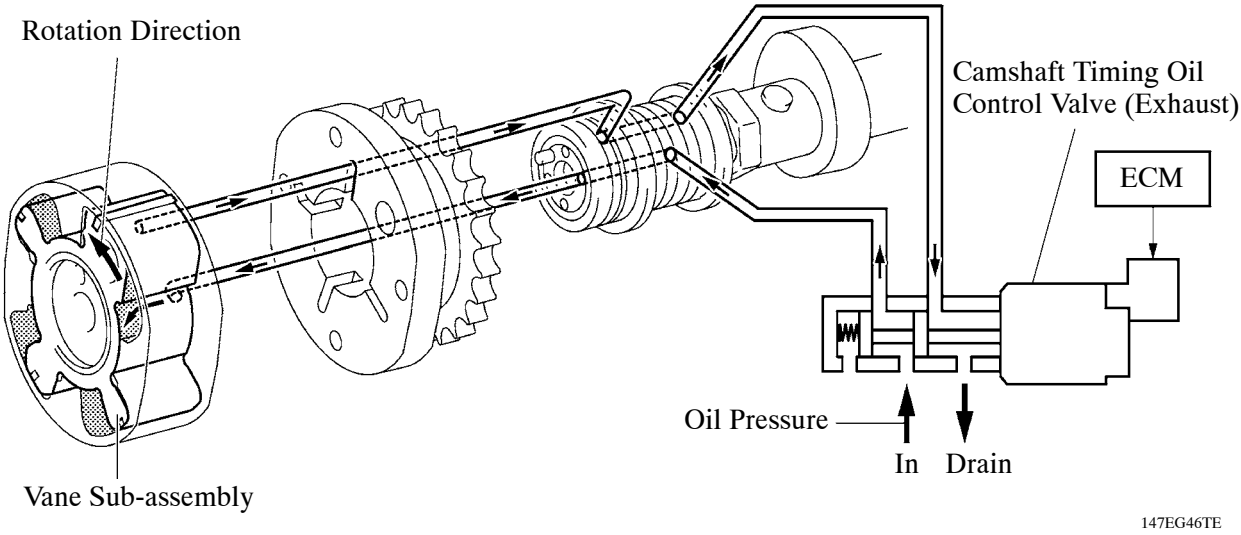
2) Retard

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

▶ Intake Side ◀



▶ Exhaust Side ◀



3) Hold

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

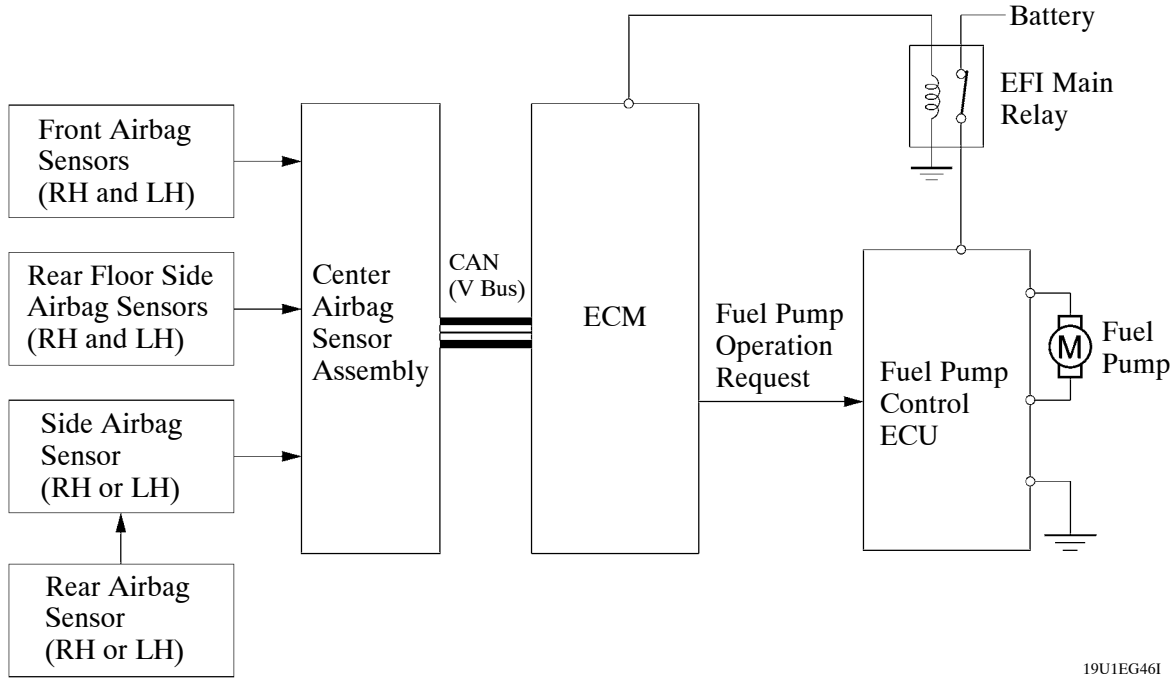
6. Fuel Pump Control

General

The fuel pump control ECU has been changed. As a result, the fuel pump control has also been changed.

- On the previous models, 3 stage signals are used and sent to the fuel pump, in order to regulate the fuel pump speed. On the new models, linear signals are used and sent to the fuel pump, achieving further power consumption reduction.
- The circuit opening relay has been discontinued due to the change in the fuel pump control.

▶ System Diagram ◀



Fuel Pump ECU

In the fuel pump speed control, the ECM transmits fuel pump operation request signals in accordance with the engine operating conditions. In response to the request signals, the fuel pump control ECU then transmits linear output signals to the fuel pump, optimally regulating the fuel pump speed.

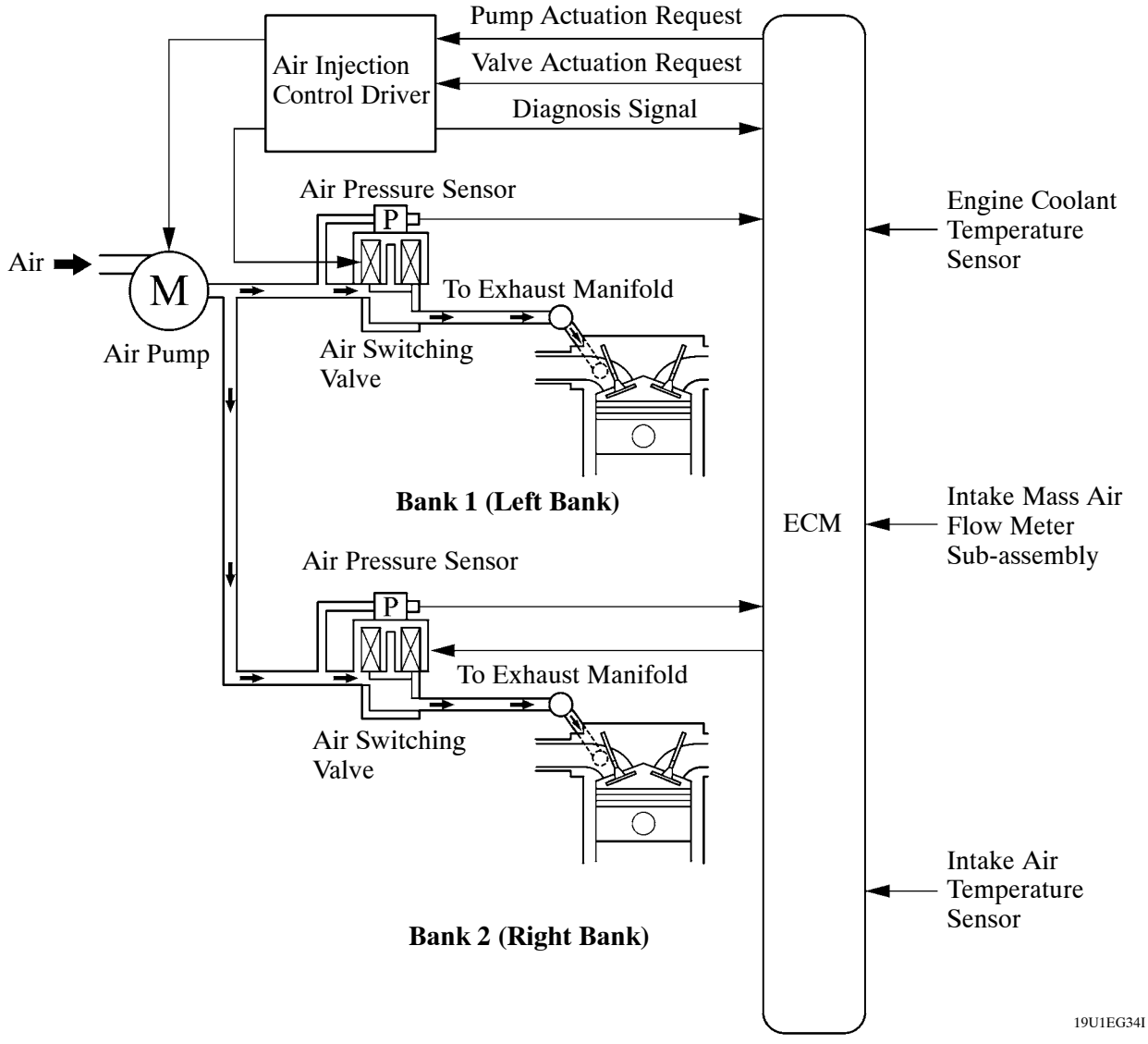
7. Air Injection System

General

To ensure the proper warm-up performance of the Three-Way Catalytic converters (TWCs) after starting a cold engine, an air injection system is used.

- This system is comprised of an air injection control driver, an air pump, and 2 air switching valves with the built-in air pressure sensors.
- Air switching valves are installed on each bank, and are controlled by the air injection control driver on the left bank (bank 1) and by the ECM on the right bank (bank 2).
- The ECM estimates the amount of air injected to the TWCs based on signals from the intake mass air flow meter sub-assembly in order to regulate the air injection time.

▶ System Diagram ◀

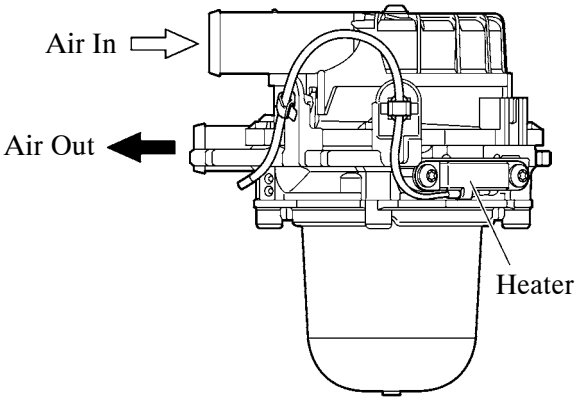


Construction and Operation

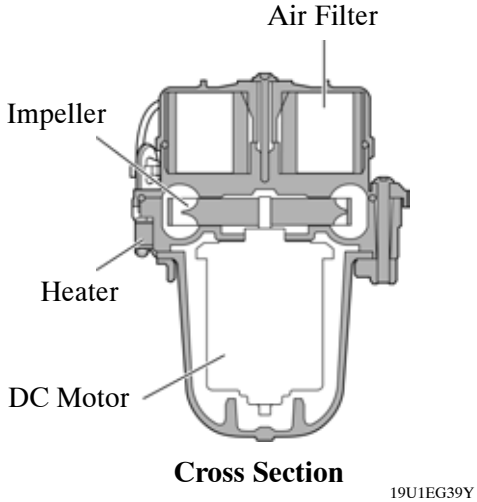
1) Air Pump

The air pump consists of a DC motor, an impeller, and an air filter.

- The DC motor is controlled by the air injection driver in accordance with signals from the ECM. The motor supplies air into an air switching valve through the impeller.
- The air filter is maintenance-free.



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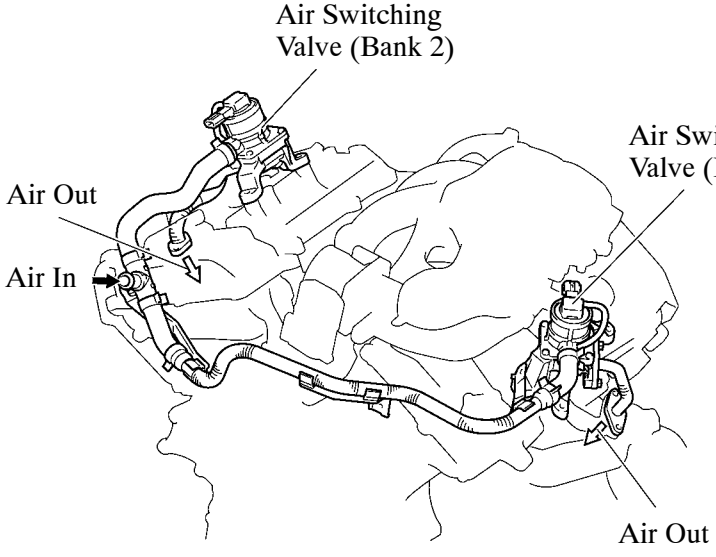


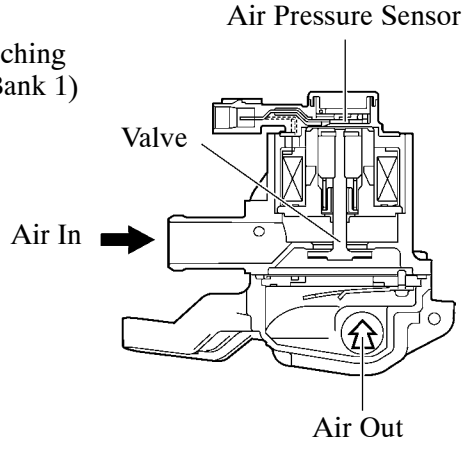
Cross Section

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2) Air Switching Valve

- The air switching valves consist of a valve that switches the air flow and a reed valve that restricts the exhaust flow to one direction.
- The air switching valves are solenoid valves that are actuated by the ECM and air injection control driver.
- An air pressure sensor is built into the corresponding air switching valve.
- The air switching valves for bank 1 and bank 2 have the same basic structure and function.



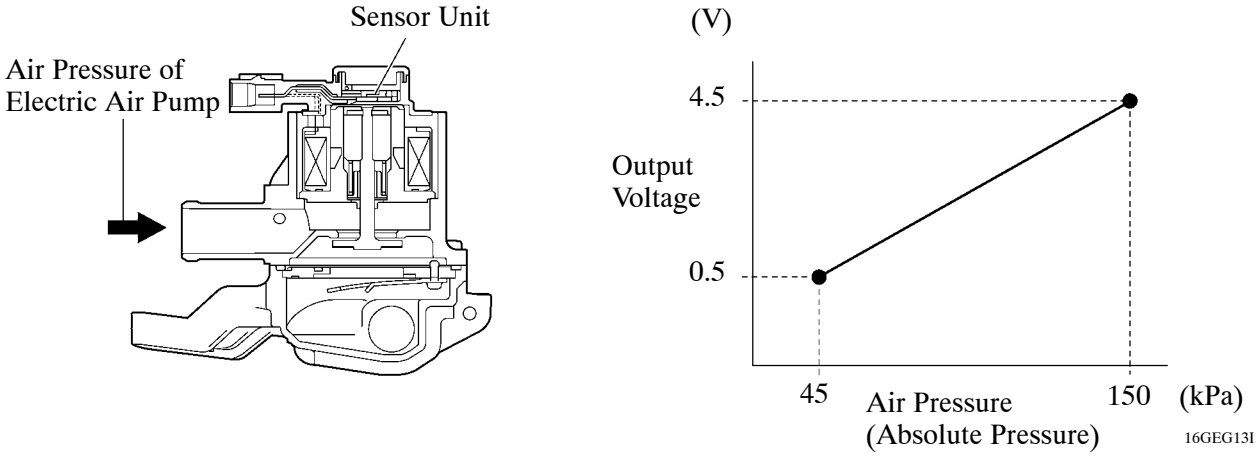


Cross Section (for Bank 1)

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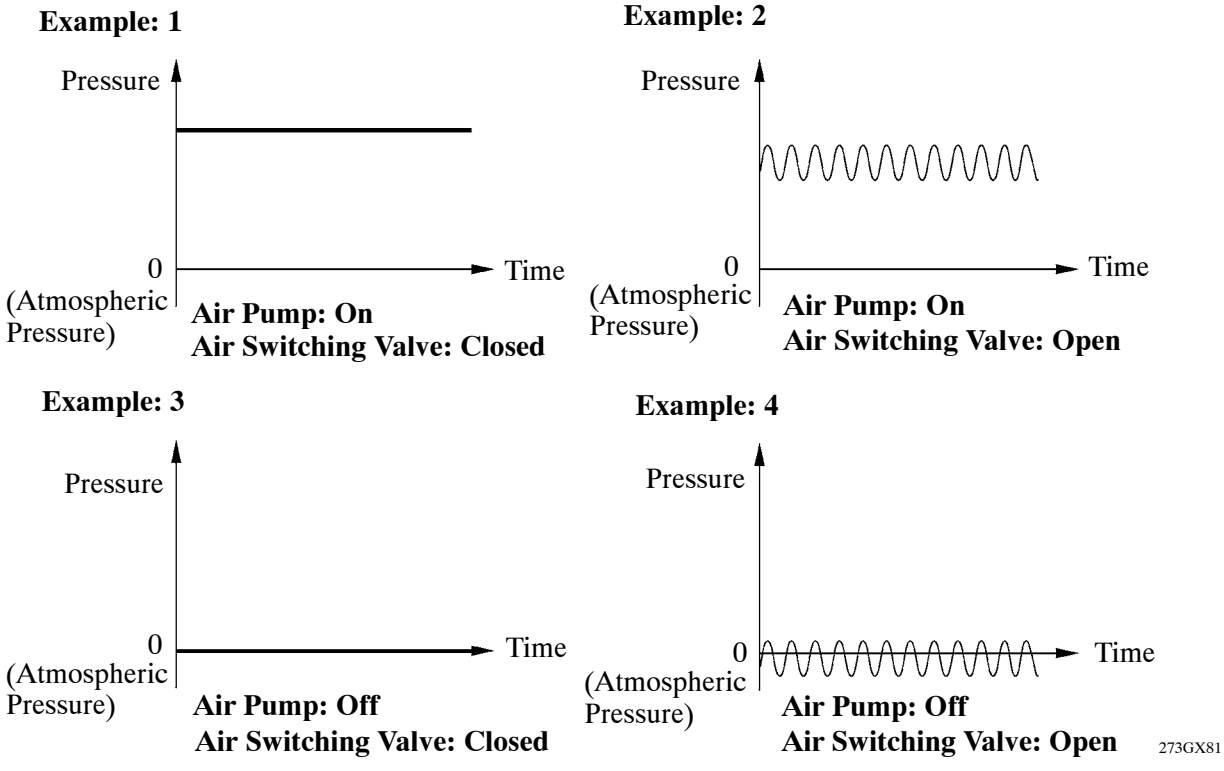
3) Air Pressure Sensor

- The air pressure sensor consists of a semiconductor, which has a silicon chip that changes its electrical resistance when pressure is applied to it. The sensor converts the pressure into an electrical signal, and sends it to the ECM in an amplified form.
- The air pressure sensors for bank 1 and bank 2 have the same basic structure and function.



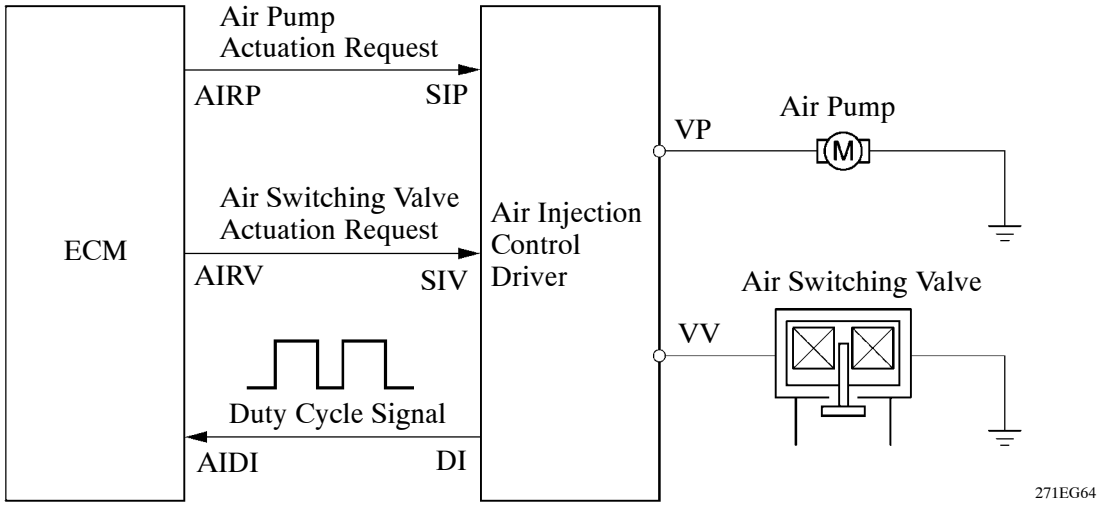
The ECM detects operation of the air injection system based on signals from the air pressure sensor as follows:

1) When the air pump is on and the air switching valve is closed, the pressure is stable.
2) When the air pump is on and the air switching valve is open, the pressure drops slightly and becomes unstable because of exhaust pulses.
3) When the air pump is off and the air switching valve is closed, the pressure remains at atmospheric pressure.
4) When the air pump is off and the air switching valve is open, the pressure drops below atmospheric pressure and becomes unstable because of exhaust pulses.



4) Air Injection Control Driver

- A semiconductor type air injection control driver is used. Activated by the ECM, this driver actuates the air pump and the air switching valve.
- The air injection control driver also detects failures in the input and output circuits of the air injection driver and transmits the failure status to the ECM via duty cycle signals.
- The following system chart shows bank 1 (left bank):



▶ DI Terminal Output ◀

Condition	AIRP	AIRV	Output (Duty Cycle Signal)
Open circuit in line between AIDI and DI terminals	—	—	GND 273GX28
Failure in line between ECM terminals and air injection control driver	—	—	GND 273GX29
Output failure at air injection control driver (failure in air pump actuation circuit)	—	—	200 ms, Duty 20%, GND 273GX30
Output failure at air injection control driver (failure in air switching valve actuation circuit)	—	—	Duty 40%, GND 273GX31
Overheat failure of air injection control driver	—	—	Duty 60%, GND 273GX32
Normal	On	On	Duty 80%, GND 273GX33
	Off	Off	GND 273GX29
	On	Off	
	Off	On	