

## **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
- Canister purge control\*
- Radiator fan control
- Fuel pump control
- Air conditioner cut control
- On-board diagnosis function

\*: Canister purge control is described under "Chapter 2-1 Emission Control".

**MECHANISM AND FUNCTION****B: INPUT AND OUTPUT SIGNALS****1. MT VEHICLES**

	Unit	Function
Input signal	Intake manifold pressure sensor	Detects the amount of intake air (Measure the absolute pressure).
	Intake air temperature sensor	Detects the temperature of intake air.
	Throttle position sensor	Detects the throttle position.
	Front oxygen (A/F) sensor	Detects the amount of oxygen in exhaust gases at the above of front catalytic converter.
	Rear oxygen sensors	Detects the density of oxygen in exhaust gases behind the front catalytic converter.
	Crankshaft position sensor	Detects crankshaft position.
	Camshaft position sensor	Detects the relative cylinder positions.
	Engine coolant temperature sensor	Detects the engine 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.
	Neutral position switch (MT)	Detects gear position being in the neutral.
	Heater circuit of front and rear oxygen sensor	Detects the abnormal for heater circuit of front and rear oxygen sensor.
	A/C switch	Detects the ON-OFF operation of the A/C switch.
	Fuel temperature sensor	Detects the temperature of the fuel in fuel tank.
	Fuel level sensor	Detects the level of the fuel in fuel tank.
	Fuel tank pressure sensor	Detects the evaporation gas pressure in fuel tank.
	Small light switch	Detects the ON-OFF operation of the light switch.
	Blower fan switch	Detects the ON-OFF operation of the blower fan switch.
Rear defogger switch	Detects the ON-OFF operation of the rear defogger switch.	
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 purge of evaporative gas absorbed by canister.
	Power supply	Control the ON/OFF switching of main relay.
	Pressure control solenoid valve	Controls the evaporation gas pressure in fuel tank.
	Drain valve	Closes the evaporation line between the fuel tank and canister to detect the leak of evaporation gases.

## MECHANISM AND FUNCTION

### 2. AT VEHICLES

	Unit	Function
Input signal	Intake air temperature and pressure sensor	Detects the temperature of intake and amount of intake air (Measure the absolute pressure).
	Atmospheric pressure sensor	Detects the amount of intake air (Measure the atmospheric pressure).
	Throttle position sensor	Detects the throttle position.
	Front oxygen (A/F) sensor	Detects the amount of oxygen in exhaust gases at the above of front catalytic converter.
	Rear oxygen sensor	Detects the density of oxygen in exhaust gases behind the front catalytic converter.
	Crankshaft position sensor	Detects crankshaft position.
	Camshaft position sensor	Detects the relative cylinder positions.
	Engine coolant temperature sensor	Detects the engine 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.
	Park/Neutral position switch	Detects shift positions.
	Torque control signal	Controls the engine torque.
	Heater circuit of front and rear oxygen sensor	Detects the abnormal for heater circuit of front and rear oxygen sensor.
	Diagnostics of AT	Detects the self-diagnostics of AT.
	A/C switch	Detects the ON-OFF operation of the A/C switch.
	Fuel temperature sensor	Detects the temperature of the fuel in fuel tank.
	Fuel level sensor	Detects the level of the fuel in fuel tank.
	Fuel tank pressure sensor	Detects the evaporation gas pressure in fuel tank.
	Small light switch	Detects the ON-OFF operation of the light switch.
	Blower fan switch	Detects the ON-OFF operation of the blower fan switch.
Rear defogger switch	Detects the ON-OFF operation of the rear defogger switch.	
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 purge of evaporative gas absorbed by canister.
	Power supply	Control the ON/OFF switching of main relay.
	Pressure control solenoid valve	Controls the evaporation gas pressure in fuel tank.
	Drain valve	Closes the evaporation line between the fuel tank and canister to detect the leak of evaporation gases.

**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 engine 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:

- During engine starts:  
Duration of fuel injection = Duration of fuel injection during engine starts
- During normal operation:  
Basic duration of fuel injection x correction factors + 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 FACTORS**

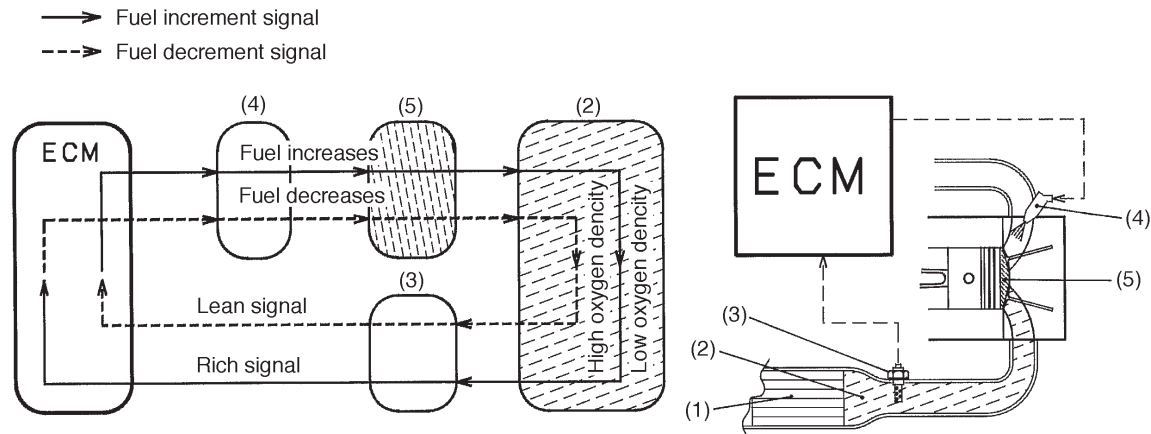
Correction factors are used to correct the basic duration of fuel injection so that the air-fuel ratio meets the requirements of varying engine operations.

These correction factors are classified as follows:

- **Air-fuel ratio coefficient:**  
Allotted to provide the optimum air-fuel ratio in relation to engine speed and the basic amount of fuel injected.
- **Start increment coefficient:**  
Increases the amount of fuel injected only when cranking the engine, which improves starting ability.
- **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.
- **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.
  - The amount of fuel to be compensated for depends on the water temperature during engine starting.
- **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.
- **Acceleration increment coefficient:**  
Compensates for time lags of air flow measurement and/or fuel injection during acceleration to provide quick response.

### 3. AIR-FUEL RATIO FEEDBACK COEFFICIENT

This feedback coefficient utilizes the front 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 NO<sub>x</sub> are also reduced when the air-fuel ratio is close to stoichiometric mixture ratio.)



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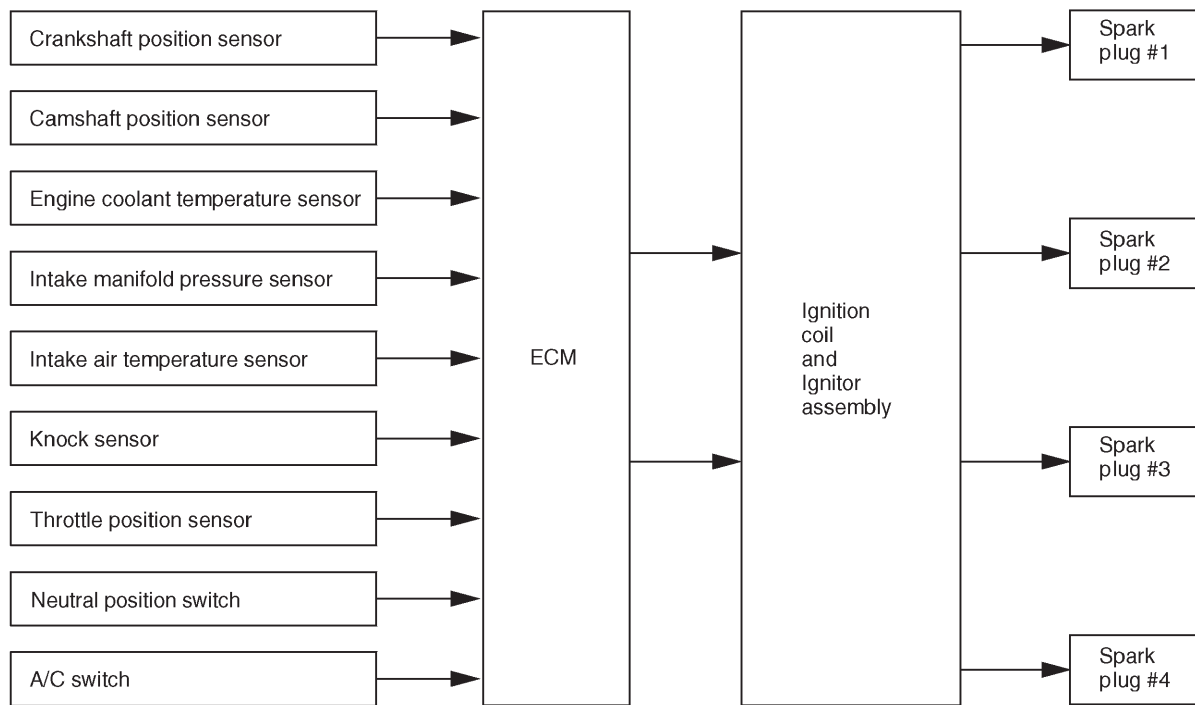
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|-------------------------------|------------------------|
| (1) Front catalyst            | (4) Fuel injector      |
| (2) Exhaust gas               | (5) Combustion chamber |
| (3) Front oxygen (A/F) sensor |                        |

### 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**
**1. MT VEHICLES**

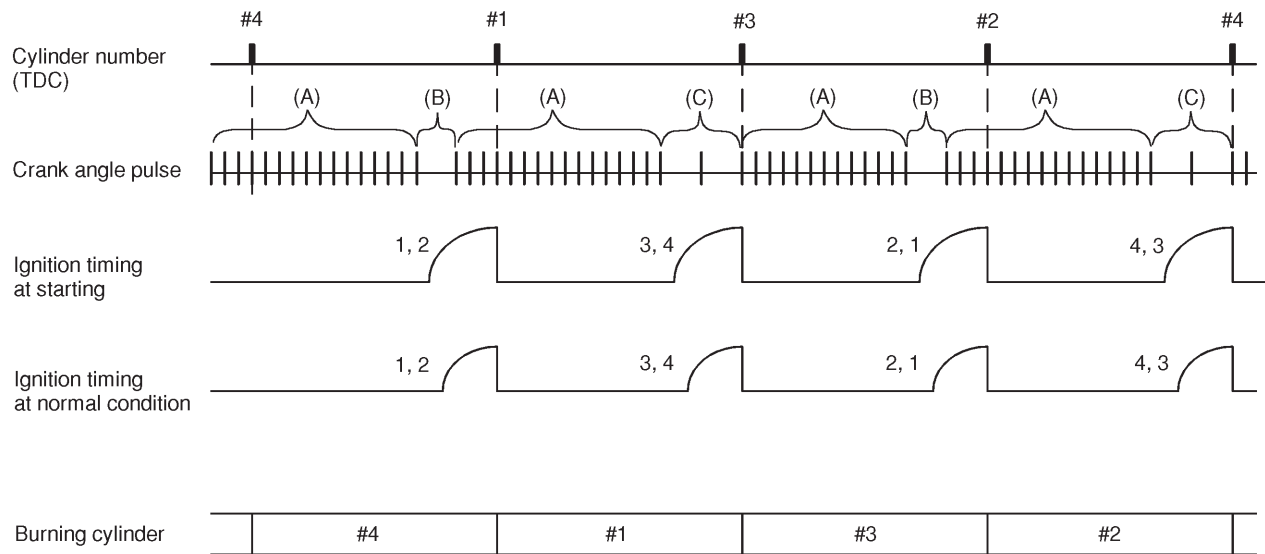
- The ECM receives signals emitted from the pressure sensor, engine coolant temperature sensor, intake air temperature sensor, crankshaft position sensor, etc., to judge the operating condition of the engine. It then selects the optimum ignition timing stored in the memory and immediately transmits a 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 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.



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**MECHANISM AND FUNCTION****[M6D1] 2-7**  
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- Within the range (A), the crank angle signal is input every 10° rotation of the crankshaft.
- The discrimination between the cylinder groups is accomplished by detecting the ranges (B) and (C) where no signals are input.
- The ECM judges that the No. 1 and No. 2 cylinders are at TDC when detecting the range (B), and that the No. 3 and No. 4 cylinders are at TDC when detecting the range (C).



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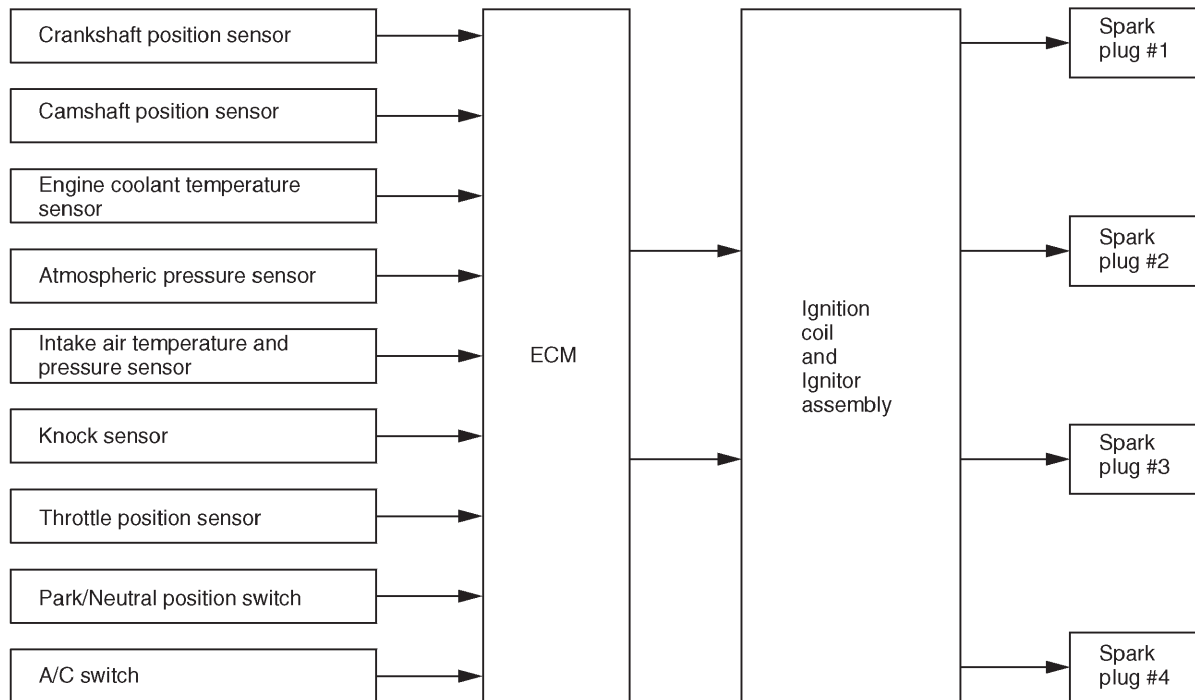


## 2-7 [M6D2] 6. Control System

### MECHANISM AND FUNCTION

#### 2. AT VEHICLES

- The ECM receives signals emitted from the pressure sensor, engine coolant temperature sensor, intake air temperature sensor, crankshaft 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 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.

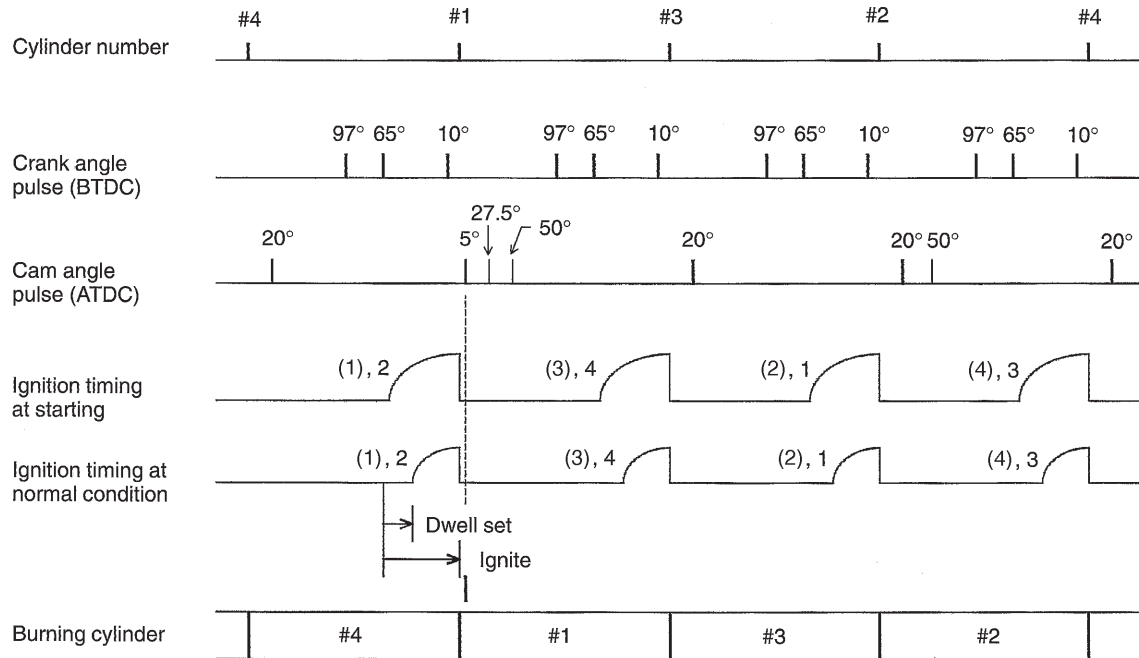


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## MECHANISM AND FUNCTION

[M6D2] 2-7  
6. Control System

- 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 fluctuate 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.

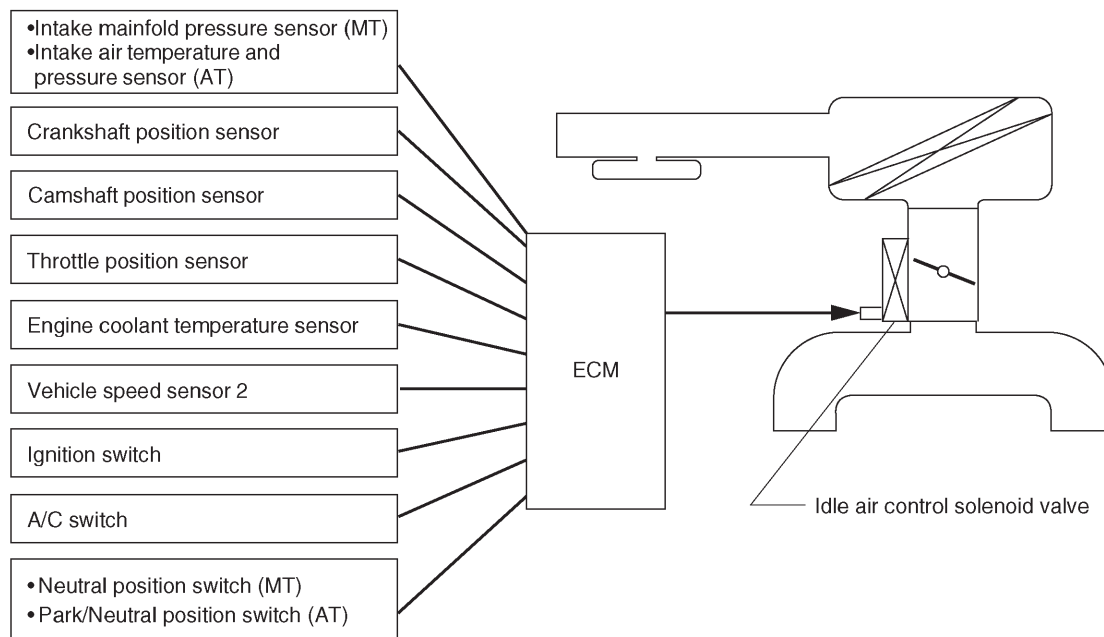


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**E: IDLE AIR CONTROL**

- 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, engine coolant temperature sensor, pressure sensor and A/C switch. etc., so that the proper idle speed specified for each engine load is achieved.
- The idle air control solenoid valve utilizes a duty solenoid design which the opening area of by-pass port is changed by the amount of rotary valve moving. For this reason, the by-pass air flow is regulated by controlling the duty ratio. The relationship between the duty ratio, rotary valve moving and by-pass air flow is as follows:
  - Duty ratio (high) → Increases rotary valve moving and by-pass air flow.
- Bypass air control features the following advantages:
  - Compensation for engine speed under A/C (air conditioning) system and electrical loads.
  - Increase in idle speed during early stage of warm up period.
  - A dashpot function during the time the throttle valve is quickly closed.
  - Prevention of engine speed variations over time.

Diagram



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**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.