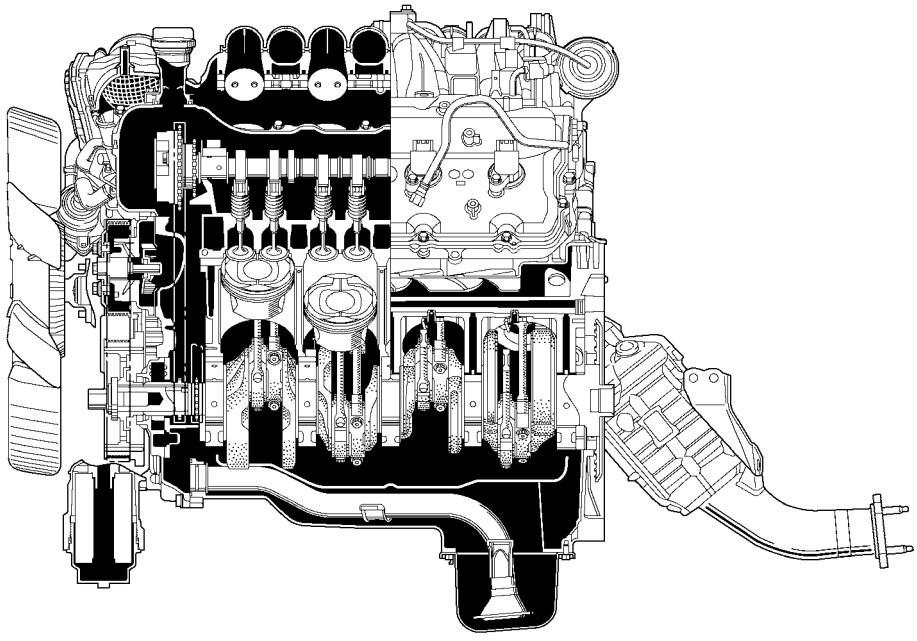
NEW FEATURES

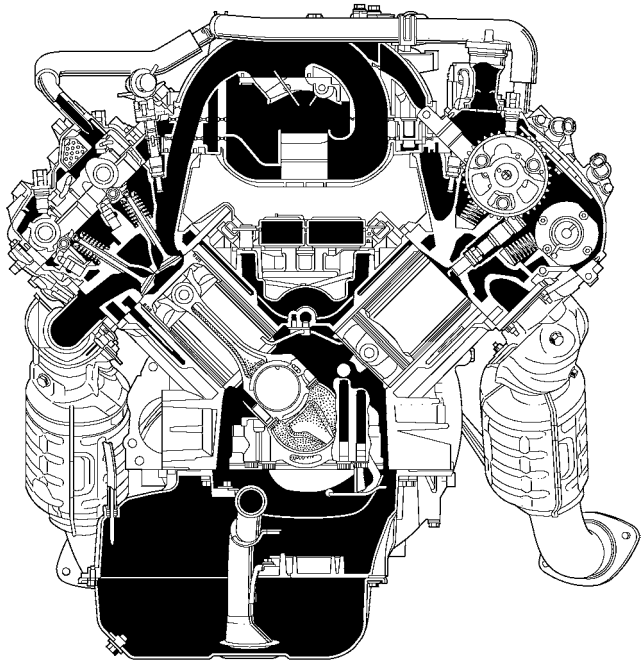
■3UR-FE ENGINE

1. General

The 3UR-FE engine is a 5.7-liter, 32-valve DOHC V8. This engine uses the Dual Variable Valve Timing-intelligent (Dual VVT-i) system, Direct Ignition System (DIS), Acoustic Control Induction System (ACIS), and Electronic Throttle Control System-intelligent (ETCS-i). These control functions achieve improved engine performance, fuel economy, and clean emissions.



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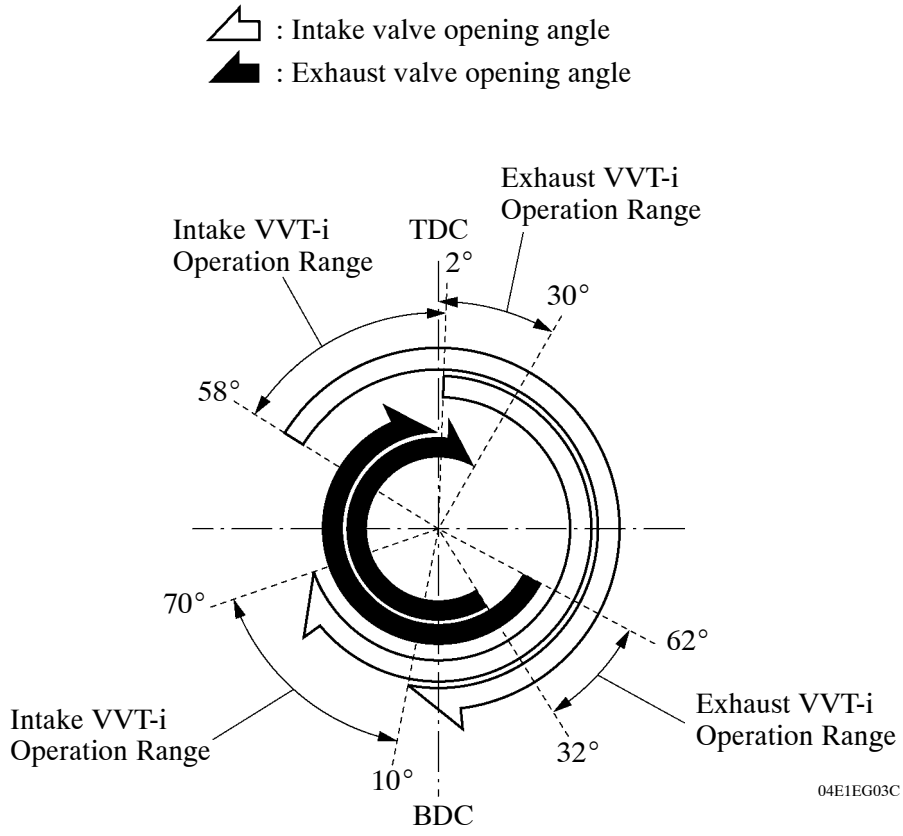
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▶ Engine Specifications ◀

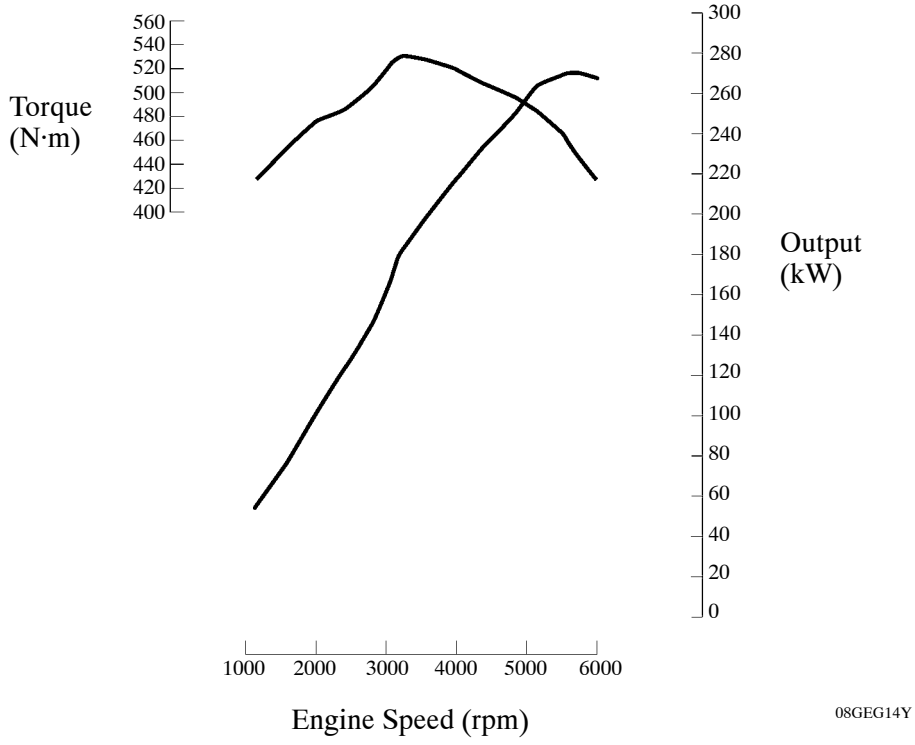
No. of Cyls. & Arrangement			8-cylinder, V Type
Valve Mechanism			32-valve DOHC, Chain Drive (with Dual VVT-i)
Combustion Chamber			Pentroof Type
Manifolds			Cross-flow
Fuel System			EFI
Ignition System			DIS
Displacement			5663 cm^3 (345.6 cu. in.)
Bore × Stroke			94.0 × 102.0 mm (3.70 × 4.02 in.)
Compression Ratio			10.2 : 1
Max. Output (ECC)			270 kW @ 5600 rpm
Max. Torque (ECC)			530 N·m @ 3200 rpm
Valve Timing	Intake	Open	– 2° to 58° BTDC
		Closed	70° to 10° ABDC
	Exhaust	Open	62° to 32° BBDC
		Closed	0° to 30° ATDC
Firing Order			1 – 8 – 7 – 3 – 6 – 5 – 4 – 2
Research Octane Number (RON)			91 or higher
Emission Regulation			EURO II
Engine Service Mass* (Reference)			219.3 kg (483.5 lb)

*: The figure shown is the weight of the part without water and oil.

▶ Valve Timing ◀



▶ Performance Curve ◀



2. Features of 3UR-FE Engine

The 3UR-FE engine has achieved the following performance features through the use of the items listed below:

(1) High performance and reliability

(2) Low noise and vibration

(3) Lightweight and compact design

(4) Good serviceability

(5) Clean emissions and fuel economy

Item		(1)	(2)	(3)	(4)	(5)
Engine Proper	A taper squish shape is used for the combustion chamber.	○				○
	An aluminum alloy cylinder block containing a water distribution pathway is used.	○		○		
	Spiny-type liners are used in the cylinder bores.	○		○		
	Water jacket spacers are used.	○				
	The piston skirt is coated with resin.	○	○			○
	A No. 1 oil pan made of aluminum alloy is used.	○	○	○		
Valve Mechanism	Timing chains and chain tensioners are used.	○		○		
	Hydraulic lash adjusters are used.	○	○		○	○
	Roller rocker arms are used.	○				○
Lubrication System	An oil filter with a replaceable element is used.				○	
	A water-cooled type oil cooler is used.	○				
Cooling System	TOYOTA Genuine Super Long Life Coolant (SLLC) is used.				○	
Intake and Exhaust System	A linkless-type throttle body is used.	○		○		
	An intake manifold made of plastic is used.	○		○		
	Stainless steel exhaust manifolds are used.	○		○		○
	Ceramic type Three-Way Catalytic converters (TWCs) are used.					○
Fuel System	12-hole type fuel injectors are used to improve the atomization of fuel.	○				○
	A fuel delivery pipe with an integrated pulsation damper function is used.			○		
Ignition System	The Direct Ignition System (DIS) makes ignition timing adjustment unnecessary.	○			○	○
	Long-reach type iridium-tipped spark plugs are used.	○			○	○
Charging System	A segment conductor type alternator is used.	○		○		
Starting System	A planetary reduction type starter is used.			○		
Serpentine Belt Drive System	A serpentine belt drive system is used.			○	○	

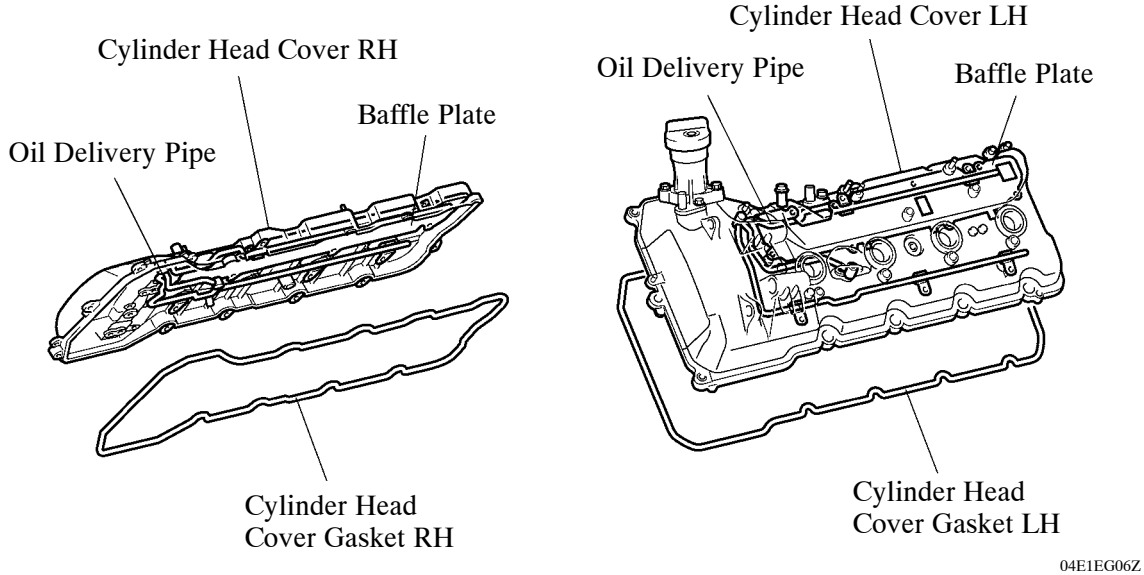
(Continued)

Item		(1)	(2)	(3)	(4)	(5)
Blowby Gas Ventilation System	A separator case is provided between the cylinder block and the intake manifold.	○				○
Engine Control System	Magnetic Resistance Element (MRE) type crankshaft position, camshaft position, and VVT sensors are used.	○				
	The Electronic Throttle Control System-intelligent (ETCS-i) is used.	○				○
	The Dual Variable Valve Timing-intelligent (Dual VVT-i) system is used.	○				○
	The Acoustic Control Induction System (ACIS) is used.	○				○
	The starter control (cranking hold function) is used.	○				
	An evaporative emission control system is used.					○

3. Engine Proper

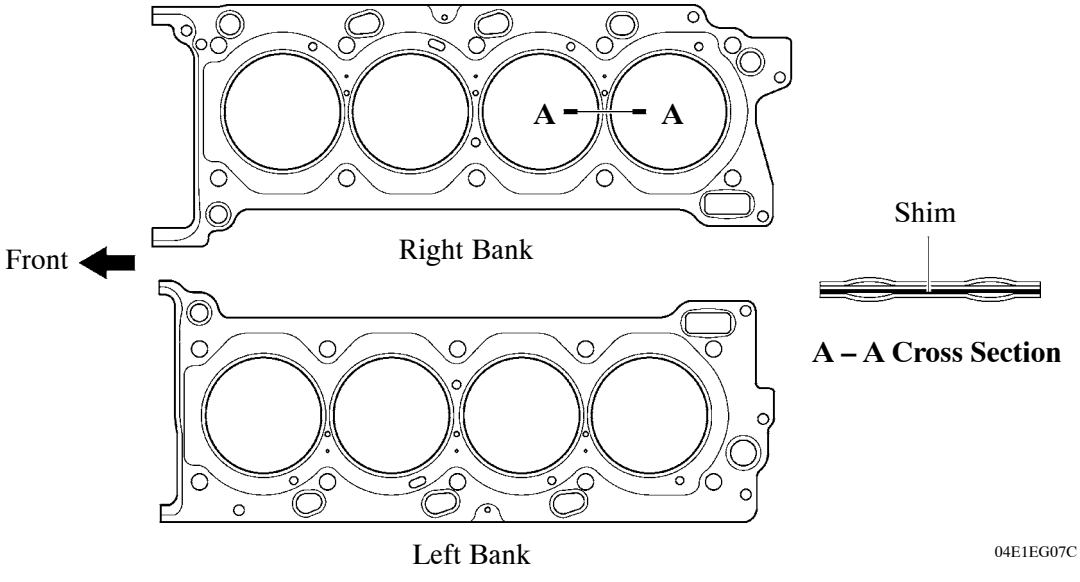
Cylinder Head Cover

- Lightweight yet high-strength aluminum cylinder head covers are used.
- An oil delivery pipe is installed inside the cylinder head covers. This ensures lubrication to the sliding parts of the valve rocker arms, improving reliability.
- Large baffle plates are built into the cylinder head covers. As a result, the speed of blowby gas flow is reduced, and the oil mist is removed from the blowby gas. Due to this, the amount of oil lost is reduced.



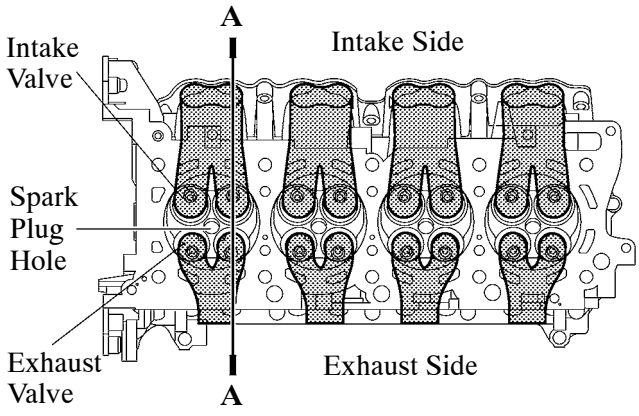
Cylinder Head Gasket

- 3-layer steel-laminate type cylinder head gaskets are used. A shim is used around the cylinder bore of each gasket to help enhance sealing performance and durability. This results in improved fuel economy, a reduced consumption rate of engine oil and reduced emission of exhaust gases.
- The surface is coated with highly heat-resistant fluoro rubber to support high power output.



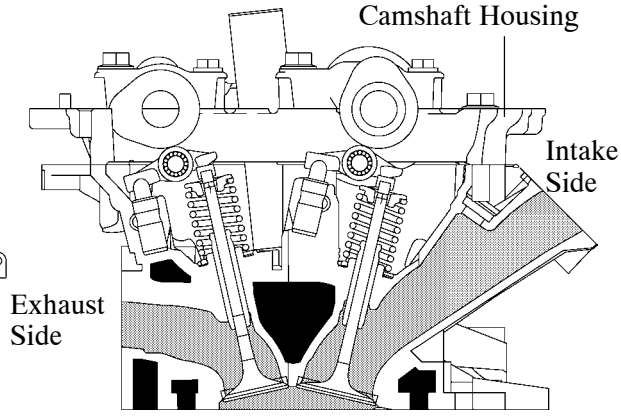
Cylinder Head

- The cylinder head structure has been simplified by separating the cam journal portion (camshaft housing) from the cylinder head.
- The cylinder head, which is made of aluminum, contains a pentroof-type combustion chamber. The spark plug is located in the center of the combustion chamber in order to improve the engine's anti-knocking performance.
- The port configuration is an efficient cross-flow type in which the intake ports face the inside of the V bank and the exhaust ports face the outside.
- A siamese type intake port is used. The port diameter gradually decreases toward the combustion chamber to optimize the airflow speed and intake pulsation.



View from Bottom Side

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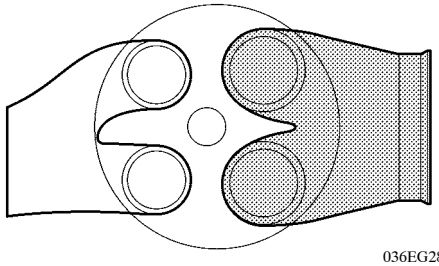


A – A Cross Section

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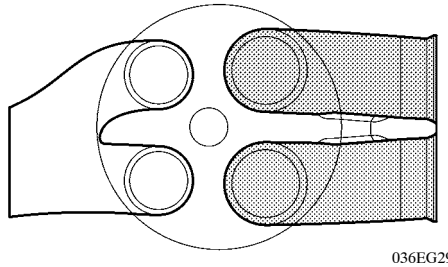
— REFERENCE —

Siamese Type



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Independent Type

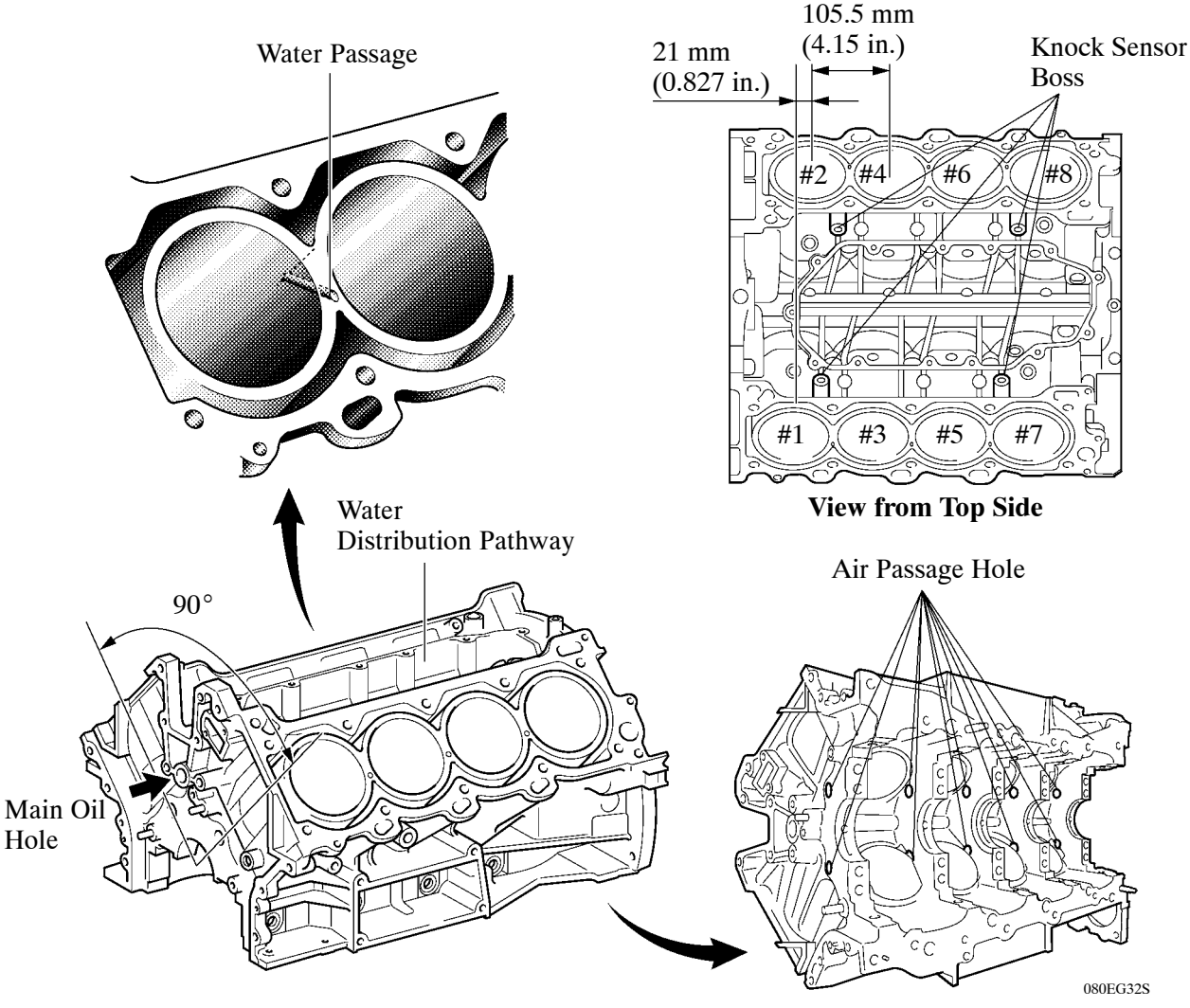


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Cylinder Block

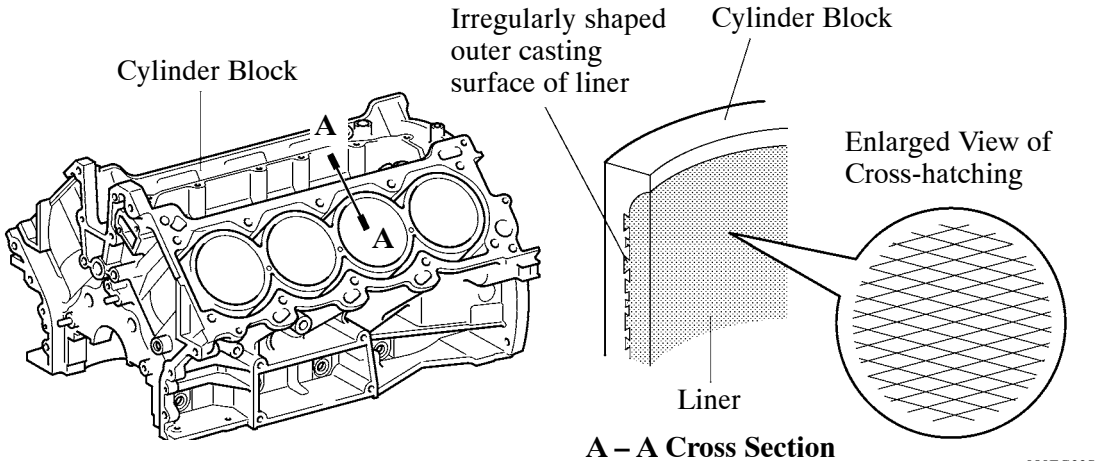
1) General

- The cylinder block is made of aluminum alloy.
- The cylinder block has a bank angle of 90°, a bank offset of 21 mm (0.827 in.) and a bore pitch of 105.5 mm (4.15 in.), resulting in a compact block in its length and width considering its displacement.
- The spiny-type liners are used.
- A water distribution pathway is provided between the left and right banks. The water sent by the water pump passes through the water distribution pathway and flows to the cylinder head and water jackets of both banks. The water distribution pathway also cools the engine oil in the main oil hole located directly below the pathway.
- A water passage has been provided between the cylinder bores. By allowing the water to flow between the cylinder bores, this construction enables the temperature of the cylinder walls to be kept uniform.
- Plastic cylinder block water jacket spacers are inserted in the water jacket. They control the flow of the water in order to attain a uniform temperature around the combustion chambers.
- Installation bosses of the four knock sensors are located on the inner side of left and right banks to enhance the accuracy of the knock sensors.
- Air passage holes are provided on the bulkheads of the cylinder block. As a result, the air at the bottom of the cylinder flows smoother, and pumping loss (back pressure at the bottom of the piston generated by the piston's reciprocating movement) is reduced to improve the engine's output.



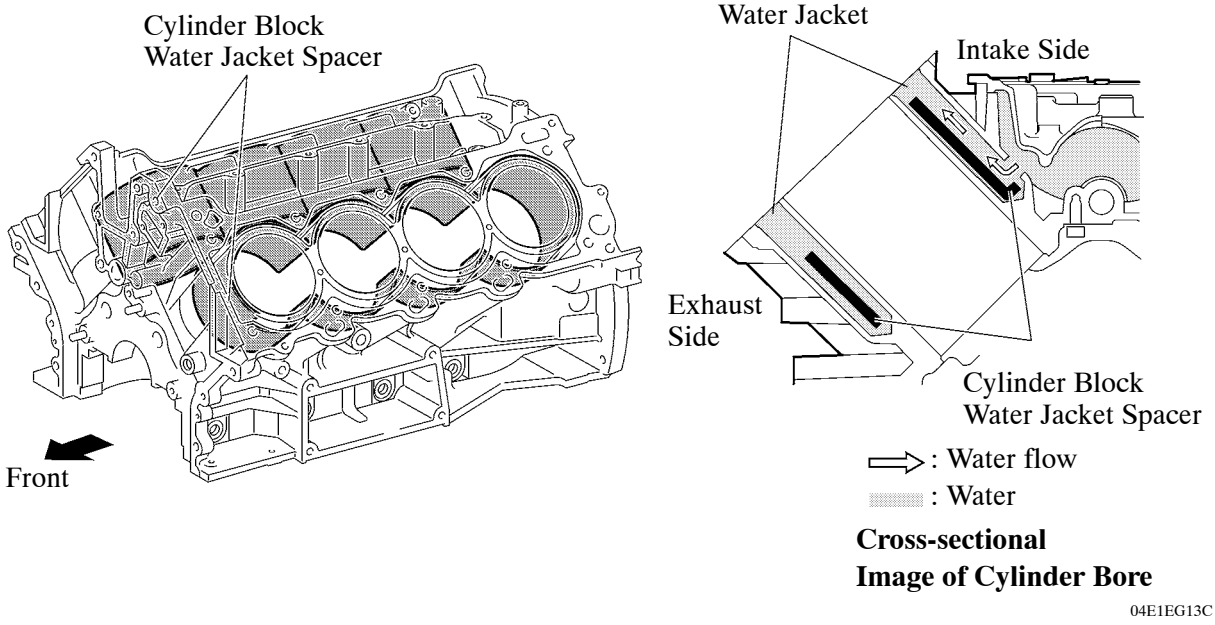
2) Spiny-type Liner

- The liners are the spiny-type which have been manufactured so that their casting exteriors form large irregular surfaces in order to enhance the adhesion between the liners and the aluminum cylinder block. The enhanced adhesion helps heat dissipation, resulting in a lower overall temperature and heat deformation of the cylinder bores.
- The shape of the cross-hatching of the liner surface has been optimized to improve oil retention performance, resulting in reduced friction.



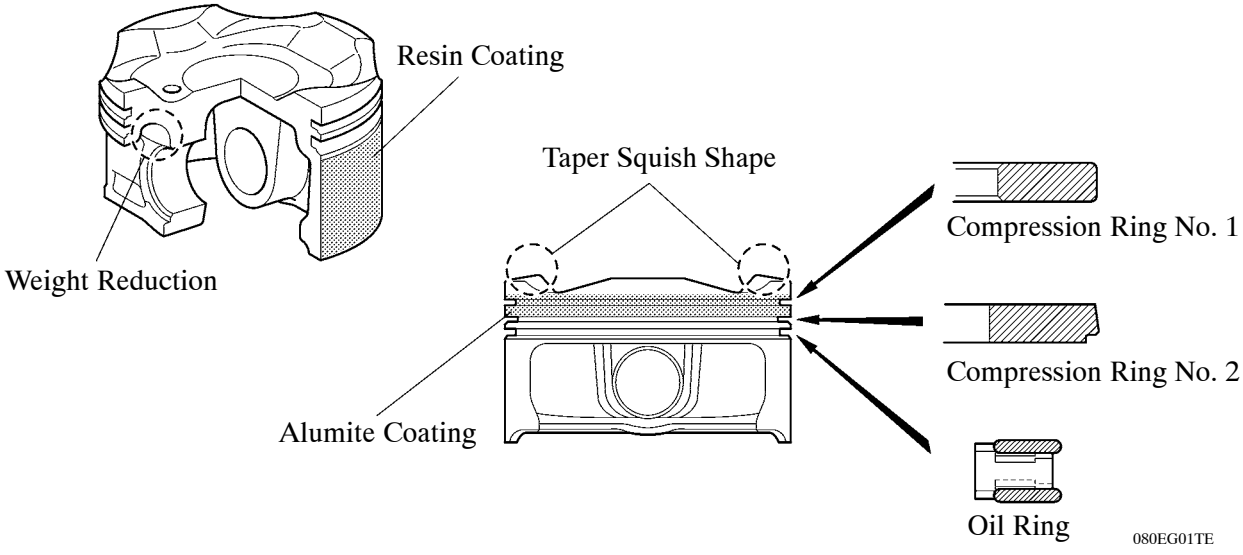
3) Cylinder Block Water Jacket Spacer

The temperature of the intake side of a cylinder bore tends to be lower. For this reason, a wide cylinder block water jacket spacer covers the cylinder bores in order to suppress the flow of the water and prevent excessive cooling. On the other hand, the temperature of the exhaust side of a cylinder bore tends to be higher. A cylinder block water jacket spacer covers the lower area of the cylinder bores in order to direct the water to the upper area of the cylinder bores where the temperature is higher. This makes the temperature around the cylinder bores more uniform. As a result, the viscosity of the engine oil (which lubricates the area between the wall surface of the cylinder bore and the piston) decreases, thus reducing friction between the cylinder bore and the piston.



Piston

- The pistons are made of aluminum alloy.
- A compact combustion chamber is provided on top of the piston to achieve stable combustion. Together with the pentroof type combustion chamber of the cylinder head, this achieves a high compression ratio, resulting in both high performance and excellent fuel economy.
- A taper squish combustion chamber is used to improve anti-knocking performance and intake efficiency. In addition, engine performance and fuel economy are improved.
- In order to reduce weight, cast holes have been provided on the bottom of the piston head near the pin bosses as shown in the illustration below.
- The piston skirt is coated with resin to reduce friction losses.
- The groove of the top ring is coated with alumite (anodic oxide coating) to ensure abrasion resistance.
- By increasing the machining precision of the cylinder bore diameter in the block, only one size piston is required.

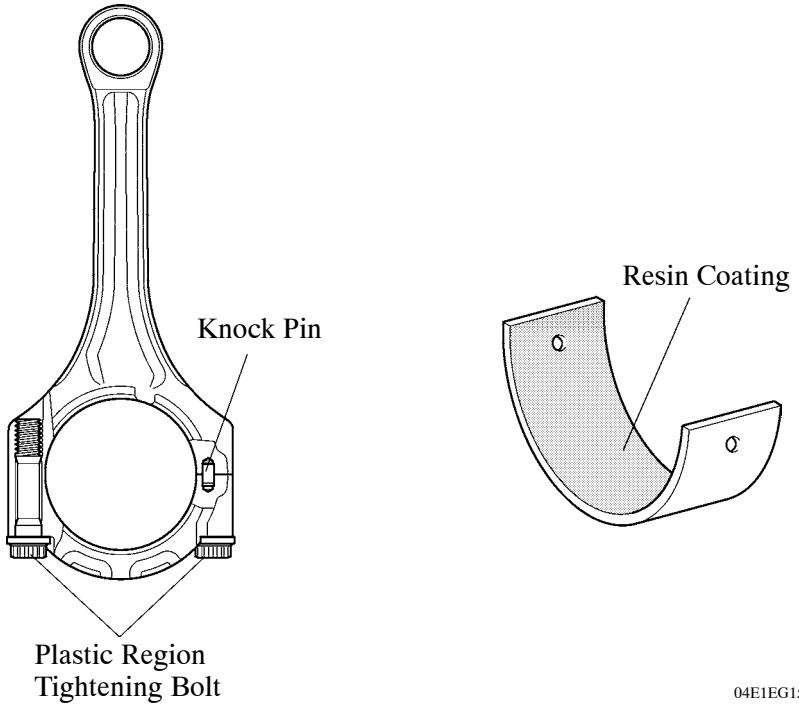


Service Tip

The same pistons are used for both right and left banks. When installing a piston, the front mark should face the front of the engine.

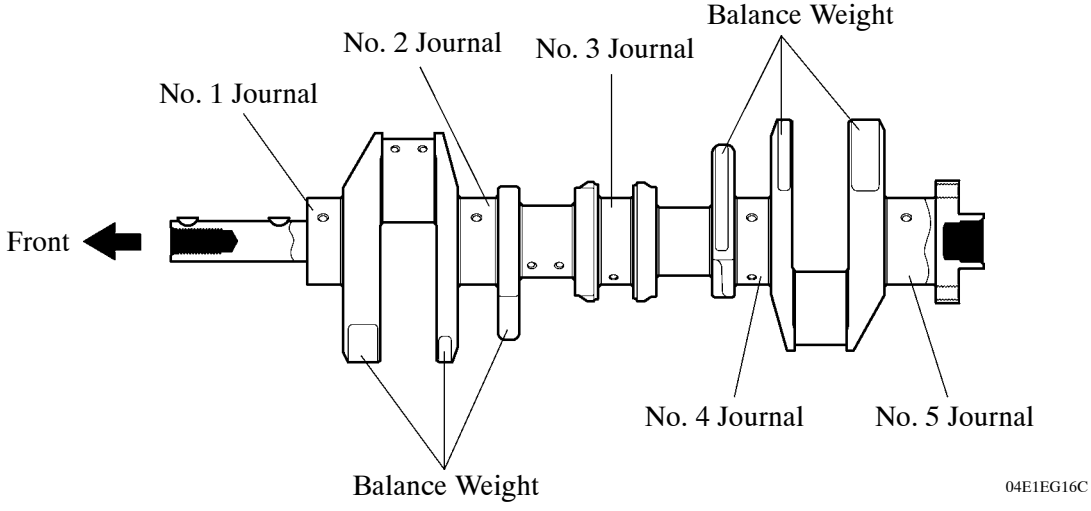
Connecting Rod and Connecting Rod Bearing

- Connecting rods that have been forged for high strength are used for weight reduction.
- Knock pins are used at the mating surfaces of the bearing caps of the connecting rod to minimize the shifting of the bearing caps during assembly.
- Nutless-type plastic region tightening bolts are used on the connecting rods for a lightweight design.
- Resin-coated aluminum bearings are used for the connecting rod bearings. The connecting rod bearings are reduced in width to reduce friction.



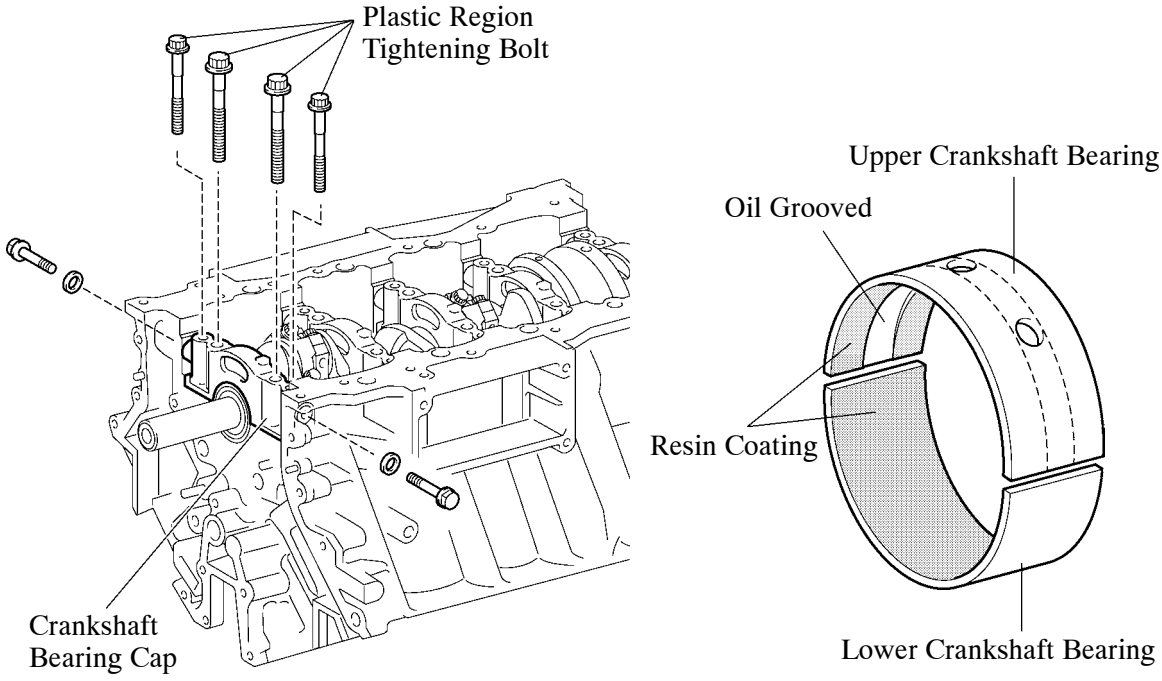
Crankshaft

- A crankshaft made of forged steel, which excels in rigidity and wear resistance, is used.
- The crankshaft has 5 main bearing journals and 6 balance weights.



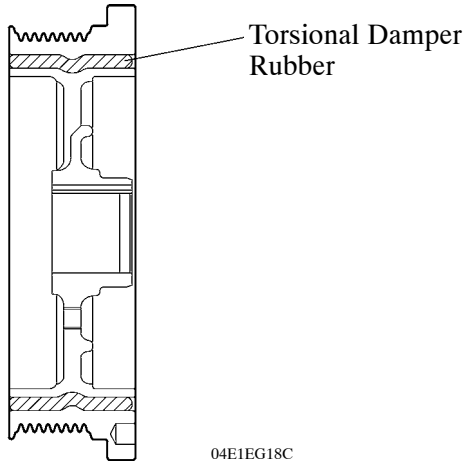
Crankshaft Bearing and Crankshaft Bearing Cap

- The crankshaft bearings are made of aluminum alloy.
- The crankshaft bearings are reduced in width to reduce friction. The bearing lining surface is coated with resin to improve wear and seizure resistance.
- The upper crankshaft bearing has an oil groove around its inside circumference.
- The crankshaft bearing caps use 4 plastic region tightening bolts of different sizes for the inner and outer sides to secure the journals. This makes the crankshaft bearing caps more compact and lightweight. In addition, each cap is tightened laterally to improve its reliability.



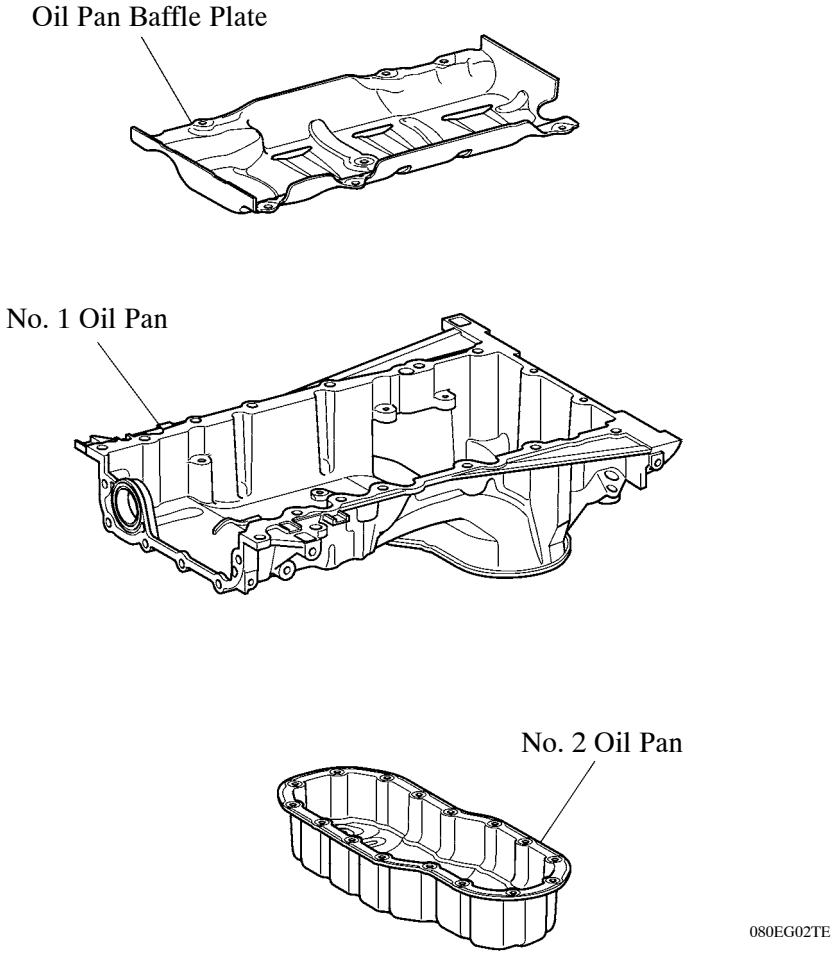
Crankshaft Pulley

The crankshaft pulley uses a torsional rubber damper and is optimized to reduce noise and vibration.



Oil Pan

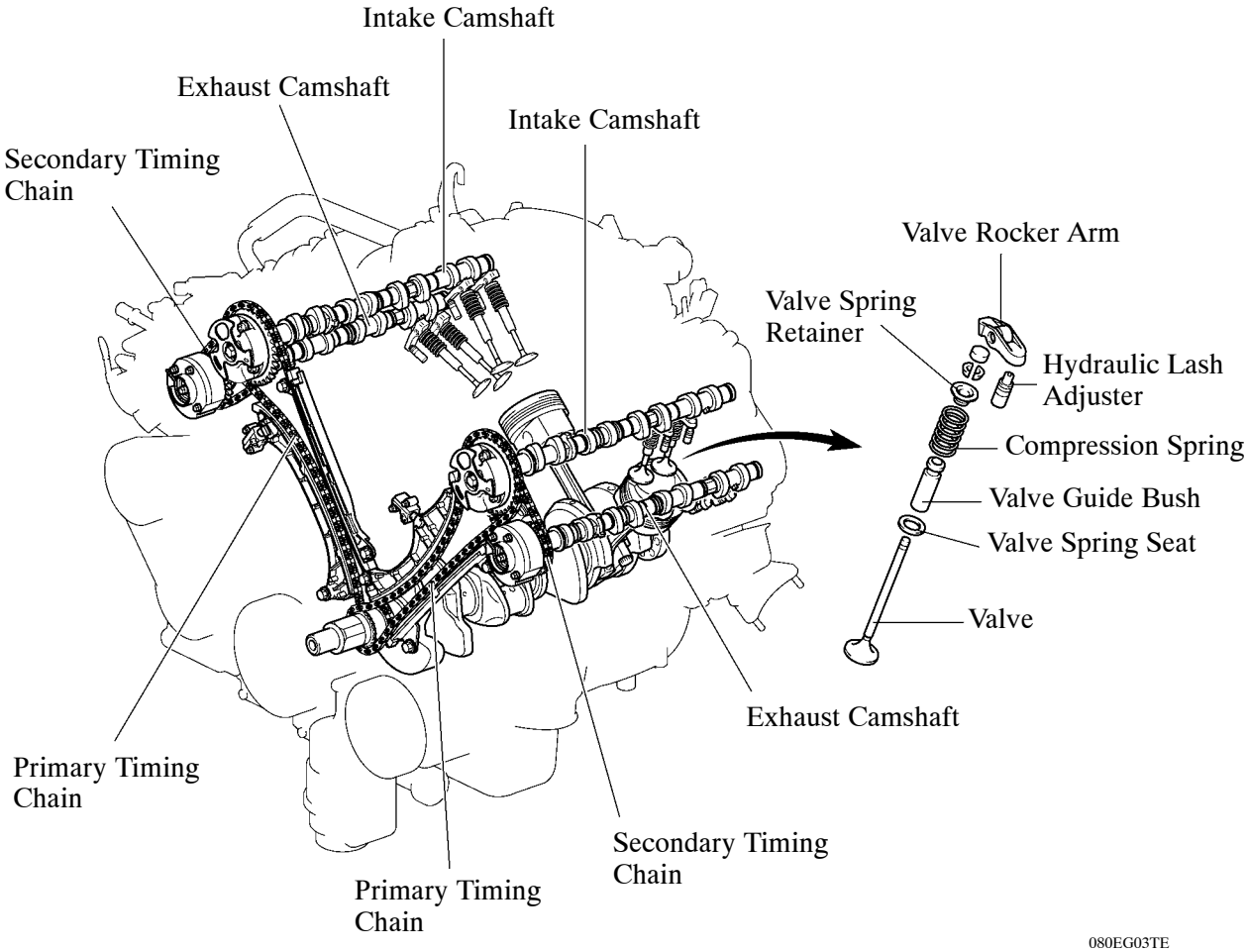
- The No. 1 oil pan is made of aluminum alloy.
- The No. 1 oil pan is secured to the cylinder block and the transmission housing to increase rigidity.
- The shape of the oil pan baffle plate has been optimized to ensure the proper space between the crankshaft and the engine oil surface. This enhances the separation of oil flow and ventilation gases, thereby reducing friction and improving lubrication performance.



4. Valve Mechanism

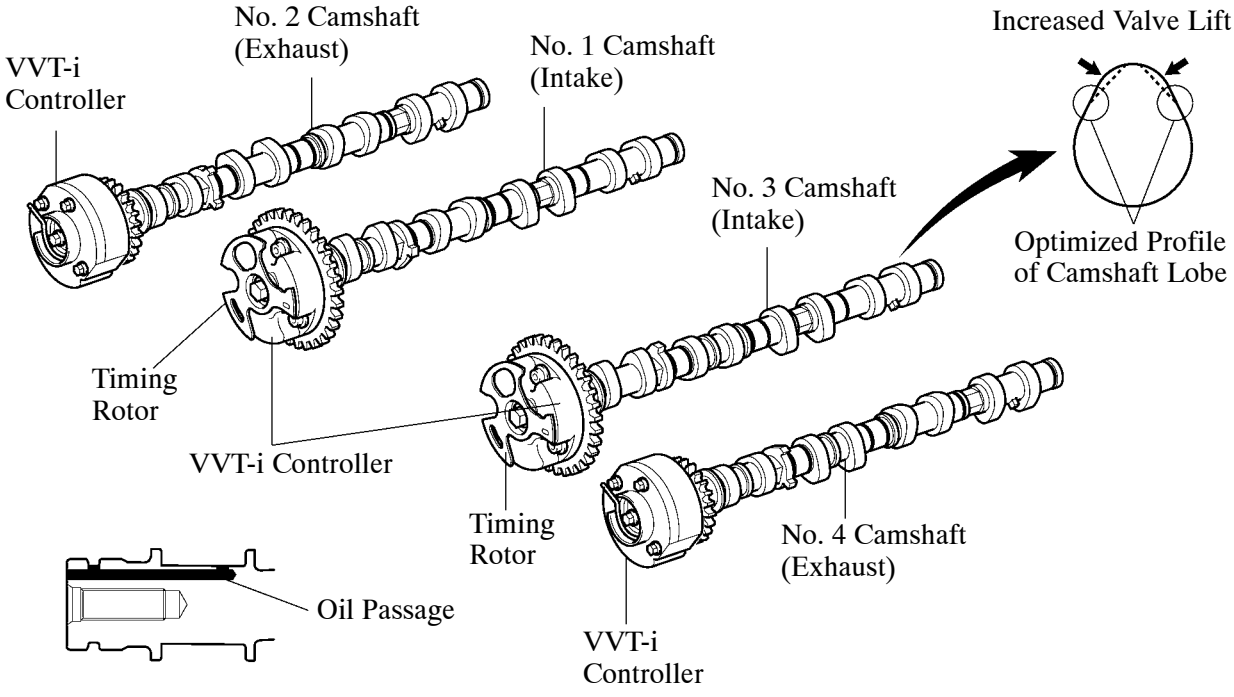
General

- Each cylinder of this engine has 2 intake valves and 2 exhaust valves. Intake and exhaust efficiency has been increased due to the larger total port areas.
- This engine uses roller rocker arms with built-in needle bearings. This reduces the friction that occurs between the cams and the valve rocker arms that push the valves down, thus improving fuel economy.
- Hydraulic lash adjusters, which maintain a constant zero valve clearance through the use of oil pressure and spring force, are used.
- To ensure highly accurate valve timing, separate primary timing chains are driven by the crankshaft in order to rotate the intake camshafts of the left and right banks. The exhaust camshafts are driven by the intake camshaft of the respective bank via secondary timing chains.
- This engine has a Dual Variable Valve Timing-intelligent (Dual VVT-i) system which controls the intake and exhaust camshafts to provide optimal valve timing in accordance with driving conditions. As a result, lower fuel consumption, higher engine performance, and reduced exhaust emissions have been achieved. For details of Dual VVT-i control, see page 78.

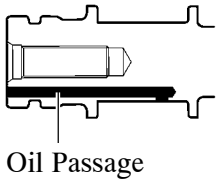


Camshaft

- The camshafts are made of cast iron alloy.
- Oil passages are provided in the intake and exhaust camshafts in order to supply engine oil to the VVT-i system.
- VVT-i controllers are installed on the front of the intake and exhaust camshafts to vary the timing of the intake and exhaust valves.
- Together with the use of the roller rocker arms, the cam profile has been optimized. This results in increased valve lift when the valve begins to open and as it finishes closing, helping to achieve enhanced output performance.



Cross Section of End of Intake Camshaft

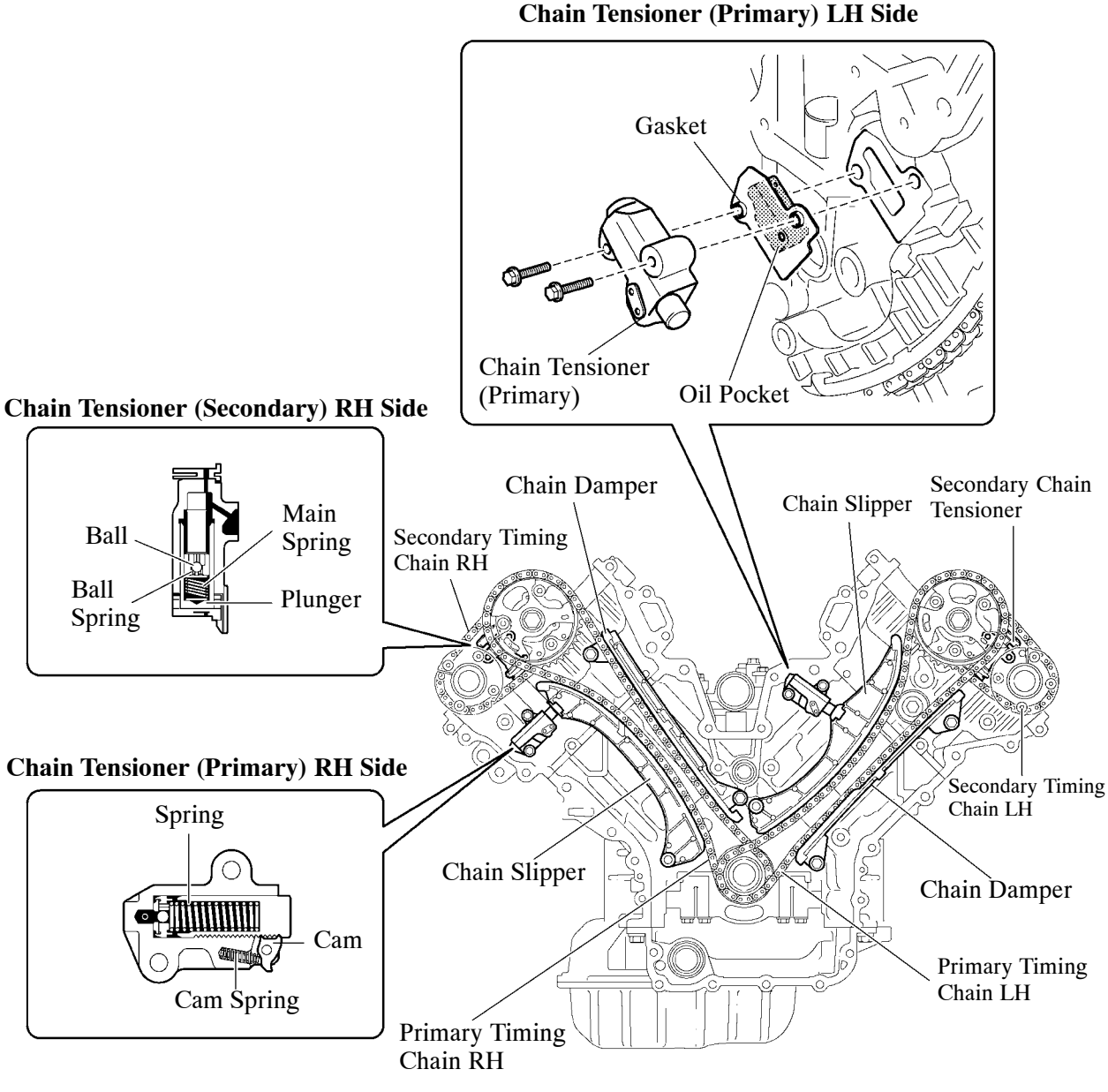


Cross Section of End of Exhaust Camshaft

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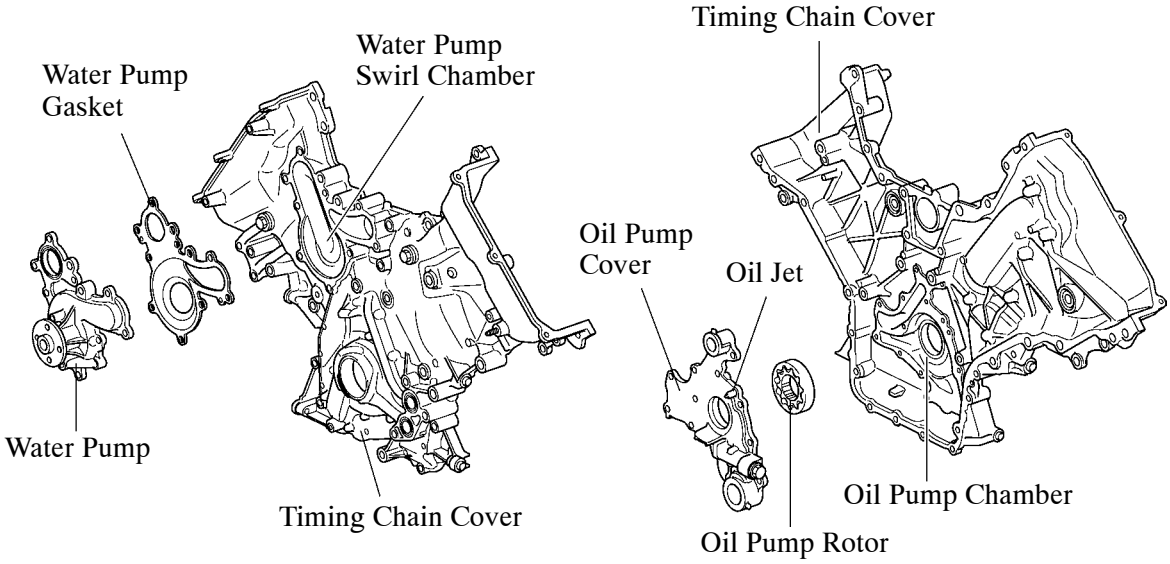
Timing Chains and Chain Tensioners

- Both the primary and secondary chains use roller chains with a pitch of 9.525 mm (0.375 in.).
- A timing chain tensioner is provided for each primary timing chain and secondary timing chain on each bank.
- Both the primary and secondary chain tensioners use a spring and oil pressure to maintain proper chain tension at all times. The tensioners suppress noise generated by the timing chains.
- The chain tensioner for the primary timing chain is a ratchet type with a non-return mechanism. Furthermore, an oil pocket creates oil pressure when the engine is started, and simultaneously applies oil pressure to the chain tensioner. This prevents the timing chain from flapping and reduces noise.



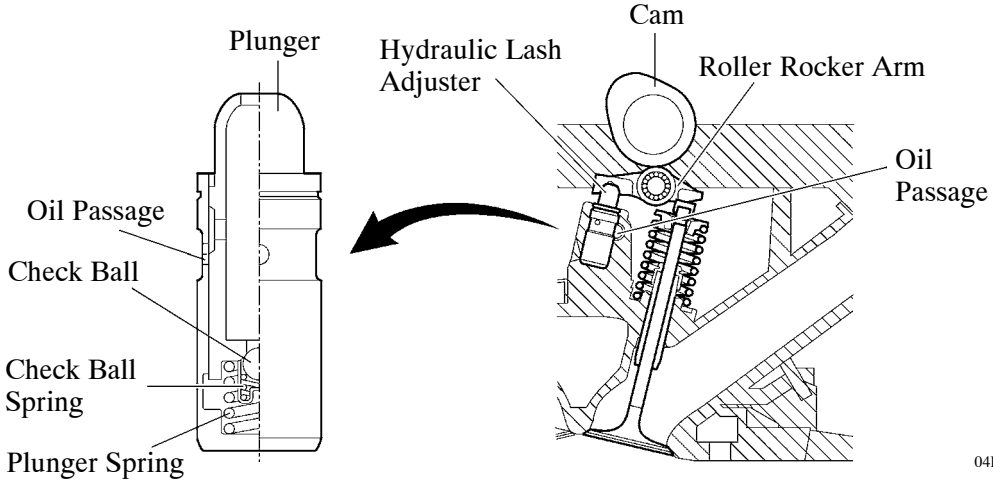
Timing Chain Cover

- The timing chain cover has an integrated construction consisting of the cooling system (water pump and water passage) and the lubrication system (oil pump and oil passage). Thus, the number of parts has been reduced to reduce weight.
- An oil jet is provided in the oil pump cover to lubricate the timing chains.



Hydraulic Lash Adjuster

- The hydraulic lash adjusters, which are located at the fulcrum (pivot point) of the roller rocker arms, each consist primarily of a plunger, plunger spring, check ball, and check ball spring.
- The engine oil that is supplied from the cylinder head and the built-in spring actuate the hydraulic lash adjuster. The oil pressure and the spring force that act on the plunger push the roller rocker arm against the cam, in order to adjust the clearance between the valve stem and rocker arm. This prevents the generation of noise during the opening and closing of the valves. As a result, engine noise is reduced.



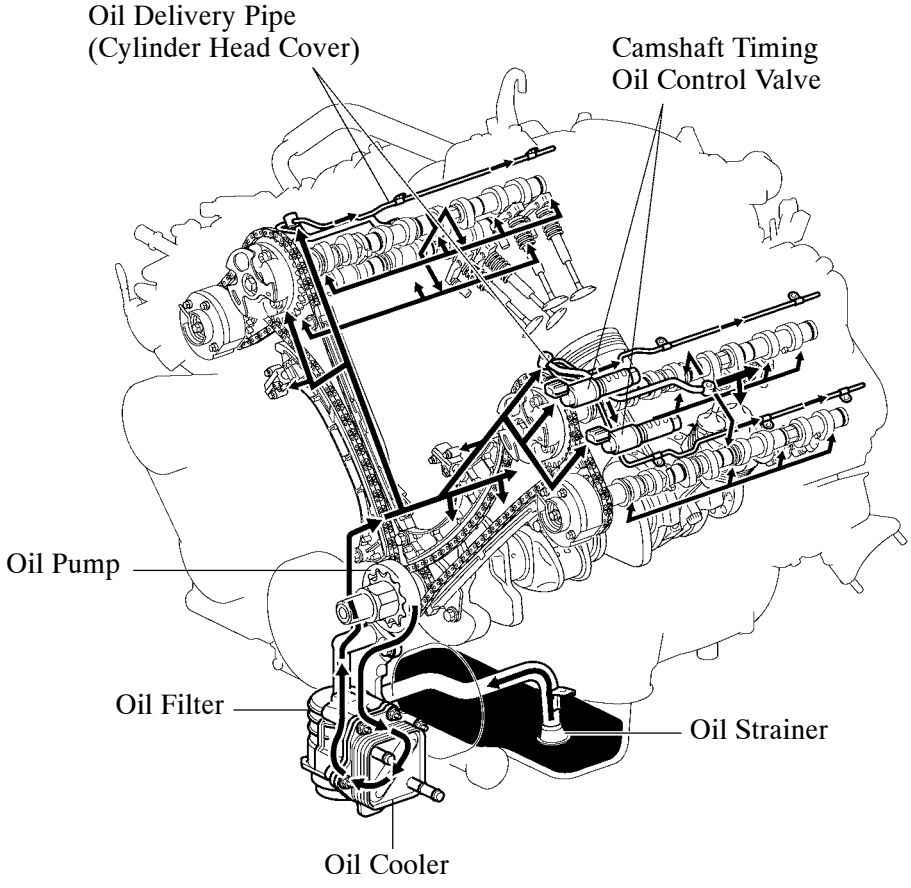
Service Tip

Valve clearance adjustment is not necessary because hydraulic lash adjusters are used on this model.

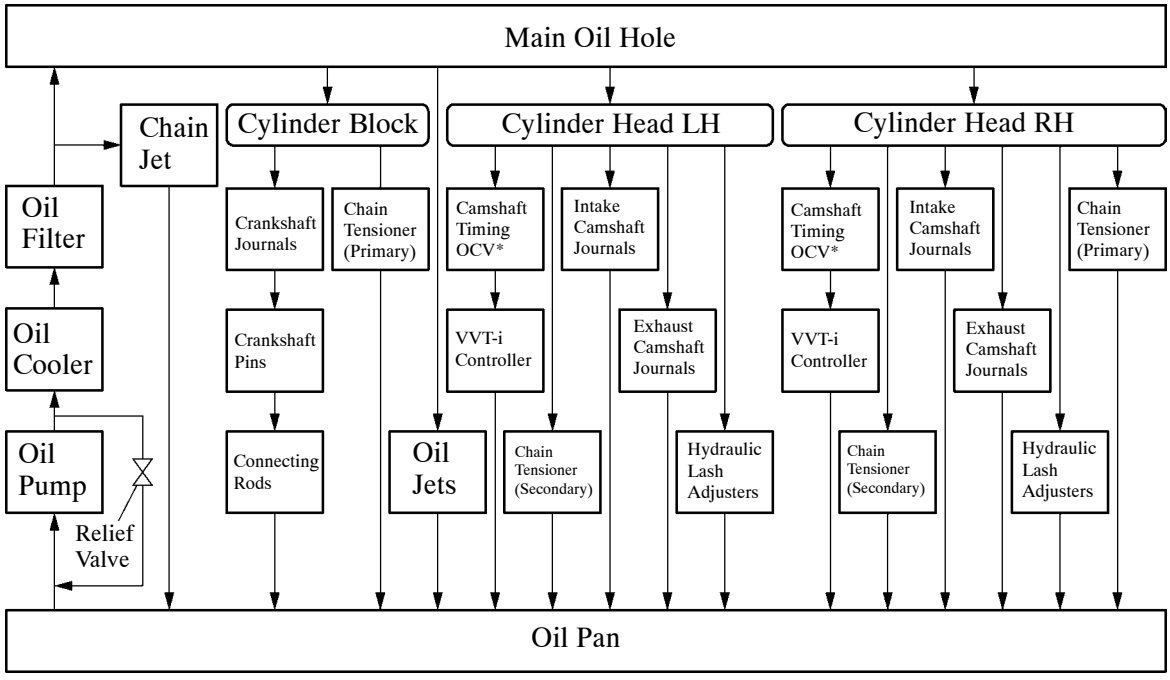
5. Lubrication System

General

- The lubrication circuit is fully pressurized and oil passes through an oil filter.
- A cycloid rotor type oil pump is used.
- An oil filter with a replaceable element is used.
- A water-cooled type oil cooler is used.



▶ Oil Circuit ◀

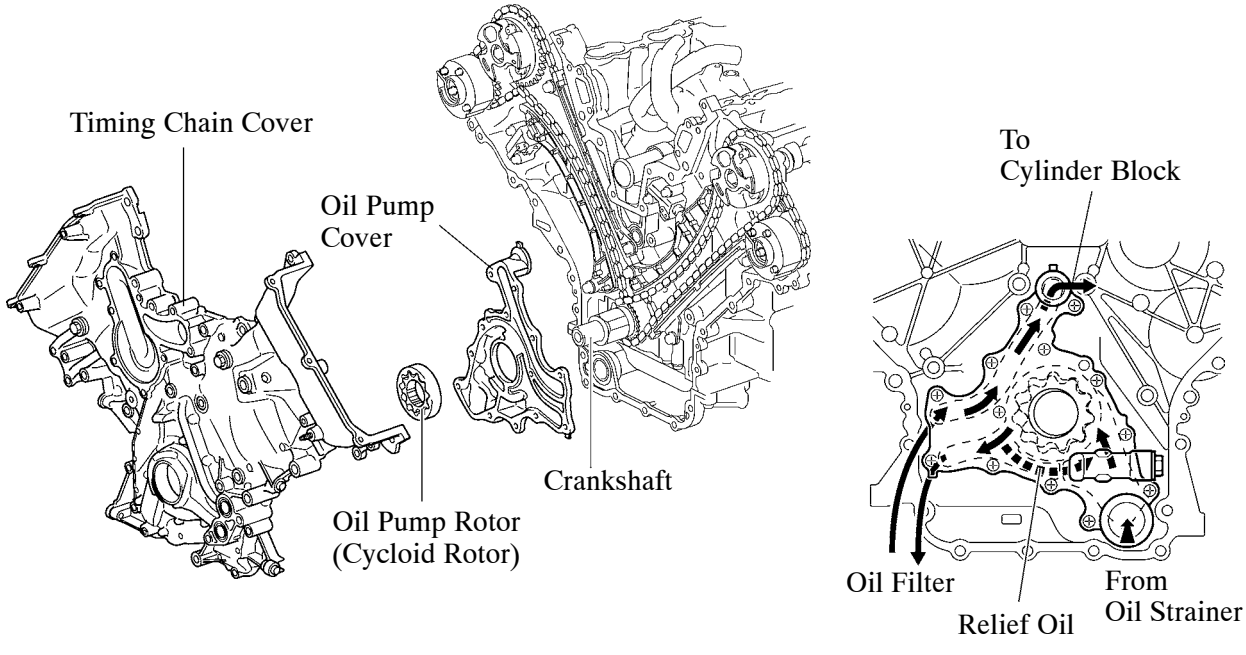


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*: Oil Control Valve

Oil Pump

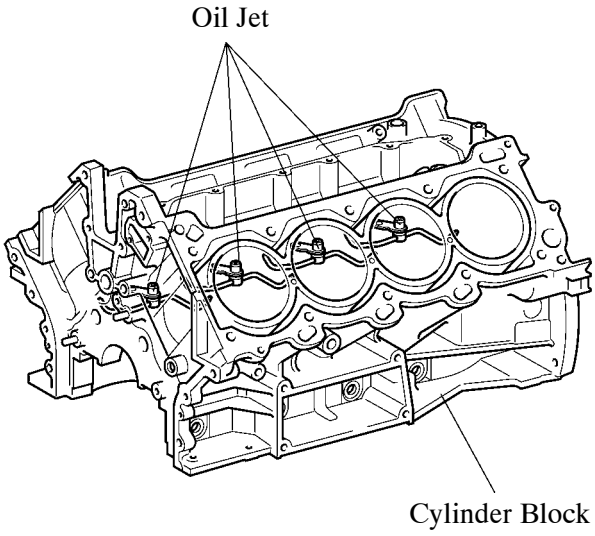
- A compact cycloid rotor type oil pump directly driven by the crankshaft is used.
- This oil pump uses an internal relief method which circulates relief oil to the suction passage in the oil pump. This aims to minimize oil level change in the oil pan, reduce friction, and reduce the air mixing rate in the oil.

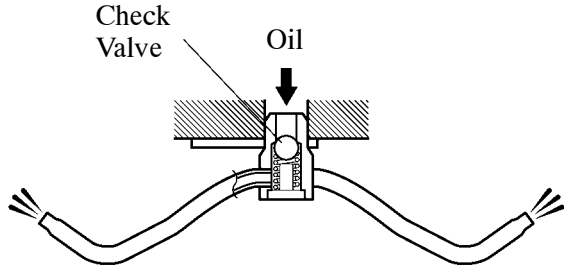


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Oil Jet

- Four oil jets for cooling and lubricating the pistons are provided in the cylinder block, in the center of the right and left banks.
- These oil jets contain a check valve to prevent oil from being fed when the oil pressure is low. This prevents the overall oil pressure in the engine from dropping.



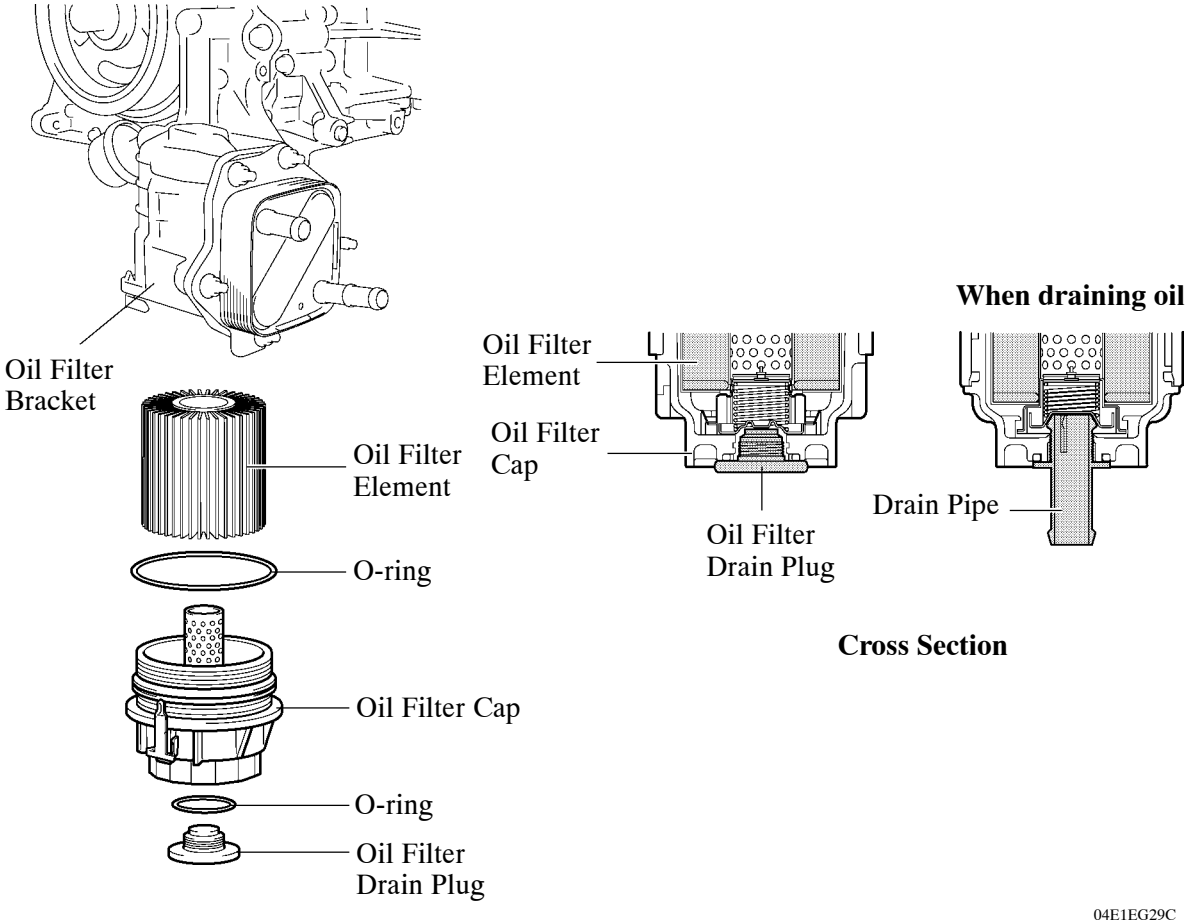


Oil Jet Cross Section

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Oil Filter

- An oil filter with a replaceable element is used. The oil filter element uses high-performance filter paper to improve filtration performance. It is also burnable for environmental protection.
- A plastic oil filter cap is used for weight reduction.
- This oil filter has a structure which can drain the oil remaining in the oil filter. This prevents oil from spattering when the element is replaced and allows the technician to work without touching hot oil.

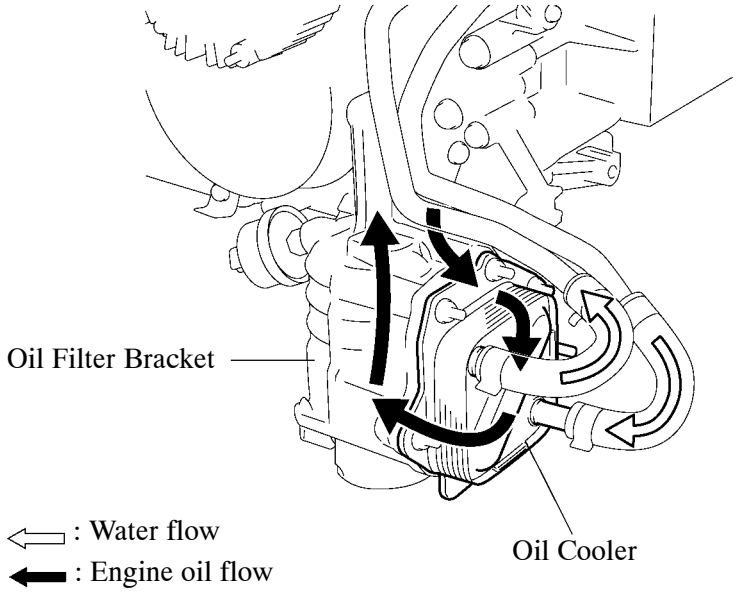


Service Tip

- The oil in the oil filter can be drained by removing the oil filter drain plug and inserting the drain pipe supplied with the element into the oil filter. For details, refer to the Land Cruiser Station Wagon Repair Manual.
- The engine oil maintenance interval for a model that has an oil filter with a replaceable element is the same as that for the conventional model.

Oil Cooler

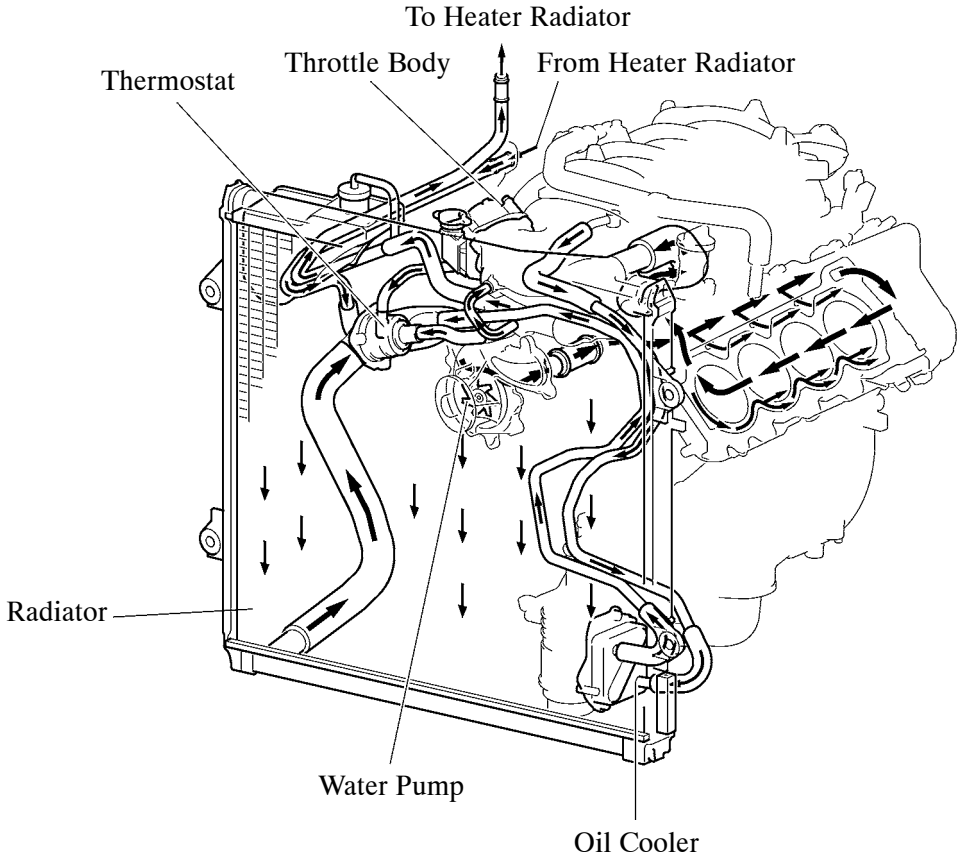
- To suppress the increase of oil temperature while towing, and to improve reliability, a water-cooled type oil cooler is used.
- This oil cooler uses a square shaped laminated aluminum core to achieve light weight, compact size, and a high heat radiation design.



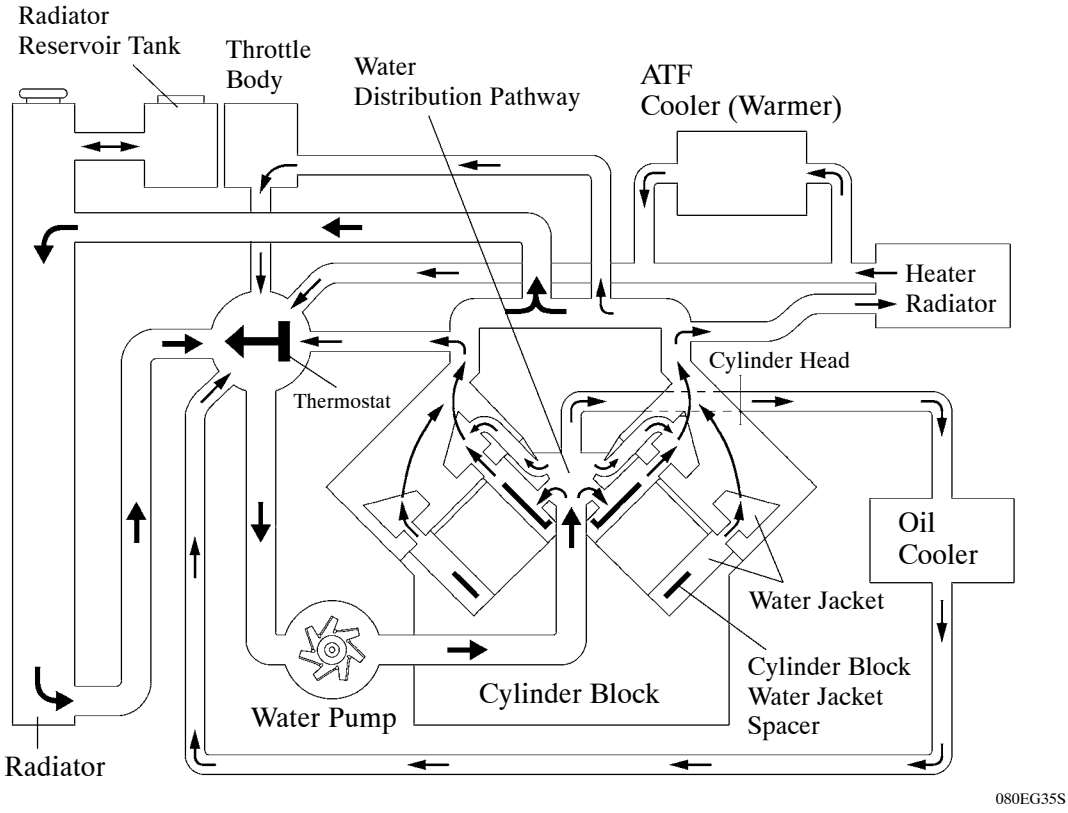
6. Cooling System

General

- The cooling system uses a pressurized forced circulation system with open air type reservoir tank.
- A water distribution pathway is provided between the left and right banks of the cylinder block.
- A thermostat with a bypass valve is located on the plastic water inlet to maintain suitable temperature distribution in the cooling system.
- An aluminum radiator core is used for weight reduction.
- A 2-stage temperature-controlled coupling fan is used. It rotates at lower speeds when the engine is cold to minimize fan noise.
- TOYOTA Genuine Super Long Life Coolant (SLLC) is used.



▶ Water Circuit ◀



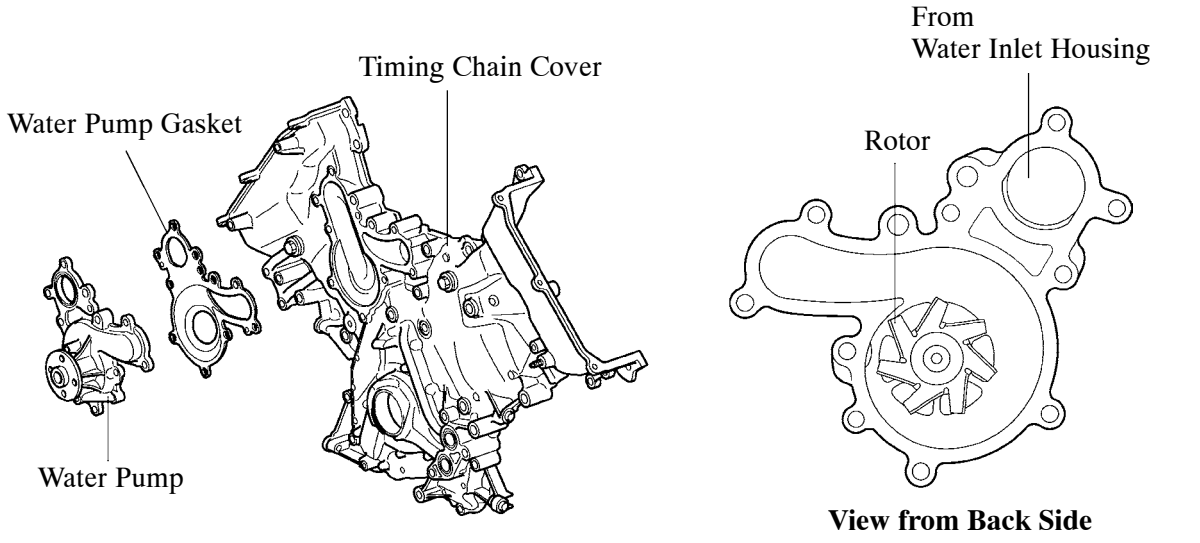
▶ Specifications ◀

Engine Coolant	Type		TOYOTA Genuine Super Long Life Coolant (SLLC) or similar high quality ethylene glycol based non-silicate, non-amine, non-nitrite and non-borate coolant with long-life hybrid organic acid technology (coolant with long-life hybrid organic acid technology is a combination of low phosphates and organic acids.) Do not use plain water alone.
	Color		Pink
	Maintenance Intervals	First Time	160000 km (100000 miles)
		Subsequent	Every 80000 km (50000 miles)
Thermostat	Opening Temperature		80 – 84°C (176 – 183°F)

SLLC is pre-mixed (50% coolant and 50% deionized water). Therefore, no dilution is needed when SLLC in the vehicle is added or replaced.

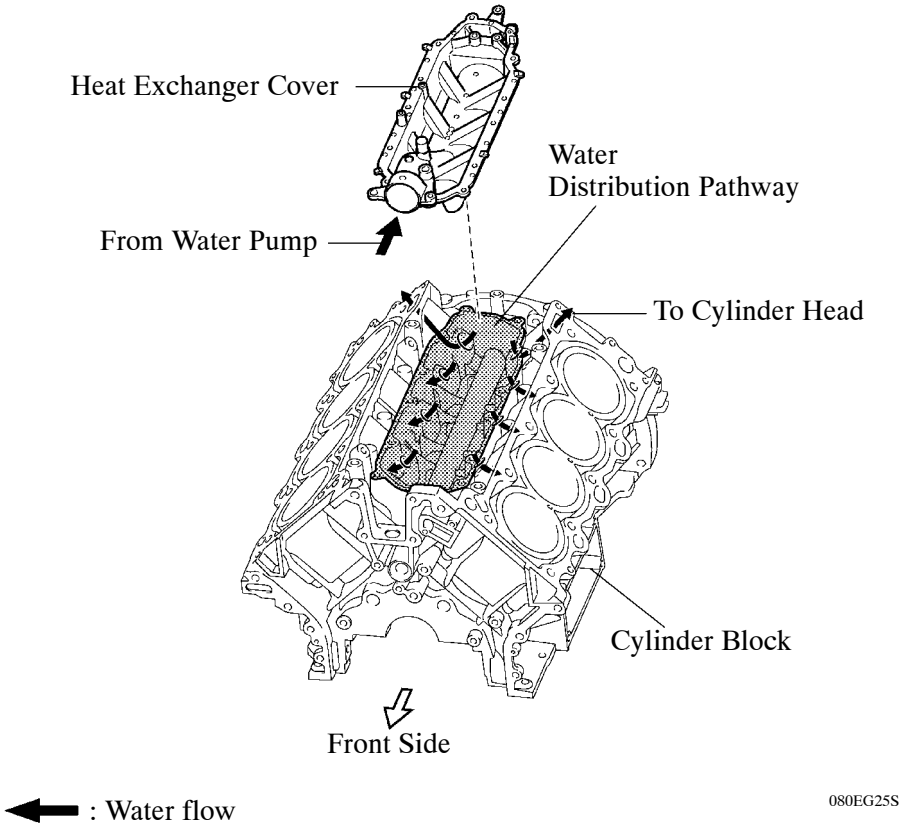
Water Pump

- A rust-resistant water pump rotor made of stainless steel is used.
- The water pump circulates the water to the water distribution pathway located between the left and right banks of the cylinder block.



Water Distribution Pathway

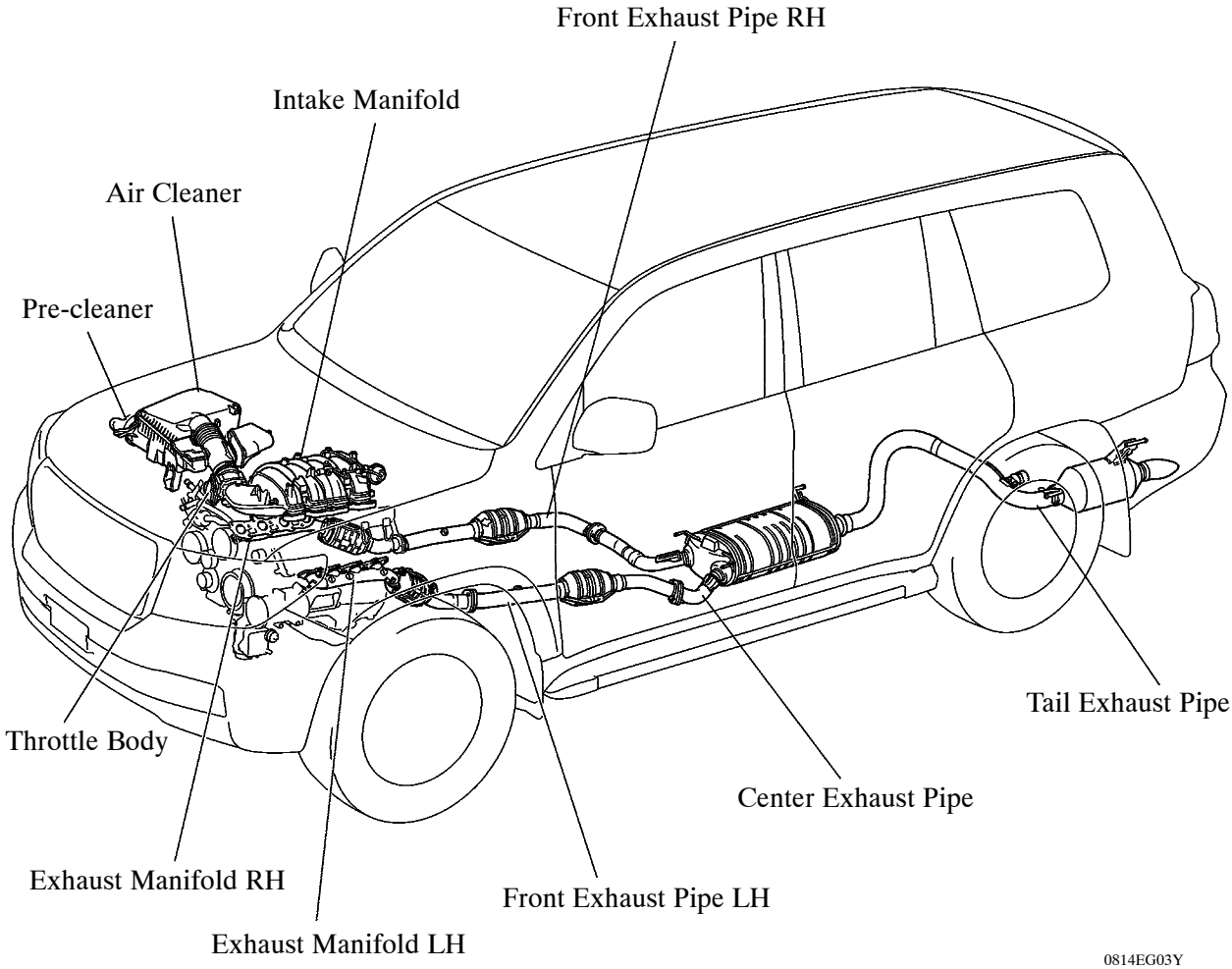
The water pump circulates the water and directs it to the water distribution pathway located between the left and right banks. From there, the water is uniformly distributed to each cylinder of the cylinder block, and also directly discharged to the cylinder heads. As a result, the cooling performance of the cylinder heads is assured and reliability is improved.



7. Intake and Exhaust System

General

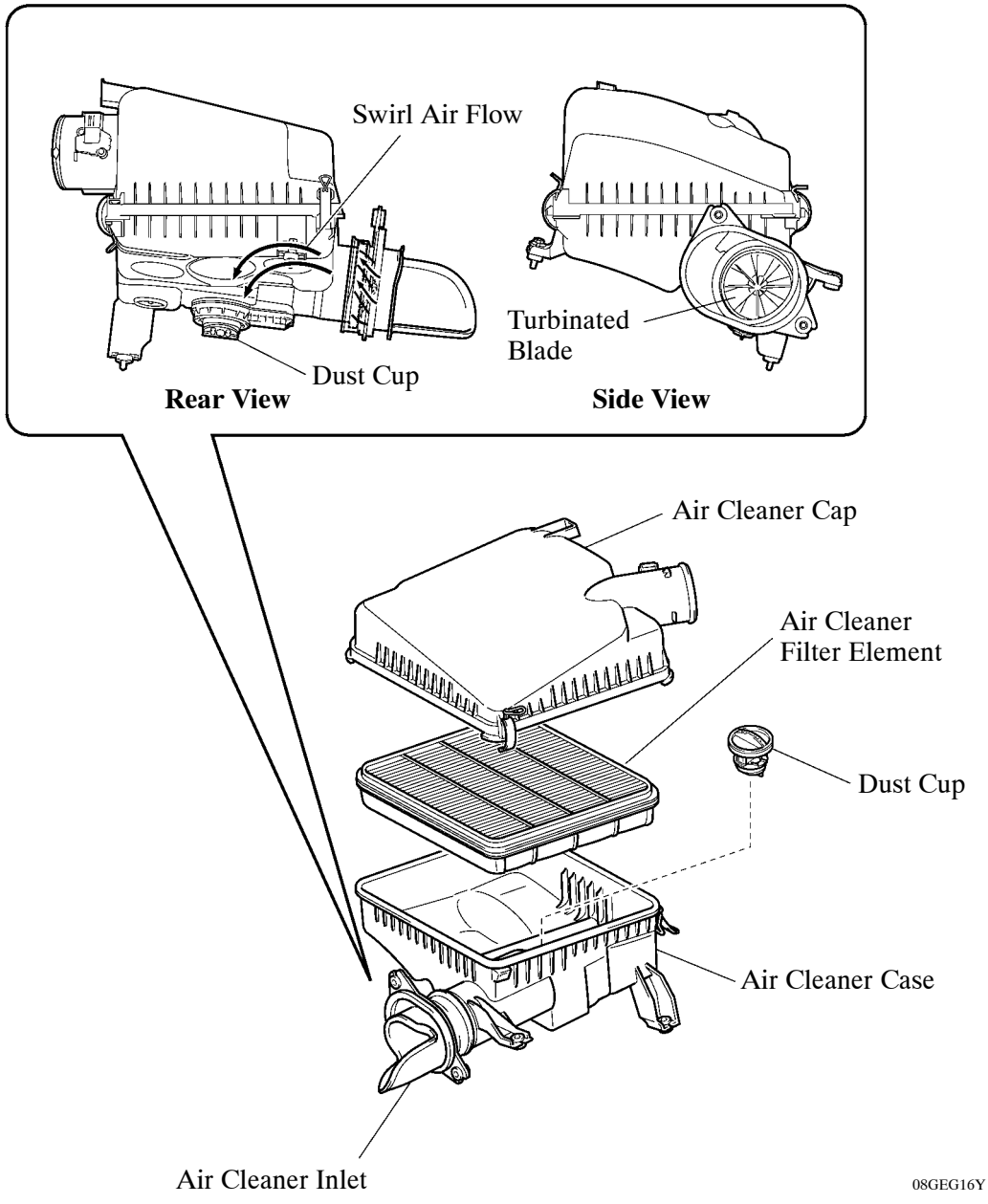
- A cyclone pre-cleaner is used.
- The Electronic Throttle Control System-intelligent (ETCS-i) is used to ensure excellent throttle control in all operating ranges. For details, see page 73.
- The Acoustic Control Induction System (ACIS) is used to improve the engine performance in all speed ranges. For details, see page 84.
- A plastic intake manifold is used.
- Stainless steel exhaust manifolds and exhaust pipes are used.



Air Cleaner

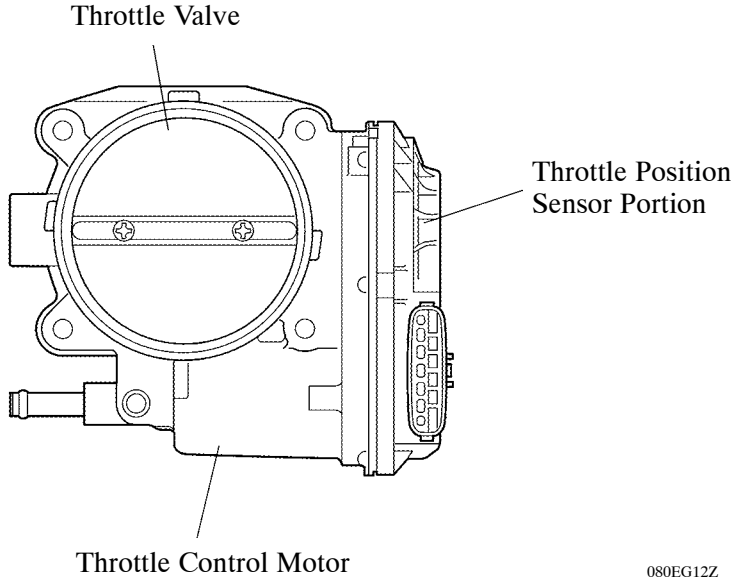
- A nonwoven, full-fabric type air cleaner filter element is used.
- A cyclone pre-cleaner has been provided in the air cleaner case. This cyclone pre-cleaner has a screw shape (turbinated blade) and gathers large dust particles in a dust cup by swirling the inlet air. The dust cup is removable from the inside of the air cleaner case, so the gathered dust can be disposed of.

Cyclone Pre-cleaner



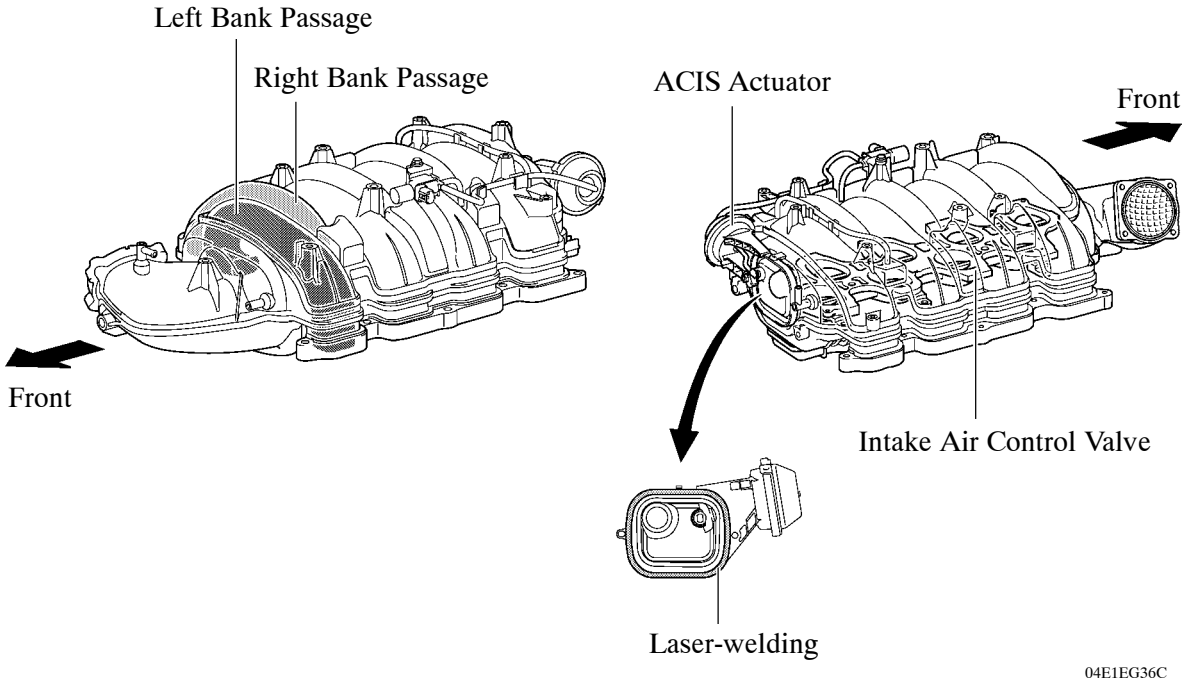
Throttle Body

- A throttle body in which the throttle position sensor and the throttle control motor are integrated is used. It achieves excellent throttle valve control.
- For a throttle control motor, a DC motor with excellent response and minimal power consumption is used. The ECM performs duty cycle control of the direction and the amperage of the current that is supplied to the throttle control motor in order to regulate the throttle valve angle.



Intake Manifold

- An intake manifold with a built-in plastic intake air chamber is used for weight reduction.
- The port diameter and length are optimized to achieve high torque in all driving ranges.
- The intake manifold contains valves for the Acoustic Control Induction System (ACIS), and the actuator is laser-welded to the intake manifold.



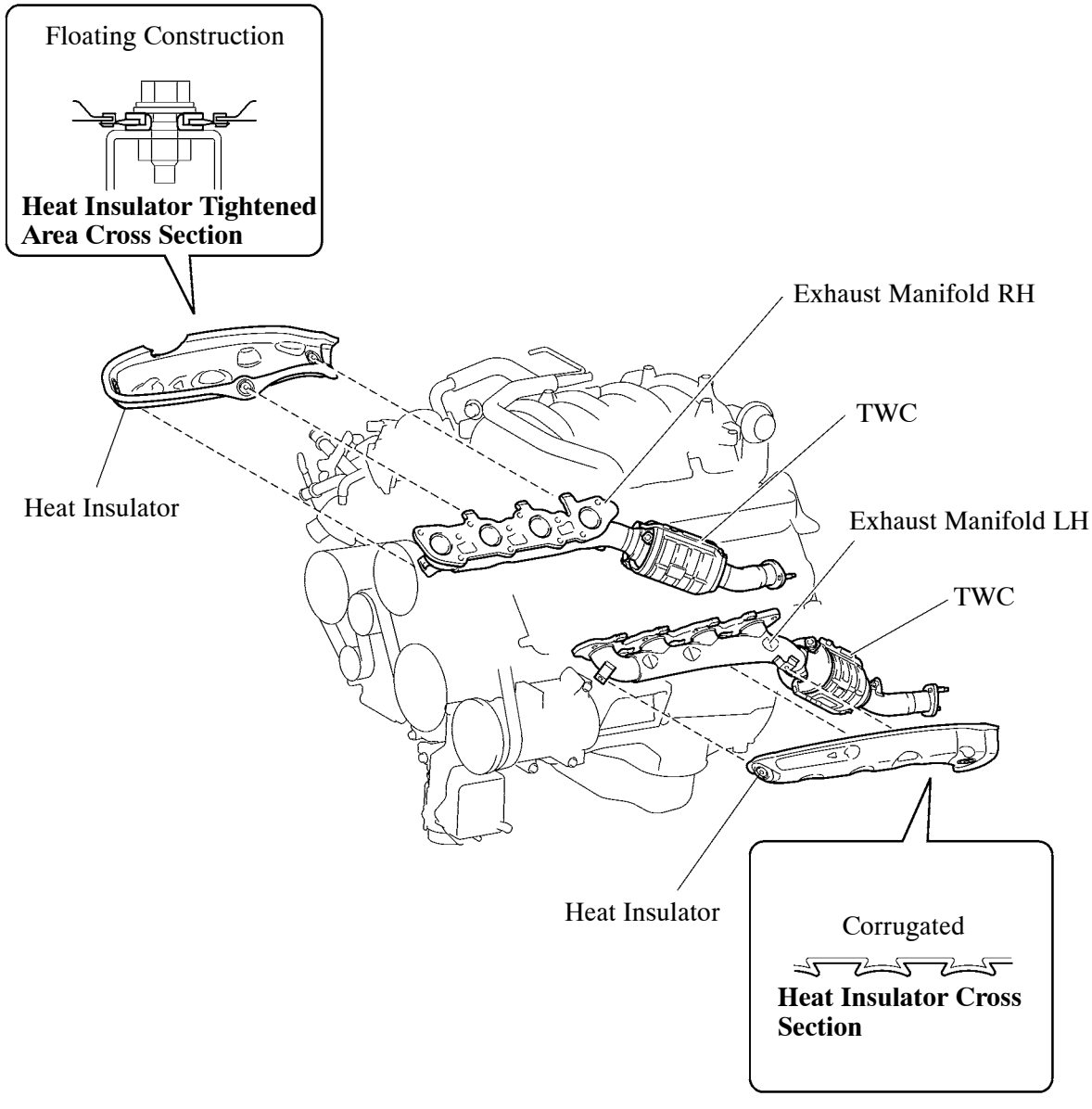
— REFERENCE —

Laser-welding:

In laser-welding, a laser-absorbing material (for the intake manifold) is joined to a laser-transmitting material (for the ACIS actuator). Laser beams are then irradiated from the laser-transmitting side. The beams penetrate the laser-transmitting material to heat and melt the surface of the laser-absorbing material. Then, the heat of the laser-absorbing material melts the laser-transmitting material and causes both materials to become welded.

Exhaust Manifold

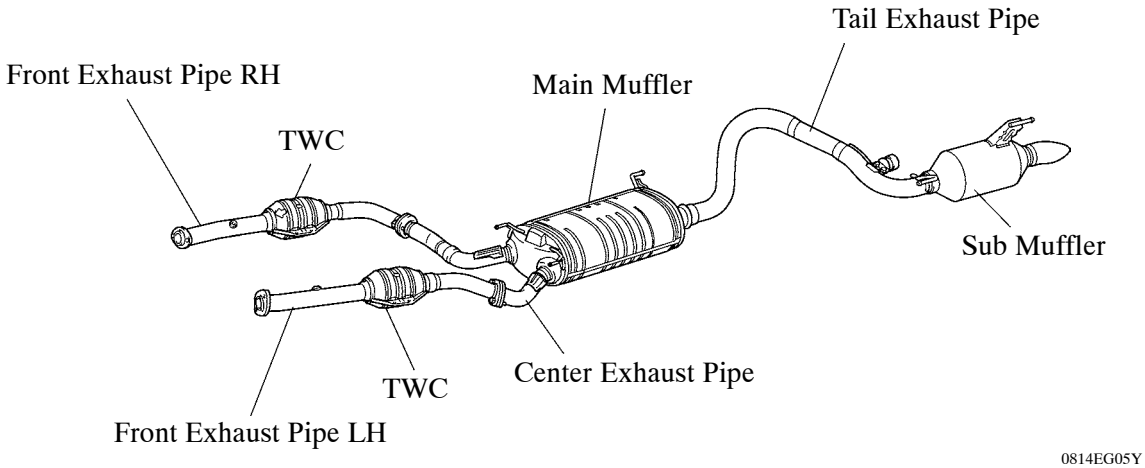
- A stainless steel exhaust manifold is used for weight reduction and rust resistance.
- A ceramic type Three-Way Catalytic converter (TWC) is provided in each exhaust manifold for the right bank and the left bank. The exhaust emission performance of the engine is improved as a result of these TWCs.
- The exhaust manifold heat insulator is made of corrugated aluminum. This ensures rigidity, and at the same time, increases the surface area to improve heat dissipation. Furthermore, a floating construction is used at the tightened area to reduce the transfer of heat and vibration to the heat insulator and improve reliability.



Exhaust Pipe

1) General

- The exhaust pipes are made of stainless steel to reduce their weight and improve rust resistance.
- A 2-way exhaust control system is provided in the main muffler.
- A ceramic type TWC is provided in each front exhaust pipe for the right bank and the left bank. As a result, exhaust emission performance of the engine is improved.



2) 2-way Exhaust Control System

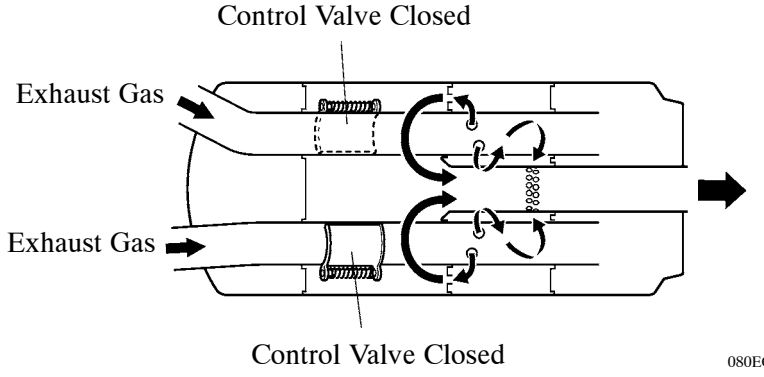
a. General

- 2-way exhaust control system reduces the back pressure by opening and closing a control valve that is enclosed in the main muffler, thus varying the exhaust gas pressure.
- The control valve opens steplessly in accordance with the operating condition of the engine, thus enabling a quieter operation at lower engine speeds, and reducing back pressure at higher engine speeds.
- When the exhaust pressure overcomes the spring force of the control valve, the control valve opens steplessly in accordance with the exhaust gas pressure.

b. Operation

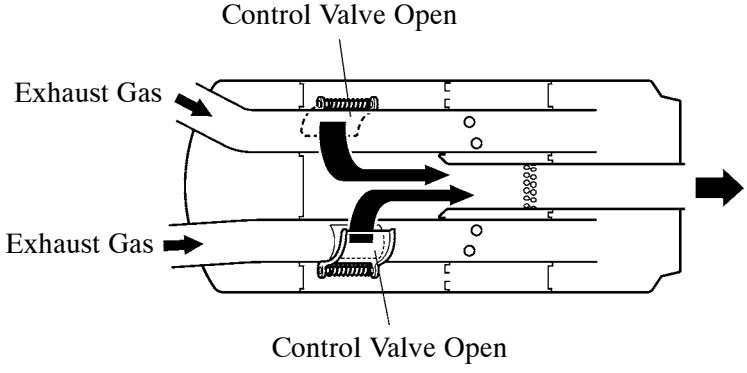
i) When Control Valve is Closed (Low Engine Speed)

Since the pressure in the muffler is low, the control valve is closed. Hence exhaust gas does not pass the bypass passage, and exhaust noise is decreased in the muffler.



ii) When Control Valve is Open (Middle to High Engine Speed)

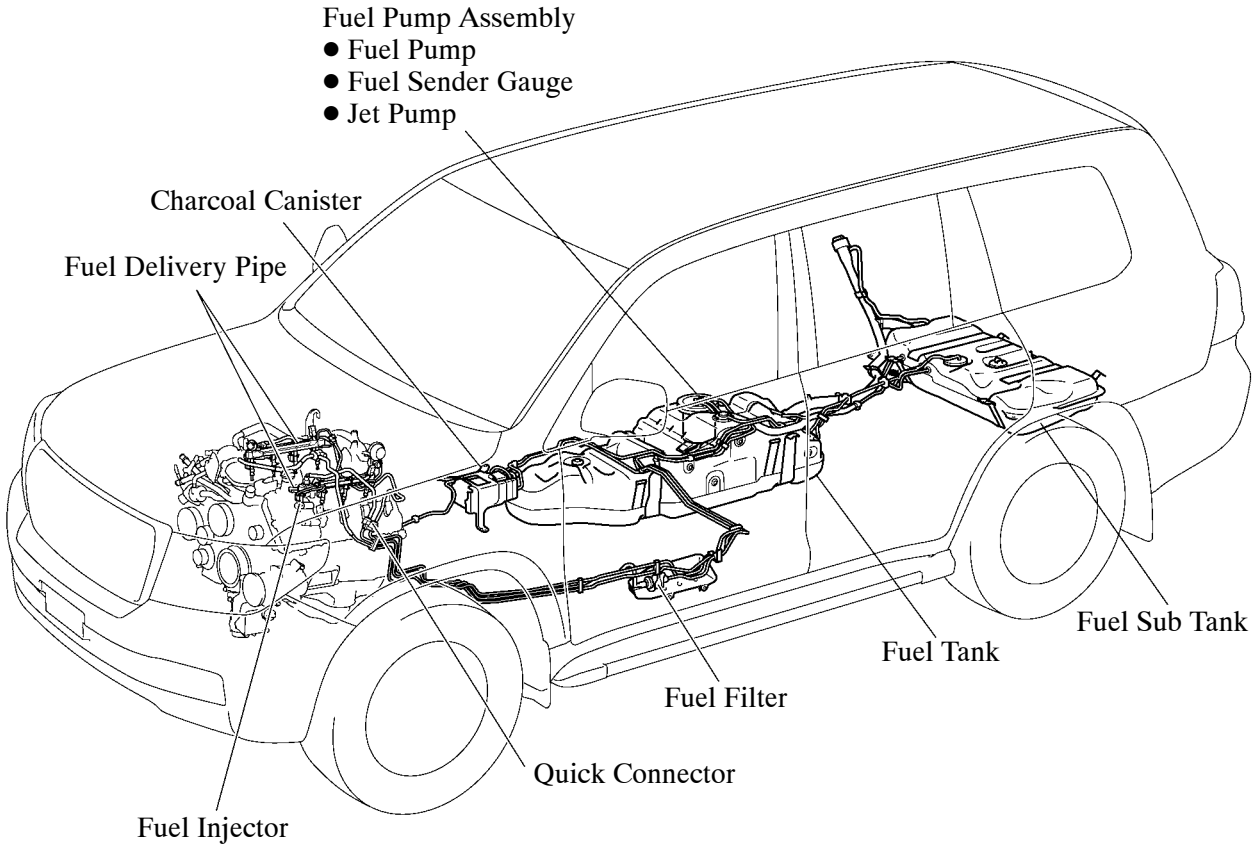
The valve opens as the engine speed and the back pressure in the muffler increase. This allows a large volume of exhaust gas to pass the bypass passage, thereby substantially decreasing the back pressure.

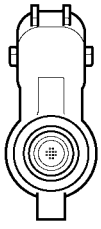


8. Fuel System

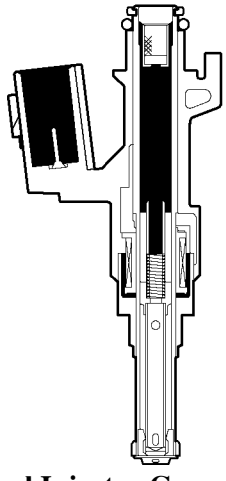
General

- A fuel cut control is used to stop the fuel pump when SRS airbags deploy in a frontal or side collision. For details, see page 86.
- Compact 12-hole type fuel injectors are used to improve the atomization of fuel.
- Fuel delivery pipes formed from stamped steel, which has a pulsation damper function, are used.
- Quick connectors are used to connect the fuel lines for ease of serviceability.
- A multi-layer plastic fuel tank and fuel sub tank are used.





View from Bottom Side

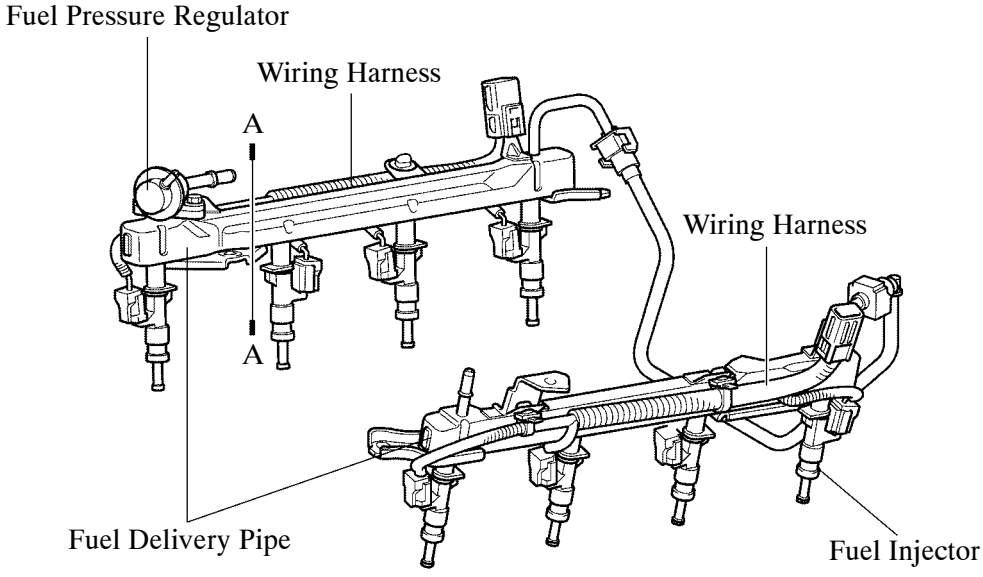


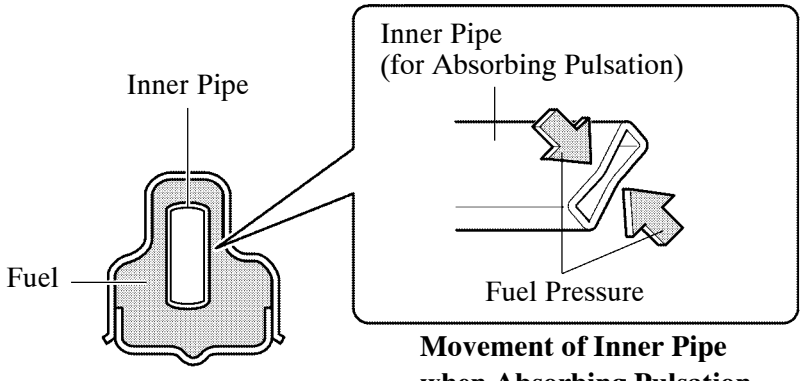
Fuel Injector Cross Section

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Delivery Pipe

- Fuel delivery pipes formed from stamped steel are used to deliver fuel to the fuel injectors.
- An inner pipe inside the delivery pipe is used to absorb fuel pulsations. This eliminates the use of the pulsation damper provided on conventional models, making the fuel system more compact and lightweight. When the fuel pulsates, the shape of the inner pipe changes with the pulsation, thus changing the internal capacity of the delivery pipe. This change in capacity absorbs the fuel pulsations.
- The wiring harnesses that connect to the fuel injectors are combined into a single strand at each bank. Furthermore, they each connect to the engine harness at a single connector for improved serviceability.





A – A Cross Section (Delivery Pipe)

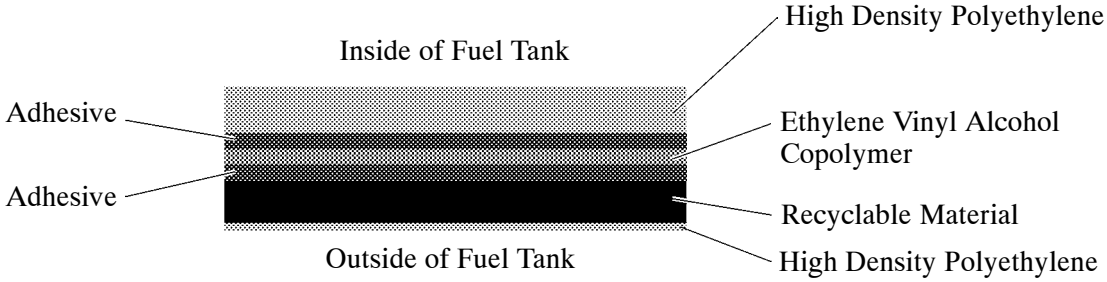
Movement of Inner Pipe when Absorbing Pulsation

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Fuel Tank

1) General

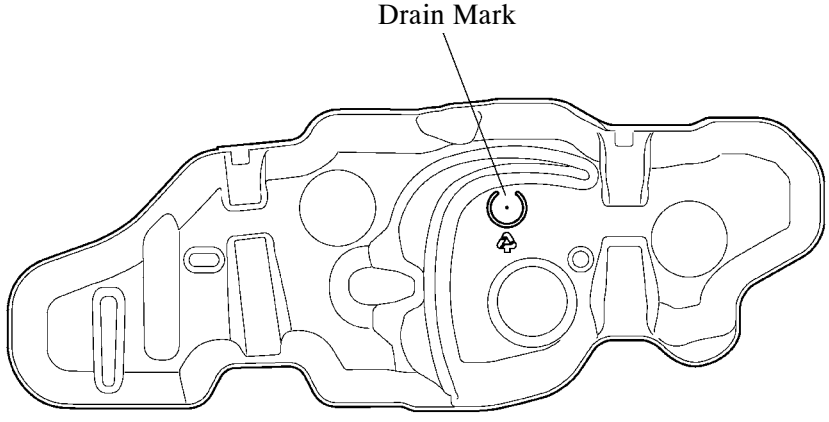
- The multi-layer plastic fuel tank consists of 6 layers of 4 types of materials, one of which is a recyclable material to address environmental concerns.
- A jet pump, which automatically transfers fuel from the fuel sub tank to the fuel tank, is provided in the fuel tank on models with a dual fuel tank.



Cross Section of Fuel Tank D13N27

Service Tip

A drain mark has been provided at the lowest position of the fuel tank. When dismantling (scrapping) the vehicle, drain fuel by drilling holes at the drain mark.



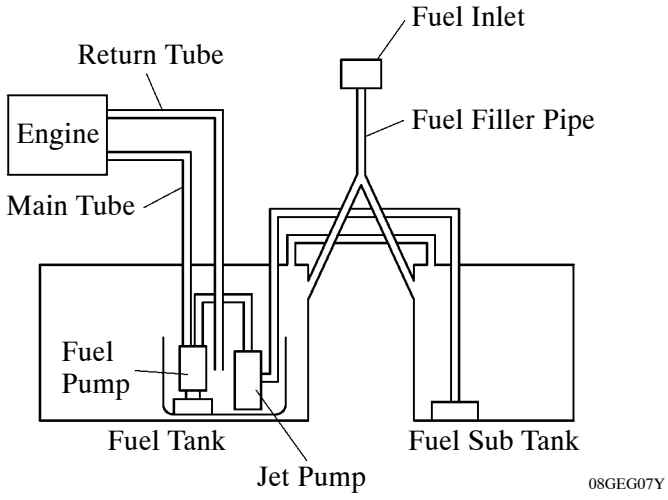
View from Bottom Side 080EG14TE

2) Construction of Dual Fuel Tank

a. General

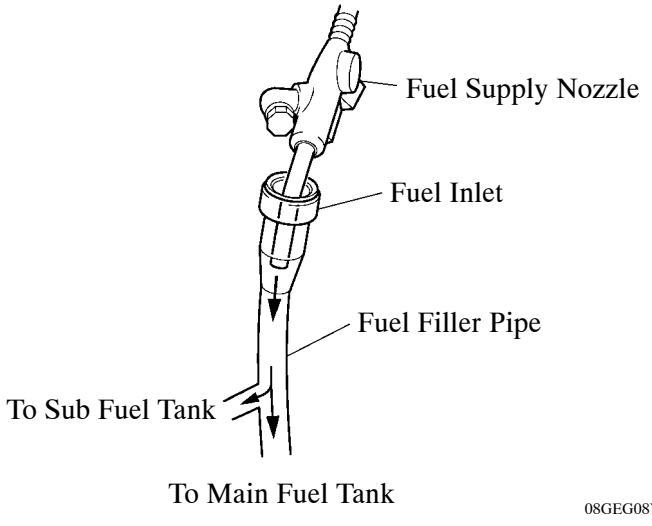
- A jet pump is provided in the fuel tank in order to automatically transfer fuel from the fuel sub tank to the fuel tank.
- For the fuel filler pipe, the structure that is united directly beneath the fuel inlet and forked into two in the middle is used in its configuration. Therefore, the driver can refuel without the need to distinguish the fuel tank from the fuel sub tank.

▶ System Diagram ◀



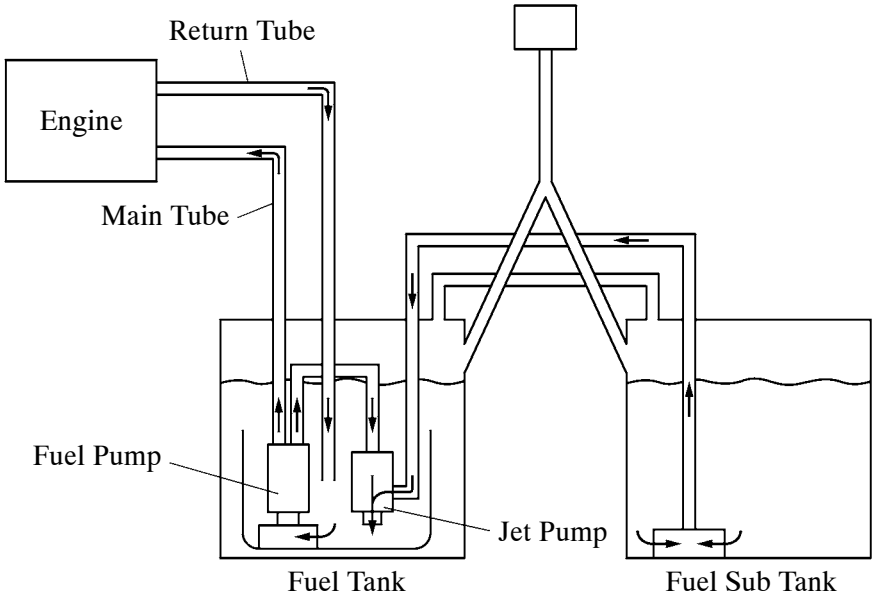
b. Fuel Inlet

There is only one fuel filler pipe directly below the fuel inlet, which branches into two pipes at a midway point.

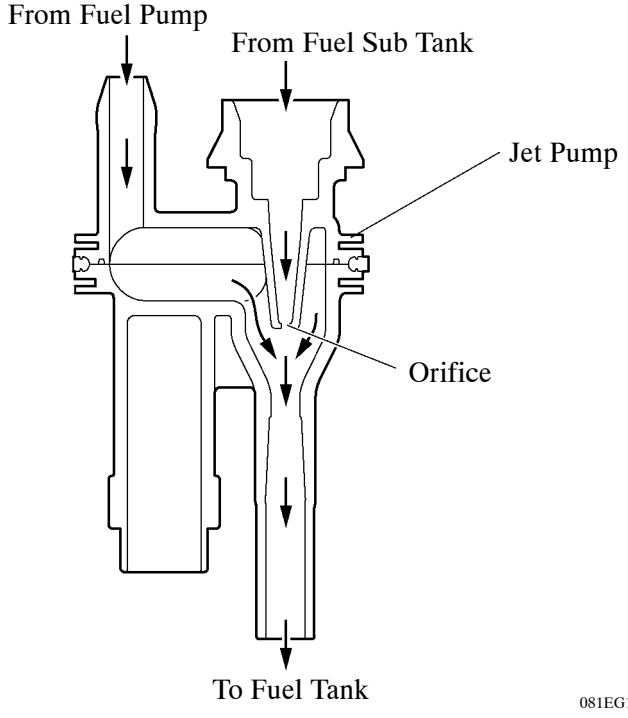


c. Operation

- The fuel from the fuel pump actuates the jet pump in the fuel tank, in order to draw fuel from the fuel sub tank to the fuel tank.



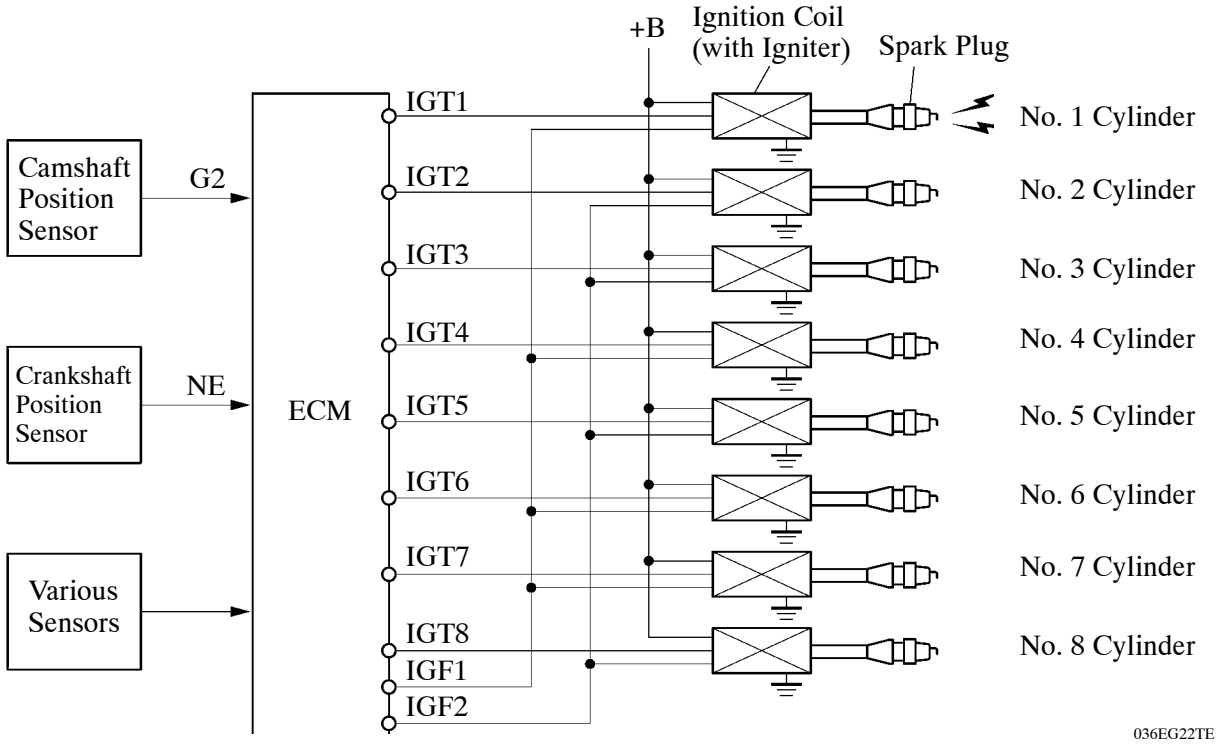
- The fuel from the fuel pump passes through the orifice in the jet pump and returns to the fuel tank. Because the flow speed of the fuel from the fuel pump increases as it passes through the orifice, a vacuum is created near the exit of the orifice. This vacuum causes the fuel to be drawn from the fuel sub tank to the fuel tank.



9. Ignition System

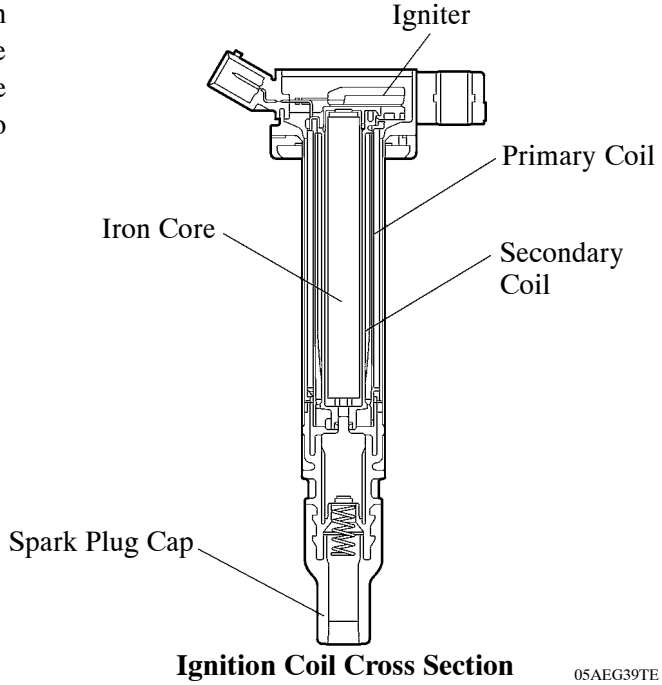
General

- A Direct Ignition System (DIS) is used. The DIS improves ignition timing accuracy, reduces high-voltage loss, and enhances the overall reliability of the ignition system by eliminating the distributor.
- The DIS is an independent ignition system which has one ignition coil (with an integrated igniter) for each cylinder.



Ignition Coil

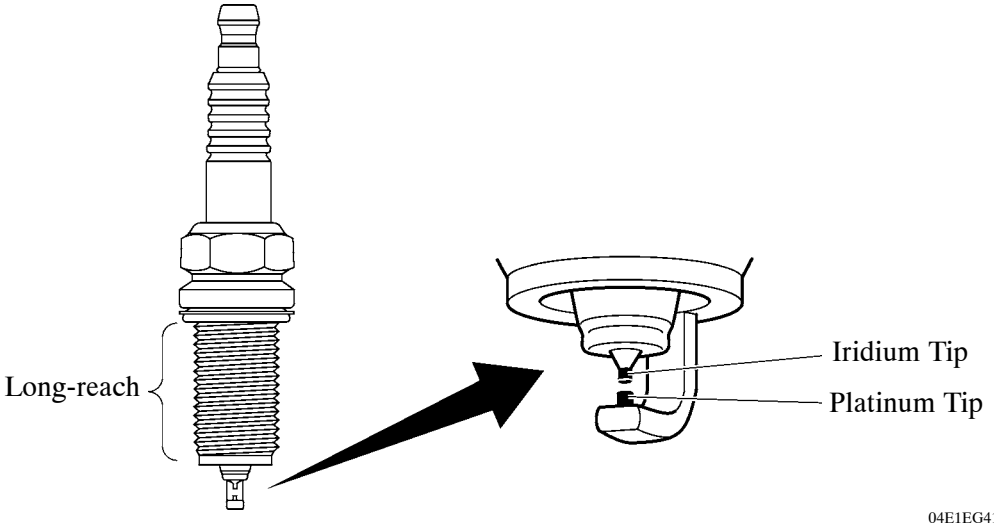
The DIS provides 8 ignition coils, one for each cylinder. The spark plug caps, which provide contact to the spark plugs, are integrated with the ignition coil. Also, an igniter is enclosed to simplify the system.



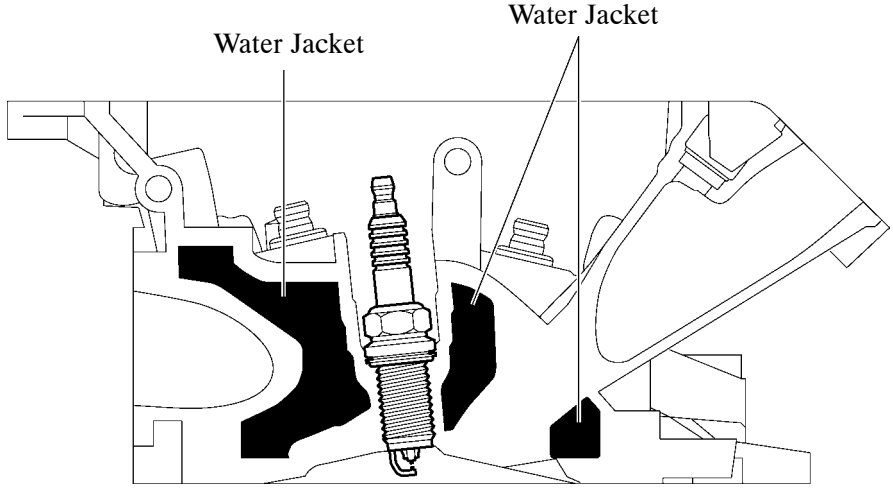
Ignition Coil Cross Section

Spark Plug

- Long-reach type spark plugs are used. This type of spark plug allows the area of the cylinder head that receives the spark plugs to be made thick. Thus, the water jacket can be extended near the combustion chamber, contributing to cooling system performance.
- Iridium-tipped spark plugs are used to achieve a 100000 km (60000 miles) maintenance interval. By using an iridium center electrode, superior ignition performance to platinum-tipped spark plugs is achieved and durability is increased.



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Cylinder Head Cross Section

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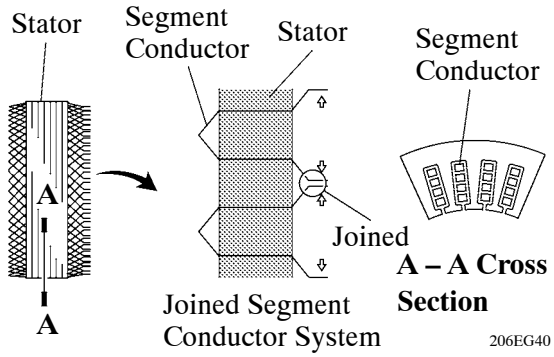
▶ Specifications ◀

Manufacturer	DENSO
Type	SK20HR11
Plug Gap	1.0 – 1.1 mm (0.0394 – 0.043 in.)

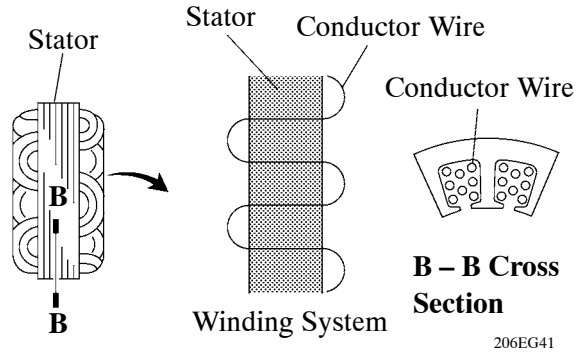
10. Charging System

General

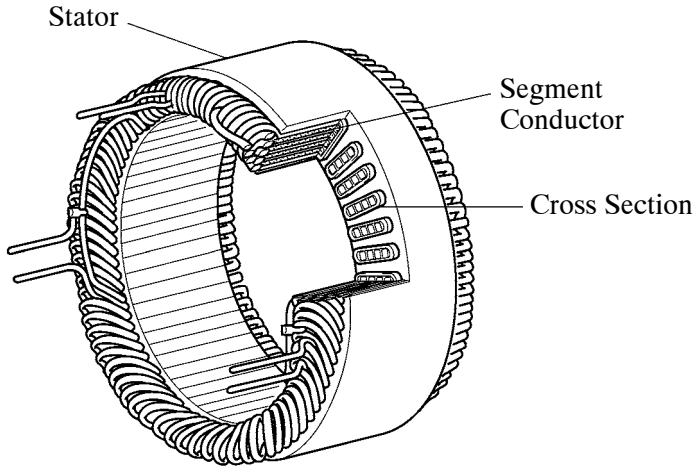
- A compact and lightweight segment conductor type alternator that generates high amperage output in a highly efficient manner is standard equipment.
- This alternator has a joined segment conductor system in which multiple segment conductors are welded together to form the stator. Compared to the conventional winding system, the electrical resistance is reduced due to the shape of the segment conductors, and their arrangement helps to make the alternator compact.



Segment Conductor Type Alternator



Conventional Type Alternator



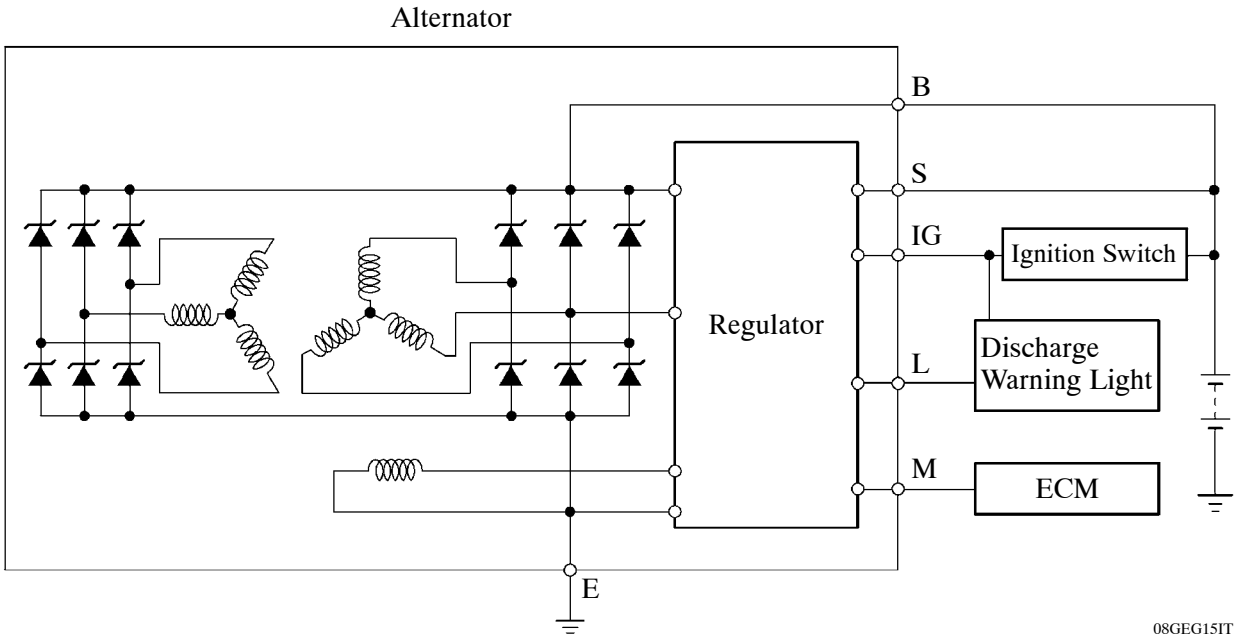
Stator of Segment Conductor Type Alternator

206EG42

▶ Specifications ◀

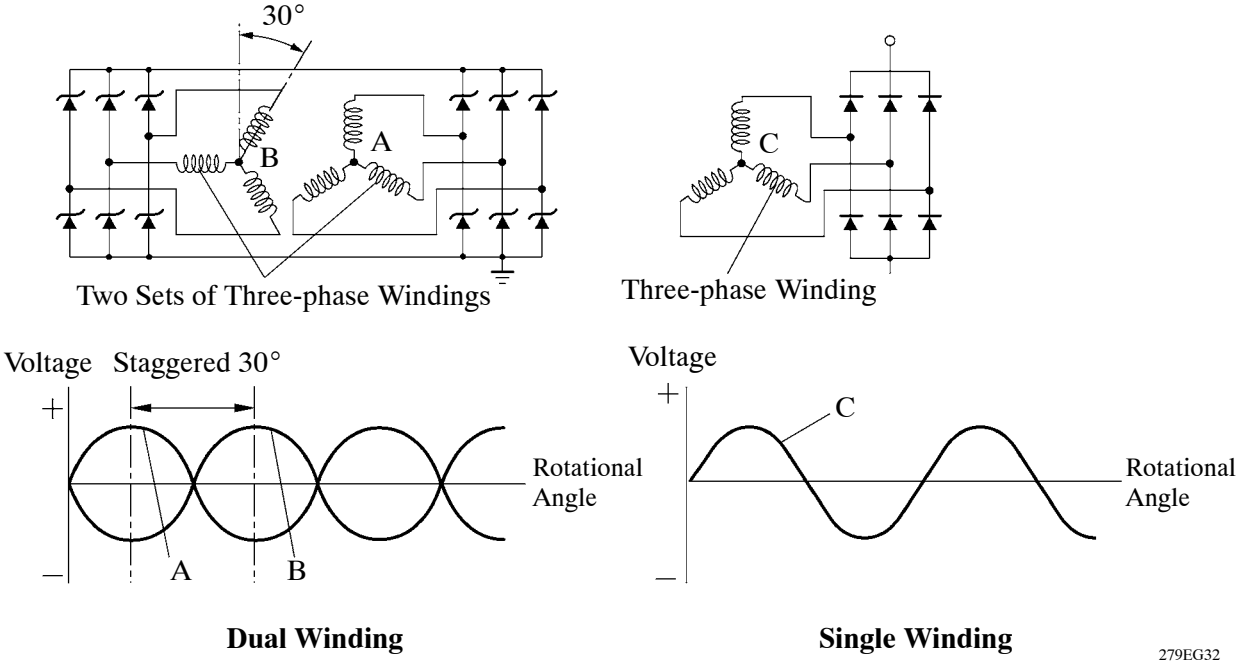
Type	SC6
Rated Voltage	12 V
Rated Output	180 A
Initial Output Starting Speed	Max. 1000 rpm

▶ Wiring Diagram ◀



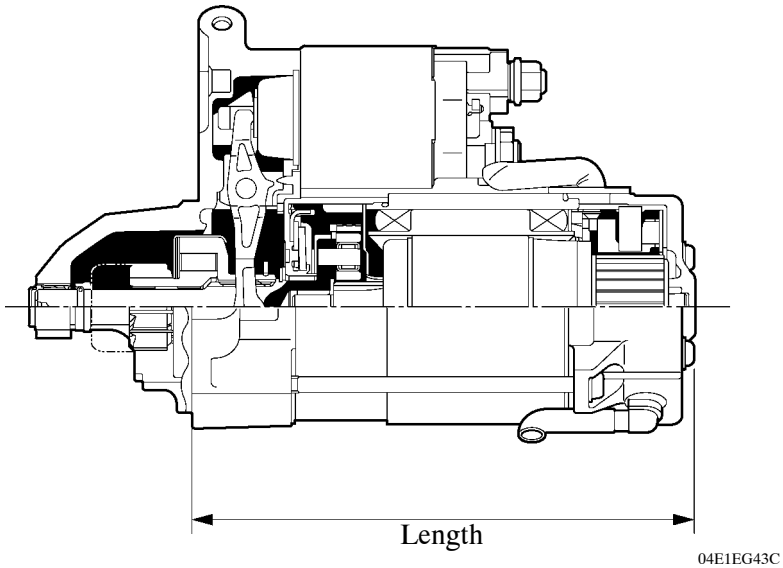
Dual Winding System

A dual winding system is used. This system consists of two sets of three-phase windings whose phases are staggered 30°. This system results in the reduction of both electrical noise (ripple and spike) and magnetic noise (a hum that is heard as alternator load is increased). This system significantly suppresses noise at the source (alternator). Because the waves that the respective windings generate have opposite polarities, magnetic noise is reduced. However, the electrical power generated does not cancel itself out due to the use of separate rectifiers. The opposite polarities that are generated are shown below:



11. Starting System

The planetary reduction type starter is used.



▶ Specification ◀

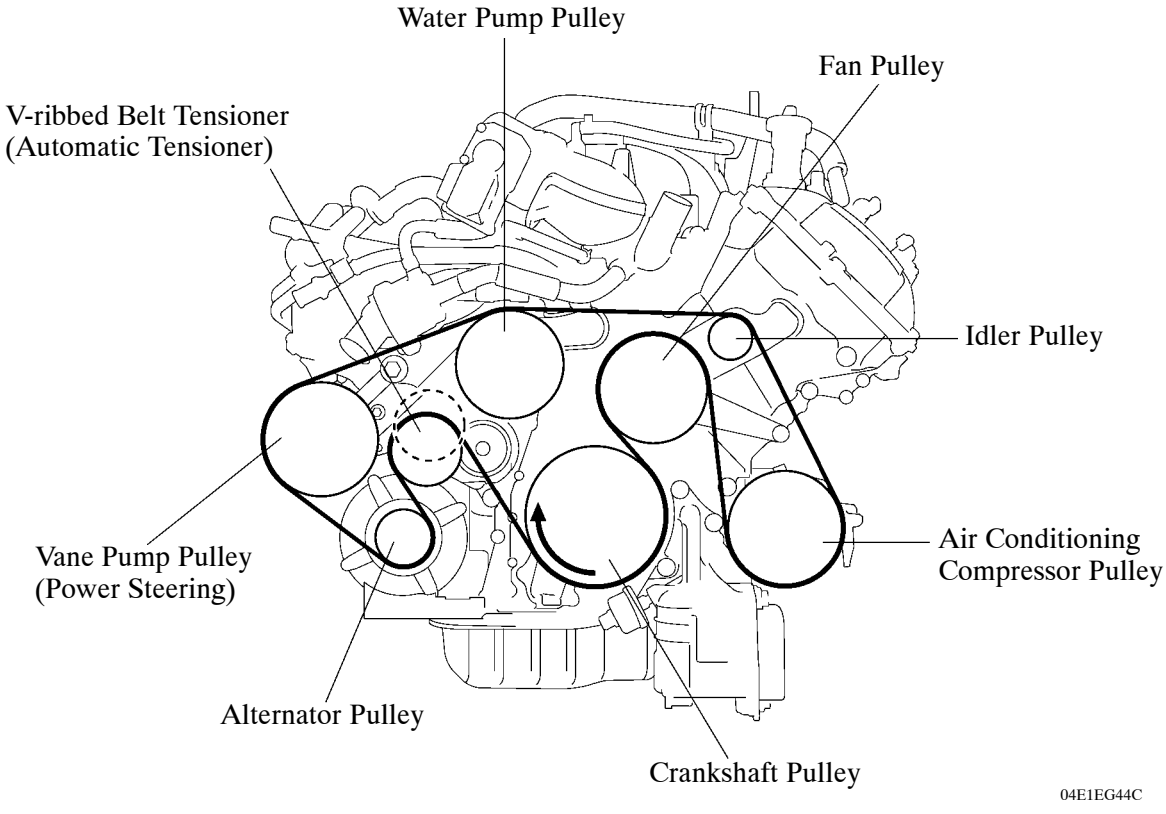
Type	PA78S
Rated Output	2.0 kW
Rated Voltage	12 V
Length*1	172.35 mm (6.79 in.)
Weight	4300 g (9.5 lb)
Rotating Direction	Clockwise*2

*1: Length from the mounted area to the rear end of the starter

*2: Viewed from pinion side

12. Serpentine Belt Drive System

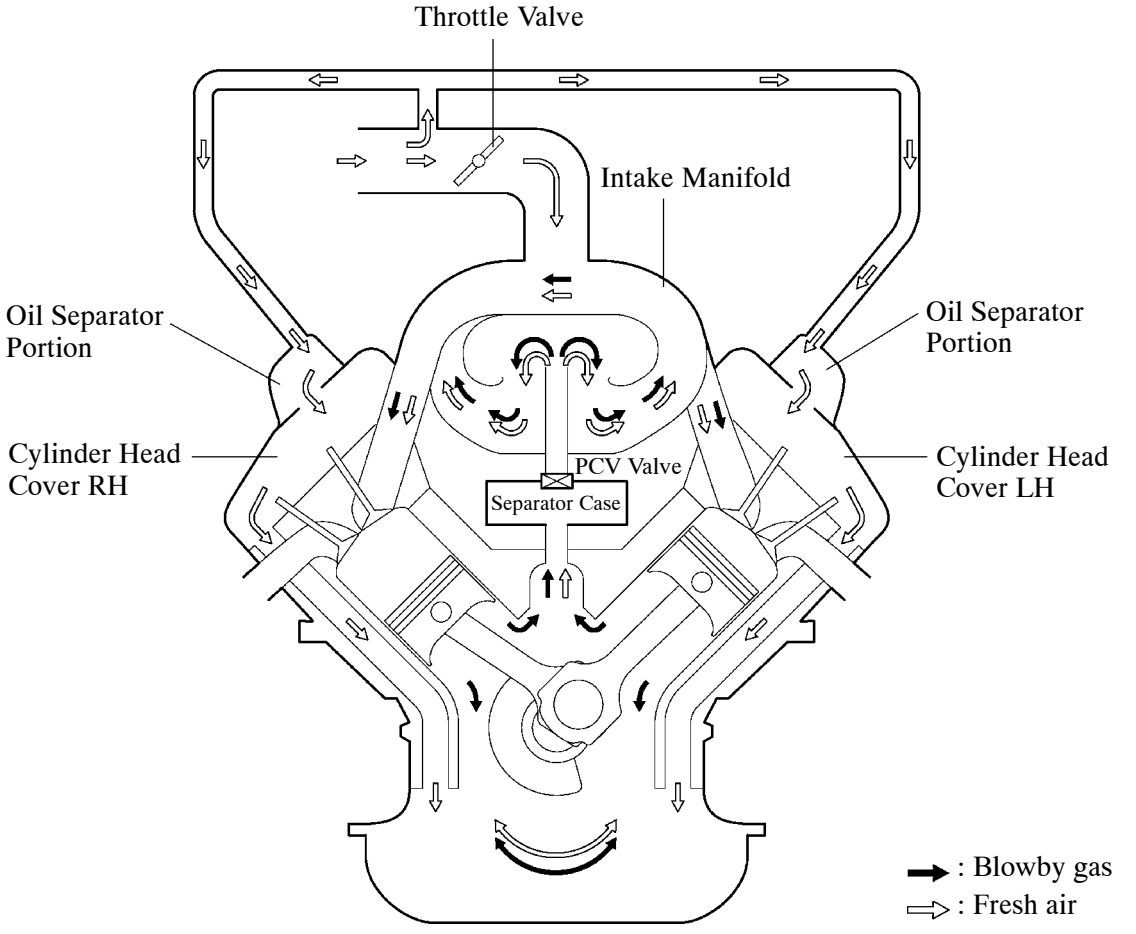
- A serpentine belt drive system, which drives all accessory components by a single V-ribbed belt, is used. It reduces the overall engine length, weight and the number of engine parts.
- An automatic tensioner is used. This makes the tension adjustment unnecessary.



13. Blowby Gas Ventilation System

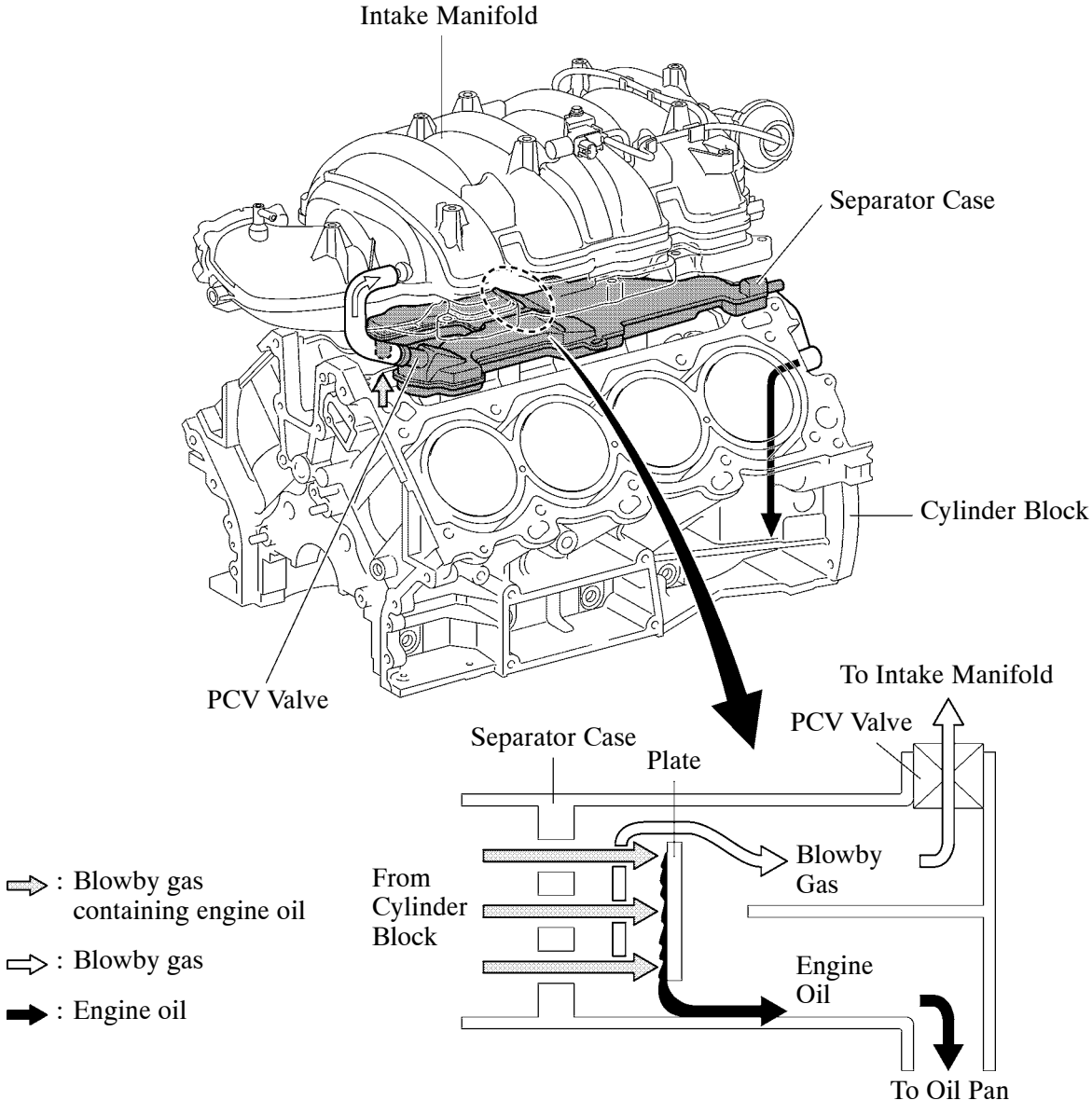
General

- The oil separator portion of the cylinder head covers has been made compact through the use of an independent separator case. This contributes to making the entire engine compact.
- Fresh air is drawn from the right and left bank cylinder head covers to improve the ventilation inside the engine and improve the deterioration resistance of the engine oil.



Separator Case

- A plastic separator case is provided between the cylinder block and the intake manifold in order to separate the engine oil that is included in the blowby gas.
- An inertial impaction system is used in the construction for separating the engine oil in the separator case. The blowby gas that contains engine oil hits the plate, causing the engine oil to adhere and accumulate on the plate. Then, the oil drips down by way of gravity. Thus, this system efficiently separates the engine oil from the blowby gas. This improves the rate of the collection of the engine oil and reduces the amount of engine oil consumption.



Cross-sectional Image of Separator Case

04E1EG46C

14. Engine Control System

General

The engine control system of the 3UR-FE engine has the following features:

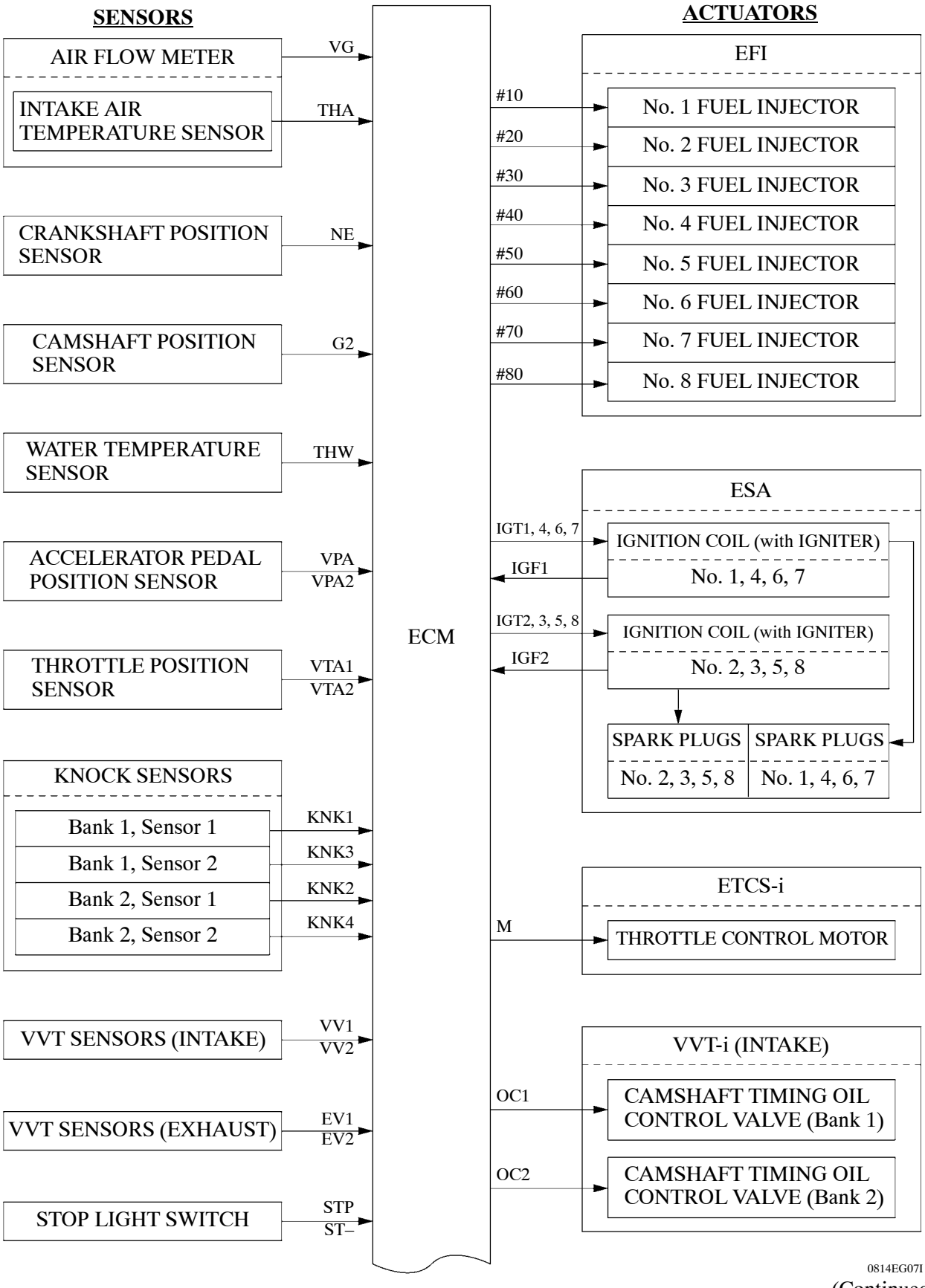
System	Outline
Electronic Fuel Injection (EFI)	● An L-type EFI system directly detects the intake air mass using a hot wire type air flow meter. ● An independent injection system (in which fuel is injected once into each intake port for each two revolutions of the crankshaft) is used. ● Fuel injection takes two forms: – Synchronous injection, in which injection always occurs at the same timing relative to the firing order. – Non-synchronous injection, in which injection is effected regardless of the crankshaft angle. ● Synchronous injection is further divided into group injection during a cold start, and independent injection after the engine is started.
Electronic Spark Advance (ESA)	● 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.
Electronic Throttle Control System-intelligent (ETCS-i) [See page 73]	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 Variable Valve Timing-intelligent (Dual VVT-i) [See page 78]	Controls the intake and exhaust camshafts to optimal valve timing in accordance with the engine operating conditions.
Acoustic Control Induction System (ACIS) [See page 84]	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 [See page 86]	● Based on signals from the ECM, the fuel pump ECU controls the fuel pump to 3 stages. ● The fuel pump is stopped when the SRS airbag is deployed in a frontal, side, or side rear collision.
Starter Control (Cranking Hold Function) [See page 88]	Once the engine switch is pushed while the brake pedal is depressed, this control continues to operate the starter until the engine starts.
Air-fuel Ratio Sensor and Heated Oxygen Sensor Heater Control	Maintains the temperature of the air-fuel ratio sensors or heated oxygen sensors at an appropriate level to increase the detection accuracy of the exhaust gas oxygen concentration.

(Continued)

System	Outline
Air Conditioning Cut-off Control	By turning the air conditioning compressor on or off in accordance with the engine condition, driveability is maintained.
Evaporative Emission Control	The ECM controls the purge flow of evaporative emissions (HC) in the charcoal canister in accordance with the engine conditions.
Engine Immobiliser	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid key.
Diagnosis [See page 90]	When the ECM detects a malfunction, it records the malfunction and memorizes information related to the fault.
Fail-safe [See page 90]	When the ECM detects a malfunction, it stops or controls the engine according to the data already stored in the memory.

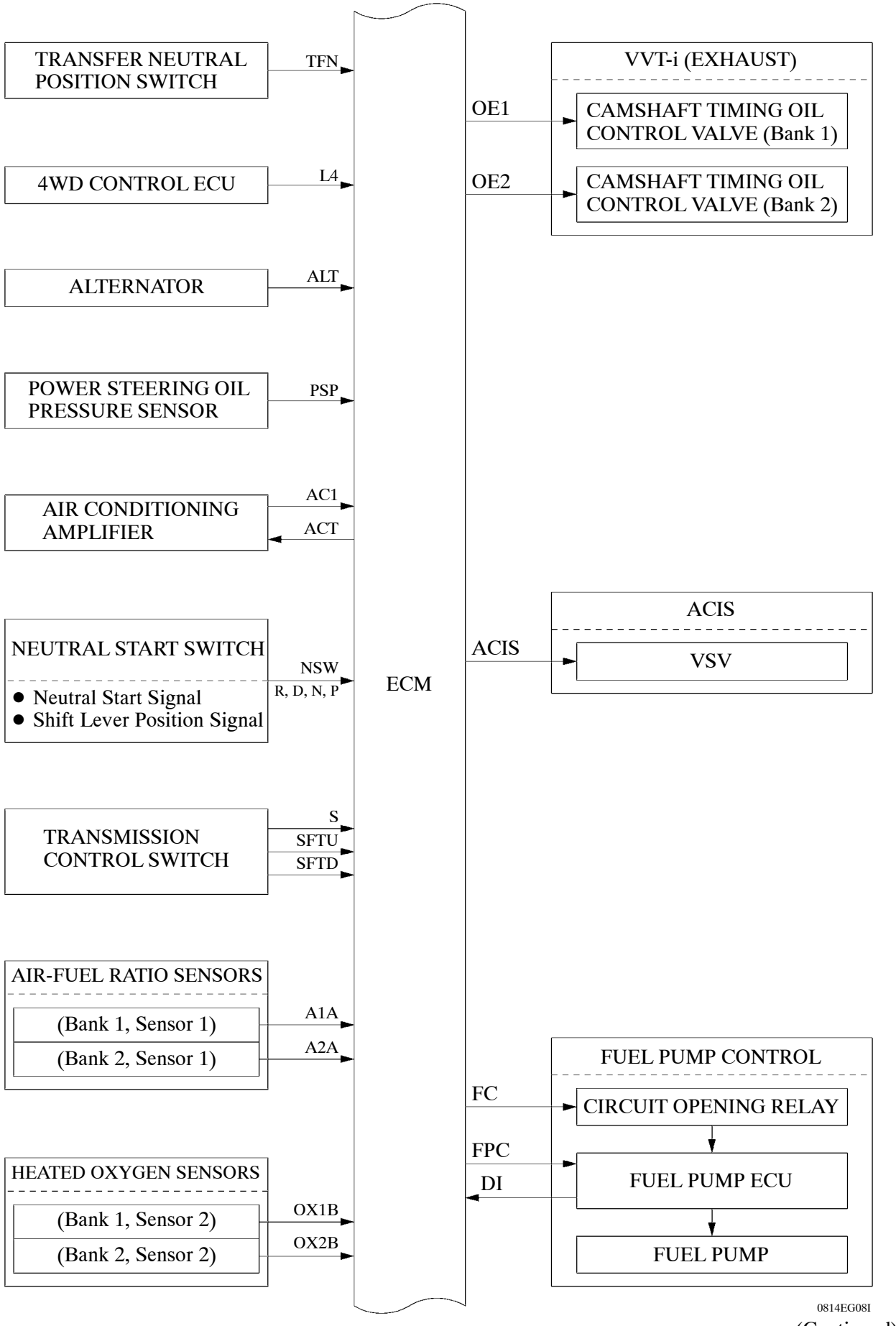
Construction

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



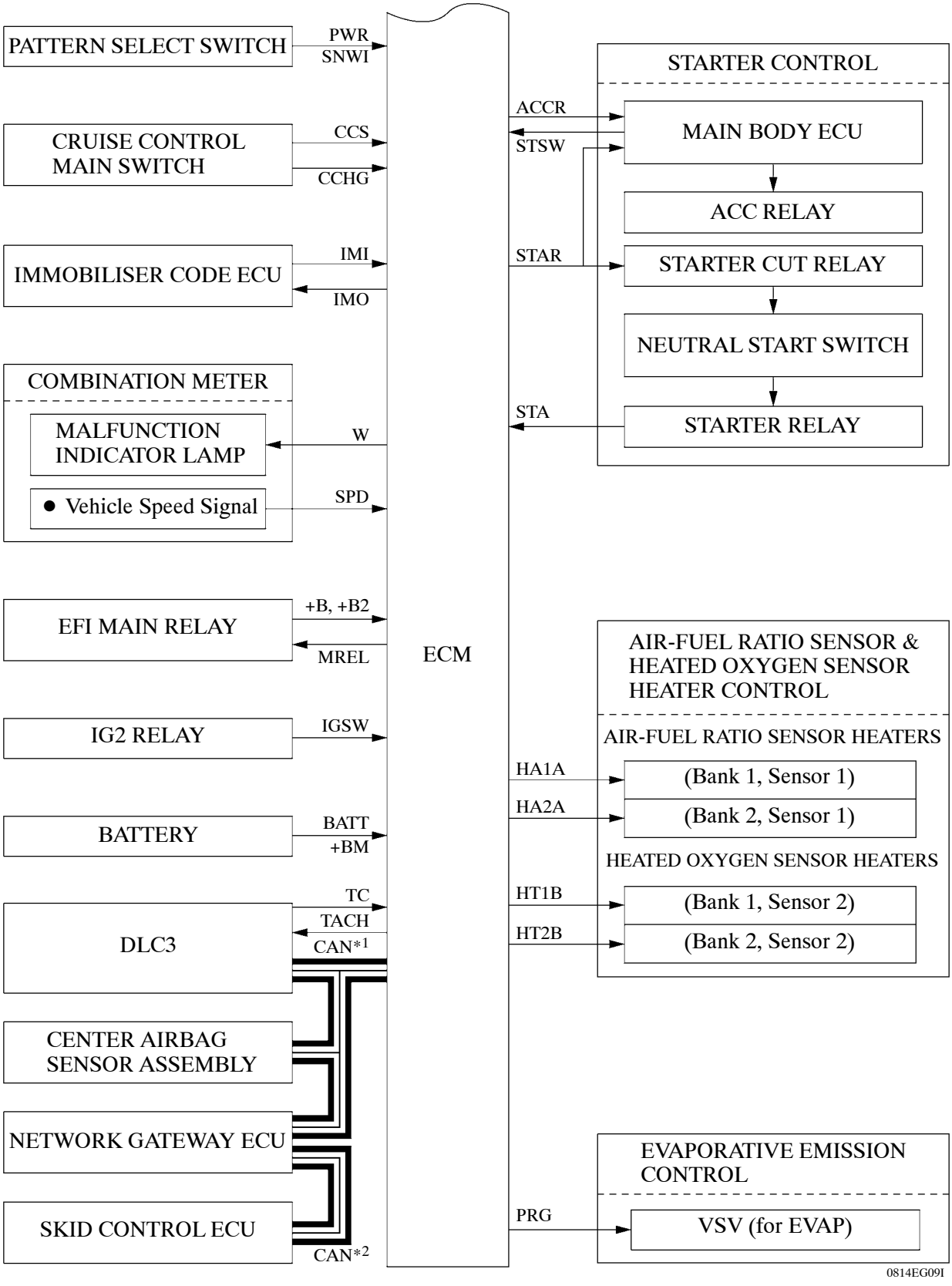
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0814EG08I

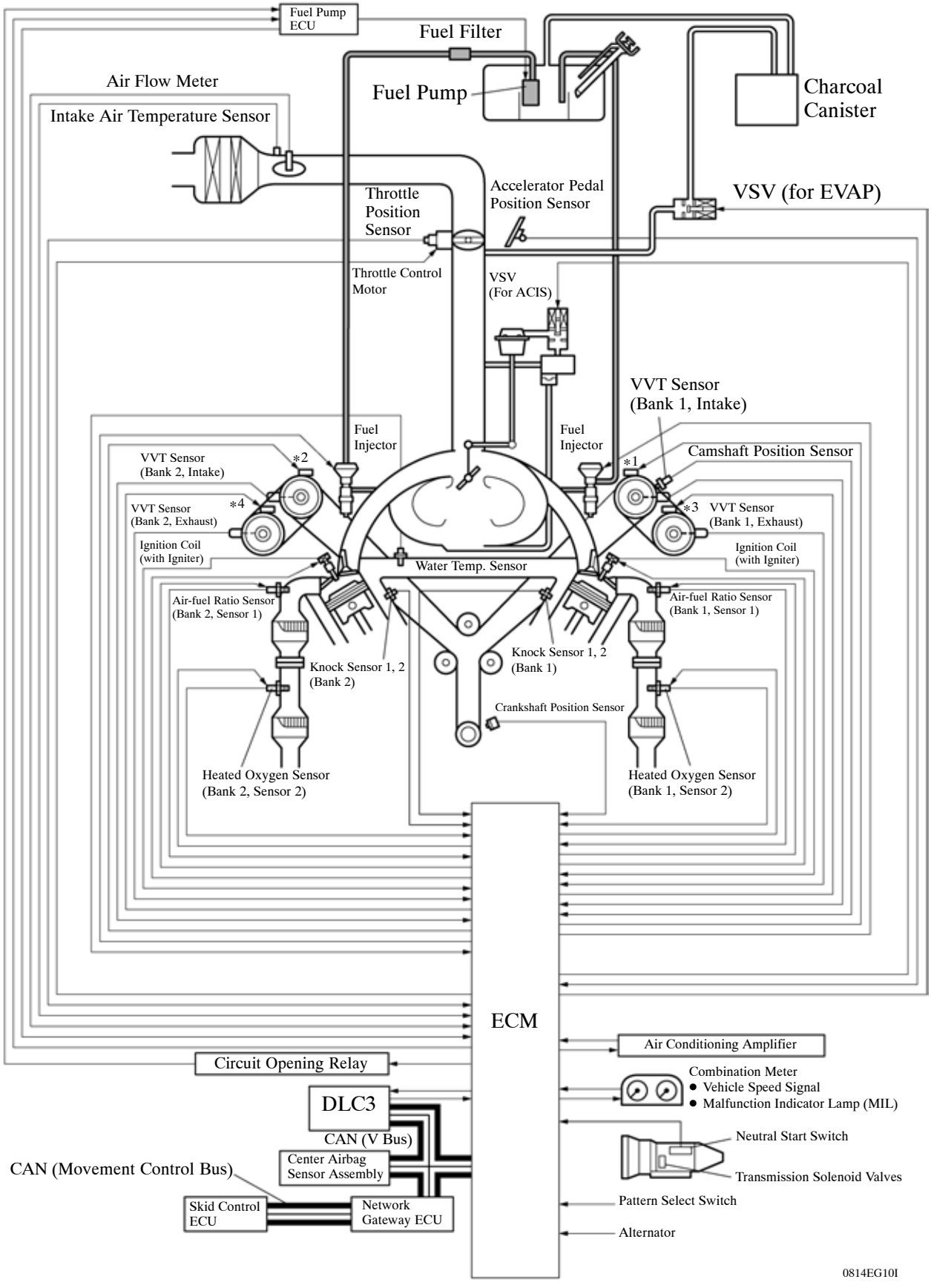
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*1: V bus

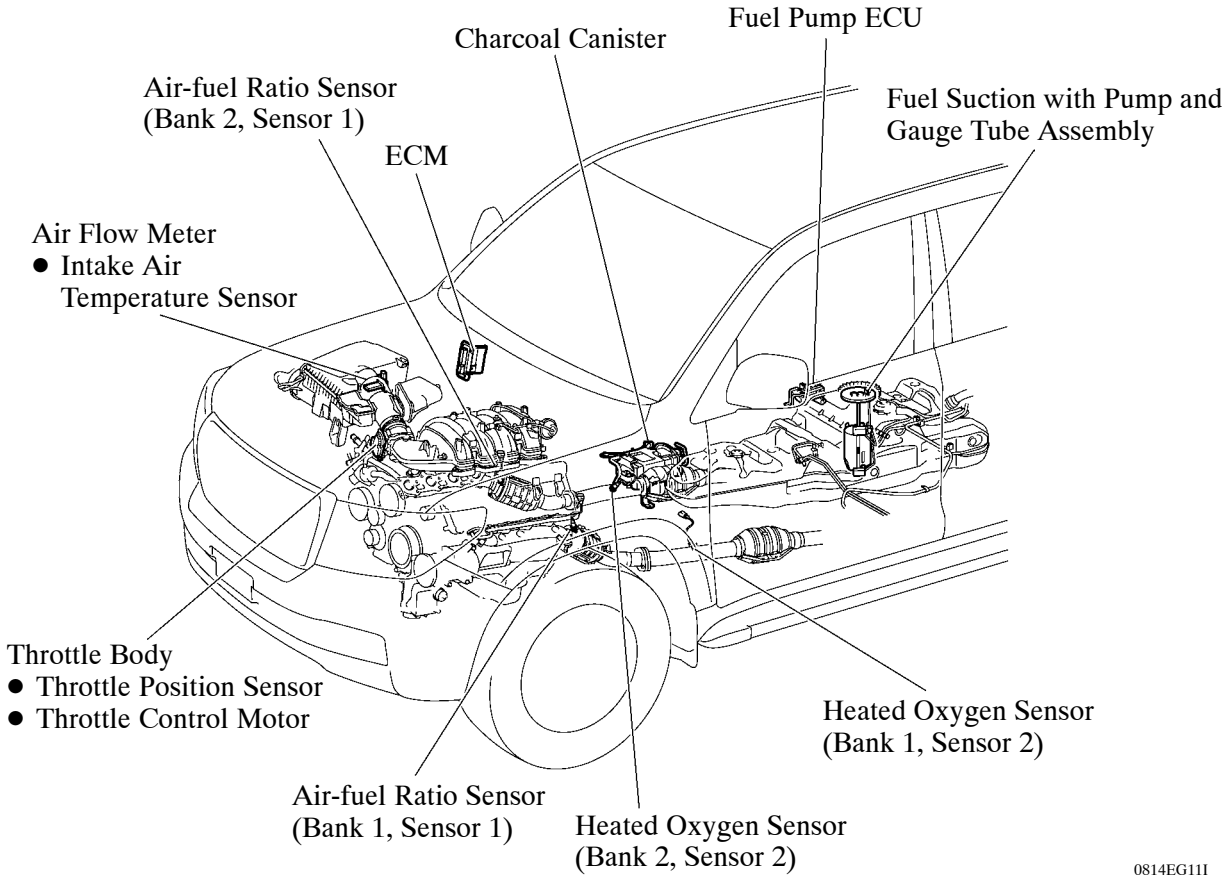
*2: Movement control bus

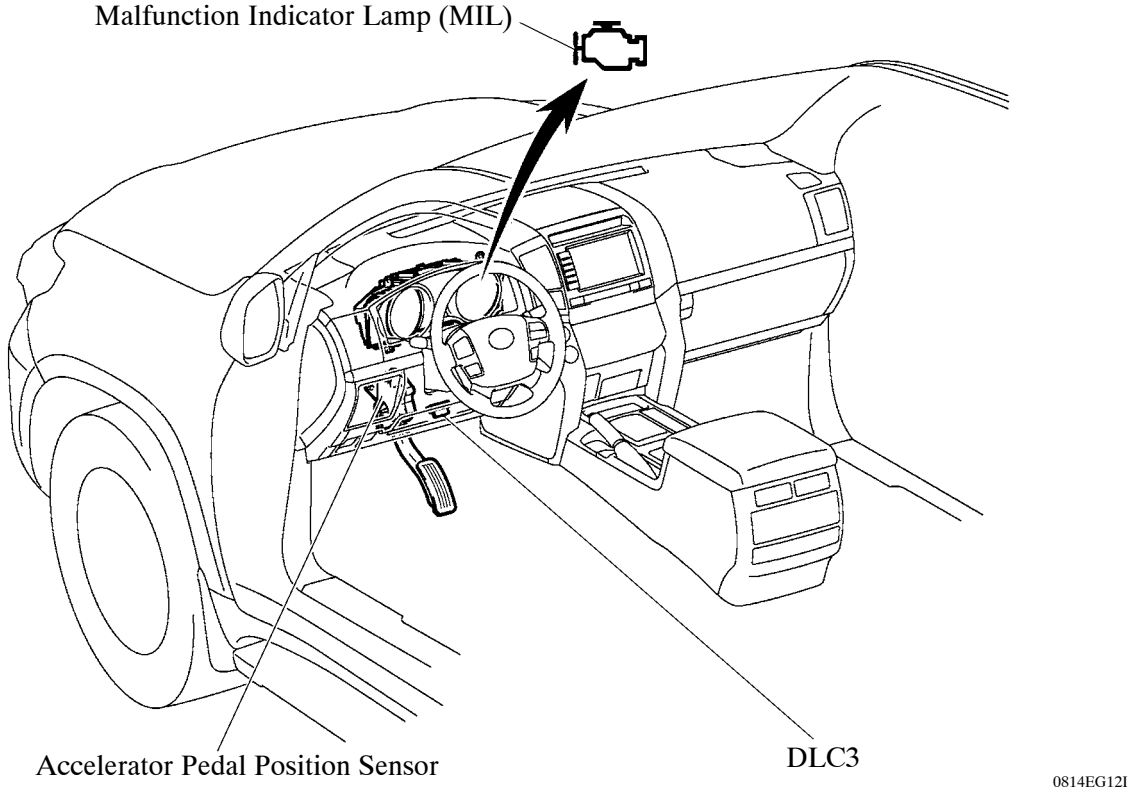
Engine Control System Diagram

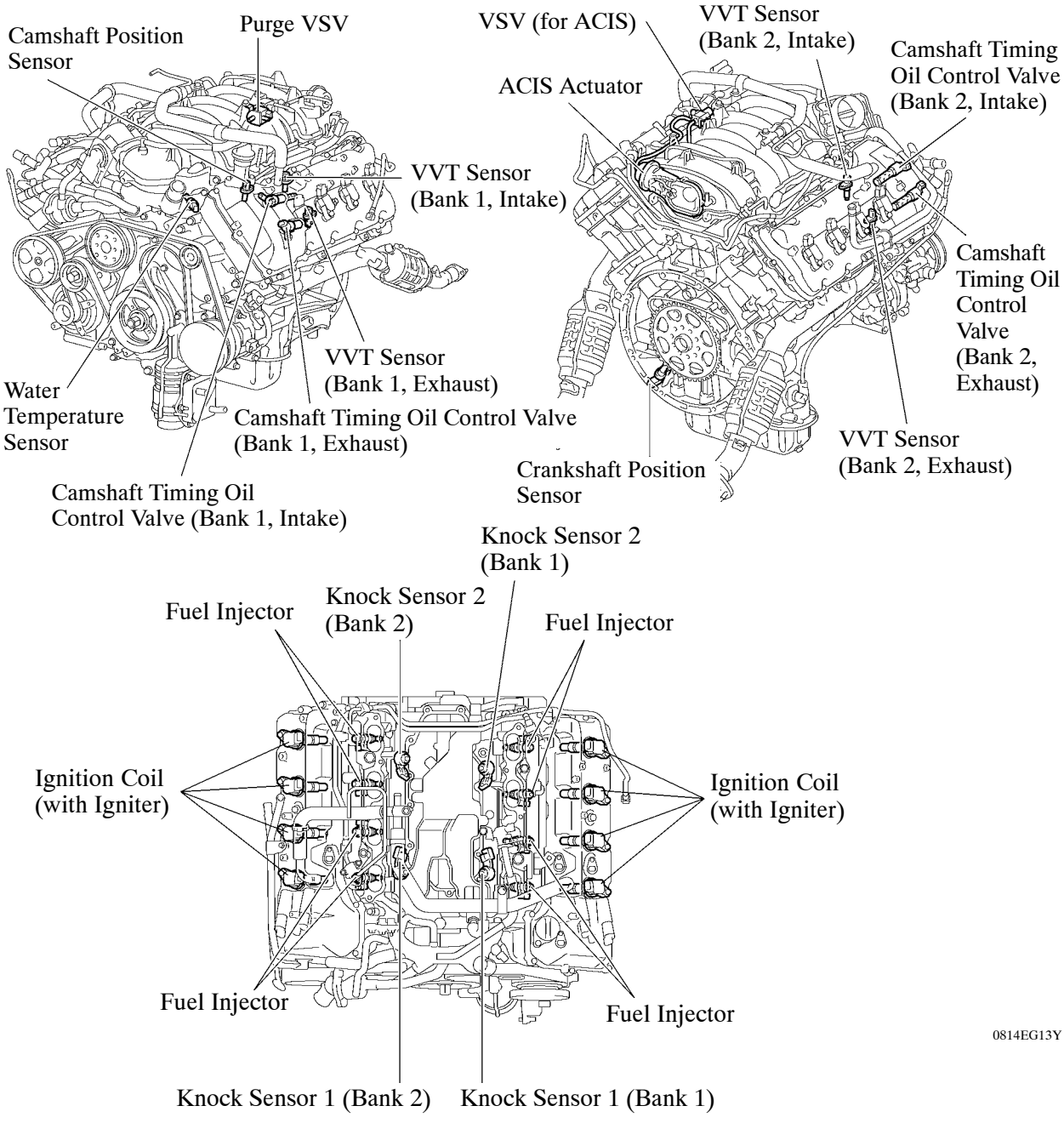


*1: Intake camshaft timing oil control valve (Bank 1)
*2: Intake camshaft timing oil control valve (Bank 2)
*3: Exhaust camshaft timing oil control valve (Bank 1)
*4: Exhaust camshaft timing oil control valve (Bank 2)

Layout of Main Components






Camshaft Position Sensor
Purge VSV
VVT Sensor (Bank 1, Intake)
VVT Sensor (Bank 1, Exhaust)
Water Temperature Sensor
Camshaft Timing Oil Control Valve (Bank 1, Exhaust)
Camshaft Timing Oil Control Valve (Bank 1, Intake)
VSV (for ACIS)
VVT Sensor (Bank 2, Intake)
Camshaft Timing Oil Control Valve (Bank 2, Intake)
ACIS Actuator
Camshaft Timing Oil Control Valve (Bank 2, Exhaust)
VVT Sensor (Bank 2, Exhaust)
Crankshaft Position Sensor
Knock Sensor 2 (Bank 1)
Fuel Injector
Knock Sensor 2 (Bank 2)
Fuel Injector
Ignition Coil (with Igniter)
Ignition Coil (with Igniter)
Fuel Injector
Fuel Injector
Knock Sensor 1 (Bank 2)
Knock Sensor 1 (Bank 1)
0814EG13Y

Main Components of Engine Control System

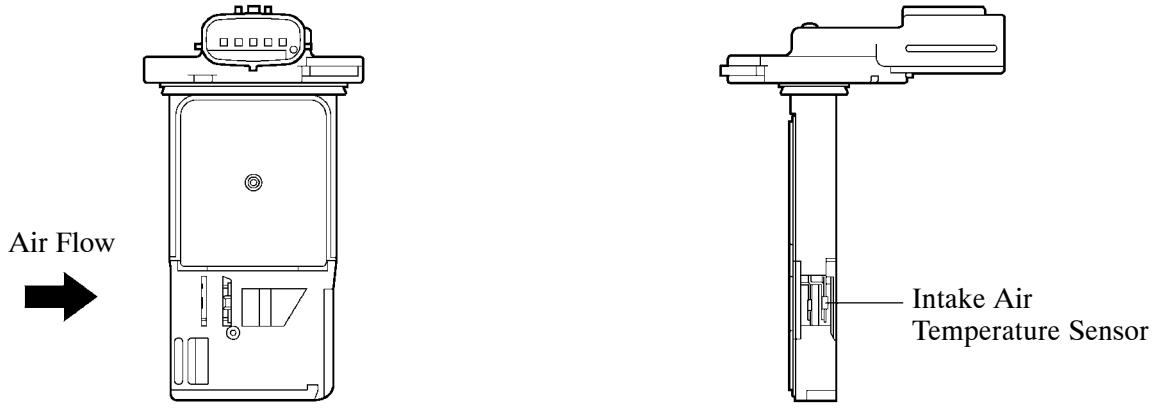
1) General

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

Components	Outline	Quantity	Function
ECM	32-bit CPU (DENSO)	1	The ECM optimally controls the engine control system to suit the operating conditions of the engine in accordance with the signals provided by the sensors.
Air Flow Meter [See page 63]	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.
Crankshaft Position Sensor [See page 64]	MRE Type (Rotor Teeth/36 - 2)	1	This sensor detects the engine speed and the crankshaft position.
Camshaft Position Sensor [See page 64]	MRE Type (Rotor Teeth/3)	1	This sensor detects the camshaft position and performs the cylinder identification.
VVT Sensor (Intake) [See page 64]	MRE Type (Rotor Teeth/3)	1 each bank	This sensor detects the actual valve timing.
VVT Sensor (Exhaust) [See page 64]	MRE Type (Rotor Teeth/3)	1 each bank	This sensor detects the actual valve timing.
Accelerator Pedal Position Sensor [See page 67]	Hall IC Type (Non-contact Type)	1	This sensor detects the amount of pedal effort applied to the accelerator pedal.
Throttle Position Sensor [See page 68]	Hall IC Type (Non-contact Type)	1	This sensor detects the throttle valve opening angle.
Knock Sensor [See page 69]	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 71]	Cup Type with Heater	1 each bank	This sensor detects the oxygen concentration in the exhaust emissions by measuring the electromotive force which is generated in the sensor itself.
Air-fuel Ratio Sensor [See page 71]	Planar Type with Heater	1 each bank	As with the heated oxygen sensor, this sensor detects the oxygen concentration in the exhaust emissions. However, it detects the oxygen concentration in the exhaust emissions linearly.
Water Temperature Sensor	Thermistor Type	1	This sensor detects the water temperature by means of an internal thermistor.
Fuel Injector	12-hole Type	8	This fuel injector contains an electro-magnetically operated nozzle to inject fuel into the intake port.
Camshaft Timing Oil Control Valve	Electro-magnetic Coil Type	2 each bank	The camshaft timing oil control valve changes the valve timing by switching the oil passage that acts on the VVT-i controller in accordance with the signals received from the ECM.

2) Air Flow Meter

- This air flow meter, which is a slot-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 air flow meter has a built-in intake air temperature sensor.

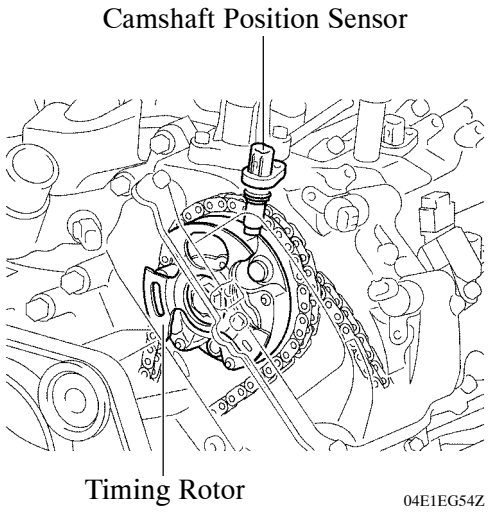


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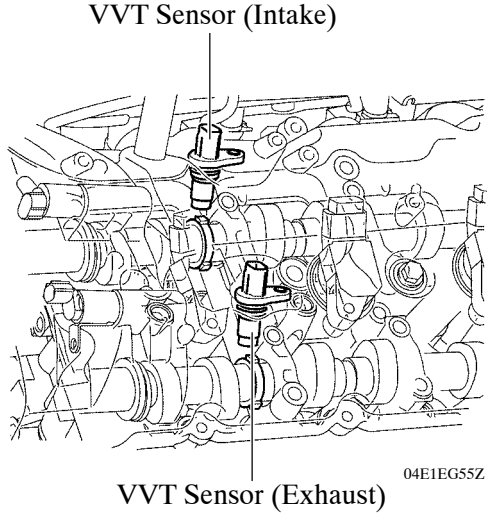
3) Crankshaft Position, Camshaft Position and VVT Sensors

a. General

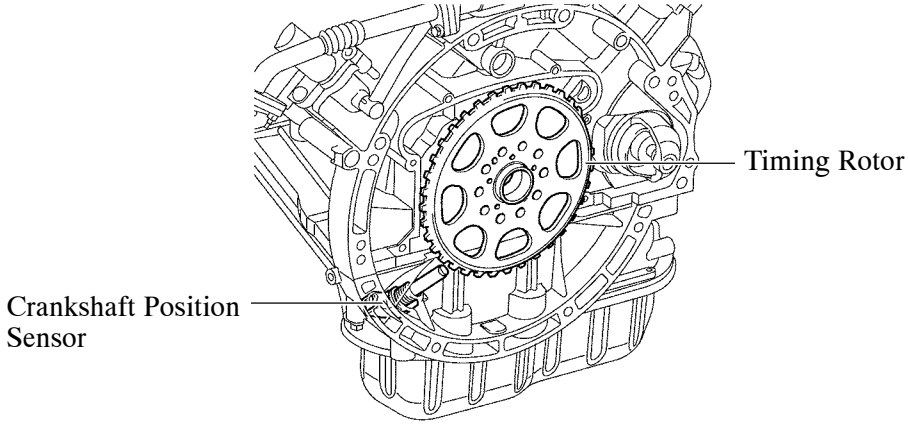
- Magnetic Resistance Element (MRE) sensors are used for the crankshaft position, camshaft position, and VVT sensors.
- The timing rotor for the crankshaft position sensor is installed on the back end of the crankshaft. The timing rotor has 34 teeth, with 2 teeth missing, at 10° intervals. Based on these 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 left bank. Based on the timing rotor, the sensor outputs camshaft position signals (G2 signal) consisting of 3 (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 VVT sensors (intake and exhaust) 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 3 (3 high output, 3 low output) pulses for every 2 revolutions of the crankshaft. The ECM compares these VVT position signals and the NE signal to detect the actual valve timing.



Camshaft Position Sensor

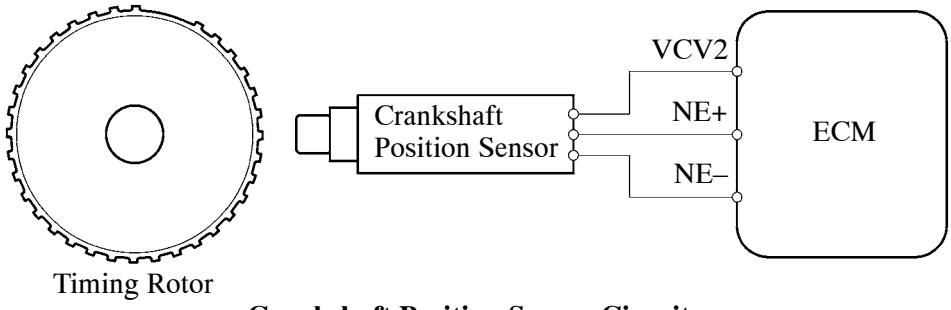


VVT Sensor (Bank 1)



Crankshaft Position Sensor

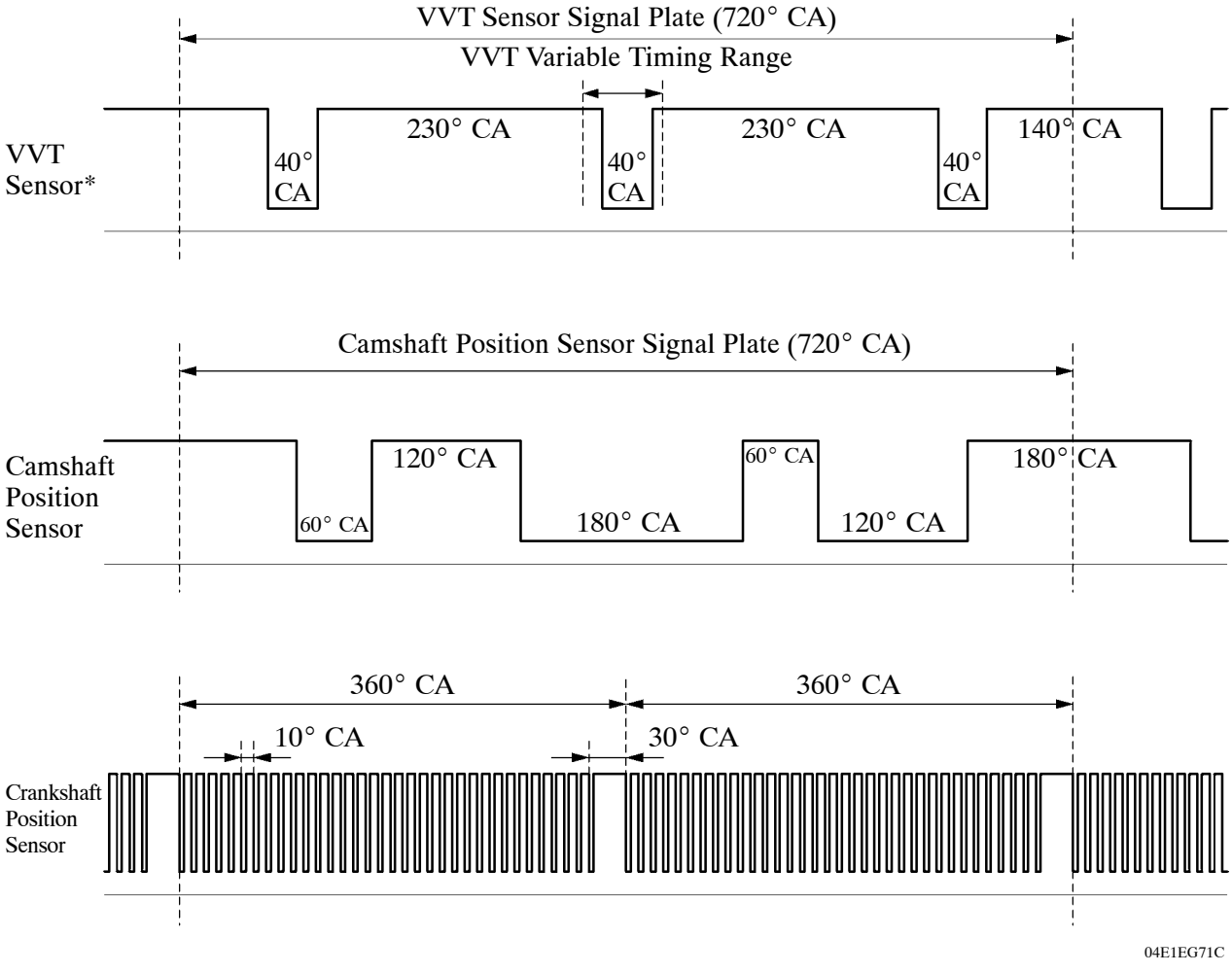
▶ Wiring Diagram ◀



Crankshaft Position Sensor Circuit

036EG110TE

▶ Sensor Output Waveforms ◀



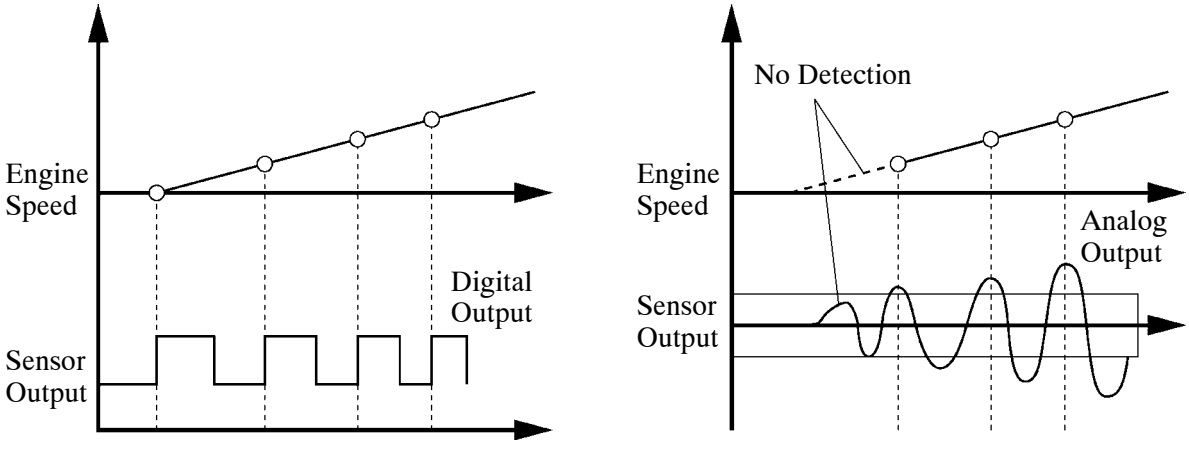
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*: This is an example of an output waveform of the VVT sensor (bank 1, intake).

b. MRE Type Sensor

- The MRE type sensor consists of an MRE, a magnet and a sensor.
- The direction of the magnetic field changes due to the profile (protruding and non-protruding 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. The ECM detects the crankshaft and camshaft positions based on this output voltage.
- 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 pick-up coil type sensor outputs analog signals with levels that change with the engine speed.

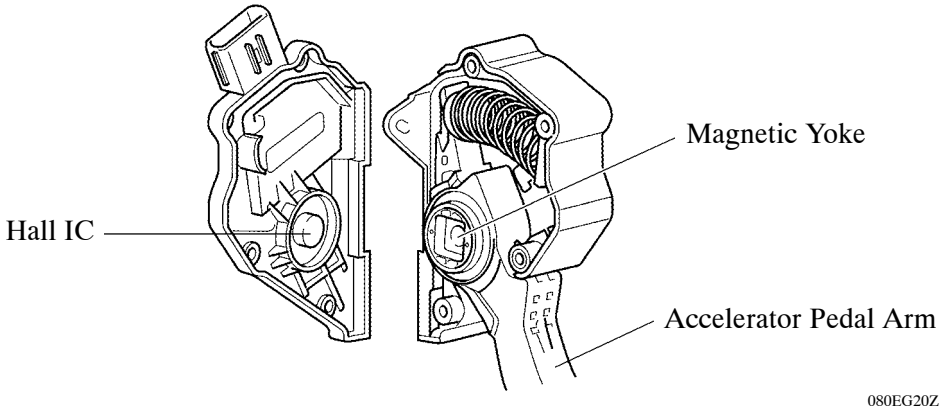
▶ MRE Type and Pick-up Coil Type Output Waveform Image Comparison ◀



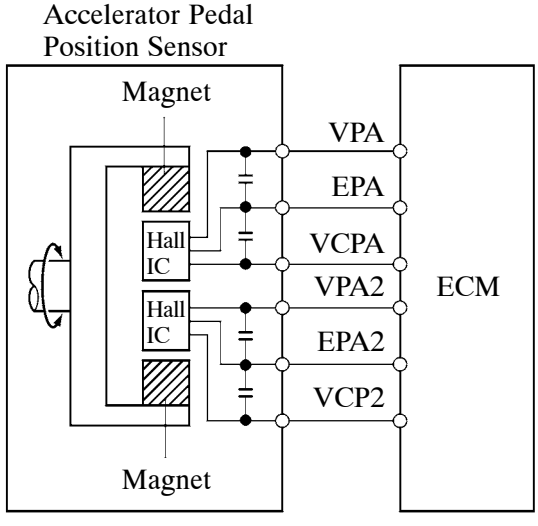
MRE Type **Pick-up Coil Type** 232CH41

4) Accelerator Pedal Position Sensor

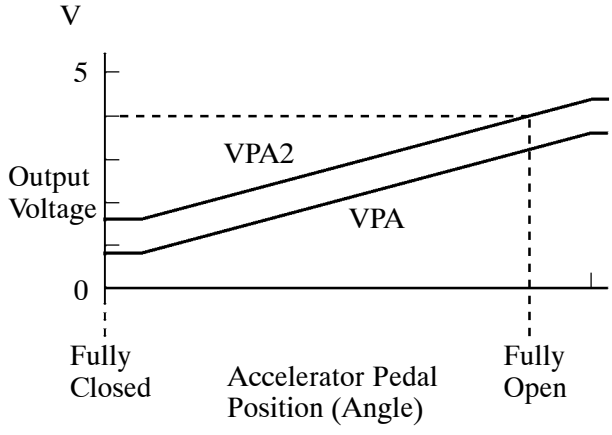
- The non-contact type accelerator pedal position sensor uses a Hall IC, which is mounted on the accelerator pedal arm.
- A magnetic yoke is mounted at the base of the accelerator pedal arm. This yoke rotates around the Hall IC in accordance with the amount of effort that is applied to the accelerator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



080EG20Z



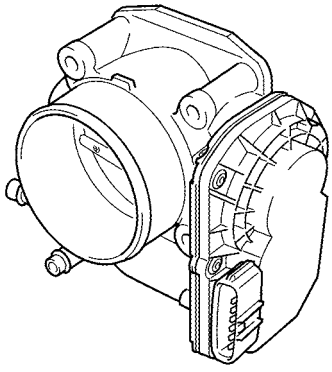
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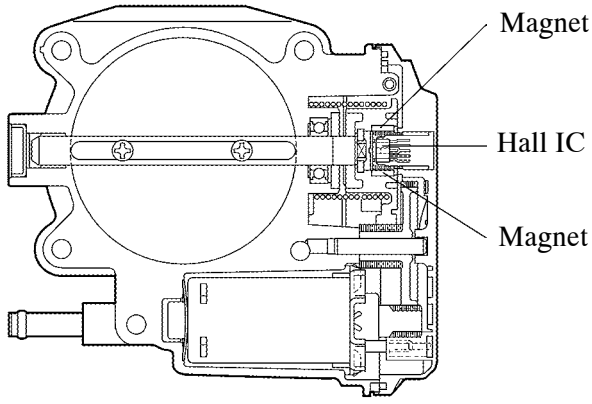


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5) Throttle Position Sensor

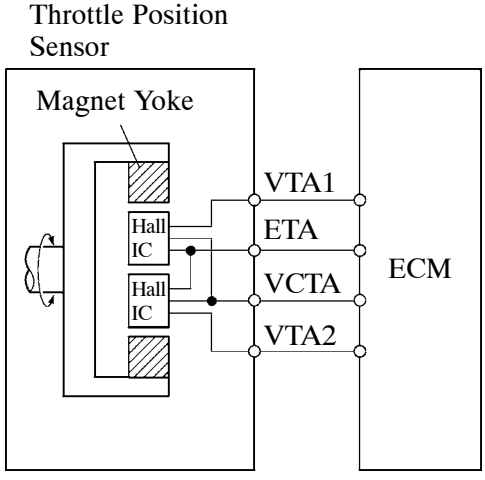
- The non-contact type throttle position sensor uses a Hall IC, which is mounted on the throttle body.
- The Hall IC is surrounded by a magnetic yoke. The Hall IC converts the changes that occur in the magnetic flux into electrical signals, and outputs them in the form of throttle valve position signals to the ECM.
- The Hall IC contains circuits for the main and sub signals. It converts the throttle valve opening angle into two electrical signals that have differing characteristics and outputs them to the ECM.



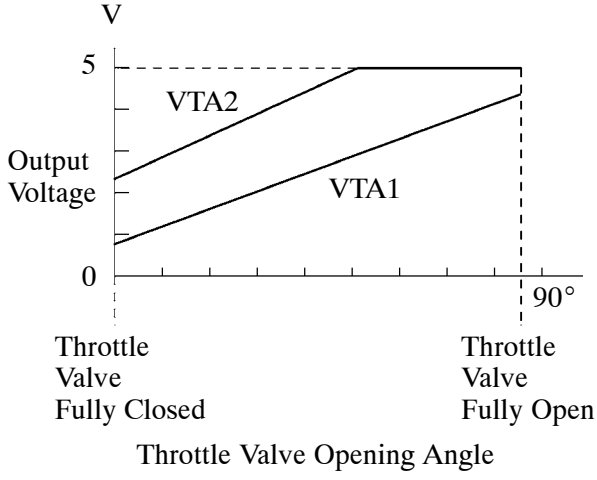


Cross Section

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230LX12



238EG79

6) Knock Sensor (Flat Type)

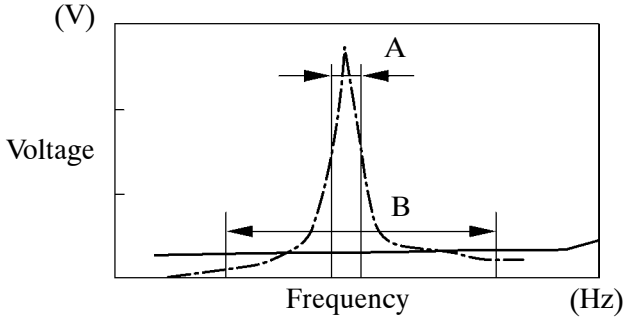
a. General

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 approximately 6 kHz to 15 kHz, and has the following features:

- The engine knocking frequency will change slightly depending on the engine speed. The flat type knock sensor can detect 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.

— · — : Conventional type
——— : Flat type

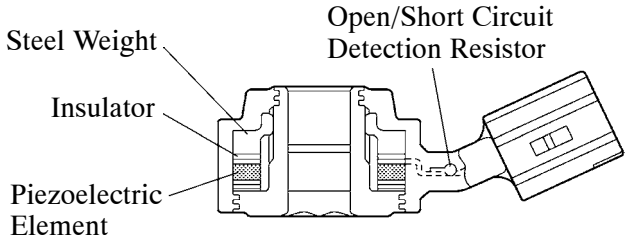
A: Detection band of conventional type
B: Detection band of flat type



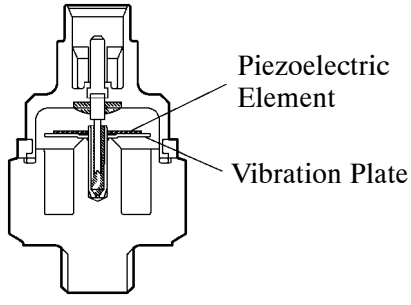
Characteristic of Knock Sensor 214CE04

b. 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 runs through 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.



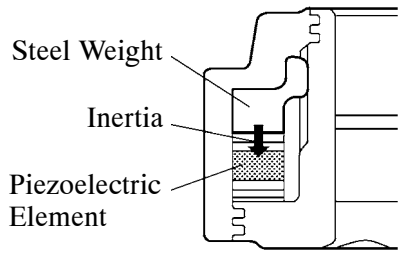
Flat Type Knock Sensor (Non-resonant Type) 214CE01



Conventional Type Knock Sensor (Resonant Type) 214CE02

c. Operation

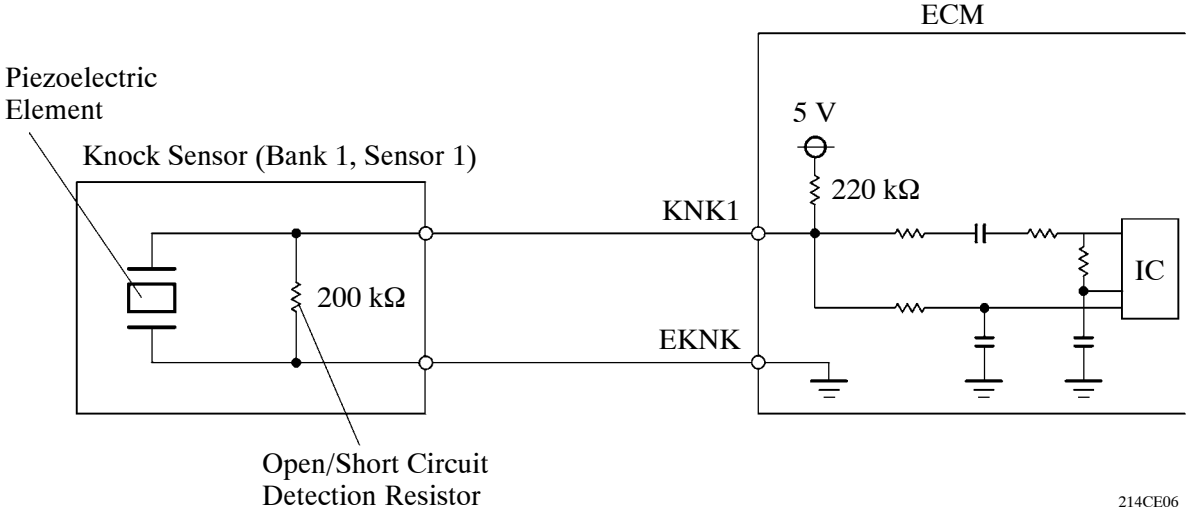
The knocking vibration is transmitted to the steel weight and its inertia applies pressure to the piezoelectric element. The action generates electromotive force.



214CE08

d. Open/Short Circuit Detection Resistor

While the engine switch is on (IG), the open/short circuit detection resistor in the knock sensor and the resistor in the ECM keep the voltage at the terminal KNK1 of engine constant.
An Integrated Circuit (IC) in the ECM constantly monitors the voltage of the terminal KNK1. If the open/short circuit occurs between the knock sensor and the ECM, the voltage of the terminal KNK1 changes and the ECM detects the open/short circuit and stores a DTC (Diagnostic Trouble Code).



214CE06

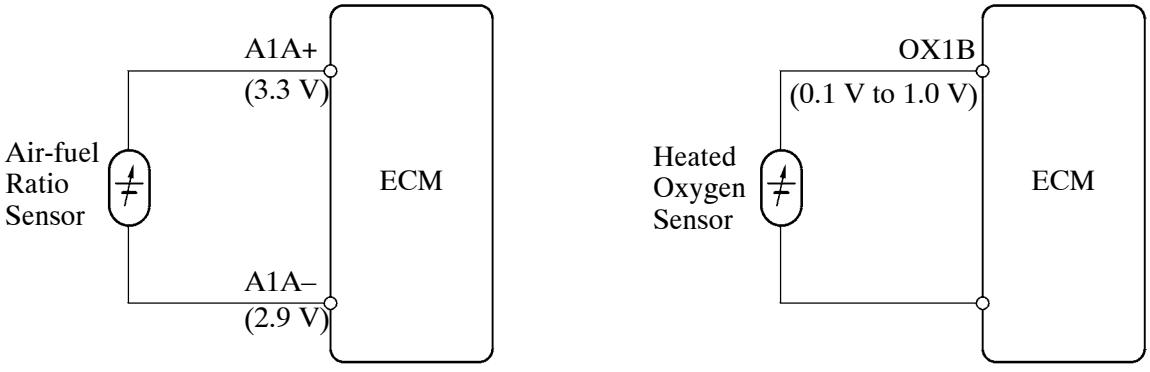
Service Tip

These knock sensors are mounted in specific directions at specific angles. To prevent the right and left bank wiring connectors from being interchanged, make sure to install each sensor in its prescribed direction. For details, refer to the Land Cruiser Station Wagon Repair Manual.

7) Air-fuel Ratio Sensor and Heated Oxygen Sensor

a. General

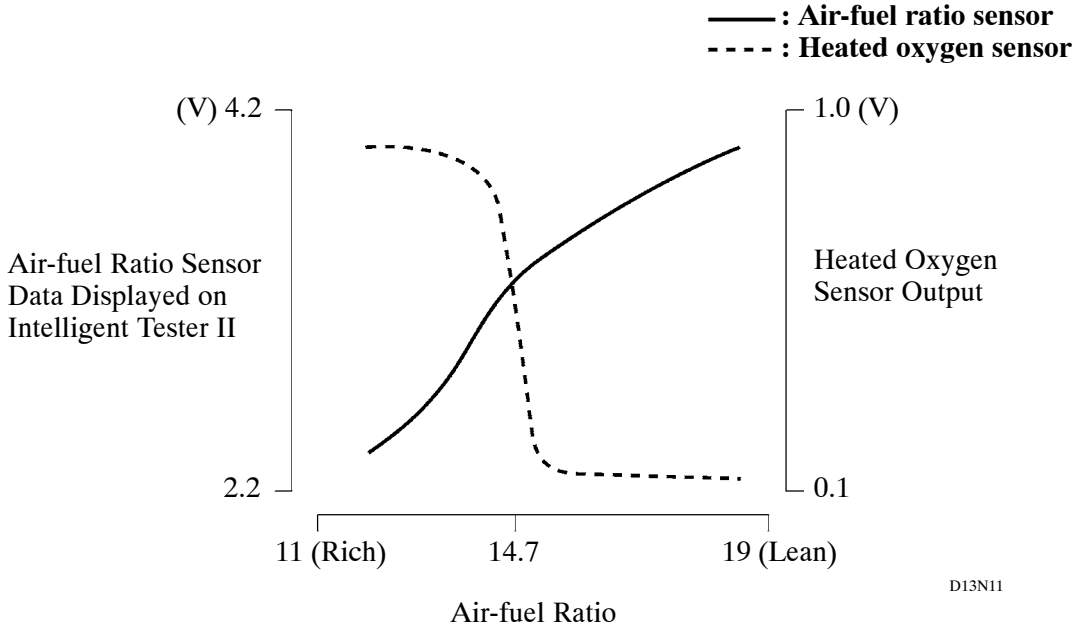
- The heated oxygen sensor and the air-fuel ratio sensor differ in output characteristics.
- The output voltage of the heated oxygen sensor changes in accordance with the oxygen concentration in the exhaust gas. The ECM uses this output voltage to determine whether the present air-fuel ratio is richer or leaner than the stoichiometric air-fuel ratio.
- Approximately 0.4 V is constantly applied to the air-fuel ratio sensor, which 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 linearly detect the present air-fuel ratio.



Air-fuel Ratio Sensor Circuit (Bank 1, Sensor 1)

Heated Oxygen Sensor Circuit (Bank 1, Sensor 2)

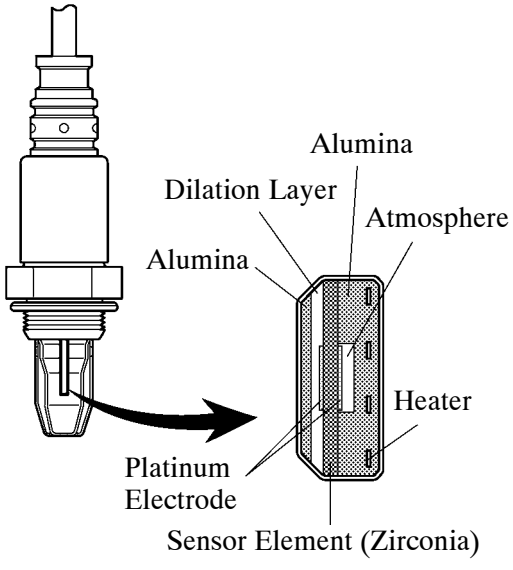
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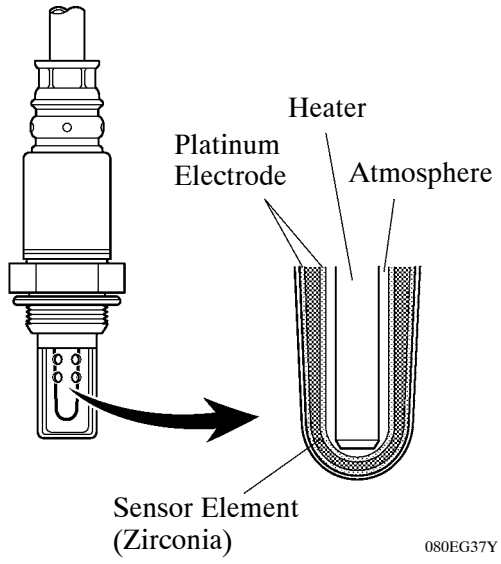
D13N11

b. 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, in accordance with 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 insulation, to integrate a sensor element with a heater, thus improving the warm-up performance of the sensor.



Air-fuel Ratio Sensor (Planar Type)



Heated Oxygen Sensor (Cup Type)

▶ Warm-up Specification ◀

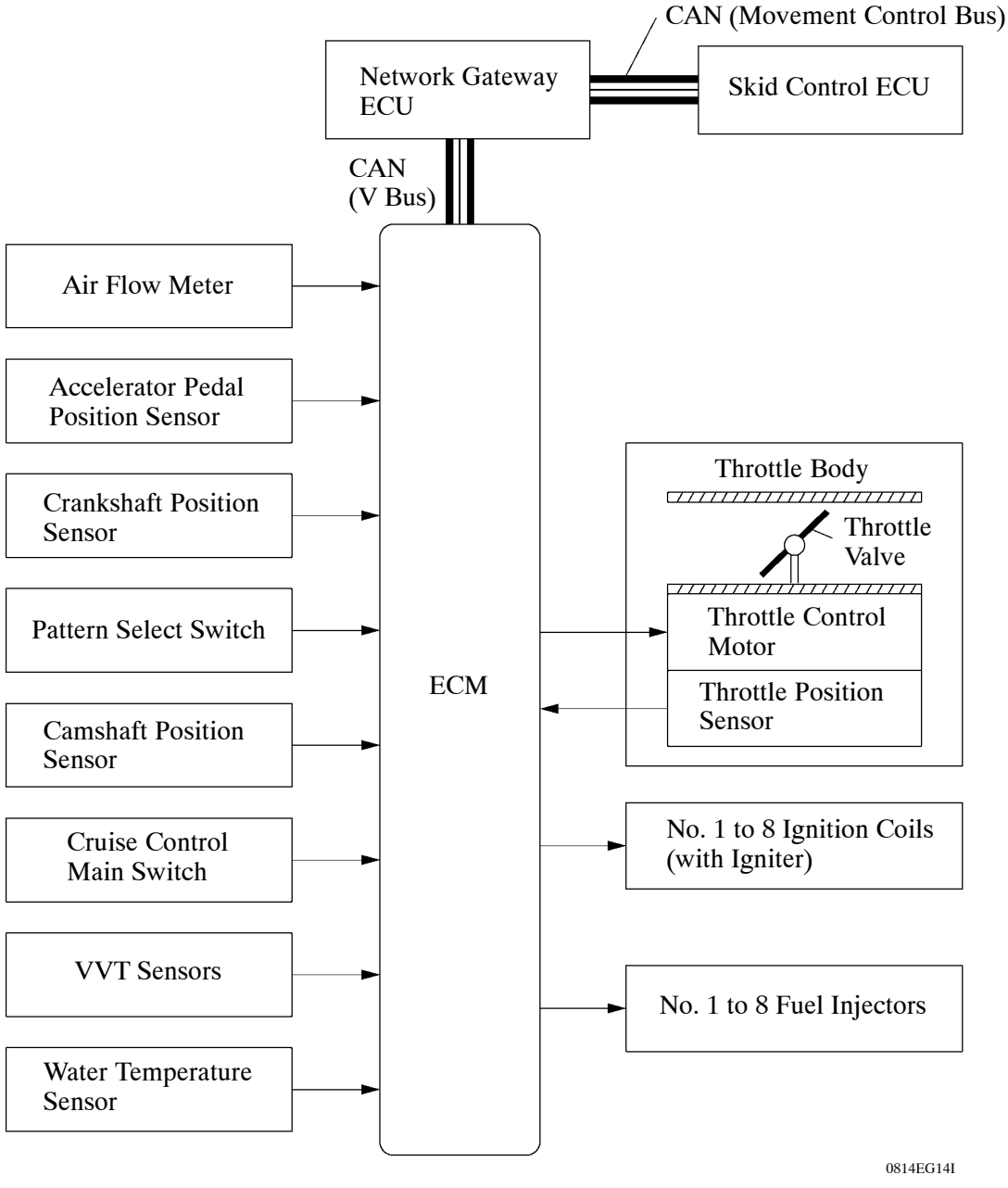
Sensor Type	Planar Type	Cup Type
Warm-up Time	Approx. 10 sec.	Approx. 30 sec.

Electronic Throttle Control System-intelligent (ETCS-i)

1) General

- In the conventional throttle body, the throttle valve angle is determined invariably by the amount of the accelerator pedal effort. In contrast, ETCS-i 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 an abnormal condition, this system transfers to the fail-safe mode.

▶ System Diagram ◀



2) Control

a. General

The ETCS-i consists of the following functions:

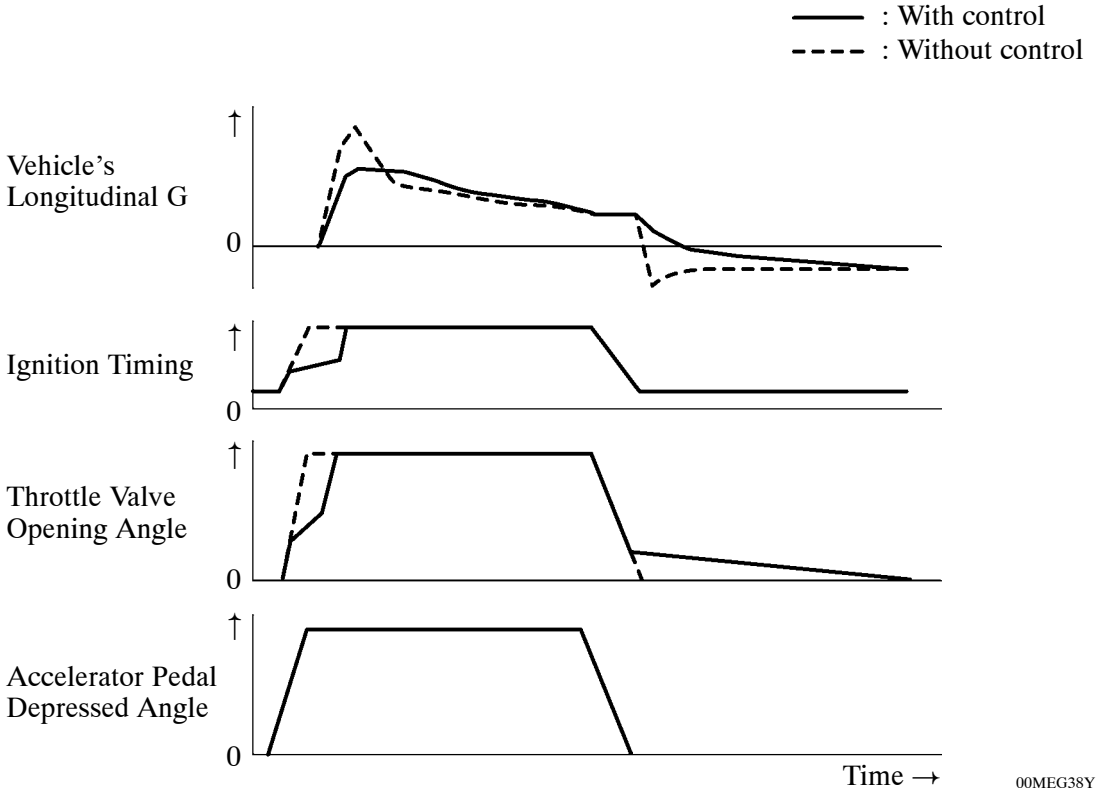
- Normal Throttle Control (Non-linear Control)
- Idle Speed Control (ISC)
- Active Traction Control (A-TRC)
- Vehicle Stability Control (VSC) Coordination Control
- Crawl Control (CRAWL) Coordination Control
- Cruise Control

b. Normal Throttle Control (Non-linear Control)

i) General

Controls the throttle to an optimal throttle valve angle that is appropriate for driving conditions such as the amount of the accelerator pedal effort and the engine speed in order to achieve excellent throttle control and comfort in all operating ranges.

▶ Conceptual Diagrams of Engine Control During Acceleration and Deceleration ◀



ii) 2nd Start Control

In situations in which low-μ (low friction) road surface conditions can be anticipated, such as when the vehicle is driving in the snow, the rate of throttle valve opening can be controlled to ensure vehicle stability while the vehicle is driving on a slippery surface. This is accomplished by turning on 2nd start control. Pressing the 2nd side of the pattern select switch activates this control. This control 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.

c. Idle Speed Control

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

d. A-TRC

As part of the A-TRC, the throttle valve opening is reduced by a demand signal sent from the skid control ECU to the ECM. This demand signal will be sent if an excessive amount of slippage occurs at a drive wheel, thus ensuring vehicle stability and applying the appropriate amount of power to the road.

e. VSC Coordination Control

In order to bring the effectiveness of the VSC into full play, the throttle valve angle is regulated through a coordination control with the skid control ECU.

f. CRAWL Coordination Control

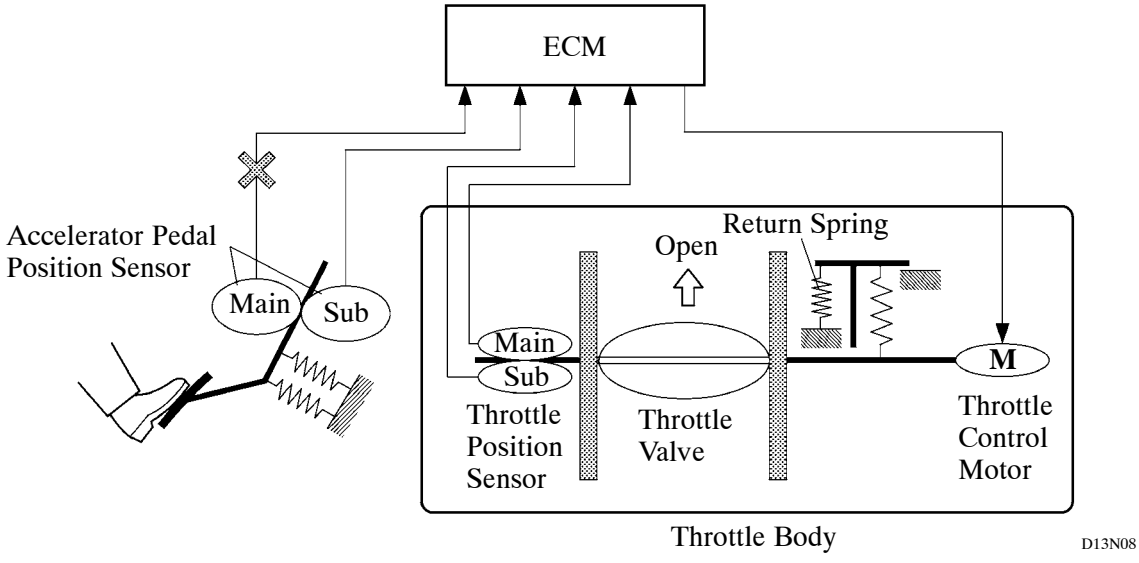
While the CRAWL is operating, the throttle valve is regulated through a coordination control with the skid control ECU.

g. Cruise Control

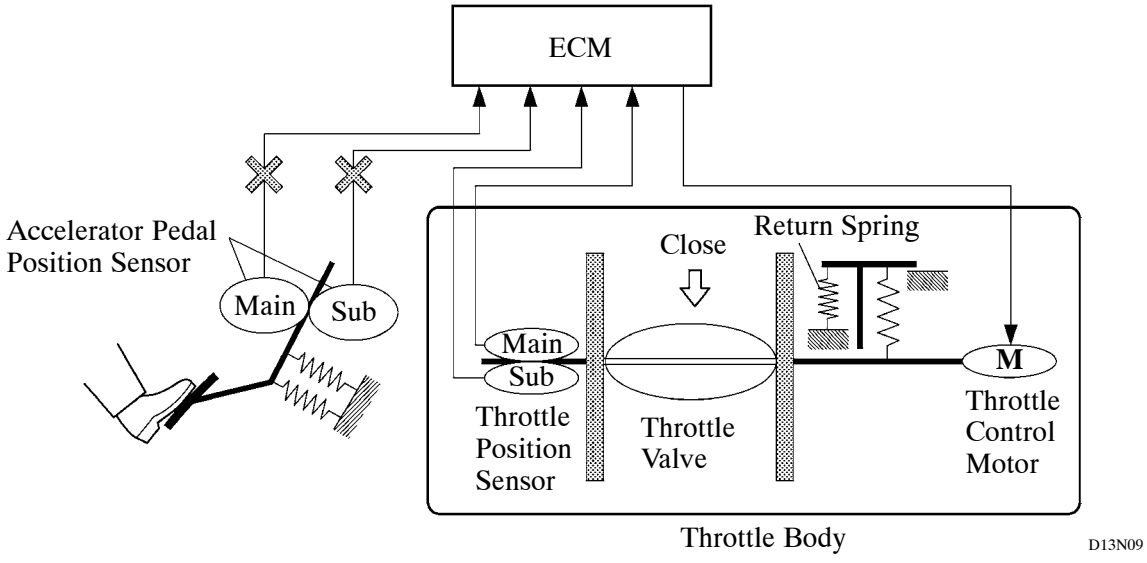
The ECM directly actuates the throttle valve for operation of the cruise control.

3) Fail-safe Operation due to Accelerator Pedal Position Sensor Trouble

- The accelerator pedal position sensor comprises two (main, sub) sensor circuits.
- If a malfunction occurs in either of the sensor circuits, the ECM detects the abnormal signal voltage difference between these two sensor circuits and switches into a fail-safe mode. In this fail-safe mode, the remaining circuit is used to calculate the accelerator pedal opening, in order to operate the vehicle under fail-safe mode control.

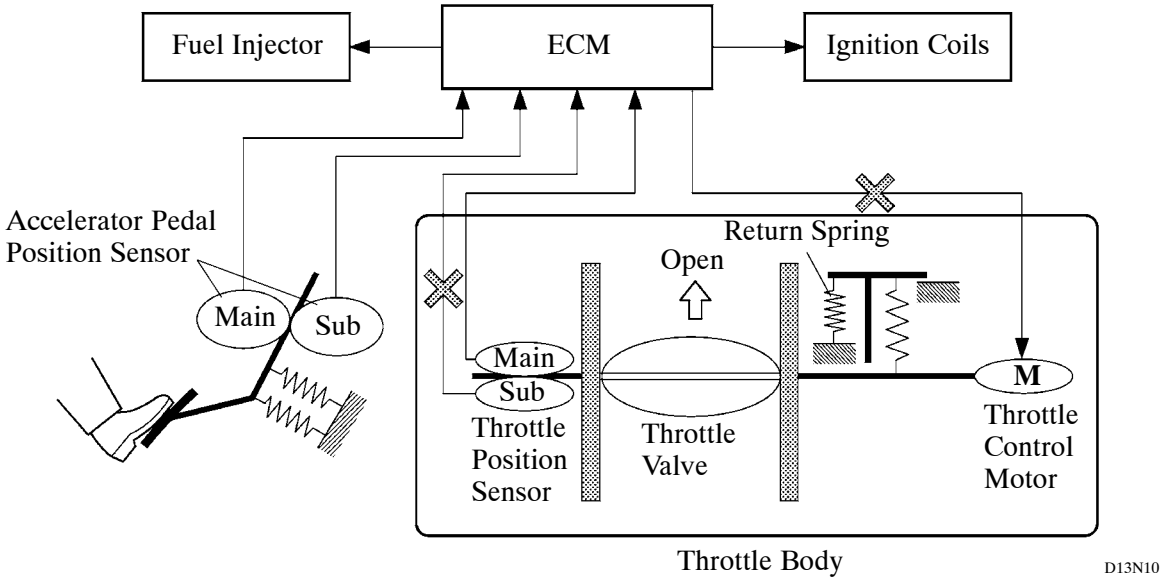


- If both circuits malfunction, the ECM detects the abnormal signal voltage from these two sensor circuits and discontinues the throttle control. At this time, the vehicle can be driven within its idling range.



4) Fail-safe Operation due to Throttle Position Sensor Trouble

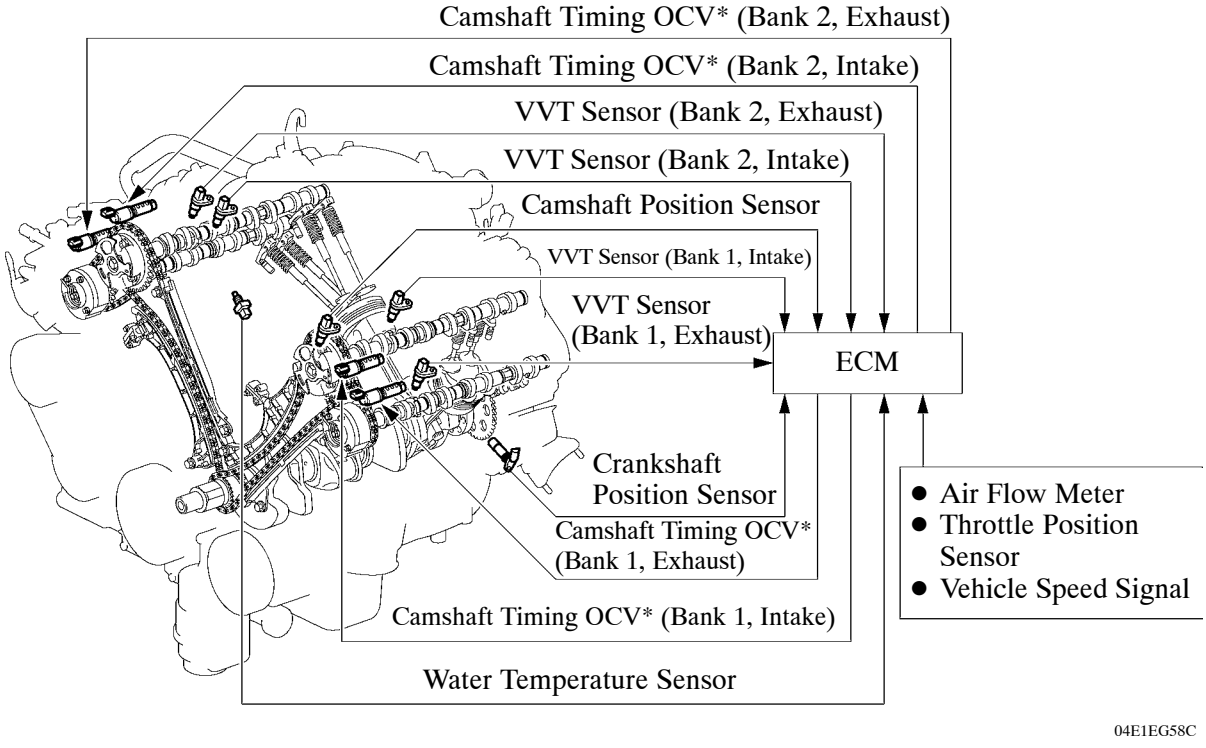
- The throttle position sensor comprises two (main, sub) sensor circuits.
- If a malfunction occurs in either of the sensor circuits, the ECM detects the abnormal signal voltage difference between these two sensor circuits, cuts off the current to the throttle control motor, and switches to a fail-safe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



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

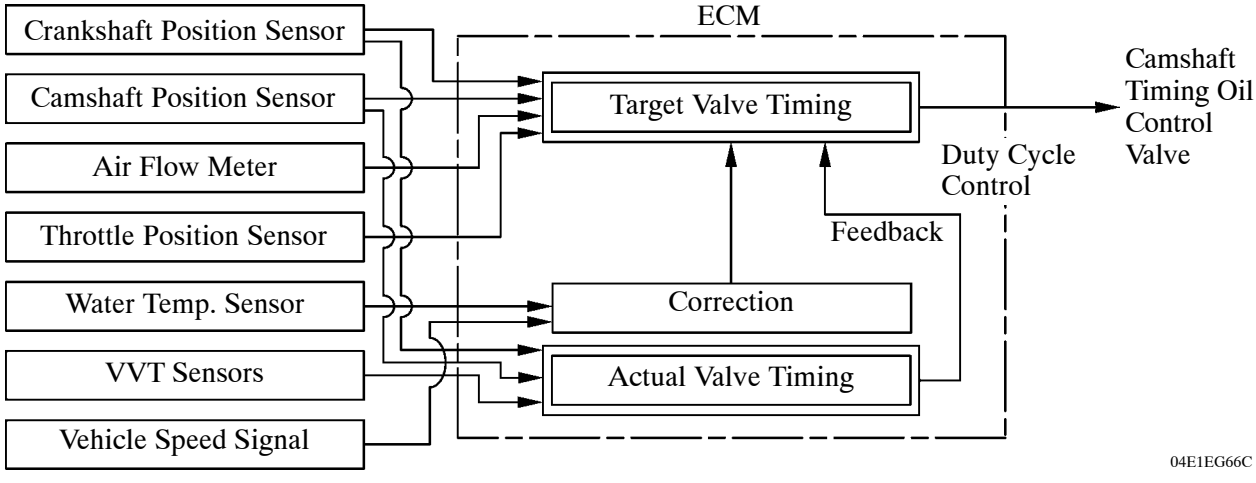
1) General

- The Dual VVT-i system is designed to control the intake and exhaust camshafts within a range of 60° and 30° respectively (of Crankshaft Angle) to provide valve timing that is optimally suited to the engine operating conditions. This improves torque in all the speed ranges as well as increasing fuel economy, and reducing exhaust emissions.

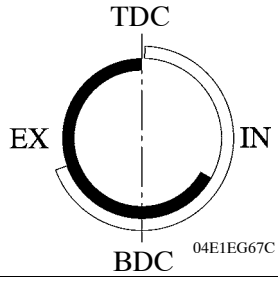
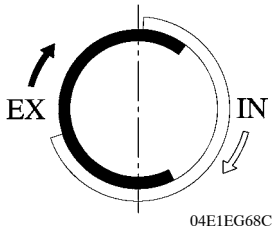
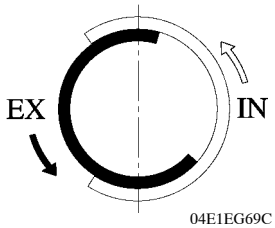
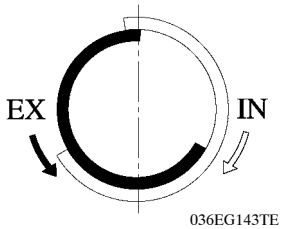
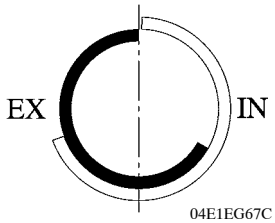
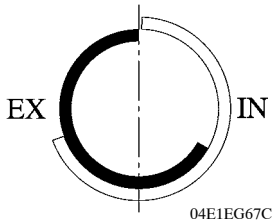


*: Oil Control Valve

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



2) Effectiveness of Dual VVT-i System

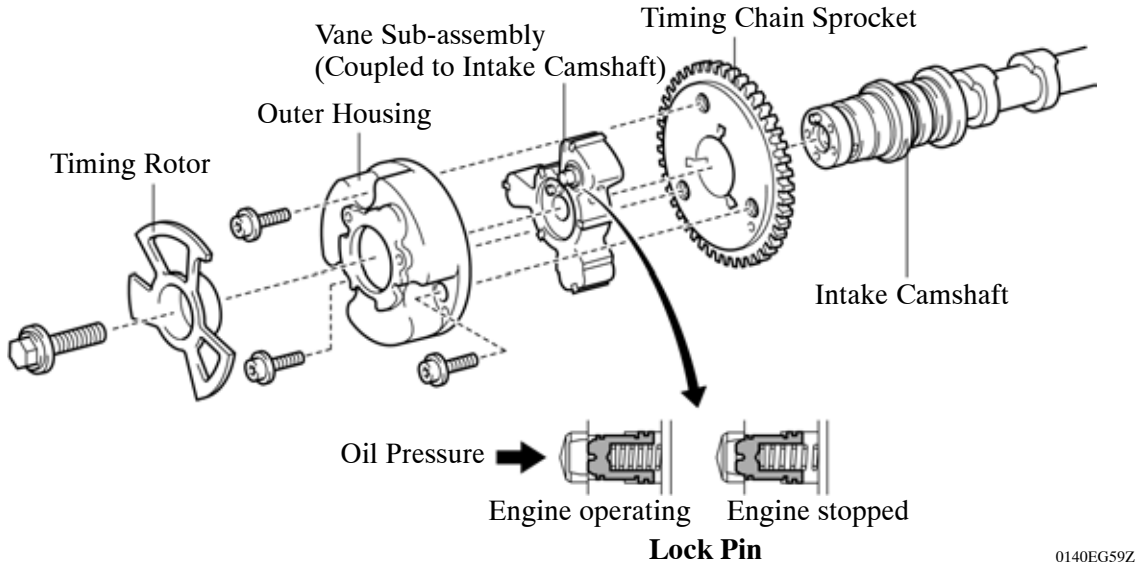
Condition	Operation		Timing/ Position	Objective	Effect
During Idling		IN	Most Retarded Position	Eliminating overlap to reduce blow back to the intake side.	● Stabilized idle speed ● Better fuel economy
		EX	Most Advanced Position		
In Low Speed Range with Light to Medium Load		IN	Retarded	Retarding the intake valve close timing and reducing pumping loss. Increasing overlap and increasing internal EGR.	● Better fuel economy ● Improved emission control
		EX	Retarded		
In Low to Medium Speed Range with Heavy Load		IN	Advanced	Advancing the intake valve close timing, reducing intake air blow back to the intake side, and improving volumetric efficiency.	Improved torque in low to medium speed range
		EX	Advanced		
In High Speed Range with Heavy Load		IN	Retarded	Retarding the intake valve close timing and improving volumetric efficiency using the inertia force of the intake air.	Improved output
		EX	Advanced		
At Low Temperatures		IN	Most Retarded Position	Eliminating overlap to reduce blow back to the intake side. Fixing valve timing at extremely low temperatures and increasing the control range as the temperature rises.	● Stabilized fast idle speed ● Better fuel economy
		EX	Most Advanced Position		
● Upon Starting ● Stopping the Engine		IN	Most Retarded Position	Controlling valve timing and fixing it to the optimal timing for engine start.	Improved startability
		EX	Most Advanced Position		

3) Construction

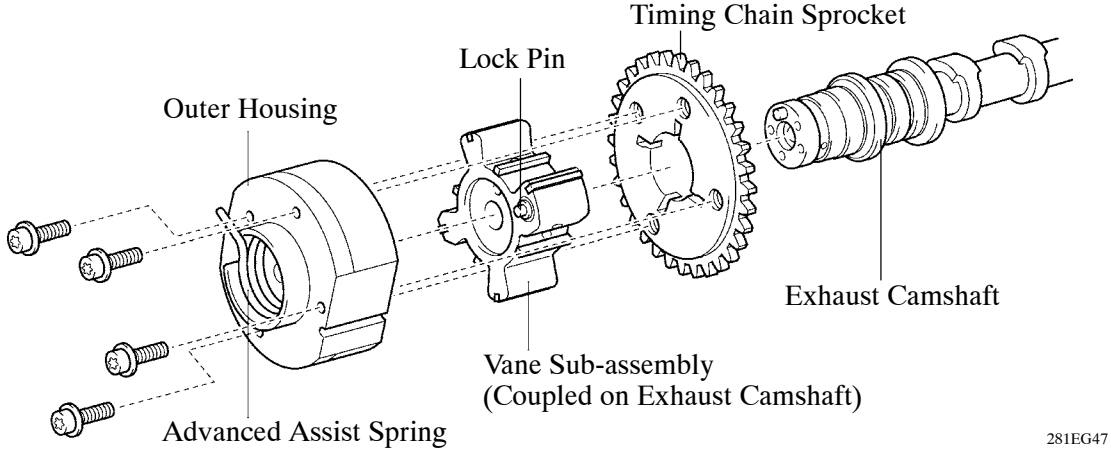
a. VVT-i Controller

- This controller 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 VVT-i controller with 3 vanes, and the exhaust side uses one with 4 vanes.
- When the engine stops, the intake side VVT-i controller is locked at the most retarded angle by its lock pin, and the exhaust side controller 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 VVT-i controller vane sub-assembly relative to the timing chain sprocket, to vary the valve timing continuously.
- An advance assist spring is provided on the exhaust side VVT-i controller. 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 VVT-i Controller ◀

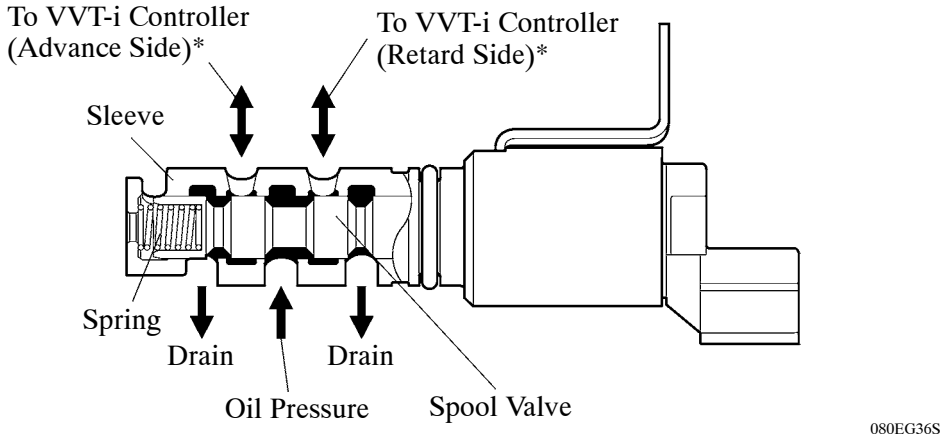


▶ Exhaust Side VVT-i Controller ◀



b. 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 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.



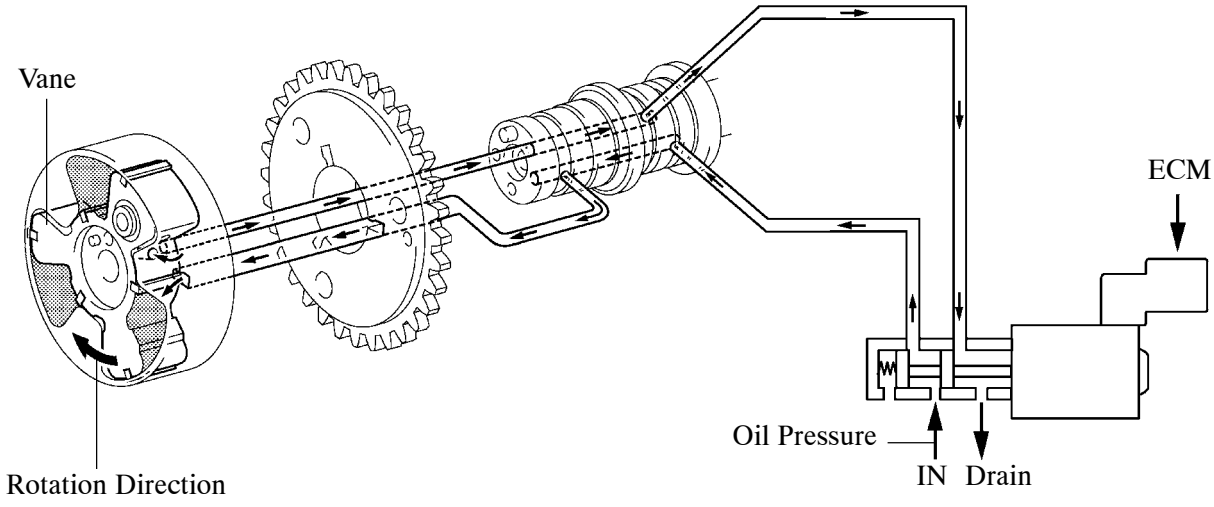
*: On the exhaust side oil control valve, the advance and retard sides are reversed.

4) Operation

a. Advance

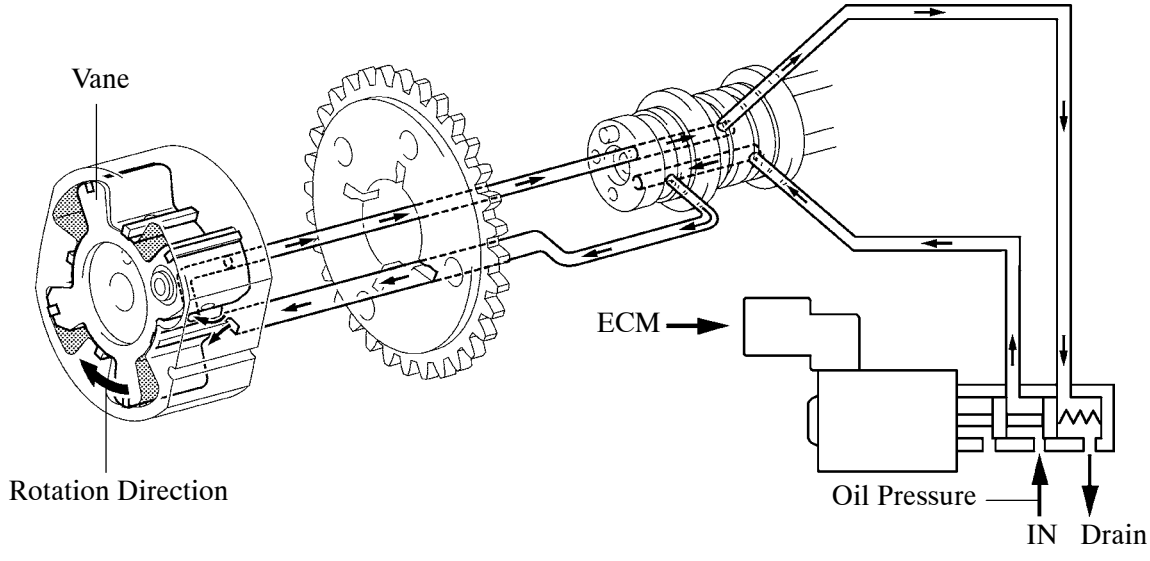
When the camshaft timing oil control valve is positioned as illustrated below by the advance signals from the ECM, the resultant oil pressure is applied to the timing advance side vane chamber to rotate the camshaft in the timing advance direction.

▶ Intake Side ◀



238EG63

▶ Exhaust Side ◀

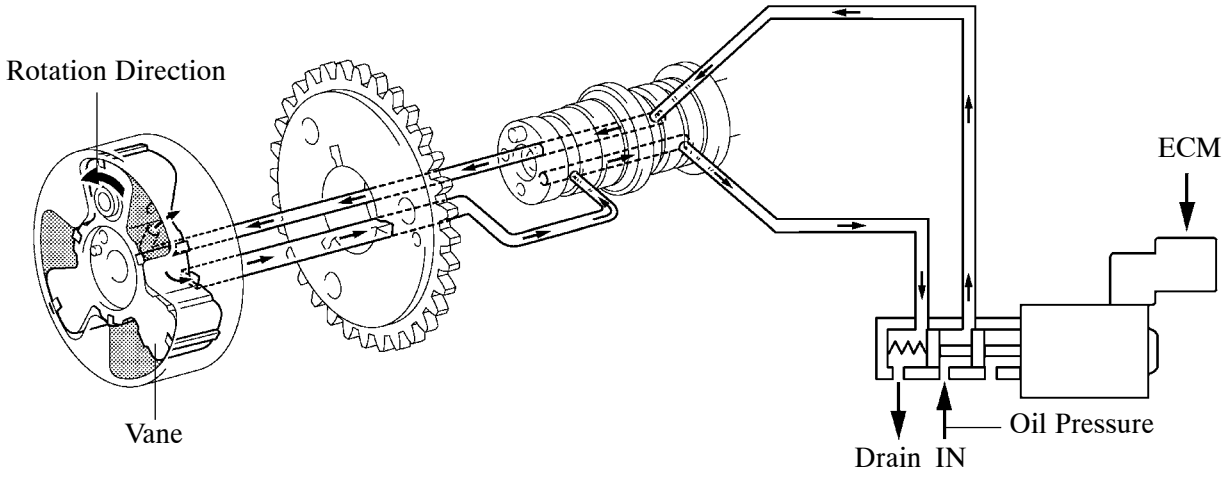


281EG48

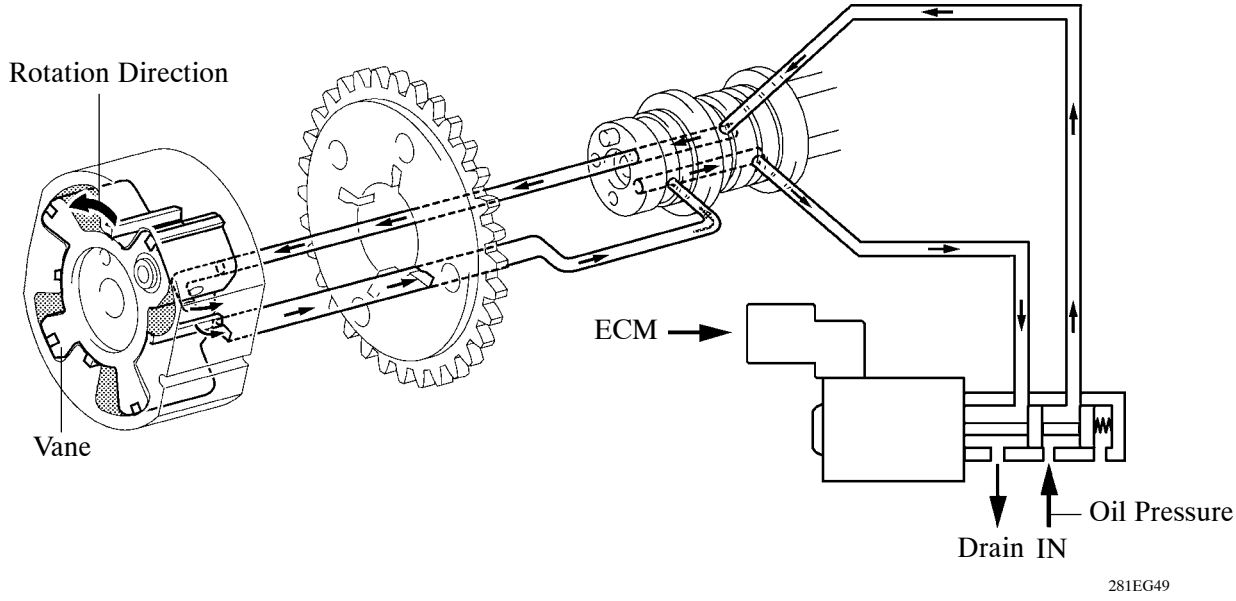
b. Retard

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 ◀



c. Hold

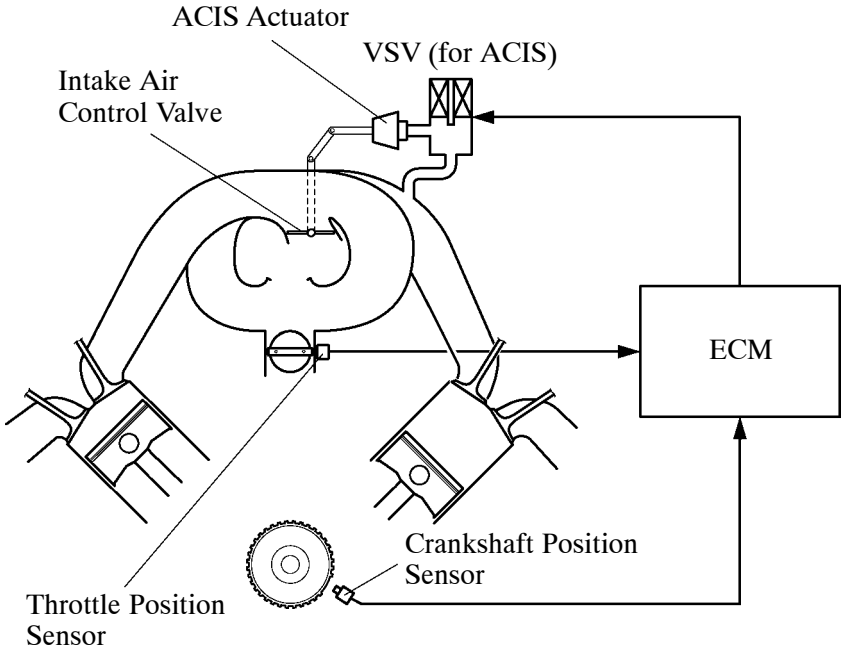
After reaching the target timing, the engine valve timing is maintained by keeping the camshaft timing oil control valve in the neutral position unless the engine operating conditions change.
This maintains the engine valve timing at the desired target position by preventing the engine oil from running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

Acoustic Control Induction System (ACIS)

1) General

The ACIS uses a bulkhead to divide the intake manifold into two stages, with an intake air control valve in the bulkhead being opened and closed to vary the effective length of the intake manifold in accordance with the engine speed and throttle valve opening angle. This increases the power output in all ranges from low to high speed.

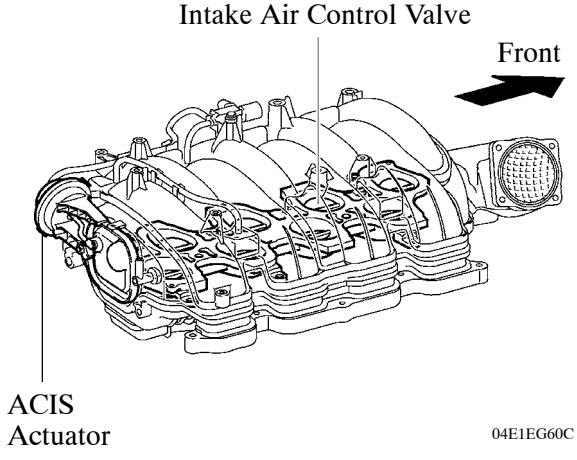
▶ System Diagram ◀



04E1EG59C

2) Intake Air Control Valve and ACIS Actuator

The intake air control valve and ACIS actuator are integrated with the intake manifold. This valve opens and closes to change the effective length of the intake manifold in two stages.



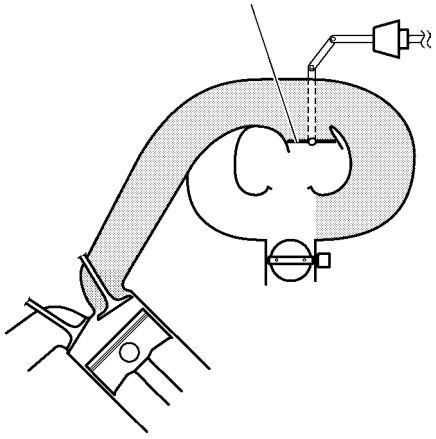
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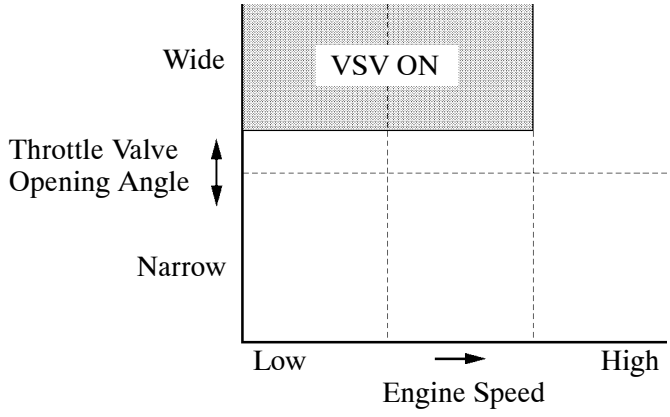
3) Operation

a. When the Intake Control Valve Closes (VSV ON)

The ECM activates the VSV so that the negative pressure acts on the diaphragm chamber of the actuator. This closes the control valve to match the longer pulsation cycle. As a result, the effective length of the intake manifold is lengthened and the intake efficiency in the low-to-medium engine speed range under heavy load is improved due to the dynamic effect of the intake air, thereby increasing the power output.

Intake Air Control Valve (Closed)





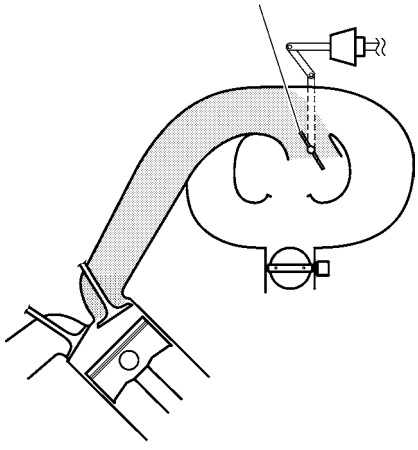
: Effective intake manifold length

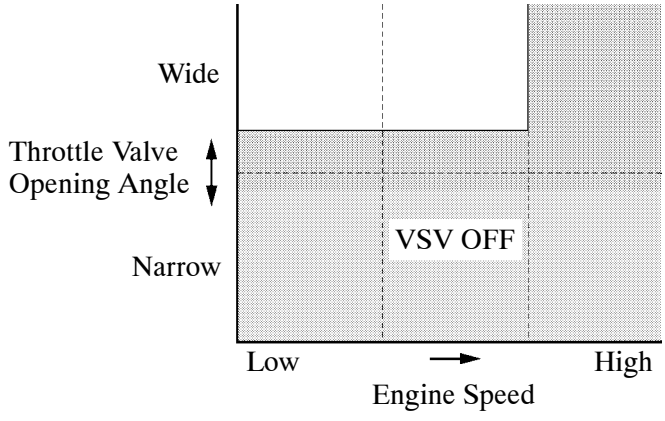
04E1EG61C 04E1EG62C

b. When the Intake Control Valve Opens (VSV OFF)

The ECM deactivates the VSV so that atmospheric air is led into the diaphragm chamber of the actuator. This opens the control valve to match the shorter pulsation cycle. When the control valve is open, the effective length of the intake manifold is shortened and peak intake efficiency is shifted. This benefits the low, medium and high engine speed ranges at low loads and the high engine speed range under heavy load, thus providing greater output at high engine speeds.

Intake Air Control Valve (Open)





: Effective intake manifold length

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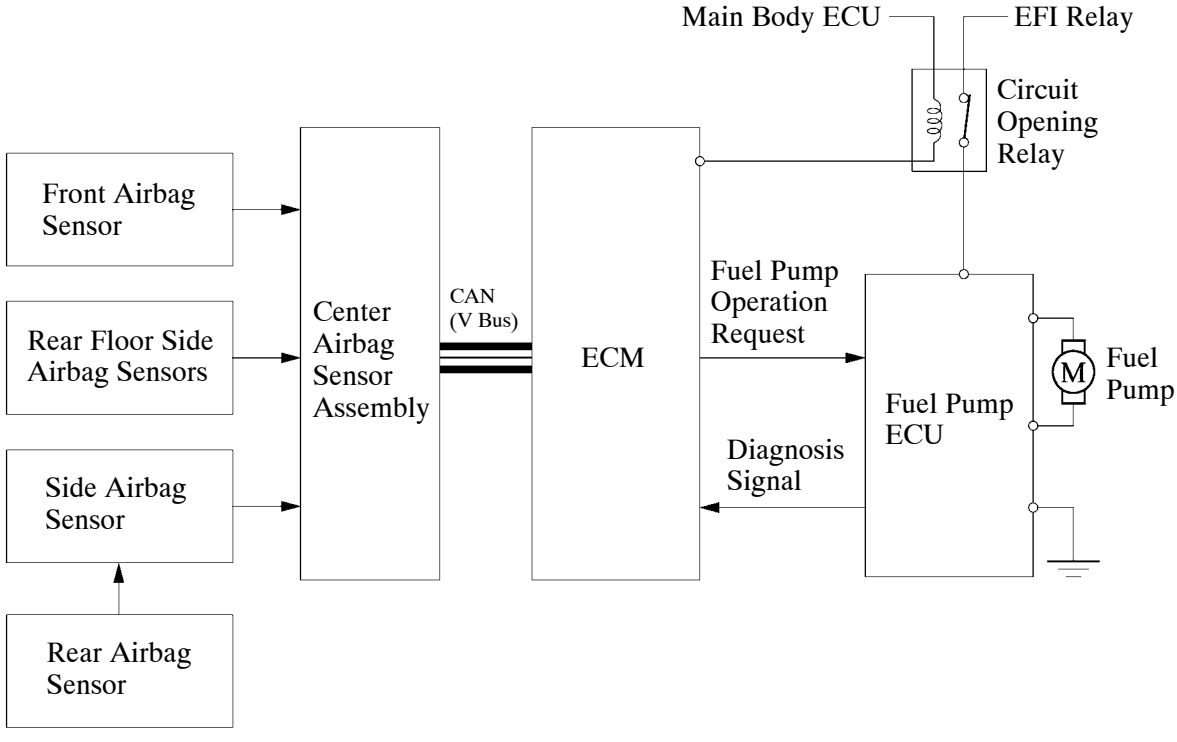
Fuel Pump Control

1) General

In this vehicle, there are 2 types of fuel pump controls. The fuel pump is controlled to an optimum speed to match the engine operating conditions, and the fuel pump operation is stopped when the SRS airbags deploy.

- The ECM transmits a fuel pump operation request signal to the fuel pump ECU that corresponds to the engine operating conditions. The fuel pump ECU receives this request signal and controls the speed of the fuel pump in 3 stages. As a result, under light engine loads, fuel pump speed is kept low to reduce electric power loss.
- A fuel cut control is used to stop the fuel pump when any of the SRS airbags deploys. In this control, if an airbag deployment signal from the center airbag sensor assembly is detected by the ECM, the ECM will turn off the circuit opening relay. As a result, the power supply to fuel pump ECU is stopped, causing the fuel pump to stop operating. After the fuel cut control has been activated, turning the engine switch from off to on (IG) cancels the fuel cut control, and the engine can be restarted.

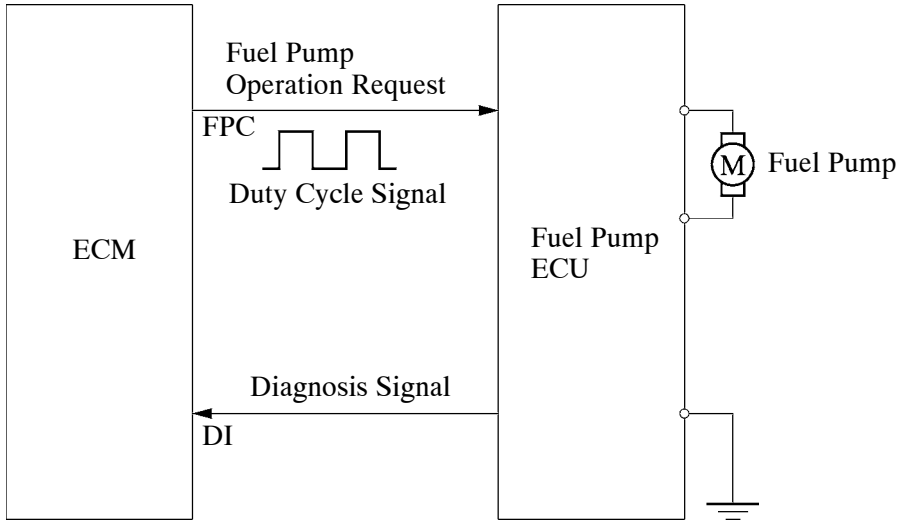
▶ System Diagram ◀



080EG27S

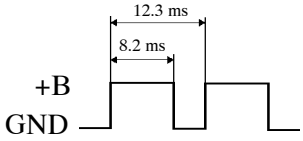
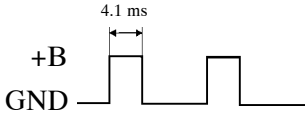
2) Fuel Pump ECU

- The fuel pump ECU controls fuel pump speed by receiving a duty cycle signal (FPC terminal input) from the ECM, and control is performed in three stages.
- The fuel pump ECU also detects failures in the input and output circuits at the fuel pump ECU and transmits the failure status to the ECM.



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▶ FPC Terminal Input ◀

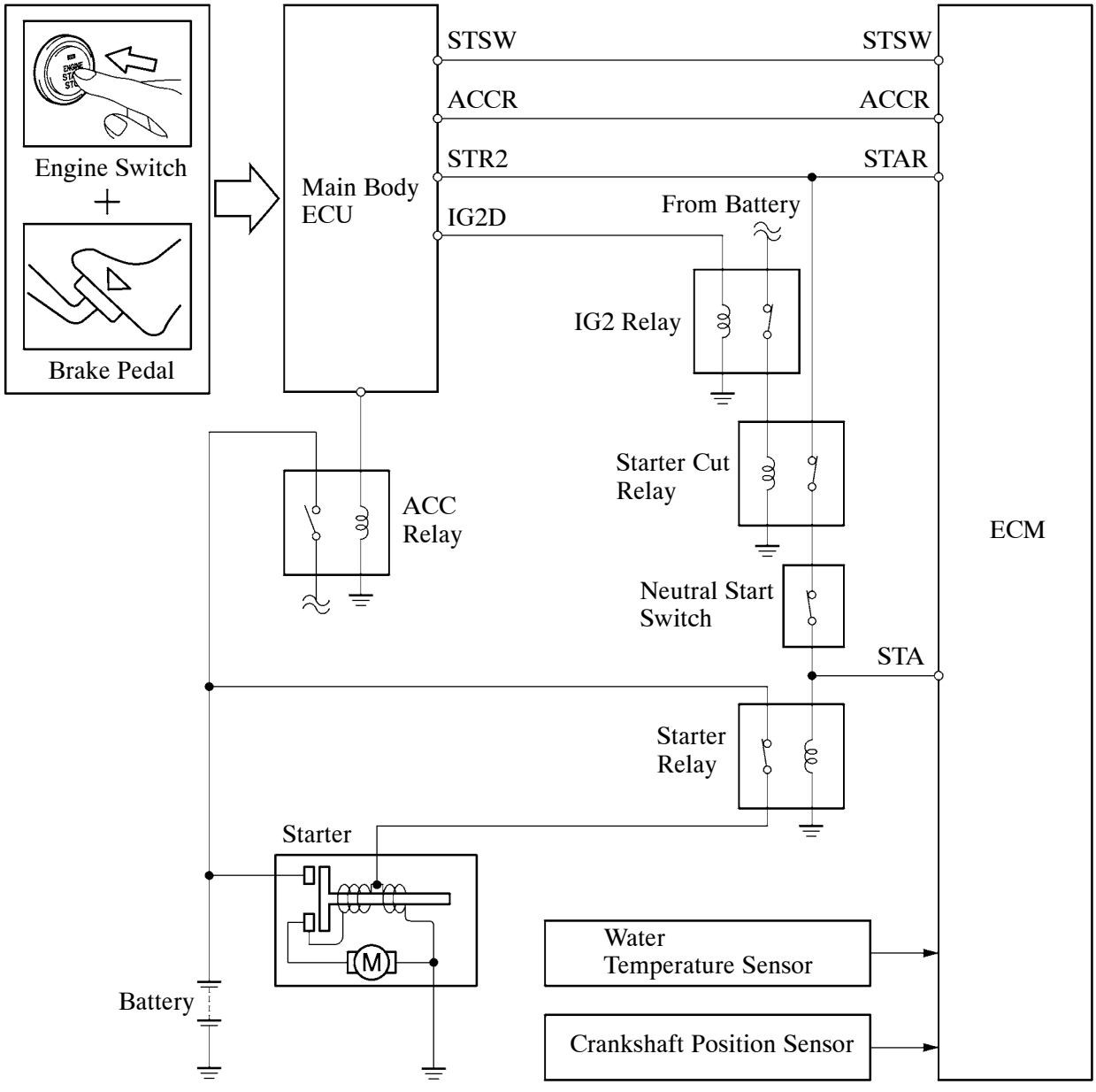
FPC Input Signal (Duty Cycle Signal)	Fuel Pump Speed
 04E0EG25C	High
 04E0EG26C	Middle
 04E0EG27C	Low
04E0EG28C	Stop

Starter Control (Cranking Hold Function)

1) 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 the engine from being cranked after it has started.
- When the ECM detects a start signal from the main body 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 main body ECU, this system will not operate the starter if the ECM has determined that the engine has already started.

▶ System Diagram ◀

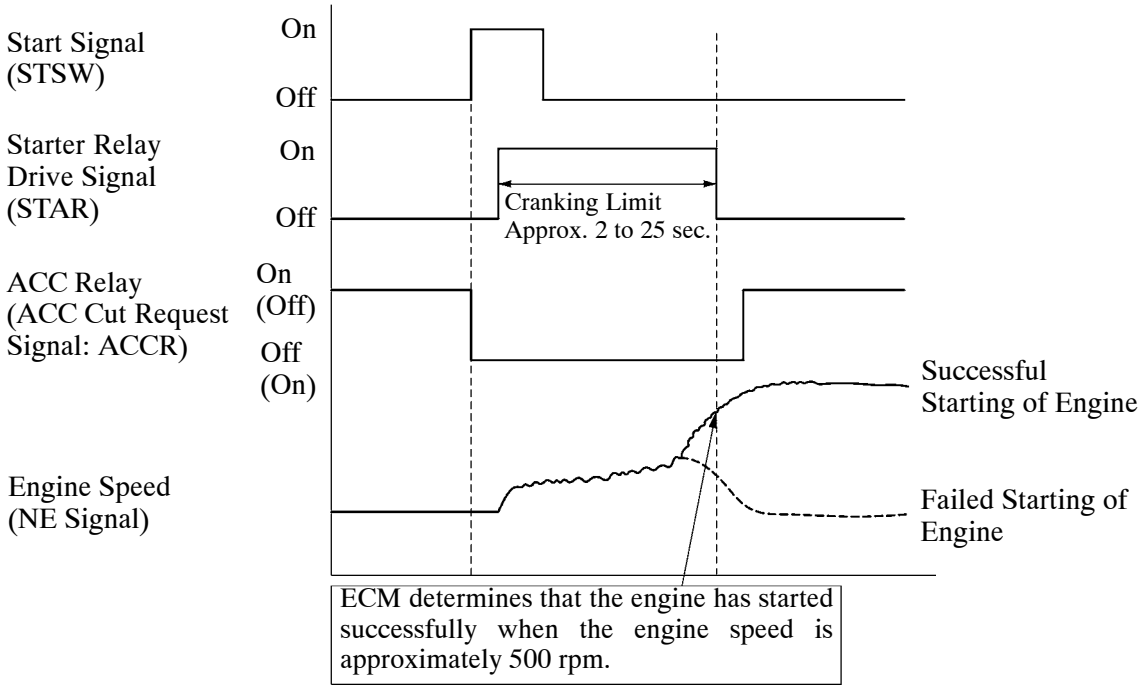


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2) Operation

- As indicated in the timing chart below, when the ECM detects an STSW signal (start signal) from the main body ECU, the ECM outputs a STAR signal (starter relay drive signal) through the starter cut relay to the starter relay and actuates the starter. The ECM also outputs an ACCR signal (ACC cut request signal) to the main body ECU. Thus, the main body 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 the ACCR signal to the main body ECU. Thus, the starter operation stops and the main body ECU energizes the ACC relay.
- If the engine has any failure and does not start, the starter operates as long as its maximum continuous operation time and stops automatically. The maximum continuous operation time is approximately 2 seconds through 25 seconds depending on the water temperature condition. When the water temperature is extremely low, it is approximately 25 seconds and when the engine is warmed up sufficiently, it is approximately 2 seconds.
- 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 the 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 stops and the main body ECU energizes 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 stops and the main body ECU energizes 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 stops and the main body ECU energizes the ACC relay.

▶ Timing Chart ◀



036EG162TE

Diagnosis

- When the ECM detects a malfunction, it makes a diagnosis and memorizes the failed section. Furthermore, the Malfunction Indicator Lamp (MIL) in the combination meter illuminates or blinks to inform the driver.
- The ECM will also store the Diagnostic Trouble Code (DTC) of the malfunctions. The DTC can be accessed by using the intelligent tester II.
- For details, refer to the Land Cruiser Station Wagon Repair Manual.

Service Tip

To clear the DTC that is stored in the ECM, use the intelligent tester II, disconnect the battery terminal or remove the EFI MAIN fuse and ETCS fuse for 1 minute or longer.

Fail-safe

When a malfunction is detected at any of the sensors, 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 Land Cruiser Station Wagon Repair Manual.