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COMPONENT DETAILS

Component	Location	Fixing
Air conditioning sensor		
Air flowmeter	Air filter outlet	Retaining clips
Air pump	Engine LH front	Nuts and bolts
Air pump relay	Engine comp't LH front	Securing tab
Battery	Battery tray	Bolt
Coolant temperature sensor	Thermostat housing	Body union
Crankshaft sensor:		
Variable reluctance coil	Timing chain cover	Allen screw
Reference disc	Crankshaft pulley	Bolts
ECU	Passenger footwell	Screws
Fuel Filter	Underside rear footwell LH	Nuts and bolts
Fuel pump	Underside rear footwell LH	Nuts and bolts
Fuel pump relay	Engine comp't LH front	Securing tab
Fuel rail	Inlet manifold	Bolts
Gearbox sensor		
HT distributor	Engine RH front	Bolt
Idle speed control valve		
Ignition 'on' relay	Passenger footwell	Securing tab
Ignition amplifier	Engine comp't RH front	Screws
Ignition coil	Engine RH front	Bolts
Inertia switch	Driver footwell	Screws
Injectors	Inlet manifold	Retaining clips
Lambda sensor	Exhaust downpipe	Body union
Main relay	Passenger footwell	Securing tab
Pressure regulator	Fuel rail	Union nuts
Start relay	Passenger footwell	Securing tab
Start switch	Column switch assembly	
Supplementary air valve	Inlet manifold tract	Bolts
Throttle potentiometer	Underside inlet manifold	Bolts

CABLE COLOUR CODES

N – Brown	B – Black	W – White	K – Pink	G – Green
R – Red	Y – Yellow	O – Orange	S – Slate	L – Light

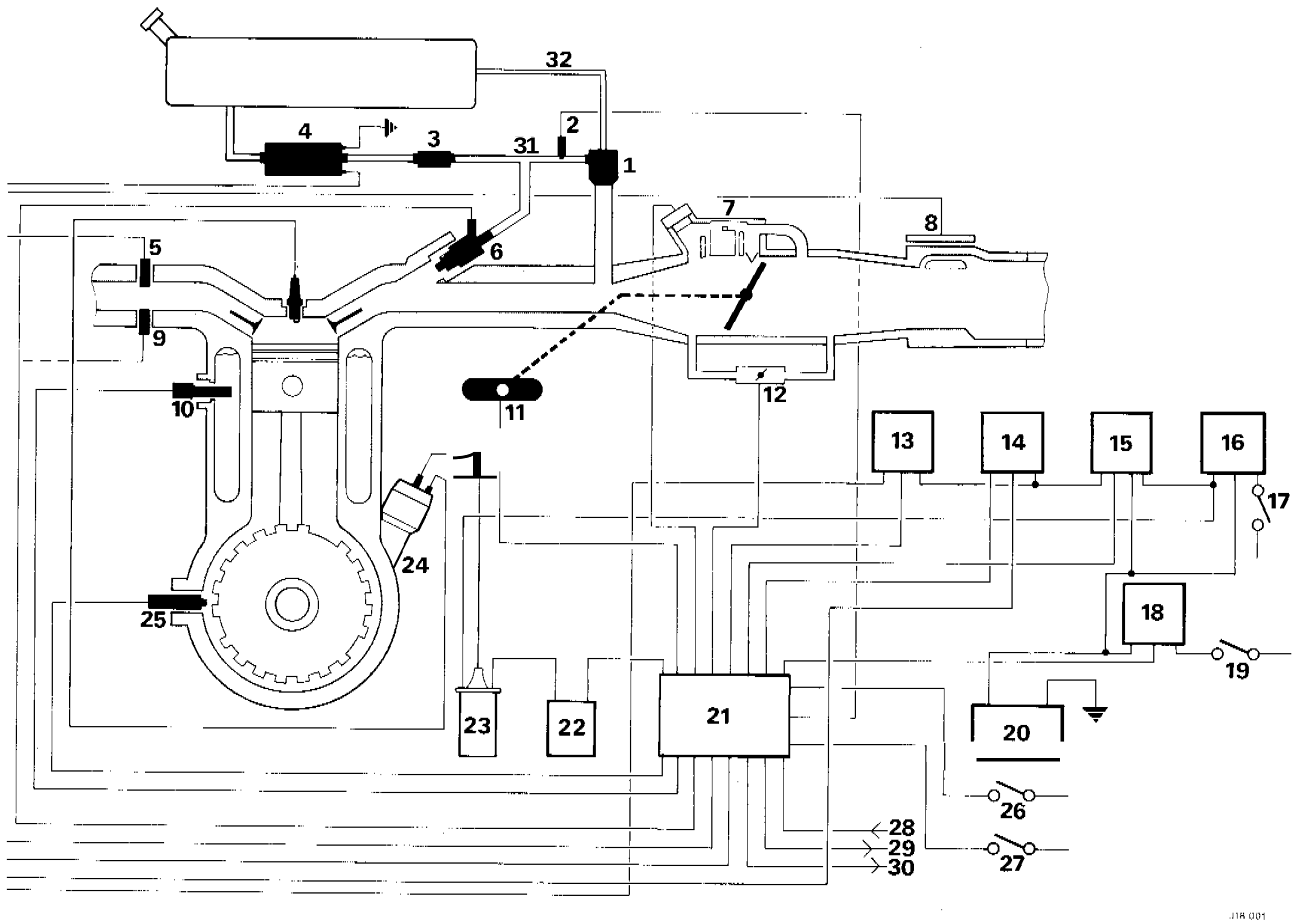

Fig 1 Engine management system

Key to Illustration

1. Pressure regulator
2. 6.8 kilohm resistor
3. Filter
4. Pump
5. Lambda sensor
6. Injector
7. Idle speed control valve
8. Air flowmeter
9. Air pump
10. Coolant temperature sensor
11. Throttle potentiometer
12. Supplementary air valve
13. Air pump relay
14. Fuel pump relay
15. Main relay
16. Ignition 'on' relay
17. Inertia switch
18. Start relay
19. Start switch
20. Battery
21. ECU
22. Ignition amplifier
23. Ignition coil
24. HT distributor
25. Crankshaft sensor
26. Gearbox sensor
27. Air conditioning clutch sensor
28. Idle override
29. VCM 1
30. VCM 2
31. Fuel rail
32. Fuel return

INTRODUCTION

The engine management system maintains optimum engine performance over its entire operating range by metering the fuel into each cylinder's inlet tract and adjusting the ignition timing angle at the sparking plugs. Each of these functions is performed by an Electronic Control Unit (ECU) which, from data received from sensors located on and around the engine (Fig. 1), evaluates optimum ignition timing and fuel metering parameters relative to engine load and speed. Additional functions of the system include:

1 Fuel pump control to prevent fuel flooding and/or spillage when the engine is stationary with the ignition switch in position "II".
2 Cold start control to ensure sufficient fuel exits in the inlet manifold to create a combustible air/fuel mixture in the combustion chamber.
3 Idle speed control to compensate for varying engine temperature and load conditions, e.g. the engaging or disengaging of the transmission (automatic only) and/or the air conditioning clutch.
4 Fuel cut-off during engine overrun conditions to improve fuel economy by minimising the quantity of unburnt fuel discharged into the exhaust system.
5 Engine overspeed control to impose a maximum engine speed limit of 6300 rev/min.
6 Air pollution control to reduce exhaust contamination to levels which comply with different country exhaust regulations.
7 Fuel monitoring to provide precise fuelling information to the trip computer.
8 Fault monitoring to provide data to the instrumentation system for display.

The system also incorporates a "limp home" feature which permits continued engine operation on certain sensor failure, the sensor failure being indicated on the instrument pack.

Fuel Metering

Fuel is delivered to solenoid operated injectors, via a variable pressure regulator, by an electrically driven pump operating at a virtual constant pressure. Actual injector pressure, however, fluctuates between 35-45 lbf/in^2 depending on the absolute manifold pressure acting on the regulator at the time. The quantity of fuel injected for a given duration of injector 'on' (open) time is thus maintained constant, irrespective of the back pressure on the injector nozzles, and accurate fuel monitoring is achieved.

Injector operation is by means of an electrical pulse which actuates a solenoid valve within the injector body. The duration of the pulse, and hence the quantity of fuel injected, is determined by the ECU on a basis of intake air (engine load) and engine speed information derived from air flowmeter and crankshaft sensors. This information is used to access mapped data stored in 128 memory locations containing injector pulse durations pertaining to eight engine loads at 16 different speeds.

Correction factors are imposed on the basic injector pulses to compensate for varying conditions. The resultant pulses are then normally applied to the injectors twice per engine cycle, i.e. once per crankshaft revolution, with only half the amount of fuel being injected at each injector 'on' time.

Injector pulse adjustments are necessary to provide:

Cranking enrichment during starting.

Temperature enrichment during starting and warm-up.

After-start enrichment during warm-up.

Demand corrections during idle, full power and acceleration.

Voltage corrections for variations in the electrical system voltage.

Contamination corrections for emission control.

Cranking enrichment

Cranking enrichment is provided, irrespective of prevailing temperature conditions, when the starter motor is activated. This is achieved by increasing the injector operating frequency from one pulse to three pulses per crankshaft revolution and is implemented by the ECU in response to an input from the starter solenoid. Cranking enrichment is terminated at an engine speed of 600 rev/min.

Temperature enrichment

Temperature enrichment is provided during starting and warm-up. This is achieved by increasing the injector 'on' time above that of basic requirements and is implemented **by** the ECU in response to an input from a coolant temperature sensor.

After-start enrichment

After-start enrichment is provided, irrespective of temperature, to supply added fuel during warm-up. This is achieved by the ECU which increases the injector 'on' time above that of basic requirements and then decreases the amount of additional fuel supplied at a fixed rate with time.

Demand corrections

Corrections are provided **for** idle, acceleration and full power demands. This is achieved by increasing the injector 'on' time above that of basic reqirements and is implemented by the ECU in response to an input from a throttle potentiometer.

Voltage corrections

The ECU constantly monitors the electrical system voltage, i.e. the state of the battery and electrical load, because the time taken for an injector to open is affected by voltage and results in a corresponding change in the quantity of fuel delivered. The ECU compensates for any voltage change detected by adjusting the injector 'on' time accordingly.

Contamination corrections

On certain vehicles exhaust pollution is reduced to a minimum by monitoring the oxygen content of the exhaust and correcting the fuel/air mixture to maintain an intake ratio of approximately 14.7:1. This is achieved by the ECU in response to an input from a Lambda sensor.

Additional air is also introduced into the exhaust system by a relay activated air pump and solenoid vacuum valve. The relay is actuated by the ECU at temperatures between 15°C and 45°C with the ignition 'on'.

Ignition timing

Ignition pulses are applied, via a separate ignition amplifier, to the ignition coil which generates high energy pulses **for** the sparking plugs via the distributor. Unlike conventional ignition systems, however, the distributor has no centrifugal **or** vacuum advance mechanisms and no LT circuit exists. The distributor is only required, therefore, to distribute the high energy pulses to the plugs.

Ignition timing is controlled by the ECU from information supplied by the air flowmeter and crankshaft sensor. This information is used to access mapped data stored in **128** memory locations containing ignition timing angles pertaining to eight engine loads at 16 different speeds.

Depending on the monitored engine speed and supply voltage, the dwell-period (dwell angle) is determined and the ignition energy is adapted to that required at any instant in time. The unnecessary consumption of energy in the ignition coil is thus prevented. In addition, a peak coil current cut-off facility prevents current flowing through the ignition coil below a specific engine speed and, therefore, prevents the battery being discharged and the ignition coil overheating.

Description

The ECU contains a microprocessor and discrete electronic component circuits that provide interfacing to peripheral input/output devices.

The microprocessor performs all system control functions and has a memory pre-loaded with system parameters that are accessed under software control. System response times are, therefore, reduced to a minimum and the system is rendered operational immediately the ignition switch is set to position "II". System perhipherals are as follows:

1 Fuel injectors: solenoid actuated devices which spray quantities of fuel into the inlet manifold.
2 Ignition amplifer: an electronic device which, through the ignition coil, generates high energy electrical pulses for distribution to the sparking plugs.

3 Air flowmeter: a hot wire sensing device which monitors inlet manifold air flow for optimum fuelling and ignition control.
4 Idle speed control valve: a stepper motor driven device which controls the volume of air entering the engine to maintain a correct idle speed.
5 Crankshaft sensor: a device which generates engine speed and crankshaft position information for precise ignition timing and fuelling control.
6 Throttle potentiometer: a device which interprets the throttle position to identify idle, acceleration and full power demands.
7 Gearbox sensor: two linear gearbox selector actuated switches that induce idle speed corrections which compensate for engine load changes that occur when 'N' or 'P' is engaged or disengaged. On vehicles fitted with manual transmission units, the switch input to the ECU is connected to logic earth.
8 Fuel pump relay: a device which implements controlled fuel pump switching.
9 Coolant temperature sensor: a thermal device which monitors the coolant temperature to induce cold starting and warm-up enrichment.
10 Supplementary air valve: a solenoid actuated device which provides additional air during cold starting and warm-up at temperatures below - 10°C.
11 Lambda sensor: a device which monitors the oxygen content of the exhaust to induce contamination corrections on vehicles exported to specified countries.
12 Air conditioning sensor: an air conditioning compressor clutch actuated switch that induces idle speed corrections which compensate for engine load changes that occur when the clutch is engaged or disengaged.
13 Air pump relay: a device which controls exhaust system air pump and solenoid vacuum valve operation on vehicles fitted with exhaust emmission control.
14 Idle fuel potentiometer: a device which provides fine adjustment of engine idle fuel. This device is set during vehicle manufacture and only requires adjustment when the air flowmeter assembly, of which it forms an integral part, is renewed.

Other system devices and communications are as follows:

1 Ignition 'on' sensing: an input taken from contact 87 of the ignition 'on' relay which, in addition to applying power to the ignition coil, energises the main and fuel pump relays through the ECU. A timer is also initiated which, through the fuel pump relay, permits fuel pump operation for approximately 0.5 seconds to ensure the fuel rail is pressurised prior to cranking.
2 Cranking sensing: an input which induces cranking enrichment when the starter solenoid is activated.
3 Battery voltage sensing: an input taken from contact 87 of the main relay which, in adddition to applying power to the supplementary air valve, air flowmeter, fuel injectors and both fuel and air pump relays, induces fuelling corrections that compensate for battery voltage fluctuations.
4 Idle override: an input derived from the instrumentation system which, in addition to displaying the vehicle road speed on the instrument pack, inhibits engine idle control at road speeds greater than 3 mph (4.8 kph).
5 VCM 1: an output applied to the instrumentation system to provide indication of an engine management system fault on the instrument pack.
6 VCM 2: a dual purpose output applied to the instrumentation system to (1) identify individual engine management system faults when the ignition switch is initially set to to position "II", and (2) provide precise fuelling conditions to the trip computer when the engine is running.

OPERATION

A circuit diagram of the engine management system detailing interconnections between the ECU and the various input/output pheripheral devices is shown in Figure 4.

Ignition On

Power is applied to the various devices through contacts LI4-87/30 of the main relay which is energised, via contacts B17-87/30 of the ignition 'on' relay, when the vehicle ignition switch is in position "II", i.e. when O Volts is applied to B 17-85 of the ignition 'on' relay.

Application of power to the ECU at LI3-1 and LI2-10 generates a system reset which causes the microprocessor to perform an initialization routine (a sofware program stored in memory), condition input circuits for sensor scanning and initiates fuel pump operation to pressurise the fuel rail prior to cranking. The fuel pump is activated via contacts LI5-87/30 of the fuel pump relay which is energised by an output from the ECU at LI2-7.

On completion of the initialization routine, sensor scanning commences and analogue information from the sensors is converted into digital data for storage. The data thus stored is then evaluated to determine prevailing engine conditions and memory locations are accessed to obtain appropriate ignition timing and fuel metering parameters. In addition, the following functions are performed:

1 The stepper motor of the idle speed control valve is driven, via LI2-15/16 and LI2-18/19, to set the valve at a position suitable for engine starting. Rapid valve positioning is achieved for all conditions by extending or retracting its stem from a mid-travel position restored each time the ignition switch is set to "off".
2 The solenoid of the supplementary air valve is actuated, via LI2-20, to open the valve at temperatures below – 10°C.
3 Fuel pump operation is terminated, i.e. the output at LI2-7 is removed, after approximately 0.5 seconds to eliminate possible fuel flooding should an injector be stuck in the open position. This feature is also used to eliminate possible fuel spillage creating a hazardous condition at an accident scene if fuel line fracture occurs due to impact damage.
4 The exhaust system air pump and solenoid vacuum valve (if fitted) are activated by the air pump relay which is energised, via LI2-2, at temperatures between 15°C and 45°C.
5 A number relating to a fault which may have occurred during the last period that the engine was run is recalled from memory and displayed on the instrument pack fascia.
6 A breather pipe heater is actuated, via a breather pipe heater relay, under the control of a screenwash jet heater sensor.

Engine Cranking

Fuel pump operation is reinstated and any fault number displayed on the instrument pack fascia is erased when the engine is cranked, provided that the ECU detects a crankshaft sensor input at LI3-13 and 14. The Lambda sensor heater is also activated to heat the sensor on vehicles fitted with exhaust emission control.

As the engine rotates under the influence of the starter motor, fuel is introduced into the air flow of the inlet manifold by the fuel injectors which are actuated by the ECU under control of the crankshaft sensor input. Injector triggering occurs, through LI2-12, 13 and 25, three times per crankshaft revolution with appropriate correction factors imposed. The ignition amplifier is also actuated at the correct times, through LI2-1, to fire the sparking plugs.

Engine Running

When the engine starts, cranking enrichment is terminated at 600 rev/min, i.e. injector pulses occur once per crankshaft revolution, and both warm-up and after-start enrichment is imposed. In addition, any extra manifold air is delivered by the supplementary air valve which is driven in response to coolant temperature, throttle potentiometer and crankshaft sensor inputs.

The engine idle speed is controlled, through LI2-15/16 and LI2-18/19, by the ECU which drives the idle speed control valve stepper motor from coolant temperature, throttle position and crankshaft speed information. Compensation is also provided for fluctuating engine load by monitoring air conditioning clutch and gearbox (automatic only) sensor inputs at LI3-21 and 3 respectively. The engine idle speeds are set as follows:

1. Cold in neutral – 800 rev/min.
2. Hot in neutral – 700 rev/min.
3 Cold in drive – 650 rev/min.
4. Hot in drive – 580 rev/min.

If the supplementary air valve is deployed, i.e. temperature below -10°C. the idle speed control valve intercepts the engine speed on Supplementary air valve closure. This ensures that the desired engine idle speed is maintained without searching.

Fuel and ignition requirements are calculated at each sensor scanning to maintain optimum engine efficiency over its entire range, including full power and acceleration demands. Should a sensor failure be detected, an output is applied to the instrument pack to provide indication of the failure on the fascia. The nature of the fault is also stored in ECU memory and is output as a fault number the next time the ignition switch is set to position "II".

Exhaust emission regulation is implemented by the ECU under control of the Lambda sensor (if fitted) which monitors the oxygen content of the exhaust system and provides a corresponding signal to the ECU at LI3-17. This signal imposes corrections on the basic injector 'on' times to reduce exhaust emissions to a minimum. Power to the Lambda sensor heater is supplied from contact LI5-87/30 of the fuel pump relay and, therefore, exhaust emission control is only operational during periods that fuel pump operation is permitted.

Additional air is introduced into the exhaust system by a relay actuated air pump and solenoid vacuum valve (if fitted) to reduce the density of the gases emitted, the relay being actuated by an output from the ECU at LI2-2.

NOTE: During periods that the air pump is operating, Lambda sensor operation is inhibited.

Fault identification:

Definitions of fault numbers displayed on the instrument pack fascia are as follows:

1 Cranking signal failure: no crankshaft sensor signal detected after cranking for 6 seconds, or the cranking signal line at LI2-8 is active above 2000 rev/min.
2 Air flowmeter failure: either open-circuit or short-circuit to ground.
3 Coolant temperature sensor failure.
4 Feedback circuit failure (Federal/Japan only).
5 Air flowmeter failure: low throttle potentiometer voltage with high air flowmeter voltage.
6 Air flowmeter failure: high throttle potentiometer voltage with low air flowmeter voltage.
7 Idle fuel adjustment potentiometer failure.
8 Not allocated: should this fault number be displayed, a 6.8 kilohm resistor fitted in place of a hot start sensor is faulty.