

CONTENTS

Page

DESCRIPTION AND OPERATION

ENGINE MANAGEMENT SYSTEM COMPONENT LAYOUT	2
ENGINE MANAGEMENT SYSTEM CONTROL DIAGRAM - SHEET 1 OF 2	4
ENGINE MANAGEMENT SYSTEM CONTROL DIAGRAM - SHEET 2 OF 2	6
ENGINE MANAGEMENT DESCRIPTION	8
General	8
ECM	8
Engine sensors	15
Fuel injectors	20
Ignition coils	20
Idle Air Control (IAC) valve	21
Malfunction Indicator Lamp (MIL)	21
ENGINE MANAGEMENT OPERATION	22
General	22
Fuelling control	22
Overrun fuel cut off	24
Ignition timing	24
Catalytic converter monitoring	25
Air Conditioning (A/C)	25
Cooling fans	26
Evaporative emissions (EVAP) canister purge valve	26
Variable Intake System (VIS) valves	26
Gear shift torque reduction	27
Diagnostics	27
CRUISE CONTROL SYSTEM COMPONENT	32
CRUISE CONTROL SYSTEM COMPONENT	33
CRUISE CONTROL SYSTEM CONTROL DIAGRAM	34
CRUISE CONTROL SYSTEM DESCRIPTION	36
General	36
Master switch	36
Steering wheel switches	36
Interface ECU	36
Cruise control ECU	38
Warning lamp	39
Vacuum pump assembly	39
Vacuum actuator	41
CRUISE CONTROL SYSTEM OPERATION	42
Engagement	42
Acceleration	42
Suspend/Resume	42
Cancelling	43
Diagnostics	43

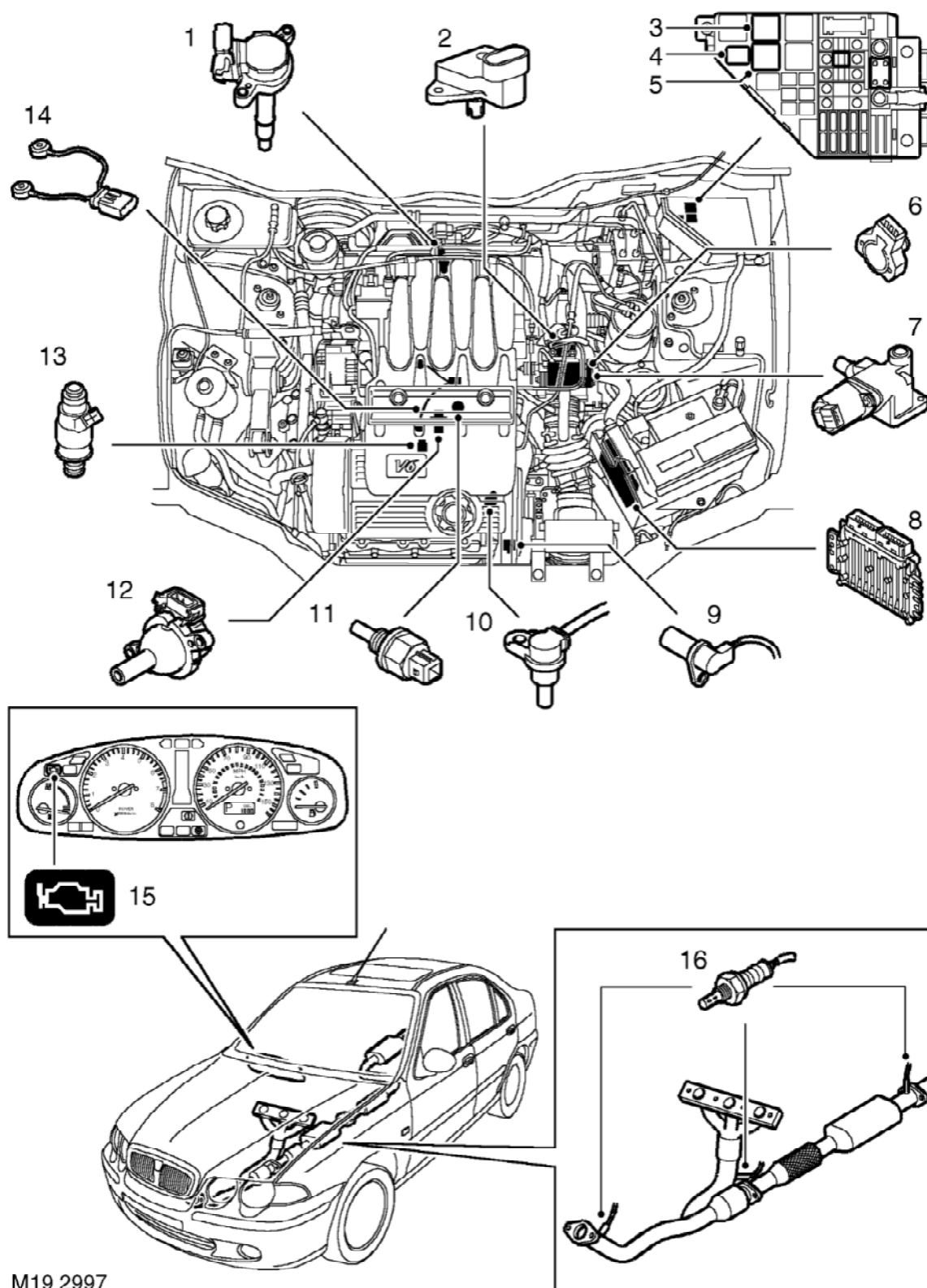




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ENGINE MANAGEMENT SYSTEM - SIEMENS

ENGINE MANAGEMENT SYSTEM COMPONENT LAYOUT



M19 2997

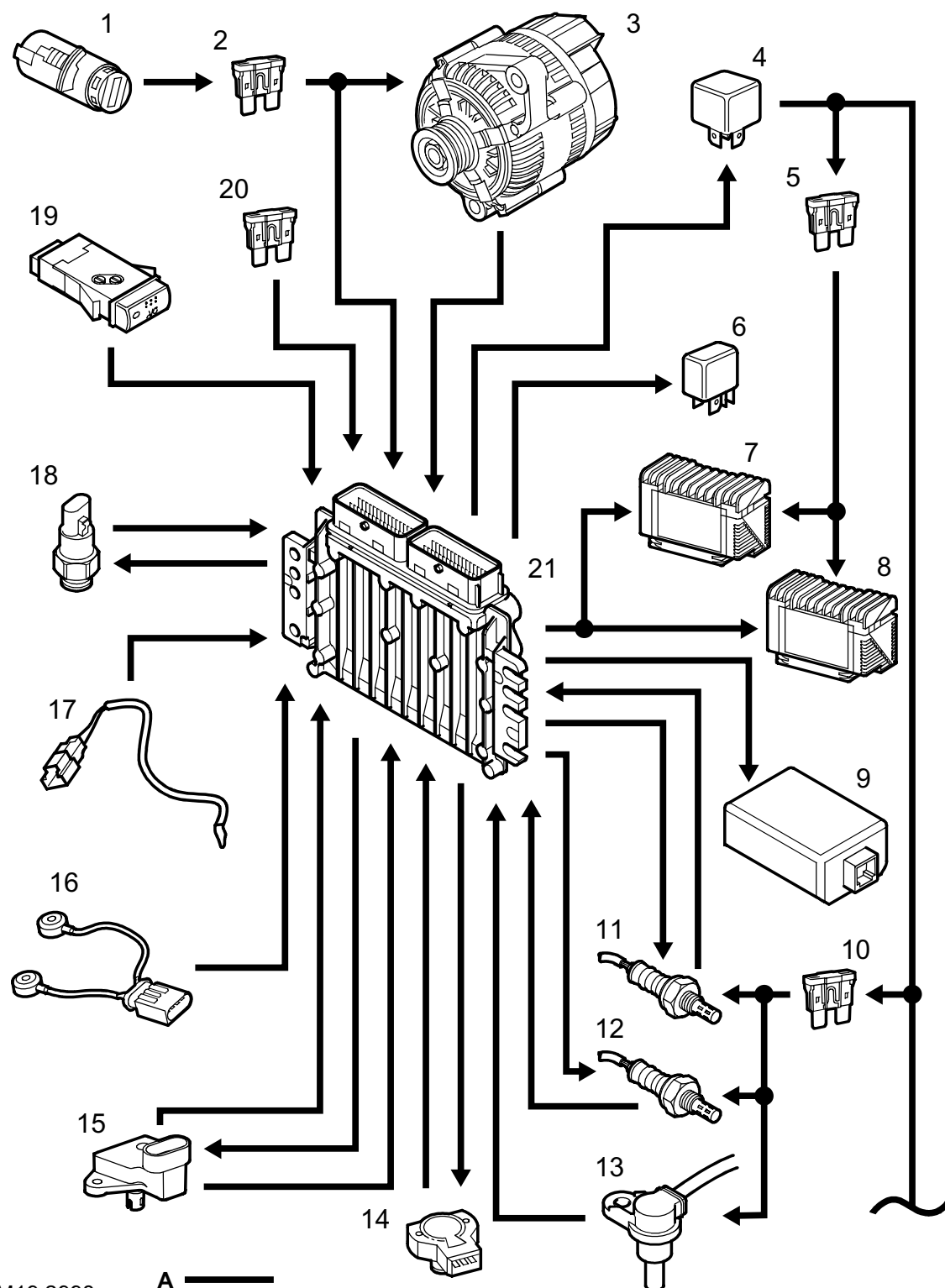
RHD shown, LHD similar



1. RH bank ignition coil (x 3)
2. IAT/MAP sensor
3. Fuel pump relay
4. A/C compressor clutch relay
5. Main relay
6. TP sensor
7. IAC valve
8. ECM
9. CKP sensor
10. CMP sensor
11. ECT sensor
12. LH bank ignition coil (x 3)
13. Fuel injector (x 6)
14. Knock sensors
15. MIL
16. HO2S (x 3)

ENGINE MANAGEMENT SYSTEM - SIEMENS

ENGINE MANAGEMENT SYSTEM CONTROL DIAGRAM - SHEET 1 OF 2

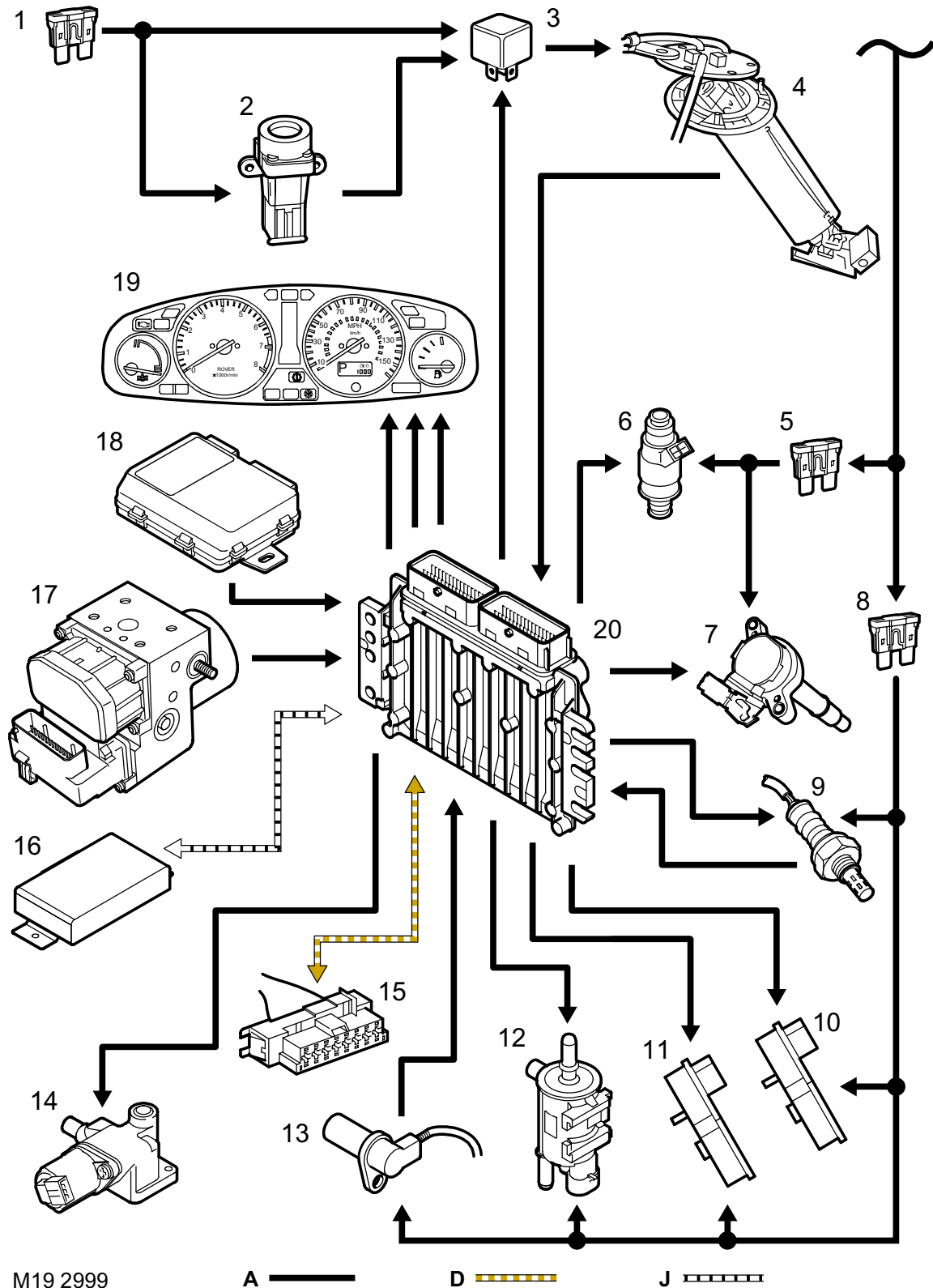




1. Ignition switch
2. Fuse 24, passenger compartment fuse box
3. Alternator
4. Main relay
5. Fuse 4, engine compartment fuse box
6. A/C compressor clutch relay
7. RH cooling fan controller
8. LH cooling fan controller
9. Cruise control interface ECU (where fitted)
10. Fuse 3, engine compartment fuse box
11. LH front HO2S
12. RH front HO2S
13. CMP sensor
14. TP sensor
15. IAT/MAP sensor
16. Knock sensors
17. A/C evaporator temperature sensor
18. A/C refrigerant pressure sensor
19. A/C switch
20. Fuse 11, passenger compartment fuse box
21. ECM

ENGINE MANAGEMENT SYSTEM - SIEMENS

ENGINE MANAGEMENT SYSTEM CONTROL DIAGRAM - SHEET 2 OF 2



A = Hardwired connection; D = CAN bus; J = Diagnostic ISO 9141 K line bus



1. Fuse 10, engine compartment fuse box
2. Inertia fuel shutoff switch
3. Fuel pump relay
4. Fuel tank unit
5. Fuse 2, engine compartment fuse box
6. Fuel injector (x 6)
7. Ignition coil (x 6)
8. Fuse 1, engine compartment fuse box
9. Rear HO2S
10. VIS balance valve motor
11. VIS pressure valves motor
12. EVAP canister purge valve
13. CKP sensor
14. IAC valve
15. Diagnostic socket
16. EAT ECU
17. ABS ECU
18. Alarm ECU
19. Instrument pack
20. ECM

ENGINE MANAGEMENT SYSTEM - SIEMENS

ENGINE MANAGEMENT DESCRIPTION

General

The KV6 engine is fitted with a Siemens Engine Management System (EMS). The Siemens EMS is an adaptive system that maintains engine performance at the optimum level throughout the life of the engine.

The EMS consists of an Engine Control Module (ECM) that uses inputs from engine sensors and from other vehicle systems to continuously monitor driver demand and the current status of the engine. From the inputs the ECM calculates the Air Fuel Ratio (AFR) and ignition timing required to match engine operation with driver demand, then outputs the necessary control signals to the fuel injectors and ignition coils. The ECM also outputs control signals to operate the:

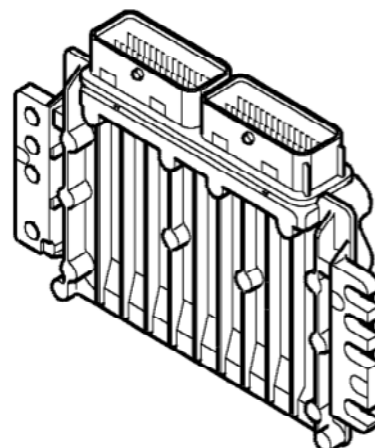
- Idle Air Control (IAC) valve.
- Air Conditioning (A/C) compressor. ***See AIR CONDITIONING, Description and Operation.***
- Cooling fan(s).
- Evaporative emissions (EVAP) canister purge valve. ***See EMISSION CONTROL, Description and Operation.***
- Fuel pump. ***See FUEL DELIVERY SYSTEM, Description and Operation.***
- Variable Intake System (VIS). ***See MANIFOLDS & EXHAUST SYSTEMS - KV6, Description and Operation.***

The EMS interfaces with the:

- Alarm ECU, for re-mobilisation of the engine fuel supply.
- Cruise control interface ECU, to enable the system.
- Electronic Automatic Transmission (EAT) ECU, to assist with control of the gearbox. ***See AUTOMATIC GEARBOX - JATCO, Description and Operation.***

Sensor inputs and engine performance are monitored by the ECM, which illuminates a Malfunction Indicator Lamp (MIL) if a fault is detected.

ECM



M19 3001

The ECM is located in the engine compartment, in the battery carrier. A dual connector provides the interface between the ECM and the vehicle wiring.

As part of the security system's immobilisation function, a vehicle specific security code is programmed into the ECM and alarm ECU during production. The ECM cannot function unless it is connected to an alarm ECU with the same code. In service, replacement ECM are supplied uncoded and must be programmed using TestBook to learn the vehicle security code from the alarm ECU.

A 'flash' Electronic Erasable Programmable Read Only Memory (EEPROM) allows the ECM to be externally configured, using TestBook, with market specific or new information.



The ECM memorises the position of the crankshaft and the camshaft when the engine stops, which allows immediate sequential fuel injection and ignition timing during cranking on the subsequent start. The position data is lost if the battery is disconnected or the battery voltage is too low (e.g. flat battery). After battery recharging or reconnection, during the subsequent start sequence fuelling and ignition is delayed slightly until the ECM has determined the position of the crankshaft and the camshaft from the CKP and CMP sensor inputs.

To achieve optimum performance the ECM is able to 'learn' the individual characteristics of an engine and adjust the fuelling calculations to suit. This capability is known as adaptive fuelling. Adaptive fuelling also allows the ECM to compensate for wear in engine components and to compensate for the tolerance variations of the engine sensors.

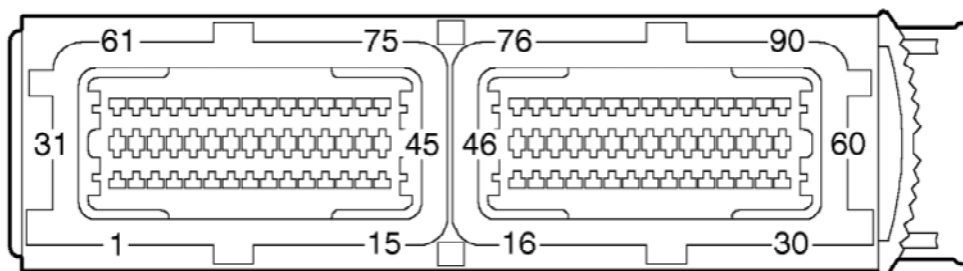
If the ECM suffers an internal failure, such as a breakdown of the processor or driver circuits, there is no back up system or limp home capability. If a sensor circuit fails to supply an input, where possible the ECM adopts a substitute or default value, which enables the engine to function, but with reduced performance.

ENGINE MANAGEMENT SYSTEM - SIEMENS

Inputs and outputs

The ECM inputs and outputs are detailed in the Table below:

ECM harness connector (C0371)



ECM harness connector pin details

Pin No.	Description	Input/Output
1	Ignition coil - 4	Output
2	Ignition coil - 3	Output
3	ECM earth	-
4	EVAP canister purge valve	Output
5	Engine speed	Output
6	Gearbox display on instrument pack	Output
7	Main relay	Output
8	VIS balance valve motor supply	Output
9	Fuel pump relay	Output
10	Cruise control enable (where fitted)	Output
11	Not used	-
12	IAT/MAP sensor earth	-
13	LH front HO2S signal	Input
14	RH front HO2S signal	Input

Continued.....



Pin No.	Description	Input/Output
15	ECT sensor earth	Input
16	Rear HO2S signal	Input
17	A/C pressure sensor signal	Input
18	CKP sensor earth	-
19	CMP sensor earth	-
20	LH knock sensor signal	Input
21	Vehicle speed	Input
22	Mobilisation signal	Input
23	VIS power valve motor position feedback	Input
24	Not used	-
25	A/C request	Input
26	Not used	-
27	CAN bus high	Input/Output
28	ECM earth	-
29	Ignition power supply	Input
30	Permanent battery power supply	Input
31	Ignition coil - 6	Output
32	Ignition coil - 5	Output
33	ECM earth	-
34	Not used	-
35	Rear HO2S heater	Output
36	RH front HO2S heater	Output
37	Not used	-
38	VIS power valve motor supply	Output
39 to 41	Not used	-
42	IAC valve stepper motor (step 3)	Output
43	Not used	-
44	Throttle position sensor signal	Input

Continued.....

Pin No.	Description	Input/Output
45	ECT sensor signal	Input
46	Evaporator temperature sensor signal	Input
47	IAT/MAP sensor (IAT signal)	Input
48	Fuel tank sender signal	Input
49	Not used	-
50	RH knock sensor signal	Input
51	Alternator (engine running signal)	Input
52	Not used	-
53	Sensor earth (A/C pressure and evaporator temperature sensors)	-
54	CKP sensor signal	Input
55	Not used	-
56	Diagnostic ISO 9141 K line	Input/Output
57	CAN bus low	Input/Output
58	Fuel injector No. 4	Output
59	Fuel injector No. 2	Output
60	Fuel injector No. 1	
61	Ignition coil - 1	Output
62	Ignition coil - 2	Output
63	ECM earth	-
64	A/C relay	Output
65	LH front HO2S heater	Output
66	Power supply from main relay	Input
67	ECM earth	-
68	Malfunction indicator lamp	Output
69	Not used	-
70	IAC valve stepper motor (step 2)	Output
71	IAC valve stepper motor (step 1)	Output
72	IAC valve stepper motor (step 4)	Output

Continued.....



Pin No.	Description	Input/Output
73	IAT/MAP sensor (MAP signal)	Input
74	Throttle position sensor reference supply	Output
75	Throttle position sensor earth	-
76	Rear HO2S heater earth	-
77	LH and RH front HO2S heater earth	-
78	IAT/MAP sensor reference supply	Output
79	Not used	-
80	Knock sensors earth	-
81	A/C pressure sensor supply	Output
82	CMP sensor signal	Input
83	Not used	-
84	VIS balance valve motor position feedback	Input
85	Cooling fan PWM signal	Output
86 and 87	Not used	-
88	Fuel injector No. 3	Output
89	Fuel injector No. 5	Output
90	Fuel injector No. 6	Output

Fuel level

The fuel tank level is transmitted by the fuel tank sender unit as a variable voltage and interpreted by the ECM.

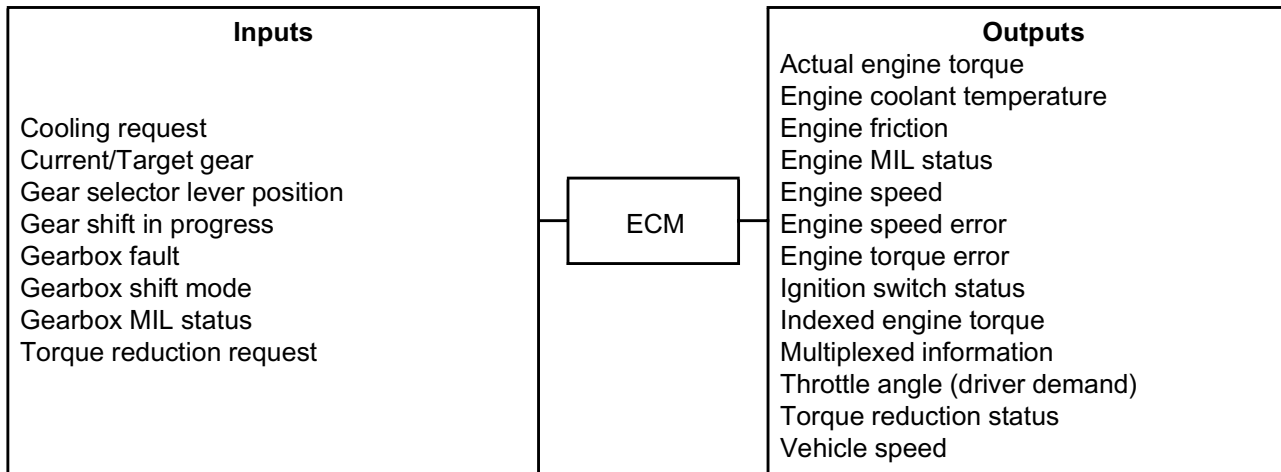
Road speed signal

The road speed signal is produced by the ABS ECU and output to the ECM as a 12 volt square wave signal at a frequency of 40000 Hz/mile (24855 Hz/kilometre).

Controller Area Network (CAN) bus

A CAN bus is connected between the ECM and the EAT ECU. The CAN bus is a serial communications data bus, consisting of a pair of wires twisted together, that allows the high speed exchange of digital messages between the two units.

ECM CAN messages



CAN inputs:

- Cooling request. Request for additional cooling of the transmission fluid. The ECM switches on, or increases the speed of, the cooling fans.
- Current/Target gear. Informs the ECM what gear is currently engaged or, if a gear shift is in progress, the gear to which the gearbox is shifting. Used for engine load change prediction and relayed to instrument pack for display of engaged gear.
- Gear selector lever position. Informs the ECM of the gear selector lever position selected by the driver. Relayed to instrument pack for display of gear selector lever position.
- Gear shift in progress. Informs the ECM when a gear shift is in progress. Used at idle speed to compensate for engine load changes during the gear shift.
- Gearbox fault. Informs the ECM there is a transmission fault. The ECM signals the instrument pack to illuminate the gearbox fault lamp.
- Gearbox shift mode. Relayed to instrument pack for display of gearbox shift mode.
- Gearbox MIL status. Informs the ECM there is a transmission fault that increases emissions above the legislated limit. The ECM signals the instrument pack to illuminate the MIL.
- Torque reduction request. Requests the ECM to reduce engine torque for a gear shift (equivalent to lifting off the throttle in manual gearbox models). Amount of torque reduction required expressed as a percentage of maximum engine torque.

CAN outputs:

- Actual engine torque. Current engine torque including any torque reduction. Expressed as a percentage of maximum engine torque. Used for gear shift scheduling.
- Engine coolant temperature. Used for diagnostic functions and to detect when the engine has completed a 'warm up' cycle.
- Engine friction. Informs the EAT ECU of the current frictional torque losses within the engine. Expressed as a percentage of maximum engine torque. Used for gear shift scheduling.
- Engine MIL status. Informs the EAT ECU if there is an engine fault that increases emissions above the legislated limit. The EAT ECU then suspends emissions fault monitoring of the gearbox.
- Engine speed. Used to calculate gearbox oil pressure to assist with gear shift scheduling.
- Engine speed error. Informs the EAT ECU if there is a fault with the engine speed calculation. If necessary, the EAT ECU then adjusts gearbox operation to prevent possibility of mechanical damage.
- Engine torque error. Informs the EAT ECU if there is a torque measurement error.
- Ignition switch status. Used to initiate the EAT ECU power-down routine at ignition off.



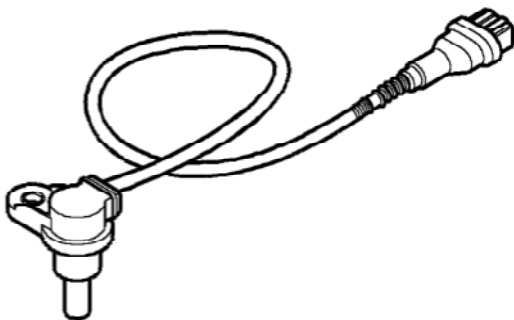
- Indexed engine torque. Theoretical maximum engine torque for current engine operating conditions. Expressed as a percentage of maximum engine torque. Used for gear shift scheduling.
- Multiplexed information. Informs EAT ECU of CAN standard being implemented, OBD functions supported, ECM identity and maximum engine torque (for engine type). Used by EAT ECU to verify messages from ECM and for gear shift scheduling.
- Throttle angle. Used for gear shift scheduling.
- Torque reduction status. Informs EAT ECU of the success of a torque reduction request.
- Vehicle speed. Informs EAT ECU of vehicle speed received from ABS ECU. Used by EAT ECU for comparison with inputs from gearbox speed sensors.

Engine sensors

The EMS incorporates the following engine sensors:

- A Camshaft Position (CMP) sensor.
- A Crankshaft Position (CKP) sensor.
- An Engine Coolant Temperature (ECT) sensor.
- Three Heated Oxygen Sensors (HO2S).
- An Intake Air Temperature/ Manifold Absolute Pressure(IAT/MAP) sensor.
- Two knock sensors.
- A Throttle Position (TP) sensor.

Camshaft Position (CMP) sensor



M19 3002A

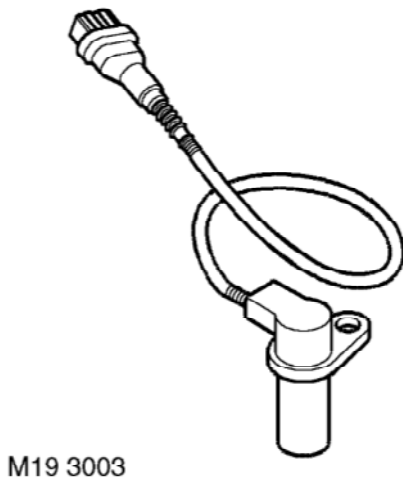
The CMP sensor provides a signal which enables the ECM to determine the position of the camshaft relative to the crankshaft. This allows the ECM to synchronise fuel injection for start and run conditions.

The CMP sensor is located on the camshaft cover of the LH cylinder bank, at the opposite end to the camshaft drive, in line with a 'half moon' reluctor on the exhaust camshaft. The reluctor comprises a single tooth which extends around 180° of the camshaft circumference.

The CMP sensor operates using the Hall effect principle. A permanent magnet inside the sensor applies a magnetic flux to a semiconductor, which receives a power supply from the main relay. The output voltage from the semiconductor is fed to the ECM. As the gap in the reluctor passes the sensor tip, the magnetic flux is interrupted, causing a fluctuation of the output voltage and producing a digital signal.

If the CMP sensor fails during engine running, the engine will run normally until turned off, but will not restart until the CMP sensor input is restored.

Crankshaft Position (CKP) sensor



The CKP sensor provides the ECM with a digital signal of the rotational speed and angular position of the crankshaft, for use in ignition timing, fuel injection timing and fuel quantity calculations. To determine the exact position of the crankshaft in the engine cycle, the ECM must also use the input from the CMP sensor.

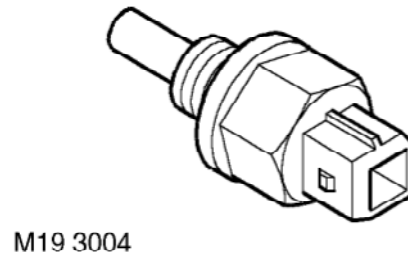
The CKP sensor is mounted on the front of the gearbox housing, in line with the outer circumference of the torque converter. The sensing tip of the CKP sensor is adjacent to a reluctor ring formed in the periphery of the torque converter.

The reluctor ring has 58 teeth spaced at 6° intervals. A gap equivalent to two missing teeth, 36° After Top Dead Centre (ATDC) of cylinder 1, provides the ECM with a reference point.

The CKP sensor operates using the Hall effect principle. A permanent magnet inside the sensor applies a magnetic flux to a semiconductor, which receives a power supply from the main relay. The output voltage from the semiconductor is fed to the ECM. As the gaps between the poles of the reluctor ring pass the sensor tip the magnetic flux is interrupted, causing a fluctuation of the output voltage and producing a digital signal.

If the CKP sensor fails the ECM immediately stops the engine.

Engine Coolant Temperature (ECT) sensor



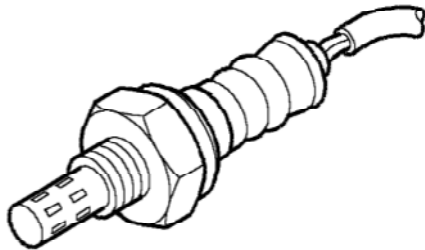
The ECT sensor provides the ECM with a signal voltage that varies with coolant temperature. The ECT sensor is located between the cylinder banks, between cylinders 3 and 6.

The ECT sensor consists of an encapsulated Negative Temperature Coefficient (NTC) thermistor which is in contact with the engine coolant. As the coolant temperature increases the resistance across the sensor decreases and as the coolant temperature decreases the sensor resistance increases. To determine the coolant temperature, the ECM supplies the sensor with a regulated 5 volts power supply and monitors the return signal voltage.



If the ECT signal is missing, or outside the acceptable range, the ECM assumes a default temperature reflecting a part warm engine condition. This enables the engine to function, but with reduced driveability when cold and increased emissions, resulting from an over rich mixture, when the engine reaches normal operating temperature. The ECM will also switch on the cooling fans to prevent the engine and gearbox from overheating.

Heated Oxygen Sensors (HO2S)



M19 3005

The EMS has three HO2S:

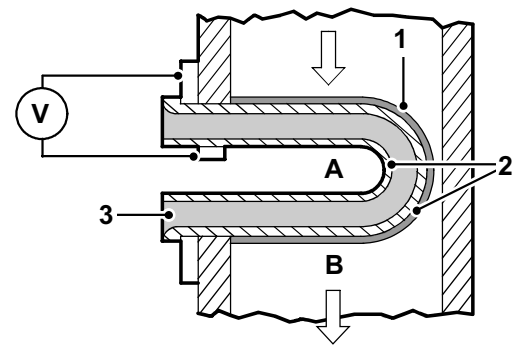
- Two in the RH exhaust manifold, upstream of the starter catalytic converter, identified as LH and RH front HO2S.
- One in the exhaust front pipe immediately downstream of the main catalytic converter, identified as the rear HO2S.

The LH and RH front HO2S enable the ECM to determine the AFR of the mixture being burned in each cylinder bank of the engine. The rear HO2S enables the ECM to monitor the performance of the catalytic converters.

Each HO2S consists of a sensing element with a protective 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. With a rich mixture, the low oxygen content in the exhaust gas results in a higher sensor voltage. With a lean mixture, the high oxygen content in the exhaust gas results in a lower sensor voltage.

During closed loop control the voltage of the two front HO2S switches from less than 0.3 volt to more than 0.5 volt. The voltage switches between limits every two to three seconds. This switching action indicates that the ECM is varying the AFR within the Lambda window tolerance, to maximise the efficiency of the catalytic converters.

Sectioned view of HO2S



M19 3021

1. Protective ceramic coating
2. Electrodes
3. Zirconium oxide

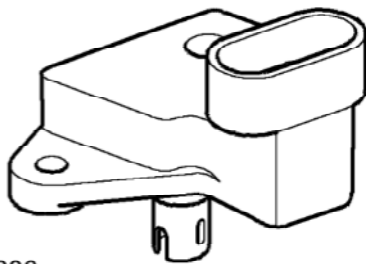
- A.** Ambient air
B. Exhaust gases

The material of the sensing element only becomes active at a temperature of approximately 300 °C (570 °F). To shorten the warm up time and minimise the emissions from a cold start, each HO2S contains a heating element powered by a supply from the main relay. The earth paths for the heating elements are controlled by the ECM. On start up, the current supplied to the heating elements is increased gradually to prevent sudden heating from damaging the ceramic coating. After the initial warm up period the ECM modulates the earth of the heating elements, from a map of engine speed against mass air flow, to maintain the HO2S at the optimum operating temperature.

The nominal resistance of the heating elements is 6Ω at 20 °C (68 °F).

If a front HO2S fails the ECM adopts open loop fuelling and catalytic converter monitoring is disabled. If the rear HO2S fails only catalytic converter monitoring is affected.

Intake Air Temperature/ Manifold Absolute Pressure (IAT/MAP) sensor



M19 3006

The dual IAT/MAP sensor provides the ECM with temperature and pressure signals for use in mass air flow calculations. The IAT/MAP sensor is located on the throttle body, downstream of the throttle plate.

IAT sensor

The IAT sensor is a NTC thermistor which is exposed to the intake air. As the intake air temperature increases the resistance across the sensor decreases and as the intake air temperature decreases the sensor resistance increases. To determine the intake air temperature, the ECM supplies the sensor with a regulated 5 volts power supply and monitors the output signal voltage.

If the IAT sensor fails the ECM adopts a default temperature value of 45 °C (113 °F) and disables adaptive fuelling. The fault may not be apparent to the driver.

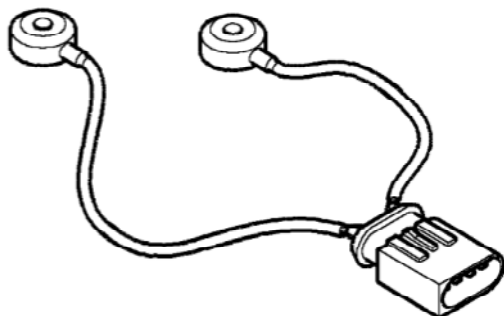
MAP sensor

The MAP sensor is a piezo resistive sensor. The resistance of the sensor varies in proportion to the pressure of the intake air. The ECM supplies the sensor with a regulated 5 volts power supply and, from the sensor output voltage, calculates the pressure of the intake air.

If the MAP sensor signal is missing the ECM will adopt a default value based on crankshaft speed and throttle angle. The engine will continue to run with reduced driveability and increased emissions, although this may not be apparent to the driver.



Knock sensors



M19 3007

The knock sensors enable the ECM to operate the engine at the limits of ignition advance, for optimum efficiency, without combustion knock damaging the engine. The ECM uses two knock sensors, one for each cylinder bank, located between the cylinder banks on cylinders 3 and 4.

The knock sensors consist of piezo ceramic crystals that oscillate to create a voltage signal. During combustion knock, the frequency of crystal oscillation increases, which alters the signal output to the ECM. The ECM compares the signal to known signal profiles in its memory. If the onset of combustion knock is detected the ECM retards the ignition timing for a number of cycles. When the combustion knock stops, the ignition timing is gradually advanced to the original setting.

The knock sensor leads are of different lengths to prevent incorrect installation.

Throttle Position (TP) sensor



M19 3008

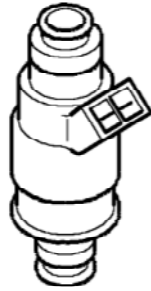
The TP sensor provides the ECM with a throttle plate position signal. The TP sensor is located on the throttle body.

The TP sensor is a variable potentiometer that consists of a resistive track and a sliding contact. The sliding contact is connected to the spindle of the throttle plate. The sensor receives a regulated 5 volts supply from the ECM. As the throttle is opened and closed, the sliding contact moves along the resistive track to change the output voltage of the sensor. The ECM determines throttle plate position and angular change rate by processing the output voltage, which ranges from approximately 0.14V at closed throttle to 4.36V at wide open throttle.

The TP sensor requires no adjustment in service, since the ECM adapts to any minor changes of the upper and lower voltage limits which occur due to normal wear. However, when a new TP sensor is fitted, a TestBook initialisation procedure must be carried out to enable the ECM to 'fast learn' the new TP sensor positions and overwrite old data. Without the initialisation procedure, poor throttle response and idle control may be experienced until the ECM adapts to the voltage limits of the new sensor.

If the TP signal is missing the ECM will substitute a value based on information from the IAT/MAP sensor and CKP sensor. The engine will continue to run but may suffer from poor idle control and throttle response.

Fuel injectors



M19 3009

A split stream, air assisted fuel injector is installed for each cylinder. The injectors are located in the inlet manifolds and connected to a common fuel rail assembly.

Each injector contains a pintle type needle valve and a solenoid winding. The needle valve is held closed by a return spring. An integral nozzle shroud contains a ported disc, adjacent to the nozzles. 'O' rings seal the injector in the fuel rail and the inlet manifold.

The solenoid winding of each injector receives a 12 volt supply from the main relay. To inject fuel, the ECM supplies an earth path to the solenoid winding, which energises and opens the needle valve. When the needle valve opens, the two nozzles direct a spray of atomised fuel onto the back of each inlet valve. Air drawn through the shroud and ported disc improves atomisation and directional control of the fuel. The air is supplied from a dedicated port in the IAC valve via a tube and tracts formed in the gasket face of the intake manifolds.

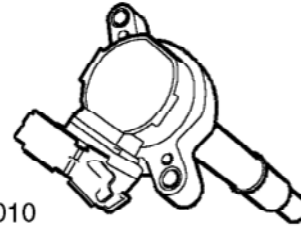
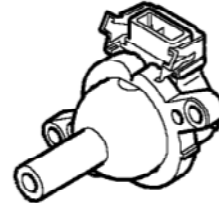
Each injector delivers fuel once per engine cycle, during the inlet stroke. The ECM calculates the open time (duty cycle) of the injectors from:

- Engine speed.
- Mass air flow.
- Engine temperature.
- Throttle position.

Fuel pressure at the injector inlets is maintained at 3.5 bar (50 lbf/in²) above intake manifold pressure by a fuel pressure regulator mounted on the fuel rail.

The nominal resistance of the injector solenoid winding is 13 - 16 Ω at 20 °C (68 °F).

Ignition coils



M19 3010

The ECM uses a separate ignition coil for each spark plug. The ignition coils for the LH bank of cylinders are positioned on the forward tracts of the inlet manifold and connected to the spark plugs through HT leads. The ignition coils for the RH bank spark plugs are of the plug top design, secured to the camshaft cover with 2 screws.



Each ignition coil has 3 connections in addition to the spark plug connection; an ignition feed from the main relay, an earth wire for the secondary winding, and a primary winding negative (switch) terminal. The switch terminal of each ignition coil is connected to a separate pin on the ECM to allow independent switching. The ignition coils are charged whenever the ECM supplies an earth path to the primary winding negative terminal. The duration of the charge time is held relatively constant by the ECM for all engine speeds. Consequently, the dwell period increases with engine speed. This type of system, referred to as Constant Energy, allows the use of low impedance coils with faster charge times and higher outputs.

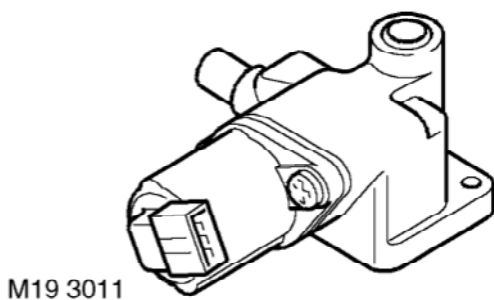
The ECM calculates dwell angle using inputs from the following:

- Battery voltage (main relay).
- CKP sensor.
- Ignition coil primary current (internal ECM connection).

The spark is produced when the ECM breaks the primary winding circuit. This causes the magnetic flux around the primary winding to collapse, inducing High Tension (HT) energy in the secondary coil, which can only pass to earth by bridging the air gap of the spark plug.

Ignition related faults are monitored indirectly by the misfire detection function.

Idle Air Control (IAC) valve



The IAC valve regulates the flow of throttle bypass air and the flow of air to the fuel injectors. The throttle bypass air enables the ECM to:

- Control engine idle speed.
- Provide a damping function when the throttle plate closes during deceleration, to reduce Hydrocarbon (HC) emissions.

The IAC valve is located on a port in the throttle body downstream of the throttle plate. A hose, from the duct between the air cleaner and the throttle body, is connected to an inlet port on the valve housing to provide a source of air from upstream of the throttle plate. A tube supplies air from an outlet port on the valve housing to the intake manifolds, for the air assisted fuel injectors. A stepper motor on the valve housing operates a pintle valve to control the flow of air through the valve housing.

The stepper motor core is rotated by the magnetic fields of two electro-magnetic bobbins set at 90° to each other. The bobbins are connected to driver circuits in the ECM. Each of the four connections can be connected to 12 volts or earth, enabling four phases to be produced. The ECM modulates the four phases as necessary to move the motor core and pintle valve, and so adjust the flow of air from the inlet port to the throttle bypass and fuel injector outlet ports.

When the ignition is switched off the ECM enters a power down routine which includes referencing the stepper motor. This means that the ECM will rotate the motor so that it can memorise the position when it next needs to start the engine. The referencing procedure takes from three to five seconds. If the ECM cannot reference the stepper motor during power down, it will do so at ignition on.

There are no back up idle control systems. If the stepper motor fails the idle speed may be too high or too low, the engine may stall and/or the engine may be difficult to start.

Malfunction Indicator Lamp (MIL)

The MIL is located in the instrument pack and consists of an engine graphic on an amber background. The ECM connects an earth to the instrument pack to illuminate the MIL.

ENGINE MANAGEMENT OPERATION

General

Engine starting

When the ignition switch is in position II a power feed is connected from the ignition switch to the ECM. The ECM then initiates 'wake up' routines and energises the main and fuel pump relays. If the ignition switch remains in position II without the engine running, the ECM de-energises the fuel pump relay after approximately 2 seconds. When the ignition switch is in position II with the engine running, or position III, the fuel pump relay is permanently energised.

When the engine cranks, the ECM initiates fuelling and ignition to start the engine. Provided a valid mobilisation signal is received from the alarm ECU, the ECM maintains fuelling and ignition control of the engine as necessary to meet driver demand. If no mobilisation code is received from the alarm ECU, or the code is invalid, the ECM stops the engine after 2 seconds.

The electrical circuit from the fuel pump relay to the fuel pump is routed through the inertia switch. In the event of a collision the inertia switch breaks the circuit to prevent further fuel being delivered to the engine. The inertia switch is situated behind the centre console and is reset by pressing the rubber top.

During the start sequence, the ECM also illuminates the MIL, as a bulb check, for 4 seconds after the ignition switch turns to position II or until the ignition switch turns to position III.

Engine stopping

When the ignition switch is turned to position I, the ECM switches off the ignition coils, injectors and fuel pump to stop the engine. The ECM continues to energise the main relay until the power down functions are completed. Power down functions include engine cooling, referencing the IAC valve stepper motor and memorising data for the next start up. When the power down process is completed, the ECM de-energises the main relay and enters a low power mode. In the low power mode, maximum quiescent drain is 0.5 mA.

Fuelling control

The ECM controls the amount of fuel injected into the engine by adjusting the duty cycle of the fuel injectors. The amount of fuel required is a rolling process determined from maps of engine speed against mass air flow. The value from the map is then corrected for engine coolant temperature, throttle position, vehicle speed and any adaptive value stored in memory.

Mass air flow is calculated using engine speed, inlet air temperature and inlet air pressure. The engine speed indicates the volume of air flowing into the cylinders; the inlet air temperature and inlet air pressure indicate the density of the air. The pressure of the inlet air varies according to the following:

- The position of the throttle valve (driver input).
- The atmospheric pressure (altitude and weather conditions).
- The mechanical condition of the engine (volumetric efficiency).

To ensure the accuracy of the amount of fuel injected, the ECM adjusts the fuel injector duty cycle to compensate for low battery voltage by monitoring the fuel injector power supplies. At lower voltages, fuel injector response is slower and, unless compensated for, results in a leaner AFR than intended.

The ECM operates the fuel injectors during their related cylinder's induction stroke, in cylinder firing order. Fuel injector timing is determined from the CMP and CKP sensor inputs.

Fuelling control operates in either closed loop or open loop.



Closed loop fuelling

Closed loop fuelling is used for the following conditions:

- Idle.
- Lower mass air flows.
- Cruise.

During closed loop fuelling the ECM maintains the AFR within a lambda window of 1.00 ± 0.03 , where lambda 1.00 is equivalent to an AFR of 14.7 : 1 by weight. The ECM uses the inputs from the two front HO2S to monitor the engine's AFR and, if necessary, adds a correction to maintain the AFR within the lambda window. If, over a number of ignition cycles, a significant correction is consistently applied, the ECM stores the correction as an adaptive value.

The efficient operation of the catalytic converters relies on the ECM cycling the AFR from rich to lean within the lambda window, i.e. between lambda 0.97 and 1.03. The continuous cycling within the lambda window allows the catalytic converters to absorb and release oxygen for optimum efficiency.

Open loop fuelling

The ECM uses open loop fuelling when it is not possible or desirable to use feedback from the front HO2S to monitor the AFR. During open loop fuelling the ECM uses information from the engine sensors and fuelling maps to determine the required fuel quantity.

Open loop fuelling is used for the following conditions:

- Cold start.
- Warm up.
- Maximum mass air flow.
- Wide open throttle.
- Hot start.
- HO2S failure.

Cold start

During cold starting the engine temperature is low enough to promote fuel condensation on the cold surfaces of the inlet manifold and cylinder walls. This would leave the AFR lean and the fuel content too poorly distributed to provide a readily combustible mixture. To overcome this the ECM increases the amount of fuel injected to produce a rich AFR and adjusts the idle speed to a 'fast idle' value.

Warm up

Once the engine has fired the ECM references the ECT, IAT/MAP, TP and CMP sensors to modify the fuelling as the engine warms up. As the engine temperature rises, the AFR is leaned off until the HO2S are functional and the ECM adopts closed loop fuelling.

Maximum mass air flow/ wide open throttle

For maximum power output on sudden opening of the throttle or continuous wide open throttle, the ECM switches to open loop fuelling and enriches the AFR to 12 : 1.

Hot start

When a hot engine is turned off, the fuel in the injectors and injector rail absorbs heat, which causes the characteristics of the fuel to change. A hot start becomes more demanding due to difficulties in achieving the correct AFR and an even mixture distribution. To overcome this the ECM references the ECT sensor and enriches the AFR.

HO2S failure

If the input from one of the front HO2S is missing, or outside tolerances, the ECM adopts open loop fuelling.

Overrun fuel cut off

During overrun, if engine speed is sufficiently above stalling speed the ECM temporarily inhibits fuel injection. Fuel injection is reinstated when the throttle opens or engine speed approaches stalling speed. The engine speeds at which the ECM inhibits and reinstates fuel injection varies with coolant temperature; the lower the coolant temperature the higher the engine speeds.

Ignition timing

The ECM calculates ignition timing using inputs from the following sensors:

- CKP sensor.
- Knock sensors.
- IAT/MAP sensor.
- TP sensor (idle only).
- ECT sensor.

At start up and idle the ECM sets ignition timing by referencing the ECT and CKP sensors. Once above idle the ignition timing is controlled according to maps stored in the ECM memory and modified according to additional sensor inputs and any adaptive value stored in memory. The maps keep the ignition timing within a narrow band that gives an acceptable compromise between power output and emission control. The ignition timing advance and retard is controlled by the ECM in order to avoid combustion knock.

Knock control

The ECM uses active knock control to prevent combustion knock damaging the engine. If the knock sensor inputs indicate the onset of combustion knock, the ECM retards the ignition timing for that particular cylinder by 3°. If the combustion knock indication continues, the ECM further retards the ignition timing, in decrements of 3°, for a maximum of 15° from where the onset of combustion knock was first sensed. When the combustion knock indication stops, the ECM restores the original ignition timing in increments of 0.75°.

To reduce the risk of combustion knock at high intake air temperatures, the ECM retards the ignition timing if the intake air temperature exceeds 55 °C (169 °F). The amount of ignition retard increases with increasing air intake temperature.

Idle speed control

The ECM controls the engine idle speed using a combination of ignition timing and the IAC valve.

When the engine idle speed fluctuates the ECM initially varies the ignition timing, which produces rapid changes of engine speed. If this fails to correct the idle speed, the ECM also operates the IAC valve stepper motor to vary the amount of air allowed to bypass the throttle plate. To increase the idle speed the ECM signals the stepper motor to allow more air to bypass the throttle plate. To decrease the idle speed the ECM signals the stepper motor to allow less air to bypass the throttle plate. The IAC valve is also opened during deceleration to decrease the manifold vacuum and reduce emissions.

Misfire detection

The ECM uses the CKP sensor input to monitor the engine for misfires. As the combustion charge in each cylinder is ignited the crankshaft accelerates, then subsequently decelerates. By monitoring the acceleration/ deceleration pulses of the crankshaft the ECM can detect misfires.



Low fuel level

When the fuel tank is almost empty there is a risk that air may be drawn into the fuel system, due to fuel 'slosh', causing fuel starvation and misfires. If a misfire occurs when the fuel tank content is less than 15% (8.25 litres), the ECM stores an additional fault code to indicate the possible cause of the misfire.

Rough road disable

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 OBD misfire monitor is disabled when a rough road surface is detected. The ECM is calibrated to recognise a rough road surface from fluctuations in the road speed signal from the ABS ECU.

Catalytic converter monitoring

The ECM monitors the operating efficiency of the catalytic converters by comparing the input of the rear HO2S with the inputs from the two front HO2S.

Air Conditioning (A/C)

When A/C is requested on the A/C switch, the ECM grants the request by energising the A/C compressor clutch relay provided that:

- Driver demand is less than wide open throttle.
- The engine coolant temperature is within limits.
- There is no engine running problem.
- The engine is running below the maximum permitted continuous speed.

- The input from the A/C pressure switch indicates that refrigerant system pressure is within limits.
- The input from the evaporator temperature sensor indicates that the temperature of the air from the evaporator is above the minimum limit, i.e. the evaporator is free from ice.

When it energises the A/C compressor clutch relay, the ECM also operates the cooling fans. The speed of the cooling fans depends on refrigerant system pressure. At pressures below 16 bar (232 lbf/in²) the fans run at minimum speed. If the pressure increases to 16 bar (232 lbf/in²), the speed of the fans progressively increases up to maximum speed at 27 bar (392 lbf/in²). When the fans are at maximum speed, if the refrigerant pressure decreases the speed of the fans progressively decreases down to minimum speed at 15 bar (218 lbf/in²).

While the A/C is on, if the throttle position or engine coolant temperature exceed preset limits the ECM de-energises the A/C compressor clutch relay to suspend A/C operation and reduce the load on the engine. When the parameter returns within limits the ECM re-energises the A/C compressor clutch relay to restore A/C. Similarly, to protect the refrigerant system, the ECM suspends A/C operation if the refrigerant system pressure exceeds the high or low limit.

A/C compressor clutch switching points

Input component	Off	On
TP sensor	Accelerating at maximum load	Stable maximum load and below
ECT sensor	More than 118 °C (244 °F)	Less than 112 °C (234 °F)
A/C pressure sensor: Low limit High limit	1.6 bar (23.2 lbf/in ²) 29 bar (421 lbf/in ²)	2.0 bar (29.0 lbf/in ²) 23 bar (334 lbf/in ²)

Cooling fans

The ECM controls the operation of the variable speed cooling fans with a common Pulse Width Modulated (PWM) signal to the controller of each fan. The controllers regulate the voltage of the power feeds to the fans, and relate the voltage to the duty cycle of the PWM signal. The ECM varies the duty cycle of the PWM signal between 10 and 90%. At duty cycles between 10 and 49% the fans are off. At a duty cycle of 50% the controllers switch 6 volts to the fans to run them at the minimum speed of approximately 1300 rev/min. As the duty cycle increases above 50%, the controllers increase the voltage, non linearly, until, at a duty cycle of 90%, the fans are supplied with 12 volts and run at the maximum speed of approximately 3000 rev/min. If the PWM signal from the ECM is outside the 10 to 90 % range, the controllers interpret the signal as an open or short circuit and run the fans at maximum speed to ensure the engine and gearbox do not overheat.

The ECM operates the fans in response to inputs from:

- The ECT sensor, for engine cooling. The fans come on, at minimum speed, at a coolant temperature of 95 °C (208 °F) and increase speed with increases in coolant temperature up to maximum speed at 114 °C (239 °F). The fans go off when the coolant temperature decreases to 93.5 °C (200 °F).
- The A/C switch and A/C pressure sensor, for refrigerant system cooling. **See Air Conditioning (A/C), above.**
- The EAT ECU, for gearbox cooling. **See AUTOMATIC GEARBOX - JATCO, Description and Operation.**

If there is a conflict between requested fan speeds from the different inputs, the ECM adopts the highest requested speed.

As part of the power down routine, the ECM monitors the engine coolant temperature for approximately 4 minutes after the ignition is switched off. If the fans are already running at ignition off because of a high coolant temperature, or if, within the 4 minutes monitoring time, the coolant temperature exceeds 114 °C (237 °F), the ECM switches the cooling fans on. The cooling fans operate at minimum speed until the coolant temperature decreases to less than 112 °C (234 °F) or for a maximum of 8 minutes from ignition off, whichever occurs first.

Evaporative emissions (EVAP) canister purge valve

The ECM provides a PWM earth path to control the operation of the purge valve. When the ECM is in the open loop fuelling mode the purge valve is kept closed. When the vehicle is moving and in the closed loop fuelling mode the ECM opens the purge valve.

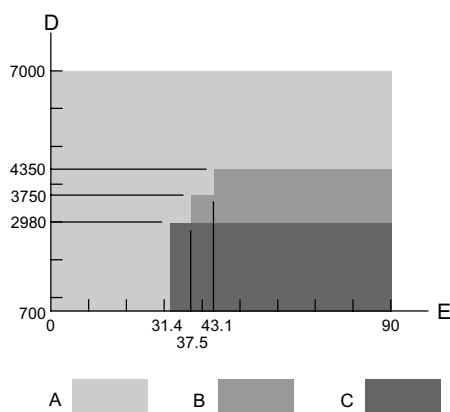
When the purge valve is open fuel vapour is drawn from the EVAP canister into the inlet manifold. The ECM detects the resultant enrichment of the AFR, from the inputs of the front HO2S, and compensates by reducing the open duration of the fuel injectors.

Variable Intake System (VIS) valves

The ECM operates the two VIS valve motors to open and close the VIS valves in a predetermined sequence based on engine speed and throttle opening. Each VIS valve motor has a permanent power feed from the main relay, feedback and signal connections with the ECM, and a permanent earth connection. When the engine starts, the VIS valve motors are both in the valve open position. To close the VIS valves, the ECM applies a power feed to the signal line of the applicable VIS valve motor. To open the VIS valves, the ECM disconnects the power feed from the signal line and the VIS valve motor is closed by the power feed from the main relay.



VIS valve operating strategy



M19 3020

- A. Balance valve open; power valves open
- B. Balance valve open; power valves closed
- C. Balance valve closed; power valves closed
- D. Engine speed, rev/min
- E. Throttle opening, degrees

Gear shift torque reduction

The ECM retards the ignition timing to reduce engine torque during a gear shift. Once the gear shift is completed the ignition timing is returned to normal control.

Diagnostics

The ECM software is programmed to meet current emission standard ECD 3. This regulation is being introduced throughout Europe from the year 2000 and is similar to the OBD (phase II) regulations in place in North America.

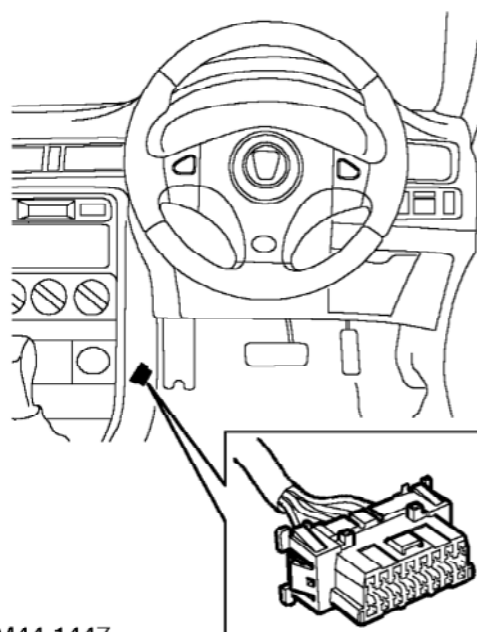
OBD is concerned with the monitoring of certain functions, the failure of which would result in an increase of exhaust emissions above legislated thresholds. The OBD is concentrated on the engine management system.

During engine operation the ECM performs self test and diagnostic routines to monitor the performance of the engine and the EMS. If a fault is detected the ECM stores a related diagnostic trouble code ('P' code) in a non volatile memory and, for most faults, illuminates the MIL. Codes are retrieved using TestBook, which communicates with the ECM via an ISO 9141 K line connection from the diagnostic socket.



NOTE: The diagnostics related to diagnostic trouble codes introduced by ECD3 are disabled on vehicles built prior to the ECD3 compliance date.

Diagnostic socket



M44 1447

ENGINE MANAGEMENT SYSTEM - SIEMENS

Diagnostic trouble codes

P Code	Component	Description	MIL
P0107	Manifold air pressure sensor (IAT/MAP sensor, pressure signal)	Short to battery or open circuit	✓
P0108	Manifold air pressure sensor (IAT/MAP sensor, pressure signal)	Short to earth	✓
P0112	Air intake temperature sensor (IAT/MAP sensor, temperature signal)	Short to battery or open circuit	✓
P0113	Air intake temperature sensor (IAT/MAP sensor, temperature signal)	Short to earth	✓
P0117	Coolant temperature sensor	Short to battery or open circuit	✓
P0118	Coolant temperature sensor	Short to earth	✓
P0122	Throttle position sensor	Short to earth or open circuit	✓
P0123	Throttle position sensor	Short to battery	✓
P0131	Upstream O2 sensor odd bank (LH front HO2S)	Electrical (short to earth, air leakage or open circuit)	✓
P0132	Upstream O2 sensor odd bank (LH front HO2S)	Electrical (short to battery)	✓
P0133	Upstream O2 sensor odd bank (LH front HO2S)	Slow response	✓
P0135	Upstream O2 sensor heater odd bank (LH front HO2S heater)	Electrical (short to battery, short to earth or open circuit)	✓
P0137	Downstream O2 sensor (Rear HO2S)	Electrical (short to earth, air leakage or open circuit)	✓
P0138	Downstream O2 sensor (Rear HO2S)	Electrical (short to battery)	✓
P0140	Downstream O2 sensor (Rear HO2S)	No activity detected	✓
P0141	Downstream O2 sensor (Rear HO2S)	Electrical (short to battery, short to earth or open circuit)	✓
P0151	Upstream O2 sensor even bank (RH front HO2S)	Electrical (short to earth, air leakage or open circuit)	✓
P0152	Upstream O2 sensor even bank (RH front HO2S)	Electrical (short to battery)	✓

Continued.....



P Code	Component	Description	MIL
P0153	Upstream O2 sensor even bank (RH front HO2S)	Slow response	✓
P0155	Upstream O2 sensor heater even bank (RH front HO2S heater)	Electrical (short to battery, short to earth or open circuit)	✓
P0171	Fuelling odd bank (LH bank)	Lean limit	✓
P0172	Fuelling odd bank (LH bank)	Rich limit	✓
P0174	Fuelling even bank (RH bank)	Lean limit	✓
P0175	Fuelling even bank (RH bank)	Rich limit	✓
P0261	Injector 6	Short to earth or open circuit	✓
P0262	Injector 6	Short to battery	✓
P0264	Injector 5	Short to earth or open circuit	✓
P0265	Injector 5	Short to battery	✓
P0267	Injector 4	Short to earth or open circuit	✓
P0268	Injector 4	Short to battery	✓
P0270	Injector 3	Short to earth or open circuit	✓
P0271	Injector 3	Short to battery	✓
P0273	Injector 2	Short to earth or open circuit	✓
P0274	Injector 2	Short to battery	✓
P0276	Injector 1	Short to earth or open circuit	✓
P0277	Injector 1	Short to battery	✓
P0300	Cylinder banks	Misfire increased emissions	✓
P0301	RH cylinder bank	Misfire detected cylinder 6	✓
P0302	LH cylinder bank	Misfire detected cylinder 5	✓
P0303	RH cylinder bank	Misfire detected cylinder 4	✓
P0304	LH cylinder bank	Misfire detected cylinder 3	✓
P0305	RH cylinder bank	Misfire detected cylinder 2	✓
P0306	LH cylinder bank	Misfire detected cylinder 1	✓

Continued.....

ENGINE MANAGEMENT SYSTEM - SIEMENS

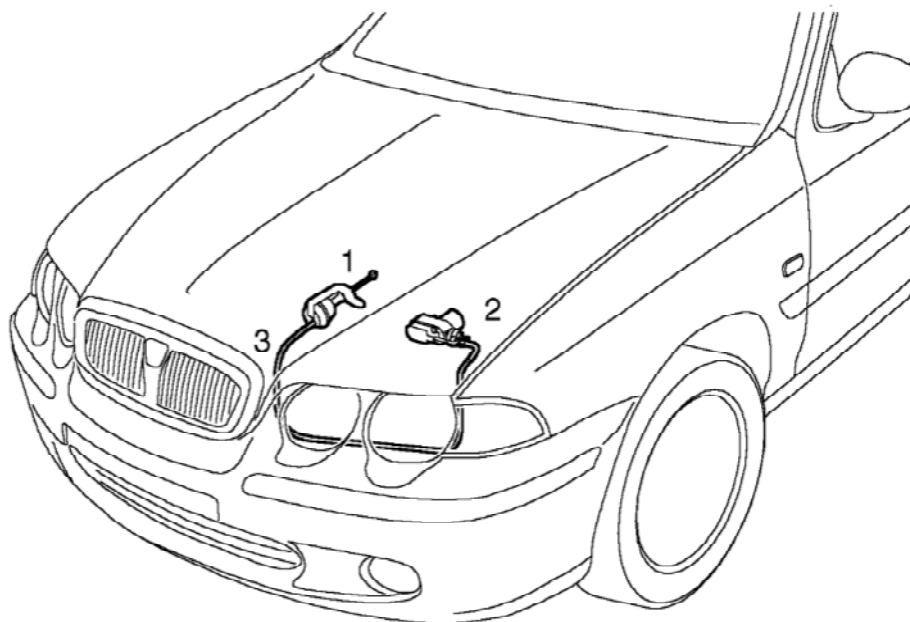
P Code	Component	Description	MIL
P0325	Knock sensor odd bank (LH knock sensor)	Noise level too low	✓
P0330	Knock sensor even bank (RH knock sensor)	Noise level too low	✓
P0335	Crankshaft sensor	No signal	✓
P0336	Crankshaft sensor	Signal not plausible	✓
P0340	Camshaft sensor	No signal	✓
P0341	Camshaft sensor	Signal not plausible	✓
P0351	Ignition control signal coil A - cyl 6	Short to battery, short to earth or open circuit	✓
P0352	Ignition control signal coil B - cyl 5	Short to battery, short to earth or open circuit	✓
P0353	Ignition control signal coil C - cyl 4	Short to battery, short to earth or open circuit	✓
P0354	Ignition control signal coil D - cyl 3	Short to battery, short to earth or open circuit	✓
P0355	Ignition control signal coil E - cyl 2	Short to battery, short to earth or open circuit	✓
P0356	Ignition control signal coil F - cyl 1	Short to battery, short to earth or open circuit	✓
P0420	Catalytic converter	Catalyst malfunction	✓
P0444	Purge valve	Electrical (open circuit)	✓
P0445	Purge valve	Electrical (short to battery or short to earth)	✓
P0500	Vehicle speed sensor	Implausible signal	X
P0505	Idle speed stepper motor (IAC valve)	Short to battery, short to earth or open circuit	✓
P0562	System relay (main relay)	Open circuit	✓
P0563	System relay (main relay)	Short to battery	✓
P1230	Fuel pump relay	Open circuit	✓
P1231	Fuel pump relay	Short to earth	✓
P1232	Fuel pump relay	Short to battery	✓
P1319	Cylinder banks	Misfire at low fuel level	✓
P1320	CKP sensor	Flywheel adaption for misfire detection, adaption limit	✓

Continued.....



P Code	Component	Description	MIL
P1321	CKP sensor	Flywheel adaption for misfire detection, tooth error	✓
P1470	Variable intake balance valve	Always open	✓
P1471	Variable intake balance valve	Always closed	✓
P1472	Variable intake butterfly (power) valves	Always open	✓
P1473	Variable intake butterfly (power) valves	Always closed	✓
P1474	Variable intake balance valve	Electrical (short to battery)	✓
P1475	Variable intake balance valve	Electrical (short to earth or open circuit)	✓
P1476	Variable intake butterfly (power) valves	Electrical (short to battery)	✓
P1477	Variable intake butterfly (power) valves	Electrical (short to earth or open circuit)	✓
P1537	Air conditioning compressor clutch	Relay short to earth or open circuit	X
P1538	Air conditioning compressor clutch	Relay short to battery	X
P1565	Cruise control (interface ECU)	Short to battery	✓
P1566	Cruise control (interface ECU)	Short to earth or open circuit	✓
P1610	Main relay	Short to battery	✓
P1611	Main relay	Short to earth or open circuit	✓
P1641	CAN bus	Bus failure	✓
P1646	CAN bus	Automatic transmission message fault	✓
P1666	Alarm ECU	Security code not received	X
P1672	Alarm ECU	Security code incorrect	X
P1775	CAN bus	Auto gearbox ECU MIL request	✓

CRUISE CONTROL SYSTEM COMPONENT LAYOUT - SHEET 1 OF 2

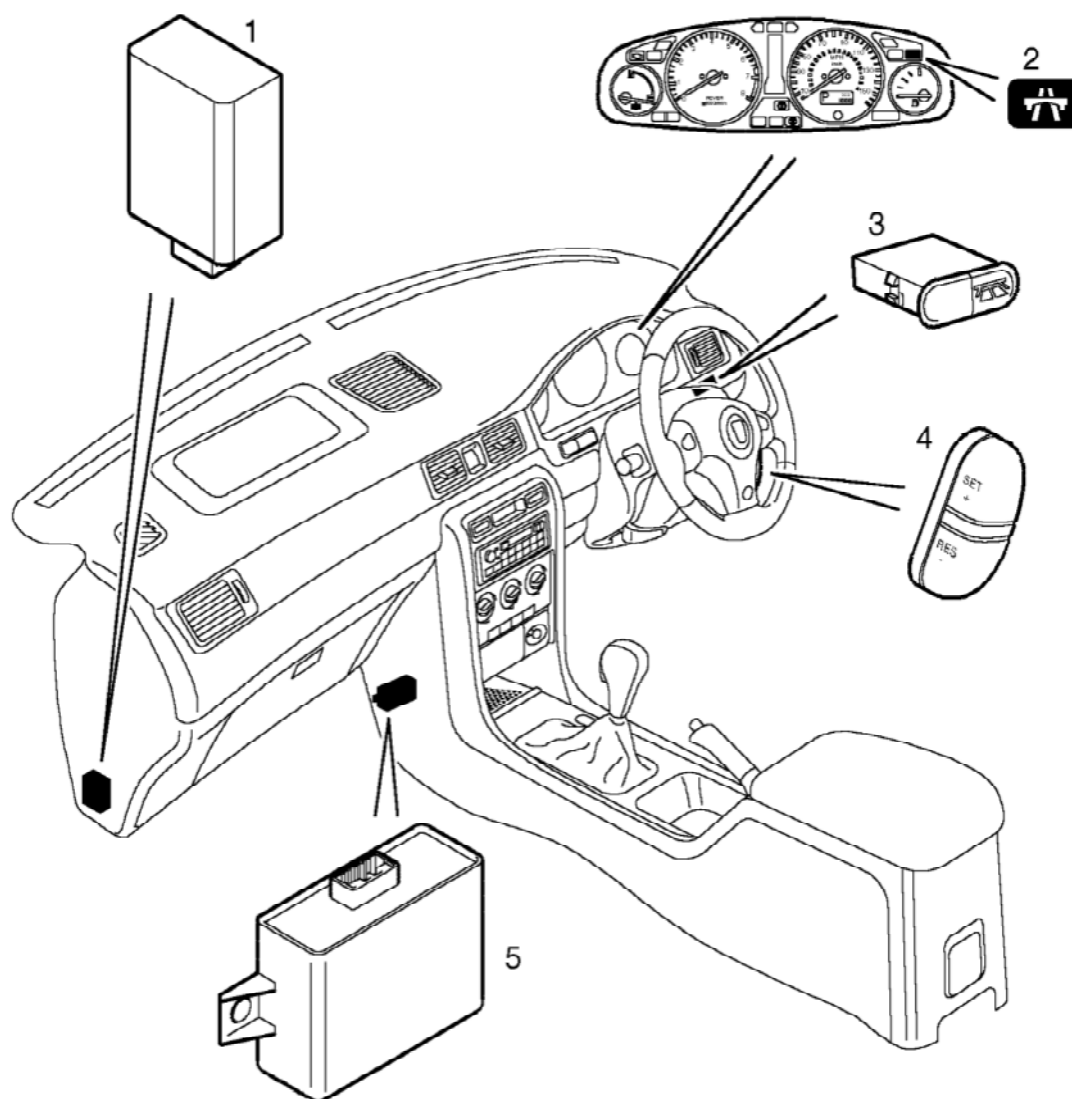


M19 3012

- 1. Vacuum pump assembly
- 2. Vacuum actuator
- 3. Pipe



CRUISE CONTROL SYSTEM COMPONENT LAYOUT - SHEET 2 OF 2



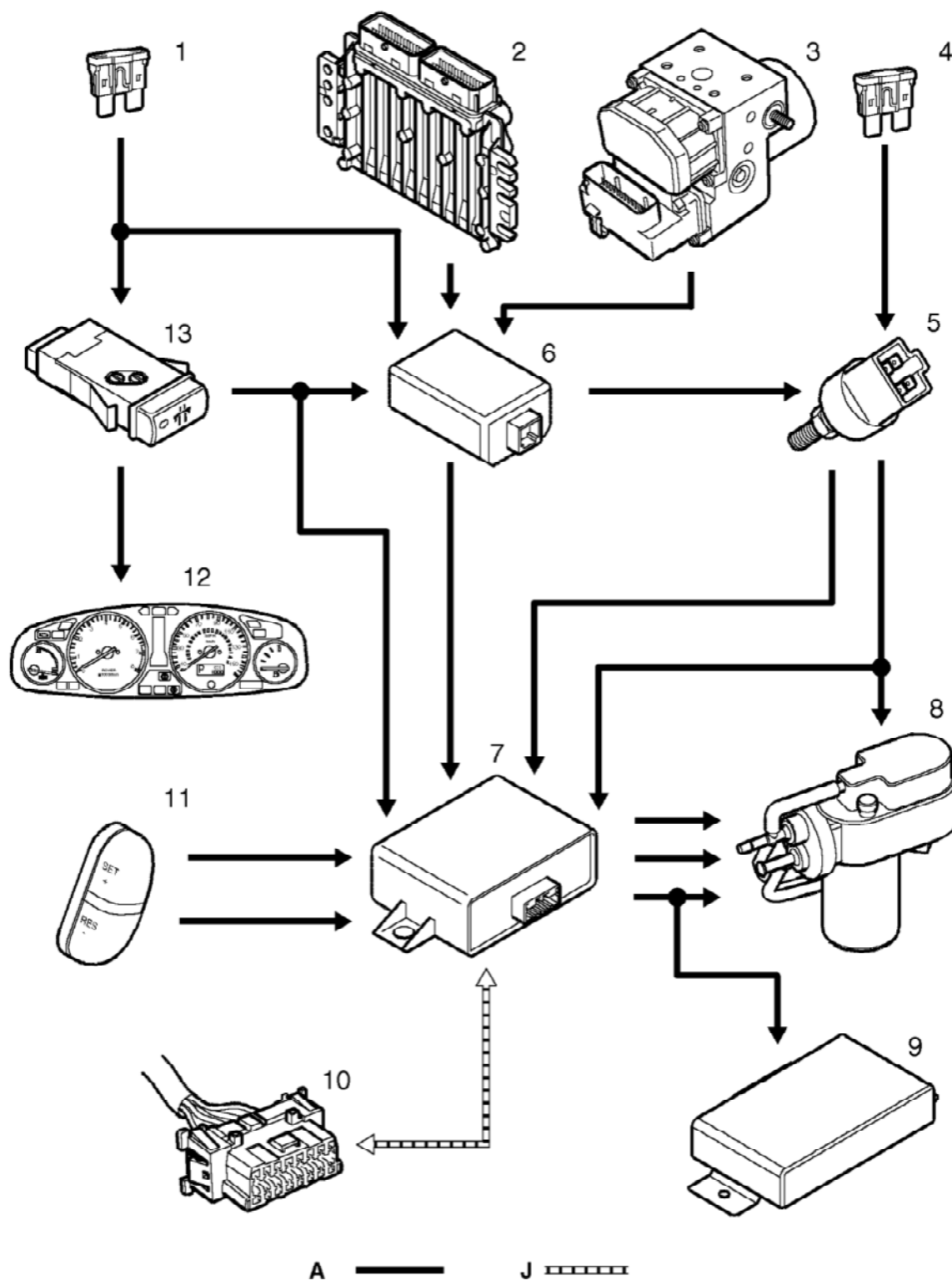
M19 3013

RHD shown, LHD similar

1. Interface ECU
2. Warning lamp
3. Master switch

4. Steering wheel switches
5. Cruise control ECU

CRUISE CONTROL SYSTEM CONTROL DIAGRAM



M19 3014

A = Hardwired connection; J = Diagnostic ISO 9141 K line bus



1. Fuse 24, passenger compartment fuse box (ignition power)
2. ECM
3. ABS modulator
4. Fuse 5, engine compartment fuse box (battery power)
5. Brake switch
6. Interface ECU
7. Cruise control ECU
8. Vacuum pump
9. EAT ECU
10. Diagnostic socket
11. Steering wheel switches
12. Instrument pack
13. Cruise control master switch

CRUISE CONTROL SYSTEM DESCRIPTION

General

The cruise control system is an electro-pneumatic system that uses throttle intervention to automatically maintain a set vehicle speed. Once engaged, the system can also be used to accelerate the vehicle without using the accelerator pedal. The cruise control system consists of:

- A master switch.
- SET+ and RES- steering wheel switches.
- An interface ECU.
- A cruise control ECU.
- A warning lamp.
- A vacuum pump assembly.
- A vacuum actuator.

The system also uses inputs from:

- The brake switch and the Anti-lock Braking System (ABS) modulator. **See BRAKES, Description and Operation.**
- The Engine Control Module (ECM).

Cruise control is enabled when the master switch is pressed and the vehicle is in a suitable driving configuration. Once enabled, the cruise control system is engaged using the steering wheel switches. The steering wheel switches output signals to the cruise control ECU, which runs the vacuum pump assembly to operate the vacuum actuator and produce the required control of the throttle.

The cruise control warning lamp provides a visual indication of when the system is enabled.

Master switch

The master switch controls an ignition feed to the interface ECU and the cruise control ECU to enable the system. The switch is an electrically latching push switch installed in the centre console switch panel.

Steering wheel switches

The steering wheel switches, SET+ and RES-, are push switches that engage and disengage cruise control and adjust the set speed. While pressed, the switches connect a battery power supply to the cruise control ECU.

Interface ECU

The interface ECU controls the output of a power supply to the cruise control ECU, and transforms a road speed signal to a frequency that can be utilised by the cruise control ECU. The interface ECU is installed at the base of the passenger side A post, behind the interior trim.

Power supply

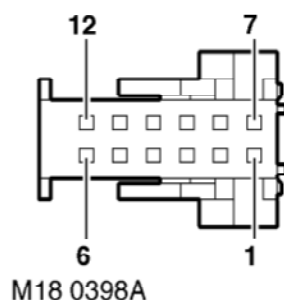
The power supply is output to the cruise control ECU, via normally closed contacts in the brake switch, when the system is enabled. The cruise control ECU uses the power supply to operate the vacuum pump assembly.

Road speed signal

The interface ECU receives a road speed signal from the ABS modulator. The signal is received as a 12 volt square wave with a frequency of 40000 pulses/mile. The interface ECU converts the frequency of the signal to 8000 pulses/mile and outputs it to the cruise control ECU.



Interface ECU harness connector (C0895)



Interface ECU harness connector pin details

Pin No.	Description	Input/Output
1	Earth	Input
2 and 3	Not used	-
4	Earth	Input
5	ECM cruise enable	Input
6	Earth	Input
7	Road speed	Input
8	Ignition power supply	Input
9	Cruise control ECU power supply (via brake switch)	Output
10	Road speed	Output
11	Earth	Input
12	Master switch	Input

Cruise control ECU

The cruise control ECU controls the operation of the vacuum pump in response to the inputs from the steering wheel switches. The cruise control ECU is installed on the tunnel, behind the centre console.

Cruise control ECU harness connector (C0239)

Cruise control ECU connector pin details

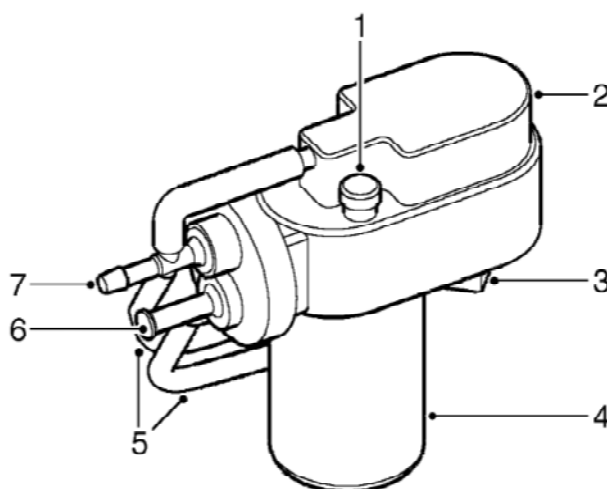
Pin No.	Description	Input/Output
1	Brake switch (power supply from normally closed contacts)	Input
2	RES- switch	Input
3	Not used	-
4	SET+ switch	Input
5	Brake switch (normally open/ brake lamp contacts)	Input
6	Not used	-
7	Vacuum pump control	Output
8	Master switch	Input
9 and 10	Not used	-
11	Vacuum pump and valves supply	Output
12 to 14	Not used	-
15	Road speed	Input
16	Diagnostic ISO 9141 K line	Input/Output
17	Control valve signal	Output
18	System earth	-



Warning lamp

The warning lamp indicates when the cruise control master switch is selected on. Located in the instrument pack, the warning lamp consists of a motorway graphic on a yellow background that illuminates when the cruise control switch is latched on.

Vacuum pump assembly

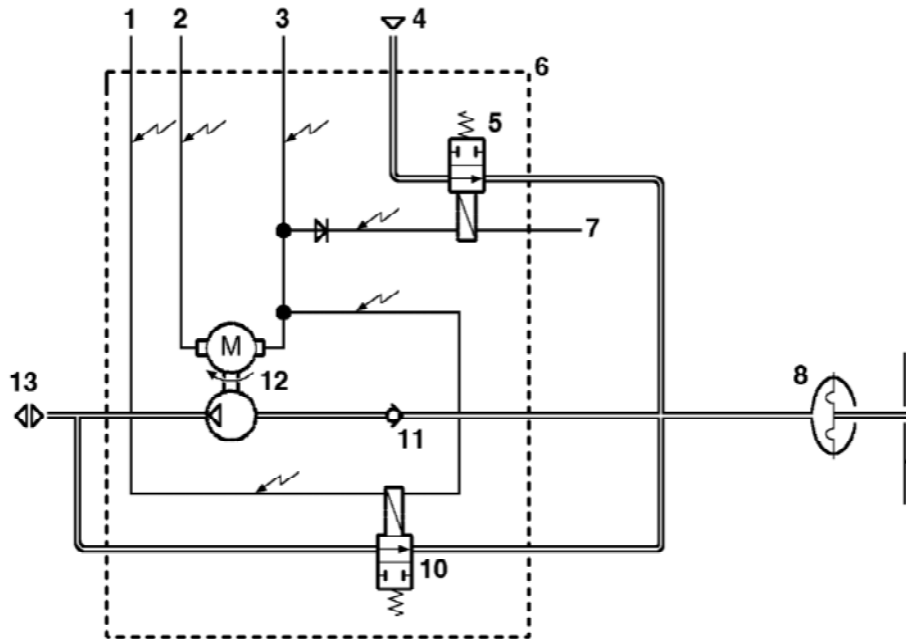


M19 3017

- | | |
|-------------------------|-------------------------------|
| 1. Vent | 5. Connecting hoses |
| 2. Valve housing | 6. Vent |
| 3. Electrical connector | 7. Vacuum actuator connection |
| 4. Motor housing | |

The vacuum pump assembly controls the operation of the vacuum actuator. Installed in the RH rear corner of the engine compartment, on a mounting bracket attached to the sidemember, the vacuum pump assembly consists of a vacuum pump, driven by an electric motor, and two normally open solenoid valves: a control valve and a dump valve.

Connecting hoses link the outlets of the control valve and the dump valve to the inlet side of the vacuum pump, at a vacuum actuator connection. A further connecting hose links the inlet side of the control valve to the outlet side of the vacuum pump at a common vent. A second vent is provided for the inlet to the dump valve. A non return valve between the vacuum pump and the vacuum actuator connection prevents the reverse flow of air through the vacuum pump. An electrical connector on the underside of the valve housing connects the vacuum pump assembly to the ECM via the vehicle wiring.



M18 0580

1. Control valve control signal
2. Vacuum pump control signal
3. Vacuum pump and valves supply
4. Vent
5. Dump valve
6. Vacuum pump assembly
7. Dump valve control signal
8. Vacuum actuator
9. Throttle
10. Control valve
11. Non return valve
12. Vacuum pump
13. Vent

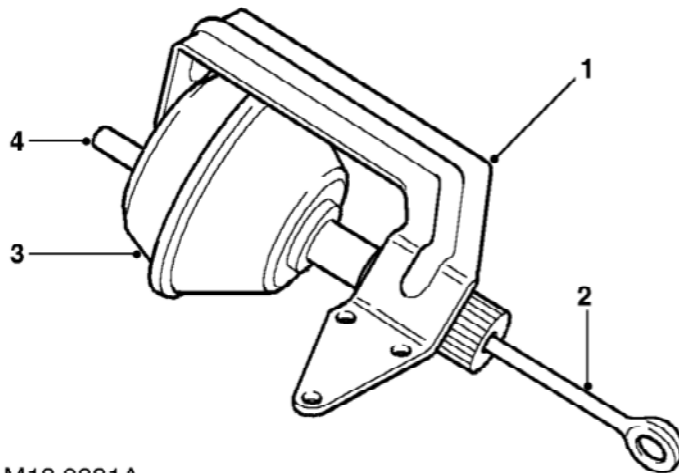
When cruise control is selected and the vehicle is in the correct driving configuration, the cruise control ECU outputs the pump and valves power supply. The cruise control ECU also closes the control and dump valves, and runs the vacuum pump, using individual Pulse Width Modulated (PWM) control signals.

When the vacuum pump runs, it draws air through the non return valve and creates a depression on one side of the diaphragm in the vacuum actuator, which moves to open the throttle. When the vehicle is at the set speed, the cruise control ECU stops the vacuum pump, and the non return valve closes to maintain the depression in the vacuum actuator and hold the throttle in position. If vehicle speed decreases below the set speed, or a higher set speed is required, the cruise control ECU starts the vacuum pump again to increase the depression in the vacuum actuator and increase the throttle angle. If the vehicle speed increases above the set speed, the cruise control ECU opens the control valve to reduce the depression in the vacuum actuator and reduce the throttle angle.



When cruise control is disengaged, the cruise control ECU removes the pump and valves power supply from the vacuum pump assembly, to disable the vacuum pump and open the control and dump valves. The open valves allow atmospheric pressure into the vacuum actuator, which moves to close the throttle. The dump valve provides additional safety for the system, by ensuring the vacuum is released from the vacuum actuator even if the control valve remains closed or the control valve vent line is obstructed. As a further safety feature, to ensure the dump valve is open, when the brakes are applied the brake switch connects a power feed to the dump valve control line.

Vacuum actuator



M18 0381A

- 1. Mounting bracket
- 2. Actuating rod

- 3. Diaphragm chamber
- 4. Vacuum pipe connection

The vacuum actuator translates pneumatic pressure changes into axial movement to operate the throttle. The actuator is installed in a mounting bracket attached to the throttle body.

A diaphragm installed in a chamber is connected to the vacuum pump assembly on one side and vented to atmosphere on the other. An actuating rod connects the diaphragm to the throttle linkage on the throttle body. When cruise control is engaged, the vacuum pump assembly reduces the pressure on one side of the diaphragm and the diaphragm

moves the actuating rod to operate the throttle. The operating range of the vacuum actuator is from 0 to 88 ± 4 % of throttle opening. This ensures there is sufficient range to induce normal downshifts, but prevents kickdown.

The throttle linkage allows the vacuum actuator to operate the throttle without moving the accelerator pedal, and also allows the accelerator pedal to override the vacuum actuator, to increase throttle opening, when the driver wants to accelerate the vehicle above the set speed.

CRUISE CONTROL SYSTEM OPERATION

Cruise control is enabled when the master switch is pressed, provided the interface ECU is in receipt of a cruise enable signal from the ECM and the vehicle is in the following driving configuration:

- Brakes off.
- Moving at a road speed between 22 and 125 mph (35 and 200 km/h).

The ECM outputs the cruise enable signal to the interface ECU, when:

- The engine is running and vehicle speed is above 3 mph (5 km/h).
- Engine speed does not exceed 6496 rpm.
- The gearbox is not in Park, Neutral or Reverse.

Engagement

When the system is enabled, cruise control is engaged by pressing the SET+ steering wheel switch. On receipt of the input from the SET+ switch, the cruise control ECU stores the current vehicle speed as the set speed and operates the vacuum pump assembly, which causes the vacuum actuator to operate the throttle and maintain the vehicle at the set speed.

When cruise control is engaged, the pump and valve power supply, that the cruise control ECU outputs to operate the vacuum pump assembly, is also connected to the Electronic Automatic Transmission (EAT) ECU. On receipt of the power supply the EAT ECU adopts the cruise control mode, which uses a shift map less sensitive to changes of throttle opening, to prevent unnecessary gear shifts. This improves operating refinement for a minor loss of performance.

Acceleration

While cruise control is engaged, the vehicle can be accelerated using either the SET+ switch or the accelerator pedal.

A momentary press (less than 0.5 second) of the SET+ switch increments the set speed by 1 mph (1.6 km/h) and the vehicle accelerates to the new set speed; pressing and holding the SET+ switch causes the vehicle to accelerate until the switch is released, at which point the increased vehicle speed is adopted as the new set speed.

If the accelerator pedal is used to accelerate the vehicle, cruise control remains engaged and the set speed is resumed once the accelerator pedal is released or, if the SET+ switch is pressed before the accelerator pedal is released, the higher speed is adopted as the new set speed.

Suspend/Resume

Cruise control is suspended when the RES- switch is pressed or one of the conditions required to enable the system is no longer present (e.g. the brakes are applied). Cruise control is also suspended if the vehicle speed decreases to less than 75% of the set speed, e.g. when travelling up a steep hill.

When cruise control is suspended:

- The cruise control ECU stops operating the vacuum pump assembly and control of the throttle returns to the accelerator pedal.
- The set speed is retained in memory by the cruise control ECU.
- The EAT ECU returns to its previous operating mode.

Provided the system is enabled, pressing the RES- switch causes the system to resume cruise control operation and accelerate or decelerate the vehicle to the stored set speed.



Cancelling

Cruise control is cancelled by pressing the master switch or turning the ignition switch to 0. When cruise control is cancelled, the set speed is deleted from the memory of the cruise control ECU and the cruise control warning lamp is extinguished. If cruise control was engaged when it was cancelled:

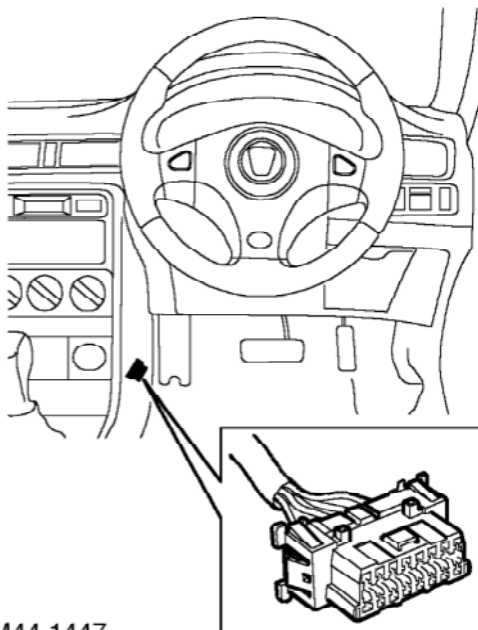
- The cruise control ECU stops operating the vacuum pump assembly and control of the throttle returns to the accelerator pedal.
- The EAT ECU returns to its previous operating mode.

Diagnostics

While the system is active, the cruise control ECU performs self-checks and plausibility checks of the outputs to the vacuum pump assembly and the two inputs it from the brake switch. If a fault is detected, a related fault code is stored in the non volatile memory of the cruise control ECU and cruise control is cancelled for the remainder of the ignition cycle. Codes are retrieved using TestBook, which communicates with the cruise control ECU via an ISO 9141 K line connection from the diagnostic socket.

The system is reset at the beginning of each ignition cycle and operates normally if a previously detected fault is no longer present.

Diagnostic socket



M44 1447