■ENGINE CONTROL SYSTEM

1. General

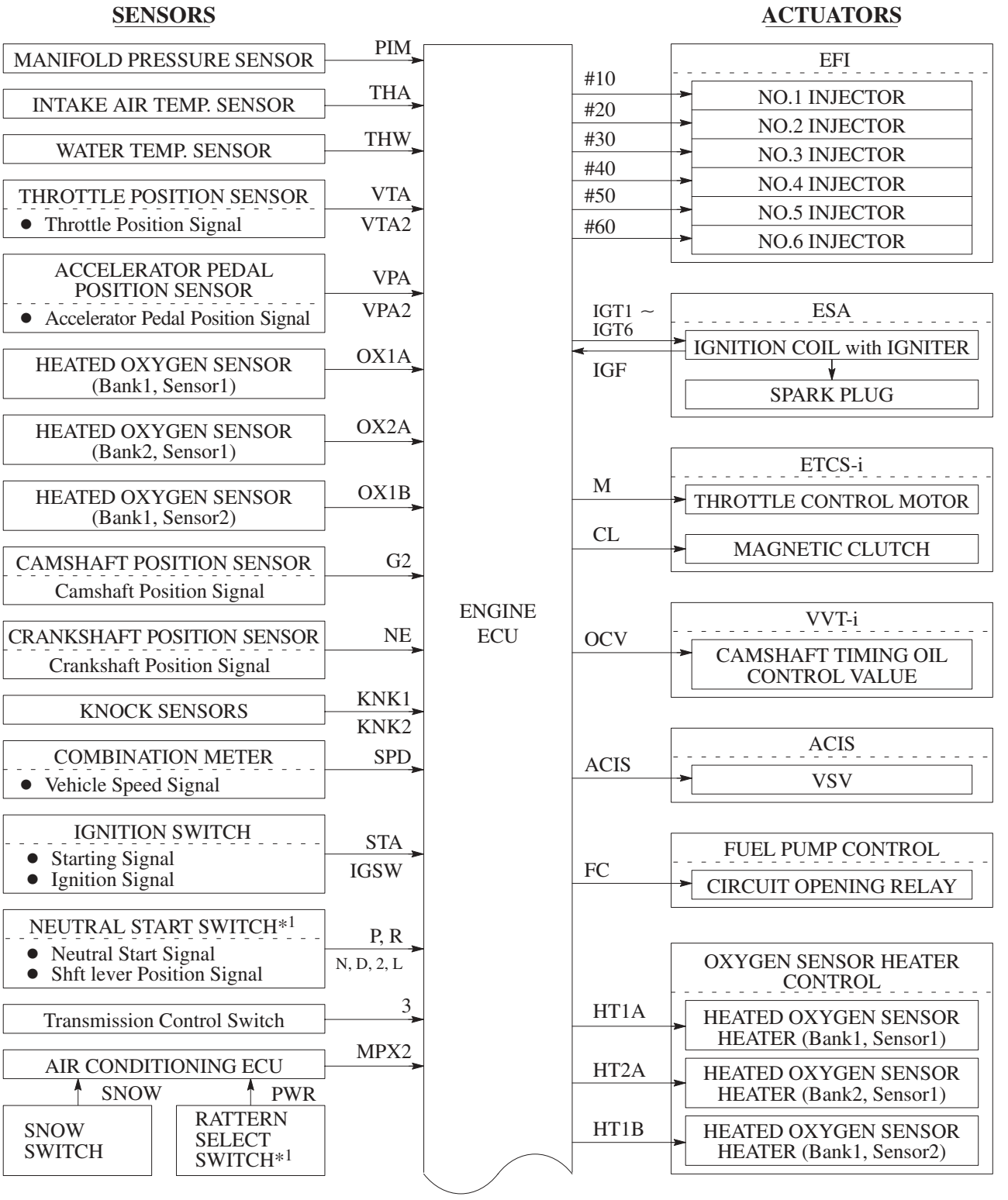
The engine control system for the 1G-FE engine has following system.

System	Outline
EFI (Electronic Fuel Injection)	● A D-type EFI system is used, which indirectly detects intake air volume by manifold pressure sensor signal. ● The fuel injection 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. Corrects ignition timing in response to engine knocking. ● The torque control correction during automatic transmission 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.
ETCS-i (Electronic Throttle Control System-intelligent)	Optimally controls the throttle valve opening in accordance with the amount of the accelerator pedal effort, and the conditions of the engine and the vehicle, and comprehensively controls the ISC, cruise control, snow mode and the TRC system.
ACIS (Acoustic Control Induction System)	The intake air passages are switched according to the engine speed and throttle valve opening angle to provide high performance in all speed ranges.
Fuel Pump Control	Fuel pump operation is controlled by signal from the engine ECU.
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.
Air Conditioning Cut-off Control	By turning the air conditioning 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 conister 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	Comunicates with the body ECU, A/C ECU, meter 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.

*: Only for Automatic Transmission Model

2. Construction

The configuration of the engine control system in the 1G-FE engine is shown in the following chart.



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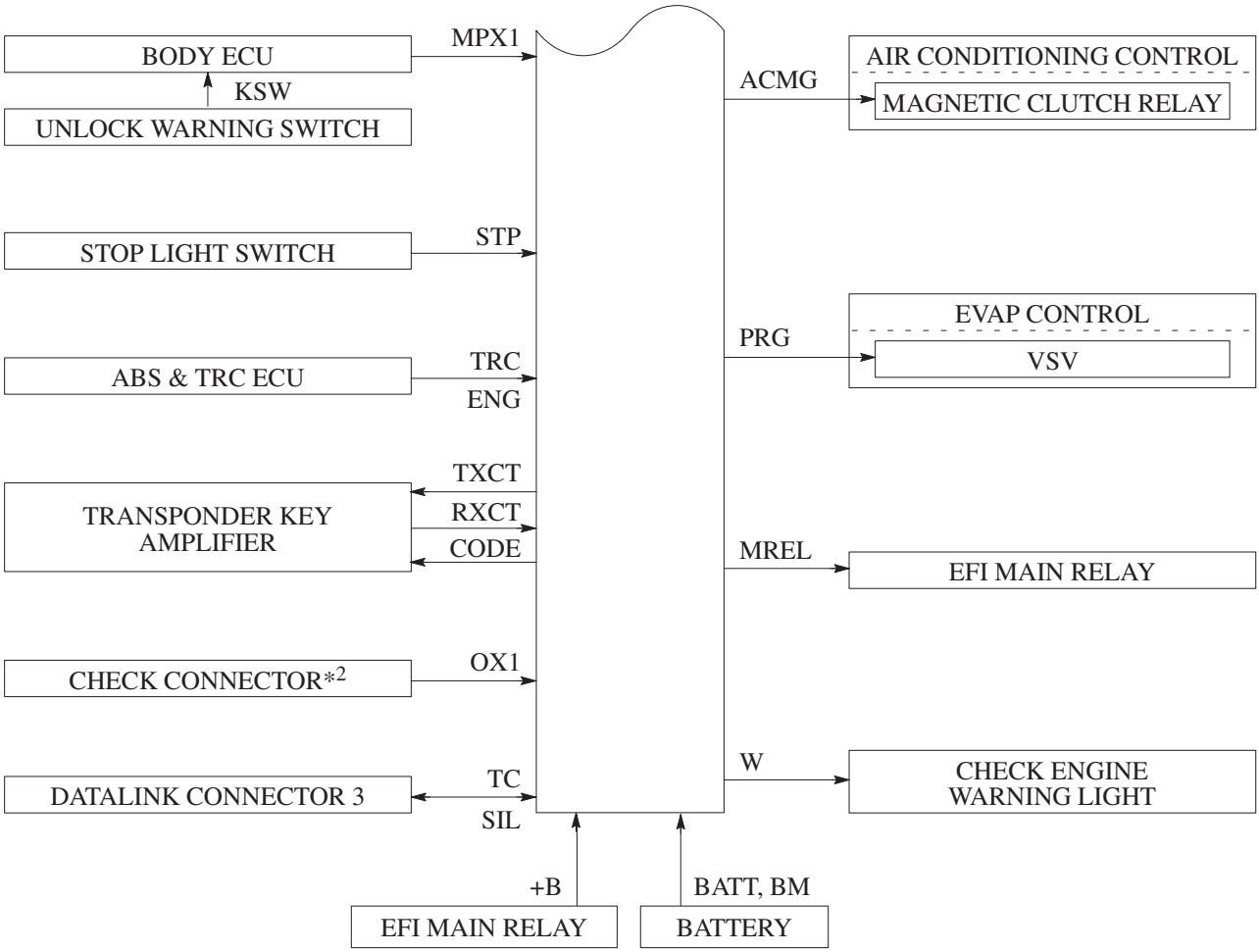
*1: Only for Automatic Transmission Model



*2: Only for Germany Model

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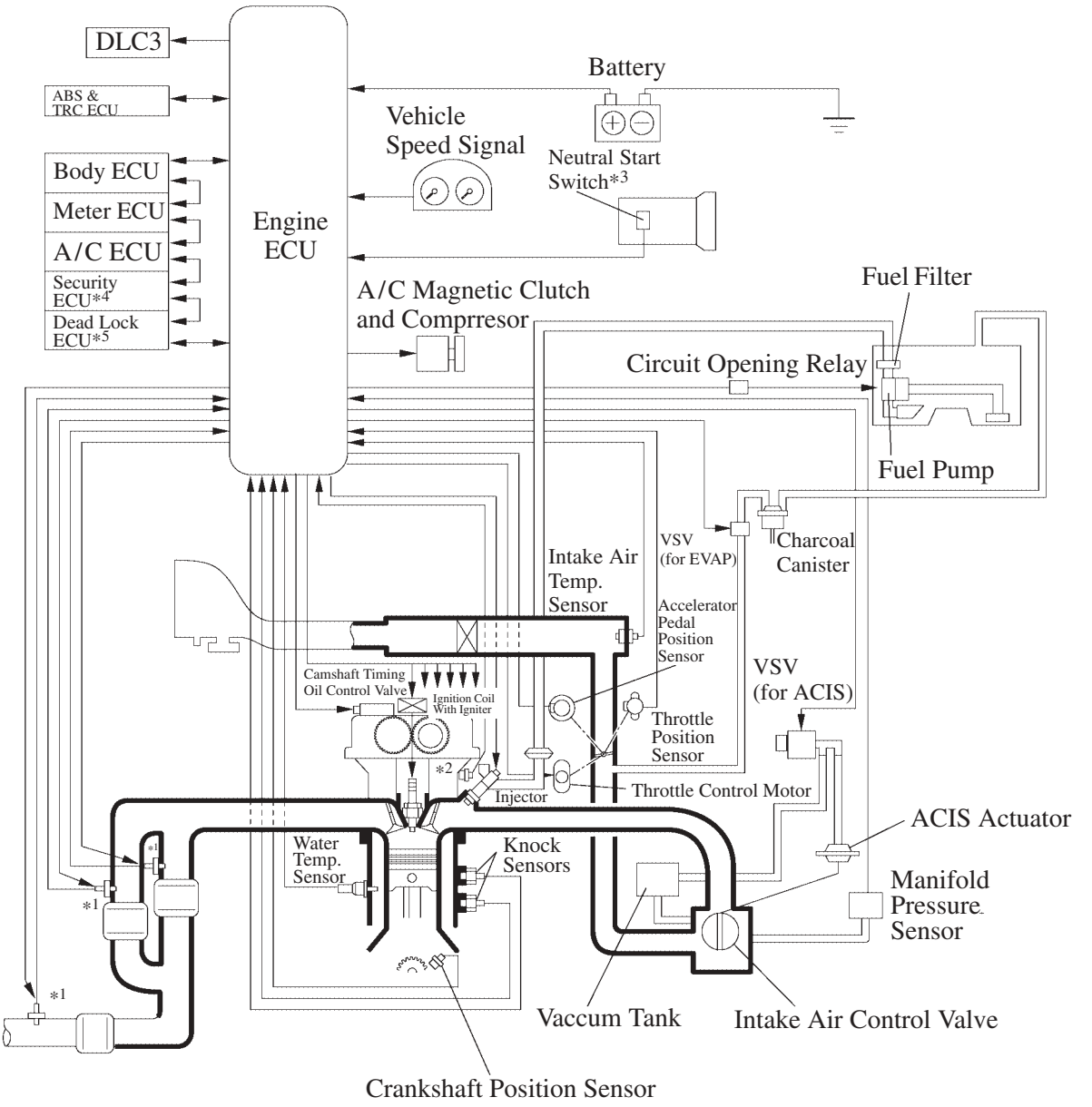
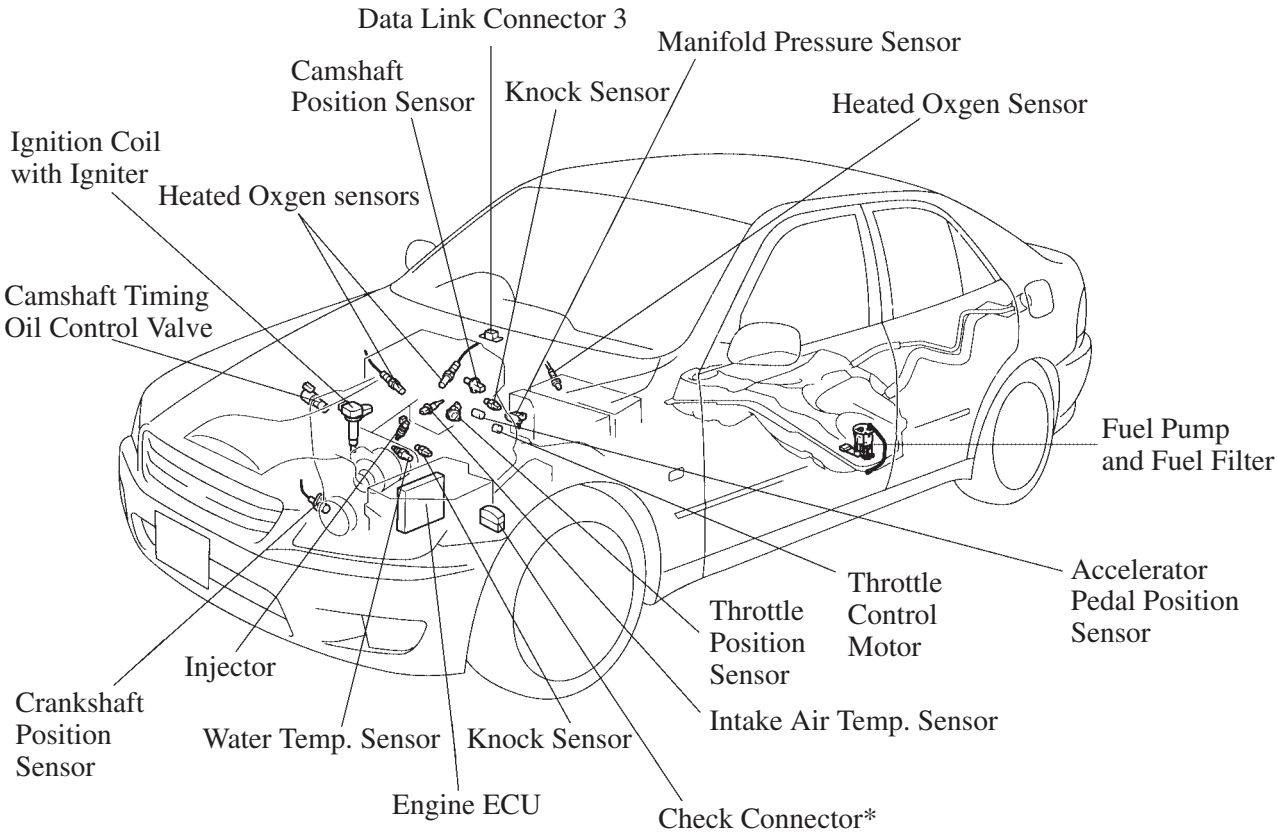
3. Engine Control System Diagram



*1: Heated Oxygen Sensor
*2: Camshaft Position Sensor
*3: Only for Automatic Transmission Model
*4: With Theft Detterrent System
*5: With Dead Lock System

4. Layout of Main Components



163EG43

*: Only for Germany Model

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5. Main Components of Engine control system

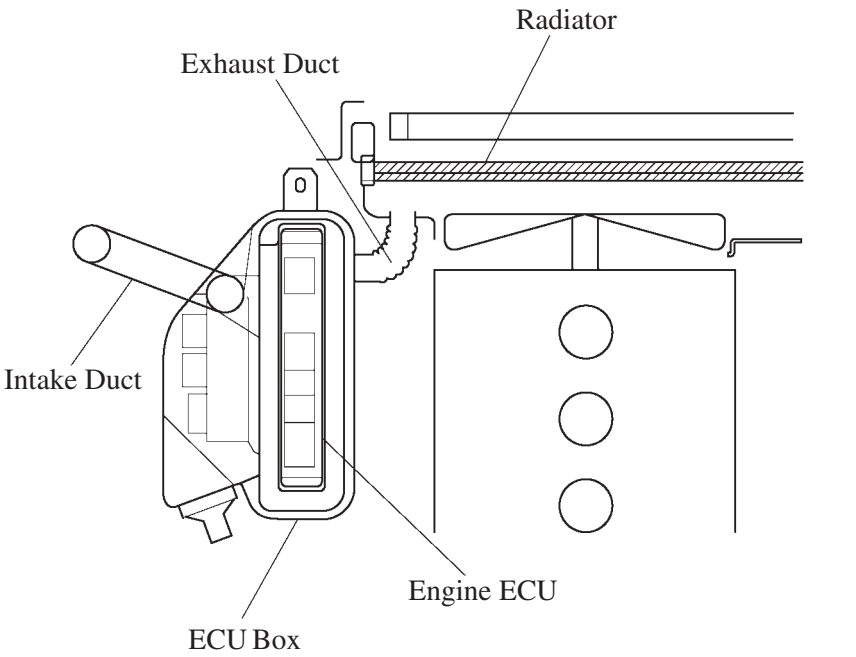
General

The main components of the 1G-FE engine control system are as follows:

Components	Outline	Quantity
Manifold Pressure Sensor	Semiconductor Type	1
Crankshaft Position Sensor (Rotor Teeth)	Pick-Up Coil Type (36-2)	1
Camshaft Position Sensor (Rotor Teeth)	Pick-Up Coil Type (3)	1
Throttle Position Sensor	Linear Type (Double)	1
Accelerator Pedal Position Sensor	Linear Type (Double)	1
Knock Sensor	Built-In Piezoelectric Type	2
Oxygen Sensor	Heated Oxygen Sensor (Bank 1, Sensor 1) (Bank 2, Sensor 1) (Bank 1, Sensor 2)	3
Injector	4-Hole Type	6

Engine ECU

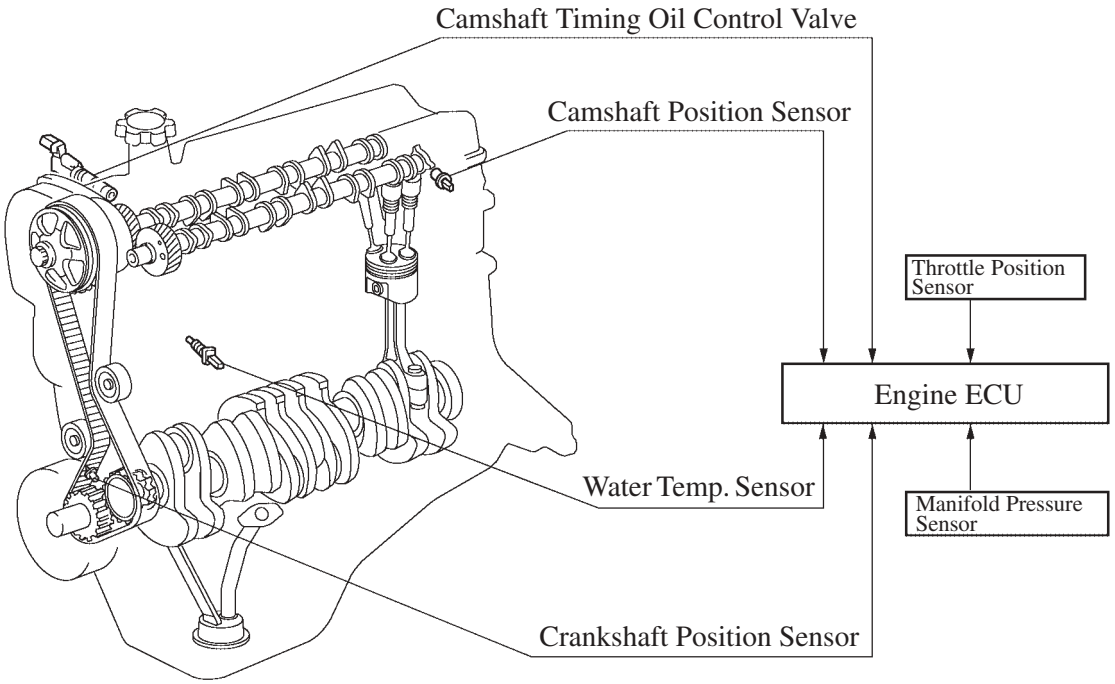
- The engine ECU is installed in the ECU box in the engine compartment. As a result, the wiring harness has been shortened, thus realizing weight reduction.



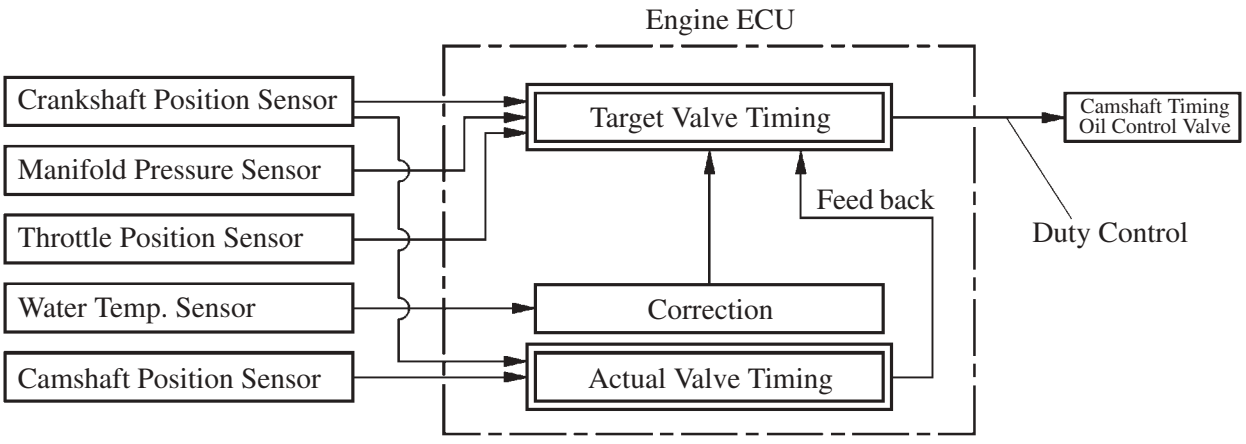
6. VVT-i (Variable Valve Timing-intelligent) System

General

This system controls the intake camshaft valve timing so as to obtain balance between the engine output, fuel consumption and emission control performance. The actual intake side valve timing is feed back by means of the camshaft position sensor for constant control to the target valve timing.



163EG44



157EG23

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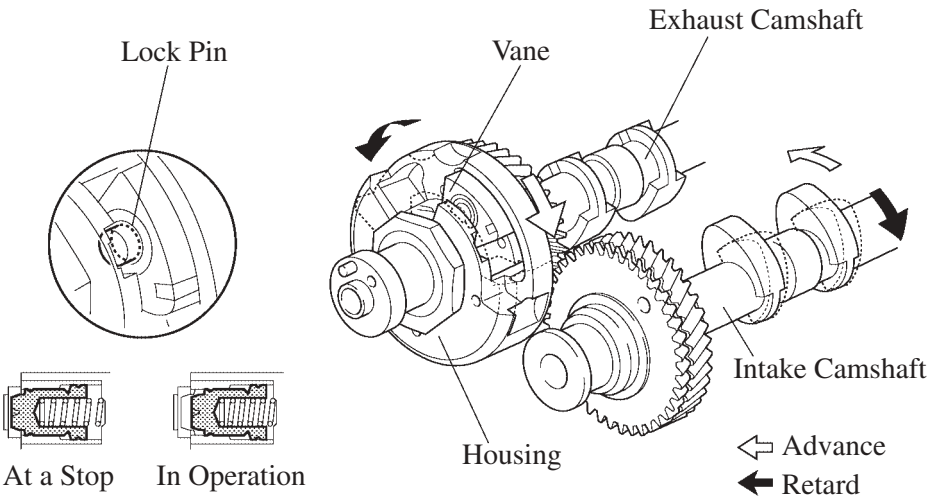
Construction

1) VVT-i Controller

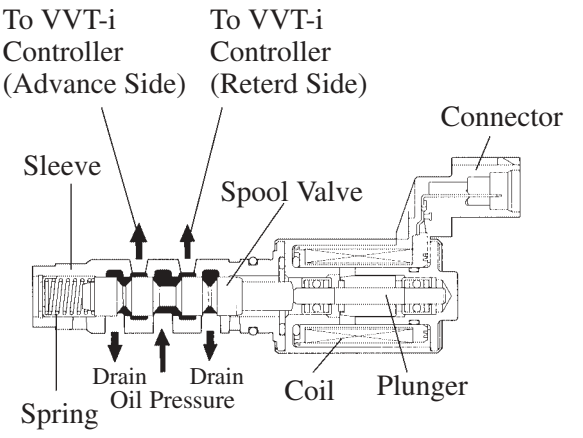
This controller consists of the housing which drives the intake camshaft and the vane coupled with the exhaust camshaft.
The oil pressure sent from the advance or retard side path at the exhaust camshaft causes rotation in the VVT-i controller housing circumferential direction to vary the intake valve timing continuously.
Also, when the engine is stopped, in order to improve startability, intake camshaft will be come the most retarded state because of the external force such as the valve spring force. At this time, a lock pin fixes the housing and the vane in the VVT-i controller, After the engine starts, the lock pin is released by the hydraulic pressure.



163EG45

2) Camshaft Timing Oil Control Valve

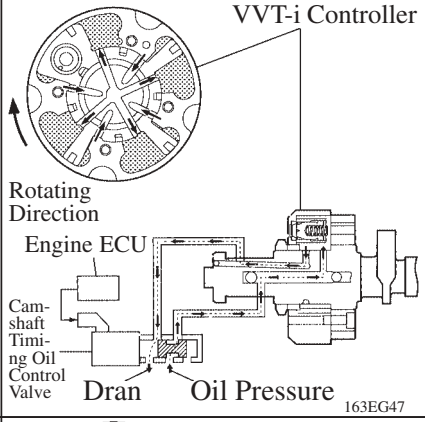
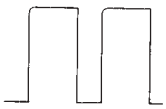
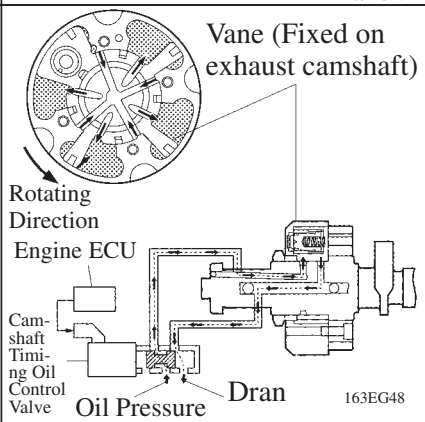
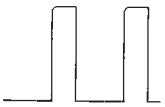
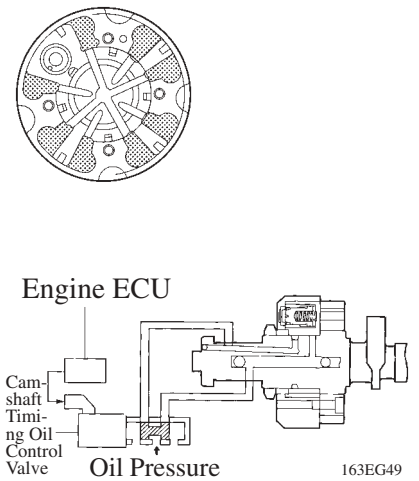
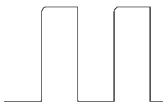
The camshaft timing oil control valve controls the spool valve position in accordance with the command of the engine ECU thus allocating the hydraulic pressure that is applied to the VVT-i controller to the advance and the retard side. When the engine is stopped, the camshaft timing oil control valve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



163EG46

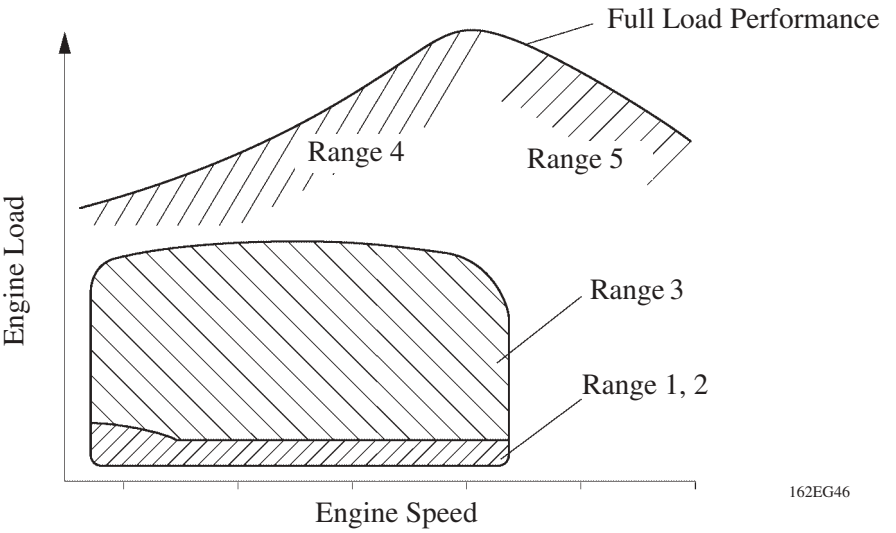
3) Operation

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		Advance Signal  Duty Ratio 157EG35	When the camshaft timing oil control valve is positioned as illustrated on the left in accordance with the advance signal received from the engine ECU, the oil pressure is applied to the advance side chamber to rotate the housing, thus rotating the intake camshaft in the advance direction.
Retard		Retard Signal  Duty Ratio 157EG36	When the camshaft timing oil control valve is positioned as illustrated on the left in accordance with the retard signal received from the engine ECU, the oil pressure is applied to the retard side chamber to rotate the housing, thus rotating the intake camshaft in the retard direction.
Hold		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 hold 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 camshaft position sensor 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 Conditions (Conceptual Diagram) ◀



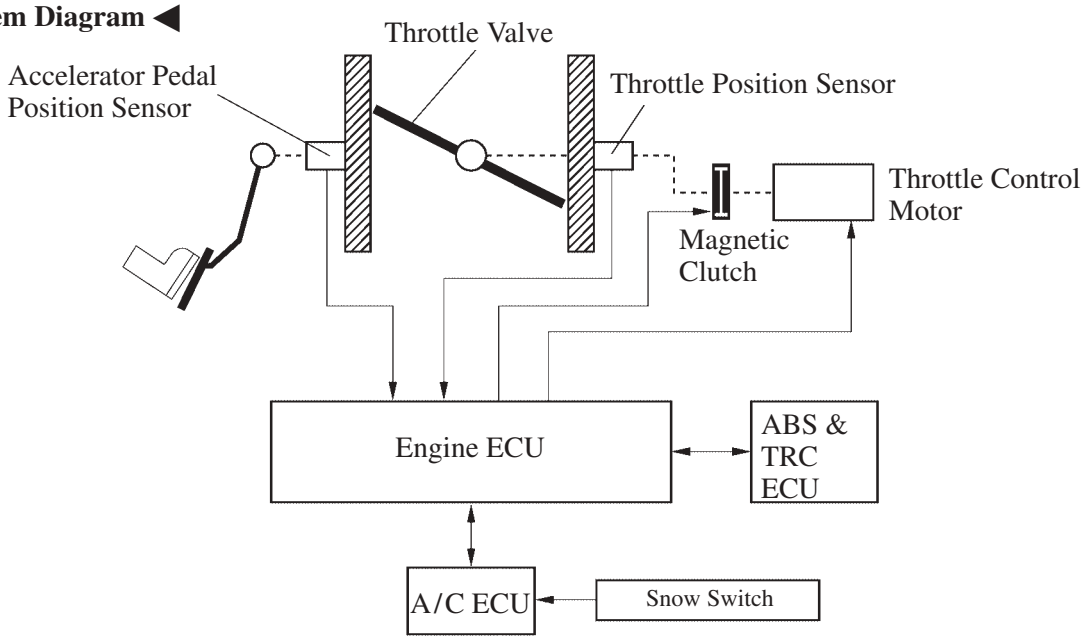
Operation state	Range	Valve timing	Objective	Effect
During idling	1	TDC, IN, EX, Latest timing	Eliminating overlap to reduce blow back to the intake side	Stabilized idling rpm Better fuel economy
At light load	2	IN, EX, To retard side	Decreasing overlap to eliminate blow back to the intake side	Ensured engine stability
At medium load	3	IN, EX, To advance side	Increasing overlap to increase internal EGR for pumping loss elimination	Better fuel economy Improved emission control
In low to medium speed range with heavy load	4	IN, EX, To advance side, BDC	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	IN, EX, To retard side	Retarding the intake valve close timing for volumetric efficiency improvement	Improved output
At low temperatures	–	IN, EX, Latest timing	Eliminating overlap to prevent blow back to the intake side for reduction of fuel increase at low temperatures, and stabilizing the idling rpm for decreasing fast idle rotation	Stabilized fast idle rpm Better fuel economy
Upon starting/ stopping the engine	–	IN, EX, Latest timing	Eliminating overlap to eliminate blow back to the intake side	Improved startability

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

General

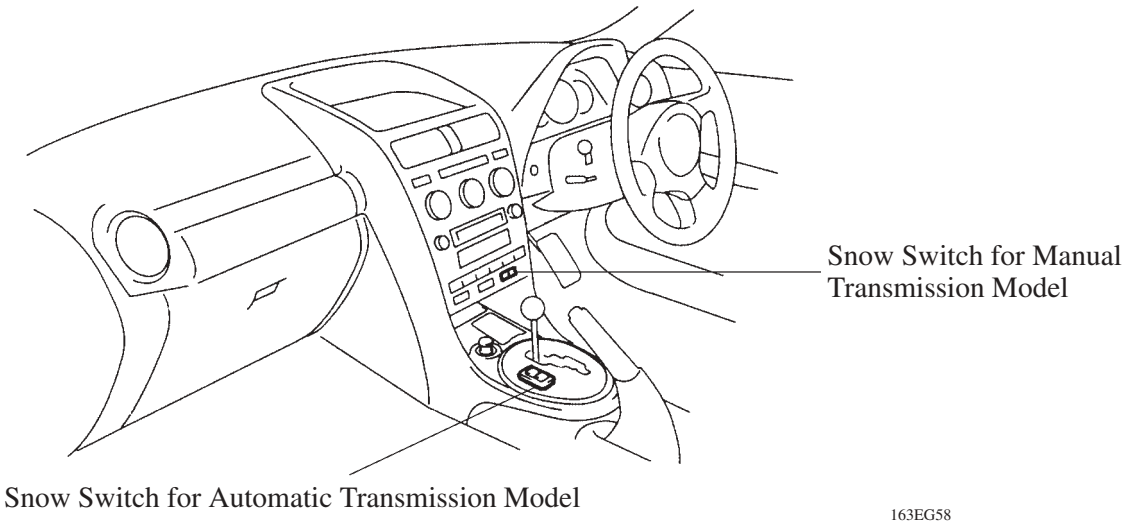
- The ETCS-i system, which realizes excellent throttle control in all the operating ranges, has been adopted.
- In the conventional throttle body, the throttle valve opening is determined invariably by the amount of the accelerator pedal effort. In contrast, the ETCS-i uses the engine ECU to calculate 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 cruise control system, the TRC (Traction Control) system, and the snow mode.
- A duplicate system is provided to ensure a high level of reliability, and the system shuts off in case of an abnormal condition. Even when the system is shut off, the accelerator pedal can be used to operate the vehicle in the limp mode.

▶ System Diagram ◀



163EG37

▶ Snow Switch Location ◀

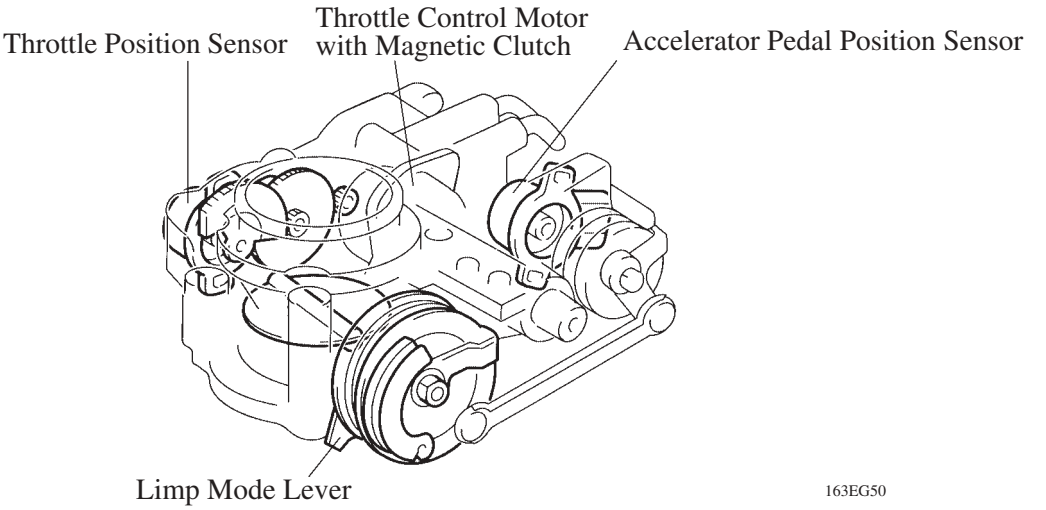


163EG58

Construction

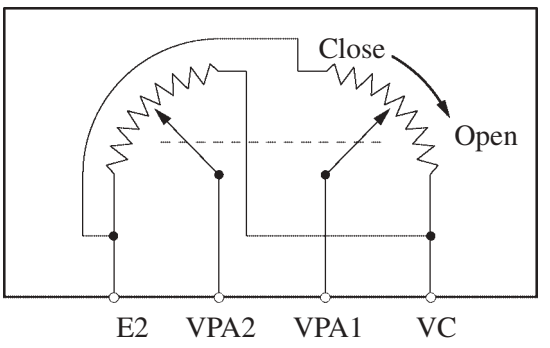
1) General

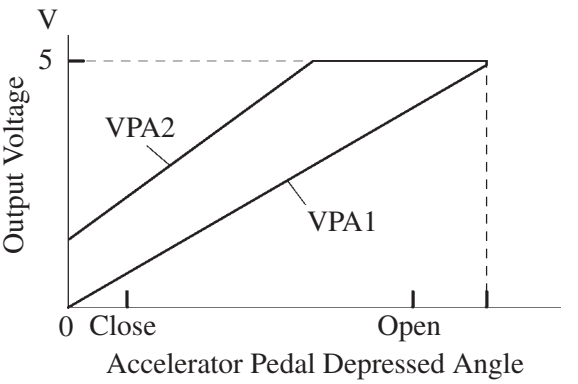
The ETCS-i consists of accelerator pedal position sensor, throttle position sensor, throttle control motor, magnetic clutch, etc.



2) Accelerator Pedal Position Sensor

The accelerator pedal position sensor, which is mounted on the throttle body, is integrated with the throttle lever, which is connected to the cable that extends from the accelerator pedal.
The accelerator pedal position sensor converts the amount of accelerator pedal effort into two types of electrical signals with distinct output characteristics. The signals are then input into the engine ECU.





3) Throttle Position Sensor

The throttle position sensor converts the throttle valve opening into an electrical signal and inputs into the engine ECU. The output characteristics are the same as those of the accelerator pedal position sensor.

4) 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.

5) Magnetic Clutch

Ordinarily, the magnetic clutch engages the clutch to enable the throttle control motor to open and close the throttle valve. In case a malfunction occurs in the system, this clutch is disengaged to prevent the throttle control motor to open and close the throttle valve.

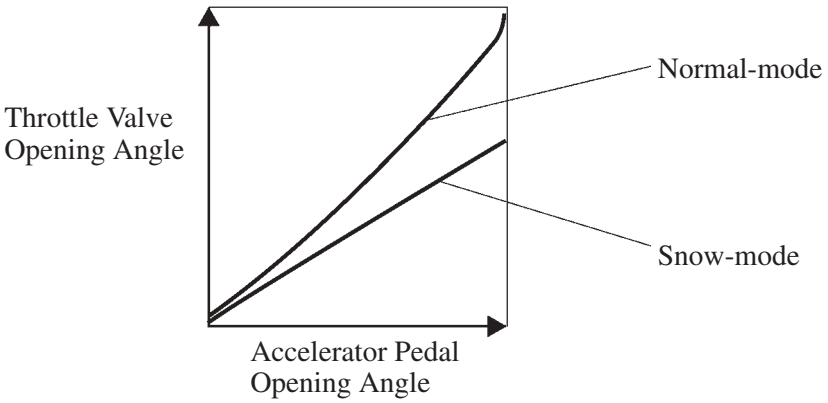
Operation

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

1) Normal-mode Control and Snow-mode Control
2) Idle Speed Control
3) TRC Throttle Control
4) Cruise Control

1) Normal-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 speed in order to realize excellent throttle control and comfort in all operating ranges.
- 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, 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.



Conceptual Diagram

163EG51

2) Idle Speed Control

The idle speed control is effected entirely by the ETCS-i. The following are the contents of the control: idle-up control during cold engine operation, intake air volume control to improve the startability of the engine, shift shock reduction control for automatic transmission models (when shifting from N to D), and control for when the electrical load changes such as when the air conditioning switch is turned ON or OFF.

3) TRC Throttle Control

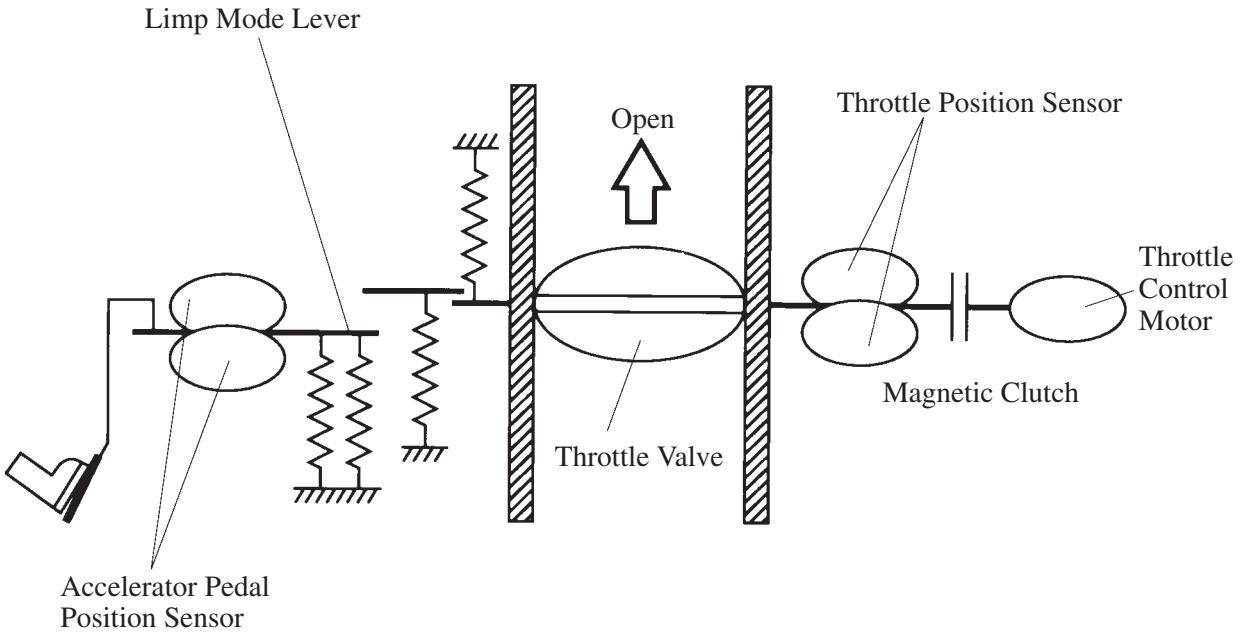
As part of the TRC system, the throttle valve is closed by a demand signal from the ABS & TRC ECU if an excessive amount of slippage is created at a driving wheel, thus facilitating the vehicle in ensuring stability and driving force.

4) Cruise Control

Through the adoption of the ETCS-i, the vehicle speed is now controlled by the throttle control motor, which controls the throttle valve.

Fail Safe

If an abnormal condition occurs with the ETCS-i, the check engine warning light in the combination meter illuminates to alert the driver. The current to the throttle control motor and the magnetic clutch is cut off to prevent the ETCS-i from operating. This enables the return spring to close the throttle valve. Even in this situation, the vehicle can be driven in the limp mode by pressing the accelerator pedal, which operates the throttle valve via the limp mode lever.



Diagnosis

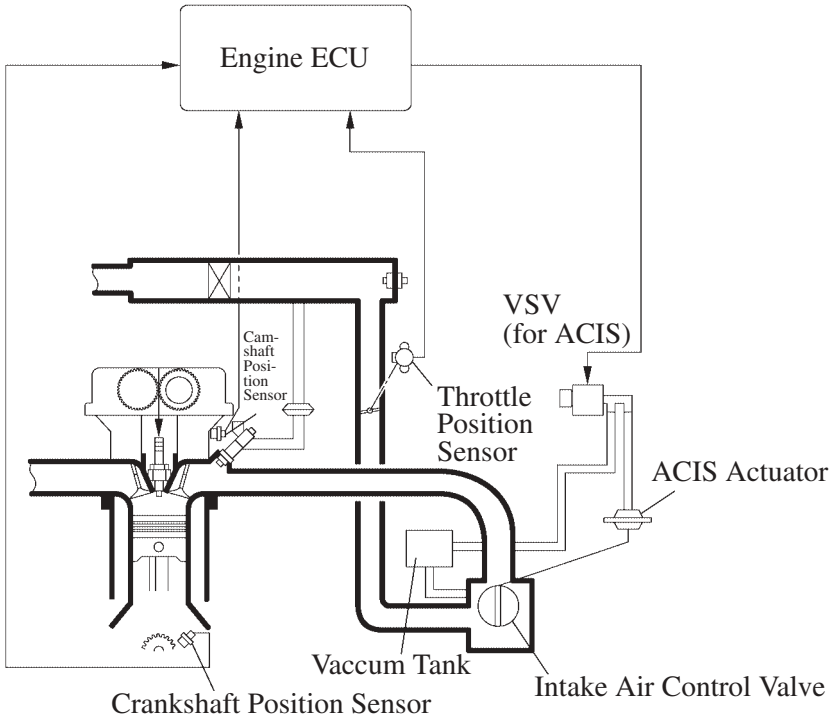
If the diagnostic frouble code 89 is being output to the combination meter check engine warning light, it means that the engine ECU has detected a malfunction in the ETCS-i, and outputs the diagnostic trouble code of the ETCS-i to the snow indicator light.
Also, the diagnostic trouble code can be output to a hand-held tester via the data link connector 3.
For details, refer to the LEXUS IS200 Repair Manual (Pub. No. RM684E).

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.

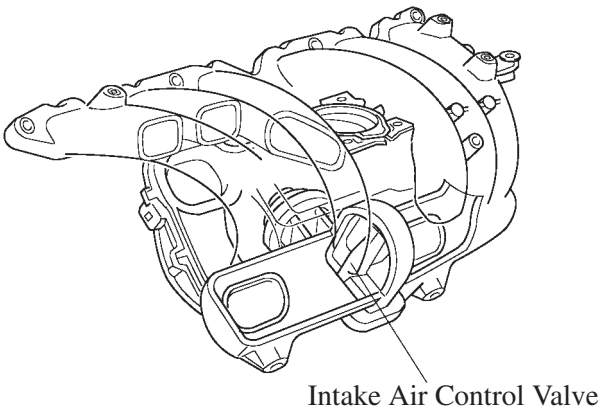
▶ System Diagram ◀



163EG52

Intake Air Control Valve

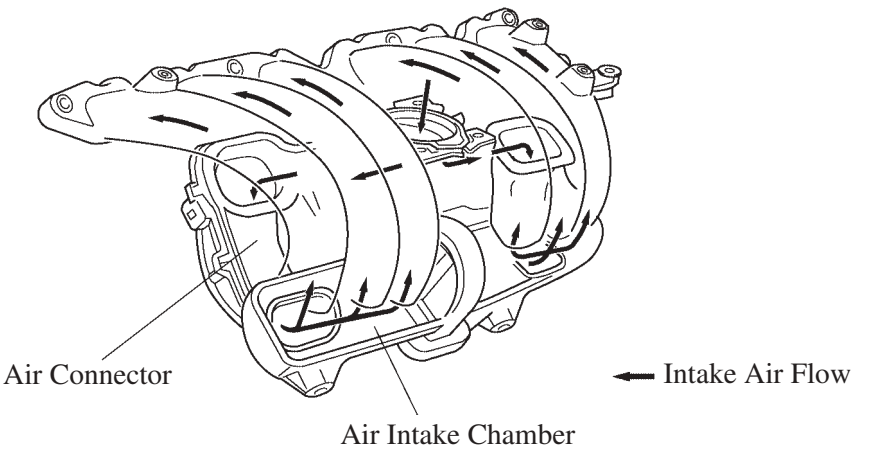
The intake air control valve, which is provided in the middle of the intake manifold in the air intake chamber, opens and closes to change the effective length of the intake manifold in two stages.



163EG53

Intake Air Flow

The intake air that is drawn in from the throttle body is divided into two air connectors and enters the air chamber. Then, it flows via the intake manifolds to the intake ports.



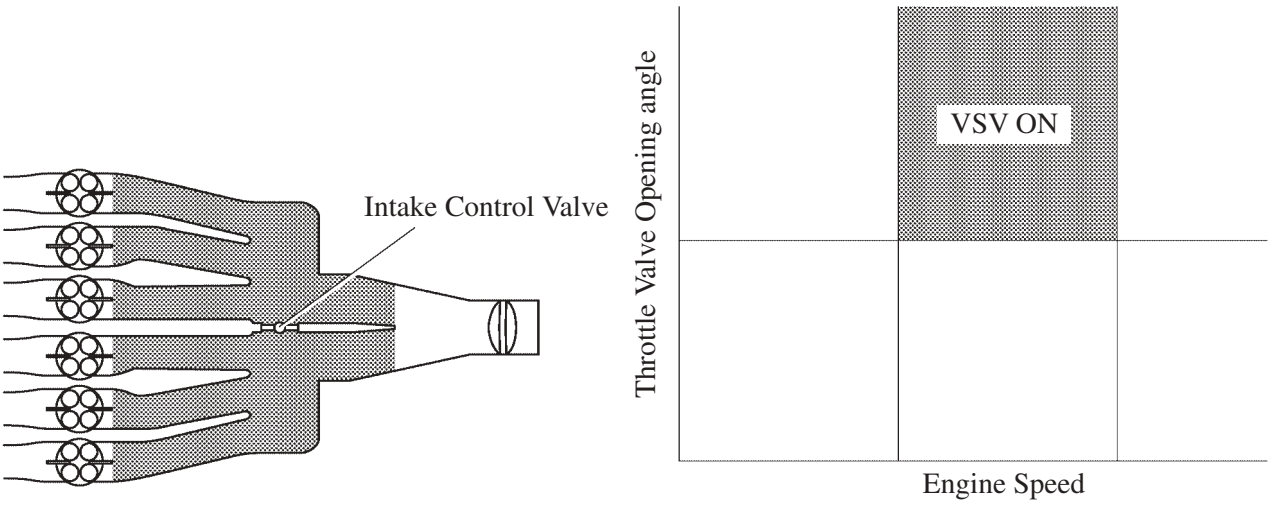
163EG54

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 actuator. This closes the control valve. As a result, the effective length of the intake manifold is lengthened and the intake efficiency in the medium speed range is improved due to the dynamic effect of the intake air, thereby increasing the power output.

: Effective Intake Manifold Length

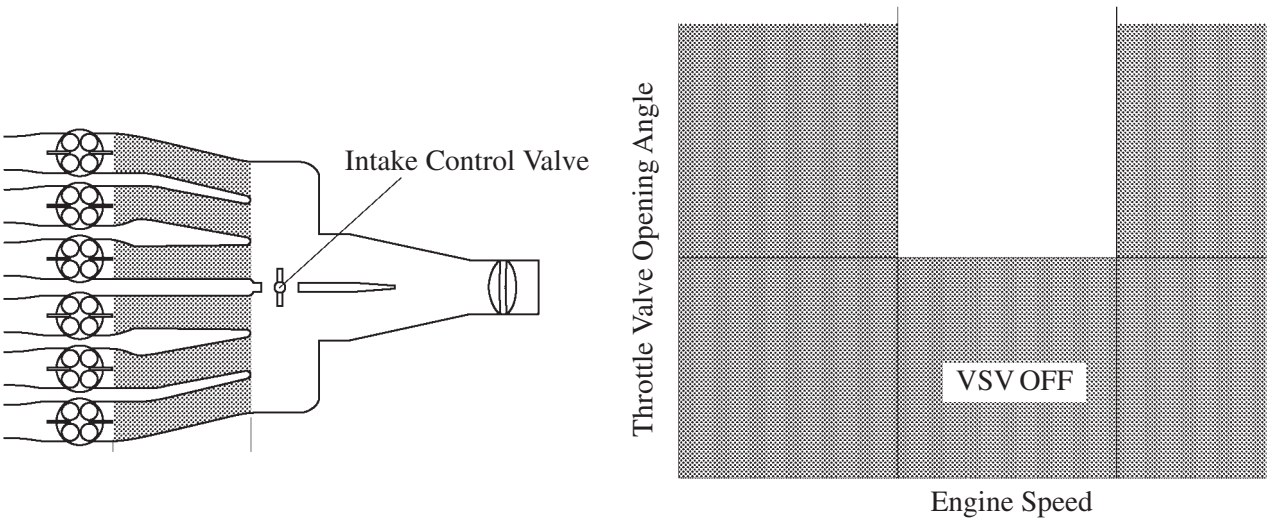


162EG52

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 actuator and opens the control valve. When the control valve is open, the effective length of the air intake chamber is shortened and peak intake efficiency is shifted to the low-to-high engine speed range, thus providing greater output at low-to-high engine speeds.

: Effective Intake Manifold Length



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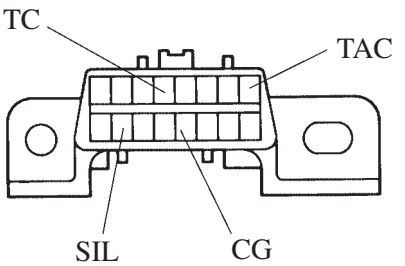
9. Engine Immobiliser System

The engine immobiliser system has been designed to prevent the vehicle from being stolen. This system uses a engine ECU that stores the ID code of the authorized ignition key. If an attempt is mode to start the engine using an unauthorized key, the engine ECU prohibit fuel delivery and ignition, effectively disabling the engine. The basic construction and operation are the same as those of the current LS400. For details, see the LEXUS LS400 New Car Features Supplement (Pub. No. NCF144E).

10. Diagnosis System

The diagnosis system of the 1G-FE engine on the European model has adopted the EURO-OBD (Europe On-Board Diagnosis) that complies with European regulations. For other destinations, the M-OBD (Multiplex On-Board Diagnosis) system has been adopted.

Item	EURO-OBD, M-OBD
Data Link Connector	The DLC3 (Data Link Connector 3) has been newly provided. In addition, the check connector has been discontinued except Germany model. ▶ **DLC3** ◀  165EG39 CG: Chassis Ground SIL: Provides communication between the engine ECU and the hand-held tester. TAC: Outputs the engine speed signal. TC: Provides the same function as the previous TE1 teminal.
Diagnostic Trouble Code Check Method	The diagnostic trouble codes can be displayed by connecting a hand-held tester to the DLC3. After terminals TC and CG of the DLC3 are connected, the codes are displayed on the check engine warning light in the combination meter.

Furthermore, on the 1G-FE engine, the functions listed below can be utilized by connecting the hand-held tester to the DLC3.
The diagnosis system of the EURO-OBD system and M-OBD system are compared below.

Function	Details	EURO -OBD	M-OBD
Diagnostic Trouble Code	The system can output 5-digit diagnostic trouble codes to the tester, which are more detailed than the previous 2-digit diagnostic trouble codes, thus making if easier to identify the location of the problem. Example: Code 28 (Oxygen Sensor) → P0130 (Oxygen Sensor) → P0135 (Oxygen Sensor Heater) However, in the EURO-OBD system, the diagnostic trouble codes that are not output by the M-OBD, such as misfires, are also output, Refer to the LEXUS IS200 Repair Manual (Pub. No. RM684E).	○	○
Continuous Test Results	A diagnostic trouble code may require a condition to be present for several drive cycles, while the equivalent continuous test code may be set with the first occurrence of the condition.	○	–
Freeze-Frame Data	The system can output freeze-frame data to the tester. This data (while depicts the condition of the engine control system and the vehicle) is stored in the engine ECU at the very moment when the engine ECU has detected its last data of malfunction.	○	○
Output Engine ECU Data	The engine ECU's control data can be output. Output Data Speed: 9.6 kbps.	–	○
	The engine ECU's control data can be output. Output Data Speed: 10.4 kbps.	○	–
Active Test	Through the use of the tester, the actuators (VSV, fuel pump, VVT-i system, etc.) can be activated to a desired state.	○	○
Trouble Code Clear	Through the use of the tester, trouble codes that are stored in the engine ECU can be cleared.	○	○
Check Engine Warning Light Clear	If the engine ECU detects the malfunction of the vehicle, it makes the check engine warning light come on. Later, if that malfunction will not occur again, it automatically turns off the check engine warning light.	–	○
	If the engine ECU detects the malfunction of the vehicle, it makes the check engine warning light come on. Later, if the same malfunction will not occur again during 3 trips continuously, it automatically turns off the check engine warning light.	○	–

- For details on the diagnostic trouble codes, active test, etc. described above, refer to the LEXUS IS200 Repair Manual (Pub. No. RM684E).
- For details of the hand-held tester, refer to the Hand-Held Tester Operator's Manual.

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