

Oxygen Sensor

SO-100 & 200 Series



Oxygen Sensor

This is a galvanic-cell type oxygen sensor that measures oxygen gas (O_2) in air. It has a lead anode, a gold cathode, an acid electrolyte, and a fluorine resin membrane. The current flow between the electrodes is proportional to the oxygen concentration being measured. An internal bridge resistor is used to provide an mV output linearly proportional to O_2 . Unlike polarographic oxygen sensors, galvanic do not require a power supply.

The mV output responds to the partial pressure of oxygen in air. The standard units for partial pressure are kPa. However, gas sensors that respond to partial pressure are typically calibrated to read out in mole fraction of the gas in air, or units of moles of oxygen per mole of air. These units can be directly converted to % O_2 in air, or ppm O_2 in air. The concentration of oxygen in our atmosphere is 20.95%. This precise percentage has not changed for decades. It is also constant across changing temperatures or pressures. This allows for precise calibration of the instrument.

Being a galvanic cell type sensor, a small amount of oxygen is consumed in the reaction in order to produce the current flow and subsequent mV output. The oxygen consumption was measured to be 2.2 $\mu\text{mol } O_2$ per day when the O_2 concentration was 20.95% at 23 C.



Using the Sensor

For the most stable reading, the sensor should be used with the sensor opening facing down. This facilitates the best contact of the electrolyte and the electronics.

1. Connect the O₂ lead wires to a volt meter or a datalogger.
2. To calibrate, measure the mV output of the sensor in a well-ventilated area. Do not breathe on the sensor as exhaled breath has a lower O₂ concentration compared to ambient air (20.95%). The output is approximately 50 mV for the soil sensor and 12 mV for the fast response sensor in ambient air. To derive the multiplier, divide 20.95 by the mV output minus the zero offset. The zero offset can be measured in pure N₂ gas or approximated as 2.5 mV for the soil sensor and 0.25 mV for the fast response sensor.

Example: $20.95\% / (50 - 2.5 \text{ mV}) = 0.441\% \text{ O}_2 \text{ per mV}$

To derive the intercept, multiply the measured voltage offset by the calibration factor.

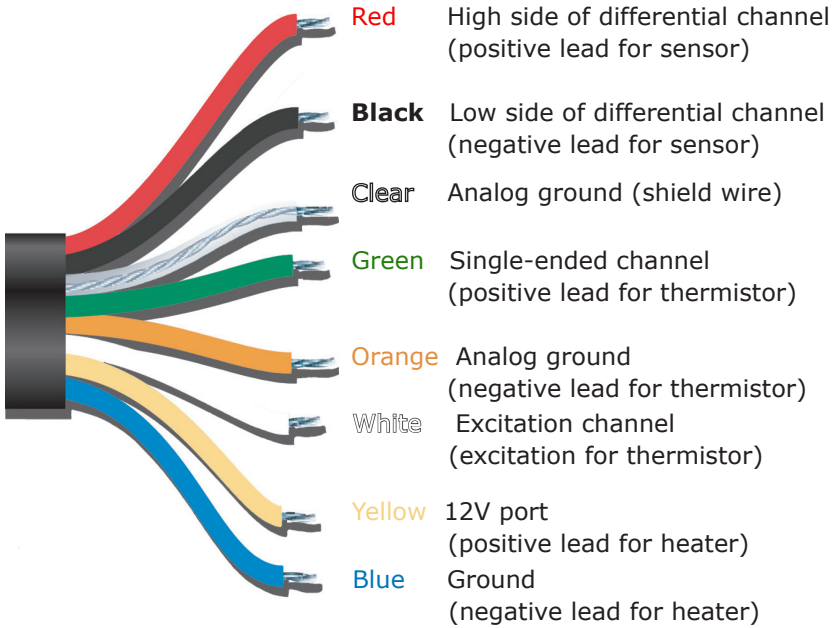
Example: $2.5 \text{ mV} * 0.441\% \text{ O}_2 \text{ per mV} = 1.103\% \text{ O}_2$

The calibration factor and intercept are correct for the current elevation, pressure, temperature, and humidity.

3. Calibration establishes the multiplier and offset necessary to convert the mV reading to % O₂. Install the multiplier and offset values in your datalogger program.

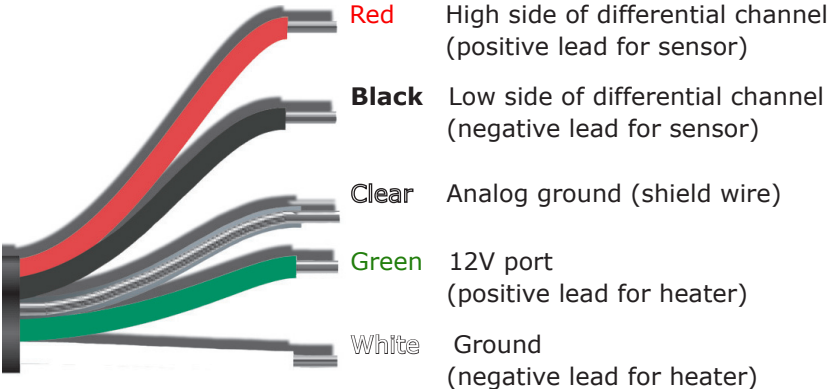
Connection Instructions

Sensor with Thermistor

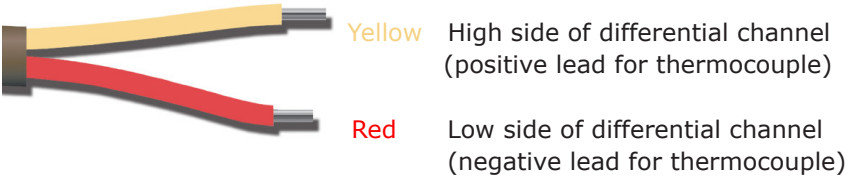


Connection Instructions (cont.)

Sensor with Thermocouple



Thermocouple



Characteristics

Zero Offset

The mV output in ultra-pure nitrogen gas (0.000% O₂) is typically 5% of the ambient (20.95%) output for the soil sensor and 2% of the ambient output for the fast response sensor. Precise measurements of hypoxic and anaerobic conditions can be made by making a periodic zero calibration of the sensor with ultra-pure nitrogen gas.

Life Expectancy

The life expectancy of the sensor is expressed in %-years as follows:

[Oxygen Concentration (%) * Exposure Time (years)]

The life of the sensor is 5 years of continuous use at 21% oxygen at 20 C.

Storage Temperature

The life of the sensor can be extended by storage at a lower temperature. For example, a sensor stored at 0 C will have a life expectancy approximately twice that of a sensor stored at 20 C. The minimum storage temperature is -20 C. Below -20 C, the electrolyte will freeze. This does not damage the sensor, but to resume measurement the electrolyte must be thawed. Maximum storage temperature is 60 C.

Shock and Vibration

The sensor is resistant to 2.7 g of shock. However, vibration may influence the sensitivity of the sensor and should be minimized.



Factors Affecting Output

Influence from Various Gases

The sensor is unaffected by CO, CO₂, NO, NO₂, H₂S, H₂, and CH₄. There is a small effect (approximately 1%) from NH₃, HCl, and C₆H₆ (benzene). The sensor is sensitive to SO₂ and can be damaged by O₃.

Temperature Sensitivity

A change in temperature changes the amount of O₂ available to the sensor and therefore changes the mV output that correlates to the atmospheric constant of 20.95%. Additionally, the sensor electronics have a small temperature dependence. To eliminate temperature effects, simply recalibrate or use the correction equations found on our website.

Pressure Sensitivity

A change in barometric pressure changes the amount of O₂ available to the sensor and therefore changes the mV output that correlates to the atmospheric constant of 20.95%. To eliminate pressure effects, simply recalibrate or use the correction equations found on our website. This requires a pressure measurement, which can be done with the Apogee barometric pressure sensor (model SB-100).

Model SB-100



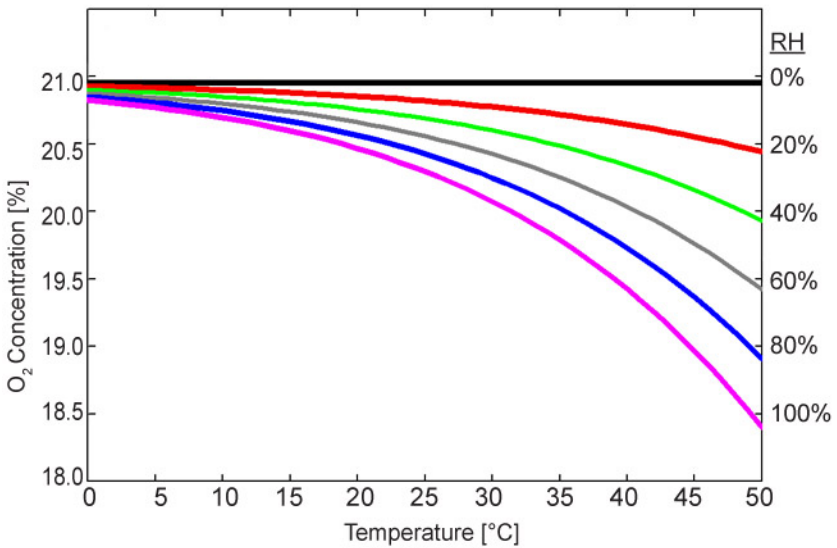
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Factors Affecting Output (cont.)

Humidity Changes

The graph below shows the effect humidity on output. The sensor chemistry is not influenced by humidity, but its output decreases because O_2 is displaced by water vapor molecules in the air. The effect of humidity is larger at warmer temperatures because there is more water vapor in the air.

Humidity Effects on Relative O_2 Concentration (at 101.324 kPa)



For use in high humidity, such as in soil, remove the head and take the calibration measurement over water in a sealed container as shown at right. To account for humidity effects, simply recalibrate or use the correction equations found on our website.



Specifications

Sensor Dimensions

- 3.15 diameter by 6.85 cm long
- ½" by 20 threaded end

Mass

- 175 g

Diffusion Head

- 3.5 cm long by 3.5 cm diameter
- 125 mesh screen

Flow-Through Head

- 3.2 cm long by 3.2 cm diameter
- ⅛" barbed adapters for hose connections

Range

- 0 to 100% O₂

Accuracy

- < 0.02% O₂ drift per day

Response Time

- SO-100 Series: 60 seconds
- SO-200 Series: 12 seconds

Repeatability

- ± 0.001% O₂ (10 ppm)

Output

- SO-100 Series: 50 mV
- SO-200 Series: 12 mV

Input Power

- 12 V power for heater
 - * Current drain: 74 mW typical at 12 VDC
- 2.5 V excitation for thermistor

Operating Environment

- -20 to 60 C
- 0 to 100% relative humidity
- 60 to 140 kPa

Cable

- 5 meters foil-shielded cable
- Santoprene jacket
- Ending in pigtail leads
- Additional cable is available in multiples of 5 meters

Warranty

- 1 year against defects in materials and workmanship



www.apogeeinstruments.com
techsupport@apogeeinstruments.com
435.792.4700
Fax: 435.787.8268