Application Note

Testing Automotive Engine Oxygen Sensors Using the IET Labs 1900 Series Precision LCR Meter

Today's automobiles have evolved to the point of sophistication where the engine control decisions are under the command of the car's main processor. One important way of controlling the engine's operation and efficiency is to control the presence of oxygen. Engine oxygen sensors are used to monitor the oxygen level of the exhaust and are installed into the manifold at a location where exhaust from all cylinders has merged. The sensors are tested after assembly in order to identify any defective units prior to installation in the car. The 1900 Series LCR Meter was used to test these oxygen sensors due to its capacitance measurement capability yet its other impedance measurement capabilities make the 1900 instrument ideal for testing multiple types of sensors.

A sensor receives a stimulus and responds by sending out a signal. The stimulus can be a change in temperature, pressure, flow rate or pH or in the volume of light, sound or radio waves. A pressure sensor responds to changes in pressure – it is comprised of two parallel plates between a flexible ceramic and a rigid ceramic (i.e. a variable capacitor). A pressure change causes the flexible ceramic (diaphragm) to move changing the distance between the two plates. An IC in the sensor then converts the capacitance to a voltage and sends the signal out. A gas sensor operates in a similar manner except its stimulus is a change in temperature. A slight change in temperature causes a dramatic increase in resistance thus causing the sensor to respond. Therefore in testing sensors it is desirable to have an instrument capable of measuring capacitance and resistance as well as the dissipation factor to determine the dielectric constant for evaluation of the sensor material(s).

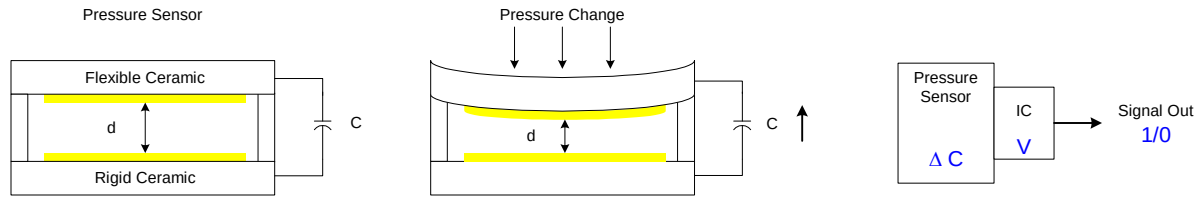

Figure 1: Basic Pressure Sensor

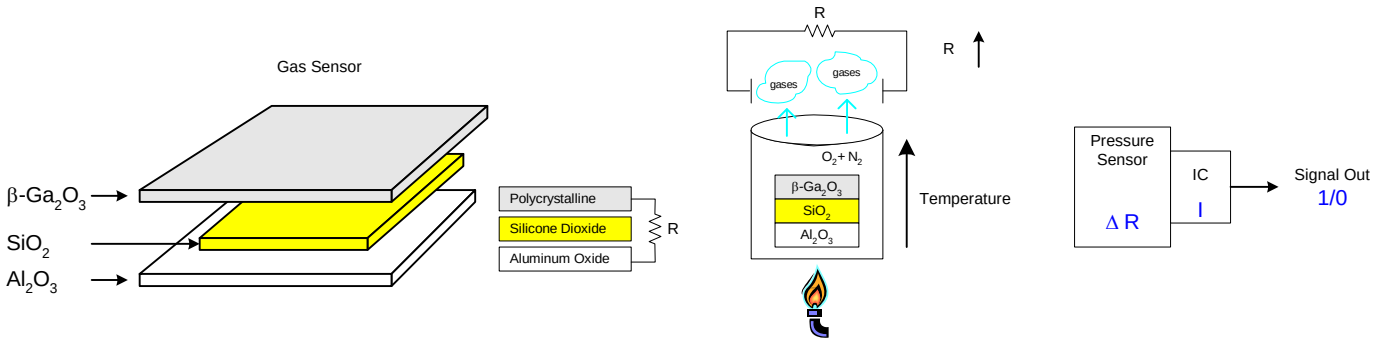

Figure 2: Basic Gas Sensor

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Oxygen Sensor

A typical oxygen sensor is comprised of a thin rolled ceramic material plated with platinum and exhibiting the characteristics of a capacitor. The sensor also includes a heater element for maintaining operating temperature, all of which is mounted in an enclosure for threading into the engine's manifold. During final assembly a laser weld is required to attach the enclosure to the threaded gasket portion, thus the ceramic capacitor, being especially fragile, is subject to cracking or damage during this process. For this reason, verification of electrical characteristics after assembly helps eliminate a number of possible defective devices.

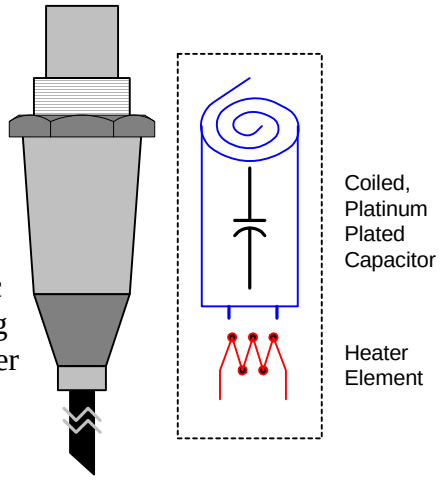

Figure 3: Oxygen Sensor

Measurement Characteristics

For this oxygen sensor application, using the 1900 Series LCR Meter to measure the **C value of the capacitive element** proved effective in determining the sensor quality and eliminating defective units. The typical value was on the order of 100pF or slightly less and for those units considered defective a value 50% lower was common. Oxygen sensors provide one indication of engine performance. Improper control of the engine based on oxygen analysis of the exhaust can have serious consequences. Too much oxygen can result in irreversible damage to the engine, or too little oxygen result in improper burning and cause air pollution. By real-time analysis of the engines exhaust the automobiles control system monitors the results and adjusts accordingly for optimum performance and efficiency.

Another impedance parameter important in evaluating the characteristic of a (pressure) sensor is **conductance** (**G**, measured in Siemens, S). The conductivity of the electrode/ceramic arrangement - or the amount of electrical energy in response to the pressure's mechanical energy helps determine sensor performance. The thickness of the flexible ceramic is proportionate to the amount of pressure it can withstand in its final application. High pressure applications use a thicker ceramic diaphragm layer.

The 1900 Series LCR Meter is ideal for sensor testing because of some of its unique features. When measuring the low capacitance values of these devices the instrument's low noise level is important in obtaining useful and consistent results. The ability to measure the voltage across and current through the DUT provides real-time operating conditions. The open/short circuit zeroing is critical in compensating for fixture and/or lead connection errors.

Figure 4: IET Labs 1900 Series Precision LCR Meter

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