GM Multec EMS (SPi) : System overview

The GM Multec (**Mul** tiple **Tec** hnology) EMS was developed by General Motors and first appeared on vehicles in the USA. It was also used in GM vehicles on the mainland of Europe before appearing in the UK in about 1989. Original applications were SPi, but MPi equipped vehicles began to appear in 1992. Engine sizes vary from 1.4 through 1.6 to 1.8.

GM Multec was designed as a modular system that was capable of controlling a wide range of engines utilising both MPi and SPi systems. In European vehicles it is always available equipped with a catalytic converter. Unlike many other modular systems, ECM pin numbers to common components may differ according to application and care should be taken when making tests at the ECM multi-plug.

The GM Multec ECM is designed with three main areas of control. These are the ignition, fuel system and idle speed. The Multec ignition point and injection duration are jointly processed by the ECM so that the best moment for ignition and fuelling are determined for every operating condition.

The correct ignition dwell and timing for all engine operating conditions are calculated from data provided by crankshaft position, engine speed and engine load. Multec uses various means to provide this data depending upon the vehicle. The various means include, the distributor based Hall-effect switch or inductive trigger, the crankshaft based CAS, and the MAP sensor. However, the MAP sensor is the standard means to determine engine load across both MPi and SPi applications.

Two multi-plugs (32 and 24 pin) connect the ECM to the battery, sensors and actuators.

In some models, the programmed memory unit in the ECM can be renewed if it becomes faulty. This includes, C16NZ, C18NZ, X16SZ - usually marked with blue socket connections. Models where the memory cannot be renewed include the C12NZ and C14NZ engines.

Basic ECM operation (SPi)

Voltage is permanently applied to the ECM from the system battery. This allows the self-diagnostic function to retain data of an intermittent nature.

Once the ignition is switched on, voltage is applied to the ignition coil, VSS, injector, amplifier and to the ECM. This causes the ECM to briefly apply voltage to the fuel pump relay which actuates momentarily to pressurise the fuel lines. After two seconds the voltage is turned off to await a cranking or running signal.

The majority of sensors (other than those that generate a voltage such the CAS, OS and VSS), are now provided with a 5.0 volt reference supply from a relevant pin on the ECM. When the engine is cranked or run, a speed signal from the ignition causes the ECM to apply voltage to the relay once more so that the fuel pump will run. Ignition and injection functions are also activated. The injector circuit is completed by pulsing the relevant actuator wire to earth, and the stepper motor regulates the idle speed under ECM control when the engine is at idle.

Reference voltage

Voltage supply from the ECM to the engine sensors is made at a 5.0 volt reference level. This ensures a stable working voltage unaffected by variations in system voltage.

The earth return connection for most engine sensors is made through an ECM pin and this pin is not directly connected to earth. The ECM internally connects all sensors to earth via an ECM earth pin that is directly connected to earth.

Signal shielding

To reduce RFI, a number of sensors (ie CAS or HES, amplifier and OS) use a shielded cable.

Signal processing

Basic ignition timing is stored in a map and the engine load and speed signals determines the ignition timing. The main engine load sensor is the MAP sensor and engine speed is determined from the CAS, distributor based inductive trigger or HES as appropriate.

Correction factors are then applied for starting, idle, deceleration and part and full-load operation. The main correction factor is engine temperature (CTS). Minor corrections to timing are made with reference to the TPS signal.

Likewise, the basic AFR is also stored in a two dimensional map and the engine load and speed signals determines the basic injection pulse value. Using the speed / density method, GM Multec calculates the AFR from the pressure in the inlet manifold (MAP) and the speed of the engine.

This method relies on the theory that the engine will draw in a fixed volume of air per revolution. The AFR and the pulse duration are then corrected on reference to the CTS, battery voltage and rate of throttle opening (TPS). Other controlling factors are determined by operating conditions such as cold start and warm-up, idle condition, acceleration and deceleration.

Self Diagnostic function
The GM Multec system has a self-diagnostic capability that regularly examines the signals from engine sensors and internally logs a code in the event of a fault being present. This code can be extracted from the serial port by a suitable Fault Code Reader.

When the ignition is first switched on the warning lamp on the dash will light. The lamp will stay lit until the engine is started when it should extinguish. If the ECM recognises that a fault is present, the warning lamp will light until the fault is no longer permanently present. However, if the fault clears the code will remain logged in ECM memory until wiped clean with a suitable FCR, or until the engine has been started for more than 20 times when the fault code is automatically cleared. Logging of intermittent codes is a useful aid to the detection of intermittent system and component faults.

In addition to the self-diagnostic capability, GM Multec has a limp home facility. In the event of a serious fault in one or more of the sensors, the EMS will substitute a fixed default value in place of the defective sensor.

This means that the engine may actually run quite well with failure of one or more minor sensors. Since the substituted values are those of a hot engine, cold starting and running during the warm-up period may be less than satisfactory. Also, failure of a major sensor, ie the MAP sensor, will lead to a considerable reduction in performance and in some instances, the engine speed at idle may appear higher than normal.

AT communication (where appropriate)
Two-way communication with the AT control module ensures that gear shifting is accomplished optimally and smoothly with less stress.

From model year 1993 two-way communication with the AT control unit was designed into both units. The engine ECM signals the AT module on engine speed and load conditions. For its part the AT module informs the ECM when a transmission shift is imminent and the ECM immediately retards the ignition point for the duration of the change. Timing retard lowers the engine torque and ensures that gear shifting is accomplished optimally and smoothly with less stress.

HES (1.2 / 1.4 SPi)
The amplifier supplies a voltage slightly under nbv to the Hall-effect switch in the distributor. An earth return wire completes the circuit to the amplifier where it is internally connected to the amplifier main earth path.

Opposite the Hall switch is a magnet whose field causes the switch to return a small voltage back to the amplifier. Attached to the distributor shaft is a trigger vane with the same number of cut-outs as cylinders. Passing the trigger vane between the switch and the magnet will cause the Hall switch to be turned off and on. As the cut-out space proceeds past the switch, a voltage is returned to the module via a third wire termed the output wire.

When the solid portion comes between the switch and magnet, the voltage is turned off as the magnetic field is diverted. Essentially, the voltage signal is returned as either voltage or no voltage and the waveform produced is that of a square wave.

Inductive trigger (1.6 SPi)
The primary signal to initiate both ignition and fuelling emanates from an inductive trigger mounted in the distributor. The inductive trigger consists of an inductive magnet that radiates a magnetic field. The distributor shaft incorporates a reluctor containing 4 lobes set at 90° intervals.

As the distributor spins, and the reluctor teeth are rotated in the magnetic field, an AC voltage signal is generated to indicate the ignition point.

The peak to peak voltage of the signal (when viewed upon an oscilloscope) can vary from 5 volts at idle to over 100 volts at 6000 rpm. The ECM uses an analogue to digital converter to transform the AC pulse into a digital signal.

CAS (1.8 SPi and DIS models)
The primary signal to initiate both ignition and fuelling emanates from a CAS mounted in proximity to the flywheel. The CAS consists of an inductive magnet that radiates a magnetic field. The flywheel incorporates a reluctor disk containing 60 positions set at regular intervals. 58 of those positions contain reluctor teeth with two positions vacant.

As the flywheel spins, and the teeth are rotated in the magnetic field, an AC voltage signal is generated to indicate speed of rotation. The two missing teeth (set at 180° intervals) are a reference to TDC and indicate crankshaft position by varying the signal as the flywheel spins. One missing tooth indicates TDC for cylinders 1 and 4 and the other missing tooth indicates TDC for cylinders 2 and 3.

The peak to peak voltage of the speed signal (when viewed upon an oscilloscope) can vary from 5 volts at idle to over 100 volts at 6000 rpm. The ECM uses an analogue to digital converter to transform the AC pulse into a digital signal.

Ignition
Data on engine load (MAP) and engine speed from the ignition are collected by the ECM, which then refers to a digital ignition map stored within its microprocessor. This map contains an advance angle for basic load and speed operating conditions. The advance angle is corrected after reference to engine temperature (CTS), so that the best ignition advance angle for a particular operating condition can be determined. The engine speed range is from 30 to 8000 rpm.

Amplifier
The amplifier contains the circuitry for switching the coil negative terminal at the correct moment to instigate ignition. The signal received by the amplifier from the trigger (of whatever type), is of an insufficient level to complete the necessary coil switching. The signal is thus amplified to a level capable of switching the coil negative terminal.

For 1.4 and 1.8 vehicles with distributor, a separate amplifier is mounted on a heat sink plate adjacent to the coil. For the 1.6 model with distributor, the amplifier is mounted on the baseplate under the distributor cap. For models with DIS, the amplifier is an integral part of the coil pack.

The amplifier used in the HES system also supplies voltage to the HES and provides a separate HES earth path. An internal connection completes the circuit through the main amplifier earth terminal.

The ECM calculates the correct ignition dwell time and timing advance from data received from its sensors, and sends a signal to the amplifier which then switches the coil negative terminal. The advantage of a separate amplifier, is that if the amplifier fails, it is less costly to renew than a new ECM.

Dwell operation
Dwell operation in GM Multec is based upon the principle of the `constant energy current limiting' system. This means that the dwell period remains constant at about 3.0 to 3.5 ms, at virtually all engine running speeds. However, the dwell duty cycle, when measured in percent or degrees, will vary as the engine speed and battery voltage varies.

During engine cranking (starting mode) the ECM increases dwell duration to a value dependent upon battery voltage. Once engine speed exceeds 400 rpm, the ECM exits starting mode and operating mode begins.

The signal received by the amplifier from the trigger (of whatever type), is of an insufficient level to complete the necessary coil switching. The signal is thus amplified to a level capable of switching the coil negative terminal.

Ignition coil
The ignition coil utilises low primary resistance in order to increase primary current and primary energy. The amplifier limits the primary current to around 8 amps and this permits a reserve of energy to maintain the required spark burn time (duration).

Distributor (when fitted)
All models: The distributor contains secondary HT components (distributor cap, rotor and HT leads) and serves to distribute the HT current from the coil secondary terminal to each spark plug in firing order. The distributor is located on the camshaft at the cylinder number four end. Either a Bosch or Lucas distributor may be used.
1.4 models: The distributor also contains the HES and magnet.
1.6 models: The distributor also contains the inductive trigger and the amplifier.
1.8 models: The distributor only contains the HT components and ignition is triggered from a CAS mounted adjacent to the flywheel.

Vehicles without a distributor (DIS)
Although the ignition system is termed DIS, the basic operation is similar to models with conventional ignition. In a DIS or so called `wasted spark' system, a double ended coil is used to fire two plugs at the same time. This means that the system can only be used where two cylinders rise and fall together.

One cylinder will fire on the compression stroke and the companion cylinder will fire on the exhaust stroke where the spark is ` wasted'. Two pairs of coils are therefore required for a four cylinder engine. About 3 KV is still needed to fire the `wasted spark' plug, but this is far less than that required to bridge the rotor gap when a distributor is fitted.

In GM Multec DIS, the amplifier is integral with the twin coils The ECM calculates the correct ignition dwell time and timing advance from data received from the CAS and other sensors, and sends a timed control signal to the amplifier which then switches the coil negative terminal. Two control signals are sent, one to each coil, and the signals are alternately timed at 180° of crankshaft rotation. Four signals are therefore sent over 720° and this results in all four sparkplugs being fired during two revolutions of the engine.

The DIS unit will normally operate in a voltage range of 6.0 to 16.0 volts. Short circuit and over-voltage protection against reversal of supply and earth wires, short circuits to earth, short circuits to battery voltage and a maximum of 24 volts are built into the unit for a maximum period of 60 seconds over the entire engine speed range. Any of these faults will activate the SD warning lamp.

Octane coding
It is possible to adjust the base ignition timing on early variations of the GM Multec system that are equipped with a hall sensor ignition. However, the ignition timing for later models is not adjustable. An octane coding plug is provided to enable the ECM to adopt different characteristics to suit various grades of unleaded fuel. Simply turning the standard 95/91 Octane Plug to its alternate position will fulfill the alternative condition. The X16SZ engine practises knock control and an octane plug is therefore deemed unnecessary.

Knock control **diagram X16SZR** **diagram X12/16SZ**
The optimal ignition timing (at engine speeds greater than idle) for a given high compression engine is quite close to the point of onset of knock. However, running so close to the knock point, means that knock will certainly occur on one or more cylinders at certain times during the engine operating cycle.

Since knock may occur at a different moment in each individual cylinder, Multec employs selective knock control to pinpoint the actual cylinder or cylinders that are knocking. The selective knock control system is comprised of the Knock Sensor (KS), the Knock Control Module (KCM) and the ECM. The KCM for the X16SZR engine is contained within the ECM. In the X12/16SZ engines the KCM is a separate unit mounted in the engine bay.

The KS is mounted on the engine block between cylinders 2 and 3 and consists of a piezoceramic measuring element that responds to engine noise oscillations. The KS converts these noise oscillations into a small AC output voltage. A reference voltage of 2.50 volts is applied to the KS from the ECM and the ECM monitors the voltage level at this pin. If the circuit becomes shorted or open circuit, the voltage level will change and the ECM will assume a fault. For safety purposes, when a fault is evident in the knock control system, the ECM switches to the 91 RON ignition map and retards the ignition timing by 5°.

The KS AC output signal is filtered by the knock control module and converted to a digital signal before being returned to the ECM for evaluation and action. The GM engines have a knocking frequency in the 8 kHz frequency band and noise signals in this band form the basis for the output signal. The KCM consists mainly of analogue circuits, except for the digital.output stage to the ECM. The KCM output voltage is nominally 9.0 volts. When knock occurs, the output voltage drops to zero volts. The pulse length (width) is proportional to the knock signal intensity. However, if the pulse width is longer than 4.0 seconds, the ECM will assume a fault. Most other faults including a short or open circuit will also be recognised. For safety purposes, when a fault is evident in the knock control system, the ECM switches to the 91 RON ignition map and retards the ignition timing by 5°.

Because of the sophistication of knock and timing control an octane coding plug is not considered necessary for engines with knock control. Multec is programmed with three different timing (octane) maps for 91, 95 and 98 octane fuel. The ECM selects the appropriate map according to the following conditions.

Initially, timing will occur at its mapped optimal ignition point. When the ECM receives knock signals from the KCM, further complex analysis and filtration is applied to determine if the signal can be correctly recognised as engine knock. The signal profile is compared to a pulse window which is only opened for the period in which knock may occur. Pulses are further filtered by eliminating all pulse widths below an engine load-dependent/ speed minimum value.

All pulse that pass the filtering processes are then allocated to the particular cylinder that fired most recently. The ECM keeps count by way of a software cylinder counter retained in ECM memory.

When the cylinder next fires, the timing angle is retarded by an amount that depends upon engine speed. All other cylinders fire at their nominal mapped timing unless the ECM has identified knock in one or more of the other cylinders. This means that each cylinder is independently fired at its optimum timing. If knock is identified at the next firing, the cylinder is again retarded and this process continues until knock ceases. Once knock ceases, the ECM advances the timing in steps of 0.3° over a time period that is dependent on engine speed. Advance will cease when the mapped timing value is reached or if knock commences once more. In the latter case, the whole knock control process will begin again. The process is termed 'Fast or engine-synchronised firing angle correction'.

In addition the knock control program has an adaptive ability that has a slower learning curve. Fifteen learn cells are allocated to each cylinder and if fast adjustment is greater than a limiting value, part of the correction is allocated to a learn cell. The ECM monitors the learn cells and adapts the knock control in conjunction with the learned values. If the adaption is large enough the ECM will switch to a lower octane map and the learn cell values are reset to zero. The whole process begins again with the newly selected lower octane map..

VSS
The VSS is used to advise the ECM of vehicle speed. It operates upon the Hall-effect principle and can be mounted directly upon the gearbox or behind the dash.

When it is switched on, a voltage of approximately 10 volts is applied to the VSS from the ignition switch. As the speedometer cable turns, the hall switch is alternately turned on and off to return a square wave signal to the ECM. The frequency of the signal denotes the vehicle speed.

Fuel injection
The GM Multec ECM contains a fuel map with an injector opening time for basic conditions of load and speed. Information is then gathered from engine sensors such as the MAP sensor, CAS, CTS, and TS. As a result of this information, the ECM will look-up the correct injector pulse duration right across the engine rpm, load and temperature range.

Single point injection (SPi)
The SPi system consists of a single injector mounted in the throttle body. The amount of fuel delivered by the injector is determined by the fuel pressure and the injector opening time - otherwise known as the pulse duration. The ECM controls the period of time that the injector is held open and this is determined by the signals from the various sensor inputs. During engine start-up from cold, the pulse duration is increased to provide a richer air / fuel mixture.

Fuel injector
The fuel injector is a magnetically operated solenoid valve that is actuated by the ECM. Voltage to the injector is applied from the ignition switch and the earth path is completed by the ECM for a period of time (called pulse duration) of between 1.5 and 10 milliseconds. The pulse duration is very much dependant upon engine temperature, load, speed and operating conditions. When the magnetic solenoid closes, a back EMF voltage of up to 60 volts is induced.
The injector is switched using two circuits. Operation depends on the principle that more current is required to open an injector than to keep it open. This kind of system is often termed `current controlled injection system'.

Once the injector is open, a second circuit rapidly pulses the injector to earth. The switching is so rapid that the injector is effectively held open and less current is required during the operation. Advantages of this arrangement include a reduction in injector operating temperature and immediate injector closure once the holding circuit is switched off.

Injection operation can be synchronous or asynchronous. During normal operation ie during steady throttle cruise conditions - injection operation is synchronous. This means that the injector operation is synchronised with the ignition pulses and four injection pulses occur for every two engine revolutions.

During sharp acceleration, injection operation becomes asynchronous. Injection operation is no longer synchronised with the ignition pulses and injection pulses now occur every 12.5 milliseconds. Injection duration may also be increased. Asynchronous operation also occurs during operation where the injection duration is very small (less than one millisecond) and control of the mixture becomes poor.

Deceleration fuel cut-off
A reduction in the injection pulse is implemented during engine over-run conditions to improve economy and emissions. Injection operation will become asynchronous with pulses every 12.5 ms. Under extreme deceleration the injector operation may be cut-off completely.

MAP
The main engine load sensor is the MAP sensor. A vacuum hose connects the MAP sensor (located on the bulkhead) and the inlet manifold. Manifold vacuum acts upon the MAP sensor diaphragm and the ECM converts the pressure into an electrical signal. MAP is calculated from the formula: Atmospheric Pressure less Manifold pressure = Manifold Absolute Pressure.

Using the speed/density method, GM Multec calculates the AFR from the MAP signal and the speed of the engine. This method relies on the theory that the engine will draw in a fixed volume of air per revolution. When manifold vacuum is high (ie idle condition), MAP is moderately low and the ECM provides less fuel. When manifold vacuum is low (ie wide open throttle), MAP is high and the ECM provides more fuel.

A 5.0 volt reference voltage is applied to the sensor and connected to the sensor return circuit. A third wire is connected to a transducer which converts the manifold pressure signal into a voltage. As the pressure in the manifold varies, so too does the signal voltage returned to the ECM. When the ignition is first turned on, the ECM reads and records the signal as a measure of atmospheric pressure at that moment. Since atmospheric pressure will vary every time the vehicle is used, the ECM is able to account for the changed pressure in its fuel requirement calculations.

Air temperature control
The air filter casing contains a thermal valve system to regulate the temperature of the air supply to the throttle body. The supply functions very much like those fitted to carburettor models.

Manifold vacuum is piped via a small hose to the thermal valve in the air filter casing. Another hose is connected to a vacuum motor which controls a flap in the air filter nozzle. The flap opens or closes according to under-bonnet air temperature. The thermal valve is a bi-metal valve which contains a passage to allow the passing of vacuum. As the temperature rises, the valve opens to form an air bleed in the passage and this causes the vacuum in the passage to collapse.

When the under-bonnet air temperature is low, the bi-metal valve is closed and vacuum acts to fully open the flap. Thus, heated air from the exhaust system enters the throttle body intake. As under bonnet air temperature rises, the bi-metal air bleed begins to open and the vacuum pull upon the flap is reduced. A mixture of heated and unheated air is thus fed to the throttle body. As the air temperature rises above a pre-determined value, the air bleed becomes fully open. The flap, therefore, fully closes to shut off the exhaust heated air. Fully unheated air now enters the throttle body. Air is thus introduced to the throttle body at a fairly constant temperature, irrespective of ambient temperature.

CO adjustment
There is no provision for CO adjustment on any of the models in this range.

CTS
The CTS is immersed in the coolant system and contains a variable resistance that operates on the NTC principle. When the engine is cold, the resistance is quite high. Once the engine is started and begins to warm-up, the coolant becomes hotter and this causes a change in the CTS resistance. As the CTS becomes hotter, the resistance of the CTS reduces (NTC principle) and this returns a variable voltage signal to the ECM based upon the coolant temperature.

The open circuit supply to the sensor is at a 5.0 volt reference level and this voltage reduces to a value that depends upon the resistance of the CTS resistance. Normal operating temperature is usually from 80° to 100° C.

To increase sensitivity, the relationship between voltage and temperature is switched by the ECM at a point between 40° to 50° C. This will result in two different voltage measurements between certain temperatures.

The ECM uses the CTS signal as a main correction factor when calculating ignition timing and injection duration.

TPS
A TPS is provided to inform the ECM of idle position and rate of acceleration. The TPS is a potentiometer with three wires. A 5 volt reference voltage is supplied to a resistance track with the other end connected to earth. The third wire is connected to an arm which wipes along the resistance track and so varies the resistance and voltage of the signal returned to the ECM.

Stepper motor
The air valve stepper motor is an actuator that the ECM uses to automatically control idle speed during normal idle and during engine warm-up. When the throttle is closed, the throttle plate is locked in a position where very little air passes by. The throttle position then, will have no effect upon the idle speed.

A by-pass port to the throttle plate is located in the inlet manifold. A valve is positioned in the port. As the valve moves, the volume of air passing through the port will vary and this directly affects the idle speed. The idle speed then, depends upon the position of the stepper air valve in the by-pass port.

The stepper motor is controlled by the ECM through two motor windings. The circuit for each winding both originate and terminate at the ECM. By pulsing these windings, the ECM is able to position the air valve exactly in its task to control the idle speed.

The ECM moves the stepper motor in very small measurements called steps. A maximum number of 256 steps are possible although the working range is restricted to 160 steps. If a suitable FCR is available the remainder of the steps can be used to reset the stepper motor position in a 25 rpm idle speed range. Resetting the stepper motor should be undertaken as a last resort and other reasons for poor idle should always be first investigated.

When an electrical load, such as headlights or heater fan etc are switched on, the idle speed would tend to drop. In this event, the ECM opens the stepper motor valve to maintain the previous idle speed.

During periods of cold running, the stepper motor will regulate the valve position so that the engine speed will be set to a suitable fast idle.

On switching off the engine, the ECM actuates the air valve to its fully closed position (thus preventing engine run-on). After a few seconds more, the ECM actuates the air valve to a slightly open position where it is ready for the next engine start.

At engine speeds over 16 mph, the stepper motor will position the air valve to completely shut-off the air supply. During engine deceleration, the stepper motor will open the by-pass to allow additional air into the inlet manifold. This aids the reduction of excessive CO and HC emissions during deceleration.

Fuel pump relay
The GM Multec fuel pump is controlled by a single relay. A permanent voltage supply is made to the fuel pump relay terminal 30 from the battery positive terminal. Operation of the relay is similar on all engines, although the C18NZ engine is actuated by a different method to the other models. Operation of both types is described below.

C12, 14 and 16NZ
When the ignition is switched on, the ECM briefly applies voltage to relay terminal 86 which is directly connected to earth through

terminal 85. This energises the fuel pump relay winding and causes the fuel pump relay contacts to close.

C18NZ relay
When the ignition is switched on, a voltage supply from the ignition switch is applied to relay terminal 86 which is connected to ECM pin B6 through relay terminal 85. The ECM actuates pin B6 by connecting it to earth. This energises the fuel pump relay winding and causes the fuel pump relay contacts to close.

DIS models relay
When the ignition is switched on, a voltage supply from the ignition switch is applied to relay terminal 86 which is connected to ECM pin B6 through relay terminal 85. The ECM does NOT actuates pin B6 at this time and the ECM awaits a cranking or running signal before the fuel pump driver is actuated.

All SPi relays (except DIS models)
Voltage is connected from terminal 30 to terminal 87 and thereby output to the fuel pump circuit. After approximately two seconds, the ECM switches off the circuit and the pump stops. This brief running of the fuel pump allows pressure to build within the fuel pressure lines, and provides for an easier start.

All relays
The fuel pump circuit will then remain open until the engine is cranked or run. Once the ECM receives a trigger signal from the ignition system, the fuel pump winding will again be energised by the ECM, and the fuel pump will run until the engine is stopped.

Fuel pressure system
The fuel system includes a fuel tank, with swirl pot and a submerged fuel pump. The fuel pump draws fuel from the tank and pumps it to the fuel rail via a fuel filter.

Switching the ignition key on causes the ECM to energise the fuel pump relay for approximately one or two seconds so that the fuel system is pressurised (not X16SZ). The fuel pump relay is then switched off to await a cranking or running signal.

The swirl pot prevents air from entering the fuel supply line by ensuring that the pick-up strainer is always immersed in fuel when the fuel level is low -even during fuel movement due to centrifugal forces acting upon the vehicle during cornering.

The pump is of the 'wet' variety in that fuel actually flows through the pump and the electric motor. There is no actual fire risk because the fuel drawn through the pump is not in a combustible condition.

The fuel pump assembly comprises an outer and inner gear assembly termed a gerotor. Once the pump motor becomes energised, the gerotor rotates and as the fuel passes through the individual teeth of the gerotor, a pressure differential is created. Fuel is drawn through the pump inlet, to be pressurised between the rotating gerotor teeth and discharged from the pump outlet into the fuel supply line.

To reduce the effect of fluctuations in fuel pressure, a pulsation damper is provided in the pump outlet thereby preventing hydraulic knock. The pump is protected from over pressurising by a relief valve mounted in the inlet side of the pump. Once the engine is running, fuel is fed through a non-return valve and fuel filter to the single throttle body injector.

To prevent pressure loss in the supply system, a non-return valve is provided in the fuel pump outlet. When the ignition is switched off, and the fuel pump ceases operation, pressure is thus maintained for some time.

Fuel pressure regulator
Fuel pressure of approximately one bar is controlled by the pressure regulator which is located within the throttle body next to the injector. As the pressure rises over the pre-determined level, excess fuel is returned to the fuel tank via a return pipe. To prevent pressure loss in the supply system, a non-return valve is provided in the fuel pump outlet. When the ignition is switched off, and the fuel pump ceases operation, pressure is thus maintained for some time.

Fuel pressure regulation according to manifold vacuum is unnecessary in SPi vehicles. This is because injection is made into the airstream above the throttle plate, and injection is therefore unaffected by changes in manifold vacuum.

Catalytic Converter and emission control
All UK models with the GM Multec EMS are fitted with a catalyst as standard equipment.

The GM Multec injection system fitted to catalyst vehicles implements a closed loop control system so that exhaust emissions may be reduced. Closed loop systems are fitted with a Zirconia oxygen sensor which monitors the exhaust gas for its oxygen content. A low oxygen level in the exhaust signifies a rich mixture. A high oxygen level in the exhaust signifies a weak mixture.

The OS only produces a signal when the exhaust gas, has reached a minimum temperature of approximately 300 degrees centigrade. The OS is mounted in the exhaust manifold close to the cylinder head so that exhaust heat quickly brings it to operating temperature.

Evaporative emission control

An activated carbon canister is employed to prevent petrol (hydrocarbon) fumes from escaping to atmosphere. Fumes from the fuel tank are routed to the carbon canister via the fuel tank ventilation line. When the engine is stopped or at idle, the fumes are trapped in the canister and cannot escape. A one-way valve operated by engine vacuum or actuated by the ECM, is used to purge the canister.

In early Multec systems, the canister is mechanically controlled by engine vacuum. A vacuum line runs from above the throttle plate to the canister. As the throttle plate is opened, vacuum is applied to the canister and the one way valve opens a direct channel to the inlet manifold via a second vacuum line. The fumes are then drawn into the engine to be burnt during normal combustion.

Later models employ an ECM actuated CFSV (previously termed a FTVV) to purge the canister under strictly controlled operating conditions.

EGR system **diagram (X16SZR)** **diagram (X12/16SZ)**

Modern engine that run at high temperatures with high compression tend to produce a high level of NOx. NOx production can be reduced by recycling a small amount of exhaust gas into the combustion chamber. So long as the recycling of the exhaust gas is properly controlled, the engine operation will be little affected. The EGR system used in later versions of the GM-Multec equipped vehicles is controlled by the ECM according to signals received from the various sensors. Components used in this EGR control system include a combined EGR CS (EGR Control Solenoid), EGR lift valve sensor and EGR valve and an EGR amplifier (X12/16SZ only). The EGR CS and the EGR amplifier are both supplied with voltage from the ignition switch.

A passage connects the the inlet and exhaust manifolds and the EGR valve is located so that it controls the opening and closing of the passage. The EGR valve is normally held closed by a spiral spring. On receipt of a pulsed signal from the ECM, the EGR CS acts upon the EGR valve which opens to allow a metered volume of exhaust gas into the inlet manifold. The opening time of the EGR valve is varied according to the control signal acting upon the EGR CS with a duty cycle that varies according to the degree of control required.

EGR is controlled by the ECM with regard to vehicle speed, coolant temperature and engine load. EGR must not occur during idle speed or full load conditions (at all temperatures) or during the cold start and engine warm-up period.

When EGR conditions are suitable, the ECM consults a map detailing the amount of lift required to meter exhaust gas recycling. A signal is then sent directly to the EGR CS (X16SZR) or to the EGR amplifier (X12/16SZ) which in turn amplifies the signal in order to pulse the EGR CS valve. On receipt of the pulse, the CS opens the EGR valve to introduce a metered volume of exhaust gas into the inlet manifold. The EGR sensor detects the actual amount of EGR lift and the ECM compares the signal from the sensor to the stored map value. If the two values differ, the ECM signals the EGR control solenoid valve to make the requisite adjustment. This procedure continually occurs whilst the EGR system is active.

The EGR lift valve sensor is an example of a three wire sensor with a resistance that varies according to the position of the lift valve. A 5.0 volt supply is connected to the sensor and to the ECM sensor return circuit. A signal voltage varying from 1.2 to 4.3 volt is returned to the ECM depending upon the position of the lift valve.

< END >