

ENGINE CONTROL SYSTEM

1. General

The engine control system of the new 3UZ-FE engine on the LS430 is basically same in construction and operation as that of the previous 1UZ-FE engine for the LS400.

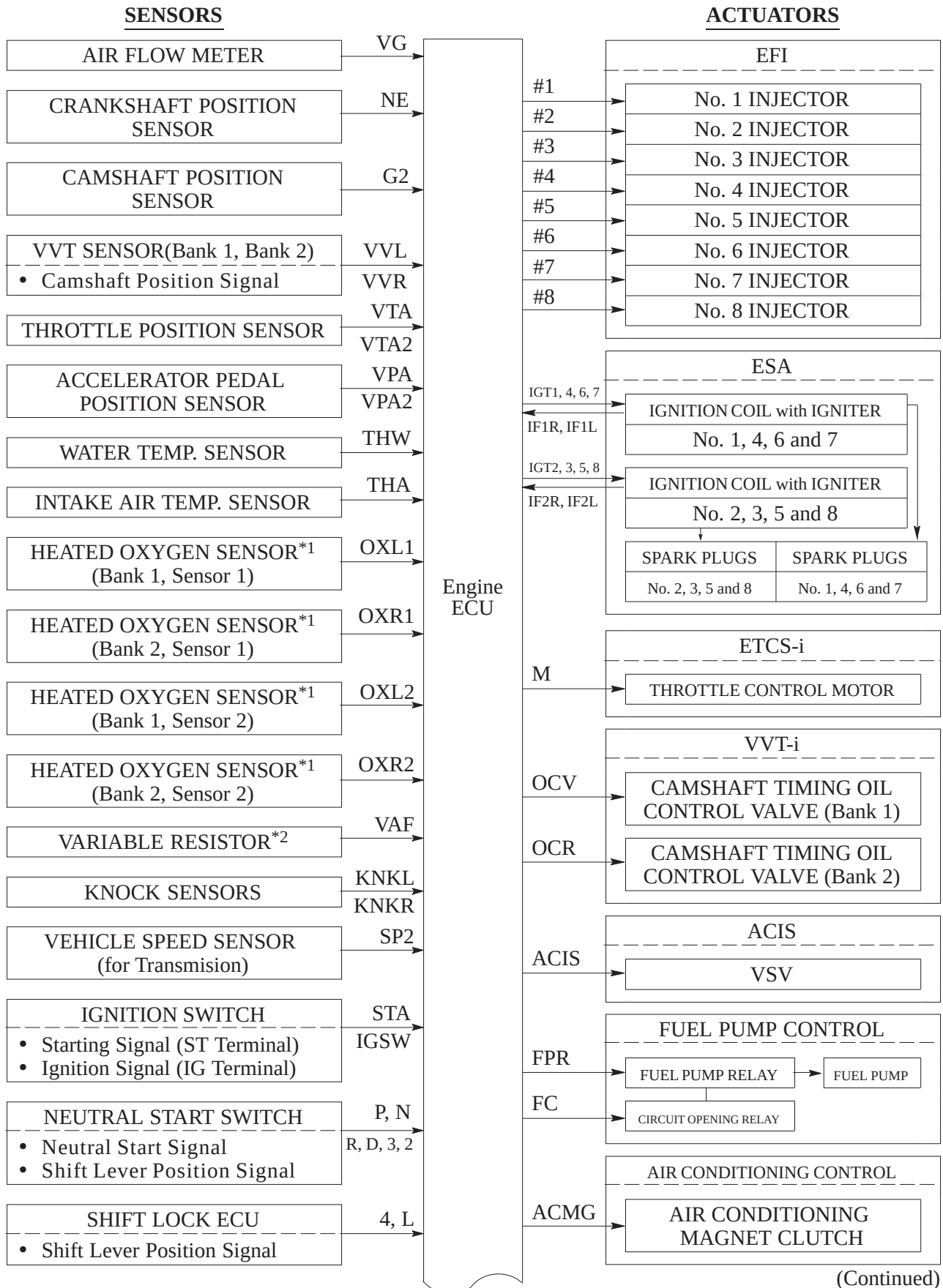
The engine control system of the new 3UZ-FE engine in the new LS430 and previous 1UZ-FE engine in the LS400 are compared below.

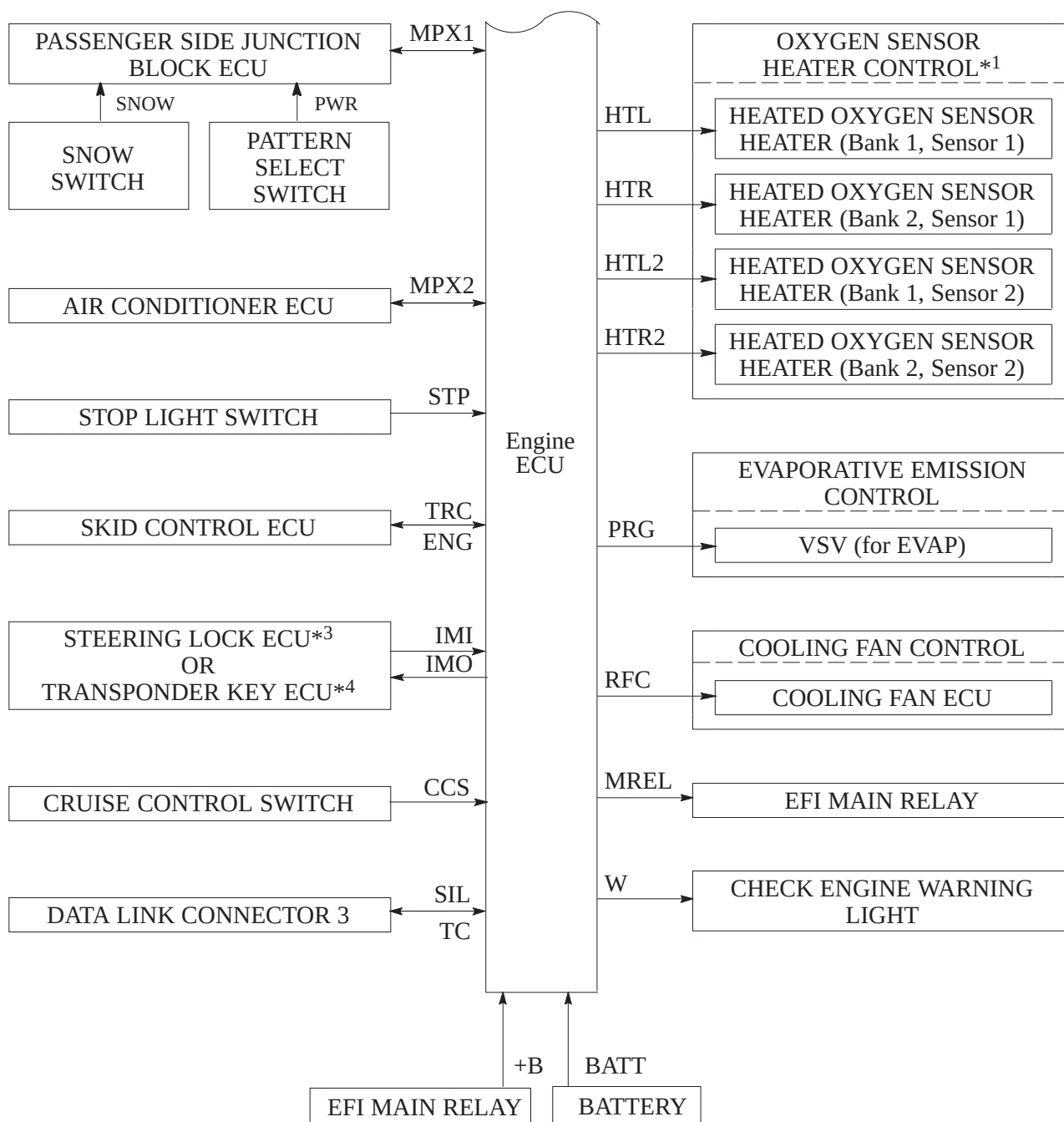
System	Outline	3UZ-FE	1UZ-FE
EFI (Electronic Fuel Injection)	An L-type EFI system directly detects the intake air mass with a hot wire type air flow meter.	○	○
	The fuel injection system is a sequential multiport fuel injection system.	○	○
ESA (Electronic Spark Advance)	Ignition timing is determined by the engine ECU based on signals from various sensors. The engine ECU corrects ignition timing in response to engine knocking.	○	○
	2 knock sensors are used to improve knock detection.	○	○
	The torque control correction during gear shifting has been used to minimize the shift shock.	○	○
VVT-i (Variable Valve Timing-intelligent)	Controls the intake camshaft to an optimal valve timing in accordance with the engine condition. For details, see page 69 .	○	○
ETCS-i (Electronic Throttle Control System-intelligent)	Optimally controls the throttle valve opening in accordance with the amount of accelerator pedal effort and the condition of the engine and the vehicle. In addition, comprehensively controls the ISC, snow mode control, cruise control, VSC system and TRC systems. For details, see page 74 .	○	○
	Torque activated power train control has been adopted. Also, the fail-safe control has been reconsidered with the adoption of the link-less type throttle body. For details, see page 74 .	○	—
ACIS (Acoustic Control Induction System)	The intake air passages are switched according to the engine speed and throttle valve angle to increase performance in all speed ranges. For details, see page 80 .	○	○
Fuel Pump Control	The fuel pump speed is controlled by the fuel pump relay and the fuel pump resistor.	○	○
	The operation of the fuel pump will stop when the air-bag is deployed at the front or side collision. For details, see page 84 .	○	—
Oxygen Sensor Heater Control*	Maintains the temperature of the oxygen sensor at an appropriate level to increase accuracy of detection of the oxygen concentration in the exhaust gas.	○	○

*: Models for Europe and Australia

(Continued)

System	Outline	3UZ-FE	1UZ-FE
Cooling Fan Control	An electric cooling fan system has been adopted. The engine ECU steplessly controls the speed of the fans in accordance with the engine coolant temperature, vehicle speed, engine speed, and air conditioner operating conditions. As a result, the cooling performance has been improved.	○	—
Air Conditioner Cut-Off Control	By controlling the air conditioner compressor ON or OFF in accordance with the engine condition, drivability is maintained.	○	○
Evaporative Emission Control	The engine ECU controls the purge flow of evaporative emissions (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.	○	○
Function to communicate with multiplex communication system	Communicates with the meter ECU, A/C ECU, etc., on the body side, to input/output necessary signals.	○	○
Diagnosis	When the engine ECU detects a malfunction, the engine ECU diagnoses and memorizes the failed section.	○	○
Fail-Safe	When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the data already stored in the memory.	○	○





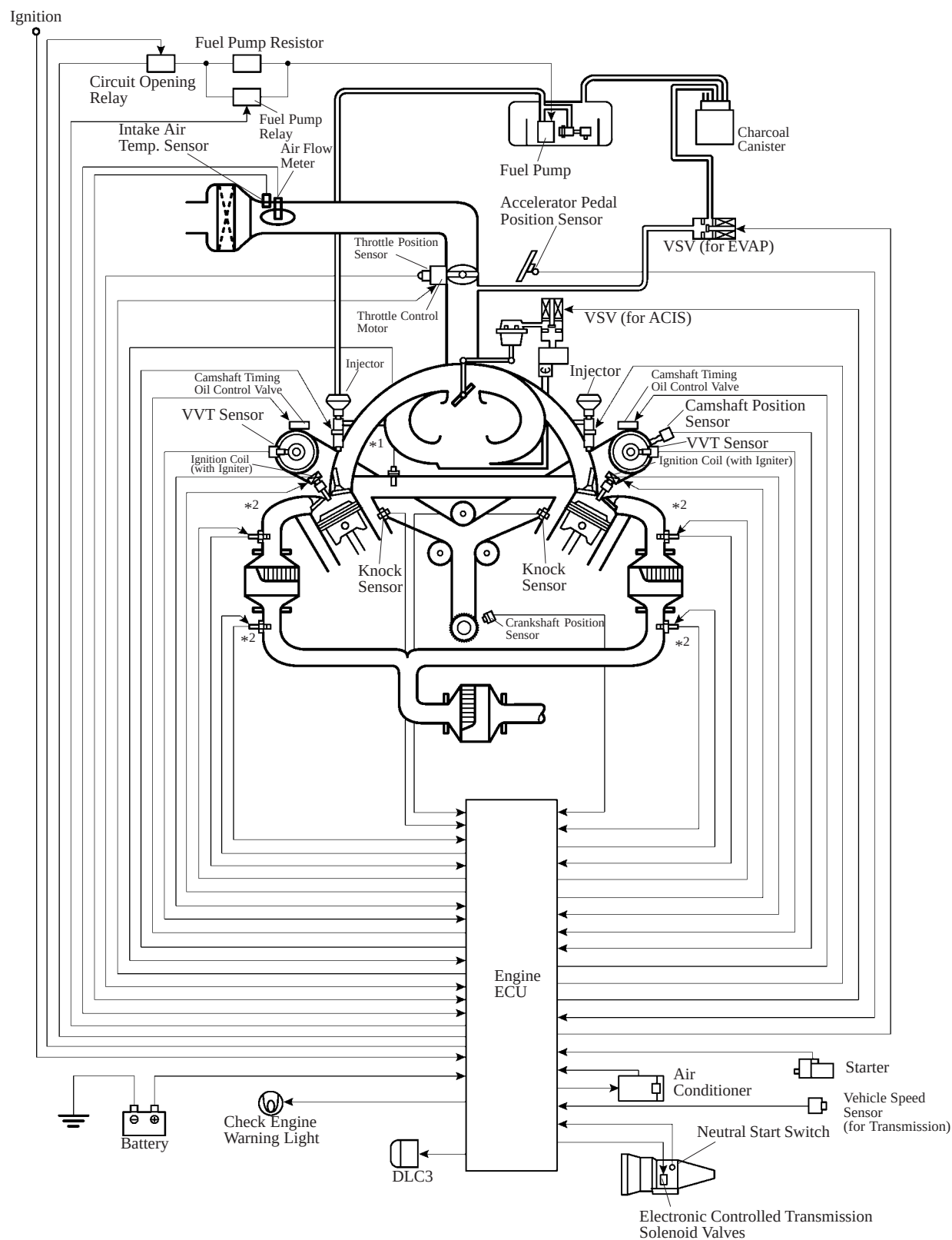
*1: Models for Europe and Australia

*2: Models for G.C.C. Countries

*3: with Smart Key System

*4: without Smart Key System

3. Engine Control System Diagram



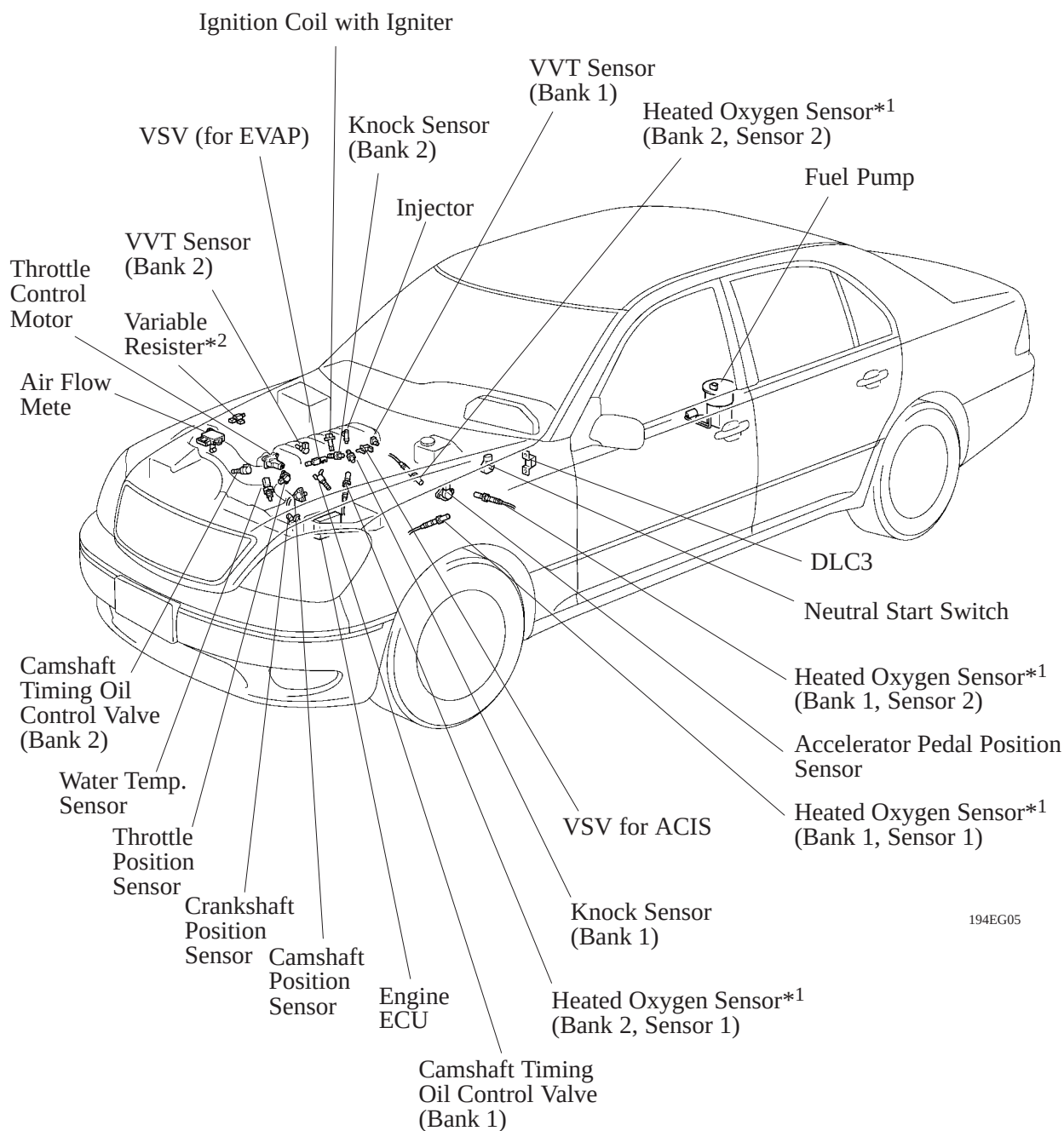
*1: Water Temp. Sensor

*2: Heated Oxygen Sensor (Models for Europe and Australia)

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4. Layout of Main Components



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*¹: Models for Europe and Australia

*²: Models for G.C.C. Countries

5. Main Components of Engine Control System

General

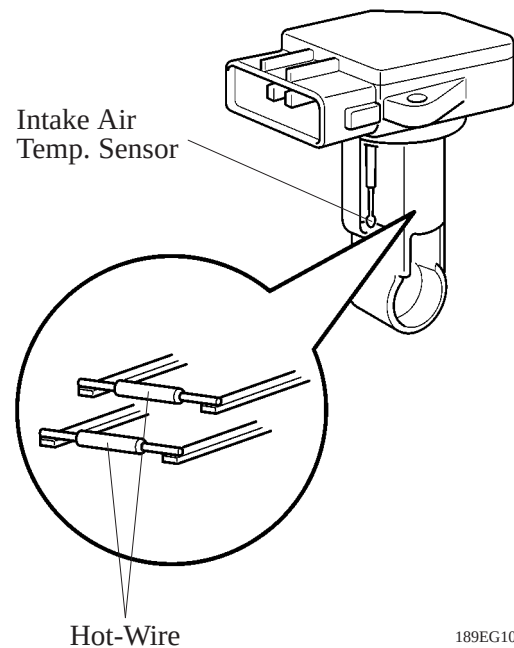
The following table compares the main components of the new 3UZ-FE engine in the LS430 and previous 1UZ-FE engine in the LS400.

Engine Type Components	3UZ-FE		1UZ-FE	
	Outline	Quantity	Outline	Quantity
Air Flow Meter	Hot-Wire Type	1	←	
Crankshaft Position Sensor (Rotor Teeth)	Pick-Up Coil Type (36-2)	1	←	
Camshaft Position Sensor (Rotor Teeth)	Pick-Up Coil Type (1)	1	←	
VVT Sensor	Pick-Up Coil Type (3)	2	←	
Throttle Position Sensor	Linear Type	2	←	
Accelerator Pedal Position Sensor	Linear Type	2	←	
Knock Sensor	Built-In Piezoelectric Type	2	←	
Oxygen Sensor (Bank 1, Sensor 1) (Bank 2, Sensor 1) (Bank 1, Sensor 2) (Bank 2, Sensor 2)	With Heater Type	4	←	
Injector	4-Hole Type with Air Assist	8	←	

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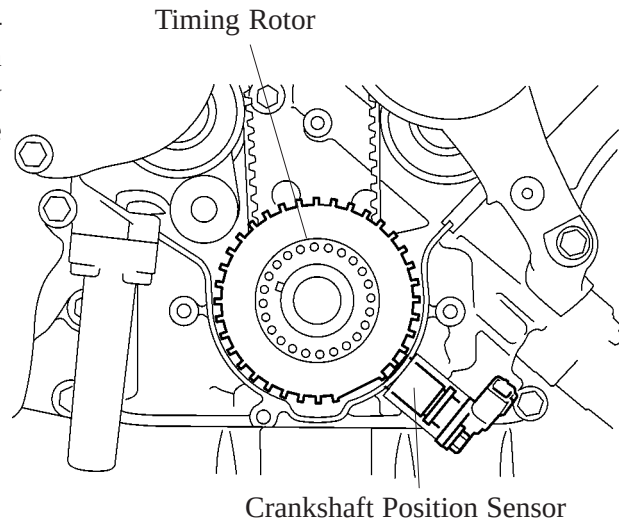
Air Flow Meter

A hot-wire type air flow meter has been adopted. 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.



Crankshaft Position Sensor

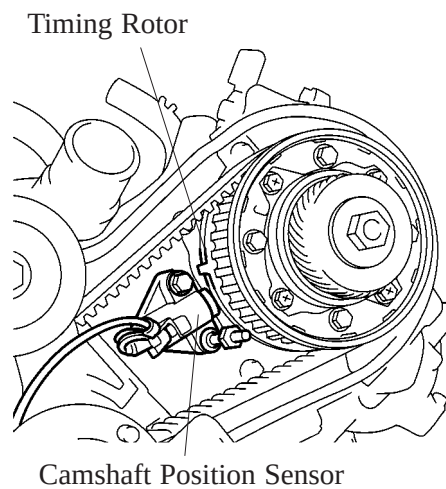
The timing rotor of the crankshaft consists of 34 teeth, with 2 teeth missing. The crankshaft position sensor outputs the crankshaft rotation signals every 10°, and the missing teeth are used to determine the top-dead-center.



151EG18

Camshaft Position Sensor

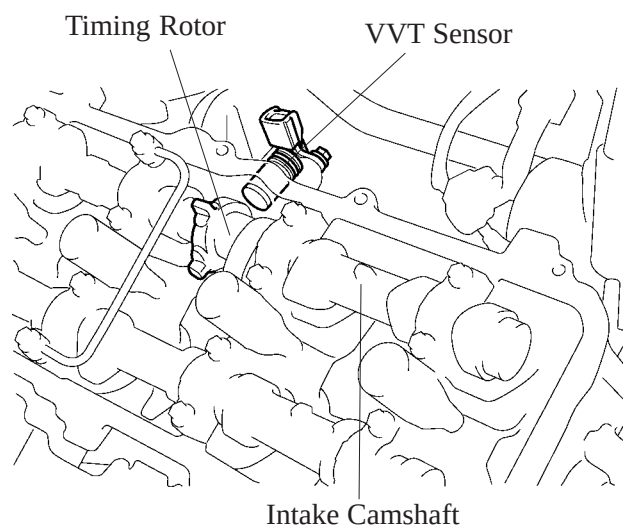
The camshaft position sensor is mounted on the left bank cylinder head. To detect the camshaft position, a protrusion that is provided on the timing pulley is used to generate 1 pulse for every 2 revolutions of the crankshaft.



151EG19

VVT Sensor

A VVT sensor is mounted on the intake side of each cylinder head. To detect the camshaft position, a timing rotor that is provided on the intake camshaft is used to generate 3 pulses for every 2 revolutions of the crankshaft.

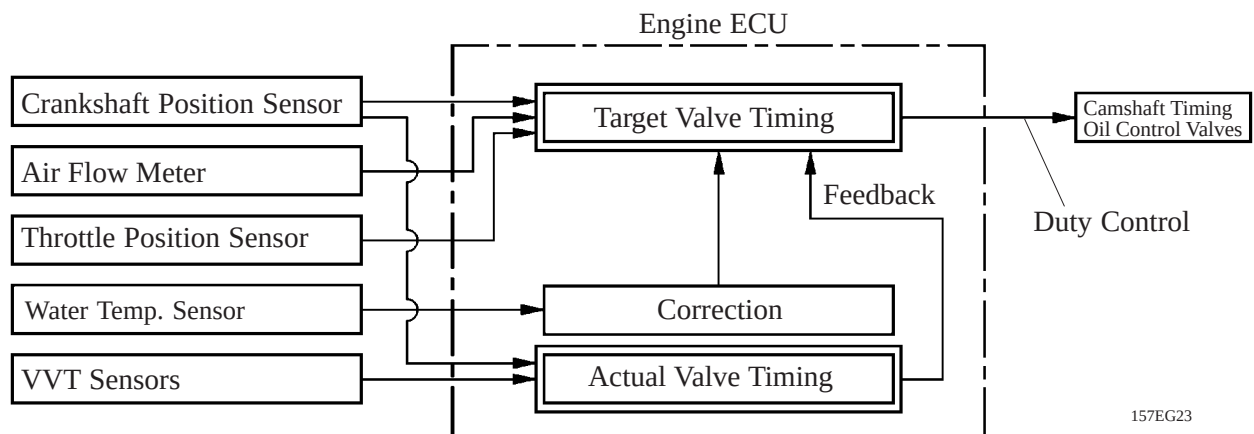
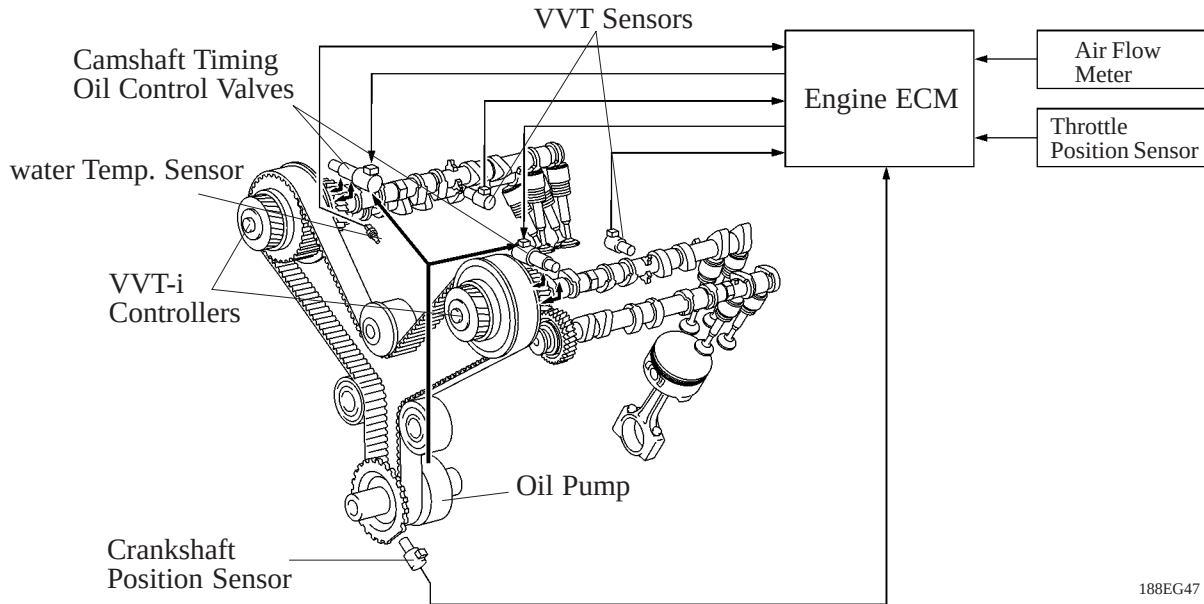


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6. VVT-i (Variable Valve Timing-intelligent) System

General

The VVT-i system is designed to control the intake camshaft within a wide range of 45° (of crankshaft angle) to provide a valve timing that is optimally suited to the engine condition, thus realizing improved torque in all the speed ranges and fuel economy, and reduce exhaust emissions.

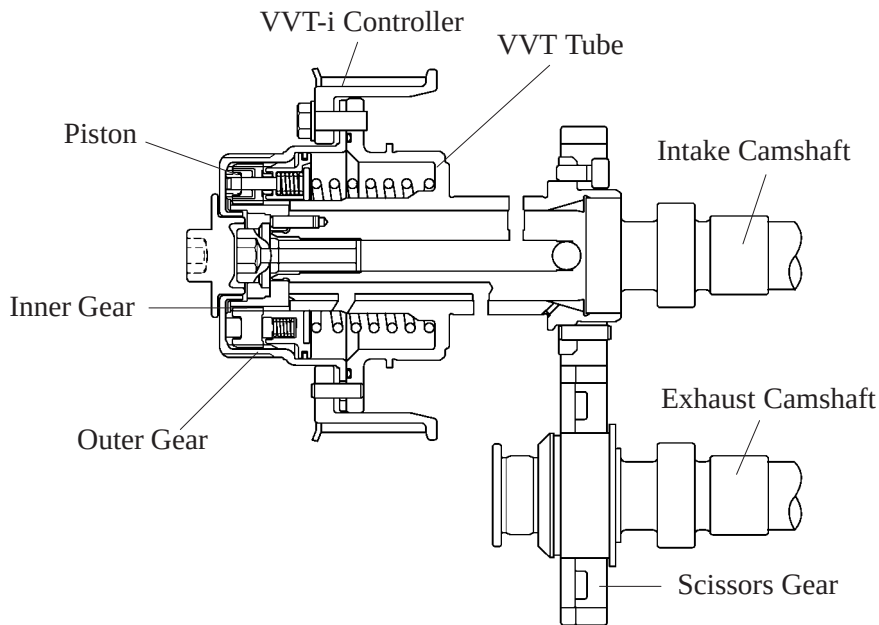


Construction and Operation

1) VVT-i Controller

The VVT-i controller comprises the outer gear that is driven by the timing belt, the inner gear that is affixed to the camshaft and a movable piston that is placed between the outer gear and inner gear. Having helical splines (twisted, vertical grooves) on its inner and outer periphery, the piston moves in the axial direction to shift the phase of the outer gear and inner gear, thus causing the valve timing to change continuously.

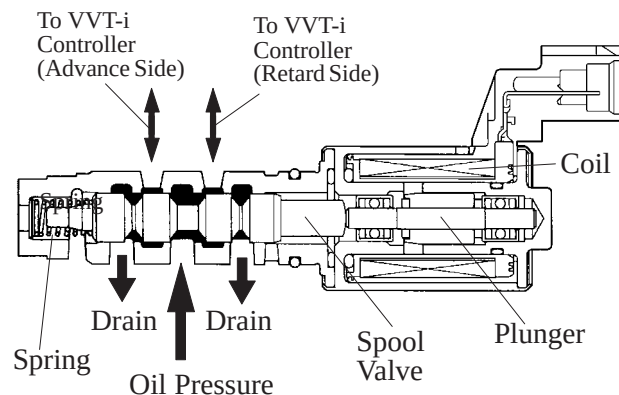
The VVT tube drives the exhaust camshaft via the scissors gear that is installed on the back.



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2) Camshaft Timing Oil Control Valve

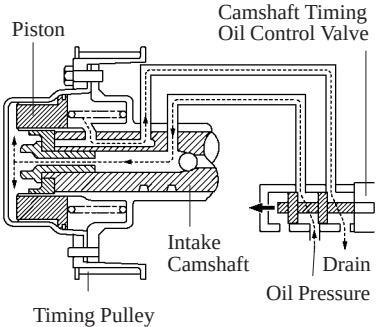
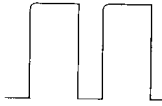
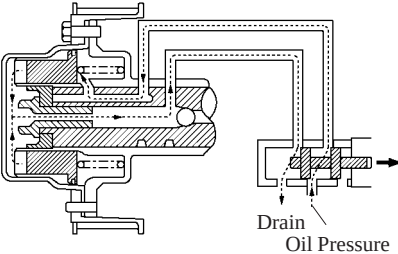
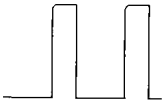
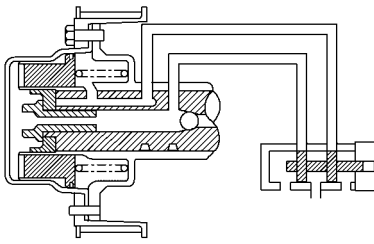
The camshaft timing oil control valve controls the spool valve position in accordance with the duty control from the engine ECU thus allocating the hydraulic pressure that is applied to the VVT-i controller to the advance and the retard side. When the engine is stopped, the camshaft timing oil control valve is in the most retarded state.



165EG34

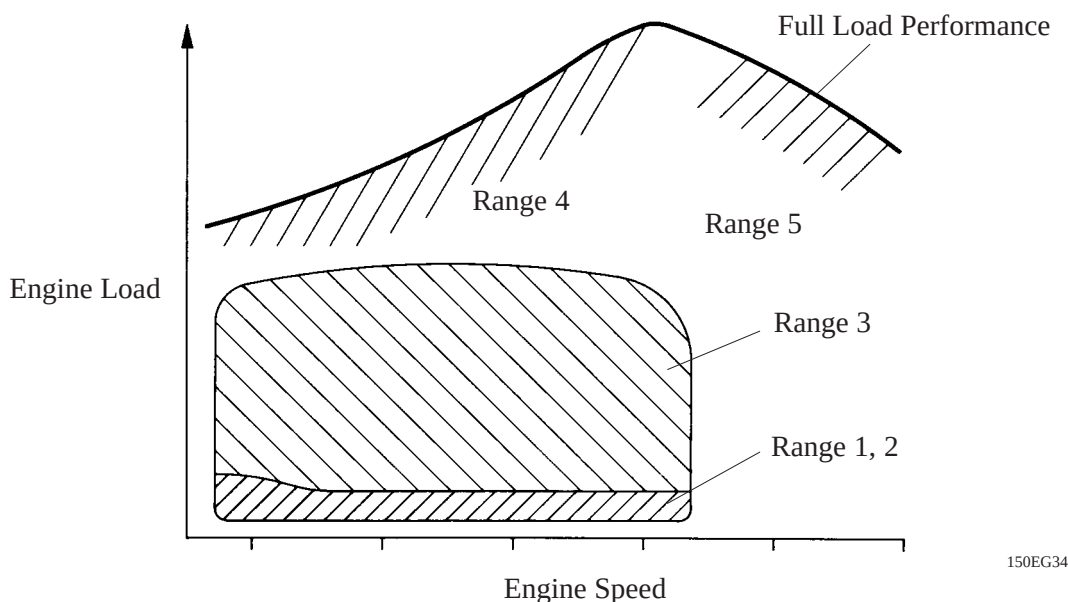
Operation

- The camshaft timing oil control valve selects the path to the VVT-i controller according to the advance, retard or hold signal from the engine ECU. The VVT-i controller rotates the intake camshaft in the timing advance or retard position or holds it according to the position where the oil pressure is applied.

	Operation	Camshaft Timing Oil Control Valve Drive Signal	Description
Advance	 188EG48	Advance Signal  Duty Ratio 157EG35	When the camshaft timing oil control valve is positioned as illustrated in accordance with the advance signal from the engine ECU, the oil pressure is applied to the chamber at the advance side. Then, the twist of the helical spline causes the camshaft to rotate in the direction of timing advance.
Retard	 188EG49	Retard Signal  Duty Ratio 157EG36	When the camshaft timing oil control valve is positioned as illustrated in accordance with the retard signal from the engine ECU, the oil pressure is applied to the chamber at the retard side. Then, the twist of the helical spline causes the camshaft to rotate in the direction of timing retard.
Hold	 188EG50	Hold Signal  Duty Ratio 157EG37	The engine ECU calculates the target timing angle according to the traveling state to perform control as described above. After setting at 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.

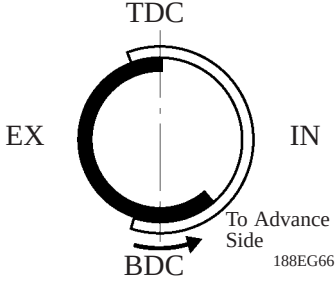
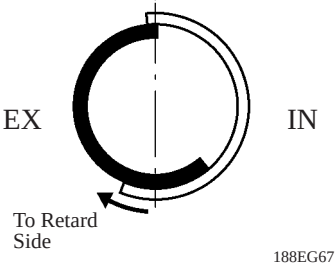
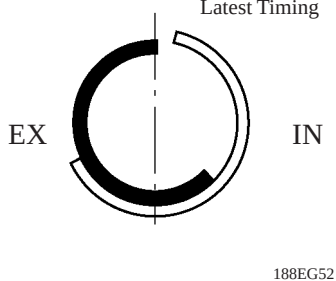
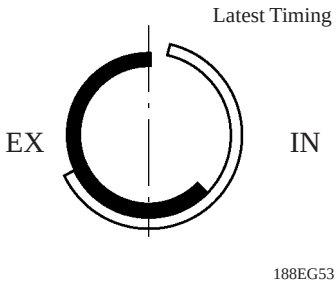
- In proportion to the engine speed, intake air volume, throttle position and water temperature, the engine ECU calculates an optimal valve timing under each driving condition and control the camshaft timing oil control valve. In addition, engine ECU uses signal from the VVT sensors and the crankshaft position sensor to detect the actual valve timing, thus performing feed back control to achieve the target valve timing.

► Operation During Various Driving Condition (Conceptual Diagram) ◀



150EG34

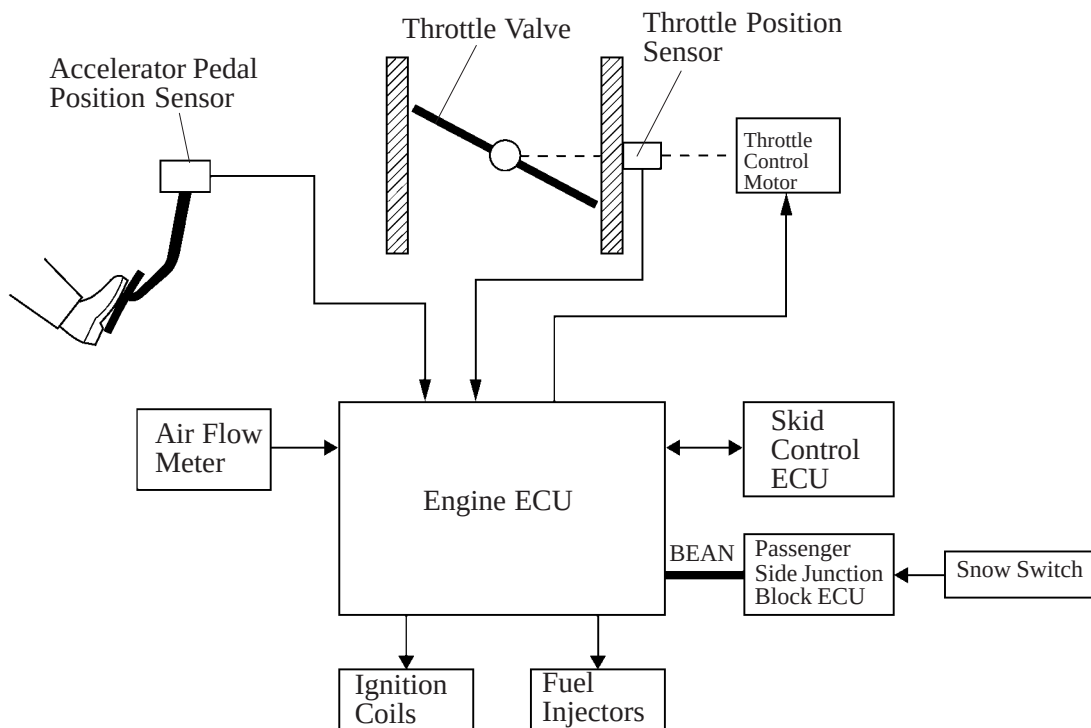
Operation State	Range	Valve Timing	Objective	Effect
During Idling	1	TDC Latest Timing EX IN BDC 188EG51	Eliminating overlap to reduce blow back to the intake side	Stabilized idling rpm Better fuel economy
At Light Load	2	To Retard Side EX IN 188EG64	Decreasing overlap to eliminate blow back to the intake side	Ensured engine stability
At Medium load	3	To Advance Side EX IN 188EG65	Increasing overlap to increase internal EGR for pumping loss elimination	Better fuel economy Improved emission control

Operation State	Range	Valve Timing	Objective	Effect
In Low to Medium Speed Range with Heavy Load	4		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	5		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 idling.	Stabilized fast idle rpm Better fuel economy
Upon Starting/Stopping the Engine	—		Eliminating overlap to minimize blow back to the intake side	Improved startability

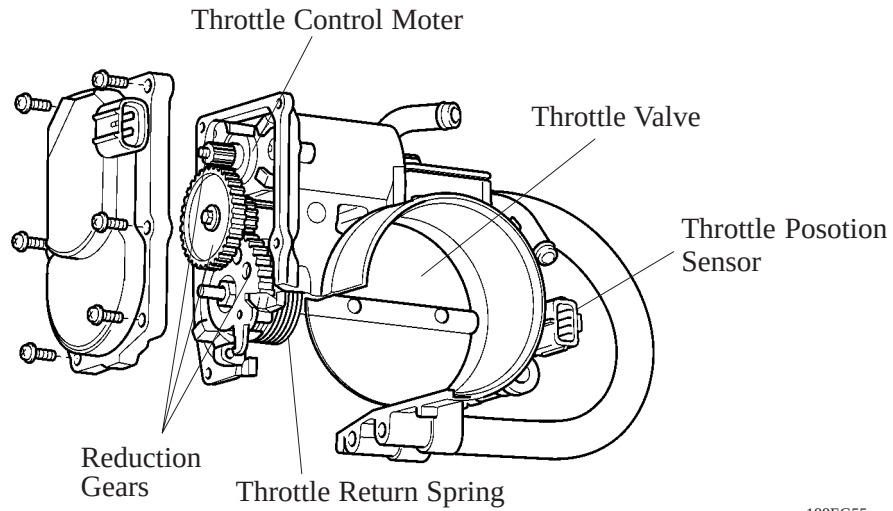
7. ETCS-i (Electronic Throttle Control System-intelligent)

General

- The ETCS-i system, which realizes excellent throttle control in all the operating ranges, has been adopted. However, in the new 3UZ-FE engine, the accelerator cable has been discontinued, and an accelerator position sensor has been provided on the accelerator pedal. Accordingly, the limp-mode control during the fail-safe mode has been changed.
- In the conventional throttle body, the throttle valve opening is determined invariably 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 snow mode control, the cruise control system, the TRC (Traction Control) system, and the VSC (Vehicle Stability Control) system.
- The torque-activated power train control has been newly adopted. This control enables the engine to generate the necessary torque as desired by the driver, as well as to realize a smooth engine output characteristic.



Construction

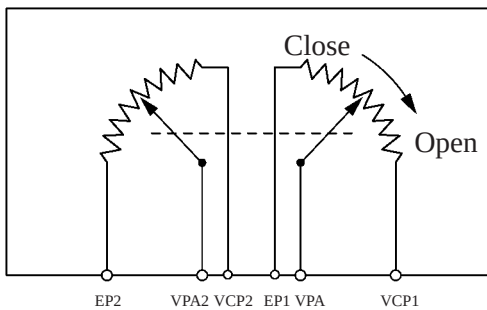


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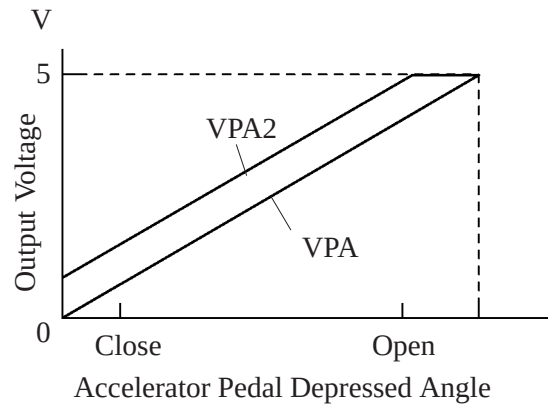
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1) Accelerator Pedal Position Sensor

The accelerator pedal position sensor is attached to the accelerator pedal. This sensor converts the accelerator pedal depressed angles into electric signals with two differing characteristics and outputs them to the engine ECU. One is the VPA signal that linearly outputs the voltage along the entire range of the accelerator pedal depressed angle. The other is the VPA2 signal that outputs an offset voltage.



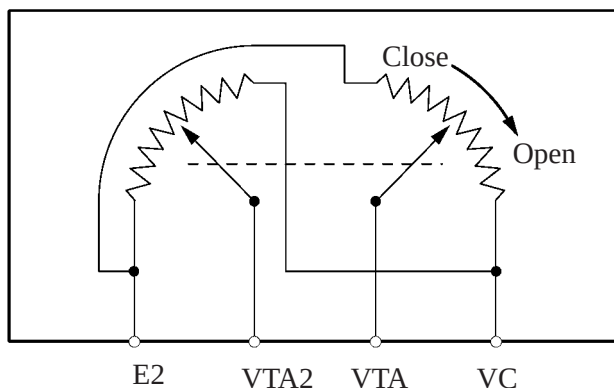
188EG56



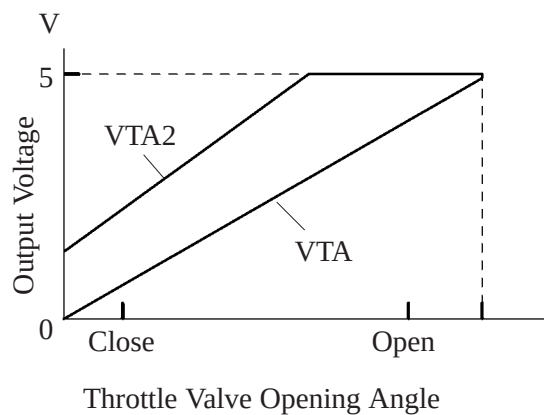
188EG57

2) Throttle Position Sensor

The throttle position sensor is attached to the throttle body. This sensor converts the throttle valve opening angles into electric signals with two differing characteristics and outputs them to the engine ECU. One is the VTA signal that linearly outputs the voltage along the entire range of the throttle valve opening angle. The other is the VTA2 signal that outputs an offset voltage.



150EG40



150EG39

3) 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 angle of the throttle valve.

Operation

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

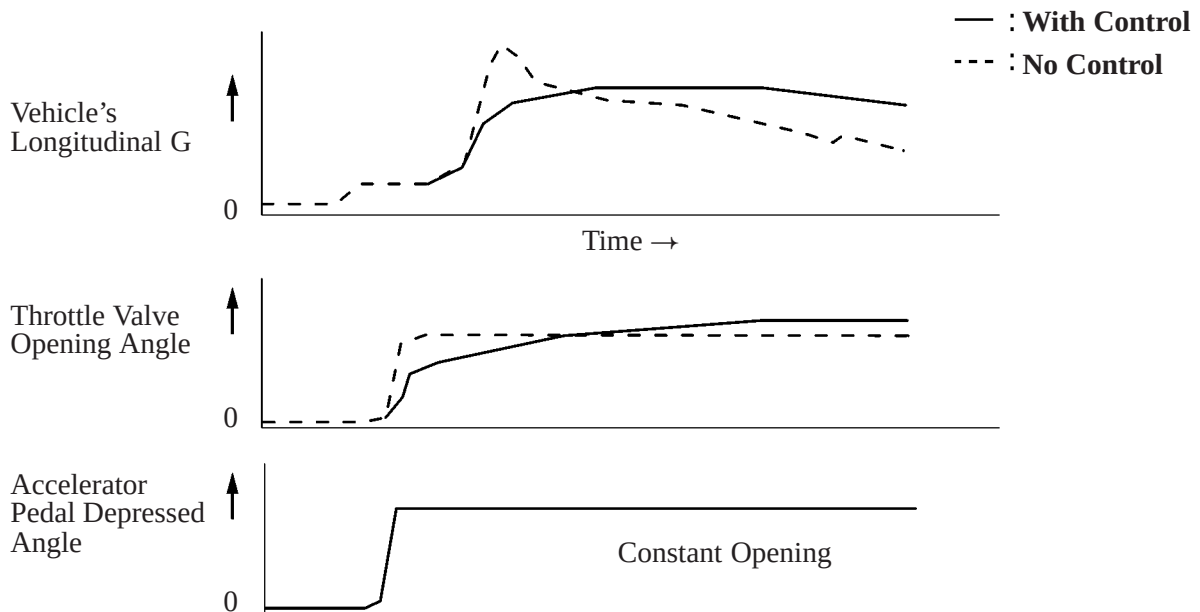
In addition to the controls listed below, torque-activated power train control has been newly adopted in the LS430.

- 1) Torque Activated Power Train Control ← New Control
- 2) Nomal-mode Control, Power-mode Control and Snow-mode Control
- 3) Idle Speed Control
- 4) Shift Shock Reduction Control
- 5) TRC Throttle Control
- 6) VSC Coordination Control
- 7) Cruise Control

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1) Torque Activated Power Train Control

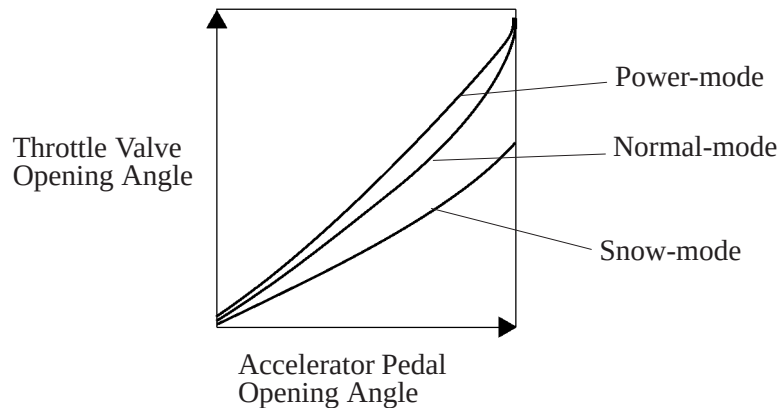
Controls the throttle to an optimal throttle valve opening that is appropriate for the driving condition such as the amount of the accelerator pedal effort and the engine operating condition. As a result, excellent throttle control and comfort in all operating ranges, as well as smooth startoff acceleration and elastic acceleration have been achieved.



188EG58

2) Normal-mode Control, Power-mode Control and Snow-mode 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 operating condition in order to realize excellent throttle control and comfort in all operating ranges.
- If turning ON the POWER switch of the pattern select switch and selecting the power-mode, the throttle valve opening angle is controlled to react more directly to the operation of the accelerator pedal than the normal mode. With this, sporty driving is realized.
- In situations in which low- μ surface conditions can be anticipated, such as when driving in the snow, the throttle valve can be controlled to help vehicle stability while driving over the slippery surface. This is accomplished by turning on the SNOW switch of the pattern select switch, which, in response to the amount of the accelerator pedal effort that is applied, reduces the engine output from that of the normal driving level.



189EG38

Conceptual Diagram

3) Idle Speed Control

Controls the engine ECU and the throttle valve in order to constantly effect ideal idle speed control.

4) Shift Shock Reduction Control

The throttle control is synchronized to the ECT (Electronically Controlled Transmission) control during the shifting of the transmission in order to reduce the shift shock.

5) 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 ensuring stability and driving force.

6) 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.

7) Cruise Control

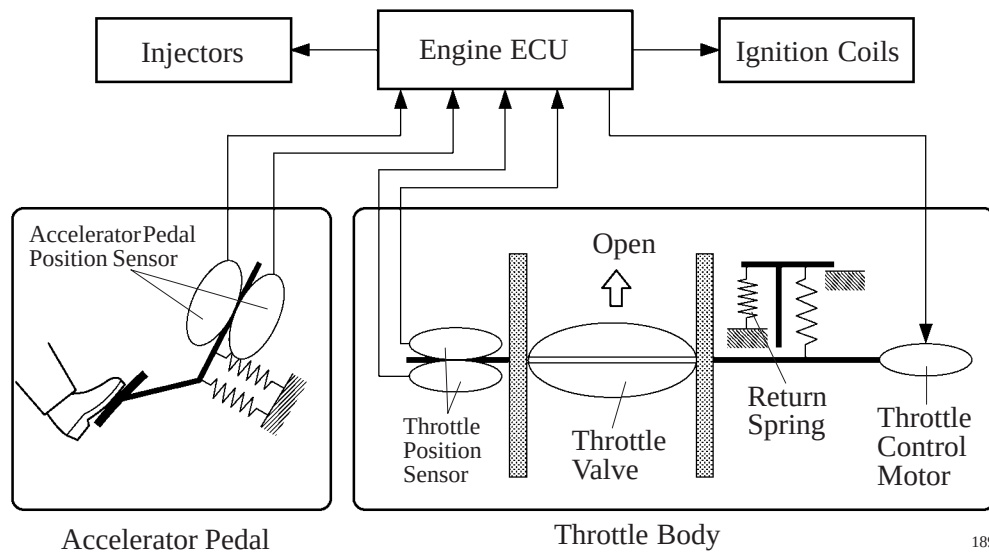
An engine ECU with an integrated cruise control ECU directly actuates the throttle valve to effect the operation of the cruise control.

Fail-Safe

If an abnormal condition occurs with the ETCS-i system, the check engine warning light in the combination meter illuminates to inform the driver.

The accelerator pedal position sensor comprises two sensor circuits. Therefore, if an abnormal condition occurs in the accelerator pedal position sensor, and the engine ECU detects the abnormal voltage difference of the signals between these two sensor circuits, the engine ECU transfers to the limp mode by limiting the accelerator opening signal.

If an abnormal condition occurs in the throttle body system which comprises two sensor circuits, the engine ECU detects the abnormal voltage difference of the signals between these two circuits and cuts off the current to the throttle motor, causing the throttle valve to close. However, when the throttle motor is OFF, because a return spring is provided in the throttle valve, the force of the spring keeps the throttle valve slightly open from the fully closed state. In this state, fuel injection control and ignition timing retard control are effected in accordance with the accelerator opening, thus enabling the vehicle to be operated within the range of idling and limp mode.



EG

Diagnosis

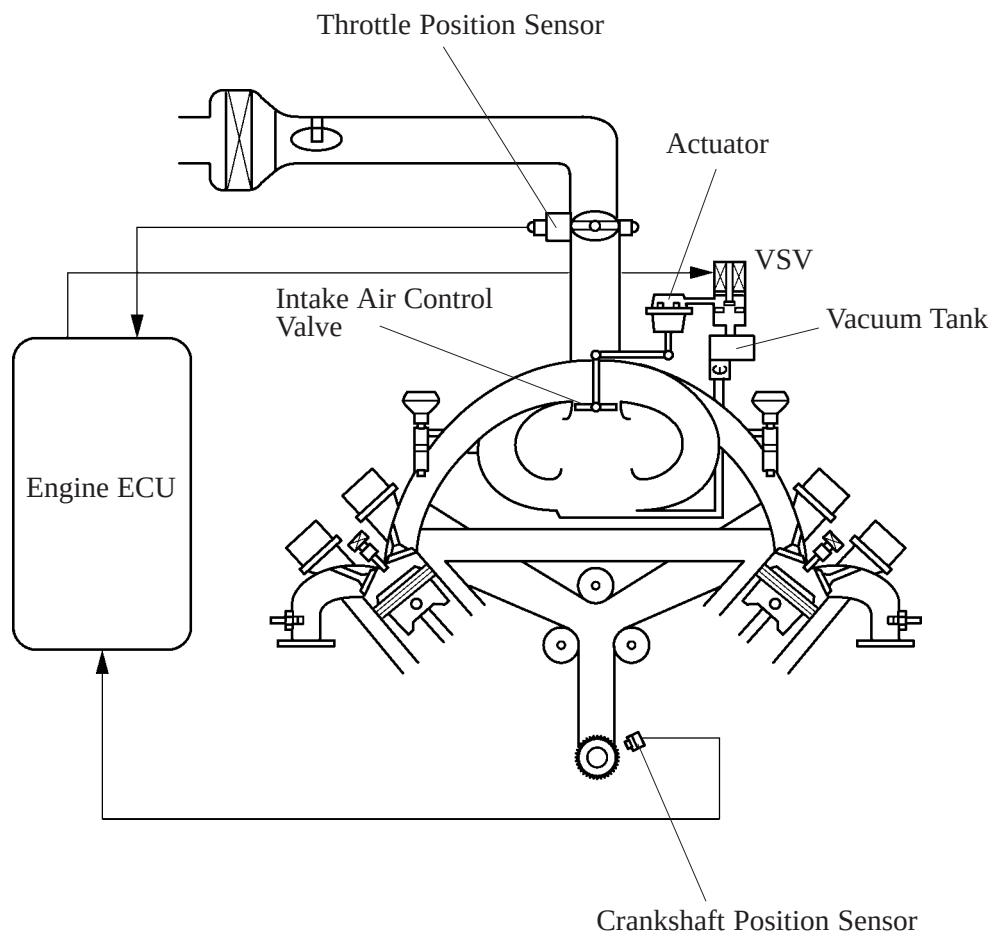
The DTCs (Diagnosis Trouble Codes) can be output to a hand-held tester via the DLC3. For details, refer to the LEXUS LS430 Repair Manual (Pub. No. RM792E).

8. ACIS (Acoustic Control Induction System)

General

The ACIS (Acoustic Control Induction System) 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.

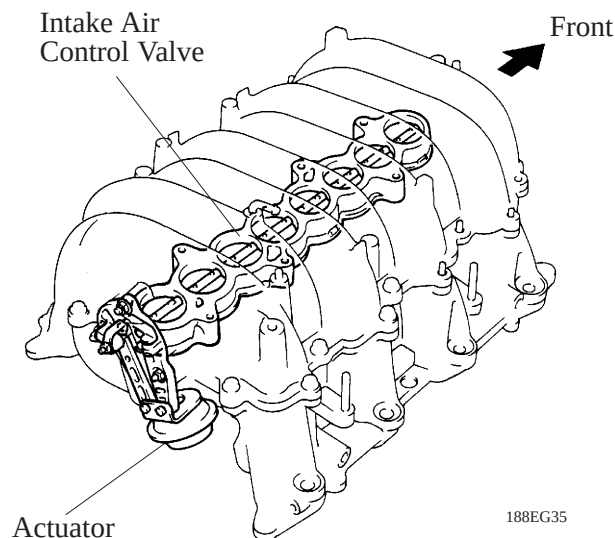
► System Diagram ◀



Construction

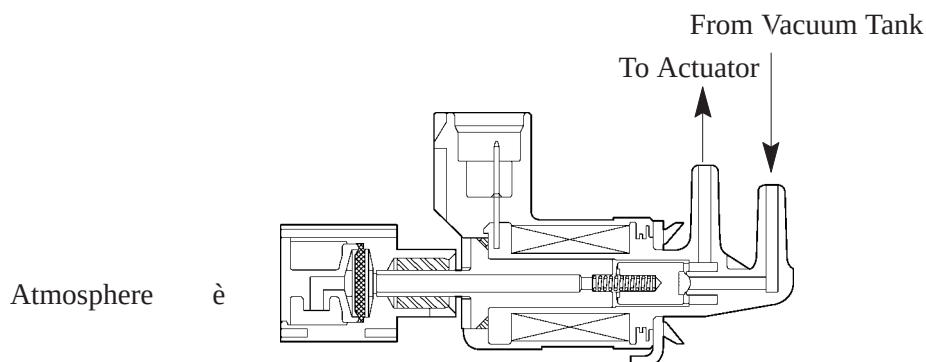
1) Intake Air Control Valve

The intake air control valve, which is provided in the middle of the intake manifold in the intake air chamber, opens and closes to change the effective length of the intake manifold in two stages.



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.



151EG42

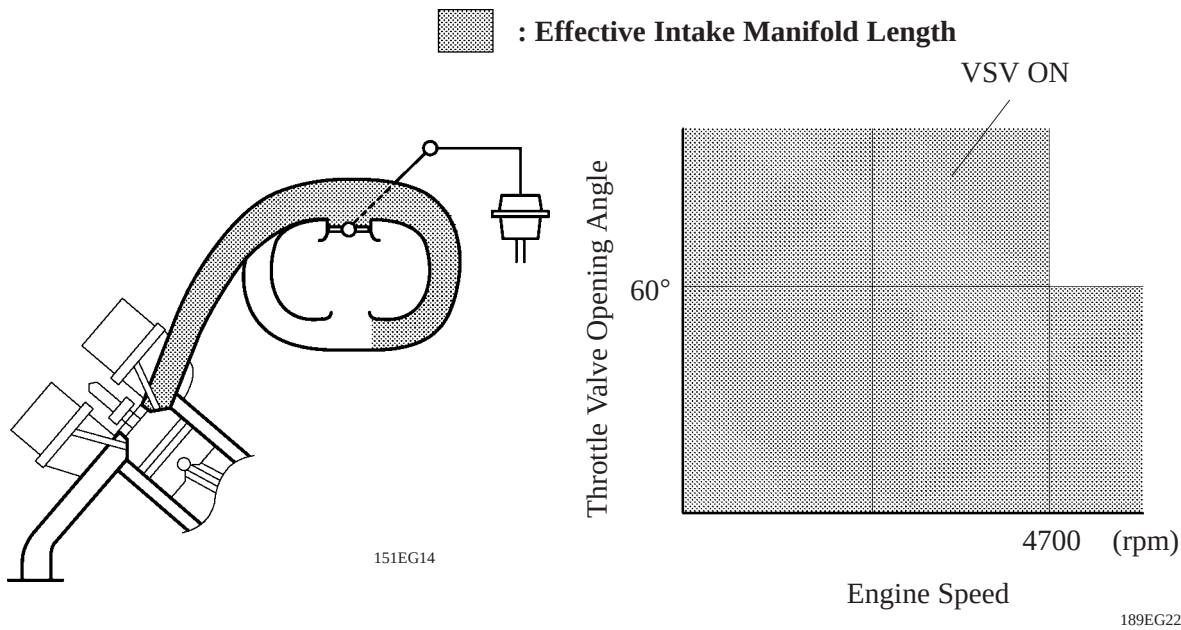
3) Vacuum Tank

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

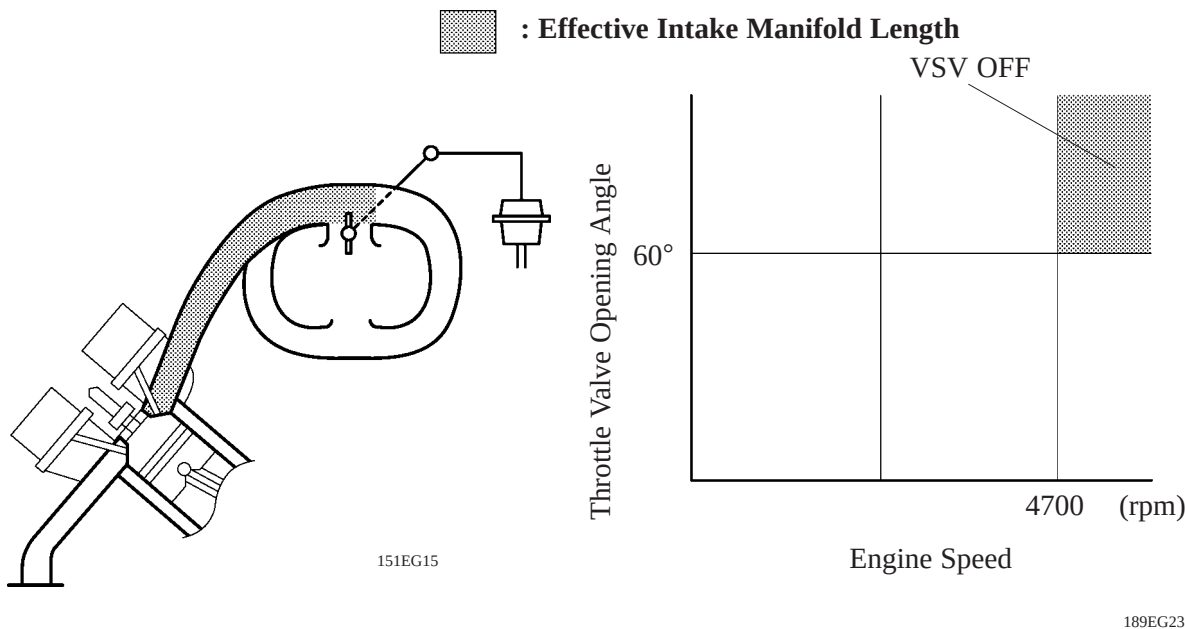
1) When the Intake Control Valve Closes (VSV ON)

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.



2) When the Intake Control Valve Open (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 speeds.

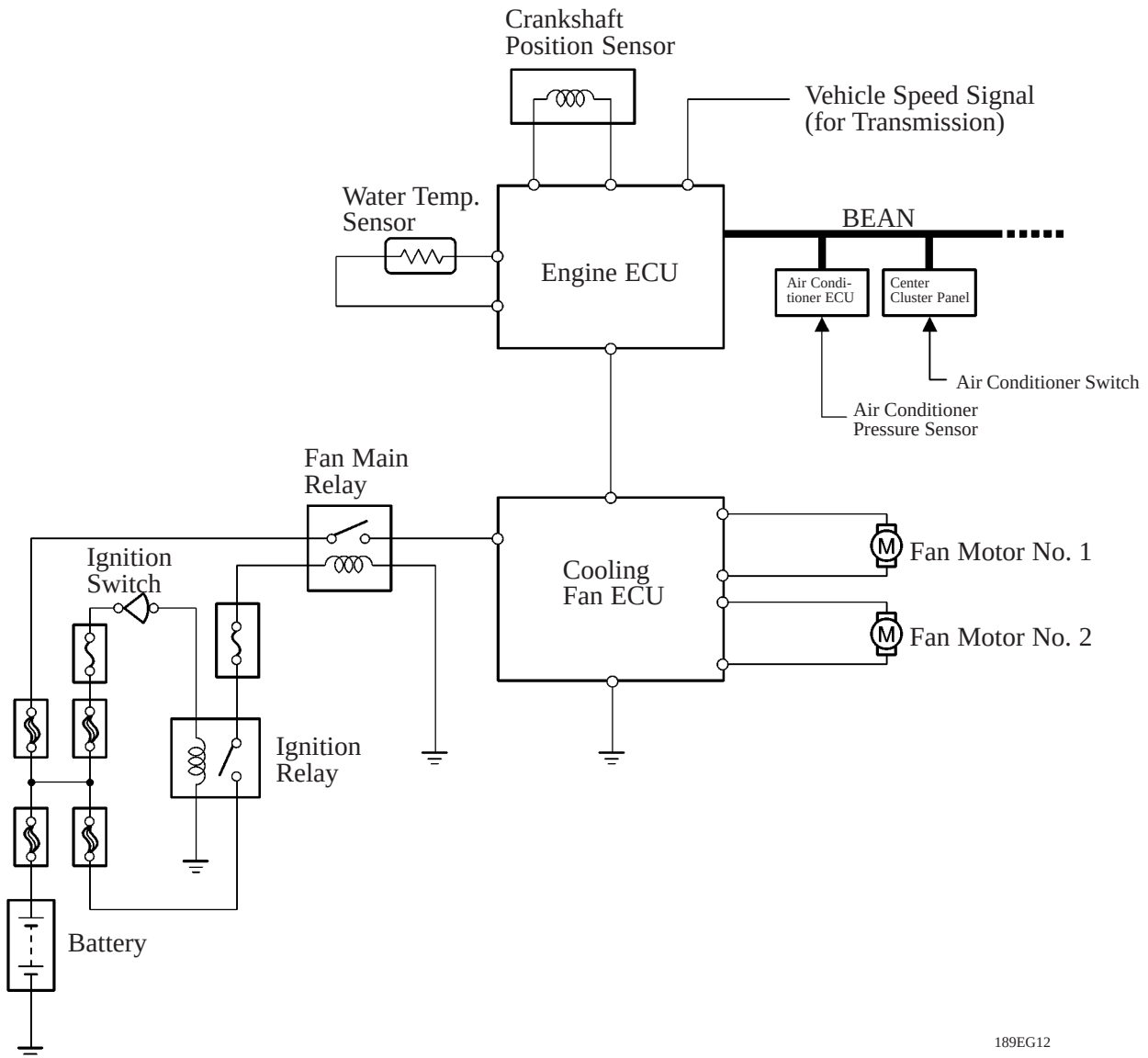


9. Cooling Fan System

General

A cooling fan system has been adopted by the new 3UZ-FE engine on the LS430. To achieve an optimal fan speed in accordance with the engine coolant temperature, vehicle speed, engine speed, and air conditioner operating conditions, the engine ECU calculates the proper fan speed and sends the signals to the cooling fan ECU. Upon receiving the signals from the engine ECU, the cooling fan ECU actuates the fan motors. Also, the fan speed is controlled by engine ECU using the stepless control.

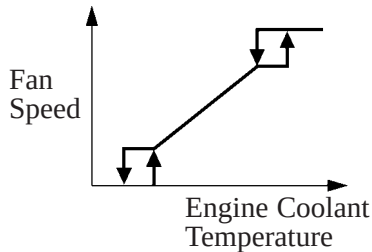
► Wiring Diagram ◀



Operation

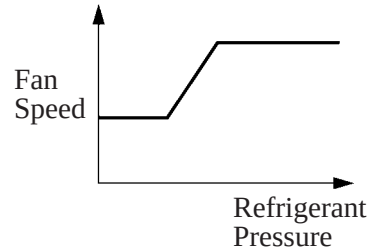
As illustrated below, the engine ECU determines the required fan speed by selecting the fastest fan speed from among the following:

(A) The fan speed required by the engine coolant temperature, (B) the fan speed required by the air conditioner refrigerant pressure, (C) the fan speed required by the engine speed, and (D) the fan speed required by the vehicle speed.



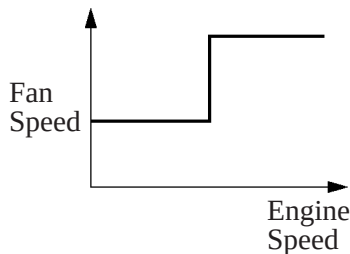
(A) Fan speed required by engine coolant temperature

189EG13



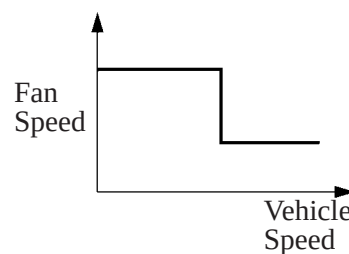
(B) Fan speed required by air conditioner refrigerant pressure

189EG14



(C) Fan speed required by engine speed

189EG15



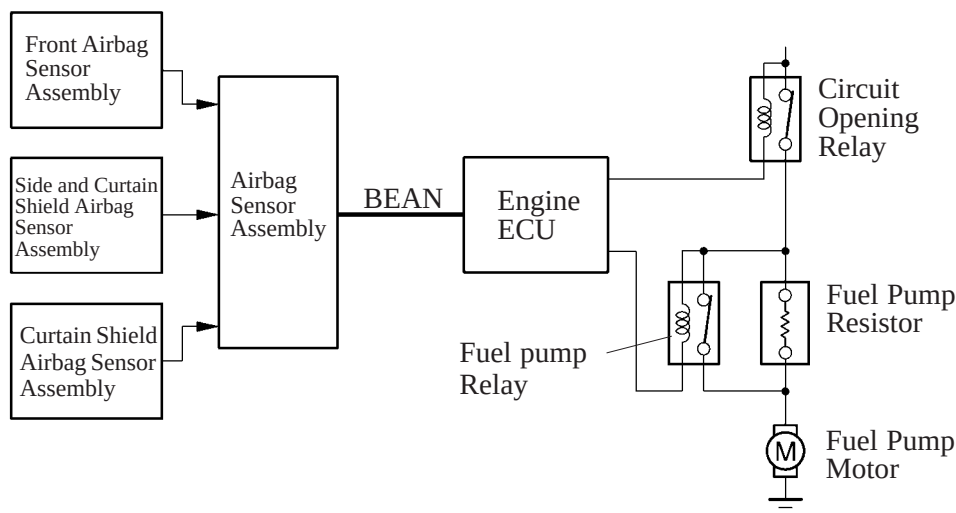
(D) Fan speed required by vehicle speed

189EG16

10. Fuel Pump Control

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, thus engine can be restarted.



189EG17