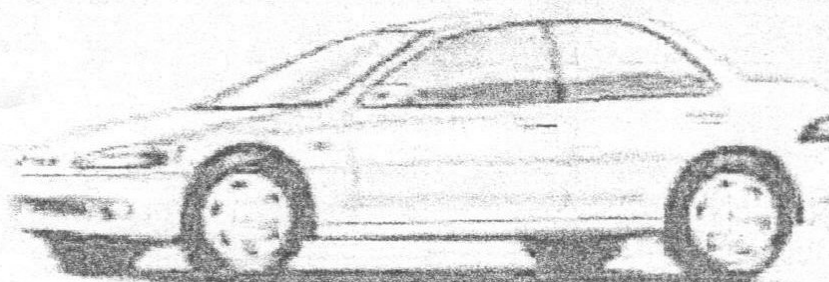


SERVICE MANUAL



SUBARU IMPREZA



FUEL INJECTION SYSTEM
(TURBO MODEL)

2-7c

SERVICE MANUAL

● Diagnostics section

FUEL INJECTION SYSTEM [TURBO MODEL]

2-7c

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1. General

- The Multipoint Fuel Injection (MFI) system is a system that supplies the optimum air-fuel mixture to the engine for all the various operating conditions through the use of the latest electronic technology.

With this system fuel, which is pressurized at a constant pressure, is injected into the intake air passage of the cylinder head. The injection quantity of fuel is controlled by an intermittent injection system where the electro-magnetic injection valve (fuel injector) opens only for a short period of time, depending on the quantity of air required for one cycle of operation. In actual operation, the injection quantity is determined by the duration of an electric pulse applied to the fuel injector and this permits simple, yet highly precise metering of the fuel.

- Further, all the operating conditions of the engine are converted into electric signals, and this results in additional features of the system, such as large improved adaptability, easier addition of compensating element, etc.
- The MFI system also has the following features:
 - Reduced emission of harmful exhaust gases.
 - Reduced in fuel consumption.
 - Increased engine output.
 - Superior acceleration and deceleration.
 - Superior startability and warm-up performance in cold weather since compensation is made for coolant and intake air temperature.
 - Suitable to turbocharged engine.

2. Air Line

A: GENERAL

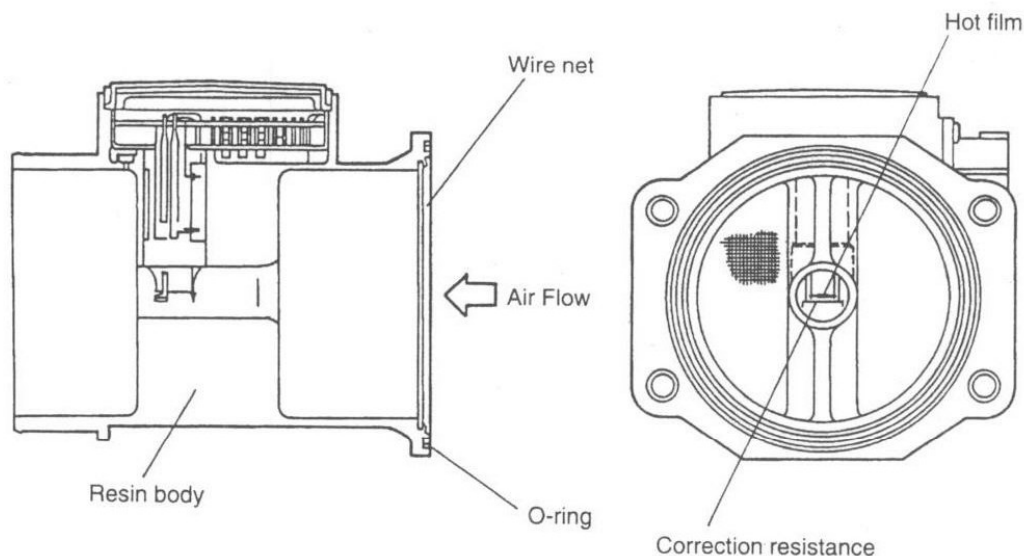
Air which is drawn in and filtered by the air cleaner is metered by the mass air flow sensor. Air is supercharged by the turbocharger and cooled down by the intercooler, and sent to the throttle body. From the throttle body, the air is regulated by the open-close operation of the throttle valve and is delivered to the intake manifold. It is then distributed to the respective cylinders to mix with fuel injected by the fuel injectors. Thus, the air-fuel mixture is delivered into the cylinder. Part of the air branched at the upstream of the throttle body is sent to the idle air control solenoid valve which regulates engine idle speed.

B: MASS AIR FLOW SENSOR

- The MFI system employs a hot-film type mass air flow sensor.

These mass air flow sensors convert the amount of air taken into the engine into an electric signal by utilizing the heat transfer phenomenon between the incoming air and a heating resistor (hot film) located in the air intake.

- The features of these flow sensor types are as follows:
 - High-altitude compensation is made automatically.
 - Quick response.
 - These are no moving parts.
 - They are compact.



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C: THROTTLE BODY

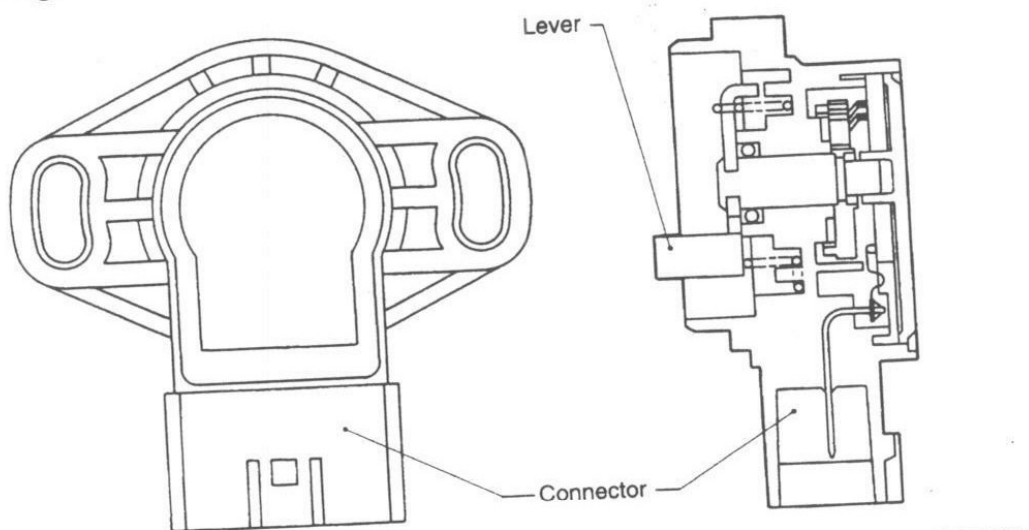
In response to the depressing stroke of the throttle pedal, the throttle body opens/closes its valve to regulate the air volume to be taken in the combustion chamber.

During idling, the throttle valve is almost fully closed and the air flow through the throttle body is less than that passing through the carburetor.

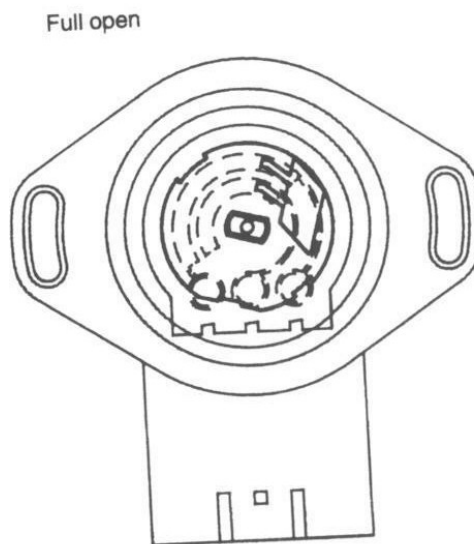
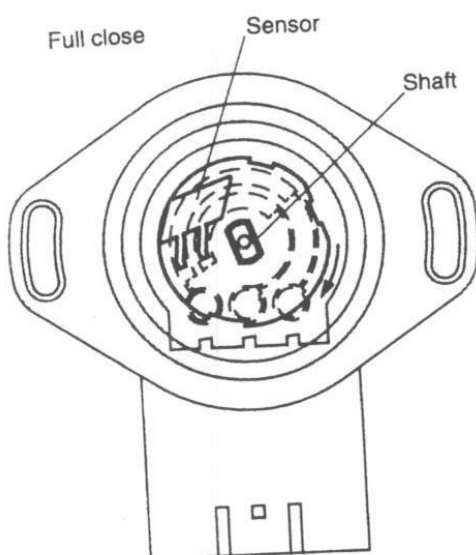
More than half of the air necessary for idling is supplied to the intake manifold via the idle air control solenoid valve.

D: THROTTLE POSITION SENSOR

- A throttle position sensor is provided with a potentiometer which is interlocked with the throttle valve shaft.
- This throttle position sensor sends the ECM a potentiometer output signal corresponding to the opening of the throttle valve. When the level of this signal exceeds a predetermined value, the ECM interprets it as complete closure of the throttle valve and makes a control most suitable for the engine operation with the throttle valve fully closed. For correcting error of this signal, the ECM is provided with a learning function.
- Thus, the ECM precisely controls the air-fuel ratio during acceleration and deceleration as well as engine idling.



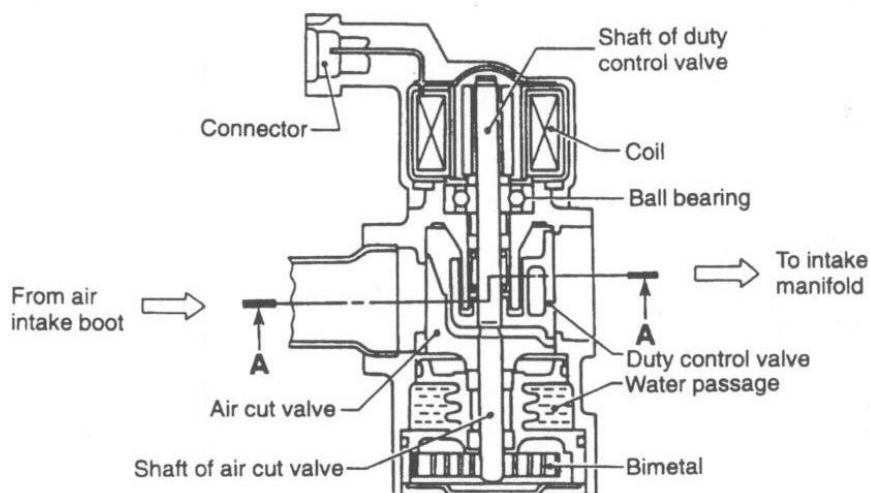
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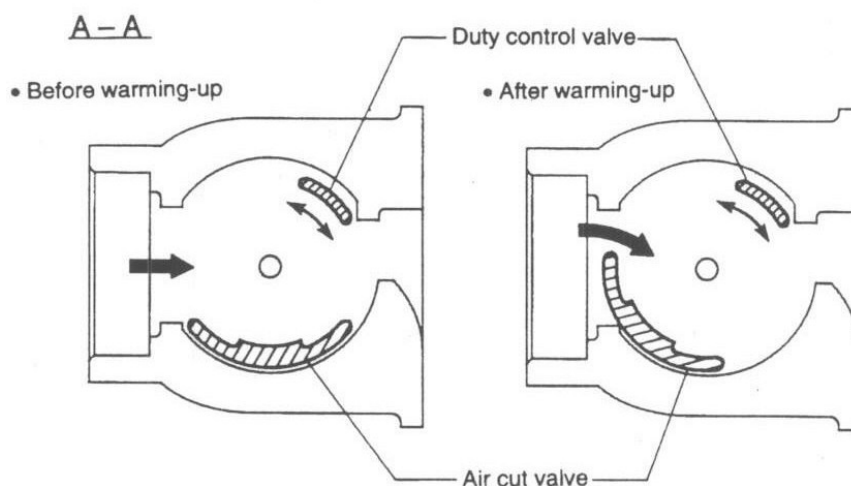
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E: IDLE AIR CONTROL SOLENOID VALVE

- Idle air control solenoid valve consists of an air cut valve, duty control valve, intake air passage and a coolant passage.
- Air cut valve contains a bimetallic substance which responds to coolant temperature, and a duty control valve which is operated by a signal sent from ECM.
- When engine coolant temperature is low, air cut valve is fully opened by the action of the bimetallic substance so that the air flow required for low engine coolant temperatures is maintained.
- ECM controls duty control valve to bring the operating engine speed as close to preset idle speed as possible.



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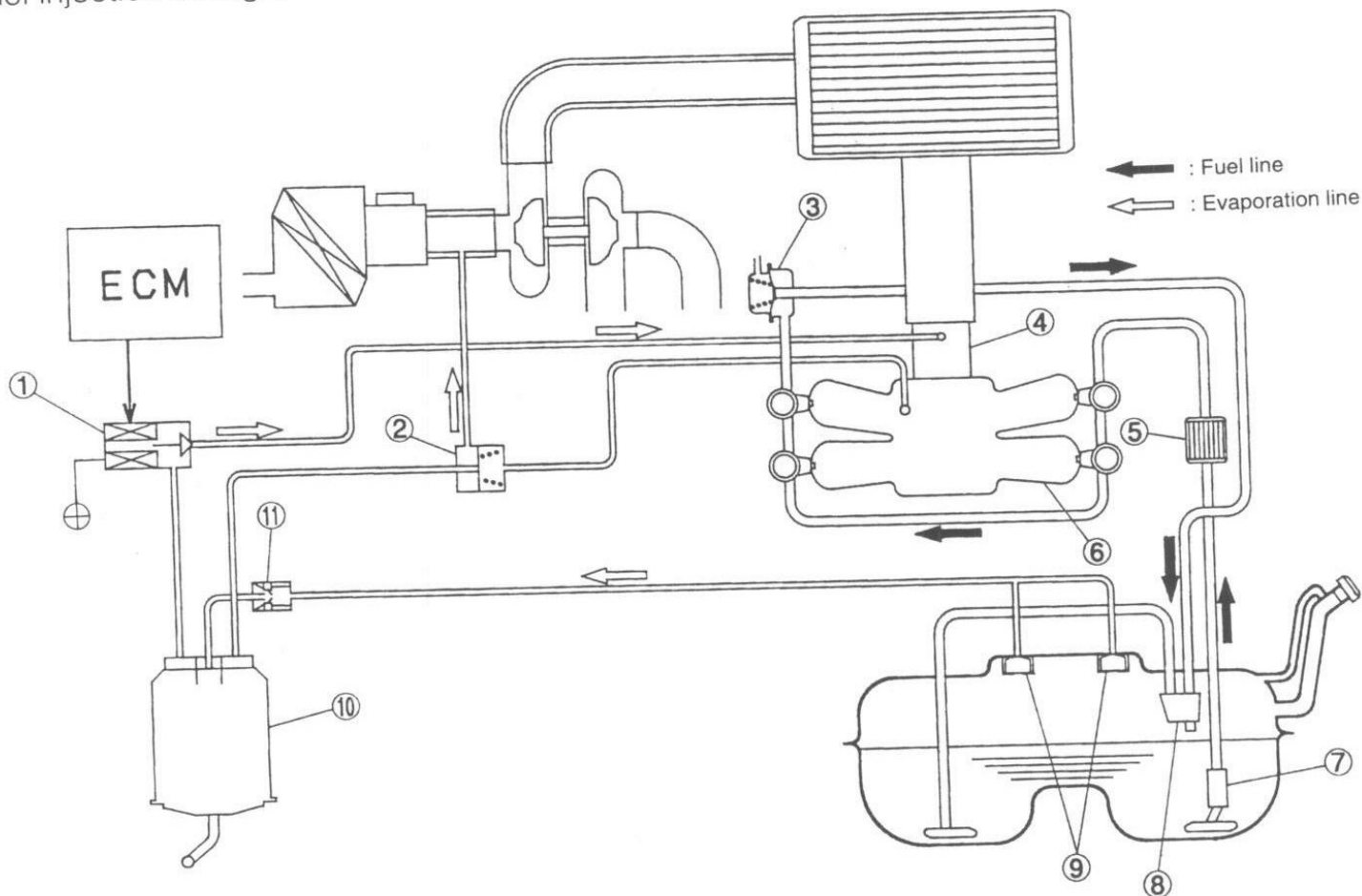


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3. Fuel Line

A: GENERAL

- Fuel pressurized by the fuel pump built into the fuel tank is delivered to fuel injectors by way of the fuel pipe and fuel filter. Fuel is regulated to the optimum pressure level by the pressure regulator on the way to the injectors.
 - From the injectors, fuel is injected into the intake manifold where it is mixed with intake air, and is then delivered to the respective cylinders.
- Fuel injection timing and the amount of fuel injected is regulated by the ECM.



- ① Purge control solenoid valve
- ② Auxiliary purge control valve
- ③ Pressure regulator
- ④ Throttle body
- ⑤ Fuel filter
- ⑥ Intake manifold

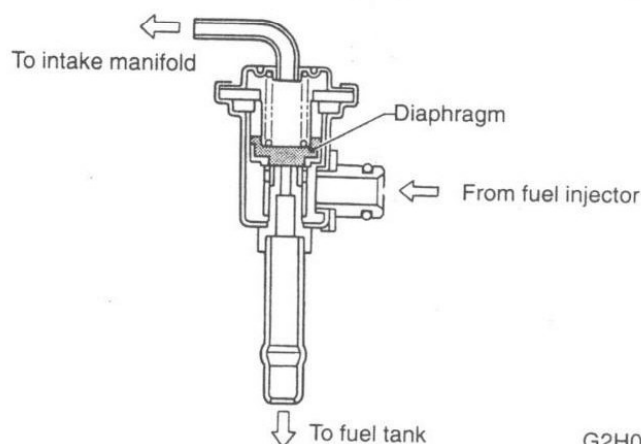
- ⑦ Fuel pump
- ⑧ Jet pump
- ⑨ Fuel cut valve
- ⑩ Canister
- ⑪ Two-way valve

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B: PRESSURE REGULATOR

- The pressure regulator is divided into the fuel chamber and the spring chamber by the diaphragm as illustrated below. Fuel is fed to the fuel chamber through the fuel inlet connected with the injector. A difference in pressure between the fuel chamber and the spring chamber connected with the intake manifold causes the diaphragm to be pushed down, and fuel is fed back to the fuel tank through the return line.

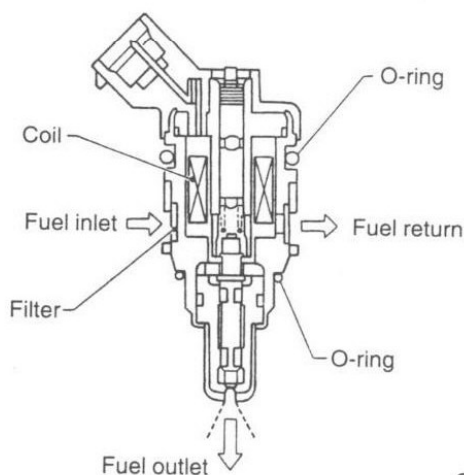
- By returning fuel so as to balance the above pressure difference and the spring force, the fuel pressure is kept at a constant level 299.1 kPa (3.05 kg/cm², 43.4 psi) against the intake manifold pressure.



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C: FUEL INJECTOR

- The MFI system employs a gallery type (side-feed type) fuel injector.
- The gallery type fuel injector is installed in the fuel pipe to allow cooling of the injector by the fuel.
- The features of this type of fuel injector are as follows:
 - High heat resistance
 - Low driving noise
 - Easy to service
 - Small size
- The fuel injector injects fuel according to the valve open signal received from the ECM.
- The nozzle is attached on the top of the fuel injector. The ball valve is lifted by the solenoid coil through the plunger on arrival of the valve open signal.
- Since the injection opening, the lifted level of valve and the regulator-controlled fuel pressure are kept constant, the amount of fuel to be injected can be controlled only by the valve open signal from the ECM.

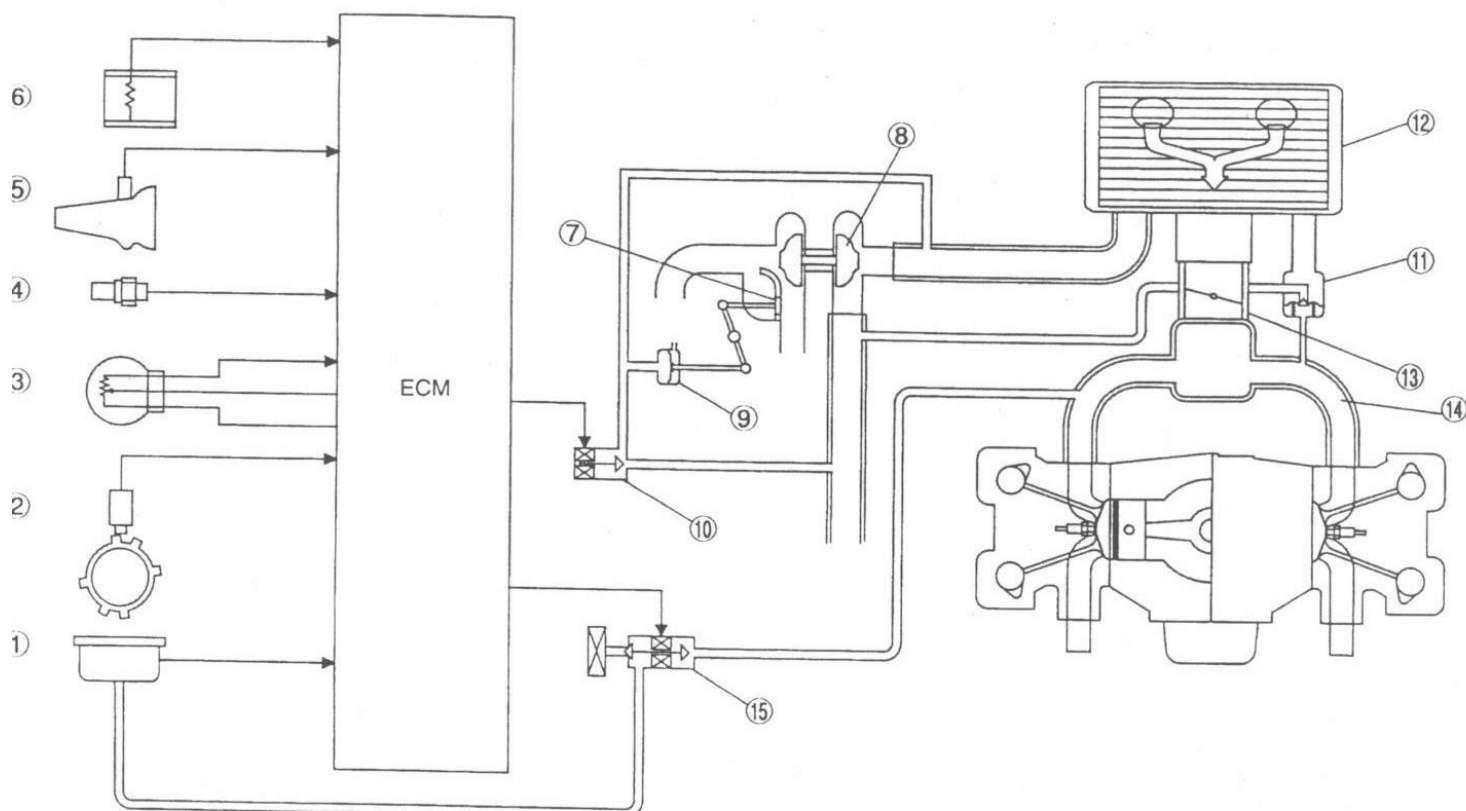


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4. Turbocharger System

A: GENERAL

- This turbocharger system consists of a water-cooled turbocharger, air-cooled intercooler, waste-gate control solenoid valve, pressure sources switching solenoid valve, etc.
- The outlet side turbine, rotated by the energy of exhaust gas it receives, rotates the inlet side turbine. As a result, the intake air is compressed before it is delivered to the intake manifold.
- The intake air, heated when passed through the turbocharger unit, is cooled as it passes through the intercooler.
- This turbocharger system controls supercharging pressure on the basis of the difference from the atmospheric pressure. Even at a high altitude, therefore, the system offers stable performance without being affected by variations in atmospheric pressure.



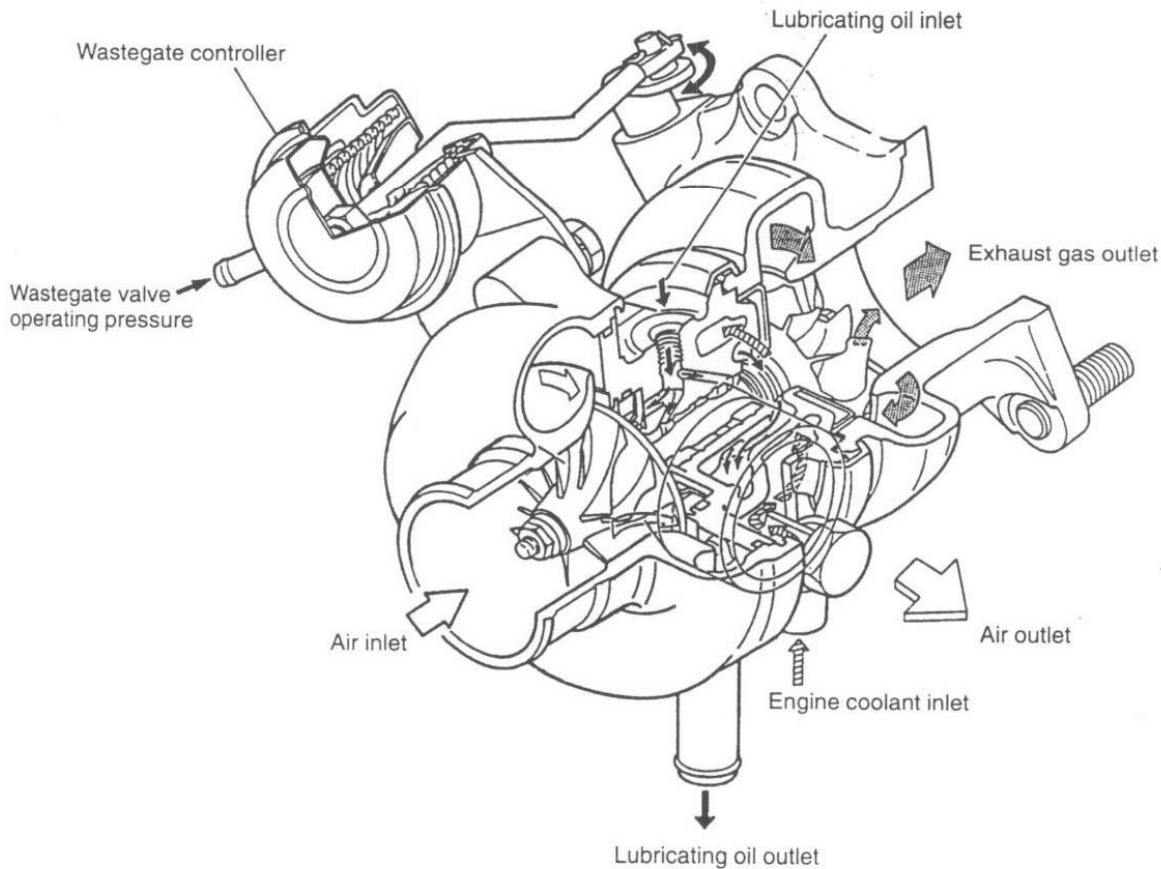
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- ① Pressure sensor
- ② Crankshaft position sensor
- ③ Throttle position sensor
- ④ Engine coolant temperature sensor
- ⑤ Vehicle speed sensor 2
- ⑥ Mass air flow sensor
- ⑦ Wastegate valve
- ⑧ Turbocharger unit

- ⑨ Wastegate controller
- ⑩ Wastegate control solenoid valve
- ⑪ Air by-pass valve
- ⑫ Intercooler
- ⑬ Throttle body
- ⑭ Intake manifold
- ⑮ Pressure sources switching solenoid valve

B: TURBOCHARGER UNIT

The turbocharger is water-cooled, and utilizes a wastegate valve to normalize supercharged pressure. The turbine is constructed of a lightweight, thin walled, and heat-resistant casting. The compressor is a thin wall aluminum alloy casting. The bearing section uses a full-floating metal system.

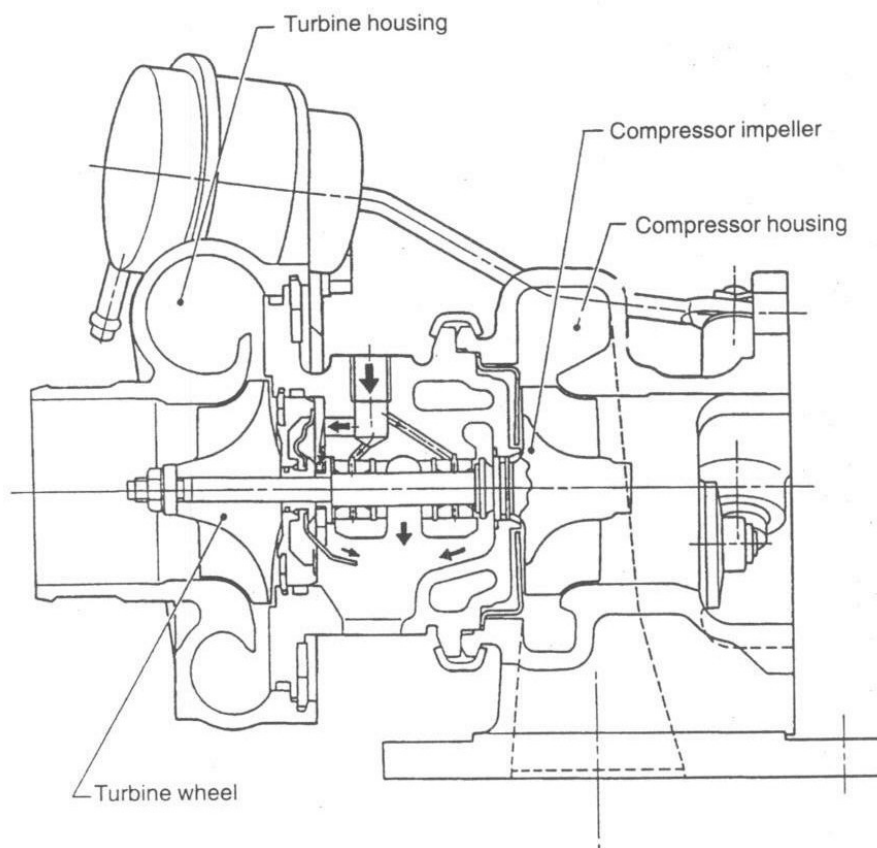


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C: LUBRICATION OF TURBOCHARGER

The turbocharger is lubricated by the engine oil branched out from the oil pump. Since the turbocharger turbine and the compressor shaft reach a maximum of several hundred thousand revolutions per minute, the full-floating type bearings are used to form desirable lubrication films on their inside and outside during running.

Further the oil supplied to the turbocharger also plays an important role of cooling the heat from exhaust gas in the turbine not to propagate to the bearings.



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D: COOLING OF TURBOCHARGER

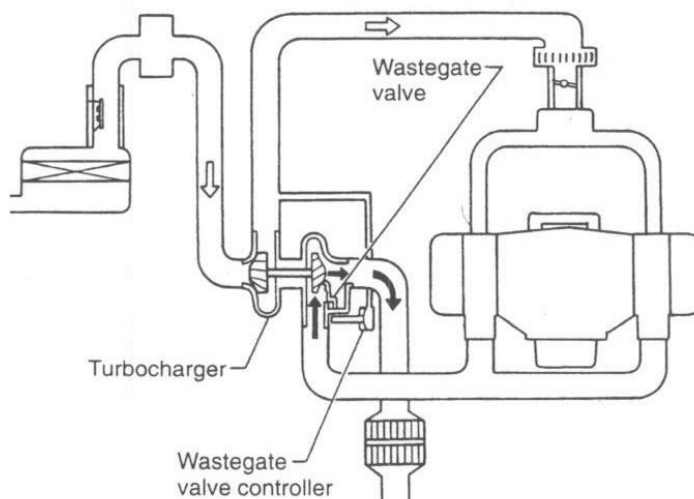
The turbocharger unit is water cooled for higher reliability and durability. The engine coolant from the coolant drain hose under the engine cylinder head is led to the coolant passage, through a pipe, provided in the turbocharger bearing housing. After cooling the bearing housing, the engine coolant is led into the coolant filler tank through a pipe.

E: REGULATION OF SUPERCHARGING PRESSURE

1. BASIC FUNCTION OF THE WASTEGATE VALVE

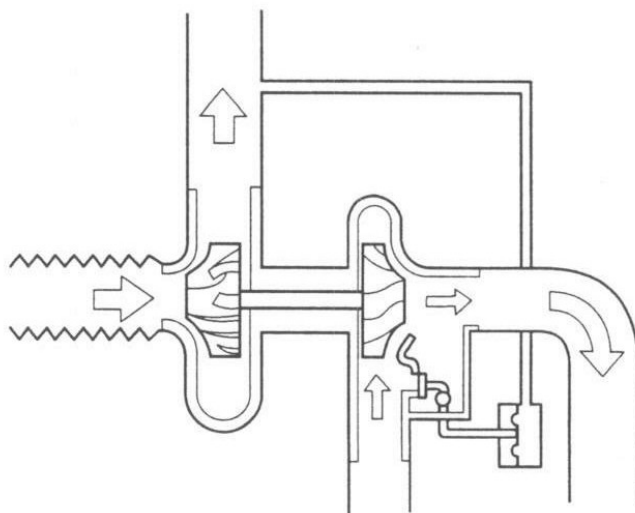
As the engine speed increases with the opening of the throttle valve, the amount of exhaust gas increases. This leads to increase in the rotational speed of turbine (approx. 20,000 to 150,000 rpm), the supercharging pressure and the output.

However, excessive supercharging pressure may cause occurrence of the knocking and heavier thermal load on such a part as piston. In the worst case, the engine may be damaged or broken. To prevent this, the wastegate valve and its controller are equipped. By sensing the supercharging pressure, the wastegate valve restricts it below a predetermined level.



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While the supercharging pressure is lower than the predetermined level, the wastegate valve is closed so that all the exhaust gas is carried through the turbine.



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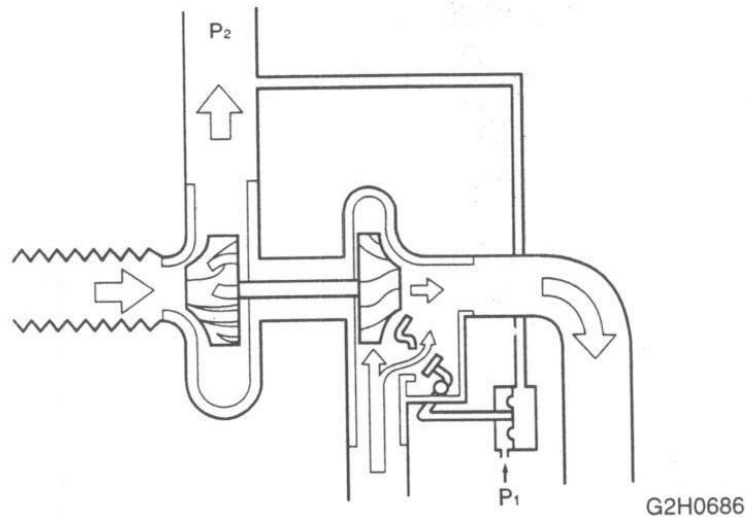
When it reaches the predetermined level, the wastegate controller lets the supercharging pressure to press the diaphragm, causing the linked wastegate valve to open. With the wastegate-valve opened, a part of the exhaust gas is allowed to flow into the exhaust gas pipe by bypassing the turbine.

This decreases the turbine rotating energy to keep the supercharging pressure constant.

It means $P_2 - P_1 = \text{constant}$

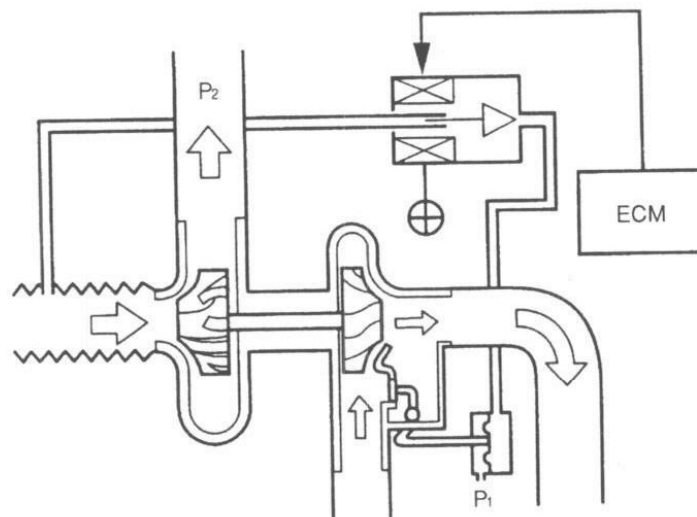
P_1 : Atmospheric pressure

P_2 : Supercharging pressure



2. CONCEPT OF THE WASTEGATE VALVE CONTROL

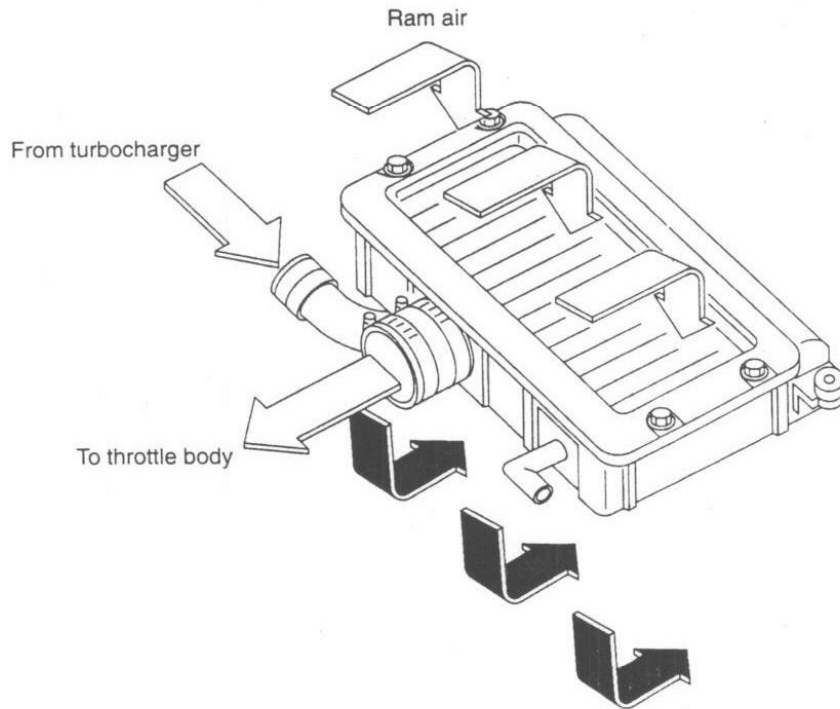
The higher the altitude, the lower the atmospheric pressure (P_1) and supercharging pressure (P_2). The duty solenoid valve acts as a control to maintain maximum supercharging pressure (P_2) under absolute pressure.



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F: INTERCOOLER

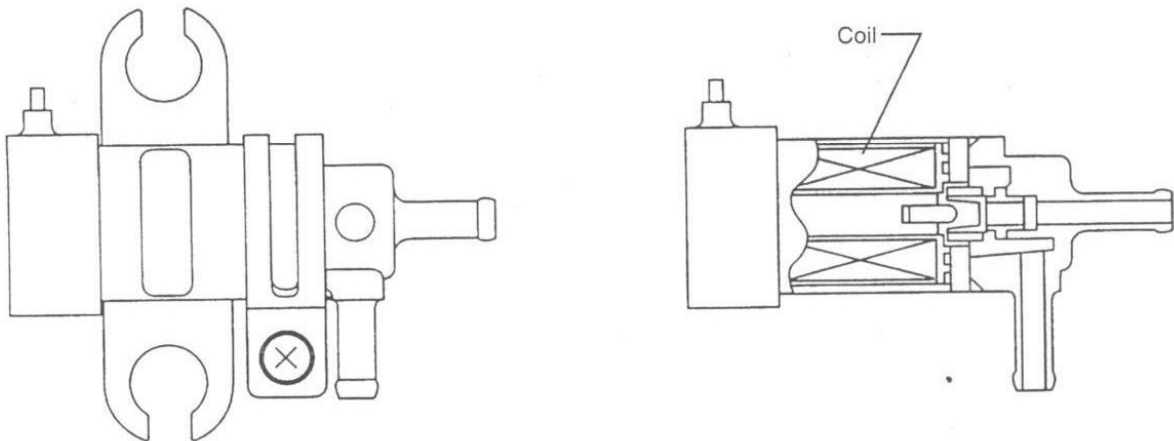
- Since the intake air passed through the turbocharger unit is heated to a very high temperature, the air itself is expanded, resulting in a lower engine charging efficiency. To lower the temperature of the intake air, therefore, the intercooler is provided just before the throttle body.
- The intercooler is an air cooled type. The air delivered from the air duct provided at the engine hood flows through the core and cools the intake air passing through the intercooler.



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G: WASTEGATE CONTROL SOLENOID VALVE

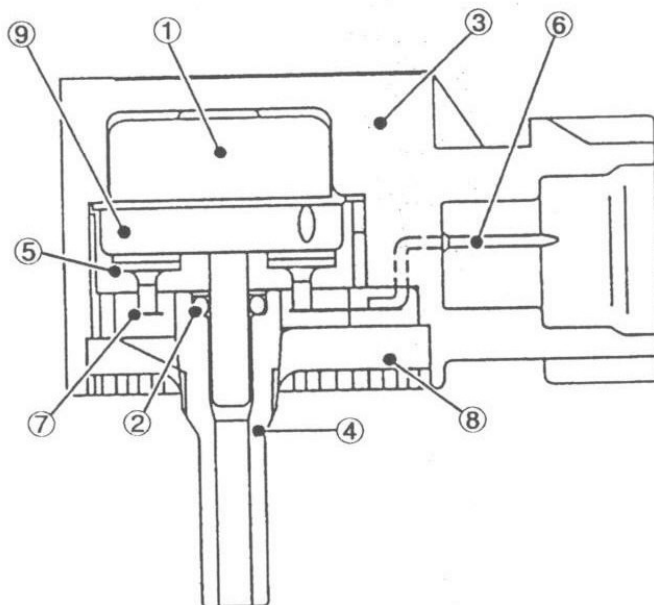
The wastegate control solenoid valve, coupled with the wastegate controller, switches the intake air pressure to be delivered to the wastegate controller in response to a signal from ECM. When the solenoid valve is closed, the intake air pressure upstream of the turbocharger unit is delivered to the wastegate controller. When the solenoid valve is opened, the intake air pressure downstream of the turbocharger unit (supercharged air pressure) is delivered to the wastegate controller.



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H: PRESSURE SENSOR

The pressure sensor alternately receives the intake air pressure in the collector chamber and the atmospheric pressure, converts the pressure values into signals, and sends the signals to ECM. Switchover between the intake air pressure and atmospheric pressure is accomplished by the pressure exchange solenoid valve.

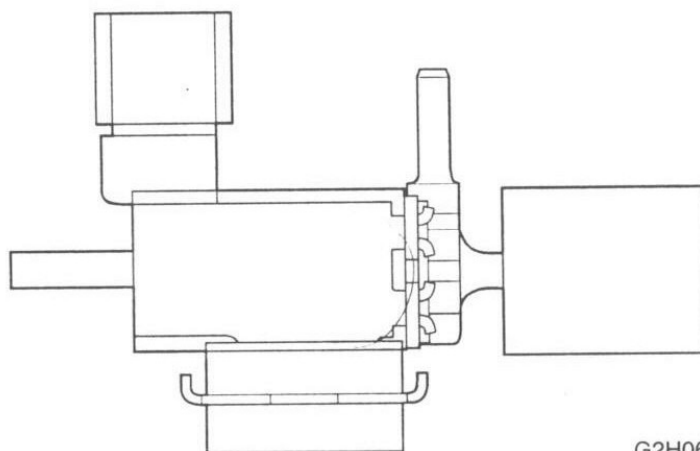


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- | | |
|--------------------|--------------|
| ① Sensor unit | ⑥ Terminal |
| ② O-ring | ⑦ Inner lead |
| ③ Case | ⑧ Resin |
| ④ Pipe | ⑨ Metal lid |
| ⑤ Through capacity | |

I: PRESSURE SOURCES SWITCHING SOLENOID VALVE

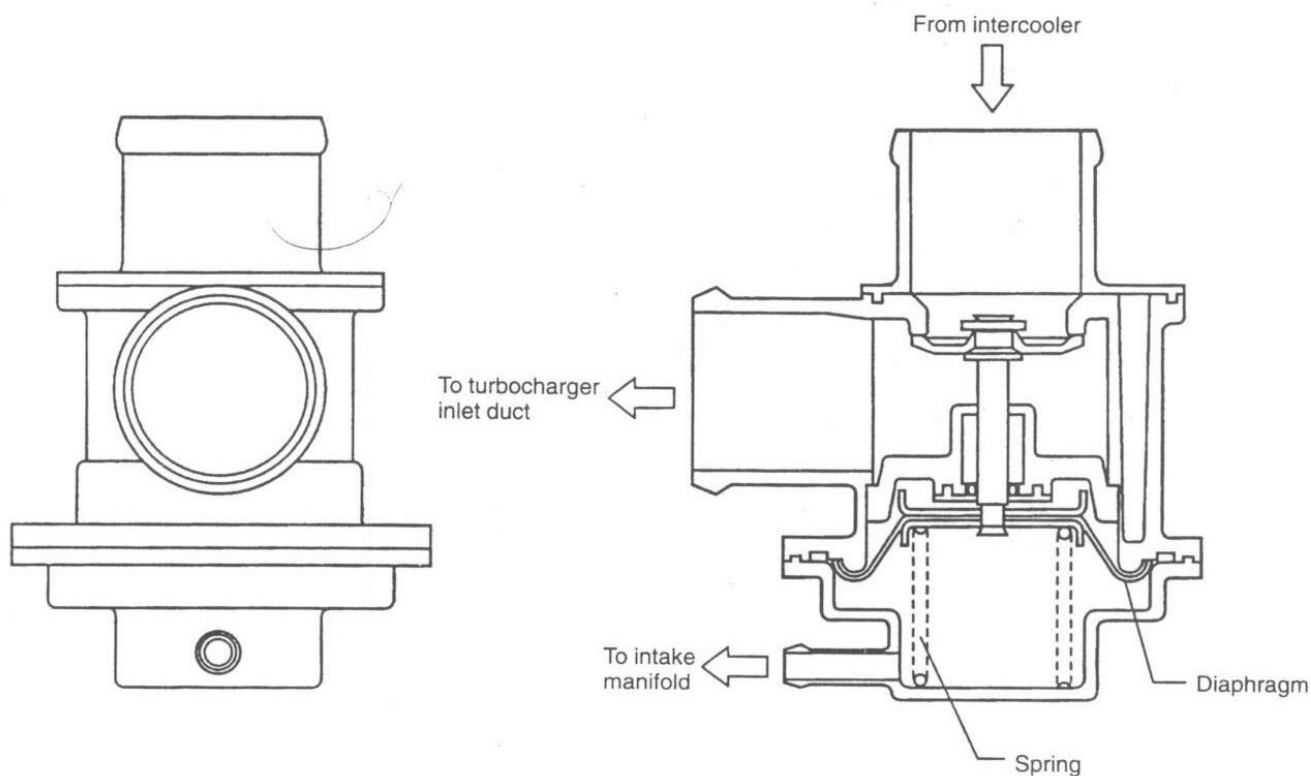
Located at an intermediate point of the line between the collector chamber and pressure sensor, the pressure sources switching solenoid valve switches between the intake air pressure and atmospheric pressure from which the pressure sensor produces signals.



G2H0691

J: AIR BY-PASS VALVE

When a throttle valve is suddenly closed, low air suction noise may occur due to a sudden rise of the air pressure in the passage between the turbocharger and throttle body. To prevent this, an air by-pass valve and air passage are provided. The air by-pass valve, actuated by the vacuum created by a sudden closure of the throttle valve, allows the suction air to by-pass the turbocharger and pass directly upstream, thus lowering the pressure in the air passage.

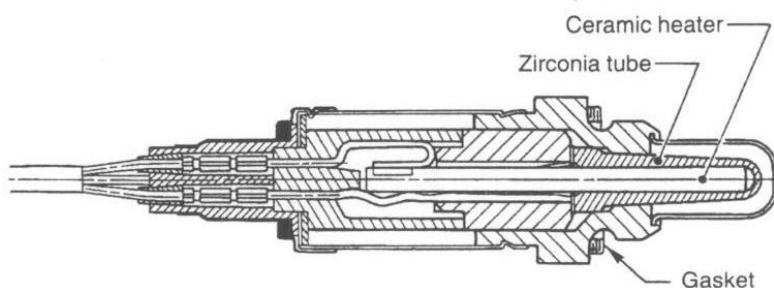


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5. Sensor and Switch

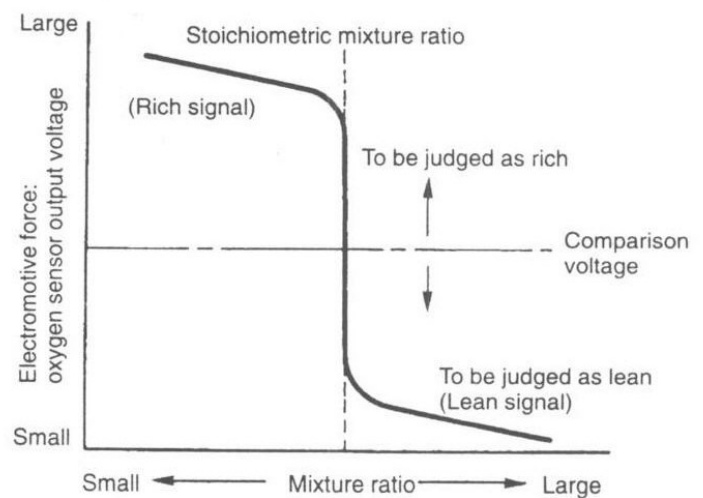
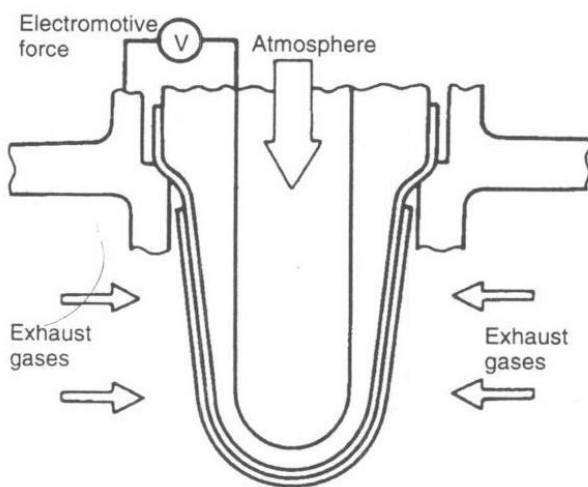
A: OXYGEN SENSOR

- The oxygen sensor is used to sense oxygen concentration in the exhaust gas. If the fuel ratio is leaner than the stoichiometric ratio in the mixture (i.e. excessive amount of air), the exhaust gas contains more oxygen. To the contrary, if the fuel ratio is richer than the stoichiometric ratio, the exhaust gas contains hardly any oxygen.
- Therefore, examination of the oxygen concentration in exhaust gas makes it possible to show whether the air/fuel ratio is leaner or richer than the stoichiometric ratio.
- The oxygen sensor has a zirconia tube (ceramic) which generates voltage if there is a difference in oxygen concentration between the inside and outside of the tube. Platinum is coated on the inside and outside of the zirconia tube for the purpose of catalysis and electrode provision. The hexagon screw on the outside is grounded to the exhaust pipe, and the inside is connected to the ECM through the harness.
- A ceramic heater is employed to improve performance at low temperature.



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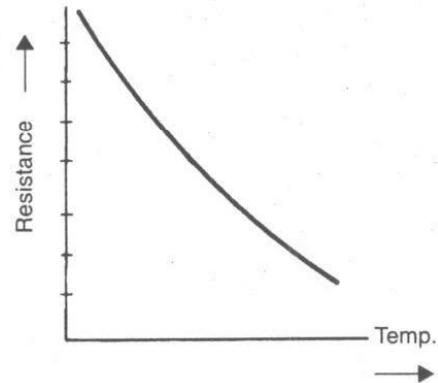
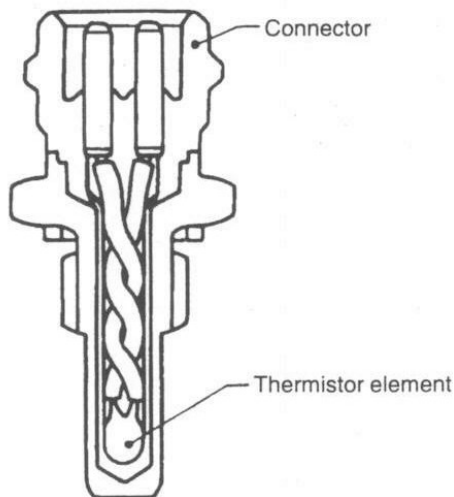
- When rich air-fuel mixture is burnt in the cylinder, the oxygen in the exhaust gases reacts almost completely through the catalytic action of the platinum coating on the surface of the zirconia tube. This results in a very large difference in the oxygen concentration between the inside and outside, and the electromotive force generated is large.
- When a lean air-fuel mixture is burnt in the cylinder, oxygen remains in the exhaust gases even after the catalytic action, and this results in a small difference in the oxygen concentration. The electromotive force is very small.
- The difference in oxygen concentration changes greatly in the vicinity of the optimum air-fuel ratio, and hence the change in the electromotive force is also large. By inputting this information into the MFI control unit, the air-fuel ratio of the supplied mixture can be determined easily. The oxygen sensor does not generate much electromotive force when the temperature is low. The characteristics of the electromotive force stabilize at temperature of approximately 300 to 400°C (572 to 752°F).



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B: ENGINE COOLANT TEMPERATURE SENSOR

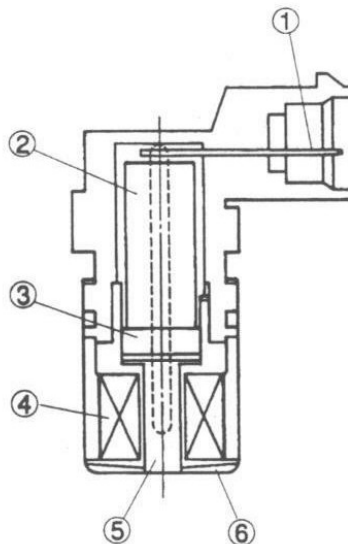
The engine coolant temperature sensor is located on the engine coolant pipe which is made of aluminum alloy. Its thermistor changes resistance with respect to temperature. A engine coolant temperature signal converted into resistance is transmitted to the ECM to control the amount of fuel injection, ignition timing, etc.



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C: CRANKSHAFT POSITION SENSOR

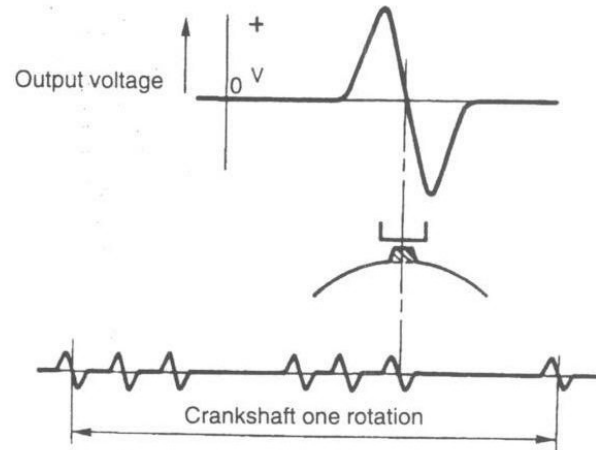
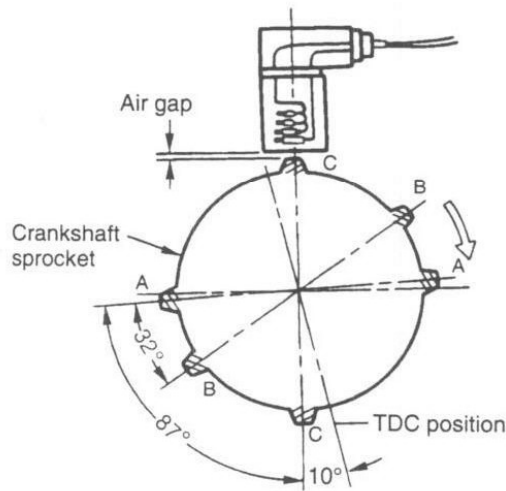
- The crankshaft position sensor is installed on the oil pump, located in the front center portion of the cylinder block, to detect the crankshaft position. It is designed so that the ECM accurately reads the number of pulses which occur when protrusions provided at the perimeter of the crankshaft sprocket (rotating together with the crankshaft) cross the crankshaft position sensor.
- The crankshaft position sensor is a molded type which consists of a magnet, core, coil, terminals, etc.



- | | |
|-------------|---------|
| ① Terminal | ④ Coil |
| ② Yoke core | ⑤ Core |
| ③ Magnet | ⑥ Cover |

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- The crankshaft sprocket is provided with six protrusions. Crankshaft rotation causes these protrusions to cross the crankshaft position sensor so that magnetic fluxes in the coil change with the change in air gap between the sensor pickup and the sprocket. The change in air gap induces an electromotive force which is transmitted to the ECM.

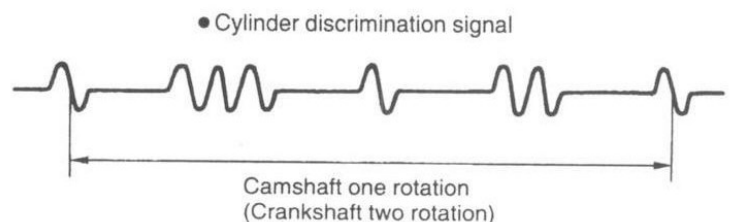
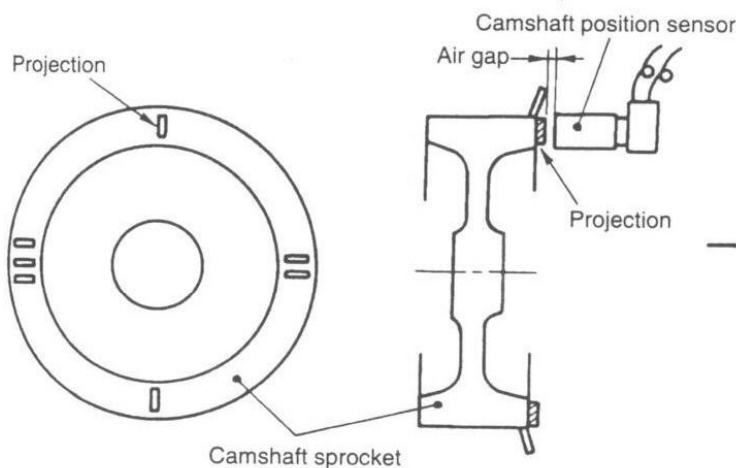


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D: CAMSHAFT POSITION SENSOR

- The camshaft position sensor is located on the left-hand camshaft support to detect the combustion cylinder at any one moment.
- It is designed so that the ECM accurately reads the number of pulses which occur when protrusions provided on the back of the LH camshaft-drive sprocket cross the sensor.

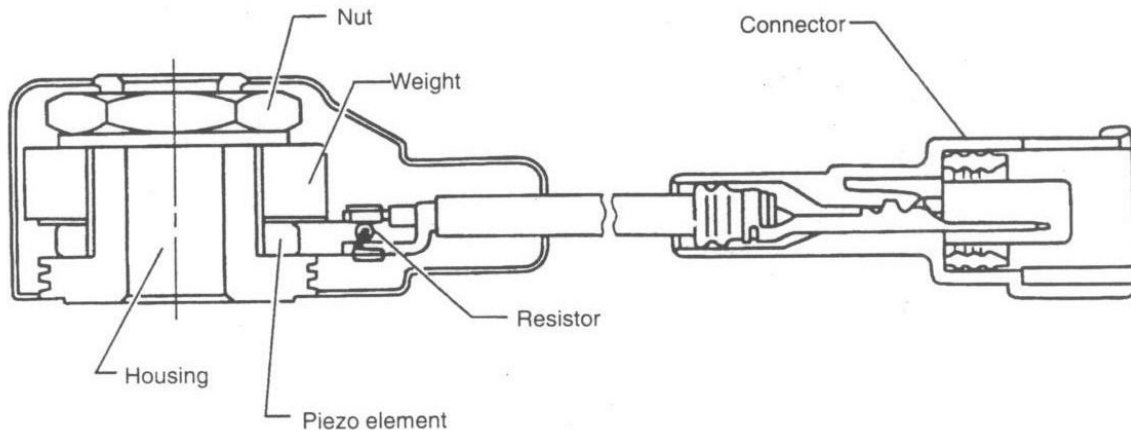
Internal construction and the basic operating principle of the camshaft position sensor are similar to those of the crankshaft position sensor. A total of seven protrusions (one each at two locations, two at one location and three at one location) are arranged in four equal parts of the sprocket, as shown below.



G2H0693

E: KNOCK SENSOR

- The knock sensor is installed on the cylinder block, and senses knocking signals.
- This knock sensor is a piezo-electric type which converts knocking vibrations into electric signals.
- It consists of a piezo-electric element, weight, and case. If knocking occurs in the engine, the weight in the case moves causing the piezo-electric element to generate a voltage.



G2H0681

F: VEHICLE SPEED SENSOR 2

- Vehicle speed sensor 2 is installed onto transmission case, the signal emitted from it is sent to the ECM and speedometer.
- The inner shaft in vehicle speed sensor 2 is connected to speedometer shaft in transmission with plate. The pick-up signal is emitted by rotation of the shaft.

6. Control System

A: GENERAL

The ECM (Engine Control Module) receives signals sent from various sensors and switches to judge the engine operating condition and emits output signals to provide the optimum control and/or functioning of various systems.

Major items governed by the ECM are as follow:

- Fuel injection control
- Ignition system control
- Idle air control
- Wastegate control
- Canister purge control
- Radiator fan control
- Fuel pump control
- Air conditioner cut control
- On-board diagnosis function
- Fail-safe function

B: INPUT AND OUTPUT SIGNALS

	Unit	Function
Input signal	Mass air flow sensor	Detects the amount of intake air.
	Throttle position sensor	Detects the throttle position.
	Oxygen sensor	Detects the density of oxygen in exhaust gases.
	Crankshaft position sensor	Detects engine speed and crankshaft position.
	Camshaft position sensor	Detects relative cylinder position.
	Engine coolant temperature sensor	Detects the coolant temperature.
	Knock sensor	Detects engine knocking.
	Vehicle speed sensor 2	Detects vehicle speed.
	Ignition switch	Detects ignition switch operation.
	Starter switch	Detects the condition of engine cranking.
	A/C switch	Detects the ON-OFF operation of the A/C switch.
	Neutral switch	Detects gear shift in neutral position.
	Pressure sensor	Detects atmospheric pressure and intake manifold pressure.

	Unit	Function
Output signal	Fuel Injector	Inject fuel.
	Ignition signal	Turns primary ignition current ON or OFF.
	Fuel pump relay	Turns the fuel pump relay ON or OFF.
	A/C control relay	Turns A/C control relay ON or OFF.
	Radiator fan control relay	Turns radiator fan control relay ON or OFF.
	Idle air control solenoid valve	Adjusts the amount of idle air flowing through the throttle valve.
	Malfunction indicator lamp	Indicates trouble.
	Purge control solenoid valve	Controls the amount of canister purge through the throttle body.
	Pressure sources switching solenoid valve	Switches pressure detection line between atmospheric pressure and intake manifold pressure.
	Wastegate control solenoid valve	Controls the supercharging pressure.

C: FUEL INJECTION CONTROL

- The ECM receives signals emitted from various sensors to control the amount of fuel injected and the fuel injection timing. Sequential fuel injection control is utilized over the entire engine operating range except during standing starts.
- The amount of fuel injected by the injector valve is dependent upon the length of time it remains open. The optimum fuel injection timing is determined by transmitting a signal to the injector from the ECM according to varying engine operations. Feedback control is also accomplished by means of a learning control. As a result, the fuel injection control system is highly responsive and accurate in design and structure.
- The sequential fuel injection system is designed so that fuel is injected at a specific time to provide maximum air intake efficiency for each cylinder. In other words, fuel injection is completed just before the intake valve begins to open.

1. FUEL INJECTION CHARACTERISTICS

Fuel injection timing is basically expressed as indicated below:

- 1) During engine starts:
Duration of fuel injection = Duration of fuel injection during engine starts
 - 2) During normal operation:
Basic duration of fuel injection x correction factor + voltage correction time
- Basic duration of fuel injection The basic length of time fuel is injected. This is determined by two factors — the amount of intake air detected by the mass air flow sensor and the engine speed (rpm) monitored by the crankshaft position sensor.
 - Duration of fuel injection during engine starts Determined according to the engine coolant temperature detected by a signal emitted from the engine coolant temperature sensor to improve starting ability.
 - Voltage correction time Compensates for the fuel injector's time lag affected by the battery voltage.

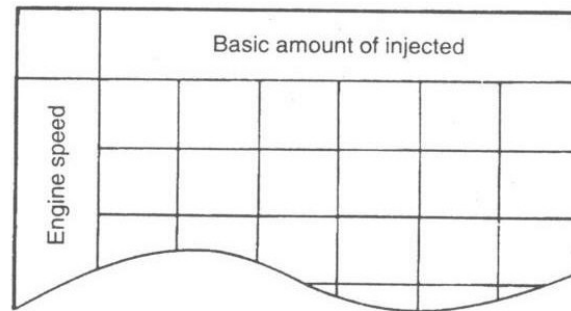
2. CORRECTION COEFFICIENTS

Correction coefficients are used to correct the basic duration of fuel injection so that the air-fuel ratio meets the requirements of varying engine operations.

These correction coefficients are classified as follows:

1) Air-fuel ratio coefficient:

Allotted to provide the optimum air-fuel ratio in relation to engine speed and the basic amount of fuel injected.

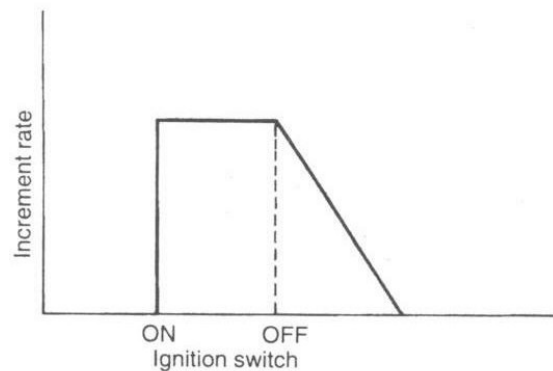


Air-fuel ratio characteristic

G2H0044

2) Start increment coefficient:

Increases the amount of fuel injected only when cranking the engine, which improves starting ability.

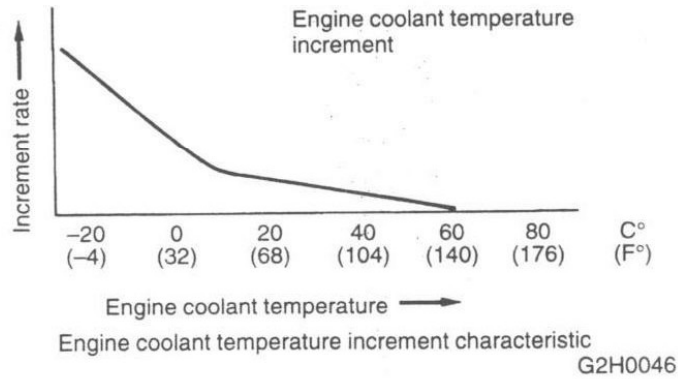


Start increment characteristic

G2H0045

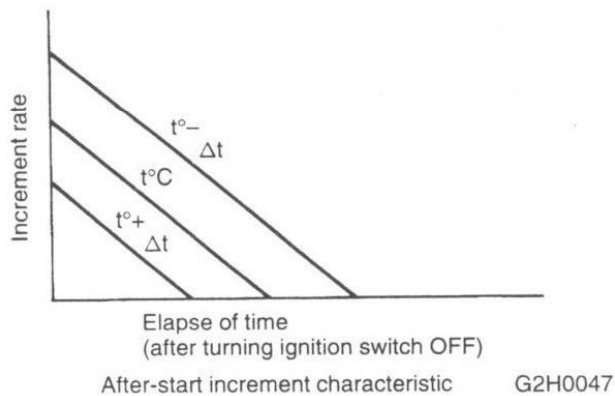
3) Engine coolant temperature increment coefficient:

Used to increase the amount of fuel injected in relation to a signal emitted from the engine coolant temperature sensor for easier starting of a cold engine. The lower the engine coolant temperature, the greater the increment rate.



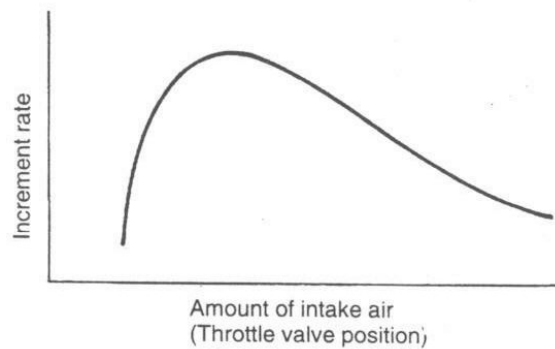
4) After-start increment coefficient:

Increases the amount of fuel injected for a certain period of time immediately after the engine starts to stabilize engine operation.



5) Full increment coefficient:

Increases the amount of fuel injected by a signal emitted from the throttle position sensor in relation to a signal emitted from the mass air flow sensor.

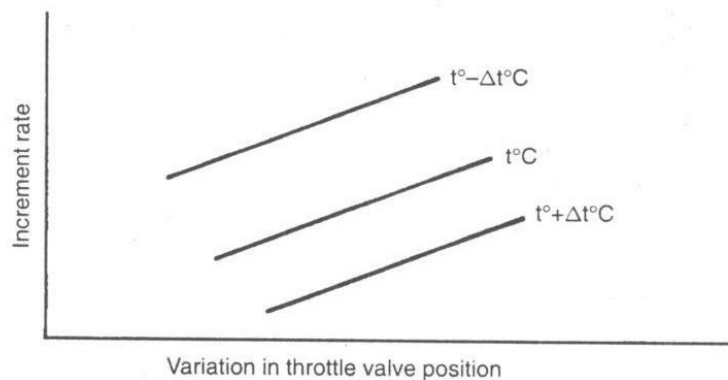


Full increment characteristic

G2H0048

6) Acceleration increment coefficient:

Compensates for time lags of air flow measurement and/or fuel injection during acceleration to provide quick response.

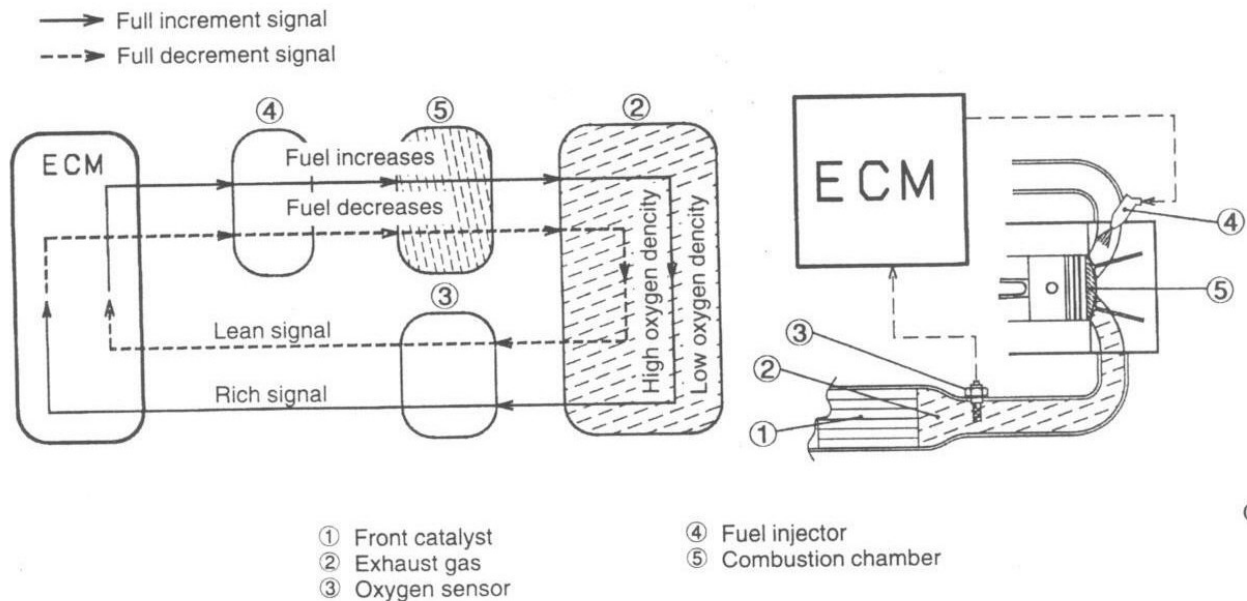


Acceleration increment characteristic

G2H0049

3. AIR-FUEL RATIO FEEDBACK COEFFICIENT "ALPHA"

This feedback coefficient utilizes the oxygen sensor's electromotive force (voltage) as a signal to be entered into the ECM. When low voltage is entered, the ECM judges it as a lean mixture, and when high voltage is entered, it is judged as a rich mixture. In other words, when the air-fuel ratio is richer than the stoichiometric mixture ratio, the amount of fuel injected is decreased. When it is leaner, the amount of fuel injected is increased. In this way, the air-fuel ratio is compensated so that it comes as close to the stoichiometric mixture ratio as possible on which the three-way catalyst acts most effectively. (CO, HC and NOx are also reduced when the air-fuel ratio is close to stoichiometric mixture ratio.)

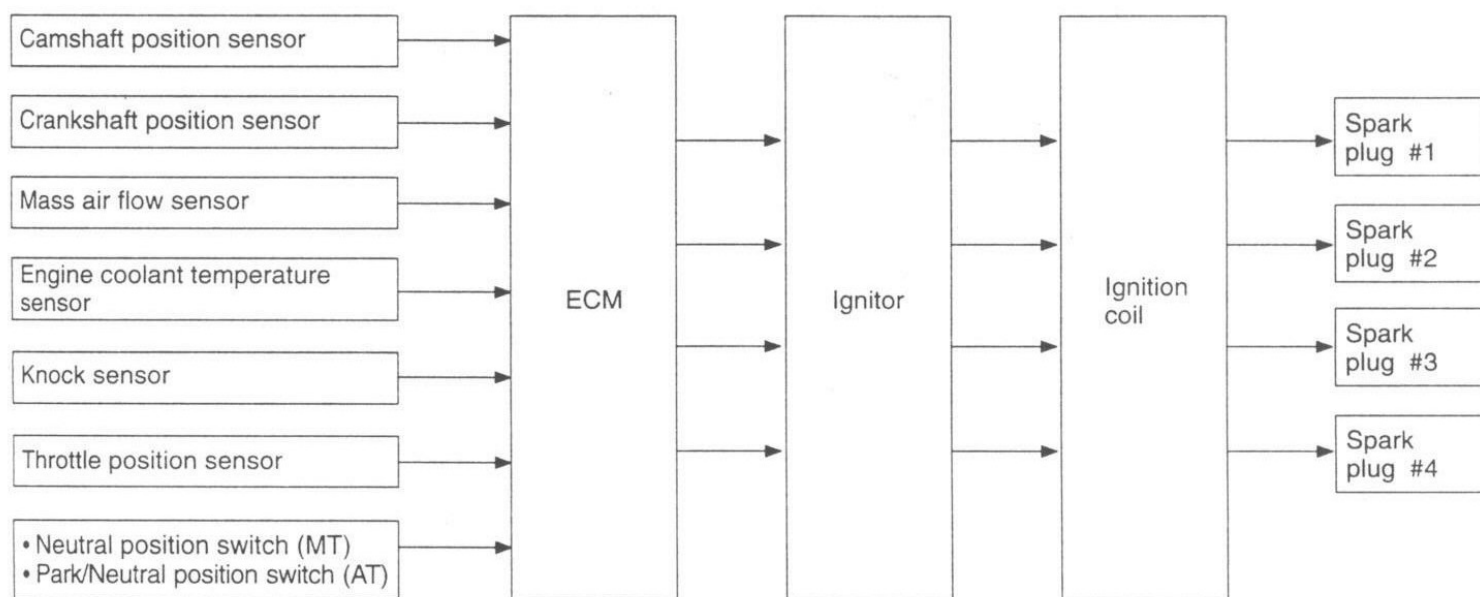


4. LEARNING CONTROL SYSTEM

- In a conventional air-fuel feedback control system, the basic amount of fuel injected (according to engine speed and various loads) is stored in the memory. After the ECM receives a signal emitted from the oxygen sensor, the basic amount of fuel injected is corrected so that it is close to the stoichiometric mixture ratio. This means that the greater the air-fuel ratio is corrected, the lesser the control accuracy.
- In SUBARU engines, however, an air-fuel ratio learning control system constantly memorizes the amount of correction required in relation to the basic amount of fuel to be injected (the basic amount of fuel injected is determined after several cycles of fuel injection), so that the correction affected by feedback control is minimized. Thus, quick response and accurate control of variations in air-fuel ratio, sensors' and actuators' characteristics during operation, as well as in the air-fuel ratio with the time of engine operation, are achieved. In addition, accurate control contributes much to stability of exhaust gases and driving performance.

D: IGNITION SYSTEM CONTROL

- The ECM receives signals emitted from the mass air flow sensor, engine coolant temperature sensor, crankshaft position sensor, camshaft position sensor, etc., to judge the operating condition of the engine. It then selects the optimum ignition timing stored in the memory and immediately transmits a primary current OFF signal to the ignitor to control the ignition timing.
- This system control type features a quick-to-response learning control method by which data stored in the ECM memory is processed in comparison with information emitted from various sensors and switches.
- Thus, the ECM constantly provides the optimum ignition timing in relation to output, fuel consumption, exhaust gas, etc., according to various engine operating conditions, etc.

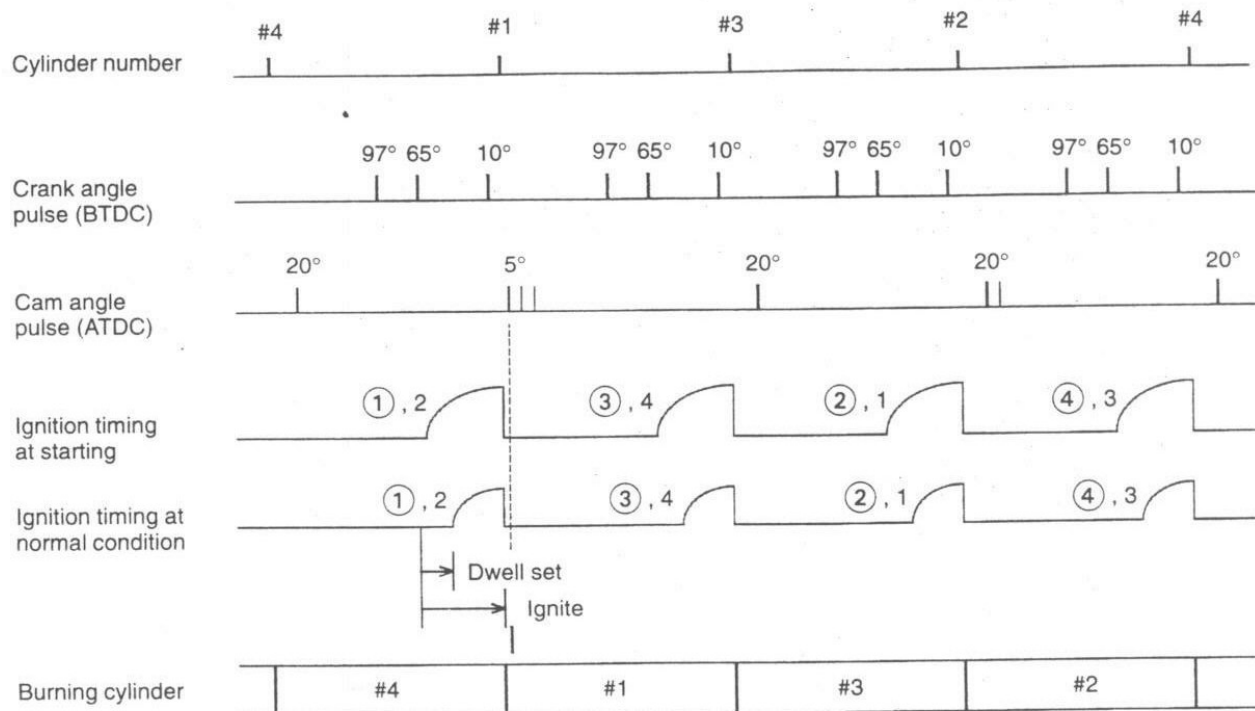


- Ignition control under normal engine conditions

Between the 97° signal and the 65° signal, the ECM measures the engine speed, and by using this data it decides the dwell set timing and ignition timing according to the engine condition.

- Ignition control under starting conditions

Engine speed fluctuates at the starting condition, so the ECM cannot control the ignition timing. When such a condition exists, ignition timing is fixed at 10° BTDC by using the 10° signal.



G2H0051

E: IDLE AIR CONTROL

• The ECM activates the idle air control solenoid valve in advance to control the amount of by-pass air flowing through the throttle valve in relation to signals emitted from the crankshaft position sensor, camshaft position sensor, engine coolant temperature sensor and A/C switch, so that the proper idle speed specified for each engine load is achieved.

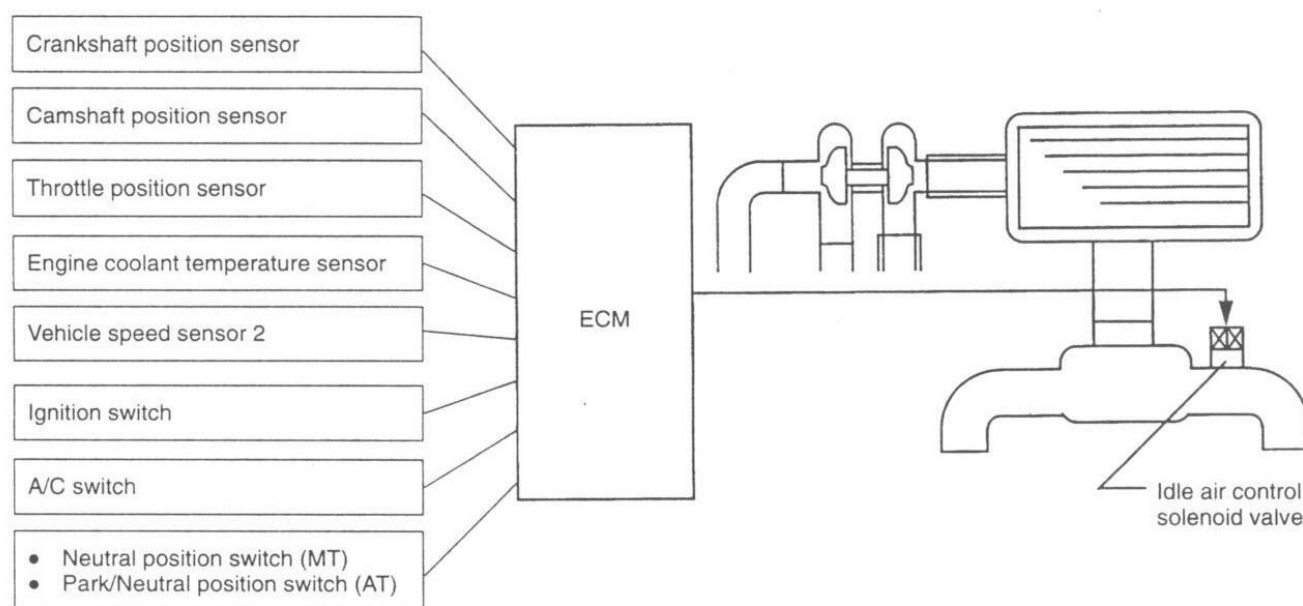
• The idle air control solenoid valve utilizes a duty solenoid design so that the amount of valve "lift" is determined by a certain operating frequency. For this reason, the by-pass air flow is regulated by controlling the duty ratio. The relationship between the duty ratio, valve lift and by-pass air flow is as follows:

Duty ratio (high) → Increases valve lift and by-pass air flow.

Bypass air control features the following advantages:

1. Compensation for engine speed under A/C (air conditioning) system and electrical loads.
2. Increase in idle speed during early stage of warm up period.
3. A dashpot function during the time the throttle valve is quickly closed.
4. Prevention of engine speed variations over time.

Diagram



H2H1871A

F: CANISTER PURGE CONTROL

• The ECM receives signals emitted from the engine coolant temperature sensor, vehicle speed sensor 2 and crankshaft position sensor to control the purge control solenoid. Canister purge takes place during operation of the vehicle except under certain conditions (during idle, etc.).

• The purge line is connected to the throttle chamber to purge fuel evaporation gas from the canister according to the amount of intake air.

G: RADIATOR FAN CONTROL

- The Hi-Low control of the radiator fan is governed by the ECM which receives signals sent from the engine coolant temperature sensor and vehicle speed sensor 2.

Vehicle speed	Engine coolant temperature		
	Less than 92°C (Less than 198°F)	Between 92 and 95°C (Between 198 and 203°F)	More than 96°C (More than 205°F)
	Operation of radiator main fan	Operation of radiator main fan	Operation of radiator main fan
Less than 19 km/h (Less than 12 MPH)	OFF	OFF	Low
Between 20 and 69 km/h (Between 12 and 43 MPH)	OFF	OFF	Hi
Between 70 and 105 km/h (Between 43 and 65 MPH)	OFF	OFF	Hi
More than 106 km/h (More than 66 MPH)	OFF	OFF	Hi

- On models which are equipped with an air conditioning system, the ECM receives signals sent from the engine coolant temperature sensor, vehicle speed sensor 2 and A/C switch. These signals simultaneously turn ON or OFF the radiator main fan and radiator sub fan as well as setting them at "Hi" or "Low" speed.

Vehicle speed	A/C compressor	Engine coolant temperature					
		Less than 92°C (Less than 198°F)		Between 92 and 95°C (Between 198 and 203°F)		More than 96°C (More than 205°F)	
		Operation of radiator fan		Operation of radiator fan		Operation of radiator fan	
		Main	Sub	Main	Sub	Main	Sub
Less than 19 km/h (Less than 12 MPH)	OFF	OFF	OFF	OFF	OFF	Low	Low
	ON	Low	Low	Hi	Hi	Hi	Hi
Between 20 and 69 km/h (Between 12 and 43 MPH)	OFF	OFF	OFF	OFF	OFF	Hi	Hi
	ON	Hi	Hi	Hi	Hi	Hi	Hi
Between 70 and 105 km/h (Between 43 and 65 MPH)	OFF	OFF	OFF	OFF	OFF	Hi	Hi
	ON	Low	Low	Low	Low	Hi	Hi
More than 106 km/h (More than 66 MPH)	OFF	OFF	OFF	OFF	OFF	Hi	Hi
	ON	OFF	OFF	Low	OFF	Hi	Hi

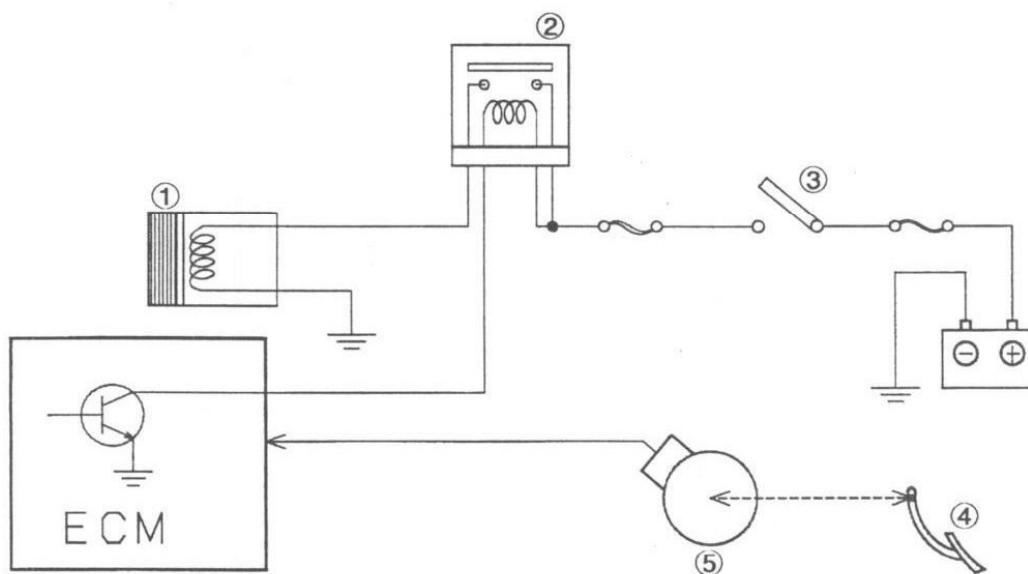
H: FUEL PUMP CONTROL

The ECM receives a signal emitted from the crankshaft position sensor and turns the fuel pump relay ON or OFF to control fuel pump operation. To improve safety, the fuel pump will stop if the engine stalls with the ignition switch ON.

Ignition switch ON	Fuel pump relay	Fuel pump
A certain period of time (after ignition switch is turned ON)	ON	Operates
While cranking the engine	ON	Operates
While engine is operating	ON	Operates
When engine stops	OFF	Does not operate

I: A/C CUT CONTROL

When the ECM receives a "full-open" signal emitted from the throttle position sensor while the air conditioning system is operating, the A/C cut relay turns off for a certain period of time to stop the compressor. This prevents degradation of output during acceleration and stabilizes driveability.



- ① A/C compressor
- ② A/C cut relay
- ③ Ignition switch

- ④ Accelerator pedal
- ⑤ Throttle position sensor

G2H0053

J: POWER SUPPLY CONTROL

- When the ECM receives an ON signal emitted from the ignition switch, current flows through the main relay. This turns the ignition relay ON so that power is supplied to the ignition coil, mass air flow sensor, idle air control solenoid valve, etc.
- Power to the above parts is turned off five seconds after the ECM receives an OFF signal from the ignition switch. The fuel injectors stop fuel injection immediately after the ignition switch is turned OFF because the injection signal is cut off.

7. On-board Diagnosis System

A: GENERAL

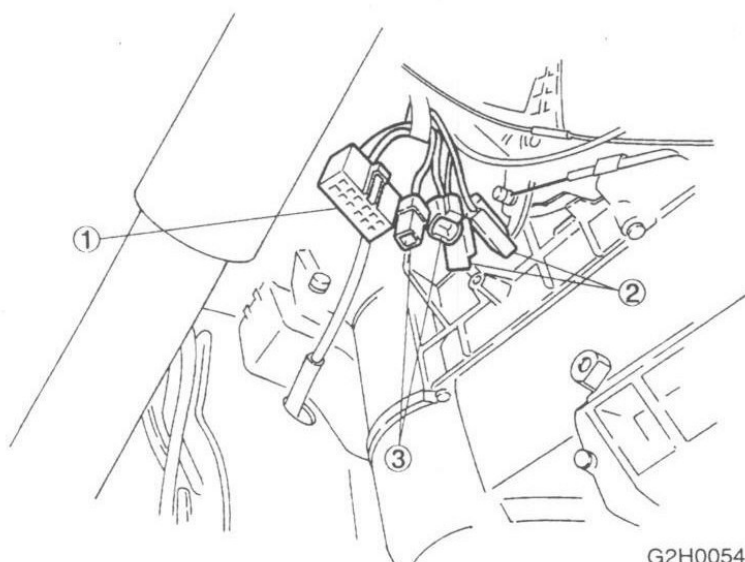
- The on-board diagnosis system detects and indicates a fault in various inputs and outputs of the complex electronic control. The malfunction indicator lamp (CHECK ENGINE light) on the instrument panel indicates occurrence of a fault or trouble.
- Further, against such a failure or sensors as may disable the drive, the fail-safe function is provided to ensure the minimal driveability.

B: FUNCTION OF ON-BOARD DIAGNOSIS

The on-board diagnosis function has four modes: U-check mode, Read memory mode, D-check mode and Clear memory mode. Two connectors (Read memory and Test mode) and a light (CHECK ENGINE light) are used. The connectors are for mode selection and the light monitors, the type of problem.

- Relationship between modes and connectors

Mode	Condition	Read memory connector	Test mode connector
U-check	Ignition ON (engine on)	DISCONNECT	DISCONNECT
Read memory	Ignition ON	CONNECT	DISCONNECT
D-check	Ignition ON (engine on)	DISCONNECT	CONNECT
Clear memory	Ignition ON (engine on)	CONNECT	CONNECT



- ① Data link connector
- ② Test mode connector
- ③ Read memory connector

• U-check mode

The U-check is a user-oriented mode in which only the MFI system components necessary for start-up and drive are diagnosed. On occurrence of a fault, the malfunction indicator lamp (CHECK ENGINE light) is lighted to indicate to the user that the dealer's inspection is necessary. The diagnosis of other parts which do not give significant adverse effect to start-up and drive are excluded from this mode in order to avoid unnecessary uneasiness to be taken by the user.

• Read memory mode

This mode is used by the dealer to read past problems (even when the vehicle's monitor lights are off). It is most effective in detecting poor contact or loose connections of connectors, harnesses, etc.

• D-check mode

This mode is used by the dealer to check the entire MFI system and detect faulty parts.

• Clear memory mode

This mode is used by the dealer to clear the trouble code from the memory after the affected part is repaired.

C: BASIC OPERATION OF ON-BOARD DIAGNOSIS SYSTEM**• NO TROUBLE**

Mode	Read memory connector	Test mode connector	Condition	CHECK ENGINE light
U-check	DISCONNECT	DISCONNECT	Ignition switch ON (Engine OFF)	ON
			Engine ON	OFF
Read memory	CONNECT	DISCONNECT	Ignition switch ON (Engine OFF)	Blink
			Engine ON	ON
D-check	DISCONNECT	CONNECT	Ignition switch ON (Engine OFF)	ON
			Engine ON	OFF → Blink*
Clear memory	CONNECT	CONNECT	Ignition switch ON (Engine OFF)	ON
			Engine ON	OFF → Blink*

• TROUBLE

Mode	Read memory connector	Test mode connector	Condition	CHECK ENGINE light
U-check	DISCONNECT	DISCONNECT	Engine ON	ON
Read memory	CONNECT	DISCONNECT	Ignition switch ON	Trouble code (memory)
D-check	DISCONNECT	CONNECT	Engine ON	Trouble code**
Clear memory	CONNECT	CONNECT	Engine ON	Trouble code**

* When the engine operates at a speed greater than 2,000 rpm for more than 40 seconds, the check engine light blinks. However, when all check items check out "O.K.", even before the 40 seconds is reached, the check engine light blinks.

** When the engine operates at a speed greater than 2,000 rpm for more than 40 seconds, a trouble code is emitted.

D: FAIL-SAFE FUNCTION

For the part which has been judged faulty in the on-board diagnosis, the ECM generates the associated pseudo signal (only when convertible to electric signal) and carries out the computational processing. In this fashion, the fail-safe function is performed.

E: TROUBLE CODES AND FAIL-SAFE OPERATION

Trouble code	Item	Contents of diagnosis	Fail-safe operation
11	Crankshaft position sensor	No signal entered from crankshaft position sensor, but signal (corresponding to at least one rotation of crankshaft) entered from camshaft position sensor.	—
12	Starter switch	Abnormal signal emitted from starter switch.	Turns starter switch signal OFF.
13	Camshaft position sensor	No signal entered from camshaft position sensor, but signal (corresponding to at least two rotations of camshaft) entered from crankshaft position sensor.	—
21	Engine coolant temperature sensor	Abnormal signal emitted from engine coolant temperature sensor.	Adjusts engine coolant to a specific temperature. Maintains radiator fan "ON" to prevent overheating.
22	Knock sensor	Abnormal voltage input entered from knock sensor.	Sets in regular fuel map, and retards ignition timing by 5°.
23	Mass air flow sensor	Abnormal voltage input entered from mass air flow sensor.	Controls the amount of fuel (injected) in relation to engine speed and throttle valve position.
24	Idle air control solenoid valve	Idle air control valve inoperative. (Abnormal signal produced in monitor circuit.)	Prevents abnormal engine speed using "fuel cut" in relation to engine speed, vehicle speed and throttle valve position.
31	Throttle position sensor	Abnormal voltage input entered from throttle position sensor.	Sets throttle position sensor's voltage output to a fixed value.
32	Oxygen sensor	Oxygen sensor inoperative.	—
33	Vehicle speed sensor 2	Abnormal voltage input entered from vehicle speed sensor 2.	Sets vehicle speed signal to a fixed value.
38	Torque control signal (AT)	Abnormal signal entered from TCM.	—
44	Wastegate control solenoid valve	Solenoid valve inoperative.	Cut off the fuel when throttle valve is fully opened under heavy loads.
45	● Pressure sensor ● Pressure sources switching solenoid valve	Abnormal signal entered from pressure sensor, or pressure exchange solenoid valve inoperative.	Cut off the fuel when throttle valve is fully opened under heavy loads.
51	Neutral position switch (MT)	Abnormal signal entered from neutral position switch.	—
51	Park/Neutral position switch (AT)	Abnormal signal entered from inhibitor switch.	—
53*	Immobiliser system	Faulty immobiliser system.	—

*: Immobiliser system equipped model only