

Subject: Oxygen Sensors – Purpose, Design & Function

Bosch pioneered the invention of the Oxygen Sensor in the early 1970's drawing upon experience in the technology of high temperature ceramics developed from many years of spark plug development. The Oxygen Sensor's first vehicle application came in 1976 used on a Volvo 264 for the Californian market. This was the start of one of the most widely used emission control devices in automotive history.

Since then, Bosch has produced nearly 300 million sensors worldwide, supplying the majority of global manufacturers. Currently Bosch produces approximately 30 million units per year in plants located across the globe including Germany and the USA.

As a major worldwide developer of automotive technologies, Bosch has continually improved the design and control of the engine management systems we produce to optimise Oxygen Sensor functionality and constantly improve vehicle exhaust emissions and overall performance.

The exhaust gas Oxygen Sensor, or "Lambda Sensor" as it may be referred to, is located prior to the catalytic converter in the exhaust manifold or pipe. The sensor generates a voltage for the engine management system related to the amount of excess oxygen in the exhaust gas, providing "feedback" of the mixture composition.

The engine management system is designed to provide optimum power and economy over the entire engine operating range and various driving conditions. The Oxygen Sensor allows the engine management system to reference the optimal air/fuel ratio of 14.7:1 and then adjust the engine air/fuel requirements to suit various operating conditions.

The Oxygen Sensor is a "Galvanic Cell", a type of battery. The sensor contains two platinum electrodes with a ceramic electrolyte (Zirconium Dioxide) between them. The Oxygen Sensor generates a very small voltage, ranging from as little as 100mV (0.1 volts), up to a maximum of 900mV (0.9 volts) dependent upon exhaust gas oxygen level. The sensor references atmospheric oxygen, typically approximately 20%, and the varying amount of excess oxygen in the exhaust. The larger the differential in oxygen between the atmosphere and exhaust the higher the voltage output of the sensor. A rich mixture typically has 0% oxygen, whilst a lean mixture may have 3-4%. During normal engine operation the sensor voltage will oscillate between 100mV - 900mV as the mixture quickly swings between rich and lean. The system will average the sensor voltage to ~ 465mV which will result in the mixture ratio of 14.7:1.

Evolution of the sensor over the years has resulted in design improvements in both operation and replacement intervals. The original design of sensor has a single wire for the output signal whilst the sensor earth was through the body of the sensor. Considering the minute voltage and current values involved with the Oxygen Sensor, earthing quality of the sensor was improved by adding an additional wire providing an internal earth circuit via the vehicle wiring harness.

The temperature of the Oxygen Sensor is an important factor in its operation, with the optimal operating temperature being ~ 360°C. With this in mind the physical position of the sensor may compromise the accuracy of sensor output with the possibility of overheating or temperature loss under certain conditions. A heating element was introduced to allow the sensor to be more remotely mounted whilst keeping the sensor at a stable regulated temperature. Oxygen Sensors with a heating element will have three or four wires, three wire sensors have a positive and

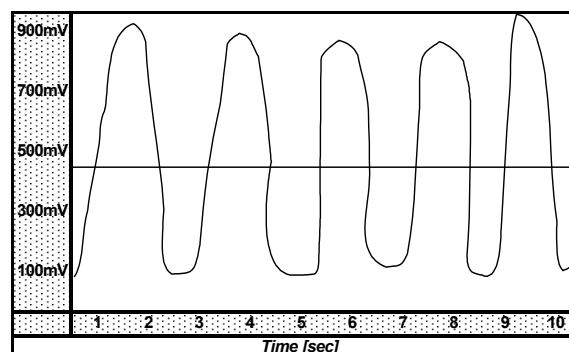
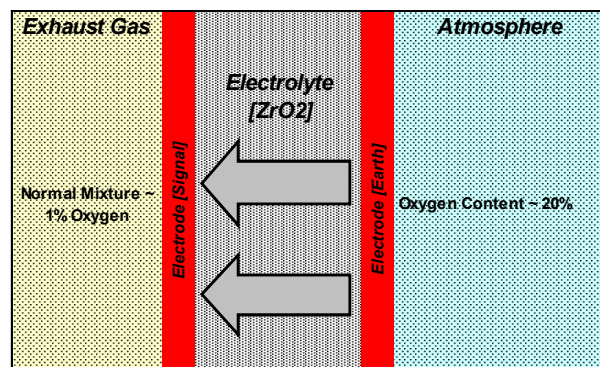
negative heater connection and a signal wire, the four wire sensor also has an incorporated earth circuit common with the two wire unit.

Bosch Oxygen Sensor construction and operation can be summarised as follows –

- The Oxygen Sensor allows the fuel management system to maintain the “Ideal” air/fuel ratio [14.7:1] across various engine operating conditions.
- The Oxygen Sensor compares the amount of excess oxygen in the exhaust gas against the amount of oxygen in the atmosphere.
- An Oxygen Sensor is actually a “Galvanic Cell” a type of battery. The sensor contains two Platinum electrodes with an electrolyte between them.
- There are two types of electrolyte used, Zirconium Dioxide and Titania.
- Oxygen Sensor output voltage will range between 100 – 900 mV.

Future Bosch bulletins will discuss the reasons and effects of Oxygen Sensor failure and important design features of Bosch Oxygen Sensors.

As Bosch continually strives for superior product design and functionality, we constantly improve on current technology. This commitment has seen the evolution of the Oxygen Sensor from a “narrow band” sensor that can only operate in a small air/fuel ratio window to a broader range sensor or “Wide Band” sensor. This design technology is referred to as “Planar” technology and will be covered in future articles.



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