Microfire LLC Mod-ORP Datasheet

Release Information

Release History

Release	Date	Description
2.0.0	1/22/2023	Updates for version 2 of hardware.
1.1.0	8/13/2021	Added additional reflow procedures.
1.0.0	4/23/1021	Initial

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About the Mod-ORP Module

A module for interfacing with ORP probes. It has been designed to be flexible and simple to incorporate into new or existing electrical designs.

- ORP range of -2.2 to 2.2 volts
    - Accuracy ±0.1 mV
    - Resolution 0.1 mV
- I²C with software definable address
    - Default address 0x0E
    - 10kHz, 100 kHz, 400 kHz compatible
- 25 mm wide x 15 mm high x 0.8mm thick
    - Material type: FR-4 TG155
    - DIP and castellated edges
- Calibration options include:
    - Single point

Mechanical Specification

The Mod-ORP module is a single-sided 25x15 mm 0.8 mm thick PCB with dual castellated/through-hole pins around the east and west edges. It is designed to be usable as a surface mount module as well as in Dual Inline Package (DIP) type format, with the 12 pins on a 2.54mm pitch grid with 0.9mm holes.

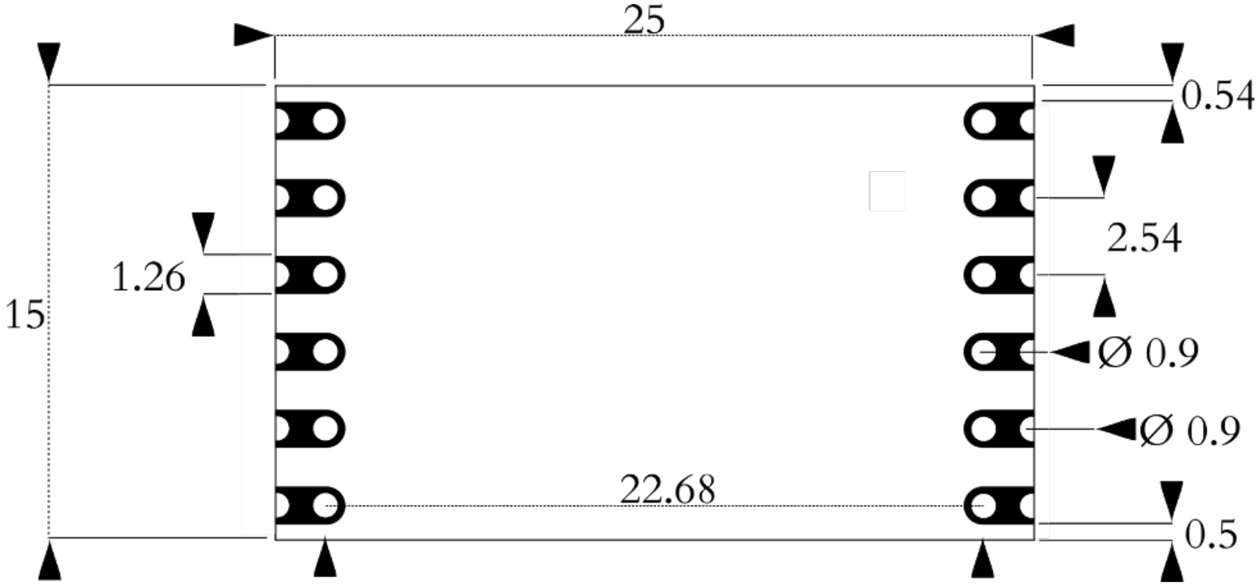


Figure 1. Physical dimensions of the module.

Pinout

The pinout of the module has been designed to provide as many interface options as possible.

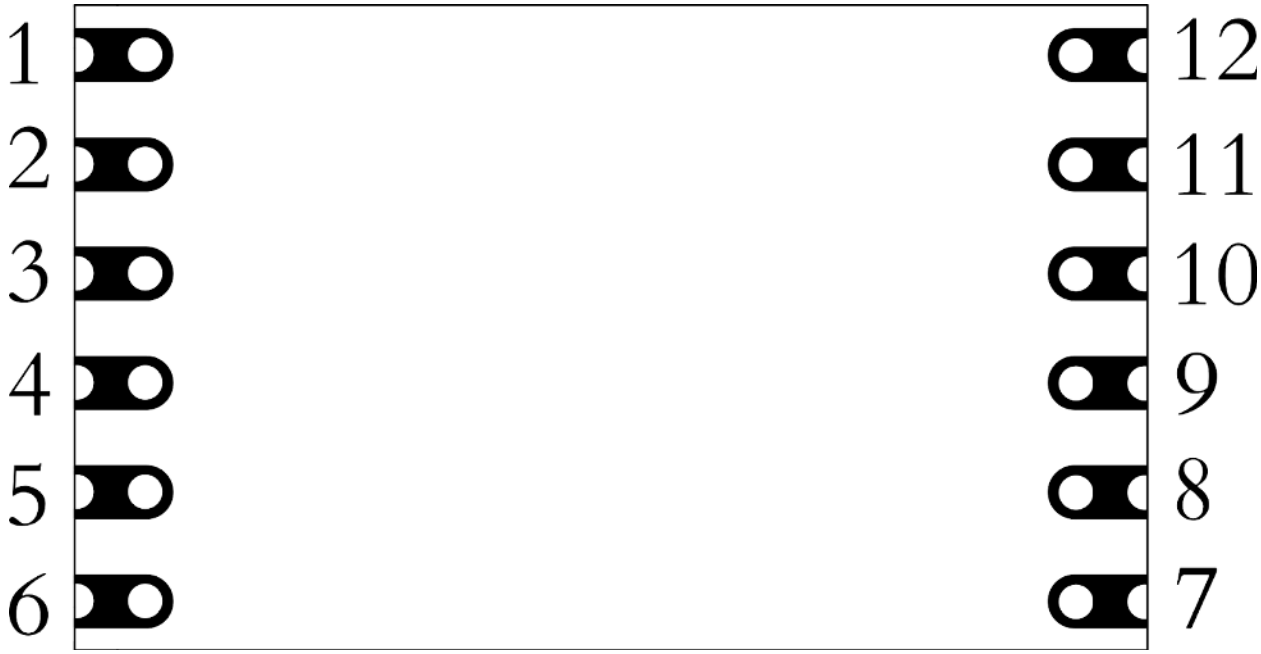
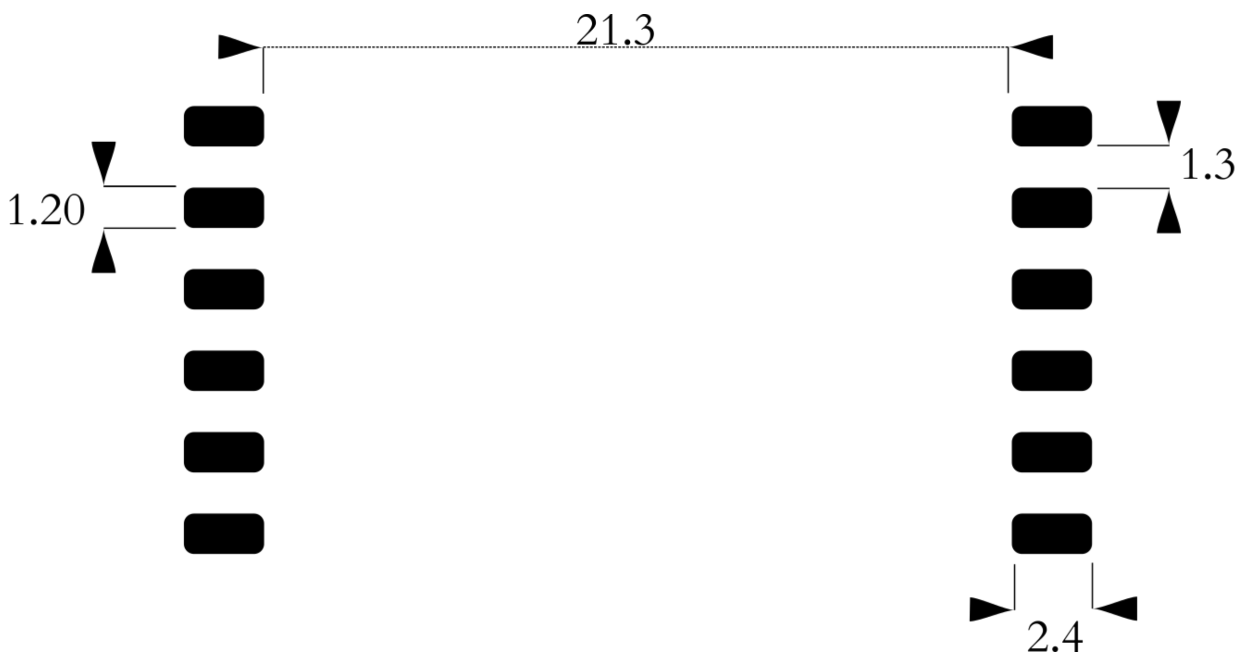


Figure 2. Pinout of the module.

Pin 1: Probe 1 input. Provides a connection to the sensing electrode of an ORP probe.
Pin 2: Probe 2 input. Provides a connection to the reference electrode of an ORP probe.
Pin 3: Not used in this module.
Pin 4: Not used in this module.
Pin 5: Not used in this module.
Pin 6: Not used in this module.
Pin 7: Not used in this module.
Pin 8: Not used in this module.
Pin 9: I²C SCL. Clock line for I2C interface.
Pin 10: I²C SDA. Data line for I2C interface.
Pin 11: VIN. 3.3-volt power supply.
Pin 12: Ground. Ground for the module.

Surface Mounting

The following figure shows the recommended footprint for mounting the module through reflow processes. It provides for a Class 1 connection (*IPC-A-610G § 8.3.4 Castellated Terminations*).



It is recommended that the stencil be 8 mils in thickness to ensure enough solder paste can flow into the castellations.

The module is assembled with [Chip Quik SMD291SNL50T3] (Sn96.5/Ag3.0/Cu0.5) solder paste, a lead-free paste with a 249-degree Celsius peak reflow temperature. Reflowing the module multiple times can cause malfunction. To avoid the issue, if it is possible, use a lower melting-point temperature solder paste.

Operating Conditions

Temperature:

- **Absolute:**
  - **Maximum:** 85 C
  - **Minimum:** -40 C
- **Recommended:**
  - **Maximum:** 50 C
  - **Minimum:** 10 C

When approaching the absolute temperature ratings, it should be noted that the module's temperature will begin to affect measurements, the extent of which will need to be characterized to the specific environment the module will be deployed in.

Voltage:

- **Absolute Maximum:** 5.5 volts
- **Absolute Minimum:** 1.8 volts (3.3 volts is required for proper operation)

Electrical Specification

Power Supply

The module requires 3.3 volts for proper operation. It can be supplied with less and still communicate through the various peripheral interfaces, but this will not allow the analog circuitry to operate correctly. Voltage should not exceed 5.5 volts.

There is no reverse polarity protection on the module.

Power Isolation

Due to the nature of electrochemical sensors, galvanic isolation between the probe from other parts of the circuit is needed to eliminate or reduce interference from external sources. The simplest way to achieve this is to use an isolated power supply and isolated peripheral coupler device. For example, if using I^2C, a device to supply isolated power, ground, SDA, and SCL lines will provide sufficient isolation.

Power Consumption

All modules are designed to be low-power. Power usage has been characterized at two points, idle and active sensor measurement.

- Current use is typically 0.15 mA

I²C

The module supports speeds of 10kHz, 100 kHz, and 400 kHz at 3.3 volts.

The I²C interface uses the following pins:

- **Pin 9 SCL**: serial clock
- **Pin 10 SDA**: data

Additional Circuitry

The module has no pullup resistors on the I²C bus. For reliable communication, appropriate resistors must be chosen for the SDA and SCL lines.

I²C Address

The default address is 0x0E. It can be changed through firmware.

I²C Write

Writing is done by sending a start condition followed by the module's address with the write bit set. The master device then sends data 8 bytes at a time. The first byte received is considered to be the register address. Successive writes will automatically increment the registered address by one byte. Transmission is finished with a stop condition.

I²C Read

Reading is done by sending a start condition followed by the module's address with the read bit set. The master sets the register to read from, then requests data. The device then sends the appropriate number of bytes as determined by the register being read.

Design Incorporation

Adding the module is a straightforward process.

Power

A suitable power supply must be supplied. Ideal solutions will provide an isolated, low-ripple, low-EMI, 3.3-volt supply.

Ground

The module operates at the same ground potential as what **Pin 11**: Ground is connected to, so a low-impedance connection is needed.

Probe Connection

An ORP probe that is compatible with the module consists of two wires. This is most commonly provided with a BNC, SMA, or U.FL connector.

Considerations

- **Pin 1**: Probe 1 input and **Pin 2**: Probe 2 input pins should be on their own island plane pour or otherwise isolated by no pour surrounding them.
- **Pin 1**: Probe 1 input and **Pin 2**: Probe 2 input pins should be as short as possible.
- If the PCB is 4 or more layers, consider routing **Pin 1 and Pin 2** traces on internal layers to protect the probe input signal from interference.
- Avoid routing other traces near **Pin 1** and **Pin 2**.
- Flux residue on **Pin 1, Pin 2,** and at the probe connection must be removed.

Unused Pins

Any unused pins should be left unconnected to any other trace or net.

ORP Measurements

ORP Theory

Oxidation-Reduction Potential of a solution's electron transfer capability. A solution that is strongly reductive is weakly oxidative, and vice versa. The exact process varies by the specific chemical reaction that takes place. One species will undergo oxidation, losing electrons, while another species accepts those electrons and is reduced.

ORP doesn't measure a specific substance, rather it is a measure of activity. The unit of measure is simply the millivolt, which is the output of the ORP probe. The probe consists of an electrode made of platinum and a reference electrode. An electrical potential develops between the two electrodes in response to the solution it is immersed in.

The platinum will either donate or accept electrons, which will be indicated by the millivolt response. Tap water is typically around 300 mV, and green tea, an antioxidant, is around -100 mV. A swimming pool may be around 600 mV.

It should be noted that pH and ORP are different measurements. However, in many reactions, a low or high pH may create conditions that change the ORP.

Considerations

Measuring ORP can be complicated due to potentially complex chemical reactions, so it is important to keep some things in mind.

Response Time

ORP probes are electrochemical devices. They don't react instantly as a purely electrical device would. The probes need some time to stabilize. Depending on the reaction taking place, this may be quick, on the order of seconds, or slow, on the order of hours. Long stabilization is particularly present when the probe is measuring in the negative.

Interference

An ORP probe outputs a weak signal in the millivolt range. This signal is then carried through the wire of the probe, where it is measured. This leaves a lot of opportunities for the signal to experience interference. Other probes, faulty electrical equipment, poor grounding, strong sources of EMI, and any number of other sources may contribute to a faulty reading. Isolation can help with some sources, but not all of them.

Temperature

The temperature of a solution affects the ORP reading. Due to ORP not being a measure of a specific substance, there is no temperature compensation.

Calibration

Calibration is needed to obtain accurate measurements. Each module is very slightly different from the next, and each probe will have a slightly different response from another. For these reasons, neither modules nor probes are interchangeable without both being calibrated together. Also, ORP probes gradually degrade, requiring recalibration to maintain accuracy.

Procedure

Following good lab procedures is important to obtain the best results while also staying safe. ORP measurements typically involve calibration solutions which are generally all toxic or hazardous to some extent. Aside from safety considerations, the following is a step-by-step process calibration:

1. Collect all the materials needed: calibration solutions, clean water, towels, equipment, etc.
2. Rinse the probe in clean water. RO/DI, deionized, or distilled water is best. Tap off excess water drops trapped in the probe tip and blot dry.
3. Pour some calibration solution into a separate container. It should be enough to fully submerge the tip of the probe, then submerge the probe.
4. Continually take measurements, watching for the measurement to stabilize. When the reading stabilizes, have the module calibrate itself for the solution.
5. Safely dispose of the calibration solution and clean or dispose of the container.

It is important to note that ORP solutions change slightly with temperature. The solution may provide temperature-compensated values. In this case, the solution should be brought to one of those temperatures and that value used.

Calibration

Single Point

ORP is calibrated using a single point.

I²C Interface

The module's I²C interface operates similarly to many common I²C sensors. There are several registers that hold values such as calibration, ORP, or version information. The registers are used to pass information both to the module and the controlling device. Tasks are performed by writing a specified value to a certain register.

Registers

All registers are either 1 byte or a float which is 4 bytes formatted as an IEEE 754 32-bit floating point, little-endian. The firmware will allow the registers to be read and written.

Register Listing

Register Name	Value	Type	Description
HW_VERSION_REGISTER	0	byte	To initiate tasks
FW_VERSION_REGISTER	1	byte	Hardware version
TASK_REGISTER	2	byte	Firmware version
STATUS_REGISTER	3	byte	Status of measurement
MV_REGISTER	4	float	Measured mV
TEMP_C_REGISTER	8	float	Measured temperature in Celsius
CALIBRATE_SINGLE_OFFSET_REGISTER	12	float	Single-offset calibration data

All the CALIBRATE_* registers are automatically saved when written.

Tasks

When a particular value is written to TASK_REGISTER, it starts an operation within the module.

For example, when MEASURE_ORP_TASK is written to the TASK_REGISTER register, an ORP measurement is performed. To read the resulting measurement, you would read the MV_REGISTER register.

Task Listing

Task Name	Duration	Value	Description
MEASURE_ORP_TASK	750 ms	80	ORP measurement
CALIBRATE_SINGLE_TASK	750 ms	4	Single-point calibration
I2C_TASK	1 ms	2	I²C address change

MEASURE_ORP_TASK – ORP Measurement

Starts an ORP measurement.

Request Registers

Register	Description
None	

Response Registers

Register	Description
MV_REGISTER	Value of ORP measurement
STATUS_REGISTER	An error code for the measurement. Can be one of the following: **0**: no error **1**: system error

CALIBRATE_SINGLE_TASK - Single Point Calibration

Performs a single-point calibration.

Note: When passing the calibration solution's value, use the temperature-compensated value.

Required Registers

Register	Description
ORP_REGISTER	The ORP of the calibration solution.

Response Registers

Register	Description
CALIBRATE_SINGLE_OFFSET_REGISTER	Single-offset calibration data
STATUS_REGISTER	An error code for the measurement. Can be one of the following: **0**: no error **1**: outside lower range **2**: outside upper range **3**: system error

I2C_TASK – I²C address change

Changes the device's I²C address.

Required Registers

Register	Description
MV_REGISTER	Used to temporarily store the new I²C address.

Response Registers

Register	Description
None	

Microfire LLC

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Modules

Mod-EC
Mod-pH
Mod-ORP
Mod-ISO_I2C_UART
Mod-Temp

Development Boards

Isolated Dev Board
Mod-EVAL
Mod-EVAL_ISO

Probes

Industrial pH Probe
Industrial EC Probe
Industrial ORP Probe
Lab pH Probe
Lab EC Probe
Lab ORP Probe

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