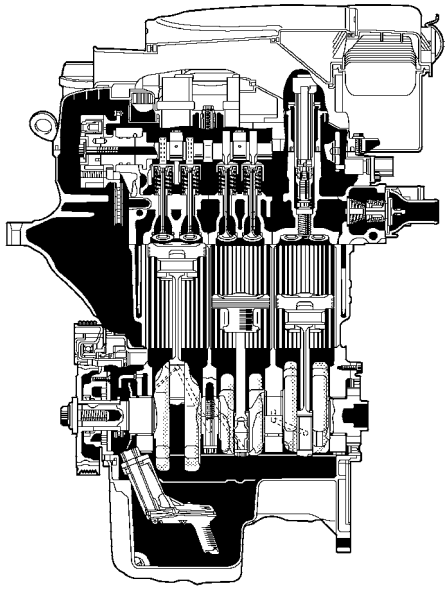
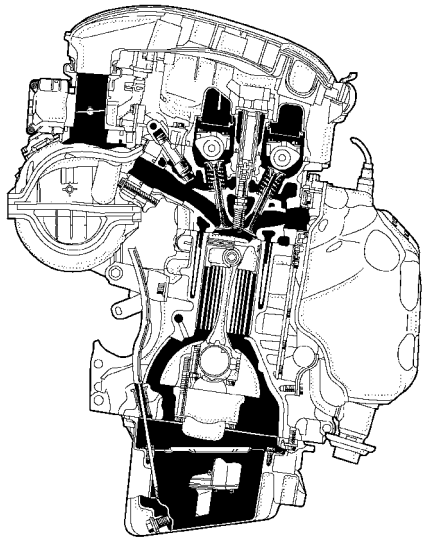
■1KR-FE ENGINE

1. General

- A water jacket spacer and an EGR system have been added to the 1KR-FE engine to achieve low friction and improve fuel economy.
- A charging control system has been added to reduce the engine load, thus improving fuel economy.



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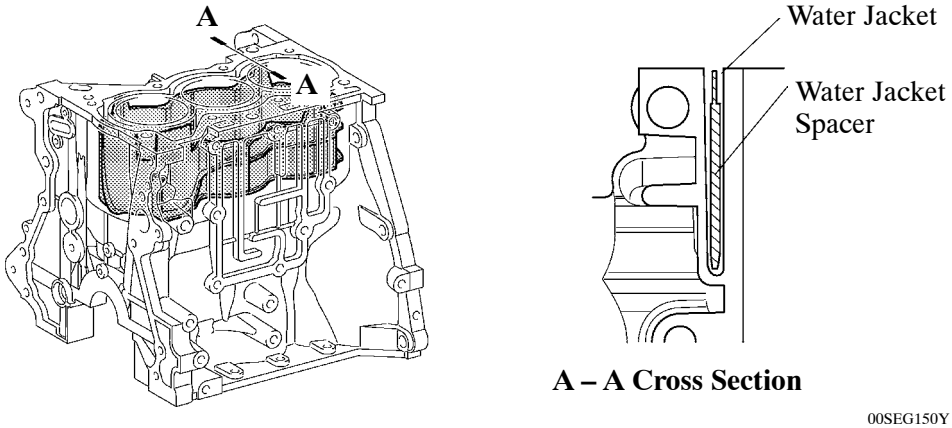


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2. Engine Proper

Cylinder Block

- A water jacket spacer is used in the water jackets of the cylinder block.
- The water jacket spacer suppresses the water flow in the center of the water jackets, guides the water above and below the cylinder bores, and ensures uniform temperature distribution. As a result, the viscosity of the engine oil that acts as a lubricant between the bore walls and the pistons can be lowered, thus reducing friction.



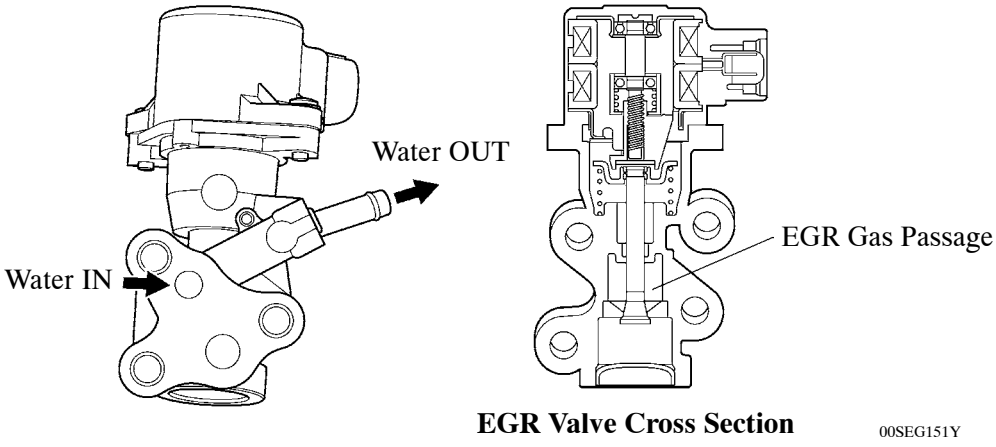
A – A Cross Section

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3. Intake and Exhaust System

EGR Valve

- A step motor is used on the EGR valve to enable the ECM to directly control the EGR valve.
- The water circulates through the EGR valve to ensure proper cooling performance.

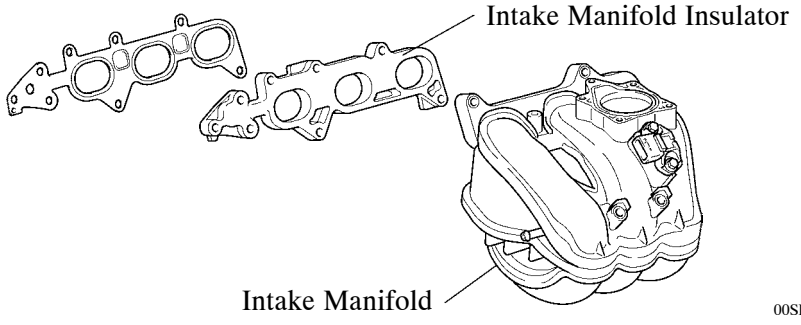


EGR Valve Cross Section

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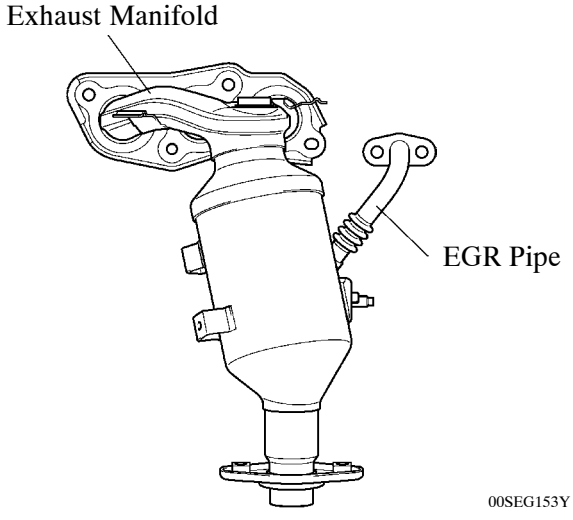
Intake Manifold Insulator

- Along with the addition of the EGR system, an intake manifold insulator has been added. The intake manifold insulator is installed between the cylinder head and the intake manifold.
- The EGR gas from the cylinder head is regulated in its flow volume at the EGR valve. It then passes through the intake manifold insulator, and enters each cylinder.



Exhaust Manifold

An exhaust manifold with an integrated EGR pipe is provided.



4. Engine Control System

General

The engine control system of the 1KR-FE engine has the following systems:

System	Outline	New	Previous
EFI (Electronic Fuel Injection)	● The D-type EFI system calculates the intake air volume based on the engine speed and the intake manifold pressure signal received from the vacuum sensor. ● An independent injection system, in which fuel is injected into each cylinder once for each two revolutions of the crankshaft, is used. ● Fuel injection takes two forms: Synchronous injection, which always takes place with the same timing in accordance with the basic injection duration and an additional correction based on the signals provided by the sensors. Non-synchronous injection, which takes place at the time an injection request based on the signals provided by the sensors is detected, regardless of the crankshaft position.	○	○
ESA (Electronic Spark Advance)	● 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 ignition signal (IGT) to the igniter.	○	○
ETCS-i (Electronic Throttle Control System-intelligent)	Optimally controls the throttle valve opening angle in accordance with the amount of accelerator pedal effort, the throttle valve opening control request from the ECM, and the condition of the engine and the vehicle.	○	○
VVT-i (Variable Valve Timing-intelligent)	Controls the intake camshaft to an optimal valve timing in accordance with the engine condition.	○	○
Air Conditioning Cut-off Control*	By turning the air conditioning compressor ON or OFF in accordance with the engine condition, drivability is maintained.	○	○
Cooling Fan Control	The cooling fan operation is controlled by signals from the ECM based on the water temperature sensor signal.	○	○
Fuel Pump Control	The fuel pump operation is controlled by signals from the ECM.	○	○
	A fuel cut control is used to stop the fuel pump when the SRS airbags are deployed during front or side collision.	○	○
EGR Control [See page 30]	Based on the signals received from the sensors, the ECM determines the EGR volume via the EGR valve in accordance with the engine condition.	○	—
Charging Control [See page 31]	The power management ECU and ECM control the charging voltage in accordance with the driving conditions and the state of the battery.	○	—

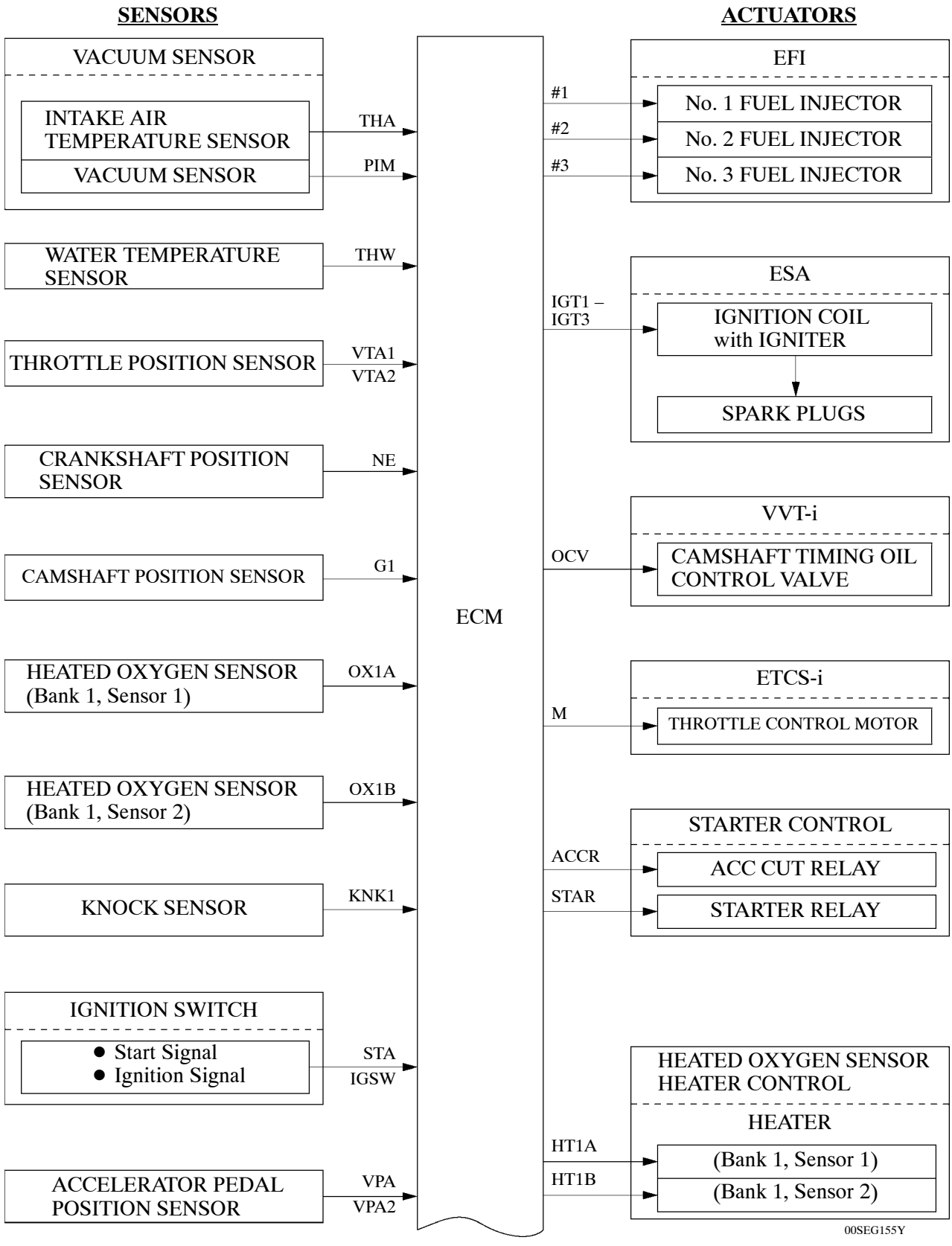
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*: Models with air conditioning system

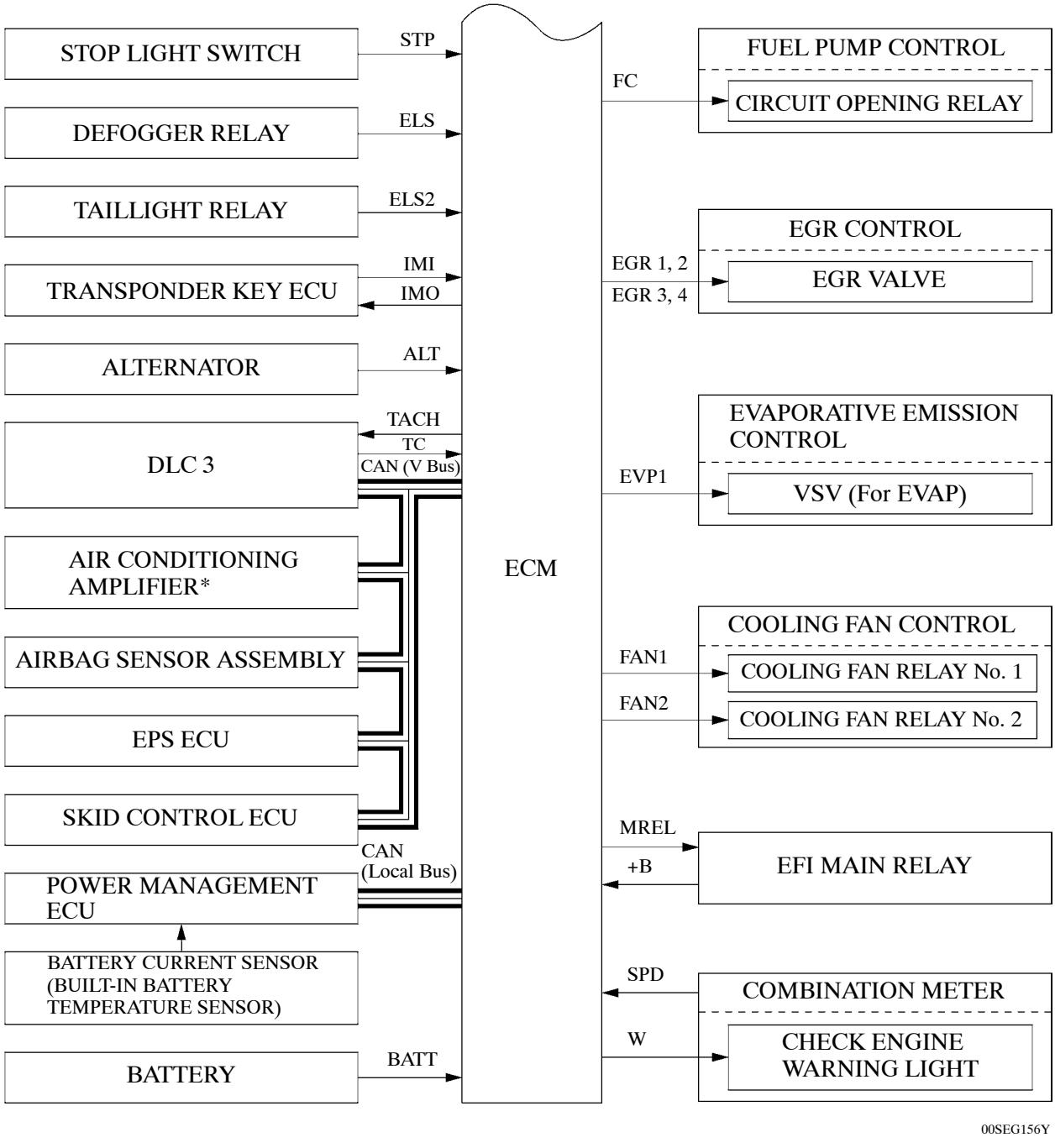
System	Outline	New	Previous
Heated Oxygen Sensor Heater Control	Maintains the temperature of the heated oxygen sensor at an appropriate level to increase accuracy of detection of the oxygen concentration in the exhaust gas.	○	○
Evaporative Emission Control	The ECM controls the purge flow of evaporative emission (HC) in the charcoal canister in accordance with engine conditions.	○	○
Starter Control (Cranking Hold Function)	Once the ignition switch is turned to the START position, this control continues to operate the starter until the engine is started.	○	○
Engine Immobilizer	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid key.	○	○
Diagnosis	When the ECM detects a malfunction, it diagnoses and memorizes the failed section.	○	○
Fail-safe	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 in the 1KR-FE engine is as shown in the following chart:

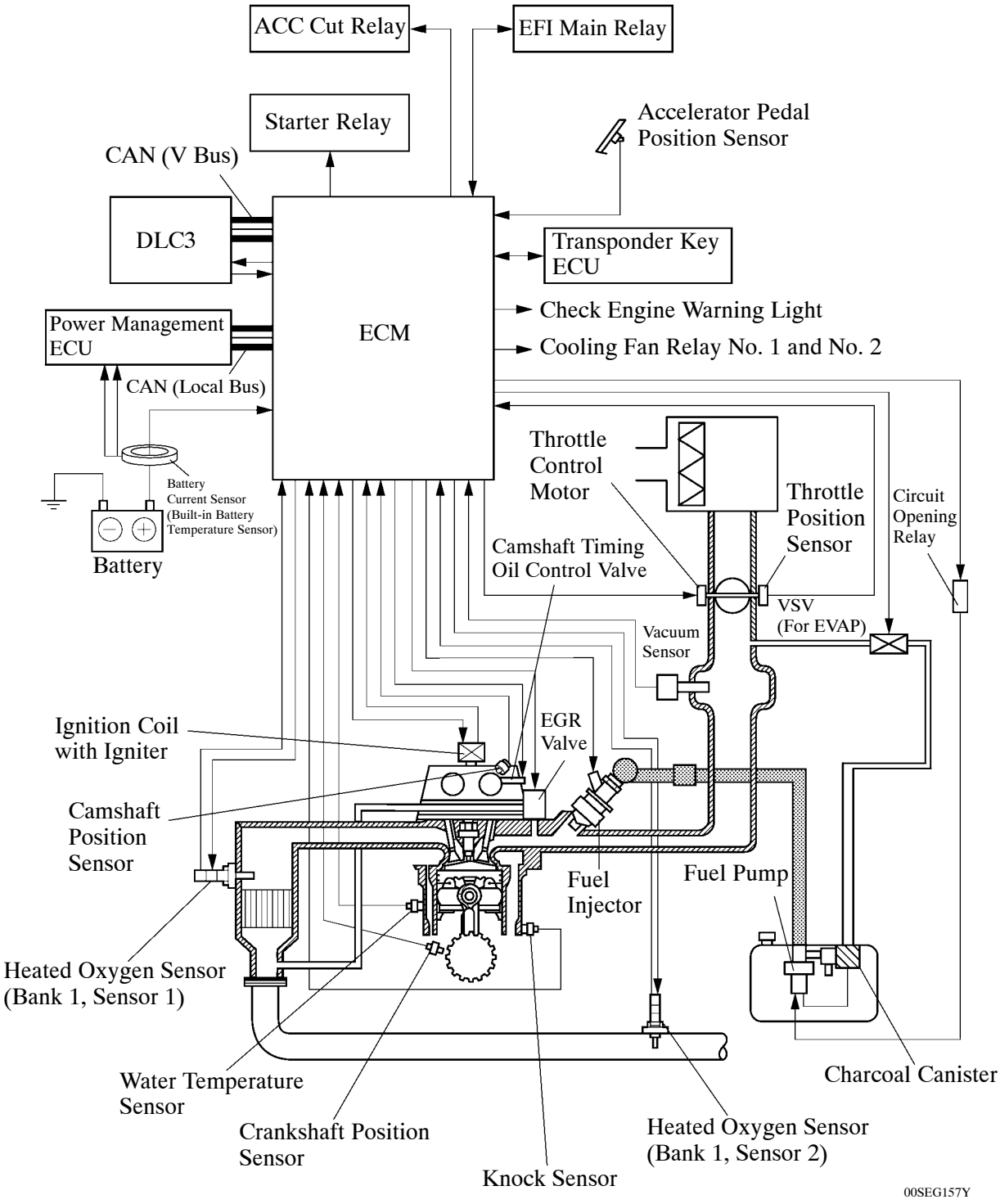


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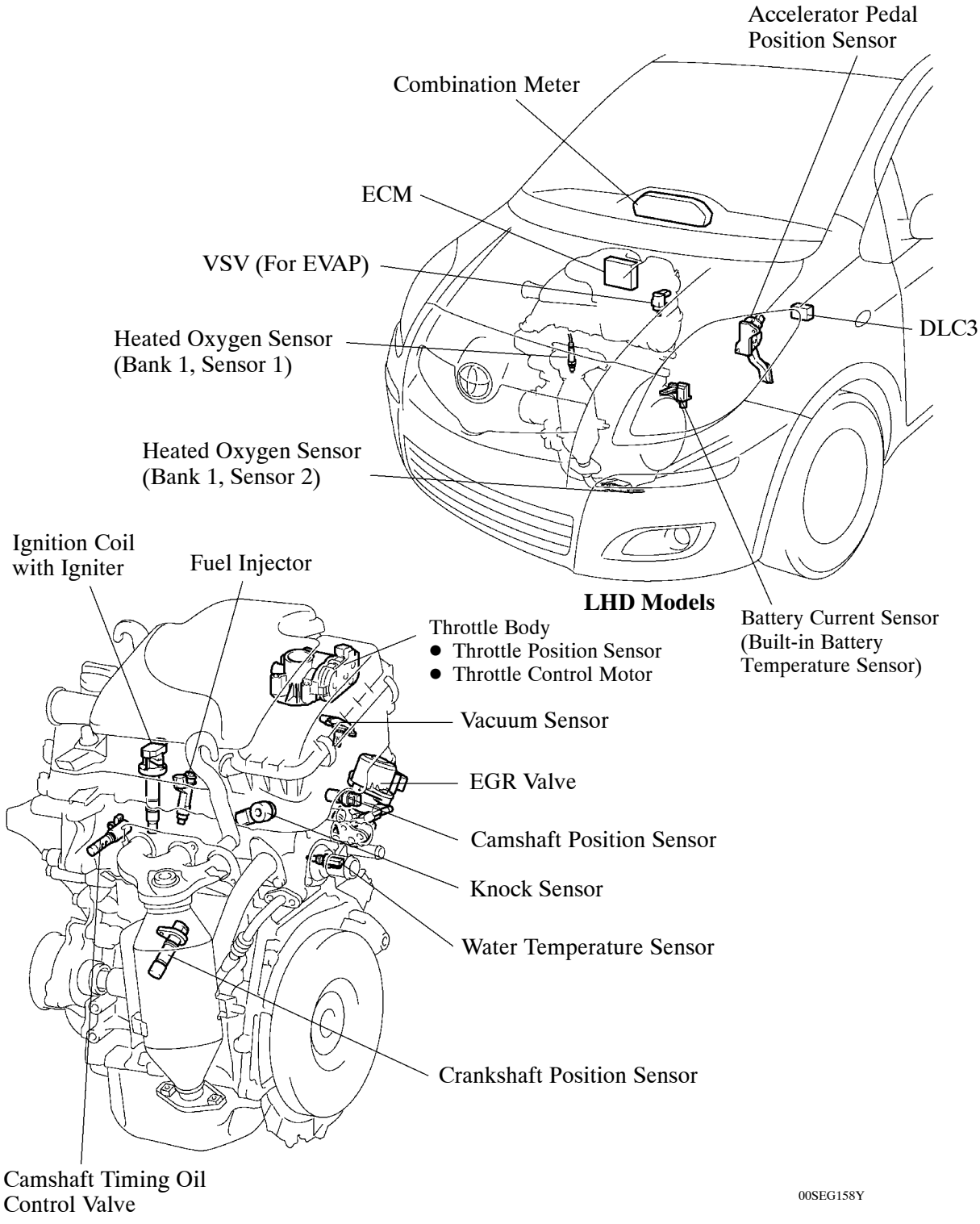


*: Models with air conditioning system

Engine Control System Diagram

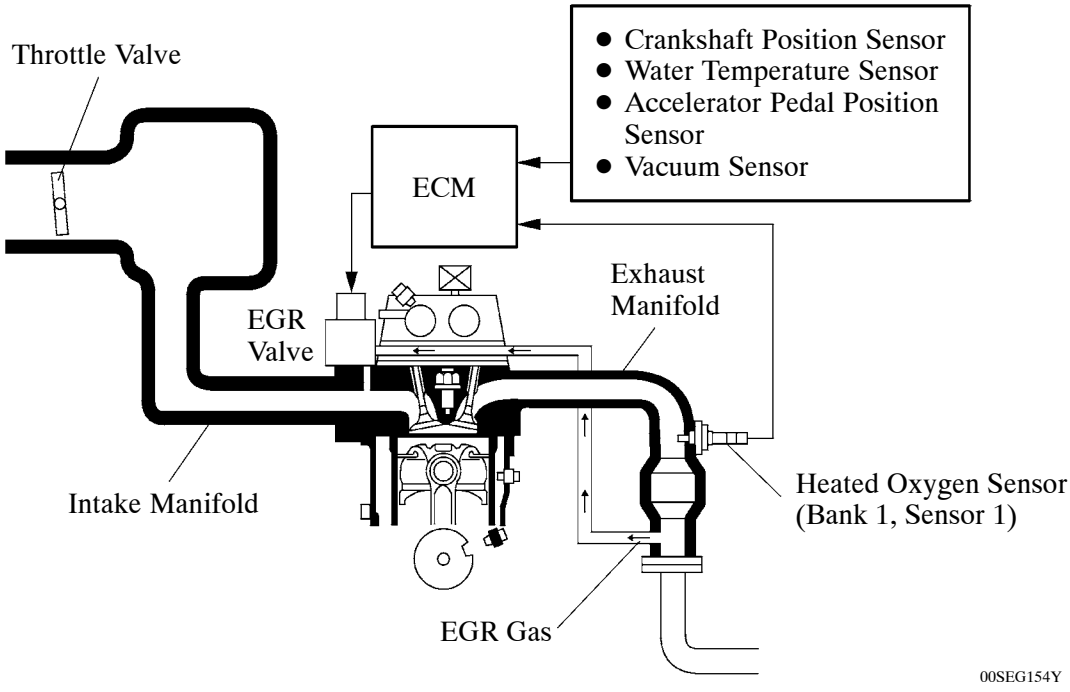


Layout of Main Components



EGR Control

The ECM actuates the EGR valve in accordance with the engine driving conditions, in order to regulate the volume of EGR gas recirculation.



Charging Control

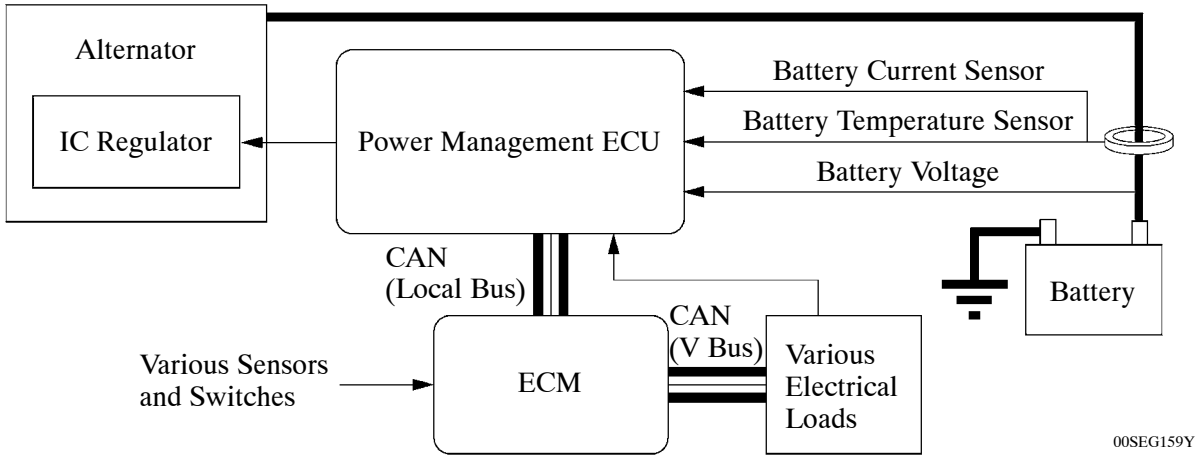
1) General

This system lowers the generated voltage when the vehicle is accelerating, and raises the generated voltage when the vehicle is decelerating. This reduces the load applied to the engine by the alternator while it is generating electricity, resulting in improved fuel economy.
During idle or constant-speed driving, this system regulates the generated voltage in order to bring the amperage estimation value closer to the target value.

- This control consists of the ECM, power management ECU, battery current sensor with a built-in battery temperature sensor, an alternator, and various sensors and switches.
- The ECM detects the driving conditions based on the signals output by various sensors and switches. To give voltage instructions to the alternator, the power management ECU performs calculations based on battery voltage as well as the signals output by the battery current sensor and the battery temperature sensor.

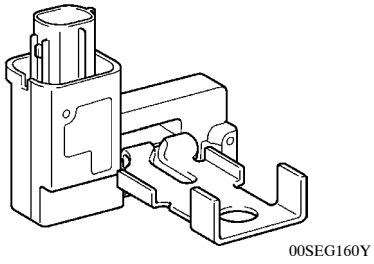
If a particular condition occurs due to a malfunction in the sensors, the state of the battery or the operating conditions of electrical loads, the power management ECU will stop effecting charging control and switches to normal electric generation.

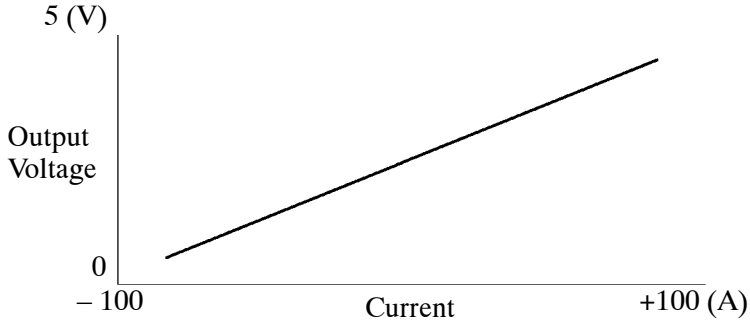
▶ System Diagram ◀



2) Battery Current Sensor

This sensor is attached to the positive terminal of the battery. It detects the charging and discharging current of the battery and sends signals to the power management ECU. The power management ECU measures the battery capacity by way of this signal. This sensor contains a Hall IC to detect the charging and discharging current of the battery. The changes in the magnetic flux density, which are created at the core of the sensor by the charging and discharging current of the battery, are converted into voltage and output by the sensor.





Characteristic of Current Sensor

3) Battery Temperature Sensor

- The battery temperature sensor is built into the battery current sensor.
- The battery characteristic (battery internal resistance) of taking in current for charging varies according to battery electrolyte temperature. If the electrolyte temperature is too low or too high, the battery internal resistance will increase, resulting in early deterioration. To prevent this, the battery temperature sensor changes its resistance as shown below to detect the temperature:

