TURTLE TOUGH®

MANUAL

SMART DIGITAL SUSPENDED SOLIDS SENSOR

+ TSS

turtletoughsensors.com

Chapter 1. Introduction

1.1 | Product Overview

The digital Total Suspended Solids (TSS) is a used to detect the presence of suspended solid particles in a fluid. The sensor utilises infrared scattered light technology to measure the intensity of scattered light in a solution. The value of scattered light is proportional to the number of suspended solids within the solution. The product is widely used in the monitoring of suspended solids/sludge concentration in sewage plants, waterworks, water stations, surface water, aquaculture, industry, and other fields.

The sensor can come with an automatic cleaning brush to wipe away debris during operation.

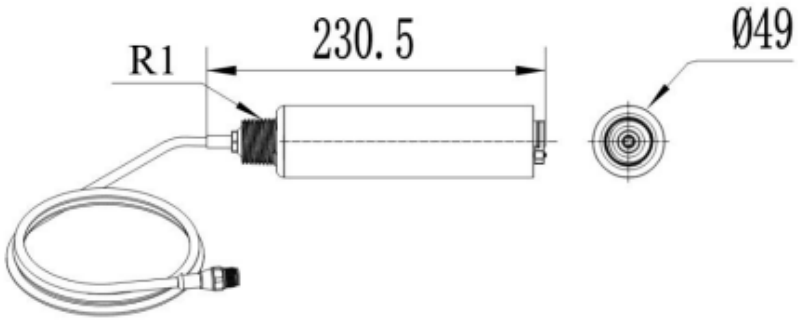
1.2 | Product Specifications

Specification	Value	Unit
Measurement Range (Customisable)	**Standard Range:** 0.01 - 50,000 **Low Range:** 0.01 - 20,000 **High Range:** 0.01 - 120,000	mg/L
Dual Beam Measurement Accuracy	±5% of Measured Reading or ±10mg/L. Whichever is greater.	
Single Beam Measurement Accuracy	±10% of Measured Reading or ±10mg/L. Whichever is greater.	
Repeatability	±3%	
Resolution	0.1 or 1, Depending on measurement range	mg/L
Pressure Range	≤ 0.2	MPa
Main Material	**Body:** SUS316L **Cover:** PPS+ Glass Fibre **Cable:** PUR	
Power Supply	9~36	VDC
Communication Protocol	Modbus RS485	
Modbus Baud Rate	19200	
Modbus Data Bits	8	
Modbus Parity	Even	
Modbus Stop Bit	1	
Storage Temperature	-15~50	℃
Measuring Temperature	0-45 (Non-Freezing)	℃
Weight	0.8	Kg
Protective Rate	IP68 / NEMA6P	
Cable Length	Standard: 10m. Maximum: 100m	

1.3 | Product Dimensions

SUS316L/Titanium alloy external dimension

With automatic cleaning device:



No automatic cleaning device:

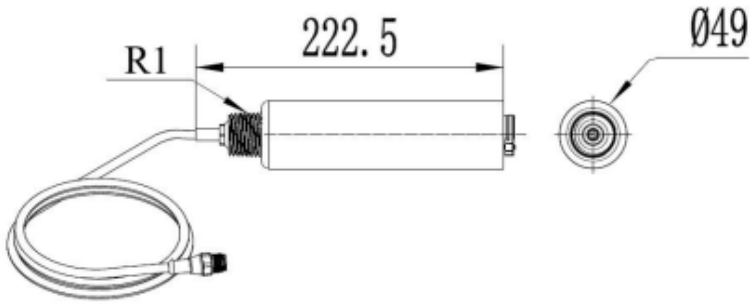


Figure 1: Dimensional Diagram of TSS Sensor

1.4 | Sensor Installation Example Methods

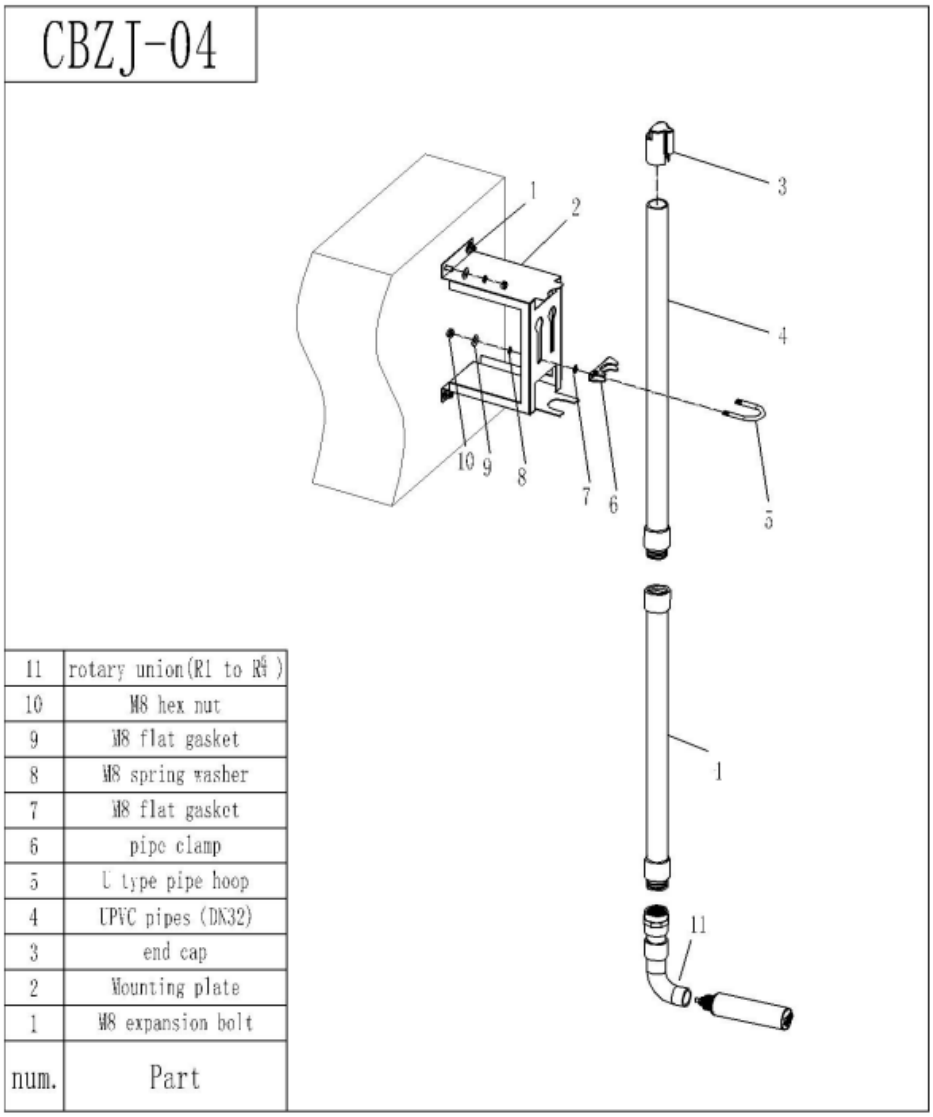


Figure 2: Quick-Dismantling Pool-side Installation of TSS Sensor

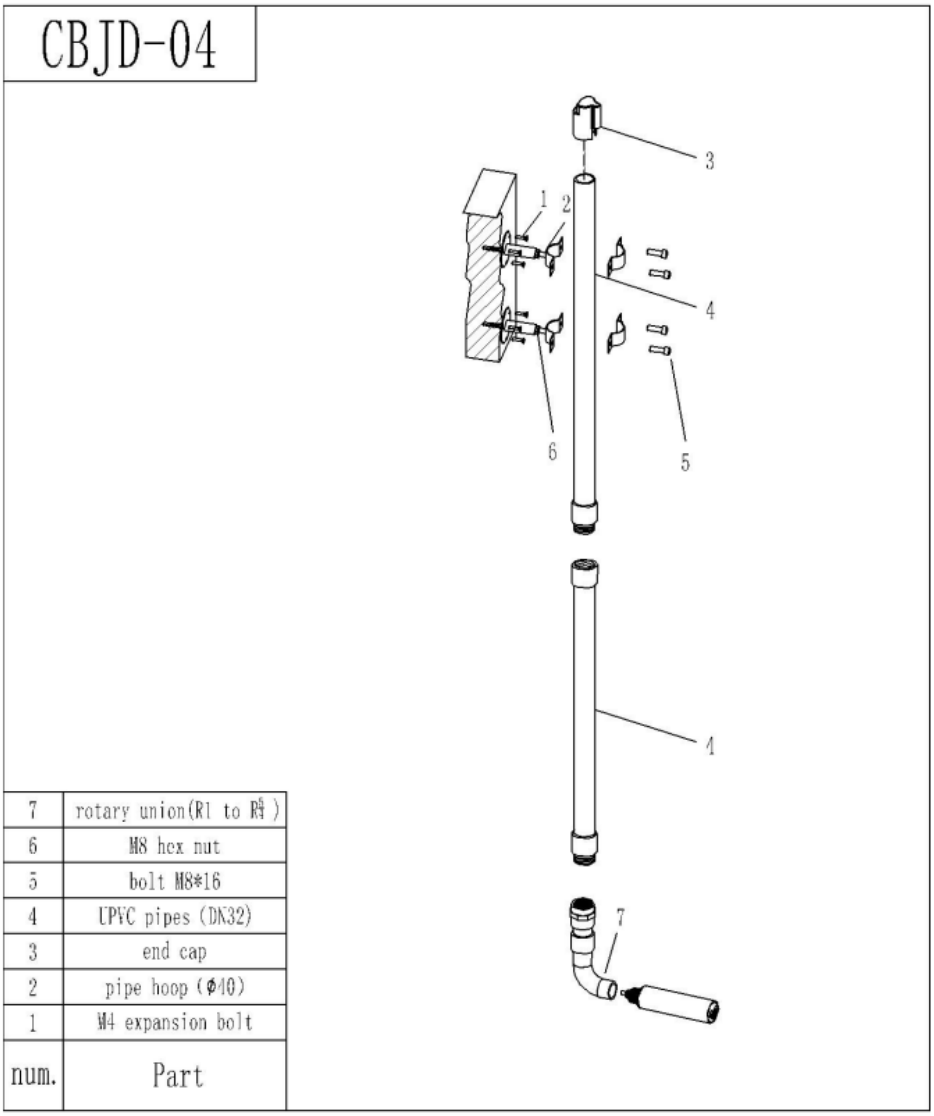


Figure 3: Classic Pool-side Installation of TSS Sensor

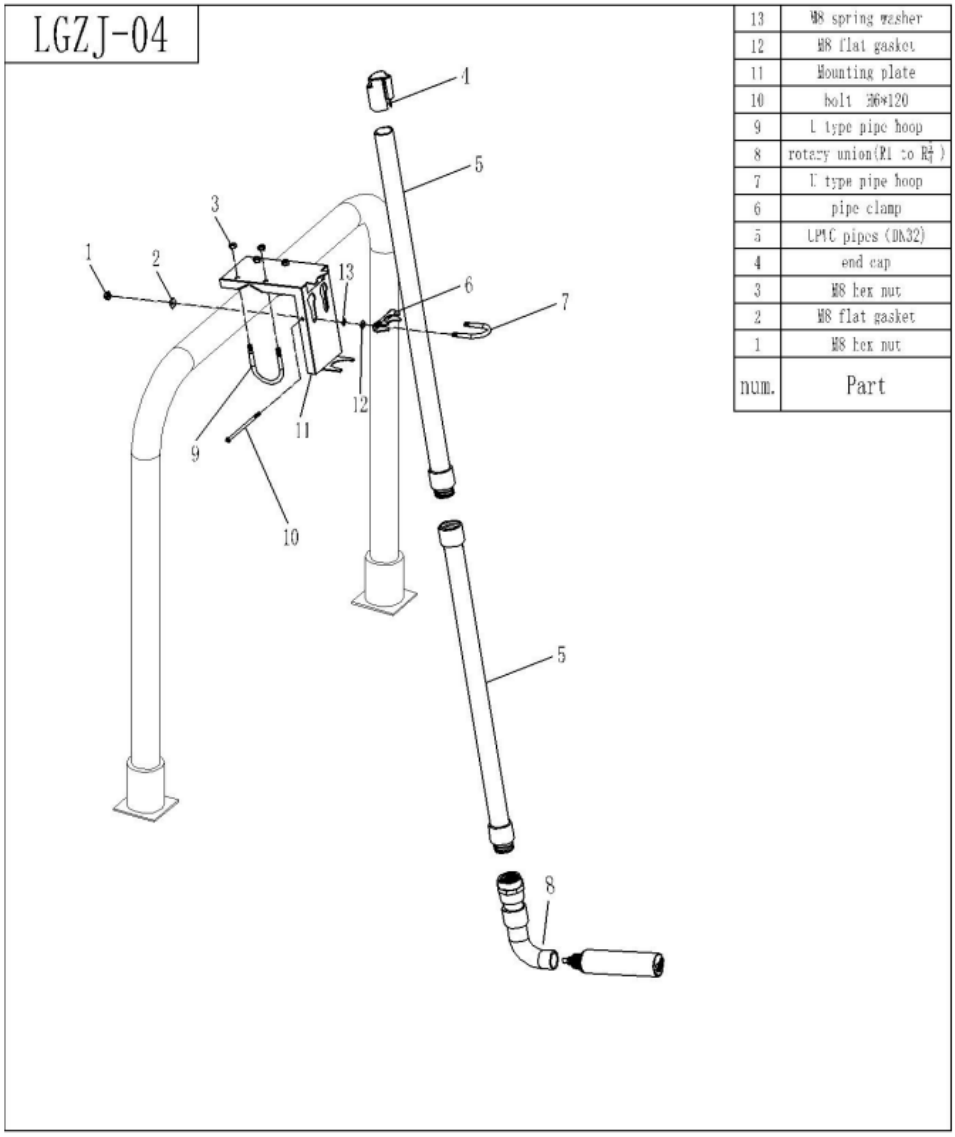


Figure 2: Railing Installation of TSS Sensor

Chapter 2. Digital Operation

2.1 | Sensor Connection

The Turbidity sensor should be connected using the following terminations:

#	1	2	3	4	5
Cable Colour	Red/Brown	Black	Blue	White	Yellow + Green
Signal	+12VDC	AGND	RS485 +	RS485 -	GND

2.2 | Modbus Communication Settings

By default, this sensor has the following Modbus communication settings. These settings can be modified by writing values to their respective holding registers on the sensor. See the Modbus register table for more information.

MODBUS-RTU Default Settings	
Baud-Rate	19,200
Data-Bits	8
Parity	Even
Stop Bit	1
Node Address	10

2.3 | Reading and Writing Values

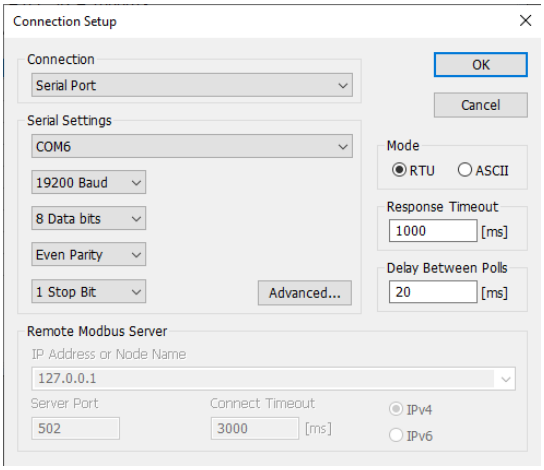
Note: *The turbidity sensor stores values in its registers as either a 16-bit integer or an in the IEEE754 32-bit floating point format. In applications such as Modbus Poll, a readable number can be gathered from the Modbus registers by changing the format to "Little-Endian Byte Swapped" or "Float CDAB". In software terms, this means when reading a value, two registers must be combined in the order Register 2; Register 1 such that it creates a single 32-bit value. This value must then be converted to binary and read as an IEEE745.*

Register #	***Hexadecimal***	***Binary***
Register 1	*40 20*	*0100 0000 0010 0000*
Register 2	*23 45*	*0010 0011 0100 0101*
Combined	*23 45 40 20*	*0010 0011 0100 0101 0100 0000 0010 0000*
IEEE754 Float	*1.06929703959e-17*	

Any Modbus software must be designed to be able to handle the complexities of converting a set of two registers into IEEE754 format. The method for converting from a 32-bit binary number to a 32-bit float can be found here: http://mathcenter.oxford.emory.edu/site/cs170/ieee754/.

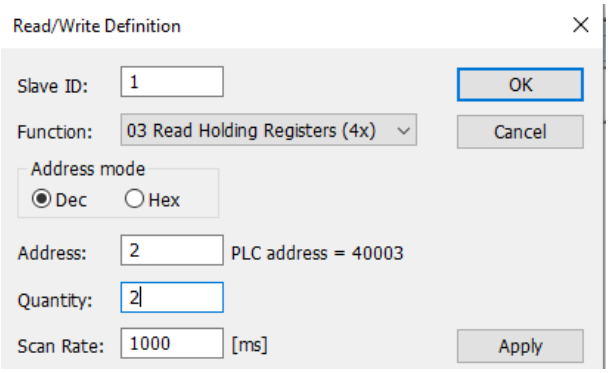
2.3.1 | Reading Values Using Modbus Poll:

The third-party program “Modbus Poll” can be used to diagnose and set up the sensor. It is the simplest method of communication to the Turbidity Sensor and shall be used in this document for demonstration purposes. To begin, connect the sensor to a PC using a Turtle Tough Windows Interface Box. Once connected open Modbus Poll and connect to the sensor using the following settings: 19200 Baud Rate, 8 Data Bits, Even Parity and 1 Stop Bits. Ensure the correct COM port is selected.

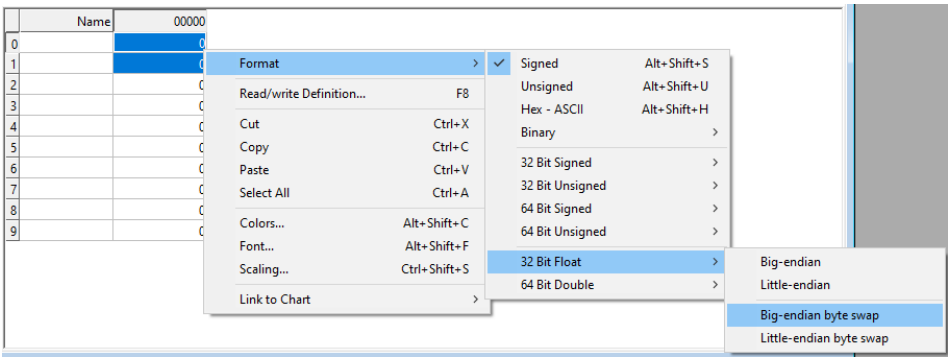


2.3.2 | Reading the TSS value using Modbus Poll:

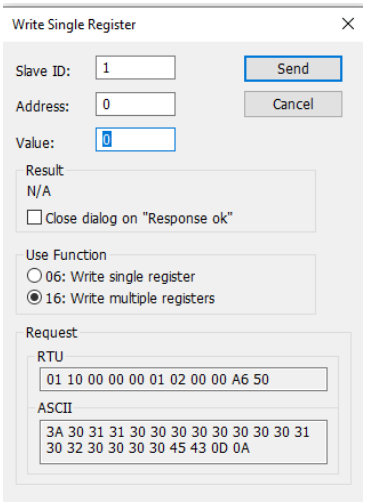
1) In the menu at the top of the application, select “Setup” then “Read/Write Definitions”.
2) In the menu set the following parameters:
    - Slave Address = 1 (or whatever the slave address of your sensor is).
    - Function = “03 Read Holding Registers”.
    - Address = 2
    - Quantity = 2.



3) This will read the first two holding registers on the sensor. These holding registers contain a 32-bit floating point representation of the TSS value stored in the IEEE754 format (see above). To convert the IEEE754 to a single floating-point number, select the two registers then right-click them and navigate to Format -> 32 Bit Float -> Little-endian byte swap. This will combine the two registers and display the TSS value.



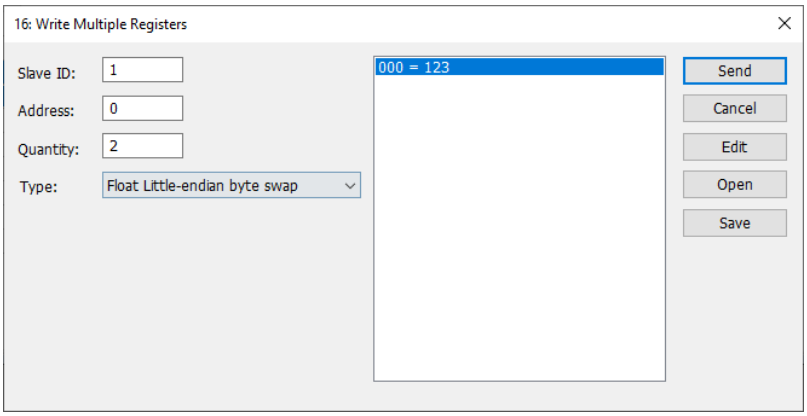
2.3.3 | Writing a 16-bit integer using Modbus Poll



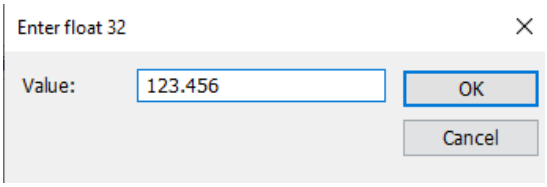
1) In Modbus Poll, press the "06" button in the header menu.
2) In the menu enter the following parameters:
    - **Slave ID:** 1 (or the node address of your sensor)
    - **Address:** The address you are changing (See Modbus Table Below)
    - **Value:** The Value you are changing the register to.
    - **Use Function:** "16: Write Multiple Registers"
3) Press "Send"

2.3.4 | Writing an IEEE754 32-bit float using Modbus Poll.

4) In Modbus Poll, press the "16" button in the header menu.
5) In the menu enter the following parameters:
    - **Slave ID:** 1 (or the node address of your sensor)
    - **Address:** The address you are changing (See Modbus Table Below)
    - **Quantity:** 2
    - **Type:** "Float Little-Endian byte swap"



3) In the box on the right double click the register displayed.
4) Enter the floating-point value that you want the register to have then press "OK".



5) Press "Send".

2.4 | Modbus Register Table

Register Name	Address	Read / Write	Data Type	Range	Unit	Description
TSS Value	2	Read	IEEE754	0~50000	NTU	Stores the currently read TSS value.
Brushing Time	11	Read	16-Bit Integer	15/ 30/ 60/ 240/ 720/ 1440/ 4320/ 10080	Minutes	The amount of time between automatic brushing of the lens.
Parameter	13	Read	16-Bit Integer	1 or 2	Seconds	1 is Turbidity, 2 is TSS. This value should always be 2/
Probe Humidity	14	Read	16-Bit Integer	1		Should be less than 10 (10 Indicates the sensor has been flooded)
Baud Rate	16	Read & Write	16-Bit Integer	0 = 4800 1 = 9600 2 = 19200 3 = 38400		Baud Rate of the sensor. Should be 2 by default.
Node Address	17	Read & Write	16-Bit Integer	1		The Modbus node address of the sensor. By default, will be 1.
Serial No. 1	18	Read	16-Bit Integer	-		First 4 numbers of the serial number
Serial No. 2	19	Read	16-Bit Integer	-		Middle 4 numbers of the serial number
Manual Brushing Order	20	Write	16-Bit Integer	66		Send 66 to manually activate the sensor cleaning brush.
Automatic Brushing Time	21	Read & Write	16-Bit Integer	15/ 30/ 60/ 240/ 720/ 1440/ 4320/ 10080	Minutes	Use this register to write the amount of time between automatic brushings.
Calibration						
Factor Calibration						
TSS Factor	6	Read & Write	IEEE754	0.1 ~ 10		**Send:** Standard Solution Value / Read Value
Two/Four Point Calibration						
Calibration Mode	27	Read & Write	16-Bit Integer	**2:** 2 Point Calibration **3:** Four-Point Calibration		**Send 2** to enter 2-point calibration mode. **Send 3** to enter 3-point calibration mode.
Set Calibration Point	28	Read & Write	16-Bit Integer	**1:** First Point **2:** Second Point **3:** Third Point **4:** Fourth Point		Send to signify the sensor is ready to calibrate the given point
Set Standard Solution Value	20	Read & Write	IEEE754	0-50000	TSS	Send Target Value
Set Actual Solution Value	22	Read & Write	IEEE754	0-50000	TSS	Send Actual Value

Chapter 3. Calibration

Notes:

1. Ensure that the probe lens is 15cm away from the bottom of the container during calibration.
2. Ensure that there are no air bubbles at the front end of the lens during calibration.
3. When correcting, it is recommended that the calibration cup be protected from light.

3.1 | Factor Calibration

The TSS sensor has been calibrated at the factory. If a self-calibration is needed, it can be carried out using either factor or multi-point calibration modes. Factor calibration is a simple way to calibrate the sensor by multiplying the non-engineered sensor reading by a coefficient "*factor*" to create a more accurate engineered value.

If there is a large deviation between the measured value and a standard value, the slope of the calibration curve can be corrected using factor calibration using the following method:

1) Connect the sensor to a PC and set up Modbus Poll (as explained above)
2) Slowly immerse the sensor into the TSS standard solution
3) Calculate the correction factor using the formula:

$$Factor = \frac{TSS\ Standard\ Value}{Measured\ Value}$$

4) Write the calculated factor to address 6 & 7 using the IEEE754 method (as shown above):

3.2 | Multi-Point Calibration

In situations where increased levels of accuracy are needed, a multi-point calibration can be performed. The method to perform this calibration is:

1) Connect the sensor to a PC and set up Modbus Poll (as explained above)
2) Enter 2-point calibration mode by writing 2 to address 27 OR enter 4-point calibration mode by writing 3 to address 27.

If performing a 2-point OR 4-point calibration:

3) Immerse the sensor into the first calibration standard solution.
4) Write 1 to address 28 to prepare the first point.
5) Write the standard solution value to address 20 (in IEEE754 format)
6) Write the measured value to address 22 (in IEEE754 format)

7) Immerse the sensor into a second calibration standard solution.
8) Write 2 to address 28 to prepare the second point.
9) Write the standard solution value to address 20 (in IEEE754 format)
10) Write the measured value to address 22 (in IEEE754 format)

If performing a 4-point calibration:

11) Immerse the sensor into a third calibration standard solution.
12) Write 3 to address 28 to prepare the third point.
13) Write the standard solution value to address 20 (in IEEE754 format)
14) Write the measured value to address 22 (in IEEE754 format)

15) Immerse the sensor into the fourth calibration standard solution.
16) Write 4 to address 28 to prepare the fourth point.
17) Write the standard solution value to address 20 (in IEEE754 format)
18) Write the measured value to address 22 (in IEEE754 format)

Chapter 4. Maintenance

To get the most accurate measurement results the sensor must undergo regular maintenance including sensor cleaning and inspection for damage.

4.1 | Sensor Cleaning

Two lenses on the sensor need to be cleaned. Please perform regular cleaning and maintenance according to the actual use to ensure the accuracy of the measurement. Rinse with water before cleaning, then wipe with detergent and a rag to remove stubborn stains.

4.2 | WARNING: Handling the Brush

The brush that cleans the sensor tip is driven by a motor, as such, it must never be moved by hand. Doing so will damage the sensor.

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 common causes of sensor damage. If you are experiencing unusual or erratic readings, please refer to our support document on ground loops.

5.5 | 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.

5.6 | 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.

5.7 | Support

For technical support 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.

Chapter 5. Warranty, Return Goods & Support

5.1 | 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 being involved in an accident.
- The repairs are not required because 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.

5.2 | 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 from several weeks to several years. There are special cases in extreme environments where operating life will only be a few days. Characteristics 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.

5.3 | 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.

5.4 | 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