TURTLE TOUGH®

# OPERATION MANUAL

## TT-MA ANALYSER

+ pH +ORP + Conductivity + Dissolved Oxygen + Ion Specific


turtletoughsensors.com

# Contents

# Safety Precautions

Before attempting to unpack, set up, or operate this instrument, please read this entire manual.

- Make certain the unit is disconnected from the power source before attempting to service or remove any component.
- Make certain the unit is disconnected from other sources of force or pressure (for example, pneumatic or hydraulic), before attempting to service or remove any component.
- Failure to follow these precautions could result in personal injury and damage to the equipment.

**General**

This manual contains basic information to be noted during installation, operation and maintenance. It is therefore essential that this manual be read by the contractor before installing and commissioning the system, as well as by the relevant operating personnel/owner of the unit. It must remain available for reference at all times. In addition to the general safety instructions under this main heading Safety Precautions, the special safety precautions outlined in other sections must also be observed.

**Warnings used in this manual**

This manual contains vital information relating to the safety of people and the environment, the analyser and any equipment attached. These statements are identified by the following symbols:

| | |
|---|---|
| **Danger**<br>**Electric shock risk** | **Disconnect electrical supply before working on this equipment.** |

| | |
|---|---|
| Danger | **DANGER**<br>Refers to an imminent danger.<br>Non-compliance can lead to death or extremely serious injury. |
| Warning | **WARNING**<br>Refers to a potential hazardous situation.<br>Non-compliance can lead to death or extremely serious injury. |
| Caution | **CAUTION**<br>Refers to a potential hazardous situation.<br>Non-compliance can lead to minor injury or property damage. |
| Notice | **NOTICE**<br>Appears in conjunction with safety instructions which may endanger the analyser and its operation if disregarded. |
| Important | **IMPORTANT**<br>Draws attention to supplementary information to make the work easier and ensure trouble-free operation. Markings which are affixed directly to the equipment mut be observed without fail, and must remain full legible at all times. |

## Qualification and Training of Personnel

The personnel employed for installation, operation, inspection, and maintenance, must be suitably qualified for this work. The areas of responsibility, competence and supervision of the personnel must be precisely defined by the owner. Personnel who do not have the required know-how must be trained and instructed. In addition, the owner of the system must ensure that the relevant personnel are fully familiar with and have understood the contents of this manual.  Should training be required please contact your Turtle Tough distributor

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## Important Safety Instructions

When installing and using this electrical equipment, basic safety precautions should always be observed, including the following:

Danger

**NOTICE**

Read and follow all instructions. Save these instructions.

Warning

**WARNING**

To reduce the risk of injury, do not permit children to use this product.

Electric Shock Hazard

**WARNING**

Risk of Electric Shock. Connect only to a suitable isolated, hard wired electrical outlet. It is recommended that the outlet is protected by an RCD (Residual Current Detector) or is in any event in compliance with all local electrical regulations. Do not bury electrical supply cable.

Electric Shock Hazard

**WARNING**

To reduce the risk of electric shock, replace damaged electrical cable immediately.

Danger Electric Shock Hazard

**WARNING**

To reduce the risk of electric shock, do not use an extension cable to connect the unit to an electric supply; provide a properly located outlet

## Hazards due to Non-compliance

Failure to comply with the safety instructions may endanger not only people, but also the environment and the system.
**The following hazards in particular may arise:**

- Failure of major system functions.
- Failure of specified methods for maintenance and repair.
- Danger to people due to electrical, mechanical and chemical effects.

## Safe Operation

The safety instructions contained in this manual must be observed.
The owner is responsible for ensuring compliance with local safety regulations.

## Safety Instructions for the Owner/Operator

Danger due to electric current must be excluded. Refer to local electrical safety standards and regulations.

## Installation, Maintenance and Inspection


Warning

The owner must ensure that all maintenance, inspection and installation work is undertaken by authorised and duly qualified personnel who have also studied this manual.

- Sensors must always by isolated before starting any work.
- Please be aware that the connected sensor(s) and the associated analyser may be controlling chemical dosing and as such shutting down the unit without due regard to the systems it is controlling can lead to chemical release.

## Impermissible Modes of Operation


Caution

Usage other than as described in this manual will lead to the immediate cancellation of the warranty and any other manufacturer's liability.

## Unauthorised Modification


Danger

Usage other than as described in this manual will lead to the immediate cancellation of the warranty and any other manufacturer's liability.

## Chemicals


Important

Should the sensor(s) be in contact with hazardous chemicals, great care must be taken when handling them.

## CAUTION


Disconnect electrical supply before working on this equipment

When handling this equipment, the accident prevention regulations applicable on site must be observed and the specified personal protective equipment worn.
PPE: examples of protective clothing, gloves and goggles.

**DANGER** Fire hazard. No parts are suitable for use in a hazardous rated area.

## IMPORTANT


Appropiate PPE to be worn when in contact with the sensor

Please unpack the equipment and ordered accessories carefully in order not to miss small parts. Immediately compare the scope of delivery to the delivery note. If there are any discrepancies, contact your Turtle Tough Representative.

## Sensors

### Health and Safety


Take care when removing the sensor

Before making or breaking any electrical or signal connections, ensure that the instrument is isolated from the electrical supply. When handling the sensor please wear the appropriate PPE.

### Environmental Considerations

Please use this product in a manner sensitive to the environment and at the end of its life dispose or recycle in a manner appropriate at that time that is in compliance with local regulations.

# Introduction

Congratulations on purchasing a Turtle Tough TT-MA Analyser System. Turtle Tough sensors are handmade with care and precision, combining state-of-the art technology and materials to deliver superior performance under extreme conditions. The TT-MA Family of Modular Analysers have been specifically developed to achieve the optimum performance from your Turtle Tough Sensor.

This instruction manual provides information for the correct installation and use of a Turtle Tough TT-MA Analyser System to ensure you get the maximum life and performance from your sensor.

Through our experience in the world's toughest applications we have developed systems that have been optimised for high hydrofluoric acid, saturated sodium, high sulphide, organic solvents, high temperature and slurry/viscous applications. Our application specific sensors include Industrial, Waste Water, Acid Etching, Nickel, Gold, Titanium Dioxide, Food & Beverage and Pharmaceutical.

Please ensure that the system you are using is suitable for your intended application. You can locate your specific sensor in the sensor selection matrix, which can be found under support at: **www.turtlesensors.com**

# System Contents

All Turtle Tough instruments undergo a thorough quality control and calibration before delivery and always include a detailed instruction manual.

**Your TT-MA System may include these items:**

- ☐ 110-240V AC Power Supply
- ☐ pH/ORP Analyser Module
- ☐ Dissolved Oxygen Analyser Module
- ☐ Conductivity Analyser Module
- ☐ Ion Selective Analyser Module
- ☐ Datalogger Module
- ☐ Temperature Module
- ☐ TOT pH Compensation Module
- ☐ Relay Module
- ☐ IP65 Enclosure
- ☐ pH/ORP Sensor
- ☐ Dissolved Oxygen Sensor
- ☐ Conductivity Sensor
- ☐ Ion Selective Sensor
- ☐ User's manual

# Installation


Danger
Electric
Shock
Hazard

As with all instrumentation the installation and commissioning of this instrument is crucial to its safe and effective operation. This instrument must only be used for itspurpose as outlined in this manual. It must be installed and commissioned in accordance with this manual and by trained, qualified personnel.

### Site Selection


Important

Please choose a suitable location for the installation of the electronics. The choice of installation point on any site is a compromise and is best undertaken by an experienced installation engineer. The following is a list of the factors that need to be taken into consideration.

- Ensure that the mounting allows access to all serviceable parts.
- Try to mount the electronics in a position where they are not habitually hosed down in a cleaning process.
- The electronics enclosure should be mounted away from sources of heat or direct sunlight.
- Consider the length of wiring runs when mounting the instrument.
- Try to keep the electronics away from substations, motors or other large EMI emitters.
- Consider whether the sample will be representative and well mixed.
- Consider sample line run times.
- Consider sample return points.
- In a plastic run, with a low conductivity liquid sample, consider earthing the sample.
- If the instrument is controlling a dosing pump, size the pump appropriately.

**Note:** This list is not intended as a check-list neither is it implied that the list is complete.

### Unpacking


Important

- Please have a copy of your order with you when you unpack your instrument.
  All orders are checked when they leave the factory.
- Please check that you have all the parts that were ordered as soon as you open the box.
- If anything is missing, or damaged, please contact your sales outlet immediately.
- If the instrument needs to be returned for any reason please follow the return instructions given in this manual.
- Please dispose of the packing in an environmentally responsible manner and in compliance with local regulations.

# PH/ORP ANALYSER MODULE


## Specifications

| | |
|---|---|
| **Power supply** | 24VDC ±10% |
| **Consumption** | 60 mA max |
| **Sensor** | Combination Sensor |
| **Ph/mv range** | 0-14 pH, ±1000Mv |
| **Ph input** | < 1pA, >10GΩ |
| **Accuracy** | ±0.2% Excluding Sensor (Ideal) |
| **Temp sensor** | Pt100, Pt1000 |
| **Temp range** | 0-210°C ± 0.3°C |
| **Temp comp** | Fixed (Manual) or Automatic using Temperature (TC) Measurement |
| **Analogue output** | 0-20mA or 4-20mA, max. 500Ω |
| **Output hold** | Automatic when in calibration mode |
| **Housing** | Lexan UL94V-0 (Upper part)  Noryl UL94V-0 (Lower part) |
| **Mounting** | M36 for 35 mm DIN rail |
| **Ip class** | Housing IP40. Connector IP20 |
| **Connector** | Max 16A. Max 2.5mm² Max torque 0.6 Nm |
| **Temp** | Usage -15 to +50 °C (Storage -35 to +75 °C) |
| **Weight** | 75 grams (2.64 ounces) |
| **Dimensions** | L 86 x W 36 x H 58 mm (3.4” X 1.4” X 2.3”) |
| **Ce mark:** | EN61326A |

## Sensor Theory of Operation

pH is measured potentiometrically when using an electrode. A potential develops across the glass membrane of a pH electrode when it comes into contact with a solution. This potential varies as the pH varies, but requires a constant second potential to compare the changes against. This is provided by the integral reference electrode, to provide a constant potential, regardless of pH.

In acidic or alkaline solutions, the voltage on the outer membrane surface changes proportionally to changes in hydrogen ion activity as described by the Nernst equation:

$$E = E_0 + (2.3RT/nF)\log[H+]$$

Where:

**E** = total potential difference (measured in mV)

**$E_0$** = standard potential

**R** = gas constant

**T** = temperature in Kelvin

**n** = number of electrons

**F** = Faraday's constant

**[H+]** = hydrogen ion activity

Voltage output from the electrode changes linearly in relationship to the changes in pH.
The temperature of the solution determines the slope of the response.
One pH unit corresponds to 59.16mV at 25 ◦C, the standard voltage and temperature to which all calibrations are referenced.

## Electrical and Sensor Connections

### Installation


Danger

As with all instrumentation, the installation and commissioning of this sensor is crucial to its safe and effective operation. This sensor must only be used for its purpose as outlined in this manual. It must be installed and commissioned in accordance with this manual and by trained, qualified personnel.

### Sensor Site Selection


Electric Shock Hazard

Please choose a suitable location for the installation of the sensor. The choice of installation point on any site is a compromise and is best undertaken by an experienced installation engineer. The following is a list of the factors that need to be taken into consideration. Ensure that the sensor is positioned to ensure adequate flow.

- Avoid installing the sensor within 1m of any dosing point.
- Minimise all potential sources of electrical interference.
- Static and Ground Loop Faults can damage the sensor or cause erroneous readings and all precautions should be taken to avoid them.

**Note:** This list is not intended as a check-list neither is it implied that the list is complete.

### Unpacking


Important

- Please have a copy of your order with you when you unpack your instrument. All orders are checked when they leave the factory.
- Please check that you have all the parts that were ordered as soon as you open the box.
- If anything is missing, or damaged, please contact your sales outlet immediately.
- If the instrument needs to be returned please follow the return instructions given in this manual.
- Please dispose of the packing in an environmentally responsible manner and in compliance with local regulations.

### Mounting


Important

A Turtle Tough pH/ORP Sensor has been engineered for installation into industrial processes. Use within the specifications is highly recommended to obtain optimal sensor life.

Care should be taken to avoid any moisture ingress through the cable inlet/outlet. pH Sensors are optimally installed at 45° as this avoids air bubbles being trapped at the sensor/process interface and ensures optimal glass/silver-chloride interaction. It is also acceptable to install vertically down. They should never be installed inverted (ie upside down).

All pH/ORP Sensors can be installed in-line. Submersible installation is also possible provided adequate waterproofing is selected at time of order or adequate sealing is made between the sensor and installation hardware at time of installation.

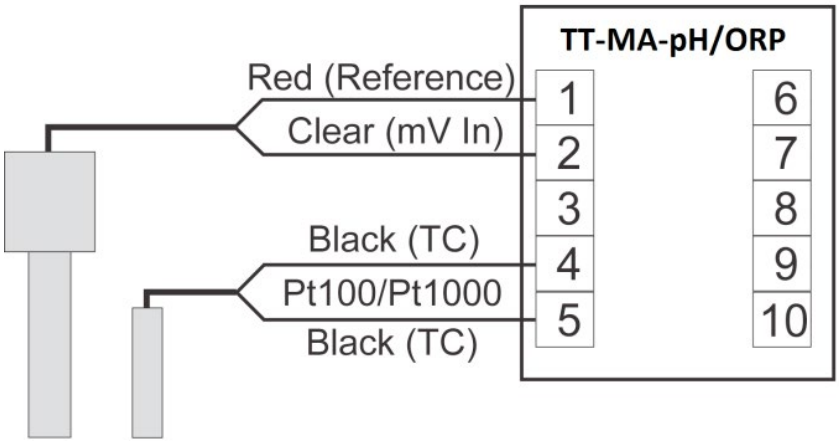
Turtle Tough has a range of installation hardware available as optional accessories including but not limited to KYNAR/PEEK Twistlock fittings, Stainless Steel Immersion Rods, Stainless Steel Sanitary Sensor Holders and Extension Tubes and Valve Retractable Assemblies. Contact your Turtle Tough Distributor for technical support on the optimal installation hardware to suit your application. Please Note: Avoid excessive force when installing pH/ORP Sensor.

## Wiring

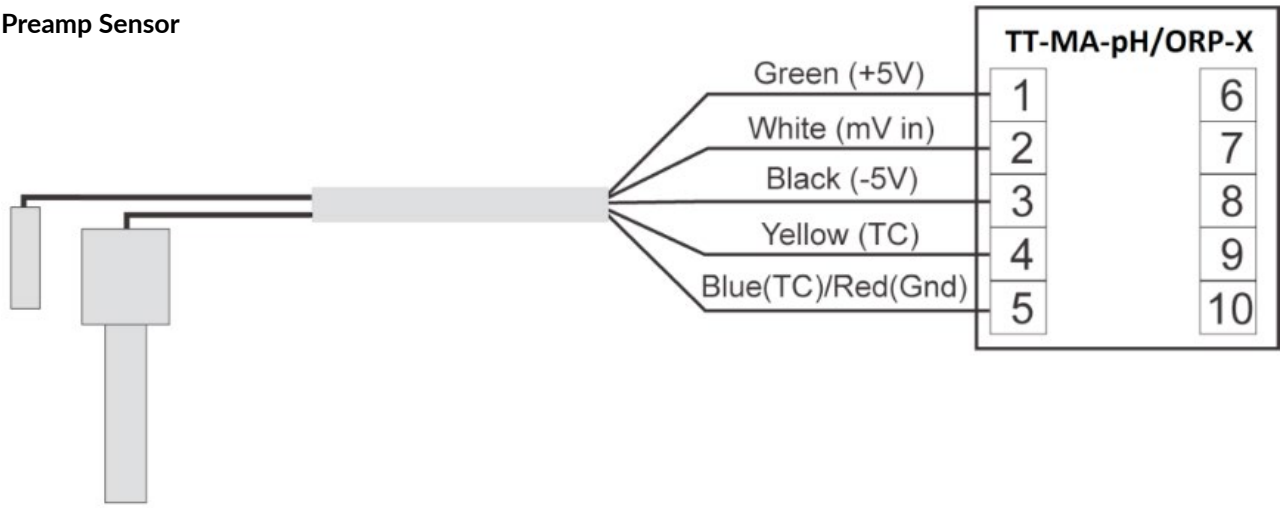
Caution

Turtle Tough pH/ORP Sensors are designed to provide optimal life when connected to a TT-MA Online Analyser. Wiring of Non-Preamp, Preamp and External Preamp Sensors to the TT-MA are as follows:

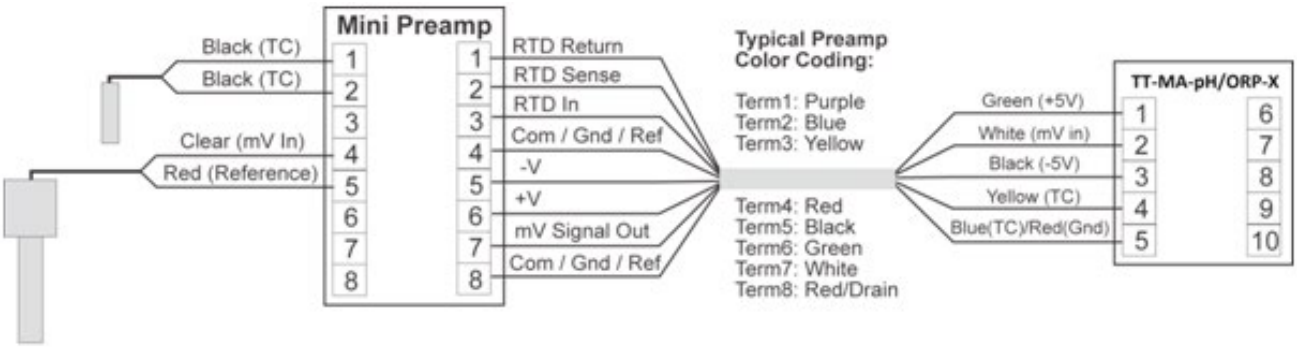
**Non-Preamp Sensor**




**Preamp Sensor**




**External Preamp Sensor**




**Note:** Please consult the Turtle Tough website [www.turtlesensors.com](http://www.turtlesensors.com) for additional wiring information.

## Menu Navigation

The TT-MA family has a 3 digit display and 6 LEDs for setup and displaying values. The Mode key is used to navigate. The LED marked Com is illuminated when MODbus is active. Programming the module is accessed by use of the 3 keys located on the front panel. The Mode key is for selecting setup and the Up and Down keys are used to scroll through the parameters. To adjust a parameter select with the Mode key then modify the value using the Up and Down keys.

### Lock Function

**Please note:** Parameter No. 01 is a LOCK function which MUST be turned OFF to change ANY parameter, including temperature, buffer and slope calibrations. The default for the lock is ON. Once the lock is OFF, if there is a period of inactivity for 60 seconds the lock then defaults back to ON.

Important

### Function and Programming

| No | Parameter | Description | Range | Default |
|---|---|---|---|---|
| **01** | Lock | Software Lock | On/Off | On |
| **02** | Address | MODbus | Off, 1...247 | Off |
| **03** | pH/mV | Type of Input | pH, mV | pH |
| **04** | Temperature | Type of Input | Pt100, Pt1000 | Pt1000 |
| **05** | Compensation | Temp. Comp. | Auto, Set | Auto |
| **06** | Manual Temp | Fixed Temp | 0...210 | 25 |
| **07** | Cable Impedance | Impedance of Pt100 Cable | 0.0 ... 9.9 Ohm | 0.0 |
| **08** | 3-Point Slope Option | Calibration of Sensor Slope | Off (2-Point), On (3-Point) | Off |
| **09** | Range mV | Range for mV | ±1000, -1000 to 0, 0 to +1000 | ±1000 |
| **10** | Input for Iout | Input used for output | pH or Temperature | pH |
| **11** | Iout | Type of output | 4-20mA, 0-20mA | 4-20 |
| **12** | Iout mode | Iout mode | Non-inverted, inverted | Non-inverted |
| **13** | 0/4mA Set | Low Set point | 0.0-13.0 pH | 0.0 |
| **14** | 20mA Set | High Set point | 1.0-14.0 pH | 14.0 |
| **15** | Step Change | mV Increment for Calibration | 0=0.2, 1=0.5, 2=1.0, 3=2.0 | 1 (0.5mV) |
| **16** | Offset | mV @ pH 7 | ±250 mV | 0 |
| **17** | Slope 1 | mV per pH | 30 to 90 | 59.2 |
| **18** | Slope 2 | mV per pH | 30 to 90 | --- |
| **19** | 0/4mA Offset | Trim Low | ±9.99% | 0.00 |
| **20** | 20mA Gain | Trim High | ±9.99% | 0.00 |
| **21** | Energy Save | Energy Save | On/Off | On |
| **22** | Baud rate | MODbus | 9,600/19,200 | 19,200 |
| **23** | Reset to Default | Reset to Factory Default | Def = Reset, Par=No Reset | Par |

## Parameters Explained

To access the programmable parameters see Menu Navigation. The following is a description of each parameter settings.

| Parameter | Description |
|---|---|
| **P01** | Software lock. If the software lock is set to **ON** the parameter can only be read.<br>Set Software Lock to **OFF** to change values. |
| **P02** | Sets the module's address for MODbus communication. |
| **P03** | Indicates the type of input for the pH/mV input. |
| **P04** | Indicates the sensor type for the temperature input. |
| **P05** | If parameter 3 is set to pH, the signal is temperature compensated. Parameter 5 sets the temperature compensation to either set (manual) or based on the measured temperature value (auto). |
| **P06** | Sets the temperature when temperature compensation of the pH measurement is set to manual mode. |
| **P07** | If a long cable is used for the Pt100 sensor the cable impedance should be entered and compensated for in this offset. |
| **P08** | Used to set how the pH sensor slope is calibrated. If 3-Point Slope Option is **ON**, the sensor is calibrated to have two different slopes for the acidic pH range (i.e. between 6.86/7.00 and 4.01 buffers) and the alkaline pH range (i.e. between 6.86/7.00and 9.18/10.00). If 3-Point Slope Option is **OFF**, the slope from a single slope calibration will be used in all pH ranges (0-14). |
| **P09** | If P03 is set to mV, the range is set using this parameter. It is possible to select the whole range (±1000mV), the negative range (-1000-0mV) or the positive range (0-1000mV). This setting impacts the analogue output and transferred data. |
| **P10** | Sets the analogue output proportional to either the pH/mV signal or the temperature signal. |
| **P11** | Sets the analogue output to either 0-20 mA or 4-20 mA. |
| **P12** | Allows setting the output to be inverted (i.e. for use in control) with the output corresponding to 20-0mA or 20-4mA. |
| **P13** | Sets the pH value that corresponds to 0/4mA output set point.<br>Note: The minimum difference between P13 and P14 must be at least 1.0 pH unit although it is fully scalable without the ranges specified. |
| **P14** | Sets the pH value that corresponds to 20mA output set point.<br>Note: The minimum difference between P13 and P14 must be at least 1.0 pH unit although it is fully scalable without the ranges specified. |
| **P15** | Variable that defines the mV change for each **Up** or **Down** button depression when calibration is performed. |
| **P16** | View and edit working sensor offset (Abs mV at pH 7). |
| **P17** | View and edit working sensor slope 1. If P08 is **OFF** (default) then slope for full 0-14 range.<br>If P08 is **ON** (3-Point Cal / Dual Slope mode) then this is the slope for 0-7 pH range. |
| **P18** | View and edit working sensor slope 2 for 7-14 pH range.<br>This is valid only if P08 is **ON**, or else just blank "---"no value. |
| **P19** | Offset adjustments for 0/4mA low analogue output trim. |
| **P20** | Gain adjustment for 20mA high analogue output trim. |
| **P21** | If no keys are pressed for 10 minutes the display will show a flashing bar (Energy Save). Pressing any key to return. |
| **P22** | The MODbus standard requires a baud rate of 9,600 or 19,200 set in accordance with the MODbus-master. |
| **P23** | Feature to reset the analyser back to factory default. |

## Calibration

This section covers calibration of Turtle Tough pH & ORP Sensors when mated with a TT-MA Analyser Module. If you are using a different analyser than this please consult the manual supplied with your unit or contact your Turtle Tough representative.

**pH Calibration - Buffer and Slope Adjustment**

- Ensure software lock is **Off** prior to commencement.
- Using **Mode** select **Offset** and calibrate to the first solution value by using the **Up** and **Down** keys.
- The recommend pH buffer for calibration is 6.86 (preferred) or 7.00.
- Next using **Mode** select **Slope** and use the **Up/Down** keys until the display reads the second solution value, typically using pH buffer 4.01 (when measuring pH<7) or pH Buffer 9.18 (preferred) or 10.00 (when measuring pH>7).

Enabling dual slope mode is recommended when the process media frequently crosses the pH 7 boundary. The dual slope mode is disabled **(Off)** by default, but can be enabled by setting parameter P08 to the **On** state. When dual slope is enabled, the pH sensor is calibrated at three points: one near pH 7 (in **Buffer** mode), then in a pH buffer below pH7 (in **Slope** mode) and then in a pH buffer above pH7 (in **Slope** mode).

**You must exit the Slope mode by using the mode key after completing the acidic slope (below pH7) calibration before entering the alkaline slope (above pH7) calibration.**

The **Offset** calibration can achieve a process offset whereby the online reading can be made to agree with any grab sample analysis. All calibrations are saved instantaneously as they are performed so there is no “save” or “enter” operation required. Note that a two (2) second dampener exists for both calibrate modes and a ten (10) second dampener for the measure mode.

The temperature can be calibrated by pushing the **Up** and **Down** buttons when in the temperature display (°C) mode provided the software lock is **Off.**

**ORP Calibration**

Unlike pH two point calibrations which establishes offset and slope, an ORP Calibration is a single point offset adjustment. Ensure software lock is **Off** prior to commencement. Using **Mode** select **Slope**

(Note: **Offset** will not be an option) and calibrate to the mV value of your prepared calibration solution by using the **Up** and **Down** keys.

Fresh mV Solution is required to ensure accurate calibration.
Unlike a pH buffer they do not self- stabilise and deteriorate in air.
Solutions will maintain ideal values for about two hours.

## Troubleshooting

There are many potential issues that are involved in the uncertainty of an online pH/ORP measurement. Some of the most common possible issues are summarised below and may be applicable to your particular installation:

### Raw mV Display

For troubleshooting it is often useful to access the raw uncompensated mV potential of the pH sensor. When assisting you with a diagnosis, a Turtle Tough customer representative may ask you to place the analyser into the

**Raw mV Display mode.** This can be accessed by pressing the **Down** key in the main pH/mV display mode. The display now changes from pH to mV units. Negative values will be displayed as flashing.

### Common Thermal Related Issues

Make sure that the online industrial sensor is in thermal and chemical equilibrium with the process before making any one-point offset calibration. Please note that sensors that run in hot processes should be allowed to cool down to room temperature before performing a 2-point calibration. The temperature indicated on the sensor can be used as a gauge of when it is ready to proceed with a calibration having reached a thermal equilibrium with ambient conditions. Calibrating a pH sensor when it is not at thermal equilibrium is a very common cause of calibration error.

### Common Offset Type Issues

If the display of the online sensor diverges from the lab expected reference value it is possible to force agree between these two readings with the TT-MA-pH analyser even after a calibration has been performed with pH buffers. Such a one point grab sample type offset calibration is performed when in the Offset LED mode.

Navigate with the Mode key to the Offset mode while the pH sensor is installed into the process and while the reading is quite stable. Use the Up and Down keys to adjust the displayed value to agree with the laboratory determined reference value if desired. Such a grab sample offset type calibration should only be performed after all pH buffer calibrations have been completed.

### Temperature effects on pH Reading

More generally, note that temperature compensation for pH mode ONLY accounts for the change in potential of the pH sensor itself due to temperature. Any other temperature induced changes to the pH of any given solution (such as changing the effective mean activity coefficient or equilibrium of the process media or pH buffer) are NOT accounted for by temperature compensation and thus must all be considered separately. Lastly, for ORP measurements there exists no temperature compensation at all meaning that temperature displayed is simply for reference purposes.

**pH Buffer During Calibration**

Since the TT-MA-pH/ORP analyser does not automatically correct for the temperature effects on your particular pH buffer, you will need to manually enter the correct buffer pH value at your particular temperature to ensure optimum accuracy during the calibration process. Each pH buffer solution is always labeled with the pH value at various temperatures so that you can adjust the pH to the appropriate number. Temperature compensation on the TT-MA-pH does not account for the change in the pH buffer values due to temperature and so this correction must be done manually.

**pH Buffer Accuracy and Stability Issues**

It is important to consider that some pH buffers degrade in quality much more quickly than others when left open to air, or else with exposure to heat and/or light. In particular, both commonly used pH buffer 7.00 and 10.00 are notorious for losing the accuracy of their values when exposed to the air, sunlight or just simply degrade with time. In contrast, the 4.01 pH buffer is a well-known VERY stable pH buffer and so is the industry default standard for both conditioning and spot 1-point tests for pH sensors.

One important step to ensure accurate calibrations with pH buffers is to check whether the buffers employed are still within the expiry period and that they were stored in a cool, dry storage location away from sunlight. In addition to the 4.01 pH buffer, the 6.86 and 9.18 pH buffers are amongst the most stable pH buffers available.

It is strongly recommend colourless pH buffers be used rather than the more common coloured pH buffers. If coloured pH buffers are used for calibrations, it is important that they are NOT also used as the conditioning solution in which pH sensors are stored (this should be reserved for colourless type pH buffers).

For higher value pH buffers (10+) it is recommended to purchase only smaller amounts (to ensure that they stay within expiry) and keeping them stored in a sealed container in a cool, dry place. This minimises the absorption of carbon dioxide from the air that can alter the value of these high pH buffers. In general, the higher value pH buffers are very unstable, much as the very low pH buffers also tend to be rather more unstable.

The best available option for calibration of pH above 10 is the 12.45 type pH buffer. The best available option for calibration of pH below 4 is the 1.68 type pH buffer. For general purpose calibrations, the MOST stable pH buffers are 4.01 and 6.86 and to a lesser degree 9.18. If the preferred 6.86 or 9.18 buffers are not available, then 7.00 and 10.00 buffers can be substituted with some slight loss of precision due to the differences in relative pH buffer stabilities.

## Sensor Care and Maintenance

**Maintenance Free**

Turtle Tough pH and ORP sensors are a completely sealed assembly and are sealed for life. This provides extreme process resistance as well as a totally maintenance free sensor which greatly increases sensor life and reduces labour costs. A Turtle Tough sensor does not contain any O-rings, washers, gaskets, or serviceable components/ assemblies. It does not require refreshing or refilling of electrolyte. The only requirement is regular cleaning in accordance with our recommended cleaning schedule for your application.

**----- Regular cleaning will prolong the life of your sensor and ensure hassle free operation. -----**

**Storage**

- The standard shelf life for all Turtle Tough pH and ORP sensors is one year from the date of shipment.
- Sensors stored longer than this period may still be functional but are no longer under warranty.
- Sensors should be stored in a cool, dry location with the sensor tip (sensing element) oriented toward the ground.

All sensors come standard with a conditioning solution in the cap. This conditioning solution is 50% pH 4 buffer and 50% saturated potassium chloride (mixed by volume). The sensor cap should be kept tightly affixed to the sensor body and sealed with common PVC tape when the sensor is not in use. Sensors that are to be returned for shelf life warranty claim must have the original sensor cap and conditioning solution intact to be eligible for warranty replacement.

**Cleaning a Turtle Tough pH/ORP Sensor: Recommended Cleaning Schedule**

The recommended cleaning interval is based upon the difficulty index for your application.
Please contact your agent or refer to the website to identify your difficulty rating.

| Application Difficulty Rating | Cleaning Schedule |
|---|---|
| 1-3 | Monthly |
| 4-6 | Fortnightly |
| 6-7 | Weekly |
| 8-9 | Twice (2x) per week |
| 10 | Daily |

If a Turtle Tough pH/ORP sensor response slows down, it is most likely the result of a fouled reference or dirty coated glass. Cleaning should be performed as required and will vary across applications.

Cleaning requirements will vary depending on the application for which the sensor is used. The following should always be observed when cleaning:

- Never scratch or aggressively scrub the pH or ORP (sensing) elements. These are delicate glass electrochemical electrodes. They can be easily broken by mechanical force.
- The reference junction is a solid state material and can be cleaned with aggressive chemicals. See list below of recommended cleaning solutions. This solid state reference can also be cleaned effectively by using a sharp razor edged tool.
- Great care should be taken not to scratch the pH glass or ORP element during cleaning of the reference junction.

**Cleaning Kit (optional)**

Turtle Tough recommend the use of our cleaning kit Part Number: TT-SCK-3001 to clean the sensor. This kit has been specially formulated to provide optimal care for the sensing element and reference components to enhance sensor life and performance. The kit contains a special powdered glass cleaner/polish, sensor conditioning solution, 10% HCl solution, and various tools for polishing the glass and cleaning the reference.

**Instructions for use:**

- Use brush to remove large solids and contaminants from sensor tip while rinsing under tap water.
- Soak in HCl solution for a minimum of 10 minutes, longer if required to dissolve deposits.
- Rinse thoroughly with water.
- Use blade to scrape the reference material clean, avoiding contact with the glass or sensing element.
- Empty a small amount of glass cleaning powder (1/4 tsp) into the beaker. Wet a cotton bud tip and make a paste with the powder. Apply the paste to the glass with cotton bud and polish the glass tip to remove any film or coatings.
- Rinse thoroughly with water.
- Soak sensor in conditioning solution for at least 10 minutes, longer if required to improve sensor response. (see Conditioning for Calibration below).

**Other commonly available approved cleaning solutions include:**

- 5-15% Hydrochloric Acid – (For Alkaline deposits)
- 5-15% Sodium Hydroxide – (For Organic Contaminants)
- Surfactant (non-ionic soaps such as micro-90)
- Please contact your local Turtle Tough representative if you plan to use any other cleaning agent.

**Conditioning for Calibration**

After the sensor has been cleaned, it must be thoroughly rinsed with deionised water to remove any residual cleaning reagents. The sensor can then be soaked in pH 4 buffer to recondition the pH and reference elements. Some sensors will also require conditioning in saturated potassium chloride if the reference junction has been depleted of the ions in the solid state conductive polymer (typical for clean water applications). Condition the sensor in saturated potassium chloride and/or pH 4 buffer for whatever period of time is required to achieve optimal calibration results.

**Avoiding Thermal Shock**

For high temperature applications where process liquid exceeds 70°C you will prolong the life of the sensor by avoiding thermal shock. Thermal shock occurs when you rapidly change the temperature of the sensor from hot to cold or vice versa. This rapid expansion/contraction of sensor components can damage internal elements and cause micro-cracking that will accelerate the rate of deterioration. In extreme cases it will crack the sensing element causing a total failure. To avoid this, the sensor should be heated or cooled slowly during removal/ insertion and cleaning and calibration processes. Consult your Turtle Tough representative for techniques to avoid thermal shock.

## MODbus Communication Option

MODbus communication is an option for the pH/ORP Analyser Module and must be specified at time of order. Turtle Tough Analyser Modules may be used as a slave for the Datalogging Module or as a slave in a SCADA data acquisition system. The setup and communication for each case is explained below.

### Datalogging Module and MODbus

If the pH/ORP Module is used with the Datalogging Module, the baud rate on the pH/ORP Module as well as the address should be noted. The baud rate (P22) must be set to the baud rate of the Datalogging Module. Whether a baud rate of 19,200 or 9,600 is used is of no importance, as long as all units connected to the Datalogging Module are set to the same baud rate. The address (P02) must be unique in the network; Two units cannot have the same address. In a network with the Datalogging Module as the master, all addresses must be assigned in series; i.e. if 3 units are connected the addresses 1, 2 & 3 must be assigned to the three units. The order of the addresses is of no importance. In a network with a Datalogging Module, up to 63 Analyser Modules (slaves) may be connected.

### SCADA System and MODbus

The baud rate (P22) must be set to the baud rate of the SCADA system. The address (P02) must be unique in the network and up to 247 Analyser Modules may be connected on a single network.

### MODbus Scaling

The pH/ORP MODbus Analyser Module in pH mode has the full 0-14 pH range and in ORP mode it will be set in P09 (mV range). Note that the MODbus scaling can differ from 0/4-20 mA analogue scaling for both units. The pH/ORP MODbus Analyser Module contains 2 measurements (pH/mV and temperature). Access is gained through function code ***Read_Input_Registers (04).***

### Read Input Registers

| Function Code | Start Address | Number of Values |
|---|---|---|
| 04 | 1 | 1 or 2 |

Value 1 is pH/mV and value 2 is temperature. The measurements are transmitted in sequence; If 2 values are chosen both pH/mV and temperature are transmitted. If the value for temperature is wanted, 2 values must be requested. Both values are rated 0-1000 corresponding to the range, but the temperature has an offset of 1024; i.e. 0-14pH is transmitted as 0-1000 & 0-210°C as 1024-2024.

The Module gives access to different diagnostic values as well via Diagnostics (08) as shown in the table below.

| Function Code | Sub Code (HEX) | Description |
|---|---|---|
| **08** | 00 | Return Query Data |
| | 0A | Clear counters and diagnostics register |
| | 0B | Return Bus Message Count |
| | 0C | Return Bus Message Communication Error |
| | 0D | Return Exception Error count |
| | 0E | Return Slave Message count |
| | 0F | Return Slave No Response count |
| | 12 | Return Bus Character Overrun count |

# Contacting Conductivity Analyser Module


## Specifications

| | |
|---|---|
| **Power Supply** | 24VDC ±10% |
| **Consumption** | 60 mA max |
| **Sensor** | 2-Wire Contacting Cell |
| **Measuring Range** | See Par. 21 for Max Full Range |
| **Cell Constant** | See Par. 22 (Nominal) & 15 (Gain) |
| **Accuracy** | ±1% Excluding Sensor (Ideal) |
| **Temp Sensor** | Pt100, Pt1000 |
| **Temp Range** | 0-210°C ± 0.3°C |
| **Temp Comp** | Fixed (Manual) or Automatic using Temperature (TC) Measurement |
| **Analogue Output** | 0-20mA or 4-20mA, max. 500Ω |
| **Output Hold** | Automatic when in calibration mode |
| **Housing** | Lexan UL94V-0 (Upper part) Noryl UL94V-0 (Lower part) |
| **Mounting** | M36 for 35 mm DIN rail |
| **IP Class** | Housing IP40. Connector IP20 |
| **Connector** | Max 16A. Max 2.5mm$^2$<br>Max torque 0.6 Nm |
| **Temperature** | Usage -15 to +50 °C (Storage -35 to +75 °C) |
| **Weight** | 75 grams (2.64 ounces) |
| **Dimensions** | L 86 x W 36 x H 58 mm (3.4” X 1.4” X 2.3”) |
| **CE mark** | EN61326A |

## Conductivity Sensor Theory of Operation

**What is Conductivity?**
Conductivity is the ability of a solution, a metal or a gas - in brief all materials - to pass an electric current. In solutions the current is carried by cations and anions whereas in metals it is carried by electrons.

How well a solution conducts electricity depends on a number of factors:
- Concentration
- Mobility of ions
- Valence of ions
- Temperature

All substances possess some degree of conductivity. In aqueous solutions the level of ionic strength varies from the low conductivity of ultra-pure water to the high conductivity of concentrated chemical samples.

**How is Conductivity measured?**
Conductivity may be measured by applying an alternating electrical current (I) to two electrodes immersed in a solution and measuring the resulting voltage (V). During this process, the cations migrate to the negative electrode, the anions to the positive electrode and the solution acts as an electrical conductor.

**Conductance**
Conductance (G) is defined as the reciprocal of the electrical resistance (R) of a solution between two electrodes.

$$G = 1/R \text{ (S)}$$

A Conductivity Analyser measures the conductance, and displays the reading converted into conductivity.

**Cell constant**
This is the ratio of the distance (d) between the electrodes to the area (a) of the electrodes.

$$K = d/a$$

Where:

**K** = cell constant ($cm^{-1}$)

**a** = effective area of the electrodes ($cm^2$)

**d** = distance between the electrodes (cm)

**Conductivity**
Electricity is the flow of electrons. This indicates that ions in solution will conduct electricity. Conductivity is the ability of a solution to pass current. The conductivity reading of a sample will change with temperature.

$$\kappa = G \bullet K$$

Where:
**κ** = conductivity (S/cm)
**G** = conductance (S), where G = 1/R
**K** = cell constant ($cm^{-1}$)

**Temperature and Conductivity**

Increasing the temperature of an electrolyte solution always increases the conductivity. The increase is significant, between 1.5 and 5.0% per °C. To compensate for temperature changes, conductivity readings are commonly corrected to the value at a reference temperature, typically 25°C. All process conductivity sensors have integral temperature sensors that allow the Analyser Module to measure the process temperature and correct the raw conductivity.

Three temperature correction algorithms are in common use:

- Linear temperature coefficient
- High purity water or dilute sodium chloride
- Cation conductivity or dilute hydrochloric acid

No temperature correction is perfect. Unless the composition of the process liquid exactly matches the model used in the correction algorithm, there will be an error. In addition, errors in the temperature measurement itself will lead to errors in the corrected conductivity.

**Cable Correction**

The cable correction takes into account the cable resistance and the cable capacitance.

$$Gm = Gs/1 + (Rc \bullet Gs)$$

Where:

**Gm** = measured conductance (S)

**Gs** = solution conductance (S)

**Rc** = cable resistance (Ω)

## Electrical and Sensor Connections

### Installation

As with all instrumentation, the installation and commissioning of this sensor is crucial to its safe and effective operation. This sensor must only be used for its purpose as outlined in this manual. It must be installed and commissioned in accordance with this manual and by trained, qualified personnel.


Danger

### Sensor Site Selection

Please choose a suitable location for the installation of the sensor. The choice of installation point on any site is a compromise and is best undertaken by an experienced installation engineer. The following is a list of the factors that need to be taken into consideration.


Important

- Ensure that the sensor is positioned to ensure adequate flow.
- Avoid installing the sensor within 1m of any dosing point.
- Minimise all potential sources of electrical interference.
- Static & Ground Loop Faults can damage the sensor or cause erroneous readings and all precautions should be taken to avoid them.

**Note:** This list is not intended as a check-list neither is it implied that the list is complete.

### Unpacking

- Please have a copy of your order with you when you unpack your instrument. All orders are checked when they leave the factory.
- Please check that you have all the parts that were ordered as soon as you open the box. If anything is missing, or damaged, please contact your sales outlet immediately.
- If the instrument needs to be returned for any reason please follow the return instructions given in this manual.


Important

### Mounting

A Turtle Tough Conductivity Sensor has been engineered for installation into industrial processes. Use within the specifications is highly recommended to obtain optimal sensor life.


Caution

Care should be taken to avoid any moisture ingress through the cable inlet/outlet.
Conductivity Sensors are optimally installed at 45° as this avoids air bubbles being trapped at the sensor/process interface.

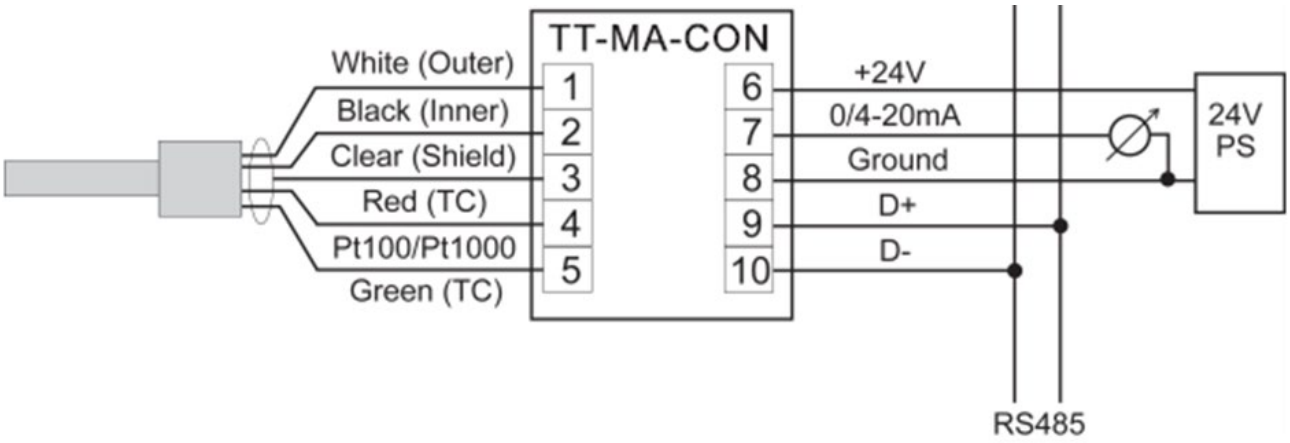
All Conductivity Sensors can be installed in-line. Submersible installation is also possible provided adequate waterproofing is selected at time of order or adequate sealing is made between the sensor and installation hardware at time of installation for example.

Turtle Tough has a range of installation hardware available as optional accessories including but not limited to Stainless Steel Immersion Rods, Stainless Steel Sanitary Sensor Holders & Extension Tubes and Valve Retractable Assemblies. Contact your Turtle Tough Distributor for technical support on the optimal installation hardware to suit your application.

**Please Note:** Avoid excessive force when installing Conductivity Sensors

## Wiring

Turtle Tough Conductivity Sensors are designed to provide optimal life when connected to a TT-MA Online Analyser. Wiring of a Conductivity Sensor to the TT-MA is as follows:




**Note:** Please consult the Turtle Tough website www.turtletoughsensors.com for additional wiring information.

## Menu Navigation

The TT-MA family has a 3 digit display and 6 LEDs for setup and displaying values.
The **Mode** key is used to navigate.
The LED marked **Com** is illuminated when MODbus is active.
**Programming** the module is accessed by use of the 3 keys located on the front panel.
The **Mode** key is for selecting setup and the **Up** and **Down** keys are used to scroll through the parameters.
To adjust a parameter select with the **Mode** key then modify the value using the **Up** and **Down** keys.

### Lock Function


Important

**Please Note:** Parameter No. 01 is a LOCK function which **MUST** be turned **OFF** to change ANY parameter. The default for the lock is **ON.** Once the lock is **OFF,** if there is a period of inactivity for 60 seconds the lock then defaults back to **ON.**

### Function and Programming

| No | Parameter | Description | Range | Default |
|---|---|---|---|---|
| **01** | Lock | Software Lock | On / Off | On |
| **02** | Address | MODbus | Off, 1...247 | Off |
| **03** | Temperature | Type of Input | Pt100, Pt1000 | Pt1000 |
| **04** | Compensation | Temp. Compensation | Auto, Fixed | Auto |
| **05** | Comp. Temp. | Compensating Temp. | 0...210 | 25 |
| **06** | Temp. Comp. Factor | Compensation Factor | 0.50-5.00 %/°C | 2.10 |
| **07** | Wire Gauge | Sensor AWG | 20, 22, 24 | 22 |
| **08** | Cable Length | Length in feet | 1...999 feet | 10 |
| **09** | Input for Iout | Input used for output | Conductivity or Temp. | Conductivity |
| **10** | Iout | Type of output | 4-20mA, 0-20mA | 4-20 |
| **11** | 0/4mA Set | Low Set point | 0-90% of Full Range | 0% |
| **12** | 20mA Set | High Set point | 10-100% of Full Range | 100% |
| **13** | Step Change | Increment for Calibration | 0=0.1%, 1=0.2%, 2=0.5%, 3=1.0% | 2 (0.5%) |
| **14** | Offset Adjustment | Zero Calibration | 0=0.1%, 1=0.2%, 2=0.5%, 3=1.0% | N/A |
| **15** | Working Gain (Slope) | Gain on Cell Constant | ±50% or ±70% | 1.00 |
| **16** | 0/4mA Offset | Trim Low | ±9.99% | Factory |
| **17** | 20mA Gain | Trim High | ±9.99% | Factory |
| **18** | Energy Save | Energy Save | On / Off | On |
| **19** | Baud rate | MODbus | 9,600/19,200 | 19,200 |
| **20** | Reset to Default | Reset to Default | Def=Reset,Par=No Reset | Par |
| **21** | Full Range | Max Range | Per Cell K | N/A |
| **22** | Nominal Cell Constant | Cell Constant a.k.a. "K" | As defined on order | N/A |
| **23** | Iout mode | Iout modetion | Non-inverted, inverted | Non-inverted |
| **24** | Not Utilised | | | |
| **25** | Not Utilised | | | |
| **26** | Reset Cals Only | Reset P14, & P15 Cals | 20, 22, 24 | Par |

**Parameters Explained**

To access the programmable parameters see Menu Navigation. The following is a description of each parameter settings.

| | |
|---|---|
| **P01** | Software lock. If the software lock is set to ON the parameter can only be read. Set Software Lock to OFF to change values. |
| **P02** | Sets the module's address for MODbus communication. |
| **P03** | Indicates the sensor type for the temperature input. |
| **P04** | Sets the temperature compensation to either set (manual) or based on the measured temperature value (auto). |
| **P05** | Sets the temperature when temperature compensation of the Conductivity measurement is set to manual mode. |
| **P06** | Is the temperature compensation coefficient used, expressed in %/°C units (valid for auto or manual TC mode). |
| **P07** | The wire gauge (AWG) for the sensor cable used. |
| **P08** | The length of sensor cable in units of feet. |
| **P09** | Select the conductivity measurement (S) or temperature measurement (°C) signal used for the analogue output. |
| **P10** | Sets the analogue output to either 0-20 mA or 4-20 mA. |
| **P11** | Sets the conductivity value that corresponds to 0/4mA output set point. **Note:** The minimum difference between P11 and P12 must be at least 10% of full range scaling per parameter P21. |
| **P12** | Sets the conductivity value that corresponds to 20mA output set point. **Note:** The minimum difference between P11 and P12 must be at least 10% of full range scaling per parameter P21. |
| **P13** | Step change for up or down button during calibration. |
| **P14** | Zero offset calibration done when sensor is dry in air. |
| **P15** | Set/display the gain on cell constant. The effective cell constant is the product of P15 (gain) and P22 (nominal cell). |
| **P16** | Offset adjustments for 0/4mA low analogue output trim. |
| **P17** | Gain adjustment for 20mA high analogue output trim. |
| **P18** | If no keys are pressed for 10 minutes the display will show a flashing bar (Energy Save). Pressing any key to return. |
| **P19** | The MODbus standard requires a baud rate of 9,600 or 19,200 set in accordance with the MODbus master. |
| **P20** | Feature to reset the analyser back to factory default. |
| **P21** | Shows the full range of the particular TT-MA-CON module/analyser. This is a display (read-only) parameter. P21 and P22 are set at the factory prior to dispatch and cannot be changed in the field. |
| **P22** | Represents the nominal conductivity cell constant. This is a display (read-only) parameter. Both P21 and P22 are set at the factory prior to dispatch and cannot be changed in the field |
| **P23** | Allows setting the output to be inverted (i.e. for use in control) with the output corresponding to 20-0mA or 20-4mA. |
| **P24** | This parameter is not utilised. |
| **P25** | This parameter is not utilised. |
| **P26** | Resets back to factory default parameters P14 (Zero Offset) and P15 (Working Gain) without affecting any other settings. |

## Calibration

Ensure software lock is Off prior to commencement and the sensor is clean and free from air bubbles inside the measuring cell. For best results the conductivity sensor should be at temperature equilibrium prior to commencing any calibration.

**Temperature Calibration**
The temperature can be calibrated by pushing the Up or Down buttons when in the temperature display (°C) mode.

**Zero Calibration**
A zero calibration is performed with the sensor clean and dry and exposed to only air using Par no. 14, with the step change as determined in Par no. 13.
**Care should be taken when making adjustments as this is a sensitive calibration.**

**Wet Calibration**
Once the Temperature and Zero Calibrations have been performed, a wet calibration can be conducted using either a standard conductivity solution or a grab sample where the conductivity value has been determined. Using **Mode** select **Gain**, then use **Up** or **Down** to adjust the readout corresponding to the expected value.

The adjustment may be ±50% or ±70% from nominal value depending upon model, and may be entered manually using Par No. 15. The effective cell constant is found by multiplying the nominal cell constant (P22) with effective gain (P15).

**NOTES:**
- The raw (uncompensated) conductivity can be viewed by pushing the **Down** button in the main measure display mode.
- When performing a zero calibration, care must be taken not to over-run zero and place the unit in negative values as this will require the calibration values to be reset (via parameter 26) and the process will need to be restarted.
- Standard Conductivity Solutions vary with temperature and this must be accounted for when conducting a calibration.
- The conductivity sensor should be cleaned prior to calibration and free from air bubbles inside the measuring cell to ensure proper results.

## Troubleshooting

There are many potential issues that are involved in the uncertainty of an online conductivity measurement. Some of the most common possible issues are summarised below and may be applicable to your particular installation.

### Raw mV Display

For troubleshooting it is often useful to access the raw uncompensated mV potential of the conductivity sensor. When assisting you with a diagnosis, a Turtle Tough customer representative may ask you to place the analyser into the **Raw mV Display** mode. This can be accessed by pressing the **Down** key in the main Con/mV display mode. The display now changes from Conductivity to mV units. Negative values will be displayed as flashing.

### Erratic Readings

Trapped Air Bubbles can cause the system to produce erratic or unexpected readings. On the chance that bubbles are the whole problem there is a good way to check for them. The sensor entry from the top of a line or vessel often results in an air-trapping cavity around the short sensor stem. If this sort of installation was used, examine it and make sure that the sensor tip is completely submerged at all times.

To check for the presence of bubbles gently rap the sensor back cap sharply from the side several times with the plastic or wooden handle of a screwdriver. This will sometimes dislodge outgassing bubbles that form on all the surfaces of a sensor and you can observe a sudden increase in conductivity when the sensor is struck a few times. Use common sense about how hard to hit the sensor. Hold the screwdriver loosely by the blade between your thumb and forefinger to control the amount of muscle that goes into the raps. Naturally, there is no warranty for hammer blows that result in mechanical damage to the sensor.

### Lower Than Expected Readings

If the system is providing results less than the expected values then this could be due to the sensor being fouled. Sensor cleaning should be undertaken to resolve the issue.

### Higher Than Expected Readings

Should higher than expected readings be experienced then this could be due to a short in the sensor and may be an indication that the sensor is coming to the end of its useful life.

### Common Thermal Related Issues

Make sure that the online industrial sensor is in thermal and chemical equilibrium with the process before making any calibration. The temperature indicated on the sensor can be used as a gauge of when it is ready to proceed with a calibration having reached a thermal equilibrium with ambient conditions.

Calibrating a sensor when it is not at thermal equilibrium is a very common cause of calibration error.

## Sensor Care and Maintenance

**Maintenance Free**

Turtle Tough Conductivity sensors are a completely sealed assembly and are sealed for life. This provides extreme process resistance as well as a totally maintenance free sensor which greatly increases sensor life and reduces labour costs. A Turtle Tough sensor does not contain any O-rings, washers, gaskets, or serviceable components/ assemblies. The only requirement is regular cleaning in accordance with our recommended cleaning schedule for your application. Regular cleaning will prolong the life of your sensor and ensure hassle free operation.

**Storage**

The standard shelf life for all Turtle Tough Conductivity sensors is one year from the date of shipment. Sensors stored longer than this period may still be functional but are no longer under warranty. Sensors should be stored in a cool, dry location.

**Cleaning a Turtle Tough Conductivity Sensor: Recommended Inspection Schedule**

The recommended inspection interval requirements is based upon the difficulty index for your application. Please contact your agent or refer to the website to identify your difficulty rating.

| Application Difficulty Rating | Cleaning Schedule |
|---|---|
| 1-5 | Monthly |
| 5-7 | Fortnightly |
| 8-10 | Weekly |

**Cleaning should be performed as required and will vary across applications.**

In order to ensure proper readings, it is necessary to scrub the center electrode, vent hole and in general the lower half of the outer body around the cross-hole of the sensor upon sufficient fouling in service.

- Use a soft tuft pipe cleaner or a Q-tip to wipe down the center electrode. Do this by inserting it into the cross-hole and rotate.
- Clean the sensor with your choice of hot detergent in water or isopropyl alcohol solvent. All sensors except those with CPVC insulators or sensor body material of construction can also be cleaned with acetone as well.
- In the event of hard scale, try vinegar first, or some mild acid solution. Any solution that will dissolve what is coating the surface is encouraged so long as it does not otherwise damage the electrodes, insulator, or sensor body.
- It is possible to get clear coatings of a hard substance in some processes. If such a coating is suspected, a high grit (400 grade or higher) sandpaper can be used to remove it. This procedure should not be done routinely as it removes metal from the already small electrode. It should be noted that coatings of this nature are rare outside of boiler applications.

The same cleaning remedies and tests apply to the body of the sensor, which is the outer electrode, except you don't have to worry about access or Q-tips.An ultrasonic cleaning bath may also be used with an all-purpose surface cleaning solution or detergent and hot water. The all purpose commercial detergent Simple Green or similar can also work effectively for such cleaning tasks. For biological fouling a solution of 50% bleach and 50% water will do a good stripping job with warm or hot water giving best results. Soak the tip in this solution for anywhere from 30 to 60 minutes for most situations. A good detergent cleaning without rinsing will minimise air bubbles upon reinsertion if the detergent residue can be tolerated.

## MODbus Communication Option

MODbus communication is an option for the Contacting Conductivity Analyser Module and must be specified at time of order. Turtle Tough Analyser Modules may be used as a slave for the Datalogging Module or as a slave in a SCADA data acquisition system. The setup and communication for each case is explained below.

### Datalogging Module and MODbus

If the Contacting Conductivity Module is used with the Datalogging Module, the baud rate on the Conductivity Module as well as the address should be noted. The baud rate (P19) must be set to the baud rate of the Datalogging Module. Whether a baud rate of 19,200 or 9,600 is used is of no importance, as long as all units connected to the Datalogging Module are set to the same baud rate.

The address (P02) must be unique in the network; Two units cannot have the same address. In a network with the Datalogging Module as the master, all addresses must be assigned in series; i.e. if 3 units are connected theaddresses 1, 2 and 3 must be assigned to the three units. The order of the addresses is of no importance. In a network with a Datalogging Module, up to 63 Analyser Modules (slaves) may be connected.

### SCADA System and MODbus

The baud rate (P19) must be set to the baud rate of the SCADA system. The address (P02) must be unique in the network and up to 247 Analyser Modules may be connected on a single network.

### MODbus Scaling

The MODbus scaling for the conductivity process measurement output is the same as the analogue output range as defined by P11 (low 0/4mA setpoint) and P12 (high 20mA setpoint). The Contacting Conductivity MODbus Analyser Module contains 2 measurements (Conductivity and temperature). Access is gained through function code Read_Input_Registers (04).

### Read Input Registers

| Function Code | Start Address | Number of Values |
|---|---|---|
| 04 | 1 | 1 or 2 |

**Value 1** is Conductivity **Value 2** is temperature

The measurements are transmitted in sequence; If 2 values are chosen both Conductivity and temperature are transmitted. If the value for temperature is wanted, 2 values must be requested. Both values are rated 0-1000 corresponding to the range, but the temperature has an offset of 1024; i.e. the conductivity range as set by P11 and P12 is transmitted as 0-1000 & 0-210°C as 1024-2024. The Module gives access to different diagnostic values as well via Diagnostics (08) as shown in the table below.

| Function Code | Sub Code (HEX) | Description |
|---|---|---|
| **08** | 00 | Return Query Data |
| | 0A | Clear counters and diagnostics register |
| | 0B | Return Bus Message Count |
| | 0C | Return Bus Message Communication Error |
| | 0D | Return Exception Error count |
| | 0E | Return Slave Message count |
| | 0F | Return Slave No Response count |
| | 12 | Return Bus Character Overrun count |

# Galvanic Dissolved Oxygen (DO) Analyser Module


## Specifications

| | |
|---|---|
| **Power Supply** | 24VDC ±10% |
| **Consumption** | 60 mA max |
| **Resolution** | 0.01 ppm anywhere in the range |
| **Galvanic Sensor** | 1.0-6.0 mV per ppm |
| **Response Range** | 0.25-2.50 mV per % saturation |
| **Accuracy** | ±1% Excluding Sensor (Ideal) |
| **Temp Sensor** | Pt100, Pt1000 |
| **Temp Range** | 0-50°C ± 0.2°C |
| **DO Temp Comp** | Automatic in all configurations |
| **Analogue Output** | 0-20mA or 4-20mA, max. 500Ω |
| **Housing** | Lexan UL94V-0 (Upper part)<br>Noryl UL94V-0 (Lower part) |
| **Mounting** | M36 for 35 mm DIN rail |
| **IP Class** | Housing IP40. Connector IP20 |
| **Connector** | Max 16A. Max 2.5mm$^2$<br>Max torque 0.6 Nm |
| **Temperature** | Usage -15 to +50 °C (Storage -35 to +75 °C) |
| **Weight** | 75 grams (2.64 ounces) |
| **Dimensions** | L 86 x W 36 x H 58 mm (3.4” X 1.4” X 2.3”) |
| **CE mark** | EN61326A |

## Galvanic Dissolved Oxygen Sensor Theory of Operation

A membrane-type dissolved oxygen sensor using a galvanic cell consists of a:

- Cathode
- Anode
- Electrolyte which is an alkaline solution
- Membrane which is highly oxygen-permeable and usually Teflon

Oxygen is consumed by the cathode which will create a partial pressure across the membrane. Oxygen then diffuses into the electrolyte solution. In short, a Dissolved Oxygen meter actually measures the pressure caused by movements of oxygen molecules in water or any other medium. Galvanic Electrodes produce a millivolt output directly proportional to the oxygen present in the sample. The electrode reaction is instantaneous and a result is obtained immediately.

In theory, the amount of Dissolved Oxygen in a solution is dependent on three factors, namely temperature, salinity and atmospheric pressure.

**1. Temperature**

Solubility of oxygen reduces as temperature increases. Hence, the colder the water, the more dissolved oxygen it contains. Since temperature affects both the solubility and diffusion rate of oxygen, temperature compensation is necessary for any standardised DO measurements.

**2. Salinity**

The amount of dissolved oxygen increases as salinity level decreases. In other words, freshwater holds more oxygen than saltwater. Since the presence of dissolved salts limits the amount of oxygen that can dissolve in water, the relationship between the partial pressure and concentration of oxygen varies with the salinity of the sample.

**3. Atmospheric Pressure**

There is a direct proportional relationship between the solubility of dissolved oxygen and the surrounding atmospheric pressure. As pressure decreases with increase in altitude, the amount of dissolved oxygen found in water reduces.

## Electrical and Sensor Connections

### Installation


Danger

As with all instrumentation, the installation and commissioning of this sensor is crucial to its safe and effective operation. This sensor must only be used for its purpose as outlined in this manual. It must be installed and commissioned in accordance with this manual and by trained, qualified personnel.

### Sensor Site Selection


Electric Shock Hazard

Please choose a suitable location for the installation of the sensor. The choice of installation point on any site is a compromise and is best undertaken by an experienced installation engineer.

The following is a list of the factors that need to be taken into consideration.

- Ensure that the sensor is positioned to ensure adequate flow.
- Avoid installing the sensor within 1m of any dosing point.
- Minimise all potential sources of electrical interference.
- Static & Ground Loop Faults can damage the sensor or cause erroneous readings and all precautions should be taken to avoid them.

**Note:** This list is not intended as a check-list neither is it implied that the list is complete.

### Unpacking


Important

Please have a copy of your order with you when you unpack your instrument. All orders are checked when they leave the factory. Please check that you have all the parts that were ordered as soon as you open the box.

If anything is missing, or damaged, please contact your sales outlet immediately. If the instrument needs to be returned for any reason please follow the return instructions given in this manual. Please dispose of the packing in an environmentally responsible manner and in compliance with local regulations.

### Mounting


Caution

A Turtle Tough Dissolved Oxygen Sensor has been engineered for installation into industrial processes. Use within the specifications is highly recommended to obtain optimal sensor life. Care should be taken to avoid any moisture ingress through the cable inlet/outlet.

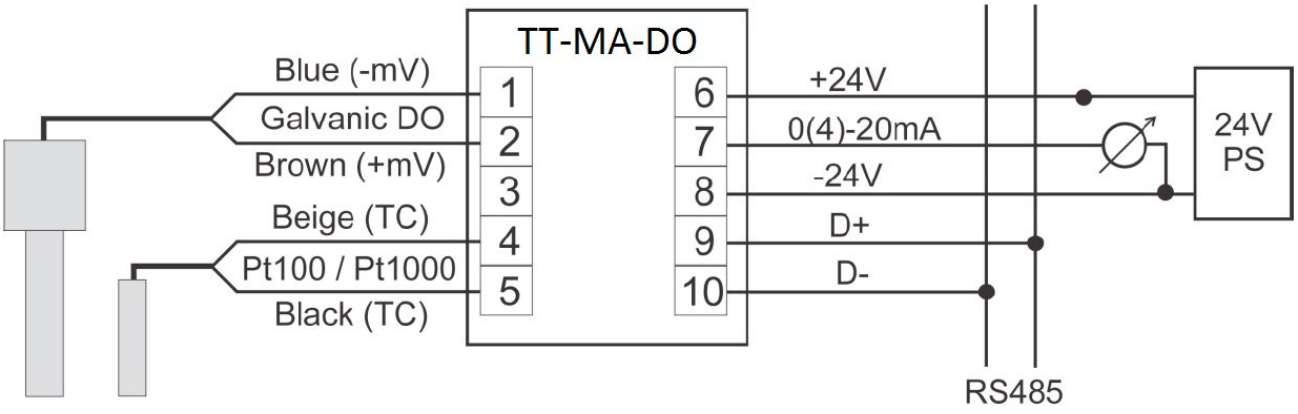
All Dissolved Oxygen Sensors can be installed in-line. Submersible installation is also possible provided adequate waterproofing is selected at time of order or adequate sealing is made between the sensor and installation hardware at time of installation for example.

Turtle Tough has a range of installation hardware available as optional accessories including but not limited to Stainless Steel Immersion Rods, Stainless Steel Sanitary Sensor Holders & Extension Tubes and Valve Retractable Assemblies. Contact your Turtle Tough Distributor for technical support on the optimal installation hardware to suit your application.

**Please Note:** Avoid excessive force when installing Dissolved Oxygen Sensors

## Wiring

Wiring of a Dissolved Oxygen Sensor to the TT-MA is as follows:




**Note:** Please consult the Turtle Tough website www.turtletoughsensors.com for additional wiring information.

## Menu Navigation

The TT-MA family has a 3 digit display and 6 LEDs for setup and displaying values.
The **Mode** key is used to navigate.
The LED marked **Com** is illuminated when MODbus is active.
**Programming** the module is accessed by use of the 3 keys located on the front panel.
The **Mode** key is for selecting setup and the **Up** and **Down** keys are used to scroll through the parameters.
To adjust a parameter select with the **Mode** key and modify the value using the **Up** and **Down** keys.

### Lock Function

**Note: Parameter No. 01 is a LOCK function** which MUST be turned **OFF** to change ANY parameter.
The default for the lock is **ON.** Once the lock is **OFF,** if there is a period of inactivity for 60 seconds the lock then defaults back to **ON**.


Important

### Function and Programming

| No | Parameter | Description | Range | Default |
|---|---|---|---|---|
| **01** | Lock | Software Lock | On / Off | On |
| **02** | Address | MODbus | Off, 1...247 | Off |
| **03** | Temperature | Type of Input | Set, Pt100, or Pt1000 | Pt100 |
| **04** | Manual Temp | Fixed Temp | 0...50 | 25 |
| **05** | Barometric Air Pressure | pressure in mm Hg units | 600 to 900 | 760 |
| **06** | Salinity | PSU Units | 0 to 50 | 0 |
| **07** | Wire Gauge | Sensor AWG | 20, 22, 24 | 20 |
| **08** | Cable Length | Length in feet | 1...999 feet | 23 |
| **09** | % Saturation Computation | Computation % Saturation | Automatic or Manual | Auto |
| **10** | Manual Saturation | ppm for 100% Saturation | 4.0 to 40.0 ppm | 10.0 |
| **11** | Input for Iout | Input used for output | DO ppm or % Saturation | DO ppm |
| **12** | Iout | Type of output | 4-20mA, 0-20mA | 4-20mA |
| **13** | Iout mode | Iout mode | Non-inverted, inverted | Non-inverted |
| **14** | 0/4mA Set | Low Set point | 0%-90% of Full Range | 0% |
| **15** | 20mA Set | High Set point | 10%-100% of Full Range | 100% |
| **16** | Working Gain (Slope) | Gain/Cal on DO Cell | ± 50% from Nominal | 1.10mV |
| **17** | 0/4mA Offset | Trim Low | ±9.99% | 0.00 |
| **18** | 20mA Gain | Trim High | ±9.99% | 0.00 |
| **19** | Energy Save | Energy Save | On / Off | On |
| **20** | Baud rate | MODbus | 9,600/19,200 | 19,200 |
| **21** | Reset to Default | Reset to Default | Def = Reset,<br>Par = No Reset | Par |

**Parameters Explained**

To access the programmable parameters see Menu Navigation.

The following is a description of each parameter settings.

| | |
|---|---|
| **P01** | Software lock. If the software lock is set to ON the parameter can only be read.<br>Set Software Lock to OFF to change values. |
| **P02** | Sets the module's address for MODbus communication. |
| **P03** | Indicates the sensor type for the temperature input. |
| **P04** | Sets the temperature when temperature compensation of the DO measurement is set to manual mode. |
| **P05** | Sets the ambient barometric air pressure in units of mm of Hg. This value is used in the gain calibration and for calculating the % DO saturation. |
| **P06** | Input for the salinity of the process sample in units of PSU. |
| **P07** | Input for the wire gauge (AWG) for the sensor cable used. |
| **P08** | Input for the length of sensor cable in units of feet. |
| **P09** | Sets the scheme used to compute % saturation. The default automatic mode takes the measured DO in ppm units and computes the % saturation against the stored theoretical value at the given temperature, ambient air pressure and salinity. Manual mode uses a fixed DO ppm value for this computation. |
| **P10** | Defines the DO ppm that constitutes 100% saturation condition when P09 is set to manual mode. |
| **P11** | Selects the analogue output (and MODbus output mode if present) of the dissolved oxygen (DO) analyser in units of ppm or % saturation and these units are also used for P14 & P15. between P11 and P12 must be at least 10% of full range scaling per parameter P21. |
| **P12** | Sets the analogue output to either 0-20 mA or 4-20 mA |
| **P13** | Allows setting the output to be inverted (i.e. for use in control) with the output corresponding to 20-0mA or 20-4mA |
| **P14** | Sets 0/4mA output scaling in DO ppm or % sat units. |
| **P15** | Sets 20mA output scaling in DO ppm or % sat units. The difference between low and high output set points (P14 & P15) must be at least 10% of full range scaling in the chosen units. |
| **P16** | Displays the result of the gain calibration and also allows manual modification.<br>Units are mV per ppm. |
| **P17** | Offset adjustments for 0/4mA low analogue output trim |
| **P18** | Gain adjustment for 20mA high analogue output trim |
| **P19** | If no keys are pressed for 10 minutes the display will show a flashing bar (Energy Save).<br>Pressing any key to return |
| **P20** | The MODbus standard requires a baud rate of 9,600 or 19,200 set in accordance with the MODbus master |
| **P21** | Feature to reset the analyser back to factory default |

## Calibration

Calibration of the system is performed in two parts – Temperature and Dissolved Oxygen Sensor.
Ensure software lock is **Off** prior to commencement.

Using **Mode** select **Gain**. Before removing the DO sensor from service, the TT-MA-DO should be placed into the gain calibrate mode. The gain calibration is performed when the sensor is clean and dry and exposed to only air. In cases where the relative humidity is not 100%, the sensor should be suspended in air over a source of water for best results.

Sufficient time must be allowed for the temperature and sensor reading to be fully stabilised in this condition to ensure a good calibration. The TT-MA-DO analyser determines from the temperature (measured or entered) together with the entered barometric pressure the theoretical 100% saturated DO ppm value.

### Temperature Calibration

Ensure software lock is **Off** prior to commencement.

The temperature is calibrated with the **Up** or **Down** keys in the temperature display (°C) mode. This should be done against the sensor body temperature (established by an external device) and after the internal temperature compensator has had sufficient time to reach the operating environment temperature.

### DO Sensor Calibration

Ensure software lock is **Off** prior to commencement.

### Auto Calibration Routine

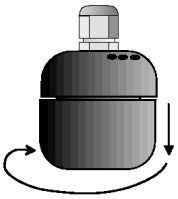
To initiate an automatic calibration, simultaneously hold the **Up** and **Down** keys until the display flashes CAL.
After eight seconds, the unit will either return a value of **Go** to indicate success or **Err** to indicate a failed calibration. You must press **Mode** to exit the automatic calibrate mode.

### Manual Calibration Routine

**F**or a manual gain calibration, adjust using the **Up** or **Down** keys until the display reads **exactly 0.0.** Positive eviations are shown as X.X or XX. Negative deviations are shown as -X.X or -XX.
If a positive value is shown adjust using the **Down** key and if a negative value is shown adjust with the **Up** key. You must press the **Mode** key to exit the manual calibrate mode.

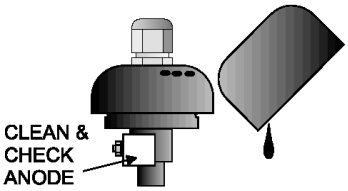
## Cleaning and Maintenance of a Turtle Tough Dissolved Oxygen Sensor

The sensor's membrane must be kept free from deposits. The membrane should be cleaned at regular intervals with the frequency depending on the actual conditions. Cleaning can be performed with a cloth or soft paper. The sensor should not be taken apart unless the membrane is damaged or you cannot calibrate to the correct value after long use.

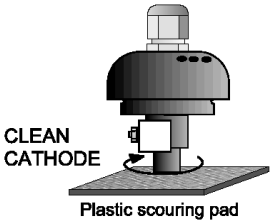


**To replace the membrane and renovate the sensor proceed as follows:**

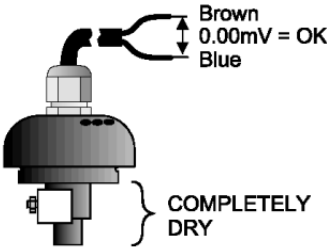
1. Remove the sensor, rinse it and unscrew the cap. If it sticks, tap the side of the sensor gently with a hammer then try again. Discard the very dark used electrolyte, rinse the cap and top part, clean off any dark coloured oxide deposits.




2. Inspect the anode. If the sensor was filled correctly when it was last renovated it will be easy to clean the dark deposits from the anode using a nailbrush or similar. If the sensor was not filled completely the anode will be very corroded and must be replaced entirely. Check that the nut under the anode is tight before fitting a new anode. Wash the new anode in soapy water before use to remove any protective oil.

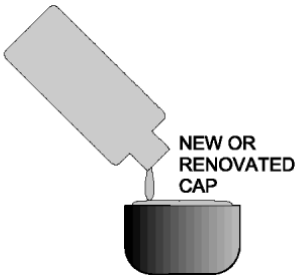



3. Check the cathode and remove any deposits using the plastic abrasive pad or a little wet or dry emery paper, grade 600. The cathode MUST NOT BE POLISHED.



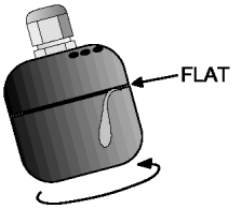

4. Rinse and dry the top part.

5. You can at this stage perform an easy check on the sensor. Dry the sensor completely taking care especially at the cathode and area around it. You can then observe the output signal of the sensor and it should be zero (less than 0.01 mV when measured at the sensor). ***Contact your Turtle Tough Representative if this is not the case.***

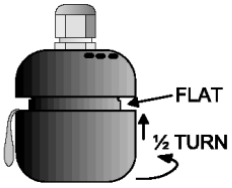



6. Fill a NEW OR RENOVATED CAP to the brim with electrolyte. The use of excess electrolyte helps to remove any entrenched air bubbles.

7. Locate the flat machined on the thread. Lower the upper part into the cap and turn the cap half a turn to engage the thread.Tilt the sensor 15° so that the flat is uppermost and screw the cap onto the top part. Excess electrolyte and air should dribble out at the flat.




**It is important that the sensor is filled completely. When you are certain that the sensor is filled completely tighten the cap hard.**




After renovation the sensor can be regarded as new. It should be hung up in air to stabilize for at least an hour before calibration. If possible re-calibrate after a day or two for best results. A new membrane can easily be fitted to the cap as described below. A cap must not be re-used without replacing the membrane, as the membrane stretches to fit the cathode, and will not fit perfectly a second time.

## Fitting a New Membrane

The four step procedure for fitting a new membrane to the cap is as shown below.

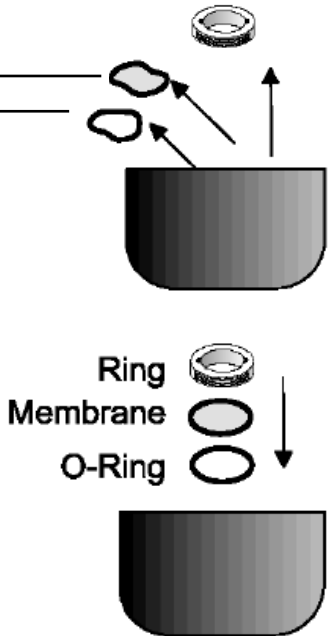
- The membrane must be completely flat. If any wrinkles are present remove it and try again with a new one.
- It is important that all parts are clean and dry.
- Neither O-ring nor membrane can be used more than once.

**1.** Unscrew ring, discard used membrane and O-ring

**2.** Clean and dry cap & ring **thoroughly**

**3.** Assemble as shown
**THE O-RING GOES UNDER THE MEMBRANE**

**4.** Tighten the ring. If the membrane wrinkles try again with a new membrane




## Spare Parts

Suggested spare parts are Membranes, O-rings, and Electrolyte. Stock of these parts will enable you to replace a damaged membrane in a few minutes. If desired you can also stock a spare sensor in which case you will then be able to replace a sensor that is accidentally mechanically destroyed, damaged, or lost. A spare sensor can be kept ready-to-use for years at a time if stored in the proper manner and conditions. Spare sensors should be stored in a cool, dry place without any electrolyte (filling solution) in the cap (completely dry). When a dry, unfilled spare sensor is taken from stock for use, follow the steps outlined on the previous pages to prepare it for installation. A stock of one or more spare caps will make it easy to renovate sensors with damaged or "old" membranes. You can also keep one or more spare anodes.

| Part Number | Description |
|---|---|
| TT-DO-THICK | Set of 10 each thick-type membrane with small O-rings |
| TT-DO-AN3 | Anode for TT-DO sensors |
| TT-DO-C3PPM | Cap for TT-DO membrane |
| TT-DO-PP | Membrane protector |
| TT-DO-E30500 | 500 ml Electrolyte (Filling Solution) |
| TT-DO-E31L | 1 Litre Electrolyte (Filling Solution) |
| TT-DO-INLINE | Inline Low-Flow Cell Adapter TT-DO sensors for ¾" Process Lines |
| TT-DO-TOOL | Membrane ring removal tool |

## MODbus Communication Option

MODbus communication is an option for the Galvanic Dissolved Oxygen Analyser Module and must be specified at time of order. Turtle Tough Analyser Modules may be used as a slave for the Datalogging Module or as a slave in a SCADA data acquisition system. The setup and communication for each case is explained below.

### Datalogging Module and MODbus

If the Dissolved Oxygen Module is used with the Datalogging Module, the baud rate on the Dissolved Oxygen Module as well as the address should be noted. The baud rate (P20) must be set to the baud rate of the Datalogging Module. Whether a baud rate of 19,200 or 9,600 is used is of no importance, as long as all units connected to the Datalogging Module are set to the same baud rate.

The address (P02) must be unique in the network; Two units cannot have the same address. In a network with the Datalogging Module as the master, all addresses must be assigned in series; i.e. if 3 units are connected the addresses 1, 2 and 3 must be assigned to the three units. The order of the addresses is of no importance. In a network with a Datalogging Module, up to 63 Analyser Modules (slaves) may be connected.

### SCADA System and MODbus

The baud rate (P20) must be set to the baud rate of the SCADA system. The address (P02) must be unique in the network and up to 247 Analyser Modules may be connected on a single network.

### MODbus Scaling

MODbus scaling for Dissolved Oxygen process measurement is the same as the analogue output set by P14 & P15. The DO ppm and % saturation are sent via MODbus scaled together with a 10-fold factor, keyed by the units selected in P11. If P11 is DO ppm and scaled as 2-10 ppm, the corresponding % saturation will be 20-100 %. If P11 is DO % saturation and scaled as 50-200%, the corresponding DO ppm will be 5-20 ppm. Temperature is always scaled as 0-100 °C.

The Galvanic Dissolved Oxygen Analyser Module contains 2 measured values (Dissolved Oxygen ppm and temperature) and 1 computed value (% saturation).
Access is gained through the function code Read_Input_Registers (04).

### Read Input Registers

| Function Code | Start Address | Number of Values |
|---|---|---|
| 04 | 1 | 1 or 2 |

**Value 1** is DO in ppm units,
**Value 2** is the DO in % saturation units
**Value 3** is Temperature

All three values are transmitted in sequence;
If 3 values are chosen then DO ppm, % saturation and temperature are transmitted.
All values are rated to 0-1000 corresponding to the scaled range; the scaled DO ppm range is sent as 0-1000, the % saturation (always 10 times the DO ppm scaling) as 1024-2024 and finally the full scale temperature range (0-100 °C) is transmitted as 2048-3048.

The Module gives access to different diagnostic values as well via ***Diagnostics (08)*** as shown in the table below.

| Function Code | Sub Code (HEX) | Description |
|---|---|---|
| **08** | 00 | Return Query Data |
| | 0A | Clear counters and diagnostics register |
| | 0B | Return Bus Message Count |
| | 0C | Return Bus Message Communication Error |
| | 0D | Return Exception Error count |
| | 0E | Return Slave Message count |
| | 0F | Return Slave No Response count |
| | 12 | Return Bus Character Overrun count |

# Ion Selective (ISE) Analyser Module


## Specifications

| | |
|---|---|
| **Power Supply** | 24VDC ±10% |
| **Consumption** | 60 mA max |
| **Sensor** | Combination Sensor |
| **ISE/mV Range** | 0-10, 0-100, 0-999 ppm; ±1000mV |
| **ISE Input** | < 1pA, >10GΩ ppm |
| **Accuracy** | ±0.2% Excluding Sensor (Ideal) |
| **Temp Sensor** | Pt100, Pt1000 |
| **Temp Range** | 0-150°C ± 0.3°C |
| **Temp Comp** | Fixed (Manual) or Automatic using Temperature (TC) Measurement |
| **Analogue Output** | 0-20mA or 4-20mA, max. 500Ω |
| **Output Hold** | Automatic when in calibration mode |
| **Housing** | Lexan UL94V-0 (Upper part)<br>Noryl UL94V-0 (Lower part) |
| **Mounting** | M36 for 35 mm DIN rail |
| **IP Class** | Housing IP40. Connector IP20 |
| **Connector** | Max 16A. Max 2.5mm$^2$<br>Max torque 0.6 Nm |
| **Temp:** | Usage -15 to +50 °C (Storage -35 to +75 °C) |
| **Weight:** | 75 grams (2.64 ounces) |
| **Dimensions:** | L 86 x W 36 x H 58 mm (3.4” X 1.4” X 2.3”) |
| **CE mark:** | EN61326A |

## Ion Selective Sensor Theory of Operation

An Ion selective electrode is a sensor which converts the activity of a specific ion (dissolved in a solution) into a voltage (potential). The voltage is theoretically dependent on the logarithm of the ion activity, as described by the Nernst Equation.

$$E = E_0 + (2.3RT/nF)\log[A]$$

Where:
**E** = total potential difference (measured in mV)
**$E_0$** = standard potential
**R** = gas constant
**T** = temperature in Kelvin
**n** = the charge on the ion (with sign)
**F** = Faraday's constant
**[A]** = measured ion activity

There are several factors which can cause difficulties when ISE technology is applied to ion measurement. These are listed below:

1. Ion-selective membranes are not entirely ion-specific and can permit the passage of other ions which may be present in the test solution. This is known as ionic interference.

2. Many ISE's show a curved calibration line in the region $10^{-5}$ to $10^{-7}$ moles/l and very few can be used to determine concentrations below $1x10^{-7}$ moles/l. For low concentration samples, it may be necessary to construct a calibration graph with several points in order to define the slope more precisely in the non-linear range.

3. The calculation of ionic concentration is far more dependent on a precise measurement of the potential difference. For example it would take an error of more than 5 millivolts to cause a change of 0.1 pH units, but only a 1 millivolt error will cause at least a 4% error in the calculated concentration of a mono-valent ion and more than 8% for a di-valent ion.

4. This is because the theoretical value for the slope at 25°C is 59.2 for mono-valent ions and 29.6 for di-valent ions. In practical application however, these slopes can vary considerably because of variations in temperature, deviations from "ideal" behaviour, and minor impurities or contamination of the ion-selective membrane, or if samples are measured near the detection limit of the electrode, in the non-linear range. The critical factor is not so much the actual value of the slope but that this should be as high as possible and remain constant over the range of concentrations and the time period required for the analyses. Thus, when measuring other ion concentrations, it is essential to take extra precautions to minimise any errors in the measurement of the electrode potential.

5. For ion concentration measurements, steps must be taken to minimise the effect of the Ionic Strength of the sample. This is because most ion measurements require the actual concentration, which can differ significantly from activity in samples with complex matrices and high Ionic Strength.

6. It is more usual to plot a calibration graph using the ionic concentration with a logarithmic scale on the X-axis rather than on a linear axis as is the case with pH.

7. Some ISE's will only work effectively over a narrow pH range.

8. As some ions can exist in a variety of forms in solution which can depend on pH, then pH compensation is required to calculate the TOTAL ion measurement.

As long as these difficulties are recognised and steps are taken to overcome them, then ISE's can still be a very useful and cost-effective analytical tool. It is strongly advised that any ISE installation be undertaken in conjunction with a trained Turtle Tough representative. Please contact your distributor or Turtle Tough to discuss your application.

**Ions which can be measured using Turtle Tough Ion Selective Sensors are:**

**CATIONS:**

Ammonium ($NH_4^+$)

Calcium ($Ca^{2+}$)

Lithium ($Li^+$)

Potassium ($K^+$)

Sodium ($Na^+$)

Silver ($Ag^+$)

**ANIONS:**

Bromide ($Br^-$)

Chloride ($Cl^-$)

Cyanide ($CN^-$)

Fluoride ($F^-$)

Iodide ($I^-$)

Nitrate ($NO_3^-$)

Nitrite ($NO_2^-$)

Perchlorate ($ClO_4^-$)

Sulphide ($S^-$)

Thiocyanate ($SCN^-$)

## Electrical and Sensor Connections

### Installation


Danger

As with all instrumentation, the installation and commissioning of this sensor is crucial to its safe and effective operation. This sensor must only be used for its purpose as outlined in this manual. It must be installed and commissioned in accordance with this manual and by trained, qualified personnel.

### Sensor Site Selection


Electric Shock Hazard

Please choose a suitable location for the installation of the sensor. The choice of installation point on any site is a compromise and is best undertaken by an experienced installation engineer. The following is a list of the factors that need to be taken into consideration.

- Ensure that the sensor is positioned to ensure adequate flow.
- Avoid installing the sensor within 1m of any dosing point.
- Minimise all potential sources of electrical interference.
- Static & Ground Loop Faults can damage the sensor or cause erroneous readings and all precautions should be taken to avoid them.

**Note:** This list is not intended as a check-list neither is it implied that the list is complete.

### Unpacking


Important

Please have a copy of your order with you when you unpack your instrument. All orders are checked when they leave the factory. Please check that you have all the parts that were ordered as soon as you open the box.

If anything is missing, or damaged, please contact your sales outlet immediately. If the instrument needs to be returned for any reason please follow the return instructions given in this manual.

Please dispose of the packing in an environmentally responsible manner and in compliance with local regulations.

### Mounting


Caution

A Turtle Tough ISE Sensor has been engineered for installation into industrial processes. Use within the specifications is highly recommended to obtain optimal sensor life.

Care should be taken to avoid any moisture ingress through the cable inlet/outlet.

ISE Sensors are optimally installed at 45° as this avoids air bubbles being trapped at the sensor/process interface and ensures sensor/process interaction. They should never be installed horizontally or inverted.

All ISE Sensors can be installed in-line. Submersible installation is also possible provided adequate waterproofing is selected at time of order or adequate sealing is made between the sensor and installation hardware at time of installation for example.

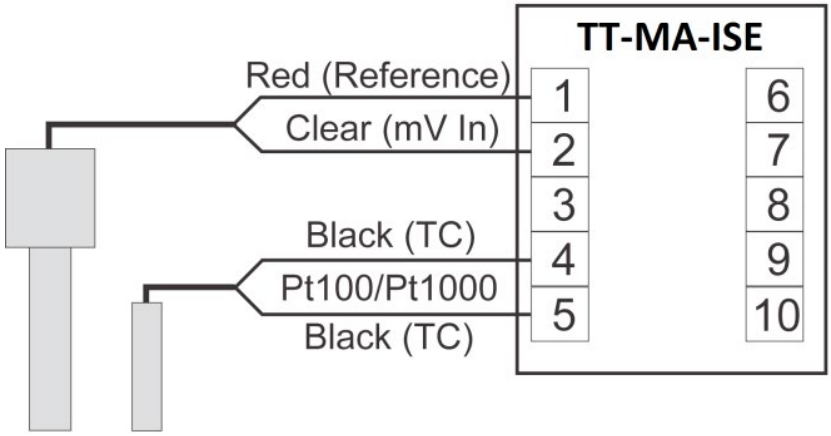
Turtle Tough has a range of installation hardware available as optional accessories including but not limited to KYNAR/PEEK Twistlock fittings, Stainless Steel Immersion Rods, Stainless Steel Sanitary Sensor Holders & Extension Tubes and Valve Retractable Assemblies. Contact your Turtle Tough Distributor for technical support on the optimal installation hardware to suit your application.

**Please Note: Avoid excessive force when installing an ISE Sensor**

## Wiring

Turtle Tough ISE Sensors are designed to work with a TT-MA Online Analyser. Wiring of Non-Preamp, Preamp and External Preamp Sensors to the TT-MA are as follows:

### Non-Preamp Sensor

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### Preamp Sensor


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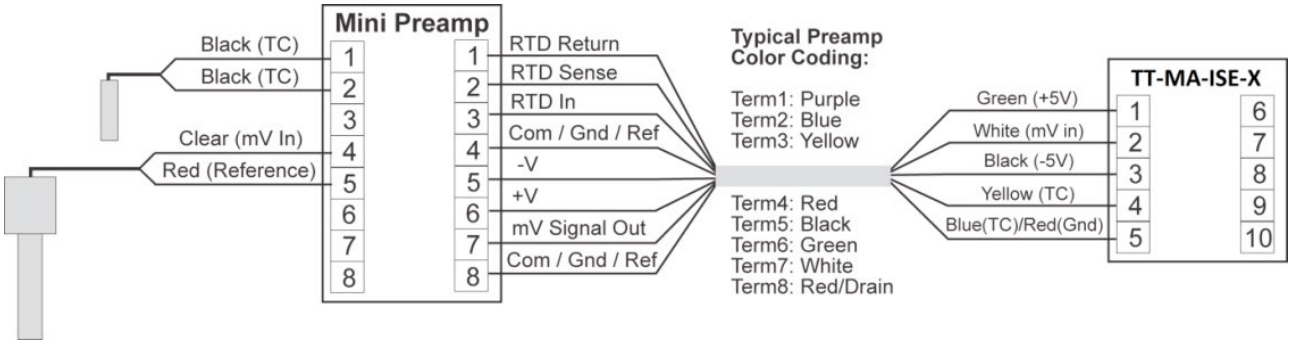
### External Preamp Sensor




**Note:** For additional wiring information please consult the Turtle Tough website [www.turtletoughsensors.com](http://www.turtletoughsensors.com)

## Menu Navigation

The TT-MA family has a 3 digit display and 6 LEDs for setup and displaying values. The **Mode** key is used to navigate. The LED marked **Com** is illuminated when MODbus is active. **Programming** the module is accessed by use of the 3 keys located on the front panel. The **Mode** key is for selecting setup and the **Up** and **Down** keys are used to scroll through the parameters. To adjust a parameter select with the **Mode** key and modify the value using the **Up** and **Down** keys.

### Lock Function

**Note: Parameter No. 01 is a LOCK function** which MUST be turned **OFF** to change ANY parameter, including temperature, buffer and slope calibrations. The default for the lock is **ON**. Once the lock is **OFF**, if there is a period of inactivity for 60 seconds the lock then defaults back to **ON**.


Important

### Function and Programming

| No | Parameter | Description | Range | Default |
|---|---|---|---|---|
| **01** | Lock | Software Lock | On/Off | On |
| **02** | Address | MODbus | Off, 1...247 | Off |
| **03** | Temperature | Type of Input | Pt100, Pt1000 | Pt1000 |
| **04** | Compensation | Temperature Compensation | Auto, Set | Auto |
| **05** | Comp. Temp. | Compensating Temperature | 0...150°C | 25 |
| **06** | Cable Impedance | Impedance of Pt100 Cable | 0.0 ... 9.9 Ohm | 0.0 |
| **07** | Output Variable | ISE or Temperature | ISE, °C | ISE |
| **08** | Analogue Output Range | ISE Output Range | 0-20mA, 4-20mA | 4-20 |
| **09** | ISE ppm Output Range | Lo (0-10), Mid (0-100) & Hi (0-999) | 10.0, 100, 999 | 10.0 |
| **10** | 0/4mA Set | Low ppm Setpoint* | 0.00...999 | 0.00 |
| **11** | 20mA Set | High ppm Setpoint* | 0.00...999 | 10.0 |
| **12** | Step Change | mV Increment for Calibration | 0=0.02 1=0.05 2=0.10 3=0.20 4=0.50 5=1.00 6=2.00 | 2(0.10mV) |
| **13** | View Formula Weight of Ion | Grams per Mol of Ion | XX.XX per Ion Weight | N/A |
| **14** | View Current Sensor Offset | mV at Isoconentration | Per ISE Sensor** | N/A |
| **15** | View Current Sensor Slope | mV per Decade Response | Per ISE Sensor** | N/A |
| **16** | 0/4mA Offset | Trim Low | ±9.99%** | 0.00 |
| **17** | 20mA Gain | Trim High | ±9.99%** | 0.00 |
| **18** | Energy Save | Energy Save | On/Off | On |
| **19** | Baud rate | MODbus | 9,600/19,200 | 19,200 |
| **20** | Reset to Default | Reset all to Factory Default | Def = Reset, Par=No Reset | Par |
| **21** | Reset Calibration Values Only | Reset all Calibrations to Factory Default | Def = Reset, Par=No Reset | Par |

* The difference between Par No. 10 and 11 must be at least 20% of the working output range selected (either low, mid or high range).
** Negative numbers will be shown as flashing.

**Parameters Explained**

To access the programmable parameters see Menu Navigation.
The following is a description of each parameter settings.

| Parameter | Description |
|---|---|
| **P01** | Software lock. If the software lock is set to **ON** the parameter can only be read. Set Software Lock to **OFF** to change values. |
| **P02** | Sets the module's address for MODbus communication. |
| **P03** | Indicates the sensor type for the temperature input. |
| **P04** | If Par. No. 7 is set to ISE, the signal is temperature compensated. Par. No. 4 sets the temperature compensation to either set (manual) or based on the measured temp. (auto). |
| **P05** | Sets the temperature for when temperature compensation of the ISE is in fixed (manual) mode. |
| **P06** | If a long cable is used for a Pt100 sensor, the cable impedance should be entered and compensated for using this parameter. |
| **P07** | Selects the output to be either ISE or temperature. |
| **P08** | Sets the analogue output to either 0-20 mA or 4-20 mA. |
| **P09** | Sets the analogue output scaling to either low (0.00-9.99ppm) mid (00.0-99.9 ppm) or high (000-999 ppm) range. |
| **P10** | Sets the ppm value that corresponds to 0/4mA output setpoint* |
| **P11** | Sets the ppm value that corresponds to 20mA output setpoint* |
| **P12** | Variable to define the mV change for each **Up** or **Down** button depression when calibration is performed. |
| **P13** | Displays formula weight of measured ion (the table below details how to determine which ion corresponds to this value) |
| **P14** | View and edit the working (effective) sensor offset. |
| **P15** | View and edit the working (effective) sensor offset. |
| **P16** | Offset adjustment for low 0/4mA analogue output trim. |
| **P17** | Gain adjustment for 20mA high analogue output trim. |
| **P18** | If no keys are pressed for 10 minutes the display will show a flashing bar (Energy Save). Pressing any key to return. |
| **P19** | Sets the MODbus Baudrate. The MODbus standard requires a Baudrate of 9,600 or 19,200 set in accordance with the MODbus master. |
| **P20** | Feature to reset all settings on the Analyser back to default values for the given factory configuration. |
| **P21** | Feature to reset ONLY the sensor offset and slope calibrations back to the factory default values. All other parameters will not be affected by invoking P21. |

* The difference between Par No. 10 and 11 must be at least 20% of the working output range selected (either low, mid or high range).
** Negative numbers will be shown as flashing.

## Table to Determined Selected ISE Module Types

| Ion Selective Analyser Type (Fixed) | Value of Parameter 13 (Formula Weight of Ion) | Ion Selective Analyser Type (Fixed) | Value of Parameter 13 (Formula Weight of Ion |
|---|---|---|---|
| $NH_4^+$ (Ammonium) | 18.0 | $F^-$ (Fluoride) | 19.0 |
| $Ca^{2+}$ (Calcium) | 40.1 | $NO_2^-$ (Nitrite) | 46.0 |
| $Na^+$ (Sodium) | 23.0 | $NO_3^-$ (Nitrate) | 62.0 |
| $Li^+$ (Lithium) | 6.94 | $CN^-$ (Cyanide) | 26.0 |

## Calibration

This section covers calibration of Turtle Tough ISE Sensors when mated with a TT-MA Analyser Module. If you are using a different analyser than this please consult the manual supplied with the unit or the Turtle Tough website www.turtletoughsensors.com

### Calibration Solutions

The calibrating solutions employed should be not more than one decade apart bridging over the anticipated concentration of your sample. If there are any other constituents in the sample to be measured, there need to be additions of these constituents to the calibrating solution to mirror (reflect) the actual sample background. Care should be taken with such ionic background if there are interfering ions in the sample.

Many factors must be taken into account to fabricate an optimal calibration standard.
These include but are not limited to:

- The total ionic strength (total concentration all of the ionic species)
- Typical process concentration of interfering ions
- Dissociation (and activity coefficients) of the salt providing the analyte ion to be measured
- The typical pH

The calibration solutions should be kept clean and out of direct sunlight and/or other high-energy radiation sources for any extended period of time.

Your Turtle Tough Distributor can assist to properly choose calibration standard formulations (and preparation procedures) that will provide for suitable calibration standards for a given application.

### 2-Point Calibration

The procedure for performing a 2-Point Calibration is as follows:

1. Ensure software lock is **Off** prior to commencement.
2. Rinse the conditioned sensor (see Conditioning section) with the first calibrating solution.
   This should reduce the overall response time.
3. Using **Mode** select **Offset** and calibrate to the first solution value by using the **Up** and **Down** keys.
4. Rinse the sensor with the second calibration solution.
   Next using **Mode** select **Slope** and use the **Up/Down** keys until the display reads the second solution value.

**Note:**

1. New sensors should be conditioned in standard solution for 3 - 5 minutes before beginning calibration
2. Any noticeable deposits on the tip of the sensor will result in less accurate calibration and measurement. Follow the cleaning procedure in this manual
3. For those ISE Measurements affected by pH, the pH should be stable to ensure meaningful and reproducible results.
4. Rinsing with D.I. (or distilled water) will dilute the solution on the surface of the sensor, thus the sensor has to start its potential development process with a much lower concentration and develop a longer response curve (which is exponential in its nature) and response time.

**1-Point Calibration**

The One Point Re-Calibration Standard (usually a process grab sample or one of the two standard solutions) is always performed by using the **Offset** Mode.

**Temperature Considerations**

The reading you obtain either during calibration or measurement is temperature dependent as described in the Nernst equation which is the basis for every potentiometric measurement.

A Turtle Tough ISE Sensor has a built in temperature element. If there is a temperature difference in the solution to ambient then the sensor has to be in equilibrium with the solution itself and not the air or other environment. The time for the temperature reading to reach equilibrium can vary from as little as 1-2 minutes to as much as 30-60 minutes under some conditions.

If the temperature is fluctuating or the sensor temperature is not in equilibrium with the solution temperature the displayed reading will not be stable even if the analyte ion activity is unchanged.

A 5°C discrepancy in temperature measurement results in a reading error of at least 4% of the actual value, assuming that no other factors are present that would cause a larger error - see points below for details:

- An ion selective sensor can only measure activity rather than concentration. The temperature induced change in the activity coefficient of the analyte ion for a given chemical system is often greatly more than the 4% change indicated for the uncompensated ISE sensor.

- The temperature induced activity coefficient change will differ for each particular chemical system and thus cannot be more generally predicted.

- Temperature induced changes in ion activity cannot be “compensated” in the same way that we are accustomed to “compensating” for temperature in pH measurements.

- Even for pH measurements, the assumption that the activity coefficient of the Hydronium (H+ or H3O+) ion does not significantly change with temperature can prove incorrect and contribute to the uncertainty of the measurement.

All Calibration Solutions and Process Grab Samples should be calibrated and tested at identical temperatures to the process temperature to minimise errors due to temperature effects. The actual temperature of the process solution (and thereby the calibrating solutions as well) is not as critical as the fact that they are calibrated at the same temperature. To optimise sensor lifetime, however, measurement should be performed as close to 25°C (room temperature process solutions) as possible.

## Troubleshooting

There are many potential issues that are involved in the uncertainty of an online ISE measurement. Some of the most common possible issues are summarised below and may be applicable to your particular installation.

### Raw mV Display

For troubleshooting it is often useful to access the raw uncompensated mV potential of the ISE sensor. When assisting you with a diagnosis, a Turtle Tough customer representative may ask you to place the analyser into the **Raw mV Display** mode. This can be accessed by pressing the **Down** key in the main ISE/mV display mode. The display now changes from ppm to mV units. Negative values will be displayed as flashing.

### Common Thermal Related Issues

Make sure that the online industrial sensor is in thermal and chemical equilibrium with the process before making any one-point offset calibration. Please note that sensors that run in hot processes should be allowed to cool down to room temperature before performing a 2-point calibration. The temperature indicated on the sensor can be used as a gauge of when it is ready to proceed with a calibration having reached a thermal equilibrium with ambient conditions. Calibrating an ISE sensor when it is not at thermal equilibrium is a very common cause of calibration error.

### Common Offset Type Issues

If the display of the online sensor diverges from the lab expected reference value it is possible to force agree between these two readings with the TT-MA-ISE module even after a calibration has been performed. Such a one point grab sample type offset calibration is performed when in the Offest LED mode. Navigate with the **Mode** key to the **Offest** mode while the ISE sensor is installed into the process and while the reading is quite stable. Use the **Up** and **Down** keys to adjust the displayed value to agree with the laboratory determined reference value if desired. Such a grab sample offset type calibration should only be performed after all ISE calibrations have been completed.

### ISE Standardised Solution Accuracy and Stability Issues

It is important to consider that some Standardised Solutions degrade in quality much more quickly than offers when left open to air, or else with exposure to heat and/or light. One important step to ensure accurate calibrations is to check whether the Standardised Solutions employed are still within the expiry period and that they were stored in a cool, dry storage location away from sunlight.

### Temperature effects on ISE Reading

More generally, note that temperature compensation for ISE mode ONLY accounts for the change in potential of the ISE sensor itself due to temperature. Any other temperature induced changes to the ISE measurement of any given solution (such as changing the effective mean activity coefficient or equilibrium of the process media) are NOT accounted for by temperature compensation and thus must all be considered separately.

## Sensor Care and Maintenance

### Maintenance Free

Turtle Tough ISE sensors are a completely sealed assembly and are sealed for life. This provides extreme process resistance as well as a totally maintenance free sensor which greatly increases sensor life and reduces labour costs. A Turtle Tough sensor does not contain any O-rings, washers, gaskets, or serviceable components/assemblies. It does not require refreshing or refilling of electrolyte. The only requirement is regular cleaning in accordance with our recommended cleaning schedule for your application. Regular cleaning will prolong the life of your sensor and ensure hassle free operation.

### Storage

The standard shelf life for all Turtle Tough ISE sensors is one year from the date of shipment. Sensors stored longer than this period may still be functional but are no longer under warranty. Sensors should be stored in a cool, dry location with the sensor tip (sensing element) oriented toward the ground. All sensors come standard with a conditioning solution in the cap or a standard solution can be used. The sensor cap should be kept tightly affixed to the sensor body and sealed with common PVC tape when the sensor is not in use. Sensors that are to be returned for shelf life warranty claim must have the original sensor cap and conditioning solution intact to be eligible for warranty replacement.

**Note: Do not allow sensor to be exposed to air for prolonged periods of time.**

### Cleaning a Turtle Tough ISE Sensor: Recommended Cleaning Schedule

The recommended cleaning interval is based upon the difficulty index for your application.
Please contact your agent or refer to the website to identify your difficulty rating.

| Application Difficulty Rating | Cleaning Schedule |
|---|---|
| 1-3 | Monthly |
| 4-6 | Fortnightly |
| 6-7 | Weekly |
| 8-9 | Twice (2x) per week |
| 10 | Daily |

If a Turtle Tough ISE sensor response slows down, it is most likely the result of a fouled reference or sensing element. Cleaning should be performed as required and will vary across applications.

Cleaning requirements will vary depending on the application for which the sensor is used. The following should always be observed when cleaning:

- Never scratch or aggressively scrub the Sensing Elements. They can be easily damaged by mechanical force.
- The reference junction is a solid state material. This solid state reference can be cleaned effectively by using a sharp razor edged tool.
- Thoroughly rinse the sensors with D.I. water and gently blot dry with a clean lint free towel.
- Be careful not to scratch or damage the Sensing Element.

Please contact your local Turtle Tough representative if you plan to use any other cleaning agent.


**Avoiding Thermal Shock**

For high temperature applications where process liquid exceeds 70°C you will prolong the life of the sensor by avoiding thermal shock. Thermal shock occurs when you rapidly change the temperature of the sensor from hot to cold or vice versa. This rapid expansion/contraction of sensor components can damage internal elements and cause micro-cracking that will accelerate the rate of deterioration. In extreme cases it will damage the sensing element causing a total failure. To avoid this the sensor should be heated or cooled slowly during removal/ insertion and cleaning and calibration processes. Consult your Turtle Tough representative for techniques to avoid thermal shock.

**Conditioning for Calibration**

After the sensor has been cleaned, the ISE Sensor will need to be conditioned prior to calibration or use.

The PVC (organic membrane) or solid-state ISE sensors must be sufficiently conditioned to give optimum stability and performance.

The PVC (organic membrane) based industrial ion selective sensors have an active sensing element that is an organic ion selective electrode based on plasticised PVC, specialised ion sensitive ligand (ionophore) and some other necessary components for industrial use. All such electrodes containing these organic measuring membranes need conditioning before use allowing the organic system to get in equilibrium with the aqueous solution.

This is best performed by soaking the sensor in the lower concentration of calibrating solution for about 16-24 hours.Solid-state ion selective sensing elements also require conditioning time for optimum performance, although satisfactory performance may be gained for many applications in a period shorter than the recommended 16-24 hour period for organic membrane based industrial ISE sensors.

## MODbus Communication Option

MODbus communication is an option for the ISE Analyser Module and must be specified at time of order. Turtle Tough Analyser Modules may be used as a slave for the Datalogging Module or as a slave in a SCADA data acquisition system. The setup and communication for each case is explained below.

### Datalogging Module and MODbus

If the ISE Module is used with the Datalogging Module, the baud rate on the ISE Module as well as the address should be noted. The baud rate (P19) must be set to the baud rate of the Datalogging Module. Whether a baud rate of 19,200 or 9,600 is used is of no importance, as long as all units connected to the Datalogging Module are set to the same baud rate.The address (P02) must be unique in the network; Two units cannot have the same address. In a network with the Datalogging Module as the master, all addresses must be assigned in series; i.e. if 3 units are connected the addresses 1, 2 & 3 must be assigned to the three units. The order of the addresses is of no importance. In a network with a Datalogging Module, up to 63 Analyser Modules (slaves) may be connected.

### SCADA System and MODbus

The baud rate (P19) must be set to the baud rate of the SCADA system. The address (P02) must be unique in the network and up to 247 Analyser Modules may be connected on a single network.

### MODbus Scaling

The MODbus scaling is defined only by P09 (low, mid or high). Note that the MODbus scaling can differ from 0/4-20 mA analogue scaling. The ISE MODbus Analyser Module contains 2 measurements (ISE and temperature). Access is gained through function code Read_Input_Registers (04).

### Read Input Register

| Function Code | Start Address | Number of Values |
|---|---|---|
| 04 | 1 | 1 or 2 |

**Value 1** is ISE ppm **Value 2** is temperature.

The measurements are transmitted in sequence; If 2 values are chosen both ISE ppm and temperature are transmitted. If the value for temperature is wanted, 2 values must be requested. Both values are rated 0-1000 corresponding to the range, but the temperature has an offset of 1024; i.e. 0-999ppm is transmitted as 0-1000 and 0-150°C as 1024-2024. The Module gives access to different diagnostic values as well via ***Diagnostics (08)*** as shown in the table below.

| Function Code | Sub Code (HEX) | Description |
|---|---|---|
| **08** | 00 | Return Query Data |
| | 0A | Clear counters and diagnostics register |
| | 0B | Return Bus Message Count |
| | 0C | Return Bus Message Communication Error |
| | 0D | Return Exception Error count |
| | 0E | Return Slave Message count |
| | 0F | Return Slave No Response count |
| | 12 | Return Bus Character Overrun count |

# Temperature Measurement Module


## Specifications

| | |
|---|---|
| **Power Supply** | 24VDC ±10% |
| **Consumption** | 60 mA max |
| **Accuracy** | ±0.2% Excluding Sensor (Ideal) |
| **Temp Sensor** | Pt100, Pt1000 |
| **Temp Range** | 0-210°C ± 0.2°C |
| **Analogue Output** | 0-20mA or 4-20mA, max. 500Ω |
| **Housing** | Lexan UL94V-0 (Upper part)<br>Noryl UL94V-0 (Lower part) |
| **Mounting** | M36 for 35 mm DIN rail |
| **IP Class** | Housing IP40. Connector IP20 |
| **Connector** | Max 16A. Max 2.5mm$^2$<br>Max torque 0.6 Nm |
| **Temp** | Usage -15 to +50 °C (Storage -35 to +75 °C) |
| **Weight** | 200 grams (7.04 ounces) |
| **Dimensions** | L 86 x W 36 x H 58 mm (3.4” X 1.4” X 2.3”) |
| **CE mark** | EN61326A |

## Why use a Temperature Measurement Module?

- A TT-MA-TEM Measurement Module adds a scalable analogue output for Temperature to any of the TT-MA Analyser Modules.

- Special hardware and software allows a single Pt100/Pt1000 to be used both as an input for a TT-MA Analyser Module and a TT-MA Temperature Measurement Module. This configuration is referred to as “spliced” input mode and is the default.

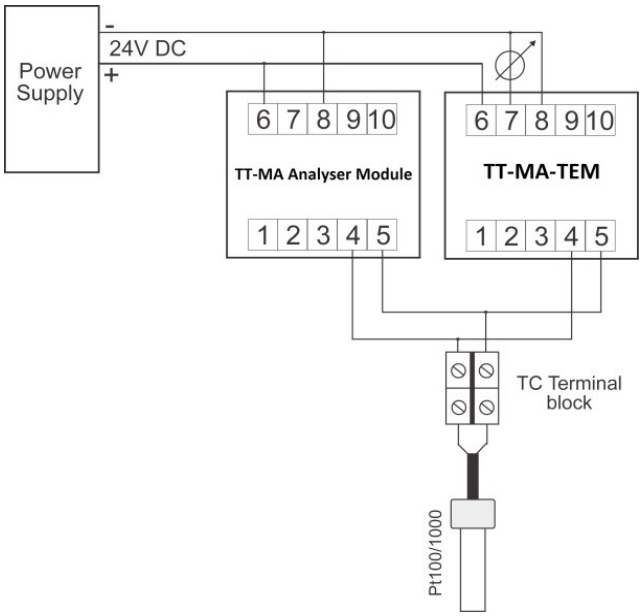
- Any pH, ORP, ISE, Conductivity or DO sensor with Pt100/Pt1000 in “splice” mode will be used both for temperature compensation on the measurement module and to send a scalable output for temperature from the TT-MA Temperature Measurement Module.

- Direct wiring from separate (rather than shared) Pt100 or Pt1000 temperature elements is also supported. This configuration is referred to as “raw” input mode.

**Unpacking**

Please have a copy of your order with you when you unpack your instrument. All orders are checked when they leave the factory. Please check that you have all the parts that were ordered as soon as you open the box. If anything is missing, or damaged, please contact your sales outlet immediately. If the instrument needs to be returned for any reason please follow the return instructions given in this manual. Please dispose of the packing in an environmentally responsible manner and in compliance with local regulations.

## Wiring




### Typical Splice Type Wiring

**Notes:**

1. Wiring schematic valid when parameter P01 is splice.
2. The wiring schematic above is valid when the mating with a TT-MA Analyser Module.
3. Be sure to select whether a Pt100 or Pt1000 is used in parameter P03. This will be the type of TC element in your pH/ORP/ISE/Conductivity or DO sensor. Only the temperature portion of the wiring is shown for simplicity.

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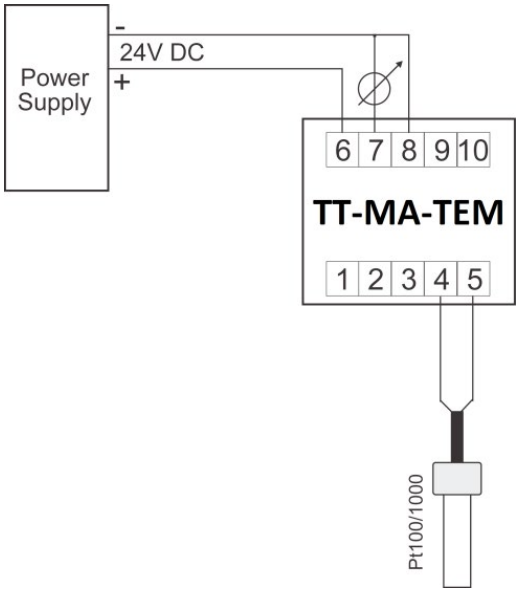



### Typical Raw (Direct) Type Wiring

**Notes:**

1. Wiring schematic valid when parameter P01 is splice.
2. The wiring schematic above is valid when the mating with a TT-MA Analyser Module.
3. Be sure to select whether a Pt100 or Pt1000 is used in parameter P03. This will be the type of TC element in your pH/ORP/ISE/Conductivity or DO sensor. Only the temperature portion of the wiring is shown for simplicity.

For additional wiring information. Please consult the Turtle Tough website www.turtletoughsensors.com

## Menu Navigation

The TT-MA family has a 3 digit display and 6 LEDs for setup and displaying values.

The **Mode** key is used to navigate. The LED marked **Com** is illuminated when MODbus is active.

**Programming** the module is accessed by use of the 3 keys located on the front panel.

The **Mode** key is for selecting setup and the **Up** and **Down** keys are used to scroll through the parameters.

To adjust a parameter select with the **Mode** key then modify the value using the **Up** and **Down** keys.

### Lock Function

**Note: Parameter No. 01 is a LOCK function** which MUST be turned **OFF** to change ANY parameter. The default for the lock is **ON**. Once the lock is **OFF**, if there is a period of inactivity for 60 seconds the lock then defaults back to **ON.**

Important

### Function and Programming

| No | Parameter | Description | Range | Default |
|---|---|---|---|---|
| **01** | Lock | Software Lock | On / Off | On |
| **02** | Temp Mode | Wiring Type | Splice, Raw | Splice |
| **03** | TC Input Select | Select the Pt Input Type | Pt100 or Pt1000 | Pt100 |
| **04** | Wire Gauge | Sensor Lead AWG | 20, 22, 24 | 24 |
| **05** | Cable Length | Length of Cable in Feet | 1...999 feet | 10 |
| **06** | Type of Output | Select 0-20mA or 4-20mA | 4-20mA, 0-20mA | 4-20mA |
| **07** | Output Mode | Analogue Output Mode | Non-inverted, Inverted | n.inv |
| **08** | 0/4mA Low Output Setpoint | Reading @ 0/4mA | 0 to 100°C | 0 |
| **09** | 20mA High Output Setpoint | Reading @ 20mA | 100 to 210°C | 210 |
| **10** | Trim Low Output | 4mA Offset Cal for Output | ± 9.99% * | Factory Cal |
| **11** | Trim High Output | 20mA Gain Cal for Output | ± 9.99% * | Factory Cal |
| **12** | Energy Save | Energy Save | On/Off | On |
| **13** | Back to Default | Reset to Default | Def=Reset, Par=No Reset | Par |

* Negative trim adjustments will be shown as flashing numbers.

**Parameters Explained**

To access the programmable parameters see Menu Navigation.

The following is a description of each parameter settings.

| Parameter | Description |
|---|---|
| **P01** | Software lock. If the software lock is set to **ON** the parameter can only be read. Set Software Lock to **OFF** to change values. |
| **P02** | Sets the type of wiring used as splice or raw (direct). |
| **P03** | Sets the temperature element to be Pt100 or Pt1000 type. |
| **P04** | Sets the wire gauge (AWG) for the sensor cable used. |
| **P05** | Sets the length of sensor cable in units of feet. |
| **P06** | Sets the analogue output to either 0-20 mA or 4-20 mA. |
| **P07** | Allows setting the output to be inverted (i.e. for use in control) with the output corresponding to 20-0mA or 20-4mA. |
| **P08** | Sets the temperature value that corresponds to 0/4mA output setpoint.** |
| **P09** | Sets the temperature value that corresponds to 20mA output setpoint.** |
| **P10** | Offset adjustment for 4mA low analogue output trim.* |
| **P11** | Gain adjustment for 20mA high analogue output trim.* |
| **P12** | If no keys are pressed for 10 minutes the display will show a flashing bar (Energy Save). Pressing any key to return. |
| **P13** | Feature to reset the analyser back to factory default. |

## Calibration

### Splice Type Wiring

**Step 1**

Obtain a valid variable resistor potentiometer (a.k.a. “turn-pot”) with a nominal value of 200 Ohms if a Pt100 element is used and a nominal value of 2,000 Ohms if a Pt1000 element is used. Wire-up the turn-pot as“splice” type input as shown in the wiring section to serve as a simulated temperature sensor.

**Step 2**

Adjust the turn-pot so that the temperature reading on the TT-MA Analyser Module is very close to 0.0°C. Use the ‘Offset’ calibration mode to make the TT-MA-TEM temperature (°C) reading agree with what is shown on the TT-MA Analyser Module.

**Step 3**

Adjust the turn-pot so that the temperature reading on the TT-MA Analyser Module is very close to 210°C. Use the ‘Gain’ calibration mode to make the TT-MA-TEM temperature (°C) reading agree with what is shown on the TT-MA Analyser Module.

### Raw (Direct) Wiring

**Step 1**

Obtain a valid variable resistor potentiometer (a.k.a. “turn-pot”) with a nominal value of 200 Ohms if a Pt100 element is used and a nominal value of 2,000 Ohms if a Pt1000 element is used. Wire-up the turn-pot as “raw” type input as shown in the wiring section to serve as a simulated temperature sensor.

**Step 2**

Adjust the turn-pot so that the temperature reading on TT-MA-TEM is very close to 0.0°C. Use the ‘Offset’ calibration mode to make the TT-MA-TEM reading agree with nominal temperature (°C) for that resistance (see Resistance Table Section). Adjust the turn-pot so that the temperature reading on TT-MA-TEM is very close to 210°C. Use the ‘Gain’ calibration mode to make the TT-MA-TEM reading agree with nominal temperature (°C) for that resistance.

**Step 3:** Determine the wire gauge and cable length of your Pt100 or Pt1000 temperature sensor and enter this into parameters P04 & P05 respectively. This corrects for any impact on temp due to resistance from cable length.

## MODbus Communication Option

No MODbus output is available for the Temperature Measurement Module.
If MODbus is desired, it is recommended to get the temperature measurement via the MODbus output of the pH, ORP, ISE, Conductivity or DO Analyser Module directly.

# Resistance and Temperature Tables: Pt100 and Pt1000

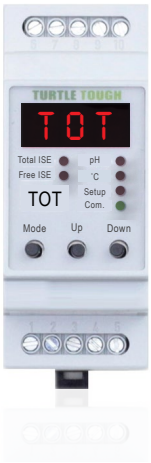
**Table: Pt100**

| °C | Ω | °C | Ω | °C | Ω | °C | Ω |
|---|---|---|---|---|---|---|---|
| 0 | 100 | 38 | 115 | 76 | 129 | 114 | 144 |
| 2 | 101 | 40 | 116 | 78 | 130 | 116 | 145 |
| 4 | 102 | 42 | 116 | 80 | 131 | 118 | 145 |
| 6 | 102 | 44 | 117 | 82 | 132 | 120 | 146 |
| 8 | 103 | 46 | 118 | 84 | 132 | 122 | 147 |
| 10 | 104 | 48 | 119 | 86 | 133 | 124 | 148 |
| 12 | 105 | 50 | 119 | 88 | 134 | 126 | 148 |
| 14 | 105 | 52 | 120 | 90 | 135 | 128 | 149 |
| 16 | 106 | 54 | 121 | 92 | 135 | 130 | 150 |
| 18 | 107 | 56 | 122 | 94 | 136 | 132 | 151 |
| 20 | 108 | 58 | 122 | 96 | 137 | 134 | 151 |
| 22 | 109 | 60 | 123 | 98 | 138 | 136 | 152 |
| 24 | 109 | 62 | 124 | 100 | 139 | 138 | 153 |
| 26 | 110 | 64 | 125 | 102 | 139 | 140 | 154 |
| 28 | 111 | 66 | 126 | 104 | 140 | 142 | 154 |
| 30 | 112 | 68 | 126 | 106 | 141 | 144 | 155 |
| 32 | 112 | 70 | 127 | 108 | 142 | 146 | 156 |
| 34 | 113 | 72 | 128 | 110 | 142 | 148 | 157 |
| 36 | 114 | 74 | 129 | 112 | 143 | 150 | 157 |

**Table: Pt1000**

| °C | kΩ | °C | kΩ | °C | kΩ | °C | kΩ | °C | kΩ | °C | kΩ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1.00 | 38 | 1.15 | 76 | 1.29 | 114 | 1.44 | 152 | 1.58 | 190 | 1.72 |
| 2 | 1.01 | 40 | 1.16 | 78 | 1.30 | 116 | 1.45 | 154 | 1.59 | 192 | 1.73 |
| 4 | 1.02 | 42 | 1.16 | 80 | 1.31 | 118 | 1.45 | 156 | 1.60 | 194 | 1.74 |
| 6 | 1.02 | 44 | 1.17 | 82 | 1.32 | 120 | 1.46 | 158 | 1.60 | 196 | 1.74 |
| 8 | 1.03 | 46 | 1.18 | 84 | 1.32 | 122 | 1.47 | 160 | 1.61 | 198 | 1.75 |
| 10 | 1.04 | 48 | 1.19 | 86 | 1.33 | 124 | 1.48 | 162 | 1.62 | 200 | 1.76 |
| 12 | 1.05 | 50 | 1.19 | 88 | 1.34 | 126 | 1.48 | 164 | 1.63 | 202 | 1.77 |
| 14 | 1.05 | 52 | 1.20 | 90 | 1.35 | 128 | 1.49 | 166 | 1.63 | 204 | 1.77 |
| 16 | 1.06 | 54 | 1.21 | 92 | 1.35 | 130 | 1.50 | 168 | 1.64 | 206 | 1.78 |
| 18 | 1.07 | 56 | 1.22 | 94 | 1.36 | 132 | 1.51 | 170 | 1.65 | 208 | 1.79 |
| 20 | 1.08 | 58 | 1.22 | 96 | 1.37 | 134 | 1.51 | 172 | 1.66 | 208 | 1.80 |
| 22 | 1.09 | 60 | 1.23 | 98 | 1.38 | 136 | 1.52 | 174 | 1.66 | | |
| 24 | 1.09 | 62 | 1.24 | 100 | 1.39 | 138 | 1.53 | 176 | 1.67 | | |
| 26 | 1.10 | 64 | 1.25 | 102 | 1.39 | 140 | 1.54 | 178 | 1.68 | | |
| 28 | 1.11 | 66 | 1.26 | 104 | 1.40 | 142 | 1.54 | 180 | 1.68 | | |
| 30 | 1.12 | 68 | 1.26 | 106 | 1.41 | 144 | 1.55 | 182 | 1.69 | | |
| 32 | 1.12 | 70 | 1.27 | 108 | 1.42 | 146 | 1.56 | 184 | 1.70 | | |
| 34 | 1.13 | 72 | 1.28 | 110 | 1.42 | 148 | 1.57 | 186 | 1.71 | | |
| 36 | 1.14 | 74 | 1.29 | 112 | 1.43 | 150 | 1.57 | 188 | 1.71 | | |

# TOT MODULE FOR TOTAL ISE




## Specifications

| | |
|---|---|
| **Power Supply** | 24VDC ±10% |
| **Consumption** | 60 mA max |
| **Input Current** | 0-20mA or 4-20mA, max. 250Ω |
| **Accuracy** | Class 1% |
| **Analogue Output** | 0-20mA or 4-20mA, max. 300Ω |
| **Serial Port 1** | RS485, 9.6/19.2k Baudrate |
| **Housing** | Lexan UL94V-0 (Upper part)<br>Noryl UL94V-0 (Lower part) |
| **Mounting** | M36 for 35 mm DIN rail |
| **IP Class** | Housing IP40. Connector IP20 |
| **Connector** | Max 16A. Max 2.5mm$^2$<br>Max torque 0.6 Nm |
| **Temp** | Usage -15 to +50 °C (Storage -35 to +75 °C) |
| **Weight** | 200 grams (7.05 ounces) |
| **Dimensions** | L 86 x W 36 x H 58 mm (3.4" X 1.4" X 2.3") |
| **CE mark** | EN61326A |

## Why use a TOT Module?

As some ions can exist in a variety of forms in solution which can depend on pH, then pH compensation is required to calculate the TOTAL ion measurement. The TOT Module determines Total ISE by using a compensation algorithm using Free ISE, pH and temperature as the primary process inputs.

Total ISE can be calculated for the following ions:

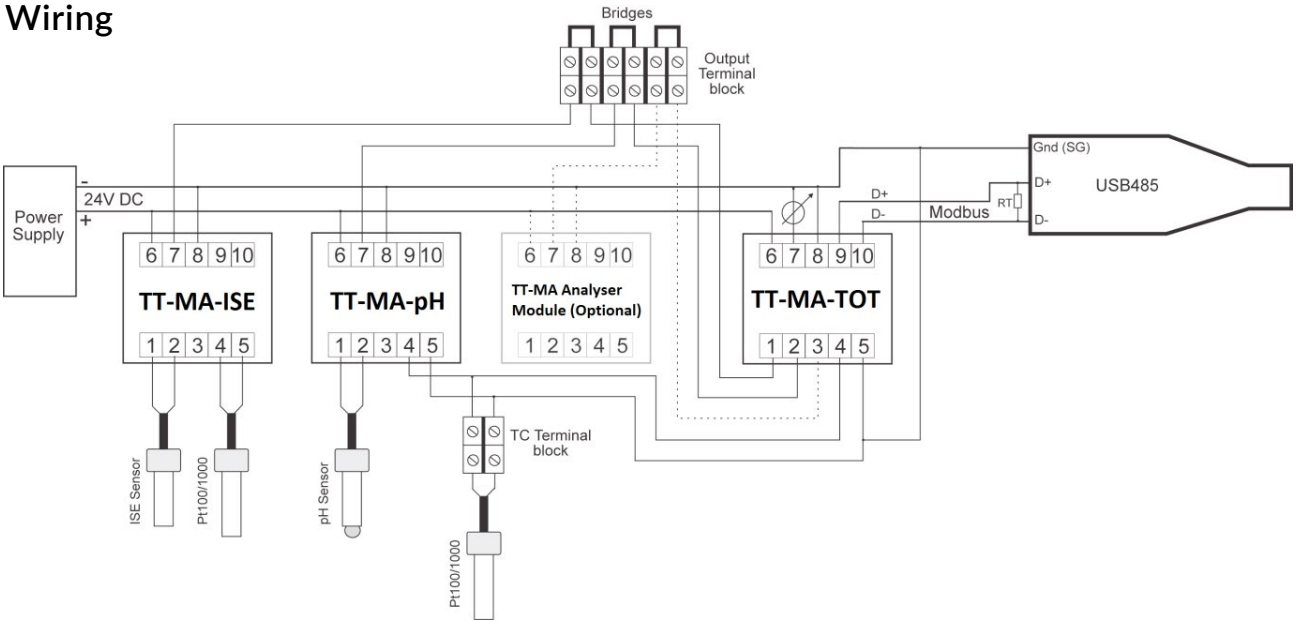
- Ammonia (NH3 + NH4+)
- Fluoride (HF + F-)
- Cyanide (HCN + CN-)
- Sulphide (HS- + S2-)

## Unpacking


Important

Please have a copy of your order with you when you unpack your instrument. All orders are checked when they leave the factory. Please check that you have all the parts that were ordered as soon as you open the box. If anything is missing, or damaged, please contact your sales outlet immediately. If the instrument needs to be returned for any reason please follow the return instructions given in this manual.

## Wiring

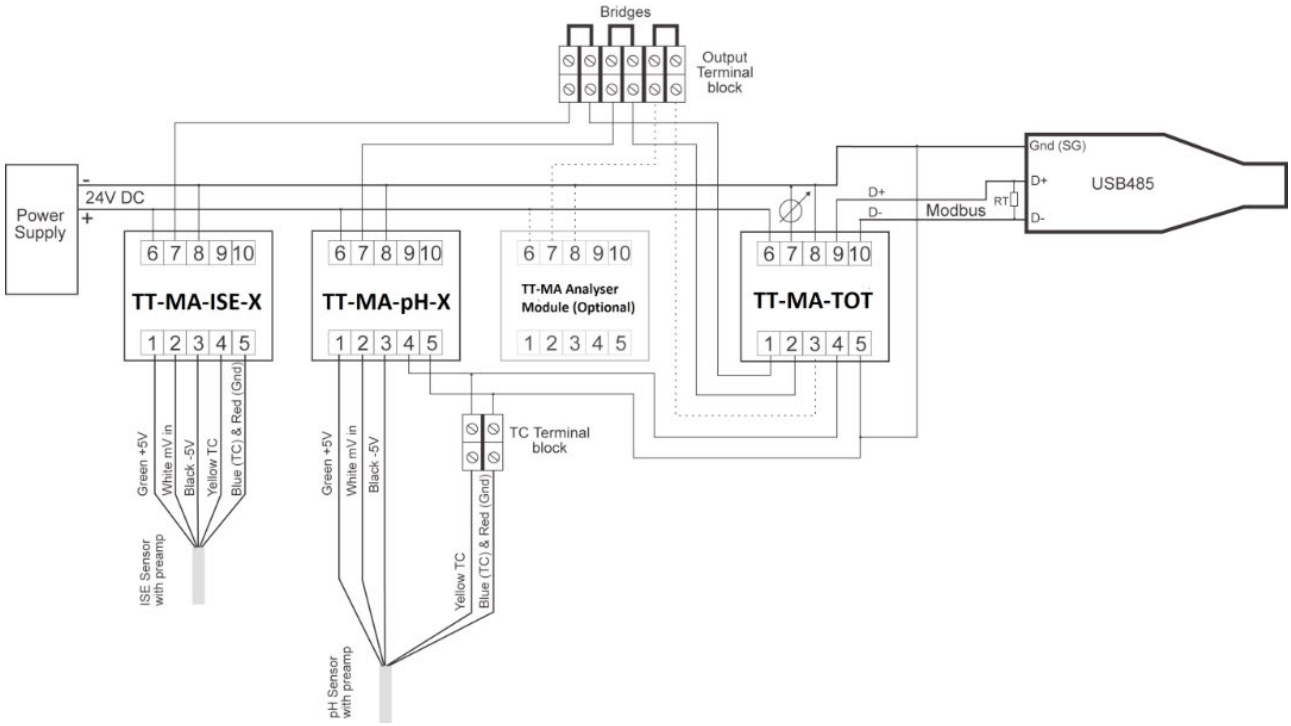



**Notes:**

1. The optional TT-MA Module can be any additional measurement module.
2. The Bridges on the Output Terminal Block can be removed so that the current loop output can be sent to any data acquisition or control system.

---

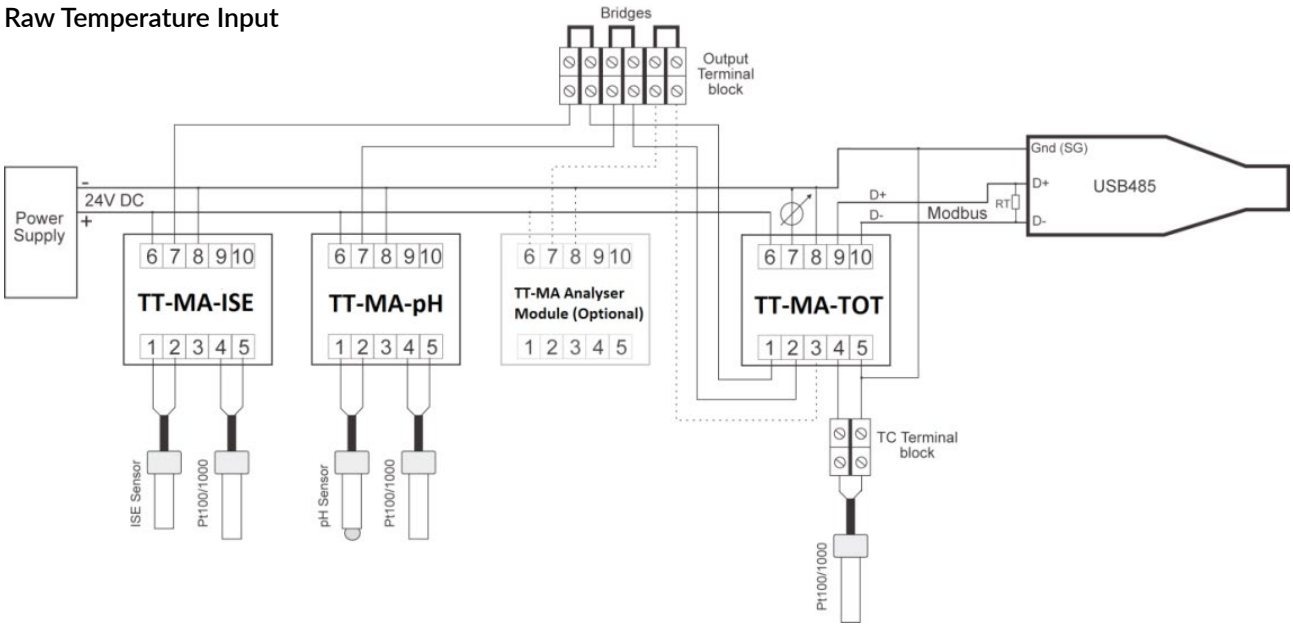
### Spliced Temperature Input for Preamp ISE and pH Sensors




**Notes:**

1. The optional TT-MA Module can be any additional measurement module.
2. The Bridges on the Output Terminal Block can be removed so that the current loop output can be sent to any data acquisition or control system.

## Raw Temperature Input




**Notes:**

1. The optional TT-MA Module can be any additional measurement module.
2. The Bridges on the Output Terminal Block can be removed so that the current loop output can be sent to any data acquisition or control system.
3. The TC Terminal block shown is optional (can be wired directly into terminals 4 & 5 on the TOT module if desired)

For additional wiring information please consult the Turtle Tough website www.turtletoughsensors.com

## Menu Navigation

The TT-MA family has a 3 digit display and 6 LEDs for setup and displaying values. The **Mode** key is used to navigate. The LED marked **Com** is illuminated when MODbus is active. **Programming** the module is accessed by use of the 3 keys located on the front panel. The **Mode** key is for selecting setup and the **Up** and **Down** keys are used to scroll through the parameters. To adjust a parameter select with the Mode key and modify the value using the **Up** and **Down** keys.

### Lock Function (IMPORTANT)

Note: **Parameter No. 01 is a LOCK function** which MUST be turned **OFF** to change ANY parameter. The default for the lock is **ON**. Once the lock is **OFF**, if there is a period of inactivity for 60 seconds the lock then defaults back to **ON**.

### Function and Programming

| No | Parameter | Description | Range | Default |
|---|---|---|---|---|
| **01** | Lock | Software Lock | On / Off | On |
| **02** | Address | Address on MODbus | Off, 1...247 | Off |
| **03** | Input 1 – Free ISE | Free ISE Analogue Input | Off, 4-20mA, 0-20mA | 4-20mA |
| **04** | Free ISE Range | Select Free ISE Input | Lo (0-10), Mid (0-100), Hi (0-999) | Lo (0-10) |
| **05** | 0/4mA Scale - Free ISE | Reading @ 0/4mA | - | - |
| **06** | 20mA Scale - Free ISE | Reading @ 0/4mA | - | - |
| **07** | Input 2 – pH | pH for Compensation | Off, 4-20mA, 0-20mA | 4-20mA |
| **08** | 0/4mA Scale - pH | Reading @ 0/4mA | - | - |
| **09** | 20mA Scale – pH | Reading @ 0/4mA | - | - |
| **10** | Temp Comp | Temperature Compensation Mode | Manual (Set) or Automatic (Aut) | Set |
| **11** | Manual Temp | Sets the Operating Temp if P10 is Set | 0...105°C | 25°C |
| **12** | Temp Mode | Sets the temperature input mode | Splice, Raw, 4-20mA | Splice |
| **13** | TC Input Select | Temp Input if P12 is Splice or Raw | Pt100 or Pt1000 | Pt1000 |
| **14** | Input 3 – Configure | Select Analogue Input 3 | Off, 4-20mA, 0-20mA | Off |
| **15** | Input 3 – Variable | Type of Input Measurement | Temp, pH, ORP/mV, CON, ISE | ISE |
| **16** | Input 3 - ISE Range (If P15 is ISE) | Select Working Input Range on TT-MA-ISE Input 3 | Lo (0-10), Mid (0-100), Hi (0-999) | Lo |
| **17** | Input 3 – Conductivity Cell Constant (If P15 is CON) | Select Conductivity Cell Constant | 0.01, 0.1, 1.0, 2.0, 10.0 | 1.0 |

| No | Parameter | Description | Range | Default |
|---|---|---|---|---|
| **18** | Lock | Software Lock | On / Off | On |
| **19** | Address | Address on MODbus | Off, 1...247 | Off |
| **20** | Input 1 – Free ISE | Free ISE Analogue Input | Off, 4-20mA, 0-20mA | 4-20mA |
| **21** | Free ISE Range | Select Free ISE Input | Lo (0-10), Mid (0-100), Hi (0-999) | Lo (0-10) |
| **22** | 0/4mA Scale - Free ISE | Reading @ 0/4mA | - | - |
| **23** | 20mA Scale - Free ISE | Reading @ 0/4mA | - | - |
| **24** | Input 2 – pH | pH for Compensation | Off, 4-20mA, 0-20mA | 4-20mA |
| **25** | 0/4mA Scale - pH | Reading @ 0/4mA | - | - |
| **26** | 20mA Scale – pH | Reading @ 0/4mA | - | - |
| **27** | Temp Comp | Temperature Compensation Mode | Manual (Set) or Automatic (Aut) | Set |
| **28** | Manual Temp | Sets the Operating Temp if P10 is Set | 0...105°C | 25°C |
| **29** | Temp Mode | Sets the temperature input mode | Splice, Raw, 4-20mA | Splice |
| **30** | TC Input Select | Temp Input if P12 is Splice or Raw | Pt100 or Pt1000 | Pt1000 |
| **31** | Input 3 – Configure | Select Analogue Input 3 | Off, 4-20mA, 0-20mA | Off |
| **32** | Input 3 – Variable | Type of Input Measurement | Temp, pH, ORP/mV, CON, ISE | ISE |
| **33** | Input 3 - ISE Range (If P15 is ISE) | Select Working Input Range on TT-MA-ISE Input 3 | Lo (0-10), Mid (0-100), Hi (0-999) | Lo |
| **34** | Input 3 – Conductivity Cell Constant (If P15 is CON) | Select Conductivity Cell Constant | 0.01, 0.1, 1.0, 2.0, 10.0 | 1.0 |
| **35** | Trim Low Output | 0/4mA Offset Calibration for Input 1 | As Defined by P23, P24, P25 & P26 | - |
| **36** | Trim High Output | 20mA Offset Calibration for Input 1 | As Defined by P23, P24, P25 & P26 | - |
| **37** | Baudrate | MODbus | 9,600/19,200 | 19,200 |
| **38** | Reset to Default | Reset to Default | Def = Reset, Par=No Reset | Par |

**Parameters Explained**

To access the programmable parameters see Menu Navigation.
The following is a description of each parameter settings.

| Parameter | Description |
|---|---|
| **P01** | Software lock. If the software lock is set to ON the parameter can only be read. Set Software Lock to OFF to change values. |
| **P02** | Sets module's address for MODbus communication. |
| **P03** | Sets Free ISE input to be 0-20mA or 4-20mA (P08 on TT-MA-ISE). |
| **P04** | Sets Free ISE input to low, mid or high.<br>This should match P09 on the TT-MA-ISE module that is used for the Free ISE input. |
| **P05** | Defines value of 0/4mA input for free ISE. This value should be adjusted to match P10 on TT-MA-ISE module to which is it connected. |
| **P06** | Defines value of 20mA input for free ISE. This should match P11 on TT-MA-ISE. P05 & P06 must be at least 20% of the operating range (P09 on the TT-MA-ISE). |
| **P07** | Sets pH input to be 0-20mA or 4-20mA (P11 on TT-MA-pH). |
| **P08** | Defines the value of 0/4mA input for pH. This value should be adjusted to match P13 on TT-MA-pH module to which is it connected. |
| **P09** | Defines the value of 20mA input for pH. This value should be adjusted to match P14 on TT-MA-pH module to which is it connected. The minimum difference between P08 and P09 should be at least 3 pH units. |
| **P10** | Sets temperature for pH compensation in automatic or manual mode. |
| **P11** | Defines temperature when P10 is "set" (in manual mode). |
| **P12** | Sets temperature input mode when P10 is Auto.<br>If P10 is manual, all temperature inputs are ignored. |
| **P13** | Sets Pt100 or Pt1000 TC input (if P12 is Splice or Raw mode). |
| **P14** | Sets 0-20mA or 4-20mA mode for Input 3. |
| **P15** | Sets type of signal to Input 3 to Temp, pH, ORP/mV, CON, or ISE. If P12 is 4-20mA then this must be set to Temp. |
| **P16** | Selects ISE Input 3 to low, mid or high when P15 is set to ISE. This should match P09 on the TT-MA-ISE module that is used as Input 3. |
| **P17** | Selects cell constant used on sensor for Input 3 when P15 is set to CON. |
| **P18** | Selects range for Input 3 when P15 is set to ORP/mV mode. |

| | |
|---|---|
| **P19** | Defines the value of the 4mA input. When P15 is ORP/mV the minimum value of P18 range selected is set. When P15 is ISE the value should be adjusted to match P10 on the TT-MA-ISE. When P15 is CON, then this will always be 0mS. When P15 is pH, the value should match P13 on the TT-MA-pH. |
| **P20** | Value of the 20mA input. When P15 is ORP/mV the maximum value of P18 range selected is set. When P15 is ISE the value should match P11 on TT-MA-ISE. P19 and P20 when P15 is ISE must be at least 20% of the operating range (P09 on TT-MA-ISE and P16 on the TT-MA-TOT should be the same also). When P15 is CON, this should match P13 on the TT-MA-CON. When P15 is pH, the value should match P14 on the TT-MA-pH. |
| **P21** | Displays the real time reading of Input 3. |
| **P22** | Selects the type of pH compensation being performed. |
| **P23** | Sets the Total ISE input to 0-20mA or 4-20mA. |
| **P24** | Sets Total ISE output to be low, mid or high. |
| **P25** | Sets Total ISE output at 0/4mA. |
| **P26** | Sets Total ISE output at 20mA. The difference between P25 and P26 should be at least 20% of the range selected by P24. |
| **P27** | Selects pH to be from Input 2 (Auto) or user defined (Manual). |
| **P28** | Sets the pH value when in P27 is in Manual mode. |
| **P29** | Offset calibration of 0mA or 4mA current signal Input 1 (Free ISE). |
| **P30** | Gain calibration adjustment of 20mA current signal Input 1 (Free ISE). |
| **P31** | Offset calibration of 0mA or 4mA current signal Input 2 (pH). |
| **P32** | Gain calibration adjustment of 20mA current signal Input 2 (pH). |
| **P33** | Offset calibration of 0mA or 4mA current signal Input 3. |
| **P34** | Gain calibration adjustment of 20mA current signal Input 3. |
| **P35** | Offset calibration of 0mA or 4mA current signal Output (Total ISE). |
| **P36** | Gain calibration adjustment of 20mA current signal Output (Total ISE). |
| **P37** | Sets the Baudrate in accordance with the MODbus master. |
| **P38** | Feature to reset the Module parameters back to factory default. |

## MODbus Communication Option

MODbus communication is included with the TOT Module. Turtle Tough Modules may be used as a slave for the Datalogging Module or as a slave in a SCADA data acquisition system. The setup and communication for each case is explained below.

### Datalogging Module and MODbus

If the TOT Module is used with the Datalogging Module, the baud rate on the TOT Module as well as the address should be noted. The baud rate (P37) must be set to the baud rate of the Datalogging Module. Whether a baud rate of 19,200 or 9,600 is used is of no importance, as long as all units connected to the Datalogging Module are set to the same baud rate.

The address (P02) must be unique in the network; Two units cannot have the same address. In a network with the Datalogging Module as the master, all addresses must be assigned in series; i.e. if 3 units are connected the addresses 1, 2 & 3 must be assigned to the three units. The order of the addresses is of no importance. In a network with a Datalogging Module, up to 63 Analyser Modules (slaves) may be connected.

### SCADA System &and MODbus

The baud rate (P37) must be set to the baud rate of the SCADA system. The address (P02) must be unique in the network and up to 247 Analyser Modules may be connected on a single network.

### MODbus Scaling

The scaling for the computed Total ISE output is defined by the range selected in P24 (low 0-10ppm, mid 0-100ppm or high 0-999ppm). Note that the MODbus scaling can differ from 0/4-20 mA analogue scaling.

The TOT Module contains a maximum of 4 input measurements (Free ISE, pH, Temp and Optional TT-MA Analyser Module) and a fifth value for the computed Total ISE as the output. All five of these can be transmitted via MODbus. Access to these are gained through the function code Read_Input_Registers (04).

### Read Input Registers

| Function Code | Start Address | Number of Values |
|---|---|---|
| 04 | 1 | 1 or 2 |

**Value 1** is ISE ppm
**Value 2** is Free ISE
**Value 3** is pH
**Value 4** is Temp

Measurements are transmitted in sequence; All values are rated to 0-1000 corresponding to the range, Output (Total ISE – 1st value) has no offset, Input 1 (Free ISE – 2nd value) an offset of 1024, Input 2 (pH – 3rd value) an offset of 2048, Input 3 (Temp – 4th value) an offset of 3072 and Optional TT-MA Analyser Module has no offset (5th value); Total ISE is sent as 0-1000, Free ISE as 1024-2024, pH as 2048-3048, Temp as 3072-4072, and Optional TT-MA Analyser Module (when present) as 0-1000.

The Module gives access to different diagnostic values as well via ***Diagnostics (08)*** as shown in the table below.

| Function Code | Sub Code (HEX) | Description |
|---|---|---|
| **08** | 00 | Return Query Data |
| | 0A | Clear counters and diagnostics register |
| | 0B | Return Bus Message Count |
| | 0C | Return Bus Message Communication Error |
| | 0D | Return Exception Error count |
| | 0E | Return Slave Message count |
| | 0F | Return Slave No Response count |
| | 12 | Return Bus Character Overrun count |

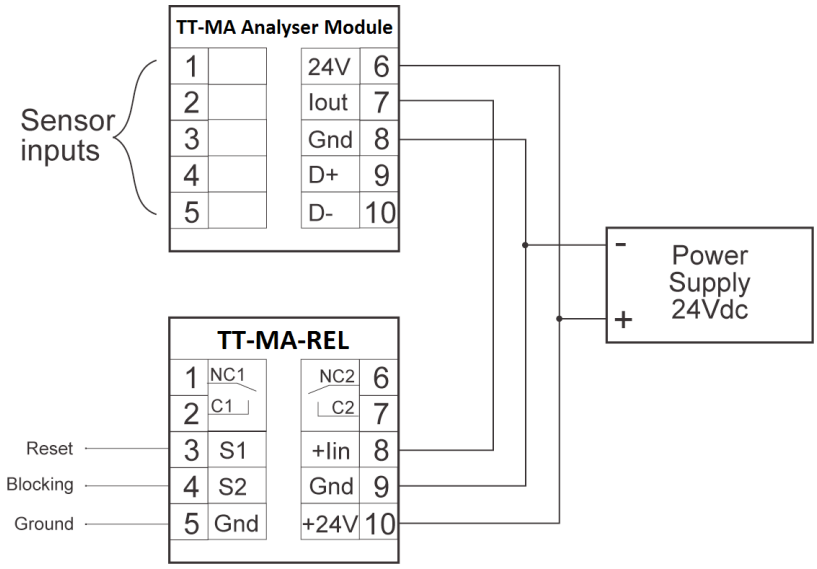
# Relay Module Specification


## Specifications

| | |
|---|---|
| **Power Supply** | 24VDC ±10% |
| **Consumption** | 60 mA max |
| **Input Current Range** | (0)4-20mA, 70Ω |
| **Digital input** | Pos. logic: 5-30VDC; Neg. logic: 0V |
| **Input S1** | External Reset |
| **Input S2** | Alarm Block |
| **Relay Description** | 2 each Single-Pole, Single-Throw (SPST) |
| **Relay Rating** | 250VAC / 5A (Dry Contact Type) |
| **Housing** | Lexan UL94V-0 (Upper part)<br>Noryl UL94V-0 (Lower part) |
| **Mounting** | M36 for 35 mm DIN rail |
| **IP Class** | Housing IP40. Connector IP20 |
| **Connector** | Max 16A. Max 2.5mm$^2$<br>Max torque 0.6 Nm |
| **Temp** | Usage -15 to +50 °C (Storage -35 to +75 °C) |
| **Weight** | 200 grams (7.04 ounces) |
| **Dimensions** | L 86 x W 36 x H 58 mm (3.4” X 1.4” X 2.3”) |
| **CE mark** | EN61326A |

## Wiring

**Typical Wiring Schematic for the TT-MA-REL Relay Module when used together with a TT-MA Analyser Module.**

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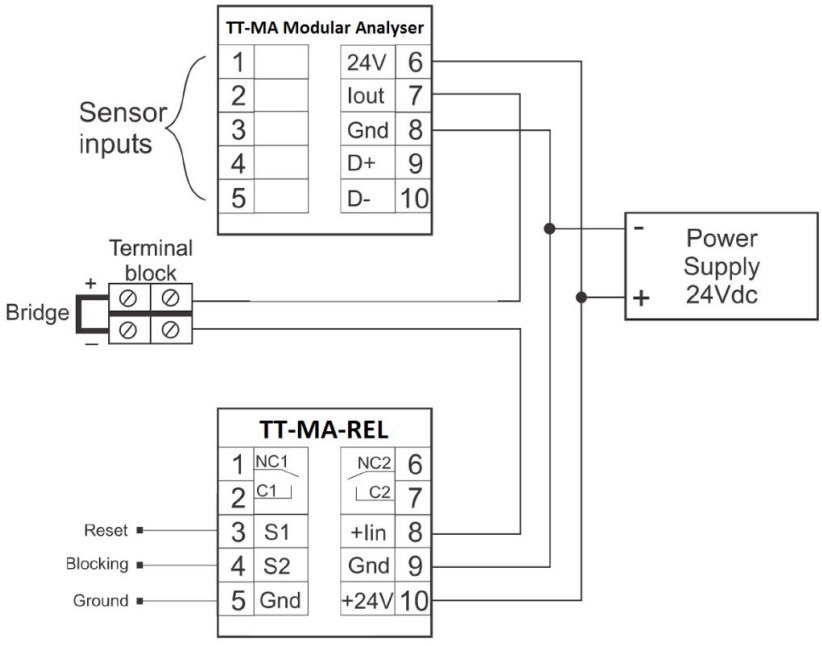
**Wiring Schematic for TT-MA-REL Relay Module when used together with a TT-MA Analyser Module and a 4-20mA Output is required to connect with additional Data Acquisition or Control Devices.**




If you wish to “insert” an external device into the current loop, it can be done by removing the bridge jumper and connecting the two terminals to the external device (“+” to device input and “–“ to device output, which may also be device ground). If no external device is to be connected, the bridge jumper must be in place to ensure normal operation of the TT-MA-REL Relay Module. For additional wiring information please consult the Turtle Tough website www.turtletoughsensors.com

## Menu Navigation

The TT-MA family has a 3 digit display and 6 LEDs for setup and displaying values.
The **Mode** key is used to navigate. The LED marked **Com** is illuminated when MODbus is active.
**Programming** the module is accessed by use of the 3 keys located on the front panel.
The **Mode** key is for selecting setup and the **Up** and **Down** keys are used to scroll through the parameters.
To adjust a parameter select with the **Mode** key then modify the value using the **Up** and **Down** keys.

**Lock Function (IMPORTANT)**
**Note: Parameter No. 01 is a LOCK function** which MUST be turned **OFF** to change ANY parameter.
The default for the lock is **ON**. Once the lock is **OFF**, if there is a period of inactivity for 60 seconds the lock then defaults back to **ON.**


Important

**Function and Programming**

| No | Parameter | Description | Range | Default |
|---|---|---|---|---|
| **01** | Lock | Software Lock | On / Off | On |
| **02** | Hold | Relay on Hold | On / Off | Off |
| **03** | Input | Analogue Input | 4-20mA, 0-20mA | 0-20 |
| **04** | Limit 1 | Type of Limit | Min (Lo), Max (Hi) | Hi |
| **05** | Limit 2 | Type of Limit | Off, Min (Lo), Max (Hi) | Lo |
| **06** | Display Mode | Type of Input Measurement | %, pH, CON, ISE | % |
| **07** | ISE Range | ISE Range Input | Lo, Mid, Hi | Lo |
| **08** | CON Range | Conductivity Cell Constant | 0.01, 0.1, 1.0, 2.0, 10.0 | 1.0 |
| **09** | 0/4mA Scale | Reading @ 0/4mA | * | * |
| **10** | 20mA Scale | Reading @ 20mA | * | * |
| **11** | Mode Lim 1 | Control Mode Limit 1 | Off, 1, 2 , 3 | Off |
| **12** | Mode Lim 2 | Control Mode Limit 2 | Off, 1, 2 , 3 | Off |
| **13** | Time Lim 1 | Time for Limit 1 | 1...250s | 10s |
| **14** | Time Lim 2 | Time for Limit 2 | 1...250s | 10s |
| **15** | Pulse Lim 1 | Pulse Rate Limit 1 | 1...250 pulses/min | 60 pulses/min |
| **16** | Pulse Lim 2 | Pulse Rate Limit 2 | 1...250 pulses/min | 60 pulses/min |
| **17** | Hysteresis 1 | Dead Band Limit 1 | 1...50% ** | 10% |
| **18** | Hysteresis 2 | Dead Band Limit 2 | 1...50% ** | 10% |
| **19** | Polarity 1 *** | Polarity for Relay 1 | Non-Inverted, Inverted | Non-Inverted |
| **20** | Polarity 2 *** | Polarity for Relay 2 | Non-Inverted, Inverted | Non-Inverted |
| **21** | Logic | Logic for Digital Inputs | Neg (Lo), Pos (Hi) | Lo |

| | | | | |
|---|---|---|---|---|
| **22** | Trim Low | Calibrate 0/4mA Input | As Defined | - |
| **23** | Trim High | Calibrate 20mA Input | As Defined | - |
| **24** | % Trim Low | Display 0/4mA Offset | ±9.99% | **** |
| **25** | % Trim High | Display 20mA Offset | ±9.99% | **** |
| **26** | Back to Default | Reset to Default | Def=Reset, Par=No Reset | Par |

* Refer to P09 & P10 section of Parameters Explained for full details on Scaling
** Value is 50% of range determined by Display mode P06 and scale parameters P09 & P10
*** Relay polarity does not apply when in TPC mode (P11/P12=2) or PFC mode (P11/P12=3)
**** Default values will depend upon 4mA and 20mA calibration performed at Turtle Tough

**Parameters Explained**

To access the programmable parameters see Menu Navigation.
The following is a description of each parameter settings.

| Parameter | Description |
|---|---|
| **P01** | Software lock. If the software lock is set to **ON** the parameter can only be read. Set Software Lock to **OFF** to change values. |
| **P02** | Hold (Relay condition held – signalled by flashing input LED) |
| **P03** | Analogue type of input is selected - 0-20mA or 4-20mA |
| **P04** | Indicates the type of Limit 1: Min or Max |
| **P05** | Indicates the type of Limit 2: Off, Min, or Max |
| **P06** | Select if display will show % (4mA=0%, 20mA=100%), pH units, Conductivity Units (either µS or mS), or ISE units (ppm) |
| **P07** | When P05 is ISE, selects full scale range on TT-MA-ISE module's 4-20mA output. 'Lo' is 0-10 ppm, 'Mid' is 0-100 ppm & 'Hi' is 0-999 ppm |
| **P08** | When P05 is set to CON, this selects the full scale range on the corresponding TT-MA-CON measurement module 4-20mA. Each cell constant will define the full range scale. For K=0.01, Max=0.5mS; K=0.1, Max=5mS; K=1.0, Max=50mS; K=2.0, Max=100mS, K=10.0, Max=500mS |
| **P09** | * This defines the value of the 0/4mA input. When P06 is % there are no adjustments possible. When P06 is ISE the value should match P10 on the TT-MA-ISE module to which it is connected. When P06 is CON, then this will always be 0mS (no matter what the cell constant). When P06 is pH, the value should match P13 on the TT-MA-pH module |

| | |
|---|---|
| **P10** | * This defines the value of the 20mA input. When P06 is % there are no adjustments possible. When P06 is ISE the value should be adjusted to match P11 on the TT-MA-ISE to which it is connected. The difference between P09 and P10 when P06 is ISE must be at least 20% of the operating range (P09 on the TT-MA-ISE). When P06 is CON then this will by default be the maximum full range scale associated with the conductivity cell constant selected. This value should match value of P12 on the TT-MA-CON. The minimum value is 10% of full range. When P06 is pH, the value should match P14 on the TT-MA-pH module. The minimum difference between P09 & P10 when P06 is pH is 3 pH units |
| **P11** | Control Mode Limit 1 settings are Off, 1, 2, or 3. Off means simple supervision with alarm relays set to limits only. If 1, then On/Off Control is enabled. If 2, then time proportional control (TPC) is enabled. If 3, then proportional frequency control (PFC) is enabled (a.k.a. variable pulse control) |
| **P12** | Control Mode Limit 2 settings are Off, 1, 2, or 3. Off means simple supervision with alarm relays set to limits only. If 1, then On/Off Control is enabled. If 2, then time proportional control (TPC) is enabled. If 3, then proportional frequency control (PFC) is enabled (a.k.a. variable pulse control) |
| **P13** | Time for Limit 1, sets the time when in TPC mode (P11=2). Value can be 1-250 seconds |
| **P14** | Time for Limit 2, sets the time when in TPC mode (P12=2). Value can be 1-250 seconds |
| **P15** | Pulse Rate for Limit 1, sets the pulse rate when in PFC mode (P11=3). Value can be 1-250 pulses per minute |
| **P16** | Pulse Rate for Limit 2, sets the pulse rate when in PFC mode (P12=3). Value can be 1-250 pulses per minute |
| **P17** | Hysteresis 1 is for Limit 1, if On/Off mode (P11=1) then hysteresis (dead band) is selected, if TPC or PFC (P11=2/3) then proportional band is selected |
| **P18** | Hysteresis 2 is for Limit 2, if On/Off mode (P12=1) then hysteresis (dead band) is selected, if TPC or PFC (P12=2/3) then proportional band is selected |
| **P19** | Polarity of Relay 1: Non-inverted/ Inverted *** |
| **P20** | Polarity of relay 2: Non-inverted/ Inverted *** |
| **P21** | Digital logic input configured to be active High (Hi) or Low (Lo) |
| **P22** | Trim Low, allows calibration offset of 0/4mA current signal input |
| **P23** | Trim High, allows calibration offset of 20mA current signal input |
| **P24** | % Trim Low displays result of 0/4mA trim offset calibration of P22 in % units |
| **P25** | % Trim High displays result of 20mA trim offset calibration of P23 in % units |
| **P26** | Feature to reset the analyser back to factory default |

** Value is 50% of range determined by Display mode P06 and scale parameters P09 & P10

*** Relay polarity does not apply when in TPC mode (P11/P12=2) or PFC mode (P11/P12=3)

**Parameters Accessible from LED Menu**

In addition to the parameters in the setup menu, the TT-MA-REL also features parameters directly accessible from the main LED menu (see below). The parameters are accessible by pressing the **'Mode'** key until the LED for the parameter to be altered is lit. Use the **'Up'** and **'Down'** keys to alter the parameter. These parameters and their functions are shown in the table below.

**Note: P01 is a "LOCK" which must be OFF to change ANY parameter at all.**

| Parameter | Description | Range | Default |
|---|---|---|---|
| Ts [s] | Start-Up – timer | 0.0 to 999s | 10.0 |
| Limit 1 | Set-point for Limit 1 *<br>Display mode %<br>Display mode pH<br>Display mode Con<br>Display mode ISE | <br>5.0– 99.9 %<br>0.1 – 14.0pH<br>1 – 500 **<br>1 – 999 *** | <br>80.0<br>11.2<br>400 **<br>800 *** |
| Limit 2 | Set-point for Limit 2 *<br>Display mode %<br>Display mode pH<br>Display mode Con<br>Display mode ISE | <br>5.0– 99.9 %<br>0.1 – 14.0pH<br>1 – 500 **<br>1 – 999 *** | <br>80.0<br>11.2<br>400 **<br>800 *** |
| Tr [s] (Limit 1) | Reaction Time Limit 1 ^ | 00.0 to 99.9s | 10.0 |
| Tr [s] (Limit 2) | Reaction Time Limit 2 ^ | 00.0 to 99.9s | 10.0 |

* Values depend on display mode and range selected with P06, P07, & P08
** Decimal point depends on selected range for conductivity
*** Decimal point depends on selected range for ISE
^ During this time period, no relay action will be undertaken when P06 is set to Off (supervision/alarm function only) or On/Off Relay control mode

## Control Functions and Modes

**On/Off control**

When the measurement crosses the chosen set-point, the relay will open and not close again until the measurement exceeds the hysteresis band.

## Hysteresis Band

A hysteresis band (a.k.a. dead band) always lies above a Min and below a Max limit.
This is P17 for Limit 1 & P18 for Limit 2 in On/Off mode.

**Proportional Band**

The proportional band is a range where a variable control is performed.
A proportion band lies above a minimum and below a maximum limit.
This is P17 for Limit 1 & P18 for Limit 2 in TPC control mode.

**Basic Frequency**

The basic frequencies for Limit 1 and 2 may be set from 1 to 250 pulse per minute (default 60).
This is valid in the PFC control mode only.

## Proportional Frequency Control (PFC a.k.a. Variable Pulse)

If the measurement lies outside the proportional band the relay will pulsate with the basic frequency. Inside the proportional band the frequency is changed linearly towards zero as the measurement approaches the set-point.

## Time Proportional Control (TPC)

The time is constant and equal to the Time for Limit. Instead the duty cycle is changed according to the same principle as for PFC control. If the measurement lies outside the proportional band the relay is closed permanently and open permanently if limit is exceeded.

### Control examples

On/Off control may be used for alarms and simple control of pumps. Proportional frequency control is primarily designed for the control of dosing pumps. Proportional time control may be used for control where more fine approach is required than simple on/off control offers.

### Example of pH Control Application using TPC Mode

The required settings needed for this TPC implementation are:

| | |
|---|---|
| **Limit P04** | Hi (Max limit) or Lo (Min limit); Here a max limit is needed |
| **Display Mode P06** | %, pH, CON, ISE; Here it is set to pH |
| **Control Mode P11** | TPC |
| **Set-point (LED Menu)** | Requested pH value; Here 9.8pH |
| **Hysteresis P17** | Band where the actual regulation is performed; Here 1 pH unit |
| **Time for Limit P13** | "Cycle time" for the TPC algorithm; In the figure shown below, this is the time for the relay on + time for relay off |
| **Start timer (LED Menu)** | Start-up time for the sensor to settle |

When the measured value crosses 5% of the measuring range (here corresponding to 0.7pH) the start-up timer is activated to avoid false readings during settling time of the sensor. This time should be selected large enough to give the sensor time to settle, but not much longer than this, since the supervision and control will be disabled in this period. The relay is off in this condition (see Period 1 on figure).

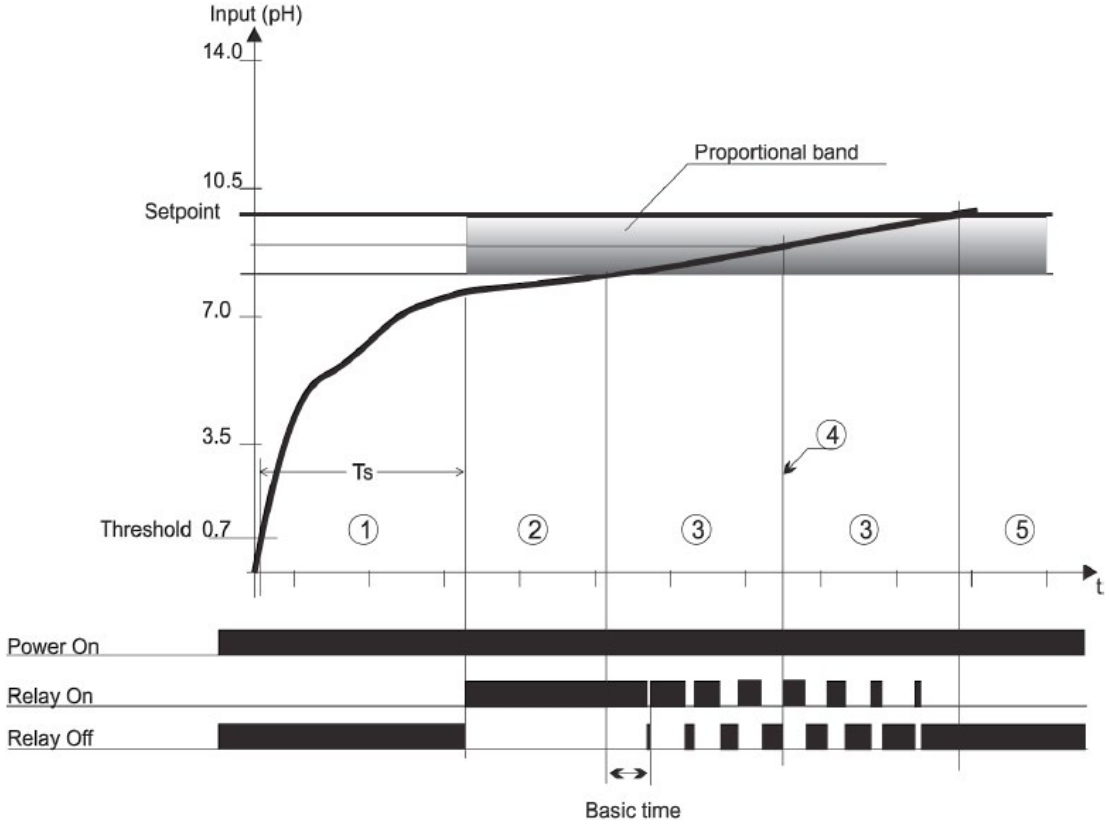
After expiration of the start-up timer the TT-MA-REL starts to control. In the example, the measured value lies below the set-point minus the proportional band (Period 2) and the relay will be continuously on to use maximum conditioning fluid.

When the measured value exceeds the set-point minus the proportional band the values is said to lie within the proportional band (Period 3) and the on-time of the relay is regulated proportional to the distance up to the set-point. This is illustrated with the two "bars" below the curve, where it is shown that the on-time drops as the value comes closer to the set-point.

At the point (4) the value is exactly in the middle of the proportional band where the on-time and off-time of the relay are equal (The relay is on half the time).

Finally when the set-point is reached the relay is kept off and will not be set on again until the measured value drops below the set-point. This is illustrated with (Period 5) conditions.

The figure below shows in principle how the TPC algorithm works. The curve depicts a process where a certain pH value (set-point) is required.




## MODbus Communication Option

No MODbus output is available for the RELAY Module. If MODbus is desired, it is recommended to get the required measurement(s) via the MODbus output of the pH, ORP, ISE, Conductivity or DO Analyser Module directly.

# DATALOGGING (DAT) MODULE


## Specifications

| | |
|---|---|
| **Power Supply** | 24VDC ±10% |
| **Consumption** | 60 mA max |
| **Serial Memory** | 8 Megabytes (8MB) |
| **Number Nodes** | Max 63 TT-MA Modules |
| **Clock/Calendar** | RTC with 10 year battery backup |
| **Serial Port 1** | RS485, 9.6/19.2k Baudrate |
| **Serial Port 2** | RS232, 115k Baudrate |
| **Housing** | Lexan UL94V-0 (Upper part)<br>Noryl UL94V-0 (Lower part) |
| **Mounting** | M36 for 35mm DIN rail |
| **IP Class** | Housing IP40. Connector IP20 |
| **Connector** | Max 16A. Max 2.5mm$^2$<br>Max torque 0.6 Nm |
| **Temperature** | Usage -15 to +50 °C (Storage -35 to +75 °C) |
| **Weight** | 200 grams (7.04 ounces) |
| **Dimensions** | L 58 x W 36 x H 86mm (2.3” X 1.4” X 3.4”) |
| **CE mark** | EN61326A |

## Why use a Datalogger Module?

When values from TT-MA Analyser Modules are required to be recorded/stored in a standalone system then the Datalogger Module for TT-MA Analyser Modules with the RS485 MODbus output option (included at time of order) is the solution.

## Unpacking

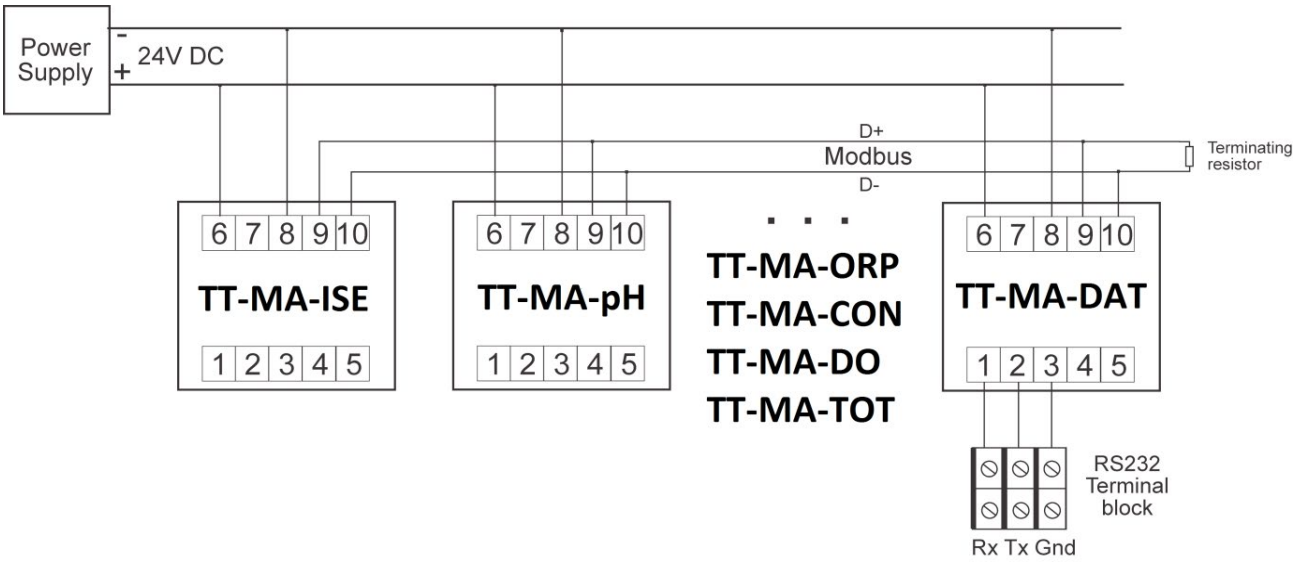

Important

Please have a copy of your order with you when you unpack your instrument. All orders are checked when they leave the factory. Please check that you have all the parts that were ordered as soon as you open the box. If anything is missing, or damaged, please contact your sales outlet immediately.

If the instrument needs to be returned for any reason please follow the return instructions given in this manual.

Please dispose of the packing in an environmentally responsible manner and in compliance with local regulations.

## Wiring




**Notes:**

1. Up to 63 TT-MA Modules may be connected to a single DAT Module. Each connected Module must have a unique valid node address from 1 to 247.
2. The value of the terminating resistor will vary based upon the number of connected nodes. Contact your Turtle Tough Distributor for assistance to choose the correct resistor.
3. The RS232 can be converted to a USB type interface with a suitable adapter (see Accessories section for details on this option).

For additional wiring information please consult the Turtle Tough **website** www.turtletoughsensors.com

## Menu Navigation

The TT-MA family has a 3 digit display and 6 LEDs for setup and displaying values. The **'Mode'** key is used to navigate. The LED marked **'Com'** is illuminated when MODbus is active. **Programming** the module is accessed by use of the 3 keys located on the front panel. The **'Mode'** key is for selecting setup and the **'Up'** and **'Down'** keys are used to scroll through the parameters. To adjust a parameter select with the **'Mode'** key and modify the value using the **'Up'** and **'Down'** keys.

### Lock Function (IMPORTANT)

**Please Note: Parameter No. 01 is a LOCK function** which MUST be turned **OFF** to change ANY parameter. The default for the lock is **ON**. Once the lock is **OFF**, if there is a period of inactivity for 60 seconds the lock then defaults back to **ON**.

**Function and Programming**

| No | Parameter | Description | Range | Default |
|---|---|---|---|---|
| **01** | Lock | Software Lock | On / Off | On |
| **02** | Sample Rate Units | Selects seconds or minutes as the units for sampling | Seconds or Minutes | Minutes |
| **03** | Sample Rate | Data Acquisition Frequency in Seconds/Minutes | 1, 2, 5, 10, 15, 30, 60 | 2 |
| **04** | RTC, Year | Set Date (Year) | 00-99 (2000-2099) | 2013 |
| **05** | Month | Set Date (Month) | 01-12 | 01 |
| **06** | Date | Set Date (Date) | 01-31 | 01 |
| **07** | Hour | Set Date (Hour) | 00-23 | 00 |
| **08** | Minute | Set Date (Minute) | 00-59 | 00 |
| **09** | Delay From Start-up | # of seconds delay before datalogging | 0, 2, 5, 10, 15, 30, 60, 120, 300 | 15 |
| **10** | Baudrate | MODbus Baudrate | 9,600 or 19,200 | 19,200 |
| **11** | Nodes | Total # of nodes datalogged | 1 to 63 | From Configuration |
| **12** | Memory Full | Action taken when the memory is full | Old = Stop logging dEL = Keep logging | dEL |
| **13** | Saver | Energy Save | On/Off | On |
| **14** | Erase Flash | **Erase all data** (See notes about when this is required) | dAt = Keep<br>dEI = Erase | dAt |

**Parameters Explained**

To access the programmable parameters see Menu Navigation.
The following is a description of each parameter settings.

| Parameter | Description |
|---|---|
| **P01** | Software lock. If the software lock is set to ON the parameter can only be read. Set Software Lock to OFF to change values. |
| **P02** | Selects sampling rate to be in units of seconds or minutes. |
| **P03** | Selects number of seconds or minutes (see P02) to be used for the sampling of all connected nodes. |
| **P04** | Sets the year. Please note the formats for setting the RTC. |
| **P05** | Sets the month. Please note the formats for setting the RTC. |
| **P06** | Sets the date. Please note the formats for setting the RTC. |
| **P07** | Sets the hour. |
| **P08** | Sets the minutes. |
| **P09** | Sets number of seconds delay before datalogging starts. |
| **P10** | Selects the Baudrate as 9,600 or 19,200. All slaves as well as the DAT MODbus master must use the same Baudrate. |
| **P11** | Displays the total number of nodes being datalogged in the current configuration (display only). Changes to the node configuration can only be made using the Windows software. |
| **P12** | Sets the action taken when the memory is full. If 'Old' is selected, datalogging will cease when memory is full. If 'dEL' is selected, datalogging will continue by erasing the oldest value. |
| **P13** | Sets the energy save mode. When enabled, the display will only periodically flash to conserve power to the LED. |
| **P14** | Erases all of the logged data. **Note that this action cannot be undone!**<br>Care should be taken that the logged data is downloaded and checked for integrity prior to taking this action. To erase, select **'dEl'** and press the **'Mode'** key.<br>See details in the"Using the Datalogging Module" section for situations when the data should first be downloaded prior to making changes & erasing the data. |

## Using the Datalogging Module

Usage assumes both the Windows datalogging and graphing software for TT-MA Modules fitted with MODbus (and all necessary RS485 MODbus wiring connections for the same) and the separate Windows software for the DAT have been correctly installed in the default configuration and are working on a single PC/tablet.

A configuration file needs to be created using the Windows MODbus datalogging and graphing software. This configuration file shall contain all of the information necessary for the DAT Module to display and record all values from all of the connected TT-MA Modules in engineering units. Specifically this includes the node type (pH, ORP, ISE, CON, DO or TOT) and the scaling associated with the 0-1000 10-bit MODbus output for each value transmitted from each node. It is assumed that each pH, ORP, ISE, CON and DO node will send both the process parameter and temperature values. The DO Module will always send 3 values, namely the DO ppm, DO % saturation and temperature. The TOT can send as many as 5 values (Total ISE, Free ISE, pH, Temperature & an additional TT-MA Module if present).

Once a configuration file has been created and tested this program shall be closed and the RS485 connection removed. The DAT Windows software will be opened which will search for the current MODbus datalogging configuration file. The Windows DAT software will automatically load the last used configuration file. Note: An alternate configuration file can be selected if desired (or else if the last used file cannot be found the config file must be chosen).

The appropriate COM port to which the DAT Module is connected must be selected before the configuration file can be loaded. This COM port can either be a native RS232 connection using just the DB9 (a.k.a. D-sub) terminal block adapter or else a USB connection using a RS232 to USB converter as detailed in the Accessories section.

Connect the 2-wire RS485 leads that were previously interfaced to the Windows datalogging and graphing software used to create the needed configuration file to terminal 9 and 10 on the DAT Module. If all units are energised, you should now be datalogging all connected modules at the sampling rate specified in P02 and P03. Be sure to check that you have also properly set the year, month, date, hour and minutes before connecting the live RS485 MODbus leads.

It is possible to validate that the uploaded configuration file is correctly working on the DAT module and that datalogging is commencing as expected by using the functionality as described in the Display section. If you want further validation of proper function, you can download an initial data set to confirm that all expected datalogging is occurring properly prior to completion of commissioning (see below).

A data set can be downloaded from the DAT Module if it is correctly connected (either by RS232 or converted USB) and the corresponding COM port has been properly selected in the Windows DAT software. The configuration file active in the Windows DAT Module must match the configuration file of the DAT that will be downloaded to ensure data integrity. The memory of the DAT Module must be manually erased from the module itself using P14. Erasing the stored logged data on the DAT module cannot be done from the Windows software as this can only upload and download a configuration or else download a set of logged data.

After download, the data can be graphed and otherwise worked up and manipulated (e.g. export to Excel) by importing the downloaded *.db file into the same Datalogging and Graphing software for TT-MA Modules with MODbus that was used to create the configuration loaded onto the DAT Module.

**Note:** Be sure to note where the downloaded DAT data set is saved (*.db) and to give it a meaningful file name (e.g. “RemoteRiverSite42_2013-01-01_to_2013-05-01.log” or something similarly useful) so that you can find and make sense of the data in the future.

## Datalogging Capacity

The capacity of the Datalogger depends upon the configuration and the number of nodes connected.
To provide an indication of the expected number of days storage based on various scenarios see the tables below:

| Number of TT-MA pH, ISE or CON Analyser Modules | SAMPLING RATE | | |
|---|---|---|---|
| | Every **30 Seconds** | Every **5 minutes** | Every **15 minutes** |
| **1** | 694 | 6,944 | 20,833 |
| **4** | 174 | 1,736 | 5,208 |
| **8** | 87 | 868 | 2,604 |
| **16** | 43 | 434 | 1,302 |
| **32** | 22 | 217 | 651 |
| **63** | 11 | 110 | 331 |

| Number of TT-MA DO Analyser Modules | SAMPLING RATE | | |
|---|---|---|---|
| | Every **30 Seconds** | Every **5 minutes** | Every **15 minutes** |
| **1** | 463 | 4,630 | 13,889 |
| **4** | 116 | 1,157 | 3,472 |
| **8** | 58 | 579 | 1,736 |
| **16** | 29 | 289 | 868 |
| **32** | 14 | 145 | 434 |
| **63** | 7 | 73 | 220 |

| Number of TT-MA TOT Analyser Modules | SAMPLING RATE | | |
|---|---|---|---|
| | Every **30 Seconds** | Every **5 minutes** | Every **15 minutes** |
| **1** | 278 | 2,778 | 8,333 |
| **4** | 69 | 694 | 2,083 |
| **8** | 35 | 347 | 1,042 |
| **16** | 17 | 174 | 521 |
| **32** | 9 | 87 | 260 |
| **63** | 4 | 44 | 132 |

### Notes:

1. *Times for datalogging capacity are shown in units of DAYS*
2. *Datalogging capacity shown are approximate for reference purposes*
3. *pH/ISE/CON send process parameter & temp for each node*
4. *DO sends DO ppm % Saturation & temp for each node*
5. *TOT sends Total ISE, Free ISE, pH, Temp & Aux each node*
6. *DAT module comes standard with two (2) year warranty*

## Display

### Capacity

The default main display mode shows the percent of the available 8MB memory that is used. This percent of memory used is shown in percentage units and is updated continuously (in real time).

When in the Capacity mode, push the **'Down'** button to show the number of days that datalogging can run without becoming full (assuming the node configuration and sampling rate are unchanged). If the DAT Module is getting close to full capacity and the data set cannot be downloaded, it is recommended to change the sampling rate with P02 & P03 and then go back to the capacity mode to see the new number of days that you can datalog with the revised sampling rate. When over 80% of capacity is exceeded, the capacity LED will flash continuously as a notification and warning.

### Node

Push **'Up'** or **'Down'** key to find the node of interest. Press '**Mode**' button to select the displayed node number.

### Type

The type of module for the selected Node is shown in the '**Type**' LED mode (pH, ORP, ISE, CON, DO or TOT). The temperature is shown in °C units by pushing the **'Down'** button when in the '**Type**' mode of that selected node.

### Reading

For the pH, ORP, ISE and Conductivity module types, the value of the process parameter is displayed (in the native units for that type) in the '**Reading**' mode for the selected Node. Negative values will show as flashing.

For the DO module type, the ppm units are shown. To see the value in % saturation units, press the **'Down'** key. For the TOT, the value in the main '**Reading**' mode shall be the Total ISE. Pushing the Up button will show the Free ISE while pushing the **'Down'** button will show the pH. Pushing the **'Up'** & **'Down'** keys together simultaneously in the '**Reading**' display mode for a TOT node type will show the Additional TT-MA Module value (if present).

### Notes

1. The scaling details and user defined name of each node can be found on the original configuration file uploaded via RS232/USB to the DAT. This configuration file must be saved as it will be required to workup all downloaded data.

2. Before adding or removing any nodes, the logged data from the DAT should be downloaded BEFORE creating and loading the new configuration file. This is critical to prevent loss of integrity to the logged data.

3. Any change to the range and/or scaling of any connected TT-MA Modules will necessitate download of the data and creation of a new modified configuration file that must be reloaded onto the DAT. Since many (most) of the TT-MA Modules have the MODbus output scaling follow the analogue 0/4-20mA setpoints, in most cases if the 0/4-20mA scaling (or associated range) is changed then a new configuration file must be created to ensure proper datalogging operation of the DAT Module. The data should be downloaded BEFORE creating & loading a new configuration file.

4. The sampling rate on the DAT Module can be changed without compromising the integrity of the logged data set.

## Troubleshooting

The DAT Module is equipped with diagnostics used to test if the network is operating as expected. If not, an error message is displayed; An error is displayed as E.AA, where E is the error code and AA is the node or the faulty input on the DAT:

**Error code 2:** Communication error, typically network problem.

**Error code 3:** Wrong setup of either master or node.

## Digital Communication

The DAT Module contains two modes of digital communication. Data is acquired via the RS485 network from terminals 9 & 10, with the DAT as MODbus master. Upload and download of node configuration and download of data is accomplished via RS232 (or USB connection with suitable converter – see Accessories section) from signals on terminals on 1, 2 & 3. No special MODbus protocol specifications are required when TT-MA Modules are paired with the DAT Datalogging Module since all communications are handled either entirely between the modules or else the Windows software.

## MODbus Communication

The DAT Module acquires data from the TT-MA nodes using the MODbus standard for multidrop communication. The units are connected using the RS485 system (see wiring section). Configuration of the nodes is performed via the included Windows software & (optionally) preconfigured at the Turtle Tough factory. The DAT module has a built in clock and calendar circuit with a 10 year battery backup.

### Communication Protocol

The basic communication information for the RS485 MODbus RTU protocol as implemented in the TT-MA family is:

- 8-bit
- Even Parity
- 1 Stop Bit

The MODbus standard includes a number of function codes giving the master of the network the ability of gathering or placing values and parameters in every slave connected to the network. The MODbus Compatible Modules in the TT-MA family have all the required function codes built-in as well as the relevant codes for each unit. The MODbus Modules each contain a number of measurements (anywhere from 1 to 5 depending upon the module type), which may be collected via the MODbus protocol. Access to these measurements is common to all units in the TT-MA family and is gained via the function code Read_Input_Registers (04). The units also give access to various diagnostics values via Diagnostics Function Code (08). The details of these function codes are described in the relevant sections of the given TT-MA-pH, TT-MA-ISE, TT-MA-TOT, TT-MA-CON and TT-MA-DO manuals.

## Transfer of Data to Windows Tablet or PC

The data accumulated in the DAT Module may be transferred to a PC using the RS232 (standard) or USB connection (see Accessories section). The transferred data may be graphed & visualised or imported to Microsoft Excel for further data analysis using the included software packages.

## Accessories

The following complementary accessories are available for use with the DAT Module:

- RS232 to USB Adapter for DAT Module (when no RS232 port is available on the Windows PC)
- RS485 to USB Converter for Windows Datalogging Software (for USB node configuration setup)
- RS485 to RS232 Converter for Windows Datalogging Software (for RS232 node configuration setup)

To find out more about these accessories please contact your Turtle Tough Distributor.

# WARRANTY

## Product Warranty

Every Turtle Tough product is thoroughly inspected and tested before leaving the factory and prior to shipping. In addition to any statutory rights and remedies you may have, Turtle Tough warrants all of its products against defective workmanship and faulty materials for 12 months from the date of purchase and undertakes, at its option, to repair or replace, free of charge, each product or part thereof on condition that:

- The complete product is returned to Turtle Tough or one of its authorised service agents, in person or freight pre-paid by you, and found, on examination, to be suffering from a manufacturing defect;
- The product or relevant part has not been subject to misuse, neglect, or been involved in an accident; and
- The repairs are not required as a result of normal wear and tear.
- Damage caused by wear and tear, inadequate maintenance, corrosion, or by the affects of chemical processes is excluded from this warranty coverage

*The above warranty excludes sensors. Please see sensor warranty below.*

## Sensor Warranty

Turtle Tough sensors are electrochemical devices and as such have a limited operating life. Life expectancy depends on the field of application such as the medium, pressure and temperature. It can vary between a number of weeks to several years. There are special cases in extreme environments where operating life will only be a few days. Characteristic and response time will also change with aging.

As such electrochemical sensor are articles of consumption and are not subject to a common guarantee. Replacements or exchanges are generally excluded unless a manufacturing defect is determined to be the cause. It is not possible to predict the rate of deterioration for a particular process, nor can we provide a guarantee on sensor life because it is impossible to predict the rate of exposure, contamination and deterioration.

Damage caused by wear and tear, inadequate maintenance, corrosion, or by the effects of chemical processes is excluded from this warranty coverage.

Our agents or representatives may provide you with a life expectancy guide based on similar applications we have experienced; however this in no-way constitutes a warranty of performance and is a general indicator.

## Shelf Life Warranty

The standard shelf life for a Turtle Tough Sensor sensors is one year from the date of shipment. Sensors stored longer than this period may still be functional but are no longer under warranty. Sensors should be stored in a cool, dry location with the sensor tip (where the pH/ORP element is located) oriented toward the ground. All pH/ORP/ISE sensors come standard with a conditioning solution in the cap. This conditioning solution is 50% pH 4 buffer and 50% saturated potassium chloride (mixed by volume). The sensor cap should be keep tightly affixed to the sensor body and sealed with common piping teflon tape when the sensor is not in use. Sensors that are to be returned for shelf life warranty claim must have the original sensor cap and conditioning solution intact to be eligible for warranty replacement.

## Blown Preamplifiers (Preamps)

Damaged preamplifiers are not covered under warranty. Preamps are electrical devices that are sensitive to electrostatic discharge. Sensors with preamps are clearly marked and extra care must be taken when handling these sensors as human contact with the electrical connections can discharge static to the preamplifier causing it to blow. This will render the product inoperable. Sensors with preamplifiers undergo additional quality checks prior to shipment to ensure that preamplifiers are 100% operational upon delivery. Ground loop or analyser problems may also cause blown preamplifiers and damage to sensors by faulty installations is not covered by warranty.

# RETURN GOODS

**For all return goods the following information must be included in the letter accompanying the returned goods:**

- Model Code and Serial Number
- Original Purchase Order and Date
- Length of time in service and description of the process
- Description of the fault and circumstances of the failure
- Process/environmental conditions that may be related to the failure of the sensor
- Statement as to whether warranty or non-warranty service is requested
- Complete shipping and billing instructions for return of material, plus the name and phone number of a contact person that can be reached for further information
- Clean Statement: returned goods that have been in contact with process fluids must be decontaminated and disinfected prior to shipment. Goods should carry a certificate to this effect, for the health and safety of our employees. Material Safety Data sheets must be included for all components of the process to which the sensor(s) have been exposed.

All sensor returns are to be accompanied by a completed Return Material Authorisation Document clearly stating the reason for the return and the with the Clean Statement Return filled in.

*See the warranty and returns section under support on our website turtletoughsensors.com for details.*

## IMPORTANT!

Please note that for sensors, cables must NOT be cut or this will void the warranty. The cable contains a unique identifier laminated to the cable end, and if this is removed we have no way of tracing the product. Sensors dying or expiring in the course of use is not covered by the product warranty.

# SUPPORT

For technical support please contact our head office **1300 781 701** or visit our website turtletoughsensors.com for information on sensor care, calibration, wiring and installation related issues.