A Mazda without a spark

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A Mazda MX-5 (MK2) was coming out of hibernation to enjoy the brief spring sunshine. The owner noticed that their pride and joy was not performing as well as it should. After a bit of tinkering, changing the spark plugs and the air filter, they decided to take it to a garage. Blue Print's Charles Figgins explains how he diagnosed and cured the Mazda.

A visual inspection was carried out under the bonnet, to check for anything obvious. A vehicle being stored for long periods of time can be prone to rodent's gnawing at wiring, plug leads and even nesting in the engine bay. In this case, everything looked to be in place and in good condition.

Before road testing the car, I carried out a quick check for fault codes and had a look at any data that may give me a clue to the symptoms described by the owner. This car was not equipped with an EOBD (European On-Board Diagnosis)16 Pin socket, so I had to use the Mazda 17 Pin connector (Blue Print part number BPTE1022) on the G-Scan 2 to access the information I needed.

The engine management had three fault codes stored; air mass, engine temperature and crank position sensors, which were all caused to being unplugged and plugged back in again at some time in the past. All of the codes were stored on the G-Scan for the owners report before erasing. On inspecting the four pages of data provided, there was nothing obvious as the engine idled quite happily.

On a road test of mixed driving, the owners concerns were proven to be correct. Under hard acceleration the engine did not perform as well as it should, possibly due to an engine misfire. Diagnosis to determine where the issue stems from is not always as easy as you may think. As this car is pre EOBD, there is no misfire detection and the ignition system is not monitored by the ECU to give you any fault codes to point you in the right direction. It was necessary to consider the relationship between fuelling, compression and timing.

Because the engine was running smoothly at idle and at partial load, I did not think it was a mechanical issue and turned my attention to the ignition. The purpose of the ignition system is to ignite the air-fuel mixture in accordance with the demands throughout the engine's operating range and the voltage levels that are required of it.

Diagnosis can be a complicated process of elimination; you turn from mechanic to crime scene investigator, to find the cause of the vehicle's problems.

Before making a start, it is always good to consider what type of systems you are going to work on; five minutes of research can save you hours of wasted time. I started my investigation with the ignition system. The ignition system fitted to this vehicle is a distributorless ignition, with two twin spark coils bolted to the rear of the cylinder head on a bracket, with an integrated ignition driver end stage built in to switch the primary coils.

The engine management calculates the optimum ignition point on the basis of the stored map, for which engine speed and load are influential. Other correction variables include engine air intake and coolant temperature, along with the knock sensor feedback for any pre-ignition or detonation.

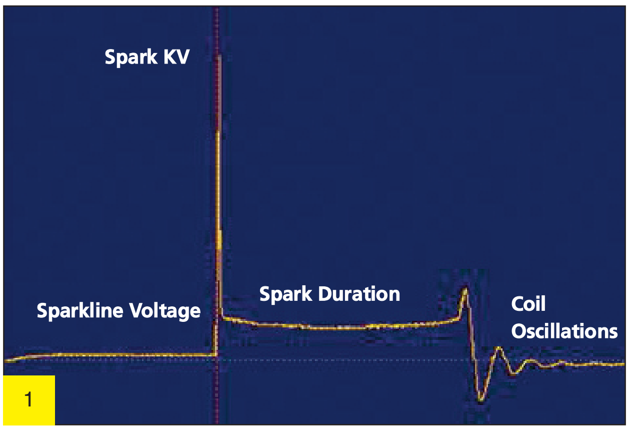
With this in mind, I browsed the serial data from the G-Scan 2 once more to see if I had over looked anything. It all seemed ok, so now was the time to do some component testing using the oscilloscope functions built into the G-Scan 2.

With the ignition system design fitted to this vehicle, I had to consider which parts could be tested; these were the ignition coil supply voltage and ground, the ECU trigger pulse, primary current, secondary output voltage, and the resistance for the secondary windings and plug leads.

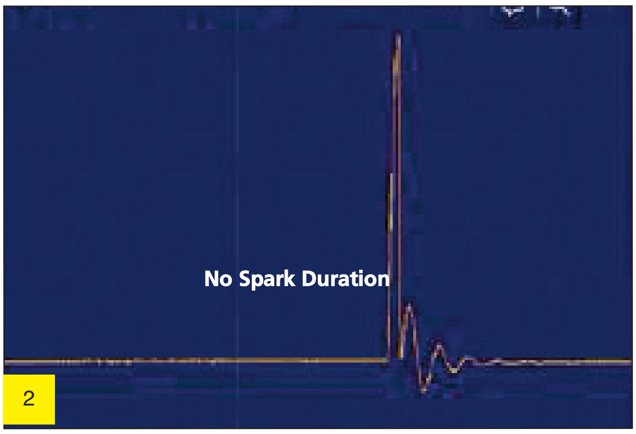
I started measuring the secondary ignition voltage with the G-Scan 2 oscilloscope with the HT lead adaptor (Blue Print part number BPTE1057), mainly because of ease of access to the plug leads. On analysis of all four secondary ignition patterns at idle, all seemed OK (Figure 1).

I carried out a snap throttle test to simulate load. On opening the throttle quickly, a large amount of air is induced on the induction stroke, causing a sudden increase in cylinder pressure and temperature, along with an increase in required ignition voltage, putting the ignition system under stress.

On doing this I noticed a slight misfire; measuring all four secondary voltage outputs again under this test, it was quite clear there was an issue with No. 4 cylinder (Figure 2). All the ignition energy was being used for the initial jump



A normal secondary ignition pattern as seen on an oscilloscope

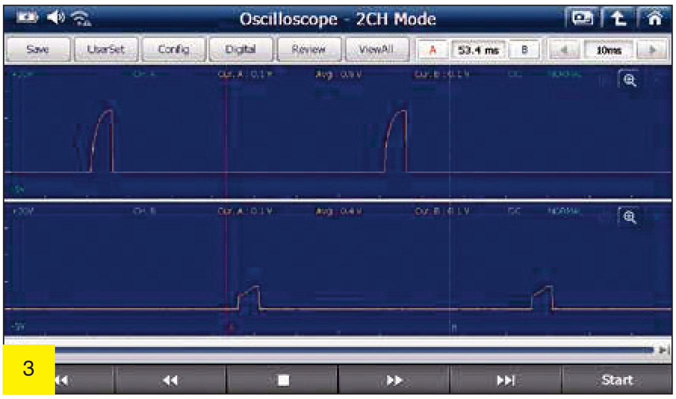


There wasn't any spark duration in cylinder number 4 across the spark plug gap, with nothing left to continue the spark duration. But what was causing it?

Could it be as simple as a plug lead or a spark plug? On inspection of the new spark plugs (including checking the specification of the engine), they were correct. I then tested the very short plug lead of No.4 for resistance which was within tolerance of 1-5 KOhms. As I had already removed No.4 plug lead, I then removed No.1 plug lead and checked the secondary winding resistance (between both secondary outputs on this coil), yet again it checked out alright, measuring between 8.2 – 12.4 KOhms. The resistance test of the secondary windings told me they were intact.

I turned my attention to the other side of the ignition coil. Mazda, in their wisdom, fitted the connector to both coils on top of the engine, making it nice and easy to access for testing.

One advantage of having two separate coils is that you have one to compare against. First, I separated the connector for inspection; it was very clean and had no corrosion to cause a high resistance. I then used a break-out lead to save using back probes. I checked both the coils supply voltage and grounds under operating conditions - both were good. Then I checked the ECU trigger pulse and compared the signal for both coils. The pulse to the coil for cylinders 1 and 4 had a different pattern and a



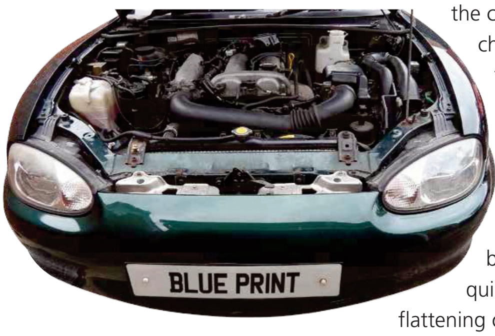
The coil pulse to cylinders 1 and 4, on top, had a higher voltage, as well as a different shape

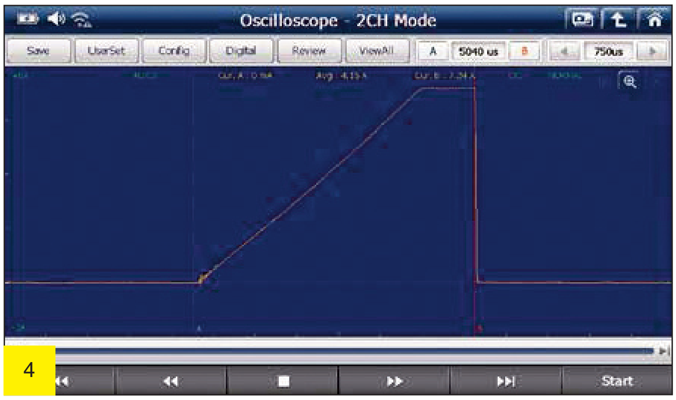
higher voltage (Figure 3).

As I was measuring between the ECU and the coils, I was measuring the voltage in a series circuit between two resistances. Did this mean I was looking at a high resistance on one of the coils?

To prove this I measured the primary ignition current of both coils under load using the current clamp (Blue Print part number BPTE1065), set to the 20 amp range. I measured the current on what I suspected to be the good coil for cylinders 2 & 3 first for reference (Figure 4).

The primary current is switched by the integrated driver end stage in this application. This provides an earth path to complete the circuit for the current to flow to charge the coil. On the oscilloscope pattern, it shows the current rising sharply to 7.24 amps. This shows that the coil is being charged quickly and is then flattening off as the coil is

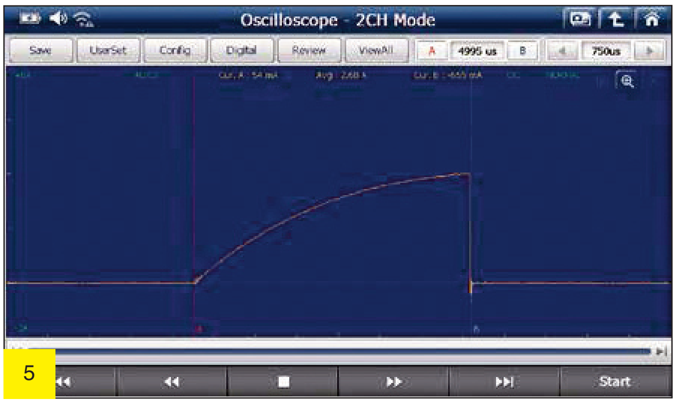




The coil for cylinders 2 and 3 charged up quickly to a maximum current of 7.24 amps

saturated. It is then being controlled by the ECU and switched off abruptly to ensure a very quick collapse of the magnetic field that generates the secondary ignition voltage.

On measuring the suspected faulty coil for cylinders 1 & 4, the dwell time was the same, but the coil was slower to charge and it only had a peak of 4 amps. With this information I concluded that the misfire was due to a high resistance in the integrated driver end stage. With this affecting the primary circuit, it will then affect the secondary ignition voltage. Quoting ohms law, if you have a high resistance, less current will



The coil for cylinders 1 and 4 charged up slowly, and only reached a maximum current or 4 amps

flow (Figure 5).

I replaced the coils on the bracket (which come as a pair), carefully removing the old plug leads. The No.3 plug lead was seized in the coil due to corrosion. This did not show up in any of my electrical tests, which meant it had a good contact and any resistance was not affecting the secondary ignition on that cylinder. However, it meant I had to replace the plug leads as well.

Diagnostics prove that even when you have diagnosed one problem, another issue sometimes comes along that you weren't expecting.

After replacing the faulty parts and road testing, the MX-5 was back to being a fun drive. A report was prepared using the G-Scan 2 utility software for the enthusiastic owner, which gave them complete satisfaction that their pride and joy had been diagnosed and repaired to a high standard.