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.

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 Vref and Vtemp.
- Insulating rubber feet.

<table>
<thead>
<tr>
<th>Target Gas</th>
<th>Max Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Monoxide – CO</td>
<td>1000 ppm</td>
</tr>
<tr>
<td>Hydrogen Sulfide – H2S</td>
<td>50 ppm</td>
</tr>
<tr>
<td>Nitrogen Dioxide – NO2</td>
<td>20 ppm</td>
</tr>
<tr>
<td>Ozone – O3</td>
<td>20 ppm</td>
</tr>
<tr>
<td>Sulfur Dioxide – SO2</td>
<td>20 ppm</td>
</tr>
<tr>
<td>Ethanol – CH6O</td>
<td>1000 ppm</td>
</tr>
</tbody>
</table>

*All dimensions in inches
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.

<table>
<thead>
<tr>
<th>Pin #</th>
<th>ULPSM Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vgas</td>
</tr>
<tr>
<td>2</td>
<td>Vref*</td>
</tr>
<tr>
<td>3</td>
<td>Vtemp</td>
</tr>
<tr>
<td>4</td>
<td>(SDA)*</td>
</tr>
<tr>
<td>5</td>
<td>(SCL)*</td>
</tr>
<tr>
<td>6</td>
<td>GND</td>
</tr>
<tr>
<td>7</td>
<td>(Vreg)*</td>
</tr>
<tr>
<td>8</td>
<td>V+</td>
</tr>
</tbody>
</table>

*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.
Calculating Gas Concentration:

Sensors that pair with the ULPSM are calibrated at KWJ Engineering, Inc. 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). \( M \) is provided on the calibration certificate that is shipped with the module.

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.

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:

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

\[ M_c = M \cdot (1 + T_c \cdot (20 - T)) \]

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). \( M \) and \( T_c \) are provided on the sensor specification sheet.

Calculating Temperature:

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

\[ T = \left(\frac{87.0}{V_{+}}\right) \cdot V_{temp} - 18.0. \]