Apollo

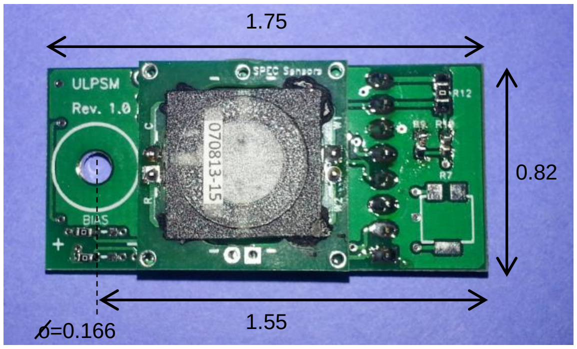
Ultra-Low Power Sensor Module with Printed Sensor

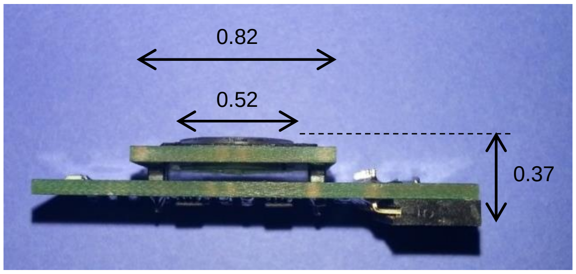
The small form-factor, ultra-low power sensor module (ULPSM) produces a linear voltage output proportional to gas concentration. This module combines the novel sub-millimeter thin electrochemical sensor technology from SPEC Sensors, Inc. with an ultra-low power analog potentiostat circuit.

Printed Sensor Features:

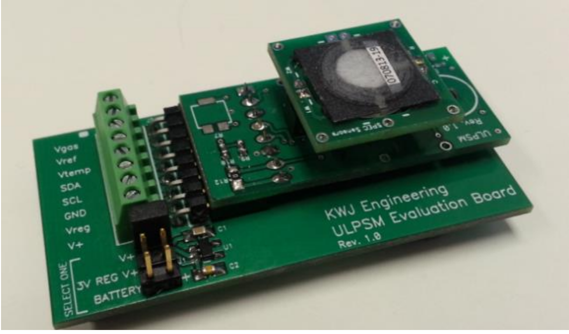
- Sub-millimeter thin electrochemical sensor technology
- Low-cost and high-performance
- Available for a variety of target gases.
- Additional sensors and configurations may be available, please contact us to discuss your application.

Target Gas	Max Range
Carbon Monoxide – CO	1000 ppm
Hydrogen Sulfide – H2S	50 ppm
Nitrogen Dioxide – NO2	20 ppm
Ozone – O3	20 ppm
Sulfur Dioxide – SO2	20 ppm
Ethanol – CH6O	1000 ppm





*All dimensions in inches



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 un-fused – do not exceed 3.3 V input.
    - External Supply: 3.0 V regulated – do not exceed 18 V input.
- Unity gain buffers for *Vref* and *Vtemp*.
- Insulating rubber feet.

Apollosense Ltd

Shenzhen:
Adress：Room 712, Huaneng Building, Shennan Zhong Road, Shenzhen 518031, China
Tel：（86-755）83680810 83680820 83680830 83680860
Fax：（86-755）83680866

Hong Kong:
Adress： Unit 1502, Hollywood Plaza, 610 Nathan Road, Mong Kok, Kln., H.K.
Tel：(852) 2737 0903
Fax：(852) 2737 0938
Email：sales@apollounion.com

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	*Vgas*
2	*Vref**
3	*Vtemp*
4	(*SDA*)*
5	(*SCL*)*
6	*GND*
7	(*Vreg*)*
8	*V+*

*Optional

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

Vref: The voltage signal output that may be used as a measurement reference for *Vgas*. The difference, *Vgas* - *Vref*, is independent of the input voltage, *V+*. See **Calculating Gas Concentration** for more details.

Vtemp: 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.

Vreg: Optional voltage regulator output voltage. When the option is not included, *Vreg* = *V+*.

V+: Input voltage.

NOTE: *Vref* and *Vtemp* 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.

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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:

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

where *Cx* is the gas concentration (ppm), *Vgas* is the voltage output gas signal (V), *Vref* is the voltage output reference signal (V), *Voffset* is a voltage offset factor, and *M* is the sensor calibration factor (V/ppm). The value, *M*, is calculated by the following method:

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

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

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

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. In lieu of measuring *Vref*, the nominal value may be utilized.

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

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Calculating Temperature Compensated Gas Concentration:

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

$$Cxc = \frac{1}{Mc} \cdot (Vgas - Vref - Voffset),$$

$$Mc = M \cdot (1 + Tc \cdot (T - 20)),$$

where *Cxc* is the temperature compensated gas concentration (ppm), *Mc* is the temperature compensated sensor calibration factor, *M* is the sensor calibration factor, *Tc* is the temperature coefficient of span, and *T* is the measured temperature (°C). *Tc* 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 ±3 °C, within the range -10 °C to 50 °C, by using the theoretical relationship:

$$T = \left({}^{87.0}/_{V+}\right) \cdot Vtemp - 18.0.$$

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