NEW FEATURES

ENGINE

■1GR-FE ENGINE

1. General

- In order to comply with the LEVII-ULEV emission regulation, the characteristics of the Three-Way catalytic Converters (TWC), which are fitted on the exhaust manifold and exhaust pipes, have been optimized and also an air injection system has been provided.
- Since the air injection system has been provided, the exhaust manifold shape has been redesigned.
- The fuel pump control computer has been changed to the one that allows a liner control.

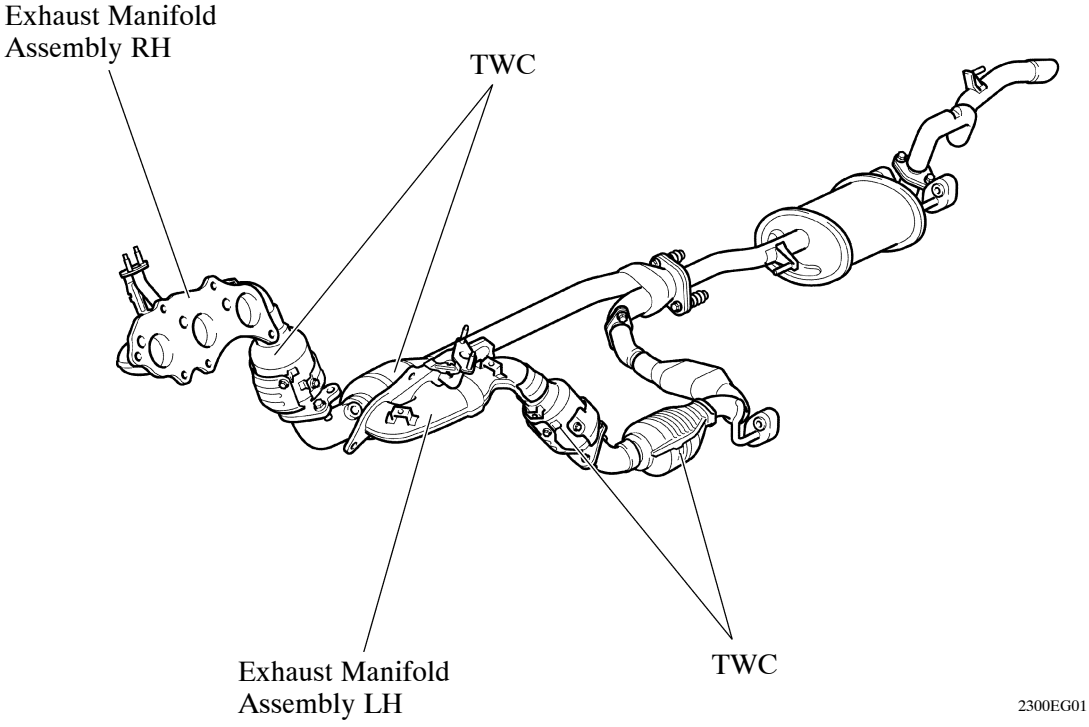
▶ Engine Specification ◀

Model			’13 FJ Cruiser		’12 FJ Cruiser	
No. of Cyls. & Arrangement			6-cylinder, V Type		←	
Valve Mechanism			24-valve DOHC, Chain Drive (with Dual VVT-i)		←	
Combustion Chamber			Pentroof Type		←	
Flow of Intake and Exhaust Gasses			Cross-flow		←	
Fuel System			SFI		←	
Ignition System			DIS		←	
Displacement cm^3 (cu. in.)			3956 (241.4)		←	
Bore × Stroke mm (in.)			94.0 × 95.0 (3.70 × 3.74)		←	
Compression Ratio			10.4 : 1		←	
Max. Output (SAE-NET)*1			194 kW @ 5600 rpm (260 HP @ 5600 rpm)		←	
Max. Torque (SAE-NET)*1			367 N·m @ 4400 rpm (271 ft·lbf @ 4400 rpm)		←	
Valve Timing	Intake	Open (BTDC)	–11° to 29°		←	
		Close (ABDC)	71° to 31°		←	
	Exhaust	Open (BBDC)	60° to 25°		←	
		Close (ATDC)	4° to 39°		←	
Firing Order			1 – 2 – 3 – 4 – 5 – 6		←	
Oil Grade			ILSAC Multigrade Engine Oil		←	
Fuel			Gasoline or Alcohol Fuel*3		←	
Octane Rating			87 or higher		←	
Research Octane Number (RON)			91 or higher		←	
Emission Regulation			CARB*4	EPA*5	CARB*4	EPA*5
		Tailpipe	LEVII-ULEV, SFTP	Tier2-Bin5, SFTP	LEVII-LEV, SFTP	Tier2-Bin5, SFTP
		Evaporative	LEVII, ORVR	Tier2, ORVR	LEVII, ORVR	Tier2, ORVR
Engine Service Mass*2 (Reference) kg (lb)			201 (443)		197 (435)	

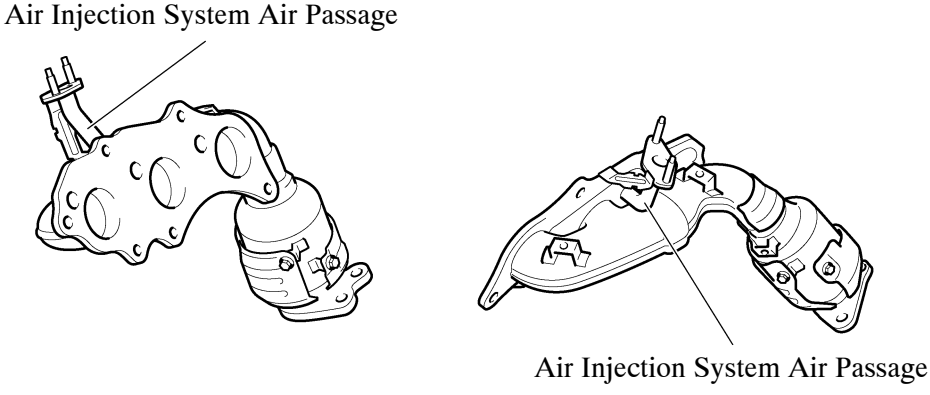
*1: Maximum output and torque rating are determined using the revised SAE J1349 standard.
*2: The figure shown is the weight of the part including the coolant and oil.
*3: Mixed fuel from 0% ethanol (E0) to 20% ethanol (E20) is available.
*4: California Air Resources Board (CARB)
*5: Environmental Protection Agency (EPA)

2. Intake and Exhaust System

- In order to enhance the efficiency of the Three-Way catalytic Converters (TWC) fitted on the exhaust manifold and exhaust pipes, the catalyst volume, amount of precious metal, cell density and wall thickness have been optimized.
- On the models with air injection system, an air injection pipe, witch directs the air from an air pump assembly to the air injection port on the cylinder head, has been provided.



▶ Exhaust Manifold ◀



3. Engine Control System

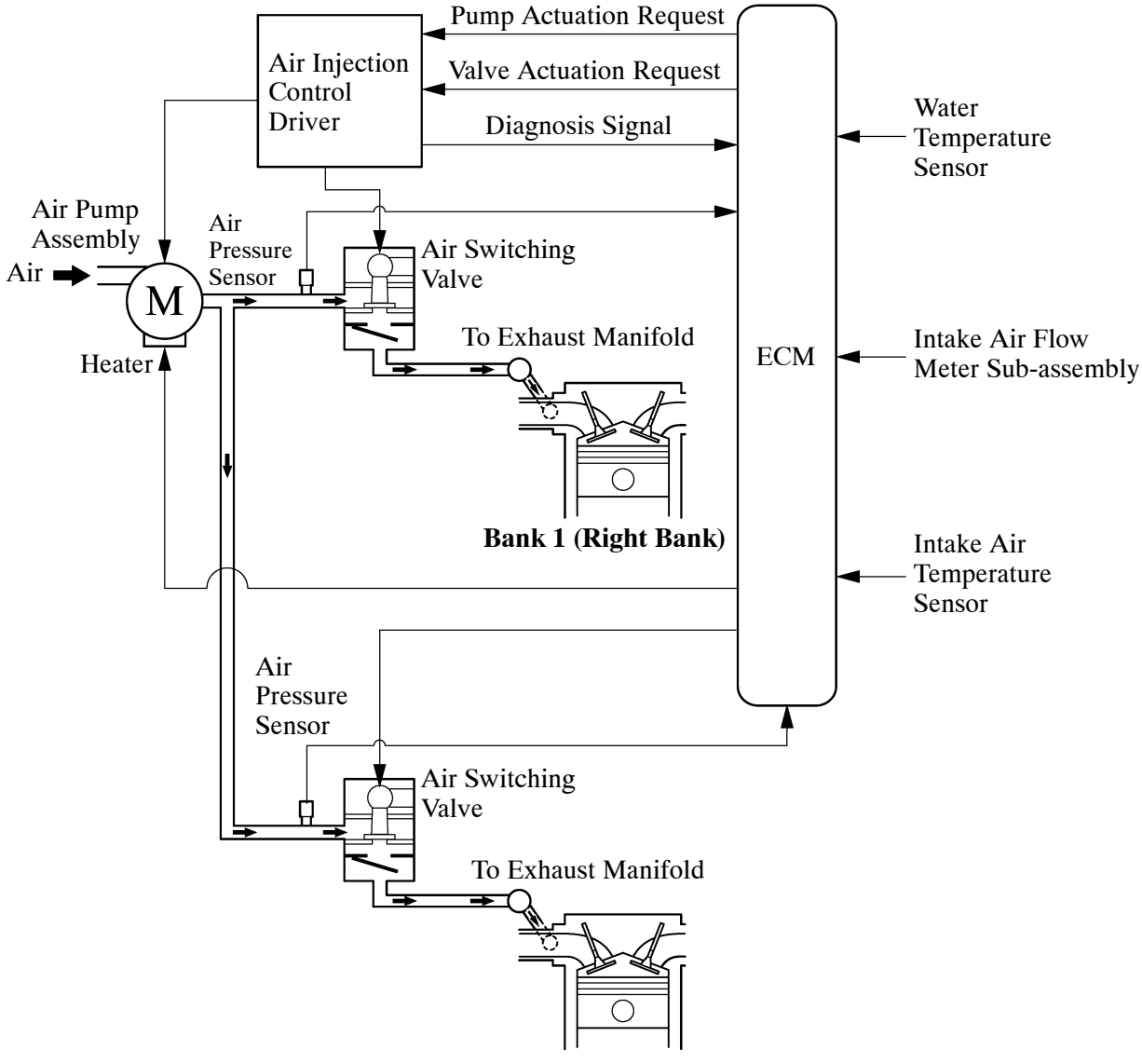
Air Injection System

1) General

To ensure the proper warm-up performance of the Three-Way Catalytic converters (TWCs) after starting a cold engine, an air injection system is used.

- This system is comprised of an air injection control driver, an air pump assembly, and 2 air switching valves (emission control valve set) with built-in air pressure sensors.
- Air switching valves are installed on each bank, and are controlled by the air injection control driver on the right bank side (bank 1) and by the ECM on the left bank (bank 2).
- The ECM estimates the amount of air injected to the TWCs based on signals from the mass air flow meter in order to regulate the air injection time.
- Air is injected under the following conditions:

▶ System Diagram ◀

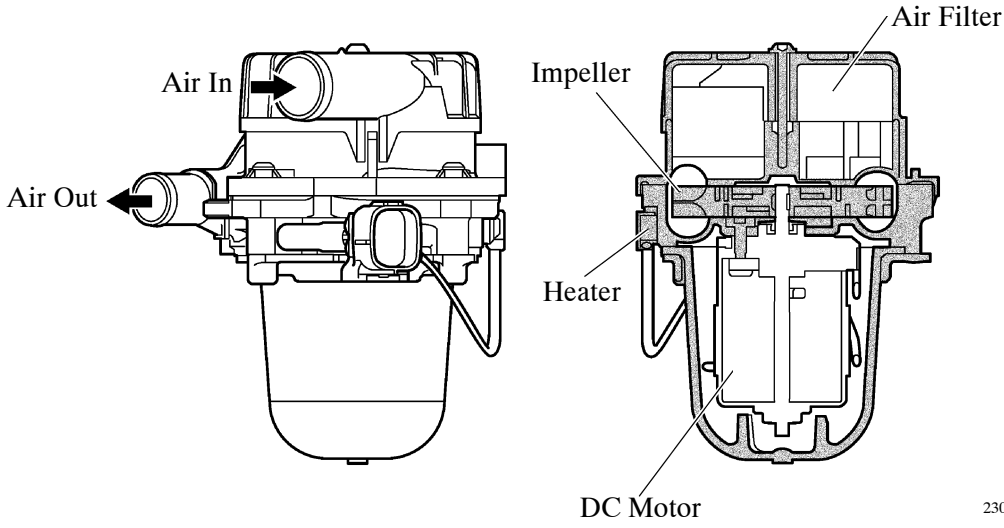


2) Construction and Operation

a. Air Pump Assembly

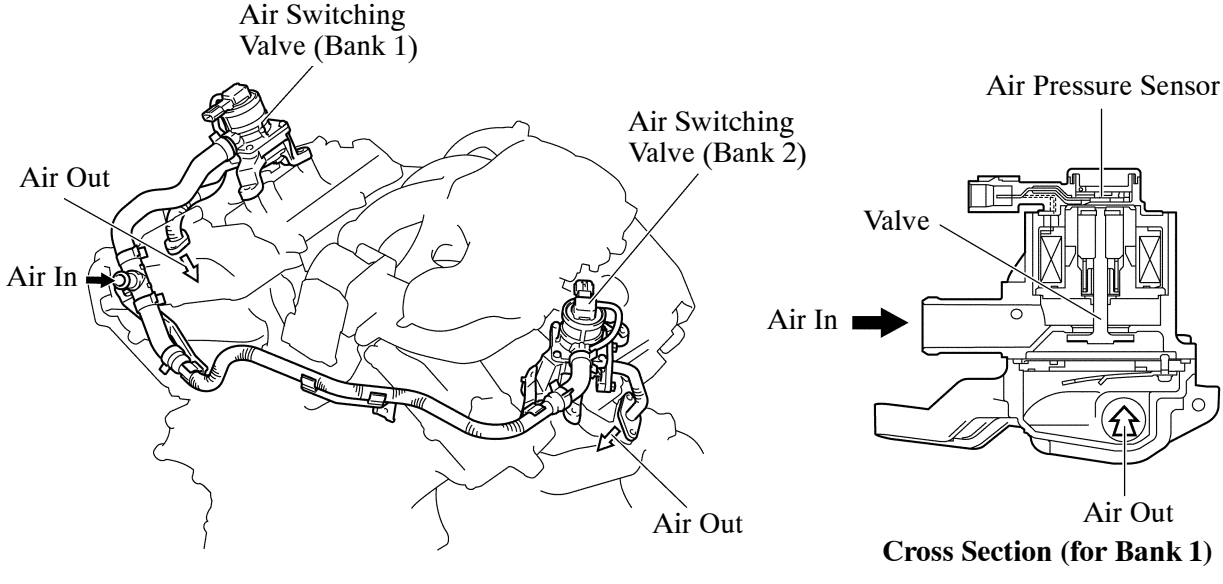
The air pump assembly consists of a DC motor, an impeller, an air filter and heater.

- The DC motor is controlled by the air injection control driver in accordance with signals from the ECM. The motor supplies air into an air switching valve through the impeller.
- The air filter is maintenance-free.
- A heater is provided to prevent operation faults in cold conditions.



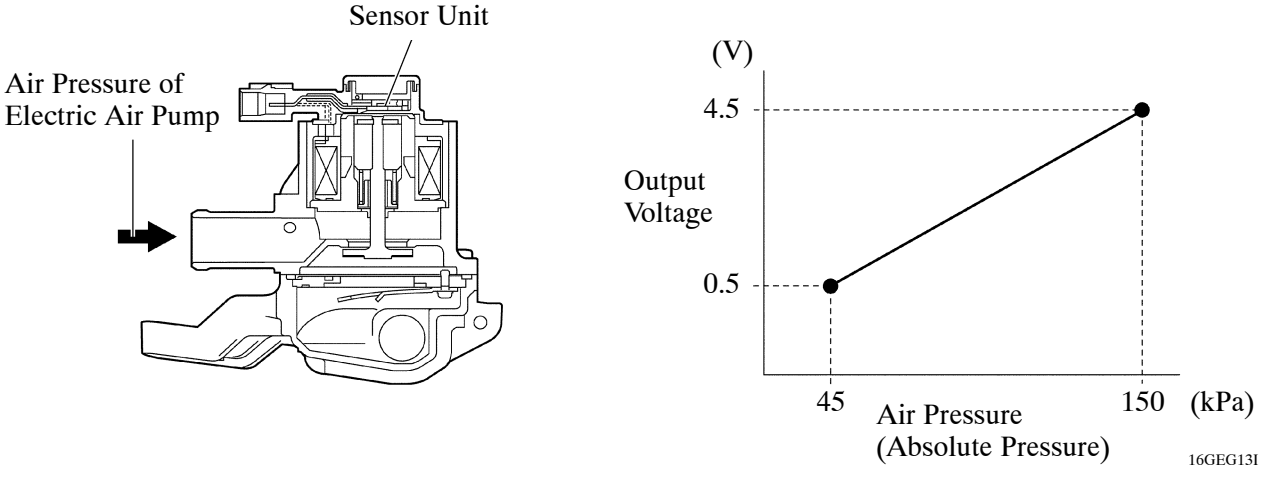
b. Air Switching Valve

- The air switching valves consist of a valve that switches the air flow and a reed valve that restricts the exhaust flow to one direction.
- The air switching valves are solenoid valves that are actuated by the ECM and air injection control driver.
- An air pressure sensor is built into the corresponding air switching valve.
- The air switching valves for bank 1 and bank 2 have the same basic structure and function.



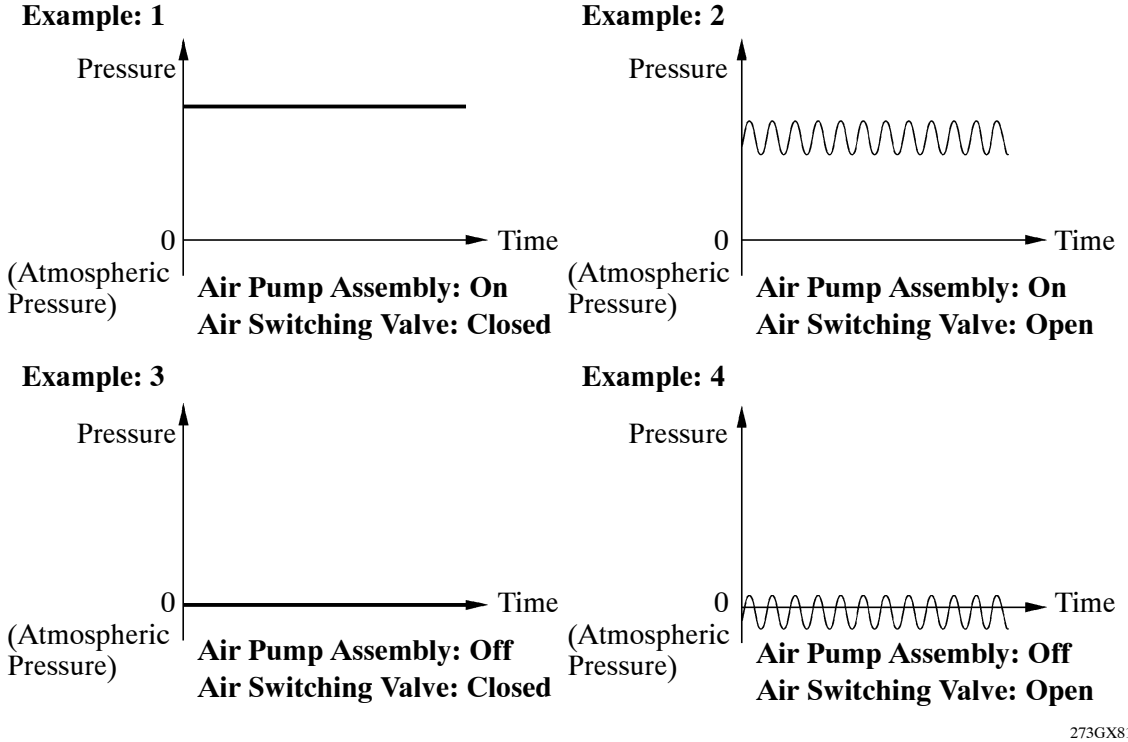
c. Air Pressure Sensor

- The air pressure sensor consists of a semiconductor, which has a silicon chip that changes its electrical resistance when pressure is applied to it. The sensor converts the pressure into an electrical signal, and sends it to the ECM in an amplified form.
- The air pressure sensors for bank 1 and bank 2 have the same basic structure and function.



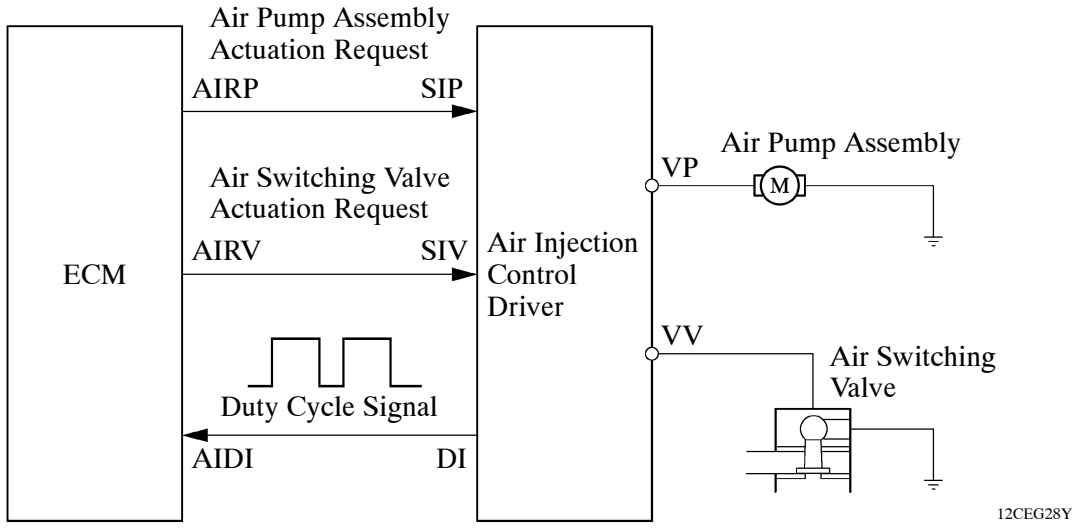
The ECM detects operation of the air injection system based on signals from the air pressure sensor as follows:

1) When the air pump assembly is on and the air switching valve is closed, the pressure is stable.
2) When the air pump assembly is on and the air switching valve is open, the pressure drops slightly and becomes unstable because of exhaust pulses.
3) When the air pump assembly is off and the air switching valve is closed, the pressure remains at atmospheric pressure.
4) When the air pump assembly is off and the air switching valve is open, the pressure drops below atmospheric pressure and becomes unstable because of exhaust pulses.



d. Air Injection Control Driver

- A semiconductor type air injection control driver is used. Activated by the ECM, this driver actuates the air pump assembly and the air switching valve.
- The air injection control driver also detects failures in the input and output circuits of the air injection control driver and transmits the failure status to the ECM via duty cycle signals.
- The following system chart shows bank 1 (right bank):



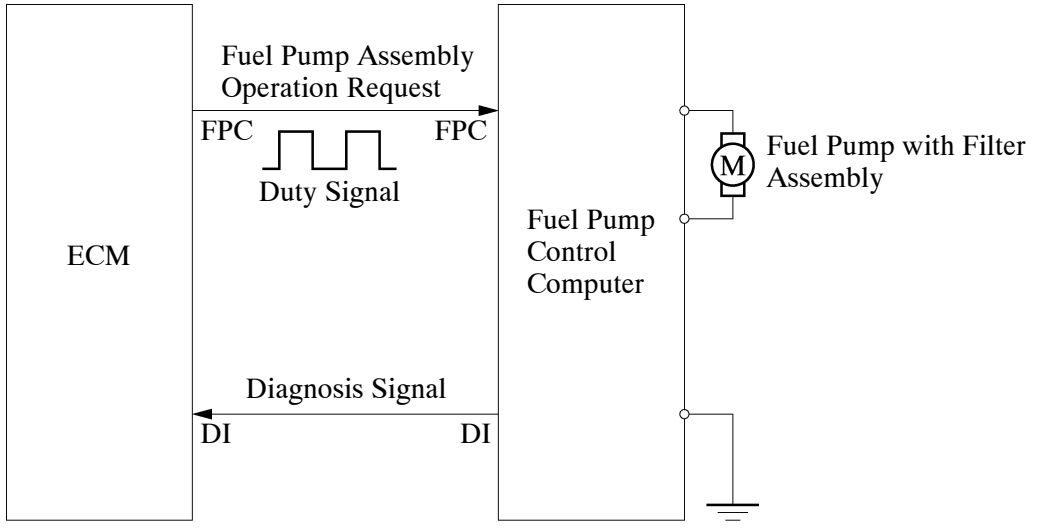
▶ DI Terminal Output ◀

Condition	AIRP	AIRV	Output (Duty Cycle Signal)
Open circuit in line between AIDI and DI terminals.	—	—	GND 273GX28
Failure in line between ECM terminals and air injection control driver.	—	—	GND 273GX28
Output failure at air injection control driver (failure in air pump actuation circuit).	—	—	200 ms, Duty 20%, GND 273GX30
Output failure at air injection control driver (failure in air switching valve actuation circuit).	—	—	Duty 40%, GND 273GX31
Overheat failure of air injection control driver.	—	—	Duty 60%, GND 273GX32
Normal	On	On	Duty 80%, GND 273GX33
	Off	Off	GND 273GX29
	On	Off	
	Off	On	

Fuel Pump Control

- By adopting a fuel pump control computer that controls the pump driving voltage in three steps according to the necessary fuel quantity, noise reduction and life extension of the fuel pump have been achieved.
- By adopting a liner type fuel pump control computer with PWM control, size and weight have been reduced by comparing to conventional register-switching type computers and fuel efficiency has been improved by suppressing the consumption electric power.
- The fuel pump control computer receives the three steps of fuel pump with filter assembly operation request signals (duty signals) from the ECM and operates the fuel pump with filter assembly.
- In addition to when the engine is stopped, the fuel pump with filter assembly is stopped when the airbags are deployed to reduce fuel leakage to minimum.

▶ System Diagram ◀



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