TomcoTechtips™

ISSUE 20

TITANIA 0XYGEN SENSORS

In Tech Tip #13 we discussed Zirconia oxygen (02) sensors. We have recently received many questions on another style 02 sensor, the Titania sensor.

The Titania sensor is made from a resistive material called Titanium Dioxide ($Ti0_2$).

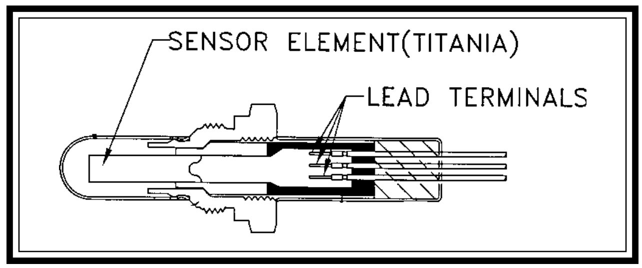
This Titanium Dioxide is silk screened onto one side of a thick film ceramic substrate. A heater is silk screened onto the other side of the ceramic substrate. The Titanium Dioxide needs to be heated to a certain temperature to work, so it always contains a heater circuit.

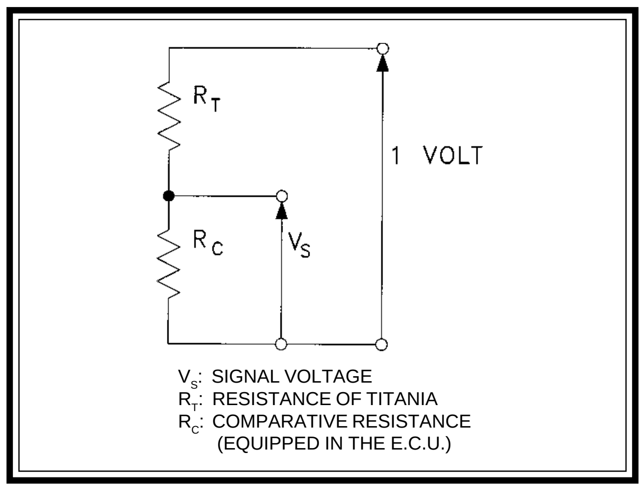
The Titania changes resistance in relation to how much oxygen is in the exhaust. When the exhaust gas contains excess oxygen (engine is running lean), the resistance of the Titania is high. In an extremely lean mixture it can be over 20,000 OHMS.

When the exhaust gas has little or no oxygen (engine running rich), the resistance of the Titania is low. In an extremely rich condition this could be lower than 1,000 OHMS.

Some Titania sensors have three wires. (Fig. 1) One of the wires is the positive feed for the heater. A second wire is the ground for the heater. The third wire is the signal input to the computer.

The Titania sensor does not produce a voltage like the Zirconia sensor. Instead, the Titania sensor is supplied a voltage. This voltage goes across the resistive Titania and the computer watches for a change in return voltage.

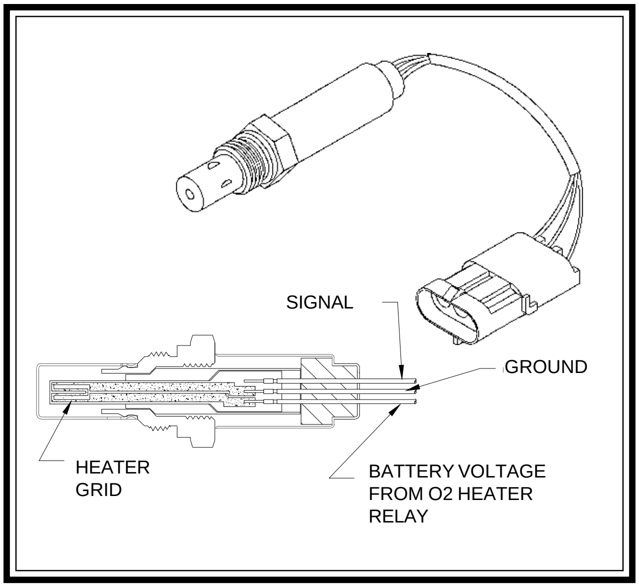




In the case of the three-wire Titania sensor, the reference voltage is supplied from the heater circuit. The heater circuitry is designed so that one volt is left after traveling across the heater. This one volt then becomes the reference voltage that goes across the resistive Titania. (Fig. 2)

When the one volt travels across the Titania and the exhaust is lean, most of the voltage will drop across the now “high” resistive Titania. This results in a low voltage signal to the computer.

When the one volt travels across the Titania and the exhaust is rich, very little of the voltage will drop across the now “low” resistive Titania.



This results in a high voltage signal to the computer.

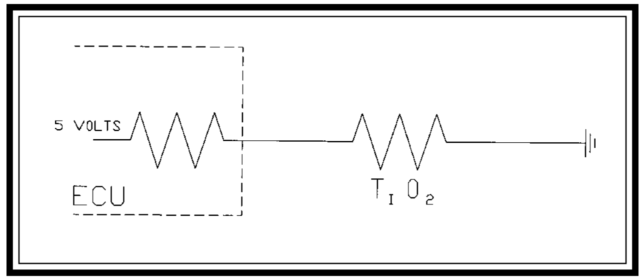
On four-wire Titania sensors the fourth wire is a dedicated one-volt reference to the sensor. This dedicated one volt goes across the Titania, and the computer looks for the return voltage.

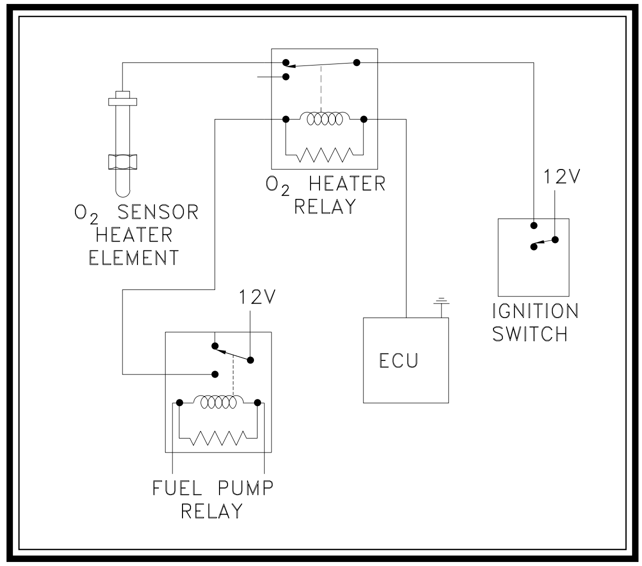
The Titania sensors we have just discussed are primarily used on the Nissans: 1987 Pulsars and Sentras; 1989-93 Maximas; 1987-93 trucks with VG30 V6s; 1986 300ZXs; 1987-89 turbocharged 300ZXs; 1987-88 200SXs with VG30 V6s; and 1993 Quest minivans.

Titania Sensors usually have a smaller thread size of 12 mm, compared to the Zirconia sensor's 18 mm threads.

Jeep also uses a Titania sensor, but with a different twist. (Fig. 3) Instead of using a one-volt reference signal, Jeep uses a five-volt reference signal.

This sensor is a three-wire sensor. Two wires are for the heater circuit, and one wire is the signal wire for the computer. In this application, the heater does not supply voltage for the sensor, but the computer supplies the voltage.

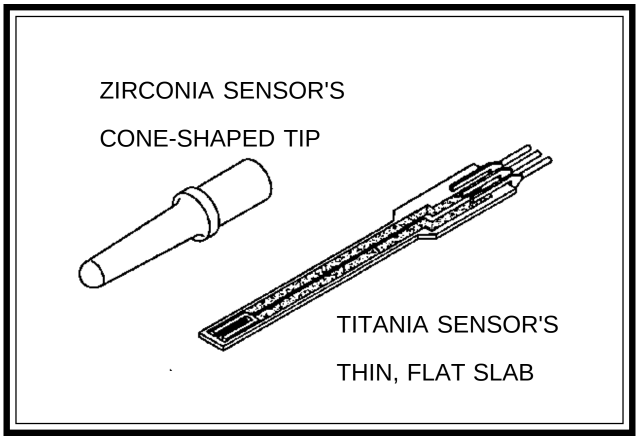




Since this five-volt signal comes from the computer through a comparative resistor, then across the Titania, the computer will see different values for rich and lean. When the system is rich the computer will see 0 to 2.5 volts. When the system is lean the computer will see 2.5 to 5.0 volts. (Fig. 4)

In some applications Jeep also runs the heater circuit through a relay. (Fig. 5) This relay is controlled by the computer. When the computer senses high RPM or a heavy engine load, it closes the ground to the relay. This opens the relay contacts and cuts off power to the heater. At these times, the sensor will be kept warm enough by the exhaust heat. As soon as the computer no longer sees these conditions, it opens the ground causing the relay contacts to close. This completes the heater circuit and keeps the sensor at operating temperature.

The Jeep sensor has 18 mm threads, like the Zirconia sensors. This can be a problem when



changing an 02 sensor. The two look very similar, but *are not interchangeable*. The connector is even the same on the Titania and Zirconia sensors on some Jeep models.

If you do put the wrong sensor in the vehicle, it will have driveability problems.

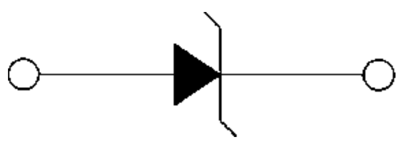
How can you tell if your sensor is Zirconia or Titania? The best way is to look at the sensor's tip. Looking through the shield, if the cell inside is thimble or cone shaped, it's Zirconia. If the cell is a thin flat slab, in most cases it's Titania. (Fig. 6)

When diagnosing these sensors, first check the heater. With the sensor disconnected, use a ohmmeter to measure across the two terminals for the heater. It should be somewhere between 7-10 OHMS on most sensors. Look for the appropriate resistance values in the service manual.

Since the Titania sensor doesn't produce a voltage, we can't bench test it to see a voltage change. But, we can hook up an ohmmeter to the signal wire and ground and read the change in the resistance of the Titania as we heat the tip.

Of course these sensors can always be checked in the vehicle by using a DVOM hooked to the signal wire that goes to the computer. The voltage should shift between 0 and 1 volts, or 0 to 5 volts, depending on your application.

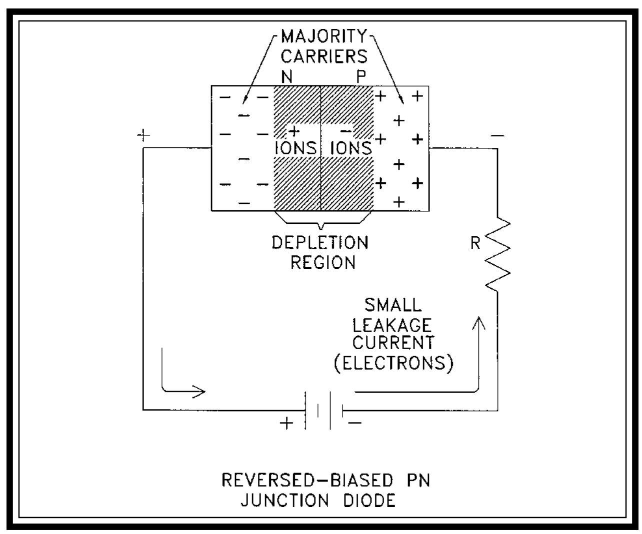
Zener Diode



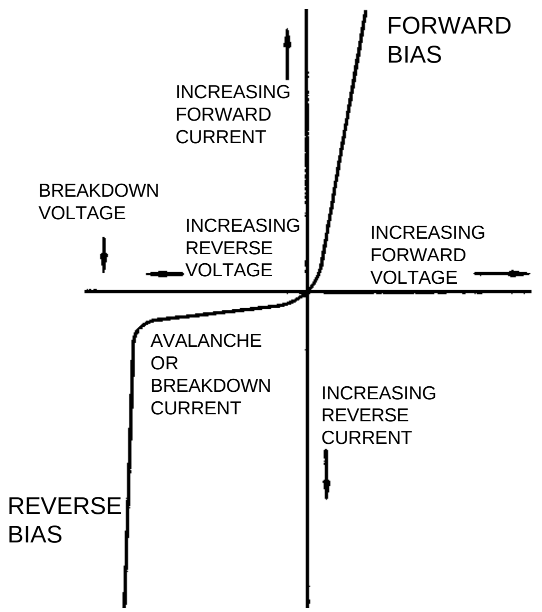
In our study of diodes in Tech Tip #17 we found that forward biasing a diode would allow current to flow through the diode. If we reverse biased the diode, no current would flow.

In actuality, reverse biasing a diode cuts off "almost" all the current through a diode. There is a small amount of reverse current through the diode which we call *leakage current*. This leakage current is usually insignificant.

This leakage current exists because heat energy in a semiconductor at normal temperatures permits a very small number of electrons to break free. This results in the P type material having a few free electrons and the N type material a few holes. The electrons will be forced towards the PN junction where they will combine with some of the holes and an extremely small current will be produced. (Fig. 7) This is typically microamperes in germanium diodes and nanoamperes in silicon diodes.



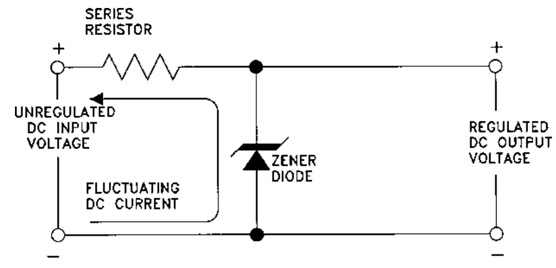
If the reverse bias voltage becomes high enough, more electrons will break free. These



CURRENT- VOLTAGE RELATIONSHIP
FOR P-N JUNCTIONS

free electrons in turn collide with other electrons to break them free. This results in a chain reaction called an avalanche of electrons. The diode breaks down and conducts a high reverse current. (Fig. 8) The point at which the voltage causes this high reverse current is called the *breakdown voltage* of the diode. This high reverse current produces heat which can damage or destroy the diode. The maximum reverse current which a diode can sustain without causing damage is called the peak inverse voltage (PIV). Many diodes are supplied with a PIV rating specification.

The zener diode is a diode built to withstand certain breakdown voltages, and serve a purpose as it does so. Zener diodes are available with breakdown voltage ratings of approximately 2 volts to 300 volts.



A TYPICAL ZENER DIODE
VOLTAGE REGULATOR
CIRCUIT

The most widely used application for a zener diode is to continuously reverse bias the diode, so it constantly operates in its breakdown voltage. A zener diode used in this manner can provide voltage regulation. This voltage regulation is often required for solid state circuits that need a fixed DC voltage to operate properly.

In Figure 9 we have a typical zener diode voltage regulator circuit. A resistor is connected in series with the zener diode, the diode being reversed biased. An unregulated DC voltage is supplied to this circuit. This voltage may be higher or lower than its specified value because it is unregulated. Because the zener diode breakdown voltage is set, the voltage across the diode will be constant. This output voltage value is the diode’s breakdown voltage. This output voltage, because it is held to a somewhat constant value, is called a regulated voltage.

By using a zener diode with a different breakdown voltage we can change the regulated output voltage to supply the regulated voltage we may need. This allows us to get a regulated DC voltage from an unregulated DC supply.