



BOSCH 5.2.1 ENGINE MANAGEMENT SYSTEM

Introduction

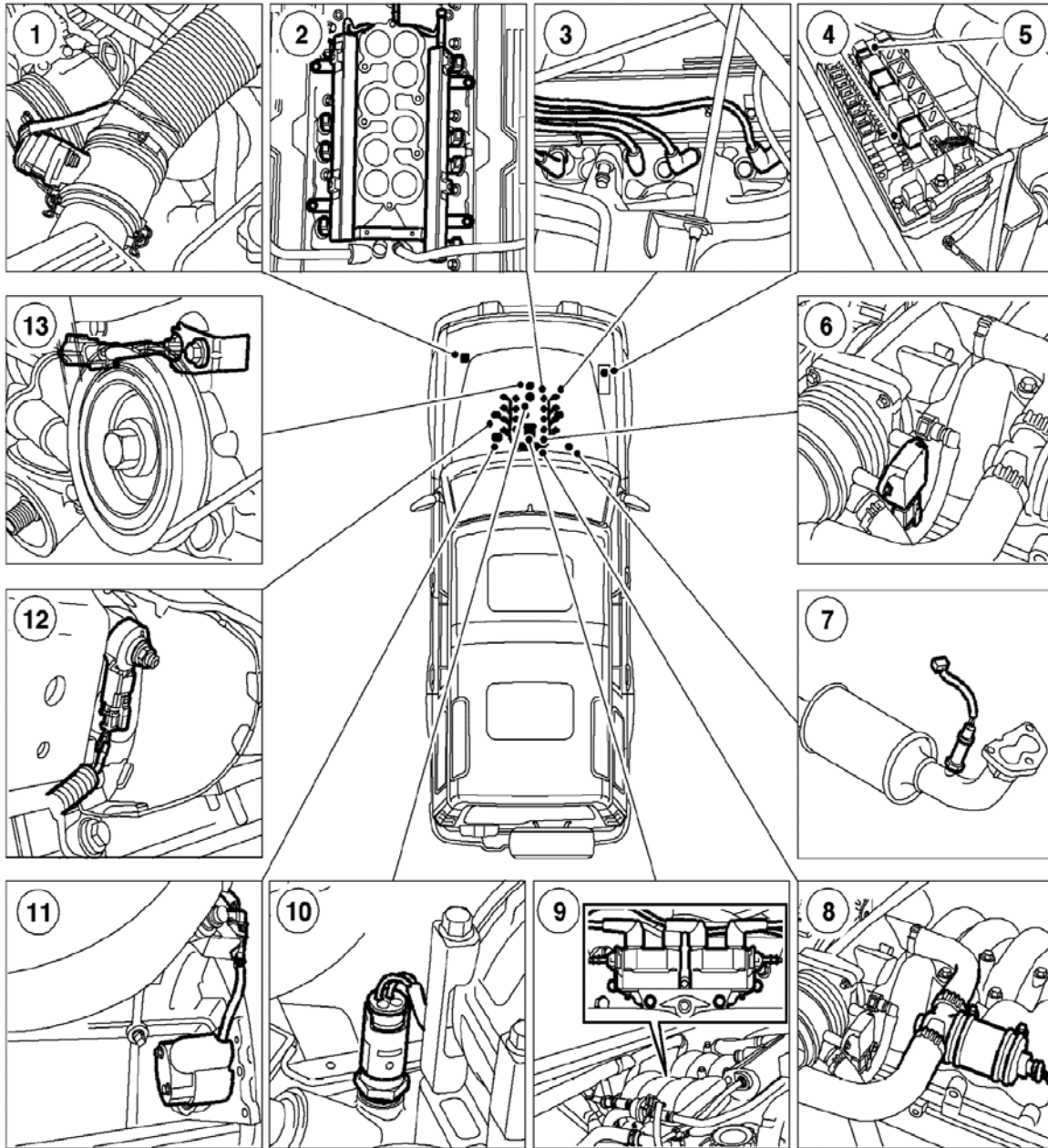
Bosch supplies the engine management system used on Discovery Series II and Range Rover beginning mid 1999 model year. It is referred to as the Bosch Motronic 5.2.1 system. The system supports sequential fuel injection and waste spark ignition. The system is designed to optimize the performance and efficiency of the engine.

The key functions of the Bosch 5.2.1 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 on each cylinder
- To optimize adjustment of the injection and ignition timings 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 catalyts operate at their maximum efficiency
- To maintain full idle speed control of the engine
- To ensure the vehicle adheres to the emission standards
- To ensure the vehicle meets with the fault handling requirements, as detailed in the 'On-board diagnostic II' (OBDII) legislation
- To provide an interface with other electrical systems on the vehicle

To deliver these key functions, the Bosch 5.2.1 engine management system 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.

System Components



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| 1. Mass Airflow & Temperature Sensor | 8. Idle Air Control Valve |
| 2. Fuel Injectors | 9. Ignition Coils |
| 3. Spark Plugs/High Tension Leads | 10. Engine Coolant Temperature Sensor |
| 4. Fuel Pump Relay | 11. Crankshaft Speed and Position Sensor |
| 5. A/C Compressor Clutch & Cooling Fan Relay | 12. Knock Sensor |
| 6. Throttle Position Sensor | 13. Camshaft Position Sensor |
| 7. Heated Oxygen Sensor | |

System Inputs

The Bosch 5.2.1 system 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 (position II)
- Throttle position sensor (TPS)
- Crankshaft position sensor (CKP)
- Camshaft position sensor (CMP)
- Engine coolant temperature sensor (ECT)
- Knock sensors (KS)
- Air mass flow and temperature sensor (MAF)
- Heated Oxygen sensors (HO2)
- Immobilization signal
- Fuel level signal
- Vehicle speed sensor (VSS)
- Rough road detection signal
- Automatic temperature control (ATC) system request
- Automatic gearbox information
- Fuel tank pressure sensor

Engine control module

The engine control module (ECM) is secured to a pressed steel bracket located at dash level on the right hand 'A' post. It features five separate electrical connectors. Each connector groups associated pin-outs together.

The five connectors interlock when connected to the ECM. Therefore, they must be connected to the ECM in a specific order. Connector 1 must be used first, connector 2 second, connector 3 third, and so on. The connectors can be disconnected only in the reverse order of this. It is not possible to remove the connectors from the ECM in any other order, the way in which the connectors interlock prevents this.

The main functions of the groups of pin outs incorporated into each connector are detailed in the following table.

Connector number	Connector color	Main functions
1	Black	Main power supply and ground connections
2	Black	Oxygen sensor inputs and Oxygen sensor
3	Black	All sensor inputs and outputs



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4	Black	Most related vehicle system communications.
5	Black	Ignition coil control

The ECM is programmed during manufacture by writing the program and the engine 'tune' into the Flash EPROM (erasable programmable read only memory). This Flash EPROM can be reprogrammed in service, using TestBook. In certain circumstances, it is possible to alter the 'tune' or functionality of the ECM using this process.

The engine management system (EMS) now used on Discovery Series II, is an improvement over existing systems. The new EMS now improves the capability with respect to the monitoring, evaluating, diagnosing and correcting of many engine mechanical irregularities. It also has improved capability for monitoring and adapting its own operation to ensure that any mechanical variations do not affect the performance or the exhaust emissions of the engine.

The ECM has advanced fault-handling capabilities. It can detect the type and severity of faults, store relevant engine operating conditions at the time a fault occurs and also store the time the fault occurred. The individual fault handling procedures the ECM completes will be explained throughout the section. The ECM stores fault codes, referred to as 'P' codes. It is this 'P' code that Land Rover has to make available to third party scanning tools. The 'P' codes are defined within the OBDII legislation. Three environment variables are stored for each fault, in addition to Freeze Frame data. Once recorded, details of a fault will stay in the ECM's memory for 40 'trips'.

A 'trip' is defined precisely by the on board diagnostic (OBD) legislation. It is a predetermined routine through which the engine or vehicle must pass before the ECM will attempt to 'validate' a previously faulty signal. There are a number of OBD set routines. They are all grouped into one of several inspection/maintenance flags (IMF). These are:

- Catalytic converter efficiency
- Purge (all markets) / evaporative emission leak detection diagnostic.
- Oxygen sensor diagnostics
- Oxygen sensor heater diagnostics

The above diagnostics all demand very strict engine conditions be met before they will run. By following the appropriate driving cycle, the IMF flags will indicate when the diagnostic completes. Most of the other diagnostics will operate within the first 30 seconds after engine starts. Refer to the appropriate service literature for details on drive cycle, trip, and journey details for any given sensor/system.

TestBook can be used to view the diagnostic routines performed by the ECM, which need to be set before the relevant IMF becomes set. When a fault code is stored, it will indicate, via TestBook, the IMF required to ensure that successful repair can be verified.

When certain fault conditions prevail, the EMS stores data relating to the value of certain engine inputs. These values, when stored, are known as 'freeze frame data'. Freeze frame data is not the same as the three environmental variables stored when a fault is detected. Environmental variables are stored along with each fault (three variable conditions for each 'P' code), whereas freeze frame data is stored for the highest priority fault (different faults have different priorities, according to their likely impact on exhaust gas emissions).

Freeze frame data always records:

- Engine speed
- Engine load
- 'P' code
- Short term fuelling trim A / B
- Long term fuelling trim A / B
- Fuelling status A / B
- Coolant temp
- Road speed

The ECM will illuminate the malfunction indicator lamp (MIL) on detection of a fault, providing the fault has occurred on two consecutive driving cycles. This strategy 'validates' the fault, ensuring that the MIL does not illuminate needlessly. There is one exception to this, this being the ECM detecting that a catalyst-damaging misfire is currently occurring. In this case, the ECM will flash the MIL immediately the fault is detected. If the fault rectifies itself, the ECM will stop flashing the MIL, changing it to continuously 'on'.

The MIL is illuminated by a bulb check facility when the ignition is switched to position II, a "MIL event fault", or if the automatic gearbox requests it.

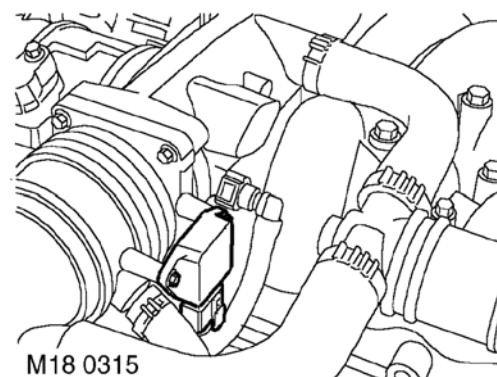
Ignition switch

The ignition switch supplies a signal to the ECM whenever it is turned to position II ('ignition on'). Using this signal, the ECM is able to detect when the ignition switch is turned 'on' and when it is turned 'off'. The ECM will initiate its 'power-up' sequence whenever the ignition is turned 'on'. At this time it will energize the main relay (which, amongst other things, supplies the main feed to the ECM), energize the fuel pump relay and initiate a 'self-check' on the EMS system.

When it detects the ignition switch has been turned 'off', the ECM will stop the engine (if it was running) and record all the relevant information within its internal memory to enable the quick-start functions to operate correctly. It will then initiate its 'power-down' sequence, which involves de-energizing the main relay.

Throttle position sensor

The throttle position sensor (TPS) is connected to the throttle valve shaft, located on the throttle body portion of the plenum chamber (see figure 50). It monitors the position and the rate of movement of the throttle valve, which is controlled by the driver via the throttle pedal and accelerator cable.





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The throttle position sensor is a potentiometer. It receives a 5 volt supply from the ECM whenever the ignition switch is turned 'on'. It then returns a proportion of the supplied voltage to the ECM to indicate its position and rate of movement. The actual position of the throttle valve, the direction in which it is moving (if it is moving) and, if so, the rate at which it is moving will determine the value of the voltage returned. The returned voltage will be in the range of 0.1 volts (throttle fully closed) to 4.8 volts (throttle fully open). The ECM will supply 5 volts on the signal wire when the throttle potentiometer is disconnected. This voltage is used in the diagnostics of the wiring harness. The sensor has gold plated terminals to reduce the environmental impact. Care must be taken not to scratch the gold coating, particularly when using a multimeter connected directly to the sensor.

In addition to using the signal supplied by the throttle position sensor to determine the driver's requirements, the ECM also uses the signal to check the plausibility of the signal supplied by the air flow meter. In circumstances where the signal supplied by the air flow meter indicates that only a small quantity of air is entering the engine, and the signal supplied by the throttle position sensor indicates a large throttle angle (i.e. throttle open), the ECM will store a 'ratio fault' indicating the throttle position and airflow have not matched.

The TPS sensor does not require any type of adjustment or calibration process. The Bosch 5.2.1 ECM is able to 'learn' the closed throttle position using the signal it supplies. If the ECM detects a sensor failure, or the signal supplied by the throttle position sensor is deemed implausible, then it will introduce a substitute signal. The actual value of the substitute signal will be dependent upon a variety of signals received from other sensors located on and around the engine. Engine performance will be affected in these circumstances and the driver will notice the following:

- The engine will idle poorly
- The vehicle will default to 3rd / 4th gear (limp home strategy automatic vehicles only)
- The engine will run poorly and respond poorly to throttle pedal movement
- The gearbox will not kickdown (automatic vehicles only)
- Altitude adaptations will be incorrect (engine performance affected even more when the vehicle is operated at high altitudes)

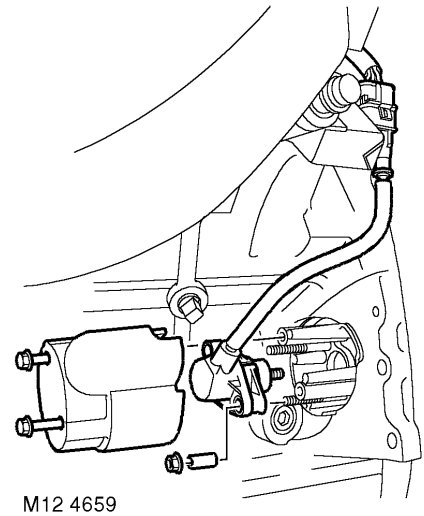
Expected Values

Throttle Angle	Max/Min Value	Nominal Value	Diagnostic Fault Value	Nominal Resistance
Closed	0.811 mV	0.894 mV	0.960 mV	1.013kW
Fully Open	0.162 mV	0.096 mV	0.040 mV	2.575kW

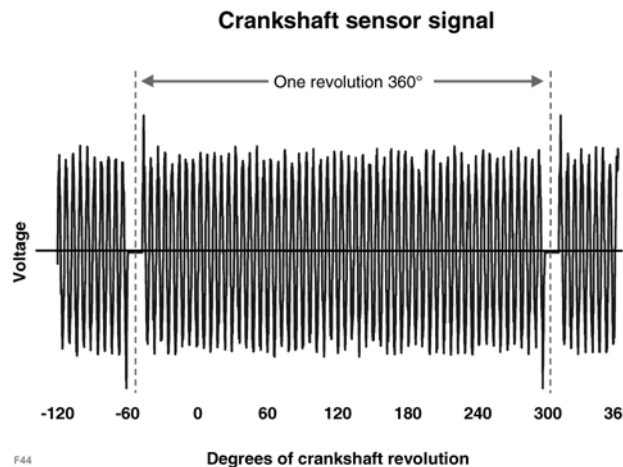
TestBook will retrieve the fault code and perform the necessary diagnostics. The sensor can also be probed directly, providing the care point mentioned above is adhered to. TestBook also has the capability of displaying the value of the TPS signal received by the ECM. It displays this on the 'live reading' screen. It will also display the altitude adaptive value currently being used on this screen.

Crankshaft position sensor

The crankshaft position sensor is located in the engine block, just below number 7 cylinder (see figure 51). It protrudes through the cylinder block and is positioned adjacent to the face of the flywheel or flex plate. The sensor reacts to a 'drilled reluctor' incorporated into the flex plate to ascertain engine speed and position information. The sensor is located on a spacer and is secured in position by a single bolt. The spacer is 18 mm (0.709 in) thick on vehicles used with automatic transmission. The thickness of the spacer determines how far the sensor protrudes through the cylinder block and, therefore, sets the position of the sensor in relation to the flywheel or flex plate. The sensor and the spacer are covered by a protective heat shield. The sensor has three wires attached to it; one signal wire, one ground wire connected to the ECM and one ground wire connected to vehicle ground. This last wire acts as a shield to earth any stray electromagnetic radiation produced from the crankshaft signal.



The crankshaft sensor is an inductive type sensor which produces a sinusoidal output voltage signal. The following illustration shows a typical crankshaft signal over a 480° crankshaft revolution. This voltage is induced by the proximity of the moving toothed reluctor, 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 rpm rises and the speed at which the reluctor passes 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) but does measure 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 teeth are spaced at 6° intervals, with two teeth missing at 60° BTDC to give the ECM a hardware point of reference, so there is a total of 58 teeth.



The ECM outputs an engine speed signal to the automatic gearbox, the SLABS ECU, the instrument pack and the ACE ECU. The signal to the automatic gearbox TCM and the SLABS ECU are supplied via the CAN link, while the signals to the ACE ECU and the instrument pack are carried via a frequency dependent digital signal.

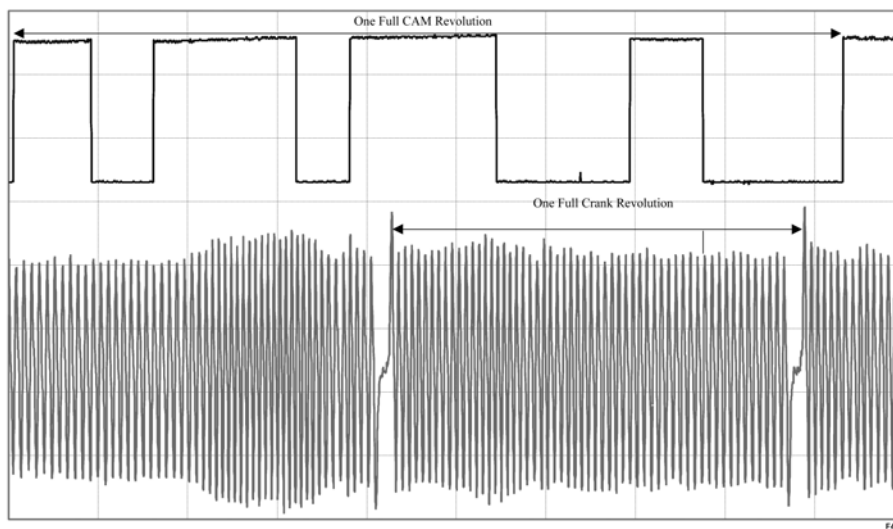
The signal produced by the crankshaft position sensor is critical to engine running. There is no backup strategy for this sensor and failure of the signal will result in the engine stalling and/or failing to start. If the sensor fails when the engine is running, then the engine will stall, a fault code will be stored and details captured, of the battery voltage, coolant temperature and 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 not extinguish.

During the power-down procedure, which occurs when the ignition is switched 'off', the ECM stores details of the position of the crankshaft. This enables the ECM to operate the injectors appropriately to aid quick engine start, which serves to reduce emissions when the engine is cold.

Camshaft position sensor

The camshaft position sensor is located in the timing cover and the tip of the sensor is positioned in close proximity to the camshaft gear. The camshaft gear incorporates four teeth. The camshaft position 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. Using this signal in conjunction with the signal supplied by the crankshaft position sensor, the ECM is able to detect the firing position of the engine (i.e. the exact position and stroke of each piston). Care must be taken to avoid fitting an incorrect camshaft gear, as the gear used on engines equipped with GEMS EMS looks similar, but if this gear is used in place of the correct gear, a fault will be stored, as the two gears have a different tooth spacing pattern.

Unlike an inductive type sensor, a hall-effect sensor does not produce a sinusoidal output voltage (sine wave).



Camshaft/Crankshaft Signal Output

Instead it produces a 'square wave' output. The edges are very 'crisp', rising very sharply and falling very sharply, giving the ECM a defined edge on which to base its calculations. An implausible signal will result in the following:

- The MIL lamp illuminated after 'validating' 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 compression stroke rather than during exhaust stroke
- Quick crank/cam synchronization 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, and the engine load calculation and the engine rpm at the time of failure. TestBook will display the live readings from the camshaft sensor.

Engine coolant temperature sensor

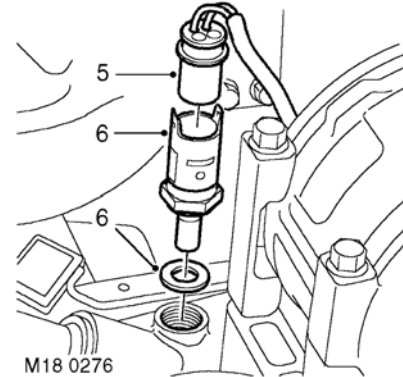
The engine coolant temperature sensor is located near the top of the engine, adjacent to the coolant outlet pipe. The sensor features four electrical connections; two are used on Discovery Series II applications and all four are used in 1999 MY Range Rover applications. The sensor conforms to the conventional negative temperature coefficient (NTC) electrical characteristics.

The signal supplied by the engine coolant temperature sensor is critical to many fuel and ignition control strategies.

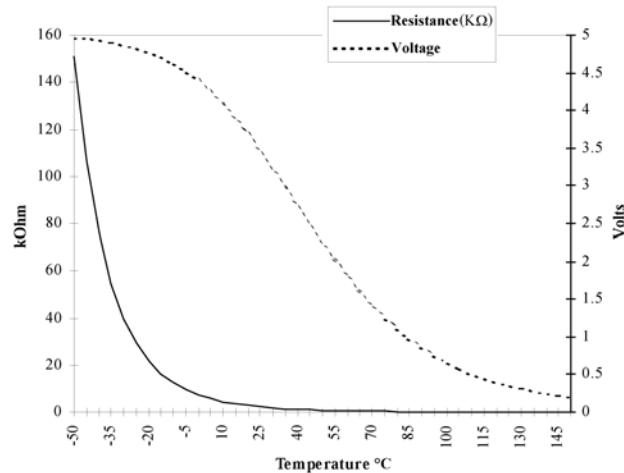
Therefore, the Bosch 5.2.1 system incorporates a complex engine coolant temperature sensor default strategy, which it implements in the event of failure. The ECM uses several alternative inputs to determine the specific default value selected in these circumstances. The amount of time the engine has been running and the temperature of the air entering the engine are the primary inputs used to determine the default value. The software model of the temperature increasing will finish when it reaches a value of 150°F (65°C). This value is then used until the engine is switched off.

The following symptoms may be noticeable in the event of an engine coolant temperature sensor failure:

- The MIL lamp illuminated (after 'validating' the fault)
- Poor engine hot and cold start
- Overheat warning lamp (incorporated within the Instrument pack) is illuminated
- Excessively hot or cold needle reading on the temperature gauge



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

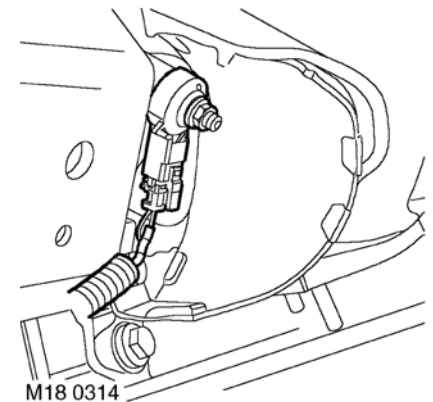


Coolant Sensor Operational Values

Knock sensors

There are two knock sensors on the V-8 engine, both located directly on the cylinder block, one on each side. The knock sensors produce a voltage signal in proportion to the amount of mechanical vibration generated at each ignition point. Each sensor monitors the four cylinders in one bank.

The knock sensors incorporate a piezoceramic crystal. This crystal produces a voltage whenever an outside force tries to deflect it, (i.e. exerts a mechanical load onto it). When the engine is running, the compression waves in the material of the cylinder block, caused by the violent combustion of the fuel/air mixture within the cylinders, deflect the crystal. As described above, these forces acting on the crystals cause them to produce an output voltage signal. These signals are supplied to the ECM and compared with sample 'mapped' signals stored within its memory. From this, the ECM can identify when the ignition is too far advanced and causing pre-ignition problems.



Care must be taken at all times to avoid damaging the knock sensors, but particularly during removal and installation procedures. The recommendations regarding to 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 camshaft sensor signal, to determine the optimum ignition point for each cylinder. The ignition point is set according to pre-programmed ignition maps stored within the ECM. In this case, 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 adaptations. 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 'adaptations'. The ECM has the capability of adapting its fuel and ignition control outputs in response to several sensor inputs.

Unlike previous Land Rover engine management systems, the Bosch 5.2.1 system is capable of advancing the ignition timing for improved power and economy, as well as retarding it.

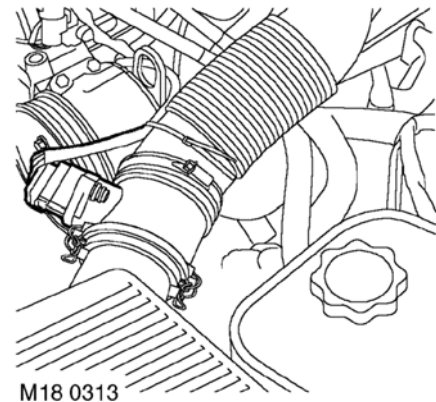
The ECM will cancel 'closed loop' control of the ignition system if the signal received from either knock sensor becomes implausible, or the signal from the camshaft sensor is corrupted at any time. In these circumstances, the ECM will default to a safe ignition map. This measure ensures the engine will not become damaged if low quality fuel is used. The MIL lamp will not illuminate at this time (in any market), although the driver may notice that the engine 'knocks' 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 and Intake Air Temperature sensor

The mass air flow (MAF) sensor is located in the air intake ducting, between the air filter housing and the plenum chamber. The MAF sensor returns a signal to the ECM to indicate how much air is entering the engine. The amount of air entering the engine is calculated from two functions:

- 1 The sensor incorporates a hot film element. This film is heated by the circuitry in the MAF sensor. A proportion of the air flowing into the engine flows past the film and acts to cool it. The greater the air flow, the greater the cooling effect. The output voltage varies in accordance with the amount of electrical power being consumed by the mass air flow meter to keep the film at a predetermined temperature.
- 2 The MAF sensor also incorporates an intake air temperature (IAT) sensor. This sensor is an NTC type of sensor. It informs the ECM of the temperature of the air entering the engine. The temperature of the air entering the engine will affect its density. The density of the air entering the engine will affect its ability to support combustion. The signal supplied by the temperature sensor is used to calculate the cooling effect on the hot film from a given mass of air, along with several other fuelling calculations.





The MAF 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 filter housing and the engine plenum chamber 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.

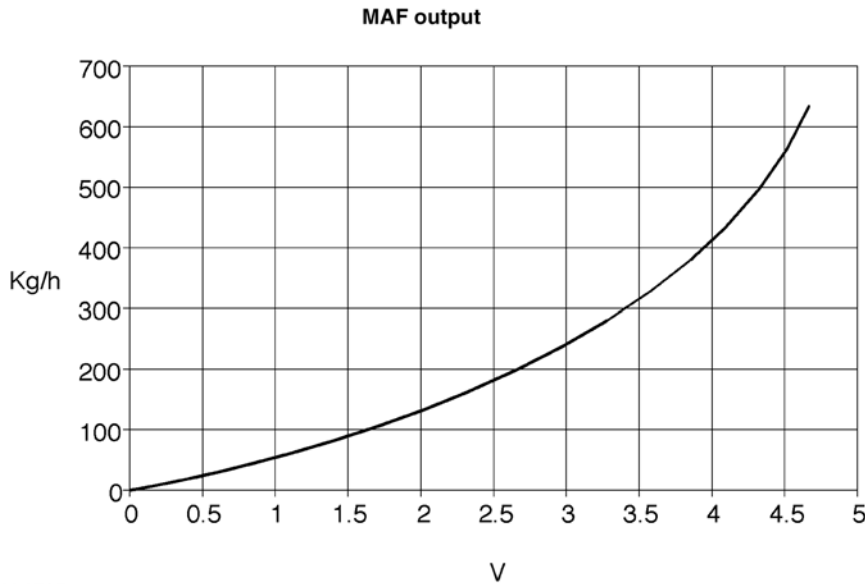
If the MAF sensor signal fails then the ECM will adopt a default strategy. This strategy will cause the ECM to assume that a certain quantity of air is entering the engine. The exact quantity will be based upon the signals received relating to throttle position, engine speed and air temperature. The following engine symptoms will be noticeable:

- The MIL lamp will be illuminated after the fault has been 'validated'
- 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 signal from the air temperature sensor fails, the ECM will assume a default value of 112°F (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 adaptations and the catalyst monitoring function of the ECM.

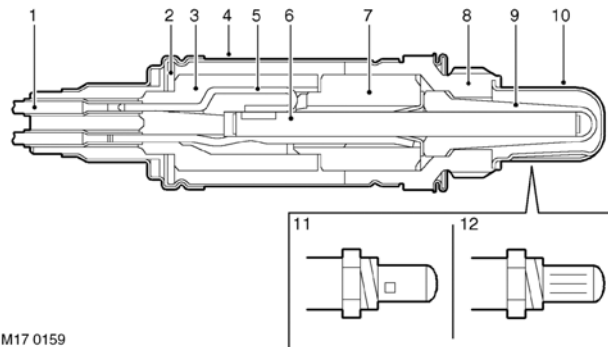
The ECM will store details of the engine speed, engine load and battery voltage when this fault is first detected.



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Oxygen sensors

There are four Oxygen sensors used on the V-8 Discovery Series II. Two of the sensors are located in each downpipe.



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11- "Downstream" Sensor tip 12- "Upstream" Sensor tip

One sensor is used upstream of the catalyst, i.e. between the catalyst and the engine, and one is used immediately downstream of the catalyst. The two sensors used upstream of the catalyst are referred to as 'pre-catalyst' sensors (12), while the two sensors used downstream are referred to as 'post-catalyst' sensors (11). It should be noted that the 'pre-catalyst' Oxygen sensors are not interchangeable with the 'post' catalyst Oxygen sensors. The pre and post sensors can be identified by the shape of the vents on their protective metal tip shell., as shown below.



The Oxygen sensors 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.

Oxygen sensors are pre-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 reinstalled, a small amount of anti-seize compound should be applied (see workshop manual for details).

The Oxygen sensors use 'Zirconium technology'. The sensors feature a Galvanic cell (6), which is surrounded by a gas permeable ceramic material (9) enclosed by a protective metal shell (10). This allows exhaust gas to come into contact with one side of the sensor. The other side of the sensor is exposed to the atmosphere. Due to its construction, the sensor produces a voltage. The precise value of the voltage produced is dependent upon the ratio of Oxygen in the atmosphere compared to the Oxygen in the exhaust gas. The voltage produced for an exhaust gas with Lambda 1 (i.e. stoichiometric air, fuel ratio of 14.7:1) is 0.45 - 0.5 volts (450 – 500 mv). The voltage will fall in value to approximately 0.1 volts (900 mv), or Lambda 0.8, when the Oxygen in the exhaust gas rises (lean mixture - too much air in relation to fuel). The voltage will rise in value to approximately 0.9 volts when the Oxygen level in the exhaust gas falls to approximately Lambda 1.2 (rich mixture - too much fuel in relation to air).

The voltage from the Oxygen sensor is communicated to the ECM via the Oxygen sensor signal wires (1, 5). The ECM monitors the effect of altering the injector pulse widths uses the information supplied by the Oxygen sensors. 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.

The ECM continuously checks the signals supplied by the Oxygen sensors for plausibility. If it detects an implausible signal, then it will store a relevant fault code. On the second concurrent 'journey' that a fault is recognized, the ECM will illuminate the MIL lamp and store details of engine speed, engine load and the Oxygen sensor voltage. The ECM requires the Oxygen sensor signals to set most of its adaptations. Failure of an Oxygen sensor will result in most of these adaptations resetting to their default values. This, in turn, will result in the engine losing its 'finesse'. The engine may exhibit poor idle characteristics and emit a strong smell of rotten eggs from the exhaust (H₂S).

The efficiency of the Oxygen sensors slowly deteriorates over many kilometers/miles (unless contamination such as excessive oil or lead has occurred causing sudden damage/ failure). The ECM is able to detect this steady deterioration using the feedback signals. When a signal from a sensor deteriorates beyond a predetermined threshold, the ECM will illuminate the MIL lamp and store a fault code. At the same time, the ECM will capture details of the engine speed, engine load and battery voltage. The sensor response time will normally deteriorate over its life, however the engine management system monitors performance, and will illuminate the MIL when a sensor requires replacement.



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The ECM also monitors the efficiency of the catalyts. The ECM uses the signal received from the two post-catalyst Oxygen sensors to do this. The state of each catalyst is assessed in line with its ability to 'hold' Oxygen. In a serviceable unit the 'excess' Oxygen in the exhaust gas is held on the surface of the precious metal coating of the ceramic blocks within the catalyst. This Oxygen is used to convert the harmful elements produced by incomplete combustion (particularly during acceleration and conditions where the engine requires a rich air/fuel ratio) into Carbon Dioxide, Nitrogen and water. By comparing the signals received from the pre-catalyst sensors with those received from the post-catalyst sensors, the ECM can calculate how much Oxygen is retained by each catalyst and can, therefore, determine their condition. If the ECM determines that one or both catalyts require replacement, then it will illuminate the MIL (after validating the fault) and store the relevant fault code. At the same time, the ECM will record details of the engine speed, engine load and air temperature.

Zirconium Oxygen sensors need high operating temperatures 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 Oxygen sensor to a temperature greater than 670°F (350°C). The heating rate (the speed at which the temperature rises) is carefully controlled by the ECM to prevent thermal shock to the ceramic material. By way of a PWM voltage supply to the heater elements, the ECM controls.

The rate at which the element temperature is increased. The sensors 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. When the fault is logged twice on consecutive 'journeys', the MIL lamp will illuminate.

Immobilisation signal

The BCU sends a coded signal to the ECM before it activates the starter motor. If the ECM accepts the immobilization signal (i.e. the code is correct), the engine will be permitted to start and will continue to run normally. If the immobilization signal is corrupted (i.e. not sent, or incorrect), then the ECM will allow the engine to start, but will then stop it immediately.

If the BCU is replaced during the service life of the vehicle, the immobilization code will need to be relearned. If an attempt to start the engine is made with a new ECM installed on the vehicle (an ECM not yet programmed with any immobilization code), the ECM will not allow the engine to start and will store a fault code. This fault code must be cleared and the immobilization code learned before the ECM will allow the engine to run.

The immobilization code must also be relearned in cases where an ECM from one vehicle is used on another.

If the ECM detects an incorrect immobilization code it will store a fault code. Simultaneously, the ECM will record the engine speed, battery voltage and the number of occurrences (the number of times the incorrect code has been detected).

Fuel level signal

This signal is supplied to the ECM by the instrument pack. It is used to alter the fault code strategy adopted by the ECM when a misfire is detected (see misfire detection) or if the ECM detects that the Oxygen signal is unexpectedly recording a weak air/fuel ratio. It will not stop a fault being logged but will modify the fault code to indicate the likely cause of the misfire.

Vehicle speed sensor signal

The ECM uses this signal within its calculations for idle control. The ECM also forwards the vehicle speed signal to the automatic gearbox TCM via the CAN bus. The vehicle speed signal is produced by the SLABS ECU. The signal is calculated from the road speed signals of all four wheel speed sensors.

Rough road signal

This signal is also produced by the SLABS ECU. It is derived from the variations between each signal received from the four wheel speed sensors (see section on ABS for full description).

The ECM alters its misfire detection strategy whenever a rough road signal is received. The ECM will not store details of a misfire fault at this time (see misfire detection strategy).

Automatic temperature control system request

A signal is supplied to the ECM whenever the ATC system requires the compressor clutch and/or condenser fans to function. The ECM integrates the control of these components with the engine management system. This ensures effective engine preparation for any sudden increase in the engine load.

The ECM will turn off the ATC compressor clutch if the engine coolant temperature exceeds 255°F (124°C). The ECM will turn on the condenser fans if the engine coolant temperature exceeds 212°F (100°C). See section on ATC for more details on the exact operation of the compressor clutch and condenser fans.

The ECM will store engine speed, battery voltage and engine load details whenever it detects a fault originating from the ATC circuit. It will store engine speed, intake air temperature and details of the battery voltage if the fault relates to the compressor clutch or condenser fan operation.

Automatic gearbox information

Information sent to and from the automatic gearbox TCM is transmitted on the CAN bus. Full details of this information are in the section on automatic gearbox.

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. Information regarding range selection is supplied by the TCU.

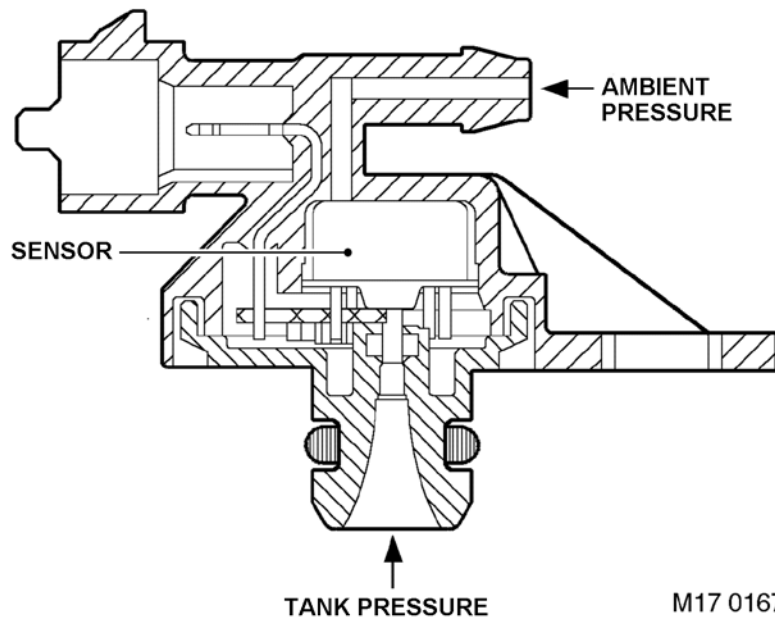
There are several possible fault codes associated with the CAN bus and the validity of information sent to and from the ECM from the TCU. In most cases, the ECM will store engine speed, engine coolant temperature and details of the battery voltage at the time when the fault is detected.

The automatic transmission TCM is able to request the illumination of the MIL lamp if it detects a fault within its systems that might lead to the vehicle emitting excessive levels of pollutants. It is good practice to check both ECM and the automatic gearbox TCM for faults when the MIL lamp is illuminated, or a MIL event is logged in the ECM.

Fuel tank pressure sensor

The fuel tank pressure sender is located in the fuel tank. This unit supplies a signal to the ECM related to the amount of fuel vapor pressure within the fuel tank. It is used as a feedback device within the ECM's evaporative emission control (EVAP) leak test. This test is detailed later in the section.

If a fault is present, the ECM will store a relevant fault code and the engine speed value, battery voltage and details of the engine coolant temperature. If the fault happen on the next 'journey', the ECM will illuminate the MIL lamp.



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 system ECUs.

The ECM drives the following components:

- Fuel injectors
- Ignition coils
- Idle speed actuator
- Main relay and fuel pump relay
- Purge valve

The ECM provides other systems with information regarding the -

- Engine speed
- Driver demand
- Grant signals ATC
- Grant signals Automatic Transmission

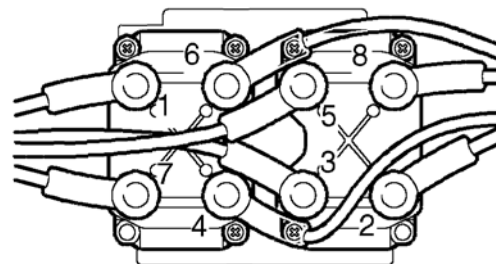
Ignition coils

The V-8 gasoline engine in Discovery Series II uses two twin-ignition coils (total of four coils). The two coils are located behind the plenum chamber at the rear of the engine (see figure 57). Each coil contains two primary windings and two secondary windings. There is a three-pin connector on each coil. Pin two connects both primary windings to an ignition supply. There is one suppression capacitor connected to each supply. This helps eliminate the effect of the magnetic radiation created by the sudden demands for power as each coil recharges.

The system employs waste spark technology to produce a powerful and precise spark. The cylinders are paired according to the table below.

Coil Set	Coil 1	Coil 2	Coil 3	Coil 4
Cylinders	1 & 6	7 & 4	5 & 8	3 & 2

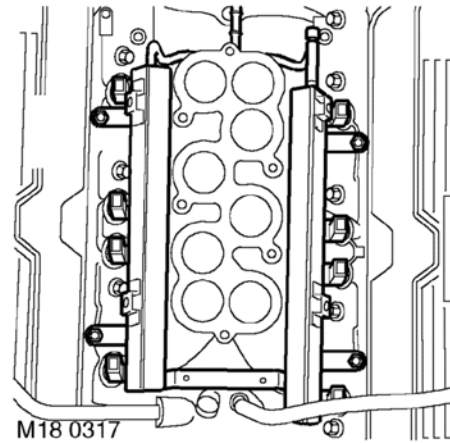
The ECM provides a path to ground whenever a spark is required. To ensure a sustained magnetic field collapse, the ECM carefully controls the rate of discharge from each coil at this time. This control also limits the amount of heat created during this process and reduces the total power consumed by each coil. Any faults detected within the primary and HT circuits will result in the ECM storing an appropriate misfire fault, but not a fault directly related to the spark creation and delivery.



M18 0279

Fuel injectors

There are eight injectors (one per cylinder) used on the V-8 gasoline engine. The ECM controls the injectors directly, and individually. It opens an injector by providing a path to ground for a voltage supplied by a common fuse. The injectors are fed fuel under pressure from a common fuel rail. A fuel pressure relief valve, incorporated into the lift pump assembly located inside the fuel tank, controls the pressure in the fuel rail. In this case, the pressure is controlled to a fixed value of 51 psi (3.5 Bar). As indicated, the fuel pressure is fixed and the relief valve provides no compensation for increases or decreases in manifold vacuum. The ECM alters injector duration to accommodate such changes.



Connecting an appropriate gauge to the Schrader valve on the fuel rail provides a method of checking the fuel pressure. The valve is located to the rear of injector no. 7. Considerable care must be taken whenever making this connection.

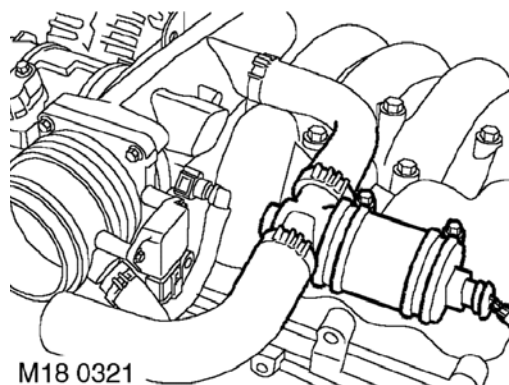
Each injector is sealed with two 'O' rings. These 'O' rings should be renewed whenever an injector is reinstalled on an engine. A small amount of engine oil can be applied to the 'O' rings to aid installation. No other form of lubrication should be used.

Measuring the electrical resistance of the injectors internal coil enables an assessment to be made of the serviceability of an injector. An injector in a serviceable condition should possess a resistance of 14.5 ohms at 68°F (20°C) with a tolerance of ± 0.7 ohms.

The ECM can detect electrical inconsistencies within each injector. It can also detect, via feedback from the Oxygen sensors, 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 one of the following: battery voltage, engine coolant temperature or intake air temperature. The precise details stored depend on the exact nature of the fault detected.

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

Idle speed actuator



The idle speed control actuator is located behind the throttle body on the intake manifold. It is connected to the intake manifold by two hoses. One hose connects upstream and the other connects downstream of the throttle valve. Therefore, the idle speed actuator effect provides an air bypass for the throttle valve.

The ECM controls the engine idle speed via the idle speed actuator. It does this by allowing a measured quantity of air into the engine when the throttle valve is closed. The idle speed actuator comprises a rotary valve and two electrical coil windings. The ECM alters the position of the idle speed actuator and, therefore, the amount of air bypassing the closed throttle valve by providing a PWM voltage to the two opposing coils inside the actuator. These coils control the position of the rotary valve by producing opposing magnetic fields. When the ECM identifies a need for a higher idle speed it enables a greater quantity of air to bypass the throttle valve. It does this by altering the PWM voltage supplied to both coils. This provides an imbalance in magnetic fields inside the actuator and, in turn, alters the amount of air bypassing the throttle valve.

The ECM controls the position of the rotary valve within the idle speed actuator to maintain a stable idle speed in all conditions. It will alter the position to obtain a pre-set target speed. The precise pre-set idle speed will vary according to the operating conditions of the engine and the transmission gear that is selected. These pre-set speeds are detailed in the table below.

Condition	Air conditioning status	Target idle speed (rpm) high range	Target idle speed (rpm) low range
First 20 seconds after a cold start	N/A	1200	1200
Low battery voltage detected	N/A	850	850
Drive selected	On	740	580
Park/ neutral selected	On	740	580
Drive selected	Off	660	580
Park/ neutral selected	Off	660	580



BOSCH 5.2.1 ENGINE MANAGEMENT SYSTEM

For 20 seconds immediately following cold start, the idle speed will be raised to 1200 rpm. At the same time the ECM will retard the ignition timing. These actions ensure the engine and the catalysis reach their operating temperatures as quickly as possible.

The ECM can identify faults with the circuitry used to control the position of the idle speed actuator. In circumstances where it detects a fault with one coil it will de-energise the other coil. This action prevents the idle speed control valve being driven to a fully open or fully closed position. The idle speed control actuator contains two permanent magnets inside the body. These magnets will determine the position of the valve at this time. In this position the engine will idle at approximately 1200 rpm. This state should not be confused with the target idle speed initiated by the ECM for the first 20 seconds immediately following cold engine start.

The ECM will store fault codes relating to the electrical properties of the idle speed actuator and to associated failures, such as poor engine response to movement of the rotary valve. The associated data stored will depend upon which fault is detected, such as battery voltage, engine coolant temperature and throttle angle for faults related to the circuitry; or engine speed, engine coolant temperature and intake air temperature for 'poor response' fault codes.

If ECM control of the idle speed actuator is suspended, (i.e. fault stored), then the driver may notice the following symptoms relating to engine performance:

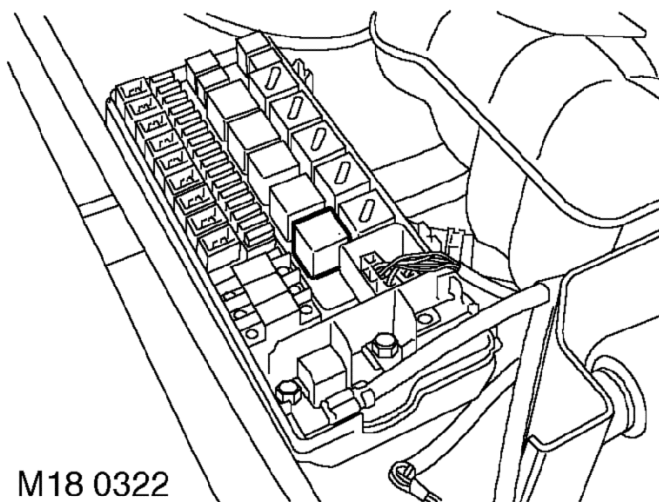
- The engine will exhibit poor idle stability
- The engine will exhibit a high idle speed
- The engine will be prone to stalling
- The engine will be difficult to start

Main relay and fuel pump relay

The ECM controls the main relay and the fuel pump relay. They are both located in the under-hood fuse box.

The ECM energizes the fuel pump relay when the ignition is first turned to position II. It also energises it during engine cranking and when the engine is running.

The ECM controls its own power supply, via the main relay. When the ignition is turned to position II, the ECM provides a ground to the relay coil winding. This, in turn, connects the main power feed to the ECM. The ECM controls the main relay and therefore its own power, so that when the ignition is turned off it can follow the previously described power-down sequence, during which it records values from various sensors and writes adaptations 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 15 seconds after the ignition has been switched off, as long as the coolant temperature is not rising.



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 its minimum), the ECM will store adaptive faults as it tries to increase the air/fuel ratio by increasing the duration (pulse width) of the injectors.

Failure of the main relay will result in engine non-start. The engine will cease to operate if the main relay fails while the engine is running.

Failure of the fuel pump relay will result in engine non-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.

Purge valve

The purge valve is located on the right hand side of the engine (when viewed from the front of the vehicle) forms part of the evaporative emission control system (EVAP) and is situated in the line between the charcoal canister and the manifold. The purge valve controls the amount of air/fuel vapor drawn from the canister into the engine. The other components incorporated into the EVAP system are:

- The charcoal canister, which is located on the right hand inner chassis rail by the hand



BOSCH 5.2.1 ENGINE MANAGEMENT SYSTEM

brake drum

- The fuel tank pressure sensor, located in the fuel sender unit
- The intake manifold

The ECM controls the amount of vapor drawn from the charcoal canister by controlling the length of time the purge valve is open. It controls the length of time it is open by supplying the purge valve with a PWM voltage. Control is used to maintain the required level of emissions, as a hydrocarbon vapor level of 1% can affect the air/fuel ratio by as much as 20%.

The ECM can diagnose faults with the purge valve and the rest of the EVAP system. The ECM will store the relative fault codes, along with details of the engine speed, battery voltage and air temperature. The driver may notice the following effects in circumstances where the EVAP system has failed:

- The engine may stall periodically when returning to idle
- The engine may suffer from poor idle quality

OTHER ECM OUTPUTS

Engine speed

The engine speed signal is supplied from the ECM to the automatic gearbox TCM via the CAN bus. All other systems requiring the engine speed input receive a frequency dependent square wave supplied by the ECM.

Driver demand

The ECM receives and processes the signal supplied by the throttle position sensor. It then digitises this information, which enables it to supply a driver demand signal, via the CAN bus, to the automatic gearbox TCM or, by a PWM signal, to any other system requiring this information.

ATC grant signal

The ECM supplies a signal to the ATC Compressor relay to activate the compressor.

Torque reduction grant signal

The ECM also informs the automatic gearbox TCM if its torque reduction request has been granted.



ECM Adaptations

The ECM, as previously mentioned, 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 adaptations associated with them are:

- The idle speed control (ISC) valve
- The throttle position sensor (TPS)
- The Heated Oxygen sensors (HO2S)
- The airflow sensor (MAF)
- The crankshaft sensor (CKP)

Idle speed control valve

Over a period of time, the ECM adapts the position it sets the idle speed control valve. The adaptations are made relative to engine coolant temperature and engine load. When a new idle speed control valve or a replacement ECM is used, this adaptation should be reset.

Subsequently, the ECM will make further adaptations to suit the particular characteristics of the new or replacement components. Failure to reset the original adaptation may result in a prolonged period of poor idling. During this time the ECM slowly adapts the original, 'incorrect' value stored in its memory.

TestBook will display the adaptation currently being applied against the model programmed into its memory. This can be used to indicate the possible cause of problems relating to the amount of air entering the engine, such as air blockages or air leaks within the induction system.

Throttle position sensor

The ECM 'learns' the closed position of the throttle position sensor. The closed voltage value supplied by the sensor is stored by the ECM and can be read using TestBook (see TPS sensor for information regarding the likely readings and signal tolerance band). If the sensor is replaced, the new closed throttle position will be learned by the ECM during the IMF cycle for the TPS.

The signal from the TPS sensor is used in conjunction with the air mass flow meter to calculate the altitude adaptations. This adaptation affects the amount of fuel entering the engine and the ignition timing. Details of the value of this adaptation are supplied to the automatic gearbox TCM. Using this information, it will adapt its gear change control maps. The altitude adaptation is continuously changing and indicates current driving conditions. Details of the altitude adaptation are stored within the ECM's memory when the ignition is switched off. This enables the ECM to provide correct fuelling on the next engine start.

Oxygen sensors & air flow meter

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



BOSCH 5.2.1 ENGINE MANAGEMENT SYSTEM

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

Crankshaft position sensor

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

The ECM supports four flywheel adaptations for the crankshaft position sensor. Each adaptation relates to a specific engine speed range. The engine speed ranges are detailed in the table below.

Engine speed range	Adaptation
1800 – 3000	1.00
3001 – 3800	2.00
3801 – 4600	3.00
4601 - 5400	4.00

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

- 1 Use TestBook to clear any adaptations currently set.
- 2 With the engine warm >187°F (86°C) select 2nd gear high range
- 3 Accelerate the vehicle until the engine speed reaches the rpm 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 adaptations has been set (read this from TestBook)
- 6 Repeat the above procedure until all four adaptations are set

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

It may not be possible to reset adaptation 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 adaptation number 4 does not reset, it is permissible to leave this adaptation and let the ECM learn it.



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 allowable levels for this 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 illuminate the MIL. The ECM will also record 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' of the likely impact to the catalysts. If the number of misfires exceeds a certain value, the ECM stores catalyst-damaging fault codes, along with the engine rpm, engine load and engine coolant temperature. It will also flash the MIL lamp until the misfires no longer exceed the predetermined number. After the flashing stops, the ECM will continue to illuminate the MIL lamp until the fault is rectified.

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. 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).



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TestBook Diagnostics

The ECM will, as explained earlier, store fault codes and environmental data. The ECM also records additional data in connection with each fault. The additional data recorded is as follows:

- 1 The number of occurrences
- 2 If the fault is currently present
- 3 If the fault is historic, the number of 'journeys' that have elapsed since the fault last occurred.
- 4 The 'current time' stored when the fault occurred. (The 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.)

This information is displayed for each fault, along with an explanation of the fault code and the stored environmental data. All the above information is stored and displayed to assist with effective fault diagnosis and repair.

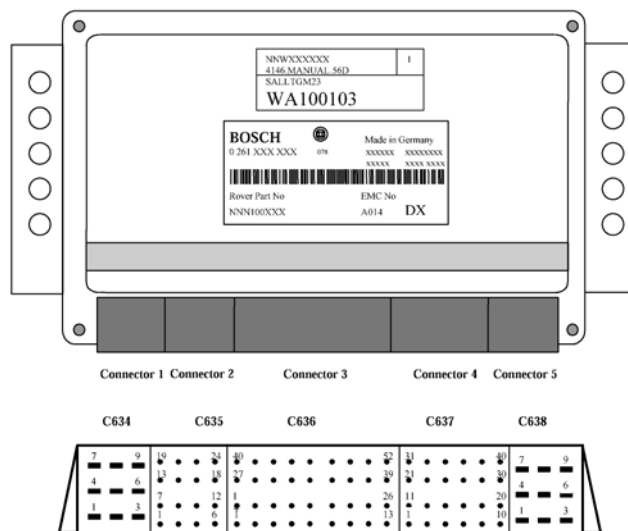
TestBook can also read real time data from each sensor, the adaptive values currently being employed and the current engine fuelling, ignition and idle settings. The live readings are displayed first as a page of readings. To gain more detail press and highlight the reading for which you require more information.

BOSCH 5.2.1 ENGINE MANAGEMENT SYSTEM

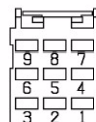


Connector Pinouts

Bosch 5.2.1



Connector 1 C0634 (9-way, Black)

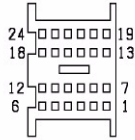


PIN	Wire Color	Description	Voltage Reading
1	W	Ignition sense (position II)	12 V
2	-		
3	-		
4	B	Chassis Earth	0V
5	B	Fuel Injectors Earth	0V
6	B	Power stage Earth	0V
7	PY	Permanent Battery supply	12 V
8	NO	Switched Relay positive	0-12V
9	-		



BOSCH 5.2.1 ENGINE MANAGEMENT SYSTEM

Connector 2
C0635 (24-way, Black)

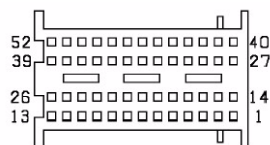


PIN	Wire Color	Description	Signal Range	PIN	Wire Color	Description	Signal Range
1	WU	HO2S Heater Bank B - downstream	12-0V	13	WO	HO2S Heater Bank B -up-stream	12-0V
2	-			14	G	HO2S signal Bank B-downstream	0-1V
3	-			15	O	HO2S signal Bank A -up-stream	0-1V
4	-			16	U	HO2S signal Bank B -up-stream	0-1V
5		Thermostat Monitoring Thermistor Ground	0V	17	Y	HO2S signal Bank A - downstream	0-1V
6	-			18	UP	Fuel pump relay [PWM]	12-0V
7	WU	HO2S Heater Bank A-downstream	12-0V	19	WO	HO2S Heater Bank A -up-stream	12-0V
8	RB	HO2S Earth Bank B-downstream	0V	20	-		
9	RB	HO2S Earth Bank A -up-stream	0V	21		Thermostat Monitoring Thermistor Signal	0-5V
10	RB	HO2S Earth Bank B -up-stream	0V	22	-		
11	RB	HO2S Earth Bank A-downstream	0V	23	UR	Main Relay Output [Earth]	0V
12	-			24		DMTL Pump Motor	12-0V

BOSCH 5.2.1 ENGINE MANAGEMENT SYSTEM



Connector 3
C0636 (52-way, Black)

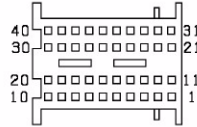


PIN	Wire Color	Description	Signal Range	PIN	Wire Color	Description	Signal Range
1	YW	Injector # 2 driver, sw. -Earth	0V	27	YB	Injector # 3 driver, sw. - Earth	0V
2	YG	Injector # 5 driver, sw. -Earth	0V	28	YK	Injector #8 driver, sw. -Earth	0V
3	NR	Purge valve driver [PWM]	12-0V	29	SP	Hill descent control [PWM]	0-12V
4		SAI Valve solenoid	12-0V	30	SY	Can. vent solenoid, sw. - Earth	0V
5	-			31	GW	Air cond. condenser fan drive	0V
6	RB	Fuel Tank pressure sensor Earth	0V	32	BY	Crankshaft sensor signal	0-300V
7	R	Air flow meter 5V supply	5V	33	-		
8	-			34	SLG	Air temperature signal	0-5V
9	RB	Air flow meter earth	0V	35	W	Knock sensor Bank B Earth	0V
10	R	Throttle Pot 5V Supply	5V	36	KB	Knock sensor Bank B Input	Analog
11	-			37	-		
12	-			38	-		
13	-			39	-		
14	YR	Injector #7 driver / sw - Earth	0V	40	YN	Injector # 4 driver, sw. -Earth	0V
15	YS	Injector #6 driver / sw - Earth		41	YU	Injector # 1 driver, sw. -Earth	0V
16		SAI Pump Relay	12-0V	42	US	Idle speed actuator open	12-0V
17	B	Cam Sensor earth	0V	43	RG	Idle speed actuator close	12-0V
18	-	Low Range Switch(Manual only)	12-0V	44	GU	Coolant Temperature output	0-12V
19	-			45	SCR	CKP shield Ground	0V
20	SU	Camshaft sensor Input signal	0-12V	46	KB	CKP Ground Ref.	0V
21	RB	Coolant sensor Earth	0V	47	-		
22	G	Coolant temperature signal Input	0-5V	48	B	Knock sensor Bank B Earth	0V
23	UG	Air flow meter signal Input	0-5V	49	KW	Knock sensor Bank A Input	Analog
24	YLG	TPS signal	0-5V	50	-		
25	RB	TPS Ground	0V	51	-		
26	-			52	-		



BOSCH 5.2.1 ENGINE MANAGEMENT SYSTEM

Connector 4
C0637 (40-way, Black)

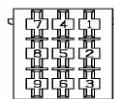


PIN	Wire Color	Description	Signal Range	PIN	Wire Color	Description	Signal Range
1	-			21	-		
2	-			22	KG	Road speed Signal [PWM]	0-12V
3	-			23	-		
4	-			24	-		
5	-			25	-		
6	RK	T-box Low Range Switch	0V= Low box	26	-		
7	-			27	-		
8	GS	Low Fuel Signal	Active= High	28	-		
9	R	Fuel Tank pressure sensor Vref	5V	29	BS	A/C. compressor "Grant" switch to earth	0V
10	-			30	-		
11	-			31	-		
12		Analogue Fuel Level	0-5V	32	K	Diagnostic K-Line Serial com.	0-12V
13	-			33	LGS	Immobiliser serial W-link	0-12V
14	GK	Fuel Tank pressure signal	0-5V	34	RG	Rough Road signal [PWM]	0-12V
15	-			35	-		
16	YS	A/Conditioning request Input	Active= Low	36	W	CAN bus 'high' line Bi-directional comms.	5-2.5V
17	WS	Engine speed output	0-5V	37	Y	CAN bus 'low' line Bi-directional comms.	0-2.5V
18	-			38	PW	A/C stand-by Signal	Active= Low
19	-			39	-		
20	RS	MIL 'on' Output; "ON" = earth	0V	40	-		

BOSCH 5.2.1 ENGINE MANAGEMENT SYSTEM



Connector 5
C0638 (9-way, Black)



PIN	Wire Color	Description	Voltage Reading
1	-		
2	U	Ignition driver, Cyl # 2 , 3 Output	Switch to Earth
3	-		
4	-		
5	B	Ignition Coil Ground	0V
6	KB	Ignition driver, Cyl # 1 , 6 Output	Switch to Earth
7	WU	Ignition driver, Cyl # 4 , 7 Output	Switch to Earth
8	R	Ignition driver, Cyl # 5 , 8 Output	Switch to Earth
9	-		



BOSCH 5.2.1 ENGINE MANAGEMENT SYSTEM
