Chapter 11
Magneti Marelli 1AP

Contents

Vehicles Covered

Citroën

Model	Engine Code	Year	EMS System
Berlingo 1.4i	TU3JP (KFX)	1996 to 1997	Magneti Marelli 1AP
Partner 1.4i cat	TU3JP (KFX)	1996 to 1999	Magneti Marelli 1AP
Saxo 1.4i	TU3JP/L3 (KFX)	1996 to 1999	Magneti Marelli 1AP
Saxo 1.6i	TU5JP4 (NFX)	1997 to 1999	Magneti Marelli 1AP
Xsara 1.4i cat	TU3JP (KFX)	1997 to 1999	Magneti Marelli 1AP
Xsara 1.8i cat	XU7JB (LFX)	1997 to 1999	Magneti Marelli 1AP
Xsara 2.0i cat	XU10J4RS (RFS)	1997 to 1999	Magneti Marelli 1AP
ZX 1.4i cat	TU3JP (KFZ)	1996 to 1998	Magneti Marelli 1AP
ZX 2.0i cat	XU10J4RS (RFS)	1996 to 1998	Magneti Marelli 1AP

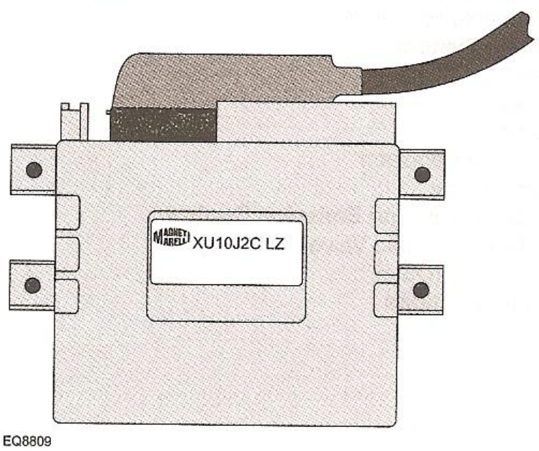
Peugeot

Model	Engine Code	Year	EMS System
106 1.4i	TU3JP/L3 (KFZ)	1996 to 1999	Magneti Marelli 1AP
106 1.6i GTi	TU5J4/L3 (NFX)	1997 to 1999	Magneti Marelli 1AP
206 1.1i cat	TU13P (HFZ)	1998 to 1999	Magneti Marelli 1AP
206 1.4i cat	TU3JP (KFX)	1998 to 1999	Magneti Marelli 1AP
306 1.4i cat	TU3JP/L3 (KFX)	1997 to 1999	Magneti Marelli 1AP
306 2.0i GTi-16	XU10J4RS/L3 (RFS)	1997 to 1999	Magneti Marelli 1AP

Introduction

The Magnetti Marelli MM1AP Engine Management System **(see Illustration 11.1)** is fitted to various Citroën and Peugeot vehicles. MM1AP is a fully integrated system that controls primary ignition, multi-point fuelling and idle control from within the same ECM. The system fitted to this range of vehicles is DIS or Distributorless Ignition System. Most versions employ a catalytic converter and a carbon canister for containing exhaust emissions.

The correct ignition dwell and timing for all engine operating conditions are calculated from data provided by the CAS (crankshaft position and speed), and the MAP sensor (engine load). A 55-pin connector and Multi-plug connects the ECM to the battery, sensors and actuators.



11.1 Magneti Marelli MM 1AP

MM1AP can be configured as a banked simultaneous injection system or, for engine XU10J4RS/L3 (RFS), a sequential injection system with the inclusion of a cylinder reference from a Camshaft Position Sensor (CMP).

Vehicles with automatic transmission and power assisted steering will have a Power Steering Pressure Switch (PSPS) included.

Basic ECM Operation

Once the ignition is switched on, power is applied to the main relay and the relay in turn provides a switched voltage supply to ECM pin No 35.

The majority of sensors such as the ATS, CTS, TPS and MAP sensor are now provided with a 5.0 volt reference supply from a relevant pin on the ECM. When the engine is cranked or run, a speed signal from the CAS causes the ECM to earth pin No 7 so that the fuel pump will run. The Fuel Pump relay is driven by ECM pin No 7 via an inertia switch, which will cut off the relay when it experiences deceleration associated with an impact. Ignition and injection functions are also activated. All actuators (Ignition coil, Injector, CFSV etc), are supplied with nbv from the fuel pump relay and the ECM completes the circuit by pulsing the relevant actuator wire to earth.

Reference Voltage

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

The earth return connection for most engine sensors are made through ECM pin No 17 and No 53 and these pins are not directly connected to earth. The ECM internally connects pin No 16 to earth via the ECM earth pins No 36 and No 54 that are directly connected to earth.

ECM power supplies and earths tests

nbv values

Condition	Value
Ignition on:	11.5 – 13.5
Engine cranking	8.0 + volts
Engine running	13.0 – 15.9

For local wiring diagram **(see Illustration 11.2)**

ECM Voltage Measurements

Terminal Numbers

ECM	Item	Condition	Volts
35	Relay output	Ignition on	nbv
52	Relay driver	Ignition off	nbv
52	Relay driver	Ignition on	1.25 max
7	Relay driver	Ignition on	nbv
7	Relay driver	Cranking/running	1.25 max
18, 19	ECM earth	Ignition on	0.25 max

Checking the ECM (General)

1 Inspect the ECM multi-plug for corrosion, and damage.
2 Check that the connector terminal pins are fully pushed home and making good contact with the ECM multi-plug.

Voltage Measurements at ECM Connections

Note: *Pin No 18 and No 19 are the ECM earths for the MM1AP EMS. For this reason, where possible, either pin No 18 or No 19 should be used for the voltmeter or 'scope earth connection.*

ECM Pin No 35

Note: *Pin No 35 is connected to the main relay output and voltage should be available with the ignition Key On.*

ECM Connected
1 Ignition Key On.
2 Backprobe ECM pin No 35, the voltmeter should indicate nbv.

ECM Disconnected
1 Ignition Key On.
2 Attach the negative voltmeter probe to an ECM earth pin.
3 Attach the positive voltmeter probe to pin No 35, the voltmeter should indicate nbv.

ECM Pin No 13

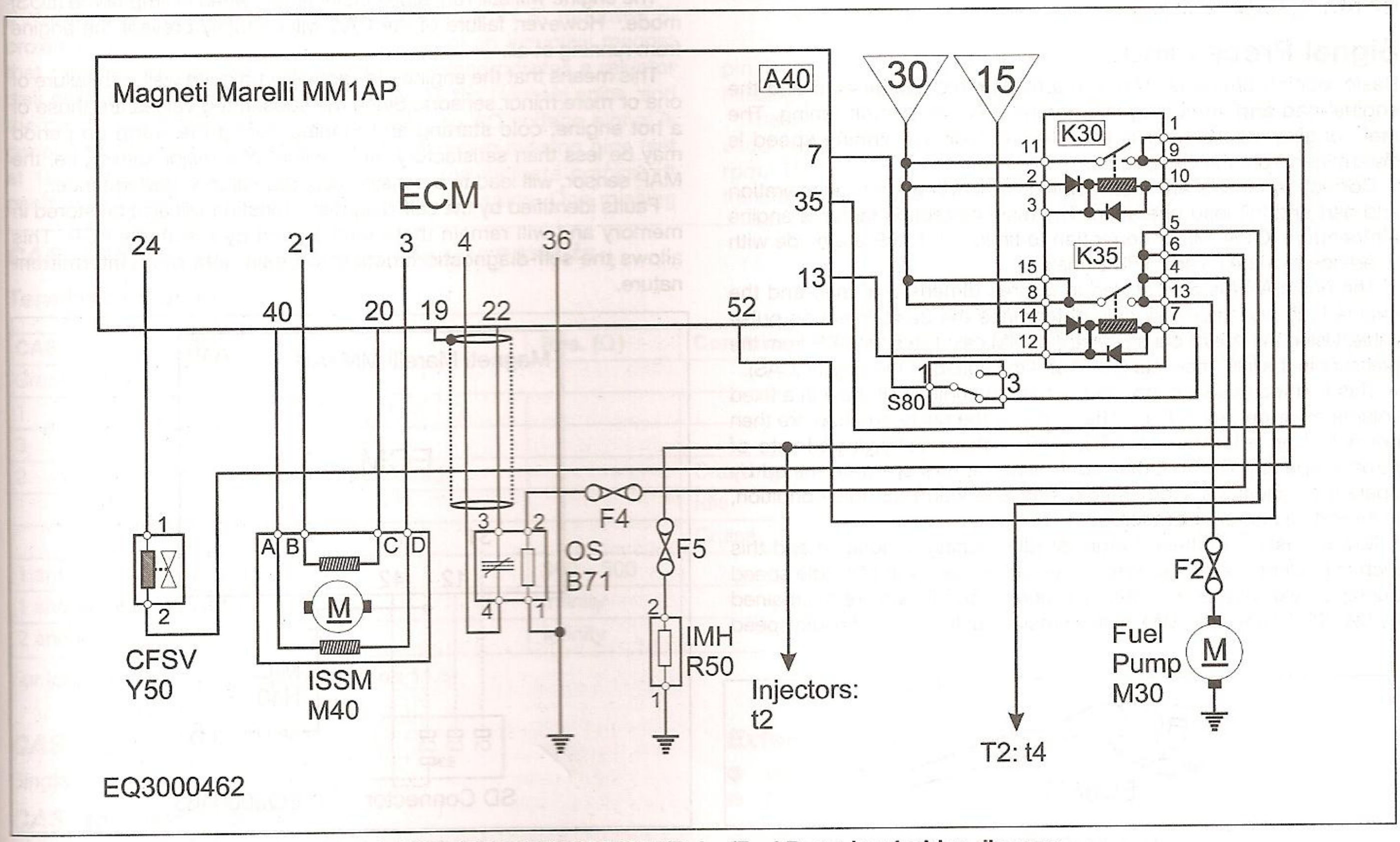
Note: *Pin No 13 is connected to the main relay ignition supply input and voltage should be available with the ignition Key On.*

ECM Connected
3 Ignition Key On.
4 Backprobe ECM pin No 13, the voltmeter should indicate nbv.

ECM Disconnected
4 Ignition Key On.
5 Attach the negative voltmeter probe to an ECM earth pin.
6 Attach the positive voltmeter probe to pin No 13, the voltmeter should indicate nbv.

ECM Pin No 52 (Main Relay Driver)

1 Relay and ECM connected.
2 Ignition Key On.
3 Backprobe pin No 52 with the voltmeter positive probe, nbv should be obtained.
4 No voltage, check the relay and the relay wiring.
5 Crank or run the engine, the voltage should drop to near zero.
6 If not, disconnect the ECM multi-plug (see Warnings No 3 in the Reference section), and connect a temporary jumper lead from pin No 52 to earth.



11.2 ECM/ISSM/CFSV/OS/IMH/Relay/Fuel Pump local wiring diagram

7 Relay operates: Check all voltage supplies and earth connections to the ECM. If the wiring is satisfactory, the ECM is suspect.
8 Relay does not operate: check the relay and the relay wiring.

ECM Pin No 7 (Fuel Pump Relay Driver)

9 Relay and ECM connected.
10 Ignition Key On.
11 Backprobe pin No 7 with the voltmeter positive probe, nbv should be obtained.
12 No voltage, check the relay and the relay wiring.
13 Crank or run the engine, the voltage should drop to near zero.
14 If not, disconnect the ECM multi-plug (see Warnings No 3 in the Reference section), and connect a temporary jumper lead from pin No 7 to earth.
15 Relay operates: Check all voltage supplies and earth connections to the ECM. If the wiring is satisfactory, the ECM is suspect.
16 Relay does not operate: check the relay and the relay wiring.

ECM Earth pin No 36, No 54, No 18 and No 19

ECM Multi-plug Connected

1 Ignition Key On
2 Attach the negative voltmeter probe to an engine earth
3 Attach the positive voltmeter probe to the earth terminal under test, the voltmeter should indicate 0.25V max.

ECM Multi-plug Disconnected

1 Ignition Key On or Off
2 Attach the negative voltmeter probe to the earth terminal under test.
3 Attach the positive voltmeter probe to a suitable battery supply point, the voltmeter should indicate nbv if the earth is satisfactory

Signal Shielding

To reduce RFI, a number of sensors (i.e. CAS, KS and OS) use a shielded cable. The shielded cable for the CAS is connected to the main ECM earth wire at pin No 19 to reduce interference to a minimum. The other shielded wires are connected to ECM earth pin No 18.

Signal Processing

Basic ignition timing is stored in a three dimensional map and the engine load and speed signals determines the ignition timing. The main engine load sensor is the MAP sensor and engine speed is determined from the CAS signal.

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

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

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

MM accesses a different map for idle running conditions and this map is implemented whenever the engine speed is at idle. Idle speed during all warm-up and normal hot running conditions are maintained by the ISCV. However, MM makes small adjustments to the idle speed by advancing or retarding the timing, and this results in an ignition timing that is forever changing during engine idle.

When the engine is equipped with an OS, the OS signal causes the ECM to modify the injector pulse so that the AFR is maintained close to the stoichiometric ratio.

Self-Diagnostic Function

MM1AP provides a serial port **(see Illustration 11.3)** for diagnostic and system tuning purposes, for local wiring diagram **(see Illustration 11.4)**. The port allows two way communication so that certain parameters can be changed (i.e. CO value on non-cat models or timing advance) and actuation of various output components. Datastream information (live values) on the status of system components is also available.

In addition, a self-test capability regularly examines signals from the engine sensors and internally logs a code in the event of a fault being present. This code can be extracted from the MM Serial Port by a suitable FCR. If the fault clears, the code will remain logged until the FCR is used to erase it from memory.

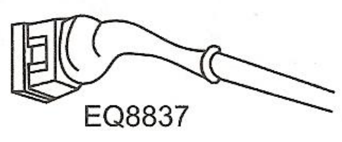
When the ECM detects that a major fault is present, it earths the appropriate ECM pin and the warning lamp on the dash will light. The lamp will stay lit until the fault is no longer present. However, if a minor fault is present the warning lamp will not light although the ECM will indeed log a fault code. Where the fault is intermittent, the lamp will light whilst the fault is present and extinguish when the fault is not present. A fault code will be logged under these circumstances and the presence of a fault code denotes that a fault was detected on the appropriate circuit at some past juncture.

In addition to the self-test capability, MM1AP has full limp home facilities, Limited Operation Strategy (LOS). In the event of a serious fault in one or more of the following sensors (ATS, CTS, TPS and MAP), the EMS will substitute a fixed default value in place of the defective sensor.

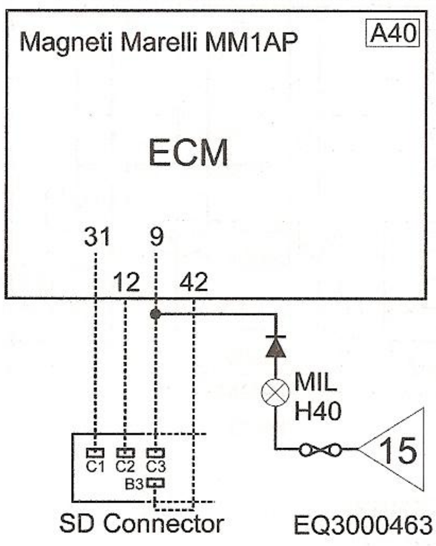
The engine will still run, albeit inefficiently, when in limp home (LOS) mode. However, failure of the CAS will certainly prevent the engine from running at all.

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

Faults identified by the self-diagnostic function will also be stored in memory and will remain there until erased by a suitable FCR. This allows the self-diagnostic function to retain data of an intermittent nature.



11.3 SD Connector



11.4 SD local wiring diagram

Ignition Systems

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

Amplifier

The MM amplifier contains the circuitry for switching the coil negative terminal at the correct moment to instigate ignition. The amplifier circuitry is contained within the ECM itself and the microprocessor controls the ignition dwell period for each condition of engine speed and battery voltage. One disadvantage of an internal amplifier is that if the amplifier fails, the whole ECM must be renewed.

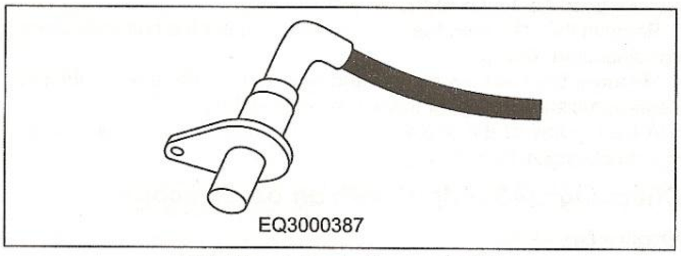
Dwell operation in MM is based upon the principle of the 'constant energy current limiting' system. This means that the dwell period remains constant at about 3.0 to 4.0 ms, at virtually all engine running speeds. However, the dwell duty cycle, when measured in percent or degrees, will vary as the engine speed varies.

Ignition timing

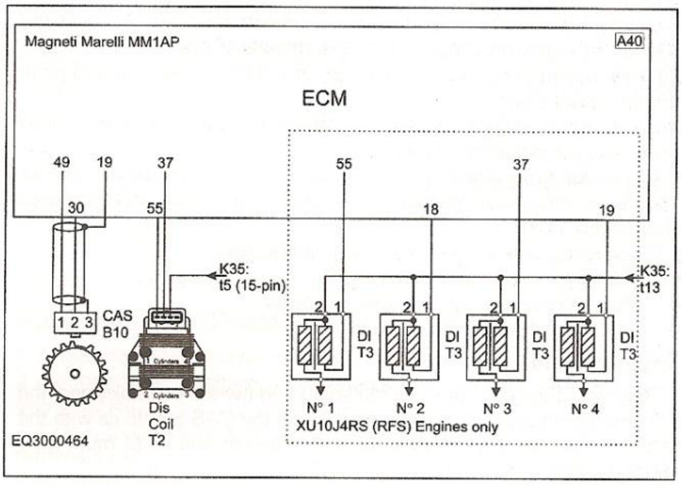
The ignition timing on MM G6 models is not normally adjustable. However, it is possible to adjust the ignition advance curve with the aid of a suitable FCR. This task should not be undertaken lightly and all other engine and system functions should be checked and evaluated before attempting advance adjustment.

Crank Angle Sensor (CAS)

The primary signal to initiate both ignition and fuelling emanates from a Crank Angle Sensor (CAS) **(see Illustration 11.5)** mounted in proximity to the flywheel. The CAS consists of an inductive magnet that radiates a magnetic field. The flywheel incorporates a reluctor disk containing steel pins set at intervals. As the flywheel spins, and the pins are rotated in the magnetic field, an AC voltage signal is generated to indicate speed of rotation. The two missing pins (set at 180° intervals) are a reference to TDC and indicate crankshaft position by varying the signal as the flywheel spins. One missing pin indicates TDC for cylinders No 1 and No 4 and the other missing pin indicates TDC for cylinders No 2 and No 3.



11.5 Crank Angle Sensor (CAS)



11.6 CAS/Primary ignition DIS local wiring diagram

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

CAS Voltage and Resistance Measurements

Terminal Numbers

CAS	ECM	Item	Res. (Ω)	Condition	Volts	VAC (rms)	VAC (pk to pk)
Cranking/ running							
1	49	Earth return			0.25 max		
3	19	Screen			0.25 max		
2	30	Output voltage		Cranking		0.7V+	2.0V+
				Idle		4.0V+	11.0V+
				Cruise		5.0V+	14.0V+
1 and 2	49 and 30		300 – 500				
1 and earth	49 and 19		Infinity				
2 and earth	30 and 19		Infinity				

For local wiring diagram **(see Illustration 11.6)**

CAS Type

Single CAS.

CAS Adjustments

There is no adjustment available for the CAS.

External Influences

- Incorrect air gap
- Faulty or incorrectly positioned flywheel

Checking the CAS (General)

1 Inspect the CAS multi-plug for corrosion, and damage.
2 Check that the connector terminal pins are fully pushed home and making good contact with the CAS multi-plug.
3 Remove the CAS from the engine block. Inspect the end surface for corrosion and damage.
4 Measure the CAS resistance and compare to the specifications. Refer to resistance tests at the end of this section.
5 A fault in any of the above areas is common reason for a poor or inaccurate signal from the CAS.

Checking CAS output with an oscilloscope

Engine Cranking

Note: *This test is more likely to be made if the engine is a non-runner.*
1 Detach the CAS or ECM multi-plug.
2 Connect an oscilloscope between terminals No 1 and No 2 at the CAS or the corresponding multi-plug terminals at the ECM.
3 Crank the engine. A minimum of about 4.0 to 5.0 VAC peak to peak should be obtained.
Note: *In some instances, a much larger waveform than expected could also be indicative of a fault.*
4 Check for even peaks. One or more peaks that are much smaller than the others would indicate a missing or damaged CAS lobe **(see Illustration 11.7)**.
5 If no signal, or a very weak or intermittent signal:

- Measure the CAS resistance.
- Check the sensor for damage, dirt or oil.
- Check the flywheel for damage

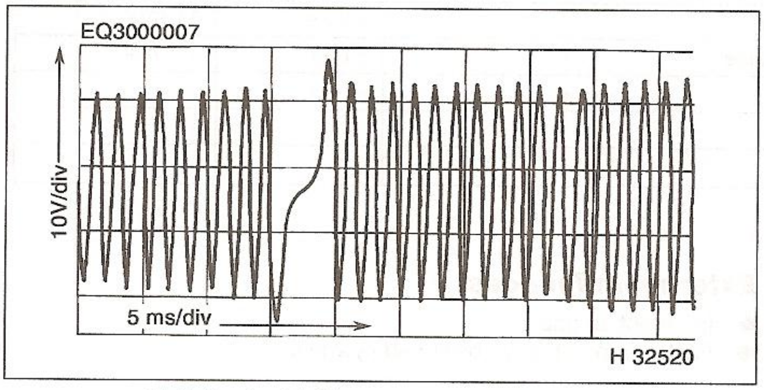
Engine Running

1 Reconnect the CAS or ECM multiplug and (where possible) peel the insulating boot back in order to backprobe the CAS terminals with the voltmeter probes (OR connect a BOB between the ECM multi-plug and the ECM).
2 Better results are usually obtained by probing the + terminal although the waveform can often be obtained upon the CAS earth return.
3 Run the engine at various engine speeds and check for a consistent signal that meets the same requirements as the cranking test.

Checking CAS Output with an AC Voltmeter

Engine Cranking

Note: *This test is more likely to be made if the engine is a non-runner.*
1 Detach the CAS or ECM multi-plug and connect an AC voltmeter between the CAS terminals
2 Crank the engine. A minimum of about 0.7 VAC rms should be obtained, although most good sensors will provide an output of more than 1.4 VAC rms.
Note: *The AC voltmeter at least proves that the CAS is generating a signal. However, the VAC is an average voltage and does not clearly indicate damage to the CAS lobes or that the sinewave is regular in formation.*



11.7 Typical CAS output signal waveform

Engine Running

Note: *Measuring the trigger output with the engine running can be a little tricky.*
1 Reconnect the multiplug and peel the insulating boot back (where possible), in order to backprobe the sensor terminals with the voltmeter probes.
2 Start the engine and allow it to idle. The AC rms voltage could be displayed at various engine speeds by regulating the throttle.
Note: *It is quite possible (even probable) that the engine will not start with the voltmeter connected. Alternatively, if the voltmeter is attached with the engine running it might stall or even misfire as the throttle is opened. This is because a small amount of current is robbed from the circuit to drive the meter, and this could be enough to cause the engine to misfire or stall.*
3 First run the engine at 2000 rpm and then attach the meter probes, the greater voltage output at this speed is usually sufficient to enable the engine to continue running. No damage will result to the engine so long as the voltmeter meets the correct specification (See Warnings No 5 in the Reference section)

Checking CAS Resistance with an Ohmmeter

1 Detach the CAS or ECM multi-plug and connect an ohmmeter between the two terminals leading to the sensor.
2 Record the resistance and compare it with the CAS resistance measurements.
Note: *Even if the resistance is within the quoted specifications, this does not prove that the CAS can generate an acceptable signal.*

CAS Shield Connection

1 The CAS may have a shield wire (not in all cases). Locate the wiring multi-plug connector or disconnect the ECM multi-plug.
2 Attach an ohmmeter probe to one of the sensor terminals No 1 or No 2.
3 Attach the other ohmmeter probe to the shield wire terminal. A reading of infinity should be obtained.
4 Move the ohmmeter probe from the shield wire terminal and connect it to earth. A reading of infinity should also be obtained.
Note: *The shield wire on the CAS in some systems is connected to the CAS earth return wire. In such a case continuity will be registered on the ohmmeter and this is normal for that vehicle. Refer to the wiring diagrams for the system under test to determine how the CAS is wired.*

Ignition Systems

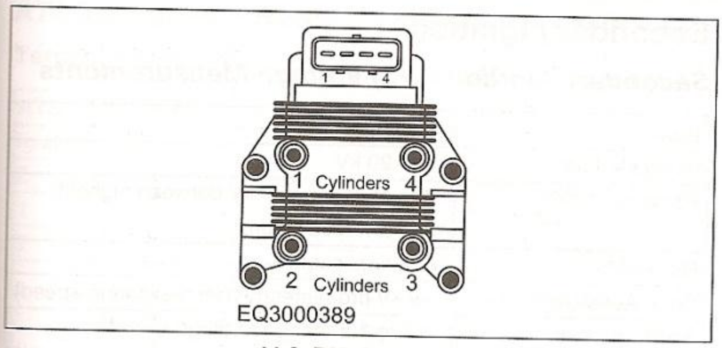
Direct Ignition (DI) (XU10J4 RFS engines only)

For the XU10J4 (RFS) engines only, each spark plug has its own ignition coil which is physically plugged directly onto the spark plug. All coils form a single unit that is housed on top of the spark plugs in the gap between the camshaft covers on top of the engine.

The ECM calculates the correct ignition dwell time and timing advance from data received from the CAS and the CMP sensor, and sends a timed control signal to each DI coil. The control signals are not strong enough to drive the ignition primary coils, therefore there is an amplifier integral to the ECM. Four amplified control signals from pins No 55, No 18, No 37 and No 19 are sent, one to each coil, alternately timed at 180° of crankshaft rotation. Four signals are therefore sent over 720° and resulting in all four sparkplugs being fired during two revolutions of the engine.

Distributorless Ignition System (DIS)

Although the ignition system is termed DIS, the basic operation is much the same as on models with conventional ignition. In a DIS or so-called 'wasted spark' system, a double-ended coil **(see Illustration 11.8)** is used to fire two plugs at the same time. This means that the system can only be used where two cylinders rise and fall together.



11.8 DIS Coil pack

One cylinder will fire on the compression stroke and the companion cylinder will fire on the exhaust stroke where the spark is 'wasted'. Two pairs of coils will therefore be required for a four-cylinder engine. About 3 kV is still needed to fire the 'wasted spark' plug, but this is far less than that required to bridge the rotor gap. Each ignition coil requires a voltage supply from the ignition switch and a separate dwell connection to the ECM, so that the ECM can switch each coil individually.

Ignition Primary Voltage Measurements

Note: *Voltage is supplied from the fuel pump relay, and is only available for approximately one second after the ignition is switched on – or during engine cranking and running conditions. By-pass the relay to provide a supply for voltage tests with the engine stopped.*

Terminal Numbers

Coil	ECM	Item	Volts
Engine cranking or running			
3	—	Supply voltage from FP relay: t5	nbv
1	55	Primary switching wire (1 and 4 cylinder)	300 (min)
2	37	Primary switching wire (2 and 3 cylinder)	300 (min)
4	—	Unused	—
1	55	Dynamic volt drop	2.0 max
2	37	Dynamic volt drop	2.0 max

For local wiring diagram **(see Illustration 11.6)**

Ignition Primary Resistance Measurements

Terminal Numbers

Coil	Item	Res. (Ω)
2 and 3	Primary resistance	0.8
1 and 3		
1-4 and 4-1	Secondary resistance	8.6 k (Valeo)
2-3 and 3-2		14.6 k (Bosch)

Ignition Primary Duty Cycle Table

rpm	Duty Cycle %	ms
Cranking	15 – 30	15.0 – 20.0
1000 rpm	5 – 20	2.5 – 4.0
2000 rpm	25 – 35	2.5 – 4.0
3000 rpm	30 – 40	2.5 – 4.0

External Influences

- Ignition system fault
- Defective ignition switch
- Alternator
- Voltage regulator

Primary Ignition Testing (General)

1 Check the coil terminals for good clean connections.
2 Clean away accumulations of dirt and the residue from the coil pack using a maintenance spray. The residue will attract dirt, and often leads to bleeding of the HT current to earth.
3 Inspect the coil for signs of tracking, particularly around the coil tower area.
4 Connect the negative oscilloscope or dwell meter probe to an engine earth.
5 Connect the positive oscilloscope or dwell meter probe to one of the two coil negative (-) terminals No 1 or No 2 (DIS) or to each negative terminal on the four DI coils (DI).
6 After making the following tests at one coil terminal, repeat the tests upon the other terminal(s).

Engine Non-runner Tests

1 Crank the engine.
2 Either a primary waveform or a duty cycle reading should be obtained. If the instrument can measure the value in milliseconds, then this is even more useful **(see Illustration 11.9)**.

Oscilloscope

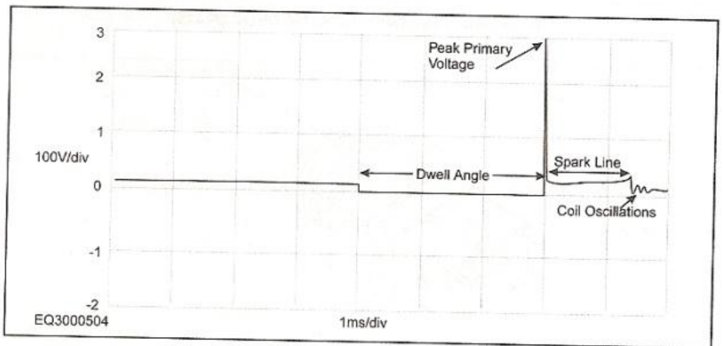
In addition to a well-defined waveform, the primary voltage peaks should be a minimum of 300 volts.
3 Good primary waveform or signal:
4 The primary ignition (including the CAS) is providing an acceptable signal. The fault is not related to the ignition primary circuit.

Poor Primary Waveform or Signal:

1 Check the CAS for a good signal.
2 Connect the positive oscilloscope or voltmeter probe to coil terminals No 3.
3 Crank the engine and check for voltage to the coil positive (+) terminal No 3.
4 No voltage, check the wiring back to the relay supply terminal.
5 Check for voltage to the coil negative (-) terminals No 1 and No 2 (DIS) or No 1 to No 4 (DI).
6 No voltage, remove the wire to the coil (-) terminal and recheck.
7 Still no voltage, check the coil primary resistance.
8 Voltage at nbv level, check for a short to earth between the appropriate coil terminal and the ECM pin.
9 Detach the ECM multi-plug and check for nbv at ECM pin No 55 and No 37 (DIS) plus No 16 and No 19 (DI) during cranking.
10 Poor or no voltage:
11 Check for continuity between the coil terminal and the ECM pin.
12 If the wiring is satisfactory, check all ECM voltage supplies and earth connections.
13 If tests find no faults, the ECM is suspect, however a substitute ignition coil should be tried before renewing the ECM.

Engine Running Tests

1 Make the following tests on coil primary terminal No 1 and then No 2 (DIS) No 1 to No 4 (DI) in turn. The results at each terminal should be very similar.



11.9 Typical primary input signal waveform to the DIS coil

2 Connect a 'scope or dwell meter to the coil negative terminal No 1.
3 Run the engine at idle and various speeds. Record the duty cycle values, primary voltage peak level and the dynamic voltage drop.
4 Compare the results with the specified figures. Please note that the quoted duty cycle figures are for guidance only and do vary between different vehicles of the same model. However, the readings in ms should be more reliable.
5 It is important that the duty cycle in % increases in value as the engine rpm is raised.
6 It is important that the duty cycle in ms does not change much in value as the engine rpm is raised.
7 If the dynamic voltage drop is high (usually over 2.5 volts) coupled with a low primary voltage peak and a high dwell % (at idle), then make the module volt drop checks. The set of conditions listed above could result in poor starting and a misfire under load.
Caution: If the dynamic voltage drop is high (usually over 2.5 volts) but the primary voltage peak and dwell % values are ok, then the amplifier is probably satisfactory. Be warned that the amplifier is an integral part of the ECM on this model and renewing the ECM just because the dynamic voltage drop is too high may not result in a better reading with a new ECM.

Module Volt-drop Checks

1 Check the ECM earth connections.
2 Check that wiring connections from devices such as a radio suppressor or a burglar alarm have not been fitted to the coil primary (-) terminal.
3 If the earth and wiring are satisfactory, yet the primary peak voltage and the dwell % at idle are particularly high, then the ECM is definitely suspect. Refer to the caution above before renewing the ECM
4 The results at each terminal should be very similar.

Secondary Ignition

Secondary Ignition (DIS) Voltage Measurements

Item	Voltage
Firing kV (idle)	8 to 20 kV
Firing kV (1500)	8 to 15 kV (max 4 kV between highest and lowest cylinder)
Rotor kV	Not applicable
Snap Acceleration kV	+8 kV (from steady rpm measuring speed)
Spark duration	1.3 to 1.5 ms (good plugs & ignition)

Secondary Resistance Measurements

Component	Item	Res. (Ω)
HT lead resistance		30000 max
Rotor resistance	Not applicable	
1-4 and 4-1)	Secondary resistance	8.6 k (Valeo)
2-3 and 3-2)		14.6 k (Bosch)

Spark plugs

Model	Spark plug		Gap
	Eyquem	Champion	
Peugeot 405 (RGZ)	RFC58LS2E	—	0.90 ± 0.1 mm

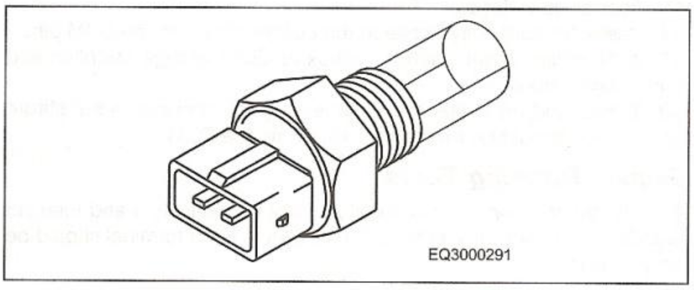
Sensors

Air Temperature and Coolant Temperature Sensors (ATS & CTS)

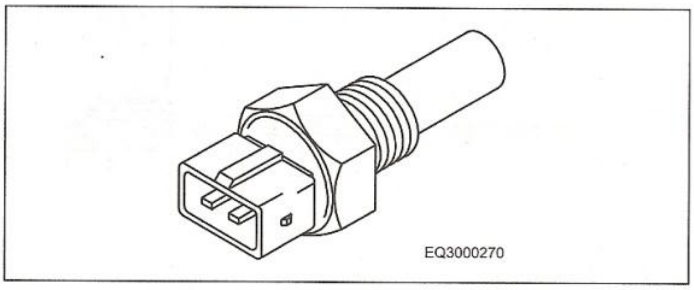
The Air Temperature Sensor (ATS) **(see Illustration 11.10)** is mounted in the air intake where it measures the air temperature flowing into the engine. Because the density of air varies in inverse proportion to the temperature, the ATS signal allows more accurate assessment of the volume of air entering the engine. This signal is approximately 2.0 to 3.0 volts at an ambient temperature of 20°C and reduces to about 1.5 volt as the temperature rises to around 40°C.

The Coolant Temperature Sensor (CTS) **(see Illustration 11.11)** is immersed in the coolant system and measures the temperature of the engine coolant.

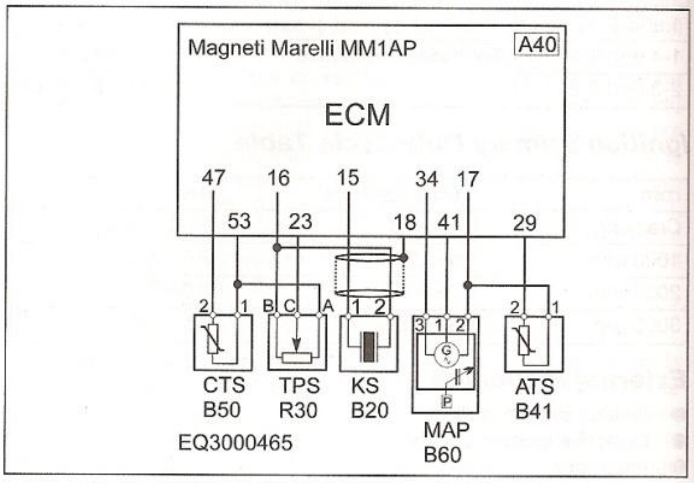
The open circuit supply to the sensors is at a 5.0 volt reference level and the earth path is through the sensor return. Both sensors operate on the Negative Temperature Coefficient (NTC) principle. A variable voltage signal is returned to the ECM based upon the air and coolant temperatures.



11.10 Air Temperature Sensor (ATS)



11.11 Coolant Temperature Sensor (CTS)



11.12 ATS/CTS/KS/MAP/TPS local wiring diagram

ATS Voltage and Resistance Measurements

Terminal Numbers

ATS	CTS	ECM	Item	Temp (°C)	Res. (Ω)	Volts
Ignition on/ running						
2		44	Supply voltage			5.0 ± 0.1
1		26	Sensor return			0.25 (max)
2		44	Signal voltage	20		2.0 to 3.0
				40		1.5
					Open circuit	5.0 ± 0.1
					Short to earth	Zero
	2	45	Supply voltage			5.0 ± 0.1
	1	26	Sensor return			0.25 (max)
	2	45	Signal voltage	0	5.95 – 6.46 k	
				20	2.2 – 2.7 k	3.0 to 3.5
				50	760 – 910	2.5
				80	290 – 370	1.0 to 1.3
					Open circuit	5.0 ± 0.1
					Short to earth	Zero

For local wiring diagram **(see Illustration 11.12)**

Sensors Type

Two-wire NTC sensors

Note: *The ATS has only a minor effect on engine operation.*

External Influences

- Vacuum leak
- Cooling system defect
- Low oil level

Checking the Sensors (General)

1 If either of the sensors is suspected of faulty operation, the following tests could be made.
2 Inspect the multi-plugs for corrosion, and damage.
3 Check that the connector terminal pins are fully pushed home and making good contact with the multiplug.

Checking Operation of Sensors with an Oscilloscope or Voltmeter

1 Roll back the rubber protection boot to the multi-plugs (where possible) OR connect a BOB between the ECM multi-plug and the ECM.
2 Connect the negative oscilloscope or voltmeter probe to an engine earth OR the sensor earth.
3 Connect the positive oscilloscope or voltmeter probe to the wire attached to the sensor signal terminal.
4 Engine at rest, ignition on

Testing the ATS

1 The signal voltage will vary according to the temperature of the air in the inlet tract or the coolant temperature. Refer to the chart for the voltages at various temperatures. As the under bonnet air rises in temperature, then the voltage signal passed to the ECM will reduce.
2 When undergoing tests at various temperatures the ATS can be warmed with a hairdryer or cooled with something like 'Freezit', which is an ice cold aerosol spray, sold in electronic component shops. As the ATS is heated or cooled, the temperature will change and so too will the resistance and voltage.
3 If the ATS signal voltage is zero (supply is open circuit or shorted to earth) or at 5.0 volt level (ATS is open circuit) see the relevant tests below.

Engine Running Tests (CTS)

1 Allow the engine to become cold.
2 Engine at rest, ignition on
3 The signal voltage will vary according to temperature. Refer to the CTS chart for the voltages at various temperatures.
4 Check that the CTS voltage corresponds to the temperature of the CTS.
5 Start the engine and allow it to warm-up to normal operating temperature. As the engine warms-up, the voltage should reduce in accordance with the CTS chart.
6 A particular problem is where the CTS varies in resistance (and voltage) outside of its normal range.

- The CTS voltage may typically be 3.0 to 3.5 volts cold and 1.0 to 1.3 volts hot. If the voltage in that typical system varies from 1.75 volts cold to 1.25 volts hot, the engine will be difficult to start when cold yet run richer than normal when hot.
- This will NOT result in the generation of a fault code in self-diagnostic systems because the CTS is still operating within its design parameters.

7 If the CTS signal voltage is zero (supply is open circuit or shorted to earth) or at 5.0 volt level (CTS is open circuit) see the relevant tests below.

Zero Volts Obtained at the Signal Terminal

1 Check that the signal wire is not shorted to earth.
2 Check for continuity of the signal wiring between the sensor and the ECM.
3 If the sensor wiring is satisfactory, check all voltage supplies and earth connections to the ECM. If the voltage supplies and earth connections are satisfactory, the ECM is suspect.

5.0 volt Obtained at the Signal Terminal

1 This is the open circuit voltage and will be obtained in one of the following conditions:
2 The signal terminal in the sensor multi-plug is not making contact with the sensor.
3 The sensor or the sensor signal wire is open circuit.
4 The sensor earth connection is open circuit.

Signal or Supply Voltage at nbv Level

- Check for a short to a wire connected to the battery positive (+) terminal or a switched supply voltage.

Resistance Tests with an Ohmmeter

ATS

- A resistance test may be made at various temperatures and a comparison made with the temperature/resistance chart. Refer to voltage tests for a method of heating/cooling the ATS.

CTS On Vehicle

- A resistance test may be made at various temperatures and a comparison made with the temperature/resistance chart. When the resistance is within the stated parameters for a cold engine (20°C) the coolant temperature should be within ± 5°C of that figure.

Note: *An allowance should be made for a temperature obtained by probing the outside of the CTS or coolant passage. This is because the actual temperature of the coolant may be hotter than the surface temperature of the CTS.*

CTS Off Vehicle

1 The recommended method is to remove the CTS from the vehicle.
2 Place it in a suitable container of water and measure the temperature of the water.
3 Measure the resistance of the CTS and check the resistance against the temperature chart.
4 Heat the water, periodically measuring the water temperature and the CTS resistance and comparing the resistance with the temperature chart.

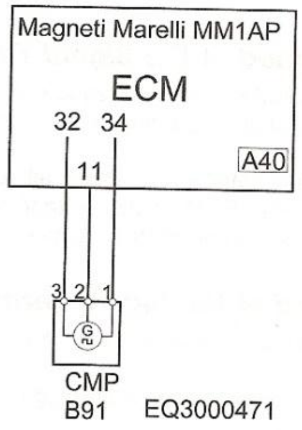
Camshaft Position (CMP) Sensor (Engine RFS)

Some engines (RFS) are multi-point sequential injection and require the addition of a Camshaft Position (CMP) Sensor to provide the system with the knowledge of which cylinder is No 1. The CMP sensor is a Hall Effect sensor.

Fitted to the inlet camshaft drive wheel is a timing lobe. As the camshaft rotates and the lobe is positioned opposite the CMP sensor, a Hall Effect signal is returned to the ECM, which exactly identifies the position of No 1 cylinder.

Once No 1 cylinder has been identified, the ECM examines the CAS position signal and injects fuel into No 1 cylinder as the inlet valve opens. Injection for all other cylinders occur as the inlet valves open in firing order sequence.

During engine start-up, the ECM examines the CMP signal. If no signal is available, the ECM enters LOS and limits the engine speed to approximately 3500 rpm.



11.13 CMP local wiring diagram

CMP Voltage Measurements

Terminal Numbers

CMP	ECM	Item	Volts
Ignition on			
1	34	Sensor supply	5.0
Engine running			
2	11	Signal voltage	0 to 5.0 (switching)
3	32	Sensor return	0.25 max

For local wiring diagram **(see Illustration 11.13)**

Sensor Type

Hall Effect

Checking the CMP Sensor (General)

- The CMP sensor is located adjacent to the camshaft pulley and tests are best executed with the aid of a BOB connected between the ECM multi-plug and the ECM.

Checking CMP Sensor Operation with an Oscilloscope or Voltmeter

1 The three wires to the connector are supply, earth and signal.
2 Connect the negative oscilloscope or voltmeter probe to an engine earth.
3 Connect the positive oscilloscope, dwell meter or voltmeter probe to the wire attached to the CMP sensor signal terminal No 2.

Checking for a CMP Sensor Signal

1 Allow the engine to idle.
2 A waveform, duty cycle or voltage should be obtained **(see Illustration 11.14).**

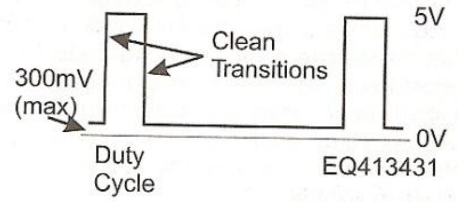
No Signal or an Erratic Signal, Duty Cycle or Voltage

1 With the ignition on, check the voltage supply to CMP sensor terminal No 1.
2 Check the sensor return connection to the CMP sensor terminal No 3
3 Move the voltmeter positive probe to the signal terminal No 2.
4 A voltage between 4 to 3 volts should be obtained.
5 If there is no signal voltage and the supply and earth voltages are OK, the CMP sensor is suspect.

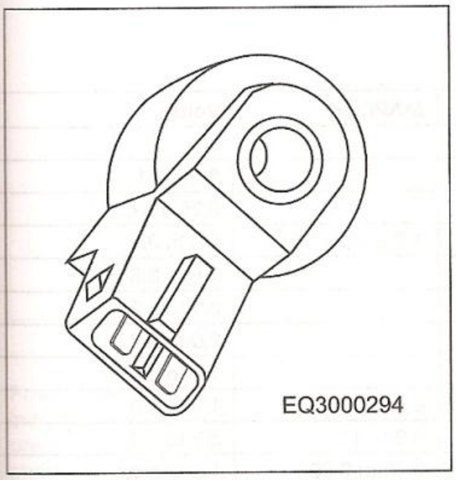
Knock Sensor (KS)

For any given high compression engine the optimal ignition timing (at engine speeds greater than idle) is quite close to the point of onset of knock. However, running so close to the point of knock occurrence, means that knock will certainly occur on one or more cylinders at certain times during the engine operating cycle.

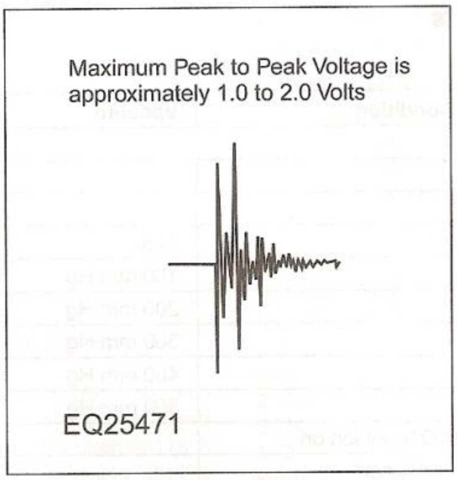
Since knock may occur at a different moment in each individual cylinder, MM1AP employs a Knock control microprocessor (in the ECM) to pinpoint the actual cylinder or cylinders that are knocking.



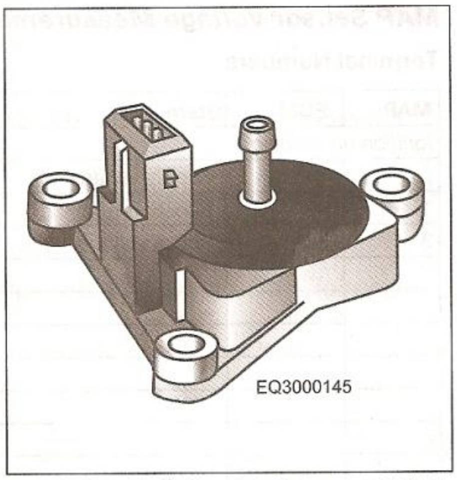
11.14 Typical CMP output signal waveform



11.15 Knock Sensor (KS)



11.16 Typical KS output signal waveform



11.17 Manifold Absolute Pressure (MAP) Sensor

The Knock Sensor (KS) **(see Illustration 11.15)** is mounted on the engine block and consists of a piezo-ceramic measuring element that responds to engine noise oscillations. Engine knock is converted to a voltage signal by the Knock Sensor and returned to the KCU for evaluation and action. The knocking frequency is in the 15kHz frequency band.

The ECM will analyse the noise from each individual cylinder and set a reference noise level for that cylinder based upon the average of the noise over a pre-determined period. If the noise level exceeds the reference level by a certain amount, the ECM identifies the presence of engine knock.

Initially, timing will occur at its optimal ignition point. Once knock is identified, the Knock Control microprocessor retards the ignition timing for that cylinder or cylinders by degrees. After knocking ceases, the timing is advanced until the reference timing value is achieved or knock occurs once more when the timing is once more retarded. This process continually occurs so that all cylinders will consistently run at their optimum timing.

KS Voltage Measurements

Note: *The KS signal will provide a maximum peak to peak voltage of approximately 1.0 volt.*

Terminal Numbers

KS	ECM	Item	Volts
Engine running, KS active			
2	16	Sensor return	0.25 max
1	15	KS signal	1.0 approx.

For local wiring diagram **(see Illustration 11.11)**

KS Frequency

Approximately 15 kHz

External Influences

- Incorrect base timing
- Low or inferior grade petrol
- Ignition system fault
- Coolant system fault
- Carbon build-up in cylinders

Checking the KS (General)

1 Inspect the KS multi-plug for corrosion, and damage.
2 Check that the connector terminal pins are fully pushed home and making good contact with the KS multi-plug.

KS Test Procedure

Note: *If the engine is not equipped with timing marks, it will be necessary to bring number one piston to TDC and make appropriate marks on the timing case and front pulley to carry out the following procedure.*

1 Attach the probe of an inductive timing light to the HT lead of No 1 cylinder.
2 Allow the engine to idle.
3 Gently tap the engine block close to No 1 cylinder.
4 The timing should be seen to retard.
5 Transfer the inductive probe to No 4 cylinder.
6 Gently tap the engine block close to No 4 cylinder.
7 The timing should be seen to retard.

KS Test Procedure (Oscilloscope)

1 Attach an oscilloscope low voltage probe to the KS signal terminal No 2
2 Gently tap the engine block close to one of the cylinders.
3 A Knock Sensor signal waveform should be displayed upon the oscilloscope **(see Illustration 11.16)**.
4 Repeat the procedure for the other cylinders.

Manifold Absolute Pressure (MAP)

The main engine load sensor is the Manifold Absolute Pressure (MAP) sensor **(see Illustration 11.17)**. A vacuum hose connects the MAP sensor and the inlet manifold. Manifold vacuum acts upon the MAP sensor diaphragm and the ECM converts the pressure into an electrical signal. MAP is calculated from the formula: Atmospheric Pressure less Manifold pressure = Manifold Absolute Pressure.

Using the speed/density method, MM calculates the AFR from the MAP signal and the speed of the engine (CAS). This method relies on the theory that the engine will draw in a fixed volume of air per revolution.

When manifold vacuum is high (i.e. idle condition), MAP is moderately low and the ECM provides less fuel. When manifold vacuum is low (i.e. wide-open throttle), MAP is high and the ECM provides more fuel.

The inlet manifold on the MPi models is a 'dry' manifold. Since fuel does not enter the manifold – due to injection being made onto the back of the inlet valve, there is no risk of fuel being drawn into the MAP sensor to contaminate the diaphragm and a fuel trap is not used.

A 5 volt reference voltage is supplied to the sensor with the other end connected to earth. The third wire is connected to a transducer that converts the manifold pressure signal into a voltage. As the pressure in the manifold varies, so too does the signal voltage returned to the ECM.

MAP Sensor Voltage Measurements

Terminal Numbers

MAP	ECM	Item	Condition	Vacuum	MAP(bar)	Volts
Ignition on/running						
2	14	Supply voltage				5.0 ± 0.1
1	16	Sensor return				0.25 max
3	32	Signal voltage		Zero	1.0 ± 0.1	3.3 to 3.9
				100 mm Hg		2.8 to 3.6
				200 mm Hg		2.4 to 3.2
				300 mm Hg		2.0 to 2.8
				400 mm Hg		1.6 to 2.4
				500 mm Hg	0.5	1.2 to 2.0
			WOT/ignition on		0.9 to 1.1	3.3 to 3.9
			Idle speed		0.40 to 0.60	1.5 approx.
			Overrun (deceleration)		0.05 to 0.10	

For local wiring diagram **(see Illustration 11.11)**

MAP Sensor Type

Analogue 3-wire type

External Influences

- Excess fuel in fuel trap or vacuum hose
- General vacuum leak (induction manifold or other vacuum hoses)
- Vacuum leak in MAP sensor hose
- Faulty vacuum hose or connection
- Faulty engine inlet or exhaust valves
- Incorrect base idle speed
- Incorrect ignition timing
- Faulty spark plugs (wide gaps particularly)

Checking the MAP Sensor (General)

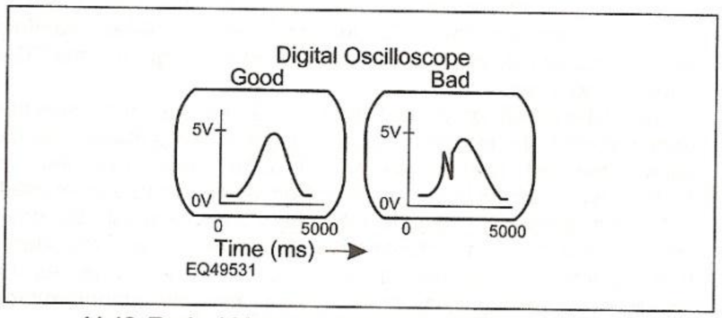
1 Inspect the MAP sensor multi-plug for corrosion, and damage.
2 Check that the connector terminal pins are fully pushed home and making good contact with the MAP sensor multi-plug.

Checking MAP Sensor Operation with an Oscilloscope or Voltmeter

1 Roll back the rubber protection boot to the MAP sensor multi-plug (where possible) OR connect a BOB between the ECM multi-plug and the ECM.
2 Connect the negative oscilloscope or voltmeter probe to an engine earth OR the earth return at terminal 1 of the MAP sensor.
3 Connect the positive oscilloscope or voltmeter probe to the wire attached to the MAP sensor signal terminal.

Check MAP Sensor with a Vacuum Gauge

1 Disconnect the vacuum pipe from the MAP sensor.



11.18 Typical MAP and TPS output signal waveform

2 Connect a vacuum pump to the sensor.
3 Switch the ignition on.
4 Compare the ignition on voltage to that specified.
5 Apply vacuum as shown in the table and check for a smooth voltage change **(see Illustration 11.18).**
6 If the voltage change is erratic, go to 'Erratic Signal Output' tests
7 Disconnect the vacuum pump and use a 'T' connector to connect a vacuum gauge between the inlet manifold and the MAP sensor.
8 Allow the engine to idle. If the engine vacuum is low, check for:

- A vacuum leak.
- A restricted vacuum connection.
- An engine problem i.e. misaligned cam belt.

Erratic Signal Output

1 An erratic output occurs when the voltage output is stepped, or drops to zero or becomes open circuit .
2 When signal output is erratic, this usually suggests a faulty MAP sensor. In this instance, a new sensor is the only cure.
3 Cease pumping vacuum once approximately 560 mm Hg is reached. The MAP sensor diaphragm should hold pressure for a minimum of 30 seconds at this vacuum setting.
4 If the MAP sensor signal voltage is non-existent go to the tests below headed 'Signal Voltage Not Available'

Signal Voltage Not Available

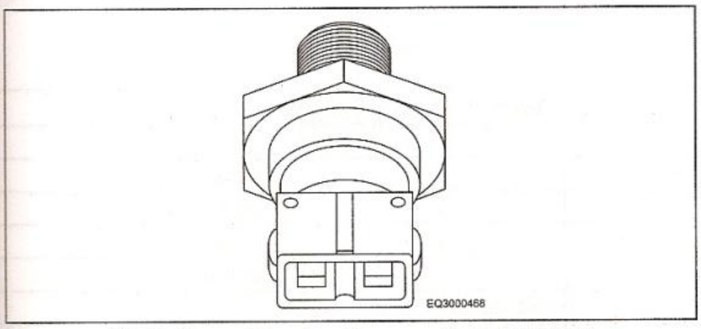
1 Check the reference voltage supply.
2 Check the earth return.
3 If the supply and earth are satisfactory, check for continuity of the signal wiring between the MAP sensor and the ECM.
4 If the supply and/or earth are unsatisfactory, check for continuity of the wiring between the MAP sensor and the ECM.
5 If the MAP sensor wiring is satisfactory, check all voltage supplies and earth connections to the ECM. If the voltage supplies and earth connections are satisfactory, the ECM is suspect.

Signal or Supply Voltage at nbv Level

- Check for a short to a wire connected to the battery positive (+) terminal or a switched supply voltage.

Power Steering Pressure Switch (PSPS) (some models)

For vehicles (some KFX and LFX) fitted with power assisted steering, a



11.19 Power Steering Pressure Switch (PSPS)

Power Steering Pressure Switch **(see Illustration 11.19)** is fitted to indicate to the ECM that there is an increase in the power steering pressure that could affect the idle speed. This switch is operated by a change in pressure when the power steering operates during movement of the front steering wheels. The PSPS is located in the engine compartment in the delivery pipe to the steering gear. The PSPS is closed when the steering gear oil pressure is low (i.e. when the steering is straight). The switch opens when the steering is turned i.e. when the oil pressure rises above a pre-determined value.

A voltage slightly less than nbv is applied to the PSPS. When the steering is straight and the PSPS is closed, the voltage drops to near zero. When the steering is turned and the steering gear pressure reaches its pre-determined value, the PSPS opens and the voltage on the PSPS pin rises to almost nbv. The ECM then increases the idle rpm to maintain the idle speed due to the increased load caused by the power steering coming into play.

PSPS Voltage Measurements

Wheels	PSPS condition	PSPS pressure	Volts
Ignition on/running			
Straight	Closed	13.5 to 24.0 bar	0.25
Turned	Open	31.5 ± 3.5 bar	nbv

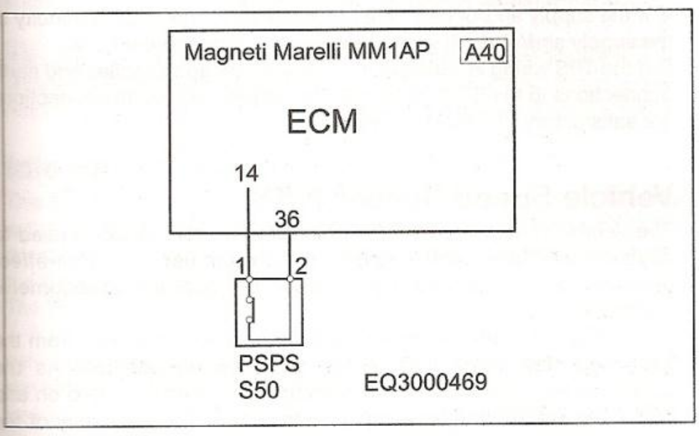
For local wiring diagram **(see Illustration 11.20)**

PSPS Resistance Measurements

Wheels	PSPS condition	Res. (Ω)
Straight	Closed	2.5 max
Turned	Open	Open circuit

Checking the PSPS (General)

1 Inspect the PSPS multi-plug for corrosion, and damage.
2 Check that the terminal pins are fully pushed home and making good contact with the PSPS. Poor contact and corrosion are common reasons for an inaccurate signal from a system sensor.



11.20 PSPS local wiring diagram

Quick PSPS Test

1 Start and run the engine until it reaches operating temperature.
2 Allow the engine to idle.
3 Turn the steering from one lock to the other.
4 Despite the increased load, the idle speed should decrease very little.
5 If the idle speed decreases, make the following tests.

Checking PSPS Operation with an Oscilloscope or Voltmeter

1 Testing is quite straightforward. The two wires to the connector are earth and signal.
2 Backprobe the PSPS multi-plug OR connect a BOB between the ECM multi-plug and the ECM.
3 Connect the negative oscilloscope or voltmeter probe to an engine earth OR the PSPS earth.
4 Connect the positive oscilloscope or voltmeter probe to the wire attached to PSPS signal terminal No 2.
5 Allow the engine to idle.
6 Turn the wheels in one direction so that full-lock is applied
7 The meter should indicate a voltage slightly under nbv.
8 No voltage, check for continuity of the signal wiring between the PSPS terminal No 2 and the ECM.
9 Turn the steering so that the wheels are straight.
10 The meter should now indicate a voltage of almost zero.
11 PSPS voltage high:
- Check the earth connection.
- Make the PSPS resistance tests.

12 If the wiring, earth and the PSPS operation are satisfactory, yet the ECM fails to respond to the PSPS signal, check all voltage supplies and earth connections to the ECM. If the wiring is satisfactory, the ECM is suspect.

PSPS Resistance Tests

1 Remove the multi-plug connection to the PSPS.
2 Connect an ohmmeter between the two terminals on the PSPS.

Wheels Straight

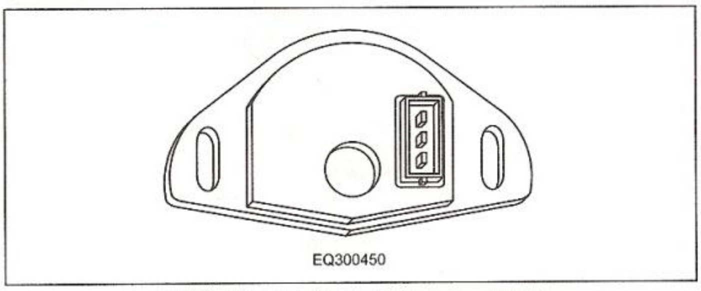
3 The ohmmeter should register continuity. If the resistance of the PSPS is greater than 2.5 ohms, the PSPS is suspect.

Wheels Turned

4 The ohmmeter should register an open circuit. If continuity or an ohmic value is displayed, the PSPS is suspect.

Throttle Position Sensor (TPS)

A Throttle Position Sensor (TPS) **(see Illustration 11.21)** is provided to inform the ECM of rate of acceleration and throttle position. The TPS is a potentiometer with three wires. A 5 volt reference voltage is supplied to a resistance track with the other end connected to earth. The third wire is connected to an arm that wipes along the resistance track and so varies the resistance and voltage of the signal returned to the ECM.



11.21 Throttle Position Sensor (TPS)

TPS Voltage Measurements

Terminal Numbers

TPS	ECM	Item	TPS posn	Res. (Ω)	Volts
Ignition on/running					
A	53	Sensor return			0.25 max
B	16	Supply voltage			5.0 ± 0.1
C	23	Signal voltage	Closed		0.3 to 0.6
			Fully open		5.0 approx.
A and B	53 and 16	Fixed		Not stated	
A and C	53 and 23	Signal	Closed	Not stated*	
			Fully open	Not stated*	
B and C	14 and 23	Signal	Closed	Not stated*	
			Fully open	Not stated*	

**Values for the TPS resistances are not stated for the MM1AP system. However, the resistance between the relevant terminals should vary smoothly as the throttle is opened and closed.*

For local wiring diagram **(see Illustration 11.11)**

Adjust the TPS

The TPS is not adjustable or repairable and must be renewed if faulty or out of specification.

External Influences

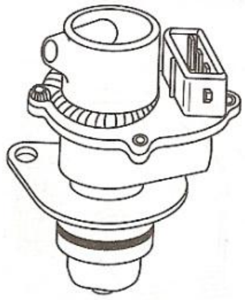
- Incorrect adjustment (where adjustment possible)
- Over tightening of fixing screws
- Loose TPS multiplug
- Maladjusted or sticking throttle plate
- Maladjusted or sticking throttle cable

Checking the TPS (General)

1 Inspect the TPS multi-plug for corrosion, and damage.
2 Check that the connector terminal pins are fully pushed home and making good contact with the TPS multi-plug.
3 Any of the above faults are common reasons for an poor or inaccurate signal from the TPS.

Checking TPS Operation with an Oscilloscope or Voltmeter

1 Roll back the rubber protection boot (where possible) to the TPS multi-plug OR connect a BOB between the ECM multi-plug and the ECM.
2 Connect the negative oscilloscope or voltmeter probe to an engine earth OR the earth return at terminal No A of the TPS.
3 Connect the positive oscilloscope or voltmeter probe to the wire attached to TPS terminal No C.
4 Throttle closed, ignition on.
5 Compare the throttle closed voltage to that specified.



11.22 Vehicle Speed Sensor (VSS)

6 Open and close the throttle several times and check for a smooth voltage increase to a maximum of 4.25 to 4.95 volts.
7 If a digital voltmeter is used, then it is useful for it to have a bar graph facility.
8 If an oscilloscope timebase of approximately 5 seconds is available, then it should be possible to plot the TPS output curve on the screen as the throttle is opened and then closed **(see Illustration 11.18)**
9 If the TPS signal voltage is non-existent go to the tests below headed 'Signal Voltage Not Available'

Erratic Signal Output

1 An erratic output occurs when the voltage output is stepped, or drops to zero or becomes open circuit.
2 Check the TPS resistance at the various terminals.
3 When the TPS signal output is erratic, this usually suggests a faulty signal track. In this instance, a new TPS is the only cure.

Signal or Supply Voltage at nbv Level

- Check for a short to a wire connected to the battery positive (+) terminal or a switched supply voltage.

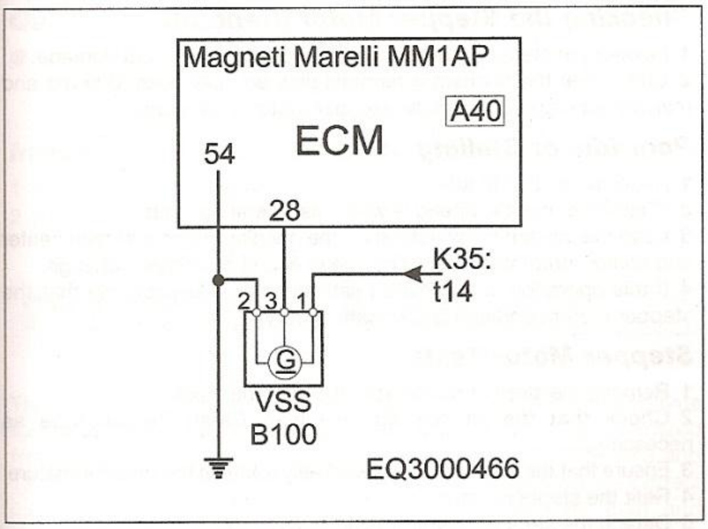
Signal Voltage Not Available

1 Check for the reference voltage supply at TPS terminal No 2.
2 Check the earth return connection at TPS terminal No 1.
3 If the supply and earth are satisfactory, check for continuity of the signal wiring between the TPS and the ECM.
4 If the supply and/or earth are unsatisfactory, check for continuity of the supply and/or earth wiring between the TPS and the ECM.
5 If the TPS wiring is satisfactory, check all voltage supplies and earth connections to the ECM. If the voltage supplies and earth connections are satisfactory, the ECM is suspect.

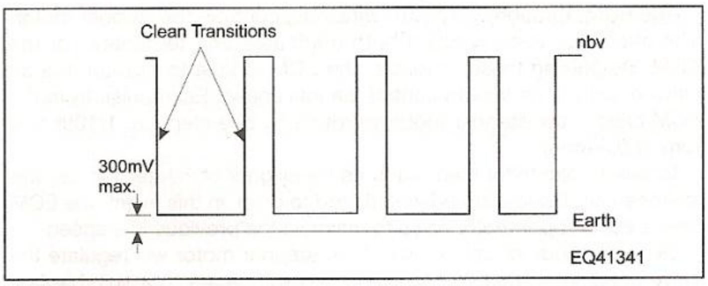
Vehicle Speed Sensor (VSS)

The Vehicle Speed Sensor (VSS) **(see Illustration 11.22)** is used to advise the ECM of vehicle speed. It operates upon the Hall-effect principle and is mounted directly upon the gearbox speedometer connection.

A voltage of approximately 12 volts is applied to the VSS from the ignition switch when it is in the switched on position. As the speedometer cable turns, the hall switch is alternately turned on and off to return a square wave signal to the ECM. The frequency of the signal (8 pulses per revolution) denotes the vehicle speed.



11.23 VSS local wiring diagram



11.24 Typical VSS signal output waveform

VSS Voltage Measurements

Terminal Numbers

VSS	ECM	Item	Volts
Ignition on/ running			
1	54	Return	0.25 max
2	—	Supply voltage	nbv
3	28	Signal voltage	nbv to zero

For local wiring diagram **(see Illustration 11.23)**

VSS Frequency

8 pulses per revolution of the speedometer cable.

Checking the VSS (General)

1 Inspect the VSS multi-plug for corrosion, and damage

2 Check that the terminal pins are fully pushed home and making good contact with the VSS plug.

Checking VSS Operation

1 Testing is quite straightforward. The three wires to the connector are supply, earth and signal.

2 Backprobe the VSS multi-plug OR connect a BOB between the ECM multi-plug and the ECM.

3 Connect the negative probe of an oscilloscope, dwell meter or voltmeter to an engine earth.

4 Connect the positive probe of the oscilloscope, dwell meter or voltmeter to the wire attached to the VSS signal terminal number.

Checking for a VSS Signal

Note: *The supply voltage may originate from the ignition switch or system relay. If the supply is applied from the system relay, the connection may be from the first or second relay contact. The first relay contact applies voltage when the ignition is on, the second relay contact applies voltage only when the engine is running.*

1 Switch on the ignition or start the engine as appropriate.

2 The drive wheels must rotate for a signal to be generated. This may be accomplished by using one of the two following methods:

3 Push the vehicle forward.

4 Place the vehicle upon a ramp so that the drive wheels can freely turn. Either rotate the wheels by hand or run the engine in gear at a very slow speed.

5 A waveform, duty cycle or voltage should be obtained **(see Illustration 11.24)**.

No Signal or an Erratic Signal, Duty Cycle or Voltage

1 VSS multi-plug disconnected, ignition on

2 Check for a voltage supply to the VSS supply terminal.

3 No voltage, check the supply from the ignition switch or system relay as appropriate.

4 Check the earth connection at the VSS earth terminal.

5 Disconnect the VSS multiplug

6 Move the voltmeter positive probe to the signal terminal.

7 A voltage between 8.5 and 10.0 volts should be obtained.

Supply and Earth Voltages OK

- The VSS is suspect or the VSS is not being rotated by the speedometer drive (i.e. broken cable or gearbox fault).

No Signal Voltage

1 Check the voltage at the ECM multiplug terminal.

2 If voltage is satisfactory at the ECM, check the continuity of the signal wiring.

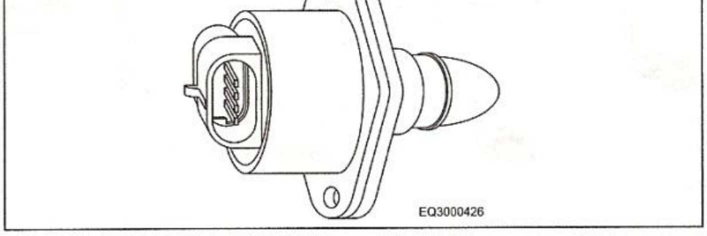
3 If no voltage is available at the ECM, check all voltage supplies and earth connections to the ECM. If the voltage supplies and earth connections are satisfactory, the ECM is suspect.

Actuators

Idle Speed Stepper Motor (ISSM)

The Idle Speed Stepper Motor (ISSM) **(see Illustration 11.25)** is an actuator that the ECM uses to automatically control idle speed during normal idle and during engine warm-up. When the throttle is closed, the throttle plate is locked in a position where very little air passes by. The throttle position then, will have no effect upon the idle speed.

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



11.25 Idle Speed Stepper Motor (ISSM)

The ECM, through two motor windings, controls the stepper motor. The circuit for each winding both originates and terminates at the ECM. By pulsing these windings, the ECM is able to position the air valve exactly in its task to control the idle speed. Each pulse from the ECM causes the stepper motor to rotate by one step (i.e. 1/10th of a turn or 0.04mm).

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

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

On switching off the engine, power remains applied to the stepper motor for 4 to 5 seconds so that the ECM can actuate the air valve to its fully closed position (thus preventing engine run-on). After a few seconds, the ECM actuates the air valve to a slightly open position where it is ready for the next engine start.

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

Stepper Motor Voltage Measurement

Terminal numbers

SM	Component	Item	Volts
Engine running, Idle			
A	ECM: t40	Switching wire	Zero to nbv
B	ECM: t21	Switching wire	Zero to nbv
C	ECM: t20	Switching wire	Zero to nbv
D	ECM: t3	Switching wire	Zero to nbv

For local wiring diagram **(see Illustration 11.2)**

Stepper Motor Resistance Measurement

Terminal Numbers

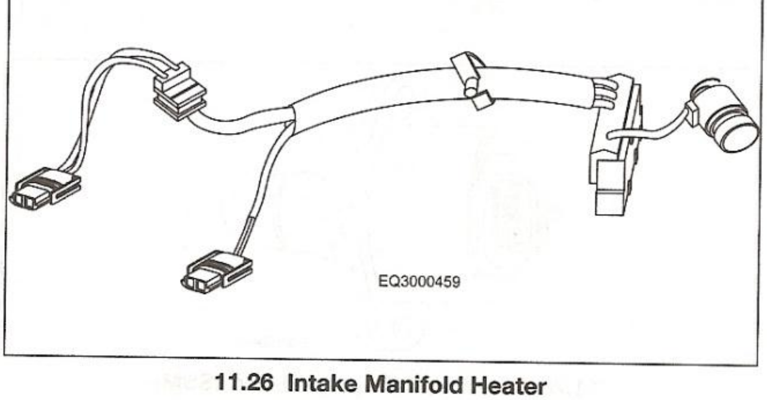
SM	ECM	Res. (Ω)
A and D	3 and 21	53
B and C	2 and 20	53

Idle Speed Control Valve Type

Stepper motor

External Influences

- Basic setting of throttle plate
- Vacuum leak
- Sticking throttle
- Sticking or maladjusted throttle cable



11.26 Intake Manifold Heater

Checking the Stepper Motor (General)

1 Inspect the stepper motor multi-plug for corrosion, and damage.
2 Check that the connector terminal pins are fully pushed home and making good contact with the stepper motor multi-plug.

Poor Idle or Stalling

1 Allow the engine to idle
2 Check that the idle speed is within its operating limits.
3 Load the system by switching on the headlamps, rear screen heater and heater motor onto high. The idle speed should barely change.
4 If this operation is completed satisfactorily, it is probable that the stepper motor condition is also satisfactory.

Stepper Motor Tests

1 Remove the stepper motor from the inlet manifold.
2 Check that the air passage is clear. Clean the passage as necessary.
3 Ensure that the shaft and cone will freely rotate in the motor armature.
4 Refit the stepper motor.
5 Detach the stepper motor or ECM multi-plug.
6 Measure the resistance of motor windings between No A to No D and No B to No C.
7 Compare the results to the specifications.
8 Reconnect all of the multi-plugs.
9 Connect the negative oscilloscope or voltmeter probe to an engine earth.
10 Connect the positive oscilloscope or voltmeter probe to the wire attached to stepper motor signal terminal No 'A'.
11 Allow the engine to idle.
12 Switch on and off a number of high electrical load components e.g. heated rear window, headlamps on high beam and the heater motor on maximum heat. The voltage should occasionally switch from zero to nbv as the motor winding is energised.
13 Repeat the test at stepper motor signal terminals No B, No C and No D.
14 If the signal is absent, check continuity of the wiring between the ECM multi-plug and the stepper motor.
15 If the stepper motor wiring is satisfactory, check all voltage supplies and earth connections to the ECM. If the voltage supplies and earth connections are satisfactory, the ECM is suspect.

Intake Manifold Heater (IMH)

The Intake Manifold Heater (IMH) **(see Illustration 11.26)** is provided to heat the throttle body so that icing does not occur during cold conditions. The heater is operating at all times whilst the engine is running. The heater works on the Positive Temperature Coefficient (PTC) principle and allows a greater current to quickly heat throttle body during the warm-up period. As the heater becomes hotter, the resistance increases and the current reduces.

Intake Manifold Heater Voltage Measurements

Terminal Cumbers

IMH	Relay	Item	Volts
Engine running			
1	—	TBH earth	0.25 max
2	6	Supply	nbv

For local wiring diagram **(see Illustration 11.2)**

Intake Manifold Heater Resistance

Terminals	Res. (Ω)
1 and 2	4.5 (when cold)

Intake Manifold Heater Type

PTC

Quick Check

- Start the engine when cold and feel the area around the throttle body, if the heater is working this area should become hot quite quickly. Take care not to burn your fingers!

Intake Manifold Heater tests

1 Allow the engine to idle.
2 Attach the negative voltmeter probe to an earth.
3 Attach the positive voltmeter probe to the heater supply connector.
4 nbv should be obtained.
5 No voltage supply.
6 Check the relay output.
7 Check continuity of the wiring between the relay and the heater.
8 nbv, but heater does not operate
9 Check the heater resistance.
10 Check the heater earth.

Fuel Injection System

The MM1AP ECM contains a fuel map with an injector opening time for basic conditions of speed and load. Information is then gathered from engine sensors such as the MAP sensor, CAS, CTS, ATS and TPS. As a result of this information, the ECM will look-up the correct injector pulse duration right across the engine rpm, load and temperature range.

The MM1AP system is a multi-point injection system and is capable of operating as a simultaneous and as a sequential controller. For all engines, apart from later RFS, the system is simultaneous i.e. it pulses all injectors at the same time twice per engine cycle. Half of the required fuel per engine cycle is injected at each engine revolution. The injectors are arranged in two banks, injectors No 1 and No 4 grouped and No 2 and No 3 grouped, with each bank simultaneously pulsed.

For RFS engines the system is sequential and therefore requires the input from a Camshaft Position Sensor to operate correctly.

Fuel Injectors

The fuel injectors **(see Illustration 11.27)** are magnetically operated solenoid valves that are actuated by the ECM. Voltage to the injectors is applied from the main relay and the earth path is completed by the ECM for a period of time (called pulse duration) of between 1.5 and 10 milliseconds. The pulse duration is very much dependent upon the engine temperature, its load, its speed and the operating conditions. When the magnetic solenoid closes, a back EMF voltage of up to 60 volts is initiated.

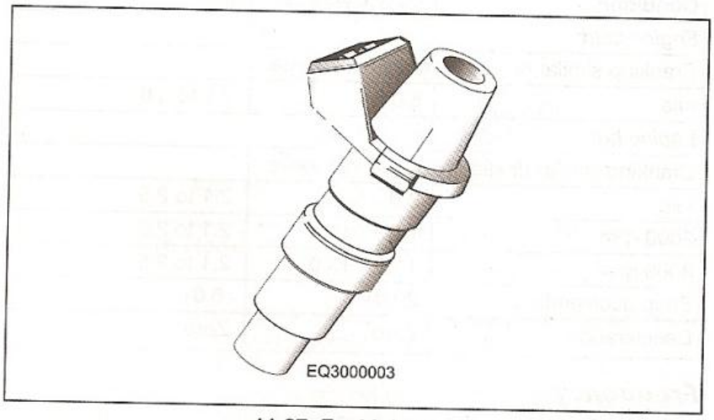
The fuel injectors are mounted in the inlet stubs to the engine inlet valves so that a finely atomised fuel spray is directed onto the back of each valve. During engine start-up the injectors are pulsed at twice the normal engine running rate.

Banked (Simultaneous)

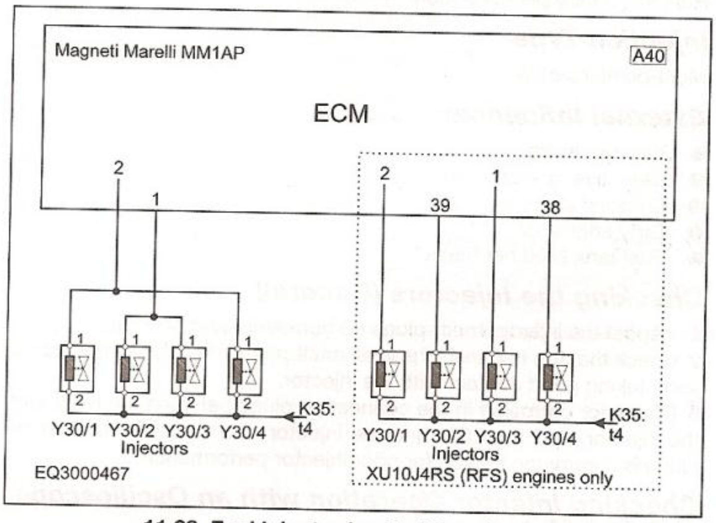
Since the injectors are in banks of two and each bank is pulsed simultaneously, fuel will briefly rest upon the back of a valve before being drawn into a cylinder.

Sequential

Each injector is pulsed in the sequence of the firing order at a predetermined point before the induction stroke.



11.27 Fuel Injector



11.28 Fuel injector local wiring diagram

Injector Voltage Measurements

Terminal Numbers

Injectors	ECM	Injection relay	Item (Non RFS)	Item RFS	Volts
Cranking/running					
2	—	4	Supply voltage	Supply voltage	nbv
1	1	—	Pulse wire (2 & 3)	Pulse wire (3)	nbv
1	2	—	Pulse wire (1 & 4)	Pulse wire (1)	nbv
1	38	—		Pulse wire (4)	nbv
1	39	—		Pulse wire (2)	nbv

For local wiring diagram **(see Illustration 11.28)**

Injector Resistance Measurements

Note: *Voltage is supplied from the fuel injection relay, and is only available for approximately one second after the ignition is switched on – or during engine cranking and running conditions. By-pass the relay to provide a supply for voltage tests.*

Injector	ECM	Res. (Ω)
1 and 2	—	14 to 18 approx.
2	1	7 to 9 approx.
2	2	7 to 9 approx.

Injector Duty Cycle Table

Condition	Duty Cycle %	ms
Engine cold		
Cranking similar or slightly above idle value		
Idle	5.0+	2.5 to 3.0
Engine hot		
Cranking similar or slightly above idle value		
Idle	3.0 – 5.0	2.1 to 2.5
2000 rpm	7.0 – 9.0	2.1 to 2.5
3000 rpm	11.0 – 13.0	2.1 to 2.5
Snap acceleration	20.0+	6.0+
Deceleration	Zero	Zero

Frequency

Starting Twice per revolution
Running Once per revolution

Injection Type

Multi-point injection

External Influences

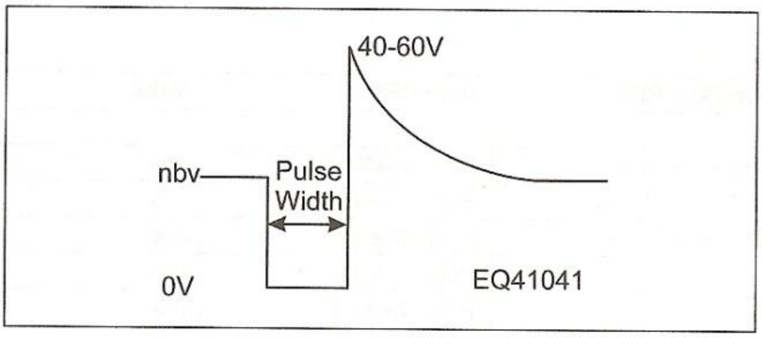
- Vacuum leaks
- Defective ignition system
- Clogged air filter
- Dirty engine oil
- Fuel tank breather faults

Checking the Injectors (General)

1 Inspect the injector multi-plugs for corrosion, and damage.
2 Check that the terminal pins in all multi-plugs are fully pushed home and making good contact with the injector.
3 Check for corrosion in the connection plugs between the relay and the injector, and the ECM and the injector. Corrosion in connection plugs is a common reason for poor injector performance.

Checking Injector Operation with an Oscilloscope or Dwell Meter

1 The two wires to the injector multi-plug are supply and signal.
2 Roll back the rubber protection boot (where possible) to the injector multi-plug OR connect a BOB between the ECM multi-plug and the ECM.



11.29 Typical Injector input signal waveform

3 Connect the negative oscilloscope or dwell meter probe to an engine earth.
4 Connect the positive oscilloscope or dwell meter probe to the wire attached to the injector signal terminal No 1. For Non-RFS engines, all injectors are pulsed simultaneously, therefore, initially, any injector will be suitable. For RFS engines all injectors may need to be tested.
Note: *An injector signal will only be obtained upon the wire connecting the injector to the ECM. If a reading cannot be obtained, reconnect the probe to the other terminal and retry.*

Engine Non-runner Tests

1 Crank the engine.
2 Either a waveform or a duty cycle reading should be obtained. If the instrument can measure the value in milliseconds, this could be even more useful **(see Illustration 11.29)**.
3 Good waveform or signal: The major considerations are:
- Does the signal waveform conform to an acceptable pattern?
- Is the pulse signal length acceptable for the temperature?

4 If the answer is yes to both questions, the reason for non-starting is unlikely to be the injection system. However, a fuel pressure test should also be carried out.
5 If the primary ignition signal is also providing an acceptable signal, the fault is unlikely to be related to the ECM.

Poor or No Injector Waveform or Signal

1 Check the CAS for a good signal.
2 Check for a voltage supply to the injector multi-plug.
3 No voltage, check the injector resistance and the injector voltage supply.
Note: *If the 'scope displays voltage at nbv level, but no waveform, voltage is reaching the injector but the circuit is not being actuated.*
4 Check for a pulse on the other injectors.
5 Disconnect the ECM multi-plug (see Warnings No 3 in the Reference section)
6 Switch on the ignition.
7 Use a jumper lead to very briefly touch the injector actuator pin in the ECM multi-plug to earth.
8 If the injector actuates, check the ECM main voltage supplies and earths. If tests reveal no fault, the ECM is suspect.
9 If the injector does not actuate, check for nbv at the ECM pin.
10 If there is a voltage, the injector is suspect.
11 If there is no voltage, check for continuity of wiring between the injector multi-plugs and the ECM multi-plug.

A Pulse Width that is too Long or too Short

1 Check the CTS.
2 Check the MAP sensor.
Note: *If the ECM has entered LOS due to a fault in one of the sensors, the engine may generally behave quite well whilst the engine is hot, but may be difficult to start when cold.*

Engine Running Tests

1 Run the engine at various speeds. Note the values obtained.
- Idle speed
- 2000 rpm
- 3000 rpm
- Slow throttle increase
- Rapid throttle increase
- Deceleration: raise the engine speed to approximately 3000 rpm and release the throttle.

2 Compare the results with the specified figures for both a cold and hot running engine.
3 The pulse width in % should increase in value as the engine rpm is raised.
4 The pulse width in ms should not change much in value as the engine rpm is slowly raised.

5 Under rapid acceleration, the pulse width should show a great increase in value.
6 Under deceleration, when the engine is hot, the pulse width should disappear (oscilloscope) or drop to zero (digital meter) and reappear as the engine speed reduces.
7 Where the meter does not drop to zero, check the throttle butterfly for correct adjustment and the TPS for correct operation. Noise from the injectors should also temporarily disappear as the cut-off operates.

A Pulse Width that is too Long or too Short

1 Check the CTS.
2 Check the MAP sensor.
Note: *If the ECM has entered LOS due to a fault in one of the sensors, the engine may generally behave quite well whilst the engine is hot, but may be difficult to start when cold*

Resistance Tests

Injector

1 Remove each injector multi-plug and measure the resistance of the injector between the two terminals.

Injector Circuit

2 Disconnect the fuel injection relay. All injectors connected.
3 Measure the resistance between the ECM terminals specified. This is either the parallel resistance of the two banks of injector circuits and the value should be as specified or the individual injectors for the sequential circuits.
4 Refer to the Injector Test Conditions for an evaluation of the injector parallel circuit.
5 A departure from the specified value is likely to be due to:
- A faulty injector resistance
- A wiring fault

Fuel Pressure System

Switching on the ignition key causes the ECM to energise the fuel pump relay for approximately one second so that the fuel system is pressurised. The fuel pump relay is then switched off, to await a cranking or running signal. Once the engine is running, fuel is fed through a non-return valve and fuel filter to the fuel rail.
To prevent pressure loss in the supply system, a non-return valve is provided in the fuel pump outlet. When the ignition is switched off, and the fuel pump ceases operation, pressure is thus maintained for some time.

Fuel Volume

2.0 to 2.4 litres per minute

Fuel Pressure

At idle	2.0 bar
Engine stopped	2.5 bar
Max pressure	Not stated

Holding Pressure

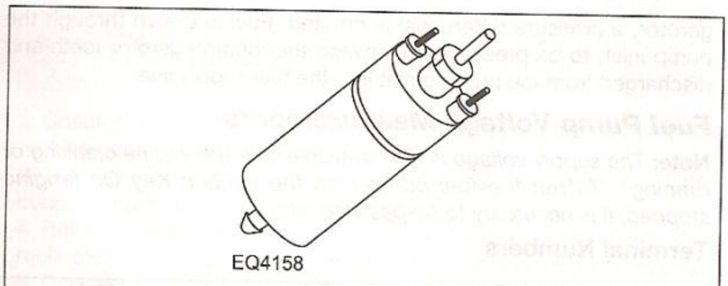
No drop in pressure immediately after pump stops.
See Chapter 3 for details of fuel system test procedures.

Fuel Pump

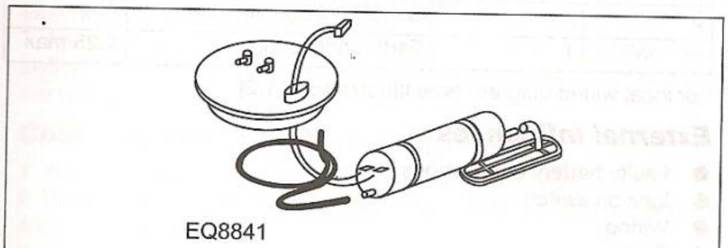
The fuel pump may be mounted externally or internally with the internal pump horizontally or vertically mounted, therefore all types are described.

External Pump (Some models)

A roller type fuel pump **(see Illustration 11.30)**, driven by a permanent magnet electric motor mounted close to the fuel tank draws fuel from the tank and pumps it to the fuel rail via a fuel filter. The pump is of the 'wet' variety in that fuel actually flows through the pump and the electric motor. There is no actual fire risk because the fuel drawn through the pump is not in a combustible condition.



1130 External fuel pump



11.31 Horizontally mounted internal fuel pump

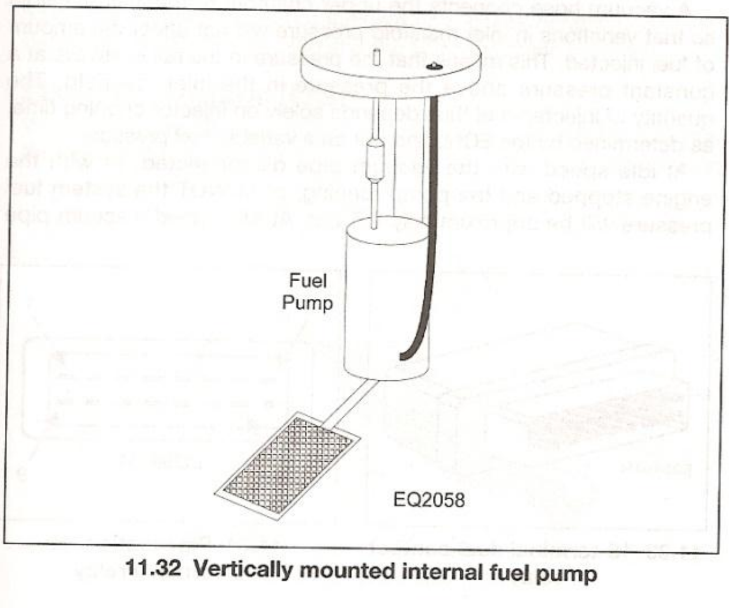
Mounted upon the armature shaft is an eccentric rotor holding a number of pockets arranged around the circumference – each pocket containing a metal roller. As the pump is actuated, the rollers are flung outwards by centrifugal force to act as seals. The fuel between the rollers is forced to the pump pressure outlet.

Internal Pump (Some models Citroën)

The two-stage fuel pump **(see Illustration 11.31)** is mounted horizontally on the floor of the fuel tank. The fuel pump first stage comprises a turbine that supplies fuel to the high-pressure gear driven second stage. Fuel is drawn through the pump inlet, to be pressurised and discharged from the pump outlet into the fuel supply line.

Internal Pump (Some models Peugeot)

The fuel pump **(see Illustration 11.32)** is mounted vertically in the fuel tank and comprises an outer and inner gear assembly termed a gerotor. Once the pump motor becomes energised, the gerotor rotates and as the fuel passes through the individual teeth of the



11.32 Vertically mounted internal fuel pump

gerotor, a pressure differential is created. Fuel is drawn through the pump inlet, to be pressurised between the rotating gerotor teeth and discharged from the pump outlet into the fuel supply line.

Fuel Pump Voltage Measurements

Note: *The supply voltage is only available with the engine cranking or running. To run the fuel pump with the ignition Key On (engine stopped) it is necessary to by-pass the relay*

Terminal Numbers

Relay	Fuel pump	Item	Volts
Cranking/ running			
5	2	Supply voltage via fuse	nbv
—	1	Earth connection	0.25 max

For local wiring diagram **(see Illustration 11.2)**

External Influences

- Faulty battery connections
- Ignition switch
- Wiring
- Relay
- Inertia switch or fuse
- Low battery voltage
- Blocked fuel filter in fuel tank
- Trapped, squashed or faulty fuel lines

See Chapter 3 for details of fuel pump test procedures.

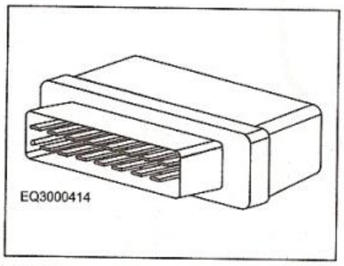
Fuel Pressure Regulator

Fuel pressure in the fuel rail is maintained at a constant 2.5 bar by a fuel pressure regulator. The fuel pump normally provides much more fuel than is required, and surplus fuel is thus returned to the fuel tank via a return pipe. Recirculation of fuel helps to keep it cool. In fact, a maximum fuel pressure in excess of 5 bar is possible in this system. To prevent pressure loss in the supply system, a non-return valve is provided in the fuel pump outlet. When the ignition is switched off, and the fuel pump ceases operation, pressure is thus maintained for some time.

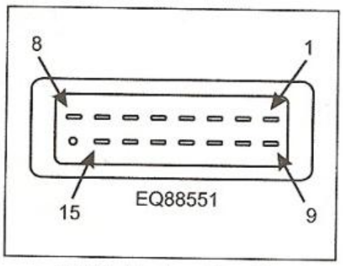
The pressure regulator is fitted on the outlet side of the fuel rail and maintains an even pressure of 2.5 bar in the fuel rail. The pressure regulator consists of two chambers separated by a diaphragm. The upper chamber contains a spring that exerts pressure upon the lower chamber and closes off the outlet diaphragm. Pressurised fuel flows into the lower chamber and this exerts pressure upon the diaphragm. Once the pressure exceeds 2.5 bar, the outlet diaphragm is opened and excess fuel flows back to the fuel tank via a return line.

A vacuum hose connects the upper chamber to the inlet manifold so that variations in inlet manifold pressure will not affect the amount of fuel injected. This means that the pressure in the rail is always at a constant pressure above the pressure in the inlet manifold. The quantity of injected fuel thus depends solely on injector opening time, as determined by the ECM, and not on a variable fuel pressure.

At idle speed with the vacuum pipe disconnected, or with the engine stopped and the pump running, or at WOT the system fuel pressure will be approximately 2.5 bar. At idle speed (vacuum pipe connected), the fuel pressure will be approximately 0.5 bar under the system pressure.



11.33 15-terminal dual contact relay



11.34 Pin location for 15-terminal relay

Fuel Pump Relay

The MM1AP electrical system is controlled by a single 15 terminal relay with dual contacts **(see Illustration 11.33 & 11.34)**. A permanent voltage supply is made to relay terminals No 2, No 8, No 11 and No 15 from the battery positive terminal.

When the ignition is switched on, a voltage supply is connected to relay terminal No 14. The ECM earths terminal No 10 through ECM pin No 52, which energises the first relay winding.

When the relay winding is energised, this causes the relay contacts to close and terminal No 11 is connected to the output circuit at terminal No 1. A voltage supply is thus output at terminal No 1 and No 9. Terminal No 9 supplies voltage to ECM pin No 35 and terminal No 1 supplies voltage to the CFSV. During the time that the ignition is switched on, pin No 35 is the main supply voltage to the ECM.

When the ignition is switched on the ECM briefly earths relay contact No 7 at ECM pin No 7 via an inertia switch. This energises the second relay winding, which closes the second relay contact and connects voltage from terminal No 8 to terminal No 13, thereby providing voltage to the fuel pump circuit. After approximately one second, the ECM opens the circuit and the pump stops. This brief running of the fuel pump allows pressure to build within the fuel pressure lines, and provides for an easier start. In addition, voltage is applied to the injectors, ignition coils, throttle body heater and the OS heater through terminals No 4, No 5 and No 6.

The second circuit will then remain open until the engine is cranked or run. Once the ECM receives a speed signal from the CAS, the ECM will again energise the second winding, and the fuel pump, ignition and injection will run until the engine is stopped.

Main Relay

Terms	Condition	Relay	Volts
2,8,11,15	Ignition off	Connected/disconnected	nbv
14	Ignition on	Connected/disconnected	nbv
10	Ignition off	Connected	nbv
10	Ignition on	Connected	1.25 max
7	Ignition on	Connected	nbv
7	Cranking/running	Connected	1.25 max
1,9	Ignition on	Connected	nbv
4,5,6,13	Cranking/running	Connected	nbv

For local wiring diagram **(see Illustration 11.2)**

Terms	Source/destination
1	Relay output to ECM: t35
2	Battery supply to relay: t30
3	Unused
4	Relay output voltage to injector: t2
5	Relay output voltage to ignition coil: t3
6	Relay output voltage to OS: t2 (via fuse), fuel pump: t2 (via fuse), IMH: t2 (via fuse)
7	Relay driver, ECM: t23.
8	Battery supply to relay: t30
9	Relay output to CFSV: t2, VSS: t2
10	Relay driver, ECM: t4
11	Battery supply to relay: t30
12	Unused
13	Unused
14	Ignition supply to relay: t15
15	Battery supply to relay: t30

See Chapter 3 for details of relay test procedures.

Catalytic Converter and Emission Control

The MM1AP injection system, fitted to catalyst vehicles, implements a closed-loop control system so that exhaust emissions may be reduced. Closed loop systems are equipped with an oxygen sensor that monitors the exhaust gas for oxygen content. A low oxygen level in the exhaust signifies a rich mixture. A high oxygen level in the exhaust signifies a weak mixture.

Carbon Filter Solenoid Valve (CFSV)

A Carbon Filter Solenoid Valve (CFSV) **(see Illustration 11.35)** and an activated carbon canister are employed to aid evaporative emission control. The carbon canister stores fuel vapours until the ECM, under certain operating conditions, opens the CFSV.

As soon as the ignition is switched 'on' the CFSV remains closed until the engine reaches normal operating temperature and the throttle is partially open (normal cruise conditions with a hot engine). Once the ECM actuates the CFSV, fuel vapours are drawn into the inlet manifold to be burnt by the engine during normal combustion.

So that engine performance will not be affected, the CFSV remains closed during cold engine operation and also during engine idle. Once the engine coolant temperature reaches normal operating temperature and the throttle position is in the mid-range (between 10.4° and 84°) the CFSV will be modulated on and off by the ECM with a duty cycle of 54%.

The closed CFSV on shutdown ensures that the engine does not run-on during this period.

CFSV Voltage Measurement

Terminal Numbers

CFSV	Component	Volts
Ignition 'on'		
2	FI relay: t1 or t9	nbv
1	ECM: t24	nbv
Engine running		
2	FI relay: t1 or t9	nbv
1	ECM: t24	0 to nbv (switching)

For local wiring diagram **(see Illustration 11.2)**

CFSV Duty Cycle

54% at normal operating temperature when the throttle is in the mid range position.

CFSV Resistance Measurements

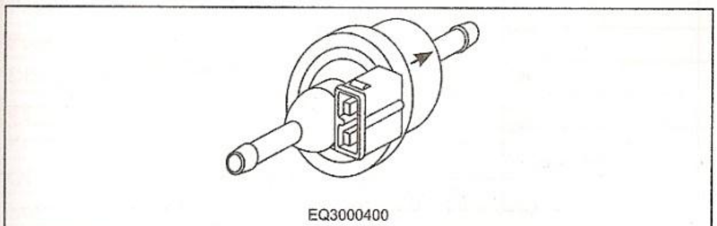
CFSV	ECM	Res. (Ω)
1 and 2	—	40 ± 10

External Influences

- Trapped or leaking vacuum hoses and connections

Checking the CFSV (General)

1 Inspect the CFSV multi-plug for corrosion, and damage.



11.35 Carbon Filter Solenoid Valve (CFSV)

2 Check that the connector terminal pins are fully pushed home and making good contact with the CFSV multi-plug.
3 Testing is quite straightforward. The two wires to the CFSV connector are supply and pulsed earth.
4 Roll back the rubber protection boot (where possible) to the CFSV multi-plug OR connect a BOB between the ECM multi-plug and the ECM.
5 Connect the negative oscilloscope or voltmeter probe to an engine earth.
6 Connect the positive oscilloscope or voltmeter probe to the wire attached to CFSV signal terminal No 1.
7 An oscilloscope is a useful instrument to make initial checks for a switching waveform. If an oscilloscope is not available, continue with the voltage tests.

Checking the CFSV Pulsed Operation

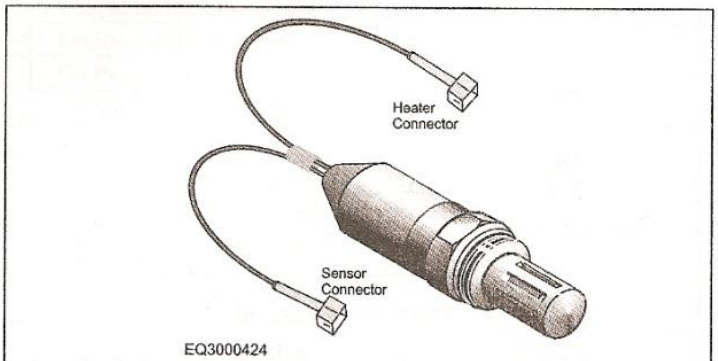
1 Warm the engine up to normal operating temperature.
2 Raise the engine speed to approximately 2000 rpm and stabilise the engine at this speed.
3 Check for a switching pulse.
4 If a pulse is not available, make the following electrical checks.

Checking the CFSV (Electrical Tests)

1 Ignition on, check for nbv at the CFSV supply terminal No 2.
2 If no voltage is obtained, trace the wiring back to the relay output terminal.
3 Check for voltage at CFSV terminal No 1, which should be approximately nbv.
4 If no voltage is obtained, check the CFSV resistance.
5 Disconnect the ECM multi-plug (See Warnings No 3 in the Reference section)
6 Switch on the ignition so that a voltage feed is applied to the CFSV.
7 Use a temporary jumper lead to very briefly touch the switching terminal (pin No 24) in the ECM multi-plug to earth.
8 If the CFSV actuates, the ECM is suspect.
9 If the CFSV does not actuate, check for nbv at pin No 24.
10 If there is a voltage, the ECM is suspect.
11 If there is no voltage remove the multi-plug from the CFSV.
12 Connect a voltmeter between terminals No 1 and No 2 at the multi-plug.
13 Use a jumper lead to very briefly touch the switching terminal (pin No 24) in the ECM multi-plug to earth.
14 If the voltmeter indicates nbv, the CFSV wiring circuit is OK and the CFSV is suspect.
15 If the voltmeter does not indicate nbv, check continuity of wiring between the CFSV multi-plug and the ECM switching terminal.

Oxygen Sensor (OS)

When the engine is operating in closed-loop control, the OS **(see Illustration 11.36)** signal causes the ECM to modify the injector pulse



11.36 Oxygen Sensor (OS)

so that the AFR is maintained close to the stoichiometric ratio. By controlling the injection pulse, during most operating conditions, so that the air/fuel ratio is always in a small window around the Lambda point (i.e. Lambda = 0.98 to 1.04), almost perfect combustion could be achieved. Thus the Catalyst has less work to do and it will last longer with fewer emissions at the tail pipe.

The closed loop control is implemented during engine operation at coolant temperatures above 45° C. When the coolant temperatures is below 45°C, or the engine is at full load or is on the overrun the ECM will operate in open loop. When operating in open loop, the ECM allows a richer or leaner AFR than the stoichiometric ratio. This prevents engine hesitation, for example, during acceleration with a wide-open throttle.

The OS only produces a signal when the exhaust gas, has reached a minimum temperature of approximately 300 degrees centigrade. In order that the OS will reach its optimum operating temperature as quickly as possible after the engine has started, the OS contains a heating element.

The OS heater supply is made from the fuel pump relay terminal number 6. This ensures that the heater will only operate whilst the engine is running.

OS Voltage Measurements

Terminal Numbers

OS	Component	Item	Condition	Volts
Engine running				
Black terminals				
1		Heater earth		0.25 max
2	FP relay: t 6	Heater supply		nbv
Blue terminals				
4	ECM: t12	Signal return		0.25 max
3	ECM: t29	Signal wire	Ignition Key On	0.4 to 0.5
			Engine running	200 to 1000 mV
			Throttle fully-open	1.0 volt constant
			Fuel cut-off	0 volt constant

For local wiring diagram **(see Illustration 11.2)**

OS Switching Frequency

1 sec intervals (approx.)

External Influences

- Poor OS earth
- Fouled OS
- Vacuum leaks
- Ignition or fuel system defects
- Oil thinning
- Clogged air filter
- Leaded fuel
- Low fuel pressure
- Exhaust leaks (upstream of OS)

OS Signal Tests

1 Connect the negative oscilloscope or voltmeter probe to an engine earth.
2 Connect the positive oscilloscope or voltmeter probe to the wire attached to the OS signal terminal No 3.
3 A useful aid to diagnosis is a gas analyser attached to the exhaust system. A 4-gas analyser with Lambda will give best results.
4 The gas analyser should indicate the following:

- CO: as specified
- HC: less than 50 ppm
- CO_2: greater than 15.0
- O_2: less than 2.0
- Lambda: 1.0 ± 0.04

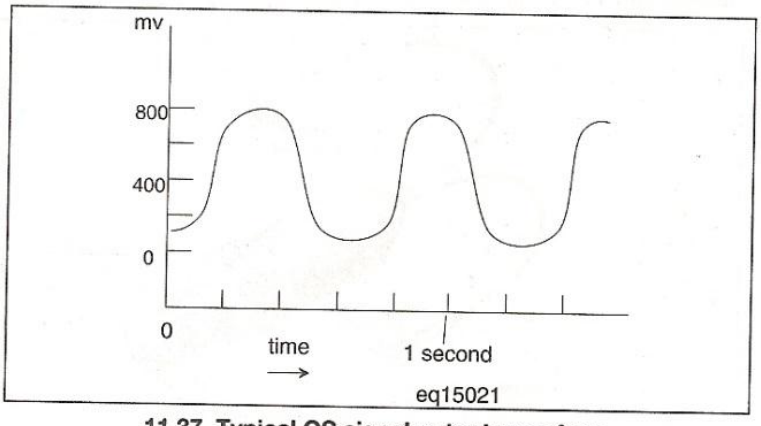
OS Switching

1 With the ignition on 0.5 volts should be obtained.
2 If no voltage, check continuity of wiring back to the ECM signal terminal.
3 Run the engine to normal operating temperature.
4 Raise the engine speed to 3000 rpm for 30 seconds. This will raise the temperature of the OS so that switching should occur.
5 Take measurements at 2000 rpm. If the engine is allowed to idle for prolonged periods, the OS will become cool and switching may stop.
6 The voltage will switch from approximately 0.8 volts (800 mV) to 0.2 volts (200 mV).
7 A digital instrument will measure an average reading of about 0.45 volts (450 mV).
8 Switching should occur at approximately 1Hz (i.e. one pulse per second).
9 If the oscilloscope can be set to a timebase greater than one second, a sinusoidal switching waveform can be obtained **(see Illustration 11.37)**.
10 If the voltage reading is mainly 0.6 to 1.0 volts the gases in the exhaust pipe have little oxygen which signifies a rich mixture **(see Illustration 11.38)**.
11 If the voltage is mainly 0.2 to 0.6 volts the gases in the exhaust pipe have excess oxygen. This could signify one of the following conditions:

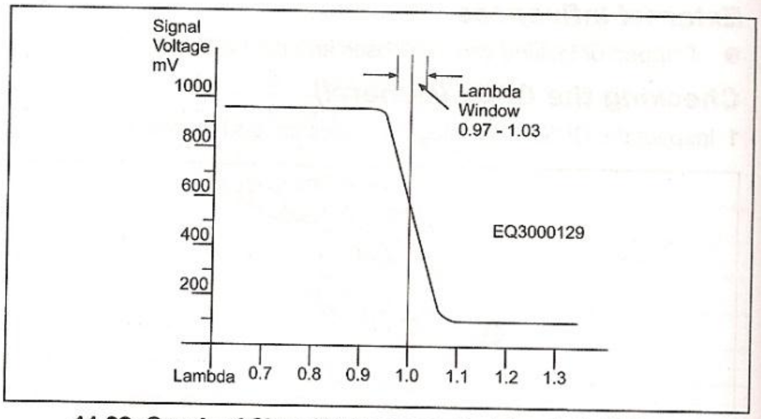
- Vacuum leak
- Weak mixture
- Misfire
- Mechanical fault
- Ignition fault
- Exhaust leak (before the OS)
- Slow switching (much greater than 1 Hz) could indicate a fouled OS.

OS Heater Tests

1 Check for nbv at OS terminal No 2.
2 If no voltage, trace the wiring back to the OS heater supply i.e. relay, ignition switch etc as appropriate.
3 Check the OS heater earth connection



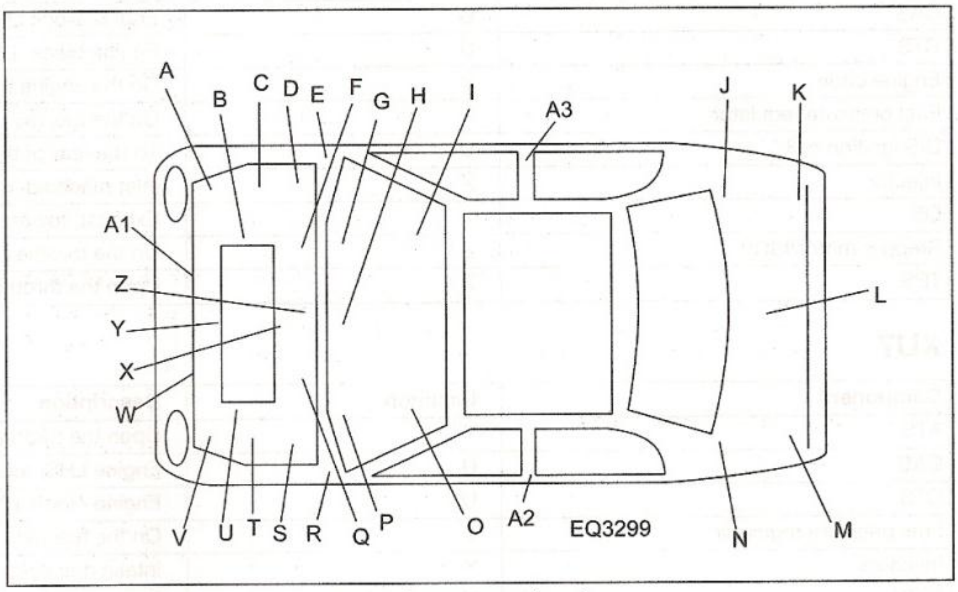
11.37 Typical OS signal output waveform



11.38 Graph of Signal Voltage against Lambda Values

Component Locations

There are various different vehicle models using MM 1AP, many of which will have the fuse/relay boxes etc. in different positions. To avoid confusion, only 'on engine' sensors/actuators will have the indication of their location listed in the tables below, as these will usually be the same for all models.



11.39 Component locations

TU1

Component	Location	Description
ATS	Z	In the throttle body
CAS	U	Engine LHS rear, adjacent to flywheel
CTS	U	Engine block, LHS rear
DIS ignition coil	U	Engine block rear
Fuel filter	J	Outside of fuel tank or engine compartment
Fuel pump	J	Inside fuel tank
Injector	X	In the Intake Manifold
OS	Y	Exhaust
Stepper motor	Z	On the throttle body
Intake Manifold Heater	Z	On the throttle body
TPS	Z	Upon the throttle body

TU3

Component	Location	Description
ATS	Z	Intake manifold
CFSV	C	Engine compartment RHS
CTS	Y	Engine block, LHS front
Engine code	Y	On the engine block/cylinder head LHS top
Fuel filter	*	On the fuel line between the fuel tank and fuel rail
Fuel pressure regulator	*	Fuel rail
Fuel pump	L	In the fuel tank
DIS ignition coil	X	To the LHS of the engine block and cylinder head
Injector	X	Inlet manifold, cylinder head rear
Knock sensor	Y	Engine block next to the exhaust
OS	Y	Exhaust, towards the front of the engine bay
Stepper motor	Z	On the throttle body, engine compartment rear centre
TPS	Z	Upon the throttle body, next to the inlet manifold

TU5

Component	Location	Description
ATS	Z	Intake manifold
CAS	U	Engine block LHS rear
CTS	U	Engine block, LHS rear
Engine code	Y	On the engine block/cylinder head LHS top
Fuel pressure regulator	*	On the fuel rail
DIS ignition coil	U	To the rear of the engine block and cylinder head
Injector	X	Inlet manifold, cylinder head rear
OS	Y	Exhaust, towards the front of the engine bay
Stepper motor/ISCV	Z	On the throttle body, engine compartment rear centre
TPS	Z	Upon the throttle body, next to the inlet manifold

XU7

Component	Location	Description
ATS	Y	Upon the throttle body
CAS	U	Engine LHS, adjacent to the top of the flywheel
CTS	U	Engine block, LHS
Fuel pressure regulator	Y	On the fuel rail.
Injectors	Y	Intake manifold
ISCV	U	Engine LHS
OS	Y	Exhaust, front of engine bay
Intake Manifold Heater	Y	Upon the throttle body
TPS	Y	Upon the throttle body
VSS	T	On the gear box

XU10

Component	Location	Description
ATS	Y	Inlet air trunking, or throttle body
CAS	U	Engine LHS, adjacent to flywheel
CTS	U	Engine block rear,
Engine code	Y	On the cylinder/engine block
Ignition coil	X/U	Engine LHS
Injectors	Y	Fuel rail, supplied from above.
KS	Y	On the cylinder head
OS	Y	Exhaust system
Stepper motor	Y	On the throttle body
Intake Manifold Heater	Y	In the throttle body
TPS	Y	Upon the throttle body
VSS	Y	On speedometer cable at gearbox take-off shaft