STARTING IGNITION CONTROL

Starting ignition control is carried out once immediately after input of the NE signal following the G (G1 or G2) signal. This ignition timing is called "initial ignition timing angle". For further details, see page 83.

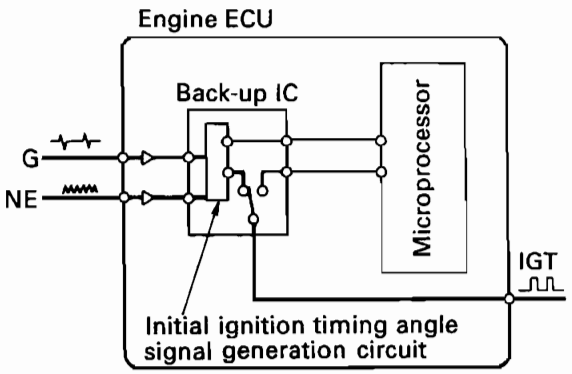
During starting, when the engine speed is still below a specified rpm (usually around 500 rpm), since the intake manifold pressure (PIM) signal or the intake air volume (VS, KS or VG) signal is unstable, the ignition timing is fixed at the initial ignition timing (which differs depending on the engine model). This initial ignition timing is set directly by the back-up IC in the Engine ECU.

RELEVANT SIGNALS

- Crankshaft angle (G)
- Engine speed (NE)

REFERENCE

In some engine models, the starter (STA) signal is also used to inform the ECU that the engine is being cranked.



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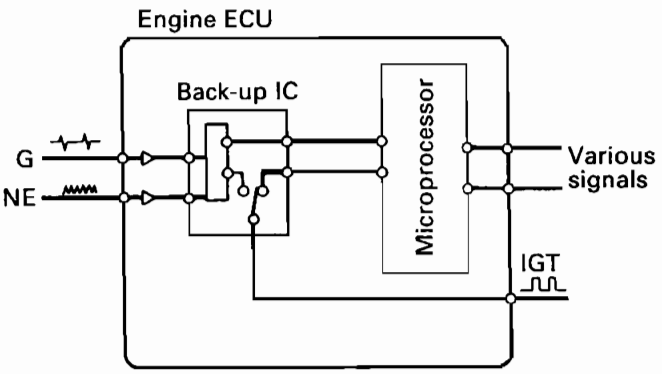
AFTER-START IGNITION CONTROL

After-start ignition control is carried out during normal operation.

The various corrections (which are based on signals from the relevant sensors) are added to the initial ignition timing angle and to the basic ignition advance angle (which is determined by the intake manifold pressure signal or the intake air volume signal, and by engine speed signal):

Ignition timing = initial ignition timing angle
+ basic ignition advance angle
+ corrective ignition advance angle

During normal operation of after-start ignition control, the ignition timing (IGT) signal calculated by the microprocessor is output through the back-up IC.



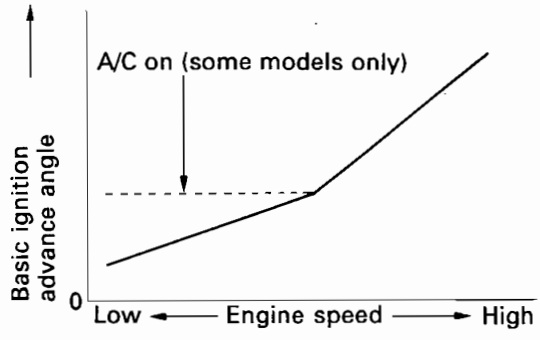
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① Basic ignition advance angle

The basic ignition advance angle in the ESA system corresponds to the vacuum advance and governor advance angles in conventional EFI. Data on the optimal basic ignition advance angle (which correspond to the engine speed and intake manifold pressure or intake air volume) are held in the memory of the Engine ECU.

IDLE CONTACT CLOSED (ON)

The ignition timing is advanced in accordance with the engine speed when the idle contact closes.



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RELEVANT SIGNALS
- Throttle position (IDL)
- Engine speed (NE)

REFERENCE

In some engine models, the basic ignition advance angle changes (as shown by the dotted line in the graph above) depending on whether the air conditioner is on or off.
In addition, there are also models in which the advance angle is "0" at the time of the standard idle speed.

IDLE CONTACT OPEN (OFF)

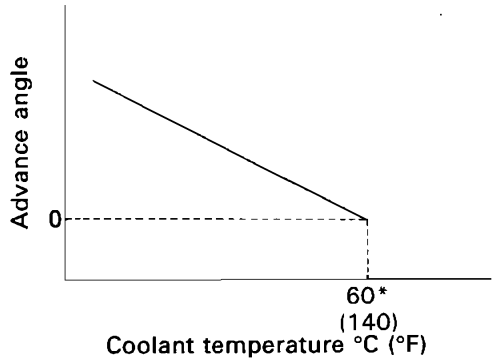
The Engine ECU determines the basic ignition advance angle based on data stored in its memory, and based on the intake manifold pressure (or the intake air volume) and engine speed.
In some engine models, two types of basic ignition advance angle data are stored in memory. One or the other of these two sets of data is then used, depending on the fuel octane rating (premium or regular).
The driver can select the data to be used by setting the fuel control switch or connector to match the octane rating of the gasoline used.
In vehicles equipped with the fuel octane judgment capability, the relevant data are accessed automatically in accordance with the knock (KNK) signal from the knock sensor (See page 116).

RELEVANT SIGNALS
- Intake manifold pressure (PIM) or intake air volume (VS, KS or VG)
- Engine speed (NE)
- Throttle position (IDL)
- Fuel control switch or connector (R-P)
- Engine knocking (KNK)

② Corrective ignition advance control

WARM-UP CORRECTION

The ignition timing is advanced to improve drivability when the coolant temperature is low. In some engine models, this correction changes the advance angle in accordance with the intake manifold pressure or the intake air volume.
The ignition timing angle is advanced by approximately 15° by this correction during extremely cold weather.



*Depending on the engine models.

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RELEVANT SIGNALS

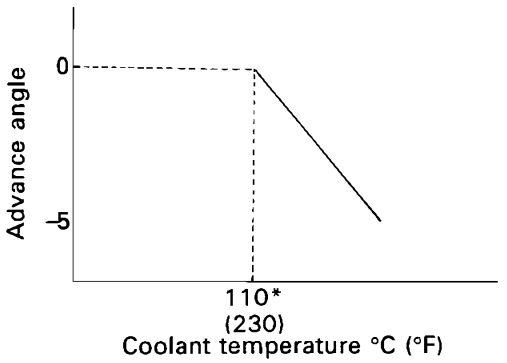
- Coolant temperature (THW)
- Intake manifold pressure (PIM) or intake air volume (VS, KS or VG)

REFERENCE

In some engine models, the throttle position (IDL) signal or the engine speed (NE) signal is used as the relevant signal for this correction.

OVER-TEMPERATURE CORRECTION

To prevent knocking and overheating, the ignition timing is retarded when the coolant temperature is extremely high.
The ignition timing angle is retarded a maximum of approximately 5° by this correction.



*Depending on the engine models.

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RELEVANT SIGNAL

- Coolant temperature (THW)

REFERENCE

In some engine models, the following signals are also used for this correction.

- Intake manifold pressure (PIM) signal or intake air volume (VS, KS or VG) signal
- Engine speed (NE) signal
- Throttle position (IDL) signal

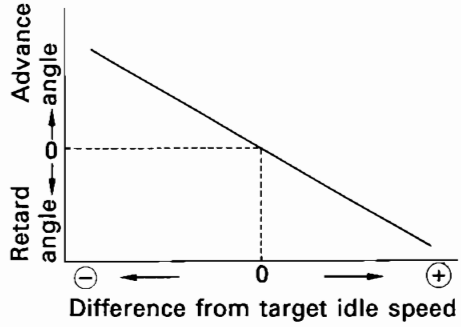
etc.

STABLE IDLING CORRECTION

When the engine speed during idling has fluctuated from the target idle speed, the Engine ECU adjusts the ignition timing to stabilize the engine speed.

The ECU is constantly calculating the average engine speed. If the engine speed falls below the target speed, the ECU advances the ignition timing by a predetermined angle. If the engine speed rises above the target speed, the ECU retards the ignition timing by a predetermined angle. The ignition timing angle is changed a maximum of approximately ±5° by this correction.

This correction is not executed when the engine exceeds a predetermined speed.



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RELEVANT SIGNALS

- Engine speed (NE)
- Throttle position (IDL)
- Vehicle speed (SPD)

REFERENCE

1. In some engine models, the advance angle changes depending on whether the air conditioner is on or off.
2. In some engine models, this correction only operates when the engine speed is below the target engine speed.

EGR CORRECTION

When the EGR is operating and the IDL contact is off, the ignition timing is advanced according to the volume of the intake air and the engine speed to improve drivability.

RELEVANT SIGNALS

- Intake manifold pressure (PIM) or intake air volume (VS, KS or VG)
- Engine speed (NE)
- Throttle position (IDL and PSW or VTA)

AIR-FUEL RATIO FEEDBACK CORRECTION (engines with oxygen sensor)

During air-fuel ratio feedback correction, the engine speed varies according to the increase or decrease in the fuel injection volume. The engine is especially sensitive to changes in the air-fuel ratio when it is idling, so stable idling is ensured by advancing the ignition timing at this time in order to match the fuel injection volume of air-fuel ratio feedback correction.

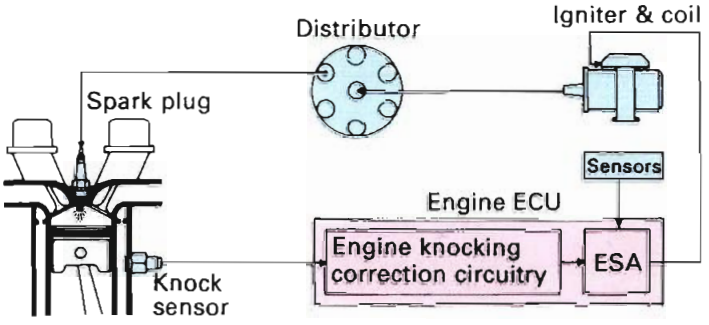
The ignition timing angle is advanced a maximum of approximately 5° by this correction. This correction is not executed while the vehicle is being driven.

RELEVANT SIGNALS

- Oxygen sensor (OX)
- Throttle position (IDL)
- Vehicle speed (SPD)

KNOCKING CORRECTION

If engine knocking occurs, the knock sensor converts the vibrations created by the knocking into voltage signals and sends them to the Engine ECU.



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The ECU judges whether the strength of the knocking is at one of three levels, strong, medium or weak, according to the strength of the KNK signals, and changes the corrective ignition retard angle accordingly. In other words, if the knocking is strong, the ignition timing is retarded a lot, while if knocking is weak, it is retarded only a little.

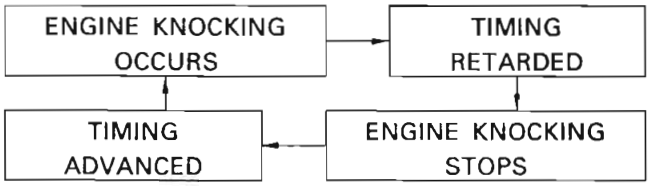
When engine knocking stops, the ECU stops retarding and begins advancing the ignition timing by fixed angles a little at a time.

This ignition timing advance continues until engine knocking recurs, at which point the ignition timing is again retarded.

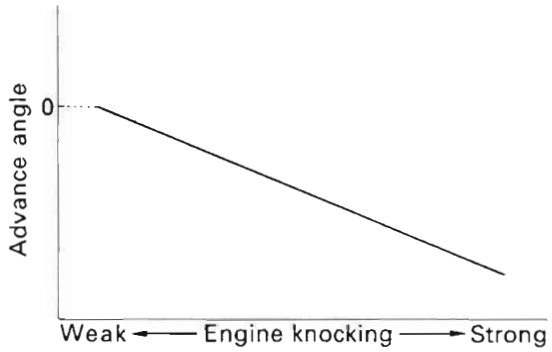
The ignition timing angle is retarded a maximum of approximately 10° by this correction.

Retarding of the ignition timing during knocking is carried out within the knocking correction range. In some engines, this means when the engine is operating under a heavy load (vacuum below approx. 26.7 kPa [200 mmHg, 7.9 in.Hg]), while in other engines, it covers virtually the full engine load range.

The ECU feeds back signals from the knock sensor to correct the ignition timing as shown below.



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RELEVANT SIGNAL

- Engine knocking (KNK)

TORQUE CONTROL CORRECTION

In the case of vehicles equipped with the ECT (electronically-controlled transmission), each clutch and brake in the planetary gear unit of the transmission or transaxle generates shock to some extent during shifting. In some models, this shock is minimized by delaying the ignition timing when gears are up- or down-shifted.

When gear shifting starts, the Engine ECU retards the engine ignition timing to reduce the engine torque.

As a result, the shock of engagement of the clutches and brakes of the planetary gear unit is reduced and the gear shift change is performed smoothly.

The ignition timing angle is retarded a maximum of approximately 20° by this correction.

This correction is not performed when the coolant temperature or battery voltage is below a predetermined level.

RELEVANT SIGNALS

- Engine speed (NE)
- Throttle position (VTA)
- Coolant temperature (THW)
- Battery voltage (+B)

OTHER CORRECTIONS

Engines have been developed with the following corrections added to the ESA system (in addition to the various corrections explained so far), in order to adjust the ignition timing with extremely fine precision.

a. Transition Correction

During the transition (change) from deceleration to acceleration, the ignition timing is either advanced or retarded temporarily in accordance with the acceleration.

b. Cruise Control Correction

When driving downhill under cruise control, in order to provide smooth cruise control operation and minimize changes in engine torque caused by fuel cut-off due to engine braking, a signal is sent from the Cruise Control ECU to the Engine ECU to retard the ignition timing.

c. Traction Control Correction

This retards the ignition timing, thus lowering the torque output by the engine, when the coolant temperature is above a predetermined temperature and the traction control system is operating.

d. ACIS (Acoustic Control Induction System) Correction

When the engine speed rises above a predetermined level, the ACIS operates. At that time, the Engine ECU advances the ignition timing simultaneously, thus improving output.

See page 120 for details on the ACIS.

e. Intercooler Failure Correction

This correction retards the ignition timing if the intercooler fail signal goes on.

MAXIMUM AND MINIMUM ADVANCE ANGLE CONTROL

If the ignition timing (initial ignition timing + basic ignition advance angle + corrective ignition advance angle) becomes abnormal, engine operation will be adversely affected.

To prevent this, the Engine ECU controls the actual ignition angle (ignition timing) so that the sum of the basic ignition advance angle and corrective ignition advance angle cannot be greater or less than certain values.

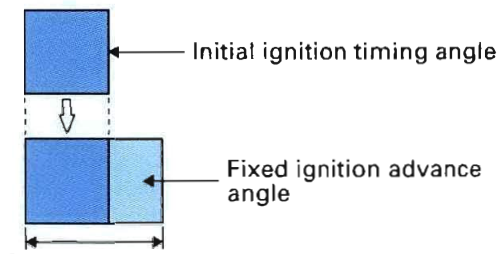
These values are:

MAX. ADVANCE ANGLE	35° – 45°
MIN. ADVANCE ANGLE	–10° ~ 0°

Advance angle = Basic ignition advance angle + corrective ignition advance angle

2. IGNITION TIMING ADJUSTMENT

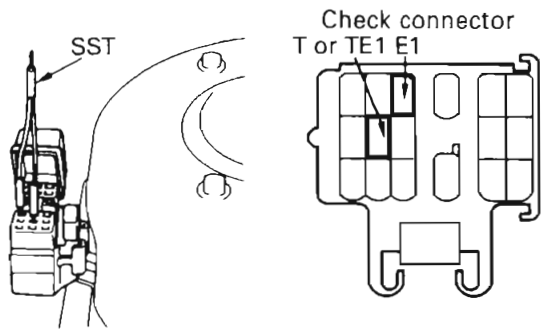
The angle to which the ignition timing is set during ignition timing adjustment is called the "standard ignition timing." It consists of the initial ignition timing (See page 83), plus a fixed ignition advance angle (a value that is stored in the ECU and output during timing adjustment regardless of the corrections, etc., that are used during normal vehicle operation).



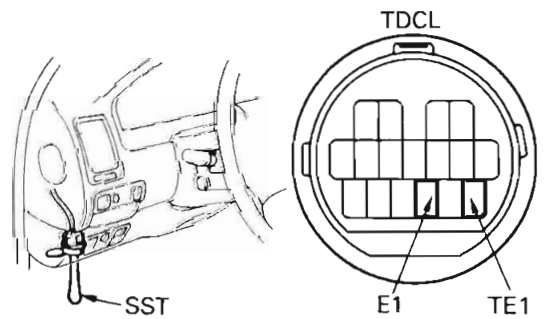
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Ignition timing adjustment is carried out as follows:

1) Set the standard ignition timing by connecting terminal T_1 (or TE_1) of the check connector or TDCL with terminal E_1, with the idle contacts on. This will cause the standard ignition timing signal to be output from the back-up IC in the same way as during after-start ignition control (See page 91).



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The standard ignition timing differs depending on the engine model, as shown in the following table. When tuning up the engine, refer to the repair manual for the relevant engine.

ENGINE MODEL	INITIAL IGNITION TIMING	FIXED IGNITION ADVANCE ANGLE	STANDARD IGNITION TIMING
Type 1	10° BTDC	0° BTDC	10° BTDC
Type 2	5° BTDC	5° BTDC	10° BTDC
Type 3	7° BTDC	0° BTDC	7° BTDC

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2) If the standard ignition timing is not as specified above, adjust it.

NOTE

1. **Even if terminal T1 or TE1 and terminal E1 are connected, the ignition timing will not be fixed at the standard ignition timing unless the idle contacts are on.**
2. **Since the G and NE signal generators are fixed in recent models, there are cases in which ignition timing cannot be adjusted.**