# FOURTH TIME'S A CHARM

The saying goes that lightning never strikes twice in the same place. Apparently, this was not the case for a Mitsubishi Eclipse 2.4 2003 4G64 that showed up with a complaint of a rough running condition and a no-start when warm. A DTC scan revealed a DTC P0340 CMP (camshaft position sensor) A Circuit Malfunction Bank 1.

This failure is common and at first look, the repair appeared uncomplicated. When the engine was cold, it started right up and ran smoothly. However, if the engine was warm, it would not restart if shut off.

A connected oscilloscope showed the waveform as it appeared in **Figure 1** on page 8 if the engine was warm. As can be seen, the output voltage at the points when the signal is designed to be close to zero volts was far from at ground level. As the working temperature of the engine increased, the low point of the waveform became 4 volts. The PCM did not recognize this as a valid signal and did not open the injectors. This type of failure is quite common.

## By Sergey Vorsin, Vasyl Postolovsky and Olle Gladso
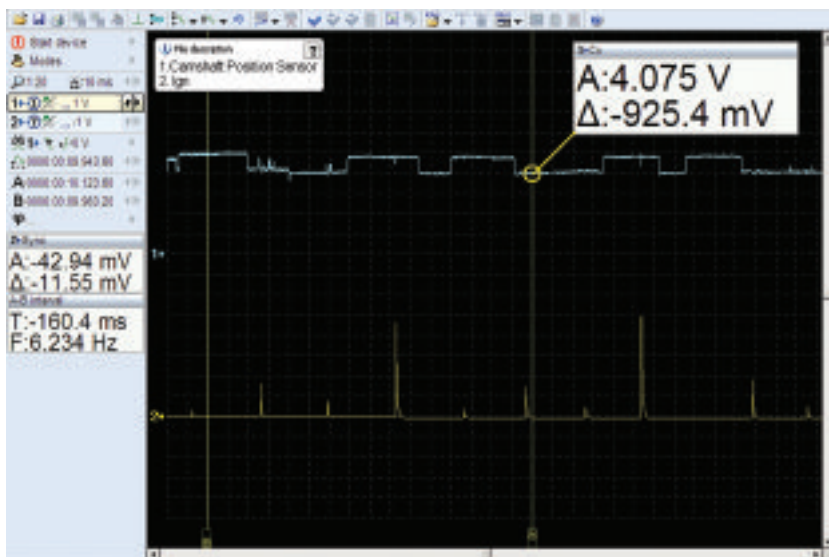Contributing Writers and Instructors at Riverland Technical and Community College in Albert Lea, MN
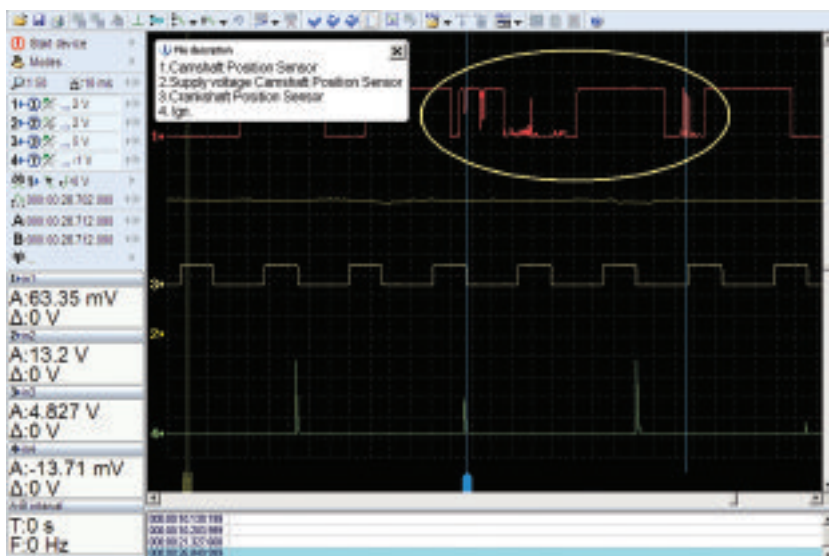
**Figure 1:** Signal not being pulled to ground.



**Figure 2:** Interference to the signal from the sensor.
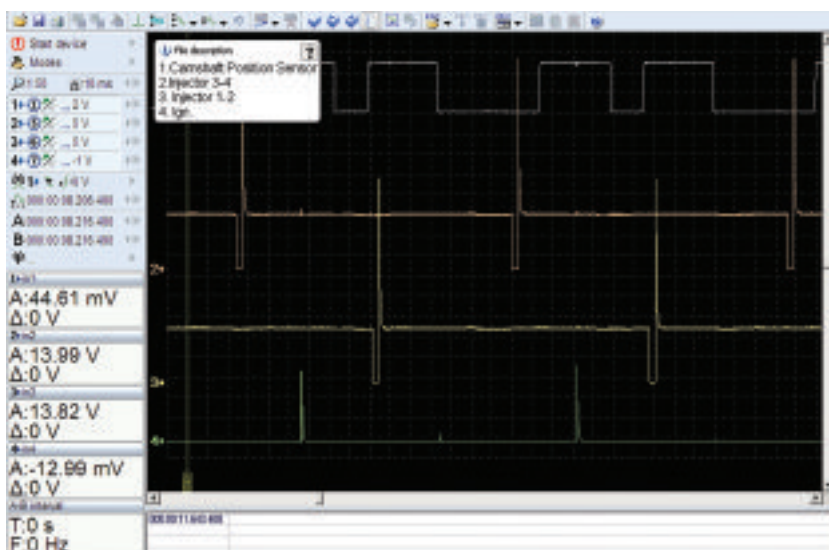


**Figure 3:** Sensor 3 at idle.

Without any further testing a new CMP was installed.

With the new sensor installed, the no-start when hot problem disappeared. However, another problem raised its ugly head. Intermittently the engine would run rough and shake. There was no clear correlation between temperature, RPM or load as to when this problem would manifest.

The oscilloscope was again connected to the signal wire from the sensor. The result is seen in the waveform shown in **Figure 2**. There is a clear interference to the signal from the CMP. This particular problem is most likely caused by a bad sensor low reference (ground or a defective sensor). The wiring was checked and verified to be in good condition. So, the sensor was replaced again.

Third is a charm, right? Not so fast! Upon installing sensor 3, the previous problem(s) were replaced with a new, more novel problem. The car starts up fine hot and cold and runs smooth at idle. As soon as the accelerator is pressed, backfires and rough running appears.

In order to fully, and hopefully for once, understand and repair the problem, the oscilloscope was again pressed into service — this time in a four-channel mode. Channel one was connected to the CMP, channel two to injectors 3-4, channel three to injectors 1-2 and finally, channel four was connected to ignition. **Figure 3** shows the waveforms when the engine is running at idle and with no apparent failure present.

**Figure 4** shows what happens when the throttle is opened so the engine is no longer at idle speed. Injectors 3-4 will only occasionally operate, most of the time they are non-functioning. Injectors 1-2 on the other hand, are open most of the time and only occasionally closed.

They are feeding a large amount of fuel into cylinders 1 and 2. At first glance, the CMP signal, oddly enough, appears nominal, with no discernible problems shown in the waveform. The ignition waveform does not show any apparent failures either.

It was decided to try to understand the problem by comparing the signals from the installed CMP to a waveform

from a known-good or reference CMP. Since the engine ran as it should with the original sensor, as long as it was cold, the waveform from that sensor can be used as a reference waveform.

A stable reference point for engine timing relationships is needed. The best reference would be mechanical TDC (top dead center), which could be obtained by using a pressure sensor in a cylinder. However, installing a pressure sensor in one of the cylinders will disable that cylinder, which will change the engine operation mode. For that reason it was decided to use the ignition in cylinder 1 as a reference at idle.

Ignition timing at idle is approximately 10 degrees before TDC and varies about +/-5 degrees. Since ignition timing is relative to and mechanically based on the CKP (crankshaft position sensor) signal, but we are mainly interested in the difference between the CKP to the CMP, the ignition timing variance is of very little consequence for the diagnosis.

**Figure 5** shows our reference waveform. It contains the CMP on channel one, the CKP on channel two and ignition on channel three. Using these waveforms we can determine that the rising edge of the signal from the CMP occurs approximately 53 degrees before the rising edge of the signal from the CKP.

The same connections and settings were used to record and analyze the signals from the third CMP sensor, which was failing once the RPM went above idle speed. The result is shown in **Figure 6**. On this capture it can be seen that the rising edge of the CMP signal occurs 37 degrees before the rising edge of the CKP signal. Thus, the delay is 3ms. At idle the 3ms delay is not large enough to affect engine operation, but at higher RPM, 3ms becomes significant and affects engine operation.

In this case, the fourth time was a charm and the next replacement of the CMP sensor finally fixed the car.

This case was a great example of how sometimes a seemingly minor problem actually requires high level diagnostic skills, a thorough troubleshooting process and last, but not least, the proper equipment and tools. *TS*
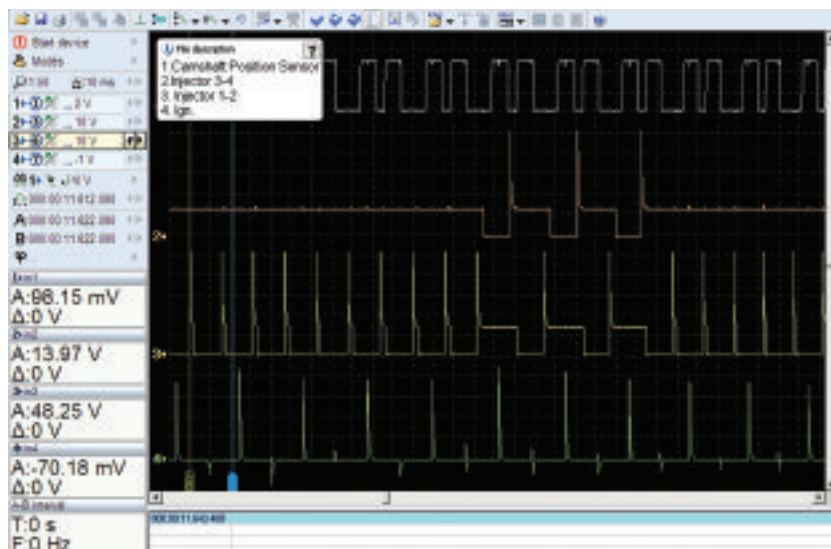


**Figure 4:** Waveforms with engine off idle.



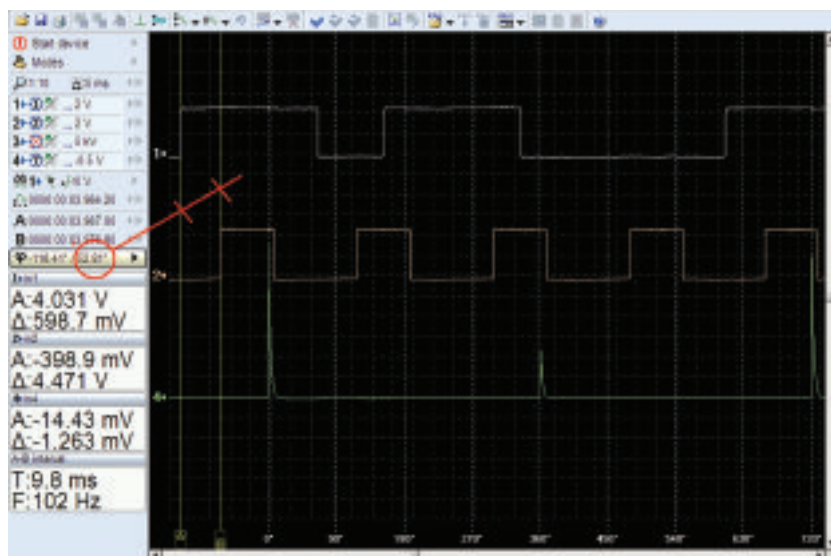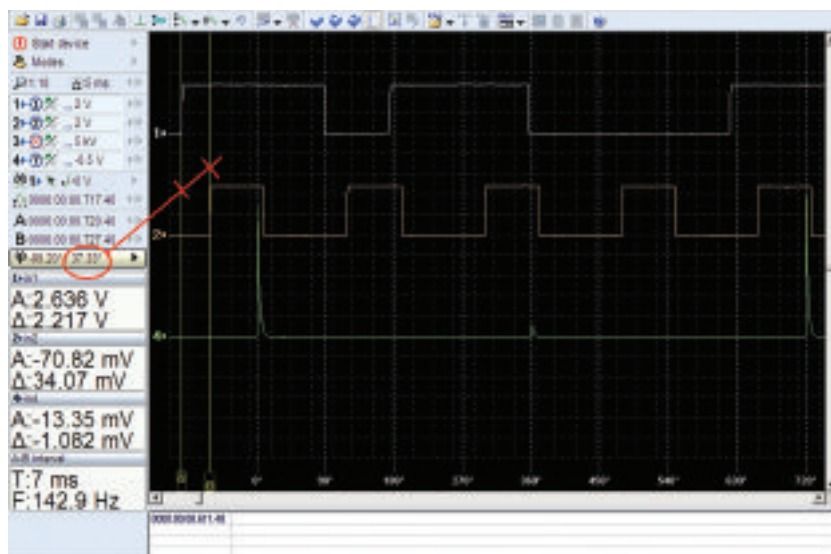**Figure 5:** Reference waveforms, known-good sensor.



**Figure 6:** Signal from the failing sensor 3.