Microfire LLC Mod-EC Datasheet

Release Information

Release History

Release	Date	Description
1.1.0	8/13/2021	Added additional reflow procedures.
1.0.0	4/23/2021	Initial

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About the Mod-EC Module

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

- EC range of 0.05 µS/cm to 1 S/cm
    - Accuracy ±0.002 mS/cm²
    - Resolution 0.001 mS/cm²
    - Temperature compensated
- Multiple hardware interfaces operating at 3.3 volts
    - I²C with software definable address
        - Default address 0x0A
        - 10kHz, 100 kHz, 400 kHz, 1 MHz and 3.4 MHz compatible
    - UART
        - NMEA formatted output
    - USB Serial
        - Same as UART
    - 1-Wire interface for DS18B20 temperature sensor
- 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
    - Dual point
    - Triple point

Mechanical Specification

The Mod-EC 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 Dual Inline Package (DIP) type format, with the 12 pins on a 2.54mm pitch grid with 0.8mm holes.

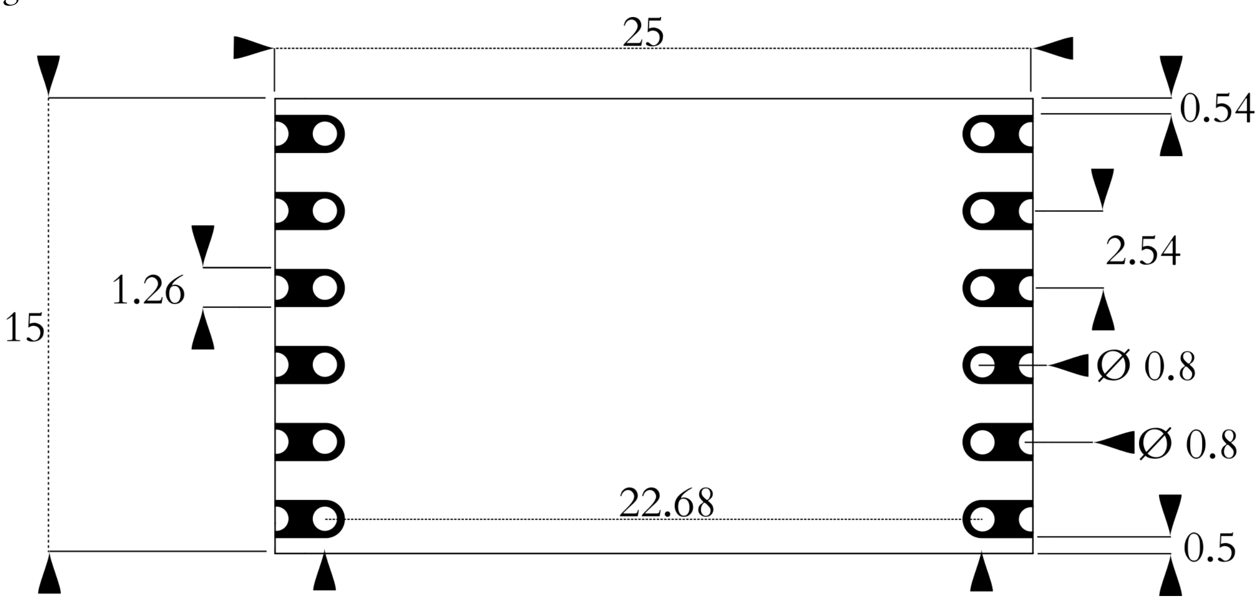


Figure 1. Physical dimensions of the module.

Pinout

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

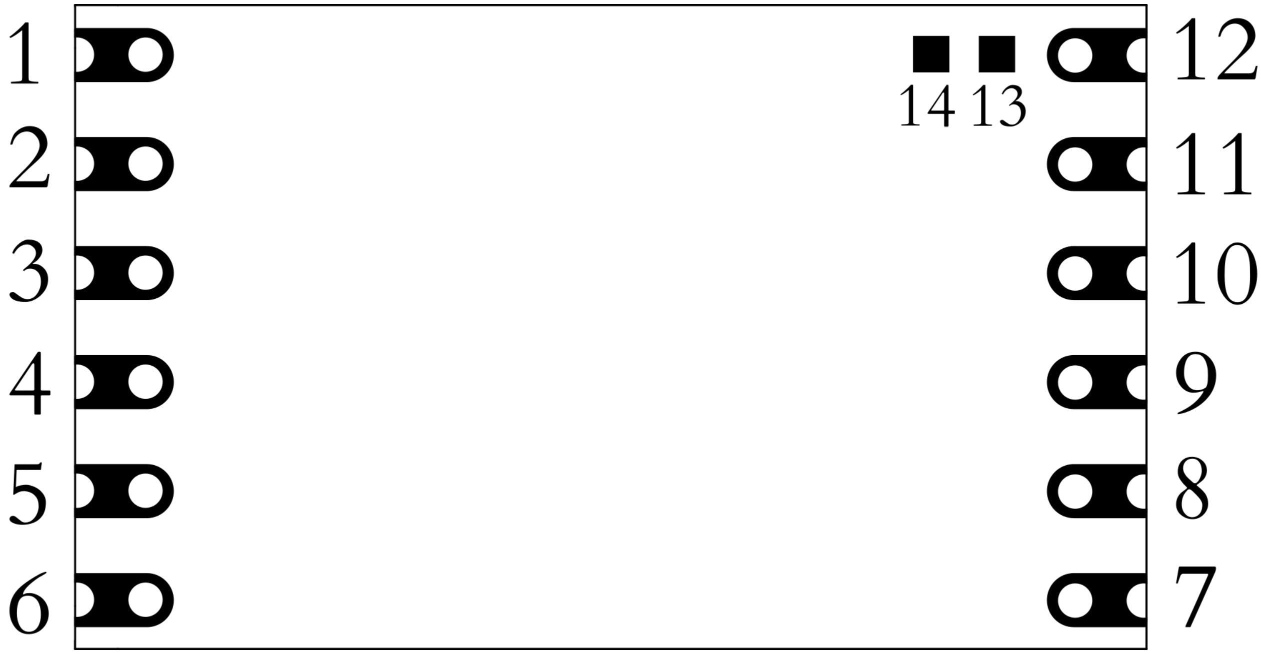
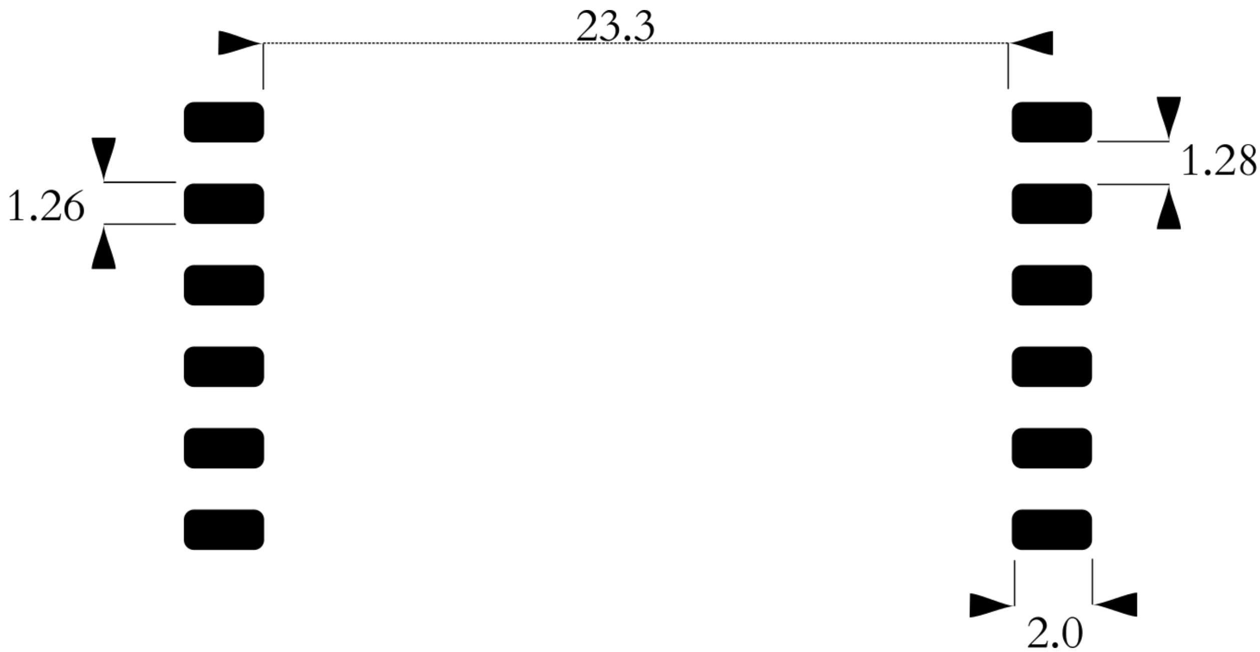


Figure 2. Pinout of the module.

Pin 1: Probe 1 input. Provides a connection to the first electrode of a EC probe.
Pin 2: Probe 2 input. Provides a connection to the second electrode of a EC probe.
Pin 3: Probe 3 input. Not used in this module.
Pin 4: 1-Wire. Provides 1-Wire DS18B20 interface.
Pin 5: USB Data-. Differential data line -.
Pin 6: USB Data+. Differential data line +.
Pin 7: UART TX. transmit line for UART serial interface.
Pin 8: UART RX. receive line for UART serial interface.
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 module.
Pin 13: SWD. Serial Wire Data pin. *Used to program the MCU.*
Pin 14: SWC. Serial Wire Clock pin. *Used to program the MCU.*

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 mil 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 to 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:

- **Absolue Maximum**: 3.63 volts
- **Absolute Minimum**: 1.62 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 properly operate. Voltage should not exceed 3.63 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.

- Active current use is typically 0.25 mA

Hardware Interfaces

The module provides I2C, UART, USB serial, and a limited-use 1-Wire interface. All interfaces are simultaneously available.

I²C

The module supports speeds of 10kHz, 100 kHz, 400 kHz, 1 MHz and 3.4 MHz 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 0x0A by default. 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 register 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.

UART

The UART interface uses:

- **Baud**: 9600
- **Data bits**: 8
- **Parity**: None
- **Stop bits**: 1
- **Voltage:** 3.3 volt only

These parameters are not configurable.

The UART interface uses the following pins:

- **Pin 8 RX**: receive in
- **Pin 7 TX**: Transmit out

Additional Circuitry

No additional components are required for operation.

USB Serial

- Compatible with the USB 2.1 specification
- Supports full (12Mbit/s) and low (1.5Mbit/s) speed communication

The USB interface uses the following pins:

- **Pin 5 D-**: differential pair -
- **Pin 6 D+**: differential pair +

VID/PID

The module can be identified with the following information:

- **VID**: 0x04D8
- **PID**: 0xE994

Additional Circuitry

If the module is to be powered through USB, the voltage must be converted from 5 volts to 3.3 volts. USB D- and D+ must be routed as a differential pair.

An example of a working combination of USB connector and power regulator would be:

Molex Micro USB Connector - 47346-0001
Analog Devices ADP150 - ADP150AUJZ-3.3-R7

1-Wire

The module provides a 1-Wire interface to connect a DS18B20 temperature sensor. The interface is limited to just the DS18B20 device.

The 1-Wire interface uses the following pin:

- **Pin 4 1-Wire**: 1-Wire

Additional Circuitry

The Pin 4 1-Wire line requires a pullup resistor for reliable communication. The resistance needed is determined, in part, by the length of the cable. For a 1 to 3 meter cable, a 4.7 kOhm resistor will work.

The DS18B20 can be operated using power, ground and 1-Wire connections, or in parasitic power mode.

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.

Communication

I²C, UART or USB all have particular hardware requirements that must be planned or provided for. Refer to their Hardware Interface sections for more details. (I²C Additional Circuitry, UART Additional Circuitry and USB Additional Circuitry). It is best to choose one communication method; having the UART connected but using I²C, for example, will introduce unneeded noise to the system.

1-Wire Temperature Sensor

This connection is optional. If it is not used, **Pin 4**: 1-Wire can be left unconnected. A connector and pullup resistor are needed to connect a DS18B20 temperature sensor. Refer to the Hardware Interface section for more details.

Probe Connection

An EC probe that is compatible with the module consists of two wires. This is most commonly provided for with a BNC, SMA, or U.FL connector. While wires and pin terminations can be used, they may not perform as well as a properly insulated connection would.

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. This is ideally accomplished by using a “no-clean” solder paste, and/or through mechanical means such as an ultrasonic bath.

Unused Pins

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

EC Measurements

EC Theory

Conductivity is the ability of water to conduct electricity, which is determined by the concentration of ions present. In the ocean or hydroponics, the ions of interest are typically chloride, but they can come from many other sources. The higher the ion concentration, the higher the conductivity.

Units

Conductivity has been a useful measure of water for a long time. In this time, there have been many techniques and advancements in the measurement. Due to this history and varied methods, there are several units of measure.

Siemens

The modern SI unit of conductivity is Siemens per meter, notated as S/m. Like any SI unit, it can be specified in other units like micro or milli Siemens, or deci or centi meters. Typically, micro or millisiemens are used per centimeter.

The length aspect of the measurement is due to the fact that resistance is dependent on the length of a conductor, so a set length needs to be specified for results to be reproducible and standardized. In practical use, the length portion is determined by the probe used and is nearly always in centimeters.

Because conductivity is heavily influenced by temperature, it is an important element of the measurement. There are no standards for notating measurements, but oftentimes, if no temperature is associated with a conductivity measurement, 25 C can be assumed. When conductivity measurements are given with a specific temperature, it is referred to as specific conductance.

TDS

TDS stands for total dissolved solids and is typically notated in parts-per-thousand, or part-per-million. TDS is determined by taking a specific measure of water, allowing it to dry, and weighing the remnants. TDS can be roughly converted into Siemens through various conversion factors. The factor can vary based on the main constituent of the water, but can also vary based on where in the world it is taken (for example, in the US, 500 is most often used, regardless of what is being measured). Due to the inherent uncertainty of this conversion factor, and that it is typically derived from a Siemen unit-of-measure anyway, this unit of measurement should be avoided.

Mho

Mho is equivalent to Siemens. It is Ohm spelled backwards since ohm measures resistance and conductivity is the reciprocal of resistance. This unit is redundant as it is essentially the same thing as a Siemen, but with a different name. It is somewhat commonly used despite not being in the International System of Units and discouraged against.

Considerations

Measuring EC is relatively straightforward, but it is important to keep some things in mind.

Response Time

EC probes are electro-chemical devices. They don't react instantly like a purely electrical device would. The probes need some time to reach an equilibrium. This is especially true when calibrating, since it moves the probe through a very wide range of values.

Interference

An EC probe operates in the millivolt range. The 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 strongly affects the EC. For example, a solution at 25°C may measure 1.413 mS/cm, and the same solution at 20°C may be 1.29 mS/cm. The change in conductivity is affected by the nature of the ions in solution. Generally, conductivity increases with an increase in temperature. The change is typically characterized by a percentage change in conductivity per degree change in temperature. With this characterization made, a temperature compensation factor can be formulated.

Temperature Compensation

Since the same solution can measure over a relatively wide range as the temperature changes, it is difficult to compare the measured value to some other value. As an example, suppose a tank of water needed to maintain an EC value of 1.0 mS/cm. The tank is exposed to the weather and the temperature increases and decreases throughout the day. The conductivity will also increase and decrease through the day in conjunction with the temperature. To have a reliable method of comparing the current conductivity to the setpoint, temperature must be compensated for. This is done by choosing a particular temperature to adjust all readings to. This is typically 25 °C. The compensation would have the effect of changing the conductivity measurement taken at the current temperature, and adjusting it so that it would represent what it would have been at 25 °C.

Several points of data are needed for this calculation:
- The solution's current temperature
- The temperature to adjust to
- The temperature coefficient

The solution's temperature and the temperature to adjust to has been discussed above. The temperature coefficient is the percent change per degree. The coefficient is different for every solution and is determined by its composition. Sometimes the solution being measured is known and a temperature calibration characterization can be done, oftentimes the exact composition isn't known and an estimation is required. For fresh water, the most typical coefficient is 0.019. For seawater, it is around 0.021, and for pure water, 0.052.

Because the coefficients are estimations, they introduce a small amount of uncertainty. It is important to note that a chart of the measurement won't be perfectly flat, indicating that all the temperature effects have been fully eliminated, it will still move with the temperature, but not nearly as much.

The module uses the following formula to calculate the compensated conductivity measurement.

$$EC_{25} = EC / [1 + \alpha (T - 25)]$$

where EC is the uncompensated measurement, α is the coefficient and T = the solution's temperature.

Calibration

Calibration is needed to obtain accurate measurements. Each module is very slightly different from the next and each EC probe will have a slightly different response from another. For these reasons, neither modules or probes are interchangeable without both being calibrated together.

Procedure

Following good lab procedures is important to obtain the best results while also staying safe. 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, deionised, 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. Eventually, only the third decimal place will vary from measurement to measurement. 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.
6. Repeat steps 2 through 5 for each calibration point.

When calibrating, use the labeled value, not the temperature adjusted value.

Calibration Types

The module supports three methods of calibration.

Single Point

Single point is the least useful and should generally not be used. It uses one point and is only accurate for a small range around that one point.

Dual Point

Dual point calibration is used for measuring between two set points. To determine the points, decide on the lowest point to be measured and the highest point. It is a good idea to add an extra buffer to either side. After calibrating between those two points, the measurements can be expected to be very accurate between them. Outside the two points, the measurements will get increasingly inaccurate.

Triple Point

The module's response is not perfectly linear throughout the entire range of possible measurements. To get the most accurate measurements over the widest range, triple point calibration can be used. It is similar to dual point, but uses three points rather than two. A good starting point for a very large range would be a low of 0.1 mS, mid of 1.0 mS, and a high point of 10.0 mS.

Precedence

The module will select the best calibration type from the available calibrated points as follows:

1. If there are high, mid, and low points, it will use triple-point calibration to calculate the result.
2. If there are high and low points, it will use dual-point calibration to calculate the result.
3. If there is a single point calibration data, it will use single-point calibration to calculate the results.
4. No calibration points used will result in an uncalibrated measurement.

Probe Selection

Conductivity probes come in several different cell-constants (K). A cell-constant allows current to flow more or less easily, thereby allowing different ranges of conductivity to be measured. To measure high conductivity, a probe with a cell-constant of K10 is chosen. The electrodes of a K10 probe are small and spaced further apart than a K1 probe which is typically used for mid-range measurements.

The choice of which cell-constant to use is heavily based on the hardware reading the probe. For Mod-EC use, the following table should be used for selection:

Measurement Range	Cell-constant
0.05 to 5 uS	0.01
2 to 100 uS	0.1
0.1 to 20 mS	1
10 mS to 1 S	10

NMEA Interface

The NMEA interface provides a human-readable text interface for interacting with the device. It is also easily machine parsed for automating tasks. All functions and data can be accessed through this interface.

NMEA Physical Connection

The NMEA interface can be accessed by connecting to the UART interface using:

- **Baud**: 9600
- **Data bits:** 8
- **Parity**: None
- **Stop bits:** 1

It is also available on the USB serial output.
Note: *Output is sent to both UART and USB Serial interfaces, regardless of which interface the command was received from.*

Once connected, the module will wait for input with a maximum of 10 ms between characters. If characters are spaced more than 10 ms apart, the module will emit a parser error and the command will not be accepted.

NMEA Sentence Structure

The modules comply with the original NMEA standard closely. A sentence consists of the following elements:

ELEMENT	DESCRIPTION
$	Always begins a sentence
TYPE	Sentence type
,	Delimiter
ARGUMENT	Arguments of any type. Spaces are allowed
,	*Delimiter if another argument follows*
*	Sentence end

00	A two digit checksum, represented in hexadecimal format.

Some examples of valid sentences;
$ECMEA,22.1,0.019,25.0,1.0*40
$PHMEA,25.0,0*78

Invalid sentences:
$ECMEA 22.1,0.019,25.0,1.0*40 – Space between type and arguments
PHMEA,25.0,0*78 – No starting **$**

NMEA Checksum

By default, the module will accept invalid checksums. Rather than passing an NMEA sentence with the correct checksum, a 00 can be sent (*$TYPE**00). This behavior can be changed with ECCRC, turning checking on or off. This setting is not saved through a power reset cycle.

The checksum is calculated for all characters between, and not including, the starting **$** and just before the ending *****. It is calculated by XORing each character with the next.

An example function in C/C++:

```
int nmea_checksum(const char *s){
  int c = 0;
  while (*s)
  {
    c ^= *s++;
  }
  return c;
}
```

Source: [Wikipedia]()

$ECMEA - EC Measurement

Starts an EC measurement. It takes 750 ms to complete a measurement.

Request Parameters

Parameter	Description
TEMP_C	The solution-under-test's temperature in Celsius. If the temperature is unknown, pass 25.0
TEMP_COEF	The temperature coefficient used for temperature compensation. Typically 0.019 for freshwater and 0.021 for seawater.
TEMP_CONSTANT	The temperature constant used for temperature compensation.
CELL_CONSTANT	The cell-constant, or K value of the attached EC probe. Typically 0.1, 1.0 or 10.0.
PRESSURE_KPA	The pressure in kilopascals at which the measurement is being made. Used in salinity and density calculations. If salinity or density measurements aren't needed, 0 should be used.

Response Parameters

Parameter	Description
EC_US	The solution-under-test's conductivity in uS/cm^2. Formatted as a floating point number with 3 decimal places.
EC_MS	The solution-under-test's conductivity in mS/cm^2. Formatted as a floating point number with 3 decimal places.

PSU	Practical Salinity Unit. Calculated according to PSS-78. 0 returned if calculated salinity is less than 2 or greater than 40.
DENSITY	Density in g/cm^3. Calculated according to EOS-80. 0 returned if salinity is 0.
STATUS	An error code for the measurement. Can be one of the following: **0**: no error **1**: no probe detected or outside range **2**: system error **3**: config error

Example Requests

$ECMEA,22.1,0.019,25.0,1.0,0*5C - an EC measurement using 22.1 as the solution's temperature, 0.019 for the temperature coefficient, 25.0 for the temperature constant, cell-constant of 1.0, and 0 for pressure.

$ECMEA,23.312,0.019,25.0,0.0986,0*6A - an EC measurement using 23.312 as the solution's temperature, 0.019 for the temperature coefficient, 25.0 for the temperature constant, cell-constant of 0.0986, and 0 for pressure.

$ECMEA,19.1,0.021,25.0,10.0,1000*5E - an EC measurement using 19.1 as the solution's temperature, 0.021 for the temperature coefficient, 25.0 for the temperature constant, cell-constant of 10.0, and 1000 kPa for pressure.

Example Responses

$ECMEA,1030,1.031,0.000,0.000,0*7C – EC value measured as 1030 uS/cm² or 1.031 mS/cm², 0 for salinity and density, without error.

$ECMEA,129,0.129,0.000,0.000,0*4D - EC value measured as 129 uS/cm² or 0.129 mS/cm², 0 for salinity and density, without error.

$ECMEA,51455,51.456,33.805,1.022,0*42 - EC value measured as 51455 uS/cm² or 33.805 mS/cm², 33.805 for salinity and 1.022 density, without error.

$ECERR – Parser Error

Unsolicited response to an NMEA parse error.

Response Parameters

Parameter	Description
ERROR	NMEA parse error. Can be one of the following: **1:** Unexpected character encountered **2:** Sentence buffer full **3:** Sentence type longer than 5 **4:** CRC error **5:** System error

Example Responses

$ECERR,1*5E – An unexpected character was encountered.

$ECCRC - CRC Error Checking

Turns NMEA sentence CRC checking on or off and retrieves the current status.

Request Parameters

Parameter	Description
0	Turns CRC checking off
1	Turns CRC checking on

Response Parameters

Parameter	Description
CRC	Returns: **0**: if CRC checking is turned off **1**: CRC checking is on

Example Requests

$ECCRC*54 – Gets the status of CRC checking.
$ECCRC,0*48 – Turns CRC checking off.
$ECCRC,1*49 – Turns CRC checking on.

Example Responses

$ECCRC,1*49 – CRC checking is on.
$ECCRC,1*49 – CRC checking off.

$ECTEM - 1-Wire Temperature

Starts a temperature measurement with the optionally attached DS18B20 sensor. The module provides a basic interface to the sensor. It is initialized with 12-bit precision and is not changeable. It takes 750 ms to complete a measurement.

Request Parameters

Parameter	Description
None	

Response Parameters

Parameter	Description
TEMP_C	Temperature in Celsius. Formatted as a floating point number with up to 3 decimal places.
TEMP_F	Temperature in Fahrenheit. Formatted as a floating point number with up to 3 decimal places.
STATUS	An error code for the measurement. Can be one of the following: **0**: No error **3**: System error

Example Requests

$ECTEM*5A – Starts a temperature measurement.

Example Responses

$ECTEM,19.688,67.438,0*46 – A temperature response without errors.
$ECTEM,-127,-127,3*45 – A temperature response with no sensor connected.

$ECINF - EC Calibration Information

Requests or sets EC calibration and other system information. To get information, the sentence can be called without parameters.

To set any parameter, either an actual value, or a default value of **-9999** can be used. If **-9999** is passed, the parameter is ignored. All parameters must be filled with an actual value or **-9999**.

To set the default value, pass `**nan**`. Internally, the module distinguishes between calibration data, which can be a large range of numbers, by using a *Not A Number* placeholder.

Request Parameters

Parameter	Description
REFERENCE_LOW	The reference-low calibration point, the point the device should measure.
READ_LOW	The read-low calibration point, the point the device measures at the REFERENCE_LOW point.
REFERENCE_MIDDLE	The reference-middle calibration point, the point the device should measure.
READ_MIDDLE	The read-low calibration point, the point the device measures at the REFERENCE_LOW point.
REFERENCE_HIGH	The reference-high calibration point, the point the device should measure.
READ_HIGH	The read-high calibration point, the point the device measures at the REFERENCE_HIGH point.
SINGLE_OFFSET	Single point calibration data.
I2C_ADDRESS	The I²C address of the module. The default value for this is 0x0A (10 decimal).

HARDWARE_VESION	The hardware version of the module.
FIRMWARE_VERSION	The firmware version on the module.

Example Requests

$ECINF*47 – Retrieves EC calibration and system information.
$ECINF,-9999,-9999,-9999,-9999,-9999,-9999,0.035,10,1,1*6E – Sets single-point offset calibration data only.
$ECINF,nan,nan,nan,nan,nan,nan,nan,10*27 – Resets all values to system default.

Example Responses

$ECINF,0.100,0.182,1.0,1.124,10.000,11.492,nan,10,1,1*24 – Full listing of calibration and system information.

$ECSIN - Single Point Calibration

Performs a single-point calibration. It takes 750 ms to complete a measurement.

Note: When passing the calibration solution's value, use the labeled value, not the temperature compensated value.

Request Parameters

Parameter	Description
CALIBRATION_MS	The conductivity of the calibration solution in mS/cm².
TEMP_C	The calibration solution's temperature in Celsius. If the temperature is unknown, pass 25.0
TEMP_COEF	The temperature coefficient used for temperature compensation. Typically 0.019 for freshwater and 0.021 for seawater.
TEMP_CONSTANT	The temperature constant used for temperature compensation.
CELL_CONSTANT	The cell-constant, or K value of the attached EC probe. Typically 0.1, 1.0 or 10.0.

Response Parameters

Parameter	Description
SINGLE_POINT_OFFSET	The calibration data of the single-point calibration.
STATUS	An error code for the measurement. Can be one of the following: **0**: no error **1**: no probe detected or outside range

	2: system error **3**: config error

Example Requests

$ECSIN,2.0,25.07,0.019,25.0,1.0*6C - performs single-point calibration at 2.0 EC and the solution is 25.07 Celsius.

Example Responses

$ECSIN,0.399,0*4F – the result of the calibration with no errors.

$ECLOW - Low Point Calibration

Performs a low-point calibration.

Note: When passing the calibration solution's value, use the labeled value, not the temperature compensated value.

Request Parameters

Parameter	Description
CALIBRATION_MS	The conductivity of the calibration solution in mS/cm^2.
TEMP_C	The calibration solution's temperature in Celsius.
TEMP_COEF	The temperature coefficient used for temperature compensation. Typically 0.019 for freshwater and 0.021 for seawater.
TEMP_CONSTANT	The temperature constant used for temperature compensation.
CELL_CONSTANT	The cell-constant, or K value of the attached EC probe. Typically 0.1, 1.0 or 10.0.

Response Parameters

Parameter	Description
LOW_POINT_REFERENCE	The reference-low calibration point, the point the device should measure. This unit is in ohms.
LOW_POINT_READING	The read-low calibration point, the point the device measures at the LOW_POINT_REFERENCE point. This unit is in ohms.

STATUS	An error code for the measurement. Can be one of the following: **0**: no error **1**: no probe detected or outside range **2**: system error **3**: config error

Example Requests

$ECLOW,1.0,22.812,0.019,25.0,1.0*54 - performs low-point calibration at 1.0 mS/cm² the solution being 22.812 Celsius, with a temperature coefficient of 0.019 and constant of 25.0.

Example Responses

$ECLOW,1041.572,1040.660,0*4F – the result of the calibration with no errors.

$ECMID - Mid Point Calibration

Performs a mid-point calibration. It takes 750 ms to complete a measurement.

Note: When passing the calibration solution's value, use the labeled value, not the temperature compensated value.

Request Parameters

Parameter	Description
CALIBRATION_MS	The conductivity of the calibration solution in mS/cm².
TEMP_C	The calibration solution's temperature in Celsius. If the temperature is unknown, pass 25.0
TEMP_COEF	The temperature coefficient used for temperature compensation. Typically 0.019 for freshwater and 0.021 for seawater.
TEMP_CONSTANT	The temperature constant used for temperature compensation.
CELL_CONSTANT	The cell-constant, or K value of the attached EC probe. Typically 0.1, 1.0 or 10.0.

Response Parameters

Parameter	Description
MID_POINT_REFERENCE	The reference-mid calibration point, the point the device should measure. This unit is in ohms.
MID_POINT_READING	The read-mid calibration point, the point the device measures at the MID_POINT_REFERENCE point. This unit is in ohms.

STATUS	An error code for the measurement. Can be one of the following: **0**: no error **1**: no probe detected or outside range **2**: system error **3**: config error

Example Requests

$ECMID,1.413,22.812,0.019,25.0,1.0*46 – performs MID-point calibration at 1.4.13 mS/cm² the solution being 22.812 Celsius, with a temperature coefficient of 0.019 and constant of 25.0.

Example Responses

$ECMID,707.714,700.381,0*55 – the result of the calibration with no errors.

$ECHIG - High Point Calibration

Performs a high-point calibration. It takes 750 ms to complete a measurement.

Note: When passing the calibration solution's value, use the labeled value, not the temperature compensated value.

Request Parameters

Parameter	Description
CALIBRATION_MS	The conductivity of the calibration solution in mS/cm².
TEMP_C	The calibration solution's temperature in Celsius. If the temperature is unknown, pass 25.0
TEMP_COEF	The temperature coefficient used for temperature compensation. Typically 0.019 for freshwater and 0.021 for seawater.
TEMP_CONSTANT	The temperature constant used for temperature compensation.
CELL_CONSTANT	The cell-constant, or K value of the attached EC probe. Typically 0.1, 1.0 or 10.0.

Response Parameters

Parameter	Description
HIGH_POINT_REFERENCE	The reference-high calibration point, the point the device should measure. This unit is in ohms.
HIGH_POINT_READING	The read-high calibration point, the point the device measures at the HIGH_POINT_REFERENCE point. This unit is in ohms.

STATUS	An error code for the measurement. Can be one of the following: **0**: no error **1**: no probe detected or outside range **2**: system error **3**: config error

Example Requests

$ECHIG,10.0,21.875,0.019,25.0,1.0*74 – performs high-point calibration at 10.0 mS/cm² the solution being 21.875 Celsius, with a temperature coefficient of 0.019 and constant of 25.0.

Example Responses

$ECHIG,105.938,125.641,0*5F – the result of the calibration with no errors.

I²C Interface

The module's I²C interface operates similarly to many common I²C sensors. There are several registers which hold values such as calibration, EC and temperature, 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
MS_REGISTER	4	float	Measured pH
PSU_REGISTER	8	float	Practical Salinity Units
TEMP_C_REGISTER	8	float	Measured temperature in Celsius
CALIBRATE_REFLOW_REGISTER	16	float	Reference-low calibration data
CALIBRATE_READLOW_REGISTER	20	float	Read-low calibration data
CALIBRATE_REFMID_REGISTER	24	float	Reference-mid calibration data
CALIBRATE_READMID_REGISTER	28	float	Read-mid calibration data
CALIBRATE_REFHIGH_REGISTER	32	float	Reference-high calibration data
CALIBRATE_READHIGH_REGISTER	36	float	Read-high calibration data
CALIBRATE_SINGLE_OFFSET_REGISTER	40	float	Single-offset calibration data

COEFFICIENT_REGISTER	44	float	Temperature coefficient
CONSTANT_REGISTER	48	float	Temperature constant
K_REGISTER	51	float	Probe cell-constant
KPA_REGISTER	56	float	Pressure in kilopascals

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_EC_TASK is written to the TASK_REGISTER register, an EC measurement is performed. To read the resulting measurement, you would read the EC_REGISTER register.

Task Listing

Task Name	Duration	Value	Description
MEASURE_EC_TASK	750 ms	80	EC measurement
MEASURE_TEMP_TASK	750 ms	40	Temperature measurement
CALIBRATE_LOW_TASK	750 ms	20	Low-point calibration
CALIBRATE_MID_TASK	750 ms	10	Mid-point calibration
CALIBRATE_HIGH_TASK	750 ms	8	High-point calibration
CALIBRATE_SINGLE_TASK	750 ms	4	Single-point calibration
I2C_TASK	1 ms	2	I²C address change

MEASURE_EC_TASK - EC Measurement

Starts an EC measurement. It takes 750 ms to complete a measurement.

Request Parameters

Parameter	Description
TEMP_C	The solution-under-test's temperature in Celsius. If the temperature is unknown, pass 25.0
TEMP_COEF	The temperature coefficient used for temperature compensation. Typically 0.019 for freshwater and 0.021 for seawater.
TEMP_CONSTANT	The temperature constant used for temperature compensation.
CELL_CONSTANT	The cell-constant, or K value of the attached EC probe. Typically 0.1, 1.0 or 10.0.
PRESSURE_KPA	The pressure in kilopascals at which the measurement is being made. Used in salinity and density calculations. If salinity or density measurements aren't needed, 0 should be used.

Response Parameters

Parameter	Description
EC_US	The solution-under-test's conductivity in uS/cm². Formatted as a long.
EC_MS	The solution-under-test's conductivity in mS/cm². Formatted as a floating point number with up to 3 decimal places.
PSU	Practical Salinity Unit. Calculated according to PSS-78. 0 returned if calculated salinity is less than 2 or greater than 40.

DENSITY	Density in g/cm^3. Calculated according to EOS-80. 0 returned if salinity is 0.
STATUS	An error code for the measurement. Can be one of the following: **0**: no error **1**: no probe detected or outside range **2**: system error **3**: config error

MEASURE_TEMP_TASK - 1-Wire Temperature

Starts a temperature measurement with the optionally attached DS18B20 sensor. The module provides a basic interface to the sensor. It is initialized with 12-bit precision and is not changeable. It takes 750 ms to complete a measurement.

Required Registers

Register	Description
None	

Response Registers

Register	Description
TEMP_C_REGISTER	The solution-under-test's temperature in Celsius.
STATUS_REGISTER	An error code for the measurement. Can be one of the following: **0**: no error **3**: system error

CALIBRATE_LOW_TASK - Low Point Calibration

Performs a low-point calibration. It takes 750 ms to complete a measurement.

Required Registers

Register	Description
EC_REGISTER	The calibration solution's conductivity in mS/cm².
TEMP_C_REGISTER	The calibration solution's temperature in Celsius. If the temperature is unknown, pass 25.0

Response Registers

Register	Description
CALIBRATE_REFLOW_REGISTER	Reference-low calibration data
CALIBRATE_READLOW_REGISTER	Read-low calibration data
STATUS_REGISTER	An error code for the measurement. Can be one of the following: **0**: no error **1**: no probe detected or outside range **2**: system error **3**: config error

CALIBRATE_MID_TASK - Middle Point Calibration

Performs a mid-point calibration. It takes 750 ms to complete a measurement.

Required Registers

Register	Description
EC_REGISTER	The calibration solution's conductivity in mS/cm².
TEMP_C_REGISTER	The calibration solution's temperature in Celsius. If the temperature is unknown, pass 25.0

Response Registers

Register	Description
CALIBRATE_REFMID_REGISTER	Reference-mid calibration data
CALIBRATE_READMID_REGISTER	Read-mid calibration data
STATUS_REGISTER	An error code for the measurement. Can be one of the following: 0: no error 1: no probe detected or outside range 2: system error 3: config error

CALIBRATE_HIGH_TASK - Middle Point Calibration

Performs a high-point calibration. It takes 750 ms to complete a measurement.

Required Registers

Register	Description
EC_REGISTER	The calibration solution's conductivity in mS/cm².
TEMP_C_REGISTER	The calibration solution's temperature in Celsius. If the temperature is unknown, pass 25.0

Response Registers

Register	Description
CALIBRATE_REFHIGH_REGISTER	Reference-high calibration data
CALIBRATE_READHIGH_REGISTER	Read-high calibration data
STATUS_REGISTER	An error code for the measurement. Can be one of the following: 0: no error 1: no probe detected or outside range 2: system error 3: config error

CALIBRATE_SINGLE_TASK - Single Point Calibration

Performs a single-point calibration. It takes 750 ms to complete a measurement.

Required Registers

Register	Description
EC_REGISTER	The calibration solution's conductivity in mS/cm^2.
TEMP_C_REGISTER	The calibration solution's temperature in Celsius. If the temperature is unknown, pass 25.0

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**: no probe detected or outside range **2**: system error **3**: config error

I2C_TASK – I²C address change

Changes the device's I²C address.

Required Registers

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

Response Registers

Register	Description
None	

Microfire LLC

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Certificate of Compliance

RoHS 3 Directive 2015/863/EU

Microfire LLC certifies to the best of its knowledge and belief, that the products listed herein conform with RoHS 3 Directive 2015/863/EU and its subsequent amendments. This declaration further certifies that Microfire LLC has obtained RoHS Certificates of Compliance from each applicable supplier of materials and parts used in the assembly and manufacture of these goods.

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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