- Modbus sensor addendum – Rev 6 – 1/25/19

Introduction

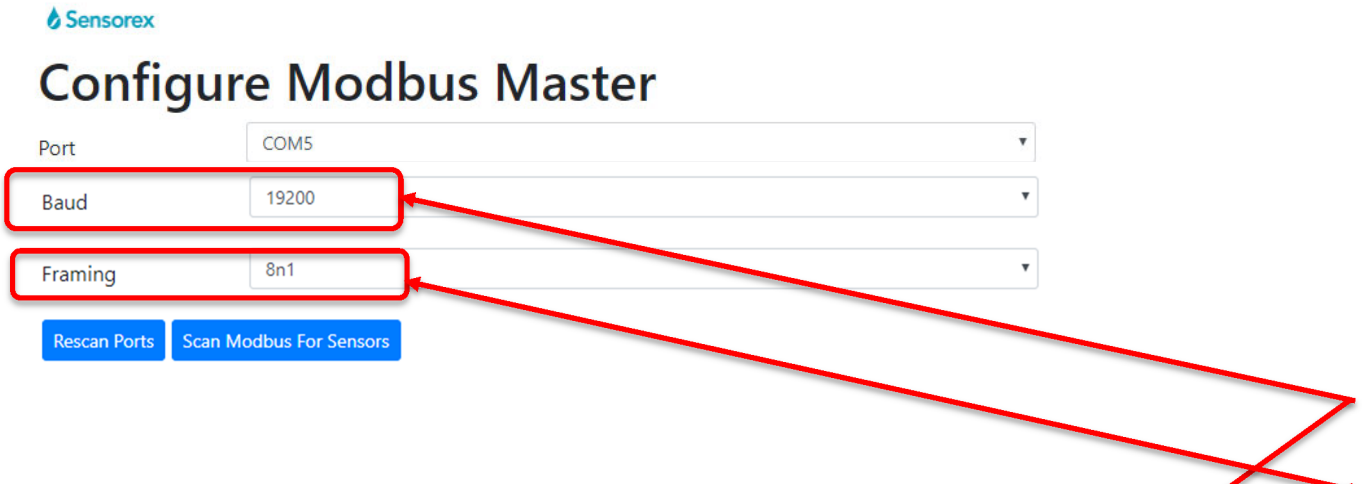
Thank you for purchasing Sensorex Modbus water quality sensors. This instruction manual is an addendum to all product instructions that only covers calibration and programming of the Sensorex Modbus RTU output sensors. For care, use and cleaning please refer to the original sensor manual included in the product box.

Calibration

For ease of calibration and configuration, your Sensorex Modbus RTU smart sensor will be calibrated via your computer using Sensorex's software. Modular sensor Series S8000 and CS8000 for pH, ORP and Conductivity (EM802-pH-MB, EM802-ORP-MB, EM802-EC-MB) will have a cable assembly with a Modbus to USB converter (model S857) that will directly connect to your computer. To download the software go to : https://sensorex.com/smart-sensor-downloads/ Download file = "***Download Smart Sensor Setup***". Open the zip file folder then double click on "***Setup***" and follow install prompts. For all other Sensorex models, **CALBOX-MB** is required. You will connect the 4 wires from your sensor to terminals on the CALBOX-MB as shown below:

Wire Color	Function	Description
Red	V+	+20VDC
Black	V -	Ground Connection
White	A+	Modbus A Connection
Green	B-	Modbus B Connection

After software is installed you will open **Launch_Sensorex_Server**. A prompt screen will open. Leave the prompt screen open and then open **Google Chrome or Firefox**. In the URL type "**localhost:5000"** then **ENTER**. The software screen below will then be seen and you are ready to use the software.

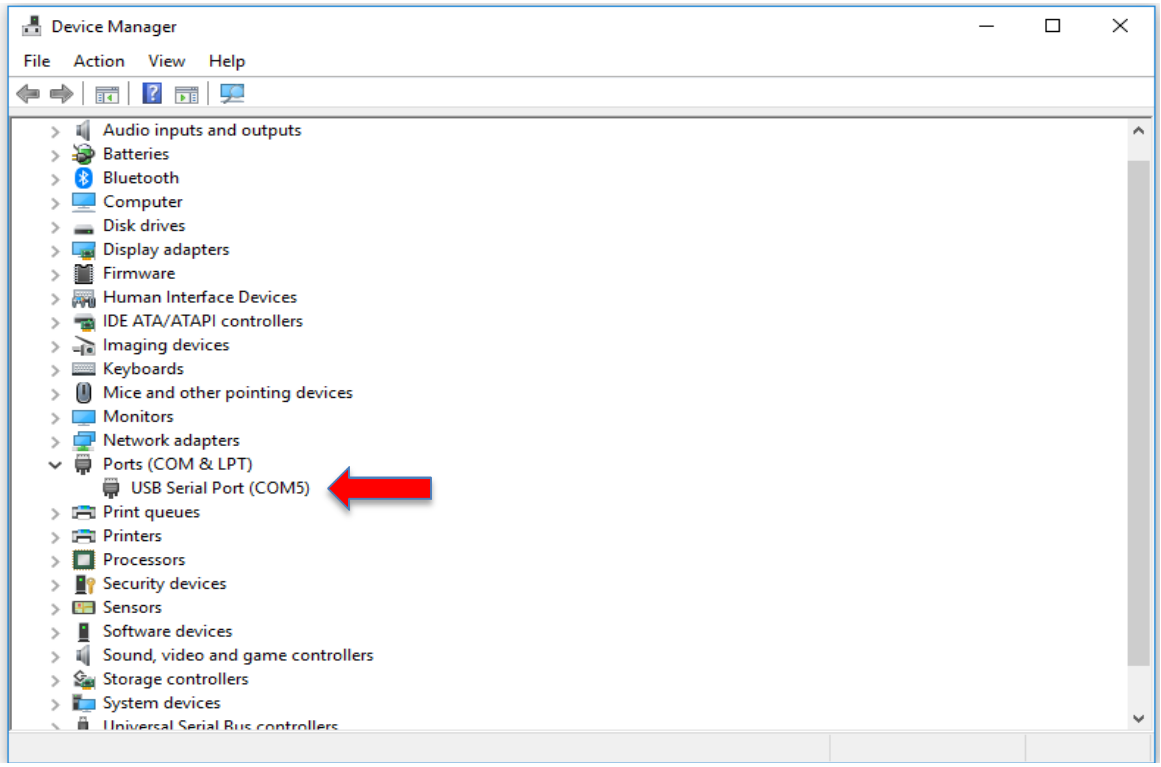


This is the initial screen you will see when the *Sensor Control* program is started. It allows you to configure your computer (the Modbus Master) to communicate with the Modbus sensor connected via the Sensorex Calibration Box(CALBOX-MB) or the S857 Modbus Cable.

- The available COM Ports are listed and can be selected from a pull-down menu.
- The Baud rate can be selected from a pull-down menu. **Default is 19200**.
- The Serial Framing can be selected from a pull-down menu. **Default is 8N1.**
- Pressing the **Rescan Ports** button will refresh the available COM ports on your computer.
- Pressing the **Scan Modbus for Sensors** button will search for Modbus sensors connected to the computer. This is useful if you have removed, added, or changed the sensor connected. See next page.

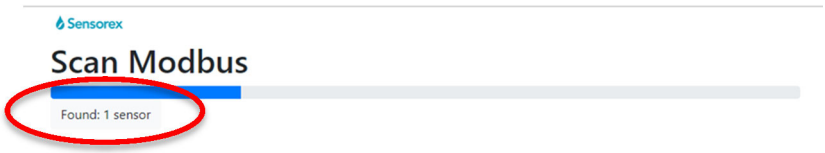
Note: The settings above are for your computer, and not the sensor.

If you are not sure which COM ports are available, go to Settings and Device Manager in your computer, look under "Ports (COM & LPT)" for available COM ports. See below. The Modbus Calibration Box or S857 Cable should appear as a "USB Serial Port". If several appear, you can unplug/plug the cable from your USB port to identify the correct COM port.

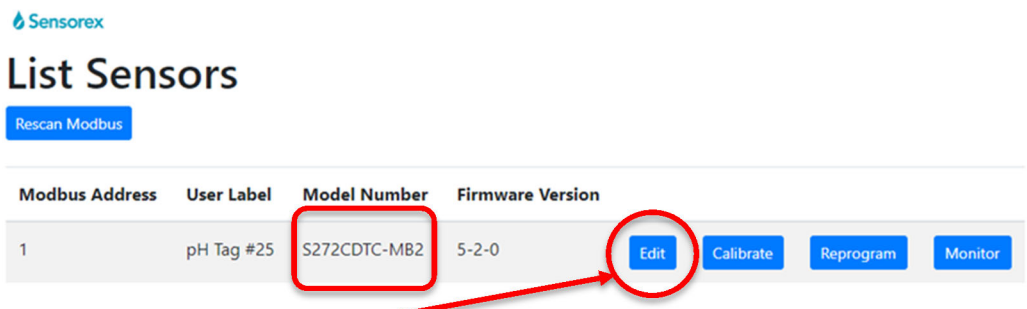


Scan Modbus for Sensors

Pressing the **Scan Modbus for Sensors** button will scan for all Sensorex Modbus sensors connected. It takes about ***30 seconds*** since it has to scan for all Modbus addresses, baud rates, and framing.



Once the scan is complete, the screen below will appear showing all sensors found.



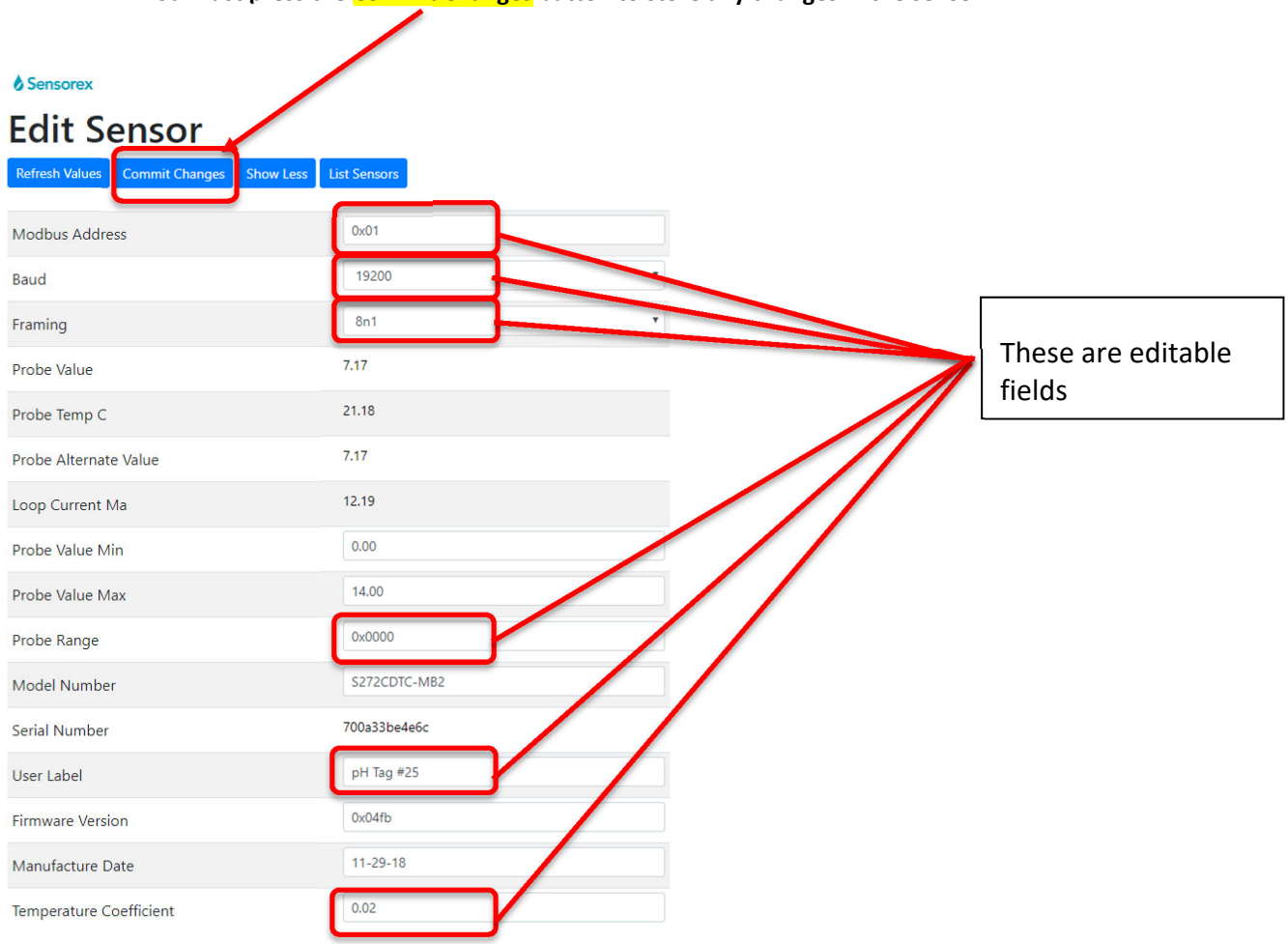
From this screen you can **Edit** sensor parameters, **Calibrate** your sensor, **Reprogram** or update the firmware in your sensor if a new version is available, and **Monitor** the operation of your sensor and ***log the data to a .csv file if needed.***

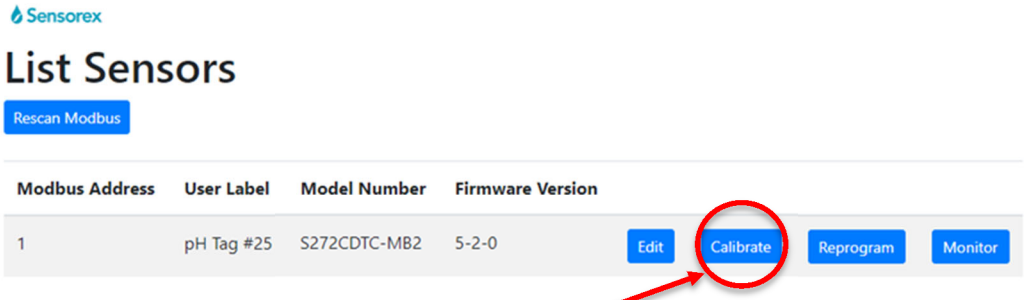
Edit Screen

Pressing the **Edit** button takes you to the edit screen. This screen allows you to configure your Modbus sensor to fit your particular installation.

- You can change the **Modbus address**, **Baud rate**, and **Framing** for your *sensor*. *Note: this is different from the initial screen, which allowed changes to your computer's settings.*
- With some sensors, you will be able to change the **Probe Range** of the sensor. For example, the DO Sensor has 2 ranges: 0-150% SAT and 0-300% SAT.
- An editable **User Label** is provided so you can enter a custom Label or Tag Number. This value will be permanently stored in the sensor.
- You can change the **Temperature Coefficient** for the sensor if desired. The industry standard 0.02%/°C is the default setting.

- **You must press the Commit Changes button to store any changes in the sensor.**



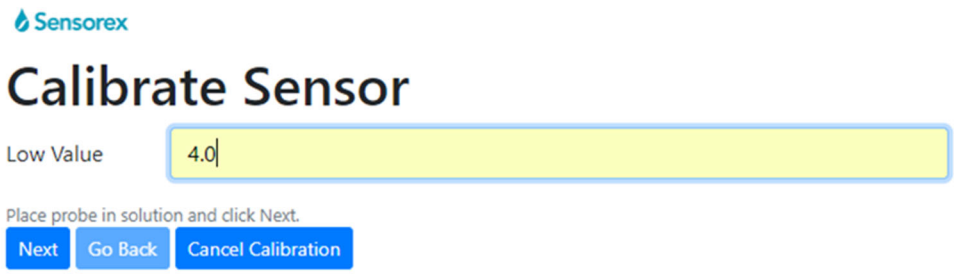


Calibration

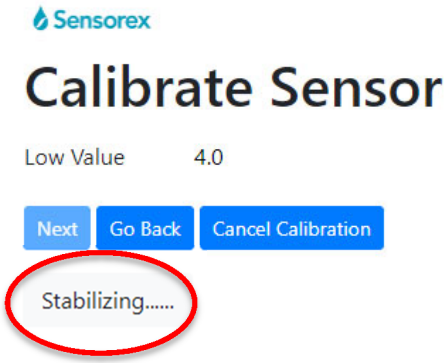
Pressing the **Calibration** Button takes you to a set of screens that allow you to calibrate the sensor. The software supports 1, 2, and 3-point calibration, depending on the sensor.

First, enter the low value for your calibration solution in the box provided, place the sensor in the solution, and press the **Next** button.

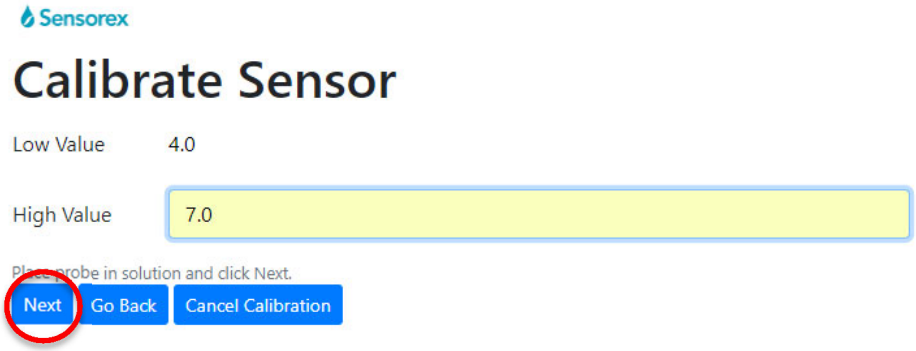
*Note: You can cancel the calibration at any time by pressing the **Cancel Calibration** button. The sensor will revert back to the previous calibration it has stored internally. You can also go back to the previous step by pressing the **Go Back** button.*



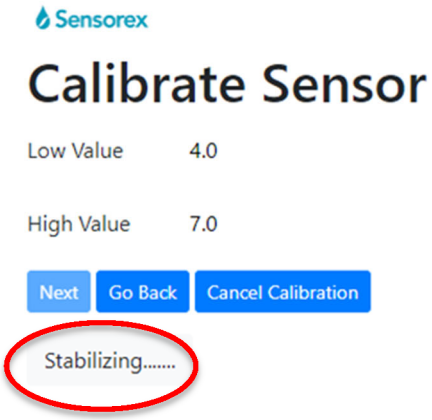
The sensor will take some time to stabilize as shown below, and then move on to the next step.



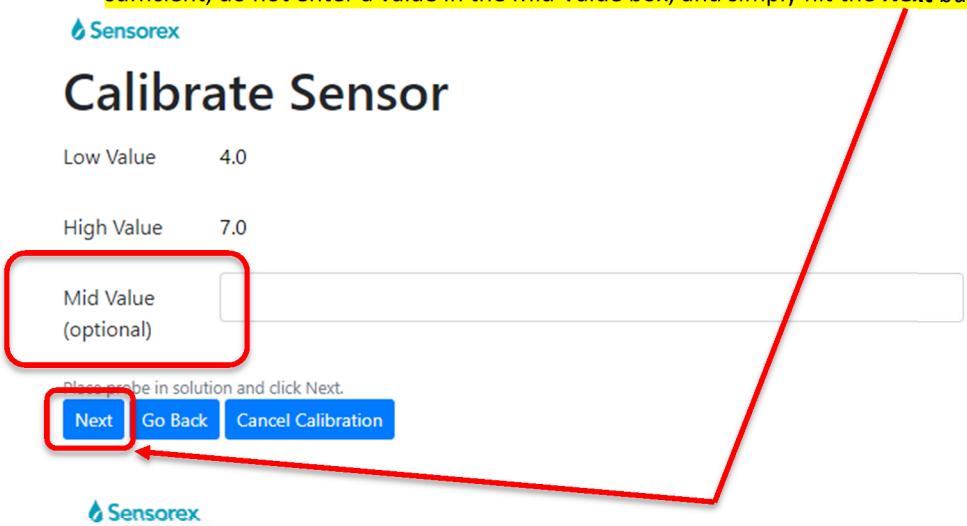
Once the value has stabilized, enter the High calibration solution value and press the **Next** button

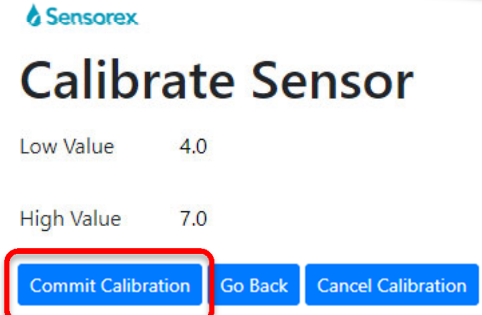


The sensor will again take some time to stabilize and move on to the next step.



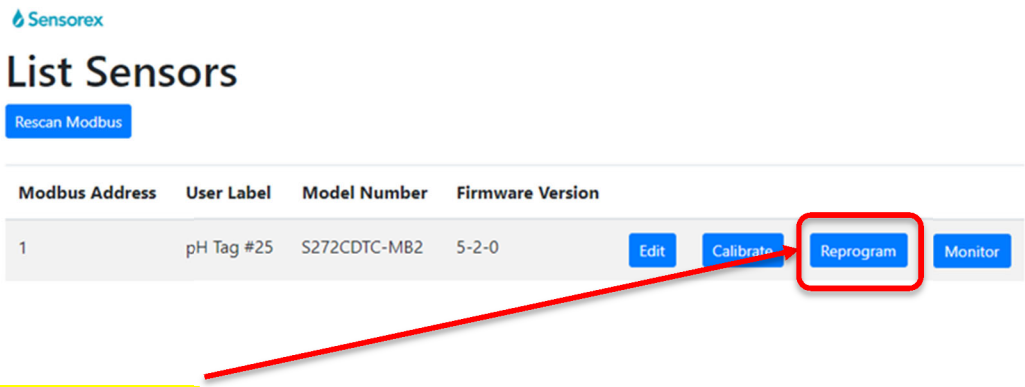
The optional Mid-Value can then be entered to complete a 3-point calibration. If 2-point calibration is sufficient, do not enter a value in the Mid Value box, and simply hit the **Next** button.





When calibration has been completed, press the **Commit Calibration** button to store the new calibration values in the sensor.

The program will then return to List Sensors screen with a message stating that the sensor has been successfully calibrated.

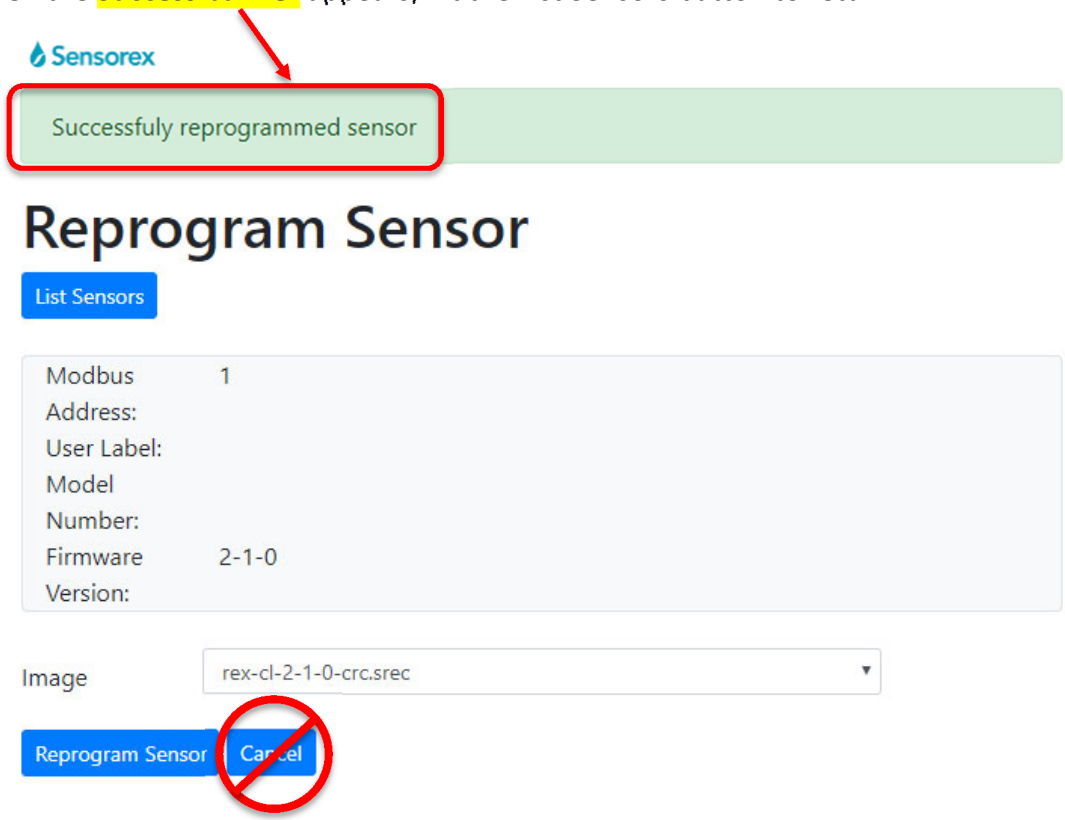


Reprogram Screen

The **Reprogram** screen allows the user to update the firmware inside the sensor to the latest version if desired. Simply select the applicable program from the pull-down list, and hit the Reprogram Sensor button.

*Warning – Do not hit the **Cancel** button during programming, as it will render the sensor unusable.*

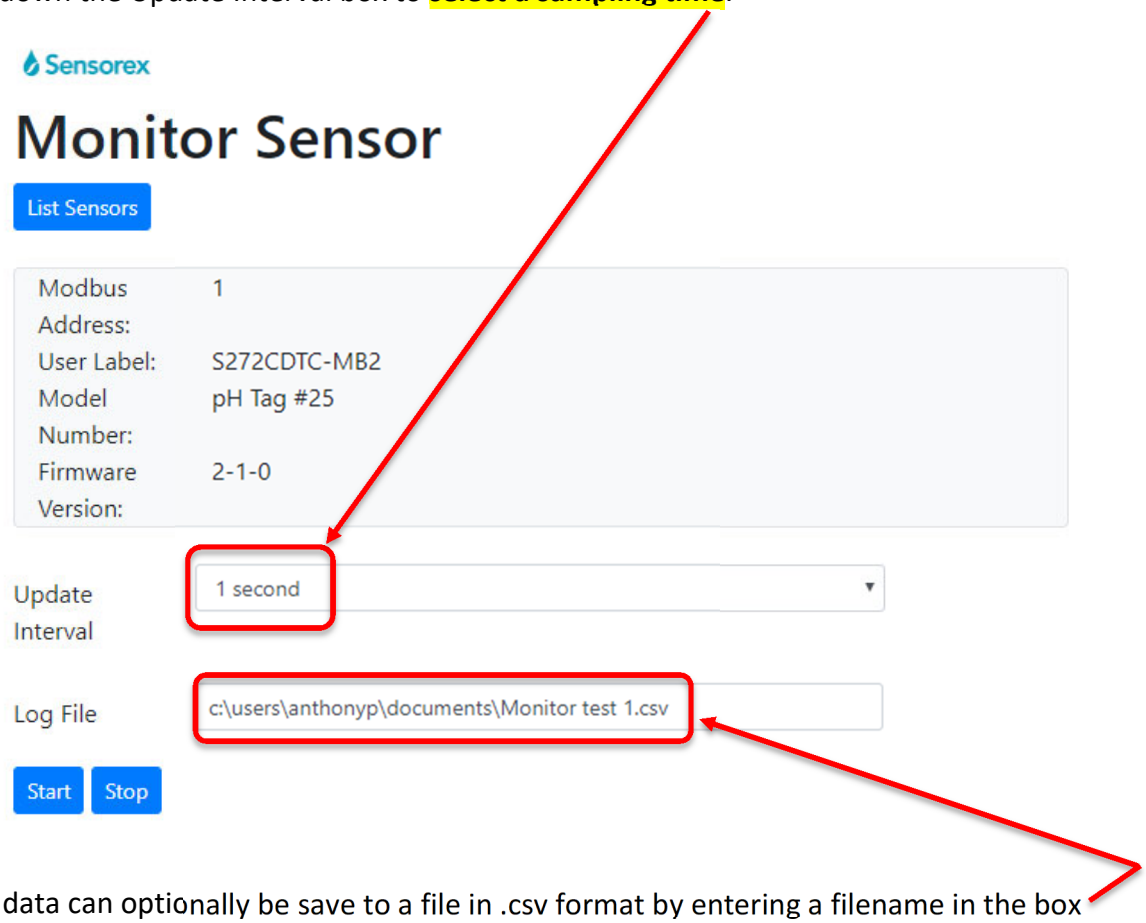
When the **Success banner** appears, hit the List Sensors button to return.



Monitor Screen

The Monitor Screen allows the user to monitor the sensor operation for a period of time. Once entered it will display the Modbus Address, User Label, Model Number, and Firmware Revision on the screen, followed by the date/time, Probe Value, and Probe Temperature, which are updated at a user specified interval.

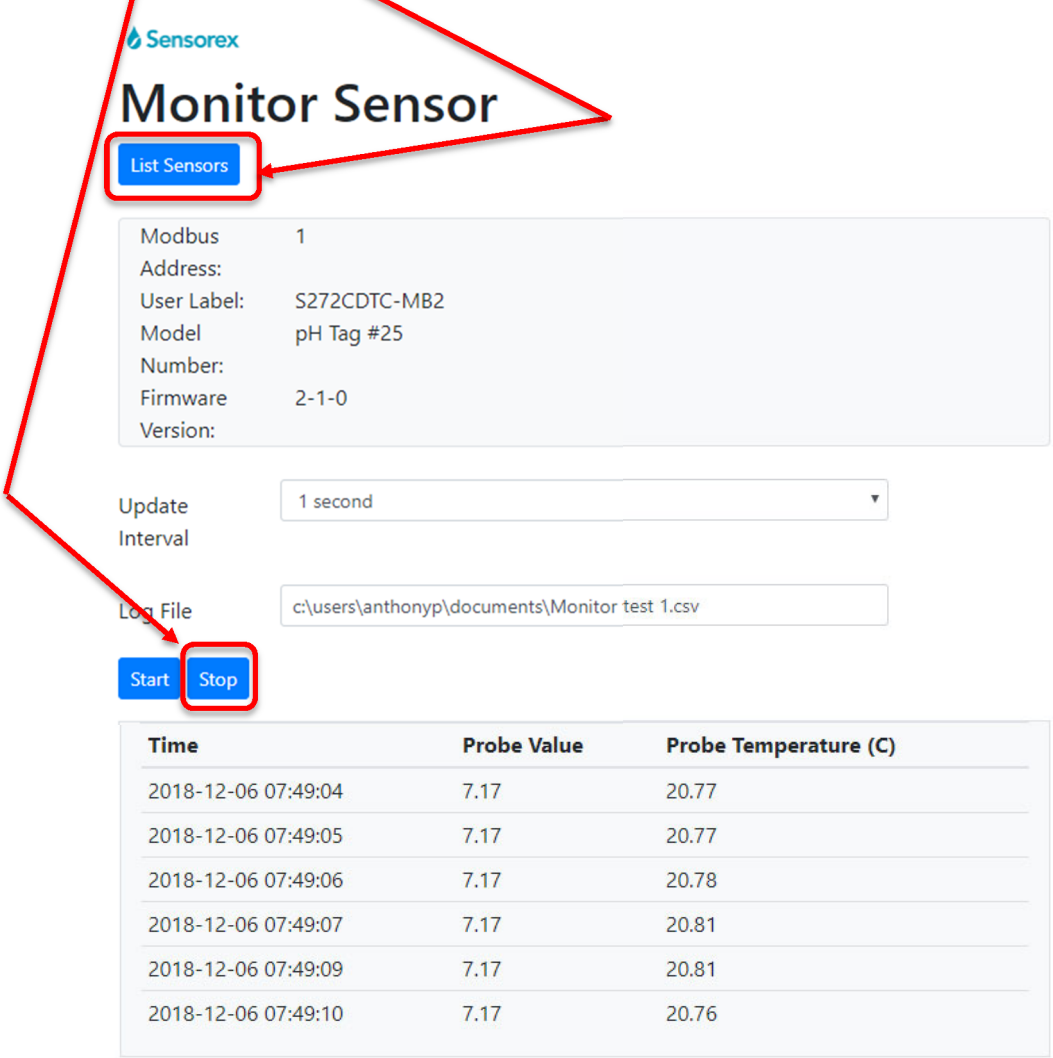
Pull down the Update Interval box to **select a sampling time**.



This data can optionally be save to a file in .csv format by entering a filename in the box provided.

Hit the Stop button to end sampling. See below for format of measurement data.

Hit the List Sensors button



Once your sensor is calibrated and set up you can connect the sensor to your PLC or SCADA system following the wiring above.

Below is the list of Modbus registers defined for the Sensorex Modbus sensor system. It is designed to cover a variety of instruments, and as such, not all fields are applicable to all instruments. ***Note: Modbus address default = 240.***

Summary

Address	Name	Type	Access	Preserved
0	Modbus address	Uint8	read/write	yes
1	Baud rate	Uint8	read/write	yes
2	serial_format	Uint8	read/write	yes
3	Probe_value	Float	Read only	yes
5	probe_temperature_c	Float	Read only	no
7	Probe_alternate_value	Float	Read only	yes
9	Loop_current_ma	Float	Read only	yes
11	Probe_value-min	Float	Read only	yes
13	Probe_value-max	Float	Read only	yes
15	Probe_range	Uint16	Read only	yes
16	Model_number	String12	Read only	yes
22	Serial_number	String12	Read only	yes
28	User_label	String12	Read/write	no
34	Firmware_version	Uint16	Read only	no
40	Manufacture_date	String12	Read only	yes
46	Temperature_coefficient	Float	Read only	yes
48	Pressure-torr	Uint16	Read/write	yes
50	Salinity_ppm	Unit16	Read/write	yes

Field Descriptions

Address

This is the base address of the Modbus Register. ***To get the true address of the register according to the Modbus specification, add 40001 to the register address shown.***

Name

This is the internal name of the modbus register. It is used for documentation and certain host-based administrative programs, such as SensorControl

Type

The type field describes the format of the data stored in that register. The following table lists the data types supported. The 'span' column indicates how many Modbus registers are spanned by the given data type.

type	span	description
char12	6	A string of 12 ASCII characters. Unused characters are null padded.
float	2	An IEEE 32 bit floating point value.
uint8	1	An unsigned 8-bit value.
uint16	1	An unsigned 16 bit value.

Access

Each modbus register conforms to one of the following access protocols:

access	description
read/write	The register may be read (via Function Code 03) or written (via Function Code 06 or 16)
read only	The register may be read (via Function Code 03) but not written.
protected	The register may be read without restriction (via Function Code 03), but a write operation must be preceded by writing the value 0x5358 to register 87 using Function Code 06.

Preserved

A preserved value of "yes" means the value is saved when written and restored when the instrument is restarted. Note that changes for many registers (such as modbus address and baud rate) don't take effect until the instrument is restarted.

User Registers

The following registers are typically read and written by end users.

Address	Name	Type	Access	Preserved
0	modbus_address	uint8	read/write	yes

modbus_address defines the address on the Modbus to which this instrument responds. Valid values are 1-245 [ed note: check this]. Note that in the Sensorex FishPac system, the following defaults are used:

- DO instrument: Modbus address 1
- pH instrument: Modbus address 2
- Toroidal Conductivity instrument: Modbus address 3

baud_rate (reg = 1)

The baud rate register defines the baud rate of the serial interface. The following values are currently supported:

Modbus Value	Interpretation
9	9600 baud
19	19200 baud
38	38400 baud

serial_format (reg = 2)

Serial format controls the format of serial communication. The following values are currently supported:

Modbus Value	Interpretation
0	8n1: 8 data bits, no parity checking, 1 stop bit
1	8e1: 8 data bits, even parity checking, 1 stop bit
2	8o1: 8 data bits, odd parity checking, 1 stop bit
3	8n2: 8 data bits, no parity checking, 2 stop bits

probe_value (reg = 3)

The probe_value field contains the current reading of the sensor. The interpretation of the value depends upon the probe type. For conductivity, the reading is in microsiemens, for pH, the units are in pH, for Dissolved Oxygen, the units are in millivolts.

probe_temperature_c (reg = 5)

The probe_temperature field contains the current temperature of the probe, expressed in degrees Celsius.

model_number (reg = 16)

The model_number register contains the Sensorex model number of the instrument.

serial_number (reg = 22)

The serial_number register contains a 12-character string with a unique factory ID for the processor / instrument.

User_label(reg = 28)

The sensor_version register contains a 12-character string with a unique ID for the processor / instrument set by the user (example = tag ID).

firmware_version (reg = 34)

The firmware_version register contains a 16-bit value describing the version of the firmware running in the instrument. The high order 8 bits are the major version number, the low order 8 bits are the minor version number.

manufacture_date (reg = 35)

The manufacture_date register contains the date of manufacture as a 'yyyy-mm-dd' formatted string.

pressure_torr (reg = 43)

The dissolved oxygen sensor requires the ambient pressure of the measured solution in order to give an accurate result. The pressure_torr register can be written to define the pressure of the measured solution. Defaults to 760 (sea level).

salinity_ppm (reg =44)

The dissolved oxygen sensor requires the salinity of the measured solution in order to give an accurate result. The Salinity PPM register can be written to define the salinity of the measured solution. Defaults to 0 ppm.

temperature_coefficient (reg =41)

The conductivity of liquids changes as a function of temperature. In order to properly calibrate and compare conductivity measurements, the industry practice is to normalize readings "as if" taken at 25C.

The Sensorex system corrects conductivity measurements using the formula:

$$C_{25} = \frac{C_t}{1 + \alpha(t - 25)}$$

where

- C_{25} = equivalent conductivity at 25C
- C_t = conductivity at ambient temperature
- t = ambient temperature
- α = temperature_coefficient

The default value for temperature_coefficient is 0.02 (2%). Please note that temperature_coefficient is described as a normalized coefficient, not a percentage. Setting the register to 2.0 would be equivalent to 200%.

Troubleshooting:

Make sure to use 120 Ohm twisted pair cable and 120 Ohm terminating resistor on all wiring.

Symptom	Possible Solution
Sensor not communicating	1) Check to be sure green LED on S857 cable is lit. 2) Make sure voltage on CAL BOX is about 20VDC by checking red and black wires with a digital multimeter 3) Swap Modbus wires. A & B may have been reversed. 4) Confirm Com Settings. Note defaults are 19.2 kBaud and 8n1. 5) Confirm device address. Default is 1.
Noisy Sensor Operation	1) Make sure wiring is using 120 Ohm impedance twisted pair to reduce noise susceptibility and noise emission. This is only an issue with long cables (>500ft). See link for recommended cable: https://www.belden.com/products/industrial/cable/bus-cable/rs485 2) Make sure that termination resistors are in place to prevent indeterminate state noise.
Customer Software Not Working	1) Verify the sensor is working with the Sensorex Sensor Control Software to see if problem is with customer software versus sensor. 2) Go to Modbus Organization to review the Modbus specifications (free) 3) For programmers and engineers, see web sites for manufacturers of RS-485 chips: Texas Instruments: http://www.ti.com/interface/rs-485-rs-422/overview.html Maxim: https://www.maximintegrated.com/en/products/interface/transceivers/rs-485-rs-422-transceivers.html Analog Devices https://www.analog.com/en/products/interface-isolation/rs-232-rs-422-rs-485-rs-562/rs-485-rs-422.html