FUEL INJECTION CONTROL OPERATION

BHE014000140T20

Fuel Injection Timing

• The PCM calculates the optimum fuel injection timing according to the engine operation conditions and operates the injectors.

• The fuel injection timing is controlled at engine start and after engine start.

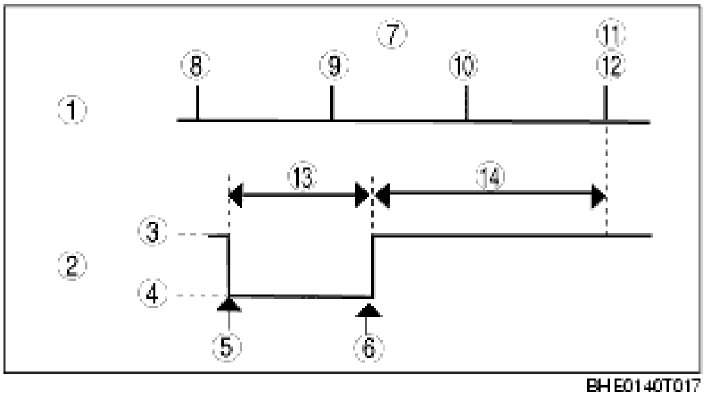
• At engine start (engine speed is within 500 rpm), fuel injection timing control at engine start is performed and after determining that the engine has started (engine speed is 500 rpm or more), injection timing control after engine start is performed.

Fuel injection timing at engine start

– The injection timing at engine start operates for a period until engine start has been determined and injects at BTDC 455°CA (crank angle position).

Fuel injection timing after engine start

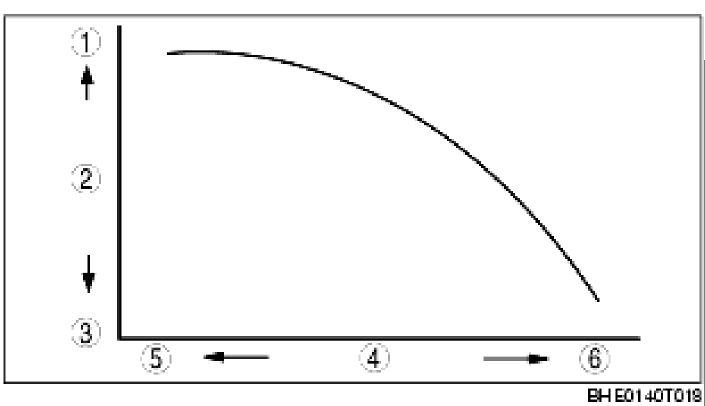
– The injection start position of the fuel injection timing after engine start is determined by the injection end position and the final injection pulse width (injection time).
– The injection start position is calculated by: (Injection start position = BTDC 275°CA + Injection end position + Final injection pulse width).



1	Eccentric shaft position sensor signal
2	Injector operation signal
3	OFF
4	ON
5	Injector start position
6	Injector end position
7	(BTDC)
8	635°CA
9	455°CA
10	365°CA
11	Standard position
12	275°CA

– The injection end position is determined by the engine speed. (The higher the engine speed the lower the fuel injection timing.)

Engine speed table



1	Fast
2	Injection end position
3	Slow
4	Engine speed
5	Low
6	High

Air/fuel Ratio Control

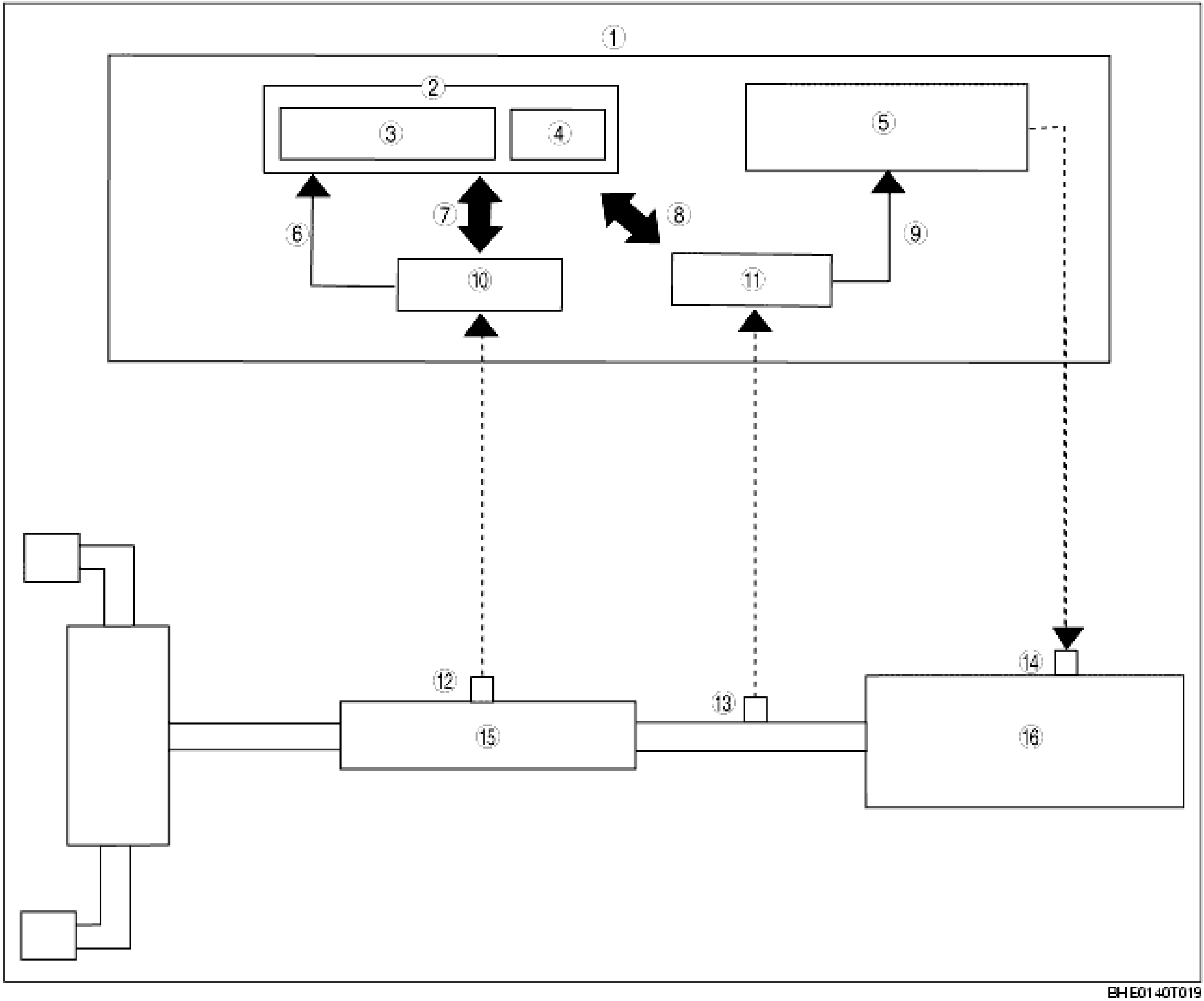
• Controls the fuel injection amount so that the actual air/fuel ratio is close to the target air/fuel ratio, to boost purification of the catalytic converter.

• air/fuel ratio feedback and target air/fuel ratio feedback are adopted for precise control of the air/fuel ratio.

• The air/fuel ratio feedback compares the air/fuel ratio in the exhaust manifold detected by the front HO2S and the target air/fuel, and feeds back the air/fuel ratio difference to the final fuel pulse width (fuel injection amount).

• The target air/fuel ratio feedback compares the air/fuel ratio in the catalytic converter detected by the rear HO2S with the target air/fuel ratio and feeds back the air/fuel ratio difference to the stoichiometric air/fuel ratio (l = 1). Due to this, the optimum target air/fuel ratio is determined.

• Repeats feedback to the target air/fuel ratio and final fuel pulse width (fuel injection amount), and by constantly calculating the optimum target air/fuel ratio and final fuel pulse width, purification of the catalytic converter at a high level has been achieved.



1	PCM
2	Target air/fuel ratio
3	Stoichiometric air/fuel ratio (lambda=1)
4	Correction
5	Final fuel pulse width (fuel injection amount)
6	Target air/fuel ratio feed back
7	Comparing
8	Comparing
9	Air/fuel ratio feed back
10	Actual air/fuel ratio feed back
11	Actual air/fuel ratio feed back

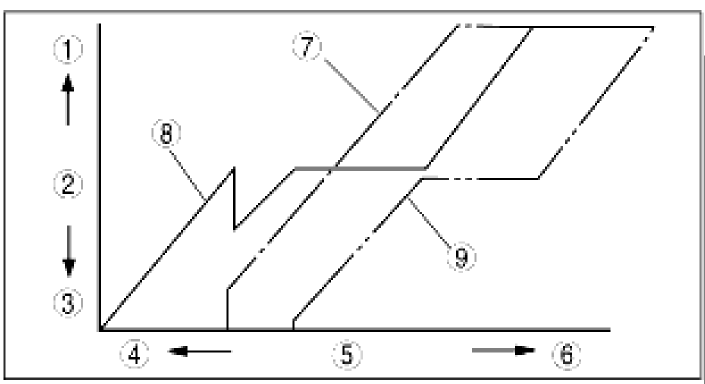
12	Rear HO2S
13	Front HO2S
14	Fuel injector
15	Catalytic converter
16	Engine

Fuel Injection Distribution Control

• There are primary 1, secondary and primary 2 (13B-MSP (High Power)) injectors, and they independently control fuel injection amount and timing according to the amount of fuel demand from the engine.

• The amount of fuel demand from the engine is determined by each correction of the charging efficiency and injection time after engine start.

• When the amount of fuel demand from the engine is low, only the primary 1 injectors inject fuel. When the amount of fuel demand from the engine increases, fuel injection in the order of secondary injector and primary 2 injector (13B-MSP (High Power)) begin injection.



1	Large
2	Effective injection pulse
3	Small
4	Low
5	Engine demand fuel volume
6	High
7	Secondary injector
8	Primary 1 injector
9	Primary 2 injector

Synchronized Injection Control

• The synchronized injection control performs fuel injection according to each timing that has been determined by the intake stroke of the rotors.

• The synchronized injection control includes fuel injection control at engine start and fuel injection control after engine start. Synchronized injection control performs fuel injection based on injection time (final injection pulse width) and fuel injection timing demanded by each rotor.

Injection time at start

- Calculated by adding the engine speed correction to the basic injection time at engine start, the throttle valve opening angle correction, the BARO correction, and the volume decrease correction at engine start, and then the final injection pulse width is calculated by adding the ineffective injection time to the injection time at engine start.
- Basic injection time at engine start is determined based on ECT and shortens as the ECT increases.
- Ineffective injection time is determined according to battery voltage and lengthens as battery voltage becomes lower.

Correction	Condition	Amount of Correction
Engine speed correction	Determines correction amount based on engine speed.	• Correction amount lengthens as the engine speed increases.
Throttle valve opening angle correction	Determines correction amount based on throttle valve opening angle.	• Correction amount shortens as the throttle valve opening angle increases.
BARO correction	Determines correction amount based on BARO sensor.	• Correction amount lengthens (time) as the BARO increases.
Volume decrease correction at engine start	Determines correction amount based on ECT and engine speed at engine start.	• After starter is on for approx. 1 s and any one of the following conditions are met, injection time gradually decreases: – ECT at fixed value or more – Engine speed at target engine speed or more – Approx. 5 s of cranking time elapsed

Injection time after engine start

• The injection time after engine start is calculated from the charging efficiency, ineffective injection time and each type of correction.

Charging efficiency

– The charging efficiency is the ratio of intake air amount that is actually taken in relation to the maximum air charging amount (mass) of the operation chamber. This value becomes larger in proportion to the increase in engine load.

Ineffective injection time

– Ineffective injection time at engine start is determined according to the battery voltage and lengthens as the battery voltage becomes lower.

Each type of correction

– Includes the following corrections:
Fast idle correction

• Determines the correction amount when the secondary air injection system operates to rapidly heat the catalytic converter. The correction amount is determined by estimating the air amount that is sent from the secondary air injection pump based on the BARO, battery positive voltage, IAT, charging efficiency and the engine speed, and by calculating the target air/fuel ratio.
Warm-up volume increase correction coefficient
• At cold-engine start, warm-up is accelerated by advanced vaporization and atomization. The warm-up volume increase correction coefficient is determined by the ECT, water temperature at engine start, charging efficiency, and the engine speed.
Volume increase correction coefficient after start coefficient
• The volume increase correction coefficient after engine start coefficient is determined by the ECT and IAT at engine start, the time elapsed, and fuel-cut conditions after engine start.
High temperature volume increase correction at engine restart
• At high temperature engine restart, increased fuel volume

correction is performed to prevent fluctuations in idle speed based on the occurrence of vapor in the fuel pipe. The correction amount is determined by the IAT and the ECT.

Acceleration correction

- Improves engine response during acceleration. The correction amount is determined by the rate of charging efficiency increase, throttle valve opening angle, engine speed, volume increase after engine start, time after engine start, and the ECT.

Deceleration correction

- Stops afterburn within the ranges fuel cut does not operate during deceleration. The correction amount is determined by the rate of charging efficiency decrease, throttle valve opening angle, engine speed, volume increase after engine start, time after engine start, and the ECT.

Power increase correction

- Volume increase correction is performed to improve output during high load and to inhibit overheating of the catalytic converter. The correction amount is determined by the throttle opening angle, charging efficiency, engine speed, volume increase after engine start, ECT, gear position (MT: determined by engine speed and vehicle speed.) (AT: determined by signal from the TCM), and BARO.

Fuel learning correction

- Learns the difference between the target air/fuel ratio and the actual air/fuel ratio (front HO2S).

Purge correction

- Performs volume decrease correction of the fuel amount for the portion of evaporative fuel inflowing from the charcoal canister. The correction amount is determined by calculating the fuel amount inflowing from the charcoal canister caused by the amount of change in air/fuel ratio feedback during activation of the evaporative purge control.

Traction volume increase correction

- Ignition timing is retarded by the torque down request signal from the DSC HU/CM and TCM. The volume increase correction is performed to prevent the increase of combustion temperature due to the ignition timing retard, which causes the combustion temperature to increase resulting in overheating of the catalytic converter.

Fuel feedback correction

- Detects the air/fuel ratio in the exhaust manifold at the front HO2S

and feeds back to the final injection pulse width (final fuel injection amount).
• Fuel feedback begins when all of the following conditions are met:
ECT is 40°C {104°F} or more.
After the engine has started and 3-100 s have elapsed (time period after engine-start lengthens as ECT becomes lower).
-Power volume increase correction
-During fuel cut recovery, non synchronized injection control stops.
-Traction correction retard stops.
-Fast idle correction stops.
-Charging efficiency is 78% or less or engine speed is 1,100 rpm or less.
-During activation of front HO2S.

Non-synchronized Injection Control

• The non-synchronized injection control allows fuel injection when fuel injection conditions are met, regardless of the position of the eccentric shaft.

• The non-synchronized injection control includes non-synchronized injection control at engine start, acceleration, idle, and fuel cut recovery.

Control name	Purpose	Injection condition
Non-synchronized injection control at engine start	Improves engine startability.	• Performs non-synchronized fuel injection at engine start until determining the engine has been started (engine speed 500 rpm or more). • Injection pulse width at engine start is calculated by adding the injection amount at engine start calculated from the following signals to the ineffective injection time: – ECT – Engine speed – Throttle valve opening angle – BARO

Non-synchronized injection control at acceleration	Prevents acceleration hesitation and lean air/fuel ratio due to delay of fuel injection during sudden acceleration.	• Performs non-synchronized fuel injection when the amount of throttle valve change is at the fixed value or more for both rotors simultaneously. • Injection pulse width is calculated from the following signals: – Charging efficiency – Throttle valve opening angle – Engine speed – ECT
Non-synchronized injection control at fuel cut recovery	Prevents engine hesitation and lean air/fuel ratio due to the delay of fuel injection during fuel cut recovery.	• Performs non-synchronized fuel injection during fuel cut recovery. • Injection time is determined by ECT.

Fuel Cut Control

• The fuel cut control stops fuel injection when the fuel cut conditions are met.

• The fuel cut control includes traction fuel cut control, continuous fuel cut control during high engine speed, fuel cut control during drive-by-wire abnormality, fuel cut control during deceleration and dechoke control.

Control name	Purpose	Fuel cut condition
Traction fuel cut control	Lowers engine torque based on the torque down request from DSC HU/CM and TCM.	Performs fuel cut based on torque down request from DSC HU/CM and TCM.
Continuous speed fuel cut control during high engine	Prevents overheating of the catalytic converter.	Performs fuel cut during continuous high engine speed while vehicle is stopped.

speed		
Fuel cut control during drive-by-wire abnormality	When there is a malfunction in the drive-by-wire, fuel cut is activated and excess increase in engine speed is prevented.	When there is an abnormality in the drive-by-wire (when related DTCs are stored in PCM), performs fuel cut only on the front rotor.
Fuel cut control during deceleration	Prevents overheating of the catalytic converter due to misfire for improved fuel economy. Performs fuel cut on one rotor for reduced deceleration shock.	Performs fuel cut on one rotor when the throttle valve is open during deceleration. Performs fuel cut on both front and rear rotors when throttle valve is fully closed.
Dechoke control	Scavenges operation chambers to improve engine startability if the spark plugs are smoldered.	Performs dechoke control when the throttle valve opening angle is 50° or more.