■ ENGINE CONTROL SYSTEM

1. General

The engine control system of the 2TR-FE engine has the following systems.

System	Outline
EFI (Electric Fuel Injection)	● An L-type EFI system directly detects the intake air mass with a hot wire type intake mass air flow meter sub-assembly. ● 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 (Electric 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 (IGT) ignition signal to the igniter.
ETCS-i (Electronic Throttle Control System-intelligent)	Optimally controls the throttle valve opening in accordance with the amount of accelerator pedal effort and the condition of the engine and the vehicle.
Dual VVT-i (Dual Variable Valve Timing-intelligent)	Optimal valve timing can be controlled by the intake and exhaust camshafts according to engine conditions.
Air Injection System Control	The ECM controls the air injection time based on the signals from the intake mass air flow meter sub-assembly and E.F.I. engine coolant temperature sensor.
Fuel Pump Control*	A fuel cut control is used to stop the fuel pump when the airbag is deployed during front or side collision.
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.

*: Models with SRS Airbag System

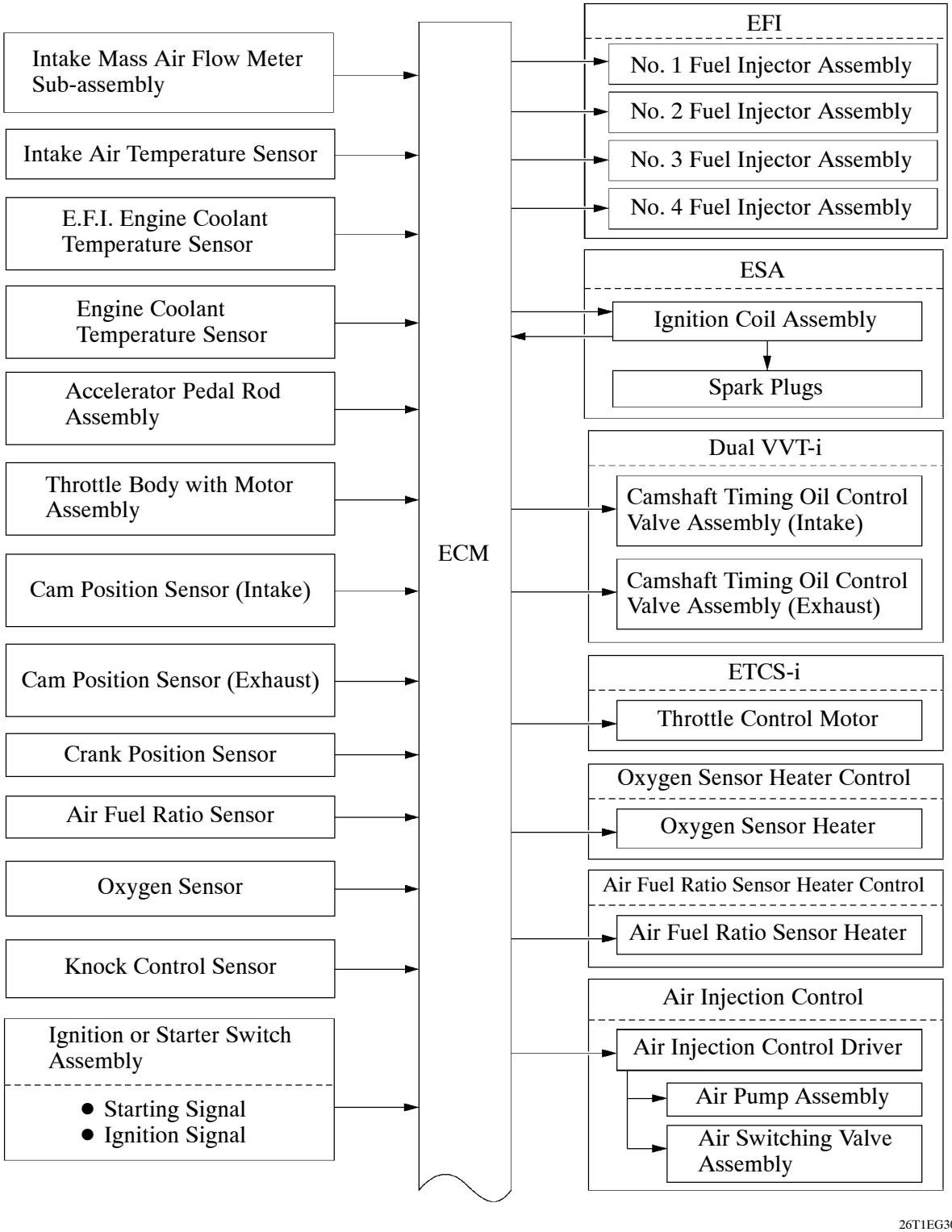
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System	Outline
Air Conditioner Cut-off Control*	By turning the air conditioner compressor ON or OFF in accordance with the engine condition, drivability is maintained.
Cooling Fan Control	The ECM steplessly controls the cooling fan speeds in accordance with the engine coolant temperature, engine speed, vehicle speed and air conditioner operating conditions. As a result, the cooling performance has been improved.
Evaporative Emission Control	The ECM controls the purge flow of evaporative emission (HC) in the charcoal canister in accordance with engine conditions.
Engine Immobilizer	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid ignition key.
	The ID code stored in the transponder key ECU is compared with that of the transponder tip in the ignition key.
Diagnosis	When the ECM detects a malfunction, the ECM diagnoses and memorizes the failed section.
Fail-Safe	When the ECM detects a malfunction, the ECM stops or controls the engine according to the data already stored in the memory.

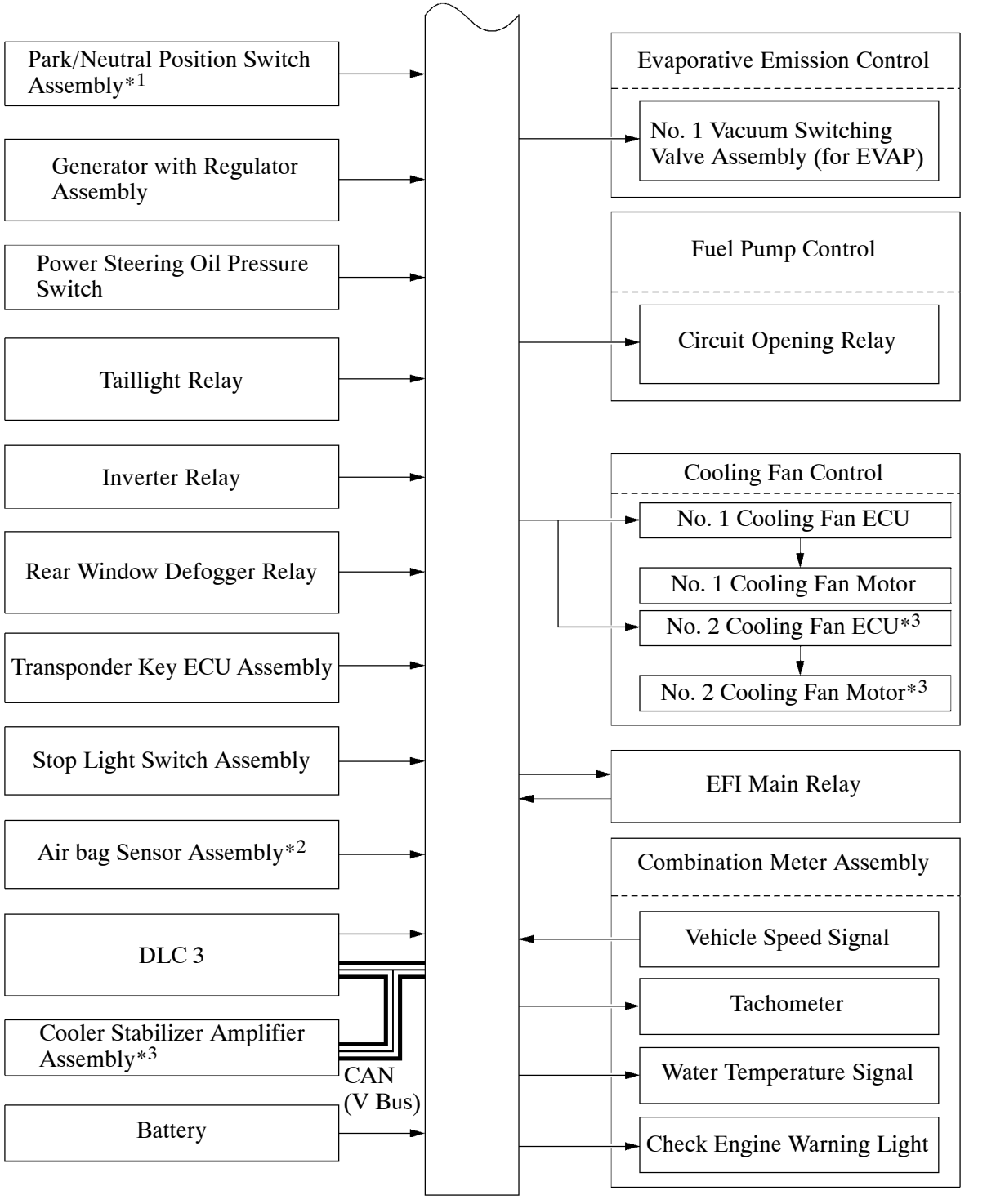
*: Models with Air Conditioner

2. Construction

The configuration of the engine control system in the 2TR-FE engine is as shown in the following chart.



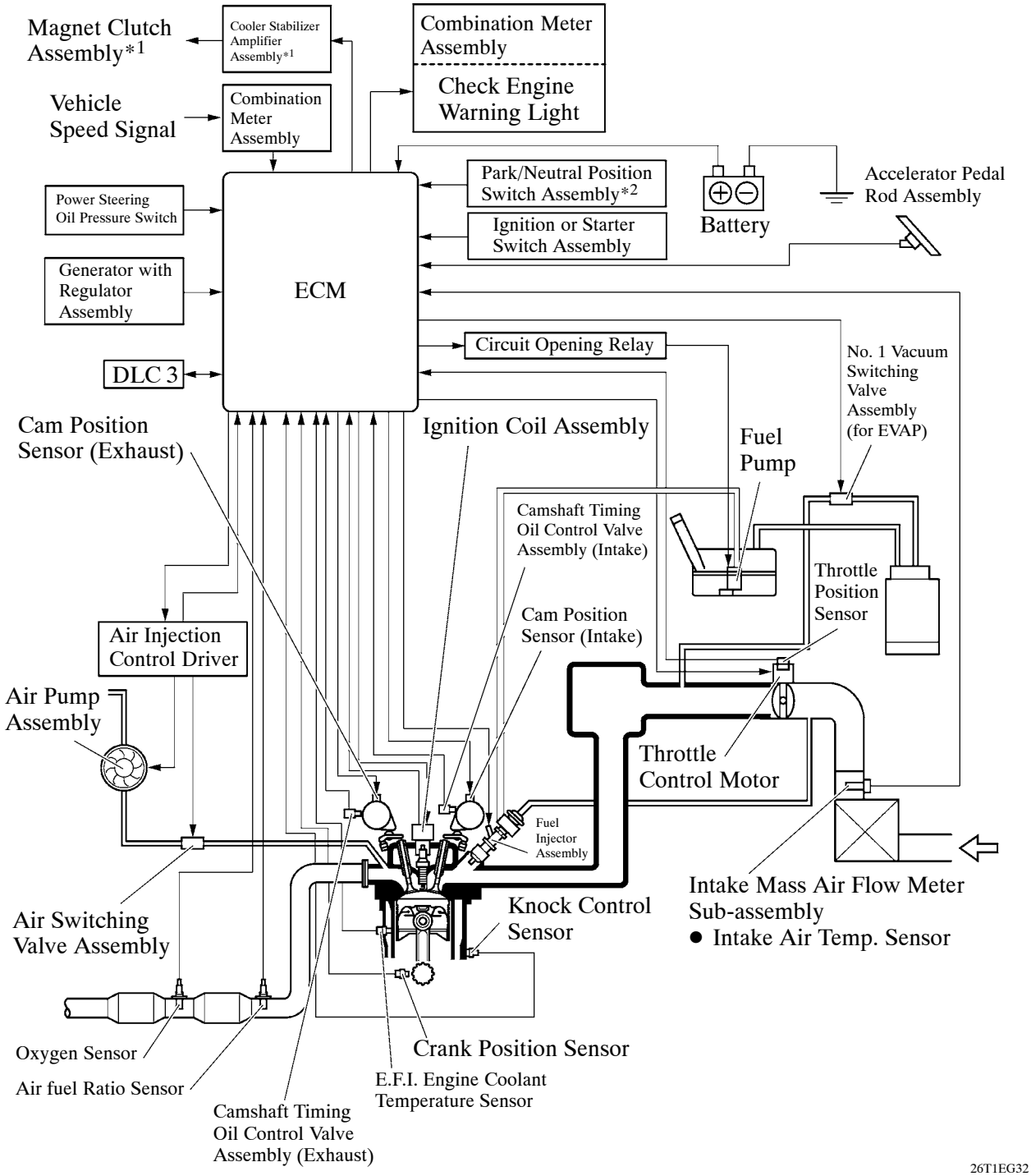
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*1: Models with Automatic Transmission
*2: Models with SRS Airbag System
*3: Models with Air Conditioner

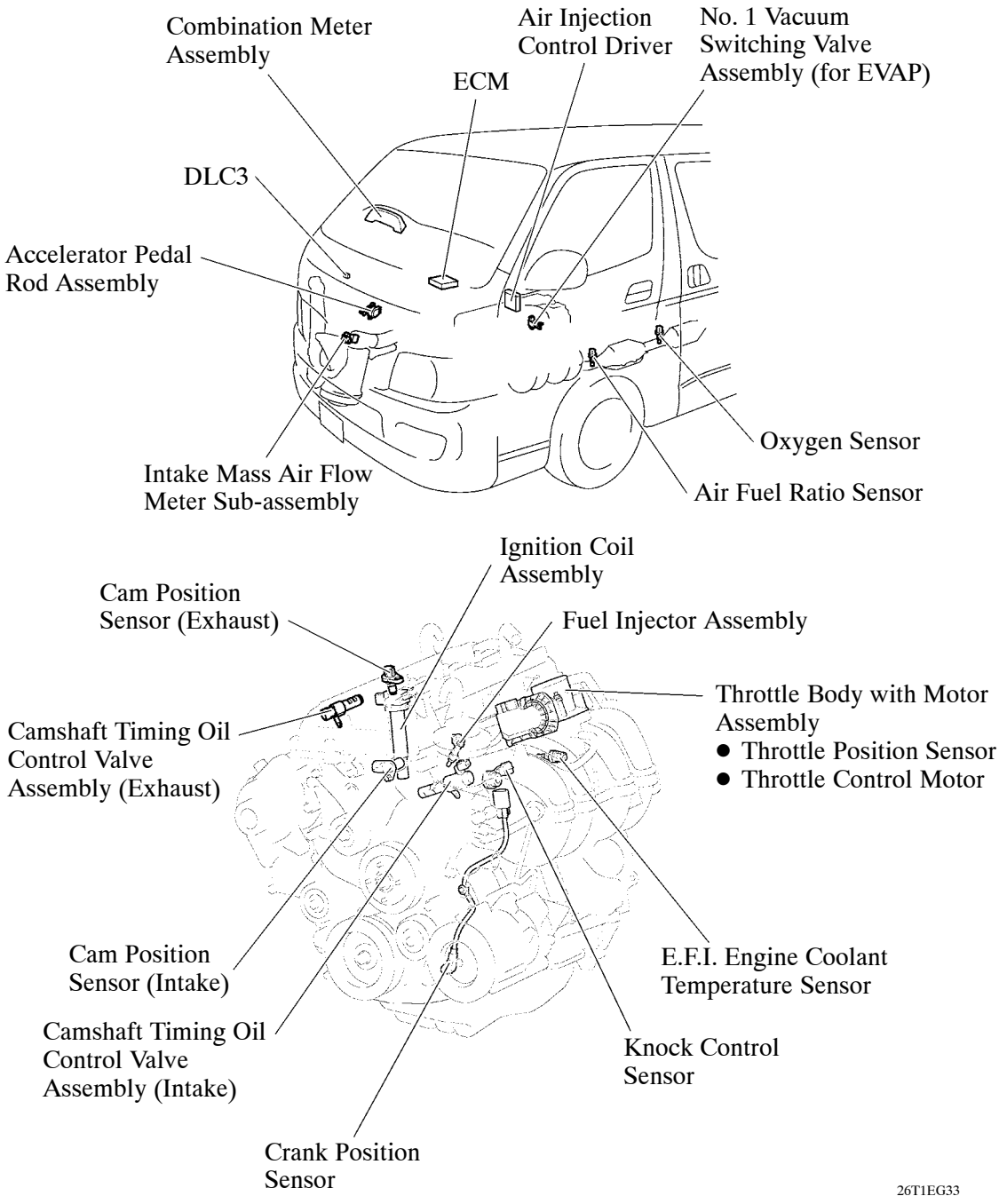
3. Engine Control System Diagram



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*1: Models with Air Conditioner
*2: Models with Automatic Transmission

4. Layout of Main Components



5. Main Components of Engine Control System

General

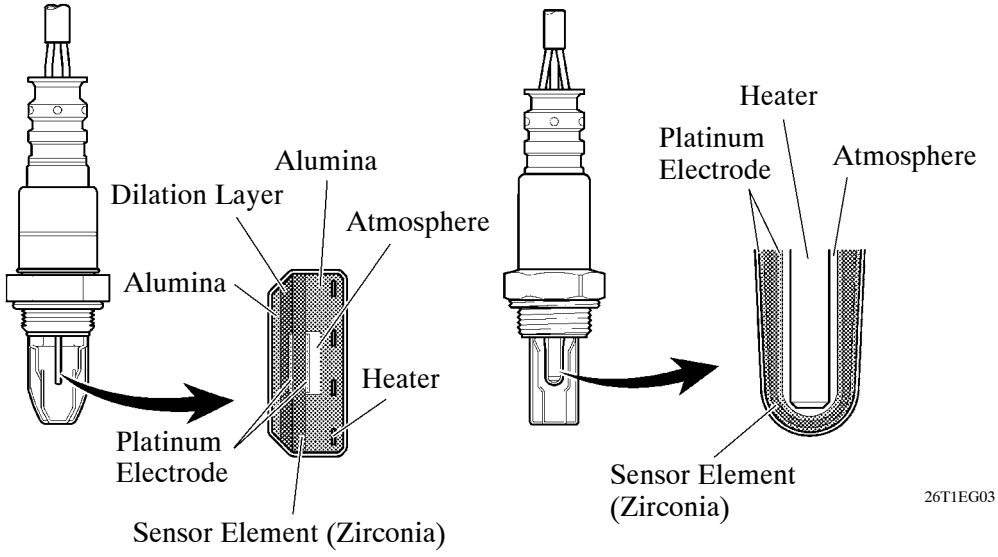
The main components of the 2TR-FE engine control system are as follows:

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.
Oxygen Sensor	Cup Type with Heater	1	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	Planar Type with Heater	1	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.
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 volume.
Crank Position Sensor (Rotor Teeth)	Pick-up Coil Type (36-2)	1	This sensor detects the engine speed and performs the cylinder identification.
Cam Position Sensor (Rotor Teeth)	Pick-up Coil Type (3)	2	This sensor performs the cylinder identification.
E.F.I. engine coolant temperature sensor	Thermistor Type	1	This sensor detects the engine coolant 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 Control Sensor	Built-in Piezoelectric Type (Flat Type)	1	This sensor detects an occurrence of the engine knocking indirectly from the vibration of the cylinder block caused by the occurrence of engine knocking.
Throttle Position Sensor	No-contact Type	1	This sensor detects the throttle valve opening angle.
Accelerator Pedal Position Sensor	No-contact Type	1	This sensor detects the amount of pedal effort applied to the accelerator pedal.
Fuel Injector Assembly	12-hole Type	4	The injector is an electromagnetically-operated nozzle which injects fuel in accordance with the signals from the ECM.

Oxygen Sensor and Air Fuel Ratio Sensor

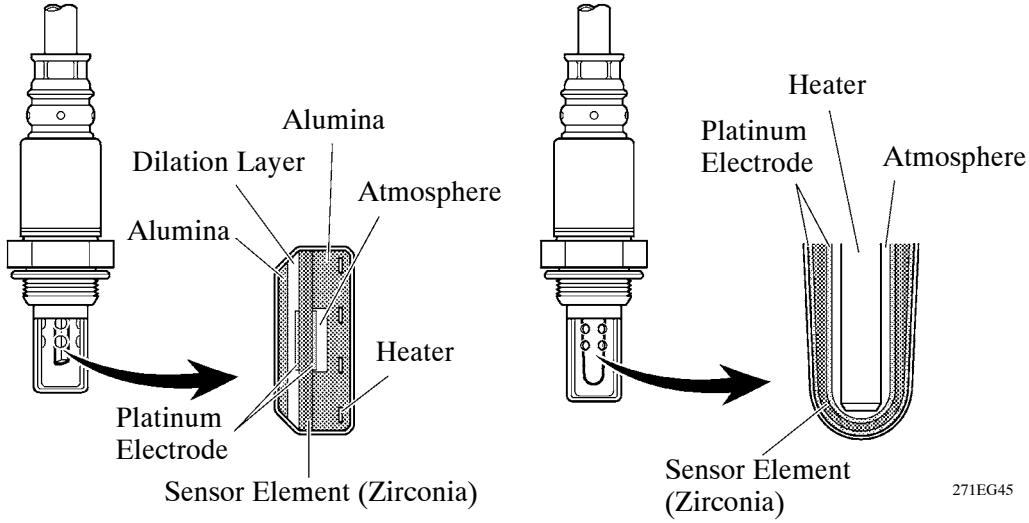
General

A newly shaped oxygen sensor and air fuel ratio sensor have been adopted.



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

New

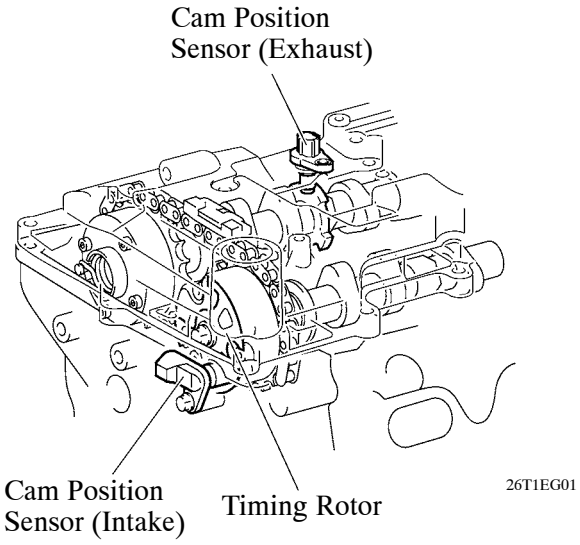


Planer Type Air Fuel Ratio Sensor **Cup Type Oxygen Sensor**

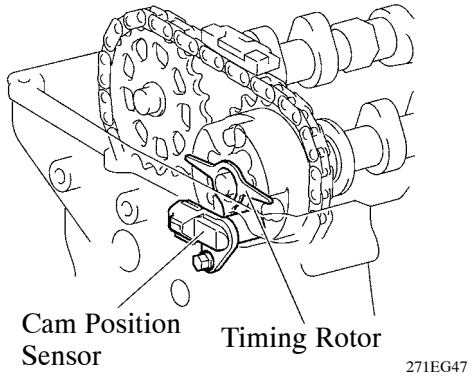
Previous

Camshaft Position Sensors

Along with the adoption of the Dual VVT-i, a cam position sensor has also been adopted on the exhaust side.



New

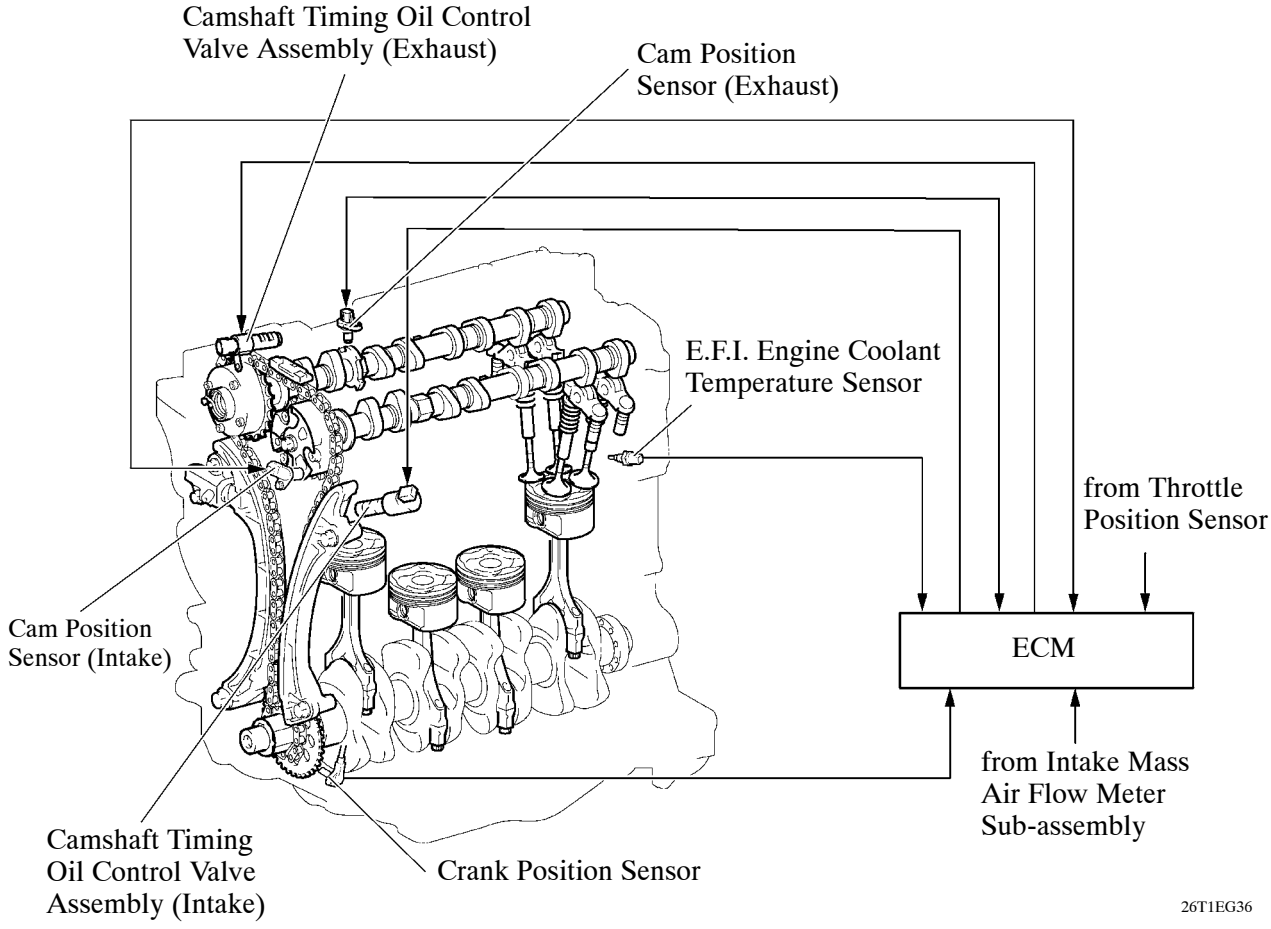


Previous

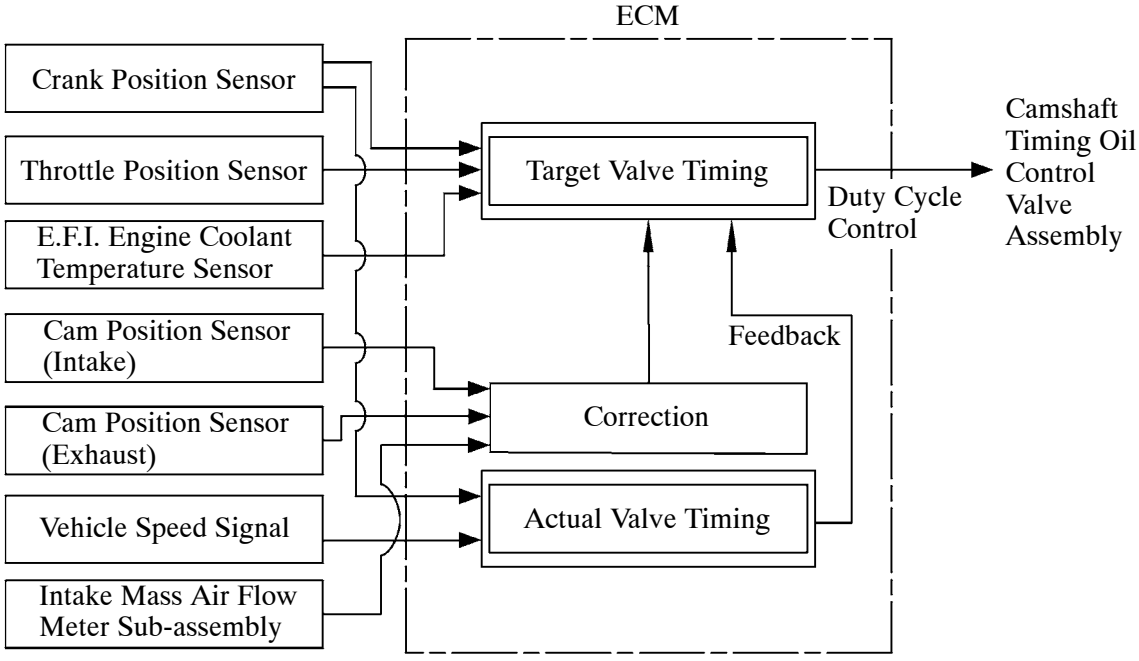
6. VVT-i (Variable Valve Timing-intelligent) System

General

The Dual VVT-i system is designed to control the intake and exhaust camshafts within a range of 50° and 45° respectively (of crankshaft angle) to provide valve timing that is optimally suited to engine operating conditions. This improves torque in all speed ranges as well as increasing fuel economy and reducing exhaust emissions.

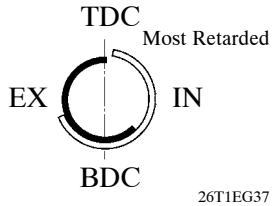
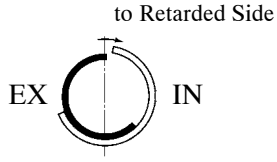
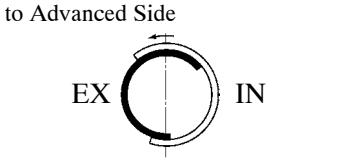
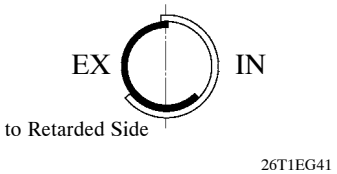
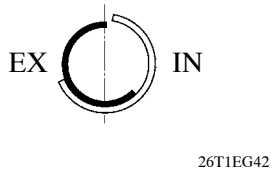
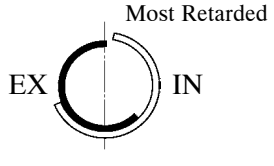


Using the engine speed, intake air volume, throttle position and water temperature, the ECM can calculates optimal valve timing for each driving condition and controls the camshaft timing oil control valve. In addition, the ECM uses the signals from the camshaft position sensor and the crankshaft position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



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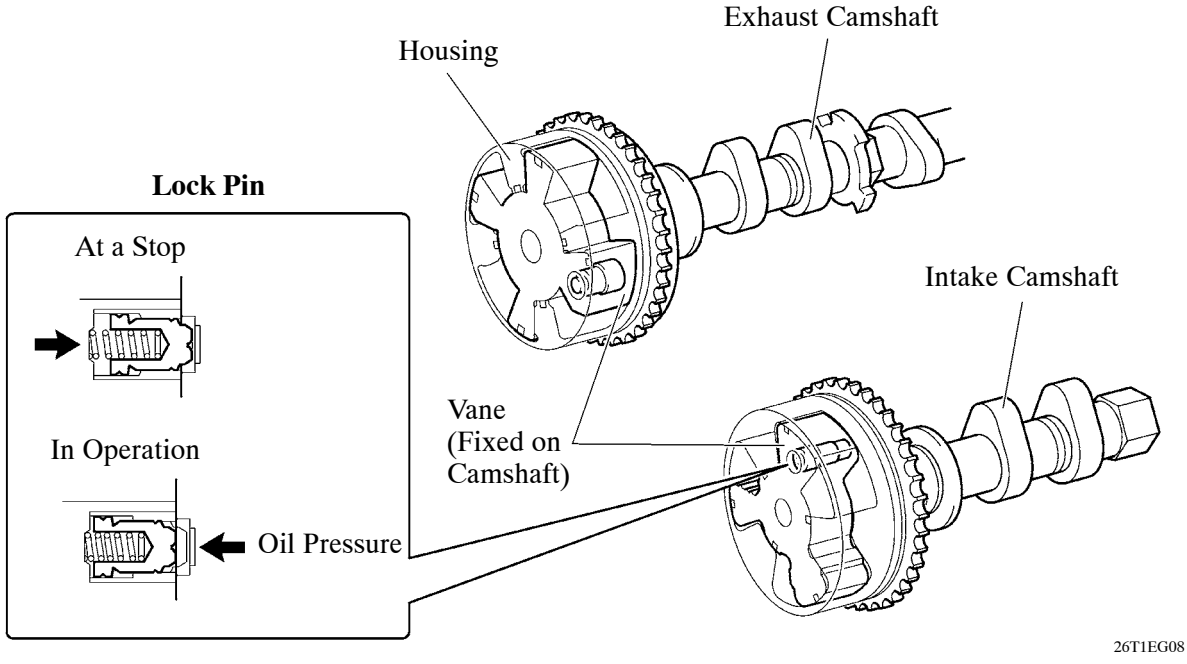
Effectiveness of the VVT-i System

Operation State	Objective		Effect
During Idle		Eliminating overlap to reduce blow back to the intake side.	● Stabilized idle engine speed ● Better fuel economy
At Light Load		Eliminating overlap to reduce blow back to the intake side.	Ensured engine stability is ensured
At Medium Load		Increasing overlap to increase internal EGR to reduce pumping losses.	● Better fuel economy ● Improved emission control
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 reduce blow back to the intake side stabilizes the idle speed during fast idle.	● Stabilized idle engine speed ● Better fuel economy
● Upon Starting the Engine ● Upon Stopping the Engine		Eliminating overlap to minimize blow back to the intake side.	Improved startability

Construction

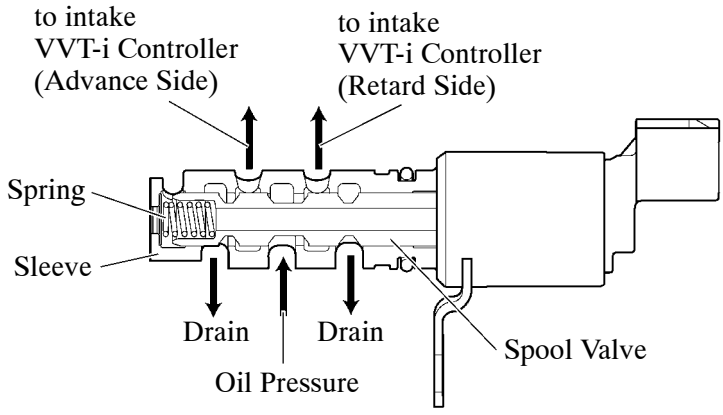
1) VVT-i Controller

- Each VVT-i controller consists of a housing driven from the timing chain and a vane coupled with the intake or exhaust camshaft.
- A 3-blade vane has been adopted for the intake side, while a 4-blade vane has been adopted for the exhaust side.
- The oil pressure sent from the advanced or retarded side path at the intake and exhaust camshafts causes rotation in a camshaft timing gear assembly vane circumferential direction to vary the intake and exhaust valve timing continuously.
- When the engine is stopped, a lock pin locks the intake camshaft at its most retarded position and the exhaust camshaft at its most advanced position, to ensure that the engine starts properly.
- An advance assist spring is provided on the exhaust side camshaft timing gear assembly. This spring applies torque in the advance direction when the engine is stopped, thus ensuring the engagement of the lock pin.

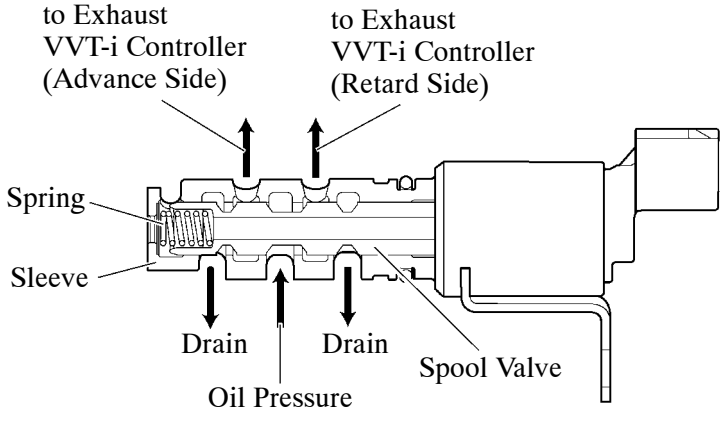


2) Camshaft Timing Oil Control Valve

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 VVT-i controller advance or retard side. When the engine is stopped, the intake camshaft timing oil control valve will move to the retard position, and the exhaust camshaft timing oil control valve will move to the advance position.



Intake Camshaft Timing Oil Control Valve



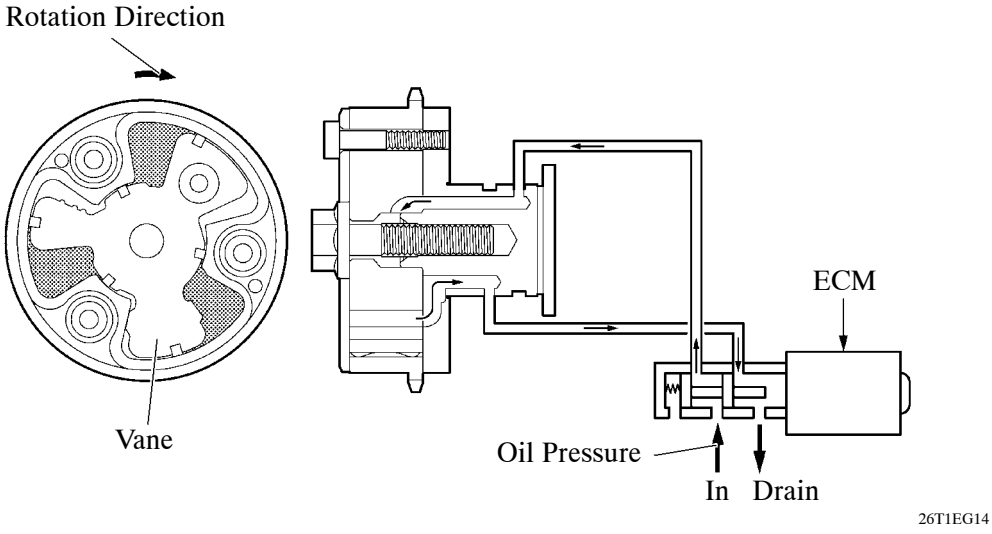
Exhaust Camshaft Timing Oil Control Valve

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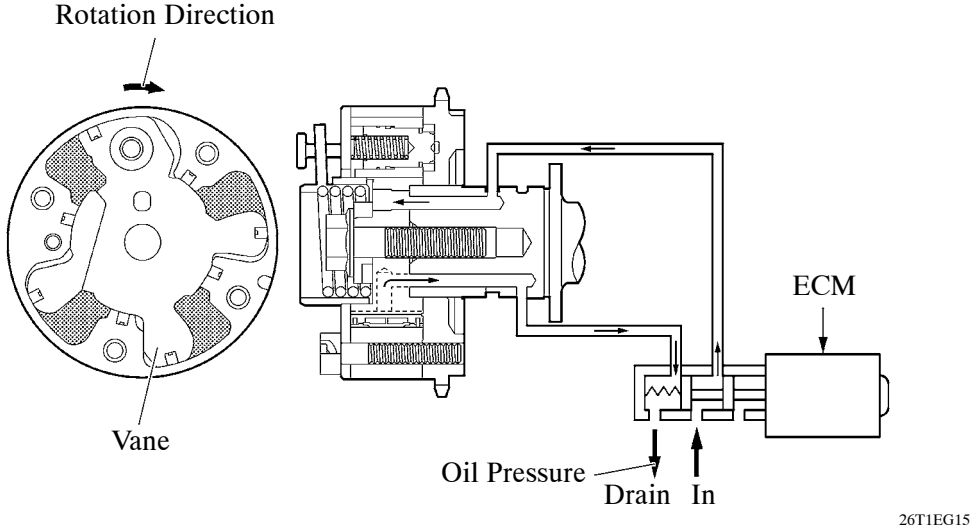
Operation

1) Advance

When the camshaft timing oil control valve assembly is operated as illustrated below by the advance signal 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.



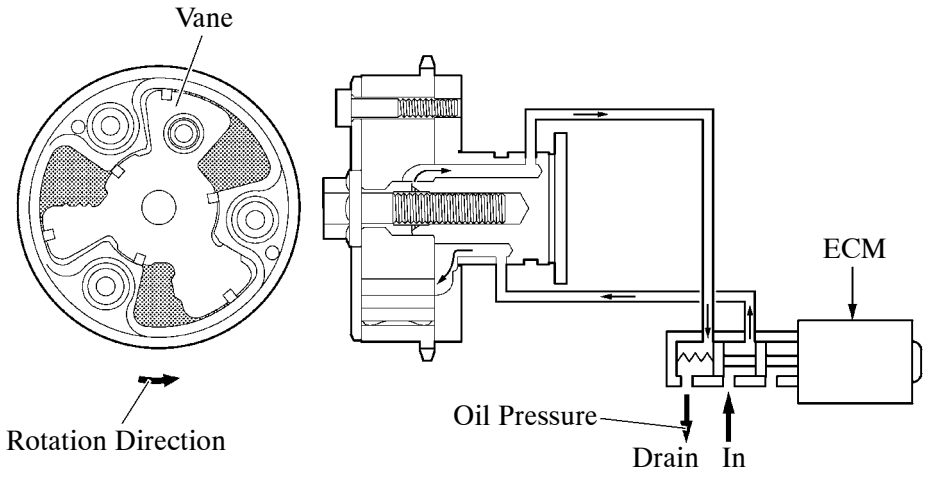
Intake Side



Exhaust Side

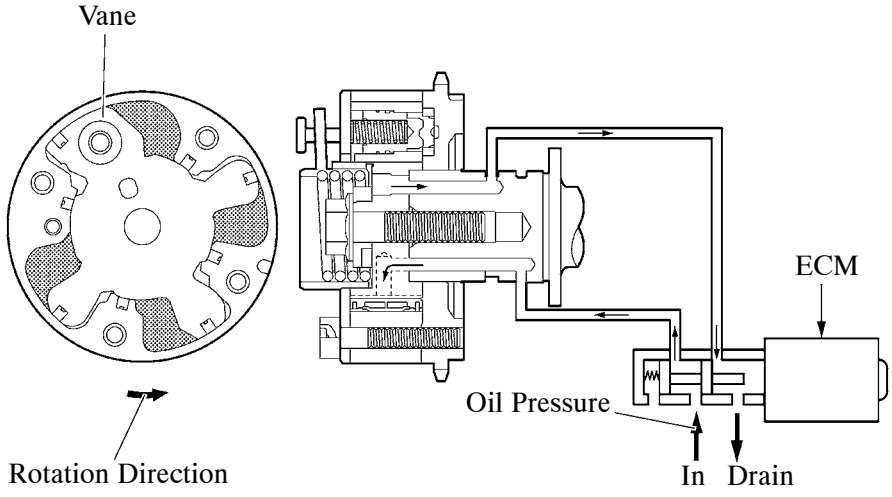
2) Retard

When the camshaft timing oil control valve assembly is operated as illustrated below by the retard signal 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

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Exhaust Side

26T1EG17

3) Hold

After reaching the target timing, the valve timing is held by keeping the camshaft timing oil control valve assembly 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.

7. Diagnosis

- When the ECM detects a malfunction, the ECM 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 ECM also stores the DTCs of the malfunctions.
- The DTCs can be accessed by connecting the SST to the DLC3 terminals TC and CG, and reading the blinking of the check engine warning light. They can also be accessed by connecting an Global TechStream (GTS).
- All the DTCs (Diagnostic Trouble Codes) have been made 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 Repair Manual).

Service Tip

To clear the DTC that is stored in the ECM, use an Global TechStream (GTS), disconnect the battery terminal or remove the EFI fuse for 1 minute or longer.

8. Fail-Safe

When a malfunction is detected by any of the sensors, there is a possibility of an engine or another malfunction occurring if the ECM 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 Repair Manual.