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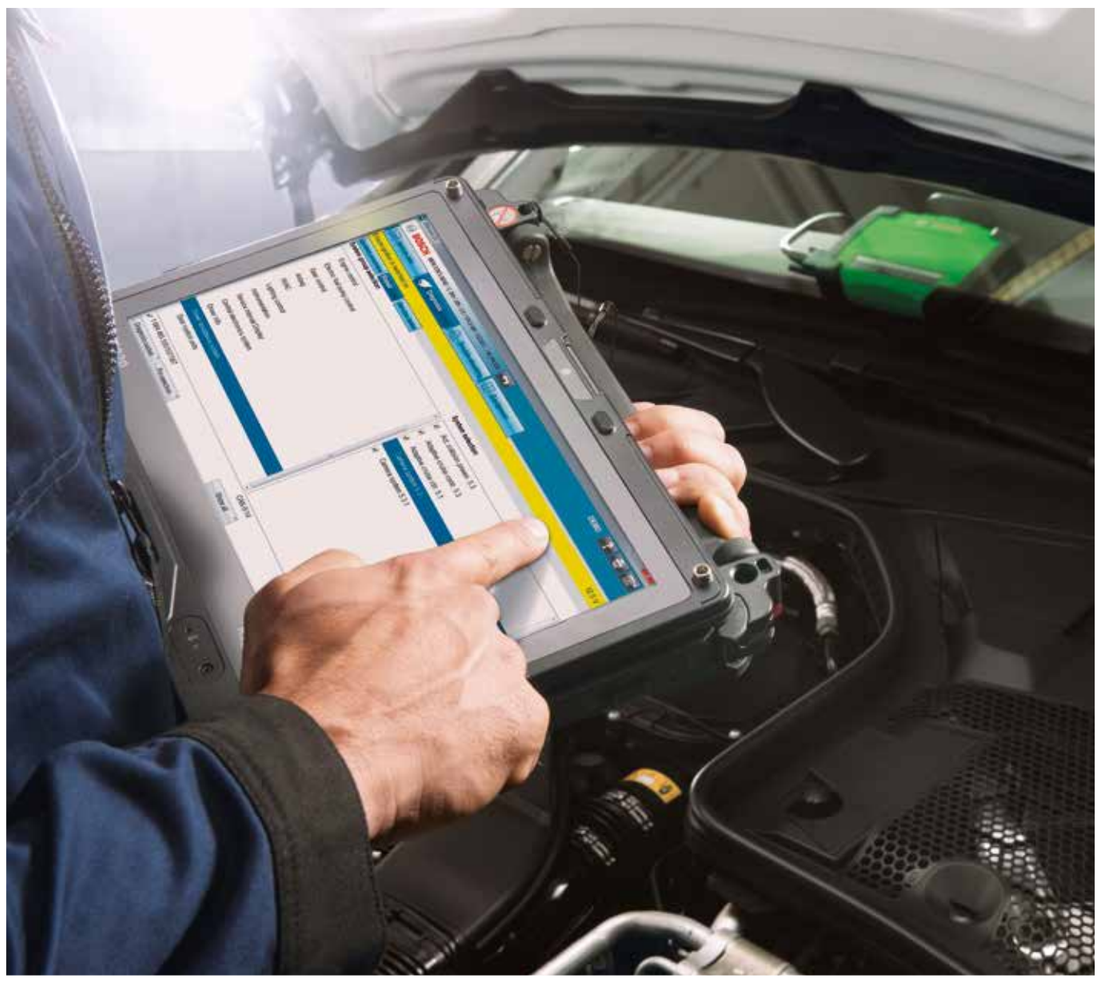
Lambda and Air Mass Sensors: An aid to fault diagnosis

There is no greater frustration than carrying out engine management component tests, only to find the problem persists. Here are two classic examples:

ASK THE EXPERTS: Genuine questions and answers from our technical hotline



CASE A: THE PROBLEM

The engine management ECU has a fault description of ‘oxygen sensor signal too low’. The oxygen (Lambda) sensor has been replaced but still outputs a low signal of 0.2 volts.

Lambda sensor and mixture adaptation fault codes don’t always mean the lambda sensors are faulty.
They can be an indication of what is wrong with vehicle engine management system.

Possible causes:

- An air leak either in the intake or exhaust system (upstream of sensor).
- The fuel pressure or delivery rate is incorrect.
- Sensor inputs to engine management ECU, causing incorrect injector opening time.
- Blocked fuel injectors

Note: In some cases the engine management ECU may have made an increase to the fuel mixture to compensate and bring the lambda sensor signal back to normal working parameters.

Diagnosis procedure:
Talk to customer and obtain as much information as possible, about the conditions when the fault occurred and the drive cycle of the vehicle, around town or motorway.

If the vehicle has fault diagnosis capability check for fault codes. If actual values are available for lambda sensor then look at these, remember that the OBD programme is emissions related and can have useful actual values when diagnosing these faults.
Compare these to any stated values, shown in your vehicle information system (eg Bosch ESI[tronic]).

Compare these actual values to the exhaust gas readings via a four gas analyser.

In some cases it may be necessary to check the output of the lambda sensor or sensors with an oscilloscope.

From this procedure you should be able to establish if the lambda sensor is reading correctly or not, and what other areas of the engine management system need further testing.

These basic principles and procedures can be applied to most of the associated lambda sensor and mixture adaptation fault codes and descriptions.

CASE B: THE PROBLEM

The engine management ECU has a fault description of ‘air mass meter signal too low’.

Note: Due to the parameters that the ECU monitors the air mass meter by, it is not uncommon for it not to be logged as a fault code.

It is generally known that air mass meters can pose some difficult problems when it comes to a clear cut fault diagnosis.
It is often asked what actual values can be expected and reliable methods for testing air mass meter sensors.

Possible causes:

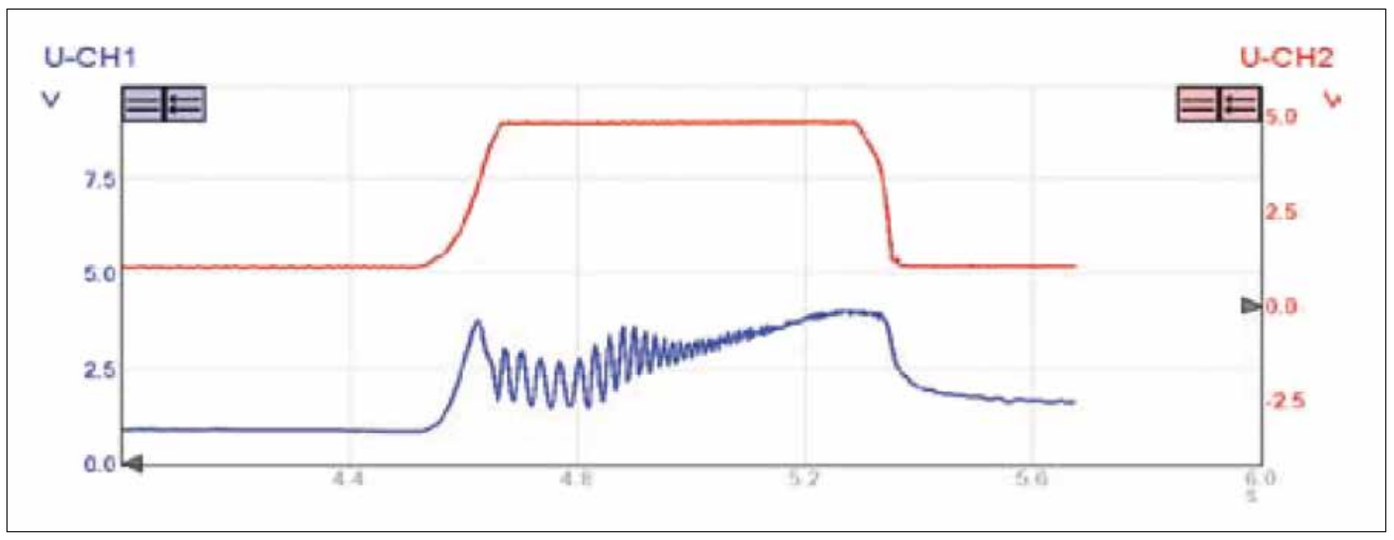
- Electrical connection and wiring between engine management ECU and sensor
- Air leaks
- Contamination of the sensor

Common causes of contamination:

- Heavily soiled air filter
- Engine breather system or the turbo-charger causing oil mist within the inlet manifold.
- Water ingress

Diagnosis procedure:

Obviously you will want to inspect the unit itself but keep it in the air box at all times whilst testing it, as removal can affect the air flow characteristics and hence its signal output.
Also be aware that hitting the unit with anything to try and remove contamination or cleaning it with solvents can cause permanent damage.
The next step is a vacuum gauge test at idle to establish that there are no mechanical problems.
Ignition or fuel supply faults should also be eliminated.
Moving on to ECU interrogation, plug in your diagnostic tester and look for actual values for the air mass signal (in Kg/hour or mg/s) at idle.
Refer to a vehicle information system (e.g. Bosch ESI[tronic] for value comparison and model specific information on testing.



Air mass sensor signal voltage in comparison to throttle sensor voltage

It’s a good idea to build up your own database on air mass values at idle (from good examples), as this can be handy for future reference.
More in-depth testing involves looking at the voltage output on ascope.
The curve characteristics must be noted with rpm increase.
Next give the throttle a hard fast blip. This will give a sharp voltage rise followed by a series of short peaks and troughs, or ‘pulses’ as the air in the engine settles back down. This is where experience and your own database of correct curves will help you. Certain deviations in the primary and secondary voltage peaks will show up a problem.
If you have a dual channel scope, test the throttle sensor voltage signal against air mass sensor signal. The voltage climb of the air mass meter should be roughly the same or even steeper. Generally, a shallower climb in the air mass meter signal will indicate deterioration.
The air mass meter can be one of the hardest components in the entire engine management system to accurately diagnose but performing these tests a number of times should give you a good feel for problems with this component.

Note: These test procedures refer to Bosch four wire Zirconium lambda sensors, and HFM 5 air mass meters.