MANUAL

TT-MA MODULAR ANALYSER

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

turtletoughsensors.com

Contents

Safety Precautions

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

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

General

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

Warnings used in this manual

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

Danger Electric shock risk	**Disconnect electrical supply before working on this equipment.**

Danger	**DANGER** Refers to an imminent danger. Non-compliance can lead to death or extremely serious injury.
Warning	**WARNING** Refers to a potentially hazardous situation. Non-compliance can lead to death or extremely serious injury.
Caution	**CAUTION** Refers to a potentially hazardous situation. Non-compliance can lead to minor injury or property damage.
Notice	**NOTICE** Appears in conjunction with safety instructions which may endanger the analyser and its operation if disregarded.
Important	**IMPORTANT** Draws attention to supplementary information to make the work easier and ensure trouble-free operation. Markings that 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. Also, 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.

 Danger	**NOTICE** Read and follow all instructions. Save these instructions.
 Warning	**WARNING** To reduce the risk of injury, do not permit children to use this product.
 Electric Shock Hazard	**WARNING** Risk of electric shock. Connect only to a suitable isolated, hard-wired electrical outlet. It is recommended that the outlet is protected by an Residual Current Detector or is in any event in compliance with all local electrical regulations. Do not bury electrical supply cable.
 Electric Shock Hazard	**WARNING** To reduce the risk of electric shock, replace damaged electrical cable immediately.
 Danger Electric Shock Hazard	**WARNING** To reduce the risk of electric shock, do not use an extension cable to connect the unit to an electric supply; provide a properly located outlet

Hazards due to Non-compliance

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

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

Safe Operation

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

Safety Instructions for the Owner/Operator

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

Installation, Maintenance and Inspection

Warning

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

- Sensors must always be 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 the chemical release.

Impermissible Modes of Operation

Caution

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

Unauthorised Modification

Danger

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

Chemicals

Important

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

CAUTION

Disconnect electrical supply before working on this equipment

When handling this equipment, the accident prevention regulations applicable on-site must be observed and the specified personal protective equipment worn.

PPE: examples of protective clothing, gloves and goggles.

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

Appropiate PPE to be worn when in contact with the sensor

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.

Sensors

Health and Safety

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

Environmental Considerations

Take care when removing the sensor

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 complies with local regulations.

Introduction

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

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

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

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

Installation

Danger
Electric
Shock
Hazard

As with all instrumentation, the installation and commissioning of this instrument are 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 by this manual and by trained, qualified personnel.

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.

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

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

Important

Unpacking

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

Specifications

pH/ORP Proprietary Digital module

The pH/ORP Proprietary Digital measurement module provides 4-20mA output or Modbus RTU. Supports two and three-point calibrations, plus auto-calibration feature.

Specifically designed to interface with Proprietary Digital sensors (-PD) sensors.

Product name	pH/ORP Proprietary Module Analyser	
Code	TT-MA-pH-PD	
Sensor technology compatibility	Proprietary Digital	
Power supply	24VDC ±10%	
Consumption	60 mA max	
pH/mv range	-2-16 pH, ±1000mV ORP	
Accuracy	±0.2% Excluding Sensor *(Ideal)*	
Temperature sensor	Integral Platinum TC Element	
Temperature range	-40-210°C ± 0.3°C	
Temperature compensation	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	
Temperature	Usage -15 to +50 °C *(Storage -35 to +75 °C)*	
Weight	75 grams *(2.64 ounces)*	
Dimensions	L 86 x W 36 x H 58 mm *(3.4" X 1.4" X 2.3")*	
CE mark	EN61326A	

Sensor Theory of Operation

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

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

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

Where:

E = Total potential difference (measured in mV)

E_0 =Standard potential

R = Gas constant

T = Temperature in Kelvin

n = Number of electrons

F = Faraday's constant

[H+] = Hydrogen ion activity

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

Electrical and Sensor Connections

Installation


Danger

As with all instrumentation, the installation and commissioning of this sensor are 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 following this manual and by trained, qualified personnel.

Sensor Site Selection


Electric Shock Hazard

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

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

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

Unpacking


Important

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

Mounting


Important

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

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

All pH/ORP Sensors can be installed in-line. Submersible installation is also possible provided adequate waterproofing is selected at the time of order or adequate sealing is made between the sensor and installation hardware at the 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 and Extension Tubes and Valve Retractable Assemblies. Contact your Turtle Tough Distributor for technical support on the optimal installation hardware to suit your application.

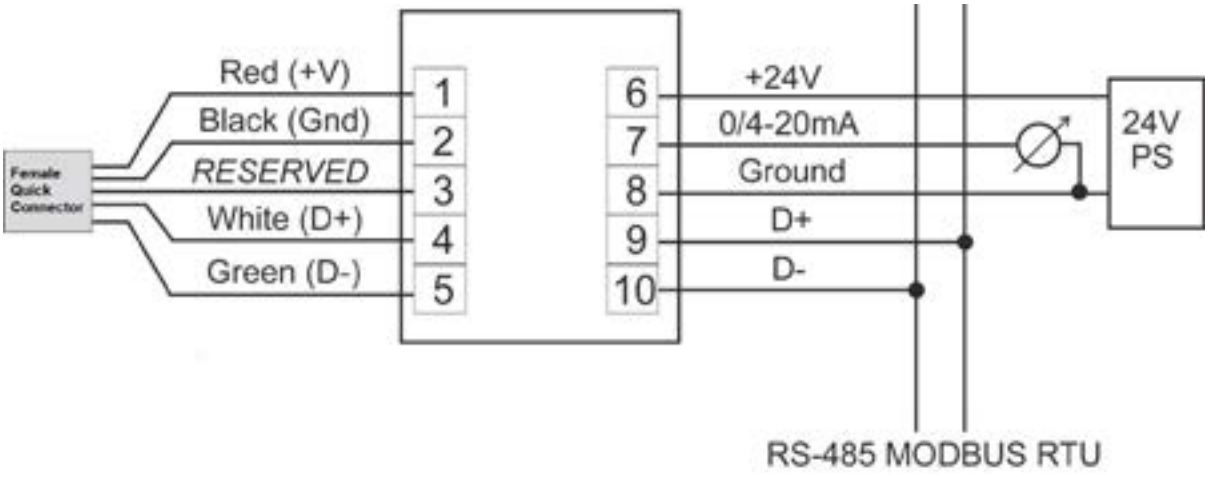
Note: *Please avoid excessive force when installing pH/ORP Sensor.*

Wiring

Turtle Tough Digital pH/ORP Sensors are designed to provide optimal life when connected to a TT-MA-PD Online Analyser. There are two connections required:

1. Power supply/output communication.
2. Female Quick Connector (either Panel Mount or Cable Extension with Enclosure Sealing Gland) for sensor input

Both connections to the TT-MA-PD are required only at installation or on change of Power Supply/Output Communication, Quick Connector, or The Digital Analyser Module. Wiring is as follows:

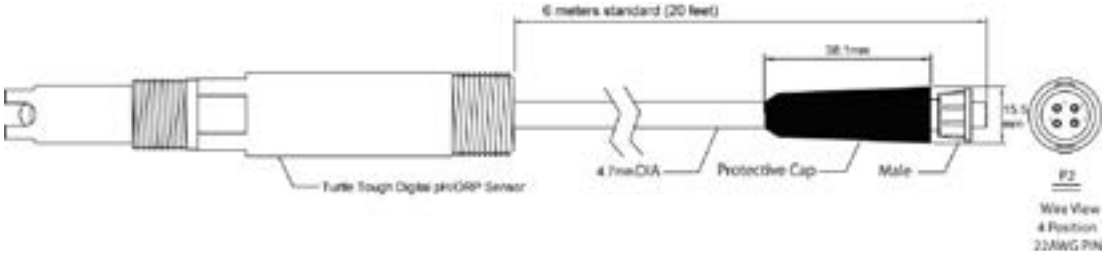


Note:

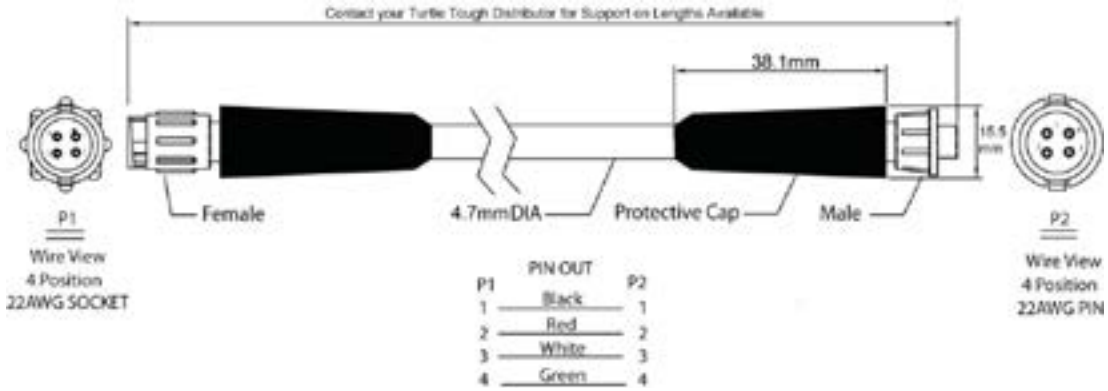
1. *Please consult the Turtle Tough website turtletoughsensors.com for additional wiring information.*
2. *All Turtle Tough Digital Sensors come with a 6m (20ft) cable fitted with a Male Quick Connector.*
3. *A range of extension cables is available if longer cable runs are required. The maximum cable length is 610m (2,000ft). Contact your Turtle Tough Distributor for assistance with selection.*

Turtle Tough Digital Sensor and Cable Drawings

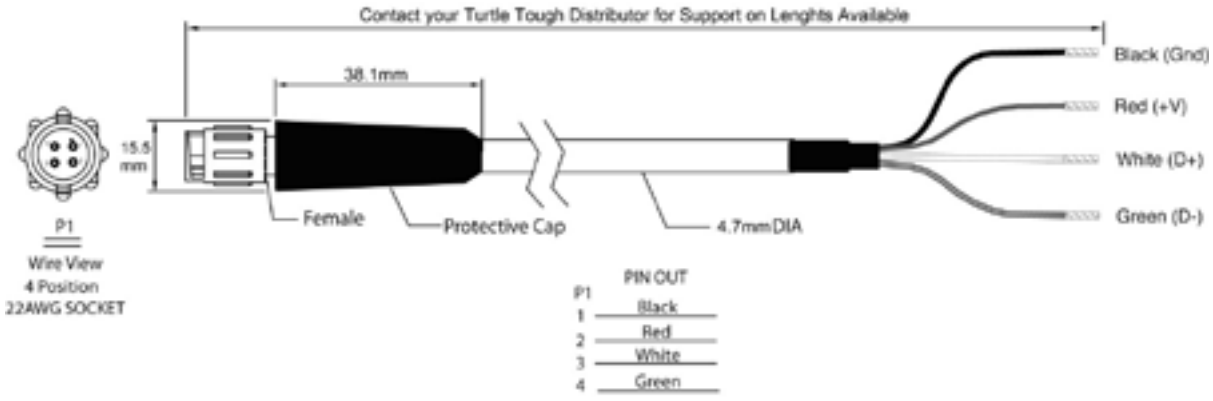
Digital pH/ORP Sensor Drawing



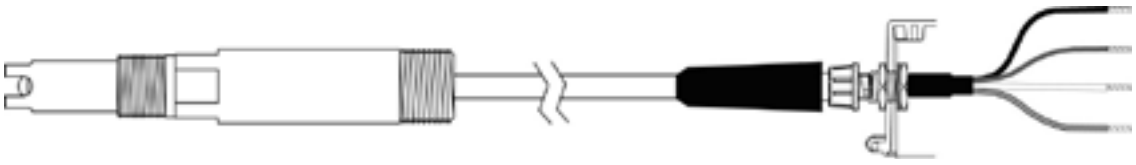
Digital Male-Female Quick Connector Cable Extension Drawing



Digital Female Quick Connector to Tinned Leads Cable Extension Drawing

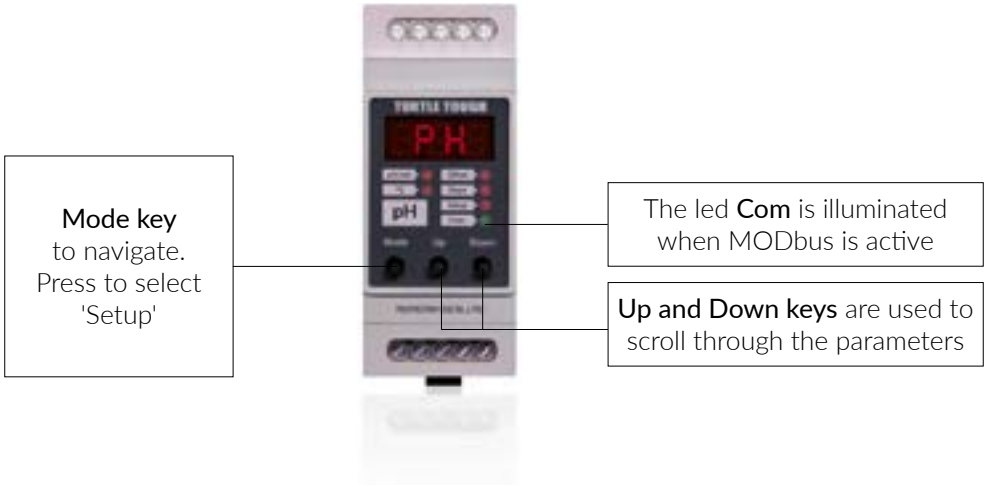


Digital Female Panel Mount Quick Connector to Tinned Leads Drawing
(Shown Connected to Digital Sensor)



Menu Navigation

The TT-MA-PD Analyser Module 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 it with the *'Mode'* key then modify the value using the '*Up*' and *'Down'* keys.



Lock Function

Important: *Parameter No. 01 is a LOCK function that 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.*

Display Features

There is a variety of information available from a TT-MA-PD Analyser Module such as:

- The absolute mV value of the sensor is displayed when the *'Down'* key is pressed in pH/mV display mode.
- The current mA output from the programmed scaling can be displayed by pressing the Up key in pH/mV display mode.

Display features that require the TT-MA-PD Analyser Module to have P01 software lock '*On*' to be enabled:

- The Temperature offset in °C units for the current Temperature Offset Calibration is displayed if the '*Down*' button is pressed in °C display mode.
- The current offset calibration in units of mV (P16) is shown if the *'Down'* button in the *'Offset'* display mode is pushed (for pH & ORP).

Function and Programming - Part 1

No	Parameter	Description	Range	Default
01	Lock	Software Lock	On/Off	On
02	Address	Modbus	Off, 1...247	Off
03	Sensor Item Number	Defines all sensor options	1-9,999 (>999 displayed with flashing)	Per Sensor
04	Sensor Serial Number	Unique traceable string for sensor	Per Turtle Tough serial number scheme	Per Sensor
05	Temp. Compensation	Correct pH slope as a function of Temp.	Auto, Set	Auto
06	Manual Temp. Compensation	Fixed Temp. Comp.	-40...210°C *	25
07	Offset from GMT	Hours offset from GMT RTC	-12 (hours) to +12 (hours)*	Per Sensor
08	3-Point Calibration Option	Dual slope feature	Off (2-Point), On (3-Point)	On
09	ORP mV Range	Range for mV	Ful (±1000), Neg (-1000 to 0) or Pos (0 to +1000)	Ful ±1000
10	MODbus Output mode	Set the mode for compatibility with DAT module or for Max resolution	Maximum Resolution pHE mode or DAT compatible mode (1000 Steps only)	DAT
11	Output Mode	Type of output	4-20mA, 0-20mA	4-20
12	Output Style	Stabdadrd or inverted modes	Non-inverted, inverted	Non-inverted
13	0/4mA pH Set	Low Set point for pH Analogue Output	-2.0 to +15.0 pH *	0.0
14	20mA Set	High Set point for pH Analogue Output	-1.0 to +16.0 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	mV Offset Calibration	mV @ pH 7 for pH or mV Offset for ORP	±250 mV*	0
17	Slope 1	mV per pH (for pH sensors only)	30 to 90	59.2
18	Slope 2	mV per pH (when P08 is “On” only)	30 to 90	59.2
19	0/4mA Offset	Trim Low	±9.99%	0.00
20	20mA Gain	Trim High	±9.99%	0.00
21	Energy Save	Energy Save Mode	On/Off	On
22	Baud rate	Modbus Communication Baud Rate	9,600/19,200	19,200
23	Show two significant figures above 9.99 pH	Substitutes integer part of pH scale with letter when greater than 9.99	Off or On; If set to “On” then 10=A, 11=b, 12=C, 13=d, 14=E, 15=F, 16=g	Off
24	0/4mA ORP Set	Low Set point for ORP analogue output	-900 to +999 * (limits set per P09)	P09
25	20mA ORP Set	High Set point for ORP analogue output	-900 to +999 * (limits set per P09)	P09

Parameters Explained

To access the programmable parameters see 'Menu Navigation'.

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	Displays sensor item number from connected sensor.
P04	Displays sensor serial number from connected sensor.
P05	Sets the temperature compensation mode to either 'Set' (manual) or 'Aut' (automatic) for pH sensors.
P06	Sets the temperature when temperature compensation of the pH measurement is set to manual mode.
P07	Offsets the time zone from GMT. Check P41-P45 to ensure that your P07 adjustment resulted in desired local time.
P08	If 3-Point Calibration is 'Off', one slope (P17) will be used in all pH ranges (-2 to +16). If 3-Point Calibration is 'On', the sensor will have two slopes; one slope (P17) for the acidic -2 to 7 pH range and another slope (P18) for the alkaline 7 to 16 pH range.
P09	Range mode for ORP sensor; 'fuL' range is ±1000mV, the 'nEg' range -1000 to 0mV or the 'PoS' range is 0 to +1000mV. P24 & P25 set analogue output scaling for these range mode limits.
P10	Is used to set the MODBUS output mode to either the maximum resolution 'pHE' mode or the 'DAT' compatible mode.
P11	Sets the analogue output to either 0-20 mA or 4-20 mA.
P12	Allows setting the output to be non-inverted (proportional and linear, 0-20mA or 4-20mA) or inverted (20-0mA or 20-4mA. i.e. for use in control).
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.
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.
P15	Variable that defines the mV change for each Up or Down button depression when calibration is performed.
P16	View and edit working sensor mV offset (Abs mV at pH 7).
P17	View and edit working sensor Slope 1 (pH only). If P08 is OFF then this slope is used for the full -2-16 pH range. If P08 is ON (3-Point Cal/Dual Slope mode) then this is the slope for -2-7 pH range.
P18	View and edit working sensor Slope 2 for 7-16 pH range (pH only). 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) when enabled. Press any key to exit Energy Save Mode.
P22	The Modbus standard requires a baud rate of 9,600 or 19,200 set in accordance with the Modbus-master.
P23	Show two significant figures when pH is 10 or greater.
P24	Defines mV for 0/4mA set point for analogue output with ORP sensor. The P24 & P25 set points must be at least 100mV apart. Defaults/limits set by P09.
P25	Defines mV for 20mA set point for analogue output with ORP sensor. The P24 & P25 set points must be at least 100mV apart. Defaults/limits set by P09.

Function and Programming - Part 2

No	Parameter	Description	Range	Default
26	Manufacture Date***	Date dispatched from Turtle Tough factory	See date display scheme	Per Sensor
27	Initial Installation Date***	Date when first connected to TT-MA-PD Analyser Module	See date display scheme	Per Sensor
28	Last used date in field***	Last date connected to TT-MA-PD Analyser Module	See date display scheme	Per Sensor
29	Days in field service	Days in use after installation date	0-65,535 (>999 displayed as flashing)	Per Sensor
30	Turtle Tough Reference for sensor	Turtle Tough Reference for sensor connected	0-65,535 (>999 displayed as flashing)	Per Sensor
31	Sampling Frequency	Set sampling frequency in Hz unit	0.5, 1.0, 2.0 and 4.0	4.0
32	Temp. Comp. Coefficient	Set Temp. compensation coefficient	Units are µV per °C (000-999)	198
33	Sensor Board Software	Revision of sensor board connected	From sensor (READ ONLY)	Per Sensor
34	Calibration Number	View with P35-P38 (READ ONLY)	From 1 to 5 per position in FIFO ring buffer	1
35	mV Offset****	mV @ pH7 for pH & mV Offset for ORP	±250 mV* (READ ONLY)	Per Cal
36	Slope 1****	mV per pH (when P03 = pH)	30 to 90 (READ ONLY)	Per Cal
37	Slope 2****	mV per pH (when P08 = On)	30 to 90 (READ ONLY)	Per Cal
38	Temperature Cal****	Shows temp offset cal in °C units	±25.0°C* (READ ONLY)	Per Cal
39	Min Temp in Use	Shows lowest temp in field use	Min -40°C* (READ ONLY)	Per Sensor
40	Max Temp in Use	Shows highest temp in field use	Max 210°C (READ ONLY)	Per Sensor
41	RTC, Year	Display Only – Year	00-255 equates to 2000–2255 (READ ONLY)	Per TT-MA-PD
42	RTC, Month	Display Only – Month	01-12 (READ ONLY)	Per TT-MA-PD
43	RTC, Date	Display Only – Date	01-31 (READ ONLY)	Per TT-MA-PD
44	RTC, Hour	Display Only – Hour	00-23 (READ ONLY)	Per TT-MA-PD
45	RTC, Minute	Display Only – Minute	00-59 (READ ONLY)	Per TT-MAD
46	Reset All Sensor Cals**	All sensor Cals reset to factory defaults	'Cur'= No Action 'Rst/Cal'=Reset sensor cals	Cur
47	Load config onto sensor	Load parameter settings to sensor	'Cur'= No Action 'Cfg/Sen'=Cfg to sensor	Cur
48	Make shadow copy**	Backup parameter settings	'Cur'= No Action, 'Cpy/Cfg'=Backup config	Cur
49	Restore to Shadow Copy**	Restores settings to P48 shadow copy	'Cur'= No Action 'Rst/Cfg'=Reset to Backup	Cur
50	Load config from sensor**	Load parameter settings from sensor	'Cur'= No Action 'Lod/Sen'=Cfg from sensor	Cur
51	Reset All**	Resets all parameters back to factory defaults	'Cur'= No Action 'Def/Rst'=Reset all values	Cur

** Negative values displayed as flashing*
*** The configuration stored on the digital sensor are unchanged by invoking these parameters*
**** Date format: "H" + last two digits of year, then "m.dd" where "m" is month shown as 1-9 for Jan-Sept, then A=Oct, b=Nov, C=Dec & "dd" is day of month (October 8th 2015 shown as "H15" followed by "b.08").*
***** Date associated with calibration is accessed by pushing the "up" button while value is shown. Date format is same as per note *** above.*
***** Calibration reference number (P34) associated with P35-P38 calibrations accessed by pushing "Down" button while value is shown.*

Parameters Explained - Part 2

To access the programmable parameters see 'Menu Navigation'.

Parameter	Description
P26	Displays the date of manufacture at Turtle Tough factory.
P27	Displays the date the sensor is first connected to the TT-MA-PD.
P28	Displays the date the sensor was last used with the TT-MA-PD.
P29	Displays total number of equivalent days (24hr periods) the sensor has been installed into field service with ±2% accuracy.
P30	Displays Turtle Tough reference number associated with sensor.
P31	Sets sampling frequency of sensor in Hz. If timeout error is reported from the TT-MA-PD, reduce the sampling rate.
P32	Sets the coefficient for temperature compensation of pH values. Contact your Turtle Tough Distributor before changing this value.
P33	Displays the software revision of the connected sensor.
P34	Defines set of historical calibrations to be viewed with P35-P38 in read only mode. P34 defines the position in the FIFO circular ring buffer that is used to store the calibrations. Note that each calibration stack is completely separate. The P34 parameter only sets the calibration reference number in the stack. The dates corresponding with each of the calibrations (mV Offset, Slope 1, Slope 2, Temperature) may differ for each calibration even when the P34 setting is identical. Date of the historical calibration provided as a display feature. P34 is the only parameter that can be changed without setting P01 lock to 'Off'.
P35	View historical mV offsets as defined by P34.
P36	View historical Slope 1 values (pH mode only).
P37	View historical Slope 2 values (When P08 = "On").
P38	View historical temperature offset calibrations in °C
P39	View historical temperature offset calibrations in °C
P40	Display highest temperature experienced by the sensor in use.
P41	Shows Year
P42	Shows Month
P43	Shows Day
P44	Shows Hours
P45	Shows Minutes
P46	Reset all live working calibrations on sensor, as shown in P16, P17, P18 & °C Display, back to Turtle Tough factory default values.
P47	Applicable parameters (P02, P05-P15, P21-P25, & P31-32) are downloaded to the sensor as configuration parameters when P47 is invoked.
P48	Applicable parameters (P02, P05-P15, P21-P25, & P31-32) are loaded into a shadow copy which can be used to revert to this configuration using P49.
P49	Restores configuration to the version from P48 shadow copy.
P50	Uploads configuration from the sensor to the TT-MA-PD Analyser Module. Note: The current configuration values will be overwritten. Use P48 to make a backup shadow copy of the current configuration before using P50.
P51	Reset ALL parameters to Turtle Tough factory default values.

Calibration

This section covers the calibration of Turtle Tough Digital pH & ORP Sensors when mated with a TT-MA-PD Analyser Module.

Temperature Calibration

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'* .

Auto pH Calibration

1. Ensure software lock is *'Off'* before commencement.
2. Using *'Mode'* select *'Offset'* or Slope.
3. Enter autocal mode by simultaneously holding the *'Up'* and *'Down'* keys. The display then toggles between dashes on the left and right LED until the auto read algorithm is complete. If all criteria of the auto read algorithm are met the auto buffer recognition feature then displays the suggested pH buffer. If all autoread criteria were not met then an Err message is returned.
4. To accept the suggested pH buffer value from the auto buffer recognition feature press the *'Mode'* key. Alternatively, you can use the *'Up'* and *'Down'* keys to pick a different pH buffer then press the *'Mode'* key to select it. If the user selected pH buffer exceeds the calibration limits for the given offset or slope mode then an Err message will also be shown and the calibration aborted.

Enabling dual-slope mode is recommended when the process media frequently crosses the pH 7 boundary. The dual-slope mode is on by default but can be disabled by setting parameter P08 to the Off state. When dual-slope is enabled, the pH sensor is calibrated at three points: one near pH 7 (in Offset mode), then in a pH buffer below pH7 (in Slope mode) and then in a pH buffer above pH7 (in Slope mode). Intelligent calibration features on the TT-MA-PD Analyser automatically assign acidic slope (P17) and alkaline slope (P18) based upon buffers used in autocal.

The pH buffer shown is nominal rather than the exact value of the pH buffer at the current temperature. Intelligent calibration of the TT-MA-PD Analyser Module includes automatic retrieval of the exact value for the pH buffer at any temperature from 0 to 60°C as sensed by the integral platinum temperature element for the 4.00, 6.86, 7.00, 9.18 & 10.00 buffers. The pH buffer solution bottle shows the exact value of the pH at various temperatures. The exact values of these pH buffers are programmed into the TT-MA-PD Analyser Module for intelligent, automatic and accurate pH calibration.

If autocal was successful YES is displayed or Err message is displayed if the autocal failed at any stage.

- For offset mode the 6.86 and 7.00 pH buffers are the choices in the automatic calibration mode.
- For slope mode the 4.00, 9.18 & 10.00 pH buffer are the choices in the autocal mode.
- To calibrate to any pH buffer or grab sample value not available in autocal use the manual mode.

Note: *There is a two second averaging for all pH calibration modes and a 10 second averaging for the pH measure mode.*

Manual pH Calibration

1. Ensure software lock is *'Off'* before commencement.
   Using 'Mode' select *'Offset'*.
2. Calibrate to the desired value using *'Up'* and '*Down'* keys. The Offset calibration can be performed anywhere in the full -2 to +16 pH operating range.
3. Using Mode select Slope.
4. Calibrate to the desired value using *'Up'* and '*Down'* keys. This is most typically pH buffer 4.00 for applications that are typically acidic to neutral and pH buffer 9.18 or 10.00 for applications that are typically neutral to alkaline. Other buffer values can be used.
5. Check the exact value of the pH buffer on the bottle at the current temperature displayed on the TT-MA-PD Analyser Module and ensure that both the pH sensor and the pH buffer are at a stable equilibrium temperature.

Set P08 to *"on"* to enable the three-point calibration mode that allows for a dual-slope operation. Parameter P17 is then used for the acidic range & P18 is activated and is used for measurements in the alkaline range. The pH sensor is calibrated at three points to create the dual-slope operating scheme:

- One calibration typically near pH 7 in Offset Mode (P16 mV offset)
- Second calibration in pH buffer below pH 7 in Slope Mode (P17 Slope 1 for Acidic pH)
- Third calibration in pH buffer above pH 7 in Slope mode (P18 Slope 2 for Alkaline pH)

Exit Slope mode after completing acidic slope calibration (below pH 7) by pressing the 'Mode' key before re-entering to perform the second Slope calibration for the alkaline (above pH 7) calibration.

The sensor offset and slope values can both be viewed and manually entered/adjusted using the parameters P16 (Offset), P17 (Slope/Acidic Slope) & P18 (Alkaline Slope). All calibration settings are stored inside the Turtle Tough Digital pH Sensor and the Sensor can be powered down or moved to a different TT-MA-PD Digital Analyser without any loss of calibration information meaning true plug and play hot-swappable functionality.

The Offset calibration can achieve a process offset whereby the online reading can be made to agree with any grab sample analysis. All calibrations are saved instantaneously as they are performed so there is no *'save'* or *'enter'* operation required.

Note: *There is a 2 second average for all pH calibration modes and a 10 second average for the pH measure mode.*

ORP Calibration

Unlike pH two-point calibrations which establish offset and slope, an ORP Calibration is a single point offset adjustment.

1. Ensure software lock is Off prior to commencement.
2. Using 'Mode' select 'Offset'
3. Calibrate to the mV value of your prepared calibration solution by using the *'Up'* and '*Down'* keys. Negative values will be shown as flashing.

Note: *There is a 2 second average for the ORP calibration mode and a 10 second average for the ORP measure mode. 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.*
The live working mV offset calibration for the ORP sensor can be viewed and manually adjusted in P16.

Troubleshooting

Many potential issues are involved in the uncertainty of an online pH/ORP measurement. Some of the most common possible issues are summarised below and may apply to your particular installation.

General Troubleshooting Tips

- Ensure that all Male-Female Quick Connections are secure and that none of the pins are damaged.
- Ensure good integrity of the PVC insulation on leads & cable jacket for both sensor and/or extension cables.
- Disconnect and reconnect the digital sensor via the Quick Connectors. Allow 5 to 10 seconds before reconnecting.
- If there are connection issues, cycle the power to the transmitter and swap out any extension cables for units that are known to be working.
- Connect a Turtle Tough Digital Sensor known to be working to ensure the TT-MA-PD Analyser Module is functioning normally.

Sensor/Analyser Compatibility

The Turtle Tough Digital pH/ORP Analyser System only works when a TT-MA-PD Analyser and a Digital pH/ORP Sensor are connected, they are not cross-compatible with any other system. The Turtle Tough Digital Sensor will not connect to an Analogue Turtle Tough Analyser Module. Similarly, an Analogue Turtle Tough pH/ORP Sensor will not connect to a Turtle Tough Digital Analyser.

Connecting any other sensor to a Turtle Tough Digital Analyser may permanently damage the Analyser and voids the warranty. If there is any doubt regarding compatibility contact your Turtle Tough Distributor for support.

Error Codes

Error codes are shown flashing on the display in the format 'X.Y' where 'X' is from 1 to 10 and 'Y' can vary from 0 to 9. The exact coding designations are generally only relevant for internal use by the Turtle Tough factory. In particular, the 'Y' portion of the error code can be ignored unless specifically requested for remote diagnostic troubleshooting assistance purposes.

No sensor connected or improper wiring errors

If a non-genuine Turtle Tough Digital Sensor is connected, it is expected that one or more error will be reported including the 2.Y type error code.

If there is a Turtle Tough Digital Sensor connected but it is not interfaced to the correct type of mating Turtle Tough Digital Analyser a 3.Y measurement type mismatch error will be displayed.

It is very important to make sure that the four leads from the Female Quick Connector are properly wired to the terminals on the TT-MA-PD Analyser Module to prevent damage to the electronics. See the Wiring section of this manual for the colour coding and terminal designations of the four leads.

Communication errors

If Turtle Tough Digital Sensor is properly connected and an error code of the type 1.Y, 4.Y, 5.Y, 6.Y, 9.Y or 10.Y is received then these indicate that some form of a communication exception has occurred. If this type of error is displayed, it is typically quite brief signifying a very brief transient temporary communication issue.

If the error codes starting with 1, 4, 5, 6 or 9 persist, this indicates that there was some damage to the electronics inside the Turtle Tough Digital Sensor and it must be replaced. Typically some ground loop or electrical/installation issue is responsible for this damage.

Date stamping errors

If an error code of the type 7.Y or 8.Y is received then this indicates that some form of an error has occurred related to setting the field activation or the last date of field use. These errors indicate either an improper configuration or else a corruption to that portion of the EPROM (very unlikely). If the issue is simply an improper configuration this can be resolved at the Turtle Tough factory. The sensor item number, serial number, reference number and dispatch date will be requested for approval of any such return. All of this information can be obtained from the Turtle Tough Digital Analyser Module to which the Turtle Tough Digital Sensor is connected by looking at the appropriate parameters (see parameter section of this manual). In addition, please follow the return instructions given in this manual for any returns.

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 the sensor is in thermal and chemical equilibrium with the process before making any one-point offset calibration. 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 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-PD Analyser even after a calibration has been performed with pH buffers. Such a one point grab sample type offset calibration is performed when in the *'Offset'* mode. Navigate with the *'Mode'* key to the Offset mode while the pH sensor is installed into the process and while the reading is quite stable. Use the *'Up/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 the 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. Is strongly recommend colourless pH buffers be used rather than the more common coloured pH buffers. If coloured pH buffers are used for calibrations, they mustn't be 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-PD Analyser does not automatically correct for the temperature effects on your particular pH buffer when performing a manual calibration, 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 labelled with the pH value at various temperatures so that you can adjust the pH to the appropriate number.

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 the temperature displayed is simply for reference purposes.

RS-485 Modbus RTU Communication Output Option

Modbus communication comes as standard with a TT-MA-PD Digital pH/ORP Analyser Module. Turtle Tough TT-MA-PD 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 are explained below.

Datalogging Module and Modbus

If the Digital 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 is set to the same baud rate.

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

SCADA System and Modbus

The baud rate (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 Digital pH/ORP Analyser Module operates in two Modbus output modes. The first mode is P10 = 'DAT' yielding the same pH/ORP and Temperature outputs as an analogue TT-MA-pH/ORP Modbus Analyser Module. The second P10 = 'pHE' high-resolution mode yields the same outputs for pH/ORP as the analogue TT-MA-pH Analyser Module (but the temperature output range is different). The Modbus scaling may differ from 0/4-20 mA analogue scaling. Low and high scaling, number of steps and resolution are detailed in the tables below.

When P10 is set to 'DAT' compatible mode both the measurement and temperature sent as 0-1,000 steps (1024 offset for 2nd temp value):

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

Registers and Diagnostics

The TT-MA-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 and 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.

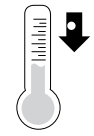
Function Code	Sub Code (HEX)	Description
08	00	Return Query Data
	0A	Clear counters and diagnostics register
	0B	Return Bus Message Count
	0C	Return Bus Message Communication Error
	0D	Return Exception Error count
	0E	Return Slave Message count
	0F	Return Slave No Response count
	12	Return Bus Character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

Sensor Care and Maintenance

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 (where the pH/ORP element is located) 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 piping Teflon tape when the sensor is not in use. Sensors that are to be returned for a shelf-life warranty claim must have the original sensor cap and conditioning solution intact to be eligible for warranty replacement. Contact Turtle Tough factory before returning any sensor for warranty claim to obtain a valid RMA.

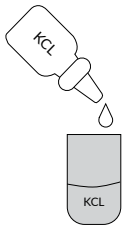
You may need to store your pH or ORP sensor if you don't need to use it right away, or you are using it intermittently. Please follow the storage steps below to ensure your sensor's longevity.



cool & dry

STEP 1

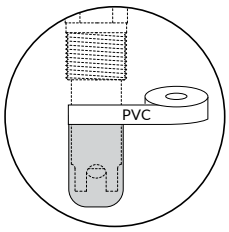
Always store pH or ORP sensors in a cool, dry location.



conditioning solution

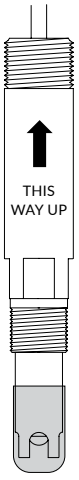
STEP 2

All Turtle Tough sensors are delivered with our conditioning solution inside the cap. If you are storing the sensor, this conditioning solution must be present. Contact us if you need to purchase some or make your own by mixing 50% pH 4 buffer with 50% saturate potassium chloride. KCl is the same electrolyte used in our reference systems.



STEP 3

Sensors should always be stored with their rubber cap tightly affixed and sealed PVC tape to ensure that the tip of the sensor remains moist.



STEP 4

The orientation of the sensor is of utmost importance. Always store with the sensor tip (sensing element) pointing downwards so the at the silver chloride solution stays in contact with the glass bulb, keeping it hydrated.

By following these simple steps, you will ensure that your Turtle Tough sensor remains in working order for 12 months or more.

IMPORTANT: *The recommendations given in this document are valid for most Turtle Tough pH and ORP sensors. Care and maintenance for your particular sensor may vary from that described here. Contact the factory for specific information regarding proper care and maintenance of your particular pH or ORP sensor for a given installation and application.*

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 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. (Please refer to our general guideline). Regular cleaning will prolong the life of your sensor and ensure hassle-free operation.

Cleaning

Cleaning methods can vary greatly depending upon the application for which the sensor is used. Common rules for cleaning include:

1. Never scratch or aggressively scrub the pH or ORP elements. These are delicate glass electrochemical electrodes. They can be broken easily by mechanical force.
2. The reference junction is a solid-state non-porous cross-linked conductive polymer embedded in a porous Kynar matrix. Since the reference is solid-state, it can be cleaned with aggressive chemicals. This solid-state reference can also be cleaned effectively by using a sharp razor-edged tool.

IMPORTANT: *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)*
- 10% Ammonium Bifluoride

Cleaning of Reference Junction in Presence of Oils and Fats

Cleaning the reference is best accomplished in a mechanical way by the use of a suitable straight-edge razor. You want to scrape clean the surface of the reference junction taking care not to touch nor scratch the pH glass. This is possible because of our unique solid-state reference technology.

Cleaning of pH Glass in Presence of Oils and Fats

There are two methods to remove oily/fatty type build-up. The first method is the milder way and should be tried first.

1. First method: Use a dye and fragrance-free surfactant. We recommend using the MICRO-90 cleaner. This is a very effective means to remove such build-up without dehydrating the pH glass element.
2. Second method: Use NaOH solution to chemically cleave the bonds in the oil/fat. This might be required if the first method is insufficient, either due to the nature or extent of the build-up. The NaOH solution is very effective at this task. The use of this kind of strong caustic cleaning solution will, however, dehydrate the pH glass and necessitate some reconditioning time with HCl acid. This will also neutralize any excess NaOH on the sensor. This should also be followed by final conditioning in the conditioning solution before recalibration.

Removing Silicate Contamination

In order to remove silicate contamination you will need to use a strong acidified ABF cleaning solution. It is recommended that 10% ammonium bifluoride (ABF) is sufficiently acidified with hydrochloric acid (HCl) such that it removes the contamination from the surface. The amount of activation needed (that is to say how much acid is added to the 10% ABF stock solution just prior to cleaning) will depend upon the extent of the silicate fouling on the sensor as well as the frequency with which the cleaning is performed. This silicate contamination cannot be removed without this strong activated ABF cleaning because it is bound to the surface of the pH glass and reference. Using the strong acidified ABF cleaning solution the deposited silicates will become soluble and much more easily removed from the sensor tip. The Turtle Tough Ultra pH sensor with High HF resistant glass is one of the few in the world able to withstand this high HF cleaning regimen itself. The pH glass for this type of cleaning service will have a rather high impedance to ensure sufficient integrity and longevity. **Warning:** *This must only be attempted if the sensor is fitted with the High HF resistant glass option.*

How often do I need to clean and calibrate my sensor?

The most common question we are asked is how often must you clean and calibrate a Turtle Tough sensor. While this question is virtually impossible to answer, a Turtle Tough sensor will have up to 10 times the stability of mainstream sensors. Most of our customers can extend calibration intervals by 2 to 5 times, whilst still maintaining their required accuracy and performance.

How often a sensor requires cleaning and calibration depends upon:

- The process conditions and how quickly the major constituents are poisoning the sensor
- The desired accuracy for the measurement to maintain acceptable process control
- The amount of fouling or process build-up that will eventually affect sensor performance
- How well the sensor is cleaned and maintained at the specified interval (ie. using the correct chemicals to decontaminate the sensor)

Turtle Tough sensors are specifically designed to improve these maintenance requirements by incorporating the following:

- Turtle Tough sensors have very tough measurement elements that are slow to deteriorate and therefore drift is minimised
- Turtle Tough sensors utilised open geometry designs and low fouling materials to reduce build-up and extend cleaning intervals
- Turtle Tough sensors have very resilient materials of construction to withstand harsh cleaning regimes. Strong acids, alkaline, organic solvents and abrasive mechanical cleaning can be deployed to efficiently and effectively clean sensors returning them to optimum operating condition

General Guideline

DRIFT (pH units)	TOUGH APPLICATION (ie: intensive chemical process)	MODERATE (ie: wastewater)	EASY (ie: clean water)
0.1	3 x per week	1 x per week	1 x per 2 weeks
0.3	1 x per week	1 x per 2 weeks	1 x per 2 months
0.5	1 x per 2 weeks	1 x per 4 weeks	1 x per 6 months

Please note this is a general guideline only and should not be relied upon for accurate process control.

How do I determine the calibration frequency?

It is important to note that you can never rely on our guideline as to the basis for your calibration requirement. Every chemical process is unique and the accuracy required can only be determined by your site requirements and expert process control personnel. Each user will need to establish a drift profile on their application before deciding on an appropriate calibration interval. Cleaning and calibration intervals can vary significantly across individual applications. To determine the drift characteristics you will need to periodically test the sensor against a known buffer or accurate grab sample to determine the rate of drift (i.e. the difference between the displayed value and the standardised solution). Test frequently at the half-life of your expected calibration frequency to determine how far the sensor has deviated from the standard solution. Once the sensor reaches the threshold of your accuracy requirement, that is a good indicator for establishing your calibration regime. It is recommended that a sensor is properly cleaned each time it is removed for calibration. Even if it does not appear dirty, you should follow the cleaning process to remove microscopic contamination that will affect the performance of the sensor.

Conditioning for Calibration

After the sensor has been cleaned, it must be thoroughly rinsed with deionized 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 is required to achieve optimal calibration results.

Sensor Selection for Individual Process Lines

No sensor should be used beyond the indicated temperature and pressure limitations for that given sensor. Sensors should only be used for the application(s) that an authorised TurtleTough representative has recommended. If you are unsure that your sensor is recommended for a particular application, please contact the factory.

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.

TIPS: Always allow sensors to air cool back to ambient before inserting into a cold liquid (i.e. such as buffer or cleaning solution). When heating the sensor, wherever possible, gradually heat the sensor. If this is not possible in the process, heat the sensor in 2 stages before inserting the sensor in the process. One such method is placing the sensor in hot tap water (i.e. at 50-60 °C) first and allowing it to get up to temperature, before inserting it into a hot process. This will greatly reduce the thermal shock and extend the life of the sensor.

Important Safety: *The above cleaning methods may involve the use of hazardous materials. The above recommendations do not purport to address all the safety measures required, please consult your workplace for the safe handling of these materials. Note: These recommendations are valid for most Turtle Tough pH/ORP sensors. Care and maintenance for your particular sensor may vary from that described here. Contact us to +61 3 9872 5055 for specific information regarding proper care and maintenance of your particular pH/ORP sensor for a given installation and application.*

Accesories and Spares

Cleaning Kit

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

Instructions:

1. Rinse the tip of the sensor in tap water
2. Then gently scrub the reference with the nail brush to remove any fouling. If you can't remove the fouling with the brush use the scraper to scrape away the top layer of the reference and expose fresh uncontaminated material. Be sure to avoid the glass element as scratching it will irreparably damage the sensor.
3. Once most of the fouling is removed, pour some of the HCl solution into the beaker and soak the tip of the sensor in the HCl for five to ten minutes. Then rinse the tip thoroughly with DI water.
4. Tap a small amount of the glass cleaning polish powder onto a hard surface and use a wet cotton bud to form a polishing paste. Gently polish the glass tip to remove any film oils or contaminants.
5. After polishing rinse the tip with the DI water and wipe clean using a lint-free cloth or chem wipes*.
6. Soak the tip of the sensor in conditioning solution for at least 10 minutes. Severely compromised sensors can even be soaked overnight to help rejuvenate the reference.

Windows Interface Box
(Optional accessory)

The Bridge Box assembly has quick connectors for an easy plug and play hot-swappable interface for both the Turtle Tough Digital pH/ORP Sensor input and USB cable output for interfacing with the Windows software for calibration, setup and configuration. The industrial grade RS-485 to USB converter is powered from the USB port while the Digital pH/ORP Sensor is powered by a replaceable 9V battery. The configuration whereby the Turtle Tough Digital pH/ORP Sensor is energised from a single 9V battery enables the normal measure and calibrate mode whereas wiring the two each 9V batteries in series invokes the boot-loader software update flashing mode.

Specifications

Base Enclosure	NEMA 4X Enclosure Assembly
Dimensions	170mm (W) x 170mm (L) x 100mm (D) (6.7" X 6.7" X 3.9") Note: Dimensions are approximate. Include peel mount sensor and USB quick connector protrusions.
Sensor Input	1 only via 4-Pin Quick Connect (hot-swappable)
Contents	1 off Industrial grade RS-485 to USB converter module suitable for use in field, laboratory or workshop 2 off 9V batteries (Purchased Separately) 2 off 9V battery clips; Setup for standard mode or wired in series to invoke bootloader
Capacity	~580mAH for typical alkaline 9V; Total ~1,160mAH when batteries used in series
Usage Time	~50 hours per 9V alkaline battery Use time for Lithium 9V batteries is approximately double that of alkaline type cells
Standby Time	Only limited by battery leakage current specifications; 9V battery does not discharge unless sensor is connected; Only 1 off 9V battery used in calibration or measure mode
Normal Sensor Connection	1 off Female 4-Pin Panel Mount Quick Connector for Turtle Tough Digital pH/ORP Sensors
USB Connection	1 off Female 6-Pin Panel Mount Quick Connector for USB Male "A" cable
Cable for PC	1 off USB male "A" cable, 2 meters, plug & play to Windows with Male 6-Pin Quick Connector
Weight	0.8 kg (1.7 lbs) with 2 off 9V batteries installed
Temperature Rating	Usage and storage from -15°C up to +50°C
Access Control	Security via user-supplied padlock installed onto integral latch hook on enclosure
Approvals	NEMA 4X assembly when snap cable connectors are installed and/or covers are secured. Suitable for use in safe areas; not recommended for use in areas
Hazardous rated Portability Package	Optional Accessory that adds rugged rubber feet and carrying handle. (Contact your Turtle Tough representative for dimensions and weight)

Calibration Station
(Optional accessory)

Turtle Tough's TT-MA-PD Calibration Station allows you to calibrate and configure the sensors offline in the laboratory or workshop. Our Smart Digital Sensors (-D) are all capable of storing calibration data onboard the sensor, and therefore they can be calibrated remotely or offsite to facilitate a hot-swap sensor maintenance regime.

Specifications

Base Enclosure	3MF NEMA 4X Enclosure Assembly
Dimensions	170mm Width X 170mm Height X 100mm Depth (6.7" X 6.7" X 3.9" Inches)
Weight	50 Grams (2 Ounces)
Sensor Input	Digital (only) pH/ORP Sensors (-PD)
Contents	1 each pH/ORP Analyser Module 1 each Power Supply Module 1 each NEMA 4X Enclosure 1 each Quick Connect Female Plug (-QCD)
Mounting	DIN Rail
Temperature Rating	Usage -15 to +50°C (Storage -35 to +75°C)
Power Supply	pH/ORP Analyser Module - 24VDC ±10% Power Supply Module - Input 100-240V / Output 24VDC 0.5A
pH/mV Range	-2 to + 16 for pH, ±1000mV for ORP
Connector Rating	Fully waterproof NEMA 6P when interfaced; Use protective cap when not in use

Specifications

pH/ORP Analogue module

The pH/ORP Analogue measurement module for conventional pH and ORP analogue sensors provides a 4-20mA output and supports two and three-point calibrations.

Designed to interface with conventional Analogue Preamplifier sensors *(-AP)*.

Also available for non-preamp sensors *(-A)*.

Product name	pH/ORP Analogue Module Analyser	
Code	TT-MA-pH-A for standard analogue sensors TT-MA-pH-AP for analogue sensors with internal preamplifier	
Sensor technology compatibility	Conventional Analogue *(-A)* or Analogue Preamplifier *(-AP)*	
Power supply	24VDC ±10%	
Consumption	60 mA max	
pH/mv range	0-14 pH, ±1000Mv ORP	
pH input	< 1pA, >10GΩ	
Accuracy	±0.2% Excluding Sensor *(Ideal)*	
Temperature sensor	Pt100, Pt1000	
Temperature range	0-210°C ± 0.3°C	
Temperature compensation	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	
Temperature	Usage -15 to +50 °C *(Storage -35 to +75 °C)*	
Weight	75 grams *(2.64 ounces)*	
Dimensions	L 86 x W 36 x H 58 mm *(3.4" X 1.4" X 2.3")*	
CE mark	EN61326A	

Sensor Theory of Operation

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

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

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

Where:

E = total potential difference (measured in mV)

E_0 = standard potential

R = gas constant

T = temperature in Kelvin

n = number of electrons

F = Faraday's constant

[H+] = hydrogen ion activity

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

Electrical and Sensor Connections

Installation


Danger

As with all instrumentation, the installation and commissioning of this sensor are 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 by this manual and by trained, qualified personnel.

Sensor Site Selection


Electric Shock Hazard

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

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

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

Unpacking


Important

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

Mounting


Important

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

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

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

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

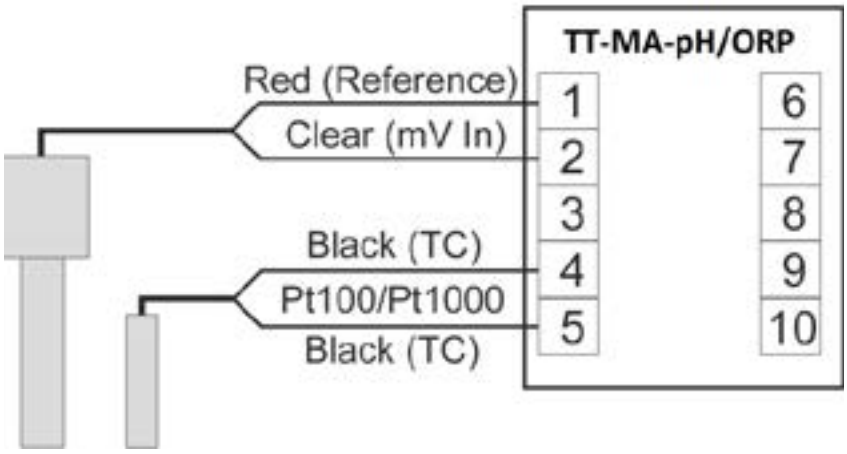
Note: Avoid excessive force when installing the pH/ORP Sensor.

Wiring

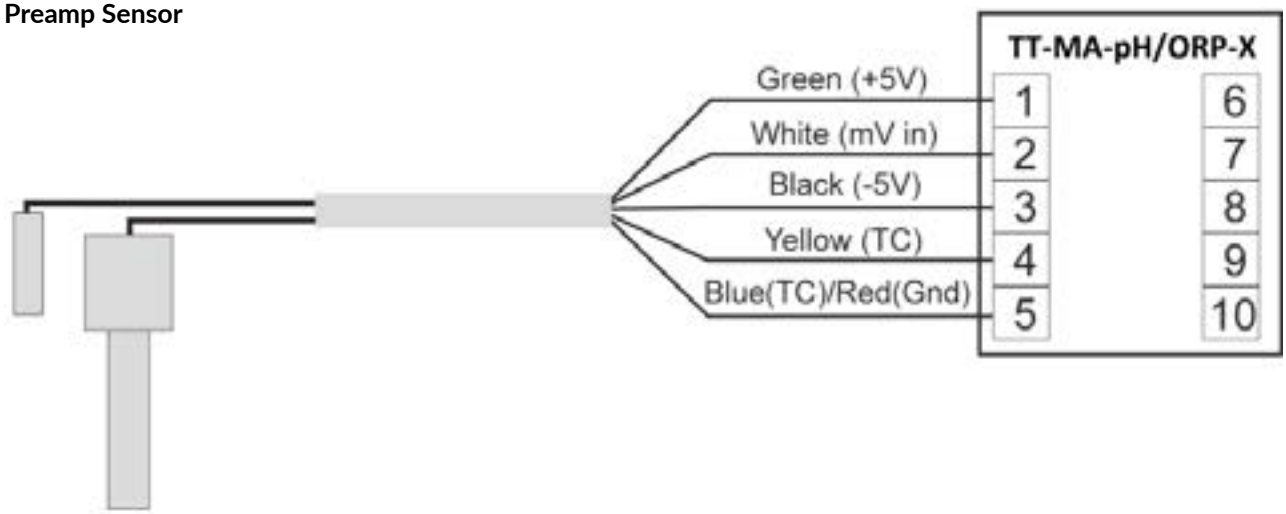
Caution

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

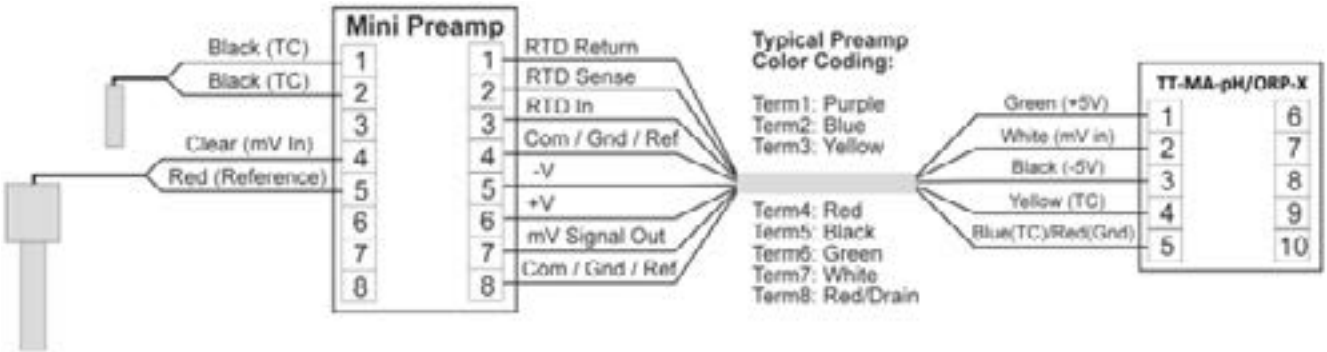
Non-Preamp Sensor



Preamp Sensor



External Preamp Sensor



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

Menu Navigation

The TT-MA-pH Analyser Module 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 it with the *'Mode'* key then modify the value using the *'Up'* and *'Down'* keys.

Lock Function

Please note: Parameter No. 01 is a LOCK function that 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 Iout	Input used for output	pH or Temperature	pH
11	Iout	Type of output	4-20mA, 0-20mA	4-20
12	Iout mode	Iout mode	Non-inverted, inverted	Non-inverted
13	0/4mA Set	Low Set point	0.0-13.0 pH	0.0
14	20mA Set	High Set point	1.0-14.0 pH	14.0
15	Step Change	mV Increment for Calibration	0=0.2, 1=0.5, 2=1.0, 3=2.0	1 (0.5mV)
16	Offset	mV @ pH 7	±250 mV	0
17	Slope 1	mV per pH	30 to 90	59.2
18	Slope 2	mV per pH	30 to 90	---
19	0/4mA Offset	Trim Low	±9.99%	0.00
20	20mA Gain	Trim High	±9.99%	0.00
21	Energy Save	Energy Save	On/Off	On
22	Baud rate	MODbus	9,600/19,200	19,200
23	Reset to Default	Reset to Factory Default	Def = Reset, Par=No Reset	Par

Parameters Explained

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

Parameter	Description
P01	Software lock. If the software lock is set to **ON** the parameter can only be read. 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 the calibration of Turtle Tough pH/ORP Sensors when mated with a TT-MA Analyser Module. If you are using a different analyser than this please consult the manual supplied with your unit or contact your Turtle Tough representative.

pH Calibration - Buffer and Slope Adjustment

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

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

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

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

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

ORP Calibration

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

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

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

Troubleshooting

Many potential issues are involved in the uncertainty of an online pH/ORP measurement. Some of the most common possible issues are summarised below and may apply 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 thermal equilibrium with ambient conditions. Calibrating a pH sensor when it is not at thermal equilibrium is a very common cause of calibration error.

Common Offset Type Issues

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

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

Temperature effects on pH Reading

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

pH Buffer During Calibration

Since the TT-MA-pH analyser does not automatically correct 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 labelled with the pH value at various temperatures so that you can adjust the pH to the appropriate number. Temperature compensation on the TT-MA-pH does not account for the change in the pH buffer values due to temperature and so this correction must be done manually.

pH Buffer Accuracy and Stability Issues

It is important to consider that some pH buffers degrade in quality much more quickly than others when left open to the 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 recommended colourless pH buffers be used rather than the more common coloured pH buffers. If coloured pH buffers are used for calibrations, they mustn't be 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.

Modbus Communication Option

Modbus communication is an option for the pH/ORP Analyser Module and must be specified at the 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 are explained below.

Datalogging Module and Modbus

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

SCADA System and Modbus

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

MOdbus Scaling

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

Read Input Registers

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

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

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

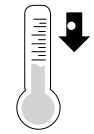
Function Code	Sub Code (HEX)	Description
08	00	Return Query Data
	0A	Clear counters and diagnostics register
	0B	Return Bus Message Count
	0C	Return Bus Message Communication Error
	0D	Return Exception Error count
	0E	Return Slave Message count
	0F	Return Slave No Response count
	12	Return Bus Character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

Sensor Care and Maintenance

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 (where the pH/ORP element is located) 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 piping Teflon tape when the sensor is not in use. Sensors that are to be returned for a shelf-life warranty claim must have the original sensor cap and conditioning solution intact to be eligible for warranty replacement. Contact Turtle Tough factory before returning any sensor for warranty claim to obtain a valid RMA.

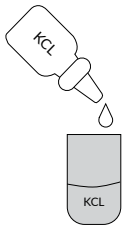
You may need to store your pH or ORP sensor if you don't need to use it right away, or you are using it intermittently. Please follow the storage steps below to ensure your sensor's longevity.



cool & dry

STEP 1

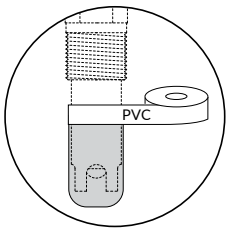
Always store pH or ORP sensors in a cool, dry location.



conditioning solution

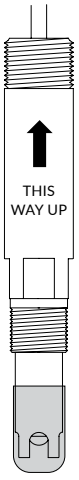
STEP 2

All Turtle Tough sensors are delivered with our conditioning solution inside the cap. If you are storing the sensor, this conditioning solution must be present. Contact us if you need to purchase some or make your own by mixing 50% pH 4 buffer with 50% saturate potassium chloride. KCl is the same electrolyte used in our reference systems.



STEP 3

Sensors should always be stored with their rubber cap tightly affixed and sealed PVC tape to ensure that the tip of the sensor remains moist.



STEP 4

The orientation of the sensor is of utmost importance. Always store with the sensor tip (sensing element) pointing downwards so the at the silver chloride solution stays in contact with the glass bulb, keeping it hydrated.

By following these simple steps, you will ensure that your Turtle Tough sensor remains in working order for 12 months or more.

IMPORTANT: *The recommendations given in this document are valid for most Turtle Tough pH and ORP sensors. Care and maintenance for your particular sensor may vary from that described here. Contact the factory for specific information regarding proper care and maintenance of your particular pH or ORP sensor for a given installation and application.*

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 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. (Please refer to our general guideline). Regular cleaning will prolong the life of your sensor and ensure hassle-free operation.

Cleaning

Cleaning methods can vary greatly depending upon the application for which the sensor is used. Common rules for cleaning include:

1. Never scratch or aggressively scrub the pH or ORP elements. These are delicate glass electrochemical electrodes. They can be broken easily by mechanical force.
2. The reference junction is a solid-state non-porous cross-linked conductive polymer embedded in a porous Kynar matrix. Since the reference is solid-state, it can be cleaned with aggressive chemicals. This solid-state reference can also be cleaned effectively by using a sharp razor-edged tool.

IMPORTANT: ***Great care should be taken not to scratch the pHglass 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)*
- 10% Ammonium Bifluoride

Cleaning of Reference Junction in Presence of Oils & Fats

Cleaning the reference is best accomplished in a mechanical way by the use of a suitable straight-edge razor. You want to scrape clean the surface of the reference junction taking care not to touch nor scratch the pH glass. This is possible because of our unique solid-state reference technology.

Cleaning of pH Glass in Presence of Oils & Fats

There are two methods to remove oily/fatty type build-up. The first method is the milder way and should be tried first.

1. First method: Use a dye and fragrance-free surfactant. We recommend using the MICRO-90 cleaner. This is a very effective means to remove such build-up without dehydrating the pH glass element.
2. Second method: Use NaOH solution to chemically cleave the bonds in the oil/fat. This might be required if the first method is insufficient, either due to the nature or extent of the build-up. The NaOH solution is very effective at this task. The use of this kind of strong caustic cleaning solution will, however, dehydrate the pH glass and necessitate some reconditioning time with HCl acid. This will also neutralize any excess NaOH on the sensor. This should also be followed by final conditioning in the conditioning solution before recalibration.

Removing Silicate Contamination

In order to remove silicate contamination you will need to use a strong acidified ABF cleaning solution. It is recommended that 10% ammonium bifluoride (ABF) is sufficiently acidified with hydrochloric acid (HCl) such that it removes the contamination from the surface. The amount of activation needed (that is to say how much acid is added to the 10% ABF stock solution just prior to cleaning) will depend upon the extent of the silicate fouling on the sensor as well as the frequency with which the cleaning is performed. This silicate contamination cannot be removed without this strong activated ABF cleaning because it is bound to the surface of the pH glass and reference. Using the strong acidified ABF cleaning solution the deposited silicates will become soluble and much more easily removed from the sensor tip. The Turtle Tough Ultra pH sensor with High HF resistant glass is one of the few in the world able to withstand this high HF cleaning regimen itself. The pH glass for this type of cleaning service will have a rather high impedance to ensure sufficient integrity and longevity. **Warning:** *This must only be attempted if the sensor is fitted with the High HF resistant glass option.*

How often do I need to clean and calibrate my sensor?

The most common question we are asked is how often must you clean and calibrate a Turtle Tough sensor. While this question is virtually impossible to answer, a Turtle Tough sensor will have up to 10 times the stability of mainstream sensors. Most of our customers can extend calibration intervals by 2 to 5 times, whilst still maintaining their required accuracy and performance.

How often a sensor requires cleaning and calibration depends upon:

- The process conditions and how quickly the major constituents are poisoning the sensor
- The desired accuracy for the measurement to maintain acceptable process control
- The amount of fouling or process build-up that will eventually affect sensor performance
- How well the sensor is cleaned and maintained at the specified interval (ie. using the correct chemicals to decontaminate the sensor)

Turtle Tough sensors are specifically designed to improve these maintenance requirements by incorporating the following:

- Turtle Tough sensors have very tough measurement elements that are slow to deteriorate and therefore drift is minimised
- Turtle Tough sensors utilised open geometry designs and low fouling materials to reduce build-up and extend cleaning intervals
- Turtle Tough sensors have very resilient materials of construction to withstand harsh cleaning regimes. Strong acids, alkaline, organic solvents and abrasive mechanical cleaning can be deployed to efficiently and effectively clean sensors returning them to optimum operating condition

General Guideline

DRIFT (pH units)	TOUGH APPLICATION (ie: intensive chemical process)	MODERATE (ie: wastewater)	EASY (ie: clean water)
0.1	3 x per week	1 x per week	1 x per 2 weeks
0.3	1 x per week	1 x per 2 weeks	1 x per 2 months
0.5	1 x per 2 weeks	1 x per 4 weeks	1 x per 6 months

Please note this is a general guideline only and should not be relied upon for accurate process control.

How do I determine the calibration frequency?

It is important to note that you can never rely on our guideline as to the basis for your calibration requirement. Every chemical process is unique and the accuracy required can only be determined by your site requirements and expert process control personnel. Each user will need to establish a drift profile on their application before deciding on an appropriate calibration interval. Cleaning and calibration intervals can vary significantly across individual applications. To determine the drift characteristics you will need to periodically test the sensor against a known buffer or accurate grab sample to determine the rate of drift (i.e. the difference between the displayed value and the standardised solution). Test frequently at the half-life of your expected calibration frequency to determine how far the sensor has deviated from the standard solution. Once the sensor reaches the threshold of your accuracy requirement, that is a good indicator for establishing your calibration regime. It is recommended that a sensor is properly cleaned each time it is removed for calibration. Even if it does not appear dirty, you should follow the cleaning process to remove microscopic contamination that will affect the performance of the sensor.

Conditioning for Calibration

After the sensor has been cleaned, it must be thoroughly rinsed with deionized 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 is required to achieve optimal calibration results.

Sensor Selection for Individual Process Lines

No sensor should be used beyond the indicated temperature and pressure limitations for that given sensor. Sensors should only be used for the application(s) that an authorised TurtleTough representative has recommended. If you are unsure that your sensor is recommended for a particular application, please contact the factory.

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.

TIPS: Always allow sensors to air cool back to ambient before inserting into a cold liquid (i.e. such as buffer or cleaning solution). When heating the sensor, wherever possible, gradually heat the sensor. If this is not possible in the process, heat the sensor in 2 stages before inserting the sensor in the process. One such method is placing the sensor in hot tap water (i.e. at 50-60 °C) first and allowing it to get up to temperature, before inserting it into a hot process. This will greatly reduce the thermal shock and extend the life of the sensor.

Important Safety: *The above cleaning methods may involve the use of hazardous materials. The above recommendations do not purport to address all the safety measures required, please consult your workplace for the safe handling of these materials. Note: These recommendations are valid for most Turtle Tough pH/ORP sensors. Care and maintenance for your particular sensor may vary from that described here. Contact us to +61 3 9872 5055 for specific information regarding proper care and maintenance of your particular pH/ORP sensor for a given installation and application.*

Accesories and Spares

Cleaning Kit

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

Instructions:

1. Rinse the tip of the sensor in tap water
2. Then gently scrub the reference with the nail brush to remove any fouling. If you can't remove the fouling with the brush use the scraper to scrape away the top layer of the reference and expose fresh uncontaminated material. Be sure to avoid the glass element as scratching it will irreparably damage the sensor.
3. Once most of the fouling is removed, pour some of the HCl solution into the beaker and soak the tip of the sensor in the HCl for five to ten minutes. Then rinse the tip thoroughly with DI water.
4. Tap a small amount of the glass cleaning polish powder onto a hard surface and use a wet cotton bud to form a polishing paste. Gently polish the glass tip to remove any film oils or contaminants.
5. After polishing rinse the tip with the DI water and wipe clean using a lint-free cloth or chem wipes*.
6. Soak the tip of the sensor in conditioning solution for at least 10 minutes. Severely compromised sensors can even be soaked overnight to help rejuvenate the reference.

Specifications

Conductivity module

The Conductivity measurement module supports most cell constants (K), including but not limited to 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1.0, 2.0, 3.0, 5.0, 10.0 and 20.0. Effective calibrated cell constants are supported from K=0.005/cm all the way up to K=34.0/cm and anywhere in between.

Designed to interface with Conductivity Analogue Sensors ***(-A)***

Product name	Conductivity Module Analyser	
Code	TT-MA-CON	
Sensor technology compatibility	Conventional Analogue *(-A)*	
Power supply	24VDC ±10%	
Consumption	60 mA max	
Sensor	2-Wire Contacting Cell	
Accuracy	±1% Excluding Sensor *(Ideal)*	
Temperature sensor	Pt100, Pt1000	
Temperature range	0-210°C ± 0.3°C	
Temperature compensation	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	
Temperature	Usage -15 to +50 °C *(Storage -35 to +75 °C)*	
Weight	75 grams *(2.64 ounces)*	
Dimensions	L 86 x W 36 x H 58 mm *(3.4" X 1.4" X 2.3")*	
CE mark	EN61326A	

Conductivity Sensor Theory of Operation

What is Conductivity?

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

How well a solution conducts electricity depends on several 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 act as an electrical conductor.

Conductance

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

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

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

Cell constant

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

$$K = d/a$$

Where:

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

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

d = distance between the electrodes (cm)

Conductivity

Electricity is the flow of electrons. This indicates that ions in the 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. Besides, errors in the temperature measurement itself will lead to errors in the corrected conductivity.

Cable Correction

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

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

Where:

Gm = measured conductance (S)

Gs = solution conductance (S)

Rc = cable resistance (Ω)

Electrical and Sensor Connections

Installation

As with all instrumentation, the installation and commissioning of this sensor are 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 following this manual and by trained, qualified personnel.


Danger

Sensor Site Selection

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


Important

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

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

Unpacking

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


Important

Mounting

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


Caution

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

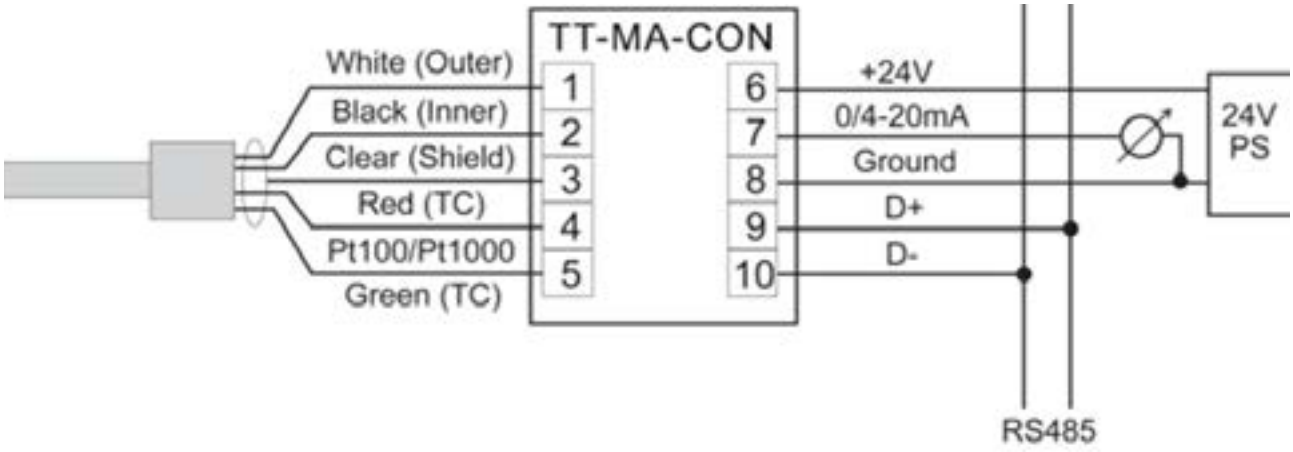
All Conductivity Sensors can be installed in-line. Submersible installation is also possible provided adequate waterproofing is selected at the time of order or adequate sealing is made between the sensor and installation hardware at the time of installation for example.

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

Please Note: Avoid excessive force when installing Conductivity Sensors

Wiring

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



Cell Constant and Ranges

Cell Constant	Full Scale Maximum Conductivity Range (Nominal)	Minimum Range at 10% of Maximum Full Range
20.0 (6.0-34.0)	0 to 1,000,000 microSiemens(µS)/cm | 0-1,000 mS/cm	0 to 100,000 microSiemens(µS)/cm | 0-100 mS/cm
10.0 (3.0-17.0)	0 to 500,000 microSiemens(µS)/cm | 0-500 mS/cm	0 to 50,000 microSiemens(µS)/cm | 0-50 mS/cm
2.0 (0.6-3.4)*	0 to 100,000 microSiemens(µS)/cm | 0-100 mS/cm*	0 to 10,000 microSiemens(µS)/cm | 0-10 mS/cm*
1.0 (0.3-1.7)	0 to 50,000 microSiemens(µS)/cm | 0-50 mS/cm	0 to 5,000 microSiemens(µS)/cm | 0-5 mS/cm
0.2 (0.06-0.34)*	0 to 10,000 microSiemens(µS)/cm | 0-10 mS/cm*	0 to 1,000 microSiemens(µS)/cm | 0-1 mS/cm*
0.2L (0.1-0.3)	0 to 400 microSiemens(µS)/cm | 0-0.4 mS/cm	0 to 100 microSiemens(µS)/cm | 0-0.1 mS/cm
0.1 (0.03-0.17)	0 to 5,000 microSiemens(µS)/cm | 0-5 mS/cm	0 to 500 microSiemens(µS)/cm | 0-0.5 mS/cm
0.1L (0.05-0.15)	0 to 200 microSiemens(µS)/cm | 0-0.2 mS/cm	0 to 50 microSiemens(µS)/cm | 0-0.05 mS/cm
0.02E (0.006-0.034)	0 to 2,000 microSiemens(µS)/cm | 0-2.0 mS/cm	0 to 200 microSiemens(µS)/cm | 0-0.2 mS/cm
0.02L (0.01-0.03)	0 to 40 microSiemens(µS)/cm | 0-0.04 mS/cm	0 to 10 microSiemens(µS)/cm | 0-0.01 mS/cm
0.01 (0.005-0.015)	0 to 500 microSiemens(µS)/cm | 0-0.5 mS/cm	0 to 50 microSiemens(µS)/cm | 0-0.05 mS/cm
0.01L (0.005-0.015)	0 to 20 microSiemens(µS)/cm | 0-0.02 mS/cm	0 to 5 microSiemens(µS)/cm | 0-0.005 mS/cm

**K=2.0/cm extended range is 0-200mS (min scale 0-20mS); K=0.2/cm extended range is 0-20mS (min scale 0-2mS) in both analog and MODbus outputs.*

Notes:

- Many alternate cell constants and ranges can be supported (inquire to factory).
- The full-scale measurement range and nominal cell constant must be defined at the time of order and cannot be changed after dispatch.
- The effective cell constant can be modified with a gain calibration from ±50%to ±70% of the nominal cell constant (depending upon model).
- The possible effective cell constants after a gain adjustment are performed are shown to the right of the cell constant (in parentheses).

Menu Navigation

The TT-MA-CON Analyser Module 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 it with the *'Mode'* key then modify the value using the *'Up'* and *'Down'* keys.

Lock Function

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


Important

Function and Programming

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

Parameters Explained

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

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

Calibration

Ensure software lock is Off before 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 before commencing any calibration.

Use *'Mode'* to select *'Gain'*, then *'Up'* or *'Down'* to adjust the readout corresponding to the expected value. The adjustment may be ±50% or ±70% from nominal value depending upon the 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).

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.

Note: 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.

Temperature Calibration

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

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'* to select *'Gain'*, then *'Up'* or *'Down'* to adjust the readout corresponding to the expected value.

NOTES:

- *The raw (uncompensated) conductivity can be viewed by pushing the 'Down' button in the main measure display mode.*
- *The mA output for the current configuration is displayed by pressing the 'Up' key in the main conductivity display mode.*
- *Standard Conductivity Solutions vary with temperature and this must be accounted for when conducting a calibration.*
- *The conductivity sensor should be cleaned before calibration and free from air bubbles inside the measuring cell to ensure proper results.*

Troubleshooting

Many potential issues are involved in the uncertainty of online conductivity measurement. Some of the most common possible issues are summarised below and may apply 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 thermal equilibrium with ambient conditions.

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

Modbus Communication Option

To utilize the Modbus interface, the Conductivity analyser module (TT-MA-CON) must be ordered with Modbus. The TT-MA-CON may be used as a slave for the Data logging (TT-MA-DAT) function module or in a SCADA data acquisition. The setup and communication for each case are explained below.

Modbus with Data logging module *(TT-MA-CON)*

If the Conductivity Module (TT-MA-CON) is used with the Data logging function module (TT-MA-DAT), the baud rate on the Modbus as well as the address of the Conductivity module should be noted. The baud rate (P19) must be set to the baud rate of the Data logging module. Whether 19,200 or 9,600 is used is of no importance, as long as all units on the Modbus 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 Data logging module as the master, all addresses must be assigned in series; i.e. if 3 units are connected the addresses 1, 2 and 3 must be assigned to the three units. The order of the addresses is of no importance. In a network with a Data logging module, up to 63 Analyser Modules (slaves) may be connected.

Modbus in a SCADA system or with Windows software

The baud rate (P22) must be set to the baud rate of the SCADA system. The address (P02) must be unique in the network. Up to 247 TT-MA Module Analysers may be connected on a single network although repeaters may be required if more than 32 nodes are used and/or to support very long cable distances in noisy areas.

Modbus Scaling

The Modbus scaling for the conductivity process measurement output is the same as the analog output range as defined by P11 (low 0/4mA setpoint) and P12 (high 20mA setpoint). The Conductivity module *(TT-MA-CON)* contains 2 measurements (Conductivity and temperature). 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 Conductivity **Value 2** is Temperature

If 2 values are chosen, both conductivity and temperature are transmitted. If, for instance, the value for temperature is wanted, 2 values must be requested. Both values are sent as 0-1000 corresponding to the effective range, but the temperature has an offset of 1024; i.e. conductivity range as set by P11 & P12 is transmitted as 0-1000 while the 0-210°C temperature is then transmitted as 1024- 2024.

The TT-MA-CON gives access to different diagnostic values 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

Sensor Care and Maintenance

Maintenance Free

Turtle Tough Conductivity sensors are a completely sealed assembly and are sealed for life. This provides extreme process resistance as well as a 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 under 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 are based upon the difficulty index for your application. Please contact your agent or refer to the website to identify your difficulty rating.

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

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

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

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

The same cleaning remedies and tests apply to the body of the sensor, which is the outer electrode, except you don't have to worry about access or Q-tips. An ultrasonic cleaning bath may also be used with an all-purpose surface cleaning solution or detergent and hot water. The all-purpose commercial detergent *Simple Green* or similar can also work effectively for such cleaning tasks. For biological fouling, a solution of 50% bleach and 50% water will do a good stripping job with warm or hot water giving the 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.

Specifications

Dissolved Oxygen module

The Dissolved Oxygen measurement module displays and outputs the concentration of dissolved oxygen in ppm, % saturation units, as well as the process temperature.

Designed to interface with conventional Dissolved Oxygen Analogue Sensors *(-A)*

Product name	Dissolved Oxygen Module Analyser	
Code	TT-MA-DO	
Sensor technology compatibility	Conventional Analogue *(-A)*	
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)*	
Temperature sensor	Pt100, Pt1000	
Temperature range	0-50°C ± 0.2°C	
DO Temperature compensation	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	
Temperature	Usage -15 to +50 °C *(Storage -35 to +75 °C)*	
Weight	75 grams *(2.64 ounces)*	
Dimensions	L 86 x W 36 x H 58 mm *(3.4" X 1.4" X 2.3")*	
CE mark	EN61326A	

Galvanic Dissolved Oxygen Sensor Theory of Operation

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

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

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

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

1. Temperature

The 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 Dissolved Oxygen measurements.

2. Salinity

The amount of dissolved oxygen increases as the 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 directly proportional relationship between the solubility of dissolved oxygen and the surrounding atmospheric pressure. As pressure decreases with an increase in altitude, the amount of dissolved oxygen found in water reduces.

Electrical and Sensor Connections

Installation

As with all instrumentation, the installation and commissioning of this sensor are 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 by this manual and by trained, qualified personnel.


Danger

Sensor Site Selection

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


Electric Shock Hazard

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

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

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

Unpacking

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 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.


Caution

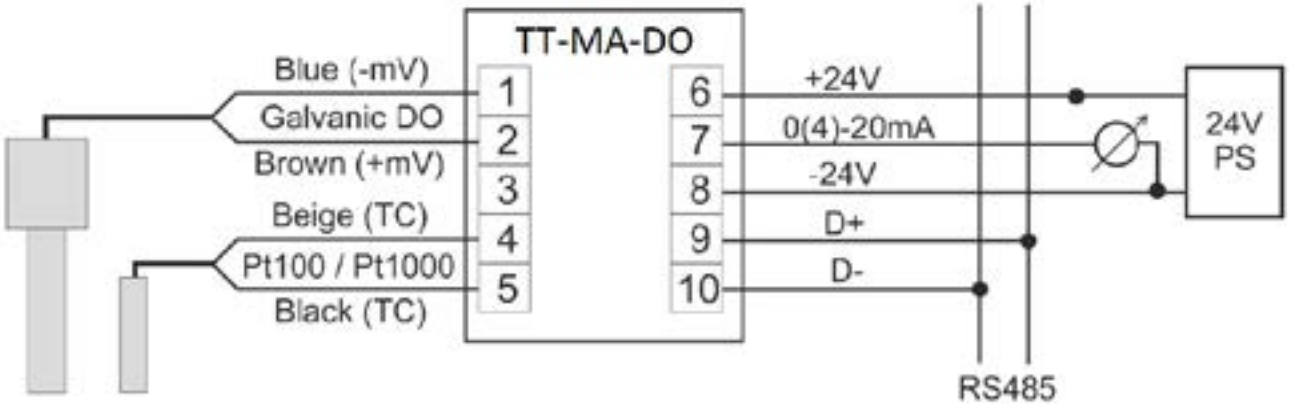
All Dissolved Oxygen Sensors can be installed in-line. Submersible installation is also possible provided adequate waterproofing is selected at time of order or adequate sealing is made between the sensor and installation hardware at time of installation for example.

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.

Note: Avoid excessive force when installing Dissolved Oxygen Sensors

Wiring

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



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

Menu Navigation

The TT-MA-DO Analyser Module 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 it with the *'Mode'* key then modify the value using the *'Up'* and *'Down'* keys.

Lock Function

Important: *Parameter No. 01 is a LOCK function that 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	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.

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 Dissolved Oxygen ppm that constitutes 100% saturation condition when P09 is set to manual mode.
P11	Selects the analogue output (and Modbus output mode if present) of the dissolved oxygen (DO) analyser in units of ppm or % saturation and these units are also used for P14 & P15. between P11 and P12 must be at least 10% of full range scaling per parameter P21.
P12	Sets the analogue output to either 0-20 mA or 4-20 mA
P13	Allows setting the output to be inverted (i.e. for use in control) with the output corresponding to 20-0mA or 20-4mA
P14	Sets 0/4mA output scaling in DO ppm or % sat units.
P15	Sets 20mA output scaling in DO ppm or % sat units. The difference between low and high output set points (P14 & P15) must be at least 10% of full range scaling in the chosen units.
P16	Displays the result of the gain calibration and also allows manual modification. 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 Dissolved Oxygen Sensor.
Ensure software lock is Off before 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 before commencement.

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

DO Sensor Calibration
Ensure software lock is off prior to commencement.

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

Manual Calibration Routine
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.

Turtle Tough TT-MA DO Sensors Membrane Replacement

Important Note Before Changing Membrane

The TT-MA-DO sensor should not be taken apart for service unless the membrane is damaged, the response (slope) is significantly reduced by fouling or deposits on the membrane that cannot be cleaned off. This is typically only the case after some prolonged period of use or an exceedingly aggressive process condition during a shorter time.

Preparation For Changing Membrane

Unscrew the cap, rinse with water and clean the anode ONLY with a PLASTIC scouring pad.
NEVER USE A METAL SCOURING PAD ON THE ANODE!
If the cathode is tarnished it can be cleaned with a 600-grade wet-or-dry paper.
DO NOT POLISH THE CATHODE!

Quick Test

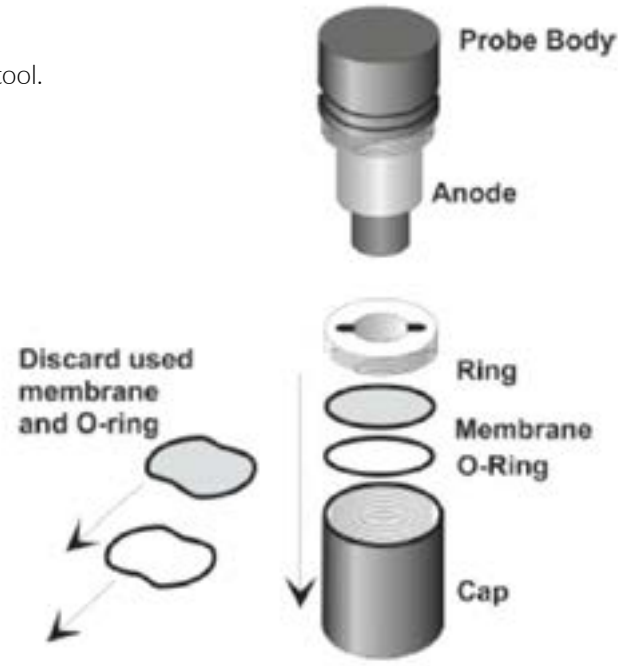
After the anode and (if necessary the cathode) was cleaned it is possible to perform a simple test to ensure the integrity of the sensor. Dry the top part of the sensor quite thoroughly, especially the cathode and the area surrounding it. Measure the output of the sensor when connected to the mating TT-MA Dissolved Oxygen transmitter. It should show zero ppm on the display. If your display does not read zero (or very near zero) contact factory for assistance.

Membrane Replacement Procedure

1. Use the tool provided to unscrew the ring.
2. Remove the used membrane and O-ring.
3. Rinse the cap and ring.
4. Dry both parts thoroughly.
5. Put a new O-ring in the bottom of the cap.
6. Put a membrane on top of the O-ring.
7. Replace the ring and tighten it firmly with the supplied tool.

Precautions and Caveats:

- All parts must be clean and dry before performing this procedure.
- The membrane must not be wrinkled before or after it is installed. If the membrane is wrinkled at any point in time it must be replaced with a new membrane immediately.
- Fill the cap to the brim with electrolyte. Hold probe upright and slowly screw-on cap until it is completely flush. Some electrolyte solution may leak out during this step.
- Wait one hour before performing a calibration after changing the membrane. For best results calibrate once again approximately 24 hours after the membrane is changed as the galvanic DO cell will have reached full equilibrium by this point in time.



Spare Parts

Suggested spare parts are Membranes, O-rings, and Electrolyte. The 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-ACC-DO-SKIT	Dissolved Oxygen Sensor Service Kit
TT-ACC-DO-MEM	Membranes for Dissolved Oxygen Sensor
TT-ACC-DO-ELEC	Dissolved Oxygen Electrolyte
TT-ACC-DO-START	Dissolved Oxygen Starter
TT-ACC-DO-G	Guard for GP-I DO Sensor

Modbus Communication Option

Modbus communication is an option for the Galvanic Dissolved Oxygen Analyser Module and must be specified at the 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 are explained below.

Datalogging Module and Modbus

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

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

SCADA System and Modbus

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

Modbus Scaling

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

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

Read Input Registers

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

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

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

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

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

Specifications

ISE module

The ISE module is a transmitter for Ion Selective (ISE) and temperature measurement. It has ranges of 0-10, 0-100 or 0-999 ppm (selectable). It supports ISE sensors with and without preamplifiers. Optional: Serial communication via RS-485 Modbus RTU digital output.

- Offset calibration for agreement between inline reading with lab and portable grab sample analysis using photometric, optical colorimetric methods
- Slope of Ion Selective Sensors can be determined with two-point calibration

Product name	ISE Module Analyser	
Code	TT-MA-ISE	
Sensor technology compatibility	Supports ISE sensors with and without preamplifiers *(max 330 feet with preamp)*	
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)*	
Temperature sensor	Pt100, Pt1000	
Temperature range	0-150°C ± 0.3°C	
Temperature compensation	Via Platinum 100 or 1000 Ohm element	
Analogue output	Scalable analog 0/4-20 mA output for ion activity in ppm or kilo-ppm units	
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	
Temperature	Usage -15 to +50 °C *(Storage -35 to +75 °C)*	
Weight	75 grams *(2.64 ounces)*	
Dimensions	L 86 x W 36 x H 58 mm *(3.4" X 1.4" X 2.3")*	
CE mark	EN61326A	

Ion Selective Sensor Theory of Operation

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

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

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

Several factors can cause difficulties when ISE technology is applied to ion measurement:

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

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

3. The calculation of ionic concentration is 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 monovalent ion and more than 8% for a divalent ion. This is because the theoretical value for the slope at 25°C is 59.2 for monovalent ions and 29.6 for divalent 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 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.

4. 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.

5. 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.

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

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

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

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

CATIONS:

Ammonium (NH_4^+)

Calcium (Ca^{2+})

Lithium (Li^+)

Potassium (K^+)

Sodium (Na^+)

Silver (Ag^+)

ANIONS:

Bromide (Br^-)

Chloride (Cl^-)

Cyanide (CN^-)

Fluoride (F^-)

Iodide (I^-)

Nitrate (NO_3^-)

Nitrite (NO_2^-)

Perchlorate (ClO_4^-)

Sulphide (S^-)

Thiocyanate (SCN^-)

Electrical and Sensor Connections

Installation


Danger

As with all instrumentation, the installation and commissioning of this sensor are 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 by this manual and by trained, qualified personnel.

Sensor Site Selection


Electric Shock Hazard

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

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

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

Unpacking


Important

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

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

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

Mounting


Caution

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

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

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

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

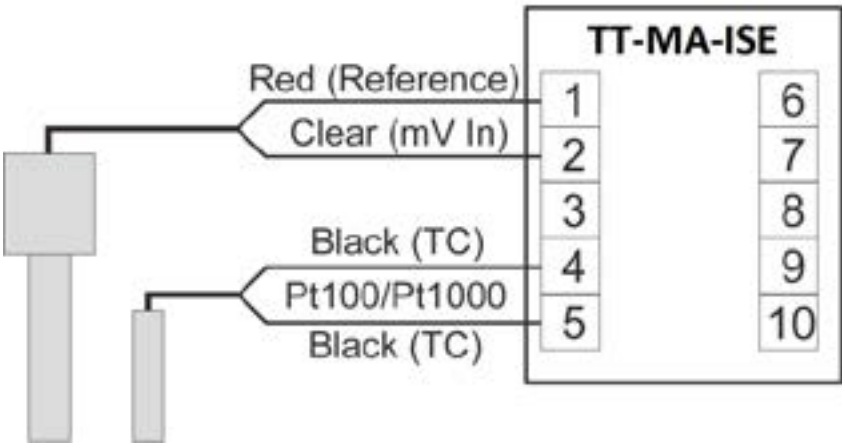
Turtle Tough has a range of installation hardware available as optional accessories including but not limited to KYNAR/PEEK Twistlock fittings, Stainless Steel Immersion Rods, Stainless Steel Sanitary Sensor Holders & Extension Tubes and Valve Retractable Assemblies. Contact your Turtle Tough Distributor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

Note: Avoid excessive force when installing an ISE Sensor

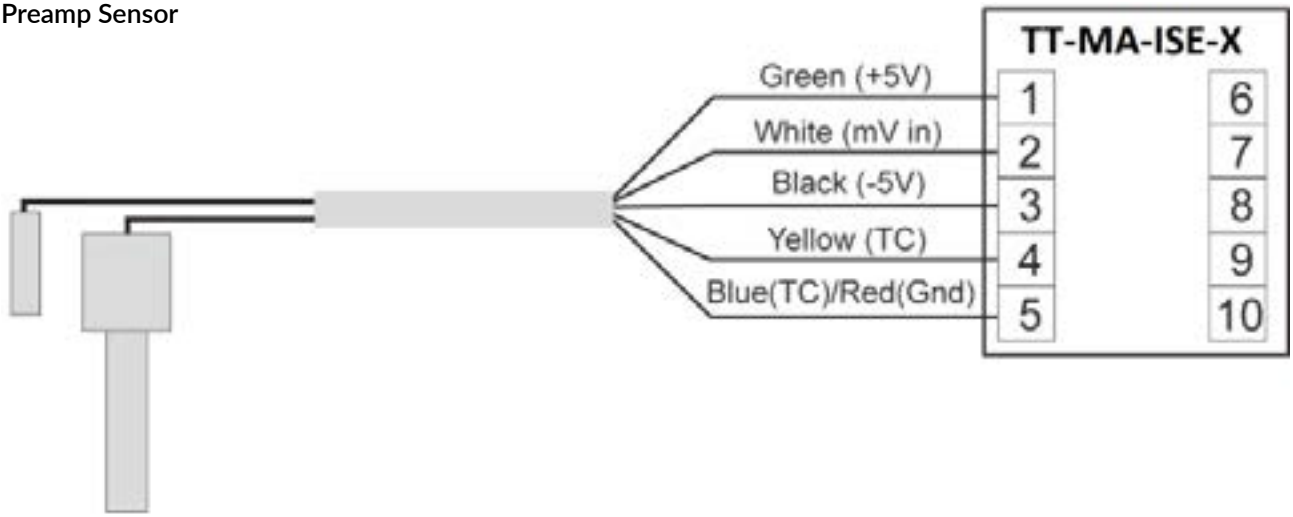
Wiring

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:

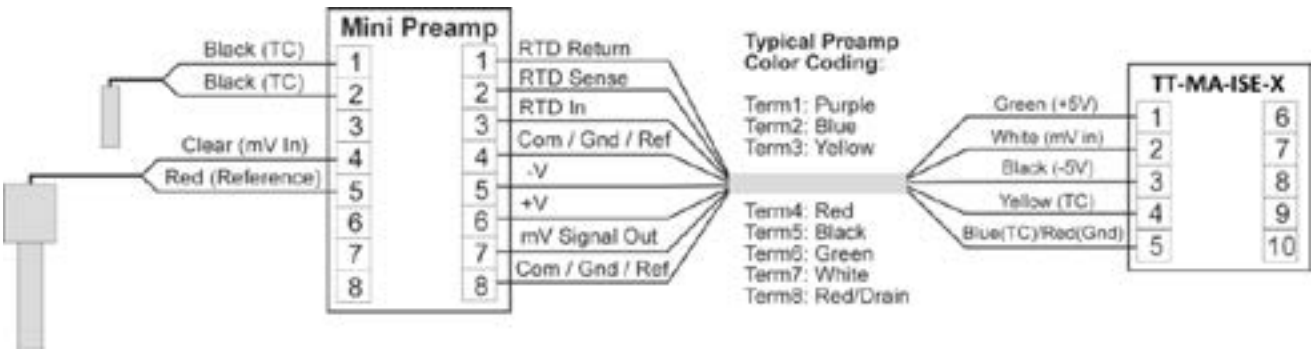
Non-Preamp Sensor



Preamp Sensor



External Preamp Sensor



Note: For additional wiring information please consult turtletoughsensors.com

Menu Navigation

The TT-MA-ISE Analyser Module 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 it with the *'Mode'* key then modify the value using the *'Up'* and *'Down'* keys.

Lock Function

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

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

Parameters Explained

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

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

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

Table to determined selected ISE module types

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

Calibration

This section covers the 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 turtletoughsensors.com

Calibration Solutions

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

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

- The total ionic strength (total concentration of 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 an extended period.

Your Turtle Tough Distributor can assist to properly choose calibration standard formulations (and preparation procedures) that will provide 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 before 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/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 ISE measurements affected by pH, the pH should be stable to ensure meaningful and reproducible results.
4. Rinsing with D.I. (or distilled water) will dilute the solution on the surface of the sensor, thus the sensor has to start its potential development process with a much lower concentration and develop a longer response curve (which is exponential in its nature) and response time.

1-Point Calibration

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

Temperature Considerations

The reading you obtain either during calibration or measurement is temperature-dependent as described in the Nernst equation which is the basis for every potentiometric measurement.
A Turtle Tough ISE Sensor has a built in temperature element. If there is a temperature difference in the solution to ambient then the sensor has to be in equilibrium with the solution itself and not the air or other environment. The time for the temperature reading to reach equilibrium can vary from as little as 1-2 minutes to as much as 30-60 minutes under some conditions.

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

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

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

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

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

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

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

Troubleshooting

Many potential issues are involved in the uncertainty of an online ISE measurement. Some of the most common possible issues are summarised below and may apply 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 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 *'Offset'* LED mode. Navigate with the *'Mode'* key to the *'Offset'* mode while the ISE sensor is installed into the process and while the reading is quite stable. Use the *'Up and Down'* keys to adjust the displayed value to agree with the laboratory determined reference value if desired. Such a grab sample offset type calibration should only be performed after all ISE calibrations have been completed.

ISE Standardised Solution Accuracy and Stability Issues

It is important to consider that some Standardised Solutions degrade in quality much more quickly than offers when left open to the air, or else with exposure to heat and/or light. One important step to ensure accurately 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.

Modbus Communication Option

Modbus communication is an option for the ISE Analyser Module and must be specified at the 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 are explained below.

Datalogging Module and Modbus

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

SCADA System and Modbus

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

Modbus Scaling

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

Read Input Register

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

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

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

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

Sensor Care and Maintenance

Maintenance Free

Turtle Tough ISE sensors are a completely sealed assembly and are sealed for life. This provides extreme process resistance as well as a 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 by 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 a shelf-life warranty claim must have the original sensor cap and conditioning solution intact to be eligible for warranty replacement.

Note: Do not allow the sensor to be exposed to air for prolonged periods.

Cleaning a Turtle Tough ISE Sensor: Recommended Cleaning Schedule

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

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

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

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

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

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

Avoiding Thermal Shock

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

Conditioning for Calibration

After the sensor has been cleaned, the ISE Sensor will need to be conditioned before 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.

Specifications

DSS Display module

The DSS Display module provides local display and isolated, scalable and reversible 0-20mA or 4-20mA output of any measured parameter from any mating SMART DSS sensor.

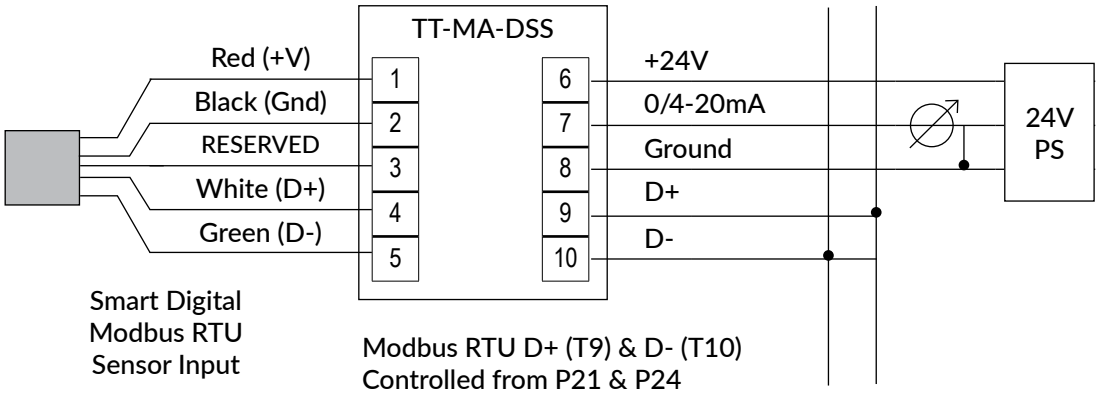
Temperature and absolute mV can be displayed for pH, ORP and DO DSS sensors. Temperature and raw conductivity can be displayed for Conductivity DSS sensors.

Product name	DSS Display Module Analyser	
Code	TT-MA-DSS	
Measurements	pH, ORP, Dissolved Oxygen (D.O.),Ion Selective (ISE), Conductivity (EC)	
Sensor technology compatibility	DSS Modbus RTU	
Power supply	24VDC ±10%	
Consumption	60mA max when pH/ORP/ISE/DO	80mA max when conductivity (EC)
pH/mv range	-2-16 pH, ±1000mV ORP	
Accuracy	±0.2% Excluding Sensor *(Ideal)*	
Temperature sensor	Integral Platinum TC Element	
Temperature range	-40 to +210°C ± 0.3°C	
Temperature compensation	Automatic Temperature Compensation (ATC)	
Analogue output	0-20mA or 4-20mA, max. 500Ω	
Output hold	Automatic if sensor is not connected	
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
Temperature	Usage -15 to +50 °C *(Storage -35 to +75 °C)*	
Weight	75 grams *(2.64 ounces)*	
Dimensions	L 86 x W 36 x H 58 mm *(3.4" X 1.4" X 2.3")*	
CE mark	EN61326A	

Field Commissioning of Transmitter

The TT-MA-DSS universal smart transmitter is typically supplied pre-configured with a female snap to tinned leads panel mount connector installed onto a suitable field ready enclosure assembly. The quick-connect plug of the smart digital MODBUS RTU sensor is interfaced with a female quick connect plug TT-MA-DSS universal smart transmitter assembly. DSS MODBUS RTU sensors are precalibrated ready for immediate plug and playfield use.

Wiring Schematic

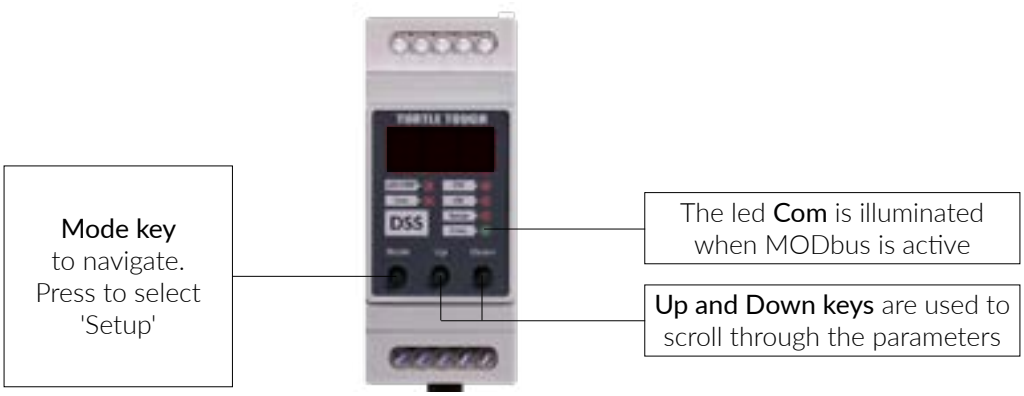


Please consult the Turtle Tough website turtletoughsensors.com for additional wiring information.

Menu Navigation

The TT-MA-DSS Display Module 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 it with the *'Mode'* key then modify the value using the *'Up'* and *'Down'* keys.

If softwarelock (P01) *'On'* no changes can be made. Set P01 to *'Off'* to allow for changes to scaling and configuration. If keys are not used for several minutes then software lock resets back *'On'*.



Lock Function

Important: *Parameter No. 01 is a LOCK function that 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	Address on Modbus	Off, 1...247	Per Order
03	Baudrate	Modbus baudrate	9,600 / 19,200	Per Order
04	Analogue Output Type	Toggle for Current Loop Type	4-20mA, 0-20mA	Per Order
05	Analogue Output Mode	Select Polarity of Analogue Output	noninverted, inverted	Per Order
06	0/4 mA Whole	Scale Low setpoint for output – Whole Percent	0% to 98%	Per Order
07	0/4 mA Dec.	Scale Low setpoint for output – Decimal Point 0-97.XX	XX.00% - XX.99%	Per Order
08	20 mA Set	Scale High setpoint for output – Whole Percent	2% to 100%	Per Order
09	20 mA Set	Scale High setpoint for output – Decimal Point 2-99.XX	XX.00% - XX.99%	Per Order
10	D.O. Units Selected	Select between ppm and % Saturation units for output	ppm or % Sat	Per Order
11	Conductivity Units Selected for Output	If Conductivity Sensor Type = 6 (Standard/High) then choices are uS/cm, Salinity (PSU) or TDS If Conductivity Sensor Type = 7 (Ultralow) then choices are uS/cm, MΩ Standard or MΩ for UPW	For Sensor Type = 6 uS/cm, PSU, TDS or For Sensor Type = 7 uS/cm, MΩ, UPW	Per Order
12	Conductivity Sensor Cell Constant (K)	Indicates nominal cell constant for connected sensor From K=0.01/cm to =20.00/cm	0.01 to 20.0	Per EC Sensor
13	Conductivity Sensor Range Mode	Indicates the range mode scaling factor for EC sensor “UL”=2, “Std”=200, “Hi”=2,000	2..2,000	Per EC Sensor
14	0/4mA Offset	Trim Low	±9.99% *	Per Factory Cal
15	20mA Gain (Span)	Trim High	±9.99% *	Per Factory Cal
16	Sampling Rate	Set sampling frequency in seconds	0.5, 1.0, 2.0 & 4.0	Per Order
17	Recalibrate Notify	Set max time since cal last peformed before notification	1 to 999 Days	Per Order
18	Display Sensor Type	1=pH, 2=ORP, 3=Wide ORP, 4=DO, 5=ISE, 6=Cond Standard/High Style, 7=Cond Ultralow Style	1..7	Per Sensor
19	Formula Weight	Formula Weight of Measured Ion – Only for ISE sensors	6.94..655.35	Per ISE Sensor
20	Type of TDS Units	Type of TDS units which are sent from EC Sensor	0=NaCl, 1=442, 2=KCl	Per EC Sensor
21	Slave Node Address	Node Address of Upstream RTU Master Device	Off, 1...247	H21
22	Slave Baudrate	Modbus baudrate of Upstream RTU Master Device	9,600 / 19,200	H22
23	Output Hold	Current State of Analog Output Hold Feature	Off, On	Off
24	Write Lock	Write Permissions for Upstream RTU Master Device	Off, RTU, All	H24
25	Back to Default	Reset to Default	Def = Reset, Par = No Reset	Par

**Negative values will be shown as flashing. Shaded portions of chart above indicate display only parameters.*

Parameters Explained

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

Parameter	Description
P02	Par. no. 2 set node address of sensor. If no sensor is found at the current node setting then *'SEn'* will flash on screen. Press any button to enter P02 node select mode. Use *'Up/Down'* keys to select between *'Set'* to manually define node address or *'SCn'* for automatic node scanning feature (use *'Mode'* to enter 'SEt' or 'SCn' feature). When node is found during scan the sensor type & node address are toggled. Accept the node address and sensor type found with *'Mode'* key or press *'Up/Down'* to continue search
P03	Sets baudrate to be used. Choices are 9,600 or 19,200
P04	Select whether output type is 0-20mA or 4-20mA.
P05	Select whether output is inverted or non-inverted type.
P06 **P07** **P08** **P09**	Define 0/4mA and 20mA setpoints. Appendix provides percentages corresponding with specific engineered units for various sensor. Min scaling between low/high setpoints 2% full range. Excel worksheet to compute % setpoints available.
P10	Selects ppm or % saturations units to be used as basis for output and main LED display for the connected D.O sensor.
P11	Selects measured conductivity or else computed PSU, TDS or MΩ units as basis for analogue output and main LED
P12 **P13**	Displays cell constant and range mode of EC sensor.
P14 **P15**	Trim offset for 4mA and Trim span for 20mA
P16	Define sampling rate for connected sensor in seconds
P17	Number of days after which recalibration notification is displayed when sensor is initially connected to transmitter. If limit is exceeded then *'CAL' 'OLd'* will be dispayed as warning.
P18	Display the sensor type which is connected
P19	Display the formula weight of the measured ion for ISE Sensor. For anion selective sensor value is shown as flashing
P20	Display type of TDS units which are sent by EC sensor
P21	Set node address of Modbus RTU slave serial port
P22	Set baudrate of Modbus RTU slave serial port
P23	Set status of analog output hold feature
P24	**Security feature for slave port. If "Off" no writing is permitted at all. If "RTU" then writing allowed to transmitter. If "All" then writing is allowed to BOTH sensor and transmitter.**
P25	Resets **ALL** parameters back to factory set defaults display

Special Modbus slave registers available only on TT-MA-DSS

Access to TT-MA-DSS modbus registers gained through Modbus function code (03) READ HOLDING REGISTERS. Nine (9) values are available when requesting process values. Each of these registers corresponds to a user parameter on the TT-MA-DSS transmitter. If parameter P24 is set to "RTU" or "All" then it is also possible to write to these registers as well as read through Modbus function code (16) preset multiple registers. Values sent in succession from starting index.

Name	Range	Engineered Values	Register	Parameter
Analog Output Hold Feature	0,1	0="Off", 1="On"	40401	P23
Analog Output Set for 0-20mA or 4-20mA	0,1	0=0-20mA, 1=4-20mA	40402	P04
Toggle non-inverted or inverted output	0,1	0=invert, 1=non.inv	40403	P05
Low 0/4mA Setpoint for Analog Output	0..9,800	0.00% to 98.00%	40404	P06/P07
High 20mA Setpoint for Analog Output	200..10,000	2.00% to 100.00%	40405	P08/P09
Units selected for D.O. sensors for output	ppm or % Sat	0=ppm, 1=% Sat	40406	P10
Units set for Std/Hi EC sensors output	EC, PSU, TDS	0=EC, 1=PSU, 2=TDS	40406	P11
Units set for Ultralow EC sensors output	EC, MW, MW UPW	0=EC, 1= MW, 2= MW UPW	40407	P11
Modbus Slave Node Address	1..247	1..247	40408	P21
Modbus Master Node Address	1..247	1..247	40409	P02

Note: Registers 40401 to 40409 correspond to Index 400 to 408

Display Features

For Sensor Type 1 pH - the *'pH/ORP'* LED will be continuous illuminated unless otherwise indicated below

- -2.00 to -0.01 displayed as 2.00 to 0.01 flashing
- 0.00 to 9.99 displayed not flashing with two decimal points
- 10.0 to 16.0 display with one decimal point

If '*Down*' button is pressed, then the temperature of connected sensor is shown*
If *'Down'* button is held for 3 to 5 seconds, then the absolute mV will be shown*
If *'Up'* button is pressed, then the mA for the current process value and scaling will be shown

For Sensor Type 2 ORP - the *'pH/ORP'* LED will be continuous illuminated unless otherwise indicated below

- -999 to -1 displayed as 999 to 1 flashing
- 0 to +999 displayed not flashing

If *'Down'* button is pressed, then the temperature of connected sensor is shown *
If *'Down'* button is held for 3 to 5 seconds, then the absolute mV will be shown *
If *Up'* button is pressed, then the mA for the current process value and scaling will be shown

For Sensor Type 3 Wide ORP - the *'pH/ORP'* LED will be continuous illuminated unless otherwise indicated below

- -2,000 to -1,000 display as 2.00 to 1.00 with LED flashing (units are Volts)
- -999 to -1 displayed as 999 to 1 flashing
- 0 to +999 displayed not flashing
- +1,000 to +2,000 display as 1.00 to 2.00 with LED not flashing (units are Volts)

If *'Down'* button is pressed, then the temperature of connected sensor is shown*
If *'Down'* button is held for 3 to 5 seconds, then the absolute mV will be shown*
If *'Up'* button is pressed, then the mA for the current process value and scaling will be shown

For Sensor Type 4 Dissolved Oxygen (D.O.) -the "D.O." LED will be continuous illuminated unless otherwise indicated below

- If P10 is 'ppm' then 0.00 to 150.00 ppm units displayed not flashing as 0.00 to 9.99, 10.0-99.9 and 100-150 ppm
- If P10 is '%Sat' then 0.0-1,500.0 percent (%) saturation units displayed not flashing as 0.0-99.9%, 100-999% with the special range of 1,000-1,500% displayed as 1.00-1.50 with LED flashing (kilo % Saturation Units)

If the 'Down' button is pressed, then the temperature of connected sensor is shown *
If the 'Down' button is held for 3 to 5 seconds, then the absolute mV will be shown *
If the 'Up' button is pressed, then the mA for the current process value and scaling will be shown
If the 'Up' button held and P10 is 'ppm' (basis of 4-20mA output) then % Saturation units are displayed
If the 'Up' button held and P10 is '%Sat' (basis of 4-20mA output) then ppm units are displayed

For Sensor Type 5 Ion Selective (ISE) - the *"ISE"* LED will be continuous illuminated unless otherwise indicated below

- 0.00-9.99, 10.0-99.9, 100-999 ppm units displayed same as per TT-MA-ISE transmitter

kilo-ppm units displayed with LED flashing to signify kilo-ppm scale is in use same as per TT-MA-ISE-kilo

- 1.00-9.99 (1,000-9,990 ppm), 10.0-99.9 (10,000-99,900 ppm) and 100-999 (100,000-999,000 ppm)

If *'Down'* button is pressed, then the temperature of connected sensor is shown*
If *'Down'* button is held for 3 to 5 seconds, then the absolute mV will be shown*
If *'Up'* button is pressed, then the mA for the current process value and scaling will be shown
If *'Up'* button held for 3 to 5 seconds, pION value is shown with same scheme used display the pH

For Sensor Type 6 or 7 Conductivity (EC) - the *'Cond'* LED will be continuous illuminated unless otherwise indicated below

- <1.00 mS shown as flashing from 1 to 999 uS/cm with 0.01-9.99, 10.0-99.9 and 100-999 floating decimal point
- 1.00 to 999 mS/cm shown displayed not flashing with 0.01-9.99, 10.0-99.9 and 100-999 floating decimal point

- 1,000 to 2,000 mS/cm display as 1.00 to 2.00 with the LED flashing *(kilo-mS/cm)*
- If P11 is 'PSU or MΩ' then salinity (sensor type 6) or resistivity (sensor type 7) is shown as 0.00-9.99 and 10.0-50.0
- If P11 is 'TDS' then ppt is shown as 0.00-9.99 and 10.0-99.9 (multiply by 1,000 to get ppm units instead of ppt units)

If *'Down'* button is pressed, then the temperature of connected sensor is shown*
If *'Down'* button is held for 3 to 5 seconds, then raw conductivity will be shown per scheme above
If *'Up'* button is pressed, then the mA for the current process value and scaling will be shown
If *'Up'* button is held for 3 to 5 seconds and P11 is *'PSU'*, *'TDS'* or 'MΩ' then reading in conductivity units will be shown (see scheme above). If conductivity units selected for P11 then nothing is shown.

Production data *(yy.m)* displayed by pressing *'Down'* and *'Mode'* simultaneously in any main LED display mode. The month will display as 1>9 and then A for October, B for November, and C for December. I.e. October 2011 will display as *'11.A'*.
Revision of software is displayed by pressing the *'Up' 'Mode'* simultaneously in any main display mode.

** Negative values will be shown as flashing.*

PH

Measurement	pH	Setup Parameter
Configuration	1	N/A
Sensor Type	1	P18
Default Node	1	P02
Default Baudrate	19,200	P03
Default Output Type	4-20mA	P04
Default Polarity	non-inverted	P05
Default Low Whole	11	P06
Default Low Decimal	11	P07
Default Hi Whole	88	P08
Default Hi Decimal	89	P09
Days to Recalibrate	14	P17

Integer Limits	Engineered pH Limits
0	**-2.000**
18,000	**16.000**

% of Full Range	Engineered pH Units	RTU Integer
0.00%	-2.000	0
5.56%	-1.000	1000
11.11%	0.000	2000
16.67%	1.000	3000
22.22%	2.000	4000
27.78%	3.000	5000
33.33%	4.000	6000
38.89%	5.000	7000
44.44%	6.000	8000
50.00%	7.000	9000
55.56%	8.000	10000
61.11%	9.000	11000
66.67%	10.000	12000
72.22%	11.000	13000
77.78%	12.000	14000
83.33%	13.000	15000
88.89%	14.000	16000
94.44%	15.000	17000
100.00%	16.000	18000

11.11%	**0.000**	**Default Low Setpoint P06/P07**
88.89%	**14.000**	**Default High Setpoint P08/P09**

CHANGING pH VALUES ABOVE GET % SCALING COMPUTED

Note 1: *Low and high analog setpoints should be at least 1,000 MODBUS RTU steps apart.*

ORP

Measurement	ORP	Setup Parameter
Configuration	2	N/A
Sensor Type	2	P18
Default Node	2	P02
Default Baudrate	19,200	P03
Default Output Type	4-20mA	P04
Default Polarity	non-inverted	P05
Default Low Whole	0	P06
Default Low Decimal	0	P07
Default Hi Whole	100	P08
Default Hi Decimal	0	P09
Days to Recalibrate	30	P17

Integer Limits	Engineered ORP Limits
0	**-1.000.0**
20,000	**1.000.0**

% of Full Range	Engineered ORP Units	RTU Integer
0.00%	-1000.0	0
5.00	-900.0	1000
10.00	-800.0	2000
15.00	-700.0	3000
20.00	-600.0	4000
25.00	-500.0	5000
30.00	-400.0	6000
35.00	-300.0	7000
40.00	-200.0	8000
45.00	-100.0	9000
50.00	0.0	10000
55.00	100.00	11000
60.00	200.00	12000
65.00	300.00	13000
70.00	400.00	14000
75.00	500.00	15000
80.00	600.00	16000
85.00	700.00	17000
90.00	800.00	18000
95.00	900.00	19000
100.00	1,000.0	20000

0%	**-1000.0**	**Default Low Setpoint P06/P07**
100%	**1000.0**	**Default High Setpoint P08/P09**

CHANGING ORP VALUES ABOVE GET % SCALING COMPUTED

Note 1: *Low and high analog setpoints should be at least 1,000 MODBUS RTU steps apart.*

Wide ORP

Measurement	Wide ORP	Setup Parameter
Configuration	3	N/A
Sensor Type	3	P18
Default Node	3	P02
Default Baudrate	19,200	P03
Default Output Type	4-20mA	P04
Default Polarity	non-inverted	P05
Default Low Whole	0	P06
Default Low Decimal	0	P07
Default Hi Whole	100	P08
Default Hi Decimal	0	P09
Days to Recalibrate	30	P17

Integer Limits	Engineered ORP Limits
0	-2,000.0
20,000	2,000.0

% of Full Range	Engineered ORP Units	RTU Integer
0.00%	-2,000.0	0
5.00%	-1,800.0	1000
10.00%	-1,600.0	2000
15.00%	-1,400.0	3000
20.00%	-1,200.0	4000
25.00%	-1,000.0	5000
30.00%	-800.0	6000
35.00%	-600.0	7000
40.00%	-400.0	8000
45.00%	-200.0	9000
50.00%	0.0	10000
55.00%	200.0	11000
60.00%	400.0	12000
65.00%	600.0	13000
70.00%	800.0	14000
75.00%	1,000.0	15000
80.00%	1,200.0	16000
85.00%	1,400.0	17000
90.00%	1,600.0	18000
95.00%	1,800.0	19000
100.00%	2,000.0	20000

0.00%	**-2,000.0**	**Default Low Setpoint P06/P07**
100.00%	**2,000.0**	**Default High Setpoint P08/P09**

CHANGING ORP VALUES ABOVE GET % SCALING COMPUTED

Note 1: *Low and high analog setpoints should be at least 1,000 MODBUS RTU steps apart.*

DO ppm

Measurement	Dissolved Oxygen ppm	Setup Parameter
Configuration	4	N/A
Sensor Type	4	P18
Default Node	4	P02
Default Baudrate	19,200	P03
Default Output Type	4-20mA	P04
Default Polarity	non-inverted	P05
Default Low Whole	0	P06
Default Low Decimal	0	P07
Default Hi Whole	100	P08
Default Hi Decimal	0	P09
Days to Recalibrate	30	P17
DO Units for Output	ppm	P10

Integer Limits	Engineered DO ppm Limits
0	0.00
15,000	150.00

% of Full Range	Engineered DO ppm Units	RTU Integer
0.00%	0.00	0
6.67%	10.00	1000
13.33%	20.00	2000
20.00%	30.00	3000
26.67%	40.00	4000
33.33%	50.00	5000
40.00%	60.00	6000
46.67%	70.00	7000
53.33%	80.00	8000
60.00%	90.00	9000
66.67%	100.00	10000
73.33%	110.00	11000
80.00%	120.00	12000
86.67%	130.00	13000
93.33%	140.00	14000
100.00%	150.00	15000

0.00%	**0.00**	**Default Low Setpoint P06/P07**
100.00%	**150.00**	**Default High Setpoint P08/P09**

CHANGING DO ppm VALUES ABOVE GET % SCALING COMPUTED

Note 1: *Low and high analog setpoints should be at least 1,000 MODBUS RTU steps apart.*

DO % Sat

Measurement	Dissolved Oxygen % Saturation	Setup Parameter
Configuration	5	N/A
Sensor Type	4	P18
Default Node	4	P02
Default Baudrate	19,200	P03
Default Output Type	4-20mA	P04
Default Polarity	non-inverted	P05
Default Low Whole	0	P06
Default Low Decimal	0	P07
Default Hi Whole	100	P08
Default Hi Decimal	0	P09
Days to Recalibrate	30	P17
DO Units for Output	% Sat with Salinity Correction	P10

Integer Limits	Engineered DO % Sat Limits
0	0.0
15,000	1,500.0

% of Full Range	Engineered DO % Sat Units	RTU Integer
0.00%	0.0	0
6.67%	100.0	1000
13.33%	200.0	2000
20.00%	300.0	3000
26.67%	400.0	4000
33.33%	500.0	5000
40.00%	600.0	6000
46.67%	700.0	7000
53.33%	800.0	8000
60.00%	900.0	9000
66.67%	1,000.0	10000
73.33%	1,100.0	11000
80.00%	1,200.0	12000
86.67%	1,300.0	13000
93.33%	1,400.0	14000
100.00%	1,500.0	15000

0.00%	0.0	Default Low Setpoint P06/P07
100.00%	1,500.0	Default High Setpoint P08/P09

CHANGING DO % SAT VALUES ABOVE GET % SCALING COMPUTED

Note 1: *Low and high analog setpoints should be at least 1,000 MODBUS RTU steps apart.*

ISE

Measurement	ISE	Setup Parameter
Configuration	6	N/A
Sensor Type	5	P18
Default Node	5	P02
Default Baudrate	19,200	P03
Default Output Type	4-20mA	P04
Default Polarity	non-inverted	P05
Default Low Whole	17	P06
Default Low Decimal	46	P07
Default Hi Whole	43	P08
Default Hi Decimal	56	P09
Days to Recalibrate	14	P17

CHANGE VALUE BELOW TO MATCH P19 WHEN SMART RTU ISE SENSOR IS CONNECTED

if P19 Value is: 19.00

Integer Limits	Engineered pION Limits
0	-2.000
18,000	16.000

% of Full Range	Engineered pION Units	RTU Integer	ppm units
0.00%	-2.000	0	19000000
5.56%	-1.000	1000	1900000
11.11%	0.000	2000	190000
16.67%	1.000	3000	19000
22.22%	2.000	4000	1900
27.78%	3.000	5000	190
33.33%	4.000	6000	19
38.89%	5.000	7000	1.9
44.44%	6.000	8000	0.19
50.00%	7.000	9000	0.019
55.56%	8.000	10000	0.0019
61.11%	9.000	11000	0.00019

45.99%	**6.279**	**ppm Low Set**	**0.01000**	**P06/P07**
18.22%	**1.279**	**ppm High Set**	**1000.00000**	**P08/P09**

% FULL RANGE COMPUTED FOR PPM VALUES ENTERED TO THE RIGHT

CHANGE ppm VALUES ABOVE TO DESIRED VALUES FOR LOW & HIGH SETPOINTS

45.99%	**6.279**	**Default Low Setpoint in pION**
18.22%	**1.279**	**Default High Setpoint in pION**

Note 1: *Low and high analog setpoints should be at least 1,000 MODBUS RTU steps apart.*
Note 2: *0 ppm not a valid number for low setpoint since there exists no corresponding pION value.*

CON in Micro Siemen Units

Measurement	Conductivity	Setup Parameter
Configuration	7	N/A
Sensor Type	6 or 7	P18
Default Node	6	P02
Default Baudrate	19,200	P03
Default Output Type	4-20mA	P04
Default Polarity	non-inverted	P05
Default Low Whole	0	P06
Default Low Decimal	0	P07
Default Hi Whole	100	P08
Default Hi Decimal	0	P09
Days to Recalibrate	90	P17
Units for Output	Con	P11

STANDARD RANGE MODE* - All values are given in microSiemens/cm

Range Scaling Factor 200		P13		P06/P07		P08/P09
Cell Constant P12	Max Conductivity	Resolution	0/4mA Low Setpoint	% of Full Range	20mA High Setpoint	% of Full Range
0.01	200	0.004	0.00	0.00%	200.00	100.00%
0.02	400	0.008	0.00	0.00%	400.00	100.00%
0.05	1,000	0.02	0.00	0.00%	1,000.00	100.00%
0.10	2,000	0.04	0.00	0.00%	2,000.00	100.00%
0.20	4,000	0.08	0.00	0.00%	4,000.00	100.00%
0.50	10,000	0.2	0.00	0.00%	10,000.00	100.00%
1.00	20,000	0.4	0.00	0.00%	20,000.00	100.00%
2.00	40,000	0.8	0.00	0.00%	40,000.00	100.00%
3.00	60,000	1.2	0.00	0.00%	60,000.00	100.00%
5.00	100,000	2	0.00	0.00%	100,000.00	100.00%
10.00	200,000	4	0.00	0.00%	200,000.00	100.00%
20.00	400,000	8	0.00	0.00%	400,000.00	100.00%

HIGH RANGE MODE * - All values are given in microSiemens/cm

Range Scaling Factor 2,000		P13		P06/P07		P08/P09
Cell Constant P12	Max Conductivity	Resolution	0/4mA Low Setpoint	% of Full Range	20mA High Setpoint	% of Full Range
0.01	2,000	0.04	0.00	0.00%	1,000.00	50.00%
0.02	4,000	0.08	0.00	0.00%	2,000.00	50.00%
0.05	10,000	0.2	0.00	0.00%	5,000.00	50.00%
0.10	20,000	0.4	0.00	0.00%	10,000.00	50.00%
0.20	40,000	0.8	0.00	0.00%	20,000.00	50.00%
0.50	100,000	2	0.00	0.00%	50,000.00	50.00%
1.00	200,000	4	0.00	0.00%	100,000.00	50.00%
2.00	400,000	8	0.00	0.00%	200,000.00	50.00%
3.00	600,000	12	0.00	0.00%	300,000.00	50.00%
5.00	1,000,000	20	0.00	0.00%	500,000.00	50.00%
10.00	2,000,000	40	0.00	0.00%	1,000,000.00	50.00%
20.00	4,000,000	80	0.00	0.00%	2,000,000.00	50.00%

ULTRALOW RANGE MODE* - All values are given in microSiemens/cm

Range Scaling Factor 2		P13		P06/P07		P08/P09
Cell Constant P12	Max Conductivity	Resolution	0/4mA Low Setpoint	% of Full Range	20mA High Setpoint	% of Full Range
0.01	2	0.00004	0.00	0.00%	2.00	100.00%
0.02	4	0.00008	0.00	0.00%	4.00	100.00%
0.05	10	0.0002	0.00	0.00%	10.00	100.00%
0.10	20	0.0004	0.00	0.00%	20.00	100.00%
0.20	40	0.0008	0.00	0.00%	40.00	100.00%
0.50	100	0.002	0.00	0.00%	100.00	100.00%
1.00	200	0.004	0.00	0.00%	200.00	100.00%
2.00	400	0.008	0.00	0.00%	400.00	100.00%
3.00	600	0.012	0.00	0.00%	600.00	100.00%
5.00	1,000	0.02	0.00	0.00%	1,000.00	100.00%
10.00	2,000	0.04	0.00	0.00%	2,000.00	100.00%
20.00	4,000	0.08	0.00	0.00%	4,000.00	100.00%

Note 1: *Difference between low & high analog setpoints should be at least 2% of the full range apart*
Note 2: *Minimum recommend Scaling is 4.00% of the full range if the low setpoint is 0.00%.*
Note 3: *For high range mode the maximum recommended high 20mA setpoint is 50% of full range*

CON in PSU Or Megohm Standard

Measurement	Conductivity	Setup Parameter
Configuration	8	N/A
Sensor Type	6 or 7	P18
Default Node	6	P02
Default Baudrate	19,200	P03
Default Output Type	4-20mA	P04
Default Polarity	non-inverted	P05
Default Low Whole	0	P06
Default Low Decimal	0	P07
Default Hi Whole	100	P08
Default Hi Decimal	0	P09
Days to Recalibrate	90	P17
Units for Output	PSU or MegaOhm	P11

Integer Limits	Engineered PSU / MOhm Limits
0	0.000
50,000	50.000

% of Full Range	Engineered PSU / MOhm Units	RTU Integer
0.00%	0.000	0
10.00%	5.000	5000
20.00%	10.000	10000
30.00%	15.000	15000
40.00%	20.000	20000
50.00%	25.000	25000
60.00%	30.000	30000
70.00%	35.000	35000
80.00%	40.000	40000
90.00%	45.000	45000
100.00%	50.000	50000

0.00%	**0.000**	**Default Low Setpoint P06/P07**
100.00%	**50.000**	**Default High Setpoint P08/P09**

CHANGING PSU VALUES GET % SCALING COMPUTED (SENSOR TYPE 6)

0.00%	**0.000**	**Default Low Setpoint P06/P07**
40.00%	**20.000**	**Default High Setpoint P08/P09**

CHANGING MOhm VALUES ABOVE GET % SCALING COMPUTED (SENSOR TYPE 7)

Note 1: Low and high analog setpoints should be at least 1,000 MODBUS RTU steps apart.
Note 2: Units are PSU for Snesor Type 6 and MegaOhms for Sensor Type 7

CON in TDS or MegaOhm UPW

Measurement	Conductivity	Setup Parameter
Configuration	9	N/A
Sensor Type	6 or 7	P18
Default Node	6	P02
Default Baudrate	19,200	P03
Default Output Type	4-20mA	P04
Default Polarity	non-inverted	P05
Default Low Whole	0	P06
Default Low Decimal	0	P07
Default Hi Whole	100	P08
Default Hi Decimal	0	P09
Days to Recalibrate	90	P17
Units for Output	TDS or MegaOhms for UPW	P11

Integer Limits	Engineered TDS ppm Limits	Engineered TDS ppt Limits
0	0	0.00
50,000	100,000	100.00

% of Full Range	Engineered TDS Units	RTU Integer
0.00%	0	0
5.00%	5,000	2500
10.00%	10,000	5000
15.00%	15,000	7500
20.00%	20,000	10000
25.00%	25,000	12500
30.00%	30,000	15000
35.00%	35,000	17500
40.00%	40,000	20000
45.00%	45,000	22500
50.00%	50,000	25000
55.00%	55,000	27500
60.00%	60,000	30000
65.00%	65,000	32500
70.00%	70,000	35000
75.00%	75,000	37500
80.00%	80,000	40000
85.00%	85,000	42500
90.00%	90,000	45000
95.00%	95,000	47500
100.00%	100,000	50000

0.00%	**0**	**Default Low Setpoint P06/P07**
100.00%	**100,000**	**Default High Setpoint P08/P09**

CHANGING TDS VALUE ABOVE GET % SCALING COMPUTED

Note 1: *Low & High Analog Setpoints should be at least 1,000 MODBUS RTU steps apart.*
Note 2: *Units are TDS for Sensor Type 6 and MegaOhms for UPW for Sensor Type 7*

Integer Limits	Engineered MOhm for UPW Limits
0	0.000
50,000	50.000

% of Full Range	Engineered MOhm for UPW Units	RTU Integer
0.00%	0.000	0
10.00%	5.000	5000
20.00%	10.000	10000
30.00%	15.000	15000
40.00%	20.000	20000
50.00%	25.000	25000
60.00%	30.000	30000
70.00%	35.000	35000
80.00%	40.000	40000
90.00%	45.000	45000
100.00%	50.000	50000
0.00%	**0.000**	**Default Low Setpoint P06/P07**
40.00%	**20.000**	**Default High Setpoint P08/P09**

Specifications

Temperature function module

The Temperature module adds a scalable analog output for the temperature to any of the measurement modules: pH/ORP, Dissolved Oxygen or Conductivity.

This function module can be used to add a temperature output at any time, before or after commissioning.

Product name	Temperature Module Analyser	
Code	TT-MA-TEM	
Power supply	24VDC ±10%	
Consumption	60 mA max	
Accuracy	±0.2% Excluding Sensor *(Ideal)*	
Temperature sensor	Pt100, Pt1000	
Temperature 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	
Temperature	Usage -15 to +50 °C *(Storage -35 to +75 °C)*	
Weight	75 grams *(2.64 ounces)*	
Dimensions	L 86 x W 36 x H 58 mm *(3.4" X 1.4" X 2.3")*	
CE mark	EN61326A	

Why use a Temperature Measurement Module?

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

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

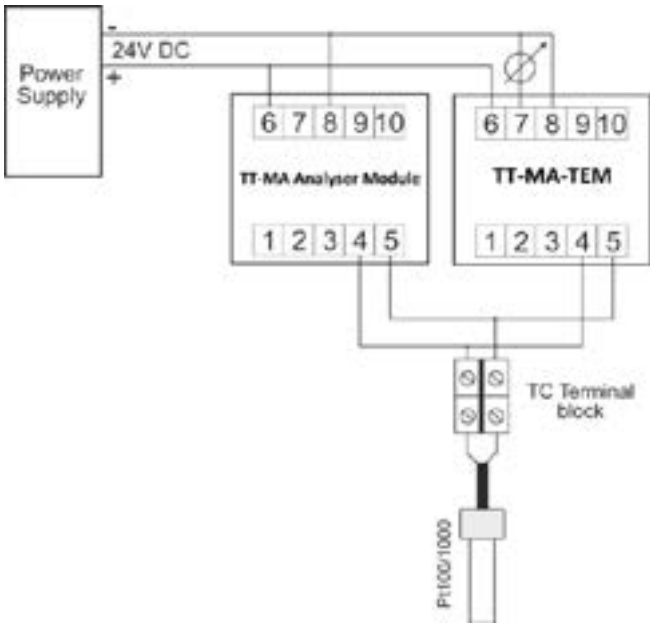
- Any pH, ORP, ISE, Conductivity or DO sensor with Pt100/Pt1000 in “splice” mode will be used both for temperature compensation on the measurement module and to send a scalable output for temperature from the TT-MA Temperature Measurement Module.

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

Unpacking

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

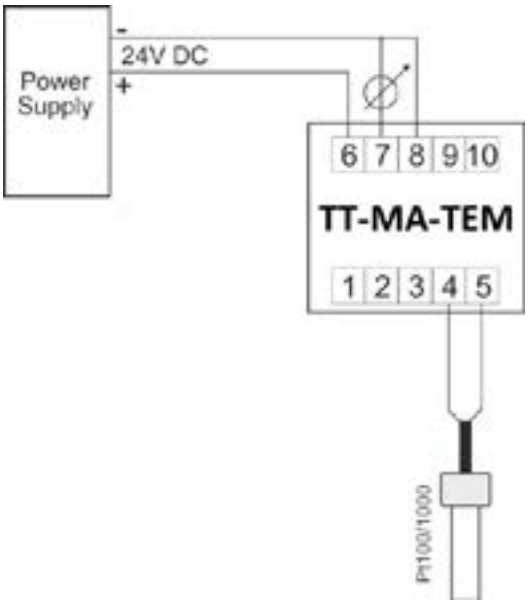
Wiring



Typical Splice Type Wiring

Notes:

1. Wiring schematic valid when parameter P01 is a splice.
2. The wiring schematic above is valid when 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:

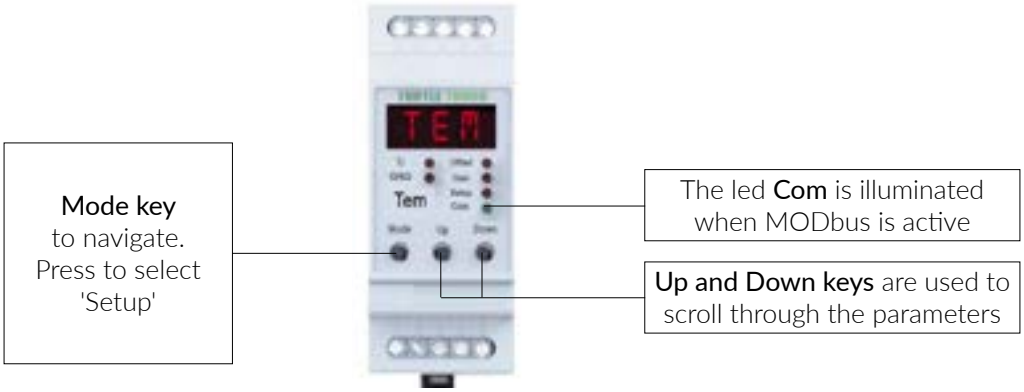
1. Wiring schematic valid when parameter P01 is a splice.
2. The wiring schematic above is valid when mating with a TT-MA Analyser Module.
3. Be sure to select whether a Pt100 or Pt1000 is used in parameter P03. This will be the type of TC element in your pH/ORP/ISE/Conductivity or DO sensor. Only the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

For additional wiring information. Please consult turtletoughsensors.com

Menu Navigation

The TT-MA-TEM Display Module 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 it with the *'Mode'* key then modify the value using the *'Up'* and *'Down'* keys.

If softwarelock (P01) *'On'* no changes can be made. Set P01 to *'Off'* to allow for changes to scaling and configuration. If keys are not used for several minutes then software lock resets back *'On'*.



Lock Function

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

* Negative trim adjustments will be shown as flashing numbers.

Parameters Explained

To access the programmable parameters see Menu Navigation. Below, a description of each parameter settings.

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

Calibration

Splice Type Wiring

Step 1 Obtain a valid variable resistor potentiometer (a.k.a. “turn-pot”) with a nominal value of 200 Ohms if a Pt100 element is used and a nominal value of 2,000 Ohms if a Pt1000 element is used. Wire-up the turn-pot as“splice” type input as shown in the wiring section to serve as a simulated temperature sensor.

Step 2 Adjust the turn-pot so that the temperature reading on the TT-MA Analyser Module is very close to 0.0°C. Use the ‘Offset’ calibration mode to make the TT-MA-TEM temperature (°C) reading agree with what is shown on the TT-MA Analyser Module.

Step 3 Adjust the turn-pot so that the temperature reading on the TT-MA Analyser Module is very close to 210°C. Use the ‘Gain’ calibration mode to make the TT-MA-TEM temperature (°C) reading agree with what is shown on the TT-MA Analyser Module.

Raw (Direct) Wiring

Step 1 Obtain a valid variable resistor potentiometer (a.k.a. “turn-pot”) with a nominal value of 200 Ohms if a Pt100 element is used and a nominal value of 2,000 Ohms if a Pt1000 element is used. Wire-up the turn-pot as “raw” type input as shown in the wiring section to serve as a simulated temperature sensor.

Step 2 Adjust the turn-pot so that the temperature reading on TT-MA-TEM is very close to 0.0°C. Use the ‘Offset’ calibration mode to make the TT-MA-TEM reading agree with nominal temperature (°C) for that resistance (see Resistance Table Section). Adjust the turn-pot so that the temperature reading on TT-MA-TEM is very close to 210°C. Use the ‘Gain’ calibration mode to make the TT-MA-TEM reading agree with nominal temperature (°C) for that resistance.

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

Modbus Communication Option

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

Resistance and Temperature Tables: Pt100 and Pt1000

Table: Pt100

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

Table: Pt1000

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

Specifications

Relay function module

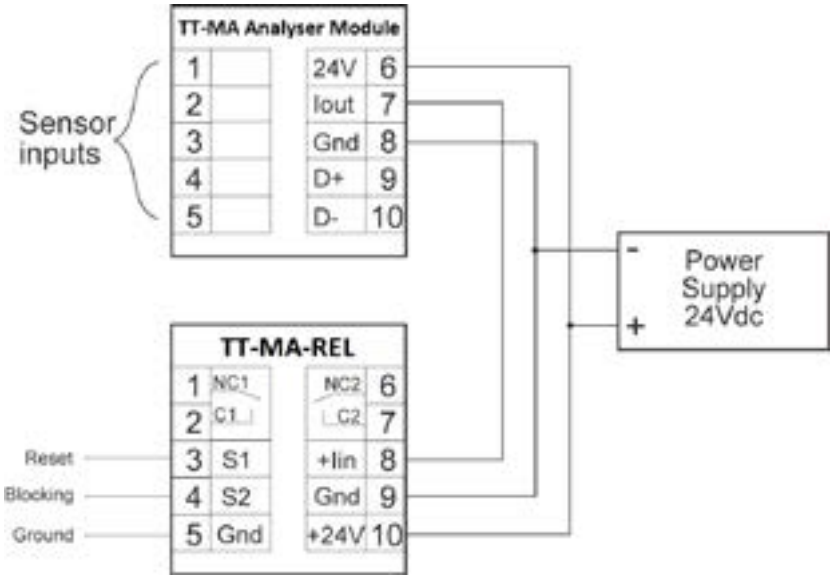
The Relay module is an alarm and controller module with two independent limits. It is fully configurable by the user as to control mode and variables for each control algorithm.

The tight integration between the Relay function module and the TT-MA measurement modules software makes the configuration and scaling simple and easy for any local control requirements of the pH, ORP, Dissolved Oxygen, Ion Selective or Conductivity parameters.

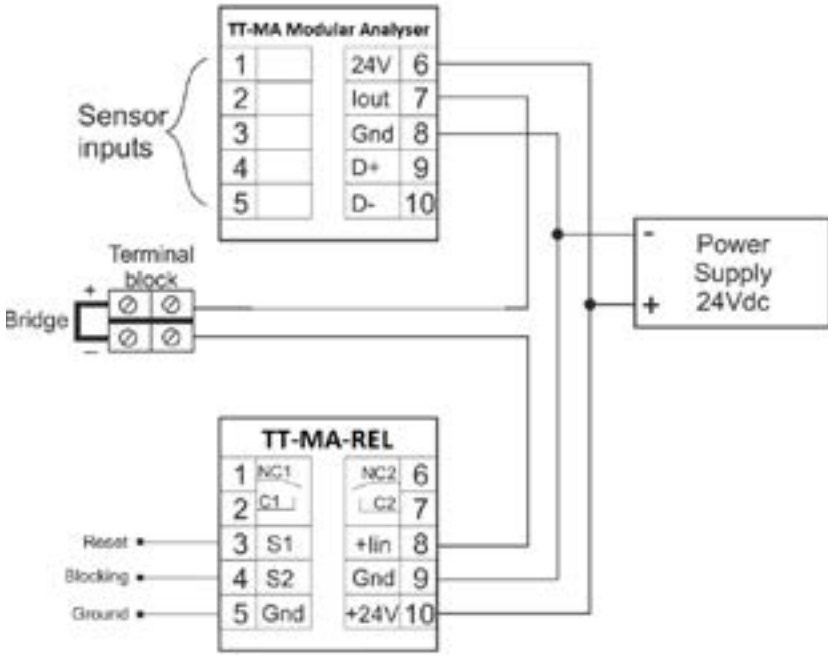
Product name	Relay Module Analyser	
Code	TT-MA-REL	
Sensor technology compatibility	Conventional Analogue *(-A)*	
Power supply	24VDC ±10%	
Consumption	60 mA max	
Input current range	(0)4-20mA, 70Ω	
Digital input	Pos. logic: 5-30VDC; Neg. logic: 0V	
Input S1	External Reset	
Input S2	Alarm Block	
Relay 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	
Temperature	Usage -15 to +50 °C *(Storage -35 to +75 °C)*	
Weight	75 grams *(2.64 ounces)*	
Dimensions	L 86 x W 36 x H 58 mm *(3.4" X 1.4" X 2.3")*	
CE mark	EN61326A	

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.

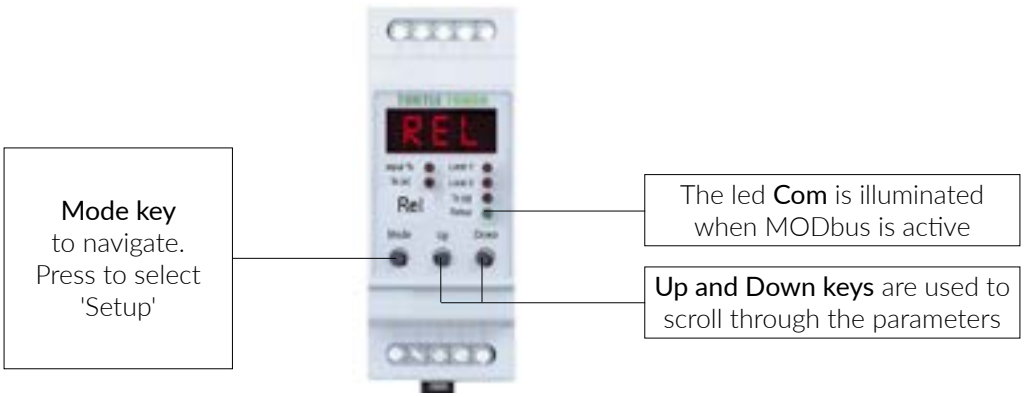


If you wish to “insert” an external device into the current loop, it can be done by removing the bridge jumper and connecting the two terminals to the external device (“+” to device input and “–“ to device output, which may also be device ground). If no external device is to be connected, the bridge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

Menu Navigation

The TT-MA-REL Display Module 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 it with the *'Mode'* key then modify the value using the *'Up'* and *'Down'* keys.

If softwarelock (P01) *'On'* no changes can be made. Set P01 to *'Off'* to allow for changes to scaling and configuration. If keys are not used for several minutes then software lock resets back *'On'*.



Lock Function

Important: *Parameter No. 01 is a LOCK function that 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	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. Below, 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

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/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 the selected range for conductivity
*** Decimal point depends on the selected range for ISE
^ During this period, no relay action will be undertaken when P06 is set to Off (supervision/alarm function only) or On/Off Relay control mode

Control Functions and Modes

On/Off control

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

Hysteresis Band

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

Proportional Band

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

Basic Frequency

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

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

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

Time Proportional Control (TPC)

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

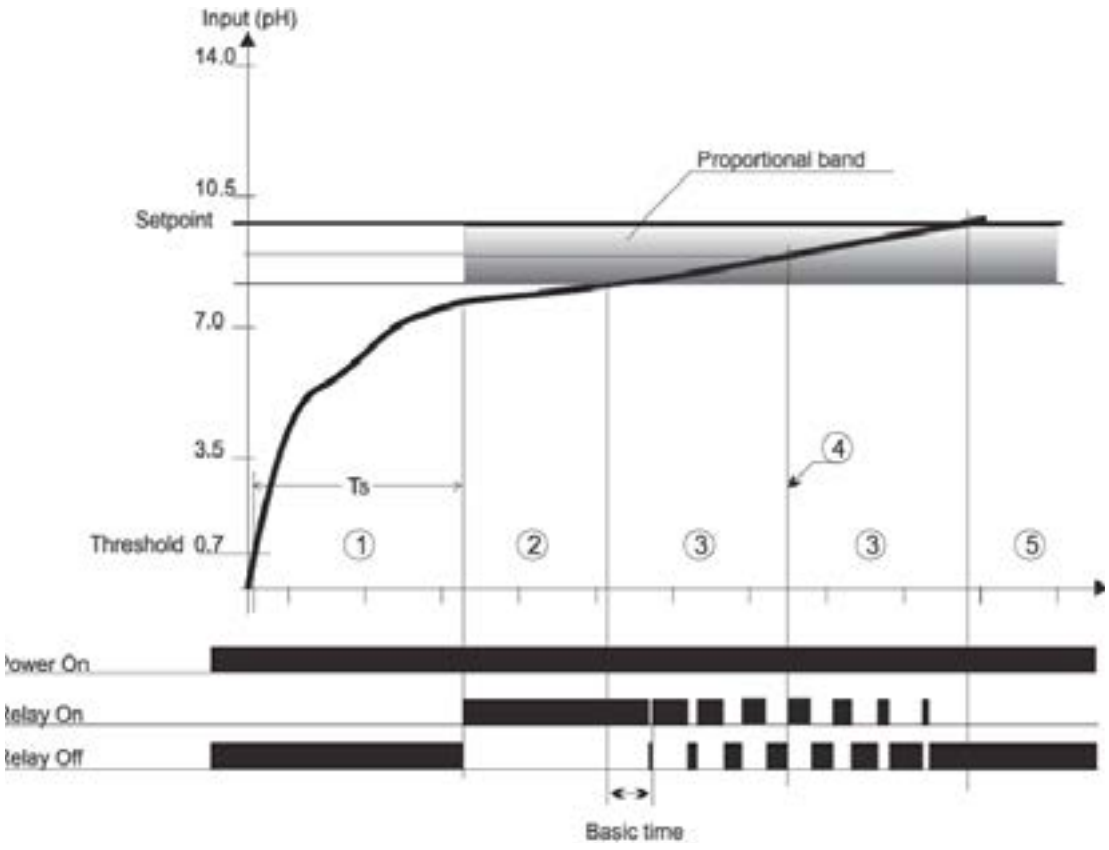
When the measured value crosses 5% of the measuring range (here corresponding to 0.7pH) the start-up timer is activated to avoid false readings during the settling time of the sensor. This time should be selected large enough to give the sensor time to settle, but not much longer than this, since the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

After the 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 are said to lie within the proportional band (Period 3) and the on-time of the relay is regulated proportionally 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 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 Dissolved Oxygen measurement module directly.

Specifications

Data Logger function module

The Data Logger module allows for data logging of up to 63 each Modbus Digital inputs from any combination of the TT-MA measurement modules: pH/ORP *(TT-MA-pH)*, Conductivity *(TT-MA-CON)* and Dissolved Oxygen *(TT-MA-DO)* as input nodes. Note that the measurement module must be ordered with Modbus RTU output.

Product name	Data Logger Module Analyser	
Code	TT-MA-DAT	
Sensor technology compatibility	Conventional Analogue *(-A)*	
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	
Temperature	Usage -15 to +50 °C *(Storage -35 to +75 °C)*	
Weight	200 grams (7.04 ounces)	
Dimensions	L 86 x W 36 x H 58 mm *(3.4" X 1.4" X 2.3")*	
CE mark	EN61326A	

Why use a 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

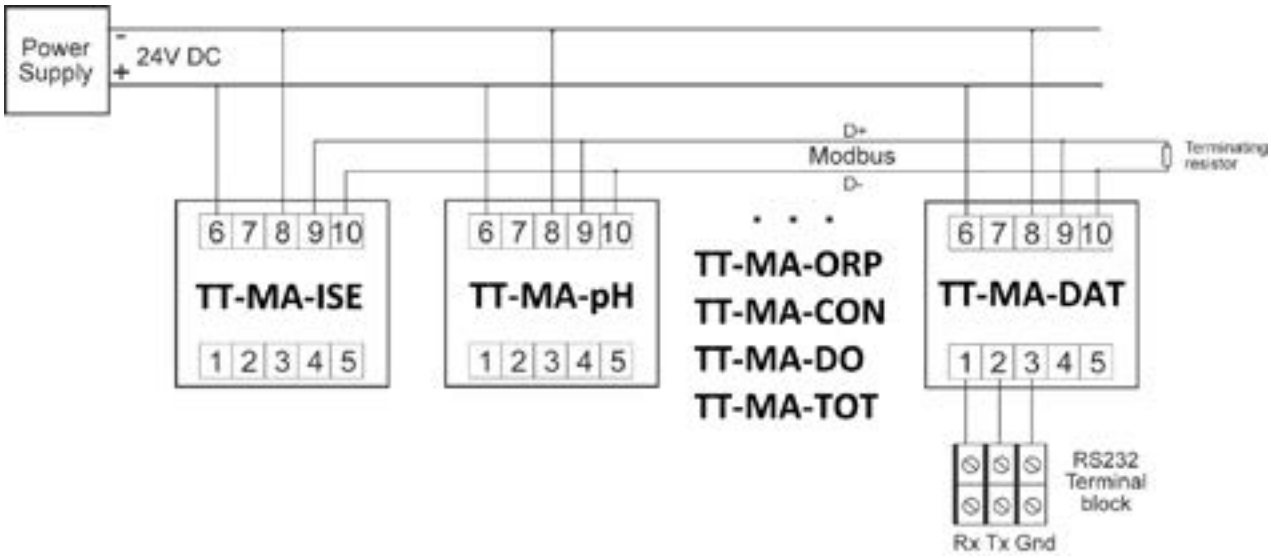

Important

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 compliance with local regulations.

Wiring



Notes:

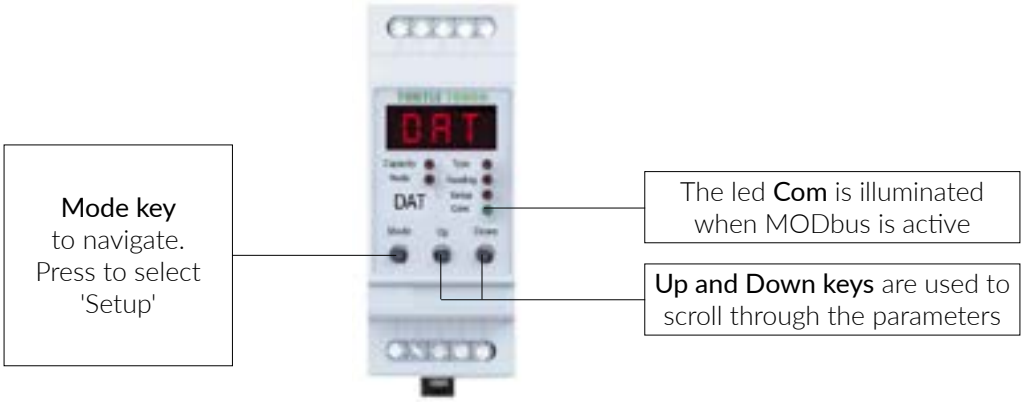
1. Up to 63 TT-MA Modules may be connected to a single DAT Module. Each connected Module must have a unique valid node address from 1 to 247.
2. The value of the terminating resistor will vary based upon the number of connected nodes. Contact your Turtle Tough Distributor for assistance to choose the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

For additional wiring information please consult turtletoughsensors.com

Menu Navigation

The TT-MA-DAT Display Module 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 it with the *'Mode'* key then modify the value using the '*Up*' and *'Down'* keys.

If softwarelock (P01) '*On*' no changes can be made. Set P01 to '*Off*' to allow for changes to scaling and configuration. If keys are not used for several minutes then software lock resets back '*On*'.



Lock Function

Important: *Parameter No. 01 is a LOCK function that 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	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 dEl = 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 data logging and graphing software for TT-MA modules fitted with Modbus (and all necessary RS485 Modbus wiring connections for the same) and the separate Windows software for the DAT have been correctly installed in the default configuration and are working on a single PC/tablet.

A configuration file needs to be created using the Windows Modbus data logging 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 data logging 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 an RS232 to USB converter as detailed in the Accessories section.

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

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

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

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

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

Datalogging Capacity

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

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

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

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

Notes:

1. Times for data logging capacity are shown in units of DAYS
2. Data logging capacity shown are approximate for reference purposes
3. pH/ISE/CON send process parameter and temp for each node
4. DO sends DO ppm % Saturation and temp for each node
5. TOT sends Total ISE, Free ISE, pH, Temp and Aux each node
6. DAT module comes standard with two 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 *'Down'* 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 work up all the 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 the download of the data and the 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 set-points, 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 data-logging operation of the DAT Module. The data should be downloaded before creating and loading a new configuration file.

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

Troubleshooting

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

Error code 2: Communication error, typically network problem.

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

Digital Communication

The DAT Module contains two modes of digital communication. Data is acquired via the RS485 network from terminals 9 and 10, with the DAT as Modbus master. Upload and download of node configuration and download of data are 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 and (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 several function codes giving the master of the network the ability to gather 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 several 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 complimentary accessories are available for use with the DAT Module:

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

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

Specifications

TOT function module

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

Total ISE can be calculated for the following ions:

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

Product name	TOT Module Analyser	
Code	TT-MA-TOT	
Sensor technology compatibility	Conventional Analogue *(-A)*	
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	
Temperature	Usage -15 °C to +50 °C *(Storage -35 °C 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 a solution that can depend on pH, then pH compensation is required to calculate the TOTAL ion measurement. The TOT Module determines Total ISE by using a compensation algorithm using Free ISE, pH and temperature as the primary process inputs.

Total ISE can be calculated for the following ions:

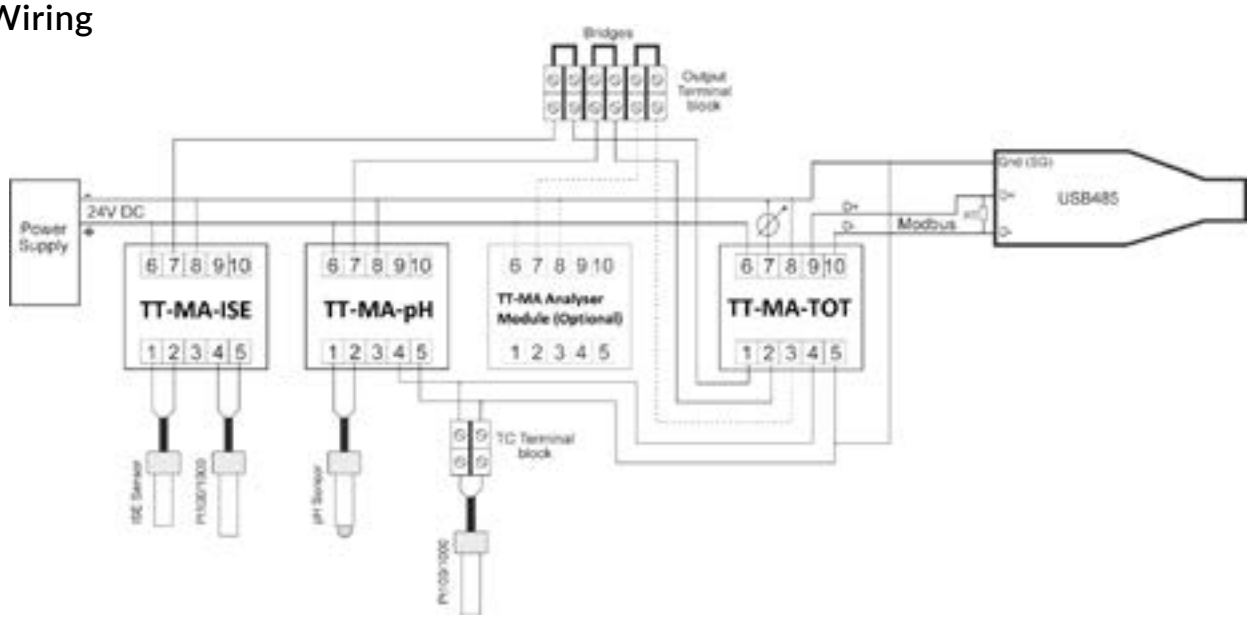
- Ammonia (NH3 + NH4+)
- Fluoride (HF + F-)
- Cyanide (HCN + CN-)
- Sulphide (HS- + S2-)

Unpacking

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

Important

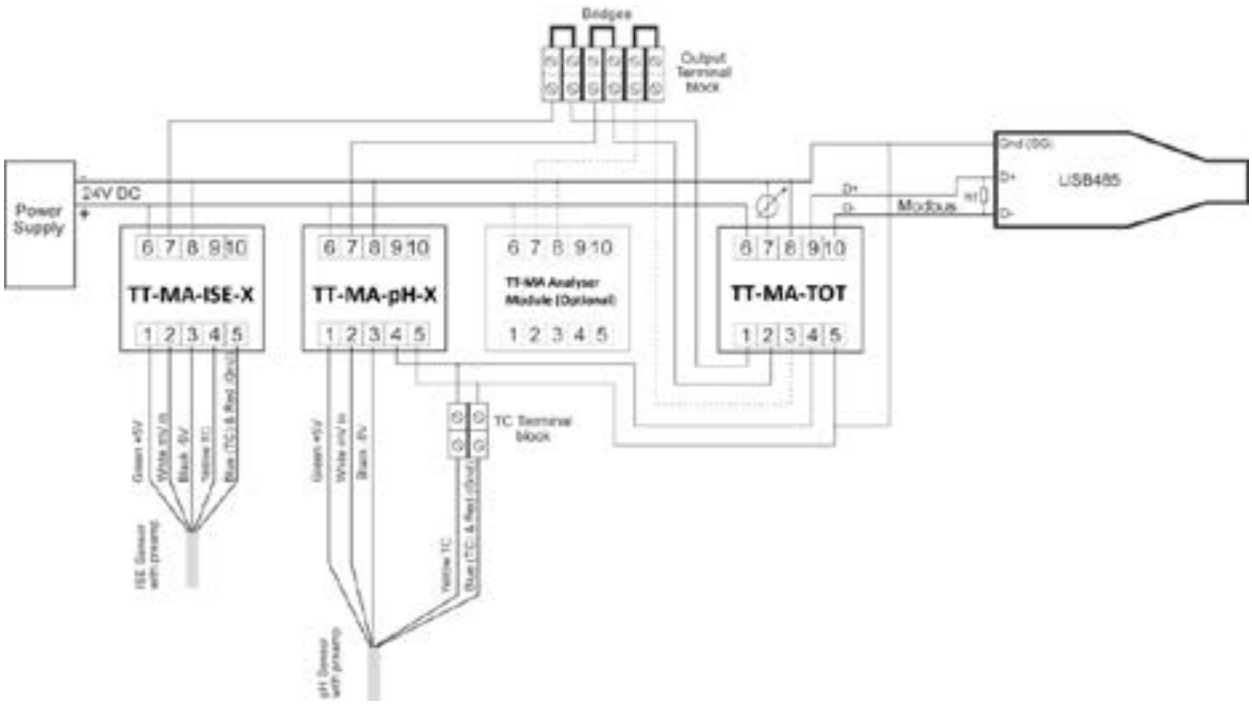
Wiring



Notes:

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

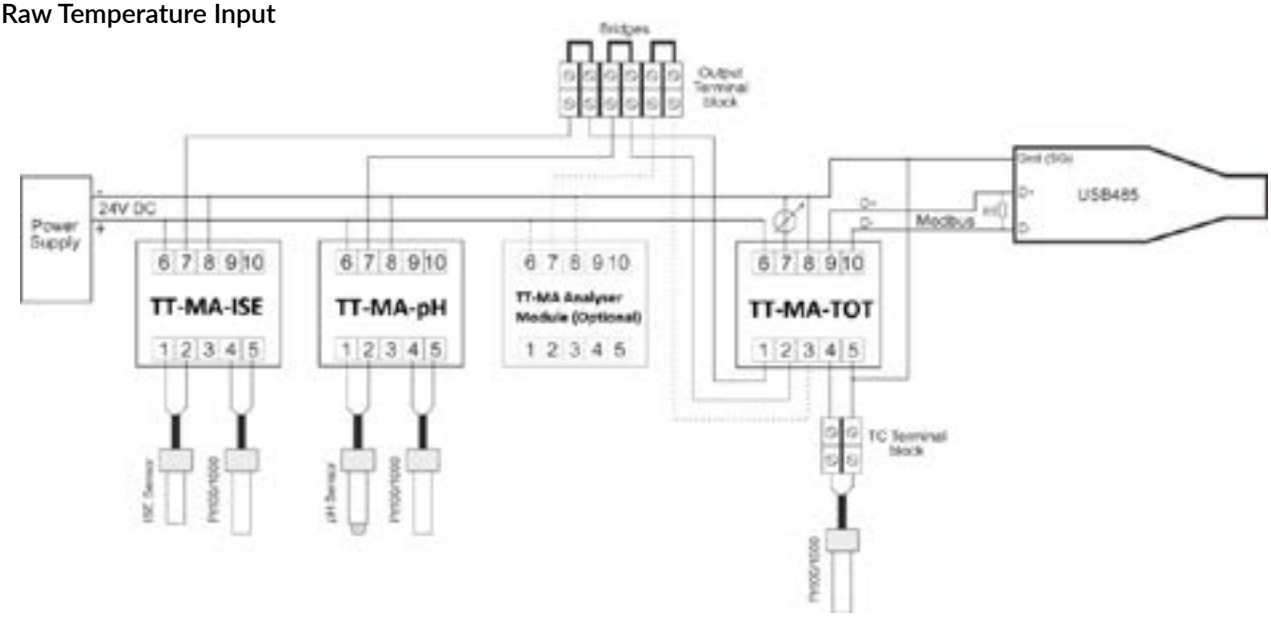
Spliced Temperature Input for Preamp ISE and pH Sensors



Notes:

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

Raw Temperature Input



Notes:

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

For additional wiring information please consult turtletoughsensors.com

Menu Navigation

The TT-MA-TOT Module 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 it with the *'Mode'* key then modify the value using the *'Up'* and *'Down'* keys.

Lock Function

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

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

Parameters Explained

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

Parameter	Description
P01	Software lock. If the software lock is set to ON the parameter can only be read. Set Software Lock to OFF to change values.
P02	Sets module's address for Modbus communication.
P03	Sets Free ISE input to be 0-20mA or 4-20mA (P08 on TT-MA-ISE).
P04	Sets Free ISE input to low, mid or high. 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 are explained below.

Datalogging Module and Modbus

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

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

SCADA System and Modbus

The baud rate (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 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 ISE ppm
Value 2 is Free ISE
Value 3 is pH
Value 4 is Temp

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

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

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

Warranty

Product Warranty

Every Turtle Tough product is thoroughly inspected and tested before leaving the factory and prior to shipping. In addition to any statutory rights and remedies you may have, Turtle Tough warrants all 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.
- The repairs are not required as a result of normal wear and tear.
- Damage caused by wear and tear, inadequate maintenance, improper installation, corrosion, or by the effects of chemical processes is excluded from this warranty coverage.

Sensor Warranty

Turtle Tough sensors are electrochemical devices and as such have a limited operating life. Life expectancy depends on the field of application such as the medium, pressure and temperature. It can vary between a number of weeks to several years. There are special cases in extreme environments where operating life will only be a few days. Characteristic and response time will also change with aging. As such electrochemical sensors are articles of consumption and are not subject to a common guarantee. Replacements or exchanges are generally excluded unless a manufacturing defect is determined to be the cause. It is not possible to predict the rate of deterioration for a particular process, nor can we provide a guarantee on sensor life because it is impossible to predict the rate of exposure, contamination and deterioration. Damage caused by wear and tear, inadequate maintenance, faulty installations, corrosion, or the effects of chemical processes is excluded from this warranty coverage. Our agents or representatives may provide you with a life expectancy guide based on similar applications we have experienced, however, this in no way constitutes a warranty of performance and is a general indicator.

Shelf Life Warranty

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

Damage to Internal Electronics

Damage to the sensor's internal electronic components is not covered under warranty. Analogue sensors with internal preamplifiers 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. Additionally, sensors containing digital RS485 boards are susceptible to damage when powered incorrectly or improperly installed. Sensors containing internal electronic boards undergo additional quality checks prior to shipment to ensure that components are 100% operational upon delivery. Ground loop and 3rd party hardware problems (including but not limited to power supplies) may also cause blown electronics or damage to the sensor components and as such faulty installations are not covered by warranty.

IMPORTANT: Ground loops, poor earthing and faulty electrical installations are a common cause of sensor damage. If you are experiencing unusual or erratic readings, please refer to our support document on ground loops.

Damage to Cables and Connectors

Please note that integral sensor cables, connectors and plugs must NOT be cut, removed or modified in any way. Sensors contain sensitive internal electronics and our cables and connectors are designed to protect the integrity of these components. Any modification or alteration to cables and connectors can compromise their integrity and will void the warranty. Always use factory-approved/manufactured cables and connectors. Additionally, the cable contains a unique identifier laminated to the cable end and this must not be removed or it will also void the warranty.

Return Goods

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

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

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

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

Support

For technical support please contact head office on +61 (0)3 9872 5055 or visit our website turtletoughsensors.com for information on sensor care, calibration, wiring and installation-related issues.

IMPORTANT INFORMATION ABOUT INTEGRATING DIRECT SMART SENSORS

Turtle Tough Direct Smart Sensors *(DSS)* are fully supported by a range of factory hardware solutions including SMART Analysers, Handheld Field Communicators, PC Communication tools and field implementation devices such as junction boxes, extensions leads and power supplies. This ecosystem provides a complete solution for reliable connectivity and sensor management.

Turtle Tough sensors may also be directly interfaced with end-user hardware via the Modbus RTU protocol. Integrating sensors directly into your industrial network requires a moderate to a high level of onsite expertise in system integration and should ONLY be undertaken by someone with the requisite experience. While direct integration provides some significant benefits, it also incurs a higher degree of risk as integrating with 3rd party hardware provides a lot of opportunities for unexpected issues to arise. 3rd party hardware includes any device or component not supplied by Turtle Tough and can include, but is not limited to, PLC's, SCADA systems, DCS's, data loggers, power supplies/isolators, or any other externally sourced interfacing device or component. We suggest you read the sensor implementation guide carefully to understand the full scope and requirement for installation, because:

1. Turtle Tough Pty Ltd and its representatives can provide only limited factory support when integrating sensors with 3rd party hardware. Unexpected behaviour or damage as the result of 3rd party hardware is not the responsibility of Turtle Tough.

2. Product support is limited to the information provided in our field implementation notes and guidelines. The product is fully supported for installation requirements, field implementation and programming protocols in direct relation to our product. It does not extend to the compatibility of our sensor with or the subsequent behaviour of third party hardware. Due to the infinite amount of third party hardware available we are unable to support issues related to 3rd party problems and it is the sole responsibility of the end-user to test and verify the compatibility of our product with their equipment.

3. Turtle Tough and its representatives are unable to provide support on 3rd party hardware or provide trouble-shooting on equipment not supplied by us. If you intend to integrate the sensor directly with your hardware, we highly recommend the following:
   - Read the Field Installation Guide and Sensor Implementation Guide. Make sure you understand the requirements and please contact us if you require clarification or further information.
   - Seek advice from your 3rd party hardware provider and make sure this equipment meets the minimum specification requirement outlined in our support documentation.
   - Purchase a handheld field communicator *(HFC)* from Turtle Tough. This stand-alone device, self-powers the sensor and provides complete diagnostics and communication. The HFC allows us to independently test and verify the sensor performance, independent of your system or hardware and is the single fastest way to rule out any sensor performance issues and be able to identify field installation problems.
   - Alternatively, you may purchase a windows PC interface box. Once again, this factory-supplied and tested component will ensure reliable communication with the sensor and it can be tested independently of your system.
   - Please note that our quick connect plugs must never be removed or modified in any way. This will immediately void the warranty. Only use Turtle Tough factory interface leads or panel mount connectors to interface with your hardware.

Frequently Asked Questions for TT-MA pH, ORP, ISE, Dissolved Oxygen & Conductivity Transmitters & controllers with application notes

1. Can I share the 24VDC power supply used to energize other instrumentation or equipment at the same installation site to also energize the TT-MA transmitters?

Absolutely not. It is altogether critical that the 24VDC power supply used to power the TT-MA transmitters is COMPLETELY separate from all other equipment. This also includes all other instrumentation as well other heavier equipment such as pumps, motors and so forth. This is because the TT-MA measurement module series is a 3-wire transmitter. The 3-wire aspect can be explained as follows: the 4-20mA analogue current loop output sent from terminal 7 returns back to terminal 8; the +24VDC is connected to terminal 6 while the ground DC common from the power supply is shared with the return of the 4-20mA scalable current loop output on terminal 8. In this way all of the ground terminal are shared between the current loop output and the DC common amongst all TT-MA measurement modules energized from a single 24VDC power supply source. There exists a 3000V opto-coupler isolation between the inputs and outputs of the TT-MA transmitter no matter the particular measurement module. The outputs are not, however, isolated from each other as the ground terminal is shared in the manner described above. Because of these reasons whatever 24VDC power supply is used to energize the TT-MA transmitters should be altogether dedicated to only power these modules only. This dedicated 24VDC power supply can either be customer supplied or using the Turtle Tough supplied TT-MA-PS module.

The 35mm DIN-RAIL mountable TT-MA-PS power supply offer a very simple and low-cost solution for the TT-MA transmitters to have their own dedicated 24VDC power supply as required. It is also quite compact being only half the width of a standard TT-MA module and 35mm DIN-RAIL mountable and so readily fitting into any of the enclosure options. When purchased as part of a complete DIN-RAIL mounted or enclosure assembled configuration, the TT-MA-PS module will be pre-wired to all of the TT-MA transmitter(s) supplied so that only the AC power input for the TT-MA-PS need to be added to have the unit(s) up and working (plus connecting the analogue and MODbus outputs as well as the sensors for input as usual).

The TT-MA-PS is a well-tested proven power supply solution at very many customer installation sites. The issue of having a dedicated 24VDC power supply for the TT-MA modules is important for both passive input measurement module types such the TT-MA-pH, TT-MA-ISE (mate with pH/ORP/ISE sensors without preamplifiers) and TT-MA-DO (mate with galvanic DO cells) as well as active input measurement module types such as the TT-MA-pH-X, TT-MA-ISE-X (mate with pH/ORP/ISE sensors with preamplifiers) and TT-MA-CON (all contacting conductivity cells). The isolation on the AC/DC transformer of the TT-MA-PS acts to isolate the 24VDC power from the rest of the electrical devices at the installation site ensuring that no such potential ground issues occur to the modules themselves nor any devices powered from the TT-MA measurement modules such as preamplifiers and contacting conductivity cells. This isolation in the TT-MA-PS also serves to ensure that no issues prevent themselves regarding ground on the analogue 4-20mA current loop output or RS485 MODbus outputs emanating from the power supply side of the system. It is still possible to have ground loop and electrical isolation issues that emanate from the process side of the system, but this is a much more complex question and larger in scope than just the TT-MA instrumentation.

The TT-MA-PS power supply has a 500mA max rating at 24VDC (12 Watts) and easily handles up to 8 each TT-MA modules with 60mA as the absolute max power consumption per TT-MA module unit. The TT-MA-PS is a universal 100 to 240 VAC 50/60 Hz power supply module. The agency approvals for the TT-MA-PS module includes CE, CSA & UL for use in safe areas. If you plan to install the TT-MA transmitters into a hazardous area please inquire Turtle Tough for special accommodations necessary to support these application and installation types.

Please see the next page for power wiring connection diagrams.

2. How do you wire up the analogue output from the TT-MA transmitter to a data acquisition or control system?

Keep in mind that all TT-MA transmitters are 3-wire devices. This means they have an ACTIVE 4-20mA analogue current loop output, like a 4-wire type device. The data acquisition or control device to which this TT-MA active 4-20mA output is connected should passively measure the current. Most PLC have a hardware or software toggle that allows you to select whether the 4-20mA received is from a 4-wire (or 3-wire) active type device or else if it is a 2-wire device which must be energized from the PLC power supply.

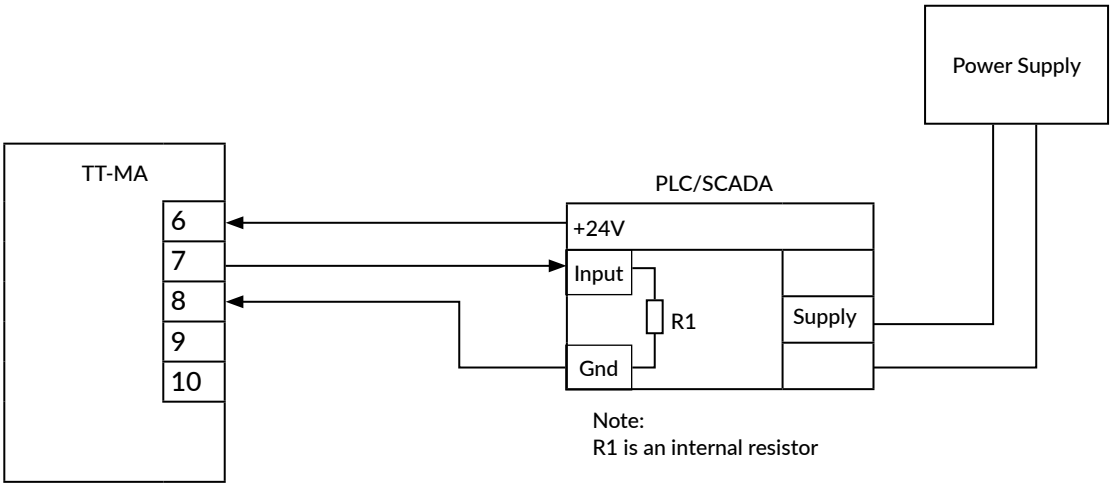
NEVER apply voltage across terminals 7 & 8 on any TT-MA transmitter! This could happen if a 3-wire type TT-MA transmitters is wired as though it were a 2-wire type devices. The result of such an improper wiring would destroy the output circuit with the damage not covered under warranty due to abuse/misuse.

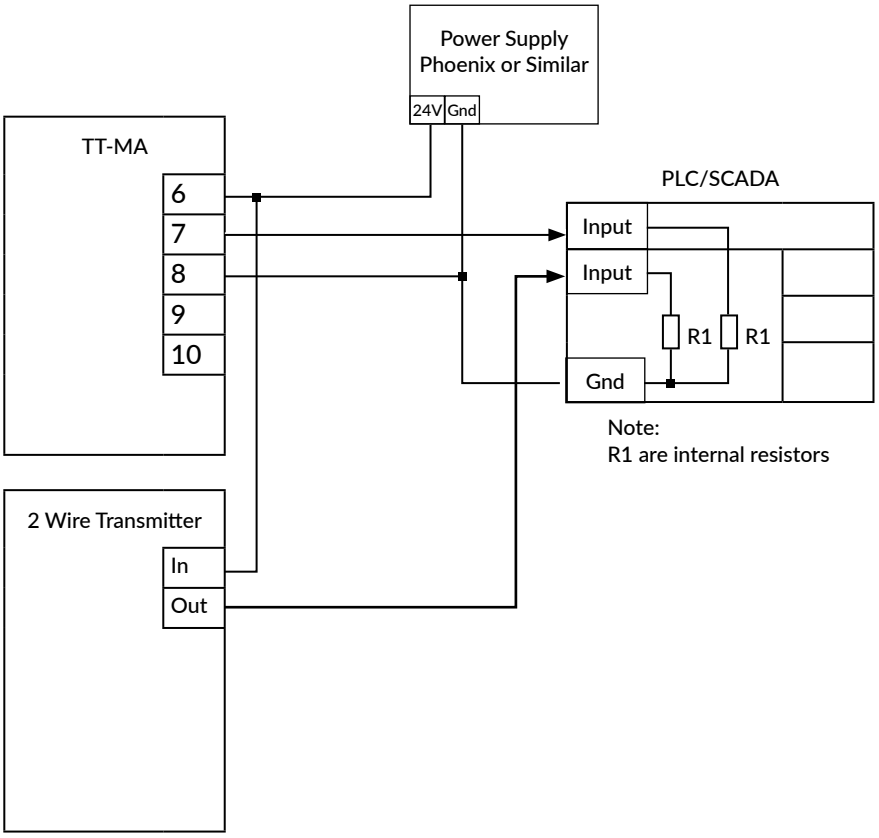
The lead providing +24VDC power always goes to terminal 6 and the 4-20mA current loop output is always sent from terminal 7. The DC common (ground) is shared as terminal 8. The current loop output is sent from terminal 7 and return to terminal 8 (ground / DC common). The TT-MA transmitters are always energized on terminal 6 with the DC ground of the 24VDC power supply (a.k.a. rail) always being the (shared) terminal 8.

3. Can I connect the output from TT-MA transmitter to non-isolated 4-20mA analogue inputs on my PLC?

No. The output from the TT-MA MUST ALWAYS be connected to isolated analogue inputs. If your PLC does not have isolated analogue inputs, then you must add an isolator for each current loop to be used. The ground cannot be shared on both the analogue current output from the TT-MA (which it is since it is a 3-wire device) and on the analogue input on the PLC. The ground for each analogue input on the PLC must then always be isolated.

Power wiring connection diagrams.





4. If I purchased a TT-MA-REL alarm/relay controller together with any of the measurement modules such as the TT-MA-pH, TT-MA-ISE, TTMA-DO or TT-MA-CON can I modify the 4-20mA output scaling set by Turtle Tough?

Yes. The output scaling for each module can be modified within the prescribed limits in the documentation. If you modify the output scaling from defaults for the TT-MA-pH, TT-MA-ISE, TT-MA-DO or TT-MA-CON modules you also need to modify the 4-20mA input scaling for the TT-MA-REL and/or TT-MA-TOT module accordingly. The 4-20mA output can be used for both connecting to the TT-MA-REL and/or the TT-MA-TOT pH compensation module as well as to other data acquisition or control devices using the bridge type wiring configuration. If you ordered your system with both a measurement module and REL controller at the time of purchase from the factory, your system will be wired as shown on the above wiring schematic.

To ensure optimal agreement between the measurement module (pH, ORP, ISE, Conductivity or Dissolved Oxygen) and the REL or TOT module to which the analogue current loop output may be bridged, it may be necessary to refine the trim calibrations. In this case it is recommended to perform the 4-20mA trim calibrations on the measurement module first with calibrated multimeter (see TT-MA transmitter documentation for the setup parameters to be adjusted). The 4-20mA trim calibration for the REL or TOT modules should be performed after the output trim calibrations have been refined on the measurement modules. When the trim calibrations are well paired, the reading should match closely. Scaling the outputs more narrowly can make
matching the values easier.

5. What does the 4mA +/- X.XX% and 20mA +/- X.XX% label on the TT-MA transmitter mean?

Prior to dispatch each TT-MA transmitter has the 4mA trim offset and 20mA trim gain calibrated for optimal analogue precision. These values may change slightly over time or due to environmental conditions. In such cases the analogue trim can be further adjusted by modifying the appropriate parameter on the transmitter for the analogue output or analogue input of interest (see the relevant instructions in the manual for that particular transmitter). If the TT-MA transmitter is reset in the field, the analogue 4mA trim offset and 20mA trim gain calibration values shown on this label will be restored from the factory calibration and any modifications to this calibration made after dispatch from the factory will be lost.

6. Why is there a serial number for each transmitter? I ordered a complete dual or triple transmitter or controller assembly. Shouldn't there be just one serial number?

Well actually not for how the modular and highly configurable TT-MA system works. Each measurement module (TT-MA-pH, TT-MA-ISE, TT-MA-DO & TT-MA-CON) or complementary module (TT-MA-REL, TT-MA-TOT & TT-MA-DAT) will have its own serial number. The complete assembly will be fabricated, prewired and calibrated as your have requested at Turtle Tough but each individual component will have its own unique traceable serial number. Unlike many other electrochemical measurement and control systems, component can be changed out, repaired or upgraded module by module and so our scheme (must) separately tracks each transmitter module. Accordingly, removing or modifying the TT-MA serial number will void your warranty on that particular module/transmitter. If no serial number exists on a unit or a label indicating "*DEMO ONLY*" exists on the transmitter then assistance will be provided on a best faith basis but no specific warranty will apply.

7. What is the sampling rate of each of the measurement modules? Is there any time averaging for the view measurement during calibration and measure modes? Can any of these settings be modified in the field?

The sampling rate for all of the measurement module is 4 Hz (4 data samples processed per second). There is time averaging (a.k.a. dampener) implemented as most appropriate for that measurement type for both calibrate and measurement modes. The time averaging can be disabled by special order units when it is desirable to measure the raw 4 Hz measurement data sample rate. In most cases, a reasonable time averaging dampener yields the best results for calibration and control purposes. The time averaging settings (in terms of the number of seconds used) is set at the factory and cannot be modified in the field. Please inquire to the factory prior to purchase regarding any questions related to the dampener settings of your TT-MA module since they can often be optimized for your use upon request at no additional charge but cannot be modified after dispatch to your location. For special applications, it is possible for Turtle Tough to supply custom configuration of the TT-MA transmitters without any dampener applied at all to see real time data at very high sampling frequency. This can be helpful for smaller pilot scale of benchtop use where these parameters can be change quite quickly as compared to larger production size systems.

8. Is there any good reason to modify the analogue output scaling from the default values for the TT-MA-pH, TT-MA-ISE and TT-MA-CON measurement transmitters?

This will really depend upon your particular data acquisition and control setup. One thing to keep in mind is that the resolution of the TTMA analogue output is fixed at 1000 steps completely independent of the scaling selected. This means that you have the same number of steps if you define your output to be the full range or a much narrower portion of that range down to the minimum scaling allowed for that module. As an example, if you have a TT-MA-CON transmitter suitable for use with a 1.0/cm cell constant you maximum full scale range would be 0-50,000 microSiemens and the minimum scaling would be 0-5,000 microSiemens. Since the output resolution is fixed independent of scaling, choosing the minimum range would give you ten times (10X) better relatively resolution in absolute microSiemens (5µS vs 50µS in this example).

As another example the full range scaling for the TT-MA-pH in the pH measurement mode is 0-14. If your application should truly only need to operate between the pH range of 4 to 11, then you relative output resolution would double by restricting it from the full range 0-14 to the more narrow 4-11 scaling since we have gone from a total of 14 pH units to only 7 pH units while the absolute output resolution is fixed. For most TT-MA measurement module the scaling can be reduced down as low as 10% or 20% of the full range. Check the relevant TT-MA transmitter specification sheet and manual to find the specific limits of your module (be sure to check revision number). Depending upon your needs it may then be advantageous to restrict the output scaling to the typical minimum and maximum operational range for that measurement point to have the highest possible resolution on the analogue output of the corresponding TT-MA module.

As discussed in the previous Question & Answer above, if you change the output scaling (and thus the\ resolution) from the measurement transmitter you will also need to be sure to change the input scaling for any mating modules (such as the TT-MA-REL or TT-MA-TOT) that use the analogue output from this measurement module. Most of the TT-MA measurement modules with the MODbus output option will follow the analogue 4-20mA scaling and the resolution is also fixed at 1000 steps by default. The MODbus protocol does allow for the possibility of much higher resolution output. One example is the TT-MA-pHE module with 20,000 steps giving\ a resolution of 0.001 in pH mode and 0.1mV units in ORP mode. As another example, the TT-MA-CON-E offers between 10,000 and 20,000 steps for the temperature compensated conductivity and 50,000 steps for the raw conductivity values giving the high possible resolution anywhere in the range for a given cell constant (see separate TT-MA-CON-E cut sheet for details). Note that the temperature is always sent as 1,000 steps no matter the TT-MA transmitter employed. Lastly, all of the measurement modules (TT-MA-pH, TT-MA-ISE, TT-MA-CON, TT-MA-DO and TT-MA-TOT) are compatible for use with the TT-MA-DAT MODbus datalogger except for the special high resolution MODbus TT-MA-pHE and TT-MA-CON-E units, although these units ARE compatible with the free of charge Windows software and most any modern MODbus PLC system.

9. The TT-MA-TOT wiring looks complicated. Will it be hard to use this total ISE measurement module?

While the documentation on the TT-MA-TOT module is exhaustive and thorough, this is primarily for the purpose to allow further customization by those that have very specific application needs. All of the wiring and configuration is performed at Turtle Tough when this module is fabricated as part of a complete total ISE measurement system. Bearing the Turtle Tough pre-configuration in mind, there is typically very few parameters (if any) that need to be changed by the most users. Normally that needs to be done is to connect the sensor inputs as shown (all other module wiring will be completed prior to dispatch).

10. Can I add Modbus to the TT-MA-pH, TT-MA-ISE, TT-MA-DO or TT-MA-CON if purchased as analogue output only units?

No. The only option if you need MODbus output for module based as analogue only units is to use a TT-MA-TOT module which can convert the analogue output to a MODbus output for selected configurations. The only other option is to purchase the identical measurement modules with the desired MODbus output and to change out the existing analogue only units installed (be they in an enclosure assembly or on a DIN-RAIL). Since the TT-MA-DAT datalogger only accepts MODbus input, if you believe that you may want to use this field measurement modules with the MODbus output in such cases.

11. Can the TT-MA-pH and TT-MA-ISE interface pH/ORP/ISE sensors with and without preamplifiers?

Yes. More specifically, the TT-MA-pH can interface pH or ORP sensors ONLY WITHOUT PREAMPLIFIERS and the TT-MA-ISE can interface ISE sensors ONLY WITHOUT PREAMPLIFIERS. Conversely, the TT-MA-pH-X can interface pH and ORP sensors ONLY WITH PREAMPLIFIERS and the TT-MA-ISE-X can interface ISE sensors ONLY WITH PREAMPLIFIERS. Note that by "ONLY WITH PREAMPLIFIERS" this can mean either that the sensor itself has an integral preamplifier or else that a sensor without an integral preamplifier is bridged across an external preamplifier (see separate documentation for mini external preamplifier option). Note that the two types of pH/ORP transmitters (TT-MA-pH & TT-MA-pH-X) and ion selective transmitters (TT-MA-ISE & TT-MA-ISE-X) are altogether different hardware versions and so are not interchangeable in the field. The decision regarding whether you plan to use a pH/ORP/ISE sensor with or without a preamplifier will need to be known prior to purchasing any pH/ORP or ISE measurement system using TT-MA transmitters so that the suitable type of pH/ORP/ISE transmitter can be selected. In particular be sure to know the precise cable lengths needed prior to any commissioning for new installation sites and to double-check the required cable lengths for any existing locations. In the case that you wish to have the flexibility to support long cable runs and/or to the benefit or noise rejection from the process equipment by using an integral or external preamplifier, you can always choose to purchase the preamplifier style (TT-MA-pH-X & TT-MA-ISE-X). The pricing is identical for both hardware versions as all software and functionality is also perfectly identical. Lastly, note that only pH/ORP/ISE sensors with integral preamplifiers can be supplied with quick disconnect terminations (see separate write-up on this option if this feature is desired). Note that the quick disconnect option must be chosen at time of order.

12. Can I change the ion to be measured on the TT-MA-ISE or TT-MA-ISE-X ion selective transmitter?

In the field the answer is no. Turtle Tough can modify the programming so that your TT-MA-ISE or TT-MA-ISE-X can measure any ion that you wish. This modification of the ion configuration, however, cannot be performed in the field. This restriction is well considered trade-off. While some potential inconvenience exists from needing to send the TT-MA-ISE or TT-MA-ISE-X transmitter back to Turtle Tough to be reconfigured for another ion selective measurement, this limitation is far outweighed by making it such that the transmitter cannot be accidentally misconfigured in the field. In addition, custom OEM configurations allow for user defined default values for all parameters so that the software reset can yield exactly the desired configuration in the field (minimum order quantities apply to be eligible for the free of charge Custom OEM configuration feature).

13. Can I change the contacting conductivity cell constant for which the TT-MA-CON is to be used?

In the field, the answer is no. Careful attention should be paid to the expected minimum, typical and maximum conductivity values for the planned measurement type. The most optimal cell constant to be employed and associated supported ranges are then defined in conjunction with the factory on the basis of this information. A cell constant and range selection guide is available upon request as a good initial guide. Prior to purchase and final specification of equipment, it is always best practice to contact the factory for an official recommendation. In many cases multiple transmitter configurations are available for the same cell constant or range and the best choice is often depend upon a variety of factors considered in totality.

14. How do you access the buttons & terminals when TT-MA modules are installed in a 2M(W), 4M(W) or 6M(W) IP65 rated enclosures or else the 3MP, 3MF, 7MF & 9MF NEMA 4X rated enclosures?

To access the three buttons for calibration and configuration of all TT-MA transmitters with the 2M(W), 4M(W), 6M(W) enclosures only the clear window need be released (the top shell can stay in place). To access the terminals on the 2M(W), 4M(W) & 6M(W) type IP65 rated enclosures you must open the clear plastic window and also remove the four screws that hold the top shell of the enclosure assembly to the bottom shell. For the 3MP (NEMA 4X ½-DIN panel mount) and 3MF, 7MF & 9MF (NEMA 4X CSA/UL rated field mount style) enclosures only the latches need to be released to access all of the internal wiring as well as accessing the terminal buttons themselves. For all enclosure types the necessary cables should be securely installed through the cable gland sealing strain reliefs and secured tightly to prevent intrusion. Unused cable glands should have the factory supplied sealing caps secured to ensure weatherproof and waterproof operation. Enclosure ratings are only valid when the unit is completely closed and cables have been properly installed.

15. Can the TT-MA systems be setup such that the top shell does not have to be removed when replacing sensors? Can sensors be changed out without having to pull the sensor cables into the enclosure each time?

Yes. For the galvanic dissolved oxygen sensors that mate with the TT-MA-DO and the contacting conductivity sensors that mate with the TT-MA-CON the sensor terminations can be bridged across ordinary good-quality terminal strips provided that such bridging is done in a waterproof J-Box assembly. For the pH/ORP/ISE measurements the terminations can only be bridged when using the preamplifier style version of the pH & ISE transmitters (TT-MA-pH-X and TT-MA-ISE-X) in combination with either an external preamplifier in a waterproof JBox assembly (a.k.a. Mini External Preamplifier) or else a pH/ORP/ISE sensor with an integral preamplifier (optionally available with quick disconnect terminations). The preamplified extension cable from the waterproof J-Box bridge in such a pH/ORP/ISE measurement installation scheme is then permanently connected to the TT-MA-pH-X or TT-MA-ISE-X transmitters inside their separate enclosure assembly. All common functionality such as calibration, configuration and simply viewing the process parameters is possible without removing the top-shell of the IP65 rated enclosures.

16. How can I determine the documentation and software revision of the TT-MA transmitter?

The documentation revision of the transmitter can be found in small font at the end of the small label located above the faceplate. For example, this small label might show as "TT-MA-pH-A R9". This means that is a pH/ORP transmitter for use with sensors without integral preamplifier and the documentation revision R9 should be used. The most current documentation revision is posted on the TT-MA website. Documentation for older versions and special software implementations are available upon request (and were supplied in hard copy with the original shipment). The software revision can be obtained as a display feature of the transmitter by pressing the "*Up*" & "*Mode*" keys simultaneously in the main TT-MA measurement mode.

Special note about documentation & software revisions:
The documentation and software revision numbering is altogether decoupled although these two can be cross-referenced by contacting Turtle Tough. You may be asked to report the both the documentation and software revision of the transmitter as part of the technical support process.

17. I set the P01 software to 'Off' but I keep getting lock out of performing calibrations and changing values on the setup parameters. How long is the software lock 'Off' until it resets back to the default 'On' condition?

The P01 software lock will revert to the default 'On' value after 60 seconds without any key being pressed. This software lock is reset back to the default 'On' condition to ensure that changes are not accidentally made to any calibration or setup parameters.

18. I am seeing a flashing "OFL" or "UFL" on my TT-MA transmitter. What does this mean?

The flashing "OFL" means that an overflow issue exists on the input while a flashing "UFL" means that an underflow issue exists on the input. When this error exists you will not be able to perform any programming or configuration of the transmitter until the issue is resolved. The "OFL" or "UFL" condition can be due to a variety of possible causes which are summarized below:

<u>Potential Temperature Input Related Problems:</u>

- A temperature element is not properly connected to the transmitter input board. Most electrochemical transmitters require a valid temperature input in order to operate properly, and this general rule is also true for the TT-MA transmitter.
  - o Check that each of leads are firmly connected to the proper terminals per the wiring schematic.
  - o If no sensor is available or the sensor employed does not have a temperature compensation element, please use a 110 Ohm axial resistor to simulate a P100 TC input @ 25°C or a 1100 Ohm axial resistor to simulate a Pt1000TC input at 25°C.
  - o Even when using manual temperature compensation mode it is best practice to employ a simulation resistor on the TT-MA
  - o transmitter. Such a simulation resistor can be supplied free of charge from the factory if requested prior to dispatch of the order.

- Check the transmitter setting for the Pt100/Pt1000 TC type matches the temperature element in sensor.

Potential signal input related problems:

- The input signal value obtained from the connected sensor exceeds the lower or upper boundary limits possible for the input circuit. There are a variety of potential causes itemized below:
  - Confirm the type of sensor is being connected matches the mating transmitter. There are a wide variety of TT-MA transmitters that interface with broad range of sensor types. For example:
    - The TT-MA pH and ISE transmitters come in separate versions that are for use with sensors without integral preamplifiers (TT-MA-pH and TT-MA-ISE) or else that will only work with pH and ISE sensors that have integral preamplifiers (TT-MA-pH-X and TT-MA-ISE-X).
    - The conductivity sensor employed must be connected to a TT-MA-CON transmitter for use with that given cell constant. Confirm by checking labels on your conductivity sensor and the TT-MA-CON conductivity transmitter to ensure that the cell constants match.
  - Leads are not secure or the colour coding is not correct. Please refer to the documentation supplied in hard copy with your shipment or the TT-MA website for assistance with obtaining proper wiring schematic. If you are not sure please contact Turtle Tough factory for assistance.
  - The connected sensor is either damaged or expired. Connect a different known working sensor on the same transmitter as a troubleshooting step to determine if the issue is with the input board in question or whether it is owing to the connected sensor.

  If you have gone through all of the troubleshooting steps detailed above and are still receiving the 'OFL' or 'UFL' error then most likely your input board has stopped working properly. Contact the factory to obtain a valid RMA so that the transmitter in question can be returned for evaluation and warranty repaired/replaced as may be applicable. You will need the 11 digit serial number that can be found in the small label below the faceplate when making an RMA request.

19. How can I determine the production date and dispatch date of the TT-MA transmitter?

The production date formatted as (yy.m) is displayed by pressing the '*Down*' and '*Mode*' key simultaneously in main TT-MA measurement mode. The month shows as 1..9 and A for October, B for November and C for December. For example October 2014 will display as '14.A'. The dispatch date from Turtle Tough can be determined from the small label showing the 11 digit numeric serial number located below the faceplate. This serial number label should not be removed or adulterated in any way or else the warranty might be voided.

Special note about production and dispatch dates:
The production and dispatch dates are altogether decoupled. The two-year warranty period shall begin from the dispatch date and not the production date. You may be asked to report the both the production date and serial number of the transmitter as part of the technical support process.