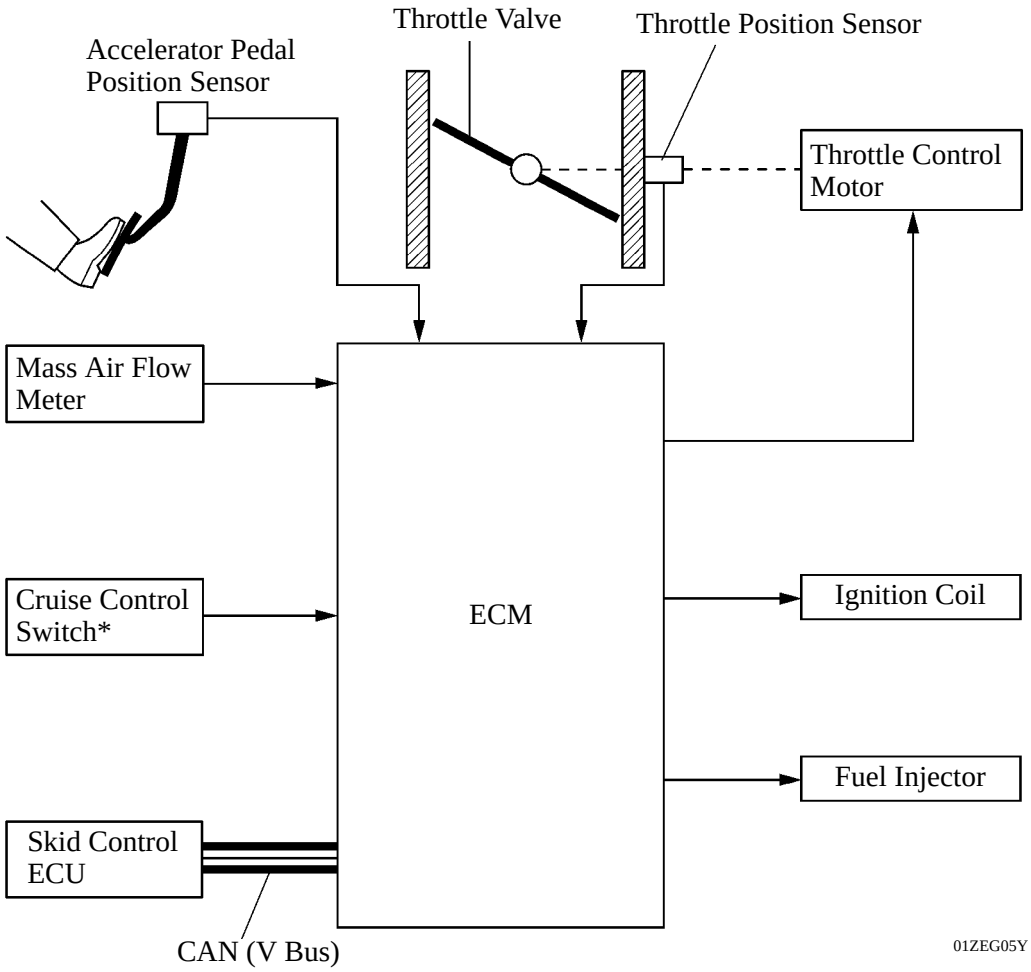
6. ETCS-i (Electronic Throttle Control System-intelligent)

General

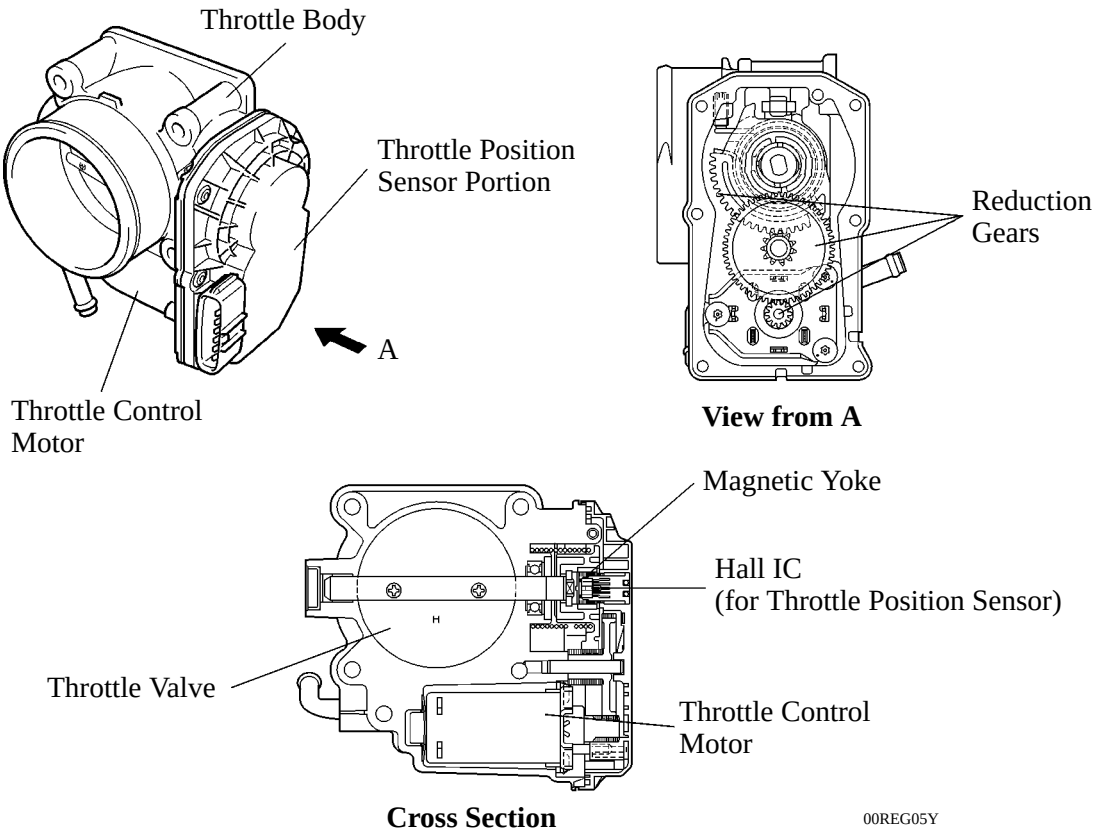
- The ETCS-i is used, providing excellent throttle control in all the operating ranges.
- The accelerator cable has been discontinued, and an accelerator pedal position sensor has been provided on the accelerator pedal.
- In the conventional throttle body, the throttle valve opening angle is determined invariably by the amount of the accelerator pedal effort. In contrast, the ETCS-i uses the ECM to calculate the optimal throttle valve opening angle that is appropriate for the respective driving condition and uses a throttle control motor to control the opening angle.
- The ETCS-i controls the ISC (Idle Speed Control) system, the TRAC (Traction Control), VSC (Vehicle Stability Control) system and cruise control system*.
- In case of an abnormal condition, this system switches to the limp mode.

▶ System Diagram ◀



*: Models with Cruise Control System

Construction



1) Throttle Position Sensor

The throttle position sensor is mounted on the throttle body to detect the opening angle of the throttle valve.

2) Throttle Control Motor

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

Operation

1) General

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

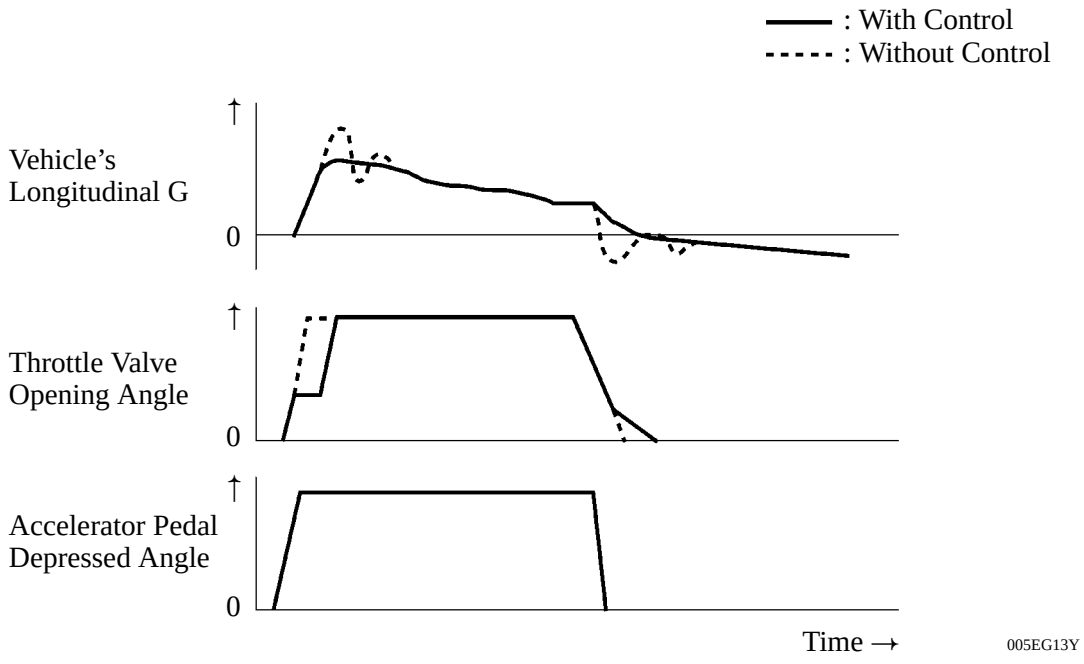
- Non-linear Control
- Idle Speed Control
- TRAC Throttle Control
- VSC Coordination Control
- Cruise Control*

*: Models with Cruise Control System

2) Non-linear Control

The ECM controls the throttle valve to an optimal opening 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.

▶ Control Examples During Acceleration and Deceleration ◀



3) Idle Speed Control

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

4) TRAC Throttle Control

As part of TRAC system, the throttle valve is closed by a request signal from the skid control ECU if an excessive amount of slippage is created at a driving wheel, thus it facilitates the vehicle in ensuring stability and driving force.

5) VSC Coordination Control

In order to bring the effectiveness of the VSC system control into full play, the throttle valve opening angle is controlled by effecting a coordination control with the skid control ECU.

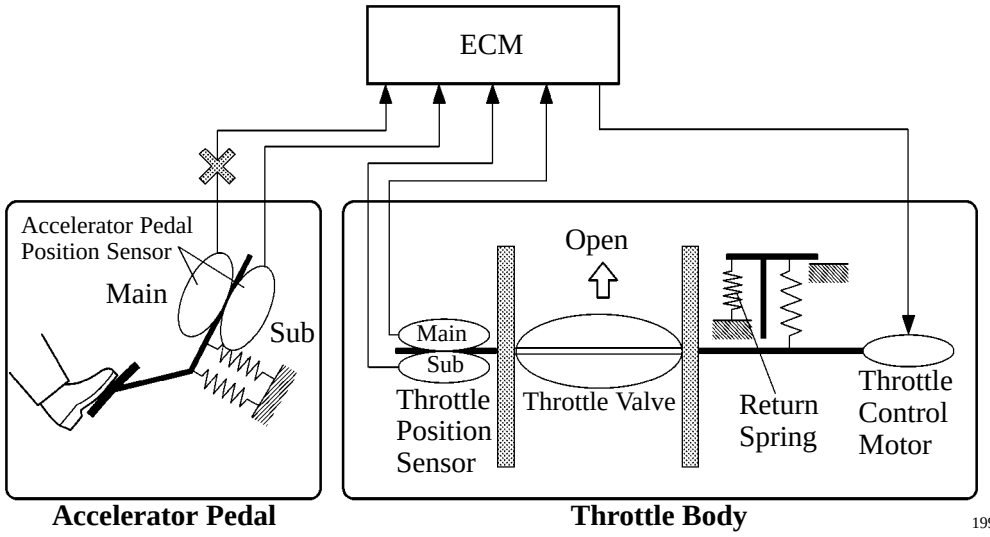
6) Cruise Control*

An ECM with an integrated cruise control ECU directly actuates the throttle valve for operation of the cruise control.

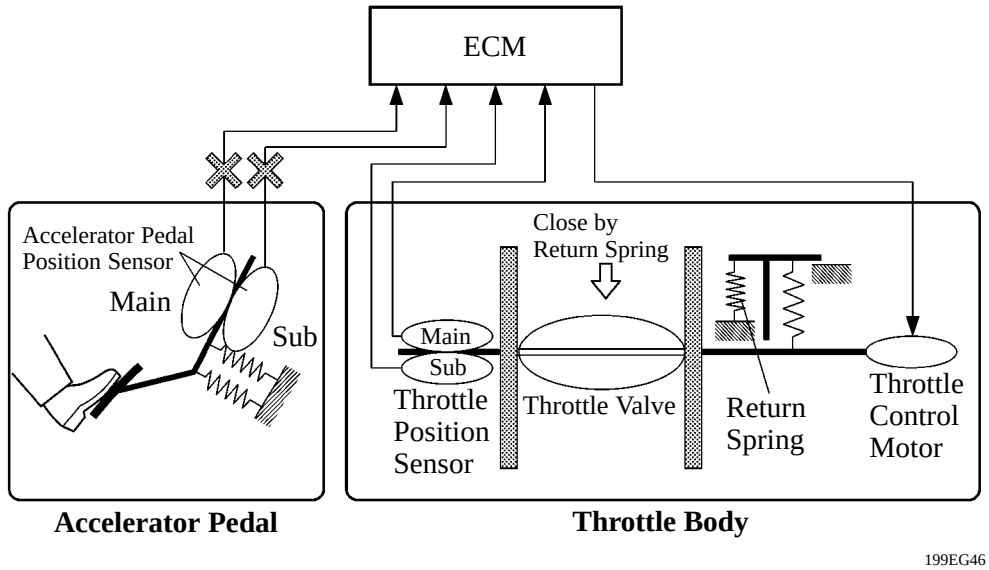
*: Models with Cruise Control System

Fail-safe of Accelerator Pedal Position Sensor

- The accelerator pedal position sensor is comprised of two (main, sub) sensor circuits. If a malfunction occurs in either one of the sensor circuits, the ECM detects the abnormal signal by voltage difference between these two sensor circuits and switches to the limp mode. In the limp mode, the remaining circuit is used to calculate the accelerator pedal depressed angle, in order to operate the vehicle under limp mode control.

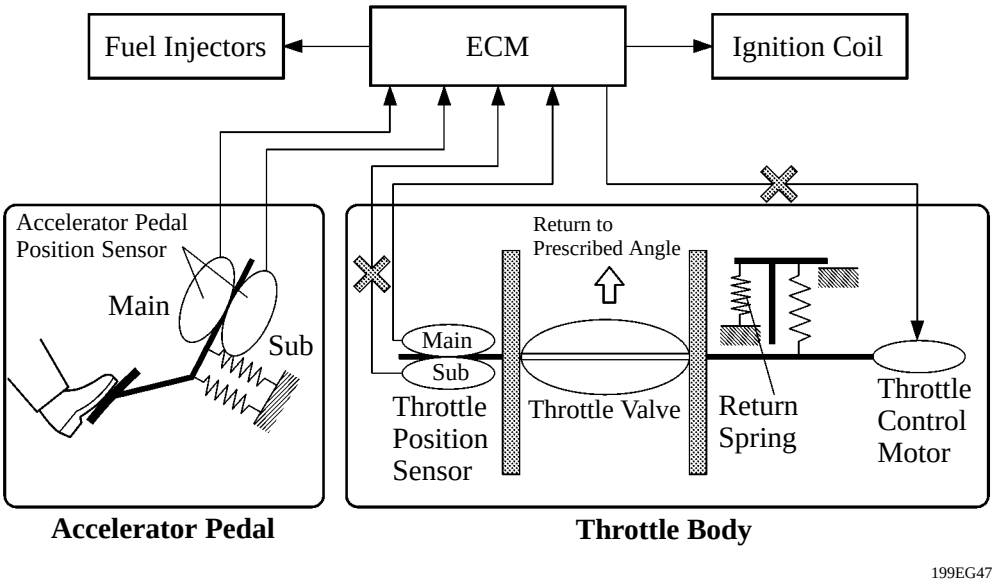


- If both circuits have a malfunction, the ECM detects the abnormal signal by voltage from these two sensor circuits and discontinues the throttle control. At this time, the vehicle can be driven within its idling range.



Fail-safe of Throttle Position Sensor

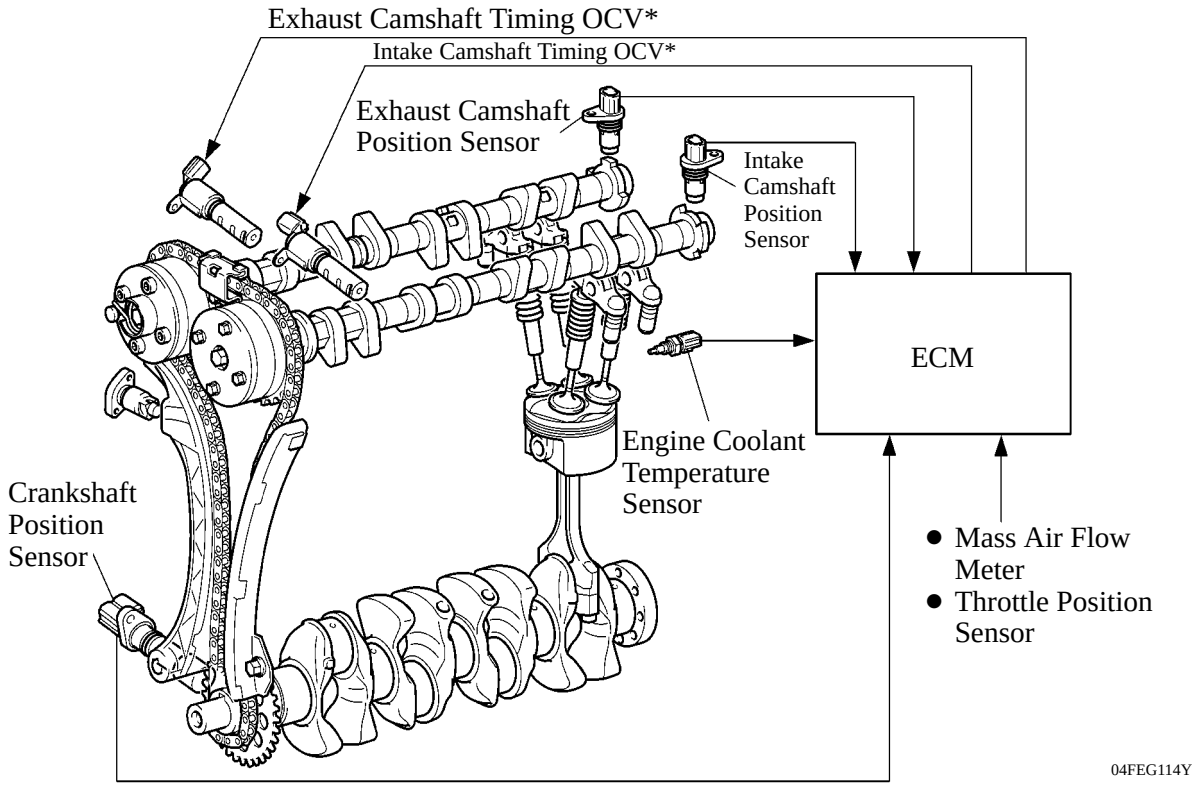
- The throttle position sensor is comprised of two (main, sub) sensor circuits. If a malfunction occurs in either one or both of the sensor circuits, the ECM detects the abnormal signal by voltage difference between these two sensor circuits, cuts off the current to the throttle control motor, and switches to the limp mode. Then, the force of the return spring causes the throttle valve to return and stay at the prescribed opening angle. At this time, the vehicle can be driven in the limp mode while the engine output is regulated through the control of the fuel injection (intermittent fuel-cut) and ignition timing in accordance with the accelerator opening.
- The same control as above is effected if the ECM detects a malfunction in the throttle control motor system.



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

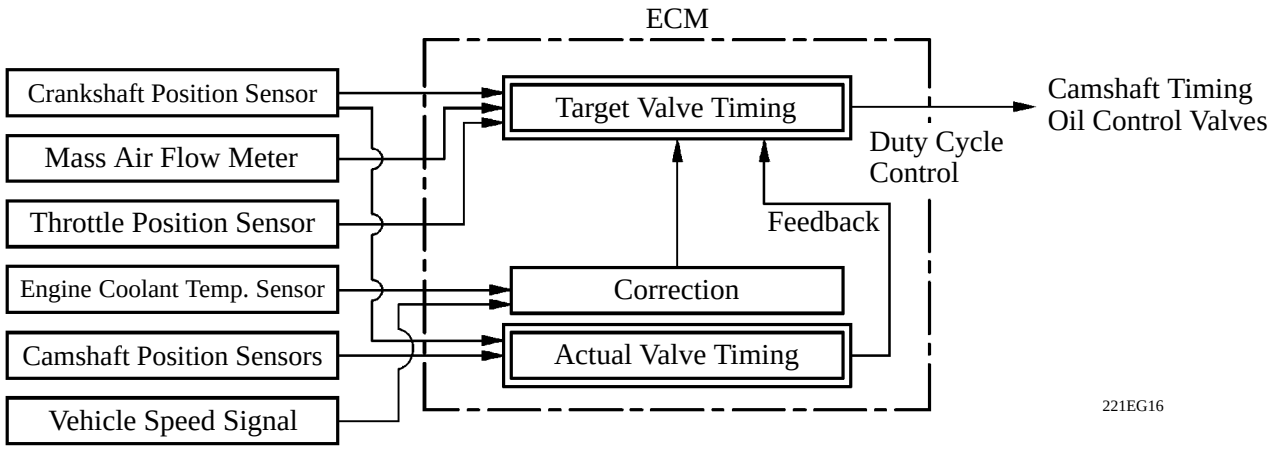
General

- The Dual VVT-i system is designed to control the intake and exhaust camshafts within a range of 55° and 40° 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.

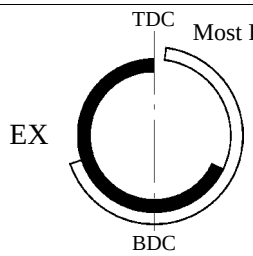
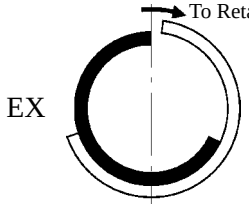
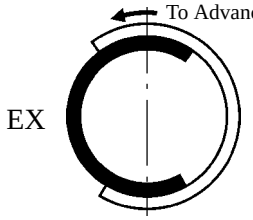
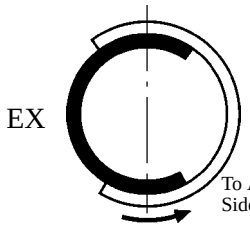
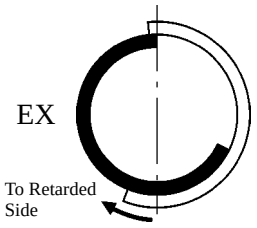
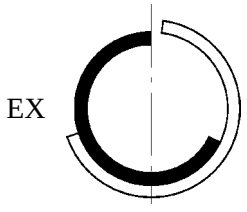
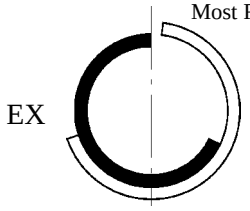


*: Oil Control Valve

- Using the engine speed, intake air mass, throttle position and engine coolant temperature, the ECM can calculate optimal valve timing for each driving condition and controls the camshaft timing oil control valve. In addition, the ECM 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.



Effectiveness of Dual VVT-i System

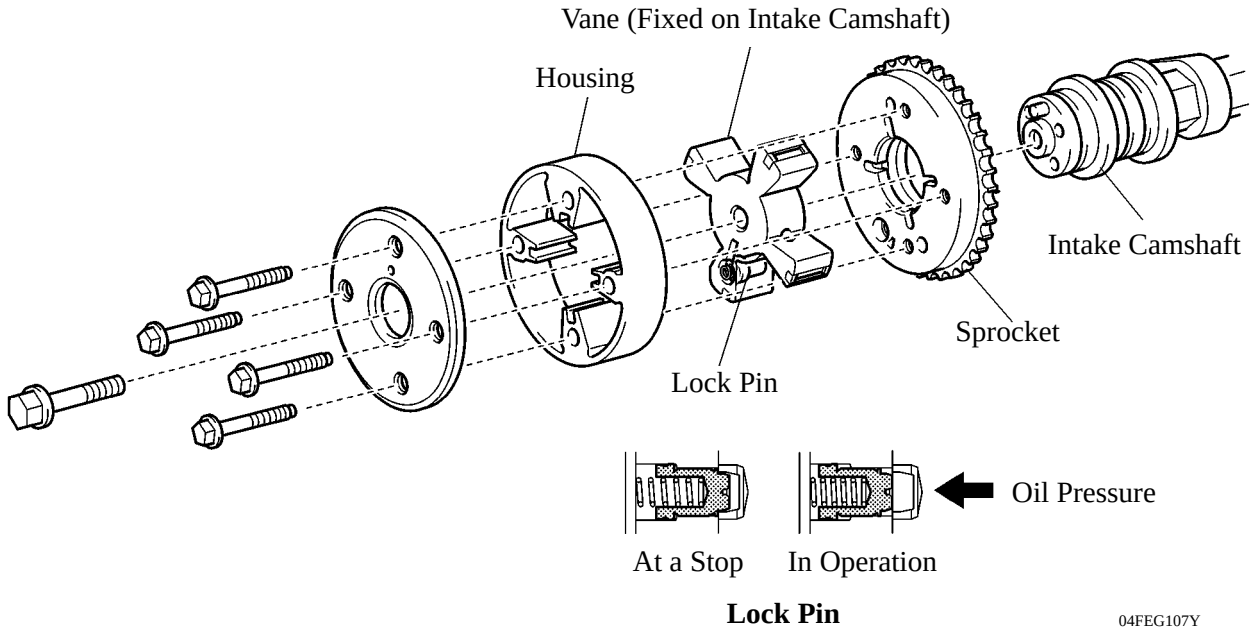
Operation State	Objective		Effect
During Idling		Eliminating overlap to reduce blow back to the intake side	● Stabilized idle speed ● Better fuel economy
At Light Load		Eliminating overlap to reduce blow back to the intake side	Ensured engine stability
At Medium Load		Increasing overlap to increase internal EGR to reduce pumping loss	● Better fuel economy ● Improved emission 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 leads to the lean burning condition, and stabilizes the idling speed at fast idle	● Stabilized idle speed ● Better fuel economy
● Upon Starting ● Stopping the Engine		Eliminating overlap to minimize blow back to the intake side	Improved startability

Construction

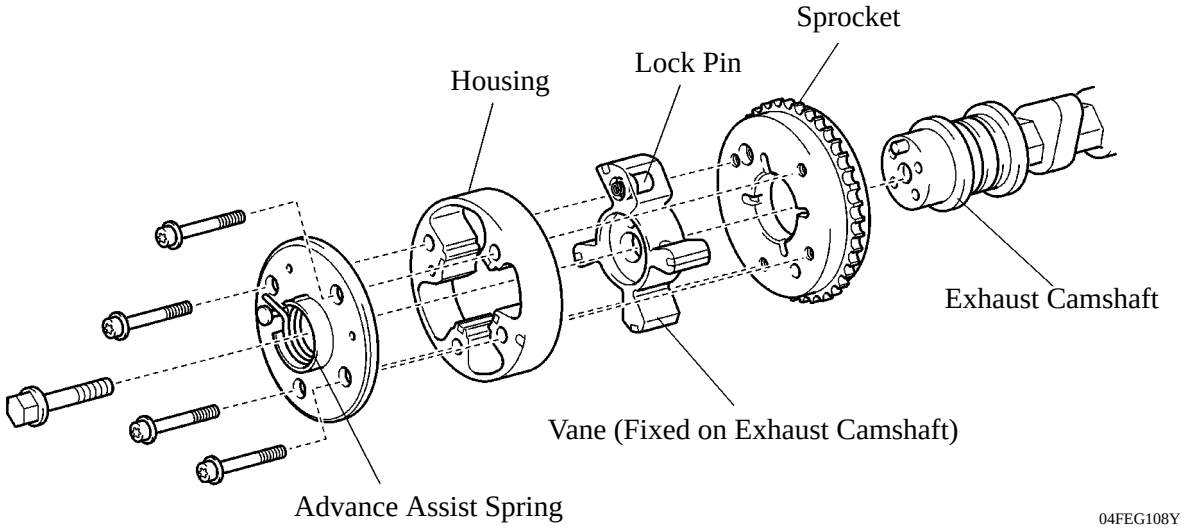
1) VVT-i Controller

- Each controller consists of the housing driven from the timing chain and the vane coupled with the intake or exhaust camshaft.
- Both the intake and exhaust sides have a four-blade vane.
- The oil pressure sent from the advanced or retarded side path at the intake and exhaust camshafts causes rotation in the VVT-i controller 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 the most retarded end and the exhaust camshaft at the most advanced end, to ensure that the engine starts properly.
- An advance assist spring is provided on the exhaust side VVT-i controller. This spring applies torque in the advance direction when the engine is stopped, thus ensuring the engagement of the lock pin.

▶ Intake Side VVT-i Controller ◀



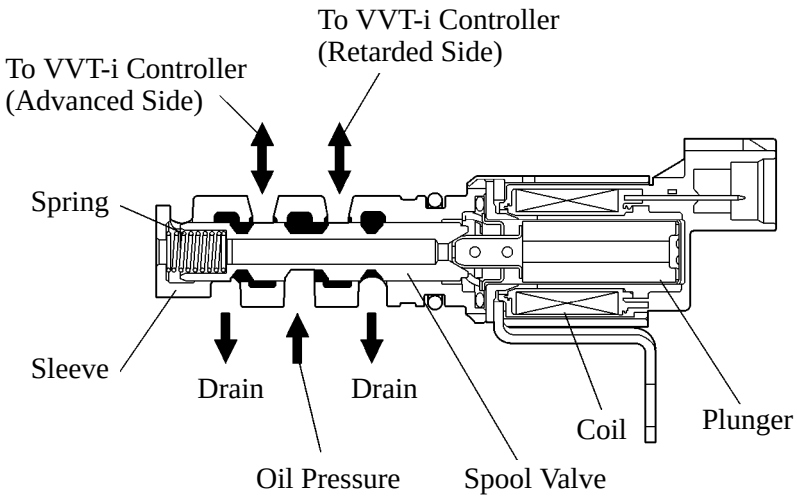
▶ Exhaust Side VVT-i Controller ◀



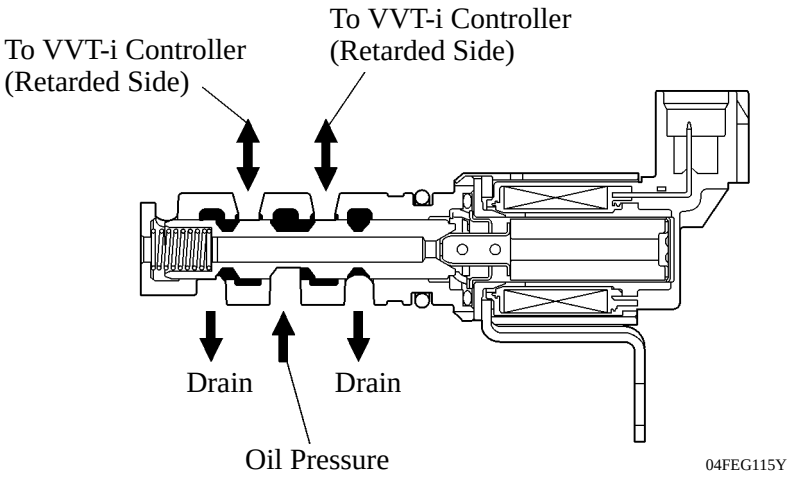
2) Camshaft Timing Oil Control Valve

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 advanced or retarded side. When the engine is stopped, the camshaft timing oil control valve (intake) will move to the most retarded position, and the camshaft timing oil control valve (exhaust) will move to the advance position.

▶ Intake Camshaft Timing Oil Control Valve ◀



▶ Exhaust Camshaft Timing Oil Control Valve ◀

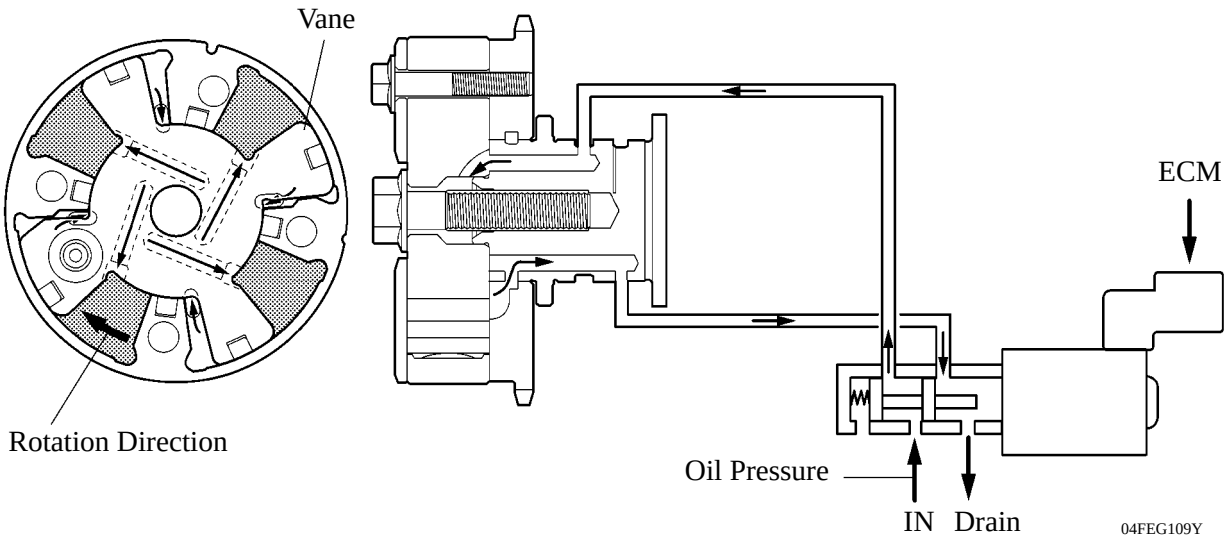


Operation

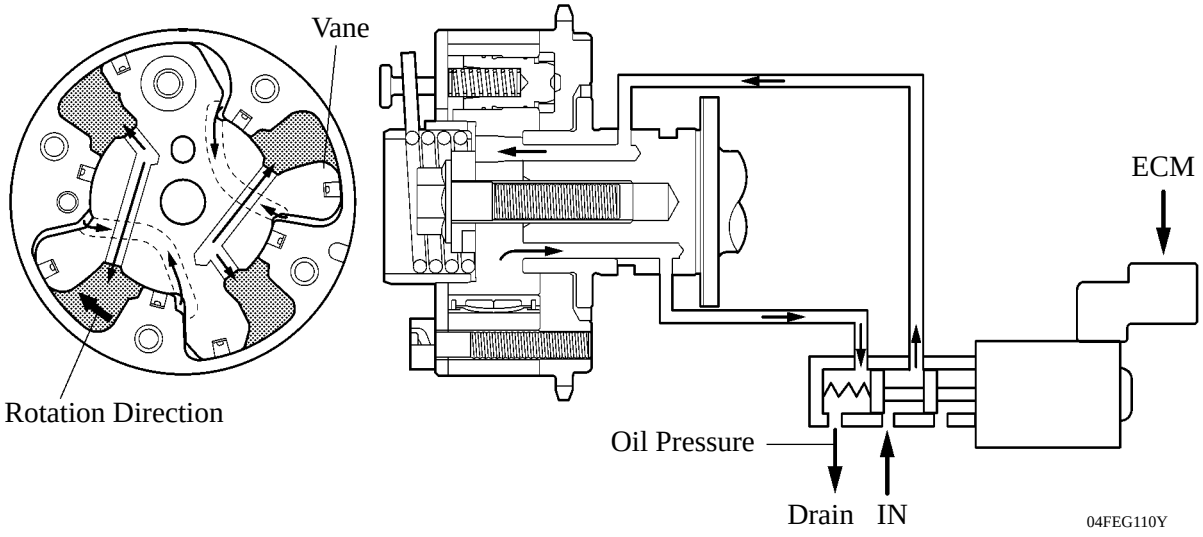
1) Advance

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 ◀



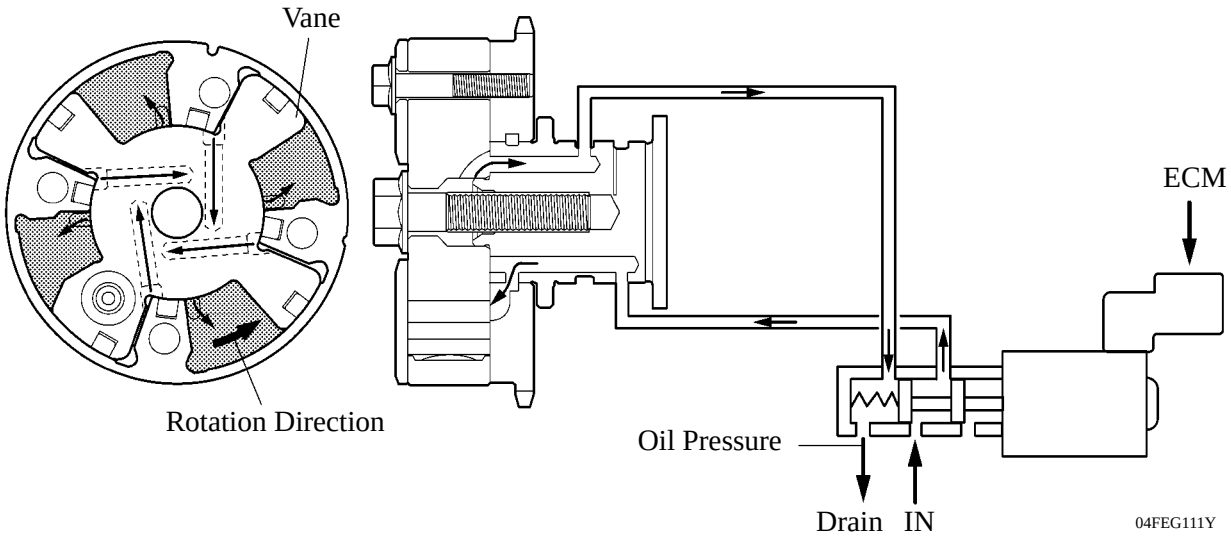
▶ Exhaust Side ◀



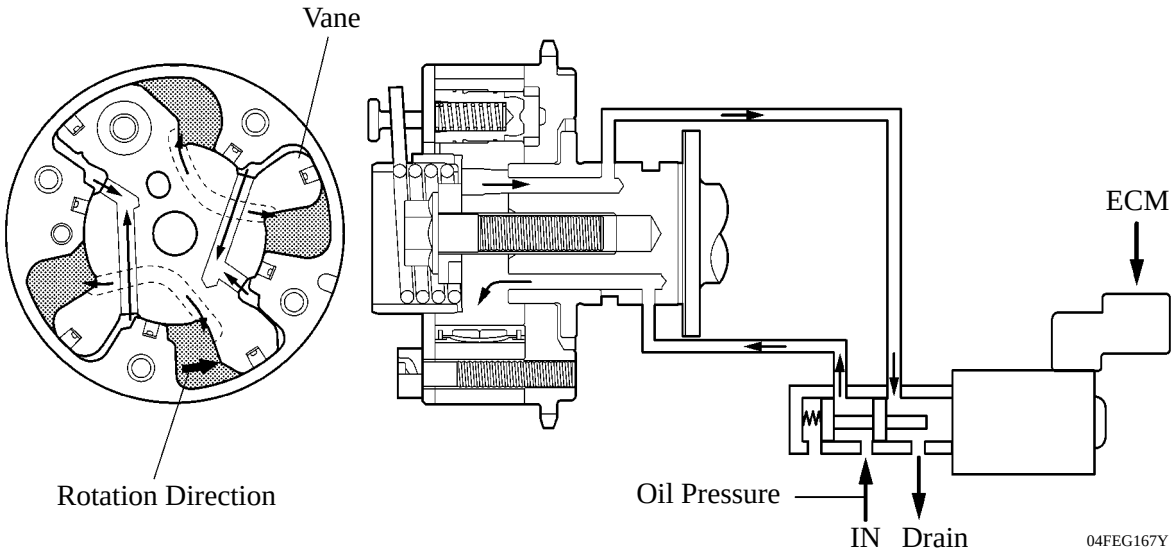
2) Retard

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 ◀

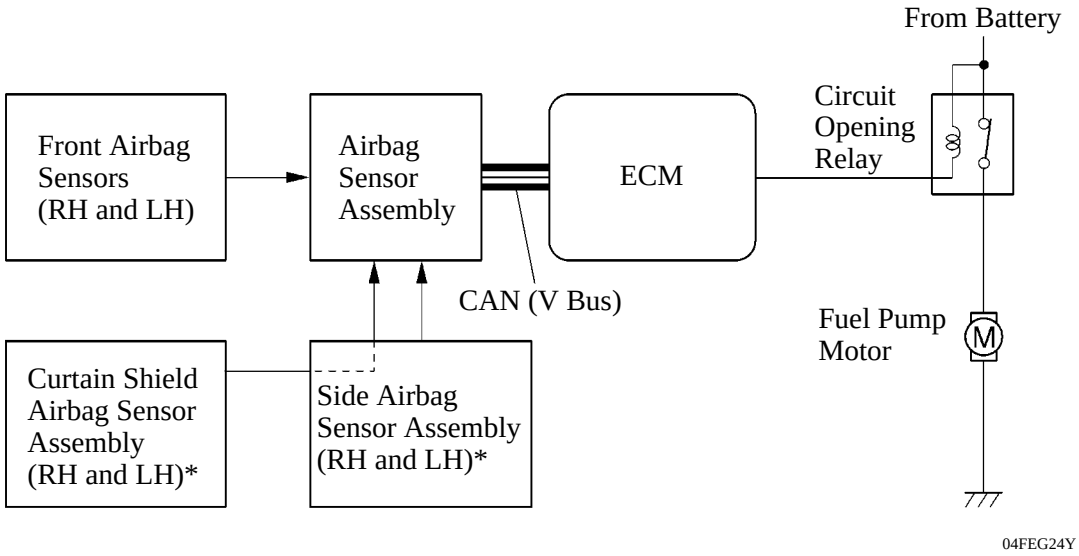


3) Hold

After reaching the target timing, the 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. Fuel Pump Control

A fuel cut control is used to stop the fuel pump when the airbag is deployed in the front or side collision. In this system, the airbag deployment signal from the airbag sensor assembly is detected by the ECM, and it turns OFF the circuit opening relay.
After the fuel cut control has been activated, turning the ignition switch from OFF to ON cancels the fuel cut control, and the engine can be restarted.



*: Models with Side and Curtain Shield Airbags