November 2016

Analog Sensor Developer Kit – User Manual

The Analog Sensor Developer Kit is configured at the time of shipment for ONE target gas. The picture below shows the SDK-CO version.

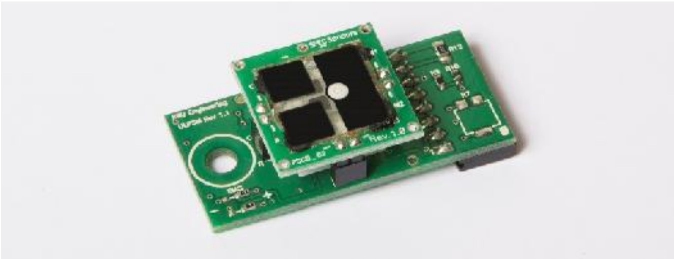
Please review contents of package to confirm that you have received everything.

- A small form-factor, ultra-low power sensor module (ULPSM) configured to work with ONE particular gas sensor in a pinned PCB package already mounted.
- An Evaluation Board that the ULPSM can plug into to allow quick evaluation of the ULPSM and Sensor combination with coin cell power supplying power during storage and shipment.
- 2 sensors in a pinned PCB package for use with the ULSPM directly
- 2 sensors in a castellation PCB package for use your PCB design when completed.
- USB drive containing: ULPSM datasheets, ULPSM schematic, parts list, and PCB gerber/design files.

ULPSM

The ULPSM converts the sensor's linear current signal output to a linear voltage signal, while maintaining the sensor at its ideal biased operation settings. ULPSM shown with sensor mounted.

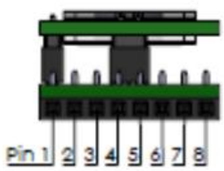
- 0 to 3 V Analog Signal Output
- Low Power Consumption < 45 µW
- Fast Response
- On-board Temperature Sensor
- Easy Sensor Replacement
- Standard 8-pin connector



EVALUATION BOARD

- Plug header that replicates the suggested layout for user-implemented solutions.
- Screw terminals for easy connection to external circuits and measurement equipment.
- Jumper-selectable power supply options
    - Position 1: BATTERY (default): CR2032 coin battery powered (included).
    - Position 2: 3V REG V+: External supply (V+) goes to 3.0V regulator in our circuit. ***V+ is un-fused – do not exceed 18 V input!***
    - Position 3: V+: For connecting a 3V External Supply. This is unregulated and un-fused – ***Do not exceed 3.3 V input!***
- Unity gain buffers for *Vref* and *Vtemp* to allow connection to instrumentation
- Insulating rubber feet.

ULPSM 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.

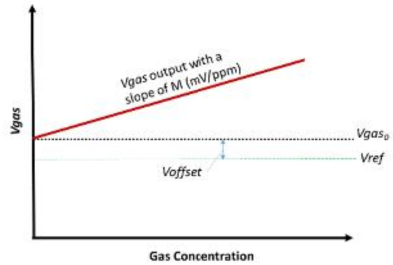
The Evaluation board screw terminals have the same pinout

Pin #	ULPSM Function	Notes
1	Vgas[1]	Voltage Output. Vgas is proportional to the target gas concentration.
2	Vref[1,2]	Voltage Output. Vref is approximately half the supply voltage. Useful as a fixed reference; equivalent to zero for Vgas.
3	Vtemp[1,2]	Voltage Output. Vtemp is proportional to temperature.
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

[1]Connecting to measurement equipment can inject AC noise onto these DC signals. Be cautious to provide robust connections that are as short as possible.

[2] This output is a low impedance output and requires a buffer to connect to any measurement device (as provided on the evaluation board).

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:

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

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. This is a very uniform and repeatable effect, easily compensated for in hardware or software.

Please refer to the datasheet for the sensor of concern to determine the characteristics of the temperature effect on zero/baseline current and sensor sensitivity.

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 with:

- Curve fit
- Look up table
- A set of linear approximations

CALCULATING TEMPERATURE

Temperature (°C) may be calculated to ±3 °C, within the range -10 °C to 50 °C, by using the theoretical relationship:

$$T = \frac{87.0}{V+} \cdot Vtemp - 18.0.$$

SENSOR ZERO/BASELINE STABILZATION AFTER BIAS

The electrochemical sensor can be thought of as a capacitor. The bias placed across the working and reference electrodes is similar to voltage across the plates of a capacitor. In the case of the electrochemical sensor, the effective surface area of the "plates" is extremely high. Thus, when the sensor is initially placed on bias, a "charging current" is observed (see **Figure 1**). This current may be as high as several hundred µA initially, but will quickly drop to the low microampere range. Ideally, this baseline current should be in the sub-microamp range. As the sensor continues to be powered on, the baseline/zero current asymptotically becomes lower and more stable, i.e. it improves in performance.

We recommend after installing an unbiased sensor, replacing a dead battery, or applying bias after it has been removed, that you wait for at least 60 minutes before taking a measurement.