Not a fun Carnival

When a Kia Carnival's Antilock Brake System (ABS) light came on at speeds greater than 110kph, the problem seemed easy to fix. It was, but only when the proper tools were used to diagnose the problem. A.D.S explains the proper steps needed to find and fix this fault.

The ABS warning light and the trouble codes in the Kia Carnival indicated that there was a fault with the left wheel sensor, so the fault appeared to be easy to solve. The sensor was replaced, but the ABS warning light still went on when the car went above 110 kilometers per hour. The newly installed sensor was itself replaced, thinking that the new sensor was also defective. This did not fix the problem. The car was then brought to A.D.S for investigation because the garage had ran out of ideas, knowledge and diagnostic gear.

Wheel Speed Sensor Function

Most wheel speed sensors work similar to crankshaft and camshaft sensors. The rotating part, in this case the wheel, has a disc with metal teeth firmly attached to it. The sensor is equipped with a coil and a permanent magnet. The coil and magnet react with the teeth on the rotating disk by creating a positive current pulse when a tooth is passing the sensor, and a negative pulse when a gap between teeth passes the sensor. When the wheel is stopped, the voltage drops to a set value. A rotating wheel produces a continuous change in voltage that indicates exactly how fast the wheel is rotating. Shorter times between peaks means that the wheel is rotating faster. The distance between the sensor and the metal teeth is very important, because a larger distance between those two parts produces a smaller magnetic change and a lower signal voltage. In this case the margin was between 0.1 and 1.5 millimeters.

ADS delves deeper

In this case, A.D.S quickly affirmed the fault and saw that a new wheel speed sensor had been installed properly. A multimeter was used to measure the generated voltage (always set the meter to AC) and to check the wiring using the ohm meter setting. Both measurements showed normal results. A multimeter alone did not provide enough information to determine the fault, it was time for something more.

In situations like this, A.D.S specialists always use the ATS 5004D automotive oscilloscope for measuring signals. The scope was used to continuously measures the wheel speed sensor signal in action, but only captured the signal and transfered them to the computer when the mechanic set the trigger. The large internal memory on the scope allowed a long measurement that contained lots of information.

Picture 1 shows the signal of the ABS wheel sensor at 30 kph, and all appears to be normal. The 'peak to peak' value of this alternating current is approximately 3 volts. Typical for this signal is an offset. The signal is not alternating around 0 volts, but at about 0.8 volts. An offset voltage is used so that the Electronic Control Module (ECM) can better recognize a short-circuit fault in the sensor wiring.The offset can be measured with a multimeter when the wheel is not rotating. At higher speeds, the problem became very apparent, as shown in picture 2.

Examining the evidence

The oscilloscope trace showed two strange anomalies in the signal. Since these anomalies appear in a fixed pattern, it could not have been an electronic fault, so it was mechanical. The repetition was caused by particular teeth on the ABS disk teeth when they passed in front of the sensor. The signal also showed a slight amplitude variation. This is not uncommon, and is caused by the fact that the ABS disk is not perfectly round. When the disk was examined the problem was obvious, some of the teeth on the sensor wheel were physically damaged.

The finer details

The only question that remained was why the fault was only reported by the ECU at speeds above 110 kph. The scope trace of the wheel speed sensor signal at 110kph showed that the signal amplitude dropped when the broken teeth passed the sensor was even greater than at low speeds. At low speed, the peak to peak amplitude when the broken teeth passed the sensor was 1.5 Volts. At 110 kph the voltage dropped to below 1.0 volt and was great enough for the ECU to recognise the fault. The ABS ECM sets a limit on the voltage of the signal coming from the ABS wheel sensors. This can be a fixed value, where the signal always must be above or under a defined value, but it is also possible that a limit is set dynamically and depends on the speed of the car. So it can be that at a lower speeds, the limits are less strict then at a high speed.

Conclusion

The ATS 5004D oscilloscope showed more information about the wheel speed sensor signal than could be seen with a multimeter. The irregularities in the sensor signal as shown by the scope were very apparent. The irregularities were rhythmic, not random, leaving only a mechanical fault as the problem. The damaged wheel speed disk was replaced and the ABS system was returned to a fully functional state. Without an oscilloscope, the cause of the fault would have been much harder to determine.

A.D.S
Automotive Diagnostic Services

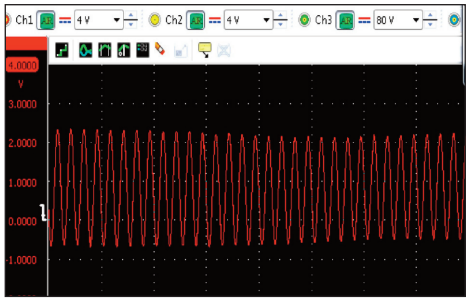

Figure 1: The ABS wheel sensor signal at 30 Kph looked to be perfectly normal

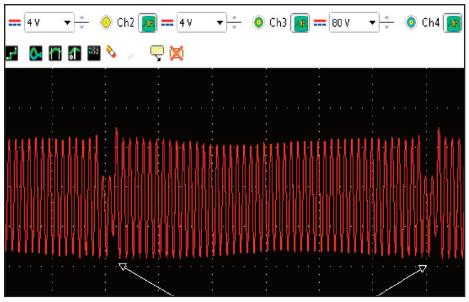

Figure 2: The sensor signal at higher speeds showed an obvious fault, at arrows

Figure 3: Defective teeth on the ABS disk were good enough for lower speeds