ELECTRONIC DIAGNOSTICS!

Tracing and fixing faults in electronic engine management systems

Number 59: ***Finally we've got round to covering a Mini! Chris Graham reports on some of the problems likely to afflict this pint-sized box of tricks.***

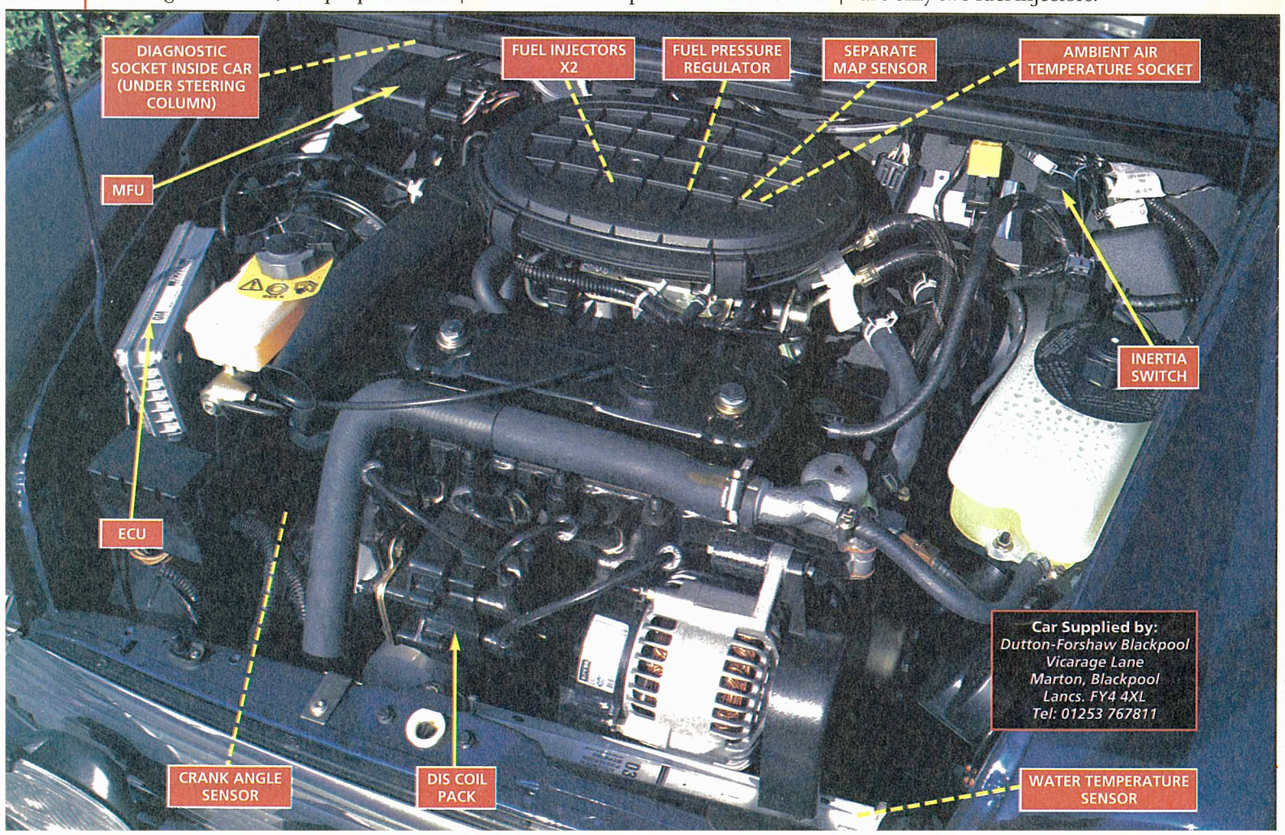
Thanks mainly to tightening safety regulations, Mini, as we know it, is into its final year of production and, engine-wise has reached perhaps the limit of its technological potential. The heart of the motor is still the trusty old A Series engine albeit festooned with many of the most up-to-date additions which Rover has to offer.

Frank Massey, our guiding light on all things electronic, and proprietor of Preston-based Fuel Injection Services (Tel: 01772 201597), is not the greatest Mini fan in the UK but was, nevertheless, keen to have a closer look at the gleaming new Cooper we presented for his expert consideration.

POSSIBLE FAULTS

1. *Earth contacts*
2. *CAS failure*
3. *Fuel injectors*

The electronic brains behind the latest Mini Cooper is the most recent version of MEMS (Modular Engine Management System), denoted simply as MEMS 2J. Added to this, Rover have finally broken away from the, at times, asthmatic single-point fuel injection system, and developed a variation on the multipoint theme. Frank would actually classify this as 'dualpoint' rather than multipoint, simply because there are only two fuel injectors.



ENGINE MANAGEMENT

This version of MEMS arrived early in 1997 and so it's still early days to be specific about problems.

The system is essentially straightforward and features DIS ignition, making use of the 'wasted spark' approach to firing the plugs. This represents a big improvement as Minis historically suffered from the old-fashioned distributor's forward location at the front of the engine.

The component layout, with regard to engine management, is pretty much conventional. The two injectors are fed from a single fuel rail with a pressure regulator at one end. Other major components include: a water temperature sensor built into the thermostat housing; an idle control stepper motor; a charcoal canister and purge valve for dealing with tank fumes.

An ambient air temperature sensor in the air intake manifold; an inertia switch found under the bonnet on the n/s rear bulkhead; the aforementioned dual ignition coil which is driven directly by the ECU; a MAP sensor mounted on the inlet manifold – no rubber hose to worry about.

There is a throttle position sensor; a crank angle sensor, at the back of the bell housing; a camshaft sensor and a four-wire Lambda sensor, running 'closed loop' control on the exhaust emissions.

The fuel pump is mounted within the petrol tank which, in effect, is in the boot. The main relays take the form of a single, multi-function unit (MFU) which combines four relays in the one component. It includes a main relay, a fuel pump relay, an oxygen sensor relay and a starter relay. Because of its construction, the MFU can only be changed as one unit.

There is a 16-pin J1962 diagnostic socket found under the dashboard. This provides access to fault codes, enables live data to be recorded and allows actuators to be driven for testing purposes. There is also a full vehicle immobiliser fitted. This is an integral system and should never be overlooked as a possible cause of trouble.

Multipoint generally refers to a set-up with one injector per cylinder. In this case, each injector is mounted in a Siamese port and features two outlet nozzles aligned at about 30° to each other. However, all other attributes you would expect to find with a full-blown multipoint system are present here.

Generally, Frank is impressed with the quality of the installation, although he admits that space is at a premium. The ECU is easy to get at, being located at the front of the engine bay on the o/s inner wing. Its socket is positioned on the underside of the unit but, despite this precaution, Frank still thinks that water ingress might be a problem in the future.

PREPARATION

The first rule to remember when dealing with this engine is that its design is an old one and so often the cause of faults can be mechanical in nature. The A Series unit still relies on mechanical pushrods, rocker shaft and rockers. Don't assume that just because this application appears to bristle with electronic control systems, that every problem will be ECU, wiring or sensor-related.

Mechanical adjustments are still vital and all settings should be checked to eliminate the obvious before wading into complex electronic diagnostics. For example, errors in the setting of the tappets can have a very significant effect on the switching of the Lambda sensor.

The air cleaner is very easy to remove and check, so always do this as part of your routine preparation procedure. The ambient air temperature sensor is no longer found within this housing, so this simplifies the checking operation.

The engine features a very simple down-draught throttle body, made largely of plastic. Frank believes that this may well be in an attempt to reduce the risk of icing-up. Carefully wash this out using a good quality carburettor cleaner spray.

NEED TRAINING?

Frank Massey runs regular courses at his well-equipped Preston workshop; everything from basic engine management introductions to full-blown, 'hands on', system-specific tuition.
Call 01772 201597 for details.

The spark plugs are simplicity itself to access and check. As always, remove them all and inspect each carefully for signs of abnormal appearance – unusual discoloration or oiling etc. Check the gaps and that the plugs themselves are the right type. Also, watch out for 'corona rings' around the base of the ceramic body sections.

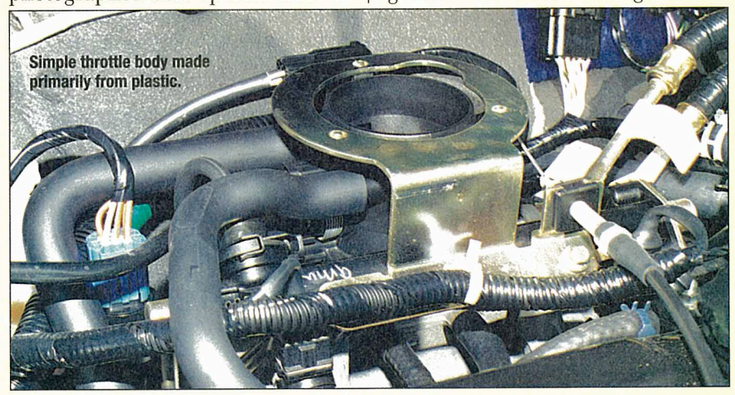
These will take the form of obvious brownish yellow staining and provide conclusive evidence that electrical tracking is occurring down the plug lead. The DIS ignition used on this car means that it's running a high powered HT system – up to 60,000V – and so problems with the leads will dramatically promote the likelihood of tracking. Remember, as well, that the leads face towards the front of the car and so will catch any road dirt or moisture going. Remove the leads and wash them. Check each carefully for cracks and splits and make sure all are clean and dry before re-fitting.

Incidentally, the brand new car we photographed here sported a set of leads which were covered in a 'beautifying' lacquer. Frank says that, as time passes, this type of product ages and alters character to create a wonderfully effective electrical conductivity path – not the best prospect in the world! Consequently, he would far rather see plug leads left untreated, clean and dry. His advice is to remove such treatments and, if you can't, then scrap the leads and buy a new set. They won't break the bank but will ensure reliable service.

Finally, run a fault code check as part of your basic preparation procedure. Extract any stored faults using a code reader, note them and then clear the lot. Drive the car and check which, if any, return. Remember that some may well have been induced by nothing more suspicious than a mechanic disconnecting sockets during some previous service or repair operations. Any which do return should be treated as faults and marked down for further investigation.

MINI MINUSES

The problem we face here is that this version of the Mini is still a relatively new car and so faults are comparatively rare. But Frank's extensive experience with the marque over the years, together with his knowledge of the


Simple throttle body made primarily from plastic.

ELECTRONIC DIAGNOSTICS!

Rover MEMS management system, means he is able to predict some of the most likely troubles in store.

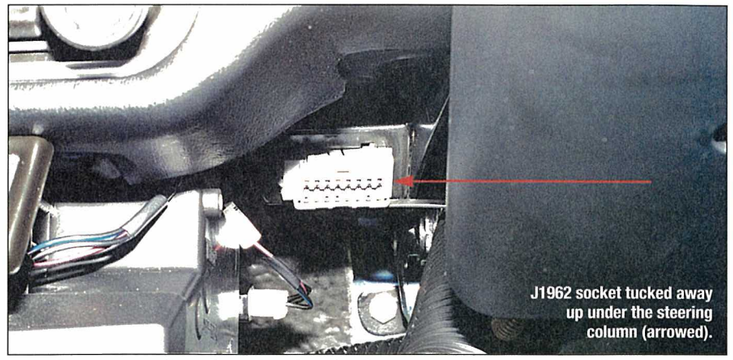
The first potential problem he came up with relates to bad earths. The battery in the Mini is found in the boot, so the earth references have to travel the entire length of the car to reach the negative battery terminal. As with most modern engine management systems, the quality of the earth references is crucial for smooth operation. Frank says that many of the sensors reference the voltage quite close to pure ground, particularly the Lambda sensor. Because of this there is always a potential for earth-related problems.

The symptoms of these can be many and varied, including high throttle potentiometer voltage, poor Lambda switching (where it's not ranging completely down), lean mixture caused by poor injector switching, loss of idle control or a misfiring engine, among others. There is, of course, significant danger of miss-diagnosis. It's easy to jump to the wrong conclusion, blaming either the components of even the ECU, for this problem.

Traditionally there has often been problems with a particular earth return on the offside of the vehicle's bulkhead – the MEMS unit itself returns to this point. The reference has then to travel back through the Mini's body to reach the battery, and down its cable which is bolted to the chassis.

When you check earths they have to be in a 'loaded' condition (ie with a running engine, or one being cranked). Static checks are simply not adequate. A good earth reference would be a maximum of 200mV (0.2V), according to Frank. If this rises to more than 0.5V when the engine's being cranked, then you're starting to get into the problem zone when trouble can strike.

There are no short cuts when dealing with earth problems. The wires must be removed so that the chassis areas can be dressed using an angle grinder. Achieving a bare metal finish is vital, after which a rust inhibitor should be applied – Frank says Vaseline is as good as anything for this. Also, check the earth tabs on the wires and, if necessary, tin-solder them. Often these days they will simply have been crimped at the factory, which can be a source of trouble. If in doubt, re-terminate completely.



J1962 socket tucked away up under the steering column (arrowed).

In the boot of the car, remove the main earth strap from the chassis and make sure it has a good, bare-metal contact too. Often, Frank says, you find these mounted straight on to paint so the system is relying on thread contact which, quite often, simply isn't good enough. Grind away the paint here as well, if necessary. Also, you might find it advisable in some cases to install additional earth circuits. Frank has done this a number of times by soldering on an additional earth loom and running it from the affected component to a new earth point elsewhere on the chassis.

Frank emphasises the importance of good earth connections, and says that checking them should always be a priority with any engine or management system which is not performing as it should.

Another potential cause of trouble on this application is the crank angle sensor (CAS). This provides the primary input to the ECU and its efficient performance is crucial. Its location, within the bell housing, makes it vulnerable to contamination from metallic dust created as the starter ring gear wears. The sensor is magnetic and so attracts this sort of debris. In time the build-up of material on the sensor body will start to have an adverse effect on the quality of the signal it produces, leading to driveability problems, including misfires, then eventually engine failure.

The 'shape' of the sensor's output signal (as viewed on an oscilloscope) is vital, as far as the ECU is concerned. If it becomes distorted by a defect, including metallic contamination, problems are sure to occur. The simplest way to check for this condition is to assess the output signal profile using an oscilloscope.

If it's discovered that any part of the signal trace is miss-shapen, then the chances are that the sensor is at fault. However, don't automatically assume this without checking first. The problem may also be mechanical in nature. Trouble with the phonic wheel, which is bolted on to the flywheel and provides the signal input for the crank angle sensor, can have the same result. The wheel can be damaged during careless repair work, for example. Bear this in mind if you get a car in with mysterious running problems.

Frank had a typical example in recently, where the car was running, but badly. It appeared to be over-fuelling because the Lambda sensor was not switching and the plugs were visibly sooty. Yet, despite carrying out a thorough assessment of the complete engine management system, no fault could be found. In fact, the only oddity at all was that the ignition timing point was incredibly advanced – by about 60°! The most likely causes of this were a problem with the ECU or a fault with the triggering mechanism. He eliminated the control unit as a cause, only then to find that the trigger signal from the crank angle sensor was good also, so this couldn't be faulted either.

Following a consultation with the dealership which had referred the car, it was discovered that the engine had been running perfectly up until a clutch change (undertaken by a rapid-fit centre!). Knowing this, Frank was immediately suspicious of the phonic wheel and, closer inspection revealed that it was not bolted correctly to the flywheel. The securing bolt layout means that it is possible to attach this important component in three different positions, although just one is correct. The two wrong positions give ignition which is advanced or retarded by a whopping 60°!

The catch is, that apart from the poor performance, everything else appeared fine. Even the trace on the oscilloscope looked perfect! This particular car arrived with Frank from a Rover main dealer, who ran into a diagnostic brick wall because they were looking at the problem electronically and had not considered the mechanical possibilities.

Finally, Frank thinks there's a possibility of fuel injector problems with this vehicle as mileage builds. Because there are only two injectors supplying the fuel for four cylinders, he believes that each employs a split nozzle arrangement. For this reason the likelihood of trouble is increased. A partial blockage in one or other of the nozzles causes a corresponding increase in flow through the remaining one. This then sets up a fuelling imbalance between those two cylinders.

The evidence of this can be seen clearly at the spark plugs. Any which looks out of place will point towards an injector-related problem with that cylinder. Another potential problem can arise if manifold bolts are not tight. This can result in a loss of pressure and driveability problems. Any air leaks on the inlet side will allow in additional oxygen that will be detected by the Lambda sensor, which, in turn, will lean off the mixture accordingly.

An air leak on the exhaust side is potentially even more critical, because this will allow oxygen in after combustion has taken place which will certainly lead to over-fuelling. This will be irrespective of the original mixture quality.

Faulty injectors should be removed and tested professionally using a flow bench so that spray patterns and delivery rates can be assessed accurately. If they do not respond to cleaning then replacement is the only solution.

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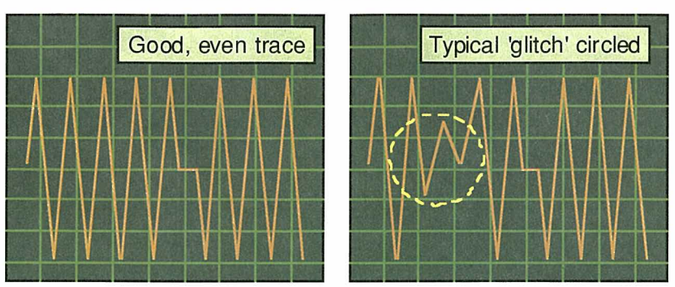
CRANK ANGLE SENSOR PROBLEMS?



MEMS 2J

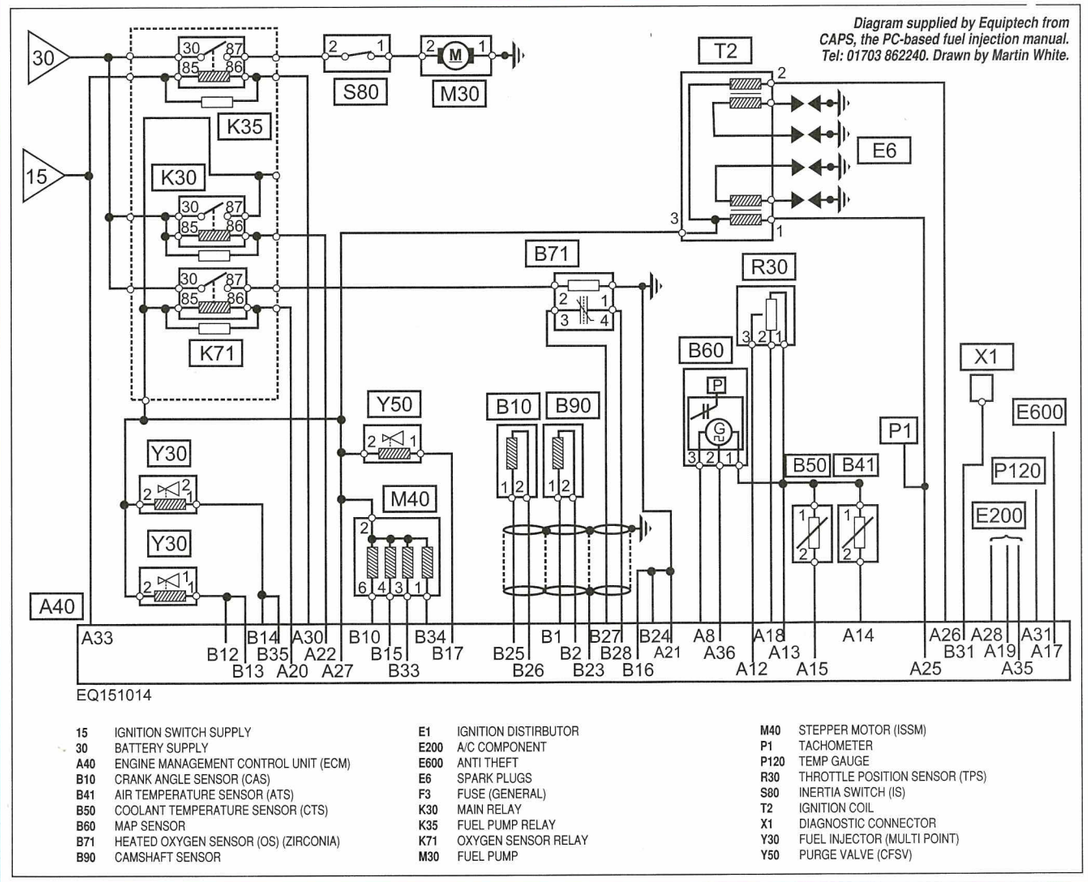


Diagram supplied by Equiptech from CAPS, the PC-based fuel injection manual. Tel: 01703 862240. Drawn by Martin White.

EQ151014

15	IGNITION SWITCH SUPPLY	E1	IGNITION DISTIRBUTOR	M40	STEPPER MOTOR (ISSM)
30	BATTERY SUPPLY	E200	A/C COMPONENT	P1	TACHOMETER
A40	ENGINE MANAGEMENT CONTROL UNIT (ECM)	E600	ANTI THEFT	P120	TEMP GAUGE
B10	CRANK ANGLE SENSOR (CAS)	E6	SPARK PLUGS	R30	THROTTLE POSITION SENSOR (TPS)
B41	AIR TEMPERATURE SENSOR (ATS)	F3	FUSE (GENERAL)	S80	INERTIA SWITCH (IS)
B50	COOLANT TEMPERATURE SENSOR (CTS)	K30	MAIN RELAY	T2	IGNITION COIL
B60	MAP SENSOR	K35	FUEL PUMP RELAY	X1	DIAGNOSTIC CONNECTOR
B71	HEATED OXYGEN SENSOR (OS) (ZIRCONIA)	K71	OXYGEN SENSOR RELAY	Y30	FUEL INJECTOR (MULTI POINT)
B90	CAMSHAFT SENSOR	M30	FUEL PUMP	Y50	PURGE VALVE (CFSV)