

Lambda sensor

General

Due to the increasing strictness of exhaust emission regulations, the vehicle manufacturers are commited to reducing their vehicle emissions. For this reason a 3-way catalytic converter is fitted to nearly all vehicles. To achieve a good conversion rate from the converter and optimal engine conditions, the fuel-air mixture must be monitored and adjusted. This is the function of the lambda sensor and the ECU.

Function

To get an optimal complete combustion the fuel-air mixture must have a ratio of 1:14,5. This proportion is called λ (lambda) = 1 (fig. 1). To ensure for the best proportion, the lambda sensor measures the residual oxygen content in the exhaust. Dependent on the residual oxygen content a lean or rich mixture is indicated to the ECU by a voltage. The ECU controls, using this measured parameter, the optimal fuel-air mixture. The measurement of the residual oxygen content can be obtained using two different types of lambda sensor: Zirconiumdioxide and Titaniumdioxide . The difference between these two sensors is that the zirconiumdioxide sensor generates a voltage and the titaniumdioxide sensor needs a supply voltage. The construction and function can be explained as following:

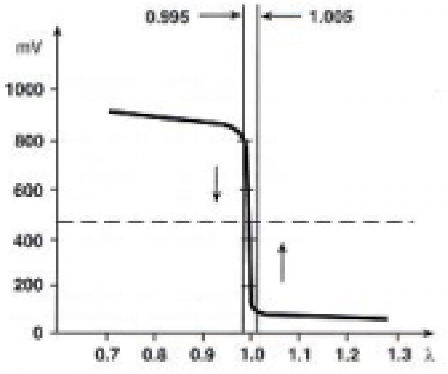


Fig. 1

Zirconiumdioxide sensor: The zirconiumdioxid eelement has direct contact to the exhaust gas, protected with a protection sleeve. The inside is exposed to ambient air. Both sides are coated with a platinium deposit acting as an electrode. Oxygen ions pass over this platinium deposit and leave a voltage. At a temperature of 300° C the zirconiumdioxide element is conductive. If the oxygen content of the out- and inside is different, a voltage is created due to the elements

property. This voltage is the measured variable for the ECU. If the voltage is high the mixture is rich, if the voltage is low the mixture is lean.
Titaniumdioxide sensor: The titaniumdioxide sensor does not generate a voltage. It works using a changing resistance. The changing of the resudial oxygen content also changes the resistance of the titaniumdioxide element. If the element is supplyed with a voltage, the output voltage changes when the oxygen concentration in the exhaust changes. This sensor, in comparison to the zirconiumdioxide sensor, requires no reference air. Due to this it is smaller in size.
Both sensors are a heated to quickly attain their operating temperature. During cold start, warm up and full throttle, lambda control is not in operation (open loop control).
When lambda control operates, this is known as closed loop control.

Zirconiumdioxide sensor

Titaniumdioxide sensor

Effects of failure

A faulty lambda sensor can produce the following effects:

- High exhaust emission
- Poor engine performance
- High fuel consumption
- Engine warning light illumination
- Storing of a fault code

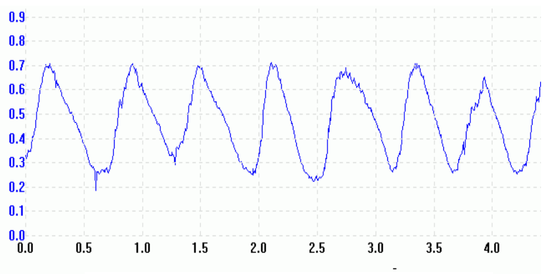
Causes of failure:

- Internal and external short circuit
- Missing supply voltage / ground
- Overheating
- Fouling / deposit build-up
- Mechanical damage
- Using leaded fuel / additive
- Faulty heating element

Fault diagnosis

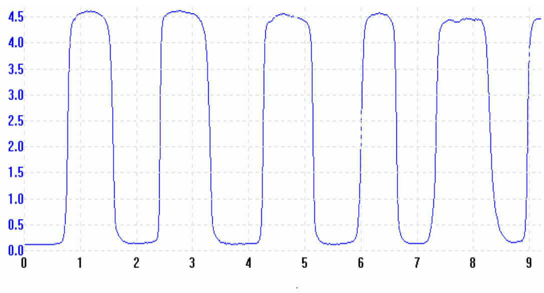
For the fault diagnosis consider the following steps:

1. Visual inspection of the plug, plug contacts and wires for damage, correct fitting and routing
2. Read out the fault memory
3. Testing with an oscilloscope:
    - Connect the test cable of the oscilloscope to the lambda sensor. Consider the cable colours (observe the manufacturer´s data):
    - Black: Signal wire
    - White: Signal ground wire
    - Grey: Heating element wire
    - Adjustment of the X and Y axes **Zirconiumdioxide** sensor:
    - X axis (time): 5 seconds
    - Y axis (voltage): 2 volt
    - Warm up engine to operation temperature and hold 2000 rpm. On the oscilloscope a pattern is shown (see picture). There must be a minimum voltage of 0,1 V and maximum voltage of 0,9 V. The reaction time (riseing up from lean 0,1 V to rich 0,9 V) should be 300 milliseconds.



Zirconiumdioxide sensor

    - Adjustment of the X and Y axes **Titaniumdioxide** sensor:
    - X axis (time): 10 seconds
    - Y axis (voltage): 5 volt
    - Warm up engine to operation temperature and hold 2000 rpm. On the oscilloscope a pattern is shown (see picture). There must be a minimum voltage of 0,2 V and maximum voltage of 4,5 V.



Titaniumdioxide sensor

Evaluation of the pattern:

- The signal voltage of the sensors must be between 0,1 V – 0,9 V for Zirconiumdioxide and 0,2 V – 4,4 V for Titaniumdioxide. If the signal voltage is out of this range the sensor is faulty. In this case, check the supply voltage of the titaniumdioxide sensor from the ECU (note manufacturer data), before renewing the sensor. Also consider the switching duration (frequency change between lean and rich) and the initial response time (reaction of a changed mixture). If the frequency is too low or the initial response time too long, the regulation is not optimal, the sensor should be renewed.

As well as the electronic check and visual check of the connectors and wires, the condition of the protection sleeve of the sensor element can provide information about the operation.
The following statements apply to this:

- The protection sleeve is heavily sooted (Fig. 1): Engine runs with a too rich mixture. The sensor should be renewed and the cause for the too rich mixture should be repaired to prevent a new sooting.
- Bright deposits on the protective sleeve (Fig. 2): Use of leaded fuel. The lead destroys the sensor element. The sensor must be renewed and the catalytic converter must be checked. The leaded fuel must be changed to unleaded fuel.
- Light (white or grey) deposit on the protective sleeve (Fig. 3): Engine burns oil, use of additional additive to the fuel. The sensor must be renewed and the cause of the oil burning must be rectified.
- Improper installation (Fig.4): An improper installation can damage the sensor so that the optimal function can not be assured. Therefore, for fitting, the right special tool and the tightness should be observed.

Fig. 1

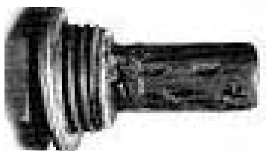


Fig. 2

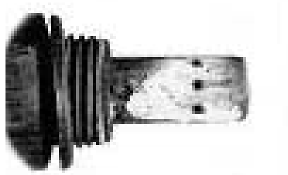


Fig.3

Fig. 4