TECHNICAL BULLETIN

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Make: Various

Model: Various

Subject: Oxygen sensors

Over the years at Injectronics, we have found that the operation of oxygen sensors is often overlooked by technicians, yet they can be easily tested and can often lead to solving engine management faults much faster than first thought.

There are several different types of oxygen sensors (also known as lambda sensors) fitted to modern vehicles, one, two, three, four and five wire configurations and they can be fitted in various positions in the exhaust system ie: the exhaust manifold, engine pipe, before, after or in the catalytic converter.

Most of these oxygen sensors have a Zirconia element which, when heated to approx. 300°c, produces voltages that are based on a comparison of the oxygen content in the exhaust compared to that of the atmosphere. This comparison is achieved through an atmospheric reference port in the external sensor housing, which if becomes blocked can cause severe drivability problems. It is also imperative that the threads of the oxygen sensor and those of the fitting location are clean as the sensor uses the engine block as an earth reference.

When the zirconia oxygen sensor has reached approx. 300°c, it acts as a voltage generator, rapidly reacting to the O2 content. When the sensor is cold it produces either no voltage or an unsuitable, slow changing voltage. In most of these types of systems the ECM will supply a steady 450mv or 550mv, low current bias voltage, (which can be measured on the O2 sensor wire) and the engine management system will operate in Open Loop mode. When the O2 sensor has reached operating temperature it begins to output a voltage in relation to the exhaust oxygen content. A lean fuel mixture will result in a higher oxygen content which in turn will drive the bias voltage low (lower than 400mv). A rich fuel mixture will result in a lower oxygen content which in turn will pull up the bias voltage above 600mv. The ECM monitors the transition above and below the 450mv bias voltage to decide when to operate in Closed Loop mode. When in Closed Loop, the ECM corrects the air fuel ratio by lengthening or shortening the injector on time to provide a richer or leaner fuel mixture ie: if the signal voltage was above 500mv (rich signal) the ECM would then shorten the injector on time to lean off the mixture and vice versa for a lean signal.

Later oxygen sensors (3 wire type) have been fitted with heaters which allow the sensors to stay at operating temperature even when exhaust temperature is below 300°c and also allows the ECM to remain in Closed Loop operation at idle. This in turn keeps exhaust emissions to a minimum during prolonged idle situations.
Four wire oxygen sensors operate the same as three wire except they have an additional earth wire which is used to ground the signal wire shield which protects the signal from radio frequency interference.

Five wire sensors (Linear Air Fuel Sensors) are presently only found in some Honda VTEC engines and are used in place of conventional oxygen sensors. The LAF sensor is a voltage generator just as normal oxygen sensors, but the difference is it has a current generated polarity, which can also generate a negative current unlike ordinary oxygen sensors, which only produce positive current. A lean mixture produces a positive current and a rich mixture a negative current.

In all cases it is imperative that engine earths are in an excellent condition. This includes battery grounds, chassis connections and engine block connections. In many cases the ECM will reference its oxygen sensor signal to an earth pin on the ECM which may go to the engine block. If the ECM reference earth is not at zero volts, a voltage differential of only 200-300mv may cause the ECM to respond incorrectly to the O2 signal (see also tech bulletin No 40 for V6 commodore dual sensors).

Testing: If the system you are testing uses a bias voltage, turn the ignition on and check for the specified bias voltage on the oxygen sensor signal wire (usually approx. ½ a volt). If the correct bias voltage is not present, disconnect the O2 sensor from the wiring harness and check if the bias voltage is now present on the harness going to the ECM. If so the O2 sensor is faulty and is grounding out the signal wire.

If the bias voltage is present, to test the O2 sensor, start the engine and raise to operating temperature. Hold engine RPM at 2000, remove one injector plug in order to create a lean mixture. Whilst observing the oxygen sensor signal it should be noticed that the voltage drops to approximately 10-200mv. Now replace the injector plug and partly restrict the return line from the fuel pressure regulator to the fuel tank. This will cause a rich mixture and inturn, a higher voltage of approximately 700-1000mv should be seen on the oxygen sensor signal wire.

If the above results are not achieved, the most common cause of incorrect oxygen sensor readings are bad engine and or chassis earths. This fault can easily be detected by firstly starting the engine, turning the headlights on high beam and the air conditioner on high. With a voltmeter, measure between the battery negative post and the engine block, the voltage measured between the two should not exceed 50mv. Another common fault can be that the engine atmospheric reference port becomes partially blocked, not allowing the sensor to perform correctly or accurately. As oxygen sensors age or become contaminated, their ability to be able to respond rapidly diminishes. The voltage signal generated by the sensor slows to a point where there is little or no response to air fuel ratio fluctuations within an acceptable time. With the engine at normal operating temperature and at 2000rpm, the oxygen sensor signal should be seen to rapidly oscillate between 10 and 1000mv which is known as 'Closed Loop' mode operation.

Above Lambda 1 = Richer mixture = Lower oxygen content in exhaust = Higher 02 Voltage
Below Lambda 1 = Leaner mixture = Higher oxygen content in exhaust = Lower 02 Voltage