EXTREME LIQUID ANALYSIS

TT-MA Family Module Manual

Contents

Safety Precautions

DANGER

- 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.

Disconnect electrical supply before working on this 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
Refers to an imminent danger. Non-compliance can lead to death or extremely serious injury.


Danger

WARNING
Refers to a potential hazardous situation. Non-compliance can lead to death or extremely serious injury.


Warning

CAUTION
Refers to a potential hazardous situation. Non-compliance can lead to minor injury or property damage.


Caution

NOTICE
Appears in conjunction with safety instructions which may endanger the analyser and its operation if disregarded.


Notice

IMPORTANT
Draws attention to supplementary information to make the work easier and ensure trouble-free operation.


Important

Markings which are affixed directly to the equipment must be observed without fail, and must remain fully 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.

Important Safety Instructions

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

NOTICE

Read and follow all instructions. Save these instructions.

Danger

WARNING

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

Warning

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.

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.

Electric Shock Hazard

Hazards due to Non-compliance

Danger

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

Electric Shock Hazard

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

Installation, Maintenance and Inspection

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.

Warning

Impermissible Modes of Operation

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

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

Chemicals

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

Caution

CAUTION

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.

Danger

IMPORTANT

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.

Important

Sensors

Health and Safety

Before making or breaking any electrical or signal connections, ensure that the instrument is isolated from the electrical supply.

Disconnect electrical supply before working on this equipment.

When handling the sensor please wear the appropriate PPE.

Appropriate PPE to be worn when in contact with the sensor.

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.

Take care when removing the sensor.

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 at: www.turtletough.com.au/ph-sensor-resistance-guide/

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 includes the following 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

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 its purpose as outlined in this manual. It must be installed and commissioned in accordance with this manual and by trained, qualified personnel.


Danger


Electric Shock Hazard


Important

Site Selection

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

- 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.

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

Specification

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

pH 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:

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

Where:
E = total potential difference (measured in mV)
E_o = 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


Electric Shock Hazard

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


Important

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

- 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.

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

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. They should never be installed horizontally or inverted.

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 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.

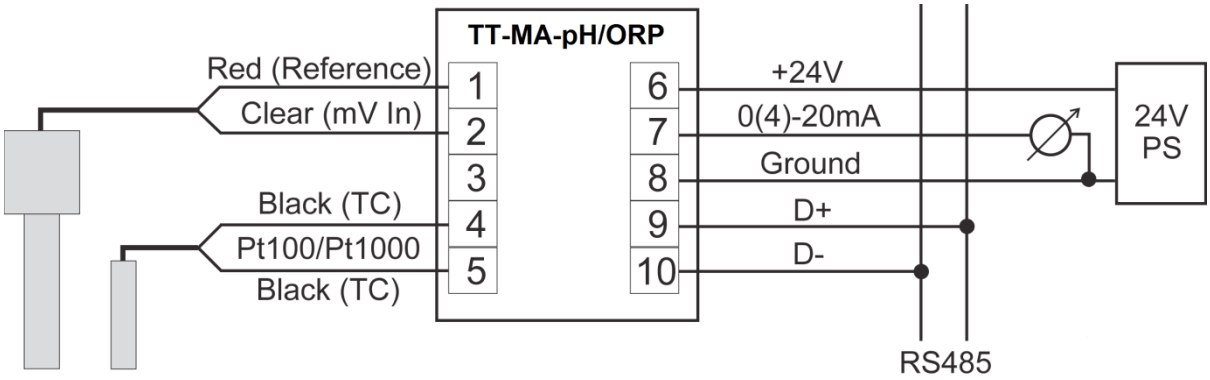
Please Note: Avoid excessive force when installing pH/ORP Sensor

Wiring

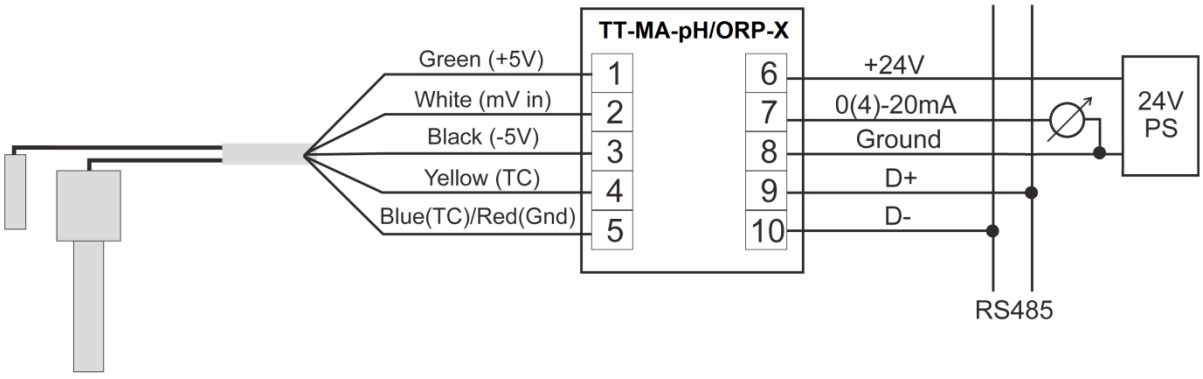
Turtle Tough pH/ORP Sensors are designed to provide optimal life when connected to a TT-MA Online Analyser or TT-pHP Portable Meter. Connection to the TT-pHP is via BNC and Banana Plug Connectors. Wiring of Non-Preamp, Preamp and External Preamp Sensors to the TT-MA are as follows:

Caution

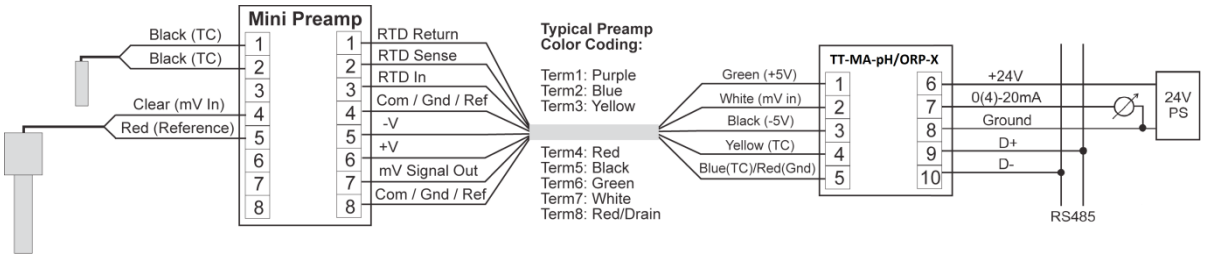
Non-Preamp Sensor



Preamp Sensor



External Preamp Sensor



Note: Please consult the Turtle Tough website (www.turtletough.com.au) for additional wiring information.

Analyser 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, 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**.

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 I_{out}	Input used for output	pH or Temperature	pH
11	I_{out}	Type of output	4-20mA, 0-20mA	4-20
12	I_{out} mode	I_{out} 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. 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. 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. 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. 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. 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 the unit or the Turtle Tough website (www.turtletough.com.au).

pH Calibration - Buffer and Slope Adjustment

Ensure software lock is **Off** prior to commencement. Using **Mode** select **Buffer** 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 **Buffer** 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: Buffer 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 **Buffer** LED mode. Navigate with the **Mode** key to the **Buffer** 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.

pH Buffer Accuracy & 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.

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.

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.

Sensor Care & 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.

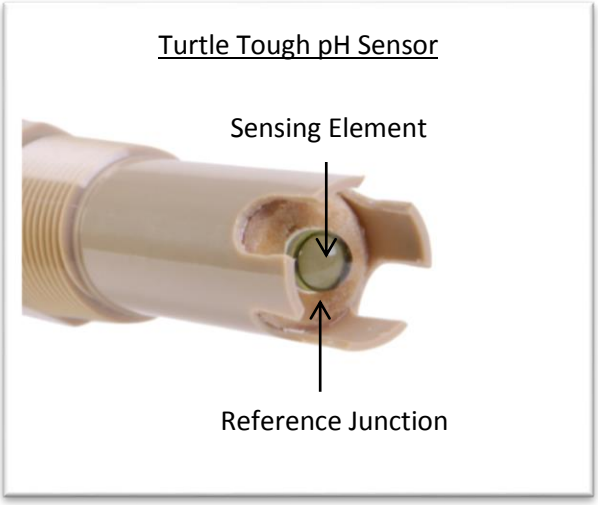
Application Difficulty Rating	Cleaning Schedule
1-3	Monthly
4-6	Fortnightly
6-7	Weekly
8-9	Twice (2x) per week
10	Daily

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

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.



Common 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.

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.

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.

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 & 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 & 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

Specification

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 2.5mm² 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

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.

$G = 1/R$ (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


Danger


Electric Shock Hazard

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.

Sensor Site Selection


Important

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

- 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.

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

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.

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.

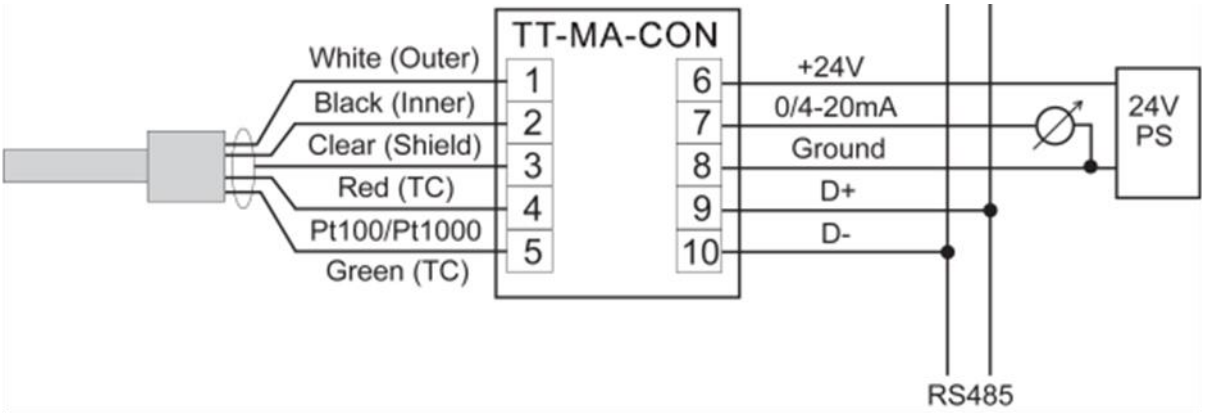
Turtle Tough has a range of installation hardware available as optional accessories including but not limited to Stainless Steel Immersion Rods, Stainless Steel Sanitary Sensor Holders & Extension Tubes and Valve Retractable Assemblies. Contact your Turtle Tough Distributor for technical support on the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

Please Note: Avoid excessive force when installing Conductivity Sensors


Caution

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.turtletough.com.au) 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	Temperature Compensation	Auto, Fixed	Auto
05	Comp. Temp.	Compensating Temperature	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 Temperature	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 mode	Non-inverted, inverted	Non-inverted
24	Not Utilised			
25	Not Utilised			
26	Reset Cals Only	Reset P14, & P15 Cals	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 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. Both 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:

1. The raw (uncompensated) conductivity can be viewed by pushing the **Down** button in the main measure display mode.
2. 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.
3. Standard Conductivity Solutions vary with temperature and this must be accounted for when conducting a calibration.
4. 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 & 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	Inspection Schedule
1-5	Monthly
5-7	Fortnightly
8-10	Weekly

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

Cleaning

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.

(1) 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.

(2) 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.

(3) 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.

(4) 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 & 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 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 & 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 and 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 set as 0-1000 corresponding to the effective range, but the temperature has an offset of 1024; i.e. the conductivity range as set by P11 & 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

Specification

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 or 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)
	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

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 DO 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 DO 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


Electric Shock Hazard

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


Important

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

- 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.

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

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.

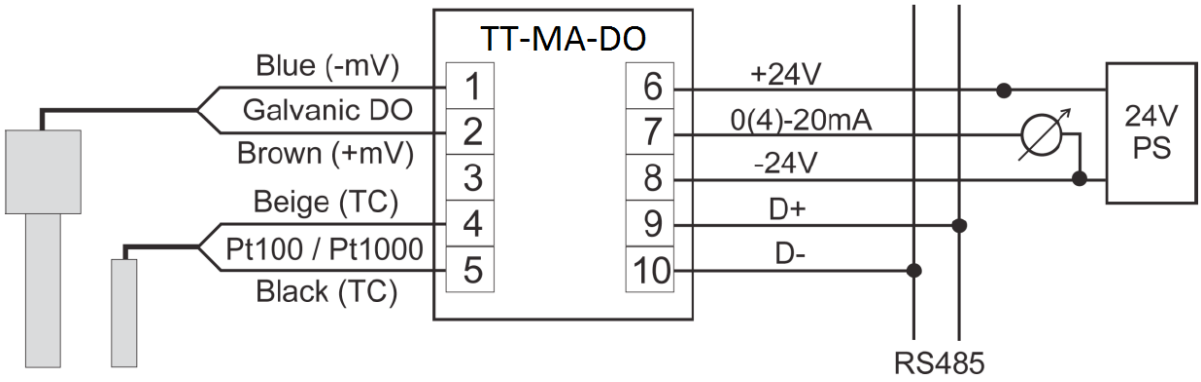
Turtle Tough has a range of installation hardware available as optional accessories including but not limited to Stainless Steel Immersion Rods, Stainless Steel Sanitary Sensor Holders & Extension Tubes and Valve Retractable Assemblies. Contact your Turtle Tough Distributor for technical support on the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

Please Note: Avoid excessive force when installing Dissolved Oxygen Sensors

Caution

Wiring

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



Note: Please consult the Turtle Tough website (www.turtletough.com.au) 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 (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	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, 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 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.
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 & 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. 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). 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 DO 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** & **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.

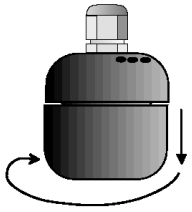
Manual Calibration Routine: For a manual gain calibration, adjust using the **Up** or **Down** keys until the display reads exactly **0.0**. Positive deviations are shown as X.X or XX. Negative deviations are shown as -X.X or -XX. If a positive value is shown adjust using the **Down** key and if a negative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

Cleaning & Maintenance of a Turtle Tough DO Sensor

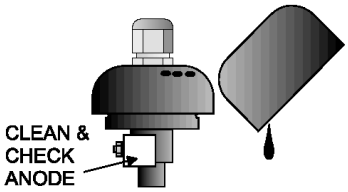
The sensor's membrane must be kept free from deposits. The membrane should be cleaned at regular intervals with the frequency depending on the actual conditions. Cleaning can be performed with a cloth or soft paper. The sensor should not be taken apart unless the membrane is damaged or you cannot calibrate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

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

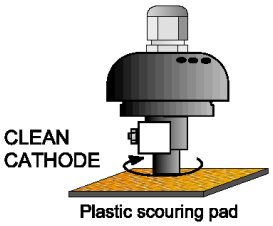
1) Remove the sensor, rinse it and unscrew the cap. If it sticks, tap the side of the sensor gently with a hammer then try again. Discard the very dark used electrolyte, rinse the cap and top part, clean off any dark coloured oxide deposits.



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.

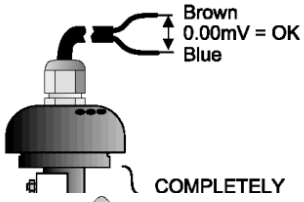


3) Check the cathode and remove any deposits using the plastic abrasive pad or a little wet or dry emery paper, grade 600. The cathode MUST NOT BE POLISHED.

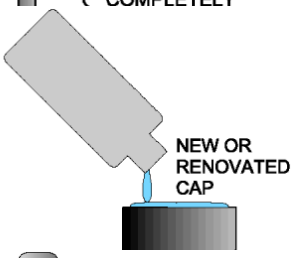


4) Rinse and dry the top part.

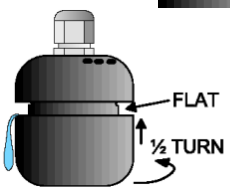
5) You can at this stage perform an easy check on the sensor. Dry the sensor completely taking care especially at the cathode and area around it. You can then observe the output signal of the sensor and it should be zero (less than 0.01 mV when measured at the sensor). Contact your Turtle Tough Representative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



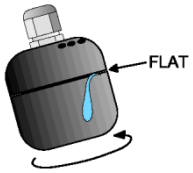
6) Fill a NEW OR RENOVATED CAP to the brim with electrolyte. The use of excess electrolyte helps to remove any entrenched air bubbles.



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.

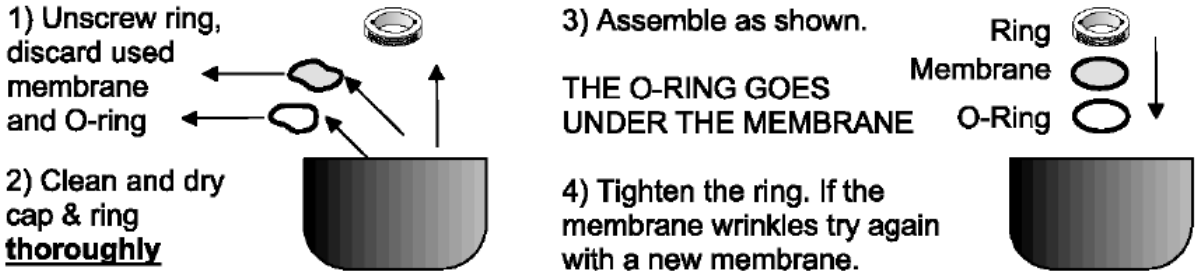


IT IS IMPORTANT THAT THE SENSOR IS FILLED COMPLETELY.

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.

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.



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 & 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 & 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 & 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 and 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

Specification

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
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) 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

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.

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

Where:
E = total potential difference (measured in mV)
E_o = 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:

i) 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.

ii) 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.

iii) 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. 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.

iv) 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.

v) 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.

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

vii) 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^-).

Danger

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

Electric Shock Hazard

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

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


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.

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.


Important

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

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.

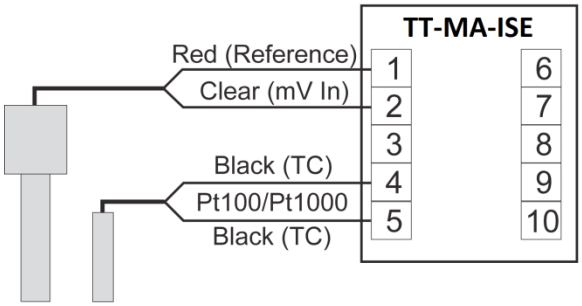

Caution

Please Note: Avoid excessive force when installing an ISE Sensor

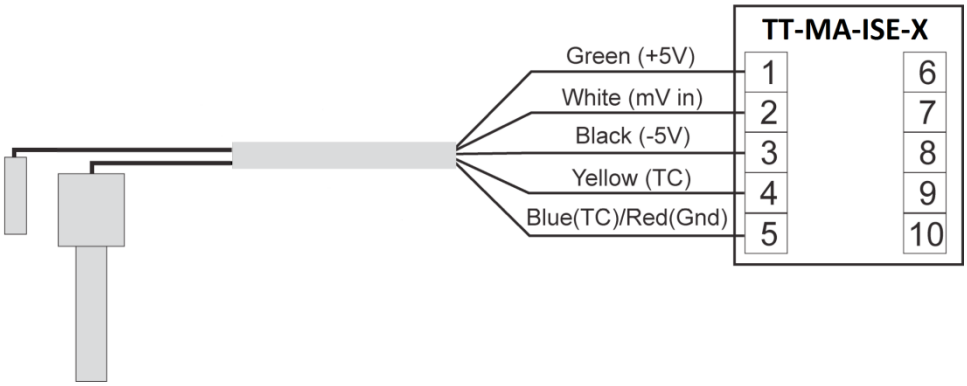
Wiring

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:

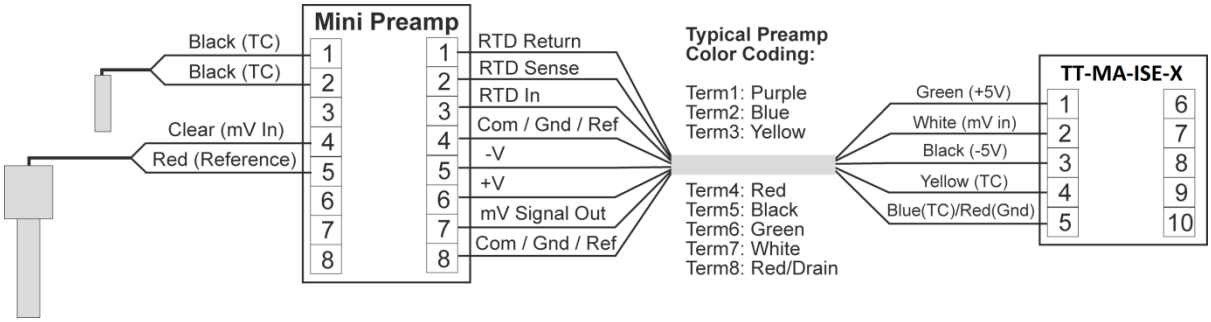
Non-Preamp Sensor



Preamp Sensor



External Preamp Sensor



Note: Please consult the Turtle Tough website (www.turtletough.com.au) for additional wiring information.

Analyser 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, 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**.

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. Comp.	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 temperature (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 slope.
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 DETERMINE 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.turtletough.com.au).

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 H_3O^+) 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 & 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 & 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

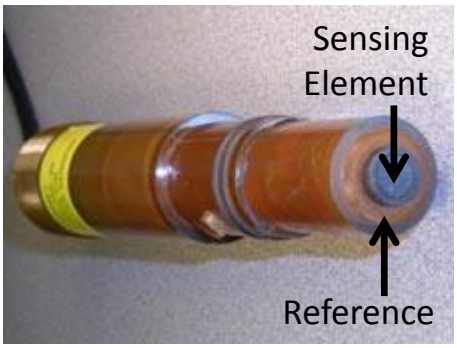
The recommended cleaning interval is based upon the difficulty index for your application. Please contact your agent or refer to the website to identify your difficulty rating.

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

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. GREAT CARE SHOULD BE TAKEN NOT TO SCRATCH THE SENSING ELEMENT DURING CLEANING OF THE REFERENCE JUNCTION.

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 & 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 & 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_Registers

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

Value 1 is ISE ppm and 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 & 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

Specification

Power Supply:	24VDC ±10%
Consumption:	60 mA max
Accuracy:	±0.2% Excluding Sensor (Ideal)
Temp Sensor:	Pt100 or Pt1000
Temp Range:	0-210°C ± 0.2°C
Analogue Output:	0-20mA or 4-20mA, max. 500Ω
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:	200 grams (7.04 ounces)
Dimensions:	L 58 x W 36 x H 86 mm (2.3” X 1.4” X 3.4”)
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 & 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.

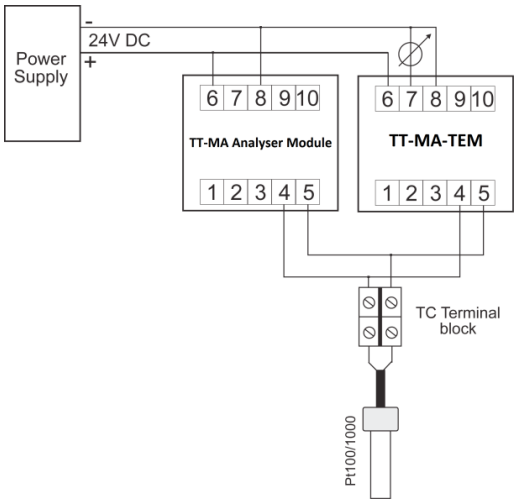
Important

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

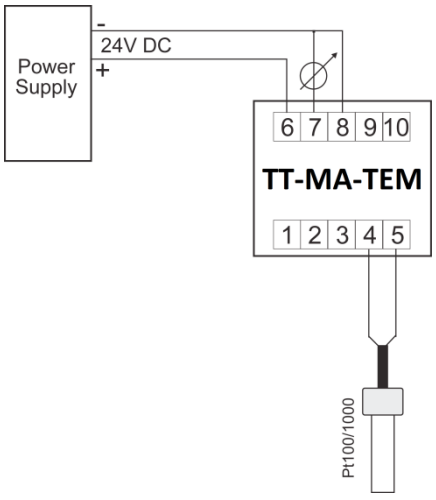
Typical Splice Type Wiring



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.

Typical Raw (Direct) Type Wiring



NOTES:

1. Wiring schematic valid when parameter P01 is raw (direct).
2. Be sure to correctly input the wire gauge (P04) and cable length (P05) when in this raw (direct) temperature input mode. Parameters P04 & P05 are used to compute the resistance due to the sensor cable length and automatically correct for this contribution. This correction is only active in raw input mode (and altogether disabled in splice mode).

Note: Please consult the Turtle Tough website (www.turtletough.com.au) 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	Temp Mode	Wiring Type	Splice, Raw	Splice
03	TC Input Select	Select the Pt Input Type	Pt100 or Pt1000	Pt1000
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.

* Negative trim adjustments will be shown as flashing numbers.
** The minimum difference between Par No. 08 and 09 must be at least 100 °C, although it is fully scalable within the range.

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.

Pt100 & Pt1000 Resistance & Temperature Tables

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

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		

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.

TOT Module for Total ISE

Specification

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)
	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:	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 (NH_3 + NH_4^+)
- Fluoride (HF + F^-)
- Cyanide (HCN + CN^-)
- Sulphide (HS^- + S^{2-})

Unpacking

Important

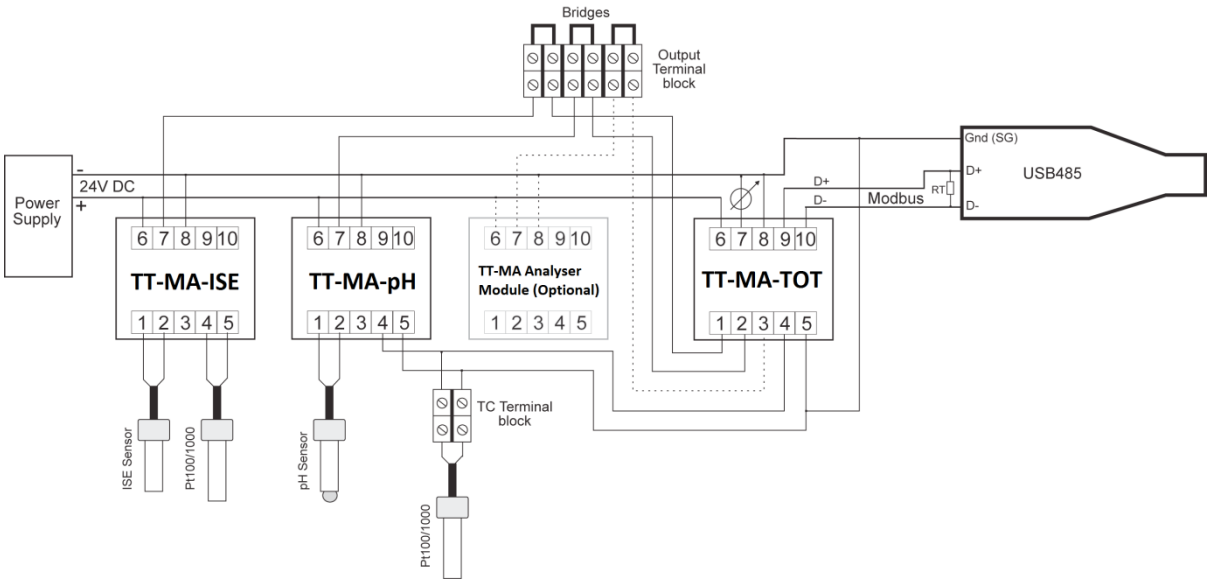
Please have a copy of your order with you when you unpack your instrument. All orders are checked when they leave the factory. Please check that you have all the parts that were ordered as soon as you open the box.
If anything is missing, or damaged, please contact your sales outlet immediately. If the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

The options for wiring of a TT-MA-TOT Module are as follows:

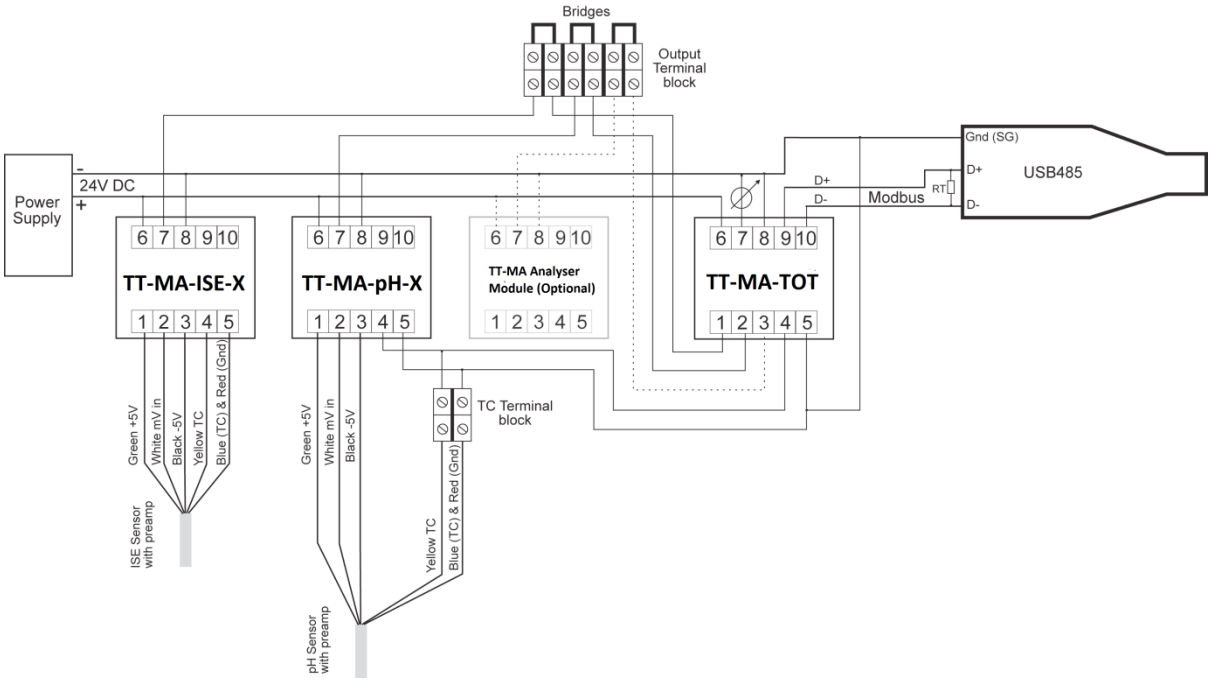
Spliced Temperature Input



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.

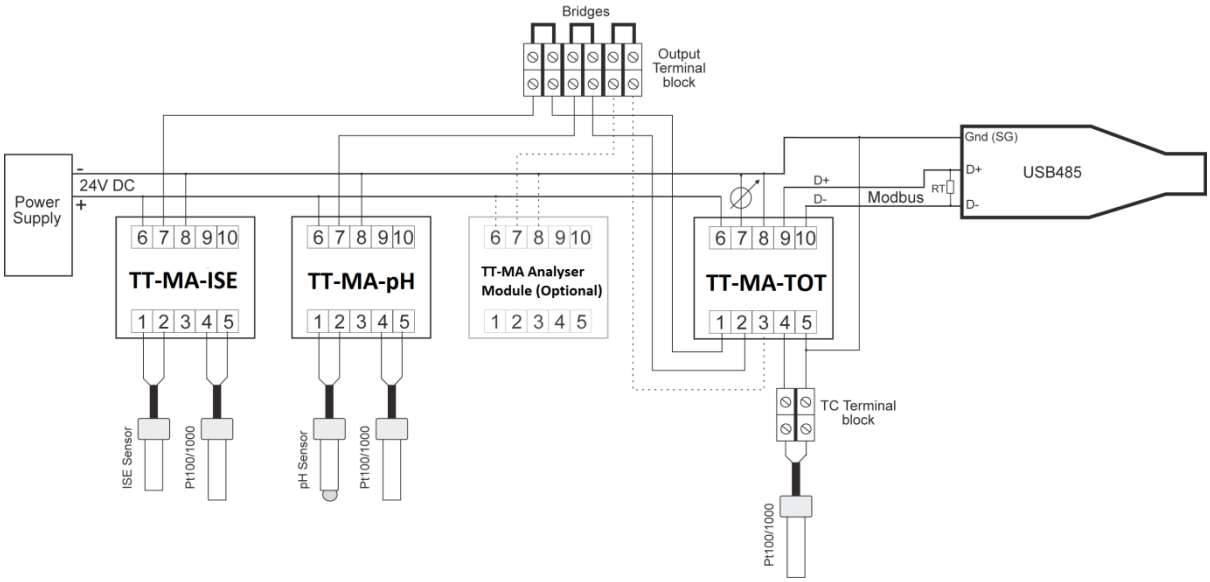
Spliced Temperature Input for Preamp ISE & pH Sensors



NOTE:

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)

Note: Please consult the Turtle Tough website (www.turtletough.com.au) 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 (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	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 @ 20mA	-	-
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 @ 20mA	-	-
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
18	Input 3 – ORP/mV (If P15 is ORP)	Set ORP/mV Scaling	±1000, -1000 to 0, or 0 to +1000	±1000
19	0/4mA Scale – Input 3	Reading @ 0/4mA	-	-
20	20mA Scale – Input 3	Reading @ 20mA	-	-
21	Display Input 3	Displays Real-Time Input 3 Reading	Temp, pH, ORP/mV, CON or ISE	Off (None)
22	Type of pH Compensation	Select the Type of pH compensation to be performed	Total Ammonia (NH_3), Total Fluoride (HF), Total Cyanide (HCN) & Total Sulphide (HS)	Depends upon Request at Time of Order
23	Type of Total ISE Output	Select 0-20mA or 4-20mA Output	4-20mA, 0-20mA	4-20mA
24	Scaling for 0/4-20mA Total ISE Output	Select Working Output Range on Computed Total ISE Output	Lo (0-10), Mid (0-100), Hi (0-999)	Hi
25	0/4mA Scale-Total ISE	Reading @ 0/4mA	-	-
26	20mA Scale-Total ISE	Reading @ 20mA	-	-
27	Set pH Compensation Mode	Set Automatic or Manual pH Input Mode	Automatic (Aut) or Manual (Set)	Automatic (Aut)
28	Manual pH Value	User entry of pH value in Manual Mode	0.00 to 14.00	7.00
29	Trim Low Input 1	0/4mA Offset Calibration for Input 1	As Defined by Free ISE Measurement	-

30	Trim High Input 1	20mA Offset Calibration for Input 1	As Defined by Free ISE Measurement	-
31	Trim Low Input 2	0/4mA Offset Calibration for Input 1	As Defined by pH Measurement	-
32	Trim High Input 2	20mA Offset Calibration for Input 1	As Defined by pH Measurement	-
33	Trim Low Input 3	0/4mA Offset Calibration for Input 1	As Defined by Input 3 Configuration	-
34	Trim High Input 3	20mA Offset Calibration for Input 1	As Defined by Input 3 Configuration	-
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 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. 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. 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. 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 & 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 & 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)*.

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

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

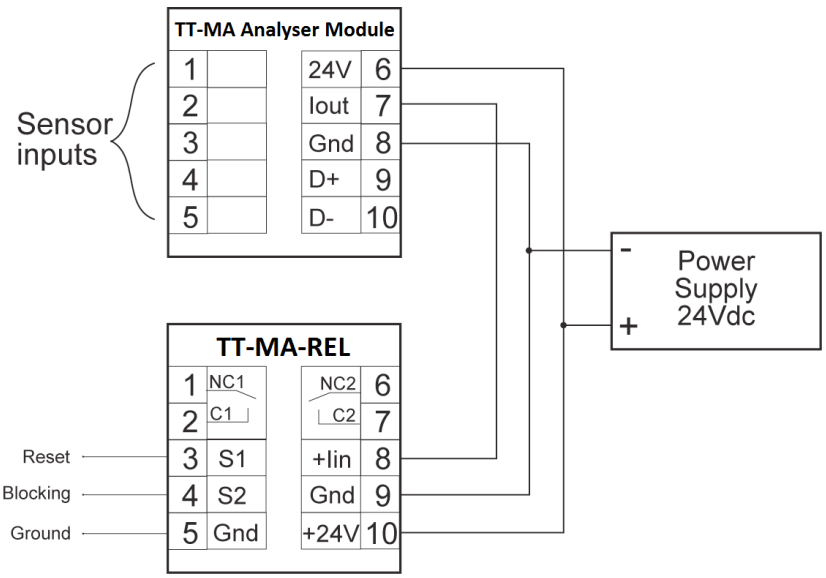
Relay Module

Specification

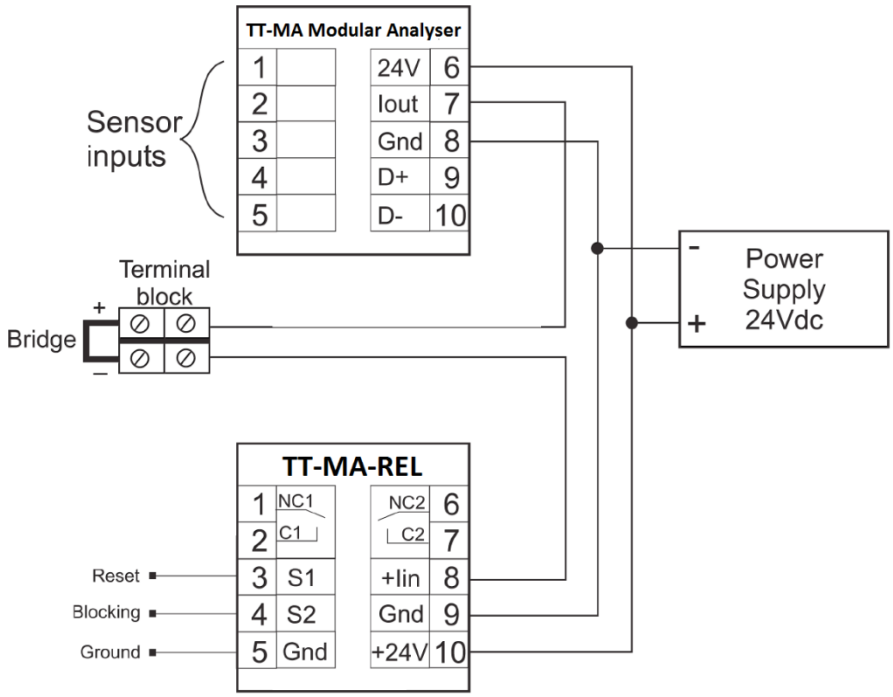
Power Supply:	24VDC ±10%
Consumption:	60 mA max
Input Current Range:	(0)4-20mA, 70Ω
Digital input:	Pos. logic: 5-30VDC; Neg. logic: 0V
Input S1:	External Reset
Input S2:	Alarm Block
Relay Description:	2 each Single-Pole, Single-Throw (SPST)
Relay Rating:	250VAC / 5A (Dry Contact Type)
Housing:	Lexan UL94V-0 (Upper part) 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:	200 grams (7.04 ounces)
Dimensions:	L 58 x W 36 x H 86 mm (2.3” X 1.4” X 3.4”)
CE mark:	EN61326A

Wiring

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



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.

Note: Please consult the Turtle Tough website (www.turtletough.com.au) 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 (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	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 * Display mode % Display mode pH Display mode Con Display mode ISE	 5.0– 99.9 % 0.1 – 14.0pH 1 – 500 ** 1 – 999 ***	 80.0 11.2 400 ** 800 ***
Limit 2	Set-point for Limit 2 * Display mode % Display mode pH Display mode Con Display mode ISE	 5.0– 99.9 % 0.1 – 14.0pH 1 – 500 ** 1 – 999 ***	 80.0 11.2 400 ** 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 & 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 & 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 & 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

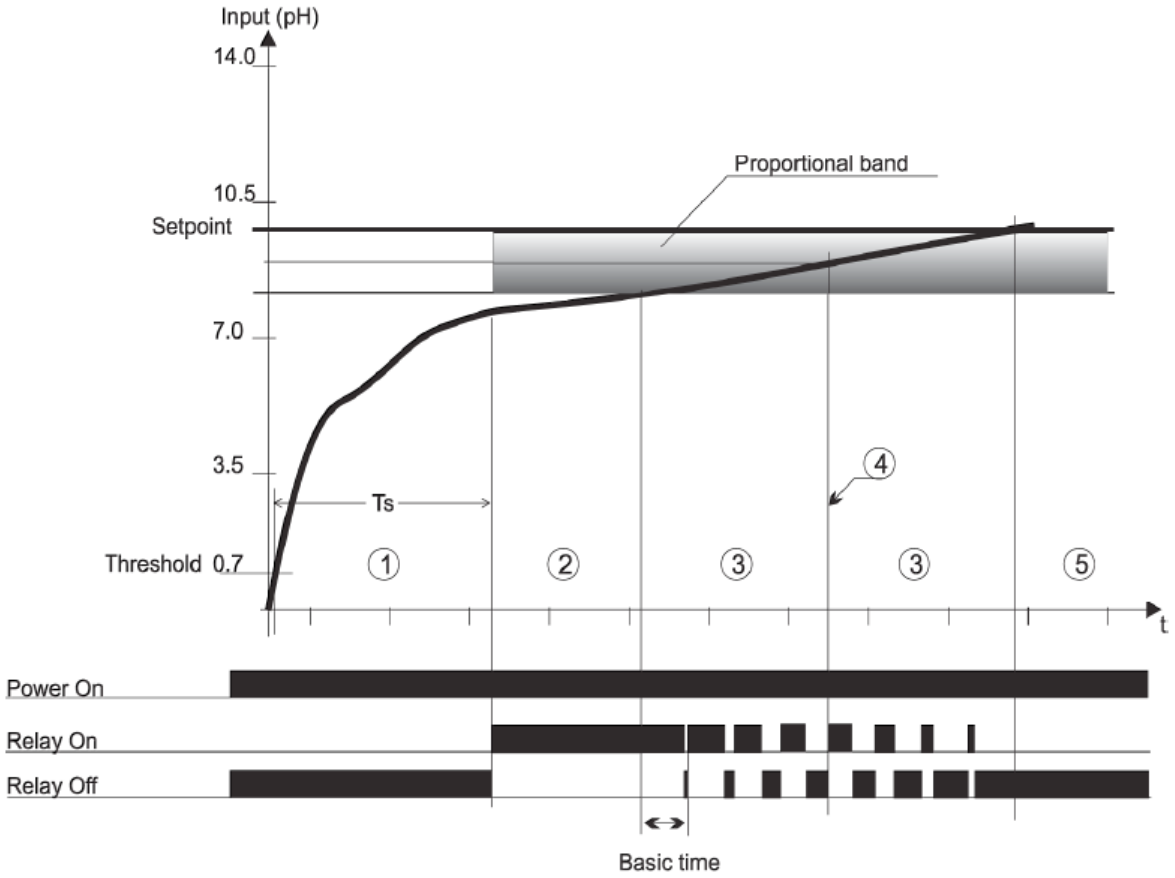
When the measured value crosses 5% of the measuring range (here corresponding to 0.7pH) the start-up timer is activated to avoid false readings during settling time of the sensor. This time should be selected large enough to give the sensor time to settle, but not much longer than this, since the supervision 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

Specification

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)
	Noryl UL94V-0 (Lower part)
Mounting:	M36 for 35mm 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:	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

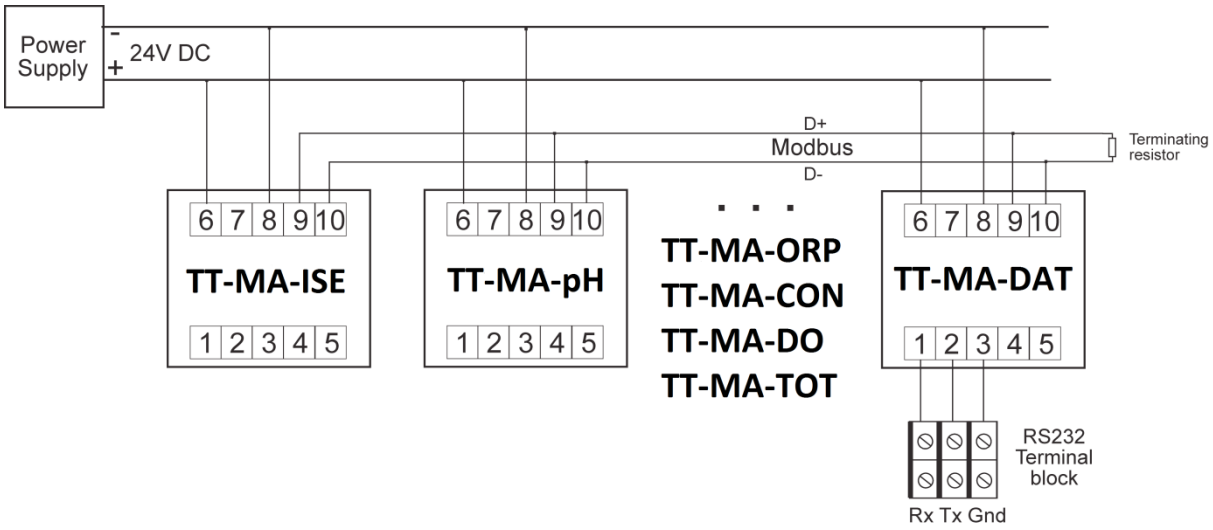
Important

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).

Note: Please consult the Turtle Tough website (www.turtletough.com.au) 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 (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 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!** Care should be taken that the logged data is downloaded and checked for integrity prior to taking this action. To erase, select 'dEI' and press the 'Mode' key. 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 & 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 & graphing software used to create the needed configuration file to terminal 9 & 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 & 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 & 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; the format & type of error messages are listed below:
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)

Please contact your Turtle Tough Distributor to find out more about these accessories.

Warranty Statement

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. Turtle tough warrants sensors for six (6) months from the date of purchase, all other conditions apply. 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. Please see sensor warranty below.

Sensor Warranty

Sensors are a consumable item and as such will deteriorate proportionally to the rate of chemical and physical exposure. 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; however this in no-way constitutes a warranty of performance and is a general indicator.

Warranty Exclusions

The following are not covered by the warranty:

1. Damage to or deterioration of the analyser housing.
2. Any unit that has been altered or on which the serial number has been defaced, modified, or removed.
3. Damage, deterioration or malfunction resulting from:
   - Accident, misuse, abuse, or neglect.
   - Failure to follow instructions supplied with the product.
   - Any shipment of the product (claims must be presented to the carrier).
   - Repair or attempted repair by anyone not authorised by Turtle Tough to repair this product.
   - Causes other than product defects, including lack of technical skill, competence or experience of the user.

Life Expectancy Guarantee

For some applications we will offer a minimum life expectancy guarantee. Consult your local agent or representative for further information. Where a minimum life expectancy is suggested, Turtle Tough will provide a limited performance warranty based on:

- Submission of a complete and accurate application questionnaire prior to purchase, approved by a Turtle Tough representative.
- The sensor must be installed in accordance with our recommended guidelines.
- The sensor must be installed on a Turtle Tough Analyser with data logging capabilities
- The sensor has been regularly cleaned and calibrated in accordance with our recommended schedule (as evidenced by the data logger).
- Data logging information is provided by you.
- Excludes blown pre-amplifiers (preamps). 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.

Return Goods

Please contact a member of our team prior to returning your sensor by calling +61 3 9872 5055 or email infor@turtletough.com.au.

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 Return Goods section of your manual for further details.

All returns to be sent to:

Attention: Quality & Calibration Workshop
Turtle Tough
15/634-644 Mitcham Road
VERMONT, VIC, 3133, Australia

Support

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