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FUNCTIONAL MEASUREMENTS OF THE AUTOMOTIVE BROADBAND LAMBDA OXYGEN SENSORS

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Key worlds: *automotive, oxygen sensor, oscilloscope.*

Abstract: *In this report is presented practical measurement and determination of the functionality of an automotive oxygen sensor. Current measurements are made with oscilloscope on a broadband zirconium sensor. In the report are presented graphics of an upright sensor and a damaged sensor.*

An oxygen sensor is an electronic device that measures the proportion of oxygen in the gas or being analyzed.

It was developed by Robert Bosch Gmbh during the late 1960 year under the supervision of Dr. Gunter Bauman. The original sensing element is made whit a thimble-shaped zirconium ceramic coated on both the exhaust and reference sides whit a thin layer of platinum and comes in both heated and unheated forms [1].

The most common application is to measure the exhaust-gas concentration of oxygen for internal combustion engines in automobiles and other vehicles in order to calculate and, if required, dynamically adjust the air-fuel ratio so that catalytic converters can work optimally, and also determine whether the converter is performing properly or not.

The Volvo first use oxygen sensor in model 240. Automotive oxygen sensor, make modern electronic fuel injection and emission control possible. They help determine, in real time, whether the air-fuel ratio of a combustion engine is rich or lean. Closed-loop feedback controlled fuel injection varies the fuel injector output according to real-time sensor data rather that operating whit a predetermined (open-loop) fuel map. The sensor does not actually oxygen concentration, but rather the difference between the amount on oxygen in the exhaust gas and the amount of oxygen air.

Modern spark-ignited combustion engines use oxygen sensor and catalytic converters in order to reduce exhaust emissions. Tampering with or modifying the signal that the oxygen sensor sends to the engine computer can be detrimental to emissions control and can even damage the vehicle. When the engine is under low-load conditions.

The sensors only work effectively when heated to approximately 316 °C, so most newer lambda probes have heating elements encased in the ceramic that bring the ceramic tip up to temperature quickly. Older probes, without heating elements, would eventually be heated by the exhaust, but there is a time lag between when the engine is started and when the components in the exhaust system come to a thermal equilibrium.

Zirconia sensor

The zirconia lambda sensor (fig.1) is based on a solid-state electrochemical fuel cell called the Nernst cell. Its two electrodes provide an output voltage carresponding to the guantity of oxygen in the exhaust relative to that in the atmosphere.

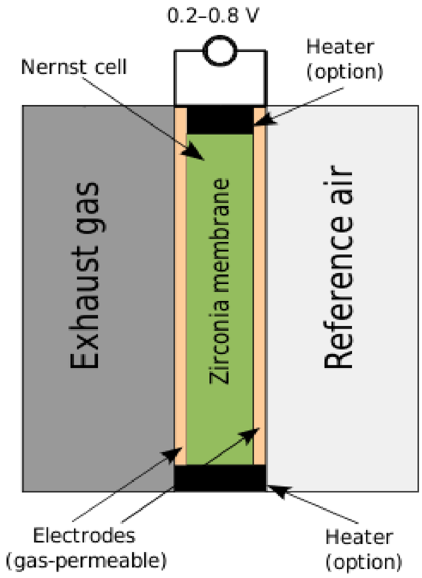

Figure 1. Zirconia sensor

An output voltage of 0.2 V (200 mV) DC represents a “lean mixture” of fuel and oxygen, where the amount of oxygen entering the cylinder is sufficient to fully oxidize the carbon monoxide (CO), produced in burning the air and fuel, into carbon dioxide (CO_2). Output voltage of 0.8 V (800mV) DC represents a “rich mixture” , which is high in unburned fuel a low in remaining oxygen. The ideal setpoint is approximately 0.45 V (450mV) DC. This is where the quantities of air an fuel are in the optimal ratio, which is 0.5 % lean of the stoichiometric point, such that the exhaust output contains minimal carbon monoxide.

Wideband zirconia sensor

A variation on the zirconia sensor, called the “wideband” (broadband) sensor (fig.2), was introduced in 1992.

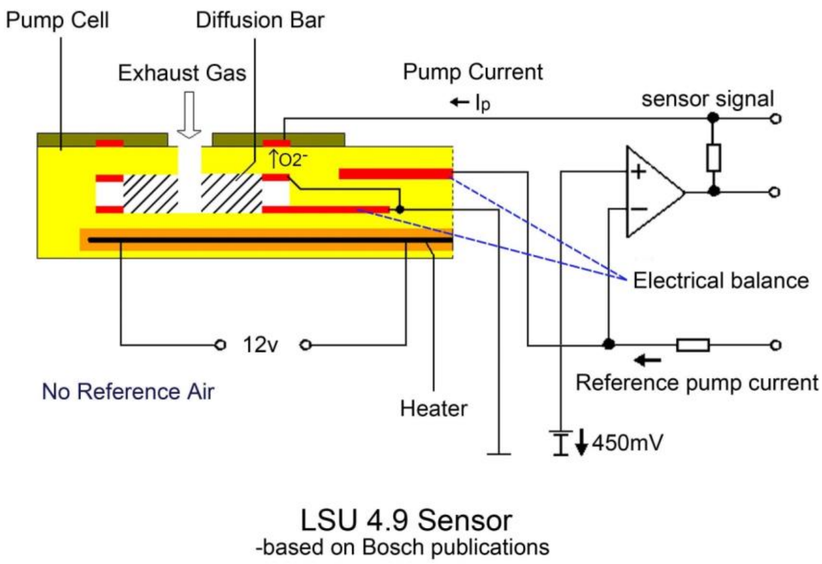

Figure 2. Broadband zirconium sensor

This type has been widely used for car engine management system in order to meet the ever-increasing demands for better fuel economy, lower emissions and better engine performance at the system time [2]. It is based on a planar zirconia element, but also incorporates an electrochemical pump. An electronic circuit containing a feedback loop controls the gas-pump current to keep the output of the electrochemical cell constant, so that the pump current directly indicates the oxygen content of the exhaust gas. This sensor eliminates the lean-rich cycling inherent in narrow bands sensor, allowing the control unit to adjust the fuel delivery and ignition timing of the engine much more rapidly.

Titania sensor

A less common type of narrow-band lambda sensor has a ceramic element.

This type does not generate its own voltage, but changes its electrical resistance in response to the oxygen concentration. Some sensors are used with a gas-temperature sensor to compensate for the resistance change due to temperature.

As titania sensor is an N-type semiconductor, crystal lattice conduct the charge. So, for fuel-lean exhaust the resistance is high. The control unit feeds the sensor whit a small electric current and measures the resulting voltage drop across the sensor, which varies from nearly 0 volts to about 5 volts.

Functional measurements

A number of measurements are performed by using the automotive oscilloscope interface Auto Scope Plus [3] and handheld oscilloscope HANTEK 1202B [4]. The obtained results are record in the database and may be use for the diagnostics of the automobile and its systems [5].

On the figure 3 is shown the waveform taken from the common zirconium sensor. The sensor functionality is evaluated by the presenting deviation of the signal (0 to 1V) during automotive acceleration (fuel enrichment). If these deviation absence the sensor has failure.

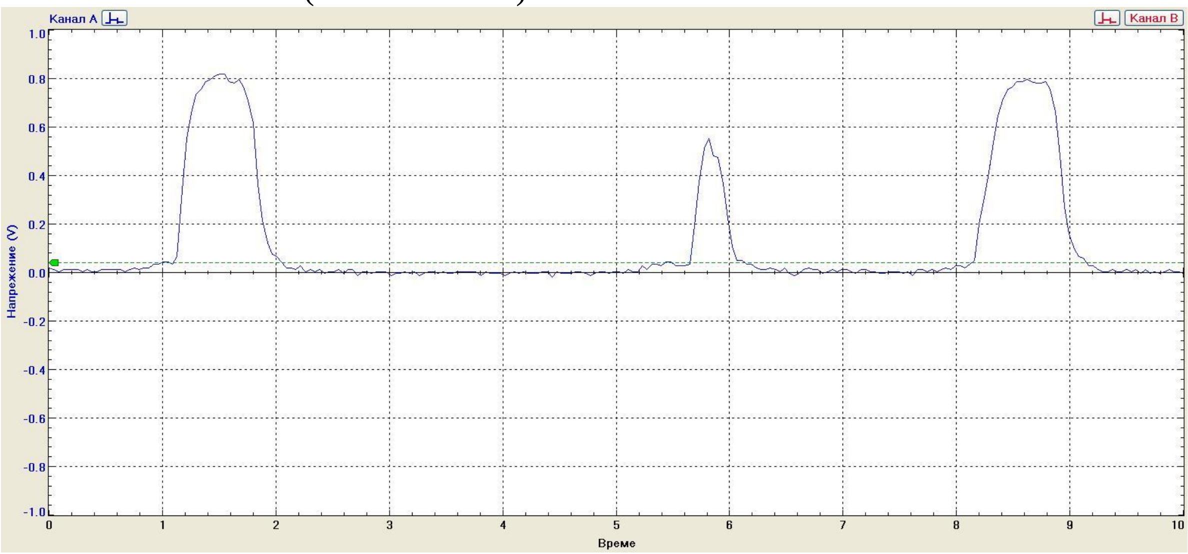

Figure 3. Waveform of common zirconia sensor during fuel enrichment

The same result is valid for the titania sensor. The zirconia and titania sensor has sensitivity only at the very rich (max value) and the very lean (min value). These results cannot be use for the precise fuel mixture and exhaust gas emission reduction.

Figure 4 represents the waveform of the broadband zirconia sensor during enricment and leaning of the fuel mixture. This is the direct signal deviation.

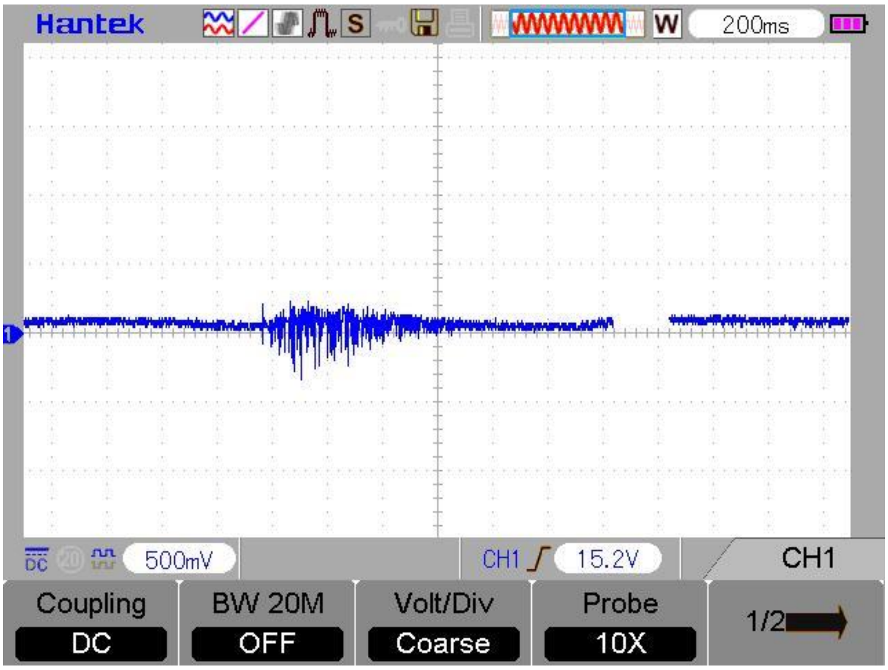

Figure 4. Waveform of broadband zirconia sensor during fuel enrichment

More significance for the lambda-close-control-loop has the signal of the pump current (fig.5). This waveform has constant amplitude and evaluates the oxygen content by the deviation of pump current time pulses. On this waveform the first pulse time evaluates the oxygen content, i.e., the air-fuel ratio.

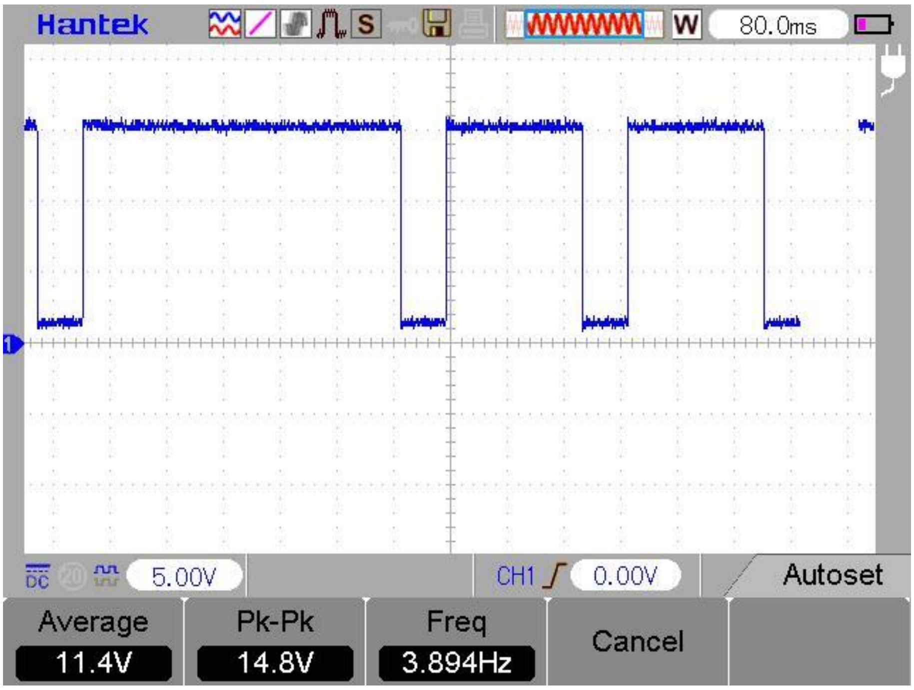

Figure 5. Waveform of pump current time of the broadband zirconia sensor during fuel enrichment

The measurement of the time deviation is more accurately and this sensor has more application in the modern trends of stringent ecological limitations. The absence of the deviation between the pump pulses during engine state changing is a sign of sensor failure.

Conclusion:

Modern automotive fuel injection systems cannot operate accurately without oxygen sensors. These sensors are one of the most important elements for determining the right air-fuel ratio of the mixture. Oxygen sensor also impact on the environment, as part of the exhaust gas treatment system.

Sources:

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[3] http://obd2-bg.com/mScope/index.html
[4] http://www.hantek.com
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ФУНКЦИОНАЛНИ ИЗМЕРВАНИЯ НА СИГНАЛИТЕ НА АВТОМОБИЛНИ ШИРОКОЛЕНТОВИ КИСЛОРОДНИ ПРЕОБРАЗУВАТЕЛИ

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Key worlds: *автомобил, кислороден преобразувател, осцилоскоп.*

Abstract: *В тази статия са представени практически измервания и определяне на работоспособността на автомобилен кислороден преобразувател. Измерванията са направени на обикновен и широколентов кислороден преобразувател с помощта на осцилоскоп. Представени са осцилограми на изправни преобразуватели и са посочени симптомите на неизправност..*