

# Sensor Development Kit

## Ultra-Low Power Sensor Module with Printed Sensor

The small form-factor, ultra-low power sensor module (ULPSM) produces a linear voltage output proportional to gas concentration. This module combines the novel sub-millimeter thin electrochemical sensor technology from SPEC Sensors, Inc. with an ultra-low power analog potentiostat circuit.

### Printed Sensor Features:

- Sub-millimeter thin electrochemical sensor technology
- Low-cost and high-performance
- Available for a variety of target gases.
- Additional sensors and configurations may be available, please contact us to discuss your application.

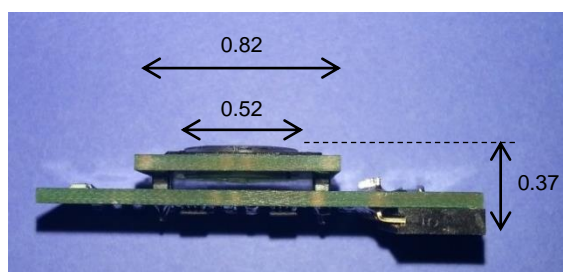
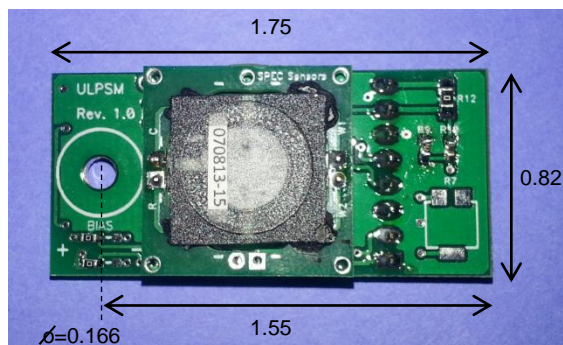
Target Gas	Max Range
Carbon Monoxide – CO	1000 ppm
Hydrogen Sulfide – H <sub>2</sub> S	50 ppm
Nitrogen Dioxide – NO <sub>2</sub>	20 ppm
Ozone – O <sub>3</sub>	20 ppm
Sulfur Dioxide – SO <sub>2</sub>	20 ppm
Ethanol – CH <sub>3</sub> OH	1000 ppm

### ULPSM Features:

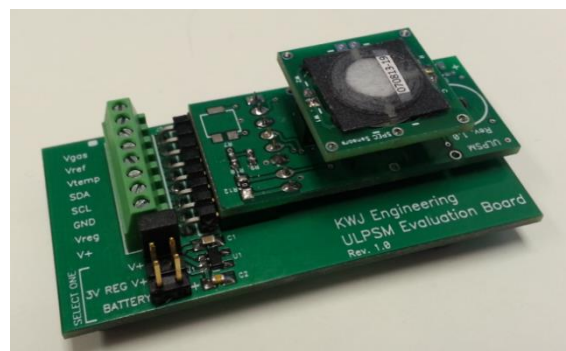
- Ultra-low power consumption
- Small form-factor gas sensor and analog front end
- Low-cost and easily replaceable
- Standard 8-pin connector for easy integration
- On-board temperature sensor
- Sensor headers allow replacement of the sensor

### Evaluation Board Features:

- 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:
  - CR2032 coin battery (included).
  - External Supply: unregulated and unfused – do not exceed 3.3 V input.
  - External Supply: 3.0 V regulated – do not exceed 18 V input.
- Unity gain buffers for  $V_{ref}$  and  $V_{temp}$ .
- Insulating rubber feet.



\*All dimensions in inches

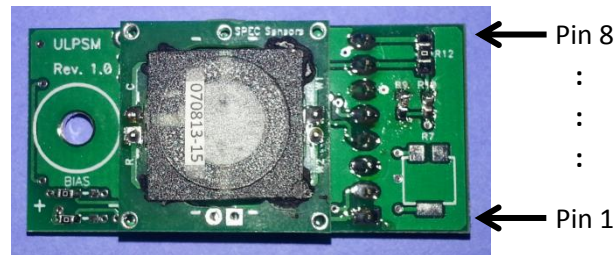


### ULPSM Device Connection:

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 or threaded standoff (Option -C) is located on the opposite end of the board to provide additional mechanical connection.

Pin #	ULPSM Function
1	$V_{gas}$
2	$V_{ref}^*$
3	$V_{temp}$
4	( $SDA$ ) <sup>*</sup>
5	( $SCL$ ) <sup>*</sup>
6	$GND$
7	( $V_{reg}$ ) <sup>*</sup>
8	$V_+$

\*Optional



**$V_{gas}$ :** The voltage signal output that is proportional to the target gas concentration throughout the specified range. See **Calculating Gas Concentration** for more details.

**$V_{ref}$ :** The voltage signal output that may be used as a measurement reference for  $V_{gas}$ . The difference,  $V_{gas} - V_{ref}$ , is independent of the input voltage,  $V_+$ . See **Calculating Gas Concentration** for more details.

**$V_{temp}$ :** Voltage signal output that is proportional to temperature. See **Calculating Temperature** for more details.

**$SDA$ :** Optional EEPROM I2C data line.

**$SCL$ :** Optional EEPROM I2C clock line.

**$GND$ :** Universal ground for power and signal.

**$V_{reg}$ :** Optional voltage regulator output voltage. When the option is not included,  $V_{reg} = V_+$ .

**$V_+$ :** Input voltage.

**NOTE:**  $V_{ref}$  and  $V_{temp}$  are high-impedance outputs. A unity gain buffer should be implemented between these pins and any measurement device, including voltmeters and analog-to-digital converters. The Evaluation Board includes unity gain buffers for these outputs.

### Calibrated Gas Sensors:

All gas sensors are tested and calibrated 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.

	Unique Serial Number	Sensor Part Number	Target Gas	Date Code (YYMM)	Sensitivity Code (nA/ppm)
Alpha-Numeric Code:	110201 CO 1501 5.57				
2D Code:	010715010101 110201 CO 1501 5.57				

### Calculating Gas Concentration:

Sensors that pair with the ULPSM are calibrated at SPEC Sensors. The target gas concentration is calculated by the following method:

$$Cx = \frac{1}{M} \cdot (V_{gas} - V_{ref} - V_{offset}),$$

where  $Cx$  is the gas concentration (ppm),  $V_{gas}$  is the voltage output gas signal (V),  $V_{ref}$  is the voltage output reference signal (V),  $V_{offset}$  is a voltage offset factor, and  $M$  is the sensor calibration factor (V/ppm). The value,  $M$ , is calculated by the following method:

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

Where the *Sensitivity Code* is provided on the sensor label and the *TIA Gain* is the gain of the transimpedance amplifier (TIA) stage of the ULPSM circuit. Standard gain configurations are listed in the table to the right.

Measuring  $V_{ref}$  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  $V_{ref}$  from  $V_{gas}$ . Alternatively, when measuring  $V_{ref}$  directly, always use a unity gain buffer. In lieu of measuring  $V_{ref}$ , the nominal value may be utilized.

Target Gas	TIA Gain (kV/A)
CO	100
H2S	49.9
NO2	499
SO2	100
O3	499
CH6O	249

Once the sensor has been powered-on and allowed to stabilize in a clean-air environment (free of the analyte gas), the value of  $V_{gas}$  is nominally equal to  $V_{ref}$ . The factor,  $V_{offset}$ , accounts for a small voltage offset that is caused by a normal sensor background current and circuit background voltage. For most applications,  $V_{offset} = 0$  is an adequate approximation. To achieve higher-precision measurements,  $V_{offset}$  must be quantified in a clean-air environment with the circuit in its final configuration.

**Calculating Temperature Compensated Gas Concentration:**

A first-order temperature compensation may be implemented using the following method:

$$C_{xc} = \frac{1}{M_c} \cdot (V_{gas} - V_{ref} - V_{offset}),$$

$$M_c = M \cdot (1 + T_c \cdot (T - 20)),$$

where  $C_{xc}$  is the temperature compensated gas concentration (ppm),  $M_c$  is the temperature compensated sensor calibration factor,  $M$  is the sensor calibration factor,  $T_c$  is the temperature coefficient of span, and  $T$  is the measured temperature (°C).  $T_c$  correction factors are supplied with the SDK System Datasheet in the USB drive or can be calculated from curves provided on the particular sensor datasheet.

**Calculating Temperature:**

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

$$T = \left( 87.0 / V_{+} \right) \cdot V_{temp} - 18.0.$$