

Ultra-Low Power Analog Sensor Module for Nitrogen Dioxide

BENEFITS

- **NEW 110-507 NO₂ sensor with O₃ filter!**
- 0 to 3 V Analog Signal Output
- Low Power Consumption < 45 μW
- Fast Response
- On-board Temperature Sensor
- Easy Sensor Replacement
- Standard 8-pin connector

APPLICATIONS

- Fixed Industrial Safety Monitoring
- Portable Industrial Safety Monitoring
- Portable Personal Safety Monitor
- Indoor Air Quality Monitoring
- Outdoor Air Quality Monitoring
- Air Purification Control

DESCRIPTION

NOW with SPEC's new 110-507 NO₂ sensor with improved low ppb performance and a filter to remove Ozone

Quickly integrate Nitrogen Dioxide sensing into your system with very low power consumption and a simple analog sensor signal output. The ULPSM converts the Nitrogen Dioxide sensor's linear current signal output to a linear voltage signal, while maintaining the sensor at its ideal biased operation settings.

MEASUREMENT PERFORMANCE CHARACTERISTICS

| | |
|------------------------------------|------------------------|
| Measurement Range | 0 to 20 ppm |
| Lower Detection Limit | <0.1 ppm |
| Resolution | <0.1 ppm |
| Accuracy | < ± 2 % of reading |
| Response Time T90 | < 30 seconds |
| Power-On Stabilization Time | 60 minutes recommended |

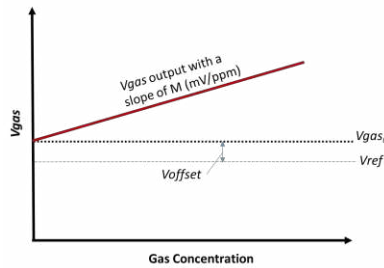
ABSOLUTE MAXIMUM RATINGS

| Parameter | Conditions | Min. | Rec. | Max. | Units |
|-----------------------|------------------------------|------|------|------|--------|
| Supply Voltage | | 2.7 | 3 | 3.3 | V |
| Storage Temperature | Vapor sealed @ 50% RH | 5 | 20 | 30 | °C |
| Storage Humidity | Non-condensing, Vapor sealed | 20 | 50 | 80 | % RH |
| Storage Pressure | Vapor sealed | 0.8 | 1 | 1.2 | atm. |
| Storage Time | Vapor sealed | - | 12 | - | Months |
| Operating Temperature | < 10 hours | -40 | - | 50 | °C |
| Operating Humidity | < 10 hours, Non-condensing | 0 | - | 100 | % RH |
| Operating Temperature | Continuous | -20 | 25 | 40 | °C |
| Operating Humidity | Continuous, Non-condensing | 15 | 50 | 95 | % RH |
| Operating Pressure | Continuous | 0.8 | 1 | 1.2 | Atm. |

ELECTRICAL CHARACTERISTICS

| Parameter | Conditions | Min. | Typ. | Max. | Units |
|-------------------|------------------|----------------------|--------------|----------------------|--------|
| Supply Current | V+ = 3.0 V | 5 | 10 | 15 | μA |
| Power Consumption | V+ = 3.0 V | 15 | 30 | 45 | μW |
| Vref | | | V+/2 – 0.1 | | V |
| Vgas Zero | | (V+/2 – 0.1) – 0.005 | (V+/2 – 0.1) | (V+/2 – 0.1) + 0.005 | V |
| Vgas Span (M) | Room temperature | -10 | -20 | -30 | mV/ppm |

CALCULATING GAS CONCENTRATION



The target gas concentration is calculated by the following method:

$$Cx = \frac{1}{M} \cdot (Vgas - Vgas_0),$$

where Cx is the gas concentration (ppm), $Vgas$ is the voltage output gas signal (V), $Vgas_0$ is the voltage output gas signal in a clean-air environment (free of analyte gas) and M is the sensor calibration factor (V/ppm). The value, M , is calculated by the following method:

$$M (V/ppm) = Sensitivity Code (nA/ppm) \times TIA Gain (kV/A) \times 10^{-9} (A/nA) \times 10^3 (V/kV),$$

where the *Sensitivity Code* is provided on the sensor label and the *TIA Gain* is the gain of the trans-impedance amplifier (TIA) stage of the ULPSM circuit. Standard gain configurations are listed in the table below.

The value $Vgas_0$ can also be represented by:

$$Vgas_0 = Vref + Voffset,$$

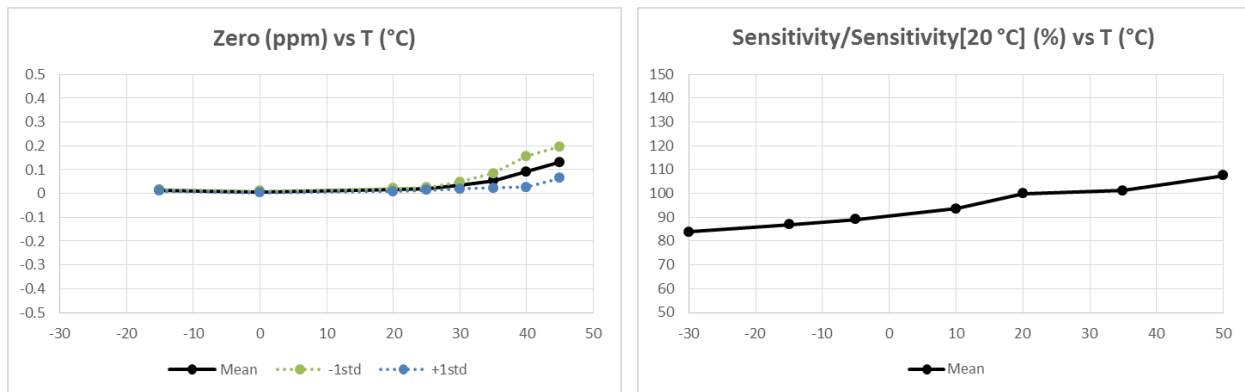
where, $Vref$ is the voltage output reference signal (V) and $Voffset$ is a voltage offset factor. The $Vref$ output acts as the reference voltage for zero concentration even as the battery voltage decreases. Measuring $Vref$ in-situ compensates for variations in battery or supply voltage, minimizing these effects on Cx . A difference amplifier or instrumentation amplifier can be used to subtract $Vref$ from $Vgas$. Alternatively, when measuring $Vref$ directly, always use a unity gain buffer.

$Voffset$, accounts for a small voltage offset that is caused by a normal sensor background current and circuit background voltage. To start, $Voffset = 0$ is an adequate approximation. To achieve higher-precision measurements, $Voffset$ must be quantified. Once the sensor has been powered-on and allowed to stabilize in a clean-air environment (free of the analyte gas) and is providing a stable output within your application's measurement goals, the value of $Vgas$ may be stored as $Vgas_0$ and used in subsequent calculations of gas concentration, Cx .

| Target Gas | TIA Gain (kV/A) |
|-----------------------|-----------------|
| Carbon Monoxide | 100 |
| Hydrogen Sulfide | 49.9 |
| Nitrogen Dioxide | 499 |
| Sulfur Dioxide | 100 |
| Ozone | 499 |
| Ethanol | 249 |
| Indoor Air Quality | 100 |
| Respiratory Irritants | 499 |

TEMPERATURE COMPENSATION

Temperature fluctuations have a predictable, easily compensated effect on the sensor signal. The figures below show the typical Temperature dependency of the output and baseline of Nitrogen Dioxide sensors under constant humidity of 40-50% RH. This is a very uniform and repeatable effect, easily compensated for in hardware or software.



From the graphs above:

- The temperature effect of zero shift is expressed as ppm change.
- The temperature effect of span (sensitivity) is expressed with respect to sensitivity at the calibration temperature of 20 °C.

When implementing temperature compensation, first correct the temperature effect on the zero (offset) and then correct the temperature effect on the span (sensitivity) of the sensor.

These corrections can be done in software by implementing one of the following:

- Curve fit
- Look up table
- A set of linear approximations, as outlined in the following table.

| | | |
|---|-----------------|---------------|
| Temperature Coefficient of Zero Shift (ppm/°C) (<i>Typical</i>) | -20 °C to 30 °C | 0 ppm/°C |
| | 30 °C to 50 °C | 0.0066 ppm/°C |
| Temperature Coefficient of Span (%/°C) (<i>Typical</i>) | -20 °C to 50 °C | 0.3%/°C |


CROSS SENSITIVITY

Most chemical sensors exhibit some cross-sensitivity to other gases. The following table lists the relative response of common potential interfering gases, and the concentration at which the data was gathered.

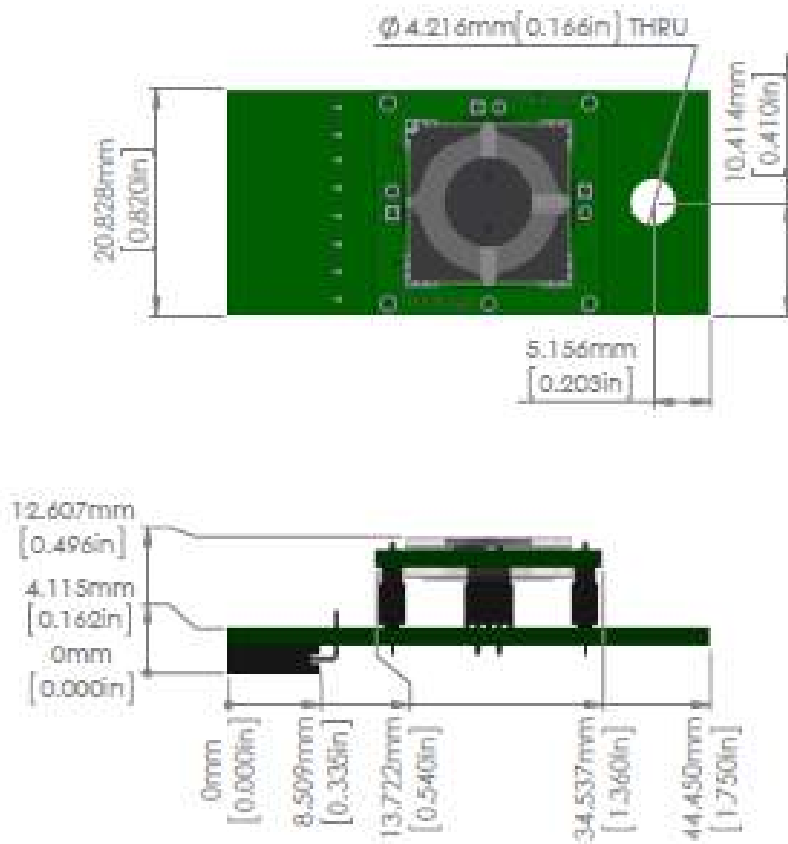
| Gas/Vapor | Applied Concentration (PPM) | Typical Response (PPM NO2) |
|------------------|-----------------------------|----------------------------|
| Nitrogen Dioxide | 5 | 5 |
| Hydrogen Sulfide | 5 | < 0.02 |
| Ozone | 1 | <0.1 |
| Nitric Oxide | 5 | < 0.1 |
| Sulfur Dioxide | 5 | < 0.02 |
| Carbon Monoxide | 100 | < 0.2 |
| Chlorine | 10 | < 0.5 |

MARKING INFORMATION

All gas sensors are tested and marked at the SPEC Sensors factory. Sensors include a label with an alpha-numeric code and a two-dimensional bar code. The codes include the information indicated in the table below. (CO used for example)

| | Unique Serial Number | Sensor Part Number | Target Gas | Date Code (YYMM) | Sensitivity Code (nA/ppm) |
|--|----------------------|--------------------|------------|---------------------|------------------------------|
|  | | | | | |
| Alph-Numerica Code: | | 100102 | CO | 1510 | 4.94 |
| 2D Code: | 101915010906 | 100102 | CO | 1510 | 4.94 |

PACKAGE OUTLINE DRAWING & DIMENSIONS



PINOUT

Electrical connections to the ULPSM are made via a rectangular female socket connector (Sullins Connector Solutions P/N: PPPC041LGBN-RC; recommended mate for host board: P/N: PBC08SBAN). This connector also provides mechanical rigidity on one end of the board. A through-hole is located on the opposite end of the board to provide additional mechanical connection.



| Pin # | ULPSM Function | Notes |
|-------|----------------|---|
| 1 | Vgas | Voltage Output. Vgas is proportional to the target gas concentration. |
| 2 | Vref | Voltage Output. Vref is approximately half the supply voltage. Useful as a fixed reference; equivalent to zero for Vgas. NOTE: High impedance output requires a buffer to connect to any measurement device. |
| 3 | Vtemp | Voltage Output. Vtemp is proportional to temperature. NOTE: High impedance output requires a buffer to connect to any measurement device. |
| 4 | N/C | |
| 5 | N/C | |
| 6 | GND | Universal ground for power and signal |
| 7 | V+ | Voltage Supply Input: 2.7 to 3.3 V |
| 8 | V+ | Voltage Supply Input: 2.7 to 3.3 V |