

Introduction: Toyota Oxygen Sensors - Air Fuel Ratio Sensors

With the ever increasing strict standards being placed upon vehicle manufacturers to produce vehicles with low exhaust tailpipe emissions, certain changes in the way exhaust emissions are monitored and controlled had to be designed, engineered and implemented in the production of new vehicles.

Earliest designs for exhaust emissions monitoring and control utilised the single wire Oxygen Sensor (O_2). Further O_2 sensor design progression has led to today's heated O_2 sensor (HO2S) the utilisation of multiple O_2 Sensors and Air Fuel Ratio Sensors.

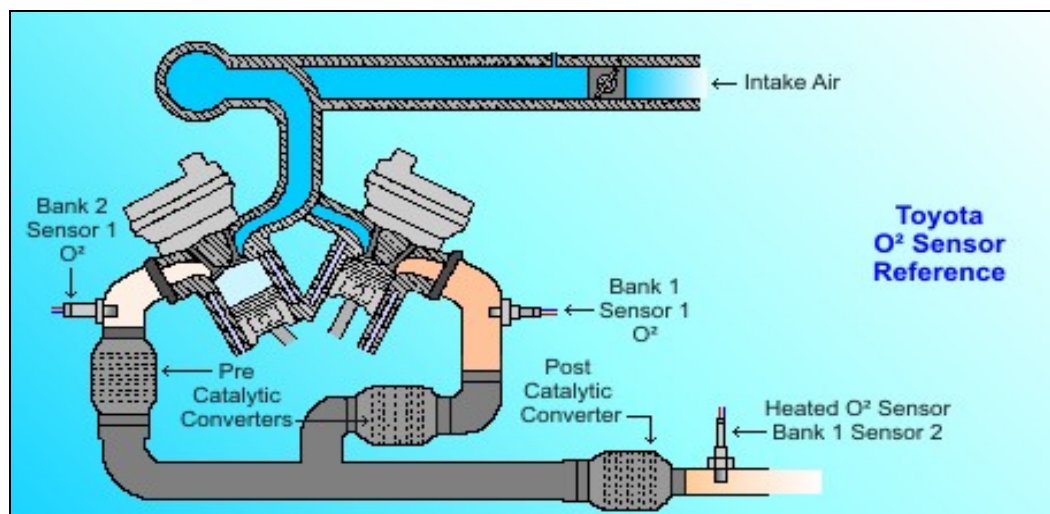
The introduction of the OBD II standard calls for far tighter control of exhaust emission monitoring and control. Vehicle manufacturers had to find a method to gain a greater control the vehicles engine air/fuel ratio. Many vehicle manufacturers already have multiple conventional O_2 sensors (narrow band) applications and vehicle manufacturers (Toyota, Subaru, Honda, European vehicle makers etc.) are now using a combination of conventional O_2 sensors and the latest type, the Air Fuel Ratio (wide band) sensor.

Toyota O_2 sensor(s) and A/F Ratio sensor numbering and engine location is specified as:

- The O_2 sensor placed before the catalytic converter (inline engine) – Sensor 1
- The O_2 placed after the catalytic converter (inline engine) – Sensor 2
- On a V engine (per bank O_2 sensors) – Bank 1 Sensor 1, Bank 2 Sensor 1
- On V engines with 2 rear converters – Bank 1 Sensor 2, Bank 2 Sensor 2
- The A/F sensor pre catalytic converter – Sensor 1

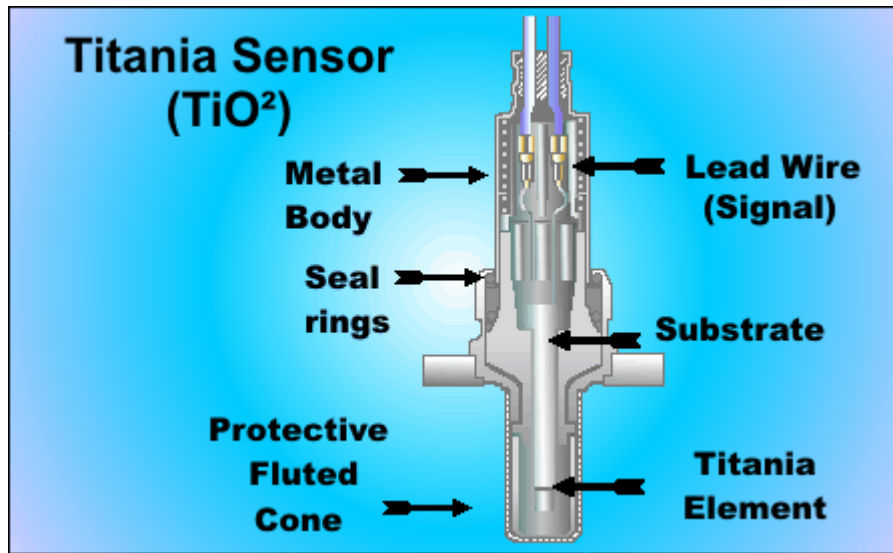
The primary function of a pre catalytic converter O_2 sensor is to send to the EFI computer (ECU/PCM) variable voltage data to allow the ECU/PCM to monitor and make corrections to the detected Air Fuel Ratio.

The rear (post) catalytic converter sensor is primarily used as a monitor for catalytic converter efficiency. In some vehicle applications, the post catalytic converter sensor will also have an effect on the ECU/PCM air fuel ratio control.



Titania O² Sensor Review

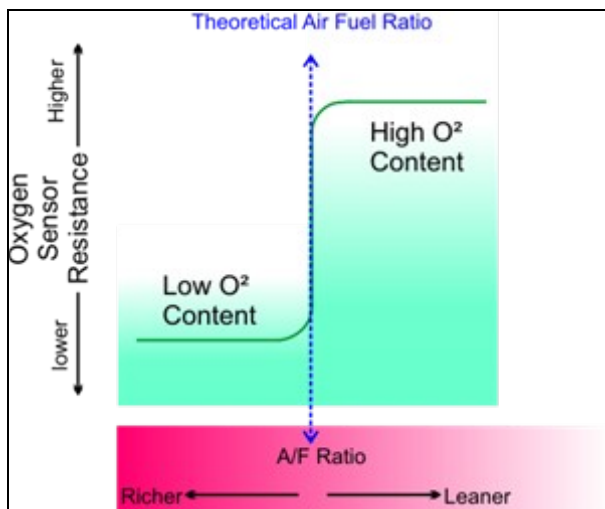
Toyota Titania O² Sensor



Titania O² Sensor Construction Schematic

Toyota has used the Titania O² Sensor in some vehicle applications since the late 1980's and the early 1990's.

The Titania sensor consists of a semiconductor ceramic material known as Titanium Dioxide (TiO₂). The sensor uses a thick film type Titania element which is formed on the front end of a laminated substrate. The sensor element is used to detect unused oxygen present in the exhaust gas stream after combustion has occurred.



Graph 1

The properties of Titania are such that its resistance will alter to the amount of oxygen contained in the exhaust gas stream.

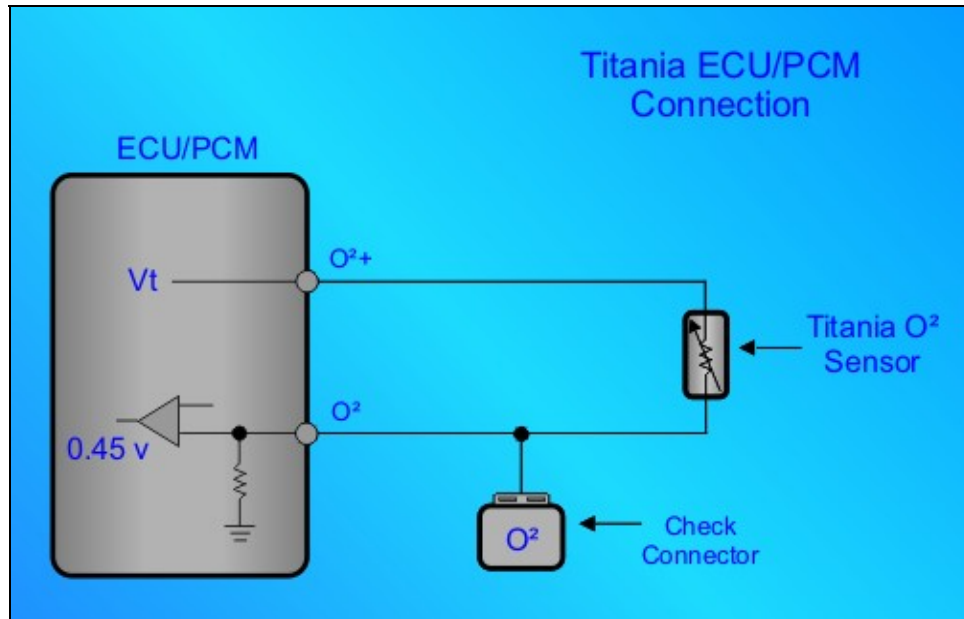
The resistance change alters sharply to the boundary difference of the lean/rich air fuel ratio – refer [Graph 1](#).

Titania resistance also changes with temperature. To help keep the temperature at a constant level, a heater element is built into the O² sensor laminated substrate.

Toyota ECU/Titania O² Sensor Electrical Circuit

When performing diagnostics on Toyota vehicles using a Titania O² sensor, please refer to Toyota vehicle technical service manuals for specification data and electrical circuits.

Typical Toyota ECU and Titania O² Sensor Wiring Circuit Schematic



Toyota ECU - Titania Oxygen Sensor Circuit Schematic

Titania O² Sensor Operation - (refer to the schematic above)

The ECU supplies a potential voltage of 1.0 volt to the **O²+** connection. The ECU built in comparator circuit compares the voltage drop (changing resistance) of the Titania O² sensor to the referenced **0.45** volt at the ECU **O²** sensor connection.

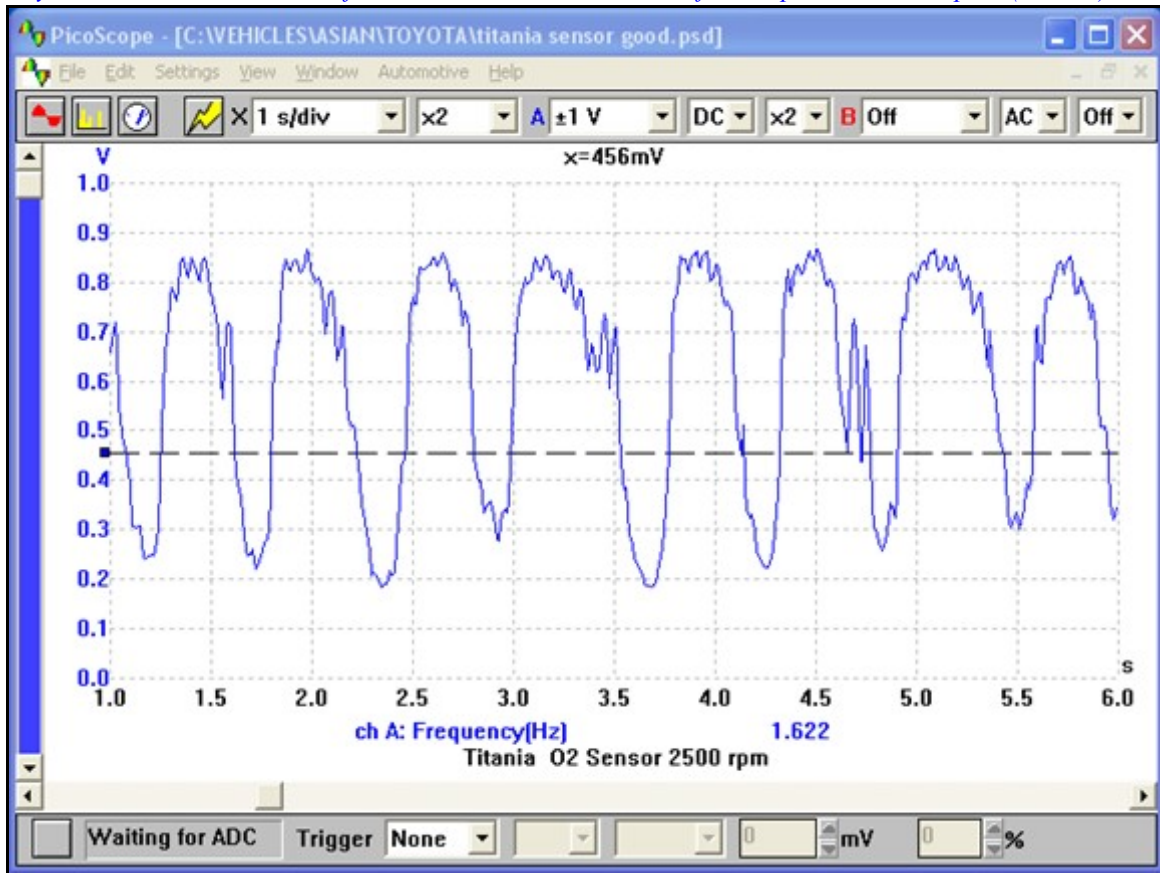
If the comparator circuit voltage is greater than 0.45 volt (sensor resistance is **LOW**) the ECU detects that the air fuel mixture is **RICH** i.e. less oxygen present in the exhaust gas stream.

If the comparator circuit voltage is less than 0.45 volt (sensor resistance is **HIGH**) the ECU detects that the air fuel mixture is **LEAN** i.e. greater amount of oxygen present in the exhaust gas stream.

The ECU will then make corrections to the base injector pulse width to maintain the correct air fuel ratio. The sensor output voltage can be viewed on your Hanatech scanner in the O² voltage data and monitored in graph mode. The voltage swings (high/low) can also be viewed as a waveform on an oscilloscope.

Toyota Titania Oxygen Sensor Waveform

Toyota Titania O₂ Sensor Waveform- Known Good Sensor Waveform captured at 2500 rpm - (no load)



Note:

The waveform horizontally centred dash line at 0.45 volt represents the stoichiometric point i.e. $\text{LAMBDA} = 1$ (excess air factor).

Stoichiometry = (14.7:1) or **LAMBDA = 1**. The symbol λ is also used to represent Lambda

Any deviation from Lambda =1 e.g. **Lambda = 0.90** indicates a 10% **RICHER** air fuel ratio and **Lambda = 1.20** indicates a 20% **LEANER** air fuel ratio than the ideal air fuel ratio of stoichiometry = 14.7:1

The Toyota Titania O₂ sensor waveform shown above was captured using a **PICO 212/50** PC based oscilloscope.

For information on pricing and availability of the **PICO** range of PC based oscilloscopes please contact **Mount AutoEquip**.