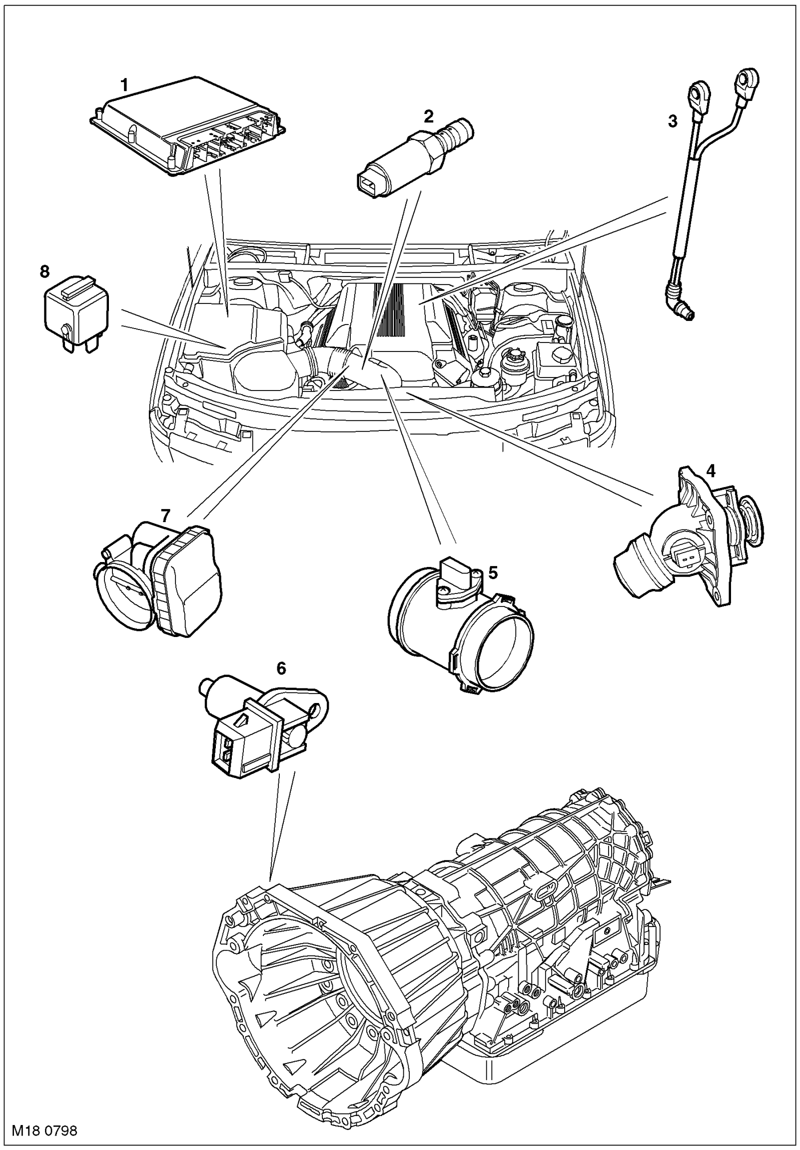
BOSCH ME 7.2 ENGINE MANAGEMENT

Introduction

The Bosch ME 7.2 engine management system (EMS) is similar to the Bosch 5.2.1 system used in previous Land Rover V8 engines. The main difference between the two systems is the "drive by wire" capabilities of the ME 7.2 EMS.

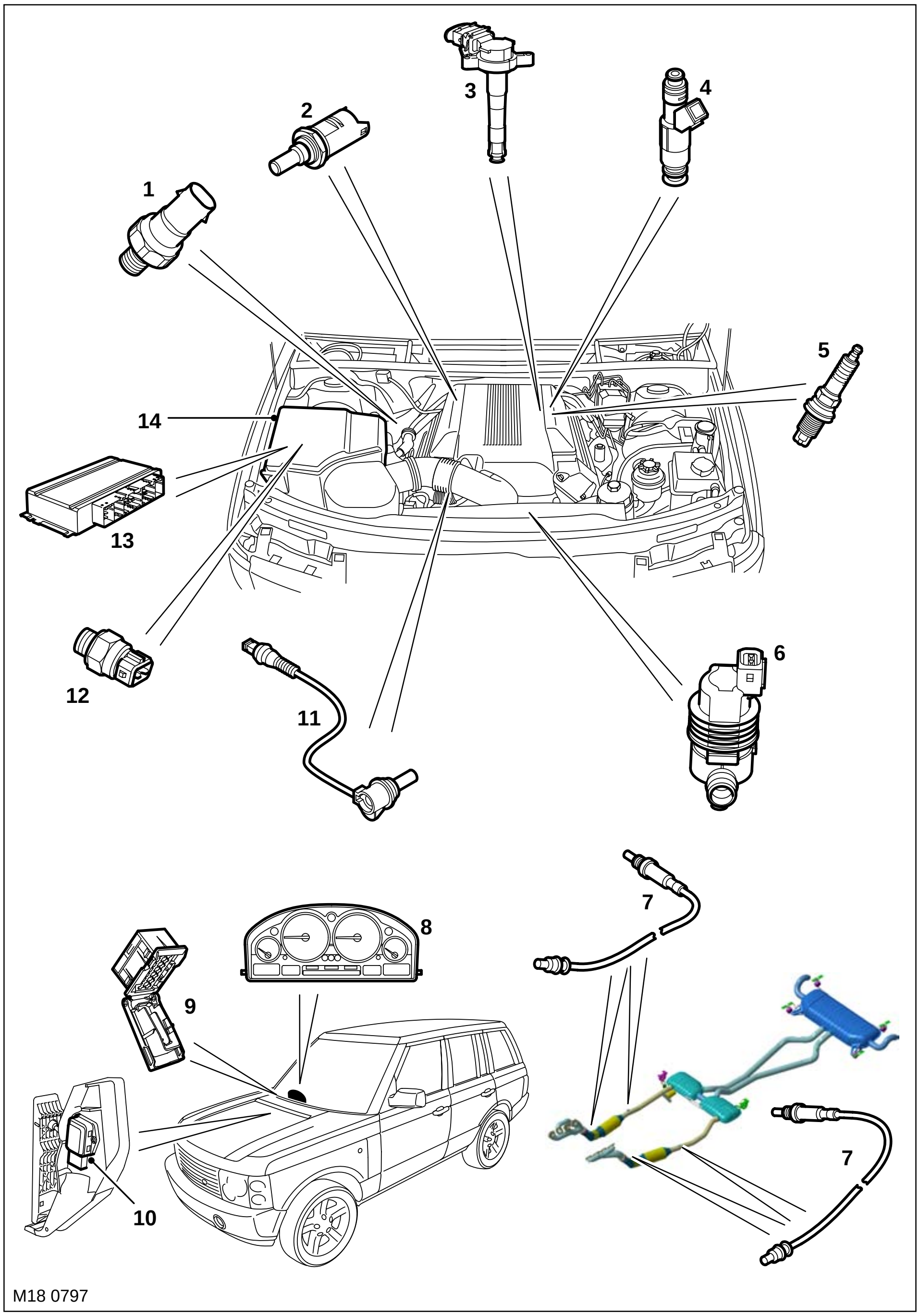
Another main difference between the 5.2.1 system and the ME 7.2 system is that ME 7.2 uses the Keyword protocol 2000* (KWP2000*) which is an ISO 91414 K line compatible version of the Key Word 2000 protocol.

Engine Management Component Location, Sheet 1 of 2



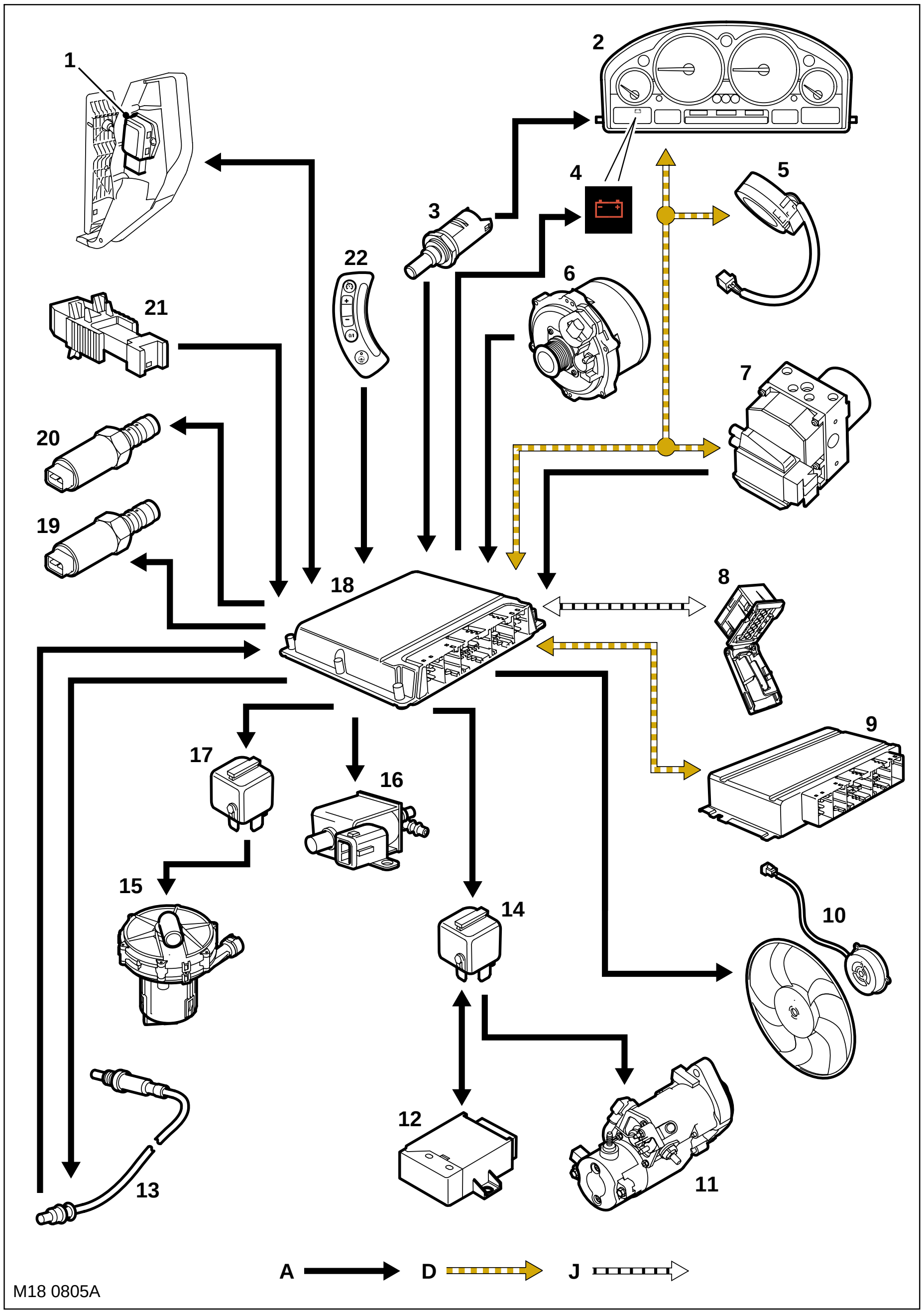
1	ECM	5	Mass Air Flow/Inlet Air Temperature (MAF/IAT) sensor
2	Variable Camshaft Control (VCC) solenoid	6	Crankshaft Position (CKP) sensor
3	Knock sensor (x4)	7	Electric throttle
4	Heated thermostat	8	Main relay

Engine Management Component Location, Sheet 2 of 2



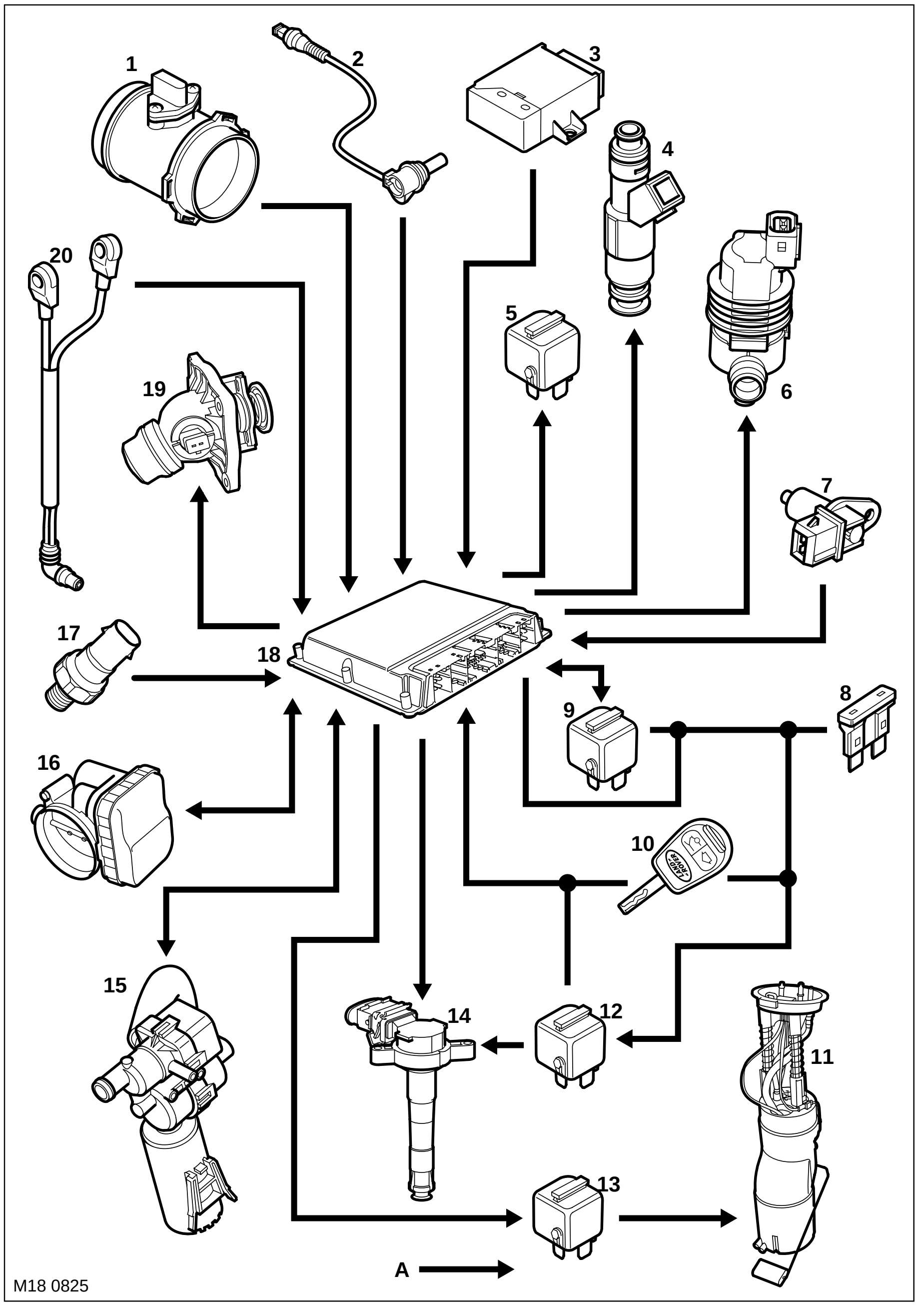
1	Radiator outlet temperature sensor	8	Instrument pack
2	Engine Coolant Temperature (ECT) sensor	9	Diagnostic socket
3	Ignition coil	10	Accelerator Pedal Position (APP) sensor
4	Injector	11	Camshaft Position (CMP) sensor
5	Spark plug	12	E-box temperature sensor
6	Purge valve	13	EAT ECU
7	Oxygen sensors	14	E-box

Engine Management Control Diagram, Sheet 1 of 2



A	Hardwired connections
D	CAN bus
J	Diagnostic ISO 9141 K line bus
1	APP sensor
2	Instrument pack
3	Radiator outlet temperature sensor
4	Ignition warning lamp
5	Steering angle sensor
6	Alternator
7	ABS modulator/ECU
8	Diagnostic socket
9	EAT ECU
10	Electric cooling fan
11	Starter motor
12	Immobilisation ECU
13	HO2S (x 4)
14	Comfort start relay
15	SAI pump
16	Vacuum vent valve
17	SAI pump relay
18	ECM
19	LH bank VCC solenoid
20	RH bank VCC solenoid
21	Brake light switch
22	Cruise control switches

Engine Management Control Diagram, Sheet 2 of 2



A	A = Hardwired connection	7	Crankshaft Position (CKP) sensor	14	Ignition coil
1	MAF/IAT sensor	8	Fuse 25	15	Tank leakage detection module
2	Camshaft sensor	9	Main relay	16	Electric throttle
3	Immobilisation ECU	10	Ignition switch	17	Radiator outlet temperature sensor
4	Injector	11	Fuel pump	18	ECM
5	Auxiliary cooling fan relay	12	Ignition coil relay	19	Electrical heated thermostat
6	Purge valve	13	Fuel pump relay	20	Knock sensors

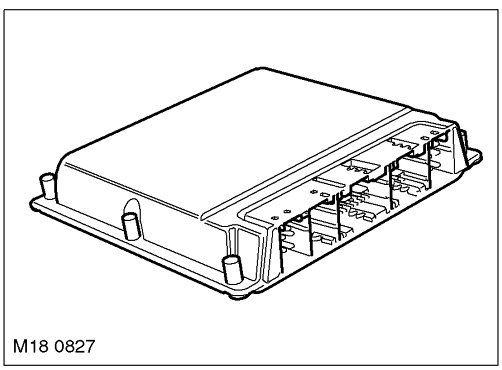
Key Functions

The key functions of the Bosch ME 7.2 engine management system are:

- To control the amount of fuel supplied to each cylinder
- To calculate and control the exact point of fuel injection
- To calculate and control the exact point of ignition in each cylinder
- To optimize adjustment of the injection timing and ignition timing to deliver the maximum engine performance throughout all engine speed and load conditions
- To calculate and maintain the desired air/fuel ratio, to ensure the 3 way catalysts operate at their maximum efficiency
- To maintain full idle speed control of the engine
- To ensure the vehicle adheres to the emission standards (set at the time of homologation)
- To ensure the vehicle meets with the fault handling requirements, as detailed in the European On-Board Diagnostic (EOBD) III legislation
- To provide an interface with other electrical systems on the vehicle
- To facilitate the drive by wire functions
- To control the Variable Camshaft Control (VCC).

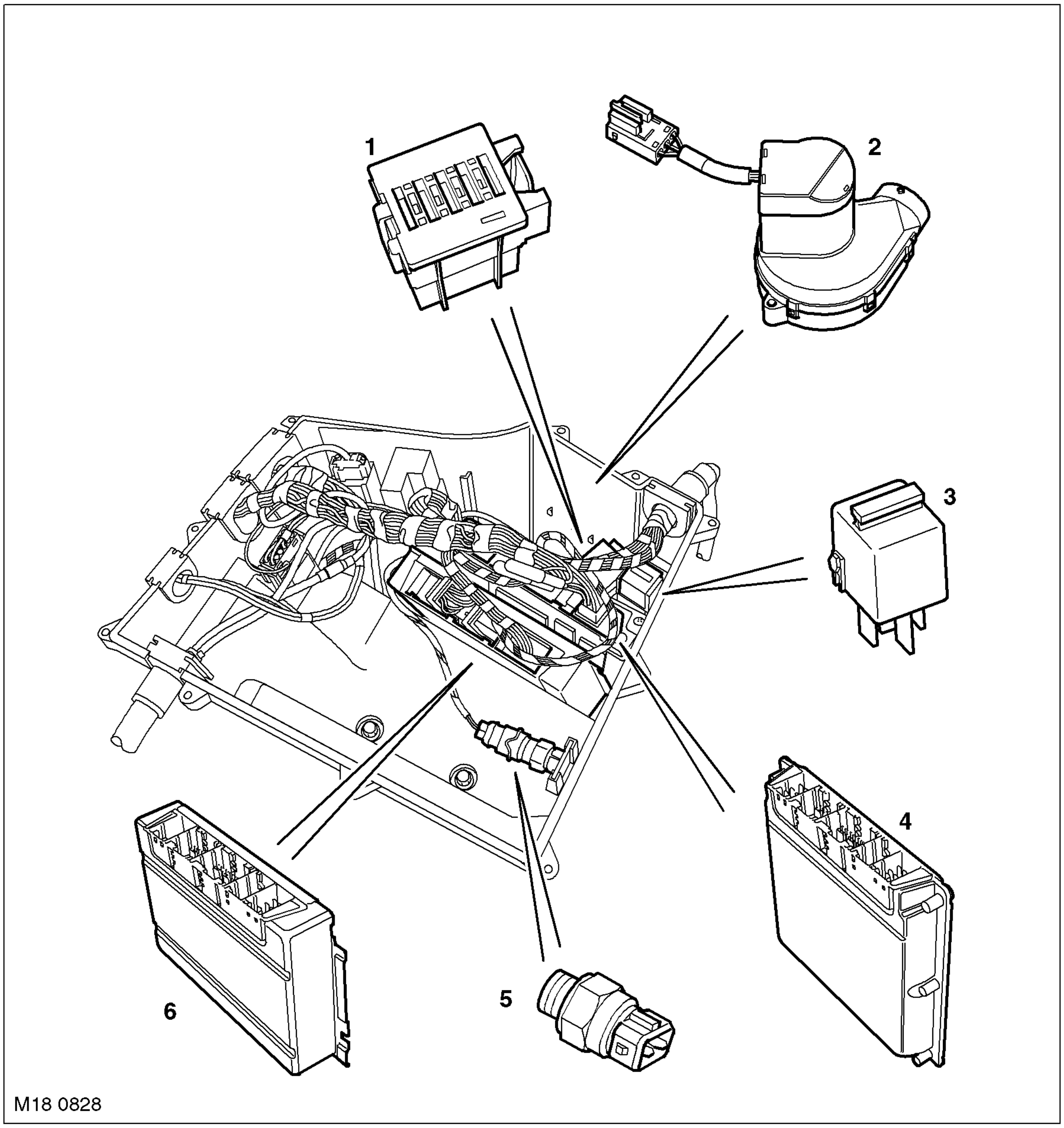
To deliver these key functions, the Bosch ME 7.2 Engine Control Module (ECM) relies upon a number of inputs and controls a number of outputs. As with all electronic control units, the ECM needs information regarding the current operating conditions of the engine and other related systems before it can make calculations, which determine the appropriate outputs. A Controller Area Network (CAN) bus is used to exchange information between the ECM and the Electronic Automatic Transmission (EAT) ECU

ECM



The ECM is located in the Environmental (E) box, in the front right corner of the engine compartment. The E-box provides a protective environment for the ECM and is cooled by an electric fan. The main relay for the ECM is also located in the E-box.

E-Box



1	Fuse block	4	ECM
2	Cooling fan	5	E Box temperature sensor
3	Main relay	6	EAT ECU

A separate temperature sensor is used to monitor E-box temperature and provides a path to earth to control the electric fan. The sensor turns the fan on when the E-box temperature reaches 35°C (95 °F) and turns the fan off when the temperature drops below 35°C (95 °F). The E-box fan draws air in from the passenger compartment, into the E-box and vents back into the passenger compartment. The fan is also driven for a short period on engine crank, independently of temperature. This is done to ensure the correct function of the fan.

The ECM is programmed during manufacture by writing the program and the engine tune into a Flash Electronic Erasable Programmable Read Only Memory (EEPROM). The EEPROM can be reprogrammed in service using TestBook/T4. In certain circumstances, it is possible to alter the tune or functionality of the ECM using this process.

Advanced fault monitoring is incorporated into the ECM. It can detect the type and severity of faults, store relevant engine operating conditions (environmental and freeze frame data) and time that a fault occurs, suspend the operation of some functions and replace the inputs from faulty sensors with default values. Environmental data is stored for each fault detected, and consists of the inputs from three engine sensors, with the inputs stored depending on the fault. The ECM also records additional data in connection with each fault, as follows:

- The number of occurrences
- If the fault is currently present
- If the fault is historic, the number of drive cycles that have elapsed since the fault last occurred
- The time the fault occurred. Time is incremented in hours, hour 0 being the first time the ECM is powered-up, hour 1 being 60 minutes of ignition 'on' time, etc.

OBD freeze frame data is only stored for emissions related faults. Only one set of freeze frame data can be stored at any one time. Faults are prioritized according to their likely impact on exhaust gas emissions. If more than one emissions related fault occurs, freeze frame data is stored for the fault with the highest priority. Freeze frame data consists of the following:

- Engine speed
- Engine load
- Short term fuelling trim of LH and RH cylinder banks
- Long term fuelling trim of LH and RH cylinder banks
- Fuelling status of LH and RH cylinder banks
- Engine coolant temperature
- Road speed.

Fault information is stored in a volatile Random Access Memory (RAM) in the ECM, so will be deleted if a power failure or battery disconnection occurs.

Five electrical connectors provide the interface between the ECM and the engine/vehicle wiring. The five connectors interlock with each other when installed in the ECM. Adjacent connectors should be disconnected in turn. The installation sequence is the reverse of removal. Each connector groups associated pins together.

System Inputs
The ECM optimizes engine performance by interpreting signals from numerous vehicle sensors and other inputs. Some of these signals are produced by the actions of the driver, some are supplied by sensors located on and around the engine and some are supplied by other vehicle systems. The inputs are as follows:

- Ignition switch
- APP sensor
- Throttle position feedback
- Crankshaft Position (CKP) sensor
- Cruise control signal (from steering wheel switch pack)
- Brake light switch
- Camshaft Position (CMP) sensors
- Engine Coolant Temperature (ECT) sensor
- Knock sensors
- Mass Air Flow/Intake Air Temperature (MAF/IAT) sensor
- Heated Oxygen Sensors (HO2S)
- Immobilisation signal (from immobilisation ECU)
- Fuel level signal (via CAN)
- Vehicle speed signal (from ABS ECU)
- Radiator outlet temperature
- Internal ambient barometric pressure sensor (altitude sensor)
- Electronic Automatic Transmission (EAT) information.

Electric Throttle System
The EMS incorporates an electric throttle control system. This system consists of three main components:

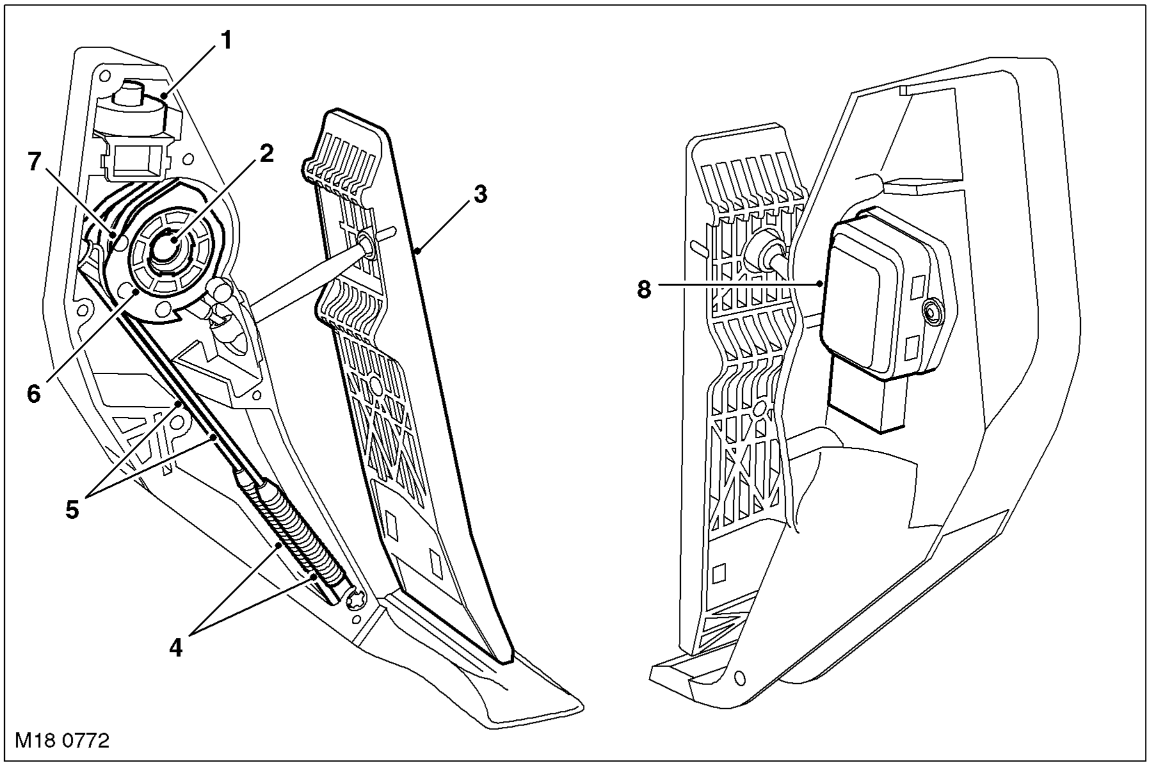
- Electronic throttle control valve
- APP sensor
- ECM.

When the accelerator pedal is depressed the APP sensor provides a change in the monitored signals. The ECM compares this against an electronic “map” and moves the electronic throttle valve via a pulse width modulated control signal which is in proportion to the APP angle signal.

The system is required to:

- Regulate the calculated intake air load based on the accelerator pedal sensor input signals and programmed mapping
- Monitor the drivers input request for cruise control operation
- Automatically position the electronic throttle for accurate cruise control
- Perform all dynamic stability control throttle control interventions
- Monitor and carry out maximum engine and road speed cut out.

Accelerator Pedal Position (APP) Sensor

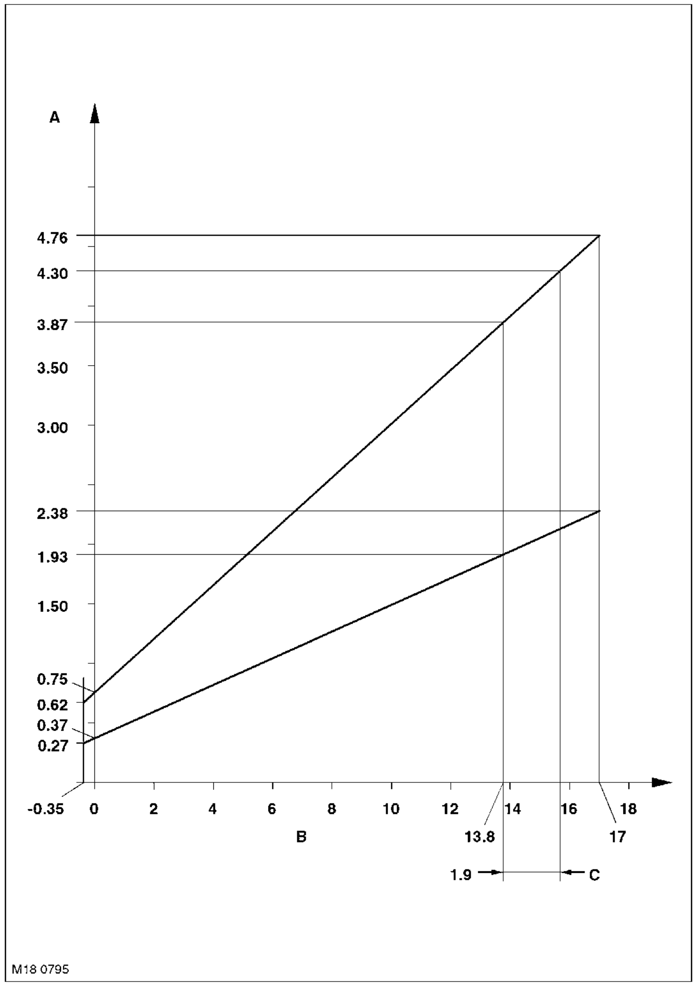


1	Detente mechanism	5	Cables
2	Sensor spigot	6	Bush
3	Pedal	7	Drum
4	Springs	8	APP sensor

The APP sensor is located in a plastic housing which is integral with the throttle pedal. The housing is injection moulded and provides location for the APP sensor. The sensor is mounted externally on the housing and is secured with two Torx screws. The external body of the sensor has a six pin connector which accepts a connector on the vehicle wiring harness.

The sensor has a spigot which protrudes into the housing and provides the pivot point for the pedal mechanism. The spigot has a slot which allows for a pin, which is attached to the sensor potentiometers, to rotate through approximately 90°, which relates to pedal movement. The pedal is connected via a link to a drum, which engages with the sensor pin, changing the linear movement of the pedal into rotary movement of the drum. The drum has two steel cables attached to it. The cables are secured to two tension springs which are secured in the opposite end of the housing. The springs provide 'feel' on the pedal movement and require an effort from the driver similar to that of a cable controlled throttle. A detente mechanism is located at the forward end of the housing and is operated by a ball located on the drum. At near maximum throttle pedal movement, the ball contacts the detente mechanism. A spring in the mechanism is compressed and gives the driver the feeling of depressing a 'kickdown' switch when full pedal travel is achieved.

APP Sensor Output Graph



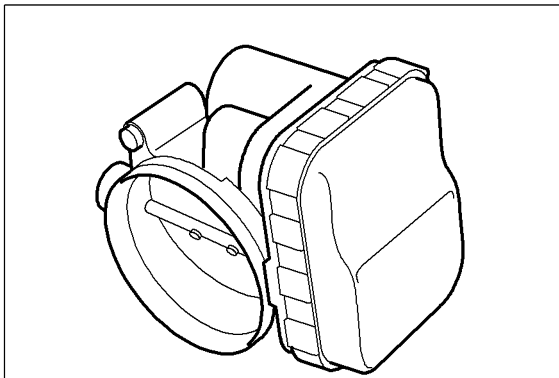
A Voltage B APP sensor angle C Kickdown angle

The APP sensor has two potentiometer tracks which each receive a 5V input voltage from the ECM. Track 1 provides an output of 0.5V with the pedal at rest and 2.0V at 100% full throttle. Track 2 provides an output of 0.5V with the pedal at rest and 4.5V at 100% full throttle. The signals from the two tracks are used by the ECM to determine fuelling for engine operation and also by the ECM and the EAT ECU to initiate a kickdown request for the automatic transmission.

The ECM monitors the outputs from each of the potentiometer tracks and can determine the position, rate of change and direction of movement of the throttle pedal. The 'closed throttle' position signal is used by the ECM to initiate idle speed control and also overrun fuel cut-off.

Electric Throttle

Electric Throttle Control Valve



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The Electric Throttle control valve is controlled by the APP sensor via the ECM. The throttle valve plate is positioned by gear reduction DC motor drive. The DC motor is controlled by a proportionally switched high/low PWM signals at a basic frequency of 2000 Hz. Engine idle speed control is a function of the Electric Throttle control valve, therefore a separate idle control valve is not required.

The electric throttle control valve throttle plate position is monitored by two integrated potentiometers. The potentiometers provide DC voltage feedback signals to the ECM for throttle and idle control functions.

Potentiometer one is used as a the primary signal, potentiometer two is used as a plausibility check through the total range of throttle plate movement.

If the ECM detects a plausibility error between Pot 1 and Pot 2 it will calculate the inducted air mass from the air mass (from the air mass sensor) and only utilize the potentiometer signal which closely matches the detected intake air mass. It does this to provide a fail-safe operation by using a 'virtual' potentiometer as a comparative source.

If the ECM cannot calculate a plausible value from the monitored potentiometers (1 and 2) the throttle motor is switched off and the fuel injection cut out is activated.

The electric throttle control valve is continuously monitored during operation. It is also briefly activated when the ignition switch is initially turned to position II. This is done to check the valves mechanical integrity by monitoring the motor control amperage and the reaction speed of the feedback potentiometers.

Should the electronic throttle need replacing the adaption values of the previous unit will need to be cleared from the ECM. This is achieved by the following process:

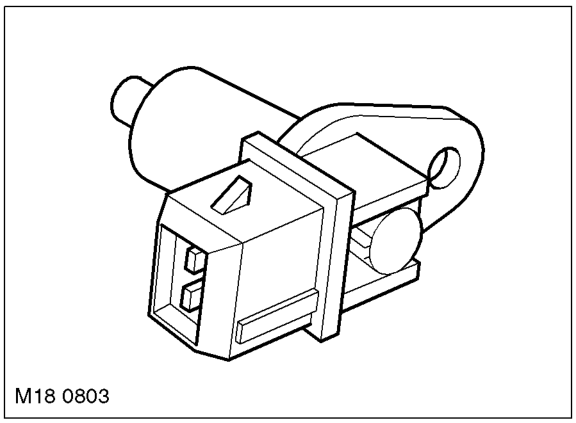
- Using TestBook/T4 clear the adaption values
- Switch the ignition “OFF” for 10 seconds
- Switch the ignition “ON”, for approximately 30 seconds the electric throttle control valve is briefly activated allowing the ECM to learn the new component

This procedure is also necessary after the ECM has been replaced. However the adaption values do not require clearing since they have not yet been established.

Crankshaft Position (CKP) Sensor

The CKP sensor is located in the transmission bell housing adjacent to the edge of the flexplate flywheel. The sensor reacts to a toothed reluctor ring incorporated into the flexplate to ascertain engine speed and position information. The sensor is located on a split spacer and is secured in position by two tube spacers and nuts. The split spacer is 18 mm thick on vehicles fitted with automatic transmission. The thickness of the split spacer determines how far the sensor protrudes through the cylinder block and, therefore, sets the position of the sensor in relation to the reluctor ring. The sensor and the spacer are covered by a protective heat shield. The sensor has three wires attached to it; two signal wires and a screen. The sensor earth screen is connected to chassis earth through the ECM.

CKP Sensor



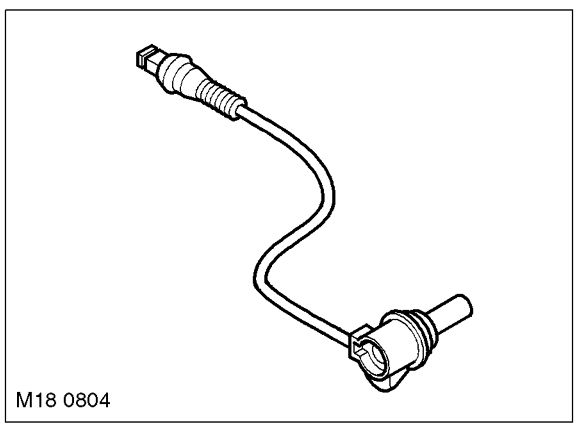
The CKP sensor is an inductive type sensor which produces a sinusoidal output voltage signal. This voltage is induced by the proximity of the moving reluctor ring, which excites the magnetic flux around the tip of the sensor when each tooth passes. This output voltage will increase in magnitude and frequency as the engine speed rises and the speed at which the teeth on the reluctor ring pass the sensor increases. The signal voltage will peak at approximately 6.5 volts if connected to the ECM (further increases in engine speed will not result in greater magnitude). The ECM neither specifically monitors nor reacts to the output voltage (unless it is very small or very large), instead it measures the time intervals between each pulse (i.e. signal frequency). The signal is determined by the number of teeth passing the sensor, and the speed at which they pass. The reluctor ring has 58 teeth spaced at 6° intervals, with two teeth missing to give the ECM a synchronisation point.

The signal produced by the CKP sensor is critical to engine running. There is no back-up strategy for this sensor and failure of the signal will result in the engine stalling and/or failing to start. If the sensor fails when the engine is running, then the engine will stall, a fault code will be stored and details captured of the battery voltage, engine coolant temperature and intake air temperature at the time of the failure. If the signal fails when the engine is cranking, then the engine will not start and no fault will be stored, as the ECM will not detect that an attempt had been made to start the engine. In both cases the tachometer will also cease to function immediately and the MIL lamp will be permanently illuminated.

During the power-down procedure, which occurs when the ignition is switched off, the ECM stores details of the position of the CKP and CMP sensors. This enables the ECM to operate the injectors in the correct sequence immediately the engine cranks, to produce a quick engine start, which serves to reduce emissions when the engine is cold.

Camshaft Position (CMP) Sensor
There are two CMP sensors which are located on the upper timing case covers. The CMP sensors monitor the position of the camshafts to establish ignition timing order, fuel injection triggering and for accurate Variable Camshaft Control (VCC) camshaft advance-retard timing feedback. The CMP sensor is a Hall-effect sensor which switches a battery fed supply on and off. The supply is switched when the teeth machined onto the camshaft gear pass by the tip of the sensor. The four teeth are of differing shapes, so the ECM can determine the exact position of the camshaft at any time.

CMP Sensor



Unlike an inductive type sensor, a Hall-effect sensor does not produce a sinusoidal output voltage (sine wave). Instead it produces a square wave output. The wave edges are very sharp, giving the ECM a defined edge on which to base its calculations.

An implausible signal from the CMP sensor will result in the following:

- The MIL lamp illuminated after debouncing the fault
- Loss of performance, due to the corrective ignition strategy being disabled. A default ignition map is used which retards the timing to a safe position
- Injector operation possibly 360° out of phase, i.e. fuel injected during exhaust stroke rather

than during compression stroke
- Quick crank/cam synchronisation on start-up feature disabled
- Some Oxygen sensor diagnostics disabled.

In addition, the ECM will store a relevant fault code and capture the input signal supplied by the engine coolant temperature sensor, the engine load calculation and the engine speed at the time of failure. TestBook/T4 will display the live readings from the CMP sensor.

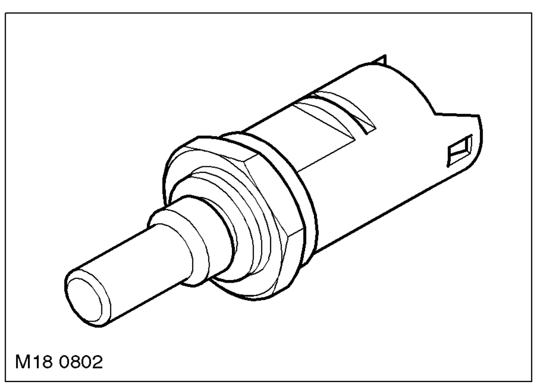
Ambient Barometric Pressure Sensor
The ECM incorporates an integral ambient barometric pressure sensor. This internal sensor is supplied with a 5V feed and returns a linear voltage of between 2.4 and 4.5 Volts. This represents the barometric pressure.

The system monitors barometric pressure for the following reasons:

- The barometric pressure along with the calculated air mass provides additional correction for refining injection “ON” time
- The value provides a base value for the ECM to calculate the air mass being injected into the exhaust system by the secondary air injection system. This correction factor changes the secondary air injection “ON” time which in turn optimizes the necessary air flow into the exhaust system
- The signal is used to recognize down hill driving and to postpone the start of evaporative emission leakage diagnosis.

Engine Coolant Temperature (ECT) Sensor
The ECT sensor is located front of the engine, adjacent to the thermostat housing. The sensor incorporates two Negative Temperature Coefficient (NTC) thermistors and four electrical connections. One set of connections are used by the ECM while the other set are used by the instrument pack temperature gauge.

ECT Sensor



Each thermistor used forms part of a voltage divider circuit operating with a regulated 5 V feed and an earth.

The signal supplied by the ECT sensor is critical to many fuel and ignition control strategies. Therefore, the ECM incorporates a complex ECT sensor default strategy, which it implements in the event of failure. The ECM uses a software model, based on the time the engine has been running and the air intake temperature, to provide a changing default value during the engine warm-up. When the software model calculates the coolant temperature has reached 60 °C (140 °F), a fixed default value of 85 °C (185 °F) is adopted for the remainder of the ignition cycle. The software model also forms part of the sensor diagnostics: if there is too great a difference between the temperatures from the sensor input and the software model, for more than 2.54 seconds, the ECM concludes there is a fault with the sensor input.

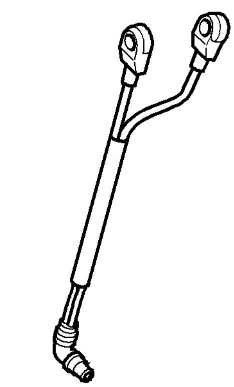
The following symptoms may be noticeable in the event of an ECT sensor failure:

- The MIL lamp illuminated
- Poor engine hot and cold start
- Instrument pack engine overheat warning lamp illuminated
- Excessively hot or cold reading on the temperature gauge.

At the time of a failure, the ECM will also store details of the engine speed, engine load and intake air temperature in its memory. This information is stored to aid diagnosis of the fault.

Knock Sensors
Two knock sensors are located on each cylinder block between the first and second and third and fourth cylinders of each cylinder bank. The knock sensors produce a voltage signal in proportion to the amount of mechanical vibration generated at each ignition point. Each sensor monitors two cylinders in the related cylinder bank.

Knock Sensor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The knock sensors incorporate a piezo-ceramic crystal. This crystal produces a voltage whenever an outside force tries to deflect it, (i.e. exerts a mechanical load on it). When the engine is running, the compression waves in the material of the cylinder block, caused by the combustion of the fuel/air mixture within the cylinders, deflect the crystal and produce an output voltage signal. The signals are supplied to the ECM, which compares them with `mapped' signals stored in memory. From this, the ECM can determine when detonation occurs on individual cylinders. When detonation is detected, the ECM retards the ignition timing on that cylinder for a number of engine cycles, then gradually returns it to the original setting.

Care must be taken at all times to avoid damaging the knock sensors, but particularly during removal and fitting procedures. The recommendations regarding torque and surface preparation must be adhered to. The torque applied to the sensor and the quality of the surface preparation both have an influence over the transfer of mechanical noise from the cylinder block to the crystal.

The ECM uses the signals supplied by the knock sensors, in conjunction with the signal it receives from the camshaft sensor, to determine the optimum ignition point for each cylinder. The ignition point is set according to pre-programmed ignition maps stored within the ECM. The ECM is programmed to use ignition maps for 95 RON premium specification fuel. It will also function on 91 RON regular specification fuel but without adaptions. If the only fuel available is of poor quality, or the customer switches to a lower grade of fuel after using a high grade for a period of time, the engine may suffer slight pre-ignition for a short period. This amount of pre-ignition will not damage the engine. This situation will be evident while the ECM learns and then modifies its internal mapping to compensate for the variation in fuel quality. This feature is called adaption. The ECM has the capability of adapting its fuel and ignition control outputs in response to several sensor inputs.

The ECM will cancel closed loop control of the ignition system if the signal received from either knock sensor becomes implausible. In these circumstances the ECM will default to a safe ignition map. This measure ensures the engine will not become damaged if low quality fuel is used. The MIL lamp will not illuminate, although the driver may notice that the engine 'pinks' in some driving conditions and displays a slight drop in performance and smoothness.

When a knock sensor fault is stored, the ECM will also store details of the engine speed, engine load and the coolant temperature.

Mass Air Flow/Air Intake Temperature (MAF/IAT) Sensor
The MAF/IAT sensor is located in the air intake ducting, between the air cleaner and the throttle body. The sensor outputs intake air flow and temperature signals to the ECM to enable calculation of the mass of the air entering the engine.

In addition to the air flow and temperature outputs, a regulated 5 V feed and an earth are connected between the sensor and the ECM, and the sensor receives a battery power feed from the main relay.

Air flow:

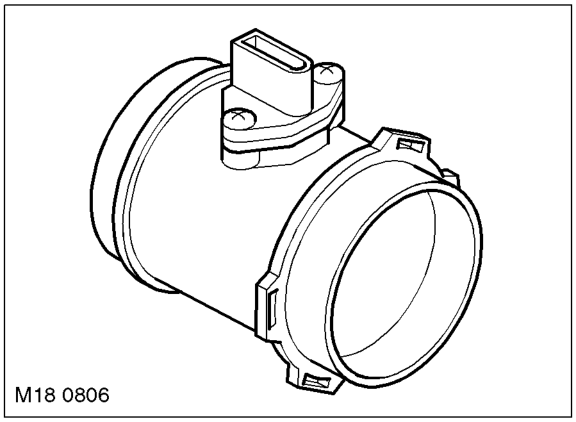
The air flow signal is produced from a hot film element in the sensor. The film is connected between the 5 V feed and the air flow output to the ECM. The film is also heated by the battery power feed and cooled by the air flow into the engine. The greater the air flow, the greater the cooling effect and the lower the electrical resistance across the sensor. So the air flow output voltage varies with changes in air flow and, from voltage/air flow maps stored in memory, the ECM determines the mass of air entering the engine.

Air intake temperature:

The air intake temperature signal is produced by a NTC thermistor connected between the 5 V feed and earth to complete a voltage divider circuit. The ECM monitors the voltage drop across the thermistor and, from voltage/temperature maps stored in memory, determines the temperature of the intake air.

The MAF/IAT sensor is sensitive to sudden shocks and changes in its orientation. It should, therefore, be handled carefully. It is also important that the intake ducting between the air cleaner and the throttle body is not altered in diameter or modified in any way. The air mass flow meter contains electronic circuitry, so never attempt to supply it directly from the battery. The terminals have a silver coating to provide a superior quality of connection over many years. If, at any time, a probe is used to measure the output directly from the sensor, then care must be taken to ensure this coating is not damaged.

MAF/IAT Sensor



If the air flow signal fails the ECM adopts a default value for air flow volume based on throttle position and engine speed. The following engine symptoms will be noticeable:

- The engine speed might 'dip' before the default strategy enables continued running
- The engine may be difficult to start and prone to stalling
- The overall performance of the engine will be adversely affected (throttle response in particular)
- Exhaust emissions will be out of tolerance, because the air/fuel ratio value is now assumed, not calculated; no closed loop fuelling
- Idle speed control disabled, leading to rough idle and possible engine stall.

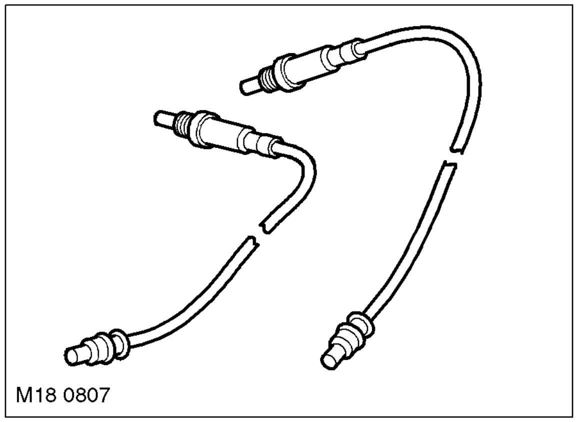
At the time of failure, the ECM will store details of the engine speed, coolant temperature and throttle angle.

If the intake air temperature signal fails, the ECM adopts a default value of 45 °C. This default value is then used within all the calculations involving intake air temperature. The effect on the vehicle of a failed air temperature signal will not be so noticeable to the driver, who may notice a reduction in engine performance when operating the vehicle at high altitudes or in hot ambient temperatures. The occurrence of this fault will also disable fuelling adaptions.

The ECM will store details of the engine speed, engine load and battery voltage when this fault is first detected.

Heated Oxygen Sensors (HO2S)
The HO2S provide feedback signals to the ECM to enable closed loop control of the Air Fuel Ratio (AFR). Four HO2S are installed, one pre-catalyst and one post-catalyst per cylinder bank. Each HO2S produces an output voltage which is inversely proportional to the oxygen content of the exhaust gases.

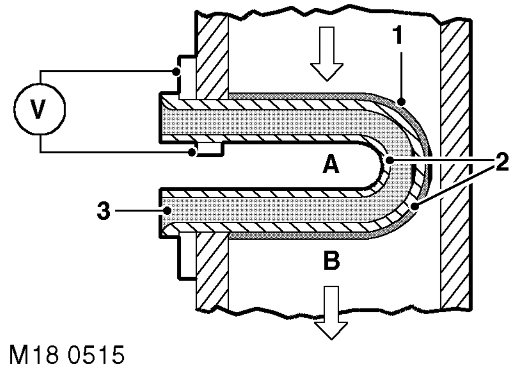
HO2S



Each HO2S consists of a zirconium sensing element with a gas permeable ceramic coating on the outer surface. The outer surface of the sensing element is exposed to the exhaust gas and the inner surface is exposed to ambient air. The difference in the oxygen content of the two gases produces an electrical potential difference across the sensing element. The voltage produced depends on the differential between the two oxygen contents. When the AFR is Lambda 1 (i.e. stoichiometric AFR of 14.7:1 by mass) the voltage produced is approximately 450 mV. With a lean mixture of Lambda 1.2, the higher oxygen content of the exhaust gases results in a voltage of approximately 100 mV. With a rich mixture of Lambda 0.8, the lower oxygen content of the exhaust gases results in a voltage of approximately 900 mV.

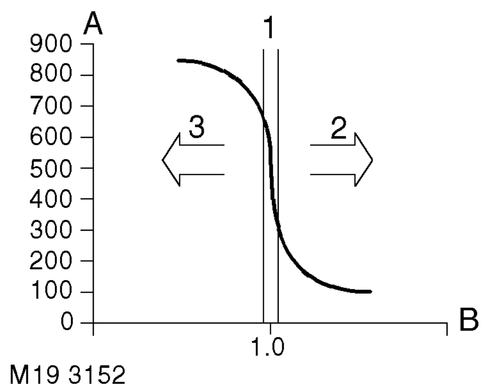
The ECM monitors the effect of altering the injector pulse widths using the information supplied by the two HO2S. Injector pulse width is the length of time the injector is energized, which determines how much fuel is injected. The response time is such that under certain driving conditions, the ECM can assess individual cylinder contributions to the total exhaust emissions. This enables the ECM to adapt the fuelling strategy on a cylinder by cylinder basis, i.e. inject the precise amount of fuel required by each individual cylinder at any given time.

HO2S Principle of Operation



A	Ambient air	2	Electrodes
B	Exhaust gases	3	Zirconium oxide
1	Protective ceramic coating		

HO2S Output



A	Output, mV	2	Lean AFR
B	AFR, lambda	3	Rich AFR
1	Lambda window		

The ECM continuously checks the signals supplied by the HO2S for plausibility. If it detects an implausible signal, the ECM stores a relevant fault code and details of engine speed, engine load and the HO2S signal voltage. The ECM requires the HO2S signals to set most of its adaptions. Failure of an HO2S results in most of these adaptions resetting to their default values. This, in turn, results in loss of engine refinement. The engine may exhibit poor idle characteristics and emit a strong smell of rotten eggs from the exhaust (caused by an increase in hydrogen sulphide).

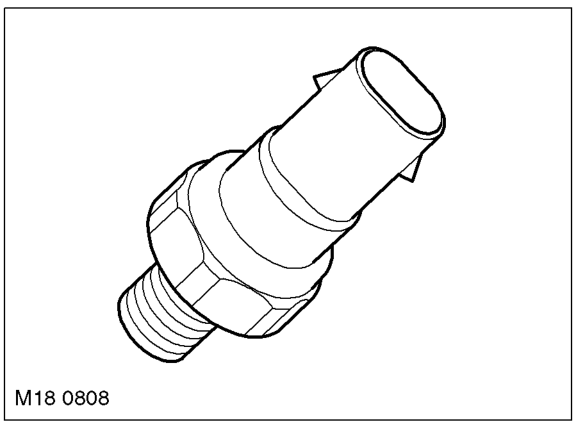
The efficiency of the HO2S slowly deteriorates with use and must be periodically replaced (currently every 120,000 miles, but refer to the maintenance schedules for the latest service replacement period). The ECM is able to detect this steady deterioration from the HO2S signals. If a sensor deteriorates beyond a predetermined threshold, the ECM stores a fault code and captures details of the engine speed, engine load and battery voltage.

The HO2S needs a high operating temperature to work effectively. To ensure a suitable operating temperature is reached as soon as possible, each sensor incorporates a heating element inside the ceramic tip. This element heats the HO2S to a temperature greater than 350 °C (662 °F). The heating rate (the speed at which the temperature rises) is carefully controlled by the ECM to prevent thermal shock to the ceramic material. The ECM supplies a Pulse Width Modulated (PWM) supply to the heater elements to control the rate at which the HO2S temperature is increased. The HO2S are heated during engine warm-up and again after a period of engine idle.

The ECM monitors the state of the heating elements by calculating the amount of current supplied to each sensor during operation. If the ECM identifies that the resistance of either heating element is too high or too low, it will store a fault code, the engine speed, coolant temperature and the battery voltage.

HO2S are very sensitive devices. They must be handled carefully at all times. Failure to handle correctly will result in a very short service life, or non-operation. HO2S are threads coated with an anti-seize compound prior to installation. Care should be taken to avoid getting this compound on the sensor tip. If the sensor needs to be removed and refitted, a small amount of anti-seize compound should be applied (see workshop manual for details).

Radiator Outlet Temperature Sensor



The ECM uses an additional engine coolant temperature sensor located in the radiator outlet. The sensor monitors the temperature of the coolant leaving the radiator for precise activation of the auxiliary fan. The sensor is an NTC thermistor type. The signal is used by the ECM to activate the auxiliary fan when the engine coolant temperature leaving the radiator is in the range of 80 to 104 °C (176 to 219 °F).

Fuel Level Signal

The ECM monitors the contents of the fuel tank as part of the misfire detection strategy. If a misfire occurs while a low fuel level exists, the ECM stores an additional fault code to indicate that fuel starvation resulting from fuel slosh is a possible cause of the misfire. On New Range Rover, the low fuel level signal is internally generated by the ECM, from a CAN signal via the instrument pack.

Vehicle Speed Signal
The ECM receives the vehicle speed signal from the ABS ECU. The ECM uses this signal within its calculations for idle speed control. The signal is transmitted at 8000 pulses/mile and is the average of the road speed signals from all four wheel speed sensors. The ABS ECU outputs the vehicle speed signal to the EAT ECU on the CAN bus.

Rough Road Signal
When the vehicle is travelling over a rough road surface the engine crankshaft is subjected to torsional vibrations caused by mechanical feedback from the road surface through the transmission. To prevent misinterpretation of these torsional vibrations as a misfire, the ECM calculates a rough road level by monitoring individual wheel speeds from the ABS ECU on the CAN bus. The ECM determines the quality of the road surface by monitoring a CAN signal from the ABS ECU, which modulates the duty cycle of the signal in response to variations between ABS sensor inputs. Misfire monitoring is restored when the quality of the road surface improves again.

If there is a fault with the CAN data, the ECM defaults to permanent misfire monitoring.

A/C Request Signals
Because of the loads imposed on the engine when the air conditioning system operates, the ECM is included in the control loop for the compressor and the cooling fans. If it becomes necessary to limit or reduce the load on the engine, the ECM can then prevent or discontinue operation of the air conditioning compressor.

Automatic Gearbox Information
Information sent to and from the EAT ECU is transmitted on the CAN bus.

The ECM requires information on gear position to calculate the likely engine load during acceleration and deceleration conditions. The ECM also disables the misfire detection function whenever low range is selected. The ECM receives this information from the transfer box ECU on the CAN Bus.

There are several possible fault codes associated with the CAN bus and the validity of the messages exchanged between the ECM and the EAT ECU. In most cases, the ECM will store engine speed, engine coolant temperature and details of the battery voltage at the time a CAN fault is detected.

If the EAT ECU detects a gearbox fault, it requests the ECM to illuminate the MIL in the instrument pack and to store freeze frame data.

Ignition Switch
The ignition switch signal enables the ECM to detect if the ignition is on or off. The signal is a power feed that is connected to the ECM while the ignition switch is positions II and III. On the New Range Rover, the power feed comes from the ignition relay in the engine compartment fuse box.

When it first receives the signal, the ECM 'wakes-up' and initiates a power-up sequence to enable engine starting and operation. The power-up sequence includes energising the main relay, which supplies the main power feed to the ECM, energising the fuel pump relay and initiating a self check of the engine management system.

When it detects the ignition has been turned off, the ECM stops activating the fuel injectors and ignition coil, to stop the engine, and de-energizes the fuel pump relay, but keeps the main relay energized while it performs a power down sequence. During the power down sequence the ECM records the engine sensor values required for a quick-start function to operate the next time the engine is cranked. At the end of the power down sequence, the ECM de-energizes the main relay to switch itself off.

System Outputs

The ECM receives and processes the input information previously described and modifies the fuelling and the ignition points for each cylinder accordingly. The ECM will also supply output information to other vehicle systems.

The ECM drives the following components:

- Fuel injectors
- Ignition coils
- Main relay and fuel pump relay
- Tank Leakage Detection (where fitted)
- Secondary Air Injection Pump
- Secondary Air Injection valve
- VCC Valves
- Electrically heated thermostat
- Air conditioning compressor (relay drive).

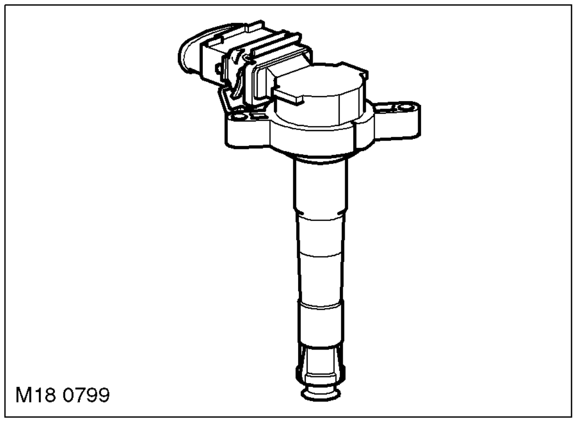
The ECM provides other systems with information regarding the:

- Engine speed
- Driver demand
- ATC request
- Automatic Transmission
- Fuel used
- Auxiliary cooling fan.

Ignition Coils

The ME 7.2 EMS utilizes plug top coils which are mounted directly on top of the spark plug.

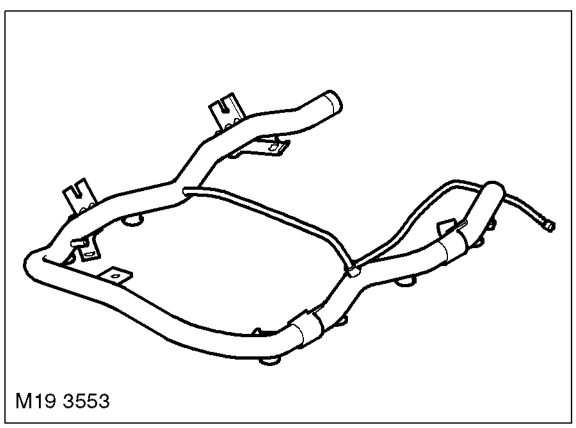
Ignition Coils



Ignition related faults are indirectly monitored via misfire detection. The are no specific checks of the primary circuits.

Fuel Injectors
An electromagnetic, top feed fuel injector is installed in each cylinder inlet tract of the inlet manifolds. A common fuel rail supplies the injectors with fuel from a returnless fuel delivery system. The fuel in the fuel rail is maintained at 3.5 bar (50.75 lbf.in ^{3}) above inlet manifold pressure by a pressure regulator incorporated into the fuel filter. A Schraeder valve is installed in the fuel rail, to the rear of injector No. 7, to enable the fuel pressure to be checked.

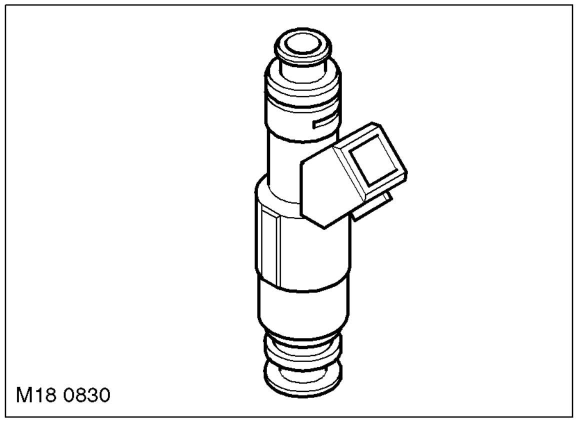
Fuel Rail and Injectors



Each injector contains a solenoid operated needle valve which is closed while the solenoid winding is de-energized. The solenoid winding is connected to a power feed from the main relay and to an earth through the ECM. The ECM switches the earth to control the opening and closing of the needle valve (injector 'firing'). While the needle valve is open, fuel is sprayed into the cylinder inlet tract onto the back of the inlet valves. The ECM meters the amount of fuel injected by adjusting the time that the needle valve is open (injector pulse width).

Each injector is sealed with two 'O' rings, which should be renewed whenever an injector is refitted to an engine. A small amount of engine oil can be applied to the 'O' rings to aid installation. No other form of lubrication should be used.

Fuel Injector



Measuring the electrical resistance of the solenoid winding enables an assessment to be made of the serviceability of an injector. Nominal resistance of the solenoid winding is $14.5 \pm 0.7\ \Omega$ at 20 °C (68 °F).

The ECM can detect electrical inconsistencies within each injector. It can also detect, via feedback from the HO2S, mechanical faults such as blockage or leakage. The ECM will store a relevant fault code in these circumstances. The ECM will also store the engine speed, engine load and details of either the battery voltage, engine coolant temperature or intake air temperature. The precise details stored depend on the exact nature of the fault detected.

TestBook/T4 will also display data regarding injector operation via its live readings. Care must be taken when analysing this data, as the precise timings will vary considerably. Individual timings will be affected by any current engine load.

Main Relay

The ECM controls its own power supply, via the main relay in the engine compartment fusebox. When the ignition is turned to position II, the ECM provides a ground to the main relay coil. The main relay then energizes and connects the main power feed to the ECM. The ECM controls the main relay, and therefore its own power supply, so that when the ignition is turned off it can follow the power-down sequence, during which it records values from various sensors and writes adaptions into its memory, etc. The last action the ECM carries out before completing its power-down sequence is to turn off the main relay. This will occur approximately 7 seconds after the ignition has been switched off, as long as the coolant temperature is not rising. For vehicles with tank module leak detection and under some vehicle system fault conditions, this period could be extended up to 20 minutes.

Failure of the main relay will result in the engine failing to start. The engine will stop immediately if the main relay fails while the engine is running.

Fuel Pump Relay
The ECM controls operation of the fuel pump via the fuel pump relay in the rear fusebox. The ECM switches the relay coil to earth to energize the relay when the ignition is first turned to position II. The relay remains energized during engine cranking and while the engine is running, but will be de-energized after approximately 2 seconds if the ignition switch remains in position II without the engine running.

A fuel cut-off function is incorporated into the ECM to de-energize the fuel pump in a collision. The cut off function is activated by a signal from the SRS DCU in the event of an airbag activation. The ECM receives an airbag activation signal from the SRS DCU on the CAN Bus.

The fuel cut-off function can only be reset by using TestBook/T4.

The ECM monitors the state of the wiring to the coil winding within the fuel pump relay. The ECM will store relevant fault codes if the ECM detects a problem. The ECM is not able to assess the state of the fuel pump circuit because it is isolated by the function of the relay. However, if the fuel pump circuit fails, or the pump fails to deliver sufficient fuel (while the fuel level is above the minimum level), the ECM will store adaptive faults as it tries to increase the air/fuel ratio by increasing the pulse width of the injectors.

Failure of the fuel pump relay will result in the engine failing to start. If the fuel pump fails while the engine is running, the symptoms will be engine hesitation and engine misfire. These symptoms will worsen progressively until the engine stops. The ECM will store several fault codes under this condition.

Electrically Heated Thermostat
The electrically heated thermostat is used to regulate the engine coolant temperature. The thermostat regulates the coolant temperature depending upon engine load and vehicle speed. This allows the engine coolant temperature to be raised when the engine is operating at part load. Raising the coolant temperature while the engine is at part load has a beneficial effect on fuel consumption and emissions.

If a conventional thermostat with higher constant operating temperature is used, poor response when accelerating and in traffic could result.

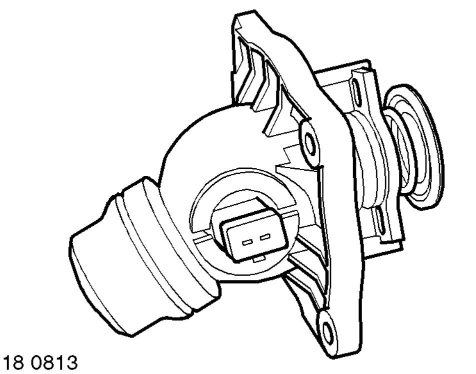
The thermostat is controlled by the ECM is response to engine load against a 'map' stored within the ECM.

The map is based upon the following inputs:

- Engine load
- Engine speed
- Vehicle speed
- Intake air temperature
- Coolant temperature.

The thermostat unit is a one piece construction comprising the thermostat, thermostat housing and heater element. The housing is of a die-cast aluminium. The electrical connection for the heater element is housed in the body. The heater element is an expanding (wax) element.

Heated Thermostat


M18 0813

The thermostat is set to open when the coolant temperature reaches 103 °C (217 °F) at the thermostat. Once the coolant has passed through the engine its temperature is approximately 110 °C (230 °F) at the engine temperature sensor.

If the ECM starts to regulate the system the ECM supplies an earth path for the heater element in the thermostat. This causes the element to expand and increase the opening dimension of the thermostat.

The warmer the element the sooner the thermostat opens and the lower the resulting coolant temperature is. The thermostat regulates the coolant temperature in the range 80 to 103 °C (176 to 217 °F). The expanding element in the thermostat is heated to a higher temperature than the surrounding coolant to generate the correct opening aperture. Should the coolant temperature exceed 113 °C (235 °F) the electrically heated thermostat is activated independently of the prevailing engine parameters.

Should the heated thermostat fail, (fault codes will be stored in the ECM) the EMS will ensure the safe operation of the engine and the thermostat will operate as a conventional unit.

ECM Adaptions

The ECM has the ability to adapt the values it uses to control certain outputs. This capability ensures the EMS can meet emissions legislation and improve the refinement of the engine throughout its operating range.

The components which have adaptions associated with them are:

- The IACV
- The APP sensor
- The HO2S
- The MAF/IAT sensor
- The CKP sensor
- Electric throttle body.

HO2S and MAF/IAT Sensor

There are several adaptive maps associated with the fuelling strategy. Within the fuelling strategy the ECM calculates short-term adaptions and long term adaptions. The ECM will monitor the deterioration of the HO2S over a period of time. It will also monitor the current correction associated with the sensors.

The ECM will store a fault code in circumstances where an adaption is forced to exceed its operating parameters. At the same time, the ECM will record the engine speed, engine load and intake air temperature.

CKP Sensor

The characteristics of the signal supplied by the CKP sensor are learned by the ECM. This enables the ECM to set an adaption and support the engine misfire detection function. Due to the small variation between different flywheels and different CKP sensors, the adaption must be reset if either component is renewed, or removed and refitted. It is also necessary to reset the flywheel adaption if the ECM is renewed or replaced.

The ECM supports four flywheel adaptions for the CKP sensor. Each adaption relates to a specific engine speed range. The engine speed ranges are detailed in the table below:

Adaptation	Engine Speed, rev/min
1	1800 - 3000
2	3001 - 3800
3	3801 - 4600
4	4601 - 5400

To set the flywheel adaptions, follow the procedure detailed below. This procedure should be carried out in an appropriate area off the public highway. TestBook/T4 must be connected throughout this procedure. The adaptive speed settings must be read from TestBook/T4 while the vehicle is moving at speed.

1. Use TestBook/T4 to clear any adaptions currently set.
2. With the engine warm (> 86 °C (187 °F)), select 2nd gear high range.
3. Accelerate the vehicle until the engine speed reaches the limiter.
4. Release the throttle and allow the vehicle to decelerate until the engine idle speed is reached.
5. Check that one of the speed range adaptions has been set (read this from TestBook/T4).
6. Repeat the above procedure until all four adaptions are set

When all four adaptions have been set, check that the ECM has not recorded any misfire detection faults. If it has, then clear the memory of the misfire fault codes.

It may not be possible to reset adaption number 4 if the ECM has already been programmed with a value. Due to the nature of the procedure and the self learn capacity of the ECM, if adaption number 4 does not reset, it is permissible to leave this adaption and let the ECM learn it during normal vehicle usage.

Misfire Detection

Legislation requires that the ECM must be able to detect the presence of an engine misfire. It must be able to detect misfires at two separate levels. The first level is a misfire that could lead to the vehicle emissions exceeding 1.5 times the Federal Test Procedure (FTP) requirements for the engine. The second level is a misfire that may cause catalyst damage.

The ECM monitors the number of misfire occurrences within two engine speed ranges. If the ECM detects more than a predetermined number of misfire occurrences within either of these two ranges, over two consecutive journeys, the ECM will record a fault code and details of the engine speed, engine load and engine coolant temperature. In addition, the ECM monitors the number of misfire occurrences that happen in a 'window' of 200 engine revolutions. The misfire occurrences are assigned a weighting according to their likely impact on the catalysts. If the number of misfires exceeds a certain value, the ECM stores catalyst-damaging fault codes, along with the engine speed, engine load and engine coolant temperature.

The signal from the crankshaft position sensor indicates how fast the poles on the flywheel are passing the sensor tip. A sine wave is generated each time a pole passes the sensor tip. The ECM can detect variations in flywheel speed by monitoring the sine wave signal supplied by the crankshaft position sensor.

By assessing this signal, the ECM can detect the presence of an engine misfire. At this time, the ECM will assess the amount of variation in the signal received from the crankshaft position sensor and assigns a roughness value to it. This roughness value can be viewed within the real time monitoring feature, using TestBook/T4. The ECM will evaluate the signal against a number of factors and will decide whether to count the occurrence or ignore it. The ECM can assign a roughness and misfire signal for each cylinder, (i.e. identify which cylinder is misfiring).

TestBook/T4 Diagnostics

The ECM stores faults as Diagnostic Trouble Codes (DTC), referred to as 'P' codes. The 'P' codes are defined by OBD legislation and, together with their associated environmental and freeze frame data, can be read using a third party scan tool or TestBook/T4. TestBook/T4 can also read real time data from each sensor, the adaptive values currently being employed and the current fuelling, ignition and idle settings.

Several different drive cycles are defined by OBD legislation for fault diagnosis. Each drive cycle is a precise routine which the engine or vehicle must undergo to produce the conditions that enable the ECM to perform diagnostic routines. TestBook/T4 can be used to view the status and results of the diagnostic routines performed by the ECM. When a fault code is stored, it will indicate, via TestBook/T4, the drive cycle required to verify a repair.

The ECM only records a fault after it has occurred on more than one drive cycle. This fault strategy is referred to as debouncing. When it is first detected, a fault is stored as a temporary fault. If the fault recurs within the next 40 warm-up cycles, the fault is stored as a permanent fault and freeze frame data for the second occurrence is recorded. If the fault does not recur within the next 40 warm-up cycles, the ECM deletes the temporary fault from memory.

The ECM illuminates the MIL when requested to do so by the EAT ECU, to perform a bulb check when the ignition is switched on, and for any emissions related fault. There is no MIL illumination for non emission related engine management faults.

Resetting the adaptions will clear all adaptions from the ECM memory.

Engine Management P Codes

P Code No.	Component/Signal	Fault Description
0010	RH bank CMP sensor	Signal malfunction
0011	RH bank CMP sensor	Timing over-advanced or system performance
0012	RH bank CMP sensor	Timing over-retarded
0020	LH bank CMP sensor	Signal malfunction
0021	LH bank CMP sensor	Timing over-advanced or system performance
0022	LH bank CMP sensor	Timing over-retarded
0030	RH bank front HO2S heater circuit	Circuit intermittent
0031	RH bank front HO2S heater circuit	Short circuit to ground
0032	RH bank front HO2S heater circuit	Short circuit to battery
0036	RH bank rear HO2S heater circuit	Circuit intermittent
0037	RH bank rear HO2S heater circuit	Short circuit to ground
0038	RH bank rear HO2S heater circuit	Short circuit to battery
0050	LH bank front HO2S heater circuit	Circuit intermittent
0051	LH bank front HO2S heater circuit	Short circuit to ground
0052	LH bank front HO2S heater circuit	Short circuit to battery
0056	LH bank rear HO2S heater circuit	Circuit intermittent
0057	LH bank rear HO2S heater circuit	Short circuit to ground
0058	LH bank rear HO2S heater circuits	Short circuit to battery
0102	MAF sensor signal	Short circuit to ground
0103	MAF sensor signal	Short circuit to battery
0106	ECM internal ambient pressure sensor	Performance problem
0107	ECM internal ambient pressure	Short circuit to ground
0108	ECM internal ambient pressure	Open circuit or short circuit to battery
0112	IAT sensor	Short circuit to ground
0113	IAT sensor	Open circuit or short circuit to battery

P Code No.	Component/Signal	Fault Description
0114	Ambient temperature input	Fault data received
0116	ECT sensor	Signal implausible
0117	ECT sensor	Short circuit to ground
0118	ECT sensor	Open circuit or short circuit to battery
0120	APP sensor switch A	Implausible
0121	APP sensor switch A	Range/ Performance problem
0122	APP sensor switch A	Open circuit or short circuit to ground
0123	APP sensor switch A	Short circuit to battery
0125	ECT sensor	Insufficient coolant temperature for closed loop control
0128	Thermostat monitoring sensor	Low coolant temperature ñ thermostat stuck open
0130	RH bank front HO2S signal	Circuit malfunction
0131	RH bank front HO2S signal	Short circuit to ground
0132	RH bank front HO2S signal	Short circuit to battery
0133	RH bank front HO2S signal	Slow response
0134	RH bank front HO2S signal	No activity
0135	RH bank front HO2S heater circuit	Circuit malfunction
0136	RH bank rear HO2S signal	Circuit malfunction
0137	RH bank rear HO2S signal	Short circuit to ground
0138	RH bank rear HO2S signal	Short circuit to battery
0139	RH bank rear HO2S signal	Slow response
0140	RH bank rear HO2S signal	No activity
0141	RH bank rear HO2S heater circuit	Circuit malfunction
0150	LH bank front HO2S signal	Circuit malfunction
0151	LH bank front HO2S signal	Short circuit to ground
0152	LH bank front HO2S signal	Short circuit to battery
0153	LH bank front HO2S signal	Slow response
0154	LH bank front HO2S signal	No activity
0155	LH bank front HO2S heater circuit	Circuit malfunction
0156	LH bank rear HO2S signal	Circuit malfunction
0157	LH bank rear HO2S signal	Short circuit to ground
0158	LH bank rear HO2S signal	Short circuit to battery
0159	LH bank rear HO2S signal	Slow response
0160	LH bank rear HO2S signal	No activity
0161	LH bank rear HO2S heater circuit	Malfunction
0171	RH bank lambda control	Fuelling too lean
0172	RH bank lambda control	Fuelling too rich

P Code No.	Component/Signal	Fault Description
0174	LH bank lambda control	Fuelling too lean
0175	LH bank lambda control	Fuelling too rich
0201	Fuel injector 1	Open circuit
0202	Fuel injector 2	Open circuit
0203	Fuel injector 3	Open circuit
0204	Fuel injector 4	Open circuit
0205	Fuel injector 5	Open circuit
0206	Fuel injector 6	Open circuit
0207	Fuel injector 7	Open circuit
0208	Fuel injector 8	Open circuit
0221	APP sensor switch B	Range/ Performance problem
0222	APP sensor switch B	Open circuit or short circuit to ground
0223	APP sensor switch B	Short circuit to battery
0231	Fuel pump motor drive	Short circuit to ground
0232	Fuel pump motor drive	Short circuit to battery
0233	Fuel pump motor drive	Circuit fault
0261	Fuel injector 1	Short circuit to ground
0262	Fuel injector 1	Short circuit to battery
0264	Fuel injector 2	Short circuit to ground
0265	Fuel injector 2	Short circuit to battery
0267	Fuel injector 3	Short circuit to ground
0268	Fuel injector 3	Short circuit to battery
0270	Fuel injector 4	Short circuit to ground
0271	Fuel injector 4	Short circuit to battery
0273	Fuel injector 5	Short circuit to ground
0274	Fuel injector 5	Short circuit to battery
0276	Fuel injector 6	Short circuit to ground
0277	Fuel injector 6	Short circuit to battery
0279	Fuel injector 7	Short circuit to ground
0280	Fuel injector 7	Short circuit to battery
0282	Fuel injector 8	Short circuit to ground
0283	Fuel injector 8	Short circuit to battery
0300	Misfire detection	Random/Multiple cylinder misfire
0301	Misfire detection	Cylinder 1 misfire
0302	Misfire detection	Cylinder 2 misfire
0303	Misfire detection	Cylinder 3 misfire
0304	Misfire detection	Cylinder 4 misfire
0305	Misfire detection	Cylinder 5 misfire
0306	Misfire detection	Cylinder 6 misfire

P Code No.	Component/Signal	Fault Description
0307	Misfire detection	Cylinder 7 misfire
0308	Misfire detection	Cylinder 8 misfire
0324	Knock sensors	Control system error
0327	RH bank knock sensor 1	Short circuit to ground
0328	RH bank knock sensor 1	Short circuit to battery
0332	LH bank knock sensor 3	Short circuit to ground
0333	LH bank knock sensor 3	Short circuit to battery
0335	CKP sensor	Signal implausible
0340	RH bank CMP sensor	Signal implausible
0342	RH bank CMP sensor	Short circuit to ground
0343	RH bank CMP sensor	Short circuit to battery
0345	LH bank CMP sensor	Signal implausible
0347	LH bank CMP sensor	Short circuit to ground
0348	LH bank CMP sensor	Short circuit to battery
0370	Reference mark detection	Timing reference high resolution signal A
0411	SAI vacuum solenoid valve	Incorrect flow detected
0412	SAI vacuum solenoid valve drive	Circuit malfunction
0413	SAI vacuum solenoid valve drive	Open circuit
0414	SAI vacuum solenoid valve drive	Short circuit
0418	SAI air injection pump relay	Open circuit
0420	RH bank catalytic converter	Efficiency below threshold/light off too long
0430	LH bank catalytic converter	Efficiency below threshold/light off too long
0442	EVAP system	Minor leak (1.0 mm or less)
0443	Purge valve drive	Circuit malfunction
0444	Purge valve drive	Open circuit
0445	Purge valve drive	Short circuit to battery or ground
0455	EVAP system	Major leak (more than 1.0 mm)
0456	EVAP system	Minor leak (0.5 mm or less)
0461	Fuel tank level signal	Range/Performance problem
0462	Fuel tank level signal	Short circuit to ground
0463	Fuel tank level signal	Short circuit to battery
0464	Fuel tank level signal	Circuit intermittent
0491	SAI system	Malfunction on RH bank
0492	SAI system	Malfunction on LH bank
0500	Vehicle speed signal	Signal implausible
0501	Rough road detection vehicle speed signal	Intermittent, erratic or high

P Code No.	Component/Signal	Fault Description
0503	Rough road detection vehicle speed signal	Range/Performance
0512	Comfort start	Request circuit malfunction
0530	A/C refrigerant pressure sensor	Signal fault
0532	A/C refrigerant pressure sensor	Short circuit to ground
0533	A/C refrigerant pressure sensor	Short circuit to battery
0561	Battery voltage monitor	System voltage unstable
0562	Battery voltage monitor	System voltage low
0563	Battery voltage monitor	System voltage high
0571	Brake lights switch	Cruise control/brake switch circuit A
0604	ECM self test	RAM error
0605	ECM self test	ROM error
0606	ECM self test	Processor fault
0615	Comfort start relay drive	Open circuit
0616	Comfort start relay drive	Short circuit to ground
0617	Comfort start relay drive	Short circuit to battery
0634	ECU internal temperature	ECU temperature high
0650	MIL output drive	Open circuit, or short circuit to ground or battery
0660	Manifold valve output drive	Control circuit malfunction
0661	Manifold valve output drive	Open circuit or short circuit to ground
0662	Manifold valve output drive	Short circuit to battery
0691	Engine cooling fan control	Short circuit to ground
0692	Engine cooling fan control	Short circuit to battery
0693	Engine cooling fan control	Circuit intermittent
0704	A/C compressor clutch switch	Input circuit malfunction
1000	DMTL pump motor drive	Intermittent or short circuit to ground or battery
1102	Throttle position to mass air flow plausibility not active	Air mass too small
1103	Throttle position to mass air flow plausibility not active	Air mass too large
1117	Thermostat monitoring sensor	Short circuit to ground
1118	Thermostat monitoring sensor	Open circuit or short circuit to battery
1120	APP sensor	Implausible signals
1121	APP sensor 1	Range/ Performance problem
1122	APP sensor 1	Short circuit to ground
1123	APP sensor 1	Short circuit to battery
1129	HO2S	Swapped sensors (LH to RH)

P Code No.	Component/Signal	Fault Description
1161	RH bank lambda control	Adaption per ignition too small
1162	RH bank lambda control	Adaption per ignition too large
1163	LH bank lambda control	Adaption per ignition too small
1164	LH bank lambda control	Adaption per ignition too large
1170	RH bank front HO2S signal	Fuel trim malfunction
1171	RH bank lambda control	Adaption over time too large
1172	RH bank lambda control	Adaption over time too small
1173	LH bank front HO2S signal	Fuel trim malfunction
1174	LH bank lambda control	Adaption over time too large
1175	LH bank lambda control	Adaption over time too small
1221	APP sensor 2	Range/ Performance problem
1222	APP sensor 2	Short circuit to ground
1223	APP sensor 2	Short circuit to battery
1300	Misfire detection	Catalyst damaging misfire
1301	Misfire detection	Multiple cylinder misfire
1327	RH bank knock sensor 2	Short circuit to ground
1328	RH bank knock sensor 2	Short circuit to battery
1332	LH bank knock sensor 4	Short circuit to ground
1333	LH bank knock sensor 4	Short circuit to battery
1413	SAI air injection pump relay	Short circuit to ground
1414	SAI air injection pump relay	Short circuit to battery
1450	DMTL pump motor	Reference current above limit
1451	DMTL pump motor	Reference current below limit
1452	DMTL pump motor	Reference current unstable
1453	DMTL pump motor	Changeover valve stuck
1454	DMTL changeover valve drive	Short circuit to battery
1455	DMTL changeover valve drive	Short circuit to ground
1456	DMTL changeover valve drive	Open circuit
1481	DMTL heater output drive	Signal intermittent
1482	DMTL heater output drive	Open circuit or short circuit to ground
1483	DMTL heater output drive	Short circuit to battery
1488	DMTL pump motor drive	Open circuit
1489	DMTL pump motor drive	Short circuit to ground
1490	DMTL pump motor drive	Short circuit to battery
1522	Plausibility MSR intervention	No activity
1523	RH bank VCC solenoid valve	Short circuit to ground
1524	RH bank VCC solenoid valve	Short circuit to battery
1525	RH bank VCC solenoid valve	Open circuit
1526	LH bank VCC solenoid valve	Open circuit

P Code No.	Component/Signal	Fault Description
1527	LH bank VCC solenoid valve	Short circuit to ground
1528	LH bank VCC solenoid valve	Short circuit to battery
1614	Electric thermostat heater drive	Open circuit
1615	Electric thermostat heater drive	Short circuit to ground
1616	Electric thermostat heater drive	Short circuit to battery
1619	5V reference voltage	Internal reference voltage error
1620	Comfort start input	Engine crank signal error (request while engine running)
1621	Serial link with immobilisation ECU	Timed out
1623	Serial link with immobilisation ECU	Exchange code in EEPROM failure
1624	Serial link with immobilisation ECU	EEPROM read/write failure
1626	ECM, throttle monitoring/ self test	Engine torque monitoring problem
1630	ECM, throttle monitoring/ self test	Throttle position control deviation
1631	Throttle drive	Motor power stage fault
1632	ECM, throttle monitoring/ self test	'Limp home' position not adapted
1633	ECM, throttle monitoring/ self test	Throttle position control band stuck short
1634	ECM, throttle monitoring/ self test	Throttle position control band stuck long
1635	ECM, throttle monitoring/ self test	Control gain adaption error
1638	ECM, throttle monitoring/ self test	Throttle control range not learned
1639	ECM, throttle monitoring/ self test	Throttle motor spring test failed
1645	CAN bus link with ABS ECU	Timed out
1646	CAN bus link with EAT ECU	Timed out
1647	CAN bus link with instrument pack	Timed out
1651	CAN bus link with transfer box ECU	Timed out
1659	ECM self test	Torque monitor error
1660	ECM self test	Limp home monitor error
1666	Serial link with immobilisation ECU	Message parity bit fault (wrong code)
1672	Serial link with immobilisation ECU	Exchange code implausible
1673	Serial link with immobilisation ECU	No start code programmed
1674	Serial link with immobilisation ECU	Message fault
1693	Serial link with immobilisation ECU	False manipulation of start code by tester interface
1694	Serial link with immobilisation ECU	Start code corrupted
1700	Transfer box ECU	Implausible signal
1709	CAN bus link with transfer box ECU	Message information error

Drive Cycles
TestBook/T4 drive cycles are as follows:

Drive cycle A

7 Switch on the ignition for 30 seconds.

8 Ensure engine coolant temperature is less than 60 °C (140 °F).

9 Start the engine and allow to idle for 2 minutes.

10 Connect TestBook/T4 and check for fault codes.

Drive cycle B

11 Switch ignition on for 30 seconds.

12 Ensure engine coolant temperature is less than 60 °C (140 °F).

13 Start the engine and allow to idle for 2 minutes.

14 Perform 2 light accelerations, i.e. 0 to 35 mph (56 km/h) with light pedal pressure.

15 Perform 2 medium accelerations, i.e. 0 to 45 mph (72 km/h) with moderate pedal pressure.

16 Perform 2 hard accelerations, i.e. 0 to 55 mph (88 km/h) with heavy pedal pressure.

17 Allow engine to idle for 2 minutes.

18 Connect TestBook/T4 and, with the engine still running, check for fault codes.

Drive cycle C

19 Switch ignition on for 30 seconds.

20 Ensure engine coolant temperature is less than 60 °C (140 °F).

21 Start the engine and allow to idle for 2 minutes.

22 Perform 2 light accelerations, i.e. 0 to 35 mph (56 km/h) with light pedal pressure.

23 Perform 2 medium accelerations, i.e. 0 to 45 mph (72 km/h) with moderate pedal pressure.

24 Perform 2 hard accelerations, i.e. 0 to 55 mph (88 km/h) with heavy pedal pressure.

25 Cruise at 60 mph (96 km/h) for 8 minutes.

26 Cruise at 50 mph (80 km/h) for 3 minutes.

27 Allow engine to idle for 3 minutes.

28 Connect TestBook/T4 and, with the engine still running, check for fault codes.

The following areas have an associated readiness test which must be flagged as complete, before a problem resolution can be verified:

- Catalytic converter fault.
- Evaporative loss system fault.
- HO2S fault.
- HO2S heater fault.

When carrying out drive cycle C to determine a fault in any of the above areas, select the readiness test icon to verify that the test has been flagged as complete.

Drive cycle D

29 Switch ignition on for 30 seconds.

30 Ensure engine coolant temperature is less than 35 °C (95 °F).

31 Start the engine and allow to idle for 2 minutes.

32 Perform 2 light accelerations, i.e. 0 to 35 mph (56 km/h) with light pedal pressure.

33 Perform 2 medium accelerations, i.e. 0 to 45 mph (72 km/h) with moderate pedal pressure.

34 Perform 2 hard accelerations, i.e. 0 to 55 mph (88 km/h) with heavy pedal pressure.

35 Cruise at 60 mph (96 km/h) for 5 minutes.

36 Cruise at 50 mph (80 km/h) for 5 minutes.

37 Cruise at 35 mph (56 km/h) for 5 minutes.

38 Allow engine to idle for 2 minutes.

39 Connect TestBook/T4 and check for fault codes.

Drive cycle E

40 Ensure fuel tank is at least a quarter full.

41 Carry out drive cycle A.

42 Switch off ignition.

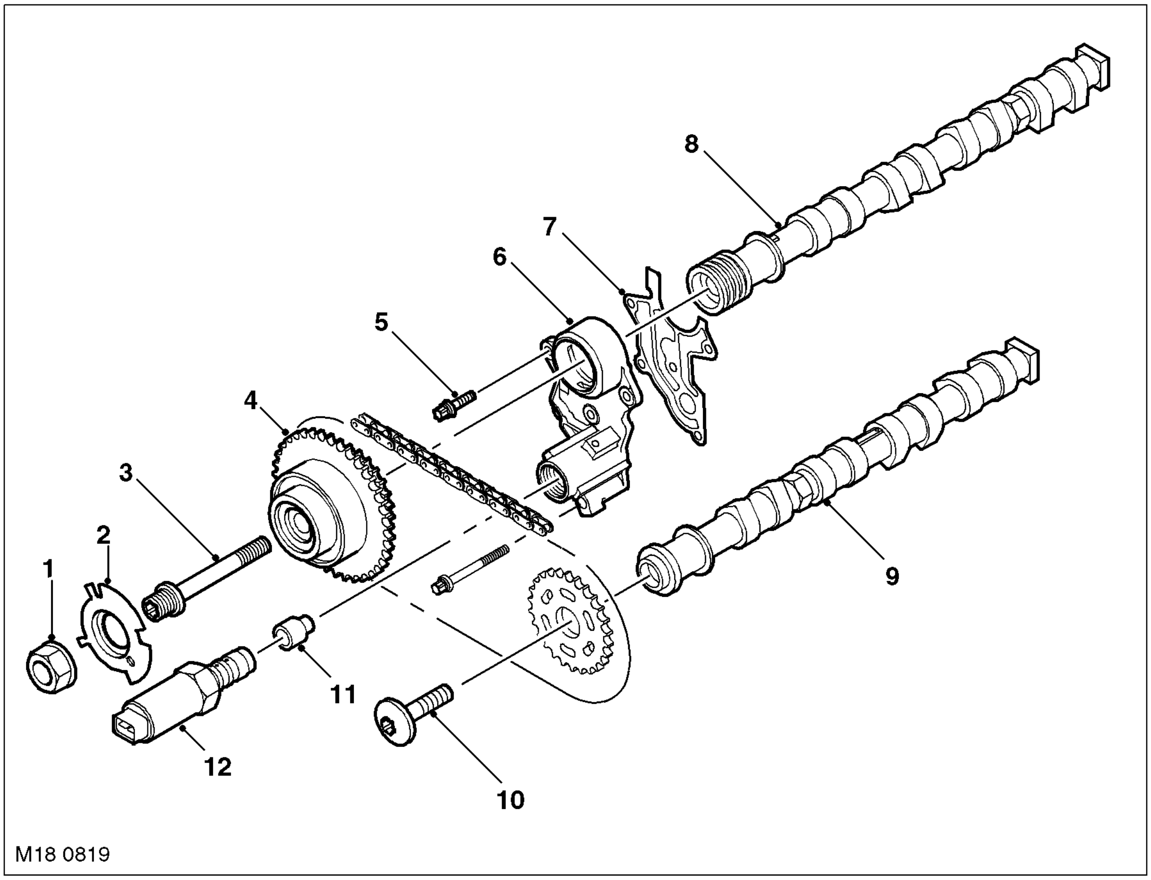
43 Leave vehicle undisturbed for 20 minutes.

44 Switch on ignition.

45 Connect TestBook/T4 and check for fault codes.

VCC System

Variable Camshaft Control Components



1	Locking nut	7	Oil distribution flange gasket
2	Impulse wheel	8	Inlet camshaft
3	Camshaft to sprocket retaining screw	9	Exhaust camshaft
4	VCC transmission unit	10	Drive train gear retaining bolt
5	Bolt	11	Check valve
6	Oil distribution flange	12	VCC solenoid valve

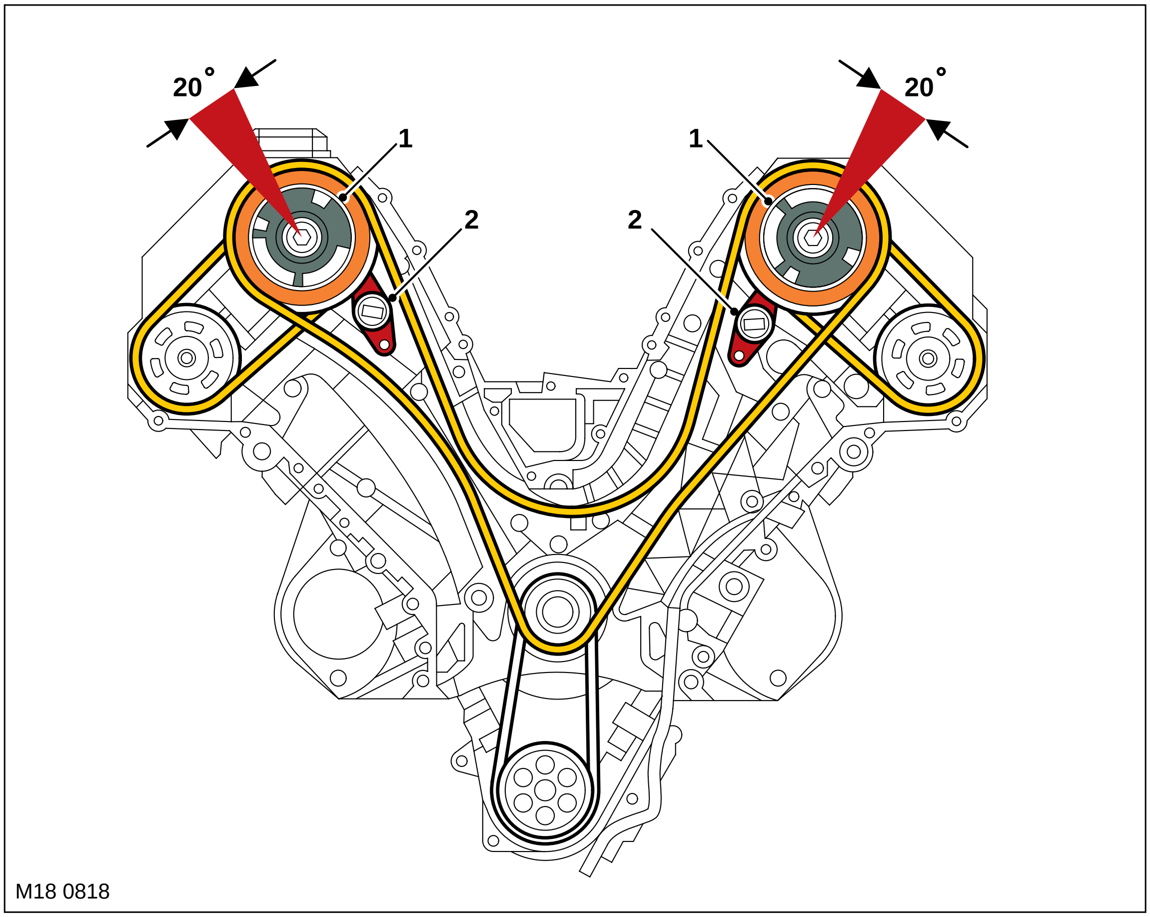
Introduction

The variable intake valve timing system is known as Variable Camshaft Control (VCC).

The VCC system is a new system providing stepless VCC functionality on each intake camshaft. The system is continuously variable within its range of adjustment providing optimized camshaft positioning for all engine operating conditions.

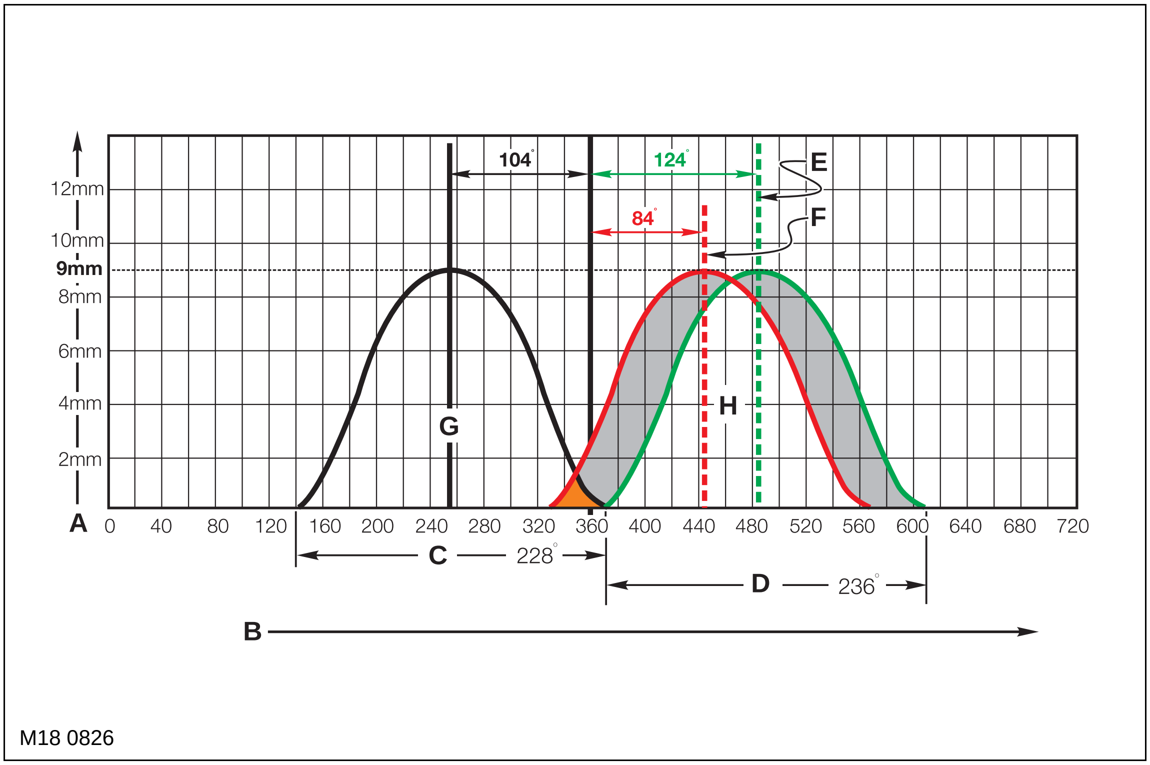
While the engine is running, both intake camshafts are continuously adjusted to their optimum positions. This enhances engine performance and reduces exhaust emissions.

Both camshafts are adjusted simultaneously within 20° (maximum) of the camshafts rotational axis.



1 VCC transmission unit 2 VCC control solenoid valve

This equates to a maximum span of 40° crankshaft rotation. The camshaft spread angles for both banks are as follows.



A	Valve lift	E	Default retard
B	Crankshaft rotation	F	Maximum retard
C	Open duration 228°	G	Exhaust valve
D	Open duration 236°	H	Intake valve

The design of a camshaft for a non adjustable valve timing system is limited to the required overall performance of the engine.

An intake camshaft with an advanced (early) profile will provide a higher performing power curve at a lower engine speed. But at idle speed the advanced position will create a large area of intake/exhaust overlap that causes a rough, unstable idle.

An intake camshaft with a retarded (late) profile will provide a very smooth, stable idle but will lack the cylinder filling dynamics needed for performance characteristics at mid range engine speeds.

The ability to adjust the valve timing improves the engines power dynamics and reduces exhaust emissions by optimizing the camshaft angle for all ranges of engine operation. VCC provides the following benefits:

- Increased torque at lower to mid range engine speeds without a loss of power in the upper range engine speeds
- Increased fuel economy due to optimized valve timing angles
- Reduction of exhaust emissions due to optimized valve overlap
- Smoother idle quality due to optimized valve overlap.

Variable Camshaft Control Electronic Control
The following describes the electronic control of the VCC system.

Electronic Control
The engine control module is responsible for activating a VCC variable position solenoid valve based on EMS program mapping. The activation parameters are influenced by the following input signals:

- Engine speed
- Load (intake air mass)
- Engine temperature
- Camshaft position.

Mechanical Control
The position of the solenoid valve directs the hydraulic flow of engine oil. The controlled oil flow acts on the mechanical components of VCC system to position the camshaft.

The hydraulic engine oil flow is directed through advance or retard activation oil ports by the VCC solenoid. Each port exits into a sealed chamber on the opposite sides of a control piston.

In its default position the oil flow is directed to the rear surface of the piston. This pulls the helical gear forward and maintains the retarded valve timing position.

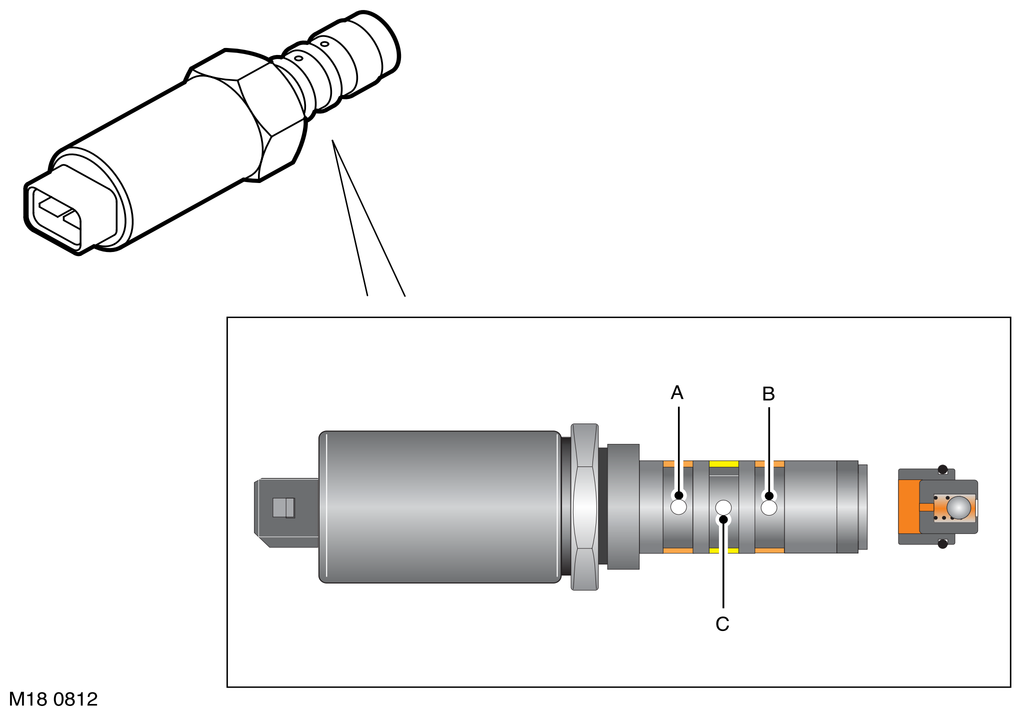
When the oil flow is directed to the front surface of the piston, the oil pushes the helical gear in the opposite direction which rotates the matched helical gearing connected to the camshaft.

The angled teeth of the helical gears cause the pushing movement to be converted into a rotational movement. The rotational movement is added to the turning of the camshaft providing the variable camshaft positioning.

System Components
The VCC components include the following for each cylinder bank:

- Cylinder heads with oil ports for VCC
- VCC transmission with sprockets
- Oil distribution flange
- Oil check valve
- PWM controlled solenoid valve
- Camshaft position impulse wheel.

Control Solenoid and Check Valve



A Advance B Retard C Vent

The VCC solenoid is a two wire, pulse width modulated, oil pressure control valve. The valve has four ports;

A check valve is positioned forward of the solenoid in the cylinder head oil gallery. The check valve maintains an oil supply in the VCC transmission and oil circuits after the engine is turned off. This prevents the possibility of piston movement (noise) within the VCC transmission system on the next engine start.

VCC Transmission

The primary and secondary timing chain sprockets are integrated with the VCC transmission. The transmission is a self contained unit.

The adjustment of the camshaft occurs inside the transmission, controlled oil pressure then moves the piston axially.

The helical gear cut of the piston acts on the helical gears on the inside surface of the transmission and rotates the camshaft to the specific advanced or retarded angle position.

Three electrical pin contacts are located on the front surface to verify the default maximum retard position using an ohmmeter. This is required during assembly and adjustment. (see service notes further on).

Oil Distribution Flanges:

The oil distribution flanges are bolted to the front surface of each cylinder head. They provide a mounting location for the VCC solenoids as well as the advance-retard oil ports from the solenoids to the intake camshafts.

Camshafts
Each intake camshaft has two oil ports separated by three sealing rings on their forward ends.

The ports direct pressurized oil from the oil distribution flange to the inner workings of the VCC transmission.

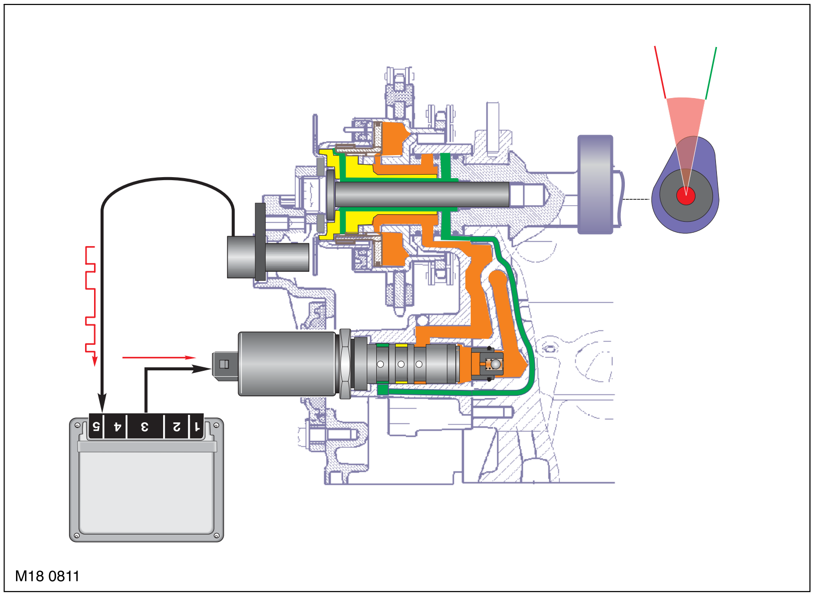
Each camshaft has REVERSE threaded bores in their centres for the attachment of the timing chain sprockets on the exhaust cams and the VCC transmissions for each intake camshaft as shown.

Camshaft Position Impulse Wheels:
The camshaft position impulse wheels provide camshaft position status to the engine control module via the camshaft position sensors. The asymmetrical placement of the sensor wheel pulse plates provides the engine control module with cylinder specific position ID in conjunction with crankshaft position.

VCC Control
As the engine camshafts are rotated by the primary and secondary timing chains, the ECM activates the VCC solenoids via a PWM (pulse width modulated) ground signal based on a program map. The program is influenced by engine speed, load, and engine temperature.

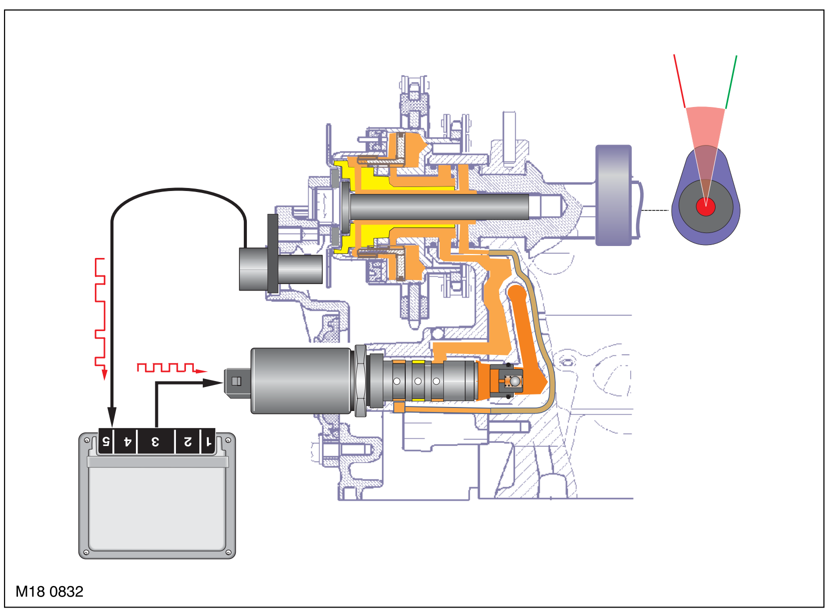
In its inactive or default position, the valves direct 100% engine oil pressure flow to achieve maximum “retard” VCC positioning

Maximum Retard Position



As the Pulse Width Modulation (PWM) increases on the control signal, the valve progressively opens the advance oil port and proportionately closes the retarded oil port.

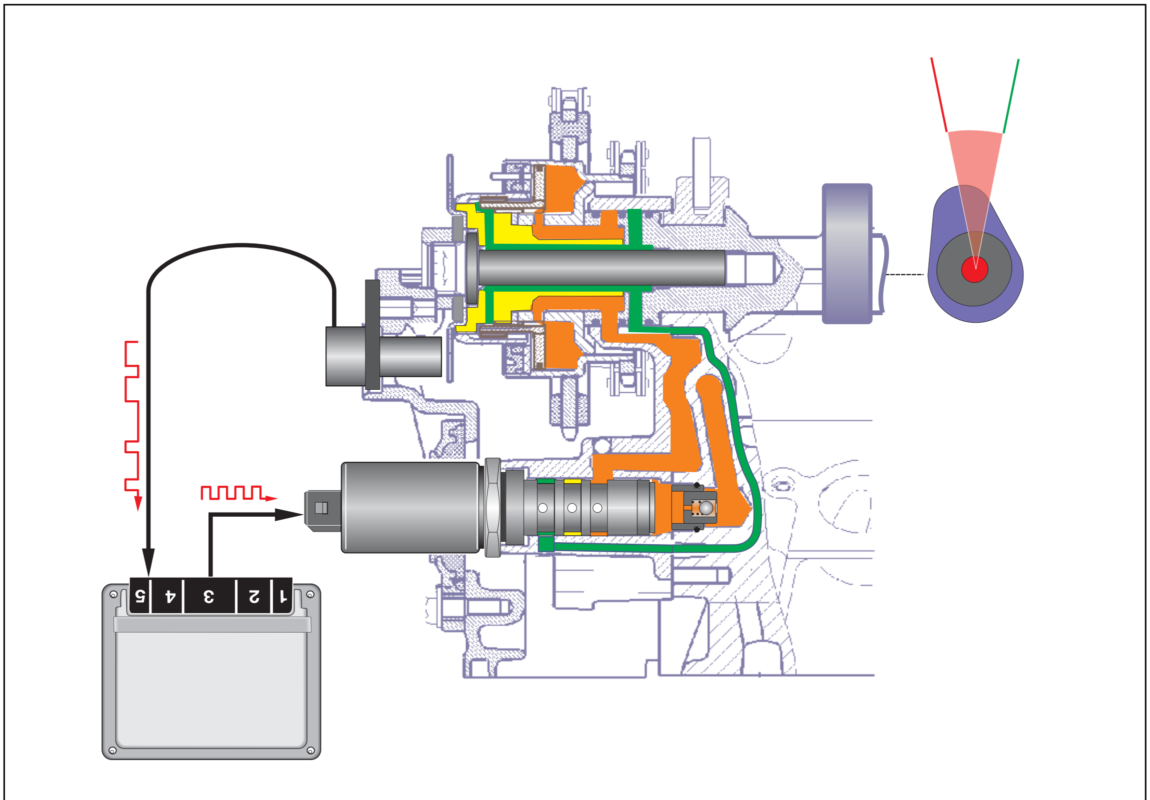
Mid Position



Oil pressure pushes the piston toward the advance position. Simultaneously the oil pressure on the retarded side (rear) of the piston is decreased and directed to the vent port in the solenoid valve and drains into the cylinder head.

At maximum PWM control, 100% oil flow is directed to the front surface of the piston pushing it rearward to maximum advance.

Maximum Advance Position



M18 0833

Varying the pulse width (on time) of the solenoids control signals proportionately regulates the oil pressures on each side of the pistons to achieve the desired VCC advance angle.

VCC Timing Procedures

Always refer to RAVE for complete Valve Timing Procedures. The valve timing adjustment requires the setting of the VCC transmissions to their maximum retard positions with an ohmmeter and attaching the camshaft gears to each camshaft with single reverse threaded bolts.

The process is as follows:

1 After locking the crankshaft at TDC, the camshaft alignment tools are placed on the square blocks on the rear of the camshafts locking them in place

2 The exhaust camshaft sprockets and VCC transmission units with timing chains are placed onto their respective camshafts

3 The exhaust camshaft sprockets and VCC transmissions are secured to the camshafts with their respective single, reverse threaded bolt. Finger tighten only at this point. Install the chain tensioner into the timing chain case and tension the chain

4 Connect an ohmmeter across two of the three pin contacts on the front edge of one of the VCC transmissions. Twist the inner hub of transmission to the left (counter clock- size). Make sure the ohmmeter indicates closed circuit. This verifies that the transmission is in

the default maximum retard position

5 Using an open end wrench on the camshaft to hold it in place, torque the VCC transmission centre bolt to specification.

Camshaft Impulse Wheel Position Tools

The camshaft impulse wheels require a special tool set to position them correctly prior to tightening the retaining nuts.

The impulse wheels are identical for each cylinder bank. The alignment hole in each wheel must align with the tools alignment pin. Therefore the tools are different and must be used specifically for their bank.

The tool rests on the upper edge of the cylinder head and is held in place by the timing case bolts.

Refer to the relevant RAVE section for complete information.

VCC Solenoid Replacement

Refer to the appropriate RAVE section for complete solenoid replacement procedure.

The solenoids are threaded into the oil distribution flanges through a small opening in the upper timing case covers.

VCC Transmission Retard Position Set Up Tools

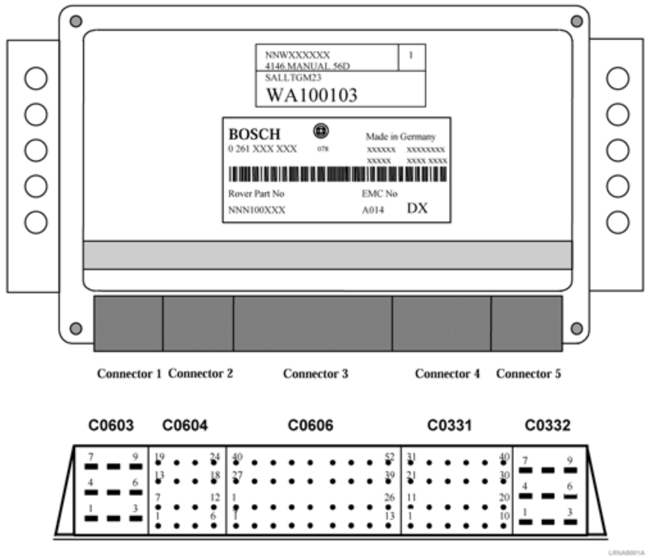
A special tool (see RAVE for correct tool number) is used to rotate the transmission to the full retard position when checking the piston position with an ohmmeter. This tool engages the inner hub of the transmission provides an easy method of twisting it to the left for the ohmmeter test.

Diagnostics

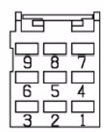
The VCC is fully compatible with the diagnostic software providing specific fault codes and test modules. Additionally, diagnostic requests section provides status of the PWM of the VCC solenoids and camshaft position feedback via the camshaft position sensors. The Service Functions section of the TestBook/T4 also provides a VCC system test.

Connector Pinouts

ME7.2 ECU Pin Out Tables

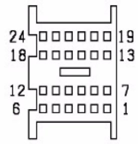


Connector 1
Connector C0603



Pin Number	Wire Color	Circuit Description	Circuit Status
1-01			
1-02			
1-03			
1-04	N	Ground	
1-05	N	Injector ground	
1-06	N	Ground	
1-07	R	Permanent battery supply	
1-08	RU	Switched battery supply (via main relay)	
1-09			

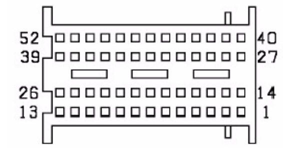
Connector 2
Connector C0604



Pin Number	Wire Color	Circuit Description	Circuit Status
2-01	NW	Rear HO2S heater drive 2	12 – 0V Switching
2-02			
2-03	YN	CAN ‘low’ signal	
2-04	YB	CAN ‘high’ signal	
2-05			
2-06			
2-07	NU	Rear HO2S heater drive 1	12 – 0V Switching
2-08	YW	Rear HO2S signal ground 2	0V
2-09	Y	Front HO2S signal ground 1	0V
2-10	YR	Front HO2S signal ground 2	0V
2-11	YU	Rear HO2S signal ground 1	0V
2-12			
2-13	NR	Front HO2S heater drive 2	12 – 0V Switching
2-14	BW	Rear HO2S signal 2	.2 - .8V Steady *
2-15	B	Front HO2S signal 1	.2 - .8V Switching *
2-16	BR	Front HO2S signal 2	.2 - .8V Switching *
2-17	BU	Rear HO2S signal 1	.2 - .8V Steady *
2-18			
2-19	N	Front HO2S heater drive 1	12 – 0V Switching
2-20			
2-21			
2-22			
2-23	N	Main power relay drive (EMS main relay)	
2-24			

* Note: The signal circuits are held at .5V by ECM when the HO2S's are not switching.

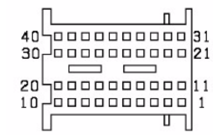
Connector 3
Connector C0606



Pin Number	Wire Color	Circuit Description	Circuit Status
3-01	NY	Cylinder 2 (Injector 8)	
3-02	NG	Cylinder 3 (Injector 6)	
3-03	N	Purge valve drive	
3-04			
3-05			
3-06	N	Ground	
3-07	RG	5V reference supply to HFM	
3-08	NR	Throttle position signal input 2	4.5 - .5V Closed – WOT
3-09	B	Air flow meter signal ground	
3-10	N	Throttle sensor reference voltage supply	
3-11			
3-12	BG	Starter motor feedback	12V Cranking
3-13	U	Generator charge signal	Batt + Charging
3-14	NR	Cylinder 7 (Injector 7)	
3-15	NS	Cylinder 6 (Injector 5)	
3-16	GS	VCC drive 2	12 – 0V Switching
3-17			
3-18			
3-19	W	Camshaft sensor input signal 2	12 – 0V Switching
3-20	Y	Camshaft sensor input signal 1	12 – 0V Switching
3-21	NO	Water temperature signal ground	
3-22	YG	Water temperature signal input	
3-23	Y	Air flow meter signal input	
3-24	P	Throttle position signal input 1	.5 – 4.5 Closed - WOT
3-25	U	Throttle position signal ground	

Pin Number	Wire Color	Circuit Description	Circuit Status
3-26			
3-27	NP	Cylinder 8 (Injector 4)	
3-28	O	Cylinder 5 (Injector 2)	
3-29	GU	VCC drive 1	12 – 0V Switching
3-30			
3-31	NW	Electrically controlled thermostat drive	
3-32	Y	Crankshaft sensor signal input A	
3-33		Electronic ground	
3-34	YU	Air temperature signal input (from HFM)	
3-35	N	Knock sensor ground (cylinders 3 & 4)	
3-36	B	Knock sensor signal (cylinders 3 & 4)	
3-37	B	Knock sensor signal (cylinders 7 & 8)	
3-38	N	Knock sensor ground (cylinders 7 & 8)	
3-39			
3-40	NU	Cylinder 4 (Injector 3)	
3-41	NW	Cylinder 1 (Injector 1)	
3-42	W	Throttle position actuator 1	12 – 0V PWM @ 2K Hz
3-43	R	Throttle position actuator 2	12V
3-44			
3-45	N	Crankshaft sensor signal ground	
3-46	B	Crankshaft sensor signal input B	
3-47			
3-48	N	Knock sensor ground (cylinders 1 & 2)	
3-49	B	Knock sensor signal (cylinders 1 & 2)	
3-50	B	Knock sensor signal (cylinders 5 & 6)	
3-51	N	Knock sensor ground (cylinders 5 & 6)	
3-52	UY	Secondary air valve solenoid drive	

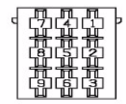
Connector 4
Connector C0331



Pin Number	Wire Color	Circuit Description	Circuit Status
4-01	U	Instrument pack generator warning lamp	
4-02	BG	Instrument pack engine cranking signal	
4-03	NU	Secondary air pump relay drive	
4-04	BG	Condensor fan drive (via power control ECU)	
4-05			
4-06	BY	Ignition switch crank position input	
4-07	NG	Pedal position sensor 1 signal ground	
4-08	W	Pedal position sensor 1 signal input	
4-09	Y	Pedal position sensor 1 reference supply	
4-10	BP	Fuel pump relay drive	
4-11			
4-12	UG	Pedal position sensor 2 signal ground	
4-13	WG	Pedal position sensor 2 signal input	
4-14	YG	Pedal position sensor 2 reference supply	
4-15		Ground	
4-16			
4-17	B	Engine speed signal output (to diagnostic connector)	0 –12V Pulse, engine running
4-18	S	DM-TL heater drive	
4-19	SP	Instrument pack	

Pin Number	Wire Color	Circuit Description	Circuit Status
4-20	BG	DM-TL motor drive	
4-21	SN	Light Control Module	
4-22	YG	Vehicle speed signal input	
4-23			
4-24	UR	Brake pedal sensor input	11V with pedal pressed
4-25			
4-26	GB	Ignition switch position 2 input	
4-27	YB	Steering wheel switches input (cruise switch input)	
4-28	NS	Brake pedal sensor input	12V with pedal pressed
4-29	BG	Air con compressor disengage output (to ATC ECU)	
4-30	NU	DM-TL changeover valve drive	
4-31			
4-32	WPY	K-Diagnostic Line	
4-33	BP	Immobilisation signal	
4-34			
4-35			
4-36	YB	CAN ‘high’ signal	
4-37	YN	CAN ‘low’ signal	
4-38	US	Thermostat monitoring coolant temperature sensor ground	
4-39	BS	Thermostat monitoring coolant temperature sensor signal	
4-40	YN	Starter motor relay drive	Batt + when cranking

Connector 5
Connector C0332



Pin Number	Wire Color	Circuit Description	Circuit Status
5-01	BY	Ignition coil 7 (Cylinder 7)	
5-02	BU	Ignition coil 8 (Cylinder 4)	
5-03	BR	Ignition coil 2 (Cylinder 8)	
5-04	BY	Ignition coil 3 (Cylinder 6)	
5-05	N	Ignition ground	
5-06	BW	Ignition coil 1 (Cylinder 1)	
5-07	BU	Ignition coil 4 (Cylinder 3)	
5-08	BW	Ignition coil 5 (Cylinder 2)	
5-09	BR	Ignition coil 6 (Cylinder 5)	