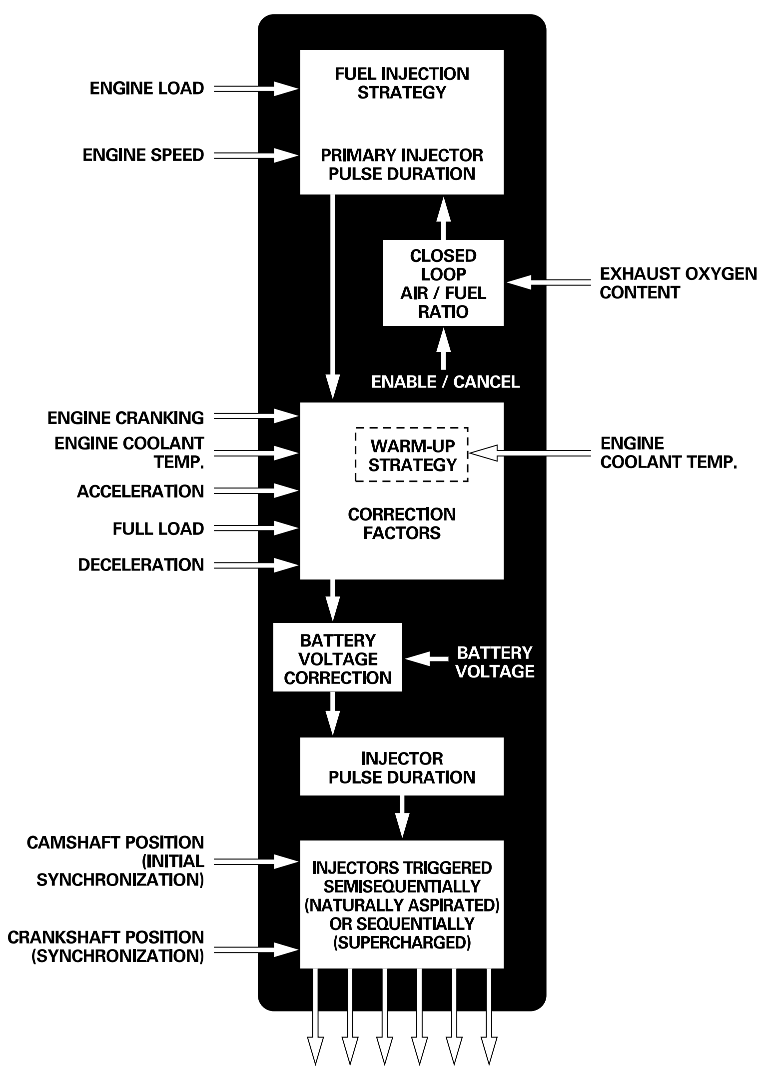
Fuel Injection

Fuel metering is obtained by controlling the injector pulse duration during each engine cycle (two crankshaft rotations). The pulse duration is varied by the engine control module (ECM) according to several sensor inputs. The sensed control inputs form two groups — primary and secondary. Primary control inputs are intake mass air flow (engine load) and engine speed; secondary control inputs consist of engine coolant temperature, cranking signal, throttle movement and position and exhaust oxygen content. The injector pulse is then corrected for actual battery voltage. On normally aspirated engines, the injectors are pulsed semisequentially. Semisequentially means twice per engine cycle (once per engine revolution) in the engine firing order. On supercharged engines, the injectors are pulsed sequentially. Sequentially means once per engine cycle (once every two engine revolutions) in the engine firing order.

Fuel metering strategies are held in memory (EPROM) in the ECM and form an engine load versus engine speed matrix. The load and speed range of the engine is divided into 16 loads and 16 speeds (256 memory sites). Digital numbers representing injector pulse duration in milliseconds fill each site and cover the entire engine load and speed range. Fuel metering correction is applied for all six cylinders simultaneously, not for individual cylinders.

FUEL INJECTION PRIMARY AND SECONDARY CONTROL



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Sequential fuel injector pulsing is ECM controlled. The ECM "learns" the compression stroke synchronization at each engine start from the camshaft position sensor (CMPS) and crankshaft position sensor (CKPS) inputs. After the firing synchronization is learned, the ECM uses the CKPS input for engine speed and position. Refer to the CMPS description on page 27 and the CKPS description on page 26.

Additional fuel injection controls are used for overrun fuel cutoff, engine overspeed prevention and fuel cutoff during wide-open-throttle cranking.

Fuel Injection Primary Control

Fuel metering is controlled primarily as a function of engine load and speed. Engine load is sensed by a mass air flow sensor (MAFS) located in the engine air intake before the throttle housing. Engine speed is sensed by a crankshaft position sensor (CKPS) located behind the front pulley. The ECM processes the input from the MAFS and the CKPS to access pulse duration from the fuel metering strategy.

NOTES

Fuel Injection Secondary Control

Secondary fuel metering control adjusts for engine coolant temperature, cranking signal, throttle movement and position, exhaust oxygen content and battery voltage.

Cranking and after-start enrichment
The ECM provides fuel metering enrichment for cranking and after-start conditions by increasing the injector pulse duration. Engine cranking is determined by an engine speed between 0 and 400 rpm. The injector pulse duration, and the rate at which the enrichment is decreased back to the warm-up phase, are dependent upon engine coolant temperature measured by the engine coolant temperature sensor.

Warm-up
The programmed warm-up enrichment provides extra fuel during engine warm-up based on the engine temperature measured by the coolant temperature sensor. The warm-up phase is applied when the coolant temperature is between 40˚F and 160˚F (5˚C and 70˚C).

Acceleration enrichment
When the ECM senses that the throttle is opening (throttle position sensor input), the injector pulse duration is lengthened by an amount dependent upon the rate at which the throttle is opened and on engine coolant temperature.

Full load enrichment
If the ECM senses a full throttle input from the throttle position sensor, full load enrichment is applied and closed loop operation is temporarily canceled.

Deceleration leaning
When the ECM senses that the throttle is closing (throttle position sensor input), the injector pulse duration is shortened dependent on the rate at which the throttle closed, preventing a momentary rich condition.

Battery voltage correction
Because the time to achieve full lift of the injector plate decreases as voltage increases, the amount of fuel delivered by the injector for a given pulse duration is dependent upon the injector operating voltage. The ECM is programmed with a voltage correction strategy. The supply voltage is monitored by a software routine and the correction applied to the pulse duration.

Closed loop fuel metering
In order to significantly reduce exhaust emission, the exhaust system incorporates two primary and one secondary 3-way catalytic converters that oxidize CO and HC, and reduce NOx. These converters operate efficiently only if engine combustion is as complete as possible. A closed loop system between fuel injection, ECM control, and exhaust oxygen content feedback is used to maintain an optimum air / fuel ratio as close to 14.7 : 1 as possible. In response to oxygen sensor voltage swings, the ECM continuously drives the air / fuel ratio rich-lean-rich by adding to, or subtracting from the baseline injector pulse duration.

NOTES

Fuel Injection (continued)

Additional Fuel Injection Controls

Overrun fuel cutoff
In order to improve fuel economy and aid in controlling exhaust emission, the ECM cancels fuel injection during engine overrun conditions. The ECM determines overrun conditions from inputs received from the throttle position sensor (TPS), crankshaft position sensor (CKPS) and engine coolant temperature sensor (ECTS). Overrun fuel cutoff is enabled when the coolant temperature is above 75˚F (35˚C). Fuel injection is cancelled when the throttle is closed and the engine speed is greater than 200 rpm.

Engine overspeed control
An engine overspeed control function limits the maximum engine speed by canceling fuel injection. Fuel injection is cancelled when the engine speed is above 5500 rpm.

Wide-open-throttle during cranking
If the ECM senses that the throttle is wide open (throttle position sensor input) during cranking, fuel injection is canceled to help clear a flooded engine.

NOTES

EMS Main Sensing Components

The inputs provided by the engine management system main sensing components are used by the ECM to control a variety of subsystems and functions.

Engine Load

Mass air flow sensor (MAFS)
The new mass air flow sensor (MAFS) has an improved and simplified design with revised calibrations for the GEMS 6 ECM.

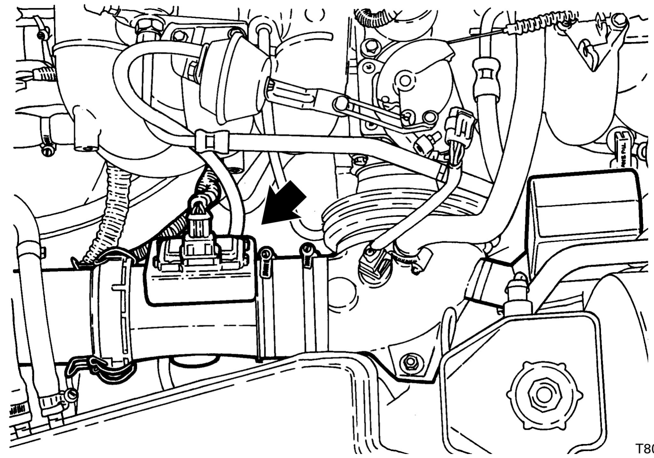
The MAFS is a hot wire type that measures air flow volume by the cooling effect of air passing over a heated platinum wire, altering the electrical resistance of the wire. The electrical resistance value is converted to an analog output voltage supplied to the ECM as a measure of air flow volume (engine load).

The heated wire sensor is located in the central column that is an integral part of the casting. The column has a central tube entry and four exit slots. A small portion of the intake air flows through the entry tube and passes over the heated wire sensor before returning to the main air flow through the four exit slots. The heated sensor is an integral part of the heat sink and control unit mounted on the main casting. The intake screen stabilizes the air flow through the MAFS and protects the sensor from debris in the air stream.

MAFS Monitoring for OBD II
The range of the MAFS signal is checked for values outside of the normal limits and for open and short circuits. A fault must occur on two consecutive trips before the CHECK ENGINE MIL is activated. Refer to Systems Readiness Test, page 53.

NOTES

MAFS LOCATION (XJ6 SEDAN RANGE)



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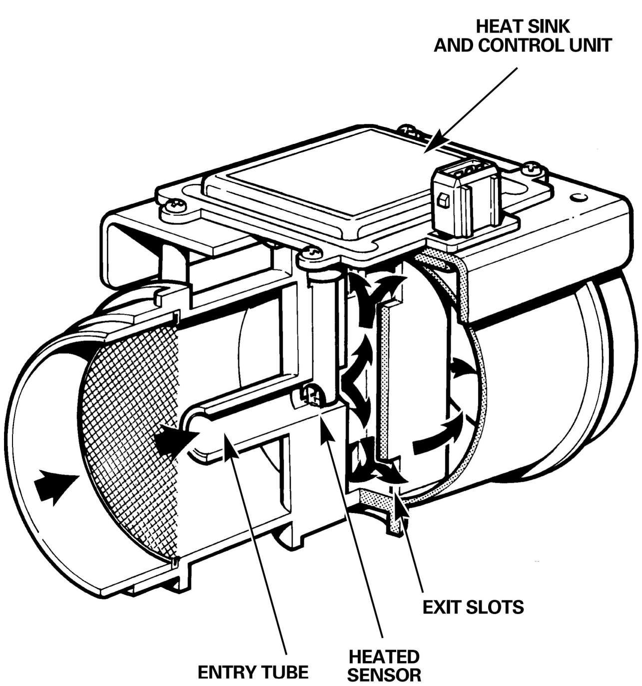
MAFS CROSS SECTION



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