DESCRIPTION

The Mpi Modular Engine Management System (MEMS) controls the fuel injection and programmed ignition systems.

The main features are as follows:

- The Engine Control Module (ECM) controls programmed ignition and fuel injection. The ECM incorporates short circuit protection and can store intermittent faults on certain inputs. Testbook can interrogate the ECM for these stored faults.

- The ECM uses the speed/density method of air flow measurement to calculate fuel delivery. This method measures the inlet air temperature and inlet manifold pressure and assumes that the engine is a calibrated vacuum pump with its characteristics stored in the ECM

- If certain system inputs fail, the ECM implements a back-up facility to enable the system to continue functioning, although at a reduced level of performance.

- A separate diagnostic connector allows engine tuning or fault diagnosis to be carried out using Testbook without disconnecting the ECM harness connector.

- The ECM harness multiplug incorporates specially plated pins to minimise oxidation and give improved reliability.

- The throttle potentiometer requires no adjustment in service. The following components supply data for both fuelling and ignition:

Ignition system

The ECM determines the optimum ignition timing based on the signals it receives from the following sensors:

1. Crankshaft sensor - Engine speed and crankshaft position.
2. Manifold absolute pressure sensor - Engine load
3. Coolant temperature sensor - Engine temperature.
4. Manifold absolute pressure sensor - Throttle closed.
5. Knock sensor - Engine noise and vibration.

MEMS uses no centrifugal or vacuum advance, timing being controlled by the ECM which is energised by the main relay, within the relay module. Spark distribution is achieved by 2 coils mounted at the rear of the engine and controlled by the ECM.

Basic ignition timing

MEMS provides the optimum ignition timing for the relevant engine speed and load. The speed and position of the engine is detected by the crankshaft sensor which is bolted to, and projects through the engine adapter plate.

The sensor incorporates an armature which runs adjacent to a reluctor insert in the flywheel, the insert consisting of 34 poles spaced at 10 °intervals, with two missing poles 180 °apart to identify the T.D.C. positions.

The sensor ’reads’ these poles to provide a constant up-date of engine speed and crankshaft position to the ECM

The load signal is provided by the manifold absolute pressure sensor mounted inside the ECM casing which detects manifold pressure via a hose connected to the manifold chamber. The sensor converts pressure variations into graduated electrical signals which can be read by the ECM

Ignition timing compensation

Coolant temperature sensor
When the ECM receives a low engine temperature signal from the coolant sensor, it provides optimum driveability and emissions by advancing or retarding the ignition timing.

Knock sensor
The knock sensor is a capacitive device mounted in the cylinder block between nos. 2 and 3 cylinders below the inlet manifold. The sensor monitors noise and vibration in the engine and passes this information to the ECM which is able to identify the characteristics of the knocking and make the necessary corrections to the ignition timing of individual cylinders.

Idle speed control
When the throttle pedal is released and the engine is at idle, the ECM uses the fast response of ignition timing to assist idle speed control.

When loads are placed on, or removed from the engine the ECM senses the change in engine speed and in conjuction with the opening of the throttle disc by the stepper motor, advances or retards the ignition timing to maintain the specified idle speed. When load is removed from the engine and the stepper motor returns to it’s original position, the ignition timing returns to the idle setting.

NOTE: Due to the sensitivity of this system the ignition timing will be constantly changing at idle speed.

Fuel system

ECM

The MEMS system is controlled by the ECM which is located in the engine compartment.

The ECM is an adaptive unit and can learn the load and wear characteristics of a particular engine.

The ECM remembers and updates two main engine requirements when the engine is fully warm:

1. The idle stepper position required to achieve the specified idle speed.
2. The fuelling change or offset required to achieve a set oxygen sensor voltage.

The stepper position is used as a reference to update the amount of stepper motor movement required to achieve the specified idle speed under all conditions.

The fuelling offset is required to enable the system when not in closed loop control to provide the correct fuelling and while in closed loop control to prevent having to apply excessive adjustments to the fuelling which can adversely affect the emissions and driveability.

NOTE: After fitting a different ECM, a full tune procedure must be carried out using Testbook.

The ECM inputs and outputs are shown in the table.

INPUTS TO MEMS ECM

Crankshaft sensor
Manifold absolute pressure
Coolant temperature sensor
Inlet air temperature sensor
Knock sensor
Oxygen sensor
Throttle potentiometer
Throttle closed
Battery supply
Ignition supply
Diagnostic input
Power earth
Sensor earth
Fuel temperature sensor
Oxygen sensor
Air conditioning switch

OUTPUTS FROM MEMS ECM

Ignition coil
Injectors
Aircon relays
Stepper motor
Temperature gauge
Fuel pump relay (inside relay module)
Main relay (inside relay module)
Diagnostic output

Injectors
The four fuel injectors are fitted between the pressurised fuel rail and inlet manifold. Each injector comprises of a solenoid operated needle valve and a specially designed nozzle to ensure good fuel atomisation.

Engine coolant temperature sensor
The coolant temperature sensor is mounted in the thermostat housing and is immersed in the engine coolant. The sensor is a resistive device in which the resistance varies with temperature

Throttle housing
The throttle housing is attached to the inlet manifold via a rubber sandwich plate and incorporates a throttle disc which is connected to the throttle pedal via the throttle lever and a cable.

There are two breather pipes; one either side of the throttle disc. When the engine is running with the throttle disc open, both pipes are subject to manifold depression and draw crankcase fumes into the manifold. When the throttle disc is closed, only the pipe on the inlet manifold side of the disc is subject to manifold depression. This pipe incorporates a restrictor to prevent engine oil being drawn into the engine by the substantially greater manifold depression.

Also incorporated in the throttle housing are the throttle potentiometer and stepper motor.

Throttle potentiometer
The throttle potentiometer is mounted in front of the throttle housing and is directly coupled to the throttle disc shaft.

Three wires connect the throttle potentiometer to the ECM; a 5 volt supply to the potentiometer, an earth return to the ECM and an output voltage to the ECM which indicates the rate of throttle disc movement.

Stepper motor
The stepper motor is contained within the throttle housing and operates a cam and push rod via a reduction gear. The push rod is in direct contact with the throttle lever and moves the throttle disc to control idle and fast idle speed. The stepper motor maximum movement is 3.75 revolutions accomplished in steps of 7.5°. The reduction gear converts this into 180°of cam movement.

The throttle lever has a throttle position setting screw which rests on the stepper motor operating pin when the throttle pedal is released and is used to set the relationship between engine speed and stepper motor position.

In the side of the throttle housing is a throttle air bypass bleed screw to provide easier and more sensitive setting of the stepper motor position at idle.

The stepper motor position is checked using Testbook and should be within the range of 20 to 40 steps when the engine is run in. If it is identified as being outside this range it can be adjusted to within range by turning the throttle air bypass bleed screw. It is important to follow Testbook setting procedure when adjusting this screw to prevent mismatching of throttle body settings. This ensures that the stepper motor is at the optimum position within its range for providing further movement to compensate for changes in engine load or temperature in accordance with signals from the ECM

NOTE: The stepper motor and throttle position setting screws must only be adjusted when Testbook identifies the requirement.

Fuel pump
The electric fuel pump, located inside the fuel tank, is a self-priming centrifugal 'wet' pump, the motor and pump are filled with fuel.

The fuel pump supplies more fuel than the maximum load requirement for the engine, so that pressure in the fuel system can be maintained under all conditions.

Fuel pressure regulator
The pressure regulator is a mechanical device controlled by manifold depression and is mounted in the fuel rail. The regulator ensures that fuel rail pressure is maintained at a constant pressure difference to that in the inlet manifold, as manifold depression increases the regulated fuel pressure is reduced in direct proportion.

When pressure exceeds the regulator setting excess fuel is spill returned to the fuel tank swirl pot which contains the fuel pick-up strainer.

Relay module
The relay module contains the main relay, fuel pump relay, starter relay and oxygen sensor relay and is mounted on the ECM mounting bracket.

The main relay is energised when the ignition is switched on and supplies current to the ECM

The fuel pump relay is energised by the ECM for a short period when the ignition is switched on, during cranking and while the engine is running.

The starter relay is energised by the cranking signal from the ignition switch.

This oxygen sensor relay is energised when the ignition is switched on and supplies current to the ECM

Intake air temperature sensor
The intake air temperature sensor is fitted in the side of the inlet manifold and sends the ECM a signal relating to air temperature. The ECM uses this signal in its calculations on air flow.

Inertia switch
The fuel pump circuit incorporates an inertia switch which in the event of sudden deceleration isolates the power supply to the fuel pump. The inertia switch is situated in the engine compartment on the bulkhead and can, if tripped, be reset by depressing the central plunger.

WARNING: Check the integrity of the fuel system before the inertia switch is reset.

Diagnostic connector
A diagnostic connector is provided to enable diagnosis to be carried out without disturbing the system electrical connections and to allow the ECM's ability to store certain faults to be utilised.

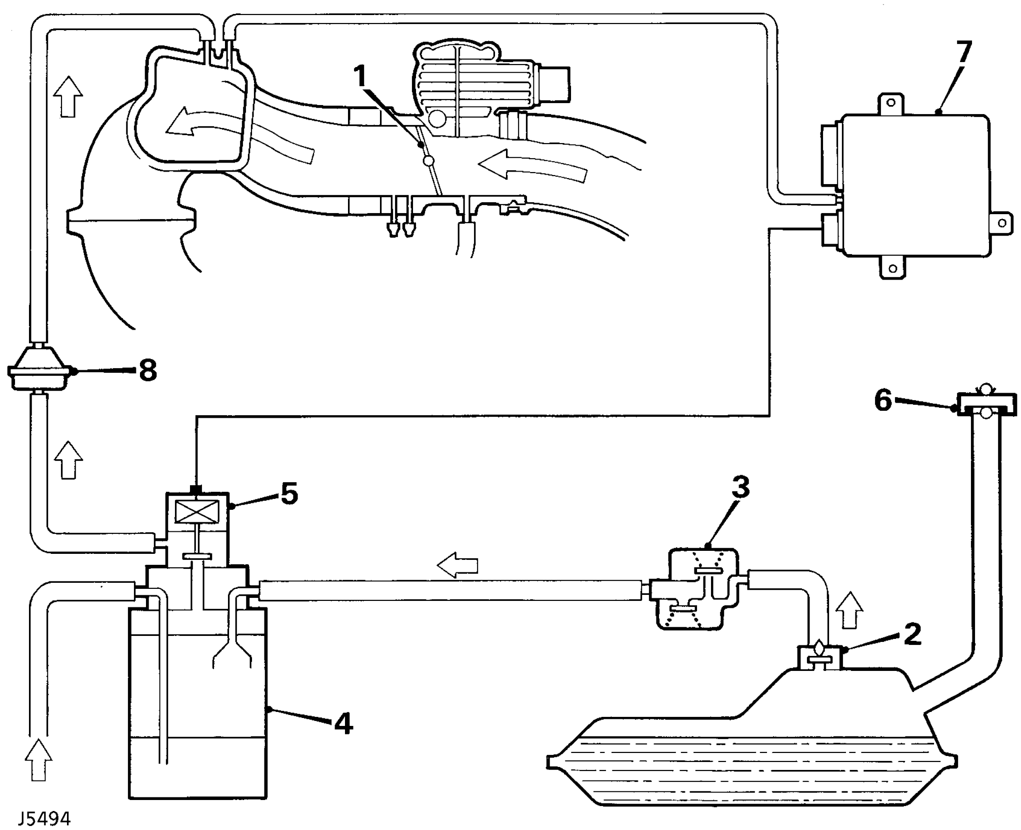
Oxygen sensor - Closed-loop emission control
The MEMS Mpi system operates a closed loop emission system to ensure the most efficient level of exhaust gas conversion.

An oxygen sensor fitted in the exhaust manifold monitors the exhaust gases. It then supplies a small voltage proportional to exhaust oxygen content to the ECM As the air/fuel mixture weakens, the exhaust oxygen content increases and so the voltage to the ECM decreases. If the mixture becomes richer so the oxygen content decreases and the voltage increases.

The ECM uses this signal voltage to determine the air/fuel mixture being delivered to the engine, and adjusts the injector duration to maintain the ratio necessary for efficient gas conversion by the catalyst.

The oxygen sensor has an integral heating element to ensure an efficient operating temperature is quickly reached from cold. The electrical supply for the heater element is controlled by the oxygen sensor relay.

Fuel temperature sensor
The fuel temperature sensor is inserted in the fuel rail and measures fuel and fuel rail temperatures. During engine cranking at high temperatures, the ECM increases fuel supply, and opens the throttle disc via the stepper motor to aid hot starting.



Non - evaporative loss equipment

1. Throttle disc
2. Fuel cut-off valve
3. Two way valve
4. Charcoal canister
5. Purge control valve
6. Fuel filler cap
7. ECM
8. One way valve

Charcoal canister

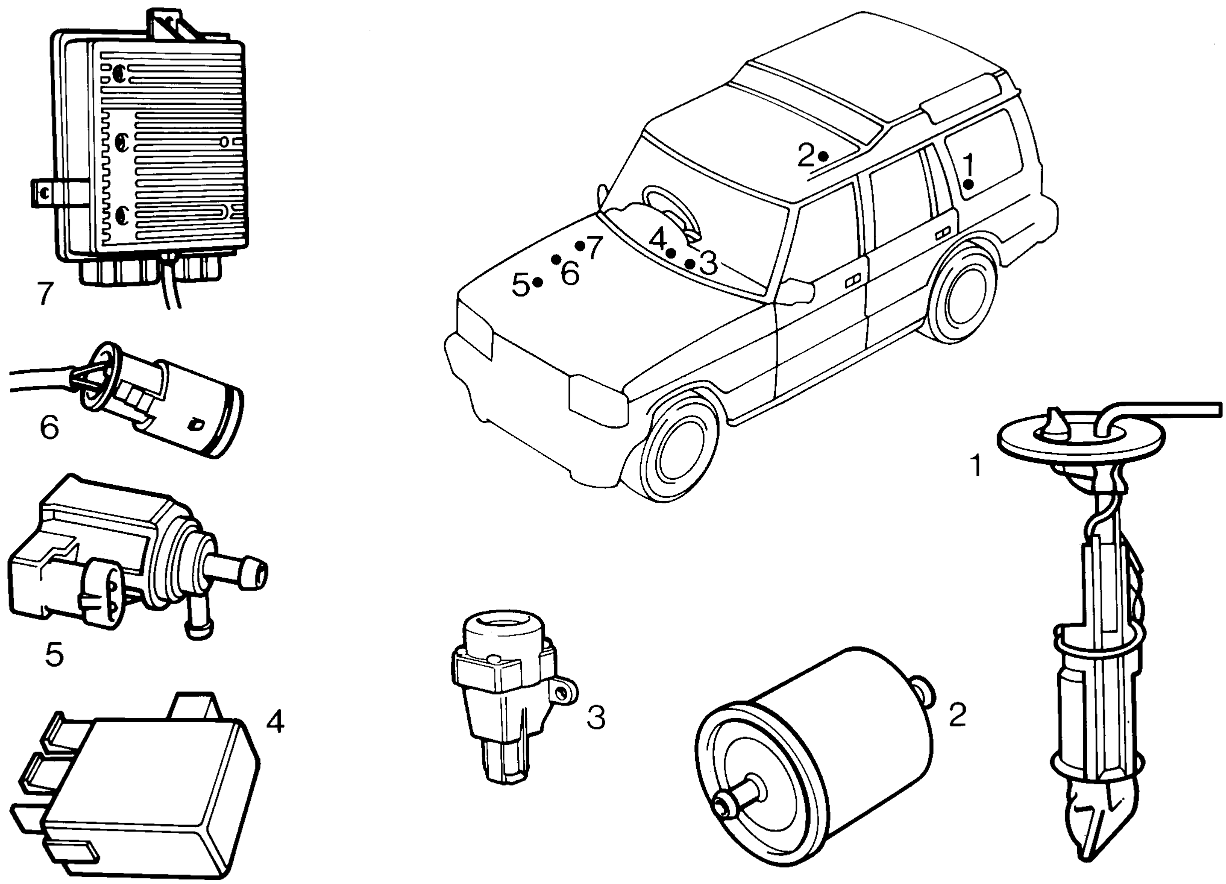
A charcoal canister is used for the temporary storage of fuel vapour from the fuel tank until the vapour can be purged from the canister into the engine and burned.

The charcoal canister is purged when the purge control valve is open, fresh air is drawn through the purge air hose, through the charcoal canister and into a port in the inlet manifold.

Purge control valve

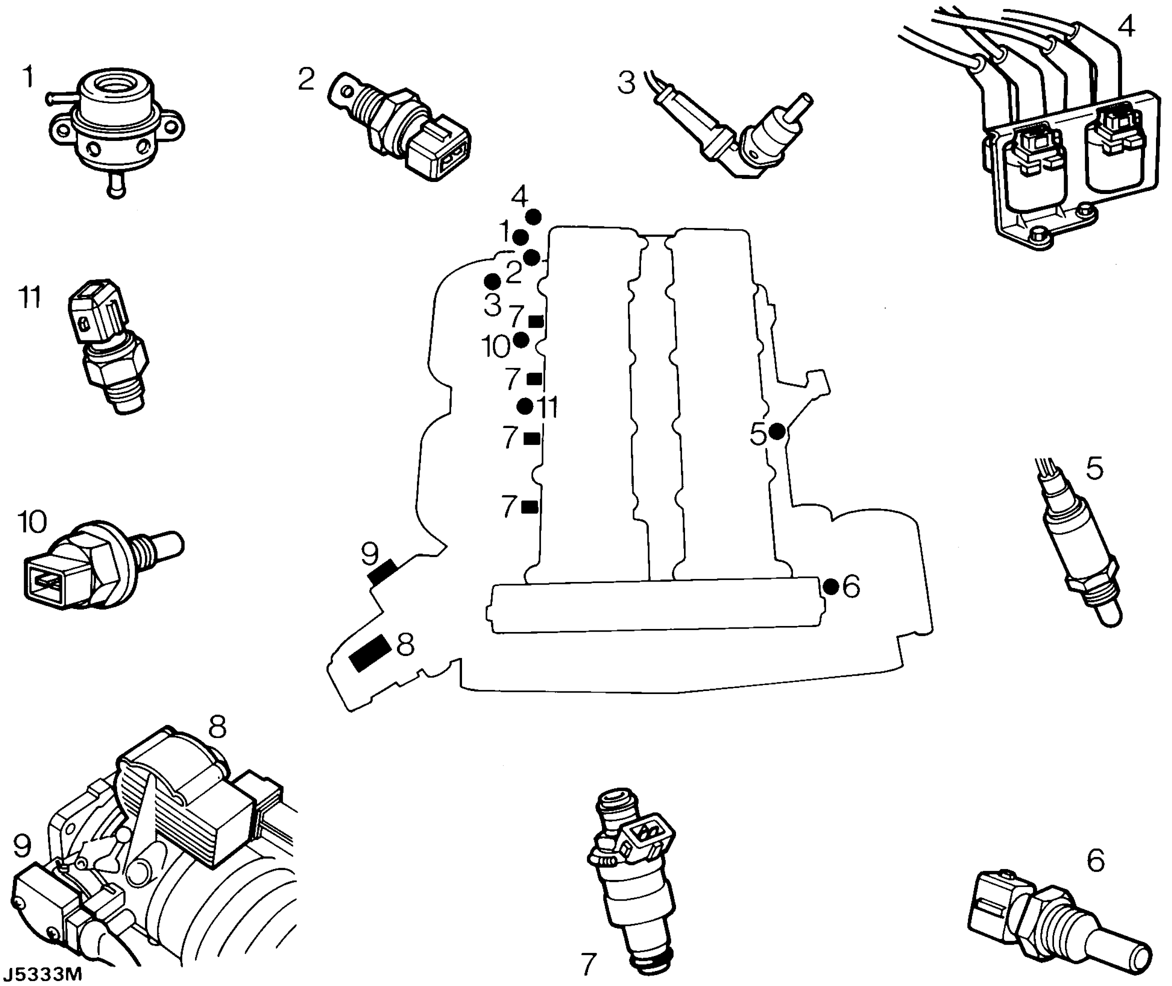
A purge control valve is operated by the ECM The valve remains closed when the engine is cold and at idling speed to protect engine tune and catalyst performance. If the charcoal canister was purged during cold running or at idling speed, the additional enrichment in fuel mixture would delay catalyst light off time and cause erratic idle. When the engine temperature is above 75°C, the purge control valve will be operational (modulated ON and OFF) whenever the engine speed is above approximately 1600 rev/min. When the purge valve is opened, fuel vapour from the charcoal canister is drawn into the inlet manifold for combustion.

MEMS COMPONENTS & LOCATION ON VEHICLE



Components		**Location**
1	Fuel pump	Fuel tank
2	Fuel filter	Right chassis rear
3	Fuel inertia switch	Bulkhead
4	Relay module	Under bonnet [hood]
5	Purge control valve	On charcoal canister
6	Diagnostic connector	Right inner wing [fender]
7	MEMS ECM.	Right inner wing [fender]

MEMS COMPONENTS & LOCATION ON ENGINE



	Components	Location
1	Fuel pressure regulator	Engine rear
2	Intake air temperature sensor	Inlet manifold
3	Crankshaft sensor	Under starter motor on flywheel housing
4	Twin ignition coils	Engine rear
5	Oxygen sensor	Exhaust manifold
6	Coolant temperature sensor	Coolant chamber
7	Injectors	
8	Stepper motor	
9	Throttle potentiometer	
10	Fuel temperature sensor	Fuel rail
11	Knock sensor	Engine block

SYSTEM OPERATION

Ignition on

When the ignition is switched on, voltage is applied to ECM pin 11. The ECM then switches on the main relay by supplying an earth path at pin 4. This allows battery voltage to pass to ECM pin 28, to the four injectors and through the ignition coil to ECM pin 25. In addition, the fuel pump relay is switched on by the ECM supplying an earth path on pin 20. Voltage is applied through the inertia switch to the fuel pump.

The pump runs for a short period to pressurise the fuel rail. The fuel pressure regulator will open at its maximum setting and excess fuel is spill returned to the tank.

The ECM determines the amount of stepper motor movement from the following signals:

- Engine coolant temperature data at pin 33.
- Inlet air temperature data at pin 16.
- Throttle potentiometer data at pin 8.
- Engine speed data at pins 31 and 32.
- Manifold absolute pressure data (via pipe from manifold).
- Battery voltage at pin 28.
- Ignition signal at pin 11.

If one or more of the following inputs fail, the ECM will substitute the back-up values shown to maintain driveability.

Input	Back-up value
Coolant temperature	Idle Speed controlled until engine is fully warm. 60°C at speeds above idle.
Inlet air temperature	Derived from engine speed and engine load.
Manifold absolute pressure	Derived from engine speed and throttle position.

Starter operation

Whilst the starter relay is energised, battery voltage is applied to the starter motor solenoid. The solenoid also energises and supplies battery voltage directly to the starter motor.

Ignition is controlled by the ECM switching the low tension circuit via pin 25.

The ECM provides an earth signal on pins 24, 23, 26 and 1 for the period the injectors are required to be open, the injector solenoids are energised (simultaneously on naturally aspirated models) and fuel is sprayed into the manifold onto the back of the inlet valves. The ECM carefully meters the amount of fuel injected by adjusting the injector opening period (pulse width). During cranking, when the engine speed is below approx. 400 rev/min, the ECM increases the injector pulse width to aid starting. The amount of increase depends upon coolant temperature. To prevent flooding, injector pulses are intermittent i.e. 24 on then 8 pulses off.

Idling

After start enrichment is provided at all temperatures immediately cranking ceases. The ECM controls the enrichment by increasing injector pulse width. The enrichment decays in relation to the rising coolant temperature.

Provided the ECM is receiving a signal that the engine speed is close to the idle speed set point, the ECM will implement idle speed control.

The ECM activates a unipolar stepper motor acting directly on the throttle lever. Idle speed response is improved by the ignition system advancing or retarding the timing when load is placed on, or removed from the engine.

If, during engine idle, the load on the engine is increased sufficiently to cause engine speed to fall, the ECM will sense this via the crankshaft sensor and instantly advance the ignition timing to increase idle speed and then energise the stepper motor to open the throttle disc thus maintaining the idle speed. Finally the ignition timing is retarded to its nominal value.

The ECM monitors battery voltage and, if voltage falls sufficiently to cause fluctuations in injector pulse widths, it increases the injector pulse widths to compensate.

On return to idle, the ECM will implement a slightly higher idle speed to prevent the engine stalling.

Driving
When the throttle pedal is depressed, the ECM implements the cruise air/fuel ratio map. During driving the ECM continually monitors inlet air temperature and engine speed and load for it’s air flow calculations, together with coolant temperature for any temperature corrections. Additional inputs are throttle potentiometer for acceleration and throttle pedal switch for cruise/idle fuel map selection and over-run fuel cut-off.

Acceleration enrichment
When the throttle pedal is depressed, the ECM receives a rising voltage from the throttle potentiometer and detects a rise in manifold pressure from the manifold absolute pressure sensor. The ECM provides additional fuel by increasing the normal injector pulse width and also provides a small number of extra injector pulses on rapid throttle openings.

Over-run fuel cut-off
The ECM implements over-run fuel cut-off when the following signals are received.

- Throttle disc closed.
- Engine speed is above 2000 rev/min - engine at normal operating temperature.

Fuel is reinstated progressively when any of the above signals cease.

Over-speed fuel cut-off
To prevent damage at high engine speeds the ECM inhibits the earth path for the injectors, cutting off injection. As engine speed falls, injection is reinstated.

Ignition switch off
When the ignition is switched off, the ECM will keep the main relay energised for approx. 30 seconds while it drives the stepper motor to the 35 step position for the next engine start.