■ENGINE CONTROL SYSTEM

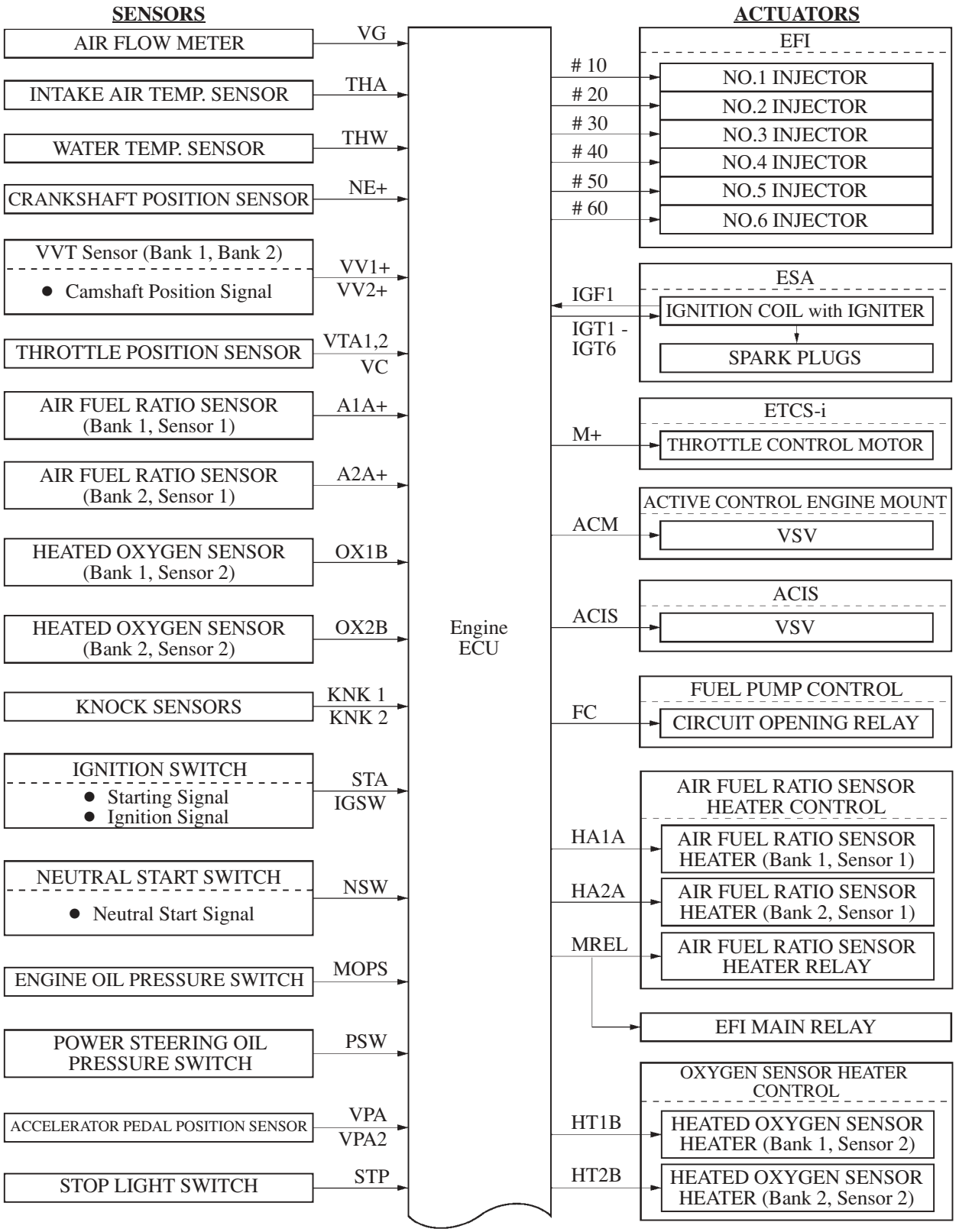
1. General

The engine control system of the 3MZ-FE engine on the new Kluger has following system.

System	Outline
EFI (Electronic Fuel Injection) (See page 46)	An L-type EFI system directly detects the intake air mass with a hot wire type mass air flow meter.
ESA (Electronic Spark Advance)	Ignition timing is determined by the engine ECU based on signals from various sensors. The engine ECU corrects ignition timing in response to engine knocking.
ETCS-i (Electronic Throttle Control System-intelligent) (See page 47)	● Optimally controls the throttle valve opening in accordance with the amount of accelerator pedal effort and the condition of the engine and the vehicle. ● A link-less type is used, without an accelerator cable. ● An accelerator pedal position sensor is provided on the accelerator pedal. ● A no-contact type throttle position sensor and accelerator pedal position sensor are used.
VVT-i (Variable Valve Timing-intelligent) (See page 52)	Controls the intake camshaft to an optimal valve timing in accordance with the engine condition.
ACIS (Acoustic Control Induction System) (See page 56)	The intake air passages are switched according to the engine speed and throttle valve opening angle to provide high performance in all speed ranges.
Active Control Engine Mount (See page 33)	The damping characteristic of the front engine mount is controlled variably to reduce idling vibration.
Air Fuel Ratio Sensor, Oxygen Sensor Heater Control	Maintains the temperature of the air fuel ratio sensor or oxygen sensor at an appropriate level to increase accuracy of detection of the oxygen concentration in the exhaust gas.
Air Conditioner Cut-off Control	By turning the air conditioning compressor ON or OFF in accordance with the engine condition, drivability is maintained.
Fuel Pump Control (See page 59)	Fuel pump operation is controlled by signal from the engine ECU.
	A fuel cut control is adopted to stop the fuel pump when the airbag is deployed during front or side collision.
Evaporative Emission Control	The engine ECU controls the purge flow of evaporative emission (HC) in the charcoal canister in accordance with engine conditions.
Engine Immobiliser	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid ignition key.
Diagnosis (See page 60)	When the engine ECU detects a malfunction, the engine ECU diagnoses and memorizes the failed section.
	All the DTCs (Diagnostic Trouble Codes) have been made to correspond to the SAE controlled codes.
Fail-Safe (See page 60)	When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the data already stored in the memory.

2. Construction

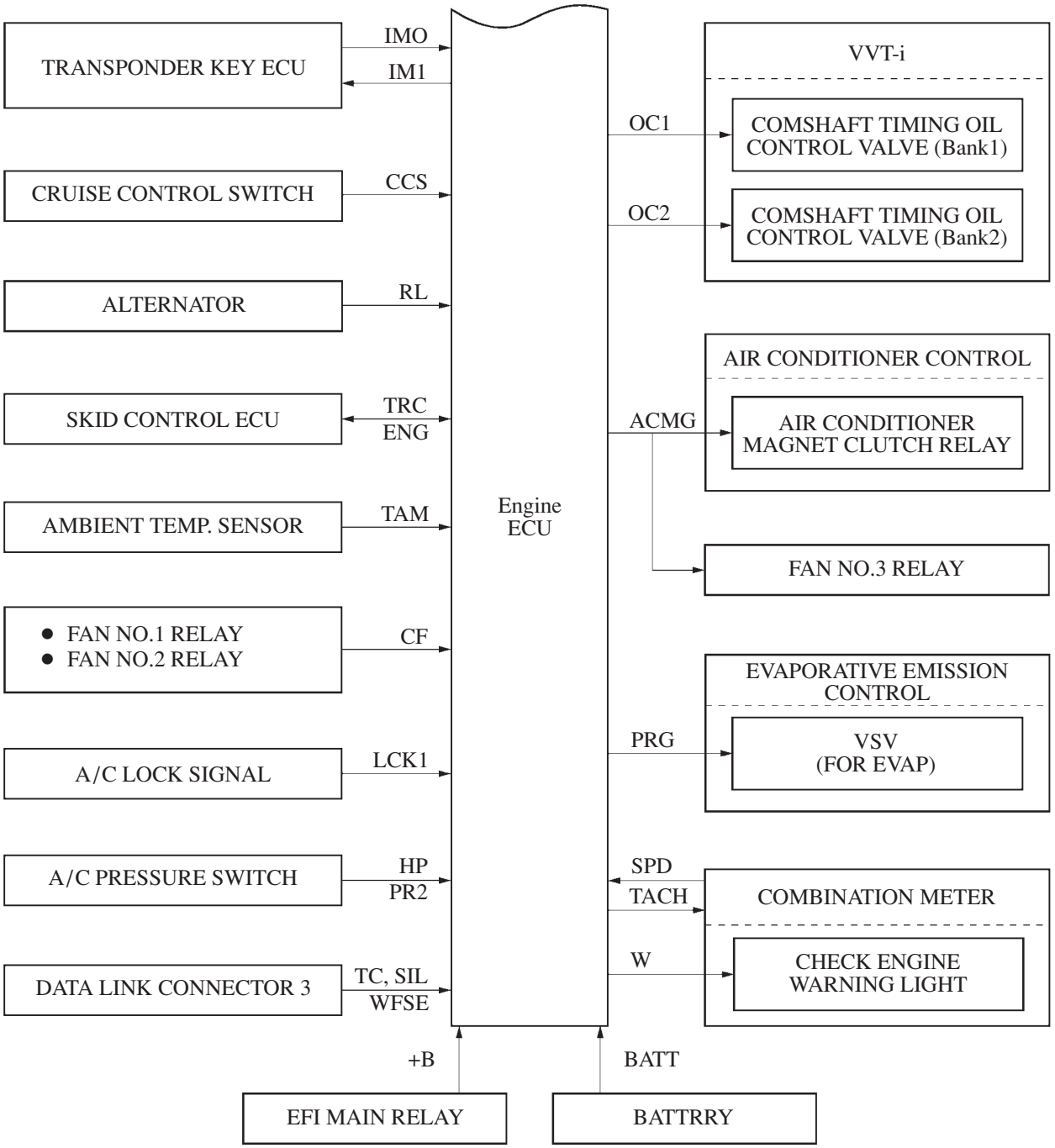
The configuration of the engine control system in the 3MZ-FE engine on the new Kluger is as shown in the following chart.



(Continued)

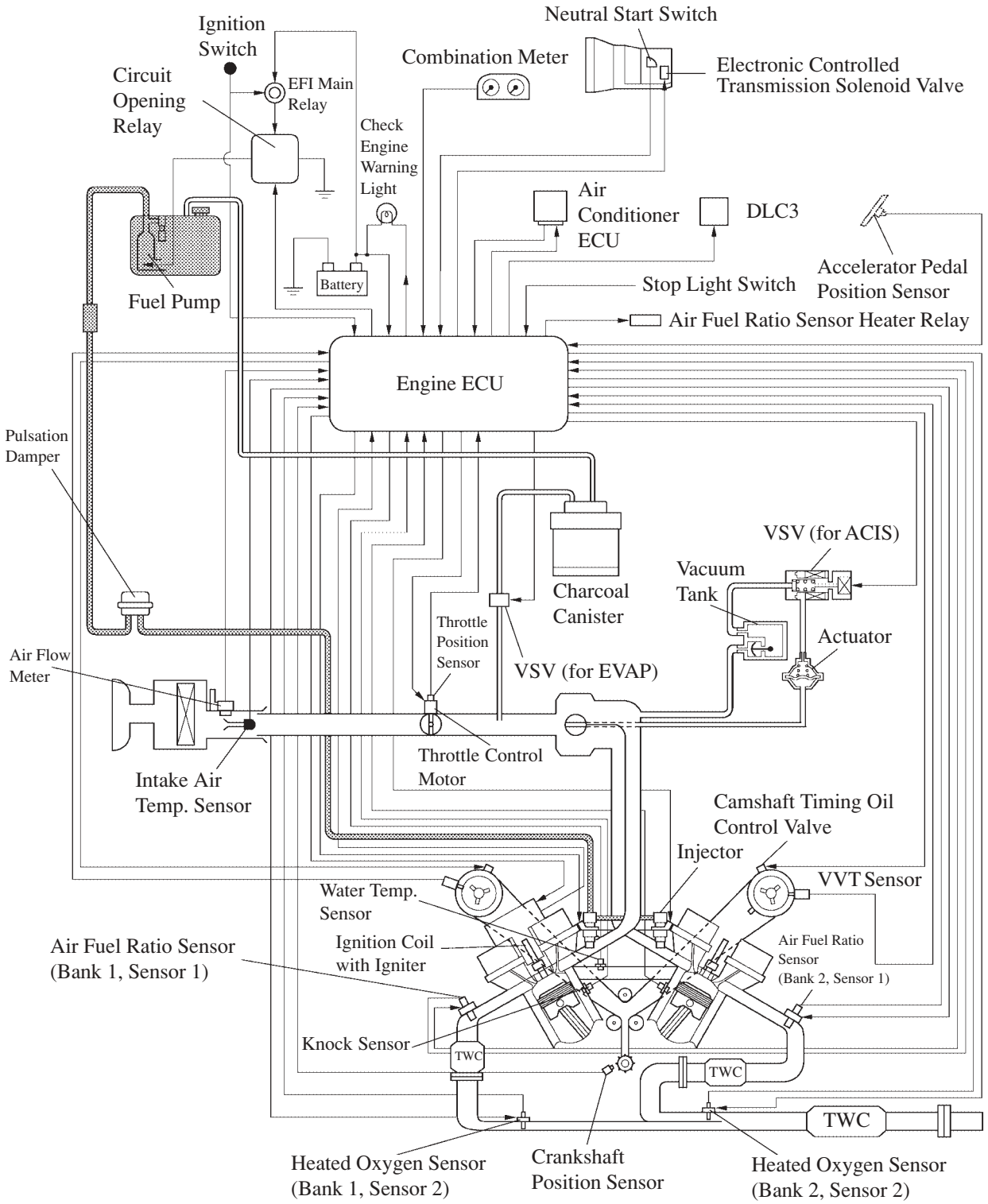
D012EG05

EG


TRANSPONDER KEY ECU
IMO
IM1
CRUISE CONTROL SWITCH
CCS
ALTERNATOR
RL
SKID CONTROL ECU
TRC
ENG
AMBIENT TEMP. SENSOR
TAM
● FAN NO.1 RELAY
● FAN NO.2 RELAY
CF
A/C LOCK SIGNAL
LCK1
A/C PRESSURE SWITCH
HP
PR2
DATA LINK CONNECTOR 3
TC, SIL
WFSE
+B
EFI MAIN RELAY
Engine ECU
BATT
BATTRRY
VVT-i
OC1
COMSHAFT TIMING OIL CONTROL VALVE (Bank1)
OC2
COMSHAFT TIMING OIL CONTROL VALVE (Bank2)
AIR CONDITIONER CONTROL
ACMG
AIR CONDITIONER MAGNET CLUTCH RELAY
FAN NO.3 RELAY
EVAPORATIVE EMISSION CONTROL
PRG
VSV (FOR EVAP)
SPD
TACH
COMBINATION METER
W
CHECK ENGINE WARNING LIGHT

D012EG06

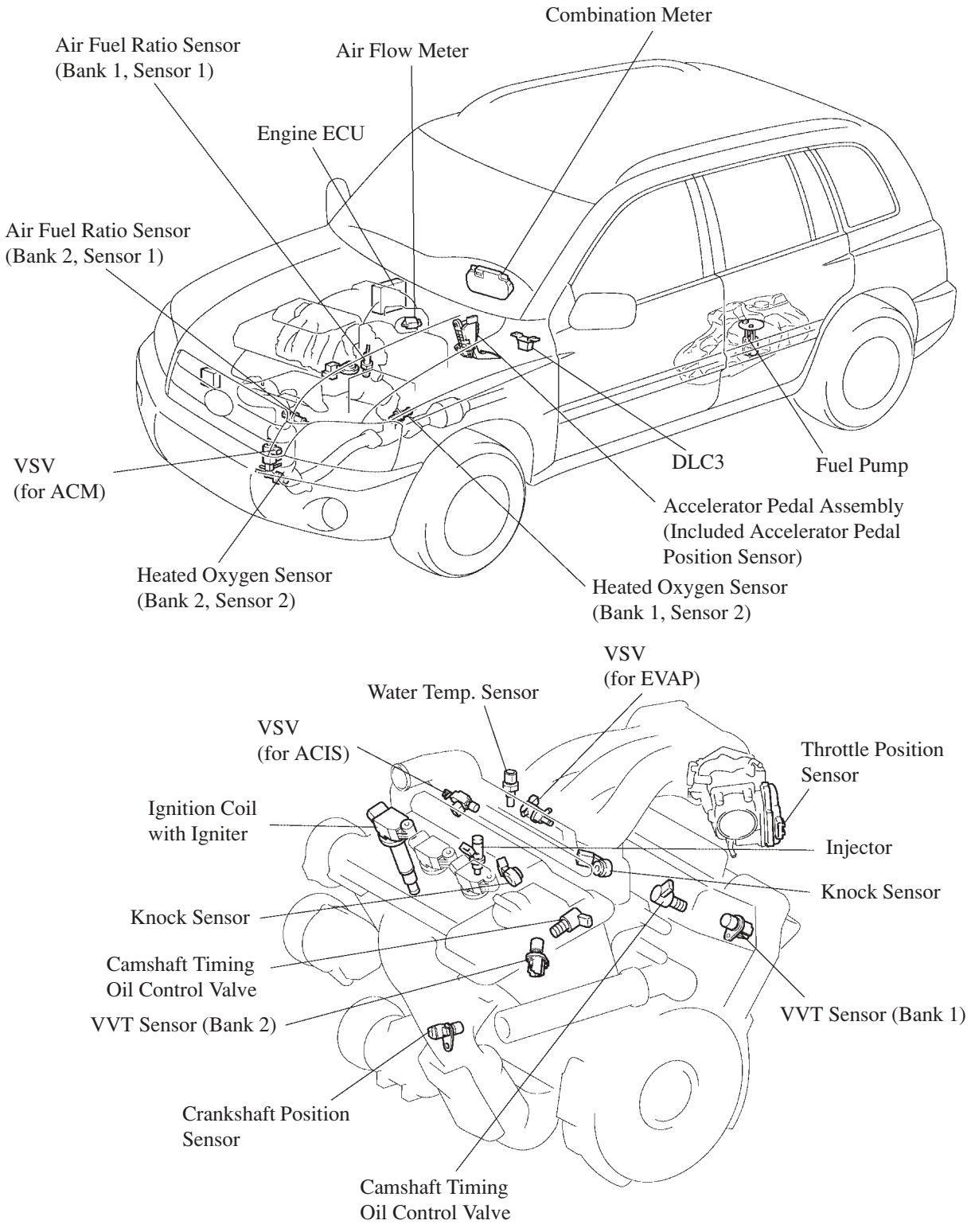
3. Engine Control System Diagram



D012EG07

EG

4. Layout of Main Components



5. Main Components of Engine Control System

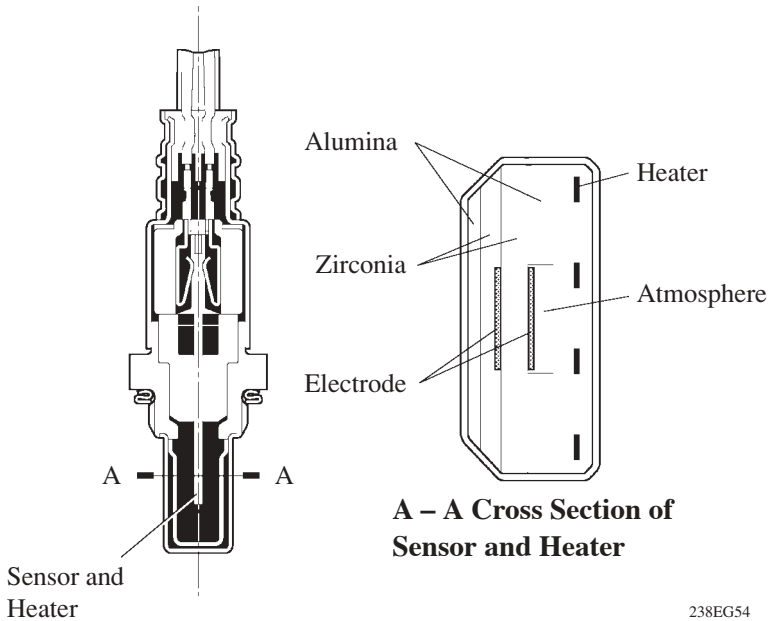
General

The following table compares the main components.

Components	Outline	Quantity
Engine ECU	32-bit CPU	1
Air Fuel Ratio Sensor (Bank 1, Sensor 1) (Bank 2, Sensor 1)	with Heater Type (Planar Type)	2
Oxygen Sensor (Bank 1, Sensor 2) (Bank 2, Sensor 2)	with Heater Type (Cup Type)	2
Air Flow Meter	Hot-wire Type	1
Crankshaft Position Sensor (Rotor Teeth)	Pick-up Coil Type (36-2)	1
VVT Sensor LH, RH (Rotor Teeth)	Pick-up Coil Type (3)	2
Knock Sensor	Built-in Piezoelectric Type (Flat Type)	2
Accelerator Pedal Position Sensor	No-contact Type (Mounted on Accelerator Pedal)	1
Throttle Position Sensor	No-contact Type	1
Injector	12-Hole Type	6

Air Fuel Ratio Sensor

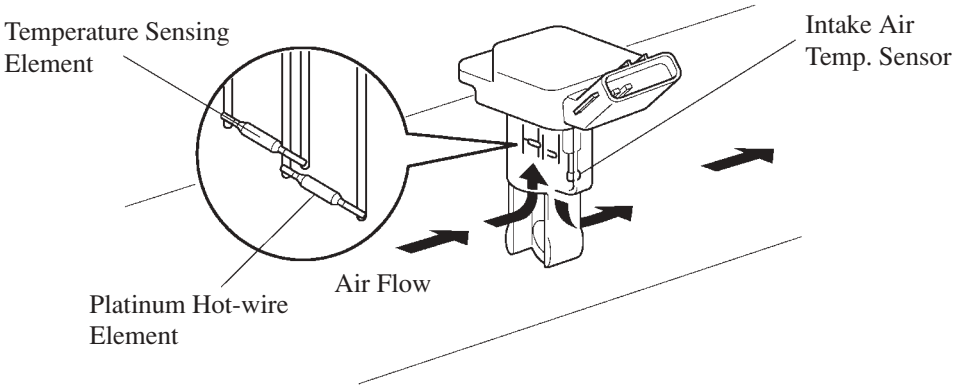
The air-fuel ratio sensor is the planar type. Compared to the conventional type, the sensor and heater portions of the planar type are narrower overall. Because the heat of the heater acts directly on the alumina and zirconia (of the sensor portion) it accelerates the activation of the sensor.



A – A Cross Section of Sensor and Heater

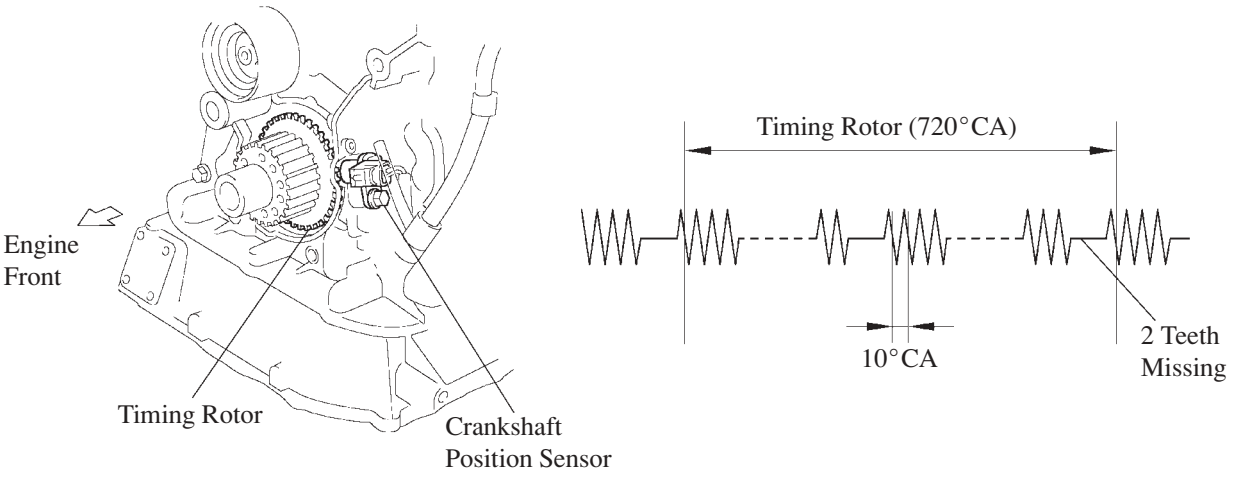
Air Flow Meter

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



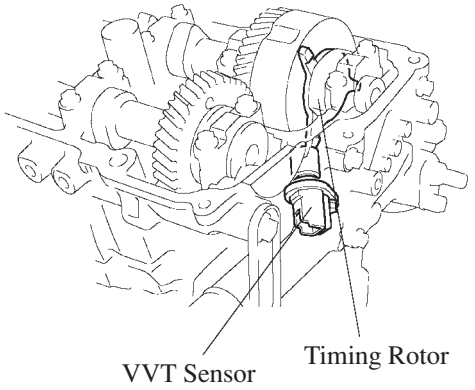
Crankshaft Position Sensor

The timing rotor of the crankshaft consists of 34 teeth, with 2 teeth missing. The crankshaft position sensor outputs the crankshaft rotation signals every 10°, and the missing teeth are used to determine the top-dead-center.

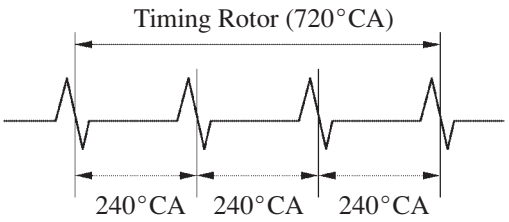


VVT Sensor

The VVT sensors are mounted on the right and left banks of the cylinder heads. To detect the camshaft position, these sensors pick up the protrusion of the timing rotor that is secured to the camshaft in front of the VVT controller. In addition, each sensor generates 3 pulses for every 2 revolutions of the crankshaft.



Left Bank



241EG35

Knock Sensor (Flat Type)

1) General

In the conventional type knock sensor (resonant type), a vibration plate which has the same resonance point as the knocking frequency of the engine is built in and can detect the vibration in this frequency band.

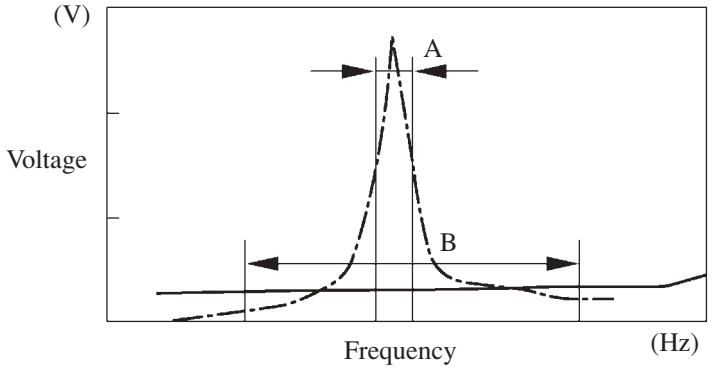
On the other hand, a flat type knock sensor (non-resonant type) has the ability to detect vibration in a wider frequency band from about 6 kHz to 15 kHz, and has the following features.

- The engine knocking frequency will change a bit depending on the engine speed. The flat type knock sensor can detect the vibration even when the engine knocking frequency is changed. Thus the vibration detection ability is increased compared to the conventional type knock sensor, and a more precise ignition timing control is possible.

▶ Characteristic of Knock Sensor ◀

—·— : Resonance Characteristic of Conventional Type

——— : Resonance Characteristic of Flat Type

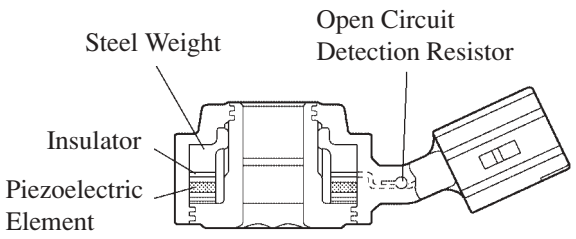


A: Detection Band of Conventional Type
B: Detection Band of Flat Type

214CE04

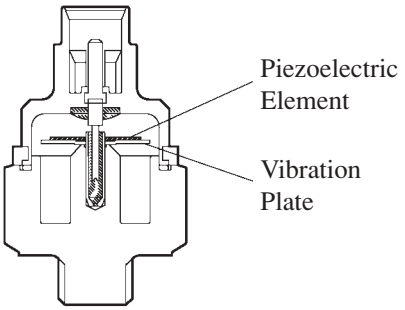
2) Construction

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



214CE01

Flat Type Knock Sensor
(Non-Resonant Type)

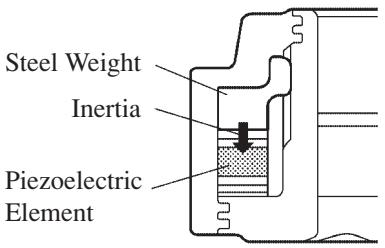


214CE02

Conventional Type Knock Sensor
(Resonant Type)

3) Operation

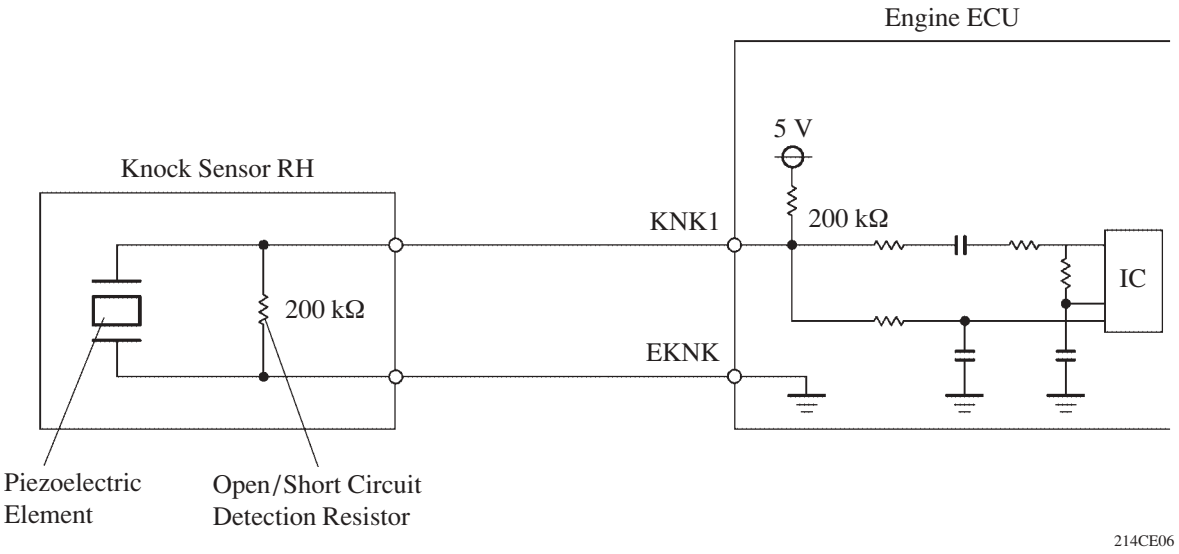
The knocking vibration is transmitted to the steel weight and its inertia applies pressure to the piezoelectric element. The action generates electromotive force.



214CE08

4) Open/Short Circuit Detection Resistor

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

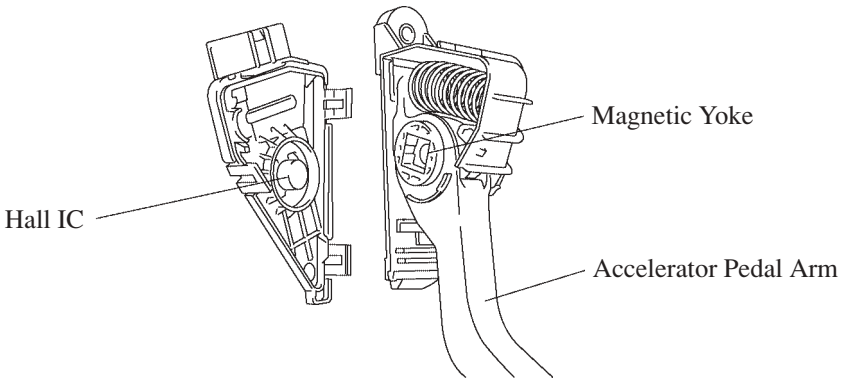


Service Tip

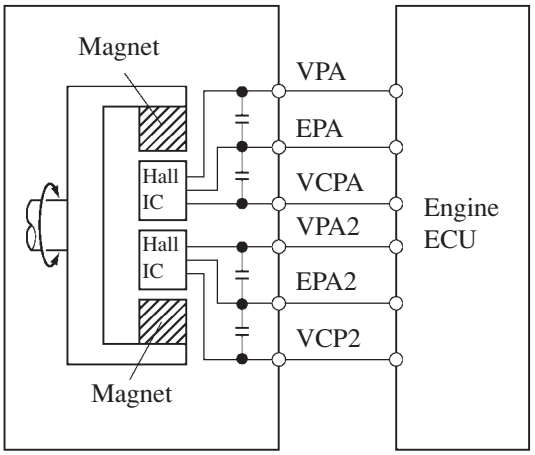
In accordance with the adoption of open/short circuit detection resistor, the inspection method for the sensor has been changed. For details, refer to Kluger Repair Manual (Pub. No. RM1087E).

Accelerator Pedal Position Sensor

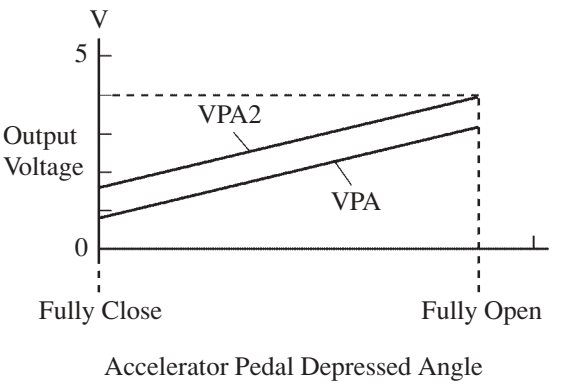
The magnetic yoke that is mounted at the base of the accelerator pedal arm rotates around the Hall IC in accordance with the amount of effort that is applied to the accelerator pedal. The Hall IC converts the changes in the magnetic flux that occur at that time into electrical signals, and outputs them in the form of accelerator pedal effort to the engine ECU.



228TU23



228TU24



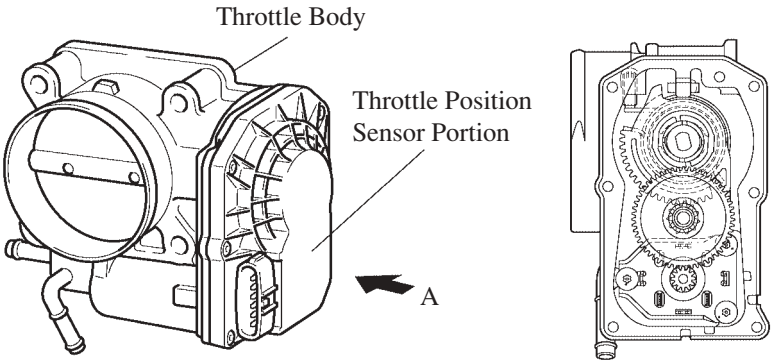
228TU25

Service Tip

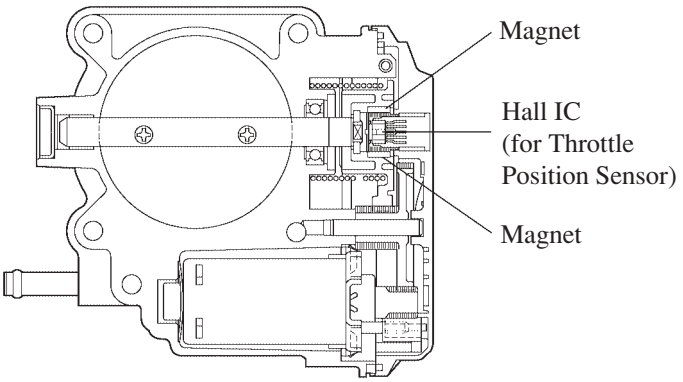
The inspection method differs from the conventional accelerator pedal position sensor because this sensor uses a hall IC. For details, refer to the Kluger Repair Manual (Pub. No. RM1087E).

Throttle Position Sensor

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

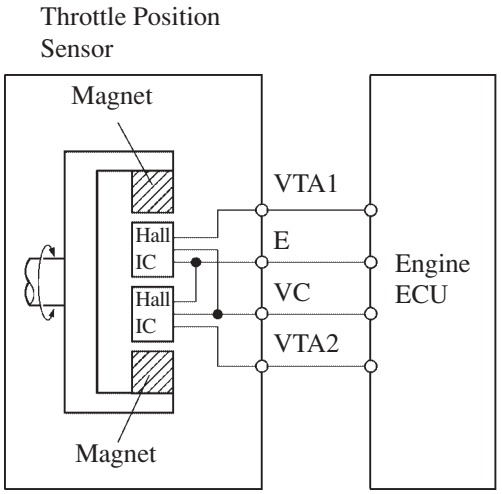


View from A

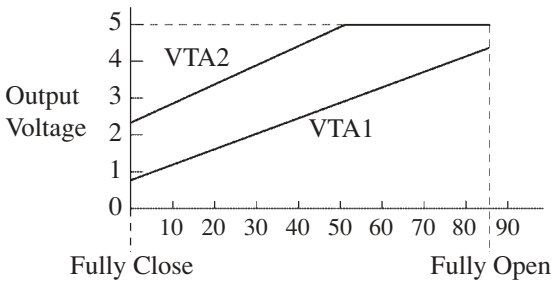


241EG28

Cross Section



230LX12



238EG79

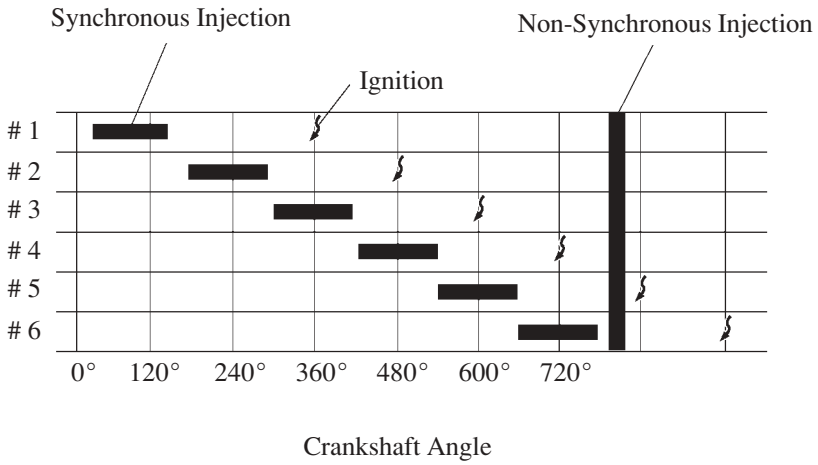
Service Tip

The inspection method differs from the conventional throttle position sensor because this sensor uses a hall IC. For details, refer to the Kluger Repair Manual (Pub. No. RM1087E).

6. EFI (Electronic Fuel Injection) System

- An L-type EFI system directly detects the intake air mass with a hot wire type air flow meter.
- An independent injection system (in which fuel is injected once into each cylinder for each two revolutions of the crankshaft) has been adopted.
- There are two types of fuel injection:
  a) One is synchronous injection in which corrections based on the signals from the sensors are added to the basic injection duration so that injection occurs always at the same timing.
  b) The other is non-synchronous injection in which injection is effected by detecting the requests from the signals of the sensors regardless of the crankshaft angle.
- This system performs group injection when the engine coolant temperature is extremely low and the engine is operating at a low speed.

▶ Independent Injection ◀



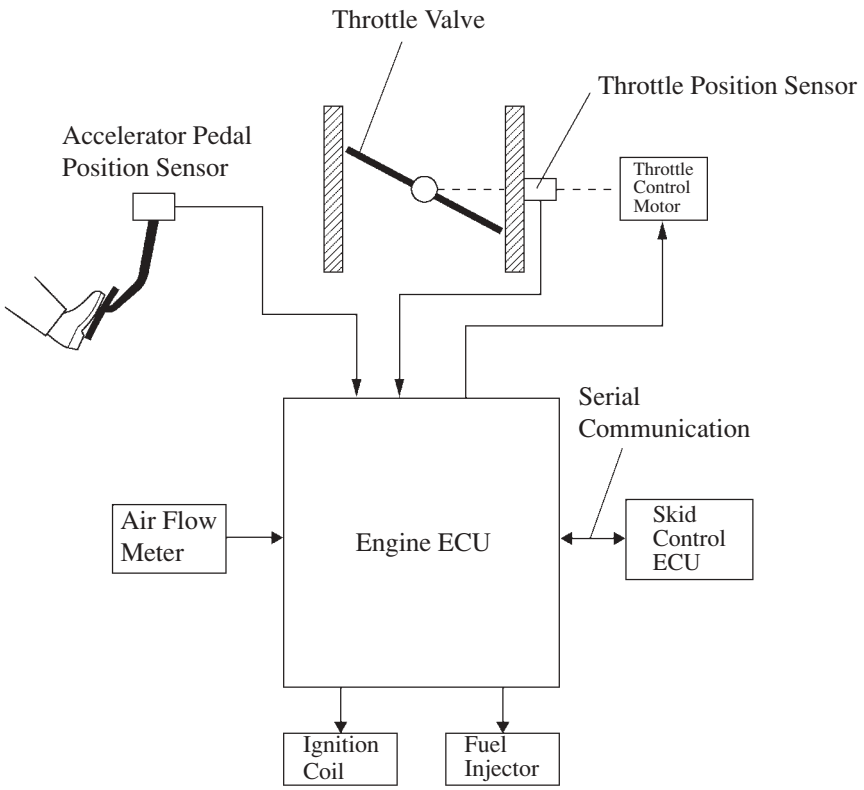
238EG70

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

General

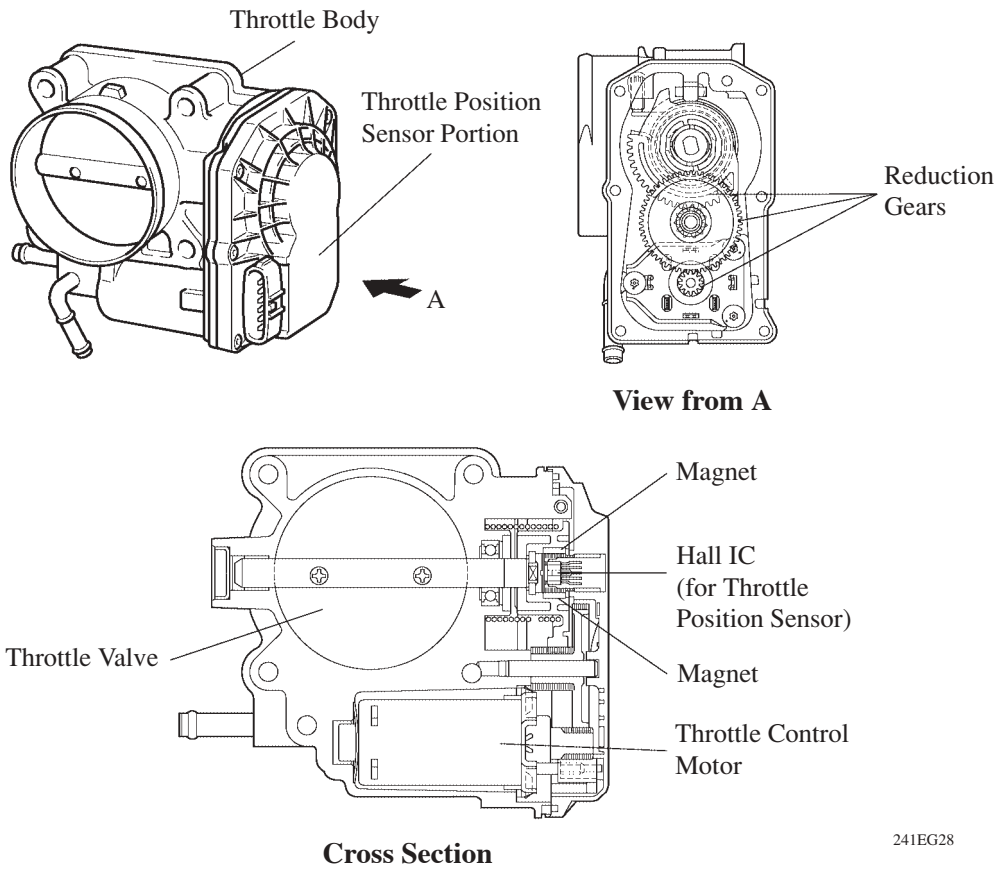
- The ETCS-i is used, providing excellent throttle control in all the operating ranges.
  An accelerator pedal position sensor has been provided on the accelerator pedal.
- In the conventional throttle body, the throttle valve opening is determined by the amount of the accelerator pedal effort. In contrast,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

▶ System Diagram ◀



208EG44

Construction



Cross Section

1) Throttle Position Sensor

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

2) Throttle Control Motor

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

Operation

1) General

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

1) Non-Linear Control

2) Idle Speed Control

3) TRC Throttle Control

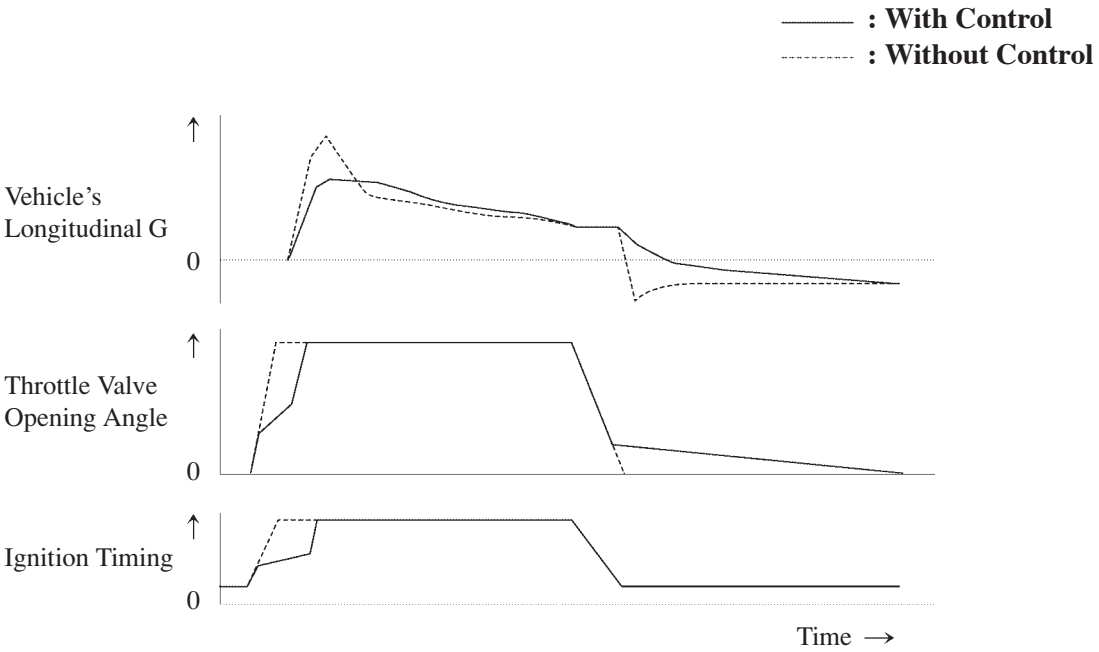
4) VSC Coordination Control

5) Cruise Control

2) Non-Linear Control

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

▶ Control Examples During Acceleration and Deceleration ◀



150EG37

3) Idle Speed Control

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

4) TRC Throttle Control

As part of the TRC system, the throttle valve is closed by a demand signal from the skid control ECU if an excessive amount of slippage is created at a driving wheel, thus facilitating the vehicle in providing excellent stability and driving force.

5) VSC Coordination Control

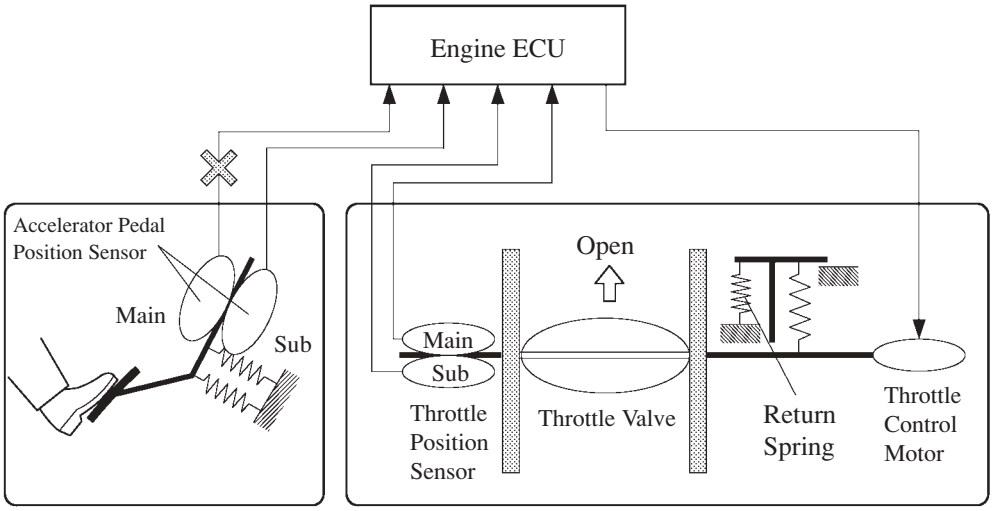
In order to bring the effectiveness of the VSC system control into full play, the throttle valve opening angle is controlled by effecting a coordination control with the skid control ECU.

6) Cruise Control

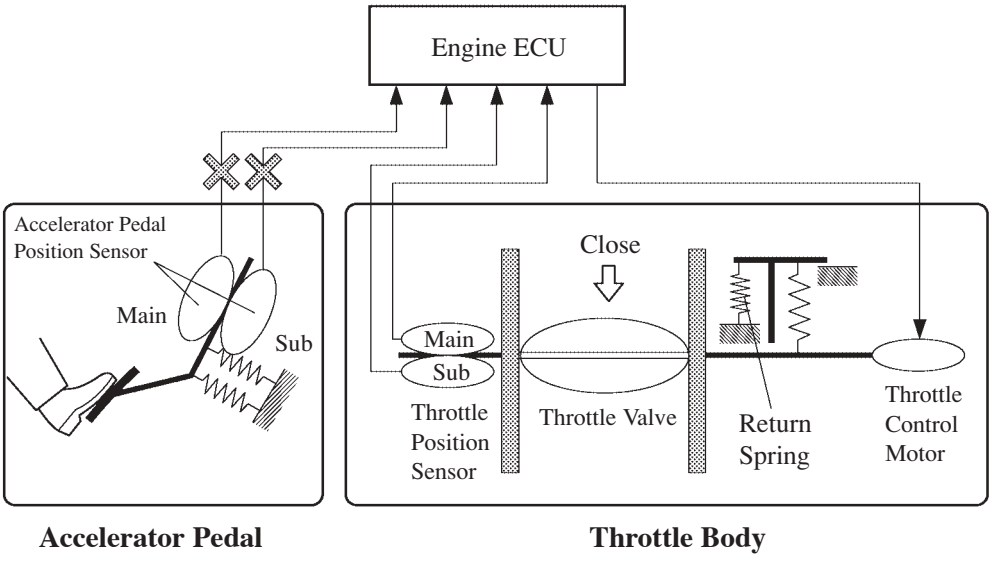
An engine ECU with an integrated cruise control ECU directly actuates the throttle valve for operation of the cruise control.

Fail-Safe of Accelerator Pedal Position Sensor

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

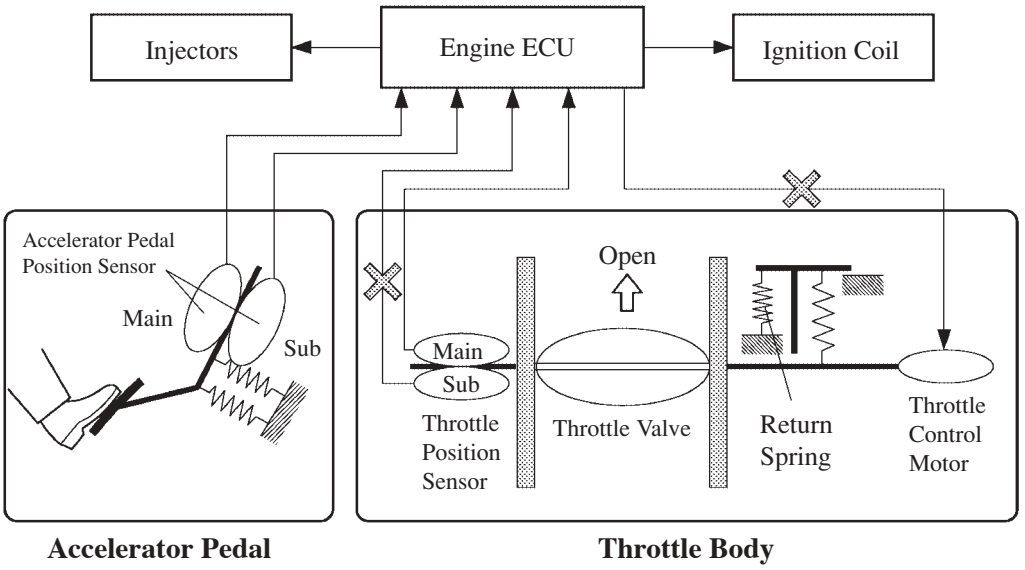


- If both circuits have a malfunction, the engine ECU detects the abnormal signal voltage from these two sensor circuits and discontinues the throttle control. At this time, the vehicle can be driven within its idling range.



Fail-Safe of Throttle Position Sensor

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

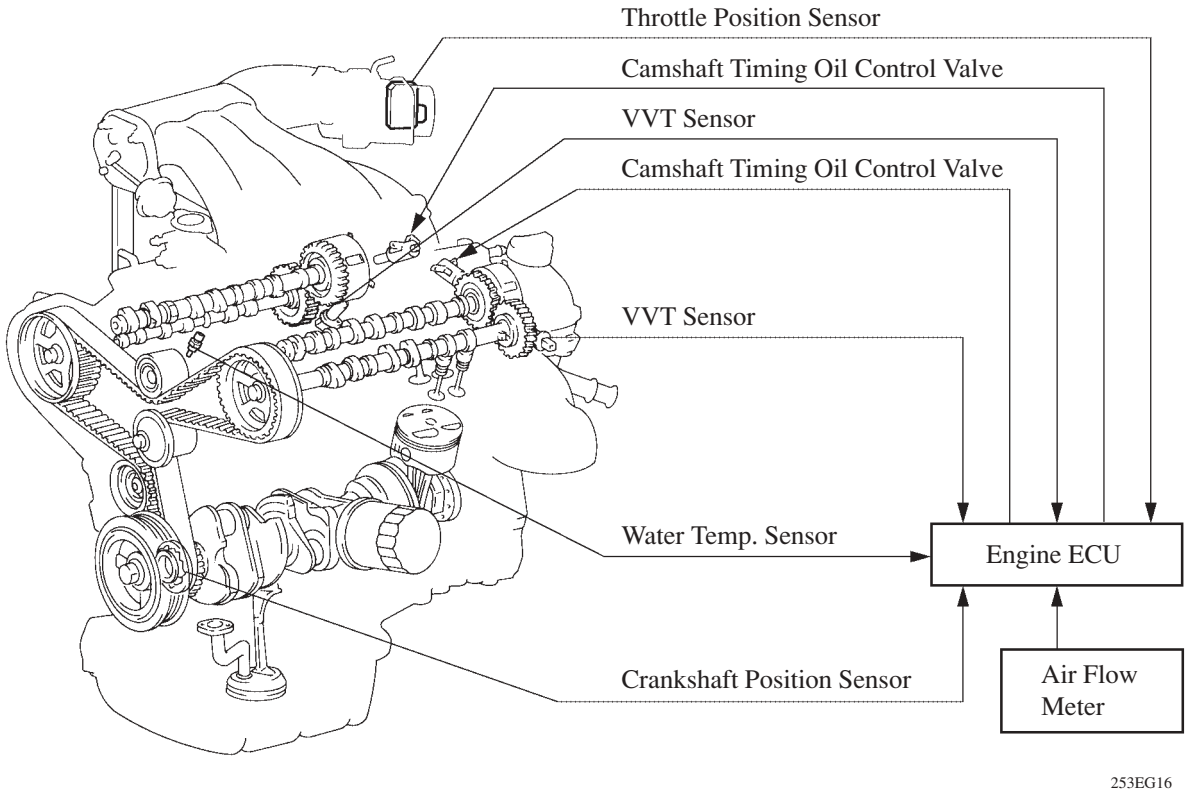


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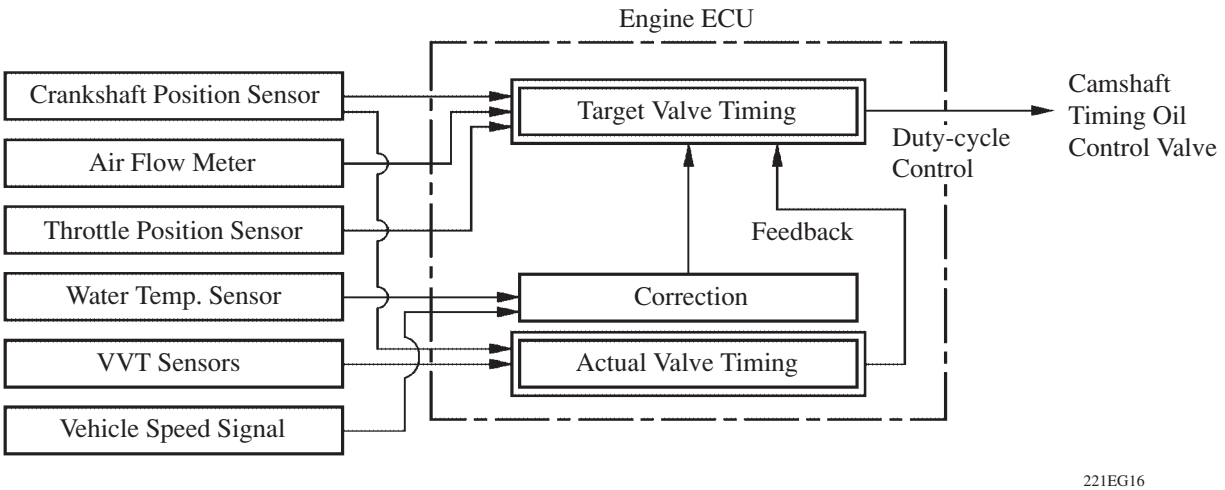
8. VVT-i (Variable Valve Timing-intelligent) System

General

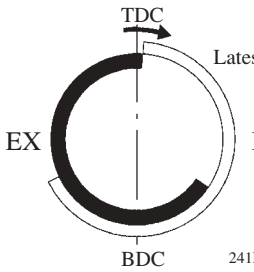
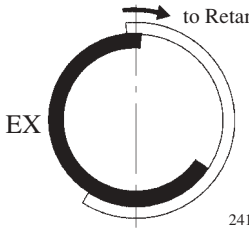
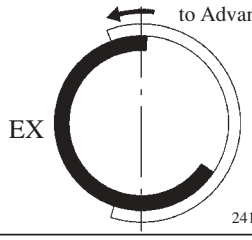
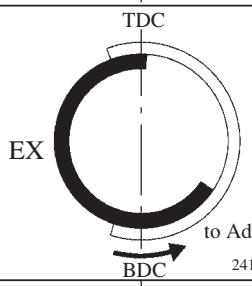
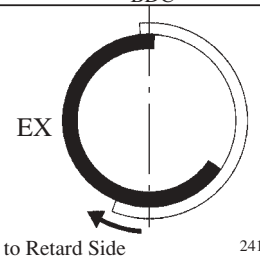
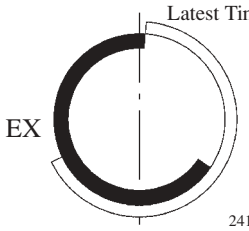
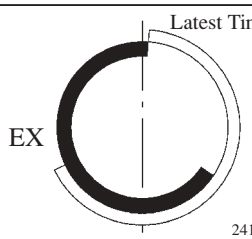
- The VVT-i system is designed to control the intake camshaft within a range of 60° (of Crankshaft Angle) to provide valve timing that is optimally suited to the engine condition. This improves torque in all the speed ranges as well as increasing fuel economy, and reducing exhaust emissions.



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



Effectiveness of the VVT-i System

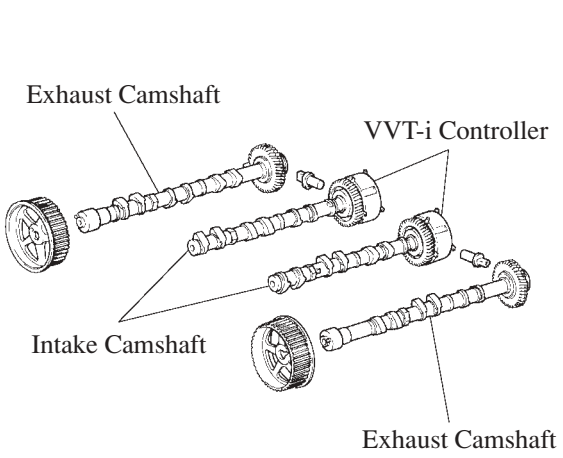
Operation State	Objective	Effect
During Idling	 Eliminating overlap to reduce blow back to the intake side	● Stabilized idling rpm ● Better fuel economy
At Light Load	 Decreasing overlap to eliminate blow back to the intake side	Ensured engine stability
At Medium Load	 Increasing overlap to increase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

EG

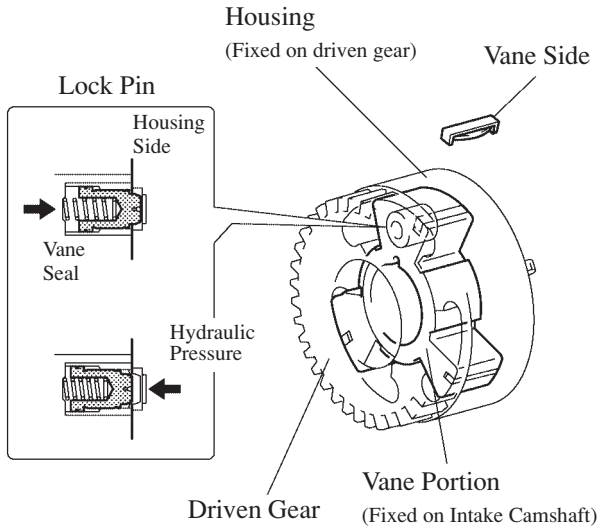
Construction

1) VVT-i Controller

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



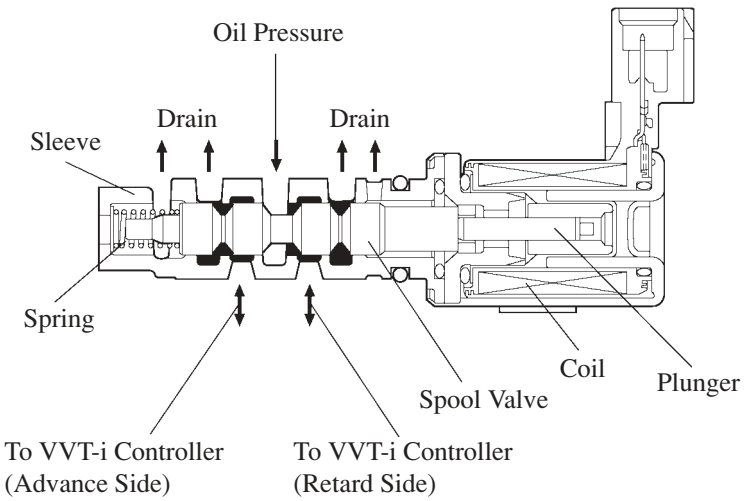
157EG24



170EG05

2) Camshaft Timing Oil Control Valve

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

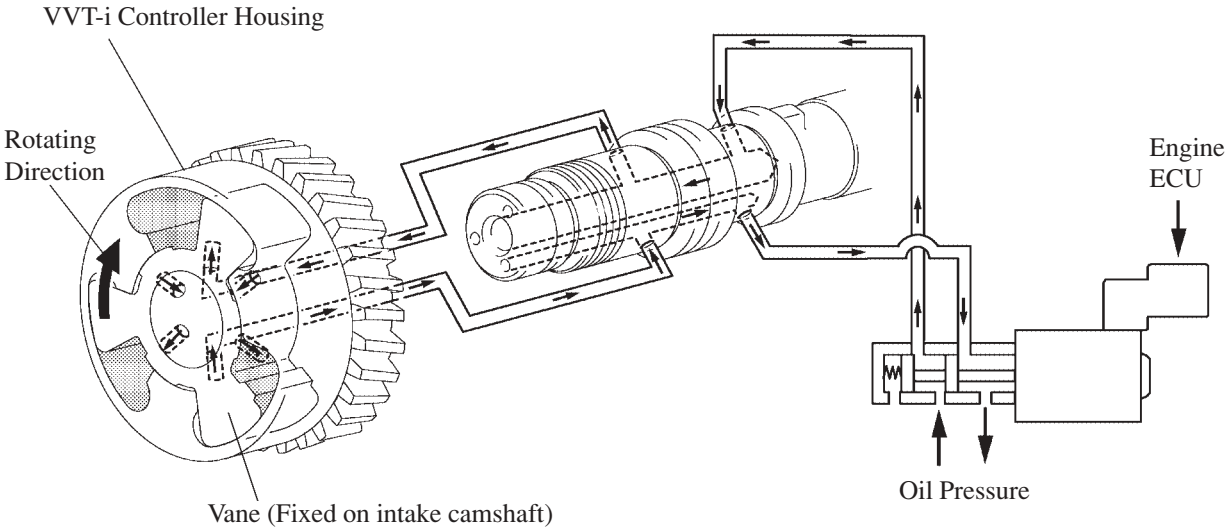


253EG17

Operation

1) Advance

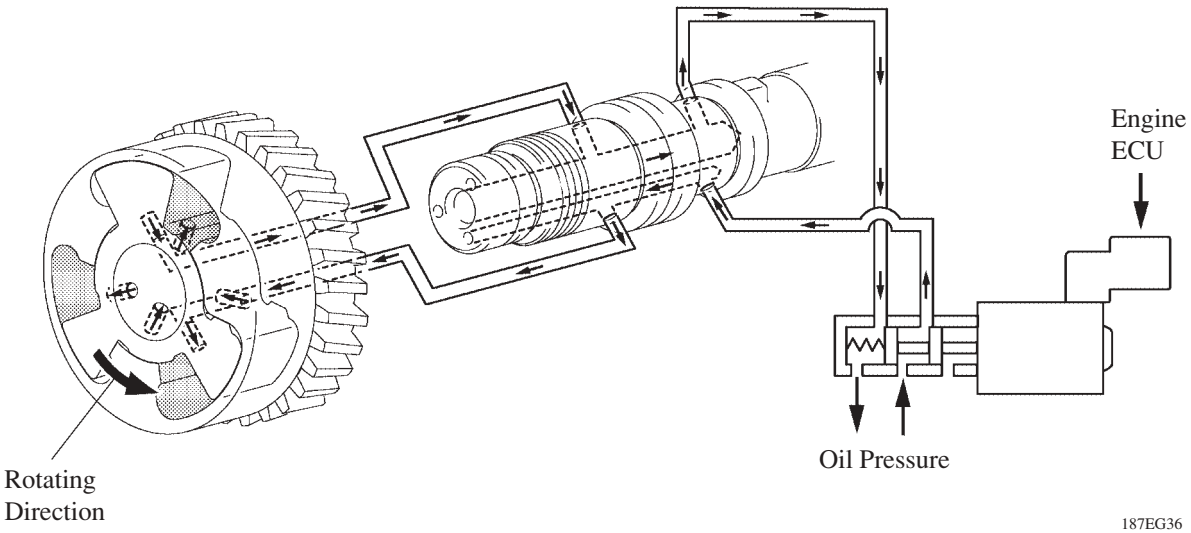
When the camshaft timing oil control valve is positioned as illustrated below by the advance signals from the engine ECU, the resultant oil pressure is applied to the vane chamber of advance side to rotate the camshaft in the timing advance direction.



187EG35

2) Retard

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



187EG36

3) Hold

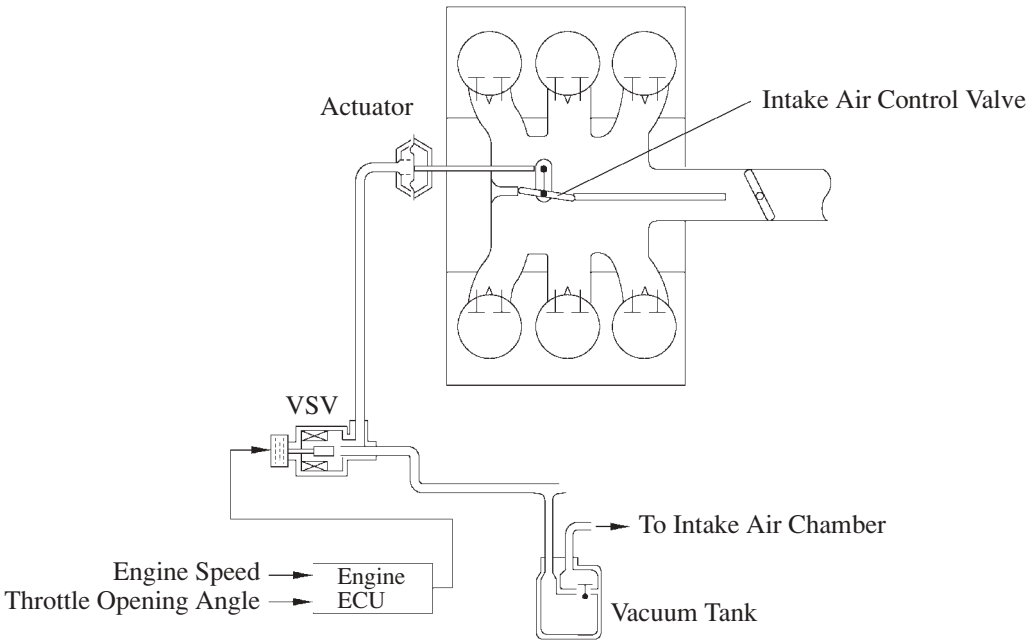
After reaching the target timing, the valve timing is held by keeping the camshaft timing oil control valve in the neutral position unless the traveling state changes.
This adjusts the valve timing at the desired target position and prevents the engine oil from running out when it is unnecessary.

9. ACIS (Acoustic Control Induction System)

General

The ACIS is realized by using a bulkhead to divide the intake manifold into 2 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 ◀

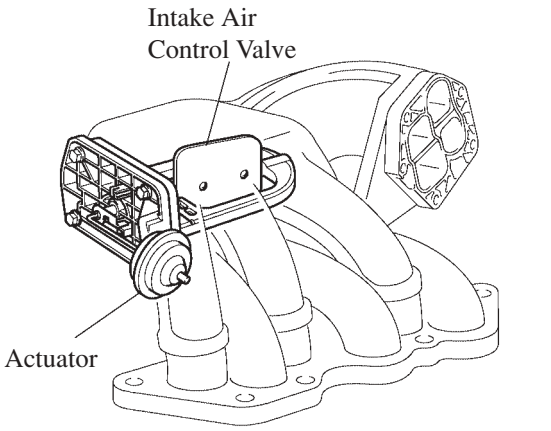


208EG45

Construction

1) Intake Air Control Valve

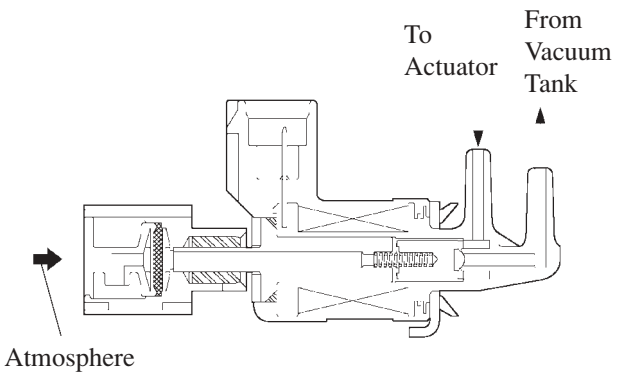
The intake air control valves, which are provided in the intake air chamber, open and close to change the effective length of the intake manifold in two stages.



241EG16

2) VSV (Vacuum Switching Valve)

Controls the vacuum that is applied to the actuator by way of the signal (ACIS) that is output by the engine ECU.



208EG47

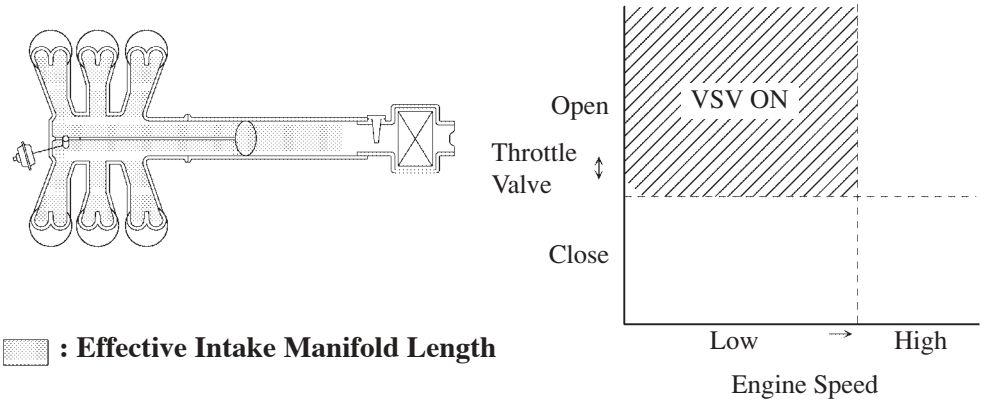
3) Vacuum Tank

Equipped with an internal check valve, the vacuum tank stores the vacuum that is applied to the actuator in order to maintain the intake air control valve fully closed even during low-vacuum conditions.

Operation

1) When the Intake Control Valve Closes (VSV ON)

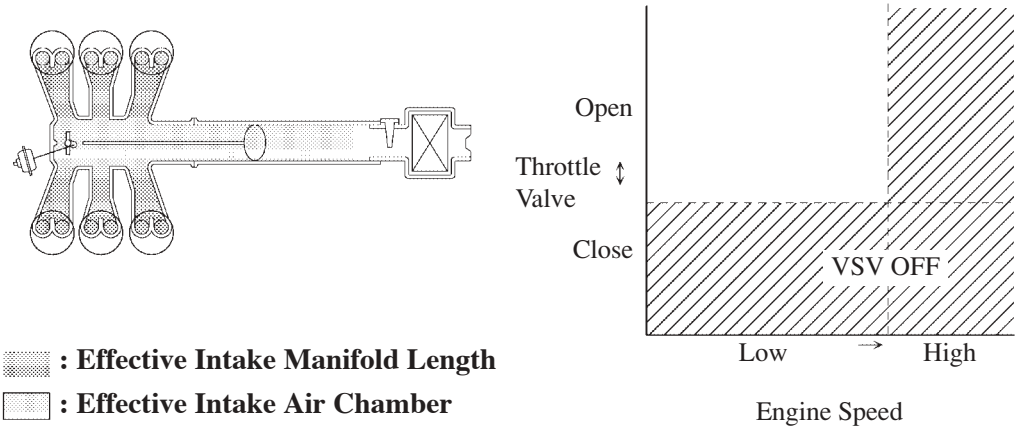
The engine ECU activates the VSV to match the longer pulsation cycle so that the negative pressure acts on the diaphragm chamber of the actuator. This closes the control valve. As a result, the effective length of the intake manifold is lengthened and the intake efficiency in the low-to-medium speed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



208EG48

2) When the Intake Control Valve Opens (VSV OFF)

The engine ECU deactivates the VSV to match the shorter pulsation cycle so that atmospheric air is led into the diaphragm chamber of the actuator and opens the control valve. When the control valve is open, the effective length of the intake air chamber is shortened and peak intake efficiency is shifted to the high engine speed range, thus providing greater output at high engine speed.

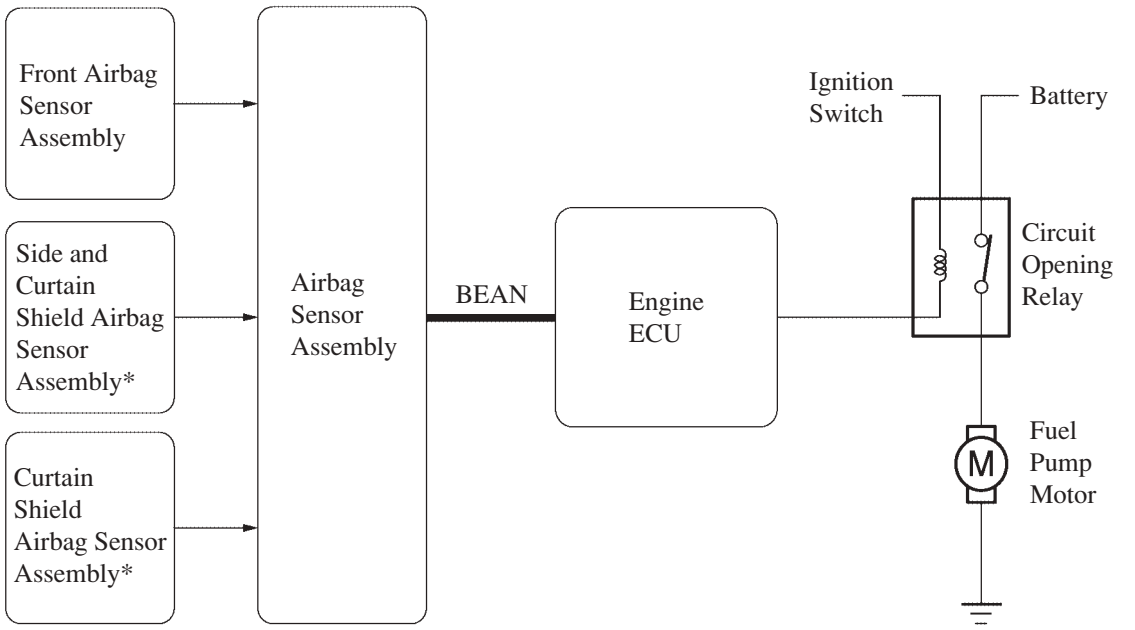


208EG49

10. Fuel Pump Control

- Fuel pump operation is controlled by signal from the engine ECU.
- A fuel cut control is adopted to stop the fuel pump when the airbag is deployed at the front or side collision. In this system, the airbag deployment signal from the airbag sensor assembly is detected by the engine ECU, which turns OFF the circuit opening relay.
  After the fuel cut control has been activated, turning the ignition switch from OFF to ON cancels the fuel cut control, and the engine can be restarted.

▶ System Diagram ◀



241EG32

*: Only for models with side and curtain shield airbags

11. Diagnosis

- When the engine ECU detects a malfunction, the engine ECU makes a diagnosis and memorizes the failed section.
  Furthermore, the check engine warning light in the combination meter illuminates or blinks to inform the driver.
- The engine ECU will also store the DTCs (Diagnostic Trouble Codes) of the malfunctions.
- The DTCs can be accessed by the use of the hand-held tester.
- All the DTCs have been made to correspond to the SAE controlled codes. Some of the DTCs have been further divided into smaller detection areas than in the past, and new DTCs have been assigned to them. For details, refer to the Kluger Repair Manual (Pub. No. RM1087E).

Service Tip

To clear the DTC that is stored in the engine ECU, use a hand-held tester or disconnect the battery terminal or remove the EFI fuse for 1 minute or longer.

12. Fail-Safe

General

When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the data already stored in the memory.

▶ Fail-Safe Chart ◀

DTC No.	Fail-Safe Operation	Fail-Safe Deactivation Conditions
P0031, P0032, P0037, P0038, P0051, P0052, P0057, P0058	The heater circuit in which an abnormality is detected is turned off.	Ignition switch OFF.
P0100, P0102, P0103	Ignition timing is calculated from an engine speed and a throttle angle.	If the engine ECU detects “Pass” condition, the engine ECU will return to “normal mode”.
P0110, P0112, P0113	Intake air temp. is fixed at 20°C (68°F).	If the engine ECU detects “Pass” condition, the engine ECU will return to “normal mode”.
P0115, P0117, P0118	Water temp. is fixed at 80°C (176°F).	If the engine ECU detects “Pass” condition, the engine ECU will return to “normal mode”.
P0120, P0121, P0122, P0123, P0220, P0222, P0223, P0604, P0606, P0607, P0657, P2102, P2103, P2111, P2112, P2118, P2119, P2135	VTA is fixed at about 16% and fuel is cut intermittently.*	If the engine ECU detects “Pass” condition, the engine ECU will return to “normal mode” and turn the ignition switch OFF.
P0325, P0327, P0328, P0330, P0332, P0333	Max. timing retardation.	Ignition switch OFF.

(Continued)

*: The vehicle can be driven slowly when the accelerator pedal is depressed firmly and slowly. If the accelerator pedal is depressed quickly, the vehicle may speed up and slow down erratically.

DTC No.	Fail-Safe Operation	Fail-Safe Deactivation Conditions
P0351, P0352, P0353, P0354, P0355, P0356, P0357, P0358	Fuel cut.	If the engine ECU detects “Pass” condition, the engine ECU will return to “normal mode”.
P2120, P2121, P2122, P2123, P2125, P2127, P2128, P2138	The accelerator pedal position sensor has 2 sensor elements. If either of the elements have malfunctions, the engine ECU controls the engine by the other elements. If both of the elements have malfunction, the engine ECU regards that the accelerator pedal position sensor is fully closed. (In this case, the throttle valve will remain closed as if engine is idling.)	If the engine ECU detects “Pass” condition, the engine ECU will return to “normal mode” and turn the ignition switch OFF.

– MEMO –